

Considerations for Implementing a Zone- Selective Interlocking Scheme on Medium and Low Voltage Systems

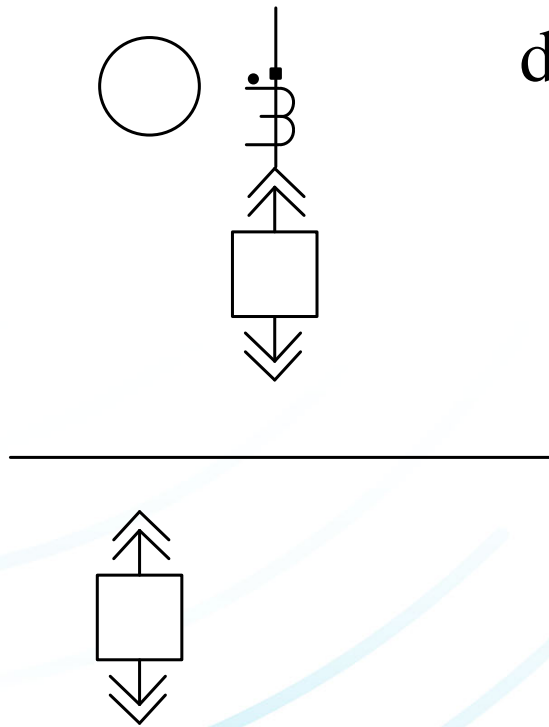
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2017 Texas A&M Protective Relay Conference

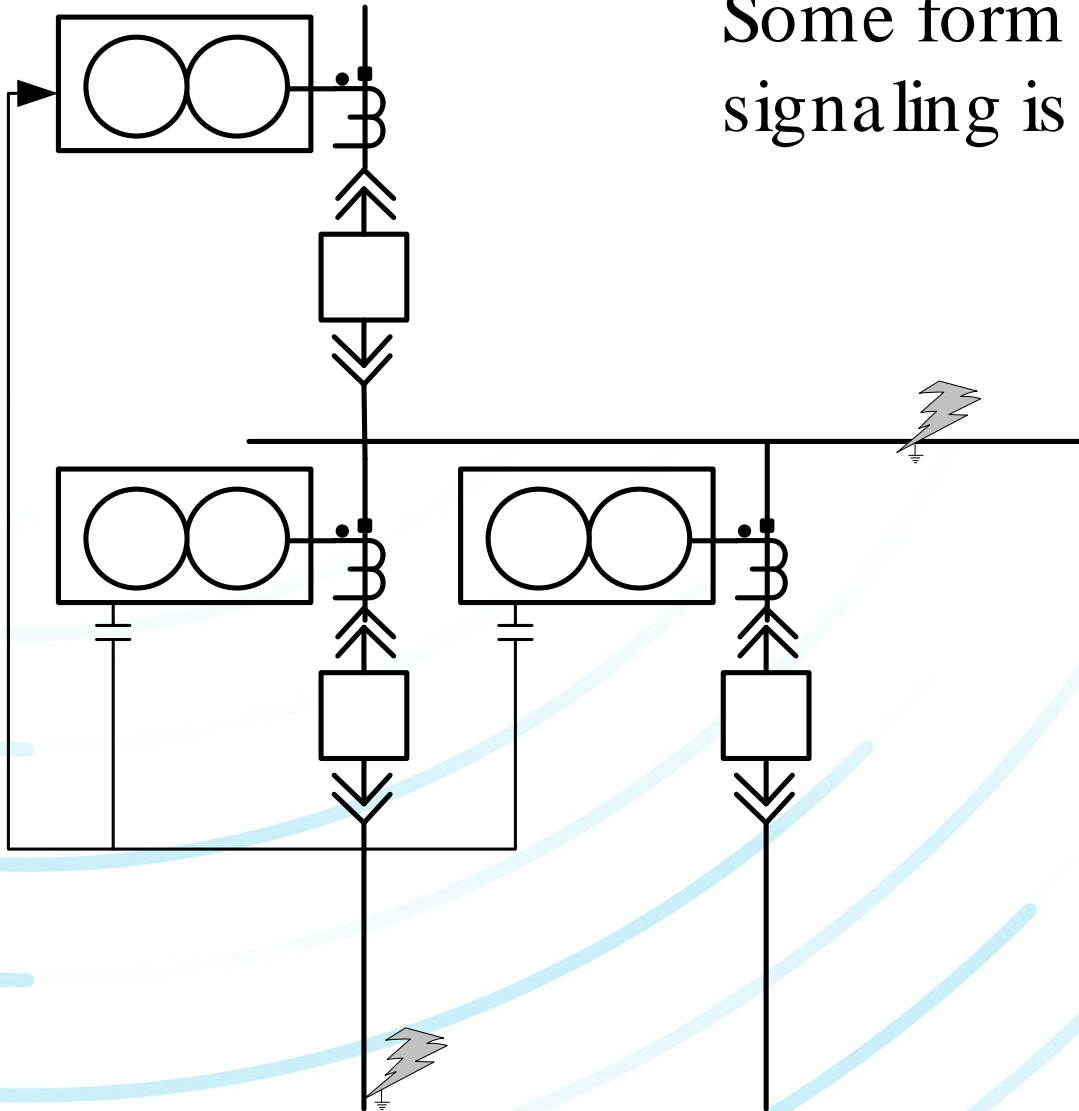
Zone-Selective Interlocking

Used when time-overcurrent delay is unacceptable.

