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
R1 18/10/2006	Revision History Added. Model table modified to show latest model range and removes older models

Software Revision History

Contents

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 + 87 HS	REF 87 REF	3P OC IDMTL/ DTL + INSTL/ DTL 51/50	Derived[1] EF 50N/ 51N	Measured EF 50G/51 G	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

$\frac{\left|I_1\right| + \left|I_2\right| + ...\left|I_n\right|}{2}$ (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

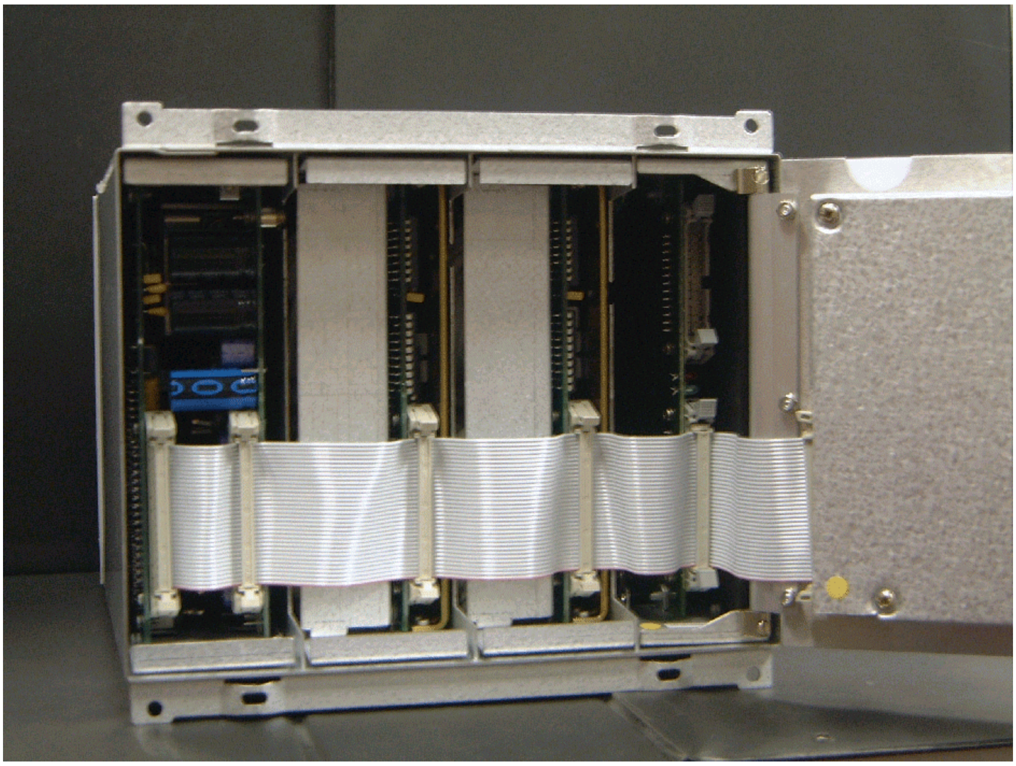

