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Autotransformer bank with 2 sets of CT

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SIPROTEC 5 Application

Autotransformer bank with 2 sets of CT on the delta connected compensation side

APN-025, Edition 1

Content

1 Autotransformer bank with 2 sets of CT on the delta connected compensation side

1.1 Introduction

Autotransformers are often applied in high voltage transmission networks.

In most cases these transformers include a so called compensation side (tertiary delta). This winding ensures symmetrical magnetization of the three limbs even under adverse conditions. In addition it may be used for the auxiliary supply of the sub-station.

The rating of this tertiary delta is generally substantially less than the rating of the actual auto-transformer. The basis for the differential protection across the entire auto-transformer is the rating of the actual primary windings.

Such a protection cannot always detect faults in the compensation side. This depends on the plant data, the number of connected CTs and their configuration!

This situation can be significantly improved by applying two sets of CTs inside the delta of the compensation side.

Two differential protection functions are configured in the 7UT87:
- Differential protection for the auto transformer 87-T1 (Figure 1)
- Differential-protection for the compensation side 87T-2 (Figure 2)

87-T1 (Base: MVA of the auto transformer winding) protects the auto transformer winding and the 3 windings of the compensation side, however not or only partially the delta connection of the tertiary winding of the auto transformer **bank.**
Fault detection is phase selective. This is more frequently required, as it reduces the time required to find the fault inside the 3 individual transformers of the bank.

87-T2 (Base: MVA of the compensation winding) protects the compensation winding including the terminal connections up to the current transformer 5.
On the 34,5 kV delta connected compensation side, a neutral earthing transformer is installed for this application. As a result a corresponding current also flows in the tertiary windings during a single phase fault in this zone. → Selective tripping is possible.
(If required, a restrictive earth fault protection (REF) can be applied; this is however not gone into further here).
The fault detection on the compensation side is NOT phase selective in this zone!
A single phase fault is fed via two limbs and a 2-phase fault via 3 limbs.

1.2 Differential Protection for Auto Transformer 87-T1

In this application the zero sequence current from all three sides of the auto transformer bank, including the circulating current in the tertiary winding are measured.
Elimination of the zero sequence current is therefore not required!

Autotransformer bank with 2 sets of CT on the delta connected compensation side

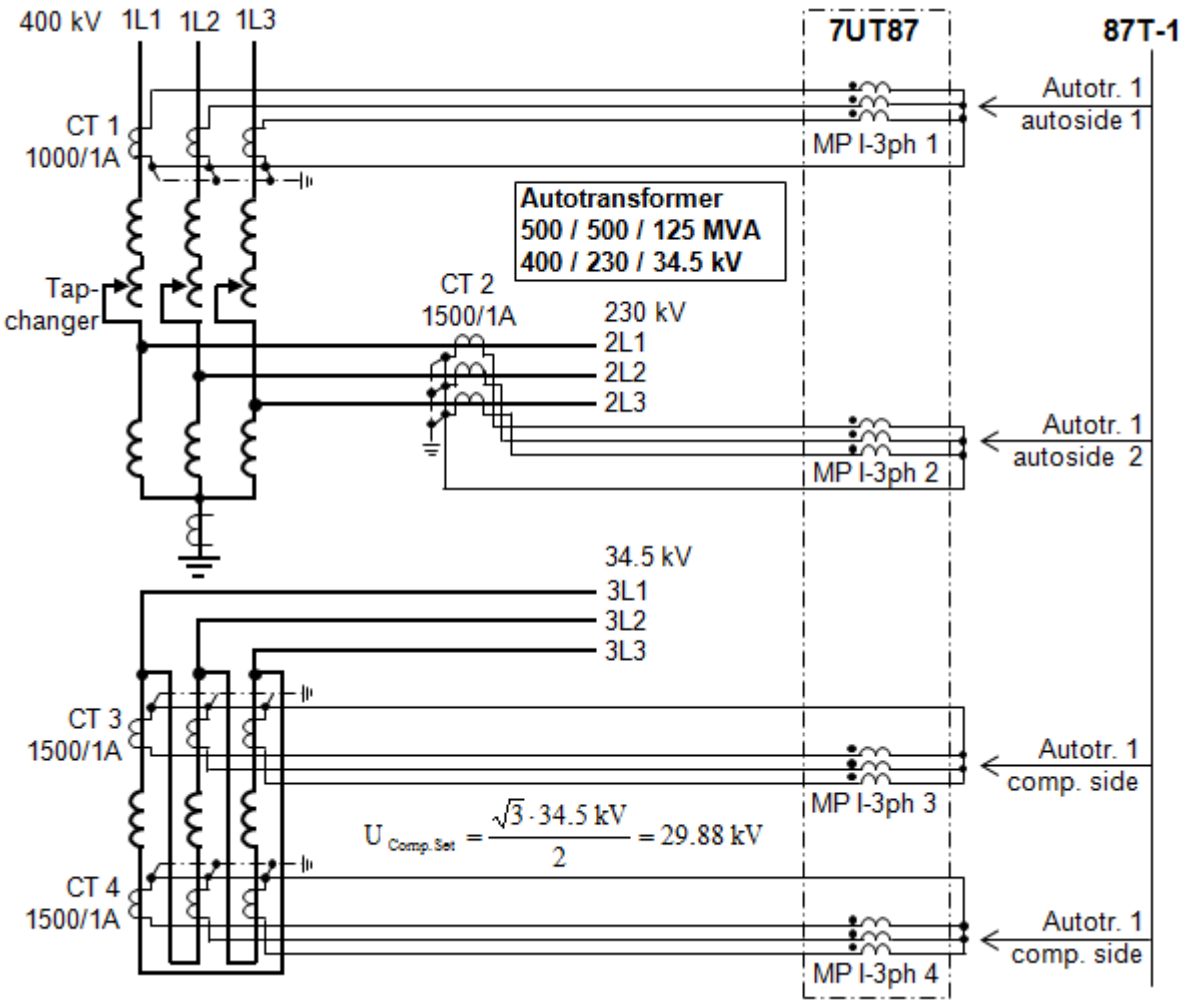


Figure 1: Differential protection for the auto transformer (87T-1)

The current transformers CT 3 and CT 4 are inside the tertiary connection of the compensation side. The measured current therefore corresponds to only I/√3. This may be compensated for by means of the voltage setting → √3·34,5 kV. Under normal operation the currents from CT 3 and CT 4 are identical are summated.

Consequently the ultimate setting value for the voltage side 3 = (√3·34,5 kV)/2 = 29,88 kV.

