7SG12 DAD N

Numerical High Impedance Relay with CT Supervision

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
R4 26/08/2005	Clarified TCS operation.
R3 20/07/2005	Second stage differential element added.
R2 24/05/2004	General update
R1 06/06/2003	First Issue for Comment.

Software Revision History

Contents

Figures

1 Introduction

The DAD-N relay represents an integration of the protection elements required to provide a complete Numerical High Impedance protection, with additional auxiliary and backup elements available to provide integrated scheme solutions. The basic relay is a single differential zone as shown below. Other models are also available which incorporate multiple zones of protection which may be used together with logic schemes to form more complex busbar protection zones with check zone capability.

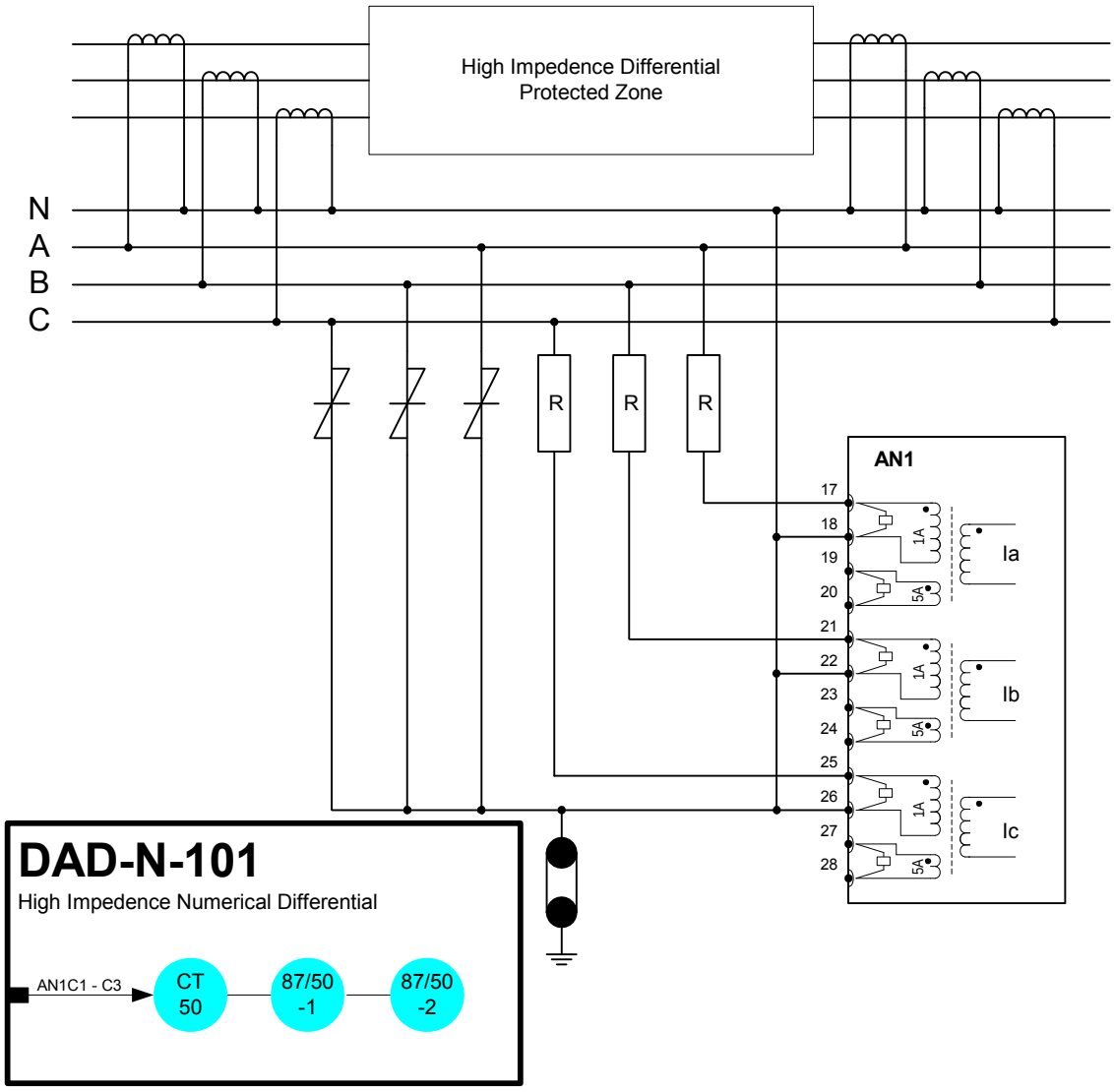


Figure 1 – DAD-N-101 Numerical High Impedance protection

2 Hardware Description

2.1 General

The structure of the relay is based upon the Modular II hardware and software platform illustrated in Figure 2 where the required cards plug in from the front after opening the front fascia. Modules are interconnected by means of ribbon cable. The basic relay is supplied in a standard Epsilon case size E8. 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.

Configuration :

Analogue Inputs	Status Inputs	Output Relays	Case	Connections
3	11	13	E8	2621W11006

Each analogue module has up to four inputs; the first three are usually for measuring the CT secondary line currents from each of the three phases A, B and C. The fourth channel is not used.

The unit consists of the following modules:

1) Analogue Input modules (4 x I)

2) One Controller CPU module

3) One Power Supply and Basic I/O module

4) Maximum of Four Output relay/Status Input Module

5) One Front Fascia

2.2 Analogue Inputs

One analogue module is used in the E8 case of 3 channels of current.

In order to ensure high accuracy true RMS measurements and accurate phase and slip frequency calculations, the current signals are sampled at a minimum of 16 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 may be fitted with up to 11 status inputs. The user can program the relay to use any status input for any function. A timer is associated with each input and a pickup time setting may be applied to each input. In addition each input may be logically inverted to allow easy integration of the relay within the user scheme. Each input may be mapped to any front Fascia LED and/or to any Output Relay contact. This allows the Relay to act as panel indication for alarms and scheme status without having to use additional external flagging elements.