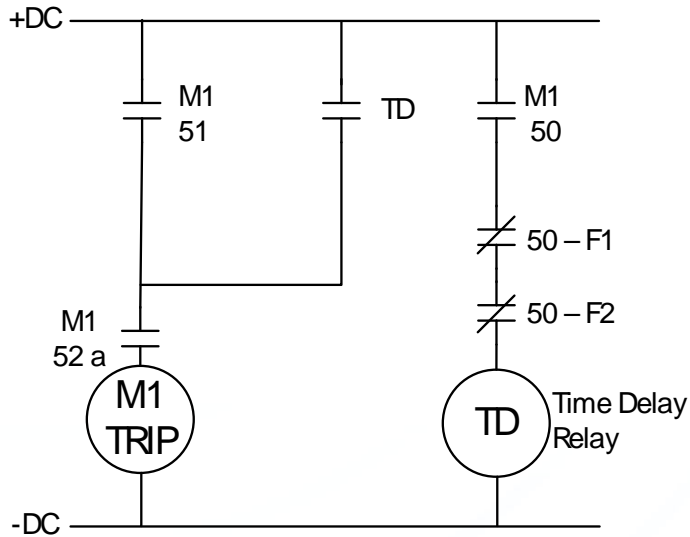


Zone-Selective Interlocking

Some form of Inter-IED signaling is required.

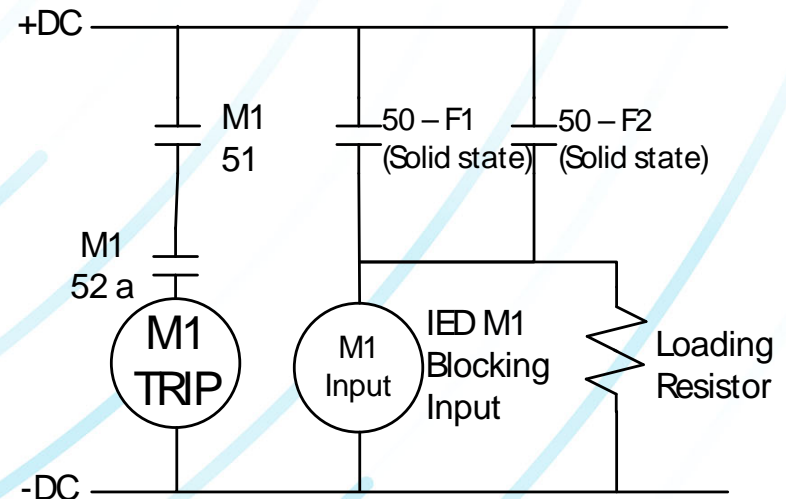


Zone-Selective Interlocking - Hardwiring

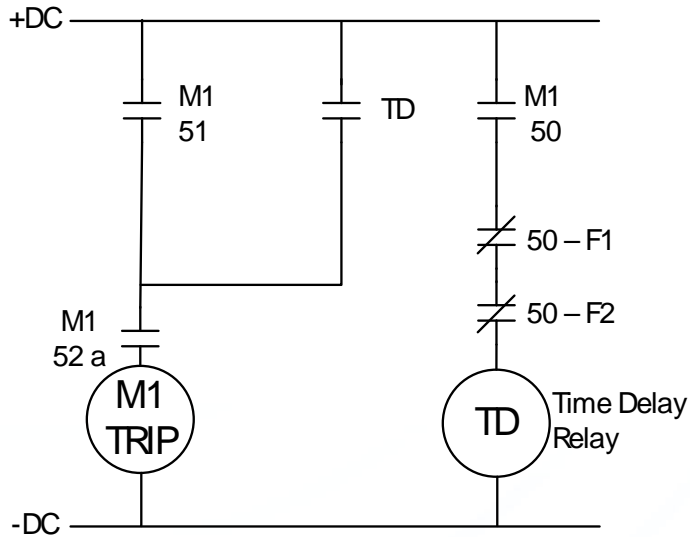


Mechanical relay contacts can take approximately 4 ms to 10 ms to operate.

Solid-state contacts can take approximately 0.1 ms to operate but have leakage current. Beware false-positives!