Figure 1 - Duobias-M in E8 case with front panel open

Figure 2 - Duobias-M Rear View

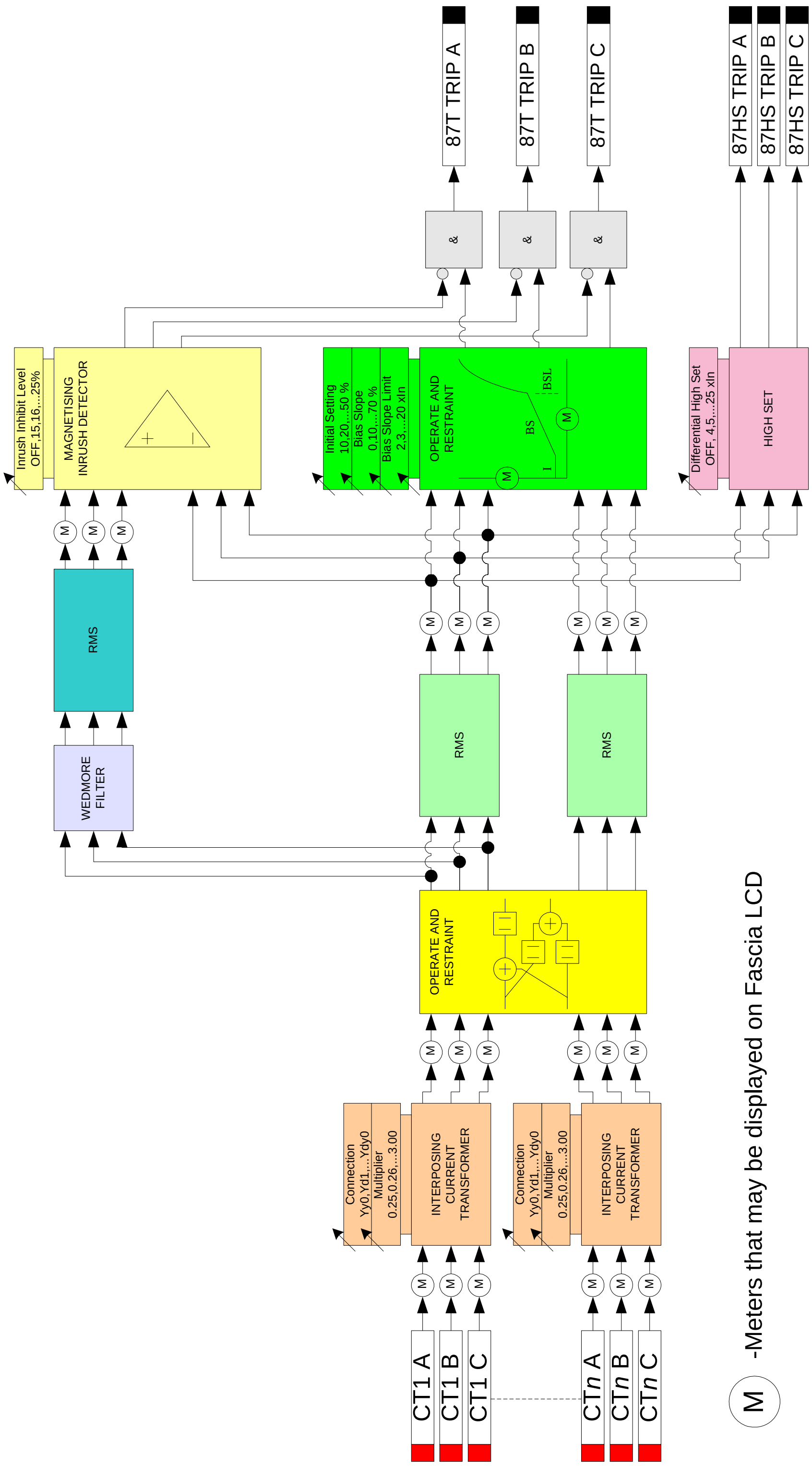

Figure 3 - Duobias-M Current Differential Algorithm

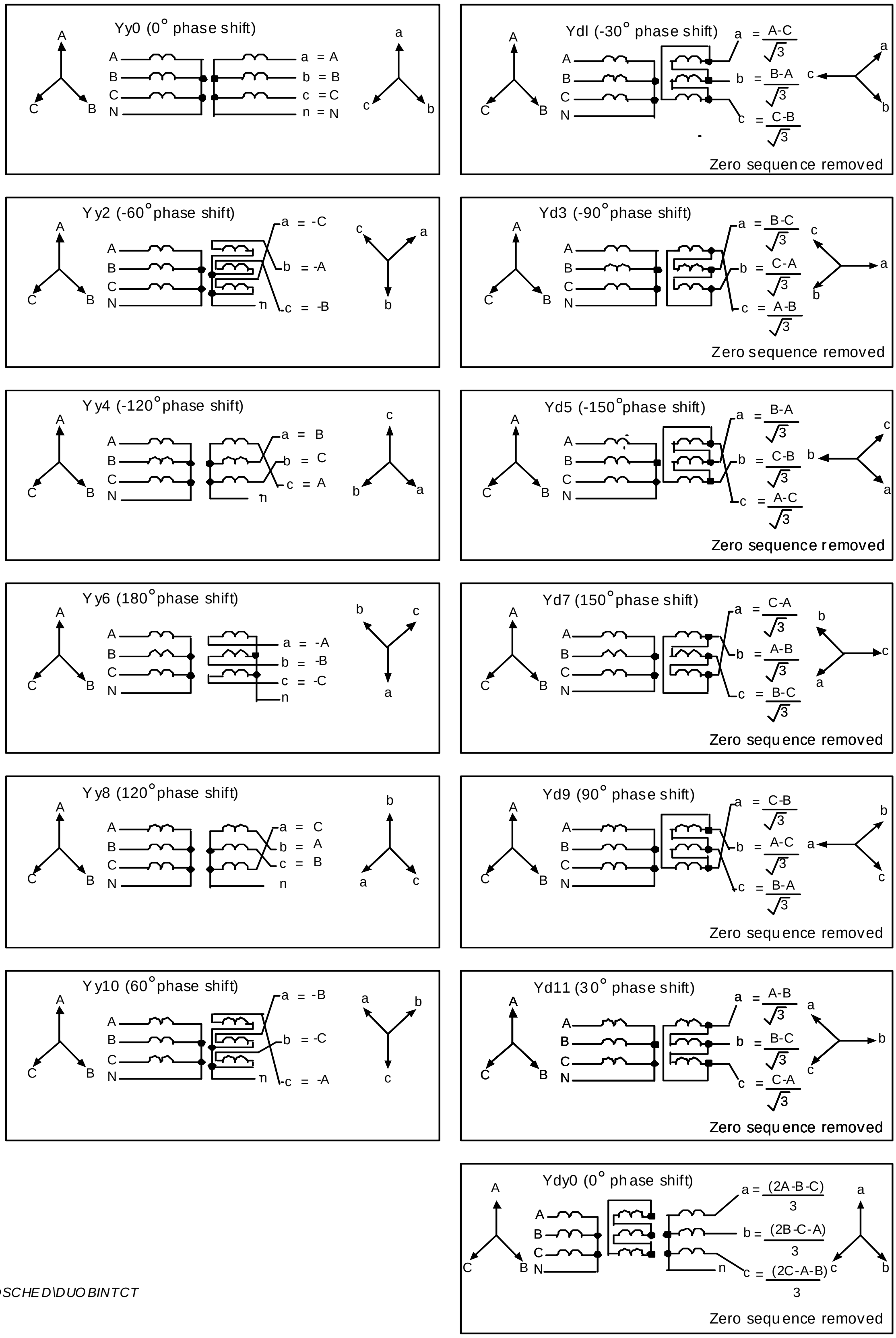

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Figure 4 - Duobias-M Interposing CT arrangements

