

Technical Note

ReFlex Power™ Fault Protection Groups

Document No. M380595-TN Rev A • 01/08/09



PURPOSE

Establish and configure Fault Protection Groups for the Elgar ReFlex Power™ system. Fault Protection Groups are presently available for DC Power Modules with Firmware Version 2.000.018xi or higher, with Controller Module

Firmware Version 2.001.029xf or higher. Fault Protection Group functionality will be added to future releases of firmware for AC and Load Modules.

BACKGROUND

The ReFlex Power™ system presently includes fault monitoring and shutdown at the individual power module level, and through the ReFlex Power™ Controller module to inhibit the outputs (Remote Inhibit) of all power modules contained within a system. All ReFlex Power™ power modules include a Module Enable (ENA) signal that allows the user to enable or disable each power module individually with an external signal or relay contact closure.

Each DC power module also includes a Trigger Input (TRIG-IN) and Trigger Output (TRIG-OUT) signal on the front panel Interface connector for implementing precise timing functions based upon internal and/or external events. List mode sequences may be preprogrammed to execute upon receipt of trigger signals. The Controller module also includes four bi-directional Digital Input/Output signals (DIG0-I/O through DIG3-I/O) that are passed through the Controller module to the ReFlex Power™ mainframe backplane for processing by DC power modules.

FAULT PROTECTION GROUPS

Fault Protection Groups provide additional capability to group and to shutdown DC power modules through the power module Enable Input and Trigger Output signals. The ability to

create fault groups through these signals provides increased flexibility and reconfigurability to meet various user requirements.

TERMS AND DEFINITIONS

ENA Enable

The Enable signal is an input on ReFlex Power™ power modules' Interface connector (ENA = Pin 1, ENA-RTN = Pin 6) that enables or disables the power module outputs. The Enable signal is internally pulled up to +5VDC with a 10K ohm resistor. To enable the module the signal is pulled low (<= 0.5VDC) with respect to ENA RTN signal. This may also be accomplished by shorting Pins 1 and 6.

TRIG-OUT Trigger Output

Signal output on ReFlex Power™ power modules' Interface connector (TRIG-OUT = Pin 2, TRIG-OUT-RTN = Pin 7) that produce a external trigger signal. The Trigger output signal is TTL compatible. Vol <= 0.3VDC @ 1mA, Voh >= 4.13VDC @ 1mA. Trigger latency is <= 5uS. Trigger outputs may be positive leading edge asserted or negative leading edge asserted.

MODF Module Fault Output

The Trigger Output (TRIG-OUT) signals on the power module Interface connector may be reconfigured via a software command as a Module Fault (MODF) output signal (MODF-OUT = Pin 2, MODF OUT-RTN = Pin 7) to assert a latched output upon detection of a internal fault condition.

SCPI Standard Commands for Programmable Instruments

Developed by the SCPI Consortium as a standard set of command to control test and measurement devices in instrumentation systems.

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THEORY OF OPERATION

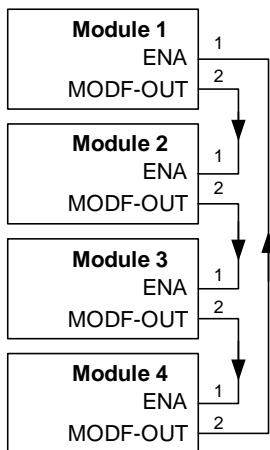
Fault Protection Groups may be implemented by external user wiring through the ReFlex Power™ front panel Interface connector on each DC power module. The flexible user implementation allows the creation of three basic fault group types:

- **Single Fault Protection Group:** All ReFlex Power™ DC modules externally interconnected to provide immediate shut down all DC power module outputs upon a fault condition in any DC power module.
- **Multiple Independent Fault Protection Groups:** Groups of ReFlex Power™ DC modules independently interconnected to shut down of all DC power module

outputs within each independent group without affecting the functions of other independent groups.

