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Protection
Devices

7SG14 Duobias M

Transformer Protection

Answers for energy

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Technical Manual Chapters

7SG14 Duobias-M

Transformer Protection

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
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2010/02	Document reformat due to rebrand
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Software Revision History

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FIGURES

1 Introduction

The use of current balance biased differential relays for the protection of power system transformers is a well-established practice. The Duobias-M-2xx is a numeric, current balance differential relay for this and similar applications. The relay has a range of additional features with variants to suit a range of differing protection and control practices.

The most basic relay the 200 is almost identical to the existing Modular 1 Duobias-M relay except it is now available with a range of status input and output relay configurations as well as having versions that can take biasing inputs from up to 5 sets of three phase current transformers. This relay includes harmonic restrained biased differential (87T), unrestrained highest differential (87HS) protection as well as Restricted Earth Fault (64REF) protection to suit the UK and overseas markets.

The other basic relay is the 205 which incorporates Current Differential (87T/87HS) protection and 2 stage DTL Overcurrent for phase and earth faults for the Star side of the power transformer and single stage DTL Overcurrent for phase faults on the Delta side of the transformer which is a typical Eastern European and Asian requirement where restricted earth fault is not widely used.

Options include Circuit Breaker Fail Protection, Over Fluxing Volts per Hertz protection, Thermal Overload, IDMTL Phase and Earth, over and under voltage, four stage under frequency, neutral voltage displacement and Residual earth fault.

The fully numerical design has been exploited to provide a unit whose settings, characteristics, and input/output configurations are software controlled which will allow the relay to be used for a wide variety of applications.

With conventional transformer differential relays, in order to obtain correct input currents for various transformer configurations, it is often necessary to specify additional interposing current transformers for ratio balance, phase angle correction and zero sequence (or third harmonic) current removal. With Duobias-M-2xx protection these additional interposing transformers are not required as current transformer star/delta ratio, phase angle correction and zero sequence current removal are determined by the relay's internal settings and algorithm. Current Amplitude correction is also accommodated using Interposing CT multiplier settings. The range of amplitude correction has been increased from 0.5 to 1.5, and is now 0.25 to 3.00 x, which allows the application where non-ideal current transformer ratios are already installed or have been specified.

To prevent the relay operating incorrectly due to magnetising inrush an algorithm is used to recognise even harmonics which inhibit the relay when the even harmonic content of any operating signal is above a set level.

The Duobias-M differential protection has proven stability for onerous system conditions including no load with severe system overvoltage. The relay, by way of its design, has an inherent immunity for conditions where fifth harmonic may be present and will remain stable provided that suitable settings are employed. Fast differential operation is maintained for internal faults.

2 Hardware Description

2.1 General

The structure of the relay is based upon the Modular II hardware and software platform illustrated in Figure 1 & 2 where the required cards plug in from the front after opening the front fascia. Modules are interconnected by means of ribbon cable. The relay is available in standard Epsilon case sizes E8, E12 and E16 depending upon the options required. The Modular II design provides commonality between products and spare parts across a range of protection and control relays including Duobias, Ohmega, Delta, Tau and Iota.

Typical case sizes are:

ANALOGUE INPUTS	STATUS INPUTS	OUTPUT RELAYS	CASE
8	3	5	E8
8	19	21	E12
8	27	29	E16
8	19	21	E12
12	11	13	E12
12	27	29	E16
16	19	21	E16
20	11	13	E16

Each analogue module has four inputs; the first three are for measuring the CT secondary line currents from each of the three phases A, B and C. The fourth input is also normally a current input for restricted earth fault or conventional earth fault applications. However it is possible to specify a voltage input channel for Volts/Hertz, under/over voltage applications. An analogue module with 4 sets of voltage inputs is also available for special applications.

The most basic 2 winding relays can be fitted into an E8 case and consist of the following modules:

1) Two Analogue Input modules (4 x I per module)

2) One Controller CPU module

3) One Power Supply and Basic I/O module

4) One Front Fascia

In the larger case sizes additional Status Input (up to a maximum of 27) and Output Relays (up to a maximum of 29) may be specified. Additionally analogue modules with three current input and one voltage input circuit may be specified for example if over fluxing (V/f) protection is required. This may be in place of an existing module (which would then lose an earth fault input) or may be an additional module as long as the chosen case style can accommodate it.

2.2 Analogue Inputs

Up to 5 analogue modules may be used in the largest case style E16. Each module consists of up to 4 channels of current and/or voltage depending upon the relay model.

In order to ensure high accuracy true RMS measurements and accurate phase and slip frequency calculations, the voltage signals are sampled at a minimum of 8 samples per cycle for both 50Hz and 60Hz system frequencies. This sampling rate also provides high accuracy and waveform storage records

2.3 Status Inputs

The relay can accommodate from 3 to 27 status inputs in total in increments of 8. The user can program the relay to use any status input for any function. A timer is associated with each input and a pickup and drop-off time setting may be applied to each input. Each input may be mapped to any front Fascia LED and/or to any Output Relay contact. This allows the Relay to act as the focal point for alarms for the transformer zone and typically is used to provide local indication of Buchholz Gas, Winding Temperature Alarm etc without having to use additional external flagging elements. The Applications Guide provides details of the connections.

2.4 Output Relays

The relay can accommodate from 5 to 29 output relays in total in increments of 8, all of which are capable of handling circuit breaker tripping duty. All relays are fully user configurable and can be programmed to operate from any or all of the control functions. The three relays on the Power Supply/Basic I/O module have 3 C/O contacts. Additional modules are available with either 8 N/C contacts or 4 N/C and 4 N/O contacts

In their normal mode of operation output relays remain energised for a minimum of 100msec and a maximum dependent on the energising condition duration. If required, however, outputs can be programmed to operate as latching relays. These latched outputs can be reset by either pressing the TEST/RESET button, or by sending an appropriate communications command.

The operation of the contacts can be simply checked by using the Protection Healthy setting on the Output Relay Menu to energise each relay in turn. Do not forget to reset this setting back to its correct value which matches the scheme wiring.

The output relays can be used to operate the trip coils of the circuit breaker directly if the circuit breaker auxiliary contacts are used to break the trip coil current and the contact rating of the relay output contacts is not exceeded for 'make and carry' currents.

With a failed breaker condition the current 'break' may be transferred to the relay output contacts and where this level is above the break rating of the contacts an auxiliary tripping relay with heavy-duty contacts should be utilised.

2.5 Fascia LEDS

In the E8 case there are 16 user programmable LED flag indicators. In the E12 or E16 case style there are 32 LED flag indicators. By opening the front panel it is possible to insert a strip into a slip in pocket, which provides legend information about the meaning of each LED. The legend may be specified when ordering the relay or alternatively the user can create a customized legend. The user can customise which LED is used for which purpose as well as being able to program each LED as being latching or self –resetting.

2.6 Self Monitoring

The relay incorporates a number of self-monitoring features. Each of these features can initiate a controlled reset recovery sequence, which can be used to generate an alarm output. In addition, the Protection Healthy LED will give visual indication.

A watchdog timer continuously monitors the microprocessor. If the software fails to service the watchdog timer the watchdog will time out and cause a reset.

The Output Relay modules are blocked in hardware if the watchdog timer expires.

The memory locations that control the Output Relays are surrounded by guard areas to intercept unintentional access.

Additionally the Output Relay modules incorporate an operational timeout feature which prevents output contacts from being held energised if the microprocessor fails to service them.

The voltage rails are also continuously supervised and the microprocessor is reset if any of the rails falls outside of their working ranges. Any failure is detected in sufficient time so that the micro can be shut down in a safe and controlled manner.

The program memory is supervised by a CRC check which runs continuously to verify its contents.

The data memory is supervised by validation checksums and boundary markers to ensure that sensitive data is not overwritten or corrupted.

2.7 Protection Healthy/Defective

The normally closed contacts of relay 1 are used to signal protection defective, whilst the normally open contacts are used to signal protection healthy. When the DC supply is not applied to the relay or a problem is detected with the operation of the relay then this relay is de-energised and the normally closed contacts make to provide an external alarm. When the relay has DC supply and it has successfully passed its self-checking procedure then the Protection Healthy contacts are made and the Protection Defective contacts are opened.

3 Ordering information

3.1 Catalogue Reference Code

The relay is ordered by reference to a code. An example of a catalogue reference code for a model used to protect transformers in the UK is DU3-201-EC 50. This code can be broken down into four parts.

DU3 The relay is Duobias M 200 series relay built on Modular 2 hardware. (DU2 was Modular 1)

201 This number specifies the relay functions included. The 201 for example is a two winding differential relay with biased differential, differential highset and restricted earth fault for both windings.

EC These two letters specifies the hardware included on a relay model. The first letter “E” specifies the power supply and status (digital) input rating. The second letter “C” specifies the arrangement of output contacts and status inputs. For this DU3-201-EC the relay has 48/110V dc power supply, 19 off - 110V rated status inputs and 21 off - output contacts (3 C/O and 18 N/O).

50 The rated frequency of the power system must also specified, in this case 50Hz for the UK.

The following two tables provide the information with which to specify a Duobias M 200 relay model

3.2 Standard Software Models

The current standard models are given in the table below:-

Cat Ref	S/W Model	CT/VT Inputs	Min Case Size	Diff 87 + 87HS	REF 87REF	3P OC IDMTL/ DTL + INSTL/ DTL 51/50	Derived[1] EF 50N/ 51N	Measured EF 50G/51G	NPS OC 46 2 Stages	CB Fail 50BF 2 Stages	Under/ Over Voltage 27/59 4 Stages	Under/ Over Frequency 81 4 Stages	Overflux IDMTL /DTL 24 1/2 Stages	Thermal Overload 49
DU3-201-**	200-2W	8 / 0	E8	2W	2W									
DU3-204-**	202-2W	8 / 0	E8	2W	1W	2W / 2W	2W / 2W	1W / 1W		2W				
DU3-207-**	207-2W	8 / 0	E8	2W		2W / 2W	2W / 2W	2W / 2W						
DU3-209-**	212-2W	8 / 0	E8	2W	2W				2W					
DU3-220-**	210-2W	7 / 1	E8	2W		2W / 2W	2W	1W			1	1	1/2	1
DU3-221-**	211-2W	7 / 1	E8	2W	1W	2W / 2W	2W				1	1	1/2	1
DU3-223-**	203-2W	8 / 0	E12	2W	2W	2W / 2W	2W			2W				
DU3-301-**	200-3W	12 / 0	E12	3W	3W									
DU3-304-**	202-3W	12 / 0	E12	3W	1W	3W / 3W	3W	2W		3W				
DU3-306-**	206-3W	11 / 1	E12	3W	1W			1W			1	1	1	1
DU3-307-**	207-3W	12 / 0	E12	3W		3W / 3W	3W / 3W	3W						
DU3-320-**	210-3W	11 / 1	E12	3W		3W / 3W	3W	2W			1	1	1	1
DU3-321-**	211-3W	11 / 1	E12	3W	2W	3W / 3W	3W				1	1	1	1
DU3-323-**	203-3W	12 / 0	E12	4W	3W	3W / 3W	3W			3W				
DU3-401-**	200-4W	16 / 0	E12	4W	3W									
DU3-404-**	202-4W	16 / 0	E12	4W	2W	4W / 4W	4W / 4W	2W		4W				
DU3-405-**	204-4W	16 / 0	E16	4W	3W	3W / 3W +sum[3]	3W / 3W +Sum[3]	0 / 1W 2 stages						1
DU3-501-**	200-5W	20 / 0	E16	5W	3W									
DU3-505-**	204-5W	20 / 0	E16	5W	3W	3W / 3W +sum[3]	3W / 3W +Sum[3]	0 / 2W 2 stages						1

Notes:

1. The derived EF is calculated using the phase CT inputs.
2. nW indicates the number of windings that are covered.
3. The over current and earth faults may be summed from two or more sets of CT's to realise a virtual CT position to assist with grading. This is indicated with "+Sum" on the relay model.
4. The relays may be supplied with combinations of features.
5. 207-2W[DU3-207] supersedes 205-2W[DU3-202]
6. 203-2W[DU3-223] supersedes 201-2W[DU3-203]

3.3 Hardware Specification

The two remaining letters (***EC - in our example***) specify the hardware and rating.

The first letter is chosen from the following list:

1ST LETTER	POWER SUPPLY RATING	STATUS INPUT RATING
A	30V dc	30
B	30V dc	48
C	48/110V dc	30
D	48/110V dc	48
E	***48/110V dc***	***110***
F	220V dc	110
G	220V dc	220
H	110V ac	110
I	110V ac	48
J	110V ac	220
K	110V ac	30

The status inputs are generally fed from a dc supply, but ac voltage may also be used subject to confirmation. The peak voltage and pickup/drop off delay must be considered when using the inputs from an ac supply.

The second letter is chosen from the following table:

2ND LETTER	TYPE AND NUMBER OF OUTPUT CONTACTS	NUMBER OF STATUS (DIGITAL) INPUTS
A	3 C/O + 2 NO	3
B	3 C/O + 10 NO	11
C	***3 C/O + 18 NO***	***19***
D	3 C/O + 26 NO	27
E	3 C/O + 2 NO	11
F	3 C/O + 26 NO	11
G	3 C/O + 22 NO + 4 NC	27
H	3 C/O + 10 NO	27
I	3 C/O + 4 NO + 4 NC	19
J	3 C/O + 6 NO + 4NC	19
K	3 C/O + 10 NO	19
L	3 C/O + 34 NO	35
M	3 C/O + 42 NO	43
N	3 C/O + 46 NO+ 4NO	51
O	3 C/O + 6 NO + 20 NO	27

Status inputs are typically used for flag indication of external protection e.g. Bucholz, trip circuit supervision and inputs to scheme logic. The scheme logic that may be user defined is called Reylogic. The relay standard logic uses ReylogiC, and this may be added to or edited if the user wishes.

The mix of additional I/O modules may be different from that above. A new letter designation may be allocated if required.

4 Protection Functions

4.1 Biased Differential (87T)

Figure 3 shows the overall block diagram of the 87T current differential algorithm.

The currents entering and leaving the transformer are measured, taking into account the Power Transformer vector grouping and transformation ratio. Software interposing current transformers can be applied to each set of current inputs to correct for any magnitude and vector mismatch and to remove zero sequence components where necessary.

They are then summed to form an operate signal which is applied to a three part biased differential characteristic on a phase-by-phase basis.

Figure 3 gives a brief overview of the 87T current differential functionality. Three phase currents from up to 5 sets of current transformers are scaled in magnitude and vector group by up to 5 sets of interposing current transformers. The operate and restraint quantities are calculated and fed to the biased differential module, differential high set and magnetising inrush detection modules.

Figure 6 shows the biased differential characteristics.

The first horizontal part of the characteristic (initial setting) takes into account both CT and relay input circuit-measuring errors for normal load levels.

The second sloping part increases the relay setting as the loading on the transformer increases to take into account of the tap changer percentage range under emergency overload and low level through fault conditions.

The third curved part further increases the setting to stabilise the relay when C.T. saturation occurs for heavy through fault.

To avoid mal-operation on energisation because of magnetising inrush/sympathetic inrush condition, the even harmonics are used to inhibit operation and a setting allows for the cross blocking of other phases to be selectable between OFF, Blocking or Restraining.

The blocking type of inrush (CROSS blocking) was developed and used in the first Modular 1 Duobias M. The Reyrolle C21 to 4C21 relays used a restraining method (SUM). With the Duobias M 200 relays it is possible to select either of these methods.

PHASE	**EACH PHASE IS INHIBITED SEPARATELY FROM ITS EVEN HARMONIC CONTENT**
CROSS	any phase detects a magnetising inrush condition all three phases are blocked from operating
SUM	the magnetising inrush current from each phase is summated and compared to each operate current individually

4.1.1 Principle Of Operation

On a conventional Star/Delta power system transformer the protection current transformers are connected in Delta on the primary side and Star on the secondary side. Under normal load and through fault conditions, the currents fed to the primary side of the relay and the currents fed to the secondary side are balanced in magnitude and phase. If a fault occurs in the power transformer, the currents on the primary side and the currents on the secondary side are not balanced and the relay is designed to operate when the difference current between primary and secondary exceeds a proportion of the average through current.

For a transformer differential protection it is necessary to correct the phase relationship and magnitude of the C.T. secondary currents resulting from the arrangement of the primary and secondary power transformer windings. Previously this was accomplished using a complicated combination of interposing C.T.'s and star / delta connections of the current transformer circuits. Duobias-M eliminates this for all applications.

Figure 4 shows the equivalent interposing current transformer connections obtained from the internal vector group compensation settings. Input and output currents are shown in capital and small letters respectively. On the right hand side is the function used to derive the correct phase relationship, at each side are the current vectors to illustrate the change in the phase relationship between the input and corrected vectors. The interposing current transformers have an overall 1:1 ratio; those with Yd transformers use 1:0.577 to achieve the overall 1:1 ratio. Vector group compensation can be applied, independently, to both primary and secondary currents.

In addition, programmable ratio correction C.T.'s are provided with current amplitude multiplier adjustable from 0.25 to 3.0 in 0.01 steps. For example if the secondary line current was 0.5amps at the transformer rating a multiplier setting of 2.0 would be applied to realise a relay current of 1.0amps. The multiplier of 3.0 may be used to advantage if the zone length is long as the burden on the CT can be reduced.

It is only for applications outside these ranges of adjustment that external interposing CT's will be required.

4.1.2 Sequence Of Operation

An analogue to digital converter samples each current waveform simultaneously at set intervals and at each interval the algorithm looks back at the last full cycle worth of data to check for a possible fault condition. Figure 3 illustrates the operating sequence on a three-phase basis for the protection algorithm. The line current samples are combined if necessary to correct for phase and magnitude differences and to remove zero sequence components i.e. the functions normally achieved using external interposing current transformers. Simulating the action of the selected transformer connection does this. The Yd ICT Connection setting will also remove third harmonics from the measurement of differential current. (Figure 4) The vector sum and the scalar sum are used to calculate the differential operate and restraint currents. The even harmonics are detected using a Wedmore filter and compared to a percentage of the operate currents on a per phase basis and if this level is exceeded used to prevent the relay from operating under magnetising inrush conditions.

4.1.3 Characteristic

The numerical technique provides an extremely flexible operate/bias characteristic with variable slopes. In general terms, the relay will operate when the value of

$\left|\vec{I}_1 + \vec{I}_2 + ...\vec{I}_n\right|$ (Vector summation on a phase-by-phase basis)

differential current is greater than a pre-set minimum pickup value and greater than a pre-set proportion of

$\frac{|I_1| + |I_2| + ...|I_n|}{2}$ (Scalar summation on a phase-by-phase basis over 2)

as illustrated in Figure 5.

All settings on the characteristic are under software control and the characteristic has been made flexible to cover the wide range of application encountered in transformer protection.

4.1.4 CT Input Configurations

The Duobias-M comes in Versions for 2 or 3 winding transformers with up to 5 sets of current transformers. The relay is also used to provide differential protection to other circuit types such as reactors, busbar zones, motors, generators and overall generator unit protection.

Figure 7 shows the some typical configurations that may be used. In addition, other configurations are available on request.

The CT and relay connections must be made in the correct manner with regard to current flow.

4.2 Differential High Set (87HS)

This function is sometimes mistakenly thought of as a highest over current function. It is not, as it is an unrestrained differential function and is fundamental to the overall relay design to provide fast tripping for high level internal faults. It is included in the relay for two main reasons.

The first reason is the differential high set function provides a fast trip time for heavy internal faults where transient CT saturation may slow down the biased differential. The second is it is very fast operating, typically under one cycle and therefore limits fault damage for solid short circuits.

The differential high set protection operates when the RMS value of the differential signal I1 –I2 is greater than a pre-set value which can be varied. Note it is always recommended to use this part of the relay. The setting used for this function is included in the calculation for the relay CT requirements.

The differential high set is an integral part of the protection designed to give fast coverage at high internal fault currents with saturated current transformers. It is always recommended to use this feature of the relay.

The high set should be set as low as possible but not less than the maximum 3 phase through fault current and not less than the half the largest peak of magnetising inrush current. A typical setting for a power transformer would be in the 7 x In.

4.3 Trip Circuit Supervision

Status inputs on the Duobias-M-200 relay can be used to supervise trip circuits while the associated circuit breakers (CB) are either open or closed. Since the status inputs can be programmed to operate output contacts and LED’s, alarms can be also generated for each trip circuit independently.

To use the function specify which status inputs are ‘Trip Cct Fail’ inputs in the STATUS INPUT menu and program the same status inputs to be ‘Inverted Inputs’ in the same menu and apply time delays (normally a 400ms delay on pickup) as required for this function.

See the Applications Guide for more details on the trip circuit supervision scheme.

4.4 Circuit Breaker Fail

The Circuit breaker Fail element may be triggered from an internal protection function or an external protection function. It may also be blocked by a status input. When a trip occurs the CB ReTrip Timer and CB BackTrip Timers are started for each phase. When either timer expires, if the current check element in that phase is also operated then a ReTrip or a BackTrip output will be issued. An additional blocking element ensures that the element has a fast reset. This monitors the RMS current level and generates a blocking signal if a switch off condition is detected.

5 Optional Protection Functions

5.1 Restricted Earth Fault (64REF)

It is usual in many parts of the world to supplement differential protection with restricted earth fault protection. This is because of the very sensitive fault detection and high speed of operation that can be achieved. Restricted Earth

Fault is inherently more sensitive than phase differential as the element receives a fault current measurement from the neutral CT, whereas the differential elements do not.

REF is unaffected by transformer magnetising inrush conditions. Many faults either involve earth or quickly develop to include earth and so its use is very beneficial. Figure 8 and Figure 9 shows typical connections to the restricted earth fault elements on the HV and LV side of the relay. As can be seen from the diagrams REF may be fitted to both the STAR (WYE) and DELTA sides of the transformer. If the DELTA side of the transformer includes an in-zone earthing transformer then the REF element is positioned in the parallel connection of the line and neutral C.T.'s. This ensures operation only for the winding where the earth faults exist. Both elements are connected to individual earth fault transformers and have a wide range of current settings. External series resistors are required as shown which effectively converts the elements into voltage operated devices. The stability of the system depends upon the voltage setting being greater than the maximum voltage which can appear across the REF elements under a through fault condition. Each REF element can be individually de-selected if not required. See the applications guide section for further details on the application of REF.

5.2 DTL Overcurrent (50 DTL)

As an option DTL Overcurrent functions can be added to each set of inputs and there may be up to 2 stages with separate pickup and time delays per phase and earth fault. In addition it is possible to locate elements on the summation point of sets of inputs to provide true winding protection even when the CT's are ideally positioned.

5.3 IDMTL Overcurrent (51 IDMTL)

As an option IDMTL Overcurrent functions using IEC or ANSI pick-up curves with definite time or decaying drop-off can be added to each set of inputs. There may be up to 2 stages with separate pickup and time delays per phase and earth fault. In addition it is possible to locate elements on the summation point of sets of inputs to provide true winding protection even when the CT's are ideally positioned.

5.4 Volts per Hertz (ANSI 24T)

The volts per hertz function (V/f) protects the power transformers against overheating due to sustained over voltage or under frequency system conditions that cause excessive flux in the transformer core. An inverse time characteristic is used to match the thermal withstand capability of the transformer, if this is known. Plain dual Definite Time Lag (DTL) elements are used to modify the characteristic for example to take into account of generator arc withstand capabilities or when the transformer capability curve is unknown.

5.5 Thermal Overload (ANSI 49)

This feature provides thermal overload protection for cables and transformers within the relay zone. Thermal protection is used to safeguard against system abnormalities rather than faults (abnormally heavy loads, etc). The temperature of the protected equipment is not measured directly. Instead, thermal overload conditions are detected by calculating the average of the currents flowing in the 3 phase conductors. This average value is fed to the thermal algorithms.

Should the average current rise above a defined level (the Overload Setting – I/O) for a defined time (the operating time t), the system will be tripped to prevent damage.

Time to trip $t(mins) = \tau \times \ln\left\{ \frac{I^2}{I^2 - (I_\theta)^2} \right\}$

Additionally, alarms will be given if:

The average current exceeds the Thermal Overload level (Thermal Overload Alarm). If left at this level the current would result in a thermal overload trip.

The thermal state of the system exceeds a specified percentage of the protected equipment's thermal capacity (Capacity Alarm).

The step rise in the thermal state of the system is greater than a specified percentage of the equipment's thermal capacity (Load Increase Alarm).

The thermal overload feature can be applied to either winding as desired. It is usual to allocate the thermal function to the source side winding.

5.6 Overvoltage (ANSI 59)

Models that include a voltage input provide a definite time overvoltage function that may be used to protect the power transformers against over voltages. Several stages may be specified if required.

5.7 Undervoltage (ANSI 27)

Models that include a voltage input provide a definite time under voltage function. The under voltage element may be guarded by an under voltage blocking element to prevent an under voltage output when the transformer is de-energised.

5.8 Negative Phase Sequence (NPS) Over current (ANSI 46)

Models that include a NPS over current function have both alarm DTL and a trip DTL/IDMTL stages with separate pickup settings.

6 Other Features

6.1 Metering

The Duobias-M metering feature provides real-time data available from the relay fascia in the 'Instruments Mode' or via the communications interface.

The following displays are available:

RMS Line Currents for A, B, C for each set of three phase current inputs

RMS Relay Current for A, B, C for each set of currents after interposing CT corrections and multipliers are applied.

RMS Operate Currents A, B, C for the differential characteristic.

RMS Restrain Current A, B, C for the differential characteristic.

RMS Magnetising Inrush (Even Harmonic) Currents A, B, C for the differential characteristic.

RMS Earth Fault or Restricted Earth Fault Current if this function is present.

Digital input status

Output relay status

Time and Date

Other real time measurements are included when optional protection functions are specified.

6.2 Data Storage

6.2.1 General

Details of relay operation are recorded in three forms, namely Waveform records, Event records and Fault Data records. All records are time and date stamped with a resolution of one millisecond.

6.2.2 Time Synchronisation

Time and date can be set either via the relay fascia using appropriate commands in the System Config menu or via an IRIG-B input or via the communications interface

6.2.3 IRIG-B Time Synchronisation

A BNC connector on the relay rear provides an isolated IRIG-B GPS time synchronisation port. One IRIG-B source may be connected to several devices in a chain using co-ax cable and BNC T-pieces. The IRIG-B input has a 4k-ohm impedance and expects a modulated 3-6 Volt signal to provide time synchronisation to the nearest millisecond. Some IRIG-B sources output voltages above this level and may require an external terminating resistor to be added to the last relay in the chain to match the output drive requirements of the IRIG-B source, typically 50 or 75 ohms.

6.2.4 IEC 60870-5-103 Time Synchronisation

Relays connected individually or in a ring or star configuration can be directly time synchronised using the IEC 60870-5-103 global time synchronisation. This can be from a dedicated substation automation system or from Reydisp Evolution Communications Support Software.

6.2.5 Real Time Clock Time Synchronisation

In the absence of IRIG-B and IEC60870 time synchronisation the relay contains a year 2000 compatible real time clock circuit which maintains real time in the absence of DC supply (See Note).

6.2.6 Waveform Records.

The waveform record feature stores analogue and digital information for the current inputs, status inputs and output relays and LED's. Internal waveforms from the operate, restraint and magnetising inrush currents for each phase are also stored for post fault diagnostics. Waveforms may be returned to VA TECH Reyrolle ACP Ltd for analysis.

The waveforms are stored with a sampling resolution of at least 8 samples per cycle depending upon relay model. The waveform recorder has the ability to store records for the previous five trip operations of the relay. These are labelled 1-5 with 1 being the most recent record. This however, can be altered using the 'Record Duration' setting, which offers the following selection:

- Five records of one second duration[1]
- Two records of two seconds duration
- One record of five seconds duration

1 –Fewer records may be available on 3W, 4W & 5W models because of the increased memory requirements.

The waveform recorder will be triggered automatically when any protection element operates. It can also be triggered by any of the following means :

Via the 'Trigger Storage" status input signal.

Via the IEC870-5-103 communications interface.

The waveform recorder has a settable pre-fault triggering capability.

6.2.7 Event Records

The event recorder feature allows the time tagging of any change of state (Event) of the relay. As an event occurs the actual event condition is logged as a record along with a time and date stamp to a resolution of 1 millisecond. There is capacity for a maximum of 500 event records that can be stored in the relay and when the event buffer is full any new record will over-write the oldest. The following events are logged:

Change of state of Output Relays.

Change of state of Status Inputs.

Change of state of any of the control functions of the relay.

Pick-up or operation of any of the protection functions.

6.2.8 Fault Recording

The led flag configuration, date and time of the last five faults are recorded for display via the Fascia LCD.

Note : the real-time clock, waveform records and event records are all maintained, in the event of loss of auxiliary d.c. supply voltage, by the backup storage capacitor. This capacitor has the ability to maintain the charges on the real-time clock IC and the SRAM memory device for typically 2-3 weeks time duration. This time, however, is influenced by factors such as temperature and the age of the capacitor and could be shorter. This overcomes the need for data storage back-up internal battery.

6.3 Communications

Two ST type fibre optic communication ports, COM1 and COM 2b are provided at the rear of the relay, which give superior EMC performance. An isolated RS232 port, COM 2a is provided at the front of the relay for local access using a PC.

Communication is compatible with the IEC870-5-103 FT 1.2 transmission and application standards. For communication with the relay via a PC (personal computer) a user-friendly software package, REYDISP EVOLUTION [1], is available to allow transfer of the following:

Relay Settings

Waveform Records

Event Records

Fault Data Records

Instrument and meters

Control Functions

Communications operation is described in detail in Section 4 of this manual. For information about all aspects of the communications protocol used in the Duobias-M range of relays see [2].

The use of Reydisp Evolution assists greatly when commissioning Duobias M transformer protection schemes.

6.4 Settings Groups

Depending up on the relay model then up to four alternative setting groups are provided, making it possible to edit one group while the relay protection algorithms operate using another ‘active’ group. An indication of which group is being viewed is given by the ‘Gn’ character in the top left of the display. Settings that do not indicate Gn in the top left corner of the LCD are common to all groups.

A change of group can be achieved either locally at the relay fascia or remotely via a communication interface command.

The programmable password feature enables the user to enter a 4 character alphanumeric code to secure access to the relay settings. The relay is supplied with the password set to ‘NONE’, which means that the password feature is not activated. The password must be entered twice as a security measure against accident changes. Once a password has been entered then it will be required thereafter to change settings. It can, however, be de-activated by using the password to gain access and by resetting it back to ‘NONE’. Again this must be entered twice to de-activate the security system.

As soon as the user attempts to change a setting the password is requested before any setting alterations are allowed. Once the password has been validated, the user is ‘logged on’ and any further changes can be made without re-entering the password. If no more changes are made within 1 hour then the user will automatically be ‘logged off’, re-enabling the password feature.

Note that the password validation screen also displays a numerical code. If the password is lost or forgotten, this code should be communicated to VA TECH Reyrolle ACP Ltd and the password can be retrieved.

If the code is 1966067850 then 4 spaces have been entered as the password. This is caused by ENTER being pressed three times on the Change Password setting screen. De-activate password by typing ‘NONE’ as described above and pressing ENTER, if this was set un-intentionally.

7 User Interface

The user interface is designed to provide a user-friendly method of entering settings and retrieving data from the relay. The relay fascia includes a 20 character by 2 line, backlit, liquid crystal display (LCD), 16 (E8), or 32 (E12) light emitting diodes (LED) and 5 push buttons.

7.1 Liquid Crystal Display

The liquid crystal display is used to present settings, instrumentation and close data in a textual format on a 2 lines by 20-character interface.

7.2 Back light Control

To conserve power the display backlighting is turned off if no push buttons are pressed for 5 minutes. After an hour the whole display is de-activated. A setting within the “SYSTEM CONFIG MENU” allows the timeout to be adjusted from 5 minutes up to “ALWAYS ON”.

7.3 LED Indications

The following indications are provided:

Protection Healthy – Green LED.

This LED is solidly illuminated to indicate that DC volts have been applied to the relay and that the relay is operating correctly. If the internal relay watchdog detects a protection relay unhealthy condition then this LED will continuously flash.

Programmable – Red LED.

An LED MENU is provided to steer any output to any LED.

7.4 Keypad

Five pushbuttons are used to control the functions of the relay. They are labelled ⇧ ⇩ ⇨ ENTER and CANCEL. Note that the ⇨ button is also labelled TEST/RESET.

When the relay front cover is in place only the □ and □ buttons are accessible. This allows only read access to all the menu displays.

⇧⇩ ⇨

7.5 Relay Identifier

The Relay Identifier setting in the SYSTEM CONFIG MENU may be used to place a circuit identifier onto the relay fascia e.g. BOLDON SGT1. This information is also returned as part of the System Information command from Reydisp Evolution Communications Support Software.

7.6 Settings Mode

7.6.1 Settings Adjustment

The push-buttons on the fascia are used to display the relay settings, display the operating signals, e.g. currents, on the LCD and to reset the fault records and flag indication on the LCDs. There are five push-buttons marked read-up, read-down, enter, cancel, and right/test/reset only two of which are accessible when the relay cover is on, namely read-down and right/rest/reset.

⇩ READ DOWN / DECREMENT

In the Settings Display this push-button is used for scrolling down through a list of settings or signals.

In Settings Modification mode it is used for selecting the next value of (or decreasing) the displayed setting or for deselecting a bit position in a particular control setting.

⇧ READ UP /INCREMENT

In Settings Display or Signal Displays this push-button is used for scrolling back up through a list of settings or signals.

In Settings Modification mode it is used for selecting the previous value of (or increasing) the displayed setting or for selecting a bit position in a particular control setting.

ENTER

This push-button is used when the cover is removed to select between two modes of operation namely Settings Display or Settings Modification.

When this push-button is pressed and a relay setting is being displayed part of the display will flash to indicate that the setting being displayed can be modified by using the ⇧ INCREMENT or ⇩DECREMENT keys on the fascia.

When the required value of the setting has been established may be entered into the relay and acted upon by pressing the **ENTER** key again.

CANCEL

This push-button is used when the cover is removed to return the relay display to its initial status. It can be used to reject any alterations to the setting being modified provided the ENTER key has not been pressed to accept the changes.

TEST/RESET

This push-button is used to reset the fault indication on the LEDs on the fascia It also acts as a lamp test button because when pressed all of the LEDs will momentarily light up to indicate their correct operation.

The ⇩READ DOWN and ⇧ READ UP push-buttons may then be used to scroll through the various signals.

7.6.2 Settings And Displays

The display menu structure is shown in Figure 5. This diagram shows the three main modes of display, which are the Settings Mode, Instruments Mode and the Fault Data Mode.

When the relay is first energised the user is presented with the following message,

SETTINGS DEFAULTED PRESS ENTER

This shows that the relay has been set with the standard factory default settings and must be loaded with the correct settings for the application. If this message is displayed ENTER must be pressed to acknowledge this initial condition, the display will then indicate the relay software variant. e.g.

DUOBIAS-M-200-2W

Pressing the ⇨ TEST/RESET key on this display initiates an LED test. Pressing ⇩READ DOWN at this display allows access to the three display modes, which are accessed in turn by pressing the ⇨ TEST/RESET key.

The Settings Mode contains 11 setting sub-menu's. These hold all of the programmable settings of the relay in separate logical groups. The sub menus are accessed by pressing the key. This enters the sub menu and presents a list of all the settings within that sub menu. Pressing ⇩READ DOWN scrolls through the settings until after the last setting in the group the next sub menu is presented. Access to this group is via the same method as before. If a particular sub menu is not required to be viewed then pressing ⇩READ DOWN will skip past that particular menu and present the next one in the list. Note that all screens can be viewed even if the password is not known. The password only protects against unauthorised changes to settings.

While viewing an editable screen pressing the ENTER key allows the user to change the displayed data. A flashing character(s) will indicate the editable field. Pressing ⇧ INCREMENT or ⇩DECREMENT scrolls through the available setting values or, pressing ⇨ TEST/RESET moves right through the edit fields. Note that all settings can be incremented or decremented using the ⇧ INCREMENT or ⇩DECREMENT keys and they all wraparound so that to go from a setting minimum value to the maximum value it is quicker to press the ⇩DECREMENT key, rather than scroll through every setting. Also, to facilitate quicker setting changes an acceleration feature is available which if ⇧ INCREMENT or ⇩ DECREMENT are depressed and held, then the rate of scrolling through the setting values increases.

If ESCAPE/CANCEL is pressed during a setting change operation the original setting value is restored and the display is returned to the normal view mode.

If changes are made to the setting value then pressing ENTER disables the flashing character mode and displays the new setting value. This is immediately stored in non-volatile memory.

The next sections give a description of each setting in the relay. The actual setting ranges and default values can be found in the Relay Settings section of this manual.

7.7 Instruments Mode

In Instrument Mode metering points can be displayed to aid with commissioning, the following meters are available

METER	DESCRIPTION
xx Line Currents	Currents entering the rear terminals of the relay
xx Relay Currents	Currents presented to the Current Differential elements after interposing CT vector group and magnitude correction
Operate Currents	Current Differential element operate spill currents which should be a low value unless a fault exists within the protected zone or the interposing CT vector group or magnitude correction settings have been incorrectly set
Restrain Currents	Current Differential element through fault restrain currents which are a measure of the loading on the transformer
Mag Inrush Currents	A measure of the even harmonics in the operate current
Status Inputs	The state of the DC status inputs
Output Relays	The state of the Output Relay contacts
Date and Time	Date & Time

Note that meters are usually displayed as multiples of nominal

i.e. x In, 1 Amp or 5 Amp.

7.7.1 Hidden Instruments

At the “Instruments Mode” title screen, pressing ENTER and DOWN simultaneously reveals some additional metering for calibration purposes. The reference channels as well as DC offsets may be displayed along with the RMS values in raw ADC counts. The relationship between current and ADC counts is 1 x In = 600 counts.

7.8 Fault Data Mode

In Fault Data Mode, the time and date of relay operations are recorded together with a record of the LED flag states.

