Grid Solutions

Application Notes

MICOM P40 AGILE P145, P14N

High Impedance Protection

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GE VERNOVA

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APPLICATION NOTES FOR MICOM P145 B/ P14N B HIGH IMPEDANCE DIFFERENTIAL PROTECTION

1. Introduction

High impedance differential schemes are popular in some countries due to following reasons:

1. Lower cost
2. Expandability for increase in numbers of feeder
3. Simple setting calculation and configuration
4. No need of CT switching in case of single bus system
5. Utility practices/preference

GE Vernova's MiCOM P145 B and P14N B can be used to provide high impedance differential protection for rotating machines, reactors, transformers and busbar installation. It provides high stability for any type of fault occurring outside the protected zone and satisfactory operation for faults within zone.

An example of a typical high impedance busbar scheme is shown below:

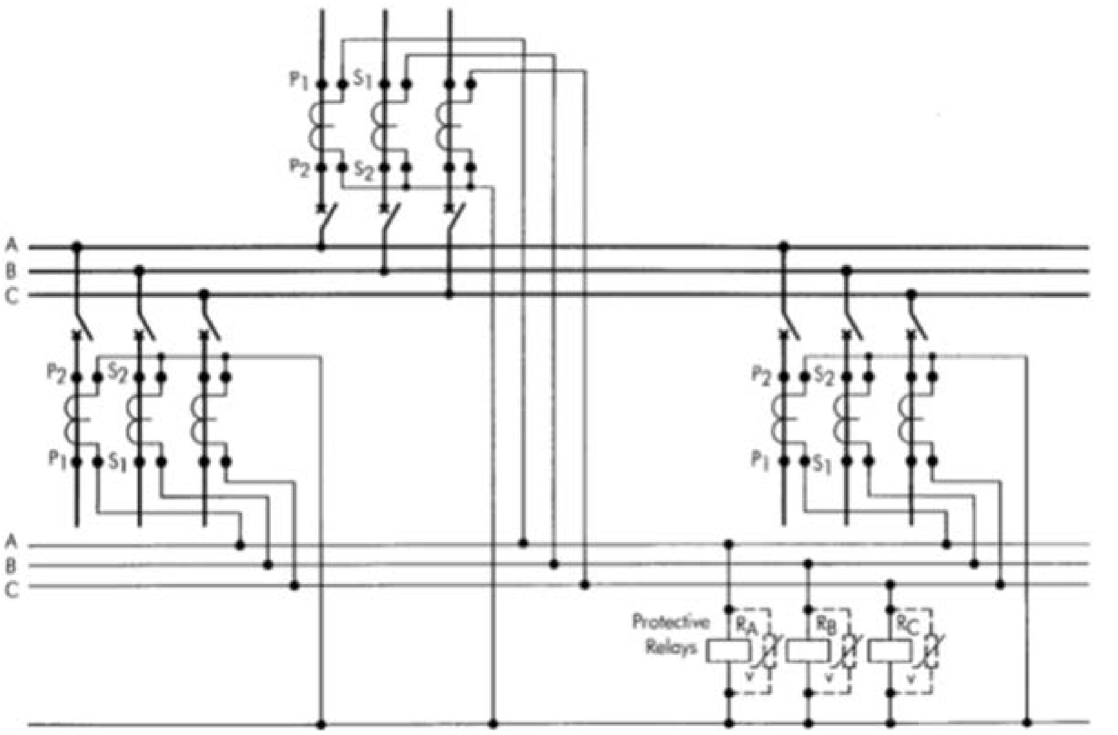


Figure 1: Typical high impedance busbar scheme

The following factors must be considered while designing a protection scheme:

- Stability
- Speed of operation
- Sensitivity

1.1 Stability of Scheme

Figure 2 shows an equivalent circuit for high impedance circulating system. During an external fault the through fault current should circulate between the current transformer secondaries. The only current that can flow through the relay circuit is that due to any difference in the current transformer outputs for the same primary current.

Magnetic saturation will reduce the output of a current transformer. The most extreme case for stability is when one current transformer is completely saturated and the other is unaffected.

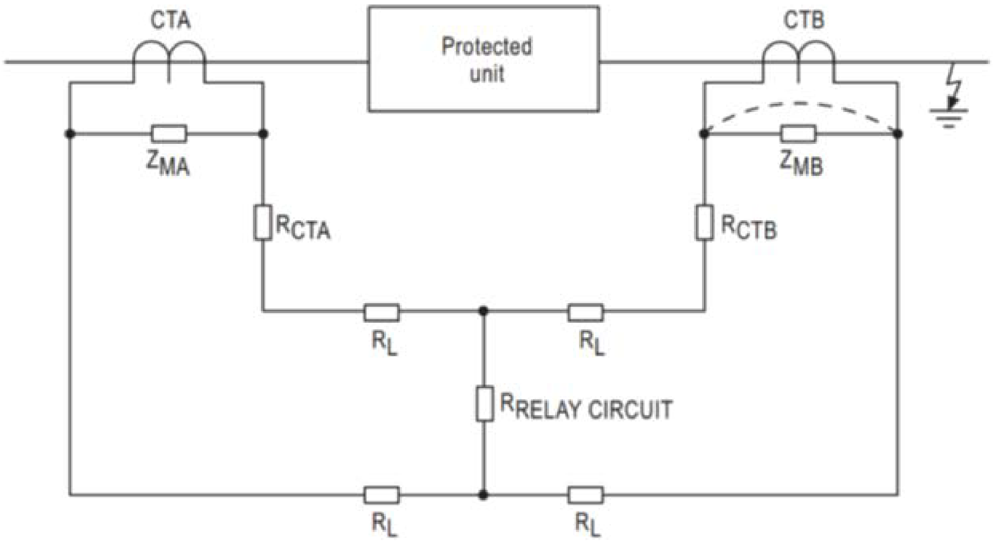


Figure 2: Equivalent circuit of high impedance scheme

At one end the current transformer can be considered fully saturated, with its magnetising impedance ZMB short circuited while the current transformer at the other end, being unaffected, delivers its full current output. This current will then divide between the relay and the saturated current transformer. This division will be in the inverse ratio of $R_{RELAY\ CIRCUIT}$ to ($R_{CTB} + 2R_L$) and, if $R_{RELAY\ CIRCUIT}$ is high compared with $R_{CTB} + 2R_L$, the relay will be prevented from undesirable operation, as most of the current will pass through the saturated current transformer.

To achieve stability for external faults, the stability voltage for the protection (Vs) must be determined in accordance with formula 1. The setting is dependent on the maximum current transformer secondary current for an external fault (If) and also on the highest loop resistance value from the relaying point ($R_{CT} + 2R_L$). The stability of the scheme is also affected by the characteristics of the differential relay and the application. For example, restricted earth fault and busbar. The value of K in the expression takes into account both of these considerations. One particular characteristic that affects the stability of the scheme is the operating time of the differential relay. The slower the relay operates the longer the spill current can exceed its setting before operation occurs and the higher the spill current that can be tolerated.

$$V_s > KI_f\ (R_{CT} + 2R_L) \quad (1)$$

Where:

R_{CT} = current transformer secondary winding resistance

R_L = maximum lead resistance from the current transformer to the relaying point

I_f = maximum secondary external fault current

K = a constant affected by the dynamic response of the relay

When high impedance differential protection is applied to motors or shunt reactors, there is no external fault current. Therefore, the locked rotor current, starting current of the motor or reactor inrush current should be used in place of the external fault current.

1.2 Speed of Operation

To obtain high speed operation for internal faults, the knee point voltage, V_K, of the CTs must be significantly higher than the stability voltage, V_s. This is essential so that the operating current through the relay is a sufficient multiple of the applied current setting. Ideally a ratio of V_K /4V_s would be appropriate, but where this is not possible refer to section 9.1.5. This describes an alternative method where lower values of V_s may be obtained.

Typical operating times for different V_K/V_s ratios derived using extensive RTDS testing are shown in the following table:

V_K/V_S	2	4	8	16
Typical operating time (ms)	94	30	25	16

These times are representative of system X/R ratios up to 120 and a fault level of 5Is or greater. Lower values of X/R and higher fault currents will reduce the operating time.

The typical operating times (tested with Omicron sine wave current injection) for currents less than 5 times set value is 30 ms and for higher values of current (greater than 5 times setting) is less than 20 ms.

The knee point voltage of a current transformer marks the upper limit of the roughly linear portion of the secondary winding excitation characteristic. This is defined exactly in the IEC standards as the point on the excitation curve where a 10% increase in exciting voltage produces a 50% increase in exciting current.

The current transformers should be of equal ratio, of similar magnetising characteristics, and of low reactance construction. In cases where low reactance current transformers are not available and high reactance ones must be used, it is essential to use the reactance of the current transformer in the calculations for the voltage setting. Therefore, the current transformer impedance is expressed as a complex number in the form RCT + jXCT. It is also necessary to ensure that the exciting impedance of the current transformer is large in comparison with its secondary ohmic impedance at the relay setting voltage.

1.3 Sensitivity of Scheme

The operating current for the high impedance relay is adjustable in discrete steps.

The primary operating current (I_{op}) will be a function of the current transformer ratio, the relay operating current (I_r), the number of current transformers in parallel with a relay element (n) and the magnetising current of each current transformer (Ie) at the stability voltage (Vs). This relationship can be expressed as follows:

$$I_{op} = (\text{CT ratio}) \times (I_r + nI_e) \tag{2}$$

To achieve the required primary operating current with the current transformers that are used, a current setting (Ir) must be selected for the high impedance relay, as detailed above. The setting of the stabilising resistor (RST) must be calculated in the following manner, where the setting is a function of the relay ohmic impedance at setting (Rr), the required stability voltage setting (Vs) and the relay current setting (I_r).

$$RST = r\frac{V_s}{I_r} - R_r \tag{3}$$

The P140 ohmic impedance over the whole setting range is small, and so can be ignored.

Therefore:

$$RST = \frac{V_s}{I_r} \tag{4}$$

2. Comparison of P145 B and P14N B Solution

MODEL	FEATURES
P145 B (60TE)	Current and Voltage based bus wire supervision (with Frequency tuned SOV function) Max. 32 output contacts 10 no. Function keys + 8 HSHB contacts + 18 Tri- colour LEDs IEC 61850 edition 1/2, IEEE 1588
P14N B (20TE)	20TE – Small size (W/O 61850), 30TE with 61850 Current based bus wire supervision Up to 8 output contacts (When used with HID module). If separate external stabilising resistor and metrosil units are being used, then only 2 no. spare output contacts will be available (6 no.s being used for bus wire shorting) 4 no.s fixed function LEDs and 4 no.s programmable (Tri- colour) LEDs IEC 61850 edition 1

The HiZ differential text customisation is only applicable for settings and PSL. Refer to the IEC 61850 documentation for details on configuration. No customization has been done on the Logical Devices/Logical Nodes in IEC 61850. If the user requires the IEC 61850 model to be completed, use the IED Configurator through the option of Manage Logical Devices under Tools Menu Item.

You can only customise IEC 61850 Logical Devices/Nodes if the IEDs are IEC 61850 Edition 2.

3. Comparison Between Use of HID Module and Separate Stabilising Resistor + Metrosil

COMPONENTS	3 PHASE STABILISING RESISTORS + METROSIL	HID
Enclosure	No special enclosure. Typically, these are mounted inside the panel.	Boxed case
Resistor	Variable. Based on application and ordering option. A suitable range of resistor value needs to be selected.	Fixed 2000 ohms (Assembled inside the boxed case)
Metrosil	Based on application and ordering option. A suitable variant needs to be selected.	Fixed MOVs (Assembled inside the boxed case)
Shorting contacts	2 no. relay output contacts are wired in series on a per phase basis. Total 6 no. of contacts are used.	Built-in. Total 3 no. of contacts are used.

4. Application of MiCOM P145 B/P14N B

The MiCOM P140 is a numerical 3 phase overcurrent, earth fault and sensitive earth fault relay, with 4 protection stages each. These elements can be used for 3 phase differential protection or restricted earth fault (REF) protection.

The following functions are discussed for applying P145 B and P14N B relays for high impedance differential applications:

- Differential function
- Supervision function
- Tripping circuit
- Alarm circuit
- Test facilities
- Mounting options

4.1 Differential Function

We recommend that the HiZ Differential ID>1 is used as the main protection element for 3 phase differential protection and the IREF>Is used for the REF applications. IREF>Is can be enabled by selecting “HiZ REF” (SEF/REF PROT’N/ SEF/REF options). The time delay characteristic should be selected to be definite time and with a setting of zero seconds.

The output relay, which trips the circuit breaker, must be allocated in the PSL for the chosen elements. For example, HiZ Differential ID >1 or IREF>Trip. We recommend that any output relay, allocated to the trip circuit breaker, has a 100 ms dwell added to the contact conditioner. This forces the output relay to remain in the closed state for a minimum of 100 ms, even if fleeting operation of the protection should occur, ensuring positive operation of the circuit breaker, or trip relay.

Separate output relays may be allocated to each phase trip if it is required to have phase segregated outputs. The The ID >1 Trip is assigned to Relay 1. Phase information will be included in the fault flags.

Any protection element not being used should be disabled.

The setting range of high impedance differential element ID >1 and IREF>Is elements are:

Group 1		
GROUP 1 HiZ Differential		
ID>1 Function	Enabled	35.23
ID>1 Direction	Non-Directional	35.24
ID>1 Current Set	100.0 mA	35.27
ID>1 Time Delay	0 s	35.29
ID>1 tRESET	0 s	35.2F
ID>2 Function	Disabled	35.32
ID>3 Status	Disabled	35.40
ID>4 Status	Disabled	35.47
ID> Blocking	0000000000111111	35.4E
ID> Char Angle	45.00 deg	35.4F
V DEPENDANT O/C		35.51
V Dep OC Status	Disabled	35.52
CF ID>1 Function	Enabled	35.63
CF ID>1 Dir	Non-Directional	35.64
CF ID>1 Cur Set	50.00 mA	35.67
CF ID>1 Time Dly	5.000 s	35.69
CF ID>1 tRESET	0 s	35.6F
CF ID>2 Status	Disabled	35.71
ID> Blocking 2	0000	35.8F

Figure 3: High impedance differential elements setting range

IREF> Is 0.05 – 1.0In

The ohmic impedance (Rr) of the P140 over the whole setting range is 0.2 Ω for 1A inputs and 0.008 Ω for 5A inputs (independent of current). To comply with the definition for a high impedance relay, in most applications, it is necessary to utilise an externally mounted stabilising resistor in series with the relay.

The typical values of the stabilising resistors normally used with the relay are 220 Ω and 47 Ω for 1A and 5A relay ratings respectively. In applications such as busbar protection, where higher values of stabilising resistor are often required to obtain the desired relay voltage setting, non-standard resistor values can be supplied. The standard resistors are wire wound, continuously adjustable and have a continuous rating of 145W.

4.2 Supervision Function

In case of high impedance differential scheme, as there are multiple CTs connected in parallel, open circuit in any one of the CT results in current flowing through the differential path (high impedance path) and it will develop voltage across high impedance circuit.

As there is current flowing through the differential path and voltage developed across differential circuit, there are two methods to detect open circuit:

- Current based supervision
- Voltage based supervision

4.2.1 Current Based Supervision (P145 B And P14N B)

During normal operation the differential current in the scheme should be zero or negligible. Any anomaly is detected through a given threshold CF ID>1 (Circuitry fault ID>1 or stage 2. An over current element is used to supervise the current circuit. A differential current will result if the secondary circuit of a CT becomes open circuited or short circuited. The amplitude of this current being proportional to the load current flowing in the circuit. The setting is chosen to be as low as possible, a minimum setting is 2% of the highest CT primary winding. However, it should also allow for any standing differential current, for example, due to CT mismatch and/or varying magnetising current losses. Typical pickup value of supervision function is in the range of 5 to 20%. The element is time delayed and the typical value is 5 seconds. This is set greater than the max. clearance time of an external fault. The time delay allows the relevant protection element, which should be substantially faster, to clear the fault instead (HiZ Diff ID>1(or stage2,3,4) in the case of an internal fault.

4.2.2 Voltage Based Supervision (P145 B Only)

The P145 HiZ Differential relay can achieve voltage-based bus wire supervision using the Supervision Overvoltage Protection (SOV) function. The SOV function allows the possibility of low pickup voltages down to 2V making it ideal for monitoring the bus wire voltages in the event of a CT open circuit condition.

Supervision overvoltage function has two stages:

- SOV>1
- SOV>2

Two measurement modes are available:

- Ph- Ph
- Ph- Neutral

The operation mode is selectable as 'Any phase' or 'Three phase'. We recommend you set the measurement mode to 'Ph- Neutral' and the operating mode to 'Any phase' for bus wire supervision purpose in differential applications.

