Electric utility customers are increasingly concerned about the frequency and duration of outages they are experiencing and are demanding more reliable service. S&C recognizes this need and now offers a pre-engineered High-Speed Fault-Clearing System featuring specially configured Remote Supervisory Vista Underground Distribution Switchgear. See Figure 1. This unique, field-proven solution does not require—but fully supports—SCADA integration.

The system can be applied in either a closed-loop or open-loop configuration. In either case, the system will enable a backbone feeder fault to be cleared in six cycles or less.

Figure 1. Remote Supervisory Vista Underground Switchgear.

The Vista switchgear fault-interrupter ways associated with the backbone feeder are each equipped with a Schweitzer Engineering Laboratories 351 Relay. An SEL-351 Relay is also required for each substation circuit breaker feeding the loop of Vista switchgear units. Each relay is configured to communicate with the other relays through a fiber-optic cable network. Relays use the established transmission relaying concepts of Permissive Overreaching Transfer Trip (POTT) and Directional Comparison Blocking (DCB) to ensure only the fault interrupters on either side of a faulted backbone cable section open.

Each SEL-351 Relay is capable of functioning as a remote terminal unit. The SEL-351 Relays can communicate with a SCADA master station via DNP 3.0 protocol, if desired. See Figure 2. Other protocols may be supported as well.

Figure 2. SEL-351 Relays housed in the low-voltage compartment of Vista Underground Distribution System.

Closed-loop applications usually require both ends of the loop to be fed from the same substation bus. With this configuration, load will not be lost while the fault is being cleared—although some customers will experience a voltage dip.

Open-loop applications require an open switching point in the loop. This approach enables two feeders from different substations to be interconnected. However, with this configuration, some customers may experience a three-to-four-second loss of voltage while the normally open switch is closed.

The High-Speed Fault-Clearing System thus eliminates (when utilizing the closed-loop configuration) or minimizes (when utilizing the open-loop configuration) the number of customers experiencing an outage due to a cable fault, because substation circuit breakers are not required to operate to clear a fault within the loop. Open-loop applications can be converted to the closed-loop configuration at any time.

Involvement by S&C's Power Systems Solutions is strongly recommended as the feasibility of this approach may require a system review, load studies, and/or fault calculations. S&C's Power Systems Solutions can provide complete turnkey project services if desired.

