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Generic Distance Relay Model for
the Western Electricity Coordinating Council

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WECC Modeling SPS and Relays Ad-Hoc Task Force (MSRATF)

Date: October 4, 2013

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1 Introduction

1.1 Background

In May of 2012, the Federal Energy Regulatory Commission (FERC) and North American Electric Reliability Corporation (NERC) issued a joint report on the September 8, 2011 Southwest Blackout Event calling for improved planning. It recommended that entities throughout WECC identify and plan for external contingencies that could impact their systems and internal contingencies that could impact their neighbors' systems, and expand entities' external visibility in their models through, for example, more complete data sharing.

To achieve WECC wide visibility of contingencies in planning and operating the Modeling SPS and Relays Ad-Hoc Task Force (MSRATF) was created by TSS to develop and/or implement models for Remedial Action Scheme (RAS), relays and contingency definitions in WECC base cases, in BCCS, and in cases that are consistent with the West-Wide System Model (WSM). This task force will also coordinate with the RAS and Protective Systems Modeling Oversight Task Force (RPSOTF).

It is envisioned that transmission planning engineers will begin to more completely model automatic actions in their simulations. This will include an emphasis on modeling relays and remedial action schemes within the modeling software environment.

1.2 Value

The current methodology in the contingency list development involves creating actions which are believed to represent the automatic actions of the relays. With the current methodology assumptions are made on the timing of the action. Implementing relay models will improve both the accuracy of actions and timing in the contingencies. A contingency list will no longer need every action of the relay defined. Rather, the contingency list will only require the application of the fault. Also, the assumptions in the contingency list made on the timing of the actions will no longer be needed.

Data sharing between entities throughout WECC will also be slightly simplified. When relays are modeled throughout the cases, any person can apply a fault to a line anywhere in the Western Interconnection and see the appropriate actions taken. Currently, the contingency list would need to be shared amongst the entities.

2 Purpose and Scope of Specifications

The intended purpose of this document is to specify a generic model of a distance relay to be used by WECC in both powerflow and stability studies for three phase faults. This specification is to be approved by MVWG and TSS. Software developers are to implement this model and the model is to be approved by the WECC MVWG and TSS for use in dynamic and powerflow simulations in accordance with various NERC standards.

3 Purpose and Scope of Model

The distance relay model is intended to model the basic automatic actions taken by a relay when a fault occurs on a transmission line. There are several existing distance relay models for three phase faults available in the GE, PTI, and PowerWorld software. These models adequately represent distance relay models but limit themselves to specific scenarios. This document will describe a new distance relay model that will combine and mimic the functions of the ZLIN1 and DISTR1 distance relay models. However, instead of being applicable to only certain scenarios, the model will be generic and usable for most scenarios. As part of the specifications, the parameters entered into this model should take little time to translate from the relay data sheets to this model.

This model will be based on a modular design philosophy which incorporates sub-models to increase its flexibility and functionality. Sub-models developed for the distance relay can be used for other relay models as well. The main model itself does not need to include all the functionality, but with additional sub-model specifications improvements can be developed when the need arises. Using this approach will lend itself to a more phased-in approach as well. As more functionality is added with the sub-models, then they can be approved accordingly without having to change the main model.

4 Existing Relay Models

There are existing dynamic distance relay models available in GE PSLF, Siemens PSS®E, and PowerWorld. The existing models each have limitations on their application.

Implementation of distance relay models in dynamic simulations with the existing models would require the use multiple relay models. The appropriate model would depend on each specific scenario. The generic distance relay model described in this specification will have the capabilities necessary to fit most scenarios. This will simplify the implementation of distance relay models in the sense that only one model will be necessary.

Below is a summary of three of the existing models and the constraints to their application.

ZLIN1	PSLF	No transfer trip capability; No load encroachment function; No blinders
DISTR1	PSSE	Transfer trip capability, but requires input parameters for both end of line if no transfer trip; No load encroachment function; Limited blinder functionality; no out of step functionality
ZPOTT	PSLF	2 zones of protection; Assumes transfer trip; No load encroachment function; No blinders

5 Specification of Distance Relay Standard

The new relay model will be named **DISTRELAY. DISTRELAY** will be calling the following sub-models to simplify and increase functionality of the distance relay model. The following are the new relay sub-models that are the modular portion of the distance relay:

- **ZONEDEF** for Zone Definition / Description
- **BLINDERDEF** for Blinder Definition
- **LOADEN** for Load Encroachment function
- **TTSCHEME** for Transfer Trip Scheme functionality

