SQUARE D
Schneider Electric

ENGINEERING SERVICES

1960 Research Drive, Suite 100, Troy, Michigan 48083

ARC FLASH REDUCTION

with

SEPAM RELAY

ZONE SELECTIVE INTERLOCKING

REVISION: December 10, 2007
(Supersedes previous versions)

Prepared by:

Van Wagner, P.E.
Staff Power System Engineer

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Preface to 2007 Revision

This report has been revised to show the design without the use of the 24 Vdc control relay in the ZSI signal path between the Micrologic and the Sepam relay. This control relay was required in the 2006 design. The elimination reduces the ZSI control logic complexity and improves response time. **This design supersedes the 2006 design.**

Startup testing has been added as a new appendix. There have been several other minor updates.

Special thanks to the design review team of Bill Brown, Louis Hapeshis, Steve Hinton, Tony Parsons, Larry Ray, and Keith Robertson.

Introduction

This report documents a method to reduce arc flash energy on low voltage switchgear with only modest equipment additions. It assumes a medium voltage breaker feeds a single low voltage transformer. (See Figure 1) A protective relay monitors the transformer secondary current and when it senses a fault, trips the medium voltage (MV) breaker. Zone Selective Interlocking (ZSI) is used to reduce clearing time compared to conventionally coordinated settings. With this method, it is possible to reduce arc flash incident energy to 20% of what it would be with standard protection provided by the MV relay.

This report documents the recommended design for the system.

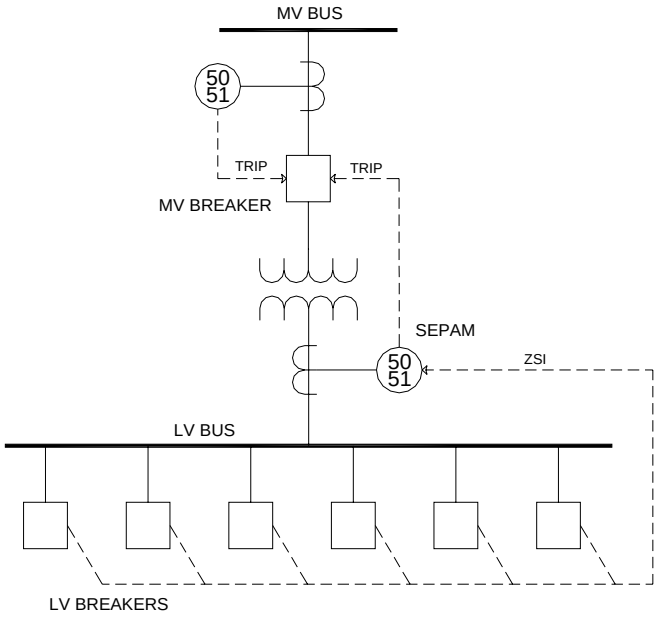


Figure 1 Low voltage "virtual main relay" configuration.

Background

Zone Selective Interlocking (ZSI) is traditionally used to reduce the stress on equipment due to a fault by eliminating the short time delay under certain circumstances. In Figure 2 if a fault occurs on the load side of a feeder breaker, a control or restraint signal is sent to the upstream device to apply the short time delay. This allows time for the downstream beaker to clear the fault.

If the fault occurs between the two breakers, no restraint signal is sent to the upstream breaker and the main applies the short time pick up setting with no intentional time delay. This reduces the energy of the fault by clearing it more quickly.

In the proposed design, a protective relay (aka virtual main) replaces the main low voltage breaker and trips the medium voltage breaker feeding the transformer. The current transformers for the relay are on the transformer secondary. The LV relay provides protection for the LV bus and for transformer overload. The relay at the MV breaker protects the MV conductors and the transformer. This would not apply where the MV breaker feeds multiple transformers.