Advantage of this solution:

- Increased sensitivity as the zero sequence current is not eliminated
- Increased sensitivity for faults inside the delta connected tertiary winding.
- **Unambiguous fault condition, only differential current in the faulted phase.**

1.3 Differential Protection for the compensation side 87-T2

The base for the differential protection is the 125 MVA of the compensation side (and not the 500 MVA).
This results in a (significantly) higher sensitivity during internal faults.

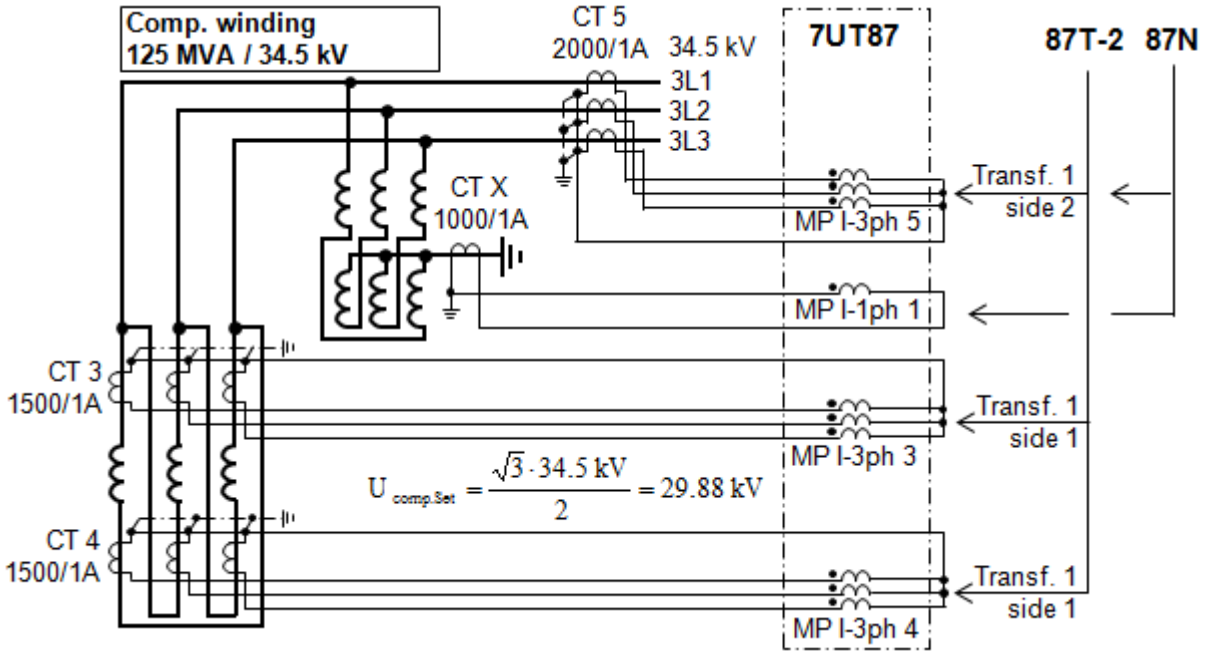


Figure 2: Differential protection for the compensation side (87T-2)

Setting as for the 2-winding transformer YNd11

In the event of a short circuit on the 230 kV or 400 kV side, a zero sequence current will flow via the current transformers CT 3 and CT 4.

With the setting transformer side 1 starpoint = earthed, this zero sequence current is eliminated from the differential current component. For the restraint component, the zero sequence current is however used **(new in the 7UT8).**

