LET'S BE PACIFIC™

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Vacuum and Load-Interrupters Combine with Metering Systems for Grid Intertie Applications – A Compendium of Choices

The July 2014 Federal Pacific Newsletter featured a 35kV primary metering unit of pad-mounted switchgear that represented a conventional installation of metering transformers for revenue metering at an industrial complex accepting power at bulk-energy rates. The switchgear assemblies subject of this September 2014 newsletter present a variety of unique configurations (a) combining a load-interrupter switch with voltage and current transformers plus a power monitoring meter; (b) combining relayed vacuum fault interrupters with metering transformers to provide switching, protection and revenue metering functions; and (c) the traditional standalone PMDF, which (in this case) combines the metering transformers with an externally mounted KWH meter. These configurations and others are equally applicable at grid inter-tie installations connecting renewable-energy resources to the electric-power grid to provide necessary metering systems for both the owner/user and the electric power utility.

Figure 1. Federal Pacific's flexibility to provide applications specific system requirements is exemplified by the variety of arrangements combining switching and protection components with metering transformers by the three units that are featured in this newsletter. Pictured above is a conventional load-interrupter switch combined with metering transformers and an externally mounted power-quality meter with fiber-optic interface for communications via SCADA with other installation systems.

Renewable-energy resources, such as those generated by solar, wind, biodegradables etc., develop power at low-voltages, typically considered below 1000 volts. Normal electric-power distribution systems are operating at the most typical system voltages of 12.47kV, 24.9kV and 34.5kV — although many other system voltages exist and are also being used.

To connect the renewable energy that is being generated onto the electric-power grid, these low-voltage distributed-generation facilities must increase the voltage to the same system voltage as that of the electric-power grid to which they are to be connected. This increased voltage, which is necessary to transmit bulk power over long distances, is accomplished by using a step-up transformer to "transform" the voltage from (for example) 690 volts to 12,470 volts, matching one of the typical electric-power distribution-system voltages.

Typically, there are also other switching and protection systems at the grid inter-tie point to remove the renewable-energy source if it is faulted or in any way creating a problem that might cause a fault condition on the grid. And, similarly, there are switching and protection systems to isolate the electric-power utility if it is causing a problem that may damage equipment at the renewable-energy source.

The remainder of this newsletter is devoted to showing three representative pieces of equipment that satisfy the requirements at a grid inter-tie.

Load-Interrupter Switch Combined with Metering Transformers

The circuit diagram at bottom right shows the component location and orientation within the pad-mounted switchgear. The single fused voltage transformer connected on the incoming side of Phase 2 of the load-interrupter switch provides control-power input to the UPS Power Supply that provides 24vdc and 120vac back-up for the SEL-735 power-monitoring meter, the onboard receptacle, other customer installed low-voltage components, Ethernet switches, and the thermostat and strip-heater circuit.

The three-phrase set of fused voltage transformers and the three-phase set of window-type current transformers on the outgoing feeder circuit provide, respectively, the voltage and current inputs to the SEL-735 Power-Monitoring relay for the customer's metering requirements.

All of the low-voltage components are housed within the externally mounted low-voltage compartment, which is sealed from the environment and includes a strip heater.

Figure 2. Open door view shows incoming termination compartment at right with incoming load-interrupter switch visible behind viewing window. Outgoing termination compartment is at left and includes sensing CTs to measure and confirm load current and provide that input to the power monitoring relay. The voltage transformers are mounted in the interior of the switchgear.

CIRCUIT DIAGRAM

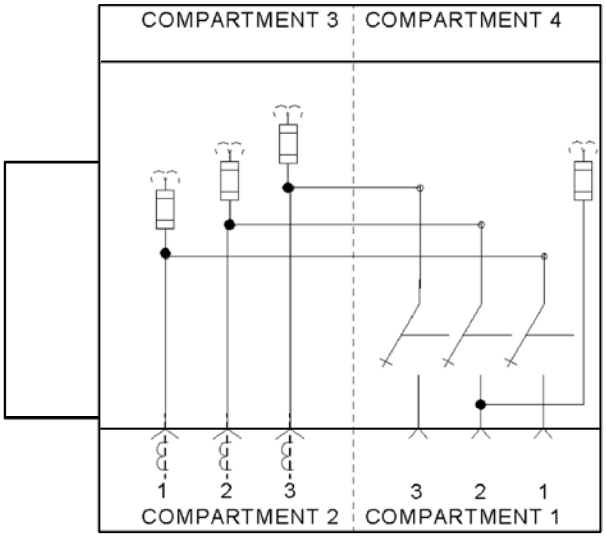

Figure 3. Photo at top shows an open door view of the compartments in which the fused-voltage transformers are mounted. Bolted, removable covers with handle grips allow access to the voltage transformers. The open door view directly above has the access cover removed to allow view of the three-phase set of voltage transformers that provide voltage sensing for the metering function. The single voltage transformer, which is not visible, is mounted in the compartment at the left and is also behind a bolted, removable cover with handle grips. This single VT provides control power to the power-monitoring relay and all the other low-voltage components.