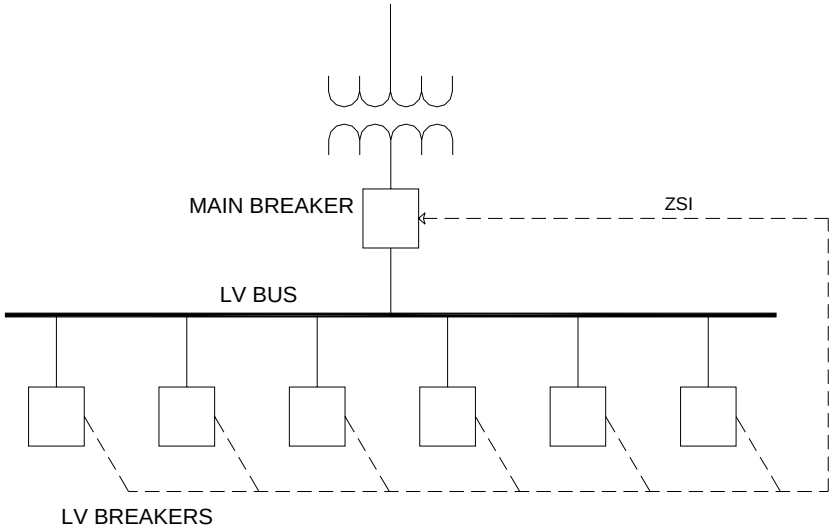


Figure 2 Typical ZSI configuration.

Many low voltage breakers have ZSI capability but it is not necessarily found on protective relays. The Sepam does have ZSI capability and completely different curves can be selected for the restrained and unrestrained conditions. For low voltage breakers, only the short time delay can be switched on and off with ZSI.

For the configuration shown in Figure 1 without the main relay, the arc flash energy at the bus will be high. The LV fault current is reduced by the transformer impedance and the MV relay must be set high enough to allow for transformer inrush current. Consequently, an arcing fault on the LV bus will not be cleared by the MV relay in the instantaneous zone. A LV main would reduce the arcing energy at the cross bus for the feeder breakers but the main would still protected by the MV relay. The main would still have a high arc flash energy. In the proposed configuration, all the LV breakers can have reduced arc flash energies.

The nomenclature of the ZSI can be confusing.

Restrained > Device must see a signal > Normal trip characteristic

Unrestrained > Device sees no signal > Faster trip characteristic

Design

The drawing for the design is shown in Figure 3 and the bill of material is in Appendix A.

The Micrologic ZSI output is fed to a Restraint Interface Module (RIM) which converts the signal to the 24 Vdc restraint signal required by the Sepam.

The Sepam can apply two separate curves for the restrained and unrestrained conditions. When restrained, it blocks the operation of the ZSI settings. For the unrestrained condition, any of the preset curves may initiate a trip. For the ZSI setting, a definite time curve is normally selected (see Figure 4) with a 70 ms time delay to allow the restraint signal to be received.

The RIM and the Sepam restraint input require 24 Vdc for operation. The Sepam can operate with a wide range of control power voltages. The recommended design is to use the MV switchgear dc battery power to operate all the components. The 125 Vdc will be fed directly to the Sepam and a Telemecanique Phaseo power supply for the 24 Vdc. The Phaseo can operate with either ac or dc input. Only the specified power supply should be used. The range of operation for the components is 100 Vdc to 250 Vdc.

Other control power configurations should be reviewed by Engineering Services.

The arc flash zone of protection afforded by the scheme is on the load side of the Sepam CT's. To fully protect the LV switchgear, the CT's should be external to the compartment. The CT's may be located in the transformer compartment, if space allows, or in a transition compartment. If they are located in the switchgear main section, the arc flash rating improvement may not be applicable. If the main section is barriered from the other sections, the other sections may be protected by the scheme. If the sections are not barriered, the scheme will not provide any additional protection. Even with barriers, vents or other openings between sections may not confine the arc flash. The actual potential confinement should be reviewed as part of the labeling process.