5.1 Block Diagrams

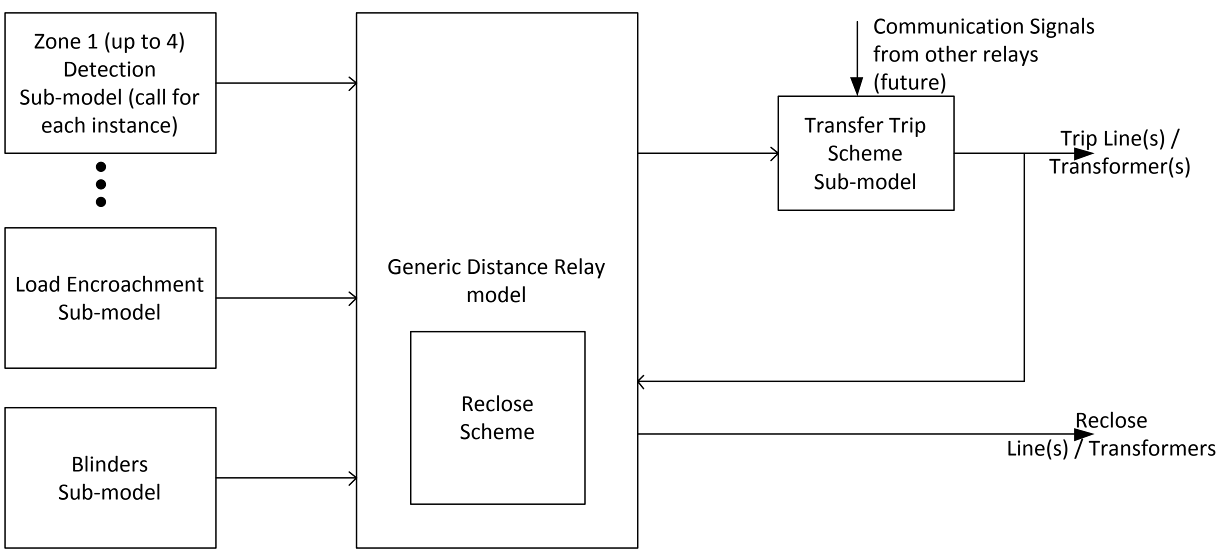

Figure 5-1: Distance Relay Model Block Diagram

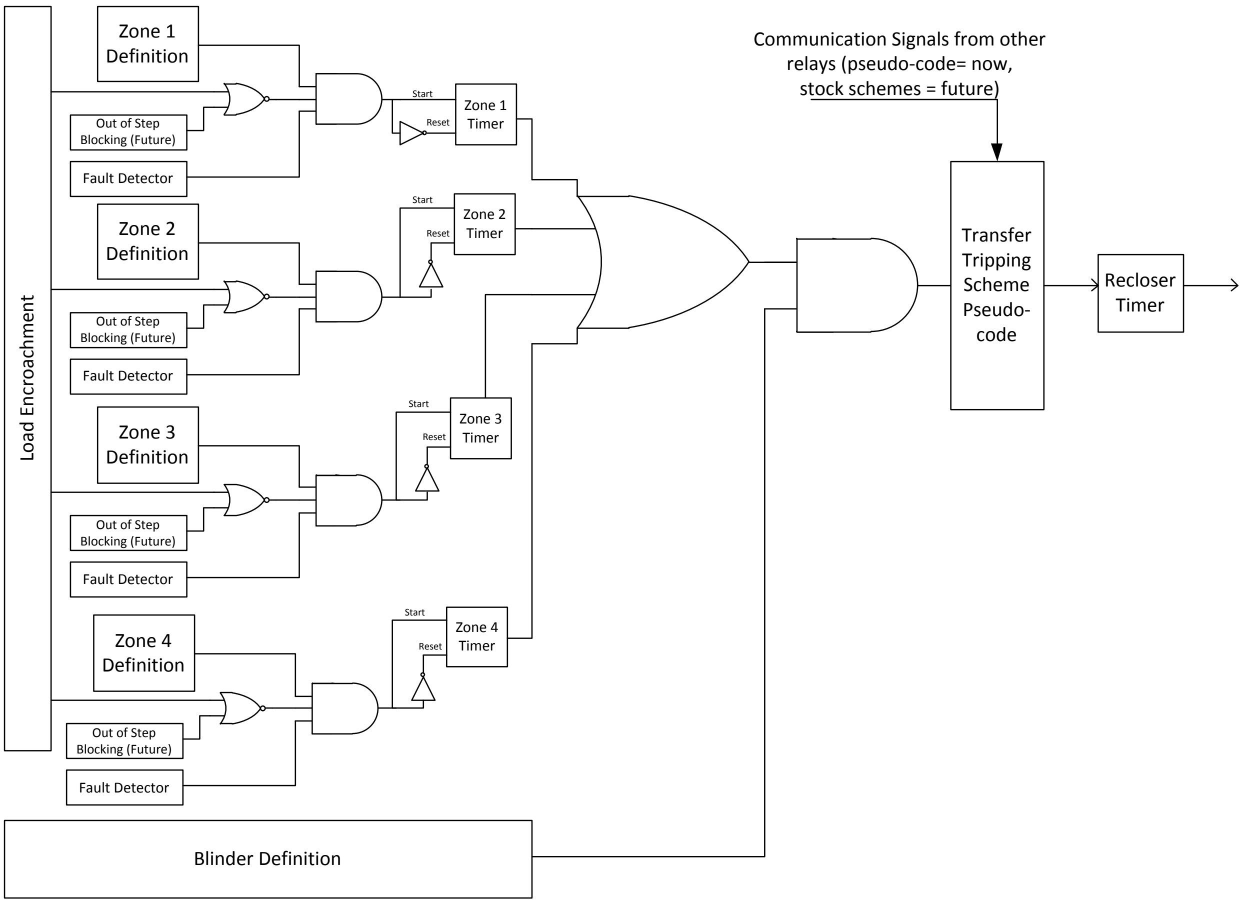

Figure 5-2: Distance Relay Detail Logic Block Diagram

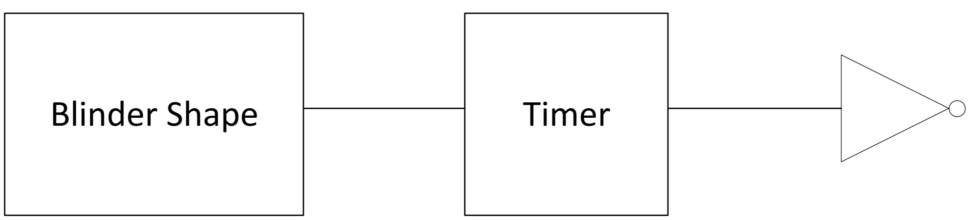

Figure 5-3: Blinder Definition Logic Block Diagram

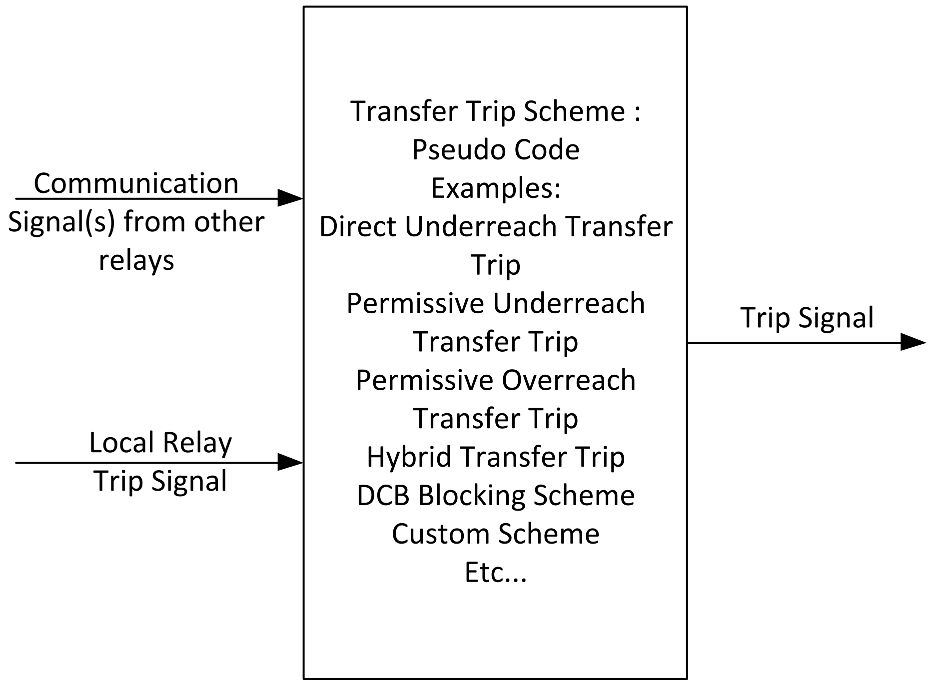

Figure 5-4: Transfer Trip Scheme Definition Logic Block Diagram

5.2 Branch Specification

DISTRELAY will be assigned to a specific end of a branch (*From* or *To* End). As shown in Figure 5-5, the **Nf** parameter corresponds to the bus number where the relay is located at. The **Nt** parameter corresponds to the bus number opposite end of the branch the relay is ***not*** located at. The **Far Bus** corresponds to the end of series of branches that this impedance relay is looking toward. If there are no other buses between **Nf** and **Far Bus** then the **Nt** and **Far Bus** would be the same.