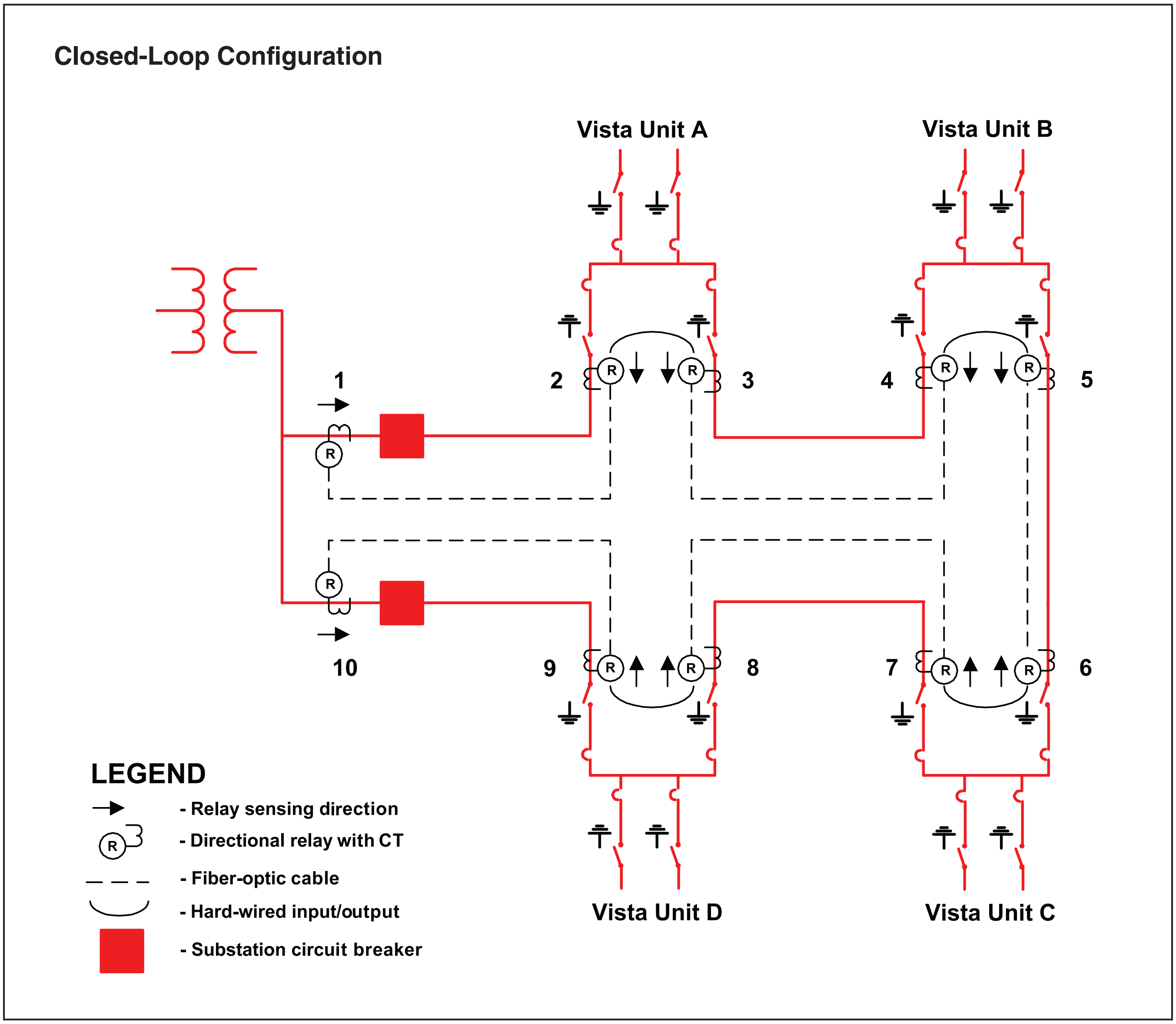

Figure 3. Closed-loop configuration on a Normal operation.

Normal Operation

In Figure 3, four Vista switchgear units are used, each furnished with four fault interrupter ways. The ways associated with the backbone feeder are furnished with 600-ampere bushings. The ways serving the loads are furnished with 200-ampere bushing wells.

Directional relays, which can determine the direction of flow of fault current, are provided on the ways associated with the backbone feeder. Pairs of relays communicate with each other by means of fiber-optic cable.

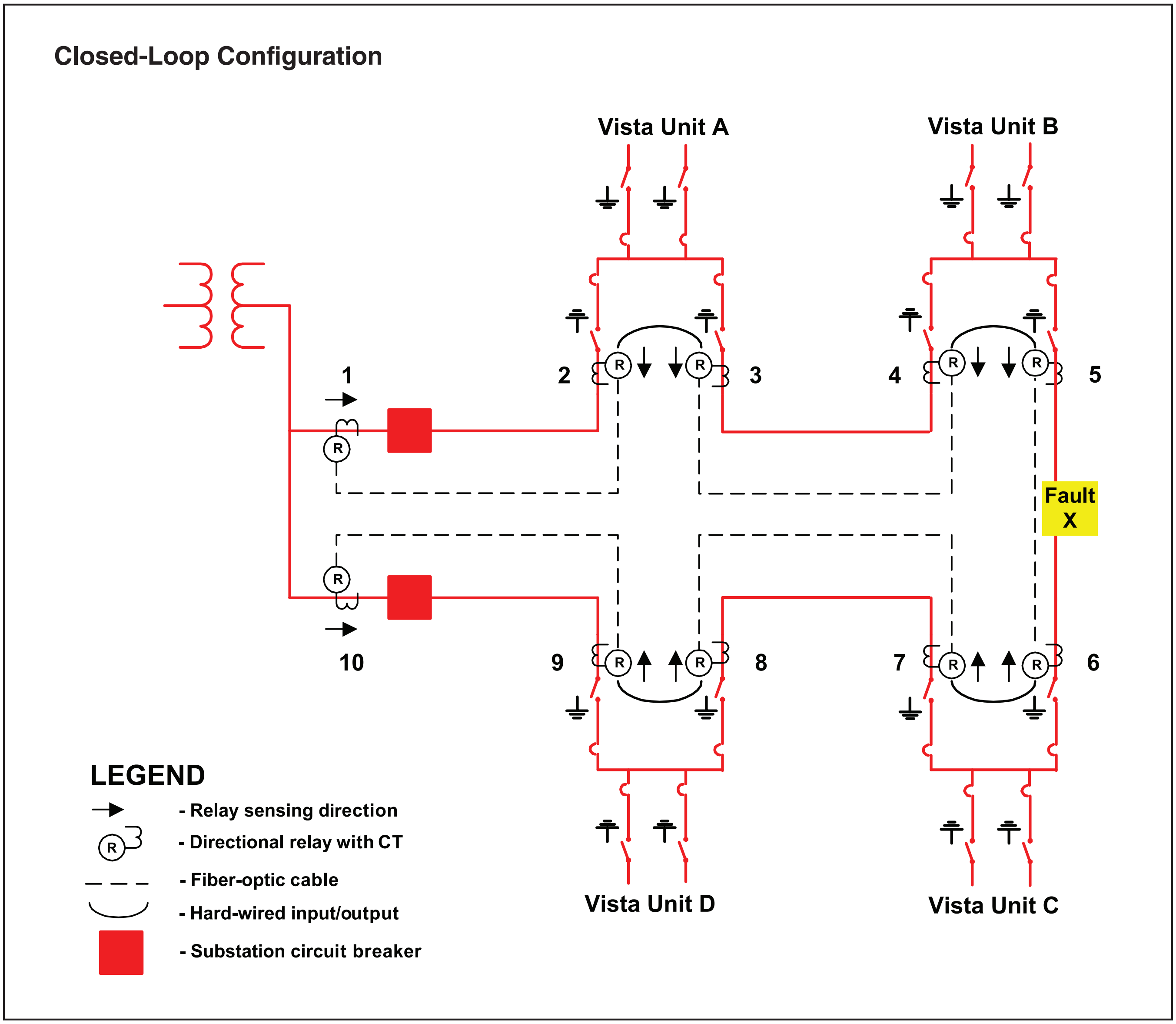

Figure 4. Closed-loop configuration with a Fault condition.

