Recommended Vital Circuit Design Guidelines for Relay Based Systems

Revised 2025 (5 Pages)

A. Purpose

This Manual Part recommends vital circuit design guidelines based on fail-safe principles and practices for the design of relay-based signal systems. The philosophy for fail-safe design is defined in Manual Part 17.1.1 Definition of Terms Used in Manual Parts Contained in Section 17.

B. General

1. The vital circuit design guidelines provided in this Manual Part shall also apply to equivalent vital electronic and/or software applications.

2. Vital circuits are designed based on the closed loop principle. This concept is discussed in each of the following applications:

    a. Track circuits are normally energized. A broken wire, loss of track circuit feed energy, shorted switch rod, or a short across the rails will cause the track circuit to de-energize. A broken rail condition should be detected to the maximum extent practicable.

    b. Lock relays are normally energized to allow a switch, derail, or movable bridge to unlock. Under normal operation, if a signal is cleared or the track circuit is occupied, the lock relay will de-energize and prevent the device from changing its current position. These relays are energized so that a broken wire or any other condition which causes the approach stick relay or the track relay to de-energize will also lock the device to prevent its movement.

    c. Route locking stick relays are used to lock switches, derails and routes. When a route is lined, the route stick relay de-energizes in order to lock the route. These relays are normally energized so that a broken wire or other condition that causes the approach stick relay to de-energize will cause the route locking stick relay to also de-energize and lock the route.

    d. Approach stick relays are used to lock switches, derails and routes and, therefore, are also normally energized. The timer relays associated with these relays are usually de-energized, since they are designed to energize after a preset safety time expires. Failure to energize keeps the route locked. When mechanical timers are used, a check contact in the circuitry ensures that the full-time interval runs for each operation.

    e. Relays that repeat the stop position of a signal are normally energized. A broken wire will cause the system to assume that a signal is displaying an aspect other than stop and will lock any switches in the route and prevent any conflicting signals from clearing.

f. Line circuits are normally energized. A broken wire or short circuit will cause the line circuits to de-energize.

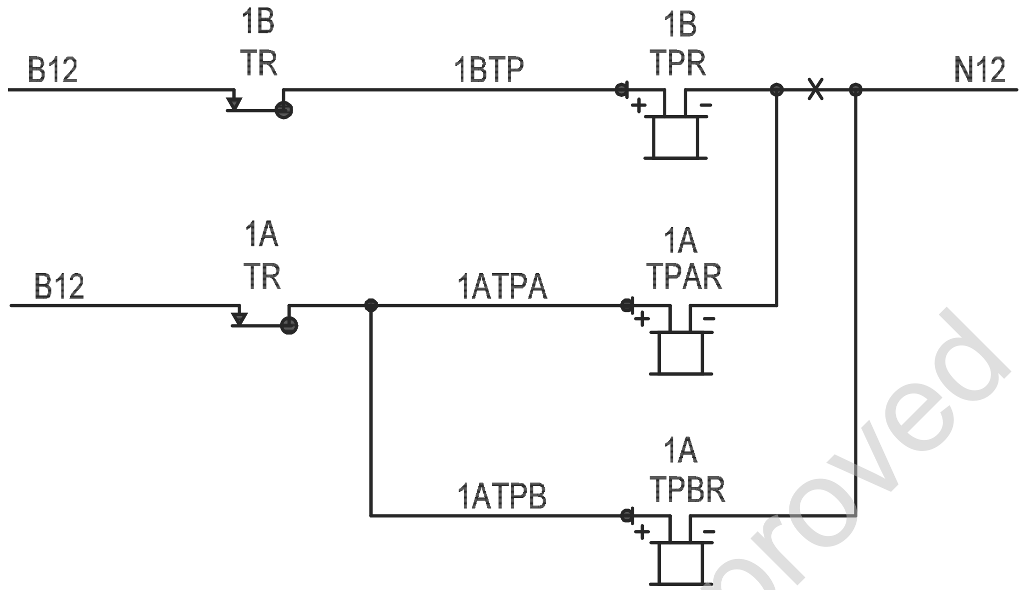
g. Relays that repeat the position of a switch, movable point frog or derail are normally energized before allowing a signal to be cleared over them. If a wire breaks, the relay will de-energize and prevent any signal from being cleared over the switch, movable point frog or derail.

h. Certain relays are used to allow signals to clear even though a track may be occupied. These relays are normally de-energized and only become energized when conditions are acceptable for clearing a signal into an occupied track. Examples of such relays are directional stick relays at automatic signals, follow stick relays and engine return stick relays. When these circuits are used, back contact checks of the stick relays shall be placed in the circuits for opposing routes.

i. Route check relays and home relays for interlocking signals are normally de-energized except when a signal is to be cleared for a train movement.

3. Whenever there are not enough contacts in a relay for all of the circuits that must check the position of that relay, repeater relays are used. The contacts that are to be used in the various circuits should be chosen carefully and timing of relay operation should be considered. In order to maintain the fail-safe concept, a contact of the original relay should be used in certain circuits rather than a contact of a repeater relay and vice versa.

a. When more than one repeater relay is required for any one original relay, the repeaters shall not be connected in multiple. The first repeater shall be a direct repeater of the original relay; the second repeater shall be a direct repeater of the first, and so on. When repeater coils are connected in multiple, it is possible that one or more repeater relays could be falsely energized in case of a broken wire. See Figure 1631-1.



A BROKEN WIRE AT THE LOCATION MARKED BY THE "X" COULD ALLOW A BACK FEED, WHICH WOULD ALLOW BOTH THE 1ATPAR AND THE 1ATPBR TO ENERGIZE WHEN THE 1BTR IS ENERGIZED.