Sensitive O/V	
SOV Meas't Mode	Phase-Neutral
SOV Operate Mode	Any Phase
SOV>1 Status	Enabled
SOV>1 Volt Set	2.000 V
SOV>1 Time Delay	3.000 s
SOV>2 Status	Disabled
SOV Filter Mod	Disabled

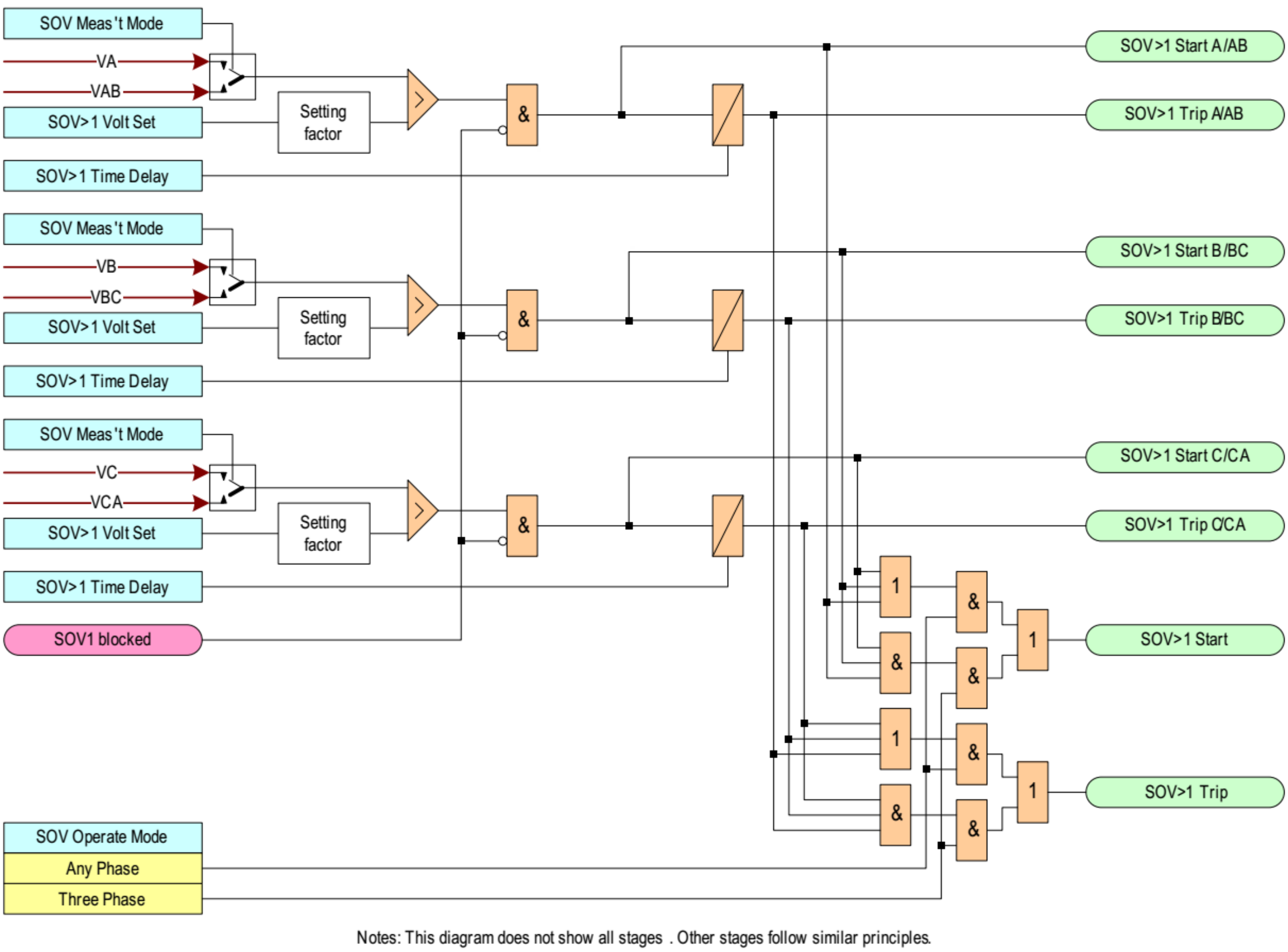


Figure 4: Supervision overvoltage logic

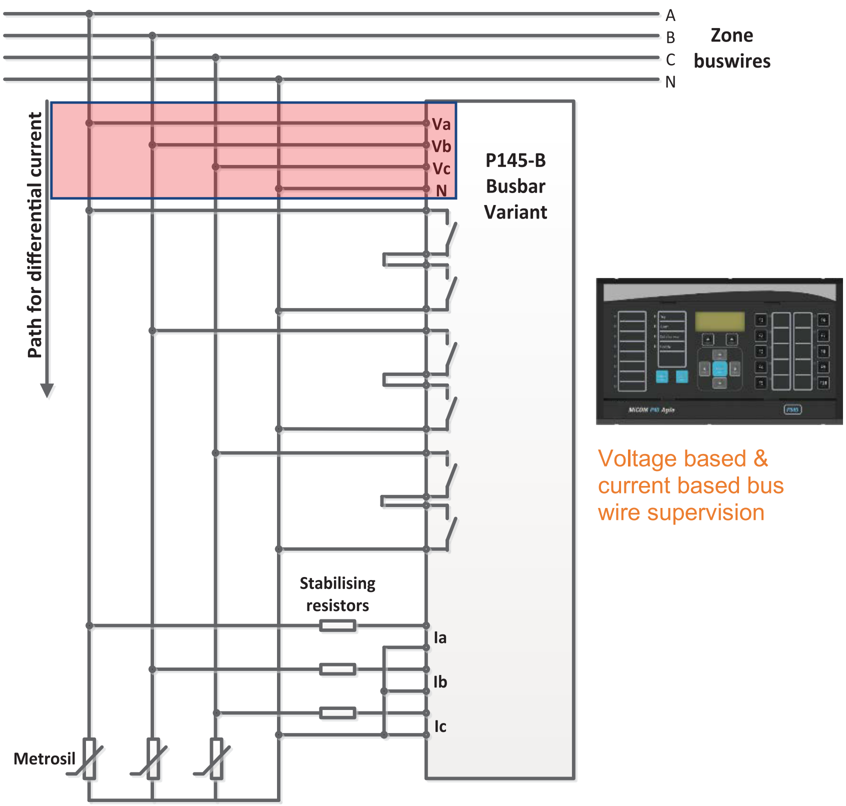


Figure 5: Current and voltage-based supervision connection arrangement for P145 B

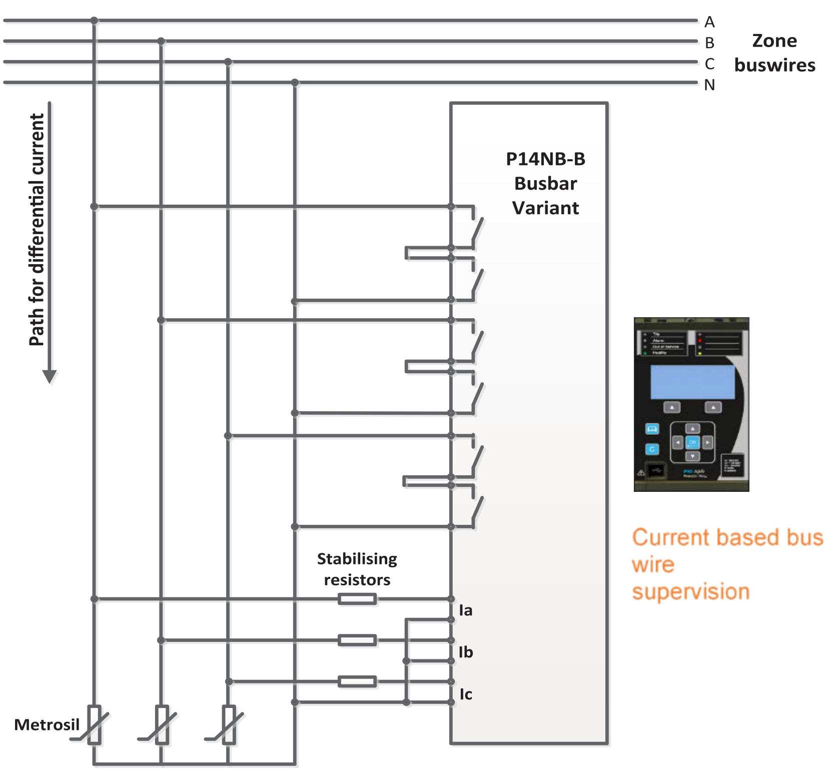


Figure 6: Current based supervision connection arrangement for P14N B

4.3 Tripping Circuit

The tripping circuits in busbar are arranged so that the accidental operation of any one of the circulating current relays does not cause an unwanted tripping of the zone in concern. Both the 'Discriminating' and 'Check' zone high impedance differential relays must be energised before the main tripping relays are energised.

4.4 Alarm Circuits

Several alarm signals in the form of user alarms, LEDs and output contacts (for external display) have been pre-configured in the default PSL. The user can generate an alarm for:

- Main zone trip (or Check zone trip)
- Alarm supply fail
- Trip supply fail
- Bus wire supervision alarm (Current based and/or Voltage based)
- Check zone confirmation not met (or Main zone confirmation not met)
- HiZ differential out of service
- HiZ differential Trip ph. A, B, C
- I_{REF} Trip

4.5 Test Facilities

Digital inputs and Function keys make it possible to:

- Test the bus wire shorting feature. This will close the bus wire shorting contacts (2 no.s each) for phase A, B and C respectively.
- Set the HiZ differential to out of service

4.6 Mounting Options

The figure below shows three mounting options:

- P14N B used with MMLG (test terminal block) and HID Module
- P14N B used with MMLG and internal (Din Rail) mounted resistors and metrosils
- P145 B used with MMLG and internal (Din Rail) mounted resistors and metrosils

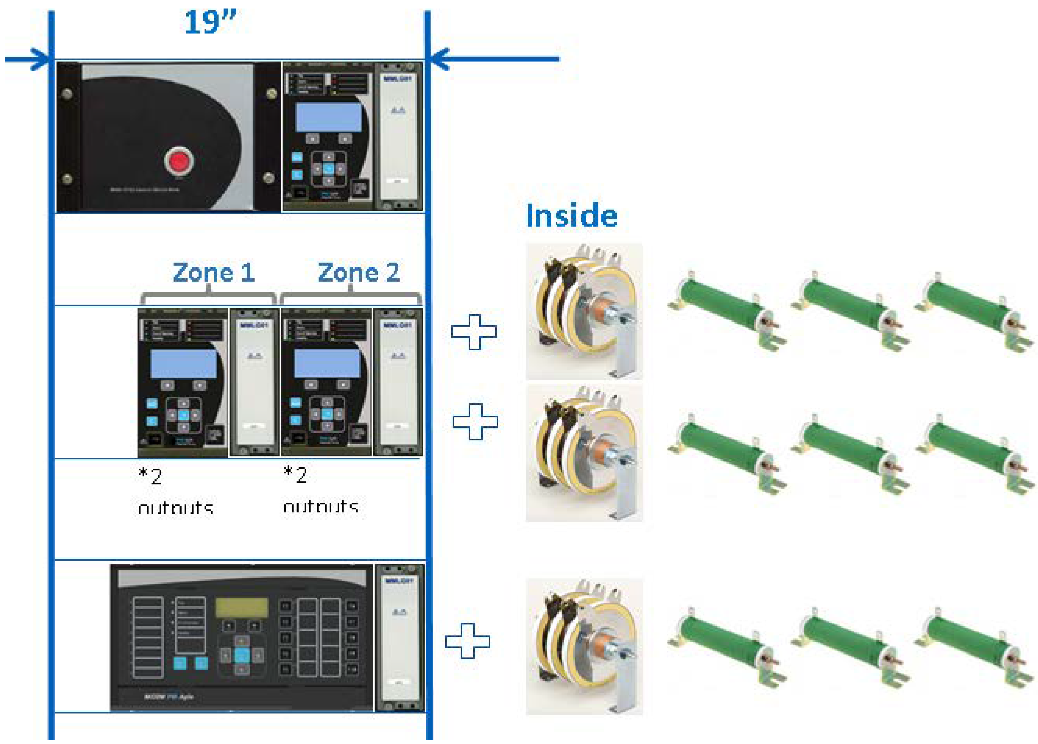


Figure 7: Relay, test block and HID mounting option

5. Default PSL

5.1 PSL Logic Page 1

PSL Logic page 1 explains the option of changing the relay setting groups using digital inputs.

Respective digital inputs can be used to trigger manual reset user alarms like ‘Main zone trip’ or ‘Check zone trip’ as applicable.

Self-reset user alarms like ‘Alarm supply fail’ and ‘Trip supply fail’ can be triggered using digital inputs as shown in the default logic representation.

The protection functions being used in the relay (HiZ Diff ID>1,2,3,4 Trip and IREF Trip) needs to be assigned to the ***Trip Command In*** DDB.

5.2 PSL Logic Page 2

PSL Logic page 2 explains the assignment of protection functions being used in the relay (HiZ Diff ID>1,2,3,4 Trip and IREF Trip) to output contacts and fault record trigger (FRT) DDBs. The bus wire supervision feature using current differential principle (available in P145 B and P14N B) or overvoltage principle (P145 B only) are assigned to output contacts R3-R4, R5-R6 and R7-R8 in the default PSL. These contacts are used in series (on a per phase basis) to short the respective bus wires A, B and C to Neutral in the event of an open circuit or wiring problem on the CT secondary. With the help of External input/switch or using the respective function keys on the relay HMI it is possible to set the bus bar protection to out of service or test the bus wire shorting feature or reset the bus wire supervision from short condition.

5.3 PSL Logic Page 3

PSL Logic page 3 explains the mapping of bus wire supervision related functions like ‘Supervision OV’ and ‘Circuitry Fault ID’ DDB to the respective output contacts. The HiZ differential trip signals for stage 1- 4 is mapped to the respective output contacts on a per phase basis.

5.4 PSL Logic Page 4

PSL Logic page 4 explains the mapping of user alarm ‘Check zone not met’ [or ‘Main zone not met’ (as applicable)]

If the P145 B or P14N B relay is being used for Main zone differential protection, then the absence of Check zone confirmation will assert this user alarm. The Check zone confirmation/operation needs to be communicated to the relay through an external input (digital input) or the other way around. If the P145 B or P14N B relay is being used for Check zone differential protection, then the absence of Main zone confirmation will assert the ‘Main zone not met’ user alarm. The Main zone confirmation/operation needs to be communicated to the relay through an external input (digital input).

5.5 PSL Logic Page 5

PSL Logic page 5 explains the mapping of respective LEDs for HiZ Differential set to out of service and bus wire short test condition. The bus wire short test can only be performed when the HiZ Differential has been set to out of service condition.

5.6 PSL Logic Page 6, 7 and 8

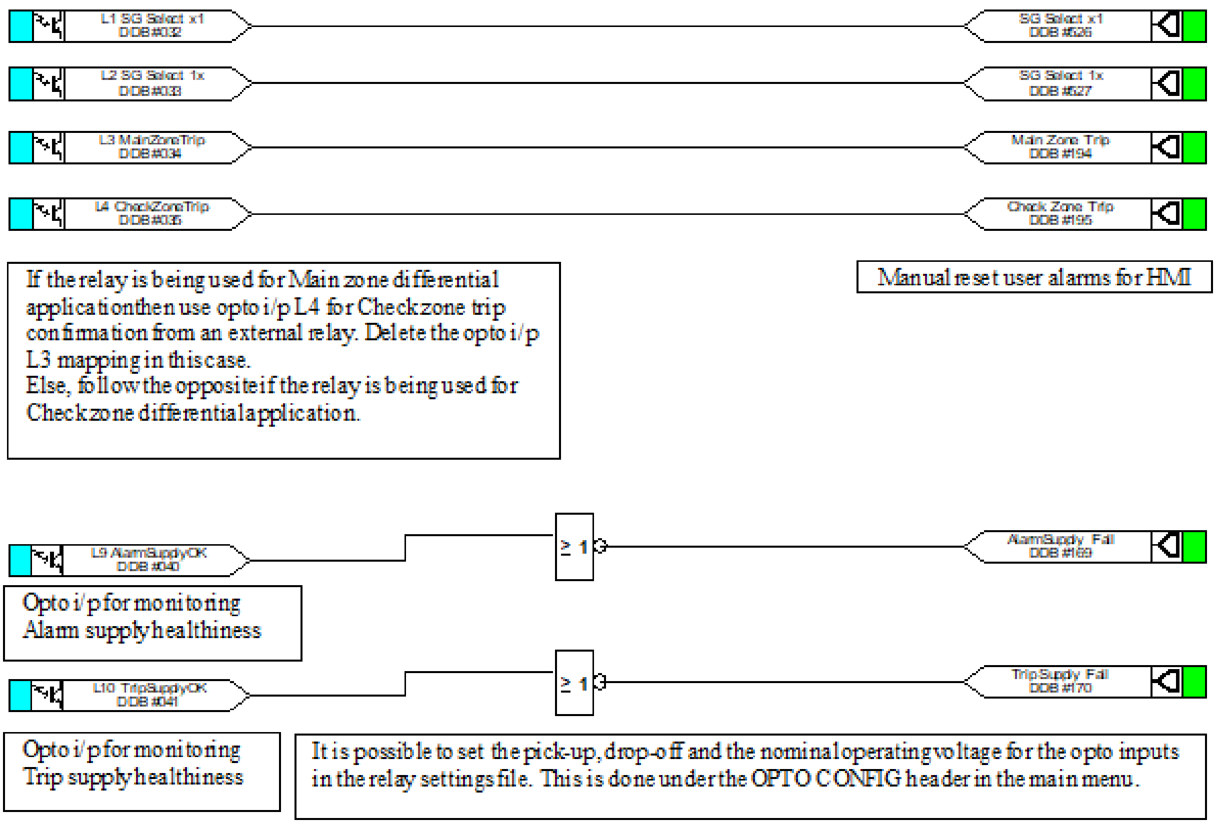
PSL Logic pages 5 to 8 explains the mapping of normal LEDs and function key LEDs.

5.7 PSL Logic Page 9 and 10

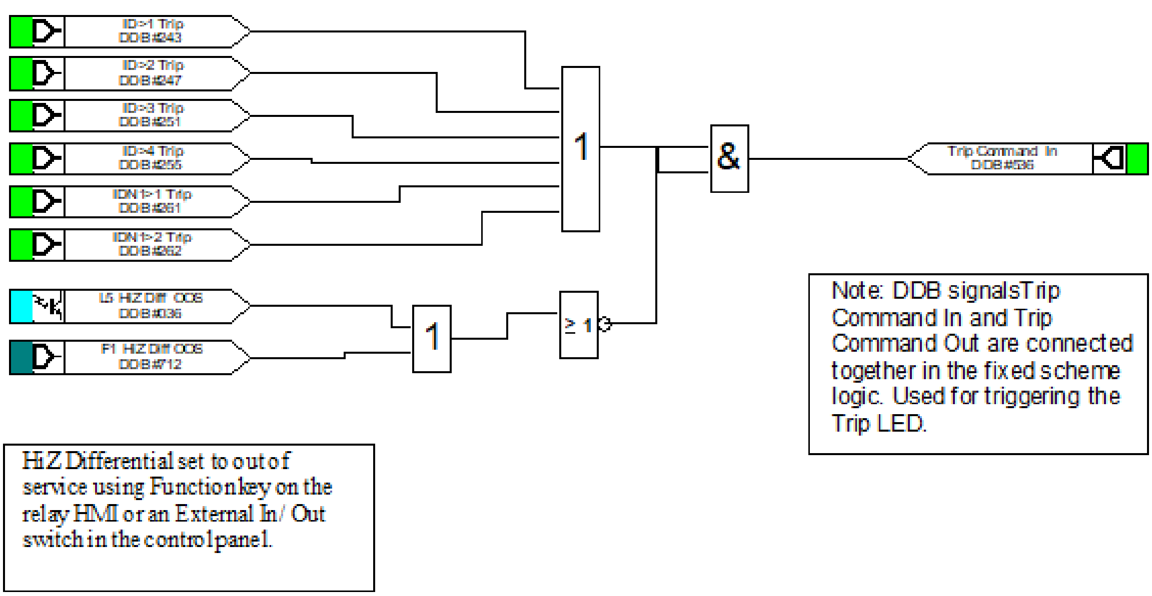
PSL Logic pages 9 and 10 explains the mapping of HiZ differential trip signals to the respective user alarms and blocking of the relevant stages when the protection is set to out of service condition.