8 Diagrams

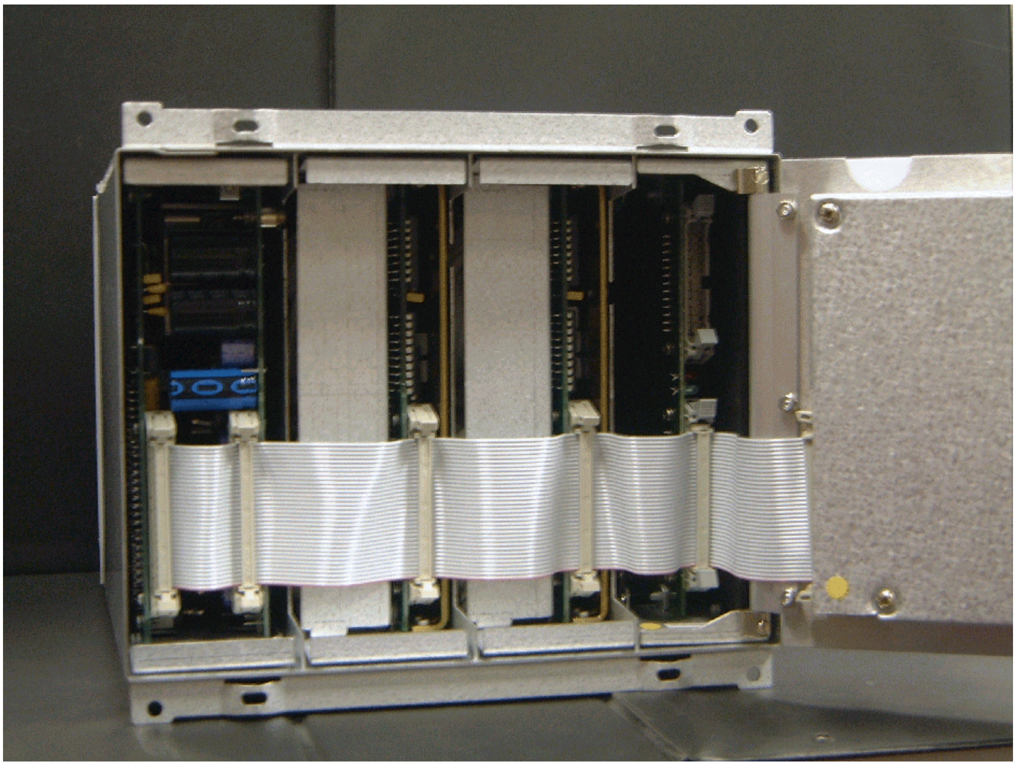


Figure 1 - Duobias-M in E8 case with front panel open

Figure 2 - Duobias-M Rear View

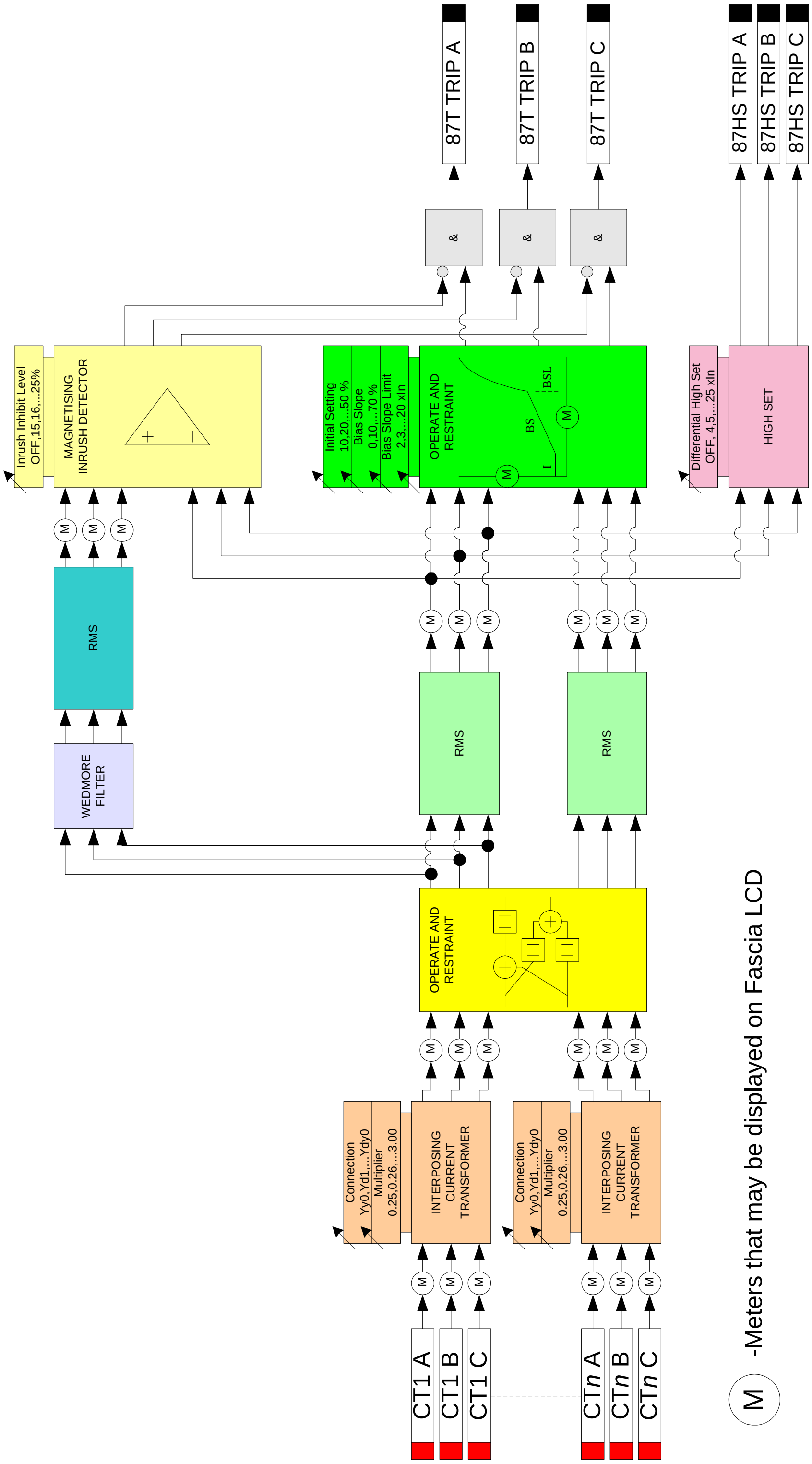
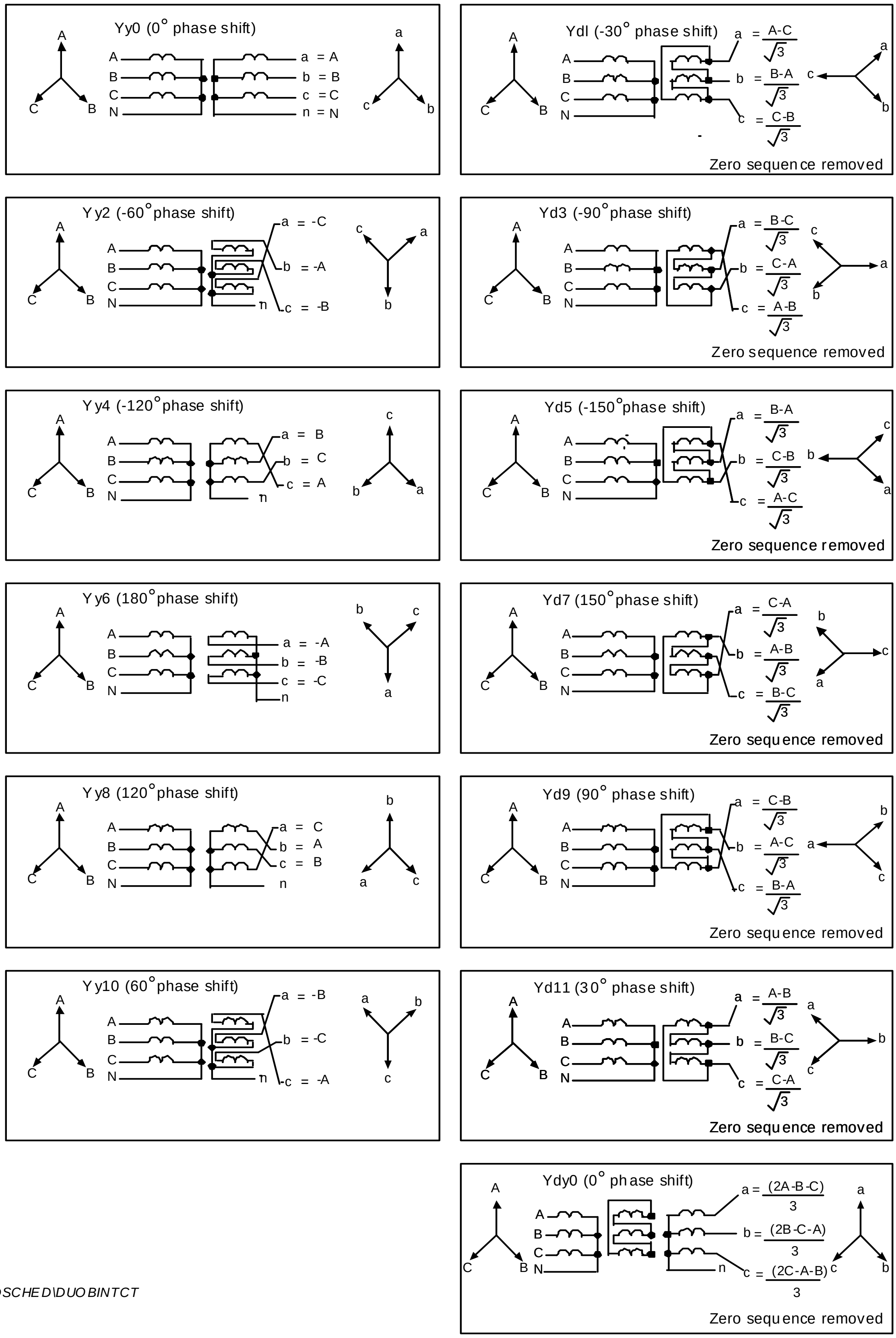


Figure 3 - Duobias-M Current Differential Algorithm



H\ORDSCHED\DUOBINTCT

Figure 4 - Duobias-M Interposing CT arrangements

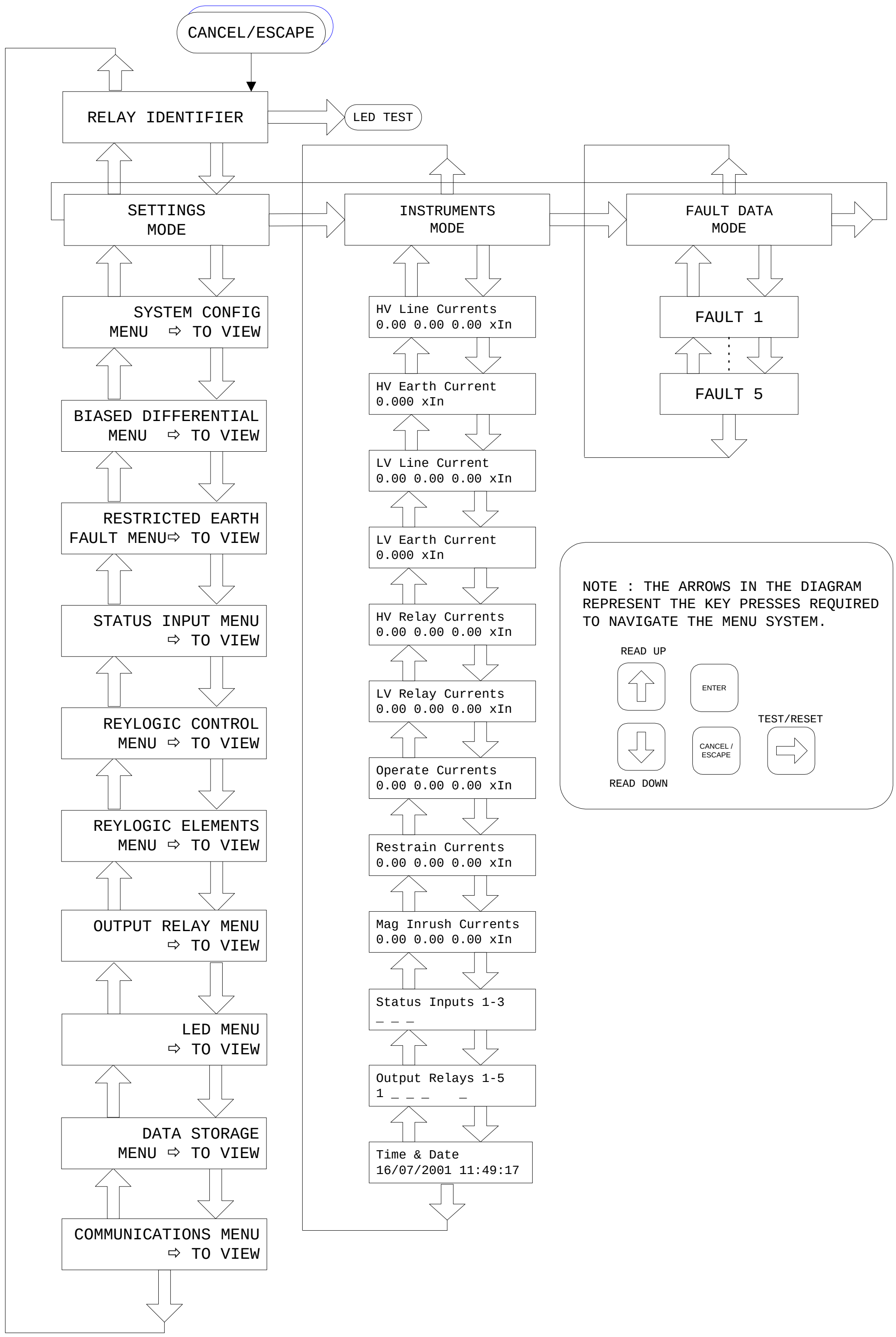


Figure 5 - Duobias-M Menu Structure

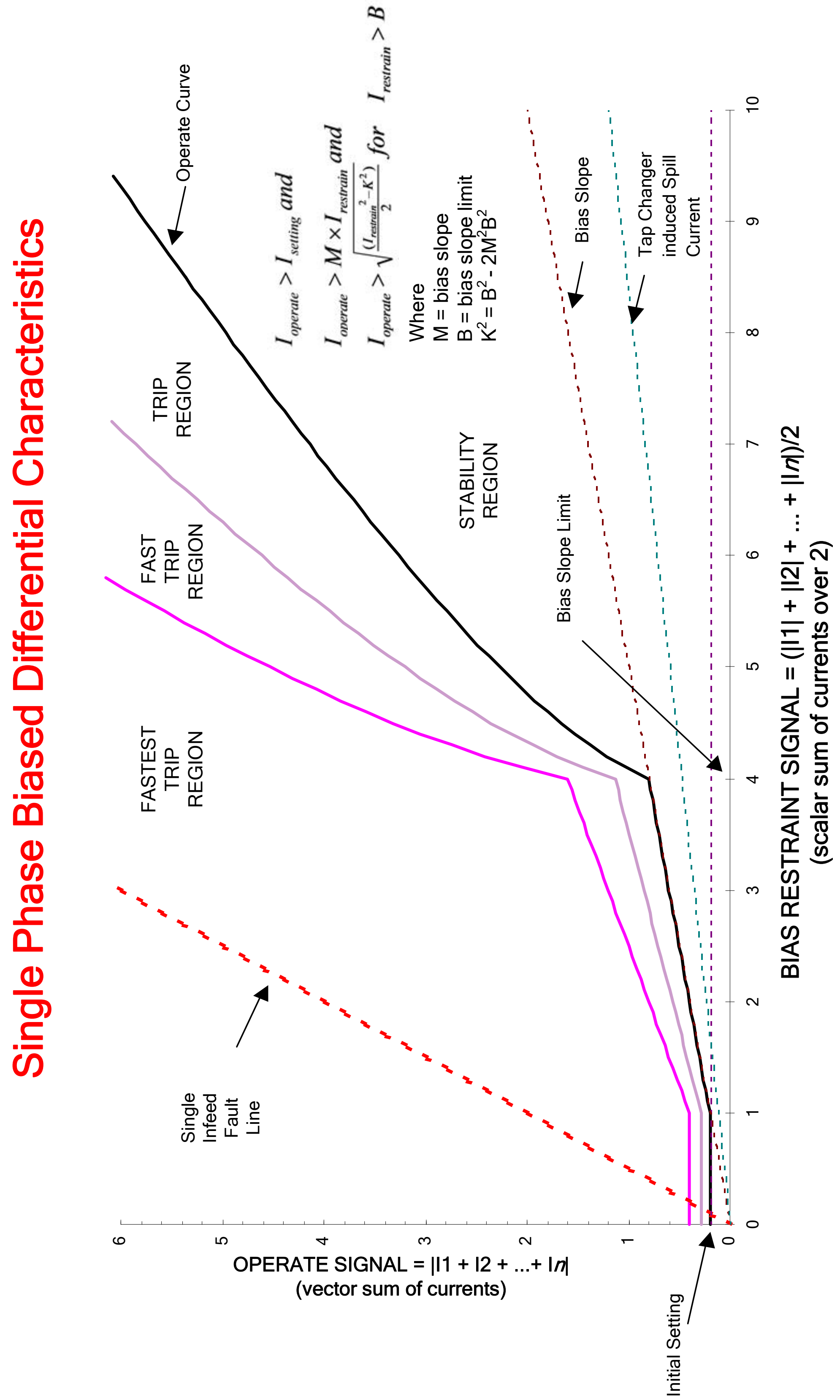


Figure 6 - Duobias-M Biased Differential Characteristics

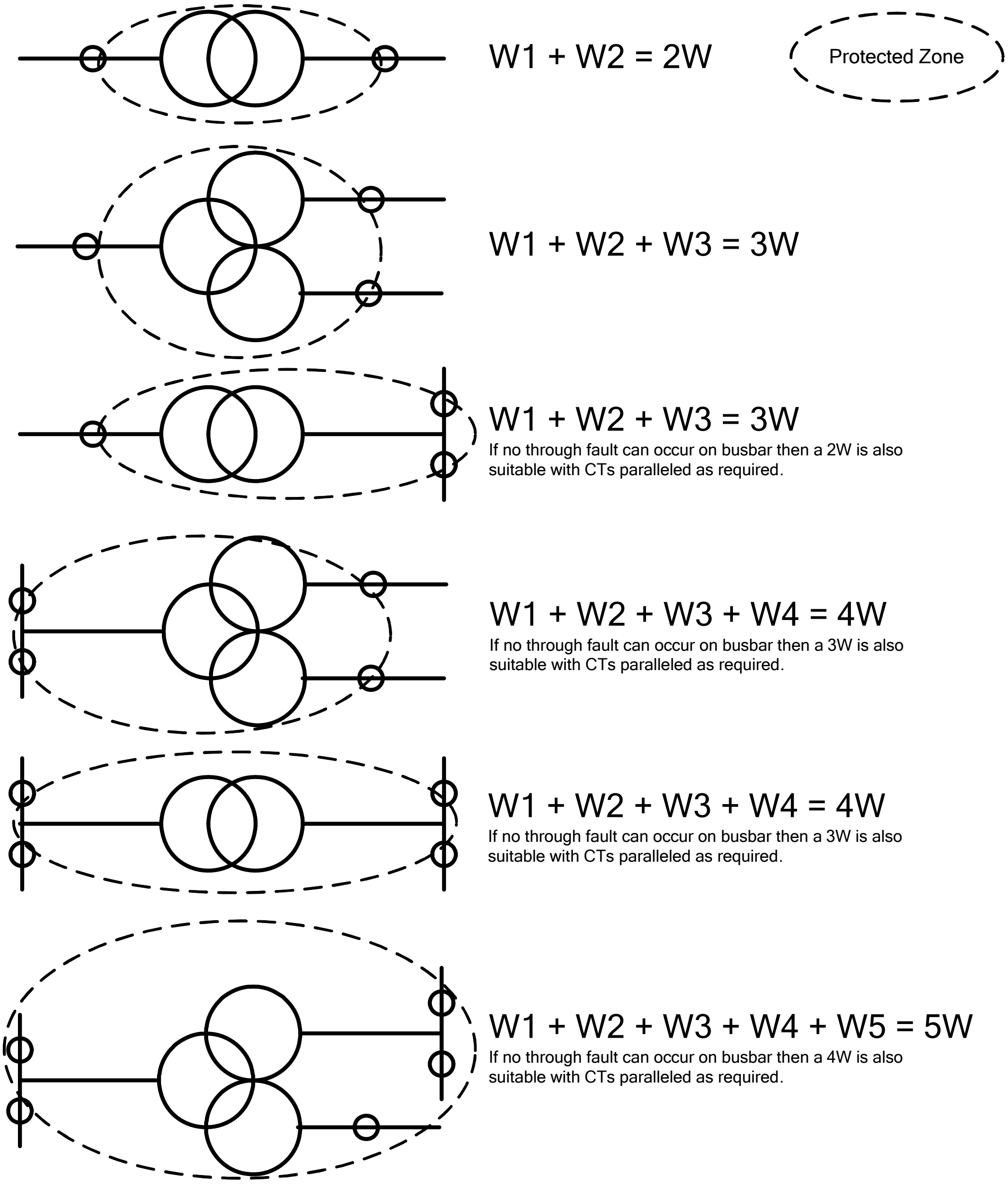


Figure 7 - Duobias-M Basic Transformer Configurations

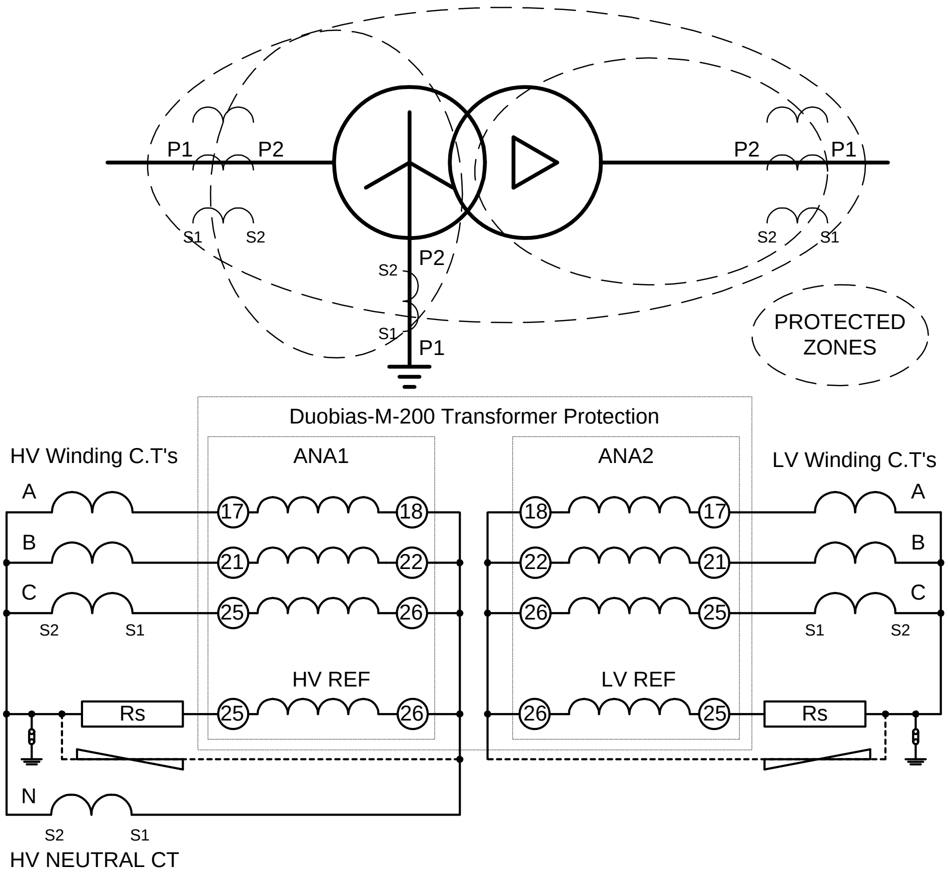


Figure 8 - Yd11 Connection Diagram

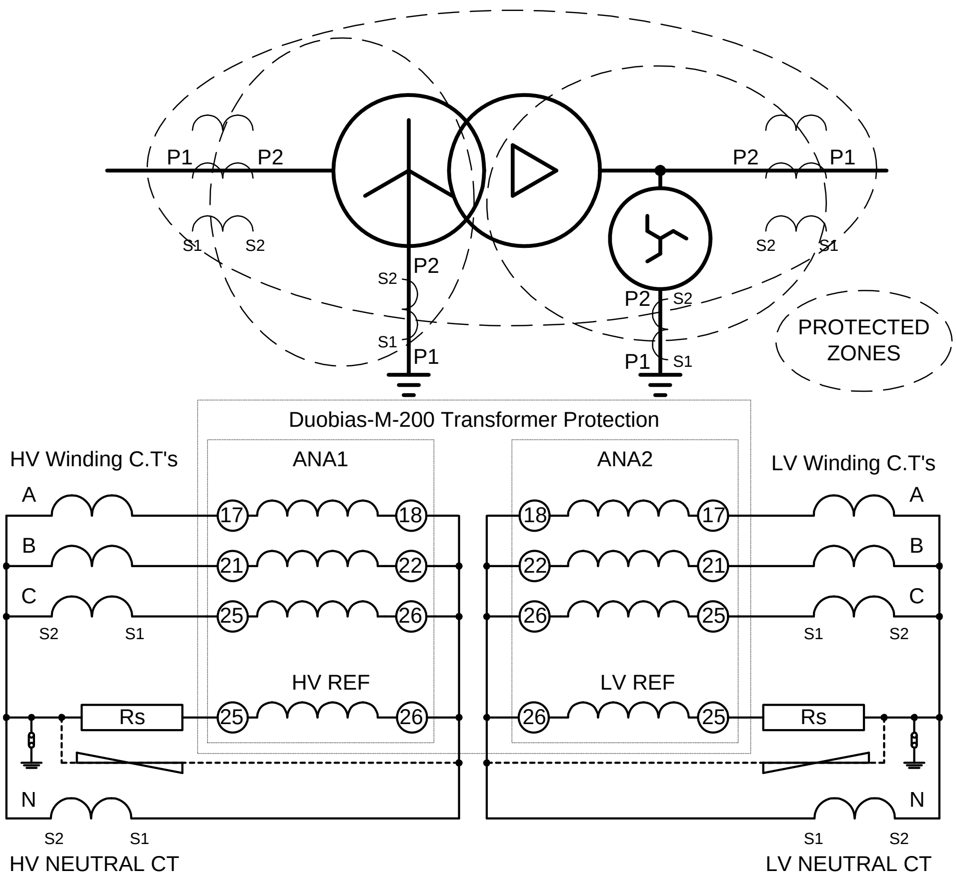


Figure 9 - Yd11 + Earthing Transformer

7SG14 Duobias-M

Transformer Protection

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
Pre release

2010/02	Document reformat due to rebrand
R3 27/09/2006	CT requirements moved to application guide
R2 03/05/2005	Corrected third part bias equation.
R1 14/11/2002	Revision History Added. VT burden added

Software Revision History

Contents

1 Introduction

The following document defines the technical and performance specification of the Duobias-M-200 series of relays. Optional features are described in section 10. The relays employ a modular construction with all modules withdrawable from the front without having to disturb rear terminal wiring. Three case sizes are available E8, E12 and E16 dependent upon the number of inputs and outputs ordered. The relay utilises proven techniques with over fifty years of operational experience in transformer differential protections C21 Monobias, 2C21 & 4C21 Duobias and Duobias-M.

Performance Data to:

IEC60255-6, IEC60255-6A and IEC60255-13.

2 Technical Specification

2.1 Rated Current

1 Amp and 5 Amp current inputs are both available on the rear terminal blocks.

2.2 Rated Frequency

Two operating frequencies are available

Frequency: 50Hz or 60Hz

2.3 87 Biased Differential

The relay operates when:-

$$I_{operate} > I_{setting} \ and$$

$$I_{operate} > M \times I_{restrain} \ and$$

$$I_{operate} > \sqrt{\frac{(I_{restrain}{}^2 - K^2)}{2}} \ for \quad I_{restrain} > B$$

Where

M = bias slope

B = bias slope limit

$K^2 = B^2 - 2M^2B^2$

Two winding transformer

$$I_{operate} = \left|\vec{I}_1 + \vec{I}_2\right|$$

$$I_{restrain} = \frac{\left|\vec{I}_1\right| + \left|\vec{I}_2\right|}{2}$$

Three winding transformer

$$I_{operate} = \left|\vec{I}_1 + \vec{I}_2 + \vec{I}_3\right|$$

$$I_{restrain} = \frac{\left|\vec{I}_1\right| + \left|\vec{I}_2\right| + \left|\vec{I}_3\right|}{2}$$

Four winding transformer

$$I_{operate} = \left|\vec{I}_1 + \vec{I}_2 + \vec{I}_3 + \vec{I}_4\right|$$

$$I_{restrain} = \frac{\left|\vec{I}_1\right| + \left|\vec{I}_2\right| + \left|\vec{I}_3\right| + \left|\vec{I}_4\right|}{2}$$

Five winding transformer

$$I_{operate} = \left|\vec{I}_1 + \vec{I}_2 + \vec{I}_3 + \vec{I}_4 + \vec{I}_5\right|$$

$$I_{restrain} = \frac{\left|\vec{I}_1\right| + \left|\vec{I}_2\right| + \left|\vec{I}_3\right| + \left|\vec{I}_4\right| + \left|\vec{I}_5\right|}{2}$$

2.3.1 Stability

Under through fault conditions the protection will be stable with fault current equivalent to 50 x In and with tap change unbalance of 0% to 35% according to the differential bias slope setting in use.

2.3.2 CT Requirements

See application guide for details.

3 Indication

There are 16 red LEDs in the E8 case size. There are 32 red LEDs in the E12 and E16 case sizes. These are fully configurable to the user.

Adjacent to each column of LED's is a removable strip on which the LED function can be printed or written on to allow comprehensive fault indication. The strips are removed by opening the front fascia door, and are located at the top right hand side. It is possible to print the indicator strip in different languages other than English. The LCD provides further fault indication and can be used for programming the relay. All indications are stored in non-volatile memory without the use of an internal backup battery.

4 Settings and configuration

Settings changes may be done via the front panel user-friendly fascia keypad and LCD or via standard Reydisp Evolution windows software either locally or remotely. Settings changes are stored in EEPROM memory. Configuration changes may be achieved locally via the front serial port with a Windows based toolbox support package. Configuration changes and software upgrades are stored in Flash EPROM memory.

5 Recording

Up to 5 fault records may be stored within the relay and are accessible via the front panel showing the date and time of trips. New faults automatically overwrite the oldest fault record when they occur.

Up to 5 waveform records each of 1-second duration may be stored within the relay. The waveform records are automatically stored whenever a trip is generated. Waveform recording can also be triggered by the status inputs. New waveform records automatically overwrite the oldest waveform record when they are triggered.

Up to 500 time tagged event records are stored within the relay. New events automatically overwrite the oldest event record when the 500 are used up.

6 Communications

IEC 60870-5-103 communications is standard at no additional cost on most of Reyrolle's numerical product range. IEC 60870-5-103 has the advantage of built in time synchronisation of all devices, reduced communications overhead, high data security and compatibility with all of the major substation automation and control systems. COM1 is a dedicated rear fibre optic serial port. COM2 can be auto-switched between rear fibre optic serial port and a front isolated RS232 serial port. All fibre optic ports can be star connected to a Sigma passive hub or simply daisy-chained in a loop-in loop-out configuration with other Reyrolle relays e.g. Argus, Delta, Ohmega, Tau. Up to 254 relays maybe connected to a Sigma network server to provide relay access over an Ethernet local area network (LAN).

7 IRIG-B Time Synchronisation

The relay incorporates an IRIG-B time synchronisation port as standard for connection to a GPS time receiver such as that manufactured by TrueTime. The input accepts an a.c. modulated input signal that should be in the range 3Vp-p or 6Vp-p.

8 Output contacts

As with the indication the output contacts are fully programmable the basic I/O module has 5 output contacts three of which are change over. Additional modules can be added with consequential increase in case size, to provide more contacts. These are added in-groups of eight up to a maximum of 29

9 Status inputs

As with the indication and output contacts the status inputs are fully programmable the basic I/O module has 3 status inputs these can be set to high speed for signalling. Additional modules can be added to provide more inputs. These are added in-groups of eight up to a maximum of 27. A pickup timer is associated with each input. Also each input may be individually inverted where necessary.

10 Optional Features

10.1 87REF Restricted Earth Fault

High impedance restricted earth fault scheme using external stabilizing resistors. Function is insensitive to third harmonic currents.

10.2 50 Overcurrent, N-Derived Earth Fault, G-Measured Earth Fault

Basic instantaneous overcurrent element with following time delay. May be applied to phase currents, derived earth fault or measured earth fault currents. Some models allow this element to be applied to the sum of the currents from two sets of current transformers where overcurrent is required for a transformer winding but the current transformers are not ideally placed.

10.3 51 IDMTL Overcurrent, N-Derived Earth Fault, G-Measured Earth Fault

Inverse time overcurrent element. May be applied to phase currents, derived earth fault or measured earth fault currents. Some models allow this element to be applied to the sum of the currents from two sets of current transformers where overcurrent is required for a transformer winding but the current transformers are not ideally placed.

CHARACTERISTIC	RANGES
IEC IDMTL CURVES	Operate times are calculated from: $t = Tm \times \left[\frac{K}{\left[\frac{I}{I_s}\right]^{\alpha} - 1} \right]$ I = fault current I_s = current setting Tm = time multiplier NI: K = 0.14, α = 0.02 VI: K = 13.5, α = 1.0 EI: K = 80.0, α = 2.0 LTI: K = 120.0, α = 1.0
Time Multiplier	0.025 to 1.600 Δ 0.025 sec
Reset	0.0 to 60.0 Δ 1.0 sec
ANSI IDMTL CURVES	Operate times are calculated from: $t = M \times \left[\frac{A}{\left[\frac{I}{I_s}\right]^{P} - 1} + B \right]$ I = fault current I_s = current setting M = time multiplier MI: A = 0.0515, B = 0.114, P = 0.02 VI: A = 19.61, B = 0.491, P = 2.0 EI: A = 28.2, B = 0.1217, P = 2.0
ANSI RESET CURVES	Operate times are calculated from: $t = M \times \left[\frac{R}{\left[\frac{I}{I_s}\right]^{2} - 1} \right]$ I = fault current I_s = current setting M = time multiplier MI: R = 4.85 VI: R = 21.6 EI: R = 29.1

10.4 49T Thermal Overload

CHARACTERISTIC	RANGES
THERMAL IEC 60255-8	Operate times are calculated from: $t = \tau \times \ln \left\{ \frac{I^2 - I_P^2}{I^2 - (K.I_n)^2} \right\}$ τ = thermal time constant I = measured current I_P = prior current I_n = current rating K = constant
K Factor	0.1 to 10.0 Δ 0.1 x In
τ Factor	1.0 to 1000.0 Δ 0.5 mins

10.5 27/59 Under/Over Voltage

Instantaneous element with following time delay. Some models have a single voltage input with an option for three phase voltage measurment. Upto 4 stages may be included, each of which can be set to over or under voltage operation. Each of which may be selectively blocked from operating by a separately set under voltage element to prevent operation when CB opens.

10.6 24DT Definite Time Overfluxing (V/f)

Instantaneous element with following time delay. Some models have a single voltage input with an option for three phase voltage measurment.

10.7 24IT Inverse Time Overfluxing (V/f)

Inverse time element specified using seven user defined points on a curve. Some models have a single voltage input with an option for three phase voltage measurement.

10.8 81 Under/Over Frequency

Instantaneous element with following time delay. Some models have upto 4 stages, each of which can be set to over or under frequency. Each of which may be selectively blocked from operating by a separately set under voltage element to prevent operation when CB opens.

11 Performance Specification

Throughout the performance specification accuracy statements are made at reference conditions. These reference conditions are as follows:

11.1 Accuracy Reference Conditions

GENERAL	IEC60255 PARTS 6, 6A & 13
Auxiliary Supply	Nominal
Frequency	50/60Hz
Ambient Temperature	20°C
Initial Setting	Any Setting
Bias Slope	Any Setting
High Set	Any Setting
Restricted Earth Fault	Any Setting
Magnetizing Inrush	Any Setting
Current Amplitude Correction	1.00
Vector Group Compensation	Yy0,0º

11.2 Accuracy

11.2.1 87 Biased Differential

INITIAL SETTING	± 5% OF SETTING OR ± 0.01 I_N
Bias Slope	± 10% of bias slope setting
Reset	□ 90% of I_s
Repeatability	± 2%
Transient Overreach	□ 5%

11.2.2 87HS Differential Highset

PICKUP	± 5% OF SETTING
Reset	□ 95% of I_s
Repeatability	± 2%
Transient Overreach	□5%

11.2.3 87REF Restricted Earth Fault

PICKUP	± 5% OF SETTING OR ± 0.01 I_N
Reset	□ 95% of I_s
Repeatability	± 2%
Transient Overreach	□5%

11.2.4 50 DTL Overcurrent

PICKUP	± 5% OF SETTING OR ± 0.01 I_N
Reset	□ 95% of I_s
Repeatability	± 2%
Operate Time	± 1% or ± 10ms

11.2.5 50N DTL Derived Earth Fault

PICKUP	± 5% OF SETTING OR ± 0.02 I_N
Reset	□ 95% of I_s
Repeatability	± 2%
Transient Overreach	□5%

11.2.6 50G DTL Measured Earth Fault

PICKUP	± 5% OF SETTING OR ± 0.01 I_N
Reset	□ 95% of I_s
Repeatability	± 2%
Transient Overreach	□5%

11.2.7 51 IDMTL Overcurrent

PICKUP	± 5% OF SETTING OR ± 0.01 I_N
Reset	□ 95% of I_s
Repeatability	± 2%
Transient Overreach	□ 5%

11.2.8 51N IDMTL Derived Earth Fault

Pickup	± 5% of setting or ± 0.02 I_N
Reset	□ 95% of I_s
Repeatability	± 2%
Transient Overreach	□ 5%

11.2.9 51G IDMTL Measured Earth Fault

Pickup	± 5% of setting or ± 0.01 I_N
Reset	□ 95% of I_s
Repeatability	± 2%
Transient Overreach	□ 5%

11.2.10 27/59 Under/Over Voltage

Pickup	± 0.1% of setting or ± 0.1 V
Reset	□ 95% of I_s
Repeatability	± 2%
Transient Overreach	□ 5%

11.2.11 81 Under/Over Frequency

Pickup	± 0.1% of setting or ± 0.010 Hz
Reset	□ 95% of I_s
Repeatability	± 2%
Transient Overreach	□ 5%

11.2.12 24DT Definite Time Overfluxing (V/f)

Pickup	± 0.1% of setting or ± 0.01 V/f
Reset	□ 95% of I_s
Repeatability	± 2%
Transient Overreach	□ 5%

11.2.13 24IT Inverse Time Overfluxing (V/f)

Pickup	± 0.1% of setting or ± 0.01 V/f
Reset	□ 95% of I_s
Repeatability	± 2%
Transient Overreach	□ 5%

11.2.14 49 Thermal Overload

Pickup	± 5% of setting or ± 0.01 I_N
Reset	□ 95% of I_s
Repeatability	± 2%
Transient Overreach	□ 5%

11.3 Accuracy General

Disengaging Time	30ms

Note: Output contacts have a minimum dwell time of 100ms, after which the disengaging time is as above.

11.4 Accuracy Influencing Factors

Temperature

Ambient range	-10°C to +55°C
Variation over range	≤ 5%

Frequency

Range	47Hz to 52Hz 57Hz to 62Hz
Setting variation	≤ 5%
Operating time variation	≤ 5%

11.5 Operate Times

11.5.1 87 Biased Differential

Current Applied	Typical
3 x setting	1.5 cycles

11.5.2 87HS Differential Highset

Current Applied	Typical
2 x setting	1 cycle
4 x setting	≤ 1 cycle

11.5.3 87REF Restricted Earth Fault

Current Applied	Typical
2 x setting	1 cycle
4 x setting	≤ 1 cycle

11.5.4 50 DTL Overcurrent

Current Applied	Typical
2 x setting	1.5 cycles
4 x setting	1 cycle

11.5.5 50N DTL Derived Earth Fault

Current Applied	Typical
2 x setting	1.5 cycles
4 x setting	1 cycle

11.5.6 50G DTL Measured Earth Fault

Current Applied	Typical
2 x setting	1.5 cycles
4 x setting	1 cycle

11.6 Thermal Withstand

Continuous and Limited Period Overload

AC Current Inputs

3.0 x In	Continuous
3.5 x In	for 10 minutes
4.0 x In	for 5 minutes
5.0 x In	for 3 minutes
6.0 x In	for 2 minutes
250A	for 1 second
625A peak	for 1 cycle

11.7 Burdens

A.C. Burden

Current 1A I/P	□ 0.1 VA
Current 5A I/P	□ 0.3 VA
Voltage I/P	□ 0.01 VA

NB. Burdens are measured at nominal rating.

D.C. Burden

Quiescent (Typical)	15
Max	27

12 Output Contact Performance

Contact rating to IEC 60255-0-2.

Carry continuously 5A ac or dc

Make and Carry

(limit L/R ≤ 40ms and V ≤ 300 volts)

for 0.5 sec	20A ac or dc
for 0.2 sec	30A ac or dc

Break

(limit ≤ 5A or ≤ 300 volts)

Ac resistive	1250VA
Ac inductive	250VA @ PF ≤ 0.4
Dc resistive	75W
Dc inductive	30W @ L/R ≤ 40 ms 50W @ L/R ≤ 10 ms

Minimum number of operations	1000 at maximum load
Minimum recommended load	0.5W, limits 10mA or 5V

13 Auxiliary Energising Quantity

Auxiliary DC Supply – IEC 60255-11

Allowable superimposed ac component	≤ 12% of DC voltage
Allowable breaks/dips in supply (collapse to zero from nominal voltage)	≤ 20ms

DC Power Supply

Nominal	Operating Range
24/30V	18V to 37.5V dc
50/110V	37.5V to 137.5V dc
220/250V	175V to 286V dc

Status Inputs

Nominal Voltage	Operating Range
30 / 34	18V to 37.5V
48 / 54	37.5V to 60V
110 / 125	87.5V to 137.5V
220 / 250	175 to 280V

NB: the status input operating voltage does not have to be the same as the power supply voltage.

Status Input Performance

Minimum DC current for operation	48V 10mA 110V 1mA 220V 2mA
Reset/Operate Voltage Ratio	≥ 90%
Typical response time	< 5ms
Typical response time when programmed to energise an output relay contact	< 15ms
Minimum pulse duration	40ms

To meet the requirements of ESI 48-4 then 48V status inputs should be ordered together with external dropper resistors as follows:-

Status Input External Dropper Resistances

NOMINAL VOLTAGE	RESISTOR VALUE (WATTAGE)
110 / 125V	2k7 ± 5% ; (2.5W)
220 / 250V	8k2 ± 5% ; (6.0W)

Each status input has associated timers that can be programmed to give time-delayed pick-up and time delayed drop-off. The pick-up timers can be set to 20ms to provide immunity to an AC input signal. Status inputs will then not respond to the following:

- 250V RMS 50/60Hz applied for two seconds through a 0.1μF capacitor.
- 500V RMS 50/60Hz applied between each terminal and earth.
- Discharge of a 10μF capacitor charged to maximum DC auxiliary supply voltage.