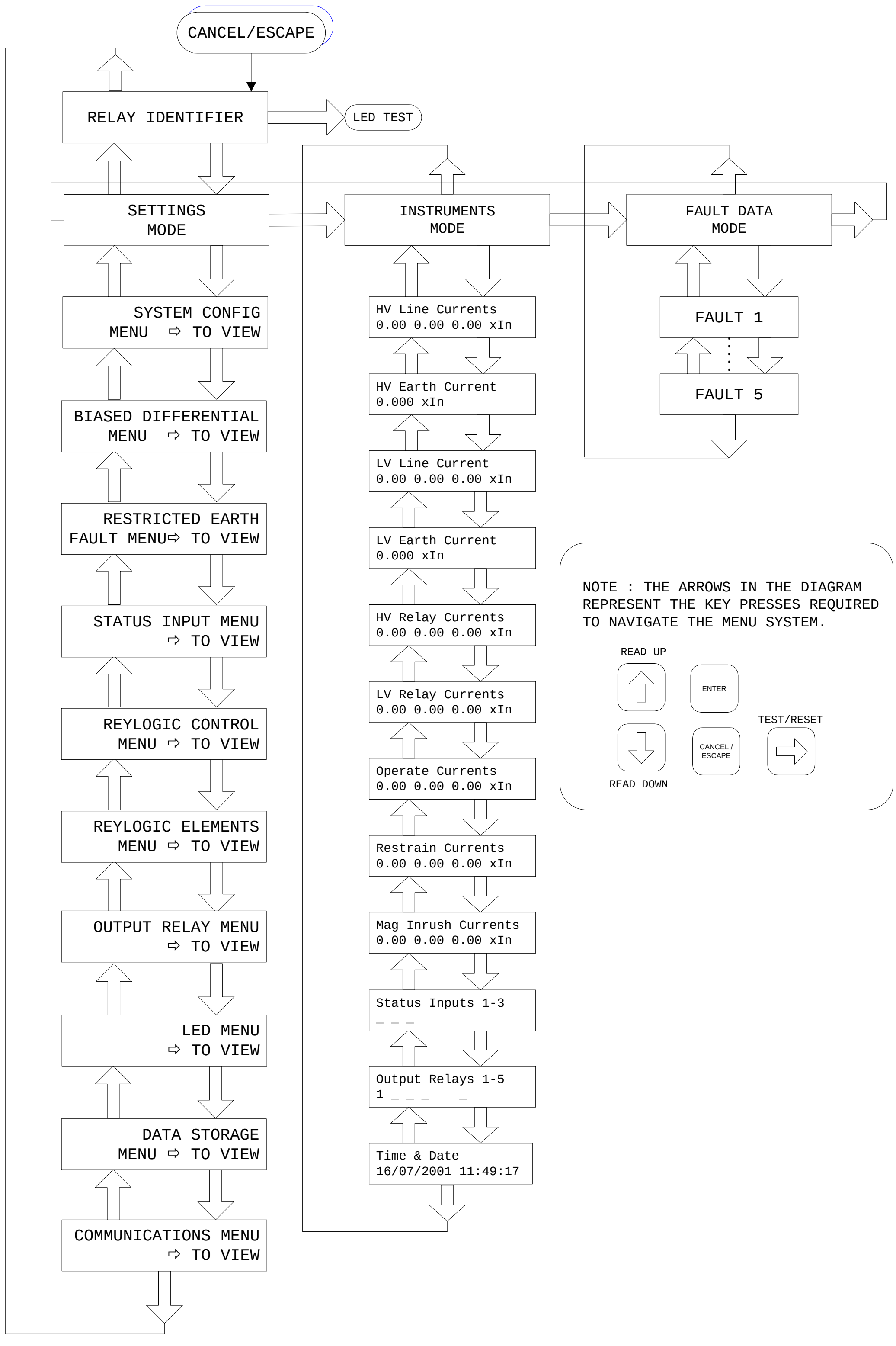

Figure 5 - Duobias-M Menu Structure

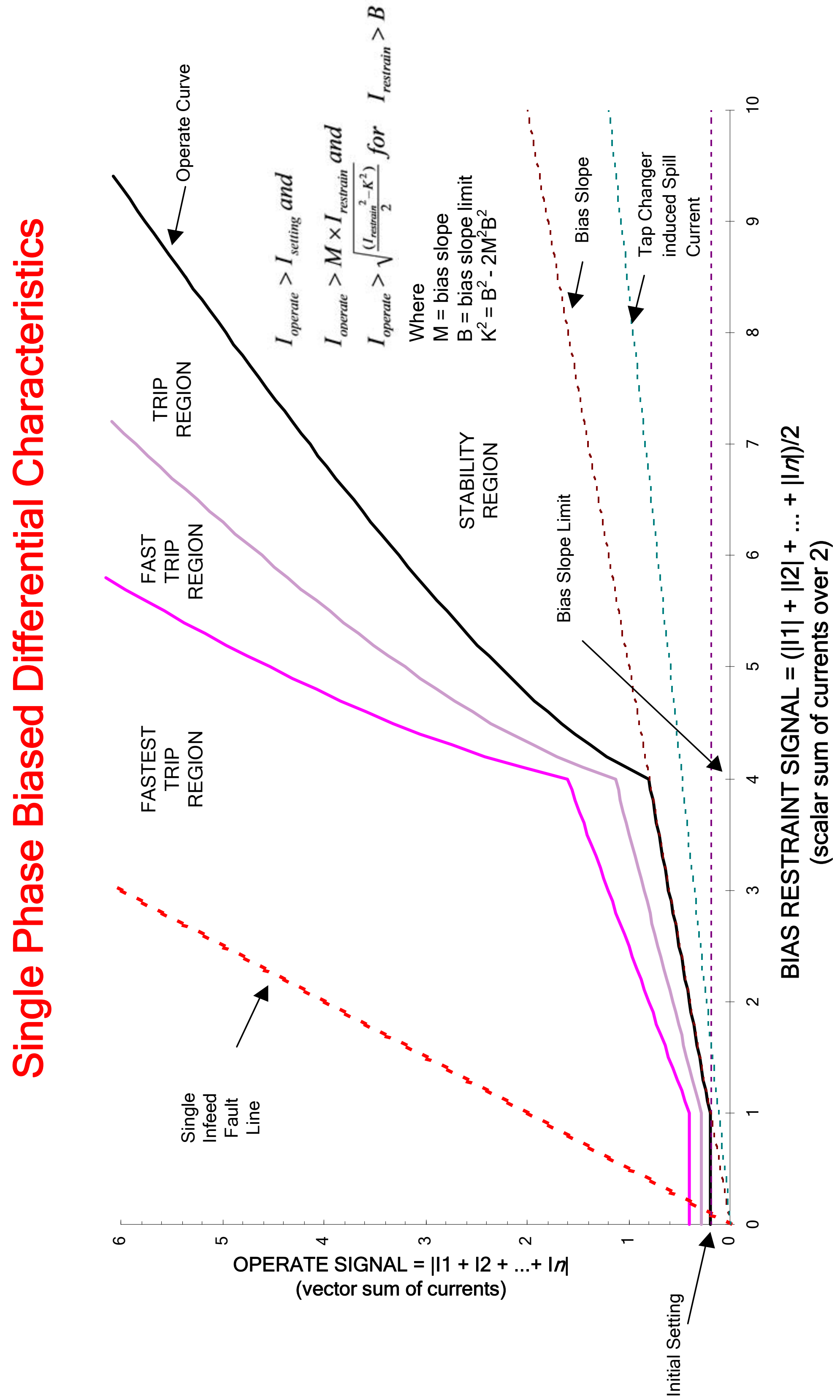