1.4 Complete current transformer connection diagram

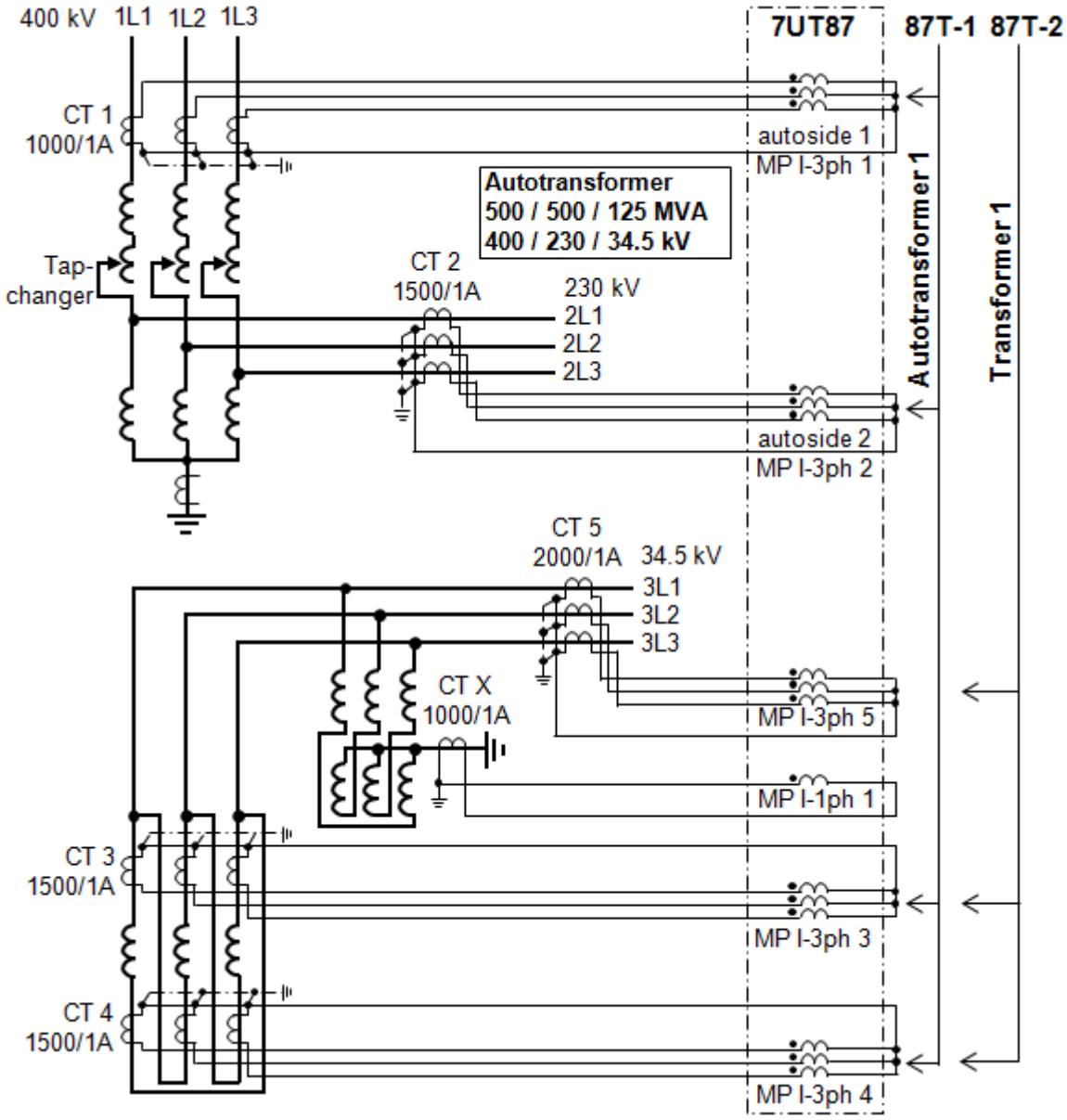


Figure 3: Complete current transformer connection diagram

CT 3 and CT 4 are used both for the auto transformer differential protection 87T-1 as well as for the differential protection of the tertiary winding 87T-2 (transformer 1 side 1).

In figure 3 the starpoint of CT3 for 87-T1 is **not** in direction of the object. For the 87-T2 however, the starpoint is in direction of the object! As there is only one setting address for the CT starpoint, it is necessary to invert the measuring point allocation for I-3ph 3 and I-3ph 4 by setting "I" under "function- group connections" for the transformer side 1.

1.5 Functiongroup connections

	Auto trf. autoside 1	Auto trf. autoside 2	Auto trf. comp. side	Circuit breaker 1	Circuit breaker 2	Circuit breaker 3	Transformer side 1	Transformer side 2	Transform. neut.p 1
Meas. point I-3ph 1	X			X					
Meas. point I-3ph 2		X			X				
Meas. point I-3ph 3			X			X	I *)		
Meas. point I-3ph 4			X				I *)		
Meas. point I-3ph 5								X	
Meas. point I-1ph 1									X

*) → Polarity inverted

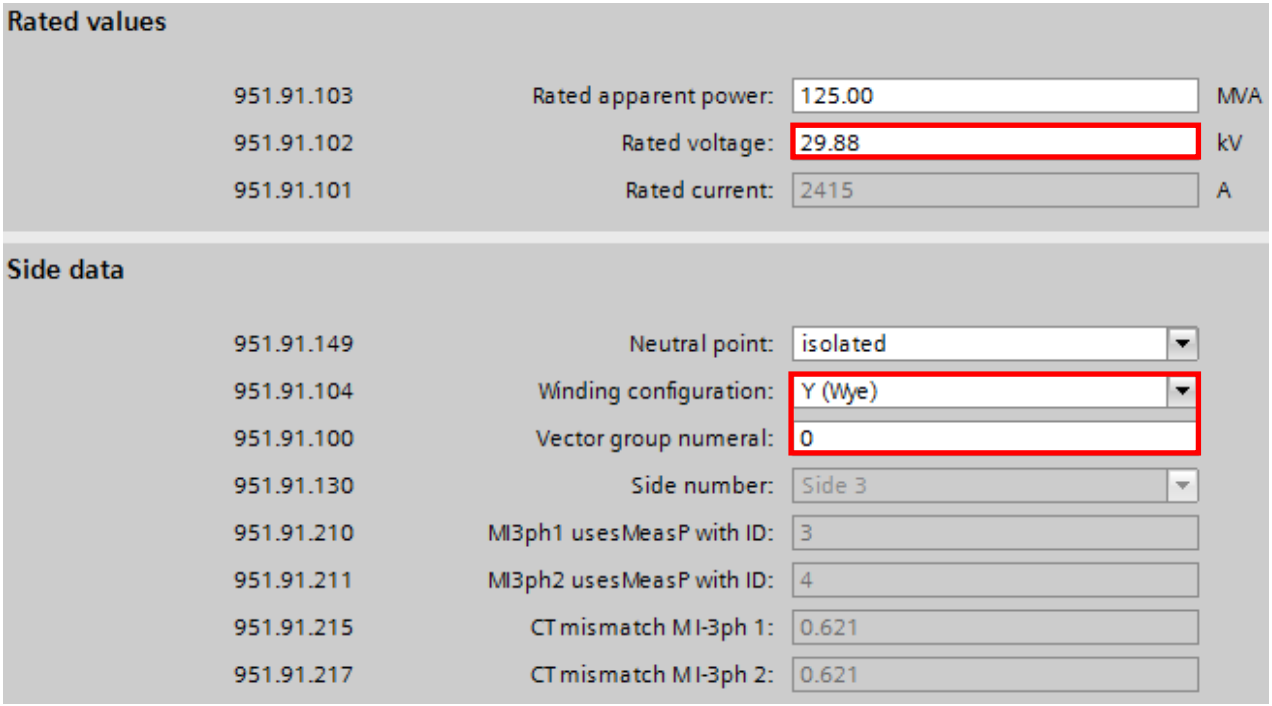
1.6 Settings (Extract)

1.6.1 Power system

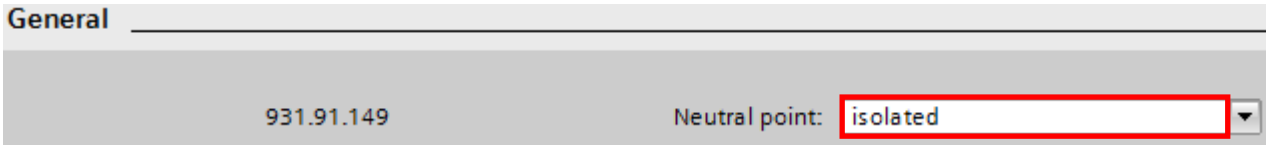
Meas.point I-3ph 1				
CT 3-phase				
11.931.8881.101	Rated primary current	1000.0	A	
11.931.8881.102	Rated secondary current	1 A		
11.931.8881.116	Neutr.point in dir.of ref.obj:	yes		
Meas.point I-3ph 2				
CT 3-phase				
11.932.8881.101	Rated primary current	1500.0	A	
11.932.8881.102	Rated secondary current	1 A		
11.932.8881.116	Neutr.point in dir.of ref.obj:	yes		
Meas.point I-3ph 3				
CT 3-phase				
11.933.8881.101	Rated primary current	1500.0	A	
11.933.8881.102	Rated secondary current	1 A		
11.933.8881.116	Neutr.point in dir.of ref.obj:	no		
Meas.point I-3ph 4				
CT 3-phase				
11.934.8881.101	Rated primary current	1500.0	A	
11.934.8881.102	Rated secondary current	1 A		
11.934.8881.116	Neutr.point in dir.of ref.obj:	no		

