

## SUBSTATION CONTROL AND PROTECTION PHILOSOPHY

Revision date = July 19, 2015 -- INCOMPLETE!!!

### (1) TOPOLOGY

(1.1) All circuit breakers in the substation will be re-configurable by means of banana-style plugs and jacks used to connect 3-phase power conductors. This will allow each substation to be a new educational challenge for different student groups.

(1.2) At least one transmission line will connect the Nooksack (north lab) and Stevens (south lab) substations together.

### (2) BREAKER CONTROL

(2.1) Each circuit breaker will have its own dedicated manual control switch.

(2.1.1) Terminals 21 and 28 on the manual breaker control switch will be used for the normally-open "trip" contact.

(2.1.2) Terminals 12 and 13 on the manual breaker control switch will be used for the normally-open "close" contact.

(2.1.3) Orange-colored wire will identify manual switch control signals to circuit breakers.

(2.2) Each circuit breaker may also be controlled via the SCADA network, with a PLC signaling it to trip or close. This SCADA control function may be enabled and disabled by means of a selector switch mounted near the respective manual control switch.

(2.2.1) Yellow-colored wire will identify PLC discrete output signals to circuit breakers.

(2.3) Protective relays will also be wired to circuit breakers for trip (and potentially) close control capability.

(2.3.1) Violet-colored wire will identify protective relay output signals.

### (3) SCADA SYSTEM

(3.1) A SCADA (Supervisory Control and Data Acquisition) system consisting of networked PLCs (Programmable Logic Controllers) and at least one central HMI (Human-Machine Interface) touch-screen panel will display the status of all generating stations and circuit breakers in the system.

### (4) PROTECTION

(4.1) All protective relaying will be re-configurable in each substation, to allow for educational challenges year after year.

(4.2) All substation busses will be equipped with differential current (87) protection.

(4.3) All transformers will be equipped with differential current (87)

protection.

(4.4) Feeder lines may be equipped with overcurrent (50/51) protection.

(4.5) Transmission lines may be equipped with differential line current (87) protection if suitable relays exist.

(4.6) A lockout relay (86) will be exist to simultaneously trip all substation circuit breakers. For single-bus topology, this 86 relay will be tripped by the bus differential current (87) relay.