

STS 83-0008B
Volume 1

SPACE SHUTTLE ORBITER
OPERATIONAL
LEVEL C
FUNCTIONAL SUBSYSTEM SOFTWARE REQUIREMENTS
GUIDANCE, NAVIGATION, AND CONTROL
PART C
FLIGHT CONTROL--ASCENT FLIGHT PHASE
VOLUME 1

June 30, 1987

Contract NAS9-14000
IRD SE-594D
WBS 19.9.1

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STS 83-0008B
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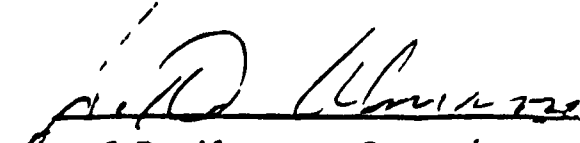
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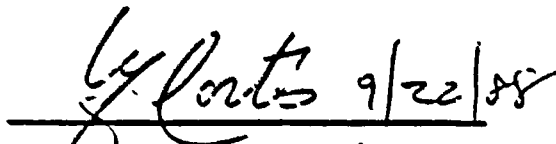
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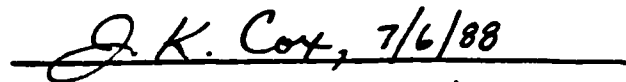
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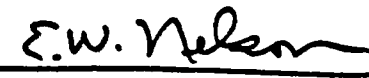
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Paragraph	CR No.	OI	Title
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4.2.11-2 (T)	89345	8B	I-load category change
4.3.5-1	89622B	8B	Guidance/control steering interface
4.3.5-2	89132D	8B	Guidance/control steering interface I-loads (G4.175)
4.6.5-2	89132D	8B	Ascent/entry attitude processor I-loads (G4.226)
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All CR pages	89413B	8C	Directional check for auto MM601-2 transition



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12337	I-Load OFT-1 Baseline
12339	I-Load OFT-1 Baseline
12404A	Proposed FCS 9 and Changes to Ascent FSSR and CR 12030
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12411B	OMS Engine FDI Simplification (Remove ACCUM DELTA VO
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12994	I-Loads OFT-1 FACI Update
19022	Modifications to 9-4-78 and 12-11-78 MPAD ILOAD Paper Baseline of 9-21-78
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CR89688

CR89718



FOREWORD

The primary avionics software system (PASS) requirements for the computer programs that execute in the Shuttle general-purpose computers (GPC's) are specified in the Computer Program Development Specifications (CPDS's) and the Functional Subsystem Software Requirements (FSSR) documents. The requirements are specified at three levels:

- Level A - System-level constraints and capabilities
- Level B - Functional requirements
- Level C - Detailed-level requirements

Level A CPDS specifies system-level constraints and capabilities that are not oriented toward any particular program end item. The Level B CPDS specifies system-level requirements for guidance, navigation, and control (GN&C) and detailed requirements for systems management (SM) and vehicle utility (VU). The Level C FSSR's specify the detailed requirements for GN&C and display/controls. The Level C reconfigurable requirements are specified in the systems management and payload documents. The Level A, Level B, and Level C requirements documents are listed in Section 2, Applicable Documents.



DOCUMENT CHANGE RECORD

The following tabulation summarizes the change activity associated with this document since Revision A dated June 30, 1985. A vertical line (change bar) and the appropriate CR number in the outer margin indicates the latest changes to each page.

Issue and Date	Change Summary
OI-8B Release (Revision B) June 30, 1987	This issue updates the baseline to OI-8B and includes the following CR's: 79646D, 79767F, 79935H, 89132D, 89219B.
PCN-1 May 6, 1988	This issue updates the previous release to include the following CR's: 89615 and 89688.
PCN-2 May 6, 1988	This issue updates the previous release. Referenced are: SCR's 89165H, 89250B, 89251B, and 89345 (I-loads).
PCN-2A June 6, 1988	This issue is an addendum to PCN-2 and includes CR 89132D and CR 89718.
PCN-3 (Appendix X) August 20, 1988	This page change notice updates the previous release to include CR 89408A and CR 89413A.
PCN-3A (Appendix X) February 6, 1989	This page change notice updates the previous release to include CR's: 89408A, 89413A, and 89865A.



DOCUMENT CHANGE RECORD

The following tabulation summarizes the change activity associated with this document since Revision A dated June 30, 1985. A vertical line (change bar) and the appropriate CR number in the outer margin indicates the latest changes to each page.

Issue and Date	Change Summary
OI-8B Release (Revision B) June 30, 1987	This issue updates the baseline to OI-8B and includes the following CR's: 79646D, 79767F, 79935H, 89132D, 89219B.
PCN-1 May 6, 1988	This issue updates the previous release to include the following CR's: 89615 and 89688.
PCN-2 May 6, 1988	This issue updates the previous release. Referenced are: SCR's 89165H, 89250B, 89251B, and 89345 (I-loads).
PCN-2A June 6, 1988	This issue is an addendum to PCN-2 and includes CR 89132D and CR 89718.
PCN-3 (Appendix X) August 20, 1988	This page change notice updates the previous release to include CR 89408A and CR 89413A.
PCN-3A (Appendix X) February 6, 1989	This page change notice updates the previous release to include CR's: 89408A, 89413A, and 89865A.



CHANGE REQUEST SUMMARY

The following tabulation lists the paragraphs, tables (T), and figures (F) that have been changed as a result of approved change requests commencing with OI-8A. Changes incorporated prior to OI-8A are listed in the Historical Change Request Summary.

Paragraph	CR No.	OI	Title
4.2.2-1 (T)	79935H	8A	SRB RGA Rechannelization
4.2.4-4B (T)	89132D	8A	APU Failure DAP Moding
4.2.4-4C (T)	89132D	8A	APU Failure DAP Moding
4.2.4-5 (T)	79935H	8A	SRB RGA Rechannelization
4.2.5	79935H	8A	SRB RGA Rechannelization
4.2.5-1A (F)	79935H	8A	SRB RGA Rechannelization
4.2.5-1D (F)	79935H	8A	SRB RGA Rechannelization
4.2.5-1E (F)	79935H	8A	SRB RGA Rechannelization
4.2.5-2 (F)	79935H	8A	SRB RGA Rechannelization
4.2.5-1 (F)	79935H	8A	SRB RGA Rechannelization
4.2.5-6 (F)	79935H	8A	SRB RGA Rechannelization
4.2.5-5 (F)	79935H	8A	SRB RGA Rechannelization
4.2.5-11 (F)	79935H	8A	SRB RGA Rechannelization
4.2.5-8 (T)	79935H	8A	SRB RGA Rechannelization
4.2.6-1 (F)	89132D	8A	APU Failure DAP Moding
4.2.6-3 (F)	89132D	8A	APU Failure DAP Moding
4.2.6-5 (F)	89132D	8A	APU Failure DAP Moding
4.2.6-3 (T)	89132D	8A	APU Failure DAP Moding
4.2.6-4 (T)	89132D	8A	APU Failure DAP Moding
4.3.2-1 (T)	89219B	8A	Auto-Loft, 1st Stage Contingency Clean-up
4.3.3	79767F	8A	Revision of GRTLS DAP Control Logic for ETSEP
4.3.3-1 (F)	79767F	8A	Revision of GRTLS DAP Control Logic for ETSEP
4.3.3-1 (F)	89219B	8A	Auto-Loft, 1st Stage Contingency Clean-up
4.3.4-1 (F)	79767F	8A	Revision of GRTLS DAP Control Logic for ETSEP
4.3.4-2 (T)	79767F	8A	Revision of GRTLS DAP Control Logic for ETSEP
4.3.4-6 (F)	79767F	8A	Revision of GRTLS DAP Control Logic for ETSEP
4.6.2-1 (T)	79767F	8A	Revision of GRTLS DAP Control Logic for ETSEP
4.6.2-1 (T)	79935H	8A	SRB RGA Rechannelization
4.6.4.7	79935H	8A	SRB RGA Rechannelization
4.6.4.7-1 (F)	79935H	8A	SRB RGA Rechannelization
4.2.6-5 (T)	89615	8A	TRIM MIX MPS
All CR pages	89688	8B	Ascent DAP errata update
All CR pages	89498	8B	Errata baseline
4.2.11-2 (T)	89165H	8B	I-load category change
4.2.11-2 (T)	89250B	8B	I-load category change

HISTORICAL CHANGE REQUEST SUMMARY

The following tabulation is a historical record of approved change requests incorporated since the initial baseline up to OI-8A. Change requests commencing with OI-8A are reformatted and listed in the Change Request Summary.

CR No.	Title
2265B	Add IMU Align Capability to OPS 3
2313A	Addition of TLM Requirements
2340	Revision to the Processing and Display of Attitude Data
2433C	Addition of GN&C/SM-PL IF(4.111) to GNC OPS 3 for GNC OPS 3/SM OPS 2 Operation
2449D	OFT Contingency Abort Requirements
2492B	Vehicle Mass Definition Inconsistency
2494C	LVL A Downlist Requirements (Entry) (Add PSI to D L)
2580	Modification to Linear Interpolations (INTERPS)
12000B	Ascent Flight Control FSSR PF I O Table Update
12001	Addition of Pitch Attitude Tape Scale to Vertical Sit Dipoles
12004	Delete Fader GRTLS in Ascent Flight Control
12005	Statement Level Simulator (SLS). Update of A E ATT_PROC
12006A	Format Caution, HAL Convention
12019	Standardization of FSSR Principal Function I O Tables
12025	Statement Level Simulator (SLS) Update of GC_STEER Initialization Requirements
12030	Statement Level Simulator (SLS) Update of GC_STEER and ASC_DAP
12035	Staging INTERPS Change
12056	Ascent/Entry Attitude Processor Formulation Corrections
12058	IMU Gimbal Angle Time Tab
12105	Reinstate Mass and Mass Rate Fill of PEG Output in Second Stage
12106B	Format Caution, HAL Convention, and Make Work Correction of Utility Functions
12177B	Dedicated Display Rate Reductions
12211A	Ascent and Transition DAP Overlap Problem Resolution
12218	Aero Actuator Command SOP Ascent Rate Scrub
12225B	GN&C Level C Uplink Requirements
12227	INTERPS NYREF Simplification
12250A	Delete SRB Vector Limiting
12252A	I Load for INIT ADI Reference Quaternion
12267A	Quaternion Utility Functions Updated and Made Re-entrant
12269	MSID Corrections to IDD Tables
12311A	Delete Priority Rate Limiting in MM10 ³
12313B	Addition of TLM Requirements
12314B	Attitude Sample Rate Reduction for Ascent
12316	GN&C Switch RM Processing Rate Reduction
12317	A/P ATT_PROC Rate for TRANS DAP



CR No.	Title
19045A	MPAD I-Load Update for Cycle 2
19054	MPAD I-Load Update for Cycle 2
19067A	Modifying Attitude Errors With Acceleration Errors for Monitoring Load Relief Performance
19069A	Resolution of I-Load Ambiguities and Errors
19084A	Removal of Crosswind Compensation
19096	Modification to W Bias Computation Logic (CR 12689B)
19097A	Additions to MPAD I-Load Update for Cycle 2
19100	Interim Change Requests for PCN1
19101A	I-Load Corrections for Ascent FCS
19136	Simplify Sideslip Computation
19167B	REL NAV Display Interface Correction
19177A	Extinguish PBI Lamps at Terminations of Ascent DAP
19179	Transition DAP/RCS SOP Rate Reduction
19183A	Fast Separation Attitude Control
19200	Redundant I-Load: TNBBODY
19204	Ascent Flight Control FCS10, Second Stage
19205	GC STEER and ASC DAP I-Load Corrections
19277	MPS TVC Gravity Initialization
19280	Three-Engine-Out RCS Roll Control
19302	Deletion of Transition Mode in ATT_PROC During RTLS
19326	Modification of GC STEER Sequencing Requirements
19329	Exempt Interps From "Unscheduled Execution of Low Rate Module" Reqmt. In Para. 4.1.3.C
19331	Corrections in the Attitude Processor Inner Loop Processing
19333A	Modifications to IDD Requirements for Ascent Flight Control
19364	FCS10 I-Load Ascent Flt. Control, First & Second Stages
19374	Attitude Error Limit for Manual Guidance
19389A	Attitude Processor I-Load Corrections (STS-1, Cycle 2)
19394C	I-Load Data Tape Corrections
19395	OV-102 IMU/ST I-Load Update for KSC (VU-5)
19397	Incorrect Requirements in an Approved GC-STEERCR
19409A	COAS Mark/ADI PB Interface
19415A	Correct I-Load CR's
19431	Sign Error in Ascent Manual Guidance
19441	Correct ADI Error Needles to "Fly-To" Reference
19448	ADI Error Needles During Ascent
19452B	I-Load Correction Necessary for 3/19 Release
19455	Measurement Attribute Corrections
19465	ADI Error Needles During RTLS
19484A	I-Loads Data Tape Corrections From Community Review
19488A	IMU Rate Change (V_IMU_CURRENT Input at 1.04 Hz)
19536	Corrections to MPS Actuator Rate Limiting
19581B	Corrections to I-Load Paper Baseline - STS1 ⁽²⁾ (Corrections to CR 19394C)
19601	Correction and Clarification of the RGA Prefilter Module in the Ascent/Entry Attitude Processor
19611A	Provide Time Homogeneous Data to NAVDAD SOP



CR No.	Title
29895B	Update GN&C/SM-PL I/F Requirements
29908B	3.1.1 I/L Changes for RTLS
29938	STS-1 Cycle 3.2.2-AOA to Edwards
29982C	Ascent ADI Reference RELMAT
39085	First-Stage SSME Out Prof I/L
39188	Quat for IMU 21 in Pos 1 (1)
39189	Quat for IMU 21 in Pos 2 (1)
39192	Cycle 3.3.3 I/Loads (1)
39218A	Cycle 3.3.3 MPAD I/L - Abort (1)
39246	Elevon Schedules for Ascent (1)
39276A	IMU S/N 12 I-L/Pos1/VAB, PAD (1)
39277A	IMU S/N 12 I-L/Pos2/VAB, PAD (1)
39278A	IMU S/N 12 I-L/Pos3/VAB, PAD (1)
39280A	STS-2 Cycle I Nom Asc & 10 (1)
39292	IMU S/N 21-Pos 3 I/L - R 18 (1)
39304	IMU 12-Pos 1 - Quaternions (1)
39305	IMU 12-Pos 2 - Quaternions (1)
39306	IMU 12-Pos 3 - Quaternions (1)
39323A	STS-2 Cycle I MPAD ABORT I/L (2)
39355	STS-2 Ascent Mass & TRIM I/L (1)
39431A	ADI Error from Q-B-I-CMD (1)
29731A	SSME & SB Posn-Recycle Count
39087A	Head Up Display (HUD)
39163	Ascent ADI Reference Relmat
39365F	HUD PROC I/O Cleanup
39401A	Transatlantic Abort Landing
39467A	DR Closeout-DOC Cleanup
39530F	STS-2 Cycle 2 I-Loads (2)
39543	IMU S/N 20 I/L Pos 3/VAB, DAD(1)
39660	Elevon Load Relief Correction
39950	FSSR Update
29490C	RCS Vernier Leak Detection
59006	Clearing OMS Gimbal Trim CMD
39899	On-Orbit Auto Maneuver
39590B	RUDDER/SB Hinge Interfer - G1 & G3
39983A	Flight Control I/L IUS P/L
59450	FSSR Update
59218	CORR ASC/ENT & Orb ATT PROC
59095A	First-Stage Engine-2 Out Guidance
59279A	SSME Pitch Parallel Second Stage
39092	Unfreeze ADI Yaw Axis
39875	TAL Abort Wings Level
397731	Delete FCS Downmoding
39640	FSSR Update No. 11/18 and No. 3/19
39950	FSSR Update No. 12/18 and No. 3/19
59267C	Adaptive First Stage Guidance (ref only)
39700D	Ent/GRTLS FCS Gain + Aero Mode (ref only)
39958A	IMU S/N 1 I-Load, Slot 2 (ref only)
59261	STS-5 CY 5 Ascent Abort I-Loads (ref only)
29886G	MVRR EXEC DISP DPIS UPDT



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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of the Flight Control (FC) Level C document is to present the requirement details and formulations of the FC Level B functional requirements for the integrated vehicle GN&C flight software.

1.2 SCOPE

This document contains the requirement details and formulations for those FC functions which are operative during the Ascent phase of OFT. The FC functions are those specified in the GN&C Level B functional requirements document.

1.3 ORGANIZATION

This document is organized into the following sections:

1.0 Introduction

2.0 Applicable Documents

3.0 Overview

4.0 Flight Control Functional Requirements

Section 1 defines the purpose, scope, and organization of this document. Section 2 lists the applicable document. Section 3 provides an overview of the OFP software functions and discusses the contents of Section 4. Section 4 specifies the requirement details.

STS 83-0007 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part C, Flight Control Entry - GRTLS

STS 83-0008 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part C, Flight Control Volume 1, Ascent Flight Phase, Volume 2, Ascent

STS 83-0009 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part C, Flight Control Orbit DAP

STS 83-0010 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part D, Redundancy Management

STS 83-0013 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part E, Inertial Measurement Unit Subsystem Operating Program

STS 83-0014 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part E, Volume 1, Navigation Aids Subsystem Operating Program, Volume 2, Star Tracker Subsystem Operating Program

STS 83-0015 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part E, Subsystem Operating Programs, FC Sensor/Controller

STS 83-0016 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part E, Subsystem Operating Programs, FC Effector

STS 87-0017 Operational Flight Level C, Functional Subsystem Software Requirements; Remote Manipulator System

STS 83-0020 Operational Flight Level C, Functional Subsystem Software Requirements; Displays and Controls

STS 83-0026 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Sequencing



2. APPLICABLE DOCUMENTS

2.1 LEVEL A DOCUMENTS

SS-P-0002-140 NSTS Downlist/Uplink Software Requirements
SS-P-0002-150 NSTS Launch Data Bus Software Interface Requirements
SS-P-0002-170 NSTS Systems Level Requirements, Software

2.2 LEVEL B DOCUMENTS

SS-P-0002-510 NSTS Functional Level Requirements, GN&C
SS-P-0002-550 NSTS Functional Level Requirements, Vehicle Utility
SS-P-0002-580 NSTS Functional Level Requirements, Systems Management

2.3 LEVEL C DOCUMENTS

STS 83-0001 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part A, Entry Through Landing Guidance
STS 83-0002 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part A, Guidance Ascent/RTLS
STS 83-0003 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part A, Guidance On-Orbit/Deorbit
STS 83-0004 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part B, Entry Through Landing Navigation
STS 83-0005 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part B, Navigation Ascent/RTLS
STS 83-0006 Operational Flight Level C, Functional Subsystem Software Requirements; Guidance, Navigation, and Control, Part B, On-Orbit Navigation



JSC-19350 NSTS Flight Software Initialization Load

- Volume I General Requirements
- Volume II Mission I-Load Requirements

JSC-19478 Payload Management, Level C Flight Software Requirements

JSC 19590 Systems Management, Level C Flight Software Requirements

2.4 ICD DOCUMENTS

ICD-3-1011-02 GPC/DEU ICD

ICD 3-0068-03 PASS/BFS ICD

In the event of a conflict between the documents referenced herein and the contents of this specification, the precedence shall be determined as defined in paragraph 1.3 of CPDS SS-P-0002-170, Volume 1, System Level Requirements, Software.



The flight control (FC) module can be thought of as containing a hierarchy of modules, the top level of which is shown in Figure 3.3-1. The presentation of the detailed functional requirements in Section 4.0 follows the same organization, as indicated by the subsection numbers shown on the figure.

Subsection 4.1 presents the high-level requirements for the modules shown in Figure 3.3-1. These requirements include constraints on execution times, delay times, cycle frequencies, and module sequencing order.

Functions, such as filters and quaternion operations that are utilized in several modules, are grouped in Subsection 4.7 under the heading of Utility Functions. This grouping is done for convenience to avoid repeating detailed specifications. Furthermore, it makes explicit the existence of identical specifications in several modules. It does not, however, imply that these functions need necessarily be subroutines in the software implementation.

3.0 OVERVIEW

3.1 OPERATIONAL FLIGHT PROGRAM

The Operational Flight Program (OFP) represents the total computer program which operates in the orbiter general-purpose flight computer subsystem. For the orbiter flight tests, the OFP will consist of two versions: one for the approach and landing test (ALT) and one for the orbital flight test (OFT). The requirements for each OFP are specified at three levels: System Level (A), Functional Level (B), and Detail Level (C) requirements. In addition, the Level B and C requirements are specified in separate documents for guidance, navigation, and control (GN&C); for system management (SM), and for vehicle utility. This document is the Flight Control (FC) part of the GN&C Level C OFP requirements for the OFT ascent flight phase.

3.2 GN&C SOFTWARE MAJOR FUNCTIONS

The orbiter general-purpose computers (GPC) provide the following GN&C major functions:

- A. Guidance
- B. Navigation
- C. Flight Control
- D. Redundancy Management/Moding, Sequencing, and Control
- E. Subsystems Operating Programs
- F. Display Interface Processor

Additional GN&C major functions provided by the GPC software are the Flight Computer Operating System, GN&C System Management and Performance Monitoring, and Checkout.

This document specifies the software functional requirements for the GN&C major function C above, Flight Control.

3.3 FLIGHT CONTROL SYSTEM OVERVIEW

In this FSSR release, the detailed functional requirements are presented for the following principal functions:

- Ascent DAP
- A/E Attitude processor
- GC Steer

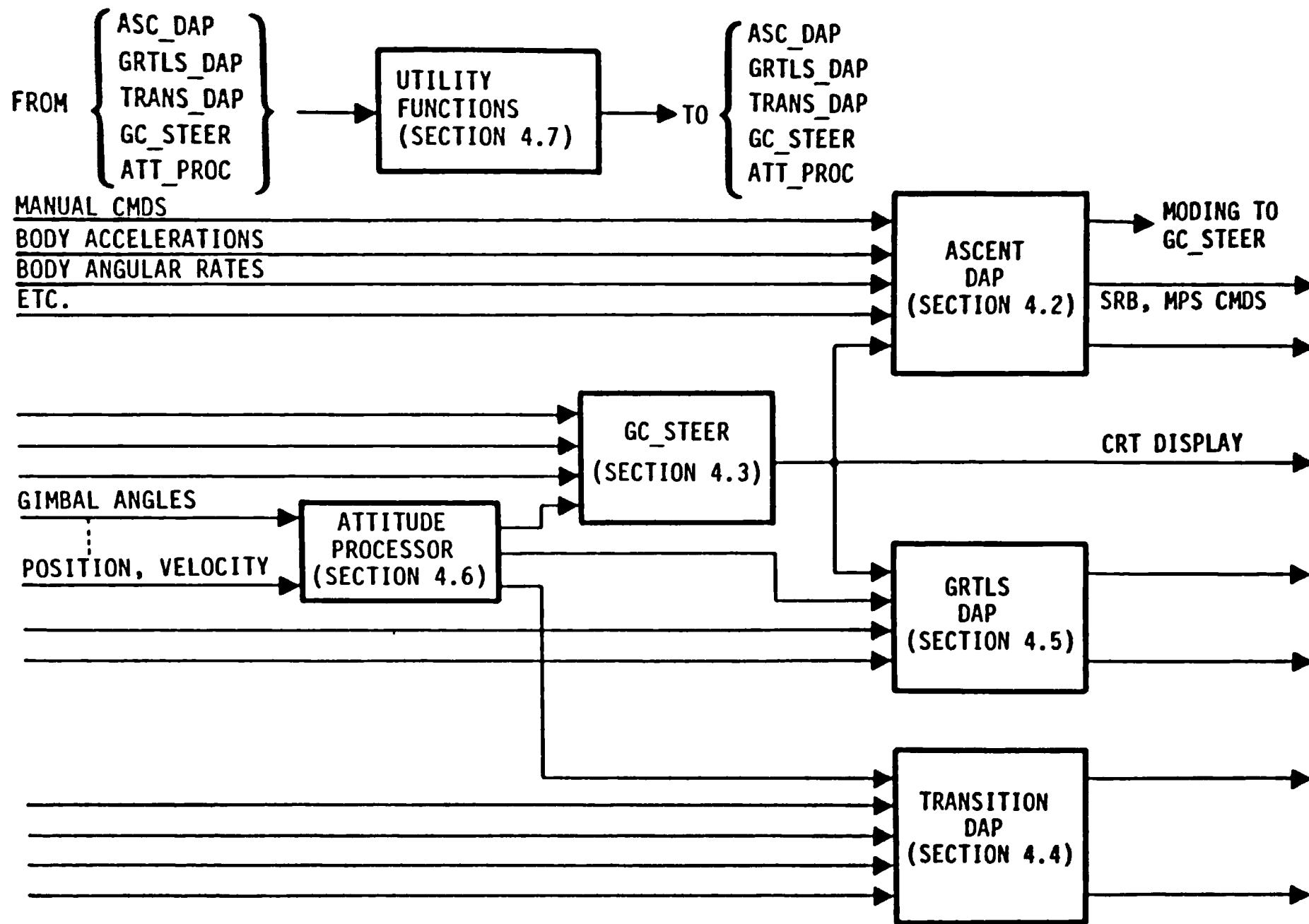


Figure 3.3-1. Ascent Phase Flight Control High-Level Organization

4.0 FLIGHT CONTROL FUNCTIONAL REQUIREMENTS

4.1 TIMING, SEQUENCING, AND INITIALIZATION REQUIREMENTS

4.1.1 Interpretation of Detailed Material

The term "module" is used generally in this document to mean a group of related functions. Specifically, the term "function module" is used in reference to the basic building blocks of this specification. Function modules are to be traceable in the flight software as identifiable entities that perform the functions specified in this document, such as filtering, limiting, integrating, and fading.

The general rules for determining the order for executing any set of modules are set forth in Subsection 4.1.3. In addition, as part of the description of each module in Section 4.0 which contains smaller, internal modules, there is a flow chart which strings together the internal modules. Although these flow charts are presented as "sequencing requirements," it should be understood that they only present one particular way of correctly sequencing these modules.

Wherever details are presented within a function module, they are included to facilitate the presentation, not as a specification. It is required only that the functional relationship between input and output of a function module be preserved. For example, if a function module contains a filter followed by a constant gain, as shown in Figure 4.1.1-1, it would be permissible to implement the module with the gain merged into the filter coefficients, as suggested by Figure 4.1.1-2. On the other hand, this document does specify everything not contained within the function modules, including traceability in the flight code and input-output signals of the modules.

It is required that initialization be functionally equivalent to that indicated in the discussions of the individual modules. It is not required that the initialization be done within the module. See Subsection 4.1.4 for a further discussion of initialization.

4.1.2 Timing Requirements

Timing in this document is related to error-free processing conditions. See Level A CPDS, SS-P-0001-170, paragraph 4.4.2A, for timing related to error processing conditions.

Timing control is performed by the flight computer operating system (FCOS). Requirements relating to the FC module are as follows:

- A. A minor cycle rate of 25 Hz. The cycle-to-cycle time period tolerance of the minor cycle is specified in CPDS Level A, Section 4.4.2.

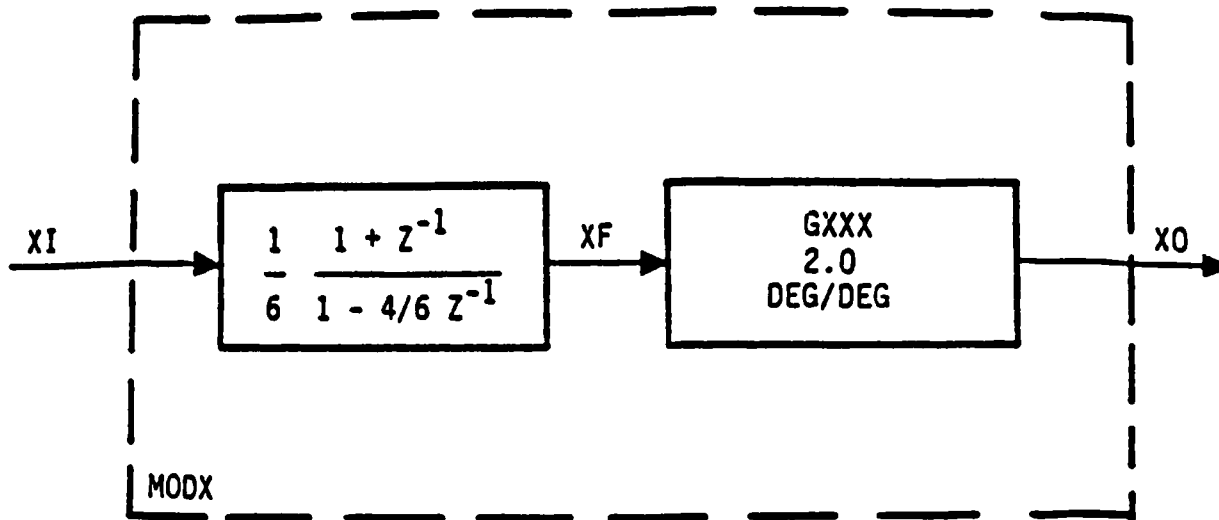


Figure 4.1.1-1. Specification of Function Module MODX

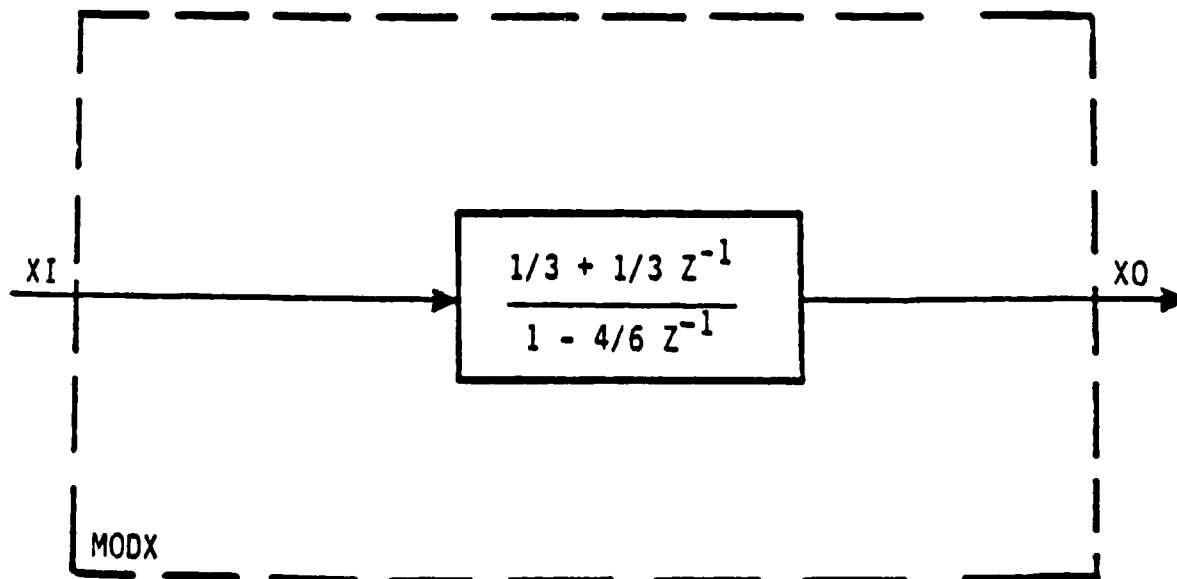


Figure 4.1.1-2. Diagram of a Permissible Implementation of Function Module MODX



- B. Worst-case transport delay in the minor cycle of 20 ms from data input to data output, including delays associated with MDM/IOP operation.

The allowable software-incurred delays are specified in CPDS Level A, Section 4.4.2

- C. A requirement for execution rates that are the following submultiples of the minor cycle rate: 25, 12.5, 6.25, $25/12 \approx 2.08$, $25/48 \approx 0.52$ Hz. Some of these rates may be achieved by use of counters within the FC module, rather than be scheduling through FCOS.

4.1.3 Sequencing Requirements

Sequencing requirements for GUID, NAV, MSC, SOP's, etc., as they relate to flight control are not dealt with, per se, in this document. A rough attempt to lay down some requirements is presented in Figure 4.1.3-1. (Note that the functions shown in dashed lines are not covered by this document.) In lieu of firm sequencing requirements for GN&C (from the flight control point of view) consideration has been given to the maximum transport lag tolerable by the flight control system or input variables. These transport lag requirements are summarized in Subsection 6.4 of the Level A CPDS SS-P-0002-170.

Whereas sequencing requirements for all of ASCENT GN&C cannot be dealt with properly in this document, the sequencing requirements for the ASCENT phase flight control can (including ASCENT DAP, GRTLS DAP, TRANSITION DAP, ATTITUDE PROCESSOR and GC STEER). These requirements are shown in Figure 4.1.3-1.

The following general statements are made regarding the sequencing requirements for the flight control system:

- A. Within a rate group, modules are executed prior to modules to which they supply data.
- *B. *Modules not processed at 25 Hz may be performed in that portion of the minor cycle which does not contribute to 25 Hz transport delay. High-rate computations which do not contribute to the output of the current non-transport-delay-critical part of the minor cycle. They are not flagged out in this document.
- C. When reconfiguration (including first pass) occurs, those modules that supply data to transport-delay-critical modules will be executed before the first pass in the new configuration. Note that this requirement, together with the requirement to mechanize reconfiguration within 80 ms of recognition of a valid mode-change request, may necessitate an unscheduled execution of low-rate modules.

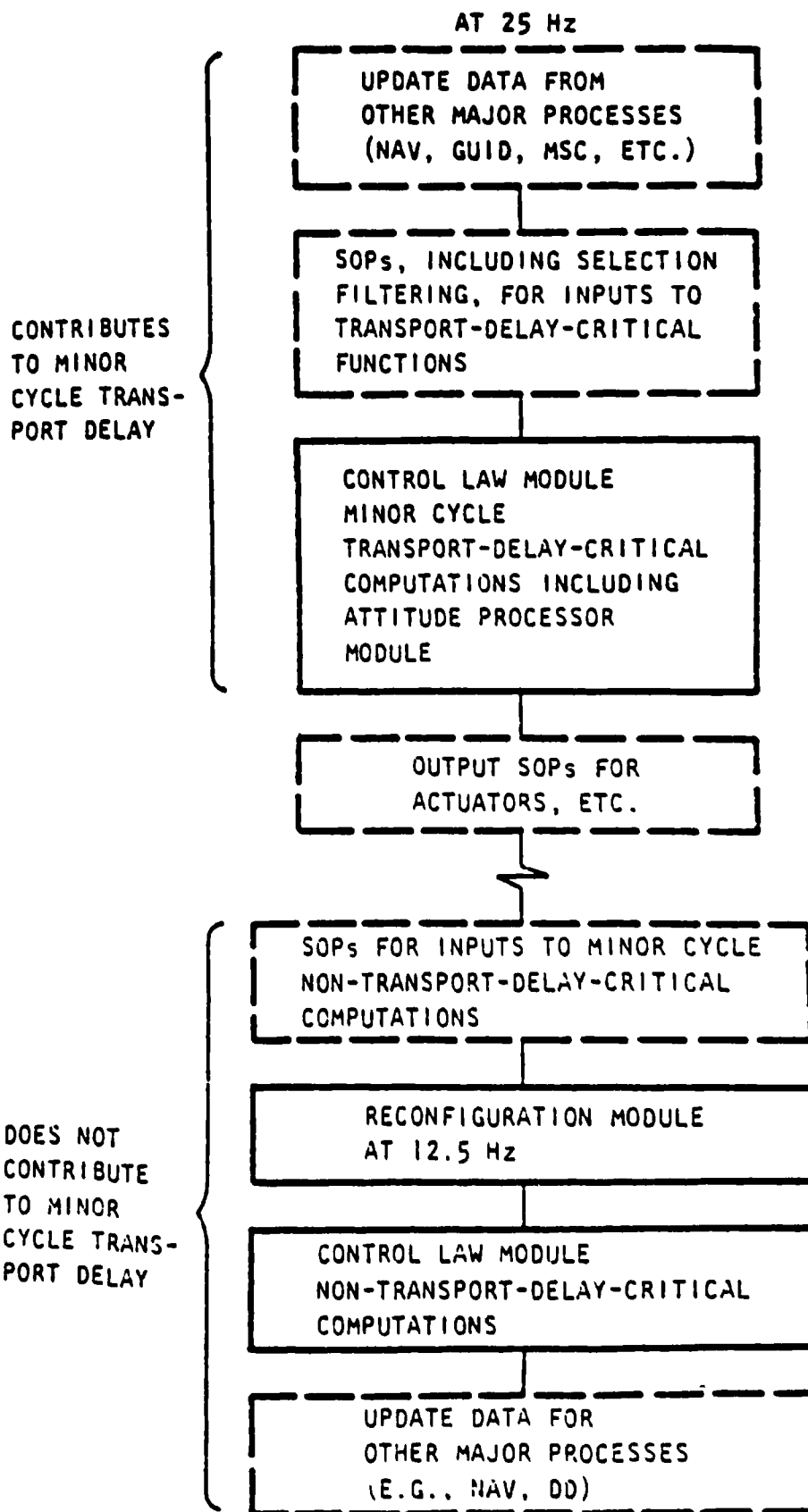


Figure 4.1.3-1. GN&C High-Level Sequencing Requirements

- D. Sequencing requirements for GN&C are presented in Figure 4.1.3-1. Functions shown in dashed lines are not covered by this document. The modules that do not contribute to transport-delay-critical modules, e.g., a separate HAL process, may be used.

4.1.4 Parameter Initialization

Parameter initialization requirements are specified in this document at the local level. The detailed requirements subsection for each function module specifies initialization requirements for variables and/or parameters within the module. This does not preclude centralized remote initialization in the software implementation, subject to the stated initialization requirements. Some general notes on initialization follow:

- A. Initialization of a module is the processor assigning values to quantities referenced by that module (variables and/or parameters), whenever required by discrete changes in external conditions.
- B. Dynamic initialization of a module uses current values of variables, instead of simple constants. An example of dynamic initialization is the dc initialization of a filter based upon the current value of its input, instead of simple nulling of the filter output and nodes.
- C. Local initialization of a module is performed by the module itself, at the local module level.
- D. Remote initialization of a module is performed in some central place, along with other similar remote initializations. Constants or globally available variables can be used.
- E. Local dynamic initialization of a module permits the use of quantities computed in modules executed prior to the one being initialized.
- F. In general, filter initialization has been specified to occur when, and only when, the filter goes from an inactive to an active state. Filters are inactive (not executed) when their outputs are not being used. Filters are discussed further in Subsections 4.7.1, 4.7.2, 4.7.3 and 4.7.4.
- G. The "first pass" condition, which is specified for some initializations, is defined as the initial activation pass through the FC module after it has been in an inactive state. Such remote initialization can be implementationally efficient, and so is suggested even though the module may not be activated until several subphases later.
- H. The impact of initialization on function module grouping according to sample rate is discussed in Subsection 4.1.3, Item C.



4.1.5 Software Implementation Constraints

Several constraints and assumptions apply to the flight software implementation of the requirements in the following subsections. The flight software shall be capable of recovering from transient erroneous inputs without causing a processing halt. Check or error interrupts shall be prevented by appropriate safeguards. Specifically, the standard fixup and error returns described below shall be provided:

- A. Floating Point Overflow. The task in process should be terminated and the previous stored value of the variable retained.
- B. Floating Point Underflow. This may be treated in the same manner as floating point overflow, or the variable may be set to zero and processing continued.
- C. Divide by Zero. This should be treated in the same manner as floating point overflow.
- D. Square Root. The square root of a negative number should be treated in the same manner as floating point overflow.

4.1.6 Traceability

Table 4.1.6-1 shows the traceability of the software segments in the FSSR Level C with respect to the Level B CPDS.

Table 4.1.6-1. Level C to Level B Traceability

Level C Document Section	Level B Principal Function Name	Level B Principal Function Paragraph Number
4.2 Ascent DAP Functional Requirements	Ascent Digital Autopilot	4.176
4.3 Guidance/Control Steering Interface	Guidance/Control Steering	4.175
4.6 Ascent/Entry Attitude Processor	Ascent/Entry Attitude Processing	4.226

4.1.7 Documented Requirements Precedence

Requirements precedence in this document shall be as follows:

1. If there is a conflict between the data in the function subtables and the standard principal function tables, the principal function tables shall have precedence.
2. If there is a conflict between the data in the flow diagrams and the written requirements, the written requirements shall have precedence.

4.2 ASCENT DAP FUNCTIONAL REQUIREMENTS



4.2 ASCENT DAP FUNCTIONAL REQUIREMENTS

4.2.1 Introduction

The ASCENT DAP module controls the vehicle in response to automatic commands during the ascent flight phase, using the SRB and SSME TVC actuating systems and RCS.

4.2.2 Interface Requirements

The interface variables required to properly execute the ASCENT DAP function are given in Tables 4.2.2-1 and 4.2.2-2.

Table 4.2.2-1. Input Variables, ASCENT DAP

FSSR Name	Description	MSID (MNEEMONIC)	Source	Type	Range	Units	Sample Rate (1z Required)
MPS_SLEW_COMPLETE	Indicator, Event 5A; MPS hydraulic system slew test complete flag	V90X8400X (G51127)	ORB ACT SLEW, RS LCH SEQ	B	0, 1	-	*
DBFOFB	COMP BF POS	V95H8310C (G09601)	BF PFB SOP	S	-15.825, +26.675	deg	6.25
DELTAP_LIB	LIB elevon actuator differential pressure	V95P8015C (G37803)	DELTA P FB SOP	S	±3,000	lb/in. ²	6.25
DELTAP_LOB	LOB elevon actuator differential pressure	V95P8017C (G37804)	DELTA P FB SOP	S	±3,000	lb/in. ²	6.25
DELTAP_RIB	RIB elevon actuator differential pressure	V95P8016C (G37801)	DELTA P FB SOP	S	±3,000	lb/in. ²	6.25
DELTAP_ROB	ROB elevon actuator differential pressure	V95P8018C (G37802)	DELTA P FB SOP	S	±3,000	lb/in. ²	6.25
GUIDANCE_INITIATE	Indicator, Event 29; Stage 2 guidance ready	V90X8630C (G33610)	MSC	B	0, 1	-	0.52
HYDRFAIL (1)	Hydraulic system failure status indicators	V96X3005X (G46363)	HYD SYS SOP	B	0, 1	-	12.5
HYDRFAIL (2)		V96X3006X (G46364)		B	0, 1	-	12.5
HYDRFAIL (3)		V96X3007X (G46365)		B	0, 1	-	12.5
VY	Lateral acceleration (AA)	V90A5361C (G14445)	SF		±1	g	25
NZ	Normal acceleration (AA)	V90A5381C (G14446)	SF	S	±4	g	25
P_4	SRB 4 thrust chamber press.	V90P2535C (G14512)	SF	S	0,+1,000	lb/in. ²	12.5
PC5	SRB 5 thrust chamber press.	V90P2536C (G14513)	SF	S	0,+1,000	lb/in. ²	12.5
P_ORB	Roll rate, orbiter rate gyro	V90R5301C (G14443)	SF	S	±40	deg s	25
Q_ORB	Pitch rate, orbiter rate gyro	V90R5321C (G14442)	SF	S	±20	deg s	25
Q5RB	Pitch rate, SRB rate gyro	V90R2511C	SF	S	±10	deg s	25
LSFB	Attitude error vector (element order is roll, pitch, yaw)	V95H3523C (G33603) V95H3521C (G33601) V95H3522C (G33602)	GC STEER	V	-180 to +180	deg	12.5

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*Single-shot initialization

Table 4.2.2-1. Input Variables, ASCENT DAP (Cont)

FSSR Name	Description	MSID (MNEEMONIC)	Source	Type	Range	Units	Sample Rate (Hz) Required
WFBI_FB	Rate command vector flight body inertial (element order is roll, pitch, yaw)	V95H3528C (G33606) V95H3526C (G33604) V95H3527C (G33605)	GC STEER	V	±40	deg/s	12.5
R_ORB	Yaw rate, orbiter rate gyro	V90R5341C (G14444)	SF	S	±20	deg/s	25
RSRB	Yaw rate, SRB rate gyro	V90R2512C	SF	S	±10	deg/s	25
SRB_IGNITION_COMMAND	Indicator, Event 19; initiate SRB ignition command	V90X8377X (G23425)	RS LCH SEQ	B	0, 1	-	12.5
AERO_SLEW	Indicator Event 4A; aerosurface slew check	V99X8822X (G36305)	LPS	B	0, 1	-	12.5
SRB_MODING_SEP	Indicator, Event 27; SRB SEP function moding flag	V90X8330X (G23709)	SRB SEP SEQ, ET SEP SEQ	B	0, 1	-	12.5
SRB_SEP_CMD_FLAG	Indicator, Event 28; SRB_SEP command flag	V90X8331X (G23710)	SRB SEP SEQ, ET SEP SEQ	B	0, 1	-	12.5
ME1_FAIL_SHUTDOWN	Main engine out indicators	V95X1207X (G47293)	SSME OPS	B	0, 1	-	12.5
ME2_FAIL_SHUTDOWN		V95X1208X (G47294)					
ME3_FAIL_SHUTDOWN		V95X1209X (G47295)					
CLOCK/CLOCKTIME	CLOCK-COMPUTER (GMT)	V91W5000C (G07829)	FCOS	S	0 to 3,000	s	12.5
REL_VEL_MAG	Magnitude earth-relative velocity in M50	V95L0151C (G03902)	ASCENT UPP	S	0 to 30,000	ft/s	6.25
S_SSME_TRIM	Indicator, Event 30A; initiate main engine pitch retrim	V90X1960X (G00316)	ASC 2STG GUID, PW RTLS GUID	B	0, 1	-	0.521
MECO_COMMAND	Indicator, Event 32; initiate main engine cut-off	V90X8569X (G32107)	SSME OPS	B	0, 1	-	12.5
SRB_SLEW_CMD	SRB actuator slew position command	V96H0323X (G48998)	SRB SLEW	S	-4.0 to +4.0	-	25
MPS_SLEW_CMD	MPS actuator slew position command	V90H1572C (G48987)	ORB ACT SLEW	S	-9.0 to +9.0	-	25
AERO_SLEW_CMD	Aerosurface actuator slew position command	V90H1571C (G48986)	ORB ACT SLEW	S	-10.0 to +10.0	-	25
AERO_SLEW_COMPLETE_FLAG	Aerosurface slew test complete flag, indicator Event 4B	V90H1570X (G48985)	ORB ACT SLEW	B	0, 1	-	12.5

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Table 4.2.2-1. Input Variables, ASCENT DAP (Cont)

FSSR Name	Description	NSID (NOMEMONIC)	Source	Type	Range	Units	Sample Rate (Hz) Required
MASS	Estimated vehicle mass	V90U1961C (G48797)	ASC 2STG GUID, PW RTLS GUID	S	5,000 to 150,000	Slugs	0.521
MDOT	Estimated rate of change of mass with time	V90R1993C	ASC 2STG GUID, PW RTLS GUID	S	0.0 to 1,000	Slugs/s	0.521
ME_ZERO_THRUST	Indicator, Event 33B or A36A; at least two main engines shutdown (zero thrust)	V90X8638X (G51070)	MSC	B	0, 1	-	12.5
MM_CODE_101	Major Mode 101 Flag	V90X8155X (G47944)	MSC	B	0, 1	-	12.5
OPS_6_IND	Indicator, Event A30 and A31 trans to OPS 6	V90X8634X (G50365)	MSC	B	0, 1	-	12.5
SSME_STOW_ COMPLETE	SSME stow complete flag	V95X1622X (G51126)	MPS TVC CMD SOP	B	0, 1	-	1.0
MPS_SLEW	Indicator, Event 5; initiate MPS slew check	V99X8823X (G36400)	LPS	B	0, 1	-	12.5
SRB_SLEW	Indicator, Event 8; initiate SRB hydraulic slew test	V99X8820X (G36601)	LPS	B	0, 1	-	12.5
SRB_SLEW_ COMPLETE	Indicator, Event 8A; SRB hydraulic slew test complete	V96X0321X (G36605)	SRB SLEW	B	0, 1	-	12.5
PREP_SSME	Indicator, Event 18A: CMD SSME's to LIPTOFF position	V90X8373X (G47249)	RS LCH SEQ	B	0, 1	-	12.5
AUTO_P	Pitch, auto FCS mode pushbutton indicator	V96X1031X (G47665)	GN&C SW RM (4.180)	B	-	-	6.25
AUTO_RY	Roll/yaw auto FCS mode pushbutton indicator	V96X1041X (G47666)	GN&C SW RM (4.180)	B	-	-	6.25
CSS_P	Pitch manual mode pushbutton indicator	V96X1035X (G50206)	GN&C SW RM (4.180)	B	-	-	6.25
CSS_RY	Roll/yaw manual mode pushbutton indicator	V96X1045X (G47669)	GN&C SW RM (4.180)	B	-	-	6.25
S_QUAT	Attitude quaternion computed flag	V90X1987X (G51128)	ASC 1STG GUID	B	0, 1	-	12.5
S_RTLS_TURN	Indicator, initiate RTLS turnaround	V90X2089X (G00904)	PW RTLS GUID	B	0, 1	-	12.5
S_PPD_QUAT	Indicator, initiate RTLS powered pitch down maneuver	V90X2087X (G00903)	PW RTLS GUID	B	0, 1	-	12.5
RETURN_SSME_ TO_START_POS	Indicator, return SSME to start position	V90X8412X (G48989)	RS LCH SEQ	B	0, 1	-	12.5

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Table 4.2.2-1. Input Variables, ASCENT DAP (Cont)

FSSR Name	Description	MSID (MNEEMONIC)	Source	Type	Range	Units	Sample Rate (Hz) Required
SRB_SEP_MONITOR	SRB monitor indicator flag	V90X8193X (G47556)	MSC	B	0, 1	-	12.5
FAST_SEP_FLAG	Fast separation flag	V90X8267X	ET SEP SEQ	D	0, 1	-	6.25
MECO_CONFIRM	MECO confirmed flag	V90X8561X (G32108)	SSME OPS	B	0, 1	-	12.5
A_D_RECYCLE_COUNT	ASC DAP recycle	V90X8669X (-)	RS LCH SEQ	B	0, 1	-	12.5
MPS_LO2_DUMP_STOP	MPS LO2 dump stop	V90X8302X (G14102)	MPS DUMP SEQ	B	0, 1	-	1.04
TAL_ABORT_DECLARED	Transatlantic abort declared	V90X8658X (-)	MSC	B	0, 1	-	
AVAILABLE_JET_AFT(2)	Jet available L1L	V90X4521X	RCS RM	B	0, 1	-	12.5
AVAILABLE_JET_AFT(3)	Jet available L1U	V90X4522X	RCS RM	B	0, 1	-	12.5
AVAILABLE_JET_AFT(17)	Jet available L2L	V90X4523X	RCS RM	B	0, 1	-	12.5
AVAILABLE_JET_AFT(18)	Jet available L2U	V90X4524X	RCS RM	B	0, 1	-	12.5
AVAILABLE_JET_AFT(19)	Jet available L2D	V90X4525X	RCS RM	B	0, 1	-	12.5
AVAILABLE_JET_AFT(10)	Jet available L3L	V90X4527X	RCS RM	B	0, 1	-	12.5
AVAILABLE_JET_AFT(11)	Jet available L3D	V90X4528X	RCS RM	B	0, 1	-	12.5
AVAILABLE_JET_AFT(23)	Jet available L4L	V90X4529X	RCS RM	B	0, 1	-	12.5
AVAILABLE_JET_AFT(24)	Jet available L4U	V90X4530X	RCS RM	B	0, 1	-	12.5
AVAILABLE_JET_AFT(25)	Jet available L4D	V90X4531X	RCS RM	B	0, 1	-	12.5
AVAILABLE_JET_AFT(5)	Jet available R1R	V90X4535X	RCS RM	B	0, 1	-	12.5
AVAILABLE_JET_AFT(6)	Jet available R1U	V90X4536X	RCS RM	B	0, 1	-	12.5
AVAILABLE_JET_AFT(20)	Jet available R2R	V90X4537X	RCS RM	B	0, 1	-	12.5
AVAILABLE_JET_AFT(21)	Jet available R2U	V90X4538X	RCS RM	B	0, 1	-	12.5
AVAILABLE_JET_AFT(22)	Jet available R2D	V90X4539X	RCS RM	B	0, 1	-	12.5

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Table 4.2.2-1. Input Variables, ASCENT DAP (Cont)

FSSR Name	Description	MSID (Mnemonic)	Source	Type	Range	Units	Sample Rate (Hz) Required
AVAILABLE JET_AFT(13)	Jet available R3R	V90X4541X	RCS RM	B	0, 1		12.5
AVAILABLE JET_AFT(14)	Jet available R3D	V90X4542X	RCS RM	B	0, 1	-	12.5
AVAILABLE JET_AFT(26)	Jet available R4R	V90X4543X	RCS RM	B	0, 1	-	12.5
AVAILABLE JET_AFT(27)	Jet available R4U	V90X4544X	RCS RM	B	0, 1	-	12.5
AVAILABLE JET_AFT(28)	Jet available R4D	V90X4545X	RCS RM	B	0, 1	-	12.5
AVAILABLE JET_FWD(1)	Jet available F1F	V90X4548X	RCS RM	B	0, 1	-	12.5
AVAILABLE JET_FWD(2)	Jet available F1L	V90X4549X	RCS RM	B	0, 1	-	12.5
AVAILABLE JET_FWD(3)	Jet available F1U	V90X4550X	RCS RM	B	0, 1	-	12.5
AVAILABLE JET_FWD(4)	Jet available F1D	V90X4551X	RCS RM	B	0, 1	-	12.5
AVAILABLE JET_FWD(6)	Jet available F2R	V90X4553X	RCS RM	B	0, 1	-	12.5
AVAILABLE JET_FWD(7)	Jet available F2U	V90X4554X	RCS RM	B	0, 1	-	12.5
AVAILABLE JET_FWD(8)	Jet available F2D	V90X4555X	RCS RM	B	0, 1	-	12.5
AVAILABLE JET_FWD(14)	Jet available F3L	V90X4557X	RCS RM	B	0, 1	-	12.5
AVAILABLE JET_FWD(15)	Jet available F3U	V90X4558X	RCS RM	B	0, 1	-	12.5
AVAILABLE JET_FWD(16)	Jet available F3D	V90X4559X	RCS RM	B	0, 1	-	12.5
AVAILABLE JET_FWD(9)	Jet available F4R	V90X4560X	RCS RM	B	0, 1	-	12.5
AVAILABLE JET_FWD(10)	Jet available F4D	V90X4561X	RCS RM	B	0, 1	-	12.5
DY1_BIAS	MPS ENG 1 P BIAS	V96U7984C	VU	S	±6.0	DEG	
DY2_BIAS	MPS ENG 2 P BIAS	V96U7985C	VU	S	±6.0	DEG	
DY3_BIAS	MPS ENG 3 P BIAS	V96U7986C	VU	S	±6.0	DEG	
DZ2_BIAS	MPS ENG 2 Y BIAS	V96U7987C	VU	S	-3.5, 0	DEG	
DZ3_BIAS	MPS ENG 3 Y BIAS	V96U7988C	VU	S	0, 3.5	DEG	

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Table 4.2.2-2. Output Variables, ASCENT DAP

FSSR Name	Description	MSID (MNEMONIC)	Destination	Type	Range	Units	Sample Rate (Hz) Required
DBFRC	Body flap deflection command	V90H1580C (G06008)	AERO ACT SOP, BF CMD RM	I	0, ± 1	deg	6.25
DLIBPC	Elevon LIB position CMD	V90H1734C (G36307)	AERO ACT SOP	S	-35, +20	deg	6.25/25*
DLOBPC	Elevon LOB position CMD	V90H1735C (G36308)	AERO ACT SOP	S	-35, +20	deg	6.25/25*
DRIBPC	Elevon RIB position CMD	V90H1737C (G47344)	AERO ACT SOP	S	-35, +20	deg	6.25/25*
DROBPC	Elevon ROB position CMD	V90H1738C (G47345)	AERO ACT SOP	S	-35, +20	deg	6.25/25*
DRPC	Rudder command	V90R1550C (G06024)	AERO ACT SOP	S	± 27.1	deg	6.25/25*
DSBPC	Speed brake command	V90R1560C (G06025)	AERO ACT SOP	S	98.6	deg	6.25/25*
DR4CL	Actuator deflection command, SRB 4 rock	V90H1728C (G33907)	SRB TVC CMD SOP	S	± 5.0	deg	25
DR5CL	Actuator deflection command, SRB 5 rock	V90H1729C (G33908)	SRB TVC CMD SOP	S	± 5.0	deg	25
DT4CL	Actuator deflection command, SRB 4 tilt	V90H1731C (G33909)	SRB TVC CMD SOP	S	± 5.0	deg	25
DT5CI	Actuator deflection command, SRB 5 tilt	V90H1732C (G33910)	SRB TVC CMD SOP	S	± 5.0	deg	25
DY11	Actuator deflection command, SSME 1 pitch	V90H1718C (G33901)	MPS TVC CMD SOP	S	± 10.5	deg	25
DYC2	Actuator deflection command, SSME 2 pitch	V90H1719C (G33902)	MPS TVC CMD SOP	S	± 10.5	deg	25
DYC3	Actuator deflection command, SSME 3 pitch	V90H1720C (G33903)	MPS TVC CMD SOP	S	± 10.5	deg	25
DZC1	Actuator deflection command, SSME 1 yaw	V90H1724C (G33904)	MPS TVC CMD SOP	S	± 8.5	deg	25
DZC2	Actuator deflection command, SSME 2 yaw	V90H1725C (G33905)	MPS TVC CMD SOP	S	± 8.5	deg	25
DZC3	Actuator deflection command, SSME 3 yaw	V90H1726C (G33906)	MPS TVC CMD SOP	S	± 8.5	deg	25
SIG	Indicator, STG1 guidance	V90X1713X (-)	GC STEER, TLM	B	0,1	-	12.5
FRZCMD	Indicator, freeze desired body command	V90X1714X (G50358)	GC STEER, TLM	B	0,1	-	12.5
ATTFILT	Indicator, filter actual body attitude	V90X1709X (-)	GC STEER, TLM	B	0,1	-	12.5

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*Rates x/y; x normal, y slew checks

Table 4.2.2-2. Output Variables, ASCENT DAP (Cont)

FSSR Name	Description	MS ID (MNEMONIC)	Destination	Type	Range	Units	Sample Rate (Hz) Required
SEC ME_FL_GNFH	2nd SSME fail confirm	V90X1721X (G30234)	MSC, SSME OPS, ABT CNTL SEQ, ET SEP SEQ, 5.21	B	0,1	-	12.5
NEW_JONLST (4)	RCS Jet F1L ON command	V90X1442X (G39305)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (5)	RCS Jet F3L ON command	V90X1450X (G39313)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (6)	RCS Jet F2R ON command	V90X1446X (G39321)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (7)	RCS Jet F4R ON command	V90X1453X (G39327)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (22)	RCS Jet L1L ON command	V90X1673X (G06038)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (29)	RCS Jet L1U ON command	V90X1674X (G06039)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (20)	RCS Jet L2L ON command	V90X1675X (G06040)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (28)	RCS Jet L2U ON command	V90X1676X (G06041)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (34)	RCS Jet L2D ON command	V90X1677X (G06042)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (21)	RCS Jet L3L ON command	V90X1678X (G06043)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (35)	RCS Jet L3D ON command	V90X1679X (G06044)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (19)	RCS Jet L4L ON command	V90X1680X (G06045)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (27)	RCS Jet L4U ON command	V90X1681X (G06046)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (33)	RCS Jet L4D ON command	V90X1682X (G06047)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (26)	RCS Jet R1R ON command	V90X1683X (G06048)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (32)	RCS Jet R1U ON command	V90X1684X (G06049)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (24)	RCS Jet R2R ON command	V90X1685X (G06050)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (31)	RCS Jet R2U ON command	V90X1686X (G06051)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (37)	RCS Jet R2D ON command	V90X1687X (G06052)	ASC RCS CMD SOP	B	0,1	-	25
NEW_JONLST (25)	RCS Jet R3R ON command	V90X1688X (G06053)	ASC RCS CMD SOP	B	0,1	-	25

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Table 4.2.2-2. Output Variables, ASCENT DAP (Cont)

FSSR Name	Description	MSID (MNEMONIC)	Destination	Type	Range	Units	Sample Rate Hz Required
NEW JONLST (38)	RCS Jet R3D ON command	V90X1689X (G06054)	ASC RCS CMD SOP	B	0	-	25
NEW JONLST (23)	RCS Jet R4R ON command	V90X1690X (G06055)	ASC RCS CMD SOP	B	0 1	-	25
NEW JONLST (30)	RCS Jet R4U ON command	V90X1691X (G06056)	ASC RCS CMD SOP	B	0 1	-	25
NEW JONLST (36)	RCS Jet R4D ON command	V90X1692X (G06057)	ASC RCS CMD SOP	B	0 1	-	25
RTLS_TURN	Indicator, RTLS turn-around maneuver	V90X1756X (G00904)	GC STEER	B	0 1	-	12.5
PEGCMD	Indicator, S2G steering mode	V90X1757X (G50357)	GC STEER, TLM	B	0 1	-	12.5
ATTCMD	Indicator, ATTFILT, SlG or PPD steering mode	V90X1712X (G50356)	GC STEER, TLM	B	0,1	-	12.5
PPD	Indicator, RTLS powered pitch down maneuver	V90X1760X (G50363)	GC STEER, TLM	B	0	-	12.5
AUTO	Indicator, automatic guidance steering mode	V90X1710X (G50361)	{ GC STEER, ASC 2STG GUID, ABT CNTL SEQ, PW RTLS GUID, GRTLS DAP, TLM }	B	0 1	-	12.5
M PP	Indicator, SRB separation subphase	V90X1761X	GC STEER, TLM	B	0	-	12.5
M FAIS	Indicator, SSME failure status	V90X1763X	INTERPS, TLM SSME_CMD_PROC	I	0 4	-	5
MMI INIT	Indicator, Event 1; first time AB DAP scheduled	V90X1764X	GC STEER, TLM	B	0	-	12.5
L P AMP	Pitch auto FCS mode lamp, left	V72X5240X (G22202)	D&C PNL, TLM	B	0	-	5
RA P AMP	Pitch auto FCS mode lamp, right	V72X5140X (G22203)	D&C PNL, TLM	B	0	-	5
A P AMP	Roll yaw auto FCS mode lamp, left	V72X5243X (G22206)	D&C PNL TLM	B	0	-	5
RA P AMP	Roll yaw auto FCS mode lamp, right	V72X5143X (G22207)	D&C PNL TLM	B	0	-	5
P AMP	Pitch manual FCS mode lamp, left	V72X5241X (G22204)	D&C PNL, TLM JAX RHC SOP	B	0	-	5
P AMP	Pitch manual FCS mode lamp, right	V72X5141X (G22205)	D&C PNL TLM	B	0	-	5

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Table 4.2.2-2. Output Variables, ASCENT DAP (Cont)

FSSR Name	Description	MSID (MNEEMONIC)	Destination	Type	Range	Units	Sample Rate (Hz) Required
LCSS_RYLAMP	Roll/yaw manual FCS mode lamp, left	V72X5245X (G22208)	D&C PNL, TLM	B	0,1	-	12.5
RCSS_RYLAMP	Roll/yaw manual FCS mode lamp, right	V72X5145X (G22209)	D&C PNL, TLM	B	0,1	-	12.5
LAUTO_BFLAMP	Auto body flap lamp, left	V72X4996X (G22212)	D&C PNL, TLM	B	0,1	-	12.5
RAUTO_BFLAMP	Auto body flap lamp, right	V72X4896X (G22213)	D&C PNL, TLM	B	0,1	-	12.5
LMNL_BFLAMP	Manual body flap lamp, left	V72X4997X (G22210)	D&C PNL, TLM	B	0,1	-	12.5
RMNL_BFLAMP	Manual body flap lamp, right	V72X4897X (G22211)	D&C PNL, TLM	B	0,1	-	12.5
LAUTO_SBLAMP	Auto speed brake lamp left	V72X5136X (G22214)	D&C PNL, TLM	B	0,1	-	12.5
RAUTO_SBLAMP	L.C. Auto speed brake lamp, right	V72X5134X (G22215)	D&C PNL, TLM	B	0,1	-	12.5
MNLSB_CMDR_O	Commander's manual speed brake lamp	V72X5137X (G22216)	D&C PNL, TLM	B	0,1	-	12.5
MNLSB_PLT_O	Pilot's manual speed brake lamp	V72X5135X (G22217)	D&C PNL, TLM	B	0,1	-	12.5
DY1	Pitch command, SSME 1	V90H1745C	Prelaunch TLM	S	±11.0	deg	25
DZ1	Yaw command, SSME 1	V90H1746C	Prelaunch TLM	S	±9.0	deg	25
DY2	Pitch command, SSME 2	V90H1747C	Prelaunch TLM	S	±11.0	deg	25
DZ2	Yaw command, SSME 2	V90H1748C	Prelaunch TLM	S	±9.0	deg	25
DY3	Pitch command, SSME 3	V90H1749C	Prelaunch TLM	S	±11.0	deg	25
DZ3	Yaw command, SSME 3	V90H1750C	Prelaunch TLM	S	±9.0	deg	25
DT4C	Tilt command, SRB 4	V90H1751C	Prelaunch TLM	S	±6.7	deg	25
DT4CL	TILT ACTR DEF, CMD (SRB 4)	V90H1731C	SRB TVR CMD SOP, TLM				
DR4C	Rock command, SRB 4	V90H1752C	Prelaunch TLM	S	±6.7	deg	25
DR4CL	ROCK ACTR DEF, CMD (SRB 4)	V90H1728C	SRB TVC CMD SOP, TLM				
DT5C	Tilt command, SRB 5	V90H1753C	Prelaunch TLM	S	±6.7	deg	25
DT5CL	TILE ACTR DEF, CMD (SRB 5)	V90H1732C	SRB TVC CMD SOP, TLM				
DR5C	Rock command, SRB 5	V90H1754C	Prelaunch TLM	S	±6.7	deg	25
DR5CL	ROCK ACTR DEF, CMD (SRB 5)	V90H1729C	SRB TVC CMD SOP, TLM				
SRB_NULL_CMD	Event 27, indicator	V90H1769C	A/E ATT PROC	B	0, 1	-	12.5
DQTVC_INT	Pitch integrator output	V90H1772C	TLM	S	±10.0	deg	12.5

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Table 4.2.2-2. Output Variables, ASCENT DAP (Cont)

FSSR Name	Description	MSID (Mnemonic)	Destination	Type	Range	Units	Sample Rate (Hz) Required
DRIVC_INT	Yaw integrator output	V90H1773C	TLN	S	+10.0	deg	12.5
DPIVC_INT	Roll integrator output	V90H1774C	TLN	S	+10.0	deg	12.5
DQIVC	Pitch TVC loop error signal	V90H1758C	TLN	S	± 10.0	deg/s	25.0
DRIVC	Yaw TVC loop error signal	V90H1759C	TLN	S	± 10.0	deg/s	25.0
ELEV_LR	Elevon load relief indicator	V90X1716X	GC STEER	S	0,1	-	12.5
NZ_FBK	Compensated Normal Accel Error	V90A1765C	GC STEER, TLN	S	± 10.0	deg/s	25.0
NY_FBK	Compensated Lateral Accel Error	V90A1766C	GC STEER, TLN	S	± 10.0	deg/s	25.0
KN_THETA	Variable Gain Attitude-Pitch	V90U1767C	GC STEER	S		deg/s/ deg	6.25
KN_PSI	Variable Gain Attitude-Yaw	V90U1768C	GC STEER	S		deg/s/ deg	6.25
K_LOAD_RELIEF	Var Load Relief Gain	V90J1704C	ASC 1STG GUID	S		-	6.25

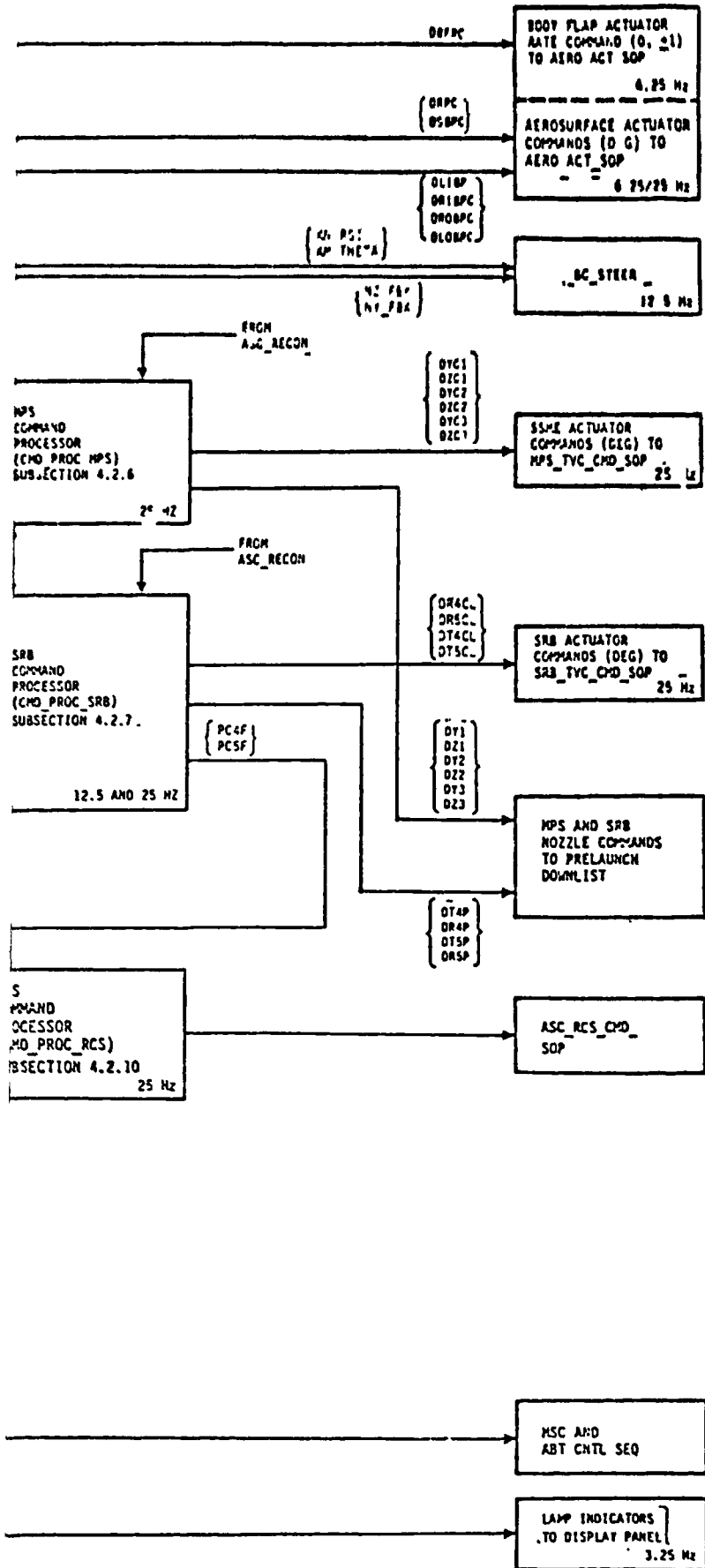
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4.2.3 System Overview

The detailed overview block diagram for the ASCENT DAP (ASC_DAP) system is presented in Figure 4.2.3-1. ASCENT DAP implements and processes the algorithms that convert steering commands and vehicle attitude, attitude rate, and acceleration inputs into control element deflections. A list of input variables is given in Table 4.2.2-1, and a list of output variables is given in Table 4.2.2-2. ASCENT DAP consists of the following functional software modules:

- A. ASCENT RECONFIGURATION LOGIC (ASC RECON) generates the moding, sequencing and initialization indicators that are required by ASC_DAP and GC STEER. In addition, it receives AUTO/MANUAL indications from pushbutton indicators and lights appropriate lamps.
- B. ASCENT THRUST VECTOR CONTROL (ASC TVC) closes acceleration and/or rate loops within the outer attitude loop to generate body axis attitude rate commands for the MPS and SRB.
- C. MPS COMMAND PROCESSOR (CMD PROC MPS) applies authority limits, trim biases, and mixing logic to generate SSME actuator commands, and applies position and rate limiting, including priority rate limiting, and also nulling of failed SSME's.
- D. SRB COMMAND PROCESSOR (CMD PROC SRB) applies pitch trim, pitch commands for clearance of the hold-down support, and mixing logic to generate SRB actuator commands. It then applies position and rate limiting.
- E. LINEAR INTERPOLATIONS (INTERPS) generates acceleration profiles, trims, elevon schedules, and scheduled gains as functions of earth relative velocity magnitude, mission elapsed time, and estimated vehicle mass.
- F. AEROSURFACE CONTROL (AEROSURFACE CONTROL) provides hinge moment load relief for the elevon actuators, positions the body flap, and positions the rudder and speed brake.
- G. RCS COMMANDS (CMD PROC RCS) provides RCS jet ON/OFF commands for roll control in the event that two or three SSME's shut down in first stage or two SSME's shut down in second stage. The CMD PROC RCS is initiated when the ENA_RCS CNTL flag is set and terminated at ZERO_THRUST in MM 103 or MECO_CMD in MM 601.

The sequencing requirements for ASCENT DAP are shown in Figure 4.2.3-2. Figure 4.2.3-2A shows the high level sequencing requirements in terms of the 25, 12.5, 6.25 and 0.521-Hz rate groups. The 12.5-Hz rate group is denoted ASC_DAP_40 and is shown in Figure 4.2.3-2B. The 12.5-Hz rate group is denoted ASC_DAP_80 and is shown in Figure 4.2.3-2C. The 6.25-Hz rate group is denoted ASC_DAP_160 and is shown in Figure 4.2.3-2D. The 3.125-Hz rate group is denoted by ASC_TVC_320 and is shown in Figure 4.2.3-2E. The 0.521-Hz rate consists of only one module denoted by INTERPS_1920, and is shown by Figure 4.2.9-3.



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ASC_1STG_GUID 6.25 Hz → TO ASC_RECON

BODY FLAP POSITION (DEG)
VIA BF_PFB_SOP 6.25 Hz

ELEVON HYDRAULIC
PRESSURE (PSI) VIA
ELVN_DP_FB_SOP 6.25 Hz

EARTH-RELATIVE
VELOCITY MAGNITUDE
(FPS) VIA MAV 6.25 Hz

ESTIMATED MASS AND
MASS RATE
VIA AS_2STG_GUID/
PW_RTL_S_GUID 0.521 Hz

BODY ANGULAR RATE
(DEG/S) VIA
SF (ORB RGA) 25 Hz

BODY ANGULAR RATE
(DEG/S) VIA
SF (SRB RGA) 25 Hz

BODY ACCELERATION
(G's) VIA SF (AA) 25 Hz

ATTITUDE RATE (DEG/S)
AND ATTITUDE ERROR
(DEG) STEERING CMD
VIA GC_STEER 12.5 Hz

SAS NUMBER PRESSURE
(PSI) F VIA
SF F FCN 12.5 Hz

SRB SLEW CMD VIA
SRB_SLEW_SOP 25 Hz

MPS AND AERO SURFACE
SLEW CMD VIA
ORB_ACT_SLEW 25 Hz

SSME FAILURE SHUTDOWN
AND MECO INDICATORS
VIA SSME_OPS 25 Hz

HYDRAULIC SYSTEM
FAILURE INDICATORS
VIA HYD_SYS_SOP 6.25 Hz

SRB IGNITION
INDICATORS VIA
RS_LCH_SEQ 25 Hz

SRB SEPARATION
INDICATOR VIA
SRB_SEP_SEQ 6.25 Hz

SSME RETRIM INDICATOR VIA
AS_2STG_GUID/PW_RTL_S_GUID/
0.521 Hz

MISSION ELAPSED TIME
VIA FCOS 25 Hz

AUTO/MANUAL PUSH-
BUTTON INDICATORS
VIA GN&C_SW_PRDC 6.25 Hz

SSME STOW COMPLETE VIA
SSME_TVC_CMD_SOP 1 Hz

MSC

SLEW CMD
VIA LPS

FAST_SEP INDICATORS
VIA ET_SEP_SEQ 6.25 Hz

LINEAR
(SUBSE)

ASCENT
THRUST
VECTOR
CONTROL
(ASC_TVC)
SUBSECTION 4.

12.5 Hz

ASCENT
RECONFIGURATION
LOGIC
(ASC_RECON)
SUBSECTION 4.2

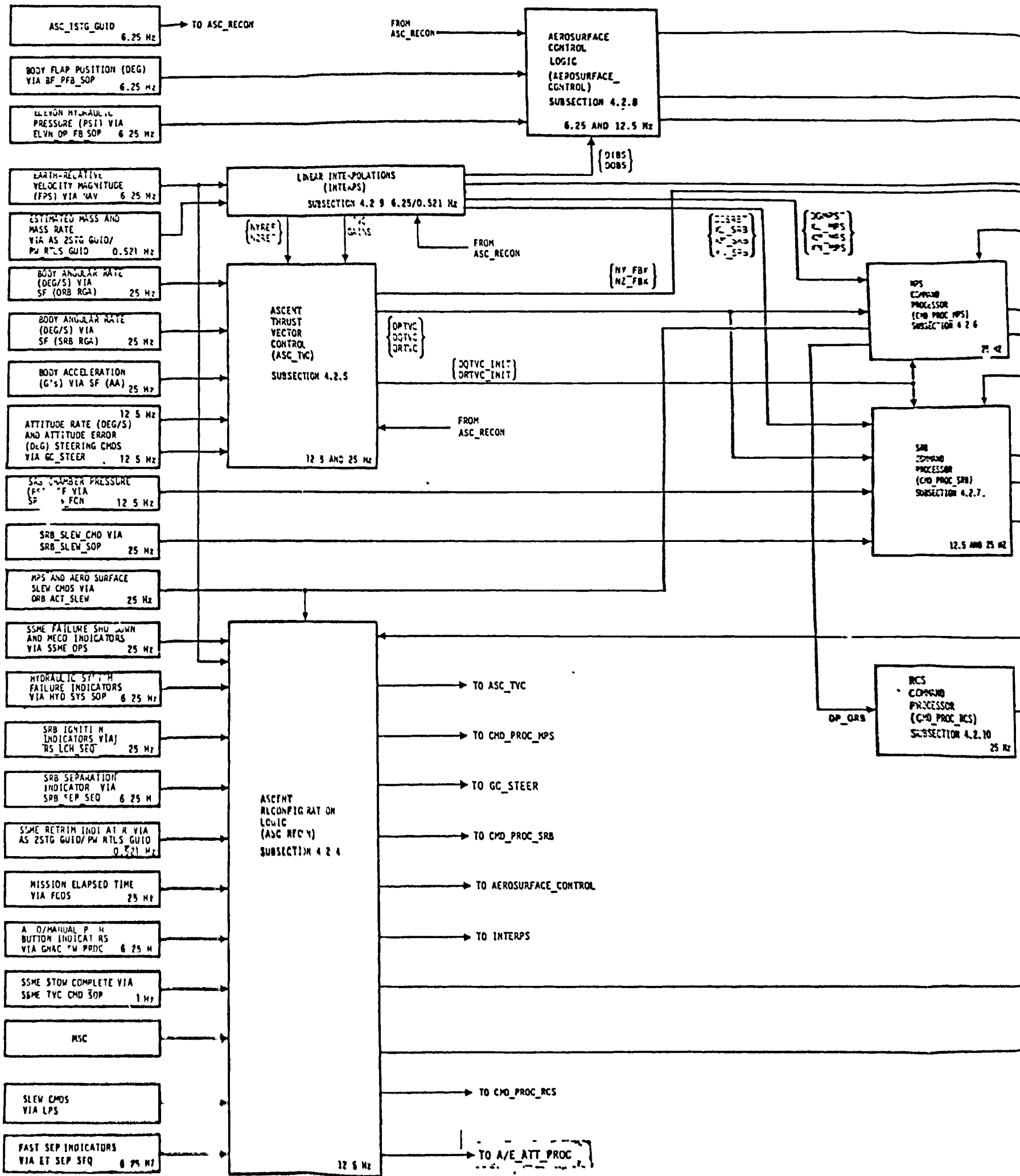
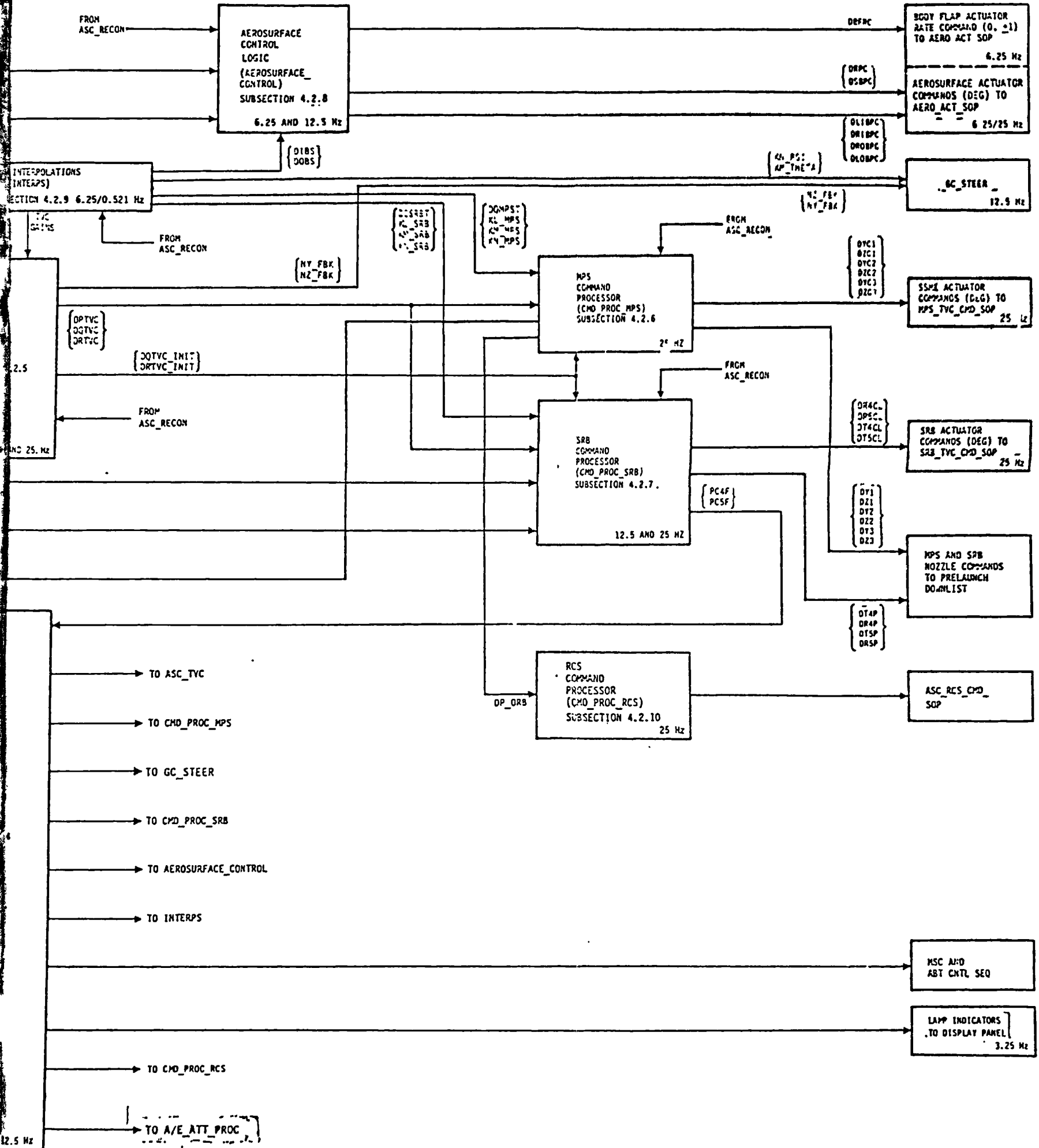


Figure 4.2.3-1. Ascent Flight Control,



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Figure 4.2.3-1. Ascent Flight Control, Functional Overview

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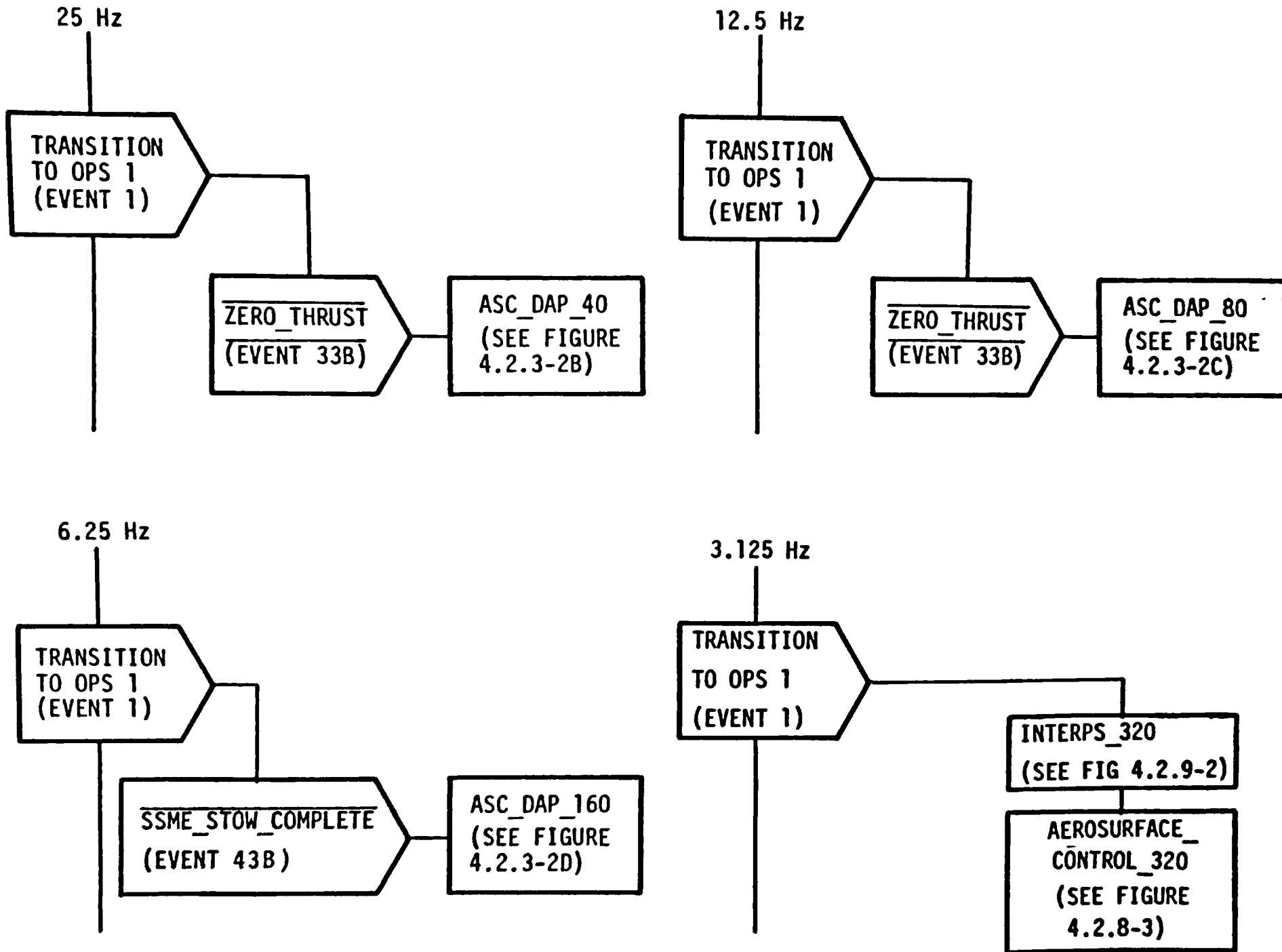


Figure 4.2.3-2A. ASCENT DAP Sequencing Requirements

4.2-15

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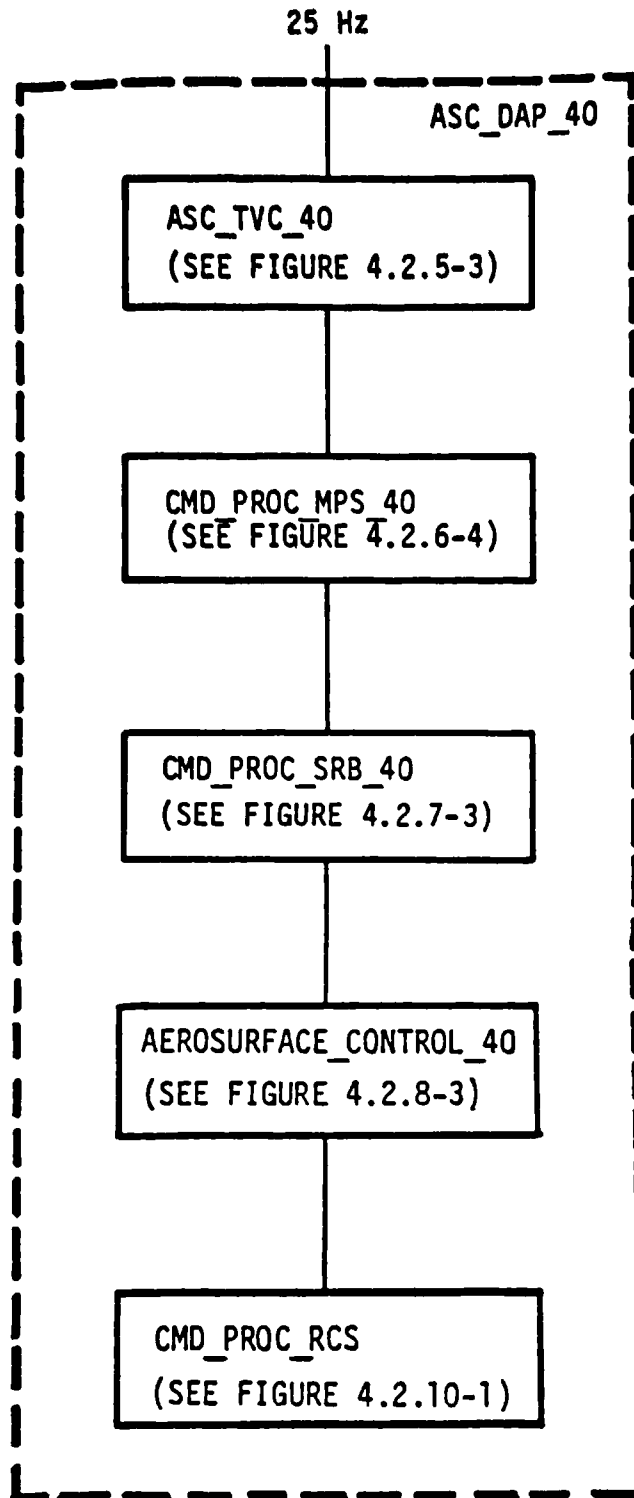


Figure 4.2.3-2B. ASC_DAP_40, 25 Hz Sequencing Requirements

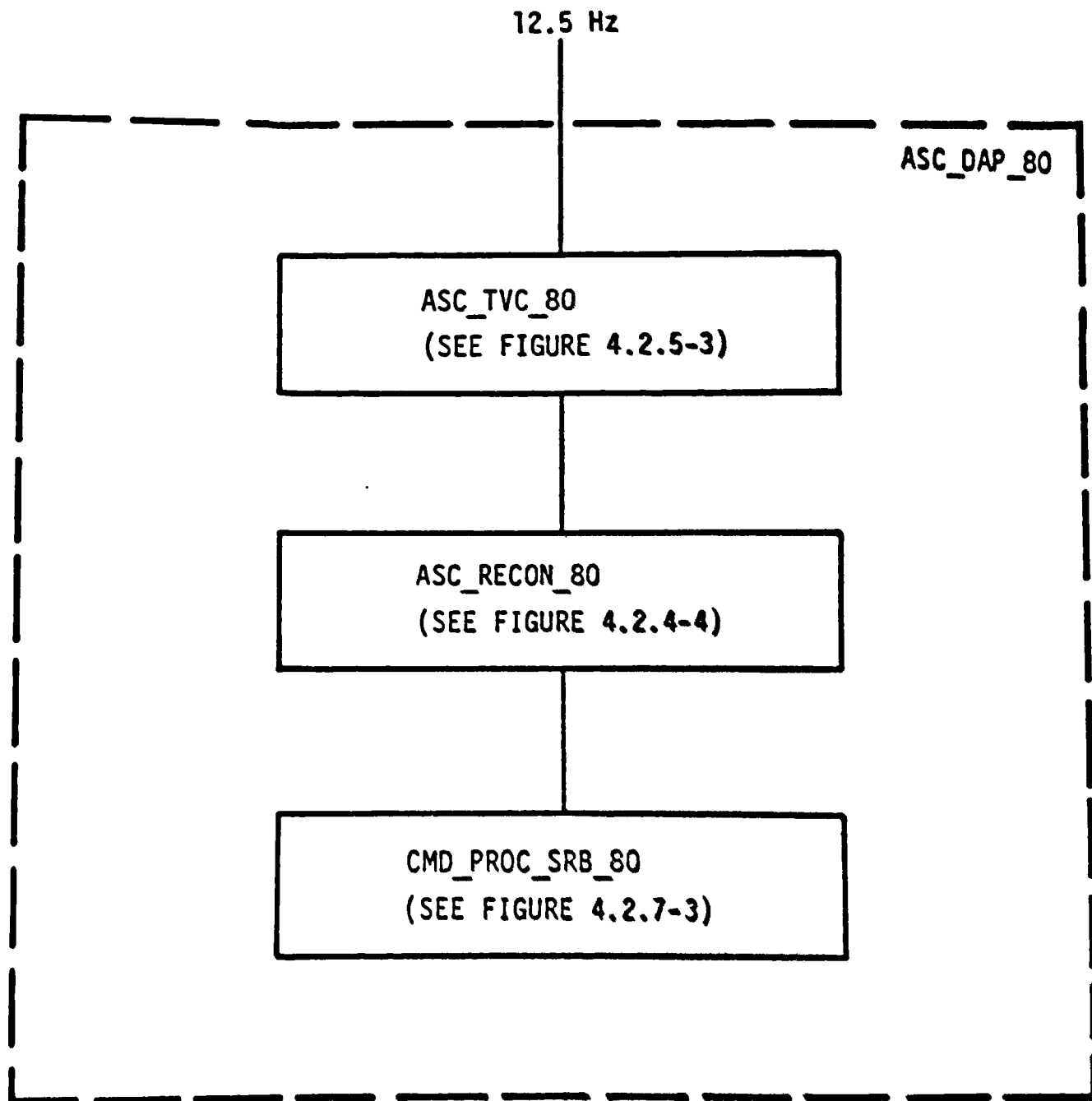


Figure 4.2.3-2C. ASC_DAP 80, 12.5 Hz Sequencing Requirements

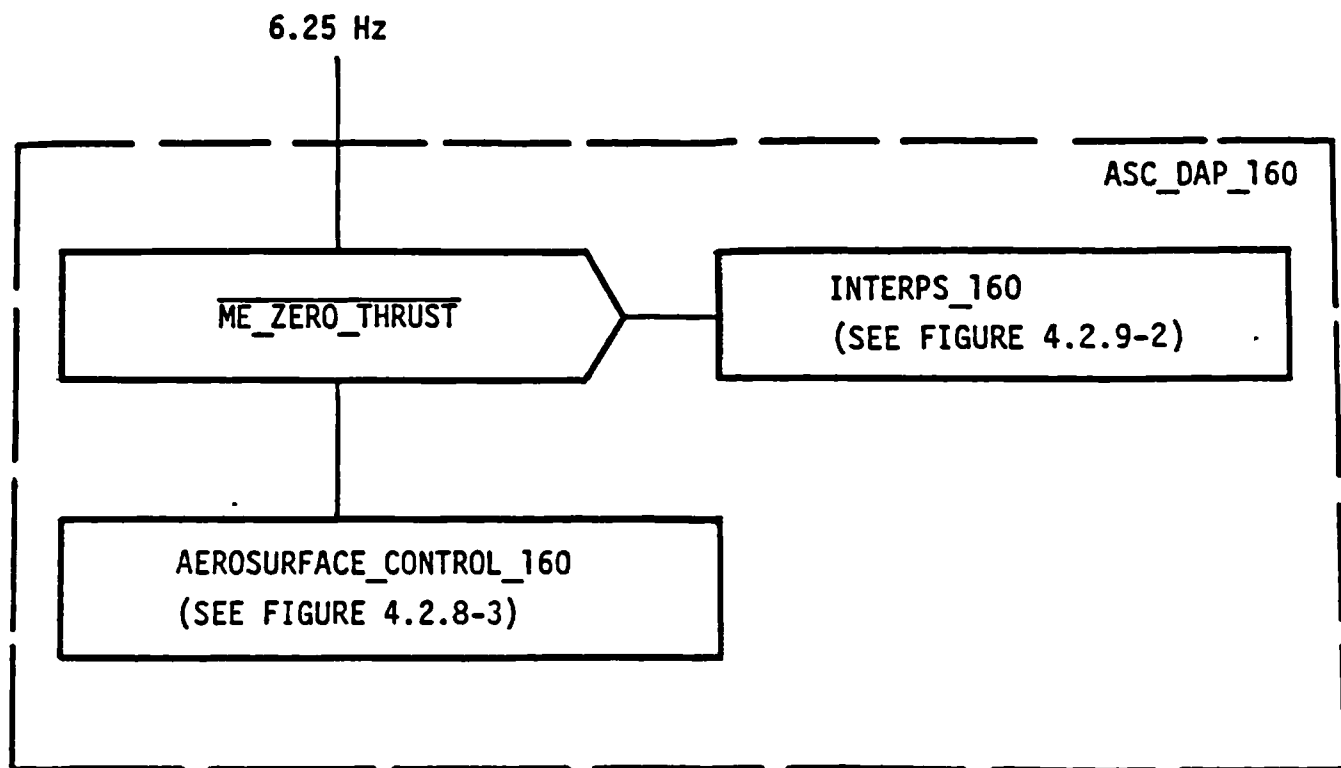


Figure 4.2.3-2D. ASC_DAP_160, 6.25 Hz Sequencing Requirements

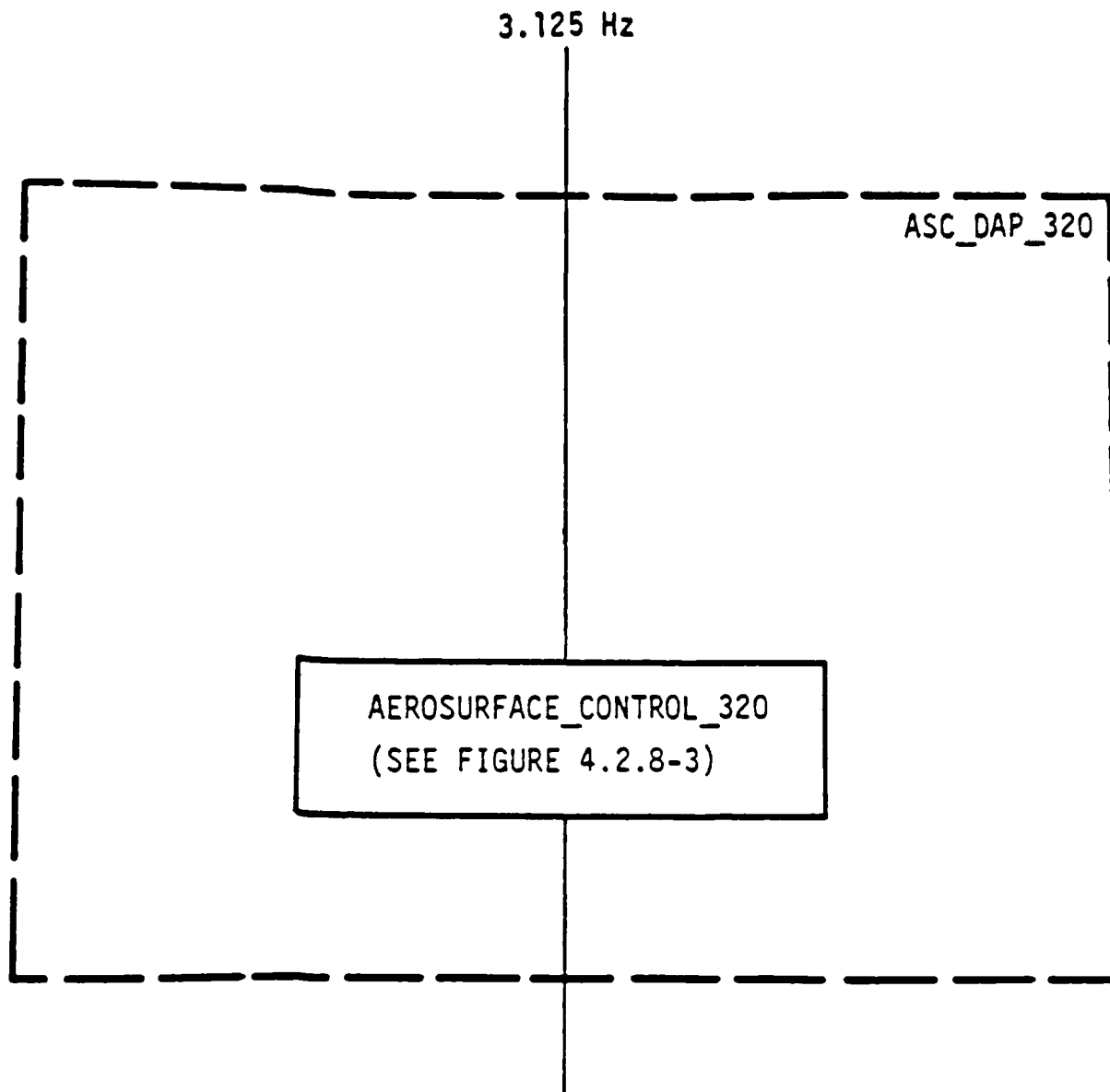


Figure 4.2.3-2E. ASC_DAP_320, 3.125 Hz Sequencing Requirements



4.2.4 ASCENT RECONFIGURATION (ASC_RECON)

A. Functional Description

In response to control mode changes, changes in failure status, and the occurrence of events, ASC_RECON generates the indicators that are needed by both ASC_DAP and GC_STEER for moding, sequencing, and initialization. The indicators needed to perform ASCENT reconfiguration are derived from events, failure status indicators, and control mode indicators that are generated externally to ASC_DAP and GC_STEER and from events generated locally by ASC_RECON. External events, failure status indicators, and control mode indicators are buffered by ASC_RECON so that initialization requirements and changes in sequencing requirements can be met prior to the execution of affected modules. Sequencing and initialization functions for ASC_DAP and GC_STEER are not shown to be performed by ASC_RECON. Sequencing requirements shown at the high level of ASC_DAP and GC_STEER are assumed to be met by an executive-type program. Initialization requirements shown at the module level are assumed to be performed by the module itself. It is recognized that, from a software point of view, it is not efficient to perform initializations at the module level. (Initialization requirements are shown at the module level because it is proper to do so from a functional requirements specification point of view.) The proper handling of initialization requirements is strongly implementation-dependent and as such should not necessarily be included as part of the functional specifications document. Part B of this subsection provides the software description of ASC_RECON consistent with the assumption that initializations are performed at the module level.

The mode panel switches and pushbutton indicators of importance to ASC_DAP and GC_STEER are shown in Figure 4.2.4-1. Subphases useful for the functional (and software) description of ASC_DAP and GC_STEER are shown in Figure 4.2.4-2 for a nominal mission and in Figure 4.2.4-3 for an RTLS abort. The subphases are defined in terms of externally and locally derived events. (External event numbers are shown inside circles, and local event numbers are shown in boxes.) A description of the function(s) performed during each subphase is summarized in Table 4.2.4-1. Many subphases have corresponding Boolean indicators that are used for sequencing and initialization purposes.

B. Software Specification

ASC_RECON consists of one module, ASC_RECON, which is sequenced at 12.5 Hz. The detailed specifications for ASC_RECON are summarized in the flow diagram shown in Figure 4.2.4-4. Interface requirements for ASC_RECON are presented in Table 4.2.4-2. ASC_RECON generates the indicators needed for sequencing and initialization from externally derived events, control mode indicators, and failure status indicators and from locally derived events. Externally derived events are buffered and given local event names. Detailed specification of the buffered "local" events and derived local events are summarized in Table 4.2.4-3. Detailed specifications of the reconfiguration



indicators used for sequencing and initialization are summarized in Table 4.2.4-4. Table 4.2.4-4A summarizes those Boolean reconfiguration indicators which are defined between events. Table 4.2.4-4B summarizes those Boolean reconfiguration indicators which are functions of mode indicators, failure status indicators, and locally derived indicators. Table 4.2.4-4C summarizes those reconfiguration indicators which are integers. Initialization requirements for ASC_RECON are summarized in Table 4.2.4-5. I-Loads for ASC_RECON are shown in Table 4.2.4-6.

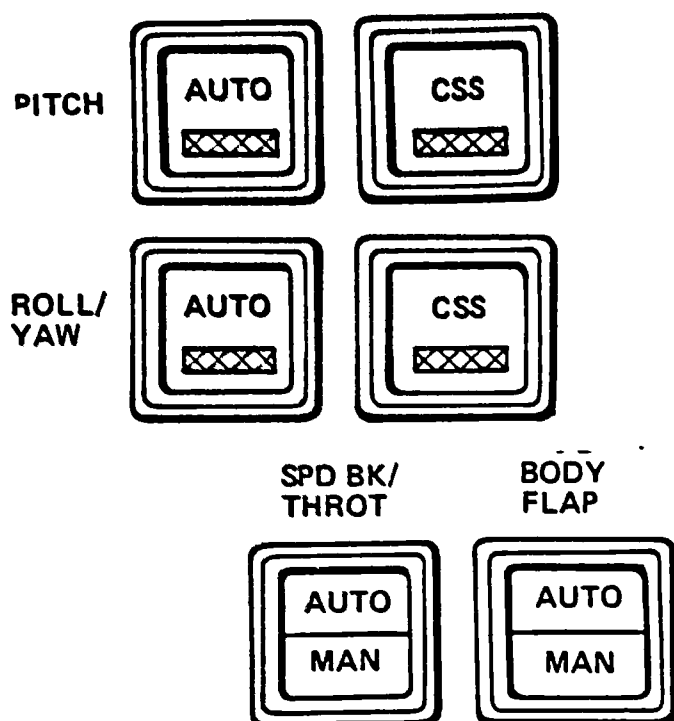
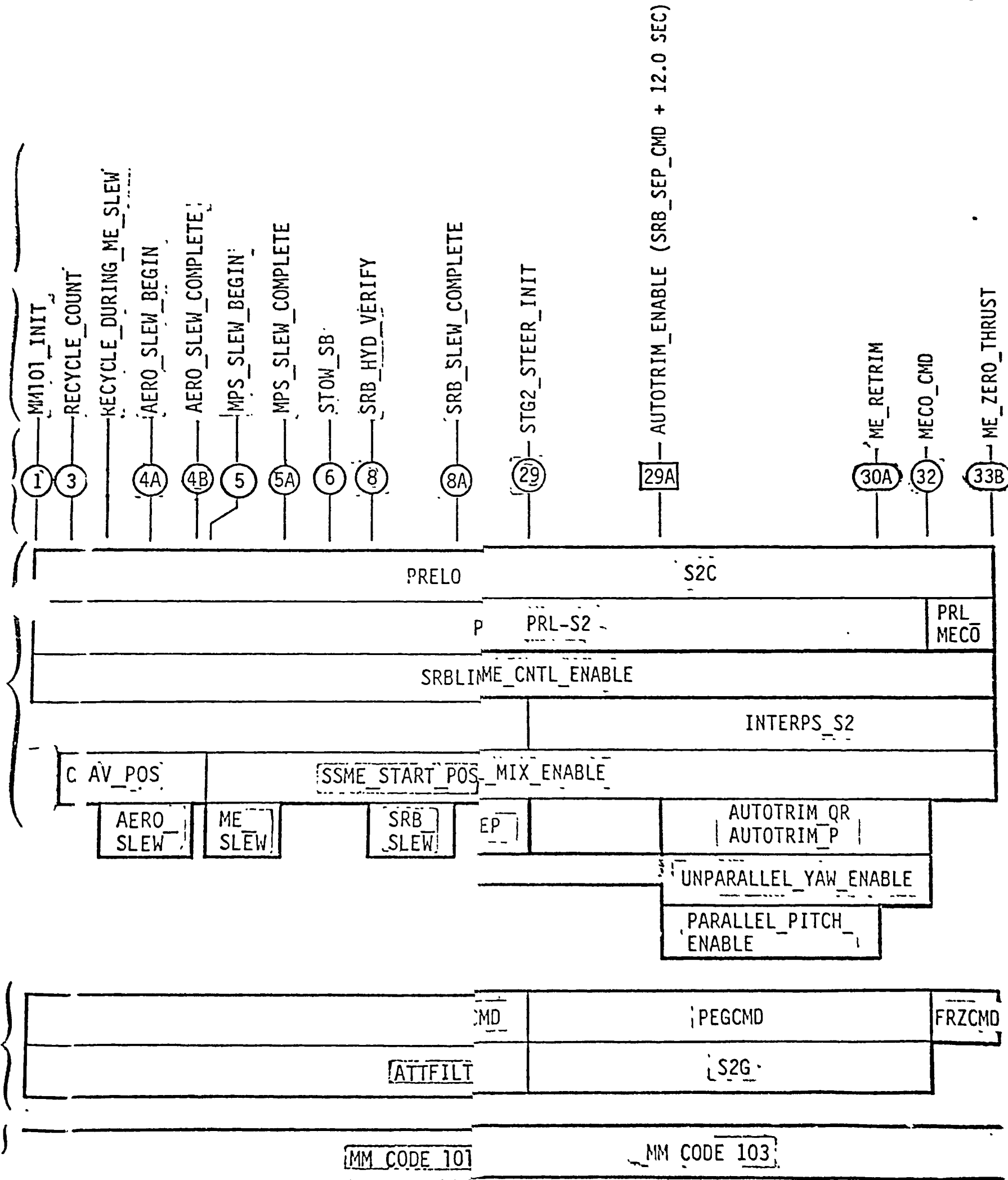
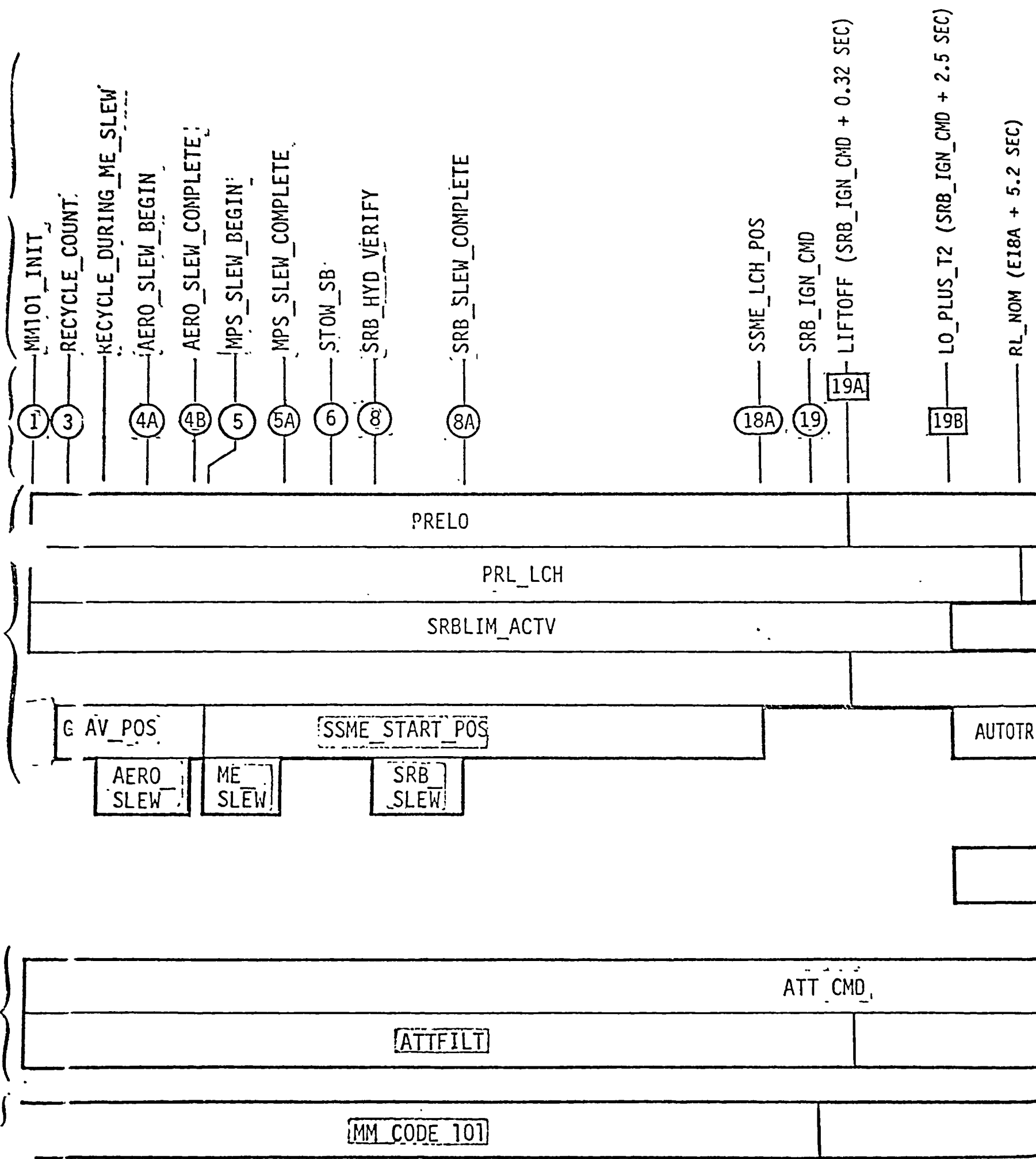


Figure 4.2.4-1. Mode Panel Switches and Pushbutton Indicators Affecting ASC_DAP and GC_STEER



NOTE: EXTERNAL STEER Subphases, Nominal Mission

LOCAL E 4.2-23, 4.2 24



NOTE: EXTERNAL EVENTS ARE IN CIRCLES
 LOCAL EVENTS ARE IN BOXES



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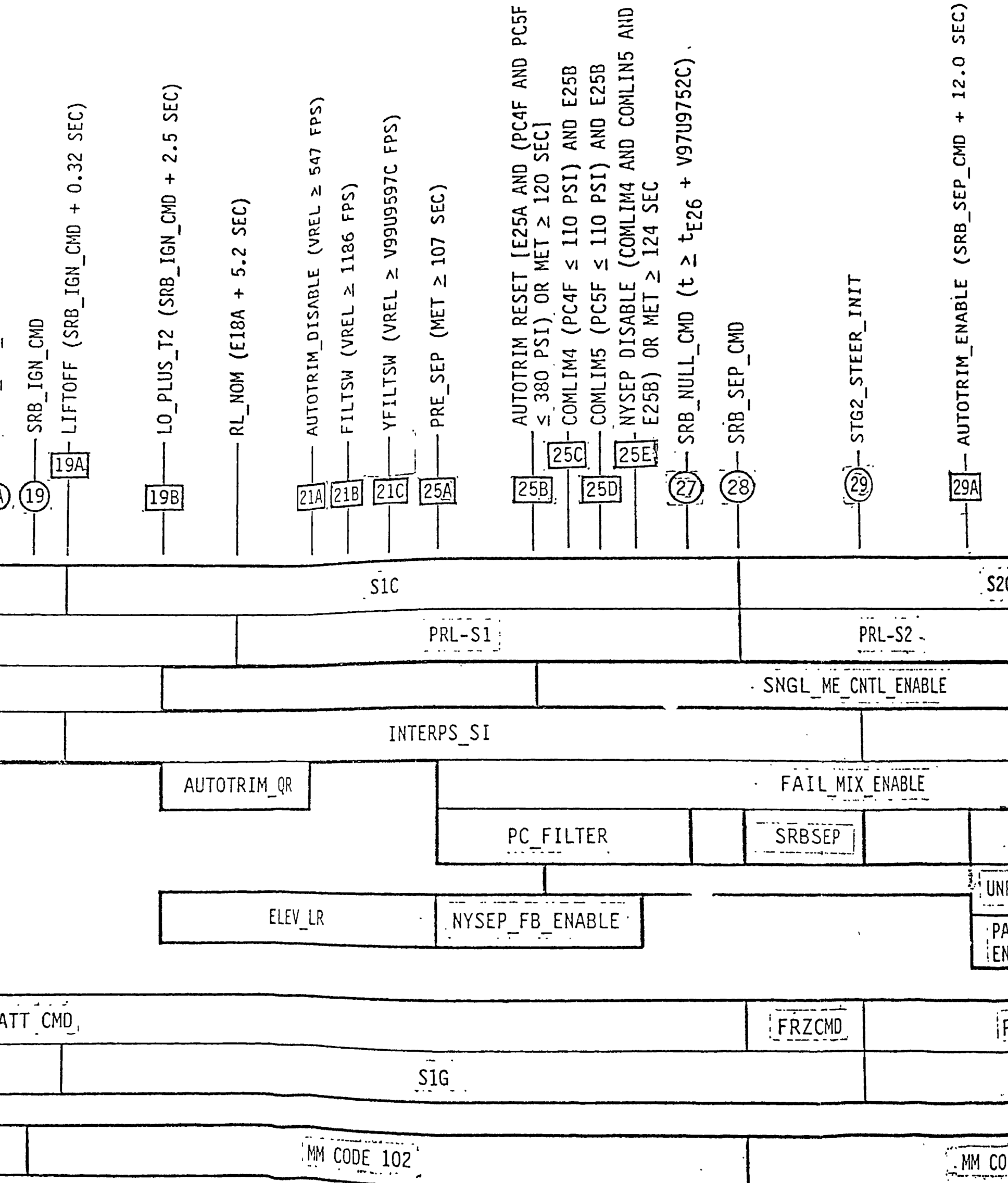


Figure 4.2.4-2. ASC DAP

STEER Subphases, Non

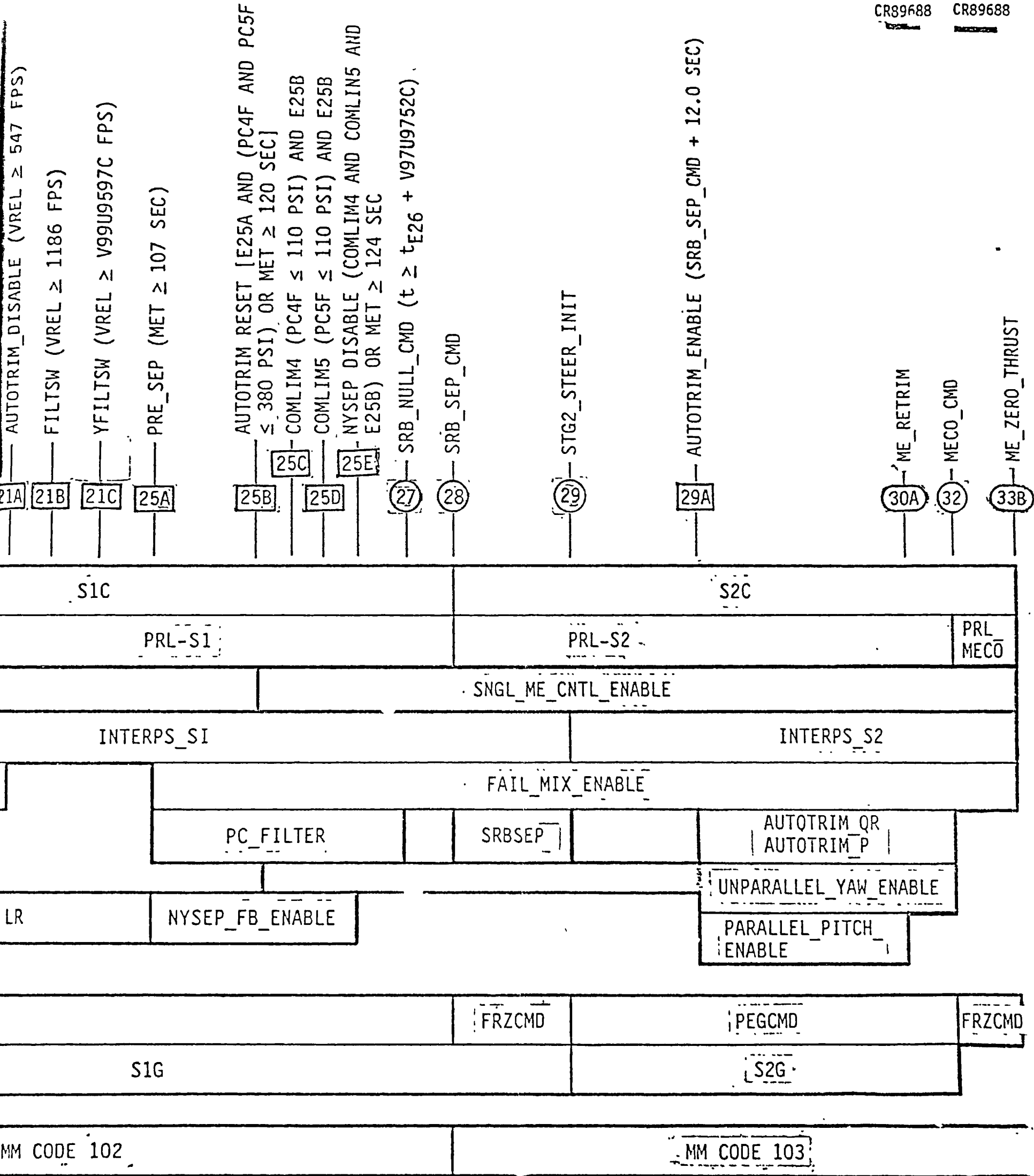


Figure 4.2.4-2. ASC DAP and GC STEER Subphases, Nominal Mission

Pre-E19 Initial Conditions:

PRELO, S1C, S2C, INTERPS_S1, INTERPS_S2; S1G, S2G, ATTFILT, ATTCMD, FRZ_CMD, PEGCMD, PRL_LCH, PRL_S1, PRL_S2, PRL_MECO; SRBLIM_ACTV; AUTOTRIM_QR, AUTOTRIM_P; AUTOTRIM_RESET; ELEV_LR; FILTSW; FAIL_MIX_ENABLE; PC_FILTER; NYSEP_FB_ENABLE; COMLIM4, COMLIM5; UNPAR_YAW_ENABLE, PAR_PITCH_ENABLE; AUTO; RTLS_TURN; SRB_SEP; TWR_CLR_BIAS; ORB_HYD_VERIFY; AERO_SLEW_COMPLETE; ME_SLEW_COMPLETE; SRB_HYD_VERIFY; SRB_SLEW_COMPLETE; LAUNCH_HOLD; LAUNCH_RESTART; SSME_LCH_POS; ME_RESTART_POS; SRB_IGN_CMD; LIFTOFF; PRL_S1; PRL_S2; AUTOTRIM_DISABLE; SRB_NULL_CMD; SRB_SEP_CMD; STC2_STEER_INIT; AUTOTRIM_ENABLE; ME_RETRIM; MECO_CMD; PPD_INIT; PPD_COMPLETE; AUTOBY_LAMP; MNLBY_LAMP; AUTOBRTC_LAMP; MNLBRTC_CMDR_LAMP; MNLBRTC_PLT_LAMP; AUTOP_LAMP; CSSF_LAMP; AUTORY_LAMP; CSSRY_LAMP; AERO_SLEW; SSME_START_POS; ME_SLEW; PPD; SRB_SLEW; PAR_PITCH; UNPAR_YAW; ME_ZERO_THRUST; AERO_SLEW_BEGIN; ME_SLEW_BEGIN; STOW_SS; GRAV_POS; RECYCLE_COUNT; RECYCLE_DURING_ME_SLEW; INHIBIT_START_POS; BNGL_ME_CNTL_ENABLE; ITRANS; YFILTWS.

HYD_FAILS = 0
SSME_FAILS = 0

Event	Event Name	Local Variable	Forcing Function*	Action*
(19)	SRB_IGN_CMD		SRB ignition command	
19A	(LIFTOFF)	<ul style="list-style-type: none"> • S1C, PRELO • LIFTOFF • INTERPS_S1 • S1G 	MET = MET_LIFTOFF (worst case liftoff)	<ul style="list-style-type: none"> • Control loops closed • initiate fader on holddown bias • Stage 1 gain scheduling initiated • Stage 1 guidance commands initiated
19B	(LO_PLUS_T2)	<ul style="list-style-type: none"> • ATTFILT • LO_PLUS_T2 	(19A) * (S_QUAT) MET = MET_LIM_LCH	<ul style="list-style-type: none"> • Accept guidance cmds
19C	(RL_NOM)	<ul style="list-style-type: none"> • SRBLIM_ACTV • AUTOTRIM_QR • ELEV_LR 	(18A) + MET_90THRUST	<ul style="list-style-type: none"> • Normal SRB component limits engaged • Pitch & yaw trim integrator turned ON • Elevon load relief turned ON • Normal SSME fixed rate limits engaged
21A	(AUTOTRIM_DISABLE)	<ul style="list-style-type: none"> • AUTOTRIM_QR 	$V_{REL} \geq V_{REL_AUTOTRIM_INHIBIT}$	<ul style="list-style-type: none"> • Pitch & yaw trim integrators turned OFF
21B	(FILTSW)	<ul style="list-style-type: none"> • FILTSW 	$V_{REL} \geq V_{REL_FILTSW}$	<ul style="list-style-type: none"> • Roll bending filter switched to B
21C	(YFILTWS)	<ul style="list-style-type: none"> • YFILTWS 	$V_{REL} > V_{REL_YFILTWS}$	<ul style="list-style-type: none"> • Switch yaw bending filter gains
25A	(PRE_SEP)	<ul style="list-style-type: none"> • FAIL_MIX_ENABLE • PRE_SEP • NYSEP_FB_ENABLE • PC_FILTER • ELEV_LR 	MET > MET_25A	<ul style="list-style-type: none"> • Enable roll mixing logic change if SSME failure has occurred • Roll lead-lag switched • Enable fader on KL_MPS & KN_NY gains • Enable Ny feedback for SRB separation control • Pc monitoring/filtering initiated • Disable elevon load relief
25B	(AUTOTRIM_RESET)	<ul style="list-style-type: none"> • AUTOTRIM_RESET 	E25A * (PC4F < PC_TRIM_RESET * PC5F < PC_TRIM_RESET) + MET > MET_25B	<ul style="list-style-type: none"> • Enable fader on trim integrators • Enable fader on KN_MPS, KL_SRB, KL_DELPSI, KM_MPS, & KM_SRB GAINS • Enable Stage 2 roll mixing logic change for no SSME failures • Enable fader to DQMPST pitch trim

○ Denotes external forcing function/event

Figure 4.2.4-2A. Overview of Events/Sequencing (Sheet 1 of 2)

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Event	Event Name	Local Variable	Forcing Function*	Action*
25B (Cont)		<ul style="list-style-type: none"> UNPAR_YAW_ENABLE SNGL_ME_CNTL_ENABLE 		<ul style="list-style-type: none"> Lateral attitude gain switched Enable RCS jet cmds at two SSME out
25C	(COMLIM4)	<ul style="list-style-type: none"> COMLIM4 	$E25B \cdot PC4F < PC_COMLIM$	<ul style="list-style-type: none"> Engage V97U2427C component limiting on both SRB's
25D	(COMLIM5)	<ul style="list-style-type: none"> COMLIM5 	$E25B \cdot PC5F < PC_COMLIM$	<ul style="list-style-type: none"> Engage V97U2427C component limiting on both SRB's
25E	(NYSEP_DISABLE)	<ul style="list-style-type: none"> NYSEP_FB_ENABLE 	$(COMLIM4 \cdot COMLIM5) + MET > MET_25E$	<ul style="list-style-type: none"> Disengage N_y feedback through 4-sec fader
(27)	SRB_NULL_CMD	<ul style="list-style-type: none"> PC_FILTER SRB_NULL_CMD 	SRB_MODING_SEP = ON	<ul style="list-style-type: none"> Terminate P_c monitoring filtering Null SRB actuators Employ orbiter pitch and yaw RGA's Stage 2 control; selected SOP's and FDIR disabled (separate CR) Enable 2nd stage pitch trim
(28)	(SRB_SEP_CMD) (SRB separation command issued)	<ul style="list-style-type: none"> S2C, S1C ATTCMD SRBSEP FRZ_CMD PRL_S2, PRL_S1 		<ul style="list-style-type: none"> Roll bending filter switches to C Pitch and yaw trim integrator limits changed to second stage values 4-sec SRB separation period initiated Three-axis attitude hold engaged; guidance initiated for convergence Engage PRL
(29)	STG2_STEER_INIT (Stage 2 guidance ready)	<ul style="list-style-type: none"> SRBSEP PEGCMD, FRZCMD S2G, S1G INTERPS_S2, INTERPS_S1 	GUIDANCE_INITIATE = ON	<ul style="list-style-type: none"> 4-sec SRB separation period complete Stage 2 guidance engaged for control Stage 2 gain scheduling initiated
29A	(AUTOTRIM_ENABLE)	<ul style="list-style-type: none"> AUTOTRIM_QR AUTOTRIM_P PAR_PITCH_ENABLE 	$[t > (t_{E28} + 12 \text{ SEC}) \cdot \text{SEC_ME_FL_CNFM}] +$ $[t > (t_{E28} + 60 \text{ SEC}) \cdot \text{SEC_ME_FL_CNFM}]$	<ul style="list-style-type: none"> Roll, pitch, and yaw trim integrators turned ON Lateral attitude gain switched
(30A)	ME_RETRIM	<ul style="list-style-type: none"> PAR_PITCH_ENABLE 	S_SSME_TRIM = ON	<ul style="list-style-type: none"> Unparallel ME's in pitch (= initiate ME retrim)
(32)	MECO_CMD	<ul style="list-style-type: none"> AUTOTRIM_QR, AUTOTRIM_P UNPAR_YAW_ENABLE PRL_S2, PRL_MECO FRZCMD, PEGCMD S2G 	MECO_CMD	<ul style="list-style-type: none"> Trim integrators disabled Unparallel ME's in yaw PRL limits reduced
(33B)	ME_ZERO_THRUST		ZERO_THRUST	<ul style="list-style-type: none"> ASC_DAP deactivated (except body flap) and TRANS_DAP activated

*Numbers in this column change when I-loads are changed.