Meas.point I-3ph 5				
CT 3-phase				
11.935.8881.101	Rated primary current	2000.0	A	
11.935.8881.102	Rated secondary current	1 A		
11.935.8881.116	Neutr.point in dir.of ref.obj:	yes		
Meas.point I-1ph 1				
General				
11.951.2311.101	Rated primary current	1000.0	A	
11.951.2311.102	Rated secondary current	1 A		
11.951.2311.116	Term. 1,3,5,7 in dir. of obj.:	yes		

1.6.2 (87-T1) Auto transformer compensation side



1.6.3 (87-T1) Auto transformer diff. 1



With the setting " Neutral point = isolated" **no** zero sequence current elimination is carried out for the sides 1 and 2

1.6.4 (87-T2) Transformer side 1

Rated values

911.91.103	Rated apparent power:	125.00	MVA
911.91.102	Rated voltage:	29.88	kV
911.91.101	Rated current:	2415	A

Side data

911.91.149	Neutral point:	grounded
911.91.104	Winding configuration:	Y (Wye)
911.91.100	Vector group numeral:	0
911.91.130	Side number:	Side 1
911.91.210	MI3ph1 usesMeasP with ID:	3
911.91.211	MI3ph2 usesMeasP with ID:	4
911.91.215	CT mismatch MI-3ph 1:	0.621
911.91.217	CT mismatch MI-3ph 2:	0.621

With the setting “Neutral point = grounded” → zero sequence current is eliminated from the differential current component

1.6.5 (87-T2) Transformer side 2

Rated values

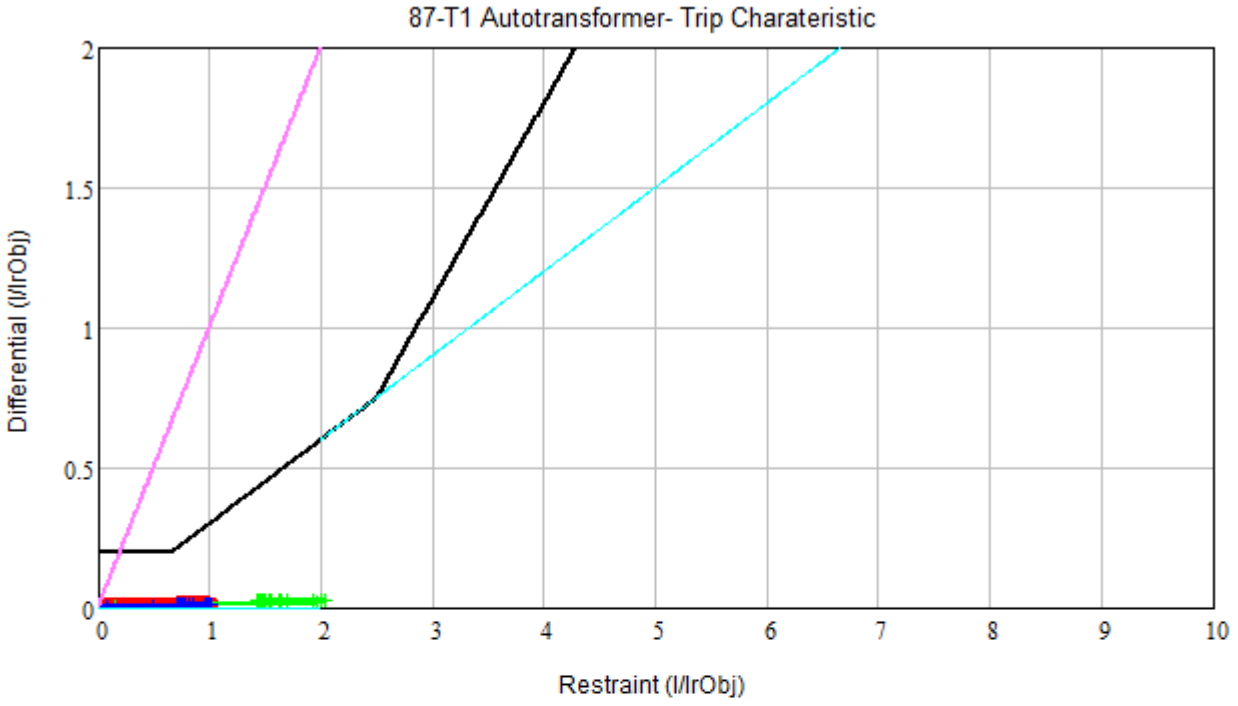
912.91.103	Rated apparent power:	125.00	MVA
912.91.102	Rated voltage:	34.50	kV
912.91.101	Rated current:	2092	A

