GE Power Management

Numerical Monitoring Bus Bar Protection System

BUS2000

Instructions

GEK 106212B

ISO 9000 Registered ISO 9000

Anything you can't find?

Anything not clear enough?

IF YOU HAVE ANY COMMENT ON THE CONTENTS OF THE PRESENT MANUAL, KINDLY FAX US A COPY OF THIS PAGE TOGETHER WITH A COPY OF THE PAGE WHERE YOU HAVE FOUND THE PROBLEM, TO THE FAX NUMBER +34 94 485 88 45 FILLING IN THE QUESTIONAIRE BELOW. WE WILL BE HAPPY TO SOLVE YOUR DOUBTS, AND WE THANK YOU FOR HELPING US IMPROVE THIS MANUAL.

Company: ______________________________

Name: ______________________________

Address: ______________________________

Phone: ________________ ***Fax:*** ________________

E-mail: ______________________________

Description of your question or suggestion:

Manual GEK code: ______________________________

____

____

____

____

TABLE OF CONTENTS

1. DESCRIPTION

The BUS2000 is a high speed static protection system aimed at detecting phase to phase and to ground faults in buses at high voltage substations.

The main unit is an overcurrent three phase differential relay with a percentage restraint and stabilization resistors.

The relay is provided with a very sensible overcurrent differential unit which provides an alarm and blocks the output of any protection trip in case of an accidental disconnection of any of the measuring units' inputs during the normal operation of the substation.

Additionally, the system incorporates a DMS module (microprocessor-based supervision module), including the following functions:

- Digital Inputs/outputs collection
- Event recorder
- Voltage oscillography data capture
- Remote communication
- IRIG-B time synchronization.
- Integration in the DDS™ system capability (1)

As an option, the protection system may include a detection device for breaker failures, associated to the differential protection and overcurrent units for individual supervision of tripping from each breaker.

The modular feature of the system allows to carry out various configurations adapted to the specific characteristics of the buses to be protected (multiple or single-bus, breaker and one half, special dispositions, etc.)

Depending on the complexity of the application, the protection system is housed in one or more 19 inches standard racks or, as an option, in complete cabinets.

The outstanding features of the BUS2000 system are:

- Does not need dedicated secondary
- Signaling and tripping contacts independent of location.
- Redundant measuring circuits for self-checking.
- Measuring "units" for line currents and operation and restraint magnitudes in order to ease the set up and maintenance.

The information given hereafter does not intend to cover all the different details or variations of the described equipment neither does it intend to foresee any event that may arise during its set up, operation or maintenance.

Should any further information be requested, or in the event of a specific problem which may need any information other than that provided, refer to GE POWER MANAGEMENT, S.A.

(1) DDS™ is the Integrated protection & control system that comprises hardware and software to protect, control and monitor Substations. More information can be found in the instruction manual.

1. DESCRIPTION

- An optional testing system to check the operation of the alarm and measuring units in normal operation conditions.
- Optional overcurrent units for the supervision of the breaker tripping in every position.
- An optional breaker failure detection device. (Several steps logic available)
- An optional undervoltage supervision (27)
- An optional Zero sequence overvoltage supervision (64G)
- Optional lock-out relays (86)
-

2. TECHNICAL SPECIFICATIONS

2.1. MODEL LIST

BUS	2	-	-	-	-	-	-	-	-	-	-	-	DESCRIPTION
		1											Single busbar
		2											Double busbar
		3											Split busbar
		4											Triple busbar
			-	-									Specify the number of lines + bus coupler
					A								Without cabinet
					D								In cabinet (2000mmx800mmx800mm)
						1							Without breaker failure
						2							With breaker failure
							2						With test rack & short cicuitable resistors
							3						Without test rack & short cicuitable
								1					50 Hz
								2					60 Hz
									C				Auxiliary voltage: 125 Vcc.
									D				Auxiliary voltage: 250 Vcc.
									E				Auxiliary voltage: 220 Vcc.
									F				Auxiliary voltage: 110 Vcc.
										-	-		Correlative numbers
												T	Auxiliary CT mounted in racks

Because of the great variety of options and configurations in the BUS2000 systems, a complete list of the models is not included in this document. The specific information corresponding to the customer's model is provided with the chosen equipment. The most usual types of models as well as the basic system components are described below:

- SINGLE-BUS SYSTEMS
- DOUBLE BUS WITH COUPLING SYSTEMS
- SPLIT BUS SYSTEMS
- BREAKER AND A HALF SYSTEMS
- DOUBLE BREAKER SYSTEMS
- MAIN BUS SYSTEMS WITH TRANSFERENCE BUS
- SYSTEMS FOR SPECIAL CONFIGURATIONS

2. TECHNICAL SPECIFICATIONS

Each of the systems may include the following functions:

Basic model .... DIFFERENTIAL PROTECTION
Option 1 .... OVERCURRENT TRIPPING SUPERVISION
Option 2 .... BREAKER FAILURE (Several steps logic available upon request)
Option 3 .... TEST UNIT

System packaging options:

A .... Board mounted standard racks
D .... Complete cabinets

2.2. MECHANICAL

- **Mechanical packing** in a 19” inch 4 units high stainless steel box.
- IP51 Grade **Protection** (IP55 housed in a cabinet).
- Local MMI with LCD screen consist of 2 rows of 16 characters, graphic LCD display and a 20 key keyboard.
- Rear connection by means of 16 strips of 8 terminals or 16 strips of 12 terminals. Stair layout of the terminal blocks if mounted in a cabinet.
- **Dimensions**:

  Rack: 484 mm x 179 mm x 349 mm.

  Cabinet: 800 mm x 800 mm x 2000 mm (Pedestal: 750x800x100 mm).
- **Ambient humidity**: up to 95 without condensing.
- **Temperature**:

  Operation: -20º to + 55º C
  Storage: -40º to + 65º C

2.3. ELECTRICAL

- **Frequency**: 50/60Hz
- **Auxiliary voltage**: 110 Vdc or 125 Vdc or 220 Vdc
- **Operation ranges**: 80%to 120% of nominal values
- **Nominal current**: 1 amp
- **Thermal capacity current circuits**:

  Input circuits:

  Continuously .... 2 x In

  For three seconds .... 50 x In

  For one second .... 100 x In

  Total current going through the bar:

  Continuously .... 20 x In
- **Thermal capacity for voltage circuits:**

  Continuous: ....2.5x Vn

  During 1min:...3.5xVn
- **Loads**:

  Current: 15VA (depending on the tap of the auxiliary transformer used)

  Voltage: 0.2 VA at Vn= 63 V
- **Requirements For Line Current Transformers**
  - Relation between the maximum and minimum C.T ratios in all the positions connected to the same bus .... 10 maximum
  - Minimum saturation voltage required for main C.T's (for IN = 5 amps) 100 V
  - Intermediate Current Transformers: Normal ratios 5/2-1.33-1-0.5-0.2 Other ratios, including multiple ratios are available according to application.

2. TECHNICAL SPECIFICATIONS

- **Stabilization Resistance**: 250 Ohms.
- **Restraint Percentage**: Adjustable form 0.5 to 0.8 in 0.1 steps
- **Sensitivity** : (for internal faults): Adjustable form 0.2 to 2.0 amps
- **Operation time** (output relay included): Below 10 milliseconds
- **Alarm Unit**:

  Operation threshold: 0.027 Amps.

  Operation time: 10 Seconds.
- **Short-Circuit link for coupling currents**: operation time adjustable between 100 and 1600 milliseconds.
- **Line Trip Supervision Units (optional)**
  - Independent Units: Operation threshold between 0.2 and 3.3 amps
  - Dependent units: Operation threshold between 25 and 100% of the breaker failure unit adjustment.
- **Breaker failure units (optional):**

  Operation threshold between 0.2 and 3.3 amps

  Reset time below 12 milliseconds

  Discrimination time between 100 and 730 milliseconds
- **Infeed Source**: 125 VDC. amps systems consumption in mA.

	Normal	Tripped
Single bus system	280	670
Trip output (per position)	-	65
Supervision and breaker Failure units (per position)	70	140

- **Trip contacts**:

  Make and carry for trip cycle (according to ANSI C37.90)........30 amps

  Break: Resistive 180 VA at 125/250 VDC.

