TESTING AN FPU-32 FEEDER PROTECTION UNIT

SE-400 Ground-Fault-Relay Test Unit

The SE-400 is an ac current source with a programmable output. The magnitude and duration of the output burst can be selected with front-panel thumbwheel switches so that ground-fault trip levels and trip times can be confirmed at the push of a button. A two-digit LED display indicates the magnitude of the output current for the duration of the output burst.

SE-410 Selector Switch

The SE-410 is a selector switch for use with a SE-400 or SE-100T Ground-Fault-Relay Test Unit. It allows up to ten ground-fault circuits to be individually tested with one ground-fault-relay test unit.

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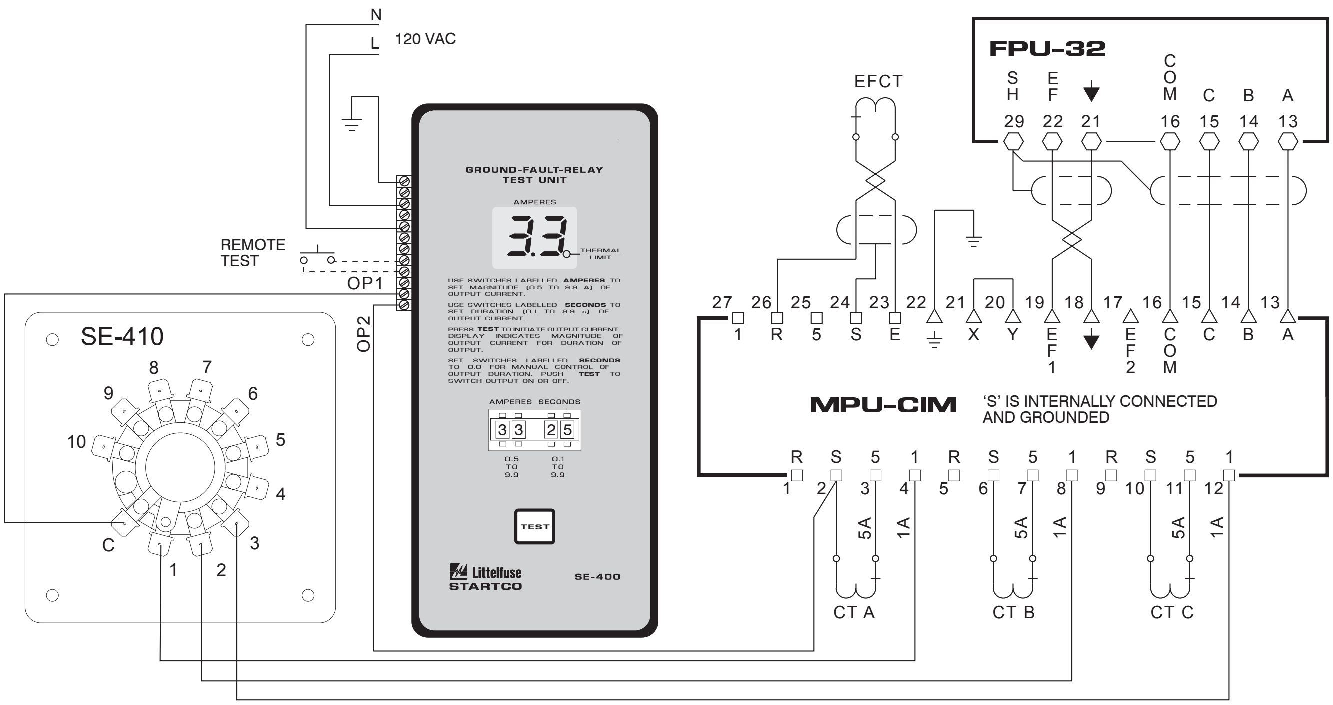
A convenient method for testing the operation of an FPU-32 Feeder Protection Unit is to utilize an SE-400 Ground-Fault-Relay Test Unit and an SE-410 Selector Switch. Considering that most retrofit installations will make use of existing 5-A secondary current transformers, the SE-400 can be connected to each phase individually via an SE-410 by connecting the leads to the 1-A inputs on the MPU-CIM Current Input Module. When 1 A of current is injected by the SE-400 into the 1-A input corresponding to one of the phases on the MPU-CIM, the FPU-32 will register full-scale primary current in that respective phase. The SE-410 can be used to test different circuits without having to disconnect and reconnect wires.



Let us consider an FPU-32 providing overcurrent protection according to an IEEE Very Inverse time-current curve. We will assume that 1200 A of current is flowing through the window of one of the 800:5 phase current transformers. We will also assume an FPU-32 inverse-time-overcurrent pickup setting (I_P) of 1.0.

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I_M represents the current in multiples of the pickup setting (I_P). It can be calculated via the formula below:

$$I_M = \frac{\text{Primary Current}}{I_P \times \text{CT-Primary Rating}} = \frac{1200\ A}{1.0 \times 800\ A} = 1.5$$

The IEEE Very Inverse curve is defined by the following formula:

$$I_M > 1.1:\ t = T_M \times 3 \times \left[\left(\frac{19.61}{I_M^{\,2} - 1}\right) + 0.491\right]\ s$$

$$I_M > 20:\ t = T_{IM} = 20\ s$$

$$I_M < 0.9:\ t_{reset} = T_M \times 3 \times \frac{21.6}{(1 - I_M^{\,2})}\ s$$

This formula, and many more that correspond to other IEC and IEEE curves, can be obtained from the FPU-32 manual. Given that $I_M = 1.5$, we will select the $I_M > 1.1$ formula to calculate the time to trip.

$$I_M = 1.4 > 1.1:\ t = 0.47 \times 3 \times \left[\left(\frac{19.61}{1.5^{\,2} - 1}\right) + 0.491\right]\ s =$$

$$t = 1.41 \times \left[\left(\frac{19.61}{1.25}\right) + 0.491\right]\ s =$$

$$t = 22.81\ s$$

In order to verify that an FPU-32 will trip after 22.81 s, an SE-400 can be set to provide a continuous 1.5 A of current to the 1-A input of one of the phases on the MPU-CIM. The FPU-32 will interpret this to mean that 1200 A of primary current is flowing (1.5 × 800 A = 1200 A).

Another thing to note is that the FPU-32 has many more protective functions than illustrated above, one of them being phase-unbalance protection. The phase-unbalance default-alarm setting is 0.1 pu with a 10 s time delay. The phase-unbalance default-trip setting is 0.25 pu with a 15 s time delay. The alarm setting will register when 0.1 pu × 800 A = 80 A is detected, and the trip setting will register when 0.25 pu × 800 A = 200 A is detected. Those current levels must be maintained for 10 and 15 s, respectively, for an unbalance alarm and trip to occur.

When the test above is initiated, and the phase-unbalance default levels are in service, the following sequence of events will occur:

1. The FPU-32 will display a phase-unbalance alarm after 10 s.
2. The FPU-32 will display a phase-unbalance trip after 15 s.
3. The FPU-32 will display an inverse-time-overcurrent trip in 22.81 s.

Effectively, both the unbalance and phase-inverse protective functions will have been tested. An SE-410 can be used to quickly test the other two phases where the above result will be the same. In the event that other protective relays are in use, the selector switch can be used to test them as well.