14 Environmental Withstand

Temperature - IEC 60068-2-1/2

OPERATING RANGE	-10°C TO +55°C
Storage range	-25°C to +70°C

Humidity - IEC 60068-2-3

OPERATIONAL TEST	56 DAYS AT 40°C AND 95% RH

Transient Overvoltage –IEC 60255-5

BETWEEN ALL TERMINALS AND EARTH OR BETWEEN ANY TWO INDEPENDENT CIRCUITS WITHOUT DAMAGE OR FLASHOVER	5KV 1.2/50μS 0.5J

Insulation - IEC 60255-5

BETWEEN ALL TERMINALS AND EARTH	2.0KV RMS FOR 1 MIN
Between independent circuits	2.0kV rms for 1 min
Across normally open contacts	1.0kV rms for 1 min

High Frequency Disturbance -

IEC 60255-22-1 Class III

	VARIATION
2.5kV Common (Longitudinal) Mode	≤ 5%
1.0kV Series (Transverse) Mode	≤ 5%

Electrostatic Discharge -

IEC 60255-22-2 Class IV

	VARIATION
8kV contact discharge	≤ 5%

Conducted & Radiated Emissions -

EN 55022 Class A (IEC 60255-25)

CONDUCTED 0.15MHZ – 30MHZ RADIATED 30MHZ – 1GHZ

Conducted Immunity -

(IEC 61000-4-6; IEC 60255-22-6)

	VARIATION
0.15MHz – 80MHz 10V rms 80% modulation	≤ 5%

Radiated Immunity -

IEC60255-22-3 Class III

	Variation
80MHz to 1000MHz, 10V/m 80% modulated	≤ 5%

Fast Transient – IEC 60255-22-4 Class IV

	Variation
4kV 5/50ns 2.5kHz repetitive	≤ 5%

Surge Impulse -

IEC 61000-4-5 Class IV; (IEC 60255-22-5)

	Variation
4KV Line-Earth (O/C Test voltage ±10%) 2KV Line-Line	≤ 10

Vibration (Sinusoidal) –IEC 60255-21-1 Class 1

		Variation
Vibration response	0.5gn	≤ 5%
Vibration endurance	1.0gn	≤ 5%

Shock and Bump–IEC 60255-21-2 Class 1

		Variation
Shock response	5 gn 11ms	≤ 5%
Shock withstand	15 gn 11ms	≤ 5%
Bump test	10 gn 16ms	≤ 5%

Seismic – IEC 60255-21-3 Class 1

		Variation
Seismic Response	1gn	≤ 5%

Mechanical Classification

Durability	In excess of 10^6 operations

7SG14 Duobias-M

Transformer Protection

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
Pre release

Revision	Date	Description
	2010/02	Document reformat due to rebrand
R6	07/07/2004	Added additional information describing Trip Cct Pickup Delay, will be renamed to be Trip Cct Fail Pickup Delay at next software release.
R5	07/05/2004	Correct Inrush Setting text, Bias Differential text
R4	26/01/2004	Corrected Settings Group command numbering
R3	09/12/2003	Added new inrush bias settings
R2	08/12/2003	Yd4 corrected to be Yy4
R1	29/09/2003	Document revision history added

Software Revision History

Contents

Figures

1 Introduction

This relay settings section covers the following Duobias-M models:-

Model No	Cat No	Configuration No
Duobias-M-200-2W-E8-50Hz	DU3-201-*A-50	2661H80014R12
Duobias-M-200-2W-E8-60Hz	DU3-201-*A-60	2661H80038R12
Duobias-M-200-2W-50Hz	DU3-201-**-50	2661H80024R12
Duobias-M-200-2W-60Hz	DU3-201-**-60	2661H80039R12
Duobias-M-200-3W-50Hz	DU3-301-**-50	2661H80015R12
Duobias-M-200-3W-60Hz	DU3-301-**-60	2661H80054R12
Duobias-M-200-4W-50Hz	DU3-401-**-50	2661H80035R12
Duobias-M-200-5W-50Hz	DU3-501-**-50	2661H80017R12
Duobias-M-200-5W-60Hz	DU3-501-**-60	2661H80058R12

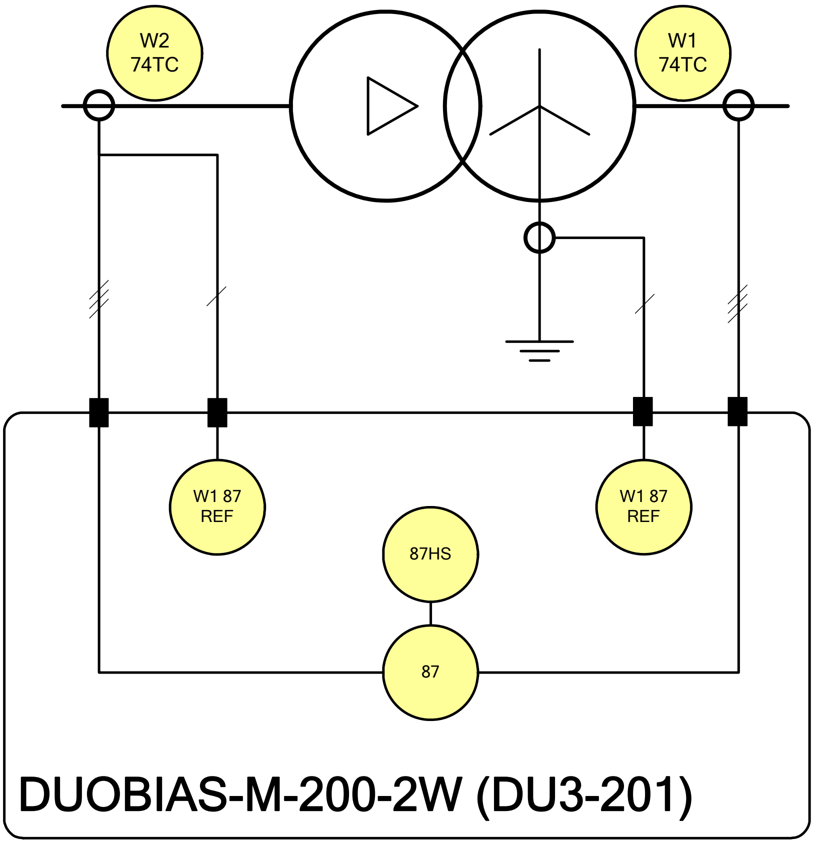


Figure 1 - Duobias-M-200-2W [DU3-201]

2 DUOBIAS-M-200-2/3/4/5W-R15 Relay Setting List

2.1 System Config Menu

Description	Range	Default	Setting
System Frequency *Selects the system frequency.* *!! Please note that the relay may have to restart for this setting to take affect. If so the relay will automatically restart after 5 seconds !!*	50,60 Hz	50 Hz	
Active Group *Selects which settings group is currently activated*	1,2…4	1	
View/Edit Group *Selects which settings group is currently being displayed*	1,2…4	1	
Default Screens Timer *Selects the time delay after which, if no key presses have been detected, the relay will begin to poll through any screens which have been selected as default instruments screens*	OFF, 1,2,5,10,15,30,60 min	60 min	
Backlight timer *Controls when the LCD backlight turns off*	OFF, 1,2,5,10,15,30,60 min	5 Min	
Date	Date	1/1/1980	
Time	Time	00:00:00	
Clock Sync. From Status *Real time clock may be synchronised using a status input (See Clock Sync. in Status Input Menu)*	Disabled, Seconds,Minutes	Minutes	
Operating Mode *To allow access to change configuration files using Reylogic Toolbox the relay must be placed Out Of Service.*	Local, Remote, Local Or Remote, Out Of Service	Local Or Remote	
Change Password *Allows a 4 character alphanumeric code to be entered as the password. Note that the display shows a password dependant encrypted code on the second line of the display*	AAAA…ZZZZ	"NONE" displayed as "NOT ACTIVE"	
Relay Identifier *An alphanumeric string shown on the LCD normally used to identifier the circuit the relay is attached to or the relays purpose*	Up to 16 characters	DUOBIAS-M-200-2W/3W/4W/5W	

2.2 CT/VT Config Menu

Description	Range	Default	Setting
W1 Input *Selects whether 1 or 5 Amp terminals are being used for winding 1*	1,5 A	1 A	
W1 CT Ratio *Winding 1 CT ratio to scale primary current instruments*	5:0.2…5000:7	2000:1	
W1 REF Input *Selects whether 1 or 5 Amp terminals are being used for winding 1 REF*	1,5 A	1 A	
W2 Input *Selects whether 1 or 5 Amp terminals are being used for winding 2*	1,5 A	1 A	
W2 CT Ratio	5:0.2…5000:7	2000:1	

Description	Range	Default	Setting
Winding 1 CT ratio to scale primary current instruments			
W2 REF Input *Selects whether 1 or 5 Amp terminals are being used for winding 2 REF*	1,5 A	1 A	
W3 Input1 *Selects whether 1 or 5 Amp terminals are being used for winding 3*	1,5 A	1 A	
W3 CT Ratio1 *Winding 3 CT ratio to scale primary current instruments*	5:0.2…5000:7	2000:1	
W3 REF Input1 *Selects whether 1 or 5 Amp terminals are being used for winding 3 REF*	1,5 A	1 A	
W4 Input2 *Selects whether 1 or 5 Amp terminals are being used for winding 4*	1,5 A	1 A	
W4 CT Ratio2 *Winding 4 CT ratio to scale primary current instruments*	5:0.2…5000:7	2000:1	
W5 Input3 *Selects whether 1 or 5 Amp terminals are being used for winding 5*	1,5 A	1 A	
W5 CT Ratio3 *Winding 5 CT ratio to scale primary current instruments*	5:0.2…5000:7	2000:1	

1) >2W Only
2) >3W Only.
3) >4W Only.

2.3 Biased Differential Menu

Description	Range	Default	Setting
W1 Interposing CT Multiplier *Winding 1 scaling factor*	0.25,0.26…3.00 x	1.00 x	
W1 Interposing CT Connection *Winding 1 transformer vector group compensation and/or zero sequence filtering*	Yy0, Yd1, Yy2, Yd3, Yy4, Yd5, Yy6, Yd7, Yy8, Yd9, Yy10, Yd11, Ydy0	Yy0, 0°	
W2 Interposing CT Multiplier *Winding 2 scaling factor*	0.25,0.26…3.00 x	1.00 x	
W2 Interposing CT Connection *Winding 2 transformer vector group compensation and/or zero sequence filtering*	Yy0, Yd1, Yy2, Yd3, Yy4, Yd5, Yy6, Yd7, Yy8, Yd9, Yy10, Yd11, Ydy0	Yy0, 0°	
W3 Interposing CT Multiplier1 *Winding 3 scaling factor*	0.25,0.26…3.00 x	1.00 x	
W3 Interposing CT Connection1 *Winding 3 transformer vector group compensation and/or zero sequence filtering*	Yy0, Yd1, Yy2, Yd3, Yy4, Yd5, Yy6, Yd7, Yy8, Yd9, Yy10, Yd11, Ydy0	Yy0, 0°	
W4 Interposing CT Multiplier2 *Winding 4 scaling factor*	0.25,0.26…3.00 x	1.00 x	
W4 Interposing CT Connection2 *Winding 4 transformer vector group compensation and/or zero sequence filtering*	Yy0, Yd1, Yy2, Yd3, Yy4, Yd5, Yy6, Yd7, Yy8, Yd9, Yy10, Yd11, Ydy0	Yy0, 0°	
W5 Interposing CT Multiplier3 *Winding 5 scaling factor*	0.25,0.26…3.00 x	1.00 x	
W5 Interposing CT Connection3 *Winding 5 transformer vector group compensation and/or zero sequence filtering*	Yy0, Yd1, Yy2, Yd3, Yy4, Yd5, Yy6, Yd7, Yy8, Yd9, Yy10, Yd11, Ydy0	Yy0, 0°	
87 Inrush Inhibit	Disabled, Enabled	Enabled	

Description	Range	Default	Setting
Selects whether the biased differential characteristic is inhibited from operating when magnetising inrush is detected			
87 Inrush Bias *Selects the bias method used for magnetising inrush* *Phase – Segregated, each phase blocks itself.* *Cross – Blocked, each phase can block the operation of other phases (Modular 1 method).* *Sum - Of Squares, each phase blocks itself using the square root of the sum of squares of the even harmonics.(Improves Switch On To Fault performance when REF not applied).*	Phase, Cross, Sum	Cross	
87 Inrush Setting *The magnetising inrush detector operates when the even harmonics in the differential operate current exceed a set percentage of the differential operate current*	0.1,0.11…0.50 xId	0.20 xId	
87 Bias Differential *Selects whether the transformer differential protection element is enabled*	Disabled, Enabled	Enabled	
87 Initial Setting *The initial unbiased pickup level*	0.1,0.15…2.00 xIn	0.2 xIn	
87 Bias Slope *The bias slope varies the pickup level to compensates for CT measuring errors and tap changer not mid tap errors as the through current (bias) increases*	0,0.05…0.7 x	0.2 x	
87 Bias Slope Limit *At this point in the characteristics the bias slope increases tot provide increased security when additional measuring errors are introduced due to CT saturation effects.*	1,2…20 xIn	4 xIn	
87 Delay *The operation of the differential may be delayed to cater for special system conditions e.g. for use on cable circuits a delay of 5ms is recommended*	0,0.005…1 s	0.005 s	
87HS Differential Highset *Selects whether the differential Highset element is enabled. Note this element is never blocked by magnetising inrush*	Disabled, Enabled	Disabled	
87HS Setting *The differential setting pickup setting*	1,2…30 xIn	4 xIn	
87HS Delay *The operation of the differential may be delayed to cater for special system conditions e.g. for use on cable circuits a delay of 5ms is recommended*	0,0.005…1 s	0.005 s	

1) >2W Only
2) >3W Only.
3) >4W Only.

2.4 Restricted E/F Menu

Description	Range	Default	Setting
Gn W1 87REF *High impedance restricted earth fault current element*	Disabled, Enabled	Disabled	
Gn W1 87REF Setting2 *Pickup level*	0.020,0.025…0.960 xIn	0.200 xIn	

Description	Range	Default	Setting
G*n* W1 87REF Delay *Pickup delay*	0,0.0025…864000 s	0.0000	
Gn W2 87REF *High impedance restricted earth fault current element*	Disabled, Enabled	Disabled	
Gn W2 87REF Setting[2] *Pickup level*	0.020,0.025…0.960 xIn	0.200 xIn	
G*n* W2 87REF Delay *Pickup delay*	0,0.0025…864000 s	0.0000	
Gn W3 87REF[1] *High impedance restricted earth fault current element*	Disabled, Enabled	Disabled	
Gn W3 87REF Setting[1] [2] *Pickup level*	0.020,0.025…0.960 xIn	0.200 xIn	
G*n* W3 87REF Delay[1] *Pickup delay*	0,0.0025…864000 s	0.0000	

1) >2W Only
2) REF versions have minimum setting of 0.020, SREF versions have minimum setting of 0.005xIn.

2.5 Status Input Menu

Description	Range	Default	Setting
Aux I/P 1 Pickup Delay *Delay on pickup of DC Status input 1*	0.000,0.005…864000 s	0 s	
Aux I/P 2 Pickup Delay	0.000,0.005…864000 s	0 s	
Aux I/P 3 Pickup Delay	0.000,0.005…864000 s	0 s	
Aux I/P 4 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 5 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 6 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 7 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 8 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 9 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 10 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 11 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 12 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 13 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 14 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 15 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 16 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 17 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 18 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 19 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 20 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 21 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 22 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 23 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 24 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 25 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 26 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Aux I/P 27 Pickup Delay[1]	0.000,0.005…864000 s	0 s	
Inhibit W1 87REF[3] *Selects which inputs inhibit the 87REF element*	NONE, 1…272	NONE	
Inhibit W2 87REF[3] *Selects which inputs inhibit the 87REF elemen2*	NONE, 1…272	NONE	
Trip Circuit Fail *Selects which inputs are monitoring trip circuits, inputs should normally also be selected as Inverted Inputs (see below)*	NONE, 1…272	NONE	
Trigger Storage *Selects which inputs can trigger a waveform record*	NONE, 1…272	NONE	

Description	Range	Default	Setting
Clock Sync. *Selects which input is used to synchronise the real time clock*	NONE, 1…272	NONE	
Inverted Inputs *Selects which inputs pickup when voltage is removed, often used when monitoring trip circuits.*	NONE, 1…272	NONE	

1) Only when fitted.
2) 27 status inputs represents maximum configuration.

2.6 Reylogic Control Menu

Description	Range	Default	Setting
General Logic *Selects whether the logic diagram is enabled, if disabled then no outputs will be driven.*	Enable, Disable	Enable	

2.7 Reylogic Element Menu

Description	Range	Default	Setting
Trip Cct Fail Pickup Delay *Delay before trip circuit failure picks up. Used in conjunction with STATUS INPUT MENU/Trip Circuit Fail setting to configure how many trip circuits are being monitored.*	0,1…60000 ms	400 ms	

2.8 Output Relay Menu

Description	Range	Default	Setting
87 *Biased Differential operated*	NONE, 1…291	4,5	
87 HS *Differential Highset operated*	NONE, 1…291	4,5	
W1 87REF *Winging 1 High Impedance Restricted Earth Fault operated*	NONE, 1…291	4,5	
W2 87REF *Winging 2 High Impedance Restricted Earth Fault operated*	NONE, 1…291	4,5	
Phase A *A phase A element operated*	NONE, 1…291	NONE	
Phase B *A phase B element operated*	NONE, 1…291	NONE	
Phase C *A phase C element operated*	NONE, 1…291	NONE	
General Starter *A starter element is picked up*	NONE, 1…291	NONE	
General Trip *An element has operated. Useful when testing individual functions!*	NONE, 1…291	NONE	
Trip Circuit Fail *A trip circuit has failed, look at status input Leds to find out which one*	NONE, 1…291	NONE	
New Data Stored *The waveform recorder has stored new information Note: this is a pulsed output*	NONE, 1…291	NONE	
Aux I/P 1 Operated *DC Status 1 has operated*	NONE, 1…291	NONE	
Aux I/P 2 Operated	NONE, 1…291	NONE	
Aux I/P 3 Operated	NONE, 1…291	NONE	
Aux I/P 4 Operated2	NONE, 1…291	NONE	
Aux I/P 5 Operated2	NONE, 1…291	NONE	
Aux I/P 6 Operated2	NONE, 1…291	NONE	

Description	Range	Default	Setting
Aux I/P 7 Operated2	NONE, 1…291	NONE	
Aux I/P 8 Operated2	NONE, 1…291	NONE	
Aux I/P 9 Operated2	NONE, 1…291	NONE	
Aux I/P 10 Operated2	NONE, 1…291	NONE	
Aux I/P 11 Operated2	NONE, 1…291	NONE	
Aux I/P 12 Operated2	NONE, 1…291	NONE	
Aux I/P 13 Operated2	NONE, 1…291	NONE	
Aux I/P 14 Operated2	NONE, 1…291	NONE	
Aux I/P 15 Operated2	NONE, 1…291	NONE	
Aux I/P 16 Operated2	NONE, 1…291	NONE	
Aux I/P 17 Operated2	NONE, 1…291	NONE	
Aux I/P 18 Operated2	NONE, 1…291	NONE	
Aux I/P 19 Operated2	NONE, 1…291	NONE	
Aux I/P 20 Operated2	NONE, 1…291	NONE	
Aux I/P 21 Operated2	NONE, 1…291	NONE	
Aux I/P 22 Operated2	NONE, 1…291	NONE	
Aux I/P 23 Operated2	NONE, 1…291	NONE	
Aux I/P 24 Operated2	NONE, 1…291	NONE	
Aux I/P 25 Operated2	NONE, 1…291	NONE	
Aux I/P 26 Operated2	NONE, 1…291	NONE	
Aux I/P 27 Operated2	NONE, 1…291	NONE	
Hand Reset Outputs *Relays selected, as Hand Reset will remain latched until manually reset from front panel or via communications link or by removing DC Supply. By default relays are Self Resetting and will reset when the driving signal is removed.*	NONE, 1…291	NONE	
Protection Healthy *Relays selected are energised whilst relay self-monitoring does NOT detect any hardware or software errors and DC Supply is healthy. A changeover contact or normally closed contact may be used to generate Protection Defective from this output*	NONE, 1…291	1	

1) 29 output relays represents maximum configuration.
2) Only when fitted.
3) 3W Only
4) 2W Only.

2.9 LED Menu

Description	Range	Default	Setting
87 *Biased Differential operated*	NONE, 1…32	18	
87 HS *Differential Highset operated*	NONE, 1…32	19	
W1 87REF *Winging 1 High Impedance Restricted Earth Fault operated*	NONE, 1…32	4	
W2 87REF *Winging 2 High Impedance Restricted Earth Fault operated*	NONE, 1…32	5	
Phase A *A phase A element operated*	NONE, 1…32	1	
Phase B *A phase B element operated*	NONE, 1…32	2	
Phase C *A phase C element operated*	NONE, 1…32	3	
General Starter *A starter element is picked up. Useful when testing individual functions!*	NONE, 1…32	NONE	
General Trip	NONE, 1…32	NONE	

Description	Range	Default	Setting
An element has operated. Useful when testing individual functions!			
Trip Circuit Fail *A trip circuit has failed, look at status inputs Leds to find out which one*	NONE, 1…32	20	
New Data Stored *The waveform recorder has stored new information*	NONE, 1…32	17	
Aux I/P 1 Operated *DC Status 1 has operated*	NONE, 1…32	9	
Aux I/P 2 Operated	NONE, 1…32	10	
Aux I/P 3 Operated	NONE, 1…32	11	
Aux I/P 4 Operated1	NONE, 1…32	12	
Aux I/P 5 Operated1	NONE, 1…32	13	
Aux I/P 6 Operated1	NONE, 1…32	14	
Aux I/P 7 Operated1	NONE, 1…32	15	
Aux I/P 8 Operated1	NONE, 1…32	16	
Aux I/P 9 Operated1	NONE, 1…32	25	
Aux I/P 10 Operated1	NONE, 1…32	26	
Aux I/P 11 Operated1	NONE, 1…32	27	
Aux I/P 12 Operated1	NONE, 1…32	NONE	
Aux I/P 13 Operated1	NONE, 1…32	NONE	
Aux I/P 14 Operated1	NONE, 1…32	NONE	
Aux I/P 15 Operated1	NONE, 1…32	NONE	
Aux I/P 16 Operated1	NONE, 1…32	NONE	
Aux I/P 17 Operated1	NONE, 1…32	NONE	
Aux I/P 18 Operated1	NONE, 1…32	NONE	
Aux I/P 19 Operated1	NONE, 1…32	NONE	
Aux I/P 20 Operated1	NONE, 1…32	NONE	
Aux I/P 21 Operated1	NONE, 1…32	NONE	
Aux I/P 22 Operated1	NONE, 1…32	NONE	
Aux I/P 23 Operated1	NONE, 1…32	NONE	
Aux I/P 24 Operated1	NONE, 1…32	NONE	
Aux I/P 25 Operated1	NONE, 1…32	NONE	
Aux I/P 26 Operated1	NONE, 1…32	NONE	
Aux I/P 27 Operated1	NONE, 1…32	NONE	
Self Reset LEDs *Leds selected, as Self Reset will automatically reset when the driving signal is removed. By default all Leds are Hand Reset and must be manually reset either locally via the front fascia or remotely via communications.*	NONE, 1…32	NONE	

1) Only when fitted.

2.10 Data Storage Menu

Description	Range	Default	Setting
Clear Faults *Clears the Fault Records, useful after routine testing.*	NO, YES	NO	
Clear Events *Clears the Event Records, useful after routine testing.*	NO, YES	NO	
Pre-Trigger Storage *Specifies the amount of pre fault data for the waveform records.*	10…90 %	20 %	
Data Record Duration1 *Specifies the duration of the waveform records and the number of records available.*	5 Recs x 1 Seconds, 2 Recs x 2 Seconds, 1 Recs x 5 Seconds	5 Recs x 1 Second	
Trigger Waveform *Triggers a waveform record.*	NO, YES	NO	
Clear Waveforms	NO, YES	NO	

Description	Range	Default	Setting
Clears the Waveform Records, useful after routine testing.			

1) Number of records and duration available is dependent upon relay model

2.11 Communications Menu

Description	Range	Default	Setting
Station Address *IEC 60870-5-103 Station Address*	0…254	0	
IEC870 On Port *Selects which port to use for IEC 60870-5-103 communications.*	None, Com1, Com2, Auto	Com1	
Line Switch Time *When IEC870 On Port is selected to Auto the communications ports are scanned for valid IEC 60870-5-103 communications frames. Once valid frames are detected the com port will remain selected. Subsequently if there are no valid frames received for the Line Switch Time period then the driver will assume the communications circuit has failed and will resume scanning the com ports.* *Only visible when set to Auto.*	1,2…60 s	30 s	
Com1 Baud Rate *Sets the communications baud rate for com port 1 (Rear upper Fibre optic port)*	75, 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	19200	
Com1 Parity *Selects whether parity information is used*	Even, Odd, None	Even	
Com1 Line Idle *Selects the communications line idle sense*	Light Off, Light On	Light Off	
Com1 Data Echo *Enables echoing of data from RX port to TX port when operating relays in a Fibre Optic ring configuration*	Off, On	Off	
Com2 Baud Rate *Sets the communications baud rate for com port 2 (Rear lower Fibre optic port AND Front Fascia RS232 port)*	75, 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	19200	
Com2 Parity *Selects whether parity information is used*	Even, Odd, None	None	
Com2 Line Idle *Selects the communications line idle sense*	Light Off, Light On	Light Off	
Com2 Data Echo *Enables echoing of data from RX port to TX port when operating relays in a Fibre Optic ring configuration*	Off, On	Off	
Com2 Direction *Selects how Com2 is shared between the front fascia port and the rear fibre optic port. This allows interlocking to prevent remote access whilst an engineer is attached locally on site if IEC870 is on Com2 and Auto-detect is enabled*	AUTO-DETECT, FRONT PORT, REAR PORT	AUTO-DETECT	

3 Instruments

INSTRUMENT	DESCRIPTION
[WINDING 1 METERS] --> press down <--	Start of meters for winding 1
W1 Primary Currents 0.00 0.00 0.00 kA	Winding 1 primary currents
W1 Sec'y Currents 0.00 0.00 0.00 A	Winding 1 secondary currents
W1 Residual Current 0.00 A	Winding 1 secondary residual current
W1 REF Current 0.00 A	Winding 1 secondary restricted earth fault current
[WINDING 2 METERS] --> press down <--	Start of meters for winding 2
W2 Primary Currents 0.00 0.00 0.00 kA	Winding 2 primary currents
W2 Sec'y Currents 0.00 0.00 0.00 A	Winding 2 secondary currents
W2 Residual Current 0.00 A	Winding 2 secondary residual current
W2 REF Current 0.00 A	Winding 2 secondary restricted earth fault current
[WINDING 3 METERS] --> press down <--	Start of meters for winding 3
W3 Primary Currents 0.00 0.00 0.00 kA	Winding 3 primary currents
W3 Sec'y Currents 0.00 0.00 0.00 A	Winding 3 secondary currents
W3 Residual Current 0.00 A	Winding 3 secondary residual current
W3 REF Current 0.00 A	Winding 3 secondary restricted earth fault current
[WINDING 4 METERS] --> press down <--	Start of meters for winding 4
W4 Primary Currents 0.00 0.00 0.00 kA	Winding 4 primary currents
W4 Sec'y Currents 0.00 0.00 0.00 A	Winding 4 secondary currents
W4 Residual Current 0.00 A	Winding 4 secondary residual current
[WINDING 5 METERS] --> press down <--	Start of meters for winding
W5 Primary Currents 0.00 0.00 0.00 kA	Winding 5 primary currents
W5 Sec'y Currents 0.00 0.00 0.00 A	Winding 5 secondary currents
W5 Residual Current 0.00 A	Winding 5 secondary residual current
[BIAS DIFF METERS] --> press down <--	Start of (87) Biased Differential meters
W1 Line Currents 0.00 0.00 0.00 xIn	Winding 1 measured currents
W2 Line Currents 0.00 0.00 0.00 xIn	Winding 2 measured currents
W3 Line Currents 0.00 0.00 0.00 xIn	Winding 3 measured currents
W4 Line Currents 0.00 0.00 0.00 xIn	Winding 4 measured currents
W5 Line Currents 0.00 0.00 0.00 xIn	Winding 5 measured currents
W1 Relay Currents 0.00 0.00 0.00 xIn	Winding 1 currents after Interposing CT correction factors applied
W2 Relay Currents 0.00 0.00 0.00 xIn	Winding 2 currents after Interposing CT correction factors applied

INSTRUMENT	DESCRIPTION
W3 Relay Currents 0.00 0.00 0.00 xIn	Winding 3 currents after Interposing CT correction factors applied
W4 Relay Currents 0.00 0.00 0.00 xIn	Winding 3 currents after Interposing CT correction factors applied
W5 Relay Currents 0.00 0.00 0.00 xIn	Winding 3 currents after Interposing CT correction factors applied
Operate Currents 0.00 0.00 0.00 xIn	Differential operate currents
Restrain Currents 0.00 0.00 0.00 xIn	Differential restrain currents
Mag Inrush Currents 0.00 0.00 0.00 xIn	Differential magnetising inrush currents (even harmonic content of operate currents but mainly 2nd harmonic content)
[MISC METERS] --> press down <--	Start of miscellaneous meters
Status Inputs 1-16 ---- ---- ---- ----	Displays the state of DC status inputs 1 to 16
Status Inputs 17-27 ---- ---- ---	Displays the state of DC status inputs 17 to 27
Output Relays 1-16 ---- ---- ---- ----	Displays the state of output relays 1 to 16
Output Relays 17-29 ---- ---- ---- -	Displays the state of output relays 17 to 29
Time & Date 13/08/2002 10:16:11	Time and Date

4 IEC 60870-5-103 Communications Information

4.1 IEC 60870-5-103 Semantics in monitor direction

FUN	INF	Description	GI	TYP	COT
60	1	IEC870 Active Com1	x	1	1,9
60	2	IEC870 Active Com2	x	1	1,9
60	3	Front Port OverRide	x	1	1,9

FUN	INF	Description	GI	TYP	COT
176	0	GI End	-	8	10
176	0	Time Synchronisation	-	6	8
176	2	Reset FCB	-	2	3
176	3	Reset CU	-	2	4
176	4	Start/Restart	-	2	5
176	22	Settings changed	-	1	1
176	23	Setting G1 selected	x	1	1,9
176	24	Setting G2 selected	x	1	1,9
176	25	Setting G3 selected	x	1	1,9
176	26	Setting G4 selected	x	1	1,9
176	27	Status Input 1	x	1	1,9
176	28	Status Input 2	x	1	1,9
176	29	Status Input 3	x	1	1,9
176	30	Status Input 4	x	1	1,9
176	36	Trip Circuit Fail	x	1	1,9
176	64	Start/Pick-up L1	x	2	1,9
176	65	Start/Pick-up L2	x	2	1,9
176	66	Start/Pick-up L3	x	2	1,9
176	67	Start/Pick-up N	x	2	1,9
176	68	General Trip	-	2	1
176	69	Trip L1	-	2	1
176	70	Trip L2	-	2	1
176	71	Trip L3	-	2	1
176	84	General Start/Pick-up	x	2	1,9
178	7	Biased Differential	-	2	1
178	8	Differential Highset	-	2	1
178	9	W1 Restricted Earth Fault	-	2	1
178	10	W2 Restricted Earth Fault	-	2	1
178	12	W3 Restricted Earth Fault	-	2	1
178	128	Cold Start	-	1	1
178	129	Warm Start	-	1	1
178	130	Re-Start	-	1	1
178	135	Trigger Storage	-	1	1
178	145	Status Input 5	x	1	1,9
178	146	Status Input 6	x	1	1,9
178	147	Status Input 7	x	1	1,9
178	148	Status Input 8	x	1	1,9
178	149	Status Input 9	x	1	1,9
178	150	Status Input 10	x	1	1,9

FUN	INF	Description	GI	TYP	COT
178	151	Status Input 11	x	1	1,9
178	152	Status Input 12	x	1	1,9
178	153	Status Input 13	x	1	1,9
178	154	Status Input 14	x	1	1,9
178	155	Status Input 15	x	1	1,9
178	156	Status Input 16	x	1	1,9
178	157	Status Input 17	x	1	1,9
178	158	Status Input 18	x	1	1,9
178	159	Status Input 19	x	1	1,9
178	160	Status Input 20	x	1	1,9
178	161	Status Input 21	x	1	1,9
178	162	Status Input 22	x	1	1,9
178	163	Status Input 23	x	1	1,9
178	164	Status Input 24	x	1	1,9
178	165	Status Input 25	x	1	1,9
178	166	Status Input 26	x	1	1,9
178	167	Status Input 27	x	1	1,9
178	181	Plant Control Relay 1	x	1	1,9
178	182	Plant Control Relay 2	x	1	1,9
178	183	Plant Control Relay 3	x	1	1,9
178	184	Plant Control Relay 4	x	1	1,9
178	185	Plant Control Relay 5	x	1	1,9
178	186	Plant Control Relay 6	x	1	1,9
178	187	Plant Control Relay 7	x	1	1,9
178	188	Plant Control Relay 8	x	1	1,9
178	189	Plant Control Relay 9	x	1	1,9
178	190	Plant Control Relay 10	x	1	1,9
178	191	Plant Control Relay 11	x	1	1,9
178	192	Plant Control Relay 12	x	1	1,9
178	193	Plant Control Relay 13	x	1	1,9
178	194	Plant Control Relay 14	x	1	1,9
178	195	Plant Control Relay 15	x	1	1,9
178	196	Plant Control Relay 16	x	1	1,9
178	197	Plant Control Relay 17	x	1	1,9
178	198	Plant Control Relay 18	x	1	1,9
178	199	Plant Control Relay 19	x	1	1,9
178	200	Plant Control Relay 20	x	1	1,9
178	201	Plant Control Relay 21	x	1	1,9
178	202	Plant Control Relay 22	x	1	1,9
178	203	Plant Control Relay 23	x	1	1,9
178	204	Plant Control Relay 24	x	1	1,9
178	205	Plant Control Relay 25	x	1	1,9
178	206	Plant Control Relay 26	x	1	1,9
178	207	Plant Control Relay 27	x	1	1,9
178	208	Plant Control Relay 29	x	1	1,9
178	209	Plant Control Relay 29	x	1	1,9

4.2 IEC 60870-5-103 Semantics in control direction

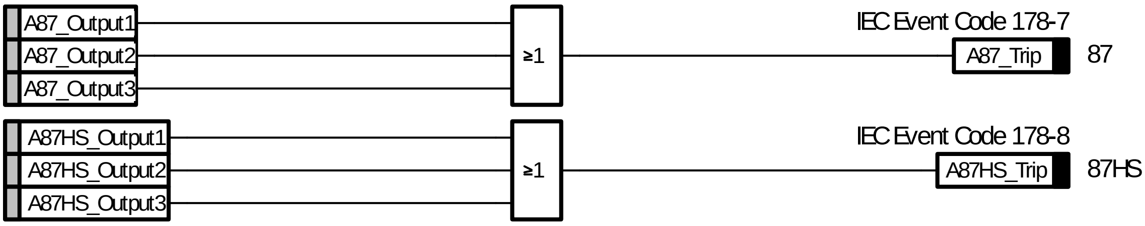
FUN	INF	Description	COM	TYP	COT
176	0	GI Initiation		7	9
176	0	Time Synchronisation		6	8
176	19	LED reset	ON	20	20
176	23	Settings Group 1 Select	ON	20	20
176	24	Settings Group 2 Select	ON	20	20
176	25	Settings Group 3 Select	ON	20	20
176	26	Settings Group 4 Select	ON	20	20
178	110	Settings Group 5 Select	ON	20	20
178	111	Settings Group 6 Select	ON	20	20
178	112	Settings Group 7 Select	ON	20	20
178	113	Settings Group 8 Select	ON	20	20

5 Reylogic Diagrams

Filename: 87.RLD
Art.No.: 2661S81460
Description: 87 n WindingLogic
Author: Paul Mudditt
Revision History

Release	Initials	Date	Comment
1	PM	14-03-2003	First version
2	PM	24-03-2003	Art No Added
3	PM	14-05-2003	Renamed, standard logic for all Duobias-M winding versions

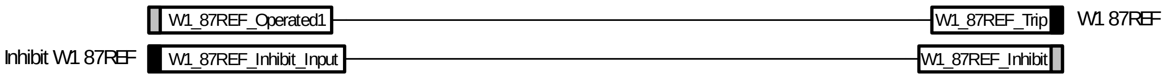
87/87HS BIASED DIFFERENTIAL LOGIC



Filename: W1-87REF.RLD
Art.No.: 2661S81462
Description: W1-87REF Logic
Author: Paul Mudditt
Revision History

Release	Initials	Date	Comment
1	PM	14-03-2003	First version
2	PM	24-03-2003	Art No Added
3	PM	06-05-2003	Inhibit added

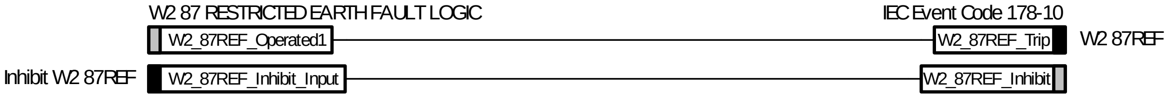
W1 87 RESTRICTED EARTH FAULT LOGIC



Filename: W2-87REF.RLD
Art.No.: 2661S81465
Description: W2-87REF Logic
Author: Paul Mudditt
Revision History

Release	Initials	Date	Comment
1	PM	14-03-2003	First version
2	PM	24-03-2003	Art No Added
3	PM	06-05-2003	Inhibit added

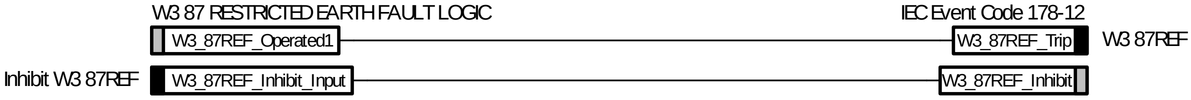
W2 87 RESTRICTED EARTH FAULT LOGIC



Filename: W3-87REF.RLD
Art.No.: 2661S81479
Description: W1-87REF Logic
Author: Paul Mudditt
Revision History

Release	Initials	Date	Comment
1	PM	14-05-2003	First version based upon W1-87REF.RLD

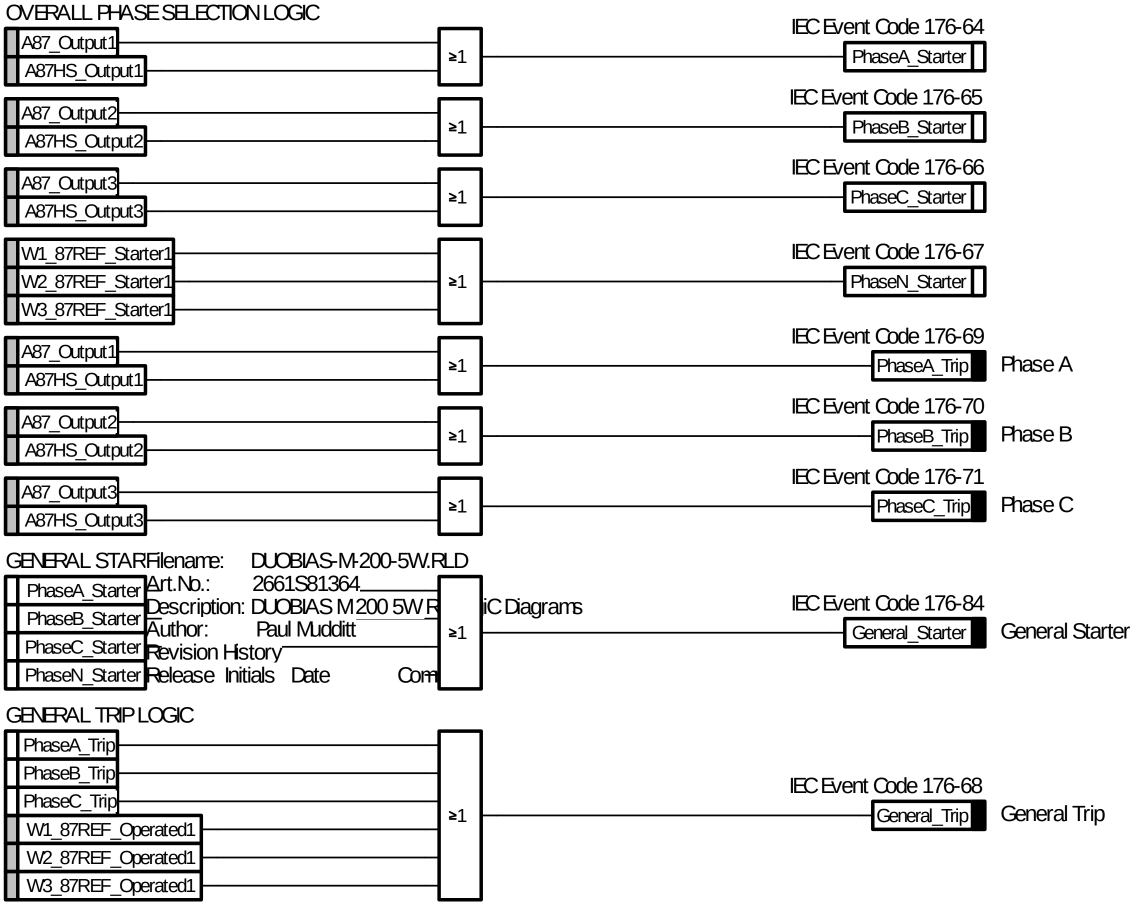
W3 87 RESTRICTED EARTH FAULT LOGIC



Filename: DUOBIAS-M-200-5W-LOGIC.RLD
Art.No.: 2661S81510
Description: DUOBIAS M 200 5W General Logic Diagram
Author: Paul Mudditt
Revision History

