

RET670/650 for Traction Applications

Protection Schemes for Special Railway Transformers



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1. Introduction

With RET670 and RET650, it is possible to protect special types of railway transformers. However it should be noted that RET670 and RET650 can only be used in 50Hz or 60Hz railway supply systems and shall not be used for railway supply systems with a frequency of 16 2/3Hz or 25Hz.

All the examples in this document can be protected by either a RET650 or RET670, except for the split-single auto transformer. For this type of transformer a RET670 should be chosen due to the number of CT inputs required. RET670 offers additional analogue and binary IO options and more protection functions – so it can protect multiple transformers with a single IED – and with better performance and accuracy compared to the RET650. The RET650 is easier to order as there are very few additional options, has multi range binary inputs (48 – 250VDC) and universal 1/5A CT inputs.

The following picture gives an overview about different railway electrical supply systems traditionally used in Europe.

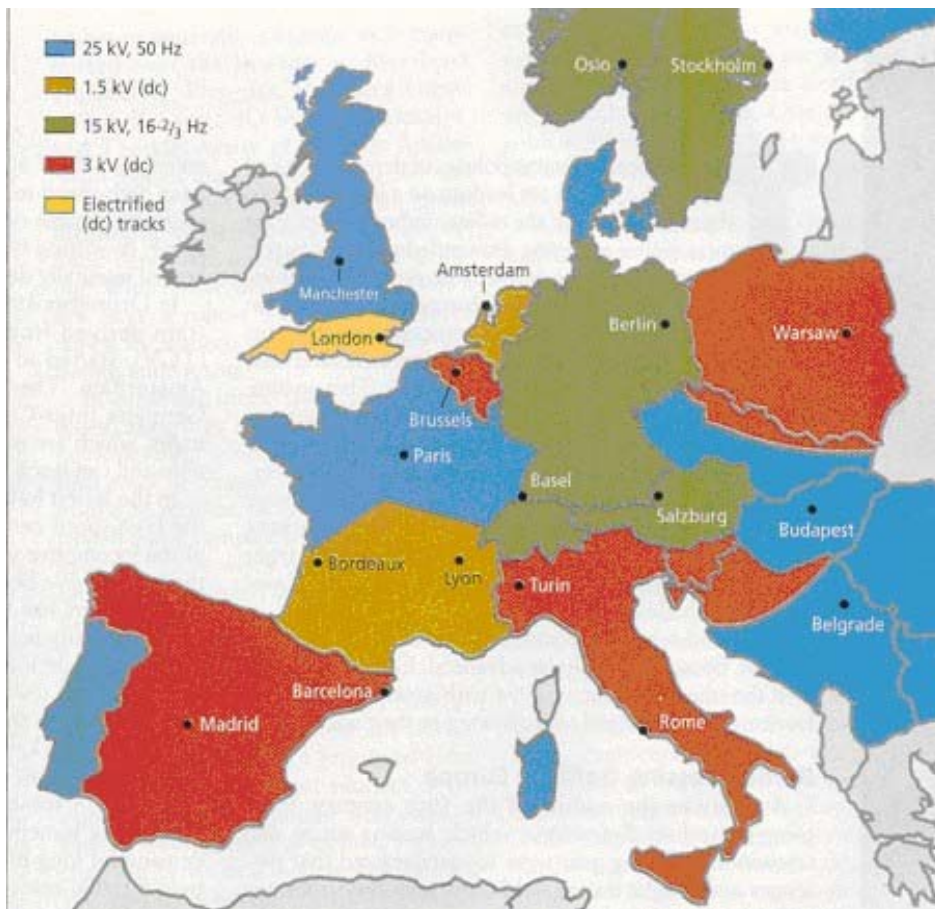


Figure 1 - Overview of European electrical supply systems for railway applications

50Hz or 60Hz railway supply systems are used in other parts of the world as well (e.g. Russia, Turkey, China, Korea, and Australia) and are often used in new railway electrification projects (e.g. Italy, Korea, UK and France).

RET670/650 can not only offer transformer differential protection without any interposing CTs, but can also provide a complete protection and control scheme for railway transformers. For example the transformer tank protection can also be included in the relay scheme for all types of the traction transformer applications shown in this document when required by the railway company. This shall be achieved by using one separate CT input into RET670/650 and one EF4 PTOC function.

2. Standard Features in RET670/650

RET670/650 is primarily designed for the protection and control of three-phase power transformers in transmission and sub transmission electric power supply networks. Since its introduction in 2006, more than 11000 units were supplied worldwide. It is used for the protection of power transformers with ratings up to and including 1200 MVA, 765kV.

RET670/650 is a multifunctional power transformer protection and control IED, which can include the following protection, control and monitoring functions:

- Differential protection for two (T2WPDIF) or three winding (T3WPDIF) power transformers with built-in 2nd harmonic blocking, 5th harmonic blocking and waveform blocking features (ANSI 87T/87H, IEC 3Id/I)
- Restricted earth fault (REFPDIF) protection functions (ANSI 87N, IEC IdN/I)
- Three-phase, four-stage time overcurrent (PHPIOC, OC4PTOC) protection functions (ANSI 50/51, IEC 3I>)
- Single-phase, four-stage time overcurrent (EFPIOC, EF4PTOC) protection functions (i.e. earth fault protection) (ANSI 50N/51N, 50G/51G, IEC IN>)
- Thermal overload protection (TRPTTR) function (ANSI 49, IEC θ >)
- Two-stage, time overvoltage (OV2PTOV) protection functions (ANSI 59, IEC 3U>)
- Two-stage, time undervoltage (UV2PTOV) protection functions (ANSI 27, IEC 3U<)
- Overexcitation (V/Hz, OEXPVPH) protection function (ANSI 24, IEC U/f>)
- Automatic voltage control function (automatic on-load tap-changer control, TR1ATCC/TR8ATCC) (ANSI 90)
- Disturbance recording (DRPRDRE) for 40 analogue signals with 1ms resolution (ANSI DFR, IEC DR)
- Disturbance recording (DRPRDRE) for 96 binary signals with 1ms resolution (ANSI DFR/SER, IEC DR)
- Internal Event List for last 1000 events with 1ms resolution (ANSI SER, IEC EL)

RET670/650 is a fully numerical protection IED. Twenty samples in each power system cycle - 1000Hz sampling rate for 50Hz power system, 1200Hz sampling rate for 60Hz power system - are used for all internal algorithms including transformer differential protection. By efficient digital filtering, phasors of the fundamental frequency component are extracted and used in all protection and control algorithms. Any dc component and all higher order harmonics in the current and voltage input signals are effectively suppressed. Hence they do not influence on the operation and the accuracy of any protection or control function in RET670/650 very much. However if required, the operation of the over-current protection and thermal overload protection functions can be based instead on the true RMS current value which will then include all higher harmonics.

All calculations inside RET670/650 are done in primary values. Therefore it is of the utmost importance that all CT and VT data - the instrument transformer ratios and the CT earthing direction - are properly set. For railway applications the CT and VT parameter settings need to be set in the same way as for a normal three-phase power transformer.

For the differential protection in RET670/650 it is necessary to set the rated data of the power transformer. These settings include the rated current and the rated voltage for every winding of the three-phase power transformer. For all railway applications these parameters need to be set in a special way, since railway transformers are not of a three-phase design. How this data needs to be set is clearly described for each specific railway transformer type.

2.1. Protection Scheme for a Three-Phase, Dd0d0 Power Transformer

As a reference we explain a protection scheme for a “normal” three-phase power transformer in order to understand how the differential currents are calculated by RET670/650. It is possible to use RET670/650 for the complete three-winding transformer protection scheme as shown in Figure 2:

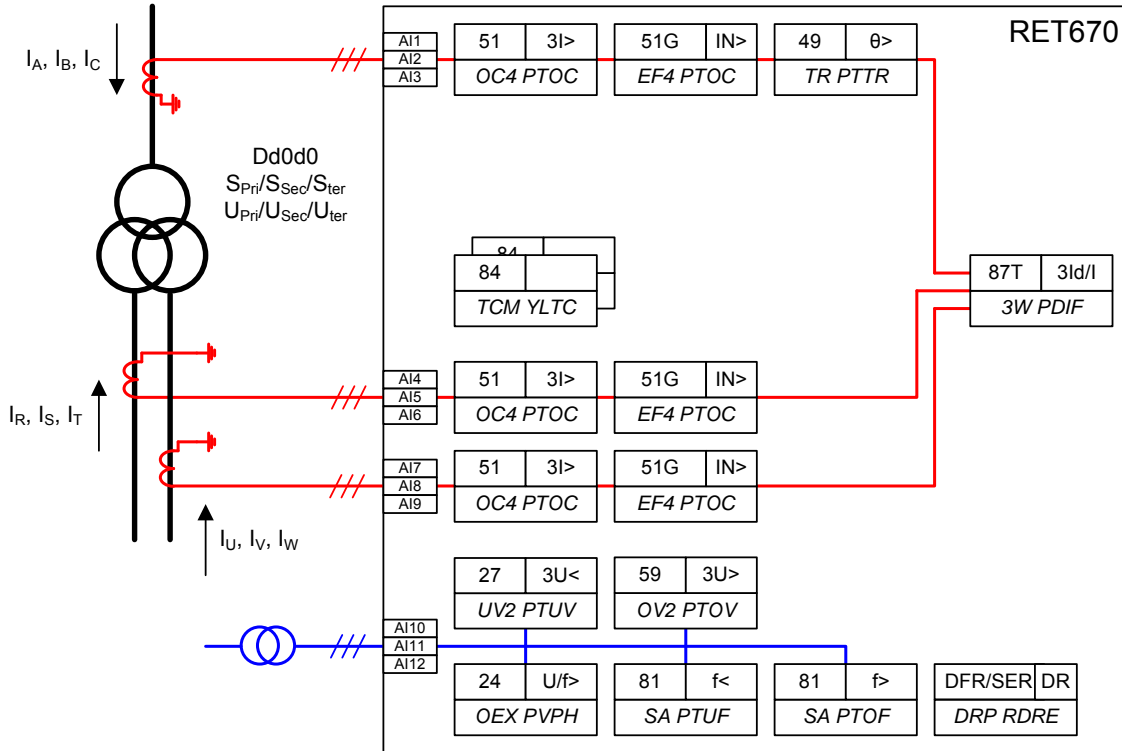


Figure 2 - Conventional 3 phase transformer block diagram for RET670

Function name	Function description
T3W PDIF	Three-winding transformer differential protection (87T and 87H, 3Id/I)
OC4 PTOC	Four-stage overcurrent protection (50/51, 3I>/3I>>)
EF4 PTOC	Four-stage earthfault protection (50N/51N, 3In>/3In>>)
TR PTTR	Thermal overload protection (49, θ>)
UV2 PTUV	Two-stage undervoltage protection (27, U</U<<)
OV2 PTOV	Two-stage overvoltage (59, U>/U>>)
OEX PVPH	Overexcitation protection, not commonly used in railway applications (24, U/f>)
SA PTUF	Underfrequency protection, not commonly used in railway applications (81, f<)
SA PTOF	Overfrequency protection, not commonly used in railway applications (81, f>)
TCM YLTC	Tap changer and voltage control for transformers with an OLTC (84/90)
DRP RDRE	Disturbance and event recorder function for 1000 events, 40 analog channels and 96 binary channels

Figure 2 shows the required analog quantities which need to be measured. The analog part of the differential protection function configuration which needs to be made in the ACT (Application Configuration Tool) for this particular application is shown in Figure 3.

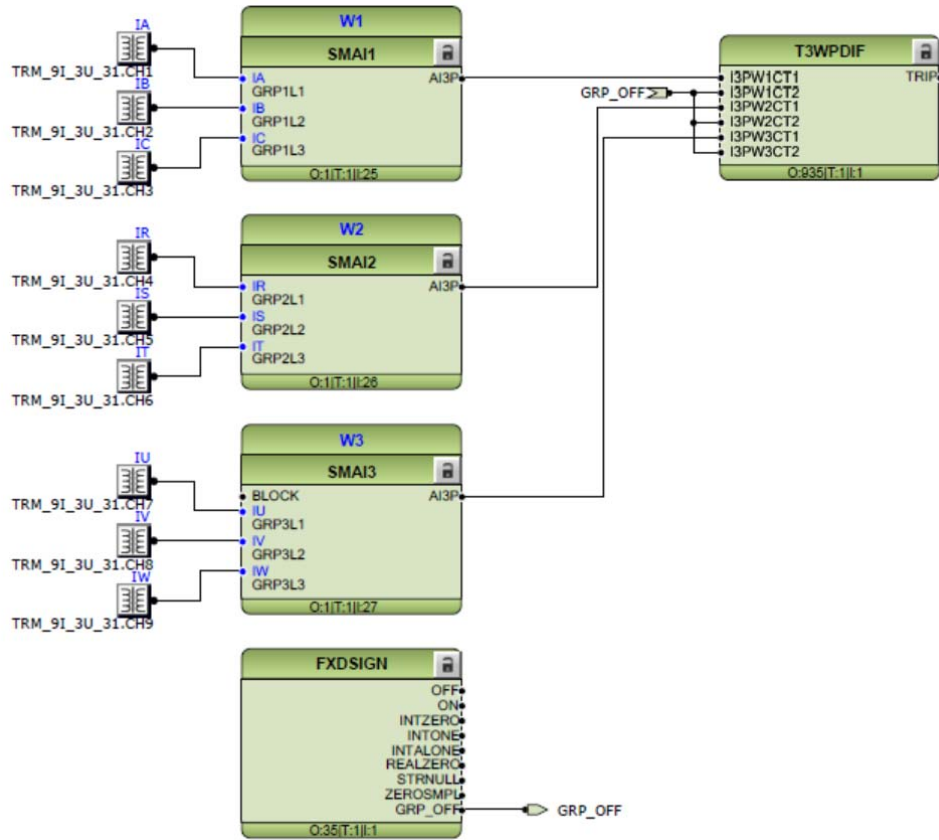


Figure 3 - Conventional 3 phase transformer application configuration for RET670

The preprocessing functions (SMAI) calculate the phasors required by the differential protection function (T3WPDIF), based on their analog input channels (TRM – transformer module).

The rated values of the transformer can be determined as per Equation 1:

$$S_{r1} = S_{Pri}; U_{r1} = U_{Pri}; I_{r1} = \frac{S_{Pri}}{\sqrt{3} \times U_{Pri}} \quad S_{r2} = S_{Sec}; U_{r2} = U_{Sec}; I_{r2} = \frac{S_{Sec}}{\sqrt{3} \times U_{Sec}} \quad S_{r3} = S_{Ter}; U_{r3} = U_{Ter}; I_{r3} = \frac{S_{Ter}}{\sqrt{3} \times U_{Ter}}$$

Equation 1

Zero sequence current subtraction shall be set 'Off'.

For all the application examples in this document the transformer configuration should be chosen as either Dd0d0 or Dd0d6. When applying a Dd0d0 vector group on a conventional three phase transformer, the differential function will calculate the three differential currents as per Equation 2:

$$I_{diff L1} = I_A + \frac{U_{r2}}{U_{r1}} \times I_R + \frac{U_{r3}}{U_{r1}} \times I_U \quad I_{diff L2} = I_B + \frac{U_{r2}}{U_{r1}} \times I_S + \frac{U_{r3}}{U_{r1}} \times I_V \quad I_{diff L3} = I_C + \frac{U_{r2}}{U_{r1}} \times I_T + \frac{U_{r3}}{U_{r1}} \times I_W$$

Equation 2

In this example the differential currents are related to the high voltage side of the transformer - i.e., the primary side. To obtain differential current value in per-unit system, divide the values from the Equation 2 with the set value for parameter I_{r1} .

2.2. Features in the RET670/650 used for special railway power transformers protection schemes

- It is possible to negate a three phase set of currents.
- Currents can be summated or subtracted in the IED by summation function blocks (SUM3PH). This feature allows for current subtraction or summation in software, without any need for galvanic connections between different CT secondary circuits.
- RET 670/650 was designed for the protection of three phase power transformers in the first place. Therefore analogue quantities inside are treated in a three-phase manner (see section 2.1 for more details), and the same rules must be used for these special railway applications as well. Because of this it will be necessary to use some "zero current" - i.e., an analogue input current with a zero value, in order to build an artificial three-phase quantity out of a two phase system. The flexibility of programming RET670/650 allows for such an application to be easily implemented.

This zero current will be obtained from an analog CT input, which will not be connected to anything - i.e., intentionally left unwired. The configuration parameters for this CT input shall be set in the following way:

CTprim=1A

CTsec=10A

Any noise from that CT input will thus be effectively suppressed, since the magnitude of the noise will be very small compared to the primary rating of the other CTs. The same analog input can be used for all of the transformer windings. In all configurations that will be shown in this document the current input AI8 will be used as this zero current input.

The combination of these features gives the opportunity to use the RET670/650 as differential protection for special railway power transformers without any external auxiliary current transformers.

