

APPLICATION GUIDE

AG011 - COMPENSATED EARTHFALT PROTECTION USING P14X RELAYS

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SUMMARY

The following report illustrates how the relay type MiCOM P14x can be used for compensated (educated) earth fault protection applications. Traditional schemes use a star/delta interposing transformer of ratio 1/0.578 and contact logic to provide restricted earth fault protection of transformer feeders. The scheme proposed in this document negates the need of the interposing transformer by the use a negative sequence overcurrent element. Combining the negative sequence function with a conventional earth fault element, compensated earth protection (CEF) can be achieved using a single relay.

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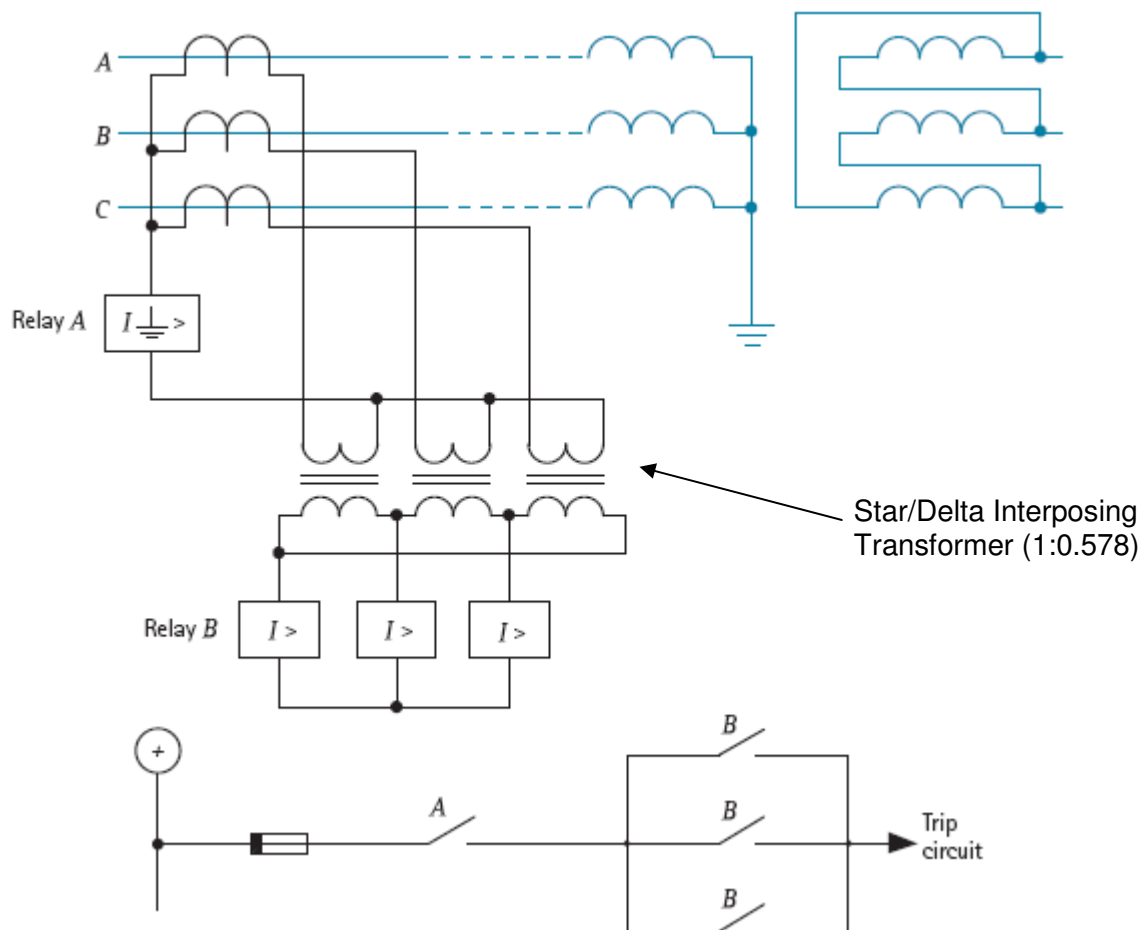
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1. INTRODUCTION