Release	Initials	Date	Comment
1	PM	15-06-2003	First version
2	PM	19-06-2003	Art No's added

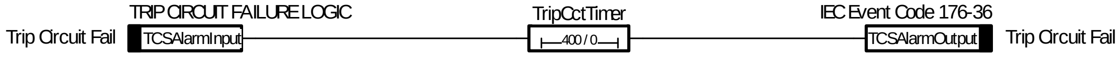
OVERALL PHASE SELECTION LOGIC



Filename: COMMON.RLD
Art.No.: 2661S81468
Description: Common Functions Logic Diagram
Author: Paul Muddittt
Revision History

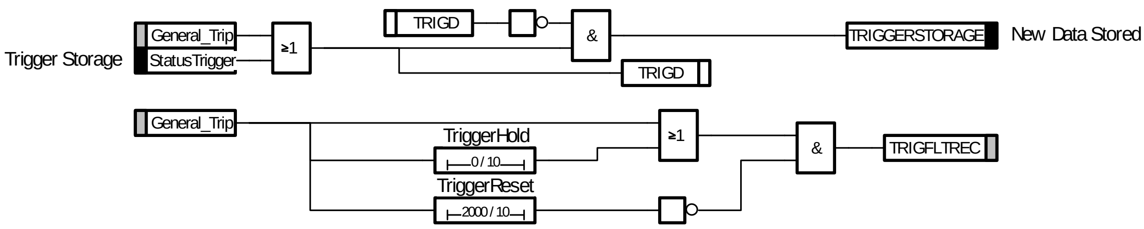
Release	Initials	Date	Comment
1	PM	20-03-2003	First RDL version
2	PM	24-03-2003	Art No Added

TRIP CIRCUIT FAILURE LOGIC



Don't forget to program Trip CCT inputs as inverted
Individual Trip CCT Fail LED or CONTACTS can be achieved by programing/labelling because of the I/O marshalling logic

FAULT AND WAVEFORM RECORDER LOGIC



6 Label Inserts

6.1 2W E8 CASE

	Duobias-M-200-2W
	R12
	E8
	23.02.10
1	NEW DATA STORED
2	PHASE A
3	PHASE B
4	PHASE C
5	(87) BIAS. DIFFERENTIAL
6	(87HS) DIFF. HIGHSET
7	(W1 87REF) RES. E/F
8	(W2 87REF) RES. E/F
9	(74TC) TRIP CIRCUIT FAIL
10	
11	
12	
13	
14	*AUX 1 I/P OPERATED*
15	*AUX 2 I/P OPERATED*
16	*AUX 3 I/P OPERATED*

6.2 2W E12, E16 CASE

	Duobias-M-200-2W	Duobias-M-200-2W	
	R12	R12	
	Left	Right	
	23.02.10	23.02.10	
1	PHASE A	NEW DATA STORED	17
2	PHASE B	(87) BIAS. DIFFERENTIAL	18
3	PHASE C	(87HS) DIFF. HIGHSET	19
4	(W1 87REF) RES. E/F	(74TC) TRIP CIRCUIT FAIL	20
5	(W2 87REF) RES. E/F		21
6			22
7			23
8			24
9	*AUX 1 I/P OPERATED*	*AUX 9 I/P OPERATED*	25
10	*AUX 2 I/P OPERATED*	*AUX 10 I/P OPERATED*	26
11	*AUX 3 I/P OPERATED*	*AUX 11 I/P OPERATED*	27
12	*AUX 4 I/P OPERATED*		28
13	*AUX 5 I/P OPERATED*		29
14	*AUX 6 I/P OPERATED*		30
15	*AUX 7 I/P OPERATED*		31
16	*AUX 8 I/P OPERATED*		32

6.3 3/4/5W E12, E16 CASE

	Duobias-M-200-nW	Duobias-M-200-nW	
	R12	R12	
	Left	Right	
	23.02.10	23.02.10	
1	PHASE A	NEW DATA STORED	17
2	PHASE B	(87) BIAS. DIFFERENTIAL	18
3	PHASE C	(87HS) DIFF. HIGHSET	19
4	(W1 87REF) RES. E/F	(74TC) TRIP CIRCUIT FAIL	20
5	(W2 87REF) RES. E/F		21
6	(W3 87REF) RES. E/F		22
7			23
8			24
9	*AUX 1 I/P OPERATED*	*AUX 9 I/P OPERATED*	25
10	*AUX 2 I/P OPERATED*	*AUX 10 I/P OPERATED*	26
11	*AUX 3 I/P OPERATED*	*AUX 11 I/P OPERATED*	27
12	*AUX 4 I/P OPERATED*		28
13	*AUX 5 I/P OPERATED*		29
14	*AUX 6 I/P OPERATED*		30
15	*AUX 7 I/P OPERATED*		31
16	*AUX 8 I/P OPERATED*		32

7SG14 Duobias-M

Transformer Protection

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
Pre release

Revision	Date	Description
	2010/02	Document reformat due to rebrand
R3	5/10/2006	Reformatted to match other manual sections.
R2	18/10/2004	Sigma 5 references removed and replaced by Lantronix UDS-10
R1	12/02/2003	Revision history added

Software Revision History

Contents

Figures

Glossary

Baud Rate	See *bits per second*.
Bit	The smallest measure of computer data.
Bits Per Second (BPS)	Measurement of data transmission speed.
Data Bits	A number of *bits* containing the data. Sent after the *start bit*.
Half-Duplex Asynchronous Communications	Communications in two directions, but only one at a time.
Hayes 'AT'	Modem command set developed by Hayes Microcomputer products, Inc.
IEC 60870-5-103	The International Electrotechnical Commission's Standard for communications with Protection Relays.
Master Station	See *primary station*.
Modem	MOdulator / DEModulator device for connecting computer equipment to a telephone line.
Parity	Method of error checking by counting the value of the bits in a sequence, and adding a parity bit to make the outcome, for example, even.
Parity Bit	*Bit* used for implementing parity checking. Sent after the *data bits*.
Primary Station	The device controlling the communication.
PSTN	Public Switched Telephone Network
RS232C	Serial Communications Standard. Electronic Industries Association Recommended Standard Number 232, Revision C.
Secondary Station	The device being communicated with.
Slave Station	See *secondary station*.
Start Bit	*Bit* (logical 0) sent to signify the start of a byte during data transmission.
Stop Bit	*Bit* (logical 1) sent to signify the end of a byte during data transmission.

1 Introduction

All Reyrolle relays utilise the International Communications Standard for Protection Relays, IEC 60870-5-103. This document describes how to connect the IEC60870-5-103 compliant communications interface to a control system or interrogating computer.

To access the interface the user will need appropriate software within the control system or on the interrogating computer such as Reydisp Evolution.

The Reyrolle Argus 1 to Argus 8 range of protection relays have a single rear communications interface. The Reyrolle Modular II relay range which includes Ohmega, Delta, Duobias, Iota, Tau and MicroTaPP have two rear communications interfaces COM1 & COM2. COM2 is multiplexed with an RS232 port mounted upon the Fascia :-

COM1: this port is used for IEC60870-5-103 communications to a substation SCADA or integrated control system by default.

COM2: this port can also be used for IEC60870-5-103 communications to a substation SCADA or integrated control system. Note however that only one port can be mapped to the IEC60870-5-103 protocol at any one time. (The COMMS INTERFACE submenu includes a setting “IEC60870 on port”, which maps the protocol to either COM1 or COM2). COM2 can also be accessed through an isolated RS232 (female 25-pin D-type) connector on the relay fascia. This provides facilities for access to the relay from a laptop or PC when commissioning or interrogating relays. A “COM2 Direction” setting is available which, when set to “AUTO-DETECT” automatically allows the front port to take control away from the rear port when a computer is plugged into the D-type connector.

2 Reydisp Evolution

Reydisp Evolution is a PC based software package providing capability for both local and remote communication to all Reyrolle Protection Relays . It provides features such as download of disturbance and event records, upload of relay settings, real-time monitoring of measurands and remote control of plant. Reydisp Evolution can be configured to connect to the relays using RS232, Fibre Optic, Modem or using Ethernet. When Ethernet is used the IEC 60870-5-103 protocol is transported using the TCP/IP protocol suite across a Local or Wide Area Network (LAN/WAN).

3 Connection specification and relay settings

This section defines the connection medium as defined by IEC60870-5-103. Appendix A shows some typical communication connections.

3.1 Recommended cable

Two types of fibre-optic connectors are available with Reyrolle relays:

1) Fibres terminated with BFOC/2.5 (ST®) bayonet-style connectors. With this type of connector the recommended cable is also 62.5 / 125μm glass fibre. This offers superior performance over the SMA connectors in terms of better coupling to the fibre and therefore has lower losses.

2) Fibres terminated with 9mm SMA connectors. With this type of connector the recommended cable is 62.5 / 125μm glass fibre. This will allow a maximum transmission distance of 1.7km between Reyrolle relays. It will also be the maximum distance between the ring network and the fibre to RS232 converter. Alternatively, 1.0mm polymer cable may be used to reduce cost. This will provide transmission distances of up to 5m between relays. Note that the distance from the transmit output of the RS232 / fibre optic converter to the receive input of the first Reyrolle relay should not be more than 6m.

No other types of cable are suitable for use with Reyrolle relays.

3.2 Connection Method

Reyrolle relays can be connected in either a Star or Ring fibre-optic communications network. If star connected then a passive fibre optic hub must be used. A lower cost option is the ring configuration where the Reyrolle relays are ‘daisy chained.’ That is, the transmit output of the first relay is connected to the receive input of the second relay, and so on until the ring is complete.

Communication to the ring may be achieved either locally in the substation or remotely via the Public Switched Telephone Network (PSTN). If remote communication is desired, then additional modem equipment must be installed.

3.3 Transmission Method

The transmission method is Half Duplex serial asynchronous transmission. In IEC 60870-5-103 the line idle state is defined as Light ON. This can alternatively be selected as Light OFF in the Communications Interface menu of the relay if required for use with alternate hardware (See Section 2.5).

3.4 Transmission Rate

Rates of 19200, 9600, 4800, 2400, 1200, 600, 300, 150, 110 and 75 bits per second (BPS) are provided. Only 19200 and 9600 BPS are standard in IEC 60870-5-103, the additional rates are provided for local or modem communications.

3.5 Line Idle Setting

The line idle setting can be set to be either ON or OFF and the setting must be compatible with the device connected to the relay. The IEC 60870-5-103 standard defines a line idle state of Light On. If the device the relay is connected to, does not have a compatible fibre-optic port then a suitable electrical to optical converter is required to connect it to a standard RS232C electrical interface. A suitable converter is the Sigma 4 type, which is available from Reyrolle Protection.

Alternative converters are the Reyrolle Dual RS232 Port (Sigma 3) or Reyrolle Passive Fibre-Optic Hub (Sigma 1).

1) The Sigma 3 Dual RS232 port provides a fibre-optic interface to a relay and two RS232 ports. The RS232 system port is typically connected to a control system while the second port is a local port. When the local port is in use the system port is automatically disabled. The Sigma 3 has an internal link to switch between line idle Light ON or Light OFF. The default configuration is Light OFF.

2) The Sigma 1 Passive Fibre-Optic Hub provides fibre-optic interfaces for up to 29 relays. It has a fibre-optic port to the control system and multiple relay connections. Each of the 30 fibre-optic ports can be configured for either Light ON or Light OFF operation. Default for all is OFF.

3.6 Parity Setting

IEC60870-5-103 defines the method of transmission as using EVEN Parity. However, in some instances an alternative may be required. This option allows the parity to be set to NONE.

3.7 Address Setting

The address of the relay must be set to a value between 1 and 254 inclusive before any communication can take place. Setting the address to zero disables communications to the relay, although if it is in an optical ring it will still obey the Data Echo setting. All relays in an optical ring must have a unique address. Address 255 is reserved as a global broadcast address.

4 Modems

The communications interface has been designed to allow data transfer via modems. However, IEC60870-5-103 defines the data transfer protocol as an 11 bit format of 1 start, 1 stop, 8 data and 1 parity bit which is a mode most commercial modems do not support. High performance modems, for example, Sonix (now 3Com), Volante and MultiTech Systems MT series will support this mode but are expensive. For this reason a parity setting (see section 2.6) to allow use of easily available and relatively inexpensive commercial modems has been provided. The downside to using no parity is that the data security will be reduced slightly and the system will not be compatible with true IEC60870 control systems.

4.1 Connecting a modem to the relay(s)

The RS232C standard defines devices as being either Data Terminal Equipment (DTE) e.g. computers, or Data Communications Equipment (DCE) e.g. modems. To connect the modem to a relay requires a fibre-optic to electrical connector and a Null Terminal connector which switches various control lines. The fibre-optic converter is then connected to the relay in the following manner :

Fibre-Optic Converter	Relay Connection
Tx	**Rx**
Rx	**Tx**

4.2 Setting the Remote Modem

Most modems support the basic Hayes ‘AT’ command format, though different manufacturers can use different commands for the same functions. In addition, some modems use DIP switches to set parameters while others are entirely software configured. Before applying the following settings it is necessary to return the modem to its factory default settings to ensure that it is in a known state.

The remote modem must be configured as Auto Answer, which will allow it to initiate communications with the relays. Auto answer usually requires 2 parameters to be set. One switches auto answer on and the other, the number of rings after which it will answer. The Data Terminal Ready (DTR) settings should be forced on which tells the modem that the device connected to it is ready to receive data. The parameters of the modem’s RS232C port need to be set to match those set on the relay i.e. baud rate and parity to be the same as the settings on the relay, and number of data bits to be 8 and stop bits 1.

Note: although it may be possible to communicate with the modem at e.g. 19200bps, it may not be possible to transmit at this rate over the telephone system, which may be limited to 14400. A baud rate setting needs to be chosen which is compatible with the telephone system. As 14400 is not available in the relay, the next lowest rate, 9600, would have to be used.

Since the modem needs to be transparent, simply passing on the data sent from the controller to the device and vice versa, the error correction and buffering must be turned off. In addition if possible force the Data Carrier Detect (DCD) setting to ON as this control line will be used by the fibre-optic converter.

Finally these settings should be stored in the modem’s memory for power on defaults.

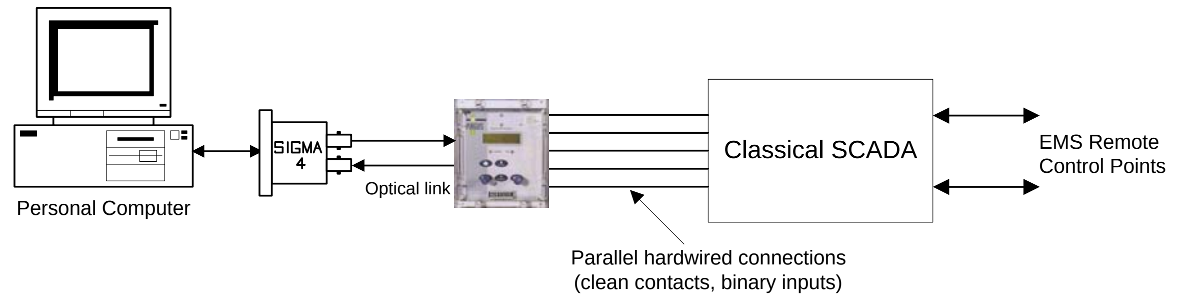
4.3 Connecting to the remote modem

Once the remote modem is configured correctly it should be possible to dial into it using the standard configuration from a local PC. As the settings on the remote modem are fixed, the local modem should negotiate with it on connecting and choose suitable matching settings. If it does not, however, set the local modem to mimic the settings of the remote modem described above.

Appendix A – Communication Connections

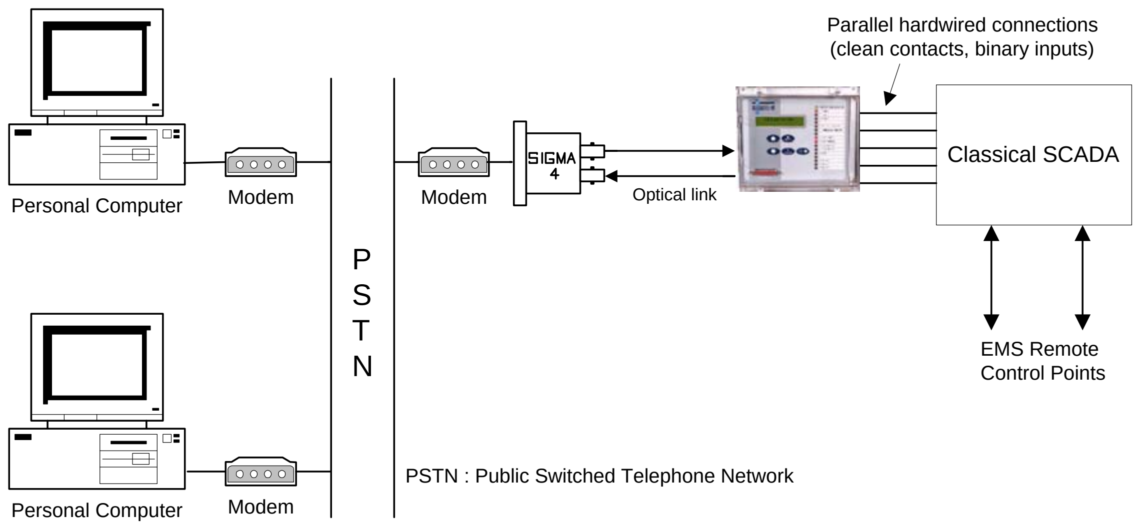
Figures 1 to 6 illustrate a number of methods of connecting relays in communications networks.

Note that in the case of the optical ring configurations (Figure 4, Figure 6 and Figure 7), the Data Echo feature must be switched ON in the communications settings menu of the relay. In all other cases this setting should be set to OFF. In the data echo mode, everything that is received on the fibre optic receiver port is automatically (in hardware) re-transmitted from the transmitter port. This is made possible because of the communications standard IEC 60870-5-103 which operates half-duplex.



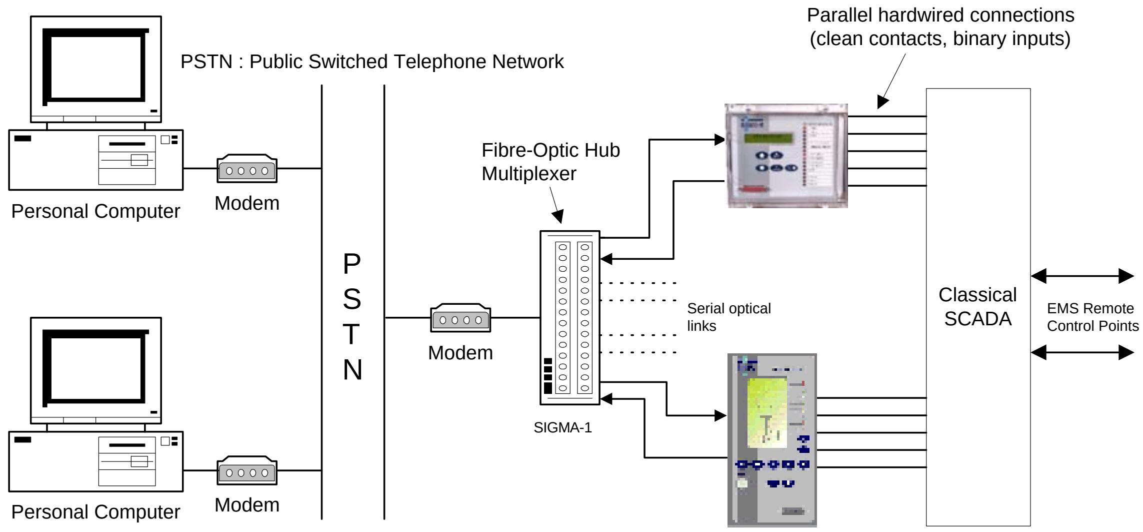
1. Dialogue type comms (connection oriented)
2. Dialogue for purpose of analogue and digital fault waveform extraction and display, setting display and change, event display, instruments etc.
3. Manufacturer specific

Figure 1 - Basic Communications Configuration



- Version of the former configuration of Figure 1. It is necessary to make dial-up connection before actual information exchange.

Figure 2 - Basic Communications Configuration (Remote)



- A more sophisticated version of the former configuration of Figure 2. Several relays within the substation can be accessed via one modem but only one can be communicated with at a time.

Figure 3 - Star Type Configuration (Using SIGMA-1 Multiplexer)

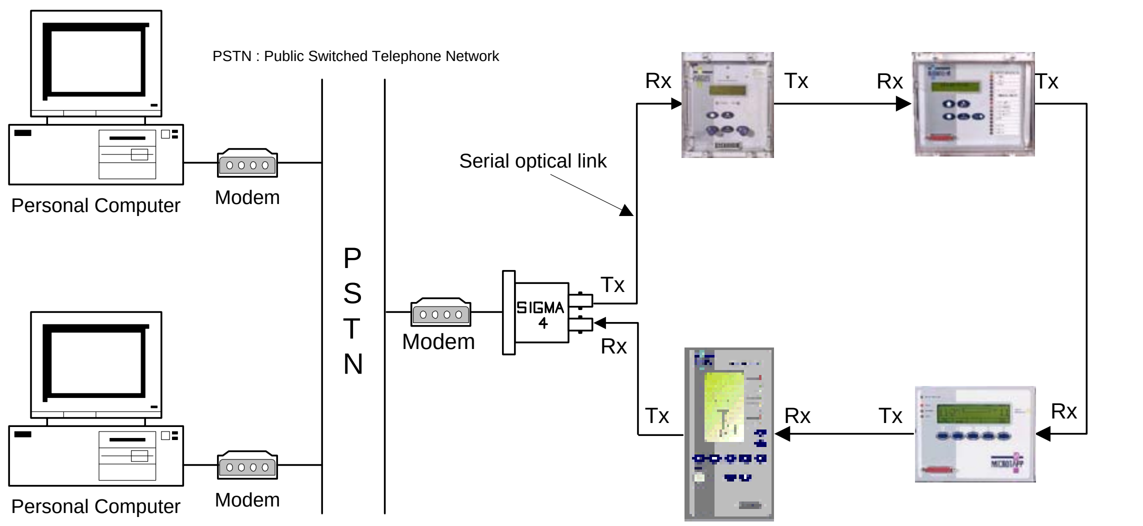


Figure 4 - Optical Ring Configuration (Using SIGMA-4 Fibre/RS232 Convertor)

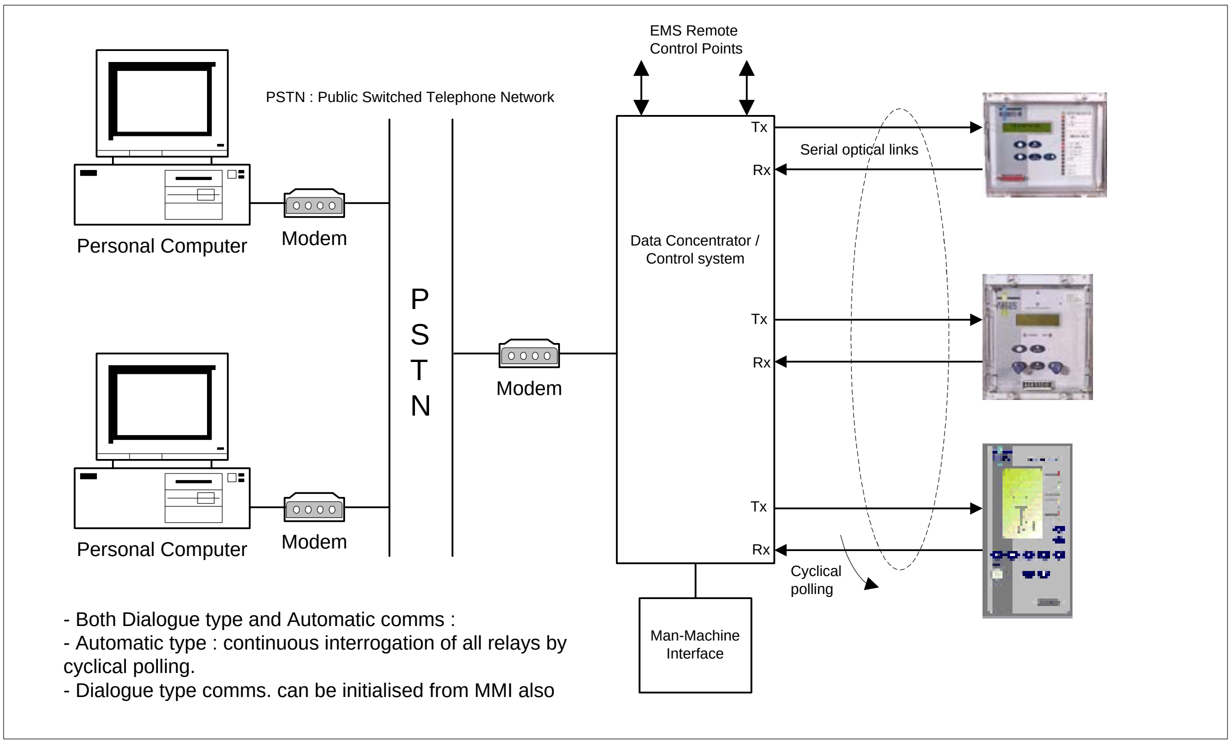


Figure 5 – Direct Control System/Data Concentrator Configuration

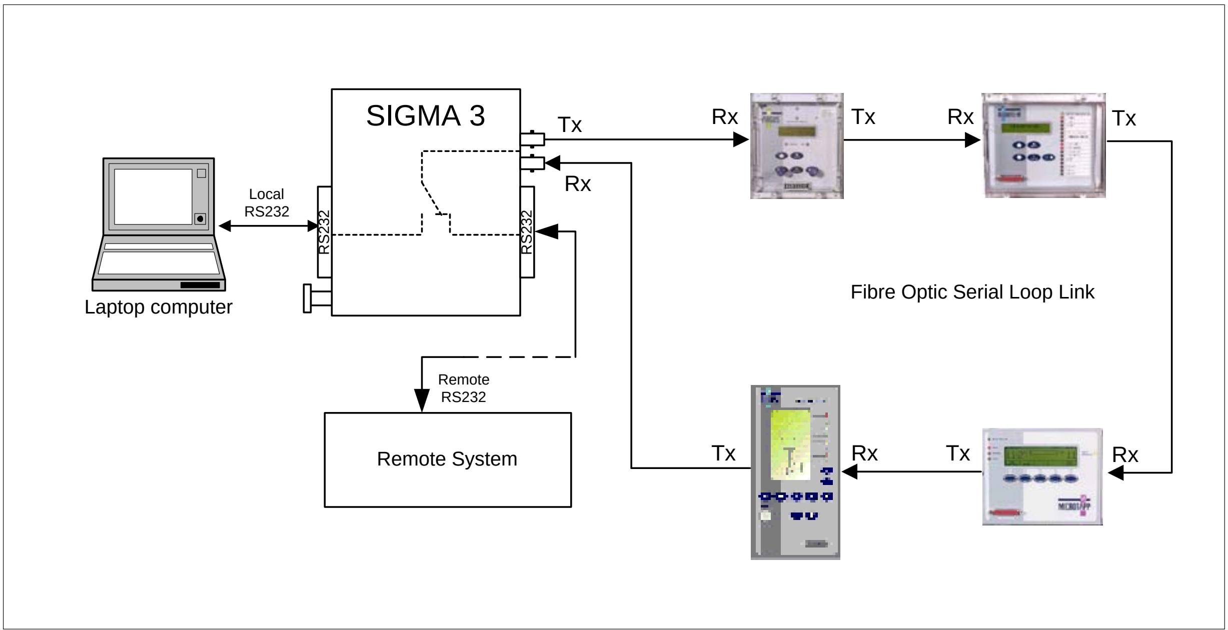


Figure 6 – Automatic switchover remote to local control using the SIGMA-3

When a portable PC is plugged into the front port of a SIGMA-3 then the remote system is automatically disconnected to ensure local control only. Alternatively on Modular II relays the portable PC may be plugged directly into the front fascia RS232 connection.

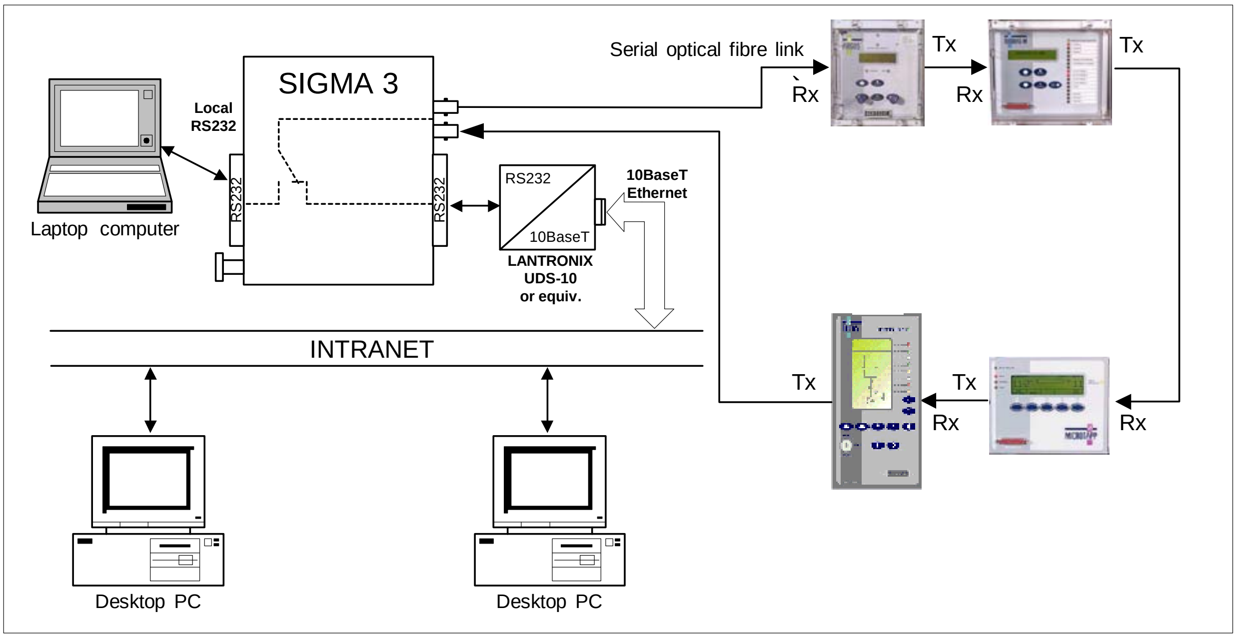


Figure 7 – LAN Network connectivity using a SIGMA-3 + Lantronix UDS-10 or equivalent

A SIGMA-3 unit may be used to as shown in Figure 7 to connect Argus and Modular II protection relays to a local area network via an Ethernet to RS232 convertor such as the Lantronix UDS-10 or similar device. SIGMA-3 units may be used on a per bay or per substation basis. They provide a single point of contact to the protection relays for monitoring and diagnostic purposes.

7SG14 Duobias-M

Transformer Protection

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
Pre release

Revision	Date	Change
	2010/02	Document reformat due to rebrand
R1	26/09/2006	Revision History Added. Reformatted to match other manual sections.

Software Revision History

Contents

FIGURES

Abbreviations

ALF	Accuracy Limiting Factor
CT	Current Transformer
HS	High set setting
I_B	Secondary line current produced by CT with circuit/transformer at full rating
I_F	Maximum fault current
I_N	CT Secondary nominal rating, typically 1A or 5A
N	CT Ratio
R_B	Rated value of the secondary connected resistive burden in ohms
R_{CT}	Secondary winding d.c. resistance in ohms
R_L	CT secondary lead resistance
V_k	CT knee point voltage
VT	Voltage Transformer
τ	Time Constant

1 Introduction

The 'Modular II' Duobias-M builds on the success of the Duobias-M 'Modular I' numerical relay. The differential algorithm of the previous relay has been retained as it was found to be stable for transformer through faults and transformer magnetizing inrush current, whilst allowing fast operation for internal faults. The Duobias-M has a long service history compared with other numerical relays of a similar type, with the first one entering service in 1988. This has enabled Reyrolle Protection to accumulate many years of field experience to date. This knowledge is incorporated into our latest modular II relays.

The main advantages of the new Duobias-M-200 series relays are flexibility in the hardware (case size/ number inputs and outputs) and the inclusion of backup protection functions. The modules that comprise the relay can be withdrawn from the front.

The Modular II relays can be purchased in 3 case sizes:

- E8 – half of 19" x 4U
- E12 – three quarters of 19" x 4U
- E16 – 19" x 4U

Generally, the three case sizes are envisaged to be used in the following applications:

- **E8 – 2 winding** Retrofit differential protection for transformers, generators, motors and reactors. This size relay case provides five output contacts and three status inputs. LED flagging of the operation of external devices such as Buchholz, is therefore limited to three, making this relay suitable for use for retrofit where existing flag relays are to be retained. The relay has 16 LED's that may be programmed to any internal or external protection.

- **E12 – 2 or 3 winding** differential protection for grid transformers and auto transformers with the Duobias-M providing LED flag indication. The number of output contacts and status inputs can be varied to suite the application. The number of status inputs provided can be 3, 11 or 19 and the number of outputs can be 5, 13 or 21. This relay size case has 32 programmable LED's that cab be used to flag internal (e.g. biased differential) or external (e.g. Buchholz or Winding temperature) protection.

- **E16 – 2 to 5 winding/input** applications at EHV or where voltage inputs are required for voltage, frequency functions and Ferro-resonance detection. Low impedance Busbar Protection for up to 8 sets CTs. This relay is suitable for single bus, mesh and 1.5 CB sub-station layouts. The relay is NOT suitable for double bus applications. This size relay case has 32 LED's that may be used to flag the operation of internal or external types of protection.

These relays allow a very flexible way of meeting varying customer requirements in terms of the functionality, number inputs and outputs relays and number and type of analogue CT/V.T. inputs.

1.1 Standard Functions:

- Biased Differential – 87T
- Highset Differential – 87HS
- Flag indication for the operation of all internal and external (e.g. Buchholz) transformer protection and alarm functions
- Fault Recording
- One Front (25 pin RS232) and two Rear (ST Fibre optics) Communications ports
- Trip Circuit Supervision (H6) -74
- Programmable Scheme Logic (ReylogiC).

1.2 Optional Functions:

- Restricted Earth Fault per winding – 87REF
- Over fluxing - Inverse and 2 stage DTL – 24ITL, 24DTL#1 and 24DTL#2
- IDMTL (IEC&ANSI) and/or DTL Backup Over Current - 50/51
- IDMTL (IEC&ANSI) and/or DTL Backup Derived Earth Fault - 50G/51G
- Measured IDMTL/DTL Earth Fault - 50N/51N
- Thermal Overload – 49
- Over/Under Voltage (4 stage) - 59/27
- Over/Under Frequency (4 stage) - 81 O/U
- Stage IDMTL/DTL Standby Earth Fault – 51N SBEF
- Neutral Voltage Displacement – 59N
- Negative Sequence Over current – 46

This list of additional functions is not limited, and functions in addition to those listed may be included upon request.

A spreadsheet of standard relay models is included in the Description of Operation Section of this Technical Manual.

New models with different mixes of protection functions can be made available upon request.

The Duobias-M relay enables all/any of these functions to be performed within one relay case, with the additional capability of allowing remote interrogation of the settings and of the stored fault data. These notes give guidance on the application of the Duobias-M relay and make reference to the Commissioning Chapter that deals with setting-up instructions and testing.

The next section deals with the Standard Features included in all Duobias-M-200 series relays. This range of relay can be identified using their article number, as they all will have a DU3- article number. The rest of this number relates to an individual model.

2 Standard protection functions

2.1 Differential Protection

The word “Duobias” literally means two (duo) types of relay bias are used to make the relay stable. The two types of bias used are magnitude restraint (load) and harmonic content (inrush). The magnitude restraint bias is used to make the relay stable for external (out of zone) through faults as it increases the differential current required for operation as the current measured increases. The harmonic bias is used to prevent relay operation due to flow of pulses of magnetizing inrush current into one winding when the transformer is first energized.

Differential protection applied to two and or more winding transformers is slightly more complicated by the way transformer windings (e.g. Yd1) are connected. This can lead to a phase change between the currents flowing at either side of the transformer. The current entering the zone will also be changed in magnitude before it leaves the zone by virtue of the ratio of turns on the transformer H.V. and L.V. windings.

Considering the change in current magnitude first of all; if the transformer ratio is fixed i.e. it does not have a tap changer, then this can be compensated for in the choice of H.V. and L.V. CT ratios. For example, a transformer of ratio 132/33kV (4/1), would have L.V. CTs with four times the ratio of the H.V. CTs. In this way the H.V. and L.V. primary currents result in identical secondary currents and there is no differential current either under load or through fault conditions.

However, if the transformer is fitted with an on-load tap changer, its nominal voltage ratio can be varied, typically, over a range of +10% to -20%. Since it is not practicable to vary the CT ratios to follow that of the transformer, any deviation from nominal tap will result in the measurement of some differential current. This will reach its maximum when the tap changer is in its extreme position, in this case 20%. In this position, a secondary current equivalent to 20% of the load or through fault current will flow in the differential circuit.

To minimize the differential current measured due to on-load tap changer position, the relay should balance at to the mid-point of the tapping range. For the +10% to -20% example, the CT ratios would be chosen to give balance at the -5% position so that the maximum deviation and differential current should be 15%. The example below shows a single line diagram of a typical transformer with the calculation of the optimum CT ratio.

The Settings to be chosen for this type of protection are:

- Interposing CT Multiplier Settings for each set of inputs to balance the secondary currents
- Interposing CT Connection Settings for Vector Group (phase) Correction.
- Biased Differential Characteristics
- Differential Highset
- Harmonic Restraint level

2.1.1 Magnitude Balance – CT Ratio’s and Multiplier Settings

The relay has 1A and 5A rated terminals for each set of line CTs and any combination of these may be used. The Interposing CT Multiplier range is 0.25 to 3.00x. These facilities provide a wide accommodation for the choice of CT ratios.

In new installations, the CT ratios should be selected so that the secondary currents fed into the relay are as close as possible to the relay nominal rating (1A or 5A), when the transformer is at its maximum nameplate rating. The Interposing CT Multiplier settings can be set to balance the relay when the tap changer is at its middle tap position.

When replacing an older biased differential relays such as C21 with a Duobias-M, existing CTs will normally be re-used. Usually the interposing CTs associated with the old scheme can be removed as the vector group compensation and current magnitude compensation is done by the Duobias-M software settings. Any sets of CTs connected in 'Delta' should be reconnected is 'star', as the standard Duobias-M connection is to have all CTs in 'star'. This helps simplify the a.c. scheme.

The Interposing CT (ICT) multiplier settings range of 0.25 to 3.00 and 1/5A rated inputs per winding, can be used to achieve perfect balance in almost all cases. A perfectly balanced relay should have virtually no differential current and nominal bias current, when the transformer is at full load rating and the tap changer is at its middle tap position. By balancing the relay bias current to nominal, the relay biased differential characteristics are matched for transformer through faults, and therefore relay sensitivity is optimized for internal faults. If an internal fault occurs the relay will measure sufficient operate current to ensure a fast operate time.

The fact the ICT Multiplier may be selected to 3.0 allows a CT ratio to be selected to produce a secondary current of 0.33 x In, for a load current of full transformer rating. This assists if the in reducing the CT burden should the differential zone cover a long section of the system. Circuits of up to 4.5km are currently protected by Duobias-M. If the zone is long (greater than 1km) it is recommended to used 1A rated CTs as this will also assist in keeping the CT burden down.

2.1.1.1 Example 1 – New two winding application

132/33KV 90MVA Yd11 Transformer
Tap Changer range: +10% to -20%

Step 1 – Choice Line CT Ratio's
If possible 1A rated CTs should be used, as the CT burden is much less than if a 5A CT is used.

HV load current = 90 MVA / (√3 x 132kV) = 393.65A
Standard CT ratio of 400/1A selected.

LV load current = 393.65 x 132/33 = 1574.59
Standard CT ratio of 1600/1A chosen

Step 2 – Selection of Interposing CT Multiplier Settings
The Duobias-M multiplier settings can now be chosen

HV Secondary current = 393.65/400 * 1/0.95 = 1.036A
HV ICT Multiplier = 1 /1.036 = 0.97

Note, the 0.95 factor relates to the voltage produced with the tap changer at mid-tap position.

LV Secondary current = 1574.59/1600 = 1.02
LV ICT Multiplier = 1 /1.02 = 0.98

Both HV and LV secondary wiring should be connected to 1A rated input terminals on the relay.

2.1.1.2 Example 2 – Retrofit of a two winding application

45MVA, 132/33kV Dyn1Transformer with 300/1A HV and 560/0.577A CTs.
Tap Changer range: +5 to –15%

Step 1 – Connection of CTs

The older schemes using relays such as the Reyrolle C21 to 4C21 often required HV CTs to be connected in 'star' and LV CTs in 'delta' (or vice-versa). The relays also used external interposing CTs to correct for phase shift across the transformer. The Duobias-M uses software settings to replace the interposing CTs. It uses all CTs connected in star as its standard. It is common practice to re-use existing CTs when upgrading protection.