Figure 6 - Duobias-M Biased Differential Characteristics

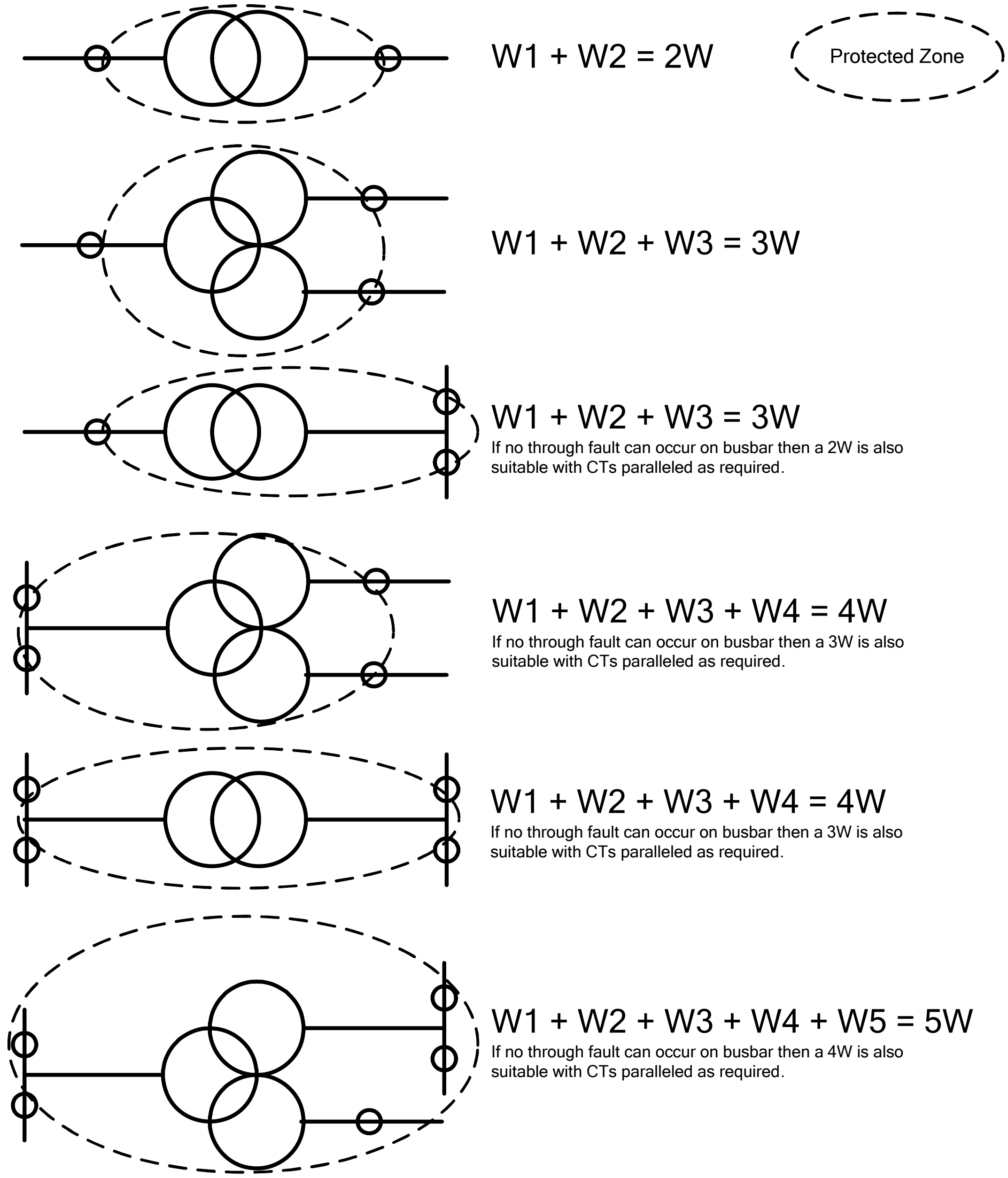