This document details the use of MiCOM P14x relays for compensated earth fault (CEF) applications. CEF schemes require the use of the two separate relays, one of which driven from a star/delta interposing transformer, in order to provide instantaneous restricted earth fault protection for low impedance earthed transformer feeders. The diagram below shows the traditional scheme together with the required contact logic to achieve tripping for feeder earth faults only. Earth faults beyond the transformer will be seen as a phase to phase fault, resulting in no operation of relay A and hence no tripping of the breaker.



In its current form, it is not possible to replicate this scheme using a single relay; which is why a small modification is required to achieve full compliance with the original specification. The modifications to the above scheme are fully explained later in this document.

2. REFERENCES

Ref	Document Number	Issue	Document Name
1	N/A	1	Network Protection & Automation Guide (NPAG)

3. CEF BASIC PRINCIPLES

3.1. ASSUMPTIONS

For simplicity, the fault position is assumed to be at 50% of the line and the transformer impedances are equal. This ensures that the residual current split is equal between the two star points thus simplifying the current distributions.

3.2. SOURCE EARTH FAULT

For a source earth fault scenario the relay must remain stable. As can be seen for a source earth fault Relay A detects the fault but operation is blocked by the lack of relay B operation. Relay B does not operate because the zero sequence component is extracted by the star/delta interposing transformer as shown below.

