

2 Description of a Relay Supervisory System

A Relay Supervisory System (RSS) supervises the existing protective relay system at a substation to increase security and prevent hidden failures from creating cascading contingency conditions. Reference [3] describes a Hidden Failure Monitoring and Control System (HFMCS) that supervises only the relays with a high vulnerability index. The HFMCS therefore increase security for some relays at a substation. The device described here supervises all relays at a substation, not just the critical or highly vulnerable.

The RSS has two operating modes to increase security. The normal operating mode performs very much like the HFMCS. However, the RSS supervises every relay at the substation that has a hidden failure mode. The other operating mode is an emergency operating mode. In this mode the RSS adapts the existing protective relay system to adjust the security and dependability balance. It accomplishes this by combining relay outputs in logical connections to have the relays "vote", so a majority of protective schemes for a device must operate for the device to trip.

The RSS works passively in conjunction with the existing relay system, in the sense that

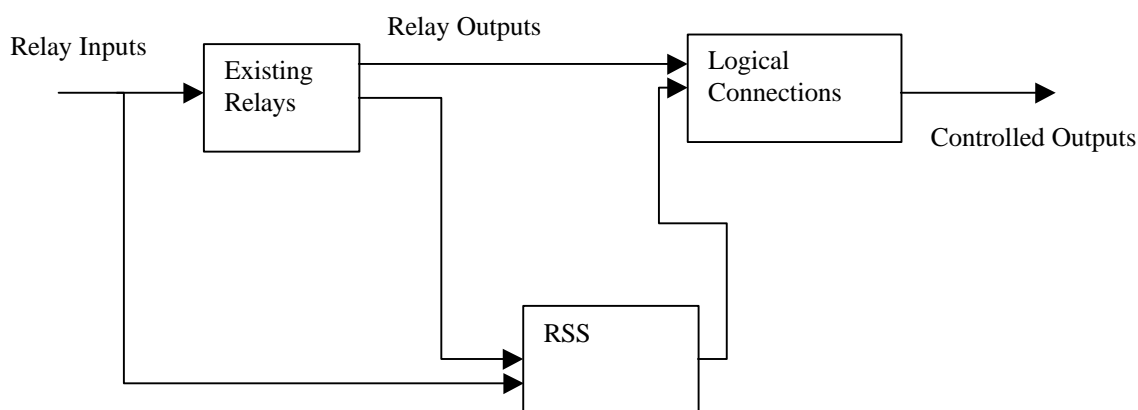


Figure 3: Protection System Schematic

it only samples and stores waveforms until receiving a trip signal from an existing relay. The RSS samples and stores voltage and current from each device to be monitored. Just as in a computer relay, these signals run through an anti-aliasing filter and A/D converter. Another input to the RSS is trip signals from the existing relays, supplied by an auxiliary contact from the relay. It is this signal that triggers the RSS into action. As an output, the RSS controls contacts in series with the circuit breaker trip coils, thereby controlling circuit breaker operation. The RSS does not receive or transmit carrier signals. This means the RSS can only control relays at the local end. Any hidden failures at the local end that result in mis-operations at the remote end are not supervised.

2.1 Normal Operating Mode

During the RSS "Normal" mode, the RSS supervises relays to prevent device operations due to a hidden failure. When an existing relay operates for a fault, the auxiliary contact triggers the RSS. The RSS takes the stored voltage and current samples for this device, and duplicates

the relay fault calculation. If this calculation indicates a fault, the line is permitted to trip. Otherwise, the RSS blocks the trip, under the assumption the relay has mis-operated.