Figure 1631-1: Example of Broken Wire

b. The track repeater relay used in approach stick relay circuits should be the same relay that is used in home relay circuits. If not, then the first repeater relay shall be used in the approach stick relay circuit and the last one in the home relay circuit. This is to ensure that approach or time locking will be effective before a signal can be cleared for train movement.

c. In home relay circuits, use back contacts of the approach stick relay, the last route locking relay involved in the route, and the lock relay rather than repeaters of these relays. This is to ensure that locking is effective even if an open circuit causes its corresponding repeater relay to de-energize.

d. In route check relay circuits use the normal switch correspondence relay and the reverse switch correspondence relay or the first repeater of them to ensure that if any of the repeaters of the correspondence relays are falsely energized no signal can be displayed.

e. In home relay circuits use the last repeaters of normal switch correspondence relays and reverse switch correspondence relays.

f. Cross-checking switch correspondence repeater relays by having the normal switch correspondence relay check the back contacts of all of the reverse switch correspondence repeater relays and the reverse switch correspondence relay check the back contacts of all of the normal switch correspondence repeater relays should not be done. For example, a reverse switch correspondence relay or a repeater of it that was falsely energized would cause all of the normal switch correspondence repeater relays to drop and the signal might be displayed over the wrong route.

g. An inverse repeater relay is one that is energized through a back contact of another relay. Insertion of inverse repeater contacts in vital circuits shall be restricted. It should be noted that if the primary relay fails to energize or de-energizes, then the inverse repeater relay will remain energized or will falsely energize.

h. Indication circuits should use the last repeater so that any failure will be indicated to the control location(s).

4. All circuits leaving the housing shall be "double break" from the first time the circuit leaves the housing until it reaches the positive and negative energy busses. See Figure 1631-2.

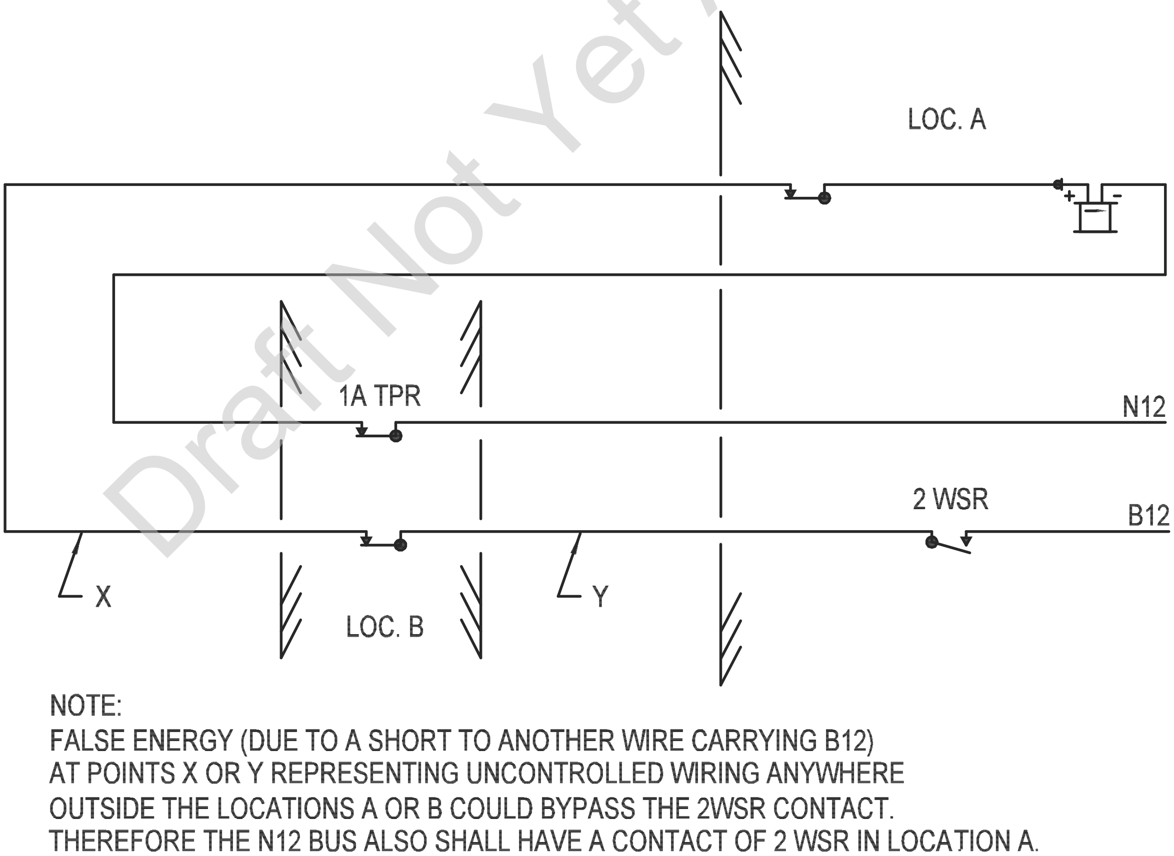


Figure 1631-2: Example of False Energy

5. Diodes shall not be used to separate vital circuits where their failure (opening or shorting) could cause an unsafe condition. Instead, separate relay contacts should be used in each circuit.

6. External devices, such as resistors, diodes, or capacitors, shall not be used for making relays slow release where their failure could cause an unsafe condition. Slow release relays using a fail-safe mechanism, such as copper or aluminum slugs in the magnetic path, shall be used.

7. Non-vital relay contacts should not be used in the middle of any vital circuits, as they may cause false energy to be applied at that location in the circuit. When used, they shall be placed at the energy end of the circuit so that bridging of contacts will only remove the non-vital break from the circuit.