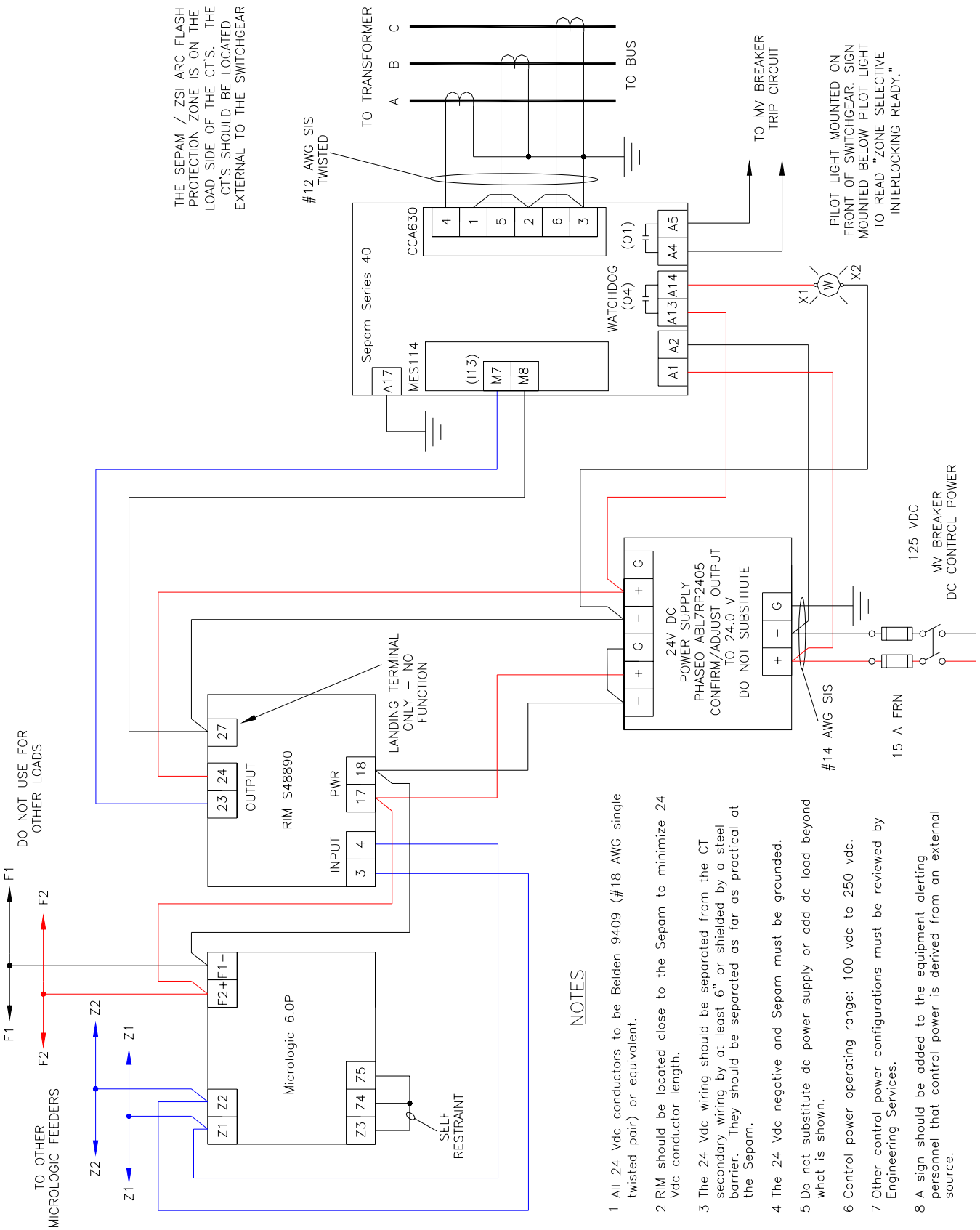
The Sepam requires a restraint signal to apply the longer clearing times. If for some reason the ZSI controls do not operate, the Sepam will default to the group with the fastest setting. That group will be the one that provides the lowest energy fault. Nevertheless, a "Zone Selective Interlock Ready" pilot light has been provided to indicate the 24 Vdc is present and the Sepam is functioning.