Figure 4.2.4-2A. Overview of Events/Sequencing (Sheet 2 of 2)

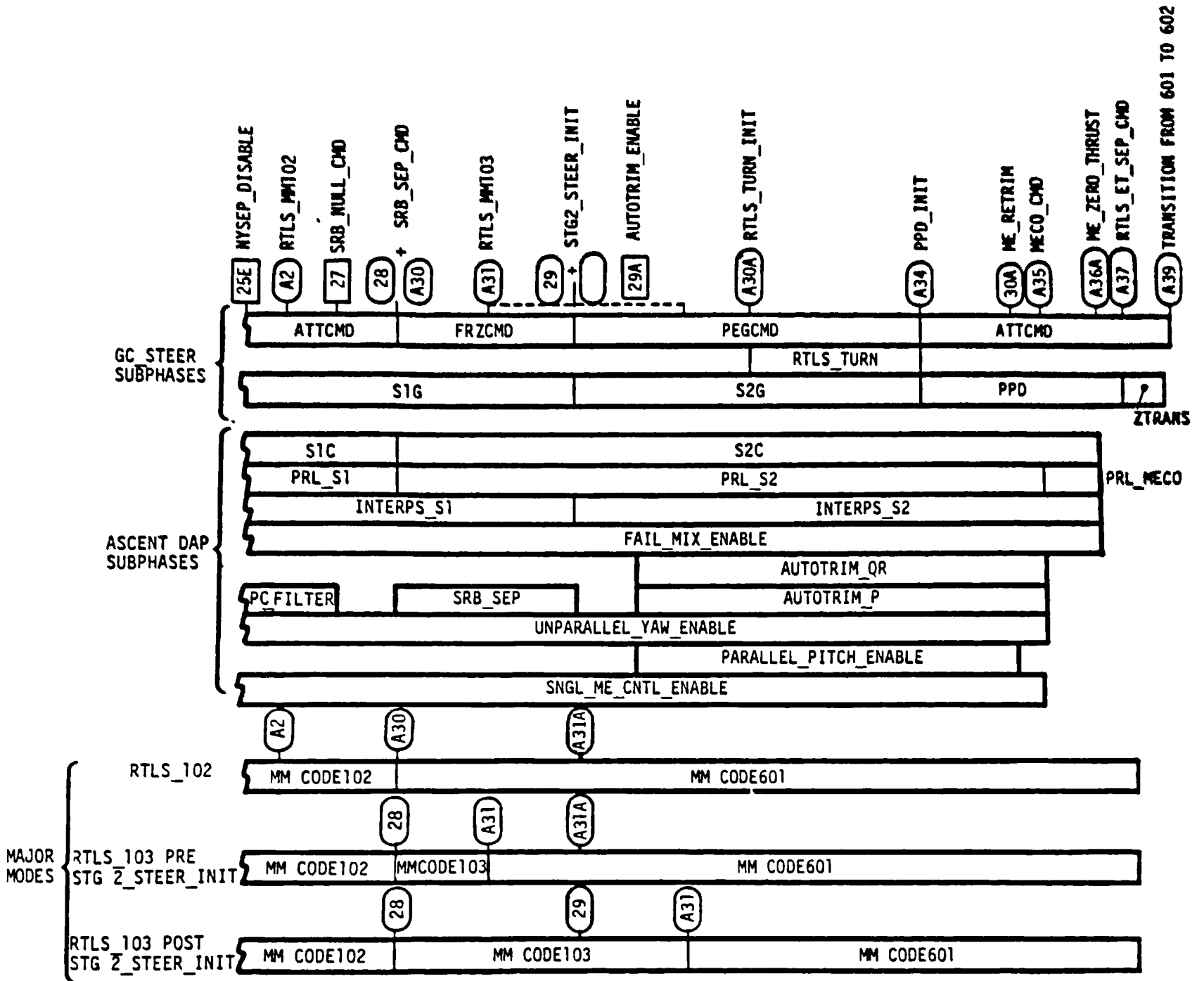


Figure 4.2.4-3. RTLS Abort Subphases

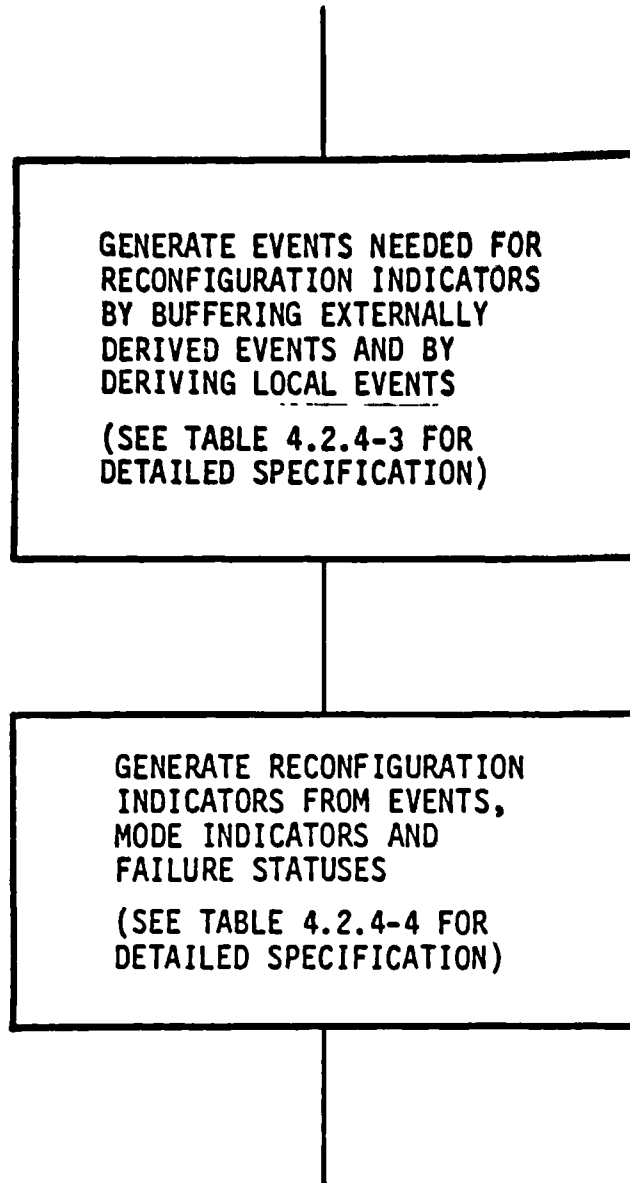


Figure 4.2.4-4. ASC_RECON Function Module, Detailed Flow Diagram

Table 4.2.4-1. Functional Description of ASC_DAP
and GC_STEER Subphases

Subphase Name	Function(s) Performed During Subphase
AERO_SLEW	Aerosurface actuator slew test
ATTCMD	GC_STEER processes body attitude quaternion prior to lift-off or guidance commanded body attitude quaternion in Stage 1 or guidance commanded body attitude in the RTLS powered pitch-down mated coast and -Z translation maneuvers
ATTFILT	Body attitude quaternion filtered by GC_STEER prior to liftoff
AUTOTRIM_P	Roll automatic trim control
AUTOTRIM_QR	Pitch/yaw automatic trim control
FRZCMD	Freeze flight body attitude commands
SSME_START_POS	Main engines biased off to start position
INTERPS_S1	Stage 1 linear interpolations; scheduled parameters functions of relative velocity and met
INTERPS_S2	Stage 2 linear interpolations; scheduled parameters functions of estimated mass
ME_SLEW	Main engine actuator slew test
PARALLEL_PITCH_ENABLE	Enable paralleling of main engines in pitch in the event of engine 2 or 3 failure, or all three SSME's are on and PARALLEL_PITCH_NOM is on.
PC_FILTER	SRB chamber pressure filtered for SRB nozzle command vector limiting and for SRB thrust tailoff control
PEGCMD	Stage 2 steering using powered explicit guidance commands or powered RTLS explicit guidance commands

Table 4.2.4-1 Functional Description of ASC_DAP
and GC_STEER Subphases (Cont)

Subphase Name	Function(s) Performed During Subphase
PRELO	Pre-lift-off functions, including initialization of GC_STEER, actuator slew tests, and attitude filtering
PRL_LCH	Restriction of rate of change of SSME actuator commands so as not to exceed hydraulic system capability while engines are throttling up at launch
PRL_MECO	Restriction of rate of change of SSME actuator commands so as not to exceed hydraulic system capability while engines are throttling down at MECO
PRL_S1	Fixed rate limiting of SSME actuator commands in Stage 1
PRL_S2	Normal restriction of rate of change of SSME actuator commands so that hydraulic system capability is not exceeded with or without APU failures; Stage 2 only
S1C	Stage 1 automatic thrust vector control using rate gyro feedback, normal and lateral acceleration feedback, and steering commands derived from commanded body attitude profiles
S2C	Stage 2 automatic thrust vector control using rate gyro feedback and steering commands derived from linear tangent guidance parameters
S1G	Stage 1 steering using open-loop guidance profile
S2G	Stage 2 steering using powered explicit guidance commands or powered RTLS explicit guidance commands
SRBLIM_ACTV	Imposes narrow limits on SRB actuator deflections at launch

Table 4.2.4-1. Functional Description of ASC_DAP and
GC_STEER Subphases (Cont)

Subphase Name	Function(s) Performed During Subphase
SRBSEP	Activates SRB separation attitude control logic
SRB_SLEW	SRB actuator slew test
FAIL_MIX_ENABLE	Enable main engine mixing logic changes for engine failures
UNPARALLEL_YAW_ENABLE	Enable unparalleling of main engines in yaw in the event of main engine failure
ELEV_LR	Provides vehicle aerodynamic load relief via elevon surface control
NYSEP_FB_ENABLE	Activates Y axis acceleration feedback for SRB separation control
SNGL_ME_CNTL_ENABLE	Allows moding DAP to provide RCS jet commands for roll control if two-SSME-out condition exists
PPD	Stage 2 steering using RTLS powered pitch-down maneuver
RTLS_TURN	Stage 2 steering using RTLS powered explicit guidance commands for the turnaround maneuver
GRAV_POS	Main engine biased to gravity position
ZTRANS	Stage 2 steering during RTLS external tank separation

Table 4.2.4-2. ASC_RECON Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Inputs</u>						
	ME1_FAIL_SHUTDOWN	Main engine out indicators	SSME_OPS	B		-	12.5
	ME2_FAIL_SHUTDOWN						
	ME3_FAIL_SHUTDOWN						
	HYDRFAIL(1)	Hydraulic system failure indicators	HYD_SYS_SOP	B		-	12.5
	HYDRFAIL(2)						
	HYDRFAIL(3)						
	MPS_SLEW_COMPLETE	Indicator, Event 5A; orbiter hydraulic system slew test complete	ORB_ACT_SLEW, RS_LCH_SEQ	B		-	12.5
	SRB_IGNITION_COMMAND	Indicator, Event 19; initiate SRB IGN command	RS_LCH_SEQ	B		-	12.5
	SRB_MODING_SEP	Indicator, Event 27; initiate SRB null command	SRB_SEP_SEQ ET_SEP_SEQ	B		-	12.5
	SRB_SEPARATION_COMMAND_FLAG	Indicator, Event 28; initiate SRB separation command	SRB_SEP_SEQ ET_SEP_SEQ	B		-	12.5
	GUIDANCE_INITIATE	Indicator, Event 29; Stage 2 guidance ready	MSC	B		-	12.5
	CLOCK	Clock-computer (GMT)	FCOS	S		sec	25
	REL_VEL_MAG	Earth-relative velocity magnitude	ASCENT_UPP	S		fps	6.25
	AUTOP	Pitch auto mode push-button indicator	GN&C_SW_RM	B		-	6.25
	S_QUAT	Ascent 1st stage guidance ready flag	ASC_1STG_GUID	B		-	6.25
	RS_AUTO_SEQ_START	Indicator, Event 6; LPS go for auto sequence start	RS_LCH_SEQ	B		-	12.5
	AUTORY	Roll/yaw auto mode push-button indicator	GN&C_SW_RM	B		-	6.25
	CSSP	Pitch manual mode push-button indicator	GN&C_SW_RM	B		-	6.25
	CSSRY	Roll/yaw manual mode push-button indicator	GN&C_SW_RM	B		-	6.25
	S_SSME_TRIM	Indicator, Event 30A, initiate main engine retrim	ASC_2STG_GUID	B		-	.521
	MECO_COMMAND	Indicator, Event 32, initiate main engine cut off	SSME_OPS	B		-	12.5
CLOCK = Time from SRB ignition command GMT = GMT _{SRB ignition}							

Table 4.2.4-2. ASC_RECON Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Inputs (Cont)</u>						
	ME_ZERO_THRUST	Indicator, Event 33B or A36A; at least two main engines shutdown (zero thrust)	MSC	B		-	12.5
	PC4F	Filtered chamber pressure, left SRB	CMD_PROC_SRB	S		-	12.5
	PC5F	Filtered chamber pressure, right SRB	CMD_PROC_SRB	S		-	12.5
	FAST_SEP_FLAG	Fast separation flag	ET_SEP_SEQ	D		-	6.25
	OPS_6_IND	Indicator, Event A30 and A31 trans to OPS 6	MSC	B		-	12.5
	SSME_STOW_COMPLETE	SSME stow complete flag	SSME_TVC_CMD_SOP	B		-	1.0
	MECO_CONFIRM	MECO_CONFIRMED FLAG	SSME_OPS	B		-	12.5
	TRANSITION_TO_OPS_1	Indicator, Event 1; transition to OPS 1	MSC	B		-	12.5
	SRB_SLEW	Indicator, Event 8; initiate SRB slew test	LPS	B		-	12.5
	SRB_SLEW_COMPLETE	Indicator, Event 8A; SRB hydraulic slew test complete	SRB_SLEW	B		-	12.5
	AERO_SLEW	Indicator, Event 4A; initiate aerosurface hydraulic system slew check	LPS	B		-	12.5
	MPS_SLEW	Indicator, Event 5; initiate MPS hydraulic system slew check	LPS	B		-	12.5
	PREP_SSME	Indicator, Event 18A; command SSMEs to liftoff position	RS_LCH_SEQ	B		-	12.5
	S_RTLS_TURN	Indicator, RTLS turnaround	PW_RTLS_GUID	B		-	12.5
	S_PPD_QUAT	Indicator, initiate RTLS powered pitch down maneuver	PW_RTLS_GUID	B		-	12.5
	EVENT_A37	Indicator, Event A37; ET separation command	ET_SEP_SEQ	B		-	12.5
	MM_CODE_602	Major Mode 602 flag	MSC	B		-	12.5
	AERO_SLEW_COMPLETE	Indicator, Event 4B; aerosurface slew test complete	ORB_ACT_SLEW	B		-	12.5
	A_D_RECYCLE_COUNT	ASC DAP recycle indicator	RS_LCH_SEQ	B		-	12.5
	RETURN_SSME_TO_START_POS	Indicator, return SSME to start position flare	RS_LCH_SEQ	B		-	12.5

Table 4.2.4-2. ASC_RECON Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Inputs (Cont)</u>						
	TAL_ABORT_DECLARED	TAL abort declared	MSC	B		-	
	MPS_LO2_DUMP_STOP	MPS dump complete	MPS_DUMP_SEQ	B		-	
	<u>Outputs</u>						
	HYD_FAILS	Indicator, buffered MYD_FAIL_STATUS	CMD_PROC_MPS	I		-	12.5
	S1C	Indicator, Stage 1 control	CMD_PROC_SRB ASC_TVC	B		-	12.5
	S2C	Indicator, Stage 2 control	ASC_TVC	B		-	12.5
	AUTOTRIM_F	Indicator, enable roll autotrim	ASC_TVC	B		-	12.5
	INTERPS_S1	Indicator, Stage 1 INTERPS	INTERPS	B		-	12.5
	INTERPS_S2	Indicator, Stage 2 INTERPS scheduling	INTERPS	B		-	12.5
	PEGCMD	Indicator, S2G steering mode	GC_STEER	B		-	12.5
	ATTCMD	Indicator, ATTFILT, S1G or PPD steering mode	GC_STEER	B		-	12.5
	AUTO	Indicator, automatic steering mode	{ ASC_2STG_GUID GC_STEER PW_RTLS_GUID ABT_CNTRL_SEQ GRTLS_DAP }	B		-	12.5
	PPD	Indicator, RTLS powered pitch down maneuver	GC_STEER INTERPS	B		-	12.5
	S1G	Indicator, Stage 1 guidance	GC_STEER	B		-	12.5
	FRZCMD	Indicator, freeze desired body command	GC_STEER	B		-	12.5
	ATTFILT	Indicator, filter actual body attitude	GC_STEER	B		-	12.5
	SRB_NULL_CMD	Indicator, initiate SRB null CMD, Event 27	{ ASC_TVC CMD_PROC_SRB A/E_ATT_PROC }	B		-	12.5
	NYSEP_FB_ENABLE	Indicator to switch NY feedback	{ ASC_TVC INTERPS }	B		-	12.5
	PC_FILTER	Indicator, SRB chamber pressure filtering	CMD_PROC_SRB	B		-	12.5
	COMLIM4	Indicator, SRB4 component limiting	CMD_PROC_SRB	B		-	12.5
	COMLIM5	Indicator, SRB5 component limiting	CMD_PROC_SRB	B		-	12.5

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Table 4.2.4-2. ASC_RECON Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/ Produced At Hz
	<u>Outputs (Cont)</u>						
	LAUTO_FLAMP	Left pitch auto FCS mode lamp	D&C_PNL, TLM	B		-	12.5
	RAUTO_FLAMP	Right pitch auto FCS mode lamp	D&C_PNL, TLM	B		-	12.5
	LAUTO_RYLAMP	Left roll/yaw auto FCS mode lamp	D&C_PNL, TLM	B		-	12.5
	RAUTO_RYLAMP	Right roll/yaw auto FCS mode lamp	D&C_PNL, TLM	B		-	12.5
	LCSS_FLAMP	Left pitch manual FCS mode lamp	D&C_PNL, TLM	B		-	12.5
	RCSS_FLAMP	Right pitch manual FCS mode lamp	D&C_PNL, TLM	B		-	12.5
	LCSS_RYLAMP	Left roll/yaw manual FCS mode lamp	D&C_PNL, TLM	B		-	12.5
	RCSS_RYLAMP	Right roll/yaw manual FCS mode lamp	D&C_PNL, TLM	B		-	12.5
	LAUTO_BFLAMP	Left auto body flap lamp	D&C_PNL, TLM	B		-	12.5
	RAUTO_BFLAMP	Right auto body flap lamp	D&C_PNL, TLM	B		-	12.5
	LNML_BFLAMP	Left manual body flap lamp	D&C_PNL, TLM	B		-	12.5
	RMNL_BFLAMP	Right manual body flap lamp	D&C_PNL, TLM	B		-	12.5
	LAUTO_SBLAMP	Left auto speed brake lamp	D&C_PNL, TLM	B		-	12.5
	RAUTO_SBLAMP	Right auto speed brake lamp	D&C_PNL, TLM	B		-	12.5
	MNLSB_CMDR_0	Commander's manual speed brake lamp		B		-	12.5
	MNLSB_PLT_0	Pilot's manual speed brake lamp		B		-	12.5
	SRBSEP	Indicator, SRB separation subphase	GC_STEER	B		-	12.5
	PNE_SEP	Indicator, initiate separation preparation	INTERPS	B		-	12.5
	SSME_FAILS	Indicator, SSME failure status	(CMD_PROC_MPS) (INTERPS)	I		-	12.5
	FILTSW	Indicator, TVC filter coefficient switching	ASC_TVC	B		-	12.5
	YFILTSW	Indicator, yaw filter coefficient switching	ASC_TVC	B		-	12.5
	PARALLEL_PITCH	Indicator, parallel pitch thrust	CMD_PROC_MPS	B		-	12.5
	UNPARALLEL_YAW	Indicator, unparallel yaw thrust	CMD_PROC_MPS	B		-	12.5

Table 4.2.4-2. ASC_RECON Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required Produced Ac (Hz)
	<u>Outputs (Cont)</u>						
	MECO_CMD	Indicator, initiate MECO command	CMD_PROC_MPS	B		-	12.5
	MM101_INIT	Indicator, MM101 startup	{ INTERPS AEROSURFACE_ CONTROL ASC_TV CMD_PROC_MPS CMD_PROC_SRB GC_STEER }	B		-	12.5
	LIFTOFF	Indicator, nominal vehicle liftoff	CMD_PROC_MPS CMD_PROC_SRB	B		-	12.5
	AUTOTRIM_RESET	Indicator, ramp autotrim integrators to zero	{ CMD_PROC_MPS ASC_TV INTERPS }	B		-	12.5
	SSME_START_POS	Indicator, SSME start position	CMD_PROC_MPS	B		-	12.5
	PRL_MECO	Indicator, PRL lamps reduced	CMD_PROC_MPS	B		-	12.5
	PRL_S2	Indicator, rate limit for Stage 2	CMD_PROC_MPS	B		-	12.5
	PRL_S1	Indicator, rate limit for Stage 1	CMD_PROC_MPS	B		-	12.5
	TWR_CLR_BIAS	ME 2 failed at lift-off prior to LO-plus-T2	ASC_TV	B		-	12.5
	SSME_LCH_POS	Indicator, retrim engines to launch position	CMD_PROC_MPS	B		-	12.5
	STOW_SB	Indicator, stow speed brake to closed position	AEROSURFACE_ CONTROL	B		-	12.5
	AUTOTRIM_OR	Indicator, enable pitch and yaw autotrim	ASC_TV	B		-	12.5
	SRBLIM_ACTV	SRB limiting active	CMD_PROC_SRB	B		-	12.5
	ELEV_LR	Elevon load relief indicator	AEROSURFACE_ CONTROL, GC_STEER	B		-	12.5
	PRE_SEP	Indicator, PRE_SEP phase	INTERPS, ASC_TV	B		-	12.5
	SRB_SEP_CMD	Indicator, SRB separation initiated	INTERPS	B		-	12.5
	FAIL_MIX_ENABLE	Indicator, enable main engine mixing logic changes for engine failures	CMD_PROC_MPS	B		-	12.5
	ME_SLEW	Indicator, main engine actuator slew test	CMD_PROC_MPS AEROSURFACE_ CONTROL	B		-	12.5
	SRB_SLEW	Indicator, SRB actuator slew test	CMD_PROC_SRB AEROSURFACE_ CONTROL	B		-	12.5

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Table 4.2.4-2. ASC_RECON Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Outputs (Cont)</u>						
	AERO_SLEW	Indicator, aerosurface actuator slew test	AEROSURFACE_CONTROL	B		-	12.5
	RTLS_TURN	Indicator, RTLS turn-around maneuver	GC_STEER	B		-	12.5
	PRL_LCH	Indicator, lower rate-limiting	CMD_PROC_MPS	B			12.5
	SEC_ME_FL_CNFM	Second ME fail confirm discrete	MSC ABT_CTL_SEQ, CMD_PROC_MPS ASC_IVC	B		-	12.5 12.5 12.5
	GRAV_POS	Indicator, SSME gravity position	CMD_PROC_MPS	B		-	12.5
	ENA_RCS_CNTL	Enable RCS control discrete	CMD_PROC_RCS	B		-	12.5
	PRELO	Indicator	AEROSURFACE_CONTROL	B		-	12.5
	ZIRANS	Indicator, RTLS external tank separation maneuver	GC_STEER	B		-	12.5

Table 4.2.4-3. Definition of Local Events Used for ASC_DAP
and GC_STEER Reconfiguration

Local Event Name	Event No.	Condition Under Which Event is "ON"
MM101_INIT	1	TRANSITION_TO_OPS_1
RECYCLE_COUNT	3	A_D_RECYCLE_COUNT
RECYCLE_DURING_ME_SLEW	3A	RECYCLE_COUNT * ME_SLEW
AERO_SLEW_BEGIN	4A	AEROSURFACE_SLEW_CHECK_INDICATOR
AERO_SLEW_COMPLETE	4B	AEROSURFACE_SLEW_COMPLETE_FLAG
ME_SLEW_BEGIN	5	MPS_GIMBAL_SLEW_CHECK_INDICATOR
ME_SLEW_COMPLETE	5A	MPS_SLEW_CHECK_COMPLETE
STOW_SB	6	RS_AUTO_SEQ_START
SRB_HYD_VERIFY	8	SRB_FCS_HYD_VERIFICATION
SRB_SLEW_COMPLETE	8A	SRB_FCS_HYD_VERIFY_COMPLETE
SSME_LCH_POS	18A	PREP_SSMES_FOR_LIFTOFF
ME_RESTART_POS	20	RETURN_SSME_TO_START_POS
SRB_IGN_CMD	19	SRB_IGNITION_CMD*
LIFTOFF	19A	MET ≥ MET_LIFTOFF
LO_PLUS_T2	19B	MET ≥ MET_LIM_LCH
RL_NOM	19C	MET (18A + MET_90THRUST)
AUTOTRIM_DISABLE	21A	REL_VEL_MAG ≥ VREL_AUTOTRIM_INHIBIT
FILTSW	21B	REL_VEL_MAG ≥ VREL_FILTSW
YFILTSW	21C	REL_VEL_MAG ≥ VREL_YFILTSW
PRE_SEP	25A	MET ≥ MET_25A
AUTOTRIM_RESET	25B	PRE_SEP * [(PC4F < PC_TRIM_RESET) * (PC5F < PC_TRIM_RESET)] + MET ≥ MET_25B
COCLIM4	25C	(AUTOTRIM_RESET) * (PC4F < PC_COCLIM)
COCLIM5	25D	(AUTOTRIM_RESET) * (PC5F < PC_COCLIM)
NYSEP_DISABLE	25E	(COCLIM4) * (COCLIM5) + (MET ≥ MET_25E)
SRB_NULL_CMD	27	SRB_MODING_SEP

*Equivalently set, MET = 0

Table 4.2.4-3. Definition of Local Events Used for ASC_DAP
and GC_STEER Reconfiguration (Cont)

Local Event Name	Event No.	Condition Under Which Event is "ON"
SRB_SEP_CMD	28 + A30	SRB_SEP_CMD_FLAG
STG2_STEER_INIT	29 + A31A	GUIDANCE_INITIATE
AUTOTRIM_ENABLE	29A	(SRB_SEP_CMD) * [SEC_ME_FL_CNFM * (MET > (MET_SRB_SEP + DELTAT AUTOTRIM_ENABLE)) + SEC_ME_FL_CNFM * (MET > (MET_SRB_SEP + 60))] ①
ME_RETRIM	30A	S_SSME_TRIM
MECO_CMD	32 + A35	MECO_COMMAND + MECO_COMMAND (MM601) ②
ME_ZERO_THRUST	33B + A36A	ZERO_THRUST_(33B OR A36A)
PPD_INIT	A34	S_PPD_QUAT
RTLS_ET_SEP_CMD	A37	EVENT_A37
RTLS_TURN_LIMIT	A30A	S_RTLS_TURN
MM_602	A39	MM_CODE_602

NOTE ① MET_SRB_SEP is a snapshot of MET at SRB_SEP_CMD which must be performed before AUTOTRIM_ENABLE is set.

② Initialization specified to occur at MECO_CMD will only be performed if SRB_SEP_CMD has occurred with the exception of SSME_FAILS. SSME_FAILS will not be reset after MECO_CMD regardless of when it occurs.

Table 4.2.4-4A. Definition of ASC_DAP and GC_STEER
Boolean Reconfiguration Indicators

Indicator Name	Definition of "ON" State			
	From		To	
	Event No.	Local Event Name	Event No.	Local Event Name
AERO_SLEW	4A	AERO_SLEW_BEGIN	4B	AERO_SLEW_COMPLETE
ATTCMD	1	MM101_INIT	28	SRB_SEP_CMD
	1	MM101_INIT	A30	SRB_SEP_CMD
	A3A	PPD_INIT	A39	MM_602
ATTFILT	1	MM101_INIT	19A'S_QUAT	LIFTOFF_AND_S_QUAT
AUTOTRIM_P	29A	AUTOTRIM_ENABLE	32	MECO_CMD
	29A	AUTOTRIM_ENABLE	A35	MECO_CMD
AUTOTRIM_QR	19B	LO_PLUS_T2	21A	AUTOTRIM_DISABLE
	29A	AUTOTRIM_ENABLE	32	MECO_CMD
	29A	AUTOTRIM_ENABLE	A35	MECO_CMD
FRZCMD	28	SRB_SEP_CMD	29	STG2_STEER_INIT
	28	SRB_SEP_CMD	A31A	STG2_STEER_INIT
	A30	SRB_SEP_CMD	A31A	STG2_STEER_INIT
	32	MECO_CMD	33B	ME_ZERO_THRUST
INTERPS_S1	19A	LIFTOFF	29	STG2_STEER_INIT
	19A	LIFTOFF	A31A	STG2_STEER_INIT
ME_SLEW	5	ME_SLEW_BEGIN	5A	ME_SLEW_COMPLETE
PARALLEL_PITCH_ENABLE	29A	AUTOTRIM_ENABLE	30A	ME_RETRIM
PC_FILTER	25A	PRE_SEP	27	SRB_NULL_CMD
PEGCMD	29	STG2_STEER_INIT	32	MECO_CMD
	29	STG2_STEER_INIT	A34	PPD_INIT
	A31A	STG2_STEER_INIT	A34	PPD_INIT
PPD	A34	PPD_INIT	A37	RTLS_ET_SEP_CMD
PRELO (= S1C·S2C)	1	MM101_INIT	19A	LIFTOFF
PRL_LCH	1	MM101_INIT	19C	RL_NOM
S1C	19A	LIFTOFF	28	SRB_SEP_CMD
	19A	LIFTOFF	A30	SRB_SEP_CMD
S2C	28	SRB_SEP_CMD	33B	ME_ZERO_THRUST
	28	SRB_SEP_CMD	A36A	ME_ZERO_THRUST
	A30	SRB_SEP_CMD	A36A	ME_ZERO_THRUST
INTERPS_S2	29	STG2_STEER_INIT	33B	ME_ZERO_THRUST
	29	STG2_STEER_INIT	A36A	ME_ZERO_THRUST
	A31A	STG2_STEER_INIT	A36A	ME_ZERO_THRUST

Table 4.2.4-4A. Definition of ASC_DAP and GC STEER
Boolean Reconfiguration Indicators (Cont)

Indicator Name	Definition of "ON" State			
	From		To	
	Event No.	Local Event Name	Event No.	Local Event Name
SIG	19A'S_QUAT 19A'S_QUAT	LIFTOFF_AND_S_QUAT LIFTOFF_AND_S_QUAT	29 A31A	STG2_STEER_INIT STG2_STEER_INIT
SRBLIM_ACTV	1	MM101_INIT	19B	LO_PLUS_T2
SRBSEP	28 28 A30	SRB_SEP_CMD SRB_SEP_CMD SRB_SEP_CMD	29 A31A A31A	STG2_STEER_INIT STG2_STEER_INIT STG2_STEER_INIT
SRB_SLEW	8	SRB_HYD_VERIFY	8A	SRB_SLEW_COMPLETE
FAIL_MIX_ENABLE	25A 25A	PRE_SEP PRE_SEP	33B A36A	ME_ZERO_THRUST ME_ZERO_THRUST
UNPARALLEL_YAW_ENABLE	25B 25B	AUTOTRIM_RESET AUTOTRIM_RESET	32 A35	MECO_CMD MECO_CMD
PRL_S1	19C 19C	RL_NOM RL_NOM	28 A30	SRB_SEP_CMD SRB_SEP_CMD
PRL_S2	28 28 A30	SRB_SEP_CMD SRB_SEP_CMD SRB_SEP_CMD	32 A35 A35	MECO_CMD MECO_CMD MECO_CMD
PRL_MECO	32 A35	MECO_CMD MECO_CMD	33B A36A	ME_ZERO_THRUST ME_ZERO_THRUST
ELEV_LR	19B	LO_PLUS_T2	25A	PRE_SEP
NYSEP_FB_ENABLE	25A	PRE_SEP	25E	NYSEP_DISABLE
S2G	29 29 A31A	STG2_STEER_INIT STG2_STEER_INIT STG2_STEER_INIT	32 A34 A34	MECO_CMD PPD_INIT PPD_INIT
RTLS_TURN	A30A	RTLS_TURN_INIT	A34	PPD_INIT
ZTRANS	A37	RTLS_ET_SEP_CMD	A39	MM_602
SNGL_ME_CNTL_ENABLE	25B	AUTOTRIM_RESET	33B + A35	ME_ZERO_THRUST + MECO_CMD
INHIBIT_START_POS	3A	RECYCLE_DURING_ ME_SLEW	5	ME_SLEW_BEGIN ¹

¹Start of ME_SLEW if any, after the one in progress at time of recycle count

Table 4.2.4-4B. Definition of ASC_DAP and GC_STEER
Complex Boolean Reconfiguration Indicators

Indicator Name	Definition of "ON" Stage
AUTO	$\overline{\text{LIFTOFF}} + [(\text{AUTOP} + \text{AUTORY}) + \text{AUTO} \cdot (\overline{\text{CSSP}} + \overline{\text{CSSRY}})] \cdot (\overline{\text{FAST_SEP_FLAG}})$
PARALLEL_PITCH	$[\text{PARALLEL_PITCH_ENABLE}] \cdot [(\text{SSME_FAILS} = 2 \text{ OR } 3) + (\text{SSME_FAILS} = 0) \cdot (\text{PARALLEL_PITCH_NOM})]$
UNPARALLEL_YAW	$(\text{SSME_FAILS} = 2 \text{ or } 3) \cdot (\text{UNPARALLEL_YAW_ENABLE}) + \text{HYD_FAILS} > 0 + \text{UNPARALLEL_YAW}$
TWR_CLR_BIAS	$\text{LIFTOFF} \cdot \overline{\text{LO_PLUS_T2}} \cdot (\text{ME2_FAIL_SHUTDOWN} = \text{ON})$
SSME_START_POS ^⑥	$[(\text{ME_RESTART_POS} \cdot \overline{\text{GRAV_POS}})] + [(\text{ME_SLEW}) \cdot (\overline{\text{SSME_LCH_POS}})] \cdot [(\text{ME_SLEW_COMPLETE}) \cdot \overline{\text{INHIBIT_START_POS}} + (\text{RS_AUTO_SEQ_START})]$
TWO_SSME_FAIL ^②	$(\text{SNGL_ME_CNTL_ENABLE}) \cdot [(\text{MULTIPLE_SSME_FAILURE}) \cdot (\overline{\text{SRB_SEP_CMD}}) + (\text{MULTIPLE_SSME_FAILURE}) \cdot (\text{SRB_SEP_CMD}) \cdot (\overline{\text{MECO_CONFIRM}})]$
GRAV_POS ^⑥	$(\text{RECYCLE_COUNT} \cdot \overline{\text{ME_SLEW}} + \text{INHIBIT_START_POS})$
SEC_ME_FL_CNFM ^③	$[\text{MET} > (\text{MET_TWO_SSME_FAIL} + \text{MM_DL})] \cdot (\text{TWO_SSME_FAIL}) + \text{SEC_ME_FL_CNFM}$
ENA_RCS_CNTL ^④	$[\text{MET} > (\text{MET_TWO_SSME_FAIL} + \text{ORI_DL})] \cdot (\text{SEC_ME_FL_CNFM}) \cdot (\text{SNGL_ME_CNTL_ENABLE})$

① This indicates more than one engine in shutdown phase. See Table 4.2.4-4C for Boolean definition

② In first stage, this indicates that 2 or 3 engines are in shutdown phase during the RCS control enable window. In second stage, it indicates that 2 engines (and not the third) have shut down during the enable window. It starts a time which allows time for a 3 sigma slow engine to reach 30 percent thrust.

③ DAP initiates abort control sequencer to interconnect OMS and RCS propellant systems, starts the RCS Command SOP, and disables roll commands to the SSME TVC.

④ Initiates commanding of RCS jets by CMD_PROC_RCS.

⑤ This allows RCS roll control.

⑥ If a recycle count is done, gravity positions are to be used. If the ME_SLEW is active at the time the recycle count is done, care must be taken to ensure use of gravity positions instead of start at completion of the slew. (This is the purpose of INHIBIT_START_POS.) When a pad shutdown is done, start positions are to be used until SSME prevalve closure is complete, after which gravity positions are to be used.

⑦ The discrete PARALLEL_PITCH_NOM will be latched to "off" by the ASC RECON if the hydraulic system fail indicator HYD_FAILS > 0. (In other words, for no hydraulic system fails and PARALLEL_PITCH_NOM enabled for the 3-engine burning case, PARALLEL_PITCH will be allowed, otherwise not).

NOTES · Logical "and" + Logical "or" XXXXX Logical not

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Table 4.2.4-4C. Definition of ASC DAP and GC_STEER
Integer Recognition Indicators

Indicator Name	Integer Values	Condition for Integer Value
HYD_FAILS	0	No hydraulic system failures
	1	HYDR_SYS1_TVC_FAIL_STATUS=ON
	2	HYDR_SYS2_TVC_FAIL_STATUS=ON
	3	HYDR_SYS3_TVC_FAIL_STATUS=ON
	4	Hydraulic System 1 and 2 failed resulting in SSME 2 lockup
	5	Hydraulic System 1 and 3 failed resulting in SSME 1 lockup
	6	Hydraulic System 2 and 3 failed resulting in SSME 3 lockup
SSME_FAILS	0	No SSME failures
	1	(ME1_FAIL_SHUTDOWN=ON) • $\overline{\text{MECO_CMD}}$ • SRB_IGN_CMD
	2	(ME2_FAIL_SHUTDOWN=ON) • $\overline{\text{MECO_CMD}}$ • SRB_IGN_CMD
	3	(ME3_FAIL_SHUTDOWN=ON) • $\overline{\text{MECO_CMD}}$ • SRB_IGN_CMD
	4	*(Multiple SSME failure) • $\overline{\text{MECO_CMD}}$ • SRB_IGN_CMD
*Multiple SSME failure = (ME1_FAIL_SHUTDOWN=ON) • (ME2_FAIL_SHUTDOWN=ON) + (ME1_FAIL_SHUTDOWN=ON) • (ME3_FAIL_SHUTDOWN=ON) + (ME2_FAIL_SHUTDOWN=ON) • (ME3_FAIL_SHUTDOWN=ON)		

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Table 4.2.4-5. ASC_RECON Initialization Requirements

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
ASC_RECON	Boolean local events	-	MM101_INIT	ORB_HYD_VERIFY	OFF
				RECYCLE_COUNT	OFF
				AERO_SLEW_BEGIN	OFF
				AERO_SLEW_COMPLETE	OFF
				RECYCLE_DURING_ME_SLEW	OFF
				ME_SLEW_BEGIN	OFF
				ME_SLEW_COMPLETE	OFF
				SRB_HYD_VERIFY	OFF
				SRB_SLEW_COMPLETE	OFF
				LAUNCH_HOLD	OFF
				LAUNCH_RESTART	OFF
				SSME_LCH_POS	OFF
				ME_RESTART_POS	OFF
				SRB_IGN_CMD	OFF
				LIFTOFF	OFF
				PRL_S1	OFF
				PRL_S2	OFF
				AUTOTRIM_DISABLE	OFF
				FILTSW	OFF
				YFILTSW	OFF
				AUTOTRIM_RESET	OFF
				COMLIM4	OFF
				COMLIM5	OFF
				NYSEP_DISABLE	OFF
				SRB_NULL_CMD	OFF
				SRB_SEP_CMD	OFF
				STG2_STEER_INIT	OFF
				AUTOTRIM_ENABLE	OFF
				ME_RETRIM	OFF
				SRBLIM_ACTV	ON
				PRELO	ON
				STOW_SB	OFF
				PRL_MECO	OFF



Table 4.2.4-5. ASC_RECON Initialization Requirements (Cont)

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
ASC_RECON (Cont)	Boolean local events (Cont)	-	MM101_INIT	TWR_CLR_BIAS	OFF
	Display panel lamp Boolean indicators			RTLS_ET_SEF_CMD	OFF
				MM_602	OFF
	Boolean reconfiguration indicators			MECO_CMD	OFF
				ME_ZERO_THRUST	OFF
	Boolean reconfiguration indicators			PPD_INIT	OFF
				PPD_COMPLETE	OFF
				LAUTO_BFLAMP	ON
				RAUTO_BFLAMP	ON
				LHNL_BFLAMP	OFF
				RHNL_BFLAMP	OFF
				LAUTO_SBLAMP	ON
				RAUTO_SBLAMP	ON
				MNLSB_CMDR_0	OFF
				MNLSB_PLT_0	OFF
				LAUTO_PLAMP	ON
				RAUTO_PLAMP	ON
				LCSS_PLAMP	OFF
				RCSS_PLAMP	OFF
				LAUTO_RYLAMP	ON
				RAUTO_RYLAMP	ON
				LCSS_RYLAMP	OFF
				RCSS_RYLAMP	OFF
	AERO_SLEN			OFF	
	ATTEND			ON	
	ATTFILT			ON	
	AUTOTRIM_P			OFF	
	AUTOTRIM_OR			OFF	
	FREQND			OFF	
	SSNE START POS			OFF	
INTERPS S1	OFF				
INTERPS S2	OFF				
ME_SLEN	OFF				

Table 4.2.4-5. ASC_RECON Initialization Requirements (Cont)

Module	Component	Initialize on Transition		Variable	Initial Value	
		From	To			
ASC_RECON (Cont)	Boolean reconfiguration indicators (Cont)	-	MM101_INIT	PARALLEL_PITCH_ENABLE	OFF	
				PC_FILTER	OFF	
				PEGCMD	OFF	
				PPD	OFF	
				ZTRANS	OFF	
				SNGL_ME_CNTL_ENABLE	OFF	
				PRL_LCH	ON	
				RTLS_TURN	OFF	
				S1C	OFF	
				S2C	OFF	
				S1G	OFF	
				S2G	OFF	
				SRBSEP	OFF	
				SRB_SLEW	OFF	
				ELEV_LR	OFF	
				NYSEP_FB_ENABLE	OFF	
				FAIL_MIX_ENABLE	OFF	
				UNPARALLEL_YAW_ENABLE	OFF	
				AUTO	ON	
				GRAV_POS	OFF	
			PARALLEL_PITCH	OFF		
			INHIBIT_START_POS	OFF		
			UNPARALLEL_YAW	OFF		
			HYD_FAILS	0		
			SSME_FAILS	0		
		Slew phase indicators	HYD_FAILS = 0	HYD_FAILS = 0	PARALLEL_PITCH_NOM	OFF
					UNPARALLEL_YAW	ON
	AERO_SLEW_BEGIN		AERO_SLEW_BEGIN	AERO_SLEW	ON	
	AERO_SLEW_COMPLETE		AERO_SLEW_COMPLETE	AERO_SLEW	OFF	
	ME_SLEW_BEGIN		ME_SLEW_BEGIN	ME_SLEW	ON	
	ME_RESTART_POS		ME_RESTART_POS	ME_SLEW	OFF	
	ME_SLEW_COMPLETE		ME_SLEW_COMPLETE	ME_SLEW	OFF	
		ME_RESTART_POS	ME_SLEW	OFF		

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Table 4.2.4-5. ASC_RECON Initialization Requirements (Cont)

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
ASC_RECON (Cont)	Slew phase indicators (Cont)	<u>SRB_HYD_VERIFY</u>	SRB_HYD_VERIFY	SRB_SLEW	ON
		<u>SRB_SLEW_COMPLETE</u>	SRB_SLEW_COMPLETE	SRB_SLEW	OFF
	Main engine position indicators	<u>ME_SLEW · SSME_LCH_POS · INHIB_START_POS</u>	<u>ME_SLEW · SSME_LCH_POS · INHIBIT_START_POS</u>	SSME_START_POS	ON
		<u>RS_AUTO_SEQ_START</u>	RS_AUTO_SEQ_START	SSME_START_POS	ON
		<u>SSME_LCH_POS</u>	SSME_LCH_POS	SSME_START_POS	OFF
		<u>RECYCLE_COUNT · ME_SLEW</u>	<u>RECYCLE_COUNT · ME_SLEW</u>	GRAV_POS	ON
		<u>ME_SLEW · INHIBIT_START_POS · SSME_LCH_POS</u>	<u>ME_SLEW · INHIBIT_START_POS · SSME_LCH_POS</u>	GRAV_POS	ON
		<u>ME_RESTART_POS</u>	ME_RESTART_POS	SSME_LCH_POS	OFF
				SSME_START_POS	ON
		<u>ME_SLEW · SSME_LCH_POS</u>	<u>ME_SLEW · SSME_LCH_POS</u>	SSME_START_POS	OFF
				GRAV_POS	OFF
				RECYCLE_DURING_ME_SLEW	OFF
	Display panel Boolean indicators	AUTO	<u>AUTO</u>	LAUTO_PLAMP	OFF
				RAUTO_PLAMP	OFF
				LAUTO_RYLAMP	OFF
				RAUTO_RYLAMP	OFF
				LCSS_PLAMP	ON
				RCSS_PLAMP	ON
				LCSS_RYLAMP	ON
				RCSS_RYLAMP	ON
		AUTO	AUTO	LCSS_PLAMP	OFF
				RCSS_PLAMP	OFF
			LCSS_RYLAMP	OFF	
		RCSS_RYLAMP	OFF		

Table 4.2.4-5. ASC_RECON Initialization Requirements (Cont)

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
ASC_RECON (Cont)	Display panel Boolean indicators (Cont)	AUTO	AUTO	LAUTO_PLAMP	ON
				RAUTO_PLAMP	ON
				LAUTO_RYLAMP	ON
				RAUTO_RYLAMP	ON
		SRB_SEP_CMD	SRB_SEP_CMD	MET_SRB_SEP	MET
		TWO_SSME_FAIL	TWO_SSME_FAIL	MET_TWO_SSME_FAIL	MET
		ME_ZERO_THRUST	ME_ZERO_THRUST	LAUTO_SBLAMP RAUTO_SBLAMP MNLB_CMDR_Q MNLB_PLT_Q	OFF OFF OFF OFF
		(TAL_ABORT_DECLARED · SSME_STOW_COMPLETE · OPS_6_IND) +	(TAL_ABORT_DECLARED · SSME_STOW_COMPLETE · OPS_6_IND) +	{ LAUTO_BFLAMP }	OFF
		(TAL_ABORT_DECLARED · MPS_LO2_DUMP_STOP)	(TAL_ABORT_DECLARED · MPS_LO2_DUMP_STOP)	{ RAUTO_BFLAMP }	OFF
		ME_ZERO_THRUST · OPS_6_IND	ME_ZERO_THRUST · OPS_6_IND	LAUTO_PLAMP RAUTO_PLAMP LAUTO_RYLAMP RAUTO_RYLAMP LCSS_PLAMP RCSS_PLAMP LCSS_RYLAMP RCSS_RYLAMP	OFF
RECYCLE_COUNT	RECYCLE_COUNT ①	RS_AUTO_SEQ_START ME_SLEW_COMPLETE STOW_SB RECYCLE_COUNT ②	OFF OFF OFF OFF		

① Causes ME to move to gravity and SB to DSB_BIAS_SLEW.

② RECYCLE_COUNT is turned off after all other initializations are done.

Table 4.2.4-6. ASC_RECON I-Loads

Module	Name	Description	Type	MSID	Units
ASC_RECON	VREL_AUTOTRIM_INHIBIT	Velocity during STG 1 above which pitch and yaw autotrim functions are inhibited	S	V97U2275C	ft/s
	MET_LIFTOFF	Nominal mission elapsed time of liftoff	S	V97U2061C	sec
	DELTAT_AUTOTRIM_ENABLE	Time relative to SRB_SEP_CMD after which roll, pitch, and yaw autotrim functions are enabled	S	V98U9809C	sec
	MET_LIM_LCH	MET (post-liftoff) at which SRB limits are raised to nominal values	S	V97U2062C	sec
	VREL_FILTSW	VREL at which TVC filters are switched	S	V97U2284C	ft/s
	VREL_YFILTSW	VREL at which yaw filters are switched	S	V99U9597C	ft/s
	PC_COMLIM	Value of filtered SRB chamber pressure at which vector limiting is activated for that SRB	S	V97U2203C	psi
	PC_TRIM_RESET	Minimum value of filtered SRB chamber pressures at which integrators are ramped to null	S	V97U2202C	psi
	MM_DL	Time delay to allow for manual MECO before setting SEC_ME_FL_CNFM flag	S	V97U2403C	sec
	MET_90THRUST	Time from ME's at 90% thrust when ME rate limits changed to normal	S	V97U2487C	sec
	MET_25A	Event 25A time	S	V97U2435C	sec
	MET_25B	Backup time for E25B	S	V97U2436C	sec
	MET_25E	Backup time for E25E	S	V97U2437C	sec
	ORI_DL	Time delay to permit OMS to RCS switching	S	V97U1362C	sec
	PARALLEL_PITCH_NOM	Discrete indicating SSME pitch paralleling is allowed for all three SSME's burning	D	V99U7557C	ND



4.2.5 Ascent Thrust Vector Control Laws (ASC TVC)

A. Functional Description. The functional block diagram for ASC TVC are shown in Figures 4.2.5-1A through E.

Functions of ASC TVC are conveniently presented on an axis-by-axis basis, i.e., roll, pitch, and yaw body-axis control algorithms. Figure 4.2.5-1B and 1C present the roll-axis overview block diagram. Figure 4.2.5-1D presents the pitch-axis overview block diagram. Figure 4.2.5-1E presents the yaw-axis overview block diagram.

TVC control differs for first- and second-stage flight. From navigation initiation until lift-off, the control subphase is designated PRELO, during which time orbiter outputs are sent to R/S LAUNCH_SEQUENCER. From lift-off until SRB separation command, the control subphase is designated S1C. From the nulling of the SRB's to the post-MECO descheduling of the TVC, the control subphase is designated S2C. Transition from first- to second-stage flight (MM_CODE = 102 to 103) occurs at the SRB separation command.

Body-axis attitude errors and body-axis rate commands from GC STEER are the command inputs to each axis. During S1C, the primary feedback inputs are body-axis rates; roll from the ORB RGA, pitch from the SRB RGA, and yaw from the SRB RGA for steel SRB cases or with SRB RGA and ORB RGA for FWC SRB's mixing with ORB RGA. A normal and lateral acceleration obtained from the AA is also fed back during S1C in the pitch and yaw axes, respectively, for load relief. Acceleration command references, which are functions of VREL or constant, are obtained from INTERPS. Body-axis rates from the orbiter RGA are the feedback inputs during S2C.

During S1C, the yaw attitude error is crossfed from the yaw axis to the roll axis. The yaw TVC loop error signal is crossfed from yaw to roll axis during SRB thrust tailoff and the early part of S2C. Scheduled gains from INTERPS are utilized during both first and second stages. The transition from S1C to S2C gains is accomplished by ramping from one gain level to the other over a specified time interval.

The output signals, namely, roll, pitch, and yaw thrust vector deflection commands for the orbiter and the SRB, are sent to the CMD_PROC_MPS and CMD_PROC_SRB modules, respectively, for trimming, mixing, biasing, and limiting.

B. Software Description. An overview of ASC TVC is presented in Figure 4.2.5-2. Its input/output requirements are summarized in Table 4.2.5-1. ASC TVC consists of ten modules separated into three functional groupings: ASC TVC_ROLL, ASC TVC_PITCH, and ASC TVC_YAW. Sequencing requirements for the ten modules are shown in Figure 4.2.5-3.

ASC TVC_ROLL consists of two modules, CMD_ROLL and ROLL_ATT_INTEGRAL, which are shown in detail in Figures 4.2.5-4A and B, respectively. The intermodule interface requirements for ASC TVC_ROLL are presented in

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Table 4.2.5-2. Initialization and I-loads/ constant requirements are presented in Tables 4.2.5-3 and 4.2.5-4, respectively.

ASC_TVC_PITCH consists of four modules, CMD_PITCH, FDBK_S1C_PITCH, FDBK_S2C_PITCH, and PITCH_ATT_INTEGRAL, which are shown in detail in Figures 4.2.5-5, 4.2.5-6, 4.2.5-7, and 4.2.5-8, respectively. The intermodule interface requirements for ASC_TVC_PITCH are presented in Table 4.2.5-5. Initialization and I-loads/constants requirements are presented in Tables 4.2.5-6 and 4.2.5.7, respectively.

ASC_TVC_YAW consists of four modules, CMD_YAW, FDBK_S1C_YAW, FDBK_S2C_YAW, and YAW_ATT_INTEGRAL, which are shown in detail in Figures 4.2.5-12, 4.2.5-11, 4.2.5-10, and 4.2.5-9, respectively. The intermodule interface requirements for ASC_TVC_YAW are presented in Table 4.2.5-8. Initialization and I-loads/constants requirements are presented in Tables 4.2.5-9 and 4.2.5-10, respectively.

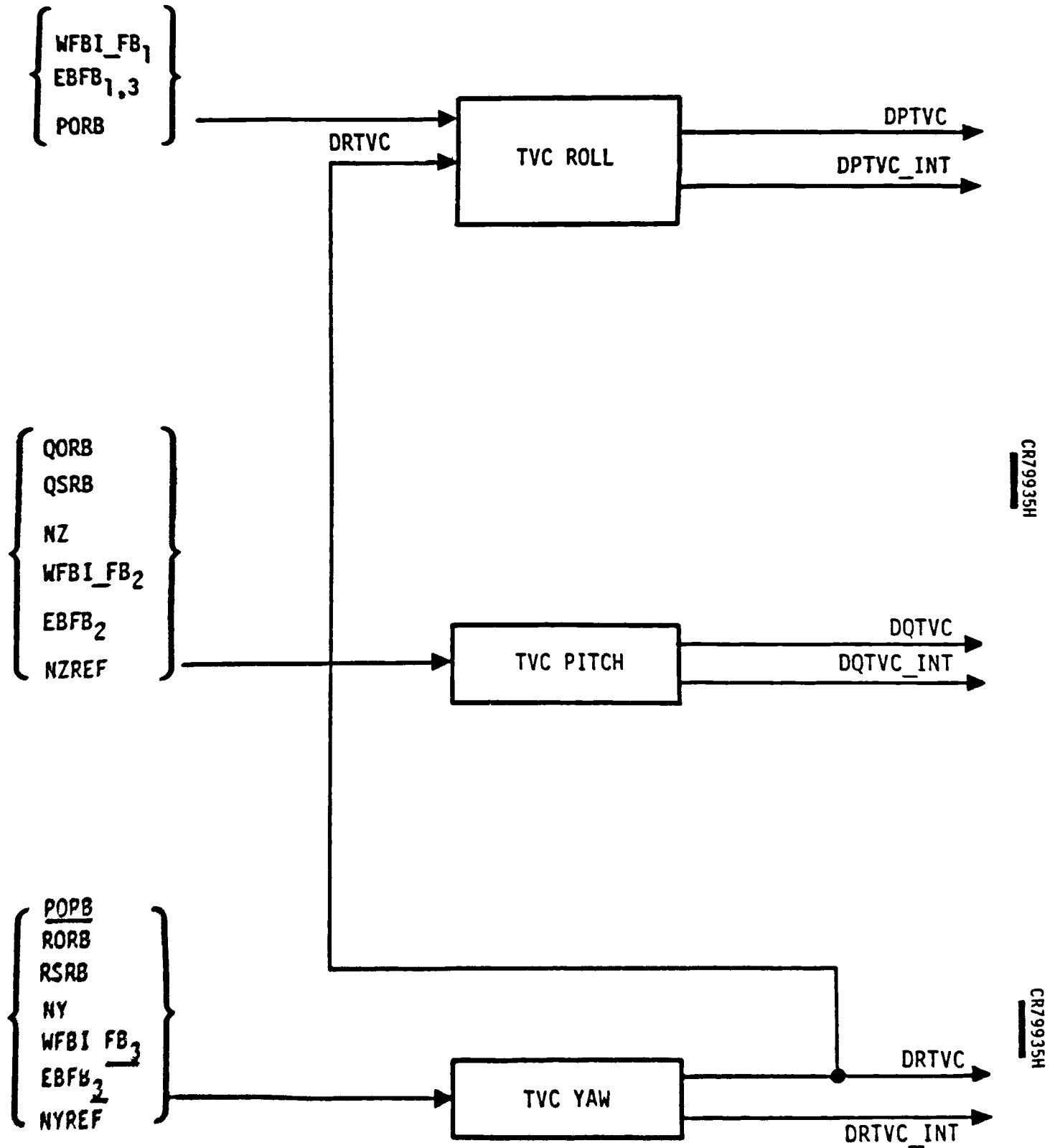


Figure 4.2.5-1A. Thrust Vector Control, Functional Overview

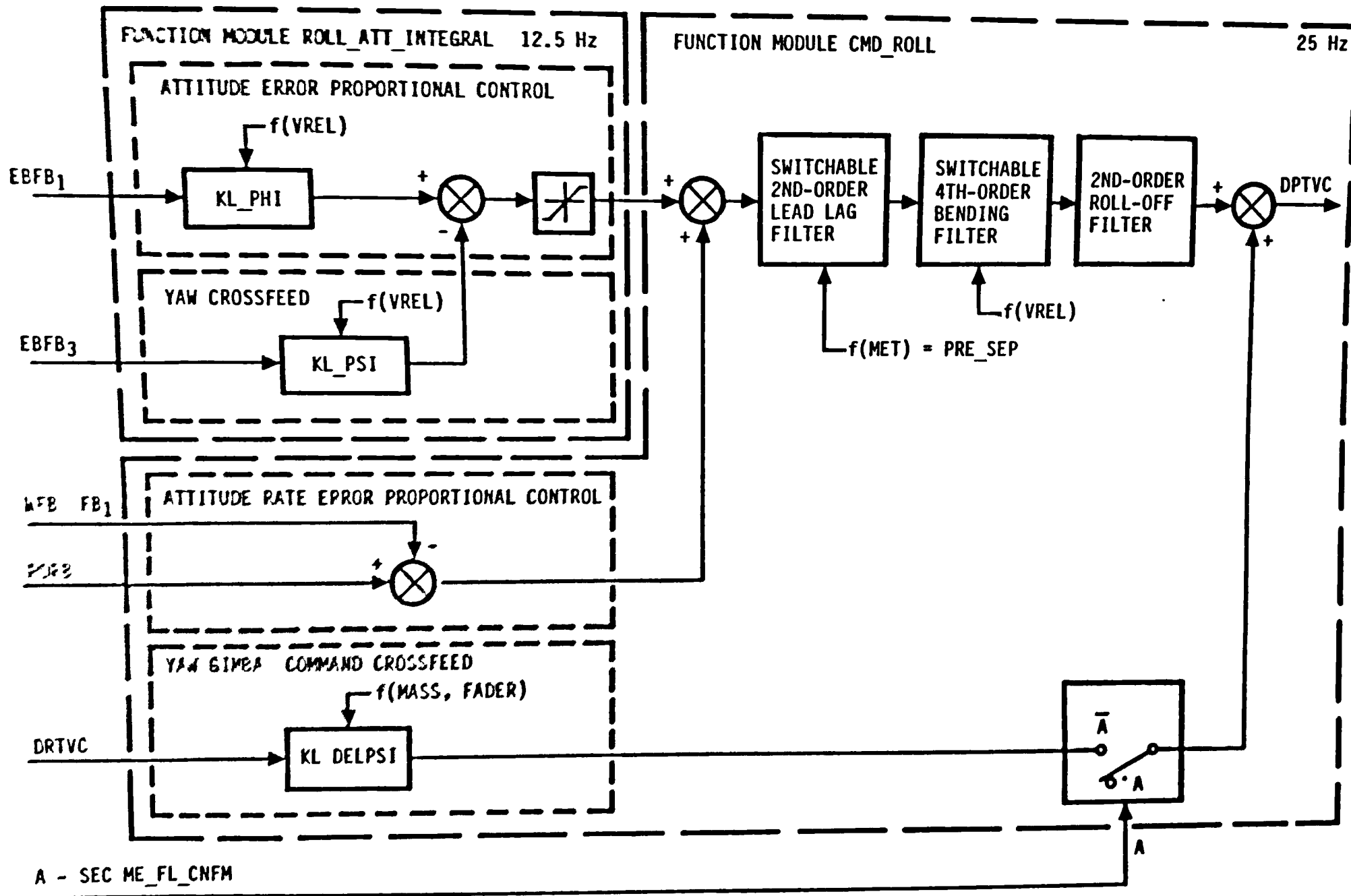


Figure 4.2.5-1B. TVC Roll Control, First Stage, Functional Block Diagram

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 A = SEC ME F CNFM

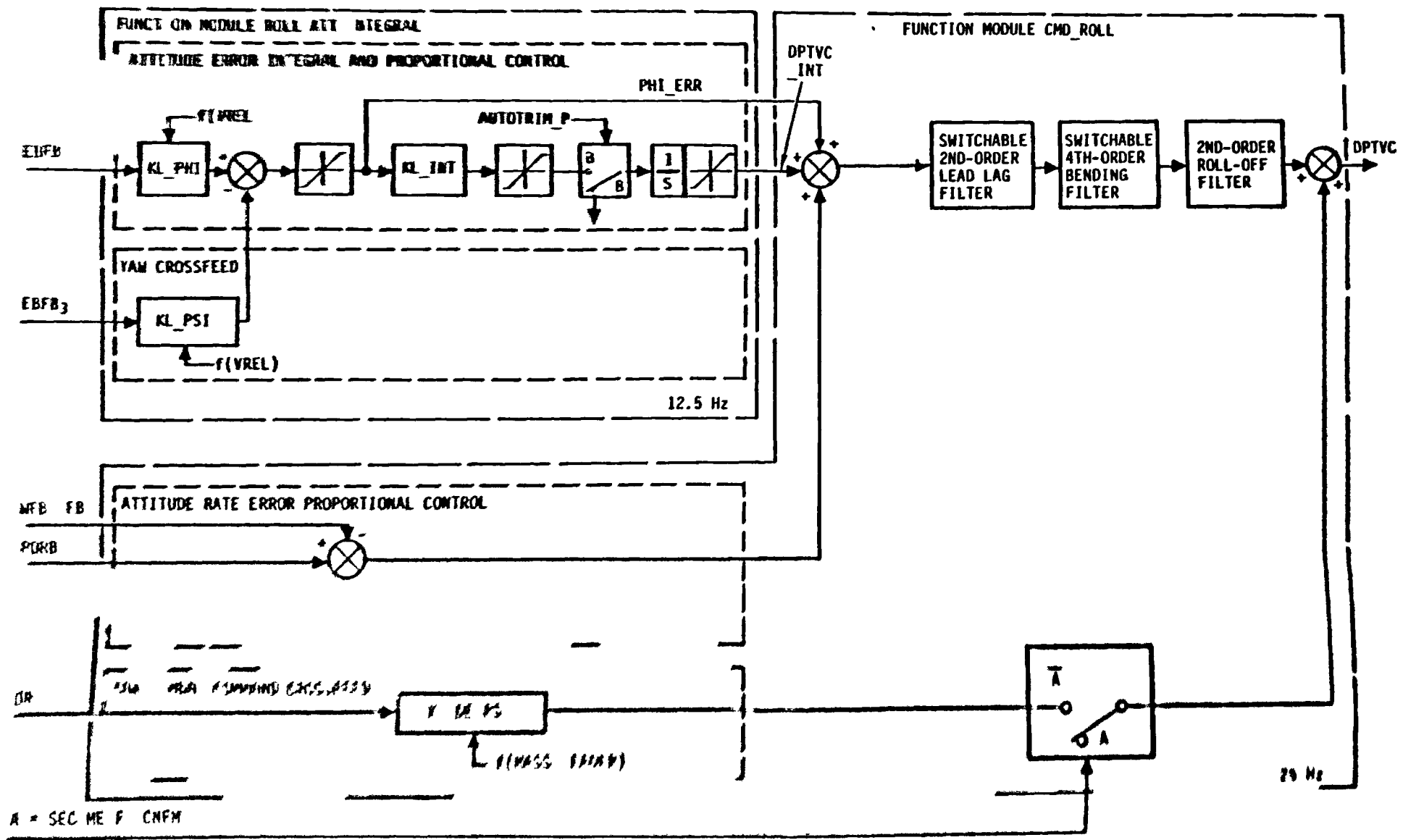


Figure 4.2.5-1C. TVC Roll Control, Second Stage, Functional Block Diagram

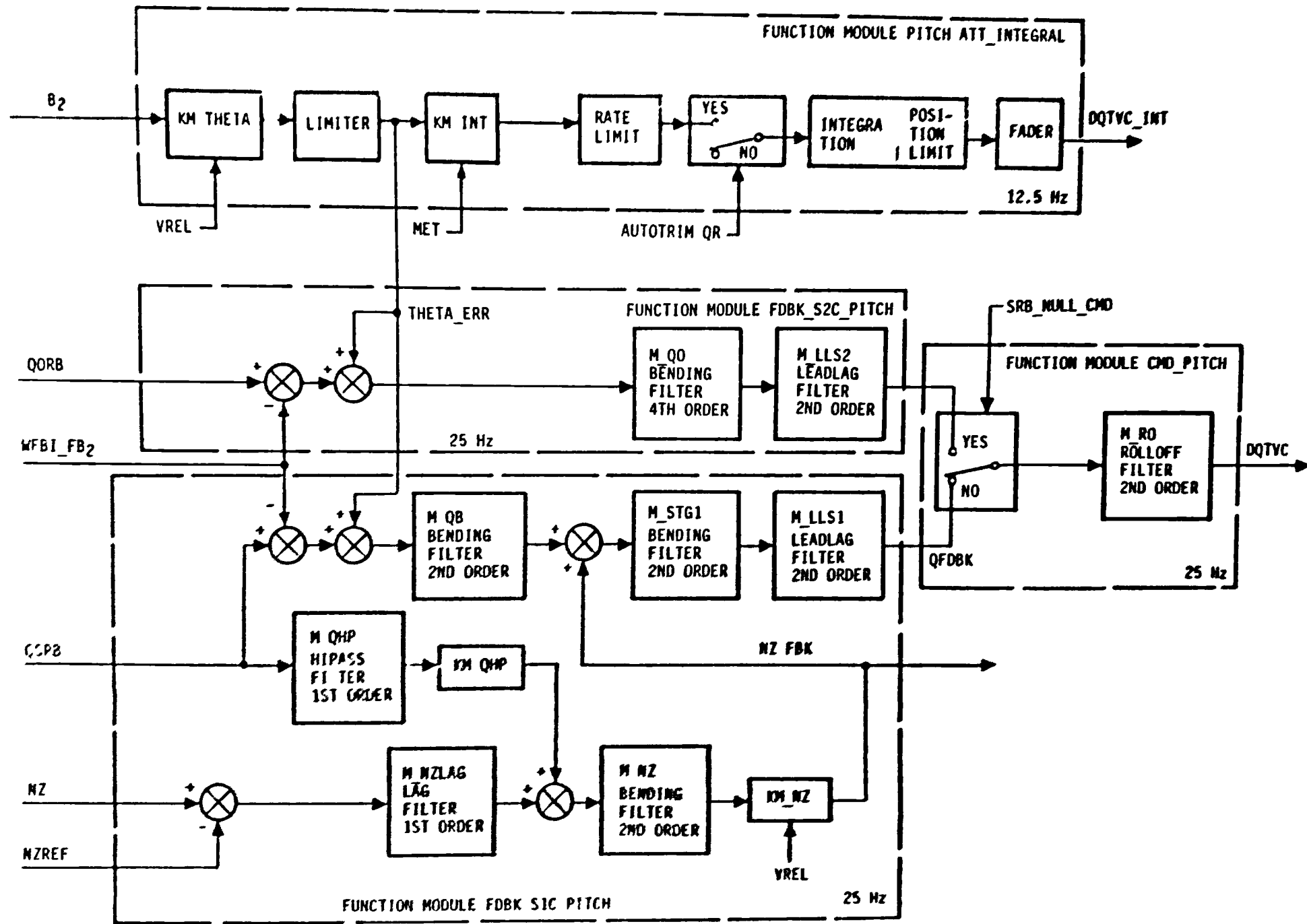
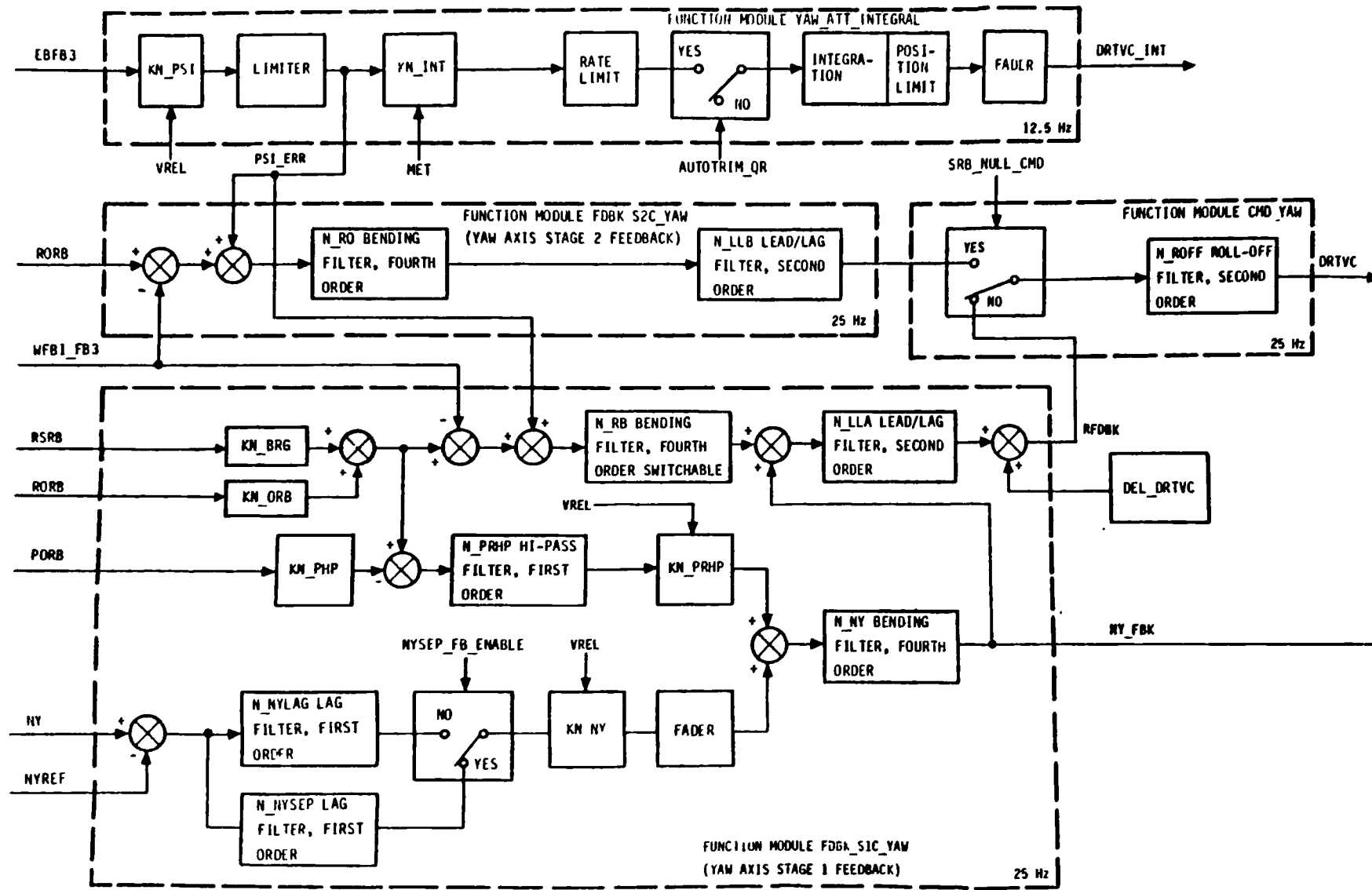


Figure 4.2.5-1D. TVC Pitch Control, First and Second Stages, Functional Block Diagram

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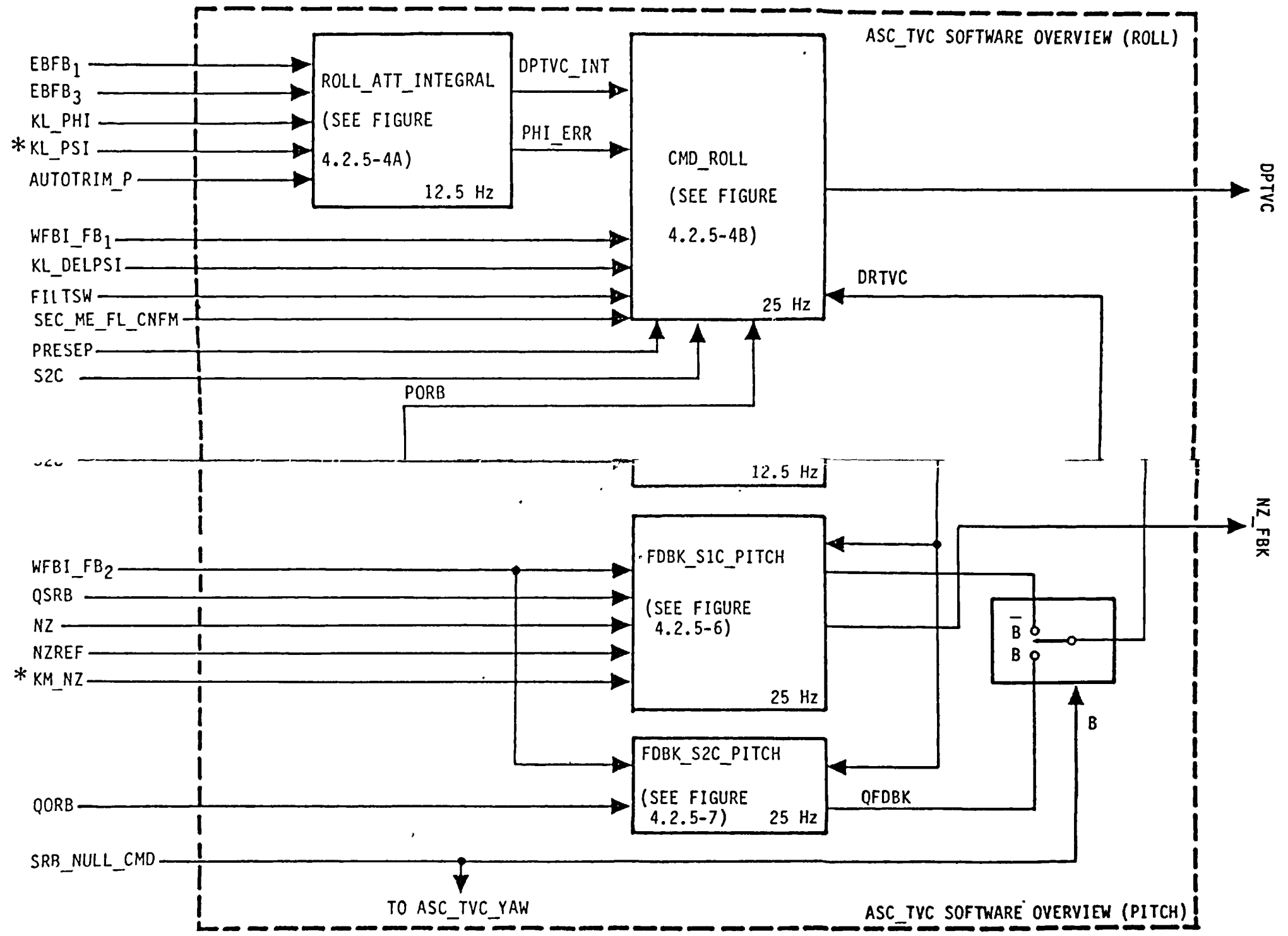
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Figure 4.2.5-1E. TVC Yaw Control, First and Second Stages, Functional Block Diagram

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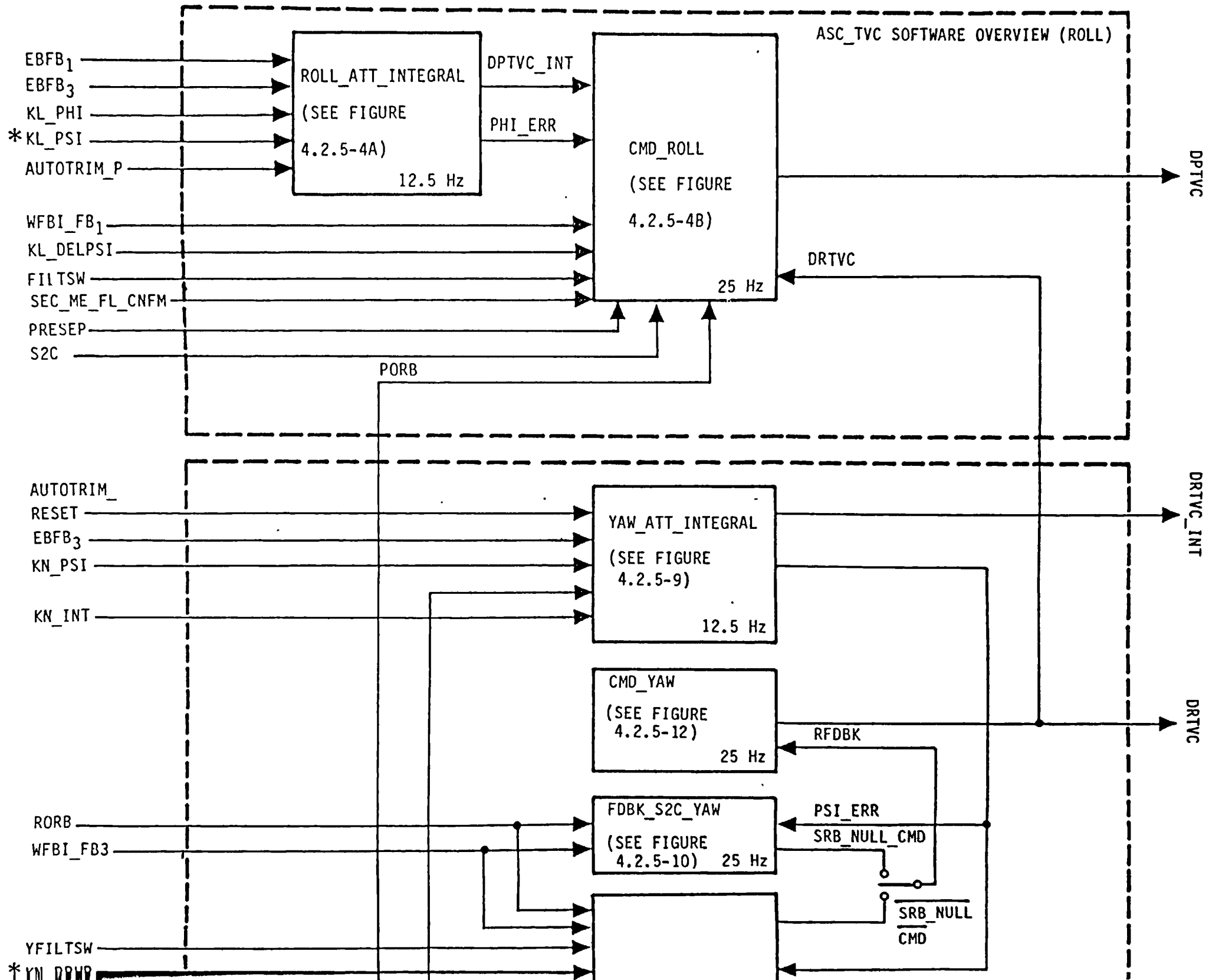


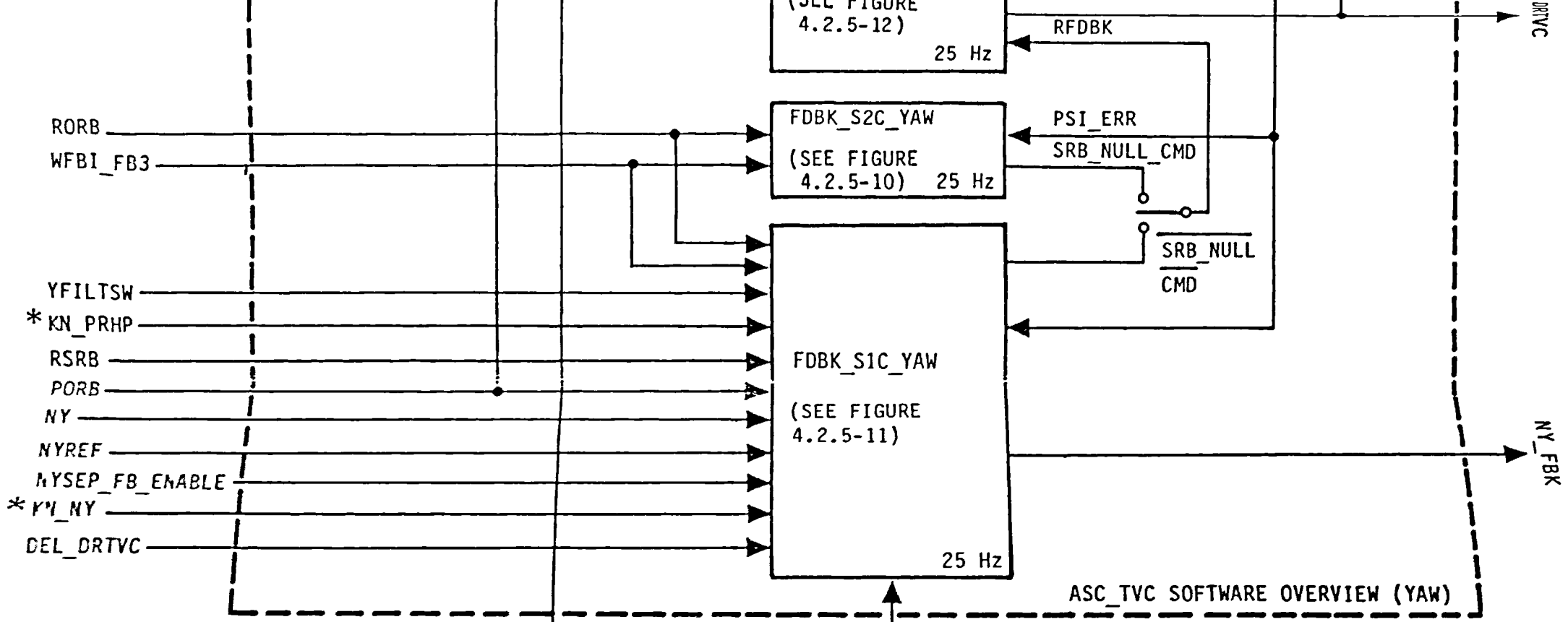
* FIRST STAGE ONLY

Figure 4.2.5-2. ASC_TVC Software Overview

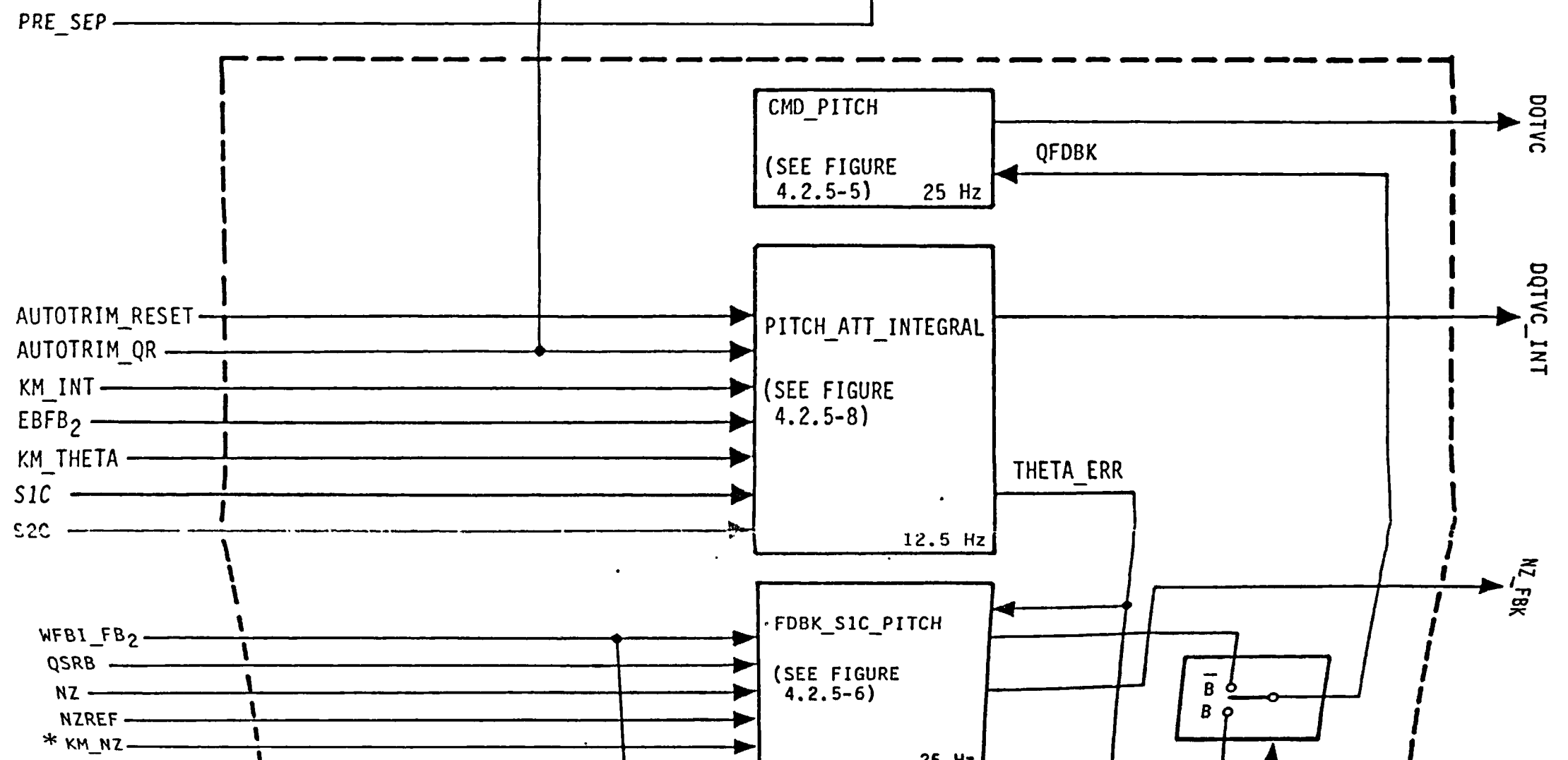
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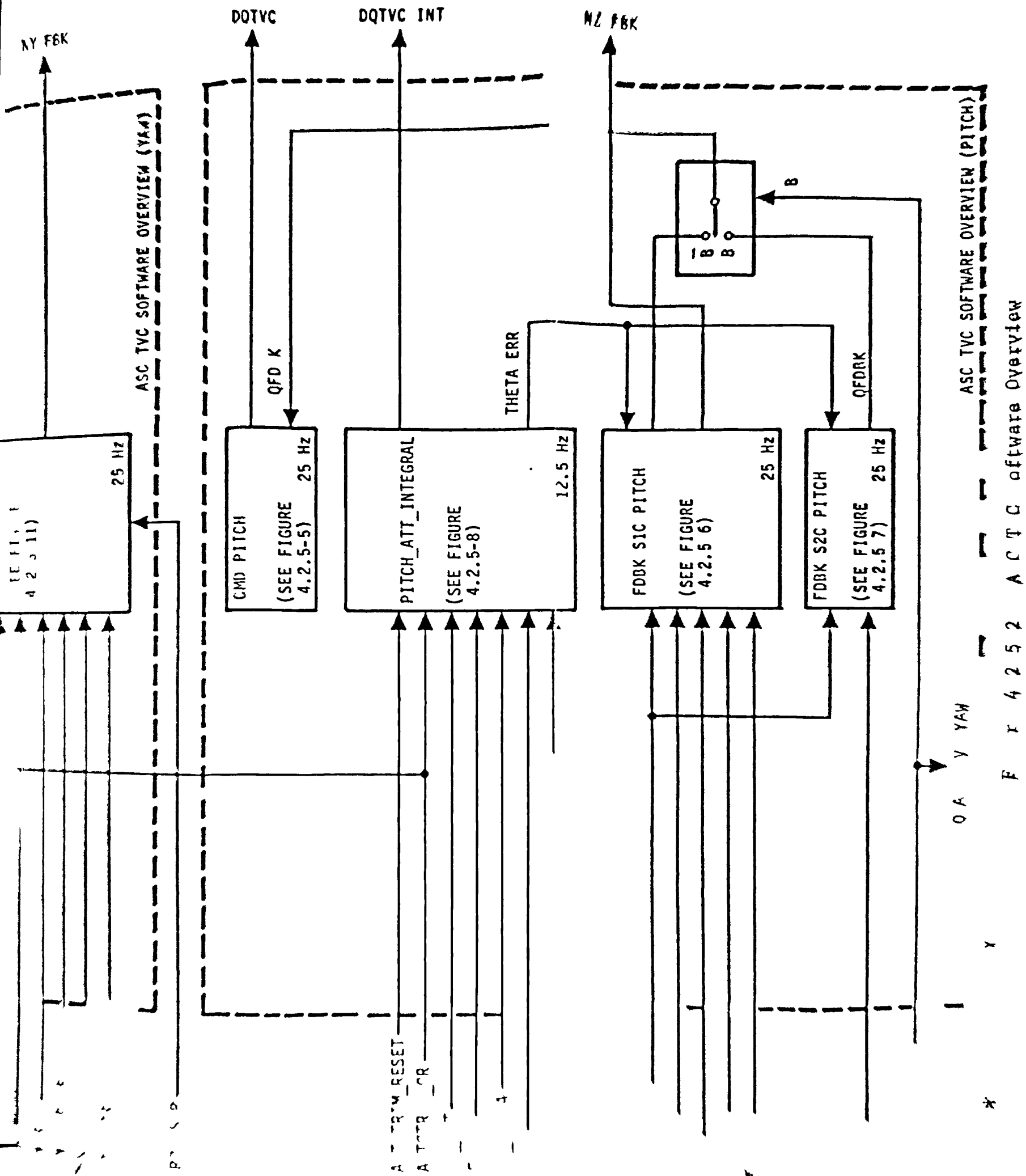


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Table 4.2.5-1. ASC_TV C Interface Requirements

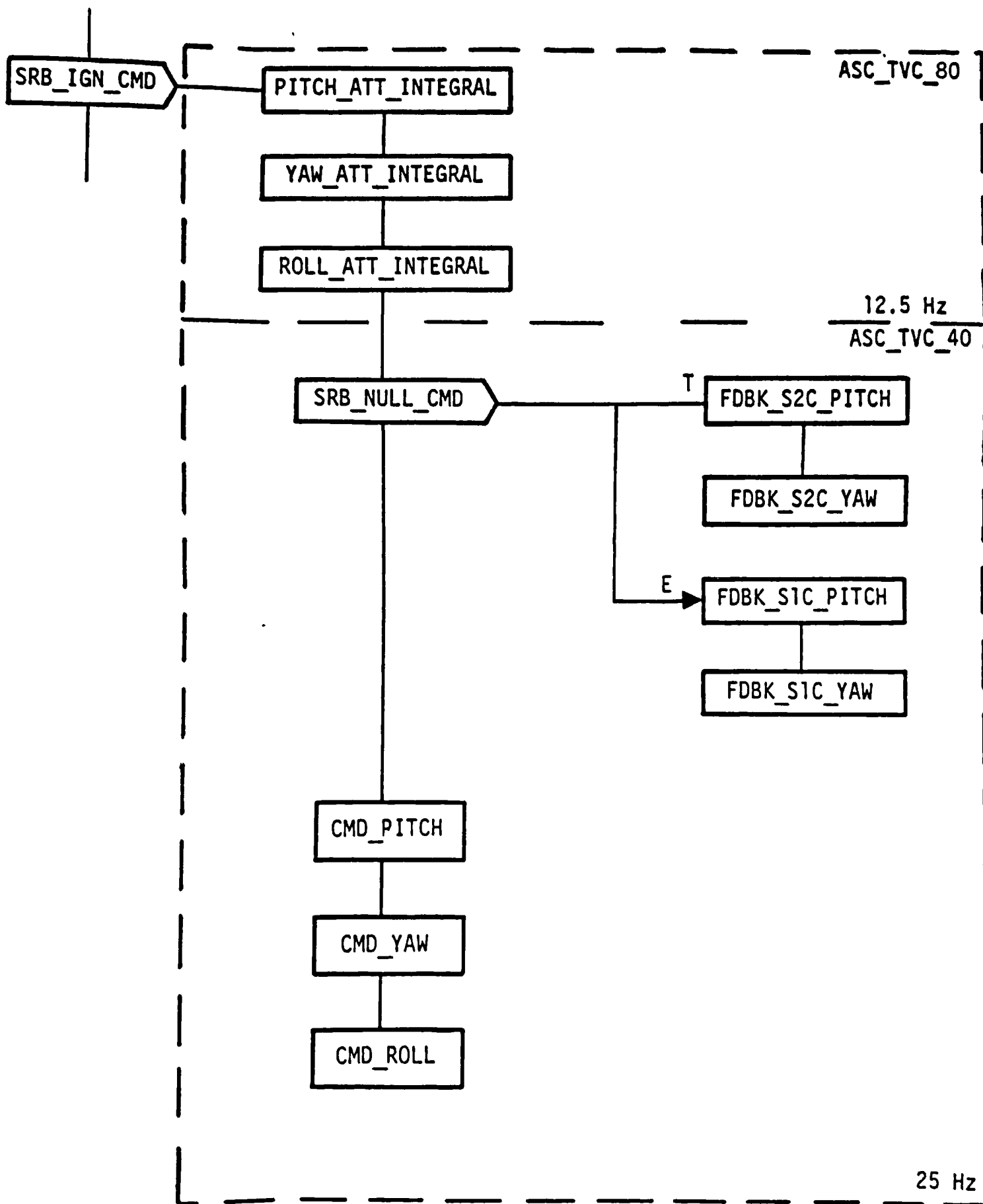
Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Inputs</u>						
	EBFB	Attitude errors	GC_STEER	V		deg	12.5
	WFBI_FB	Rotational velocity, flight body wrt inertial, coordinated in flight body	GC_STEER	V		deg/s	12.5
	PORB	Roll rate, orbiter rate gyros	SF (ORB RGA)	S		deg/s	25
	QORB	Pitch rate, orbiter rate gyros	SF (ORB RGA)	S		deg/s	25
	RORB	Yaw rate, orbiter rate gyros	SF (ORB RGA)	S		deg/s	25
	QSRB	Pitch rate, SRB rate gyro	SF (SRB RGA)	S		deg/s	25
	RSRB	Yaw rate, SRB rate gyro	SF (SRB RGA)	S		deg/s	25
	NY	Lateral acceleration	SF (AA)	S		g	25
	NZ	Normal acceleration	SF (AA)	S		g	25
	NYREF	Scheduled lateral acceleration reference	INTERPS	S		g	6.25
		Scheduled normal acceleration reference	INTERPS	S		g	6.25
	SRB_NULL_CMD	Indicator, SRB_NULL_CMD	ASC_RECON	B		-	12.5
	AUTOTRIM_P	Indicator, enable roll autotrim	ASC_RECON	B		-	12.5
	AUTOTRIM_QR	Indicator, enable yaw and pitch autotrim	ASC_RECON	B		-	12.5
	KL_PHI	Variable gain (attitude roll)	INTERPS	S		(deg/s)/deg	6.25
	KL_DELPSI	Variable gain (yaw cmd crossfeed, roll)	INTERPS	S		(deg/s)/deg	6.25
	TWR_CLR_BIAS	Indicator SSME No. 2 failed at lift off	ASC_RECON	B		-	12.5
	NYSEP_FB_ENABLE	Indicator, NY feedback	ASC_RECON	B		-	12.5
	S1C	Indicator, Stage 1	ASC_RECON	B		-	12.5
	S2C	Indicator, Stage 2	ASC_RECON	B		-	12.5
	KM_INT	Variable gain (pitch attitude integral)	INTERPS	S		-	6.25
	KN_INT	Variable gain (yaw attitude integral)	INTERPS	S		-	6.25
	KL_PS1	Variable gain (yaw attitude error crossfeed roll)	INTERPS	S		(deg/s)/deg	6.25

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Table 4.2.5-1. ASC_TVC Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Inputs (Cont)</u>						
	KN_PRHP	Variable gain (R.P. roll-yaw rate, yaw)	INTERPS	S		(deg/s)/ (deg/s)	6.25
	KN_THETA	Variable gain (attitude, pitch)	INTERPS	S		(deg/s)/ deg	6.25
	KN_NZ	Variable gain (NZ feedback, pitch)	INTERPS	S		(deg/s)/ g	6.25
	KN_PSI	Variable gain (attitude/rate ratio, yaw)	INTERPS	S		(deg/s)/ deg	6.25
	KN_NY	Variable gain (NY feedback, yaw)	INTERPS	S		(deg/s)/ g	6.25
	AUTOTRIM_RESET	Indicator	ASC_RECON	B		-	12.5
	PRE_SEP	Indicator	ASC_RECON	B		-	12.5
	FILFSW	Indicator	ASC_RECON	B		-	12.5
	YFILTSW	Indicator	ASC_RECON	B		-	12.5
	MM101_INIT	Indicator	ASC_RECON	B		-	12.5
	NYSEP_FB_ENABLE	Indicator	ASC_RECON	B		-	12.5
	<u>Outputs</u>						
	DPTVC	Roll TVC loop error signal	CMD_PROC_MPS CMD_PROC_SRB	S		deg/s	25
	DQTVC	Pitch TVC loop error signal	CMD_PROC_MPS CMD_PROC_SRB	S		deg/s	25
	DRTVC	Yaw TVC loop error signal	CMD_PROC_MPS CMD_PROC_SRB CMD_ROLL	S		deg/s	25
	DQTVC_INT	Pitch TVC trim integrator output	CMD_PROC_MPS CMD_PROC_SRB	S		deg	25
	DRTVC_INT	Yaw TVC trim integrator output	CMD_PROC_MPS CMD_PROC_SRB	S		deg	25
	NZ_FBK	Compensated normal acceleration error	GC_STEER	S		deg/s	25
	NY_FBK	Compensated lateral acceleration error	GC_STEER	S		deg/s	25



① ASC_TVC-80 MUST BE EXECUTED IN THE CRITICAL LOOP PRIOR TO ASC_TVC_40.

Figure 4.2.5-3. ASC_TVC Sequencing Requirements

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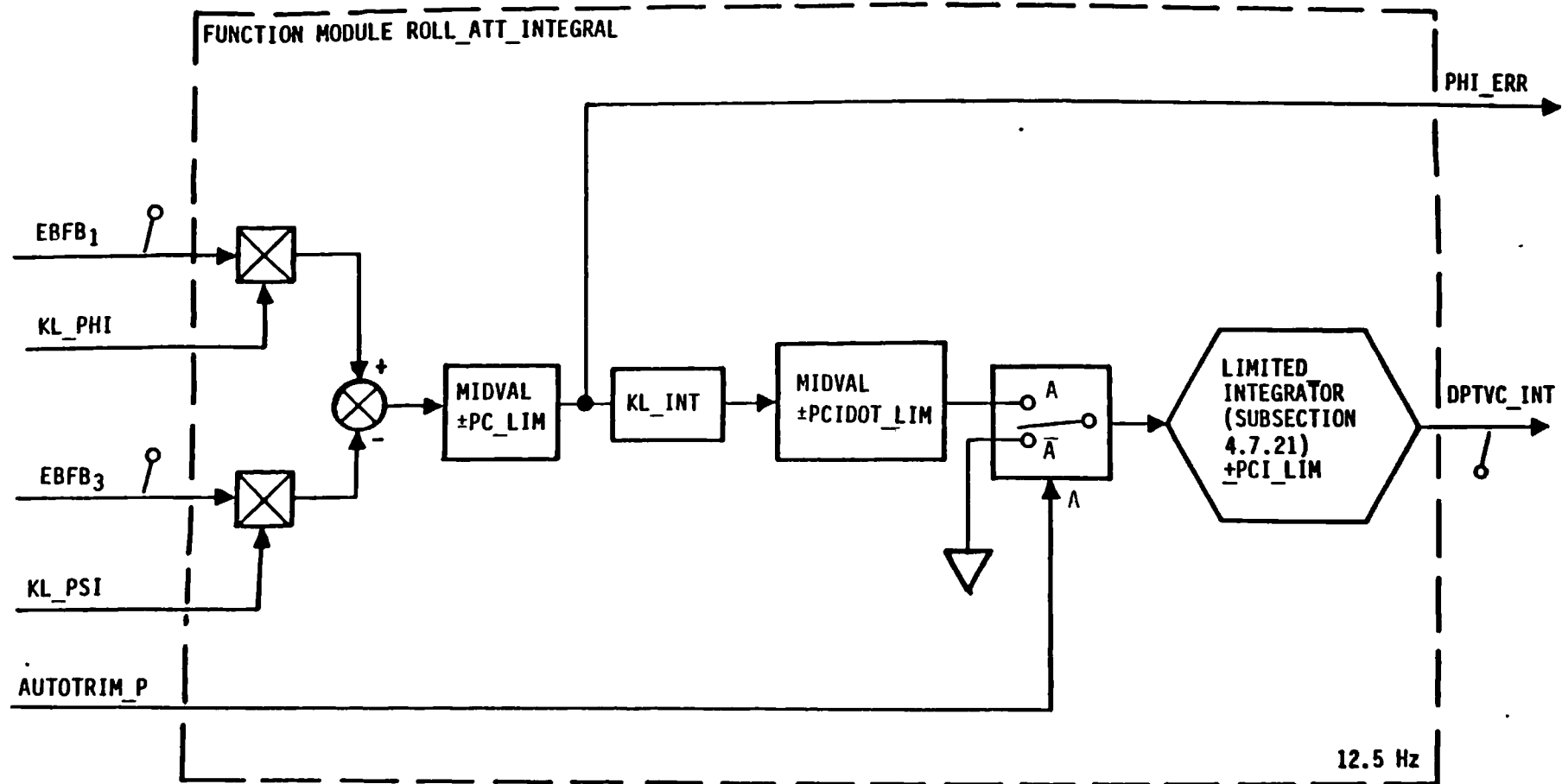
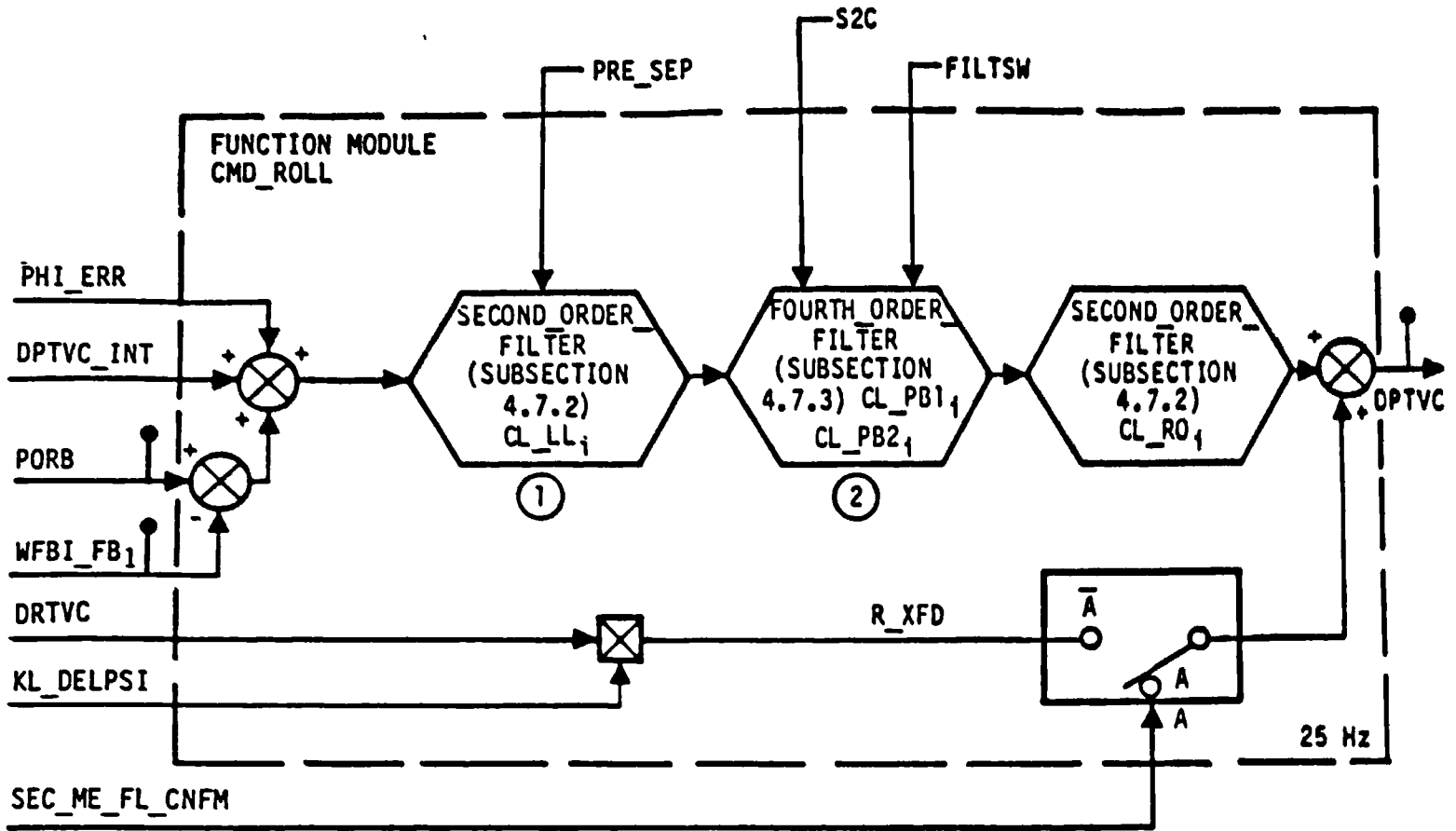


Figure 4.2.5-4A. Function Module ROLL_ATT_INTEGRAL, Detailed Diagram



① SWITCHABLE SECOND-ORDER FILTER

	$\overline{\text{PRE_SEP}}$	PRE_SEP
CL_LL_i	CL_LLA_i	CL_LLB_i

where $i = 1-5$

② SWITCHABLE FOURTH-ORDER FILTER

	$\overline{\text{FILTSW}}$	$\text{FILTSW} \cdot \overline{\text{S2C}}$	$\text{FILTSW} \cdot \text{S2C}$
CL_PB1_i	CL_PBA1_i	CL_PBB1_i	CL_PBC1_i
CL_PB2_i	CL_PBA2_i	CL_PBB2_i	CL_PBC2_i

where $i = 1-5$

Figure 4.2.5-4B. Function Module, CMD_ROLL, Detailed Diagram

Table 4.2.5-2. ASC_TVC_ROLL Inter-Module Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)	
ROLL_ATT_INTEGRAL	<u>Inputs</u>							
	AUTOTRIM_P	Indicator, enable roll autotrim	ASC_RECON	B		-	12.5	
	KL_PHI	Variable gain (attitude, roll)	INTERPS	S		(deg/s)/deg	6.25	
	EBFB ₁	Roll attitude error	GC_STEER	S(V)		deg	12.5	
	EBFB ₃	Yaw attitude error	GC_STEER	S(V)		deg	12.5	
	KL_PSI	Variable gain (yaw attitude crossfeed, roll)	INTERPS	S		(deg/s)/deg	6.25	
	<u>Outputs</u>							
DPTVC_INT	Roll integrator output	CMD_ROLL, TLM	S		deg/s	12.5		
PHI_ERR	Gained roll attitude error	CMD_ROLL	S		deg/s	12.5		
CMD_ROLL	<u>Inputs</u>							
	WFBI_FB ₁	Roll rotational velocity, flight-body wrt inertial, coordinatized in flight body	GC_STEER	S(V)		deg/s	12.5	
	PORB	Roll rate, orbiter rate gyros	SF (ORB RGA)	S		deg/s	25	
	FILTSW	Indicator	ASC_RECON	B		-	12.5	
	DRTVC	Yaw TVC loop error signal	CMD_YAW	S		deg/s	25	
	KL_DELPSEI	Variable gain (yaw actuator command crossfeed, roll)	INTERPS	S		-	6.25	
	MM101_INIT	Indicator	ASC_RECON	B		-	12.5	
	S2C	Indicator	ASC_RECON	B		-	12.5	
	PRE_SEP	Indicator, E25A	ASC_RECON	B		-	12.5	
	DPTVC_INT	Roll TVC trim integrator output	ROLL_ATT_INTEGRAL	S		deg/s	12.5	
	PHI_ERR	Gained roll attitude error	ROLL_ATT_INTEGRAL	S		deg/s	12.5	
	SEC_ME_FL_CNFM	Second ME fail confirm discrete	ASC_RECON	B		-	12.5	
	<u>Outputs</u>							
	DPTVC	Roll TVC loop error signal	CMD_PROC_MPS CMD_PROC_SRB TLM	S		deg/s	25	



Table 4.2.5-3. ASC_TV_C_ROLL Initialization Requirements

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
ROLL_ATT_INTEGRAL	LIMITED INTEGRATOR Output	-	MM101_INIT	Output	0.0
CMD_ROLL	First-order filter L_LL	-	MM101_INIT	INIT flag	
	Init flag	-	MM101_INIT	INIT flag	OFF
	Output			Output	0.0
	Node			Nodes	0.0 see Subsection 4.7.11
	Coefficients (i = 1-5)	-	MM101_INIT	CL_LL _i	CL_LL _i
		<u>PRE_SEP</u>	PRE_SEP	CL_LL _i	CL_LL _i
	Fourth-order filter L_PB	-	MM101_INIT	INIT flag	OFF
	Output			Output	0.0
	Nodes			Nodes	0.0 (see Subsection 4.7.4
	Coefficients (i = 1-5)			CL_PB1 _i CL_PB2 _i	CL_PBA1 _i CL_PBA2 _i
		<u>FILTSW</u>	FILTSW	CL_PB1 _i CL_PB2 _i	CL_PBB _i CL_PBB2 _i
		<u>S2C</u>	S2C	CL_PBC1 _i CL_PBC2 _i	CL_PBC1 _i CL_PBC2 _i
	Second-order filter L_RO	-	MM101_INIT	INIT flag	OFF
	Output			Output	0 0
Nodes			Nodes	0 0 (see Subsection 4.7.2)	
		<u>SEC_ME_FL_CNFM</u>	SEC_ME_FL_CNFM	R_XFD	0 0

Table 4.2.5-4. ASC_TV_C_ROLL I Loads/Constants

Module	Name	Description	Type	MSID/ Value	Units
ROLL_ATT_INTEGRAL	PC_LIM	Roll attitude error rate limit	S	V97U2200C	deg/s
	KL_INT	Roll trim integrator gain	S	V97U1810C	1/s
	PCIDOT_LIM	Roll trim integrator rate limit	S	V97U2206C	deg/s ²
	PCI_LIM	Roll trim integrator limit	S	V97U2205C	deg/s
CMD_ROLL	CL_LLA1	Filter L_LL coefficient	S	V97U1420C	-
	CL_LLA2	Filter L_LL coefficient	S	V97U1421C	-
	CL_LLA3	Filter L_LL coefficient	S	V97U1422C	-
	CL_LLA4	Filter L_LL coefficient	S	V97U2456C	-
	CL_LLA5	Filter L_LL coefficient	S	V97U2457C	-
	CL_LLB1	Filter L_LL coefficient	S	V97U1423C	-
	CL_LLB2	Filter L_LL coefficient	S	V97U1424C	-
	CL_LLB3	Filter L_LL coefficient	S	V97U1425C	-
	CL_LLB4	Filter L_LL coefficient	S	V97U2458C	-
	CL_LLB5	Filter L_LL coefficient	S	V97U2459C	-
	CL_PBA11	Filter L_PB coefficient	S	V97U1432C	-
	CL_PBA12	Filter L_PB coefficient	S	V97U1433C	-
	CL_PBA13	Filter L_PB coefficient	S	V97U1434C	-
	CL_PBA14	Filter L_PB coefficient	S	V97U1435C	-
	CL_PBA15	Filter L_PB coefficient	S	V97U1436C	-
	CL_PBA21	Filter L_PB coefficient	S	V97U1437C	-
	CL_PBA22	Filter L_PB coefficient	S	V97U1438C	-
	CL_PBA23	Filter L_PB coefficient	S	V97U1439C	-
	CL_PBA24	Filter L_PB coefficient	S	V97U1440C	-
	CL_PBA25	Filter L_PB coefficient	S	V97U1441C	-
	CL_PBB11	Filter L_PB coefficient	S	V97U1447C	-

Module
CMD_ROLL
(Cont)



Table 4.2.5-4. ASC_TVC_ROLL I-Loads/Constants (Cont)

Module	Name	Description	Type	MSID/ Value	Units	
CMD_ROLL (Cont)	CL_PBB12	Filter L_PB coefficient	S	V97U1448C	-	
	CL_PBB13	Filter L_PB coefficient	S	V97U1449C	-	
	CL_PBB14	Filter L_PB coefficient	S	V97U1450C	-	
	CL_PBB15	Filter L_PB coefficient	S	V97U1451C	-	
	CL_PBB21	Filter L_PB coefficient	S	V97U1452C	-	
	CL_PBB22	Filter L_PB coefficient	S	V97U1453C	-	
	CL_PBB23	Filter L_PB coefficient	S	V97U1454C	-	
	CL_PBB24	Filter L_PB coefficient	S	V97U1455C	-	
	CL_PBB25	Filter L_PB coefficient	S	V97U1456C	-	
	CL_PBC11	Filter L_PB coefficient	S	V97U2460C	-	
	CL_PBC12	Filter L_PB coefficient	S	V97U2461C	-	
	CL_PBC13	Filter L_PB coefficient	S	V97U2462C	-	
	CL_PBC14	Filter L_PB coefficient	S	V97U2463C	-	
	CL_PBC15	Filter L_PB coefficient	S	V98U9577C	-	
	CL_PBC21	Filter L_PB coefficient	S	V98U9578C	-	
	CL_PBC22	Filter L_PB coefficient	S	V98U9579C	-	
	CL_PBC23	Filter L_PB coefficient	S	V98U9580C	-	
	CL_PBC24	Filter L_PB coefficient	S	V98U9581C	-	
	CL_PBC25	Filter L_PB coefficient	S	V98U9582C	-	
	CL_R01	Filter L_RO coefficient	S	V97U1462C	-	
	CL_R02	Filter L_RO coefficient	S	V97U1463C	-	
	CL_R03	Filter L_RO coefficient	S	V97U1464C	-	
	CL_R04	Filter L_RO coefficient	S	V97U1465C	-	
	CL_R05	Filter L_RO coefficient	S	V97U1466C	-	
		TM	12.5 Hz cycle update interval for integrator	S	0.08	S

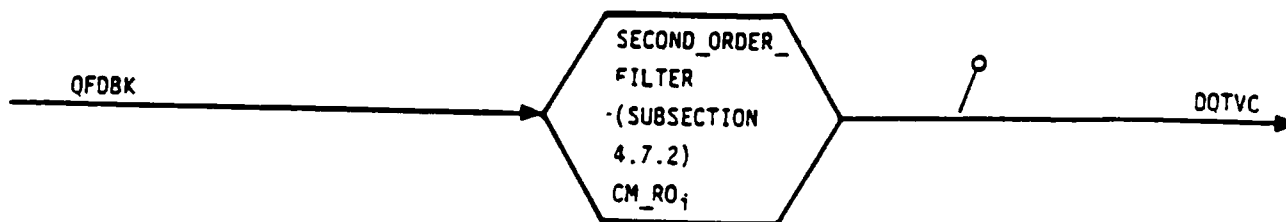
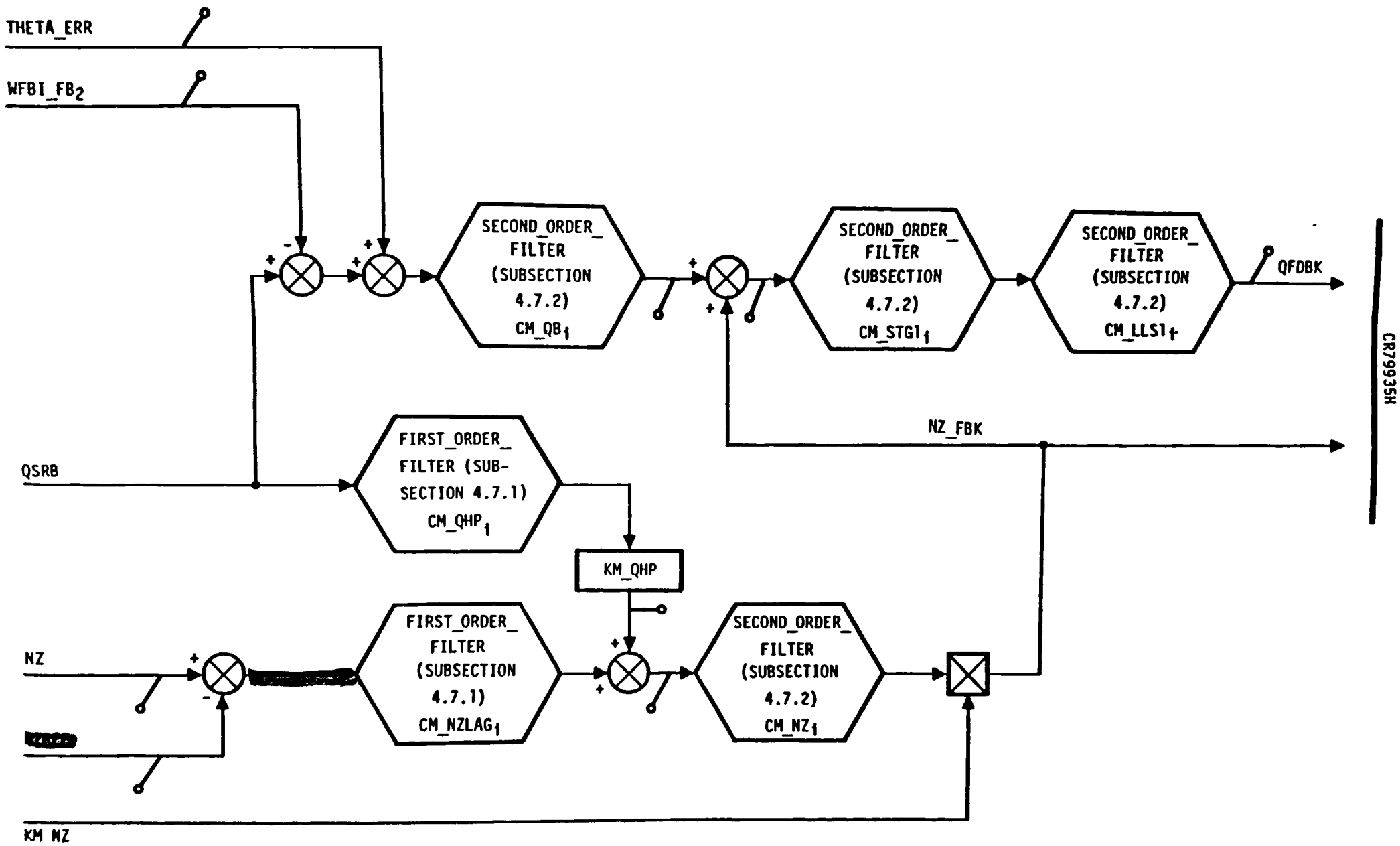


Figure 4.2.5-5. Function Module CMD_PITCH, Detailed Diagram





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Figure 4.2.5-6. Function Module FDBK_S1C_PITCH, Detailed Diagram

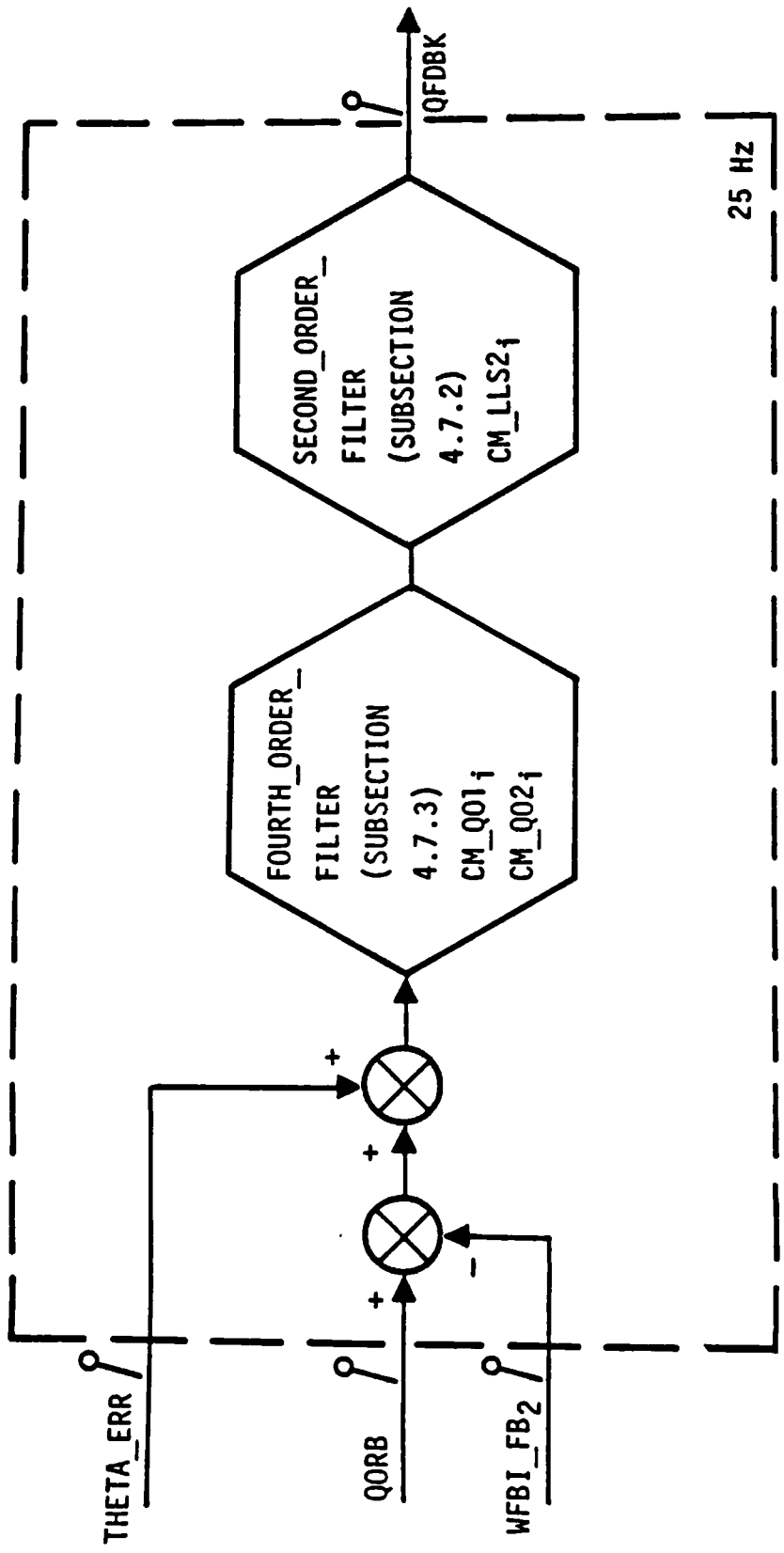
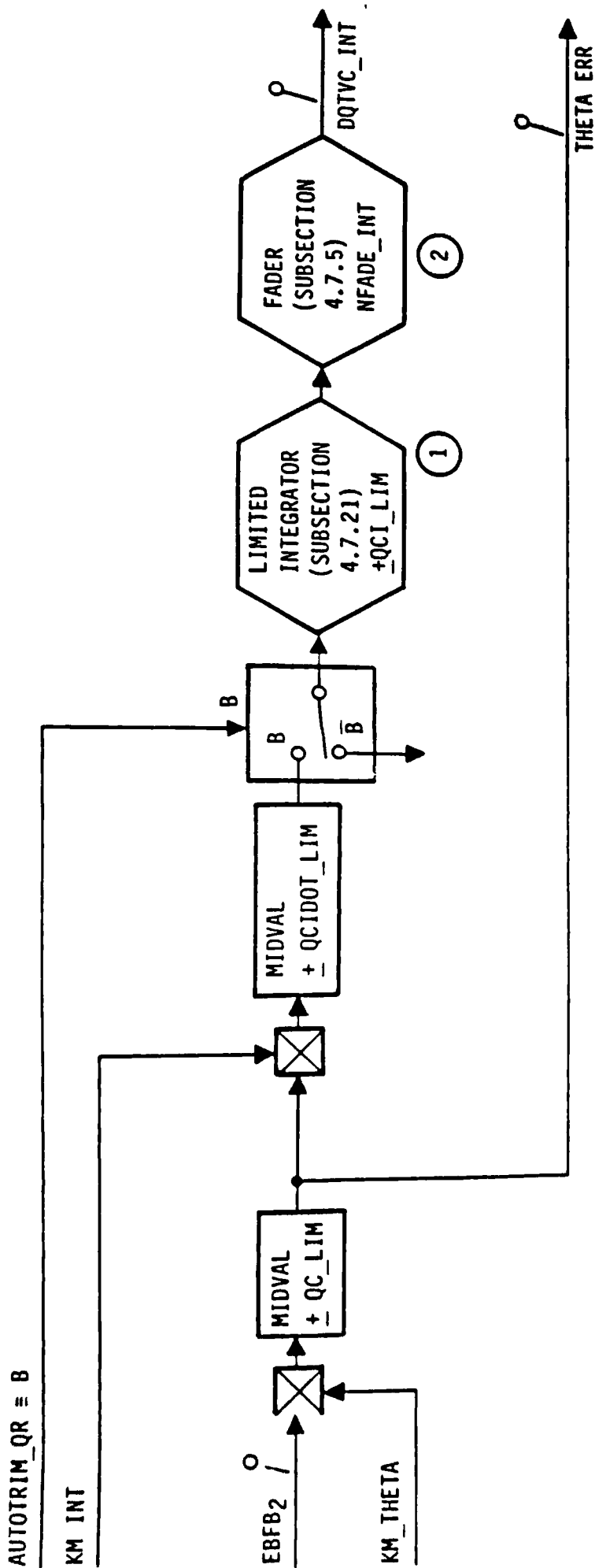


Figure 4.2.5-7. Function Module FDBK_S2C_PITCH, Detailed Diagram



NOTES

①

QCI_LIM	QCI_LIMS1	S2C
		QCI_LIMS2

②

FADE OUT AT AUTOTRIM_RESET

B: ON FROM EVENT 19B TO EVENT 21A
AND FROM EVENT 29A TO EVENT 32

Figure 4.2.5-8. Function Module PITCH_ATT_INTEGRAL, Detailed Diagram

Table 4.2.5-5. ASC_TVC_PITCH Inter-Module Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)	
CMD_PITCH	<u>Inputs</u>							
	QFDBK	Pitch rate + normal acceleration feedback error signal	FDBK_S1C_PITCH	S		deg	25	
	MM101_INIT	Indicator	ASC_RECON	B		-	12.5	
	<u>Outputs</u>							
	DQTVC	Pitch TVC loop error signal	{ CMD_PROC_MPS / CMD_PROC_SRB }	S		deg/s	25	
FDBK_S1C_PITCH	<u>Inputs</u>							
	QSRB	Pitch rate, SRB rate gyros	SF (SRB RGA)	S		deg/s	25	
	WFBI_FB ₂	Pitch rotational velocity, flight body wrt inertial, coordinatized in flight body	GC_STEER	S(V)		deg/s	12.5	
	NZ	Normal acceleration	SF (AA)	S		g	25	
	NZREF	Scheduled normal acceleration reference	INTERPS	S		g	6.25	
	KM_NZ	Variable gain (NZ feedback, pitch)	INTERPS	S		(deg/s)/g	6.25	
	THETA_ERR	Gained pitch attitude error	PITCH_ATT_INTEGRAL	S		deg/s	12.5	
	MM101_INIT	Indicator	ASC_RECON	B		-	12.5	
		<u>Outputs</u>						
		QFDBK	Pitch rate + normal acceleration feedback error signal	CMD_PITCH	S		deg/s	25
		NZ_FBK	Compensated normal acceleration error	GC_STEER	S		deg/s	25
	FDBK_S2C_PITCH	<u>Inputs</u>						
QORB		Pitch rate, orbiter rate gyros	SF (ORB RGA)	S		deg/s	25	
WFBI_FB ₂		Pitch rotational velocity, flight body wrt inertial, coordinatized in flight body	GC_STEER	S(V)		deg/s	12.5	
THETA_ERR		Gained pitch attitude error	PITCH_ATT_INTEGRAL	S		deg/s	12.5	
MM101_INIT		Indicator, first time ASCENT DAP sequenced	ASC_RECON	B		-	12.5	
	<u>Outputs</u>							
	QFDBK	Pitch rate feedback error signal	CMD_PITCH	S		deg/s	25	

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Table 4.2.5-5
Module
PITCH_ATT_INTEGRAL
AUTOTRM
CM_THETA
EBFB₂
OL_INT
AUTOTRM
MM101_INIT
Outputs
DQTVC_INT
THETA_ERR

Table 4.2.5-5. ASC_TVC_PITCH Inter-Module Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)	
PITCH_ ATT_ INTEGRAL	<u>Inputs</u>							
	AUTOTRIM_QR	Indicator, enable pitch and yaw autotrim	ASC_RECON	B		-	12.5	
	KM_THETA	Variable gain (pitch attitude)	INTERPS	S		deg/s deg	6.25	
	EBFB ₂	Pitch attitude error	GC_STEER	S(V)		deg	12.5	
	KM_INT	Pitch trim integrator gain	INTERPS	S		1/s/sec	6.25	
	AUTOTRIM_RESET	Indicator	ASC_RECON	B		-	12.5	
	MM101_INIT	Indicator	ASC_RECON	B		-	12.5	
	<u>Outputs</u>							
	DQTVIC_INT	Pitch trim integrator output signal	{ CMD_PROC_MPS } { CMD_PROC_SRB } TLM	S		deg	12.5	
	THETA_ERR	Pitch attitude error signal	FDBK_S1C_PITCH FDBK_S2C_PITCH	S		deg/s	12.5	



Table 4.2.5-6. ASC_TV_C_PITCH Initialization Requirements

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
PITCH_ATT_INTEGRAL	LIMITED_INTEGRATOR				
	OUTPUT	-	MM101_INIT	Output	0.0
		AUTOTRIM_RESET	AUTOTRIM_RESET	Output	0.0
	FADER QCI	-	MM101_INIT	NFADE_INT	0.0
		AUTOTRIM_RESET	AUTOTRIM_RESET	NFADE_INT	NFADE_INT_NOM
	Integrator output Limit	-	MM101_INIT	QCI_LIM	QCI_LIMS ₁
	S1C	S2C	QCI_LIM	QCI_LIMS ₂	
QND_PITCH	Second-order filter M_RO				
	Initialization flag	-	MM101_INIT	INIT_FLAG	OFF
	Output	-	MM101_INIT	Output	0.0
	Nodes	-	MM101_INIT	Nodes	0.0 (See Subsection 4.7.2)
FDBK_S1C_PITCH	First-order filter M_QHP				
	Initialization flag	-	MM101_INIT	INIT_FLAG	OFF
	Output	-	MM101_INIT	Output	0.0
	Node	-	MM101_INIT	Node	0.0 (See Subsection 4.7.1)
	First-order filter M_NZLAG				
	Initialization flag	-	MM101_INIT	INIT_FLAG	OFF
	Output	-	MM101_INIT	Output	0.0
	Node	-	MM101_INIT	Nodes	0.0 (See Subsection 4.7.1)
	Second-order filter M_NZ				
	Initialization flag	-	MM101_INIT	INIT_FLAG	OFF
	Output	-	MM101_INIT	Output	0.0
	Nodes	-	MM101_INIT	Nodes	0.0 (See Subsection 4.7.2)

Table 4.2.5-6
Module
FDBK_S1C_PITCH (Cont.)
FDBK_S2C_PITCH

Table 4.2.5-6. ASC_TV_C_PITCH Initialization Requirements (Cont)

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
FDBK_S1C_PITCH (Cont)	Second-order filter M_QB				
	Initialization flag	-	MM101_INIT	INIT_FLAG	OFF
	Output	-	MM101_INIT	Output	0.0
	Nodes	-	MM101_INIT	Nodes	0.0 (See Subsection 4.7.2)
	Second-order filter M_STG1				
	Initialization flag	-	MM101_INIT	INIT_FLAG	OFF
	Output	-	MM101_INIT	Output	0.0
	Nodes	-	MM101_INIT	Nodes	0.0 (See Subsection 4.7.2)
	Second-order filter M_LLS1				
	Initialization flag	-	MM101_INIT	INIT_FLAG	OFF
	Output	-	MM101_INIT	Output	0.0
	Nodes	-	MM101_INIT	Nodes	0.0 (See Subsection 4.7.2)
FDBK_S2C_PITCH	Fourth-order filter M_Q0				
	Initialization flag	-	MM101_INIT	INIT_FLAG	OFF
	Output	-	MM101_INIT	Output	0.0
	Nodes	-	MM101_INIT	Nodes	0.0 (See Subsection 4.7.3)
	Second-order filter M_LLS2				
	Initialization flag	-	MM101_INIT	INIT_FLAG	OFF
Output	-	MM101_INIT	Output	0.0	
Nodes	-	MM101_INIT	Nodes	0.0 (See Subsection 4.7.2)	

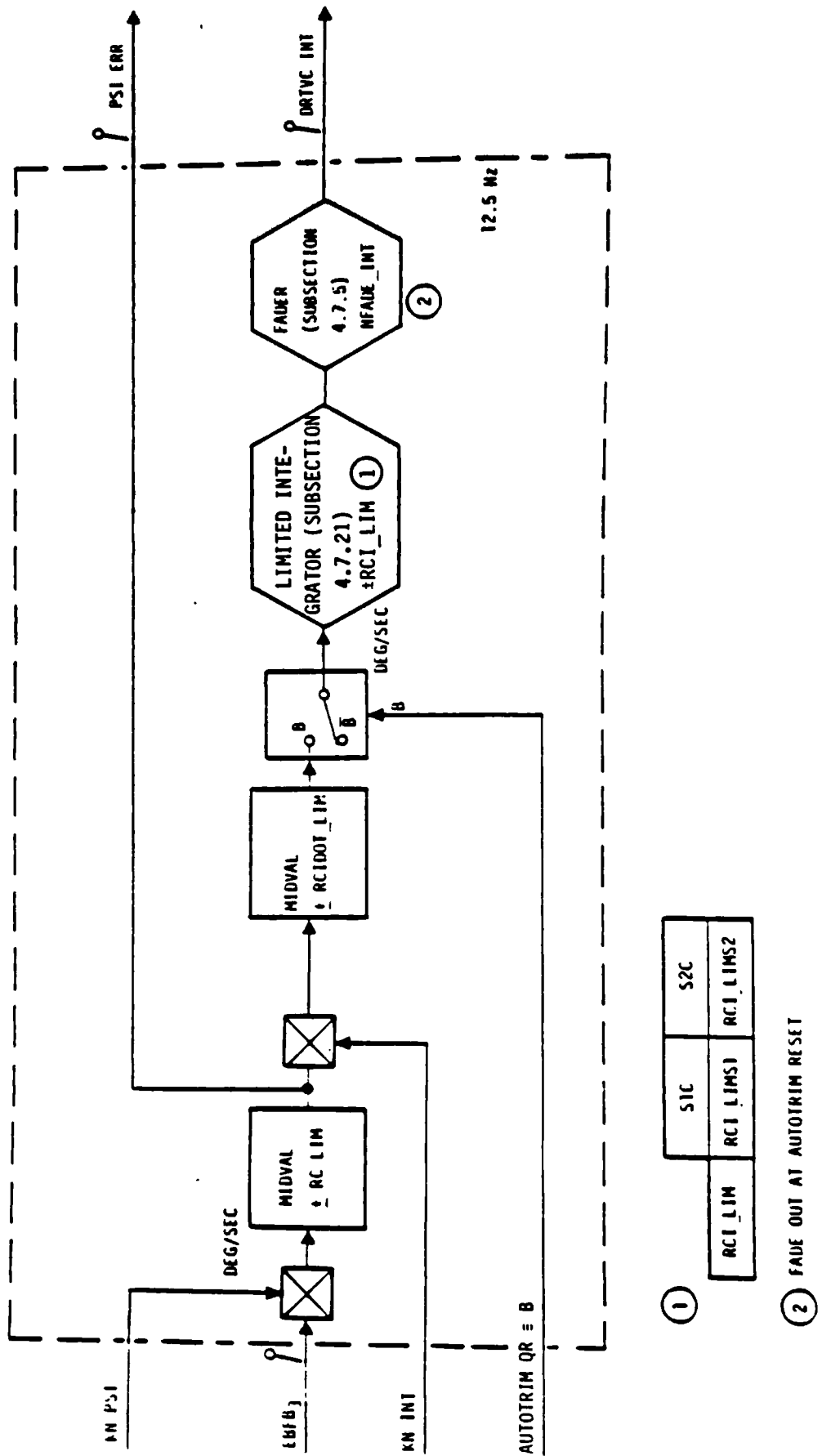
Table 4.2.5-7. ASC_TV_C_PITCH I-Loads/Constants

Module	Name	Description	Type	MSID	Units
PITCH_ATT_INTEGRAL	QC_LIM	Pitch attitude error rate limit	S	V97U2222C	deg/s
	QCIDOT_LIM	Pitch trim integrator rate limit	S	V97U2224C	deg/s
	QCI_LIMS1	Pitch trim integration limit, S1	S	V97U2438C	deg
	QCI_LIMS2	Pitch trim integration limit, S2	S	V97U2223C	deg
	NFADE_INT_NOM	Cycles to fade QCI to zero	S	V97U2075C	counts
	TM	Medium cycle time	S	0.0A	S
CMD_PITCH	CM_RO1	Filter M_RO coefficient	S	V97U1558C	-
	CM_RO2	Filter M_RO coefficient	S	V97U1559C	-
	CM_RO3	Filter M_RO coefficient	S	V97U1560C	-
	CM_RO4	Filter M_RO coefficient	S	V97U1561C	-
	CM_RO5	Filter M_RO coefficient	S	V97U1562C	-
FDBK_SIC_PITCH	KM_QHP	Fixed gain, pitch high pass	S	V97U1895C	g/d/s
	CM_QHP1	Filter M_QHP coefficient	S	V97U1540C	-
	CM_QHP2	Filter M_QHP coefficient	S	V97U1541C	-
	CM_QHP3	Filter M_QHP coefficient	S	V97U1542C	-
	CM_NZLAG1	Filter M_NZLAG coefficient	S	V97U1482C	-
	CM_NZLAG2	Filter M_NZLAG coefficient	S	V97U1483C	-
	CM_NZLAG3	Filter M_NZLAG coefficient	S	V97U1484C	-
	CM_NZ1	Filter M_NZ coefficient	S	V97U1485C	-
	CM_NZ2	Filter M_NZ coefficient	S	V97U1486C	-
	CM_NZ3	Filter M_NZ coefficient	S	V97U1487C	-
	CM_NZ4	Filter M_NZ coefficient	S	V97U1488C	-
	CM_NZ5	Filter M_NZ coefficient	S	V97U1489C	-
	CM_QB1	Filter M_QB coefficient	S	V97U1500C	-
	CM_QB2	Filter M_QB coefficient	S	V97U1501C	-
	CM_QB3	Filter M_QB coefficient	S	V97U1502C	-
	CM_QB4	Filter M_QB coefficient	S	V97U1503C	-
	CM_QB5	Filter M_QB coefficient	S	V97U1504C	-
	CM_STG11	Filter STG1 coefficient	S	V98U9583C	-
	CM_STG12	Filter STG1 coefficient	S	V98U9584C	-
	CM_STG13	Filter STG1 coefficient	S	V98U9585C	-
	CM_STG14	Filter STG1 coefficient	S	V98U9586C	-
	CM_STG15	Filter STG1 coefficient	S	V98U9587C	-

Module
FDBK_SIC_PITCH
(Cont.)
FDBK_S2C_PITCH

Table 4.2.5-7. ASC_TVC_PITCH I-Loads/Constants (Cont)

Module	Name	Description	Type	MSID	Units
FDBK_S1C_PITCH (Cont)	CM_LLS11	Filter LLS1 coefficient	S	V98U9588C	-
	CM_LLS12	Filter LLS1 coefficient	S	V98U9589C	-
	CM_LLS13	Filter LLS1 coefficient	S	V98U9564C	-
	CM_LLS14	Filter LLS1 coefficient	S	V98U9565C	-
	CM_LLS15	Filter LLS1 coefficient	S	V98U9566C	-
FDBK_S2C_PITCH	CM_Q011	Filter M_Q0 coefficient	S	V97U1549C	-
	CM_Q012	Filter M_Q0 coefficient	S	V97U1544C	-
	CM_Q013	Filter M_Q0 coefficient	S	V97U1545C	-
	CM_Q014	Filter M_Q0 coefficient	S	V97U1546C	-
	CM_Q015	Filter M_Q0 coefficient	S	V97U1547C	-
	CM_Q021	Filter M_Q0 coefficient	S	V97U1548C	-
	CM_Q022	Filter M_Q0 coefficient	S	V97U1549C	-
	CM_Q023	Filter M_Q0 coefficient	S	V97U1550C	-
	CM_Q024	Filter M_Q0 coefficient	S	V97U1551C	-
	CM_Q025	Filter M_Q0 coefficient	S	V97U1552C	-
	CM_LLS21	Filter LLS2 coefficient	S	V98U9567C	-
	CM_LLS22	Filter LLS2 coefficient	S	V98U9568C	-
	CM_LLS23	Filter LLS2 coefficient	S	V98U9569C	-
	CM_LLS24	Filter LLS2 coefficient	S	V98U9570C	-
	CM_LLS25	Filter LLS2 coefficient	S	V98U9571C	-



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Figure 4.2.5-9. Function Module YAW ATT INTEGRAL