2.3. Typically required hardware in RET670 for railway applications

All railway applications shown in this document can be realized with the identical RET670 hardware configuration as listed below:

- 1 x TRM module (9I+3U) (nine current and three voltage inputs from the protected transformer)
- 1 x BIM module (16 binary inputs for connection of winding and oil contact thermometers, buchholz relay, external tripping devices, etc.)
- 1 x BOM module (24 contact outputs for trip commands, alarms, SCADA indications, etc.)
- Optionally 1 x MIM module (six, ± 20 mA input channels, which can be used for on-load tap-changer position reading and/or oil and winding temperature measurement)

2.4. Typically required RET650 configuration for railway applications

The configured RET650 A05 version can be chosen. This IED comes configured with:

- 1 x TRM module (6I+4U) (six current and four voltage inputs from the protected transformer)
- 1 x AIM module (6I+4U) (six current and four voltage inputs from the protected transformer)
- 32 binary inputs for connection of winding and oil contact thermometers, buchholz relay, external tripping devices, etc.
- 27 contact outputs for trip commands, alarms, SCADA indications, etc.

3. Protection Scheme for Single Phase Power Transformer

This type of transformer is commonly used in Europe in older types of railway installations. It is usually connected as shown in Figure 4:

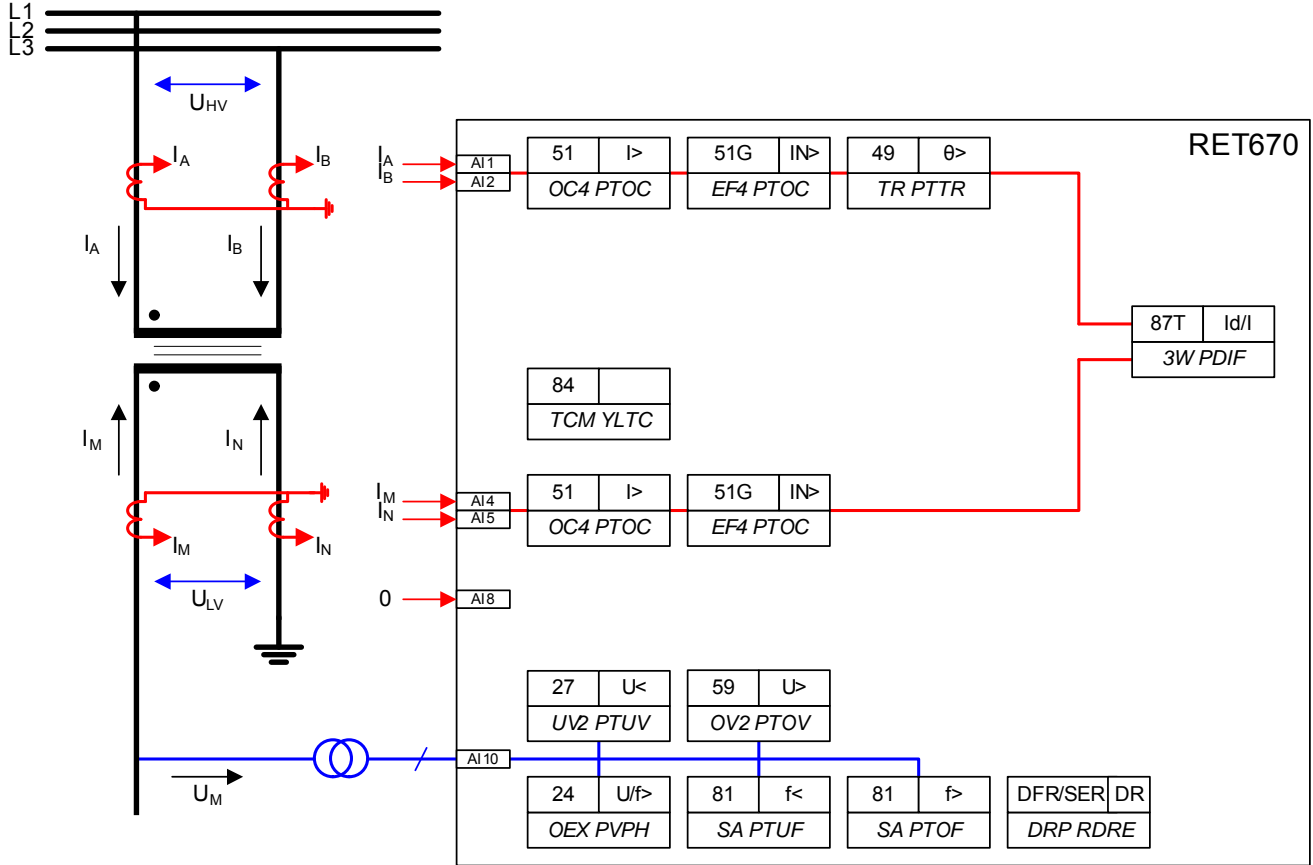


Figure 4 - Single phase power transformer block diagram

The analog inputs should be connected as shown in Figure 5 in the ACT. Since this is a two phase system and the differential function is expecting a three phase system, an additional input (AI8) is used to zero out phase L2.

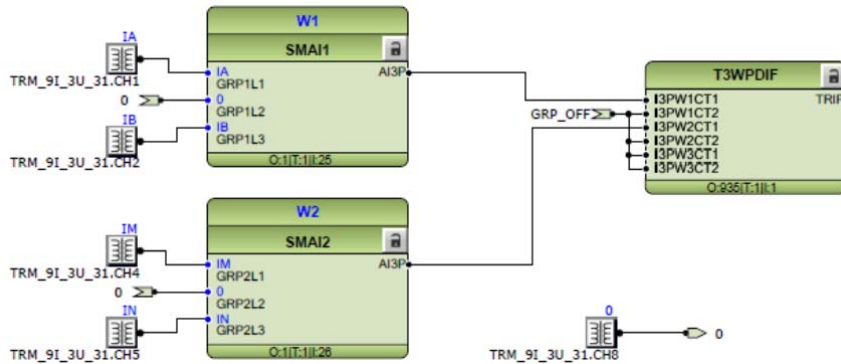


Figure 5 - Single phase power transformer differential protection application configuration for RET670

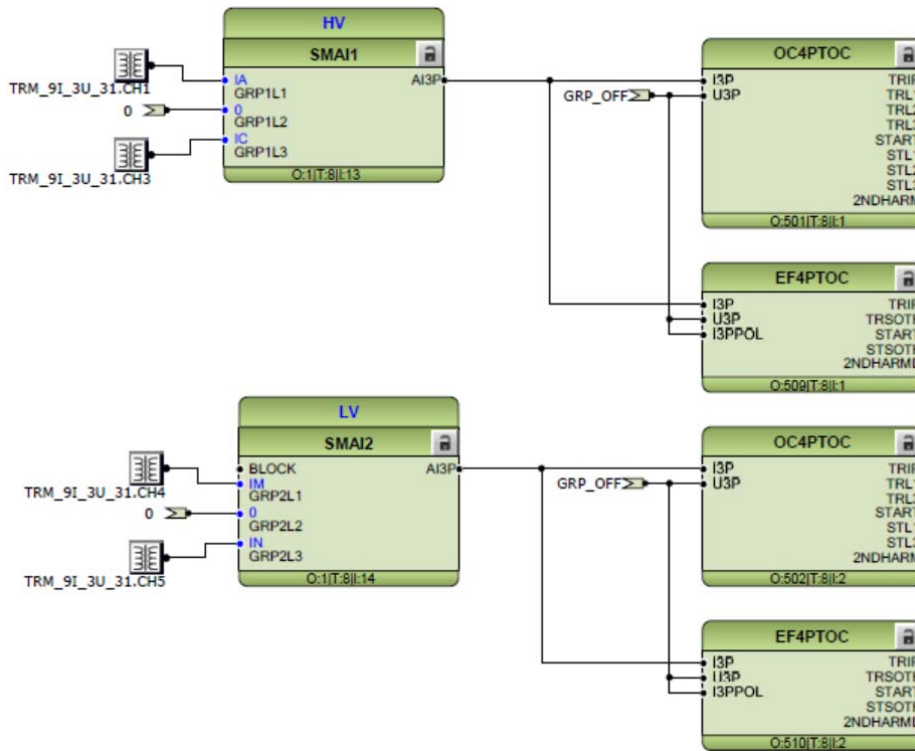


Figure 6 - Single phase power transformer back-up protection application configuration for RET670

The rated values of the transformer can be determined as per Equation 3:

$$S_{r1} = S; U_{r1} = U_{HV}; I_{r1} = \frac{S}{U_{HV}} \quad S_{r2} = S; U_{r2} = U_{LV}; I_{r2} = \frac{S}{U_{LV}}$$

Equation 3

Zero sequence current subtraction shall be set 'Off'.