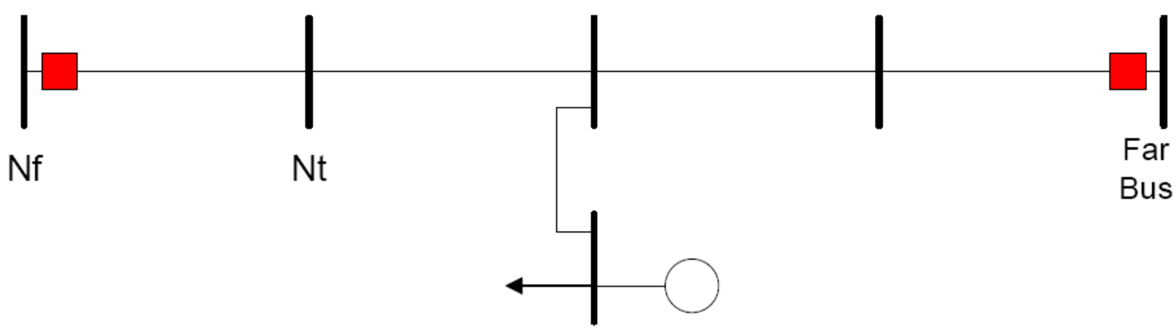

Figure 5-5: Branch Specification Parameters

5.3 Relay Operation

There are several fundamental parameters for **DISTRELAY** and the sub-models associated with it. A brief explanation of these parameters is provided in the following sections.

The zone characteristics (with load encroachment and blinders modifiers) and branch trip specifications should be able to be exported to the power flow simulations and have the program check to see if the loading of the line will enter the characteristic curves of the distance relay and report that it is within the zone and can trip the relay / line.

5.3.1 Distance Relay Model

DISTRELAY is the main model that calls on the individual sub-models to enable it to have the flexibility to emulate the options of electromechanical and digital relays have. The functionality of **DISTRELAY** is to house the main function of taking in all the detection parameters from the sub-models and then implement the necessary logic to trip or not to trip the line(s) / transformer(s). Parameters for DISTRELAY are described in the table in Section 5.4.1.

Per the TPL Standards, simulating normal clearing is part of the study process but part of the standards calls for simulating delayed clearing as well. With the **DISTRELAY** model there should be the ability in the dynamic simulation program to have the relay "fail to detect" and have zone 2 or 3 of another relay to clear the fault.

The software implementation should include a flag with each particular relay which puts that relay in a monitor only mode. For **DISTRELAY** the parameter is called "**No Trip**". When in monitor only mode, the report will indicate the lines that would have tripped, the relay that would trip them, and its zones that that would trip them, but the relay will not actually trip any lines.

The **DISTRELAY** model includes the ability to reclose transmission lines after a specified amount of time for zone 1 faults. The input parameter, **Self Reclose**, is a time (in cycles) which will tell the relay when to send a close signal to the breaker at the relay location after the branch has tripped. There is also the ability to reclose the remote end of the line with parameter **Reclose Remote End**. The timing for closing the remote end will use the self reclose timer that the remote end has and it is initiated by the near end. When **Self Reclose** and **Reclose Remote End** are both enabled (set to 1) all buses and branches (see Figure 5-5) that have been opened are reclosed and returned to in-service.

The reclose functions are disabled when the **Self Reclose** and **Reclose Remote End** input parameters are set to 0.

5.3.2 Zone Parameters

Distance relays operate based on the apparent impedance at the relay location with respect to the zones defined. The **DISTRELAY** model calls up to four instances of **ZONEDEF** for defining zones of protection. And, for each instance the **ZONEDEF** sub-model defines the shape and direction of the zone of protection with up to three shapes that can be combined with logical operators AND, OR, and NOT. The timer for each zone instance is defined in the **DISTRELAY** main model (in cycles).

The input parameters for the **ZONEDEF** reach include: **Wt** (Width total impedance)**, Rr** (reverse reach impedance), **Operator** (logical), **ZoneAng** / Maximum Torque Angle (angle), **ZoneDir** (forward or reverse direction), and **InternalAng** (shape). The shape of the zone can be specified in the **shape (#)** parameter. There is a shape parameter input for each zone. An input of '0' means circle, lens or tomato and this is further defined by the **InterAng** parameter. An input of '1' means quadrilateral (rectangle). With specifying the shape, the width can also be specified by the **Wt** input and the **Rb** parameter for the quadrilateral shape. An input of '2' means Reactance Distance which is a horizontal line. An input of '3' means an Impedance Distance which is a unit circle centered at the origin in an ohm characteristic. **InterAng** is defined as the following: greater than 90˚ then it is a lens shape, equal to 90˚ then it is a circle, less than 90˚ then it is a tomato shape. Zone reach input values should be in Primary Ohms[1], and the angle should be in degrees.

Wt is not a preferred Protection term so here is the equivalent Protection terms:

Forward Reach = ZnF ~ Wt – Rr
Reverse Reach = ZnR ~ Rr

These parameters are described in Figure 5-6 and in the table in Section 5.4.2.

[1] Primary Ohms is the actual impedance of the zone in the direction of the zone regardless of voltage or MVA base. This can be a source of error because converting to per unit without knowing exactly the voltage base would result in data error. Secondary Ohms are not used because it keeps the settings independent of the CT and VT ratios. However, actual relay settings are usually specified in secondary quantities, which must be converted to primary quantities for input to these Planning programs.