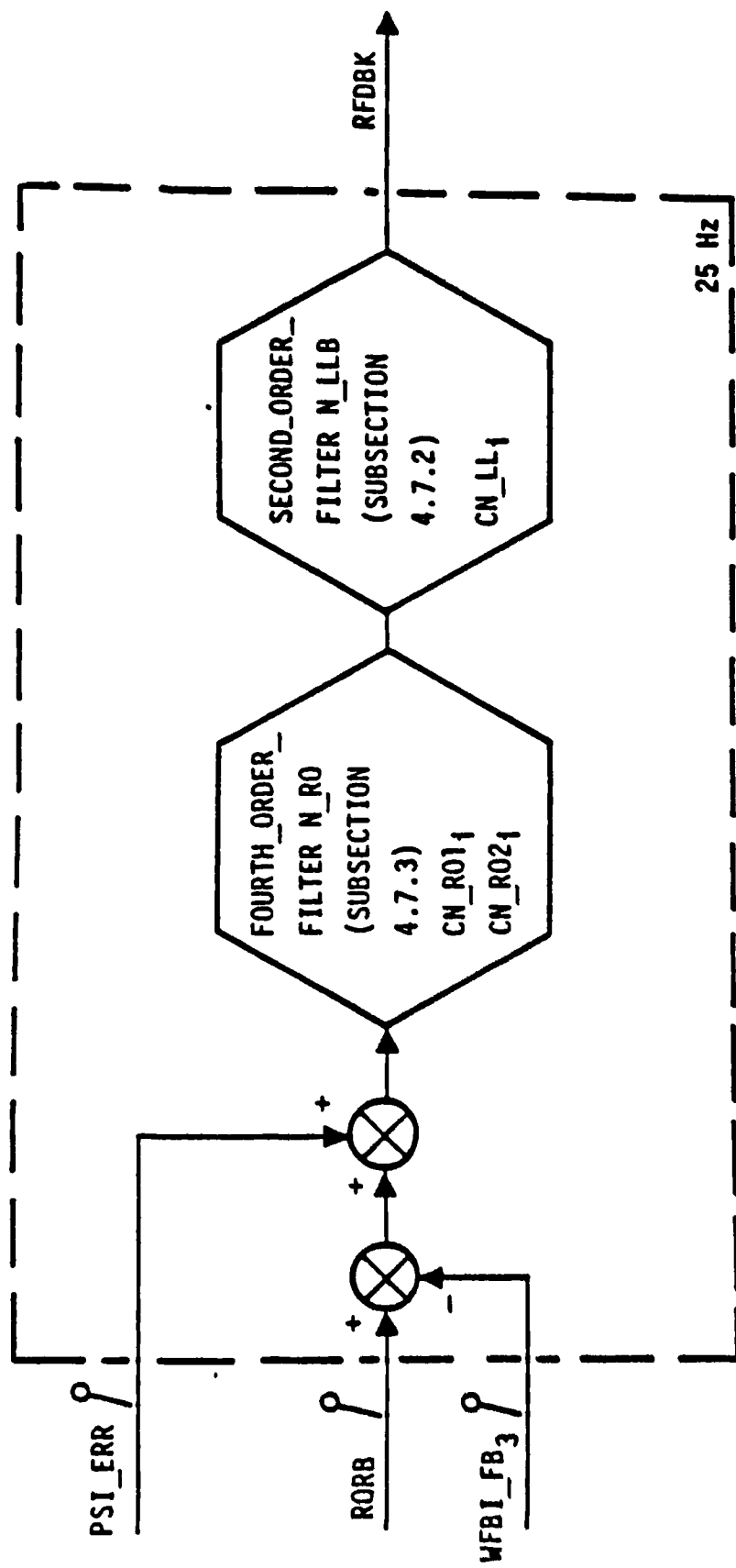


Figure 4.2.5-10. Function Module FDBK_S2C_YAW, Detailed Diagram

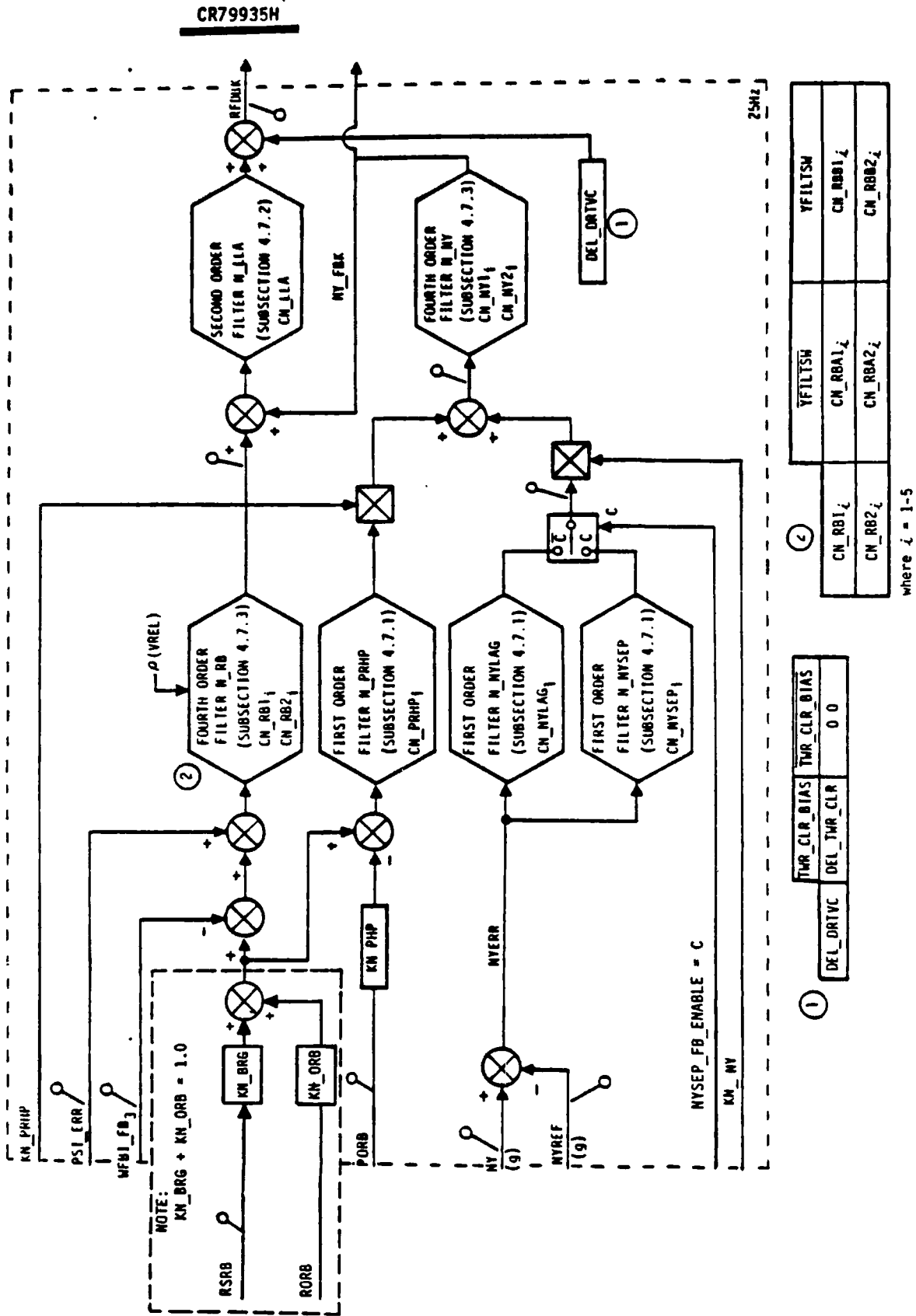


Figure 4.2 5-11. Function Module FDBK_S1C_YAW. Detailed Diagram

RFDBK

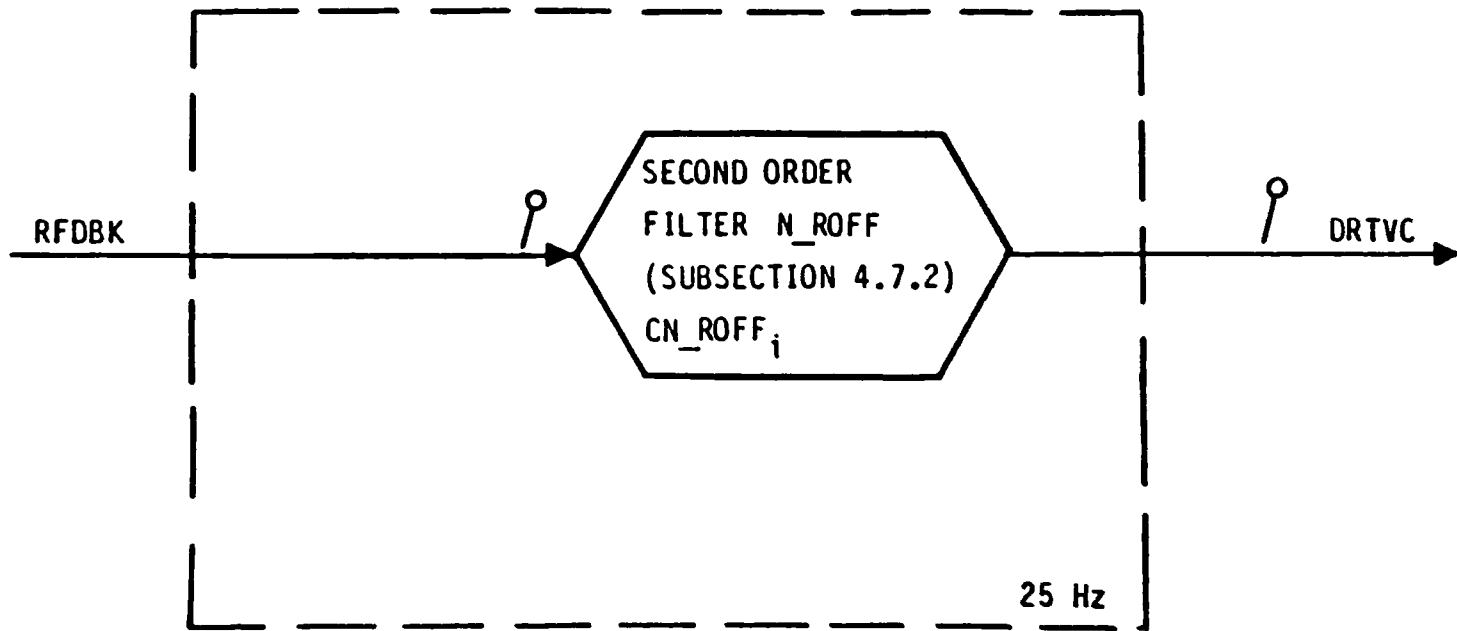


Figure 4.2.5-12. Function Module, CMD YAW

Table 4.2.5-8. ASC_TV_C_YAW Inter-Module Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
CMD_YAW	<u>Inputs</u>						
	RFDBK	Yaw rate feedback error	FDBK_S1C_YAW FDBK_S2C_YAW	S		deg/s	25
CMD_YAW	<u>Outputs</u>						
	DRTVC	Yaw TVC loop error signal	CMD_PROC_MPS CMD_PROC_SRB CMD_ROLL, TLM	S		deg/s	25
FDBK_S1C_YAW	<u>Inputs</u>						
	RSRB	Yaw rate, SRB rate gyro	SF (SRB RGA)	S		deg/s	25
	TWR_CLR_BIAS	Indicator, SSME No. 2 failed at lift-off	ASC_RECON	B			12.5
	WFBI_FB ₃	Yaw rotational velocity, flight-body wrt inertial, coordinated in flight body	GC_STEER	S		deg/s	12.5
	PORB	Roll rate, orbiter rate gyro	SF (ORB RGA)	S		deg/s	25
	NY	Lateral acceleration	SF (AA)	S		g	25
	NYREF	Scheduled lateral acceleration reference	INTERPS	S		g	6.25
	KN_PRHP	Variable gain (hi passed roll-yaw feedback)	INTERPS	S		-	6.25
	KN_NY	Variable gain (NY feedback, yaw)	INTERPS	S		deg/s	6.25
	PSI_ERR	Gained yaw attitude error	YAW_ATT_INTEGRAL	S		deg/s	12.5
	MM101_INIT	Indicator	ASC_RECON	B		-	12.5
	NYSEP_FB_ENABLE	Indicator	ASC_RECON	B		-	12.5
	RORB	Yaw rate, orbiter rate gyro	SF (ORB RGA)	S		deg/s	25
	YFILTSW	Indicator	ASC_RECON	B		-	12.5
	FDBK_S1C_YAW	<u>Outputs</u>					
RFDBK		Yaw rate feedback error signal	CMD_YAW	S		deg/s	25
FDBK_S1C_YAW	<u>Outputs</u>						
	NY_FBK	Compensated lateral acceleration error	GC_STEER	S		deg/s	25

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Table 4.2.5-8

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
FDBK_S2C_YAW							
YAW_ATT_INTEGRAL							



Table 4.2.5-8. ASC_TV_C_YAW Inter-Module Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)	
FDBK_S2C_YAW	<u>Inputs</u>							
	RORB	Yaw rate, orbiter rate gyros	SF (ORB RGA)	S		deg/s	25	
	WFBI_FB ₃	Yaw rotational velocity flight-body wrt inertial, coordinatized in flight body	GC_STEER	S		deg/s	12.5	
	PSI_ERR	Gained yaw attitude error	YAW_ATT_INTEGRAL	S		deg/s	12.5	
	MM101_INIT	Indicator, first time ASCENT_DAP sequenced	ASC_RECON	B		-	12.5	
FDBK_S2C_YAW	<u>Outputs</u>							
	RFDBK	Yaw rate feedback error signal	CMD_YAW	S		deg/s	25	
YAW_ATT_INTEGRAL	<u>Inputs</u>							
	EBFB ₃	Yaw attitude error	GC_STEER	S(V)		deg	12.5	
	KN_PSI	Variable gain, yaw attitude	INTERPS	S		deg/s deg	6.25	
	KN_INT	Yaw attitude error integral gain	INTERPS	S		-	6.25	
	AUTOTRIM_QR	Indicator	ASC_RECON	B		-	12.5	
	AUTOTRIM_RESET	Indicator	ASC_RECON	B		-	12.5	
	S1C	Indicator, Stage 1 control	ASC_RECON	B		-	12.5	
	S2C	Indicator, Stage 2 control	ASC_RECON	B		-	12.5	
	YAW_ATT_INTEGRAL	<u>Outputs</u>						
		PSI_ERR	Gained yaw attitude error	{FDBK_S1C_YAW} {FDBK_S2C_YAW}	S		deg/s	12.5
		DRTVC_INT	Yaw trim integrator output	{CMD_PROC_MPS} {CMD_PROC_SRB} TLM	S		deg	12.5



Table 4.2.5-9. ASC_TVC_YAW Initialization Requirements

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
YAW_ATT_INTEGRAL (Cont)	Limited integrator				
	Output	-	MM101_INIT	Output	0.0
		<u>AUTOTRIM_RESET</u>	AUTOTRIM_RESET	Output	0.0
	Fader, RCI	-	MM101_INIT	NFADE_INT	0
		<u>AUTOTRIM_RESET</u>	AUTOTRIM_RESET	NFADE_INT	NFADE_INT_NOM
	Integrator output limit	-	MM101_INIT	RCI_LIM	RCI_LIMS1
	SIC	S2C	RCI_LIM	RCI_LIMS2	
CMD_YAW	Second_order filter N_ROFF				
	Initialization flag	-	MM101_INIT	INIT flag	Off
	Output	-	MM101_INIT	Output	0.0
	Nodes	-	MM101_INIT	Nodes	0.0 (See Subsection 4.7.2)
FDBK_SIC_YAW	First-order filter N_PRRP				
	Initialization flag	-	MM101_INIT	INIT flag	Off
	Output	-	MM101_INIT	Output	0.0
	Node	-	MM101_INIT	Node	0.0 (See Subsection 4.7.1)
	Second-order filter N_LLA				
	Initialization	-	MM101_INIT	INIT flag	OFF
	Output			Output	0.0
	Node			Node	0.0 (See Subsection 4.7.2)
	Coefficients (i = 1-5)	<u>PRE_SEP</u>	PRE_SEP	CN_LL _i	CN_LLA _i
	First-order filter N_NYLAG			DEL_DRTVC	0.0
Initialization flag	-	MM101_INIT	INIT flag	OFF	
Output	-		Output	0.0	
Node			Node	0.0 (See Subsection 4.7.1)	

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Table 4.2

Module	First-order
FDBK_SIC_YAW (Cont)	Initialization Output Node
	Fourth-order Initializa Output Nodes
	Fourth-order Initializa Output Nodes
	Coeffic
FDBK_S2C_YAW	Fourth-order Initializa Output Nodes
	Second-order Initializa Output Nodes

Table 4.2.5-9. ASC_TVC_YAW Initialization Requirements (Cont)

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
FDBK_S1C_YAW (Cont)	First-order filter N_NYSEP				
	Initialization flag	-	MM101_INIT	fNIT flag	Off
	Output	-		Output	0.0
	Node			Node	0.0 (see Subsection 4.7.1)
	Fourth-order filter N_NY				
	Initialization flag		MM101_INIT	INIT FLAG	Off
	Output	-		Output	0.0
	Nodes	-		Nodes	0.0 (see Subsection 4.7.3)
	Fourth-order filter N_RB				
	Initialization flag	-	MM101_INIT	INIT flag	Off
	Output	-		Output	0.0
	Nodes	-		Nodes	0.0 (see Subsection 4.7.3)
	Coefficients (i = 1-5)	-	MM101_INIT	N_RB1 _i N_RB2 _i	N_RBA1 _i N_RBA2 _i
			YFILTSW	N_RB1 _i N_RB2 _i	N_RBB1 _i N_RBB2 _i
FDBK_S2C_YAW	Fourth-order filter N_RO				
	Initialization flag	-	MM101_INIT	INIT flag	OFF
	Output	-		Output	0.0
	Nodes	-		Nodes	0.0 (see Subsection 4.7.3)
	Second-order filter N_LRB				
	Initialization flag	-	MM101_INIT	INIT flag	Off
	Output	-		Output	0.0
	Nodes	-		Nodes	0.0 (see Subsection 4.7.2)

Table 4.2.5-10. ASC_TV_C_YAW I-Loads/Constants

Module	Name	Description	Type	MSID/ Value	Units
YAW_ATT INTEGRAL	RC_LIM	Yaw attitude error rate limit	S	V97U2229C	deg/s
	TM	Medium cycle time	S	0.08	s
	RCIDOT_LIM	Yaw trim integrator rate limit	S	V97U2231C	deg/s
	RCI_LIMS1	Yaw trim integrator limit, Stage 1	S	V97U2439C	deg
	RCI_LIMS2	Yaw trim integrator limit, Stage 2	S	V97U2230C	deg
	NFADE_INT_NOM	Cycles to fade RCI to zero	S	V97U2075C	-
FDBK_SIC_YAW	KN_PHP	Fixed gain, roll into yaw high pass	S	V97U1953C	-
	CN_PRHP1	Filter N_PRHP coefficient	S	V97U1602C	-
	CN_PRHP2	Filter N_PRHP coefficient	S	V97U1603C	-
	CN_PRHP3	Filter N_PRHP coefficient	S	V97U1604C	-
	CN_NYLAG1	Filter N_NYLAG coefficient	S	V97U1581C	-
	CN_NYLAG2	Filter N_NYLAG coefficient	S	V97U1582C	-
	CN_NYLAG3	Filter N_NYLAG coefficient	S	V97U1583C	-
	CN_NYSEP1	Filter N_NYSEP coefficient	S	V97U1584C	-
	CN_NYSEP2	Filter N_NYSEP coefficient	S	V97U1585C	-
	CN_NYSEP3	Filter N_NYSEP coefficient	S	V97U1586C	-
	CN_NY11	Filter N_NY coefficient	S	V97U1587C	-
	CN_NY12	Filter N_NY coefficient	S	V97U1588C	-
	CN_NY13	Filter N_NY coefficient	S	V97U1589C	-
	CN_NY14	Filter N_NY coefficient	S	V97U1590C	-
	CN_NY15	Filter N_NY coefficient	S	V97U1591C	-
	CN_NY21	Filter N_NY coefficient	S	V97U1592C	-
	CN_NY22	Filter N_NY coefficient	S	V97U1593C	-
	CN_NY23	Filter N_NY coefficient	S	V97U1594C	-
	CN_NY24	Filter N_NY coefficient	S	V97U1595C	-
	CN_NY25	Filter N_NY coefficient	S	V97U1596C	-
	CN_LLA1	Filter N_LLA coefficient	S	V97U1571C	-
	CN_LLA2	Filter N_LLA coefficient	S	V97U1572C	-
	CN_LLA3	Filter N_LLA coefficient	S	V97U1573C	-
	CN_LLA4	Filter N_LLA coefficient	S	V97U1574C	-
	CN_LLA5	Filter N_LLA coefficient	S	V97U1575C	-

Module
FDBK_SIC_YAW
(Cont)

FDBK_S2C_YAW

CMD_YAW

Table 4.2.5-10. ASC_TVC_YAW I-Loads/Constants (Cont)

Module	Name	Description	Type	MSID/ Value	Units
FDBK_S1C_YAW (Cont)	CN_RB11	Filter N_RB coefficient	S	V97U1603C	-
	CN_RB12	Filter N_RB coefficient	S	V97U1606C	-
	CN_RB13	Filter N_RB coefficient	S	V97U1607C	-
	CN_RB14	Filter N_RB coefficient	S	V97U1608C	-
	CN_RB15	Filter N_RB coefficient	S	V97U1609C	-
	CN_RB21	Filter N_RB coefficient	S	V97U1610C	-
	CN_RB22	Filter N_RB coefficient	S	V97U1611C	-
	CN_RB23	Filter N_RB coefficient	S	V97U1612C	-
	CN_RB24	Filter N_RB coefficient	S	V97U1613C	-
	CN_RB25	Filter N_RB coefficient	S	V97U1614C	-
	DEL_TWR_CLR	Tower clear bias for SSME 2	S	V97U2440C	deg/s
FDBK_S2C_YAW	CN_RO11	Filter N_RO coefficient	S	V97U1645C	-
	CN_RO12	Filter N_RO coefficient	S	V97U1646C	-
	CN_RO13	Filter N_RO coefficient	S	V97U1647C	-
	CN_RO14	Filter N_RO coefficient	S	V97U1648C	-
	CN_RO15	Filter N_RO coefficient	S	V97U1649C	-
	CN_RO21	Filter N_RO coefficient	S	V97U1650C	-
	CN_RO22	Filter N_RO coefficient	S	V97U1651C	-
	CN_RO23	Filter N_RO coefficient	S	V97U1652C	-
	CN_RO24	Filter N_RO coefficient	S	V97U1653C	-
	CN_RO25	Filter N_RO coefficient	S	V97U1654C	-
	CN_LL1	Filter N_LL coefficient	S	V98U9572C	-
	CN_LL2	Filter N_LL coefficient	S	V98U9573C	-
	CN_LL3	Filter N_LL coefficient	S	V98U9574C	-
	CN_LL4	Filter N_LL coefficient	S	V98U9575C	-
	CN_LL5	Filter N_LL coefficient	S	V98U9576C	-
CMD_YAW	CN_ROFF1	Filter N_ROFF coefficient	S	V97U2488C	-
	CN_ROFF2	Filter N_ROFF coefficient	S	V97U2489C	-
	CN_ROFF3	Filter N_ROFF coefficient	S	V97U2490C	-
	CN_ROFF4	Filter N_ROFF coefficient	S	V97U2491C	-
	CN_ROFF5	Filter N_ROFF coefficient	S	V97U2492C	-

Table 4.2.5-10. ASC_TVC_YAW I-Loads/Constants (Cont)

Module	Name	Description	Type	MSID/ Value	Units	
FDBK_S1C_YAW (Cont)	KN_ORB	Fixed blending gain of ORB RC	S	V99U9595C	-	
	KN_BRC	Fixed blending gain of SRB RC	S	V99U9596C	-	
	CN_RBA11	Filter N_RB coefficient	S	V99U9575C	-	
	CN_RBA12	Filter N_RB coefficient	S	V99U9576C	-	
	CN_RBA13	Filter N_RB coefficient	S	V99U9577C	-	
	CN_RBA14	Filter N_RB coefficient	S	V99U9578C	-	
	CN_RBA15	Filter N_RB coefficient	S	V99U9579C	-	
	CN_RBA21	Filter N_RB coefficient	S	V99U9580C	-	
	CN_RBA22	Filter N_RB coefficient	S	V99U9581C	-	
	CN_RBA23	Filter N_RB coefficient	S	V99U9582C	-	
	CN_RBA24	Filter N_RB coefficient	S	V99U9583C	-	
	CN_RBA25	Filter N_RB coefficient	S	V99U9584C	-	
	CN_RBB11	Filter N_RB coefficient	S	V99U9585C	-	
	CN_RBB12	Filter N_RB coefficient	S	V99U9586C	-	
	CN_RBB13	Filter N_RB coefficient	S	V99U9587C	-	
	CN_RBB14	Filter N_RB coefficient	S	V99U9588C	-	
	CN_RBB15	Filter N_RB coefficient	S	V99U9589C	-	
	CN_RBB21	Filter N_RB coefficient	S	V99U9590C	-	
	CN_RBB22	Filter N_RB coefficient	S	V99U9591C	-	
	CN_RBB23	Filter N_RB coefficient	S	V99U9592C	-	
	CN_RBB24	Filter N_RB coefficient	S	V99U9593C	-	
	CN_RBB25	Filter N_RB coefficient	S	V99U9594C	-	
	FDBK_S2C_YAW	CN_RO11	Filter N_RO coefficient	S	V97U1645C	-
		CN_RO12	Filter N_RO coefficient	S	V97U1646C	-
		CN_RO13	Filter N_RO coefficient	S	V97U1647C	-
CN_RO14		Filter N_RO coefficient	S	V97U1648C	-	
CN_RO15		Filter N_RO coefficient	S	V97U1649C	-	
CN_RO21		Filter N_RO coefficient	S	V97U1650C	-	
CN_RO22		Filter N_RO coefficient	S	V97U1651C	-	
CN_RO23		Filter N_RO coefficient	S	V97U1652C	-	
CN_RO24		Filter N_RO coefficient	S	V97U1653C	-	
CN_RO25		Filter N_RO coefficient	S	V97U1654C	-	

Module
FDBK_S2C_YAW
(Cont)

CHD_YAW



Table 4.2.5-10. ASC_TVC_YAW I-Loads/Constants (Cont)

Module	Name	Description	Type	MSID/ Value	Units
FDBK_S2C_YAW (Cont)	CN_LLBI	Filter N_LLBI coefficient	S	V98U9572C	-
	CN_LLBI2	Filter N_LLBI2 coefficient	S	V98U9573C	-
	CN_LLBI3	Filter N_LLBI3 coefficient	S	V98U9574C	-
	CN_LLBI4	Filter N_LLBI4 coefficient	S	V98U9575C	-
	CN_LLBI5	Filter N_LLBI5 coefficient	S	V98U9576C	-
CMD_YAW	CN_ROFF1	Filter N_ROFF1 coefficient	S	V97U2488C	-
	CN_ROFF2	Filter N_ROFF2 coefficient	S	V97U2489C	-
	CN_ROFF3	Filter N_ROFF3 coefficient	S	V97U2490C	-
	CN_ROFF4	Filter N_ROFF4 coefficient	S	V97U2491C	-
	CN_ROFF5	Filter N_ROFF5 coefficient	S	V97U2492C	-

4.2.6 MPS Command Processor (CMD_PROC_MPS)

A. Functional Description. The functional block diagram for CMD_PROC_MPS is shown in Figure 4.2.6-1. The functional requirements specification for priority rate limiting is given in Table 4.2.6-1. A functional flow chart for the priority rate limiting computations is shown in Figure 4.2.6-2.

B. Software Description. An overview of CMD_PROC_MPS is presented in Figure 4.2.6-3. Its input/output requirements are summarized in Table 4.2.6-2. CMD_PROC_MPS consists of three function modules, TRIM_MIX_MPS, BIAS_LIM_MPS, and PRL_MPS, which are sequenced as shown in Figure 4.2.6-4. The detailed block diagrams for the function modules TRIM_MIX_MPS, BIAS_LIM_MPS, and PRL_MPS are shown respectively in Figures 4.2.6-5, 4.2.6-6, and 4.2.6-7. The intermodule interface requirements for CMD_PROC_MPS are presented in Table 4.2.6-3, initialization requirements are presented in Table 4.2.6-4, and I-loads/constants are presented in Table 4.2.6-5.

4.2.6 MPS Command Processor (CMD_PROC_MPS)

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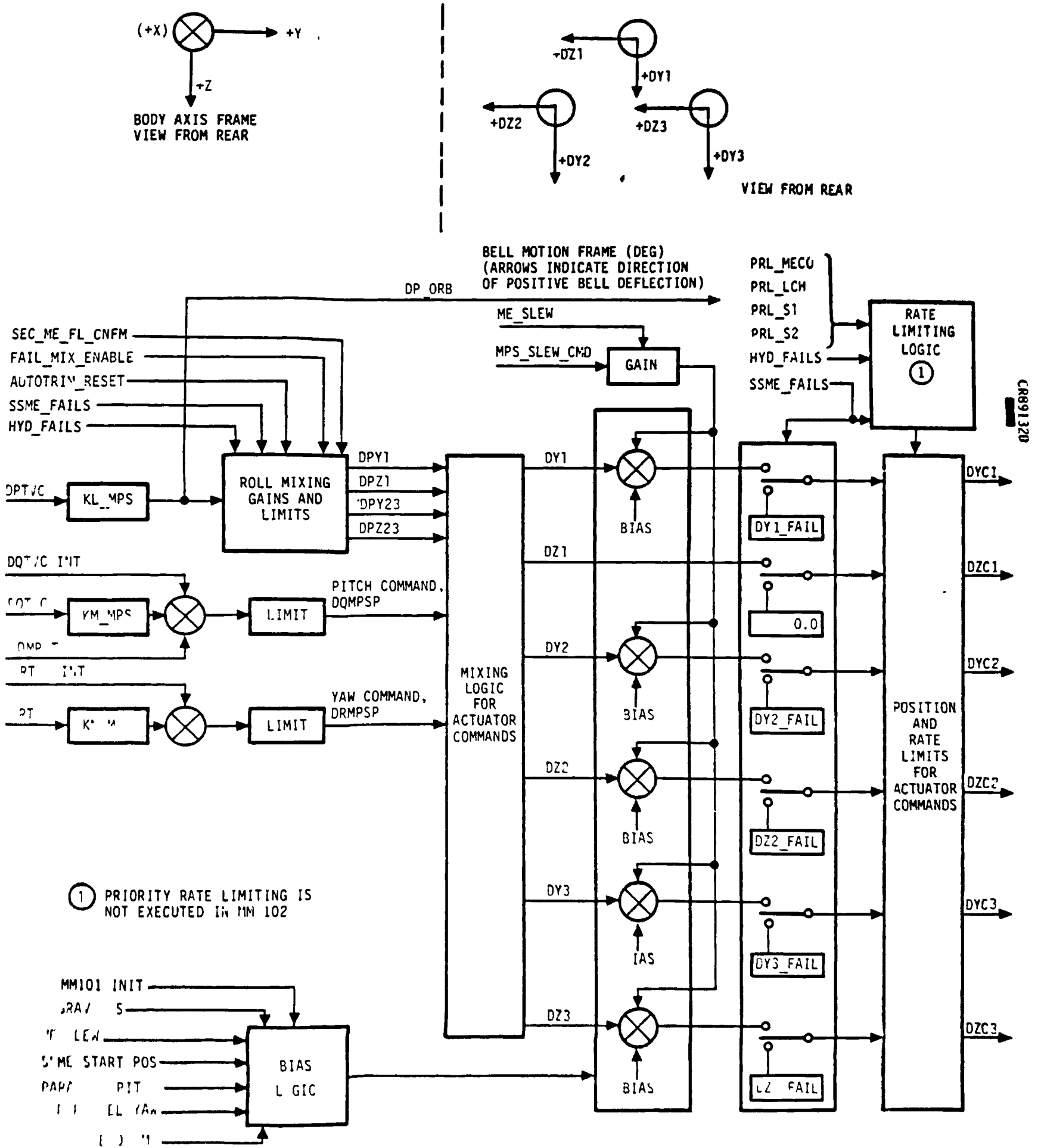


Figure 4.2.6-1. MPS Command Processor, Functional Overview

Table 4.2.6-1. Functional Requirements Specification for Priority Rate Limiting of SSME Bell Deflection Commands From SRB SEP Command

Hydraulic Sys Failed	Hydraulic Sys Oper	Actuator Rate Limit Equations ^① (\dot{Y}_i = Pitch i Actuator Rate, \dot{Z}_i = Yaw i Actuator Rate)	Rate Capability X (deg/sec)	
			Mode I ^② SRB SEP CMD to M&CO 100% APU - 0,1 Fail 110% APU - 2 Fail	Mode II MECO 100% APU - 0,1 Fail 110% APU - 2 Fail
None	1	$1.24 \dot{Y}_1 + \dot{Z}_2 = XC_1$	18.0 (V97U2228C) TF	15.6 (V97U2225C) TF
	2	$ \dot{Y}_2 + \dot{Z}_3 = XC_2$		
	3	$ \dot{Y}_3 + \dot{Z}_1 = XC_3$		
1	2	$ \dot{Y}_2 + \dot{Z}_2 + \dot{Z}_3 = XC_2$		
	3	$1.24 \dot{Y}_1 + \dot{Y}_3 + \dot{Z}_1 = XC_3$		
2	1	$1.24 \dot{Y}_1 + \dot{Y}_2 + \dot{Z}_2 = XC_1$		
	3	$ \dot{Y}_3 + \dot{Z}_1 + \dot{Z}_3 = XC_3$		
3	1	$1.24 \dot{Y}_1 + \dot{Z}_2 + \dot{Z}_1 = XC_1$		
	2	$ \dot{Y}_2 + \dot{Y}_3 + \dot{Z}_3 = XC_2$		
1 & 2	3	$1.24 \dot{Y}_1 + \dot{Z}_1 + \dot{Y}_3 + \dot{Z}_3 = XC_3$		
1 & 3	2	$ \dot{Y}_2 + \dot{Z}_2 + \dot{Y}_3 + \dot{Z}_3 = XC_2$		
2 & 3	1	$1.24 \dot{Y}_1 + \dot{Z}_1 + \dot{Y}_2 + \dot{Z}_2 = XC_1$		

① If the sum of commands (XC) is less than the rate capability (X), ($XC \leq X$); then the actuator's rate = command rate. If $XC > X$, then the actuator's rate = $(X/XC) \cdot$ (commanded rate); an absolute rate limit of 10.0 deg/sec for each actuator is assumed downstream, i.e., $|\dot{Y}_i| \leq 10.0$ deg/sec, $|\dot{Z}_i| \leq 10.0$ deg/sec.

② Includes Δ throttle effects.

③ PKL is not executed in MM 102. Fixed actuator rate limits for MM 102 are given in Table 4.2.6-1a.

**Table 4.2.6-1A. Functional Requirements Specification for SSME
Bell Deflection Commands From Liftoff to SRB SEP Command**

Time or Event	Hydraulic System Failures	SSME TVC Actuator Rate Limit ^① (deg/sec)
Before Event 19C	None	$ \dot{Y}_i \leq (\text{RATE_CAPABILITY_LIFTOFF})/TF,$
	Any one	$ \dot{Z}_i \leq (\text{RATE_CAPABILITY_LIFTOFF})/TF$
Event 19C to SRB SEP command	None	$ \dot{Y}_i \leq (\text{RATE_CAPABILITY_NOFAILS})/TF,$ $ \dot{Z}_i \leq (\text{RATE_CAPABILITY_NOFAILS})/TF$
	Any one	$ \dot{Y}_i \leq (\text{RATE_CAPABILITY_ONEFAIL})/TF,$ $ \dot{Z}_i \leq (\text{RATE_CAPABILITY_ONEFAIL})/TF$
	Any two	$ \dot{Y}_i \leq (\text{RATE_CAPABILITY_TWOFAIL})/TF,$ $ \dot{Z}_i \leq (\text{RATE_CAPABILITY_TWOFAIL})/TF$
SRB SEP command through Event 33B (ME_ZERO_THRUST)	See Table 4.2.6-1	Use PRL in Table 4.2.6-1.
^① Includes Δ throttle and Δ elevon effects.		

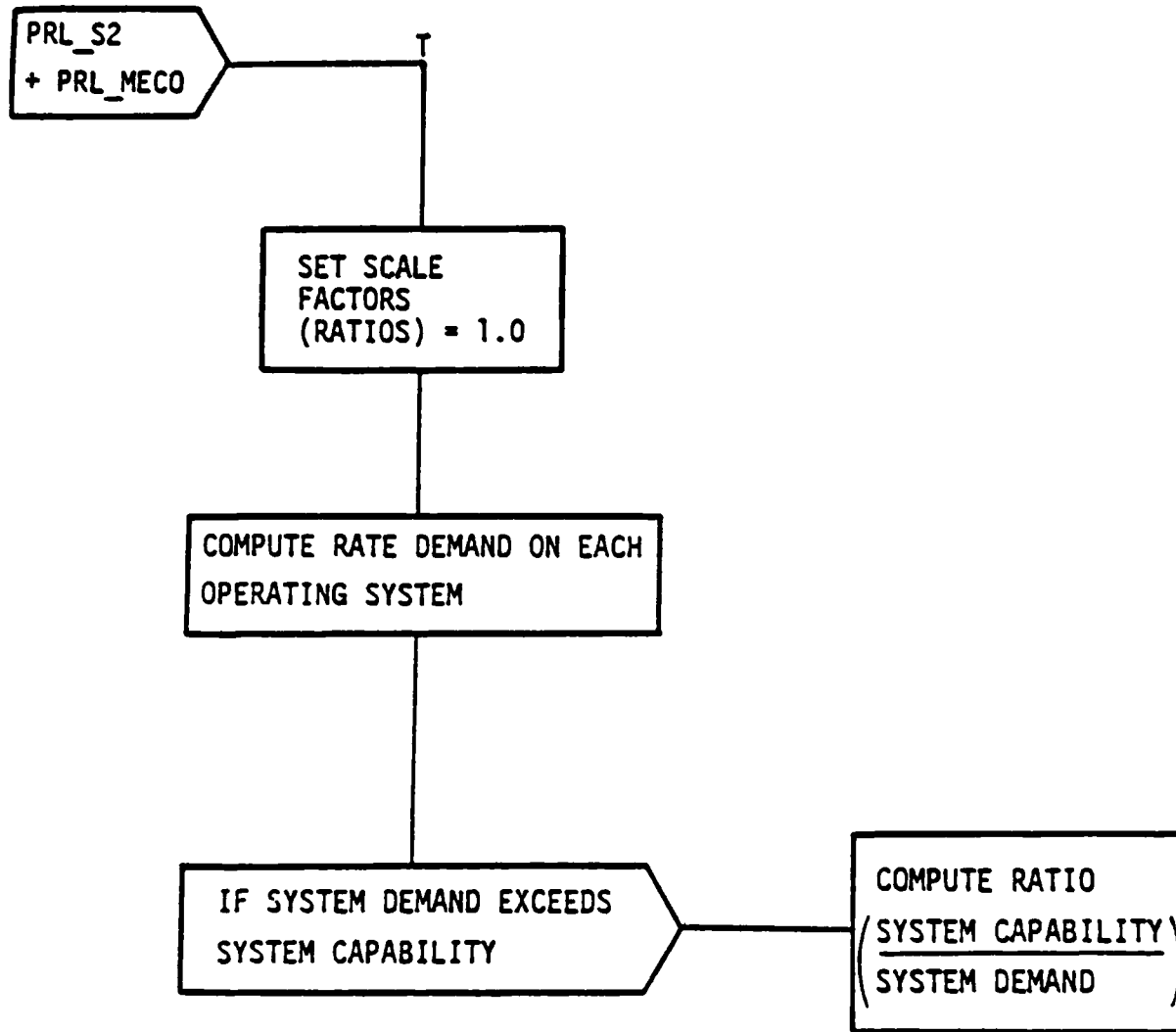
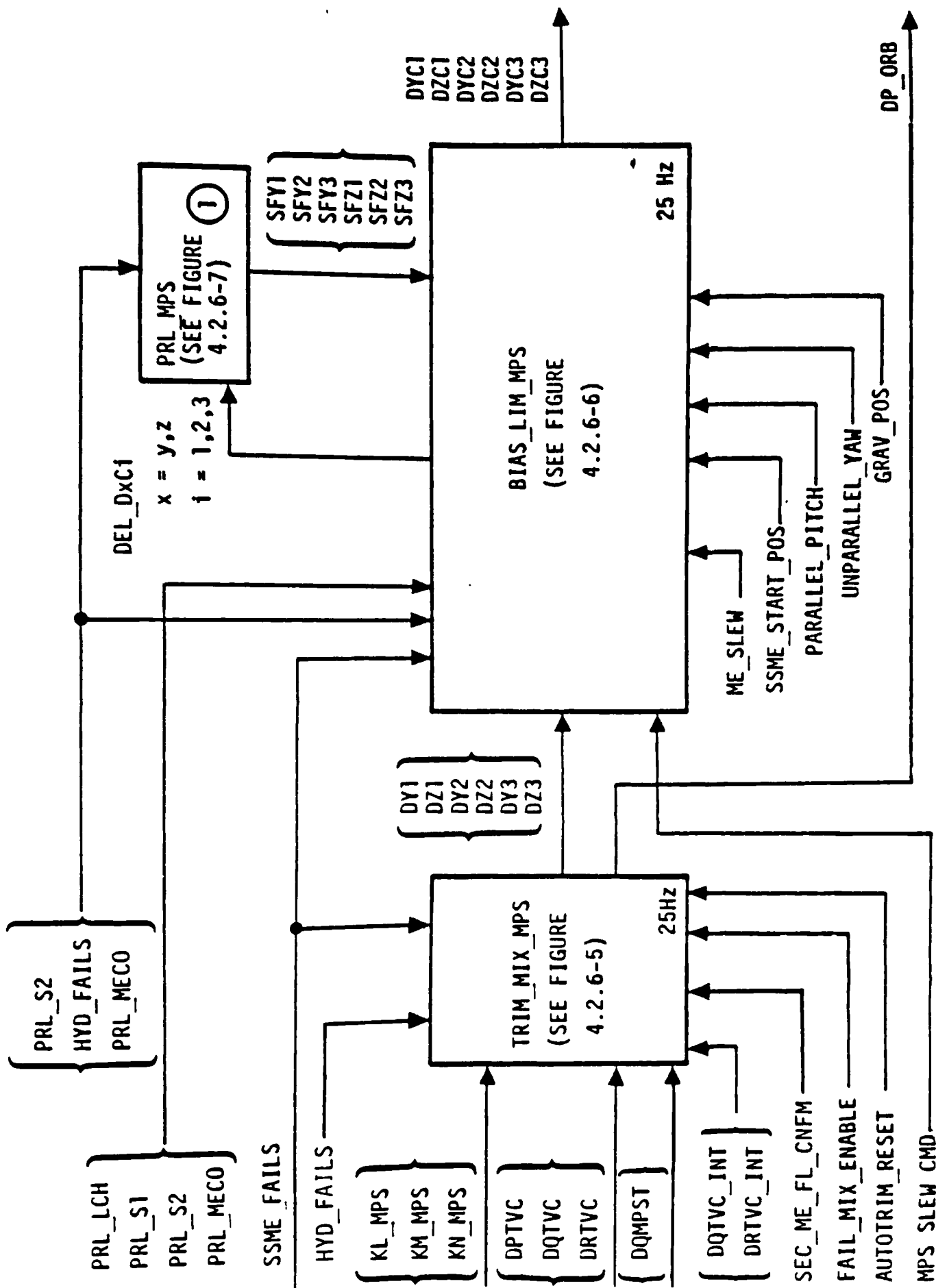


Figure 4.2.6-2. Priority Rate Limiting Logic, Functional Flow Chart



① Priority Rate Limiting is not Executed in MM102

Figure 4.2.6-3. CMD_PROC_MPS, Software Overview



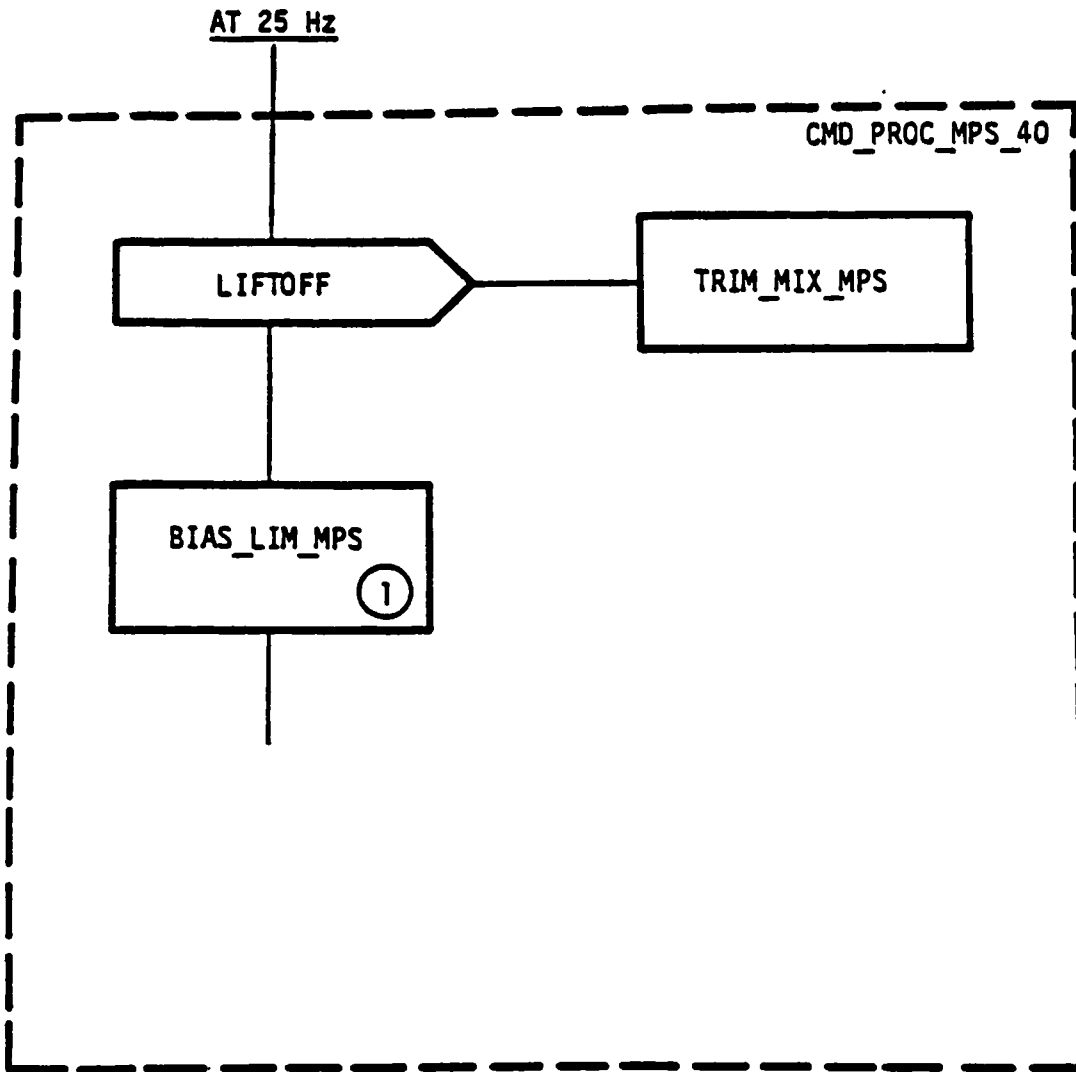
Table 4.2.6-2. CMD_PROC_MPS Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Inputs</u>						
	DPTVC	Roll TVC loop error signal	ASC_TVC	S		deg/s	25
	DQTV	Pitch TVC loop error signal	ASC_TVC	S		deg/s	25
	DRTVC	Yaw TVC loop error signal	ASC_TVC	S		deg/s	25
	DQMPST	Pitch thrust vector deflection trim, MPS	INTERPS	S		deg	6.25
	KL_MPS	Variable gain (roll rate, MPS)	INTERPS	S		$\frac{\text{deg}}{\text{deg s}}$	6.25
	KM_MPS	Variable gain (pitch rate, MPS)	INTERPS	S		$\frac{\text{deg}}{\text{deg s}}$	6.25
	KN_MPS	Variable gain (yaw rate, MPS)	INTERPS	S		$\frac{\text{deg}}{\text{deg s}}$	6.25
	MPS_SLEW_CMD	MPS actuator slew position command	ORB_ACT_SLEW	S		-	25
	SSME_FAILS	Indicator, main engine failures	ASC_RECON	B		-	12.5
	SSME_START_POS	Indicator	ASC_RECON	B		-	12.5
	ME_SLEW	Indicator	ASC_RECON	B		-	12.5
	HYD_FAILS	Indicator, hydraulic system failure	ASC_RECON	I		-	12.5
	PRL_MECO	Indicator	ASC_RECON	B		-	12.5
	PRL_LCH	Indicator	ASC_RECON	B		-	12.5
	FAIL_MIX_ENABLE	Indicator	ASC_RECON	B		-	12.5
	PARALLEL_PITCH	Indicator	ASC_RECON	B		-	12.5
	PRL_S2	Indicator, Stage 2 control	ASC_RECON	B		-	12.5
	UNPARALLEL_YAW	Indicator	ASC_RECON	B		-	12.5
	DQTV_INT	Pitch trim integ output	ASC_TVC	S		deg/s	25
	DRTVC_INT	Yaw trim integ output	ASC_TVC	S		deg/s	25
	MECO_CMD	Indicator	ASC_RECON	B		-	12.5
	SSME_LCH_POS	Indicator	ASC_RECON	B		-	12.5
	GRAV_POS	Indicator	ASC_RECON	B		-	12.5

Table 4.2.6-2. CMD_PROC_MPS Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Inputs (Cont)</u>						
	MM101_INIT	Indicator	ASC_RECON	B		-	12.5
	AUTOTRIM_RESET	Indicator	ASC_RECON	B		-	12.5
	PRELO	Indicator	ASC_RECON	B		-	12.5
	PRL_S1	Indicator	ASC_RECON	B		-	12.5
	SEC_ME_FL_CNFM	Indicator	ASC_RECON	B		-	12.5
	<u>Outputs</u>						
	DYC1	Engine bell deflection command SSME 1 pitch	MPS_TVC_CMD_SOP	S		deg	25
	DZC1	Engine bell deflection command SSME 1 yaw	MPS_TVC_CMD_SOP	S		deg	25
	DYC2	Engine bell deflection command SSME 2 pitch	MPS_TVC_CMD_SOP	S		deg	25
	DZC2	Engine bell deflection command SSME 2 yaw	MPS_TVC_CMD_SOP	S		deg	25
	DYC3	Engine bell deflection command SSME 3 pitch	MPS_TVC_CMD_SOP	S		deg	25
	DZC3	Engine bell deflection command SSME 3 yaw	MPS_TVC_CMD_SOP	S		deg	25
	DP_ORB	Orbiter roll loop error signal	CMD_PROC_RCS	S		deg s	25

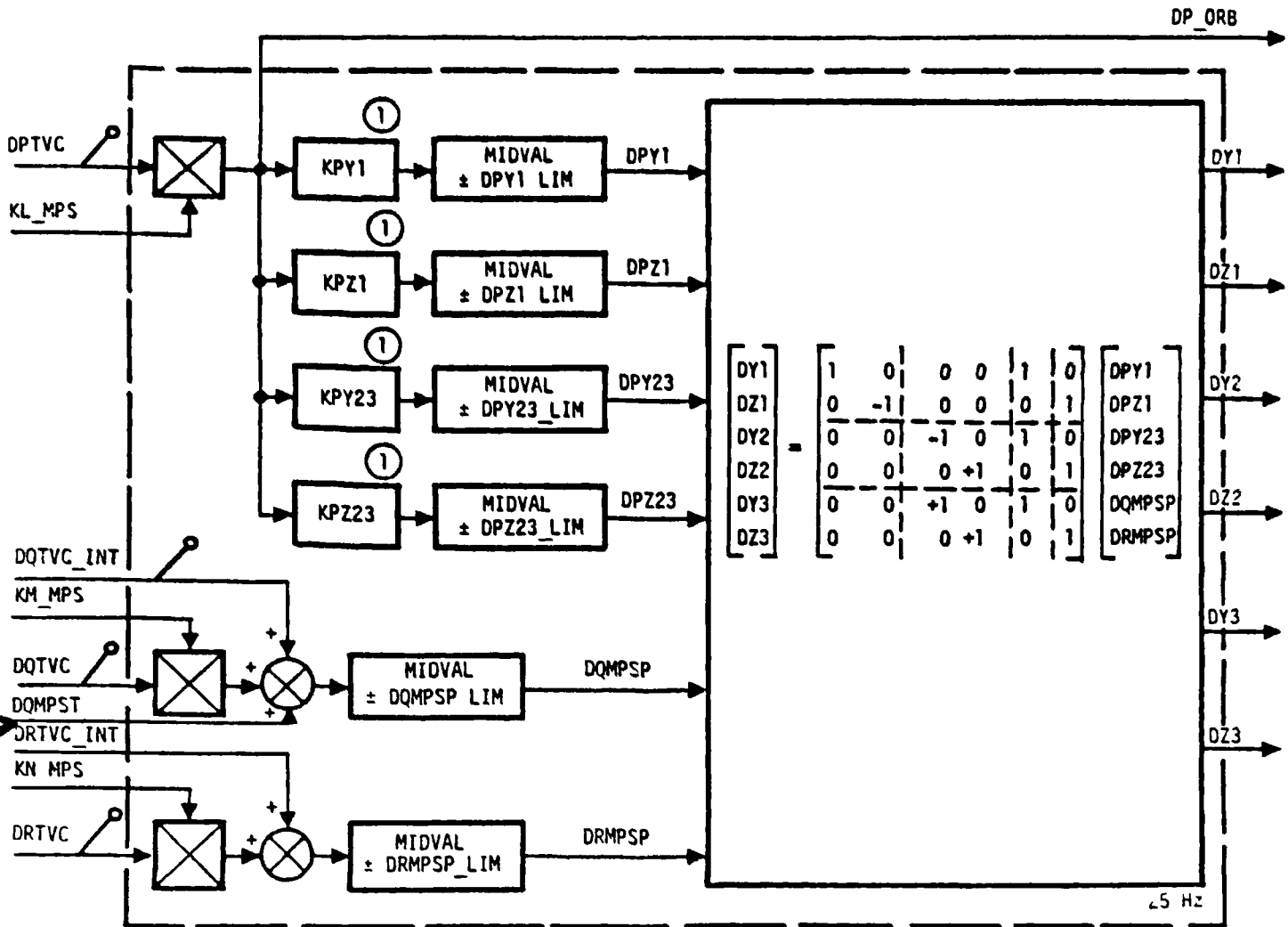
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① THIS MODULE PERFORMS THE SLEW TEST AND PRIORITY RATE LIMITING (PRL).

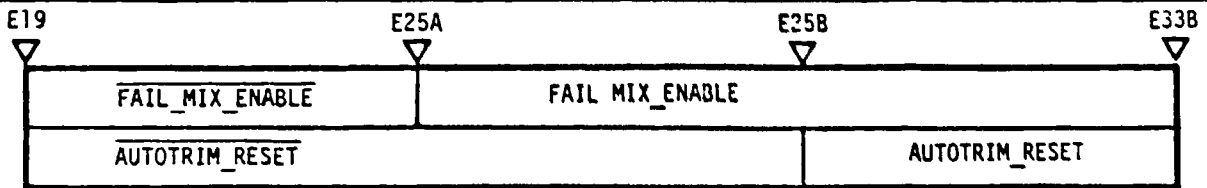
Figure 4.2.6-4. CMD_PROC_MPS Function Module Sequence Requirements

*Second Stage
Trimming*



NOTE ①

ROLL MIXING GAINS	$\overline{(\text{FAIL_MIX_ENABLE})}$ $+(\text{AUTOTRIM_RESET})$ •(SSME_FAILS = 0) •(HYD_FAILS < 4)	(AUTOTRIM_RESET) •(SSME_FAILS = 0) •(HYD_FAILS < 4)	(FAIL_MIX_ENABLE) ② •[(SSME_FAILS = 1 ≠ 0) + (HYD_FAILS = j > 3)]			SEC_ME FL_CNFM
			i = 1 + j = 5	i = 2 + j = 4	i = 3 + j = 6	
KPY1	0.0	0.0	0.0	2.5 -KPY1_FAIL23	2.5 KPY1_FAIL23	0.0
KPZ1	0.75 KPZ1_NOM	0.75 KPZ1_NOM	0.75 KPZ1_NOM	2.0 KPZ1_FAIL23	2.0 KPZ1_FAIL23	0.35
KPZ23	0.0	0.0	0.0	2.0 KPZ23_FAIL23	2.0 KPZ23_FAIL23	- 0.35
KPY23	1	2.5 KPY23_S2C	2.5 KPY23_S2C	2.5 KPY23_S2C	2.5 KPY23_S2C	0.35



- Note ② : If after an SSME fails or is locked up, a different SSME locks up or is failed, respectively, do not change roll-mixing gains.
- Note ③ . If the failure transitions from (SSME FAILS = 0 and HYD FAILS > 3) to (SSME FAILS = 0 and HYD FAILS < 3), change back to the appropriate nonfailure roll-mixing gains

Figure 4.2.6-5. TRIM_MIX_MPS Function Module, Detailed Diagram

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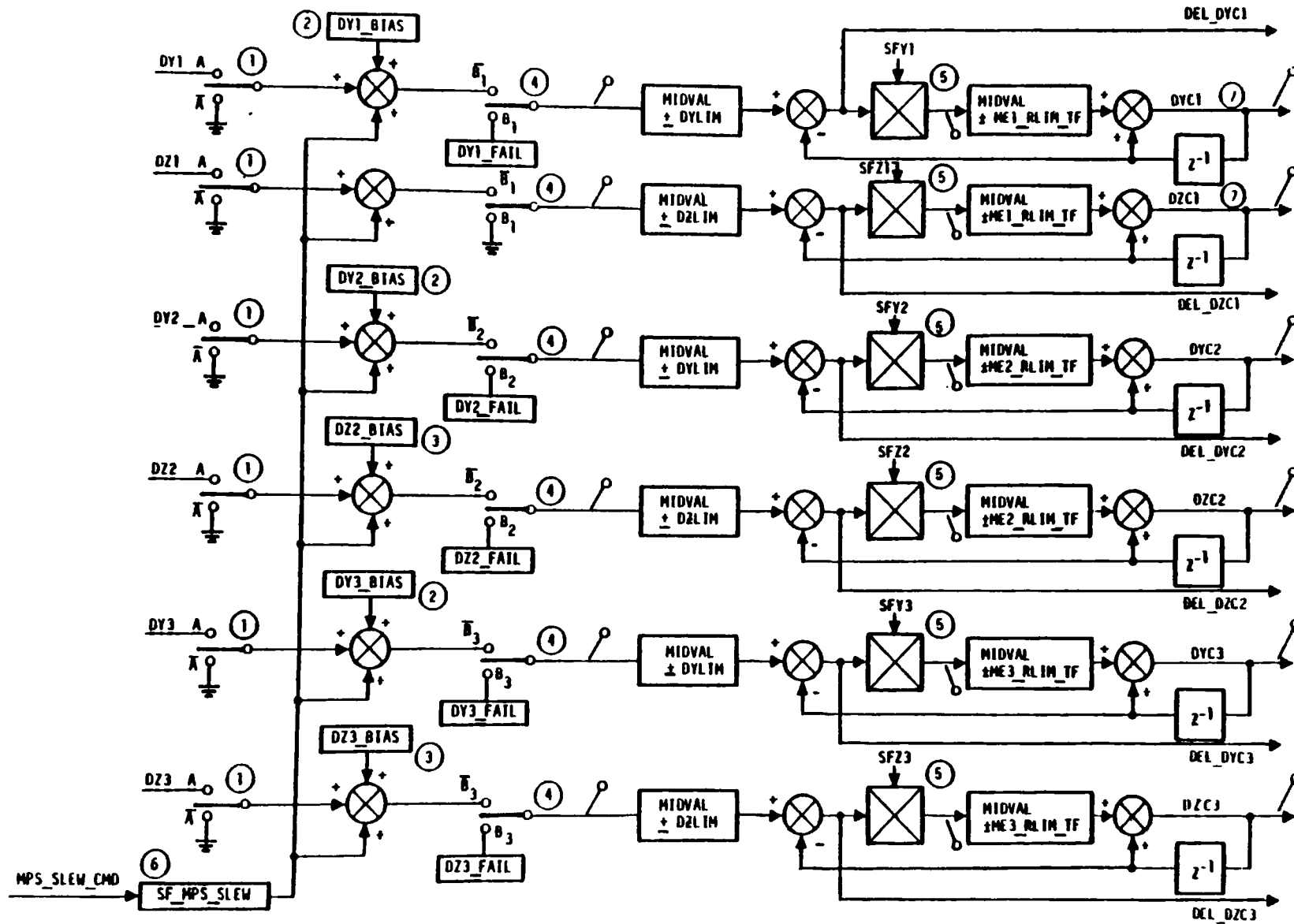


Figure 4.2.6-6. BIAS_LIM_MPS Modules, Detailed Diagram (Sheet 1 of 3)

NOTES

① $A = S1C + S2C = \overline{PRELO}$

②	SSME_START_POS	$(SSME_FAILS = 4) +$ $(ME_SLEW \cdot SSME_LCH_POS) +$ $(SSME_LCH_POS \cdot$ $\overline{PARALLEL_PITCH})$	PARALLEL PITCH		GRAV_POS	MM101_INIT
			SSME FAILS = 0	SSME FAILS = 2 OR 3		
DY1_BIAS DY2_BIAS DY3_BIAS	DY1_START DY2_START DY3_START	0.0 0.0 0.0	+4 DEG -2 DEG -2 DEG	+ PITCH_BIAS_PARALLEL - PITCH_BIAS_PARALLEL - PITCH_BIAS_PARALLEL	DY1_GRAV DY2_GRAV DY3_GRAV	CARRYOVER VALUES FROM GNC OPS 9 (V4.18)
③	SSME_START_POS	$(SSME_FAILS = 4) +$ $MECO_CMD +$ $(SSME_LCH_POS \cdot$ $ME_SLEW) +$ $\overline{UNPARALLEL_YAW}$	UNPARALLEL_YAW		GRAV_POS	MM101_INIT
			<ul style="list-style-type: none"> • SSME_LCH_POS • MECO_CMD 			
DZ2_BIAS DZ3_BIAS	DZ2_START DZ3_START	0.0 0.0	- YAW_BIAS_NOM + YAW_BIAS_NOM		DZ2_GRAV DZ3_GRAV	CARRYOVER VALUES FROM GNC OPS 9 (V4.18)

④ B_i IS TRUE IF SSME FAILS = i OR SSME FAILS = 4 AND THE ith ENGINE WAS THE FIRST ONE DETECTED TO BE FAILED. IN THE CASE OF SIMULTANEOUS FAILURES ONLY THE LOWEST NUMBERED FAILED ENGINE WILL BE PLACED IN THE FAILED POSITION.

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Figure 4.2.6-6. BIAS_LIM_MPS Modules, Detailed Diagram (Sheet 2 of 3)

⑤ RATE LIMIT ON GOOD ENGINES (ME1_RLIM_TF) IS DEFINED AS FOLLOWS:

PRL_LCH + ME_RESTART	PRL_S1			PRL_S2 + PRL_MECO
	HYD_FAILS =			
	0	1, 2, OR 3	≥ 4	
RATE_CAPABILITY_ LIFTOFF	RATE_CAPABILITY_ NOFAIL	RATE_CAPABILITY_ ONE_FAIL	RATE_CAPABILITY_ TWO_FAIL	SSME_RLIM_NOM

PRIOR TO MECO_CMD

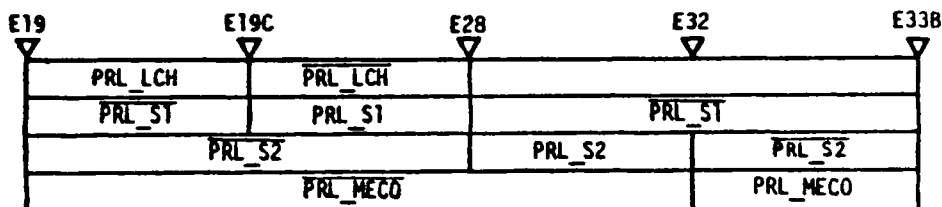
ON FIRST FAILED ENGINE RATE_CAPABILITY = SSME_RLIM_FAIL

ON 2ND FAILED ENGINE DON'T CHANGE RATE LIMIT

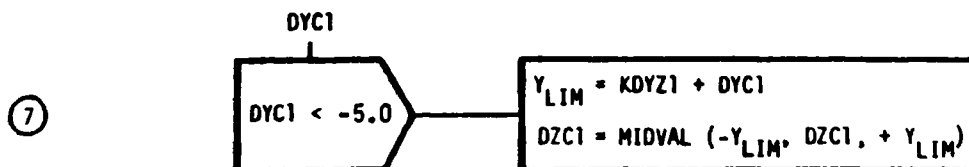
SSME_RLIM_FAIL WILL BE USED FOR ENGINE 1 IF SSME_FAILS = 1 OR SSME_FAILS = 4 AND THE 1ST ENGINE WAS THE FIRST ONE DETECTED TO HAVE FAILED. IN THE CASE OF SIMULTANEOUS FAILURES, SSME_RLIM_FAIL WILL ONLY BE USED FOR THE LOWEST NUMBERED FAILED ENGINE.

AFTER MECO_CMD

DON'T CHANGE THE RATE LIMIT ON ANY FAILED ENGINE



⑥	SF_MPS_SLEW	ME_SLEW	ME_SLEW + SSME_START_POS
		SF_MPS_SLEW_NOM	0.0



WHERE KDYZ1 = 13.7 DEG; KDYZ1 IS REQUIRED TO BE AN INDEPENDENT CONSTANT

Figure 4.2.6-6. BIAS_LIM_MPS Modules, Detailed Diagram (Sheet 3 of 3)

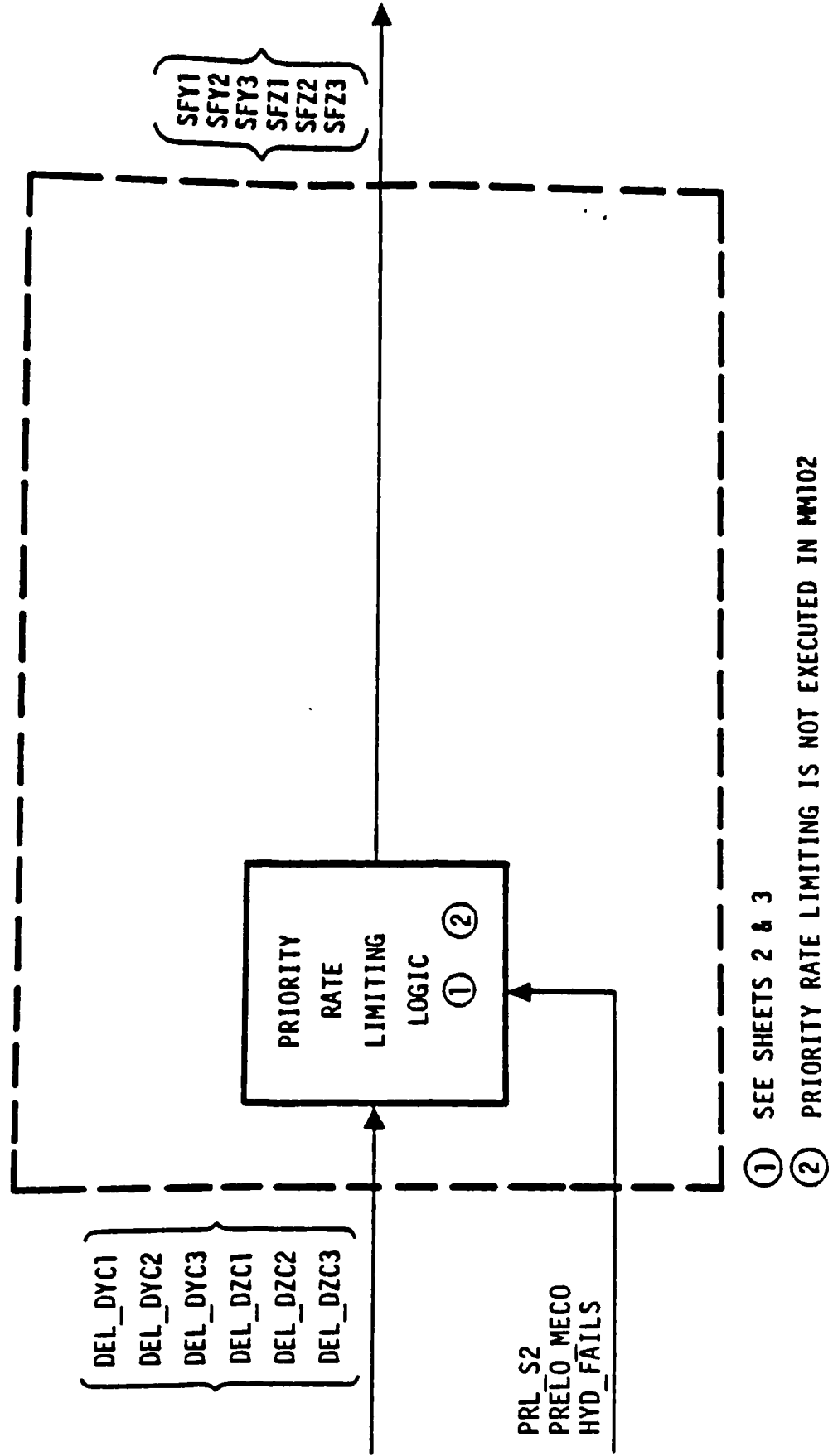
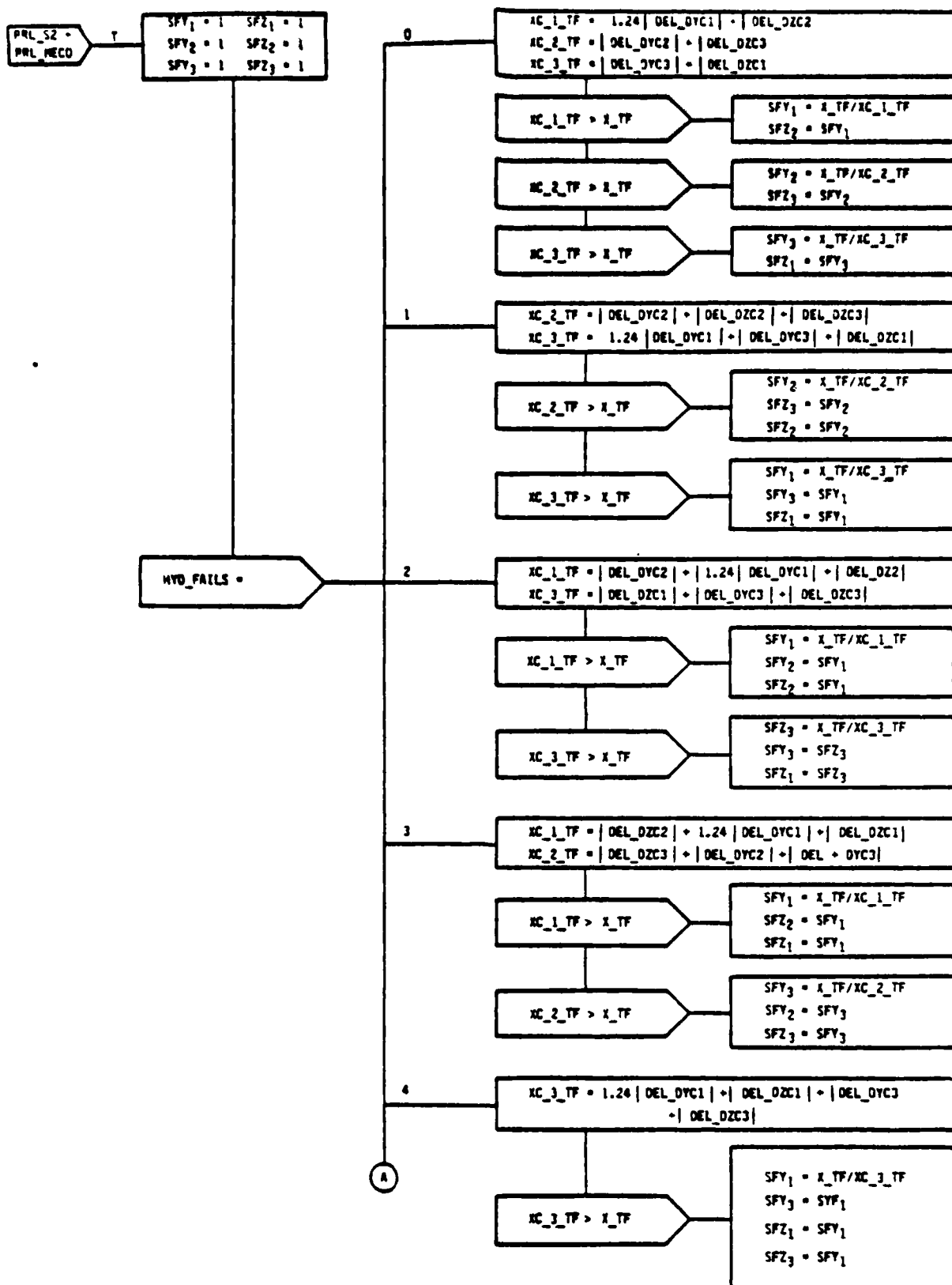


Figure 4.2.6-7. PRL MPS Function Module, Detailed Diagram (Sheet 1 of 3)



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Figure 4.2.6-7. PRL_MPS Function Module, Detailed Diagram (Sheet 2 of 3)

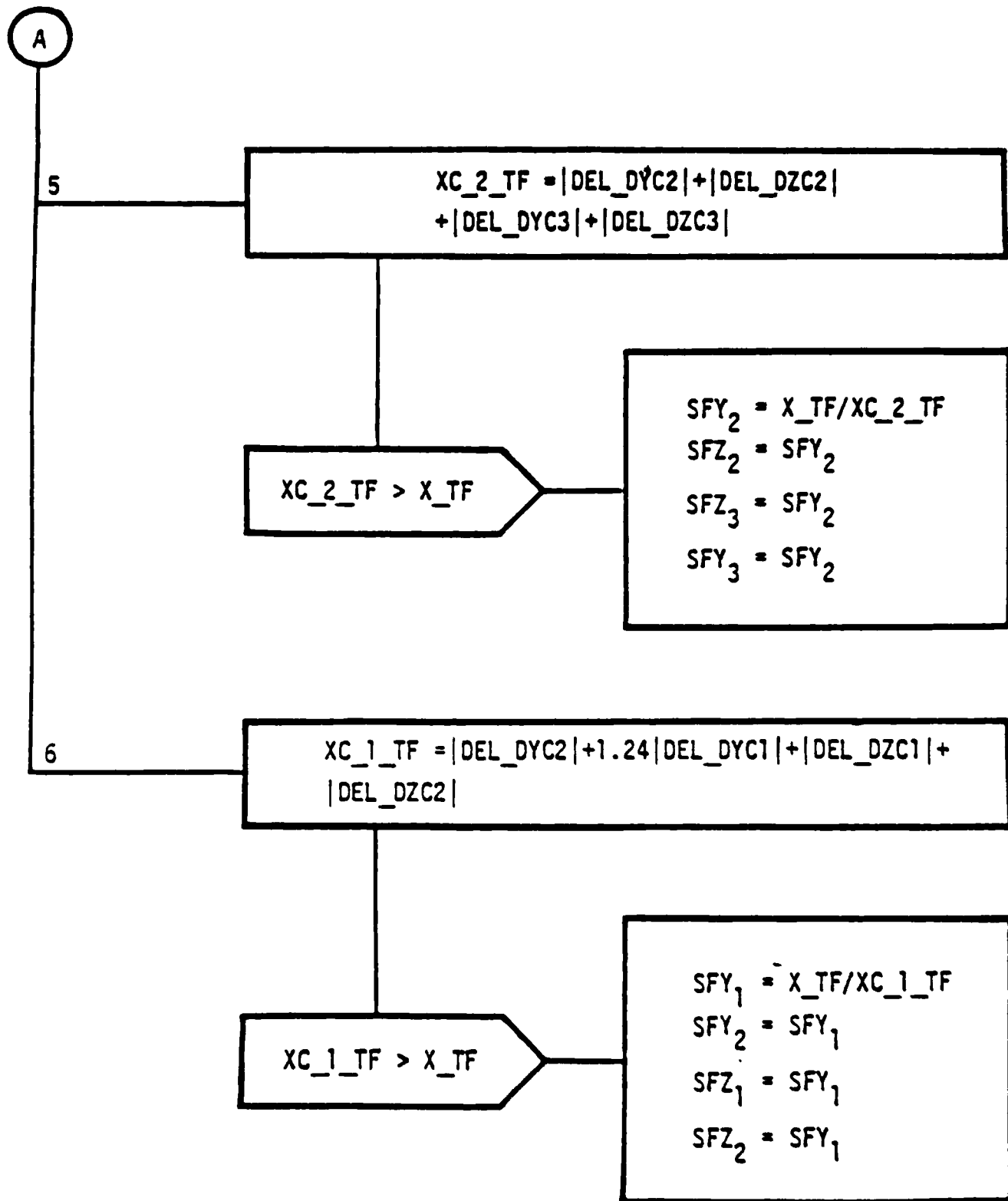


Figure 4.2.6-7. PRL_MPS Function Module, Detailed Diagram (Sheet 3 of 3)

Table 4.2.6-3. CMD_PROC_MPS Inter-Module Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
TRIM MIX_MPS	<u>Inputs</u>						
	DPTVC	Roll TVC loop error signal	ASC_TVC	S		deg/s	25
	DQTVC	Pitch TVC loop error signal	ASC_TVC	S		deg/s	25
	DQTVC_INT	Pitch TVC integrator output	ASC_TVC	S		deg	12.5
	DRTVC	Yaw TVC loop error signal	ASC_TVC	S		deg/s	25
	DRTVC_INT	Yaw TVC integrator output	ASC_TVC	S		deg	12.5
	DQMPST	Pitch thrust vector deflection trim, MPS	INTERPS	S		deg	6.25
	KL_MPS	Fixed gain (roll rate, MPS)	INTERPS	S		$\frac{\text{deg}}{\text{deg/s}}$	6.25
	KM_MPS	Variable gain (pitch rate, MPS)	INTERPS	S		$\frac{\text{deg}}{\text{deg/s}}$	6.25
	KN_MPS	Variable gain (yaw rate, MPS)	INTERPS	S		$\frac{\text{deg}}{\text{deg/s}}$	6.25
	AUTOTRIM_RESET	Indicator	ASC_RECON	B		-	12.5
	MM101_INIT	Indicator	ASC_RECON	B		-	12.5
	FAIL_MIX_ENABLE	Indicator	ASC_RECON	B		-	12.5
	SSME_FAILS	Indicator	ASC_RECON	B		-	12.5
	SEC_ME_FL_CNFM	Indicator, 2nd SSME fail confirmed	ASC_RECON	B		-	12.5
	HYD_FAILS	Indicator hydraulic system failure	ASC_RECON	I		-	12.5
	<u>Outputs</u>						
	DY1	Pitch command, SSME 1	BIAS_LIM_MPS	S		deg	25
	DZ1	Yaw command, SSME 1	BIAS_LIM_MPS	S		deg	25
	DY2	Pitch command, SSME 2	BIAS_LIM_MPS	S		deg	25
	DZ2	Yaw command, SSME 2	BIAS_LIM_MPS	S		deg	25
	DY3	Pitch command, SSME 3	BIAS_LIM_MPS	S		deg	25
	DZ3	Yaw command, SSME 3	BIAS_LIM_MPS	S		deg	25
DP_ORB	Orbiter roll loop error signal	CMD_PROC_RCS	S		deg/s	25	

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Table 4.2.6-3. CMD_PROC_MPS Inter-Module Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
BIAS LIM_MPS	<u>Inputs</u>						
	DPTVC	Roll TVC loop error signal	ASC_TVC	S		deg/s	25
	DQTVC	Pitch TVC loop error signal	ASC_TVC	S		deg/s	25
	DQTVC_INT	Pitch TVC integrator output	ASC_TVC	S		deg	12.5
	DRTVC	Yaw TVC loop error signal	ASC_TVC	S		deg/s	25
	DRTVC_INT	Yaw TVC integrator output	ASC_TVC	S		deg	12.5
	DQMPST	Pitch thrust vector deflection trim, MPS	INTERPS	S		deg	6.25
	KL_MPS	Fixed gain (roll rate, MPS)	INTERPS	S		$\frac{\text{deg}}{\text{deg/s}}$	6.25
	KM_MPS	Variable gain (pitch rate, MPS)	INTERPS	S		$\frac{\text{deg}}{\text{deg/s}}$	6.25
	KN_MPS	Variable gain (yaw rate, MPS)	INTERPS	S		$\frac{\text{deg}}{\text{deg/s}}$	6.25
	AUTOTRIM_RESET	Indicator	ASC_RECON	B		-	12.5
	MM101_INIT	Indicator	ASC_RECON	B		-	12.5
	FAIL_MIX_ENABLE	Indicator	ASC_RECON	B		-	12.5
	SSME_FAILS	Indicator	ASC_RECON	B		-	12.5
	SEC_ME_FL_CNFM	Indicator, 2nd SSME fail confirmed	ASC_RECON	B		-	12.5
	HYD_FAILS	Indicator hydraulic system failure	ASC_RECON	I		-	12.5
	<u>Outputs</u>						
	DY1	Pitch command, SSME 1	BIAS_LIM_MPS	S		deg	25
	DZ1	Yaw command, SSME 1	BIAS_LIM_MPS	S		deg	25
	DY2	Pitch command, SSME 2	BIAS_LIM_MPS	S		deg	25
	DZ2	Yaw command, SSME 2	BIAS_LIM_MPS	S		deg	25
	DY3	Pitch command, SSME 3	BIAS_LIM_MPS	S		deg	25
	DZ3	Yaw command, SSME 3	BIAS_LIM_MPS	S		deg	25
DP_ORB	Orbiter roll loop error signal	CMD_PROC_RCS	S		deg/s	25	

Table 4.2.6-3. CMD_PROC_MPS Inter-Module Interface Requirements (Cont).

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Inputs</u>						
BIAS_LIM_MPS	DY1	Pitch command, SSME 1	TRIM_MIX_MPS	S		deg	25
	DZ1	Yaw command, SSME 1	TRIM_MIX_MPS	S		deg	25
	DY2	Pitch command, SSME 2	TRIM_MIX_MPS	S		deg	25
	DZ2	Yaw command, SSME 2	TRIM_MIX_MPS	S		deg	25
	DY3	Pitch command, SSME 3	TRIM_MIX_MPS	S		deg	25
	DZ3	Yaw command, SSME 3	TRIM_MIX_MPS	S		deg	25
	MM101_INIT	Indicator	ASC_RECON	B		-	12.5
	GRAV_POS	Indicator	ASC_RECON	B		-	12.5
	ME_RESTART	Indicator	ASC_RECON	B		-	12.5
	SSME_START_POS	Indicator	ASC_RECON	B		-	12.5
	SSME_LCH_POS	Indicator	ASC_RECON	B		-	12.5
	SSME_FAILS	Indicator, main engine failure status	ASC_RECON	I		-	12.5
	ME_SLEW	Indicator	ASC_RECON	B		-	12.5
	PRL_LCH	Indicator	ASC_RECON	B		-	12.5
	PARALLEL_PITCH	Indicator	ASC_RECON	B		-	12.5
	PRL_MECO	Indicator	ASC_RECON	B		-	12.5
	UNPARALLEL_YAW	Indicator	ASC_RECON	B		-	12.5
	PRL_S1	Indicator	ASC_RECON	B		-	12.5
	HYD_FAILS	Indicator	ASC_RECON	I		-	12.5
	MPS_SLEW_CMD	MPS actuator slew position command	ORB_ACT_SLEW	S		-	25
	PRL_S2	Indicator	ASC_RECON	B		-	12.5
	SFY1	ME1 pitch rate scale factor	PRL_MPS	S		deg	12.5
	SFZ1	ME1 yaw rate scale factor	PRL_MPS	S		deg	12.5
	SFY2	ME2 pitch rate scale factor	PRL_MPS	S		deg	12.5
	SFZ2	ME2 yaw rate scale factor	PRL_MPS	S		deg	12.5
	SFY3	ME3 pitch rate scale factor	PRL_MPS	S		deg	12.5
	SFZ3	ME3 yaw rate scale factor	PRL_MPS	S		deg	12.5
	MECO_CMD	Indicator	ASC_RECON	B		-	12.5

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Table 4.2.6-3. CMD_PROC_MPS Inter-Module Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Outputs</u>						
	DYCI DZC1 DYC2 DZC2 DYC3 DZC3	Main engine bell deflection commands with priority rate limiting	MPS_TVC_CMD_SOP	S		-	25
	DEL_DYCI DEL_DZC1 DEL_DYC2 DEL_DZC2 DEL_DYC3 DEL_DZC3						
PRL_MPS	<u>Inputs</u>						
	DEL_DYCI	ME1 pitch bell deflection command increment without priority rate limiting	BIAS_LIM_MPS	S		deg	25
	DEL_DZC1	ME1 yaw bell deflection command increment without priority rate limiting	BIAS_LIM_MPS	S		deg	25
	DEL_DYC2	ME2 pitch bell deflection command increment without priority rate limiting	BIAS_LIM_MPS	S		deg	25
	DEL_DZC2	ME2 yaw bell deflection command increment without priority rate limiting	BIAS_LIM_MPS	S		deg	25
	DEL_DYC3	ME3 pitch bell deflection command increment without priority rate limiting	BIAS_LIM_MPS	S		deg	25
	DEL_DZC3	ME3 yaw deflection command increment without priority rate limiting	BIAS_LIM_MPS	S		deg	25
	HYD_FAILS	Indicator	ASC_RECON	I		-	12.5
	MM101_INIT	Indicator	ASC_RECON	B		-	12.5
	PRL_MECO	Indicator	ASC_RECON	B		-	12.5
	PRL_S2	Indicator	ASC_RECON	B		-	12.5

Table 4

Module	Page
PRL_MPS (Cont)	SFY1
	SFY2
	SFY3
	SFY3
	SFY3

Table 4.2.6-3. CMD_PROC_MPS Inter-Module Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Producer! At (Hz)
PRL_MPS (Cont)	<u>Outputs</u>						
	SFY1	Rate scale factor, SSME 1 pitch	BIAS_LIM_MPS	S		deg	25
	SFZ1	Rate scale factor, SSME 1 yaw	BIAS_LIM_MPS	S		deg	25
	SFY2	Rate scale factor, SSME 2 pitch	BIAS_LIM_MPS	S		deg	25
	SFZ2	Rate scale factor, SSME 2 yaw	BIAS_LIM_MPS	S		deg	25
	SFY3	Rate scale factor, SSME 3 pitch	BIAS_LIM_MPS	S		deg	25
	SFZ3	Rate scale factor, SSME 3 yaw	BIAS_LIM_MPS	S		deg	25

Table 4.2.6-4. CMD_PROC_MPS Initialization Requirements

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
TRIM MIX_MPS	Roll mixing gains		MM101_INIT	KPY1, KPZ23	0.0
				KPZ1	KPZ1_NOM
				KPY23	1.0
		$A \cdot (SSME_FAILS = 0) \cdot (HYD_FAILS < 4)$	$A \cdot [(SSME_FAILS > 1) + (HYD_FAILS = 4) + (HYD_FAILS = 6)]$	KPZ1 KPZ23	KPZ1_FAIL23 KPZ23_FAIL23
		$A \cdot \bar{B} \cdot (SSME_FAILS = 0) \cdot (HYD_FAILS < 4)$	$A \cdot \bar{B} \cdot [(SSME_FAILS > 0) + (HYD_FAILS > 3)]$	KPY23	KPY23_S2C
		$A \cdot (SSME_FAILS = 0) \cdot (HYD_FAILS < 4)$	$A \cdot [(SSME_FAILS = 2) + (HYD_FAILS = 4)]$	KPY1	-KPY1_FAIL23
		$A \cdot (SSME_FAILS = 0) \cdot (HYD_FAILS < 4)$	$A \cdot [(SSME_FAILS = 3) + (HYD_FAILS = 6)]$	KPY1	KPY1_FAIL23
		$\bar{B} \cdot (SSME_FAILS = 0) \cdot (HYD_FAILS < 4)$	$B \cdot (SSME_FAILS = 0) \cdot (HYD_FAILS < 4)$	KPY23	KPY23_S2C
		$\bar{A} \cdot [(SSME_FAILS > 0) + (HYD_FAILS > 3)]$	$A \cdot [(SSME_FAILS > 0) + (HYD_FAILS > 3)]$	KPY23	KPY23_S2C
		$\bar{A} \cdot [(SSME_FAILS = 2) + (HYD_FAILS = 4)]$	$A \cdot [(SSME_FAILS = 2) + (HYD_FAILS = 4)]$	KPY1	-KPY1_FAIL23
		KPY1	KPY1_FAIL23		
		KPZ1 KPZ23	KPZ1_FAIL23 KPZ23_FAIL23		
	Where A = FAIL_MIX_ENABLE and B = AUTOTRIM_RESET	SEC_ME_FL_CNFM	SEC_ME_FL_CNFM	KPY1, KPY23, KPZ1, KPZ23	0.0 .35 .35 -.35
BIAS LIM_MPS	Pitch bias offset		MM101_INIT	DY1_BIAS DY2_BIAS DY3_BIAS	*
		<u>PARALLEL_PITCH</u>	PARALLEL_PITCH · (SSME_FAILS = 2 or 3)	DY1_BIAS DY2_BIAS DY3_BIAS	PITCH_BIAS_ PARALLEL -PITCH_BIAS_ PARALLEL -PITCH_BIAS_ PARALLEL
		<u>PARALLEL_PITCH</u>	PARALLEL_PITCH · (SSME_FAILS = 0)	DY1_BIAS DY2_BIAS DY3_BIAS	+4 DEG -2 DEG -2 DEG
*Carry over values from GNC OPS 9 (V4.18)					

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Table 4.2.6-4. CMD_PROC_MPS Initialization Requirements (Cont)

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
BIAS LIM_MPS (Cont)		PARALLEL_PITCH * SSME_FAILS < 4	PARALLEL_PITCH + SSME_FAILS = 4	DY1_BIAS DY2_BIAS DY3_BIAS	0.0 0.0 0.0
		-	MM101_INIT + SSME_START_POS	SF_MPS_SLEW	0.0
		ME_SLEW	ME_SLEW	SF_MPS_SLEW	0.0
		ME_SLEW	ME_SLEW	SF_MPS_SLEW	SF_MPS_SLEW_NOM
		-	MM101_INIT	D22_BIAS D23_BIAS	*
		UNPARALLEL_YAW	UNPARALLEL_YAW	D22_BIAS D23_BIAS	0.0 0.0
		MECO_CMD	MECO_CMD	D22_BIAS D23_BIAS	0.0 0.0
		SSME_FAILS < 4	SSME_FAILS = 4	D22_BIAS D23_BIAS	0.0 0.0
		-	MM101_INIT	DY1 DZ1 DY2 DZ2 DY3 DZ3	0.0 0.0 0.0 0.0 0.0 0.0
		ME_SLEW	ME_SLEW	DY1_BIAS DY2_BIAS DY3_BIAS D22_BIAS D23_BIAS	0.0 0.0 0.0 0.0 0.0
		(SSME_LCH_POS)	(SSME_LCH_POS)		
		SSME_START_POS	SSME_START_POS	DY1_BIAS DY2_BIAS DY3_BIAS D22_BIAS D23_BIAS	DY1_START DY2_START DY3_START D22_START D23_START
		SSME_LCH_POS	SSME_LCH_POS	DY1_BIAS DY2_BIAS DY3_BIAS D22_BIAS D23_BIAS	0.0 0.0 0.0 -YAW_BIAS_NOM +YAW_BIAS_NOM
		-	MM101_INIT	ME1_RLIM_TF ME2_RLIM_TF ME3_RLIM_TF	(7)
		(SSME_FAILS = 0)	(SSME_FAILS = i), i = 1, 2, 3	MEi_RLIM_TF i = 1, 2, 3	(2)
		PRL_S1 + HYD_FAILS = 0	(SSME_FAILS = 0) * PRL_S1 * (HYD_FAILS = 0)	ME1_RLIM_TF	(8)

* Carry over values from GNC OPS 9 (V4.18)

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Table 4.2.6-4. CMD_PROC_MPS Initialization Requirements (Cont)

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
BIAS_LIM_MPS (Cont)	Engine bell deflection commands	PRL_S1 + HYD_FAILS ≠ 1,2,3	(SSME_FAILS = 0) · PRL_S1 · (HYD_FAILS = 1 or 2, or 3)	ME1_RLIM_TF	⑨
		PRL_S1 + HYD_FAILS ≠ 4	(SSME_FAILS = 0) · PRL_S1 · (HYD_FAILS ≥ 4)	ME1_RLIM_TF	⑩
		(SSME_FAILS = 0) · PRL_S1 ·	(SSME_FAILS = 0) · PRL_S1	ME1_RLIM_TF	- ①
		(SSME_FAILS = 0) · PRL_S1 · (HYD_FAILS = 0)	(SSME_FAILS = 0) · PRL_S1 · (HYD_FAILS = 1 or 2, or 3)	ME1_RLIM_TF	⑨
		ME_RESTART_POS	ME_RESTART_POS	ME1_RLIM_TF ME2_RLIM_TF ME3_RLIM_TF	⑦
		SSME_FAILS = 0	SSME_FAILS = 4	ME1_RLIM_TF i = **	②
	GRAV_POS	GRAV_POS	DYC1 DZC1 DYC2 DZC2 DYC3 DZC3	DY1_GRAV 0.0 DY2_GRAV DZ2_GRAV DY3_GRAV DZ3_GRAV	
PRL_MPS	Rate scale factors	PRL_S1 · (HYD_FAILS < 4)	PRL_S2	X_TF	③
		PRL_S2 · (HYD_FAILS < 4)	PRL_MECO	X_TF	⑤
		PRL_S1 + HYD_FAILS < 4	PRL_S2 · ≥ HYD_FAILS 4	X_TF	④
		PRL_S2 + (HYD_FAILS < 4)	PRL_MECO · ≥ (HYD_FAILS 4)	X_TF	⑥
		-	MM101_INIT	SFY1 SFZ1 SFY2 SFZ2 SFY3 SFZ3	1.0 1.0 1.0 1.0 1.0 1.0
		① SSME_RLIM_NOM	⑥ RATE_CAPABILITY_MECO_2_FAILS		
		② SSME_RLIM_FAIL	⑦ RATE_CAPABILITY_LIFTOFF		
		③ RATE_CAPABILITY_NOM_SYSO_1	⑧ RATE_CAPABILITY_NOFAIL		
		④ RATE_CAPABILITY_NOM_2	⑨ RATE_CAPABILITY_ONEFAIL		
		⑤ RATE_CAPABILITY_MECO	⑩ RATE_CAPABILITY_TWOFAIL		
**On lowest numbered failed engine only					

Module
TRIM_MIX_MPS

BIAS_LIM_MPS

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Table 4.2.6-5. CMD_PROC_MPS I-Loads/Constants

Module	Name	Description	Type	MSID/ Value	Units
TRIM_MIX_MPS	DQMPSP_LIM	Pitch axis authority limit	S	V97U1689C	deg
	DRMPSP_LIM	Yaw axis authority limit	S	V97U1775C	deg
	DPY1_LIM	Roll axis authority limit, SSME 1 pitch	S	V97U1685C	deg
	DPZ1_LIM	Roll axis authority limit, SSME 1 yaw	S	V97U1687C	deg
	DPY23_LIM	Roll axis authority limit, SSME 2 and 3 pitch	S	V97U1686C	deg
	DPZ23_LIM	Roll axis authority limit, SSME 2 and 3 yaw	S	V97U1688C	<u>deg</u> <u>deg</u>
	KPZ1_NOM	Roll axis mixing gain, nominal, for SSME 1 yaw actuator	S	V97U2039C	<u>deg</u> <u>deg</u>
	KPZ1_FAIL23	Roll axis mixing gain, ME 2 or 3 fail, for yaw actuator	S	V97U2038C	<u>deg</u> <u>deg</u>
	KPY23_S2C	Roll axis mixing gain, for SSME 2 and 3 pitch actuator	S	V97U2037C	<u>deg</u> <u>deg</u>
	KPZ23_FAIL23	Roll axis mixing gain, SSME 2 or 3 fail, for SSME 2 and yaw actuator	S	V97U2040C	<u>deg</u> <u>deg</u>
KPY1_FAIL23	Roll axis mixing gain, SSME 1 or 3 fail, for SSME 1 pitch actuator	S	V97U2036C	<u>deg</u> <u>deg</u>	
BIAS_LIM_MPS	PITCH_BIAS_PARALLEL	Nozzle pitch bias for paralleling	S	V97U2208C	deg
	YAW_BIAS_NOM	Nominal nozzle yaw bias	S	V97U2325C	deg
	DY1_START	Nozzle ignition position	S	V97U1782C	deg
	DY2_START	Nozzle ignition position	S	V97U1784C	deg
	DZ2_START	Nozzle ignition position	S	V97U1788C	deg
	DY3_START	Nozzle ignition position	S	V97U1786C	deg
	DZ3_START	Nozzle ignition position	S	V97U1790C	deg
	SSME_RLIM_FAIL	Rate limit SSME failure, LCH through MECO	S	V97U2493C	deg/cycle
	SSME_RLIM_NOM	Nominal SSME rate limit	S	V97U2494C	deg/cycle
	SF_MPS_SLEW_NOM	Scale factor for SSME slew command	S	V97U2242C	deg
	RATE_CAPABILITY_NOFAILS	Nominal hydraulic system rate capability for Systems 1 and 2 under condition of no failures	S	V97U2495C	deg/cycle
	TF	Fast cycle update interval	S	0.04	s
	DYLIM	Pitch engine bell limit	S	V97U1360C	deg
	DZLIM	Yaw engine bell limit	S	V97U1361C	deg
KDYZ1	SSME 1/OMS CLR	S	13.7	deg	

Table 4.2.6-5. CMD_PROC_MPS I-Loads/Constants

Module	Name	Description	Type	MSID/ Value	Units
TRIM_MIX_MPS	DQMPSP_LIM	Pitch axis authority limit	S	V97U1689C	deg
	DRMPSP_LIM	Yaw axis authority limit	S	V97U1775C	deg
	DPY1_LIM	Roll axis authority limit, SSME 1 pitch	S	V97U1685C	deg
	DPZ1_LIM	Roll axis authority limit, SSME 1 yaw	S	V97U1687C	deg
	DPY23_LIM	Roll axis authority limit, SSME 2 and 3 pitch	S	V97U1686C	deg
	DPZ23_LIM	Roll axis authority limit, SSME 2 and 3 yaw	S	V97U1688C	$\frac{\text{deg}}{\text{deg}}$
	KPZ1_NOM	Roll axis mixing gain, nominal, for SSME 1 yaw actuator	S	V97U2039C	$\frac{\text{deg}}{\text{deg}}$
	KPZ1_FAIL23	Roll axis mixing gain, ME 2 or 3 fail, for yaw actuator	S	V97U2038C	$\frac{\text{deg}}{\text{deg}}$
	KPY23_S2C	Roll axis mixing gain, for SSME 2 and 3 pitch actuator	S	V97U2037C	$\frac{\text{deg}}{\text{deg}}$
	KPZ23_FAIL23	Roll axis mixing gain, SSME 2 or 3 fail, for SSME 2 and yaw actuator	S	V97U2040C	$\frac{\text{deg}}{\text{deg}}$
KPY1_FAIL23	Roll axis mixing gain, SSME 1 or 3 fail, for SSME 1 pitch actuator	S	V97U2036C	$\frac{\text{deg}}{\text{deg}}$	
BIAS_LIM_MPS	PITCH_BIAS_PARALLEL	Nozzle pitch bias for paralleling	S	V97U2208C	deg
	YAW_BIAS_NOM	Nominal nozzle yaw bias	S	V97U2325C	deg
	DY1_START	Nozzle ignition position	S	V97U1782C	deg
	DY2_START	Nozzle ignition position	S	V97U1784C	deg
	DZ2_START	Nozzle ignition position	S	V97U1788C	deg
	DY3_START	Nozzle ignition position	S	V97U1786C	deg
	DZ3_START	Nozzle ignition position	S	V97U1790C	deg
	SSME_RLIM_FAIL	Rate limit SSME failure, LCH through MECO	S	V97U2493C	deg/cycle
	SSME_RLIM_NOM	Nominal SSME rate limit	S	V97U2494C	deg/cycle
	SF_MPS_SLEW_NOM	Scale factor for SSME slew command	S	V97U2242C	deg
	RATE_CAPABILITY_NOFAILS	Nominal hydraulic system rate capability for Systems 1 and 2 under condition of no failures	S	V97U2495C	deg/cycle
	TF	Fast cycle update interval	S	0.04	s
	DYLIM	Pitch engine bell limit	S	V97U1360C	deg
	DZLIM	Yaw engine bell limit	S	V97U1361C	deg
	KDYZ1	SSME 1/OMS CLR	S	13.7	deg



Table 4.2.6-5. CMD_PROC_MPS I-Loads/Constants (Cont)

Module	Name	Description	Type	MSID/ Value	Units
BIAS_LIM_MPS (Cont)	RATE_CAPABILITY_LIFTOFF	Rate limits prior to Event 19C	S	V97U2496C	deg/cycle
	RATE_CAPABILITY_ONEFAIL	Rate limit Stage 1, one failure	S	V97U2497C	deg/cycle
	RATE_CAPABILITY_TWOFAIL	Rate limit Stage 1, two failures	S	V97U2498C	deg/cycle
	DY1_FAIL	Nozzle fail position	S	V97U1781C	deg
	DY2_FAIL	Nozzle fail position	S	V97U1783C	deg
	DZ2_FAIL	Nozzle fail position	S	V97U1787C	deg
	DY3_FAIL	Nozzle fail position	S	V97U1785C	deg
	DZ3_FAIL	Nozzle fail position	S	V97U1789C	deg
	DY1_GRAV	Nozzle gravity position	S	V96U7984C	deg
	DY2_GRAV	Nozzle gravity position	S	V96U7985C	deg
	DZ2_GRAV	Nozzle gravity position	S	V96U7987C	deg
	DY3_GRAV	Nozzle gravity position	S	V96U7986C	deg
	DZ3_GRAV	Nozzle gravity position	S	V96U7988C	deg
PRL_MPS	RATE_CAPABILITY_NOM_SYSO_1	Nominal hydraulic system rate capability under condition of no failures or one failure	S	V97U2228C	deg cycle
	RATE_CAPABILITY_NOM_2	Nominal hydraulic system rate capability under conditions of two failures	S	V97U2227C	deg cycle
	TF	Fast cycle update interval	S	0.04	sec
	RATE_CAPABILITY_MECO	Hydraulic system rate capability under conditions of MECO and no failure or one failure	S	V97U2225C	deg cycle
	RATE_CAPABILITY_MECO_2_FAILURES	Hydraulic system rate capability under conditions of MECO and two failures	S	V97U2226C	deg cycle

4.2.7 SRB Com
A. Functional
shown in Figure
described below
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filtered pre
COMLIMS, as
B. Software
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CMD_PROC_SRB
and SRB_PC
detailed di
respectivel
requirement
requirement
Table 4.2.7



4.2.7 SRB Command Processor (CMD_PROC_SRB)

A. Functional Description. The functional block diagram for CMD_PROC_SRB is shown in Figure 4.2.7-1. A correlation with the software mechanization described below is provided by means of the dotted lines which delineate software modules. Functionally, CMD_PROC_SRB takes the body-axis roll, pitch, and yaw outputs from ASC TVC, and multiplies each by a gain function, adds body-axis trim signals, generates and applies a body-axis pitch command bias for clearance of the hold-down support, and then, by means of the SRB mixing logic, generates the SRB nozzle rock/tilt commands. Prelaunch nozzle slew commands are summed with the mixing logic outputs (which are set to zero until liftoff) during the SRB actuator slew test. The nozzle commands are then amplitude and rate limited. The pressure information required is obtained by filtering the measured chamber pressure through a first-order lag. The filtered pressure is used to generate the switching discretes COMLIM4 and COMLIM5, as well as other discretes.

B. Software Description. An overview of CMD_PROC_SRB is presented in Figure 4.2.7-2. Its input/output requirements are summarized in Table 4.2.7-1. CMD_PROC_SRB consists of three function modules, TRIM_MIX_SRB, BIAS_LIM_SRB and SRB_PC_FILTER, which are sequenced as shown in Figure 4.2.7-3. The detailed diagrams for TRIM_MIX_SRB, BIAS_LIM_SRB, and SRB_PC_FILTER are shown, respectively, in Figures 4.2.7-4, 4.2.7-5, and 4.2.7-6. Intermodule interface requirements for CMD_PROC_SRB are presented in Table 4.2.7-2. Initialization requirements are presented in Table 4.2.7-3. I-loads are presented in Table 4.2.7-4.

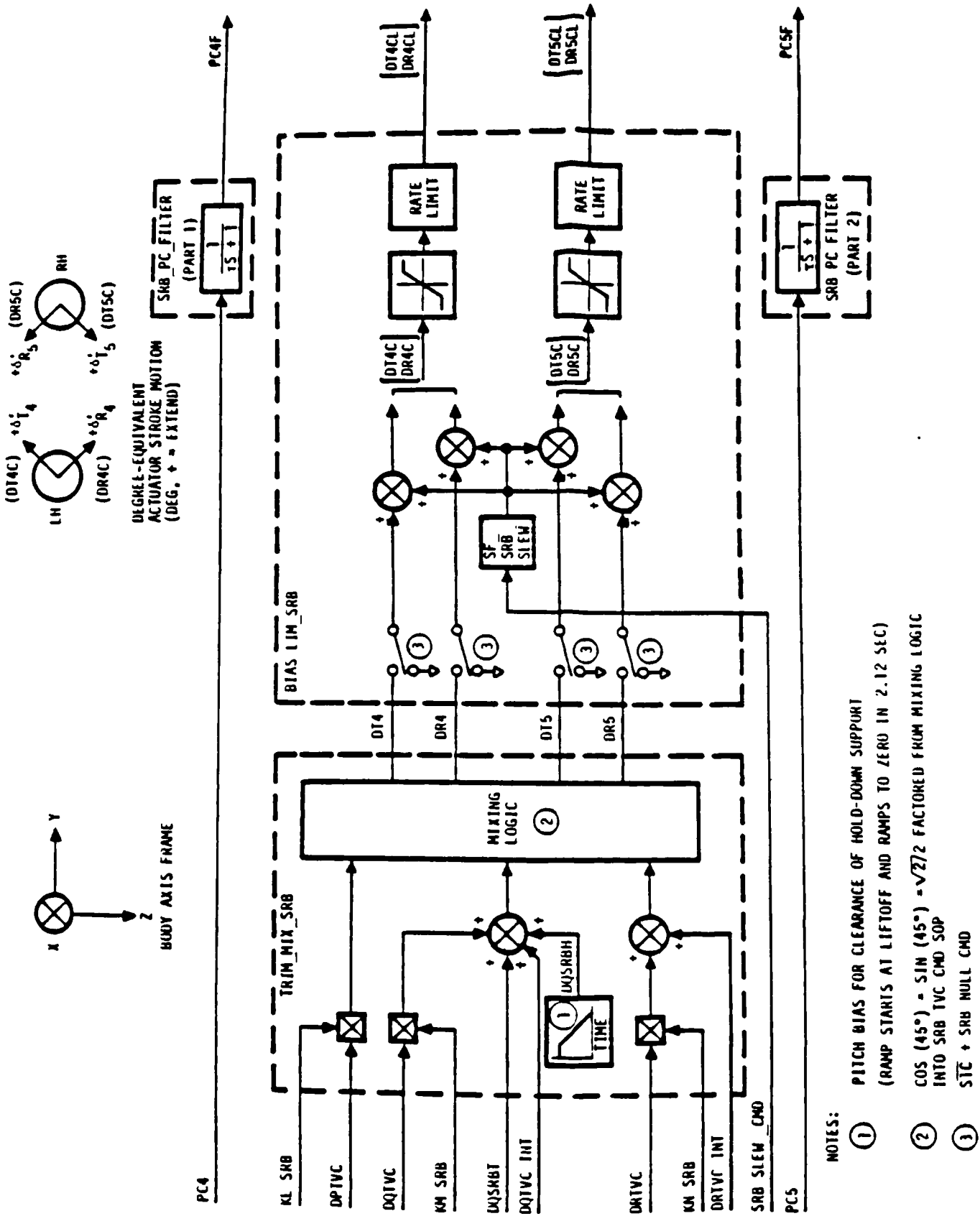


Figure 4.2.7-1. SRB Command Processor, Functional Overview

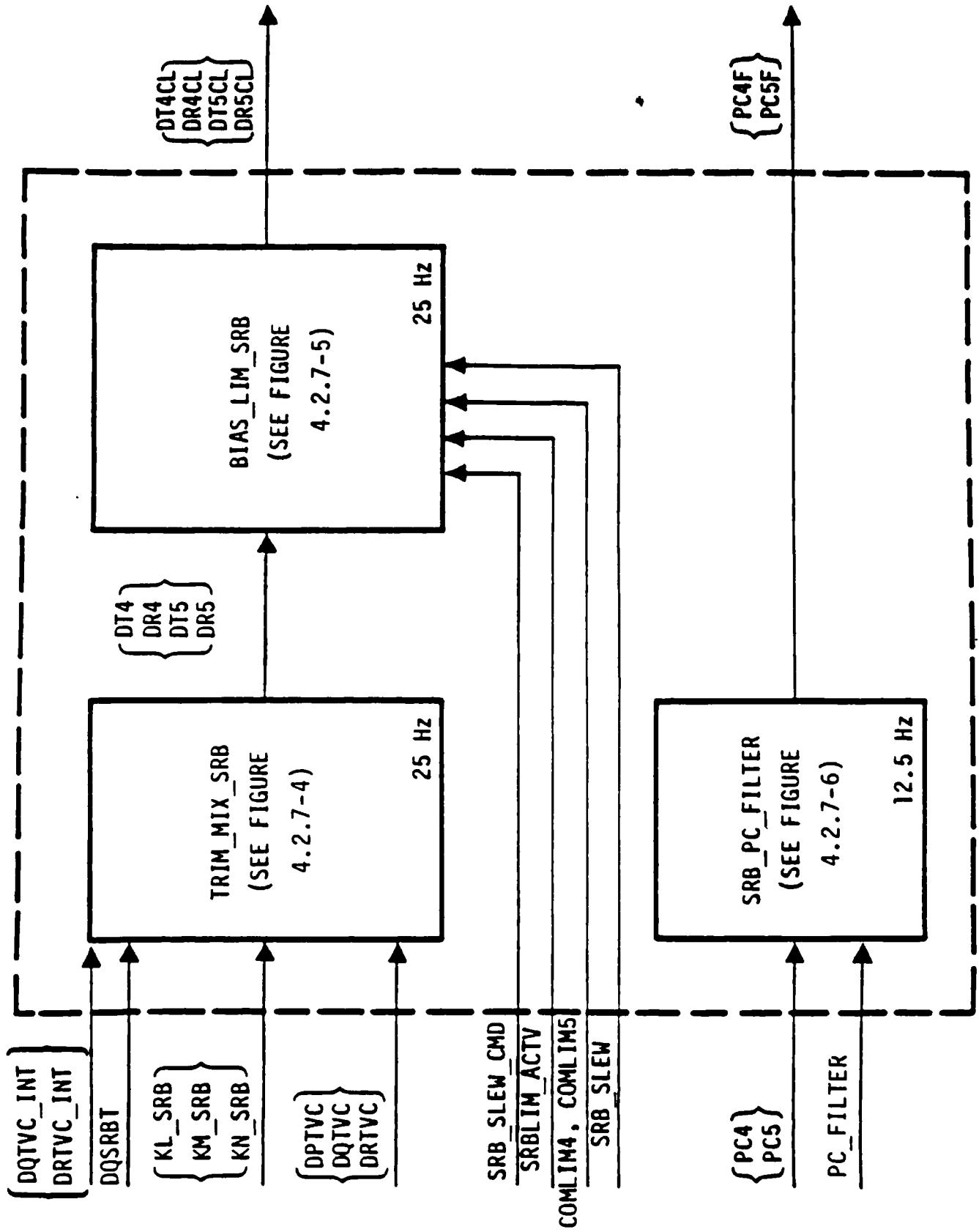


Figure 4.2.7-2. CMD_PROC_SRB, Software Overview

Table 4.2.7-1. CMD_PROC_SRB Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Inputs</u>						
	DPTVC	Roll TVC loop error signal	ASC_TVC	S		deg/s	25
	DQTVC	Pitch TVC loop error signal	ASC_TVC	S		deg/s	25
	DRTVC	Yaw TVC loop error signal	ASC_TVC	S		deg/s	25
	DQSRBT	Pitch thrust vector deflection trim, SRB	INTERPS	S		deg	6.25
	KL_SRB	Variable gain (roll rate, SRB)	INTERPS	S		$\frac{\text{deg}}{\text{deg/s}}$	6.25
	KM_SRB	Variable gain (pitch rate, SRB)	INTERPS	S		$\frac{\text{deg}}{\text{deg/s}}$	6.25
	KN_SRB	Variable gain (yaw rate, SRB)	INTERPS	S		$\frac{\text{deg}}{\text{deg/s}}$	6.25
	SRB_SLEW_CMD	SRB actuator slew position command	SRB_ACT_SLEW	S		deg	25
	PC4	Chamber pressure, SRB4	SF	S		psi	12.5
	PC5	Chamber pressure, SRB5	SF	S		psi	12.5
	SIC	Indicator, Stage 1 control	ASC_RECON	B		-	12.5
	COMLIM4	Indicator, begin vector limiting for SRB4	ASC_RECON	B		-	12.5
	COMLIM5	Indicator, begin vector limiting for SRB5	ASC_RECON	B		-	12.5
	PC_FILTER	Indicator, SRB chamber pressure filtering	ASC_RECON	B		-	12.5
	PRELO	Indicator, pre-liftoff	ASC_RECON	B		-	12.5
	SRB_SLEW	Indicator, initiate SRB slew test	ASC_RECON	B		-	12.5
	SRBLIM_ACTV	Indicator, initiate SRB rate limiting	ASC_RECON	B		-	12.5
	DQTVC_INT	Pitch TVC integrator output	ASC_TVC	S		deg	12.5
	DRTVC_INT	Yaw TVC integrator output	ASC_TVC	S		deg	12.5
	MM101_INIT	First pass initialization flag	ASC_RECON	B		-	12.5
	SRB_NULL_CMD	Indicator, initiate SRB null command	ASC_RECON	B		-	12.5
	SRB_SEP_CMD	Indicator, SRB SEP CMD (Event 28)	ASC_RECON	B		-	12.5
	LIFTOFF	Indicator, liftoff (Event 19A)	ASC_RECON	B		-	12.5



Table 4.2.7-1. CMD_PROC_SRB Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/ Produced At (Hz)
	<u>Outputs</u>						
	DT4CL	Actuator deflection command, SRB 4 tilt	SRB_TVC_CMD_SOP	S		deg	25
	DR4CL	Actuator deflection command, SRB 4 rock	SRB_TVC_CMD_SOP	S		deg	25
	DT5CL	Actuator deflection command, SRB 5 tilt	SBB_TVC_CMD_SOP	S		deg	25
	DR5CL	Actuator deflection command, SRB 5 rock	SRB_TVC_CMD_SOP	S		deg	25
	PC4F	Filtered chamber pressure SRB 4	ASC_RECON	S		psi	12.5
	PC5F	Filtered chamber pressure, SRB 5	ASC_RECON	S		psi	12.5

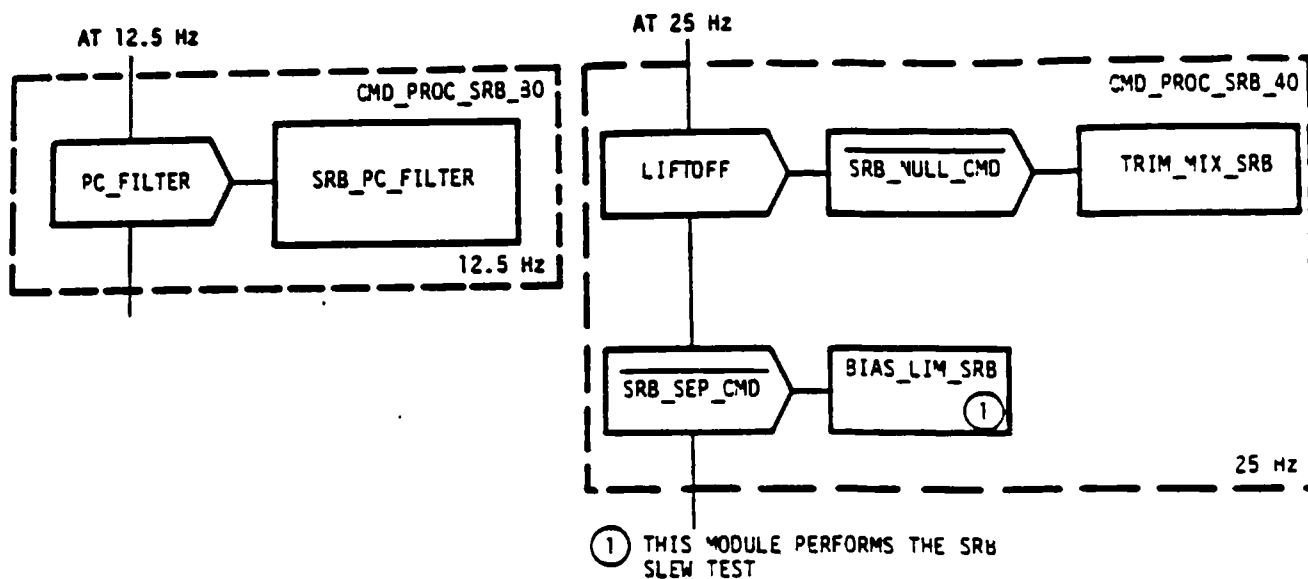


Figure 4.2.7-3. CMD_PROC_SRB Function Module Sequencing Requirements

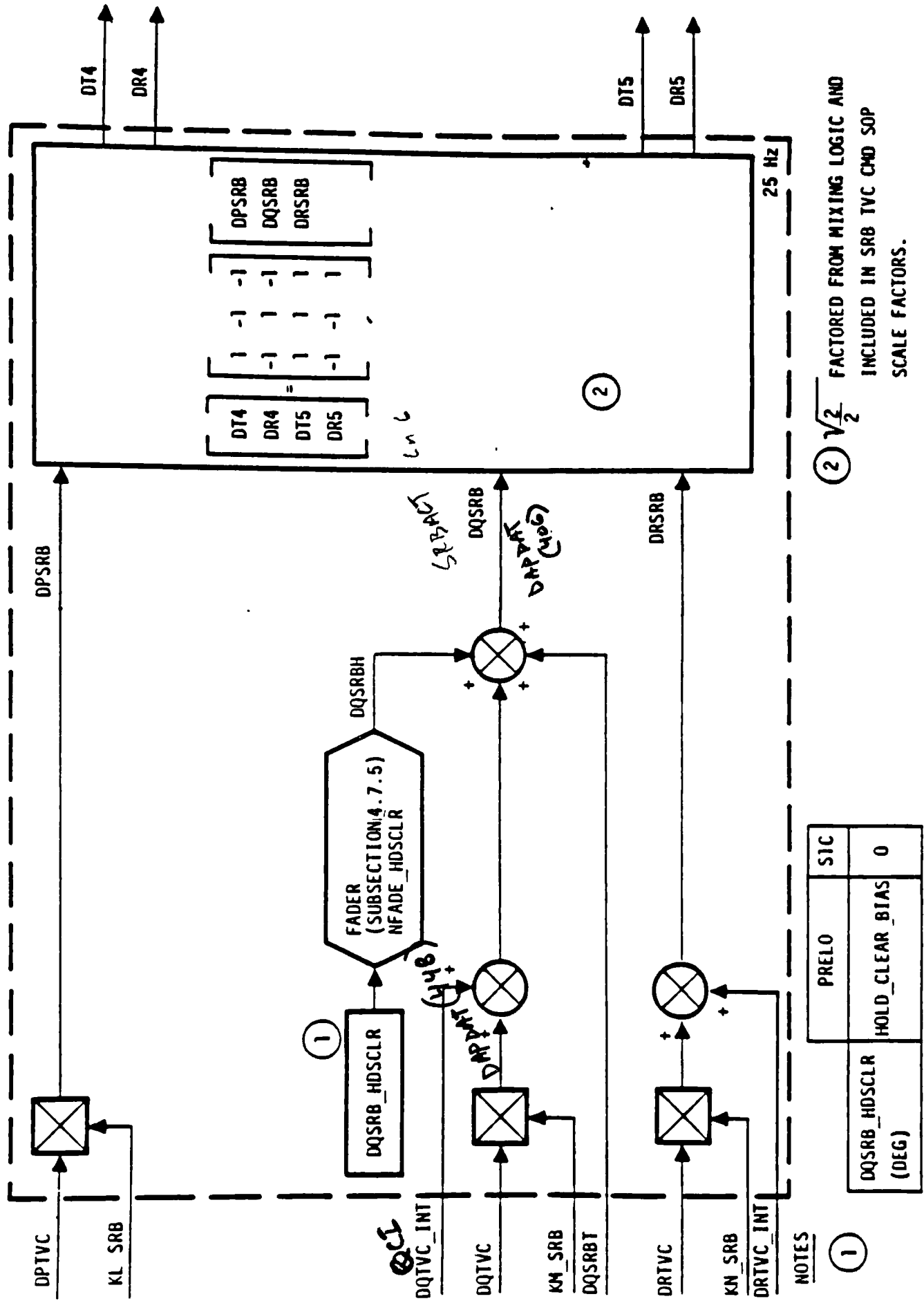


Figure 4.2.7-4. TRIM_MIX_SRB Function Module, Detailed Diagram

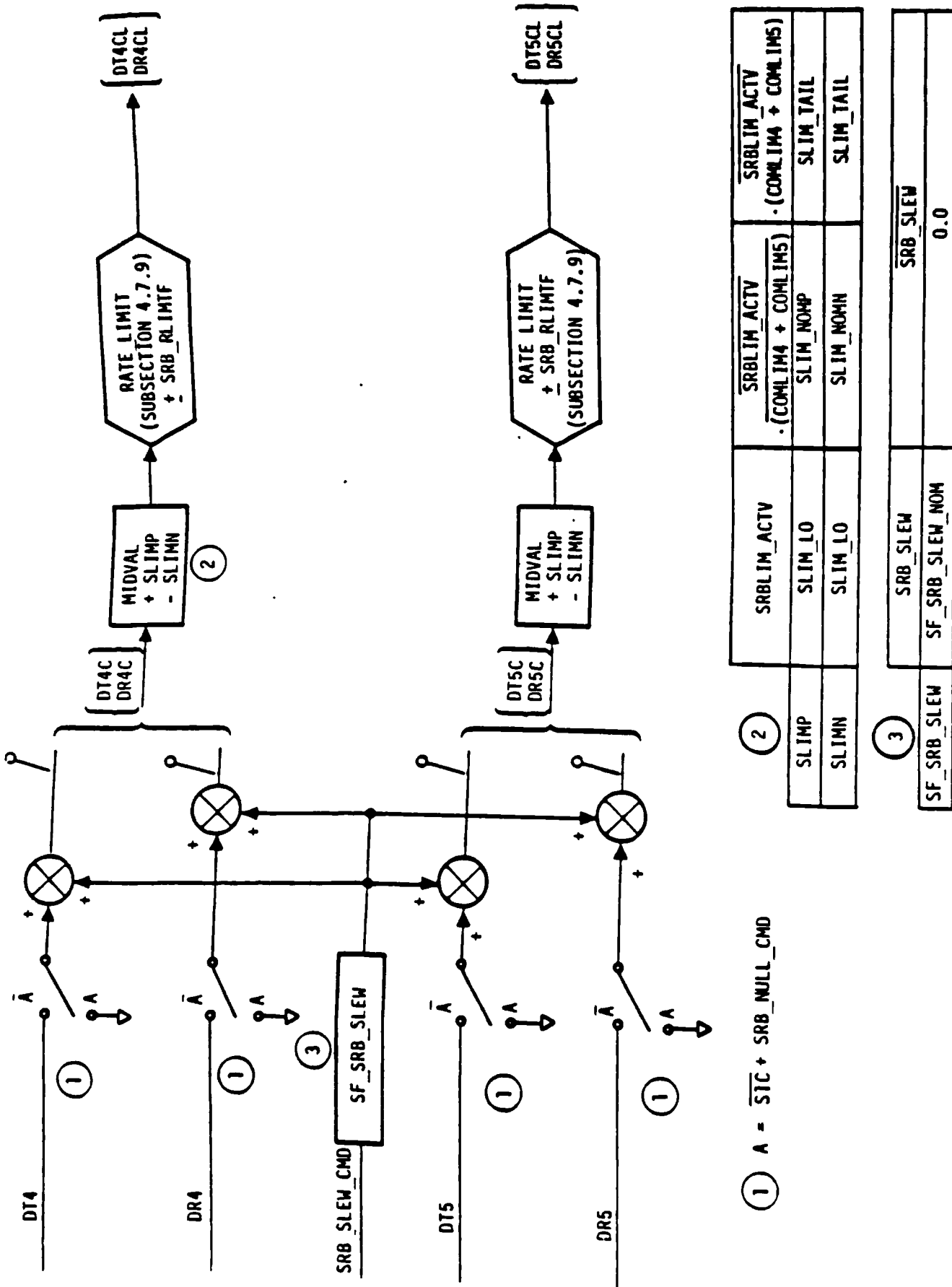


Figure 4.2.7-5. BIAS_LIM_SRB Function Module, Detailed Diagram

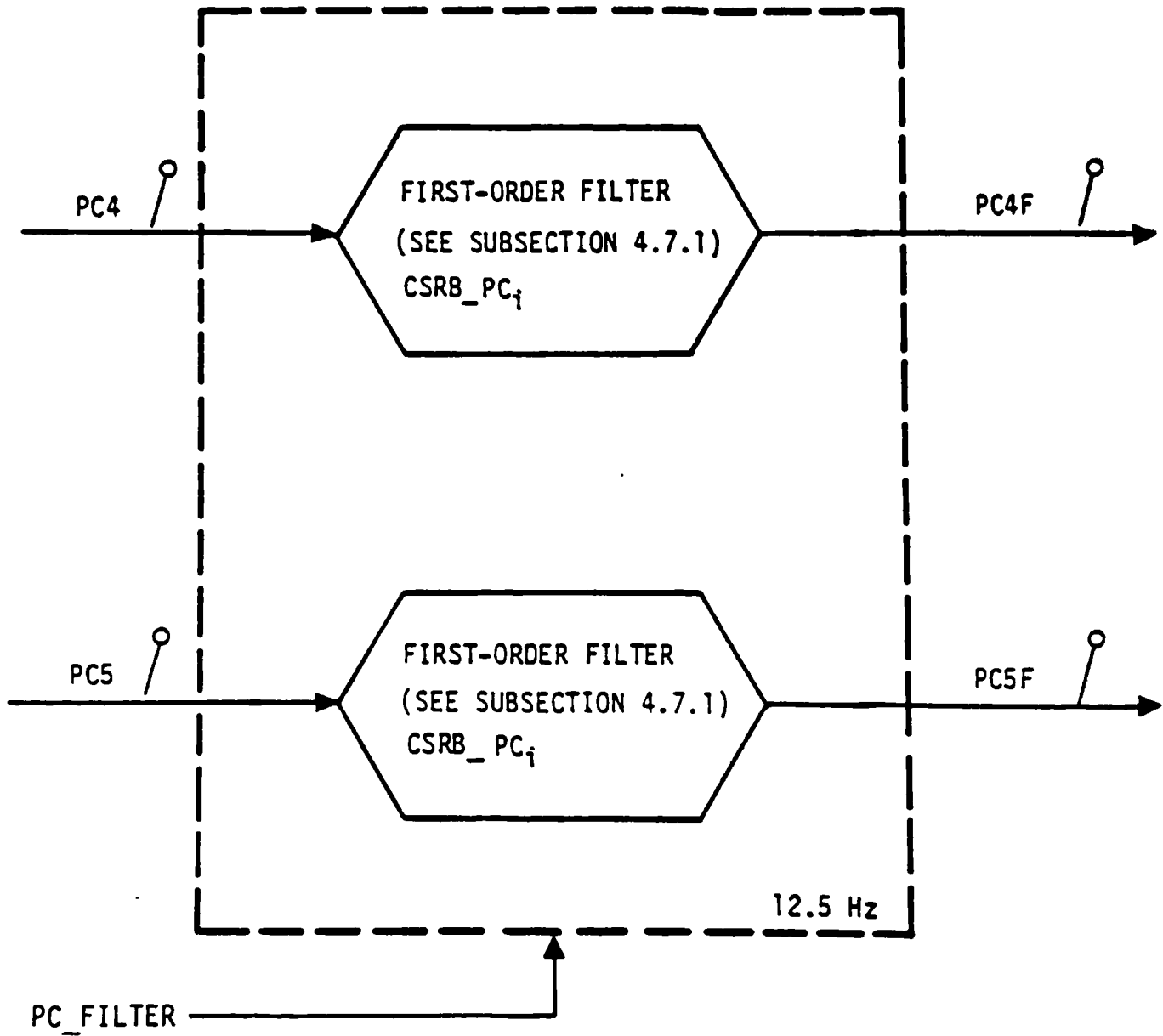


Figure 4.2.7-6. SRB PC FILTER Function Module, Detailed Diagram

Table 4.2.7-2. CMD_PROC_SRB Inter-Module Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
TRIM_MIX_SRB	<u>Inputs</u>						
	DPTVC	Roll TVC loop error signal	ASC_TVC	S		deg/s	25
	DQTVC	Pitch TVC loop error signal	ASC_TVC	S		deg/s	25
	DRTVC	Yaw TVC loop error signal	ASC_TVC	S		deg/s	25
	DQSRBT	Pitch thrust vector deflection trim, SRB	INTERPS	S		deg	6.25
	KL_SRB	Variable gain (roll rate, SRB)	INTERPS	S		$\frac{\text{deg}}{\text{deg/s}}$	6.25
	KM_SRB	Variable gain (pitch rate, SRB)	INTERPS	S		$\frac{\text{deg}}{\text{deg/s}}$	6.25
	KN_SRB	Variable gain (yaw rate, SRB)	INTERPS	S		$\frac{\text{deg}}{\text{deg/s}}$	6.25
	MM101_INIT	First pass initialization flag	ASC_RECON	B		-	12.5
	SIC	Indicator, Stage 1 control	ASC_RECON	B		-	12.5
	PRELO	Indicator, pre-liftoff	ASC_RECON	B		-	12.5
	DQTVC_INT	Pitch TVC integrator output	ASC_TVC	S		deg	12.5
	DRTVC_INT	Yaw TVC integrator output	ASC_TVC	S		deg	12.5
BIAS_LIM_SRB	<u>Outputs</u>						
	DT4	Tilt command (actuator degree-equivalent), SRB 4	BIAS_LIM_SRB	S		deg	25
	DR4	Rock command (actuator degree-equivalent), SRB 4	BIAS_LIM_SRB	S		deg	25
	DT5	Tilt command (actuator degree-equivalent), SRB 5	BIAS_LIM_SRB	S		deg	25
	DR5	Rock command (actuator degree-equivalent), SRB 5	BIAS_LIM_SRB	S		deg	25
TRIM_MIX_SRB	<u>Inputs</u>						
	DT4	Tilt command (actuator degree-equivalent), SRB 4	TRIM_MIX_SRB	S		deg	25
	DR4	Rock command (actuator degree-equivalent), SRB 4	TRIM_MIX_SRB	S		deg	25
	DT5	Tilt command (actuator degree-equivalent), SRB 5	TRIM_MIX_SRB	S		deg	25
	DR5	Rock command (actuator degree-equivalent), SRB 5	TRIM_MIX_SRB	S		deg	25
	SIC	Indicator, Stage 1 control	ASC_RECON	B		-	12.5
SRB_NULL_CMD	Indicator, initiate SRB null command	ASC_RECON	B		-	12.5	



Table 4.2.7-2. CMD_PROC_SRB Inter-Module Interface Requirements (Cont)

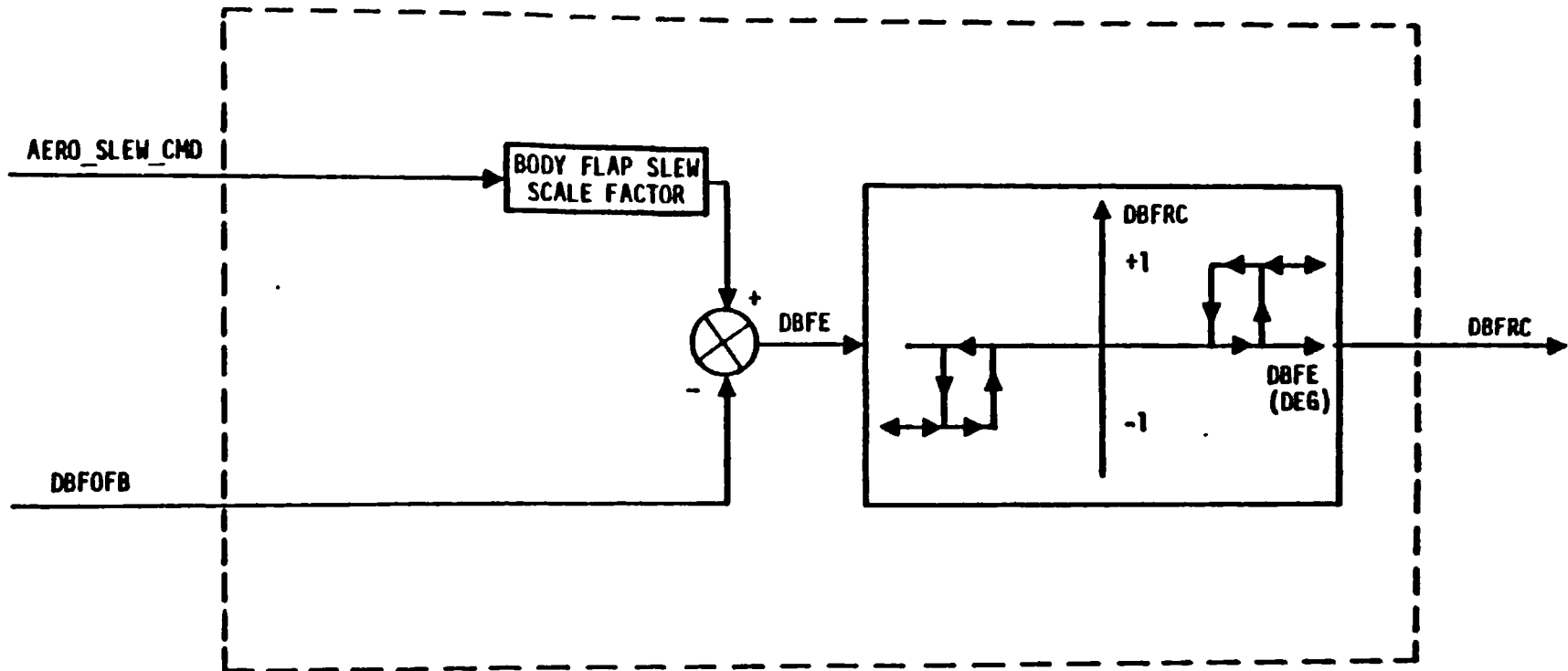
Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)	
BIAS_LIM_SRB (Cont)	<u>Inputs (Cont)</u>							
	SRB_SLEW	Indicator, SRB actuator slew test	ASC_RECON	B		-	12.5	
	SRBLIM_ACTV	Indicator, SRB rate limiting is active	ASC_RECON	B		-	12.5	
	SRB_SLEW_CMD	SRB actuator slew position command	SRB_ACT_SLEW	S		-	25	
	COMLIM4	Indicator, begin vector limiting for SRB 4	ASC_RECON	B			12.5	
	COMLIM5	Indicator, begin vector limiting for SRB 5	ASC_RECON	B			12.5	
	<u>Outputs</u>							
	DT4CL	Actuator deflection command, SRB 4 tilt	SRB_CMD_SOP	S		deg	25	
	DR4CL	Actuator deflection command, SRB 4 rock	SRB_CMD_SOP	S		deg	25	
	DT5CL	Actuator deflection command, SRB 5 tilt	SRB_CMD_SOP	S		deg	25	
DR5CL	Actuator deflection command, SRB 5 rock	SRB_CMD_SOP	S		deg	25		
SRB_PC_FILTER	<u>Inputs</u>							
	MM101_INIT	First pass initialization flag	ASC_RECON	B		-	12.5	
	PC4	Chamber pressure, SRB 4	SF	S		psi	12.5	
	PC5	Chamber pressure, SRB 5	SF	S		psi	12.5	
	PC_FILTER	Indicator, SRB chamber pressure filtering	ASC_RECON	B		-	12.5	
	<u>Outputs</u>							
PC4F	Filtered chamber pressure, SRB4	BIAS_LIM_SRB, ASC_RECON	S		psi	12.5		
PC5F	Filtered chamber pressure, SRB5	BIAS_LIM_SRB, ASC_RECON	S		psi	12.5		

Table 4.2.7-3. CMD_PROC_SRB Initialization Requirements

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
TRIM_MIX_SRB	Fader	-	MM101_INIT	NFADE_HDSCLR	0
		PRELO	SIC	NFADE_HDSCLR	NFADE_HDSCLR_START
BIAS_LIM_SRB	SRB slew command scale factor	-	MM101_INIT	SF_SRB_SLEW	0.0
		$\overline{\text{SRB_SLEW}}$	SRB_SLEW	SF_SRB_SLEW	SF_SRB_SLEW_NOM
		SRB_SLEW	$\overline{\text{SRB_SLEW}}$	SF_SRB_SLEW	0.0
	Rate limit INIT flag	-	MM101_INIT	Rate limit INIT flag, DT4	On
				Rate limit INIT flag, DR4	On
				Rate limit INIT flag, DT5	On
				Rate limit INIT flag, DR5	On
	Outputs for rate limiting	-	MM101_INIT	DT4CL	0.0
				DR4CL	0.0
				DT5CL	0.0
				DR5CL	0.0
	SRB nozzle limit	-	MM101_INIT	SLIMP	SLIM_LO
				SLIMN	SLIM_LO
		SRBLIM_ACTV	$\overline{\text{SRBLIM_ACTV}}$	SLIMP	SLIM_NOMP
			SLIMN	SLIM_NOMN	
$\left\{ \frac{\text{SRBLIM_ACTV}}{(\text{COMLIM4} + \text{COMLIM5})} \right\}$		$\left\{ \frac{\overline{\text{SRBLIM_ACTV}}}{(\text{COMLIM4} + \text{COMLIM5})} \right\}$	SLIMP	SLIM_TAIL	
			SLIMN	SLIM_TAIL	
SRB_PC_FILTER	SRB chamber pressure filters initialization flags	-	MM101_INIT	Filter SRB PC4 INIT flag	Orf
		-		Filter SRB PC5 INIT flag	Orf
		$\overline{\text{PC_FILTER}}$	PC_FILTER	Filter SRB PC4 INIT flag	On
				Filter SRB PC5 INIT flag	On

Table 4.2.7-4. CMD_PROC_SRB I-Loads

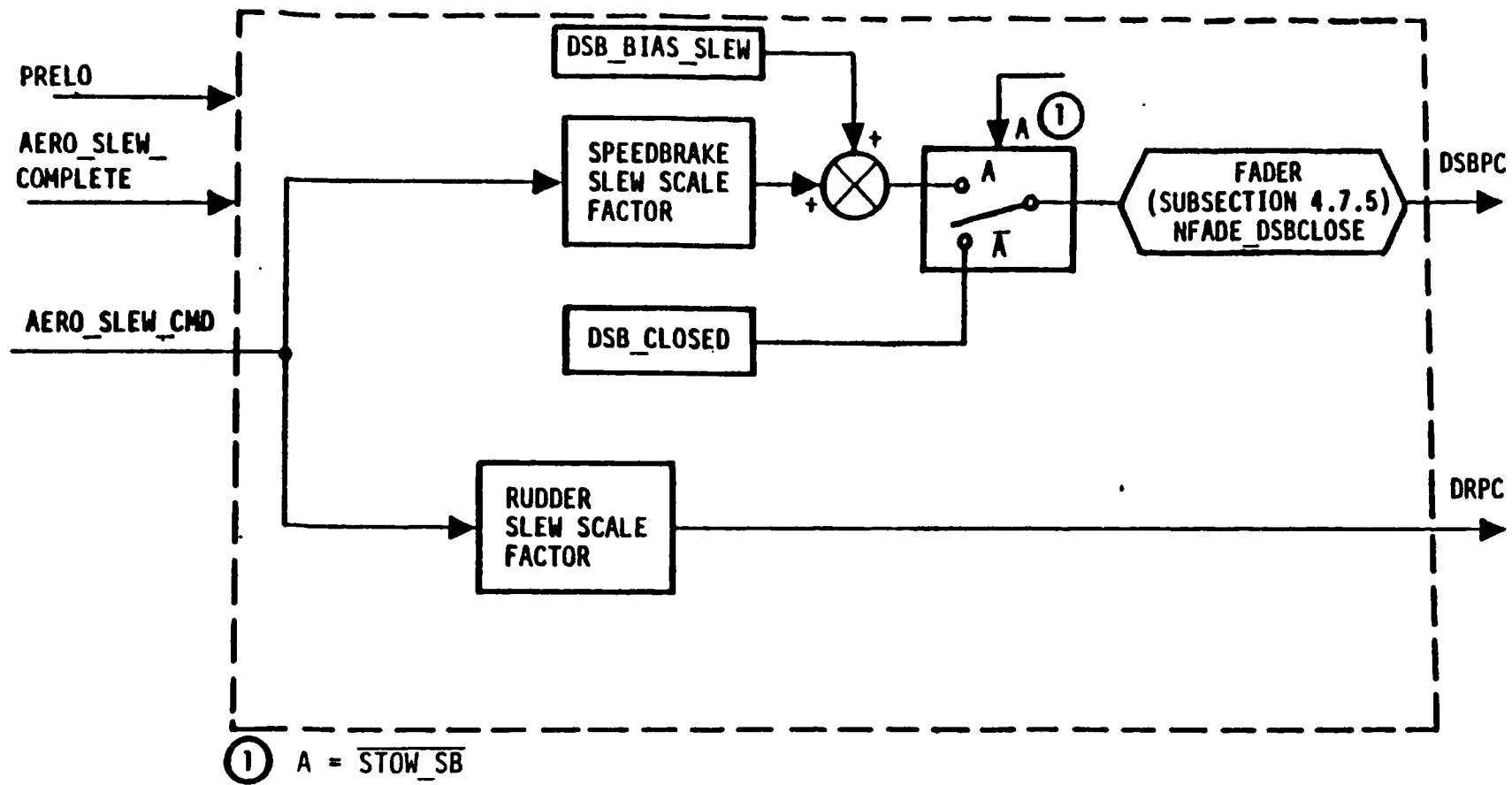
Module	Name	Description	Type	MSID	Units
TRIM_MIX_SRB	NFADE_HDSCLR_START	Fader characteristic time	S	V97U2063C	-
	HOLD_CLEAR_BIAS	Initial value of thrust vector deflection in nozzle deflection frame for clearance of the hold-down support	S	V98U9793C	deg
BIAS_LIM_SRB	SLIM_LO	Actuator stroke limit during SRBLM_ACTV	S	V97U2247C	deg
	SLIM_NOMP	Nominal positive SRB nozzle limit	S	V97U2248C	deg
	SLIM_NOMN	Nominal negative SRB nozzle limit	S	V97U2424C	deg
	SLIM_TAIL	SRB nozzle limits during tail off	S	V97U2427C	deg
	SRB_RLIMTF	SRB nozzle rate limit	S	V97U2426C	deg/ cycle
	SF_SRB_SLEW_NOM	SRB slew command scale factor	S	V97U2245C	deg
SRB_PC_FILTER	CSRB_PC1	Filter coefficients, SRB chamber pressure filter	S	V97U1660C	-
	CSRB_PC2		S	V97U1661C	-
	CSRB_PC3		S	V97U1662C	-



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Figure 4.2.8-1A. Body Flap Control, Functional Overview



NOTE: The rudder slew scale factor must be small enough so that DRPC (rudder position command) never exceeds 20°. This prevents interference between rudder/speedbrake hinges and rudder conical seal.