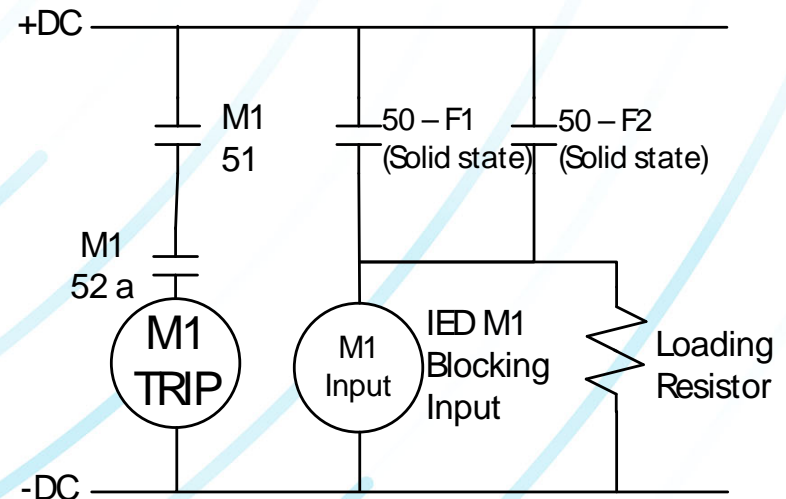


Zone-Selective Interlocking - Hardwiring

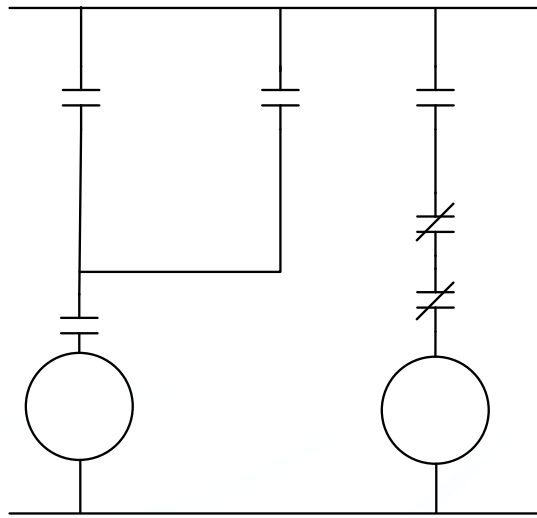


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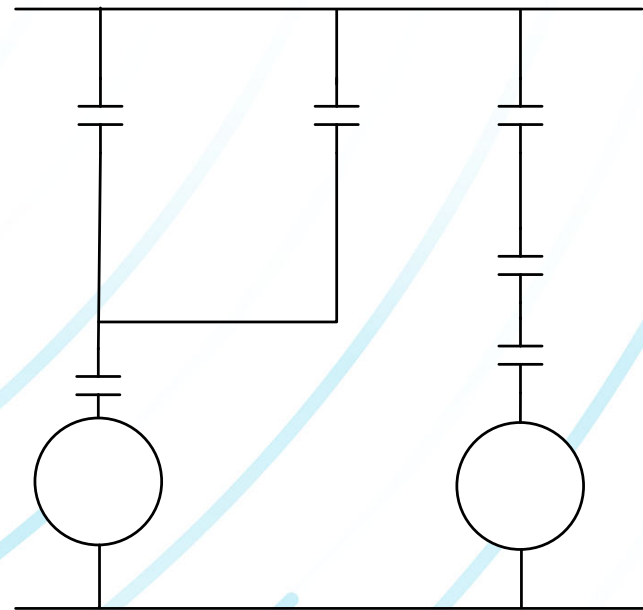


Zone-Selective Interlocking - Hardwiring

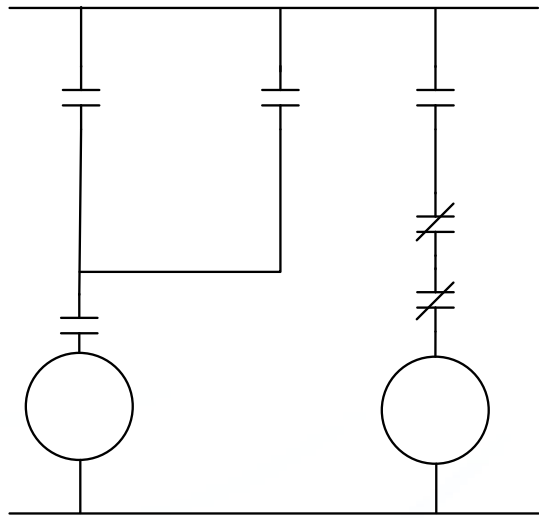


Fails into fast, non-selective mode.

Fails into slow but selective mode.