Figure 7 - Duobias-M Basic Transformer Configurations

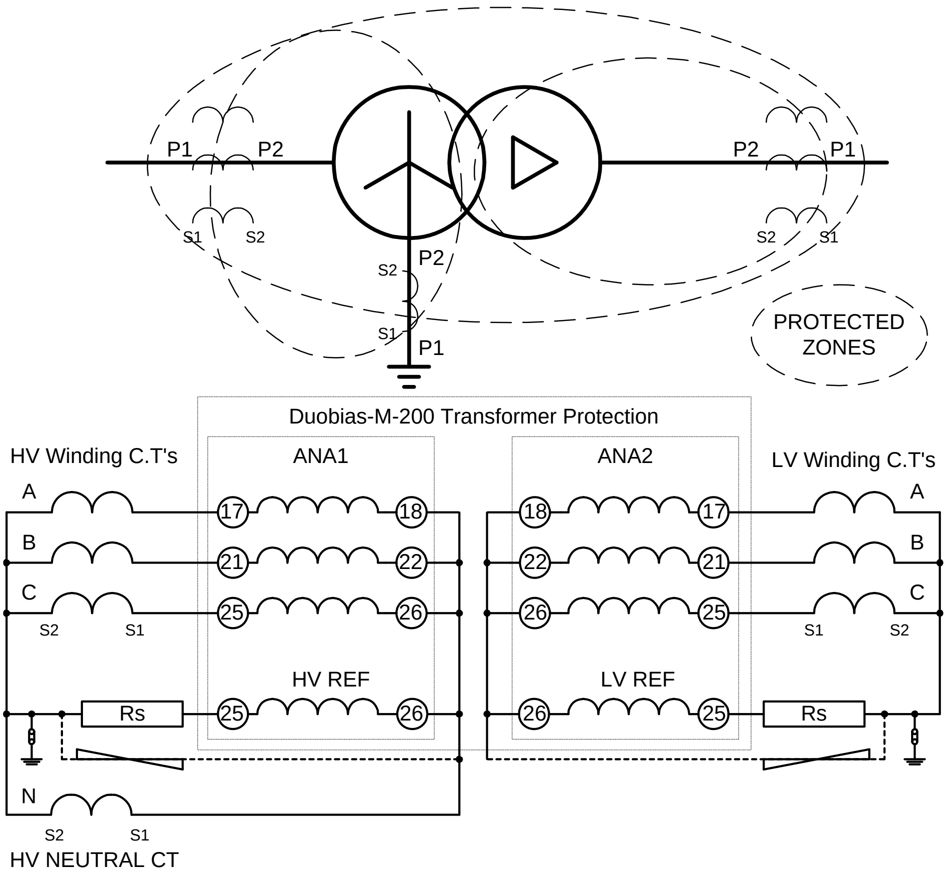