  Break: Inductive 60 VA at 125/250 VDC.
- **Accuracy**:

  Operation current: 5%

  Operation time: 5%

2.4. ELECTROMAGNETIC COMPATIBILITY STANDARDS

The BUS2000 units comply with the following standards, including the GE standard for insulation and electromagnetic compatibility and the standard required by the EU directive 89/336 for the CE marking, according to the harmonized European standard:

Test	Standard	Class.
• Insulation	IEC 255-5	2 kV 50/60 Hz 1 minute
• Impulse 1.2/50 ms	IEC 255-5	5 kV, 0.5 J
• Interference 1 Mhz	IEC 255-22-1	2.5 kV common, 1 kV differential
• Electrostatic discharge	IEC 255-22-2 EN 61000-4-2	Class IV: 8 kV contact, 15 kV air
• Fast Transient	IEC 255-22-4 EN 61000-4-4	Class IV: 4 kV
• Magnetic fields	EN 61000-4-8	30 TA/m
• Radiated Emisivity	EN 50081-2	Class A
• Immunity RF radiated	EN 50082-2 (Items 1.1 &1.2)	10V/m26-1000Mhz 1kHz AM80% 10 V/m 900 Mhz 200 Hz PM 50%
• Immunity RF conducted	EN 50082-2	10 V 0.15-80 Mhz 1 kHz AM 80% (Items 2.1, 3.1, 4.1 & 6.1)

- The units comply as well with the following ANSI standards:

C37.90	(Standard for relays and relay systems)
C37.90.1	(Surge withstand capability)
C37.90.2	(Withstand capability to radiated interference)

3. OPERATION PRINCIPLES

3.1. BASIC PRINCIPLE

The measurement method relies on Kirchhoff´s current law.

This law states that the vectorial sum of all currents flowing into a closed area must be zero. This law applies, in the first instance, to do current . It applies to ac current for instantaneous values. Thus, the sum of the currents in all feeders of a busbar must be zero at any instant in time.

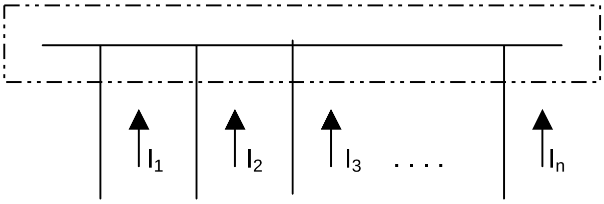


Figure 3.1. *Busbar with "n" feeders*

Assuming that the currents I_1, I_2, I_3 ... I_n flow in the feeders (Fig 3.1) connected to the busbar, the following equation applies in the fault-free condition (the currents flowing towards the busbar are defined as positive, and the currents flowing away from the busbar as negative) :

$$I_1 + I_2 + I_3 \ldots + I_n = 0$$

If this equation is not fulfilled, then there must be some other-impermissible-path through which a current flows. This means that there is a fault in the busbar region.

This law is superior, as the basis for busbar protection, to any other known way of measurement. A single quantity, **the sum of currents**, characterizes and can be used to detect faulty conditions. This sum of all currents can be formed at any time and if formed as such, using instantaneous current values, full use of above law can be made. Above law is always valid, whereas with a comparison of only the zero crossing points of the currents or of the current directions may involve phase displacements which would have to be considered accordingly. For instance, in a fault-free three-phase load, the instants of zero current are displaced by 50º or 120º with respect to one another. Unbalanced load may produce other displacements. The sum of the currents, on the other hand, remains constantly zero as long as no currents flow through some other path due to a fault.

The above considerations apply strictly to the primary conditions in a high-voltage switching station. Protection systems, however, cannot carry out direct measurements of currents in high-voltage systems. Protection equipment measurement systems, performing the current comparisons, are connected through current transformers. The secondary windings provide the currents scaled down according to the transformation ratio while retaining the same phase relation. Furthermore, the current transformers, due to the isolation of their secondary circuits from the high-voltage system and by appropriate earthing measures, can keep dangerous high voltages away from the protection system.

The current transformers are an integral part of the whole protection system and their characteristics are an important factor for the correct operation of the protection. Their physical locations mark the limits of the protection zone covered by the protection system.

3.2. DIFFERENTIAL UNIT

Figures 1 and 2 represent the simplified connection diagram of the differential protection and its behavior with internal and external faults respectively, without any saturation on C.T cores.

Auxiliary intermediate current transformers are aimed at equalizing the currents received by the relay for every input position, since the main transformers may have a different transformation ratio. They have been specially designed to provide an homogeneous response (same saturation characteristic) for all the inputs to the measure unit, thus allowing the use of main transformers with different characteristics.

The V_D current is the operation magnitude and it is proportional to the differential current. The V_F voltage is the restraint magnitude and it is proportional to the sum of the currents of all the positions associated to the bus to be protected.

In ideal conditions, for an external fault, current flows through the input circuits of the different positions without differential current; thus, V_D is zero and V_F is equal to twice the value of the fault current, whereas for an internal fault, all the fault current goes through the differential circuit which makes V_D and V_F equal.

Figure 15 shows the block diagram of the percentage restraint differential unit and the supervision differential unit.

For the main measure unit, V_D and V_F voltages are applied to a sum circuit which subtracts from the V_D value part of the V_F restraint voltage value obtaining thus a combined signal which is applied to a level detector. The restraint current ratio K subtracted from the differential voltage is called restraint percentage and it determines the operation characteristic of the unit as well as its sensitivity.

The level detector is a fixed V_O threshold level comparator (factory adjusted), with an operation time of 1.5 milliseconds and a reset time of 40 milliseconds in order to ensure a constant signal in the output relay.

The V_o level of the detector is calculated so that the unit may produce an output when the I_D - K I_F magnitude is over 0.1 Rms. Figure 3 shows the operation characteristic corresponding to this equation.

3.2.1. Behavior with Internal Faults

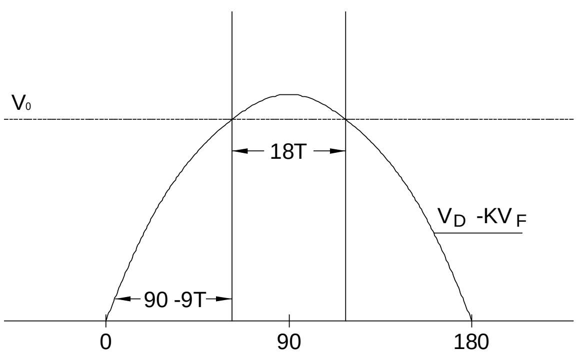
In the case of internal faults, we assume that no current transformer is saturated and therefore the equivalent circuit with its corresponding current distribution is that of fig. 1.

Note that in these conditions all the fault current will pass through the differential unit. From the design of the circuit we have:

$N_{ED} = N_{EF} = N$ (1) Input transformer's ratio

$R_D = R_F = R$ (2) Load resistance of the restraint and differential transformers.

By analyzing the behavior of the differential unit in the first half cycle of the current at a 50 Hz rated frequency in the network we will have:



Where:

V_D = RMS voltage in the differential circuit.
V_F = RMS voltage in the restraint circuit.
V_O= Threshold voltage in the level detector.
I_D = RMS current in the differential circuit.
I_F = RMS current in the restraint circuit.
K= Restraint percent in unit value.
T= Detector time (in ms.).

We will have the following values' ratio:

$$V_D = I_D * N_{ED} * R_D = I_D * N * R$$

$$V_F = I_F * N_{EF} * R_F = I_F * N * R$$

On the other hand, the differential unit will produce an output when the VA value is above the V_O one, that is, when:

$$2*(V_D - K*V_F)*\text{sen}(90-9T) \geq V_O \qquad [5]$$

or what is the same when:

$$I_D - K*I_F \geq V_O*(1/2*\text{sen}(90-9T))*(1/N*R) \qquad [6]$$

The circuit design values are:

V_o = 0.137 V
T = 1.5 ms.
N = 0.01
R = 100 Ω

With these values the equation is reduced to:

$$I_D - K*I_F \geq 0.1 \qquad [7]$$

For an internal fault $I_D = I_F$, so:

$$I_D \geq 0.1/(1-K) \qquad [8]$$

From this equation we obtain the relay's sensitivity in amperes for the different values of K.