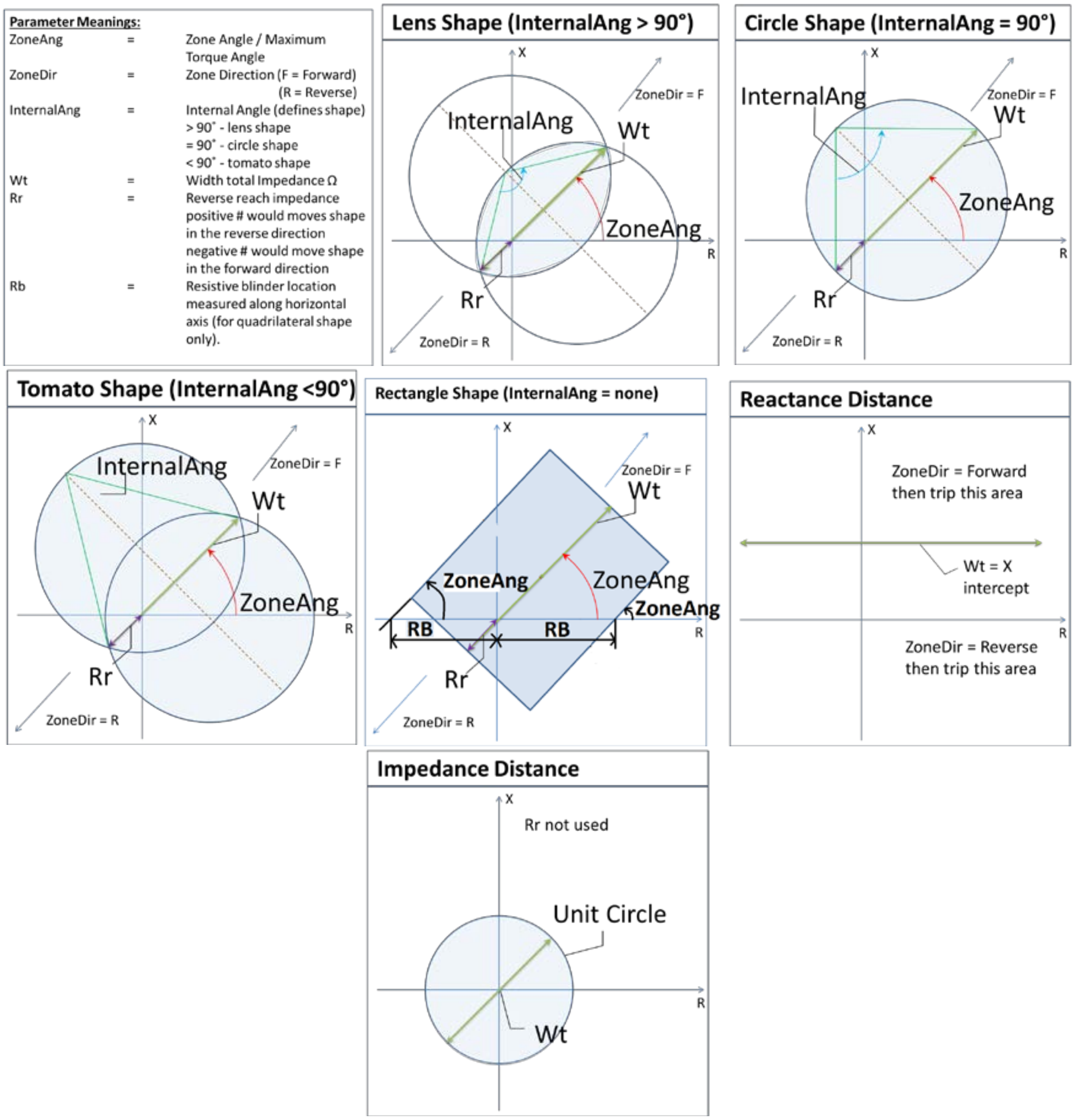

Figure 5-6: Shape Specification Parameters

For the quadrilateral shape in Figure 5-6, the parameter ZoneAng is shown three times to illustrate the fact that "Wt", the forward reach vector, and both the resistive blinders are all inclined at the same angle with respect to the horizontal (resistance) axis[2].

[2] Several digital relays allow the resistive blinder positions (RB) to be set independently in the positive-R and negative-R directions. Further, the angles of inclination for the resistive blinders can be set independently, and therefore, differently from the ZoneAng parameter. This extension may be implemented in a future revision of this specification.

Each of these zone shapes can be logically AND, OR, and NOT with other shapes to mimic the capability of the existing distance relays today as shown in Figure 5-7.

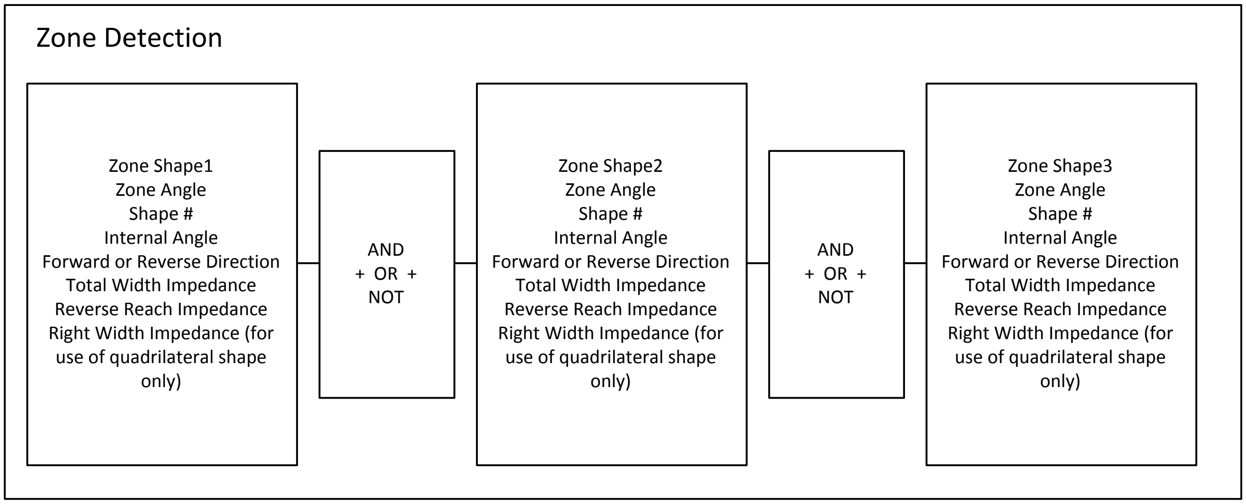

Figure 5-7: Combining Zone Shapes Specification Parameters

Each zone will have a **Fault Detection** parameter in **DISTRELAY** that corresponds to the current (in Primary Amps) at which the relay determines that the rise in current is not a fault. This value can be either a line current or a line-to-line current selectable[3].