2.4 Output Relays

The relay may be fitted with 13 output relays, 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. There are three relays on the Power Supply/Basic I/O module which have C/O contacts and 2 with N/O contacts. Additional modules may are fitted with 8 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 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 relay with heavy-duty contacts should be utilised.

2.5 Fascia LEDS

In the E8 case there are 16 user programmable red LED flag indicators. By opening the front panel it is possible to insert a label 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. 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 microprocessor can be shut down in a safe and controlled manner.

2.6.1 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 Protection Functions

3.1 Overall Differential (87/50-1, 87/50-2)

The Overall Differential protection uses the high impedance circulating current principle, a single line diagram of such a scheme is shown in Figure 4 – High Impedance Differential Schematic. The protection consists of a DTL over-current element 87/50 per phase which is used for tripping.

Transient stability under through fault conditions is a problem with many forms of differential protection, due to variations in CT magnetising characteristics. When saturation is approached the current transformer output waveforms become increasingly distorted with a high percentage of 3rd and other harmonics. The algorithms employed in the Overall Differential protection ensure complete harmonic rejection thus improving overall protection stability.

In addition the settings for high impedance differential protection are calculated assuming that one CT is completely saturated. Using this worst case condition the voltage (determined by the value of the stabilising resistor) and current settings for the 87/50 elements can be precisely calculated with known stability margins. Intermediate conditions where the CT is only partially saturated increases the stability margin. This approach enables schemes to be engineered with relatively low knee-point voltages.

There are two stages of protection, 87/50-1 and 87/50-2 both of which are identical.

3.2 CT Supervision (CT 50)

To check for CT continuity an overcurrent element (50) is available. During healthy CT conditions the current in the differential circuit is zero. If one CT becomes open circuit the current contribution from that CT will flow through the relay. If the setting is below this level of current the relay CT alarm will operate.