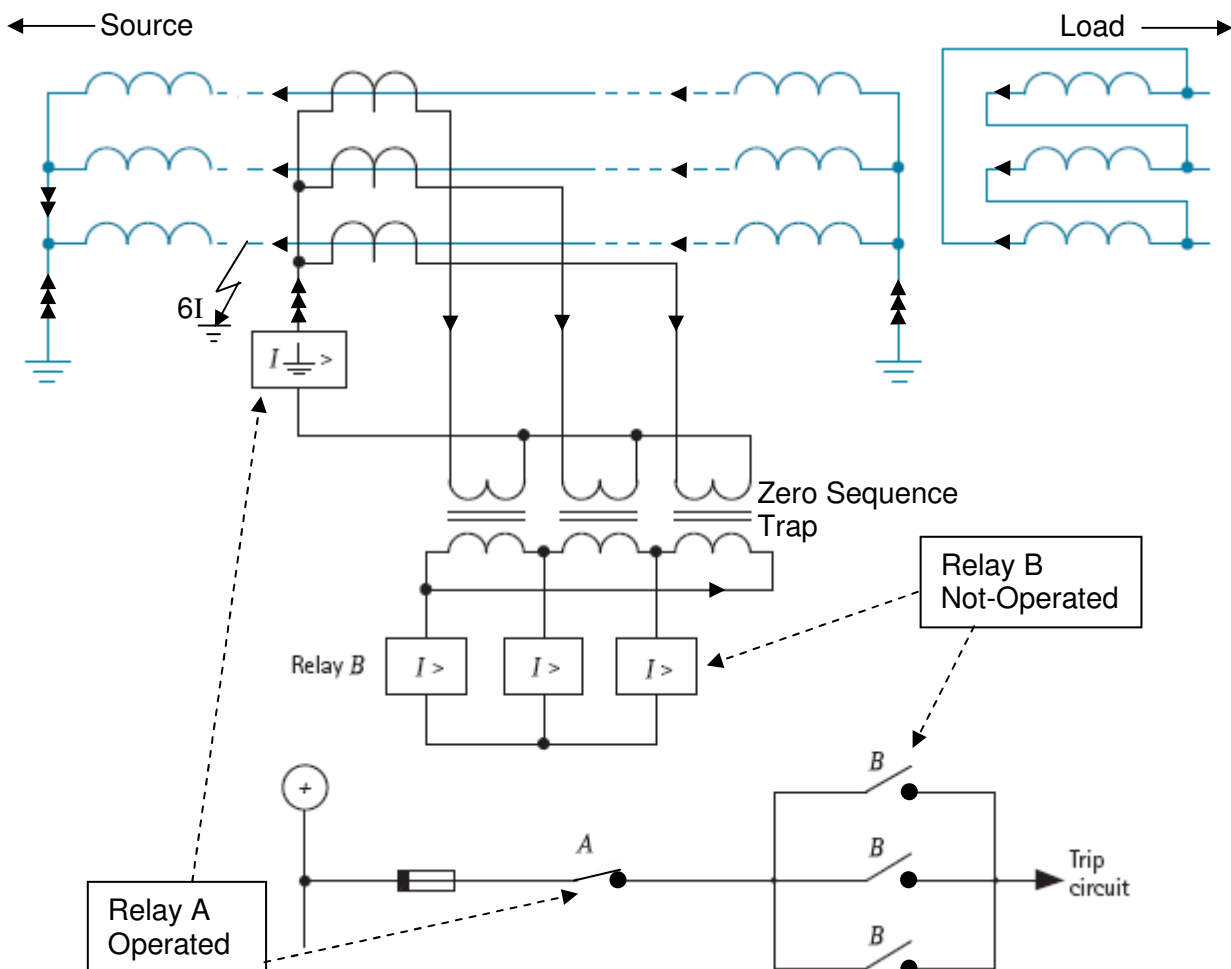


Figure 3.1 – CEF Protection With Earth Fault Behind Relay

3.3. TRANSFORMER FEEDER EARTH FAULT

For the transformer feeder earth fault scenario the relay must operate. As can be seen for a feeder earth fault both relays A and B operate thus tripping the associated breaker.