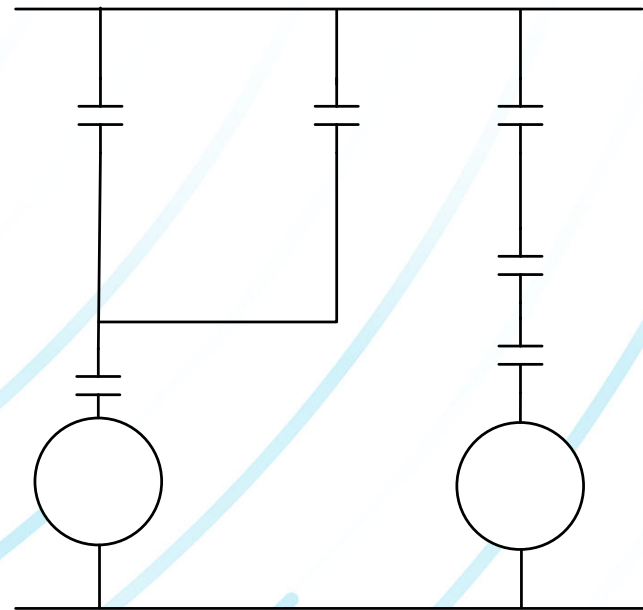


Zone-Selective Interlocking - Hardwiring

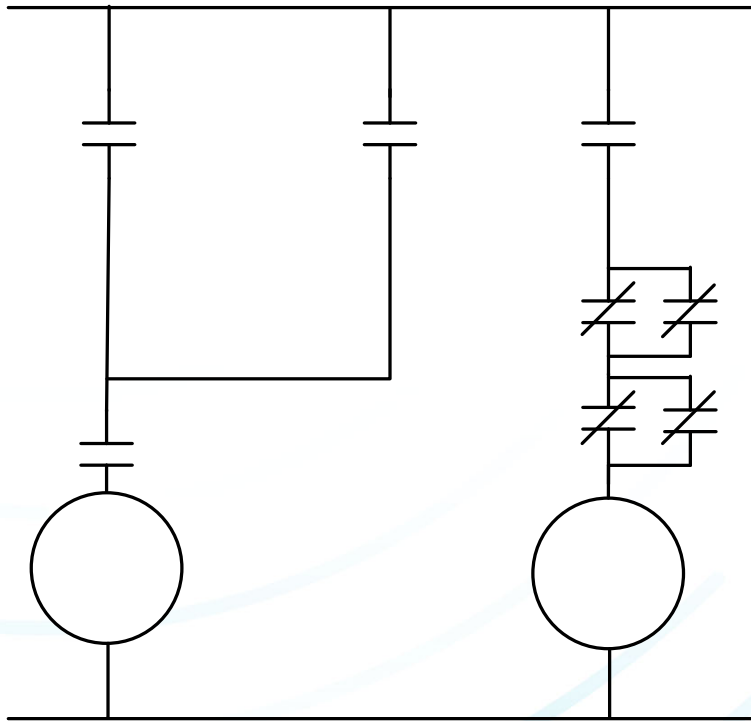


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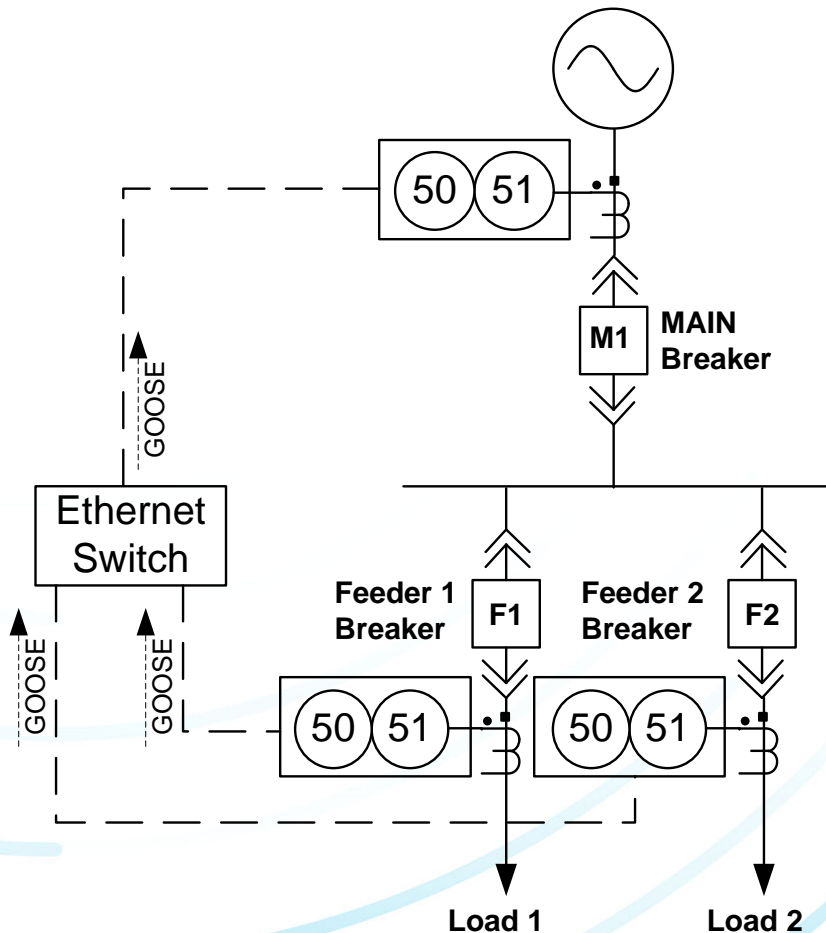


Zone-Selective Interlocking - Hardwiring



Additional logic can become cumbersome with hardwiring.

Zone-Selective Interlocking - Comms



- Communications can be used to simplify wiring.
- Count on 4ms delay for priority GOOSE messages.
- Tripping device has a finite # of devices to which it can subscribe.

Zone-Selective Interlocking - Comms

Downstream IED's
publish block &
TOC status via
GOOSE.