Figure 4.2.8-1B. Rudder and Speedbrake Control, Functional Overview

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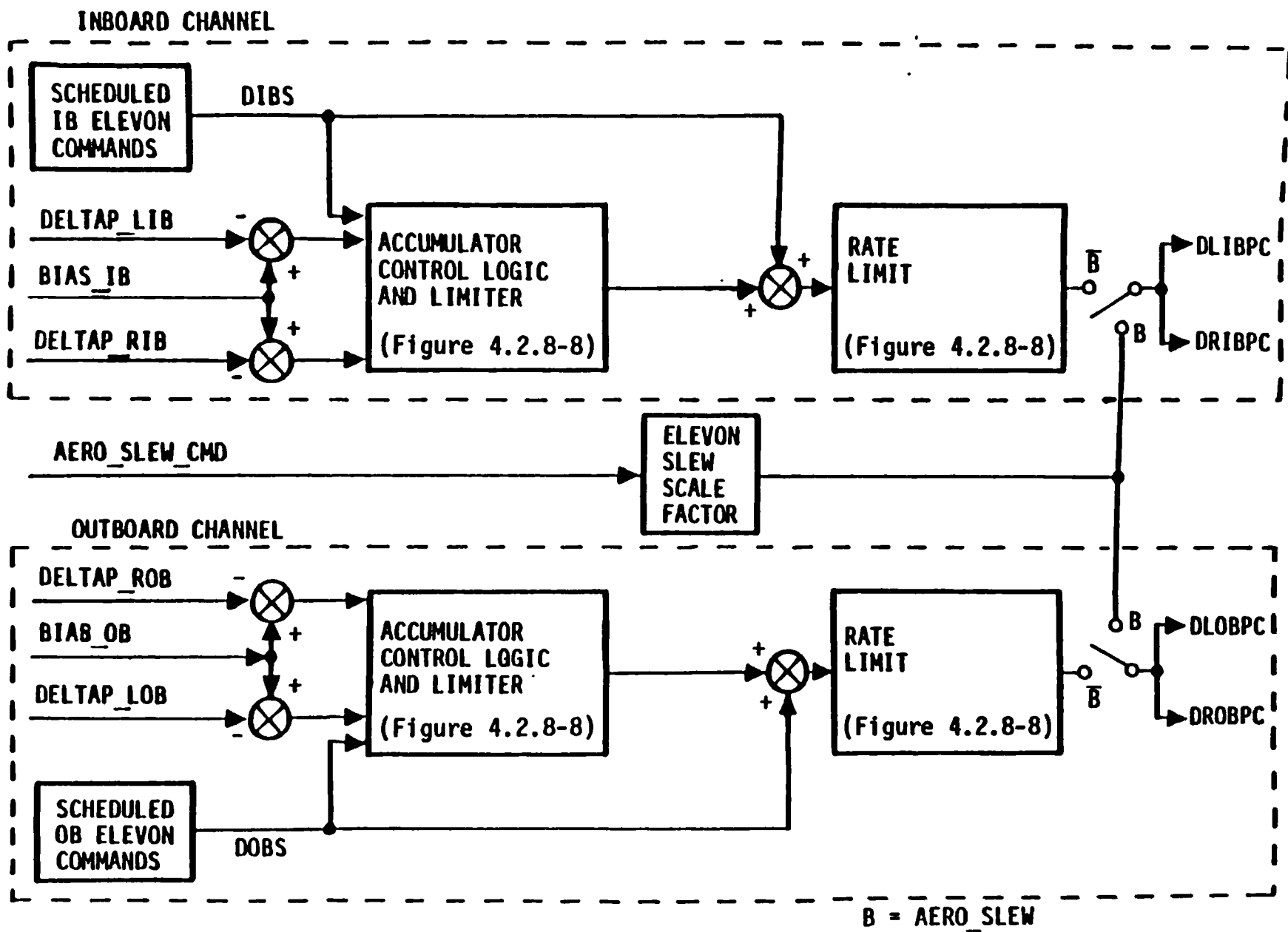


Figure 4.2.8-1C. Elevon Control, Functional Overview

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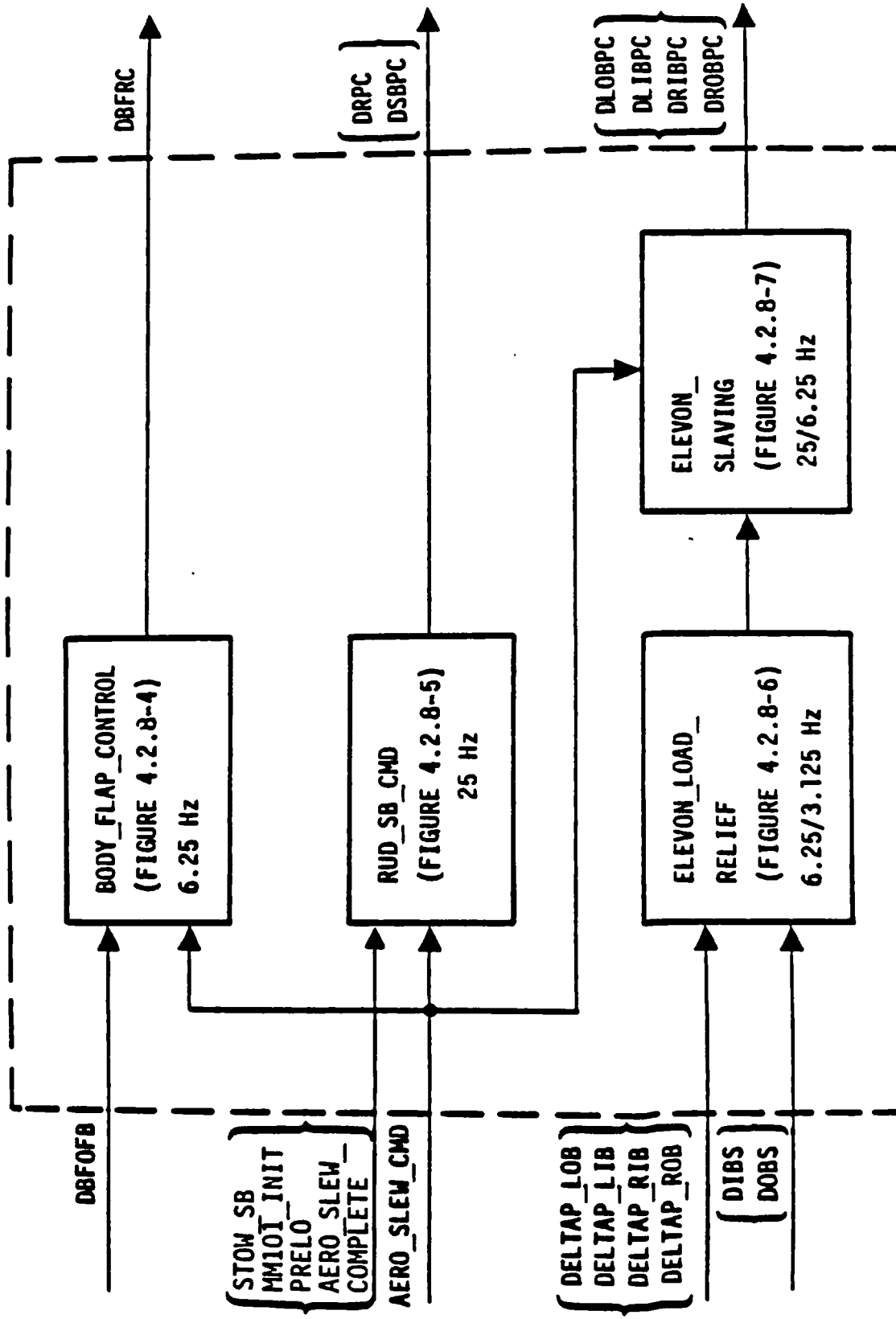
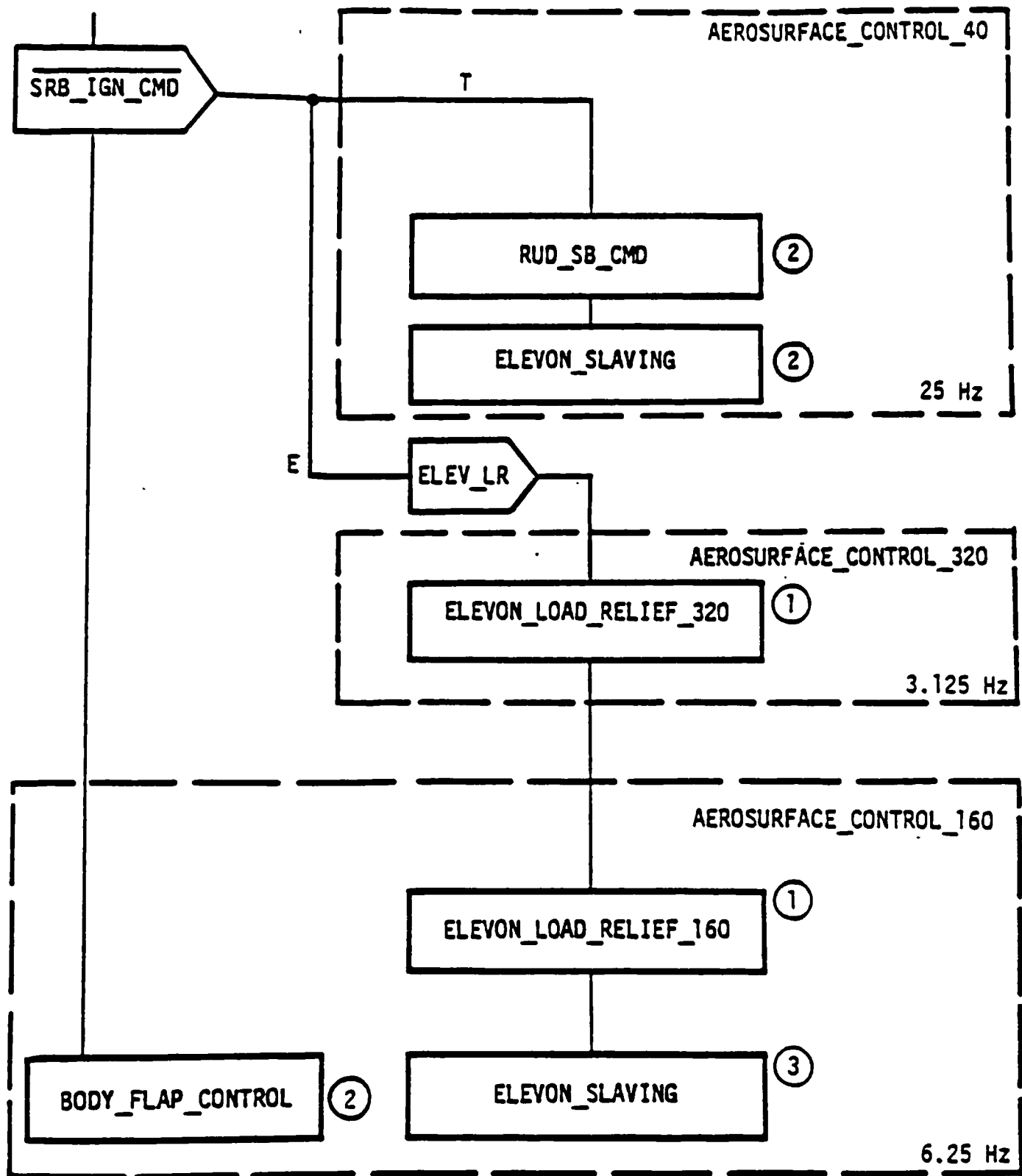


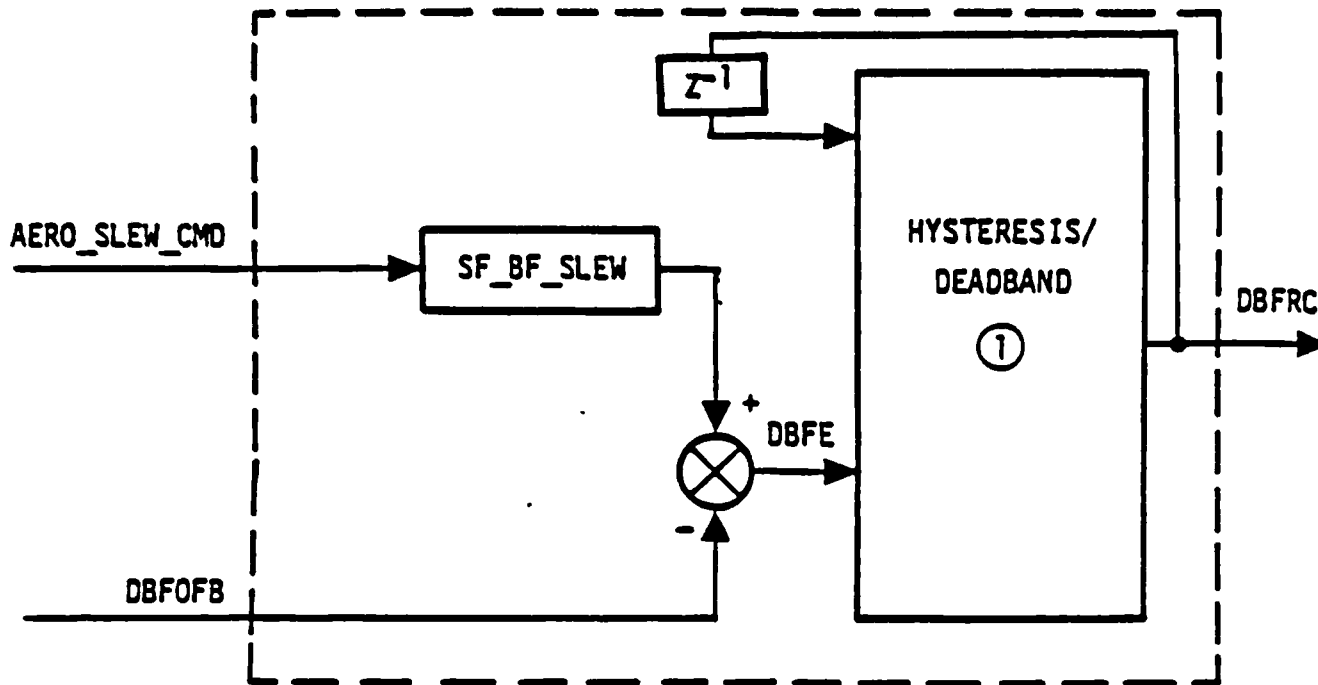
Figure 4.2.8-2. AEROSURFACE_CONTROL, Software Overview





- ① INTERPS—320 MUST BE SEQUENCED BEFORE ELEVON_LOAD_RELIEF
- ② SLEW TESTS ARE PERFORMED IN THESE MODULES
- ③ ELEVON SLAVING EXECUTES AT 25 Hz DURING INADVERTANT LATE AEROSURFACE SLEW

Figure 4.2.8-3. AEROSURFACE_CONTROL, Sequencing Requirements



NOTE

① HYSTERESIS/DEADBAND

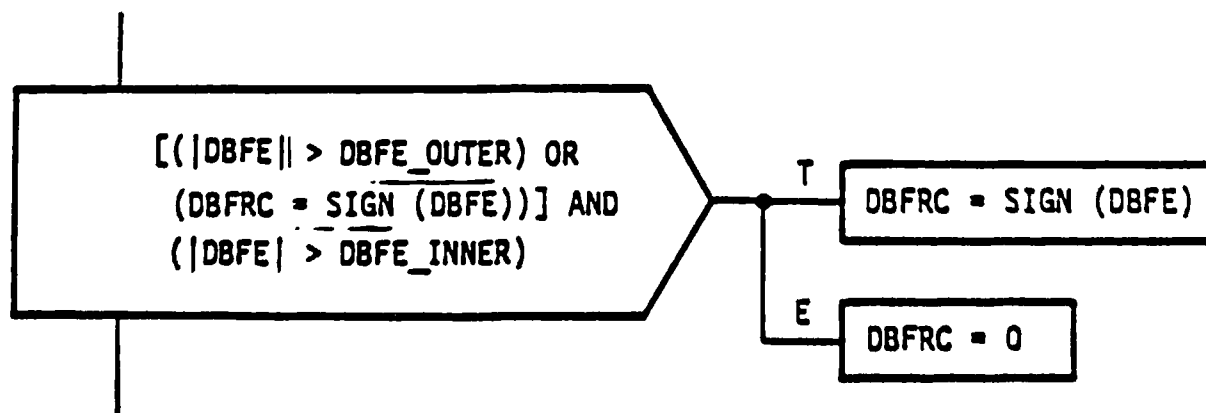
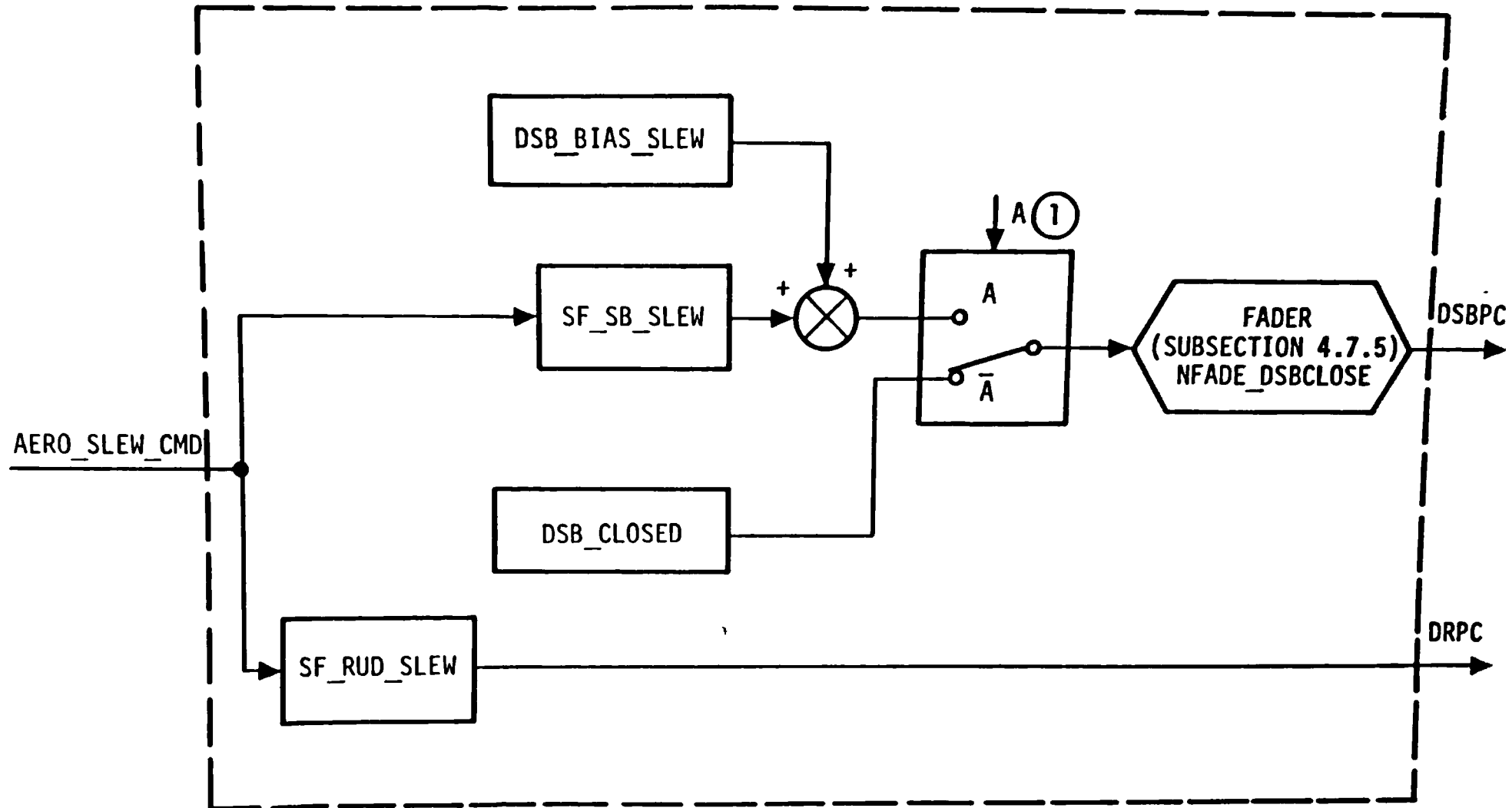


Figure 4.2.8-4. BODY_FLAP_CONTROL Function Module, Detailed Diagram

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NOTE: The rudder slew scale factor must be small enough so that DRPC (rudder position command) never exceeds 20°. This prevents interference between rudder/speed brake hinges and rudder conical seal.



①

A = $\overline{\text{STOW_SB}}$ This is not a latched transition. The speed brake is to be faded back to DSB_BIAS_SLEW whenever a recycle count is done following Event 6 to insure correct positioning of the speed brake should OPS 1 be cancelled and to permit repetition of the aero slew check after the recycle count.
 \bar{A} = STOW_SB

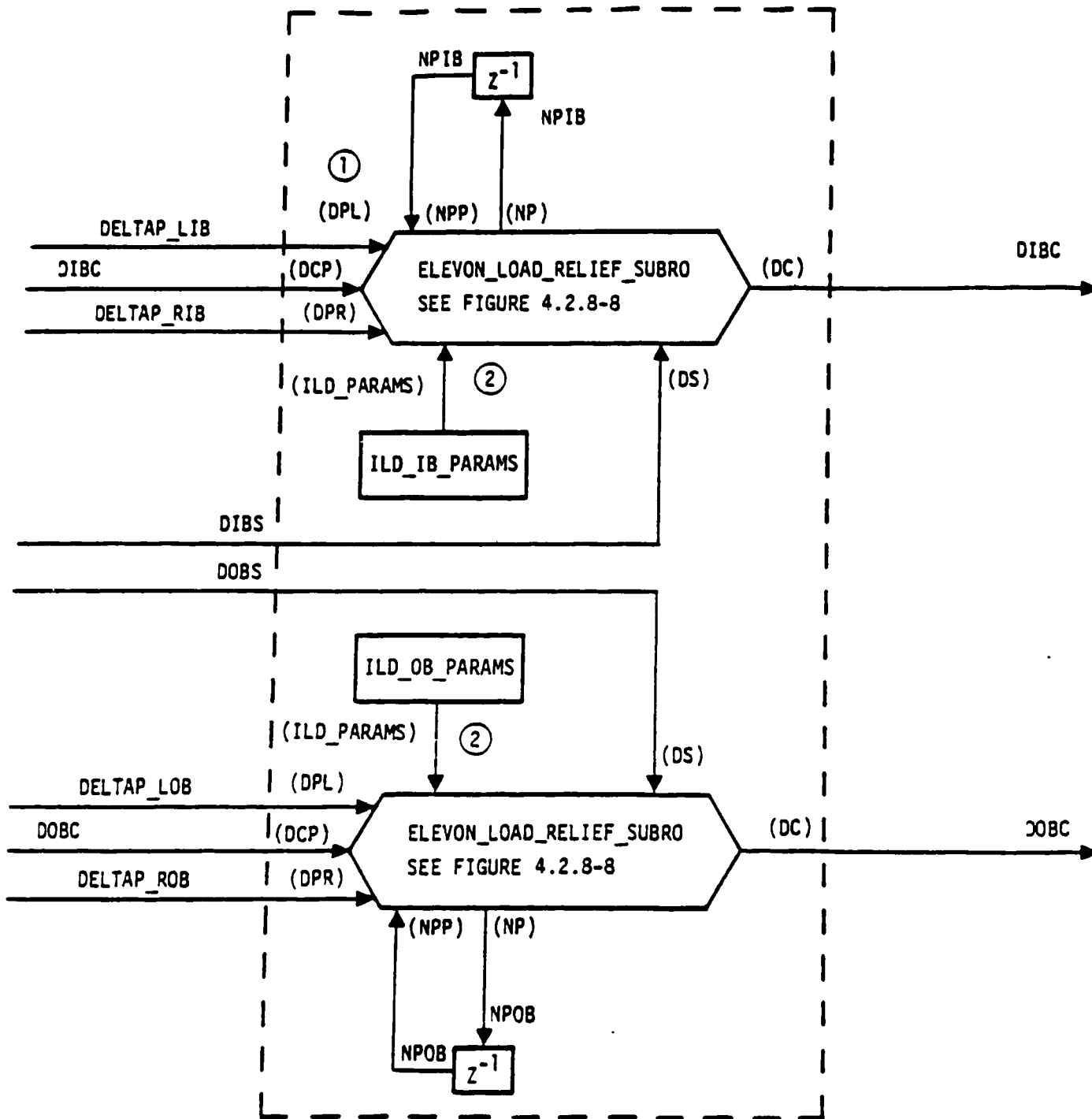
Figure 4.2.8-5. RUD_SB_CMD Function Module, Detailed Diagram

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NOTES

- ① DUMMY VARIABLE NAMES ARE SHOWN IN PARENTHESES
- ② $ILD_PARAMS \hat{=} BIAS / RETLIM / DRVLIM$
 $ILD_IB_PARAMS \hat{=} BIAS_IB / RETLIM_IB / DRVLIM_IB$
 $ILD_OB_PARAMS \hat{=} BIAS_OB / RETLIM_OB / DRVLIM_OB$

Figure 4.2.8-6. ELEVON LOAD RELIEF Function Module, Detailed Diagram

Figure 4

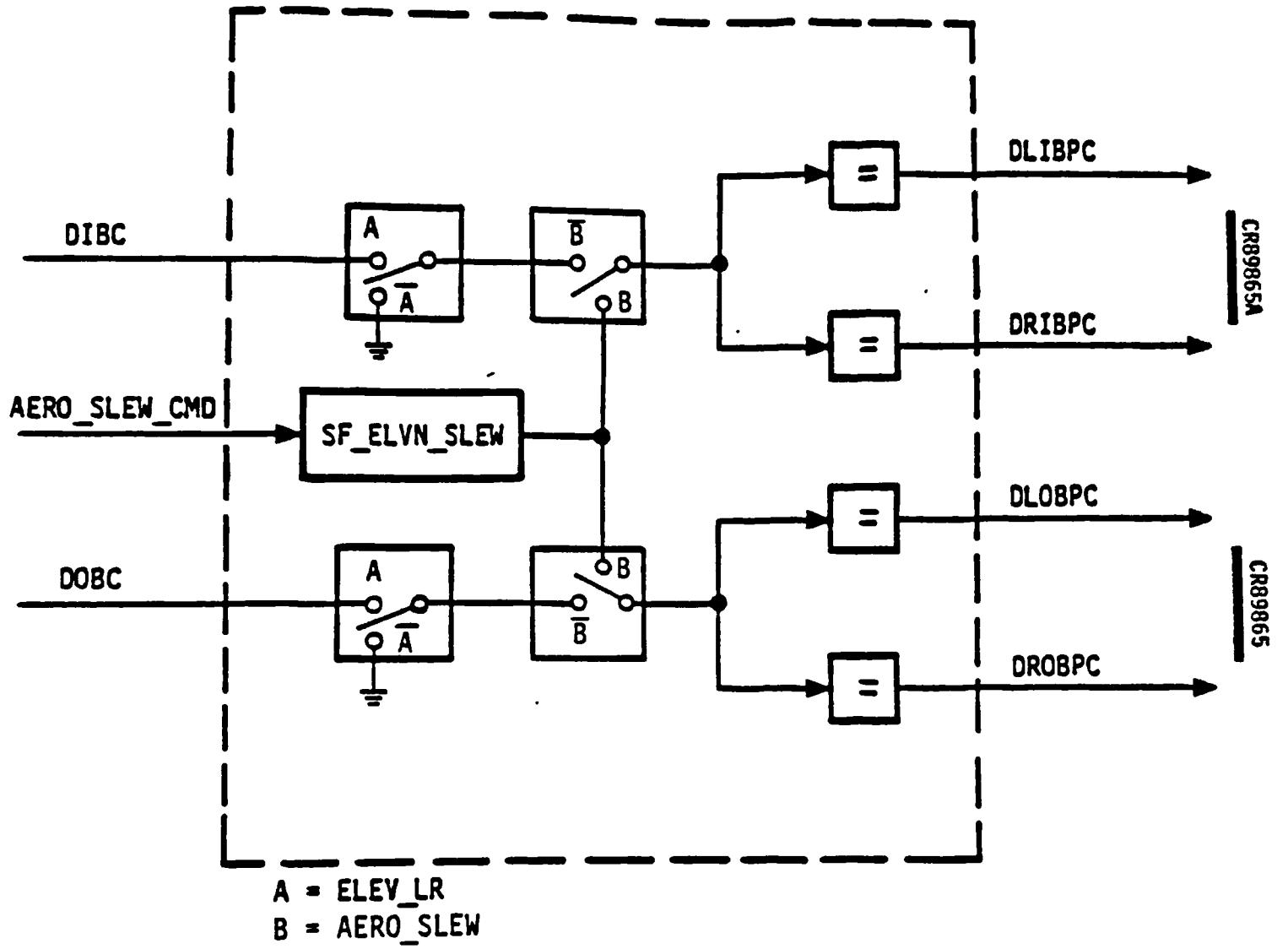


Figure 4.2.8-7. ELEVON_SLAVING Function Module, Detailed Diagram

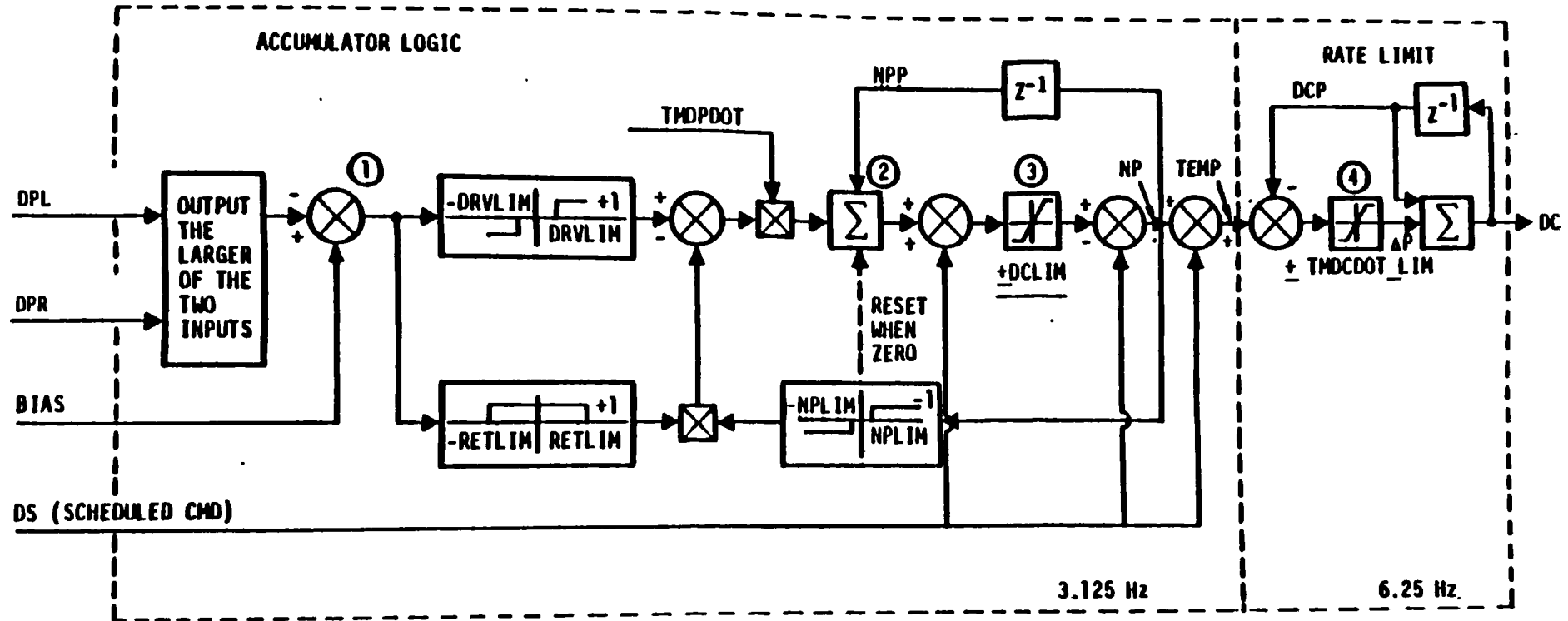
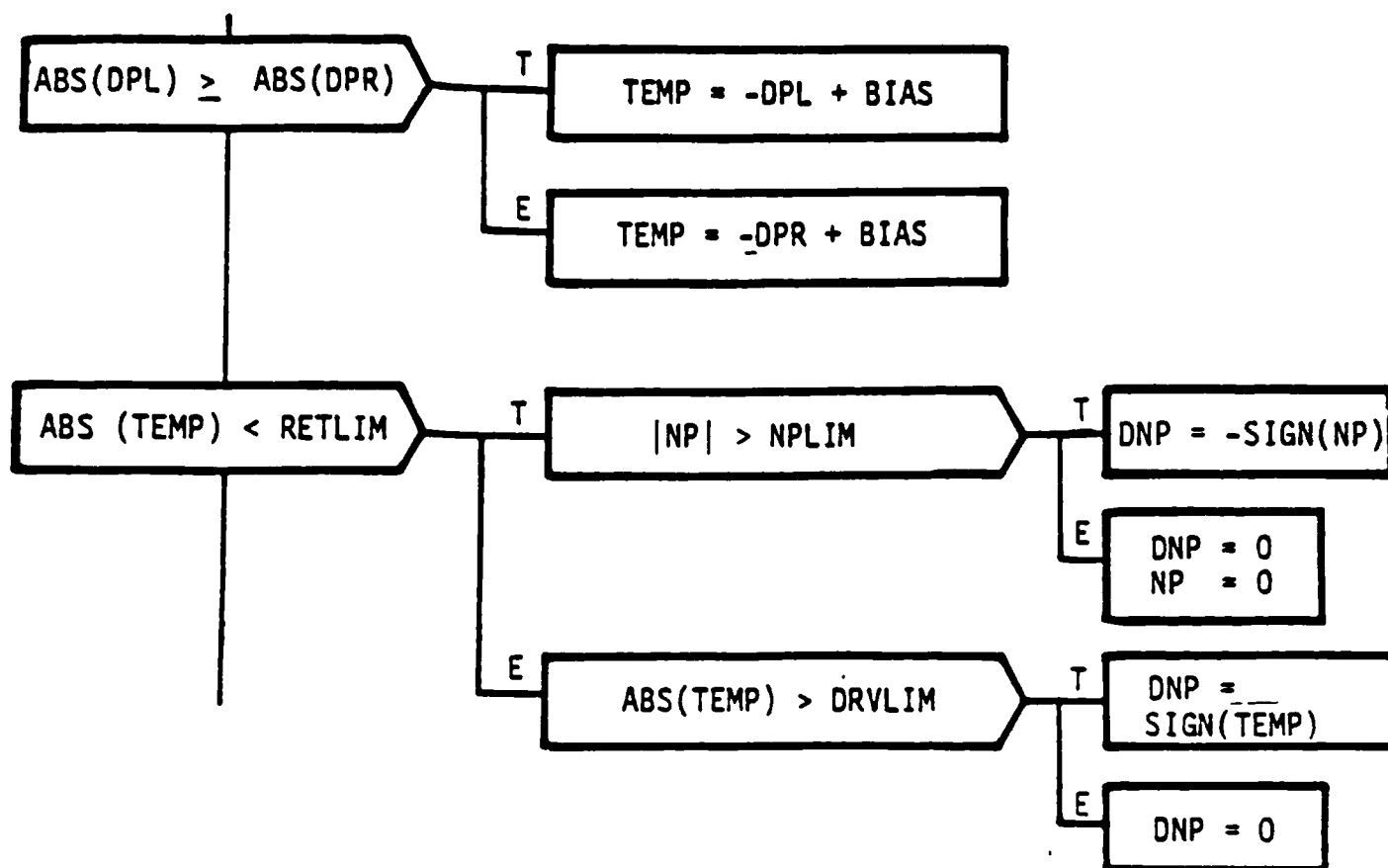


Figure 4.2.8-8. ELEVON_LOAD_RELIEF_SUBRO, Detailed Diagram (Sheet 1 of 2)

1. ABS(DPL) > ABS(DPR) → ABS(DPL) = ABS(DPR) + DPL - DPR
 2. ACCUMULATOR
 NP = NPP + (DPL - DPR) * NP / NPLIM
 3. POSITION LIM
 NP = MIDVIA * NP / NPLIM
 TEMP = NP * NPLIM
 4. RATE LIMIT
 DP = M2C/VA * NP
 DC = DP + DCP



1.



2. ACCUMULATOR (3.125 Hz)

$$NP = NPP + DNP = TMDPDOI$$

3. POSITION LIMIT (3.125 Hz)

$$NP = MIDVAL [-DCLIM, (NP + DS), DCLIM] - DS$$

$$TEMP = NP + DS$$

4. RATE LIMIT AND TOTAL COMMAND (6.25 Hz)

$$DP = MIDVAL [-TMDCDOTLIM, TEMP - DCP), TMDCDOTLIM]$$

$$DC = DP + DCP$$

Figure 4.2.8-8. ELEVON_LOAD_RELIEF_SUBRO, Detailed Diagram (Sheet 2 of 2)

Table 4.2.8-1. AEROSURFACE_CONTROL Interface Requirements

Module	Name	Description	Type	Source/ Destination	Units	Rate Required/ Produced (Hz)
	<u>Inputs</u>					
	ELEV_LR	Elevon load relief indicator	B	ASC_RECON	-	6.25
	DIBS	Inboard elevon schedule command	S	INTERPS	deg	3.125
	DOBS	Outboard elevon schedule command	S	INTERPS	deg	3.125
	DELTA_P_LIB	Elevon actuator differential pressure, left inboard	S	DELTA_P_FB_SOP (4.193)	psi	3.125
	DELTA_P_RIB	Elevon actuator differential pressure, right inboard	S	DELTA_P_FB_SOP (4.193)	psi	3.125
	DELTA_P_LOB	Elevon actuator differential pressure, left outboard	S	DELTA_P_FB_SOP (4.193)	psi	3.125
	DELTA_P ROB	Elevon actuator differential pressure, right outboard	S	DELTA_P_FB_SOP (4.193)	psi	3.125
	DBFOFB	Body flap position	S	BF_PFB_SOP (4.49)	deg	6.25
	PRELO	Indicator	B	ASC_RECON	-	12.5
	STOW_SB	Indicator, stow speed brake to closed position	B	ASC_RECON	-	12.5
	MM101_INIT	Indicator, elevon load relief	B	ASC_RECON	-	12.5
	AFCS_FIRST_PASS	Indicator	B	ASC_RECON	-	12.5
	AERO_SLEW_CMD	Aerosurface position slew command	S	ORB_ACT_SLEW (4.187)	-	25
	AERO_SLEW_COMPLETE	Indicator, aerosurface slew complete	B	ORB_ACT_SLEW (4.187)	-	12.5
	AERO_SLEW	Indicator, aerosurface slew check	B	ASC_RECON	-	12.5
	PRE_SEP	Indicator, E25A command	B	ASC_RECON	-	12.5
	SRB_IGN_CMD	Indicator	B	ASC_RECON	-	12.5
	<u>Outputs</u>					
	DLOBPC	Elevon command, left outboard	S	AERO_ACT_SOP (4.50)	deg	25/6.25*
	DLIBPC	Elevon command, left inboard	S	AERO_ACT_SOP (4.50)	deg	25/6.25*
	DRIBPC	Elevon command, right inboard	S	AERO_ACT_SOP (4.50)	deg	25/6.25*
	DROBPC	Elevon command, right outboard	S	AERO_ACT_SOP (4.50)	deg	25/6.25*
	DBFRC	Body flap rate drive command	I	AERO_ACT_SOP (4.50)	-	6.25

*Rate x/y, x = slew, y = normal

Table 4.2.8-1
Module Name
Outputs (Hz)
DRPC
DSBPC
Rate x/y, x = slew, y = normal

Table 4.2.8-1. AEROSURFACE_CONTROL Interface Requirements (Cont)

Module	Name	Description	Type	Source/ Destination	Units	Rate Required/ Produced (Hz)
	<u>Outputs (Cont)</u>					
	DRPC	Rudder command	S	AERO_ACT_SOP (4.50)	deg	25/6.25*
	DSBPC	Speed brake command	S	AERO_ACT_SOP (4.50)	deg	25/6.25*
<p>*Rate x/y, x = slew, y = normal</p>						



Table 4.2.8-2. AEROSURFACE_CONTROL Inter-Module Interface Requirements

Module	Name	Description	Type	Source/ Destination	Units	Rate Required/ Produced (Hz)
BODY FLAP CONTROL	<u>Inputs</u>					
	AERO_SLEW	Indicator, aerosurface slew check	B	ASC_RECON	-	6.25
	MM101_INIT	Indicator, first time ASCENT DAP scheduled	B	ASC_RECON	-	6.25
	AERO_SLEW_CMD	Aerosurface position slew command	S	ORB_ACT_SLEW (4.187)	-	6.25
	DBFOFB	Body flap position	S	BF_PFB_SOP (4.49)	deg	6.25
	<u>Outputs</u>					
	DBFRC	Body flap rate drive	I	AERO_ACT_SOP (4.50)	-	6.25
RUD SB_CMD	<u>Inputs</u>					
	STOW_SB	Indicator, stow speed brake to closed position	B	ASC_RECON	-	6.25
	AERO_SLEW	Indicator, aerosurface slew check	S	ASC_RECON	-	6.25
	AERO_SLEW_COMPLETE	Indicator, aerosurface slew complete	B	ASC_RECON	-	6.25
	MM101_INIT	Indicator, first time ASCENT DAP scheduled	S	ASC_RECON	-	6.25
	AERO_SLEW_CMD	Aerosurface position slew command	S	ORB_ACT_SLEW (4.187)	-	25
	PRELO	Indicator	B	ASC_RECON	-	12.5
	<u>Outputs</u>					
DSBPC	Speed brake position command	S	AERO_ACT_SOP (4.50)	deg	25	
DRPC	Rudder position command	S	AERO_ACT_SOP (4.50)	deg	25	
ELEVON LOAD RELIEF	<u>Inputs</u>					
	DELTAP_LOB	Elevon actuator differential pressure, left outboard	S	DELTAP_FB_SOP (4.193)	psi	3.125
	DELTAP_LIB	Elevon actuator differential pressure, left inboard	S	DELTAP_FB_SOP (4.193)	psi	3.125
	DELTAP_RIB	Elevon actuator differential pressure, right inboard	S	DELTAP_FB_SOP (4.193)	psi	3.125
	DELTAP ROB	Elevon actuator differential pressure, right outboard	S	DELTAP_FB_SOP (4.193)	psi	3.125
	DIBS	Inboard elevon schedule	S	INTERPS	deg	3.125
	DOBS	Outboard elevon schedule	S	INTERPS	deg	3.125

Table 4.2.8-2

Module	Inputs	Outputs
ELEVON_LOAD_RELIEF_CMD	DIBC DOBC MM101_INIT	
ELEVON_LOAD_RELIEF_SUBD	DIBC DOBC	DPL DPR DS BIAS
ELEVON_SLAVING		DC DIBC DOBC AERO_SLEW_CMD MM101_INIT AERO_SLEW ME_SLEW SRB_SLEW ELEV_LR
		DLIBPC DRIBPC DLBPC DRBPC

Table 4.2.8-2. AEROSURFACE_CONTROL Inter-Module
Interface Requirements (Cont)

Module	Name	Description	Type	Source/ Destination	Units	Rate Required/ Produced (Hz)	
ELEVON_LOAD_RELIEF (Cont)	<u>Inputs (Cont)</u>						
	DIBC DOBC	Past values of outputs	S	ELEVON_LOAD_RELIEF	deg	6.25	
	MM101_INIT	Indicator, first time ASCENT DAP scheduled	B	ASC_RECON	-	12.5	
	<u>Outputs</u>						
	DIBC	Inboard elevon command	S	ELEVON_SLAVING	deg	6.25	
	DOBC	Outboard elevon command	S	ELEVON_SLAVING	deg	6.25	
ELEVON_LOAD_RELIEF SUBRO	<u>Inputs</u>						
	DPL	Differential pressure, left elevon	S	DELTAP_FB_SOP (4.193)	psi	-	
	DPR	Differential pressure, right elevon	S	DELTAP_FB_SOP (4.193)	psi	-	
	DS	Scheduled elevon command	S	INTERPS	deg	-	
	BIAS	Command bias to center of structural capability	S	I-LOAD	psi	-	
	<u>Outputs</u>						
	DC	Total elevon command	S	Dummy variable	deg	-	
ELEVON_SLAVING	<u>Inputs</u>						
	DIBC	Inboard elevon command	S	ELEVON_LOAD_RELIEF	deg	6.25	
	DOBC	Outboard elevon command	S	ELEVON_LOAD_RELIEF	deg	6.25	
	AERO_SLEW_CMD	Aerosurface position slew command	S	ORB_SLEW_SOP (4.187)	-	25	
	MM101_INIT	Indicator, first time ASCENT_DAP sequenced	B	ASC_RECON	-	6.25	
	AERO_SLEW	Indicator, aerosurface slew check	B	ASC_RECON	-	12.5	
	ME_SLEW	Indicator, main engine actuator slew test	B	ACC_RECON	-	12.5	
	SRB_SLEW	Indicator, SRB actuator slew test	B	ACC_RECON	-	12.5	
	ELEV_LR	Elevon load relief indicator	B	ASC_RECON	-	6.25	
	<u>Outputs</u>						
	DLIBPC	Elevon position command, left inboard	S	AERO_ACT_SOP (4.50)	deg	25/6.25*	
	DRIBPC	Elevon position command, right inboard	S	AERO_ACT_SOP (4.50)	deg	25/6.25*	
	DLOBPC	Elevon position command, left outboard	S	AERO_ACT_SOP (4.50)	deg	25/6.25*	
DROBPC	Elevon position command, right outboard	S	AERO_ACT_SOP (4.50)	deg	25/6.25*		

*Rate x/y x = slew, y = normal

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Table 4.2.8-3. AEROSURFACE_CONTROL Initialization Requirements

Function Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
BODY_FLAP_CONTROL	Rate drive past value	-	AFCS_FIRST_PASS	DSFPC	0.0
	Slew scale factor	-	AFCS_FIRST_PASS	SF_BF_SLEW	0.0
		AERO_SLEW	AERO_SLEW	SF_BF_SLEW	SF_BF_SLEW_NOM
		AERO_SLEW	AERO_SLEW	SF_BF_SLEW	0.0
RUD_SB_CMD	Rudder command	-	AFCS_FIRST_PASS	DRPC	0.0
		AERO_SLEW	AERO_SLEW	DRPC	0.0
	Speed brake command	-	AFCS_FIRST_PASS	DSBPC	DSB_BIAS_SLEW
		STOW_SB	STOW_SB	DSBPC	DSB_CLOSED
	Slew scale factors	AERO_SLEW	AERO_SLEW	SF_RUD_SLEW	SF_RUD_SLEW_NOM
				SF_SB_SLEW	SF_SB_SLEW_NOM
		AERO_SLEW	AERO_SLEW	SF_RUD_SLEW	0.0
			MM101_INIT	SF_SB_SLEW	0.0
	Fader	-	MM101_INIT	NFADE_DSBCLDSE	0
		STOW_SB	STOW_SB	NFADE_DSBCLDSE	NFADE_DSBCLDSE_NOM
		STOW_SB	STOW_SB	NFADE_DSBCLDSE	NFADE_DSBCLDSE_NOM
	ELEVON_LOAD_RELIEF	Inboard integrator	-	AFCS_FIRST_PASS	NPIB
Outboard integrator		-		NPOB	0.0
Inboard elevon command		-		DIBC	0.0
Outboard elevon command		-		DOBC	0.0
ELEVON_SLAVING	Slew scale factor	-	AFCS_FIRST_PASS	SF_ELVN_SLEW	0.0
		AERO_SLEW	AERO_SLEW	SF_ELVN_SLEW	SF_ELVN_SLEW_NOM
		AERO_SLEW	AERO_SLEW	SF_ELVN_SLEW	0.0
	Elevon position commands	-	AFCS_FIRST_PASS	DLIBPC	0.0
				DRIBPC	0.0
				DLOBPC	0.0
				DROBPC	0.0
		PRESEP	PRESEP	DLIBPC	0.0
				DRIBPC	0.0
				DLOBPC	0.0
				DROBPC	0.0
		AERO_SLEW	AERO_SLEW	DLIBPC	0.0
				DRIBPC	0.0
				DLOBPC	0.0
				DROBPC	0.0
		ME_SLEW	ME_SLEW	DLIBPC	0.0
		DRIBPC	0.0		
		DLOBPC	0.0		
		DROBPC	0.0		
SRB_SLEW	SRB_SLEW	DLIBPC	0.0		
		DRIBPC	0.0		
		DLOBPC	0.0		
		DROBPC	0.0		

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ELEVON_LOAD_RELIEF	BIAS_ID
	RETLIM_1
	DRVLM_1
	BIAS_OB
	RETLIM_2
	DRVLM_2
ELEVON_LOAD_RELIEF_SLBRO	TMDPDT
	DCLIM
	NPLIM
	TMDCDOT
BODY_FLAP_CONTROL	DBFE_OUT
	DBFE_IN
	SF_BF_SLEW
RUD_SB_CMD	SF_RUD_SLEW
	SF_SB_SLEW
	DSB_CLOSED
	DSB_B.A.
ELEVON_SLAVING	NFADE_D
	SF_EL_SLEW

Table 4.2.8-4. AEROSURFACE_CONTROL I-Loads

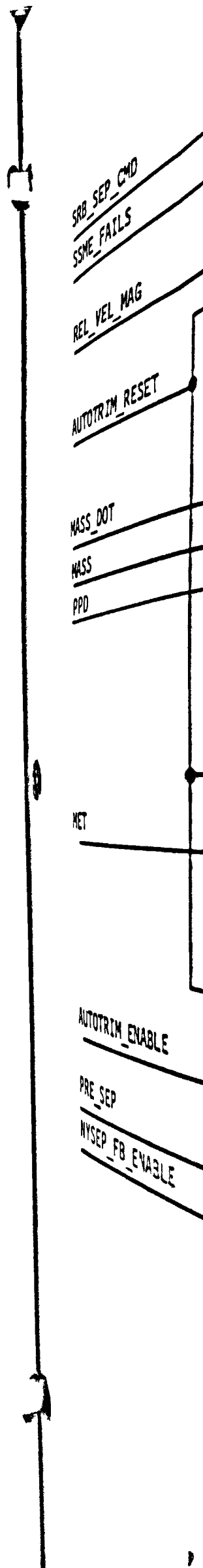
Module	Name	Description	Type	MSID	Units
ELEVON_LOAD_RELIEF	BIAS_IB	Inboard command bias to center of structural capability	S	V97U1413C	psi
	RETLIM_IB	Inboard elevon load relief return limit	S	V97U2232C	psi
	DRVLIM_IB	Inboard elevon load relief drive limit	S	V97U1776C	psi
	BIAS_OB	Outboard command bias to center of structural capability	S	V97U1416C	psi
	RETLIM_OB	Outboard elevon load relief return limit	S	V97U2233C	psi
	DRVLIM_OB	Outboard elevon load relief drive limit	S	V97U1777C	psi
ELEVON_LOAD_RELIEF_SUBRO	TMDPDOT	Commanded active elevon load relief deflection/NP	S	V97U2428C	deg/ count
	DCLIM	Elevon position limit	S	V97U2429C	deg
	NPLIM	Deadspace accumulator feedback	S	V96U8977C	deg
	TMDCDOTLIM	Maximum rate limited elevon deflection per major cycle	S	V97U2430C	deg
BODY_FLAP_CONTROL	DBFE_OUTER	Outer or drive level for body flap deadband/hysteresis function	S	V97U1666C	deg
	DBFE_INNER	Inner or deadband level for body flap deadband/hysteresis function	S	V97U1665C	deg
	SF_BF_SLEW_NOM	Body flap slew scale factor	S	V97U2240C	-
RUD_SB_CMD	SF_RUD_SLEW_NOM	Rudder slew scale factor	S	V97U2243C	-
	SF_SB_SLEW_NOM	Speed brake slew scale factor	S	V97U2244C	-
	DSB_CLOSED	Speed brake closed position command	S	V97U2425C	deg
	DSB_BIAS_SLEW	Speed brake biased position for slew check	S	V97U2441C	deg
	NFADE_DSBCLOSE_NOM	Fade time for speed brake closing	S	V97U2431C	-
ELEVON_SLAVING	SF_ELVN_SLEW_NOM	Elevon slew scale factor	S	V97U2241C	-



4.2.9 Linear Interpolations (INTERPS)

A. Software Description. An overview of INTERPS is presented in Figure 4.2.9-1. Its input/output requirements are summarized in Table 4.2.9-1. INTERPS consists of five function modules, S1 TRIMS AND ACCELREFS, ELEVON SCHEDULES, MPS SRB INT GAINS, S2 GAINS AND TRIM, and S1VREL S2ATT GAINS, which are sequenced as shown in Figure 4.2.9-2. The detail diagrams for S1 TRIMS AND ACCELREFS and ELEVON SCHEDULES are shown in Figures 4.2.9-3 and 4.2.9-4, respectively. The detail diagram for MPS SRB INT GAINS is shown in Figure 4.2.9-5. The detail diagrams for S2 GAINS AND TRIM and S1VREL S2ATT GAINS are shown in Figures 4.2.9-6 and 4.2.9-7. The inter-module interface requirements for INTERPS are given in Table 4.2.9-2. Initialization and I-loads requirements for INTERPS are presented in Tables 4.2.9-3 and 4.2.9-4, respectively.

B. Sequencing Requirements. INTERPS operating at 6.25 Hz does not require an unscheduled execution prior to transport-delay-critical modules provided that reconfiguration is mechanized within 80 ms of recognition of a valid mode-change; see paragraph 4.1.3.C.



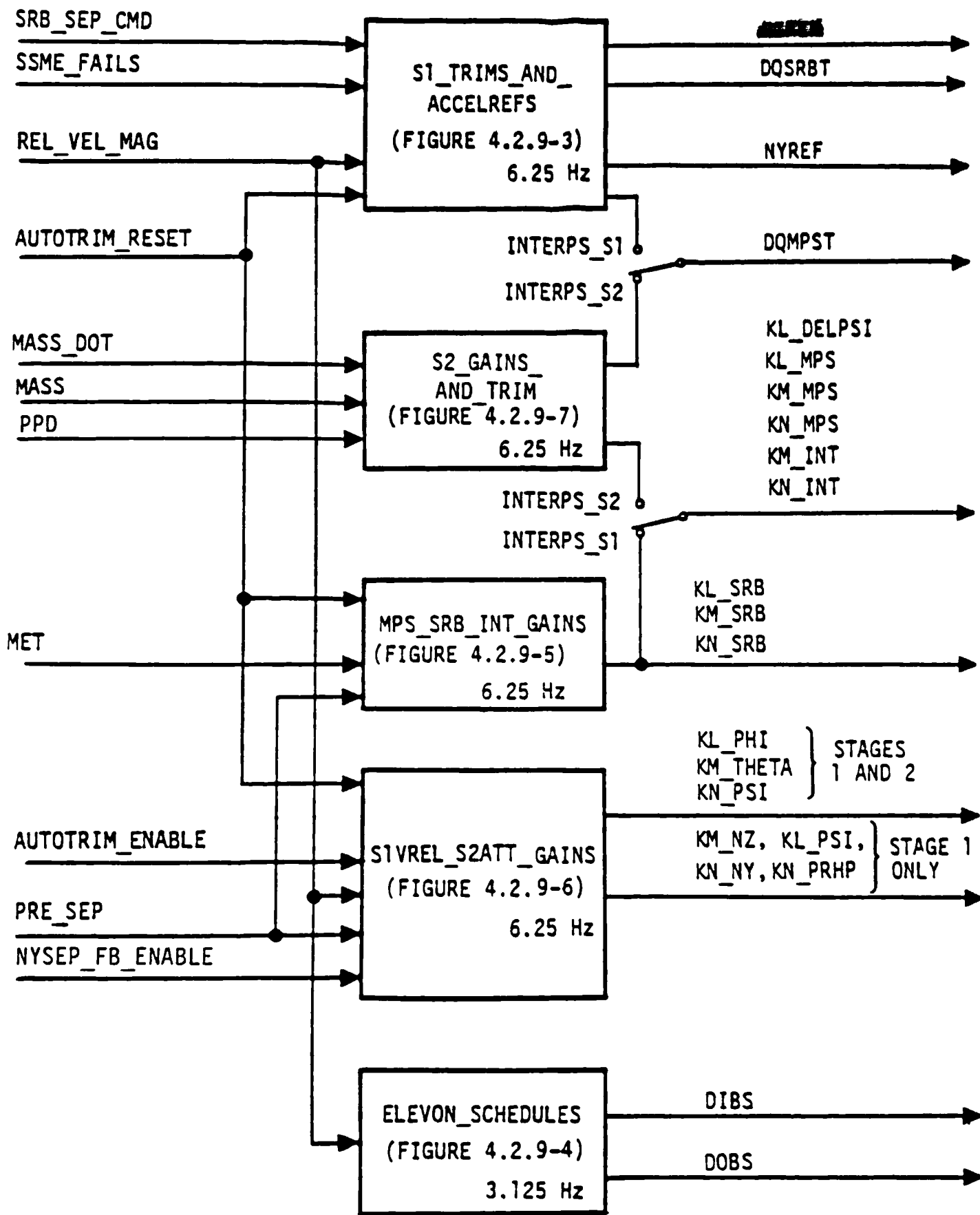


Figure 4.2.9-1. INTERPS Functional View

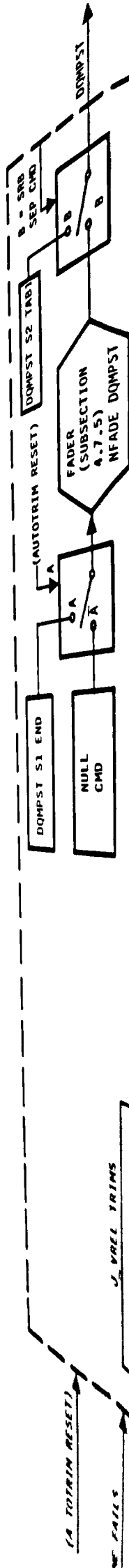
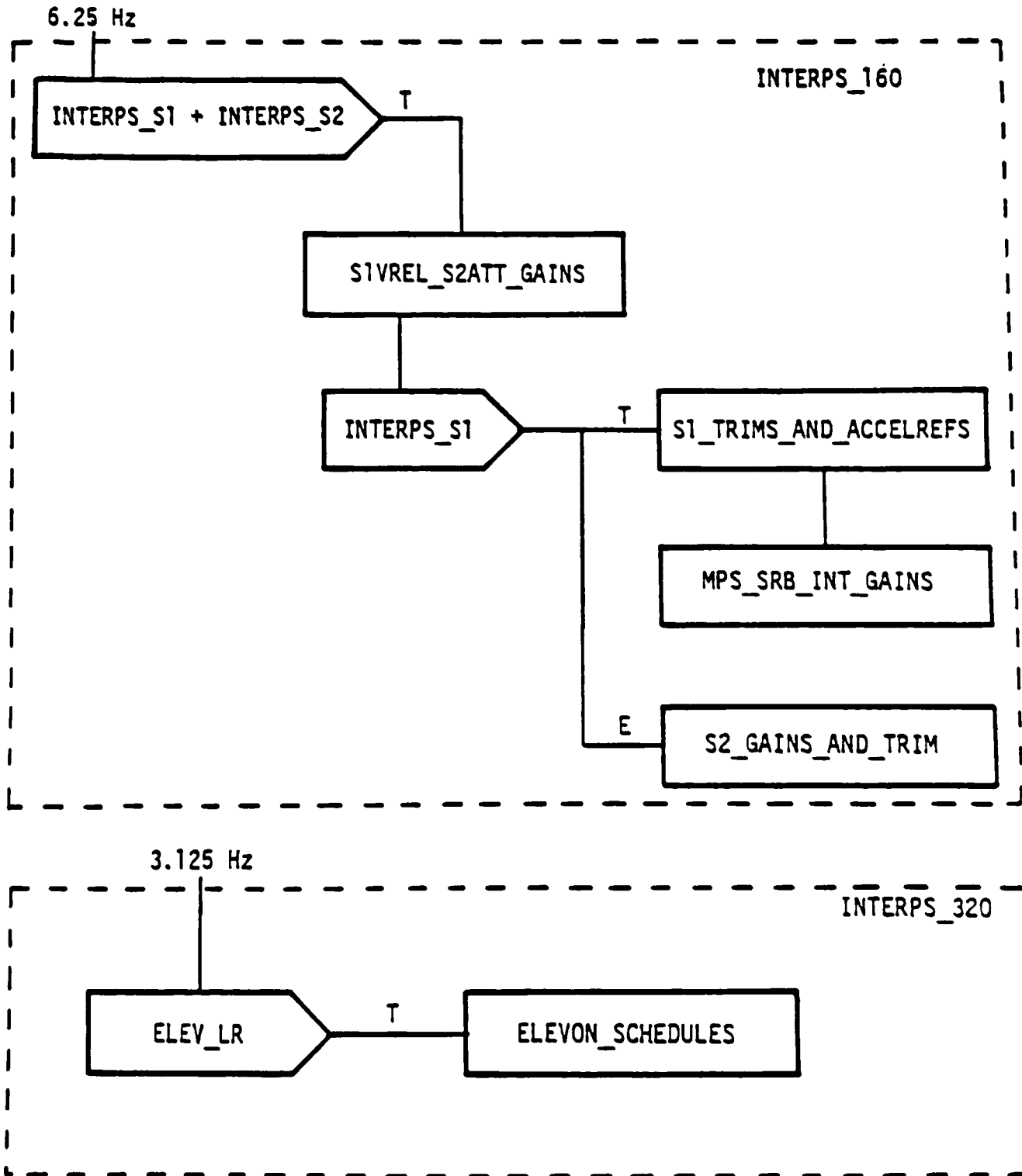


Figure 4.2.9-2. INTERPS Software Overview

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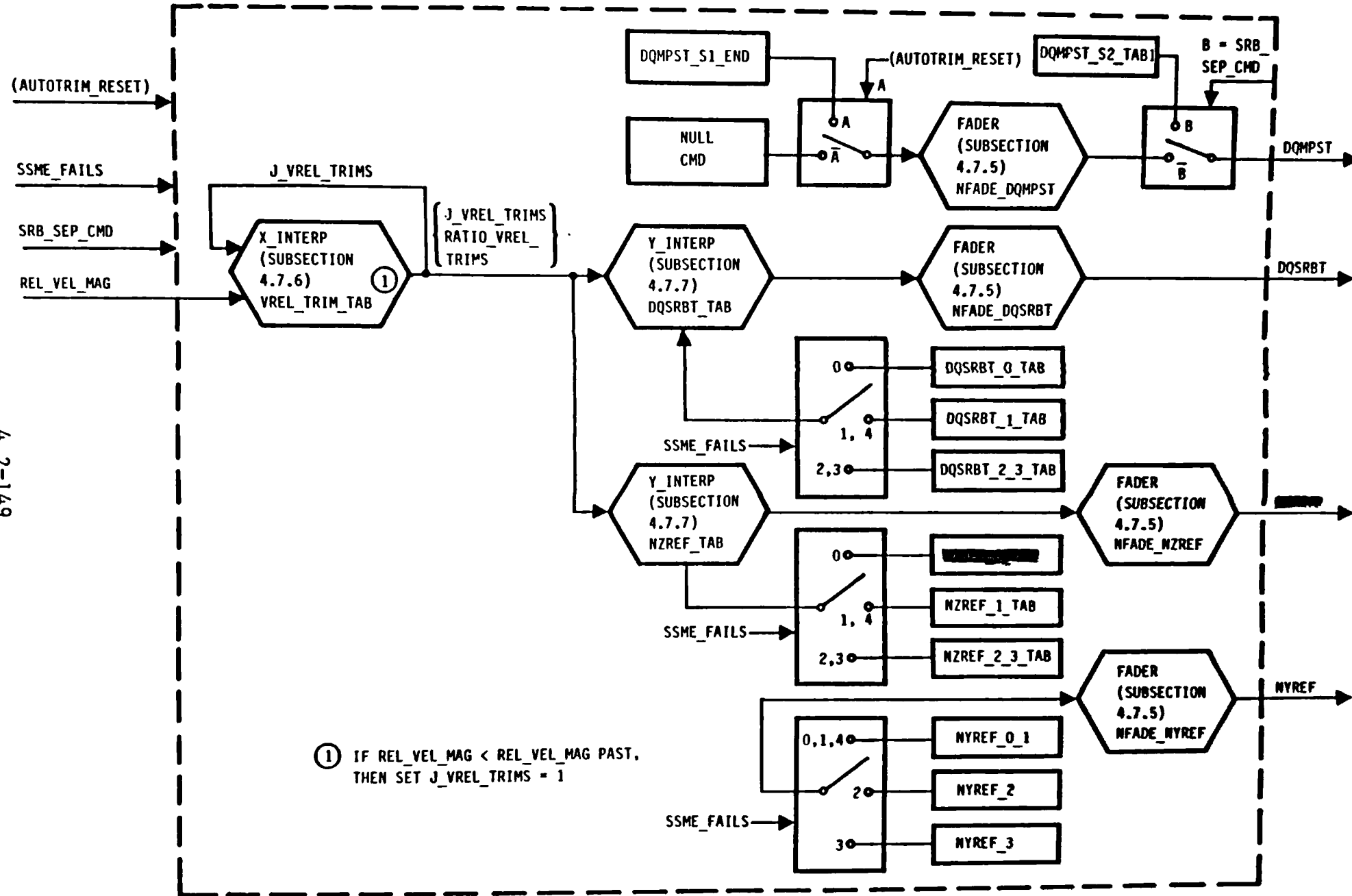


Figure 4.2.9-3. S1_TRIMS_AND_ACCELREFS Function Module, Detailed Diagram

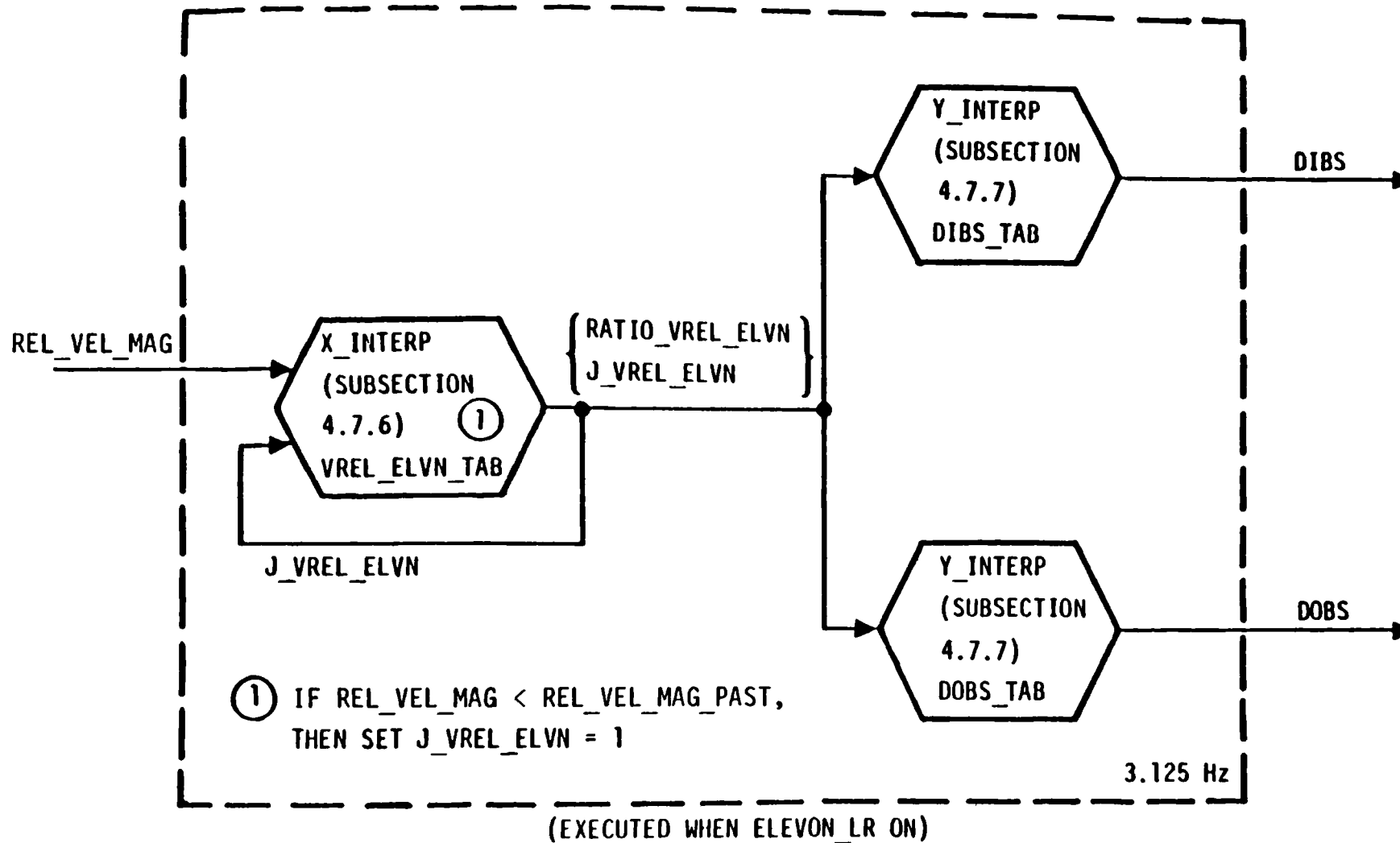
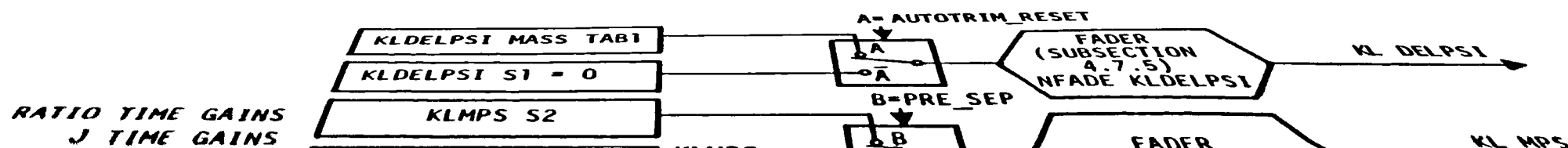


Figure 4.2.9-4. Function Module ELEVON_SCHEDULES, Detailed Diagram



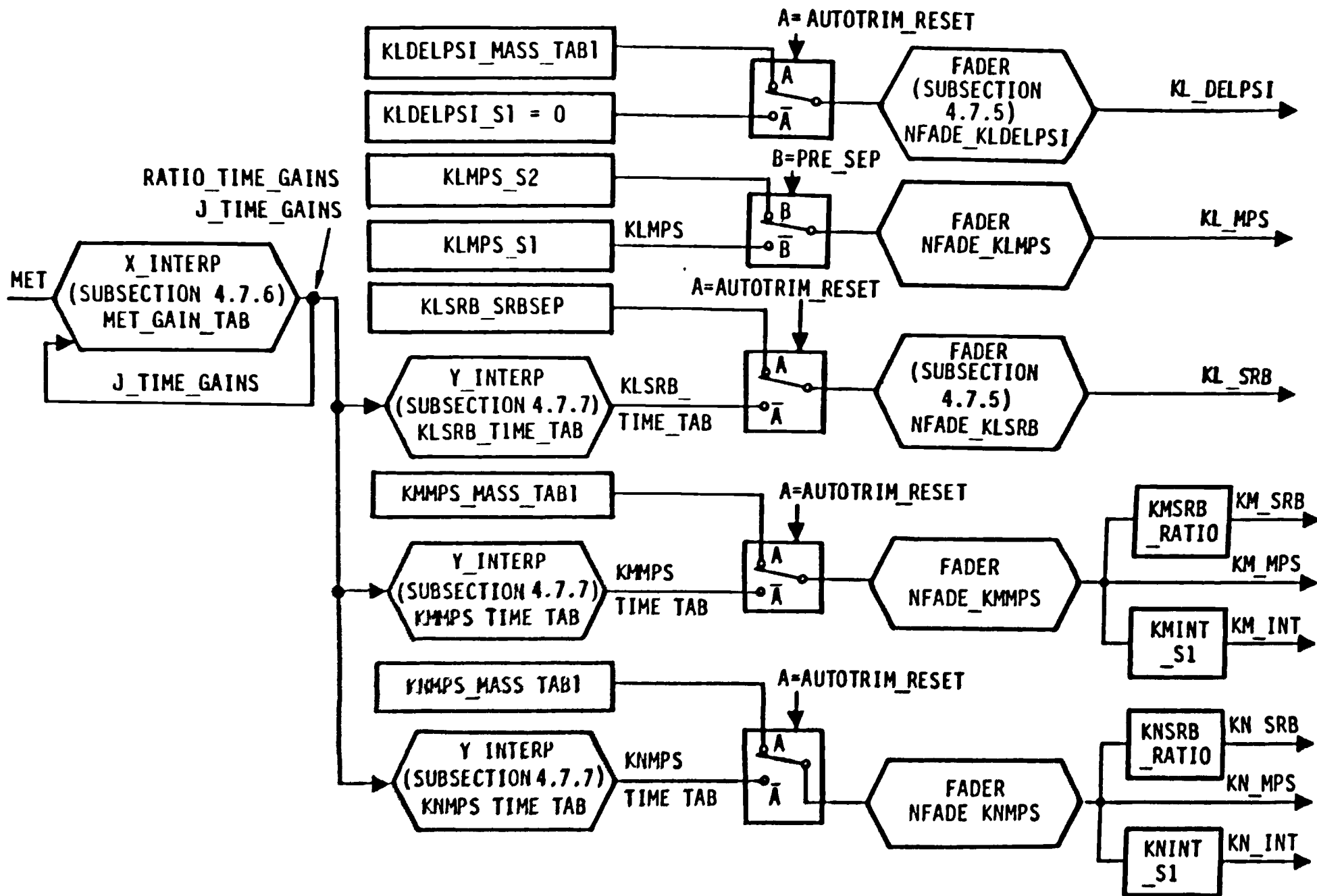


Figure 4.2.9-5. Function Module MPS_SRB_INT_GAINS, Detailed Diagram

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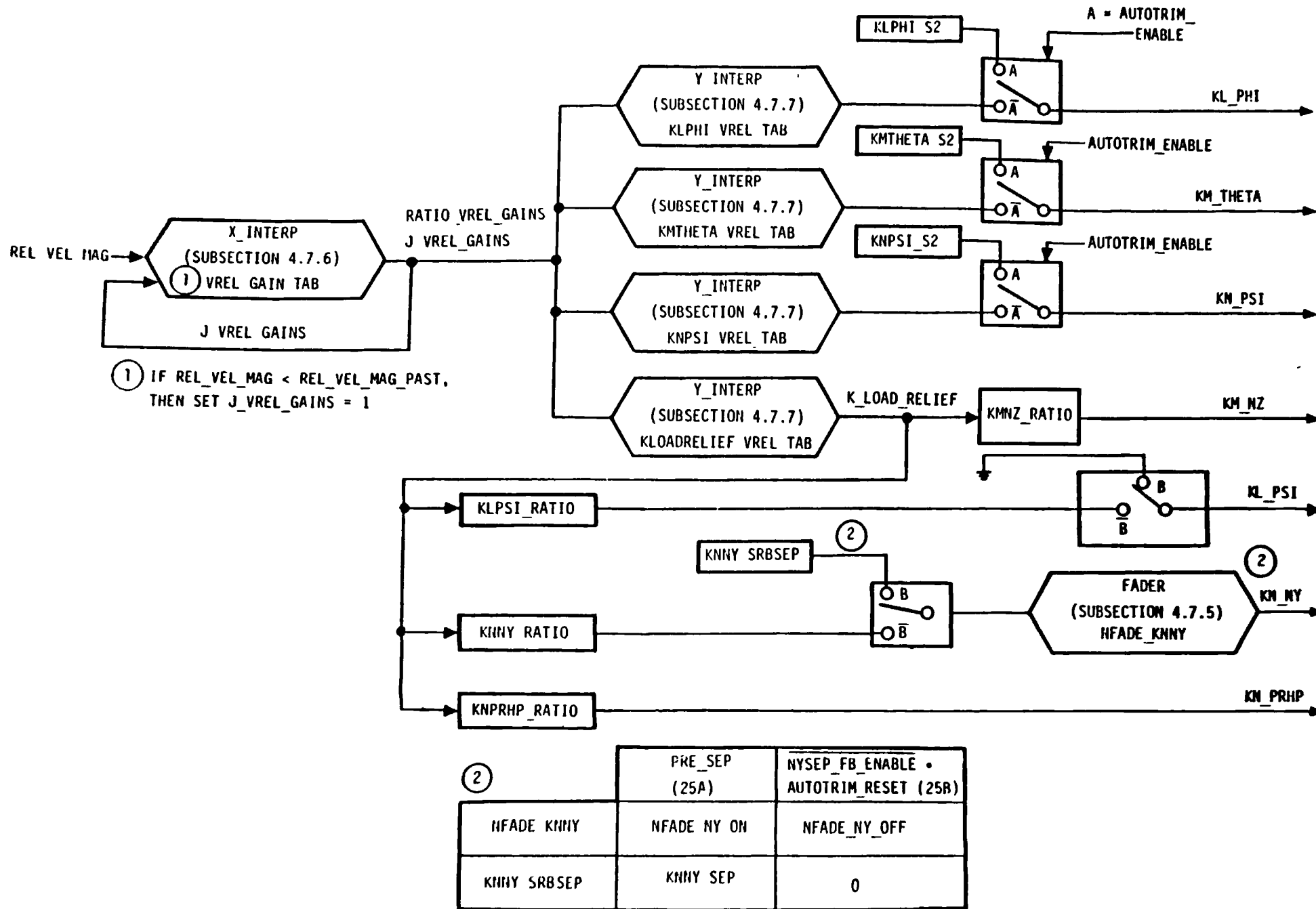
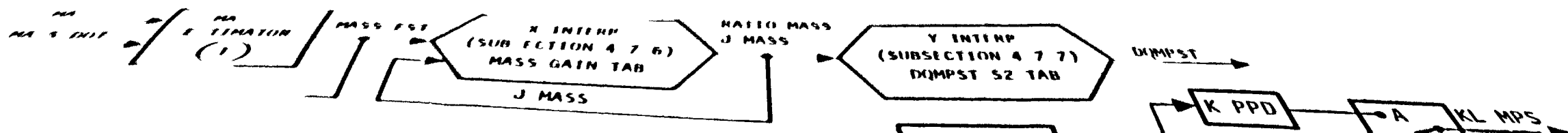
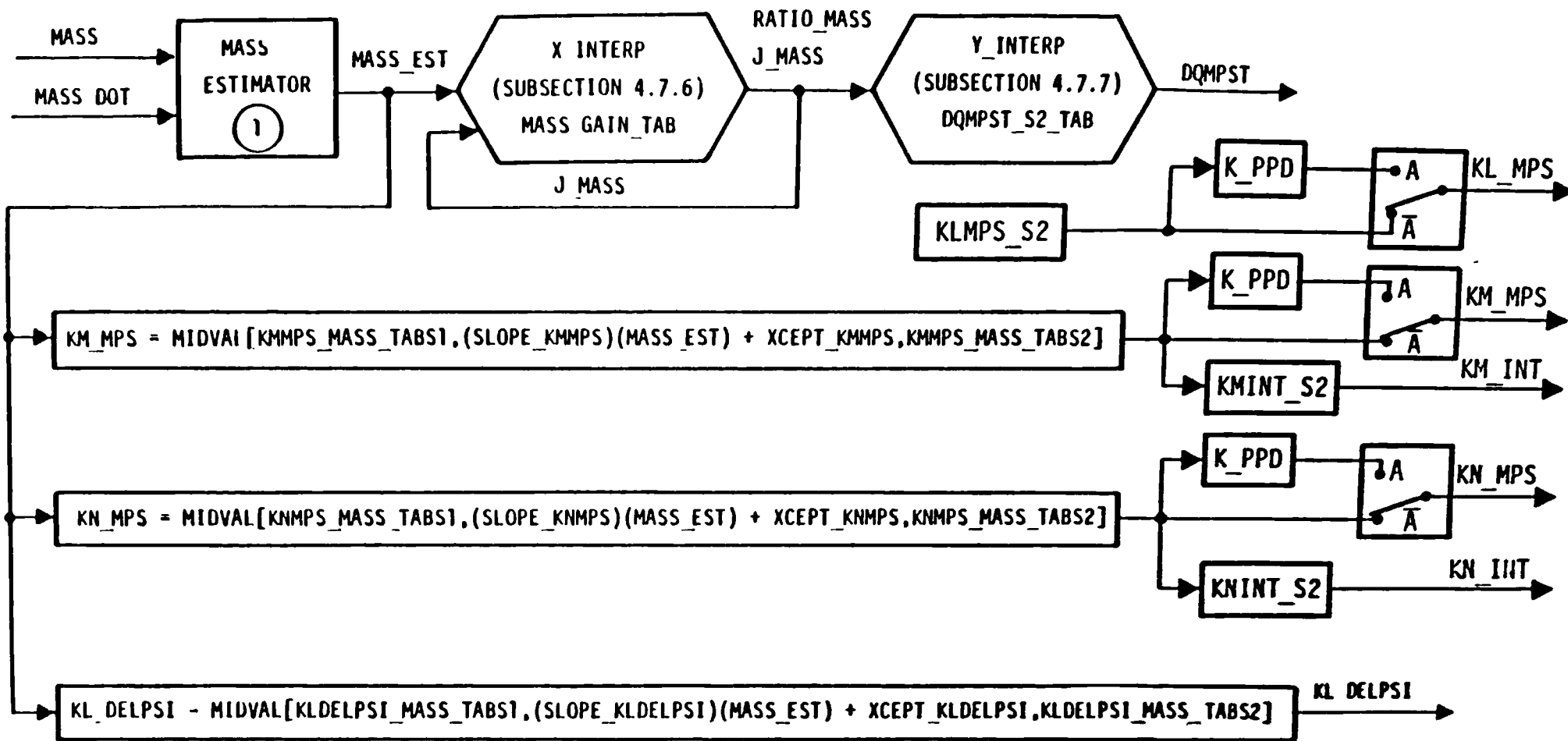


Figure 4.2.9-6. Function Module S1VREL S2ATT_GAINS Detailed Diagram





① $MASS_EST = MASS_EST - MASS_DOT * TS$
 WHERE MASS_EST IS RESET TO THE VALUE
 OF MASS AT THE 0.521 Hz RATE
 (MASS DOT IS POSITIVE)

A = PPD

Figure 4.2.9-7. S2 GAINS AND_TRIM Function Module, Detailed Diagram

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 International

Table 4.2.9-1. INTERPS Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Inputs</u>						
	MET	Mission elapsed time	ASC_RECON	S		sec	6.25
	REL_VEL_MAG	Earth-relative velocity magnitude	ASCENT_UPP	S		fps	6.25
	SSME_FAILS	Buffered version of SSME_FAIL_STATUS	ASC_RECON	I		-	12.5
	MASS_DOT	Rate of change of vehicle mass	{ASC_2STG_GUID} {PW_RTLS_GUID}	S		slug/s	0.521
	MASS	Vehicle mass	{ASC_2STG_GUID} {PW_RTLS_GUID}	S		slug	0.521
	SRB_SEP_CMD	Indicator, SRB separation command	ASC_RECON	B		-	12.5
	AUTOTRIM_RESET	Indicator, reset trim integrators to zero	ASC_RECON	B		-	12.5
	MM101_INIT	Indicator, first time ASCENT DAP is scheduled	ASC_RECON	B		-	12.5
	INTERPS_S1	Indicator, stage 1 INTERPS active	ASC_RECON	B		-	12.5
	INTERPS_S2	Indicator, stage 2 INTERPS active	ASC_RECON	B		-	12.5
	AUTOTRIM_ENABLE	Indicator, enable stage 2 AUTOTRIM	ASC_RECON	B		-	12.5
	PRE_SEP	Indicator, initiate separation preparation	ASC_RECON	B		-	12.5
	NYSEP_FB_ENABLE	Indicator, enable NY feedback for separation	ASC_RECON	B		-	12.5
	PPD	Indicator, RTLS powered pitchdown maneuver	ASC_RECON	B		-	12.5
	<u>Outputs</u>						
	DOMPST	Pitch thrust vector deflection trim, orbiter	CMD_PROC_MPS	S		deg	6.25
	DQSRBT	Pitch thrust vector deflection trim, SRB	CMD_PROC_SRB	S		deg	6.25
	NYREF	Scheduled normal acceleration reference	ASC_TVC	S		g	6.25
	NYREF	Scheduled lateral acceleration reference	ASC_TVC	S		g	6.25

Table

Module	Name
	DIBS
	DOBS
	KL_PHI
	KN_THETA
	KN_PSI
	KN_WZ
	KN_NY
	KL_MPS
	KN_MPS
	KN_MPS
	KN_MPS
	KL_SRB
	KN_SRB
	KN_SRB
	KN_SRB
	KL_PSI
	KN_INT
	KN_INT
	KL_DELPST
	KN_WHP
	K_LOAD_REL.EP

Table 4.2.9-1. INTERPS Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Outputs</u>						
	DIBS	Elevon inboard schedule	AEROSURFACE_CONTROL	S		deg	6.25
	DOBS	Elevon outboard schedule	AEROSURFACE_CONTROL	S		deg	6.25
	KL_PHI	Variable gain (attitude, roll)	ASC_TVC	S		(deg/s)/deg	6.25
	KM_THETA	Variable gain (attitude, pitch)	ASC_TVC, GC_STEER	S		(deg/s)/deg	6.25
	KN_PSI	Variable gain (attitude, yaw)	ASC_TVC, GC_STEER	S		(deg/s)/deg	6.25
	KM_NZ	Variable gain (NZ feedback, pitch)	ASC_TVC	S		(deg/s)/g	6.25
	KN_NY	Variable gain (NY feedback, yaw)	ASC_TVC	S		(deg/s)/g	6.25
	KL_MPS	Variable gain (rate, roll)	CMD_PROC_MPS	S		deg/(deg/s)	6.25
	KM_MPS	Variable gain (rate, pitch)	CMD_PROC_MPS	S		deg/(deg/s)	6.25
	KN_MPS	Variable gain (rate, yaw)	CMD_PROC_MPS	S		deg/(deg/s)	6.25
	KL_SRB	Variable gain (rate, SRB roll)	CMD_PROC_SRB	S		deg/(deg/s)	6.25
	KM_SRB	Variable gain (rate, SRB pitch)	CMD_PROC_SRB	S		deg/(deg/s)	6.25
	KN_SRB	Variable gain (rate, SRB yaw)	CMD_PROC_SRB	S		deg/(deg/s)	6.25
	KL_PSI	Variable gain (yaw attitude error crossfeed, roll)	ASC_TVC	S		(deg/s)/deg	6.25
	KM_INT	Variable pitch integrator gain	ASC_TVC	S		1/s	6.25
	KN_INT	Variable yaw integrator gain	ASC_TVC	S		1/s	6.25
	KL_DELPSI	Variable yaw command crossfeed gain	ASC_TVC	S		-	6.25
	KN_PRHP	Variable roll/yaw high pass gain	ASC_TVC	S		-	6.25
	K_LOAD_RELIEF	Variable load relief gain	ASC_1STG_GUID	S		-	6.25

Table 4.2.9-2. INTERPS Inter-Module Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
SI_TRIMS AND ACCELREFS	<u>Inputs</u>						
	REL_VEL_MAG	Earth-relative velocity magnitude	ASCENT_UPP	S		fps	6.25
	AUTOTRIM_RESET	Indicator, reset trim integrators to zero	ASC_RECON	B		-	12.5
	SSME_FAILS	Buffered, SSME_FAIL_STATUS	ASC_RECON	I		-	12.5
	MM101_INIT	Indicator, first time ASCENT DAP sequenced	ASC_RECON	B		-	12.5
	SRB_SEP_CMD	Indicator, initiate SRB separation command	ASC_RECON	B		-	12.5
	<u>Outputs</u>						
	DQMPST	Pitch thrust vector deflection trim orbiter	CMD_PROC_MPS	S		deg	6.25
	DQSRBT	Pitch thrust vector deflection trim, SRB	CMD_PROC_SRB	S		deg	6.25
	NZREF	Scheduled normal acceleration ref	ASC_TVC	S		g	6.25
NYREF	Scheduled lateral acceleration ref	ASC_TVC	S		g	6.25	
ELEVON SCHEDULES	<u>Inputs</u>						
	REL_VEL_MAG	Earth-relative velocity magnitude	ASCENT_UPP	S		fps	6.25
	MM101_INIT	Indicator, first time ASCENT DAP sequenced	ASC_RECON	B		-	12.5
	<u>Outputs</u>						
DIBS	Elevon inboard command	ELEVON_LOAD_RELIEF	S		deg	6.25	
DOBS	Elevon outboard command	ELEVON_LOAD_RELIEF	S		deg	6.25	
SIVREL S2ATT GAINS	REL_VEL_MAG	Earth-relative velocity magnitude	ASCENT_UPP	S		fps	6.25

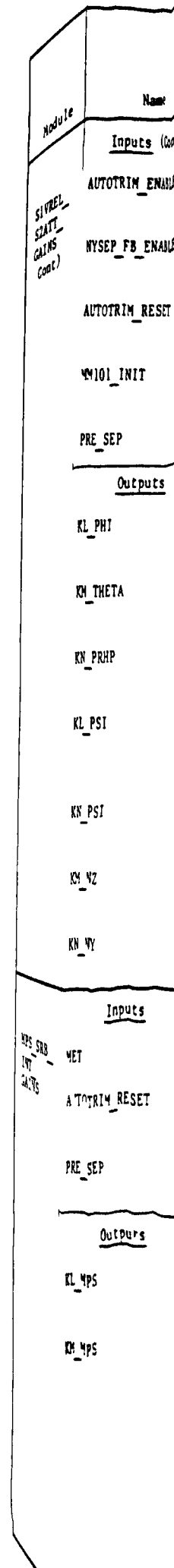


Table 4.2.9-2. INTERPS Inter-Module Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)	
SIVREL_ S2ATT_ GAINS (Cont)	<u>Inputs (Cont)</u>							
	AUTOTRIM_ENABLE	Indicator, enable AUTOTRIM	ASC_RECON	B		-	12.5	
	NYSEP_FB_ENABLE	Indicator, enable NY feedback	ASC_RECON	B		-	12.5	
	AUTOTRIM_RESET	Indicator, reset trim integrators to zero	ASC_RECON	B		-	12.5	
	MM101_INIT	Indicator, first time ASCENT DAP is sequenced	ASC_RECON	B		-	12.5	
	PRE_SEP	Indicator	ASC_RECON	B		-	12.5	
	<u>Outputs</u>							
	KL_PHI	Variable gain (attitude roll)	ASC_TVC	S		(deg/s)/deg	6.25	
	KM_THETA	Variable gain (attitude pitch)	ASC_TVC	S		(deg/s)/deg	6.25	
	KN_PRHP	Variable gain (high pass roll and yaw rates)	ASC_TVC	S		-	6.25	
	KL_PSI	Variable gain (yaw attitude error crossfeed, roll)	ASC_TVC	S		(deg/s)/deg	6.25	
	KN_PSI	Variable gain (attitude yaw)	ASC_TVC	S		(deg/s)/deg	6.25	
	KM_NZ	Variable gain (NZ feedback, pitch)	ASC_TVC	S		(deg/s)/g	6.25	
	KN_NY	Variable gain (NY feedback, yaw)	ASC_TVC	S		(deg/s)/g	6.25	
MPS_SRB_ INT GAINS	<u>Inputs</u>							
	MET	Mission elapsed time	ASC_RECON	S		s	12.5	
	AUTOTRIM_RESET	Indicator, reset trim integrators to zero	ASC_RECON	B		-	12.5	
	PRE_SEP	Indicator, fade orbiter forward loop roll gain	ASC_RECON	B		-	12.5	
	<u>Outputs</u>							
	KL_MPS	Variable gain (rate, roll)	CMD_PROC_MPS	S		deg/(deg/s)	6.25	
KM_MPS	Variable gain (rate, pitch)	CMD_PROC_MPS	S		deg/(deg/s)	6.25		

Table 4.2.9-2. INTERPS Inter-Module Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
<u>Outputs (Cont)</u>							
MPS_SRB_INT_GAINS (Cont)	KN_MPS	Variable gain (rate, yaw)	CMD_PROC_MPS	S		deg/ (deg/s)	6.25
	KL_SRB	Variable gain (rate, SRB roll)	CMD_PROC_SRB	S		deg/ (deg/s)	6.25
	KM_SRB	Variable gain (rate, SRB pitch)	CMD_PROC_SRB	S		deg/ (deg/s)	6.25
	KN_SRB	Variable gain (rate, SRB yaw)	CMD_PROC_SRB	S		deg/ (deg/s)	6.25
	KM_INT	Variable gain (pitch trim integrator rate gain)	ASC_TVC	S		1/s	6.25
	KN_INT	Variable gain (yaw trim integrator rate gain)	ASC_TVC	S		1/s	6.25
	KL_DELPSI	Variable gain (yaw error signal crossfeed, roll)	ASC_TVC	S		-	6.25
<u>Inputs</u>							
S2_GAINS_AND_TRIM	MASS	Estimated vehicle mass	(ASC_2STG_GUID) (PW_RTLS_GUID)	S		slug	0.521
	MASS_DOT	Rate of change of vehicle mass	(ASC_2STG_GUID) (PW_RTLS_GUID)	S		slug/s	0.521
	MM101_INIT	Indicator, first time ASC_DAP sequenced	ASC_RECON	B		-	6.25
	PPD	Indicator, RTLS powered pitch down maneuver	ASC_RECON	B		-	12.5
<u>Outputs</u>							
	DQMPST	MPS pitch thrust vector deflection trim	CMD_PROC_MPS	S		deg	6.25
	KL_MPS	Variable gain, roll rate	CMD_PROC_MPS	S		deg/ (deg/s)	6.25
	KM_MPS	Variable gain, pitch rate	CMD_PROC_MPS	S		deg/ (deg/s)	6.25
	KN_MPS	Variable gain, yaw rate	CMD_PROC_MPS	S		deg/ (deg/s)	6.25
	KM_INT	Variable gain (pitch trim integrator gain)	ASC_TVC	S		1/sec	6.25
	KN_INT	Variable gain (yaw trim integrator gain)	ASC_TVC	S		1/sec	6.25
	KL_DELPSI	Variable gain (yaw to roll)	ASC_TVC	S		-	6.25

Table

Module	Scheduled
S1_TRIMS AND ACCELERFS	
X_INTERP Faders	
Fader Faders	
ELEVON_SCHEDULES	Scheduled
MPS_SRB_INT_GAINS	
X_INTERP GAINS	
TRIM_DQMPST_S1_ETC	
TRIM_TVAL	



Table 4.2.9-3. INTERPS Initialization Requirements

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
S1_TRIMS_ AND_ ACCELREFS	Scheduled parameters	-	MM101_INIT	DQMPST	0.0
				DQSRBT	DQSRBT_O_TAB ₁
				NZREF	NZREF_O_TAB ₁
				NYREF	NYREF_O_1
	X_INTERP Faders	-	MM101_INIT	J_VREL_TRIMS	1
				NFADE_DQMPST	0
				NFADE_DQSRBT	0
				NFADE_NZREF	0
	Fader Faders	AUTOTRIM_RESET SSME_FAILS = 0 SSME_FAILS = 0 (SSME_FAILS = 2) + (SSME_FAILS = 3)	AUTOTRIM_RESET SSME_FAILS ≠ 0 (SSME_FAILS = 2) SSME_FAILS = 4 + (SSME_FAILS = 3)	NFADE_DQMPST	①
				NFADE_DQSRBT	②
				NFADE_NZREF	②
				NFADE_NYREF	②
ELEVON_SCHEDULES MPS_SRB_INT_ GAINS	Scheduled parameters X_INTERP GAINS	-	MM101_INIT	DIBS	DIBS_TAB ₁
				DOBS	DOBS_TAB ₁
				J_VREL_ELVN	1
				KL_DELPSI	KLDELPSI_S1
				KL_MPS	KLMP_S1
				KL_SRB	KLSRB_TIME_TAB ₁
				KM_MPS	KMMPS_TIME_TAB ₁
				KN_MPS	KNMPS_TIME_TAB ₁
KM_SRB	(KMMPS_TIME_TAB ₁)* KMSRB_RATIO				
	KM_INT	(KMMPS_TIME_TAB ₁)* KMINT_S1			
① NFADE_DQMPST_S1_END ② NFADE_MEFAIL					



Table 4.2.9-3. INTERPS Initialization Requirements (Cont)

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
MPS SRB INT GAINS (Cont)	GAINS	-	MM101_INIT	KN_SRB	(KNMPS_TIME_TAB1)* KNSRB_RATIO
				KN_INT	(KNMPS_TIME_TAB1)* KNINT_S1
		<u>PRE_SEP</u>	PRE_SEP	KL_MPS	KLMP5_S2
		<u>AUTOTRIM_RESET</u>	AUTOTRIM_RESET	KL_DELPST	KLDELPST_MASS_TAB1
		<u>AUTOTRIM_RESET</u>	AUTOTRIM_RESET	KL_SRB	KLSRB_SRRSEP
		<u>AUTOTRIM_RESET</u>	AUTOTRIM_RESET	KM_MPS	KMMPS_MASS_TAB1
		<u>AUTOTRIM_RESET</u>	AUTOTRIM_RESET	KN_MPS	KNMPS_MASS_TAB1
		X_INTERP	MM101_INIT	J_TIME_GAINS	1
		Fader	MM101_INIT	NFADE_KLDELPST	0
				NFADE_KLMPS	0
				NFADE_KLSRB	0
				NFADE_KMMPS	0
			NFADE_KNMP5	0	
			NFADE_KLDELPST	NFADE_KLDELPST_SEP	
	Fader	<u>AUTOTRIM_RESET</u>		NFADE_KLSRB	NFADE_COM_SRRSEP
				NFADE_KMMPS	NFADE_COM_SRRSEP
				NFADE_KNMP5	NFADE_COM_SRRSEP
		<u>PRE_SEP</u>	PRE_SEP	NFADE_KLMPS	NFADE_KLMPS_SEP
SIVREL_S2ATT GAINS	GAINS	-	MM101_INIT	J_VREL_GAINS	1
				KL_PHI	KLPHI_VRFL_TAB1
				KM_THETA	KMTHETA_VREL_TAB1
				KN_PSI	KNPSI_VREL_TAB1
				KLOAD_RELIEF	KLOADRELIEF_VREL_TAB1
				KM_NZ	(KLOADRELIEF_VREL_TAB1)* KMNZ_RATIO
				KL_PSI	(KLOADRELIEF_VREL_TAB1)* KLPSI_RATIO

Table 4.2.9-3
Module
SIVREL_S2ATT_GAINS (Cont)
GAINS
Fader
Gain
Fader
Gain
Fader
Gain
SIVREL_S2ATT_GAINS (Cont)
SCHEDULED P
SLOPE_KMPS = KMPS * PA
KCEPT_KMPS = KMPS * PA
SLOPE_KMPS = KMPS * PA
KCEPT_KMPS = KMPS * PA
SLOPE_KMPS = KMPS * PA
KCEPT_KMPS = KMPS * PA

Table 4.2.9-3. INTERPS Initialization Requirements (Cont)

Module	Component	Initialize on Transition		Variable	Initial Value			
		From	To					
SIVREL S2ATT GAINS (Cont)	GAINS	-	MM101_INIT	KN_MY	(KLOADRELIEF_VREL_TAB ₁)*KNMY_RATIO			
				KN_PRHP	(KLOADRELIEF_VREL_TAB ₁)*KNPRHP_RATIO			
				AUTOTRIM_ENABLE	AUTOTRIM_ENABLE	KL_PHI	KLPHI_S2	
						KM_THETA	KMTHETA_S2	
						KN_PSI	KNPSI_S2	
				Fader		NFADE_KNMY	0	
				Gain	NYSEP_FB_ENABLE	NYSEP_FB_ENABLE	KNMY_SRBSEP	KNMY_SEP
				Fader		NFADE_KNMY	NFADE_MY_ON	
				Gain	NYSEP_FB_ENABLE	NYSEP_FB_ENABLE	KNMY_SRBSEP	0
				Fader		AUTOTRIM_RESET	NFADE_KNMY	NFADE_MY_OFF
S2_GAINS AND_TRIM	Scheduled parameters	INTERPS_S2	INTERPS_S2	KL_MPS	KLMPs_S2			
				KM_MPS	KMMPs_MASS_TAB ₁			
				KN_MPS	KNMPS_MASS_TAB ₁			
				KL_DELPSI	KL_DELPSI_MASS_TAB ₁			
				SLOPE_KMMPs XCEPT_KMMPs	①			
				SLOPE_KNMPS XCEPT_KNMPS	②			
				SLOPE_KLDELPSI XCEPT_KLDELPSI	③			
<p>① $SLOPE_KMMPs = \frac{KMMPs_MASS_TAB_1 - KMMPs_MASS_TAB_2}{MASS2_GAIN_TAB_1 - MASS2_GAIN_TAB_2}$ $XCEPT_KMMPs = KMMPs_MASS_TAB_1 - (MASS_GAIN_TAB_1) * (SLOPE_KMMPs)$</p> <p>② $SLOPE_KNMPS = \frac{KNMPS_MASS_TAB_1 - KNMPS_MASS_TAB_2}{MASS2_GAIN_TAB_1 - MASS2_GAIN_TAB_2}$ $XCEPT_KNMPS = KNMPS_MASS_TAB_1 - (MASS2_GAIN_TAB_1) * (SLOPE_KNMPS)$</p> <p>③ $SLOPE_KLDELPSI = \frac{KLDELPSI_MASS_TAB_1 - KLDELPSI_MASS_TAB_2}{MASS_KLDELPSI_TAB_1 - MASS_KLDELPSI_TAB_2}$ $XCEPT_KLDELPSI = KLDELPSI_MASS_TAB_1 - (MASS_KLDELPSI_TAB_1) * (SLOPE_KLDELPSI)$</p>								

Table 4.2.9-4. INTERPS I-Loads

Module	Name	Description	Type	MSID	Units
S1 TRIMS ACCELREFS	VREL_TRIM_TAB(i) i = 02 to 20	Array of VREL breakpoints for Stage 1 trims	A(19)	V97U2299C to V97U2316C	fps
	DQSRBT_0_TAB(i) i = 01 to 20	Array of SRB pitch trim breakpoints for no main engine failures	A(20)	V97U1714C to V97U1733C	deg
	DQSRBT_1_TAB(i) i = 01 to 20	Array of SRB pitch trim breakpoints for main engine No. 1 failed	A(20)	V97U1734C to V97U1753C	deg
	DQSRBT_2_3_TAB(i) i = 01 to 20	Array of SRB pitch trim breakpoints for main engine No. 2 or 3 failed	A(20)	V97U1754C to V97U1773C	deg
	NZREF_0_TAB(i) i = 01 to 20	Array of NZREF breakpoints for no main engine failures	A(20)	V97U2139C to V97U2157C	g
	NZREF_1_TAB(i) i = 01 to 20	Array of NZREF breakpoints for main engine No. 1 failed	A(20)	V97U2158C to V97U2177C	g
	NZREF_2_3_TAB(i) i = 01 to 20	Array of NZREF breakpoints for main engine No. 2 or 3 failed	A(20)	V97U2179C to V97U2197C	g
	NYREF_0_1	NYREF for no main engine failures or engine No. 1 failed	S	V97U2079C	g
	NYREF_2	NYREF for main engine No. 2 failed	S	V97U2099C	g
	NYREF_3	NYREF for main engine No. 3 failed	S	V97U2118C	g
	NFADE_DQMPST_S1_END	Cycles to fade MPS pitch trim to final SIC valve if main engine failed	S	V97U2432C	-
	DQMPST_S1_END	Orbiter pitch trim at end of Stage 1	S	V97U2450C	deg
	NFADE_MEFAIL	Cycles to fade SRB pitch trim, NZREF, and NYREF to alternate array on main engine fail	S	V97U2073C	counts
	ELEVON SCHEDULES	VREL_ELVN_TAB(i) i = 02 to 08	Array of VREL breakpoints for scheduled elevon load relief	A(7)	V97U2277C to V97U2283C
DIBS_TAB(i) i = 01 to 08		Array of inboard elevon breakpoints for load relief	A(8)	V97U1667C to V97U1674C	deg
DOBS_TAB(i) i = 01 to 08		Array of outboard elevon breakpoints for load relief	A(8)	V97U1677C to V97U1684C	deg

Module
KDELPST_S1
KLMP_S1
KLMP_S2
NET_GAIN_TAB
i = 01 to 04
KLSRB_TIME_TAB
i = 01 to 04
KNMPS_TIME_TAB
i = 01 to 04
KNMPS_TIME_TAB
i = 01 to 04
KMSRB_RATIO
KNINT_S1
KMSRB_RATIO
KNINT_S1
KDELPST_MASS_T
KNMPS_MASS_TAB
KNMPS_MASS_TAB
NFADE_KDELPST
NFADE_COM_SRB
NFADE_KLMPS_SE_P
KLSRB_SRBSEP
VREL_GAIN_TAB
i = 02
KLPHI_RE_TAB
i = 01 to 04
KNMPS_VREL_TAB
i = 01 to 04
KNMPS_RE_TAB
i = 01 to 04
KLSRB_RE_TAB
i = 01 to 04
KLSRB

Table 4.2.9-4. INTERPS I-Loads (Cont)

Module	Name	Description	Type	MSID	Units	
MPS_SRB_ INT_GAINS	KLDELPSI_S1	S1C yaw to roll crossfeed gain	S	V97U2434C	-	
	KLMP_S1	S1C roll loop gain	S	V98U9590C	deg/deg/s	
	KLMP_S2	S2C roll loop gain	S	V97U2477C	deg/deg/s	
	MET_GAIN_TAB(i) i = 01 to 04	S1C time gain schedule common breakpoints	A(4)	V98U9591C to V98U9594C	S	
	KLSRB_TIME_TAB(i) i = 01 to 04	Array of KLSRB breakpoints	A(4)	V98U9595C to V98U9598C	deg/deg/s	
	KMPS_TIME_TAB(i) i = 01 to 04	Array of KM_MPS breakpoints	A(4)	V98U9599C to V98U9602C	deg/(deg/s)	
	KNMPS_TIME_TAB(i) i = 01 to 04	Array of KN_MPS breakpoints	A(4)	V97U2499C V98U9553C V98U9554C V98U9555C	deg/deg/s	
	KMSRB_RATIO	S1C ratio of SRB to MPS pitch loop gains	S	V98U9556C	-	
	KMINT_S1	S1C ratio of pitch integral to proportional gains	S	V98U9557C	deg/deg/s	
	KNSRB_RATIO	Ratio of SRB to MPS yaw loop gains	S	V98U9558C	-	
	KNINT_S1	Ratio of yaw integral to proportional gains	S	V98U9559C	deg/deg/s	
	KLDELPSI_MASS_TAB(1)	First S2C array point of KLDELPSI	S	V97U2478C	-	
	KMPS_MASS_TAB(1)	First S2C array point for KMPS	S	V97U1897C	deg/deg/s	
	KNMPS_MASS_TAB(1)	First S2C array point for KNMPS	S	V97U1957C	deg/deg/s	
	NFADE_KLDELPSI_SEP	Cycle to fade KLDELPSI from Stage 1 to Stage 2	S	V98U9560C	-	
	NFADE_COM_SRBSEP	Cycle to fade common gains from Stage 1 to Stage 2	S	V98U9561C	-	
	NFADE_KLMP_S1	Cycles to fade KLMP_S1 to Stage 2	S	V98U9562C	-	
	KLSRB_SRBSEP	KLSRB gain for end of Stage 1	S	V98U9563C	deg/deg/s	
	S1VREL_S2ATT_ GAINS	VREL_GAIN_TAB(i) i = 02 to 05	Array of VREL breakpoints for VREL scheduled gains	A(4)	V97U2286C to V97U2289C	ft/s
		KLPHI_VREL_TAB(i) i = 01 to 05	Array of KL_PHI breakpoints for first stage	A(5)	V97U1840C to V97U1844C	deg/s deg
KMTHETA_VREL_TAB(i) i = 01 to 05		Array of KM_THETA breakpoints for first stage	A(5)	V97U1938C to V97U1942C	deg/s deg	
KNPSI_VREL_TAB(i) i = 01 to 05		Array of KN_PSI breakpoints for first stage	A(5)	V97U2011C to V97U2015C	deg/s deg	
KLOADRELIEF_VREL TAB(i) i = 1 to 5		Array of K_LOAD_RELIEF breakpoints	A(5)	V97U2442C to V97U2446C	-	
KLPHI_S2		Second-stage KL_PHI gain	S	V97U2447C	deg/s deg	



Table 4.2.9-4. INTERPS I-Loads (Cont)

Module	Name	Description	Type	MSID	Units
S1VREL_S2ATT_GAINS (Cont)	KMTHETA_S2	Second-stage KM_THETA gain	S	V97U2448C	deg/s
	KNPSI_S2	Second-stage KN_PSI gain	S	V97U2449C	$\frac{\text{deg/s}}{\text{deg}}$
	KMNZ_RATIO	Multiplier of K_LOAD_RELIEF for KM_NZ gain	S	V97U2464C	$\frac{\text{deg/s}}{\text{deg}}$
	KLPSI_RATIO	Multiplier of K_LOAD_RELIEF for KL_PSI gain	S	V97U2465C	(deg/s)/deg
	KNNY_RATIO	Multiplier of K_LOAD_RELIEF for KN_NY gain	S	V97U2466C	(deg/s)/g
	KNPRHP_RATIO	Multiplier of K_LOAD_RELIEF for KN_PRHP gain	S	V97U2467C	-
	KNNY_SEP	Fade - to value of KN_NY during SEP	S	V97U2468C	(deg/s)/g
	NFADE_NY_ON	Cycles to fade-in KN_NY during SEP	S	V97U2469C	-
	NFADE_NY_OFF	Cycles to fade-out KN_NY during SEP	S	V97U2470C	-
S2_GAINS_AND_TRIM	MASS_GAIN_TAB	Array of mass breakpoints for DQMPST trim schedule	A(8)	V97U2056C to V97U2059C and V97U2471C to V97U2474C	slugs
	DQMPST_S2_TAB	Array of DQMPST breakpoints	A(8)	V97U1710C V97U1711C V97U1712C V97U1713C V97U2451C V97U2452C V97U2453C V97U2455C	deg
	KLMP_S2	Second-stage KL_MPS gain	S	V97U2477C	$\frac{\text{deg}}{(\text{deg/s})}$
	MASS2_GAIN_TAB	Array of mass breakpoints for second-stage gain schedules	A(2)	V97U2475C V97U2476C	slugs
	KMPS_MASS_TAB	Array of second-stage KM_MPS breakpoints	A(2)	V97U1897C V97U1898C	$\frac{\text{deg}}{(\text{deg/s})}$
	KNMPS_MASS_TAB	Array of second-stage KN_MPS breakpoints	A(2)	V97U1957C V97U1958C	$\frac{\text{deg}}{(\text{deg/s})}$
	KLDELPSI_MASS_TAB	Array of second-stage KL_DELPSI breakpoints	A(2)	V97U2478C V97U2479C	-
	MASS_KLDELPSI_TAB	Mass tab for KL_DELPSI	A(2)	V97U2482C V97U2483C	-
	KMINT_S2	Pitch integral/proportional gain ratio for second stage	A	V97U2480C	deg/sec
	KNINT_S2	Yaw integral/proportional gain ratio for second stage	S	V97U2481C	deg/sec
	K_PPD	PPD forward loop gain	S	V97U1363C	ND

4.2.10 RCS Control
A. Functional Description of three engines per stage. The function is shown in Figure 4.2.10-1.
B. Software Description given in Table 4. BRAND_HYSTER and shown, respectively requirements are given in Table 4.



4.2.10 RCS Command Processor (CMD_PROC_RCS)

A. Functional Description. The CMD_PROC_RCS provides roll control when two or three engines shut down in first stage or two engines shut down in second stage. The functional block diagram for CMD_PROC_RCS is shown in Figure 4.2.10-1.

B. Software Description. The input/output requirements of CMD_PROC_RCS are given in Table 4.2.10-1. CMD_PROC_RCS consists of two functional modules: DBAND_HYSTER and ASC_JET_SELECT. Detailed diagrams of these two modules are shown, respectively, in Figures 4.2.10-2 and 4.2.10-3. Intermodule interface requirements are given in Table 4.2.10-2. Initialization requirements are given in Table 4.2.10-3. I-loads are given in Table 4.2.10-4.

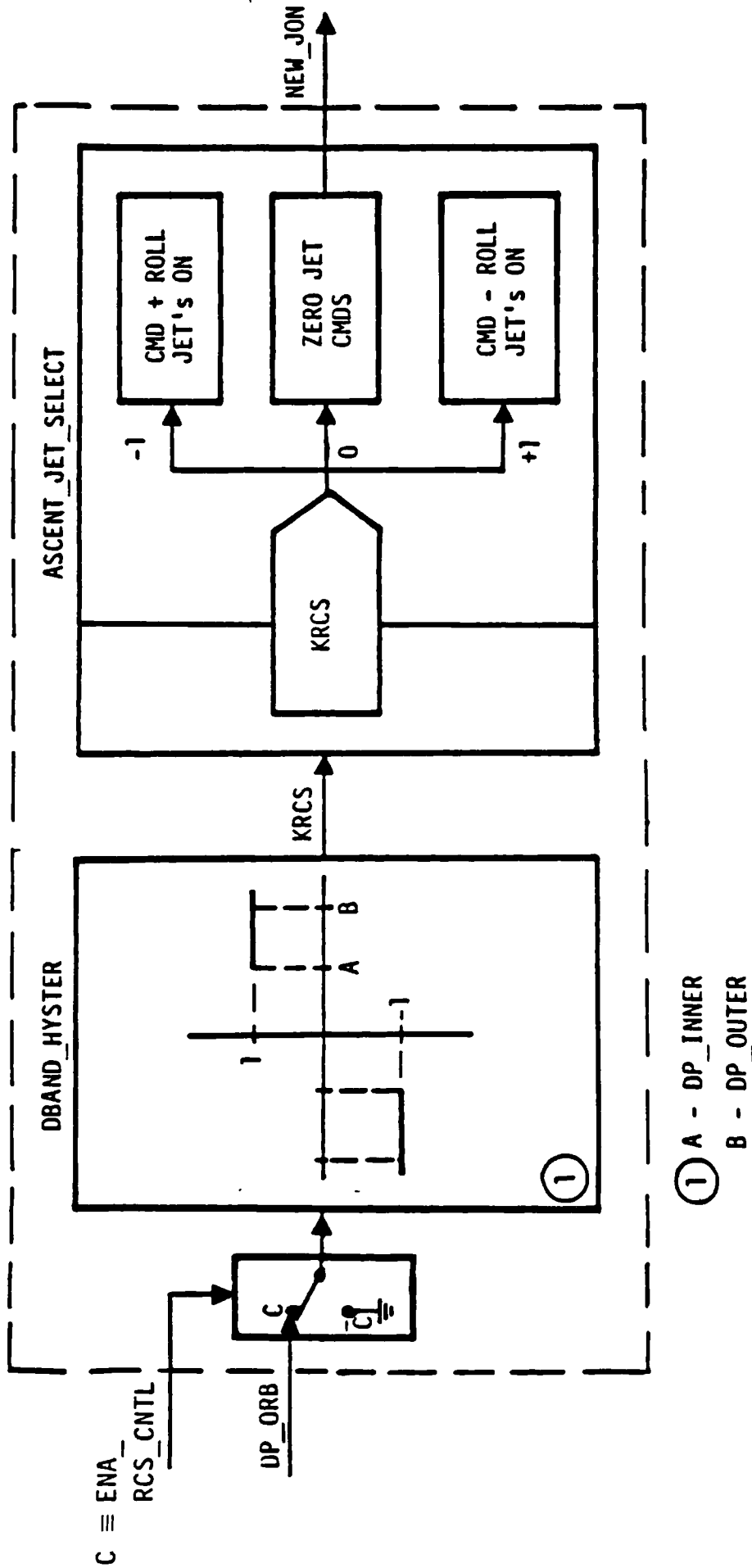


Figure 4.2.10-1. RCS Command Processor Functional Overview

(DP_ORB) ≥ DP_OUTER
OR
KRC = SIGN (DP_ORB)

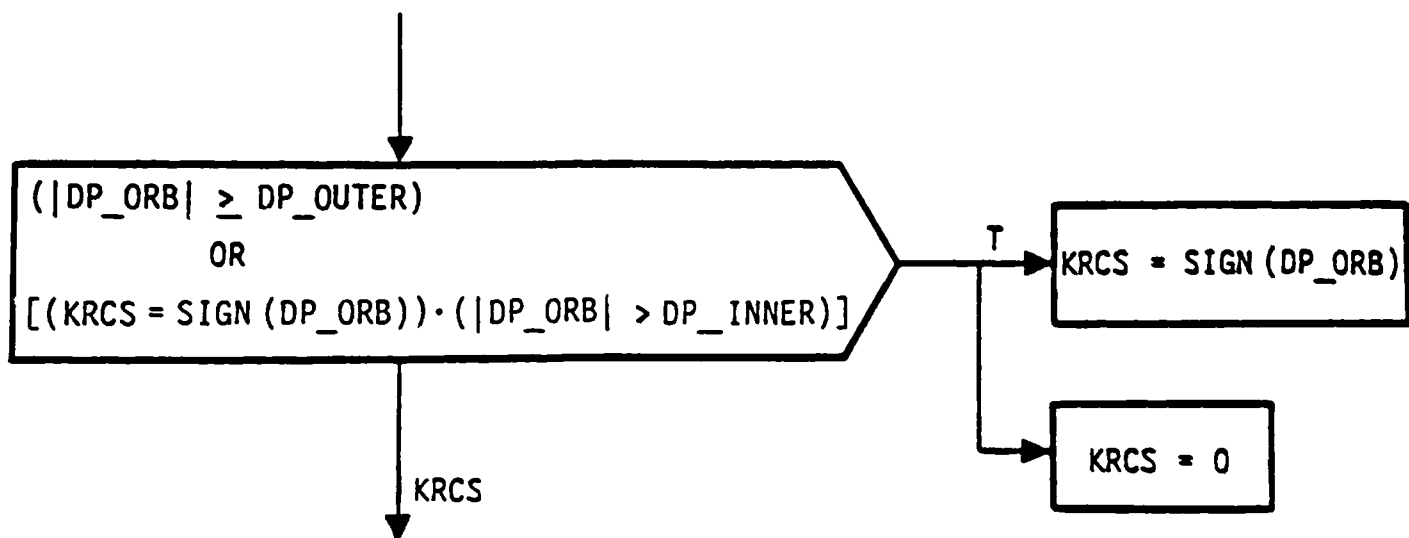


Figure 4.2.10-2. DBAND_HYSTER Function Module Detailed Diagram

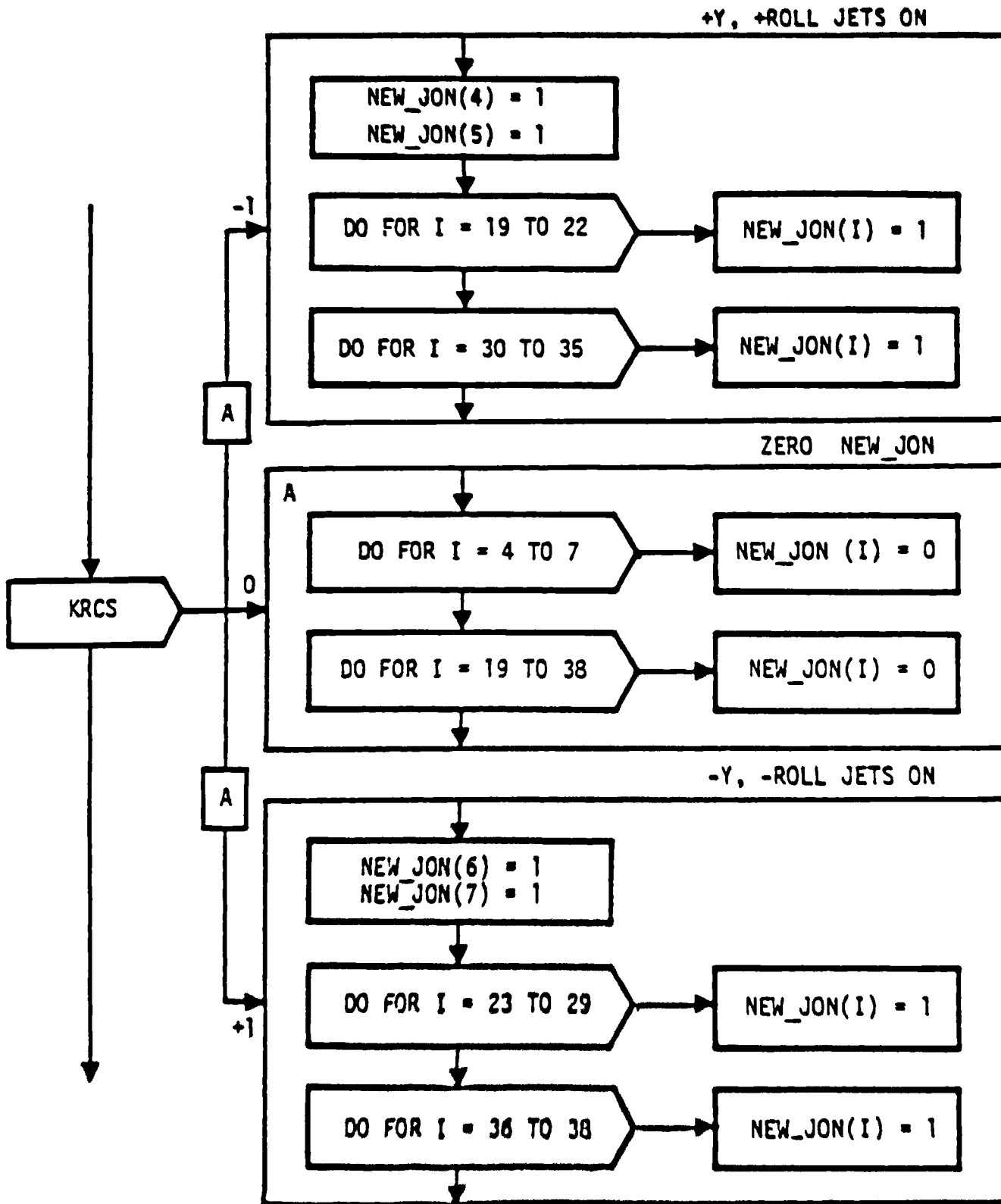


Figure 4.2.10-3. ASC JET SELECT Function Module Detailed Diagram

Table 4.2.10-1. CMD_PROC_RCS Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Inputs</u>						
	DP_ORB	Gained roll TVC loop error signal	CMD_PROC_MPS	S		deg	25
	ENA_RCS_CNTL	Enable RCS control discrete	ASC_RECON	D		-	12.5
	<u>Outputs</u>						
	NEW_JON	RCS JET ON/OFF CMDS	ASC_RCS_CMD_SOP	A		-	25

Table 4.2.10-2. CMD_PROC_RCS Inter-Module Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Inputs</u>						
DBAND_HYSTER	DP_ORB	Gained roll TVC loop error signal	CMD_PROC_MPS	S		deg	25
	<u>Outputs</u>						
	KRCS	± roll command indicator	ASC_JET_SELECT	I		-	25
	<u>Inputs</u>						
ASC_JET_SELECT	KRCS	± roll command indicator	DBAND_HYSTER	I		-	25
	<u>Outputs</u>						
	NEW_JON	RCS JET ON/OFF commands	ASC_RCS_CMD	A		-	25

Table 4.2.10-1. CMD_PROC_RCS Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Inputs</u>						
	DP_ORB	Gained roll TVC loop error signal	CMD_PROC_MPS	S		deg	25
	ENA_RCS_CNTL	Enable RCS control discrete	ASC_RECON	D		-	12.5
	<u>Outputs</u>						
	NEW_JON	RCS JET ON/OFF CMDS	ASC_RCS_CMD_SOP	A		-	25

Table 4.2.10-2. CMD_PROC_RCS Inter-Module Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
	<u>Inputs</u>						
DBAND_HYSTER	DP_ORB	Gained roll TVC loop error signal	CMD_PROC_MPS	S		deg	25
	<u>Outputs</u>						
	KRCS	± roll command indicator	ASC_JET_SELECT	I		-	25
	<u>Inputs</u>						
ASC_JET_SELECT	KRCS	± roll command indicator	DBAND_HYSTER	I		-	25
	<u>Outputs</u>						
	NEW_JON	RCS JET ON/OFF commands	ASC_RCS_CMD	A		-	25

TABLE 4.2.10-3. CMD_PROC_RCS Initialization Requirements

Module	Initialize on Transition to:	Variable	Initial Value
DBAND_HYSTER	ENA_RCS_CNTL = 1	KRCS	0
ASCENT_JET_SELECT	ENA_RCS_CNTL = 1	NEW_JON(I)	0

Table 4.2.10-4. CMD_PROC_RCS I-Loads

Name	Description	Type	MSID	Units
DP_INNER	Inner deadband value	S	V97U2484C	deg
DP_OUTER	Outer deadband value	S	V97U2485C	deg

4.2.11 Ascent DAP P
The ascent DAP
I-load tables, are p
connected interface
signal (parameter) i
software elements or
in the event of a co
input/output tables,
precedence.
Note that IDD of
input (destination) i
dominated. The par
may not appear in a

4.2.11 Ascent DAP P
The ascent DAP
I-load tables, are p
connected interface
signal (parameter) i
software elements or
in the event of a co
input/output tables,
precedence.
Note that IDD of
input (destination) i
dominated. The par
may not appear in a

4.2.11 Ascent DAP Principal Function Tables

The ascent DAP principal function input and output tables, along with the I-load tables, are presented in Tables 4.2.11-1 through 4.2.11-2. The automated Interface Definition document (IDD) table (Table 4.2.11-1) defines signal (parameter) interface requirements either between hardware (LRU) and software elements or between software elements and other software elements.* In the event of a conflict between the IDD tables and other internal text input/output tables, the SASCB data base-controlled IDD tables take precedence.

Note that IDD output (source) tables that reflect parameters going to input (destination) TLM will not be interpreted as a signal actually being downlisted. The parameter may only be available for downlist in COMPOOL and may not appear in a downlist format.

*A GN&C software element is either a sequenced principal function (PF), crew generated specialist/display function, or an OPS display function.