Ground fault ZSI functions similarly to the phase overcurrent ZSI. However, ground fault with the virtual main is no longer addressed due to the complexities introduced by four wire systems.

The restraint signals are 24 Vdc or less and very low current. The precautions in the drawing notes should be followed to minimize noise interference and possible spurious operation. The power supply and Sepam should be grounded as shown in the drawing to minimize potential interference. The power supply output should be measured and adjusted to no more than 24 Vdc.

Recommended startup testing is shown in Appendix C and will verify proper operation of the scheme. It should also be tested as part of the normal routine switchgear maintenance.

Figure 3
Recommended Design



NOTES

1 All 24 Vdc conductors to be Belden 9409 (#18 AWG single twisted pair) or equivalent.

2 RIM should be located close to the Sepam to minimize 24 Vdc conductor length.

3 The 24 Vdc wiring should be separated from the CT secondary wiring by at least 6" or shielded by a steel barrier. They should be separated as far as practical at the Sepam.

4 The 24 Vdc negative and Sepam must be grounded.

5 Do not substitute dc power supply or add dc load beyond what is shown.

6 Control power operating range: 100 vdc to 250 vdc.

7 Other control power configurations must be reviewed by Engineering Services.

8 A sign should be added to the equipment alerting personnel that control power is derived from an external source.

Arc Flash Comparison

Based on the test results, arc flash energies at the LV bus were evaluated for the configuration in Figure 1 with four transformer sizes: 750 kVA, 1500 kVA, 2500 kVA and 3750 kVA. The LV virtual main relay provides protection for the bus. The arc flash energies were compared to a configuration where the relay at the MV breaker protects the LV bus. The time delay for the unrestrained condition is 70 ms from the testing and specifications. The arc flash results are shown in Table 1.

Transformer kVA	*IE with ZSI Main Relay (cal/cm^2)*	*IE with MV Relay (cal/cm^2)*
750	2.4	10.0
1500	5.2	21.0
2500	7.8	36.5
3750	10.6	62.2

Table 1 Comparison of arc flash incident energies for ZSI LV virtual main relay to MV relay

These results are for comparison only. There are many possible MV configurations and a range of possible settings within a particular configuration. Each application is different. The incident energies should not be used in lieu of an arc flash hazard analysis for the selection of personal protective equipment.

The main relay reduces incident energy to about a fifth of the MV relay protection. For the larger transformers the reduction is from dangerous or Hazard Category 4 to Hazard Category 2 or 3. For smaller transformers, the Hazard Category is reduced to 1 or 2.