The screenshot shows a software interface for configuring GOOSE transmission. The main window is titled 'GOOSE Transmission' and contains several panels:

- Goose TX Control Blocks:** A tree view showing a control block 'ZSI_F1' with ID '850' and a sub-block 'F1_gcb01:F1_ZSI'.
- GooseTX Properties:** A table with the following data:

Property	Value
Control Block Name	F1_gcb01
Description	
GOOSE ID	F1_ZSI
Configuration revision	1
GoEna	<input checked="" type="checkbox"/>
- SubNetwork:** A table with the following data:

SubNetwork	Value
PORT4	<input checked="" type="checkbox"/>
VLAN-ID (Hex)	000
VLAN-PRIORITY	7
MAC-Address	01-0C-CD-01-00-01
APPID (Hex)	0001
UPDATE TIME (ms)	100
PORT5	<input checked="" type="checkbox"/>
VLAN-ID (Hex)	000
VLAN-PRIORITY	7
MAC-Address	01-0C-CD-01-00-01
APPID (Hex)	0001
Update Time (ms)	100
- DataSet Properties:** A table with the following data:

Name	Value
DataSet Name	GOOSE1
Description	
Number of DAs	2
- DataSet Elements:** A table with the following data:

	IdInst	prefix	InClass	InInst	doName	daName	fc
1	850	phs	PIOC	2	Op	general	ST
2	850		GGIO	2	Ind2	stVal	ST

Red arrows point to the following entries in the 'DataSet Elements' table:

- Row 1: 'Dataset Item #1: Blocking Overcurrent' (points to the 'InClass' column value 'PIOC')
- Row 2: 'Dataset Item #2: TOC Status' (points to the 'IdInst' column value '850')

At the bottom of the interface, there are buttons for 'Add GOOSE Control Block', 'Remove GOOSE Control Block', 'Save', and 'Cancel'.

Zone-Selective Interlocking - Comms

IEC61850 Configurator // ZSI Demo-M1.CID : C:\Users\220034475\Documents\Projects\Conference Papers\

ICD/CID Settings Reports GOOSE Reception GOOSE Transmission

IED List

- ZSI_F1
 - F1_ZSI
- ZSI_F2
 - F2_ZSI

Currently subscribed to 2 different RX GOOSES.
Max number of RX GOOSES is 8.

Id(Remote Device)	GOOSE Id
1	F1_ZSI
2	F2_ZSI
3	
4	
5	
6	

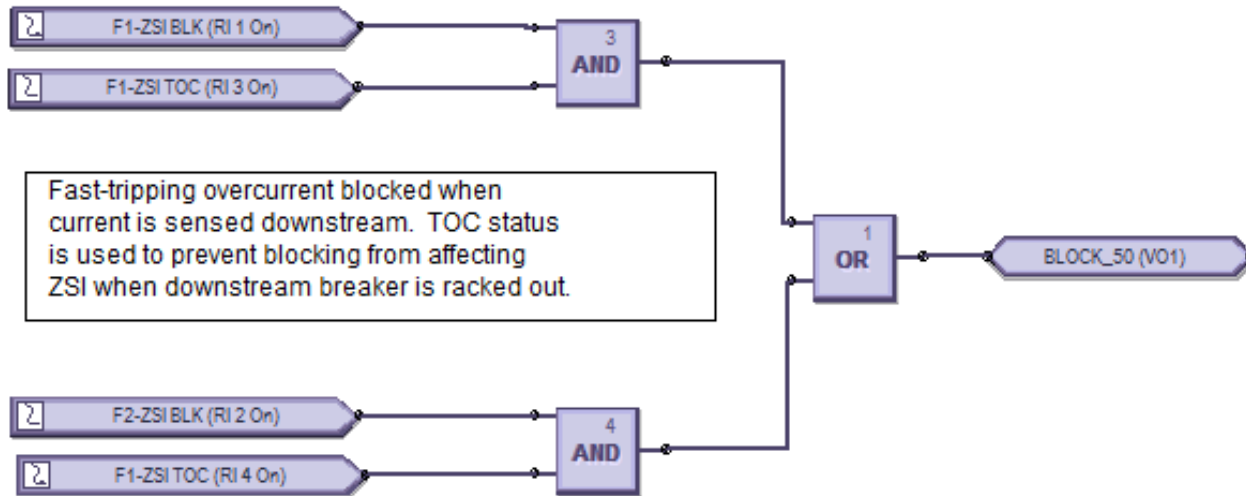
Mapping to Remote Inputs

Input	IED	LDevice	GOOSE Id	LN	Attribute	Default State
Ind1.stVal	ZSI_F1	850	F1_ZSI	phsPIOC	Op.general	On
Ind2.stVal	ZSI_F2	850	F2_ZSI	phsPIOC	Op.general	On
Ind3.stVal						Off
Ind4.stVal						Off
Ind5.stVal						Off
Ind6.stVal						Off
Ind7.stVal						Off
Ind8.stVal						Off
Ind9.stVal						Off
Ind10.stVal						Off
Ind11.stVal						Off
Ind12.stVal						Off
Ind13.stVal						Off
Ind14.stVal						Off
Ind15.stVal						Off
Ind16.stVal						Off
Ind17.stVal						Off
Ind18.stVal						Off
Ind19.stVal						Off
Ind20.stVal						Off
Ind21.stVal						Off
Ind22.stVal						Off
Ind23.stVal						Off
Ind24.stVal						Off
Ind25.stVal						Off
Ind26.stVal						Off
Ind27.stVal						Off
Ind28.stVal						Off
Ind29.stVal						Off
Ind30.stVal						Off
Ind31.stVal						Off
Ind32.stVal						Off

Default states are chosen to choose failure mode.
ON = Slow/Selective
OFF = Fast/Non-Selective

Add IED Remove IED Save Cancel

Zone-Selective Interlocking - Comms



Fast-tripping overcurrent blocked when current is sensed downstream. TOC status is used to prevent blocking from affecting ZSI when downstream breaker is racked out.