Table 4.2.11-1. Ascent DAP Interface (G4.176) Input/Output Parameters

DBFN: D2B041-C PN: VP707100034P00L JUNE 29, 1988
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FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE
A D RECYCLE_COUNT	V90X8669X	ASC DAP RECYCLE FLAG	R/S LCH SEQ		
AERO SLEM	V99X8822X	AEROSURFACE SLEM CHECK INDICATOR	LPS		
AERO SLEM_CMD	V90H1571C	AERO ACTR SLEM POSITION CMD	ORB ACT SLEM		
AERO SLEM_CHPL	V90X1570X	AEROSURFACE SLEM COMPLETE	ORB ACT SLEM		BD
AUTOP	V96X1031X	STATION SELECTED AUTO-PITCH	GN&C SH RH		
AUTORY	V96X1041X	STATION SELECTED AUTO-ROLL/YAW	GN&C SH RH		
AVAILABLE_JET_AFT(02)	V90X4521X	JET L1L AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(03)	V90X4522X	JET L1U AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(05)	V90X4535X	JET R1R AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(06)	V90X4536X	JET R1U AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(10)	V90X4527X	JET L3L AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(11)	V90X4528X	JET L3D AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(13)	V90X4541X	JET R3R AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(14)	V90X4542X	JET R3D AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(17)	V90X4523X	JET L2L AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(18)	V90X4524X	JET L2U AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(19)	V90X4525X	JET L2D AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(20)	V90X4537X	JET R2R AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(21)	V90X4538X	JET R2U AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(22)	V90X4539X	JET R2D AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(23)	V90X4529X	JET L4L AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(24)	V90X4530X	JET L4U AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(25)	V90X4531X	JET L4D AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(26)	V90X4543X	JET R4R AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(27)	V90X4544X	JET R4U AVAILABLE	RCS RH		BD
AVAILABLE_JET_AFT(28)	V90X4545X	JET R4D AVAILABLE	RCS RH		BD
AVAILABLE_JET_FHD(01)	V90X4548X	JET F1F AVAILABLE	RCS RH		BD
AVAILABLE_JET_FHD(02)	V90X4549X	JET F1L AVAILABLE	RCS RH		BD
AVAILABLE_JET_FHD(03)	V90X4550X	JET F1U AVAILABLE	RCS RH		BD
AVAILABLE_JET_FHD(04)	V90X4551X	JET F1D AVAILABLE	RCS RH		BD
AVAILABLE_JET_FHD(06)	V90X4553X	JET F2R AVAILABLE	RCS RH		BD
AVAILABLE_JET_FHD(07)	V90X4554X	JET F2U AVAILABLE	RCS RH		BD
AVAILABLE_JET_FHD(08)	V90X4555X	JET F2D AVAILABLE	RCS RH		BD
AVAILABLE_JET_FHD(09)	V90X4560X	JET F4R AVAILABLE	RCS RH		BD
AVAILABLE_JET_FHD(10)	V90X4561X	JET F4D AVAILABLE	RCS RH		BD
AVAILABLE_JET_FHD(14)	V90X4557X	JET F3L AVAILABLE	RCS RH		BD
AVAILABLE_JET_FHD(15)	V90X4558X	JET F3U AVAILABLE	RCS RH		BD
AVAILABLE_JET_FHD(16)	V90X4559X	JET F3D AVAILABLE	RCS RH		BD
CLOCK/CLOCKTIME	V91H5000C1	CLOCK-COMPUTERIGHT	FCOS	S	
CONTING_ABORT	V90X8639X	INITIATE MATED COAST CONTROL	HSC		
CSSP	V96X1035X	STATION SELECTED CSS-PITCH	GN&C SH RH		
CSSRY	V96X1045X	STATION SELECTED CSS-ROLL/YAW	GN&C SH RH		
DBFOFB	V95H8310C	COMP BODY FLAP POS	BF PFB SOP	DEG	
DELTAP_LTB	V95P8015C	LTB ELVN ACTR DIFFERENTIAL PRESS	DELTA P F/B SOP	PSI	
DELTAP_LOB	V95P8017C	LOB ELVN ACTR DIFFERENTIAL PRESS	DELTA P F/B SOP	PSI	
DELTAP_RTB	V95P8016C	RTB ELVN ACTR DIFFERENTIAL PRESS	DELTA P F/B SOP	PSI	
DELTAP ROB	V95P8018C	ROB ELVN ACTR DIFFERENTIAL PRESS	DELTA P F/B SOP	PSI	
DY1 BIAS	V96U7984C	MPS ENG 1P BIAS	VU	DEG	SPL
DY2 BIAS	V96U7985C	MPS ENG 2P BIAS	VU	DEG	SPL
DY3 BIAS	V96U7986C	MPS ENG 3P BIAS	VU	DEG	SPL
DZ2 BIAS	V96U7987C	MPS ENG 2Y BIAS	VU	DEG	SPL
DZ3 BIAS	V96U7988C	MPS ENG 3Y BIAS	VU	DEG	SPL

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Table 4.2.11-1. Ascent DAP Interface (G4.176) Input/Output Parameters (Cont)

DBFN: D2B041-C PN: VP707100026P00L MAY 31, 1988
 INPUT FUNCTIONAL PARAMETERS FOR ASCENT DIGITAL AUTOPILOT

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FSSR NAME

M/S ID

NOMENCLATURE

SOURCE

UNITS

DATA TYPE

V95H3523C

BODY ROLL ATT ERROR

G/C STEER

DEG

SPL

Table 4.2.11-1. Ascent DAP Interface (G4.176) Input/Output Parameters (Cont)

DBFN: D2B039-A PN: VP707100026POOL MAY 31, 1988
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FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE
EBFB(1)	V95H3523C	BODY ROLL ATT ERROR	G/C STEER	DEG	SPL
EBFB(2)	V95H3521C	BODY PITCH ATT ERROR	G/C STEER	DEG	SPL
EBFB(3)	V95H3522C	BODY YAW ATT ERROR	G/C STEER	DEG	SPL
EVENT 6	V90X8683X	INDICATOR EVENT 6 AUTO SEQ START	R/S LCH SEQ		
FAST_SEP_FLAG	V90X8267X	FAST SEPARATION FLAG	ET SEP SEQ		
GUIDANCE_INITIATE	V90X8630X	INITIATE STAGE 2 GUIDANCE	MSC		
HYDRFAIL(1)	V96X3005X	HYDR SYS 1 FAIL STATUS	HYD SYS SOP		BD
HYDRFAIL(2)	V96X3006X	HYDR SYS 2 FAIL STATUS	HYD SYS SOP		BD
HYDRFAIL(3)	V96X3007X	HYDR SYS 3 FAIL STATUS	HYD SYS SOP		BD
M/CURR_ORB_MASS/HEIGHT	V90U1961CG	CURRENT VEHICLE MASS	ASC 2STG GUID	SLUGS	
M/CURR_ORB_MASS/HEIGHT	V90U1961CH	CURRENT VEHICLE MASS	PH RTLS GUID	SLUGS	
MDOT	V90R1993CA	TOTAL VEHICLE MASS FLOW RATE	ASC 2STG GUID	SLUGS/S	
MDOT	V90R1993CB	TOTAL VEHICLE MASS FLOW RATE	PH RTLS GUID	SLUGS/S	
ME_ZERO	V90X8638X	ZERO THRUST	MSC		
MECO_CMD/EVENT_A36B	V90X8569XA	MECO COMMAND FLAG	SSME OPS		
MECO_CONFIRM	V90X8561X	MECO CONFIRMED FLAG	SSME OPS		BD
ME1_FAIL_SHUTDOWN	V95X1207X	MPS E1 FAIL FLAG	SSME OPS		BD
ME2_FAIL_SHUTDOWN	V95X1208X	MPS E2 FAIL FLAG	SSME OPS		BD
ME3_FAIL_SHUTDOWN	V95X1209X	MPS E3 FAIL FLAG	SSME OPS		BD
MM_CODE_101/MM_101	V90X8155X	MAJOR MODE 101 FLAG	MSC		
MPS_LO2_DUMP_START	V90X8301X	MPS LO2 DUMP START	MPS DUMP		
MPS_LO2_DUMP_STOP	V90X8302X	MPS LO2 DUMP STOP	MPS DUMP		
MPS_SLEW	V99X8823XB	MPS GIMBAL SLEW CHECK INDICATOR	LPS		
MPS_SLEW_CMD	V90H1572C	MPS ACTR SLEW POSITION CMD	ORB ACT SLEW		
MPS_SLEW_COMPLETE	V90X8400XA	MPS SLEW COMP FLAG	R/S LCH SEQ		
MPS_SLEW_COMPLETE	V90X8400XB	MPS SLEW COMP FLAG	ORB ACT SLEW		
NY	V90A5361C	SELECTED AA LATERAL ACCEL	SF	G	SPL
NZ	V90A5381C	SELECTED AA NORMAL ACCEL	SF	G	SPL
OPS_6_IND	V90X8634X	OPS 6 INDICATOR	MSC		
P_ORB	V90R5301CA	SELECTED RGA ROLL RATE	SF	DEG/S	
PC4	V90P2535C	SELECTED LEFT PRESS SRB CHAMBER	SF	PSIA	
PC5	V90P2536C	SELECTED RIGHT PRESS SRB CHAMBER	SF	PSIA	
PREP_SSME	V90X8373X	PREP SSME'S FOR LIFTOFF FLAG	R/S LCH SEQ		BD
Q_ORB/Q	V90R5321CA	SELECTED RGA PITCH RATE	SF	DEG/S	
Q_SRB	V90R2511C	SRGA SEL PITCH RATE	SF	DEG/S	
R_ORB	V90R5341CA	SELECTED RGA YAW RATE	SF	DEG/S	
R_SRB	V90R2512C	SRGA SEL YAW RATE	SF	DEG/S	
REL_VEL_MAG	V95L0151CE	GND REL VEL MAGNITUDE IN M50 SYS	ASC UPP	FT/S	
RETURN_SSME_TO_START_POS	V90X8412X	CMD SSME'S TO PRE-START POS FLAG	R/S LCH SEQ		BD
S_PPD_QUAT	V90X2087X	DISCRETE INDICATING PPD CHDS	PH RTLS GUID		BD
S_QUAT	V90X1987X	ATTITUDE QUATERNION COMPUTED FLAG	ASC 1STG GUID		
S_RTLS_TURN	V90X2089X	DSCR IND START OF TURN AROUND	PH RTLS GUID		BD
S_SSME_TRIM	V90X1960XA	FCS TVC RETRIM DISCRETE	ASC 2STG GUID		
S_SSME_TRIM	V90X1960XB	FCS TVC RETRIM DISCRETE	PH RTLS GUID		BD
SRB_IGNITION_CMD/EVENT_19	V90X8377X	SRB IGNITION CMD FLAG	R/S LCH SEQ		BD
SRB_MODING_SEP	V90X8330XA	SRB SEP FUNCTION MODING FLAG	SRB SEP SEQ		
SRB_MODING_SEP	V90X8330XB	SRB SEP FUNCTION MODING FLAG	ET SEP SEQ		
SRB_SEP_CMD_FLAG	V90X8331XA	SRB SEPARATION COMMAND FLAG	SRB SEP SEQ		
SRB_SEP_CMD_FLAG	V90X8331XB	SRB SEPARATION COMMAND FLAG	ET SEP SEQ		
SRB_SEP_MONITOR	V90X8193X	SRB SEP MONITOR FLAG	MSC		
SRB_SLEW	V99X8820X	SRB FCS/HYDR VERIFICATION FLAG	LPS		
SRB_SLEW_CMD	V96H0323C	SRB ACTR SLEW POSITION CMD	SRB SLEW		
SRB_SLEW_COMPLETE	V96X0321X	SRB FCS/HYDR VERIFICATION COMPLETE	SRB SLEW		

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Table 4.2.11-1. Ascent DAP Interface (G4.176) Input/Output Parameters (Cont)

DBFN: D2B039-A PN: VP707100026POOL MAY 31, 1988
 INPUT FUNCTIONAL PARAMETERS FOR ASCENT DIGITAL AUTOPILOT

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FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE
SSME_STOM_COMPLETE	V95X1622X	SSME STOM COMPLETE FLAG	MPS TVC CMD SOP		
TAL_ABORT_DECLARED	V90X8658X	TAL ABORT DECLARED	HSC		
MFBI_FB1	V95H3528C	ROLL RATE, FLIGHT BODY-INERTIAL	G/C STEER	DEG/S	SPL
MFBI_FB2	V95H3526C	PITCH RATE, FLIGHT BODY-INERTIAL	G/C STEER	DEG/S	SPL
MFBI_FB3	V95H3527C	YAW RATE, FLIGHT BODY-INERTIAL	G/C STEER	DEG/S	SPL

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Table 4.2.11-1. Ascent DAP Interface (G4.176) Input/Output Parameters (Cont)

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FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS
V90X1712X		STEERING MODE FLAG	G/C STEER-TLM	
V90X1709X		FILTER ACTUAL BODY ATTITUDE FLAG	G/C STEER-TLM	
V90X1710X		AUTO GUIDANCE BODY ATTITUDE FLAG	G/C STEER-TLM	

Table 4.2.11-1. Ascent DAP Interface (G4.176) Input/Output Parameters (Cont)

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	P R E C
DBFN: D2B039-A PN: VP707100026P00L OUTPUT FUNCTIONAL PARAMETERS FROM ASCENT DIGITAL AUTOPILOT						
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ATTCHD	V90X1712X	STEERING MODE FLAG	G/C STEER, TLM		BD	
ATTFILT	V90X1709X	FILTER ACTUAL BODY ATTITUDE FLAG	G/C STEER, TLM		BD	
AUTO	V90X1710X	AUTO GUIDANCE MODE FLAG	G/C STEER, PH RTLS GUID, ASC 2STG GUID, GRTLS DAP, TLM, ABT CNTL SEQ		BD	
DBF_SLEW	V90H1770C	BODY FLAP SLEW CMD	TLM			
DBFRC	V90H1580CB	BODY FLAP DEFLECTION CMD	AERO ACT SOP, BF CMD RM, TLM	DEG		
DLIBPC	V90H1734CA	LIB ELEVON POSITION CMD	AERO ACT SOP, TLM	DEG		
DLOBPC	V90H1735CA	LOB ELEVON POSITION CMD	AERO ACT SOP, TLM	DEG		
DPTVC_INT	V90H1774C	ROLL TVC TRIM INTEGRATOR OUTPUT	TLM		SPL	
DQTV	V90H1758C	PITCH TVC LOOP ERROR SIGNAL	TLM	DEG/S	SPL	
DQTV_INT	V90H1772C	PITCH TVC TRIM INTEGRATOR OUTPUT	TLM		SPL	
DRIBPC	V90H1737CA	RIB ELEVON POSITION CMD	AERO ACT SOP, TLM	DEG		
DROBPC	V90H1738CA	ROB ELEVON POSITION CMD	AERO ACT SOP, TLM	DEG		
DRPC	V90R1550CB	RATE LIMITED RUDDER CMD	AERO ACT SOP, TLM	DEG		
DRTVC	V90H1759C	YAW TVC LOOP ERROR SIGNAL	TLM	DEG/S	SPL	
DRTVC_INT	V90H1773C	YAW TVC TRIM INTEGRATOR OUTPUT	TLM		SPL	
DR4C	V90H1752C	ROCK COMMAND, SRB 4	TLM	DEG		
DR4CL	V90H1728C	SRB 4 ROCK ACTR DEFLECTION CMD	SRB TVC CMD SOP, TLM	DEG		
DR5C	V90H1754C	ROCK COMMAND, SRB 5	TLM	DEG		
DR5CL	V90H1729C	SRB 5 ROCK ACTR DEFLECTION CMD	SRB TVC CMD SOP, TLM	DEG		
DSBPC	V90R1560CB	RATE LIMITED SPDBK CMD	AERO ACT SOP, TLM	DEG		
DT4C	V90H1751C	TILT COMMAND, SRB 4	TLM	DEG		
DT4CL	V90H1731C	SRB 4 TILT ACTR DEFLECTION CMD	SRB TVC CMD SOP, TLM	DEG		
DT5C	V90H1753C	TILT COMMAND, SRB 5	TLM	DEG		
DT5CL	V90H1732C	SRB 5 TILT ACTR DEFLECTION CMD	SRB TVC CMD SOP, TLM	DEG		
DYC1	V90H1718C	MPS 1 PITCH ACTR DEFLECTION CMD	MPS TVC CMD SOP, TLM	DEG		
DYC2	V90H1719C	MPS 2 PITCH ACTR DEFLECTION CMD	MPS TVC CMD SOP, TLM	DEG		
DYC3	V90H1720C	MPS 3 PITCH ACTR DEFLECTION CMD	MPS TVC CMD SOP, TLM	DEG		
DY1	V90H1745C	PITCH COMMAND, SSME 1	TLM	DEG		
DY2	V90H1747C	PITCH COMMAND, SSME 2	TLM	DEG		
DY3	V90H1749C	PITCH COMMAND, SSME 3	TLM	DEG		
DZC1	V90H1724C	MPS 1 YAW ACTR DEFLECTION CMD	MPS TVC CMD SOP, TLM	DEG		
DZC2	V90H1725C	MPS 2 YAW ACTR DEFLECTION CMD	MPS TVC CMD SOP, TLM	DEG		
DZC3	V90H1726C	MPS 3 YAW ACTR DEFLECTION CMD	MPS TVC CMD SOP, TLM	DEG		
DZ1	V90H1746C	YAW COMMAND, SSME 1	TLM	DEG		
DZ2	V90H1748C	YAW COMMAND, SSME 2	TLM	DEG		
DZ3	V90H1750C	YAW COMMAND, SSME 3	TLM	DEG		
ELEV_LR	V90X1716X	ELEVON LOAD RELIEF FLAG	G/C STEER			
FRZCRD	V90X1714X	FREEZE DESIRED BODY CMD FLAG	G/C STEER, TLM		BD	
K_LOAD_RELIEF	V90J1704C	VAR LOAD RELIEF GAIN	ASC 1STG GUID			
KN_THETA	V90U1767C	VARIABLE GAIN ATTITUDE-PITCH	G/C STEER	DEG/S/DEG		
KN_PSI	V90U1768C	VARIABLE GAIN ATTITUDE-YAW	G/C STEER	DEG/S/DEG		
LAUTO_BFLAMP	V72X4996XB	LH BODY FLAP AUTO	D&C PNL, TLM			
LAUTO_PLAMP	V72X5240XB	FCS MODE-LH PITCH AUTO	D&C PNL, TLM			
LAUTO_RYLAMP	V72X5243XB	FCS MODE-LH R-Y AUTO	D&C PNL, TLM			
LAUTO_SBLAMP	V72X5136XB	LH SPEEDBRAKE AUTO	D&C PNL, TLM			
LCSS_PLAMP	V72X5241XB	FCS MODE-LH PITCH CSS	D&C PNL, 3-AX RHC SOP, SPTI SOP, TLM			
LCSS_RYLAMP	V72X5245XB	FCS MODE-LH R-Y CSS	D&C PNL, SPTI SOP, TLM			
LMNL_BFLAMP	V72X4997XB	LH BODY FLAP MANUAL	D&C PNL, TLM		BD	
MN10I_INIT	V90X1764X	FIRST-TIME ASC DAP SCHEDULED FLAG	G/C STEER, TLM			

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Table 4.2.11-1. Ascent DAP Interface (G4.176) Input/Output Parameters (Cont)

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FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE	PREC
MNLSB_CMDR_0	V72X5137XB	LH SPEEDBRAKE MANUAL	D&C PNL,TLM			
MNLSB_PLT_0	V72X5135XB	RH SPEEDBRAKE MANUAL	D&C PNL,TLM			
NEW_JONLST (04)	V90X1442XD	RCS JET F1L ON CMD	ASC RCS CMD SOP			
NEW_JONLST (05)	V90X1450XD	RCS JET F3L ON CMD	ASC RCS CMD SOP			
NEW_JONLST (06)	V90X1446XD	RCS JET F2R ON CMD	ASC RCS CMD SOP			
NEW_JONLST (07)	V90X1453XD	RCS JET F4R ON CMD	ASC RCS CMD SOP			
NEW_JONLST (19)	V90X1680XE	RCS JET L4L ON CMD	ASC RCS CMD SOP			
NEW_JONLST (20)	V90X1675XE	RCS JET L2L ON CMD	ASC RCS CMD SOP			
NEW_JONLST (21)	V90X1678XE	RCS JET L3L ON CMD	ASC RCS CMD SOP			
NEW_JONLST (22)	V90X1673XE	RCS JET L1L ON CMD	ASC RCS CMD SOP			
NEW_JONLST (23)	V90X1690XE	RCS JET R4R ON CMD	ASC RCS CMD SOP			
NEW_JONLST (24)	V90X1685XE	RCS JET R2R ON CMD	ASC RCS CMD SOP			
NEW_JONLST (25)	V90X1688XE	RCS JET R3R ON CMD	ASC RCS CMD SOP			
NEW_JONLST (26)	V90X1683XE	RCS JET R1R ON CMD	ASC RCS CMD SOP			
NEW_JONLST (27)	V90X1681XE	RCS JET L4U ON CMD	ASC RCS CMD SOP			
NEW_JONLST (28)	V90X1676XE	RCS JET L2U ON CMD	ASC RCS CMD SOP			
NEW_JONLST (29)	V90X1674XE	RCS JET L1U ON CMD	ASC RCS CMD SOP			
NEW_JONLST (30)	V90X1691XE	RCS JET R4U ON CMD	ASC RCS CMD SOP			
NEW_JONLST (31)	V90X1686XE	RCS JET R2U ON CMD	ASC RCS CMD SOP			
NEW_JONLST (32)	V90X1684XE	RCS JET R1U ON CMD	ASC RCS CMD SOP			
NEW_JONLST (33)	V90X1682XE	RCS JET L4D ON CMD	ASC RCS CMD SOP			
NEW_JONLST (34)	V90X1677XE	RCS JET L2D ON CMD	ASC RCS CMD SOP			
NEW_JONLST (35)	V90X1679XE	RCS JET L3D ON CMD	ASC RCS CMD SOP			
NEW_JONLST (36)	V90X1692XE	RCS JET R4D ON CMD	ASC RCS CMD SOP			
NEW_JONLST (37)	V90X1687XE	RCS JET R2D ON CMD	ASC RCS CMD SOP			
NEW_JONLST (38)	V90X1689XE	RCS JET R3D ON CMD	ASC RCS CMD SOP			
NY_FBK	V90A1766C	COMPENSATED LATERAL ACCEL ERROR	G/C STEER,TLM	DEG/S	SPL	
NZ_FBK	V90A1765C	COMPENSATED NORMAL ACCEL ERROR	G/C STEER,TLM	DEG/S	SPL	
PEGCMD	V90X1757X	S2G STEERING MODE FLAG	G/C STEER,TLM		BD	
PPD	V90X1760X	RTL5 POWERED PITCH DOWN MNVR FLAG	G/C STEER,TLM		BD	
RAUTO_BFLAMP	V72X4896XB	RH BODY FLAP AUTO	D&C PNL,TLM			
RAUTO_PLAMP	V72X5140XB	FCS MODE-RH PITCH AUTO	D&C PNL,TLM			
RAUTO_RYLAMP	V72X5143XB	FCS MODE-RH R-Y AUTO	D&C PNL,TLM			
RAUTO_SBLAMP	V72X5134XB	RH SPEEDBRAKE AUTO	D&C PNL,TLM			
RCSS_PLAMP	V72X5141XB	FCS MODE-RH PITCH CSS	D&C PNL,TLM			
RCSS_RYLAMP	V72X5145XB	FCS MODE-RH R-Y CSS	D&C PNL,TLM			
RMNL_BFLAMP	V72X4897XB	RH BODY FLAP MANUAL	D&C PNL,TLM		BD	
RTLS_TURN	V90X1756X	INITIATE RTLS TURNAROUND MNVR FLAG	G/C STEER,TLM			
SEC_RE_GL_CNFH	V90X1721X	2ND SSME FAIL CONFIRM	ABT CNTL SEQ,MSC,SSME OPS,5.21, ET SEP SEQ			
SRB_NULL_CMD	V90X1769X	INITIATE SRB NULL CMD	A/E ATT PROC		BD	
SRBSEP	V90X1761X	SRB SEPARATION SUBPHASE FLAG	G/C STEER,TLM		HXS	
SSME_FAILS	V90X1763X	SSME FAILURE STATUS FLAG	TLM		BD	
SIG	V90X1713X	STG1 GUIDANCE DISCRETE	G/C STEER,TLM		BD	
ZTRANS	V90X1755X	RTLS ET SEP MNVR FLAG	G/C STEER			

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Table 4.2.11 2. Ascent DAP (G4.176) I-Loads (Cont)

FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCIN	CAT
BIAS ID	V97U1413C	LBS/INMMZ	F	S	D	C	04.176	ADE1	
BIAS OB	V97U1416C	LBS/INMMZ	F	S	D	C	04.176	ADE1	
CL 1L41	V97U1420C	NO	F	S	D	C	04.176	ADQ2	
CL 1L42	V97U1421C	NO	F	S	D	C	04.176	ADQ2	
CL 1L43	V97U1422C	NO	F	S	D	C	04.176	ADQ2	

Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OIBC MISSIONS						
FSSR NAME	MSID	ENG UNIT	DT	PR	D S PR	FCTN CAT
BIAS_IB	V97U1413C	LBS/IN ^{MM} 2	F	S	D C	G4.176 ADE1
BIAS_OB	V97U1416C	LBS/IN ^{MM} 2	F	S	D C	G4.176 ADE1
CL_LLA1	V97U1420C	ND	F	S	D C	G4.176 ADG2
CL_LLA2	V97U1421C	ND	F	S	D C	G4.176 ADG2
CL_LLA3	V97U1422C	ND	F	S	D C	G4.176 ADG2
CL_LLA4	V97U2456C	ND	F	S	D C	G4.176 ADG2
CL_LLA5	V97U2457C	ND	F	S	D C	G4.176 ADG2
CL_LLB1	V97U1423C	ND	F	S	D C	G4.176 ADG2
CL_LLB2	V97U1424C	ND	F	S	D C	G4.176 ADG2
CL_LLB3	V97U1425C	ND	F	S	D C	G4.176 ADG2
CL_LLB4	V97U2458C	ND	F	S	D C	G4.176 ADG2
CL_LLB5	V97U2459C	ND	F	S	D C	G4.176 ADG2
CL_PBA11	V97U1432C	ND	F	S	D C	G4.176 ADG2
CL_PBA12	V97U1433C	ND	F	S	D C	G4.176 ADG2
CL_PBA13	V97U1434C	ND	F	S	D C	G4.176 ADG2
CL_PBA14	V97U1435C	ND	F	S	D C	G4.176 ADG2
CL_PBA15	V97U1436C	ND	F	S	D C	G4.176 ADG2
CL_PBA21	V97U1437C	ND	F	S	D C	G4.176 ADG2
CL_PBA22	V97U1438C	ND	F	S	D C	G4.176 ADG2
CL_PBA23	V97U1439C	ND	F	S	D C	G4.176 ADG2
CL_PBA24	V97U1440C	ND	F	S	D C	G4.176 ADG2
CL_PBA25	V97U1441C	ND	F	S	D C	G4.176 ADG2
CL_PBB11	V97U1447C	ND	F	S	D C	G4.176 ADG2
CL_PBB12	V97U1448C	ND	F	S	D C	G4.176 ADG2
CL_PBB13	V97U1449C	ND	F	S	D C	G4.176 ADG2
CL_PBB14	V97U1450C	ND	F	S	D C	G4.176 ADG2

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OI&C MISSIONS						
FSSR NAME	MSID	ENG UNIT	DT	PR	D S PR FCTM	CAT
CL_PBB15	V97U1451C	ND	F	S	D C G4.176	ADG2
CL_PBB21	V97U1452C	ND	F	S	D C G4.176	ADG2
CL_PBB22	V97U1453C	ND	F	S	D C G4.176	ADG2
CL_PBB23	V97U1454C	ND	F	S	D C G4.176	ADG2
CL_PBB24	V97U1455C	ND	F	S	D C G4.176	ADG2
CL_PBB25	V97U1456C	ND	F	S	D C G4.176	ADG2
CL_PBC11	V97U2460C	ND	F	S	D C G4.176	ADG2
CL_PBC12	V97U2461C	ND	F	S	D C G4.176	ADG2
CL_PBC13	V97U2462C	ND	F	S	D C G4.176	ADG2
CL_PBC14	V97U2463C	ND	F	S	D C G4.176	ADG2
CL_PBC15	V98U9577C	ND	F	S	D C G4.176	ADG2
CL_PBC21	V98U9578C	ND	F	S	D C G4.176	ADG2
CL_PBC22	V98U9579C	ND	F	S	D C G4.176	ADG2
CL_PBC23	V98U9580C	ND	F	S	D C G4.176	ADG2
CL_PBC24	V98U9581C	ND	F	S	D C G4.176	ADG2
CL_PBC25	V98U9582C	ND	F	S	D C G4.176	ADG2
CL_RO1	V97U1462C	ND	F	S	D C G4.176	ADG2
CL_RO2	V97U1463C	ND	F	S	D C G4.176	ADG2
CL_RO3	V97U1464C	ND	F	S	D C G4.176	ADG2
CL_RO4	V97U1465C	ND	F	S	D C G4.176	ADG2
CL_RO5	V97U1466C	ND	F	S	D C G4.176	ADG2
CH_LLS11	V98U9588C	ND	F	S	D C G4.176	ADG2
CH_LLS12	V98U9589C	ND	F	S	D C G4.176	ADG2
CH_LLS13	V98U9564C	ND	F	S	D C G4.176	ADG2
CH_LLS14	V98U9565C	ND	F	S	D C G4.176	ADG2
CH_LLS15	V98U9566C	ND	F	S	D C G4.176	ADG2

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OI&C MISSIONS						
FSSR NAME	MSID	ENG UNIT	DT	PR	D S PR FCTM	CAT
CH_LLS21	V98U9567C	ND	F	S	D C G4.176	ADG2
CH_LLS22	V98U9568C	ND	F	S	D C G4.176	ADG2

Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OI8C MISSIONS									
FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCTN	CAT
CM_LLS21	V98U9567C	ND	F	S	D	C	G4.176	ADG2	
CM_LLS22	V98U9568C	ND	F	S	D	C	G4.176	ADG2	
CM_LLS23	V98U9569C	ND	F	S	D	C	G4.176	ADG2	
CM_LLS24	V98U9570C	ND	F	S	D	C	G4.176	ADG2	
CM_LLS25	V98U9571C	ND	F	S	D	C	G4.176	ADG2	
CM_NZLAG1	V97U1482C	ND	F	S	D	C	G4.176	ADG2	
CM_NZLAG2	V97U1483C	ND	F	S	D	C	G4.176	ADG2	
CM_NZLAG3	V97U1484C	ND	F	S	D	C	G4.176	ADG2	
CM_NZ1	V97U1485C	ND	F	S	D	C	G4.176	ADG2	
CM_NZ2	V97U1486C	ND	F	S	D	C	G4.176	ADG2	
CM_NZ3	V97U1487C	ND	F	S	D	C	G4.176	ADG2	
CM_NZ4	V97U1488C	ND	F	S	D	C	G4.176	ADG2	
CM_NZ5	V97U1489C	ND	F	S	D	C	G4.176	ADG2	
CM_QB1	V97U1500C	ND	F	S	D	C	G4.176	ADG2	
CM_QB2	V97U1501C	ND	F	S	D	C	G4.176	ADG2	
CM_QB3	V97U1502C	ND	F	S	D	C	G4.176	ADG2	
CM_QB4	V97U1503C	ND	F	S	D	C	G4.176	ADG2	
CM_QB5	V97U1504C	ND	F	S	D	C	G4.176	ADG2	
CM_QHP1	V97U1540C	ND	F	S	D	C	G4.176	ADG2	
CM_QHP2	V97U1541C	ND	F	S	D	C	G4.176	ADG2	
CM_QHP3	V97U1542C	ND	F	S	D	C	G4.176	ADG2	
CM_QO11	V97U1543C	ND	F	S	D	C	G4.176	ADG2	
CM_QO12	V97U1544C	ND	F	S	D	C	G4.176	ADG2	
CM_QO13	V97U1545C	ND	F	S	D	C	G4.176	ADG2	
CM_QO14	V97U1546C	ND	F	S	D	C	G4.176	ADG2	
CM_QO15	V97U1547C	ND	F	S	D	C	G4.176	ADG2	

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OIB8 MISSIONS						
FSSR NAME	MSID	ENG UNIT	DT	PR	D S PR FCTN	CAT
CH_Q021	V97U1548C	ND	F	S	D C G4.176	ADG2
CH_Q022	V97U1549C	ND	F	S	D C G4.176	ADG2
CH_Q023	V97U1550C	ND	F	S	D C G4.176	ADG2
CH_Q024	V97U1551C	ND	F	S	D C G4.176	ADG2
CH_Q025	V97U1552C	ND	F	S	D C G4.176	ADG2
CH_R01	V97U1558C	ND	F	S	D C G4.176	ADG2
CH_R02	V97U1559C	ND	F	S	D C G4.176	ADG2
CH_R03	V97U1560C	ND	F	S	D C G4.176	ADG2
CH_R04	V97U1561C	ND	F	S	D C G4.176	ADG2
CH_R05	V97U1562C	ND	F	S	D C G4.176	ADG2
CH_STG11	V98U9583C	ND	F	S	D C G4.176	ADG2
CH_STG12	V98U9584C	ND	F	S	D C G4.176	ADG2
CH_STG13	V98U9585C	ND	F	S	D C G4.176	ADG2
CH_STG14	V98U9586C	ND	F	S	D C G4.176	ADG2
CH_STG15	V98U9587C	ND	F	S	D C G4.176	ADG2
CH_LLA1	V97U1571C	ND	F	S	D C G4.176	ADG2
CH_LLA2	V97U1572C	ND	F	S	D C G4.176	ADG2
CH_LLA3	V97U1573C	ND	F	S	D C G4.176	ADG2
CH_LLA4	V97U1574C	ND	F	S	D C G4.176	ADG2
CH_LLA5	V97U1575C	ND	F	S	D C G4.176	ADG2
CH_LLB1	V98U9572C	ND	F	S	D C G4.176	ADG2
CH_LLB2	V98U9573C	ND	F	S	D C G4.176	ADG2
CH_LLB3	V98U9574C	ND	F	S	D C G4.176	ADG2
CH_LLB4	V98U9575C	ND	F	S	D C G4.176	ADG2
CH_LLB5	V98U9576C	ND	F	S	D C G4.176	ADG2
CH_NYLAG1	V97U1581C	ND	F	S	D C G4.176	ADG2

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OIB8 MISSIONS						
FSSR NAME	MSID	ENG UNIT	DT	PR	D S PR FCTN	CAT
CH_NYLAG2	V97U1582C	ND	F	S	D C G4.176	ADG2

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OI8C MISSIONS					
FSSR NAME	MSID	ENG UNIT	DT	PR	D S PR FCTN CAT
CN_NYLAG2	V97U1582C	ND	F	S	D C G4.176 ADG2
CN_NYLAG3	V97U1583C	ND	F	S	D C G4.176 ADG2
CN_NYSEP1	V97U1584C	ND	F	S	D C G4.176 ADG2
CN_NYSEP2	V97U1585C	ND	F	S	D C G4.176 ADG2
CN_NYSEP3	V97U1586C	ND	F	S	D C G4.176 ADG2
CN_NY11	V97U1587C	ND	F	S	D C G4.176 ADG2
CN_NY12	V97U1588C	ND	F	S	D C G4.176 ADG2
CN_NY13	V97U1589C	ND	F	S	D C G4.176 ADG2
CN_NY14	V97U1590C	ND	F	S	D C G4.176 ADG2
CN_NY15	V97U1591C	ND	F	S	D C G4.176 ADG2
CN_NY21	V97U1592C	ND	F	S	D C G4.176 ADG2
CN_NY22	V97U1593C	ND	F	S	D C G4.176 ADG2
CN_NY23	V97U1594C	ND	F	S	D C G4.176 ADG2
CN_NY24	V97U1595C	ND	F	S	D C G4.176 ADG2
CN_NY25	V97U1596C	ND	F	S	D C G4.176 ADG2
CN_PRHP1	V97U1602C	ND	F	S	D C G4.176 ADG2
CN_PRHP2	V97U1603C	ND	F	S	D C G4.176 ADG2
CN_PRHP3	V97U1604C	ND	F	S	D C G4.176 ADG2
CN_RBA11	V99U9575C	ND	F	S	D C G4.176 ADG2
CN_RBA12	V99U9576C	ND	F	S	D C G4.176 ADG2
CN_RBA13	V99U9577C	ND	F	S	D C G4.176 ADG2
CN_RBA14	V99U9578C	ND	F	S	D C G4.176 ADG2
CN_RBA15	V99U9579C	ND	F	S	D C G4.176 ADG2
CN_RBA21	V99U9580C	ND	F	S	D C G4.176 ADG2
CN_RBA22	V99U9581C	ND	F	S	D C G4.176 ADG2
CN_RBA23	V99U9582C	ND	F	S	D C G4.176 ADG2

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OI&C MISSIONS	FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCTN	CAT
	CN_RBA24	V99U9583C	ND	F	S	D	C	G4.176		ADG2
	CN_RBA25	V99U9584C	ND	F	S	D	C	G4.176		ADG2
	CN_RBB11	V99U9585C	ND	F	S	D	C	G4.176		ADG2
	CN_RBB12	V99U9586C	ND	F	S	D	C	G4.176		ADG2
	CN_RBB13	V99U9587C	ND	F	S	D	C	G4.176		ADG2
	CN_RBB14	V99U9588C	ND	F	S	D	C	G4.176		ADG2
	CN_RBB15	V99U9589C	ND	F	S	D	C	G4.176		ADG2
	CN_RBB21	V99U9590C	ND	F	S	D	C	G4.176		ADG2
	CN_RBB22	V99U9591C	ND	F	S	D	C	G4.176		ADG2
	CN_RBB23	V99U9592C	ND	F	S	D	C	G4.176		ADG2
	CN_RBB24	V99U9593C	ND	F	S	D	C	G4.176		ADG2
	CN_RBB25	V99U9594C	ND	F	S	D	C	G4.176		ADG2
	CN_ROFF1	V97U2488C	ND	F	S	D	C	G4.176		ADG2
	CN_ROFF2	V97U8889C	ND	F	S	D	C	G4.176		ADG2
	CN_ROFF3	V97U2490C	ND	F	S	D	C	G4.176		ADG2
	CN_ROFF4	V97U2491C	ND	F	S	D	C	G4.176		ADG2
	CN_ROFF5	V97U2492C	ND	F	S	D	C	G4.176		ADG2
	CN_RO11	V97U1645C	ND	F	S	D	C	G4.176		ADG2
	CN_RO12	V97U1646C	ND	F	S	D	C	G4.176		ADG2
	CN_RO13	V97U1647C	ND	F	S	D	C	G4.176		ADG2
	CN_RO14	V97U1648C	ND	F	S	D	C	G4.176		ADG2
	CN_RO15	V97U1649C	ND	F	S	D	C	G4.176		ADG2
	CN_RO21	V97U1650C	ND	F	S	D	C	G4.176		ADG2
	CN_RO22	V97U1651C	ND	F	S	D	C	G4.176		ADG2
	CN_RO23	V97U1652C	ND	F	S	D	C	G4.176		ADG2
	CN_RO24	V97U1653C	ND	F	S	D	C	G4.176		ADG2

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OI&C MISSIONS	FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCTN	CAT
	CN_RO15	V97U1654C	ND	F	S	D	C	G4.176		ADG2
	CSR8 PCI	V97U1660C	ND	F	S	D	C	G4.176		ZFR4
	CSR8 PCB	V97U1661C	ND	F	S	D	C	G4.176		ZFR4

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

DI8C MISSIONS	MSID	ENG JNIT	DT PR D S PR FCTN	CAT
FNSSR NAME				
CN_R025	V97U1654C	NO	F S D C G4.176	ADG2
CSRB_PC1	V97U1660C	NO	F S D C G4.176	ZFR4
CSRB_PC2	V97U1661C	NO	F S D C G4.176	ZFR4
CSRB_PC3	V97U1662C	NO	F S D C G4.176	ZFR4
DBFE_INNER	V97U1665C	DEG	F S D P G4.176	ZSR2
DBFE_OUTER	V97U1666C	DEG	F S D P G4.176	ZSR2
DCLIM	V97U2429C	DEG	F S D C G4.176	ZSR2
DEL_THR_CLR	V97U2440C	DEG	F S D C G4.176	ZSR2
DELTAT_AUTOTRIM_ENABLE	V98U9809C	SEC	F D D P G4.176	ZFR4
DIBS_TAB(01)	V97U1667C	DEG	F S D C G4.176	ASE0
DIBS_TAB(02)	V97U1668C	DEG	F S D C G4.176	ASE0
DIBS_TAB(03)	V97U1669C	DEG	F S D C G4.176	ASE0
DIBS_TAB(04)	V97U1670C	DEG	F S D C G4.176	ASE0
DIBS_TAB(05)	V97U1671C	DEG	F S D C G4.176	ASE0
DIBS_TAB(06)	V97U1672C	DEG	F S D C G4.176	ASE0
DIBS_TAB(07)	V97U1673C	DEG	F S D C G4.176	ASE0
DIBS_TAB(08)	V97U1674C	DEG	F S D C G4.176	ASE0
DOBS_TAB(01)	V97U1677C	DEG	F S D C G4.176	ASE0
DOBS_TAB(02)	V97U1678C	DEG	F S D C G4.176	ASE0
DOBS_TAB(03)	V97U1679C	DEG	F S D C G4.176	ASE0
DOBS_TAB(04)	V97U1680C	DEG	F S D C G4.176	ASE0
DOBS_TAB(05)	V97U1681C	DEG	F S D C G4.176	ASE0
DOBS_TAB(06)	V97U1682C	DEG	F S D C G4.176	ASE0
DOBS_TAB(07)	V97U1683C	DEG	F S D C G4.176	ASE0
DOBS_TAB(08)	V97U1684C	DEG	F S D C G4.176	ASE0
DP_INNER	V97U2484C	DEG	F S D P G4.176	ZSR2

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OI8C MISSIONS	MSID	ENG UNIT	DT PR D S PR FCTN	CAT
FSSR NAME				
DP_OUTER	V97U2485C	DEG	F S D P G4.176	ZSR2
DPY1_LIM	V97U1685C	DEG	F S D C G4.176	ZFR4
DPY23_LIM	V97U1686C	DEG	F S D C G4.176	ZFR4
DPZ1_LIM	V97U1687C	DEG	F S D C G4.176	ZFR4
DPZ23_LIM	V97U1688C	DEG	F S D C G4.176	ZFR4
DQMPSP_LIM	V97U1689C	DEG	F S D C G4.176	ZFR4
DQMPST_S1_END	V97U2450C	DEG	F S H C G4.176	ADG2
DQMPST_S2_TAB(01)	V97U1710C	DEG	F S H C G4.176 G4.175	ATMO
DQMPST_S2_TAB(02)	V97U1711C	DEG	F S H C G4.176	ATMO
DQMPST_S2_TAB(03)	V97U1712C	DEG	F S H C G4.176	ATMO
DQMPST_S2_TAB(04)	V97U1713C	DEG	F S H C G4.176	ATMO
DQMPST_S2_TAB(5)	V97U2451C	DEG	F S H C G4.176	ATMO
DQMPST_S2_TAB(6)	V97U2452C	DEG	F S H C G4.176	ATMO
DQMPST_S2_TAB(7)	V97U2453C	DEG	F S H C G4.176	ATMO
DQMPST_S2_TAB(8)	V97U2455C	DEG	F S H C G4.176	ATMO
DQSRBT_O_TAB(01)	V97U1714C	DEG	F S H C G4.176	A1N2
DQSRBT_O_TAB(02)	V97U1715C	DEG	F S H C G4.176	A1N2
DQSRBT_O_TAB(03)	V97U1716C	DEG	F S H C G4.176	A1N2
DQSRBT_O_TAB(04)	V97U1717C	DEG	F S H C G4.176	A1N2
DQSRBT_O_TAB(05)	V97U1718C	DEG	F S H C G4.176	A1N2
DQSRBT_O_TAB(06)	V97U1719C	DEG	F S H C G4.176	A1N2
DQSRBT_O_TAB(07)	V97U1720C	DEG	F S H C G4.176	A1N2
DQSRBT_O_TAB(08)	V97U1721C	DEG	F S H C G4.176	A1N2
DQSRBT_O_TAB(09)	V97U1722C	DEG	F S H C G4.176	A1N2
DQSRBT_O_TAB(10)	V97U1723C	DEG	F S H C G4.176	A1N2
DQSRBT_O_TAB(11)	V97U1724C	DEG	F S H C G4.176	A1N2

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OI8C MISSIONS	MSID	ENG UNIT	DT PR D S PR FCTN	CAT
FSSR NAME				
DQSRBT O TAB(12)	V97U1725C	DEG	F S H C G4.176	A1N2
DQSRBT O TAB(13)	V97U1726C	DEG	F S H C G4.176	A1N2

Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

MISSIONS	FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FC	CTN	CAT
DQSRBT_0_TAB(12)		V97U1725C	DEG	F	S	M	C	G4.176	A1N2		A1N2
DQSRBT_0_TAB(13)		V97U1726C	DEG	F	S	M	C	G4.176	A1N2		A1N2
DQSRBT_0_TAB(14)		V97U1727C	DEG	F	S	M	C	G4.176	A1N2		A1N2
DQSRBT_0_TAB(15)		V97U1728C	DEG	F	S	M	C	G4.176	A1N2		A1N2
DQSRBT_0_TAB(16)		V97U1729C	DEG	F	S	M	C	G4.176	A1N2		A1N2
DQSRBT_0_TAB(17)		V97U1730C	DEG	F	S	M	C	G4.176	A1N2		A1N2
DQSRBT_0_TAB(18)		V97U1731C	DEG	F	S	M	C	G4.176	A1N2		A1N2
DQSRBT_0_TAB(19)		V97U1732C	DEG	F	S	M	C	G4.176	A1N2		A1N2
DQSRBT_0_TAB(20)		V97U1733C	DEG	F	S	M	C	G4.176	A1N2		A1N2
DQSRBT_1_TAB(01)		V97U1734C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(02)		V97U1735C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(03)		V97U1736C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(04)		V97U1737C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(05)		V97U1738C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(06)		V97U1739C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(07)		V97U1740C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(08)		V97U1741C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(09)		V97U1742C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(10)		V97U1743C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(11)		V97U1744C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(12)		V97U1745C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(13)		V97U1746C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(14)		V97U1747C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(15)		V97U1748C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(16)		V97U1749C	DEG	F	S	M	C	G4.176	A1P0		A1P0
DQSRBT_1_TAB(17)		V97U1750C	DEG	F	S	M	C	G4.176	A1P0		A1P0

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OI&C MISSIONS FSSR NAME	MSID	ENG UNIT	DY	PR	D	S	PR	FCIN	CAT
DQSRBT_1_TAB(18)	V97U1751C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_1_TAB(19)	V97U1752C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_1_TAB(20)	V97U1753C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(01)	V97U1754C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(02)	V97U1755C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(03)	V97U1756C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(04)	V97U1757C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(05)	V97U1758C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(06)	V97U1759C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(07)	V97U1760C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(08)	V97U1761C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(09)	V97U1762C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(10)	V97U1763C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(11)	V97U1764C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(12)	V97U1765C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(13)	V97U1766C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(14)	V97U1767C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(15)	V97U1768C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(16)	V97U1769C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(17)	V97U1770C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(18)	V97U1771C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(19)	V97U1772C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DQSRBT_2_3_TAB(20)	V97U1773C	DEG	F	S	H	C	G4.176	A1P0	A1P0
DRMPSP_LIM	V97U1775C	DEG	F	S	D	C	G4.176	ZFR4	ZFR4
DRVLIM_IB	V97U1776C	LBS/INHH2	F	S	D	C	G4.176	ADE1	ADE1
DRVLIM_OB	V97U1777C	LBS/INHH2	F	S	D	C	G4.176	ADE1	ADE1

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads

OI&C MISSIONS FSSR NAME	MSID	ENG UNIT	DY	PR	D	S	PR	FCIN	CAT
DQSRBT_1_TAB(18)	V97U1751C	DEG	F	S	H	C	G4.176	A1P0	A1P0

CR894748
CR79962F
CR69870F

Table 4.2.11-2. Ascent DAP (G4.176) I-Loads

MISSIONS	FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCIN	CAT
DSB_BIAS_SLEN		V97U2441C	DEG	F	S	D	P	G4.176	ZFR4	
DSB_CLOSED		V97U2425C	DEG	F	S	D	C	G4.176 G4.227 G4.50	ZF7D	
DY1_FAIL		V97U1781C	DEG	F	S	D	C	G4.176	ZFR4	
DY1_GRAV		V96U7984C	DEG	F	S	D	C	G4.176	ZFR4	
DY1_START		V97U1782C	DEG	F	S	D	P	G4.176	ZFR4	
DY2_FAIL		V97U1783C	DEG	F	S	D	C	G4.176	ZFR4	
DY2_GRAV		V96U7985C	DEG	F	S	D	P	G4.176	ZFR4	
DY2_START		V97U1784C	DEG	F	S	D	P	G4.176	ZFR4	
DY3_FAIL		V97U1785C	DEG	F	S	D	C	G4.176	ZFR4	
DY3_GRAV		V96U7986C	DEG	F	S	D	P	G4.176	ZFR4	
DY3_START		V97U1786C	DEG	F	S	D	P	G4.176	ZFR4	
DZ1_FAIL		V97U1361C	DEG	F	S	D	C	G4.176	ZFR4	
DZ2_FAIL		V97U1787C	DEG	F	S	D	C	G4.176	ZFR4	
DZ2_GRAV		V96U7987C	DEG	F	S	D	P	G4.176	ZFR4	
DZ2_START		V97U1788C	DEG	F	S	D	P	G4.176	ZFR4	
DZ3_FAIL		V97U1789C	DEG	F	S	D	C	G4.176	ZFR4	
DZ3_GRAV		V96U7988C	DEG	F	S	D	P	G4.176	ZFR4	
DZ3_START		V97U1790C	DEG	F	S	D	P	G4.176	ZFR4	
HOLD_CLEAR_BIAS		V98U9793C	DEG	F	S	M	C	G4.176	A1N2	
K_PPD		V97U1363C	ND	F	S	D	P	G4.176	ZFR4	
KL_INT		V97U1810C	SECM-1	F	S	D	C	G4.176	ZFR4	
KLDELPSI_MASS_TAB(01)		V97U2478C	(DEG/SEC)/IDEG /SEC)	F	S	D	X	G4.176	ZFR4	
KLDELPSI_MASS_TAB(02)		V97U2479C	(DEG/SEC)/IDEG /SEC)	F	S	D	X	G4.176	ZFR4	

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont.)

OI8C MISSIONS	FSSR NAME	MSID	ENG_UNIT	DT	PR	D	S	PR	FCTN	CAT
	KLDELPSI_S1	V97U2434C	NO	F	S	D	C	G4.176	ZFR4	
	KLHPS_S1	V98U9590C	DEG/DEG/SEC	F	S	D	C	G4.176	ADG2	
	KLHPS_S2	V97U2477C	DEG/DEG/SEC	F	S	D	C	G4.176	ADG2	
	KLOADRELIEF_VREL_TAB(01)	V97U2442C	NO	F	S	D	C	G4.176	ZFR4	
	KLOADRELIEF_VREL_TAB(02)	V97U2443C	NO	F	S	D	C	G4.176	ZSR2	
	KLOADRELIEF_VREL_TAB(03)	V97U2444C	NO	F	S	D	C	G4.176	ZSR2	
	KLOADRELIEF_VREL_TAB(04)	V97U2445C	NO	F	S	D	C	G4.176	ZSR2	
	KLOADRELIEF_VREL_TAB(05)	V97U2446C	NO	F	S	D	C	G4.176	ZSR2	
	KLPHI_S2	V97U2447C	DEG/SEC/DEG	F	S	D	C	G4.176	ADG2	
	KLPHI_VREL_TAB(01)	V97U1840C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ADG2	
	KLPHI_VREL_TAB(02)	V97U1841C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ADG2	
	KLPHI_VREL_TAB(03)	V97U1842C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ADG2	
	KLPHI_VREL_TAB(04)	V97U1843C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ADG2	
	KLPHI_VREL_TAB(05)	V97U1844C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ADG2	
	KLPSI_RATIO	V97U2445C	DEG/SEC/DEG	F	S	D	C	G4.176	ADG2	
	KLSRB_SRBSEP	V98U9583C	NO	F	S	D	C	G4.176	ADG2	
	KLSRB_TIME_TAB(01)	V98U9595C	DEG/DEG/SEC	F	S	D	C	G4.176	ADG2	
	KLSRB_TIME_TAB(02)	V98U9596C	DEG/DEG/SEC	F	S	D	C	G4.176	ADG2	
	KLSRB_TIME_TAB(03)	V98U9597C	DEG/DEG/SEC	F	S	D	C	G4.176	ADG2	
	KLSRB_TIME_TAB(04)	V98U9598C	DEG/DEG/SEC	F	S	D	C	G4.176	ADG2	
	KM_QHP	V97U1895C	G/DEG/SEC	F	S	D	C	G4.176	ADG2	
	KHINT_S1	V98U9557C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ZFR4	
	KHINT_S2	V97U2480C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ZFR4	
	KHPS_MASS_TAB(01)	V97U1897C	DEG/DEG/SEC	F	S	D	X	G4.176	ZFR4	
	KHPS_MASS_TAB(02)	V97U1898C	DEG/DEG/SEC	F	S	D	X	G4.176	ZFR4	

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont.)

OI8C MISSIONS	FSSR NAME	MSID	ENG_UNIT	DT	PR	D	S	PR	FCTN	CAT
	KHPS_TIME_TAB(01)	V98U9599C	DEG/DEG/SEC	F	S	D	C	G4.176	ADG2	
	KHPS_TIME_TAB(02)	V98U9600C	DEG/DEG/SEC	F	S	D	C	G4.176	ADG2	
	KHPS_TIME_TAB(03)	V98U9601C	DEG/DEG/SEC	F	S	D	C	G4.176	ADG2	



Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OIBC MISSIONS	FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCIN	CAT
KMPPS	TIME_TAB(01)	V98U9599C	DEG/(DEG/SEC)	F	S	D	C	G4.176	ADG2	
KMPPS	TIME_TAB(02)	V98U9600C	DEG/(DEG/SEC)	F	S	D	C	G4.176	ADG2	
KMPPS	TIME_TAB(03)	V98U9601C	DEG/(DEG/SEC)	F	S	D	C	G4.176	ADG2	
KMPPS	TIME_TAB(04)	V98U9602C	DEG/(DEG/SEC)	F	S	D	C	G4.176	ADG2	
KMNZ	RATIO	V97U2464C	DEG/SEC/O	F	S	D	C	G4.176	ADG2	
KMSRB	RATIO	V98U9556C	NO	F	S	D	C	G4.176	ADG2	
KMTHTETA	S2	V97U2448C	DEG/SEC/DEG	F	S	D	C	G4.176	ADG2	
KMTHTETA	VREL_TAB(01)	V97U1938C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ADG2	
KMTHTETA	VREL_TAB(02)	V97U1939C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ADG2	
KMTHTETA	VREL_TAB(03)	V97U1940C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ADG2	
KMTHTETA	VREL_TAB(04)	V97U1941C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ADG2	
KMTHTETA	VREL_TAB(05)	V97U1942C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ADG2	
KN_BRG		V99U9596C	NO	F	S	D	C	G4.176	ADG2	
KN_ORB		V99U9595C	NO	F	S	D	C	G4.176	ADG2	
KN_PHP		V97U1953C	NO	F	S	D	C	G4.176	ADG2	
KNINT	S1	V98U9559C	(DEG/SEC)/(DEG/SEC)	F	S	D	C	G4.176	ZFR4	
KNINT	S2	V97U2481C	(DEG/SEC)/(DEG/SEC)	F	S	D	C	G4.176	ZFR4	
KMPPS	MASS_TAB(01)	V97U1957C	DEG/(DEG/SEC)	F	S	D	X	G4.176	ZFR4	
KMPPS	MASS_TAB(02)	V97U1958C	DEG/(DEG/SEC)	F	S	D	X	G4.176	ZFR4	
KMPPS	TIME_TAB(01)	V97U2499C	DEG/(DEG/SEC)	F	S	D	C	G4.176	ADG2	
KMPPS	TIME_TAB(02)	V98U9553C	DEG/(DEG/SEC)	F	S	D	C	G4.176	ADG2	
KMPPS	TIME_TAB(03)	V98U9554C	DEG/(DEG/SEC)	F	S	D	C	G4.176	ADG2	
KMPPS	TIME_TAB(04)	V98U9555C	DEG/(DEG/SEC)	F	S	D	C	G4.176	ADG2	
KMN	RATIO	V97U2466C	DEG/SEC/O	F	S	D	C	G4.176	ADG2	
KMN	SEP	V97U2468C	DEG/SEC/O	F	S	D	C	G4.176	ADG2	

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OI8C MISSIONS FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCIN	CAT
KMPRHP_RATIO	V97U2467C	NO	F	S	D	C	G4.176	ADG2	
KNPSI_S2	V97U2449C	DEG/SEC/DEG	F	S	D	C	G4.176	ADG2	
KNPSI_VREL_TAB(01)	V97U2011C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ADG2	
KNPSI_VREL_TAB(02)	V97U2012C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ADG2	
KNPSI_VREL_TAB(03)	V97U2013C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ADG2	
KNPSI_VREL_TAB(04)	V97U2014C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ADG2	
KNPSI_VREL_TAB(05)	V97U2015C	(DEG/SEC)/DEG	F	S	D	C	G4.176	ADG2	
KNSRB_RATIO	V98U9558C	NO	F	S	D	C	G4.176	ADG2	
KPY1_FAIL23	V97U2036C	DEG/DEG	F	S	D	C	G4.176	ADG2	
KPY23_S2C	V97U2037C	DEG/DEG	F	S	D	C	G4.176	ADG2	
KPZ1_FAIL23	V97U2038C	DEG/DEG	F	S	D	C	G4.176	ADG2	
KPZ1_NOM	V97U2039C	DEG/DEG	F	S	D	C	G4.176	ADG2	
KPZ23_FAIL23	V97U2040C	DEG/DEG	F	S	D	C	G4.176	ADG2	
MASS_GAIN_TAB(01)	V97U2056C	SLUGS	F	S	H	C	G4.176	ATH0	
MASS_GAIN_TAB(02)	V97U2057C	SLUGS	F	S	H	C	G4.176	ATH0	
MASS_GAIN_TAB(03)	V97U2058C	SLUGS	F	S	H	C	G4.176	ATH0	
MASS_GAIN_TAB(04)	V97U2059C	SLUGS	F	S	H	C	G4.176	ATH0	
MASS_GAIN_TAB(05)	V97U2471C	SLUGS	F	S	H	C	G4.176	ATH0	
MASS_GAIN_TAB(06)	V97U2472C	SLUGS	F	S	H	C	G4.176	ATH0	
MASS_GAIN_TAB(07)	V97U2473C	SLUGS	F	S	H	C	G4.176	ATH0	
MASS_GAIN_TAB(08)	V97U2474C	SLUGS	F	S	H	C	G4.176	ATH0	
MASS_KLDELPSI_TAB(01)	V97U2482C	SLUGS	F	S	D	X	G4.176	ZFR4	
MASS_KLDELPSI_TAB(02)	V97U2483C	SLUGS	F	S	D	X	G4.176	ZFR4	
MASS2_GAIN_TAB(01)	V97U2475C	SLUGS	F	S	D	X	G4.176	ZFR4	
MASS2_GAIN_TAB(02)	V97U2476C	SLUGS	F	S	D	X	G4.176	ZFR4	
MET_GAIN_TAB(01)	V98U9591C	SEC	F	S	D	C	G4.176	ADG2	

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OI8C MISSIONS FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCIN	CAT
MET_GAIN_TAB(02)	V98U9592C	SEC	F	S	D	C	G4.176	ADG2	
MET_GAIN_TAB(03)	V98U9593C	SEC	F	S	D	C	G4.176	ADG2	



Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

QI&C MISSIONS	FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCIN	CAT
	MET_GAIN_TAB(02)	V98U9592C	SEC	F	S	D	C	G4.176	ADG2	
	MET_GAIN_TAB(03)	V98U9593C	SEC	F	S	D	C	G4.176	ADG2	
	MET_GAIN_TAB(04)	V98U9594C	SEC	F	S	D	C	G4.176	ADG2	
	MET_LIFTOFF	V97U2061C	SEC	F	S	D	X	G4.176	ZFR4	
	MET_LIM_LCH	V97U2062C	SEC	F	S	D	X	G4.176	ZFR4	
	MET_25A	V97U2435C	SEC	F	D	D	C	G4.176	ADG2	
	MET_25B	V97U2436C	SEC	F	S	D	C	G4.176	ADG2	
	MET_25E	V97U2437C	SEC	F	S	D	C	G4.176	XS41	
	MET_90THRUST	V97U2487C	SEC	F	D	D	X	G4.176	QSA0	
	MPL_DL	V97U2403C	SEC	F	S	D	P	G4.176	ZSR2	
	NFADE_COM_SRBSEP	V98U9561C	NO	F	S	D	X	G4.176	ZFR4	
	NFADE_DQMPST_S1_END	V97U2432C	NO	F	S	D	X	G4.176	ADG2	
	NFADE_DSBCLOSE_NOM	V97U2431C	NO	F	S	D	P	G4.176	ZFR4	
	NFADE_HDSCCLR_START	V97U2063C	COUNTS	F	S	D	X	G4.176	ZFR4	
	NFADE_INT_NOM	V97U2075C	COUNTS	F	S	D	X	G4.176	ZSR2	
	NFADE_KLDELPSI_SEP	V98U9560C	CYCLES	F	S	D	X	G4.176	ZFR4	
	NFADE_KLPPS_SEP	V98U9562C	NO	F	S	D	X	G4.176	ZFR4	
	NFADE_MEFAIL	V97U2073C	COUNTS	F	S	M	X	G4.176	ZFR4	
	NFADE_MY_OFF	V97U2470C	NO	F	S	D	X	G4.176	ZFR4	
	NFADE_MY_ON	V97U2469C	NO	F	S	D	X	G4.176	ZFR4	
	MPLIM	V96U0977C	DEG	F	S	D	P	G4.176	ZSR2	
	MYREF_0_1	V97U2078C	0	F	S	M	C	G4.176	ZF22	
	MYREF_2	V97U2098C	0	F	S	M	C	G4.176	ZF22	
	MYREF_3	V97U2118C	0	F	S	M	C	G4.176	ZF22	
	NZREF_0 TAB(01)	V97U2138C	0	F	S	M	C	G4.176	AIN2	
	NZREF_0 TAB(02)	V97U2139C	0	F	S	M	C	G4.176	AIN2	

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OI&C MISSIONS FSSR NAME	MSID	ENG UNIT	DI	PR	S	PR	FCM	CAT
NZREF_0_TAB(03)	V97U2140C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(04)	V97U2141C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(05)	V97U2142C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(06)	V97U2143C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(07)	V97U2144C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(08)	V97U2145C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(09)	V97U2146C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(10)	V97U2147C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(11)	V97U2148C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(12)	V97U2149C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(13)	V97U2150C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(14)	V97U2151C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(15)	V97U2152C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(16)	V97U2153C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(17)	V97U2154C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(18)	V97U2155C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(19)	V97U2156C	0	F	S	M	C	G4.176	A1N2
NZREF_0_TAB(20)	V97U2157C	0	F	S	M	C	G4.176	A1N2
NZREF_1_TAB(01)	V97U2158C	0	F	S	M	C	G4.176	A1P0
NZREF_1_TAB(02)	V97U2159C	0	F	S	M	C	G4.176	A1P0
NZREF_1_TAB(03)	V97U2160C	0	F	S	M	C	G4.176	A1P0
NZREF_1_TAB(04)	V97U2161C	0	F	S	M	C	G4.176	A1P0
NZREF_1_TAB(05)	V97U2162C	0	F	S	M	C	G4.176	A1P0
NZREF_1_TAB(06)	V97U2163C	0	F	S	M	C	G4.176	A1P0
NZREF_1_TAB(07)	V97U2164C	0	F	S	M	C	G4.176	A1P0
NZREF_1_TAB(08)	V97U2165C	0	F	S	M	C	G4.176	A1P0

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OI&C MISSIONS FSSR NAME	MSID	ENG UNIT	DI	PR	S	PR	FCM	CAT
NZREF_1_TAB(09)	V97U2166C	0	F	S	M	C	G4.176	A1P0
NZREF_1_TAB(10)	V97U2167C	0	F	S	M	C	G4.176	A1P0
NZREF_1_TAB(11)	V97U2168C	0	F	S	M	C	G4.176	A1P0



Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OIBC MISSIONS	FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCIN	CAT
	NZREF_1_TAB(09)	V97U2166C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_1_TAB(10)	V97U2167C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_1_TAB(11)	V97U2168C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_1_TAB(12)	V97U2169C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_1_TAB(13)	V97U2170C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_1_TAB(14)	V97U2171C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_1_TAB(15)	V97U2172C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_1_TAB(16)	V97U2173C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_1_TAB(17)	V97U2174C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_1_TAB(18)	V97U2175C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_1_TAB(19)	V97U2176C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_1_TAB(20)	V97U2177C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_2_3_TAB(01)	V97U2178C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_2_3_TAB(02)	V97U2179C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_2_3_TAB(03)	V97U2180C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_2_3_TAB(04)	V97U2181C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_2_3_TAB(05)	V97U2182C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_2_3_TAB(06)	V97U2183C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_2_3_TAB(07)	V97U2184C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_2_3_TAB(08)	V97U2185C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_2_3_TAB(09)	V97U2186C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_2_3_TAB(10)	V97U2187C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_2_3_TAB(11)	V97U2188C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_2_3_TAB(12)	V97U2189C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_2_3_TAB(13)	V97U2190C	G	F	S	H	C	G4.176	A1P0	A1P0
	NZREF_2_3_TAB(14)	V97U2191C	G	F	S	H	C	G4.176	A1P0	A1P0

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OIBC MISSIONS	FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCIN	CAT
	NZREF_2_3_TAB(15)	V97U2192C	G	F	S	M	C	G4.176		AIP0
	NZREF_2_3_TAB(16)	V97U2193C	G	F	S	M	C	G4.176		AIP0
	NZREF_2_3_TAB(17)	V97U2194C	G	F	S	M	C	G4.176		AIP0
	NZREF_2_3_TAB(18)	V97U2195C	G	F	S	M	C	G4.176		AIP0
	NZREF_2_3_TAB(19)	V97U2196C	G	F	S	M	C	G4.176		AIP0
	NZREF_2_3_TAB(20)	V97U2197C	G	F	S	M	C	G4.176		AIP0
	ORI_DL	V97U1362C	SEC	F	S	D	P	G4.176		ZSR2
	PARALLEL_PITCH_NOM	V99U7557C	ND	D	M	C	G4.176			ADM0
	PC_COHLIM	V97U2203C	LBS/IN**2	F	S	D	C	G4.176		ADG2
	PC_LIM	V97U2200C	DEG/SEC	F	S	D	C	G4.176		ZFR4
	PC_TRIM_RESET	V97U2202C	PSIA	F	S	D	C	G4.176		ADG2
	PCI_LIM	V97U2205C	DEG/SEC	F	S	D	C	G4.176		ZFR4
	PCIDOT_LIM	V97U2206C	DEG/SEC**2	F	S	D	C	G4.176		ZFR4
	PITCH_BIAS_PARALLEL	V97U2208C	DEG	F	S	D	C	G4.176		ZFR4
	QC_LIM	V97U2222C	DEG/SEC	F	S	D	C	G4.176		ZFR4
	QCI_LIMS1	V97U2438C	DEG	F	S	D	C	G4.176		ZFR4
	QCI_LIMS2	V97U2223C	DEG	F	S	D	C	G4.176		ZSR2
	QCIDOT_LIM	V97U2224C	DEG/SEC	F	S	D	C	G4.176		ZFR4
	RATE_CAPABILITY_LIFTOFF	V97U2496C	DEG/CYCLE	F	S	D	C	G4.176		ZFR4
	RATE_CAPABILITY_MECO	V97U2225C	DEG/CYCLE	F	S	D	C	G4.176		ZFR4
	RATE_CAPABILITY_MECO_2_FAILS	V97U2226C	DEG/CYCLE	F	S	D	C	G4.176		ZFR4
	RATE_CAPABILITY_NOFAILS	V97U2495C	DEG/CYCLE	F	S	D	C	G4.176		ZFR4
	RATE_CAPABILITY_NOM_SYSO_1	V97U2228C	DEG/CYCLE	F	S	D	C	G4.176		ZFR4
	RATE_CAPABILITY_NOM_2	V97U2227C	DEG/CYCLE	F	S	D	C	G4.176		ZFR4
	RATE_CAPABILITY_ONEFAIL	V97U2497C	DEG/CYCLE	F	S	D	C	G4.176		ZFR4
	RATE_CAPABILITY_TWOFAIL	V97U2498C	DEG/CYCLE	F	S	D	C	G4.176		ZFR4

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

OIBC MISSIONS	FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCIN	CAT
	RC LIM	V97U2229C	DEG/SEC	F	S	D	C	G4.176		ZFR4
	RC LIM	V97U2439C	DEG	F	S	D	C	G4.176		ZFR4

Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

MISSIONS	FSSR NAME	MSID	ENG UNIT	DT	PR	B	S	PR	FCIN	CAT
	RC_LIM	V97U2229C	DEG/SEC	F	S	D	C	G4.176	ZFR4	ZFR4
	RCI_LIMS1	V97U2439C	DEG	F	S	D	C	G4.176	ZFR4	ZFR4
	RCI_LIMS2	V97U2230C	DEG	F	S	D	C	G4.176	ZSR2	ZSR2
	RCI00T_LIM	V97U2231C	DEG/SEC	F	S	D	C	G4.176	ZFR4	ZFR4
	RETLIM_IB	V97U2232C	LBS/IN**2	F	S	D	C	G4.176	ADE1	ADE1
	RETLIM_OB	V97U2233C	LBS/IN**2	F	S	D	C	G4.176	ADE1	ADE1
	SF_BF_SLEH_NOM	V97U2240C	DEG	F	S	D	P	G4.176	ZFR4	ZFR4
	SF_ELVN_SLEH_NOM	V97U2241C	DEG	F	S	D	P	G4.176	ZFR4	ZFR4
	SF_MPS_SLEH_NOM	V97U2242C	DEG	F	S	D	P	G4.176	ZFR4	ZFR4
	SF_RUD_SLEH_NOM	V97U2243C	DEG	F	S	D	P	G4.176	ZFR4	ZFR4
	SF_SB_SLEH_NOM	V97U2244C	DEG	F	S	D	P	G4.176	ZFR4	ZFR4
	SF_SRB_SLEH_NOM	V97U2245C	DEG	F	S	D	P	G4.176	ZFR4	ZFR4
	SLIM_LO	V97U2247C	DEG	F	S	D	C	G4.176	ZFR4	ZFR4
	SLIM_NOMN	V97U2424C	DEG	F	S	D	C	G4.176	ZSR2	ZSR2
	SLIM_NOMP	V97U2248C	DEG	F	S	D	C	G4.176	ZSR2	ZSR2
	SLIM_TAIL	V97U2427C	DEG	F	S	D	C	G4.176	ZSR2	ZSR2
	SRB_RLIMTF	V97U2426C	DEG/CYCLE	F	S	D	C	G4.176	ZFR4	ZFR4
	SSHE_RLIM_FAIL	V97U2493C	DEG/CYCLE	F	S	D	C	G4.176	ZFR4	ZFR4
	SSHE_RLIM_NOM	V97U2494C	DEG/CYCLE	F	S	D	C	G4.176	ZFR4	ZFR4
	THCDOTLIM	V97U2430C	DEG	F	S	D	C	G4.176	ADE1	ADE1
	TMOPDOT	V97U2428C	DEG/COUNT	F	S	D	X	G4.176	ADE1	ADE1
	VREL_AUTOTRIM_INHIBIT	V97U2275C	FT/SEC	F	S	D	C	G4.176	ZSR2	ZSR2
	VREL_ELVN_TAB(02)	V97U2277C	FT/SEC	F	S	H	C	G4.176	AIN2	AIN2
	VREL_ELVN_TAB(03)	V97U2278C	FT/SEC	F	S	H	C	G4.176	AIN2	AIN2
	VREL_ELVN_TAB(04)	V97U2279C	FT/SEC	F	S	H	C	G4.176	AIN2	AIN2
	VREL_ELVN_TAB(05)	V97U2280C	FT/SEC	F	S	H	C	G4.176	AIN2	AIN2

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Table 4.2.11-2. Ascent DAP (G4.176) I-Loads (Cont)

MISSIONS	FSSR NAME	MSIO	ENG UNIT	DT	PR	D	S	PR	FCTN	CAT
	VREL_TRIM_TAB(19)	V97U2315C	FT/SEC	F	S	M	C	G4.176		A1N2
	VREL_TRIM_TAB(20)	V97U2316C	FT/SEC	F	S	M	C	G4.176		A1N2
	VREL_YFILTSH	V99U9597C	FT/SEC	F	S	D	C	G4.176		ADG2
	YAH_BIAS_NOM	V97U2325C	DEG	F	S	D	P	G4.176		ZFR4

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Table 4.2.11-3. Ascent Digital Autopilot (G4.176) K-Loads

BOOK: 0009

FSSR NAME DESCRIPTION	MSID	MC KLOAD VALUE	ENG UNIT	DT PR S PR FCTN	LAST CR EQTN MSID
NO REQUIREMENTS					

DATE: 109/27/88

DBFN: 0539

4.3 GUIDANCE/CONTROL STEERING INTERFACE

DATE: 09/27/88

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4.3 GUIDANCE/CONTROL STEERING INTERFACE (GC_STEER)

4.3.1 Introduction

The requirements for the principal function GC_STEER are presented in this section. During the nominal ascent Stage 1 and Stage 2 mission phases, GC_STEER provides the ASCENT DAP with attitude errors and attitude rate commands for thrust vector control. During the RTLS abort phase of ascent, GC_STEER provides the GRTLS DAP with attitude errors and attitude rate commands for attitude control. In both modes, GC_STEER provides the ascent ADI processor with attitude errors for display.

4.3.2 Interface Requirements

The interface parameters required to properly execute GC_STEER are given in Tables 4.3.2-1 and 4.3.2-2.



4.3 GUIDANCE/CONTROL STEERING INTERFACE (GC_STEER)

4.3.1 Introduction

The requirements for the principal function GC_STEER are presented in this section. During the nominal ascent Stage 1 and Stage 2 mission phases, GC_STEER provides the ASCENT DAP with attitude errors and attitude rate commands for thrust vector control. During the RTLS abort phase of ascent, GC_STEER provides the GRTLS DAP with attitude errors and attitude rate commands for attitude control. In both modes, GC_STEER provides the ascent ADI processor with attitude errors for display.

4.3.2 Interface Requirements

The interface parameters required to properly execute GC_STEER are given in Tables 4.3.2-1 and 4.3.2-2.

Table 4.3.2-1. Input Variables, GC_STEER

Name	Description	MNEMON	Source	Type	Range	Units	Rate Required (Hz)
Q_GCB_I	Quaternion, guidance commanded body wrt inertial	G00003 G00004 G00005 G00006	ASC 1STG_GUID (4.1), PW_RTLS_GUID (4.4)	Q	±UNIT	-	6.25/ 2.08
LAMC	Commanded thrust direction parameter	G00306 G00307 G00308	ASC 2STG_GUID (4.2), PW_RTLS_GUID (4.4)	V	±UNIT	-	2.08
LAMDC	Commanded thrust direction parameter	G00309 G00310 G00311	ASC 2STG_GUID (4.2), PW_RTLS_GUID (4.4)	V	±UNIT	1/s	2.08
TLAMC	Commanded thrust direction parameter	G00305	ASC 2STG_GUID (4.2), PW_RTLS_GUID (4.4)	S	0,TBD	s	2.08
PHI_WING	Wing angle criterion	G48916	ASC 2STG_GUID (4.2), PW_RTLS_GUID (4.4)	S	±π	rad	2.08
MET	Mission elapsed time	G07829	FCOS	S	0,TBD	s	2.08
VELSUMM50 (V_IMU_CURRENT)	Selected total accumulated sensed velocity	G14702 G14703 G14704	IMU RM (4.72)	V	TBD	ft/s	6.25
Q_B_I	Quaternion, body wrt inertial	G19849 G19850 G19851 G19852	A/E_ATT_PROC (4.226)	Q	±1	-	12.5
BETA_N	Nav-derived sideslip angle	G47143	A/E_ATT_PROC (4.226)	S	±10	deg	6.25
RHC_STATE_C	Commander roll, pitch, and yaw detent integer		3_AX_RHC SOP (4.171)	V	±1	-	12.5
RHC_STATE_P	Pilot roll, pitch, and yaw detent integer		3_AX_RHC SOP (4.171)	V	±1	-	12.5
DRHC (DAMAN) (DEMAN) (DYMAN)	Manual guidance command	G10502 G10501 G33003	3_AX_RHC SOP (4.171)	V		deg	12.5
AUTO	Indicator, automatic TVC mode	G50361	ASC_DAP (4.176)	B	0,1	-	12.5
ATTCHD	Indicator, attitude command subphase	G50356	ASC_DAP	B	0,1	-	12.5
FRZCHD	Indicator, freeze-attitude command subphases	G50358	ASC_DAP	B	0,1	-	12.5
ZTRANS	Indicator, RTLS external tank separation maneuver		ASC_DAP	B	0,1	-	12.5

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Table

Name	Indicator
RTLS	Indicator, guidance, RTLS
RTLS_TURN	Indicator, body attitude, RTLS
RTLS_TURN	Indicator, turn-around
RTLS_TURN	Current Sh vector
RTLS_TURN	Current Sh velocity v
RTLS_TURN	Current Sh above refe
RTLS_TURN	Indicator, pitch down
RTLS_TURN	Indicator, subphase
RTLS_TURN	Indicator, Roll rate
RTLS_TURN	Pitch rate
RTLS_TURN	Yaw rate,
RTLS_TURN	Compensat accelerat
RTLS_TURN	Compensat accelerat
RTLS_TURN	Variable attitude
RTLS_TURN	Indicator, relief a

Table 4.3.2-1. Input Variables, GC_STEER (Cont)

Name	Description	MNEMON	Source	Type	Range	Units	Rate Required (Hz)
PEGCMD	Indicator, powered explicit guidance; either STG2, or RTLS	G50357	ASC_DAP	B	0,1	-	12.5
ATTFILT	Indicator, filter actual body attitude		ASC_DAP	B	0,1	-	12.5
RTLS_TURN	Indicator, initiate RTLS turnaround maneuver	G00904	ASC_DAP	B	0,1	-	12.5
\bar{R}_{AVGG}	Current Shuttle position vector	G02701 G02702 G02703	ASCENT_UPP (4.197) RTLS_UPP (4.200)	V	0,TBD	ft	2.08
$\bar{V}REL$	Current Shuttle relative velocity vector	G47784 G47785 G47786	ASCENT_UPP, RTLS_UPP	V	0,TBD	fps	2.08
ALT	Current Shuttle altitude above reference ellipsoid	G04207	ASCENT_UPP RTLS_UPP	S	TBD	ft	2.08
MM101_INIT	Indicator, AFGS startup		ASC_DAP	B	0,1	-	12.5
PPD	Indicator, RTLS powered pitch down maneuver	G50363	ASC_DAP	B	0,1	-	12.5
SRBSEP	Indicator, SRB separation subphase		ASC_DAP	B	0,1	-	12.5
SIG	Indicator, Stage 1 guidance		ASC_DAP	B	0,1	-	12.5
PORB	Roll rate, orbiter rate gyro	G14443	SF(ORB_RGA)	S	± 40	deg s	12.5
QORB	Pitch rate, orbiter rate gyro	G14442	SF(ORB_RGA)	S	± 20	deg s	12.5
RORB	Yaw rate, orbiter rate gyro		SF(ORB_RGA)	S	± 20	deg/s	12.5
NZ_FBK	Compensated normal acceleration error		ASC_DAP	S		deg s	12.5
NY_FBK	Compensated lateral acceleration error		ASC_DAP	S		deg s	12.5
KM_THETA	Variable gain for pitch attitude error		ASC_DAP	S		deg s deg	12.5
ELEV_LR	Indicator, elevon load relief active		ASC_RECON	B	0,1	-	12.5



Table 4.3.2-1. Input Variables, GC_STEER (Cont)

Name	Description	MNEMON	Source	Type	Range	Units	Rate Required (Hz)
KN_PSI	Variable gain for yaw attitude error		ASC_DAP	S		deg/s/deg	12.5
ET_SEP_CMD	ET separation command flag	G47229	ET_SEP_SEQ	B	0,1	-	12.5
MM_CODE_601	Major Mode 601 flag		MSC	B	0,1	-	2.08
I _z	Unit vector pointing from vehicle to landing site at cutoff		PW_RTLS_GUID	V		-	2.08

Table 4.3.2-2. Output Variables, GC_STEER

Name	Description	MNEMON	Destination	Type	Range	Units	Rate Required (Hz)
EBFB	Attitude errors for TVC loops	G33601 G33602 G33603	ASC_DAP, GRTLS_DAP (4.227) ASC_1STG_GUID (4.1)	V		deg	12.5
EBDB	Attitude errors for display	G33607 G33608 G33609	ASC ADL_ PROC (4.206)	V		deg	6.25
WFBI_FB	Rotational velocity/command flight body wrt inertial, coordinatized in flight body	G33604 G33605 G33606	ASC_DAP, GRTLS_DAP	V		deg/s	12.5

4.3.3 Overview and Function
 Overview. An overview of the function for interfacing automatic or manual) and performs three specific interfacing between guidance errors, which generates vehicle attitude.

During first stage, attitude quaternion, rate and acceleration STEERING first combines to form a commanded attitude. The output from a desired attitude quaternion generated as attitude quaternion to control and DISPERRS during ATTITUDE ERRORS when ZTE PROC is substituted for errors displayed during acceleration errors from ascent, manual steering form a desired rate command generated by attitude error to replace when the RHC is out of control. When the RHC is formed by integratin

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Functional Description is shown in Figure 4.3. Another (linearized fo



4.3.3 Overview and Functional Description

A. Overview. An overview block diagram of GC_STEER is shown in Figure 4.3.3-1. In general, GC_STEER provides an extrapolation and smoothing function for interfacing between the low rate processing of guidance (either automatic or manual) and the high rate processing of flight control. GC_STEER performs three specific functions: AUTOMATIC STEERING, which provides the interfacing between guidance and flight control; MANUAL STEERING, which provides the interfacing between the pilot and flight control; and ATTITUDE ERRORS, which generates the attitude error between desired attitude and actual vehicle attitude.

During first stage, AUTOMATIC STEERING performs smoothing of the commanded attitude quaternion from guidance by means of a second-order filter having rate and acceleration limiting. During second stage, AUTOMATIC STEERING first combines the outputs from the linear tangent guidance routine to form a commanded attitude quaternion and then smooths it as in first stage. The output from AUTOMATIC STEERING is a desired attitude quaternion and a desired attitude rate. ATTITUDE ERRORS takes the desired attitude quaternion generated as described above and combines it with the actual body attitude quaternion to form the attitude errors which are sent to flight control and DISPERRS during automatic and to DISPERRS only during manual. In ATTITUDE ERRORS when ZTRANS is on, the negative value of BETA_N from A/E_ATT_PROC is substituted for the third element of the attitude error. Attitude errors displayed during first stage are augmented with load relief acceleration errors from the ASC_DAP. If manual guidance is selected during ascent, manual steering will combine the pilot's attitude rate commands to form a desired rate command. This desired rate command replaces the rate command generated by automatic steering. Manual steering also generates an attitude error to replace the one generated by automatic steering. In manual, when the RHC is out of detent at either crew station, the attitude error is zeroed. When the RHC is in detent at both crew stations, the attitude error is formed by integrating the orbiter attitude rate.

B. Functional Description. A detailed functional block diagram of GC_STEER is shown in Figure 4.3.3-2. A simplified block diagram of the maneuver smoother (linearized for coplanar maneuvers) is shown in Figure 4.3.3-3.

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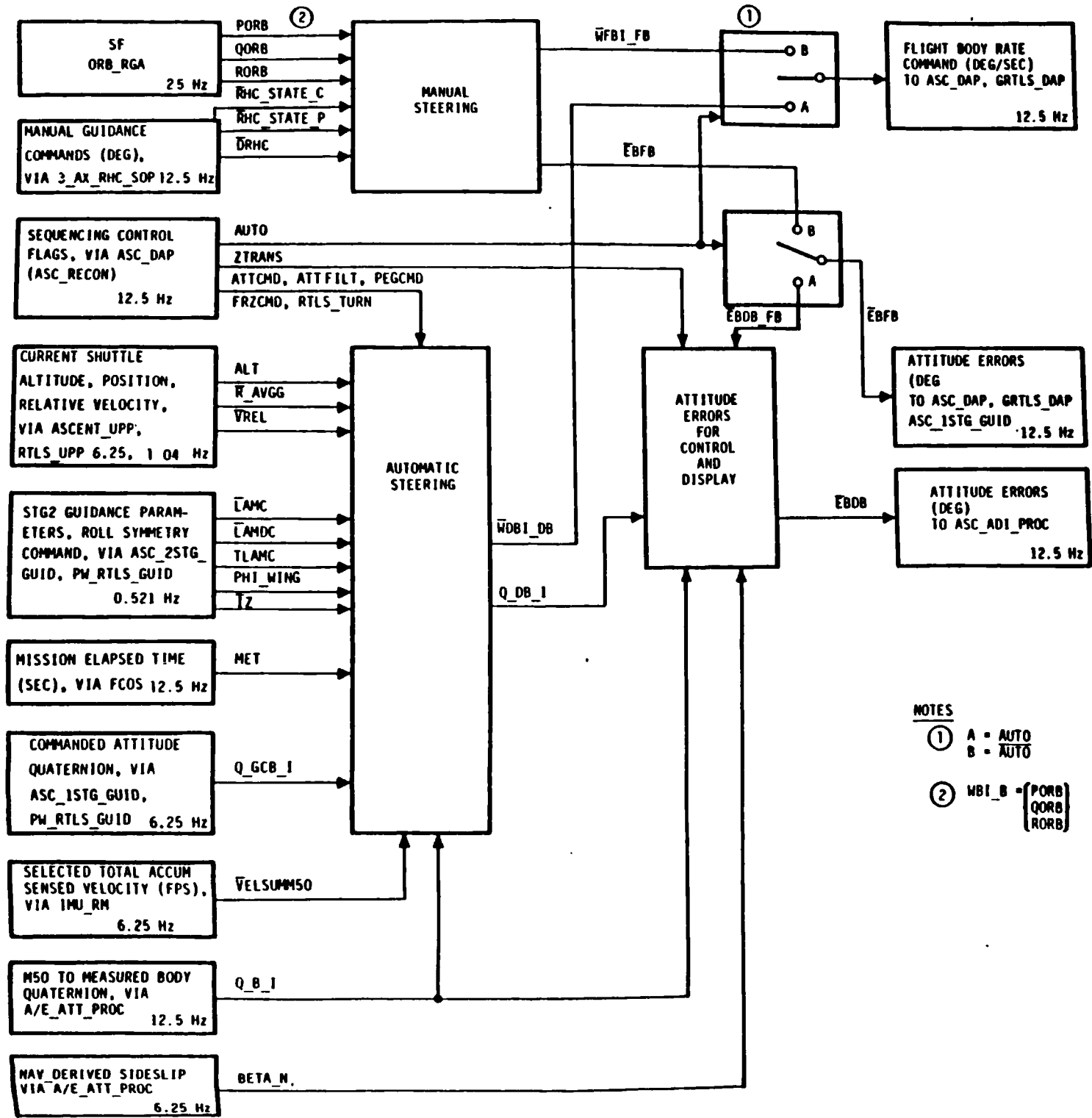
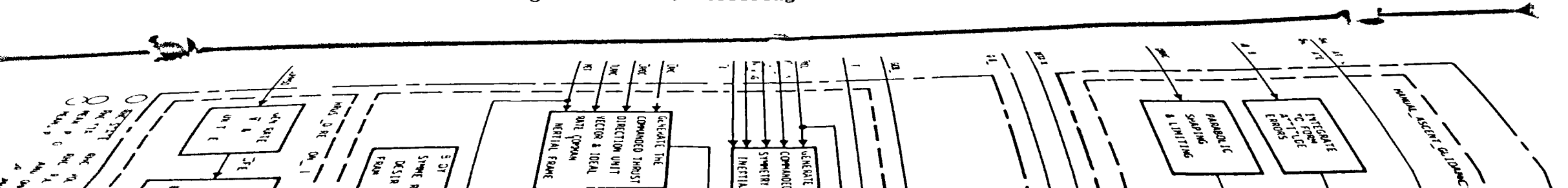


Figure 4.3.3-1. Steering Overview, Functional



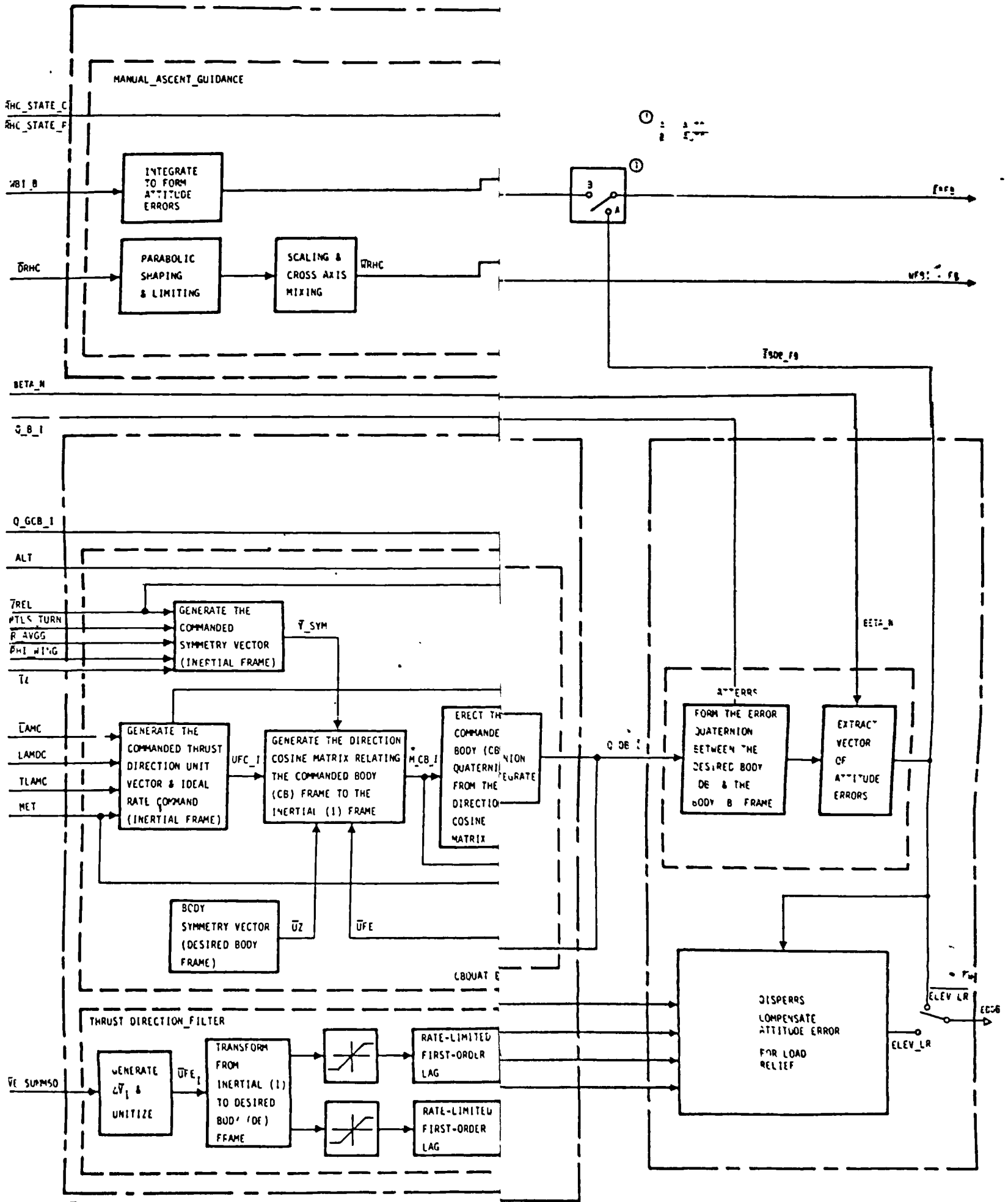


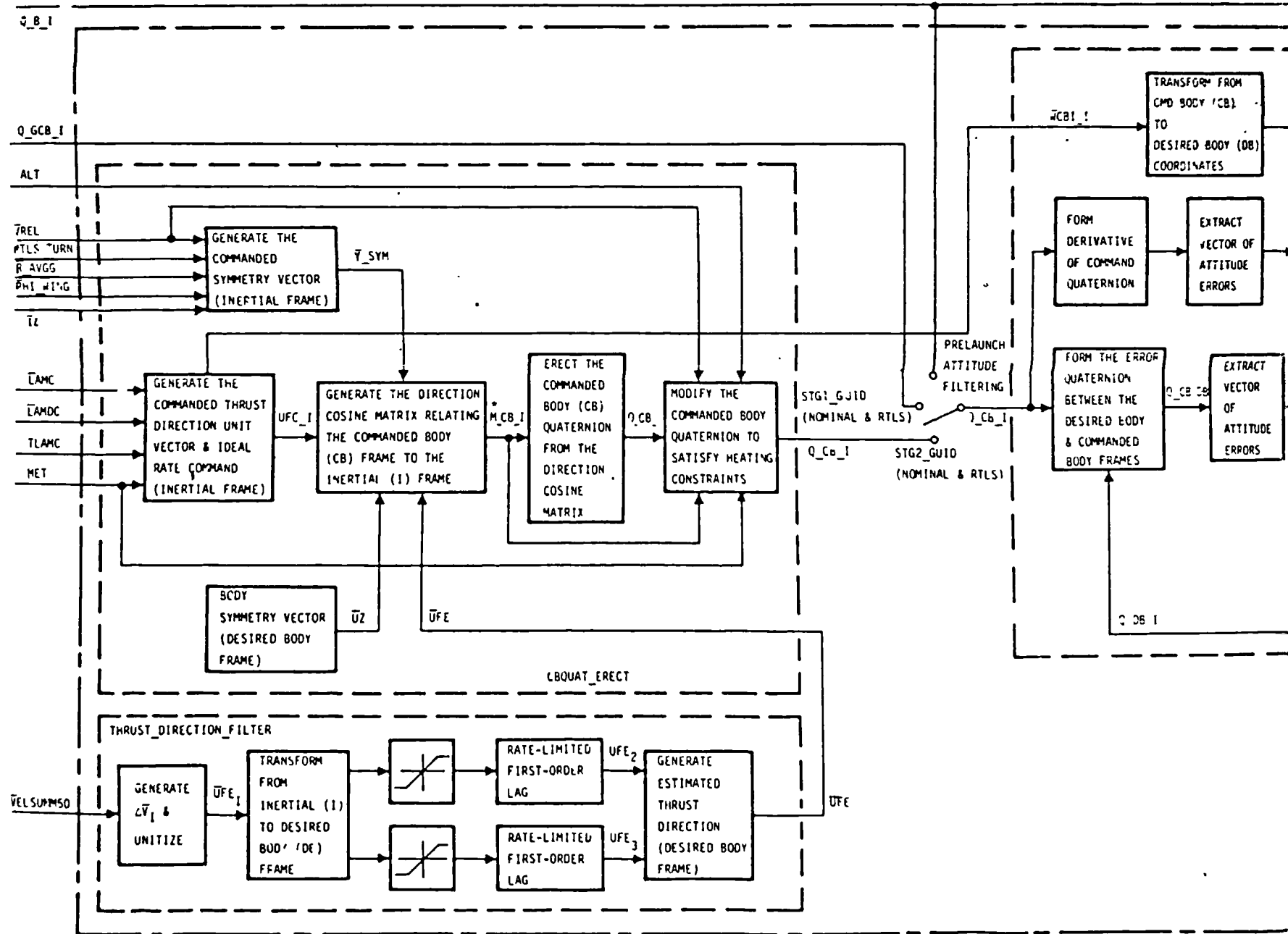
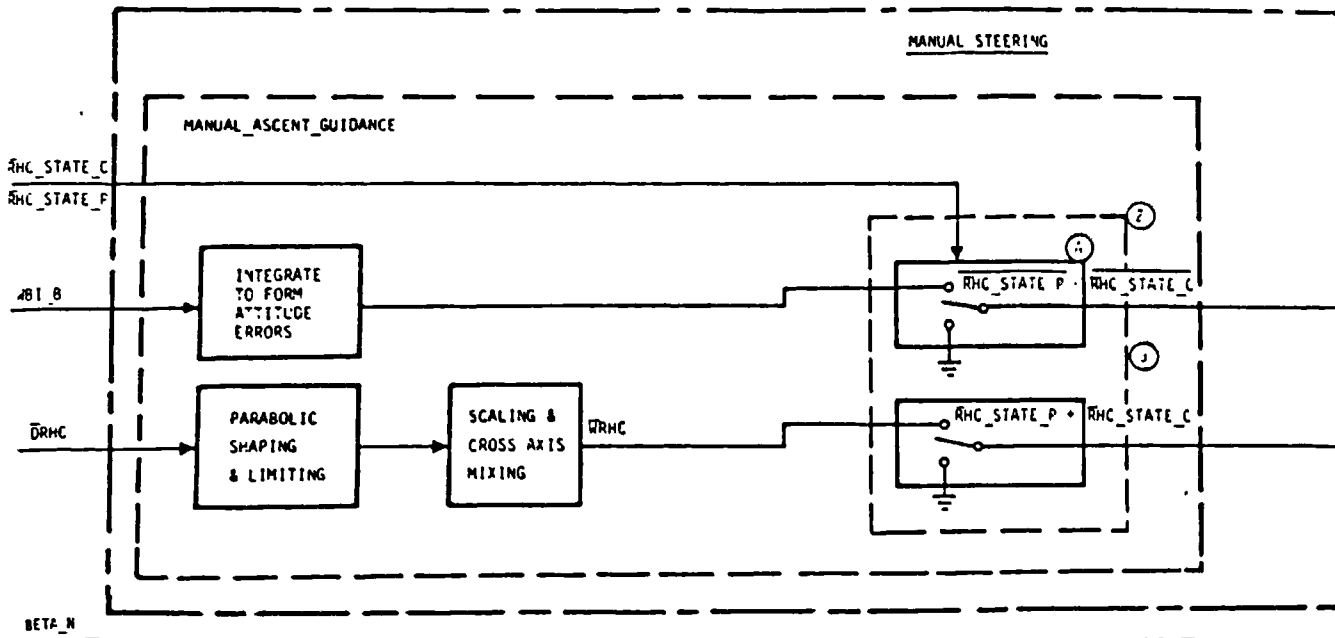
FIGURE 4-3-3 1. Steering Overview, Functional

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- Ⓐ RHC STATE = RHC, ROLL, PITCH AND YAW IN DETENT
- Ⓑ RHC STATE = RHC, ROLL, PITCH AND YAW OUT OF DETENT
- ⓪ MEANS PILOT'S AND COMMANDER'S RHC'S ARE IN DETENT IN A PARTICULAR AXIS
- Ⓛ MEANS PILOT'S OR COMMANDER'S RHC IS OUT OF DETENT IN A PARTICULAR AXIS

Overview, Detailed Function

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- ① RHC STATE = RHC, ROLL, PITCH AND YAW IN DETENT
RHC STATE = RHC, ROLL, PITCH AND YAW OUT OF DETENT
- ② MEANS PILOT'S AND COMMANDER'S RHC'S ARE IN DETENT IN A PARTICULAR AXIS
- ③ MEANS PILOT'S OR COMMANDER'S RHC IS OUT OF DETENT IN A PARTICULAR AXIS

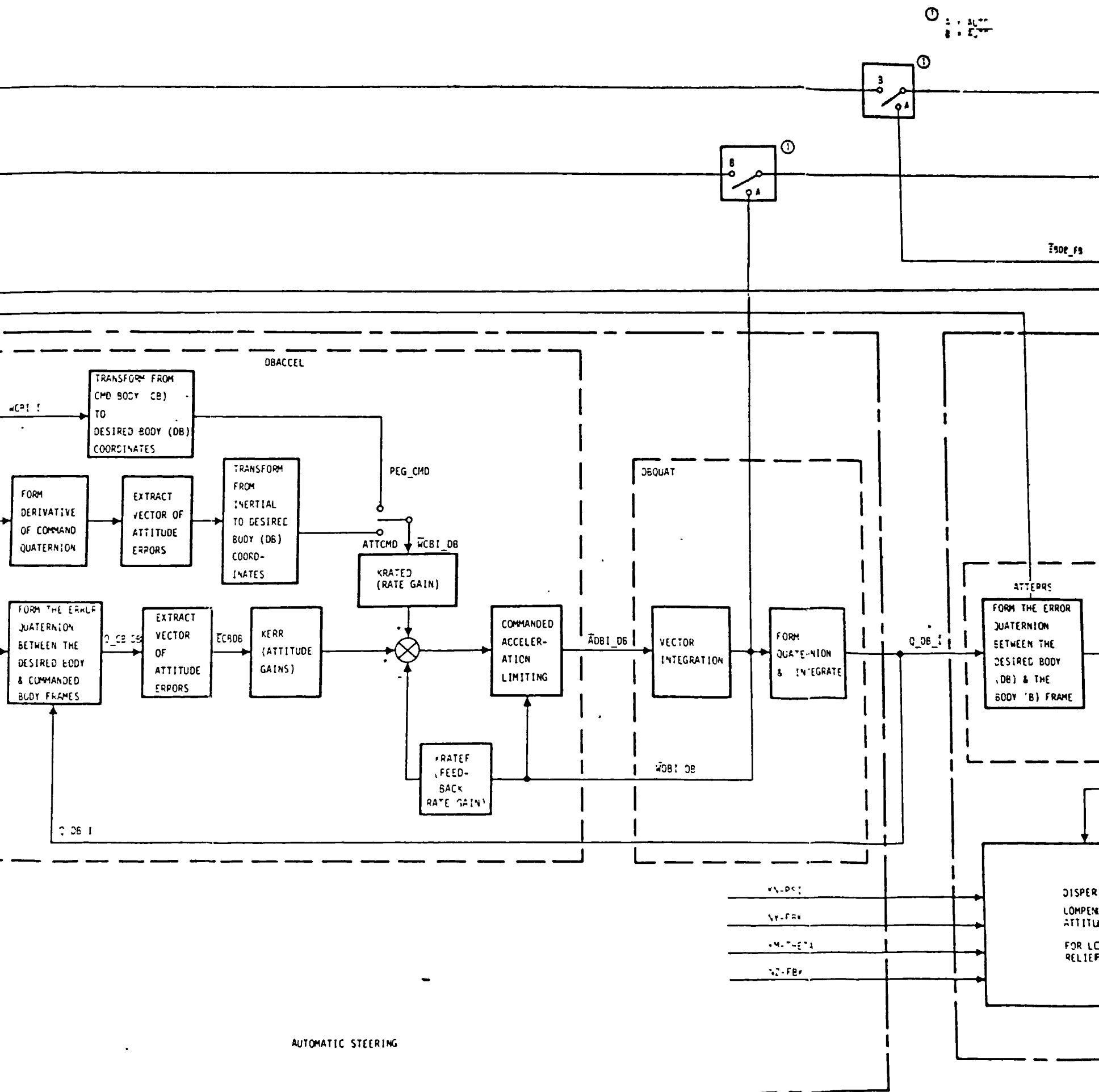


Figure 4.3.3-2. Steering Overview, Detailed Func

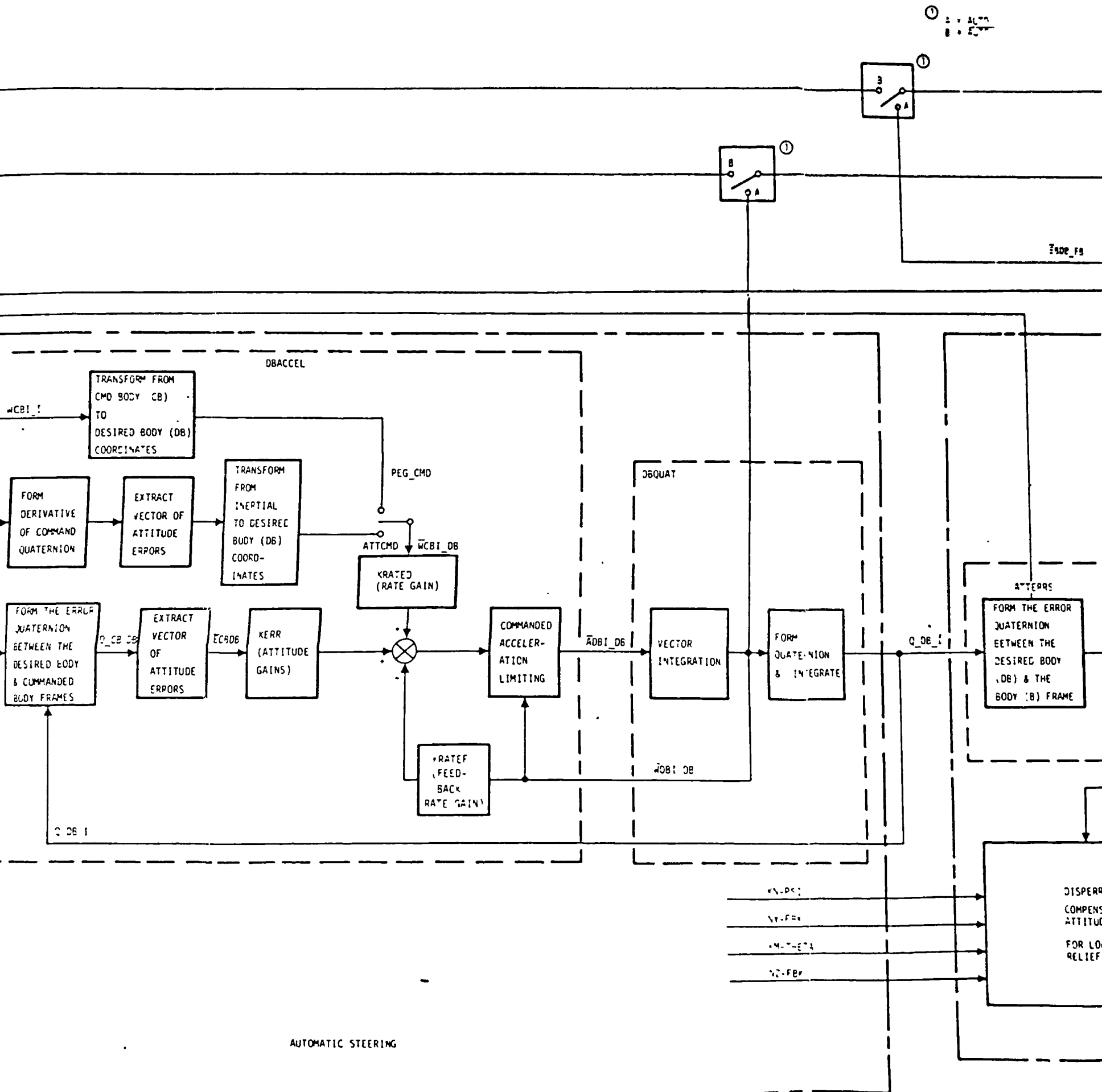


Figure 4.3.3-2. Steering Overview, Detailed Function

4.3-7.4.3-8

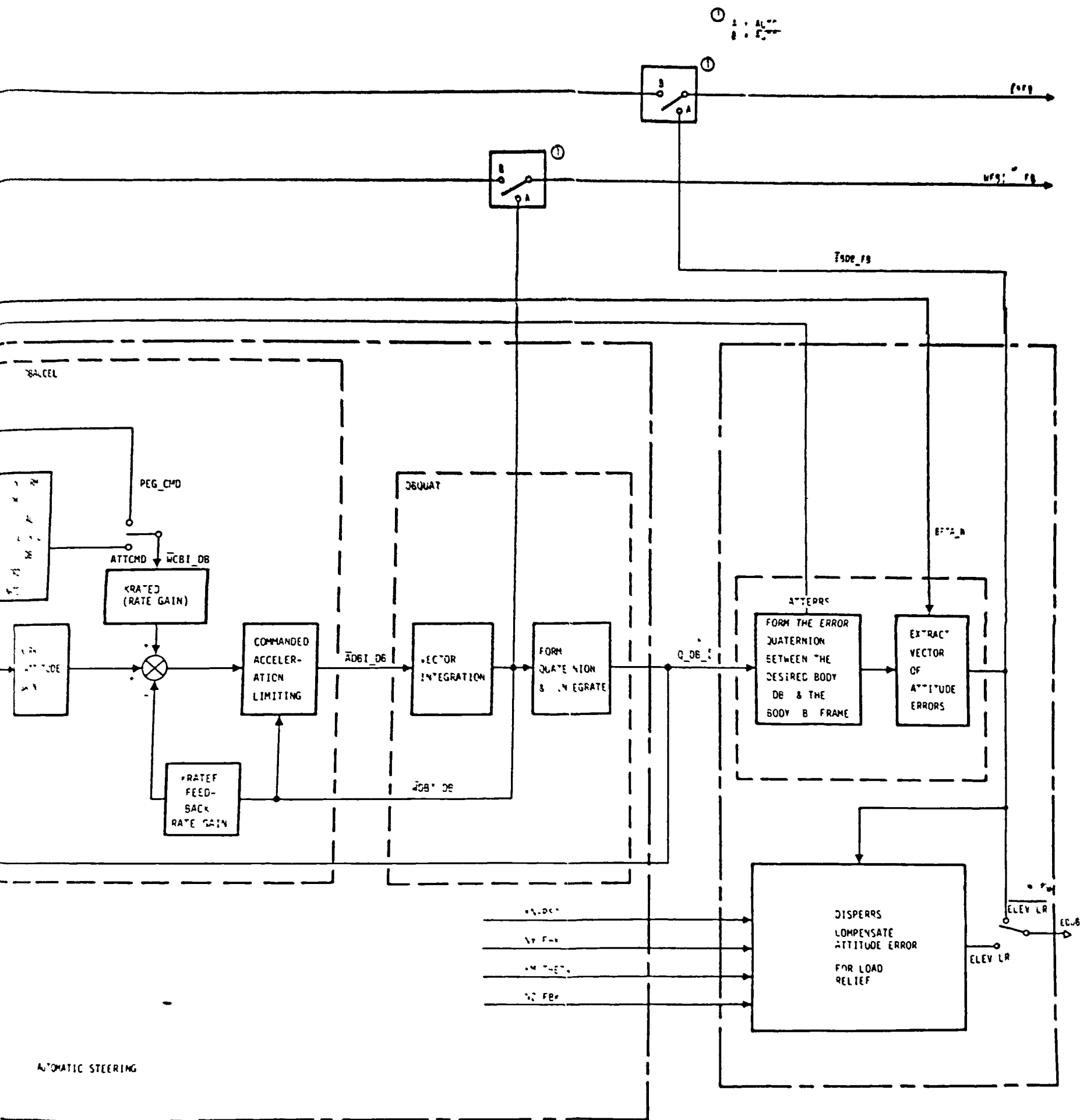
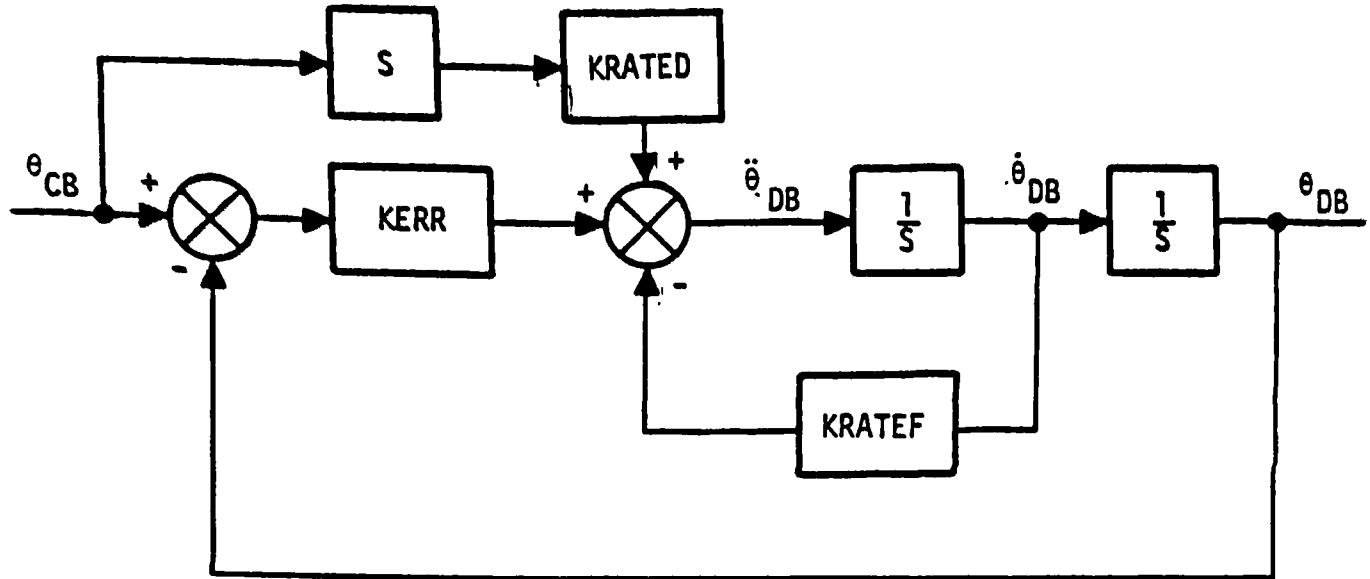


Figure 4.3.3-2. Steering Overview, Detailed Function



$$\frac{\theta_{DB}}{\theta_{CB}} = \frac{\omega_n^2 (\tau S + 1)}{S^2 + 2 \zeta \omega_n S + \omega_n^2}$$

$$\tau = \frac{KRATED}{KERR}$$

$$\omega_n^2 = KERR$$

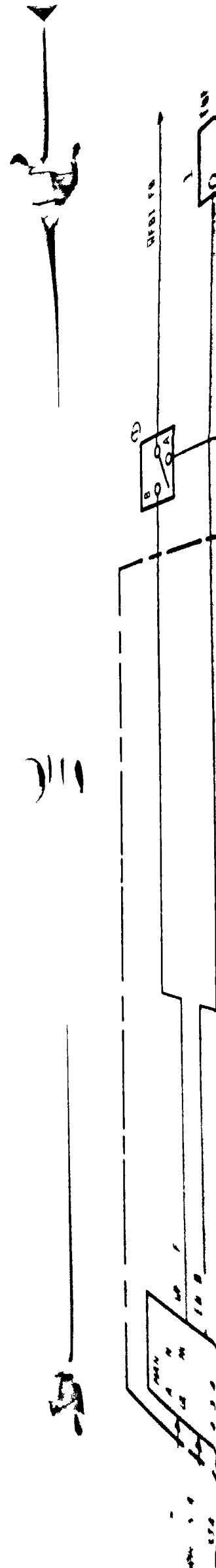
$$\zeta = \frac{KRATEF}{2\sqrt{KERR}}$$

Figure 4.3.3-3. Simplified Maneuver Smoother (Linearized for Coplanar Maneuvers)

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4.3.4 GC_STEER Software Description

A software overview of GC_STEER is shown in Figure 4.3.4-1. Its input/output requirements are shown in Tables 4.3.2-1 and 4.3.2-2, respectively. GC_STEER consists of seven function modules, CBQUAT_ERECT, DBACCEL, DBQUAT, ATTERRS, THRUST_DIRECTION_FILTER, MANUAL_ASCENT_GUIDANCE, DISPERRS, and four copy cycle modules, CBQUAT_GUID, CBQUAT_FILT, DB_QUAT_COPY, AND FBCMDS_AUTO. The high-level sequencing requirements for GC_STEER are shown in Figure 4.3.4-2A for a nominal mission and in Figure 4.3.4-2B for an RTLS abort. The sequencing requirements are specified in terms of 12.5-Hz rate group, denoted by GC_STEER_80; 6.25-Hz rate group, denoted by GC_STEER_160; the 2.08-Hz rate group, denoted by GC_STEER_480 and 2.08 Hz alternate rate group, denoted by GC_STEER_480 ALT, which are defined in Figure 4.3.4-2C. The detailed diagrams for the function modules are shown in Figures 4.3.4-3 through 4.3.4-9. The intermodule interface requirements for GC_STEER are presented in Table 4.3.4-1. Initialization requirements are presented in Table 4.3.4-2, and I-loads/constants are presented in Table 4.3.4-3. The initial values of the thrust direction filter constants UFE2 and UFE3 are based on the average gimbal angle of the MPS pitch engines (12 degrees) and orbiter trim of -1.2 degrees.



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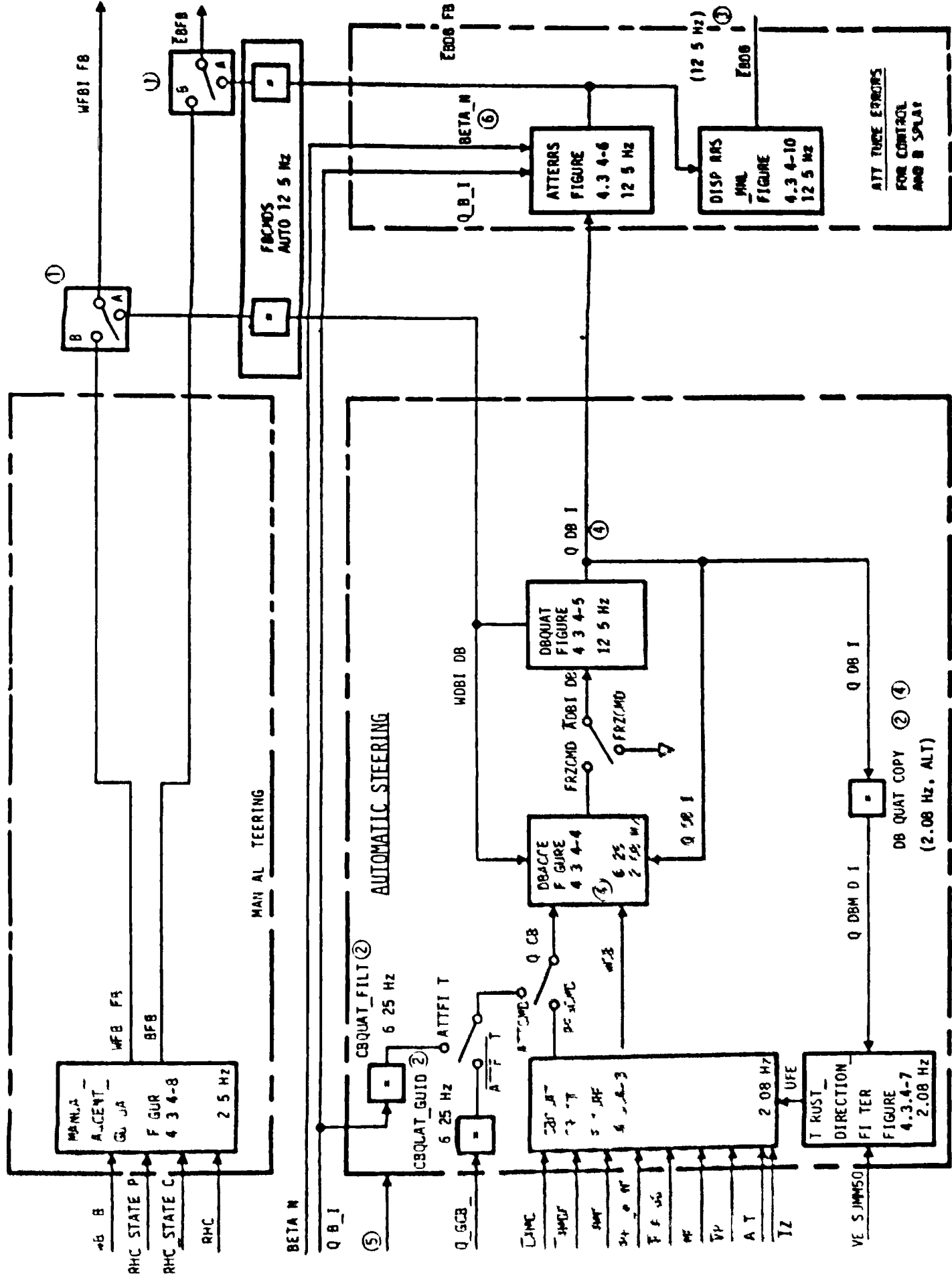


Figure 4.3.4-1. Steering Software Overview (Sheet 1 of 2)

NOTES:

① A = AUTO
B = $\overline{\text{AUTO}}$

② COPY CYCLE MODULES (OUTPUT = INPUT):

CBQUAT_FILT: Q_CB_I = Q_B_I
CBQUAT_GUID: Q_CB_I = Q_GCB_I
DB_QUAT_COPY: Q_DBMID_I = Q_DB_I
FBCMDS_AUTO: $\overline{\text{WFBI_FB}} = \overline{\text{WDBI_DB}}$
 $\overline{\text{EBFB}} = \overline{\text{EBDB_FB}}$

③ SENSE IS FEEDBACK MINUS COMMAND

④ PROCESS AT 6.25 Hz DURING ATTCMD, AND AT 2.08 Hz
DURING PEGCMD

⑤ FROM ASC_DAP (ASC_RECON)

ATTFILT	PPD
ATTCMD	SIG
	ZTRANS
PEGCMD	MM101_INIT
FRZCMD	SRB_SEP
RTLS_TURN	
AUTO	

⑥ In the module ATERRS, when ZTRANS is on, the (negative) value of $\overline{\text{BETA_N}}$ from A/E ATT_PROC is to be substituted for the third component of $\overline{\text{EBDB_FB}}$. Account should be taken of the different cycling notes of A/E ATT_PROC and GC_STEER to ensure that when the switch is activated only $-\overline{\text{BETA_N}}$ is output as the Z axis component.

Figure 4.3.4-1. Steering Software Overview (Sheet 2 of 2)

4.3-12

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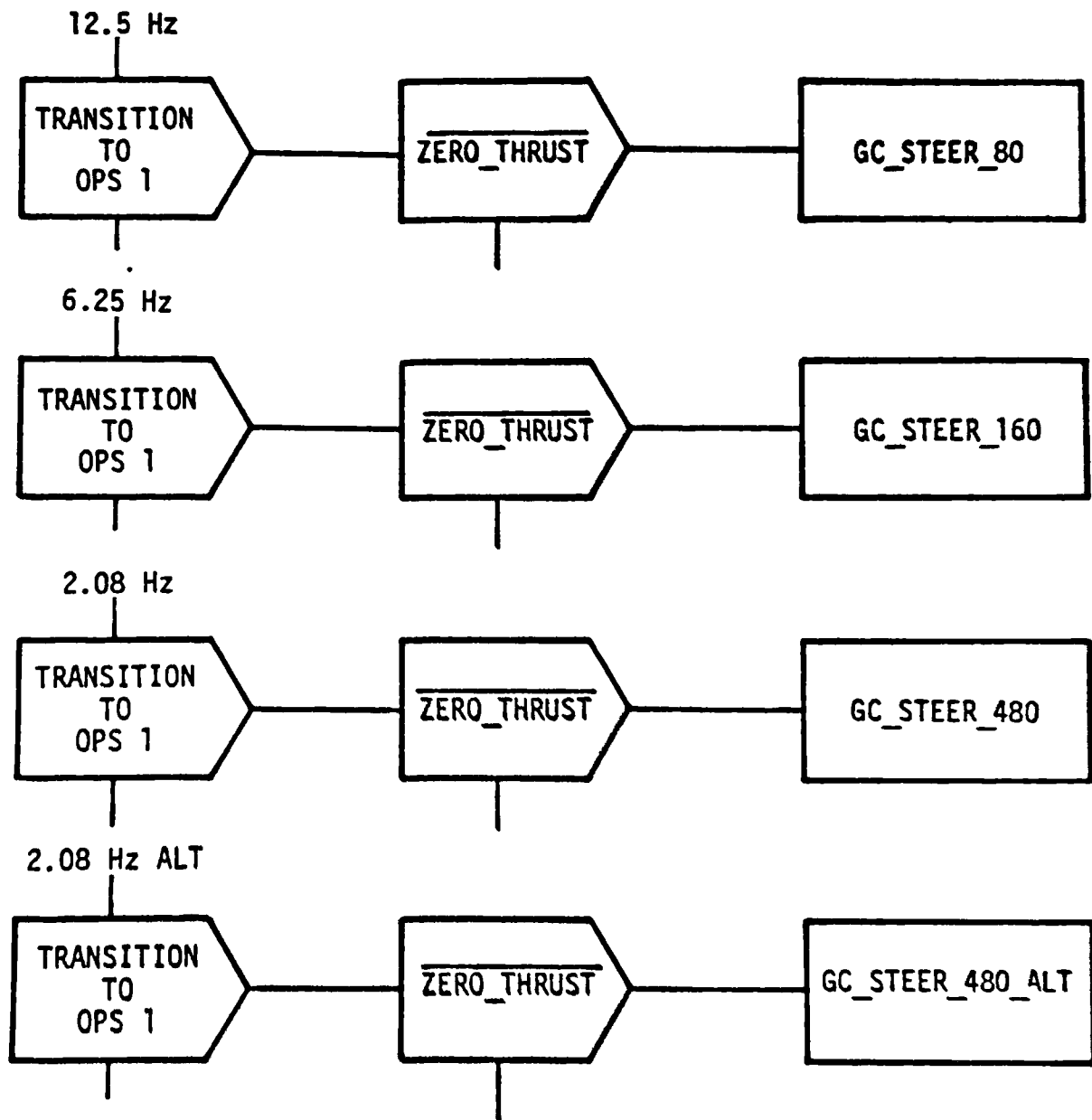


Figure 4.3.4-2A. GC_STEER Sequencing Requirements, Nominal Mission

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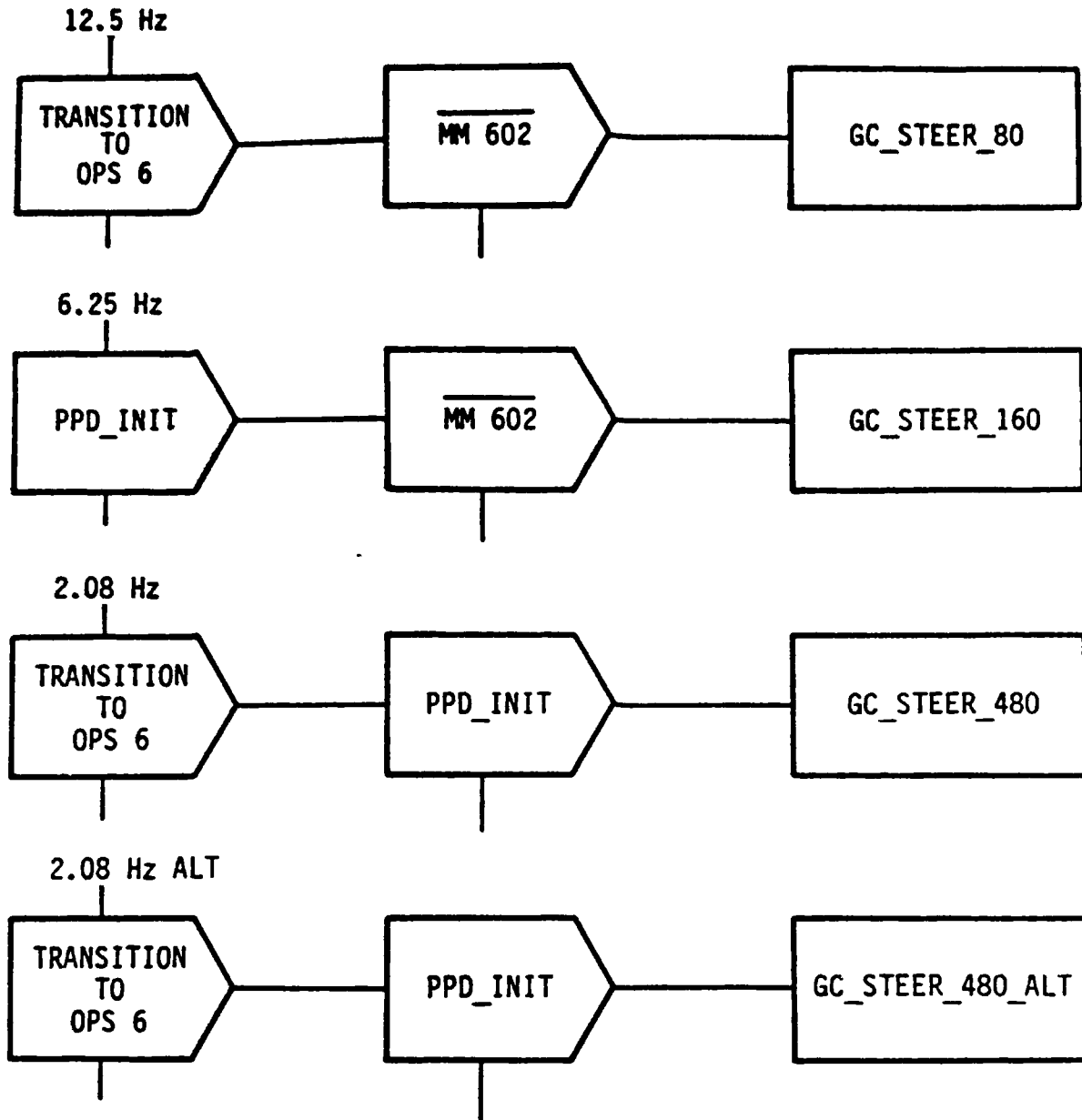
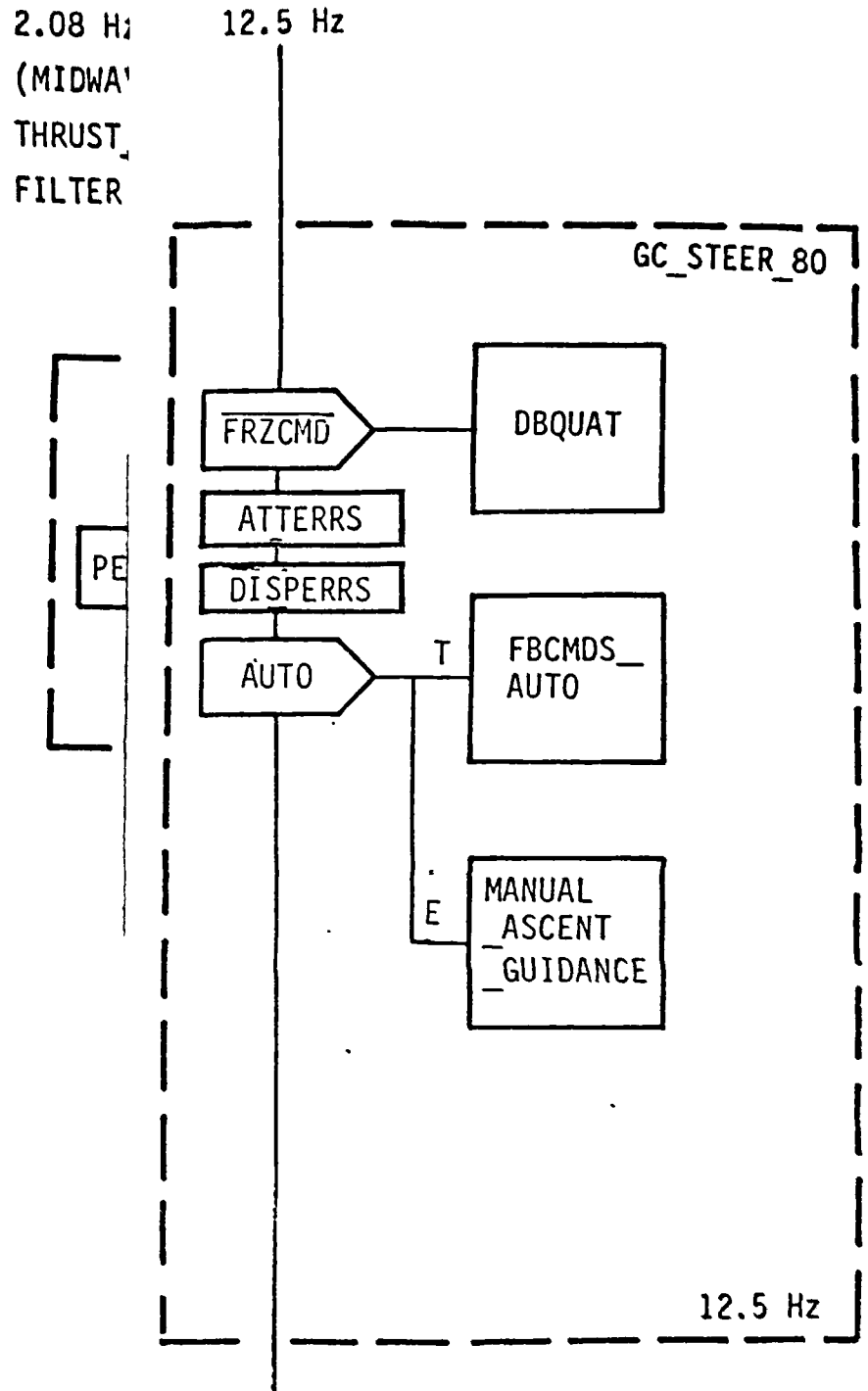


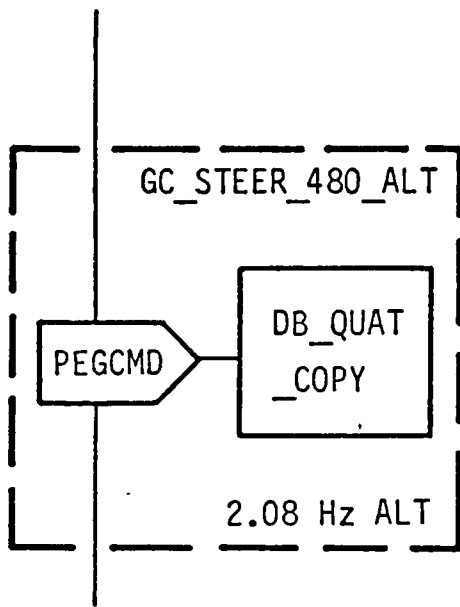
Figure 4.3.4-2B. GC_STEER Sequencing Requirements,
RTLS_ABORT



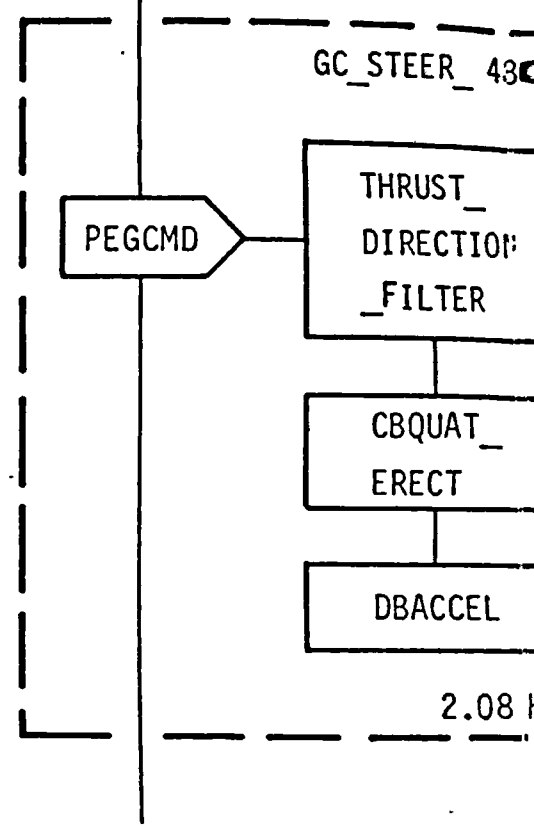
ER 12.5 Hz, 6.25 Hz, and 2.08 Hz
ng Requirements

, 4.3-16

2.08 Hz ALTERNATE
(MIDWAY THROUGH THE
THRUST_DIRECTION_
FILTER UPDATE CYCLE)



2.08 Hz



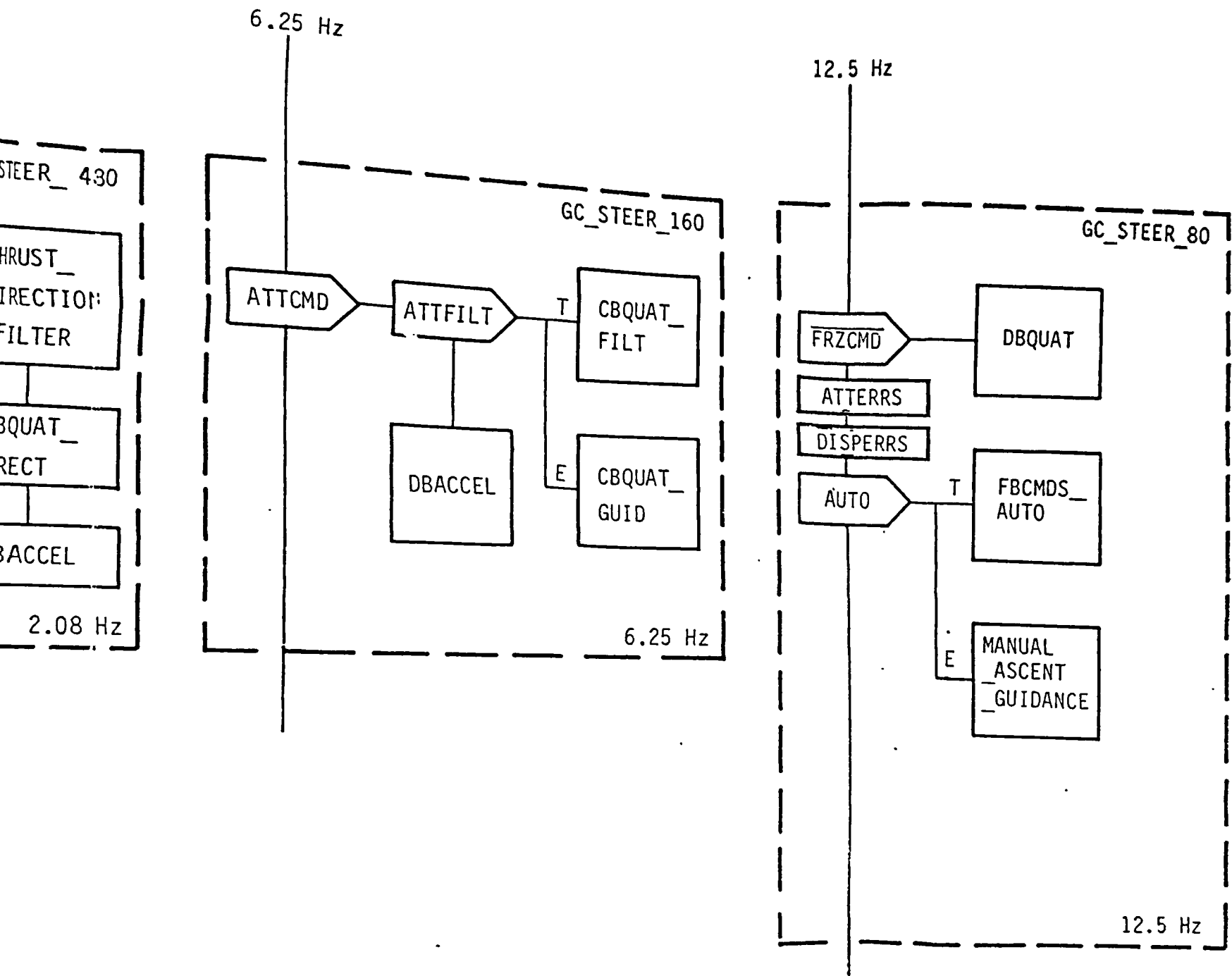


Figure 4.3.4-2C. GC_STEER 12.5 Hz, 6.25 Hz, and 2.08 Hz Sequencing Requirements

4.3-15, 4.3-16

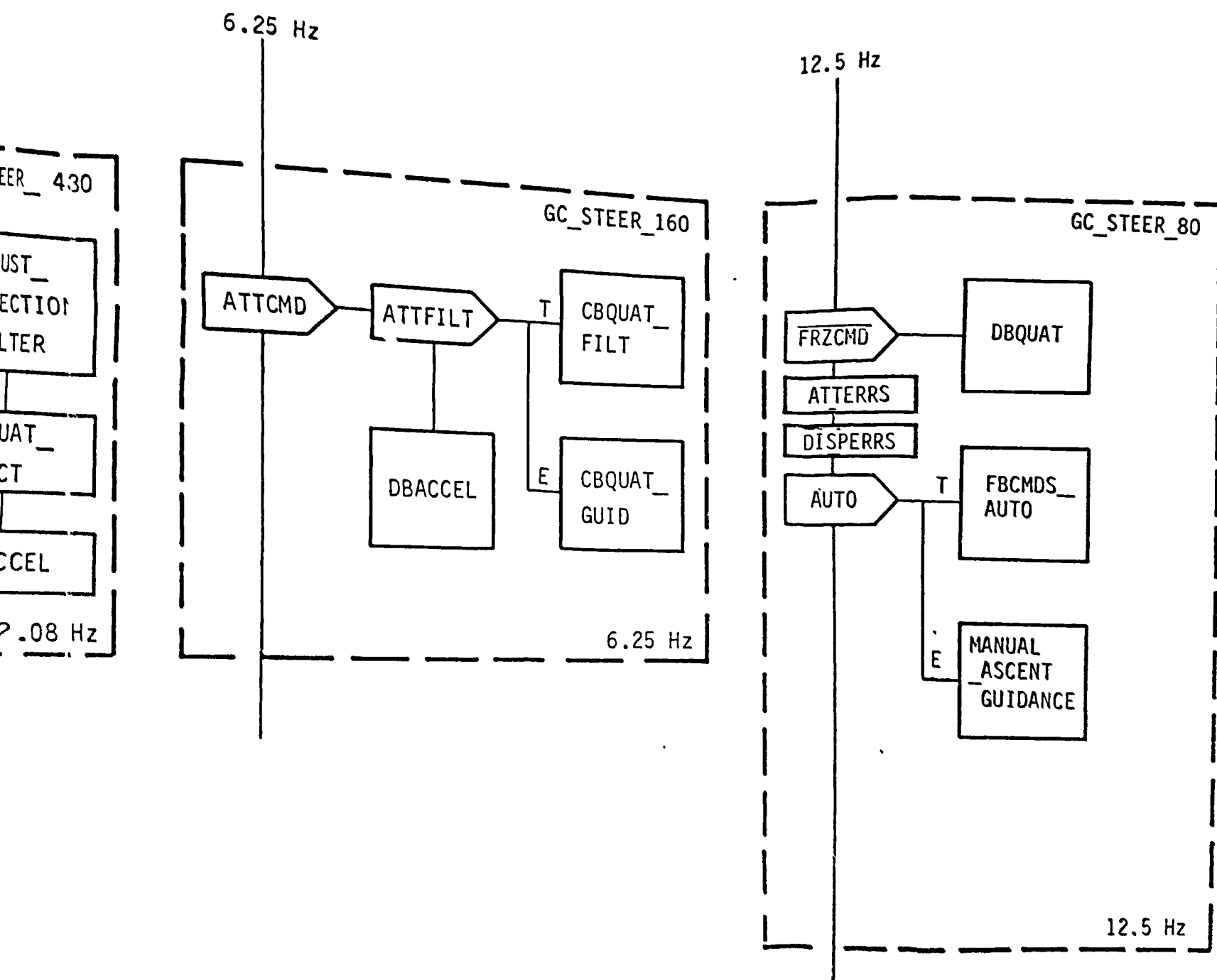


Figure 4.3.4-2C. GC_STEER 12.5 Hz, 6.25 Hz, and 2.08 Hz Sequencing Requirements

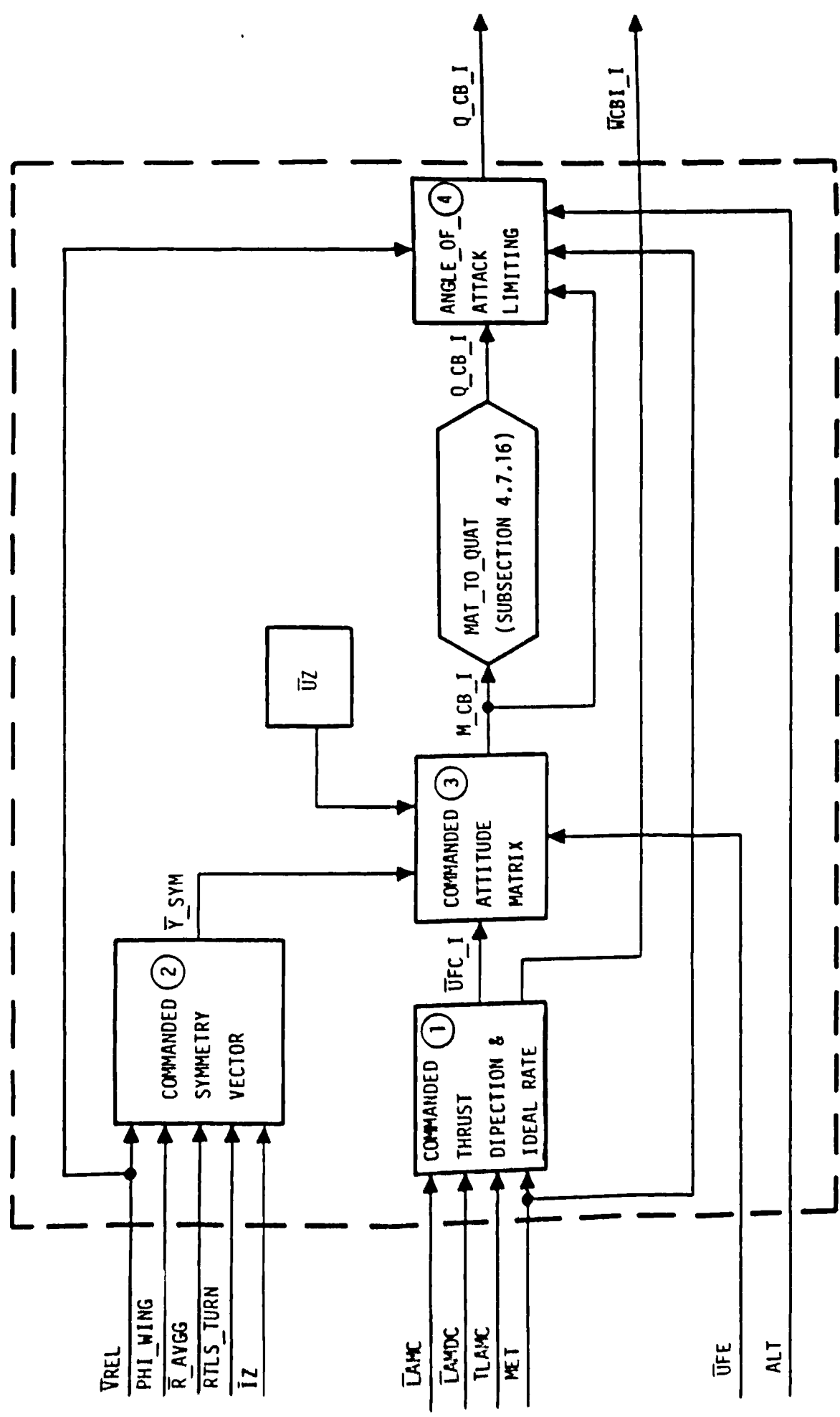


Figure 4.3.4-3. CBQUAT_ERECT Function Module Detailed Diagram (Sheet 1 of 3)

NOTES

① $\bar{U}FC_I = \text{UNIT}(\bar{L}AMC + (\text{MET-TLAMC})\bar{L}AMDC)$
 $WCBI_I = (\bar{L}AMC * \bar{L}AMDC) (\bar{L}AMC * \bar{U}FC_I)^2$

② $\bar{U}VREL = \text{UNIT}(\bar{V}REL)$
 $PHIW_OVR_2 = PHIW_WING/2$

(MM_CODE_601
.AND. RTLS_TURN)
.OR. FPASS

FPASS = OFF
 $\bar{U}XVREL = \bar{U}VREL$

$\bar{I}Z * \bar{U}FC_I > 0.08$

$\bar{U}XVREL = \bar{U}FC_I$

$\bar{U}YVREL = \text{UNIT}(\bar{U}XVREL * \bar{R_AVGG})$
 $\bar{Y_SYM} \leftarrow \text{QUAT_XFORM}(\text{COS}(PHIW_OVR_2), \text{SIN}(PHIW_OVR_2) \bar{U}XVREL, \bar{U}YVREL)$

③ $\bar{V}TEMP1 = \text{UNIT}(\bar{U}Z * \bar{U}FE)$
 $\bar{V}TEMP2 = \text{UNIT}(\bar{U}FC_I * \bar{Y_SYM})$

$M_CB_I = \text{TRANPOSE}(\text{MATRIX}(\bar{U}FE, \bar{V}TEMP1, \bar{U}FE * \bar{V}TEMP1)) \text{MATRIX}(\bar{U}FC_I, \bar{V}TEMP2 * \bar{U}FC_I, \bar{V}TEMP2)$

Figure 4.3.4-3. CBQUAT_ERECT Function Module Detailed Diagram (Sheet 2 of 3)

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MET < MET_HEAT)
ALT < ALT_HEAT)

Y_BIAS = C_ALF_BIAS * M_CB_I * ROM_I)
+ S_ALF_BIAS * M_CB_I * POW_3)
C_ALF = UVREL * U_X_BIAS

C_ALF < C_ALF_LIM

YROT_CB ← QUAT_XFORM (QCBIS, QCBIV, UNIT (UVREL*UX_BIAS))
COS_DEL = C_ALF_LIM * C_ALF + S_ALF_LIM * SQRT (1. - C_ALF²)
COS_DEL = MIDVAL (-1., COS_DEL, 1.)
Q_CB_I ← QUAT_MULT (SQRT (1. + COS_DEL)/SQRT (2.),
(SQRT (1.-COS_DEL)/SQRT (2.)) YROT_CB, QCBIS, QCBIV)

FIGURE 4-3 / 3 QUAT PRCT Function Module Detailed Diagram (Sheet 3 of 3)

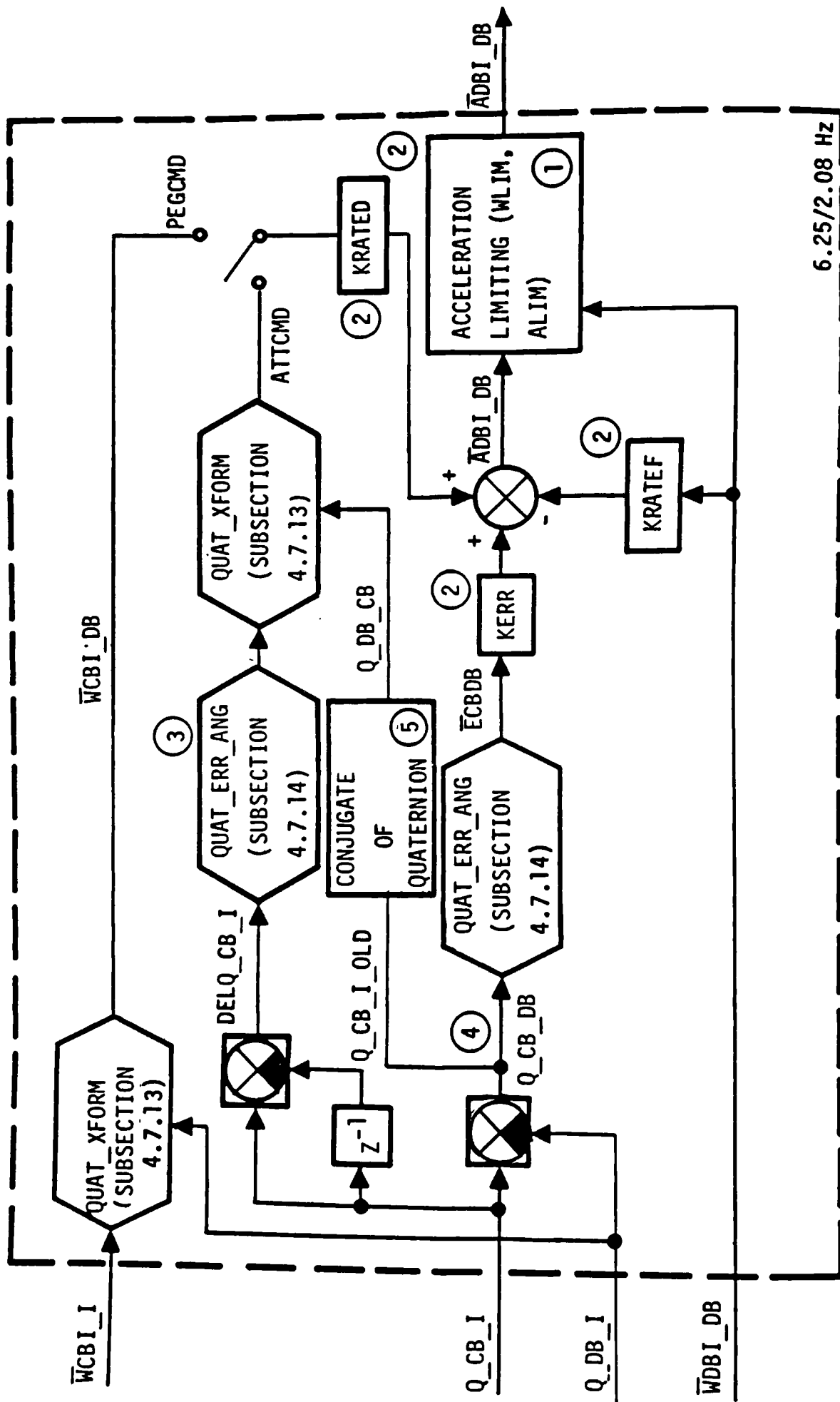


Figure 4.3.4-4. DBACCEL Function Module, Detailed Diagram (Sheet 1 of 2)

NOTES
① ACCELE

② STEERING ALLOWAB

③ DERIVED

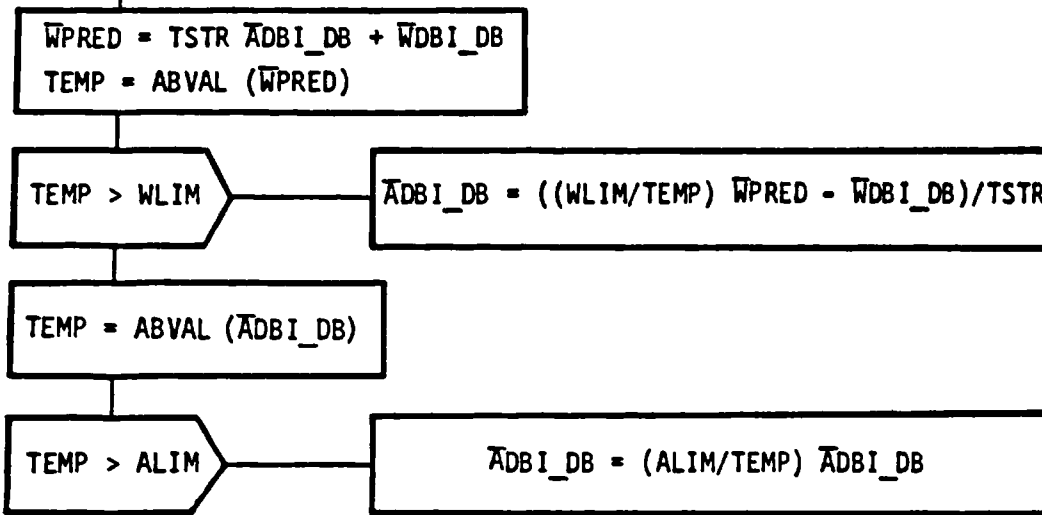
④ QUATERNION

⑤ CONJUGATE

Figure

NOTES

① ACCELERATION LIMITING



② STEERING GAINS. (SEE TABLE 4.3.4-2 FOR GAIN SELECTION BASED ON ALLOWABLE MODE TRANSITIONS.)