Fault Condition

If a fault occurs, current will flow to the fault through both substation circuit breakers. See Figure 4.

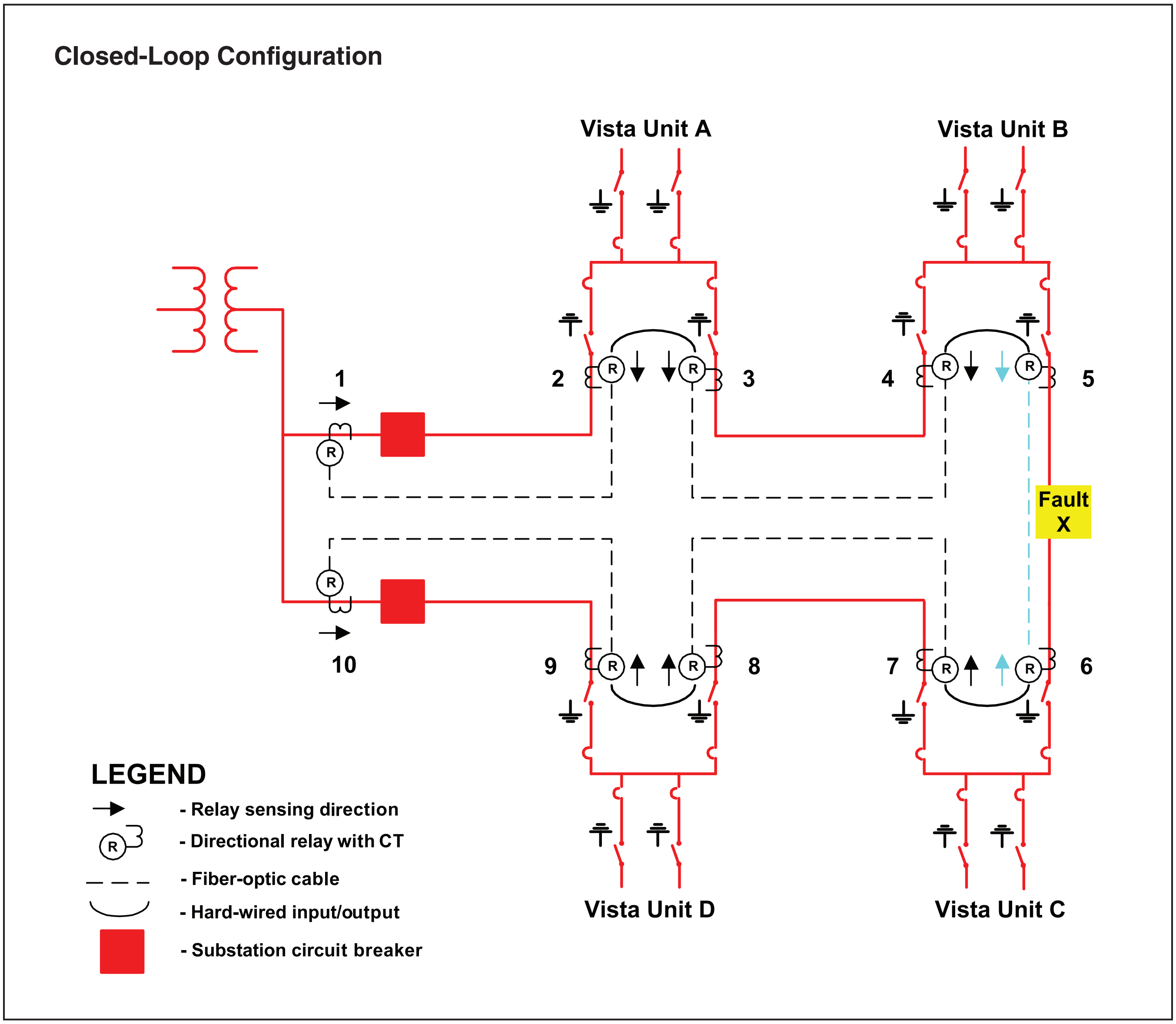

Figure 5. Relays transmitting a fault-detected communication in a closed-loop configuration.

Fault Communication

In Figure 5, Relays 5 and 6 are at either end of the faulted cable section. Each relay detects fault current flowing in the direction of its respective arrow and sends a "forward fault detected" logic signal, via the fiber-optic connection, to the other, indicating a fault has been detected which must be interrupted and isolated.

Although relays associated with unfaulted cable sections also detect fault current, the criteria for tripping is not met. For example, Relay 8 detects fault current flowing in the direction of its arrow. But Relay 7 senses fault current flowing opposite to the direction of its arrow. Thus, the information communicated between these two relays indicates no fault exists between them.