3.3 Trip Circuit Supervision

Status inputs on the relay can be used to supervise the trip circuit while the associated circuit breaker (CB) is either open or closed. Each trip circuit monitored can independently be programmed to operate output contacts, LEDs and events.

To use the function set ‘Trip Cct *n* Pickup Delay’ to the required value in the Trip Circuit Supervision Menu and then map the ‘Trip Cct Fail *n*’ settings in the Status Input Menu, Output Relay Menu and LED Menu as required.

The Trip Circuit Timer(s) are inhibited whenever one or more of the status inputs selected is energised.

4 Other Features

4.1 Metering

The 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:

Differential currents (Primary and secondary)

Digital input status

Output relay status

Time and Date

4.2 Data Storage

4.2.1 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.

4.2.2 Waveform Records.

The waveform record feature stores analogue and digital information for the current inputs, status inputs and output relays and LED’s. Waveforms may be returned to VA TECH Reyrolle ACP Ltd for analysis.

The waveforms are stored with a sampling resolution of at least 16 samples per cycle depending upon relay model. The waveform recorder has the ability to store records for the previous four trip operations of the relay. These are labelled 1-4 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
- Two records of two seconds duration
- One record of five seconds duration

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.

4.2.3 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 Settings and Settings Group

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

4.2.4 Fault Recording

The fault type, 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, fault 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.

4.3 Time Synchronisation

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

4.3.1 IRIG-B Time Synchronisation

A BNC connector on the relay rear provides an isolated IRIG-B GPS time synchronisation port. The IRIG-B input expects a modulated 3-6 Volt signal and provides time synchronisation to the nearest millisecond.

4.3.2 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.

4.3.3 Real Time Clock Time Synchronisation

In the absence of IRIG-B and IEC60870 time synchronisation the relay contains a real time clock circuit which maintains real time in the absence of DC supply.

4.4 Communications

Two 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, 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 Modular II range of relays see Section 4.

4.5 Settings Groups

Depending upon the relay model then up to eight 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 or via a status input change.

4.6 Password Feature

The programmable password feature enables the user to enter a 4 character alpha numeric code to secure access to the relay settings. The relay is supplied with the password set to ‘NOT ACTIVE’, which means that the password feature is disabled. 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 entering the password ‘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.

5 User Interface

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

5.1 Liquid Crystal Display

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

5.2 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 1 to 60 minutes and "OFF", which means the backlight is always on.

5.3 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 map any relay output or any status input to any LED.

5.4 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 read only access to all the menu displays.

5.5 Relay Identifier

The Relay Identifier setting in the SYSTEM CONFIG MENU may be used to place a circuit identifier of up to 16 alphanumeric characters onto the relay fascia. This information is also returned as part of the System Information command from Reydisp Evolution Communications Support Software.

5.6 Settings Mode

5.6.1 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 flag indication on the LCDs.

▼READ DOWN

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

In Settings Display or Signal Displays this push-button is used for scrolling 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 **▲ READ UP** or **▼ READ DOWN** keys on the facia.

When the required value of the setting has been established it 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, when pressed all 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.

5.6.2 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. If this message is displayed ENTER must be pressed to acknowledge this initial condition, the display will then indicate the relay identifier. e.g.

DAD-N-XXX

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 Prices are very competitive, starting at less than £400 and peaking at around twice that► key. This enters the sub menu and presents a list of all the settings within that sub menu. Pressing the **▼ READ DOWN** key scrolls through the settings until after the last setting in the sub menu after which the next sub menu will be shown. 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 show 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 **▲ READ UP** or **▼ READ DOWN** 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 ▲ **READ UP** or ▼ **READ DOWN** keys and they all wraparound so that to go from a setting minimum value to the maximum value it is quicker to press the ▼ **READ DOWN** key, rather than scroll through every setting. Also, to facilitate quicker setting changes an acceleration feature is available which if ▲ **READ UP** or ▼ **READ DOWN** 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.