Protective Device Settings

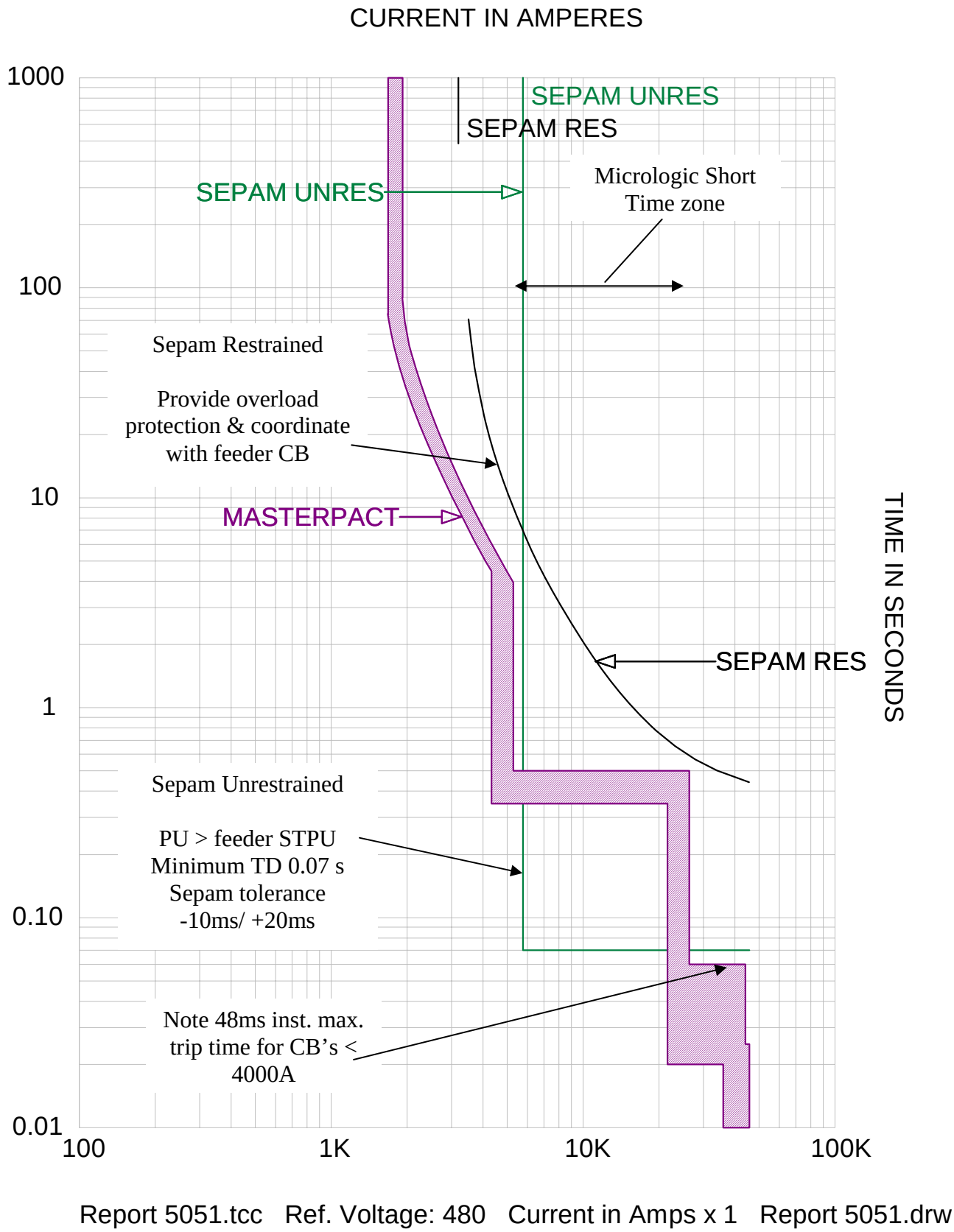
The Sepam has the ability to apply two completely separate curves for the restrained and unrestrained conditions. When a restraint signal is sensed, the ZSI group is blocked and the other enabled groups will respond to the condition. Without a restraint signal, all the groups can respond and the ZSI group, with lowest setting, will respond first. For the unrestrained condition, a definite time curve was selected (see Figure 4). The current setting should be slightly greater than the Micrologic short time pickup for the restraint to be activated. The minimum time delay is 70 ms for the restraint signal propagation. The Sepam trip characteristic has a -10 ms / +20 ms tolerance.

The Micrologic outputs a restraint signal when the current exceeds the short time pick up setting. The short time pickup should not be set so high that it could exceed the arcing fault current. It would not be possible to utilize the ZSI feature if the feeders do not have a short time function. In the Micrologic instantaneous zone, there is no restraint output and the Sepam must coordinate with Micrologic. Note that the Masterpact frame sizes under 4000 A actually have a maximum instantaneous band of 48 ms. What is shown on the time current coordination chart is for a breaker rated 4000 A or greater.

For the restrained condition, the Sepam is set just like a conventional main to coordinate with the feeders and provide bus and transformer overload protection.

From the testing and specifications, 70 ms is the recommended minimum delay for the Sepam to respond to the restraint signal assuming worst case delays. The Sepam time delay steps are in 10 ms increments.