Remove Interposing CTs from the secondary circuit.

Connect all CT secondary wiring in star.

Nominal HV load current = 45 MVA / (√3 x 132kV) = 196.82A

Re-use 300/1A CTs.

Nominal LV load current = 196.82 x 132/33 = 787.28

Re-use 560/0.577A CTs.

Step 2 – Select Interposing CT Multiplier Settings

The Duobias-M multiplier settings can now be chosen

HV Secondary current = 196.82/300 * 1/0.95 = 0.69A

HV ICT Multiplier = 1 /0.69 = 1.45

Note, the 0.95 factor relates to the voltage produced with the tap changer at mid-tap position.

LV Secondary current = 787.28 x 0.577/560 = 0.81A

LV ICT Multiplier = 1 /0.81 = 1.23

Both HV and LV secondary wiring should be connected to 1A rated input terminals on the relay.

2.1.1.3 Example 3 – Retrofit of a three winding application

It is worth looking at the application of the relay to three winding transformers. The balance of the relay is slightly more difficult as all of the windings usually have different ratings. To work out the CT ratios to use and ICT multiplier settings to apply the highest rated winding is used.

Three winding 60/40/20MVA 66/33/11kV YNyn0d11Transformer with a +10 –20% OLTC.

66kV rated current at middle tap = 60MVA / (66kV x √3 x 0.95) = 106.32A

CT ratios of 200/1A are present and are to be reused.

W1 (66kV) secondary currents = W1 rated / W1 CT ratio = 106.32/200 = 0.875A

W1 ICT Multiplier = 1/0.875 = 1.14 x

The currents in the 33kV and the 11kV windings will combine and will balance the currents in the 66kV winding. Therefore the relay balance is based on 60MVA of transformed power.

33kV rated current = 60MVA / 33kV x √3 = 1049.73A

The existing CTs with a ratio of 600/1A are to be used.

W2 (33kV) secondary current = W2 rated / W2 CT ratio = 1049.73/600 = 1.75A

W2 ICT Multiplier = 1/1.75 = 0.57 x

11kV rated current = 60MVA / 11kV x √3 = 3149.18A

The existing CTs with a ratio of 1600/1A are to be used.

W3 secondary current = W3 rated / W3 CT ratio = 3149.18/1600 = 1.97A*

W3 ICT Multiplier= 1/1.97 = 0.51 x

Transformer Ynyn0	W1	W2	W3
Voltage (kV)	66	33	11
Rating (MVA)	60	40	20
CT Ratios	200/1	600/1	1600/1
ICT Multipliers	1.14	0.57	0.51
ICT Connection	Yd11	Yd11	Yy0

* the relay inputs have a continuous rating of at least three times the rating of the input.

2.1.2 Interposing CT Connection Setting (Vector Group Correction)

A table showing the settings to apply to for all of the possible transformer vector groups is included on the following page. This provides a quick method of choosing the correct settings. If further clarification of the purpose of this setting is required please read further.

The phase angle of line currents flowing on either side of a power transformer may not be the same due to the connections adopted on the transformer windings. This requires an Interposing CT connection setting to be programmed into the relay to correct this difference in angle. Once corrected the phase angle of the ICT Relay Currents per phase should be in anti-phase.

The sets of line CTs forming the differential zone of protection should all be connected in ‘star’. Sometimes Phase crossovers will occur within the zone of protection and this is best corrected by rotating the secondary phase wiring to mirror the primary connections.

The addition of an earthing transformer on the LV side of transformer provides a path for earth fault current to flow. Usually this earthing transformer is within the zone of the differential protection. If an external earth fault occurs, the flow of fault current may lead to the differential function operating for an out of zone fault. To prevent this false operation, a Ydy0 setting is selected on the LV side (W2) input. This removes the zero sequence current from the differential measurement and makes the differential stable.

As a general rule, transformer windings connected as Yd or Dy have the phase angle ICT Connection setting to correct the phase angle difference, applied to the star side winding.

Some specific examples are included in the Appendices at the end of this section. These applications deal with the more complicated connections and vector group settings in some detail. The current distribution is shown to clarify the way the relay balances for an external fault. This may be used to explain relay indication when an operation has occurred.

2.1.3 Interposing CT Selection Guide

Power Transformer Vector Group	HV Interposing CT Selection	LV Interposing CT Selection
Yy0, YNy0, Yyn0, YNyn0, Ydy0, Yndy0, Ydyn0, Yndyn0, Dz0	Yd1,-30°	Yd1,-30°
Yd1, YNd1	Yd1,-30°	Yy0,0°
Yd1, YNd1 + Earthing Transformer	Yd1,-30°	Ydy0,0°
Yy2, YNy2, Yyn2 YNyn2, Ydy2, YNdy2, Ydyn2, Yndyn2, Dz2	Yd3,-90°	Yd1,-30°
Yd3, YNd3	Yd3,-90°	Yy0,0°
Yd3, YNd3 + Earthing Transformer	Yd3,-90°	Ydy0,0°
Yy4, YNy4, Yyn4, YNyn4, Ydy4, YNdy4, Ydyn4, Yndyn4, Dz4	Yd5,-150°	Yd1,-30°
Yd5, YNd5	Yd5,-150°	Yy0,0°
Yd5, YNd5 + Earthing Transformer	Yd5,-150°	Ydy0,0°
Yy6, YNy6, Yyn6, YNyn6, Ydy6, YNdy6, Ydyn6, Yndyn6, Dz6	Yd7,150°	Yd1,-30°
Yd7, YNd7	Yd7,150°	Yy0,0°
Yd7, YNd7 + Earthing Transformer	Yd7,150°	Ydy0,0°
Yy8, YNy8, Yyn8, YNyn8, Ydy8, YNdy8, Ydyn8, Yndyn8, Dz8	Yd9,90°	Yd1,-30°
Yd9, YNd9	Yd9,90°	Yy0,0°
Yd9, YNd9 + Earthing Transformer	Yd9,90°	Ydy0,0°
Yy10, Yny10, Yyn10, YNyn10, Ydy10, YNdy10, Ydyn10, Yndyn10, Dz10	Yd11,30°	Yd1,-30°
Yd11, Ynd11	Yd11,30°	Yy0,0°
Yd11, Ynd11 + Earthing Transformer	Yd11,30°	Ydy0,0°
Dy1, Dyn1	Yy0,0°	Yd11,30°
Dy1, Dyn1 + Earthing Transformer	Ydy0,0°	Yd11,30°
Dy3, Dyn3	Yy0,0°	Yd9,90°
Dy3, Dyn3 + Earthing Transformer	Ydy0,0°	Yd9,90°
Dy5, Dyn5	Yy0,0°	Yd7,150°
Dy5, Dyn5 + Earthing Transformer	Ydy0,0°	Yd7,150°
Dy7, Dyn7	Yy0,0°	Yd5,-150°

Dy7, Dyn7 + Earthing Transformer	Ydy0,0°	Yd5,-150°
Dy9, Dyn9	Yy0,0°	Yd3,-90°
Dy9, Dyn9 + Earthing Transformer	Ydy0,0°	Yd3,-90°
Dy11, Dyn11	Yy0,0°	Yd1,-30°
Dy11, Dyn11 + Earthing Transformer	Ydy0,0°	Yd1,-30°

Notes

1. Y or y denotes an unearthed star connection on the HV or LV side of the transformer respectively.
2. YN or yn denotes an earthed star connection on the HV or LV side of the transformer respectively.
3. D or d denotes a delta connection on the HV or LV side of the transformer respectively.
4. Z or z denotes a zigzag connection of the HV or LV side of the transformer respectively

2.1.4 Biased Differential Characteristic

87 Inrush Element (Enable, Disable)

When a transformer is energized it will experience a transient magnetizing inrush currents into its energised winding. These currents only flow into one transformer winding and the level would be sufficient to cause the biased differential relay to falsely operate. To prevent the relay operating for this non-fault condition, the presence of even harmonics in the wave shape can be used to distinguish between inrush currents and short circuit faults.

For most transformer applications this setting must be selected to [Enabled]. For certain applications of the relay to auto-transformers, shunt reactors and busbars the [Disable] setting may be selected.

87 Inrush Bias (Phase, Cross, Sum)

This setting defines the method of inrush inhibit used by the relay. Each of the three selections has specific reasons why they are chosen. The relay setting is expressed as the percentage of the even harmonic (2nd and 4th) divided by the total r.m.s. current in the differential signal.

If the relay does not have this setting available in it menu, the relay uses the cross method.

The definition of the methods and their use are as follows:

Phase – The even harmonic content in each phase is measured and compared to the total operate current in this phase. Therefore the each phase of the biased differential elements is blocked by even harmonic content in its own phase only. This method is used exclusively where large transformers are manufactured with three separate phase tanks containing a phase core. This is done to make transportation to site easier. Each phase cores are therefore not magnetically affected by the flux in the other phase cores.

These large single phase transformers are often auto-transformers used on EHV transmission systems. A typical setting level for this application is 18% of Id.

Cross – Each phase is monitored and if the even harmonic present in any phase exceeds the setting then all three phases are blocked. This method will be used for the vast majority of applications of the relay to power transformers. This method is identical to that used in the original Modular 1 Duobias-M relay.

Most existing Duobias-M transformer differential relays use this method, and are stable when set to 0.20 x Id.

Sum – The level of even harmonic current (2nd and 4th) in the differential signal for each phase is measured. The square root is taken of each of these even harmonic currents and these three values summated. This single current level is then divided by the Inrush Setting to arrive at the Harmonic Sum with which each of the phase currents are compared.

If the operate current in any phase is greater than this Harmonic Sum then its differential element will operate.

The advantage of this method is it allows fast operation of the biased differential element, if the transformer is switched onto an internal phase to earth fault. The cross method may suffer from slowed operation for this situation, as healthy phase inrush may block all three phases (including the one feeding the fault current) from operating. Where REF is used to protect the winding, the slowed operation is not critical as the REF will operate very fast, typically in about 20ms for this rare condition.

The Sum method is not slowed down when switching onto an in zone earth fault, as the Harmonic Sum is reduced by the presence of the fault current and therefore allows relay operation.

Typically the Sum method will allow the biased differential elements to operate in the normal time of about 30ms, if a transformer earth fault occurs when it is energised.

This method works in a similar way to the C21 range of Reyrolle relays. This setting is recommended if REF is not used to protect the windings for earth faults on effectively earthed power systems. The recommended setting that offers a good compromise between stability for typical inrush currents and fast operation for internal faults is 0.15 x Id.

87 Inrush Setting (0.1 to 0.5 x Id)

This defines the levels of inrush used in each of the above methods.

The setting applied will determine the level of even harmonic (second and fourth) content in the relay operating current that will cause operation of the relay to be inhibited. The lowest setting of 10% therefore represents the setting that provides the most stability under magnetising inrush conditions. In practice nearly all Modular I Duobias-M numerical relays were set to the default of 20% and to date no false operations due transformer magnetizing inrush current of any description have been reported. This is real proof of the design of the inrush inhibit or restraint used in these relays is technically sound as these relay have in service experience since 1988.

The recommended settings for each method are:

Phase – 0.18 x Id

Cross – 0.20 x Id

Sum – 0.15 x Id

These setting provide a good compromise between speed of operation of internal faults and stability for inrush current. Generally the above values will be stable for most cases, but in rare cases may not prevent relay operation for all angles of point on wave switching, and the setting may require being lower slightly. If the relay operates when the transformer is energised, the waveform record should be examined for signs of fault current and the levels of harmonic current.

Set to 20% unless a very rare false operation for inrush occurs. In which case a lower setting should be adopted after checking the Duobias-M waveform record for the presence of fault current.

87 Biased Differential, Initial Setting (0.1 to 2.0 x In)

This is the level of differential current, expressed as a percentage of the chosen current rating, at which the relay will operate with the bias current around normal load levels. This setting is selected to match the percentage on load tap-change range. For example if the tap change range is +10% to –20%, a setting of 30% would be chosen.

Differential, Bias Slope Setting (0.0 to 0.7 x In)

Some unbalance current will appear in the differential (operate) circuit of the relay for predictable reasons, e.g. due to the transformer tap position, relay tolerance and to CT measurement errors. The differential current will increase with increasing load or through fault current in the transformer so, to maintain stability, the differential current required for operation must increase proportionately with bias current. The bias slope expresses the current to operate the relay as a percentage of the biasing (restraint) current. The Differential, Bias slope setting chosen must be greater than the maximum predictable percentage unbalance.

A setting based on the tap change range plus a small CT error must be made. For example if the tap change range is +10 to –20%, the overall range is 30%. The relay and CT composite error may be 2%, so this produces and overall requirement for 32%. The relay is set in 0.05 x In steps so a 35% setting should be adopted.

Differential, Bias Slope Limit Setting (1 to 20 x In)

The purpose of this setting is to ensure the biased differential function is stable for through faults. It does this by increasing the ratio of differential current to bias current required to operate the relay above this setting.

When a through fault occurs, some CT saturation of one or more CTs may cause a transient differential current to be measured by the relay. This setting defines the upper limit of the bias slope and is expressed in multiples of nominal rated current. A setting value must be chosen which will ensure the bias slope limit introduces the extra bias at half of the three phase through fault current level of the transformer.

If an infinite source is considered connected to the transformer, the three phase through fault level can easily be estimated from the transformer impedance. For a typical grid transformer of 15% impedance, the maximum through fault will be 1/0.15 = 6.66.

The setting should be selected to half of this value, so 6.66/2 = 3.33 and a setting of 3 would be selected as it nearest lower available setting. The Bias Slope Limit is set in the range of 1 to 20 x In. The lower this setting is selected to the more stable the biased differential function becomes.

Differential Highset (1 to 30 x In)

This is an unbiased differential setting with a range of settings expressed as a multiple of the nominal current rating. This element is use to provide very fast clearance of transformer terminal faults. It also helps in reducing the kneepoint voltage requirements of the CTs.

It is NOT a highset Overcurrent element, as it operates on the differential current measured by the relay.

This function should always be used, as it provides very fast operation for terminals faults. It also is used to calculate the CT requirements.

The Differential Highset setting must consider the maximum through fault and the level of magnetising current. The high set should be set as low as possible but not less than the maximum three phase through fault current and not less than half the peak magnetizing inrush current.

For almost all applications a setting of 7 or 8 x In has shown to be a good compromise between sensitivity for internal faults and stability for external faults. Only in very rare cases will a higher setting be required. A Differential Highset Setting of 7 x In will be stable for a peak magnetizing inrush levels of 14 x rated current. Smaller rated transformers will have greater three phase through fault levels and experience larger magnetizing currents. A setting of 8 x can be used as CT saturation is reduced as system X/R is usually very low and the peak level of magnetising current does not usually ever exceed 16 x rating.

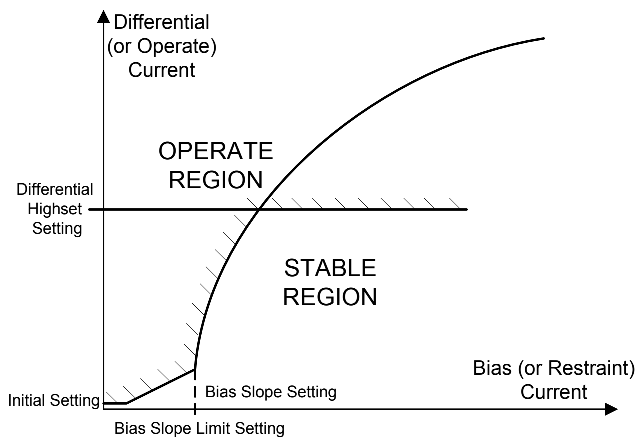


Figure 1- Biased Differential and Highset Differential Characteristics

2.2 LED Flag Indication

The Duobias-M relay has 16 (E8 case) or 32 (E12 and E16 cases) LED's to provide indication of the operation of internal protection functions, and the external protection devices fitted to the transformer. These external devices may include Buchholz Trip (Surge), Winding Temperature Trip and Pressure Relief Device. The alarm and trip indications can be flagged on the front of the relay. This saves the cost of flag relays and engineering. The other advantage is these external trip signals can be programmed to trigger waveform storage. This allows an easy method of checking for the presence of fault current. An LED Menu is included in the relay so that any protection function or Status Input can be mapped to any LED. The LED Labels may be changed very easily, as the paper slips may be removed. They are accessed by opening the front fascia door.

The recommended method for connecting external devices that trip circuit breakers should be connected as shown on the connections diagram at the end of this section. Each external tripping device requires a blocking diode. These segregate the LED flag indications and provide a direct trip should the Duobias-M supply be lost. The Status Inputs used to indicate trips may be programmed to operate the Duobias-M trip contacts to back up the tripping through the blocking diode. The alarm indications do not normally require a blocking diode.

2.3 Trip Circuit Supervision (TCS)

Any of the Status Inputs may be used to monitor the state of a trip circuit.

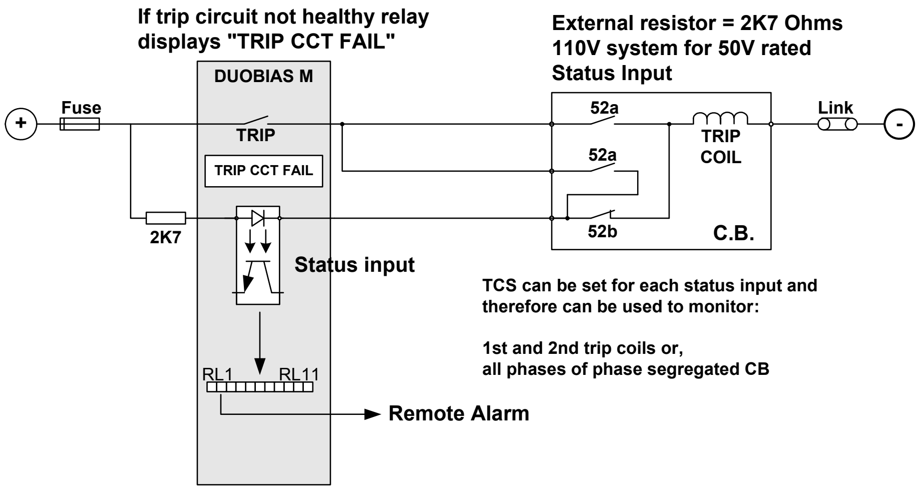


Figure 2 - Trip Circuit Supervision Connections

The 2K7 resistor is only needed to drop the dc voltage from 110V to the 48V rating of the status input. The relay may be purchased with 110V status inputs.

To use a Status Input for Trip Circuit Supervision Monitor:

Select that Input to “Trip Circuit Fail” and “Inverted Input” in the STATUS INPUT MENU. An automatic 400ms delay on pickup time delay is included when a Status input is allocated as a “Trip Circuit Fail” Input. A normally open output contact should be mapped to the Trip Circuit Fail Status input to provide an alarm contact to a remote point. The TCS alarm operation will also be logged as an IEC event.

Where strict compliance with the BEBS S15 Trip Circuit Supervision Standard is required, the relay must be specified with 48V rated status input. The 2K7 dropper resistors will then be required for the status inputs with a standard 110v dc tripping system.

Revision 14 and newer software relay models have a more flexible trip circuit supervision scheme which allows for multiple blocking inputs for each trip circuit that is supervised.

3 Optional protection functions

The Duobias-M relay can be specified to include the following optional protection functions:

- Restricted Earth Fault
- Over fluxing/Excitation
- Backup Over Current and Earth Fault (Measured or Calculated from Line CT inputs)
- Thermal Overload
- Circuit Breaker Fail
- Under and Over Voltage
- Under and Over Frequency
- Negative Sequence Over current

3.1 Restricted Earth Fault (REF)

The REF protection provides an extremely fast, sensitive and stable method of detecting winding earth faults. It is a unit type of protection and will only operate for earth faults within its zone of protection. It is inherently more sensitive and provides greater degree of earth fault protection to the transformer winding than biased differential protection. For a solidly earthed star winding, the REF function is roughly twice as sensitive in detecting a winding earth fault, than biased differential protection. Therefore its use is highly recommended and is the reason why is present in the Duobias-M range of relays.

Note REF protection is not slowed down at all if the transformer is switched onto an in zone fault, and will assist in providing high speed fault clearance for all fault conditions.

The Restricted Earth Fault (REF) must remain stable under switching and through fault conditions. This is achieved with by including stabilizing resistors in series with the REF current measuring input. The combination of the relay setting and value of resistor form a stability voltage setting. The REF input may also be used as a balanced earth fault (BEF) protection for ‘delta’ connected windings or a Sensitive Earth Fault (SEF) element.

As of May 2006 the Duobias-M REF input was altered to allow the same sensitivity as the original Modular 1 relay, i.e. a 0.005 x In setting. This new type was named SREF (sensitive restricted earth fault). This type of module will be supplied on all subsequent relay.

The normal REF input has a setting range of 0.020 to 0.960 x In for pickup and 0 to 864000 seconds for time delay. The time delay would only normally be set when the element is used for SEF protection.

Note where 5A rated line CTs are used for REF protection the recommendation is to use the 1A rated REF input so that sensitive settings and small setting steps are possible.

The procedure for establishing the relay settings and resistor values is explained in our publication "Application Guide, Restricted Earth Fault". This may be downloaded from our web site; www.reyrolle-protection.com, (Publications-> Technical Reports)

3.2 Over fluxing Protection (Volts/Hertz)

This type of protection should be included on all generator step-up transformers. Other types of power transformer that may have to withstand a sustained application of system over voltage should also be protected against over fluxing.

This type of function is necessary to protect the transformer from excessive heat generated when the power system applies excessive voltage to the transformer. The transformer core will saturate and some of the magnetic flux will radiate as leakage flux through the transformer tank. This leakage flux causes eddy currents to be induced into the transformer tank. The I2R losses from these currents heat the transformer tank. As this condition causes overheating of the transformer tank and core, an inverse V/f protection characteristic best matches the transformer over-excitation withstand.

This function uses the ratio of voltage to frequency (volts per hertz) applied the transformer to determine operation. The V/f ratio relates directly to the level of flux produced.

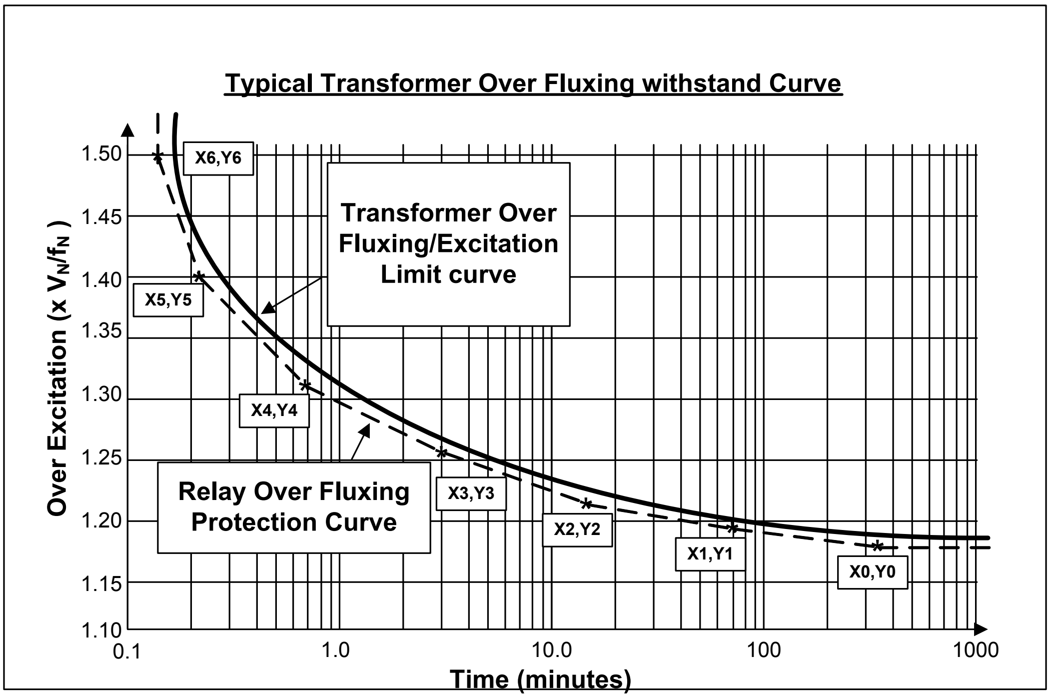
The relay has two types of V/f characteristics:

- User Definable Inverse curve
- Two Independent Definite Time Lag elements(DTL)

User Definable V/f Curve

As the leakage flux will cause overheating, an inverse type curve will be used to match the over fluxing protection characteristic of the relay with the withstand limit of a particular transformer. Therefore the relay includes an easy to set user definable curve if the Volts per Hertz withstand is known. The over excitation withstand curve can be obtained from the transformer manufacturer. The use of the inverse curve allows for the maximum scope for some limited over fluxing occurring whilst preventing damage.

Unfortunately withstand curves provided by transformer manufacturers have the V/f applied shown on the Y axis and the time on the X axis. Protection relays have this in reverse so it is necessary to tabulate the points required that approximates to the user definable curve. The advantage of using these seven points it makes it very easy for the inverse V/f curve to be matched to the transformer withstand curve, without the need for equations or a spreadsheet.



	Y (seconds)	X (x V_N/f_N)
X0,Y0	20000	1.17
X1,Y1	480	1.19
X2,Y2	780	1.22
X3,Y3	180	1.26
X4,Y4	39	1.31
X5,Y5	13	1.40
X6,Y6	8	1.50

Note the transformer withstand is normally shown with the applied over fluxing/excitation variable on the Y axis and the wihstand time on the X axis. Protection characteristics are always drawn with the time on the Y axis and the V/f on the X axis. The table to the left indicates the values applied to the protection characteristic.

Figure 3 - Inverse V/f Over Excitation Protection

Two Stage DTL Over fluxing

In addition to the inverse curve, two independent DTL V/f elements are included and are used where the over excitation withstand curve of the transformer is not known. In this case the inverse V/f curve should be set to [Disabled] and both DTL elements should be set to [Enabled]. The default DTL settings are adequate to protect almost all transformer designs, and can be used with confidence.

3.3 Backup Over current and Earth Fault (50/51/50N/51N/50G/51G)

These elements are often supplied as separate backup relays for the HV and LV side of the transformer circuit. To reduce cost and complexity some customers will accept the backup protection as part of the main protection relay. The relay is fully supervised and will alarm for a loss of its auxiliary dc supply or if a hardware fault is detected. This supervision feature provides justification for allowing the backup protection to be included as part of the main differential protection relay.

The following elements can be included:

- Three phase over current with one IDMTL (IEC or ANSI) and three DTL/instantaneous elements (50/51)
- Derived Earth Fault with one IDMTL (IEC or ANSI) and three DTL/instantaneous elements (50G/51G)
- Measured Earth Fault with one IDMTL (IEC or ANSI) and three DTL/instantaneous elements (50N/51N)
- Standby Earth Fault with two IDMTL (IEC or ANSI curve) or DTL elements. (50SBEF, 51SBEF)
- Sensitive Earth Fault with two DTL elements (50SEF, 51SEF)

These elements can be selected to any or all of the sets of CT inputs.

Voltage controlled elements can be realized by using an under voltage element to supervise an over current or earth fault element. The simple logic scheme can be written in ReylogiC script for the relay.

Grading between other relays and fuses is always possible as all of the IEC and ANSI inverse curves are available. Often highset over current protection on the HV side of a transformer is arranged to trip the LV circuit breaker first and then a short time later the HV circuit breaker in a two stage Overcurrent protection.

Multiple stages of backup over current and earth fault functions can very easily be included. The derived earth fault function is useful where a dedicated neutral CT is not provided or available.

3.4 Over and Under Voltage (27/59)

There are four elements (1-4) included in this function. Any of them can be selected to either under or over voltage. Each element can be applied in the following way:

Voltage Stage (1-4)	Enable/Disable
Voltage Stage (1-4) Operation	Under/Over
Hysteresis (Drop off as % of Pickup = 1 – Hysteresis setting)	0 to 80%
Setting	0.01 to 2.5 x Vn
Time Delay	0 to 240 hours

These elements can be used to protect the insulation if excessive voltage is applied. The excessive voltage may occur if a tap changer runs away in the high voltage direction, if the AVR generator equipment malfunctions or if control of reactive compensation malfunctions. Voltage elements may also be graded with other voltage protection devices such as arcing horns and surge arrestors.

A non-energized power system can be detected by an under voltage element set with a large hysteresis setting. Another application of an under voltage element is for voltage control of over current elements.

Some utilities are also starting to adopt a four-stage under voltage as oppose to under frequency load shedding scheme, as it allows feeder tripping to be faster. Other utilities are now implementing a combined under frequency and voltage scheme to reduce the time required for each load shed stage.

The faster the power system can be brought into balance between generation and load, the greater the chance the system will stabilize.

3.5 Under and Over Frequency (81 U/O)

There are four elements or stages included in this function. Any of them can be selected to either under or over frequency. Each element can be selected to the following settings:

Frequency Stage #	Enable/Disable
Frequency Stage # Operation	Under/Over
Hysteresis (Drop off as % of Pickup = 1 – Hysteresis setting)	0 to 80%
Setting	0.01 to 2.5 x fn
Time Delay	0 to 240 hours

The main application of these elements is for load shedding. The transformer incomers provide a convenient position from which to monitor the balance between load MW demand and generated Mw's. The power system frequency will drop if the

The Duobias-M relay can be supplied with extra output contacts (up to 29) for direct tripping of the outgoing feeders at each stage of the load shed. A load shedding scheme with an under voltage and under frequency setting per stage is now being adopted to provide a faster method of balancing load and generation. It is possible to combine relay outputs to do a four stage Under Voltage and Under Frequency load shedding scheme that is favoured by some utilities.

Over frequency protection is usually used on generator protection. A short-circuit fault generally cause the generator to increase frequency as the real power demand from the fault will be less than when feeding a normal load.

3.6 Thermal Overload (49)

Transformer design has changed over the years, with less and less metal being used per MVA of transformed power. This has reduced the withstand time a transformer can be allowed to be run in an over loaded state. It is becoming more important to provide an additional thermal protection to supplement the Winding Temperature device. A thermal protection function within the Duobias-M can be used to provide alarm and trip stages. Global warming and high peak ambient temperatures also can impinge on the thermal capacity of a given transformer design.

The difficulty in using these types of functions is arriving at suitable settings. Thresholds for both alarm and trip levels are included in the Duobias-M relay and the default settings are recommended if transformer data is not available. These default setting correspond to the lowest level of thermal withstand for an oil filled transformer

This function provides a general overload and not a winding hot spot protection functions, as it does not contain a hot thermal curve. Thermal overload protection is not provided by over current type protection, as these elements do not track the thermal state during normal load conditions.

The costs of overloading transformers are:-

- Reduced life expectancy. The insulation will chemically degrade at a faster rate for an increase in the working temperature of the windings.
- Lower insulation voltage withstand.
- Increased Mechanical stress due to expansion.
- Mineral Oil will degrade at faster rate and has a lower flashpoint.
- Gas bubble production in the mineral oil has been known to occur at extreme levels of overload.

Primary Plant items such as transformers, cables, reactors and resistors are recommended to have some type of thermal protection.

Setting the Thermal Overload Function.

The method of setting this function would be as follows.

1. Select Source side winding

For Grid Transformers the source side will normally be the HV side (normally W1 inputs).

For Generator Step up Transformers the source side will be the LV side (normally W2 inputs).

The Duobias-M relay has windings allocated Winding 1(W1), W2 etc, as up to 5 sets of CTs may be connected. Normally the highest voltage winding is connected to W1 set inputs and so on. The W1 input is marked as AN1 (Analogue 1) on the rear of the relay.

2. Enabled the Thermal Overload Function

The Thermal Overload Function has a Default setting of [Disabled]. It must be set to [Enabled].

3. Calculate the Overload Pickup Setting (I_Θ)

This setting should be set to 110% of the secondary current flowing when the transformer is at its full rating and on its minimum voltage tap position.

4. Select the Thermal Time Constant Setting (□)

This is the most difficult part of setting this function. As a general guide, most Grid Transformers are specified to run at 150% of Full Rating for two hours or 200% of rating for one hour. Utilities will differ as to the level of overload their transformers are specified to withstand.

The thermal time constants required to match these specifications are:

150% for two hours	Time constant = 178 minutes

200% for one hour	Time constant = 186 minutes

These times are applicable to an overload occurring from no load with the transformer at ambient temperature.

The actual tripping time will depend on the loading level prior to the overload occurring.

The operate time can be calculated from:

Time to trip $t(mins) = \tau \times \ln\left\{\frac{I^2}{I^2 - (I_\theta)^2}\right\}$

The steady state % thermal capacity used can be calculated from:

$$\%\ thermal\ capacity\ used = \left(\frac{I^2}{(I_\theta)^2}\right) \times 100$$

Where:

I = applied current in terms of x I_n

I_Θ = thermal pick-up setting x I_n

5. Capacity Alarm

This setting provides a means to alarm prior to a thermal trip occurring. This setting will usually be set to about 80 to 90 % of thermal capacity. The trip function operates at the point when 100% thermal capacity used is reached. The thermal capacity alarm will usually be mapped to a normally open output contact wired to the control system.

Example

45MVA Grid Transformer, 132kV/33kV, +5% to –15% Tap Changer, HV CTs 300/1 A

1. As the transformer is a Grid Transformer the direction of real power flow will be HV -> LV. If W1 input is connected to HV CTs (as is usual) select W1 for the current measurement.

2. Set Thermal Overload to [Enabled].

3. The Overload Setting is calculated as follows:

   Maximum Primary Full Load current = 45000/(132 x 0.85 x √3) = 231.5A

   Secondary Current = 231.5A / 300 = 0.772A. The thermal function should never trip for currents below this value.

   A setting margin of 110% is included to add a margin of safety.

   The Overload Setting to apply (I_θ) = 1.10 x 0.772 = 0.85 x I_n

4. The time constant to apply will depend upon the transformer overload specification, but in this case it was decided to set a time constant of 178 minutes. This will allow an overload of 150% from ambient for about two hours before a trip is issued.

5. The capacity alarm is a useful function and therefore it is set to 90%. The current required to reach this 90% figure should be calculated. It is important not to alarm for current within the normal loading range of the transformer.

The steady state thermal capacity = I^2 / I_θ^2 x 100%

For this example,

90% = I^2 / I_θ^2 x 100%. I = 0.806 x I_n and this level is above the maximum full load current of 0.772 x I_n.

The above settings are guideline only and setting philosophies do differ. Matching the Thermal Protection of the transformers lends itself well to the presence of setting groups in the relay. The Duobias-M relays have four settings groups. These may be used to match transformer loading for temporary emergency term overloads, wide variations in ambient (winter/summer loading) or if a cooling failure (pump or fan) occurs. The thermal settings applied will differ in each Setting Group and will be tailored to meet specific loading scenarios.

3.7 Circuit Breaker Fail (50BF)

The Circuit Breaker Fail functions were traditionally only implemented at transmission voltages to limit fault damage and to help avoid instability. As the circuit breaker logic is now implemented in numeric type protection relays CBF is becoming more widespread at distribution voltages also.

At transmission voltages circuit breaker fail was often implemented to ensure the power system will remain stable if the circuit breaker fails to trip and limit fault damage. Three-phase faults and to a less extent phase to phase faults can cause generators to fall into an unstable out of step state, that may damage the generation equipment.

It is therefore essential to remove either of these fault types before a critical fault clearance time is reached. Circuit breaker fail provides a solution by re-tripping the circuit breaker or back-tripping upstream circuits such as bus zones.

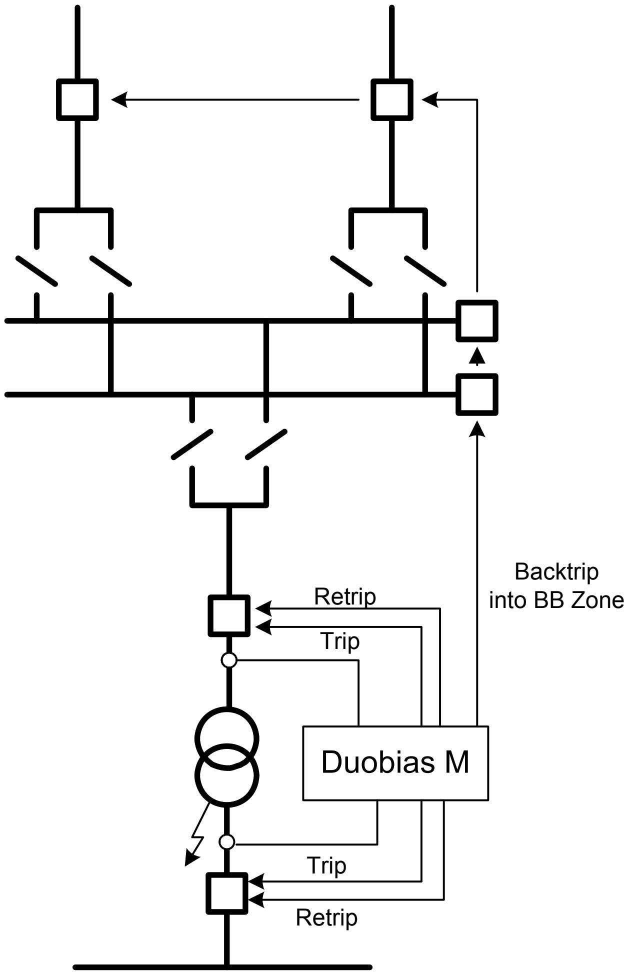


Figure 4 - Circuit Breaker Fail

The circuit breaker fail (50BF) feature uses a very sensitive three phase over current element and two stage timer. The REF elements are also included in the CBF logic as they may sense an earth fault beneath the over current sensitivity.
The CBF function is initiated by the tripping signal from the short circuit protection elements. The detector will then sense current in each phase and if all three 50BF element have not dropped off or reset the timer will expire. The first timer output is usually wired to re-trip the failed circuit breaker on a different phase, and the second timer output is wired to trip the upstream Busbar zone.
The time delays to apply to each stage are critical for the correct operation of the scheme. These should be calculated as follows:

First Stage (Retrip)	Typical Times
Trip Relay operate time	10ms
Duobias-M Reset Time	20ms
CB Tripping time	50ms
Safety Margin	40ms
Overall First Stage CBF Time Delay	120ms
Second Stage (Back Trip)	
First CBF Time Delay	120ms
Trip Relay operate time	10ms
Duobias-M Reset Time	20ms
CB Tripping time	50ms
Margin	60ms

Overall Second Stage CBF Time Delay 260ms

The safety margin is extended by 1 cycle for the second CBF stage as this will usually involve a back-trip of a Busbar zone-tripping scheme.

The sequence of operation and timing for each stage of the circuit breaker fail function are displayed below.

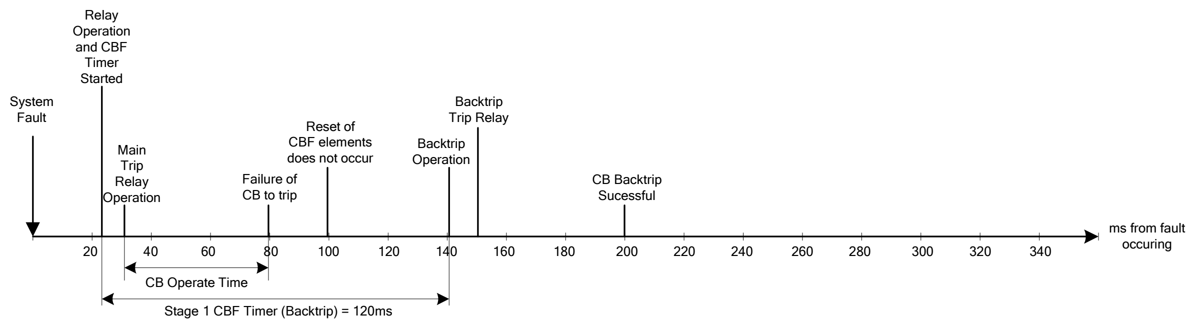


Figure 5 - Single Stage Circuit Breaker Fail Timing

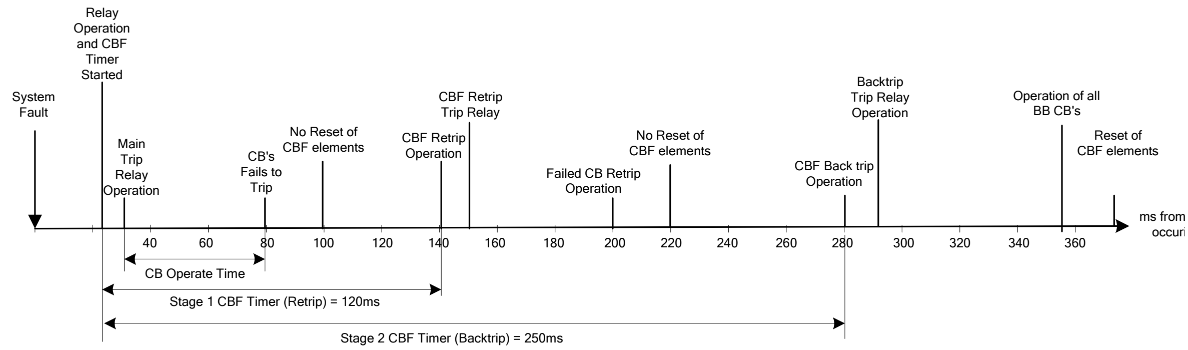


Figure 6 - Two Stage Circuit Breaker Fail Timing

3.8 NPS Over Current (46)

The Negative Phase Sequence (NPS) over current is intended to be used to detect uncleared system faults and conditions such as broken primary connections that may produce significant NPS current.