MiCOM High Impedance Differential

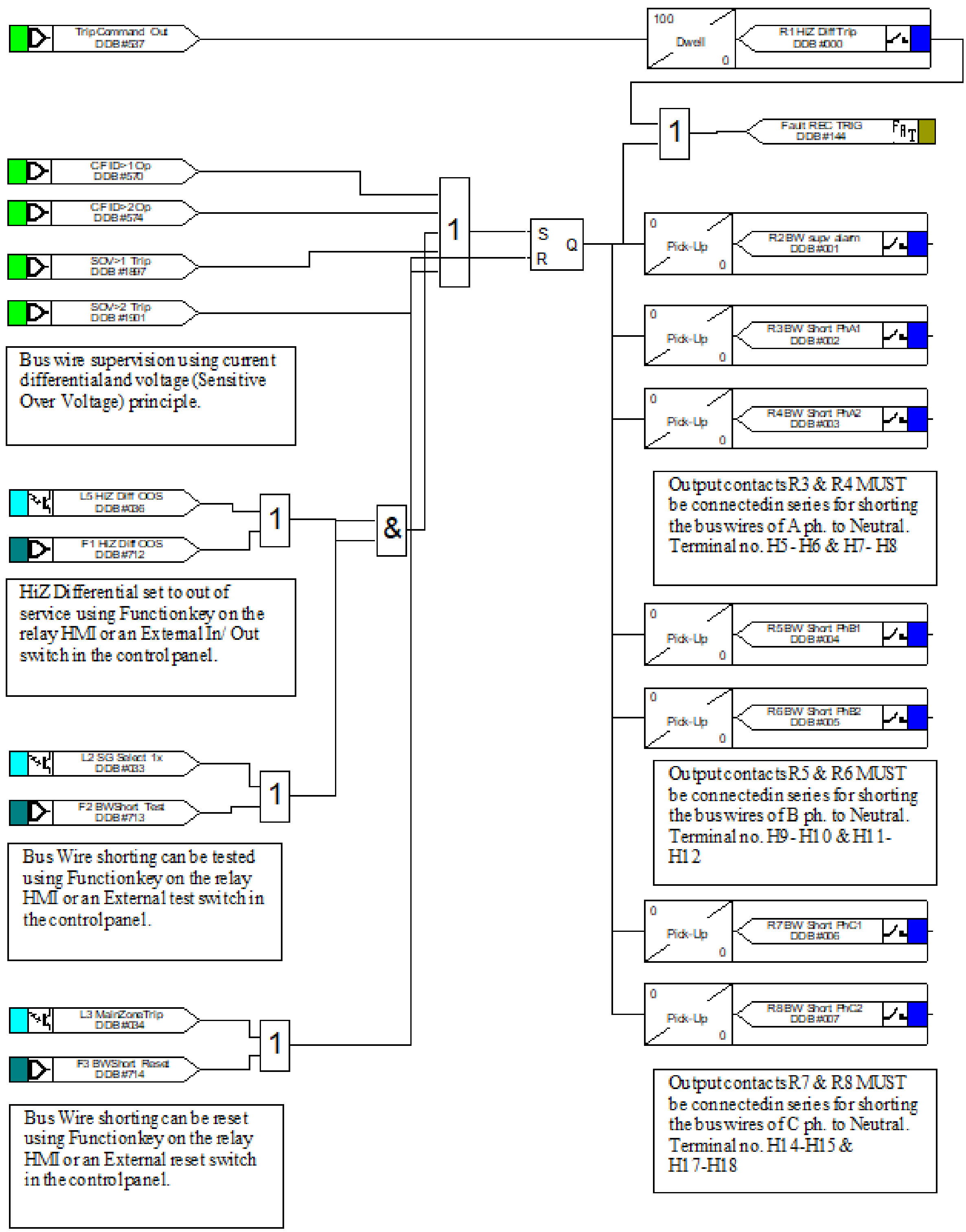
Opto Input Mappings



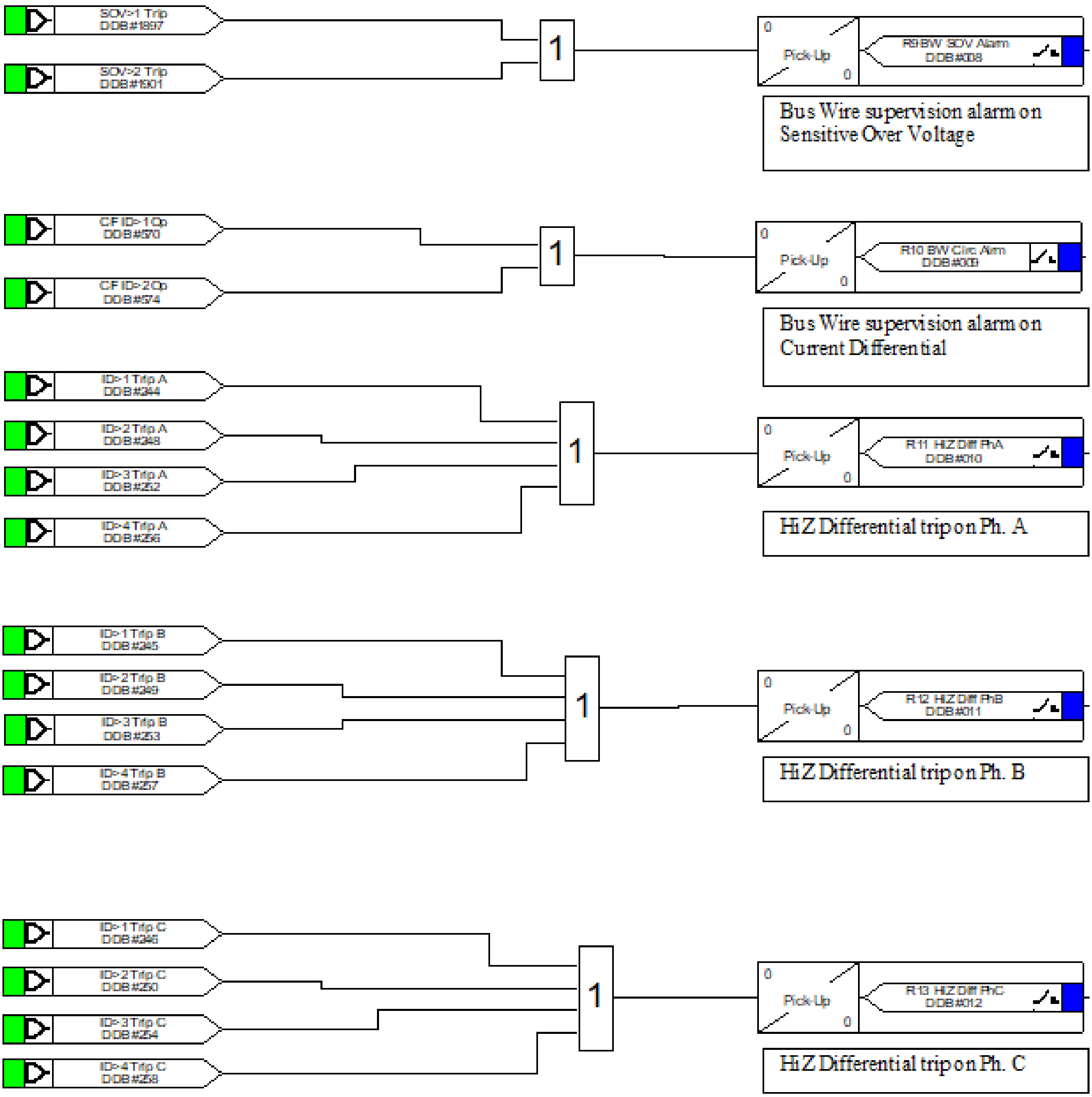
Trip output mapping



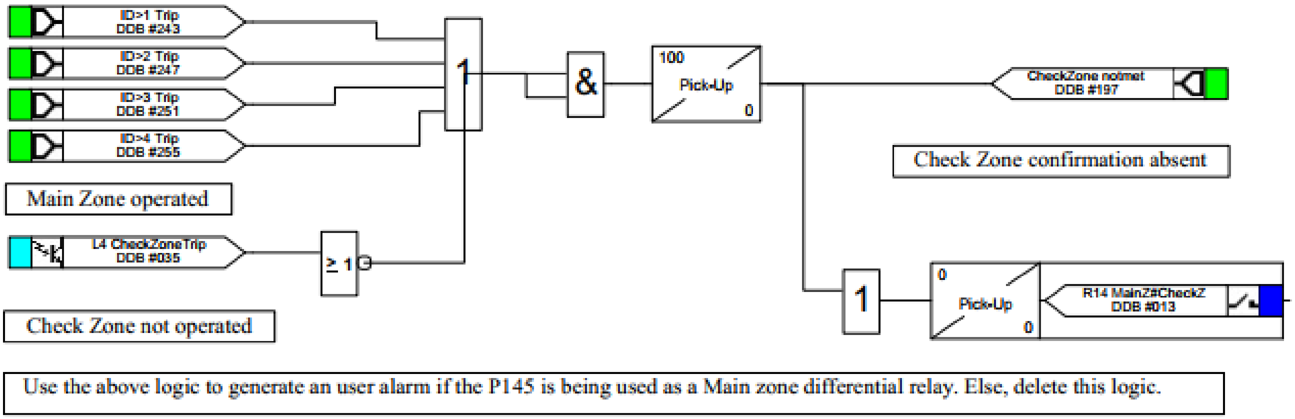
MiCOM High Impedance Differential

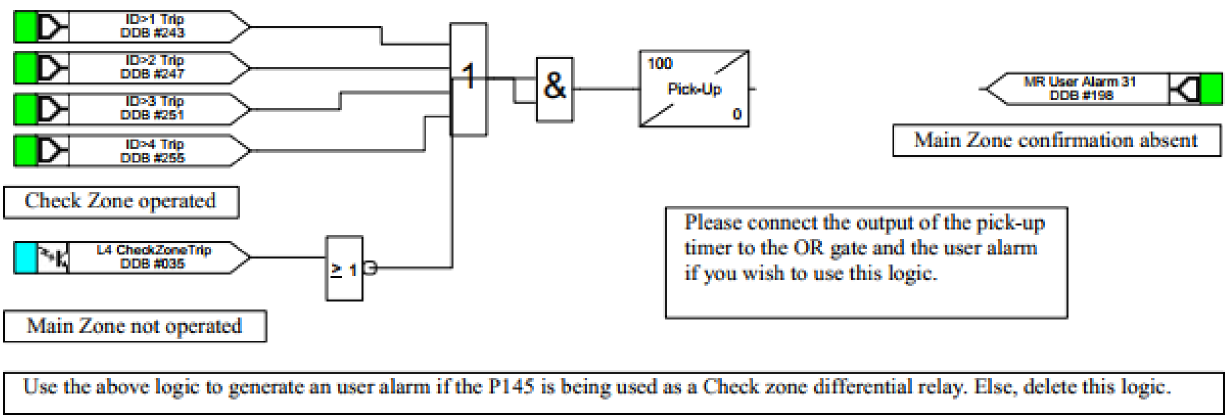


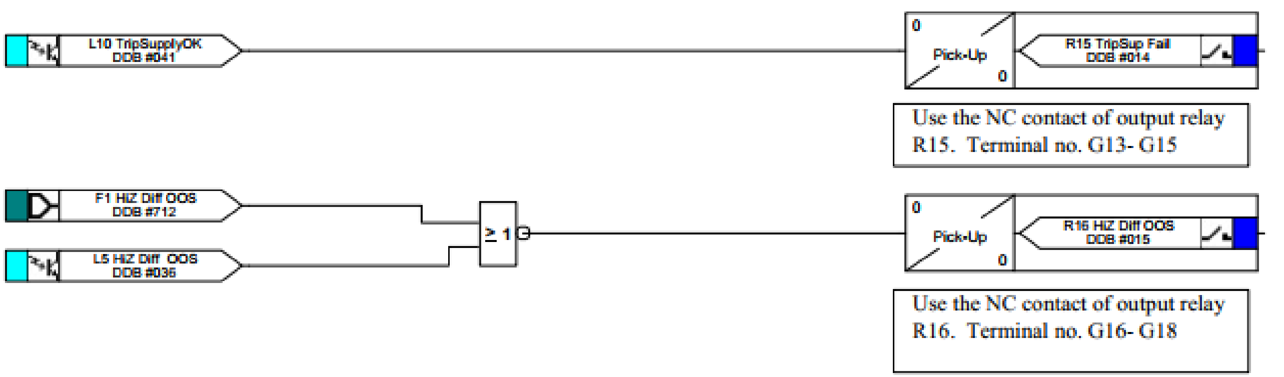
MiCOM High Impedance Differential



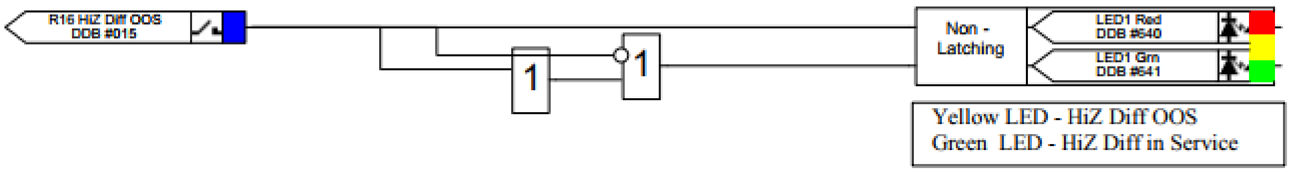
MiCOM High Impedance Differential

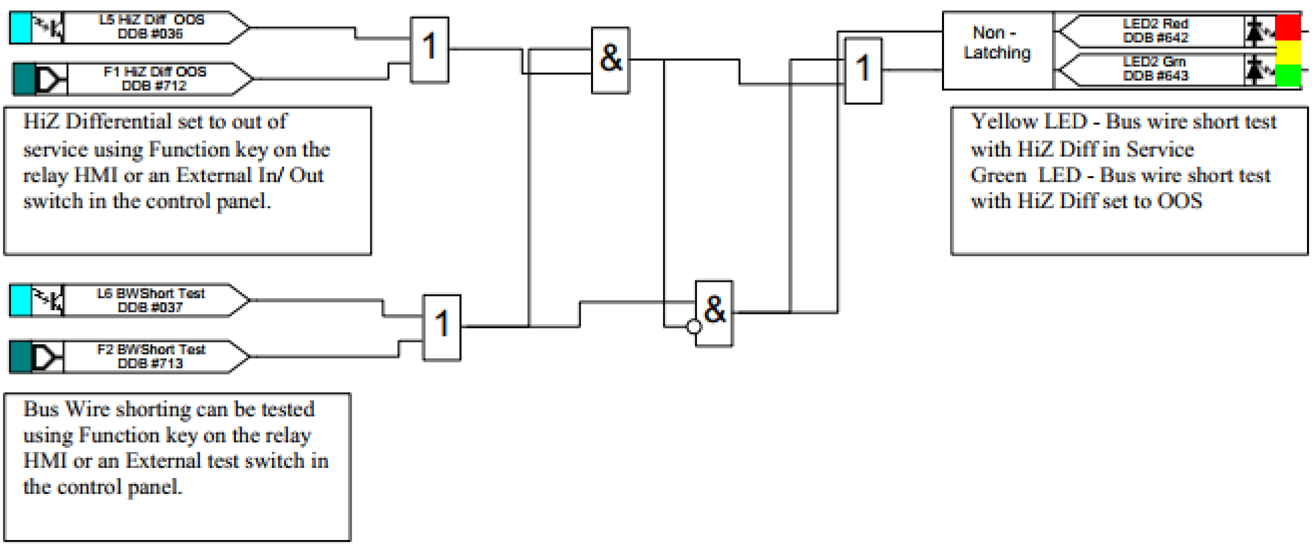






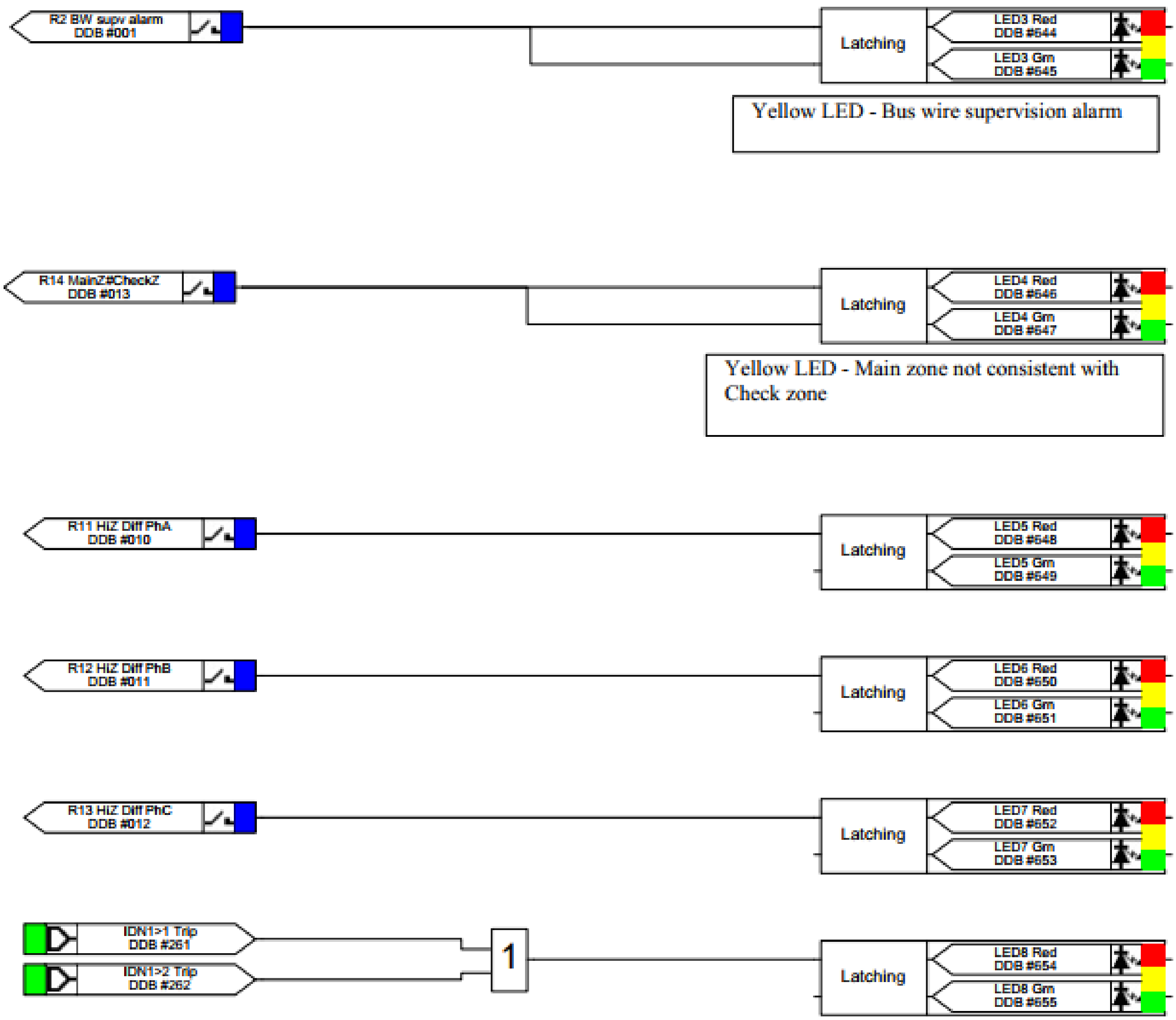
MiCOM High Impedance Differential





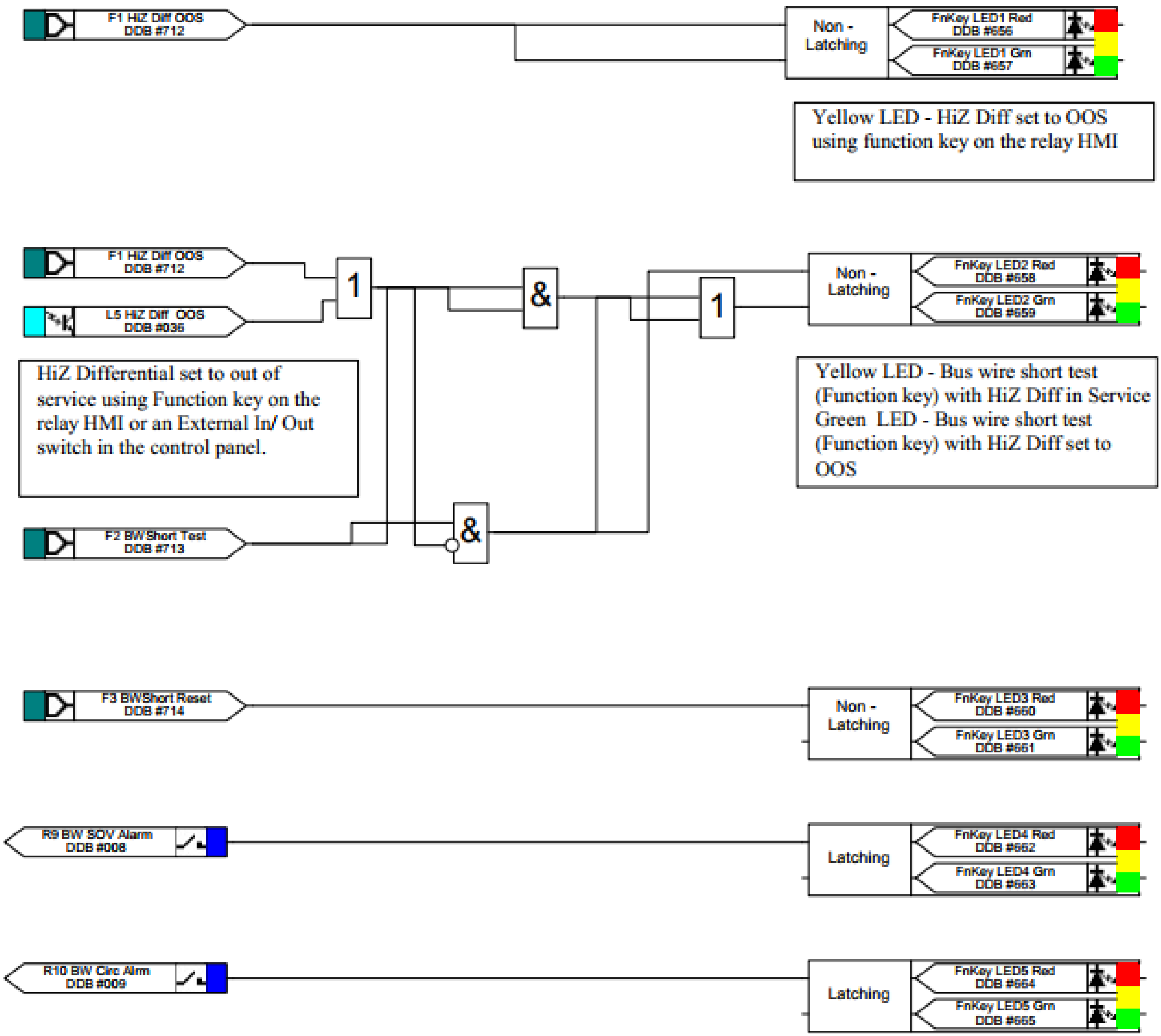
MiCOM High Impedance Differential

LED mapping



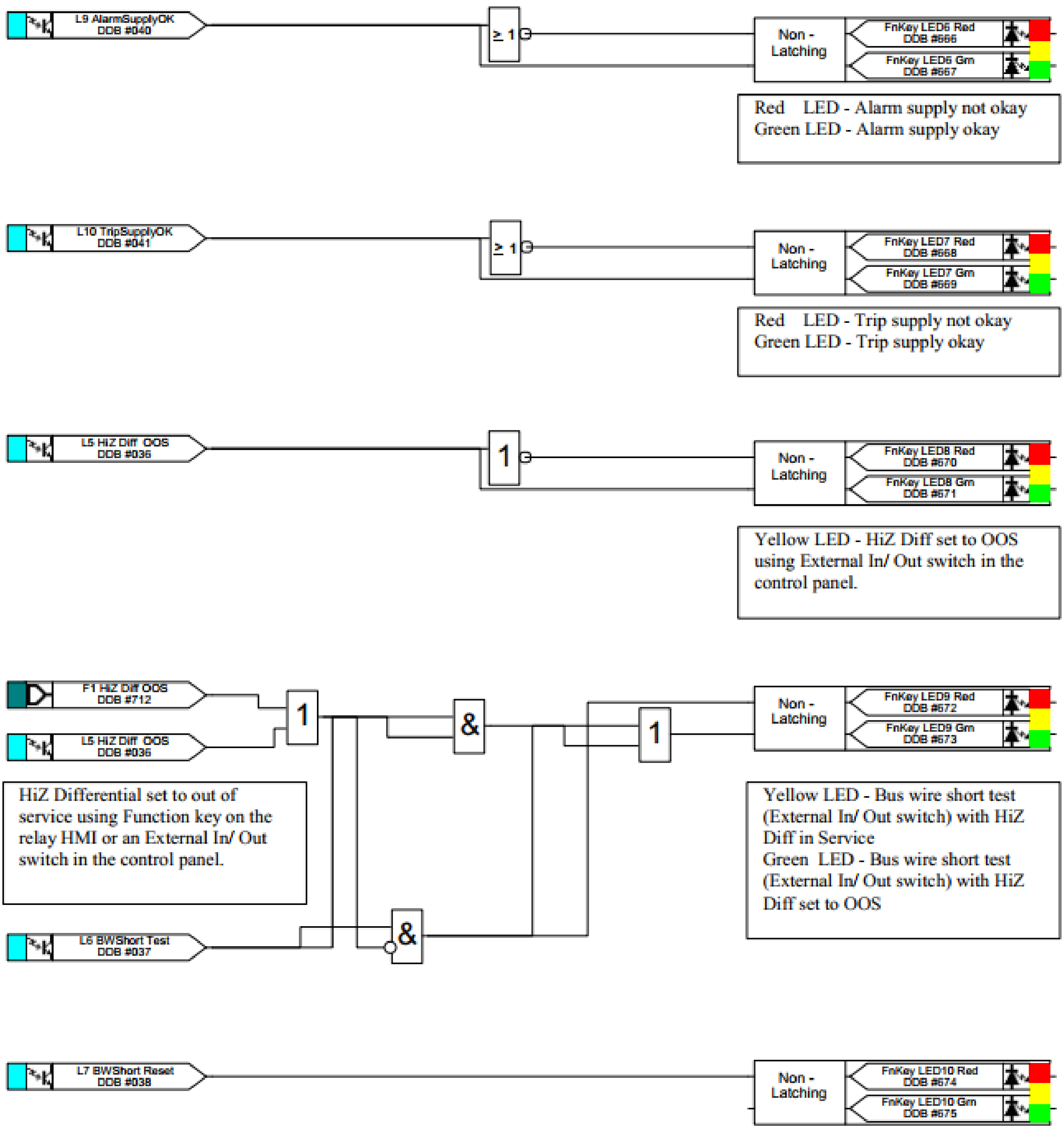
MiCOM High Impedance Differential

LED mapping



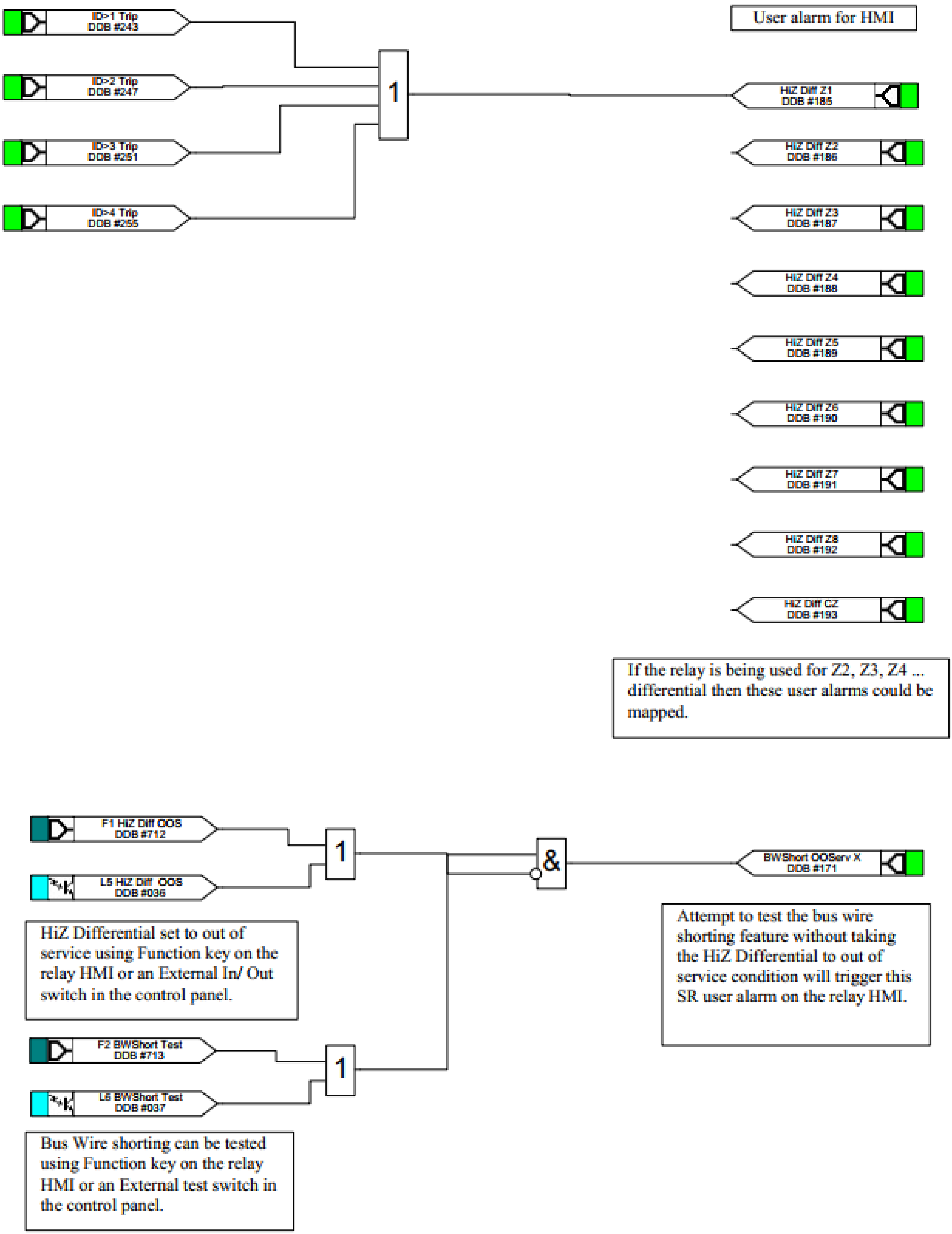
MiCOM High Impedance Differential

LED mapping

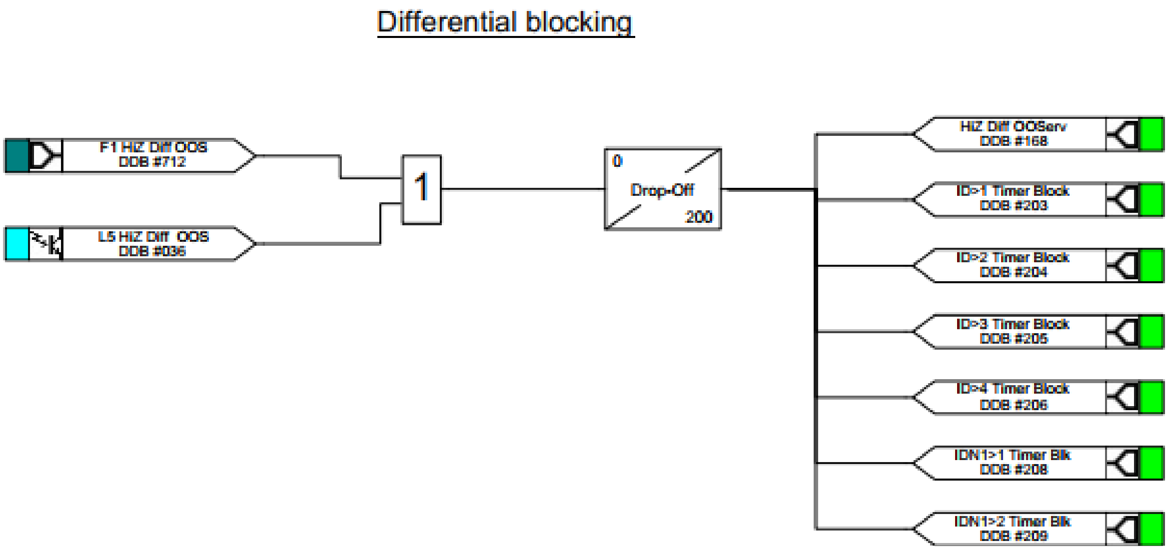


MiCOM High Impedance Differential

User alarm



MiCOM High Impedance Differential



If the P145 B or P14N B relay is being used with external stabilising resistor and Metrosil, and not with the HID module, then 2 no. of relay output contacts, which are connected in series on a per phase basis, needs to be used for bus wire shorting purpose.

However, if the HID module is being used then the relay shorting contacts are not required. This is because the HID module has built in bus wire shorting contacts.

6. Current Transformer Requirement for Various Applications

The following data should be used as a guide in order to obtain the best performance from the relay.

3 Phase Applications (Busbars, Generators and Motors)

- K-factor = 1.2
- V_K/V_S ratio = 4

REF Applications

- K-factor = 1.0
- V_K/V_S ratio = 4

The fault current (IF) for various applications are:

Motor:	Starting current of the motor
Transformer REF:	Maximum through fault current (3Ph/1Ph) of transformer
Reactor:	Inrush current of the reactor
Busbar:	External fault current

7. Use Of Metrosil Non-Linear Resistors

When the maximum through fault current is limited by the protected circuit impedance, as in the case of generator differential and power transformer restricted earth fault protection, it is generally unnecessary to use non-linear voltage limiting resistors (Metrosils). However, when the maximum through fault current is high, like busbar protection, it is more common to use a non-linear resistor (Metrosil) across the relay circuit (relay and stabilising resistor). Metrosils are used to limit the peak voltage developed by the current transformers, under internal fault conditions, to a value below the insulation level of the current transformers, relay and interconnecting leads, which can withstand 3000V peak.

You can use the following formulae to estimate the peak transient voltage that could be produced for an internal fault. This voltage is a function of the current transformer knee point voltage and the prospective voltage that would be produced for an internal fault if current transformer saturation did not occur.

On generators where the current can be fed from the supply system and the generator the internal fault level I'_f, can be significantly higher than the external fault level I_f.

$$V_p = 2\sqrt{2 V_K (V_f - V_K)} \quad (5)$$

$$V_f = I'_f (R_{CT} + 2_{RL} + R_{ST} + R_r) \quad (6)$$

Where:

V_p = Peak voltage developed by the CT under internal fault conditions.

V_K = Current transformer knee-point voltage.

V_f = Maximum voltage that would be produced if CT saturation did not occur.