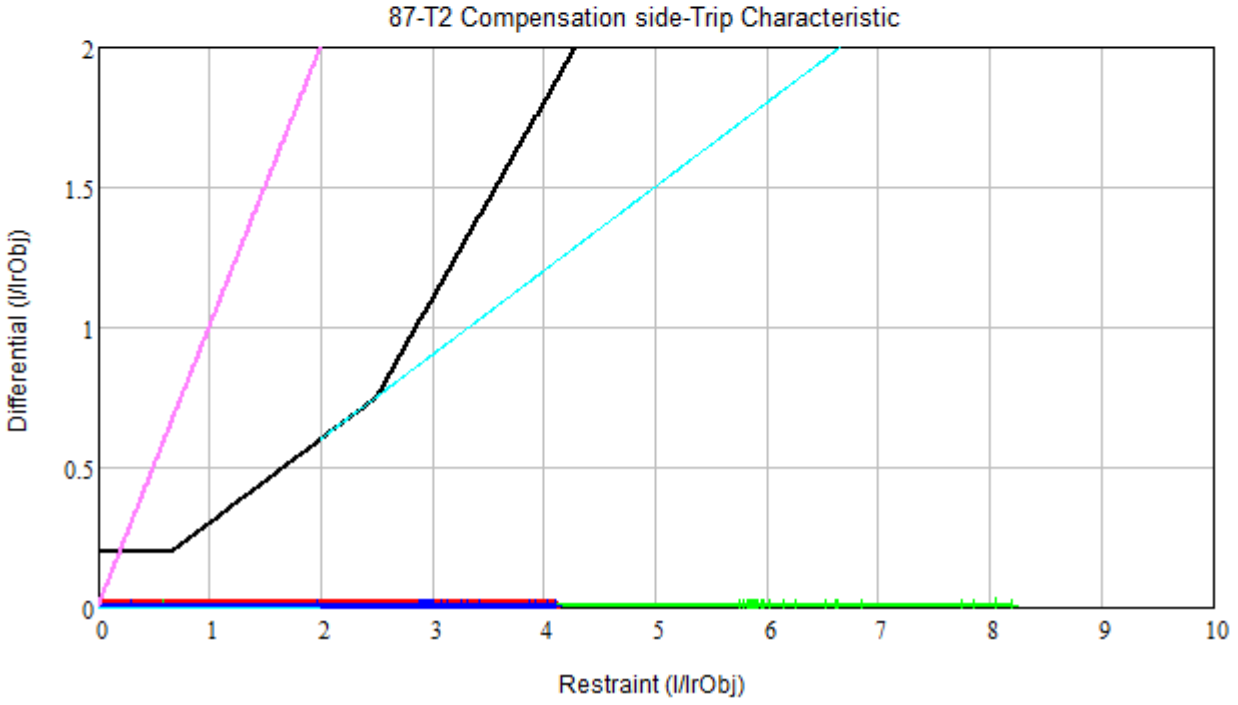
Side data

912.91.149	Neutral point:	grounded
912.91.104	Winding configuration:	D (Delta)
912.91.100	Vector group numeral:	11
912.91.130	Side number:	Side 2
912.91.210	MI3ph1 usesMeasP with ID:	5
912.91.214	MI-1ph uses MeasP with ID:	6
912.91.215	CT mismatch MI-3ph 1:	0.956
912.91.223	CT mismatch MI-1ph:	0.478

1.7 Fault examples (without load current)

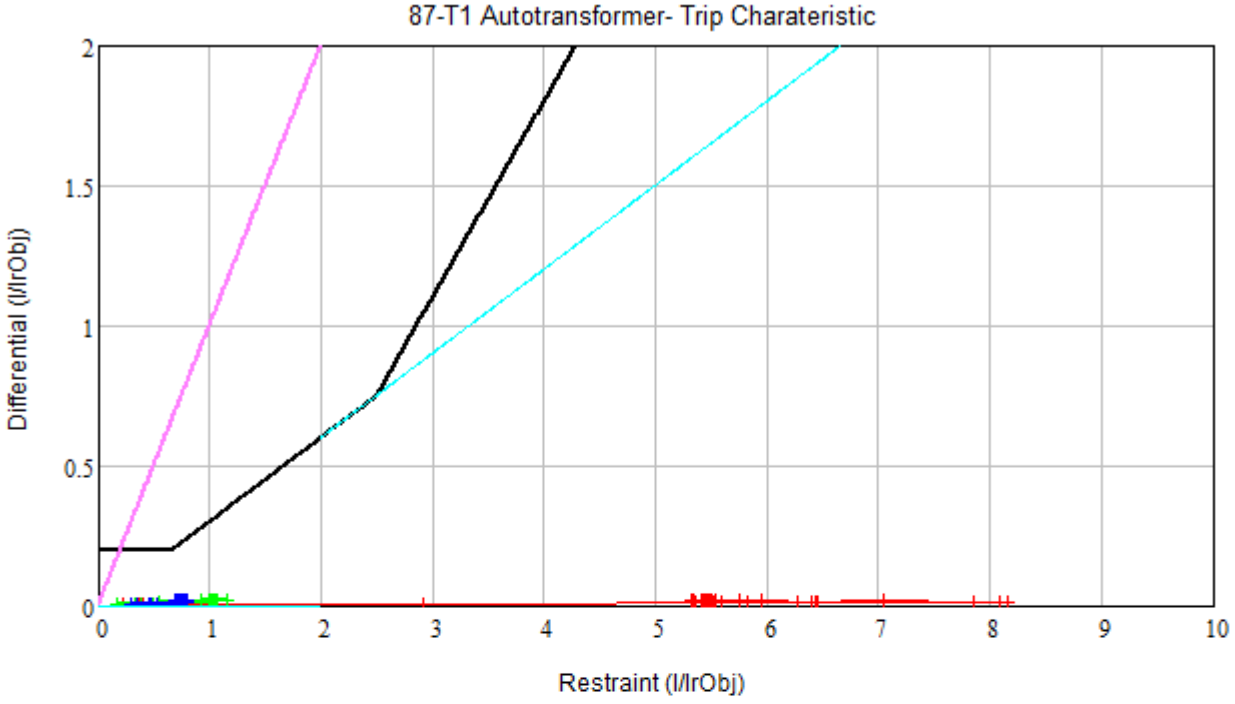
1.7.1 External fault L1-L2 on 34.5 kV side