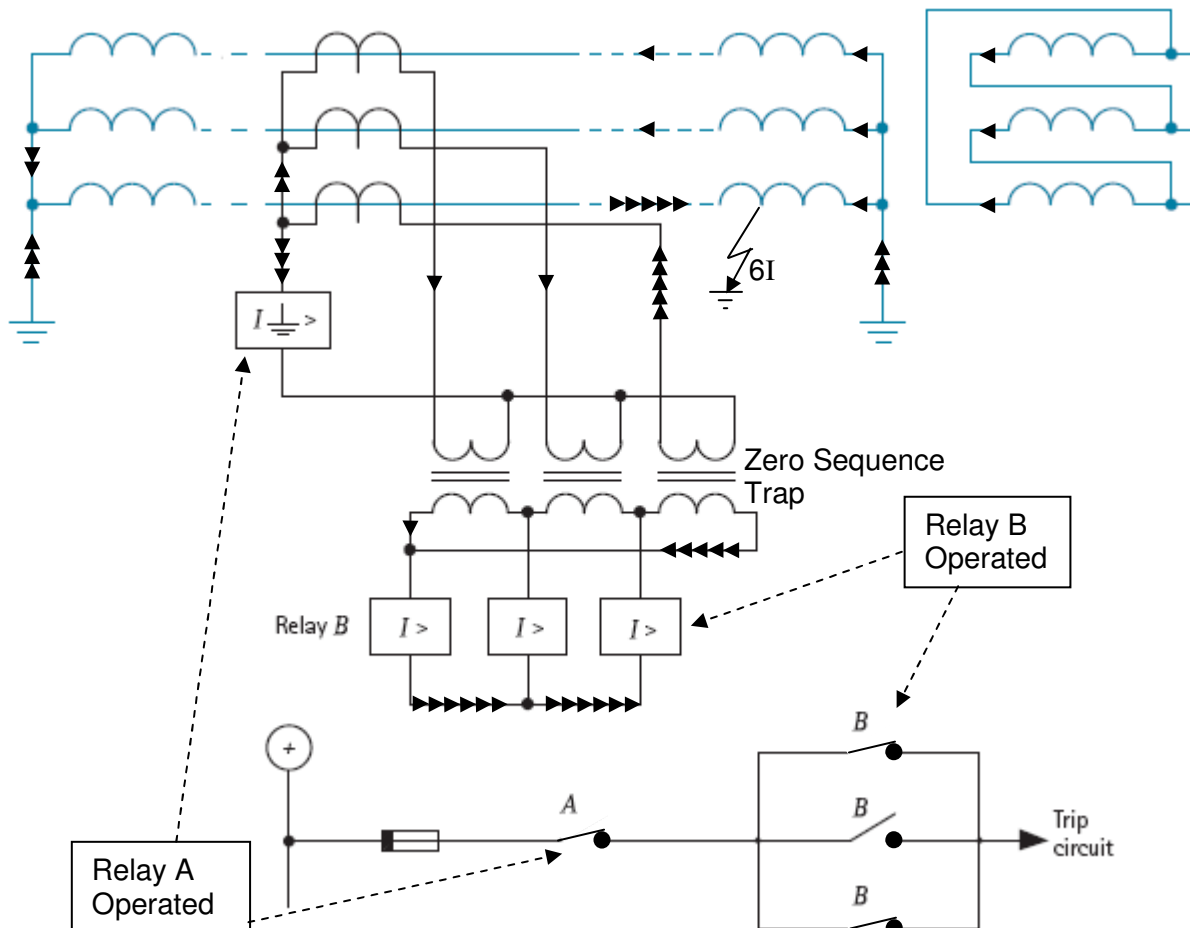


Figure 3.2 – CEF Protection With Earth Fault On The Feeder

The diagram above clearly shows that two phases within relay B operate together with relay A, giving rise to a trip. The combination of relays A and B act in tandem to block each other for all fault conditions except ground faults on the feeder / transformer.

4. PROPOSED SOLUTION USING P14X RELAYS

4.1. REQUIRED PROTECTION ELEMENTS

In order to fully replicate CEF protection in P14x relays it would be necessary to redesign the relay with a zero sequence filter included. However, similar performance can be obtained using a combination of protection functions with the negative sequence overcurrent protection (NPS O/C) taking the central roll in the scheme.

The P14x protection functions required for the proposed scheme are as follows :-

<u>Protection Function</u>	<u>Purpose</u>
<u>Sensitive Earth Fault (ISEF>) *</u>	<u>Replacement for "Relay A"</u>
<u>Neg Sequence O/C (I2>)</u>	<u>Replacement for "Relay B"</u>
<u>Overcurrent (I>)</u>	<u>Provides overcurrent protection if required</u>

*NOTE 1: Use of the SEF element leaves the standard earth fault (IN1>1) measuring input free for standby earth fault protection if required.

4.2. SCHEME DESCRIPTION

The proposed scheme utilizes the NPS OC element "AND'ed" with the sensitive earth fault element (ISEF1>) to replicate the CEF protection behavior. Both elements are required to detect the fault before a trip is issued, thus replicating the scheme. The use of the negative sequence element automatically negates the use of the star/delta interposing transformer as it is naturally unresponsive to zero sequence current (i.e. like relay B).

A further overcurrent element can be added to provide backup protection for all phase faults if required. In the existing scheme this would have been provided by a separate relay.

4.3. PROGRAMMABLE SCHEME LOGIC (PSL)

The following PSL provides the necessary logic to provide CEF using the NPS OC element. DDB start signals #323 and #509 act as relays A and B respectively. Tripping occurs when both of these signals are active. If necessary, a manual reset user alarm (e.g. DDB #185) can be applied and renamed using the menu text editor to indicate "Compensated EF" or something similar. The overcurrent trip signals DDB #243 and DDB#251 are included to provide back-up phase IDMT and instantaneous overcurrent protection if required.

NOTE: The following PSL is specific to P14x software version 43 only. Whilst it is possible to replicate this scheme in earlier versions of software, the DDB signals shown are for version 43 only.