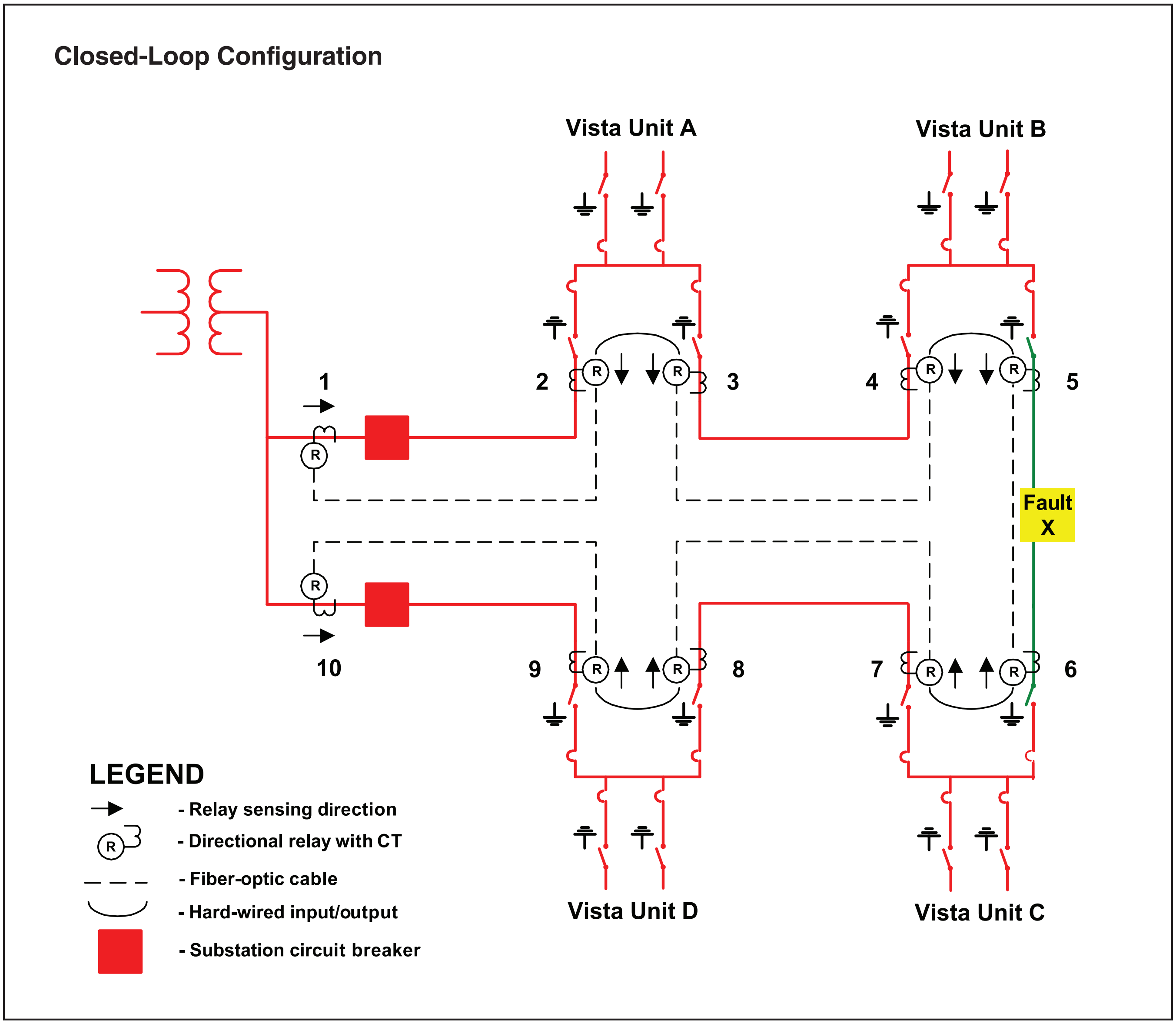

Figure 6. Isolating a fault in a closed-loop configuration.

Fault Isolation

In Figure 6, Relays 5 and 6—each having sensed fault current flowing in the direction of its respective arrow and knowing that its partner has sensed fault current flowing in the direction of its respective arrow—conclude that the faulted cabled section is between them, and trip their respective fault interrupters. The faulted cable section is de-energized but service to the loads served by Vista switchgear units B and C remains uninterrupted.

