The Importance Of Reliable Control Power

by Dave Yakel, GE Systems Engineer

Today's power systems have the potential to be more reliable, easier to maintain, and simpler to diagnose than ever before. This is made possible by the advent of microprocessors now available in everything from protective devices to programmable logic controllers (PLC's) to monitoring and diagnostic devices. While technology is rushing forward, the underlying implementation of an appropriate power system design is often lagging, especially when it comes to supplying a reliable source of control power. While these 'smart' devices may be considered the brains of the power system, the control power used to sustain them is certainly the heart.

Types of Control Power

To begin with, most manufacturers' low voltage circuit breaker devices, whether thermal-magnetic or electronic in design, are self-powered from current flowing through the breaker. That is, they need no external control power for proper and safe protective operation. They can sense the fault, trip their operating mechanism and clear the fault on their own.

Now let's add ground fault protection to that mix. As long as ground fault is part of the basic breaker's trip unit it will also be self-powered and require no external control power. That holds true even when remote current sensors are added for 3-phase, 4-wire systems, and when ground fault protection is built into a High-Pressure Contact (HPC) switch (Ref: GET-6205B pgs 3 & 16). On the other hand, low voltage breakers and fused switches do sometimes need external control power. Some electronic trip units on low voltage breakers may require external control power to activate their display panels and for communication with higher level power monitoring and control systems. Illumination of the display panel may be considered desirable but is not crucial. Breakers also have a large variety of accessories available like shunt trips and motor operators which can be used in control circuitry; the application will determine their level of importance. The HPC switch only requires separate control power to test the integral ground fault function or its remote alarming, not its operation; this is often considered desirable but not a critical control power application. However, HPC and other fuse applications often incorporate Blown Fuse Detection accessories as well as Loss Of Phase protection relays. These devices may require external control power to properly operate and when not available could result in downstream equipment damage. For such applications it is important to specify a reliable source of control power.

Reliability

Applications where molded case breakers are group mounted in panelboards or switchboards rarely require separate control power. Accessorization for these applications warrants further consideration and should be investigated when they arise. Devices or accessories in this category include multi-function meters and the alarm elements of TVSSs. Neither of these are typically considered critical but do require that determination be made by the design engineer.

Large mains in switchboards and all breakers in low voltage switchgear applications may include functions such as remote electrical open/close operation and therefore will require a source of control power. If the remote operation capability is only for convenience, or safe remote operator location, then the level of control power reliability is a matter of design evaluation.

When the system design progresses to any of the following; multi-sourced switchboards, PLCs with imbedded control logic, applications requiring coordinated or synchronized operation, timely communication of data, or when protective relays operate separate breakers, then there is a certain need for an uninterruptible source of control power. The engineer must make an informed decision on how best to fill the need.

Applications

For the classic switchgear application reliable control power is usually supplied from a battery and charger system at 48, 125 or 250VDC. For applications where the battery bank can be located close to the gear and the control power for charging and closing the circuit breakers is derived independently, 48VDC is usually selected. If the DC system supplies both tripping and closing power, 125VDC is commonly the choice with a few applications such as high control power needs and long conductor runs requiring 250VDC. One battery bank can service an entire location. The charger normally provides power to all of the control circuit continuous loads plus a small amount of current to "float" or "trickle" charge the battery. If the incoming AC supply fails, the battery takes over the duty of providing DC power. Battery systems are sized to supply the maximum conservatively estimated continuous load requirement of the application for eight hours (Ref. GET-6600F 4-2 to 4-10) and then provide one minute of inrush loads at the end of the eight-hour period. This design is time proven and is considered extremely reliable. It can, however, occupy significant floor space, requires special ventilation considerations, needs regular maintenance and monitoring, and can be costly in applications where only a few critical control elements need to be served. Battery systems are available as lead-acid units, which may require ventilation depending on their design but are lower cost or nickel-cadmium which are sealed but considered hazardous waste requiring strict government regulatory compliance. More detailed information on battery systems may be found in IEEE-446, including their sizing, design and maintenance requirements.

For systems that only require a reliable source for circuit breaker tripping and / or lockout relay operation, capacitor trip units (Cap Trips) are used. The typical Cap Trip unit consists of a rectified AC control power source with circuitry to charge and maintain the voltage level on a capacitor. These units are not designed as a continuous source of control power. The module stores just enough energy in a capacitor to operate one circuit breaker shunt trip coil or lockout relay. The remaining control circuits are usually powered from an AC control power source. This approach relegates the need for batteries to only critical control circuits which are continuous, such as PLC's. The result can be a much smaller battery system, which will permit its replacement with a small UPS. Some applications warrant the use of a special Cap Trip unit which incorporates a small rechargeable battery with a charging circuit built in (see Appendix 3). These units maintain the charge on the capacitor for up to 72 hours. When used in combination with the appropriate protective relay devices, battery back-up Cap Trip units can increase the reliability of remote and unmonitored power distribution systems where the loss of control power may not be detected for up to three days.

The optimum means of providing a clean source of power for critical needs has evolved into the Uninterruptible Power Supply or UPS (ref IEEE-602). This technology is ideal for small applications with a limited need for continuous critical control power, about 1 to 3kVA for a period of 15 minutes or so. Such a small UPS control source can be embedded in the standard switchboard or switchgear structure without rarely increasing required floor-space, and with reduced costs. The reduced capacity, however, is a limitation and therefore must be carefully considered.

When there is a large energy demand for tripping an ANSI breaker (1000 – 1300VA), most switchgear systems without station control batteries rely on individual Cap Trip units for supplying tripping and lockout relay power, and a central UPS for microprocessor based devices. In other cases such as the HPC switch example above, where tripping power requirements are limited (200VA or less), a single small UPS may meet all of the control power requirements. The UPS will still require periodic maintenance and monitoring, however many UPS manufactures incorporate alarms and monitoring ports which serve as excellent tools to aid in these tasks.