Figure 8 - Yd11 Connection Diagram

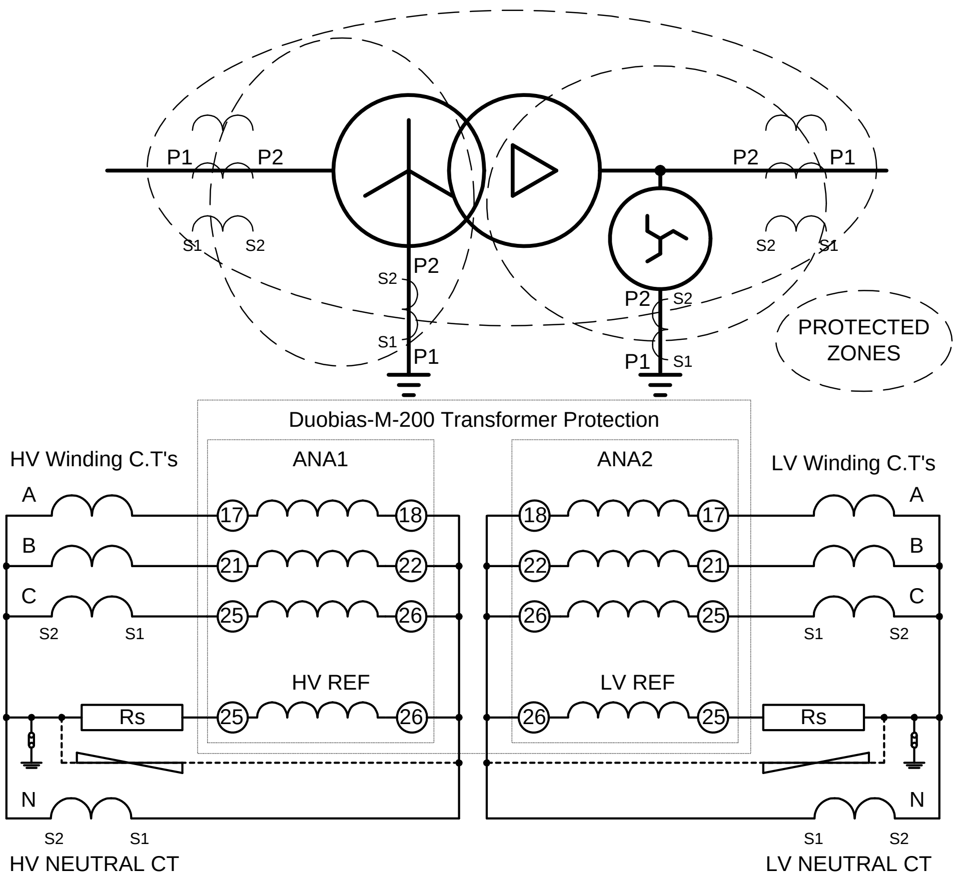

Figure 9 - Yd11 + Earthing Transformer