I'_f = Maximum internal secondary fault current.

R_{CT} = Current transformer secondary winding resistance.

R_L = Maximum lead burden from current transformer to relay.

R_{ST} = Relay stabilising resistor.

R_r = Relay ohmic impedance at setting.

When the value of V_p is greater than 3000 V peak, non-linear resistors (Metrosils) should be applied. Metrosils are connected across the circuit, or phase to neutral of the ac bus wires, to shunt the secondary current output of the current transformer from the device to prevent very high secondary voltages.

Metrosils are externally mounted and are annular discs of 152mm diameter and approximately 10mm thickness. Their operating characteristics follow the expression:

$$V = CI^{0.25} \quad (7)$$

Where:

V = Instantaneous voltage applied to the Metrosil

C = Constant of the Metrosil

I = Instantaneous current through the Metrosil

With a sinusoidal voltage applied across the Metrosil, the RMS current would be approximately 0.52 x the peak current. This current value can be calculated as follows:

$$I(rms) = 0.52 \left[\frac{V_S(rms) \times \sqrt{2}}{C}\right]^4 \quad (8)$$

Where:

$V_S(rms)$ = rms value of the sinusoidal voltage applied across the Metrosil.

This is due to the fact that the current waveform through the Metrosil is not sinusoidal but appreciably distorted.

The Metrosil characteristic should comply with the following requirements:

- The Metrosil current should be as low as possible, and no greater than 30 mA rms for 1 A current transformers or 100 mA rms for 5 A current transformers.

The Metrosil units normally recommended for use with 1A CTs are as follows:

STABILITY VOLTAGE	RECOMMENDED METROSIL TYPE	
V_S (V) rms	Single pole	Triple pole
Up to 125V	600A/S1/S256 C = 450	600A/S3/I/S802 C = 450
125- 300V	600A/S1/S1088 C = 900	600A/S3/I/S1195 C = 900

The Metrosil units normally recommended for use with 5A CTs and single pole relays are as follows:

SECONDARY INTERNAL FAULT CURRENT (A) rms	RECOMMENDED METROSIL TYPE			
	RELAY STABILITY VOLTAGE, V_S (V) rms			
	Up to 200 V	250 V	275 V	300 V
50A	600A/S1/S1213 C = 540/640	600A/S1/S1214 C = 670/800	600A/S1/S1214 C = 670/800	600A/S1/S1223 C = 740/870
100A	600A/S2/P/S1217 C = 470/540	600A/S2/P/S1215 C = 570/670	600A/S2/P/S1215 C = 570/670	600A/S2/P/S1196 C = 620/740
150A	600A/S3/P/S1219 C = 430/500	600A/S3/P/S1220 C = 520/620	600A/S3/P/S1221 C = 570/670	600A/S3/P/S1222 C = 620/740

The Metrosils recommended for use with 5 A CTs can also be used with triple pole devices and consist of three single pole units mounted on the same central stud but electrically insulated from each other. To order these units please specify "Triple pole Metrosil type", followed by the single pole reference. Metrosil for higher stability voltage settings and fault currents are available if required.

8. Use of HID Module

HID modules are available in single-phase models for applications such as restricted earth fault protection in a transformer winding, models with two resistors for applications in transformers with two grounded windings, and three-phase models for busbar high impedance differential protection.

Each HID module incorporates 2000-Ohm resistors that provide the associated high impedance relay with stability against external faults and varistors (MOV – Metal Oxide Varistors) to limit the peak voltage in the secondary under 2000V during fault conditions. Additionally, a latching relay is incorporated, whose contacts are aimed to short-circuit the resistors once the associated relay has tripped. This way, the fault current is prevented from circulating through the resistors.

The HID front plate incorporates a reset push button to reset the latching relay once the fault has been cleared. This eliminates the resistors short-circuit.

Figure 8: Front view of HID units with reset push button

The HID units incorporate the following parts:

1. Latching relay
2. Resistors
3. MOV (Metal Oxide Varistor)
4. Reset button
5. Metallic case

HIDs can be supplied with or without the latching relay. If the unit includes a latching relay, then MOVs and resistors are dimensioned according to the HLB tripping time. If you do not have a latching relay we recommend you use an external 86 device to short-circuit stability resistors after tripping.

Figure 9: Internal mounting view

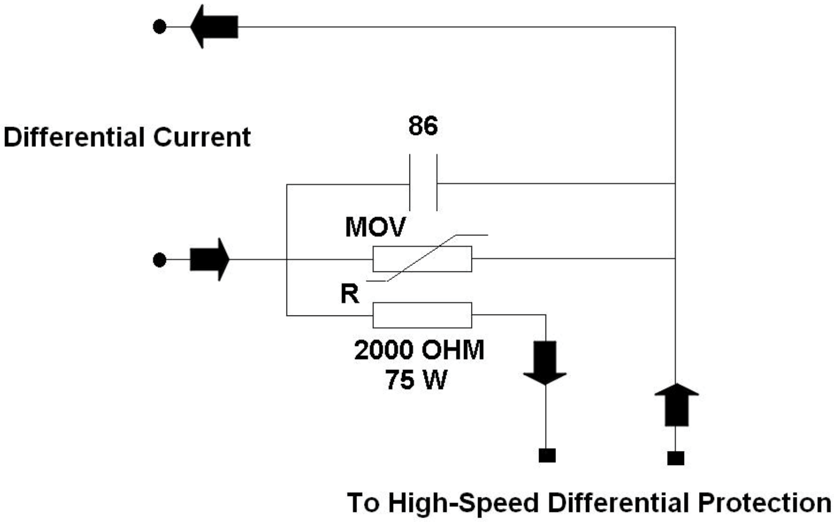


Figure 10: Connection arrangement for HID

During testing take care that continuous current is not flowing through the stabilising resistor. This must be tested in conjunction with the shorting contacts.

Current flows through stabilising resistors into current input of the overcurrent module. When the high-speed overcurrent module trips, the latching relay contacts short circuits the stabilising resistor and the current input. This means excessive heating, which causes damage to resistors is avoided. MOVs are used to avoid over voltages damaging the current input, limiting voltage to 1900V.

9. Typical Setting Examples

9.1 REF Protection

The correct application of the P14x as a high impedance relay is best illustrated by taking the case of the 11000/415V, 1000kVA, X = 5%, power transformer. This is shown in Figure 11, for which restricted earth fault protection is required on the LV winding. CT ratio is 1500/5A.

9.1.1 Stability Voltage

The power transformer full load current

$$= \frac{1000 \times 10^3}{\sqrt{3} \times 415}$$

$$= 1391A$$

Maximum through fault level (ignoring source impedance)

$$= \frac{100}{5} \times 1391$$

$$= 27820A$$

Required relay stability voltage (assuming one CT saturated)

$$= KI_f\ (R_{CT} + 2_{RL})$$

$$= 1.0 \times 27820 \times \frac{5}{1500}(0.3 + 0.08)$$

$$= 35.2V$$

9.1.2 Stabilising Resistor

If the relay effective setting for a solidly earthed power transformer is approximately 30% of full load current, we can choose a relay current setting, IN> = 20% of 5A i.e. 1A. On this basis the required value of stabilising resistor is:

$$R_{ST} = \frac{V_S}{I_r}$$

$$= \frac{35.2}{1}$$

$$= 35.2 \text{ ohms}$$

For applications where the 5A inputs are used, a 47 Ω resistor can be supplied on request. The resistor is continuously adjustable between 0 and 47 Ω. Therefore, a value of 35.2 Ω can be set.

9.1.3 Current Transformer Requirements

To ensure that internal faults are cleared in the shortest possible time the knee point voltage of the current transformers should be at least 4 times the stability voltage, V_s.

$$V_K = 4V_S$$

$$= 4 \times 35.2$$

$$= 141V$$

The exciting current to be drawn by the current transformers at the relay stability voltage, Vs, will be:

$$I_e < \frac{I_s - I_r}{n}$$

Where:

I_s = relay effective setting

$= \frac{30}{100} \times 1391 \times \frac{5}{1500}$

= 1.4A

I_r (Io>) = relay setting

= 1A

n = number of current transformers in parallel with the relay

= 4

$\therefore\ I_e$ @ 35.2V $< \frac{1.4-1}{4}$

< 0.1A

Any elements not used should be disabled.

The phase overcurrent elements not used for restricted earth fault protection could be used to provide normal overcurrent protection.

9.1.4 Metrosil Non-Linear Resistor Requirements

If the peak voltage appearing across the relay circuit under maximum internal fault conditions exceeds 3000V peak then a suitable non-linear resistor (Metrosil), should be connected across the relay and stabilising resistor, in order to protect the insulation of the current transformers, relay and interconnecting leads. In the present case the peak voltage can be estimated by the formula:

$$V_p = 2\sqrt{2 V_K (V_f - V_K)}$$

Where:

V_K = 141V (In practice this should be the actual current transformer knee point voltage, obtained from the current transformer magnetisation curve).

$V_f = I_f (R_{CT} + 2_{RL}\ R_{ST} + R_r)$

$= 27820 \times \frac{5}{1500} \times (0.3 + 0.08 + 35.2)$

$= 92.73 \times 35.58$

= 3299V

Therefore, substituting these values for VK and Vf into the main formula, it can be seen that the peak voltage developed by the current transformer is:

$$V_p = 2\sqrt{2 V_K (V_f - V_K)}$$

$$= 2\sqrt{2 \times 141 \times 3299 - 141}$$

= 3158V

This value is above the maximum of 3000V peak and therefore a non-linear resistor (Metrosil) would have to be connected across the relay and the stabilising resistor. The recommended non-linear resistor type would have to be chosen in accordance with the maximum secondary internal fault current and the voltage setting.

9.1.5 Advanced REF Application Requirements for Through Fault Stability

The previous REF protection example is used here to demonstrate the use of the advanced application requirements for through fault stability.

To ensure through fault stability with a transient offset in the fault current the required voltage setting is given by:

$$V_S = (0.0123\ X/R + 0.68) \text{ x } I_f\ (2_{RL} + R_{CT})$$

To be used when X/R is less than or equal to 25. The standard equation should be used for X/R ratio greater than 25.

If the calculated value is lower than that given by equation 1 (with K = 1.0) then it should be used instead.

9.1.6 Transient Stability Limit

$$V_S = (0.0123\ X/R + 0.68) \text{ x } \frac{27820 \times 5}{1500} \text{ x } (0.3 + 0.08)$$

Where:

$$V_S = 0.86 \times 92.73 \times 0.38$$

$$V_s = 30.3V$$

The relay current setting, I_r = 1A

$$R_{ST} = \frac{V_S}{I_r}$$

$$R_{ST} = \frac{30.3}{1} = 30.3\Omega$$

Assuming $V_K = 4_{VS} = 4 \times 30.3 = 121.2V$

Using the advanced application method the knee point voltage requirement has been reduced to 121.2V compared to the conventional method where the knee point value was calculated to be 141V.

9.2 Busbar Protection

A typical 132kV double bus generating station is made up of two 100MVA generators and associated step-up transformers, providing power to the high voltage system, by means of four overhead transmission lines, as shown in Figure 16.

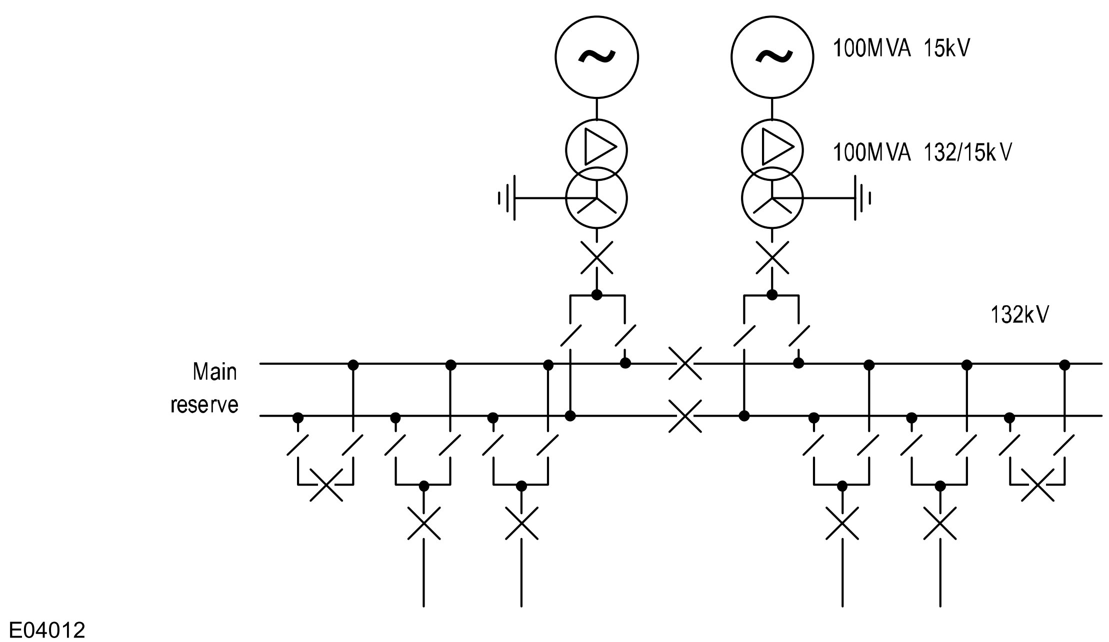


Figure 11: HID Double busbar generating station

The main and reserve busbars are sectionalised with bus section circuit breakers. The application for a high impedance circulating current scheme having 4 zones and an overall check feature, is as follows:

The switchgear rating is 3500MVA, the system voltage is 132kV solidly earthed and the maximum loop lead resistance is 2 ohms. The current transformers are of ratio 500/1 amp and have a secondary resistance of 0.7 ohms. The system has an X/R ratio of 20.

9.2.1 Stability Voltage

The stability level of the busbar protection is governed by the maximum through fault level which is assumed to be the switchgear rating. Using the switchgear rating allows for any future system expansion.

$$= \frac{3500 \times 10^6}{\sqrt{3} \times 132 \times 10^3} = 15300A$$

Required relay stability voltage (assuming one CT is saturated)

$$= K\, I_f\, (R_{CT} + 2_{RL})$$

$$= \frac{1.2 \times 15300}{500}(0.7 + 2)$$

$$= 99V$$

9.2.2 Current Setting

The primary operating current of busbar protection is normally set to less than 30% of the minimum fault level. It is also considered good practice by some utilities to set the minimum primary operating current in excess of the rated load. Therefore, if one of the CTs becomes open circuit the high impedance relay does not maloperate.

The primary operating current should be made less than 30% of the minimum fault current and more than the full load current of one of the incomers. Therefore, if one of the incomer CTs becomes open circuit the differential protection will not maloperate. It is assumed that 30% of the minimum fault current is more than the full load current of the largest circuit.

Full load current

$$= \frac{100 \times 10^3}{\sqrt{3} \times 132} = 438A$$

9.2.3 Discriminating Zone

Magnetising current taken by each CT at 99V = 0.072A
Maximum number of CTs per zone = 5
Relay current setting, Ir(I>) = 400A = 0.8In
Relay primary operating current,

$$I_{op} = \text{CT ratio} \times (I_r + n\, I_e)$$

$$= 500 \times (0.8 + (5 \times 0.072))$$

$$= 500 \times 1.16$$

$$= 580A \text{ (132\% full load current)}$$

9.2.4 Check Zone

Magnetising current taken by each CT at 99V = 0.072A
Maximum number of circuits = 6
Relay current setting, I_r (I>) = 0.8A
Relay primary operating current,

$$I_{op} = 500 \times (0.8 + (6 \times 0.072))$$

$$= 500 \times 1.232$$

$$= 616A$$

(141%- full load current)

Therefore, by setting I^r (I>) = 0.8A, the primary operating current of the busbar protection meets the requirements stated earlier.

9.2.5 Stabilising Resistor

The required value of the stabilising resistor is:

$$R_{ST} = \frac{V_S}{I_r}$$

$$= \frac{99}{0.8}$$

$$= 124\ \Omega$$

Therefore, the standard 220 Ω variable resistor can be used.

9.2.6 Use With HID Module

The minimum setting available in P145 B and P14N B are 50ma and 10ma respectively. This is for 1A CT sec. The stabilising resistor in the HID module is fixed to 2000 ohms.

In the case of P145 B the HID module can be used for a stability voltage:

$$V_S = 0.050 \times 2000$$

$$= 100 \text{ Volts}$$

In the case of P14N B the HID module can be used for a stability voltage:

$$V_S = 0.010 \times 200$$

$$= 20 \text{ Volts}$$

9.2.7 Current Transformer Requirements

To ensure that internal faults are cleared in the shortest possible time the knee point voltage of the current transformers should be at least 4 times the stability voltage, Vs.

$$V_k/V_s = 4$$

$$V_k = 396\text{V}$$

When used with HID module, the Vk requirement for P145 with setting of 0.05 A is 400 V and for P14NB set to 0.01 A is 80 V.

9.2.8 Metrosil Non-Linear Resistor Requirements

If the peak voltage appearing across the relay circuit under maximum internal fault conditions exceeds 3000V peak then a suitable non-linear resistor (Metrosil), externally mounted, should be connected across the relay and stabilising resistor, in order to protect the insulation of the current transformers, relay and interconnecting leads. In the present case the peak voltage can be estimated by the formula:

$$V_P = 2\sqrt{2\, V_K\, (V_f - V_K)}$$

where VK = 396V (In practice this should be the actual current transformer knee point voltage, obtained from the current transformer magnetisation curve).

$$V_f = I'_f\, (R_{CT} + 2_{RL} + R_{ST} + R_r)$$

$$= 15300 \times \frac{1}{500}\, (0.7 + 2 + 124)$$

$$= 30.6 \times 126.7$$

$$= 3877\text{V}$$

Therefore, substituting these values for VK and Vf into the main formula, it can be seen that the peak voltage developed by the current transformer is:

$$V_P = 2\sqrt{2 V_K (V_f - V_K)}$$

$$= 2\sqrt{2 \times 396 \times (3877 - 396)}$$

$$= 3320V$$

This value is above the maximum of 3000V peak and therefore a non-linear resistor (Metrosil) would have to be connected across the relay and the stabilising resistor. The recommended non-linear resistor type would have to be chosen in accordance with the maximum secondary internal fault current and voltage setting.