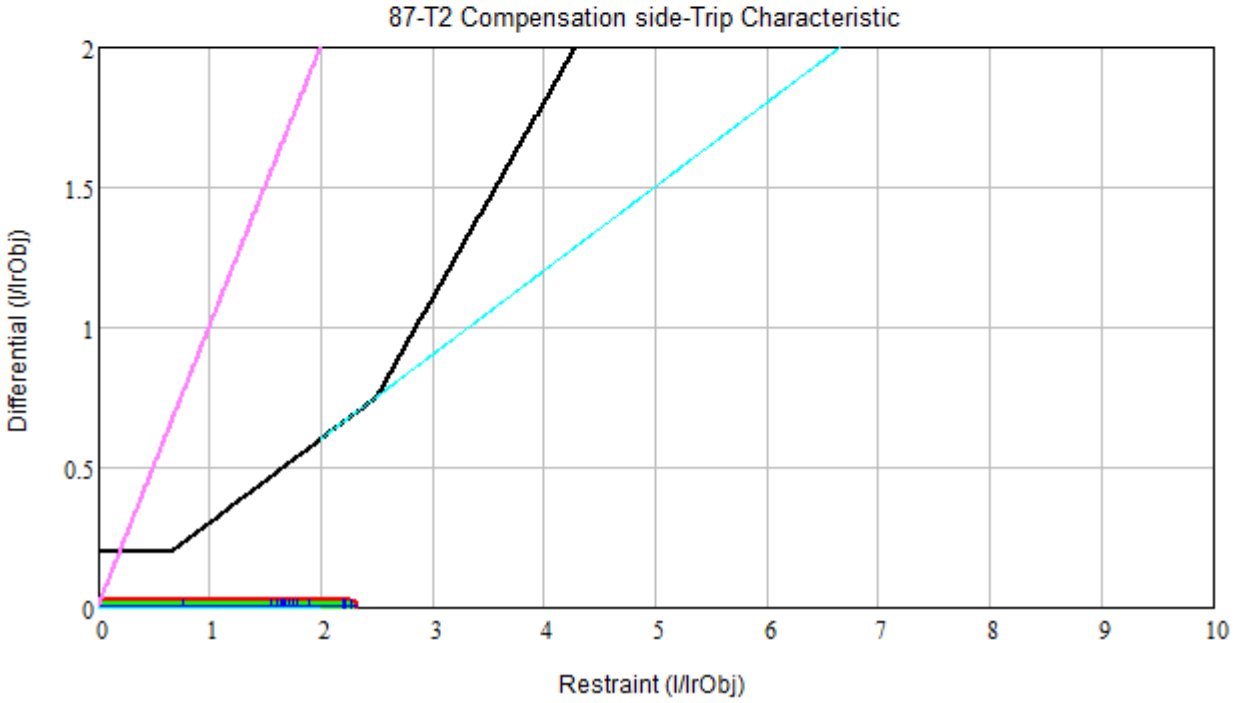




The stabilizing current with the 87-T2 (125 MVA) is 4 times greater than with the 87-T1 (500 MVA).

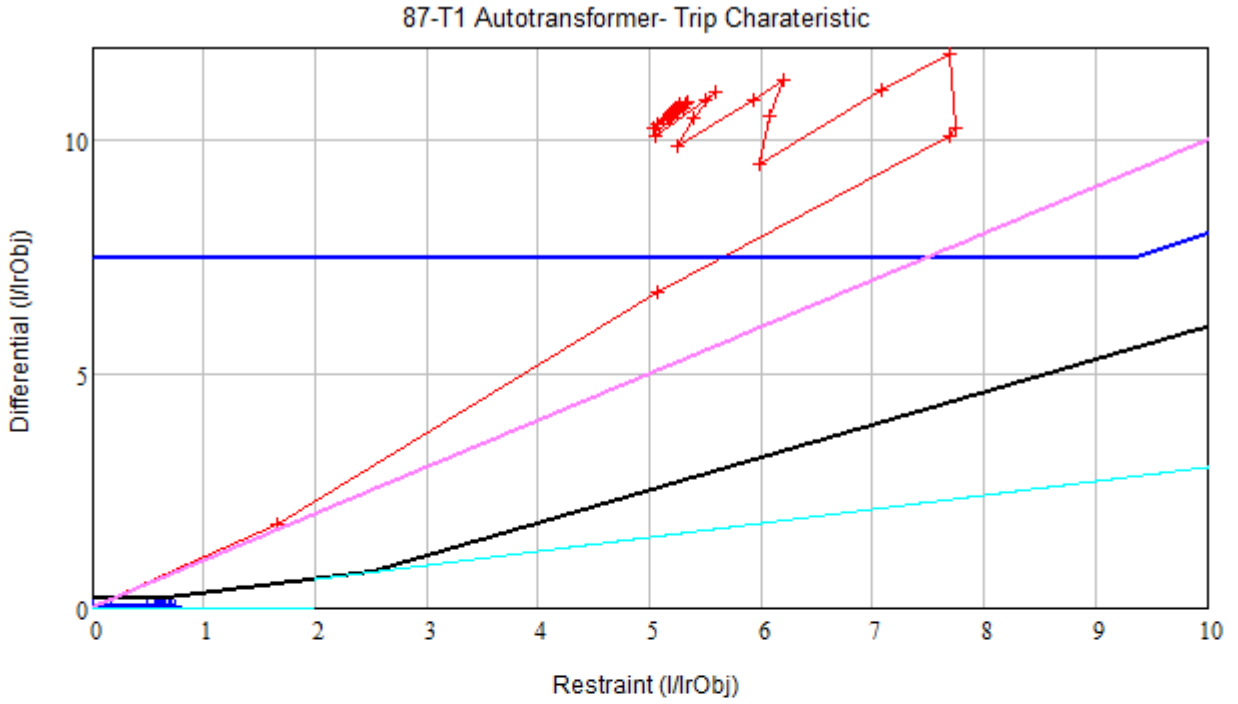
1.7.2 External fault L1-E on the 230 kV side

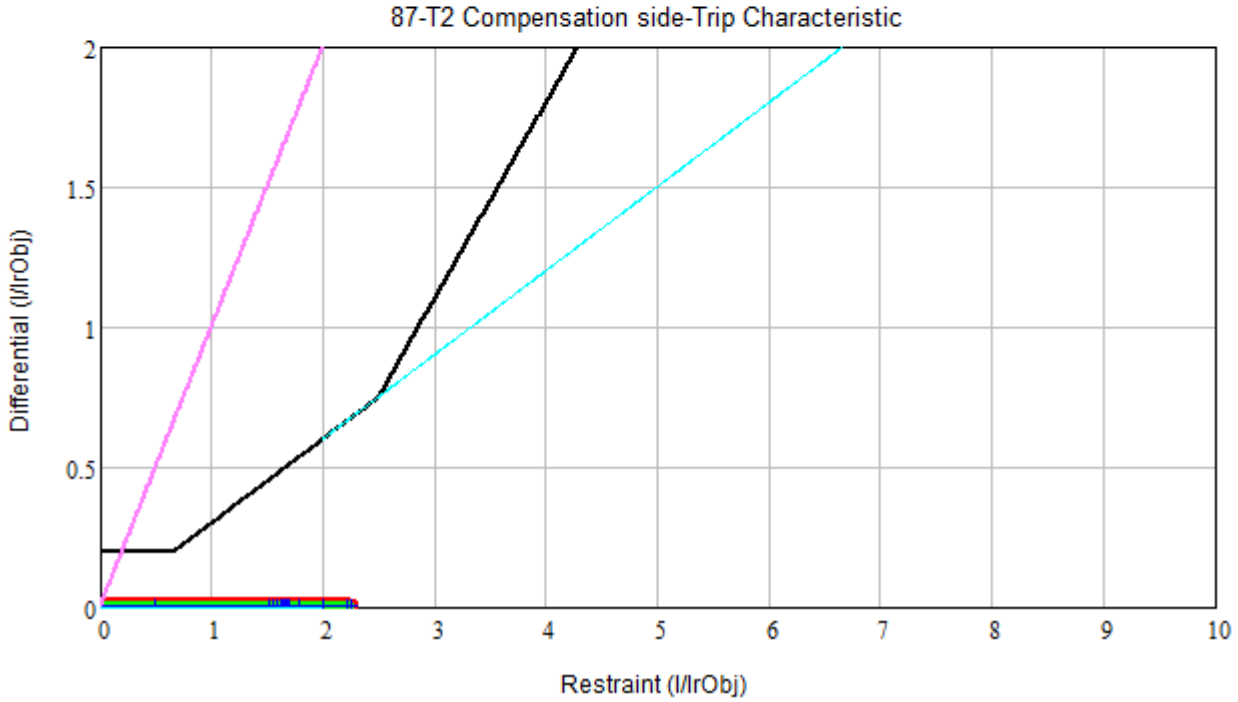




A zero sequence current circulates in the tertiary winding. This has a stabilizing effect on the 87-T2.