	ATTFILT	SIG	PEGCMD. RTLS_TURN	RTLS_TURN.	PPD	ZTRANS
TSTR	TSTR_160	TSTR_160	TSTR_480	TSTR_480	TSTR_160	TSTR_160
ALIM	ALIM_ATT	ALIM_SIG	ALIM_S2G	ALIM_TURN	ALIM_PPD	ALIM_ZTRANS
WLIM	WLIM_ATT	WLIM_SIG	WLIM_S2G	WLIM_TURN	WLIM_PPD	WLIM_ZTRANS
KERR	KERR_ATT	KERR_SIG	KERR_S2G	KERR_TURN	KERR_PPD	KERR_ZTRANS
KRATED	KRATED_ATT/ TSTR	KRATED_SIG/ TSTR	KRATED_S2G/ DEG_TO_RAD	KRATED_TURN/ DEG_TO_RAD	KRATED_PPD/ TSTR	KRATED_ZTRANS/ TSTR
KRATEF	KRATEF_ATT	KRATEF_SIG	KRATEF_S2G	KRATEF_TURN	KRATEF_PPD	KRATEF_ZTRANS

③ DERIVED RATE:

$$\text{DELQ_CB_I} \leftarrow \text{QUAT_MULT} (\text{QCBIS}, \overline{\text{QCBIV}}, \text{QCBIOlds}, -\overline{\text{QCBIOldV}})$$

$$\text{Q_CB_I_OLD} = \text{Q_CB_I}$$

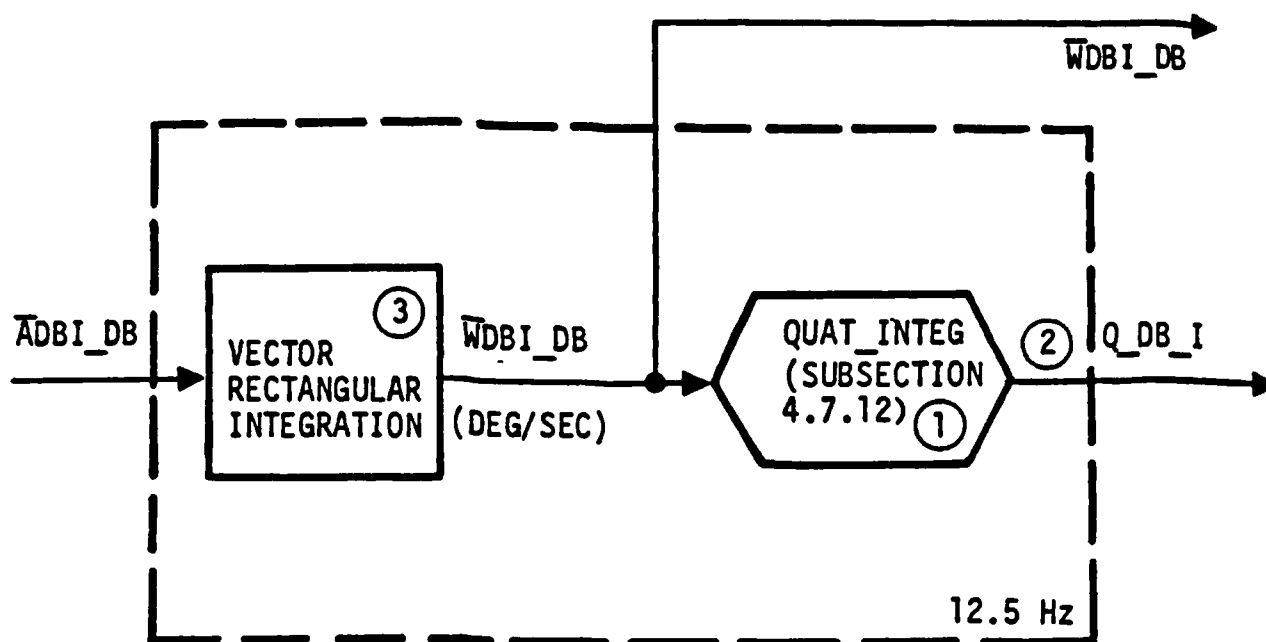
④ QUATERNION ERROR:

$$\text{Q_CB_DB} \leftarrow \text{QUAT_MULT} (\text{QCBIS}, \overline{\text{QCBIV}}, \text{QDBIS}, \overline{\text{QDBIV}})$$

⑤ CONJUGATE OF QUATERNION

$$\text{QDBCBS} = \text{QCBDBS}; \overline{\text{QDBC BV}} = -\overline{\text{QCBDBV}}$$

Figure 4.3.4-4. DBACCEL Function Module Detailed Diagram (Sheet 2 of 2)



① $DTCON_M = -\frac{TM}{2} \left(\frac{\pi}{180}\right)$.

② Q_DB_I MUST BE NORMALIZED BY A CALL TO QUAT_NORM AT THE 2.08 Hz ALTERNATE RATE JUST PRIOR TO EXECUTION OF DB_QUAT_COPY. NORMALIZATION OF Q_DB_I IS NOT REQUIRED DURING FIRST STAGE.

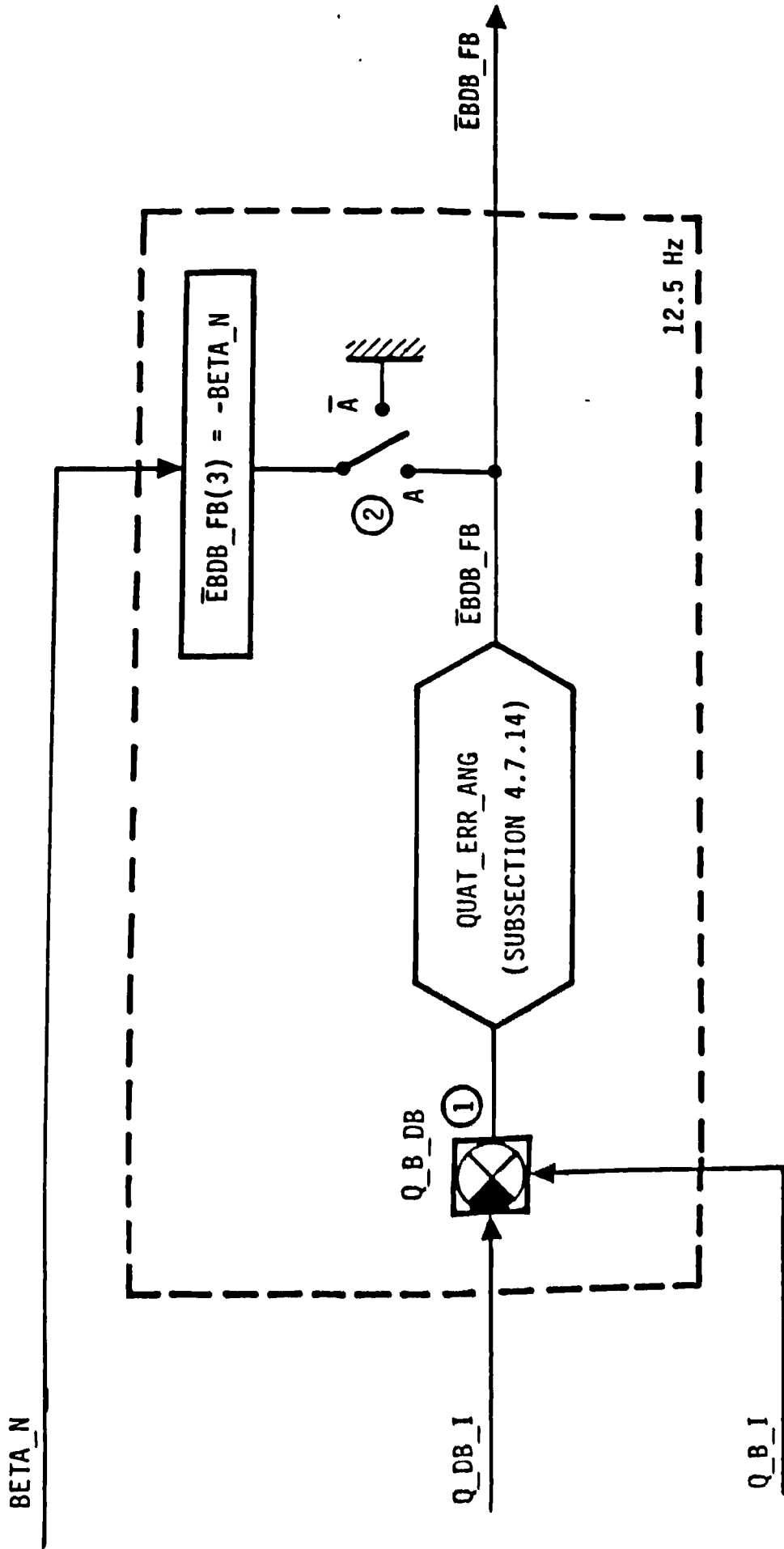
③ VECTOR RECTANGULAR INTEGRATION

$$\overline{WDBI_DB} = TM \overline{ADBI_DB} + \overline{WDBI_DB}.$$

Figure 4.3.4-5. DBQUAT Function Module Detailed Diagram

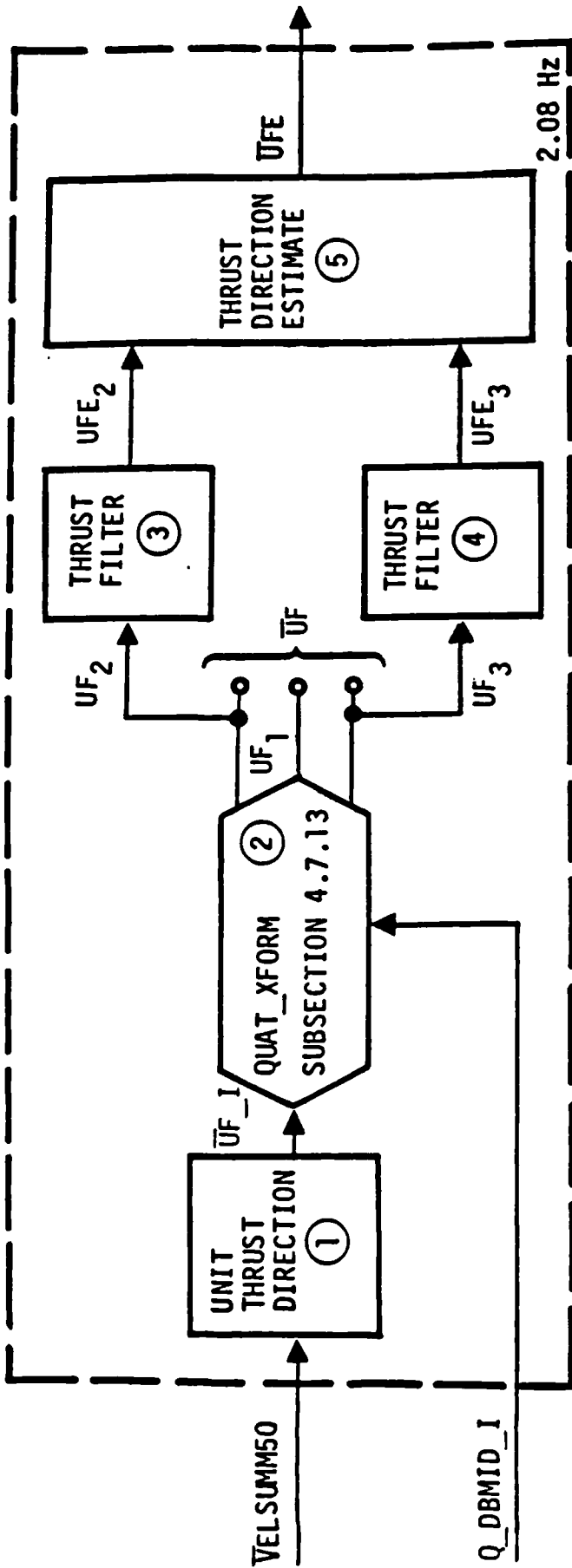
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- NOTES:
- ① $Q_B_DB = QUAT_MULT(QBIS, \bar{Q}BIV, QBIS, (-\bar{Q}DBIV))$.
 - ② $A = ZTRANS$

Figure 4.3.4 6. ATTERRS Function Module Detailed Diagram



NOTES:

- ① $UF_I = UNIT (VELSUMM50 - VELSUMM50_OLD) * \text{WHERE } VELSUMM50 = \bar{V}_{IMU_CURRENT}$
 $VELSUMM50_OLD = \bar{VELSUMM50}$
- ② $\bar{UF} \leftarrow QUAT_XFORM (Q_DBMIDIS, \bar{Q_DBMIDIV}, UF_I) *$
- ③ $UF_2 = MIDVAL (-UF_2_LIM, UF_2, +UF_2_LIM) *$
 $UFE_2 = MIDVAL (- (UF_2_RLIM_TTDF), (UF_2 - UFE_2) GUF, + (UF_2_RLIM_TTDF)) + UFE_2 *$
- ④ $UF_3 = MIDVAL (UF_3_MIN, UF_3, UF_3_MAX) *$
 $UFE_3 = MIDVAL (- (UF_3_RLIM_TTDF), (UF_3 - UFE_3) GUF, + (UF_3_RLIM_TTDF)) + UFE_3 *$
- ⑤ $UFE_1 = SQRT (1. - UFE_2^2 - UFE_3^2)$

* BYPASS THESE EQUATIONS ON INITIALIZATION PASSES AND UPDATE $VELSUMM50_OLD$, UFE_2 AND UFE_3 AS SHOWN IN TABLE 4.3.4-2.

Figure 4.3.4-7. THRUST_DIRECTION_FILTER Function Module Detailed Diagram

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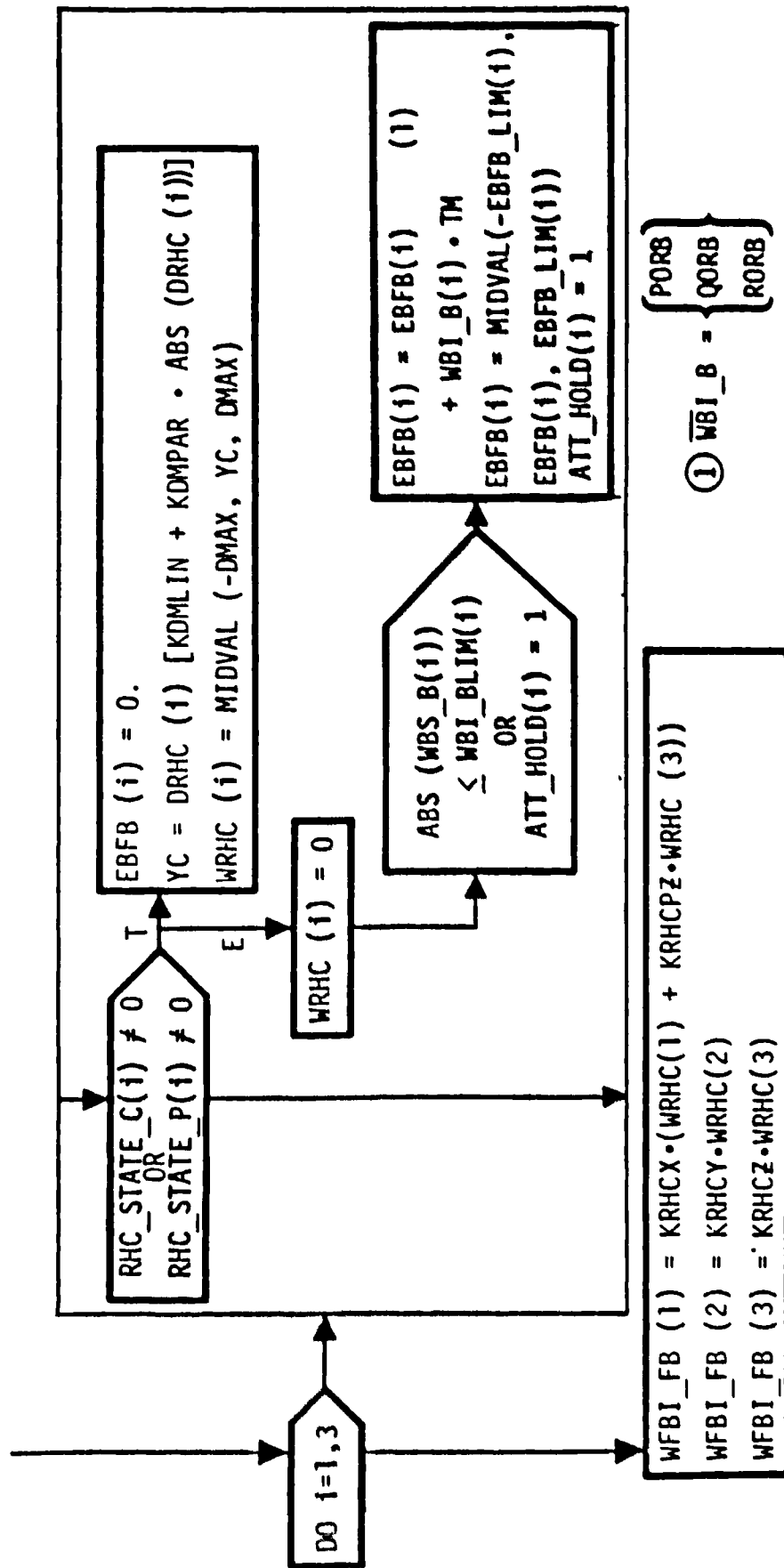
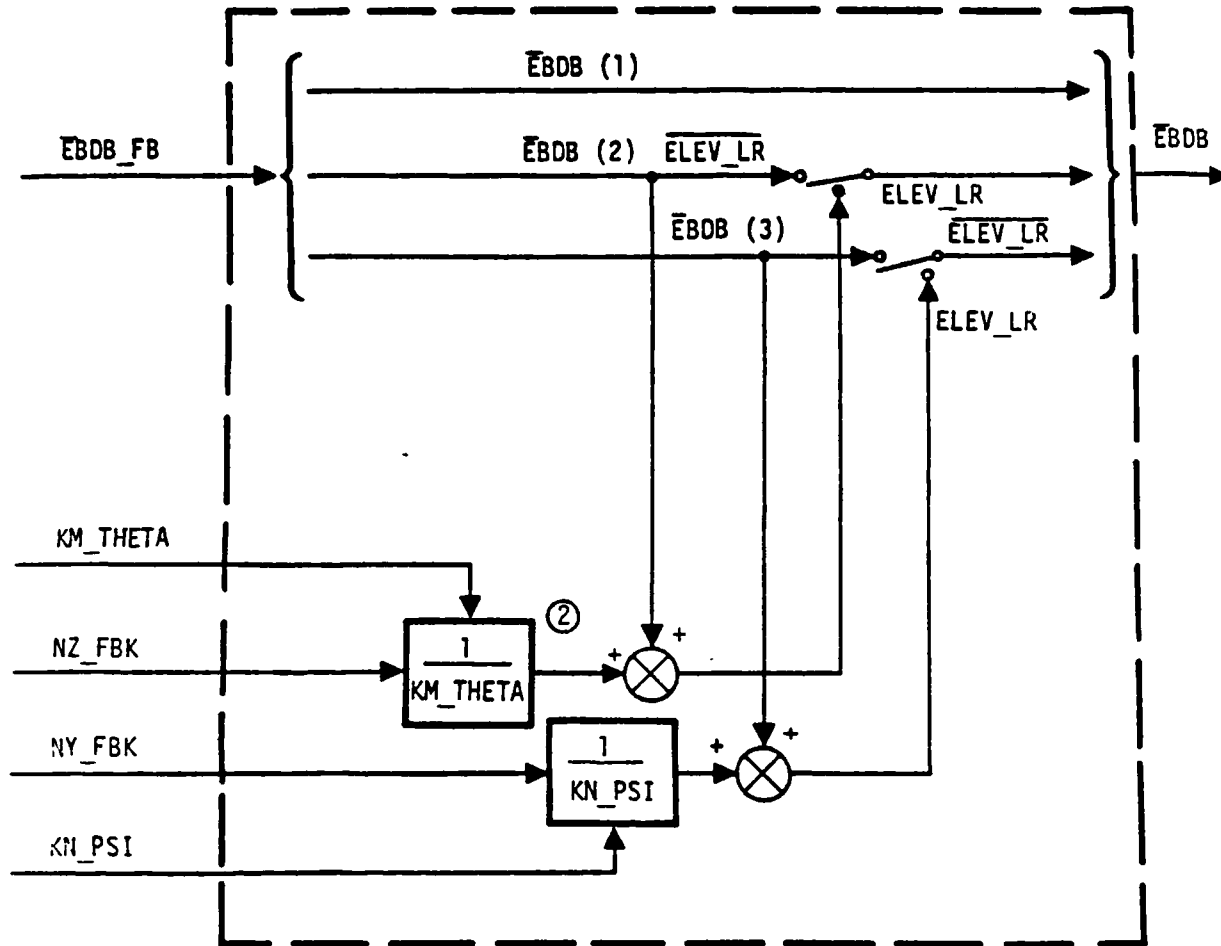
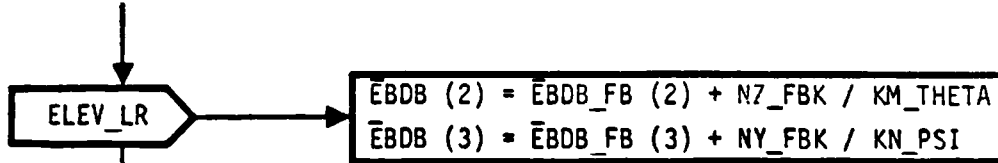


Figure 4.3.4-8. MANUAL ASCENT GUIDANCE Detailed Block Diagram



(1) REQUIRES ONLY ONE SWITCH



(2) DEFAULT VALUE FOR DIVISION ($1/KM_THETA$ AND $1/KN_PSI$) IS 10.0. DIVISOR NEVER EXPECTED TO BE LESS THAN 0.1.

Figure 4.3.4-9. DISPERRS Detailed Block Diagram

Table 4.3.4-1. GC_STEER Inter-Module Interface Requirements

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
CBQUAT_ERECT	<u>Inputs</u>						
	$\bar{L}AMC$	Commanded thrust direction parameters	ASC_2STG_GUID, PW_RTLS_GUID	V		-	2.08
	$\bar{L}AMDC$		ASC_2STG_GUID, PW_RTLS_GUID	V		1/s	2.08
	$\bar{T}LAMC$		ASC_2STG_GUID, PW_RTLS_GUID	S		s	2.08
	MET	Mission elapsed time	FCOS	S		s	2.08
	$\bar{\Phi}I_WING$	Commanded roll symmetry angle	ASC_2STG_GUID, PW_RTLS_GUID	S	$\pm \pi$	rad	2.08
	$\bar{U}FE$	Estimated filtered thrust-direction	THRUST_DIRECTION_FILTER	V		-	2.08
	\bar{R}_AVGG	Position wrt earth center, coordinatized in inertial	ASCENT_UPP, RTLS_UPP	V		ft	2.08
	$\bar{V}REL$	Earth-relative velocity vector, coordinatized in inertial	ASCENT_UPP, RTLS_UPP	V		fps	2.08
	ALT	Altitude above reference ellipsoid	ASCENT_UPP, RTLS_UPP	S		ft	2.08
	RTLS_TURN	Indicator, begin RTLS turnaround	ASC_RECON	B		-	2.08
	$\bar{I}Z$	Unit vector pointing from vehicle to landing site at cutoff	PW_RTLS_GUID	V		-	2.08
	MM_CODE_601	Major Mode 601	MSC	B		-	2.08
	<u>Outputs</u>						
	Q_CB_I	Quaternion, commanded body wrt inertial	DBACCEL	Q		-	2.08
	$\bar{W}CBI_I$	Ideal rate, commanded body wrt inertial, coordinatized in inertial	DBACCEL	V		deg/s	2.08
DBACCEL	<u>Inputs</u>						
	Q_DB_I	Quaternion, desired body wrt inertial	DBQUAT	Q		-	6.25/ 2.08
	Q_CB_I	Quaternion, commanded body wrt inertial	{ CBQUAT_FILT CBQUAT_GUID CBQUAT_ERECT }	Q		-	6.25/ 2.08
	$\bar{W}CBI_I$	Ideal rate, commanded body wrt inertial, coordinatized in inertial	CBQUAT_ERECT	V		deg/s	2.08
	$\bar{W}DBI_DB$	Rotational velocity, desired body wrt inertial, coordinatized in desired body	DBQUAT	V		deg/s	6.25/ 2.08

Table 4.3.4-1. GC_STEER Inter-Module Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)	
DBACCEL (Cont)	MM101_INIT	Indicator	ASC_RECON	B		-	12.5	
	ATTCMD	Indicator	ASC_RECON	B		-	12.5	
	FRZCMD	Indicator	ASC_RECON	B		-	12.5	
	PEGCMD	Indicator	ASC_RECON	B		-	12.5	
	PPD	Indicator	ASC_RECON	B		-	12.5	
	RTLS_TURN	Indicator	ASC_RECON	B		-	12.5	
	SIG	Indicator	ASC_RECON	B		-	12.5	
	ATTFILT	Indicator	ASC_RECON	B		-	12.5	
	ZTRANS	Indicator	ASC_RECON	B		-	12.5	
		<u>Outputs</u>						
	$\overline{\text{ADBI_DB}}$	Rotational acceleration, desired body wrt inertial, coordinatized in desired body	DBQUAT	V		deg/s ²	6.25/ 2.0k	
DBQUAT	<u>Inputs</u>							
	$\overline{\text{ADBI_DB}}$	Rotational acceleration, desired body wrt inertial, coordinatized in desired body	DBACCEL	V		deg/s ²	6.25/ 2.0k	
	MM101_INIT	Indicator	ASC_RECON	B		-	12.5	
	AUTO	Indicator	ASC_RECON	B		-	12.5	
	FRZCMD	Indicator	ASC_RECON	B		-	12.5	
	SRBSEP	Indicator	ASC_RECON	B		-	12.5	
	<u>Outputs</u>							
	Q_DB_I	Quaternion, desired body wrt inertial	ATTERRS DB_QUAT_COPY DBACCEL	Q		-	12.5	
	$\overline{\text{WDBI_DB}}$	Rotational velocity, desired body wrt inertial, coordinatized in desired body	FBCMDS AUTO DBACCEL	V		deg/s	12.5	
MANUAL ASCENT GUIDANCE	<u>Inputs</u>							
	$\overline{\text{DRHC}}$	Manual attitude commands (rotation hand controller)	3-AX RHC SOP	V		deg	12.5	
	MM101_INIT	Indicator	ASC_RECON	B		-	12.5	
	AUTO	Indicator	ASC_RECON	B		-	12.5	
	FRZCMD	Indicator	ASC_RECON	B		-	12.5	
	$\overline{\text{RHC_STATE_C}}$	Commander RHC out of detent signals	3-AX RHC SOP	V		-	12.5	
	$\overline{\text{RHC_STATE_P}}$	Pilot RHC out of detent signals	3-AX RHC SOP				12.5	
	PORB } QORB } RORB }	$\overline{\text{WBI_B}}$ Orbiter att rates	SF (ORB_RGA)	S S S		deg/s deg/s deg/s	12.5 12.5 12.5	
		<u>Outputs</u>						
		$\overline{\text{WFBF_FB}}$	Rotational velocity, flight body wrt desired body or inertial, coordinatized in flight body	ASC_TVC	V		deg/s	12.5
	$\overline{\text{EBFB}}$	Attitude errors for TVC loops	ASC_TVC	V		deg	12.5	

Table 4.3.4-1. GC_STEER Inter-Module Interface Requirements (Cont)

Module	Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced At (Hz)
ATTERRS	<u>Inputs</u>						
	Q_DB_I	Quaternion, desired body wrt inertial	DBQUAT	Q		-	12.5
	Q_B_I	Quaternion, actual body wrt inertial	A/E_ATT_PROC	Q		-	12.5
	MM101_INIT	Indicator	ASC_RECON	B		-	12.5
	BETA_N	NAV-derived sideslip angle	A/E_ATT_PROC	S		deg	6.25
	ZTRANS	Indicator	ASC_RECON	B		-	12.5
	<u>Outputs</u>						
	EBDB_FB	Attitude errors for thrust vector control	GRTLS_DAP, ASC_TVQ, DISPERRS_AUTO	V		deg	12.5
THRUST DIRECTION FILTER	<u>Inputs</u>						
	V_IMU_CURRENT (VELSUM50)	Selected total accumulated sensed velocity M50	IMU_RM	V		ft/s	6.25
	Q_DBMID_I	Transformation quaternion, inertial frame to flight body frame at mid THRUST_DIRECTION_FILTER cycle	DB_QUAT_COPY	Q		-	2.08
	MM101_INIT	Indicator	ASC_RECON	B		-	12.5
	PEGCMD	Indicator	ASC_RECON	B		-	12.5
	<u>Outputs</u>						
	JFE	Estimated filtered thrust direction	CBQUAT_ERECT	V		-	2.08
DISPERRS	<u>Inputs</u>						
	EBDB_FB	Uncompensated attitude errors for display	ATTERRS	V		deg	6.25
	KN_THETA	Variable gain for pitch attitude error	ASC_DAP	S		deg s/ deg	6.25
	KN_PSI	Variable gain for yaw attitude error	ASC_DAP	S		deg s/ deg	6.25
	NZ_FBK	Compensated normal acceleration error	ASC_DAP	S		deg s	12.5
	NY_FBK	Compensated lateral acceleration error	ASC_DAP	S		deg s	12.5
	ELEV_LR	Indicate active elevon load relief	ASC_RECON	B		-	12.5
	<u>Outputs</u>						
	EBIB	Compensated attitude errors for display	ASC_ADI_PROC	V		deg	12.5

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Table 4.3.4-2. GC_STEER Initialization Requirements

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
DBACCEL	<u>Input</u>	-	MM101_INIT	Q_DB_I WDBI_DB ADBI_DR Q_DB_I Q_CB_I_OLD	0.0 ^① NULLVEC NULLVEC Q_B_I Q_B_I ^①
		FRZCMD	FRZCMD	Q_CB_I_OLD	Q_CB_I
	Past value of error quaternion	PPD	PPD	Q_CB_I_OLD	Q_CB_I
		Steering gains	MM101_INIT	TSTR ALIM WLIM KERR KRATED KRATEF	TSTR_160 ALIM_ATT WLIM_ATT KERR_ATT KRATED_ATT/ TSTR KRATEF_ATT
	SIG		SIG	ALIM WLIM KERR KRATED KRATEF	ALIM_SIG WLIM_SIG KERR_SIG KRATED_SIG/ TSTR KRATEF_SIG
	PEGCMD		PEGCMD	TSTR ALIM WLIM KERR KRATED KRATEF	TSTR_480 ALIM_S2G WLIM_S2G KERR_S2G KRATED_S2G/ DEG TO RAD KRATEF_S2G
	RTLS_TURN		RTLS_TURN	ALIM WLIM KERR KRATED KRATEF	ALIM_TURN WLIM_TURN KERR_TURN KRATED_TURN/ DEG TO RAD KRATEF_TURN
	PPD	PPD	TSTR ALIM WLIM KERR KRATED KRATEF	TSTR_160 ALIM_PPD WLIM_PPD KERR_PPD KRATED_PPD/ TSTR KRATEF_PPD	
ZTRANS	ZTRANS	TSTR ALIM WLIM KERR KRATED KRATEF	TSTR_160 ALIM_ZTRANS WLIM_ZTRANS KERR_ZTRANS KRATED_ZTRANS/ TSTR KRATEF_ZTRANS		

① ATI_PROC_OUTER, at 1.04 Hz, is processed before the first execution of DBACCEL on transition to AFCS_FIRST_PASS.

Module
DBQUAT
TSTR
DIRECTION
FILTER
FCMS_AUTO
DB_QUAT_COPY
DISPERS
MANUAL_ASCENT
GLIDANCE
ATTERRS
CRQUAT_ERECT
① ATI_PROC_OUT
to AFCS_FIRS
② WF2_RLIM_TST
③ WF3_RLIM_TST
④ 12.0 - DQMP

Table 4.3.4-2. GC_STEER Initialization Requirements (Cont)

Module	Component	Initialize on Transition		Variable	Initial Value
		From	To		
DBQUAT	Quaternion integral		MM101_INIT	Q_DB_I	0.0 (1)
		AUTO	AUTO	Q_DB_I	Q_B_I
	Input	FRZCMD	FRZCMD	ADB1_DB	NULLVEC
		-	MM101_INIT	WDB1_DB	NULLVEC
	Rate integral	FRZCMD	FRZCMD	WDB1_DB	NULLVEC
		AUTO	AUTO	WDB1_DB	WFBI_FB
	Quaternion integral	SRBSEP	SRBSEP	Q_DB_I	Q_B_I
THRUST DIRECTION FILTER	Thrust direction filter outputs	PEGCMD	PEGCMD	UFE ₂	0.0
				UFE ₃	(6)
	Accumulated sensed velocity	PEGCMD	PEGCMD	VELSUMM50_OLD	VELSUMM50
	Thrust filter		MM101_INIT	UF2_RLIM_TTDF	(4)
		MM101_INIT	UF3_RLIM_TTDF	(5)	
FBCMDS_AUTO	Output	-	MM101_INIT	WFBI_FB EBFB	NULLVEC NULLVEC
DB_QUAT_COPY	Output	PEGCMD	PEGCMD	Q_DBMID_I	Q_DB_I
DISPERS	Copy cycle for display		MM101_INIT	EBDB	NULLVEC
MANUAL_ASCENT GLIDANCE		AUTO	AUTO	ATT_HOLD(1) ATT_HOLD(2) ATT_HOLD(3)	0 0 0
ATTERRS	Yaw attitude error	ZTRANS	ZTRANS	EBDB_FB(3)	-BETA_N
CBQUAT_ERECT	RTLS Flyback first pass flag	-	MM101_INIT	FPASS	ON

(1) ATT_PROC_OUTER, at 1.04 Hz, is processed before the first execution of DBACCEL on transition to AFCS_FIRST_PASS.

(4) UF2_RLIM TSTR_480.

(5) UF3_RLIM TSTR_480.

(6) (12.0 - DQMPST_S2_TAB1) DEG_TO_RAD.

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Table 4.3.4-3. GC_STEER I-Loads/K-Loads/Constants

Module	Name	Description	Type	MSID/ Value	Units
DBACCEL	KRATEF_ATT	Feedback rate gain	S	V97U2046C	1/s
	KRATEF_S1G	Feedback rate gain	S	V97U2048C	↑
	KRATEF_S2G	Feedback rate gain	S	V97U2049C	
	KRATEF_TURN	Feedback rate gain	S	V97U2050C	↓
	KRATEF_PPD	Feedback rate gain	S	V97U2047C	
	KRATED_ATT	Rate gain	S	V97U2041C	↓
	KRATED_S1G	Rate gain	S	V97U2043C	
	KRATED_S2G	Rate gain	S	V97U2044C	↓
	KRATED_TURN	Rate gain	S	V97U2045C	
	KRATED_PPD	Rate gain	S	V97U2042C	1/s
	TSTR_160	Steer cycle sample period	S	0.160	s
	TSTR_480	Steer cycle sample period	S	0.480	s
	ALIM_ATT	Angular acceleration limit	S	V97U1400C	deg/s ²
	ALIM_S1G	Angular acceleration limit	S	V97U1402C	↑
	ALIM_S2G	Angular acceleration limit	S	V97U1403C	
	ALIM_TURN	Angular acceleration limit	S	V97U1404C	↓
	ALIM_PPD	Angular acceleration limit	S	V97U1401C	
	WLIM_ATT	Angular rate limit	S	V97U2319C	deg/s
	WLIM_S1G	Angular rate limit	S	V97U2321C	deg/s
	WLIM_S2G	Angular rate limit	S	V97U2322C	deg/s
	WLIM_TURN	Angular rate limit	S	V97U2323C	deg/s
	WLIM_PPD	Angular rate limit	S	V97U2320C	deg/s
	KERR_ATT	Angle error gain	S	V97U1805C	1/s ²
	KERR_S1G	Angle error gain	S	V97U1807C	↑
	KERR_S2G	Angle error gain	S	V97U1808C	
	KERR_TURN	Angle error gain	S	V97U1809C	↓
	KERR_PPD	Angle error gain	S	V97U1806C	1/s ²
	NULLVEC	NULL vector	V	(0,0,0)	-
	UNIT_QUAT	Unit quaternion, structure	Q	(1,0,0,0)	-
	RAD_PER_DEG	Conversion factor, degrees to radians	S	π/180	Rad/deg
	ALIM_ZTRANS	Angular accel limit	S	V97U1331C	deg/s ²
	WLIM_ZTRANS	Angular rate limit	S	V97U1329C	deg/s
	KERR_ZTRANS	Angular error gain	S	V97U1330C	1/s ²
KRATED_ZTRANS	Rate gain	S	V97U1328C	1/s	
KRATEF_ZTRANS	Rate gain	S	V97U1327C	1/s	

Module
QUAT
MANUAL
ASCENT
GUIDANCE

Table 4.3.4-3. GC_STEER I-Loads/K-Loads/Constants (Cont)

Module	Name	Description	Type	MSID Value	Units
DBQUAT	RAD_PER_DEG	Conversion factor, degrees to radians	S	$\pi/180$	rad/deg
	TM	Medium cycle sample period	S	0.08	s
	DTCON_M	Rate vector gain for quaternion integration	S	$-TM \cdot RAD_PER_DEG/2$	s/deg
	NULLVEC	Null vector	V	(0,0,0)	-
THRUST DIRECTION FILTER	RAD_PER_DEG	Scale factor, degrees to radians	S	$\pi/180$	rad/deg
	DQMPST_S2_TAB(01)	Second stage pitch trim table point 1	S	V97U1710C	deg
	GUF	Filter coefficient	S	V97U1799C	-
	TSTR_480	Module sample period	S	0.48	s
	UF2_LIM	Lateral position limit	S	V97U2270C	-
	UF3_MAX	Normal maximum position limit	S	V97U2272C	-
	UF3_MIN	Normal minimum position limit	S	V97U2273C	-
	UF2_RLIM	Lateral rate limit	S	V97U2271C	1/s
UF3_RLIM	Normal rate limit	S	V97U2274C	1/s	
MANUAL ASCENT GUIDANCE	NULLVEC	Null vector	V	(0,0,0)	-
	TM	Medium cycle sample interval	S	0.080	s
	DMAX	Maximum value of shaped manual attitude command	S	V97U1676C	deg
	KDMLIN	Linear coefficient in parabolic shaping equation	S	V97U8755C	deg/deg
	KDMPAR	Parabolic coefficient in parabolic shaping equation	S	V97U1804C	deg/deg ²
	KRHCX } KRHCY } KRHCZ }	Manual attitude commands gains	S	V97U2052C	(deg/s/deg)
			S	V97U2053C	(deg/s/deg)
			S	V97U2054C	(deg/s/deg)
	KRHGPZ	Manual attitude crossfeed gain	S	V97U2051C	(deg/deg)
	UNIT_QUAT	Unit quaternion	Q	(1,0,0,0)	-
	RAD_PER_DEG	Conversion factor, degrees to radians	S	$\pi/180$	rad/deg
	DTCON_M	Rate vector gain for quaternion integration	S	$-TM \cdot RAD_PER_DEG/2$	s/deg
WBI_BLIM(i) i = 1 to 3	Rate limit for initiation of attitude hold	V	V97U1321C to V97U1323C	deg/s	
EBFB_LIM(i) i = 1 to 3	Attitude error limit for initiation of attitude hold	V	V97U1324C to V97U1326C	deg	



Table 4.3.4-3: GC_STEER I-Loads/K-Loads/Constants (Cont)

Module	Name	Description	Type	MSID/ Value	Units
CBQUAT_ERECT	ALT_HEAT	Altitude boundary for heating	S	V97U1408C	ft
	MTT_HEAT	Time boundary for heating constraint algorithm	S	V97U2060C	s
	C_ALF_LIM	Cosine of angle-of-attack limit	S	V97U1419C	-
	S_ALF_LIM	Sine of angle-of-attack limit	S	V97U2237C	-
	C_ALF_BIAS	Cosine of bias angle-of-attack	S	V97U1418C	-
	S_ALF_BIAS	Sine of bias angle-of-attack	S	V97U2236C	-
	RAD_PER_DEG	Conversion factor, degrees to radians	S	$\pi/180$	rad/deg
	\bar{U}_Z	Unit Z-axis	V	(0,0,1)	-

4.3.5
output to
through
(Table 4.3.4-3)
between
other
and other
IDD Table
Note
input (de
downlist
may not

TA QAC
Generat



4.3.5 Guidance/Control Steering Interface Principal Function Tables

The guidance/control steering interface principal function input and output tables, along with the I-load tables, are presented in Tables 4.3.5-1 through 4.3.5-2. The automated Interface Definition Document (IDD) table (Table 4.3.5-1) defines signal (parameter) interface requirements either between hardware (LRU) and software elements or between software elements and other software elements.* In the event of a conflict between the IDD tables and other internal text input/output tables, the SASCB data base controlled IDD table take precedence.

Note that IDD output (source) tables that reflect parameters going to input (destination) TLM will not be interpreted as a signal actually being downlisted. The parameter may only be available for downlist in COMPOOL and may not appear in a downlist format.

*A GN&C software element is either a sequenced principal function (PF), crew generated specialist/display function, or an OPS display function.

Table 4.3.5-1. Guidance/Control Steering Interface (G4.175) Input/Output Parameters

DBFN: D2B041-C PN: YP707100034P00L
INPUT FUNCTIONAL PARAMETERS FOR GUIDANCE/CONTROL STEERING INTERFACE

JUNE 29, 1988
OIOC REV00 G4.175 G/C STEER

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE
ALT	V95H0175CA	CURR ORB ALT ABOVE REF ELLIPSOID	RTLS UP	KFT	BD
ALT CMD	V95H0175CB	CURR ORB ALT ABOVE REF ELLIPSOID	ASC DAP	KFT	BD
ATTILT	V90X1712X	STEERING MODE FLAG	ASC DAP	S	BD
AUTO	V90X1709X	FILTER ACTUAL BODY ATTITUDE FLAG	ASC DAP	S	BD
BETA N	V90H2249C	AUTO GUIDANCE MODE FLAG	A/E ATT	DEG	SPL
CLOCK/CLOCKTIME	V91H500C1	INERTIAL SIDESLIP ANGLE	FCDS	DEG	S
DAHAN/RHCT(1)	V96H0005CB	CLOCK-COMPUTER(RIGHT)	3-AX RHC SOP	DEG	S
DAHAN/RHCT(2)	V96H0007CB	CLOCK-COMPUTER(RIGHT)	3-AX RHC SOP	DEG	S
DYHAN/RHCT(3)	V96H0004CA	CLOCK-COMPUTER(RIGHT)	3-AX RHC SOP	DEG	S
ELEV LR	V90X1716X	MANUAL ROLL CMD	ASC DAP	S	BD
EVENT A37	V90X8250X	MANUAL YAW COMMAND	ET SEP SEQ	S	BD
FRZCMD	V90U1714X	ELEVON LOAD RELIEF FLAG	ASC DAP	S	BD
IZIXI	V90U2095CA	ET SEPARATION CMD FLAG	ASC 2STG GUID	DEG/S/DEG	BD
IZIXI	V90U2095CB	FREEZE DESIRED BODY CHD FLAG	PM RTLS GUID	DEG/S/DEG	BD
IZIYI	V90U2096CA	X-UNIT VECTOR TO LANDING SITE	ASC 2STG GUID	DEG/S/DEG	BD
IZIYI	V90U2096CB	Y-UNIT VECTOR TO LANDING SITE	ASC 2STG GUID	DEG/S/DEG	BD
IZIZI	V90U2097CA	Z-UNIT VECTOR TO LANDING SITE	ASC 2STG GUID	DEG/S/DEG	BD
IZIZI	V90U2097CB	Z-UNIT VECTOR TO LANDING SITE	ASC 2STG GUID	DEG/S/DEG	BD
KM THETA	V90U1747C	VARIABLE GAIN ATTITUDE-PITCH	ASC DAP	DEG/S/DEG	BD
KN PSI	V90U1768C	VARIABLE GAIN ATTITUDE-YAW	ASC DAP	DEG/S/DEG	BD
LAH(X)	V90U1954CA	X-COMP OF H50 REF THR VECTOR	ASC 2STG GUID	DEG/S/DEG	BD
LAH(X)	V90U1954CB	Y-COMP OF H50 REF THR VECTOR	ASC 2STG GUID	DEG/S/DEG	BD
LAH(Y)	V90U1955CA	X-COMP OF H50 REF THR VECTOR	ASC 2STG GUID	DEG/S/DEG	BD
LAH(Y)	V90U1955CB	Y-COMP OF H50 REF THR VECTOR	ASC 2STG GUID	DEG/S/DEG	BD
LAH(Z)	V90U1956CA	Z-COMP OF H50 REF THR VECTOR	ASC 2STG GUID	DEG/S/DEG	BD
LAH(Z)	V90U1956CB	Z-COMP OF H50 REF THR VECTOR	ASC 2STG GUID	DEG/S/DEG	BD
LAHDC(X)	V90U1957CA	X-H50 DESIRED THR TRAINING RATE	ASC 2STG GUID	RAD/S	BD
LAHDC(X)	V90U1957CB	Y-H50 DESIRED THR TRAINING RATE	ASC 2STG GUID	RAD/S	BD
LAHDC(Y)	V90U1958CA	Y-H50 DESIRED THR TRAINING RATE	ASC 2STG GUID	RAD/S	BD
LAHDC(Y)	V90U1958CB	Z-H50 DESIRED THR TRAINING RATE	ASC 2STG GUID	RAD/S	BD
LAHDC(Z)	V90U1959CA	Z-H50 DESIRED THR TRAINING RATE	ASC 2STG GUID	RAD/S	BD
LAHDC(Z)	V90U1959CB	Z-H50 DESIRED THR TRAINING RATE	ASC 2STG GUID	RAD/S	BD
MM CODE 601/WH_601	V90X8194X	MAJOR MODE 601 FLAG	HSC	DEG/S	SPL
MM101 INIT	V90A1764X	FIRST-TIME ASC DAP SCHEDULED FLAG	ASC DAP	DEG/S	SPL
NY FBK	V90A1766C	COMPENSATED LATERAL ACCEL ERROR	ASC DAP	DEG/S	SPL
NZ-FBK	V90A1765C	COMPENSATED NORMAL ACCEL ERROR	ASC DAP	DEG/S	SPL
PEGCMB	V90R5301CA	SELECTED RGA ROLL RATE	SF	DEG/S	SPL
PHI ORB	V90X1757X	S2G STEERING MODE FLAG	ASC DAP	DEG/S	SPL
PHI CMD	V90H1969CA	COMMANDERED ROLL ANGLE	ASC 2STG GUID	DEG/S	SPL
PHI CHD	V90H1969CB	COMMANDERED ROLL ANGLE	ASC 2STG GUID	DEG/S	SPL
PPD	V90X1760X	RTLS POWERED PITCH DOWN MVWR FLAG	ASC DAP	RAD	SPL
Q BOD	H5011/Q B	H50 TO BODY QUAT MEASURED ELEM 1	A/E ATT PROC	RAD	SPL
Q BOD	H5012/Q B	H50 TO BODY QUAT MEASURED ELEM 2	A/E ATT PROC	RAD	SPL
Q BOD	H5013/Q B	H50 TO BODY QUAT MEASURED ELEM 3	A/E ATT PROC	RAD	SPL
Q BOD	H5014/Q B	H50 TO BODY QUAT MEASURED ELEM 4	A/E ATT PROC	RAD	SPL
Q CB	H5011/Q GCB	H50-TO-CMD BODY QUATERNION ELE 1	ASC 1STG GUID	RAD	SPL
Q CB	H5011/Q GCB	H50-TO-CMD BODY QUATERNION ELE 2	ASC 1STG GUID	RAD	SPL
Q CB	H5011/Q GCB	H50-TO-CMD BODY QUATERNION ELE 3	ASC 1STG GUID	RAD	SPL
Q CB	H5011/Q GCB	H50-TO-CMD BODY QUATERNION ELE 4	ASC 1STG GUID	RAD	SPL
Q CB	H5012/Q GCB	H50-TO-CMD BODY QUATERNION ELE 1	ASC 1STG GUID	RAD	SPL
Q CB	H5012/Q GCB	H50-TO-CMD BODY QUATERNION ELE 2	ASC 1STG GUID	RAD	SPL
Q CB	H5012/Q GCB	H50-TO-CMD BODY QUATERNION ELE 3	ASC 1STG GUID	RAD	SPL
Q CB	H5012/Q GCB	H50-TO-CMD BODY QUATERNION ELE 4	ASC 1STG GUID	RAD	SPL

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Table 4.3.5.2. Guidance/Control Steering (C4,175) I Loads

TABLE 4.3.5.2 OIOB MISSIONS	G/C STEER	(C4 175) I LOADS	GUIDANCE/CONTROL STEERING INTERFACE
FSSR NAME	MSID	ENG UNIT	DT PR D S PR FCIM CAT
ALIM_ATT	V97U1400C	DEG/SEC#2	F S D C C4.175 ADF0
ALIM_PPD	V97U1401C	DEG/SEC#2	F S D C C4.175 ZFR4
ALIM_S1G	V97U1402C	DEG/SEC#2	F S D C C4.175 ZFR4
ALIM_S2G	V97U1403C	DEG/SEC#2	F S D C C4.175 ZFR4
ALIM_TURN	V97U1404C	DEG/SEC#2	F S D C C4.175 ZFR4
ALIM_ZTRANS	V97U1331C	DEG/SEC#2	F S D C C4.175 ZSR1
ALT_HEAT	V97U1408C	FT	F S D C C4.175 ZFR4
C_ALF_BIAS	V97U1410C	ND	F S D C C4.175 ZFR4
C_ALF_LIM	V97U1419C	ND	F S D C C4.175 ZFR4
DMAX	V97U1676C	DEG	F S D P C4.175 ZSR1
DQMPST_S2_TAB(01)	V97U1710C	DEG	F S H C C4.176 ATM0
EDFB_LIM(1)	V97U1324C	DEG	F S D P C4.175 ZSR1
EDFB_LIM(2)	V97U1325C	DEG	F S D P C4.175 ZSR1
EDFB_LIM(3)	V97U1326C	DEG	F S D P C4.175 ZSR1
GUF	V97U1799C	MD	F S D C C4.175 ZSR1
KDMLIN	V97U8755C	DEG/DEG	F S D P C4.175 ZSR1
KDMPAR	V97U104C	DEG/DEG#2	F S D P C4.175 ZSR1
KERR_ATT	V97U105C	SEC#-2	F S D C C4.175 ADF0
KERR_PPD	V97U106C	SEC#-2	F S D C C4.175 ZFR4
KERR_S1G	V97U107C	SEC#-2	F S D C C4.175 ZFR4
KERR_S2G	V97U108C	SEC#-2	F S D C C4.175 ZFR4
KERR_TURN	V97U109C	SEC#-2	F S D C C4.175 ZFR4
KERR_ZTRANS	V97U1330C	SEC#-2	F S D C C4.175 ZSR1
KRATED_ATT	V97U2041C	SEC#-1	F S D C C4.175 ADF0
KRATED_PPD	V97U2042C	SEC#-1	F S D C C4.175 ZFR4
KRATED_S1G	V97U2043C	SEC#-1	F S D C C4.175 ZFR4

DBFN: 0464 DATE: 04/10/89



Table 4.3.5-1. Guidance/Control Steering Interface (G4.175) Input/Output Parameters (Cont)

DBFN: D2B039-A PN: VP707100026P001 MAY 31, 1988 OI88 REV00 G4.175 PAGE 290
 OUTPUT FUNCTIONAL PARAMETERS FROM GUIDANCE/CONTROL STEERING INTERFACE G/C STEER BOOK: 8-1

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FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE
EBDB(1)	V95H3534C	ROLL ERROR DISPLAY	ASC ADI PROC, ILM	DEG	SPL
EBDB(2)	V95H3533C	PITCH ERROR DISPLAY	ASC ADI PROC, ILM	DEG	SPL
EBDB(3)	V95H3533C	YAW ERROR DISPLAY	ASC ADI PROC, ILM	DEG	SPL
EBFB(1)	V95H3523C	BODY ROLL ATT ERROR	ASC DAP, GRILS DAP, ILM	DEG	SPL
EBFB(2)	V95H3521C	BODY PITCH ATT ERROR	ASC DAP, GRILS DAP, ASC 1STG GUID, ILM	DEG	SPL
EBFB(3)	V95H3522C	BODY YAW ATT ERROR	ASC DAP, GRILS DAP, ILM	DEG	SPL
MFBI_FB1	V95H3528C	ROLL RATE, FLIGHT BODY-INERTIAL	ASC DAP, GRILS DAP, ILM	DEG/S	SPL
MFBI_FB2	V95H3526C	PITCH RATE, FLIGHT BODY-INERTIAL	ASC DAP, GRILS DAP, ILM	DEG/S	SPL
MFBI_FB3	V95H3527C	YAW RATE, FLIGHT BODY-INERTIAL	ASC DAP, GRILS DAP, ILM	DEG/S	SPL



Table 4.3.5-1. Guidance/Control Steering Interface (G4.175) Input/Output Parameters (Cont)

MISSIONS	FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCIM	CAT
ALIM_ATT	V97U1400C	DEG/SECM2	F	S	D	C	G4.175	ADFO		
ALIM_PPD	V97U1401C	DEG/SECM2	F	S	D	C	G4.175	ZFR4		
ALIM_SIG	V97U1402C	DEG/SECM2	F	S	D	C	G4.175	ZFR4		
ALIM_S2G	V97U1403C	DEG/SECM2	F	S	D	C	G4.175	ZFR4		
ALIM_TURN	V97U1404C	DEG/SECM2	F	S	D	C	G4.175	ZFR4		
ALIM_ZTRANS	V97U1331C	DEG/SECM2	F	S	D	C	G4.175	ZSR1		
ALT_HEAT	V97U1400C	FT	F	S	D	C	G4.175	ZFR4		
C_ALF_BIAS	V97U1418C	ND	F	S	D	C	G4.175	ZFR4		
C_ALF_LIM	V97U1419C	ND	F	S	D	C	G4.175	ZFR4		
DHAX	V97U1676C	DEG	F	S	D	P	G4.175	ZSR1		
DQMPST_S2_TAB(01)	V97U1710C	DEG	F	S	M	C	G4.176 G4.175	ATM0		
EDFB_LIM(1)	V97U1324C	DEG	F	S	D	P	G4.175	ZSR1		
EDFB_LIM(2)	V97U1325C	DEG	F	S	D	P	G4.175	ZSR1		
EDFB_LIM(3)	V97U1326C	DEG	F	S	D	P	G4.175	ZSR1		
GUF	V97U1799C	ND	F	S	D	C	G4.175	ZSR1		
KDMLIN	V97U0755C	DEG/DEG	F	S	D	P	G4.175	ZSR1		
KDMPAR	V97U1004C	DEG/DECM2	F	S	D	P	G4.175	ZSR1		
KERR_ATT	V97U1005C	SECM-2	F	S	D	C	G4.175	ADFO		
KERR_PPD	V97U1006C	SECM-2	F	S	D	C	G4.175	ZFR4		
KERR_SIG	V97U1007C	SECM-2	F	S	D	C	G4.175	ZFR4		
KERR_S2G	V97U1008C	SECM-2	F	S	D	C	G4.175	ZFR4		
KERR_TURN	V97U1009C	SECM-2	F	S	D	C	G4.175	ZFR4		
KERR_ZTRANS	V97U1330C	SECM-2	F	S	D	C	G4.175	ZSR1		
KRATED_ATT	V97U2041C	SECM-1	F	S	D	C	G4.175	ADFO		
KRATED_PPD	V97U2042C	SECM-1	F	S	D	C	G4.175	ZFR4		
KRATED_SIG	V97U2043C	SECM-1	F	S	D	C	G4.175	ZFR4		

DBFM: 0464 DATE: 04/10/89



Table 4.3.5-2. Guidance/Control Steering (G4.175) I-Loads (Cont)

MISSIONS	FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCIN	CAT
	KRATED_S2G	V97U2044C	SECM-1	F	S	D	C	G4.175	ZFR4	CR89132D
	KRATED_TURN	V97U2045C	SECM-1	F	S	D	C	G4.175	ZFR4	CR89132D
	KRATED_ZTRANS	V97U1328C	SECM-1	F	S	D	C	G4.175	ZFR4	CR89132D
	KRATEF_ATT	V97U2046C	SECM-1	F	S	D	C	G4.175	ADFO	CR89132D
	KRATEF_PPD	V97U2047C	SECM-1	F	S	D	C	G4.175	ZFR4	CR89132D
	KRATEF_SIG	V97U2048C	SECM-1	F	S	D	C	G4.175	ZFR4	CR89132D
	KRATEF_S2G	V97U2049C	SECM-1	F	S	D	C	G4.175	ZFR4	CR89132D
	KRATEF_TURN	V97U2050C	SECM-1	F	S	D	C	G4.175	ZFR4	CR89132D
	KRATEF_ZTRANS	V97U1327C	SECM-1	F	S	D	C	G4.175	ZSR1	CR89132D
	KRHCPZ	V97U2051C	DEG/DEG	F	S	D	P	G4.175	ZSR1	CR89132D
	KRHGX	V97U2052C	(DEG/SEC)/DEG	F	S	D	P	G4.175	ZSR1	CR89132D
	KRHGY	V97U2053C	(DEG/SEC)/DEG	F	S	D	P	G4.175	ZSR1	CR89132D
	KRHGZ	V97U2054C	(DEG/SEC)/DEG	F	S	D	P	G4.175	ZSR1	CR89132D
	HET_HEAT	V97U2060C	SEC	F	S	D	C	G4.175	ZFR4	CR89132D
	S_ALF_BIAS	V97U2236C	ND	F	S	D	C	G4.175	ZFR4	CR89132D
	S_ALF_LIM	V97U2237C	ND	F	S	D	C	G4.175	ZFR4	CR89132D
	UF2_LIM	V97U2270C	ND	F	S	D	C	G4.175	ZSR1	CR89132D
	UF2_RLIM	V97U2271C	SECM-1	F	S	D	A	G4.175	ZFR4	CR89132D
	UF3_MAX	V97U2272C	ND	F	S	D	C	G4.175	ZSR1	CR89132D
	UF3_MIN	V97U2273C	ND	F	S	D	C	G4.175	ZSR1	CR89132D
	UF3_RLIM	V97U2274C	SECM-1	F	S	D	A	G4.175	ZFR4	CR89132D
	WBI_BLIM(1)	V97U1321C	DEG/SEC	F	S	D	P	G4.175	ZSR1	CR89132D
	WBI_BLIM(2)	V97U1322C	DEG/SEC	F	S	D	P	G4.175	ZSR1	CR89132D
	WBI_BLIM(3)	V97U1323C	DEG/SEC	F	S	D	P	G4.175	ZSR1	CR89132D
	WLIM_ATT	V97U2319C	DEG/SEC	F	S	D	C	G4.175	ADFO	CR89132D
	WLIM_PPD	V97U2320C	DEG/SEC	F	S	D	C	G4.175	ZFR4	CR89132D

DBFN: 0464 DATE: 04/10/89

Table 4.3.5-2. Guidance/Control Steering Interface (G4.175) I-Loads (Cont)
O10B MISSIONS

FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCIM	CAT
WLIM_S10	V97U2321C	DEG/SEC	F	S	D	C	G4.175	ZFR4	
WLIM_S20	V97U2322C	DEG/SEC	F	S	D	C	G4.175	ZFR4	
WLIM_TURN	V97U2323C	DEG/SEC	F	S	D	C	G4.175	ZFR4	
WLIM_ZTRANS	V97U1329C	DEG/SEC	F	S	D	C	G4.175	ZSRI	

CR891320

DBFM:0464 DATE:04/10/89



Table 4.3.5-3. Guidance/Control Steering Interface (G4.175) K-Loads

MISSIONS	MSID	MC KLOAD VALUE	ENG UNIT	DT PR S PR FCTN	LAST CR EQTN MSID
FSSR NAME DESCRIPTION					
NO REQUIREMENTS					

DBFN:0539 DATE:09/27/88

Table 4.3.5-4. Guidance/Control Steering (G4.175) Constants

MSIB	NC	VALUE	UNITS	DT	PR	S	PF REF	LAST CR	EQTM MSIB
<p>NRJARM FSSB3 DATA X22 W0008V1 P/S CONSTANTS UPDATE 8/1</p>									
<p>FSSR NAME DESCRIPTION</p>									
<p>ITTDW M LATE VECTOR GAIN FOR QUATERNION INTEGRATION</p>									
		-6.901 E-04	SEC/DEG	F					
<p>NULL VECTOR ELEM 1</p>									
		0	NO	I					
<p>NULL VECTOR ELEM 2</p>									
		0	NO	I					
<p>NULL VECTOR ELEM 3</p>									
		0	NO	I					
<p>RAD DEG DEG'S CONVERSION FACTOR DEGREES TO RAD ANS</p>									
V97U0343C		+0.017453293	RAD/DEG	F	S				
<p>TM 2 5 HZ CYC E UPDATE INTERVAL FOR INTEGRATOR</p>									
		0.06	SEC	F					
<p>TS R 160 STEER CYCLE SAMPLE PERIOD</p>									
		0.160	SEC	F					
<p>TSTR 480 STEER CYCLE SAMPLE PERIOD</p>									
		0.400	SEC	F					
<p>UNIT QUAT(1) UNIT QUATERNION, STRUCTURE ELEM 1</p>									
		1	NONE	I					
<p>UNIT QUAT(2) UNIT QUATERNION, STRUCTURE ELEM 2</p>									
		0	NONE	I					
<p>UNIT QUAT(3) UNIT QUATERNION, STRUCTURE ELEM 3</p>									
		0	NONE	I					
<p>UNIT QUAT(4) UNIT QUATERNION, STRUCTURE ELEM 4</p>									
		0	NONE	I					
<p>UZ 1 UNIT Z AXIS ELEM 1</p>									
		0	NONE	I					
<p>UZ 2 UNIT Z AXIS ELEM 2</p>									
		0	NONE	I					
<p>UZ 3 UNIT Z AXIS ELEM 3</p>									
		1	NONE	I					

4.6 ASCENT/ENTRY ATTITUDE PROCESSOR

4.6 ASCENT/ENTRY ATTITUDE PROCESSOR (ATT_PROC)

4.6.1 Introduction

The function of the attitude processor is to derive attitude-related data for several user principal functions. These data include attitude, display variables, air data, and velocity coordinatized in the body frame. ATT_PROC is intended to meet these requirements in all flight phases except on-orbit operations (OPS 2 and 8).

ATT_PROC is structured to derive the vehicle attitude quaternion using a selected IMU at low rate (1.04 Hz), and to propagate the attitude by integrating a quaternion differential equation, driven by selected prefiltered RGA outputs, at high rate (12.5 Hz in ascent and transition, 6.25 Hz in entry). All other quantities are derived using the attitude quaternion, at the rate and during those mission phases in which users require them.

In writing software requirements, approximations have been introduced in place of exact solutions to minimize CPU usage. These approximations are indicated in the text.

The overview, functional design, and coding of ATT_PROC are given in Section 4.6.3.

The attitude processor consists of eight modules, as listed in Table 4.6.1-1 and defined in Sections 4.6.4.1 to 4.6.4.8.

Table 4.6.1-1. ATT_PROC Function Modules

Subsection	Function Module
4.6.4.1	ATT_PROC_INIT
4.6.4.2	ATT_PROC_OUTER
4.6.4.3	ATT_PROC_INNER
4.6.4.4	ATT_PROC_EULER
4.6.4.5	ATT_PROC_DISP
4.6.4.6	ATT_PROC_PREFIL
4.6.4.7	ATT_PROC_RGASW
4.6.4.8	ADI_QUAT_UPLINK

4.6.2 Interface Tables

Attitude processor input/output is listed in Table 4.6.2-1. Intermodule variables are listed in Table 4.6.2-2. Initialization requirements are listed in Table 4.6.2-3; I-loads/K loads are listed in Table 4.6.2-4. Constants are listed in Table 4.6.2 5.



Table 4.6.2-1. ATT_PROC Input/Output

Module	Name	Description	Source or Destination	Type	Range	Unit	Rate Required/Produced (Hz)*
ATT_PROC_INIT	<u>Inputs</u>						
	DP(K)	Pitch-outer roll gimbal nonorthogonality, IMU _K , K = 1, 2, 3	IMU GND CAL (V4.9A)	A(3)S	±0.006	rad	on demand
	MM_CODE_101	Major mode 101 flag	MSC	B	0, 1	-	once
	CLOCKTIME	Current time	FCOS	S	0	-	once
	T_CLUSTERM50(K)	M50 wrt stable number transform matrix, IMU _K , K = 1, 2, 3	IMU ORB A/CAL (4.208) IMU GC ALIGN (V4.11)	A(3)M	±1	-	on demand
	IMU_QUAT_UPD_REQ	IMU reference quat update request	IMU ORB A/CAL (4.208) IMU GC ALIGN (V4.11)	B	0, 1	-	on demand
	<u>Outputs</u>						
	SDP(K)	Sine 1/2 gimbal non-orth, IMU _K , K = 1, 2, 3	ORB ATT PROC (4.97)	A(3)S	±1	-	on demand
	CDP(K)	Cosine 1/2 gimbal non-orth, IMU _K , K = 1, 2, 3	ORB ATT PROC (4.97)	A(3)S	±1	-	on demand
	Q_SM_M50(K)	Stable member wrt M50 quat, IMU _K , K = 1, 2, 3	ORB ATT PROC (4.97)	Struc (3)S,V	±1	-	on demand
ATT_PROC_OUTER	<u>Inputs</u>						
	ORANG(K)	Compensated outer roll gimbal angle, IMU _K , K = 1, 2, 3	IMU INT PROC (4.38)	A(3)S	0-360	deg	1.04/ 1.04/ 1.04
	PANG(K)	Compensated pitch gimbal angle, IMU _K , K = 1, 2, 3	IMU INT PROC (4.38)	A(3)S	0-360	deg	1.04/ 1.04/ 1.04
	IRANG(K)	Compensated inner roll gimbal angle, IMU _K , K = 1, 2, 3	IMU INT PROC (4.38)	A(3)S	0-15, 345-360	deg	1.04/ 1.04/ 1.04
	AZANG(K)	Compensated azimuth gimbal angle, IMU _K , K = 1, 2, 3	IMU INT PROC (4.38)	A(3)S	0-360	deg	1.04/ 1.04/ 1.04
	SEL_IMU_ID	Selected IMU number	IMU RM (4.72)	I	1-3	-	1.04/ 1.04/ 1.04
	ATT_DG	Attitude data good flag	IMU RM (4.72)	B	0, 1	-	1.04/ 1.04/ 1.04
	T_IMUS_GA	IMU gimbal angle time tag	IMU INT PROC (4.38)	S	0	s	1.04/ 1.04/ 1.04
Q_B_M50	Body wrt M50 quaternion computed on-orbit	ORB ATT PROC (4.97)	Struc S, V	±1	-	once**	

*Rates are given as X/Y/Z, in Hz. Rate is X in ascent, Y in transition, and Z in entry.
**Carryover from OPS 2 or OPS 8 to OPS 3.

Module
ATT_PROC_OUTER (Cont.)
**Computed on
PH 102,
***Sampled at

Table 4.6.2-1. ATT_PROC Input/Output (Cont)

Module	Name	Description	Source or Destination	Type	Range	Unit	Rate Required/Produced (Hz)
ATT_PROC_OUTER (Cont)	<u>Inputs (Cont)</u>						
	R_AVGG	Shuttle position vector	ASC UPP (4.19) RTLS UPP (4.20) ENTRY UPP (4.23) TAEM UPP (4.24) A/L UPP (4.25)	V	TBD	ft	1.04/ 1.04/ 1.04
	I_YD_M50**	Unit vector normal to insertion plane, in M50 system	ASC UPP (4.19) ASC 2STG GUID (4.2) PW RTLS GUID (4.4)	V	±1	-	***
	MM_CODE_101	Major Mode 101 flag	MSC	B	0, 1	-	1.04/ 1.04/ 1.04
	MM_CODE_102	Major Mode 102 flag	MSC	B	0, 1	-	1.04/ 1.04/ 1.04
	MM_CODE_103	Major Mode 103 flag	MSC	B	0, 1	-	1.04/ 1.04/ 1.04
	MM_CODE_601	Major Mode 601 flag	MSC	B	0, 1	-	1.04/ 1.04/ 1.04
<p>**Computed once by ATT_PROC_INIT when beginning MM 101; then recomputed once by ASC UPP when first entering MM 102, ***Sampled at 1.04 Hz in MM 101, 102, 103, and 601, and at 0 Hz elsewhere.</p>							

Table 4.6.2-1. ATT_PROC Input/Output (Cont)

Module	Name	Description	Source or Destination	Type	Range	Unit	Rate Required/Produced (Hz)
ATT_PROC_OUTER (Cont)	<u>Inputs (Cont)</u>						
	V_AVGG	Shuttle velocity vector	ASC UPP (4.19) RTLS UPP (4.20) ENT UPP (4.23) TAEM UPP (4.24) A/L UPP (4.25)	V	-1, 0, +1	ft/s	1.04/ 1.04/0
	ATT_SEL_SW(K)	ADI mode switch ADI _K	GN&C SW RM (4.180)	A(2)I		-	1.04/ 1.04/0
	IMU_ALIGN_DISP	IMU ALIGN DISP active flag	MSC	B	0, 1	-	0/1.04**/0
	SDP(K)	Sine 1/2 gimbal non-orth, IMU _K , K = 1, 2, 3	ORB ATT PROC (4.97)	A(3)S	±1	-	0/1.04*/0
	CDP(K)	Cosine 1/2 gimbal non-orth, IMU _K , K = 1, 2, 3	ORB ATT PROC (4.97)	A(3)S	±1	-	0/1.04*/0
	Q_SM_M50(K)	Stable member wrt M50 quaternion, IMU _K	ORB ATT PROC (4.97)	Struc (3) S, V	±1	-	0/1.04*/0
	<u>Outputs</u>						
	PSI_IMU(K)	M50 to body Euler angle, IMU _K , K = 1, 2, 3	IMU ALIGN DISP (6.26)	A(3)S	0-360	deg	0/1.04**/0
	THETA_IMU(K)	M50 to body Euler angle, IMU _K , K = 1, 2, 3	IMU ALIGN DISP (6.26)	A(3)S	0-90, 270-360	deg	0/1.04**/0
	PHI_IMU(K)	M50 to body Euler angle, IMU _K , K = 1, 2, 3	IMU ALIGN DISP (6.26)	A(3)S	0-360	deg	0/1.04**/0
	Q_SM_SM(K)	Platform wrt platform quaternion, IMU pair K	IMU RM (4.72), TLM	Struc (3) S, V	±1	-	1.04/ 1.04/ 1.04
	Q_ROLL_SM(K)	Roll wrt stable member quaternion IMU _K , K = 1, 2, 3	TLM	Struc (3) S, V	±1	-	1.04/ 1.04/ 1.04
	Q_LVLH_BIASLVLH	LVLH wrt BIASLVLH ADI quat	TLM	Struc S, V	±1	-	1.04/ 1.04/0
Q_M50_LVLH	M50 wrt LVLH quat	TLM, ASC MNVR DIP (4.210) DEORBIT MNVR DIP (4.211)	Struc S, V	±1	-	1.04/ 1.04/0	

*Initialized once on transition to MM 301 by ORB_ATT_PROC and subsequently used at 1.04 Hz.
**In MM 301 only.

Table 4.6.2-1. ATT_PROC Input/Output (Cont)

Module	Name	Description	Source or Destination	Type	Range	Unit	Rate Required/Produced (Hz)
ATT_PROC_INNER	<u>Inputs</u>						
	CLOCKTIME	Current time	FCOS	S	>0	s	12.5/ 12.5/ 6.25
	T_INUS_GA	INU gimbal angle time tag	INU INT PROC (4.38)	S	>0	s	12.5/ 12.5/ 6.25
	ATT_DG	Attitude data good flag	INU RM (4.72)	B	0, 1	-	12.5/ 12.5/ 6.25
	<u>Outputs</u>						
	Q_B_I	Body wrt M50 quaternion	ENT UPP (4.23) G/C STEER (4.175) TRANS DAP (4.201) AS MNVE DIP (4.210) ENT NAV (4.127) DEORB MNVE DIP (4.211) DEORB GUID (4.209) ORB INS GUID (4.3) TLM, GN&C/SM-PL IF (4.111)	Struc S, V	sl	-	12.5/ 12.5/ 6.25
	RATE_GYRO_CORR	Compensated body rate	TRANS DAP (4.201)	V	±0	deg	0/12.5/ 0
	PAYLOAD_PITCH	Pitch Euler angle, EF to body	GN&C/SM-PL IF (4.111)	S	±π	rad	0/0.52π/ 0
	PAYLOAD_YAW	Yaw Euler angle, EF to body	GN&C/SM-PL IF (4.111)	S	±π/2	rad	0/0.52π/ 0
	PAYLOAD_ROLL	Roll Euler angle, EF to body	GN&C/SM-PL IF (4.111)	S	±π	rad	0/0.52π/ 0
ATTITUDE_INCREMENT	Body attitude increment	TRANS DAP (4.201), TLM, ORB DAP (4.35)**	V	±10	deg	0/12.5/0	
T_NOW	M50 to body quaternion time tag	TRANS DAP (4.201) GN&C/SM-PL IF (4.111), TLM	S	>0	s	0/12.5/0	
ATT_PROC_EULER	<u>Inputs</u>						
ANGLE_CORR_INTOMAG_RM	Magnetic declination at runway	ENTRY SITE LOOKUP (4.124) ASC SITE LOOKUP (4.288)	S	0-2π	rad	0/0/ 6.25	
<p>*During M5 301, 302, 303 only. **Carryover to OPS 2</p>							

Table 4.6.2-1. ATT_PROC Input/Output (Cont)

Module	Name	Description	Source or Destination	Type	Range	Unit	Rate Required/Produced (Hz)
ATT_PROC_INNER	<u>Inputs</u>						
	CLOCKTIME	Current time	PCOS	S	>0	s	12.5/ 12.5/ 6.25
	T_INUS_GA	IMU gimbal angle time tag	IMU INT PROC (4.38)	S	>0	s	12.5/ 12.5/ 6.25
	ATT_DG	Attitude data good flag	IMU EM (4.72)	B	0, 1	-	12.5/ 12.5/ 6.25
	<u>Outputs</u>						
	Q_B_I	Body wrt NSO quaternion	ENT UPF (4.23) G/C STEER (4.175) TRANS DAP (4.201) AS MNVR DIP (4.210) ENT NAV (4.127) DEORB MNVR DIP (4.211) DEORB GUID (4.209) ORB INS GUID (4.3) TLM, GN&C/SM-PL IF (4.111)	Struc S, V	al	-	12.5/ 12.5/ 6.25
	RATE_GYRO_CORR	Compensated body rate	TRANS DAP (4.201)	V	±40	deg	0/12.5/ 0
	PAYLOAD_PITCH	Pitch Euler angle, EF to body	GN&C/SM-PL IF (4.111)	S	±π	rad	0/0.52*/ 0
	PAYLOAD_YAW	Yaw Euler angle, EF to body	GN&C/SM-PL IF (4.111)	S	±π/2	rad	0/0.52*/ 0
	PAYLOAD_ROLL	Roll Euler angle, EF to body	GN&C/SM-PL IF (4.111)	S	±π	rad	0/0.52*/ 0
ATTITUDE_INCREMENT	Body attitude increment	TRANS DAP (4.201), TLM, ORB DAP (4.35)**	V	±10	deg	0/12.5/0	
T_BOW	NSO to body quaternion time tag	TRANS DAP (4.201) GN&C/SM-PL IF (4.111), TLM	S	>0	s	0/12.5/0	
ATT_PROC_EULER	<u>Inputs</u> ANGLE_CORR_INTOMAG_EV	Magnetic declination at runway	ENTRY SITE LOOKUP (4.124) ASC SITE LOOKUP (4.288)	S	0-2π	rad	0/0/ 6.25

*During TM 301, 302, 303 only.
**Carryover to OPS 2

Table 4.6.2-1. ATT_PROC Input/Output (Cont)

Module	Name	Description	Source or Destination	Type	Range	Unit	Rate Required/Produced (Ms)
ATT_PROC_INNER	<u>Inputs</u>						
	CLOCKTIME	Current time	PCOS	S	>0	s	12.5/ 12.5/ 6.25
	T_IMUS_GA	IMU gimbal angle time tag	IMU INT PROC (4.38)	S	>0	s	12.5/ 12.5/ 6.25
	ATT_DG	Attitude data good flag	IMU EM (4.72)	S	0, 1	-	12.5/ 12.5/ 6.25
	<u>Outputs</u>						
	Q_B_I	Body wrt H50 quaternion	ENT UPP (4.23) G/C STEER (4.175) TRANS DAP (4.201) AS MNVR DIP (4.210) ENT MAV (4.127) DEORS MNVR DIP (4.211) DEORS GUID (4.209) ORS INS GUID (4.3) TLM,GN&C/SM-PL IF (4.111)	Struc S, V	±1	-	12.5/ 12.5/ 6.25
	RATE_GYRO_CORR	Compensated body rate	TRANS DAP (4.201)	V	±60	deg	0/12.5/ 0
	PAYLOAD_FITCH	Pitch Euler angle, EF to body	GN&C/SM-PL IF (4.111)	S	±π	rad	0/0.52*/ 0
	PAYLOAD_YAW	Yaw Euler angle, EF to body	GN&C/SM-PL IF (4.111)	S	±π/2	rad	0/0.52*/ 0
	PAYLOAD_ROLL	Roll Euler angle, EF to body	GN&C/SM-PL IF (4.111)	S	±π	rad	0/0.52*/ 0
ATTITUDE_INCREMENT	Body attitude increment	TRANS DAP (4.201), TLM, ORS DAP (4.35)**	V	±10	deg	0/12.5/0	
T_NOW	H50 to body quaternion time tag	TRANS DAP (4.201) GN&C/SM-PL IF (4.111), TLM	S	>0	s	0/12.5/0	
ATT_PROC_EULER	<u>Inputs</u> ANGLE_CORR_INTOMAG_HW	Magnetic declination at runway	ENTRY SITE LOOKUP (4.124) ASC SITE LOOKUP (4.288)	S	0-2π	rad	0/0/ 6.25

*During MM 301, 302, 303 only.
**Carryover to OPS 2

Table 4.6.2-1. ATT_PROC Input/Output (Cont)

Module	Name	Description	Source or : Location	Type	Range	Unit	Rate Required/ Produced (Hz)
ATT_PROC EULER (Cont)	<u>Outputs</u>						
	V_RHO	Earth-relative velocity	ASC UPP (4.19) RLTS UPP (4.20) ENTRY UPP (4.23) TAEM UPP (4.24) A/L UPP (4.25)	V		ft/s ft/s	6.25/ 6.25/ 6.25
	COSPHI	Cos(PHI)	TAEM GUID (4.9) AEROJET DAP (4.36) GRTLS TAEM GUID (4.204) GRTLS DAP (4.227) VERT SIT DIP (4.154), TLM	S	±1	-	0/0/ 6.25
	SINPHI	Sin(PHI)	AEROJET DAP (4.36) GRTLS DAP (4.227) TLM	S	±1	-	0/0/ 6.25
	BANK	Bank angle	ENT DIP (4.150)	S	±180	deg	0/0/ 6.25
	BETA_N	Nav-derived sideslip angle	AEROJET DAP (4.36) ET SEP SEQ (4.116) GRTLS DAP (4.227) ENT PREC PRED (4.223) ASC PREC PRED (4.236) ASC NAV (4.15) ENT NAV (4.127) RLTS NAV (4.205) HSI PROC (4.104) HORIZ SIT SPEC (5.7), TLM	S	±10	deg	6.25/ 6.25/ 6.25

Module
ATT_PROC
EULER (Cont)

Table 4.6.2-1. ATT_PROC Input/Output (Cont)

Module	Name	Description	Source or :	Type	Range	Unit	Rate Required/ Produced (Hz)
ATT_PROC EULER (Cont)	<u>Outputs</u>						
	V_RHO	Earth-relative velocity	ASC UPP (4.19) RLTS UPP (4.20) ENTRY UPP (4.23) TAEM UPP (4.24) A/L UPP (4.25)	V		ft/s ft/s	6.25/ 6.25/ 6.25
	COSPFI	Cos(PHI)	TAEM GUID (4.9) AEROJET DAP (4.36) GRTLS TAEM GUID (4.204) GRTLS DAP (4.227) VERT SIT DIP (4.154), TLM	S	±1	-	0/0/ 6.25
	SINPHI	Sin(PHI)	AEROJET DAP (4.36) GRTLS DAP (4.227) TLM	S	±1	-	0/0/ 6.25
	BANK	Bank angle	ENT DIP (4.150)	S	±180	deg	0/0/ 6.25
	BETA_N	Nav-derived sideslip angle	AEROJET DAP (4.36) ET SEP SEQ (4.116) GRTLS DAP (4.227) ENT PREC PRED (4.223) ASC PREC PRED (4.236) ASC NAV (4.15) ENT NAV (4.127) RTLS NAV (4.205) HSI PROC (4.104) HORIZ SIT SPEC (5.7), TLM	S	±10	deg	6.25/ 6.25/ 6.25

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Table 4.6.2-1. ATT_PROC Input/Output (Cont)

Module	Name	Description	Source or Destination	Type	Range	Unit	Rate Required/Produced (Hz)
ATT_PROC EULER (Cont)	<u>Outputs (Cont)</u>						
	ALPHA_N	Compensated nav-derived angle of attack	GC STEER (4.175) ADTA SOP (4.39) ET SEP SEQ (4.116) RTLS UPP (4.20) ENTRY UPP (4.23) TAEM UPP (4.24) A/L UPP (4.25) AEROJET DAP (4.36) ASC NAV (4.15) ENT NAV (4.127) RTLS NAV (4.205) ENT PREC PRED (4.223) AMI PROC (4.105) ASC PREC PRED (4.236) GRTLS DAP (4.227), TLM ASC ISTG GUID (4.1)	S	±90	deg	6.25/ 6.25/ 6.25
	PSI_HSIMV	Heading relative to magnetic north	ENT AREA NAV (4.220) ASC AREA NAV (4.237) E/L ADI PROC (4.103)	S	±2°	rad	0/0 6.25
	PSI	Body yaw angle	TLM	S	±180	deg	0 0 6.25
	UBI	First component of body frame relative velocity vector	GRTLS DAP (4.227)	S		ft/s	6.25 6.25 6.25
	THETA	Body pitch angle	RTLS UPP (4.20) A/L UPP (4.25) TAEM UPP (4.24) AEROJET DAP (4.36) PRELAND NAV (4.144) RTLS NAV (4.205) GRTLS DAP (4.227) TLM VERT SIT DIP (4.154) LANDING SOP (4.37)	S	±90	deg	0/0/ 6.25
	SINTH	Sin(THETA)	RTLS UPP (4.20) TAEM UPP (4.24) A L UPP (4.25) AEROJET DAP (4.36), TLM GRTLS DAP (4.227) HLD PROC (4.252)	S	±1	-	0 0 6.25

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Table 4.6.2-1. ATT_PROC Input/Output (Cont)

Module	Name	Description	Source or Destination	Type	Range	Unit	Race Required/Produced (Rs)	
ATT_PROC ESLER (Coac)	<u>Outputs (Coac)</u>							
	COSTH	Cos(THETA)	TAEM GUID (4.9) RTLS UPP (4.20) TAEM UPP (4.24) A/L UPP (4.25) AKROJET DAP (4.36) GRTLS TAEM GUID (4.204) GRTLS DAP (4.227), TLM HUD PROC (4.25.2)	S	nl	-	0/0/ 4.25	
	PHI	Body roll angle	ENT GUID (4.8) AKROJET DAP (4.36) GRTLS DAP (4.227), ENT DIP (4.150) E/L ADI PROC (4.103), WORM SIT (5.7) TLM GRTLS TAEM GUID	S	±180	deg	0/0 6.25	
ATT_PROC_DISP	<u>Inputs</u>							
	V_DN_CURRENT	Selected total accum sensed velocity	INH RM (4.72)	V	±10 ⁶	ft/s	0 1 04 0	
	Q_B_I CMD_DISPLAY	Commanded body wrt M50 quaternion	TRANS DAP (4.201)	Struc S, V	±1	-	0 6.25 0	
	PHD_ATT_REF_PB	Attitude reference PB (LN or RM)	GN&C SW RM (4.180)	S	0, 1	-	6.25 6.25 0	
	DESEL	COAS deselect cmd	STRK/COAS DISP (6.44)	I	0, 1	-	6.25 6.25 0	
	ATT_SEL_SW(K)	ADI mode switch, ADL _K , K = 1, 2	GN&C SW RM (4.180)	A(2)I	-1, 0, +1	-	6.25 6.25 0	
	MM_CODE_101 MM_CODE_102 MM_CODE_103 MM_CODE_601	Major mode code flags	MSC	S	0, 1	-	6.25 6.25 0	
	<u>Outputs</u>							
	DVB-SEC	Body Delta-V over last 0.960 s	TRANS DAP (4.201) ONS RM (4.92) TLM	V	±10	ft s	0 1 04 0	
	BODY_ERR_ANG	Body attitude error	E/L ADI PROC (4.103) ANG ADI PROC (4.168), TLM	V	±180	deg	0 6 0	
	PITCHSINE(K)	ADI pitch sine, ADL _K , K = 1, 2	E/L ADI PROC (4.103) ANG ADI PROC (4.168), TLM	A(2)S	±1	-	3 3 3	

Table 4.6.2-1. ATT_PROC Input/Output (Cont)

Module	Name	Description	Source or Destination	Type	Range	Unit	Rate Required/Produced (Hz)
ATT_PROC_DISP (Cont)	<u>Outputs (Cont)</u>						
	PTCHCOS(K)	ADI pitch cosine, ADI _K , K = 1, 2	E/L ADI PROC (4.103) ASC ADI PROC (4.168), TLM	A(2)S	±1	-	3.125 3.12 3.125
	YAWSINE(K)	ADI yaw sine, ADI _K , K = 1, 2	E/L ADI PROC (4.103) ASC ADI PROC (4.168) TLM	A(2)S	±1	-	3.125 3.125 3.125
	YAWCOS(K)	ADI yaw cosine, ADI _K , K = 1, 2	E/L ADI PROC (4.103) ASC ADI PROC (4.168) TLM	A(2)S	±1	-	3.125 3.125 3.125
	ROLLSINE(K)	ADI roll sine, ADI _K , K = 1, 2	E/L ADI PROC (4.103) ASC ADI PROC (4.168) TLM	A(2)S	±1	-	3.125 3.125 3.12
	ROLLCOS(K)	ADI roll cosine, ADI _K , K = 1, 2	E/L ADI PROC (4.103) ASC ADI PROC (4.168) TLM	A(2)S	±1	-	3.125 3.125 3.125
	Q_M50_REF	M50 wrt REF ADI quat	TLM	Struc S, V	±1	-	3.125 3.125
	Q_M50_INRTL	M50 wrt INRTL ADI quat	TLM	Struc S, V	±1	-	3.125 3.125
	YAW_IY	HSI yaw (PSI) command	HSI PROC (4.104)	S	±π	rad	***
ROLL_SW	HSI heads up (+1) or heads-down (-1) indicator	HSI PROC (4.104)	I	±1	-	***	
ATT_PROC_RGASW	<u>Inputs</u>						
	P_ORB	Roll rate, selected orbiter rate gyro	SF(RGA) (4.71)	S	±π	deg sec	25.125 25
	Q_ORB	Pitch rate, selected orbiter rate gyro	SF(RGA) (4.71)	S	±20	deg sec	25.125 25
	R_ORB	Yaw rate, selected orbiter rate gyro	SF(RGA) (4.71)	S	±20	deg sec	25.125 25
	Q_SRB	Pitch rate, SRB rate gyro	SF(RGA) (4.71)	S	±10	deg sec	25.00
	R_SRB	Yaw rate, SRB rate gyro	SF(RGA) (4.71)	S	±10	deg sec	25.00
SRB_NULL_CMD	Event 27, indicator	ASC_DAP (4.176)	B	0, 1	-	25.00	

***Computed at 3.125 Hz in MM 101, 102, 103, and 601, and at 0 Hz elsewhere.

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Table 4.6.2-1. ATT_PROC Input/Output (Cont)

Module	Name	Description	Source or Destination	Type	Range	Unit	Rate Required/Produced (Hz)
ATT_PROC_RGASW (Cont)	<u>Outputs</u>						
	None						
ADI_QUAT_UPLINK	<u>Inputs</u>						
	OP_CODE	OP code for uplink	Uplink buffer	B	0011000 0011101 0011110	-	on demand
	Q_M50_REF_UL	Uplinked M50 wrt REF ADI quat	Uplink buffer	Struc S, V	±1	-	on demand
	Q_M50_INRTL_UL	Uplinked M50 wrt INRTL ADI quat	Uplink buffer	Struc S, V	±1	-	on demand
	Q_LVLH_BIASLVLH_UL	Uplinked LVLH wrt BIASLVLH ADI quat	Uplink buffer	Struc S, V	±1	-	on demand
	<u>Outputs</u>						
	None						

***Computed at 3.125 Hz in MM 101, 102, 103, and 601, and at 0 Hz elsewhere.

Mod
ATT_PROC
ATT_PROC
INIT
ATT_PROC
OUTER
*Rates er
**Computed
***Sampled

Table 4.6.2-2. ATT_PROC Inter-Module Variables

Module	Name	Description	Source or Destination	Type	Range	Unit	Rate Required/Produced (Hz)*
ATT_PROC	ATT_MODE	ATT_PROC mode	Table 4.6.2-3	I	1-3	-	12.5/ 12.5/ 6.25
ATT_PROC_INIT	<u>Inputs</u>						
	None						
	<u>Outputs</u>						
	$\bar{I}_{YD_M50}^{**}$	Unit vector normal to insertion plane in M50 system	ATT_PROC_OUTER	V	± 1	-	once
	SDP(K)	Sine 1/2 gimbal non-orth, IMU _K , K = 1,2,3	ATT_PROC_OUTER	A(3)S	± 1	-	on demand
	CDP(K)	Cosine 1/2 gimbal non-orth, IMU _K , K = 1,2,3	ATT_PROC_OUTER	A(3)S	± 1	-	on demand
	Q_BODY_ROLL(K)	Body wrt roll gimbal quat, IMU _K , K = 1,2,3	ATT_PROC_OUTER	Struc (3) S,V	± 1	-	on demand
Q_SM_M50(K)	Stable member wrt M50 quat, IMU _K , K = 1,2,3	ATT_PROC_OUTER	Struc (3) S,V	± 1	-	on demand	
Q_ROLL_ROLL(K)	IMU _J wrt IMU _I mounting misalignment quat, IMU pair _K , K = 1,2,3	ATT_PROC_OUTER	Struc (3) S,V	± 1	-	on demand	
ATT_PROC_OUTER	<u>Inputs</u>						
	SDP(K)	Sine 1/2 gimbal non-orth, IMU _K , K = 1,2,3	ATT_PROC_INIT	A(3)S	± 1	-	1.04 1.04 1.04
	CDP(K)	Cosine 1/2 gimbal non-orth, IMU _K , K = 1,2,3	ATT_PROC_INIT	A(3)S	± 1	-	1.04 1.04 1.04
	Q_BODY_ROLL(K)	Body wrt roll gimbal quat, IMU _K , K = 1,2,3	ATT_PROC_INIT	Struc (3) S,V	± 1	-	1.04 1.04 1.04
	Q_ROLL_ROLL(K)	IMU _J wrt IMU _I mounting misalignment quat, IMU pair _K , K = 1,2,3	ATT_PROC_INIT	Struc (3) S,V	± 1	-	1.04 1.04 1.04
	Q_SM_M50(K)	Stable member wrt M50 quaternion, IMU _K , K = 1,2,3	ATT_PROC_INIT	Struc (3) S,V	± 1	-	1.04 1.04 1.04
	$\bar{I}_{YD_M50}^{**}$	Unit vector normal to insertion plane in M50 system	ATT_PROC_INIT	V	± 1	-	***
	Q_LVLH_BIAS_LVLH	Uplinked LVLH wrt BIAS_LVLH ADI quat	ADI QUAT_UPLINK	Struc S,V	± 1	-	on demand

*Rates are given as X/Y/Z in Hz. Rate is X in ascent, Y in transition, and Z in entry.
 **Computed once by ATT_PROC_INIT when MM 101 is begun, then recomputed once by ASC UPP when MM 102 is begun.
 ***Sampled at 1.04 Hz in MM 101, 102, 103, and 601 (at 0 Hz elsewhere).

Table 4.6.2-2. ATT_PROC Inter-Module Variables (Cont)

Module	Name	Description	Source or Destination	Type	Range	Unit	Rate Required/Produced (Hz)
ATT_PROC_OUTER (Cont)	<u>Outputs</u>						
	QBI_UPDATE	Body wrt M50 quaternion using IMU data	ATT_PROC_INNER	Struc S,V	±1	-	1.04/ 1.04/ 1.04
	Q_M50_TD	M50 wrt topodetic quaternion	ATT_PROC_EULER	Struc S,V	±1	-	0/0/ 1.04
	Q_M50_BIASLVLH	M50 wrt BIASLVLH ADI quat	ATT_PROC_DISP	Struc S,V	±1	-	*
	Q_M50_REF	M50 wrt REF ADI quaternion	ATT_PROC_DISP	Struc S,V	±1	-	**
	Q_M50_LVIY	M50 wrt ascent LVIY ADI quaternion	ATT_PROC_DISP	Struc S,V	±1	-	***
ATT_PROC_INNER	<u>Inputs</u>						
	QBI_UPDATE	Body wrt M50 quaternion using IMU DATA	ATT_PROC_OUTER	Struc S,V	±1	-	1.04/ 1.04/ 1.04
	P_FIL	Filtered selected RGA roll rate	ATT_PROC_PREFIL	S	±40	deg/s	12.5/ 12.5/ 6.25
	Q_FIL	Filtered selected RGA pitch rate	ATT_PROC_PREFIL	S	±20	deg/s	12.5/ 12.5/ 6.25
	R_FIL	Filtered selected RGA yaw rate	ATT_PROC_PREFIL	S	±20	deg/s	12.5/ 12.5/ 6.25
	INT_ROLL_INC	Integrated roll attitude increment	ATT_PROC_DISP	S	0	deg	0/6.25/ 0
	<u>Outputs</u>						
	Q_B_I	Body wrt M50 quaternion	ATT_PROC_EULER, _DISP	Struc S,V	±1	-	12.5/ 12.5/ 6.25
ATT_PROC_EULER	<u>Inputs</u>						
	Q_M50_TD	M50 wrt topodetic quaternion	ATT_PROC_OUTER	Struc S,V	±1	-	0/0/ 6.25
	Q_B_I	Body wrt M50 quaternion	ATT_PROC_INNER	Struc S,V	±1	-	6.25/ 6.25/ 6.25

*At 1.04 Hz when ATT_MODE ≠ ENTRY and when not in MM 101, 102, 103 AND 601 (at 0 Hz elsewhere).

**At 1.04 Hz when in MM 101, 0 Hz elsewhere.

***At 1.04 when ATT_MODE ≠ ENTRY and when in MM 101, 102, 103, 601 (at 0 Hz elsewhere).

Module
ATT_PROC_E
(Cont.)
ATT_PROC_DI
*At 1.04 Hz
**At 1.04 Hz
***At 1.04 Hz

Table 4.6.2-2. ATT_PROC Inter-Module Variables (Cont)

Module	Name	Description	Source or Destination	Type	Range	Unit	Rate Required/Produced (Hz)
ATT_PROC_EULER (Cont)	<u>Outputs</u>						
	SINTH	Sin(THETA)	ATT_PROC_DISP	S	±1	-	0 0 6.25
	COSTH	Cos(THETA)	ATT_PROC_DISP	S	±1	-	0 0 6.25
	SINPHI	Sin(PHI)	ATT_PROC_DISP	S	±1	-	0 0 6.25
	COSPHI	Cos(PHI)	ATT_PROC_DISP	S	±1	-	0 0 6.25
ATT_PROC_DISP	<u>Inputs</u>						
	Q_B_I	Body wrt M50 quaternion	ATT_PROC_INNER	Struc S,V	±1	-	3.125 6.25 3.125
	Q_M50_BIASLVLH	M50 wrt BIASLVLH ADI quat	ATT_PROC_OUTER	Struc S,V	±1	-	*
	SINTH	Sin(THETA)	ATT_PROC_EULER	S	±1	-	0/0 3.125
	COSTH	Cos(THETA)	ATT_PROC_EULER	S	±1	-	0 0 3.125
	Q_M50_LVIY	M50 wrt ascent LVIY quaternion	ATT_PROC_OUTER	Struc S,V	±1	-	**
	Q_M50_REF	M50 wrt REF ADI quaternion	ATT_PROC_OUTER	Struc S,V	±	-	***
	SINPHI	Sin(PHI)	ATT_PROC_EULER	S	±1	-	0 0 3.125
	COSPHI	Cos(PHI)	ATT_PROC_EULER	S	±1	-	0 0 3.125
	Q_M50_INRTL	Uplinked M50 wrt INRTL ADI	ADI_QUAT_UPLINK	Struc S,V	±1	None	on demand
Q_M50_REF	Uplinked M50 wrt REF ADI	ADI_QUAT_UPLINK	Struc S,V	±1	None	on demand	
	<u>Outputs</u>						
	INT ROLL INC	Integrated roll attitude increment	ATT_PROC_INNER	S	0	deg	0 6.25 0
<p>*At 1.04 Hz when ATT MODE ≠ ENTRY and when not in MM 101, 102, 103, or 601 (at 0 Hz elsewhere). **At 1.04 Hz when ATT MODE ≠ ENTRY and when in MM 101, 102, 103, or 601 (at 0 Hz elsewhere) ***At 1.04 Hz when in MM 101 (at 0 Hz elsewhere).</p>							

Table 4.6.2-2. ATT_PROC Inter-Module Variables (Cont)

Module	Name	Description	Source or Destination	Type	Range	Unit	Rate Required/Produced (Hz)
ATT_PROC_PREFIL	<u>Inputs</u>						
	P	Selected RGA roll rate	ATT_PROC_RGASW	S	±40	deg/s	25/12.5/25
	Q	Selected RGA pitch rate	ATT_PROC_RGASW	S	±20	deg/s	25/12.5/25
	R	Selected RGA yaw rate	ATT_PROC_RGASW	S	±20	deg/s	25/12.5/25
	<u>Outputs</u>						
	P_FIL	Filtered selected RGA roll rate	ATT_PROC_INNER	S	±40	deg/s	25.0/12.5*/12.5
Q_FIL	Filtered selected RGA pitch rate	ATT_PROC_INNER	S	±20	deg/s	25.0/12.5*/12.5	
R_FIL	Filtered selected RGA yaw rate	ATT_PROC_INNER	S	±20	deg/s	25.0/12.5*/12.5	
ATT_PROC_RGASW	<u>Inputs</u>						
	None						
	<u>Outputs</u>						
	P	Selected RGA roll rate	ATT_PROC_PREFIL	S	±40	deg/s	25/12.5/25
Q	Selected RGA pitch rate	ATT_PROC_PREFIL	S	±20	deg/s	25/12.5/25	
R	Selected RGA yaw rate	ATT_PROC_PREFIL	S	±20	deg/s	25/12.5/25	
ADI_QUAT_UPLINK	<u>Inputs</u>						
	None						
	<u>Outputs</u>						
	Q_M50_INRTL	Uplinked M50 wrt INRTL ADI quat	ATT_PROC_DISP	Struc S,V	±1	-	on demand
Q_M50_REF	Uplinked M50 wrt REF ADI quat	ATT_PROC_DISP	Struc S,V	±1	-	on demand	
Q_LVLH_BIASLVLH	Uplinked LVLH wrt BIASLVLH quat	ATT_PROC_OUTER	Struc S,V	±1	-	on demand	
*During ATT_MODE = TRANSITION, these parameters are set equal to the selected orbiter RGA rates and are not filtered.							

Module
ATT_PROC
ATT_PROC_INN
ATT_PROC_EUL
ATT_PROC_DISP
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Table 4.6.2-3. ATT_PROC Initialization Requirements

Module	Name	Initialize on Transition		Variable	Initial Value	Unit
		From	To			
ATT_PROC	ATT_PROC mode	OPS 9	OPS 1	ATT_MODE	1	-
	ATT_PROC mode	on MECO_CMD flag in MM 103		ATT_MODE	2	-
	ATT_PROC mode	on MECO_CMD flag in MM 102**		ATT_MODE		
	ATT_PROC mode	on MM 304 flag		ATT_MODE	3	-
	ATT_PROC mode	on MM 602 flag		ATT_MODE	3	
ATT_PROC_INNER	ATT_PROC time increment	OPS 9	OPS 1	DELTIME	0.08	s
	ATT_PROC time increment	OPS 1 or OPS 2	OPS 3	DELTIME	0.08	s
	ATT_PROC time increment	ATT_MODE = 2	ATT_MODE = 3	DELTIME	0.16	s
	Body rate vector	OPS 9	OPS 1	RATE_GYRO_READ	0	rad/s
	Body rate vector	OPS 2	OPS 3	RATE_GYRO_READ	0	rad/s
	Integrated roll attitude increment	OPS 9	OPS 1	INT_ROLL_INC	0	deg
	Integrated roll attitude increment	OPS 2	OPS 3	INT_ROLL_INC	0	deg
	Rate bias	OPS 9	OPS 1	W_BIAS	0	rad/s
	Rate bias	OPS 2	OPS 3	W_BIAS	0	rad/s
	Rate gyro correction	OPS 9	OPS 1	RG_CORR	0	rad/s
	Rate gyro correction	OPS 2	OPS 3	RG_CORR	0	rad/s
ATT_PROC_EULER	Initial angle-of-attack and angle-of-sideslip commands	OPS 0	OPS 1 (MM 101)	ALPHA_N BETA_N	0 0	deg deg
ATT_PROC_DISP	$\Delta \bar{V}$ body over last 0.96 s	OPS 9	OPS 1	$\bar{DVB_SEC}$	0	ft/s
	$\Delta \bar{V}$ body over last 0.96 s	OPS 2	OPS 3	$\bar{DVB_SEC}$	0	ft/s
	Previous $\bar{V_IMU_CURRENT}$	ATT_MODE = 1	ATT_MODE = 2	$\bar{V_IMU_OLD}$	$\bar{V_IMU_CURRENT}$	ft/s
	Quaternion of M50 frame wrt ADI INRTL frame during ascent	OPS 0	OPS 1	Q_M50_INRTL	*	
	Quaternion of M50 frame wrt ADI INRTL frame during entry	OPS 1 or OPS 2	OPS 3	Q_M50_INRTL	*	

*Value specified in A/E ATT_PROC KLOAD
** i.e., for fast ET SEP, remain in ASCENT mode)

Table 4.6.2-3. ATT_PROC Initialization Requirements (Cont)

Module	Name	Initialize on Transition		Variable	Initial Value	Unit
		From	To			
ATT_PROC_DISP (CONT)	Quaternion of M50 frame wrt ADI REF frame during entry	OPS 1 or OPS 2	OPS 3	Q_M50_REF	****	-
	Initial ADI/MSI commands	OPS 9	OPS 1 (MM 101)	PTCMSINE(K) PTCCOS(K) YAWSINE(K) Per ROLLSINE(K) ADI _x YAWCOS(K) K=1,2 ROLLCOS(K) YAW_Y ROLL_SW	* * 0 * 1 * 0 -1	- - - - - rad -
	Previous \bar{V} _IMU_CURRENT	OPS 1 or OPS 2	OPS 3	V_IMU_OLD	\bar{V} _IMU_CURRENT	ft/s
	Commanded body attitude quaternion	OPS 9 OPS 2	OPS 1 OPS 3	Q_B_I_CMD_DISPLAY Q_B_I_CMD_DISPLAY	Q_B_I Q_B_I	- -
ATT_PROC_PREFIL	Prefilter states	OPS 0	OPS 1	P_FILL1, Q_FILL1, R_FILL1 P_FIL01, Q_FIL01 R_FIL01	0	deg/s
	Prefilter states	OPS 1 or OPS 2	OPS 3	P_FILL1, Q_FILL1, R_FILL1, P_FIL01, Q_FIL01, R_FIL01	0	deg/s
	RGA prefilter init flag	OPS 9	OPS 1	PRE_FILT_INT	ON	-
	RGA prefilter init flag	OPS 1 or OPS 2	OPS 3	PRE_FILT_INT	ON	-
	Entry RGA prefilter 2nd-stage flag	OPS 9	OPS 1	2ND_STAGE_FILT	ON	-
	Entry RGA prefilter 2nd-stage flag	OPS 1 or OPS 2	OPS 3	2ND_STAGE_FILT	ON	-
	RGA prefilter entry initialization flag	OPS 9	OPS 1	PRE_FILT_ENTRY	OFF	-
	RGA prefilter entry initialization flag	OPS 1 or OPS 2	OPS 3	PRE_FILT_ENTRY	OFF	-
ATT_PROC_OUTER	Quaternion of LVLH frame wrt BIASLVLH frame during ascent	OPS 9	OPS 1	Q_LVLH_BIASLVLH	****	-
	Quaternion of LVLH frame wrt BIASLVLH frame during entry	OPS 1 or OPS 2	OPS 3	Q_LVLH_BIASLVLH	****	-
	IMU ALIGN DISP active flag	OPS 9	OPS 1	IMU_ALIGN_DISP	0	-
	Body wrt M50 quaternion using IMU data	OPS 2 or OPS 8	OPS 3	QBI_UPDATE	Q_B_M50**	-
	Body wrt M50 quaternion using IMU data	OPS 1	OPS 3	QBI_UPDATE	Q_B_I***	-

*Value specified in A/E ATT_PROC ILOAD.
**Value carried over from On-orbit ATT_PROC
***Value carried over from A/E ATT_PROC in OPS 1
****Value specified in A/E ATT_PROC K-load

Module
 ATT_PROC_DISP
 ATT_PROC_IN
 ATT_PROC_EU
 ATT_PROC_DI
 ATT_PROC_IN
 ATT_PROC_PR

Table 4.6.2-4. ATT_PROC I-Loads/K-Loads

Module	Name	Description	Type	MSID/ Value	Unit
ATT_PROC_OUTER	Q_LVLH_BIASLVLH_ASCENT	Quaternion of LVLH frame wrt BIASLVLH frame during ascent	Struc S,V	V97U2210CA to V97U2213CA	-
	Q_LVLH_BIASLVLH_ENTRY	Quaternion of LVLH frame wrt BIASLVLH frame during entry	Struc S,V	V97U2210CB to V97U2213CB	-
ATT_PROC_INNER	DTIMU	Delta time from start of 40 ms period to IMU read	S	V97U1780C	s
ATT_PROC_EULER	JB_EPS	Test value of earth-relative velocity computation in body X-Z plane	S	V97U1315C	ft sec
ATT_PROC_DISP	Q_M50_INRTL_ASCENT	Quaternion of M50 frame wrt ADI INRTL frame during ascent	Struc S,V,	V97U2214CA to V97U2217CA	-
	Q_M50_INRTL_ENTRY	Quaternion of M50 frame wrt ADI INRTL frame during entry	Struc S,V,	V97U2214CB to V97U2217CB	-
	Q_M50_REF_ENTRY	Quaternion of M50 frame wrt ADI REF frame during entry	Struc S,V,	V97U2218CB to V97U2221CB	-
	ROLLSINE(1)	ADI roll sine, ADI ₁	S	V90H2208CA	-
	ROLLSINE(2)	ADI roll sine, ADI ₂	S	V90H2206CA	-
	ROLLCOS(1)	ADI roll cosine, ADI ₁	S	V90H2209CA	-
	ROLLCOS(2)	ADI roll cosine, ADI ₂	S	V90H2207CA	-
	PCHSINE(1)	ADI pitch sine, ADI ₁	S	V90H2221CA	-
	PCHSINE(2)	ADI pitch sine, ADI ₂	S	V90H2220CA	-
	PCHCOS(1)	ADI pitch cosine, ADI ₁	S	V90H2222CA	-
PCHCOS(2)	ADI pitch cosine, ADI ₂	S	V90H2218CA	-	
ATT_PROC_INIT	TNBBODY	Nav base to body frame transform matrix	M	V96U7096C to V96U7104C	-
	TNB_CASE(K)	Nav base to IMU case transform matrix, IMU _K , K = 1, 2, 3	A(3)M	V96U7132C to V96U7158C	-
	RGAD(K)	Roll gimbal azimuth offset, IMU _K , K = 1, 2, 3	A(S)S	V99U9559C to V99U9561C	rad
	RGPO(K)	Roll gimbal pitch offset, IMU _K , K = 1, 2, 3	A(3)S	V99U9562C to V99U9564C	rad
	IYD	Unit vector normal to insertion plane in earth-fixed or M50 coordinates	V	V97U4413C V97U4414C V97U4415C	-
	EF_PLANE_SW	EF plane constraint switch	D	V99U7441C	-
ATT_PROC_PREFIL	PRE_R01	First stage filter coefficient for nominal ascent and entry	S	V97U2393C	-
	PRE_R02	First stage filter coefficient for nominal ascent and entry	S	V97U2394C	-
	PRE_R03	First stage filter coefficient for nominal ascent and entry	S	V97U2395C	-
	PRE_R04	Second stage filter coefficient for nominal entry and GRTLS	S	V97U2396C	-
	PRE_R05	Second stage filter coefficient for nominal entry and GRTLS	S	V97U2397C	-
	PRE_R06	Second stage filter coefficient for nominal entry and GRTLS	S	V97U2398C	-

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Table 4.6.2-5. ATT_PROC Constants

Name	Description	Data Type	Precision	Value	Units
ALPHA_GXF1	D_ALPHA first order hold gains	F	S	0.0	-
ALPHA_GXF2		F	S	0.0	-
ALPHA_GXF3		F	S	0.0	-
D_ALPHA_LIM	Limit on D_ALPHA	F	S	10.0	deg
DEG_PER_RAD	Radian to degree conversion	F	S	$180/\pi$	deg/rad
DELTIME	ATT_PROC time increment (ATT_MODE = 1 or 2) (ATT_MODE = 3)	F	S	0.08	s
				0.16	
GX_PRE_R01	First stage filter coefficients for CRTLS	F	S	0.285714	-
GX_PRE_R02		F	S	0.285714	-
GX_PRE_R03		F	S	-0.428572	-
RAD_PER_DEG	Degree to radian conversion	F	S	$\pi/180$	rad/deg

Table 4.6.2-6. Cross-Reference of ATT_PROC Parameter Names
and Source Names

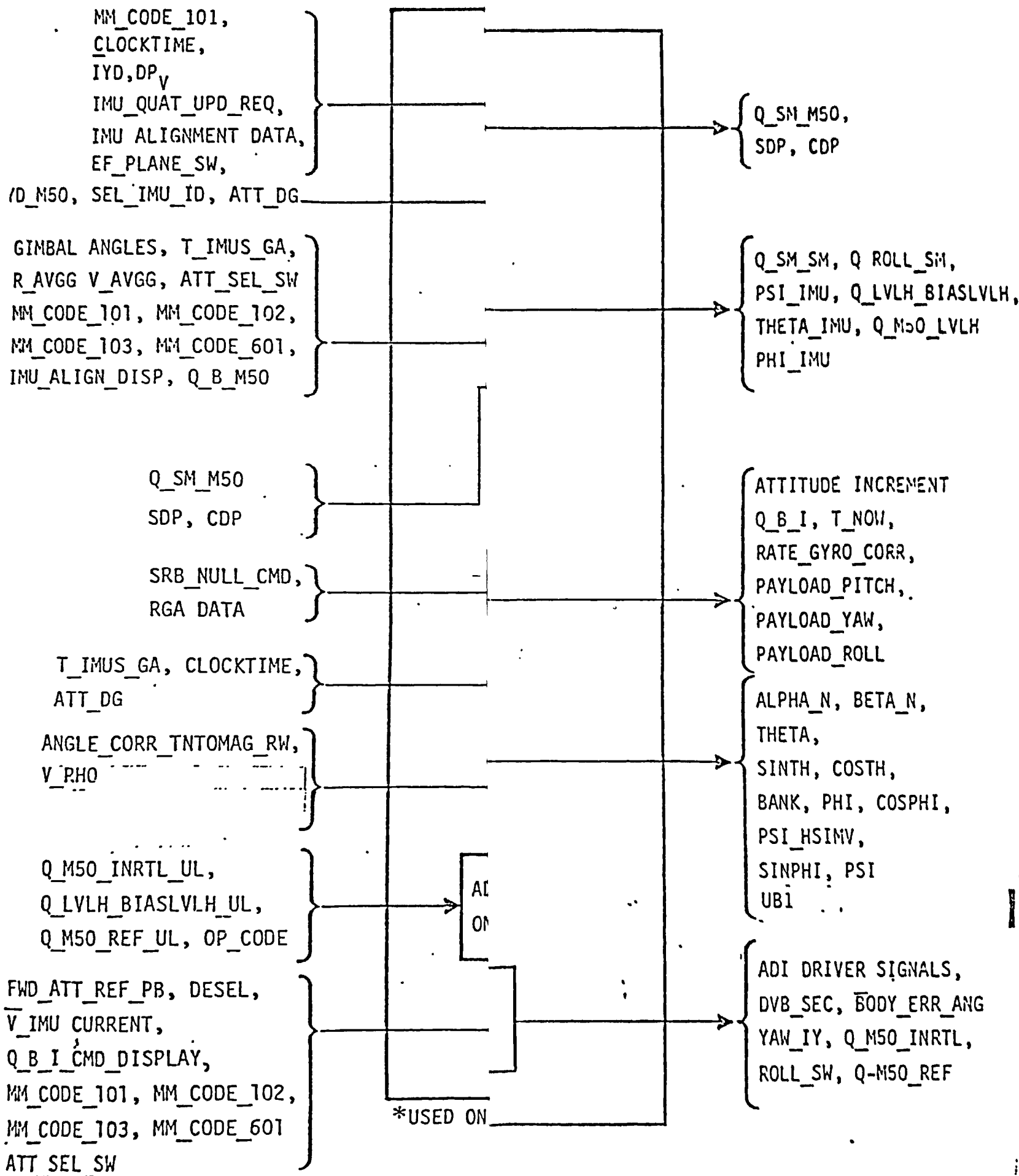
ATT_PROC Parameter	Description	Source Name	Source
CLOCKTIME	Current time	Clock	FCOS
IMU_ALIGN_ DISP	IMU_ALIGN_DISP active flag	IMU_ALIGN_DISPL	MSC
IMU_QUAT UPD_REQ	IMU reference quat update request flag	IMU_QUAT_UPD_ REQ	IMU ORB A/CAL
Q_B_I_CMD_ DISPLAY	Commanded body wrt M50 quaternion	Q_B_I_CMD_DISPL	TRANS DAP
Q_B_M50	Body wrt M50 quaternion computed on-orbit	Q_BOD_M50	ORB_ATT_PROC

4.6.3 Overview and Functional Design

The attitude processor comprises eight modules whose interrelationship is shown in Figure 4.6.3-1. Sequencing of ATT_MODE is shown in Figure 4.6.3-2.