Figure 4. The external low-voltage control compartment is mounted on the side of the unit and includes all of the low-voltage components. The compartment includes a door handle that is padlockable and a wind brace to hold the door open. The door opening is fully gasketed on all four sides to seal the compartment against the weather and contamination. The bottom of the enclosure includes screened vents to allow the interior to breath with modest air circulation.

Figure 5. The SEL-735 Power-Monitoring relay is panel mounted on a hinged steel plate, which also provides the mounting surface for the test switches (in center of panel) and the 120vac outlet (at lower right on panel).

Figure 6. Opening the hinged panel provides access to the remaining low-voltage components. Included are (1) the instructions and drawings on the bottom plate; (2) an SEI UPS Power Supply; (3) secondary circuit breakers, thermostat and heater (not visible); (4) an Ethernet switch; (5) a Black Box patch panel, and all the associated terminal blocks.

Vacuum Fault Interrupter Combined with Metering Transformers

The electric power utility will require some means to separate the renewable-energy resource or any other IPP (independent power producer) from its power delivery system when there is any disturbance on the source-voltage installation. For such grid disconnect locations, vacuum circuit breakers of one kind or another are typically used (rather than load-interrupting switches) because they have a fault interrupting capability and a very fast response. For example, Federal Pacific's MAVRiC® 200 has an operating speed in the range of three (3) cycles or less. In addition, MAVRiC® 200 can be furnished with an integral visible disconnect, whereas circuit breakers are either drawout or include an independent disconnect switch, both of which require considerable additional space. The following unit illustrates the capability to combine relayed vacuum fault interrupters, featuring an integral visible disconnect, with metering transformers to meet the two specific needs as a grid intertie system (a) provide rapid isolation from a fault whether on the utility source or on the generated-power source complex and (b) provide revenue-metering class transformers and meters for billing power supplied to the grid.

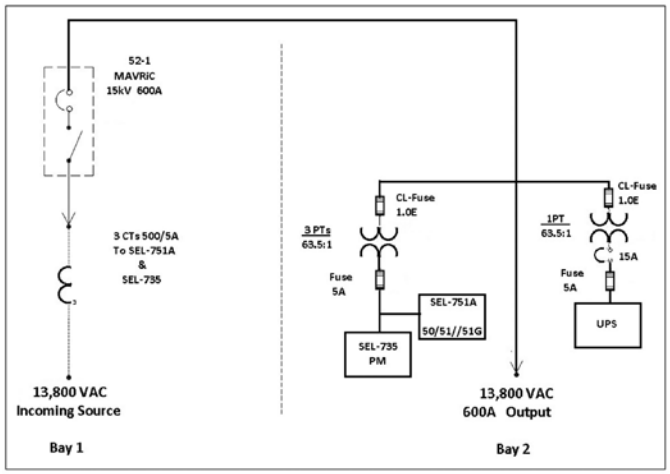

Figure 7. The low-profile, minimum footprint, switchgear assembly pictured above features a vacuum fault interrupter for both load switching and fault interrupting, allowing rapid disconnect of the renewable-energy source from the electric-power utility distribution system whether there is a fault condition on the utility side or the supplier side of grid inter-tie.

Figure 8. The incoming bushings are shown in photo A at left and the compartment also includes (1) the vacuum fault interrupter that provides switching and protection for the load circuit, (2) the single PT that is connected to Phase B of the incoming circuit and provides control power for the low-voltage components in the control compartment, and (3) the current transformers that provide current sensing for the power monitoring and overcurrent-protection relays. The outgoing bushings are shown in photo B at right and the compartment also includes the three (3) voltage transformers that provide voltage sensing inputs to the power-monitoring relay, which is the revenue metering scheme.

Figure 9. The photos above show the control compartment with its grouping of low-voltage components, which are described in detail below. The compartment door has a cast-aluminum door handle that is padlockable. The door opening is fully gasketed to seal out the environment. Louvers are provided with external covers as well as interior perforated, stainless-steel screens.

