PRECISION SBRIO-BASED MAGNET POWER SUPPLY ANNUNCIATOR AND CONTROL INTERFACE FOR ACCELERATOR CONTROL SYSTEMS

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Abstract

Magnet-power supplies are ubiquitous at accelerators. Beam physicists require more data and performance information that is commonly provided by the modern switch-mode power supplies installed at these facilities. We describe single-board RIO (sbRIO) [1] -based power-supply controller that provides the functionality required for integrating these supplies into control and safety systems at these facilities.

The unit allows local control and presents a visual representation of the operational status of each power supply, independent digitized read back of power-supply output current, EPICS control via a CA server, status information and electrical connections to independent and redundant accelerator safety systems.

MAGNET POWER SUPPLIES AT ACCELERATORS

Magnet-power supplies are ubiquitous at accelerators. They excite the magnetic fields for magnet optics used for steering and focusing the charged particle beams. A typical large accelerator can have hundreds or thousands of magnets with a comparable number of power supplies.

Typically, there are redundant safety and monitoring systems with which a power supply needs to communicate.

Power supplies need to be self-monitoring and capable of reporting electrical and electro-mechanical faults to the variety of control and safety systems to which they are attached.

They also need to be monitored and controlled locally, that is where they are physically located. They need, therefore a human to machine interface (HMI).

Large power supplies typically have controls and HMI's built in. [2] Small supplies, those under 20 kW or so, require an external interface for both control and monitor functions. Smaller supplies tend to be commercial units that come from a variety of manufacturers, each with a limited and unique interface.

REQUIREMENTS FOR A MAGNET POWER SUPPLY MONITOR AND INTERFACE

The challenge arises from the diversity of the size, manufacturer and native control interfaces of the hundreds of power supplies at an accelerator facility. We have designed a companion chassis that allows these diverse set of devices a common combined control-system and human machine interface.

High-Level Monitor Requirements

The external controller needs to be able to connect to a diverse set of modern-commercial-off-the-shelf (COTS) power supplies and meet the following requirements:

- Provide detailed-remote reporting and display of interlock faults in power supply.
- Any user-determined external faults that should turn off the power supply, such as magnet temperature and magnet water flow.
- Provide independent monitoring of actual output current and ground-fault current.
- EPICS-Channel access connectivity [3] [4] or other SCADA (supervisory control and data acquisition) control protocols such Modbus TCP etc.
- Provide power supply-status and run-permit-type dry contacts to the accelerator control system. [5].
- Provide a detailed, easily-recognized indicator-light pattern as a standard local display of interlock faults.
- Provide local-remote switch with lockout. Or allow a custom control-contention protocol.
- Provide External Circuit breaker (True AC-mains disconnect).
- Electrical safety certification from a Nationally Recognized Testing Laboratory (NRTL),such as UL.

Power-Supply Interlocks and State Management

Although internally a power supply usually monitors individual faults (see figure 1) most small COTS supplies don't provide the exact fault on the front panel and have only a single fault LED indicator. This is not sufficient for accelerator operation purposes. With hundreds of power supplies one would like to know the nature of a failure in some detail. The power supply, in many instances, acts as an interlock monitor for its load as well. These pieces of data are also sent back to the control system. These data are typically accessible via a serial connection at the power supply.

Accelerators have a number of different systems that require real-time status of each power supply. Most large installations have two safety systems. There is one for machine protection and one for personnel safety. That means that the power supply must interact with three independent control systems.

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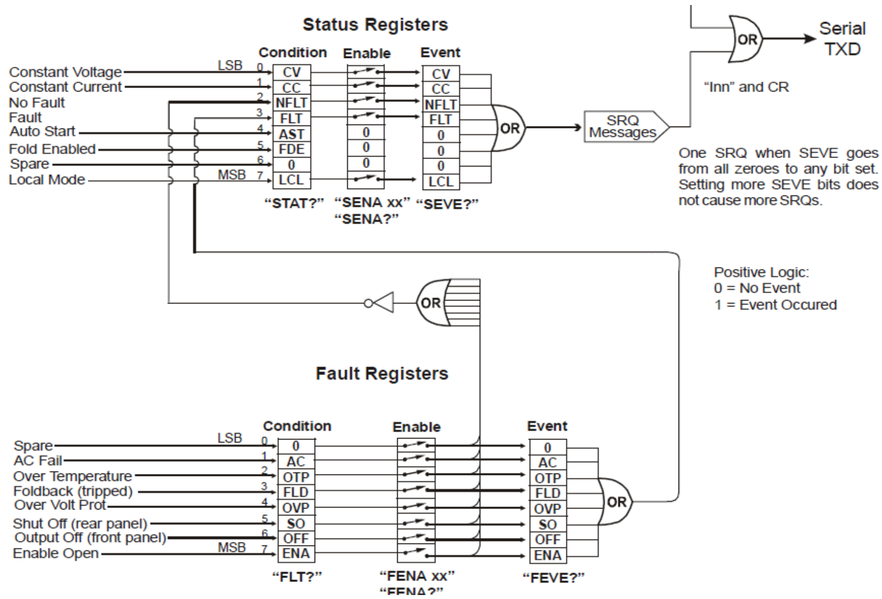

Figure 1: Example internal Interlock logic for a modern switch mode power supply. This is a Lambda Genesys™power supply interlock logic tree. These are accessible via a rear-panel serial-communications port. [6].

Power-Supply Annunciator Design

Given the requirements above, BiRa has designed a power supply annunciator module that is based on a National Instruments single-board RIO (sbRIO) controller. This provides a solution that will fit in a 2U high 19-inch rack-mountable enclosure. The flexibility of Labview Real Time I/O Server software allows communications interfaces using RS-232 and Ethernet ports. There is also a choice of using a variety of communications and control protocols including Modbus TCP, ASCII, and EPICS ChannelAccess.