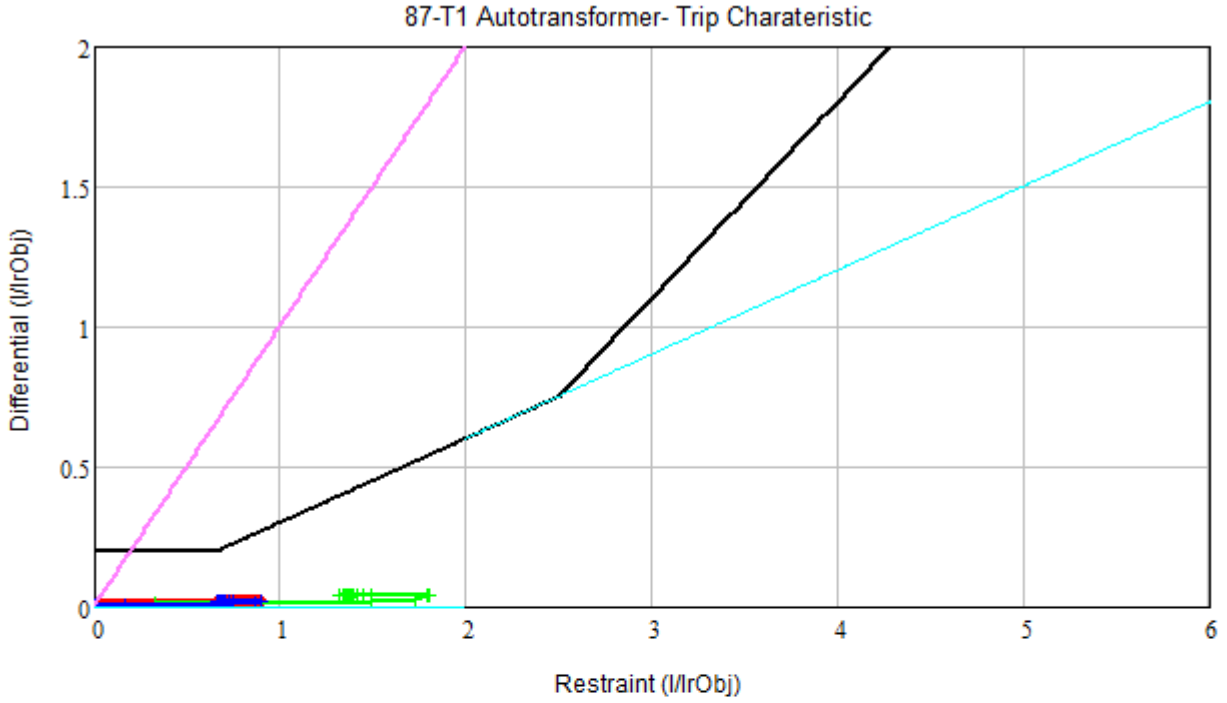
1.7.3 Internal fault L1-E on 230 kV side

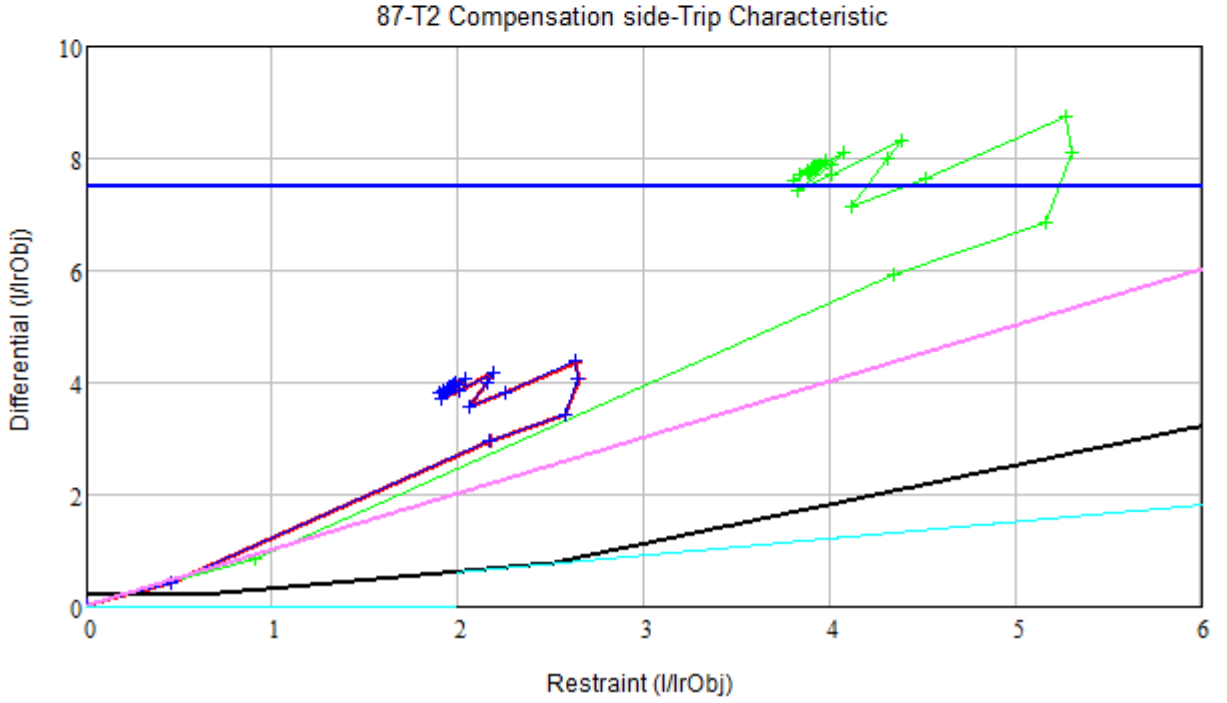




87-T1 only trips the faulted phase L1 → unambiguous!
A zero sequence current circulates in the tertiary winding, similar as with the external fault. Here again the zero sequence current has a stabilizing effect on the 87-T2.