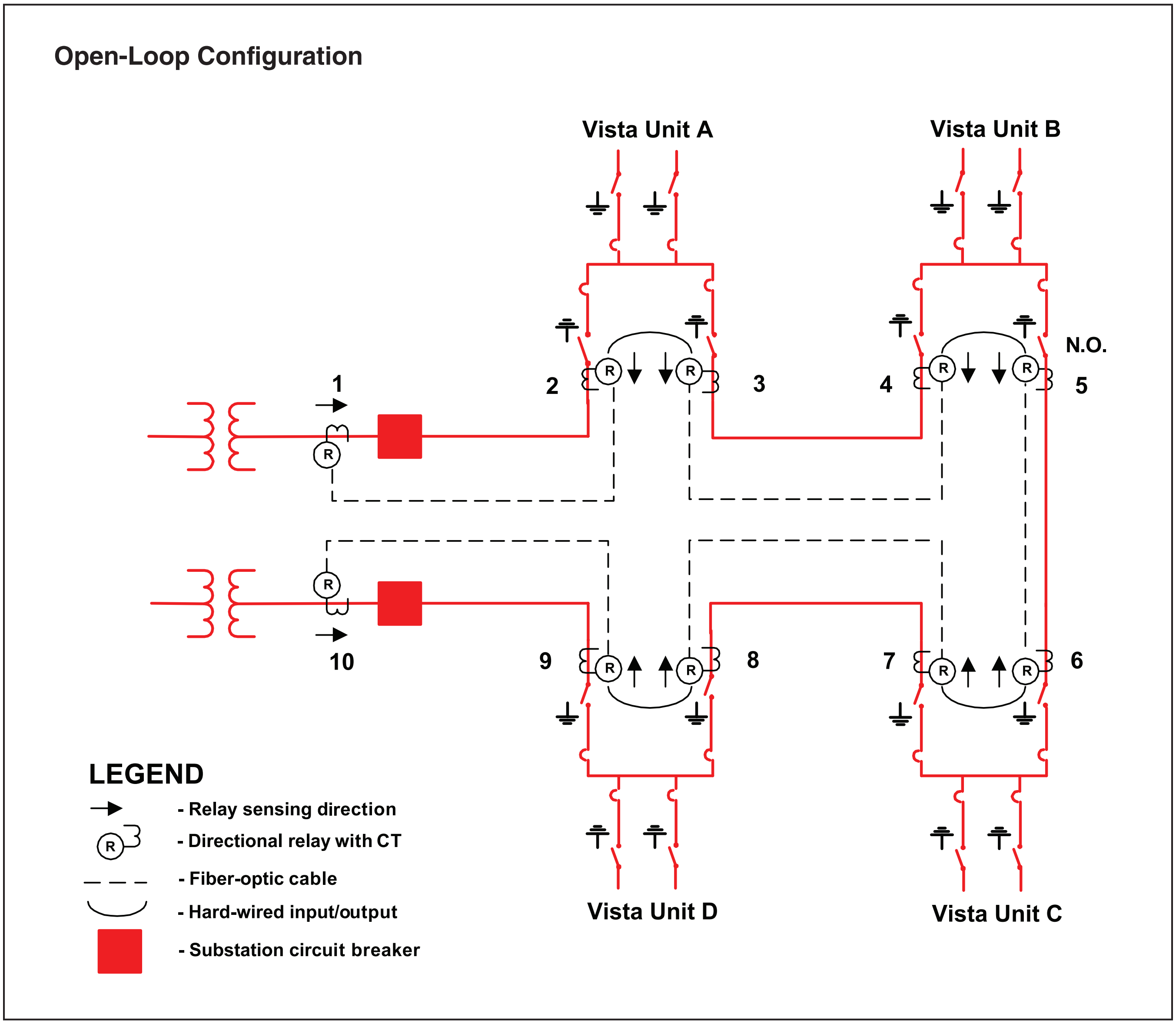

Figure 7. Open-loop configuration on a Normal operation.

Normal Operation

In Figure 7, four Vista switchgear units are used, each furnished with four fault interrupter ways. The ways associated with the backbone feeder are furnished with 600-ampere bushings. The ways serving the loads are furnished with 200-ampere bushing wells.

One of the backbone feeder ways—on Vista Unit B—is normally open, so each feeder serves a portion of the loop.

Directional relays, which can determine the direction of flow of fault current, are provided on the ways associated with the backbone feeder. Pairs of relays communicate with each other by means of fiber-optic cable.