1. Surface-Mounted Low-Voltage Fuses
2. Vacuum Fault Interrupter Control Switch allows local manual open/close operation of the vacuum interrupter and includes LED lamps to display open/close/trip status.
3. ON/OFF Low-Voltage Secondary Breaker Switch
4. Weather-Resistant Low-Voltage Outlet
5. Test Switches for CT and VT inputs to relay circuits
6. SEL-735 Power Quality and Revenue Meter
7. SEL-751 Feeder Protection Relay provides trip signal when system parameters exceed programmed settings

Figure 10. Low-voltage control compartment is mounted integral within the switchgear assembly, but has a separate door and is fully isolated from high voltage. Thus, all operations can be performed without requiring access to the interior of the high-voltage compartment. All controls are surface mounted on a hinged panel making all components and associated wiring readily accessible.

Traditional Standalone Primary-Metering Dead-Front Units

Voltage Transformers in combination with the Revenue Metering CTs provide the suitable high accuracy necessary when billing the electric power utility for quality power delivered to the grid. The revenue metering function performed by this equipment is typically owned, operated and controlled by the electric power utility. But, the power supplier in this case is the owner of the renewable-energy resource and, in such cases, the primary metering equipment is also provided by that owner. Federal Pacific's traditional standalone metering units have the flexibility to provide a host of choices to the customer. The equipment can be furnished with provisions only for the metering transformers; or the customer can provide the metering equipment and Federal Pacific will install; or alternately, Federal Pacific can provide, install and wire the metering components. Also, the meter socket can be mounted in the interior of the unit or on the exterior of the unit. And, when installed on the exterior, the meter can be surface mounted to the enclosure; mounted on an exterior meter box, which may include a test switch as shown in Figure 12 below, or the meter can be mounted and secured inside a low-voltage compartment with additional metering components at the customer's choice.

Figure 11. Federal Pacific Primary-Metering Dead-Front unit can be provided with a variety of optional features to accommodate meter sockets, test switches and metering transformers. Labels are provided on the exterior to identify the metering transformer side from the elbow side.

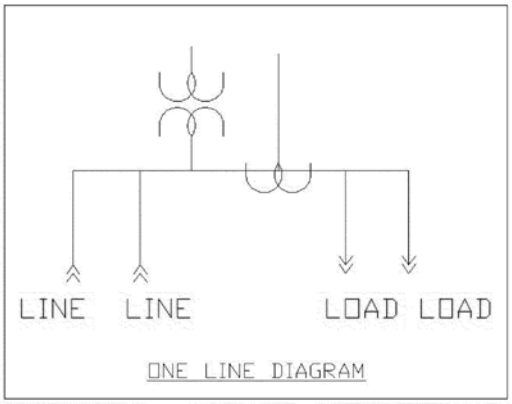

Figure 12. An externally mounted box (see photo at left) for the meter socket with a test switch on the interior is provided on this unit and was specified by this customer. The one-line diagram at right shows that the unit is configured with line and load bushing wells differentiated and arranged for application in a loop scheme (in and out on the line side) and to serve two independent load circuits.

Figure 13. Pictured at left is the dead-front elbow side of the unit. The arrangement shown is phase isolated and the Line and Load bushing wells for each phase are grouped together with Phase A at left, Phase B at center and Phase C at the right. There is suitable label identification for each line-side connection by phase and each load-side connection by phase as well as labels for mimic bus and to identify locations for metering transformers with CTs in series with the bus and VTs tapped from the bus.

Figure 14. Federal Pacific purchased, installed and wired the outdoor style metering transformers furnished with this unit. In some cases, only mounting provisions are provided for customer furnished and installed metering transformers or, alternately, Federal Pacific will install and wire customer-furnished metering transformers.

Figure 15. The unit includes, as a customer-selected option, clear polycarbonate barriers over each phase-set of metering transformers. Solid, red GPO-3 barriers are normally furnished as the standard barriers. The optional clear barriers provide improved visibility of the interior without requiring barriers to be removed. The CTs are mounted at the top and are connected in series with the bus and the voltage transformers are mounted on the bottom and tapped from the bus. The barriers can be temporarily stored on the door with one edge behind the door latches, helping to avoid contaminating the barriers if they were to be placed on the ground or on the enclosure roof. The clear-polycarbonate barriers include a penta-head bolt so they can be secured closed as an added precaution against inadvertent entry. A stainless-steel wind brace secures each door open.