3.2.2. Behavior with External Faults

3.2.2.1. Without saturation

During the time prior to the saturation of any of the main C.T's and assuming ideal conditions for an external fault, the fault current flows through input circuits of the various positions without any differential current.

In these conditions the value of $V_D = 0$ and in our case, the value of V_F will be proportional to twice the fault current. See fig. 2.

3.2.2.2. With saturation

In the case of an external fault, saturation may be produced in the current transformers associated to any of the protected bus positions. In this case, the inputs' currents will not be compensated, thus a differential current will be produced which must not lead to the operation of the relay. The combination of the percent restraint operation characteristic together with the R_E stabilization resistance in the differential circuit ensure the correct behavior of the unit in these circumstances.

The worst case from the point of view of the possibility of false operations with external faults is that of a complete saturation (total absence of signal in the secondary) of only one of the main C.T's while the rest behave correctly.

In our case, the equivalent circuit is shown in fig. 4. Here, the fault current provided by the rest of the current transformers is divided between the totally saturated I_X circuit and the I_D differential circuit in an inversely proportional way to the resistance of every circuit.

Thus, when the R_E resistance value increases in the differential circuit, the differential current flowing erroneously in case of saturation of a current transformer decreases. In the same way, when the K restraint percent value increases, a greater differential current is allowed without providing a trip in the unit since V_F will increase.

3.3. SENSITIVITY EQUATION OF THE PERCENT RESTRAINT UNIT

From fig. 4 we may draw out the following equations.

$$I_D = I_{FAULT} - I_X \quad [9]$$

$$I_D * R_E = I_X * R_{MAX} \quad [10]$$

From (1) and (2) we have:

$$I_{FAULT} = I_D + I_D * (R_E / R_{MAX}) = = I_D * (1 + (R_E / R_{MAX})) \quad [11]$$

$$I_F = I_D * (1 + 2 * (R_E / R_{MAX})) \quad [12]$$

$$I_F = I_{FAULT} + I_X = I_D * (1 + (R_E / R_{MAX})) + I_D * (R_E / R_{MAX}) \quad [13]$$

We find that the unit will produce an output (operate) when:

$$I_D - K * I_F \geq 0.1$$

So:

$$I_D \geq K * I_D * (1 + 2 * (R_E / R_{MAX})) \quad [14]$$

$$I_D * (1 - K * (1 + 2 * (R_E / R_{MAX}))) \geq 0.1 \quad [15]$$

In the same way the unit does not operate when:

$$I_D * (1 - K * (1 + 2 * (R_E / R_{MAX}))) < 0.1 \quad [16]$$

For more security we can say that the unit will not trip if:

$$I_D * (1 - K * (1 + 2 * (R_E / R_{MAX}))) < 0$$

OR

$$1 - K * (1 + 2 * (R_E / R_{MAX})) < 0$$

Thus:

$$1 < K * (1 + 2 * (R_E / R_{MAX})) \quad [17]$$

$$R_{MAX} < K * R_{MAX} + 2 * K * R_E \quad [18]$$

From this we can finally deduce that:

$$R_E > R_{MAX} * (1 - K) / 2K \quad [19]$$

$$R_{MAX} < \frac{2 * K * R_E}{1 - K} \quad [20]$$

The R_E has a fixed value set at 250 Ω, so the R_{MAX} value must be such that the below equation is accomplished in order to avoid false operations with external faults, even in the worst saturation conditions of the main C.T's

3.4. DIFFERENTIAL SUPERVISION UNIT

The supervision differential unit consists of a level detector with similar characteristics to that of the main unit, to which is applied the V_D voltage only, proportional to the differential current. Its operation threshold is directly adjustable in Amps from 0.2 A to 2 A and independently from the K adjustment of the main unit (see block diagram in figure 3).

The combination of both units described provides a great security to the protection, thus guarantying that any failure of a component will not provide a non desired trip to all the positions associated to the protected bus. Both units must operate simultaneously so that a trip output is produced. In the case where due to a failure only one of the units is operating incorrectly, the alarm unit described below will detect it, thus providing a signaling output and the blocking of the protection.

3.5. ALARM UNIT

The alarm unit associated to the differential protection consists of a very sensitive overcurrent unit (0.027 amps) connected in series to the differential circuit through its own input transformers.

It is aimed at detecting unbalances in the differential circuit due to leaks or accidental disconnection of any of the inputs to the measure unit. It is also provided with a circuit that detects discordance among the outputs of the main measuring units and the outputs of the main measuring and supervision units.

The unit provides a timed output (10 seconds).

Figure 5 shows the block diagram.

3.6. LINE OVERCURRENT AND BREAKER FAILURE SUPERVISION UNITS

These units are optional and may belong to a complete BUS2000 system (current supervision only, breaker failure only or both).

Figures 6 show the block diagrams of a double bus system with both functions for three-phase trip line protection and single-phase trip respectively.

The units are connected in series to the inputs of every position of the bus differential (one for each position), through their own input transactors and signal conditioning. Signals coming from each phase are combined in a selection circuit of the larger before going on to the level detectors of the trip supervision unit (50) and of the breaker failure unit (BF).

The breaker failure unit picks up its timer only when an external signal comes from line protection relays. In the case of lines with single-phase trip protection, the level detector receives only signals from those phases which have been tripped, in order to avoid the operation of the unit with the load current of the non faulted phases. (see drawing 226B6429F20,21,22). Signals 89AY and 89BY provide information to the bus to which the line is connected (double-bus systems), in order to lead the trip to the positions connected to the corresponding bus.

3.6.1. Breaker Failure Logic.

Depending on the different schemes of each substation or power plant, several breaker failure's logics are available. These logic is composed of several steps:

- One step: Standard, trip all the breakers connected to the same bar as the breaker in failure.
- Two steps (only under request):
  - First: Retrip the breaker in which the failure has been detected.
  - Second: Trip all the breakers connected to the same bar.
- Three steps (only under request):
  - First: Retrip the breaker in which the failure has been detected.
  - Second: Retrip the breaker in fault, and trip the ties (if any) connected to the same bar, and the bus coupler
  - Third: Trip all the breakers connected to the same bar.

In each step the timer is adjustable from 100ms to 730ms.

3.7. TEST BOX

As an option, the bus differential protection may be provided with a testing element, whose aim is to check the differential circuit operation (including the stabilization resistors) and the alarm and differential units. These includes the following modules:

- DAL: Alarm board (one per bar).
- DDF: Differential board (one per pole).
- DRD: Differential output module (one per bar).
- DDI: Differential unit input module (one per bar).

This element is provided with elements (latching relays: 3B/87) for the connection and disconnection of the trip of the differential units (see drawing 22B6429F26).

3.7.1. Description

The test box unit is housed in a 19" rack and consists of the following elements:

- **HLB100** (3B/87 in the schemes) latching relay (one for every differential). This relay inhibits the trips of the corresponding differential units (see drawing 22B6429F26).

- **HLA100** (3P/87 in the schemes) auxiliary relay (one for every differential). This relay is in charge of introducing the test current in the corresponding differential unit (see drawing 22B6429F16).

- **DPR** test module. This module is provided with the following elements:

  - Connection button (green color): This button operates on the HLB100 (3B/87) latching relay allowing the trip output of the differential units.

  - Disconnection button (red color): This button operates on the HLB100 (3B/87) latching relay

  - Test button (white color): This button operates on the HLA100 (3P/87) auxiliary relay following the below sequence:

a) Disconnection of the trips of the differential unit through the HLB100 (3B/87) latching relay (if connected), while memorizing whether it was connected or disconnected. Trips from the breaker failure logic are not disconnected.
b) It blocks the reset of the HLB100 (3B/87) relay during the whole time the test is being carried out and until all the elements which make up the trip circuits have been reset.
c) It operates on the HLA100 (3P/87) relay introducing the test current in the differential circuit.
d) When releasing the button, it carries out the opposite operation firstly disconnecting the test current and connecting secondly (if it were memorized) the trips of the differential units, once the trip circuits have been completely reset.

- **AL, DIF selector switch**: It allows for selection between the differential units test and the alarm unit test.

- **Phase selector switch**: It allows for selection of the phase to be tested.

- **Current level selector switch**: It allows for selection of three different test current levels.