9.2.9 Busbar Supervision

Whenever possible the supervision primary operating current should not be more than 25 amps or 10% of the smallest circuit, whichever is the greater.

The IN>1 earth fault element in the P140 with its low current settings can be used for busbar supervision.

Assuming that 25A is greater than 10% of the smallest circuit current.

$$I_N>1 = 25/500 = 0.05In$$

Using the I>3 element for 3 phase busbar supervision.

$$I>3 = 0.08\ In\ \text{(minimum setting)}$$

The time delay setting of the I_N>1 and I>3 elements, used for busbar supervision, is 3s.

Any elements not used should be disabled.

9.2.10 Advanced Busbar Application Requirements For Through Fault Stability

The previous busbar protection example is used here to demonstrate the use of the advanced application requirements for through stability.

To ensure through fault stability with a transient offset in the fault current the required voltage setting is given by:

$$V_S = (0.005\ X/R + 0.78) \times I_f\ (2_{RL} + R_{CT})$$

To be used when X/R is less or equal to 80. The standard equation should be used for X/R ratios greater than 80.

If the calculated value is lower than that given by equation 1 (with K = 1.2) then it should be used instead.

9.2.11 Transient Stability Limit

$$V_S = 0.005\ X/R + 0.78) \times \frac{15300}{500} \times (0.7 + 2)$$

$$V_S = 0.88 \times 30.6 \times 2.7$$

$$V_S = 73V$$

The relay current setting, I_r = 0.8In

$$R_{ST} = \frac{V_S}{I_r}$$

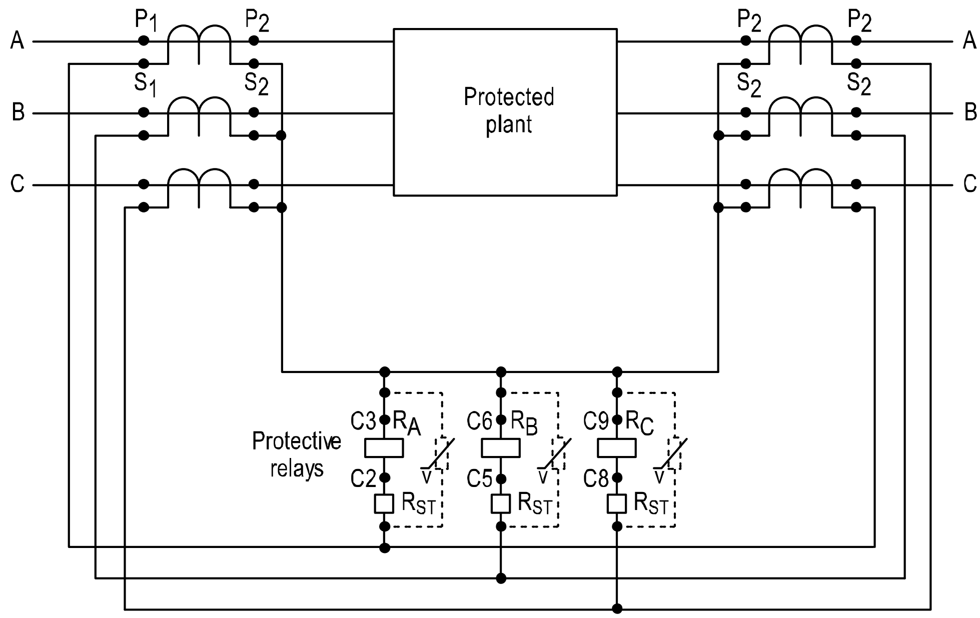
$$R_{ST} = \frac{73}{0.8} = 91\Omega$$

Assuming $V_K = 4V_s$

$$V_K = 4V_S = 292V$$

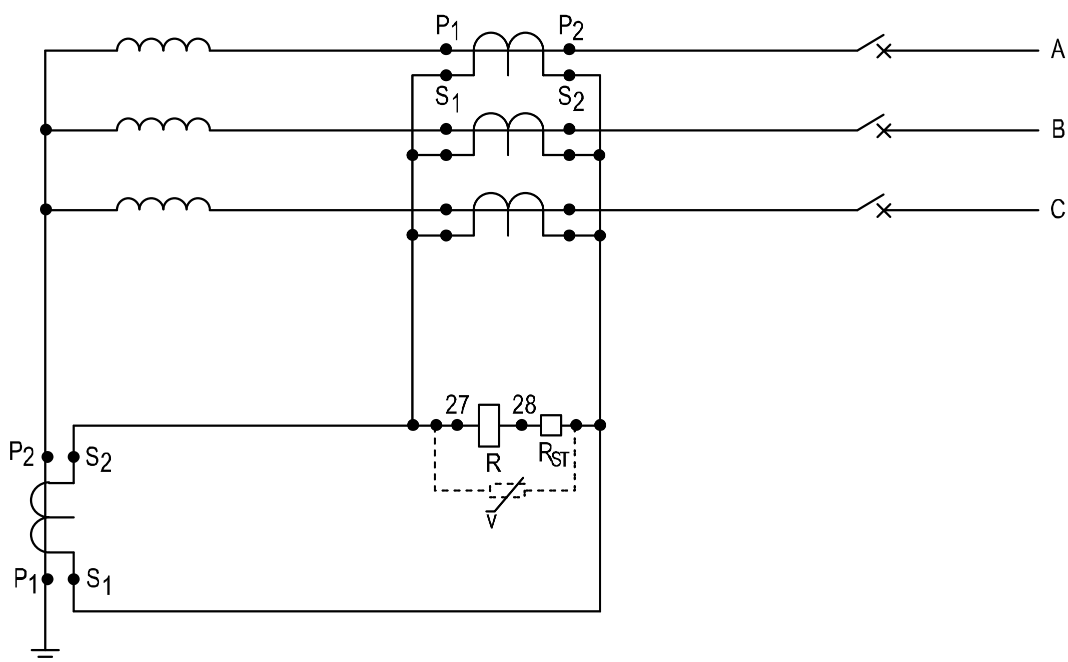
Using the advanced application method, the knee point voltage requirement has been reduced to 292V compared to the conventional method where the knee point voltage was calculated to be 396V.

10. Various High Impedance Busbar Schemes



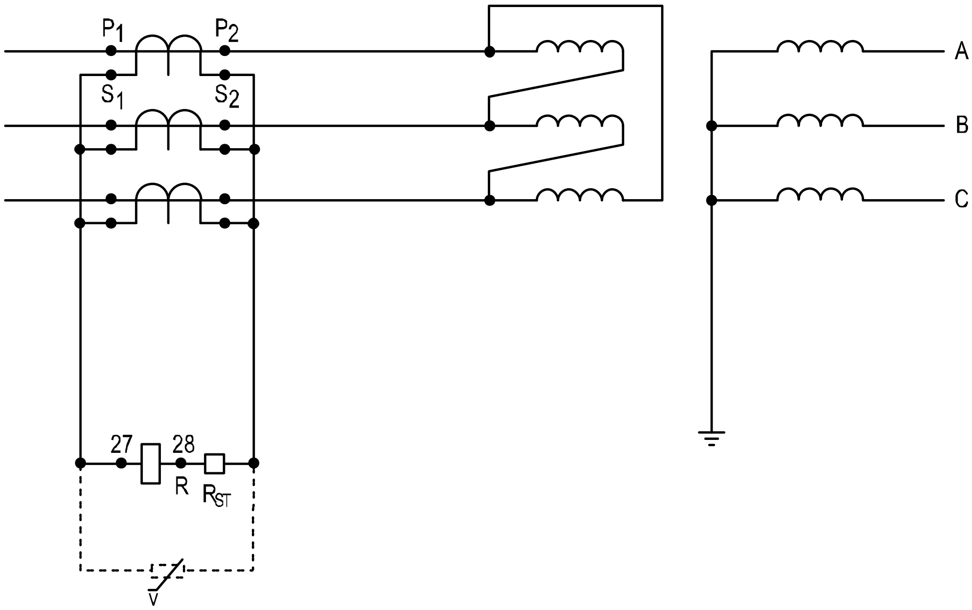
E04013

Figure 12: Phase and earth fault differential protection for generators, motors or reactors



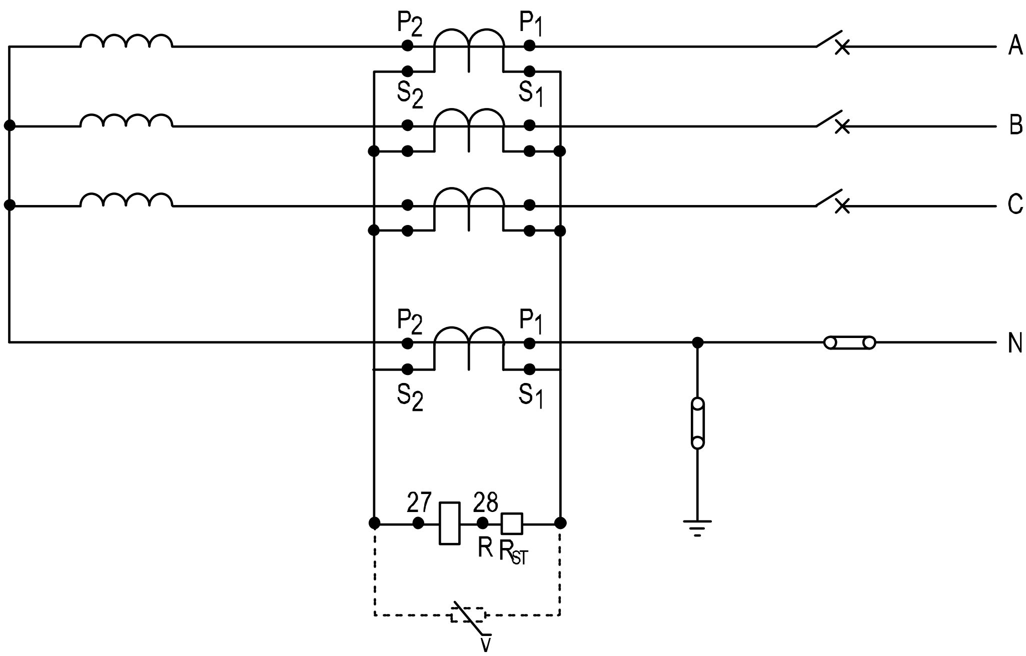
E04014

Figure 13: Restricted earth fault protection for 3 phase, 3 wire system-applicable to star connected generators or power transformer windings



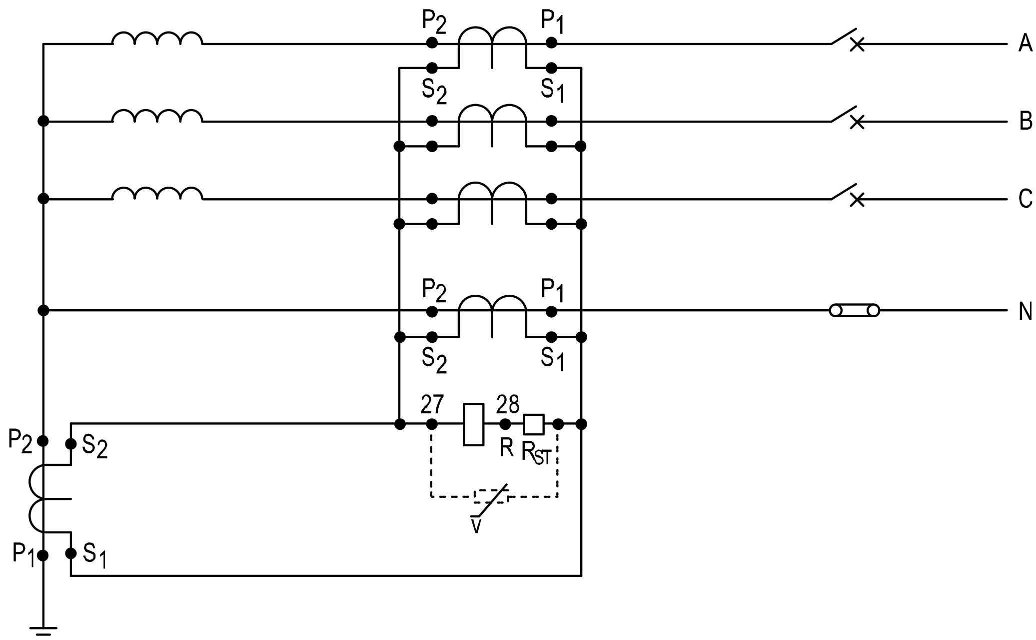
E04015

Figure 14: Balanced or restricted earth fault protection for delta winding of a power transformer with supply system earthed



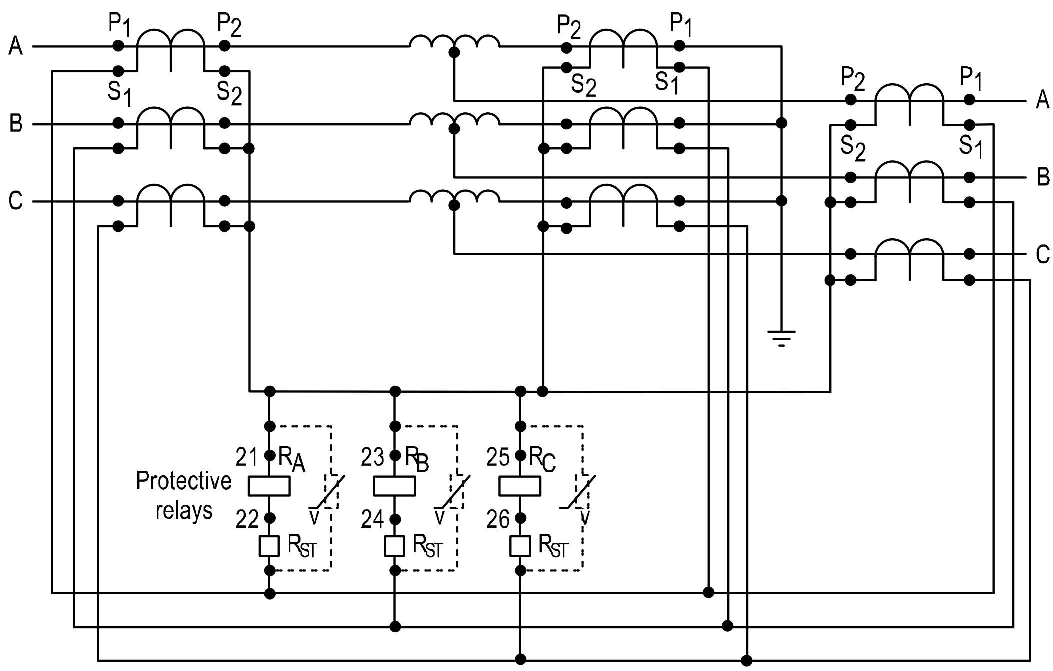
E04016

Figure 15: Restricted earth fault protection for 3 phase, 4 wire system-applicable to star connected generators or power transformer windings with neutral earthed at switchgear



E04017

Figure 16: Restricted earth fault protection for 3 phase, 4 wire system-applicable to star connected generators or power transformer windings earthed directly at the star point



E04018

Figure 17: Phase and earth fault differential protection for an auto-transformer with CT's at the neutral star point

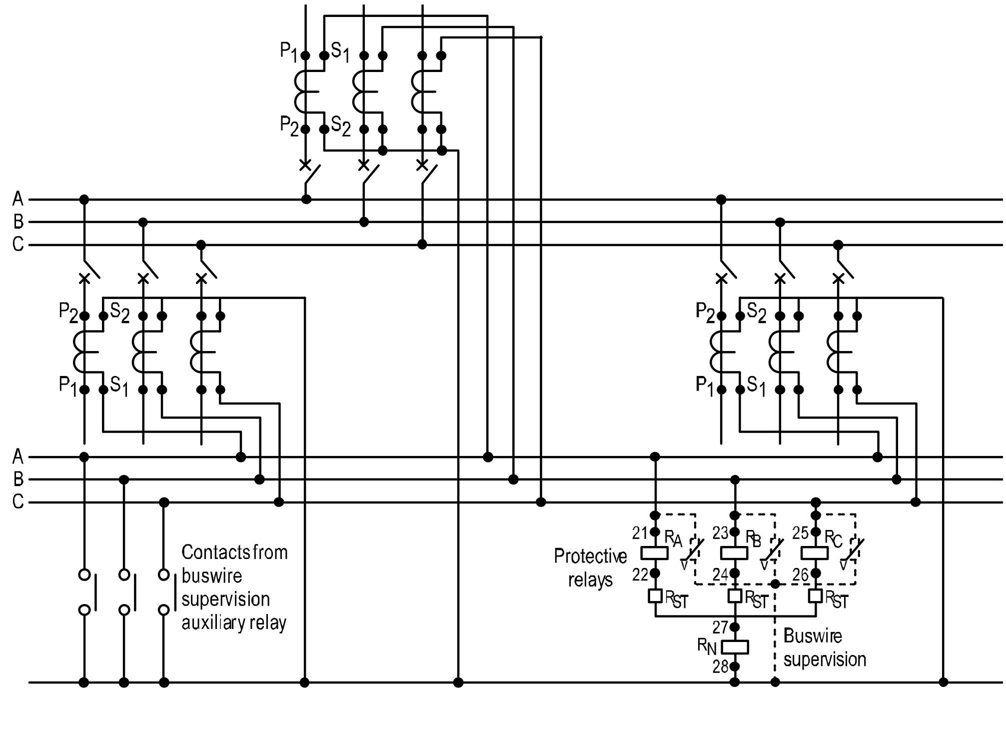


Figure 18: Busbar protection – simple single zone phase and earth fault scheme

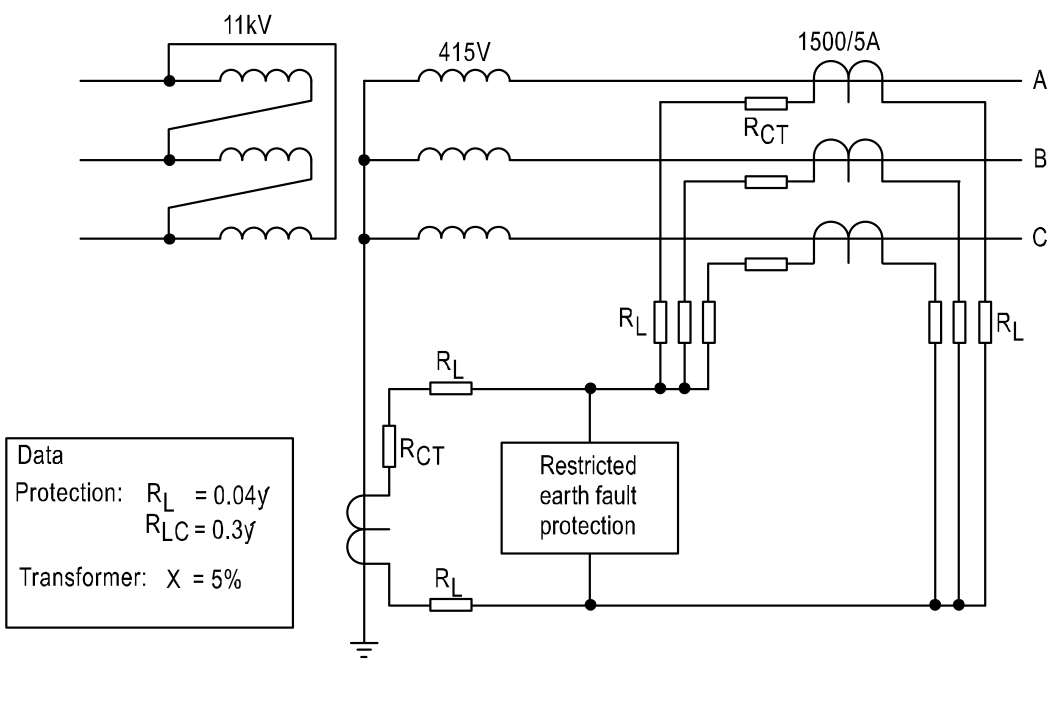


Figure 19: Restricted earth fault protection on a power transformer LV winding

11. Applying P14x For High Impedance Busbar Application

If a line differential, distance protection, transformer differential, motor protection or any other device operates incorrectly it will trip an individual unit or section in a given system. If the busbar protection relay operates incorrectly it will result in the simultaneous loss of multiple number of bays, which are connected to the affected zone. Therefore, the stability of the busbar protection system is of paramount importance and should have two independent features, which both must assert before a tripping occurs. These two features are commonly referred as 'Discriminating' and 'Check' features. The tripping of CB does not take place until, and unless, the relays associated with both the 'Discriminating' and 'Check' features have operated.