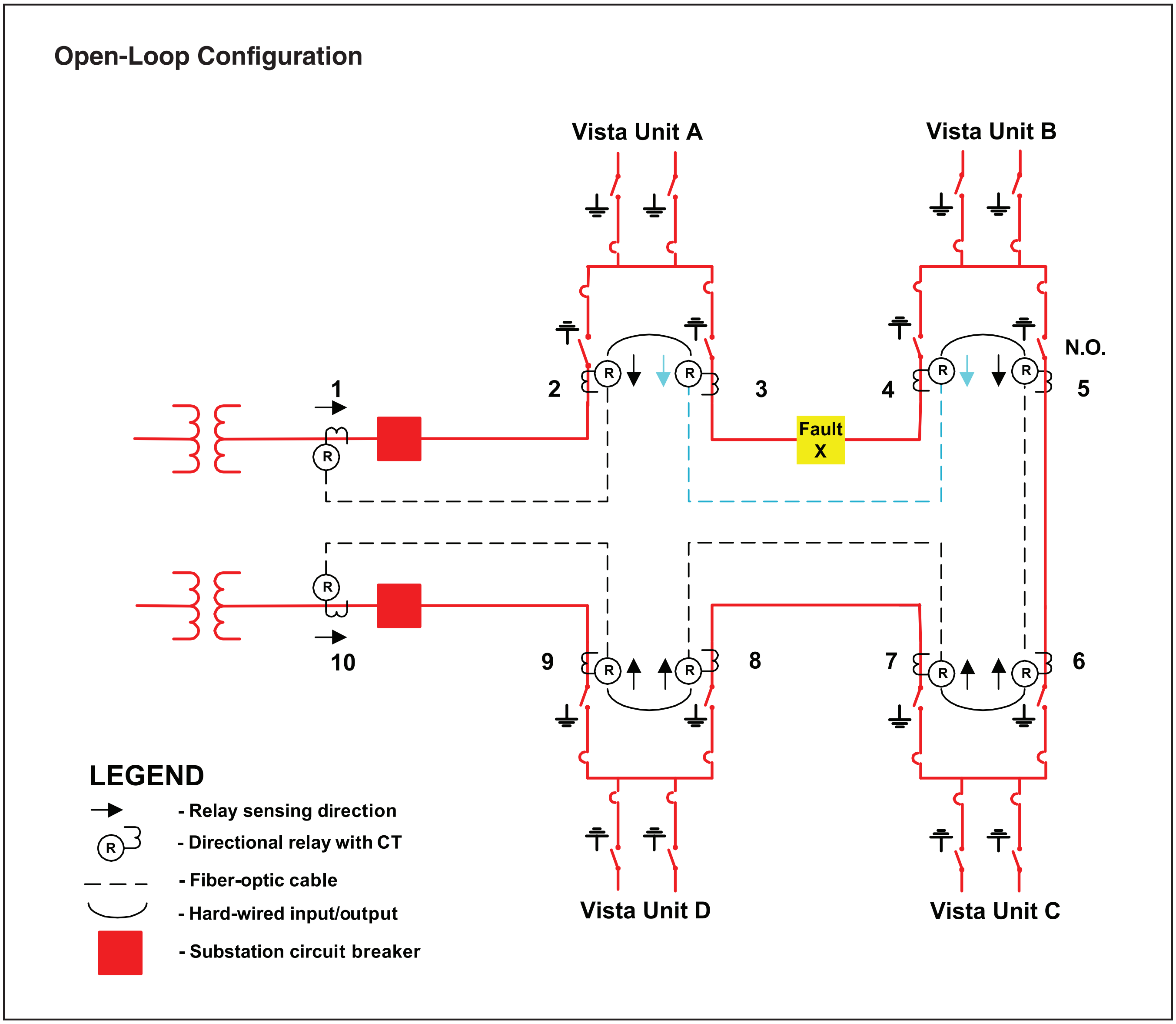

Figure 8. Open-loop configuration with a Fault condition.

Fault Condition

If a fault occurs, current will flow to the fault through its respective substation circuit breaker. See Figure 8.