For 0Ω three-phase faults close-in to the relay, the measured voltage will collapse to zero in all three phases (and therefore, in the positive-sequence). The measured impedance will be zero for this "forward" fault. It will also be zero for a bus fault directly behind the relay, a "reverse" fault. The relay model should use appropriate techniques to correctly discriminate fault direction and operate or not according to the following:

- Forward direction zone: Operate for the "forward" 0Ω fault and not operate for the "reverse" 0Ω fault
- Reverse direction zone: Not operate for the "forward" 0Ω fault and operate for the "reverse" 0Ω fault

5.3.3 Transfer Trip Scheme

Protection schemes often vary depending on the type of communication on the transmission lines being protected. Therefore, the **DISTRELAY** model will call on the sub-model **TTSCHEME** to determine when to trip and when not to trip. After the sub-model **TTSCHEME**, the **DISTRELAY** would have the ability to trip for up to five lines per relay model (more can be added if need is shown). The branches that can be opened by the actions of the specific relay are defined in the **Trip (#)** parameter, this is also known as the Trip Bus (Protection term).

Seeing that there are many variations of the transfer trip schemes such as Direct Underreaching Transfer Trip, Permissive Overreaching Transfer Trip, Hybrid Transfer Trip, etc…, the best way to create flexibility is to have the ability to write the code to describe the appropriate scheme with inputs from the zone definitions on the other side of the line(s), timers, and logical operations (which will be modeled after

[3] Most GE relays have this value as the single phase line current and SEL relays have this value as phase to phase line current. This function is added to keep the "translation" of relay data sheets to a minimum.

the RAS specification for the code and be part of the future revision) then perform the appropriate function of how to trip the necessary lines. If there is none, then it is called the Step Distance Trip Scheme.

5.3.4 Blinders

The **DISTRELAY** model will call the sub-model(s) **BLINDERDEF** that has the capability to implement blinders. These blinders can be used as part of shaping the zone shape and it can also be used as part of the out of step blocking. There will be 4 blinders that can be defined. There are 2 available blinder types which are specified in the **1st blind type** and **2nd blind type** parameters. There are also 2 additional parameters for each blinder type specified. The **blind int** corresponds to the blinder intercept (in Primary Ohms). The **blind rot** corresponds to the blinders rotation (in degrees). Figure 5-8 identifies the input parameters in diagrams. The shaded area is the part of the blinder that allows the tripping function.

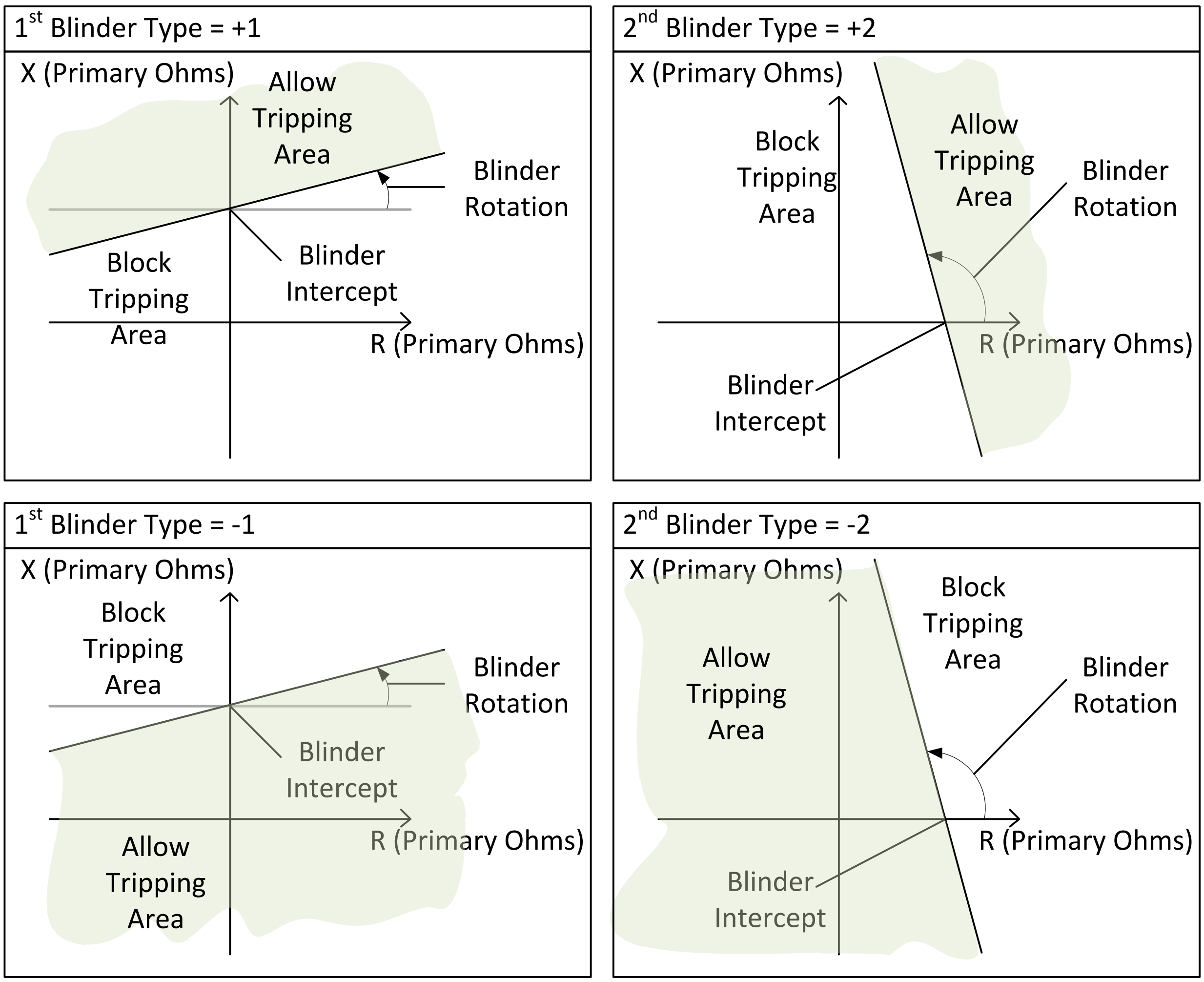

Figure 5-8: Blinder Specification Parameters

5.3.5 Load Encroachment

The load encroachment function is deployed due to load getting near or even exceeding the **DISTRELAY** setting in absence of a fault along the line. Relay manufacturers would let the Protection Engineers to "notch out" part of the zone shape so that when loading of the line reaches that portion of the characteristic zone shape then the load encroachment would block the relay so it does not trip.

The **LOADEN** sub-model has the following parameters **FREACH** (forward impedance) **RREACH** (reverse impedance), **PLAF** (positive forward load angle in degrees), **PLAR** (positive reverse load angle in degrees)**, NLAR** (negative reverse load angle in degrees)**,** and **NLAF** (negative forward load angle in degrees)**.** Of note, some relay models just have REACH and the same angle for **PLAF, PLAR, NLAR,** and **NLAF**. Figure 5-9 describes each of these parameters.