It is also essential to have continuous supervision of CTs and the wiring to ensure that the scheme operates as expected.

Figure 23 shows the CT circuits for a typical busbar configuration comprising of one bus section and two bus coupler CB's. This enables three zones of protection with the CTs connected in a way to assist overlapping at the bus section and bus coupler CB's.

11.1 Discriminating Zone Feature

Figure 23 shows the 3 Ph. CT's available at each of the feeder CBs (Incoming, Outgoing), bus section CB and the bus coupler CB forms the discriminating (Main) zone. This example shows there are three discriminating zones, Zone A, Zone B and Zone C, which provides differential protection for Bus A, Bus B and Bus C respectively.

The CTs associated with the Zone A differential are connected to the Zone A bus wires. Zone B differential are connected to the Zone B bus wires and Zone C differential are connected to the Zone C bus wires.

The CTs which are associated with the feeder CBs (Feeder CB bay 1) could be part of either Zone A or Zone C, depending on the Isolator position Q11 and Q12. The CTs which are associated with Feeder CB bay 2 could be part of either Zone B or Zone C, depending on the Isolator position Q21 and Q22. Therefore, it is important to switch the CTs across the Zone A and Zone C bus wires as far as Feeder CB bay 1 is concerned. The CTs which are associated with Feeder CB bay 2 need to be switched across Zone B and Zone C bus wires. This switching is dynamic in nature. For example, if the Feeder CB bay 1 is connected to Zone A via Q11 then with the use of Isolator auxiliary contacts 89a and/or 89b, the respective CT is associated with Zone A bus wires. If the Feeder CB bay 1 is connected to Zone C via Q12 then (with the use of Isolator auxiliary contact 89a and/or 89b) the respective CT is associated with Zone C bus wires. As far as the CTs associated with the bus section CB or the bus coupler CBs are concerned, they are fixed in nature. These CTs are permanently connected to their respective bus wires and there is no switching involved.

Discriminating zone helps in localizing or discriminating the fault in the given bus bar configuration. This is achieved by creating individual zones on a per bus or a per section basis. Figure 23 shows, we have 3 no.s bus in total and therefore we have 3 no.s discriminating zones.

11.2 Check Zone Feature

As explained in the busbar protection it is important to double check before any trip command is issued. Therefore, a second confirmation is necessary. This is achieved by incorporating an additional zone, which is referred as 'Check zone' or Check feature. The Check zone differential is achieved by using CTs which are associated with the feeder CBs only. The CTs which are associated with the bus section CB or the bus coupler CB are not taken into consideration, as far as the Check zone application is concerned. Therefore, Check zone forms an overall zone for the complete bus configuration. Any fault that is present in either Zone A or Zone B or Zone C will be seen by the Check zone differential element and will act as a second confirmation to the trip decision (if any) given by the discriminating (Main) zone, as shown in Figure 23. Also, since Check zone is looking for the total zone differential of the complete bus configuration (in this case Zone A + Zone B + Zone C altogether combined), the CTs associated with the feeder CBs bay 1 and bay 2 are therefore permanently connected to the Check zone bus wires. There is no requirement for CT switching relays in the case of Check zone. This brings extra advantages. If there is any problem with the Isolator auxiliary contacts 89a and/or 89b or the CT switching relays, then this will affect the discriminating zone only and not the check zone. This means Check zone is the vector summation of all the currents entering and leaving any given bus configuration. It does not take into account Isolator or CB status for zone identification and is therefore free of issues arising out of switchgear status discrepancy or problems associated with CT switching relays. All of this adds extra security to the Check zone application. A trip is only issued by the bus bar protection relay if the discriminating zone AND the check zone are in congruence with each other.

11.3 Tripping Circuits

The tripping circuits are arranged so that the accidental operation of any one of the circulating current relays does not cause an unwanted tripping of the zone in concern. Both the 'Discriminating' and 'Check' zone high impedance differential relays must be energised before the main tripping relays are energised. One no. main tripping relay is required for each feeder circuit breaker and two such relays are required for each bus section and each bus coupler circuit breaker.

11.4 Alarm Circuits

Several alarm signals in the form of user alarms, LEDs and output contacts (for external display) have been pre-configured in the default PSL. The user can generate an alarm for:

- Main zone trip (or Check zone trip)
- Alarm supply fail
- Trip supply fail
- Bus wire supervision alarm (Current based and/ or Voltage based)
- Check zone confirmation not met (or Main zone confirmation not met)
- HiZ differential out of service
- HiZ differential Trip ph. A, B, C
- I_{REF} Trip

11.5 Test Facilities

With Digital inputs and Function keys it is possible to:

- Test the bus wire shorting feature. This will close the bus wire shorting contacts (2 no.s each) for phase A, B and C respectively.
- Set the HiZ differential to out of service.

11.6 Equipment Per Zone

When implementing HiZ differential scheme, one relay is required on a per zone basis. Figure 23 shows there are 3 Discriminating (Main) zones and one Check zone (for overall supervision). Therefore, 4 no.s differential relays are required for the complete scheme.

Bus wire supervision feature:

- If current differential based bus wire supervision is used then no additional relays are required. This is a built in feature of P145 B as well as P14N B relays.
- If voltage based bus wire supervision is used then this is possible only in P145 B relay. This uses the ‘Supervision OV’ function to monitor the healthiness of the bus wire.
- Indication for various different Alarms, Trips and zone operation are possible through the LEDs and display on the relay front HMI. External display units are not mandatory.
- 3 no.s stabilising resistors and 3 no.s Metrosil each on a per zone basis.

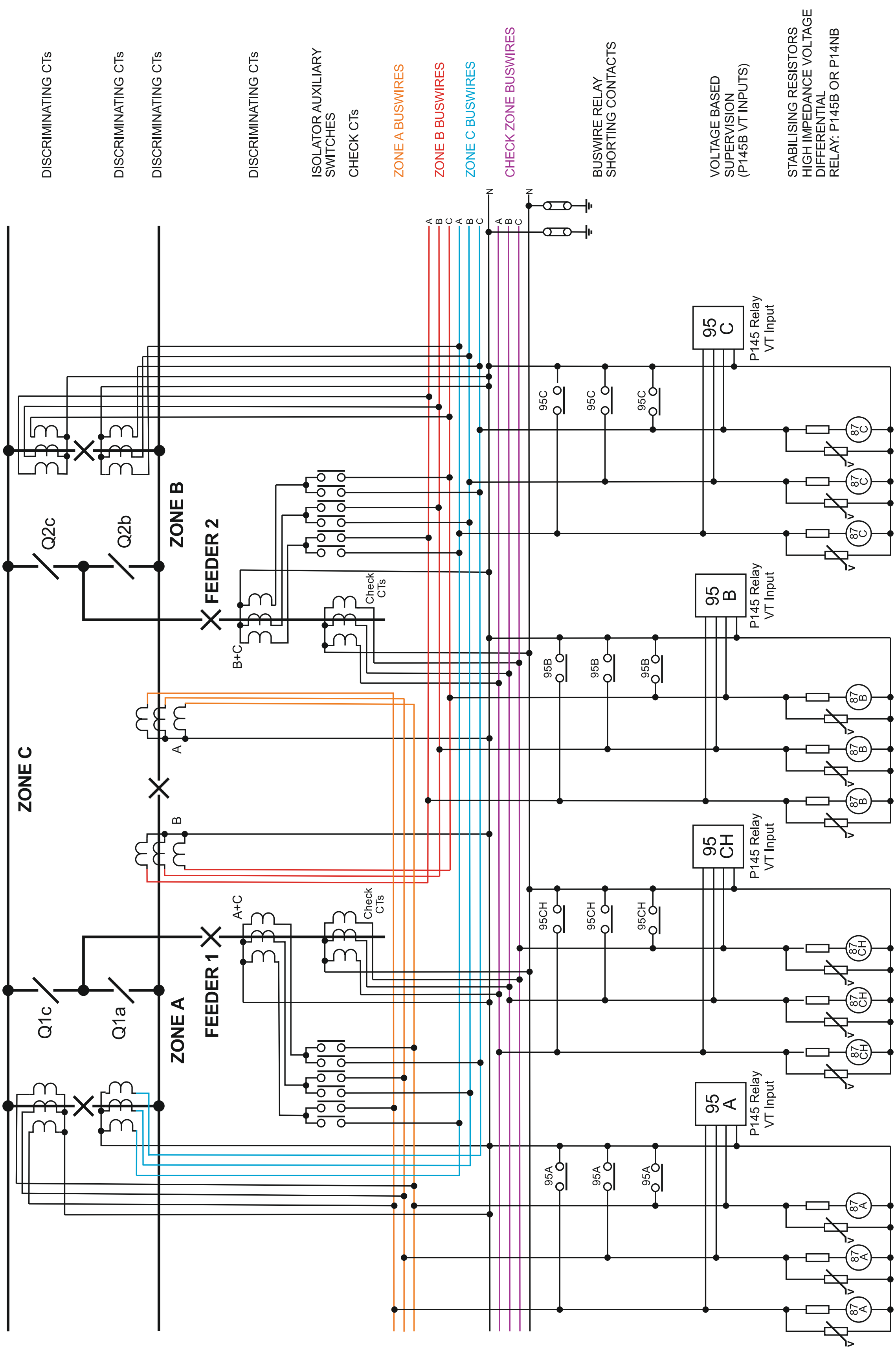


Figure 20: Double Busbar Protection – AC Circuits

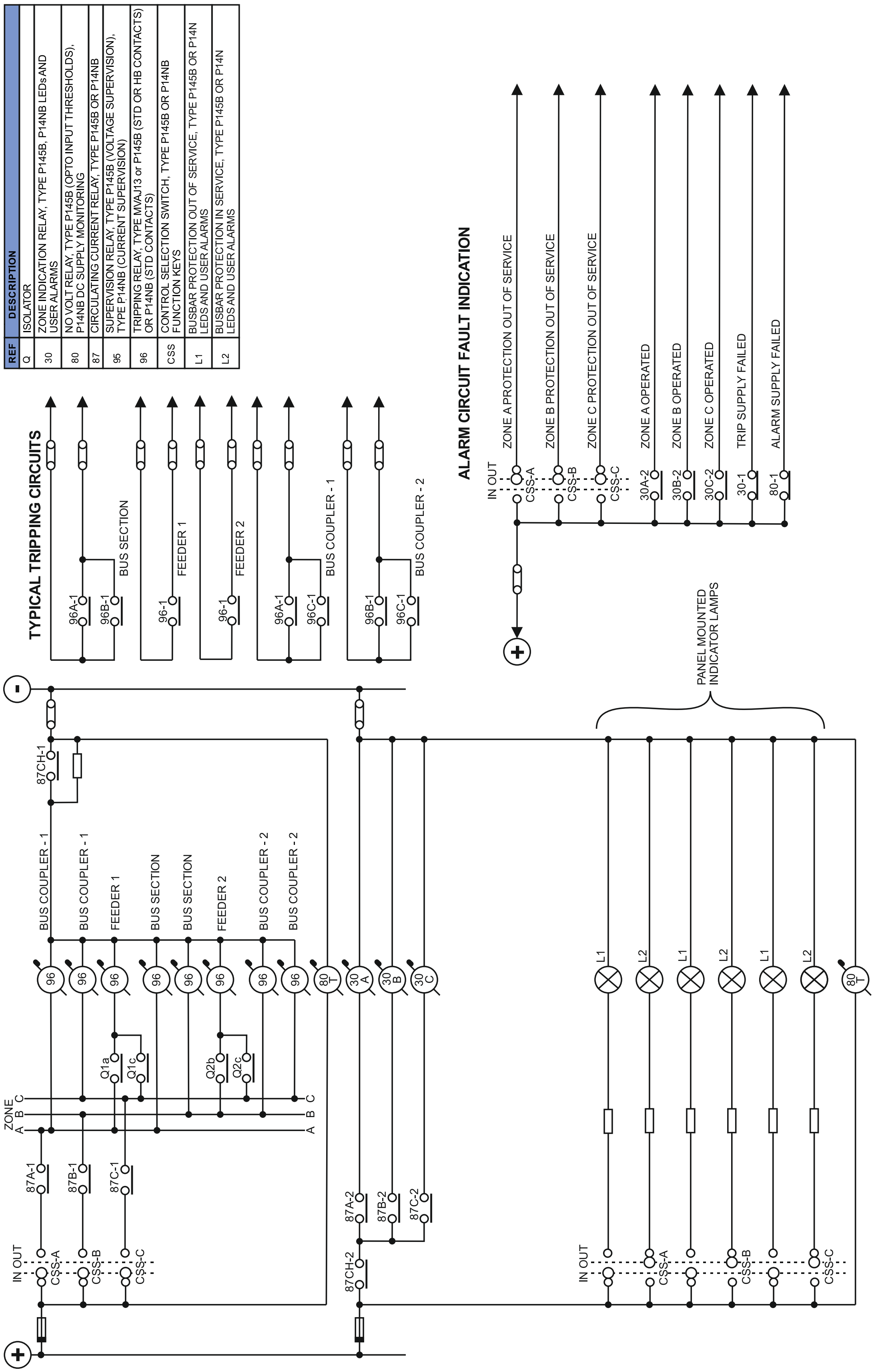


Figure 21: Double Busbar Protection – DC Circuits

12. P145 B Connection Diagram with HID Module

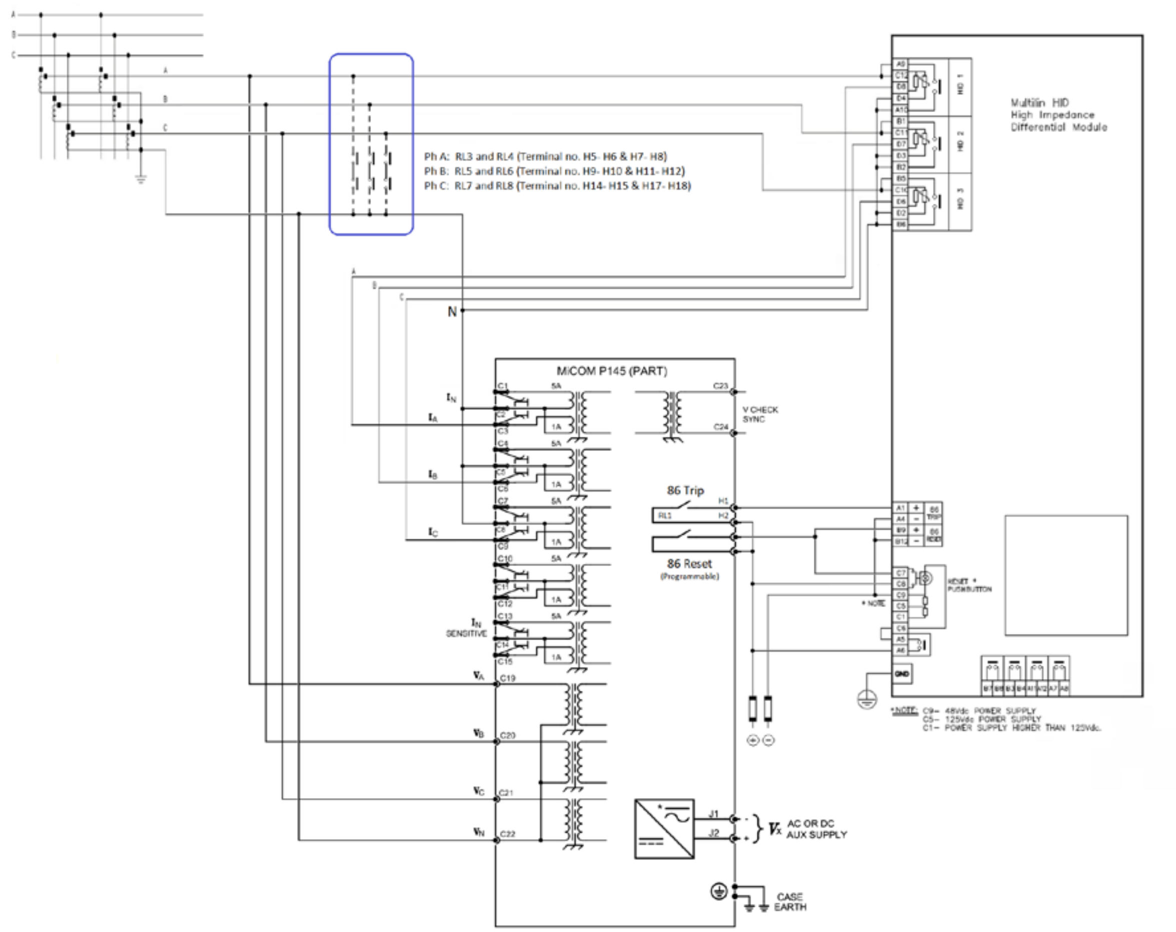
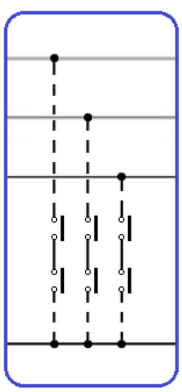


Figure 22: P145 B HID wiring diagram



If the P145 B or P14N B relay is being used with external stabilising resistor and Metrosil (and not with the HID module) then 2 no. of relay output contacts, which are connected in series on a per phase basis, needs to be used for bus wire shorting purpose.