Figure 4
Sepam Phase Overcurrent ZSI
Setting Recommendations



Report 5051.tcc Ref. Voltage: 480 Current in Amps x 1 Report 5051.drw

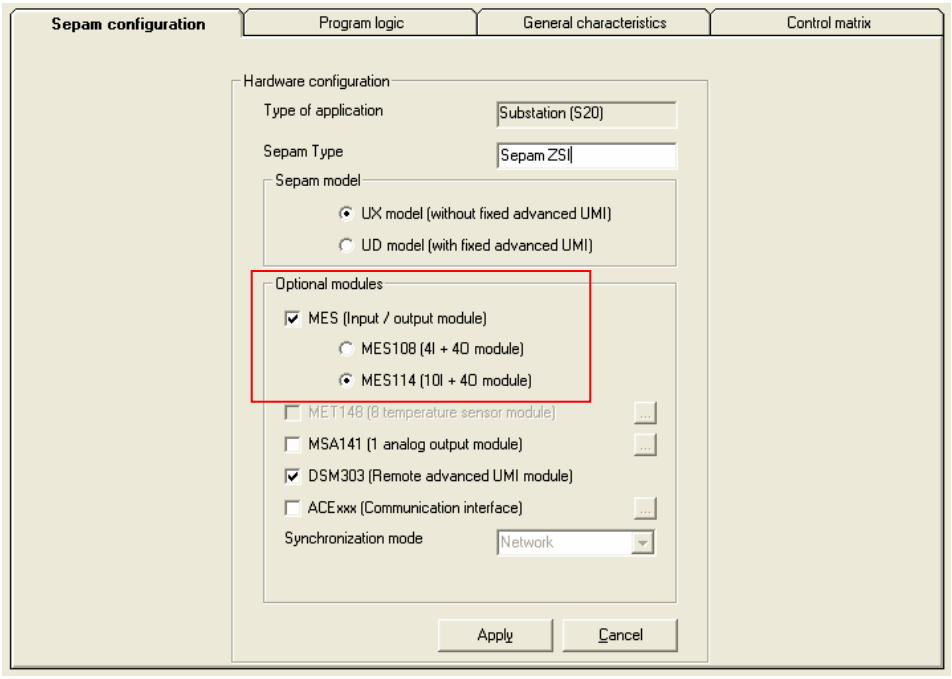
Appendix A
Bill of Material

_	Masterpact circuit breaker LV trip unit	Schneider	Micrologic 5.0 or 6.0 A, P, or H
1	Sepam relay	Schneider	Series 20, 40, or 80
1	Sepam 24 Vdc I/O module	Schneider	MES114 (series 20 & 40) (Series 80 => MES120)
1	22mm White LED Pilot Lite Body	Telemecanique	ZB4BVB1
1	22mm White Pilot Lite Head	Telemecanique	ZB4BV013
3	Current transformers		C50 minimum
1	Restraint Interface Module*	Schneider	S48890
1	DC Power Supply*	Telemecanique	ABL7 RP2405
1	Fused Disconnect Switch	Telemecanique	GS1EERU20
2	Fuses	Bussmann	FRN-15
1	Pilot Light Sign	“Zone Selective Interlocking Ready”	
100’	AWG #18 twisted pair	Belden	9409
_	AWG #12 SIS		
_	AWG #14 SIS		