The electronic capabilities built into today's protective, metering and control equipment require power to function properly, especially under extreme conditions. The design engineer must evaluate the application and nature of the control power needed by the system elements being applied and determine when a supplemental source of back-up control power is appropriate. In those cases many options are available which are both economically and space-effectively incorporated into the system design. Several such approaches have been reviewed in this article. For more detailed discussions regarding this subject drop this publication an e-mail request, or contact your local Systems Engineer. Detailed specifications and publication brochures are also available by requested.

Appendix 1 ITEMS TO INCLUDE IN A UPS SWITHGEAR/SWITCHBOARD SPECIFICATION

- The UPS shall be integrated within the gear by its Manufacturer.
- The UPS shall conform to UL1778 and CSA22.2-107.
- The UPS shall be a double conversion unit, utilizing high-frequency PWM (Pulse Width Modulation) digital control techniques for low output distortion and fast transient response.
- The control voltage (UPS output) shall be 120VAC with 120VAC input for easy interface to PLC's, Communication Networks, Protective Relays and Electronic Meters
- The batteries used in the UPS shall be long life, maintenance-free sealed type, self-contained with an option to add additional batteries. Batteries must not be detrimental to an environment which incorporates copper or silver-plated bus.
- The Backup time at 50% load shall be no less than 14 minutes.
- The UPS shall have optional LAN and Serial Connections for monitoring and management with the manufacturer's UPS management software

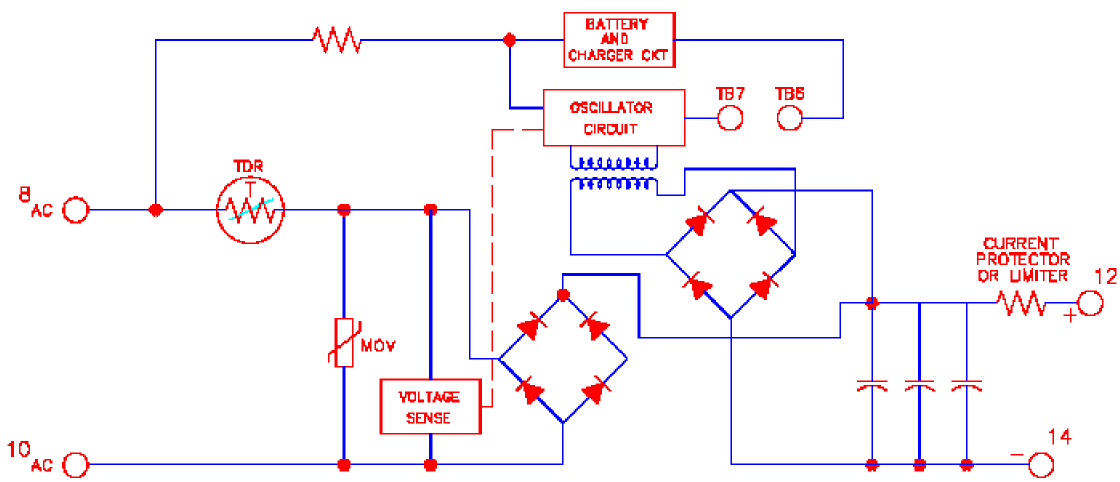
Appendix 2 TYPICAL CONTROL POWER REQUIREMENTS FOR CRITICAL SWITCHGEAR/ SWITCHBOARD COMPONENTS

Low Voltage 120VAC Shunt Trip Requirements

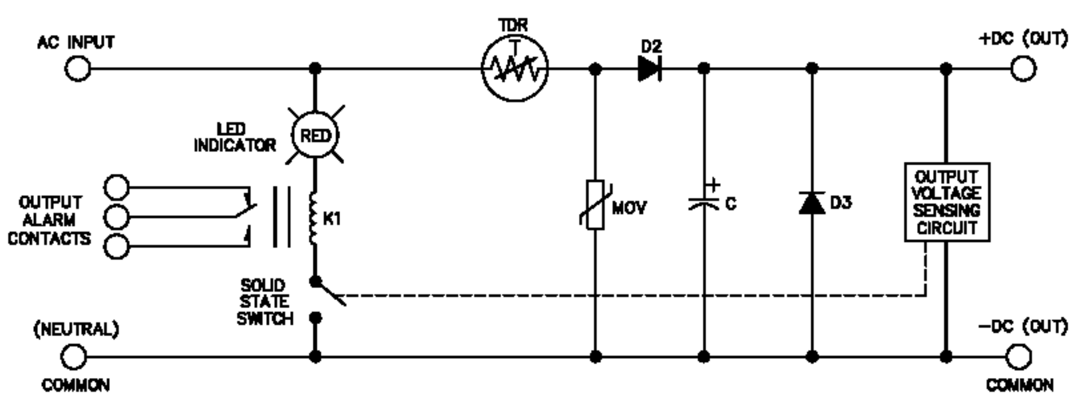
- ANSI Metal Frame Breakers 1300VA (GE WavePro)
- HPC and Insulated Case 200VA (GE PowerBreak, HPC)
- Molded Case 60VA (GE Specra RMS)

Protective Relays	30VA (GE Multilin 745 Transformer Management)
Electronic Meters	10VA (GE Multilin PQMII)
PLC's	35VA (GE Fanuc 90-30 PLC)
Lockout Relay	1300VA (GE Type HAS / HEA)

Appendix 3 CAP TRIP UNITS FUNCTIONAL DIAGRAMS



CAP TRIP UNIT WITH BATTERY BACK-UP



STANDARD CAP TRIP UNIT