3.7.2. Operation

The testing element, which may be optionally provided with bus differential protection, has been designed to check the alarm and differential units, during maintenance.

In the alarm and differential units test it is not necessary to disconnect the protection through its OFF button. The TEST button itself is, as a step prior to the application of test current, in charge of disconnecting the trips and not allowing for reset until all the elements in the trip circuits have not been reset.

Bear in mind that while doing the test there will come out the Differential Tripping signaling caused by the test, and the Blocking signaling. Do not forget to reset the alarm and the differential modules, whose led will lit as a probe that each unit has no problem.

3.7.3. Differential Units Test:

The differential units test will be carried out separately in every phase and with the current level corresponding to the restraint measured in the protection measuring terminals.

Set the AL - DIF selector to the DIF position and we shall then select the phase to be tested and the level corresponding to the restraint, with the appropriate switches.

Once the previous adjustments have been carried out, push the TEST button and check that the selected unit has operated and the unit trip signaling the corresponding LED remains lit.

3.7.4. Alarm Unit Test:

The alarm unit test will be carried out separately in every phase. Set the AL - DIF switch to the AL position and we shall then select the phase to be tested with the phase selector switch. In this case the test current is fixed and does not depend on the current level selector switch.

Once the previous adjustments have been carried out, push the TEST button and do not release it until the unit operates (usually 10 seconds). Check that the unit selected has operated and the unit trip signaling LED remains on.

3.8. MONITORING MODULE

3.8.1. General Description

The DMS module includes all the required protection (undervoltage supervision), measuring and monitoring functions for the BUS2000.

Each DMS module includes several boards (CPU, analog and digital data acquisition, output boards, etc.).

The DMS unit receives analog inputs for metering and monitoring as well as digital inputs. It performs monitoring and recording functions. The recorded information can be accessed in local or remote mode through its communication sub-module.

The following diagram shows the connection of a DMS with the BUS2000 system in a typical arrangement:

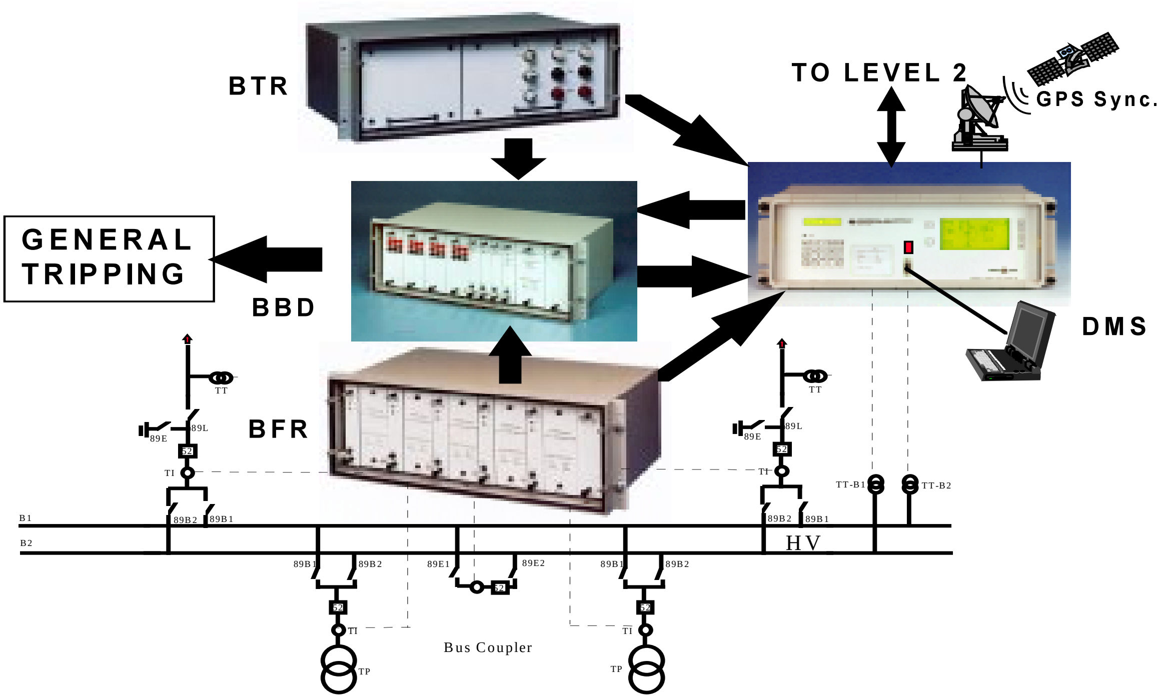


Figure 3.2. *Connection of a DMS module with the BUS2000 system*

3.8.2. Hardware Description

The Level 1 basic field units consist of modular control units in standard 19” racks. There is a common hardware platform for all the DMS units. The different functions of each module are in the application software.

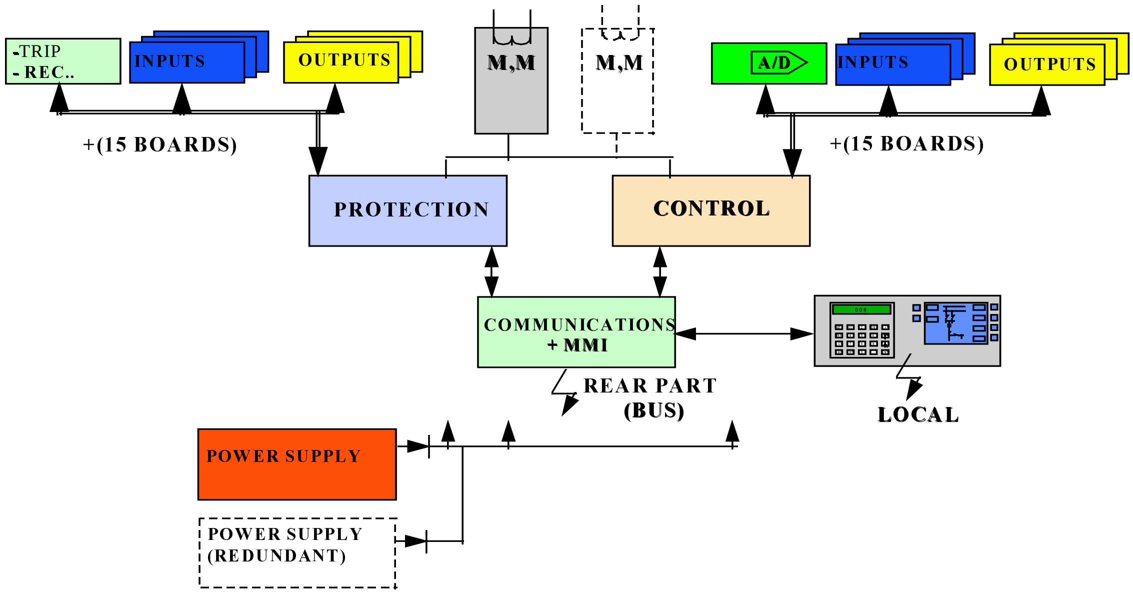


Figure 3.3. *Hardware architecture*

This architecture, as shown above, is modular and is based on the well known architecture of industrial PLCs. There are several independent hardware modules, each of them with a different functionality (data acquisition, outputs, power supply, etc.), connected via a front bus.

The DMS unit includes the hardware boards. The number of boards can be defined up to a maximum. This maximum depends on three different limiting sources: a logic limit given by the addressing capability (a maximum of 15 identical boards the outputs and inputs management limitation of the firmware and the physical limitation due to the case size (19” rack).

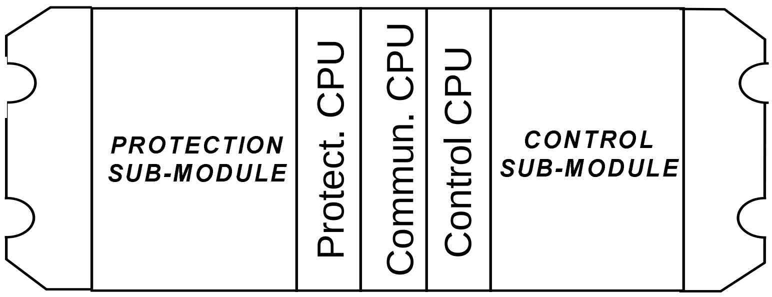


Figure 3.4*. DMS unit module disposition (front view)*

Each board includes all the elements required to perform its complete functionality, including connectors for front and rear connection. The rear male connector is inserted in the rear female connector of the case, and this is wired to the external devices of the bay. This connection is draw out type and has short circuit capabilities for current inputs, so that the boards can be easily removed allowing easy maintenance.