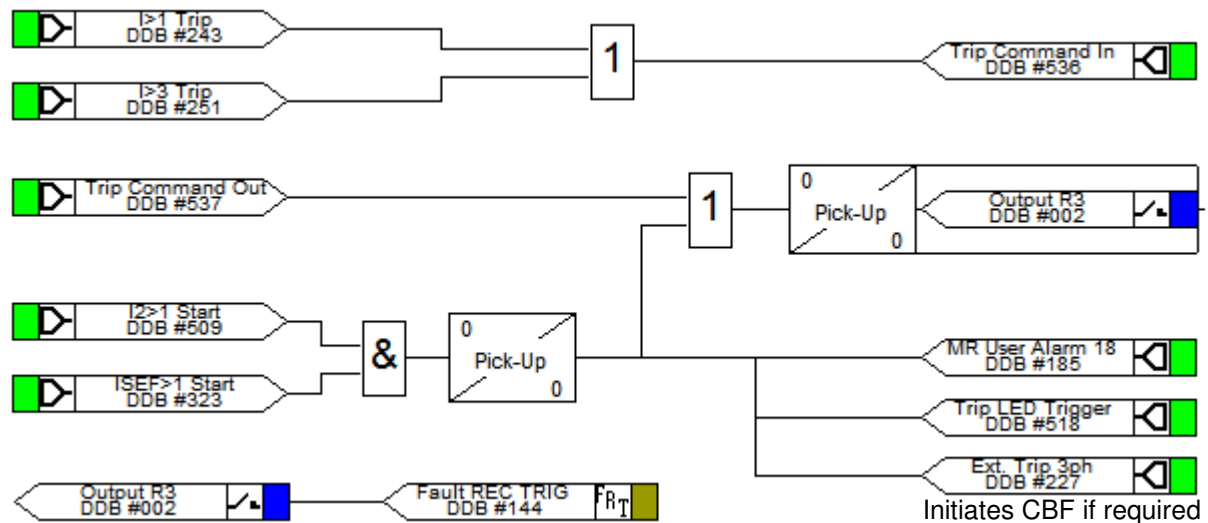


Figure 4.1 – Compensated Earth Fault PSL

4.4. SETTING GUIDELINES

It is assumed that this scheme has been chosen to replace an existing CEF scheme where the settings are already known; hence a full setting guide is not included.

4.4.1. Earth Fault Element (ISEF>1)

This element must be set with the same threshold as the existing relay. Since the start element is being used, instead of the trip, a time delay is not required. However, to avoid an “ISEF>1 trip” indication in the event file a long time delay can be chosen if required.

4.4.2. Negative Sequence Element (I2>)

The negative sequence element replaces Relay B in the original scheme, which would normally be set greater than load. In this case, however, the relay needs to be set above the maximum standing unbalance on the system instead of load. In cases where the standing unbalance can not be established, the relay should be set to 50% of the original overcurrent setting for relay B. The reasoning behind this setting is that for both phase and earth faults, the positive and negative sequence currents are equal, hence when the positive sequence is removed 50% of the current is left over (i.e. negative sequence).

As with the earth fault element, a long time delay can be chosen to avoid “I2>1 trip” indication in the event file. This time delay is not essential however.

4.4.3. Pick-Up Timer

Should the earth fault element have no stabilizing resistor, a small time delay may be required to account for asymmetric CT saturation during transformer energisation or external faults. A setting of 200ms is typical, although some adjustment may be necessary should a mal-operation occur.

If the earth fault element has a stabilizing resistor then no time delay is required.

4.4.4. Overcurrent Elements I>1 and I>3

Since this relay will see faults either side of the transformer it must be set in-line with usual overcurrent guidelines. For example, the relay can have an IDMT element set to co-ordinate with downstream protection as well as an instantaneous element to detect HV faults.

4.4.5. Time Delayed Earth Fault tripping

In the unlikely event that time delayed tripping is required for earth faults on the feeder (i.e. if no stabilizing resistor is fitted), the "ISEF>1 Start" (DDB #323) signal can be removed and replaced with the "ISEF>1 Trip" signal (DDB #269). The additional PSL timer can either be removed or set to zero, whichever is more convenient. It must be noted, however, that the fault record will indicate an SEF trip as well as the "CEF" trip (i.e. from the renamed user alarm).