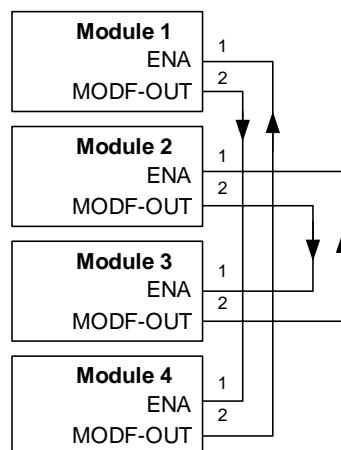
- **Multiple Dependent Fault Protection Groups:** Using an external resistor and Schottky Diode the user may create dependent Fault Protection Groups wherein a fault in Group A will shut down all DC power modules in Group A and Group B, but a fault in Group B will not affect the module outputs in Group A. The following diagram depicts the external wiring required to create each of these Fault Protection Group types.

USER APPLICATION WIRING



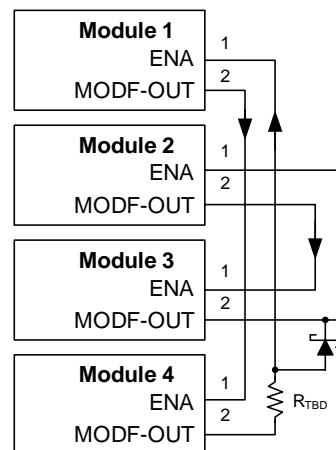
Example 1

Single (System)
Fault Group



Example 2

Multiple, Independent
Fault Groups



Example 3

Multiple, Dependent
Fault Groups

Example 1 depicts the MODF-OUT signal of Module 1 connected to the ENAble input of Module 2. This method is repeated from module-to-module until the final module MODF-OUT signal is connected back to the ENAble input of Module 1. A fault condition on any module will assert the MODF-OUT signal to the next power module ENAble line, causing it to de-assert its enable (disable) and shutdown the module output. This chain reaction quickly disables the outputs of all DC power modules within the system. Since the ENAble inputs are de-asserted on all other modules in the chain, only the module with the fault that started the sequence will indicate a fault condition. All connected modules shall remain latched in shutdown until the original fault condition is cleared.

Example 2 depicts two independent fault groups connected in a similar fashion. Module 1 and Module 4 will shutdown when either experiences a fault condition. Likewise, Module 2 and Module 3 will shutdown when either experiences a fault condition. However, the fault group comprised of Module 1 and Module 4 will continue to operate independently of a fault condition with Module 2 and Module 3.

In **Example 3**, if either Module 2 or 3 faults off, then Modules 1 and 4 will also shutdown; however, if either Module 1 or 4 faults off, then Modules 2 & 3 will *not* be shut down

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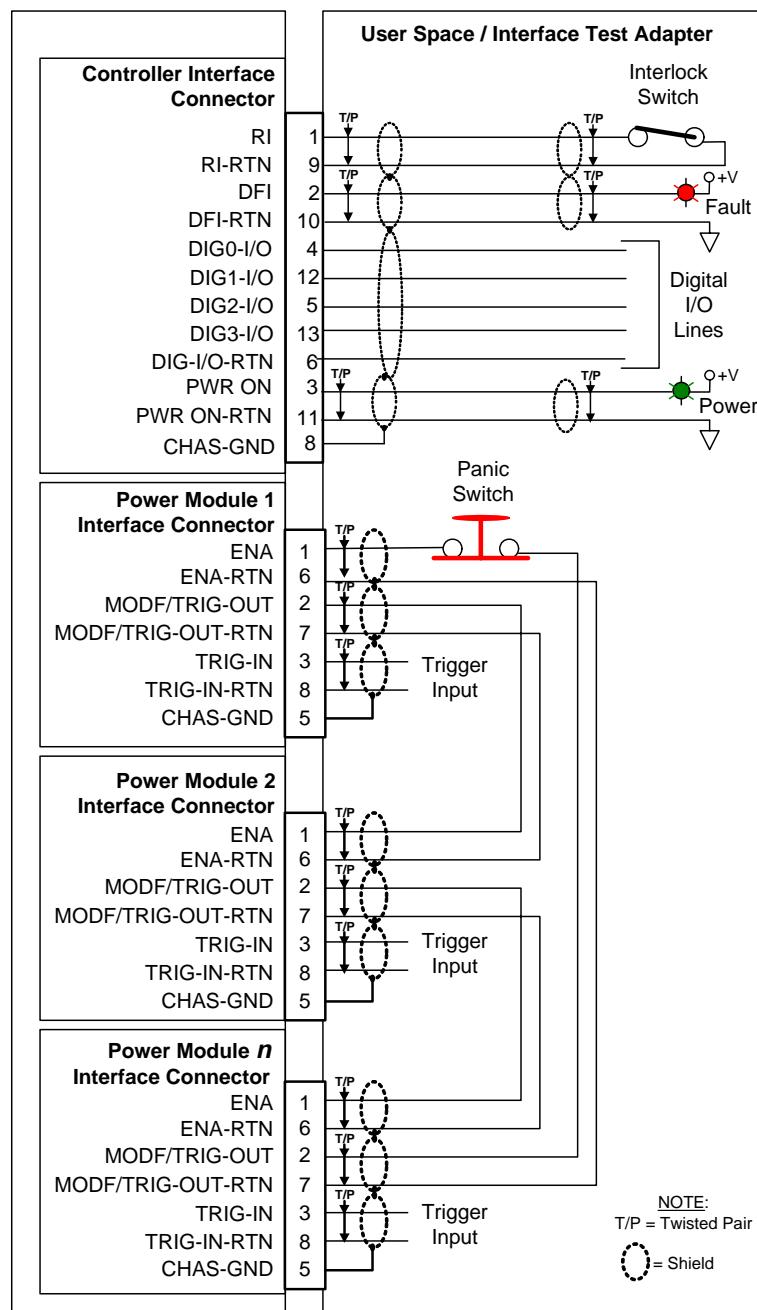