The hardware modules available to configure the hardware of the DMS units are the following:

1. **Power Supply**: Including one alarm relay (ready), four tripping duty relays (used as main protection trip and reclose output contacts) and two supervision units for monitoring of trip and/or closing circuits of the breaker.

These breaker supervision circuits monitor both the battery voltage level and the continuity of the trip and/or closing circuits, applying current through those circuits and checking that it flows properly.

As an option, a second redundant power supply can be included in the equipment. This redundant power supply has neither contacts nor supervision circuits available. If the redundant power supply is included, both the main and the redundant power supplies are ready to feed the complete unit. However, during normal operation, both are supplying power to the unit, but if one of the power supplies fails, the other provides all the power to the equipment.

2. **Magnetic module**: With a capacity of 8 voltage or current analog channels.

3. **Standard digital inputs board**: With a capacity of 21 digital inputs grouped in three sets of 7 inputs with the same common terminal. This board is available for protection and control modules.

4. **Analog inputs board**: With a capacity to read mA inputs from transducers.

5. **Standard digital outputs board**: With 12 output relays with trip or signaling characteristic and configurable contacts as n.o. This board is available for protection and control modules.

6. **Digital input/outputs board**: With 7 digital inputs (selectable as one group of 7 inputs with one common terminal or two groups of 3 contacts with separate common terminals) and 8 digital outputs.

7. **CPU board**: Based on 16 bits microprocessor.

8. **Communication CPU board**: Based on 16 bits microprocessor, with future capability to support different communication protocols. The communication is available via RS-232, plastic and glass fiber optics and RS-485.

All the modules described above are draw out type and are connected via an internal front bus board. This front bus must be removed before removing any other board. The frontal MMI covers all the boards and is connected to the communication CPU board through a flat cable.

9. **MMI module**: This module includes a 20 key functional keyboard (6 keys) and two LCD displays (one alphanumeric and one graphical).

The fact that process and communication functions are controlled by two independent microprocessors (with 2 different CPU boards) connected via an internal high speed serial communications protocol provides important advantages:

- Improved processing and functional capacity by increasing the global computation ability of the unit.

- More reliability: If one of the functions is lost due to a hardware failure, the rest of the functions can continue working correctly.

- This configuration allows easier modification and upgrading. Any individual module can be easily removed and changed to include technical improvements, allowing longer life of the product with lower costs.

This last advantage is specially important referring to the communication CPU board. In this area, the tendency is to increase the capability of the communication systems (improved speed and horizontal communications “peer to peer”). The modular concept of the DDS communication board allows an easy and low cost future upgrading to include new communication protocols or improved features.

3.9. FUNCTIONS INCLUDED IN THE DMS MODULES

This section shows a description of the characteristics of the different functions included in the DMS modules. To see what functions are included in one particular DMS unit, please refer to the Model Selection Table.

3.9.1. Protection Functions: Voltage Functions 27/64G

The phase undervoltage (27) function is a three-phase unit, that is, the measurement is made in phases A, B and C separately and the unit operates when an undervoltage condition (depending on the unit) is detected in any of the three phases. The setting of the undervoltage unit is referred to phase-phase voltage values, calculated from the phase-to-ground voltages applied to the DMS. The undervoltage unit is supervised by the breaker status, in such a way that the unit cannot be activated when the breaker is opened.

There is one ground overvoltage units: 64G. The operating voltage must be provided through an additional independent voltage input. This function responds only to the fundamental frequency at the neutral since the voltage input is filtered and the harmonics eliminated.

3.9.2. Metering Functions

Up to 32 analog measurements are available in any DMS module. The measurements displayed are fixed for each standard model.

For example, these measurements could be:

- Phase - phase voltages: Vab, Vbc, Vca.
- Frequency.
- etc...

These measurements can be accessed directly on the two line liquid crystal display (LCD) on the front of the equipment, the graphic LCD display (if this option is requested), or via the GE-LOCAL communication software.

The source of the measured values can be different:

1. From current and voltage transformers of the magnetic module: The DMS unit can have only one magnetic module for protection and control modules, or one magnetic module for protection functions and a different one for control and metering functions. This second dedicated module could be connected to external metering transformers in order to get better accuracy in the measurements.

2. A second source of the measured quantities is the analog measurements from external transducers or converters. For that purpose, analog input boards are provided (as an option) in the DMS units. Each analog input board has four independent inputs which range is programmable by means of internal hardware jumpers. The analog available input ranges are: +/-2.5 mA, 0-1mA, 0-5mA, 4-20mA, or +/-10V.

3.9.3. Monitoring Functions

3.9.3.1. Alarms

The DMS units have alarm monitoring and management functions. The alarms are important states of the system that the user wants to monitor and configure for signaling purposes.

Up to 96 alarms can be configured in one DMS module (32 protection alarms, 48 control alarms and 16 communication alarms). The alarms are defined from the items defined in the protection and control states. It is possible to define logical combinations of several states to define an alarm.

The alarms are displayed in the graphic LCD as soon as they are generated by the system. If desired, the DMS module can be programmed to send the alarms generated in each DMS unit to higher levels: Level 2 (substation) or Level 3 (Central control).

One signaling Alarm can be in one of the following four states:

- The alarm is active and not acknowledged by the operator.
- The alarm is active and acknowledged by the operator.
- The alarm is not active and not acknowledged by the operator.
- The alarm is not active and has been acknowledged by the operator.

To distinguish the different possible status of an alarm, the DDS units show the text of the alarm (that is user configurable) in different ways in the equipment graphic display (please refer to the Alarms Management section later in this instruction book).

Using the Function Keys of the graphic display it is possible to acknowledge only one selected alarm or all the alarms at the same time.

3.9.4. Analysis and Record Functions

3.9.4.1. Event Recorder

The DMS units keep a record of the last 150 events. These events can be generated in the protection sub-module by the trip or pickup actions of the different protection units, self-check or monitoring function alarms, setting changes, etc.

The following information is stored for each recorded event:

- Name (description text) of the event.
- Time and date (1 millisecond accuracy).
- Current and voltages measured at the time that the event has been registered.
- A complete report of the status (digital flags) of the module that has generated the event.

The following diagram shows the format of the recorded events as shown in the GE-LOCAL communication program:

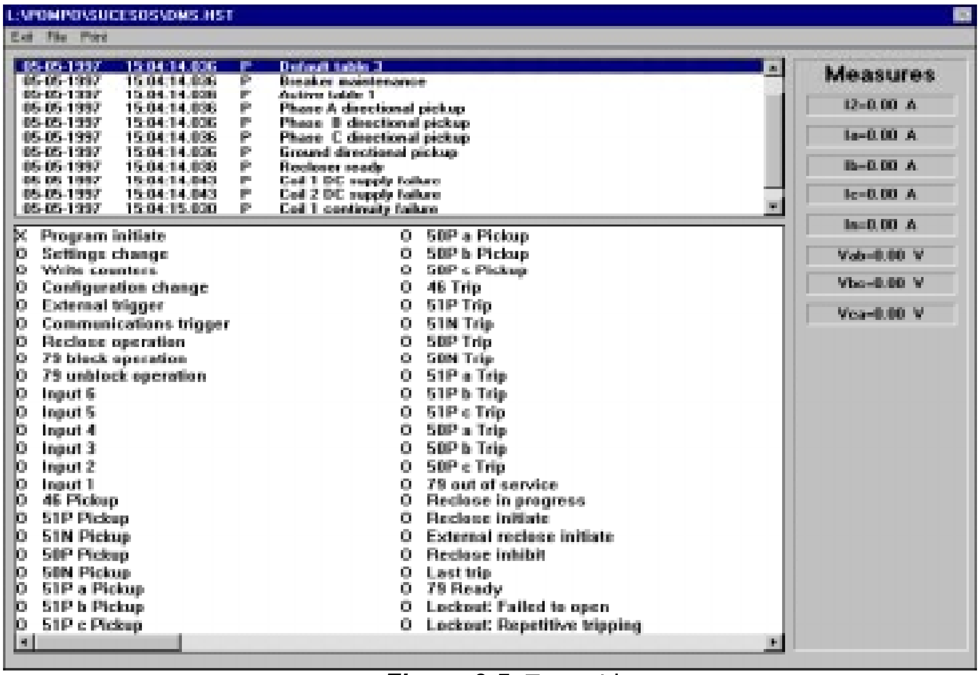


Figure 3.5. Event List

These events are stored in non-volatile memory (EEPROM), and are maintained even when dc power supply is removed from the DMS unit.