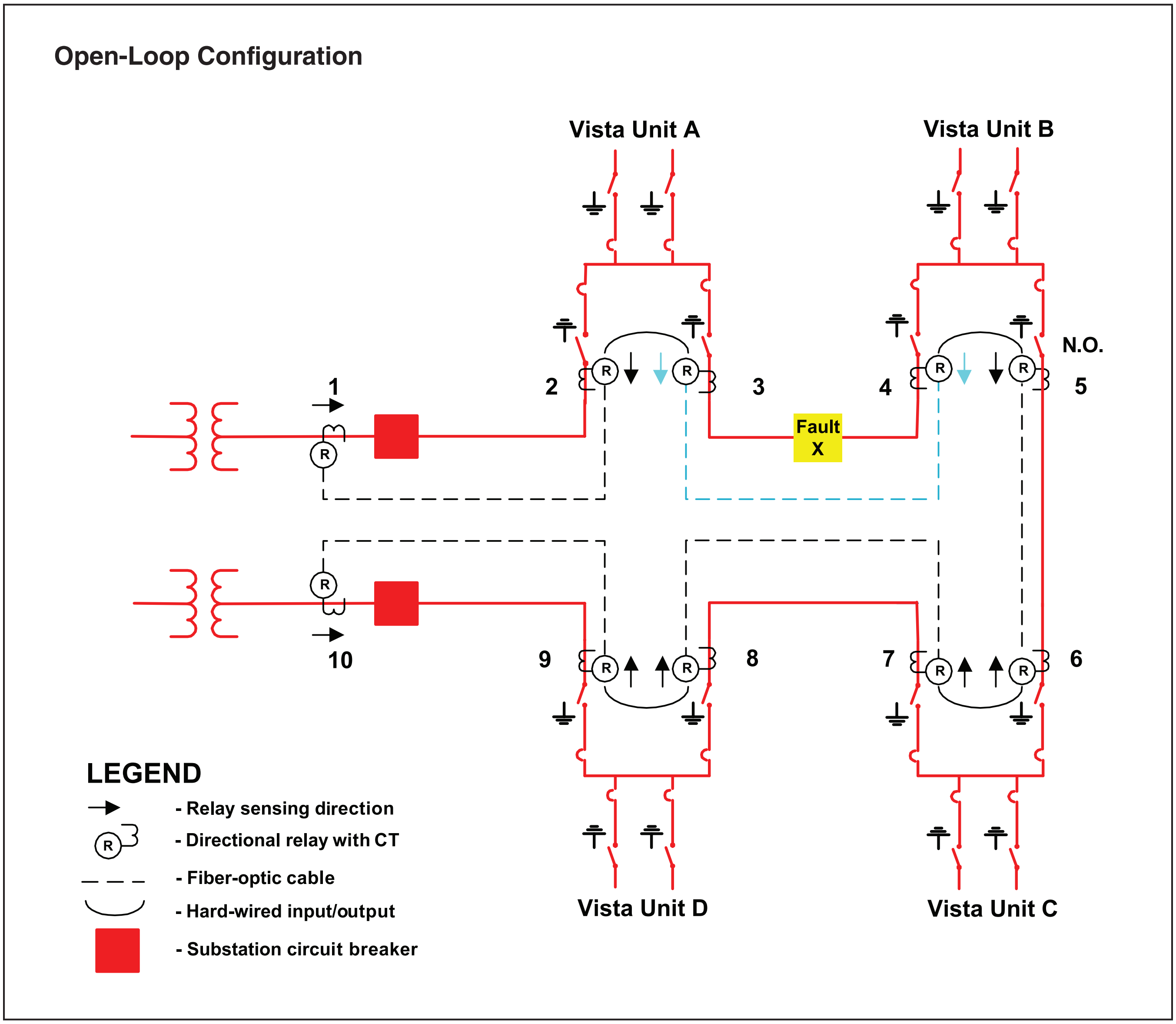

Figure 9. Relays transmitting a fault-detected communication in an open-loop configuration.

Fault Communication

In Figure 9, Relays 3 and 4 are at either end of the faulted cable section. Relay 3 detects fault current flowing in the direction of its respective arrow and sends a "forward fault detected" logic signal via fiber-optic connection to Relay 4, indicating a fault has been detected that must be interrupted and isolated.

However, Relay 4 *does not* detect fault current flowing in the direction of its respective arrow and hence *does not* send a corresponding "forward fault detected" logic signal to Relay 3.

Relay 3 waits two cycles for a "reverse fault detected" *blocking* logic signal from Relay 4, indicating the fault resides beyond the cable section protected by Relay 4.

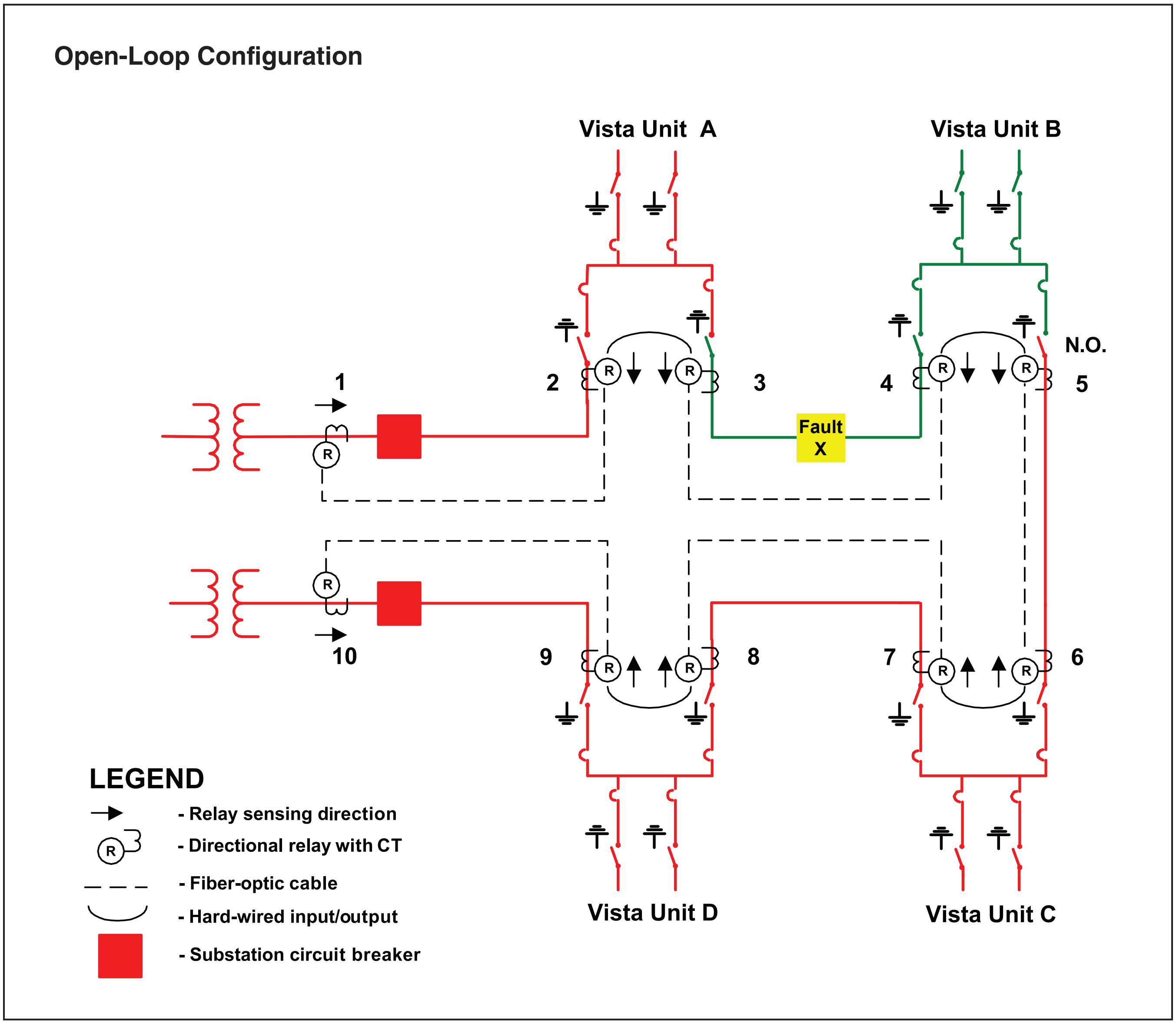

Figure 10. Isolating a fault in an open-loop configuration.