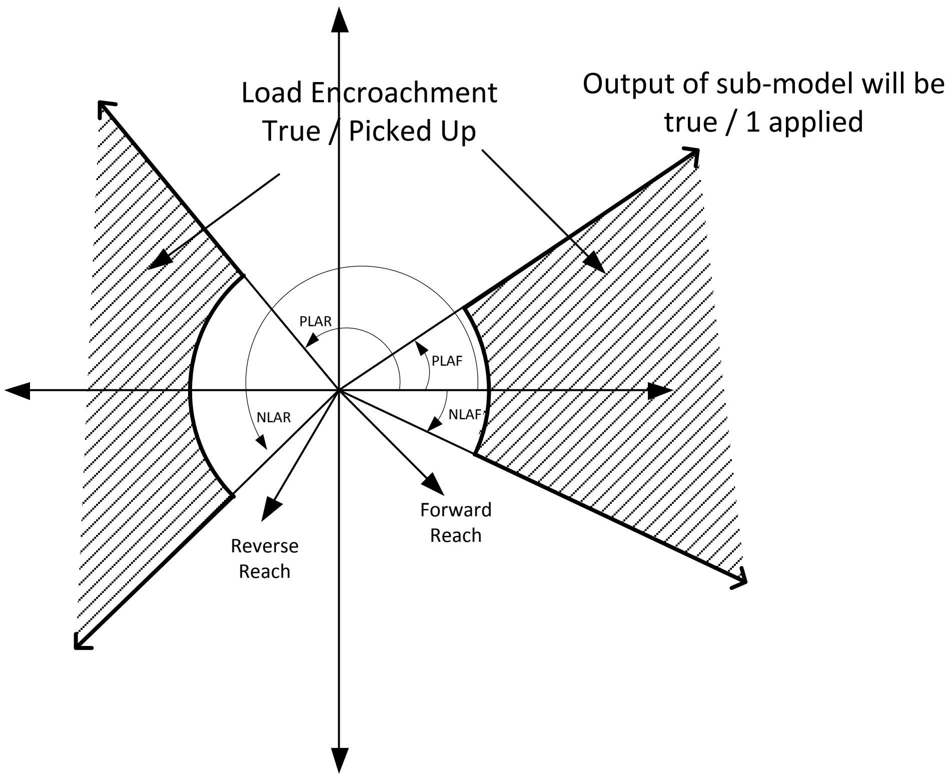

Figure 5-9 : Load Encroachment Description

5.4 Input Parameters

5.4.1 Distance Relay Model Parameters (DISTRELAY)

PARAMETER	TYPE	DESCRIPTION
Nf		The bus where the relay is located.
Nt		The bus at the other end of the line the relay is located on.
Ckt#		Circuit number of line
Far Bus		This relay will only trip the end of the branch specified by the **Device Location**. The Far Bus specifies the other end of a series of branches that this impedance relay is looking toward. This parameter has no functional purpose in the stability run. It is only provided so that various GUI features which show the percentage reach of the relay can automatically sum up the series of impedances.
ZT1	**FLOAT**	Zone 1 Pickup Time (in cycles)
ZT2	**FLOAT**	Zone 2 Pickup Time (in cycles) (if not used or available then -1)
ZT3	**FLOAT**	Zone 3 Pickup Time (in cycles) (if not used or available then -1)
ZT4	**FLOAT**	Zone 4 Pickup Time (in cycles) (if not used or available then -1)
Trip 1		Transmission branch that will be tripped if the relay operates (direct trip) In the From Bus, To Bus, Ckt format
Trip 2		Additional transmission branch that will be tripped if the relay operates In the From Bus, To Bus, Ckt format
Trip 3		Additional transmission branch that will be tripped if the relay operates In the From Bus, To Bus, Ckt format
Trip 4		Additional transmission branch that will be tripped if the relay operates In the From Bus, To Bus, Ckt format
Trip 5		Additional transmission branch that will be tripped if the relay operates In the From Bus, To Bus, Ckt format
No Trip	**INTEGER**	0 means to monitor and Trip; -1 means it will only monitor
Self Reclose	**INTEGER**	1 means allow self reclose; 0 will disable self reclose
Reclose Remote End	**INTEGER**	1 means allow reclose remote end; 0 will disable reclose of remote end
Self Trip Time	**FLOAT**	Self trip time for relay + communications + breaker (in cycles)
Self Reclose Timer	**FLOAT**	Self reclose (in cycles)
Zone1 FaultD	**FLOAT**	Fault Detector / Threshold Current (in Primary Amps) (if not used or available then -1)
Zone 1 FaultD Value	**INTEGER**	If Threshold Current is Line then input 0 If Threshold Current is Line to Line then input 1
Zone2 FaultD	**FLOAT**	Fault Detector / Threshold Current (in Primary Amps) (if not used or available then -1)
Zone 2 FaultD Value	**INTEGER**	If Threshold Current is Line then input 0 If Threshold Current is Line to Line then input 1
Zone3 FaultD	**FLOAT**	Fault Detector / Threshold Current (in Primary Amps) (if not used or available then -1)
Zone 3 FaultD Value	**INTEGER**	If Threshold Current is Line then input 0 If Threshold Current is Line to Line then input 1 (if not used or available then -1)
Zone4 FaultD	**FLOAT**	Fault Detector / Threshold Current (in Primary Amps) (if not used or available then -1)
Zone 4 FaultD Value	**INTEGER**	If Threshold Current is Line then input 0 If Threshold Current is Line to Line then input 1 (if not used or available then -1)