* DIN rail mountable

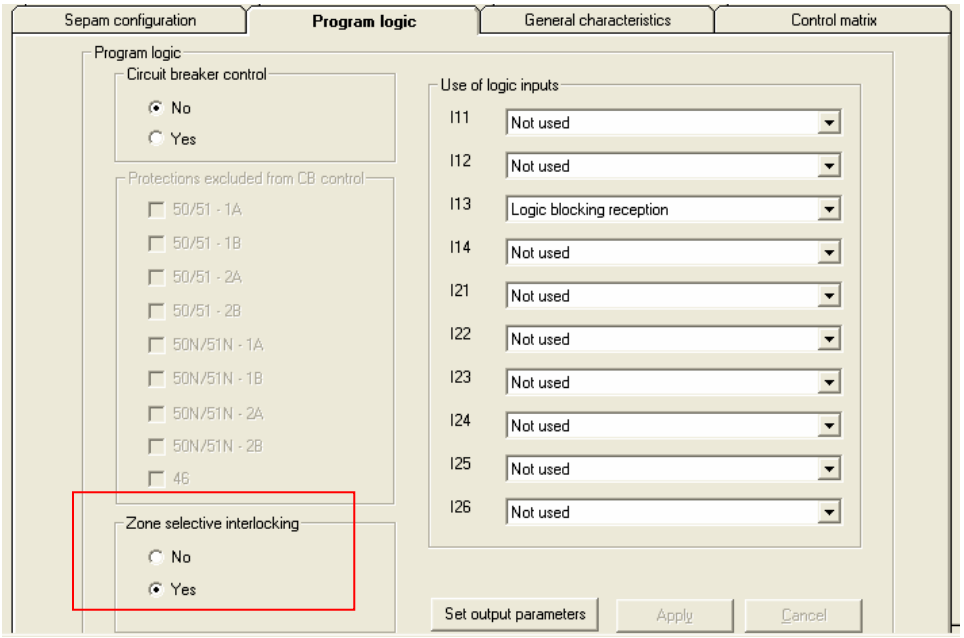
Appendix B

Sepam Programming



These are the selections for the Sepam setup.

A MES (input/output module) is required for the input of the restraint signal. Select the MES114 for 24 Vdc input.



Under the Program Logic tab select the following:

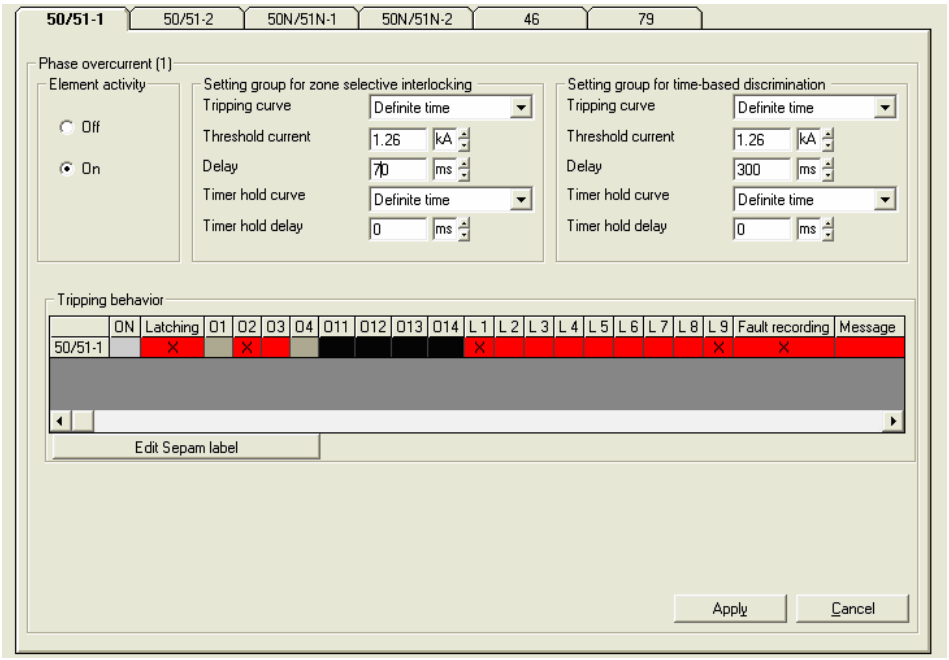
Zone Selective Interlocking → Yes

Assignment of logic inputs

I13 → Blocking reception

Assignment of logic Outputs

O4 → Yes (Watchdog) This is preset



50/51: Phase overcurrent

ZSI – When a restraint signal is sensed, the ZSI group is blocked. Without a restraint, all enabled groups can respond. Definite time is recommended with a min delay of 70 ms.

Time-based disc. – is based on the relay operating under the restrained condition. Set as the main would normally be set for proper selectivity and protection.