5.7 Instruments Mode

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

Instrument	Description
[DIFF METERS] --> press down <--	Start of Differential current meters
Primary Currents 0.000 0.000 0.000 kA	Differential Primary currents
Secondary Currents 0.000 0.000 0.000 A	Differential Secondary currents
Nominal Currents 0.00 0.00 0.00 xIn	Differential Nominal currents
[MISC METERS] --> press down <--	Start of miscellaneous meters
Status Inputs 1-16 ---- ---- ---- ----	Displays the state of DC status inputs 1 to 16[1]
Status Inputs 17-27 ---	Displays the state of DC status inputs 17 to 27[1]
Output Relays 1-16 ---- ---- ---- ----	Displays the state of output relays 1 to 16[2]
Output Relays 17-29 ---- -	Displays the state of output relays 17 to 29[2]
Time & Date 13/08/2002 10:16:11	Time and Date

1) Display is different when fewer status inputs are fitted

2) Display is different when fewer output relays are fitted

Note that meters not designated as primary or secondary values are usually displayed as multiples of nominal

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

5.7.1 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.

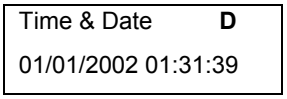
5.8 Fault Data Mode

In “FAULT DATA MODE”, the time and date of relay operations are recorded together with a record of the LED flag states.

5.9 Default Instruments Screens

The menu presentation of the various instruments allows the user to view a single screen at a time. However, for in service use, it is desirable that a small number of high interest, user selectable screens are presented automatically by default without user intervention. The instrument screens of interest to the user e.g. those required to be presented to a visiting engineer for record purposes can be selected by the user

by pressing ENTER when viewing the required screen. On pressing ENTER a **'D'** symbol will appear at the top right of that screen. The '**D'** indicates that a screen is a 'default screen'. To de-select a default screen, simply press ENTER while on that particular screen and the **'D'** symbol will be cleared.



If no keys have been pressed for a pre-determined time the relay will jump to the default instrument display regardless of where the menu has been left by the user. It will then scroll through each of the selected default instruments and remain on each for approximately 5 seconds. The Default Screens Timer that sets the time to elapse before the relay goes into the default instruments mode is found in the SYSTEM CONFIG MENU.