This unbalance may cause rotating plant such as generators or motors to overheat and fail.

This may also be used to monitor the state of the tap changer and alarm for faults with diverter resistors or switches. Typical Settings are 5 to 10% for Tap Changer alarm and 10 to 15% for system fault or broken conductor.

4 Programmable Inputs and Outputs

The relay can be mapped with the use of its settings and does not rely on access to software packages to configure the relay I/O. This is an advantage in saving time and simplifies the setting of the relay. In rare occasions where more complex logic is required a software package called ReylogiC can be used. This allows the user to define logic scripts within the relay.

The Duobias-M-200 series of relays have from 5 to 29 output relays, all of which are "voltage-free" contacts and relays one, two and three have changeover contacts. It also has provision for receiving operating signals from 3 to 27 external contacts; these are referred to as the d.c. Status Inputs. Each of these Status Inputs can be programmed to operate one or more of the output relays. Similarly, the protection functions of the Duobias-M relay can each be programmed to operate one or more of the output relays. The output contacts can be programmed either to follow the status inputs i.e. be self-reset, or to Hand Reset in their operated state. If programmed to be latched, they will remain operated after their associated Status Inputs have reset and will stay operated until the 'Reset' button is pushed or a remotely initiated reset signal is received. The Commissioning Chapter describes the method of programming the output relay configuration.

The amount of I/O to include in the Duobias-M relay should be considered when the application engineering is being carried out. The total protection and alarm requirements of the installation should be assessed so that the relay can be fully exploited. The Relay Settings Chapter shows the relay configured for a typical transformer installation. The Matrix Planner shows how the d.c. Status inputs have been allocated to the various trip and alarm sources. It also shows how they have been programmed to operate one or more output relays so enabling one alarm source to initiate a discrete alarm plus a grouped alarm; and one tripping source to operate its appropriate tripping relay plus an alarm output. If there are spare Status Inputs and spare output relays more alarm or trip sources can be connected. For example, if the transformer has H.V. or L.V. electro-mechanical or static type over current relays, these can be connected to spare d.c. Status Inputs and programmed to initiate the appropriate alarm and trip output relays. Similarly, if the transformer cooler control scheme is arranged to initiate a "cooler fail" alarm, this can be added and programmed to initiate a discrete and/or a grouped alarm.

Where the transformer is part of an installation that is equipped with auto-switching, i.e. auto-isolation and auto-reclosing, the tripping output relays will probably require to operate separate, latched tripping relays which will then provide the various contact inputs to the auto-switching equipment. The same applies if a number of local and remote circuit breakers have to be tripped as is the case with certain designs of mesh substation. Where these constraints do not apply, the output relays can be arranged to operate the circuit breaker trip coils direct so long as the trip coil current is broken by a circuit breaker auxiliary switch and the 'make and carry' currents are not exceeded. A remote risk with this arrangement is that of the "stuck-breaker" condition which will probably result in damage to the output relay contacts. When the output relay is arranged to drive an external latched tripping relay, this risk is transferred to the tripping relay contacts and it is a matter of judgement as to which arrangement is most acceptable.

5 Current transformer requirements for transformer applications

The specification of CTs must meet the requirements of all the protection functions used on an application. If REF protection is used, the CTs must meet both the biased differential requirement and the REF requirement. If the CTs meet the requirement for the differential elements, they also will be suitable for all other current measuring functions such as backup over current and earth fault and overload protections.

5.1 CT Requirement for Differential Protection

The quality of CTs will always affect the performance of any protection system to a lesser or greater extent. The kneepoint voltage (V_k) a CT can deliver is one of the main criteria for assessing its performance. For biased differential relays the CTs kneepoint voltage is particularly important. All relays of this type have some form of harmonic restraint or inhibit to prevent operation from the flow of magnetizing inrush current when a transformer is energized.

If a high level internal short circuit occurs the dc offset in the primary fault current may push the CTs into transient saturation. This is more likely to occur if the CT kneepoint is low and or the burden is high. Saturated CTs produce high levels of even harmonics and this may slow down the operate time of the biased differential function. To overcome this, the CTs kneepoint voltage must be chosen to maintain high-speed operation of the biased differential element. A non-harmonically restrained highset differential element is included to cut off this slowed operate time of the biased element. The use of Restricted Earth Fault also helps ensure fast tripping as it is not slowed significantly by CT saturation.

The guidance on CT requirements is that the CT knee-point voltage must be equal to, or exceed

$Vk = 4 \times HS \times I_B \times R_B$

This equation is suitable for use if Restricted Earth Fault is not used to protect all windings.

Where REF is used to protect all transformer windings the CT requirements can be lowered to:

$Vk = 2 \times HS \times I_B \times (R_{CT}+R_L)$

It is always advised to use REF protection, as it is a very sensitive, very stable and very fast. Usually one set of current transformers is used for both Differential and Restricted Earth Fault protections they must meet the requirements for both protection systems.

A typical highset differential setting to use is 7 x I_n. Smaller transformers below 5MVA will require the highset differential to be set to 9 x I_n. Line current transformer ratios should be selected to match the main transformer rating and ratio. Other ratios can be used provided these are in the range of the relay current multiplier adjustment and do not exceed the current transformer and relay ratings.

Advice on CT Selection.

If possible use 1A rated secondary CTs instead of 5A CTs. The CT burden is 25 times (I2) less by using a 1A rated CT rather than using 5A rated CT.

Choose a CT ratio that produces at least 1/3rd (eg 0.33A if 1A CT are used) of the nominal secondary rating, when based on the transformer is at nameplate rating.

Use REF to lower the CT requirement

Where long secondary lead lengths must be used, choose CT ratios to produce about a secondary current of 0.35 x I_n. ICT multiplier settings of up to 3x can then be used to increase the relay currents to about 1 x I_n. This reduces burden imposed on the CT. Two cores per phase may also be used to half the lead resistance.

Typical Example

Taking the previous 45MVA 132/33kV Transformer with 300/1A CTs:

Secondary at transformer rating = 0.66A

Differential Highset (87HS) setting to 7 x I_n

A – 3.5 ohms

C - 2.5 ohms

V_k should equal or exceed 111 volts if REF is not used and 66 volts if REF is used to protect all windings.

An indication of the suitability of a protective CT whose performance is defined by a B.S.3938 classification can be obtained. The product of its rated burden expressed in ohms and the secondary current equivalent of its accuracy limit primary current will give an approximation of the secondary voltage it can produce while operating within the limit of its stated composite error. However this is an approximation and should not replace the recommended method.

5.2 CT Requirement for Restricted Earth Fault

For Restricted Earth Fault protection it is recommended that all current transformers should have an equal number of secondary turns. A low reactance CT to IEC Class PX is recommended, as this will allow a sensitive current setting to be adopted. The low reactance CT will limit the magnetizing current drawn by the CT at the REF setting voltage. The CT kneepoint voltage must be sufficient to allow a stable voltage setting to be selected. It is recommended to use and specify 1A rated CTs for REF protection as a sensitive setting is more easily obtained. Line and neutral CT ratios must be identical and it is also best to have similar magnetizing characteristics.

A full explanation of how to specify CTs for use with REF protection, and set REF relays is available on our Website: www.reyrolle-protection.com (Publications->Technical Reports)

6 Secondary Connections

The a.c. connections to use for specific applications must be considered.

Two and three winding transformer applications with a set of line CTs per winding will be the most common type of application of the relay. Most applications are simple, but some are more complicated due to primary connections:

- Mixture of 5A and 1A CTs
- Cross over of the primary connections of two phases.
- Phase Rotations between HV and LV primary connections.
- Two sets of inputs per winding e.g. Teed Circuits, Meshes and 1.5 CB applications.
- Reversed primary connections
- Multiple Winding Transformers (3 Windings or more)

6.1 Mixing 5A and 1 A CTs

As discussed on the section on CT requirements, 1A rated CTs are always technically superior to 5A rated CTs in terms of protection performance. However sometime because of space limitations and re-use of existing CTs, 5A CTs must be accommodated. All Reyrolle numerical protection relays have 1A and 5A rated terminals for connection to each CT. It is therefore very easy for example to use 1A rated CTs on the HV side and 5A rated CTs on the LV side.

6.2 Parallel Connection of Two Sets of CTs into one winding

It is important that the relay connections are chosen to suite the application of the relay. Modern digital relays offer the option of multiple current inputs that allows the relay to be specified with a set of current inputs for each set of CTs that can greatly enhance stability for external through faults.

Sometimes two sets CTs would be connected in parallel into one relay input, as shown in Figure 7 below. Often the two CTs sets will use different core steel, have different kneepoint voltages and lead burdens. Therefore a through fault may cause transient saturation to different degrees which may lead to a false relay operation. The main reason for this is the fact that during a through fault the majority of the current (when the CTs are not saturated) only flows in the CT wiring and not in the relay input. The biasing affect of current from these CTs is lost.

Therefore it is not technically sound to parallel two sets of CTs together and connect them to one relay input.

The difference between the secondary currents in each set of CTs will flow into the relay as a pulse of differential current that may cause a false trip.

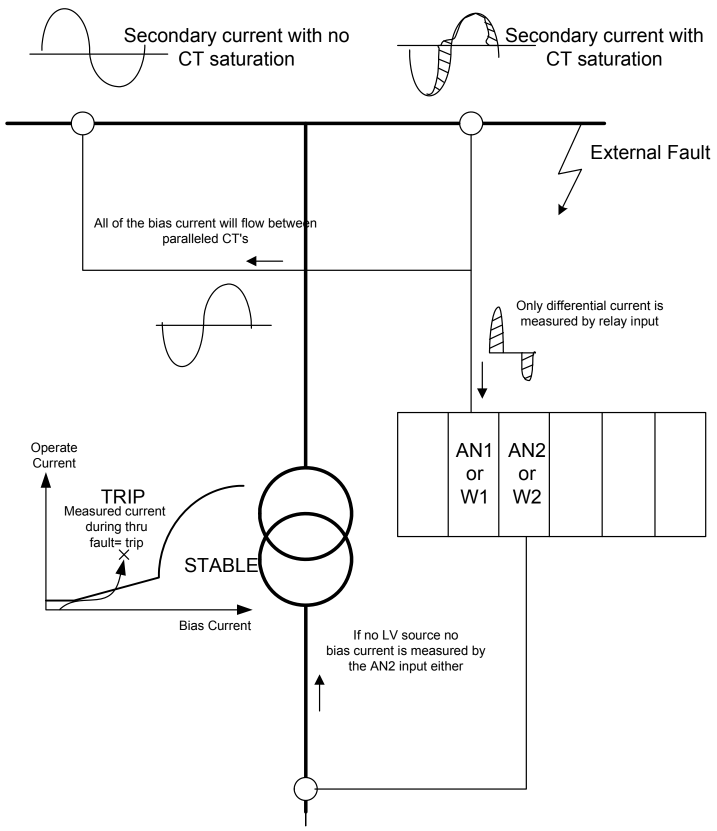


Figure 7 - Incorrect relay connections using parallel connected CTs into one relay input

It is better to use separate relay inputs for each set of CTs, as shown in Figure 8 below, as a greater bias current will be measured by the relay making it much more stable for through faults.

This is now easily dealt with as the Duobias M relay may be specified with up to 5 sets of CT inputs. As the relay input modules are referred to as windings W1, W2 etc the inputs can now be connected to any set of CT inputs.

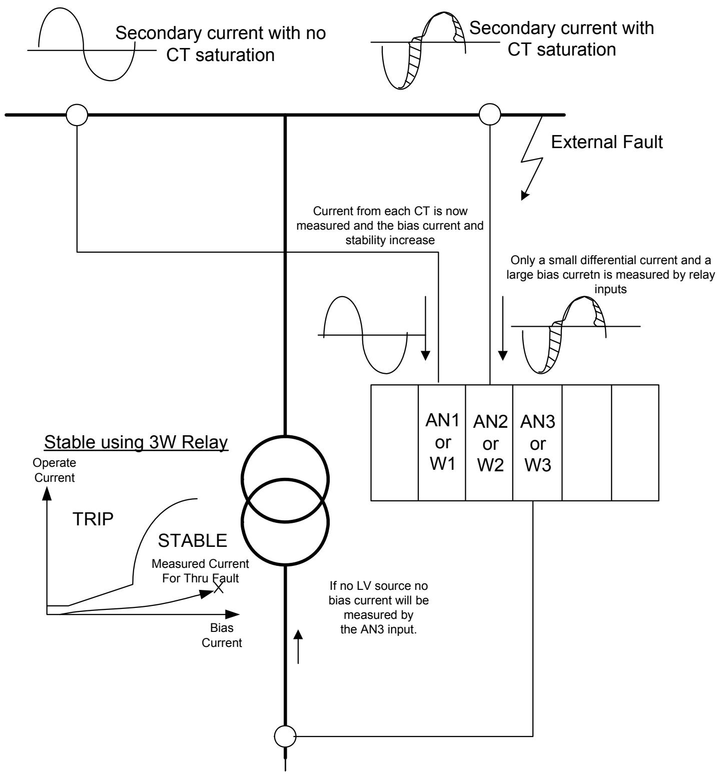


Figure 8 - Correct Method of Protection using a 3-winding relay

6.3 Differential Connections

As discussed above the relay is supplied with between 2 and 5 sets of CT inputs. Therefore almost all primary configurations, vector groups and CT locations can be catered for.

Historically a differential relay would be connected with external interposing CTs to correct for vector group and CT ratio mismatch and to compensate for zero sequence current removal to ensure stability for all through fault conditions.. Figure 9 is quite important in terms of understanding how this type of protection works. The relay bias windings are shown as circles and the relay differential elements as A, B and C. The differential relay measures operate current if a difference in the secondary currents as fed to it from the interposing CTs exists. Because the transformer delta connected secondary does not permit the transfer of zero sequence components and because an earthing transformer provides an in zone path for zero sequence currents to flow then it is important that these are removed from the currents applied to the relay. In this diagram this is done using a Ydy0 interposing current transformer.

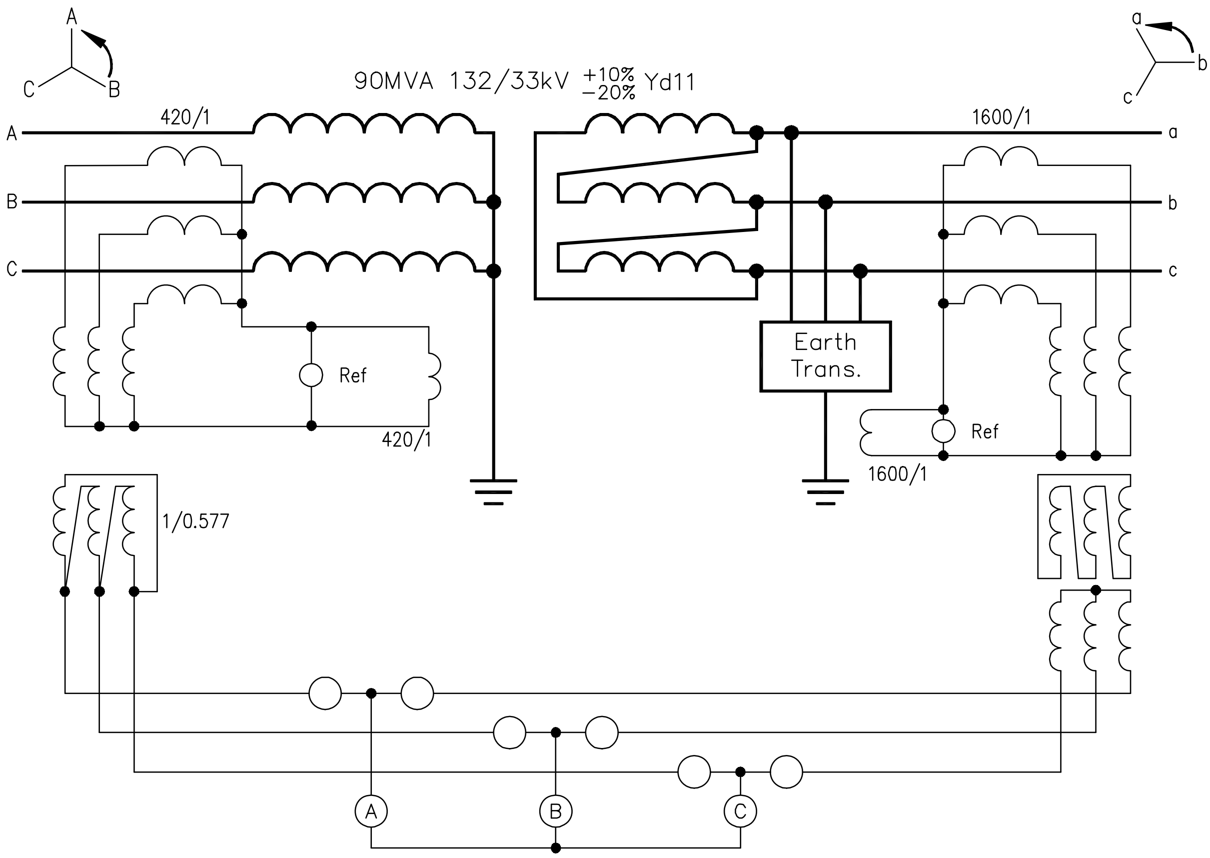


Figure 9 - with dedicated Biased Differential, HV & LV REF and associated Interposing CTs.

The numerical equivalent is shown in Figure 10, and is more abstract in terms of understanding how this protection works.
Here the vector compensation, matching of the current magnitudes and zero sequence current removal is done mathematically by the relay algorithms.

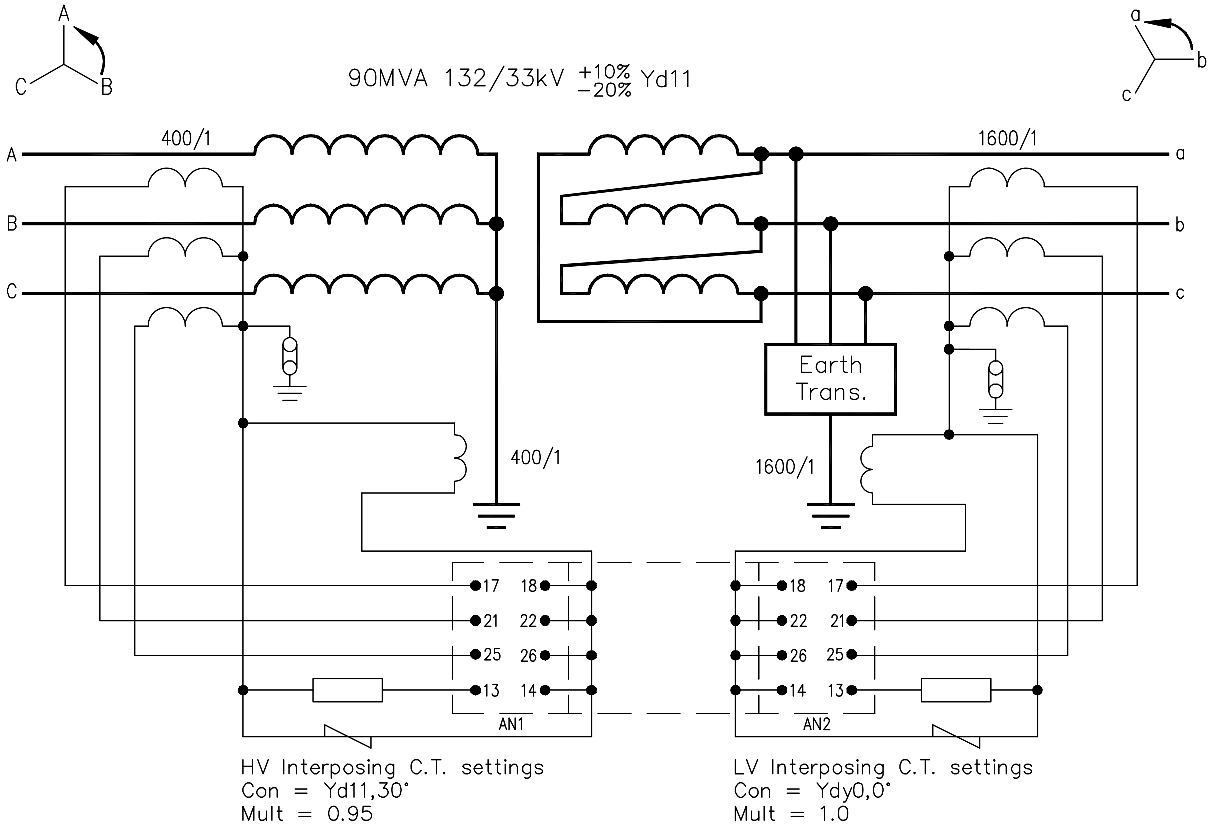


Figure 10 - Yd11 Transformer with Duobias-M protection applied

6.4 Phase Crossovers and Rotations

An example of the complication produced by primary connections is shown below in Figure 11. This has a rotation on the HV side and a crossover on the LV side.

6.4.1 Protection of a transformer with 90° phase shift

132/33KV 90MVA Yd11 +10% -20% Transformer

Where the phase-shift between the W1 and W2 primary systems is such that main connections have to be crossed, for example Figure 11 shows a typical arrangement where a Yd11 transformer is arranged to give a primary system phase-shift of +90° by appropriate crossing of its main connections. There are two optional methods of setting up Duobias-M protection.

One solution is shown in Figure 11 shows the H.V. and L.V. CT secondary wiring replicating the main connection crossovers with the 'A' phase connected to terminal 25, the 'B' phase to terminal 21 and the 'C' phase to terminal 17. The L.V. 'B' and 'C' connections are similarly crossed over. With this arrangement, the Duobias-M relay can be set to correspond to the vector group of the main transformer. i.e. Yd11, +30°.

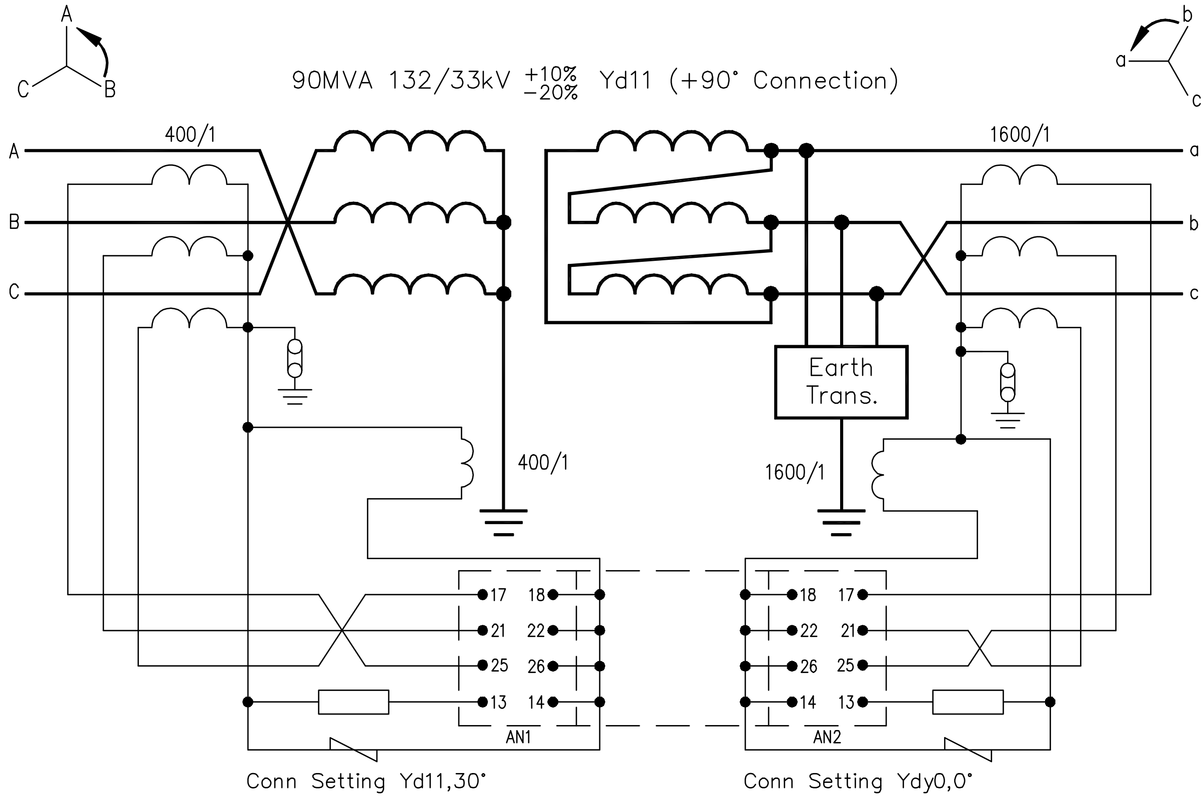


Figure 11 - Yd11 transformer connected as Yd9, +90 with crossover corrected at relay terminals.

In the second solution shown in Figure 12 the function of the interposing CTs is carried out within the relay by setting the H.V. interposing CT connection to Yd9, +90° and the L.V. interposing CT connection to Ydy0, 0°.

The secondary CT wiring is connected to a Duobias-M relay in the conventional way with the 'A' phase CT connected to terminal 17, the 'B' phase to terminal 21 and the 'C' phase to terminal 25. With this method, the H.V. interposing connection must be set to Yd9, 90°.

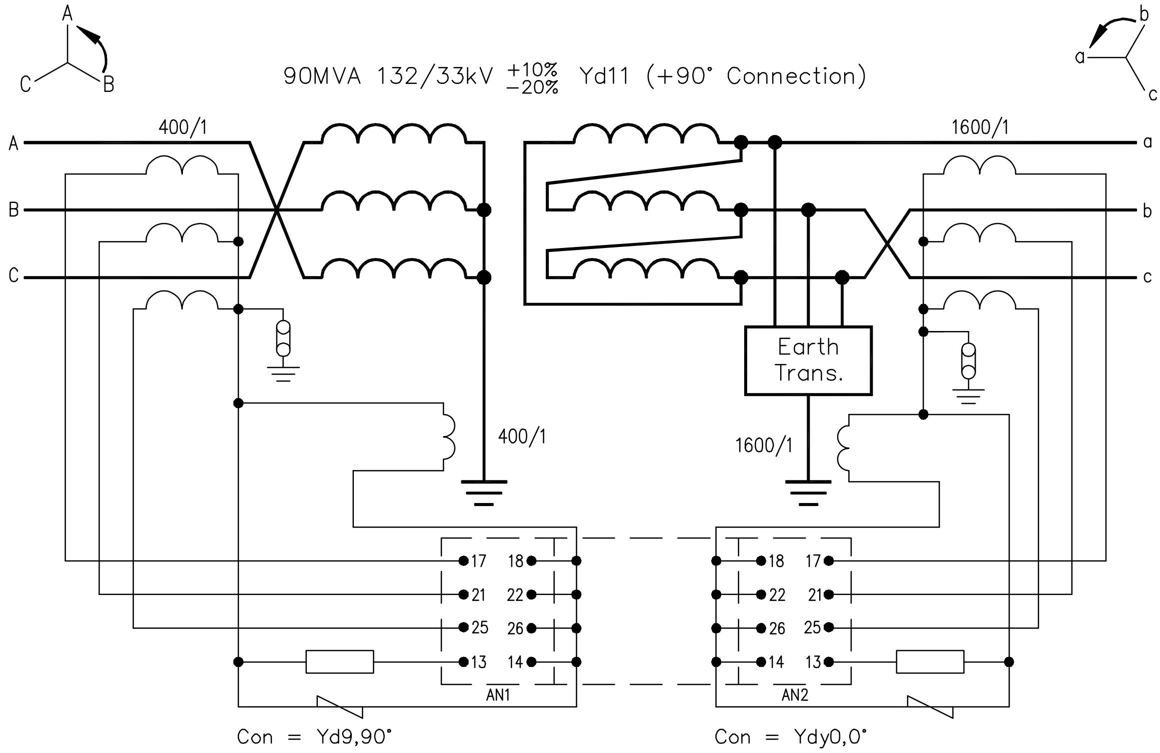


Figure 12 - Yd11 transformer connected to produce Yd9, +90⁰ with correction using relay settings

7 Specific relay applications

7.1 Protection of Star/Star Transformer

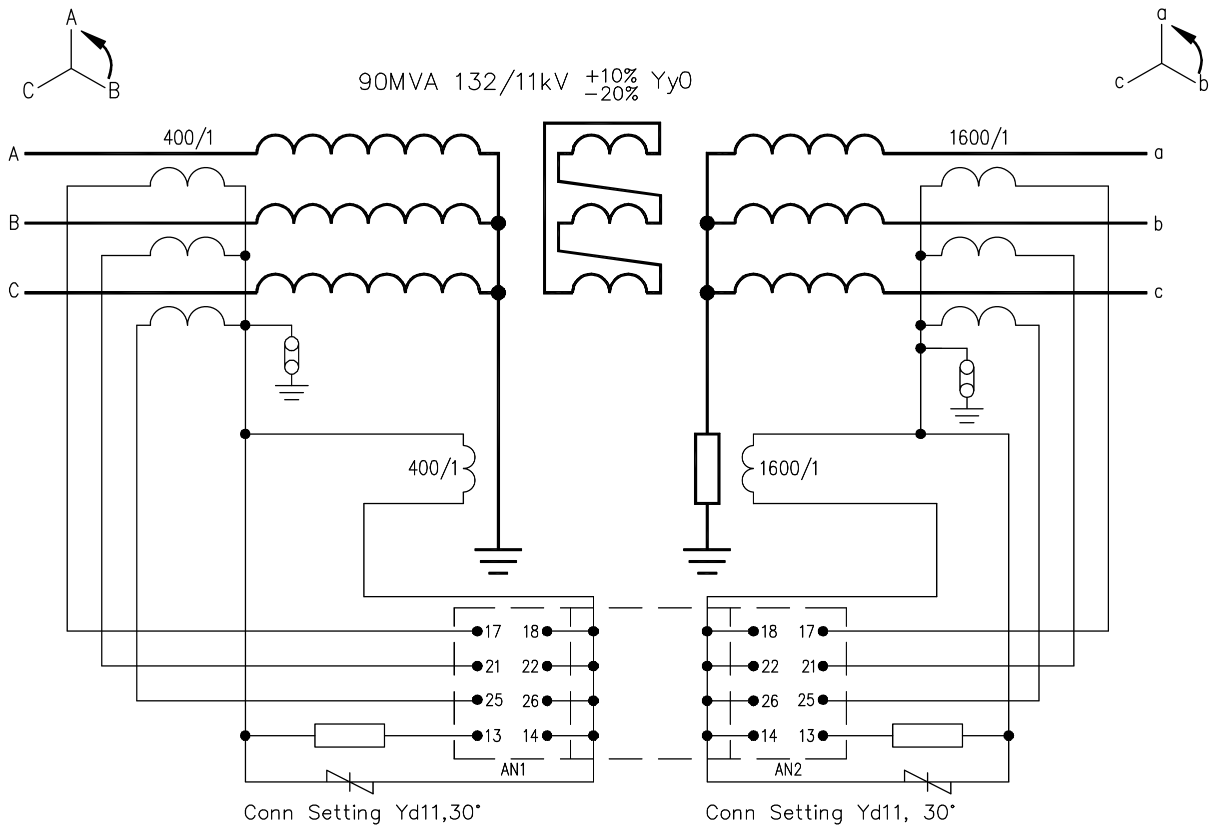


Figure 13 – YNdyn0 Transformer with Biased Differential and Restricted Earth Fault

The star/star transformer shown in Figure 13 has a phase shift of zero but still requires the zero sequence shunt which, in the dedicated relay arrangement, is provided either by delta connected main CTs or by selecting a star/delta interposing CT setting on the Duobias-M relay. The Interposing CT Connection setting on all sets of current inputs must be set to the same Yd setting. They can all be either Yd1, -30° or Yd11, 30°, but the H.V. and L.V. must have the same setting for the relay to balance.

Note 1 The connection setting can also be Yd1, -30° but both sides must be the same

Note 2 The HV and LV CTs must be of appropriate ratio for their associated system voltage and the transformer MVA rating.

Note 3 The change in transformer ratio due to the tap changer must be taken into account and the interposing CT multipliers set accordingly.

Note 4 The effect of the tap changer and of magnetising inrush current must be taken into account when setting the bias and the differential high set Overcurrent.

7.2 Protection Of Three Winding Transformers

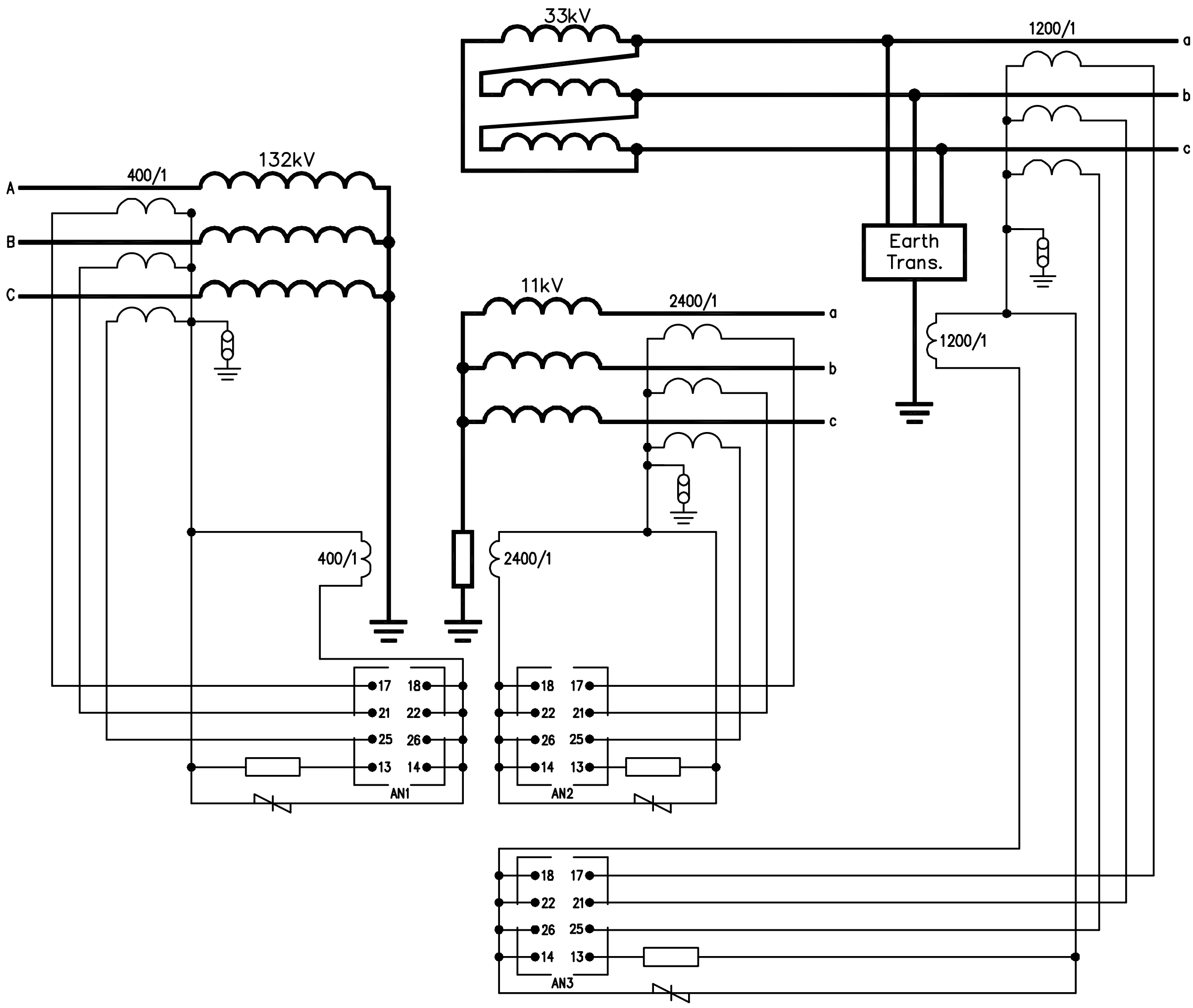


Figure 14 - Application to three winding transformer

Transformer: -
132/33/11KV 90MVA Yd11y0.
33KV DELTA WINDING 60MVA.
11KV STAR WINDING 30MVA.
TAPPING RANGE +10% TO -20%.

Figure 14, shows Duobias-M protection applied to a three winding transformer. The example chosen shows a 90MVA transformer. Its H.V. winding is rated at 132kV and is star connected, it has two L.V. windings, one star connected rated at 30MVA, 11kV and the other delta connected rated at 60MVA, 33kV. The H.V. winding has an on-load tap changer with a tapping range of +10% to -20%. The procedure to determine the CT ratios and protection settings is as follows.

Each combination of H.V./L.V. winding, i.e. 132/llkV and 132/33kV must be treat separately and the settings determined as shown in earlier examples. The H.V winding is common to both combinations so its settings must obviously be compatible for each arrangement. Considering the 132/33kV arrangement first. This is the same as that shown in Figure 10 and the same CT ratios and protection settings can be chosen. The L.V. CT ratio must be four times the H.V. ratio of 400/1, i.e. 1600/1, because the main transformer voltage ratio is 132/33kV, i.e. 4/1. Because the H.V. CT ratio was chosen to be appropriate to 90MVA, this means that the 33kV ratio selected of 1600/1 is also appropriate to 90MVA.

Since the 33kV winding is rated at 60MVA, the use of lower ratio CTs may be preferred; this can be achieved conveniently by suitable selection of the L.V. interposing CT multiplier setting. In this example, the CT ratio chosen is 1200/1A for the 60MVA winding. This is used in conjunction with an L.V. interposing CT multiplier setting of 0.75 giving an effective ratio of 1600/1 for protection balancing purposes.

Considering the 132/llkV arrangement, this is the same as that shown in Figure 13 for a Yy0 transformer and the same settings can be chosen. Once again, a more suitable 11kV. CT ratio of 2400/1 can be used in conjunction with the minimum L.V. interposing CT multiplier of 0.5 giving an effective ratio of 4800/1.

It can be seen that the H.V. interposing CT connection settings required for the 132/33kV. The 132/11kV arrangements are compatible so the settings shown in Fig.6 would be applied. If the three winding transformer shown was re-arranged to be of vector group Yd1y0, then the H.V. interposing CT connection and the 11kV, L.V. interposing CT connection would both have to be set to Yd1, -30.

The settings must, of course balance when the L.V. winding combination is treated as a two winding transformer and the procedure described above will produce the correct settings. In the Fig.7 example, if the 11/33kV combination is viewed as a Y/d11 transformer, the connection settings will be seen to correspond with those for the Y/d11 example shown in Fig.4B and the CT multiplier settings will also be seen to produce the required balance with effective CT ratios of 4800/1 and 1600/1 reflecting the voltage ratio of 11/33kV.

When applying the three winding Duobias-M relay to transformers where the rated voltage and therefore CT ratio of transformer windings differ greatly most of the ratio correction must be achieved by the appropriate selection of the CT ratio as the interposing CT multiplier is limited to 0.25 to 3.0. The appropriate CT ratio's to be used can be found by calculating primary currents to a common MVA base (usually the highest MVA rated winding).

132/33KV 90MVA Yd11 +10% -20% Transformer

The function of the interposing CTs is now carried out within the relay by setting the H.V. interposing CT connection to Yd11, 30° and the L.V. interposing CT connection to Ydy0, 0°. The preferred ratio of 400/1 can now be used for the H.V. CTs and the optimising of the ratios carried out by setting the H.V. interposing CT multiplier to 0.95.

7.3 Protection of Auto Transformers

In the past the main protection applied to large auto-transformers would be overall high impedance with three phase sets of line CTs on all of the terminals of the winding. This arrangement is shown below.

The discussion of biased differential protection has, up to this point, been confined to two and three winding transformers. However, it is possible to treat an auto-transformer in the same way as normal two winding transformer. The Duobias-M can be supplied with two to five sets of CT inputs for unit protection of a transformer.

Two common arrangements are shown in Figure 15 and Figure 16. It can be seen that the need for neutral and connection CTs can be eliminated but at cost. The H.V. and L.V. and neutral end CTs must now have ratios appropriate to the rated voltage of their associated windings and the ratios must be optimized as shown in Figure 17.