Appendix C

Startup Testing

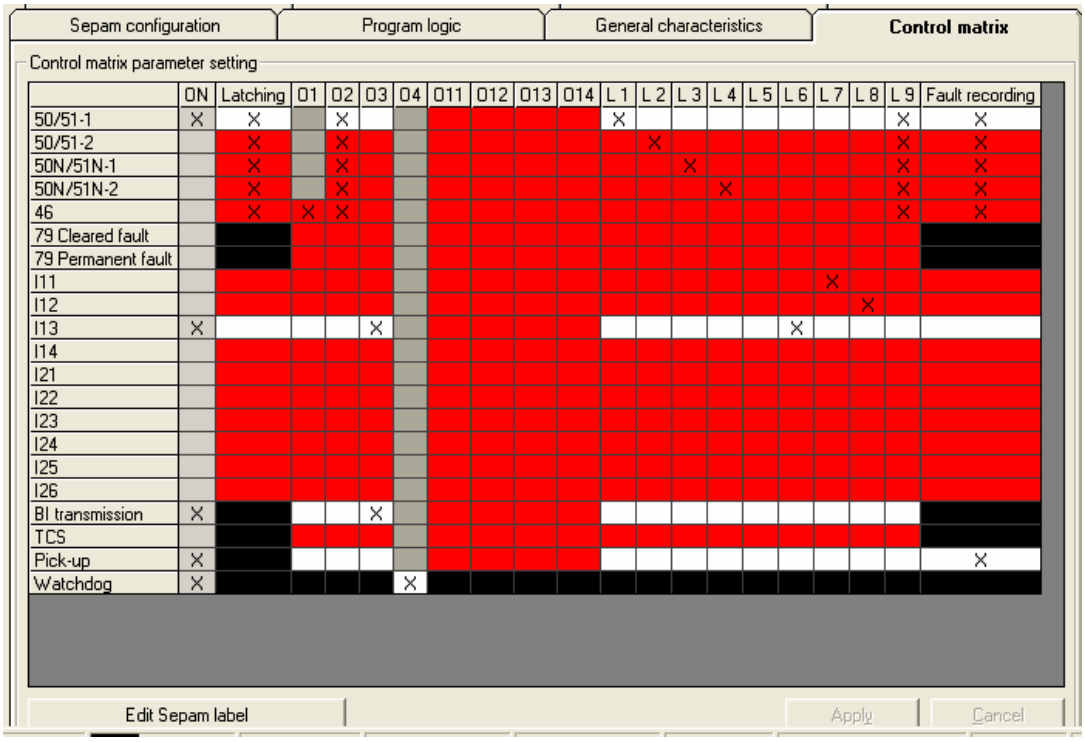
Verify Wiring

Connect the Square D Full Function Test Unit (S33595) to one of the Micrologic trip units. Configure the Sepam to illuminate one of the cover LEDs when the restraint signal input (I13) is active (See below). Simulate a restraint signal output from the trip unit with the test set (Press the "Test ZSI Function"). The ML-0 input indicator should blink, all the output indicators on the RIM should blink, and the cover LED on the Sepam should also blink. This demonstrates that the wiring between the devices is correct and the Sepam will receive the restraint signal from the Micrologic trip unit. Verify operation for each of the feeder breakers.

For a partial test only from the RIM to the Sepam, push the RIM test button. All the RIM output indicators should blink as well as the Sepam cover LED.

To confirm Sepam operation, set up secondary current injection into the Sepam. Confirm the recommended settings from the approved time current coordination study have been entered. The ZSI pickup setting should be lower than the Time Based Discrimination. Set the current injection between the two settings. Simulate a restraint signal by jumpering terminals 23 and 24 of the RIM. Inject the current. The Sepam should not trip by the ZSI group. Repeat the test with the RIM jumper removed (no restraint signal). The Sepam should trip with the ZSI group.

Remove test equipment.



Screen view showing how to program the front panel to indicate the restraint signal. In this case LED 6 is configured to illuminate when 24 Vdc is present at the ZSI input (I13).