However, if the HID module is being used then the relay shorting contacts are not required. This is because the HID module has built in bus wire shorting contacts, as shown in the figure above.

13. P14N B Connection Diagram With HID Module

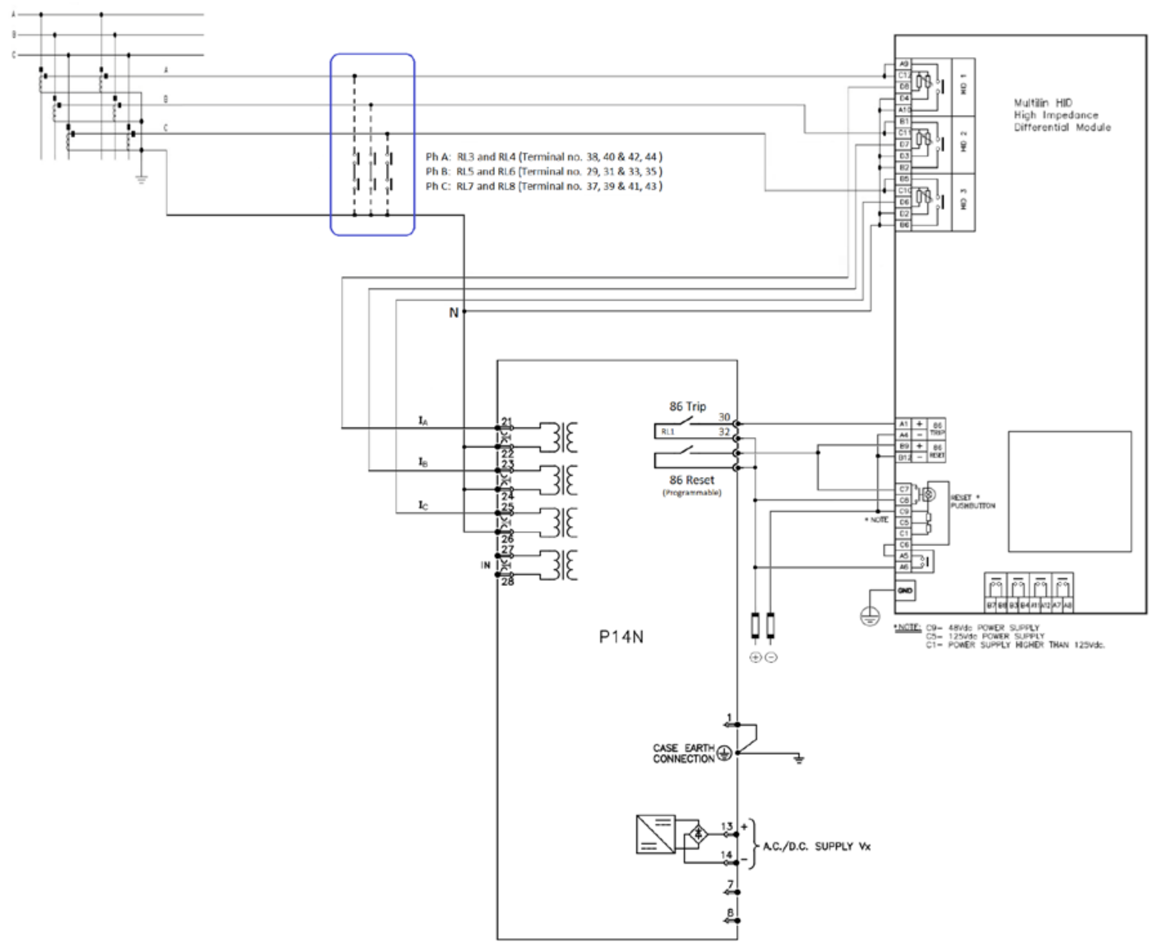
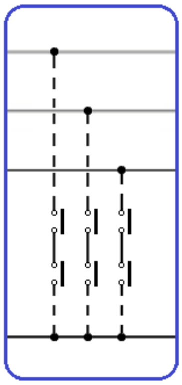


Figure 23: P14N B HID wiring diagram



If the P145 B or P14N B relay is being used with external stabilising resistor and Metrosil (and not with the HID module) then 2 no. of relay output contacts, which are connected in series on a per phase basis, needs to be used for bus wire shorting purpose.

However, if the HID module is being used then the relay shorting contacts are not required. This is because the HID module has built in bus wire shorting contacts, as shown in the figure above.

14. Ordering Option P145

VARIANTS		Code
Directional Phase O/C and E/F with Auto-Reclose and Check Synch with Extended Function User Interface	P145	* * *
Vx Auxiliary Rating		
24-54 Vdc		7
48-125 Vdc (40-100 Vac)		8
110-250 Vdc (100-240 Vac)		9
In/Vn Rating		
In = 1/5A, Vn = 100 - 120Vac		1
In = 1/5A, Vn = 380 - 480Vac (Min 196Vac Max 560Vac)		2
Hardware Option		
None		1
IRIG-B Only		2
Fibre Optic Port (ST) for SCADA Protocols (Courier,Modbus,IEC60870-5-103 or DNP3) (withdrawn)		3
Fibre Optic Port (ST) for SCADA Protocols (Courier,Modbus,IEC60870-5-103 or DNP3) + IRIG-B		4
Ethernet with 10Mbps fibre optic port		5
Ethernet with 100Mbps fibre optic port		6
Courier Rear Port		7
IRIG-B (Modulated) & Courier Rear Port		8
Ethernet (100Mbit/s) plus IRIG-B (Modulated)		A
Ethernet (100Mbit/s) plus IRIG-B (Un-modulated)		B
IRIG-B (Un-modulated)		C
InterMiCOM + Courier Rear Port		E
InterMiCOM + Courier Rear Port + IRIG-B modulated		F
Redundant Ethernet Self-Healing Ring, 2 multi-mode fibre ports + Modulated IRIG-B		G
Redundant Ethernet Self-Healing Ring, 2 multi-mode fibre ports + Un-modulated IRIG-B		H
Redundant Ethernet RSTP, 2 multi-mode fibre ports + Modulated IRIG-B		J
Redundant Ethernet RSTP, 2 multi-mode fibre ports + Un-modulated IRIG-B		K
Redundant Ethernet Dual-Homing Star, 2 multi-mode fibre ports + Modulated IRIG-B		I
Redundant Ethernet Dual-Homing Star, 2 multi-mode fibre ports + Un-modulated IRIG-B		M
Redundant Ethernet PRP/HSR, 2 fibre ports + Modulated IRIG-B		N
Redundant Ethernet PRP/HSR, 2 fibre ports + Unmodulated IRIG-B		P
Redundant Ethernet PRP/HSR/RSTP/Failover, 2 multi-mode fibre ports + Modulated/Un-Modulated IRIG-B		R
Redundant Ethernet PRP/HSR/RSTP/Failover, 2 copper ports RJ45 + Modulated/Un-Modulated IRIG-B		S
Redundant Ethernet PRP/HSR/RSTP/Failover, 1 copper port RJ45 + 1 multi-mode fibre port + Modulated/Un-Modulated IRIG-B		T
Product Specific Option		
60TE case, 16 inputs and 16 output relays		A
60TE case, 12 inputs and 12 output relays with ANSI Symbol Terminal labelling		B
60TE case, 24 inputs and 16 output relays		C
60TE case, 16 inputs and 24 output relays		D
60TE case, 24 inputs and 24 output relays		E
60TE case, 32 inputs and 16 output relays		F
60TE case, 16 inputs and 32 output relays		G
60TE case, 16 inputs and 20 output relays (including 4 High Break)		H
60TE case, 24 inputs and 20 output relays (including 4 High Break)		J
60TE case, 16 inputs and 28 output relays (including 4 High Break)		K
60TE case, 16 inputs and 24 output relays (including 8 High Break)		L
Comms Protocol		
K-Bus - (NOT with Hardware Options 5 & 6)		1
Modbus - (NOT with Hardware Options 5 & 6)		2
IEC60870 - (NOT with Hardware Options 5 & 6)		3
DNP3- (NOT with Hardware Options 5 & 6)		4
UCA2 over Ethernet and Courier via rear K-Bus/RS485 - (ONLY with Hardware Options 5 & 6) *		5
IEC 61850 over Ethernet and Courier via rear K-Bus/RS485		6
IEC61850 over ethernet with CS103 rear port RS485 protocol		7
DNP3 over Ethernet with Courier rear port K-Bus/RS485 protocol		8
*** NB: UCA2 option is not available with software versions 35 & later (Design Suffix J)**		
Case Size / Mounting / Livery		
Flush/Panel Mounting with Harsh Env.Coating, White Front Panel		M
Flush/Panel Mounting with Harsh Env. Coating, with USB Port, Black and Silver Front Panel		S
Language Option		
Multilingual - English/French/German/Spanish		0
Multilingual - English/French/German/Russian		5
English, Italian, Polish and Portuguese **(Software '50' and later)**		7
Chinese, English or French via HMI, with English or French only via Communications port *		C
*** NB: Chinese etc. HMI is not available with 12 logic inputs and 12 relay outputs with ANSI Symbol Terminal labelling**		
Software Version		
Date Dependent		* *
Customisation		
Default		0
Customised		A
High Impedance Differential Settings		B
Hardware Design Suffix		
Date Dependent		*

15. Ordering Option P14N

VARIANTS	1-4	5	6	7	8	9	10	11	12-13	14	15
Model Type											
Feeder Management Protection IED - Non Directional	P14N										
Application											
Base		B									
Current transformer											
Standard Earth CT			1								
Hardware Options											
EIA RS485/IRIG-B (demodulated)	20TE/30TE			1							
EIA RS485/IRIG-B (demodulated) and Ethernet - Single channel Fibre/Copper (setting configurable as Failover*)	30TE			6							
EIA RS485/IRIG-B (demodulated) and EIA RS485	30TE			8							
EIA RS485/IRIG-B (demodulated) and Dual Redundant Copper Ethernet - 2x RJ45 Copper (setting configurable as Failover)	30TE/40TE			A							
EIA RS485/IRIG-B (demodulated) and Dual Redundant Fibre Ethernet - 2x multimode fibre (setting configurable as Failover)	30TE/40TE			B							
EIA RS485/IRIG-B (demodulated) and Dual Redundant Copper Ethernet - 2x RJ45 Copper (RSTP)	30TE/40TE			C							
EIA RS485/IRIG-B (demodulated) and Dual Redundant Fibre Ethernet - 2x multimode fibre (RSTP)	30TE/40TE			D							
EIA RS485/IRIG-B (demodulated) and Dual Redundant Copper Ethernet - 2x RJ45 Copper (setting configurable as PRP or HSR)	30TE/40TE			E							
EIA RS485/IRIG-B (demodulated) and Dual Redundant Fibre Ethernet - 2x multimode fibre (setting configurable as PRP or HSR)	30TE/40TE			F							
I/O Options	**Case**										
Standard (8 logic inputs + 8 relay outputs)	20TE/30TE				A						
*** Please contact Product Manager**											
Communication protocol											
Courier						1					
Modbus						2					
IEC60870-5-103 (VDEW)						3					
DNP3.0						4					
IEC 61850 over Ethernet and Courier via rear RS485						6					
IEC 61850 over Ethernet and IEC60870-5-103 via rear RS485						7					
DNP3.0 over Ethernet and Courier via rear RS485						8					
IEC 61850 over Ethernet and Modbus via rear RS485						9					
IEC 61850 over Ethernet and DNP3.0 via rear RS485						A					
IEC61850 over Ethernet + DNP3.0 over Ethernet and Courier via RS485						B					
IEC61850 over Ethernet + DNP3.0 over Ethernet and Modbus via RS485						C					
IEC61850 over Ethernet + DNP3.0 over Ethernet and IEC60870-5-103 via RS485						D					
Case											
20TE Flush (no function keys, 4 programmable LEDs)							B				
30TE Flush (3 function keys with LEDs, 8 programmable LEDs)							C				
Software only							0				
Language											
Multilingual (English, French, German, Spanish)								0			
Multilingual (English, Russian, Italian, Portuguese)								6			
Chinese, English or French via HMI, with English or French only via Communications port								C			
Software Reference											
Unless specified the latest version will be delivered									**		
Customisation / Regionalisation											
High impedance busbar application **										B	
**** Available for 20TE option B and 62 Software and in English Language**											
Hardware design suffix											
Initial release											A

Note: The cortecs in this Application Note should only be used for guidance as it provides a snapshot of the interactive data taken at the time of publication. All current models and variants for this product are defined in an interactive spreadsheet, which is located in the Resources > Specifications tab on the company website.

16. Ordering Option HID Module

To be ordered separately:

High Impedance Differential Module	HID	-		-	
Application Version					
1 winding transformer REF - 1 resistor + 1 MOV			1		
2 winding transformer REF - 2 resistors + 2 MOV			2		
Busbar Applications 3 High impedance differential element			3		
Latching relay / Power supply					
Without latching relay					1
48 Vdc latching relay					2
125 Vdc latching relay					3
220 Vdc latching relay					4

17. Ordering Option Variable Stabilising Resistor

Stabilising Resistor & Metrosil (Contact GE for Metrosil details)	
Nominal Value	**Stabilising Resistor**
ZB9016710	Large Tubular Wirewound Resistor 24 ohm 165W @ 70º 180W @ 20º ± 10%
ZB9016720	Large Tubular Wirewound Resistor 47 ohm 165W @ 70º 180W @ 20º ± 10%
ZB9016732	Large Tubular Wirewound Resistor 100 ohm 165W @ 70º 180W @ 20º ± 10%
ZB9016738	Large Tubular Wirewound Resistor 150 ohm 165W @ 70º 180W @ 20º ± 10%
ZB9016744	Large Tubular Wirewound Resistor 220 ohm 165W @ 70º 180W @ 20º ± 10%
ZB9016747	Large Tubular Wirewound Resistor 270 ohm 165W @ 70º 180W @ 20º ± 10%
ZB9016756	Large Tubular Wirewound Resistor 470 ohm 165W @ 70º 180W @ 20º ± 10%
ZB9016765	Large Tubular Wirewound Resistor 820 ohm 165W @ 70º 180W @ 20º ± 10%
ZB9016768	Large Tubular Wirewound Resistor 1000 ohm 165W @ 70º 180W @ 20º ± 10%
ZB9016774	Large Tubular Wirewound Resistor 1500 ohm 165W @ 70º 180W @ 20º ± 10%
ZB9016783	Large Tubular Wirewound Resistor 2700 ohm 165W @ 70º 180W @ 20º ± 10%
ZB9016795	Large Tubular Wirewound Resistor 5600 ohm 165W @ 70º 180W @ 20º ± 10%

18. Logical Node Representation in IEC 61850

18.1 HIZ DIFF ID> 1- 4 AND CIRCUITRY FAULT 1 & 2 MAPPING

LD	LN INSTANCE	LN TYPE	DESCRIPTION
ProtOvCur			
	LLN0	LLN0_STANDARD_WITH_CTRLMOD	Logical Device for Overcurrent Protection
	OcpPTOC1	PTOC_SEG	HiZ Diff ID > 1
	OcpPTOC2	PTOC_SEG	HiZ Diff ID > 2
	OcpPTOC3	PTOC_SEG	HiZ Diff ID > 3
	OcpPTOC4	PTOC_SEG	HiZ Diff ID > 4
	OcpPTOC5	PTOC_SEG	Circ Flt ID > 1
	OcpPTOC6	PTOC_SEG	Circ Flt ID > 2
	OcpPTRC2	PTRC_INDIVID_NO_SEG	Protection trip for Overcurrent Protection

18.2 HIZ REF Mapping

LD	LN INSTANCE	LN TYPE	DESCRIPTION
ProtSef			
	LLN0	LLN0_STANDARD_WITH_CTRLMOD	Logical Device for SEF Protection
	SenEftPTRC6	PTRC_INDIVID_NO_SEG	Protection trip for Sensitive Earth Fault Protection
	SenRefPDIF1	PDIF_NEU	IREF> 1 Restricted Earth Fault

18.3 Supervision Overvoltage Mapping

LD	LN INSTANCE	LN TYPE	DESCRIPTION
ProtVtp			
	LLN0	LLN0_STANDARD_WITH_CTRLMOD	Logical Device for Vtp Protection
	VtpPhsPTOV5	PTOV_SEG	SOV > 1 Overvoltage
	VtpPhsPTOV6	PTOV_SEG	SOV > 2 Overvoltage
	VtpPhsPTRC7	PTRC_INDIVID_NO_SEG	Protection trip for Vtp Protection

For more information, visit
gevernova.com/grid-solutions

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