Set the vector group to Dd0. Because the Dd0 vector group is used, the differential function will calculate the three differential currents as per Equation 4:

$$I_{diffL1} = I_A + \frac{U_{LV}}{U_{HV}} \times I_M \quad I_{diffL2} = 0 \quad I_{diffL3} = I_B + \frac{U_{LV}}{U_{HV}} \times I_N$$

Equation 4

Phase L1 and phase L3 will be used for differential protection, while phase L2 will measure zero current all the time - i.e. phase L2 will not be used in the differential protection function.

In practice very often only one HV CT and one LV CT are available. In that case phase L3 would have to be connected to AI8 as well, to zero out this phase. In such installations it is even possible to protect two identical railway power transformers with one RET670 IED. This gives possibility for more cost effective solutions.

Another possibility is to use RED670 (this solution is not available for RET650 or RET670) to protect a transformer including the overhead line or cable feeding the railway transformer. The utility substation and traction transformer can sometimes be in different locations and in order to reduce costs there might only be a circuit breaker on the utility side. In such a case RED670 can apply differential protection over the whole section of line and the traction transformer. Additionally it would be possible to utilize the programming and functional flexibility to implement backup distance protection as well.

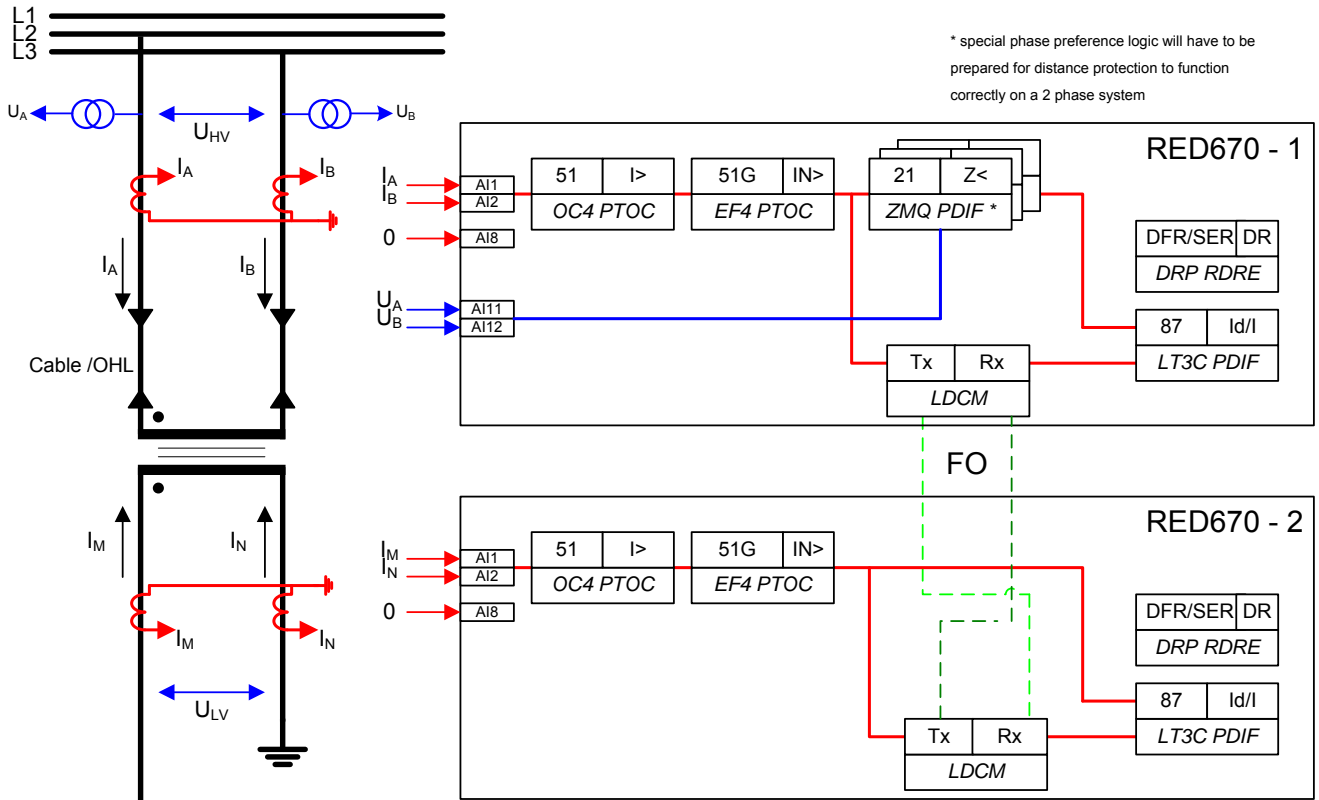


Figure 7 - Single phase power transformer with line protection block diagram for RED670

The calculations for the rated values of the protected transformer and the differential current are the same as for the single phase power transformer without the line within the protected zone. The differential protection application configuration is similar as well, except that the LT3CPDIF function is used instead of the T3WPDIF, and that the HV CTs will be connected to one RED670 and the LV CTs to the other RED670. Communication between the two RED670s will be via a digital link (either direct optical fiber or via a telecommunication provider).

In order to apply distance protection, the phase selection logic has to be configured in a special way in order to work properly on a two phase system. Contact ABB when applying distance protection on such two phase system for more information.

3.1. Example 1

T3wPDIF: 1		
RatedVoltageW1	132,00	kV
RatedVoltageW2	27,50	kV
RatedCurrentW1	174	A
RatedCurrentW2	836	A
ConnectTypeW1	Delta (D)	
ConnectTypeW2	Delta (D)	
ClockNumberW2	0 [0 deg]	
ZSCurrSubtrW1	Off	
ZSCurrSubtrW2	Off	

$$\text{RatedVoltageW1} = U_{HV} = 132\text{kV}$$

$$\text{RatedVoltageW2} = U_{LV} = 27,5\text{kV}$$

$$\text{RatedCurrentW1} = \frac{S}{U_{HV}} = \frac{23\text{MVA}}{132\text{kV}} = 174\text{A}$$

$$\text{RatedCurrentW2} = \frac{S}{U_{LV}} = \frac{23\text{MVA}}{27,5\text{kV}} = 836\text{A}$$

4. Protection Scheme for Split-Single Phase Power Transformer

This type of transformer is commonly used in Europe for new railway installations (i.e. Italy, France and the UK). It is usually connected as shown in Figure 8:

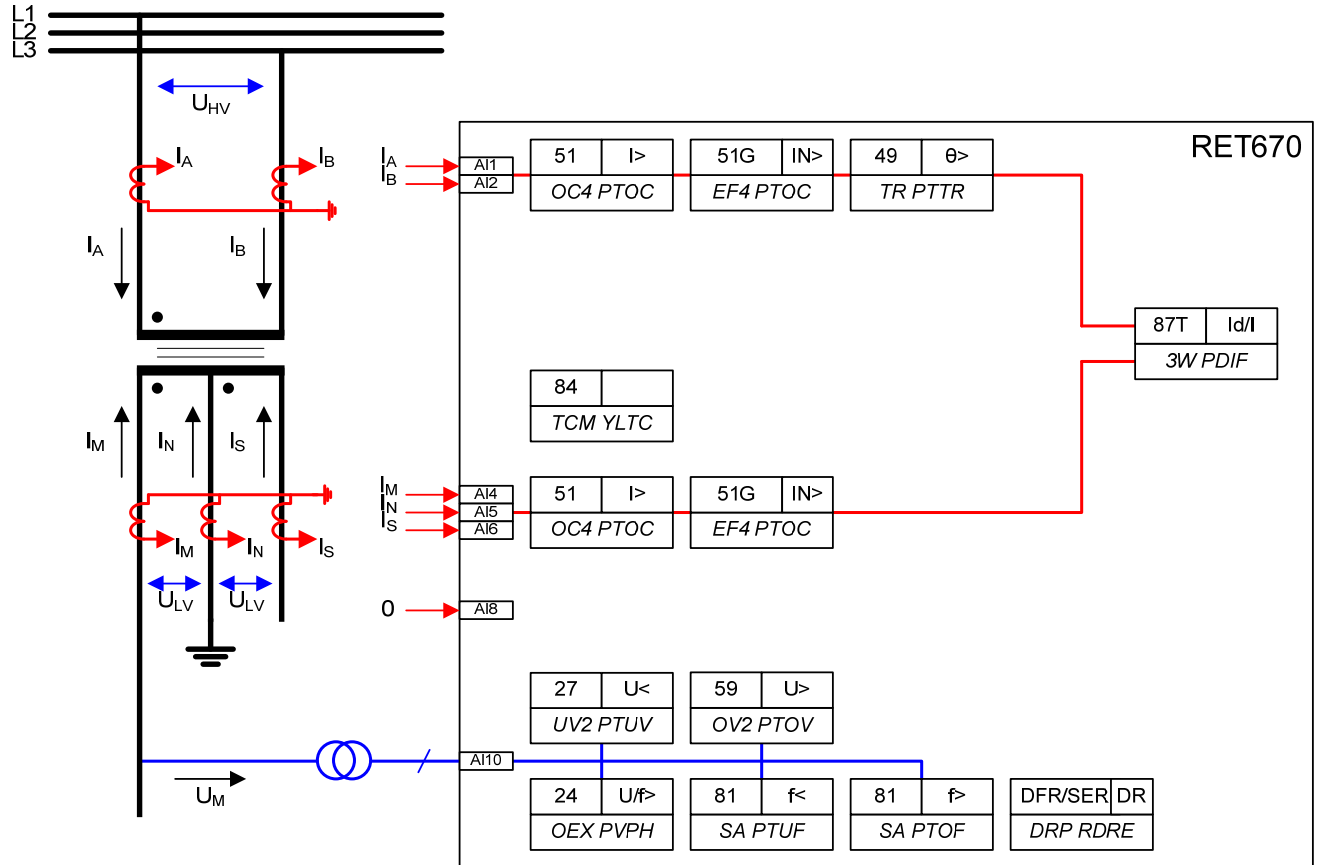


Figure 8 - Split-single phase power transformer block diagram

The analog inputs should be connected as shown in Figure 9 in the ACT. Since this is a two phase system and the differential function is expecting a three phase system, an additional input (AI8) is used to zero out phase L2.

If required low impedance restricted earth fault protection (REF PDIF) can be used for the LV windings.

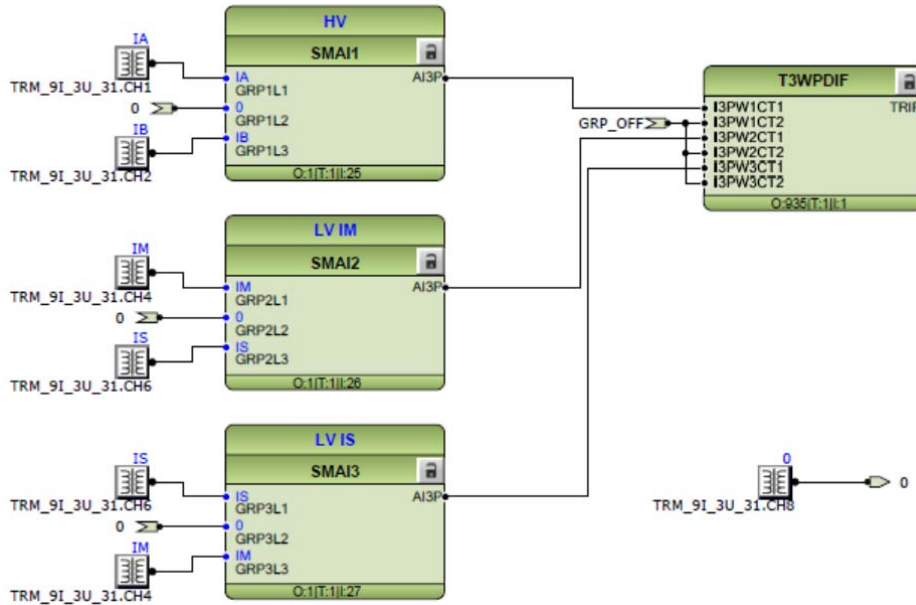


Figure 9 - Split-single phase power transformer differential protection application configuration for RET670

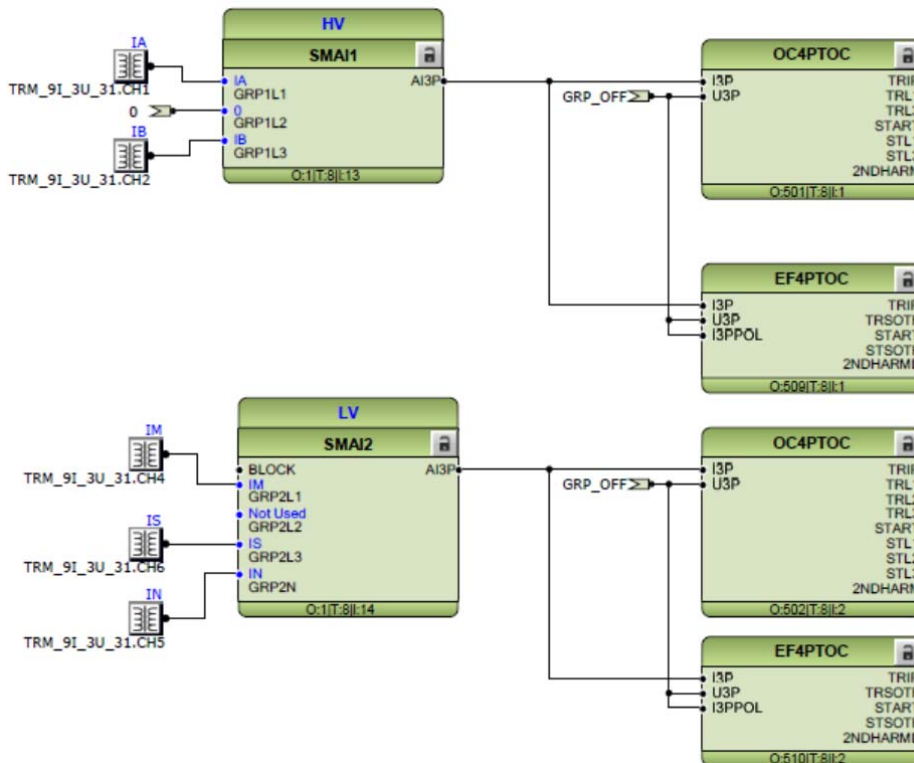


Figure 10 - Split-single phase power transformer back-up protection application configuration for RET670

The rated values of the transformer can be determined as per Equation 5:

$$S_{r1} = S; U_{r1} = U_{HV}; I_{r1} = \frac{S}{U_{HV}} \quad S_{r2} = \frac{S}{2}; U_{r2} = U_{LV}; I_{r2} = \frac{S}{2 \times U_{LV}} \quad S_{r3} = \frac{S}{2}; U_{r3} = U_{LV}; I_{r3} = \frac{S}{2 \times U_{LV}}$$

Equation 5

Zero sequence current subtraction shall be set 'Off'.

Set the vector group to Dd0d6. Because the Dd0d6 vector group is used, the differential function will calculate the three differential currents as per Equation 6:

$$I_{diff L1} = I_A + \frac{U_{LV}}{U_{HV}} \times I_M - \frac{U_{LV}}{U_{HV}} \times I_S \quad I_{diff L2} = 0 \quad I_{diff L3} = I_B + \frac{U_{LV}}{U_{HV}} \times I_S - \frac{U_{LV}}{U_{HV}} \times I_M$$

Equation 6

Phase L1 and phase L3 will be used for differential protection, while phase L2 will measure zero current all the time - i.e. phase L2 will not be used in the differential protection function.

Please note that, with some restriction, it may be possible to protect two of these transformers with one RET670.

4.1. Example 2

Differential protection		
TransformerDiff3Wind(PDIF,87T)		
T3WPDIF: 1		
RatedVoltageW1	400,00	k
RatedVoltageW2	26,25	k
RatedVoltageW3	26,25	k
RatedCurrentW1	200	A
RatedCurrentW2	1524	A
RatedCurrentW3	1524	A
ConnectTypeW1	Delta (D)	
ConnectTypeW2	Delta (D)	
ConnectTypeW3	Delta (D)	
ClockNumberW2	0 [0 deg]	
ClockNumberW3	6 [180 deg]	
ZSCurrSubtrW1	Off	
ZSCurrSubtrW2	Off	
ZSCurrSubtrW3	Off	

$$\text{RatedVoltageW1} = U_{HV} = 400 \text{ kV}$$

$$\text{RatedVoltageW2} = U_{LV} = 26,25 \text{ kV}$$

$$\text{RatedVoltageW3} = U_{LV} = 26,25 \text{ kV}$$

$$\text{RatedCurrentW1} = \frac{S}{U_{HV}} = \frac{80 \text{ MVA}}{400 \text{ kV}} = 200 \text{ A}$$

$$\text{RatedCurrentW2} = \frac{S}{2 \times U_{LV}} = \frac{80 \text{ MVA}}{2 \times 26,25 \text{ kV}} = 1524 \text{ A}$$

$$\text{RatedCurrentW3} = \frac{S}{2 \times U_{LV}} = \frac{80 \text{ MVA}}{2 \times 26,25 \text{ kV}} = 1524 \text{ A}$$

5. Protection Scheme for Railway Autotransformer

Railway autotransformers are always used together with a split-single phase transformer design - i.e. on a $\pm 25\text{kV}$ railway supply system. Such autotransformers are located in the paralleling or traction stations and one autotransformer is often shared between two railway track sections. It is usually connected as shown in Figure 11:

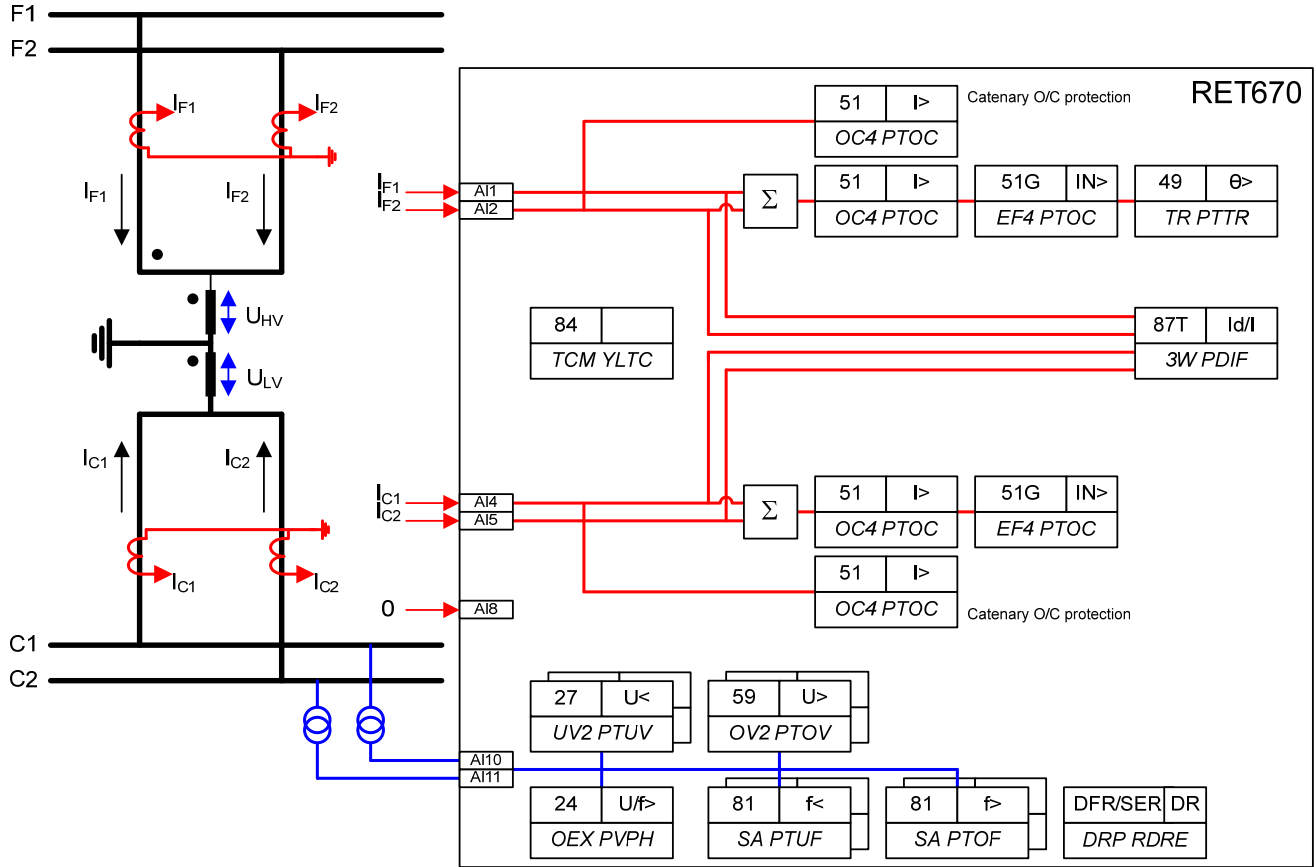


Figure 11 - Railway autotransformer block diagram

The analog inputs should be connected as shown in Figure 12 in the ACT. Since this is a one phase system and the differential function is expecting a three phase system, an additional input (AI8) is used to zero out phases L1 and L2 as shown in Figure 12.

Since two CTs are available for each winding - two restrain inputs are needed per winding. Thus, in total 4 restrain inputs are used, all connected as shown in Figure 12.

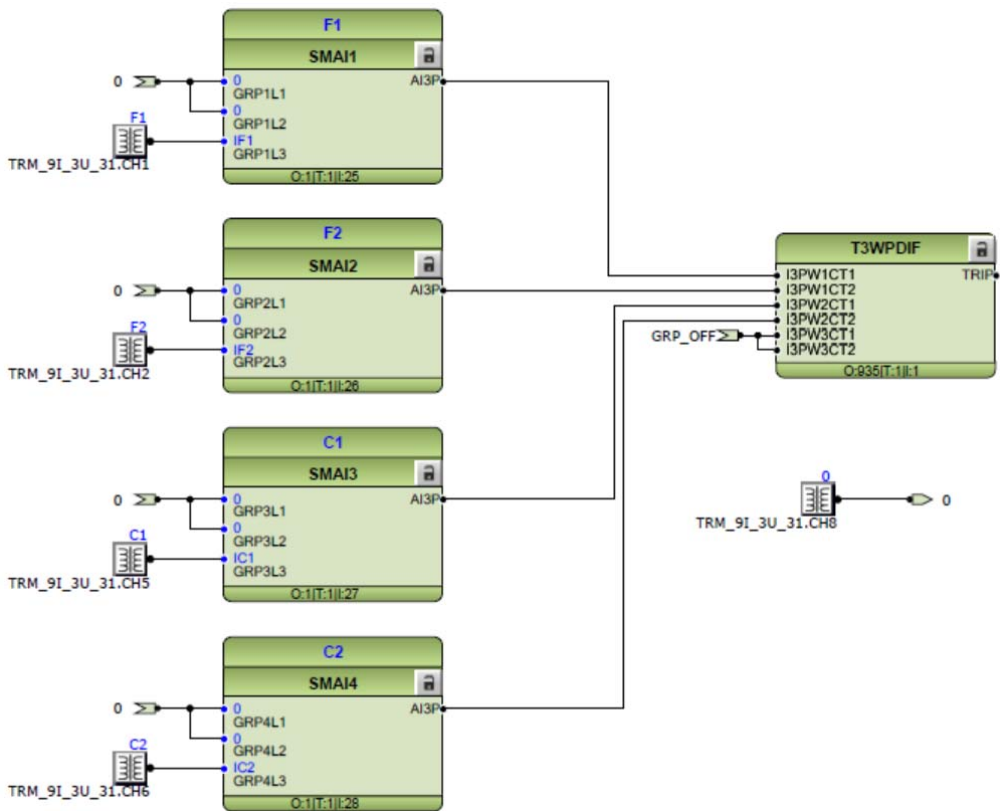


Figure 12 - Railway autotransformer differential protection application example for RET670

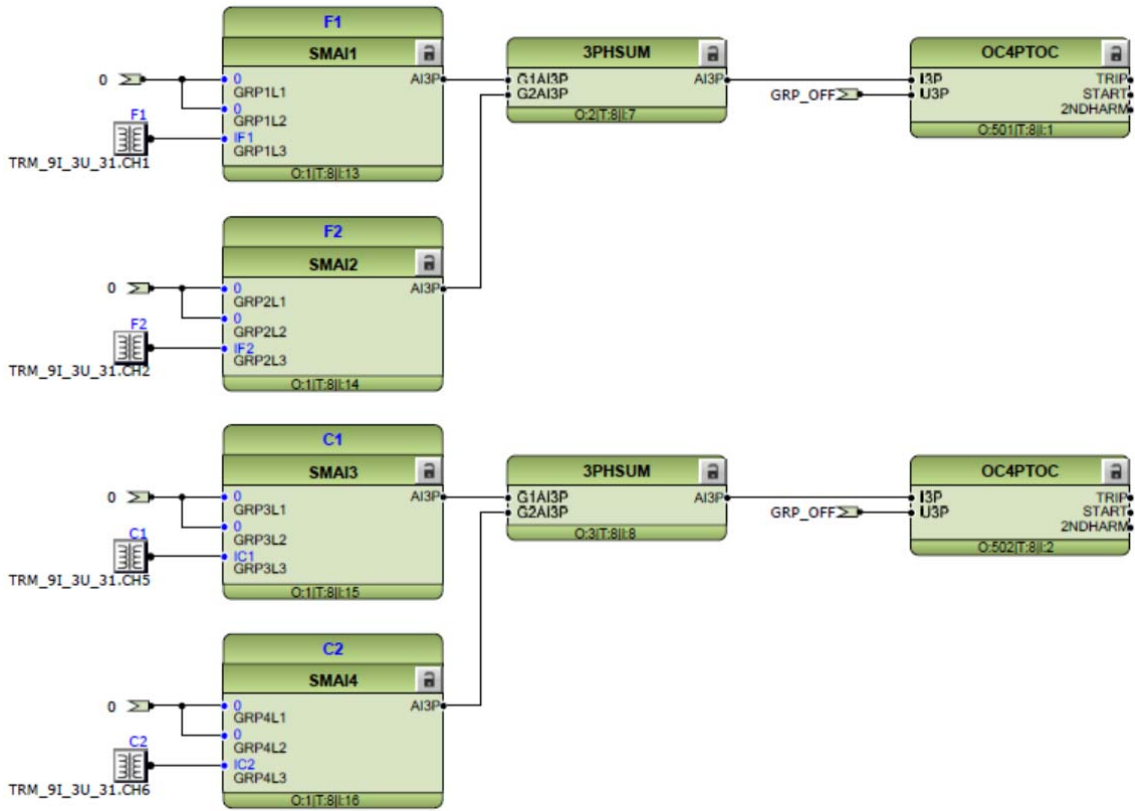


Figure 13 - Railway autotransformer back-up protection application example for RET670