IED logic is created.

Phase IOC // ZSI Demo-M1.CID : C:\Users\ZZ0034475\Documents\Pro...

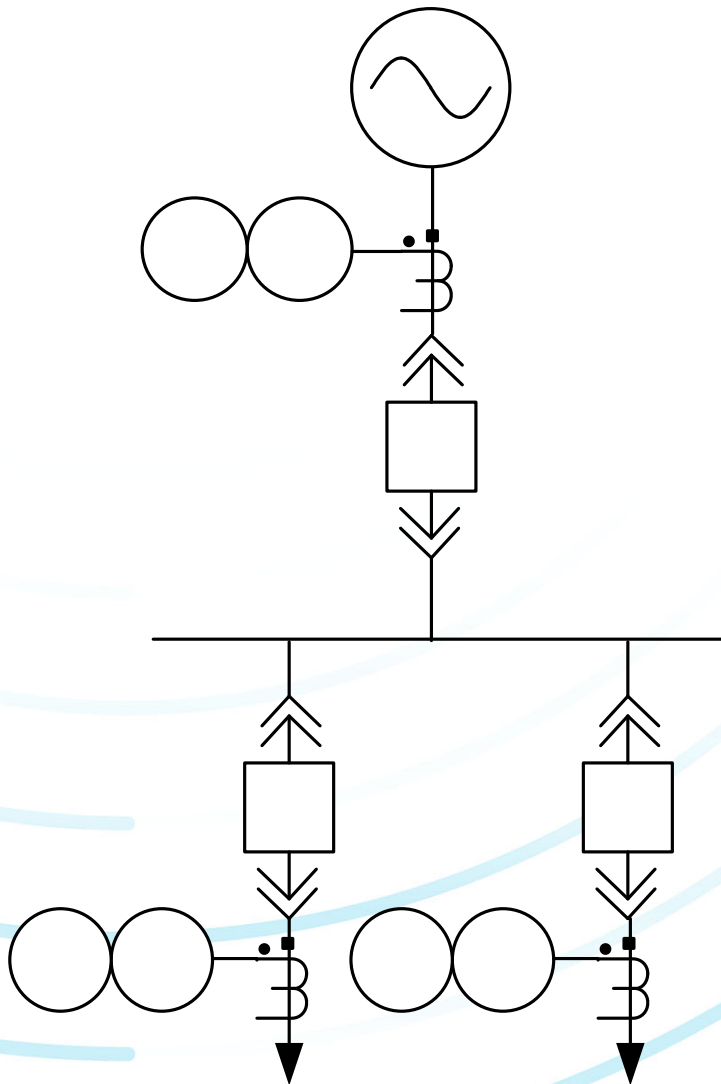
Save Restore Default

SETTING [GROUP 1]	PARAMETER
Phase IOC 2	
Function	Trip
Input	RMS
Pickup	2.000 x CT
Pickup Delay	0.100 s
Dropout Delay	0.000 s
Block	Virtual Output 1 On (BLOCK_50)
Relays	Relay : Disabled
Events	Enabled
Targets	Latched

ZSI Demo-M1.CID | Protection: Group 1: Current

Logic is applied to fast-tripping element.