6 Diagrams

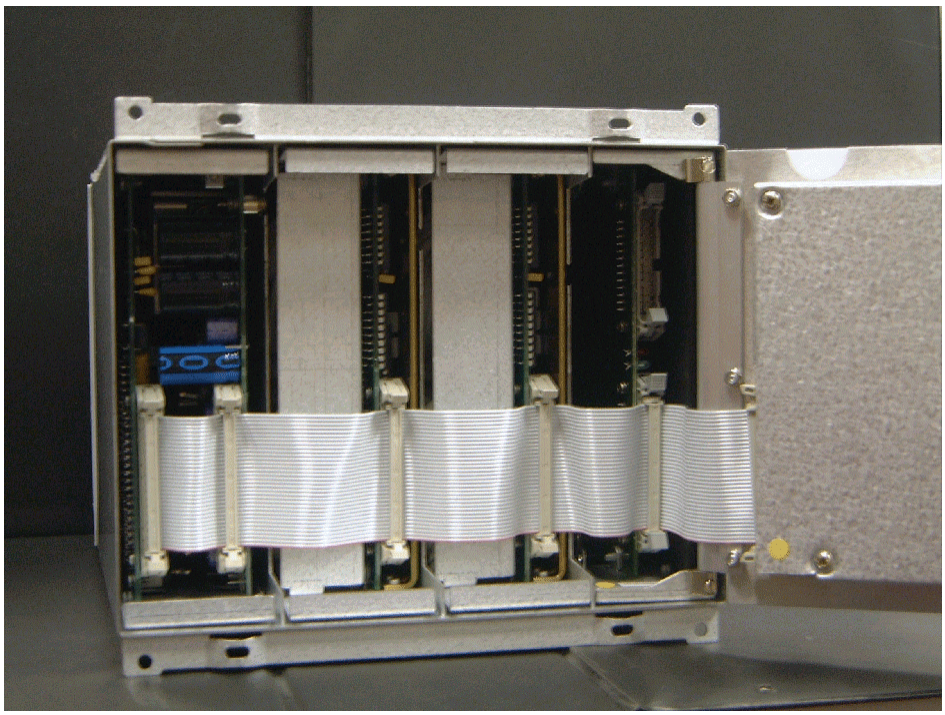


Figure 2 – DAD-N in E8 case with front panel open

Figure 3 – DAD-N Rear View