The rated values of the transformer can be determined as per Equation 7:

$$S_{r1} = S; U_{r1} = U_{HV}; I_{r1} = \frac{S}{U_{HV}} \quad S_{r2} = S; U_{r2} = U_{LV}; I_{r2} = \frac{S}{U_{LV}} \quad \text{Equation 7}$$

Zero sequence current subtraction shall be set 'Off'.

Set the vector group to Dd6d0. Because the Dd6d0 vector group is used, the differential function will calculate the three differential currents as per Equation 8:

$$I_{diff} L1 = 0 \quad I_{diff} L2 = 0 \quad I_{diff} L3 = (I_{F1} + I_{F2}) - \frac{U_{LV}}{U_{HV}} \times (I_{C1} + I_{C2}) \quad \text{Equation 8}$$

Only phase L3 will be used for differential protection, while phases L1 and L2 will measure zero current all the time – i.e., phases L1 and L2 will not be used in the differential protection function. The differential current values will be related to HV transformer side.

The backup overcurrent, earth fault and thermal overload protection of the autotransformer is achieved by internally summing the current from I_{F1}/I_{F2} and I_{C1}/I_{C2} . Since this is a transformer protection and we are interested only in the magnitude of current actually going through the transformer, the 3PHSUM function blocks should be set to 'Group1+Group2'. The protection functions will not pick up on any fault current flowing through the T-connection due to any fault on the catenaries.

The backup overcurrent protection function for the catenaries is achieved as a two phase system. The third phase will have to be connected to AI8 again.

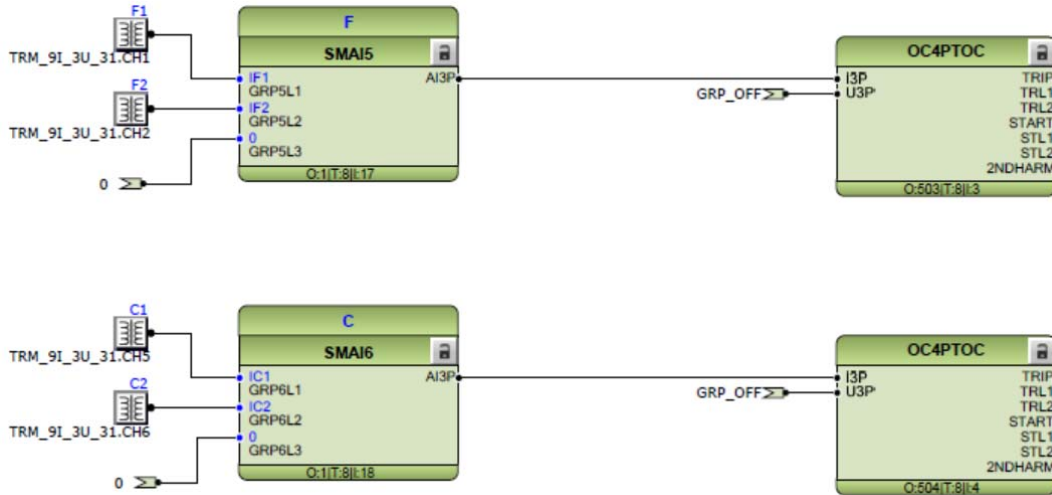


Figure 14 - Railway autotransformer catenary protection application example for RET670

For solutions where there is more than one autotransformer in the same paralleling station, it would be possible as well - with some restrictions - to protect two or even three autotransformers with one RET670 IED.

5.1. Example 3

T3WPDIF: 1		
RatedVoltageW1	27,50	kV
RatedVoltageW2	27,50	kV
RatedCurrentW1	182	A
RatedCurrentW2	182	A
ConnectTypeW1	Delta (D)	
ConnectTypeW2	Delta (D)	
ClockNumberW2	6 [180 deg]	
ZSCurrSubtrW1	Off	
ZSCurrSubtrW2	Off	

$$\text{RatedVoltageW1} = U_{HV} = 27,5\text{kV}$$

$$\text{RatedVoltageW2} = U_{LV} = 27,5\text{kV}$$

$$\text{RatedCurrentW1} = \frac{S}{U_{HV}} = \frac{5\text{MVA}}{27,5\text{kV}} = 182\text{A}$$

$$\text{RatedCurrentW2} = \frac{S}{U_{LV}} = \frac{5\text{MVA}}{27,5\text{kV}} = 182\text{A}$$

6. Protection Scheme for Scott Power Transformer

This type of transformer is commonly used in Asia for railway installations (i.e. China and Korea). Its main feature is the ability to transfer a three-phase power supply system to a two-phase railway supply system. It is usually connected as shown in Figure 15:

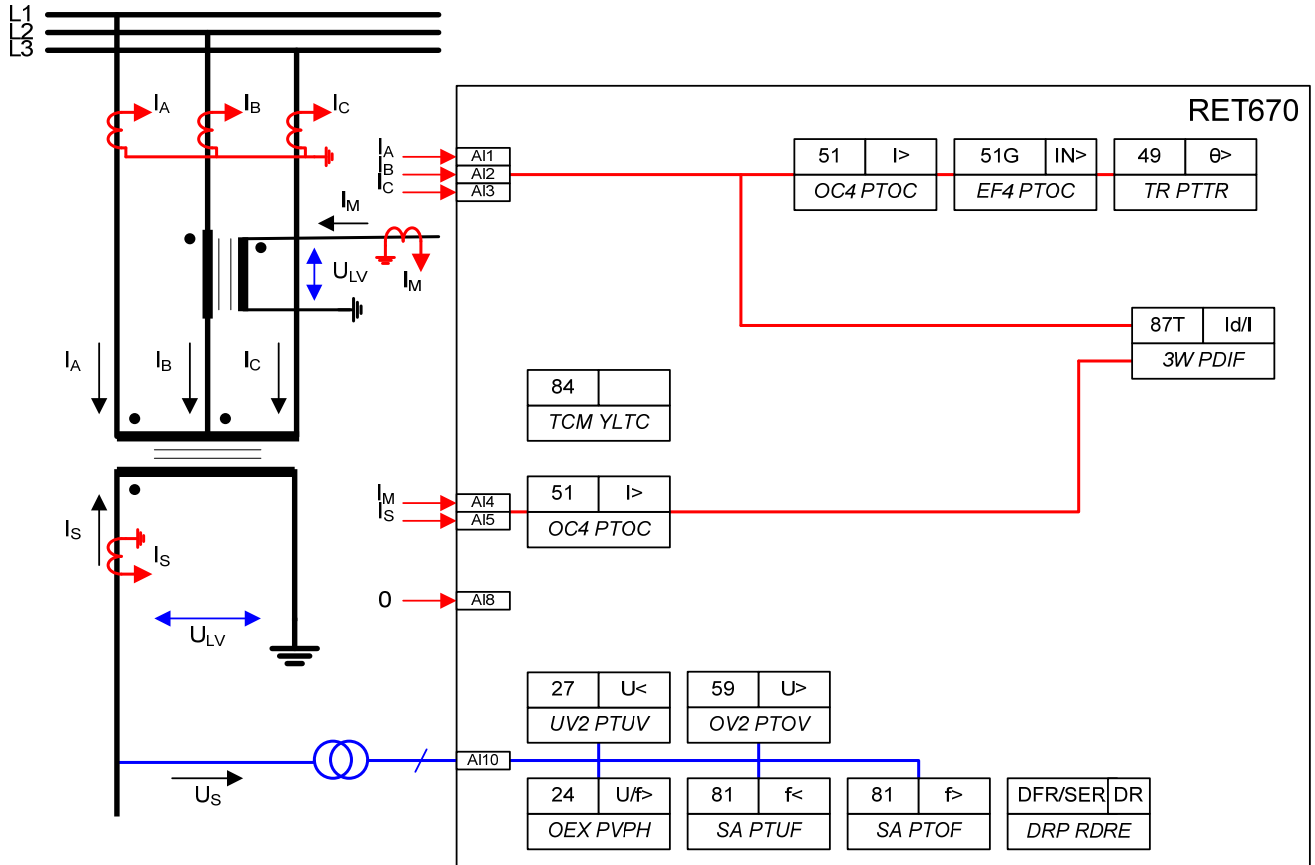


Figure 15 - Scott Power Transformer block diagram

Only one phase voltage (i.e. U_T) of the 2-phase railway supply system is connected to RET670/650 in this example. However it is possible to connect the other phase voltage (U_M) to the VT analog input 11. If required another set of over/under voltage protection functions can be included to monitor/protect that winding voltage as well.