Fault Isolation

After waiting two cycles, Relay 3 trips its respective fault interrupter and transfer-trips the fault interrupter of Vista switchgear unit B associated with Relay 4. See Figure 10. The faulted cable section is de-energized.

Service to the loads served by Vista switchgear unit B is interrupted.

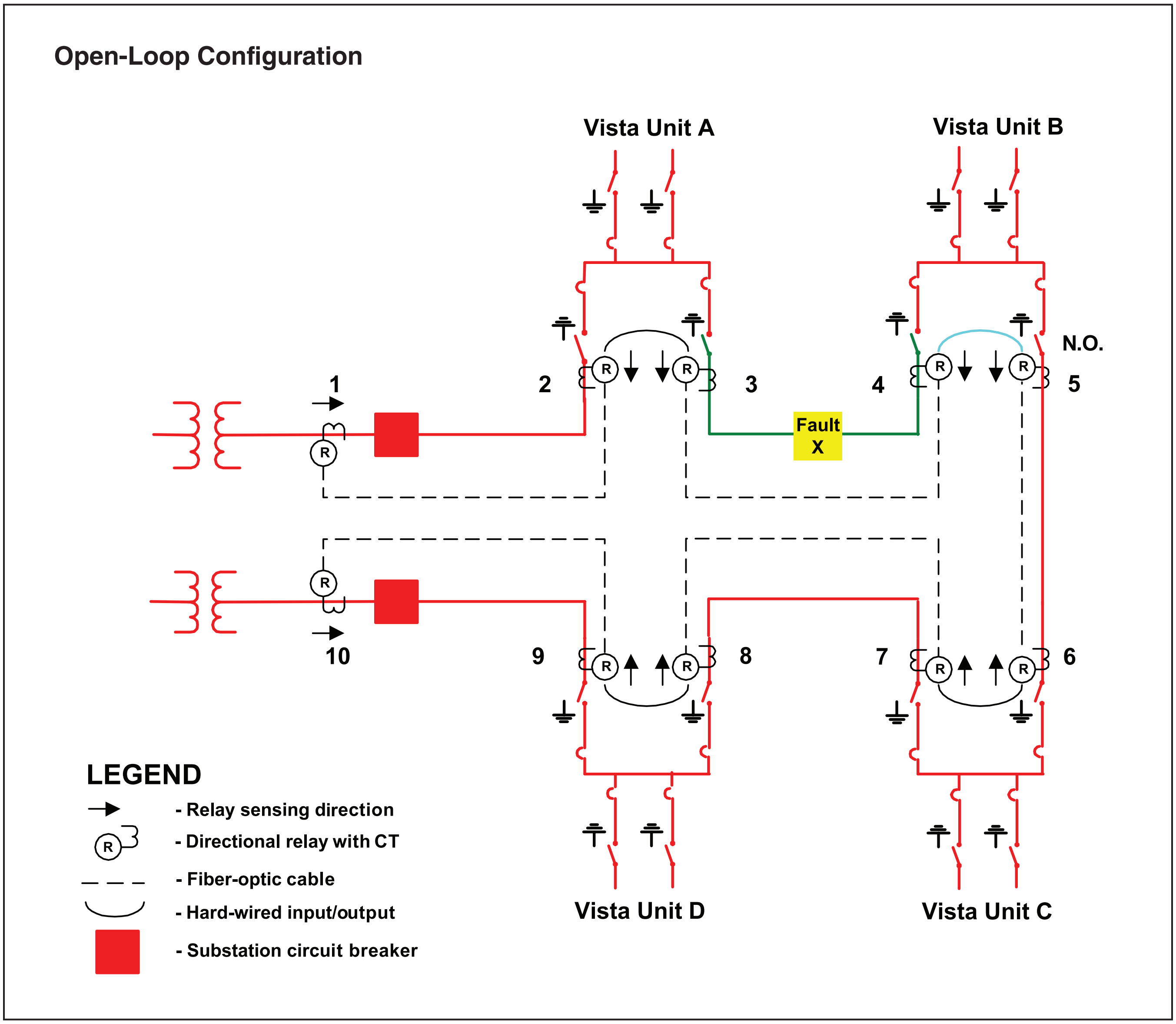

Figure 11. Load restoration in an open-loop configuration.

Load Restoration

In Figure 11, Relay 5 has not sensed fault current flowing in the direction of its arrow. However, Relay 4 signals Relay 5 that it has isolated a fault.

Based on this sequence of events, Relay 5 sends a signal to its respective fault interrupter to close. After three to four seconds, service to the loads served by Vista switchgear unit B is restored from the other end of the loop.