3.9.4.2. Oscillography Recorder

The DMS units store up to 4 oscillography records, with a resolution of 16 samples per cycle. Each oscillography record has a maximum capacity of 62 cycles. The number of pre-fault cycles can be selected from 2 to 10 cycles. The information stored in each record depends on the DMS model. As an example, a oscillography record can include the following information:

- 66 cycles with the instantaneous values for current inputs (I_A, I_B, I_C):
  - 2 to 10 pre-fault cycles.
  - Rest of cycles are post-fault cycles.
- Digital information.
  - Pickup and dropout of protection functions.
  - Inputs status..
- Date and time.
- Causes that triggered the oscillography record.

A configurable mask determines which function operations or trip actions trigger oscillography record. It is also possible to trigger the oscillography by closing a configurable digital input.

The oscillography is stored in capacitor backed dynamic RAM. The oscillography data is maintained at least 24 hours in case of failure of the power supply. The oscillography data is captured and converted in a file using the GE-LOCAL communication program, and can be visualized using the GE-OSC program, with the EXCEL commercial program, or by means of a format conversion program, using the GLOBAL-LAB visualization and mathematical processing software packages.

The following are some examples of oscillography records as shown by GE-OSC program:

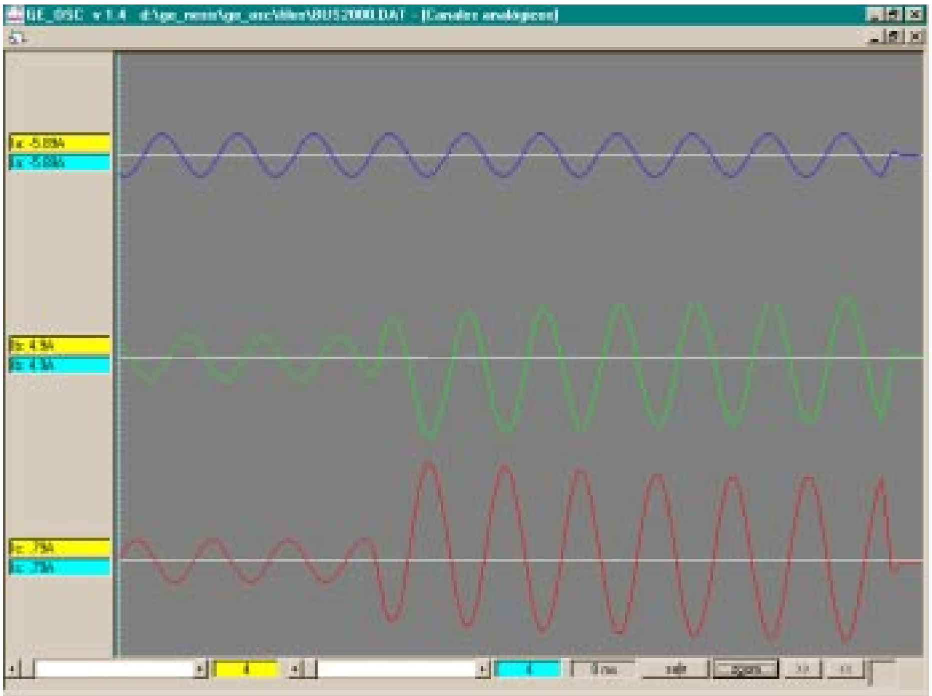


Figure 3.6. Displaying of analog channels

3.9.5. Control Functions

3.9.5.1. Combinational Circuits

With these circuits, the user can define actions related to different signals received by the DMS unit, remaining the action active while those signals are as defined.

The DMS has 4 programmable combinational circuits. The user can program each circuit using logical AND, NOT and OR type gates. The input of these gates can be selected from the 64G control states. The combinational circuits 1 and 3 allows to define OR gates where the inputs are up to 4 AND gates. The combinational circuits 2 and 4 allows to define OR gates where the inputs are up to 3 AND gates.

One application of this combinational circuits is the replacement of some of the auxiliary latching relays (HLB100) in the BUS2000 switching module, in order to simplify the connection & disconnection logic when the circuit breaker of the coupler (case of double busbar arrangement) is in open or close position, and the single busbar reduction logic when busbar the disconnector switches of both buses are in open or close position.

3.9.5.2. Configuration of inputs and outputs

All the inputs and outputs of DMS units are configurable. The configuration of the inputs and outputs are performed using the GE-INTRO configuration software, that allows the user to define the following parameters:

- Define the logic inputs the user wants to monitor and/or use as part of the internal programmable logic.
- Define timing functions for logic inputs.
- Define the output contacts to initiate the defined operations.
- Define the physical contacts for the logic outputs, defined from the internal signals and the digital inputs.

The number of inputs and outputs available and their configuration possibilities are different for each DMS equipment (or DDS compatible) depending on the particular characteristics of that equipment. To have a better information in this matter, please refer to the instructions books of the different devices and of the GE-INTRO configuration software.

Besides the digital inputs, the DMS units can have analog inputs, binary inputs and pulse count inputs, that allows the system to perform the following functions:

- Define inputs for analog metering of mA or mV (SCADA), temperature, fault distances coming from other protection devices, and in general, of signals coming from any standard transducer.
- Configure binary inputs: Each input of a set of inputs defines a bit, so that the total set defines a binary number of up to 8 bits. The system allows binary, BCD or Gray codes.

3.10. USER INTERFACE AND COMMUNICATIONS

3.10.1. User Local Interface

The local man machine interface in the DMS systems is developed through two keyboard/display sets, one for protection functions and the other for control functions.

3.10.1.1. Protection local MMI

The protection MMI incorporates keyboard (with 20 keys) and alphanumeric LCD display with two rows of 16 characters each, that allows access to all the information available in the protection system, that is:

- Display and change protection and control settings.
- Display of states and measurements.
- Perform operations (only protection operations).
- Access to the Configuration Menu and to the Single Key Menu (the single key menu shows the most important information of the device by pressing only one key).

3.10.1.2. Local control MMI

The control MMI incorporates a graphic LCD display. This graphic LCD shows four different screens that can be accessed sequentially:

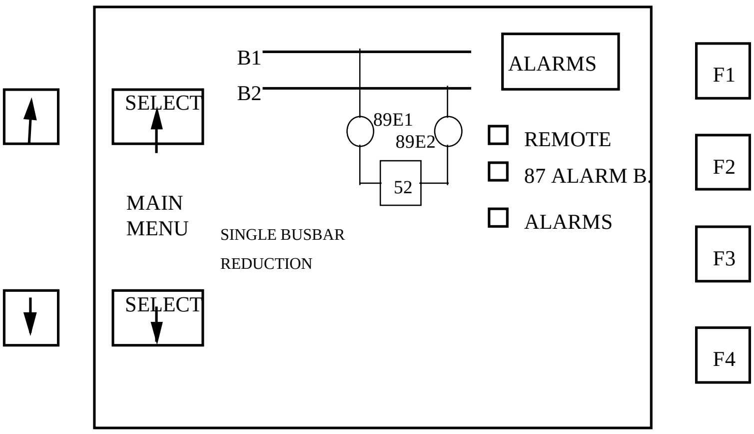


Figure 3.7 *Bus bar mimic*

This screen shows the “mimic” of the double busbar, that is, a diagram of the busbar related to that DMS module. This screen can be configured with the GE-INTRO configuration software. The following figure shows an example of this screen:

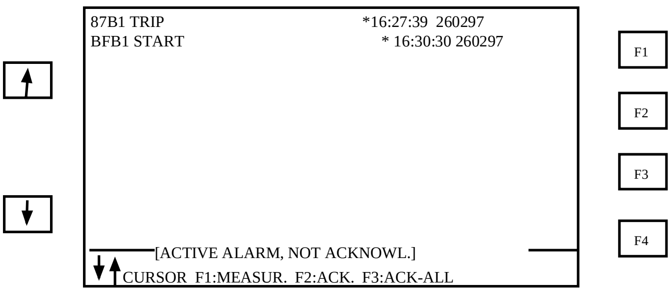


Figure 3.8 *Alarms Screen:*

This screen displays the alarms generated in the system with the following format:

- Identification name of the alarm.
- Time when the alarm was generated.
- Date of the alarm.