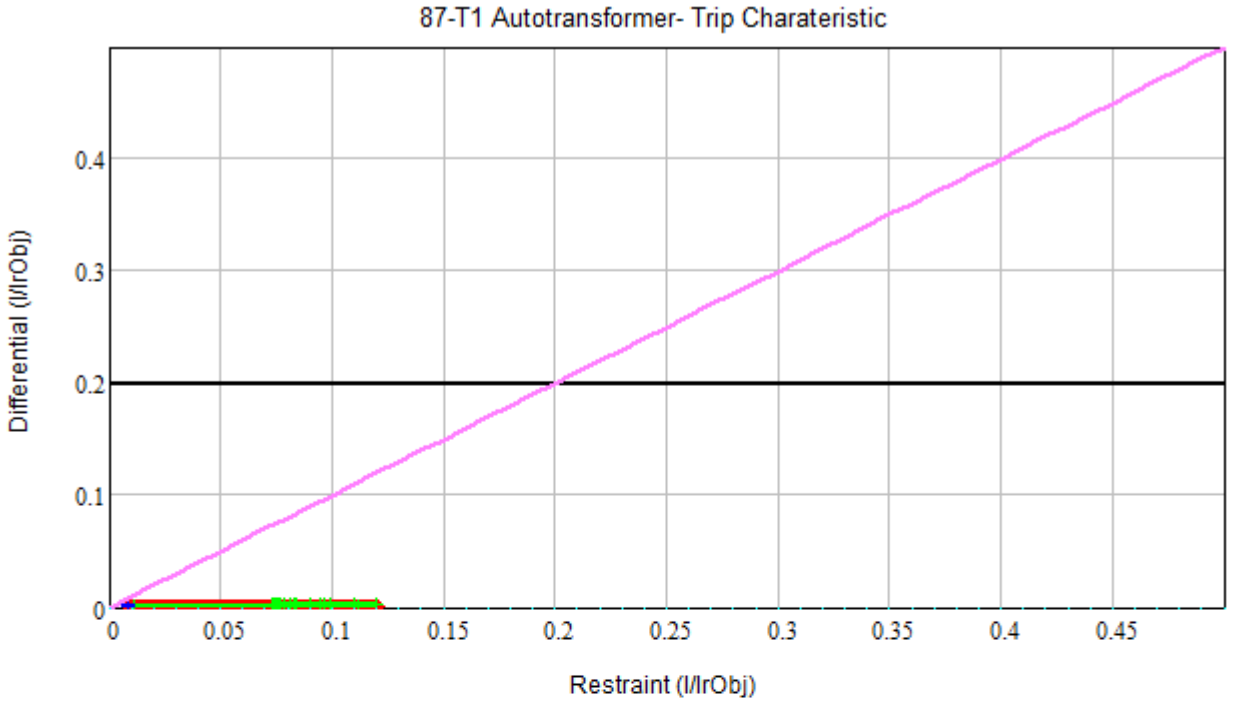
1.7.4 Internal fault L1-L2 on 34,5 kV side (outside the delta connection)

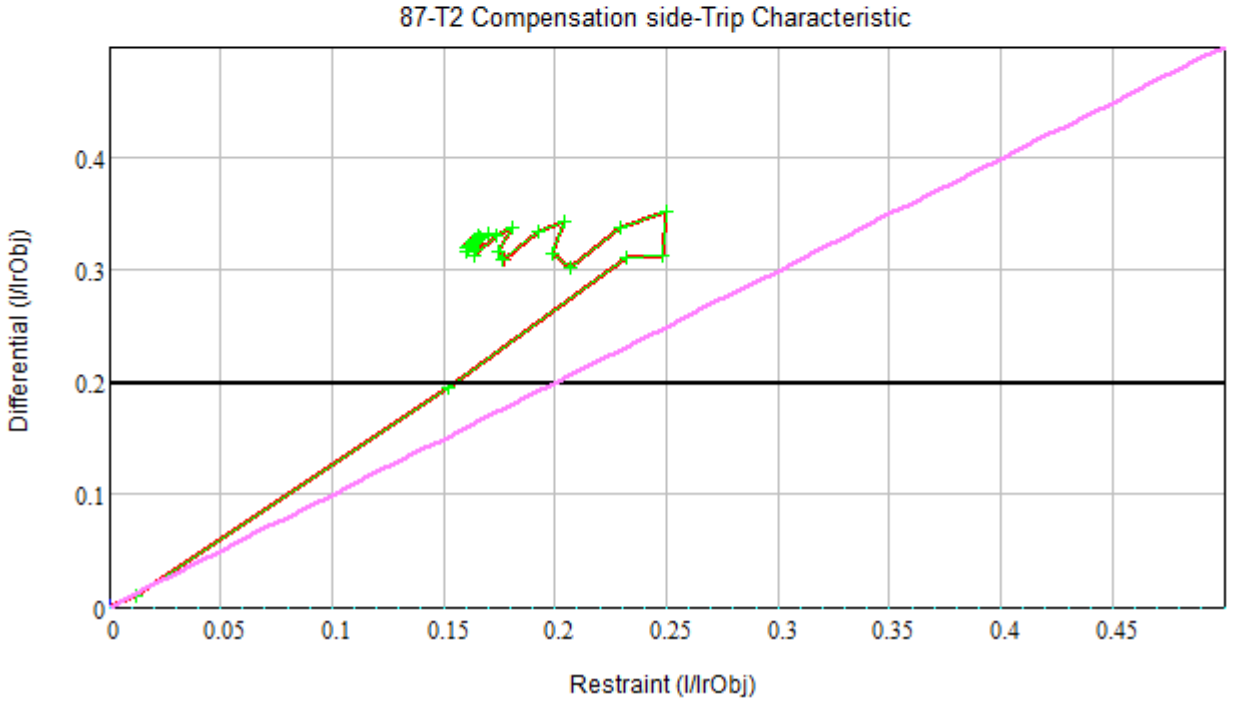




This is an external fault for the 87-T1, the 87-T2 on the other hand trips.
The trip is issued on all three phases. Although there is no zero sequence current, there is fault current in-feed on all three limb windings during the fault L1-L2.

1.7.5 Internal fault L1-LE on the 34,5 kV side (outside the delta connection)





This is an external fault for the 87-T1, the 87-T2 on the hand trips.
Due to the neutral grounding transformer, a fault current which results in tripping in this case is also present during the single phase fault. This fault current is fed via two limb windings (no zero sequence current).

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