5.4.2 Zone Definition Sub-Model Parameters (ZONEDEF)

PARAMETER	TYPE	DESCRIPTION
Nf		The bus where the relay is located.
Nt		The bus at the other end of the line the relay is located on.
Ckt#		Circuit number of line
Zone Number		Zone Number (valid numbers are 1,2,3, and 4)
ZoneAng1	Float	Zone Angle for 1st shape (in degrees)
ZoneDir1		Zone Direction for 1st shape (F= Forward and R = Reverse)
ShapeNum1	Integer	Zone Shape Specification: 0 means circle, lens, tomato; 1 means rectangle ; 2 means Reactance Distance; 3 means Impedance Distance
InternalAng1	Float	Internal Angle (in degrees) ; > 90˚ - lens shape, =90˚ - circle shape, <90˚ - tomato shape
Wt1	Float	Width total Impedance (in Primary Ohms)
Rr1	Float	Reverse reach impedance (in Primary Ohms) positive number would move shape in the reverse direction and a negative number would move shape in the forward direction
Rb1	Float	Resistive blinder location measured along the horizontal axis for quadrilateral shape only (in Primary Ohms)
Operator		AND, OR, or NOT applied between Shape 1 and Shape 2
ZoneAng2	Float	Zone Angle for 2nd shape (in degrees)
ZoneDir2	Float	Zone Direction (F= Forward and R = Reverse)
ShapeNum2	Integer	Zone Shape Specification: 0 means circle, lens, tomato; 1 means rectangle ; 2 means Reactance Distance; 3 means Impedance Distance
InternalAng2	Float	Internal Angle (degrees) ; > 90˚ - lens shape, =90˚ - circle shape, <90˚ - tomato shape
Wt2	Float	Width total Impedance (in Primary Ohms)
Rr2	Float	Reverse reach impedance (in Primary Ohms) positive number would move shape in the reverse direction and a negative number would move shape in the forward direction
Rb2	Float	Resistive blinder location measured along the horizontal axis for quadrilateral shape only (in Primary Ohms)
Operator		AND, OR, or NOT applied between the result of Shape 1 and Shape 2 to Shape 3
ZoneAng3	Float	Zone Angle for 3rd shape
ZoneDir3	Float	Zone Direction (F= Forward and R = Reverse)
ShapeNum3	Integer	Zone Shape Specification: 0 means circle, lens, tomato; 1 means rectangle ; 2 means Reactance Distance; 3 means Impedance Distance
InternalAng3	Float	Internal Angle (degrees) ; > 90˚ - lens shape, =90˚ - circle shape, <90˚ - tomato shape
Wt3	Float	Width total Impedance (in Primary Ohms)
Rr3	Float	Reverse reach impedance (in Primary Ohms) positive number would move shape in the reverse direction and a negative number would move shape in the forward direction
Rb3	Float	Resistive blinder location measured along the horizontal axis for quadrilateral shape only (in Primary Ohms)

5.4.3 Transfer Trip Sub-Model Parameters (TTSCHEME)

PARAMETER	TYPE	DESCRIPTION
Nf		The bus where the relay is located.
Nt		The bus at the other end of the line the relay is located on.
Ckt#		Circuit number of line
TTtype		Transfer Trip Type: 1 – Direct Underreaching Transfer Trip 2 – Permissive Overreaching Transfer Trip (Future) 3 – Permissive Underreaching Transfer Trip (Future) 4 – Custom Code (Future)
PseudoCode		Will use RAS specification for syntax to create the Transfer Trip Schemes (future)

5.4.4 Blinder Definition Sub-Model Parameters (BLINDERDEF)

PARAMETER	TYPE	DESCRIPTION
Nf		The bus where the relay is located.
Nt		The bus at the other end of the line the relay is located on.
Ckt#		Circuit number of line
1st blind type	Float	First blinder type (+/-1 or +/-2)
1st blind int	Float	First blinder intercept (Primary Ohms)
1st blind rot	Float	First blinder rotation (degrees)
2nd blind type	Float	Second blinder type (+/-1 or +/-2)
2nd blind int	Float	Second blinder intercept (Primary Ohms)
2nd blind rot	Float	Second blinder rotation (degrees)
3rd blind type	Float	Third blinder type (+/-1 or +/-2)
3rd blind int	Float	Third blinder intercept (Primary Ohms)
3rd blind rot	Float	Third blinder rotation (degrees)
4th blind type	Float	Fourth blinder type (+/-1 or +/-2)
4th blind int	Float	Fourth blinder intercept (Primary Ohms)
4th blind rot	Float	Fourth blinder rotation (degrees)

5.4.5 Load Encroachment Sub-Model Parameters(LOADEN)

PARAMETER	TYPE	DESCRIPTION
Nf		The bus where the relay is located.
Nt		The bus at the other end of the line the relay is located on.
Ckt#		Circuit number of line
Func		This sub-model is used for distance relay and overcurrent: 1. Distance Relay 2. Overcurrent Relay (directional / non-directional) 3. All relays in the line
FReach	Float	Forward Load Impedance (in Primary Ohms)
Rreach	Float	Reverse Load Impedance (in Primary Ohms)
PLAF	Float	positive forward load angle in degrees
PLAR	Float	positive reverse load angle in degrees
NLAR	Float	negative reverse load angle in degrees
NLAF	Float	negative forward load angle in degrees

6 Example

This is an example for illustration purposes, it will not cover all the necessary variations but it will demonstrate the key functions of **DISTRELAY** with its associated sub-models. Figure 6-1 is the ohm characteristic of a relay.