To get more information about the alarms format and management, please refer to section "Monitoring Functions".

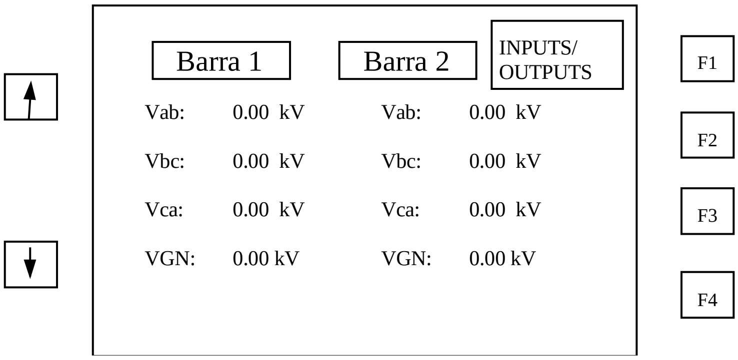


Figure 3. 9 *Screen of Measurements:*

This screen shows the real time measurements (referred to the primary side) that reads the DMS unit. This screen is different depending on the DMS model selected, and shows the system voltage and frequency parameters defined in the application option of the model selection table.

This screen shows the status of all the protection and control inputs and outputs. A dark background means that the input or output is activated. As the number of inputs and outputs is different for different DMS model, this screen will vary depending on the particular model. The following figure shows one example of this screen:

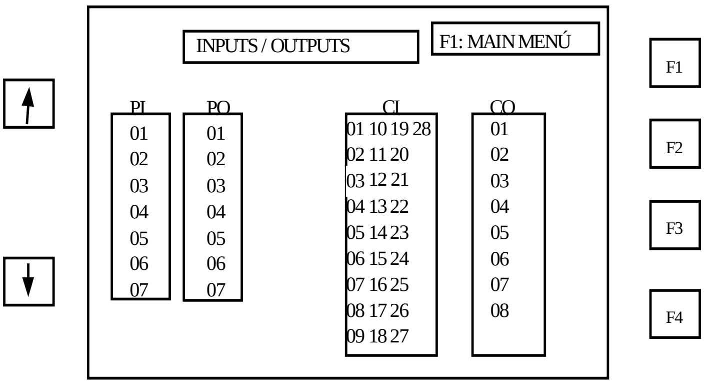


Figure 3.10 *Screen of Digital Inputs and Outputs Status*

3.10.2. Remote Communications. Software

Each DMS unit is provided with two communication ports, one RS-232 front port for local communication and a rear port for remote communication (where the Level 2 system is connected). The rear port can be RS-232 or Fiber Optic type. Both ports allows the user to establish communication with the DMS unit using the different programs included in the GE-NESIS software.

The integration of the different Level 1 units is performed through a communication system, that connects these units with higher levels (substation level or level 2). That communication system is point-to-point and uses the GE's MLINK protocol, with a maximum speed of 115 kb. The level 1-level 2 global communication system includes typically the following items:

- A PC for the whole substations that acts as a MMI of all the substation.

- A communication concentrator that is connected to all the level 1 units and receives their data, controls the data bases and provides connection with the MMI and the Level 3.

- One or more communication multiplexers that provide point-to-point communication channels for several devices.

The GE-NESIS software includes five different programs each one with a different function:

- **GE-LOCAL**: Level 1 communication software.
- **GE-INTRO**: Level 1 configuration software.
- **GE-OSC**: Oscillography data management and analysis software.
- **GE-POWER**: Level 2 communication software.
- **GE-CONF**. Level 2 configuration software (substation configuration).

The GE-LOCAL, GE-INTRO and GE-OSC programs constitute the basic communication and configuration software for DMS and DDS compatible devices, allowing the communication with one device at a time, either for level 1 devices integrated in a system or for non integrated devices (operating as individual relays).

In the other hand, GE-POWER and GE-CONF programs provide tools for manage and configure all the DMS module as a unit (substation level).

The functions that can be performed with each program are the following:

GE-LOCAL:

- Display of Level 1 units status.
- Display and change of settings.
- Display of metering data.
- Perform predefined busbar operations or maneuvers.
- Reading, display and reset of counters.
- Display of alarms.
- Upload and display events.
- Upload oscillography records.
- Time synchronization.

GE-INTRO:

- Configuration of protection inputs and outputs.
- Configuration of control inputs and outputs.
- Configuration of alarms.
- Definition of operations and interlocking conditions.
- Definition and configuration of switching elements.
- Configuration of LED indicators.
- Configuration of the displays.