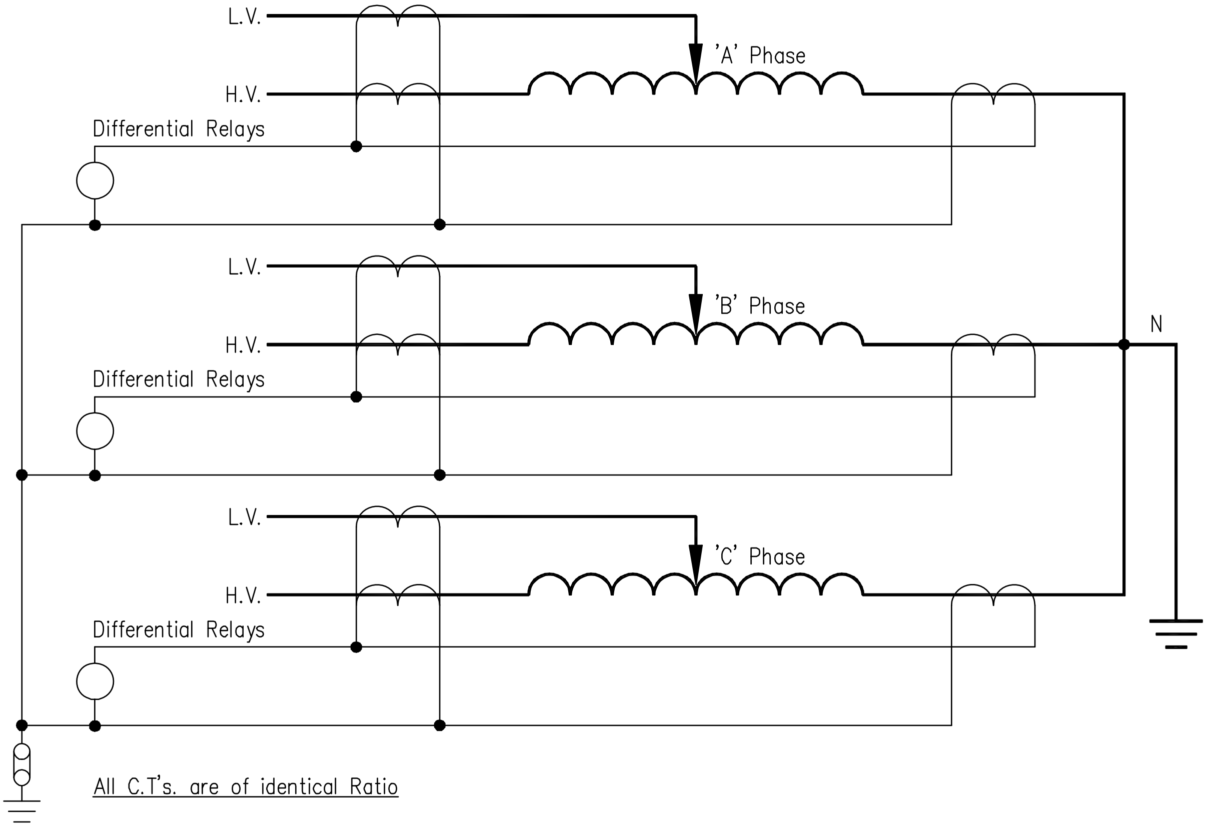


Figure 15 - Traditional High Impedance Transformer Protection

These relays would typically be static type relays.

The use of numerical biased relays to replace static high impedance relays offers a number of benefits:

- Supervision of relay power supply.
- Supervision of the relay hardware.
- Remote Communications.
- Lower CT requirements.
- Relay Instruments make commission easier.
- LED's provide flagging of all external protection devices such as Buchholz relays etc via the relay status inputs.
- Waveform Recording for the operations of all external and internal protection functions
- The existing CTs may be re-used in most cases

7.3.1 Preferred Application to Auto Transformers

The Duobias-M relay may be used to protect auto-transformers. The settings and connections will depend on the presence and location of CTs. Line CTs will always be required but the magnetising inrush settings to use will be depend on the neutral end CTs. If a three-phase set of CTs is neutral end CTs are available the Magnetizing Inrush may be set to [Disabled]. In this case the magnetizing inrush will balance out between the CTs as only one winding is present and all terminals have CTs.

The scheme uses the W1 REF to provide a high speed overall earth fault differential zone of protection. Overall EF provides sensitive earth fault protection for earth faults near to the neutral end of the winding. High speed protection (15 to 25ms) for all fault levels is provided.

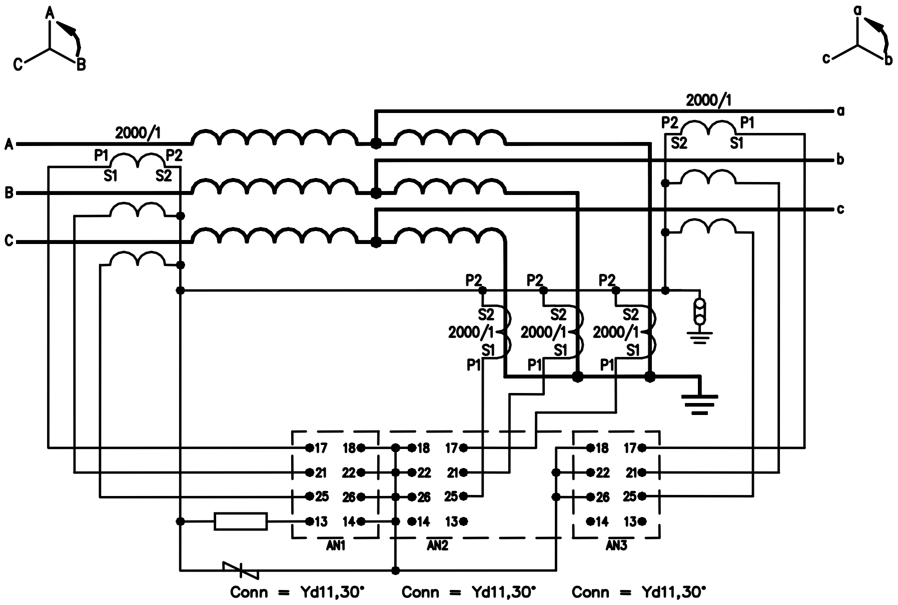


Figure 16 - Recommended Method of Auto Transformer Protection

7.3.2 Alternative Applications to Auto Transformers

An alternative scheme for auto transformer protection is shown in Figure 17. This scheme gives REF protection and hence is more comprehensive than the Figure 18 scheme but all line and neutral CTs must have the same ratio. The interposing CTs in the Duobias-M must have the ratio of the primary voltages. For instance, with a 400/275 kV auto transformer, the interposing CTS on module B (HV) should be set to a ratio of 1.45/1 and on Module C (LV) should be set to 1/1. These interposing CTs must be configured in a star/delta mode as indicated above. Where only one neutral CT is present as shown in Figure 17, the Magnetizing Inrush Inhibit must be set to [Enabled] as the magnetizing inrush currents in each phase will not balance. The overall earth fault high impedance zone can still be used.

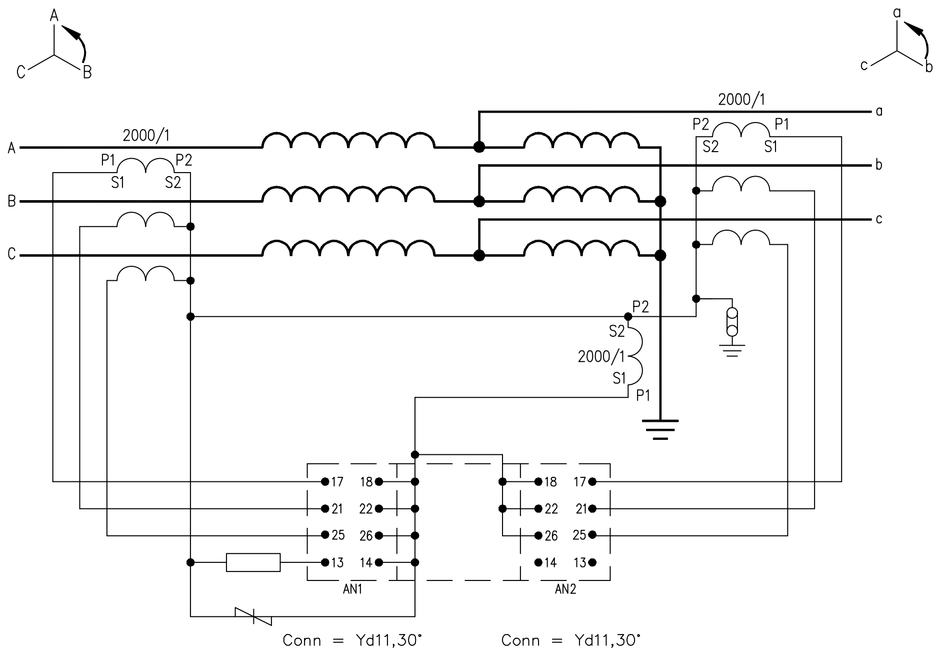


Figure 17 - Alternative Application to an Auto Transformer

The auto transformer shown in Figure 18 can be treat in the same way as the double wound, star/star transformer shown in Figure 13 and will have the same interposing CT connection settings. It is not equipped with neutral CTs however so it cannot have R.E.F. protection.

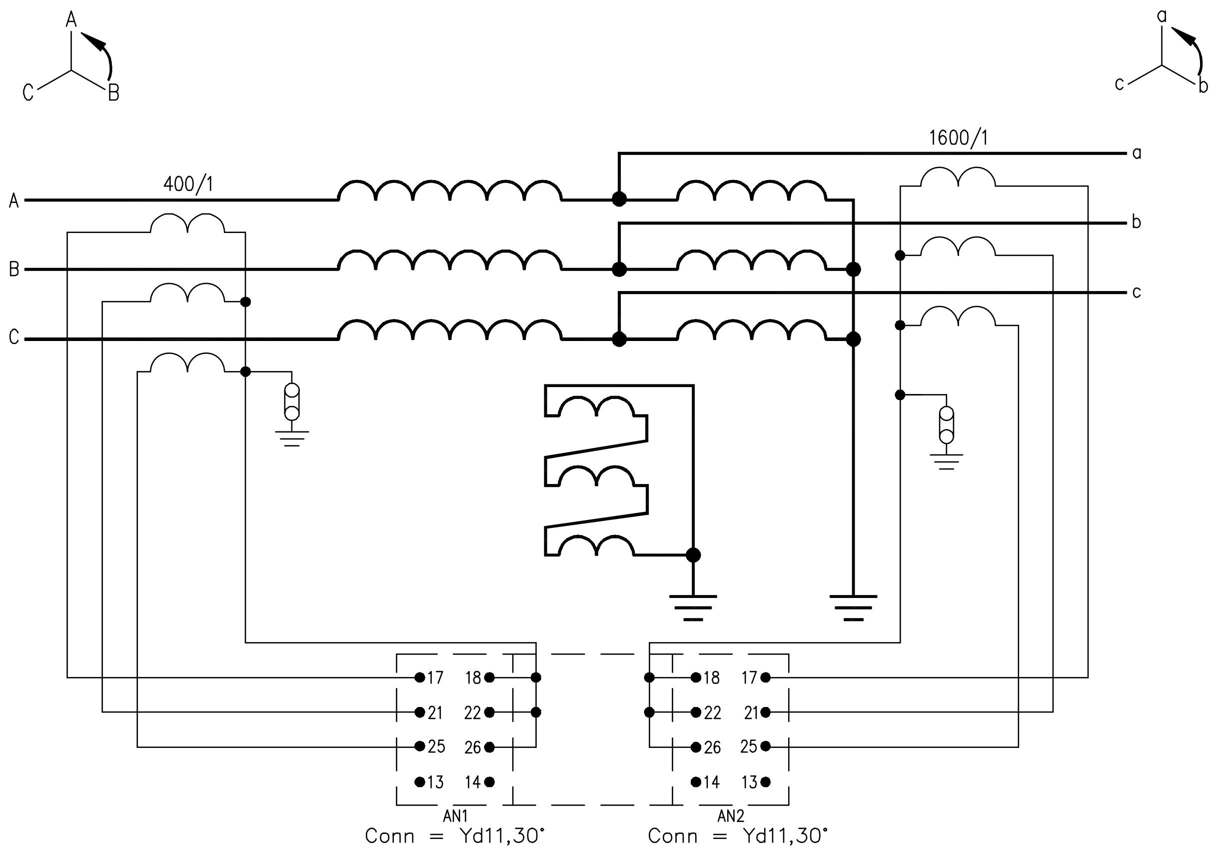


Figure 18 - Autotransformer with Biased Differential Protection

8 Appendix 1 – Application to YNyn6yn6 Transformer (3 winding)

8.1 Introduction

Relay settings appropriate for the protection of a Yyn6yn6 transformer where the red phase is at 8 o'clock (transformer phase C) on the primary winding and at 10 o'clock (transformer phase B) on the secondary windings.

8.2 Design considerations

The transformer connection implies a 60 degree phase shift between the primary and secondary windings i.e. the transformer is overall a Yy2y2 connection.

This at first suggests protection by using Yy2 interposing connection on the HV interposing current transformers and Yy0 on the LV interposing transformers.

However the HV winding is not earthed and therefore zero sequence currents seen by the LV current transformers will not be seen by the HV current transformers and such a selection would result in maloperation of the protection. The answer is therefore to remove the zero sequence components seen by the LV current transformers.

This could be done in several ways.

- Using delta connected current transformers on all windings.
- External zero sequence shunts in current transformer circuit.
- Star delta star interposing current transformers, externally or internally to the Duobias M relay on the LV side.
- Inserting a delta circuit by means of similar star delta interposing current transformations to both sides of the transformer. This may be done typically by means of a Yd1 connection LV side and an additional Yd1 on the HV side also i.e. Yy2 + Yd1 = Yd3 connected on the HV side. This is the method recommended.

8.3 Design calculations

Note: All calculations assuming no tap changer fitted.

HV rated current = 60MVA / 66kV x Ã3 = 524.86A

HV secondary currents = HV rated / HV CT ratio = 524.86/600 = 0.875A

LVA rated current = 60MVA / 11kV x Ã3 = 3149.18A

LVA secondary current = LVA rated / LVA CT ratio = 3149.18/1500 = 2.099A

LVB rated current = 60MVA / 11kV x Ã3 = 3149.18A

LVB secondary current = LVB rated / LVB CT ratio = 3149.18/1500 = 2.099A

Minimum multiplier which can be applied on LVA/B sides is 0.5x.

Therefore after interposing CT correction,

LVA relay current = LVA CT secondary current x 0.5 = 1.05A

LVB relay current = LVA CT secondary current x 0.5 = 1.05A

HV multiplier = LVA relay current / HV CT secondary current = 1.05/0.875 = 1.2x.

Transformer Yy6y6	HV	LVA	LVB
Voltage (kV)	66	11	11
Rating (MVA)	60	30	30
CT Ratios	600/1	1500/1	1500/1

Multipliers	1.20	0.50	0.50
Interposing CT Connection	Yd3	Yd1	Yd1

9 Appendix 2 – Application to Dyn11 Transformer with primary crossover

9.1 Introduction

Relay settings appropriate for the protection of a 66/11Kv transformer with reverse phase rotation.

9.2 Scheme details

Reverse phase rotation requires phase reversal at the transformer. This necessitates careful consideration of the selection of interposing CTs to maintain balance. A number of possible solutions are possible.

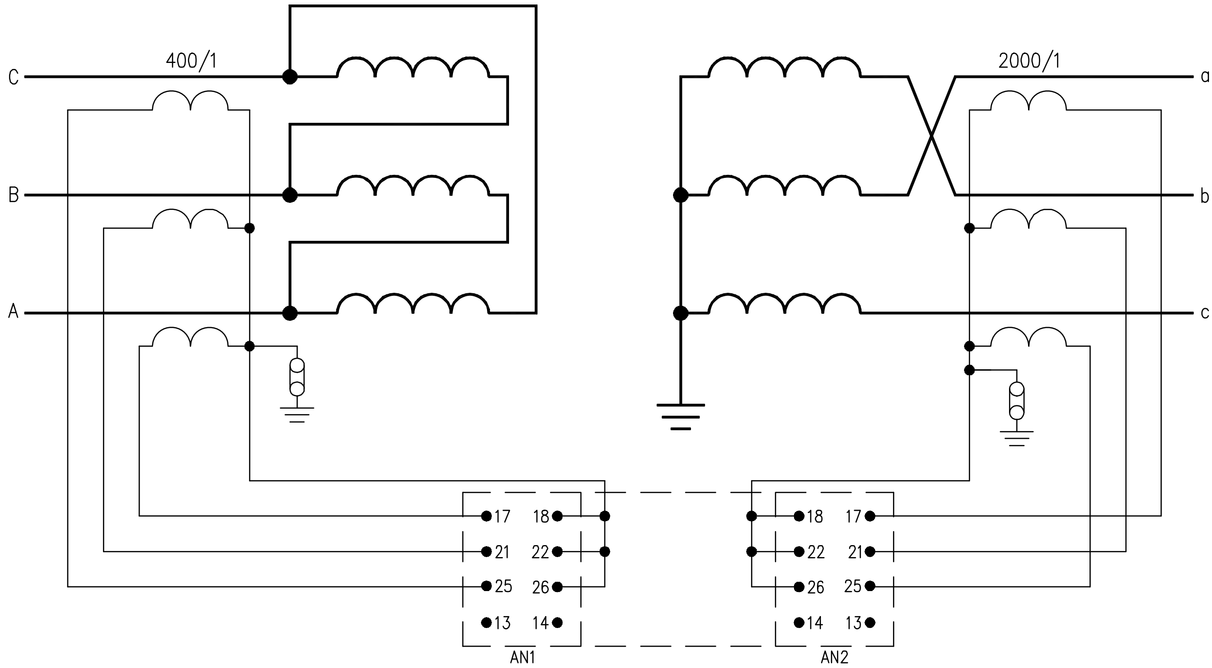


Figure 19 - Dyn11 Transformer with reverse phase rotation

9.3 Duobias-M settings

Differential Initial Setting: 20%

This is chosen to take account of the percentage tolerance difference of line CTs. This setting should be the same as that for the Differential Bias Slope.

Differential Bias Slope: 20%

This setting is selected to maintain balance when through fault or heavy load current is passed through the transformer when the tap change unit is in its extreme position. Recommend setting to be 1x tap change range (+5% to –15%).

Differential Bias Slope Limit: 4x

The bias slope limit is chosen to protect against CT saturation under through fault conditions. The lower the setting the more stable the protection.

Differential High Set Overcurrent: 8

This is set above the maximum through fault with the tap changer in the extreme position. The setting to be as low as possible but not less than the maximum three phase through fault or not less half of the peak maximum magnetising inrush current whichever is greater. A value of 8 x In is used as this equates to a transformer impedance of 12.5%.

Magnetising Inrush Restrain: 20%

A safety factor of 2 times the expected inrush secondary current is used. This commonly gives a factor of 20%. Note that the lower the setting the more stable the relay because this level represents the level of second harmonic which will cause the relay to be inhibited.

W1 (HV) Interposing CT multiplier: 1.14
W1 Interposing CT connection: Yd5

Taking account of scheme connection resulting in equivalent Yd5 transformer.

W2 (LV) Interposing CT multiplier: 1.00
W2 Interposing CT connection: Ydy0

Yy0 for Yd5 transformer but transformer still Dyn11 therefore zero sequence currents have to be removed from the LV side due to star connection and earth path.

HV rated current: 40MVA / 66kV x √3 = 349.9A

HV CT ratio: 400/1

HV CT secondary current: 349.9A/400 = 0.8747A

Transformer ratio at mean tap of tap changer range (+5% to –15%) is –5%±10. The mean tap is chosen in preference to the nominal tap thus avoiding larger unbalance at the extremes of the tap changer range. Although this may result with a small operate current at the nominal tap this is quite acceptable and does not cause any problem or burden. This also takes account of the difference to the voltage range. Reyrolle do not recommend using the nominal tap position in this calculation because balance cannot be guaranteed at the limit of the tap changer range.

66kV x 0.95/11kV = 5.7

LV rated current at mean tap: 349.9A x 5.7 = 1994.43A

LV CT ratio: 2000/1

LV CT secondary current: 1994.93/2000 = 0.9972A

Current input amplitude correction by W1 CT multiplier and W2 CT multiplier to balance HV and LV inputs. The ICT settings to apply to the relay should aim to adjust the relay currents to as close to 1 x in as possible.

0.8747 x W1 ICT = 0.9972 x W2 ICT = 1 x In for balance

Set W2 ICT multiplier = 1/0.9972 = 1.00, since CT ratio of 2000/1 is closest to relay 1A input terminal rating.

W1 ICT = 1/0.8747 = 1.14

9.4 Determination of interposing CT balance

9.4.1 Incorrect interposing CT selection

HV interposing CT Yd5
LV interposing CT Yy0

This example shows the flow of current for a through fault condition. Unbalanced loads produce the same effect.

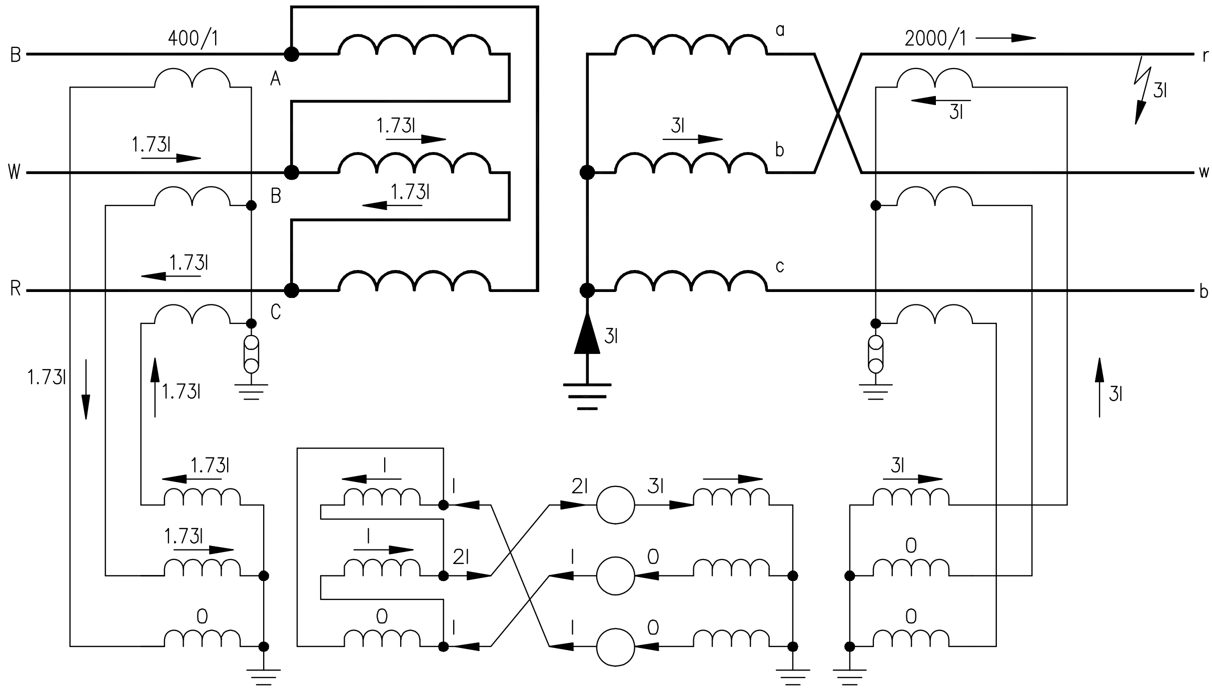


Figure 20 - Effect of incorrect interposing CT selection

9.4.2 Correct Interposing CT Selection

HV interposing CT Yd5
LV interposing CT Ydy0

This example shows the flow of current for a through fault condition.

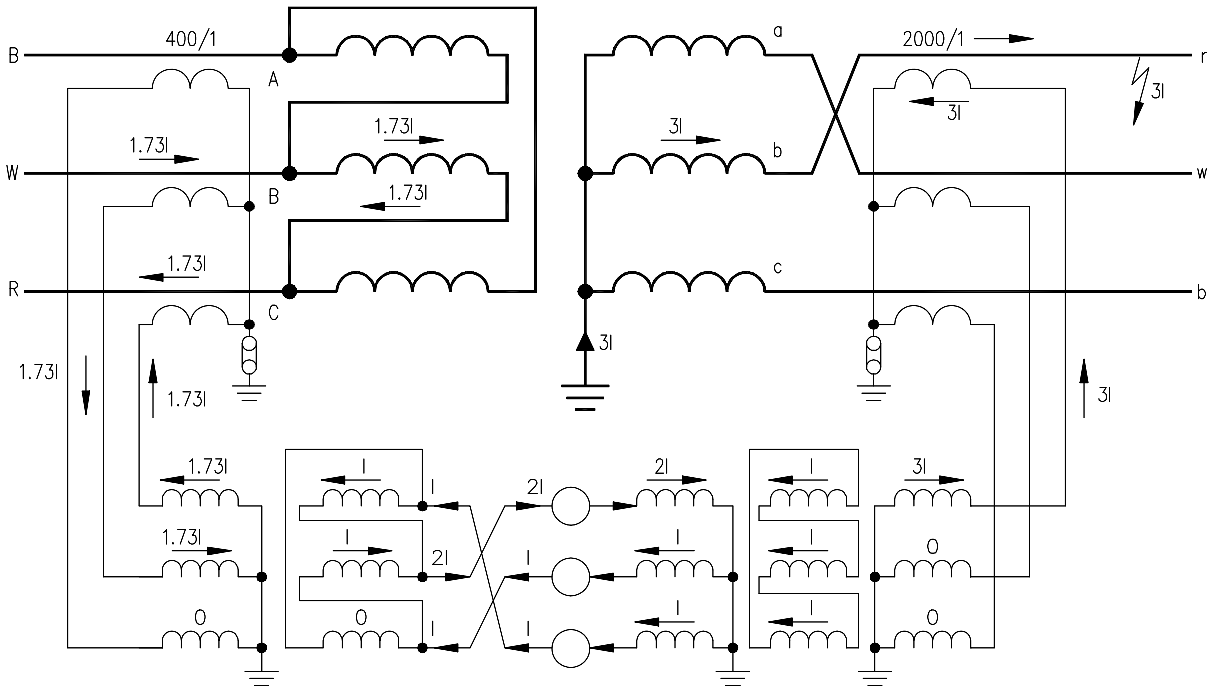


Figure 21 - Correct Interposing CT selection

10 Appendix 3 – Two winding connection diagram

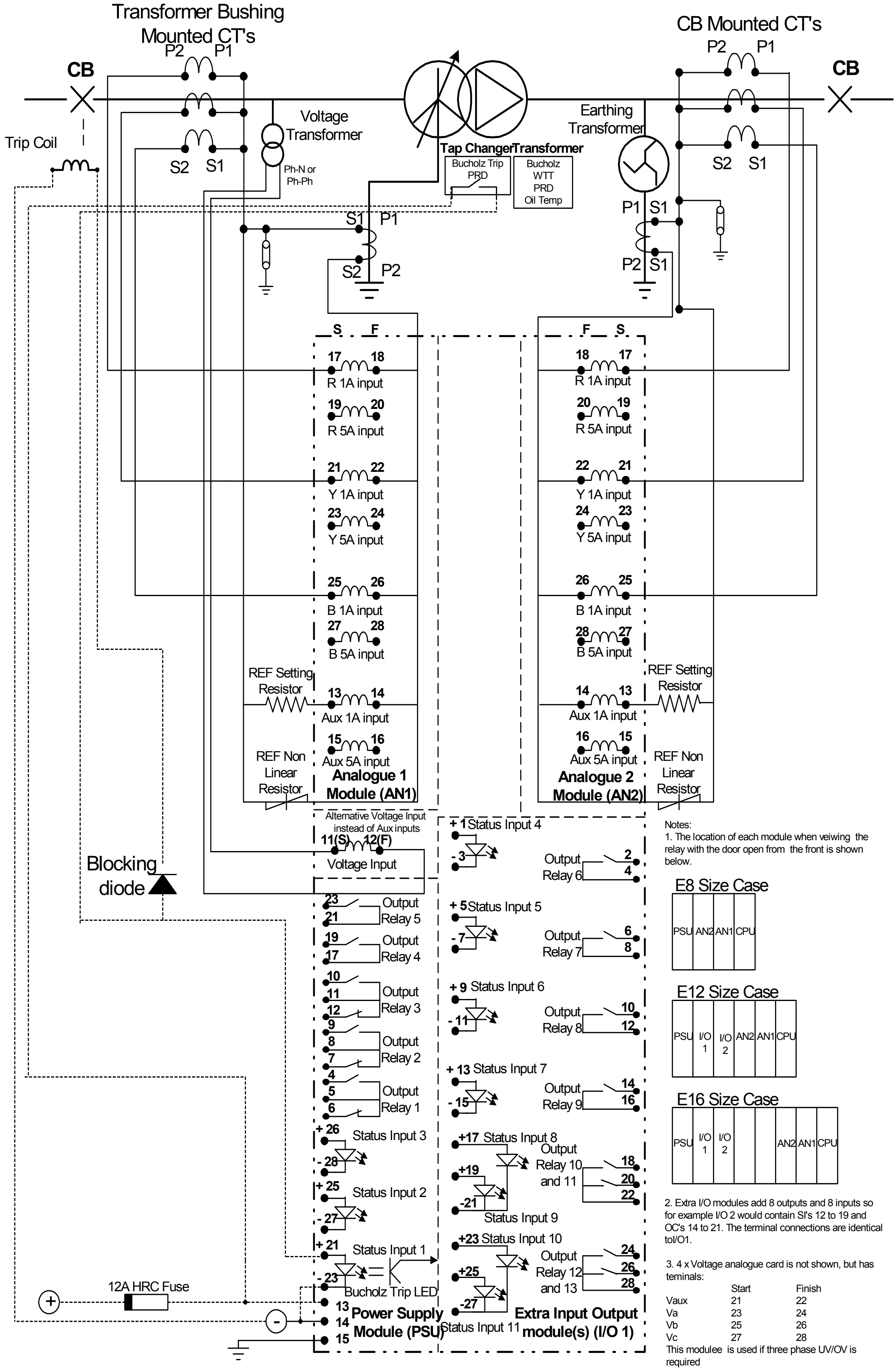


Figure 22 - Two Winding Connection Diagram

10.1 Notes on Diagram

The module types are standardised and can be multiplied to give extra digital input and output contacts and analogue measurement cards to suite the application.

1.The type of Analogue modules available are:

- 4 x current inputs – 1A and 5A inputs per phase and earth input.(4I module)
- 3 x currents + 1 x voltage. (3I+1V module)
- 4 x voltages (4V module)

2. The types of input and output (I/O) modules available are:

- Standard I/O on Power supply module - Outputs - 3C/O + 2NO + 3 Status Inputs.

- Additional Standard I/O Modules provide 8 status inputs and 8 output relays.

  There are two variations in the type of outputs for each additional I/O module:

  8 Normally Open

  4 Normally Open and 4 Normally closed.

  The ordering table in the Description of Operation provides details of the hardware variants that may be ordered. This table includes the rating of power supply and status inputs.

  An Input module type with 16 status inputs may be ordered, if a particular scheme requires more logic inputs. This may be of use if ReylogiC is used to provide a bespoke control scheme.

  An Output module with 16 output contacts may also be specified.

11 Appendix 4 – Low impedance busbar protection

The Duobias-M relay has been used for the protection of generator station and single bus busbars in the past. It provides a low cost solution to Busbar protection for the simpler layouts. The relay is NOT suitable for double bus sub-station layouts, as there are no facilities to switch current inputs between differential groups.

11.1 Application

The modular II relay has up to five sets of inputs for the protection of various types Busbar layout:

Applications include:

- Distribution Single Bus substations.
- Generator Station Isolated Phase Bus Systems.
- Bus Protection for 1.5 CB Layouts.
- Mesh Corner Protections.

The relay when applied as a Busbar protection relay must be set in a different manner to other applications. The differential current produced for an internal Busbar fault will always be substantial and the relay can be set in a more stable manner. The relay could also be supplied with one input as an REF type, and this could provide sensitive earth fault Busbar protection. This may be useful if a system is non-effectively earthed using neutral earthing resistors or reactors.

The relays can use a mix of 1A and 5A rated CTs as both are provided on the relay. CTs of 1A rating are preferred however as they produce 25 times less burden on the CT at nominal current. The CT quality will determine the settings to apply to the relay. Generally the poorer the CTs are in terms of kneepoint voltage the higher the biased setting must be raised to ensure stability.

11.2 Settings

When the relay is used for Busbar protection the following settings should be adopted:

Initial Bias	50%
Bias Slope	70%
Bias Slope Limit	2x
Differential Highset	15 to 20 x In (used for phase fault tripping only)
Inrush Inhibit	DISABLED

All Interposing CTs settings should be set to Yy0. Using the 1/5A inputs and Interposing CTs Multiplier Setting (0.25 to 3.0) all the inputs can be adjusted to balance the relay to rated current when the Busbar is at its full continuous rating.

11.3 CT Requirements

For Biased Differential Protection using the above settings the CTs must meet the minimum:

$V_k > 2 \times I_B \times I_f / N \times R_B$

e.g.

600/1A 15VA 5P20 Protection CTs R_{CT} = 2.5 ohms and R_L = 1.5 ohms, applied to a 33kV bus substation. Maximum Fault levels are 15.1kA for three phase and phase to and 11kA for earth faults.

The CT knee point V_k can be estimated using:

$V_k \approx VA \times ALF / I_n + ALF \times I_n \times R_{ct}$

In this case the Vk is approximately = 15 x 20 / 1 + 20 x 1 x 2.5 = 350 volts.

The quality of this CT with respect to use with the Duobias-M BB Protection must be assessed.

Vk > 2 x 15100/600 x (2.5 + 1.5) = 201 volts

Therefore this CT may be used with the relay BB default settings. If the Vk requirements are not quite met, the bias settings should be adjusted to produce a more stable relay and the relay may also operate slightly slower.

11.4 High Impedance EF Busbar Zone Protection

It is possible to include one input on the relay as a high-impedance earth fault input. A fast and sensitive EF Busbar scheme can be included if earth fault levels are very low.

If the residual connection from each set of line CTs are used to form a high impedance type zone the magnetizing currents of the CTs become important in terms of sensitivity and low reactance type PX CTs must be used. It is advised to use a dedicated set of CTs, if the high impedance earth fault input is used. The CTs may saturate on internal earth faults and affect the performance of other earth fault relays. The relay must be ordered with one of the inputs as an EF type, and therefore only seven sets of line CTs may be accommodated in the relay.

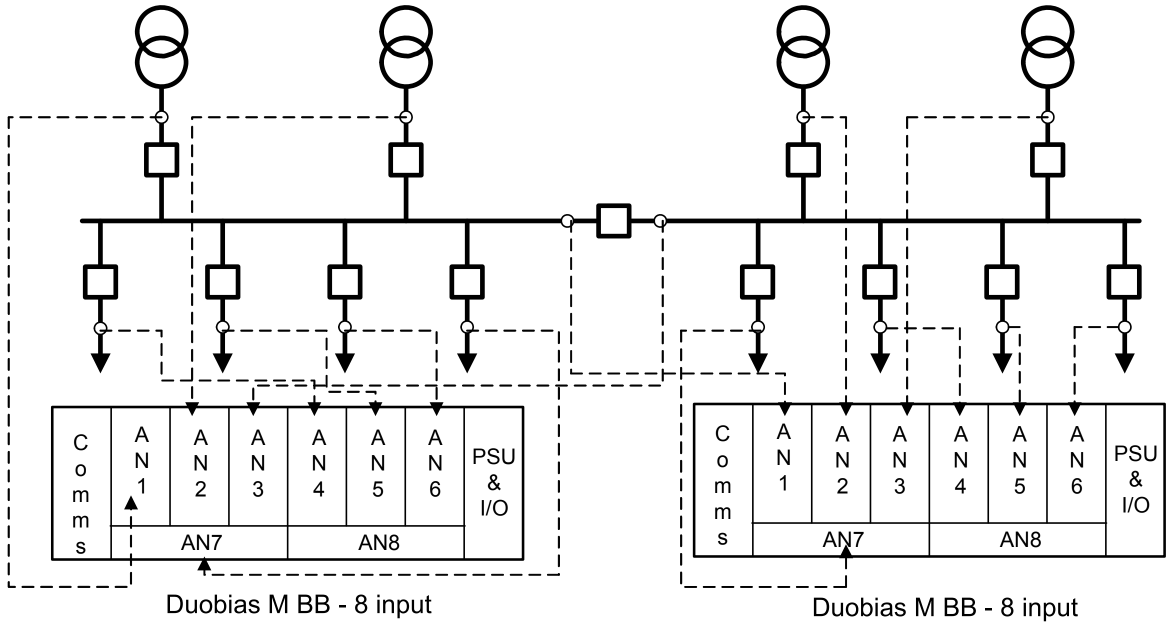


Figure 23 - Typical Application to Single Bus Substation

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Transformer Protection

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
Pre release

2010/02	Document reformat due to rebrand

Software Revision History

Contents

1 Unpacking, storage and handling

On receipt, remove the relay from the container in which it was received and inspect it for obvious damage. It is recommended that the relay modules are not removed from the case. To prevent the possible ingress of dirt, the sealed polythene bag should not be opened until the relay is to be used.

If damage has been sustained a claim should immediately be made against the carrier, also inform Reyrolle Protection and the nearest Reyrolle agent.

When not required for immediate use, the relay should be returned to its original carton and stored in a clean, dry place.

The relay contains static sensitive devices, these devices are susceptible to damage due to static discharge and for this reason it is essential that the correct handling procedure is followed.

The relay's electronic circuits are protected from damage by static discharge when the relay is housed in its case. When individual modules are withdrawn from the case, static handling procedures should be observed.

- Before removing the module from its case the operator must first ensure that he is at the same potential as the relay by touching the case.
- The module must not be handled by any of the module terminals on the rear of the chassis.
- Modules must be packed for transport in an anti-static container.
- Ensure that anyone else handling the modules is at the same potential.

As there are no user serviceable parts in any module, there should be no requirement to remove any component parts.

If any component parts have been removed or tampered with, then the guarantee will be invalidated. Reyrolle Protection reserve the right to charge for any subsequent repairs.

2 Recommended mounting position

The relay uses a liquid display (LCD) which is used in programming and or operation. The LCD has a viewing angle of ± 45º and is back lit. However, the best viewing position is at eye level, and this is particularly important when using the built-in instrumentation features.

The relay should be mounted to allow the operator the best access to the relay functions.

3 Earthing

Terminal 15 of the PSU (Power Supply Unit) should be solidly earthed by a direct connection to the panel earth. The Relay case should be connected to terminal 15 of the PSU. It is normal practice to additionally 'daisy chain' together the case (safety) earths of all the Relays installed in a panel to prevent earth current loops posing a risk to personnel.

4 Relay Dimensions

The relay is supplied in an Epsilon case. Diagrams are provided elsewhere in this manual.

5 Fixings

5.1 Crimps

Amp Pidg or Plasti Grip Funnel entry ring tongue

Size	AMP Ref	Reyrolle Ref
0.25-1.6mm^2	342103	2109E11602
1.0-2.6mm^2	151758	2109E11264

5.2 Panel Fixing Screws

2-Kits – 2995G10046 each comprising:

- Screw M4 X10
  2106F14010 – 4 off

- Lock Washes
  2104F70040 – 4 off

- Nut M4
  2103F11040 – 4 off

5.3 Communications

Fibre optic connections – 4 per relay (Refer to section 4 – Communications Interface).

6 Ancillary Equipment

The relay can be interrogated locally or remotely by making connection to the fibre optic terminals on the rear of the relay or the RS232 port on the relay fascia.

For local interrogation a portable PC is required. The PC must be capable of running Microsoft Windows Version 3.1 or greater. Connection is made through a standard RS232 port on the PC. A standard straight-through (not cross-over) modem cable is required to connect from the PC to the 25 pin female D type connector on the front of the relay. If only a USB port is available on the PC, a suitable USB – RS232 converter must be used.

For remote communications more specialised equipment is required.

See the section on Communications for further information, and also see Report No. 690/0/01 on Relay Communications.

7 Precautions

When running fibre optic cable, the bending radius must not be more than 50mm.

If the fibre optic cables are anchored using cable ties, these ties must be hand tightened – under no circumstances should cable tie tension tools or cable tie pliers be used.

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Transformer Protection

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
Pre release

2010/02	Document reformat due to rebrand
R1 05/10/2006	Revision History Added. Reformatted to match other manual sections.

Software Revision History

Contents

Figures

1 Introduction

These commissioning recommendations apply to the testing, putting into service and subsequent maintenance of Duobias-M 200 (DU3-xxx**)** series of numerical protection relays. This range of relays is built on the **Modular II** hardware platform.

This range of relays can provide differential protection to two and three winding power transformers and other plant items such as busbars, motors and reactors. Relay models are available for connection of two to five sets (terminals) of CT's. VT's may also be connected to the relay if optional functions are required.

A separate technical manual is available for **Modular I** (DU2-XXX) Duobias M. The type of relay can be easily checked as **Modular II** relays have two pairs (Tx&Rx) of rear mounted fibre ports and Modular I relay have only one pair.

The relay can be used to protect other plant items such as reactors, busbars and motors.

A software program called Reydisp Evolution is available for download from the www.reyrolle-protection.com website. This allows access to settings, waveform records and event records via relay communications with an IBM PC compatible computer.

Before starting the test procedures all protection settings and schemes showing the D.C. status input and output relay configuration must be available.

It is recommended use is made of the Test Result Tables provided so that a comprehensive record of the protection settings, as commissioned, is available for future reference.