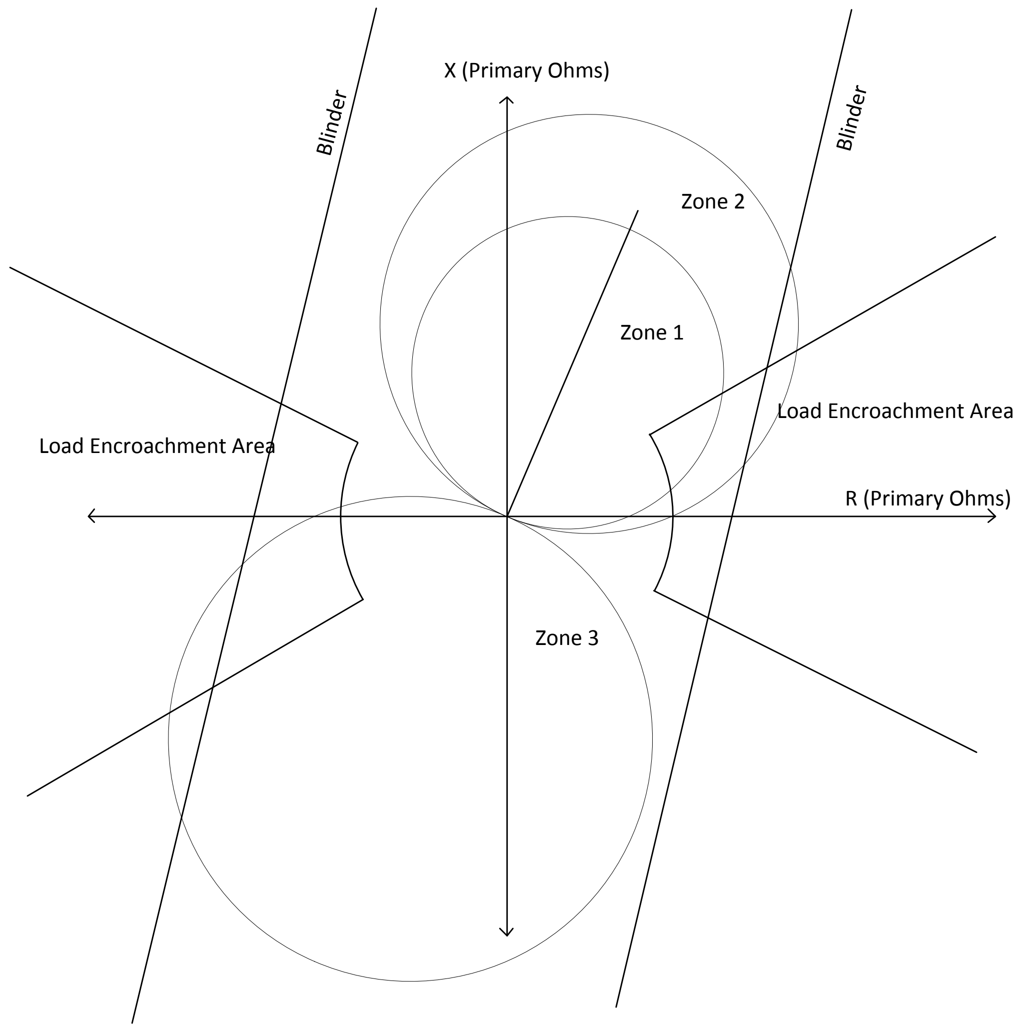

Figure 6-1 : Example relay Ohm Characteristic for Bus# 12345

The following figure is the bus branch model which the relay is located at Bus # 12345

The following are the parameters for Figure 6-1:

Zone 1 Angle	66.8 degrees
Zone 1 Width	22.3 Ohms
Zone 1 Time Delay	0
Zone 1 Fault Detector Current	30,000 Amps / Line current
Zone 2 Angle	66.8 degrees
Zone 2 Width	29.8 Ohms
Zone 2 Time Delay	20 cycles
Zone 2 Fault Detector Current	20,000 Amps / Line current
Zone 3 Angle	66.8 degrees
Zone 3 Width	33.6 Ohms
Zone 3 Time Delay	40 cycles
Zone 3 Fault Detector Current	25,000 Amps / Line current
Load Encroachment (LE) Forward Reach	11.9 Ohms
LE Reverse Reach	11.9 Ohms
LE PLAF	29.8 degrees
LE NLAF	26.5 degrees
LE PLAR	153.5 degrees
LE NLAR	210.2 degrees
1st Blinder type	2
1st Blinder intercept	16.3 Ohms
1st Blinder rotation	76 degrees
2nd Blinder type	2
2nd Blinder intercept	-18.1 Ohms
2nd Blinder rotation	76 degrees
Transfer Trip Scheme	DUTT
Reclosing	Yes
Reclosing Timer	10 cycles
Self Trip / Breaker Time	4 cycles

Writing the model would then be the following:

Distance Relay Parameters | Zone Sub-Model Parameters

PARAMETER	DATA		PARAMETER	DATA
Nf	12345		Nf	12345
Nt	23456		Nt	23456
Ckt#	1		Ckt#	1
Far Bus	23456		Zone Number	1
ZT1	0		ZoneAng1	66.8
ZT2	20		ZoneDir1	F
ZT3	40		ShapeNum1	0
ZT4	-1		InternalAng1	90
Trip 1	Line 12345_23456_1		Wt1	22.3
Trip 2	0		Rr1	0
Trip 3	0		Rb1	-1
Trip 4	0		Operator	-1
Trip 5	0		ZoneAng2	-1
No Trip	0		ZoneDir2	-1
No Self Reclose	0		ShapeNum2	-1
No Reclose Remote End	0		InternalAng2	-1
Self-Trip Time (cycles)	4		Wt2	-1
Self Reclose Timer (cycles)	10		Rr2	-1
Zone1 FaultD (amps)	30,000		Rb2	-1
Zone 1 FaultD Value	0		Operator	-1
Zone2 FaultD (amps)	20,000		ZoneAng3	-1
Zone 2 FaultD Value	0		ZoneDir3	-1
Zone3 FaultD (amps)	25,000		ShapeNum3	-1
Zone 3 FaultD Value	0		InternalAng3	-1
Zone4 FaultD (amps)	-1		Wt3	-1
Zone 4 FaultD Value	-1		Rr3	-1
			Rb3	-1

Zone Sub-Model Parameters

PARAMETER	DATA
Nf	12345
Nt	23456
Ckt#	1
Zone Number	2
ZoneAng1	66.8
ZoneDir1	F
ShapeNum1	0
InternalAng1	90
Wt1	29.8
Rr1	0
Rb1	-1
Operator	-1
ZoneAng2	-1
ZoneDir2	-1
ShapeNum2	-1
InternalAng2	-1
Wt2	-1
Rr2	-1
Rb2	-1
Operator	-1
ZoneAng3	-1
ZoneDir3	-1
ShapeNum3	-1
InternalAng3	-1
Wt3	-1
Rr3	-1
Rb3	-1

Zone Sub-Model Parameters

PARAMETER	DATA
Nf	12345
Nt	23456
Ckt#	1
Zone Number	3
ZoneAng1	66.8
ZoneDir1	R
ShapeNum1	0
InternalAng1	90
Wt1	33.6
Rr1	0
Rb1	-1
Operator	-1
ZoneAng2	-1
ZoneDir2	-1
ShapeNum2	-1
InternalAng2	-1
Wt2	-1
Rr2	-1
Rb2	-1
Operator	-1
ZoneAng3	-1
ZoneDir3	-1
ShapeNum3	-1
InternalAng3	-1
Wt3	-1
Rr3	-1
Rb3	-1

Blinder Sub-Model / Load Encroachment Sub-Model

PARAMETER	DATA		PARAMETER	DATA
Nf	12345		Nf	12345
Nt	23456		Nt	23456
Ckt#	1		Ckt#	1
1st blind type	-2		FReach	11.9
1st blind int	16.3		Rreach	11.9
1st blind rot	76		PLAF	29.8
2nd blind type	2		PLAR	26.5
2nd blind int	-18.1		NLAR	153.5
2nd blind rot	76		NLAF	210.2
3rd blind type	0			
3rd blind int	0	**Transfer Trip Scheme Sub-Model**		
3rd blind rot	0		PARAMETER	DATA
4th blind type	0		Nf	12345
4th blind int	0		Nt	23456
4th blind rot	0		Ckt#	1
			TTType	1

7 Summary

This model is to represent the behavior of the distance relay, but not to model the relay in detail. This is to simulate for the purposes of operations/planning studies, which is not the same as a protection system level model of a relay. These relay "models" mostly REPLACE switch "decks" and other non-syntax based files/scripts/code.

8 References

[1] Distance element settings are described starting on page 5-75 of the GE D60 Line Distance Relay Manual at http://www.gedigitalenergy.com/products/manuals/d60/d60man-f5.pdf.

[2] "SEL-311C Relay Protection and Automation System – Instruction Manual," Schweitzer Engineering Laboratories, Inc., date code 20100526. (More recent version downloadable from www.selinc.com but registration required at website.) Description of distance elements can be found in Section 3.