5. USING P14X RELAYS WITH EXISTING INTERPOSING TRANSFORMER

In situations where the customer wishes to keep the interposing transformer, the P14x can still be used to provide CEF protection. The following section discusses how this can be achieved.

5.1. CONNECTIONS USING EXISTING INTERPOSING TRANSFORMER

It is assumed that the CEF scheme is replicated using the phase overcurrent and sensitive earth fault elements. The following diagram provides a generic connection diagram for the scheme with terminal numbers omitted. Specific terminal numbers can be obtained from the connection diagrams section of the P14x manual.

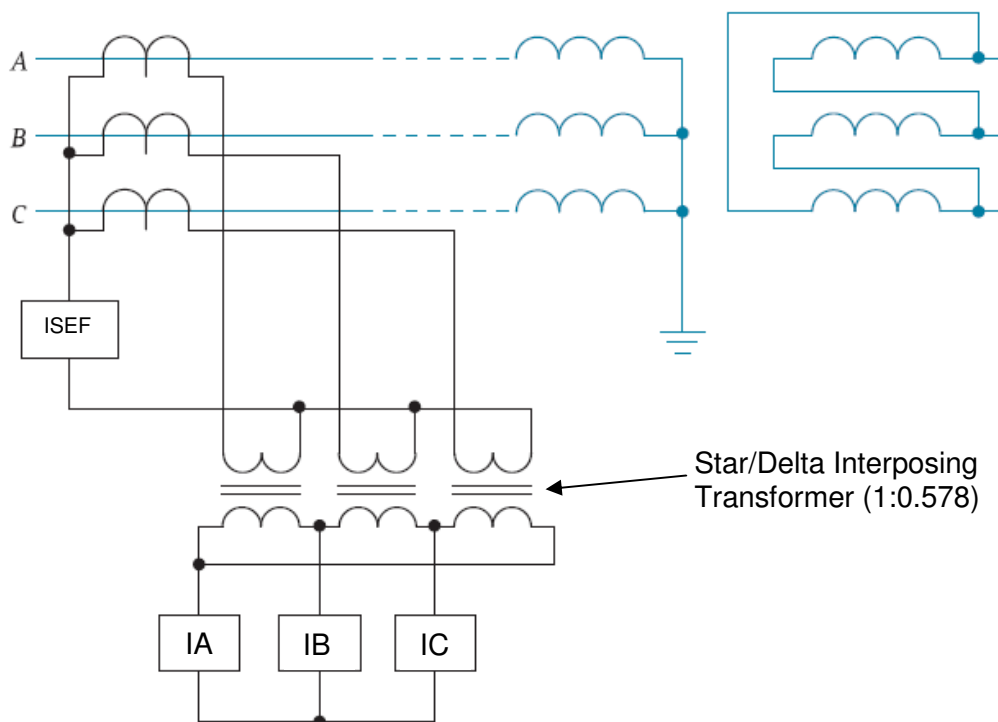


Figure 5.1 – P14x With Existing Interposing Transformer

5.2. SETTING GUIDELINES

Since this relay is a straight swap with the existing protection device all settings should be replicated using the phase overcurrent ($I > 1$) and sensitive earth fault elements ($ISEF > 1$). No other protection functions are required for the scheme. However the standard earth fault element is available as a standby earth fault device if required.

5.3. PROGRAMMABLE SCHEME LOGIC PSL

The following PSL provides the necessary logic to provide CEF assuming the existing interposing transformer remains in use. DDB start signals #295 and #323 act as relays A and B respectively. Tripping occurs when both of these signals are active.

The delayed pick-up timer is included in the event that the earth fault element has no stabilizing resistor and transient CT saturation occurs during transformer energisation. A time delay of 200ms is normally adequate although adjustment may be required if a mal-operation is experienced.