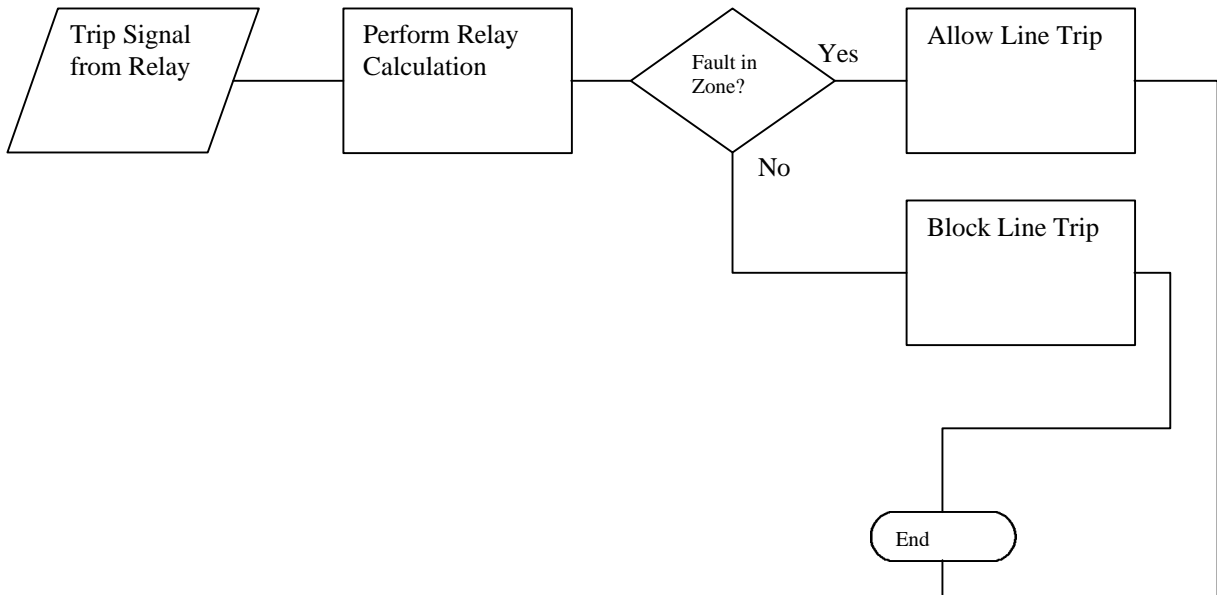


Figure 4: Hidden Failure Schematic

2.2 Emergency Operating Mode

The RSS adapts the relay system security and dependability balance to increase security while in emergency operations mode. The system is adapted to a "vote" logic scheme requiring a majority of protection schemes for a protected device to operate before the device can be removed from service. This "vote" scheme can be permanently implemented in the existing system by wiring the output contacts together. Using a computer to perform the vote allows this system to change back and forth between modes. This mode of operation protects against false trips and relay hidden failures. For this mode to function, the supervised device must have at least three levels of protection. This is a "dumb" adaptive mode, requiring a command from the

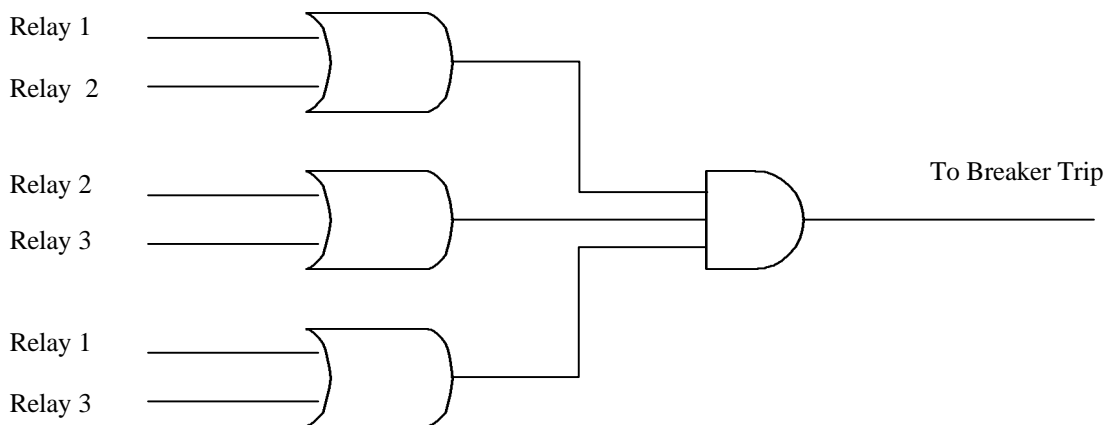


Figure 5: Vote Schematic

system operator to switch over to adaptive mode. This requires the box to have communications ability. Emergency situations generally are wide area network disturbances, where tripping a line inadvertently may have disastrous effects on the power system.

There is a difference in philosophy between the normal mode and the emergency mode. Normal mode attempts to maintain the existing level of dependability, while increasing protection against hidden failures. Emergency mode lowers the level of dependability to maximize security. During an emergency operating situation, such as a wide area network disturbance, it may be acceptable to keep a device in service for some extreme overload conditions.

2.3 Out of Service Mode

The RSS does have another operational mode, the Out of Service mode. The RSS closes all the breaker trip contacts when it is out of service, returning the protection system to the normal mode of operation without the RSS.. The box may be out of service for maintenance, turned off on command from the system operator, or take itself out when it fails a self-test.