Zone-Selective Interlocking - Pickups



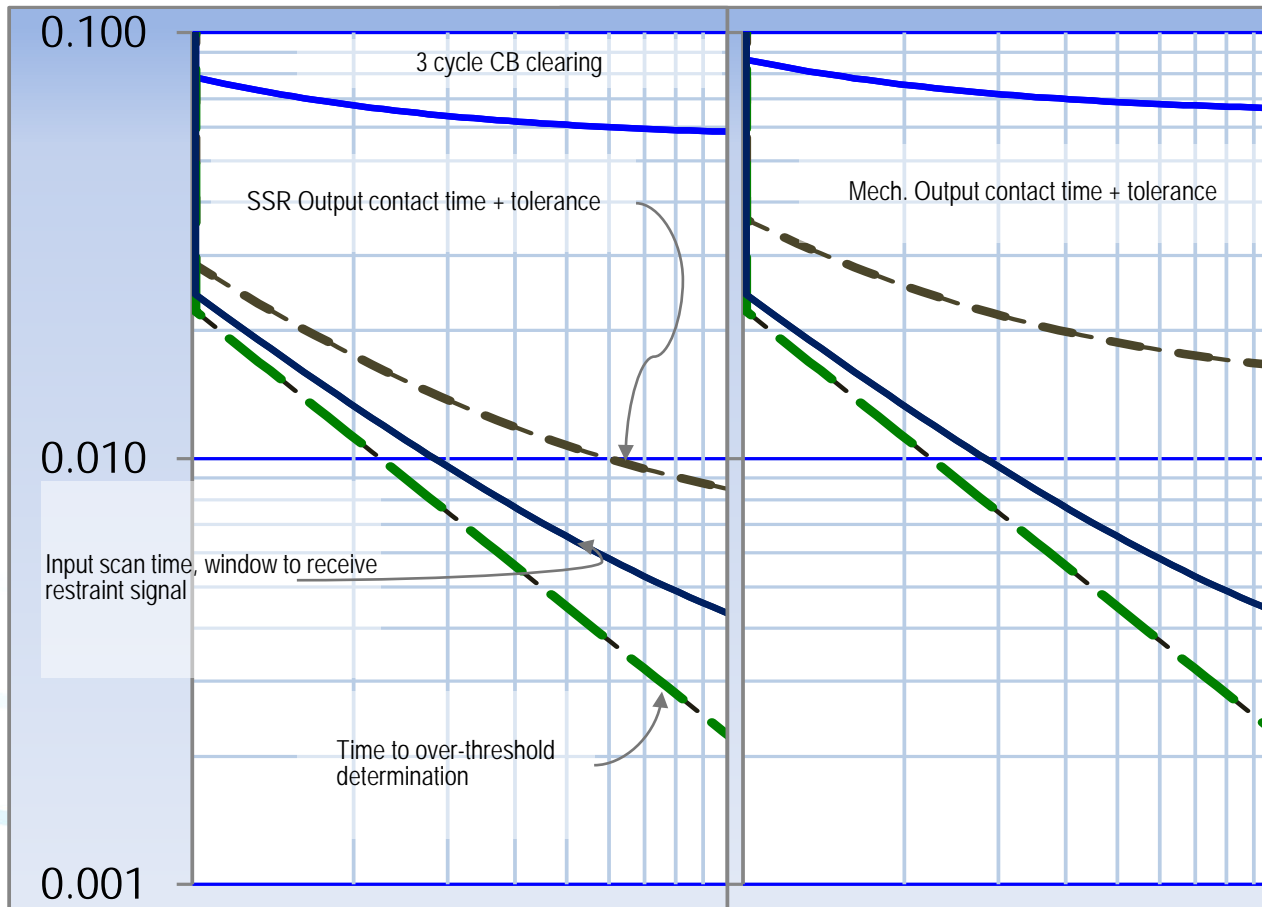
Upstream pickup must not be more sensitive than any downstream pickup.

Upstream pickup must not pick up for charging current, inrush, etc.

Downstream pickup must not have any delay!

Beware excessively high pickup settings – DSP clamping

Zone-Selective Interlocking - Timing



Left TCC shows plot for the relay's IOC algorithm, 2 ms scan time, SSR output contacts plus tolerance. Right TCC shows mechanical output contacts in lieu of SSR contacts

Tripping must be delayed to allow restraint signal.

Precise timing requires detailed info from manufacturer.

Even "instantaneous" overcurrents have a time/current characteristic.

Zone-Selective Interlocking - Timing

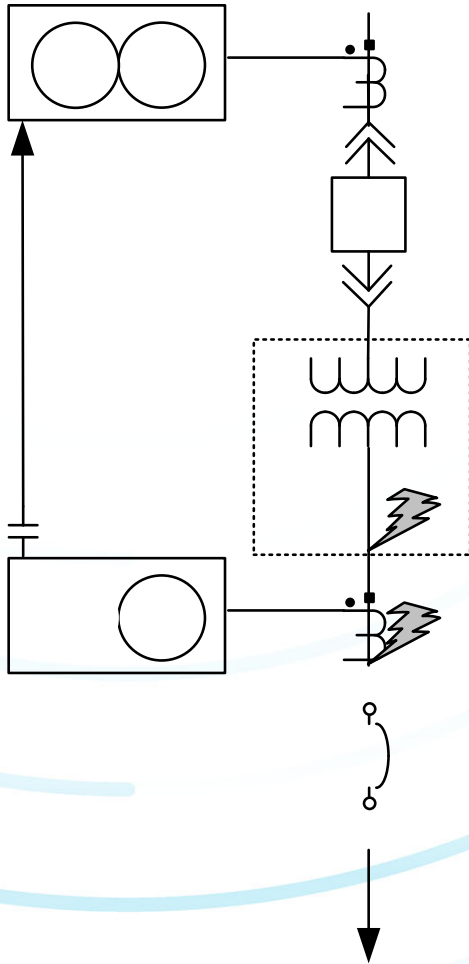
Tripping delay can be set more generally based on readily available manufacturer info.

PHASE/NEUTRAL/GROUND IOC

Current:	Phasor only
Pickup level:	0.020 to 30.000 pu in steps of 0.001
Dropout level:	97 to 98% of pickup
Level accuracy:	
0.1 to 2.0 × CT rating:	±0.5% of reading or ±0.4% of rated (whichever is greater)
> 2.0 × CT rating:	±1.5% of reading
Overreach:	<2%
Pickup delay:	0.00 to 600.00 s in steps of 0.01
Reset delay:	0.00 to 600.00 s in steps of 0.01
Operate time:	<16 ms at 3 × pickup at 60 Hz (Phase/Ground IOC) <20 ms at 3 × pickup at 60 Hz (Neutral IOC)
Timer accuracy:	±3% of operate time or ±1/4 cycle (whichever is greater)

Always weigh the benefits and risks when setting the delay. Cost of false-operation vs. Benefit of reduced 20 ms clearing time?