Logic Design and Implementation

We used the feedback we've received from accelerator operations personnel and have taken design queues from older power supply controllers that were used in the early 1970's to design a front panel that has the functions that will provide ease of use and meet the control requirements for a wide variety of power supplies and control systems.

Figure 4 shows the block diagram for the annunciator. Note that there are individual-independently-lit indicators for each interlock and fault condition. This allows a person who is responsible for troubleshooting to scan an array of rack-mounted controllers and recognize status-light patterns for multiple power supplies in a rack. Rapid identification of anomalous conditions can be recognized immediately.

For electrical safety, a panel-mount circuit breaker functions as a local-mains cut off is right in on the annunciator front panel. New COTS switch-mode power supplies have an on-off switch, but the switch does not turn off the AC input.

A Direct Current Current Transformer (DCCT) or meter shunt is used to provide an independent current measurement.

A set of four relays are used to provide a dry-contact for interfacing to machine-safety and personnel safety systems.

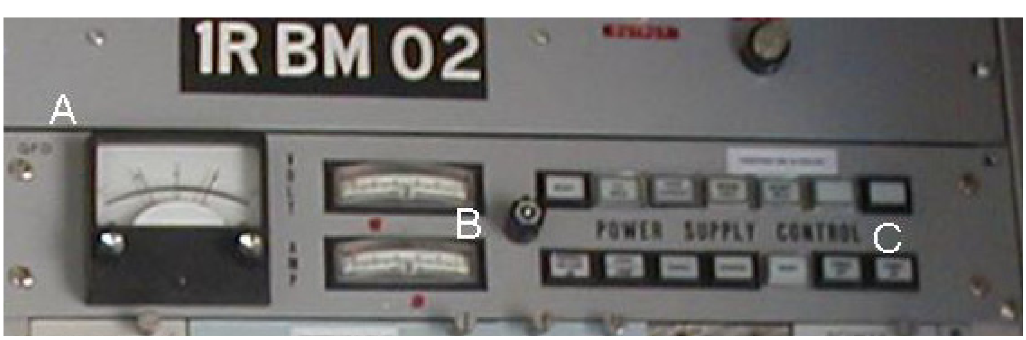

Figure 2: LAMPF-Standard power-supply controller circa 1970. (A) – Ground-Fault Meter with trip setting. (B) – Output Current ant Voltage (C) – Integrated control switches and indicators. Picture taken 2003

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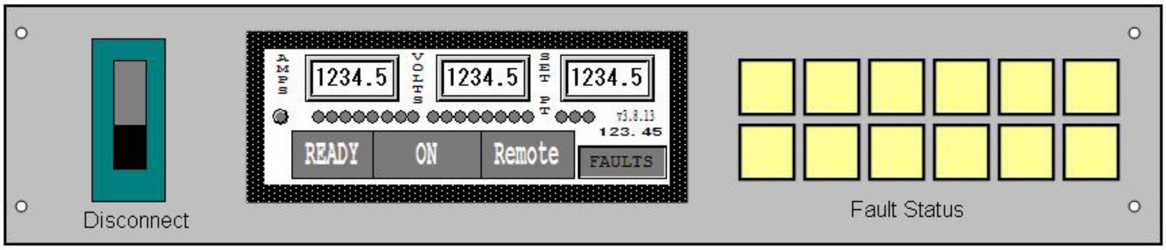

Figure 3: Updated Annunciator / Controller that retains the features of annunciator-fault lights but incorporates a modern, but simple readout of major elements of the power supply's operational parameters.

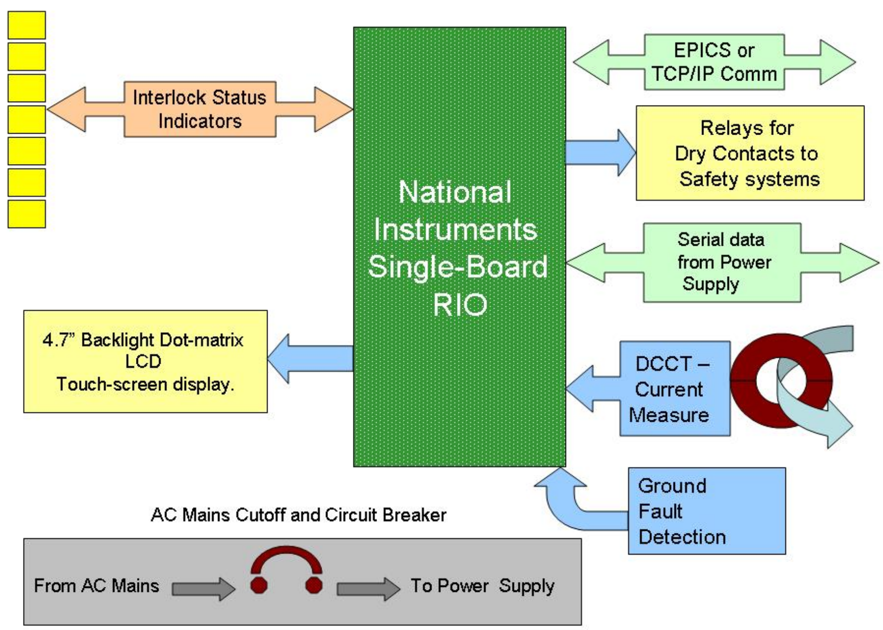

Figure 4: Single Board RIO annunciator block diagram.

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