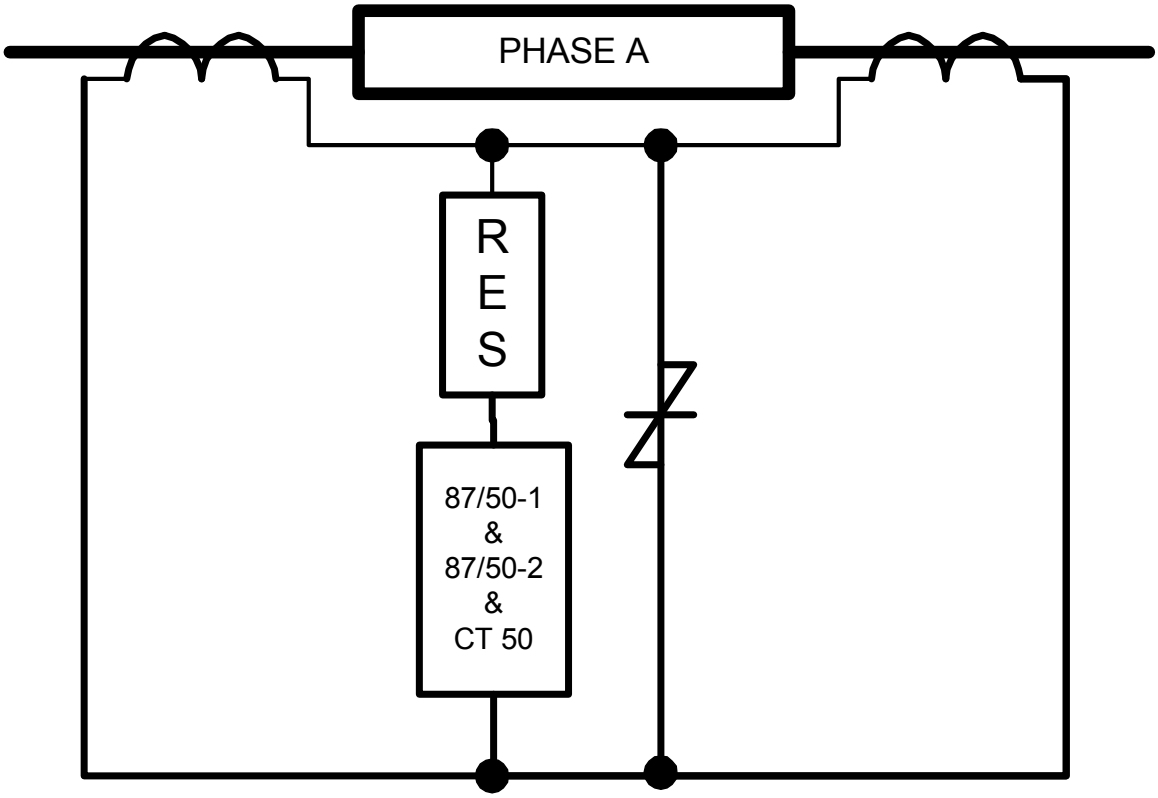


Figure 4 – High Impedance Differential Schematic

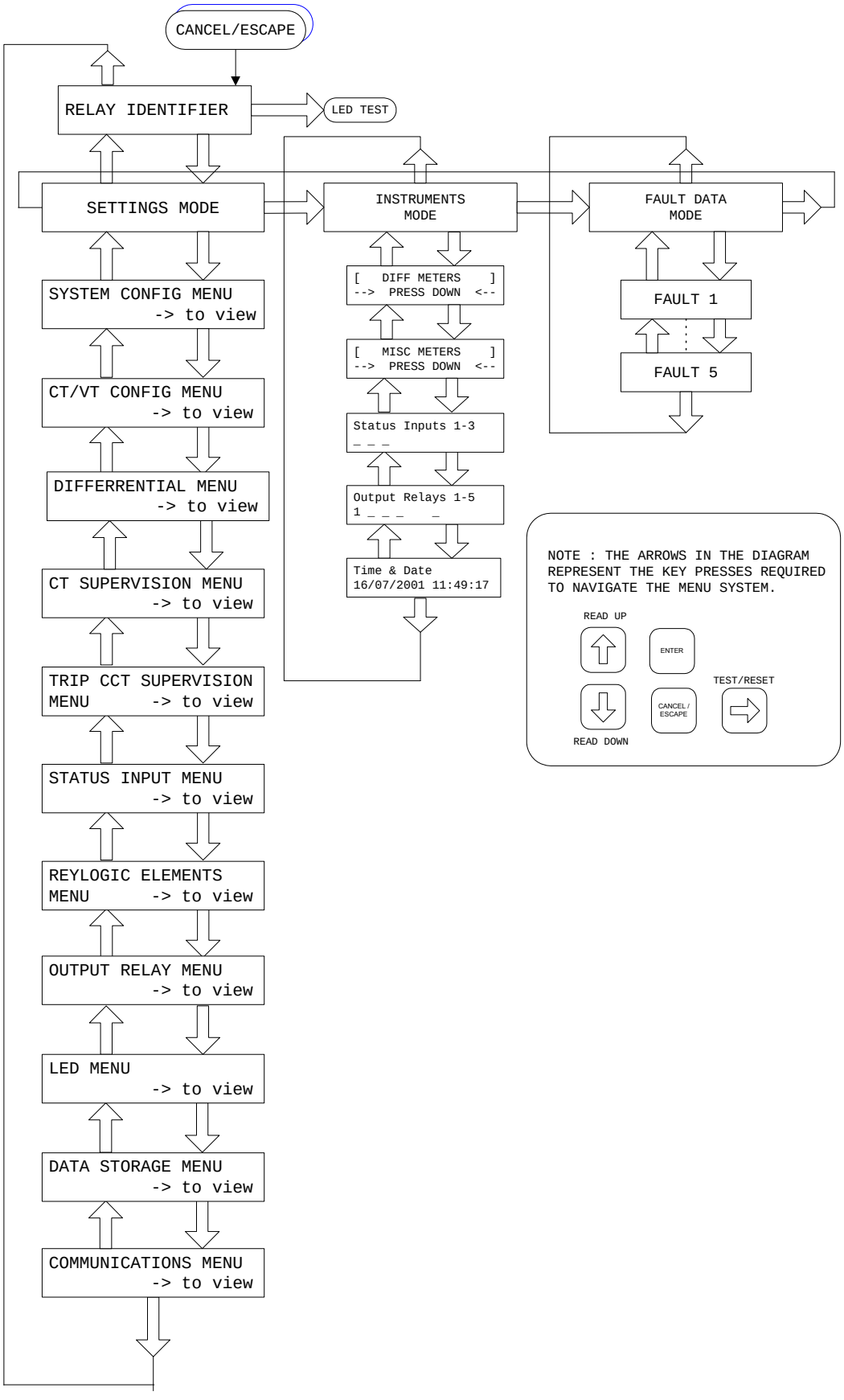


Figure 5 – DAD-N Menu Structure