ZSI Challenge #1: Transformer In-zone



Harmonic Detection // ZSI Demo-M1.CID : C:\Users\220034475\Docume...

Save Restore Default

SETTING	PARAMETER
Harmonic Detection 1	
Function	Configurable
Harmonic	2nd
Pickup	20.0 %
Pickup Delay	0.000 s
Phases for Operation	Any Two
Minimum Oper Current	0.80 x CT
Block	Off
Output Relays	Relay : Disabled
Events	Enabled
Targets	Self-Reset

F1-ZSI BLK (RI 1 On)

F2-ZSI BLK (RI 2 On)

Fast-tripping overcurrent blocked when current is sensed downstream.

Fast-tripping overcurrent blocked for harmonic content conducive to magnetizing inrush.

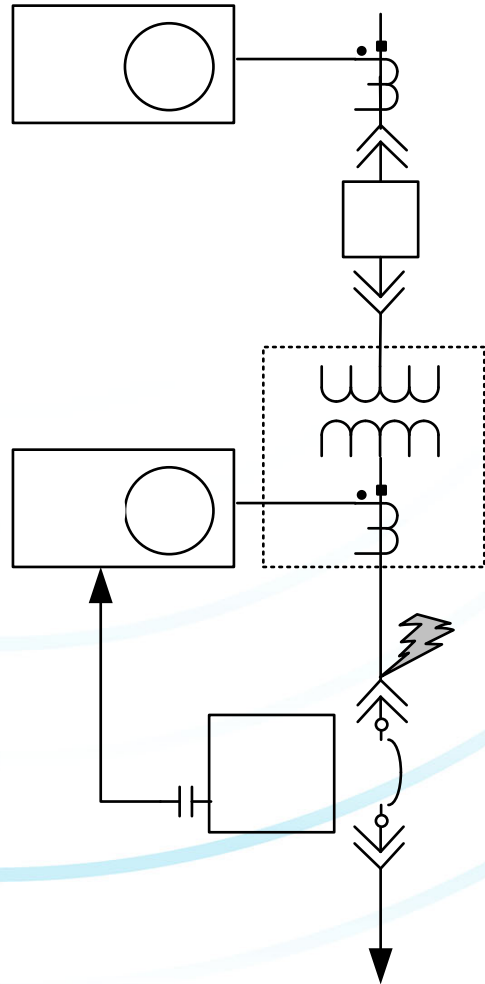
Harm Det 1 OP

OR

BLOCK_50 (V01)

2nd Harmonic detection can be used to address inrush.

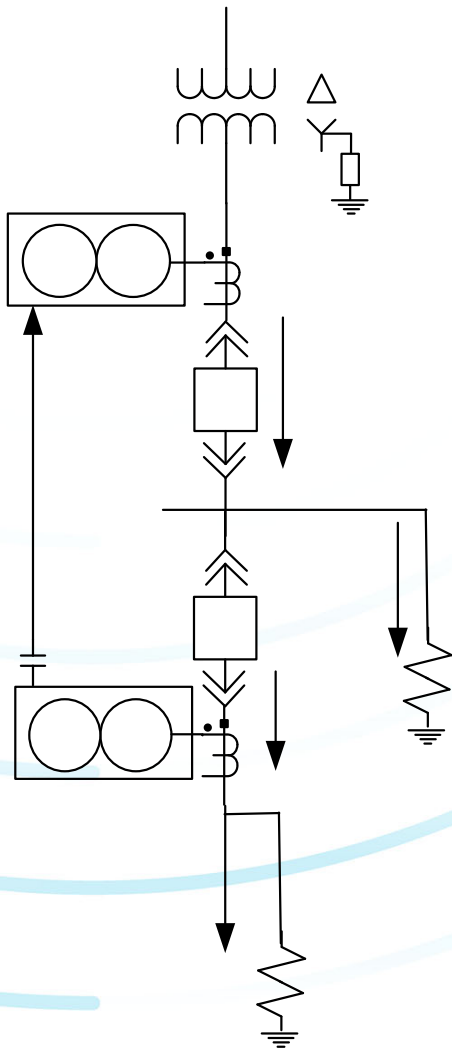
ZSI Challenge #1: Transformer In-zone



This implementation can expedite tripping for F1.

It is important for the LV IED CT's to be removed from the F1 protected area.

ZSI Challenge #2: Simultaneous Faults



Stress of 1 fault can cause a simultaneous fault.

Under very specific circumstances, the blocking relay would prevent the tripping relay from operating fast.

Normally, fault current would be re-directed into upstream fault so block would be removed.

Conclusions

- ZSI is a longstanding technology that can be used to expedite otherwise slow time-overcurrent protection.
- The scheme can be implemented in many different ways. Consider the failure mode of the scheme.
- Transformer inrush and simultaneous faults offer challenges to ZSI implementation.
- Choose your ZSI timing carefully.

Thank You

Questions?