2 Safety

The commissioning and maintenance of this equipment should only be carried out by skilled personnel trained in protective relay testing and capable of observing all the Safety Precautions and Regulations appropriate to this type of equipment and also the associated primary plant in substations and power stations.

Ensure that all test equipment and leads have been correctly maintained and are in good condition. It is recommended that all power supplies to test equipment be connected via a Residual Current Device (RCD) which should be located as close to the supply source as possible.

The choice of test instrument and test leads must be appropriate to the application. Fused instrument leads should be used when measurements of power sources are involved, since the selection of an inappropriate range on a multi-range instrument could lead to a dangerous flashover. Fused test leads should not be used where the measurement of a current transformer (CT) secondary current is involved, the failure or blowing of an instrument fuse or the operation of an instrument cut-out could cause the secondary winding of the CT to become an open circuit.

Open circuit secondary windings on energised current transformers are a hazard that can produce high voltages dangerous to personnel and damaging to equipment, test procedures must be devised so as to eliminate this risk.

3 Sequence of Tests

If other substation equipment is to be tested at the same time as the Duobias-M, then such testing must be co-ordinated to avoid danger to personnel and equipment.

When cabling and wiring is complete, a comprehensive check of all terminations for tightness and compliance with the approved diagrams must be carried out. This can then be followed by the insulation resistance tests, which if satisfactory allows the wiring to be energised by either the appropriate supply or test supplies. When injection tests are completed satisfactorily, all remaining systems can be functionally tested before the primary circuit is energised. Some circuits may require further tests, e.g. synchronizing before being put on load.

4 Test equipment required

Various test sets designed for protection testing can be used to test the relay providing these allow injection the current sources with a sinusoidal waveform. If the CT secondary rating is 5A the bias characteristic may be tested single phase to allow test set amplifiers to be paralleled.

Test currents of the following range are required:

The bias characteristic requires 2 sources to be applied simultaneously.

The sources must be capable of delivering at least 5 x the rated current of the relay terminal used.

If differential high-set settings greater than 4 x I_N are intended to be tested then a larger current source will be required. The basic test equipment for primary and secondary injection test is as follows:

A digital test set capable of at least 2 x three phase current injection. The set must be capable of injecting at least 4 x the rated current on any of the relay inputs. For relay models with voltage inputs the amplifiers need to be reconfigured for voltage output.

500V insulation resistance test set.

Digital Multimeter

Laptop PC to drive the test set and the Reydisp Evolution relay software.

500volt Variac to measure CT magnetizing characteristics and inject the Restricted Earth Fault elements.

Primary test leads and injection set.

Suitable primary injection connectors, secondary injection test plugs, test leads and a suitable a.c supply may be required. These must be suitable for the connections available at the site concerned.

When making secondary injection tests ensure that the test circuit is earthed at one point only. All trip and alarm wiring must be isolated to ensure no unexpected tripping or alarms occur.

5 Insulation resistance test

The relay terminals are factory tested to 3.5kV rms for 1 second and therefore the relay itself does not requires a pressure test. The external wiring must still be tested for any insulation breaks.

Before commencing a visual inspection of the wiring take the following precautions:

Isolate the auxiliary supplies

Remove the trip and inter-trip links

Check that the relay wiring is complete and that all terminal connections are tight and remove the earth links before conducting insulation resistance tests.

Measure the insulation resistance between each section of the wiring and the other sections connected together and to earth.

The sections comprise:

a) CT secondary wiring connected to module AN 1
b) CT secondary wiring connected to module AN 2
c) Other optional CT and V.T. secondary winding connected to modules AN 3, 4 or 5.
d) D.C. wiring connected to PSU and I/O modules, excluding power supply wiring to the PSU module.

Before testing the d.c. wiring to earth, apply test connections between suitable points to short circuit each status input and series resistor to avoid possible damage to the opto-coupler should the wiring be earthed.

e) Test the power supply wiring to module PSU separately. Note that the d.c. +ve and d.c. -ve are each connected to earth by surge capacitors. This will lead to a slight drain current of 5 to 15mA.

Record the results in Table 1.

Insulation resistance values that are considered satisfactory must depend upon the amount of wiring involved. Generally, where a considerable amount of multi-core wiring is included, a reading of 2 to 3 mega-ohms is reasonable but higher readings should be expected. A reading of 1M ohm should not normally be considered satisfactory.

6 REF protection - CT and secondary wiring resistance

This test is to be applied to each of the restricted earth fault protections.

- Isolate the auxiliary supplies
- Remove the trip and intertrip links

Refer to the calculated data for the REF protection settings. This will give the maximum permissible lead resistance values.

Measure the resistance of the wiring between the relay equipment and the CTs. The readings obtained should be recorded in table 2 below. These should be approximately equal to or less than the values used in the calculated settings for the restricted earth fault function. This measurement is taken to ensure the REF calculations used suitable data and will be stable for through earth faults.

7 Relay power supply

Remove the relay front cover to give access to all the fascia push buttons. Relays are provided with a power supply suitable for one of the standard auxiliary supply ratings of 24V, 30V, 48V, 110V, 220V d.c. Ensure that the actual supply is within the range of the Vx marked on the relay fascia. Ensure the polarity of the supply is correct before energising the relay. The minimum recommended fuse rating of the supply is 12 amps.

It is normal for the relay to take some time while booting up.

With the relay energised the green LED will provide a steady illumination. None of the red LED's should be illuminated after the relay has completed booting up. Operate the TEST/RESET button and check that all the red LEDs are illuminated while the push is depressed.

8 Programming the Relay

The relay can either be set using the fascia buttons or from a laptop PC running Reydisp Evolution. Due to the number of settings, it is recommended that the laptop method be used for speed and ease of commissioning.

8.1 Setting by Laptop PC

The relay is supplied with a 25pin RS232C type communications port on the front of the fascia. This should be connected to a laptop using a 25 to 9 pin RS232 cable. Alternatively a USB connection to the laptop may be used, but this may require some Reydisp Configuration changes. Reydisp Evolution should be installed on the laptop, and this should run on any MS Windows © operating system.

To use the relay communications port the Communications Settings in the relay, must match the Communications settings selected in the Reydisp Evolution software.

To change the communications settings on the relay use the following procedure. On the relay fascia, keep tapping the ⇩ key until the COMMUNICATIONS MENU is displayed on the relay LCD. Press the TEST/RESET ⇨ once to bring up the STATION ADDRESS on the LCD. Press the ENTER button to alter the address to any desired number between 1 and 254. Set each relay communication address to a unique number. The address selected on the relay and the relay address selected on Reydisp Evolution must be set identically. The relay address can be changed by pressing the ⇩ or ⇧ buttons. Press ENTER to register the selected address number.

Continue to scroll down and set IEC 870 ON PORT to COM2 (front RS232 and bottom rear fibre ports are COMM 2 relay ports) and set AUTO DETECT to ON. The Auto Detect feature will automatically toggle the active port to the front RS232 from the bottom rear fibre port when connection is made.

Ensure that the Communications baud rate and parity check settings on the Reydisp Evolution software and Relay are the same. It is advisable to select the maximum baud rate on the relay and Reydisp Evolution to speeds up response times.

The communications setting can be changed in Reydisp Evolution by selecting:

OPTIONS -> COMMUNICATIONS. Note this window displays the active port of the laptop And not the relay. Select "OK" when changes are complete. Set the address on Reydisp Evolution to be the same as the relay station address.

Check the communications link by retrieving the relay settings (Relay->Settings->Get Settings)

Reydisp Evolution allows off line generation of relay setting by saving the relay Settings File and then downloading it. This saves time at site as late setting changes will then be minimised.

To download a Settings File from the laptop to the relay; select Relay->Settings->Send All Settings. Confirm the action and the user will be informed whether the settings have been successfully entered into the relay. It is worth doing a few spot checks on the setting to be confident the correct settings are installed.

8.2 Setting via Relay Fascia Pushbutton

The relay can be set from the fascia by utilising the ⇧, ⇩ ,⇨ and ENTER buttons. Settings can be selected with the arrow buttons. Pressing ENTER when the setting to change is found will make the setting flash. This allows the ⇧ and ⇩ buttons to be used to alter the setting. Once the desired setting is selected, the ENTER pushbutton **must** be pressed for the relay to register the selected setting. The setting will now stop flashing indicating this value will be utilised by the relay software.

The menu structure is shown in the “Description of Operation “ Section of this manual.

9 Secondary injection tests

Isolate the auxiliary D.C. supplies for alarm and tripping from the relay and remove the trip and inter-trip links.

The recommended test set to use is an Omicron Type CMC256 (or CMC156 plus CMA156). Automatic test software can be provided to allow input of settings and automatic testing and reporting. The Omicron set should be connected in accordance with the manufacturer’s instructions.

The following settings must be selected on relay to avoid any confusion during testing: -

The initial and bias slopes settings should be set to the chosen values.

W1 Interposing CT Multiplier	1.00
W1 Interposing CT Connection	Yy0
W2 Interposing CT Multiplier	1.00
W2 Interposing CT Connections	Yy0
Bias Slope Limit	4x
Differential Highset	4x

9.1 Proving Inputs and Outputs

The number of inputs and output contacts present will vary with model.

The easiest way to prove output contact operation is to use Reydisp Evolution. The relay output contacts can be closed by selecting RELAY -> CONTROL -> CLOSE OUTPUT RELAY menus. All outputs can also be selected to “Protection Healthy” to test the contact sense.

The status inputs must be tested by application of rated voltage. The “high” (operated) or “low” (unoperated) state of each status input is most easily checked using the Instruments window of the Reydisp Evolution software.

9.2 Accuracy of Measurement

Inject all of the current inputs with nominal current (including neutral and REF inputs) in turn, and record the Relay Currents measured by the relays in Table 4 below. Tap [⇩] to select Secondary Meters: -

e.g.

W1 Sec’y Currents x I_N
1.00 1.00 1.00

Use ⇩ and ⇧ to select the current measured by each of the inputs injected: -

e.g.

W2 Sec’y Currents x I_N
1.00 1.00 1.00

If voltage inputs are provided on the relay, apply nominal voltage to the relay and record the results displayed on the relay Instruments display (Voltage Meters). The voltage input terminals may be identified by viewing the label on the rear of the fascia door. These are normally terminal 11 and 12 of one of the analogue modules.

Record the Results in Table 1 below.

If the relay measurement is within tolerance proceed to 9.2 below. If any of the measurements are outside the stated tolerance (±5%) the relay must be sent back to the Quality Assurance Department for investigation. Otherwise advice can be obtained from Customer Services Department (++00 44 (0)191 401 5190).

9.3 Checking the Bias Characteristic (87BD)

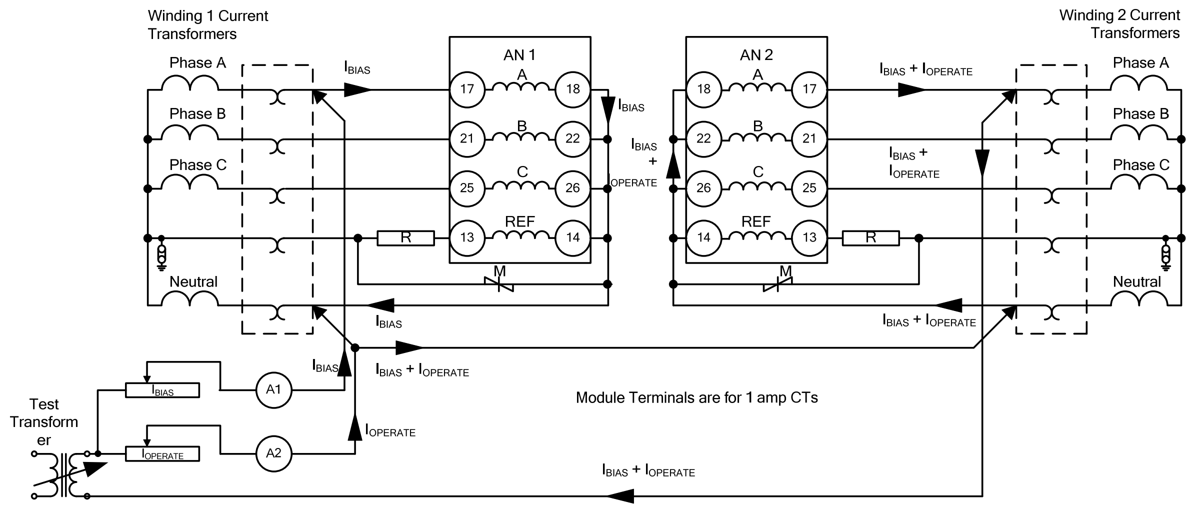

Figure 1 - Biased Differential Test Circuit using Variacs

When testing the bias characteristic, the Relay Currents can be displayed on the LCD by changing to the INSTRUMENTS mode and scrolling down to [BIAS DIFF METERS]. The Instruments to view to help check the relay bias characteristics are the Relay Currents, the Operate (differential) currents and the Restrain (bias) currents.

Inject nominal current into W1 Red and W2 Red Phase current inputs. If the test set has the facilities it can also be done three-phase.

While testing the bias slope, select the Instrument display: -

W1 Relay Currents x I_N
0.00 0.00 0.00

The Differential Operate and Restrain Current Meters should also be checked.

Repeat the tests with increasing bias currents up to 2.5 times the relay rating.

Record the results and check for accuracy in Table 5

Repeat the tests for the other phases if necessary.

Check that the Bias Currents on the Instruments Display are as expected. The upper bias characteristic may also be checked if required. Some of the more common bias characteristics used are displayed in Section 2 of this manual.

The Biased Differential may also be conveniently tested using an Omicron Test Unit. Please contact Siemens Protection Devices Ltd for an Omicron test object template (.occ) for the Duobias-M Biased Differential Test Characteristics.

9.4 Inrush Inhibit

The relay has an anti-aliasing filter that does attenuate the even harmonic content slightly. The attenuation differs depending upon whether the relay is used on a 50 or 60Hz power system. Software revisions R15 onwards include an automatic adjustment for this filter loss.

The relay has a built feature to avoid a false operation when energising a transformer. This uses the presence of even harmonic in the operate signals to distinguish between an inrush and an internal fault. Three different methods are included in the relay.

The test method will depend upon the Inrush Restraint Method selected. As previously mentioned the SUM method has an advantage over the CROSS method in terms of operating speed if an internal fault occurs on energising the transformer.

Only the Inrush Restraint method selected need be tested.

Sum - Restraint Method

This method uses one Inrush Sum some with which to compare the operate current in each phase. The square roots of the even harmonic content in each phase differential current is summed and then divided by the Inrush Setting to arrive at an overall threshold.

Cross – Inhibit Method

The magnetising inrush restraint feature can be checked by injecting the relay with 2nd harmonic current into one set of inputs while fundamental is injected into another set of inputs. If possible the test should be done three phase as all phases are blocked if one phase exceeds the Inrush Inhibit Setting.

Check the **87 Inrush Inhibit** setting is set to [Enabled].

Inject W1 inputs with a balanced three phase current of nominal amplitude and frequency. This will operate all three phases of the biased differential function. The 87BD and phase LED's will be lit.

Inject about 5% of nominal 2nd harmonic current into W2 inputs. Slowly raise the 2nd Harmonic Current until the biased differential resets. The approximate levels of 2nd harmonic to block operation are set out in the table below. Digital Test sets such a Omicron 256-6 use a ratio injection to test the relay inhibit, the Duobias M does not work like this as its setting is a percentage of the operate current.

INRUSH SETTING (FRACTION OF I_{OP})	2ND HARMONIC CURRENT INTO W2 REQUIRED TO BLOCK 87BD FOR NOMINAL FUNDAMENTAL CURRENT INJECTION OF W1 INPUTS		SETTING AT RECOMMENDED TEST POINT IN TERMS OF 2ND / OPERATE	
	50 Hz Relay(x I_n)	60 Hz Relay(x I_n)	50Hz Relay(x I_n)	60Hz Relay(x I_n)
0.10	0.108	0.120	0.100	0.132
0.12	0.128	0.144	0.121	0.159
0.14	0.150	0.168	0.141	0.186
0.16	0.172	0.192	0.161	0.213
0.18	0.194	0.219	0.181	0.241
0.20	0.216	0.245	0.200	0.268
0.22	0.239	0.268	0.220	0.296
0.24	0.262	0.293	0.240	0.325

The relay will filter out some of the second harmonic content in currents due to the anti-aliasing filter roll off.

The filter response attenuates the 2nd (100Hz) harmonic current by approximately x 0.94 for a 50Hz Relay, and by x 0.84 for a 60Hz relay.

The root mean square value of operate current must be calculated, as this is what is used to set the Inrush Inhibit level. Typically digital test sets such as the Omicron uses 2nd Harmonic / Fundamental to check the relay accuracy. However the relay uses the percentage of second harmonic to the root mean square of operate current. As the operate current includes the injected 2nd harmonic as well as the fundamental this must be taken into account.

9.5 Checking the Differential Highset (87HS)

Connect the test current source to relay or test plug. The test can be done single phase or three phase. This tests requires the injection of current in excess of the relay rating, so ensure that the duration of the test does not exceed the relay overload withstand rating.

Use the LCD display to check that the LV input settings are as follows:

LV Interposing CT Multiplier 1.00

LV Interposing CT Connection Yy0

These ensure a 1:1 ratio between the injected phase and the relay setting.

Note, the LV interposing CT multiplier could be set to 3.0 for test purposes to reduce the test current requirements if the test set has limited range.

Select Instruments Mode and select the following display.

W1 Relay Currents

0.00 0.00 0.00 x In

Switch on and increase the value of the test current until the highset relay operates, record the value in Table 2.

Operation of the Differential Highset on phase A is indicated by illumination of the appropriate LED. Check that the contacts operate on all the output relays selected for this function, both trip and alarm. (Note that the differential will also operate). Repeat the test for other phases if required and record the results.

9.6 Restricted Earth Fault (87REF)

Refer to the calculated setting data and check that the relay has the correct settings for each of REF protections. Measure the resistance of the REF series setting resistors and adjust each one to match the REF setting data. Record the values in Table 6.

This should be done in two stages: A by current injection or B - By application voltage.

A - Current Injection by test set

Inject the REF inputs with the CT's disconnected and record the pickup values in Table 6. The setting resistor should be temporarily be shorted out to allow injection from digital test set.

B – Applied Voltage using Variac

Follow safety procedure to ensure no other personnel can come into contact with secondary wiring during this test. Tests are carried out with the current transformers connected in idle shunt to the REF parallel leg. Apply voltage across the REF parallel leg input via the test block or lead and connect an a.c. voltmeter to verify the voltage applied. Slowly increase the applied voltage and note the voltage required for the REF protection to operate on the voltmeter. Ensure that appropriate LED's illuminate and selected output relays operate.

9.7 Over Fluxing or Volts per Hertz Protection (24)

The testing of over fluxing element requires a variable voltage source.

The settings are set in terms of nominal voltage and frequency. Application of a voltage of nominal voltage and frequency represents 100% or 1 per unit. Apply the required settings prior to testing.

24IT – inverse time

The inverse V/f element is best tested at the settings selected that constitute the overall inverse characteristics. The seven setting points require the voltage to be calculated to check for pickup with nominal frequency applied. The voltage may be raised or the frequency dropped to determine the pickup of the Volts per Hertz settings applied. Usually it is easier to increase the voltage while applying h nominal frequency.

Record the results in Table 6

24 DTL – definite time

The voltage required for operation should be calculated and tested. The pickup and operate time should be recorded for each stage used.

9.8 Thermal Overload (49)

The thermal pickup and operating time should be checked. The thermal overload equations for calculating the operate time are:

Time to trip $t(mins) = \tau \times \ln\left\{\frac{I^2}{I^2 - (I\theta)^2}\right\}$

where,

t – operate time in minutes
I - applied current in terms of x In
I_Θ - thermal pick-up setting x In

The steady state % thermal capacity used can be calculated from:

$$\%\ thermal\ capacity\ used = \left(\frac{I^2}{(I\theta)^2}\right) \times 100$$

The pickup value and accuracy of timing should be within 5% of setting.

A typical operate time with 2 x pickup applied and a time constant of 1 minute would result in a calculated operate time of 17.26 seconds.

9.9 Over Current and Earth Fault (51, 51N, 50, 50N, 50G, 51G)

The pickup and timing should be tested for each element. Earth Fault elements may be measured (51N) from a neutral CT's or derived for line CT inputs (51G). This will affect where the injection must be made to allow testing.

The pickup level, operate and reset time should be recorded in Table 10. The ANSI overcurrent elements also have inverse reset curves that may be tested. The IEC curves may have a DTL reset applied. The reset delays are used to ensure grading between differing types of relays, if "pecking" or intermittent type of faults earth occurs. These are quite common on power cables particularly XLPE.

The 50G/51G elements require current to be applied to the phase inputs as the earth fault current is derived from the residual (sum) of the three phase current inputs. The 50N/51N elements are measured directly from the single Aux I/P input.

NOTE

All (51) elements have a minimum pickup of 1.05 xI_S, all (50) elements have a minimum pickup of 1.00 xI_S.

9.10 Negative Phase Sequence Over Current (46DTL, 46ITL)

The negative sequence current is measured from the phase inputs. Pure negative phase sequence current can be injected by swapping the phase relationship of two of the phase currents. This can be achieved by swapping over two leads or changing the set phase angle of two of the three currents.

The NPS current then equals the value of the phase current injected.

The pickup level and operate times can be recorded in Table 13.

10 Primary injection tests

Primary injection is recommended to prove the relay connections, CT polarity and settings before putting the protection scheme into service. To prove the connections of REF protection a primary injection must be done. The differential protection can also be proven using load current if a risk of trip is permitted and step 10.1 is then not necessary.

WARNING!

It is important before carrying out any primary injection to ensure appropriate CTs are shorted to avoid operation of mesh corner or busbar type unit protection. If the injected primary current is large enough, the bus zones protection may trip out unnecessarily!

10.1 Biased Differential Protection

Sufficient primary current to prove the connections and settings is required so that a minimum secondary current of about 10mA rms circulates in the relay inputs.

An external three-phase primary short is required on one side of the transformer, ideally the HV side. Apply 415 LVAC to the other side ensuring the primary current is injected through all of the biased differential CT's. The following procedure should be followed to check the a.c. scheme and settings are correct.

i Use Reydisp Evolution software to trigger a Waveform Record of the currents.
ii Retrieve the waveform record from the relay.
iii View the Waveform Record in Reydisp Evolution.
iv Check the W1 and W2 Relay Currents are in anti-phase by placing the cursors on the peak relay currents. Check each phase in turn.

If the current transformers associated with the protection are located in power transformer bushings it may not be possible to apply test connections between the current transformer and the power transformer windings. Primary injection is needed however to verify the secondary connection of a neutral CT relative to the phase CTs and the relay. In these circumstances primary current must be injected through the associated power transformer winding. It may be necessary to short-circuit another winding in order to allow sufficient current to flow.

If difficulty is experience due to physical restraints, the differential may be proven using load current.

10.2 Restricted Earth Fault

The CT polarities forming the Restricted Earth Fault (REF) protection must be proved, and the recommended way to achieve this is by primary injection. Inject single phase or three phase current from a suitable primary test set through earth and primary conductors. The results of these tests may be recorded in Table

During these primary injection tests the injected current may be limited due to the impedance of the neutral connection. Temporary shorts must be added to allow a definite result to be established. Place a temporary short across the setting resistor to allow the secondary current to be measured.

Insert the test block with necessary shorts across from CT to relay side. Inject primary current sufficient to allow measurement. Measure and record the REF spill current displayed by the appropriate relay Instrument. This spill current should be very small e.g. a few mA's.

Reverse the connections to the secondary winding of the neutral CT the spill current should become larger. Repeat for other phases if necessary.

Re-connect the auxiliary d.c. supplies for trip and alarm operations and insert the Trip and InterTrip links.

The differential protection should be operated by secondary injection to check that correct tripping (or intertripping) and indication occurs.

Simulate the operation of each external contact that initiates a Duobias M status input. This can be done by temporarily shorting across the operating contact. In each case check the appropriate LED illuminates and that the correct tripping, intertripping and alarm initiation occurs.

Disconnect the d.c. power supply to the Duobias-M relay and check the correct PROTECTION UNHEALTHY alarm contact operates. If this alarm is wired to a remote indication point e.g. a control centre, the operation of the alarm at this point should also be checked.

Operate the differential protection and the REF protections in turn by primary or secondary injection and check that the correct tripping and indication occurs.

11 Tests using load currents

Re – insert all the d.c. fuse and links for all supply, trip and alarm functions.

Connect the laptop and check communications is established with the relay by downloading all settings. Ensure that the Duobias-M relay is set with the correct setting for the specific application of the relay. Select INSTRUMENTS MODE.

Under steady load conditions record in to Table 15 the readings displayed on the instruments. If the secondary connections and the matching of the differential protection to the transformer ratio and vector group connections are correct the readings "OPERATE A, B, C" should be negligible for all three phases.

Next unbalance the differential protection by 180° reversing a vector group compensation setting. e.g.

Yd1 would become yD7

Yy0 would become Yy6

Repeat the tests and record the currents inTable 15.

The operate currents "OPERATE A, B, C" should now be comparatively large.

Reset the vector group compensation setting back to the correct setting, re-check that the "OPERATE A, B, C" currents are negligible.

12 Putting into service

Ensure that: The trip supply is connected.

Press the CANCEL button several times on the front of the relay to move back to the top of the menu structure

Press the TEST/RESET pushbutton

None of the RED LEDs should be illuminated.

Check the Protection Healthy GREEN LED has continuous illumination.

Ensure that all earth links, trip links and inter-trip links are in their normal operational positions.

Operate the Cancel PUSH BUTTON

Replace the cover.

13 Site test sheet

See following pages

.

SITE TEST SHEET

CUSTOMER ______________________________

CUSTOMER CONTRACT NUMBER ______________________________

SIEMENS CONTRACT NUMBER ______________________________

SITE/CIRCUIT REF. ______________________________

RELAY SERIAL NUMBER ______________________________

RELAY MODEL **DUOBIAS-M-2______**

RELAY ARTICLE NUMBER ______________________________

Signatures and Date:

Test Engineer **Customers Representative**

………………………………… …………………………………..

1 Site tests

1.1 Insulation Resistance

CIRCUIT TEST	FITTED	INSULATION RESISTANCE (MEGOHMS)
AN 1	√	
AN 2	√	
AN 3	□	
AN 4	□	
AN 5	□	
I/O 1	□	
I/O 2	□	
I/O 3	□	
PSU I/O	√	
PSU DC SUPPLY	√	

Table 1 - Insulation Resistance

1.2 Hardware Tests

1.2.1 Status Inputs

STATUS INPUT (MODULE)	TERMINAL NO.S		USAGE BY PROTECTION SCHEME	CHECKED
	+	-		
Status 1 (PSU)	21	23	□ *e.g. Buchholz*	□ OK
Status 2 (PSU)	25	27	□	□ OK
Status 3 (PSU)	26	28	□	□ OK
Status 4 (I/O 1)	1	3	□	□ OK
Status 5 (I/O 1)	5	7	□	□ OK
Status 6 (I/O 1)	9	11	□	□ OK
Status 7 (I/O 1)	13	15	□	□ OK
Status 8 (I/O 1)	17	21	□	□ OK
Status 9 (I/O 1)	19	21	□	□ OK
Status 10 (I/O 1)	23	27	□	□ OK
Status 11 (I/O 1)	25	27	□	□ OK
Status 12 (I/O 2)	1	3	□	□ OK
Status 13 (I/O 2)	5	7	□	□ OK
Status 14 (I/O 2)	9	11	□	□ OK
Status 15 (I/O 2)	13	15	□	□ OK
Status 16 (I/O 2)	17	21	□	□ OK
Status 17 (I/O 2)	19	21	□	□ OK
Status 18 (I/O 2)	23	27	□	□ OK
Status 19 (I/O 2)	25	27	□	□ OK
Status 20 (I/O 3)	1	3	□	□ OK
Status 21 (I/O 3)	5	7	□	□ OK
Status 22 (I/O 3)	9	11	□	□ OK
Status 23 (I/O 3)	13	15	□	□ OK
Status 24 (I/O 3)	17	21	□	□ OK
Status 25 (I/O 3)	19	21	□	□ OK
Status 26 (I/O 3)	23	27	□	□ OK
Status 27 (I/O 3)	25	27	□	□ OK

Table 2 - Status Inputs

1.2.2 Output Relays

OUTPUT RELAY(LOCATION)	TYPE	TERMINAL NO.	USED IN SCHEME	CHECKED
Relay 1(PSU)	C/O	4 (NO) 5 (COM) 6 (NC)	□ □ □	□ OK
Relay 2(PSU)	C/O	9 (NO) 8 (COM) 7 (NC)	□ □ □	□ OK
Relay 3(PSU)	C/O	10 (NO) 11 (COM) 12 (NC)	□ □ □	□ OK
Relay 4 (PSU)	N/O	17 –19	□	□ OK
Relay 5 (PSU)	N/O	18 – 20	□	□ OK
Relay 6 (I/O 1)	N/O	2-4	□	□ OK
Relay 7 (I/O 1)	N/O	6-8	□	□ OK
Relay 8 (I/O 1)	N/O	10-12	□	□ OK
Relay 9 (I/O 1)	N/O	14-16	□	□ OK
Relay 10 (I/O 1)	N/O	18-22	□	□ OK
Relay 11 (I/O 1)	N/O	20-22	□	□ OK
Relay 12 (I/O 1)	N/O	24-28	□	□ OK
Relay 13 (I/O 1)	N/O	26-28	□	□ OK
Relay 14 (I/O 2)	N/O	2-4	□	□ OK
Relay 15 (I/O 2)	N/O	6-8	□	□ OK
Relay 16 (I/O 2)	N/O	10-12	□	□ OK
Relay 17 (I/O 2)	N/O	14-16	□	□ OK
Relay 18 (I/O 2)	N/O	18-22	□	□ OK
Relay 19 (I/O 2)	N/O	20-22	□	□ OK
Relay 20 (I/O 2)	N/O	24-28	□	□ OK
Relay 21 (I/O 2)	N/O	26-28	□	□ OK
Relay 22 (I/O 3)	N/O	2-4	□	□ OK
Relay 23 (I/O 3)	N/O	6-8	□	□ OK
Relay 24 (I/O 3)	N/O	10-12	□	□ OK
Relay 25 (I/O 3)	N/O	14-16	□	□ OK
Relay 26 (I/O 3)	N/O	18-22	□	□ OK
Relay 27 (I/O 3)	N/O	20-22	□	□ OK
Relay 28 (I/O 3)	N/O	24-28	□	□ OK
Relay 29 (I/O 2)	N/O	26-28	□	□ OK

Table 3 - Output Relay Contacts

1.3 Secondary Injection

1.3.1 Accuracy of Measurement

TEST	AVAILABLE	APPLIED VALUE	RELAY INSTRUMENTS DISPLAY (±5%)
Winding 1 Line Currents	√	1.00 xI_n	(I_A, I_B, I_C)
Winding 2 Line Currents	√	1.00 xI_n	(I_A, I_B, I_C)
Winding 3 Line Currents	□	1.00 xI_n	(I_A, I_B, I_C)
Winding 4 Line Currents	□	1.00 xI_n	(I_A, I_B, I_C)
Winding 5 Line Currents	□	1.00 xI_n	(I_A, I_B, I_C)
W1 EF/REF	□	0.200 xI_n	
W2 EF/REF	□	0.200 xI_n	
W3 EF/REF	□	0.200 xI_n	
Voltage Input	□	1.00 xV_n	

Table 4 - Measurement Accuracy

1.3.2 Biased Differential Characteristics

87BD Initial Setting	87BD Bias Slope Setting	Bias Current (x I_N) Measured on Ammeter A1				
		0.00	1.00	1.50	2.00	2.50
		Operate Current Measured on Ammeter A2				
0.10	**0.10**	0.10	0.11	0.16	0.21	0.26
0.20	**0.20**	0.20	0.22	0.33	0.44	0.56
0.30	**0.30**	0.30	0.35	0.53	0.71	0.88
0.40	**0.40**	0.40	0.50	0.75	1.00	1.25
0.50	**0.50**	0.50	0.67	1.00	1.33	1.67
0.50	**0.60**	0.50	0.86	1.29	1.71	2.14
0.50	**0.70**	0.50	1.08	1.62	2.15	2.69
Selected Settings		**Test Results**				
		0.00	**1.00**	**1.50**	**2.00**	**2.50**
Phase A Pickup						
Phase B Pickup						
Phase C Pickup						

Table 5 - Biased Differential Characteristics

1.3.3 Inrush Inhibit Pickup

87 Inrush Setting (xI_D)	Actual Blocking Level (xI_D)

Table 6 - Inrush Inhibit

The tolerance for the Inrush Setting is ±10% of setting.

1.3.4 Differential Highset Pickup

Phase Setting (xI_N)	A Phase Pickup	B Phase Pickup	C Phase Pickup

Table 7 - Highset Differential Pickup

1.3.5 Restricted Earth Fault

Test	Fitted	Value/Setting	Measured / Pickup	Units
W1 REF Resistor	☐			ohms
W1 REF Current Setting				xIn
W1 Voltage Setting				volts
W2 REF Resistor	☐			ohms
W2 REF Current Setting				xIn
W2 Voltage Setting				volts
W3 REF Resistor	☐			ohms
W3 REF Current Setting				xIn
W3 Voltage Setting				volts

Table 8 - Restricted Earth Fault

1.3.6 Overfluxing

TEST	SETTING X (VOLTS)	SETTING Y (SECONDS)	PICKUP X (VOLTS)	PICKUP Y (SECONDS)
X0, Y0				
X1, Y1				
X2, Y2				
X3, Y3				
X4 ,Y4				
X5, Y5				
X6, Y6				

Table 9 - Over Fluxing Inverse Curve 24IT

TEST	SETTING (VOLTS)	ACTUAL PICKUP (VOLTS)	TIME DELAY SETTING (SECONDS)
24DT-1			
24DT-2			

Table 10 - Over Fluxing Dual Definite Time 24DT

1.3.7 Thermal Overload

PICKUP SETTING (X IN)	ACTUAL PICKUP (X IN)	CALCULATED TIME (SECONDS)	ACTUAL OPERATE TIME (SECONDS)

Table 11 - Thermal Overload

1.3.8 Backup Over current and Earth Fault

ELEMENT ANSI NO. (E.G. 51N)	PICKUP SETTING	ACTUAL PICKUP	CALCULATED OPERATE TIME (S) AT MULTIPLE OF PU.		ACTUAL OPERATE TIME DELAY (S)	RESET TIME APPLIED	RESET TIME RECORDED
			(s)	(x PU)			

Table 12 - Backup Overcurrent and Earth Fault

1.3.9 Negative Phase Sequence Over current

ELEMENT ANSI NO. (E.G. 46DTL)	PICKUP SETTING	ACTUAL PICKUP	CALCULATED OPERATE TIME (S) AT MULTIPLE OF PU		ACTUAL OPERATE TIME DELAY (S)	RESET TIME APPLIED	RESET TIME RECORDED
			(s)	(x PU)			

Table 13 - Negative Phase Sequence Over current

1.4 Primary Injection / On Load Tests

1.4.1 Differential Protection

1.4.1.1 Line And Relay Magnitude Checks From Relay Instruments

INSTRUMENT	PRIMARY CURRENTS (kA)	SECONDARY CURRENTS (A) [BEFORE ICT]	ICT RELAY CURRENTS (xI_N) [AFTER ICT]
W1 Phase A			
W1 Phase B			
W1 Phase C			
W2 Phase A			
W2 Phase B			
W2 Phase C			

Table 14 - Primary Inject Magnitude Check

1.4.1.2 Operate and Restrain Magnitude Checks From Relay Instruments

INSTRUMENT	ACUAL SETTINGS	180° UNBALANCED SETTINGS
Operate Phase A		
Operate Phase B		
Operate Phase C		
Restrain Phase A		
Restrain Phase B		
Restrain Phase C		

Table 15 - Operate Currents Check

1.4.1.3 Phase Checks

PHASE DIFFERENCE OF WINDING ICT CURRENTS	ANTI PHASE CHECK
A Phase	☐ OK
B Phase	☐ OK
C Phase	☐ OK

Table 16 - Primary Injection Phase Difference Check

The Winding (W1,W2 etc) ICT Currents for each phase should be in anti-phase. For a two winding transformer the W1 ICT A phase current should be in anti-phase (180 degrees apart) with the W2 ICT A phase current. All phases should be checked to ensure wiring errors are not present.

1.4.2 Restricted Earth Fault

TEST	PRIMARY CURRENT INJECTED (A)	REF SECONDARY CURRENT (mA)	CHECK
W1 Neutral CT Normal Polarity			☐ OK (no spill current)
W1 Neutral CT Reversed			☐ OK (significant spill current)
W2 Neutral CT Normal Polarity			☐ OK (no significant spill current)
W2 Neutral Neutral CT Reverse			☐ OK (significant spill current)

Table 17 - REF Primary Injection Tests

1.5 Trip, Alarm and Indication Tests

TEST	ACTION	RESULT
Trip/Intertrip	Local and Remote CB Trip Operation Confirmed	□ OK
Remote Alarms	All external Alarms confirmed	□ OK
LED Indication for operation of external protection	All LED's correctly indicate for the operation of each device	□ OK
Protection Healthy Alarm	Local (and Remote) indication and alarm confirmed	□ OK

Table 18 - Trip, Alarm and Indication Test

1.6 Communication

TEST	ACTION	RESULT
Local Relay Port	Download Settings Confirmed	□ OK
Saved Settings File	Record the name of the As Installed Settings File(s) and storage location	
Remote Relay Access(if used)	Relay Access Confirmed	□ OK
Relay Password	Enter Password(NONE is entered if not used)	□ OK
Numeric Password Code	_ _ _ _ _ _ _ _ _ _ _ _	□ Record Password Code

Table 19 - Communication

7SG14 Duobias M

Transformer Protection

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
Pre release

Revision	Date	Change
	2010/02	Document reformat due to rebrand
R1	05/10/2006	Revision History Added. Reformatted to match other manual sections.

Software Revision History

1 Maintenance

Duobias-M is a maintenance free relay with no user serviceable parts. It includes an internal monitoring programme and provision for Protection Inoperative alarm. In the event of an internal fault the LCD will display fault messages, these features effectively mean that no annual maintenance is required on the relay.

It is recommended to make a periodic test of the operation of all the equipment. It is suggested that it should include, but not necessarily be limited to, the following.

- General check of the connections (every year)
- Insulation resistance check (every 5 years)
- Inspect the trip circuit fuse links, if necessary renew them (every year)
- Operate relays that trip and see that the trip and intertrip circuits are energised (every 2 years)
- Check that the Duobias-M LED’s operate (every year)
- Secondary injection tests of operation from the HV and LV sides (every 5 years)

To confirm that the relay is operating correctly a record of the relay currents at the metering points at the fault setting may be used for reference in future maintenance tests.

If the protection includes neutral current transformers check the continuity of these and their pilots.

A balance test using load current can be carried out at routine intervals.

2 Defect Report Form

Form sheet for repairs and returned goods (fields marked with * are mandatory fields)

Sender:

*** Name, first name:**	Complete phone number (incl. country code):	Complete fax number (incl. country code):
Email address:	*** Org-ID and GBK reference:**	*** AWV:**

*** Order-/ reference-no (choosing at least 1 option):**

Order-no for repair:	order-/ delivery note-no for return of commission failure:	Beginning order-no for credit note demand:

Information concerning the product and its use:

*** Order Code (MLFB):**	Firmware version: V	*** Serial number:**	
* Customer:	Product was in use approximately since:	Station/project:	Hotline Input no.:
Customer original purchase order number:	Delivery note number with position number:	Manufacturer:	

*** Type of order (choosing at least 1 option):**

- ☐ Repair
- ☐ Upgrade / Modification to ...
- ☐ Return of commission failure
- ☐ Warranty repair
- ☐ For collection
- ☐ Credit Note
- ☐ Quotation (not repair V4 and current products! See prices in PMD)

Type of failure:

- ☐ Device or module does not start up
- ☐ Sporadic failure
- ☐ Permanent failure
- ☐ Repeated breakdown
- ☐ Mechanical problem
- ☐ Knock sensitive
- ☐ Temperature caused failure
- ☐ Failure after firmware update
- ☐ Overload
- ☐ Transport damage
- ☐ Failure after ca ☐ hrs in use

Error description:

- ☐ Display message:
  (use separated sheet for more info)
- ☐ Active LED messages:
- ☐ Faulty Interface(s), which?
- ☐ Wrong measured value(s), which?
- ☐ Faulty input(s)/output(s), which?

***Detailed error description** (please refer to other error reports or documentation if possible):

*** Shall a firmware update be made during repair or mechanical upgrade of protective relays? (choosing at least 1 option)**

- ☐ Yes, to most recent version
- ☐ No
- ☐ Yes, actual parameters must be reusable

repair report:

- ☐ Yes, standard report (free of charge)
- ☐ Yes, detailed report (charge: 400EUR)

Shipping address of the repaired/upgraded product:

Company, department

Name, first name

Street, number

Postcode, city, country

Date, Signature

Please contact the Siemens representative office in your country to obtain return instructions.

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