Manual reset user alarm (e.g. DDB #185) can be applied and renamed using the menu text editor to indicate "Compensated EF" or something similar. The overcurrent trip signal DDB#251 is included to provide back-up phase instantaneous overcurrent protection if required.

If the existing relay “B” is IDMT, then a corresponding phase IDMT overcurrent element is required. In this case DDB #295 (I>1 Start) should be replaced by DDB #243 (I>1 Trip) instead. Should this be the case, the delayed pick-up timer can be removed or set to zero, whichever is more convenient. The use of the “I>1 Trip” in the PSL instead of the “start”, will result in an overcurrent trip as well as a CEF trip in the fault record.

NOTE: The following PSL is specific to P14x software version 43 only. Whilst it is possible to replicate this scheme in earlier versions of software, the DDB signals shown are for version 43 only.

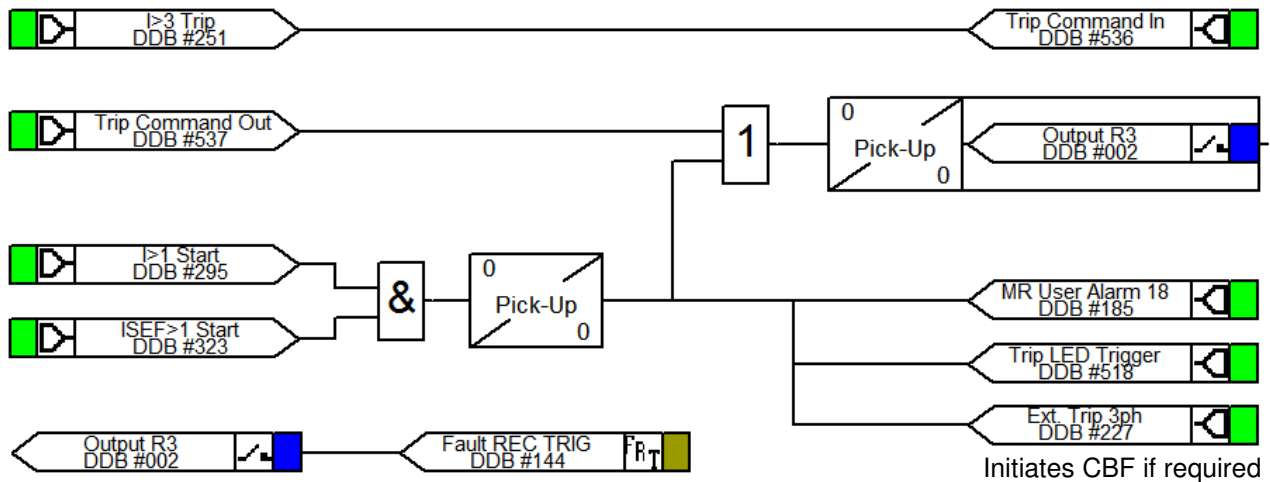


Figure 5.1 – Compensated Earth Fault PSL Using Existing Interposing Transformer

6. CONCLUSIONS

The compensated earthfault protection scheme provides REF protection for a transformer feeder. This is particularly beneficial where the protective relay is remote from the transformer and is advantageous as the scheme does not require a CT to be connected to the star point.

Compensated earthfault protection can be implemented in P14x relays, by utilising the existing protection elements and PSL functionality. Additional transformer and feeder protection may also be provided by the same P14x relay. These additional protections typically include IDMT and instantaneous overcurrent protection together with optional thermal and broken conductor features. Naturally this is a cost effective solution for MV/LV applications.

REVIEW HISTORY

Issue	Name	Position
C	P. Newman	Senior Applications Engineer

VERSION CONTROL

Issue	Author(s)	Reason for change	Date
A	A. Wixon	Original	03/06/10
B	A. Wixon	Use of existing interposing transformer section added	07/06/10
C	A. Wixon	Changed to Alstom format	09/02/12