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The following diagram depicts all the required connections to implement an entire system fault group. An external Panic Switch is included in the diagram to define the interconnections for an operator commanded shutdown. In this application, the Panic Switch shall allow all interconnected modules to follow the function of the switch. Since no fault has been reported, the user may use this feature to command all power modules off.

An external Interlock Switch is shown connected to the Remote Inhibit pins of the Controller module to prevent turning on power module outputs until conditions are safe. Finally, the Discrete Fault Indicator (DFI) and Power On (PWR ON) output signals of the Controller are shown illuminating indicators in the user space.



Detailed Fault Protection Group Wiring Diagram

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FAULT PROTECTION GROUP SCPI COMMANDS

The ReFlex Power™ MODF signal requires the following SCPI command to setup or preprogram power modules to execute a shutdown on individual faults or when the ENable input is

deasserted. For additional details of ReFlex Power™ SCPI programming commands please refer to the Programming Manual, M380056-03.

SCPI Command	Description
OUTP<n>:MODFault bval	Establish on module n, bval = On, that Trig Out is in Module Fault output mode, bval = Off, normal trigger mode (Power on default).
OUTP<n>:MODFault?	Query if Trig Out is configured for MODF operation on module n.

When a Fault occurs, if the cause of the fault is external to the RFP system, the user will need to take corrective action to remove the cause of the fault. Only the Module that caused the fault will show a fault other than GroupFault if the fault was triggered from a Series or Parallel Group. If the fault was caused by a non-group module then its fault indicator will be illuminated. For example, if the fault was caused by an OCP, and the Current protection limit turned out to be too low, then the OCP limit would need to be modified. To resume

operation of the fault group, issue the following command sequence: *CLS<n> to the module that caused the fault that brought down the group; this will de-assert the MODF signal, and then issue OUTP<n>:STATE 1 commands to the modules/Group Masters in the proper order to bring up the voltages in proper sequence. A system Reset (*RST) will clear all Fault Protection Groups restore all modules to power-on default conditions. Fault Protection Groups must be reprogrammed after a system rese

FAULT PROTECTION GROUP TIMING CHARACTERISTICS

The Module Fault Output signal is generated in VHDL to ensure fast response to any reported fault condition with a latency of 500 nanoseconds maximum from module-to-module. The Oscillograph below shows two ReFlex Power™

modules MODF signals on Ch. 1 and 3, and output signals on Ch. 2 and 4, respectively. A fault condition on one module immediately de-asserts the ENABLE input to the second module, resulting in both modules shutting down.