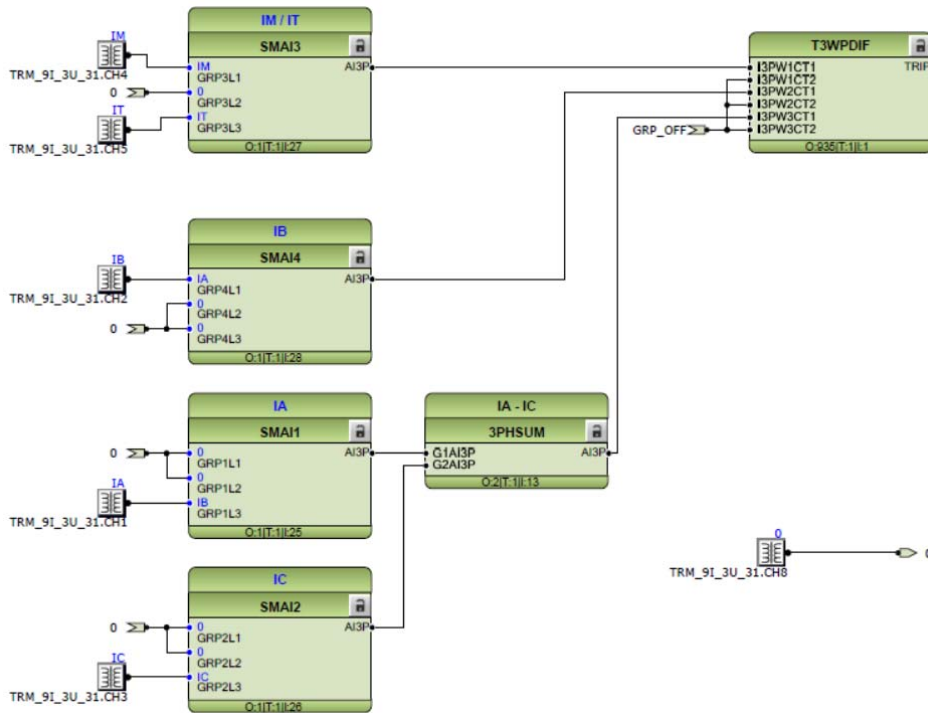


Figure 16 - Scott Power Transformer differential protection application configuration for RET670

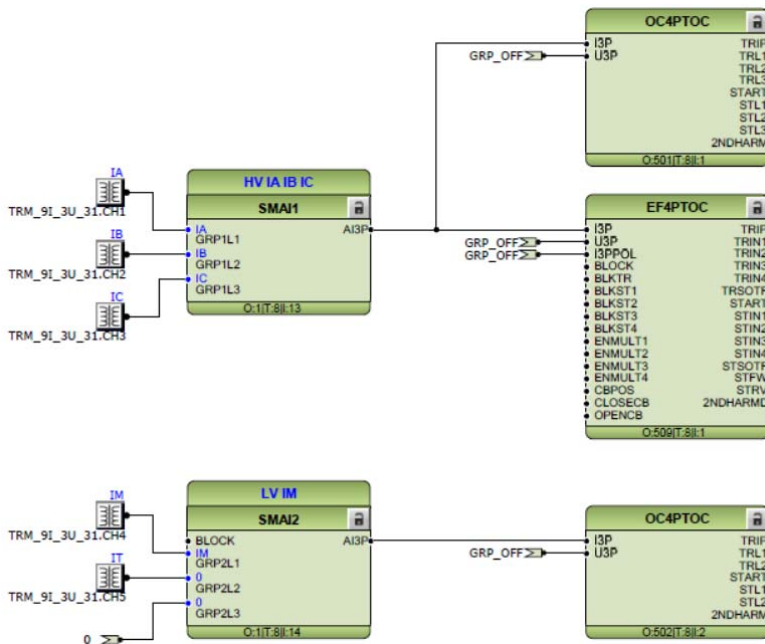


Figure 17 - Scott Power Transformer back-up protection application configuration for RET670

The rated values of the transformer can be determined as per Equation 9:

$$S_{r1} = \frac{S}{2}; U_{r1} = U_{LV}; I_{r1} = \frac{S}{2 \times U_{LV}} \quad S_{r2} = \frac{S}{2}; U_{r2} = \frac{\sqrt{3}}{2} \times U_{HV}; I_{r2} = \frac{S}{\sqrt{3} \times U_{HV}} \quad S_{r3} = \frac{S}{2}; U_{r3} = \frac{U_{HV}}{2} \times U_{HV}; I_{r3} = \frac{S}{\sqrt{3} \times U_{HV}}$$

Equation 9

Zero sequence current subtraction shall be turned 'Off'.

Set the vector group to Dd0d0. Because the Dd0d0 vector group is used, the differential function will calculate the three differential currents as per Equation 10:

$$I_{diff L1} = I_M + \frac{\sqrt{3} U_{HV}}{2 U_{LV}} \times I_B + \frac{U_{HV}}{2 U_{LV}} \times 0 = I_M + \frac{\sqrt{3} U_{HV}}{2 U_{LV}} \times I_B \quad I_{diff L3} = I_T + \frac{\sqrt{3} U_{HV}}{2 U_{LV}} \times 0 + \frac{U_{HV}}{2 U_{LV}} \times (I_A - I_C) = I_T + \frac{U_{HV}}{2 U_{LV}} \times (I_A - I_C)$$

$$I_{diff L2} = 0$$

Equation 10

Phase L1 and phase L3 will be used for the differential protection function, while phase L2 will measure zero current all the time - i.e., phase L2 will not be used. The differential current values will be related to the LV-side supply system for this Scott transformer application.

The backup over-current protection function for two LV sides is achieved as for a two-phase system. The third phase will have to be connected to AI8 again. Note that if required it is possible to provide separate (i.e. segregated) overcurrent protection by using two over-current protection functions in order to get different pick up levels and time grading for two LV supply systems.

6.1. Example 4

T3WPDIF: 1		
RatedVoltageW1	55,00	kV
RatedVoltageW2	133,35	kV
RatedVoltageW3	77,00	kV
RatedCurrentW1	818	A
RatedCurrentW2	337	A
RatedCurrentW3	337	A
ConnectTypeW1	Delta (D)	
ConnectTypeW2	Delta (D)	
ConnectTypeW3	Delta (D)	
ClockNumberW2	0 [0 deg]	
ClockNumberW3	0 [0 deg]	
ZSCurrSubtrW1	Off	
ZSCurrSubtrW2	Off	
ZSCurrSubtrW3	Off	

$$\text{RatedVoltageW1} = U_{LV} = 55\text{ kV}$$

$$\text{RatedVoltageW2} = \frac{\sqrt{3}}{2} \times U_{HV} = \frac{\sqrt{3}}{2} \times 154\text{ kV} = 133,35\text{ kV}$$

$$\text{RatedVoltageW3} = \frac{U_{HV}}{2} = \frac{154\text{ kV}}{2} = 77\text{ kV}$$

$$\text{RatedCurrentW1} = \frac{S}{2 \times U_{LV}} = \frac{90\text{ MVA}}{2 \times 55\text{ kV}} = 818\text{ A}$$

$$\text{RatedCurrentW2} = \frac{S}{\sqrt{3} \times U_{HV}} = \frac{90\text{ MVA}}{\sqrt{3} \times 154\text{ kV}} = 337\text{ A}$$

$$\text{RatedCurrentW3} = \frac{S}{\sqrt{3} \times U_{HV}} = \frac{90\text{ MVA}}{\sqrt{3} \times 154\text{ kV}} = 337\text{ A}$$

7. Conclusion

Some typical protection schemes with RET670/650 for most common types of railway power transformers have been presented. It should be noted however that these are only typical schemes. If you have any other requirements for protection of electrical railway supply system, please do contact your local ABB representative in order to make a tailor-made solution in accordance with your needs.

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