MM
CL
TY
IM
EF
ID_M50, SE
GIMBAL AN
R_AVGG V
MM_CODE_1
MM_CODE_1
IMU_ALIGH

T_IMU
ATT_DC
ANGLE_C
V_RHO
Q_M50_I
Q_LVLH
Q_M50_R
FWD_ATT_RE
V_IMU_CURR
Q_B_I_CMD
MM_CODE_10
MM_CODE_10
ATT_SEL_SW



ATT_PROC Software Overview

MM_CODE_101,
 CLOCKTIME,
 IYD,DP
 IMU_QUAT_UPD_REQ,
 IMU ALIGNMENT DATA,
 EF_PLANE_SW,
 /D_M50, SEL_IMU_ID, ATT_DG

GIMBAL ANGLES, T_IMUS_GA,
 R_AVGG V_AVGG, ATT_SEL_SW
 MM_CODE_101, MM_CODE_102,
 MM_CODE_103, MM_CODE_601,
 IMU_ALIGN_DISP, Q_B_M50

Q_SM_M50
 SDP, CDP

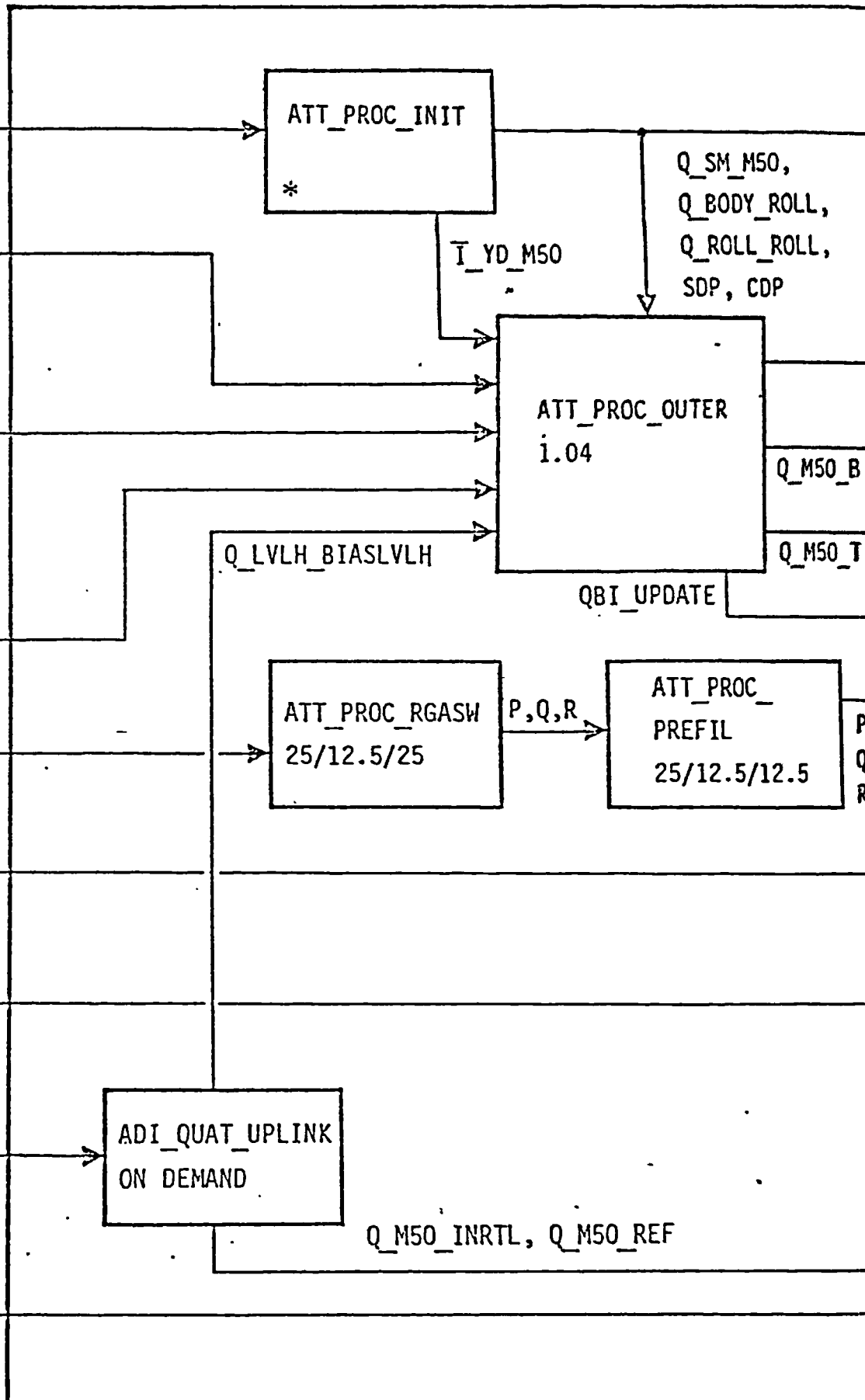
SRB_NULL_CMD,
 RGA DATA

T_IMUS_GA, CLOCKTIME,
 ATT_DG

ANGLE_CORR_TNTOMAG_RW,
 V_RHO

Q_M50_INRTL_UL,
 Q_LVLH_BIASLVLH_UL,
 Q_M50_REF_UL, OP_CODE

FWD_ATT_REF_PB, DESEL,
 V_IMU_CURRENT,
 Q_B_I_CMD_DISPLAY,
 MM_CODE_101, MM_CODE_102,
 MM_CODE_103, MM_CODE_601
 ATT_SEL_SW



*USED ONLY ONCE IN MCI AND AS REQUIRED IN MC3

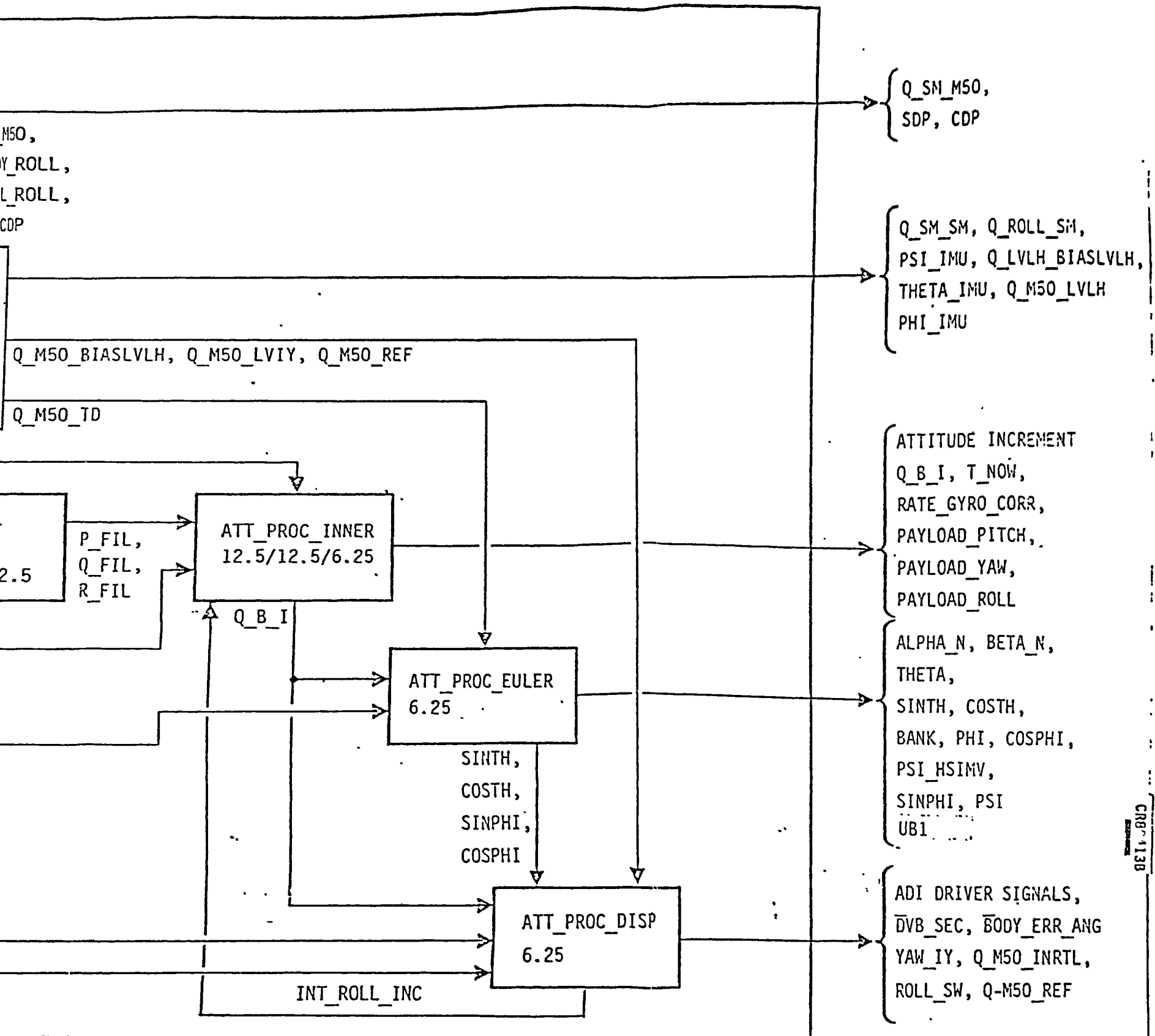
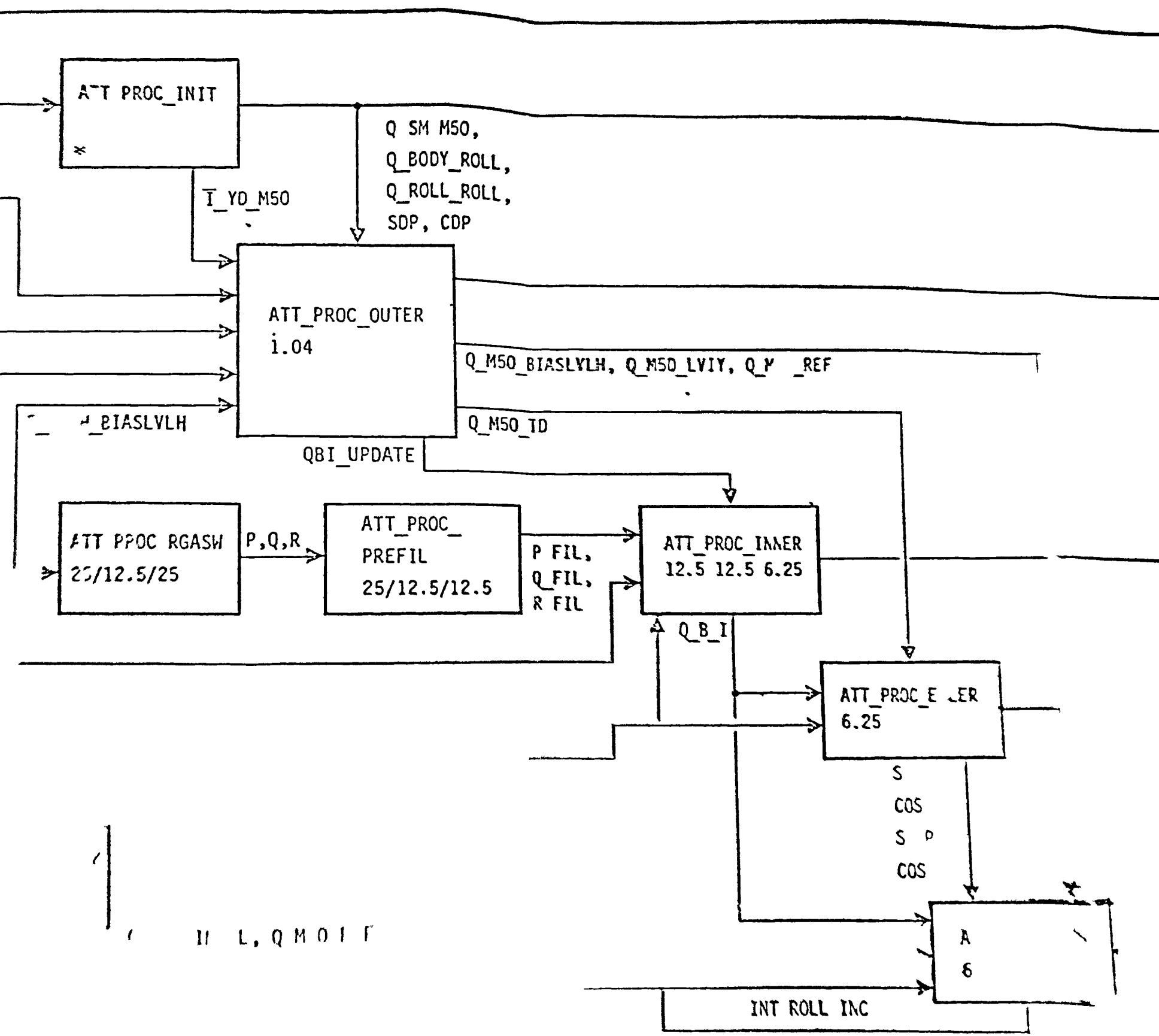


Figure 4.6.3-1. ATT_PROC Software Overview

4.6-21, 4.6-22

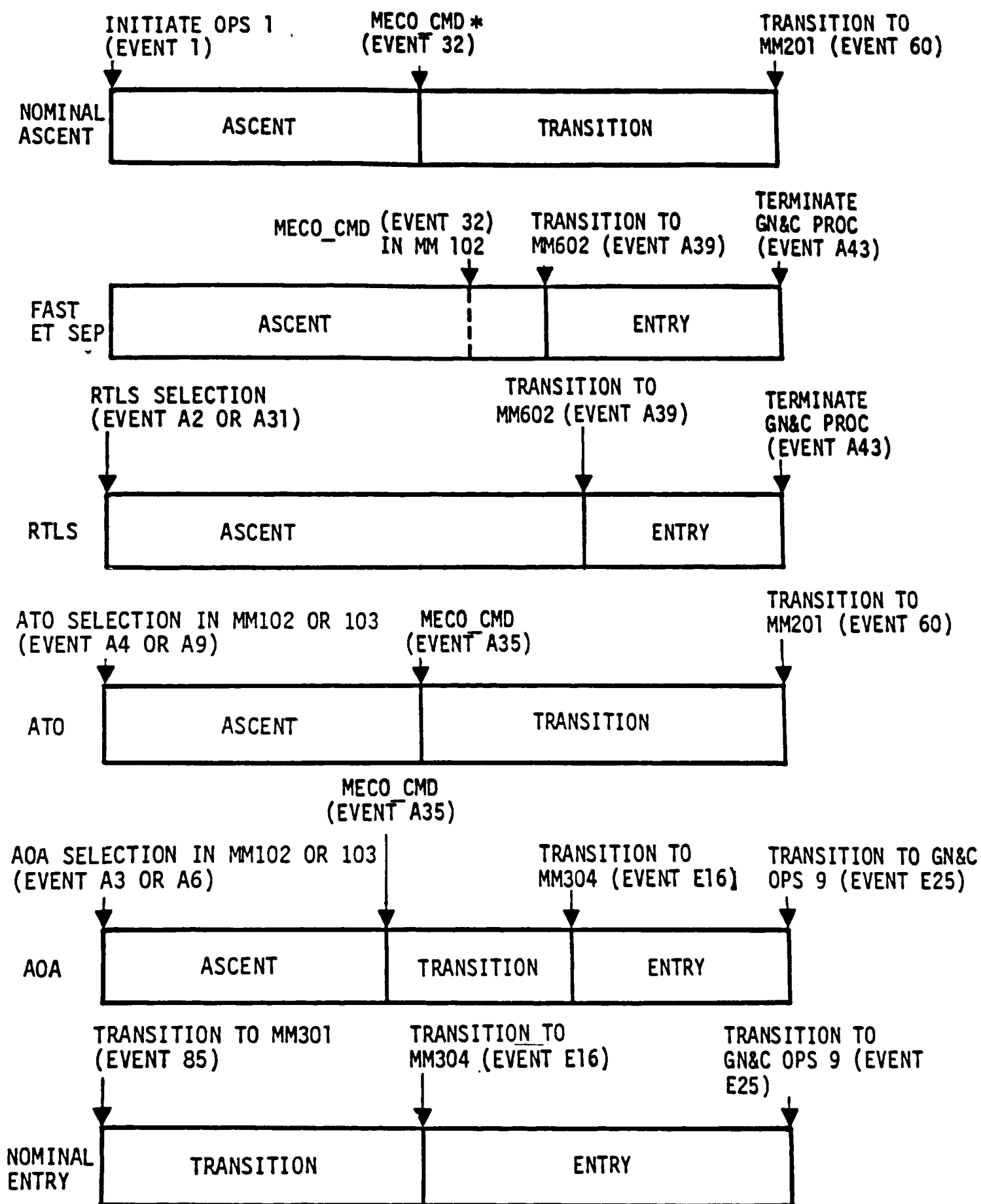
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II M

F 4



*ONLY FOR MECO IN MM103 (i.e., FOR FAST ET SEP STAY IN ASCENT MODE UNTIL MM602)

Figure 4.6.3-2. ATT_PROC Moding

4.6.4 Software Description

The attitude processor comprises eight modules whose interrelationship and processing rates are shown in Figure 4.6.3-1, ATT_PROC Software Overview. Sequencing and processing rates for each module are given in the description of each module.

Much of the processing, particularly of display data, is controlled by an internal flag, ATT_MODE. ATT_MODE is initialized to ASCENT (ATT_MODE = 1) prelaunch. On receipt of the OPS 1 MECO CMD flag, if MM = 103, ATT_MODE is advanced to TRANSITION (ATT_MODE = 2). Otherwise, ATT_MODE remains in ASCENT (e.g., for FAST ET SEP). On receipt of MM304 flag, ATT_MODE is advanced to ENTRY (ATT_MODE = 3). ATT_MODE is advanced directly from ASCENT to ENTRY during FAST ET SEP or RTLS at transition to MM602. Moding is shown in Figure 4.6.3-2. During ASCENT (ATT_MODE = 1) and TRANSITION (ATT_MODE = 2) modes, additional logic branching is shown directly as a function of MSC major modes.

Except where input variables are double precision numbers (for example, \bar{R}_{AVGG} , \bar{V}_{AVGG} , \bar{V}_{RHO} , $\bar{V}_{IMU_CURRENT}$), all processing will be single precision. All ATT_PROC output will be single precision.

The quaternion and direction cosine matrix notation used in this description is explained in Section 4.7.16 of this document.

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4.6.4.1 Attitude Processor Initialization (ATT_PROC_INIT)

A. Function. ATT_PROC_INIT serves to initialize certain internal constants. It is performed on demand, on or before the first pass through ATT_PROC, whether prelaunch (but after platform release) or preorbit coast, and following IMU alignments during preorbit coast. An overview block diagram of ATT_PROC_INIT is provided in Figure 4.6.4.1-1. With the exception of forming Q_{SM_M50} , all of these steps may be performed after IMU hanger calibration.

B. Processing Requirements. The module ATT_PROC_INIT is performed once to initialize constants in both MC1 and MC3 and following IMU alignments in MM301 to compute $Q_{SM_M50_K}$.

C. Interface Requirements. The interface requirements for the module ATT_PROC_INIT are shown in Tables 4.6.2-1 and 4.6.2-2.

D. Constants. The constants used in the module ATT_PROC_INIT are shown in Table 4.6.2-4.

E. Initialization Requirements. None.

F. Detailed Technical Description. ATT_PROC_INIT initializes IMU attitude constants and IMU-to-IMU mounting misalignments.

The following constants are initialized for each IMU_K , $K = 1, 2, 3$. They are a quaternion representing the transformation from the roll gimbal frame to the body frame, a quaternion representing the transformation from the M50 frame to the platform frame, and the sine and cosine of $1/2 DP_K$, the IMU's pitch-outer roll gimbal nonorthogonality.

First, the navigation base to outer roll gimbal transformation matrix, TNB_RL_K , is computed. TNB_RL_K is a product of two single-axis rotations (roll gimbal azimuth and pitch offsets) and the navigation base to case transformation.

$$TAZ_K = \begin{bmatrix} \cos(RGAO_K) & -\sin(RGAO_K) & 0 \\ \sin(RGAO_K) & \cos(RGAO_K) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$TPT_K = \begin{bmatrix} \cos(RGPO_K) & 0 & \sin(RGPO_K) \\ 0 & 1 & 0 \\ -\sin(RGPO_K) & 0 & \cos(RGPO_K) \end{bmatrix}$$

$$TNB_RL_K = TAZ_K TPT_K TNB_CASE$$

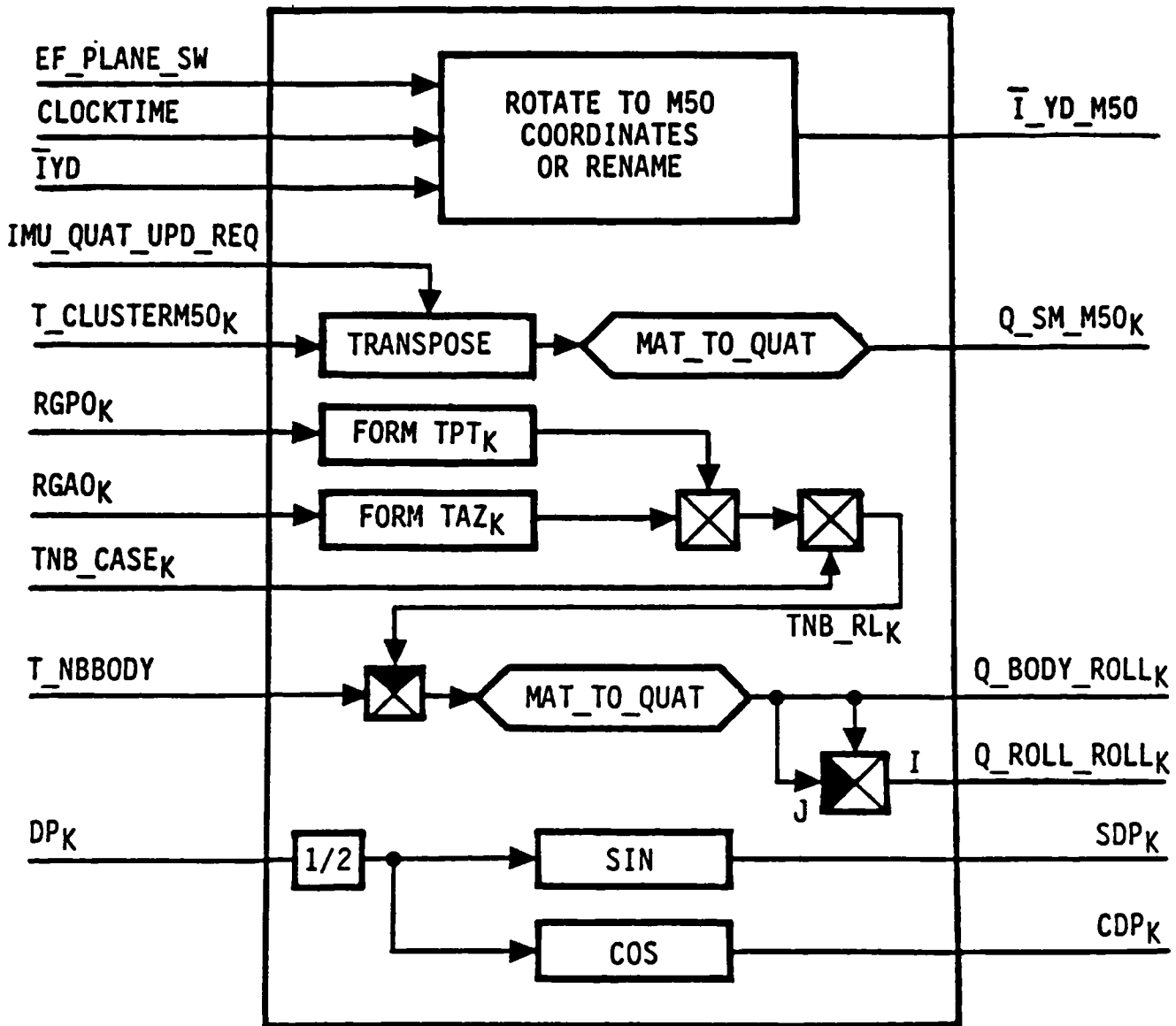


Figure 4.6.4.1-1. ATT_PROC_INIT Block Diagram

Then, the matrix $M_ROLLBODY_K$ is formed by

$$M_ROLLBODY_K = T_NBBODY (TNB_RL_K)^T$$

Then the quaternions $Q_BODY_ROLL_K$ and $Q_SM_M50_K$ are formed from the equivalent matrices $M_ROLLBODY_K$ and $(T_CLUSTERM50_K)^T$ by use of MAT_TO_QUAT, the matrix to quaternion utility routine. The sine and cosine of one-half the pitch-outer roll gimbal nonorthogonality follows from

$$SDP_K = \sin (DP_K/2)$$

$$CDP_K = \cos (DP_K/2)$$

The pairwise IMU gimbal-case mounting misalignments are determined for each IMU pair K, where the index K is the number of the excluded IMU.

$$Q_ROLL_ROLL_K = Q_BODY_ROLL_J^* Q_BODY_ROLL_I$$

where for

$$K = 1: I = 2, J = 3$$

$$K = 2: I = 1, J = 3$$

$$K = 3: I = 1, J = 2$$

When the ASCENT mode (ATT_MODE = 1, MM101) is first begun, the following calculations will be performed for ADI and HSI processing during MM101. If the orbital plane constraint in earth-fixed, EF_PLANE_SW = ON, then the unit vector $\bar{I}YD$ which is normal to the desired trajectory plane is transformed from earth-fixed coordinates to M50 coordinates. That is,

If EF_PLANE_SW = ON, then

$$\bar{I}YD_M50 = EARTH_FIXED_TO_M50_COORD(CLOCKTIME) \bar{I}YD$$

This unit vector $\bar{I}YD_M50$ is later recomputed by ascent user parameter processing when MM102 is begun, so as to be valid at the time of liftoff.

If the orbital plane constraint is not earth-fixed, EF_PLANE_SW = OFF, indicating a rendezvous mission, then the unit vector $\bar{I}YD$ which is normal to the desired trajectory plane and given in M50 coordinates is renamed for use by ATT_PROC. That is,

If EF_PLANE_SW = OFF, then

$$\bar{I}YD_M50 = \bar{I}YD$$

The unit vector $\bar{I}YD_M50$ is later recomputed by ascent user parameter processing when MM102 is begun in order to account for nodal regression between nominal and actual launch times. This delay in launch time, in the case of a rendezvous mission, is constrained to be only a few minutes. This initialization is not required for TRANSITION or ENTRY modes.

When entering MC3, the only initialization required is that associated with the computations of $Q_BODY_ROLL_K$ and $Q_ROLL_ROLL_K$. The values of $Q_SM_M50_K$ and SDP_K , CDP_K are carried over from MC2.

Whenever an IMU alignment is completed in MM 301 (denoted by $IMU_QUAT_UPD_REQ = ON$), $Q_SM_M50_K$ is computed from $(T_CLUSTERM50_K)^T$ by use of MAT_TO_QUAT . Subsequently, the flag $IMU_QUAT_UPD_REQ$ is reset OFF.

This concludes module ATT_PROC_INIT .

Note that the unit vector \bar{I}_YD_M50 will be recomputed by ascent second-stage guidance during MM103 if a transatlantic abort is declared or by powered RTLS guidance during MM601.

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4.6.4.2 Attitude Processor Outer-Loop (ATT_PROC_OUTER)

A. Function. ATT_PROC_OUTER is a precision attitude processor. It computes the body wrt M50 quaternion (QBI_UPDATE) and the M50 wrt topodetic quaternion (Q_M50_TD). Pairwise stable member wrt stable member quaternions (Q_SM_SM_K) are formed for use in IMU selection and IMU failure detection and isolation. An overview block diagram of ATT_PROC_OUTER is shown in Figure 4.6.4.2-1.

B. Processing Requirements. ATT_PROC_OUTER is performed before the first pass through ATT_PROC_INNER. It is performed thereafter at 1.04 Hz.

C. Interface Requirements. The interface requirements for the module ATT_PROC_OUTER are shown in Tables 4.6.2-1 and 4.6.2-2.

D. Constants. Constants used in module ATT_PROC_OUTER are shown in Table 4.6.2-4.

E. Initialization Requirements. Initialization requirements for ATT_PROC_OUTER are shown in Table 4.6.2-3.

F. Detailed Technical Description. The quaternions Q_SM_SM_K, representing platform wrt platform misalignment of the IMU pair K, are formed for use in selecting an IMU for attitude data and for IMU failure detection and isolation. The following steps are performed for each IMU_K, K = 1, 2, 3.

The roll gimbal mounting wrt stable member quaternion, Q_ROLL_SM_K, is formed for each IMU_K, K = 1 to 3. Q_ROLL_SM_K is the product of five single axis rotations (four gimbal angles and the pitch-outer roll gimbal nonorthogonality).

$$\overline{GA}_K = \frac{\text{RAD_PER_DEG}}{2} \begin{bmatrix} \text{ORANG}(K) + \text{IRANG}(K) \\ \text{ORANG}(K) - \text{IRANG}(K) \\ \text{PANG}(K) \\ \text{AZANG}(K) \end{bmatrix}$$

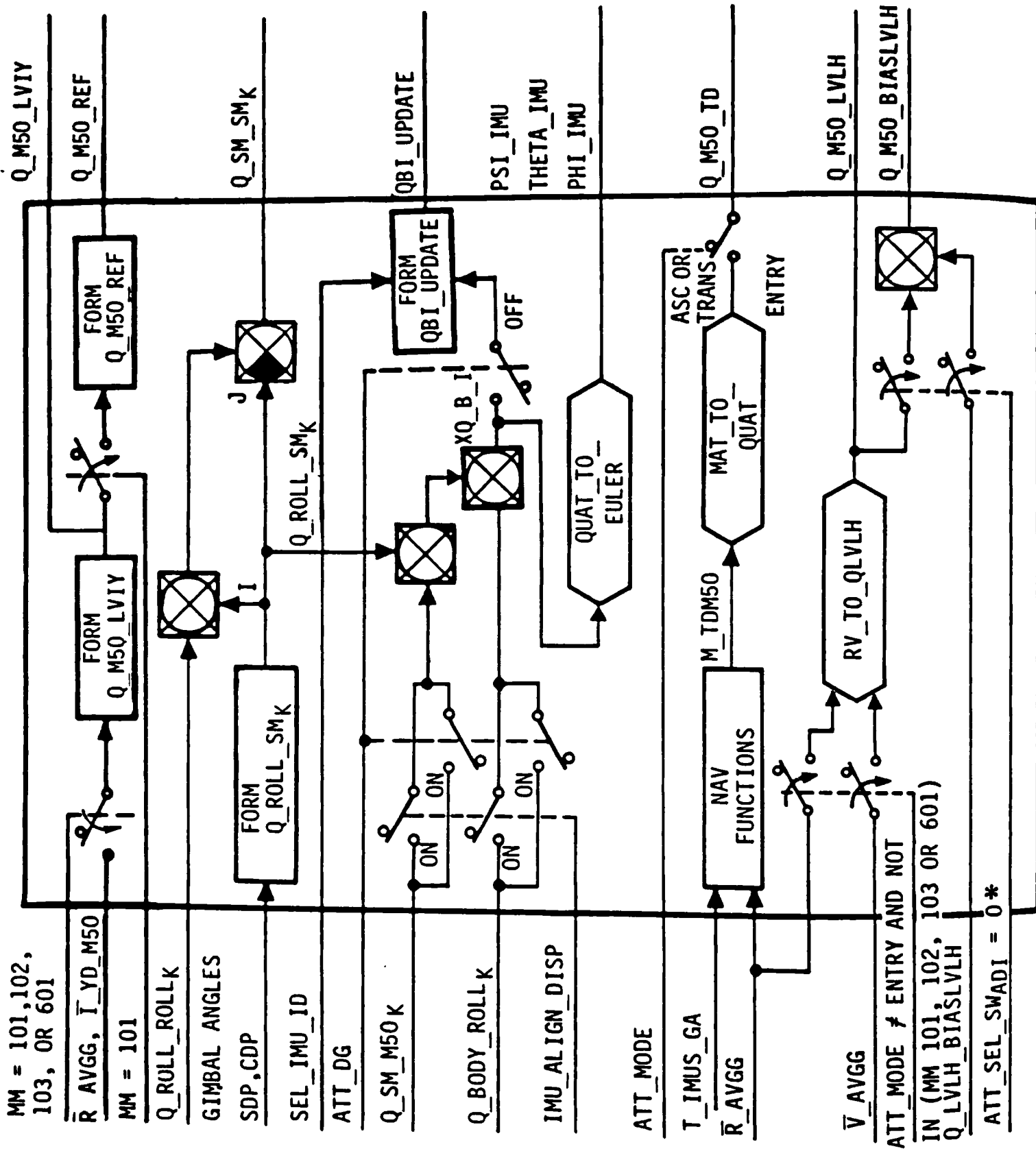
$$\text{SRPL}_K = \text{SIN}(\text{GA}_{K:1}); \quad \text{CRPL}_K = \text{COS}(\text{GA}_{K:1});$$

$$\text{SRMN}_K = \text{SIN}(\text{GA}_{K:2}); \quad \text{CRMN}_K = \text{COS}(\text{GA}_{K:2});$$

$$\text{SP}_K = \text{SIN}(\text{GA}_{K:3}); \quad \text{CP}_K = \text{COS}(\text{GA}_{K:3});$$

$$\text{SY}_K = \text{SIN}(\text{GA}_{K:4}); \quad \text{CY}_K = \text{COS}(\text{GA}_{K:4})$$

$$\text{QROLLSMS}_K = \text{CDP}_K(\text{CP}_K \text{CRPL}_K \text{CY}_K + \text{SP}_K \text{SRMN}_K \text{SY}_K) - \text{SDP}_K(\text{SP}_K \text{SRPL}_K \text{CY}_K + \text{CP}_K \text{CRMN}_K \text{SY}_K)$$



* FOR ADI NO. 1 OR ADI NO. 2
Figure 4.6.4.2-1. ATT_PROC_OUTER Block Diagram

$$\bar{Q}_{ROLLSMV}_K = \begin{bmatrix} CDP_K (-CP_K SRPL_K CY_K + SP_K CRMN_K SY_K) \\ + SDP_K (-SP_K CRPL_K CY_K + CP_K SRMN_K SY_K) \\ CDP_K (-SP_K CRMN_K CY_K - CP_K SRPL_K SY_K) \\ + SDP_K (-CP_K SRMN_K CY_K - SP_K CRPL_K SY_K) \\ CDP_K (-CP_K CRPL_K SY_K + SP_K SRMN_K CY_K) \\ + SDP_K (SP_K SRPL_K SY_K - CP_K CRMN_K CY_K) \end{bmatrix}$$

where

$$Q_ROLL_SM_K = [Q_{ROLLSMS}_K, \bar{Q}_{ROLLSMV}_K]$$

Stable member wrt stable member quaternions are then formed for each IMU pair K:

$$Q_SM_SM_K = Q_ROLL_SM_J^* Q_ROLL_ROLL_K Q_ROLL_SM_I$$

where for

$$K = 1: I = 2, J = 3$$

$$K = 2: I = 1, J = 3$$

$$K = 3: I = 1, J = 2$$

The three quaternions $Q_SM_SM_K$ are sent to RM (IMU selection), which returns a selected IMU number (SEL_IMU_ID) and an attitude data good flag (ATT_DG). The sense of this flag is $ATT_DG = ON$ implies data are good.

If $IMU_ALIGN_DISP = ON$, a set of Euler angles from M50 to Body is computed independently for each IMU. A quaternion $XQ_B_I_K$ is formed for each IMU_K and the angles are extracted by the $QUAT_TO_EULER$ routine. Thus, if $IMU_ALIGN_DISP = ON$, $XQ_B_I_K$ is computed for each IMU_K , $K = 1, 2, 3$. Otherwise, if $IMU_ALIGN_DISP = OFF$ and $ATT_DG = ON$, it is computed only for $K = SEL_IMU_ID$.

$$XQ_B_I_K = Q_BODY_ROLL_K Q_ROLL_SM_K Q_SM_M50_K$$

IF $IMU_ALIGN_DISP = ON$

CALL $QUAT_TO_EULER (XQ_B_I_K)$ ASSIGN ($PSI_IMU_K, THETA_IMU_K, PHI_IMU_K,$
 $TEMP, TEMP, TEMP, TEMP$)

The Euler angles are constrained to the range 0-360 degrees by adding 360 degrees to negative angles.



The following processing in the outer loop (ATT_PROC_OUTER) is performed only for the single selected IMU SEL_IMU_ID, where gimbal angle data are incorporated only if ATT_DG = ON. If so,

$$QBI_UPDATE = (XQ_B_I_SEL_IMU_ID)$$

If ATT_DG = OFF, QBI_UPDATE is not computed.

NOTE: On the first pass after transition from OPS 2 or OPS 8 to OPS 3, QBI_UPDATE is initialized to the last value of Q_B_M50 computed by ON-ORBIT_ATT_PROC. This initialization is performed to protect against possible bad attitude data indication from IMU RM (ATT_DG = OFF). IMU RM may have processed transient IMU comfaults due to unexpected powered-off LRU's or there may be an IMU dilemma.

If this is the first pass after transition from OPS 1 to OPS 3, QBI_UPDATE is initialized to the last value of Q_B_I computed by A/E_ATT_PROC in OPS 1. This initialization is performed to protect against ATT_DG being set OFF during an IMU dilemma.

The following calculations are performed if (ATT_MODE ≠ ENTRY and it is not Major Mode 101, 102, 103, or 601). First an M50 wrt LVLH quaternion is computed for guidance and ADI related calculations.

CALL RV_TO_QLVLH(\bar{R} _AVGG, \bar{V} _AVGG) ASSIGN(Q_M50_LVLH)

Then a quaternion representing M50 wrt BIASLVLH is computed for use in deriving ADI driver functions in ATT_PROC_DISP, but only if (ATT_SEL_SW₁ = 0 and/or ATT_SEL_SW₂ = 0).

$$Q_M50_BIASLVLH = Q_M50_LVLH \ Q_LVLH_BIASLVLH$$

Q_M50_LVLH AND Q_M50_BIASLVLH will be assumed constant for 0.96 second.

The following ADI- and HSI-related calculations are also to be performed by ATT_PROC_OUTER, but only if major mode = 101, 102, 103, or 601.

These calculations define a quaternion of M50 with respect to the desired ascent LVIY reference ADI coordinate system for use in ATT_PROC_DISP. The quaternion is formed from present vehicle position (\bar{R} _AVGG) and from an initially defined M50 unit vector (\bar{I} _YD_M50) normal to the insertion plane (at MECO), as

1. Compute a temporary vector normal to both \bar{R} _AVGG and \bar{I} _YD_M50

$$\bar{V}_TEMP = \bar{R}_AVGG * \bar{I}_YD_M50$$

2. Then call the RV_TO_QLVLH utility function to compute the desired quaternion

```
CALL RV_TO_QLVLH (R_AVGG, V_TEMP)
```

```
ASSIGN(Q_M50_LVIY)
```

Q_M50_LVIY will be assumed constant for 0.96 second.

If MM = 101, then set Q_M50_REF = Q_M50_LVIY

If ATT_MODE = ENTRY, the M50 wrt topodetic quaternion is derived as a function of time and vehicle position. NAV coordinate transformation functions are used. T_IMUS_GA is the time tag associated with the IMU data read. R_AVGG is the present vehicle position vector in M50 coordinates.

```
M_EFM50 = EARTH_FIXED_TO_M50_COORD (T_IMUS_GA)
```

$$\bar{R} = (M_EFM50)^T \bar{R}_AVGG$$

```
CALL EF_TO_GEODETTIC(R) ASSIGN (LAT, LON, ALT)
```

```
M_EFTD = EF_TO_TOPDET (LAT, LON)
```

```
M_TDM50 = M_EFM50 (M_EFTD)^T
```

The equivalent quaternion Q_M50_TD is extracted from M_TDM50 using the MAT_TO_QUAT utility routine. Q_M50_TD will be assumed constant for 0.96 second.

This concludes module ATT_PROC_OUTER.

4.6.4.3 Attitude Processor Inner Loop (ATT_PROC_INNER)

A. Function. ATT_PROC_INNER serves to propagate the body attitude quaternion incrementally at a high rate using body rate from selected filtered RGA outputs. During ATT_MODE = TRANSITION, the payload attitude is derived at 0.52 Hz rate. Payload attitude must represent vehicle attitude within ± 100 milliseconds of the time the vehicle state vector is passed to the payload. An overview block diagram of ATT_PROC_INNER is given in Figure 4.6.4.3-1.

B. Processing Requirements. The ATT_PROC_INNER module is called at 12.5 Hz during ascent and transition and 6.25 Hz during the entry through landing phases.

C. Interface Requirements. The interface requirements for the module ATT_PROC_INNER are shown in Tables 4.6.2-1 and 4.6.2-2.

D. Constants. The I-Loads/K-Loads used in module ATT_PROC_INNER are shown in Table 4.6.2-4. The constants are shown in Table 4.6.2-5.

E. Initialization Requirements. Initialization requirements for ATT_PROC_INNER are shown in Table 4.6.2-3.

F. Detailed Technical Description. The inner loop propagates the attitude reference through trapezoidal integration of filtered body rate compensated for rate bias to form an incremental quaternion, \bar{Q}_{INCR} , representing the small rotation BODY (t) wrt BODY ($t-\Delta t$). First, if the attitude data good flag indicates bad IMU data, then the rate bias is zeroed. (This only needs to be done once each time ATT_DG is set OFF.)

If ATT_DG = OFF, then $\bar{W}_{BIAS} = \bar{0}$.

$$\bar{R}_{ATE_GYRO_READ} = RAD_PER_DEG \text{ VECTOR}(P_FIL, Q_FIL, R_FIL)$$

$$\bar{R}_{G_CORR_PAST} = \bar{R}_{G_CORR}$$

$$\bar{R}_{G_CORR} = \bar{R}_{ATE_GYRO_READ} - \bar{W}_{BIAS}$$

$$\bar{Q}_{INCRV} = -0.25 \text{ DELTIME } (\bar{R}_{G_CORR_PAST} + \bar{R}_{G_CORR})$$

If ATT_MODE = TRANSITION, then

$$\bar{R}_{ATE_GYRO_CORR} = DEG_PER_RAD \bar{R}_{G_CORR}$$

Then the scalar part of the incremental quaternion is given by

$$Q_{INCRS} = \text{SQRT}(1 - \bar{Q}_{INCRV} \cdot \bar{Q}_{INCRV})$$

which may be approximated by

$$Q_{INCRS} = 1 - 0.5(\bar{Q}_{INCRV} \cdot \bar{Q}_{INCRV})$$

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The body wrt M50 quaternion is then integrated to the current time

$$Q_B_I = Q_INCR Q_B_I$$

If this is a minor cycle when IMU gibal angles have just been read and will be used in the outer loop for updating the attitude reference $[(CLOCKTIME - T_IMUS_GA) \leq DELTIME]$, then the body wrt M50 quaternion at T_IMUS_GA is computed.

$$\bar{Q}TEMPV = \frac{DTIMU}{DELTIME} \bar{Q}INCRV$$

$$QTEMPV = 1 - 0.5 (\bar{Q}TEMPV \cdot \bar{Q}TEMPV)$$

$$QBI_IMU_READ = QTEMP Q_B_I$$

If this is a minor cycle when the outer loop (ATT_PROC_OUTER) has just computed the body wrt M50 quaternion using gibal angles, then Q_B_I is updated by

$$Q_CORR = QBI_UPDATE QBI_IMU_READ^*$$

$$Q_B_I = Q_CORR Q_B_I$$

and the updated Q_B_I is normalized by calling the QUAT NORM utility routine. The rate bias is determined from the IMU update (Q_CORR). The IMU update is first limited to 0.1 degree per axis to protect against large transients due to changes in selected IMU. If $|QCORRV_i| > 0.05 \text{ RAD_PER_DEG}$, then $QCORRV_i = 0.05 \text{ RAD_PER_DEG SIGN}(QCORRV_i)$.

$$\bar{THINCR} = -2 QCORRS \bar{Q}CORRV$$

$$\bar{DEL_W_BIAS} = \frac{-\bar{THINCR}}{9.6}$$

$$\bar{W_BIAS} = \bar{W_BIAS} + \bar{DEL_W_BIAS}$$

The calculation of the rate bias change ($\bar{DEL_W_BIAS}$) over the current update interval (0.96 second) includes the multiplication by a scale factor of 0.1 to help flight control meet gain and phase stability requirements. When $ATT_MODE = TRANSITION$, the following additional steps are performed. The body attitude increment is computed at 12.5 Hz (and compensated for IMU updates at 1.04 Hz).

$$\bar{ATTITUDE_INCREMENT} = DEG_PER_RAD (-2 \bar{Q}INCRV + \bar{THINCR})$$

$$\bar{THINCR} = \bar{0}$$

and a time tag is formed for Q_B_I : $T_NOW = CLOCKTIME$.



The roll component of ATTITUDE_INCREMENT is integrated over 0.160-second periods as INT_ROLL_INC:

$$\text{INT_ROLL_INC} = \text{INT_ROLL_INC} + \text{ATTITUDE_INCREMENT}_1$$

where INT_ROLL_INC is reset to zero at 6.25 Hz in ATT_PROC_DISP. The requirement to continue INT_ROLL_INC is maintained even though the calculation is no longer used by any principal function.

During ATT_MODE = TRANSITION in MM301, 302, 303 and at the 0.52 Hz rate, the following payload attitude computations are performed:

If ATT_MODE = TRANSITION

Then the earth-fixed-to-M50 matrix is defined as a function of time. Nav coordinate transformation functions are used. CLOCKTIME is used as the argument in the calling statement

$$\text{M_EFM50} = \text{EARTH_FIXED_TO_M50_COORD}(\text{CLOCKTIME})$$

Next, extract Q_M50_EF from the matrix M_EFM50 via the MAT_TO_QUAT utility function. The product Q_BODY_EF = Q_B_I Q_M50_EF is then used as the argument in a call to QUAT_TO_ADI_ANG. QUAT_TO_ADI_ANG returns (XPTCHSINE, XPTCHCOS, XYAWSINE, XYAWCOS, XROLLSINE, XROLLCOS, XFLAG). If XFLAG = OFF, PITCH and ROLL functions were not updated in QUAT_TO_ADI_ANG due to the singularity at YAW = +90; and PAYLOAD functions are not updated. If XFLAG = ON,

$$\text{PAYLOAD_YAW} = \text{ARCSIN}(\text{XYAWSINE})$$

$$\text{PAYLOAD_PITCH} = \text{ARCTAN2}(\text{XPTCHSINE}, \text{XPTCHCOS})$$

$$\text{PAYLOAD_ROLL} = \text{ARCTAN2}(\text{XROLLSINE}, \text{XROLLCOS})$$

G. Constraints. Outputs to GN&C/SM-PL IF shall be protected time homogenous parameters. These outputs shall be referenced to T_NOW (time tag of Q_B_I).

This concludes ATT_PROC_INNER.

0.52 Hz
ATT_MODE = 2
AND MM'S 301, 302,

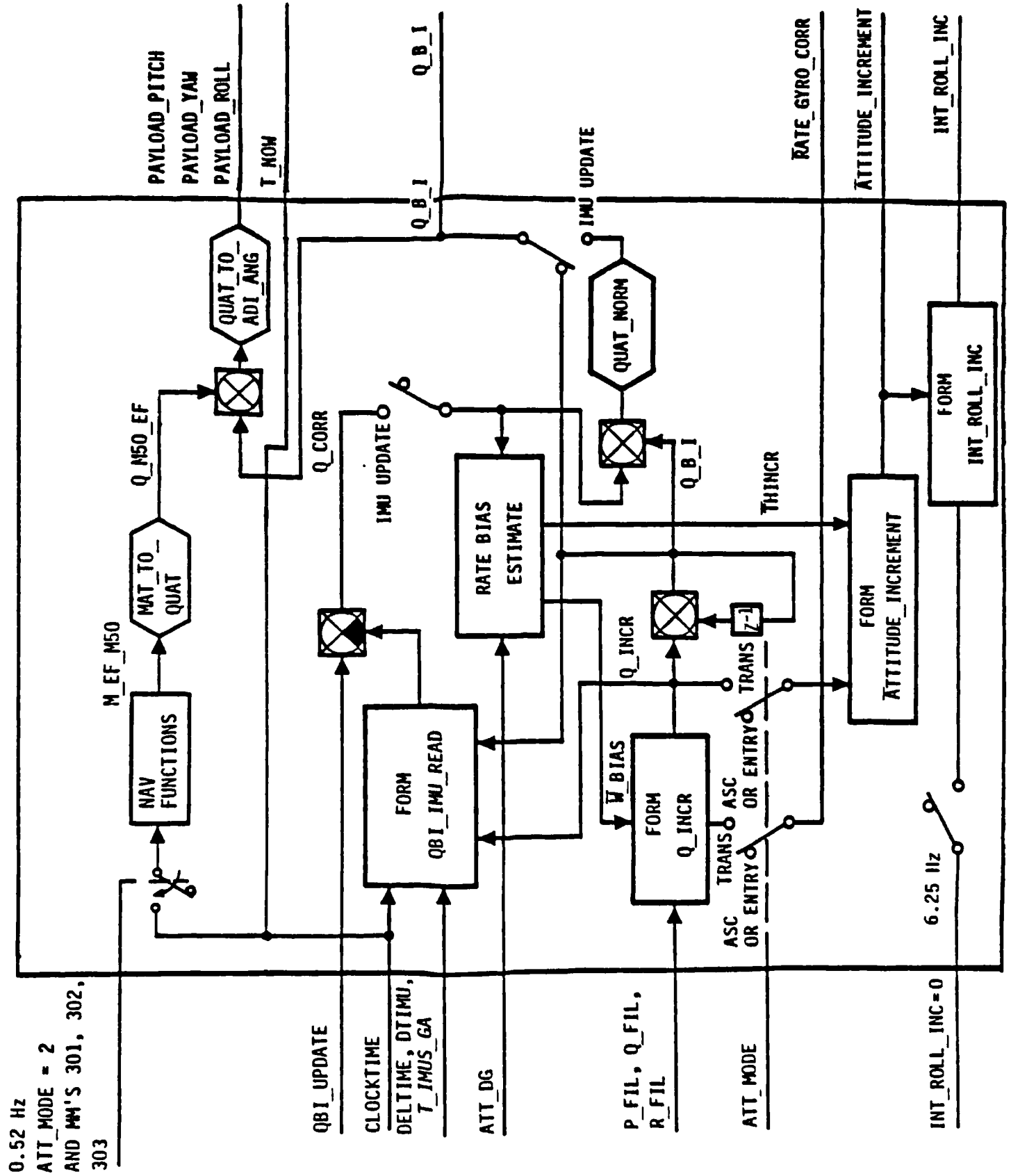


Figure 4.6.4.3-1. ATT_PROC_INNER Block Diagram

4.6.4.4 Attitude Processor Derived Air Data and Euler Angle Processing (ATT_PROC_EULER).

A. Function. ATT_PROC_EULER calculates several additional variables which are required at 6.25 Hz or less. These variables are computed from the body attitude quaternion. An overview block diagram of ATT_PROC_EULER is given in Figure 4.6.4.4-1.

B. Processing Requirements. ATT_PROC_EULER is performed at 6.25 Hz, after ATT_PROC_INNER.

C. Interface Requirements. The interface requirements for the module ATT_PROC_EULER are shown in Tables 4.6.2-1 and 4.6.2-2.

D. Constants. I-Loads/K-Loads used in module ATT_PROC_EULER are given in Table 4.6.2-4. The constants are shown in Table 4.6.2-5.

E. Initialization. Initialization requirements are shown in Table 4.6.2-3.

F. Detailed Technical Description. The vehicle velocity relative to the earth's surface (V_{RHO}) is transformed into body coordinates using the QUAT_XFORM utility function. The assigned vector \bar{UB} is used to develop angle of attack, sideslip angle, BANK and trigonometric functions of them. The first component UB_1 of the assigned vector \bar{UB} is sent to GRTLS DAP each time it is computed. CALL QUAT_XFORM with arguments Q_{B_I} and V_{RHO} . ASSIGN \bar{UB} . Then

$$UB_X = \text{SQRT}(UB_1^2 + UB_3^2)$$

If $UB_X < UB_EPS$ (a K-LOADED small test velocity), do not perform the following update calculations for ALPHA_N and BETA_N. If $UB_X \geq UB_EPS$, then compute ALPHA_N and BETA_N as follows:

$$\text{SINALF} = UB_3 / UB_X$$

$$\text{ALPHA_N} = \text{DEG_PER_RAD ARCSIN}(\text{SINALF})$$

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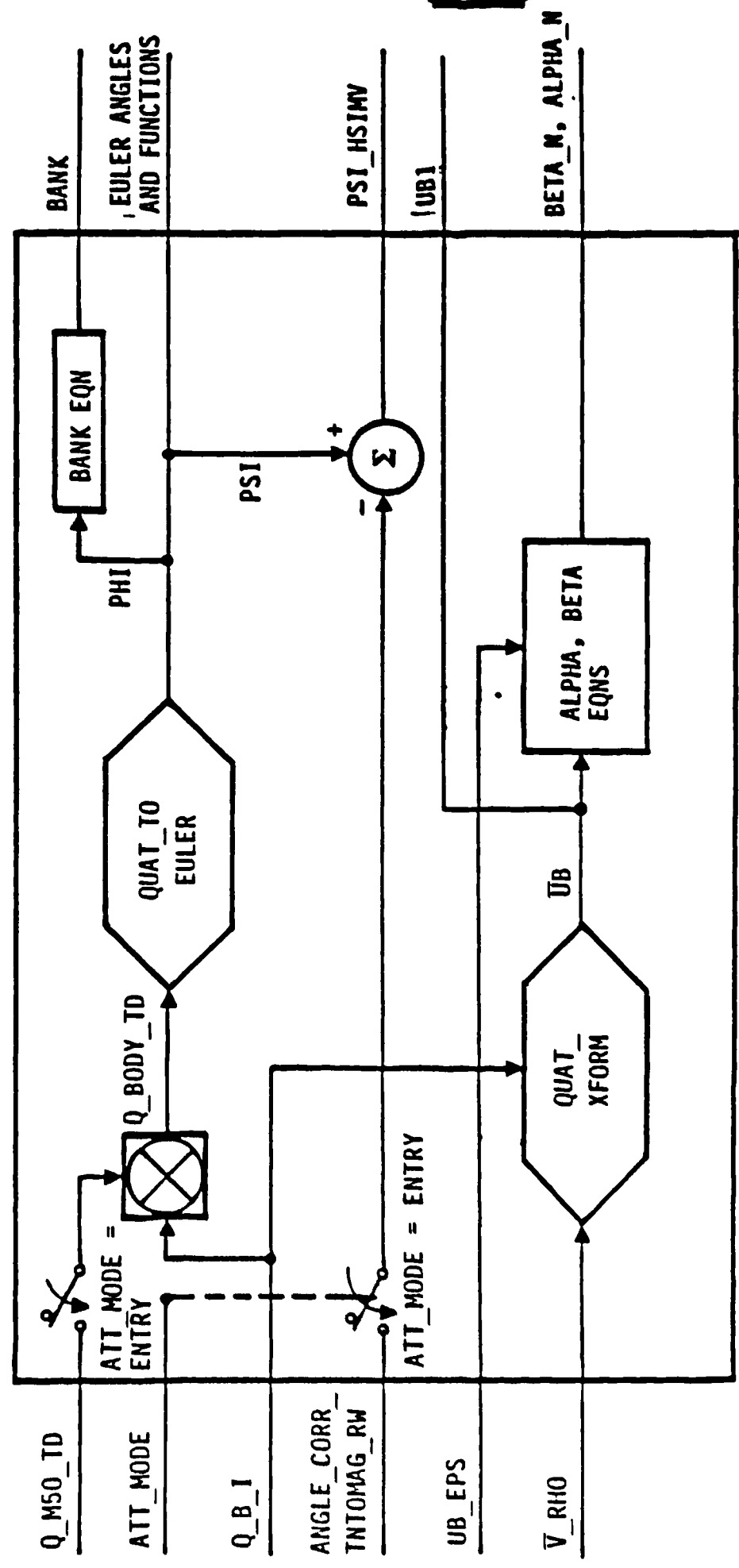


Figure 4.6.4.4-1. ATT_PROC_EULER Block Diagram

$$\text{BETA}_N = \text{DEG_PER_RAD } \overline{UB}_2 / |\overline{UB}|$$

If ATT_MODE = ENTRY, the following additional steps are performed. Prior to the first cycle through these calculations, it is necessary that the ATT_PROC_OUTER module execute.

The body wrt topodetic quaternion, Q_BODY_TD, is formed by

$$Q_BODY_TD = Q_B_I \quad Q_M50_TD$$

The FCS-sequence Euler angles body wrt topodetic, and certain trigonometric functions of them are then obtained. The utility routine QUAT_TO_EULER is called with argument Q_BODY_TD, and PSI, THETA, PHI, SINTH, COSTH, SINPHI, and COSPHI are returned. The angles are in degrees. Heading with respect to magnetic north at the runway is given by

$$\text{PSI_HSIMV} = \text{RAD_PER_DEG } \text{PSI} - \text{ANGLE_CORR_TNTOMAG_RW}$$

BANK is then set equal to the body roll angle

$$\text{BANK} = \text{PHI}$$

This concludes processing during ATT_MODE = ENTRY.

This concludes ATT_PROC_EULER.

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4.6.4.5 Attitude Processor Display Processing (ATT_PROC_DISP)

A. Function. ATT_PROC_DISP calculates the ADI ball driver functions. During ATT_MODE = 2 (TRANSITION), delta velocity is calculated and transformed into the body frame, and body attitude errors are derived. An overview block diagram of ATT_PROC_DISP is given in Figure 4.6.4.5-1.

B. Processing Requirements. The module ATT_PROC_DISP is performed at 6.25 Hz, after ATT_PROC_EULER has been performed. ADI driver functions are computed at 3.125 Hz, which may be accomplished either by computing driver functions for both ADI's every second pass or by computing the driver functions for each on alternate passes. ATT_PROC_DISP also computes HSI driver functions at 3.125 Hz.

C. Interface Requirements. The interface requirements for module ATT_PROC_DISP are shown in Tables 4.6.2-1 and 4.6.2-2.

D. Constants. ATT_PROC_DISP I-loads/K-loads are shown in Table 4.6.2-4. The constants are shown in Table 4.6.2-5.

E. Initialization Requirements. The initialization requirements for ATT_PROC_DISP are shown in Table 4.6.2-3.

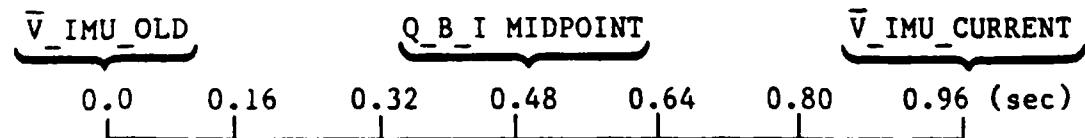
F. Detailed Technical Requirements. When ATT_MODE = 2 (TRANSITION), body delta velocity is formed at 1.04 Hz, and attitude errors are derived. The integrated roll attitude increment is first zeroed.

INT_ROLL_INC = 0

For derivation of body delta velocity (ΔV) at low rate (1.04 Hz), the body attitude quaternion at the midpoint of the ΔV cycle is saved

Q_B_I_MIDPOINT = Q_B_I

on every sixth 6.25 Hz cycle starting three cycles after IMU RM velocity processing, i.e.



Then at 1.04 Hz

$\bar{DEL_V_IMU} = \bar{V}_{IMU_CURRENT} - \bar{V}_{IMU_OLD}$

$\bar{V}_{IMU_OLD} = \bar{V}_{IMU_CURRENT}$

$\bar{DVB_SEC} = Q_{B_I_MIDPOINT} \bar{DEL_V_IMU} Q_{B_I_MIDPOINT}^*$

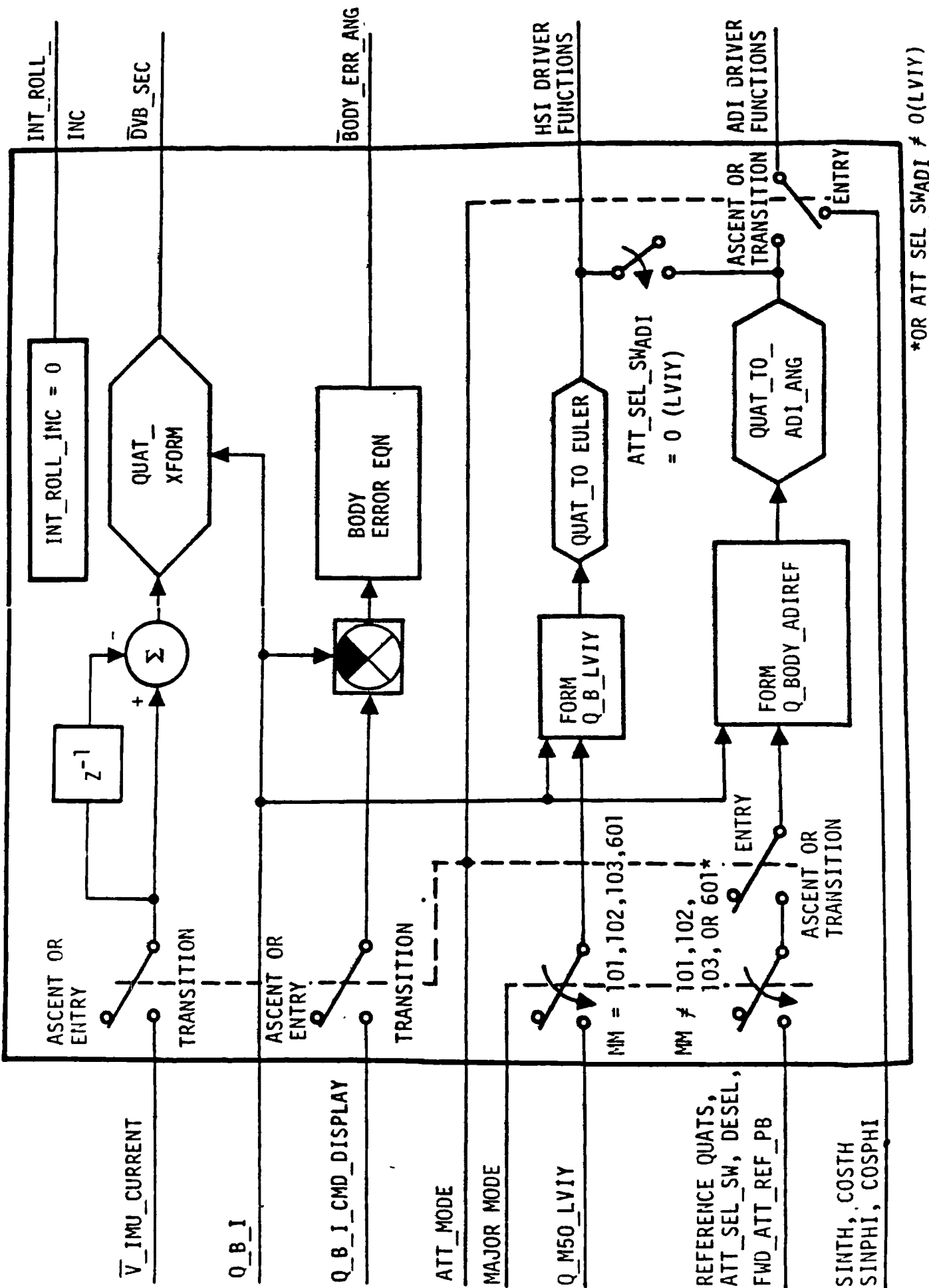


Figure 4.6.4.5-1. ATT_PROC_DISP Block Diagram

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The attitude errors which can be displayed on the ADI error needles are derived from a small angle approximation to the error quaternion. This is not equivalent to the Euler angles which would define the precise rotation angles from the present to the desired attitude. It should be expected, therefore, that for a 3-axis attitude maneuver on the order of five degrees or larger, the crew would have to repeat the maneuver sequence at least once. Q_{B_I} is the present body wrt M50 quaternion, and $Q_{B_I_CMD_DISPLAY}$ is the commanded body wrt M50 quaternion. Then

$$Q_ERROR = [QERRORS, \bar{Q}ERRORV] \\ = Q_{B_I_CMD_DISPLAY} Q_{B_I}^*$$

and the error angles from the body attitude to the commanded attitude are

$$\bar{BODY_ERR_ANG} = +2 \text{ DEG_PER_RAD SIGN}(QERRORS) \bar{Q}ERRORV$$

This concludes processing done only in $ATT_MODE = TRANSITION$.

ATT_PROC_DISP now performs HSI driver function processing. Whenever $MM = 101, 102, 103, \text{ or } 601$, a quaternion of the body with respect to the LVIY reference is computed as follows:

$$Q_{B_LVIY} = Q_{B_I} Q_{M50_LVIY}$$

where Q_{M50_LVIY} is computed in ATT_PROC_OUTER module at 1.04 Hz.

Next, the utility function $QUAT_TO_EULER$ is called with Q_{B_LVIY} as the argument and returns $XPSI, XTHETA, XPHI, XSINTH, XCOSTH, XSINPHI,$ and $XCOSPHI$. Then if $|COSTH| \geq 0.03$, the HSI heading parameter, YAW_IY , is assigned the Euler yaw angle, $XPSI$.

$$YAW_IY = RAD_PER_DEG \ XPSI$$

and a heads-up/heads-down indicator, $ROLL_SW$, is determined as a function of the Euler roll angle $XPHI$, that is, if $|XPHI| \leq 90^\circ$,

$$ROLL_SW = 1$$

otherwise

$$ROLL_SW = -1$$

The parameters returned from the call to $QUAT_TO_EULER$ are also used in subsequent ADI processing whenever the LVIY reference is desired.

ATT_PROC_DISP next calculates ADI ball driver functions for the two forward balls, as indicated in "B. Processing Requirements" above. In ASCENT and TRANSITION, they are driven independently to one of three switch selectable references (showing ADI sequence Euler angles from the reference to the body). These references are chosen by $ATT_SEL_SW_{ADI}$, where $ADI = 1, 2$ to indicate the left forward and right forward station, respectively.

The three ATT_SEL_SW positions indicate reference frames defined by quaternions:

ATT_SEL_SW = -1 (=INRTL)

INRTL is an arbitrary inertial reference frame defined by Q_M50_INRTL.

ATT_SEL_SW = 0 (=BIASLVLH, during TRANSITION mode, but not when Major Mode is MM103)

BIASLVLH is a noninertial frame defined by Q_M50_BIASLVLH which is computed in the ATT_PROC_OUTER module at 1.04 Hz. BIASLVLH is a constant rotation away from LVLH given by Q_LVLH_BIASLVLH. LVLH is the local orbital frame \bar{X}_{LVLH} = downrange

\bar{Y}_{LVLH} = crossrange

\bar{Z}_{LVLH} = down (along negative \bar{R}_{AVGG})

ATT_SEL_SW = 0 (=LVIY, during ASCENT and TRANSITION modes, but only when in MM101, 102, 103, or 601)

LVIY is a rotating reference frame intended primarily for ascent powered flight regions, and defined by Q_M50_LVIY.

The frame is oriented such that

\bar{Z}_{LVIY} = down (along negative \bar{R}_{AVGG})

\bar{X}_{LVIY} = downrange (normal to plane formed by \bar{R}_{AVGG} and unit vector \bar{I}_{YD_M50})

\bar{Y}_{LVIY} = crossrange (forms right-handed orthogonal triad)

ATT_SEL_SW = +1 (=REF)

In MM101, REF is defined by Q_M50_REF, which is set equal to Q_M50_LVIY in ATT_PROC_OUTER. Otherwise, REF is an inertial reference frame defined by Q_M50_REF. It is then redefined as an inertial frame coincident with the instantaneous BODY frame whenever an ADI attitude reference switch is sensed and COAS mode is not selected.

Each forward station has an ADI attitude reference switch, which is processed by the switch processor to yield:

FWD_ATT_REF_PB = OFF = no selection

FWD_ATT_REF_PB = ON = LH or RH forward ADI's attitude reference switch is selected

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The following processing is done for each ADI in ASCENT and TRANSITION. (ADI processing in ENTRY is treated separately below.)

First, if FWD ATT_REF_PB = ON and DESEL - 1 (COAS DESELECT COMMAND), Q_M50_REF is updated by $Q_M50_REF = Q_B_I^*$.

If not in major modes (101, 102, 103, or 601) or $ATT_SEL_SW_{ADI} \neq 0$, then a quaternion of the body wrt the selected reference, Q_BODY_ADIREF , is formed as a function of $ATT_SEL_SW_{ADI}$. If both ADI's ATT_SEL_SW are set the same, then this computation for Q_BODY_ADIREF need only be performed once.

$$ATT_SEL_SW_{ADI} = -1: Q_BODY_ADIREF = Q_B_I Q_M50_INRTL$$

$$ATT_SEL_SW_{ADI} = 0: Q_BODY_ADIREF = Q_B_I Q_M50_BIASLVLH$$

$$ATT_SEL_SW_{ADI} = +1: Q_BODY_ADIREF = Q_B_I Q_M50_REF.$$

If in major modes (101, 102, 103, or 601) and the $ATT_SEL_SW_{ADI} = 0$, the following ADI commands are computed (for each ADI) from the previous call to QUAT_TO_EULER (see HSI driver function processing).

$$PTCHSINE_{ADI} = XSINTH$$

$$PTCHCOS_{ADI} = XCOSTH$$

$$YAWSINE_{ADI} = 0$$

$$YAWCOS_{ADI} = 1$$

and, if $|XCOSTH| < 0.03$, the sine and cosine of the roll angle should not be updated on this pass. If, however, $|XCOSTH| \geq 0.03$, then compute the following roll commands.

$$ROLLSINE_{ADI} = XSINPHI$$

$$ROLLCOS_{ADI} = XCOSPHI$$

If both ADI's have their $ATT_SEL_SW = 0$, then the same values are used to update both ADI's.

If in major modes (101, 102, 103, or 601) and the $ATT_SEL_SW_{ADI} = +1$ or if not in major modes (101, 102, 103, or 601), then the utility function QUAT_TO_ADI_ANG is called with Q_BODY_ADIREF . It returns XPTCHSINE, XPTCHCOS, XYAWSINE, XYAWCOS, XROLLSINE, XROLLCOS, and XFLAG (if both ADI's ATT_SEL_SW are set the same, then this call to QUAT_TO_ADI_ANG need only be performed once). Output update equations are:

If XFLAG = ON:

$$PTCHSINE_{ADI} = XPTCHSINE$$

$$PTCHCOS_{ADI} = XPTCHCOS$$



1. If not in MM101, 102, 103, or 601.

$$\text{YAWSINE}_{\text{ADI}} = \text{XYAWSINE}$$

$$\text{YAWCOS}_{\text{ADI}} = \text{XYAWCOS}$$

$$\text{ROLLSINE}_{\text{ADI}} = \text{XROLLSINE}$$

$$\text{ROLLCOS}_{\text{ADI}} = \text{XROLLCOS}$$

If XFLAG = OFF, the yaw functions are updated but the pitch and roll functions are not.

When ATT_MODE = ENTRY the two ADI's display only attitude with respect to the topodetic frame with YAW caged to zero. Q_BODY_ADIREF is not formed. Driver functions are the pitch and roll Euler angle sines and cosines derived in ATT_PROC_EULER. The following processing is to be done for each ADI:

$$\text{PTCHSINE}_{\text{ADI}} = \text{SINTH}$$

$$\text{PTCHCOS}_{\text{ADI}} = \text{COSTH}$$

$$\text{YAWSINE}_{\text{ADI}} = 0$$

$$\text{YAWCOS}_{\text{ADI}} = 1.$$

$$\text{ROLLSINE}_{\text{ADI}} = \text{SINPHI}$$

$$\text{ROLLCOS}_{\text{ADI}} = \text{COSPFI}$$

This concludes ATT_PROC_DISP.

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4.6.4.6 Attitude Processor Rolloff Filter (ATT_PROC_PREFIL)

A. Function. ATT_PROC_PREFIL is a rolloff filter on RGA input rates. It functions to minimize energy content above the half sample rate of ATT_PROC_INNER. The block diagrams are presented in Figure 4.6.4.6-1 for ascent and in Figure 4.6.4.6-2 for entry/landing, RGA data are not filtered during ATT_MODE = TRANSITION.

B. Processing Requirements. ATT_PROC_PREFIL is processed as follows:

Ascent: 25 Hz

Transition: 12.5 Hz

Entry: 25 Hz - first stage of filter
12.5 Hz - second stage of filter

C. Interface Requirements. Interface requirements for ATT_PROC_PREFIL are shown in Tables 4.6.2-1 and 4.6.2-2.

D. Constants. I-loads/K-loads for ATT_PROC_PREFIL are shown in Table 4.6.2-4. The constants are shown in Table 4.6.2-5.

E. Initialization Requirements. Initialization requirements for ATT_PROC_PREFIL are shown in Table 4.6.2-3 and Figure 4.6.4.6-3 (detailed mechanization).

F. Detailed Description. For ascent, see Figure 4.6.4.6-1. For transition, the outputs are set equal to the selected orbiter RGA rates. For entry, see Figure 4.6.4.6-2. The detailed mechanization for ATT_PROC_PREFIL is shown in Figure 4.6.4.6-3.

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The selected RGA rates are filtered via a first-order filter, prior to use in ATT_PROC_INNER. The computations, in order, are:

$$\begin{array}{l}
 1 \left\{ \begin{array}{l}
 P_{FIL} = RO_{FILT_1} P + P_{FILO} \\
 Q_{FIL} = RO_{FILT_1} Q + Q_{FILO} \\
 R_{FIL} = RO_{FILT_1} R + R_{FILO}
 \end{array} \right. \\
 \\
 2 \left\{ \begin{array}{l}
 P_{FILO} = RO_{FILT_2} P - RO_{FILT_3} P_{FIL} \\
 Q_{FILO} = RO_{FILT_2} Q - RO_{FILT_3} Q_{FIL} \\
 R_{FILO} = RO_{FILT_2} R - RO_{FILT_3} R_{FIL}
 \end{array} \right.
 \end{array}$$

Note: On the initial pass of ATT_PROC_PREFIL, the first three equations above (Set 1) should not be computed.

For entry, ATT_PROC_PREFIL consists of two cascaded first-order rolloff filters--the first operating at 25 Hz and the second at 12.5 Hz.

The technical description given above for ascent applies to each section of ATT_PROC_PREFIL entry with appropriate change of symbols.

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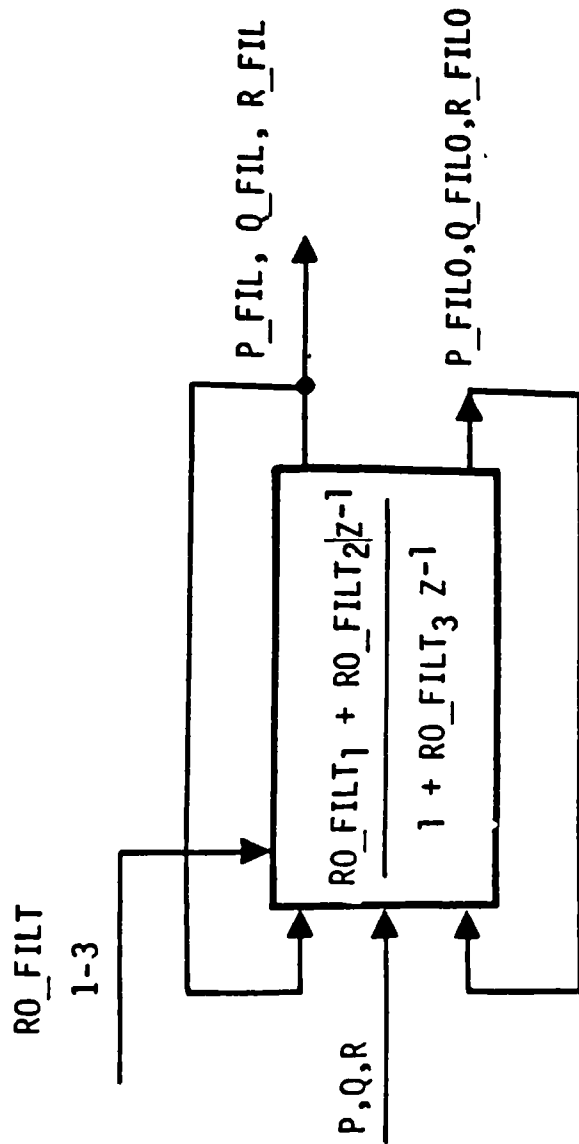


Figure 4.6.4.6-1. ATT_PROC_PREFIL Ascent/PRTLS Block Diagram

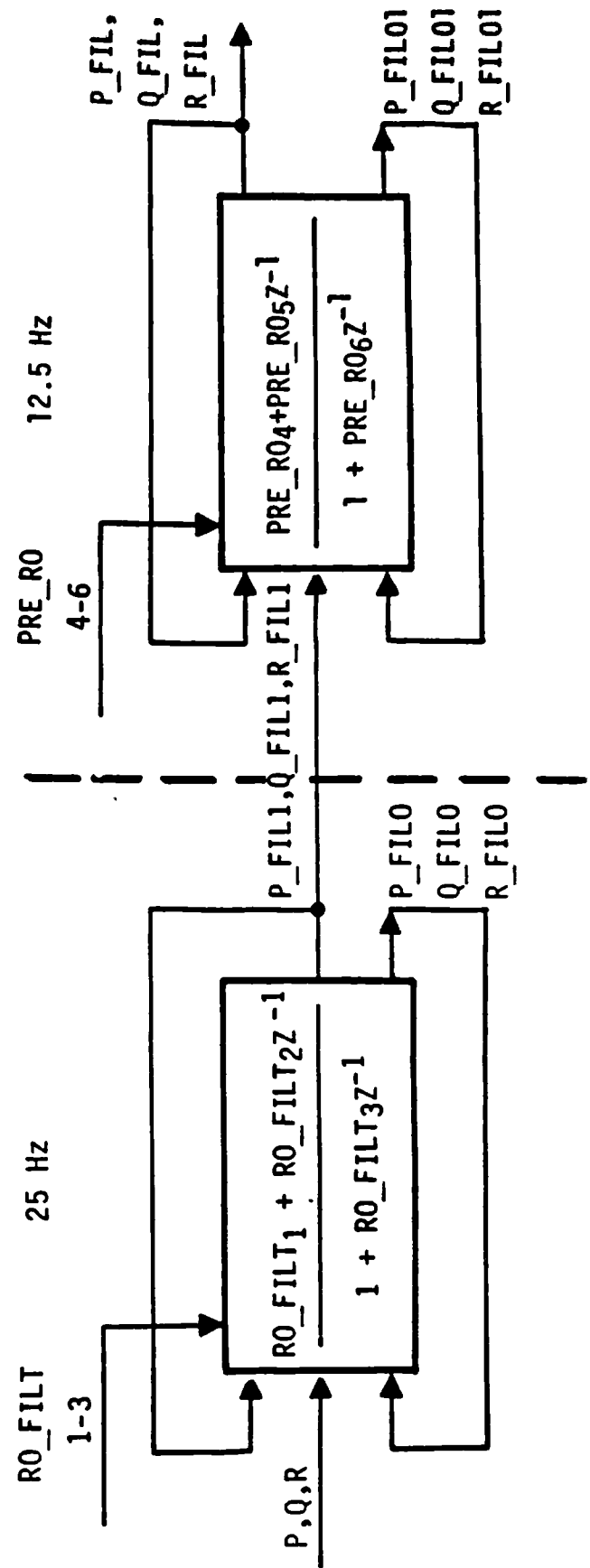


Figure 4.6.4.6-2. ATT_PROC_PREFIL Entry/GRTLS Block Diagram

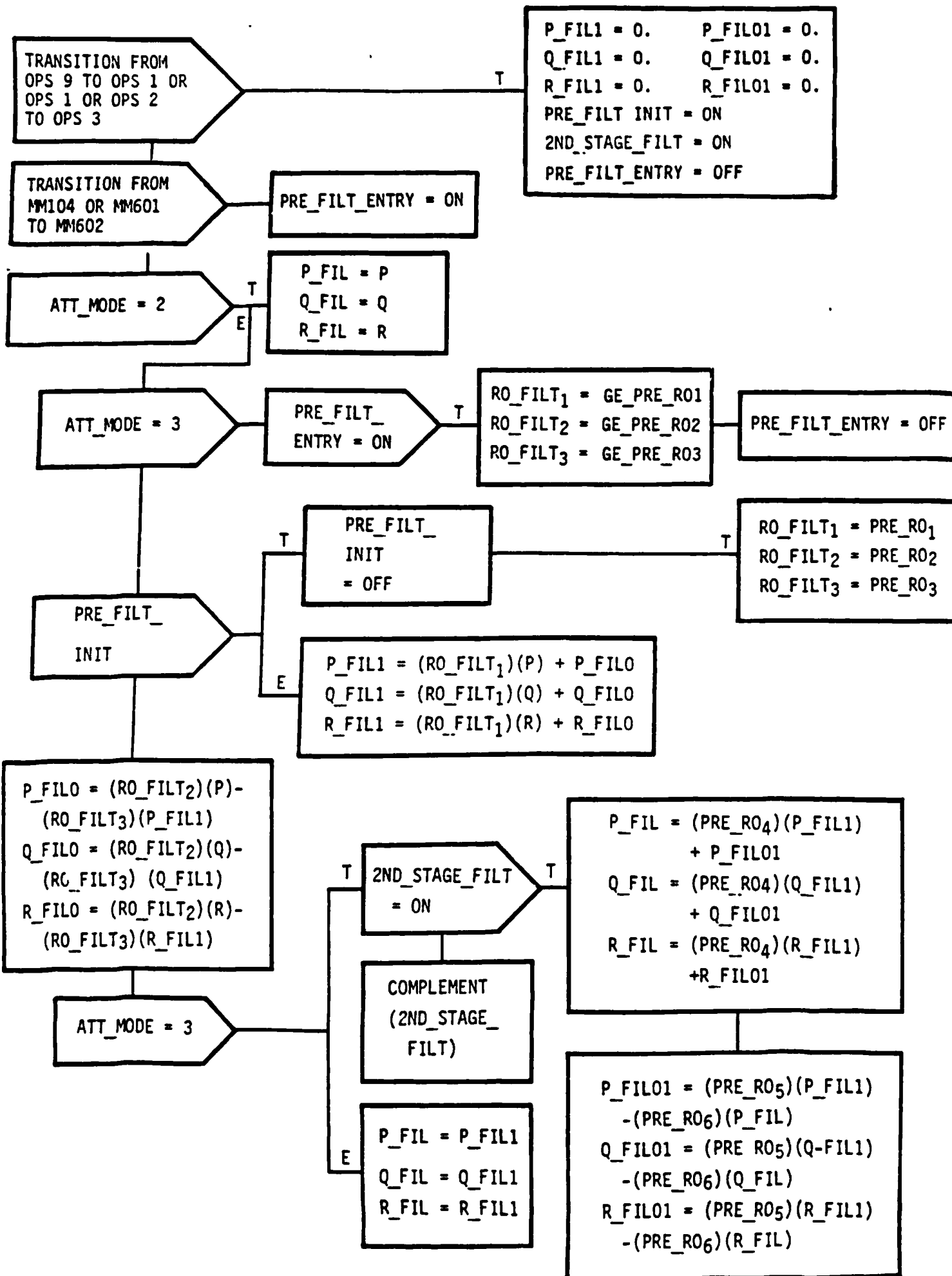


Figure 4.6.4.6-3. Detailed Mechanization for ATT_PROC_PREFIL

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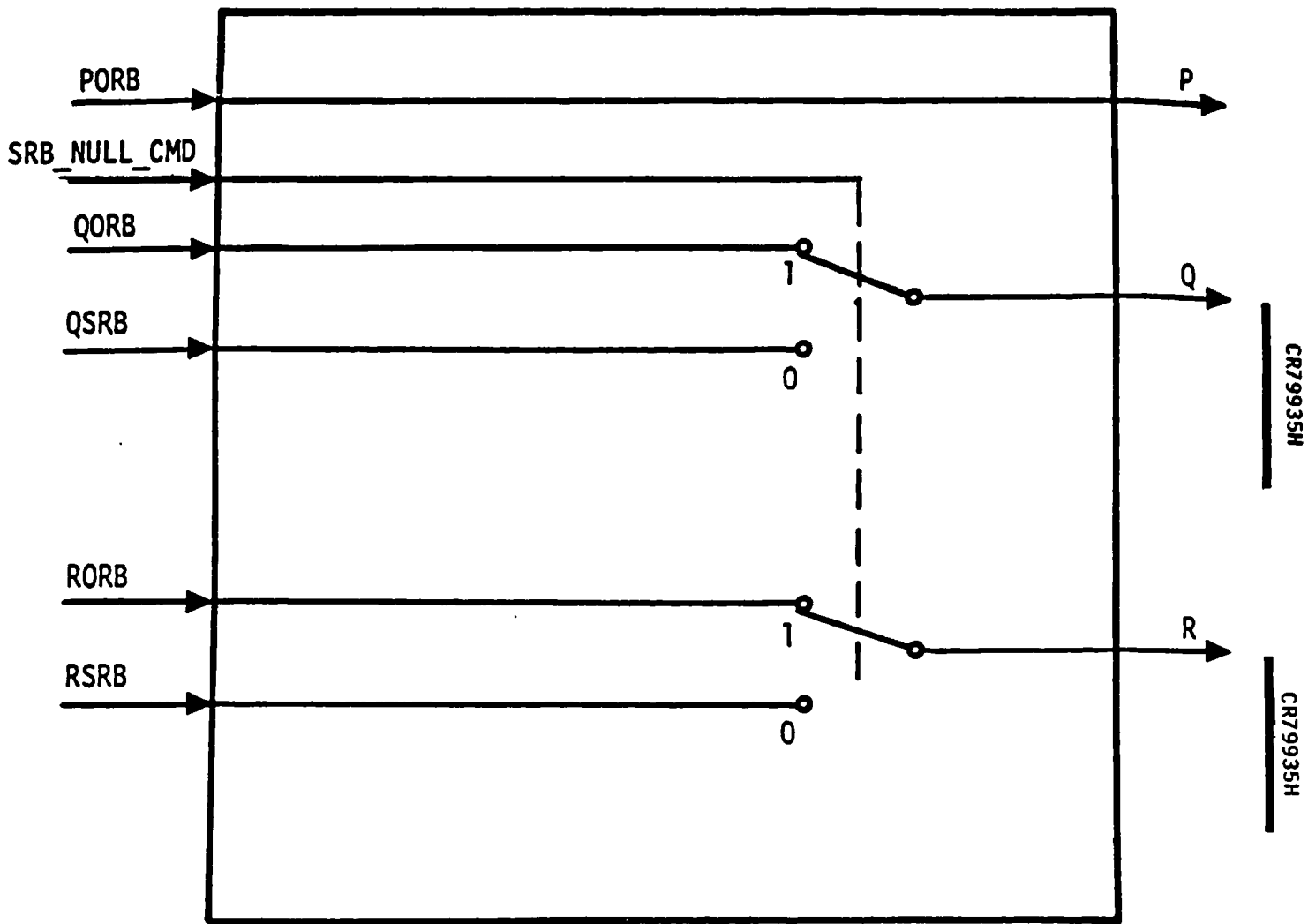
4.6.4.7 Attitude Processor RGA Switch (ATT_PROC_RGASW)

- A. Function. ATT_PROC_RGASW provides SRB pitch and yaw rate signals to ATT_PROC_PREFIL during ascent first stage, and orbiter pitch and yaw rate signals to ATT_PROC_PREFIL for the remainder of ascent, transition, and entry through landing. It provides orbiter roll rate to ATT_PROC_PREFIL during ascent, transition, entry through landing. The block diagram for ATT_PROC_RGASW is given in Figure 4.6.4.7-1.
- B. Processing Requirements. ATT_PROC_RGASW operates at 25 Hz during ascent and entry through landing. During transition, ATT_PROC_RGASW is performed at 12.5 Hz.
- C. Interface Requirements. The interface requirements for the module ATT_PROC_RGASW are shown in Tables 4.6.2-1 and 4.6.2-2.
- D. Constants. There are no constants for ATT_PROC_RGASW.
- E. Initialization Requirements. There are no initialization requirements for ATT_PROC_RGASW.
- F. Detailed Technical Description. Switching is controlled by SRB_NULL_CMD during ascent.

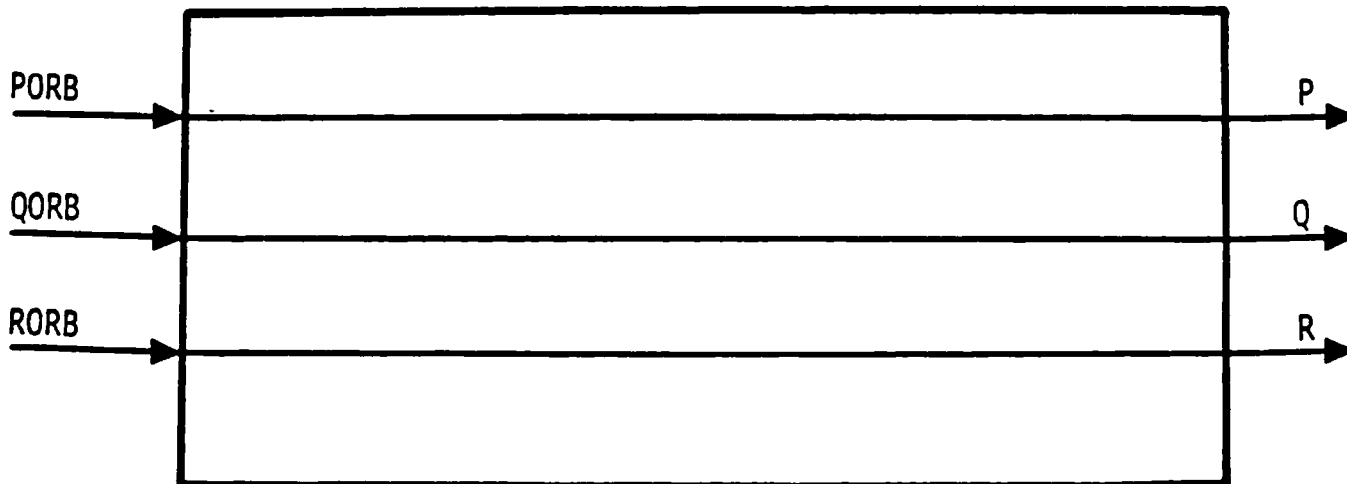
P = PORB

If (SRB_NULL_CMD \neq 0),
then Q = QORB and R = RORB
else Q = QSRB and R = RSRB

Orbiter values for P, Q, and R are used during all other flight phases.



A. ASCENT



B. TRANSITION, ENTRY THROUGH LANDING

Figure 4.6.4.7-1. ATT_PROC_RGASW Block Diagram

4.6.4.8

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4.6.4.8 ADI Quaternion Uplink (ADI_QUAT_UPLINK)

A. Functional Requirements. ADI_QUAT_UPLINK is a procedure that performs the following functions.

1. Determine if new ADI quaternion loads have been uplinked and made available.
2. Move the new data from the uplink buffers into appropriate compool storage locations.

The block diagram for ADI_QUAT_UPLINK is given in Figure 4.6.4.8-1.

B. Processing Requirements. ADI_QUAT_UPLINK is performed on demand.

C. Interface Requirements. The interface requirements for ADI_QUAT_UPLINK are given in Tables 4.6.2-1 and 4.6.2-2.

D. Detailed Requirements. The following set of equations and sequences are used to perform the ADI_QUAT_UPLINK function.

1. If the uplink OP code is for the ADI INERTIAL QUATERNION LOAD (0011000), then transfer the values of the quaternion elements from the uplink buffer into the storage locations used by ATT_PROC_DISP for the ADI inertial quaternion.
2. If the uplink OP code is for the ADI REFERENCE QUATERNION LOAD (0011101), then transfer the values of the quaternion elements from the uplink buffer into the storage locations used by ATT_PROC_DISP for the ADI reference quaternion.
3. If the uplink OP code is for the ADI BIASLVLH QUATERNION LOAD (0011110), then transfer the values of the quaternion elements from the uplink buffer into the storage locations used by ATT_PROC_OUTER for the ADI bias LVLH quaternion.

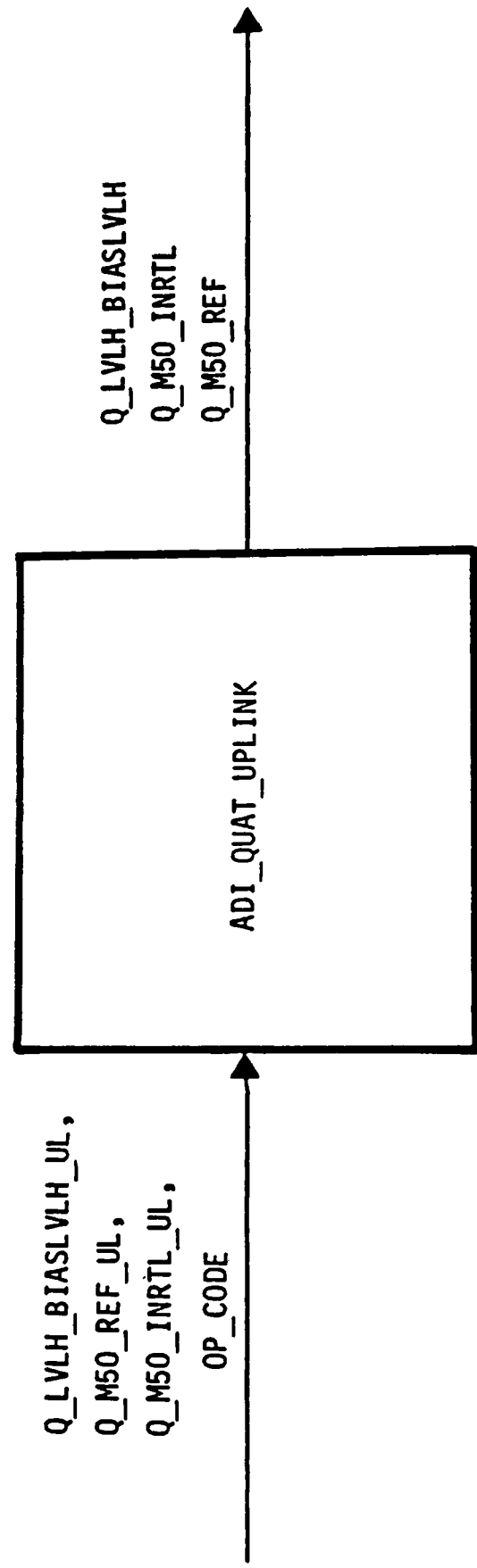


Figure 4.6.4.8-1. ADI_QUAT_UPLINK Block Diagram

4.6.5 Ascent/Entry Attitude Processor Principal Function Tables

The ascent/entry attitude processor principal function input and output tables, along with the I-load and K-load tables, are presented in Tables 4.6.5-1 through 4.6.5-3. The automated Interface Definition Document (IDD), Table 4.6.5-1, defines signal (parameter) interface requirements either between hardware (LRU) and software elements or between software elements.* In the event of a conflict between the IDD tables and other internal text input/output tables, the SASCB data base-controlled IDD tables take precedence.

Note that IDD output (source) tables that reflect parameters going to input (destination) TLM will not be interpreted as a signal actually being downlisted. The parameter may only be available for downlist in COMPOOL and may not appear in a downlist format.

*A GN&C software element is either a sequenced principal function (PF), crew generated specialist/display function, or OPS display function.



Table 4.6.5-1. Ascent/Entry Attitude Processor Interface (G4.226)
Input/Output Parameters

DBFN: 02B041-C PN: VP707100034P00L JUNE 29, 1988
INPUT FUNCTIONAL PARAMETERS FOR ASCENT/ENTRY ATTITUDE PROCESSOR

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BOOK 1 0-1

010C REV00 G4.226

A/E ATT PROC

DATA TYPE C

DATA TYPE C

UNITS

SOURCE

NOMENCLATURE

M/S ID

FSSR NAME

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE C
ANGLE_CORR_TINTOMAG_RM	V90H1820CA	MAGNETIC VARIATION OF RM	ENT SITE LOOKUP	RAD	
ANGLE_CORR_TINTOHAG_RM	V90H1820CB	MAGNETIC VARIATION OF RM	ASC SITE LOOKUP	RAD	
ATT_DG	V90J2555C	ATTITUDE DATA GOOD FLAG	IMU RM		
ATT_SEL_SMI 1)	V90J7503C	LH ADI ATTITUDE SELECT SM	GNIC SM RM		HXS
ATT_SEL_SMI 2)	V90J7504C	RH ADI ATTITUDE SELECT SM	GNIC SM RM		HXS
AZANGI 1)	V95H0051CA	IMU 1 COMP AZIMUTH RES ANGLE	IMU INT PROC	DEG	
AZANGI 2)	V95H1051CA	IMU 2 COMP AZIMUTH RES ANGLE	IMU INT PROC	DEG	
AZANGI 3)	V95H2051CA	IMU 3 COMP AZIMUTH RES ANGLE	IMU INT PROC	DEG	
CDPI 1)	V90U2648CA	COS OF 1/2 IMU 1 R/P NONORTHOGON	ORB ATT PROC		
CDPI 2)	V90U2649CA	COS OF 1/2 IMU 2 R/P NONORTHOGON	ORB ATT PROC		
CDPI 3)	V90U2650CA	COS OF 1/2 IMU 3 R/P NONORTHOGON	ORB ATT PROC		
CLOCK/CLOCKTIME	V91H5000C1	CLOCK-COMPUTER(RIGHT)	FCOS	S	
DESEL	V93X6647X	COAS DES CMD	6.44		
DPI 1)	V99H2660CA	IMU 1 ROLL/PITCH NONORTHOGONALITY	IMU GND CAL	RAD	
DPI 2)	V99H2661CA	IMU 2 ROLL/PITCH NONORTHOGONALITY	IMU GND CAL	RAD	
DPI 3)	V99H2662CA	IMU 3 ROLL/PITCH NONORTHOGONALITY	IMU GND CAL	RAD	
FWD_ATT_REF_PB	V90X7897X	STA SEL FWD ADI ATT REF PB	GNIC SM RM		
I_YD_M501 1)	V95U0494C	H50 INSERTION TARGET UNIT VECTOR-1	ASC UP		
I_YD_M501 2)	V95U0495C	H50 INSERTION TARGET UNIT VECTOR-2	ASC UP		
I_YD_M501 3)	V95U0496C	H50 INSERTION TARGET UNIT VECTOR-3	ASC UP		
IMU_ALIGN_DISP	V90X8020X	IMU ALIGN DISP ON FLAG	HSC		
IMU_QUAT_UPD_REQ	V95X0532XA	IMU REFERENCE QUAT UPDATE REQUEST	IMU ORB A/CAL		
IMU_QUAT_UPD_REQ	V95X0532XB	IMU REFERENCE QUAT UPDATE REQUEST	IMU ORB A/CAL		
IRANGI 1)	V95H0053CA	IMU 1 COMP INNER ROLL RES ANGLE	IMU INT PROC	DEG	
IRANGI 2)	V95H1053CA	IMU 2 COMP INNER ROLL RES ANGLE	IMU INT PROC	DEG	
IRANGI 3)	V95H2053CA	IMU 3 COMP INNER ROLL RES ANGLE	IMU INT PROC	DEG	
IYDI 1)	V97U4413CB	UNIT VEC NORM TRAJ PLANE X COMP	UL		
IYDI 2)	V97U4414CB	UNIT VEC NORM TRAJ PLANE Y COMP	UL		
IYDI 3)	V97U4415CB	UNIT VEC NORM TRAJ PLANE Z COMP	UL		
MECO_CMD_EVENT_A36B	V90X8569XA	MECO COMMAND FLAG	SSME OPS		
MM_CODE_101/MM_101	V90X8155X	MAJOR MODE 101 FLAG	HSC		
MM_CODE_102/MM_102	V90X8156X	MAJOR MODE 102 FLAG	HSC		
MM_CODE_103/MM_103	V90X8157X	MAJOR MODE 103 FLAG	HSC		
MM_CODE_304/MM_304	V90X8158X	MAJOR MODE 304 FLAG	HSC		
MM_CODE_601/MM_601	V90X8159X	MAJOR MODE 601 FLAG	HSC		
MM_CODE_602/MM_602	V90X8160X	MAJOR MODE 602 FLAG	HSC		
ORANGI 1)	V95H0054CA	IMU 1 COMP OUTER ROLL RES ANGLE	IMU INT PROC	DEG	
ORANGI 2)	V95H1054CA	IMU 2 COMP OUTER ROLL RES ANGLE	IMU INT PROC	DEG	
ORANGI 3)	V95H2054CA	IMU 3 COMP OUTER ROLL RES ANGLE	IMU INT PROC	DEG	
P_ORB	V90R5301CA	SELECTED RGA ROLL RATE	SF		
PANGI 1)	V95H1050CA	IMU 1 COMP PITCH RES ANGLE	IMU INT PROC	DEG	
PANGI 2)	V95H1050CA	IMU 2 COMP PITCH RES ANGLE	IMU INT PROC	DEG	
PANGI 3)	V95H2050CA	IMU 3 COMP PITCH RES ANGLE	IMU INT PROC	DEG	
Q_B_I_CMD_DISPLAY 1)	V90H2721CC	CHD BODY HRT H50 QUAT ELEM 1	TRANS DAP		
Q_B_I_CMD_DISPLAY 2)	V90H2722CC	CHD BODY HRT H50 QUAT ELEM 2	TRANS DAP		
Q_B_I_CMD_DISPLAY 3)	V90H2723CC	CHD BODY HRT H50 QUAT ELEM 3	TRANS DAP		
Q_B_I_CMD_DISPLAY 4)	V90H2724CC	CHD BODY HRT H50 QUAT ELEM 4	TRANS DAP		
Q_BOD_M501 1/Q_B_M501 1)	V90U2240CB	M50 TO BODY QUAT MEASURED ELEM 1	ORB ATT PROC		
Q_BOD_M501 2/Q_B_M501 2)	V90U2241CB	M50 TO BODY QUAT MEASURED ELEM 2	ORB ATT PROC		
Q_BOD_M501 3/Q_B_M501 3)	V90U2242CB	M50 TO BODY QUAT MEASURED ELEM 3	ORB ATT PROC		
Q_BOD_M501 4/Q_B_M501 4)	V90U2243CB	M50 TO BODY QUAT MEASURED ELEM 4	ORB ATT PROC		
Q_LVLH_BIAS/VLH_UL 1)	V97U22210CC	ADY TO LVLH QUAT MEASURED ELEM 1	UL		

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Table 4.6.5-1. Ascent/Entry Attitude Processor Interface (G4.226)
Input/Output Parameters (Cont)

DBFN: D2B039-A PN: VP707100026P00L
INPUT FUNCTIONAL PARAMETERS FOR ASCENT/ENTRY ATTITUDE PROCESSOR
MAY 31, 1988

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DBFN: D2B039-A PN: VP707100026P00L
INPUT FUNCTIONAL PARAMETERS FOR ASCENT/ENTRY ATTITUDE PROCESSOR
MAY 31, 1988

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE
Q LVLH_BIASLVLH_UL(2)	V97U2211CC	ADI TO LVLH QUAT ELEM 2	UL		
Q LVLH_BIASLVLH_UL(3)	V97U2212CC	ADI TO LVLH QUAT ELEM 3	UL		
Q LVLH_BIASLVLH_UL(4)	V97U2213CC	ADI TO LVLH QUAT ELEM 4	UL		
Q M50_INRTL_UL(1)	V97U2214CC	ADI INERT QUAT ELEM 1	UL		
Q M50_INRTL_UL(2)	V97U2215CC	ADI INERT QUAT ELEM 2	UL		
Q M50_INRTL_UL(3)	V97U2216CC	ADI INERT QUAT ELEM 3	UL		
Q M50_INRTL_UL(4)	V97U2217CC	ADI INERT QUAT ELEM 4	UL		
Q M50_REF_UL(1)	V97U2218CC	ADI REF QUAT ELEM 1	UL		
Q M50_REF_UL(2)	V97U2219CC	ADI REF QUAT ELEM 2	UL		
Q M50_REF_UL(3)	V97U2220CC	ADI REF QUAT ELEM 3	UL		
Q M50_REF_UL(4)	V97U2221CC	ADI REF QUAT ELEM 4	UL		
Q ORB7	V90R5321CA	SELECTED RGA PITCH RATE	SF	DEG/S	
Q SM_M50(1,1)	V90U2666CA	IMU 1 REFERENCE QUATERNION 1	ORB ATT PROC		
Q SM_M50(1,2)	V90U2666CA	IMU 1 REFERENCE QUATERNION 2	ORB ATT PROC		
Q SM_M50(1,3)	V90U2666CA	IMU 1 REFERENCE QUATERNION 3	ORB ATT PROC		
Q SM_M50(1,4)	V90U2666CA	IMU 1 REFERENCE QUATERNION 4	ORB ATT PROC		
Q SM_M50(2,1)	V90U2667CA	IMU 2 REFERENCE QUATERNION 1	ORB ATT PROC		
Q SM_M50(2,2)	V90U2667CA	IMU 2 REFERENCE QUATERNION 2	ORB ATT PROC		
Q SM_M50(2,3)	V90U2667CA	IMU 2 REFERENCE QUATERNION 3	ORB ATT PROC		
Q SM_M50(2,4)	V90U2667CA	IMU 2 REFERENCE QUATERNION 4	ORB ATT PROC		
Q SM_M50(3,1)	V90U2672CA	IMU 3 REFERENCE QUATERNION 1	ORB ATT PROC		
Q SM_M50(3,2)	V90U2672CA	IMU 3 REFERENCE QUATERNION 2	ORB ATT PROC		
Q SM_M50(3,3)	V90U2672CA	IMU 3 REFERENCE QUATERNION 3	ORB ATT PROC		
Q SM_M50(3,4)	V90U2672CA	IMU 3 REFERENCE QUATERNION 4	ORB ATT PROC		
Q SRB	V90R2511CC	SRGA SEL PITCH RATE	SF	DEG/S	
R AVGG1(1)	V95H0185CA	X-COMP OF CURRENT SHUTTLE POS	RTLS UPP		DPL
R AVGG1(2)	V95H0185CA	X-COMP OF CURRENT SHUTTLE POS	ASC UPP		DPL
R AVGG1(3)	V95H0185CA	X-COMP OF CURRENT SHUTTLE POS	ENT UPP		DPL
R AVGG1(4)	V95H0185CA	X-COMP OF CURRENT SHUTTLE POS	TAEM UPP		DPL
R AVGG2(1)	V95H0185CD	Y-COMP OF CURRENT SHUTTLE POS	A/L UPP		DPL
R AVGG2(2)	V95H0185CE	Y-COMP OF CURRENT SHUTTLE POS	RTLS UPP		DPL
R AVGG2(3)	V95H0185CE	Y-COMP OF CURRENT SHUTTLE POS	ASC UPP		DPL
R AVGG2(4)	V95H0185CE	Y-COMP OF CURRENT SHUTTLE POS	ENT UPP		DPL
R AVGG3(1)	V95H0186CA	Z-COMP OF CURRENT SHUTTLE POS	TAEM UPP		DPL
R AVGG3(2)	V95H0186CB	Z-COMP OF CURRENT SHUTTLE POS	A/L UPP		DPL
R AVGG3(3)	V95H0186CC	Z-COMP OF CURRENT SHUTTLE POS	RTLS UPP		DPL
R AVGG3(4)	V95H0186CC	Z-COMP OF CURRENT SHUTTLE POS	ASC UPP		DPL
R AVGG4(1)	V95H0187CA	Z-COMP OF CURRENT SHUTTLE POS	ENT UPP		DPL
R AVGG4(2)	V95H0187CB	Z-COMP OF CURRENT SHUTTLE POS	TAEM UPP		DPL
R AVGG4(3)	V95H0187CC	Z-COMP OF CURRENT SHUTTLE POS	A/L UPP		DPL
R AVGG4(4)	V95H0187CC	Z-COMP OF CURRENT SHUTTLE POS	RTLS UPP		DPL
R AVGG5(1)	V95H0187CD	Z-COMP OF CURRENT SHUTTLE POS	ASC UPP		DPL
R AVGG5(2)	V95H0187CE	Z-COMP OF CURRENT SHUTTLE POS	ENT UPP		DPL
R AVGG5(3)	V95H0187CE	Z-COMP OF CURRENT SHUTTLE POS	TAEM UPP		DPL
R AVGG5(4)	V95H0187CE	Z-COMP OF CURRENT SHUTTLE POS	A/L UPP		DPL
R ORB	V90R5341CA	SELECTED RGA YAW RATE	SF	DEG/S	
R SRB	V90R2512CC	SIN OF 1/2 IMU 1 R/P NONORTHOGON	SF	DEG/S	
SDPI(1)	V90U2645CA	SIN OF 1/2 IMU 2 R/P NONORTHOGON	ORB ATT PROC		
SDPI(2)	V90U2646CA	SIN OF 1/2 IMU 3 R/P NONORTHOGON	ORB ATT PROC		
SDPI(3)	V90U2647CA	SELECTED IMU ID	ORB ATT PROC		
SEL_V_M50(1,1)	V90J2560C	SELECTED IMU 1 VEL M50	IMU RM	FT/S	MXS
SEL_V_M50(1,2)	V90L2557C	SELECTED IMU 2 VEL M50	IMU RM	FT/S	DPL
SEL_V_M50(1,3)	V90L2558C	SELECTED IMU 3 VEL M50	IMU RM	FT/S	DPL
SEL_V_M50(1,4)	V90L2559C	SELECTED IMU 4 VEL M50	IMU RM	FT/S	DPL
SEL_V_M50(2,1)	V90X1769X	INITIATE SRB NULL CMD	:SC DIAP	FT/S	
SEL_V_M50(2,2)	V99U3450CA	CLUSTER TO M50/IMU-1 COMPONENT 1,1	IMU ORB A/CAL	FT/S	
SEL_V_M50(2,3)	V99U3450CB	CLUSTER TO M50/IMU-1 COMPONENT 1,1	IMU GC ALIGN	FT/S	
SEL_V_M50(2,4)	V99U3450CB	CLUSTER TO M50/IMU-1 COMPONENT 1,1	IMU ORB A/CAL	FT/S	
SEL_V_M50(3,1)	V99U3450CB	CLUSTER TO M50/IMU-1 COMPONENT 1,1	IMU ORB A/CAL	FT/S	
SEL_V_M50(3,2)	V99U3450CB	CLUSTER TO M50/IMU-1 COMPONENT 1,1	IMU ORB A/CAL	FT/S	
SEL_V_M50(3,3)	V99U3450CB	CLUSTER TO M50/IMU-1 COMPONENT 1,1	IMU ORB A/CAL	FT/S	
SEL_V_M50(3,4)	V99U3450CB	CLUSTER TO M50/IMU-1 COMPONENT 1,1	IMU ORB A/CAL	FT/S	



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Table 4.6.5-1. Ascent/Entry Attitude Processor Interface (G4.226)
Input/Output Parameters (Cont)

DBFN: D2B039-A PN: VP707100026P00L MAY 31, 1988 OIBB REV00 G4.226 A/E ATT PROC DATA TYPE C
INPUT FUNCTIONAL PARAMETERS FOR ASCENT/ENTRY ATTITUDE PROCESSOR

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DPL
T_CLUSTER M50(1,1,2)	V99U3453CB	TO M50/IMU-1	IMU GC ALIGN		
T_CLUSTER M50(1,1,3)	V99U3456CA	TO M50/IMU-1	IMU ORB A/CAL		
T_CLUSTER M50(1,2,1)	V99U3459CA	TO M50/IMU-1	IMU GC ALIGN		
T_CLUSTER M50(1,2,2)	V99U3462CA	TO M50/IMU-1	IMU ORB A/CAL		
T_CLUSTER M50(1,2,3)	V99U3465CA	TO M50/IMU-1	IMU GC ALIGN		
T_CLUSTER M50(1,3,1)	V99U3468CA	TO M50/IMU-1	IMU ORB A/CAL		
T_CLUSTER M50(1,3,2)	V99U3471CA	TO M50/IMU-1	IMU GC ALIGN		
T_CLUSTER M50(1,3,3)	V99U3474CA	TO M50/IMU-1	IMU ORB A/CAL		
T_CLUSTER M50(2,1,1)	V99U3451CA	TO M50/IMU-2	IMU GC ALIGN		
T_CLUSTER M50(2,1,2)	V99U3454CA	TO M50/IMU-2	IMU ORB A/CAL		
T_CLUSTER M50(2,1,3)	V99U3457CA	TO M50/IMU-2	IMU GC ALIGN		
T_CLUSTER M50(2,2,1)	V99U3460CA	TO M50/IMU-2	IMU ORB A/CAL		
T_CLUSTER M50(2,2,2)	V99U3463CA	TO M50/IMU-2	IMU GC ALIGN		
T_CLUSTER M50(2,2,3)	V99U3466CA	TO M50/IMU-2	IMU ORB A/CAL		
T_CLUSTER M50(2,3,1)	V99U3469CA	TO M50/IMU-2	IMU GC ALIGN		
T_CLUSTER M50(2,3,2)	V99U3472CA	TO M50/IMU-2	IMU ORB A/CAL		
T_CLUSTER M50(2,3,3)	V99U3475CA	TO M50/IMU-2	IMU GC ALIGN		
T_CLUSTER M50(3,1,1)	V99U3452CA	TO M50/IMU-3	IMU GC ALIGN		
T_CLUSTER M50(3,1,2)	V99U3455CA	TO M50/IMU-3	IMU ORB A/CAL		
T_CLUSTER M50(3,1,3)	V99U3458CA	TO M50/IMU-3	IMU GC ALIGN		
T_CLUSTER M50(3,2,1)	V99U3461CA	TO M50/IMU-3	IMU ORB A/CAL		
T_CLUSTER M50(3,2,2)	V99U3464CA	TO M50/IMU-3	IMU GC ALIGN		
T_CLUSTER M50(3,2,3)	V99U3467CA	TO M50/IMU-3	IMU ORB A/CAL		
T_CLUSTER M50(3,3,1)	V99U3470CA	TO M50/IMU-3	IMU GC ALIGN		
T_CLUSTER M50(3,3,2)	V99U3473CA	TO M50/IMU-3	IMU ORB A/CAL		
T_CLUSTER M50(3,3,3)	V99U3476CA	TO M50/IMU-3	IMU GC ALIGN		
T_IMUS UP_CODE	V95M0002C	IMU INPUT TRANS TIME	IMU GC ALIGN	S	DPL
	V96J3521C	OP CODE FOR UPLINK	INT PROC		

Table 4.6.5-1. Ascent/Entry Attitude Processor Interface (C4.226)
Input/Output Parameters (Cont)

DBFN: 028033-A PNI: VP707100026POOL DECEMBER 10, 1987
 INPUT FUNCTIONAL PARAMETERS FOR ASCENT/ENTRY ATTITUDE PROCESSING
 0100 REV00 4.226 A/E ATT PROC DATA TYPE C

FSSR NAME	M/S ID	NOMENCLATURE	SOURCE	UNITS	DATA TYPE
T CLUSTER M5013,3,3,3	V99033476CA	CLUSTER TO H50/IMJ-3 COMPONENT 3,3	IMJ ORG A/CAL	S	DPL
T IMUS	V99033476CB	IMJ INPUT TRANS Y TAG	IMJ GC ALIGN	S	DPL
V AVGG1 1	V95L0190CA	X-COMP OF CURRENT SHUTTLE	ATLS LPP	F	DPL
V AVGG1 1	V95L0190CB	Y-COMP OF CURRENT SHUTTLE	ASC LPP	F	DPL
V AVGG1 1	V95L0190CC	Z-COMP OF CURRENT SHUTTLE	ENT LPP	F	DPL
V AVGG1 2	V95L0190CD	X-COMP OF CURRENT SHUTTLE	VAEM LPP	F	DPL
V AVGG1 2	V95L0190CE	Y-COMP OF CURRENT SHUTTLE	A/L LPP	F	DPL
V AVGG1 2	V95L0190CF	Z-COMP OF CURRENT SHUTTLE	ATLS LPP	F	DPL
V AVGG1 3	V95L0190CG	X-COMP OF CURRENT SHUTTLE	ASC LPP	F	DPL
V AVGG1 3	V95L0190CH	Y-COMP OF CURRENT SHUTTLE	ENT LPP	F	DPL
V AVGG1 3	V95L0190CI	Z-COMP OF CURRENT SHUTTLE	VAEM LPP	F	DPL
V RH01 1	V95L0215CA	X-COMP OF RELATIVE VEL IN H50	A/L LPP	F	DPL
V RH01 1	V95L0215CB	Y-COMP OF RELATIVE VEL IN H50	ASC LPP	F	DPL
V RH01 1	V95L0215CC	Z-COMP OF RELATIVE VEL IN H50	ENT LPP	F	DPL
V RH01 2	V95L0216CA	X-COMP OF RELATIVE VEL IN H50	VAEM LPP	F	DPL
V RH01 2	V95L0216CB	Y-COMP OF RELATIVE VEL IN H50	A/L LPP	F	DPL
V RH01 2	V95L0216CC	Z-COMP OF RELATIVE VEL IN H50	ASC LPP	F	DPL
V RH01 3	V95L0217CA	X-COMP OF RELATIVE VEL IN H50	ENT LPP	F	DPL
V RH01 3	V95L0217CB	Y-COMP OF RELATIVE VEL IN H50	VAEM LPP	F	DPL
V RH01 3	V95L0217CC	Z-COMP OF RELATIVE VEL IN H50	A/L LPP	F	DPL
V RH01 3	V95L0217CD	X-COMP OF RELATIVE VEL IN H50	ASC LPP	F	DPL
V RH01 3	V95L0217CE	Y-COMP OF RELATIVE VEL IN H50	ENT LPP	F	DPL
V RH01 3	V95L0217CF	Z-COMP OF RELATIVE VEL IN H50	VAEM LPP	F	DPL
V RH01 3	V95L0217CG	X-COMP OF RELATIVE VEL IN H50	A/L LPP	F	DPL
V RH01 3	V95L0217CH	Y-COMP OF RELATIVE VEL IN H50	ASC LPP	F	DPL
V RH01 3	V95L0217CI	Z-COMP OF RELATIVE VEL IN H50	ENT LPP	F	DPL

Table 4.6.5-1. Ascent/Entry Attitude Processor Interface (G4.226)
Input/Output Parameters (Cont)

DBFM: 028041-C PN: VP707100034P00L
OUTPUT FUNCTIONAL PARAMETERS FROM ASCENT/ENTRY ATTITUDE PROCESSOR

JUNE 29, 1988
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FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE
ALPHA_N	V90H2246C	NAV DERIVED ANGLE OF ATTACK	ADTA SOP, RTLS UPP, ENT UPP, TAEM UPP, ENT NAV, AMI PROC, AEROJET DAP, ASC NAV, RTLS NAV, ASC PREC, PRED, ENT, PREC, PRED, A/L UPP, ET SEP, SECT, GRTLS DAP, ASC 1ST G, GUID, VERT, SIT DIP, TLM TRANS DAP, ORB DAP, TLM TRANS DAP, ORB DAP, TLM TRANS DAP, ORB DAP, TLM ENT OIP, TLM AEROJET DAP, ET SEP, GRTLS DAP, B.7, ENT NAV, ASC NAV, RTLS NAV, HSI PROC, G/C STEER, ASC PREC, PRED E/L ADI PROC, ASC ADI PROC E/L ADI PROC, ASC ADI PROC ORB ATT PROC ORB ATT PROC ORB ATT PROC TAEM GUID, AEROJET DAP, GUID, VEAT SYT, DIP, TLM TAEM GUID, TAEM UPP, TLM, A/L UPP, GRTLS TAEM GUID, RTLS UPP, AEROJET DAP, GRTLS DAP, HUD PROC TRANS DAP, OMS RM, TLM TRANS DAP, OMS RM, TLM TRANS DAP, OMS RM, TLM TRANS DAP, OMS RM, TLM GNIC/SH-PL IF GNIC/SH-PL IF GNIC/SH-PL IF ENT GUID, AEROJET DAP, ENT DIP, B.7, GRTLS DAP, E/L ADI PROC, GRTLS TAEM GUID, TAEM GUID, TLM 6.26 6.26 6.26 TLM ENT AREA NAV, E/L ADI PROC, ASC AREA NAV 6.26 6.26 6.26 E/L ADI PROC, TLM, ASC ADI PROC E/L ADI PROC, TLM, ASC ADI PROC E/L ADI PROC, ASC ADI PROC, TLM G/C STEER, TRANS DAP, ENT UPP, ASC NAV, DEORB MNRV DIP, ASC NAV, DEORB GUID.	DEG	SPL
ATTITUDE_INCREMENT(1)	V90U2333C	ATTITUDE INCREMENT-HI RATE ROLL		DEG	SPL
ATTITUDE_INCREMENT(2)	V90U2334C	ATTITUDE INCREMENT-HI RATE PITCH		DEG	SPL
ATTITUDE_INCREMENT(3)	V90U2335C	ATTITUDE INCREMENT-HI RATE YAW		DEG	SPL
BANK	V90H2207C	BANK ANGLE		DEG	SPL
BETA_N	V90H2249C	INERTIAL SIDESLIP ANGLE		DEG	SPL
BODY_ERR_ANGLE(1)	V90H2233CA	BODY ROLL ATTITUDE ERROR		DEG	SPL
BODY_ERR_ANGLE(2)	V90H2234CA	BODY PITCH ATTITUDE ERROR		DEG	SPL
BODY_ERR_ANGLE(3)	V90H2235CA	BODY YAW ATTITUDE ERROR		DEG	SPL
CDP(1)	V90U2648CB	COS OF 1/2 IMJ 1 R/P NONORTHOGON		DEG	SPL
CDP(2)	V90U2649CB	COS OF 1/2 IMJ 2 R/P NONORTHOGON		DEG	SPL
CDP(3)	V90U2650CB	COS OF 1/2 IMJ 3 R/P NONORTHOGON		DEG	SPL
COSPHI	V90H2204C	EULER ANGLE ROLL COSINE		DEG	SPL
COSTH	V90H2215C	EULER ANGLE PITCH COSINE		DEG	SPL
DVB_SEC(1)	V90U2307C	BODY VEL INCREMENT LO RATE X AXIS		FT/S	SPL
DVB_SEC(2)	V90U2308C	BODY VEL INCREMENT LO RATE Y AXIS		FT/S	SPL
DVB_SEC(3)	V90U2309C	BODY VEL INCREMENT LO RATE Z AXIS		FT/S	SPL
GMTC/T_MOM	V90H2310CA	M50 TO BODY QUAT TIME		RAD	SPL
PAYLOAD_PITCH	V95L3887CC	EF TO BODY EULER ANGLE PITCH		RAD	SPL
PAYLOAD_ROLL	V95L3889CC	EF TO BODY EULER ANGLE ROLL		RAD	SPL
PAYLOAD_YAW	V95L388ACC	EF TO BODY EULER ANGLE YAW		RAD	SPL
PHI	V90H2202C	BODY ROLL ATTITUDE EULER ANGLE		DEG	SPL
PHI_IMJ(1)	V90H2317CB	M50 TO BODY EULER ANGLE 1 PHI		DEG	SPL
PHI_IMJ(2)	V90H2318CB	M50 TO BODY EULER ANGLE 2 PHI		DEG	SPL
PHI_IMJ(3)	V90H2319CB	M50 TO BODY EULER ANGLE 3 PHI		DEG	SPL
PSI	V90H2210C	BODY YAW ATTITUDE EULER ANGLE		DEG	SPL
PSI_HSIHV	V90H2212C	HEADING RELATIVE TO MAG NORTH		RAD	SPL
PSI_IMJ(1)	V90H2311CB	M50 TO BODY EULER ANGLE 1 PSI		DEG	SPL
PSI_IMJ(2)	V90H2312CB	M50 TO BODY EULER ANGLE 2 PSI		DEG	SPL
PSI_IMJ(3)	V90H2313CB	M50 TO BODY EULER ANGLE 3 PSI		DEG	SPL
PITCHCOS(1)	V90H2222CA	LH ADI SEL EULER ANG PITCH COSINE		DEG	SPL
PITCHCOS(2)	V90H2218CA	RH ADI SEL EULER ANG PITCH COSINE		DEG	SPL
PITCHSINE(1)	V90H2221CA	LH ADI SEL EULER ANG PITCH SINE		DEG	SPL
PITCHSINE(2)	V90H2220CA	RH ADI SEL EULER ANG PITCH SINE		DEG	SPL
Q_BOD_H50(1) / Q_B_I(1)	V90U2240CA	M50 TO BODY QUAT MEASURED ELEN 1		DEG	SPL

Table 4.6.5-1. Ascent/Entry Attitude Processor Interface (G4.226)
Input/Output Parameters (Cont)

Table 4.6.5-1. Ascent/Entry Attitude Processor Interface (G4.226)
Input/Output Parameters (Cont)

DBFN: D28041-C PN: VP707100034P00L
OUTPUT FUNCTIONAL PARAMETERS FROM ASCENT/ENTRY ATTITUDE PROCESSOR

JUNE 29, 1988
A/E ATT PROC OI8C REV00 G4.226

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS	DATA TYPE
ALPHA_N	V90H2246C	NAV DERIVED ANGLE OF ATTACK		DEG	SPL
ATTITUDE_INCREMENT(1)	V90U2333C	ATTITUDE INCREMENT-HI RATE ROLL	ADTA SOP, RTLS UPP, ENT UPP, AEROJET DAP, ENT NAV, AHT PROC, ASC PREC, ENT NAV, RTLS NAV, A/L UPP, ENT SEP, SEG, GRTLS DAP, ASC 1STG GUID, VERT SYT DIP, TLM TRANS DAP, ORB DAP, TLM TRANS DAP, ORB DAP, TLM ENT DIP, TLM AEROJET DAP, ET SEP, SEG, GRTLS DAP, 5.7, ENT NAV, ASC NAV, RTLS NAV, HSI, PROC, G/C STEER, ASC PREC, ENT UPP, ENT NAV, RTLS NAV, ENT PREC, ENT UPP, ENT NAV, RTLS NAV, E/L ADI PROC, ASC ADI PROC, E/L ADI PROC, ASC ADI PROC, ORB ATT PROC, ORB ATT PROC, ORB ATT PROC, TAEM GUID, AEROJET DAP, GRTLS DAP, GRTLS TAEM GUID, VEAT SYT DIP, TLM TAEM GUID, TAEM UPP, TLM, A/L UPP, GRTLS TAEM GUID, RTLS UPP, AEROJET DAP, GRTLS DAP, HU0 PROC TRANS DAP, CHS RH, TLM TRANS DAP, CHS RH, TLM TRANS DAP, CHS RH, TLM GNIC/SH-PL IF, TLM GNIC/SH-PL IF, GNIC/SH-PL IF, ENT GUID, AEROJET DAP, ENT DIP, 5.7, GRTLS DAP, E/L ADI PROC, GRTLS TAEM GUID, TAEM GUID, TLM, 6.26, 6.26, 6.26, TLM ENT AREA NAV, E/L ADI PROC, ASC AREA NAV, 6.26, 6.26, 6.26, E/L ADI PROC, TLM, ASC ADI PROC, E/L ADI PROC, TLM, ASC ADI PROC, E/L ADI PROC, ASC ADI PROC, G/C STEER, TRANS DAP, ENT UPP, ENT NAV, ORB, DEORB, MVR DIP, ASC NAV, DEORB GUID.	DEG	SPL
BANK	V90H2201C	BANK ANGLE		DEG	SPL
BETA_N	V90H2249C	INERTIAL SIDESLIP ANGLE		DEG	SPL
BODY_ERR_ANG(1)	V90H2233CA	BODY ROLL ATTITUDE ERROR		DEG	SPL
BODY_ERR_ANG(2)	V90H2233CA	BODY PITCH ATTITUDE ERROR		DEG	SPL
BODY_ERR_ANG(3)	V90H2233CA	BODY YAW ATTITUDE ERROR		DEG	SPL
CDP(1)	V90U2648CB	COS OF 1/2 IMU 1 R/P NONORTHOGON		DEG	SPL
CDP(2)	V90U2649CB	COS OF 1/2 IMU 2 R/P NONORTHOGON		DEG	SPL
CDP(3)	V90U2650CB	COS OF 1/2 IMU 3 R/P NONORTHOGON		DEG	SPL
COSPHI	V90H2204C	EULER ANGLE ROLL COSINE		DEG	SPL
COSTH	V90H2215C	EULER ANGLE PITCH COSINE		DEG	SPL
DVB_SEC(1)	V90U2307C	BODY VEL INCREMENT LO RATE X AXIS		FT/S	SPL
DVB_SEC(2)	V90U2308C	BODY VEL INCREMENT LO RATE Y AXIS		FT/S	SPL
DVB_SEC(3)	V90U2309C	BODY VEL INCREMENT LO RATE Z AXIS		FT/S	SPL
GMTC/T NOW	V90H2310CA	M50 TO BODY QUAT TIME		AD	SPL
PAYLOAD_PITCH	V95L3887CC	EF TO BODY EULER ANGLE PITCH		RAD	SPL
PAYLOAD_ROLL	V95L3889CC	EF TO BODY EULER ANGLE ROLL		RAD	SPL
PAYLOAD_YAW	V95L388ACC	EF TO BODY EULER ANGLE YAW		DEG	SPL
PHI	V90H2202C	BODY ROLL ATTITUDE EULER ANGLE		DEG	SPL
PHI_IMU(1)	V90H2317CB	M50 TO BODY EULER ANGLE 1 PHI		DEG	SPL
PHI_IMU(2)	V90H2318CB	M50 TO BODY EULER ANGLE 2 PHI		DEG	SPL
PHI_IMU(3)	V90H2319CB	M50 TO BODY EULER ANGLE 3 PHI		DEG	SPL
PSI_HSIMV	V90H2212C	HEADING RELATIVE TO MAG NORTH		DEG	SPL
PSI_IMU(1)	V90H2311CB	M50 TO BODY EULER ANGLE 1 PSI		DEG	SPL
PSI_IMU(2)	V90H2312CB	M50 TO BODY EULER ANGLE 2 PSI		DEG	SPL
PSI_IMU(3)	V90H2313CB	M50 TO BODY EULER ANGLE 3 PSI		DEG	SPL
PITCHCOS(1)	V90H2222CA	LH ADI SEL EULER ANG PITCH COSINE		DEG	SPL
PITCHCOS(2)	V90H2218CA	RH ADI SEL EULER ANG PITCH COSINE		DEG	SPL
PICHSSINE(1)	V90H2221CA	LH ADI SEL EULER ANG PITCH SINE		DEG	SPL
PICHSSINE(2)	V90H2220CA	RH ADI SEL EULER ANG PITCH SINE		DEG	SPL
Q BOD M50(1)/Q B I(1)	V90U22440CA	M50 TO BODY QUAT MEASURED ELEM 1		DEG	SPL

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Table 4.6.5-1. Ascent/Entry Attitude Processor Interface (G4.226)
Input/Output Parameters (Cont)

Table 4.6.5-1. Ascent/Entry Attitude Processor Interface (G4.226)
Input/Output Parameters (Cont)

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018C REV00 G4.226

A/E ATT PROC

JUNE 29, 1988

DBFN: D2B041-C PNI: VP707100034P00L
OUTPUT FUNCTIONAL PARAMETERS FROM ASCENT/ENTRY ATTITUDE PROCESSOR

FSSR NAME M/S ID NOMENCLATURE DESTINATION UNITS

DATA
TYPE C

FSSR NAME	M/S ID	NOMENCLATURE	DESTINATION	UNITS
SM SH1 1 1	V90U2263CA	SH2	RM, TLM	DEG/S
SM SH1 1 2	V90U2264CA	SH3	RM, TLM	DEG/S
SM SH1 1 3	V90U2265CA	SH2	IMU RH, TLM	DEG/S
SM SH1 1 4	V90U2266CA	SH3	IMU RH, TLM	DEG/S
SM SH2 1 1	V90U2267CA	SH1	IMU RH, TLM	DEG/S
SM SH2 1 2	V90U2268CA	SH1	IMU RH, TLM	DEG/S
SM SH2 1 3	V90U2269CA	SH2	IMU RH, TLM	DEG/S
SM SH2 1 4	V90U2270CA	SH2	IMU RH, TLM	DEG/S
SM SH3 1 1	V90U2271CA	SH1	IMU RH, TLM	DEG/S
SM SH3 1 2	V90U2272CA	SH1	IMU RH, TLM	DEG/S
SM SH3 1 3	V90U2273CA	SH1	IMU RH, TLM	DEG/S
SM SH3 1 4	V90U2274CA	SH2	IMU RH, TLM	DEG/S
SM SH3 2 1	V90U2275CA	SH1	IMU RH, TLM	DEG/S
SM SH3 2 2	V90U2276CA	SH1	IMU RH, TLM	DEG/S
SM SH3 2 3	V90U2277CA	SH1	IMU RH, TLM	DEG/S
SM SH3 2 4	V90U2278CA	SH2	IMU RH, TLM	DEG/S
SM SH3 3 1	V90R2279C	COMPENSATED BODY RATE	TRANS DAP	DEG/S
SM SH3 3 2	V90R2280C	COMPENSATED BODY PITCH RATE	TRANS DAP	DEG/S
SM SH3 3 3	V90R2281C	COMPENSATED BODY YAW RATE	TRANS DAP	DEG/S
SM SH3 3 4	V90R2282C	COMPENSATED BODY ROLL RATE	TRANS DAP	DEG/S
RATE_GYRO_CORR(1)	V90J2283C	HSI HEADS-UP/HEADS-DOWN INDICATOR	HSI PROC	DEG/S
RATE_GYRO_CORR(2)	V90J2284C	LH ADI SEL	E/L ADI PROC, TLM, ASC ADI PROC	DEG/S
RATE_GYRO_CORR(3)	V90J2285C	RH ADI SEL	E/L ADI PROC, TLM, ASC ADI PROC	DEG/S
ROLL_COS(1)	V90H2286C	LH ADI SEL	E/L ADI PROC, TLM, ASC ADI PROC	DEG
ROLL_COS(2)	V90H2287C	RH ADI SEL	E/L ADI PROC, TLM, ASC ADI PROC	DEG
ROLL_SINE(1)	V90H2288C	LH ADI SEL	ORB ATT PROC	DEG
ROLL_SINE(2)	V90H2289C	RH ADI SEL	ORB ATT PROC	DEG
SDPI 1	V90U2290C	SIN OF 1/2 IMU 1 R/P NONORTHOGON	AEROJET DAP, TLM, CRTLS DAP, UP	DEG
SDPI 2	V90U2291C	SIN OF 1/2 IMU 2 R/P NONORTHOGON	AEROJET DAP, TLM, CRTLS DAP, UP	DEG
SDPI 3	V90U2292C	SIN OF 1/2 IMU 3 R/P NONORTHOGON	AEROJET DAP, TLM, CRTLS DAP, UP	DEG
SINPHI	V90H2293C	EULER ANGLE PITCH SINE	AEROJET DAP, TLM, CRTLS DAP, UP	DEG
SINTH	V90H2294C	EULER ANGLE PITCH SINE	AEROJET DAP, TLM, CRTLS DAP, UP	DEG
THETA	V90H2217C	BODY PITCH ATTITUDE EULER ANGLE	AEROJET DAP, TLM, CRTLS DAP, UP	DEG
THETA_IMU(1)	V90H2314CB	M50 TO BODY EULER ANGLE 1 THETA	AEROJET DAP, TLM, CRTLS DAP, UP	DEG
THETA_IMU(2)	V90H2315CB	M50 TO BODY EULER ANGLE 2 THETA	AEROJET DAP, TLM, CRTLS DAP, UP	DEG
THETA_IMU(3)	V90H2316CB	M50 TO BODY EULER ANGLE 3 THETA	AEROJET DAP, TLM, CRTLS DAP, UP	DEG
UB1	V90U2295C	FRST COMP OF BODY FRM REL VEL VCTR	AEROJET DAP, TLM, CRTLS DAP, UP	FT/S
YAMC(1)	V90U2296C	HSI YAW COMMAND	AEROJET DAP, TLM, CRTLS DAP, UP	DEG
YAMC(2)	V90H2297C	LH ADI SEL EULER ANG YAW COSINE	AEROJET DAP, TLM, CRTLS DAP, UP	DEG
YAMC(3)	V90H2298C	RH ADI SEL EULER ANG YAW COSINE	AEROJET DAP, TLM, CRTLS DAP, UP	DEG
YAMC(4)	V90H2299C	LH ADI SEL EULER ANG YAW SINE	AEROJET DAP, TLM, CRTLS DAP, UP	DEG
YAMC(5)	V90H2300C	RH ADI SEL EULER ANG YAW SINE	AEROJET DAP, TLM, CRTLS DAP, UP	DEG
YAMC(6)	V90H2301C	LH ADI SEL EULER ANG YAW SINE	AEROJET DAP, TLM, CRTLS DAP, UP	DEG
YAMC(7)	V90H2302C	RH ADI SEL EULER ANG YAW SINE	AEROJET DAP, TLM, CRTLS DAP, UP	DEG

Table 4.6.5-2. Ascent/Entry Attitude Processor (G4.226) I-Loads

MISSIONS	FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCIM	CAT
EF_PLANE_SW										
IYD(1)		V99U7441C	ND			B		M C	G4.2 G4.3 G4.19 G4.20 G4.210 G4.226	A2M2
IYD(2)		V97U4413C	ND			F		M C	G4.226 G4.2 G4.3 G4.19 G4.20 G4.210	A2M2
IYD(3)		V97U4414C	ND			F		M C	G4.226 G4.2 G4.3 G4.19 G4.20 G4.210	A2M2
PRE_R01		V97U4415C	ND			F		M C	G4.226 G4.2 G4.3 G4.19 G4.20 G4.210	A2M2
PRE_R02		V97U2393C	ND			F	S	D P	G4.226	ZFR4 ZFR4
PRE_R03		V97U2394C	ND			F	S	D P	G4.226	ZFR4 ZFR4
PRE_R04		V97U2395C	ND			F	S	D P	G4.226	ZFR4 ZFR4
PRE_R05		V97U2396C	ND			F	S	D P	G4.226	ZSR1
PRE_R06		V97U2397C	ND			F	S	D P	G4.226	ZSR1
PTCHCOS(1)		V97U2398C	ND			F	S	D P	G4.226	ZSR1
PTCHCOS(2)		V90H2222CA	ND			F	S	M P	G4.226	YB22
PTCHSINE(1)		V90H2218CA	ND			F	S	M P	G4.226	YB22
PTCHSINE(2)		V90H2221CA	ND			F	S	M P	G4.226	YB22
PTCHSINE(2)		V90H2220CA	ND			F	S	M P	G4.226	YB22

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DBFM: 0464

Table 4.6.5-2. Ascent/Entry Attitude Processor (G4.226) I-Loads (Cont)

MISSIONS	MSID	ENG UNIT	DI PR D S PR FC TN CAT
FSSR NAME			
RGAO(1)	V99U9559C	RAD	F S L P G4.226 G4.97 V4.9A IH12
RGAO(2)	V99U9560C	RAD	F S L P G4.226 G4.97 V4.9A IH22
RGAO(3)	V99U9561C	RAD	F S L P G4.226 G4.97 V4.9A IH32
RGPO(1)	V99U9562C	RAD	F S L P G4.226 G4.97 V4.9A IH12
RGPO(2)	V99U9563C	RAD	F S L P G4.226 G4.97 V4.9A IH22
RGPO(3)	V99U9564C	RAD	F S L P G4.226 G4.97 V4.9A IH32
ROLLCOS(1)	V90H2209CA	ND	F S M P G4.226 YD22
ROLLCOS(2)	V90H2207CA	ND	F S M P G4.226 YD22
ROLLSINE(1)	V90H2208CA	ND	F S M P G4.226 YD22
ROLLSINE(2)	V90H2206CA	ND	F S M P G4.226 YD22
TNB_CASE1(1,1)	V96U7132C	ND	F S L P V4.9A G4.226 G4.97 IPRI
TNB_CASE1(1,2)	V96U7135C	ND	F S L P V4.9A G4.226 G4.97 IPRI
TNB_CASE1(1,3)	V96U7138C	ND	F S L P V4.9A G4.226 G4.97 IPRI
TNB_CASE1(2,1)	V96U7141C	ND	F S L P V4.9A G4.226 G4.97 IPRI
TNB_CASE1(2,2)	V96U7144C	ND	F S L P V4.9A G4.226 G4.97 IPRI

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DATE: 04/10/89



Table 4.6.5-2. Ascent/Entry Attitude Processor (G4.226) I-Loads (Cont)

FSSR NAME	MSID	ENG UNIT	DT	PR	D	S	PR	FCTM	CAT
TNB_CASE1(2,3)	V96U7147C	ND	F	S	L	P	V4.9A G4.226 G4.97		IPR1
TNB_CASE1(3,1)	V96U7150C	ND	F	S	L	P	V4.9A G4.226 G4.97		IPR1
TNB_CASE1(3,2)	V96U7153C	ND	F	S	L	P	V4.9A G4.226 G4.97		IPR1
TNB_CASE1(3,3)	V96U7156C	ND	F	S	L	P	V4.9A G4.226 G4.97		IPR1
TNB_CASE2(1,1)	V96U7133C	ND	F	S	L	P	V4.9A G4.226 G4.97		IPR1
TNB_CASE2(1,2)	V96U7136C	ND	F	S	L	P	V4.9A G4.226 G4.97		IPR1
TNB_CASE2(1,3)	V96U7139C	ND	F	S	L	P	V4.9A G4.226 G4.97		IPR1
TNB_CASE2(2,1)	V96U7142C	ND	F	S	L	P	V4.9A G4.226 G4.97		IPR1
TNB_CASE2(2,2)	V96U7145C	ND	F	S	L	P	V4.9A G4.226 G4.97		IPR1
TNB_CASE2(2,3)	V96U7148C	ND	F	S	L	P	V4.9A G4.226 G4.97		IPR1
TNB_CASE2(3,1)	V96U7151C	ND	F	S	L	P	V4.9A G4.226 G4.97		IPR1
TNB_CASE2(3,2)	V96U7154C	ND	F	S	L	P	V4.9A G4.226 G4.97		IPR1
TNB_CASE2(3,3)	V96U7157C	ND	F	S	L	P	V4.9A G4.226 G4.97		IPR1

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Table 4.6.5-2. Ascent/Entry Attitude Processor (G4.226) I-Loads (Cont)

FSSR NAME	MSID	ENG UNIT	DI PR D S PR FCIN	CAT
TNB_CASE3(1,1)	V96U7134C	ND	F S L P V4.9A G4.226 G4.97	IPRI
TNB_CASE3(1,2)	V96U7137C	ND	F S L P V4.9A G4.226 G4.97	IPRI
TNB_CASE3(1,3)	V96U7140C	ND	F S L P V4.9A G4.226 G4.97	IPRI
TNB_CASE3(2,1)	V96U7143C	ND	F S L P V4.9A G4.226 G4.97	IPRI
TNB_CASE3(2,2)	V96U7146C	ND	F S L P V4.9A G4.226 G4.97	IPRI
TNB_CASE3(2,3)	V96U7149C	ND	F S L P V4.9A G4.226 G4.97	IPRI
TNB_CASE3(3,1)	V96U7152C	ND	F S L P V4.9A G4.226 G4.97	IPRI
TNB_CASE3(3,2)	V96U7155C	ND	F S L P V4.9A G4.226 G4.97	IPRI
TNB_CASE3(3,3)	V96U7158C	ND	F S L P V4.9A G4.226 G4.97	IPRI
TNBODY(1,1)	V96U7096C	ND	F S L P V4.9A G4.66 G4.226 G4.97	IPRI
TNBODY(1,2)	V96U7097C	ND	F S L P V4.9A G4.66 G4.226 G4.97	IPRI
TNBODY(1,3)	V96U7098C	ND	F S L P V4.9A G4.66 G4.226 G4.97	IPRI

DBFN: 0464

DATE: 04/10/69

Table 4.6.5-2. Ascent/Entry Attitude Processor (G4.226) I-Loads

TABLE: 4.6.5-2 018B MISSIONS	A/E ATT PROC	(G4.226) I-LOADS	ASCENT/ENTRY ATTITUDE PROCESSOR
FSSR NAME	MSID	ENG UNIT	DT PR D S PR FCIN CAT
TNBBODY(2,1)	V96U709C	ND	F S L P V4.9A G4.66 G4.226 G4.97
TNBBODY(2,2)	V96U710C	ND	F S L P V4.9A G4.66 G4.226 G4.97
TNBBODY(2,3)	V96U7101C	ND	F S L P V4.9A G4.66 G4.226 G4.97
TNBBODY(3,1)	V96U7102C	ND	F S L P V4.9A G4.66 G4.226 G4.97
TNBBODY(3,2)	V96U7103C	ND	F S L P V4.9A G4.66 G4.226 G4.97
TNBBODY(3,3)	V96U7104C	ND	F S L P V4.9A G4.66 G4.226 G4.97

DBFN:0464 DATE:04/10/89

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Table 4.6.5-3. Ascent/Entry Attitude Processor (G4.226) K-Loads

FSSR NAME DESCRIPTION	MSID	MC KLOAD VALUE	ENG UNIT	DT PR S PR FCTN	LAST CR EQTN MSID
DTIMJ TIME_BETWEEN_IMJ_&_RGA_READS	V97U1780C	-2.262	E-02 SEC	F S C G4.226	59954
Q_LVLH_BIASLVLH_ASCENT(1)	V97U2210CA	+1.0000000	E+00 ND	F S C G4.226	59955
Q_LVLH_BIASLVLH_ASCENT(2)	V97U2211CA	+0.0	E+00 ND	F S C G4.226	59955
Q_LVLH_BIASLVLH_ASCENT(3)	V97U2212CA	+0.0	E+00 ND	F S C G4.226	59955
Q_LVLH_BIASLVLH_ASCENT(4)	V97U2213CA	+0.0	E+00 ND	F S C G4.226	59955
Q_LVLH_BIASLVLH_ENTRY(1)	V97U2210CB 03	+1.00	E+00 ND	F S C G4.226	59955
Q_LVLH_BIASLVLH_ENTRY(2)	V97U2211CB 03	+0.00	E+00 ND	F S C G4.226	59955
Q_LVLH_BIASLVLH_ENTRY(3)	V97U2212CB 03	+0.00	E+00 ND	F S C G4.226	59955
Q_LVLH_BIASLVLH_ENTRY(4)	V97U2213CB 03	+0.00	E+00 ND	F S C G4.226	59955
Q_M50_INRTL_ASCENT(1)	V97U2214CA	+1.0	E+00 ND	F S C G4.3 G4.210 G4.226	896888
Q_M50_INRTL_ASCENT(2)	V97U2215CA	+0.0	E+00 ND	F S C G4.3 G4.210 G4.226	896888
Q_M50_INRTL_ASCENT(3)	V97U2216CA	+0.0	E+00 ND	F S C G4.3 G4.210 G4.226	896888
Q_M50_INRTL_ASCENT(4)	V97U2217CA	+0.0	E+00 ND	F S C G4.3 G4.210 G4.226	896888
Q_M50_INRTL_ENTRY(1)	V97U2214CB 03	+1.0	E+00 ND	F S C G4.209 G4.226 G4.211	896888
Q_M50_INRTL_ENTRY(2)	V97U2215CB 03	+0.0	E+00 ND	F S C G4.209 G4.226 G4.211	896888
Q_M50_INRTL_ENTRY(3)	V97U2216CB 03	+0.00	E+00 ND	F S C G4.209 G4.226 G4.211	896888
Q_M50_INRTL_ENTRY(4)	V97U2217CB 03	+0.00	E+00 ND	F S C G4.209 G4.226 G4.211	896888

DBFN: 0529 DATE: 06/21/88



Table 4.6.5-3. Ascent/Entry Attitude Processor (G4.226) K-Loads (Cont)

FSSR NAME DESCRIPTION	MSID	MC KLOAD VALUE	ENG UNIT	DT PR S PR FCTN	LAST CR EQTN MSID
Q_M50_REF_ENTRY(1) ADI_REF_QUAT_ELEM 1	V97U2218CB 03	+7.0710678	E-01 ND	F S C G4.226	59955
Q_M50_REF_ENTRY(2) ADI_REF_QUAT_ELEM 2	V97U2219CB 03	+7.0710678	E-01 ND	F S C G4.226	59955
Q_M50_REF_ENTRY(3)	V97U2220CB 03	+0.00	E+00 ND	F S C G4.226	59955
Q_M50_REF_ENTRY(4)	V97U2221CB 03	+0.00	E+00 ND	F S C G4.226	59955
UB_EPS ANGLE OF ATTACK TEST VALUE	V97U1315C	+1.0	E+02 FT/SEC	F S C G4.226	59954

DATE: 06/21/88

DBFN: 0529



CR89718

Table 4.6.5-4. Ascent/Entry Attitude Processor (G4.226) Constants

NR0KRMH.FSSR3.DAT(1X23)BOOK0V1
PFS CONSTANTS UPDATE B/L

FSSR NAME DESCRIPTION	MSID	MC	VALUE	UNITS	DT	PR	S	PF REF	LAST CR	EQTN MSID
DEG PER RAD RADIAN TO DEGREE CONVERSION	V97U0112C		+57.2957795131	DEG/RAD	F		S			
DELTIME ATT_PROC TIME INCREMENT (ATT_MODE = 1 OR 2) (ATT_MODE = 3)			0.08 0.16	SEC	F		S			
GE PRE R01 FIRST STAGE FILTER COEFFICIENTS FOR GR1LS			0.285714	NONE	F		S			
GE PRE R02 FIRST STAGE FILTER COEFFICIENTS FOR GR2LS			0.285714	NONE	F		S			
GE PRE R03 FIRST STAGE FILTER COEFFICIENTS FOR GR3LS			-0.428572	NONE	F		S			
RAD PER DEG DEGREE TO RADIAN CONVERSION	V97U0303C		+0.17453293	RAD/DEG	F		S			

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4.7 UTILITY FUNCTIONS

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4.7 UTILITY FUNCTIONS

Utility functions constitute those modules which appear two or more times in the preceding sections. To avoid redundant specification of these functions, and thus simplifying the documentation, detailed specifications for these functions are presented just once, in this subsection. Note that some of these functions are also used during non-ascent mission phases (e.g., SECOND_ORDER_FILTERS in entry-through-landing flight control); some are also used by principal functions covered in other documents (e.g., MAT_TO_QUAT in first-stage guidance). It must be borne in mind that reentrant capability is required for those functions in use simultaneously by modules which are implemented in more than the HAL task.

CAUTION: Quaternions and direction cosine matrices are used to represent transformations of coordinates. The notation used for both methods is briefly described.

Given two coordinate frames A and B, with common origin, and a vector whose coordinates in each frame are \bar{V}_A and \bar{V}_B , respectively, the notation $Q_{B A}$ denotes the quaternion which represents the transformation from frame A to frame B:

$$\bar{V}_B = Q_{B A} \bar{V}_A (Q_{B A})^*$$

This equation is valid if (i) \bar{V}_A and \bar{V}_B are viewed as quaternions with zero scalar part and (ii) $Q_{B A} = (QBAS, QBAV)$ is normalized; the conjugate of $Q_{B A}$ is defined by $(Q_{B A})^* \triangleq (QBAS, -QBAV)$. Transformation of coordinates from frame A to frame B may also be viewed as the result of a rotation through an angle θ about an oriented axis $\bar{\omega}$; the connection with $Q_{B A}$ is as follows:

$$QBAS = \cos \frac{\theta}{2}, \quad QBAV = -\text{unit}(\bar{\omega}) \sin \frac{\theta}{2}$$

With this convention, transformations from frames A and B, each to a third frame C, are related as follows:

$$Q_{C A} = Q_{C B} Q_{B A}$$

Block diagram symbology for quaternion multiplication is described in Section 4.7.10 (QUAT_MULT) of this document.

Notation for direction cosine matrices is slightly different and is briefly described. Given two coordinate frames A and B, with common origin, and a vector whose coordinates in each frame are \bar{V}_A and \bar{V}_B , respectively, the notation M_{AB} denotes the direction cosine matrix and represents the transformation from frame A to frame B:

$$\bar{V}_B = M_{AB} \bar{V}_A$$

With this convention, transformations from frames A and B, each to a third frame C, are related as follows:

$$M_{AC} = M_{BC} M_{AB}$$

While there are potential core savings when these functions are subroutinized, there are time penalties attendant with the invocation process. In-line replicated code may be desirable in many applications. No implementational constraint is intended by this choice of documentation format. Likewise, the particular form of an algorithm has been chosen to show how the functional requirements could be implemented, but other implementations may produce the same results in a more economical manner.

The utility functions described in this section are listed in Table 4.7-1 with the subsection numbers where detailed descriptions can be found.

Table 4.7-1. Utility Functions

Subsection	Utility Function
4.7.1	FIRST_ORDER_FILTER
4.7.2	SECOND_ORDER_FILTER
4.7.3	FOURTH_ORDER_FILTER
4.7.4	SIXTH_ORDER_FILTER
4.7.5	FADER
4.7.6	X_INTERP
4.7.7	Y_INTERP
4.7.8	MINITABLE
4.7.9	RATE_LIMIT
4.7.10	QUAT_MULT
4.7.11	QUAT_NORM
4.7.12	QUAT_INTEG
4.7.13	QUAT_XFORM
4.7.14	QUAT_ERR_ANG
4.7.15	SMOOTHER
4.7.16	MAT_TO_QUAT
4.7.17	RV_TO_QLVLH
4.7.18	QUAT_TO_EULER
4.7.19	QUAT_TO_ADI_ANG
4.7.20	PARSHAPE
4.7.21	LIMITED_INTEGRATOR

4.7-1
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4.7.1 FIRST_ORDER_FILTER

A. Function. The detailed block diagram for the module FIRST_ORDER_FILTER is presented in Figure 4.7.1-1. With appropriate coefficients, FIRST_ORDER_FILTER can represent any nonintegral first-order filter (low pass, high pass, washout, etc.). The steady-state gain need not be unity, but it must be finite (hence the nonintegral requirement). A nodal implementation has been chosen for illustrative purposes. Local initialization (steady-state response to present input) is provided in response to an initialization flag. Detailed equations are presented in Section F below. Consider FIRST_ORDER_FILTER for generation of in-line code (e.g., a macro), especially if initialization can be handled remotely.

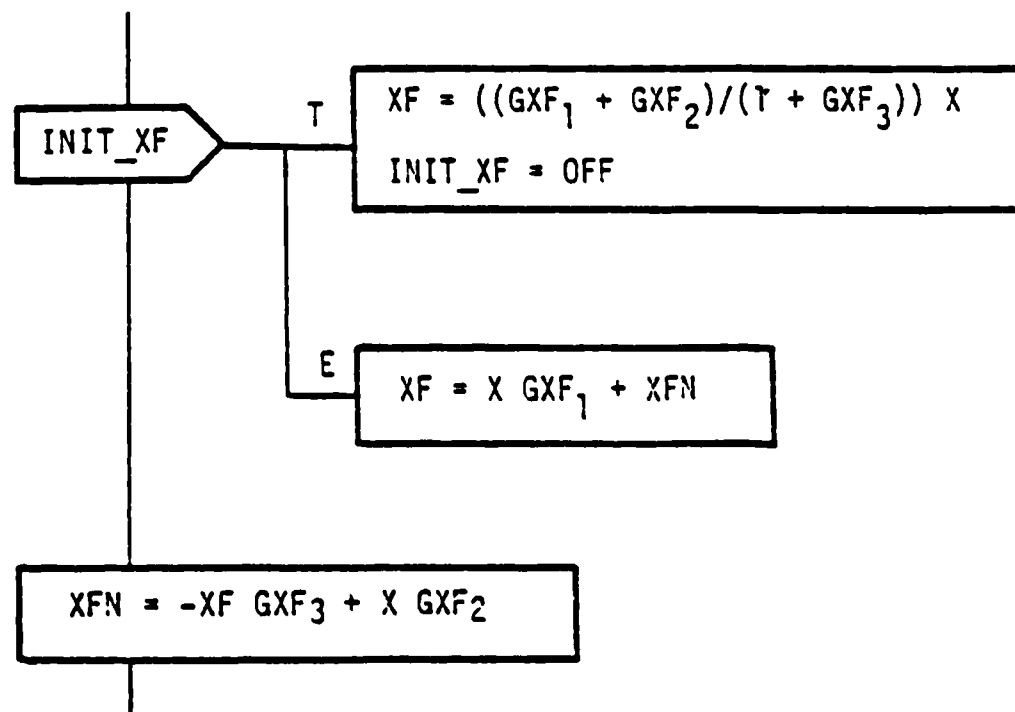
B. Processing Requirements. The module FIRST_ORDER_FILTER is processed when invoked by a user. Single precision coefficients and calculations are utilized.

C. Interface Requirements. The interface requirements for module FIRST_ORDER_FILTER are shown in Table 4.7.1-1.

D. Constants. None.

E. Initialization Requirements. The initialization requirements for the module FIRST_ORDER_FILTER are shown in Table 4.7.1-2.

F. Detailed Technical Descriptions.



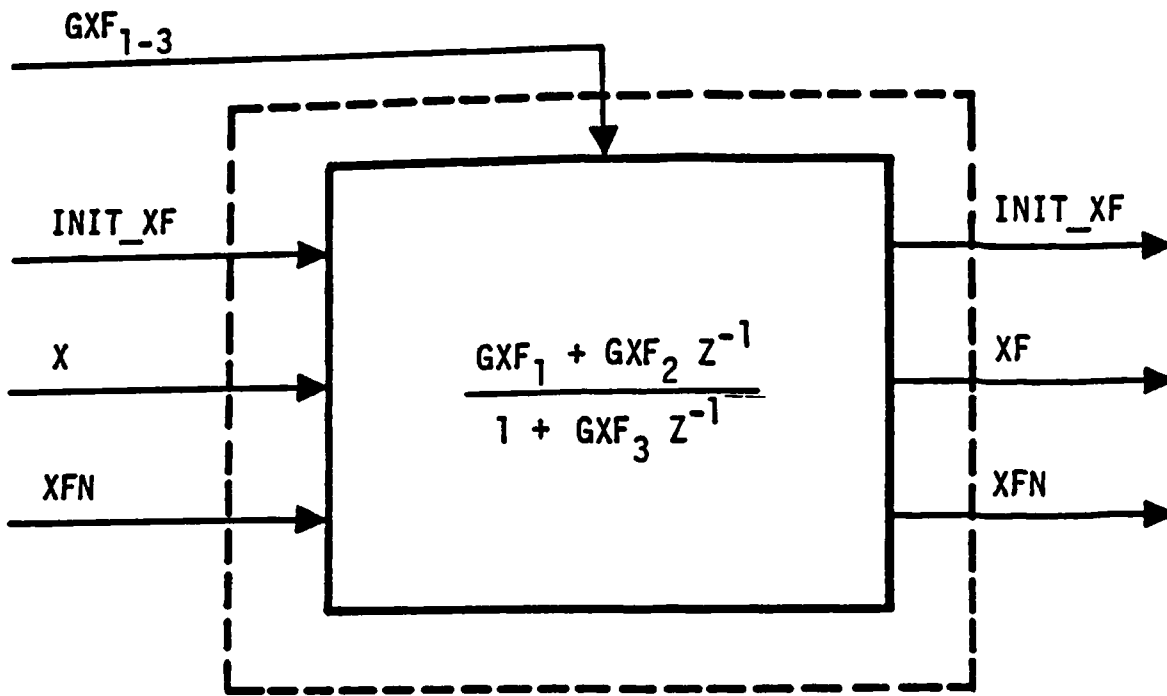


Figure 4.7.1-1. FIRST_ORDER_FILTER

Name	
<u>Inputs</u>	
X	
GXF	
XF	
XFN	
INIT_XF	
<u>Outputs</u>	
XF	
XFN	
INIT_XF	

First-order
*Some app
XF =
XFN =

Table 4.7.1-1. FIRST_ORDER_FILTER Interface Requirements

Name	Description	Source or Destination	Type	Units	Rate Required/Produced (Hz)
<u>Inputs</u>					
X	Input		S	-	-
GXF	Coefficients		A(3)	-	-
XF	Past value of output		S	-	-
XFN	Past value of node		S	-	-
INIT_XF	Initialization flag		B	-	-
<u>Outputs</u>					
XF	Output		S	-	-
XFN	Node		S	-	-
INIT_XF	Initialization flag		B	-	-

Table 4.7.1-2. FIRST_ORDER_FILTER Initialization Requirements

Component	Initialize on Transition		Variable	Initial Value
	From	To		
First-order filter	--	INIT_XF	XF } XFN }	*

*Some appropriate combination of the following (see Section F above for one approach):

$$XF = \left(\frac{GXF_1 + GXF_2}{1 + GXF_3} \right) X, \text{ where } GXF_3 \neq -1$$

$$XFN = XF - X GXF_1$$

4.7.2 SECOND ORDER FILTER

A. Function. The detailed block diagram for the module SECOND ORDER FILTER is presented in Figure 4.7.2-1. With appropriate coefficients, SECOND ORDER FILTER can represent any nonintegral second-order filter (low pass, high pass, washout, notch, rolloff, pair of first-order filters, etc.). The steady-state gain need not be unity, but it must be finite (hence the nonintegral requirement). A nodal implementation has been chosen for illustrative purposes. Local initialization (steady-stage response to present input) is provided in response to an initialization flag. Detailed equations are given in Section F below.

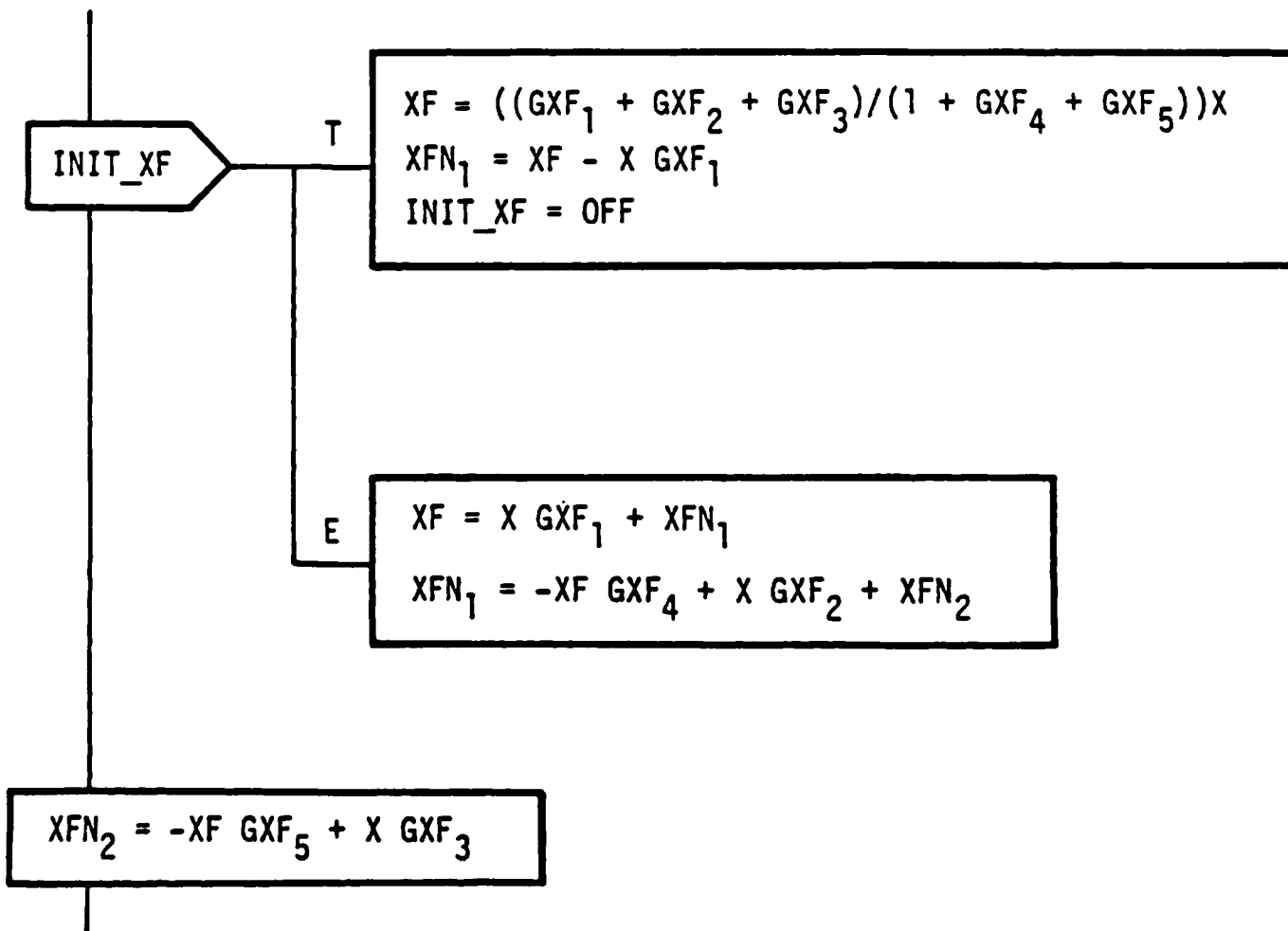
B. Processing Requirements. The module SECOND ORDER FILTER is processed when invoked by a user. Single precision coefficients and calculations are utilized.

C. Interface Requirements. The interface requirements for SECOND ORDER FILTER are shown in Table 4.7.2-1.

D. Constants. None.

E. Initialization Requirements. The initialization requirements for SECOND ORDER FILTER are shown in Table 4.7.2-2.

F. Detailed Technical Descriptions.



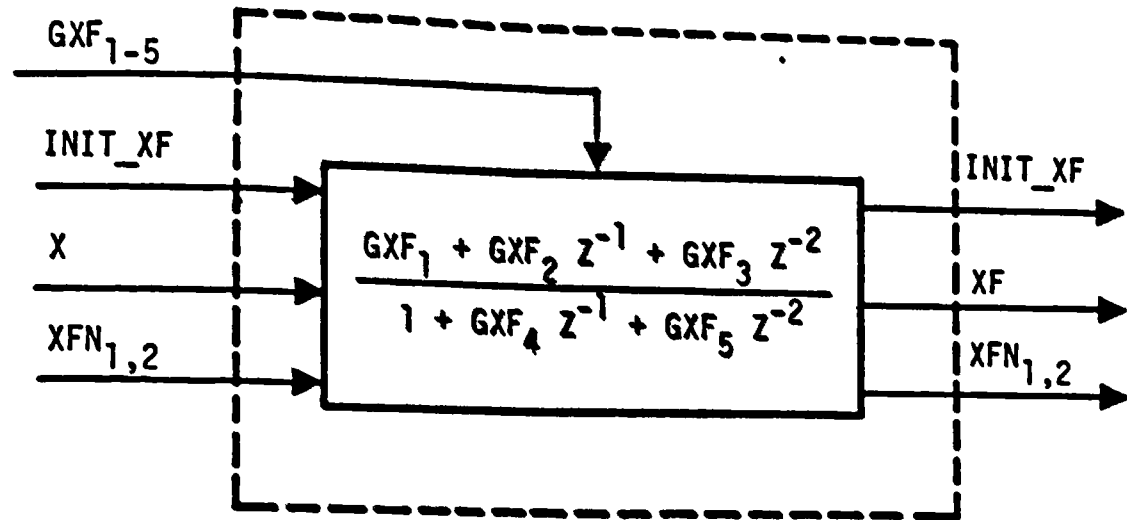


Figure 4.7.2-1. SECOND_ORDER_FILTER

Table 4.7.2-1. SECOND_ORDER_FILTER Interface Requirements

Name	Description	Source or Destination	Type	Units	Rate Required/Produced (Hz)
<u>Inputs</u>					
X	Input		S	-	-
GXF	Coefficients		A	-	-
XF	Past value of output		S	-	-
XFN	Past value of nodes		A(2)	-	-
INIT_XF	Initialization flag		B	-	-
<u>Outputs</u>					
XF	Output		S	-	-
XFN	Nodes		A(2)	-	-
INIT_XF	Initialization flag		B	-	-

Table 4.7.2-2. SECOND_ORDER_FILTER Initialization Requirements

Component	Initialize on Transition		Variable	Initial Value
	From	To		
Second-order filter	—	INIT_XF	XF XFN _{1,2}	*
<p>*Some appropriate combination of the following (see Section F above for one approach:</p> $XF = \left(\frac{GXF_1 + GXF_2 + GXF_3}{1 + GXF_4 + GXF_5} \right) X, \text{ where } (GXF_4 + GXF_5) \neq -1$ $XFN_1 = XF = X GXF_1$ $XFN_2 = -XF GXF_5 + GXF_3$				

4.7.3 FOURTH_ORDER_FILTER

A. Function. The detailed block diagram for the module FOURTH_ORDER_FILTER is presented in Figure 4.7.3-1. With appropriate coefficients, FOURTH_ORDER_FILTER can represent any cascaded pair of nonintegral second-order filters. The choice of cascade versus polynomial implementation avoids numerical inaccuracies and permits use of single precision rather than double precision for coefficients and calculations.

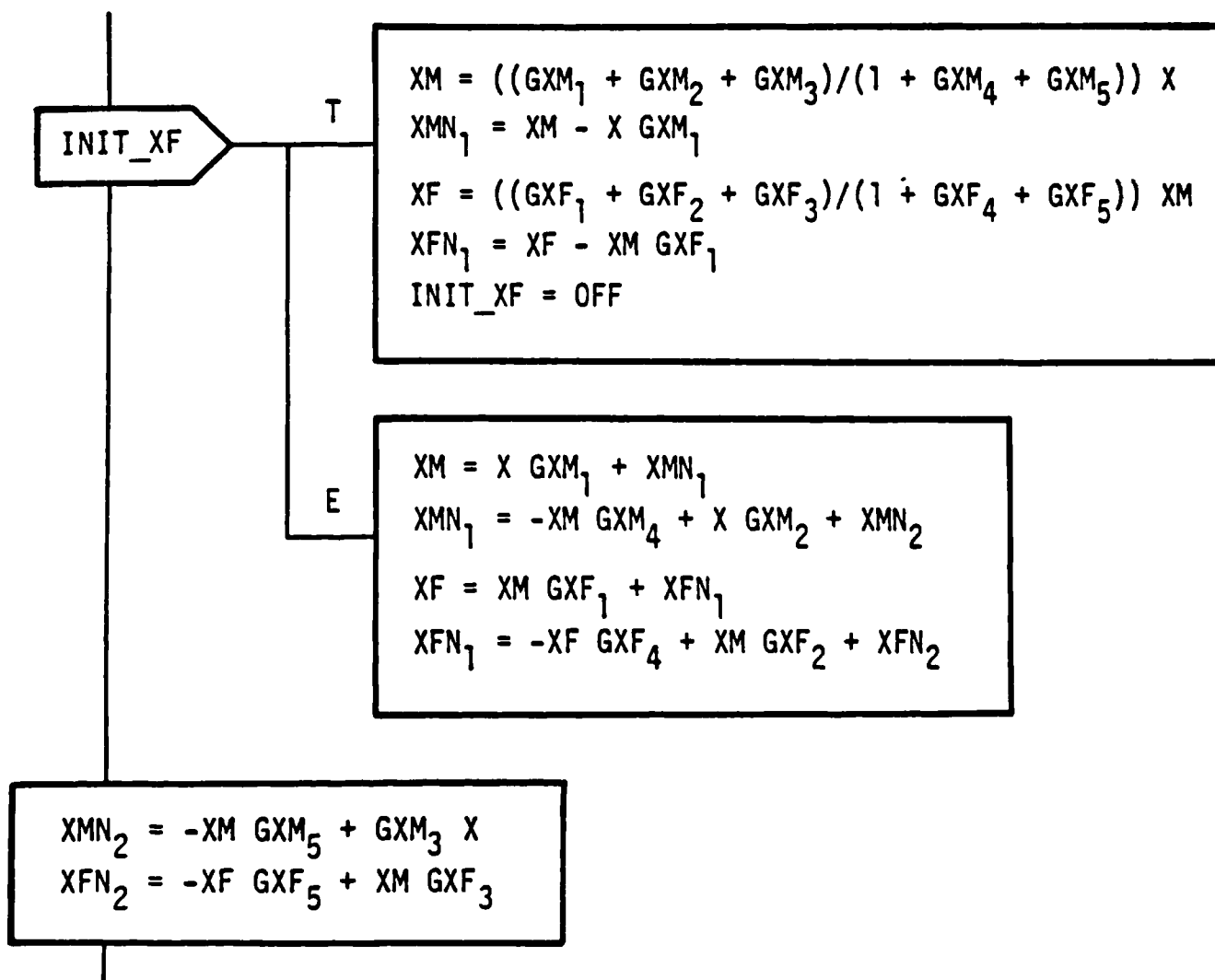
B. Processing Requirements. The module FOURTH_ORDER_FILTER is processed when invoked by a user. Single precision coefficients and calculations are utilized.

C. Interface Requirements. The interface requirements for FOURTH_ORDER_FILTER are shown in Table 4.7.3-1.

D. Constants. None.

E. Initialization Requirements. The initialization requirements for FOURTH_ORDER_FILTER are shown in Table 4.7.3-2.

F. Detailed Technical Descriptions.



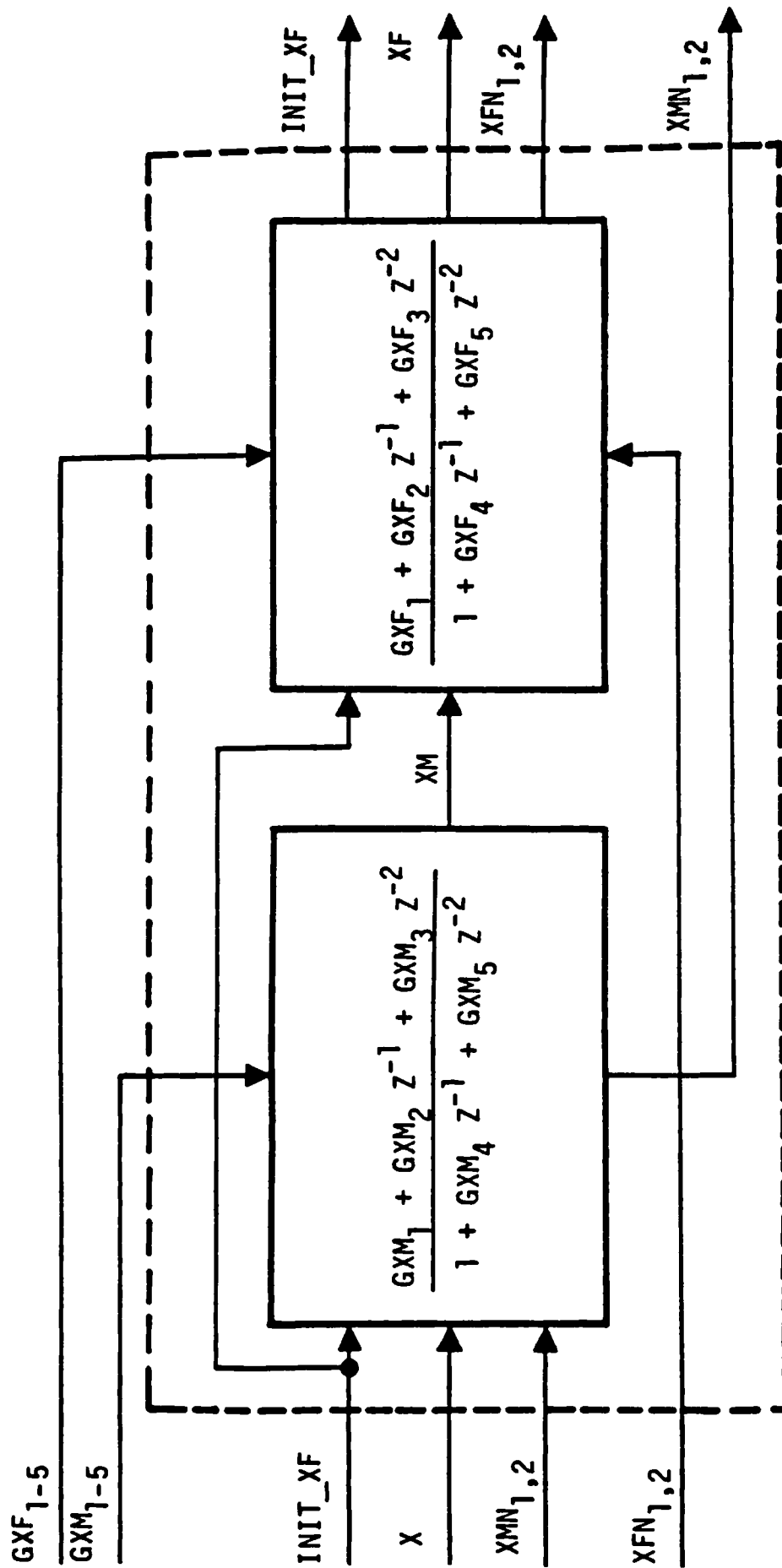


Figure 4.7.3-1. FOURTH_ORDER_FILTER

Name	Input	Output
X		
GXM		
GXF		
XF		
XM		
XFN		
XMN		
INIT_XF		
XF		
XFN		
XM		
XMN		
INIT_XF		

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Table 4.7.3-1. FOURTH_ORDER_FILTER Interface Requirements

Name	Description	Source or Destination	Type	Units	Rate Required/Produced (Hz)
<u>Inputs</u>					
X	Input		S	-	-
GXM	Coefficients, first or input element		A(5)	-	-
GXF	Coefficients, second or output element		A(5)	-	-
XF	Past value of element outputs		S	-	-
XM	Past value of element outputs		S	-	-
XFN	Past value of element nodes		A(2)	-	-
XMN	Past value of element nodes		A(2)	-	-
INIT_XF	Initialization flag		B	-	-
<u>Outputs</u>					
XF	Output, second element		S	-	-
XFN	Nodes, second element		A(2)	-	-
XM	Output, first element		S	-	-
XMN	Nodes, first element		B	-	-
INIT_XF	Initialization flag		B	-	-

Table 4.7.3-2. FOURTH_ORDER_FILTER Initialization Requirements

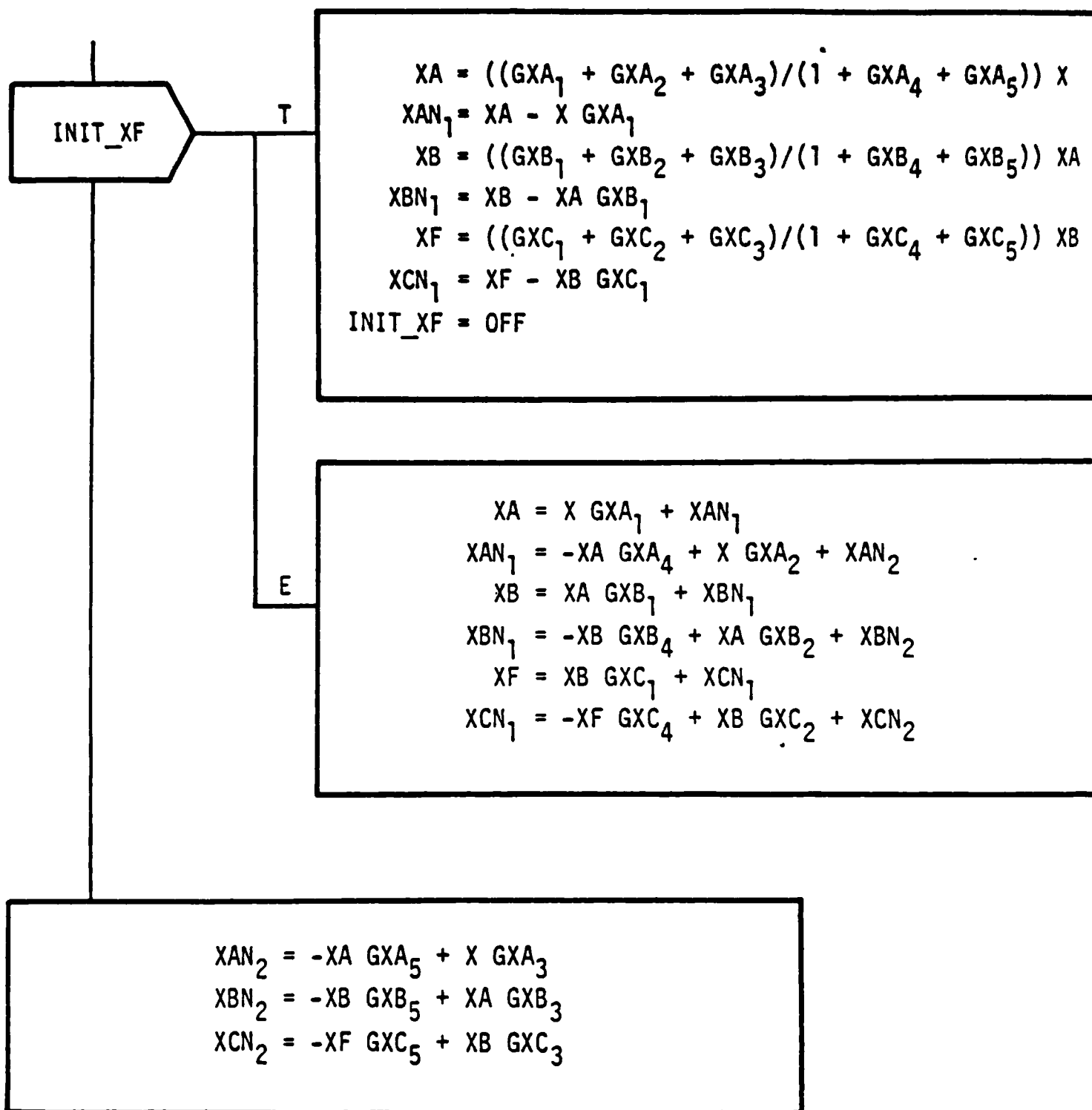
Component	Initialize on Transition		Variable	Initial Value
	From	To		
Fourth-order filter	--	INIT_XF	$\left. \begin{array}{l} XF \\ XFN_{1,2} \\ XM \\ XMN_{1,2} \end{array} \right\}$	*
<p>*Some appropriate combination of the following (see Section F above for one approach):</p> $XM = \left(\frac{GXM_1 + GXM_2 + GXM_3}{1 + GXM_4 + GXM_5} \right) X, \text{ where } (GXM_4 + GXM_5) \neq -1$ $XMN_1 = XM - X GXM_1$ $XMN_2 = -XM GXM_5 + X GXM_3$ $XF = \left(\frac{GXF_1 + GXF_2 + GXF_3}{1 + GXF_4 + GXF_5} \right) XM, \text{ where } (GXF_4 + GXF_5) \neq -1$ $XFN_1 = XF - XM GXF$ $XFN_2 = -XF GXF_5 + XM GXF_3$				

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4.7.4 SIXTH ORDER FILTER

- A. Function. The detailed block diagram for the module SIXTH ORDER FILTER is presented in Figure 4.7.4-1. With appropriate coefficients, SIXTH ORDER FILTER can represent any cascaded set of three nonintegral second-order filters. The choice of cascaded versus polynomial implementation avoids numerical inaccuracies and permits use of single precision rather than double precision for coefficients and calculations.
- B. Processing Requirements. The module SIXTH ORDER FILTER is processed when invoked by a user. Single precision coefficients and calculations are utilized.
- C. Interface Requirements. This interface requirements for SIXTH ORDER FILTER are shown in Table 4.7.4-1.
- D. Constants. None.
- E. Initialization Requirements. The initialization requirements for SIXTH ORDER FILTER are shown in Table 4.7.4-2.

F. Detailed Technical Description.



X
XA
XB

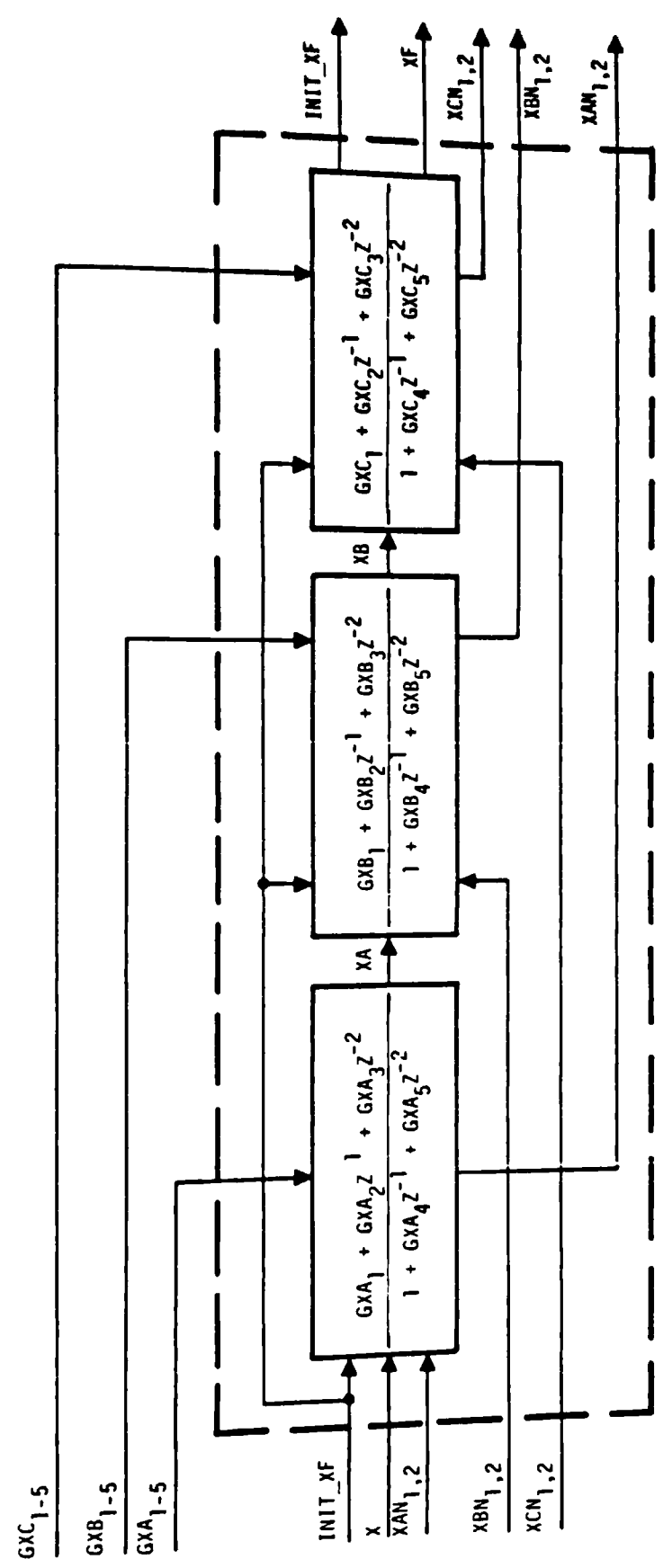


Figure 4.7.4-1. SIXTH ORDER FILTER

Table 4.7.4-1. SIXTH_ORDER_FILTER Interface Requirements

Name	Description	Source or Destination	Type	Units	Rate Required/Produced (Hz)
<u>Inputs</u>					
X	Input		S	-	-
GXA	Coefficients, first or input element		A(5)	-	-
GXB	Coefficients, second or middle element		A(5)	-	-
GXC	Coefficients, third or output element		A(5)	-	-
XF	} Past value of element output		S	-	-
XB			S	-	-
XA			S	-	-
XCN	} Past value of element nodes		A(2)	-	-
XBN			A(2)	-	-
XAN			A(2)	-	-
INIT_XF	Initialization flag		B	-	-
<u>Outputs</u>					
XF	Output, third element		S	-	-
XCN	Nodes, third element		A(2)	-	-
XB	Output, second element		S	-	-
XBN	Nodes, second element		A(2)	-	-
XA	Output, first element		S	-	-
XAN	Nodes, first element		A(2)	-	-
INIT_XF	Initialization flag		B	-	-

Sixth-order

*Some approx

$$XA = \left(\frac{G}{\dots} \right)$$

$$XAN_1 = \dots$$

$$XAN_2 = \dots$$

$$XB = \left(\frac{G}{\dots} \right)$$

$$XBN_1 = \dots$$

$$XBN_2 = \dots$$

$$XF = \left(\frac{G}{\dots} \right)$$

$$XCN_1 = \dots$$

$$XCN_2 = \dots$$

Rate required reduced (Hz)

Table 4.7.4-2. SIXTH_ORDER_FILTER Initialization Requirements

Component	Initialize on Transition		Variable	Initial Value
	From	To		
Sixth-order filter	--	INIT_XF	$\left. \begin{array}{l} XA \\ XAN_{1,2} \\ XB \\ XBN_{1,2} \\ XF \\ XCN_{1,2} \end{array} \right\}$	*
<p>*Some appropriate combination of the following (see Section F):</p> $XA = \left(\frac{GXA_1 + GXA_2 + GXA_3}{1 + GXA_4 + GXA_5} \right) X, \text{ where } GXA_4 + GXA_5 \neq -1$ $XAN_1 = XA - X GXA_1$ $XAN_2 = -XA GXA_5 + X GXA_3$ $XB = \left(\frac{GXB_1 + GXB_2 + GXB_3}{1 + GXB_4 + GXB_5} \right) XA, \text{ where } GXB_4 + GXB_5 \neq -1$ $XBN_1 = XB - XA GXB_1$ $XBN_2 = -XB GXB_5 + XA GXB_3$ $XF = \left(\frac{GXC_1 + GXC_2 + GXC_3}{1 + GXC_4 + GXC_5} \right) XB, \text{ where } GXC_4 + GXC_5 \neq -1$ $XCN_1 = XF - XB GXC_1$ $XCN_2 = -XF GXC_5 + XB GXC_3$				



4.7.5 FADER

A. Function. The detailed block diagram for the module FADER is presented in Figure 4.7.5-1. The purpose of a fader is to avoid the jump that might otherwise occur when the source of a signal is switched. Rather than allow the signal to jump from one value to another, the fader is "triggered" at the moment of switching, and the differences between the values of the sources before and after the change are added to the signal incrementally over some time period. The effect of a fader is shown in Figure 4.7.5-2. If the input is constant after the switching time, the output of the fader simply ramps from the value at the switching time to the value of the new input. However, if there are variations in the input, they are reflected in the output without attenuation or delay. Thus, the fader has no effect on the loop gain.

B. Processing Requirements. The module FADER is processed when invoked by user.

C. Interface Requirements. The interface requirements for FADER are shown in Table 4.7.5-1.

D. Constants. None.

E. Initialization Requirements. The initialization requirements for FADER are shown in Table 4.7.5-2.

NFADE

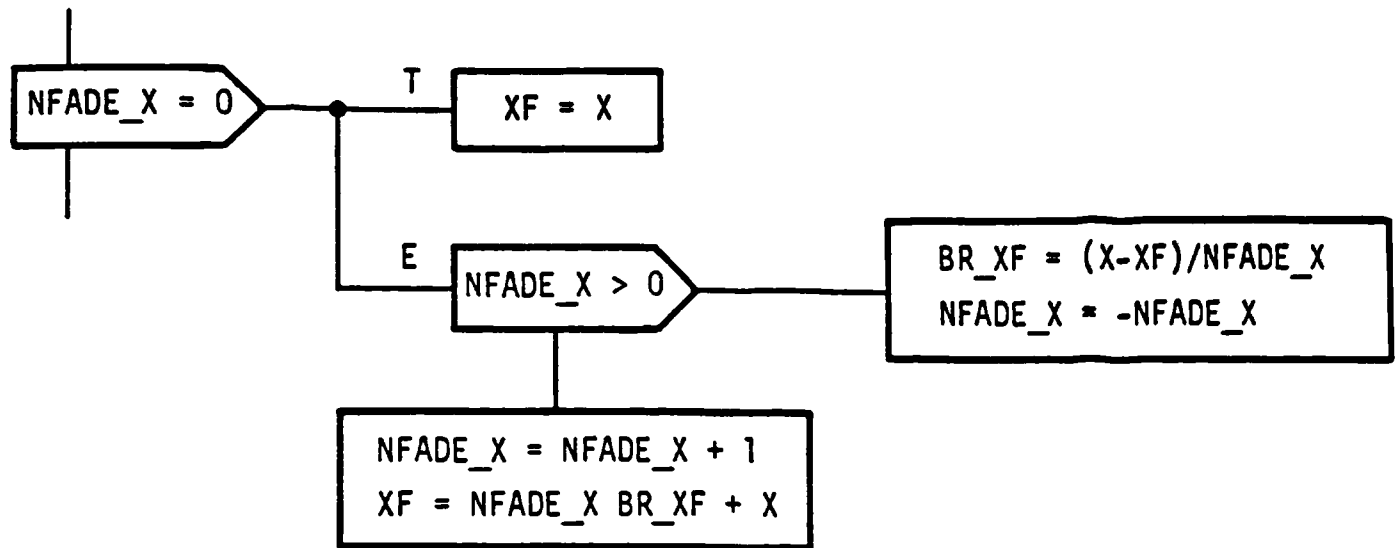


Figure 4.7.5-1. FADER, Detailed Block Diagram

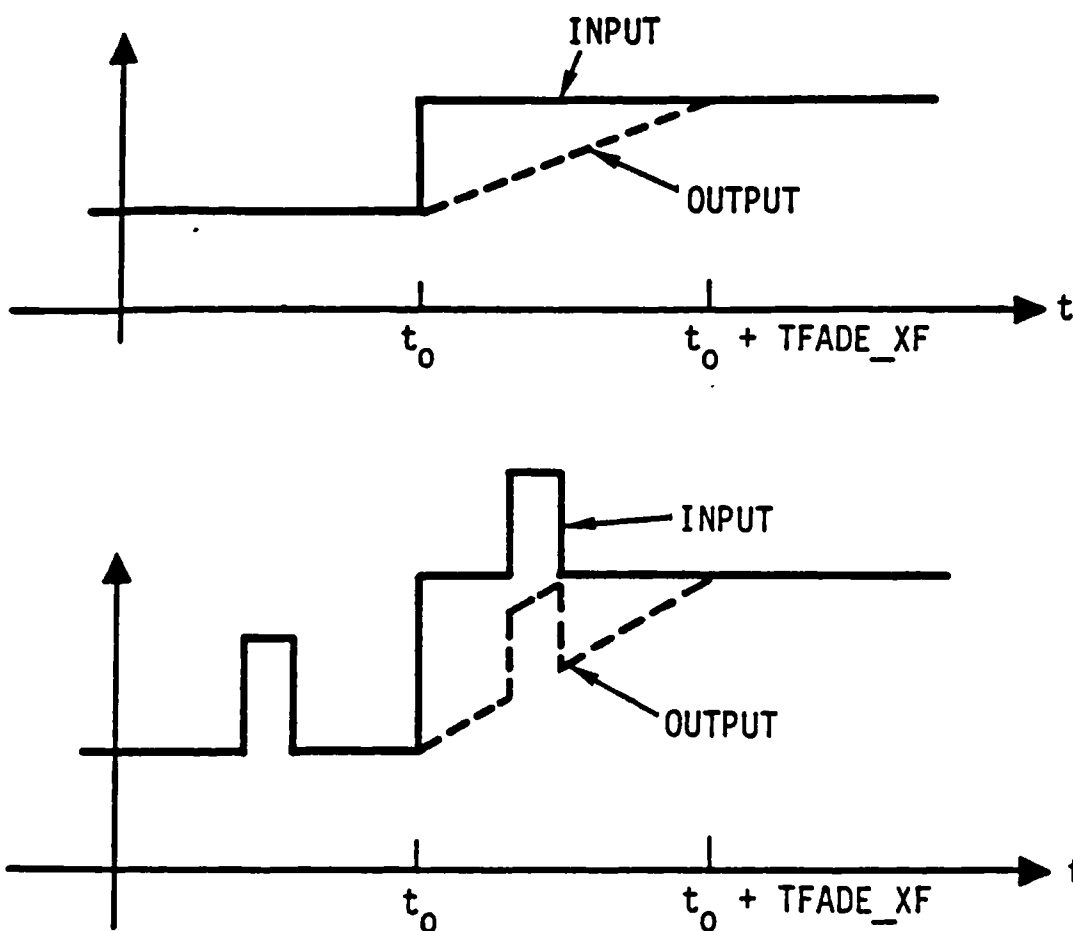


Figure 4.7.5-2. Effect of Fading

Name	
Inputs	
X	
NFADE_X	
XF	
BR_XF	
Outputs	
XF	
NFADE_X	
BR_XF	

Table 4.7.5-1. FADER Interface Requirements

Name	Source or Description	Destination	Type	Range	Units	Rate Required/Produced (Hz)
<u>Inputs</u>						
X	Input		S		-	-
NFADE_X	Counter		I		-	-
XF BR_XF	Past value of intermediate variable		S S			
<u>Outputs</u>						
XF	Output		S		-	-
NFADE_X	Counter		I		-	-
BR_XF	Intermediate variable (current input minus past output)/NFADE_X		S		-	-

Table 4.7.5-2. FADER Initialization Requirements

Component	Initialize on Transition		Variable	Initial Value
	From	To		
Fader	--	NFADE_X > 0	NFADE_X BR_XF	-NFADE_X (X-XF)/ NFADE_X

4.7.6 X_INTERP

A. Function. The detailed block diagram for the module X_INTERP is presented in Figure 4.7.6-1. This utility function is used in conjunction with Y_INTERP (Subsection 4.7.7) for linear interpolation, using a table of breakpoints (tabs). X_INTERP and Y_INTERP are especially useful when dependent variables can be tabulated for a single set of independent variables. The X_TAB is an array of table entry breakpoints of the independent variable X. For a given X, the array index J_X is found so that either

$$X_TAB_{J_X} \leq X < X_TAB_{J_X + 1}$$

for a monotonically increasing table or

$$X_TAB_{J_X} \geq X > X_TAB_{J_X + 1}$$

for a monotonically decreasing table.

Then a (scalar) quantity suitable for efficient interpolation of the dependent variable is computed:

$$RATIO_X = (X - X_TAB_{J_X}) / (X_TAB_{J_X + 1} - X_TAB_{J_X})$$

Note that infinite slopes (repeated X_j) are not allowed by this algorithm.

In many cases, X is monotonic. With J_X an input, the starting value for the present search can be that value which satisfied the last search. This is especially useful for many-valued tables. The feature is disabled by setting J_X to unity at each invocation.

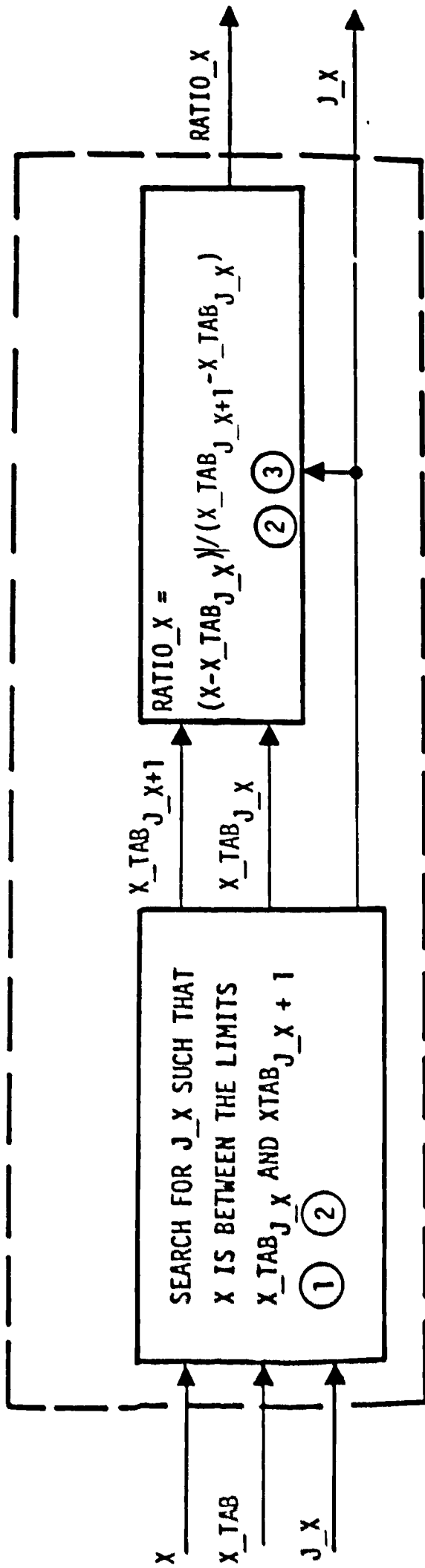
If $X \leq X_TAB_1$ or $X \geq X_TAB_N$ for an increasing table, or if $X \geq X_TAB_1$ or $X \leq X_TAB_N$ for a decreasing table (beyond left or right extremities of tabular data) then X_INTERP sets RATIO_X = 0, which will force Y_INTERP to provide horizontal extrapolation beyond the tabular extremities.

B. Processing Requirements. The module X_INTERP is processed when invoked by a user.

C. Interface Requirements. The interface requirements for the module X_INTERP are shown in Table 4.7.6-1.

D. Constants. None.

E. Initialization Requirements. The initialization requirements for the module X_INTERP are shown in Table 4.7.6-2.



NOTES

- ① FOR INCREASING TABLE, $X_TAB_J_X \leq X < X_TAB_J_X + 1$
FOR DECREASING TABLE, $X_TAB_J_X \geq X > X_TAB_J_X + 1$
- ② IF X IS OUTSIDE THE RANGE OF THE TABLE
SET $RATIO_X = 0$, WHICH WILL FORCE Y_INTERP TO PROJECT HORIZONTALLY:
 $Y = Y_TAB_J_X$
- ③ ASSUME $X_TAB_J_X + 1 \neq X_TAB_J_X$ (I.E., NO VERTICAL SEGMENT)

Figure 4.7.6 1. X INTERP



Table 4.7.6-1. X_INTERP Interface Requirements

Name	Description	Source or Destination	Type	Units	Rate Required/Produced (Hz)
<u>Inputs</u>					
X	Independent variable	-	S	-	-
X_TAB	Array of table entry breakpoints for independent variable	-	A(n)	-	-
J_X	Past value of J_X	X_INTERP	I	-	-
<u>Outputs</u>					
RATIO_X	Ratio used for interpolating dependent variable	Y_INTERP	S	-	-
J_X	Index value to left of current value of dependent variable	Y_INTERP	I	-	-

Table 4.7.6-2. X_INTERP Initialization Requirements

Component	Initialize on Transition		Variable	Initial Value
	From	To		
X_INTERP	As specified in the particular user application		J_X	As required



4.7.7 Y_INTERP

A. Function. The detailed block diagram for the module Y_INTERP is presented in Figure 4.7.7-1. This utility function performs linear interpolation of a dependent variable and is normally used in conjunction with X_INTERP (Subsection 4.7.6), which calculates RATIO_X and J_X. Y_INTERP receives RATIO_X and the index, J_X, corresponding to the first break point prior to X, and an array, Y_TAB, which contains the independent variable breakpoints that correspond to the dependent variable breakpoints. The output Y is the linear interpolated value of the dependent variable, given as follows:

$$Y = (Y_TAB_{J_X + 1} - Y_TAB_{J_X}) \text{RATIO_X} + Y_TAB_{J_X}$$

Extrapolation beyond the extremities of the tabular data is horizontal: $Y = Y_TAB_{J_X}$. This is indicated in X_INTERP by setting X_RATIO = 0.

B. Processing Requirements. The module Y_INTERP is processed when invoked by a user.

C. Interface Requirements. The interface requirements for the module Y_INTERP are shown in Table 4.7.7-1.

D. Constants. There are no constants for Y_INTERP.

E. Initialization Requirements. There are no initialization requirements for Y_INTERP.

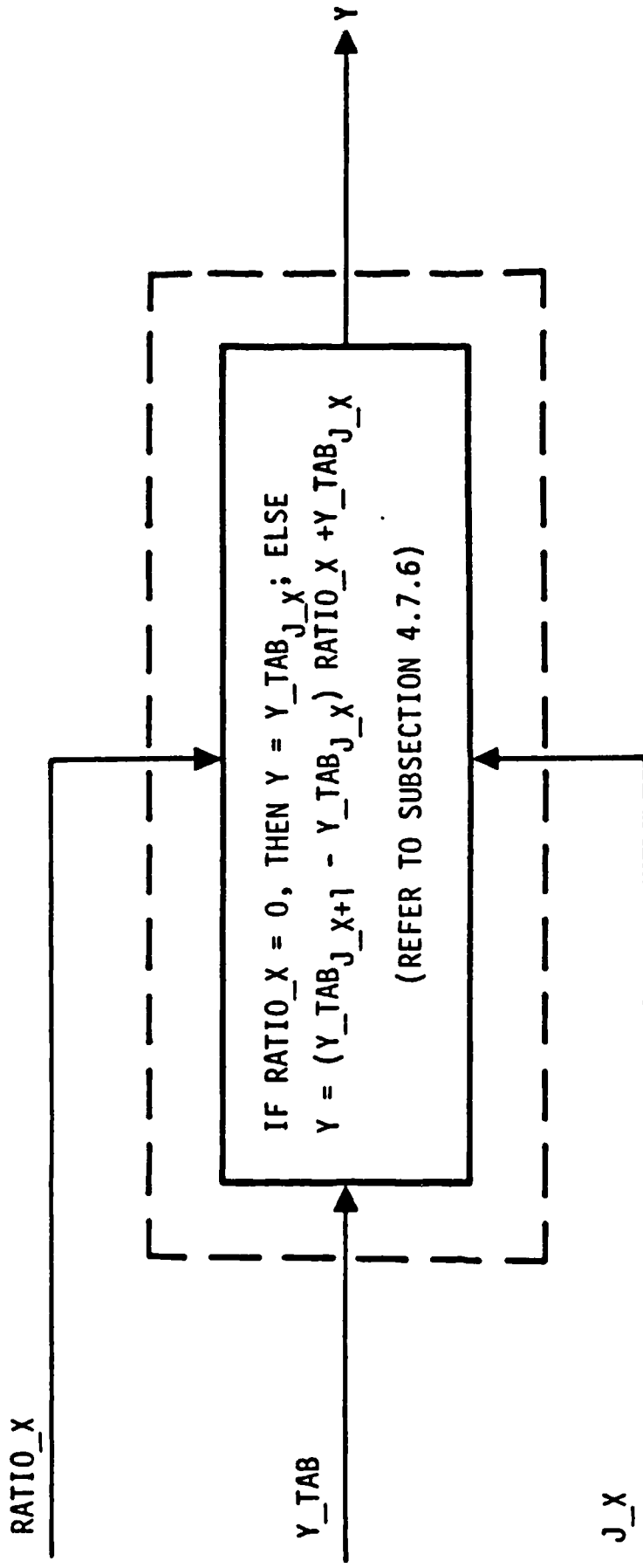


Figure 4.7.7-1. Y_INTERP

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Table 4.7.7-1. Y_INTERP Interface Requirements

Name	Description	Source or Destination	Type	Units	Rate Required/ Produced (Hz)
<u>Inputs</u>					
RATIO_X	Ratio used for interpolating dependent variable	X_INTERP	S	-	-
J_X	Index value to left of current value of dependent variable	X_INTERP	I	-	-
Y_TAB	Array containing dependent variable breakpoints	-	A(n)	-	-
<u>Outputs</u>					
Y	Interpolated value of dependent variable	-	S	-	-

Final

Table 4.7.7-1. Y_INTERP Interface Requirements

Name	Description	Source or Destination	Type	Units	Rate Required/Produced (Hz)
<u>Inputs</u>					
RATIO_X	Ratio used for interpolating dependent variable	X_INTERP	S	-	-
J_X	Index value to left of current value of dependent variable	X_INTERP	I	-	-
Y_TAB	Array containing dependent variable breakpoints	-	A(n)	-	-
<u>Outputs</u>					
Y	Interpolated value of dependent variable	-	S	-	-

4.7.8 MINITABLE

A. Function. The detailed block diagram for the module MINITABLE is presented in Figure 4.7.8-1. MINITABLE is useful for interpolating functions with only two breakpoints and is intended for in-line code generation (e.g., a macro). If the input X is between XLFT and XRGT, then a linear interpolation is performed to obtain Y. If $X \leq XLFT$, then $Y = YLFT$; and if $X \geq XRGT$, $Y = YRGT$. It is assumed that $XLFT \leq XRGT$, but is not necessary for YLFT to be less than YRGT; e.g., slopes can be positive or negative but must be finite ($XLFT \neq XRGT$). The HAL in-line implementation is as follows:

$$Y = (X - XLFT) [(YRGT - YLFT)/(XRGT - XLFT)] + YLFT$$

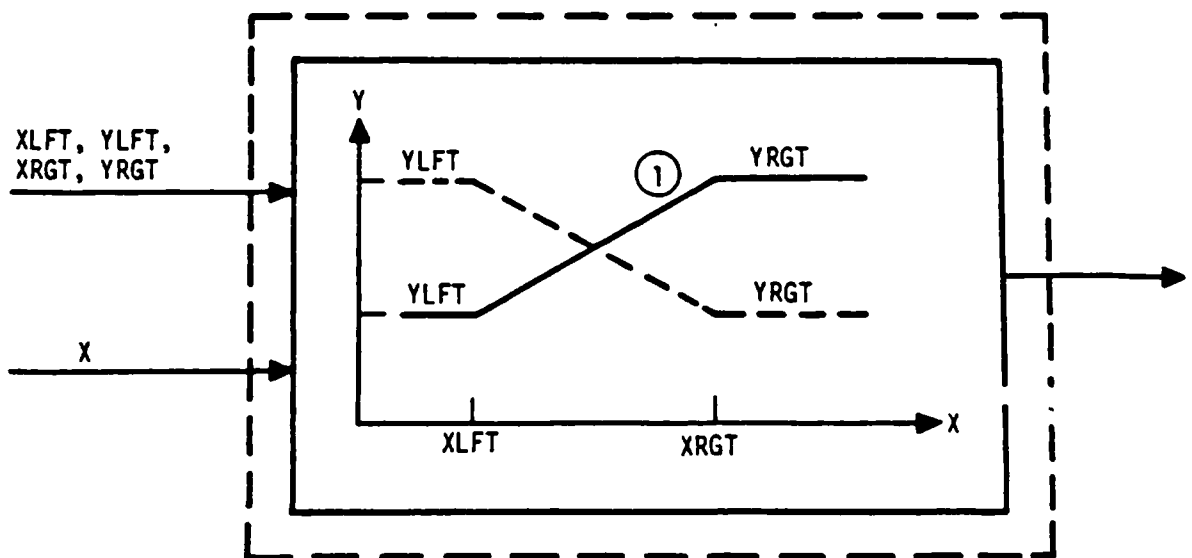
where the term in square brackets will be a HAL-derived constant.

B. Processing Requirements. The module MINITABLE is processed when invoked by the user.

C. Interface Requirements. The interface requirements for the module MINITABLE are shown in Table 4.7.8-1

D. Constants. None.

E. Initialization Requirements. None.



NOTES

- ① FUNCTION SPECIFICATION
- IF $X \leq XLFT$: $Y = YLFT$
- IF $XLFT < X < XRGT$: $Y = (X - XLFT) [(YRGT - YLFT)/(XRGT - XLFT)] + YLFT$
- IF $X \geq XRGT$: $Y = YRGT$
- ASSUME $XLFT < XRGT$
- ② INLINE HAL (WHERE TERM IN SQUARE BRACKETS WILL BE A SINGLE DERIVED CONSTANT):
- $Y = MIDVAL (YLFT, (X - XLFT)((YRGT - YLFT)/(XRGT - XLFT)) + YLFT, YRGT)$

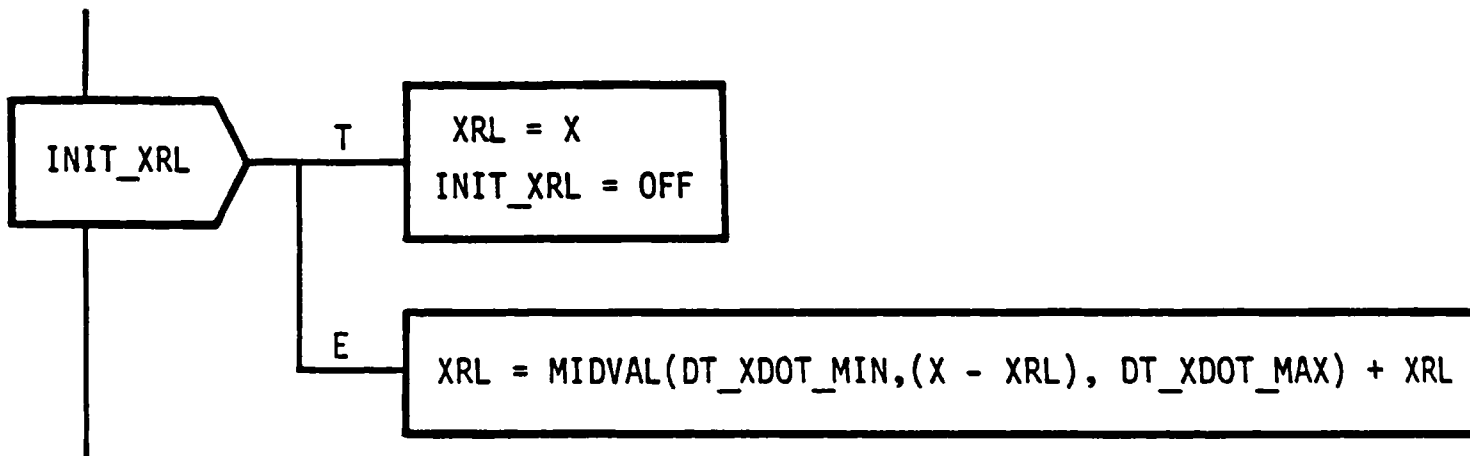
Figure 4.7.8-1. MINITABLE

Table 4.7.8-1. MINITABLE Interface Requirements

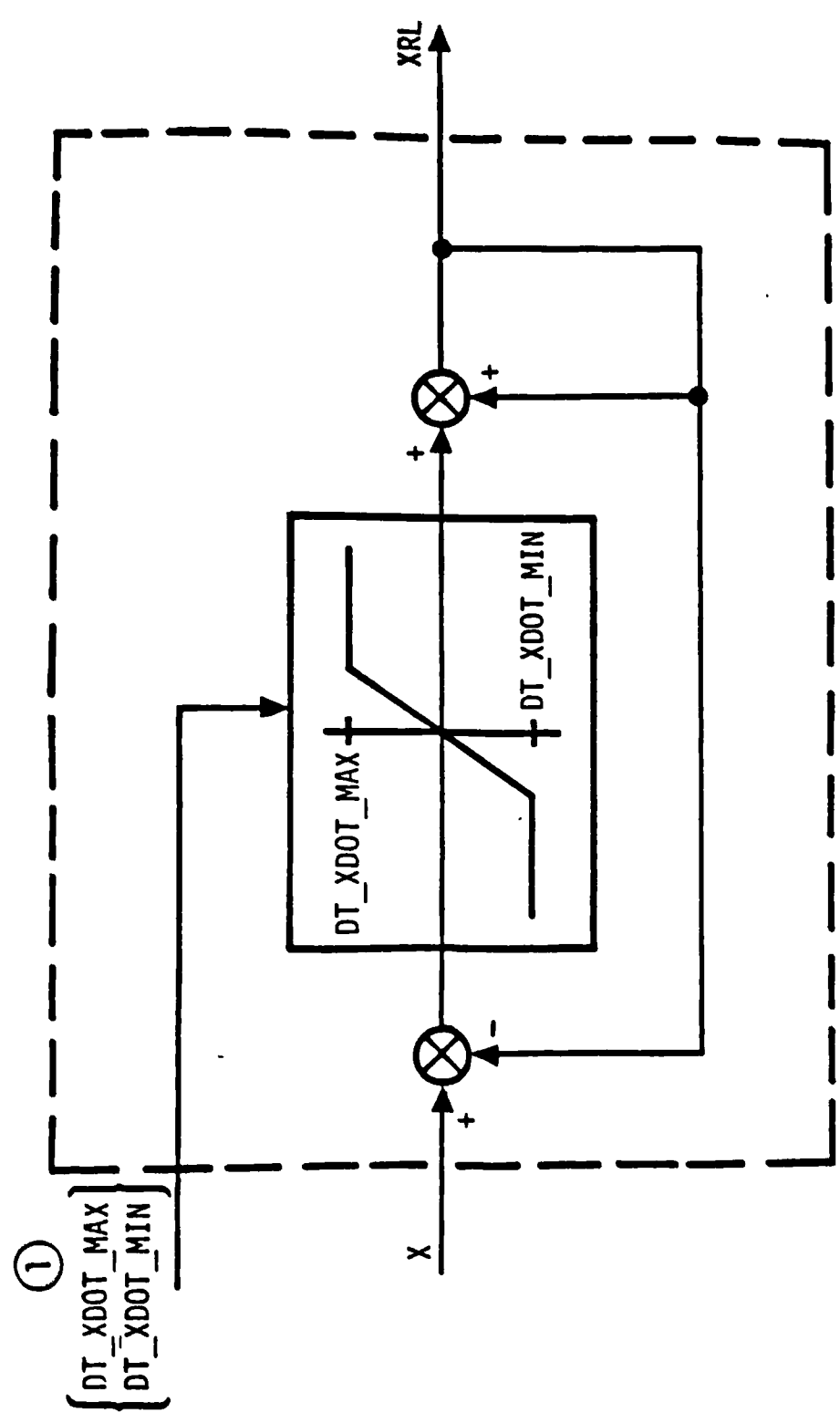
Name	Description	Source or Destination	Type	Units	Rate Required/Produced (Hz)
<u>Inputs</u>					
X	Independent variable	-	S	-	-
XLFT	Lower value of X between which output is to be interpolated	-	S	-	-
YLFT	Value of dependent variable corresponding to XLFT	-	S	-	-
XRGT	Upper value of X between which output is to be interpolated	-	S	-	-
YRGT	Value of dependent variable corresponding to XRGT	-	S	-	-
<u>Outputs</u>					
Y	Dependent variable	-	S	-	-

4.7.9 RATE_LIMIT

- A. Function. The detailed block diagram for the module RATE_LIMIT is presented in Figure 4.7.9-1. This utility function limits the rate of change of the output.
- B. Processing Requirements. The module RATE_LIMIT is processed when invoked by the user.
- C. Interface Requirements. The interface requirements for the module RATE_LIMIT are shown in Table 4.7.9-1.
- D. Constants. There are no constants for RATE_LIMIT.
- E. Initialization Requirements. The initialization requirements for the module RATE_LIMIT are shown in Table 4.7.9-2.



NOTE: IF ALL USERS REQUIRE ONLY SYMMETRIC LIMITS \pm DT_XDOT_LIM, THEN USE OF THE SINGLE QUANTITY WILL SAVE CORE



NOTES: (1) PRODUCTS OF SAMPLE INTERVAL & RATE LIMITS

Figure 4.7.9-1. RATE LIMIT

Table 4.7.9-1. RATE_LIMIT Interface Requirements

Name	Description	Source or Destination	Type	Units	Rate Required/Produced (Hz)
<u>Inputs</u>					
X	Input to be rate-limited	-	S	-	-
DT_XDOT_MIN	Product of minimum rate limit and processing interval	-	S	-	-
DT_XDOT_MAX	Product of maximum rate limit and processing interval	-	S	-	-
XRL	Past value of output	-	S	-	-
INIT_XRL	Initialization flag	-	B	-	-
<u>Outputs</u>					
XRL	Rate-limited output	-	S	-	-
INIT_XRL	Initialization flag	-	B	-	-

Table 4.7.9-2. RATE_LIMIT Initialization Requirements

Component	Initialize on Transition		Variable	Initial Value
	From	To		
Past value of output	-	INIT_XRL	XRL	X

4.7.10 QUAT_MULT

A. Function. The detailed block diagram for the module QUAT_MULT is presented in Figure 4.7.10-1. QUAT_MULT is invoked with an ordered quadruple of scalar and vector parts of operand quaternions [Q1S, Q1V, Q2S, Q2V]. Quaternion multiplication is generally not commutative, so the order of the operands (leftmost/rightmost) is important. Conjugation, if required, is handled by the user by complementing the appropriate vector part. Figure 4.7.10-2 shows typical user applications and block diagram symbology, including conjugate multiplication and quaternion integration.

B. Processing Requirements. The module QUAT_MULT is processed when invoked by a user.

C. Interface Requirements. The interface requirements for the module QUAT_MULT are shown in Table 4.7.10-1.

D. Constants. None.

E. Initialization Requirements. None.

F. Detailed Technical Descriptions. For the operation $Q3 = Q1 Q2$, where the leftmost quaternion $Q1 = [Q1S, Q1V]$ and the rightmost quaternion $Q2 = [Q2S, Q2V]$, the product quaternion $Q3 = [Q3S, Q3V]$ is given by the following equations:

$$Q3S = Q1S Q2S - \bar{Q1V} \cdot Q2V$$

$$\bar{Q3V} = Q1S \bar{Q2V} + Q2S \bar{Q1V} + \bar{Q1V} * \bar{Q2V}$$

Since QUAT_MULT will be used from 75 to 125 times per second, depending upon mode, the equations should be expanded to save significant CPU at the expense of minimal core:

$$Q3S = Q1S Q2S - (Q1V_1 Q2V_1 + Q1V_2 Q2V_2 + Q1V_3 Q2V_3)$$

$$Q3V_1 = Q1S Q2V_1 + Q2S Q1V_1 + Q1V_2 Q2V_3 - Q1V_3 Q2V_2$$

$$Q3V_2 = Q1S Q2V_2 + Q2S Q1V_2 - Q1V_1 Q2V_3 + Q1V_3 Q2V_1$$

$$Q3V_3 = Q1S Q2V_3 + Q2S Q1V_3 + Q1V_1 Q2V_2 - Q1V_2 Q2V_1$$

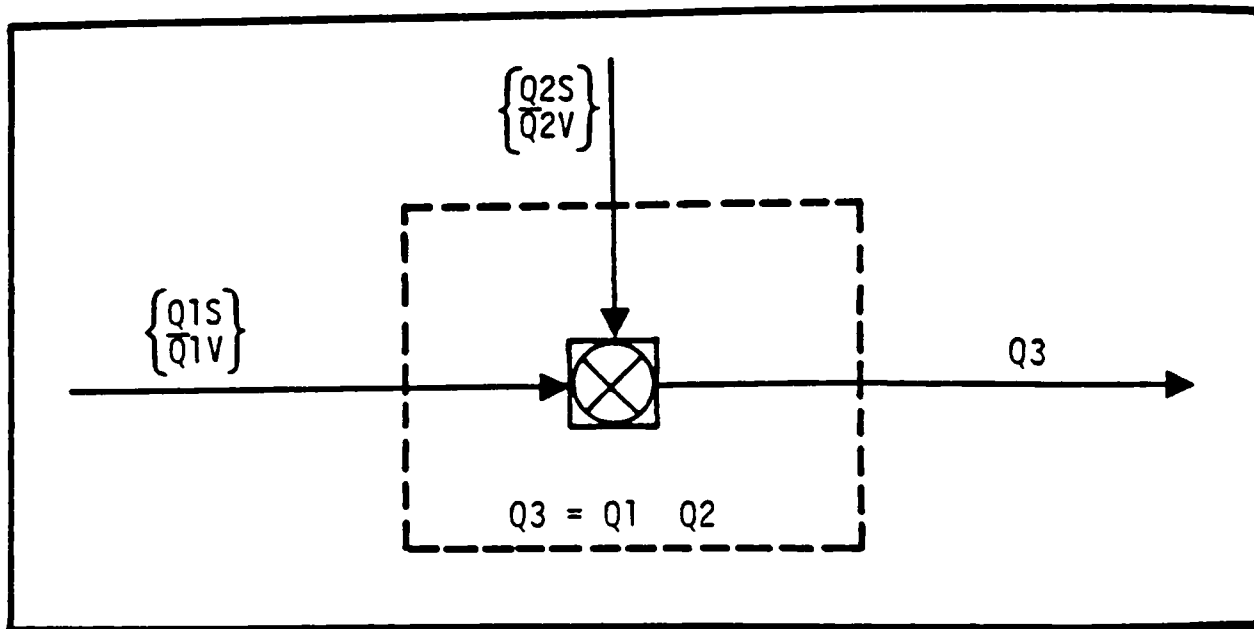


Figure 4.7.10-1. QUAT_MULT

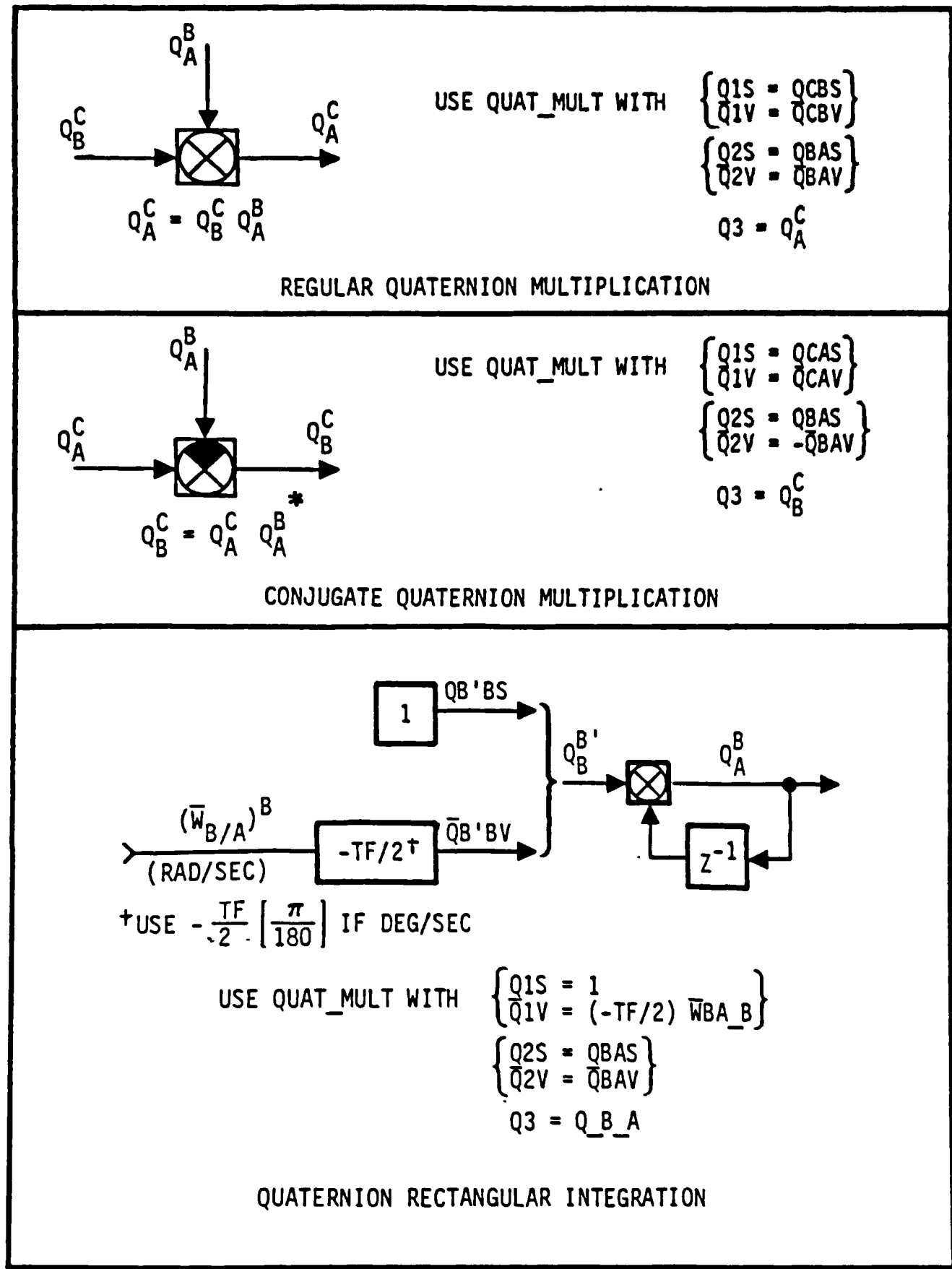


Figure 4.7.10-2. QUAT_MULT Symbology and Applications

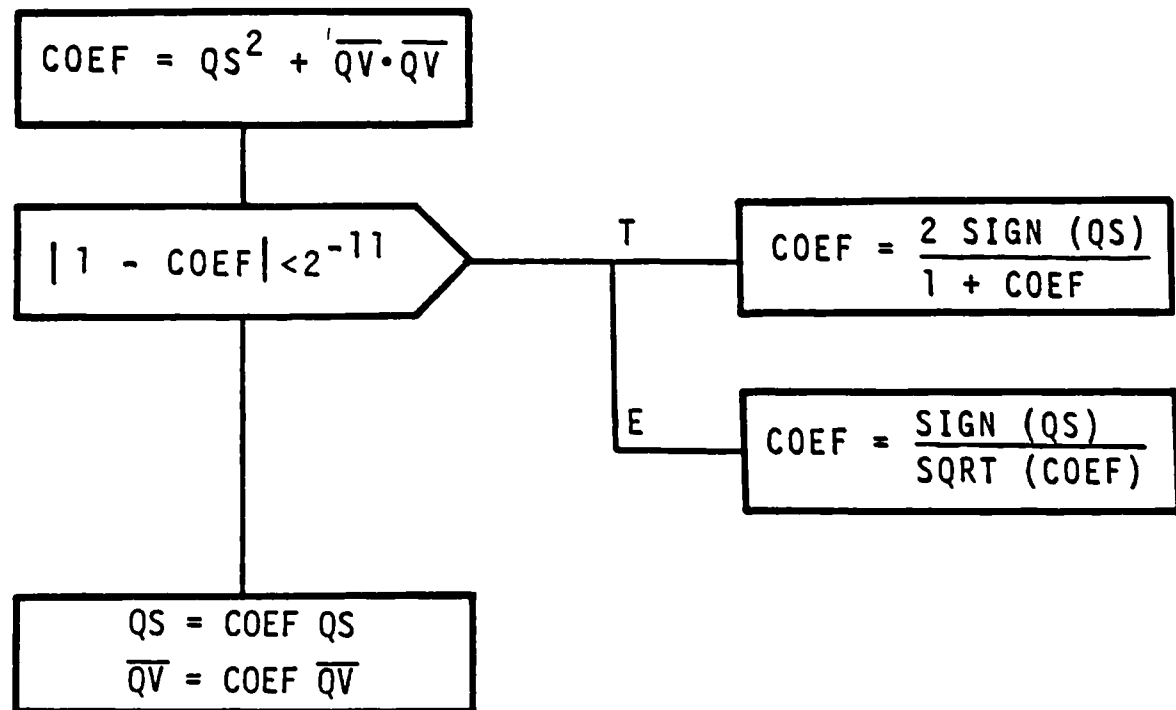
Table 4.7.10-1. QUAT_MULT Interface Requirements

Name	Description	Source or Destination	Type	Units	Rate Required/Produced (Hz)
<u>Inputs</u>					
Q1S Q1V	A scalar and a vector corresponding to the part of the leftmost quaternion*		S V	- -	- -
Q2S Q2V	A scalar and a vector corresponding to the parts of the rightmost quaternion*		S V	- -	- -
<u>Outputs</u>					
Q3	Output quaternion*		Q	-	-
* Where Q3 = Q1 Q2					

Rate Required Produced (Hz)
-
-
-
-
-

4.7.11 QUAT_NORM

- A. Function. The detailed block diagram for the module QUAT_NORM is presented in Figure 4.7.11-1. QUAT_NORM yields a properly normalized quaternion, with a positive scalar part. If the incoming scalar is negative, QUAT_NORM complements the elements. It computes the scalar part based on the vector part. Numerical problems in the vicinity of 180 degrees are avoided; the resulting quaternion corresponds to an exact 180-degree rotation.
- B. Processing Requirements. The module QUAT_NORM is processed when invoked by a user.
- C. Interface Requirements. The interface requirements for the module QUAT_NORM are shown in Table 4.7.11-1.
- D. Constants. None.
- E. Initialization Requirements. None.
- F. Detailed Technical Descriptions.



WHERE THE CONSTANT 2^{-11} ASSUMES SINGLE PRECISION CALCULATION.

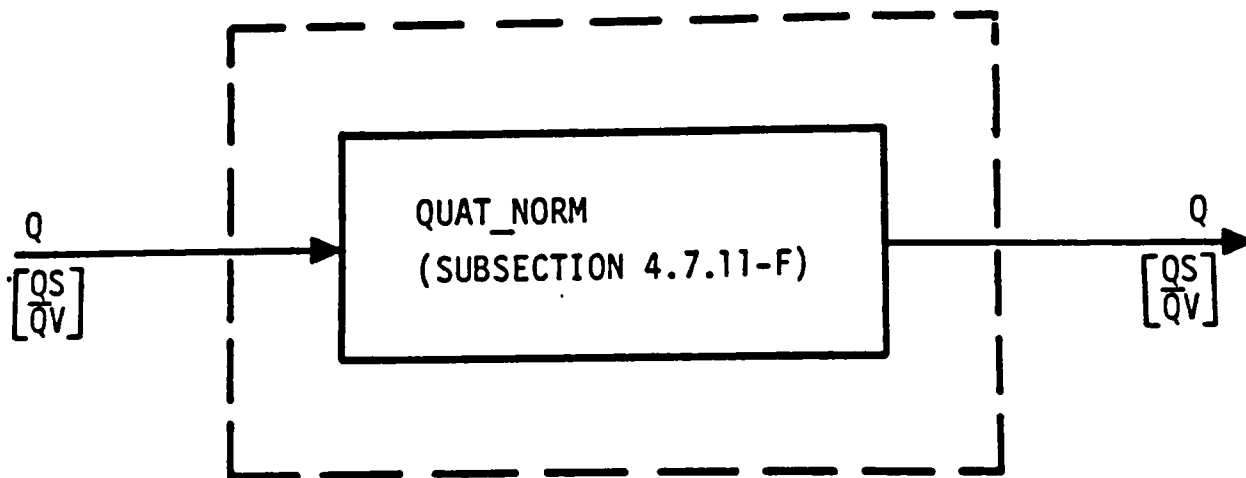


Figure 4.7.11-1. QUAT_NORM

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Table 4.7.11-1. QUAT_NORM Interface Requirements

Name	Description	Source or Destination	Type	Units	Rate Required Produced (Hz)
<u>Inputs</u>					
Q	Quaternion to be normalized		Q	-	-
<u>Outputs</u>					
Q	Normalized quaternion		Q	-	-



4.7.12 QUAT_INTEG

A. Function. The detailed block diagram for the module QUAT_INTEG is presented in Figure 4.7.12-1. QUAT_INTEG performs quaternion integration subject to a specific assumption on the coordinatization of the rate vector; namely, that if \bar{W} represents the angular velocity of frame B with respect to frame A, then W is coordinatized in frame B. As such, it is not as general as QUAT_MULT (Subsection 4.7.10), which can handle all four quaternion integration algorithms. QUAT_INTEG is intended for in-line code generation (e.g., a macro), which invokes QUAT_MULT.

B. Processing Requirements. The module QUAT_INTEG is processed when invoked by a user.

C. Interface Requirements. The interface requirements for QUAT_INTEG are shown in Table 4.7.12-1.

D. Constants. None.

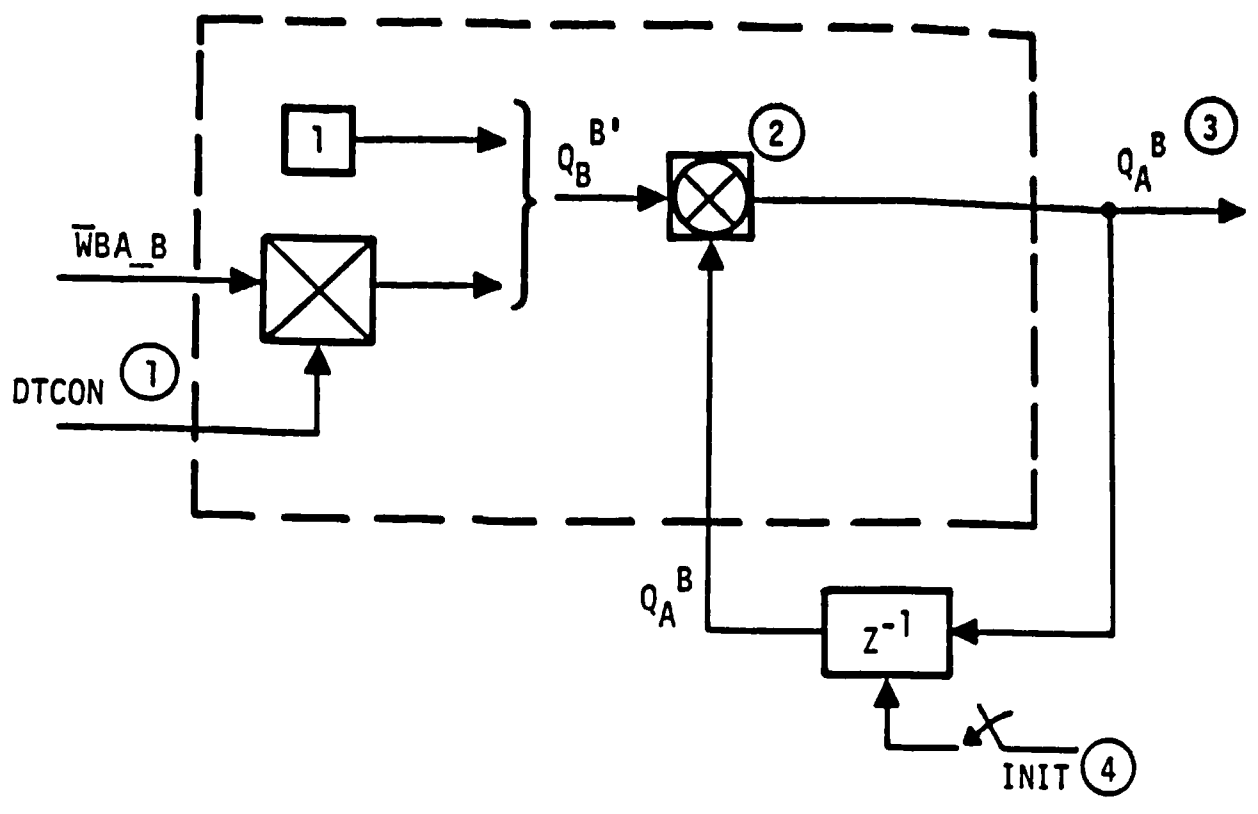
E. Initialization Requirements. The initialization requirements for QUAT_INTEG are shown in Table 4.7.12-2.

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- NOTES
- ① $DTCON = \begin{cases} -\frac{\Delta T}{2} & \text{IF } \bar{WBA_B} \text{ IN RAD/SEC} \\ -\frac{\Delta T}{2} \left(\frac{\pi}{180}\right) & \text{IF } \bar{WBA_B} \text{ IN DEG/SEC} \end{cases}$
 - ② $Q_A^B \leftarrow \text{QUAT_MULT}(1, (DTCON \bar{WBA_B}), Q_{BAS}, \bar{Q}_{BAV})$
(SUBSECTION 4.7.10)
 - ③ USE QUAT_NORM (SUBSECTION 4.7.11) TO PERIODICALLY NORMALIZE Q_A^B
 - ④ USER INITIALIZATION OF Q_A^B IS REQUIRED

Figure 4.7.12-1. QUAT_INTEG



Table 4.7.12-1. QUAT_INTEG Interface Requirements

Name	Description	Source or Destination	Type	Units	Rate Required/Produced (Hz)
<u>Inputs</u>					
WBA_B	Rotational rate, frame B wrt frame A, coordinated in frame B		V	1/s or deg/s	-
DTCOM	Multiplicative factor for rate input vector		S	s or s/deg	-
Q_B_A	Past value of output quaternion		Q	-	-
<u>Outputs</u>					
Q_B_A	Quaternion, B frame wrt A frame		Q	-	-

Table 4.7.12-2. QUAT_INTEG Initialization Requirements

Component	Initialize on Transition		Variable	Initial Value
	From	To		
Past value of quaternion output	User-defined initialization condition		Q_B_A	User dependent

Rate Required/ Produced (Hz)
-
-
-

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4.7.13 QUAT_XFORM

A. Function. The detailed block diagram for the module QUAT_XFORM is presented in Figure 4.7.13-1. This utility routine performs a coordinate transformation on a vector, using quaternions. The input includes a quaternion representing the coordinate transformation and the vector to be transformed. The output is the transformed vector. It is assumed that the input quaternion is normal.

B. Processing Requirements. The module QUAT_XFORM is processed when invoked by a user.

C. Interface Requirements. The interface requirements for the module QUAT_XFORM are shown in Table 4.7.13-1.

D. Constants. None.

E. Initialization Requirements. None.

F. Detailed Technical Descriptions.

1. $QTMP = (QBAS, \bar{Q}BAV) (0, \bar{W}_A)$:
 $QTMP_S = -\bar{Q}BAV \cdot \bar{W}_A$
 $\bar{Q}TMPV = QBAS \bar{W}_A + \bar{Q}BAV * \bar{W}_A$
2. $(0, \bar{W}_B) = (QTMP_S, \bar{Q}TMPV) (QBAS, -\bar{Q}BAV)$:
 $\bar{W}_B = -QTMP_S \bar{Q}BAV + QBAS \bar{Q}TMPV - \bar{Q}TMPV * \bar{Q}BAV$

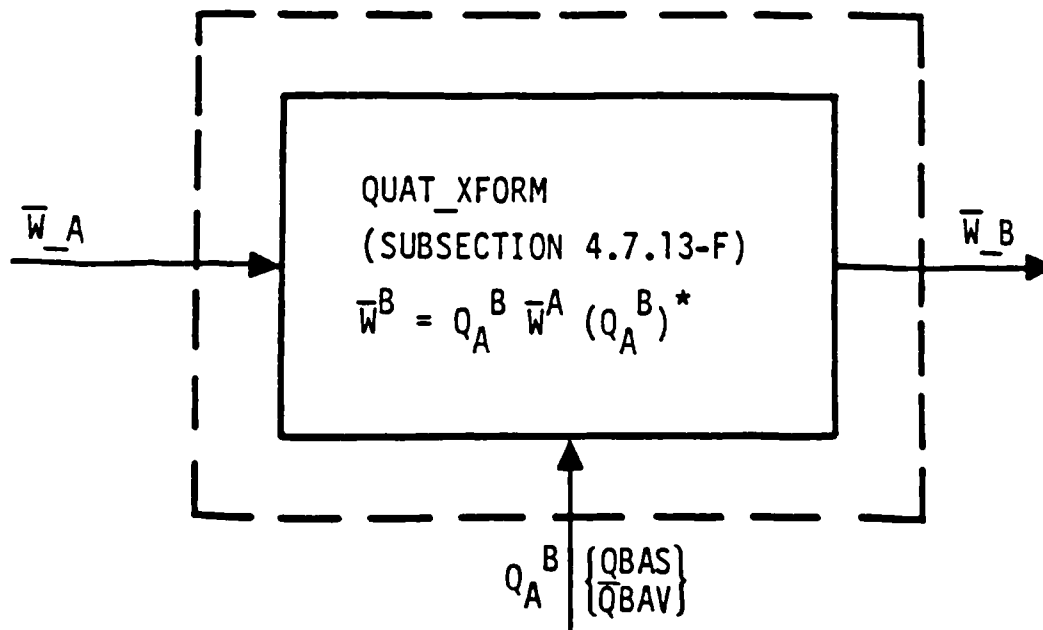


Figure 4.7.13-1. QUAT_XFORM

Table 4.7.13-1. QUAT_XFORM Interface Requirements

Name	Description	Source or Destination	Type	Units	Rate Required/Produced (Hz)
<u>Inputs</u>					
\bar{W}_A	Input vector in frame A		V	-	-
Q_{B_A}	Quaternion, frame B wrt frame A		Q	-	-
<u>Outputs</u>					
W_B	Output vector in frame B		V	-	-

Rate Required/Produced (Hz)
-
-
-

4.7.14 QUAT_ERR_ANG

A. Function. The detailed block diagram for the module QUAT_ERR_ANG is presented in Figure 4.7.14-1. QUAT_ERR_ANG extracts a vector of attitude errors, in degrees, from an error quaternion, using the algorithm:

$$\bar{E}BA_A = -2 \left(\frac{180}{\pi} \right) \text{SIGN} (QBAS) \bar{Q}BAV$$

This algorithm is a linear approximation; it is reasonably valid only to the extent that the true angle of rotation θ represented by the quaternion

satisfies the equations $\sin \frac{\theta}{2} \approx \frac{\theta}{2}$, $\cos \frac{\theta}{2} \approx 1$.

B. Processing Requirements. The module QUAT_ERR_ANG is processed upon invocation by a user.

C. Interface Requirements. The interface requirements for the module are shown in Table 4.7.14-1.

D. Constants. The constants for QUAT_ERR_ANG are shown in Table 4.7.14-2.

E. Initialization Requirements. There are no initialization requirements for QUAT_ERR_ANG.

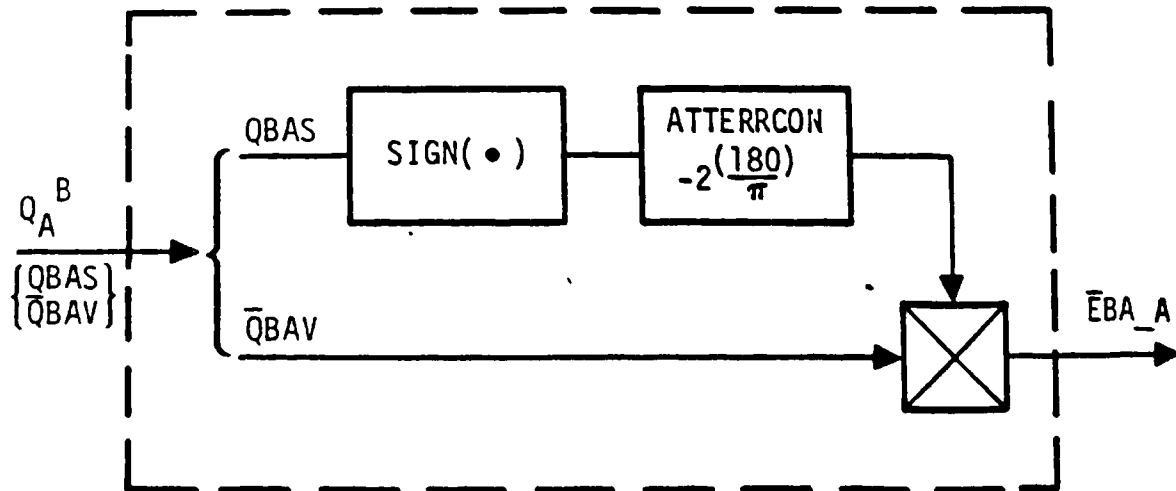


Figure 4.7.14-1. QUAT_ERR_ANG



Table 4.7.14-1. QUAT_ERR_ANG Interface Requirements

Name	Description	Source or Destination	Type	Units	Rate Required/Produced (Hz)
<u>Inputs</u>					
Q_B_A	Quaternion, frame B wrt frame A		Q	-	-
<u>Outputs</u>					
EBA_A	Attitude errors, frame B wrt frame A coordinatized in frame A		V	deg	-

Table 4.7.14-2. QUAT_ERR_ANG Constants

Name	Description	Type	Value	Units	Other References
DEG_PER_RAD	Conversion factor, radians to degrees	S	180/ π	deg/rad	many
ATTERRCON	Scale factor for extracting a vector of attitude errors in degrees from a quaternion	S	(-2) DEG_PER_RAD	deg	-

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4.7.15 SMOOTHER

- A. Function. This routine provides a smoothed, high-rate output between samples of a low-rate input signal. The detailed block diagram for SMOOTHER is presented in Figure 4.7.15-1.
- B. Processing Requirements. SMOOTHER is processed at the high rate specified by the particular application.
- C. Interface Requirements. The interface requirements for SMOOTHER are shown in Table 4.7.15-1.
- D. Constants. The constants for SMOOTHER are shown in Table 4.7.15-2.
- E. Initialization Requirements. The initialization requirements for SMOOTHER are shown in Table 4.7.15-3.
- F. Detailed Technical Description. A detailed description in terms of a logic flow diagram is presented in Figure 4.7.15-1. XIN is updated at the low rate; that is, every TMAJOR seconds.

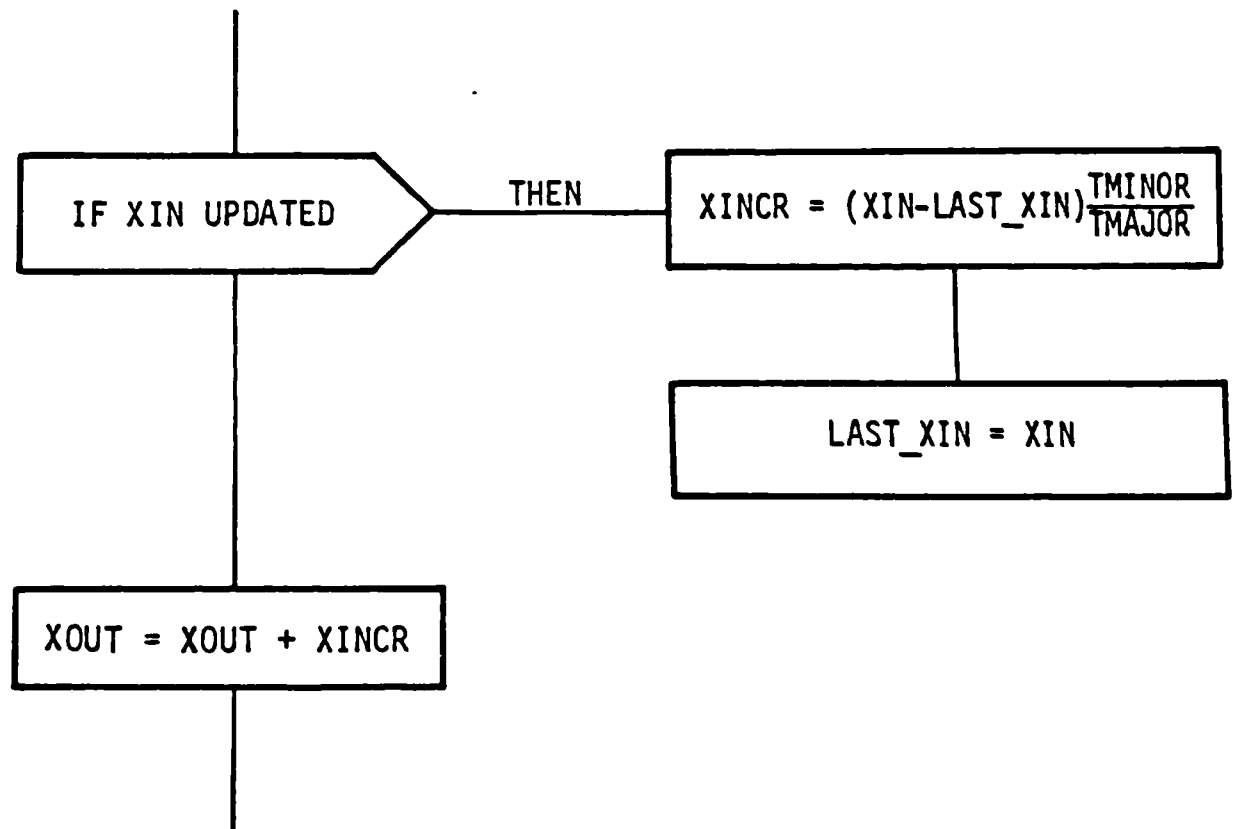


Figure 4.7.15-1. SMOOTHER Logic Flow Diagram



Table 4.7.15-1. SMOOTHER Interface Requirements

Name	Description	Source or Destination	Type	Units	Rate Required/Produced (Hz)
<u>Input</u>					
XIN	Smoother input	-	F	*	*
<u>Output</u>					
XOIT	Smoother output	-	F	*	*

Table 4.7.15-2. SMOOTHER Constants

Name	Description	Type	Value	Units
TMAJOR	Period at which the input signal is updated	F	*	sec
TMINOR	Period at which the output signal is updated	F	*	sec
*As specified in the particular application				

Table 4.7.15-3. SMOOTHER Initialization Requirements

Component	Initialize on Transition		Variable	Initial Value
	From	To		
SMOOTHER	-	First invocation	Last_XIN XOUT	XIN XIN

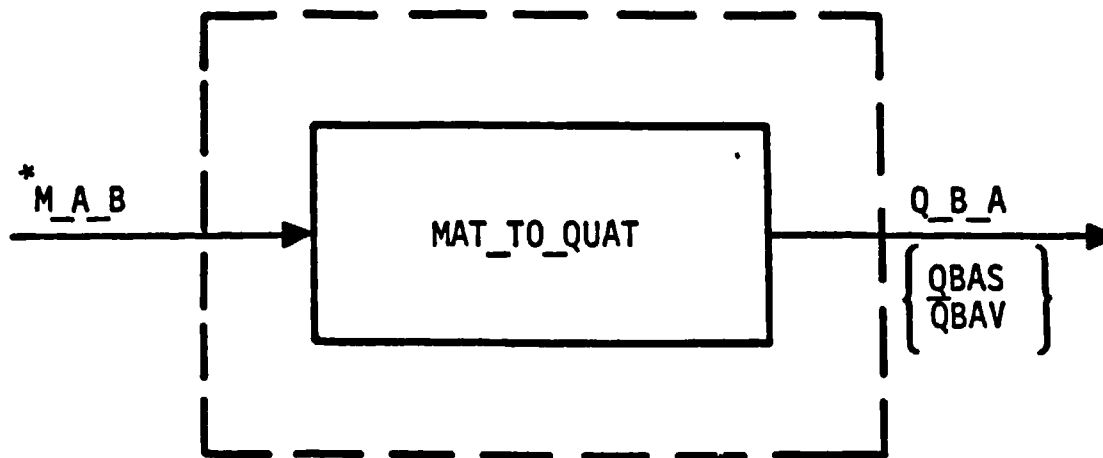
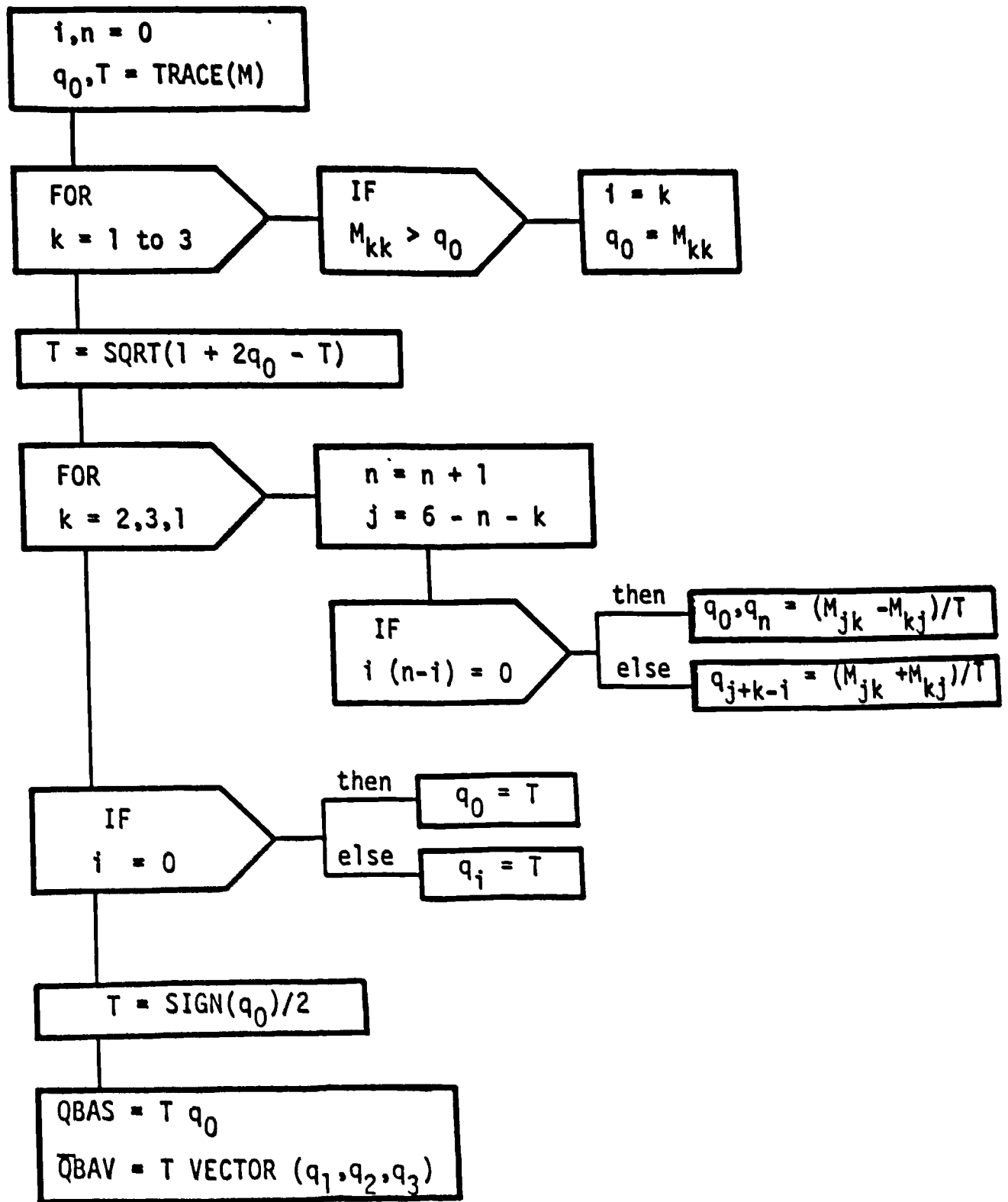


Figure 4.7.16-1. MAT_TO_QUAT

- B. Processing Requirements. The module MAT_TO_QUAT is processed when invoked by a user.
- C. Interface Requirements. The interface requirements for MAT_TO_QUAT are shown in Table 4.7.16-1.
- D. Constants. None.
- E. Initialization Requirements. None
- F. Detailed Technical Descriptions.



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Table 4.7.16-1. MAT_TO_QUAT Interface Requirements

Name	Description	Source or Destination	Type	Units	Rate Required/Produced (Hz)
<u>Input</u> M_A_B	Direction cosine matrix, B frame wrt A frame		M	-	-
<u>Outputs</u> Q_B_A	Quaternions, B frame wrt A frame		Struct S, V	-	-

4.7.17 RV_TO_QLVLH

A. Function. RV_TO_QLVLH is a PROCEDURE which, given a position vector ($\bar{X}R$) and velocity vector ($\bar{X}V$), both coordinated in M50, returns a quaternion $XQ_M50_LVLH = (XQM50LVLHS, \bar{X}QM50LVLHV)$ representing the M50 frame with respect to the local orbital frame. The CALL to RV_TO_QLVLH is

CALL RV_TO_QLVLH ($\bar{X}R$, $\bar{X}V$) ASSIGN (XQ_M50_LVLH)

A block diagram of RV_TO_QLVLH is shown in Figure 4.7.17-1.

B. Processing Requirements. The module RV_TO_QLVLH is processed when invoked by a user.

C. Interface Requirements. The interface requirements for module RV_TO_QLVLH are shown in Table 4.7.17-1.

D. Constants. None.

E. Initialization Requirements. None.

F. Detailed Technical Description.

$$\bar{X}Z = \text{UNIT} (-\bar{X}R)$$

$$\bar{X}Y = \text{UNIT} (\bar{X}V * \bar{X}R)$$

$$\bar{X}X = \text{UNIT} (\bar{X}X * \bar{X}Z)$$

$$\bar{X}M = (\text{MATRIX} (\bar{X}X, \bar{X}Y, \bar{X}Z))^T$$

XQ_M50_LVLH is formed from $\bar{X}M$ by invoking the utility function MAT_TO_QUAT.

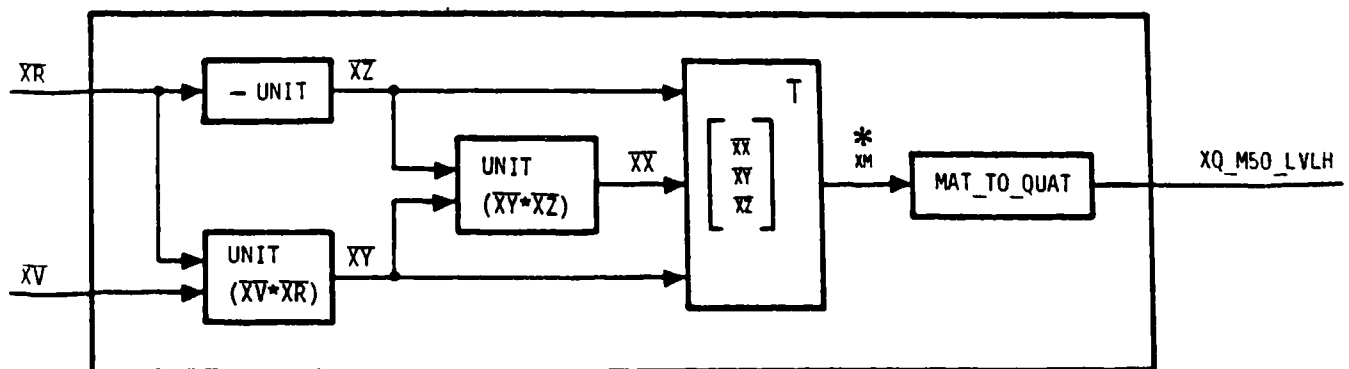


Figure 4.7.17-1. RV_TO_QLVLH

Table 4.7.17-1.. RV_TO_QLVLH Interface Requirements

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Name	Description	Source or Destination	Type	Range	Units	Sample Rate (Hz)
<u>Inputs</u>						
\overline{XR}	Vehicle position in M50	CALLing prog	V		ft	once
\overline{XV}	Vehicle position in M50	CALLing prog	V		ft/s	once
<u>Output</u>						
XQ_M50_LVLH	M50 wrt LVLH quaternion	CALLing prog	Struc: S, V		-	once

4.7.18 QUAT TO EULER

A. Function. QUAT_TO_EULER is a procedure which extracts Euler angles from a quaternion assuming a yaw, pitch, roll rotation sequence. The resulting angles (in degrees), XPSI, XTHETA, XPHI, $|XTHETA| < 90^\circ$, represent the same transformation as the arbitrary quaternion. $\sin(\text{PHI})$, $\cos(\text{PHI})$, $\sin(\text{THETA})$, and $\cos(\text{THETA})$ are also returned for use in ATT PROC and FCS. $|\cos(\text{PHI})|$ is limited to be $\geq 2^{-16}$. For $XTHETA = \pm 90^\circ$, XPHI is arbitrarily chosen to be 0° , and XPSI is extracted so that (XPSI, XTHETA, 0) represents the same attitude as the input quaternion. The CALL to QUAT_TO_EULER is

```
CALL QUAT_TO_EULER (XQ) ASSIGN (XPSI, XTHETA, XPHI, XSINTH,  
XCOSTH, XSINPHI, XCOSPHI)
```

A block diagram of QUAT_TO_EULER is shown in Figure 4.7.18-1.

B. Processing Requirements. The module QUAT_TO_EULER is processed when invoked by a user.

C. Interface Requirements. The interface requirements for QUAT_TO_EULER are given in Table 4.7.18-1.

D. Constants. The constant $\text{DEG_PER_RAD} = 180/\pi$ deg is used.

Numerical constants are chosen based on single precision computation.

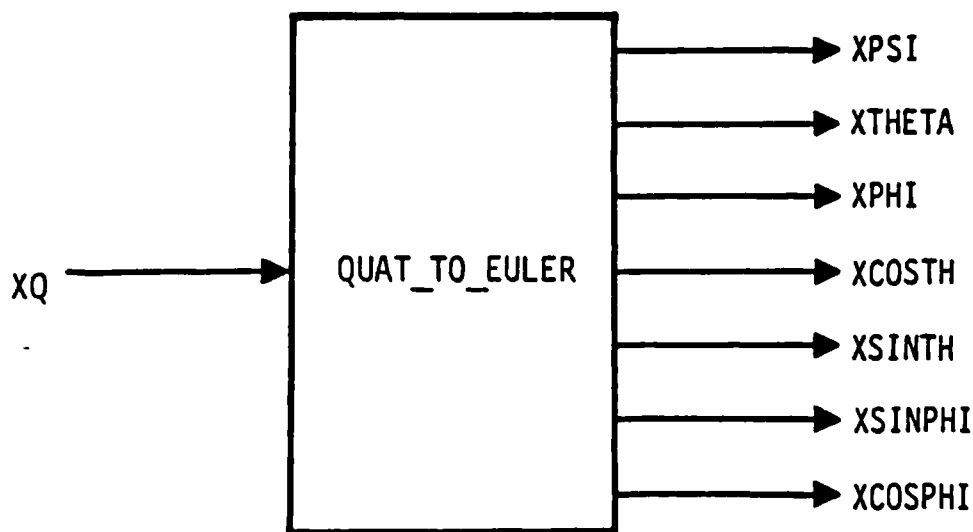


Figure 4.7.18-1. QUAT_TO_EULER

E. Initialization Requirements. There are no initialization requirements for QUAT_TO_EULER.

F. Detailed Technical Description.

$$XSINTH = -2(XQV_1 XQV_3 + XQS XQV_2)$$

$$XCOSTH = \text{SQRT} (1 - XSINTH^2)$$

$$XTHETA = \text{DEG_PER_RAD ARCSIN} (XSINTH)$$

If $XCOSTH \geq 2^{-11}$, then the following steps are performed:

$$DUMMY1 = 2(XQV_2 XQV_3, - XQS XQV_1)$$

$$DUMMY2 = 1 - 2(XQV_1^2 + XQV_2^2)$$

$$XPSI = \text{DEG_PER_RAD ARCTAN2}[2(XQV_1 XQV_2 - XQS XQV_3), \\ (1 - 2(XQV_2^2 + XQV_3^2))]$$

$$XPHI = \text{DEG_PER_RAD ARCTAN2}[DUMMY1, DUMMY2]$$

$$XSINPHI = DUMMY1/XCOSTH$$

$$XCOSPHI = DUMMY2/XCOSTH$$

If $|XCOSPHI| < 2^{-16}$, $XCOSPHI = \text{SIGN} (XCOSPHI) 2^{-16}$

If $XCOSTH < 2^{-11}$, then the following steps are performed

$$XPHI, XSINPHI = 0$$

$$XCOSPHI = 1$$

$$XPSI = \text{DEG_PER_RAD ARCTAN2}[-2(XQV_1 XQV_2 + XQS XQV_3), \\ (1 - 2 (XQV_1^2 + XQV_3^2))]$$

Table 4.7.18-1. QUAT_TO_EULER Interface Requirements

Name	Description	Source or Destination	Type	Range	Units	Sample Rate (Hz)
<u>Input</u>						
XQ	Quaternion to be decomposed	CALLing prog	Struc: S, V		-	once
<u>Outputs</u>						
XPSI	First Euler angle (YAW)	CALLing prog	S		deg	once
XTHETA	Second Euler angle (PITCH)	CALLing prog	S		deg	once
XPHI	Third Euler angle (ROLL)	CALLing prog	S		deg	once
XCOSTH	Cos(XTHETA)	CALLing prog	S		-	once
XSINTH	Sin(XTHETA)	CALLing prog	S		-	once
XSINPHI	Sin(XPHI)	CALLing prog	S		-	once
XCOSPHI	Cos(XPHI)	CALLing prog	S		-	once

4.7.19 QUAT_TO_ADI_ANG

A. Function. QUAT_TO_ADI_ANG is a procedure that extracts sines and cosines of ADI angles (in a pitch, yaw, roll sequence) from an arbitrary quaternion. A flag is returned indicating whether or not PTCH and ROLL functions have been updated. That quaternion represents the rotation of the body frame with respect to the reference frame. The sines and cosines represent the ordered set of angles, PTCH, YAW, ROLL, with $|YAW| \leq \pi/2$. The call to QUAT_TO_ADI_ANG is

```
CALL QUAT_TO_ADI_ANG (XQ) ASSIGN (XPTCHSINE, XPTCHCOS, XYAWSINE,
    XYAWCOS, XROLLSINE, XROLLCOS, XFLAG)
```

where XQ is a structure of a scalar and a vector, $XQ = (XQS, \bar{X}QV)$. It is assumed that XQ is normalized. A block diagram of QUAT_TO_ADI_ANG is given in Figure 4.7.19-1.

B. Processing Requirements. The module QUAT_TO_ADI_ANG is processed when invoked by a user.

C. Interface Requirements. The interface requirements for the module QUAT_TO_ADI_ANG are given in Table 4.7.19-1.

D. Constants. The constant EPSILON = 0.03 is used. EPSILON is the lowest value of YAWCOS for which PTCH and ROLL functions are updated, and is given by COS (88.28).

E. Initialization Requirements. There are no initialization requirements for QUAT_TO_ADI_ANG.

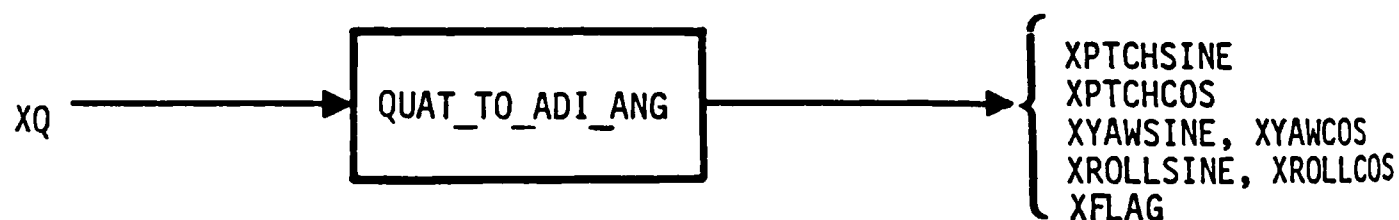


Figure 4.7.19-1. QUAT_TO_ADI_ANG

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Systems Division



F. Detailed Technical Description.

$$XFLAG = ON$$

$$XYAWSINE = 2(XQV_1 XQV_2 - XQS XQV_3)$$

$$XYAWCOS = SQRT (1 - XYAWSINE^2)$$

If XYAWCOS < EPSILON, the PTCH and ROLL functions are not updated on this pass and XFLAG = OFF. If XYAWCOS ≥ EPSILON, the update equations are:

$$XYAWSEC = 1/XYAWCOS$$

$$XROLLSINE = -2 XYAWSEC (XQV_2 XQV_3 + XQS XQV_1)$$

$$XROLLCOS = XYAWSEC (1 - 2(XQV_1^2 + XQV_3^2))$$

$$XPTCHSINE = -2 XYAWSEC (XQV_1 XQV_3 + XQS XQV_2)$$

$$XPTCHCOS = XYAWSEC (1 - 2(XQV_2^2 + XQV_3^2))$$

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Table 4.7.19-1. QUAT_TO_ADI_ANG Interface Requirements

Name	Description	Source or Destination	Type	Range	Units	Sample Rate (Hz)
<u>Input</u>						
XQ	Quaternion to be decomposed	CALLing prog	Struc: S, V	±1	-	once
<u>Outputs</u>						
XPTCHSINE	Sin(PTCH)	CALLing prog	S	±1	-	once
XPTCHCOS	Cos(PTCH)	CALLing prog	S	±1	-	once
XYAWSINE	Sin(YAW)	CALLing prog	S	±1	-	once
KYAWCOS	Cos(YAW)	CALLing prog	S	±1	-	once
XROLLSINE	Sin(ROLL)	CALLing prog	S	±1	-	once
XROLLCOS	Cos(ROLL)	CALLing prog	S	±1	-	once
XFLAG	PTCH, ROLL update flag	CALLing prog	B	0, 1	-	once

4.7.20 Parabolic Shaping and Limiting (PARSHAPE)

A. Function. The detailed block diagram for the module PARSHAPE is presented in Figure 4.7.20-1. The algorithm is simple enough and used infrequently enough to consider for implementing as in-line code (e.g., a macro). The linear, or small-signal, gain is KLIN, The parabolic correction gain is KPAR. An antisymmetric parabolic curve is generated. Output limiting is asymmetric, via the YMIN and YMAX parameters. Note that bang-bang output can be approximated by selected large KLIN and/or KPAR. Note that there are no inherent restrictions on the numerical values for the four parameters (as there are, for example, in certain alternative implementations used in other FSSR's).

B. Processing Requirements. The module PARSHAPE is processed when invoked by the user.

C. Interface Requirements. The interface requirements for PARSHAPE are presented in Table 4.7.20-1.

D. Constants. None.

E. Initialization Requirements. None.

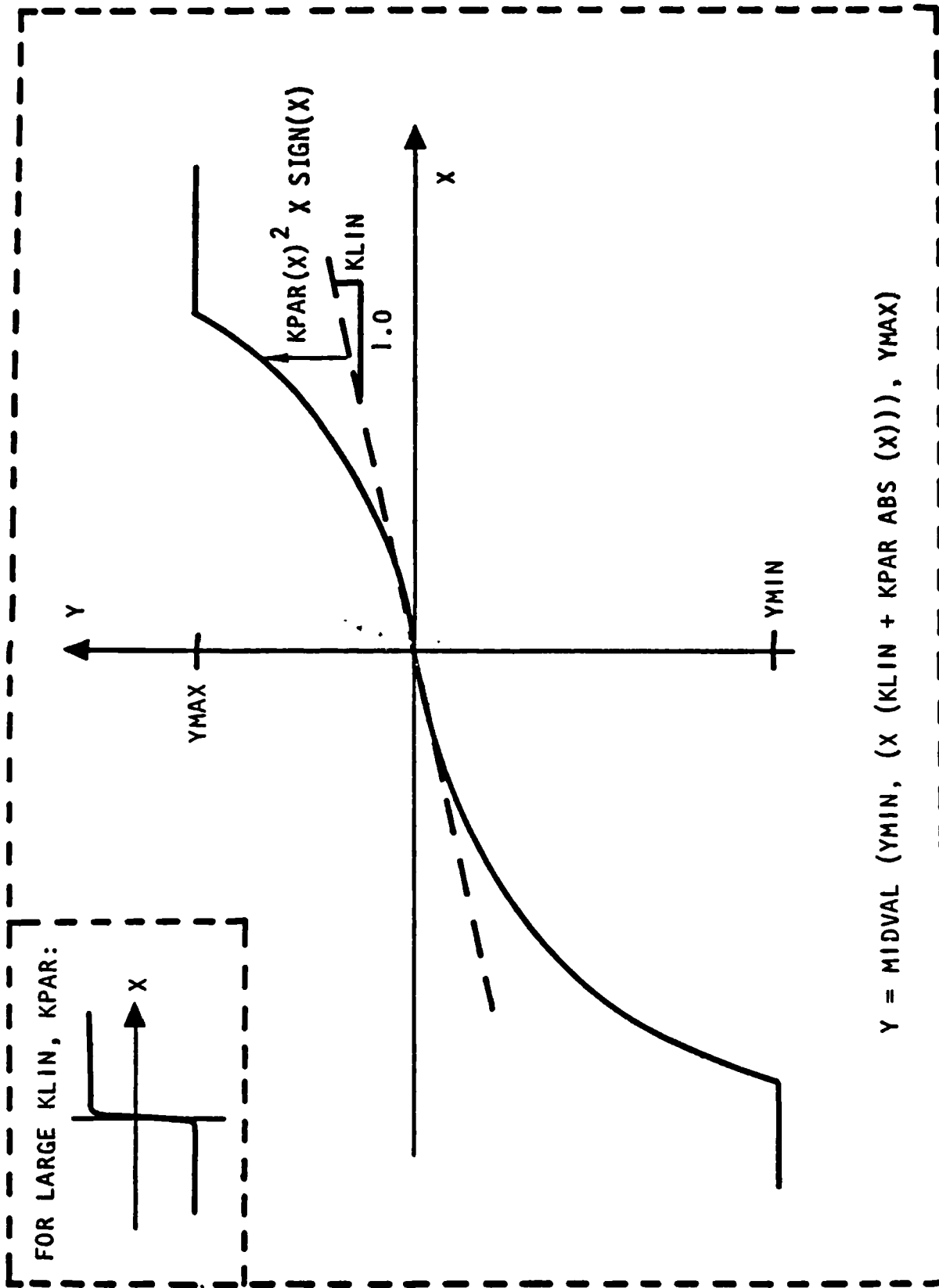


Figure 4.7.20-1. PARSHAPE

Final

Table 4.7.20-1. PARSHAPE Interface Requirements

Name	Description	Source or Destination	Type	Range	Units	Sample Rate (Hz)
<u>Inputs</u>						
X	Input variable	-	S		-	-
KLIN	Linear shaping parameter	-	S		-	-
KPAR	Parabolic shaping parameter	-	S		-	-
YMIN	Output lower limit parameter	-	S		-	-
YMAX	Output upper limit parameters	-	S		-	-
<u>Outputs</u>						
Y	Output variable	-	S		-	-

Figure 4.7.20-1. PARSHAPE

4.7.21 LIMITED_INTEGRATOR

A. Functional Description. A functional block diagram for the module LIMITED_INTEGRATOR is shown in Figure 4.7.21-1. LIMITED_INTEGRATOR is a rectangular rule digital representation of an integrator. Amplitude limiting is provided to keep the output from going beyond specified limits.

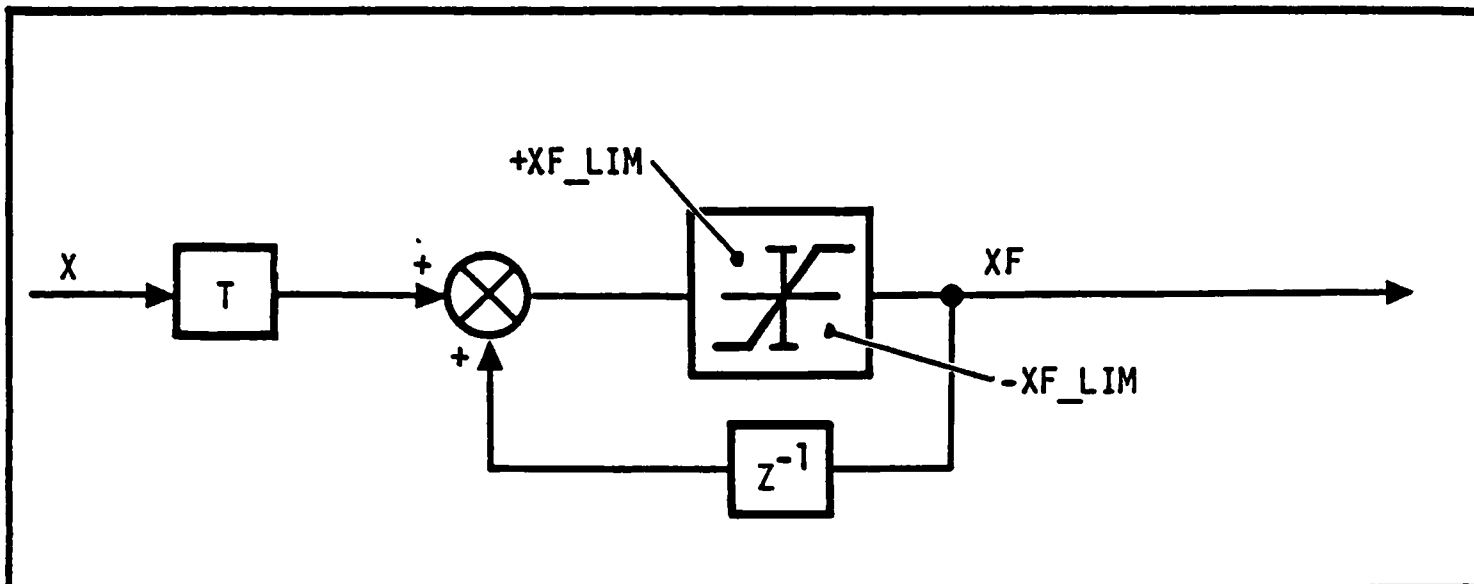


Figure 4.7.21-1. Integrator (GRTLS)

B. Software Description. The software description for LIMITED_INTEGRATOR is given by the statement

$$XF = \text{MIDVAL}(-XF_LIM, XF + X T, XF_LIM)$$

The interface requirements and initialization requirements for LIMITED_INTEGRATOR are presented in Tables 4.7.21-1 and 4.7.21-2, respectively.

Table 4.7.21-1. LIMITED_INTEGRATOR Interface Requirements

Name	Description	Source or Destination	Type	Range	Units	Rate Required/Produced (Hz)
<u>Inputs</u>						
X	Input		S		-	-
T	Update period		S		s ⁻¹	-
XF_LIN	Limit value for output		S		-	-
XF	Past value of output		S		-	-
<u>Output</u>						
XF	Output		S		-	-

Table 4.7.21-2. LIMITED_INTEGRATOR Initialization Requirements
(Performed by Invoker)

Component	Initialize on Transition		Variable	Initial Value
	From	To		
LIMITED_INTEGRATOR	-	First pass	XF	As required

4.1 TIMING, SEQUENCING, AND INITIALIZATION REQUIREMENTS

IDENTIFICATION NUMBER SE-694D DOCUMENT NUMBER STS83-0008

TITLE FUNCTIONAL SUBSYSTEM SOFTWARE REQUIREMENTS FLIGHT CONTROL ASCENT

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