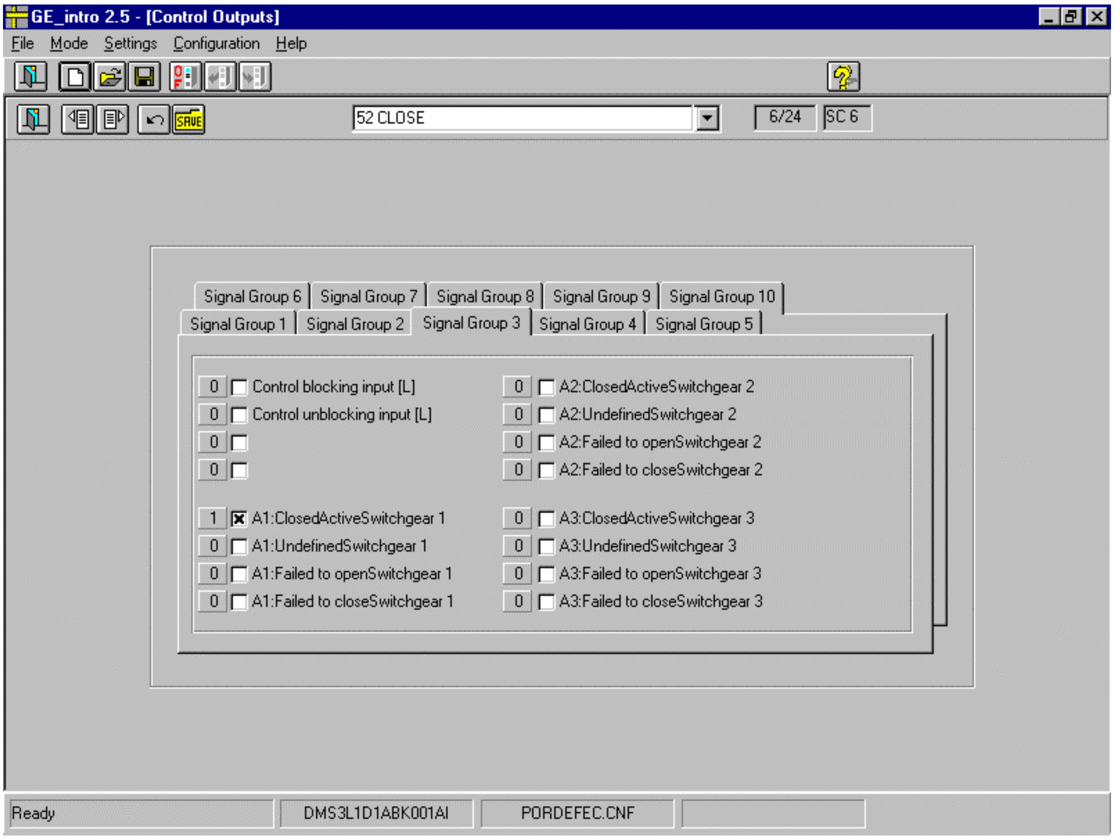


Figure 3.11 *Screen of GE-INTRO program.*

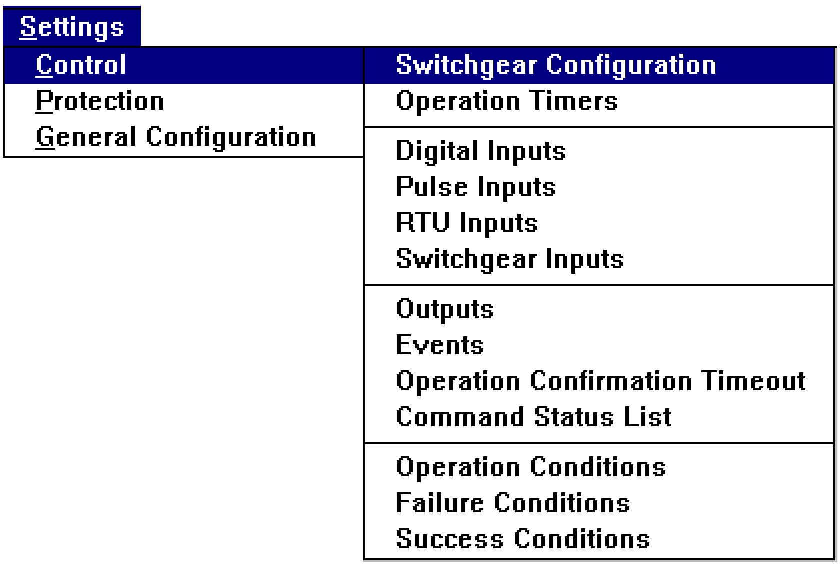


Figure 3.12 *Control configuration menus of the GE-INTRO program.*

GE-OSC:

- Display (in several formats) analog channels.
- Display of digital channels.
- Calculation and display of phasors and symmetrical components.
- Display of fault reports and/or files of settings.
- Analysis tools for different applications: distance, etc.

GE-POWER:

- Display of the single line diagrams of the substation.
- Zoomed display of the single line diagrams of the busbar.
- Access to information as:
    - States.
    - Measurements.
    - Alarms.
    - Events.
    - Oscillography.

for each busbar and for the complete substation.

- Perform operations.
- Display and remote change of the setting of each busbar.

GE-CONF:

- Configuration of users, access levels and security passwords.
- Configuration of busbars (name, type, etc.).
- Configuration of states, measurements, events, etc., that each Level 1 unit must send to Level 2.
- Generation of data bases for the substation.

4. APPLICATION

The BUS2000 system has been devised for bus protection in high voltage substations from 30 KV to 500 KV. It´s main characteristic are:

- ***Short operation time***, especially where fault levels are high, in order to minimise damage to the switchgear and assist system stability. The BUS2000 is characterized by a high speed selective detection and clearing of any fault produced in the protected area.

- ***Careful design to operate on internal faults***. Busbar faults are rear, only by regular comprehensive routine testing of the BUS2000 can the desired reliability be achieved.

- ***Remain stable during all external faults***. Since many more faults occur externally to busbars than internally, busbar protection is called upon to stabilise many more times than to operate. The protection stability (correct operation with severe external faults which result in a saturation of one of the line current transformers), is assured by selecting the adequate restraint percentage, depending only on the total resistance of the saturated circuit seen from the relay.

- ***Discriminate correctly*,** that is decide on which section of the busbars the fault has occurred, and then trip rapidly only those circuit breakers connected to that section.

- ***Immune from maloperation***.

- ***The protection does not require the use of dedicated current transformers***, neither need the latter be of the same relation and characteristics for all the positions associated with the protected bus. Special intermediate current transformers with the appropriate characteristics and relation are provided as part of the protection system. This BUS2000 feature makes its application possible in existing facilities.

- The BUS2000 system is provided for its application in double bar arrangements with air switches per each position, with latching relays. These relays type HLB connects the secondary currents of the auxiliary CT's (1 Amp. rated current) to the input of its corresponding differential unit (the same bar to which the position is connected.

4.1. SELECTION GUIDE

In order to select adequately the protection system required, the following data must be considered:

- System frequency
- Auxiliary infeed voltage
- Bus disposition
- Transformer relation and characteristics (including burdens and cable lengths) of the current transformers for each position
- Optional functions required:
  - Position overcurrent supervision
  - 27 supervision
  - 64 supervision
  - Breaker failure logic
  - Tests system
  - Housing in separate 19 inch racks or in complete cabinets.
  - 86

4.2. CALCULATION OF SETTINGS

For a correct application of the BUS2000 protection system and selection of its adjustments, the following points must be considered:

4.2.1. Main Current Transformers

The BUS2000 system ***does not require the use of dedicated current transformers*** for bus differential protection. Current transformers with positions associated to busses may be of different types and ratios.

Check that the relation between the highest and lowest transformation ratios of the current transformers associated with the protected bus is not greater than 10.

Check that the saturation voltage in every current transformer is at least equal to the quotient between 500 V and the transformation ratio of the auxiliary transformer connected to it. For example, for a position with an auxiliary transformer of a 5/1 ratio, the saturation voltage of the main current transformer must be equal or greater than 100 Volts.

4.2.2. Intermediate Auxiliary Current Transformers

The transformation ratio of the auxiliary transformers provided for every position must be selected in such a way that the global transformation ratio (resulting from the relation of the main transformers multiplied by the auxiliary transformers) for every position associated to the busses to be protected is the same.

The first step to be taken is to start with the position whose main transformer has the greatest ratio, selecting the lowest possible ratio for its auxiliary transformer, but without overloading the input to the bus protection relay (2 I_N maximum).

As an example, for a bus whose positions are provided with current transformers with 1000/5, 600/5 and 300/5 ratios, 5/1.67, 5/1 and 5/0.5 ratios will be selected respectively. This selection will provide a 600/1 global ratio for bus protection and will result in a full load current of 1.67 amps. for inputs corresponding to the circuits with CT ratio of 1000/5 A (full load primary current of 1000 A).

Check that the total of the currents of all the positions applied to the differential protection in maximum current conditions going through the busses is not above 20 I_N.

The auxiliary transformers must be placed preferably as near as possible from the main current transformers, in order to reduce the cables resistance seen by the differential protection and thus allow a lower stabilization resistance value or a lower restraint value. This arrangement also reduces the possibility for an accidental opening of the main current transformers secondary circuit. Fig 17 represents the secondary saturation characteristic of the auxiliary transformers.

4.2.3. Measurement of K Restraint Percentage

Figure 1 shows a simplified diagram of the differential unit and its operation with an internal fault.

Figure 3 shows the operation characteristic of the BUS2000 system percentage restraint differential unit, whose equation is:

$$I_D > K\ I_F + 0.1$$

The K restraint percentage value is defined as the ratio between the current needed in the differential circuit for the operation of the relay I_D and the total in absolute values of all the currents in the I_F relay input circuits (not the current going through the bus).

This unit's sensitivity for internal faults (differential current equal to restraint current) depends on the K adjustment selected according to the table:

K	SENSITIVITY (A)
0.5	0.2
0.6	0.25
0.7	0.33
0.8	0.5

The selection of the K value is related, as will be shown below, to the R_E (stabilization resistance in the differential circuit, 250 Ω). The value of the K required for a complete stability of protection for external faults, which may produce a saturation in any of the current transformers.

The K value must be selected in order to obtain the required sensitivity for protection according to the fault 's minimum current.

4.2.4. Measurement of R_{MAX}

Figure 9 shows a simplified diagram of the differential unit and its operation on an external fault which produces saturation in the faulted line current transformer.

The selection of the adequate stabilization resistance value in the differential circuit and the operation characteristic of the measuring unit percentage restraint, cause a lack of sensitivity in the protection in these conditions if the following equation is true:

$$R_E > \frac{R_{MAX}\,(1-K)}{2K}$$

R_{MAX} being the total resistance seen from the relay terminal supposing the main current transformer is completely saturated, for the most unfavorable position (greatest resistance value).

The measuring of R_{MAX} must be done calculating the value of R for every position:

$R = (RsTI + Rp)(NTIX)^2 + Rs$

Where:

RsTI Secondary resistance of the main transformer

Rp Total resistance (wires and other connected circuits)between the main transformer and the auxiliary transformer

NTIX Transformation ratio of the auxiliary transformer

Rs Total resistance between the auxiliary transformer and the relay

The highest R value found will be considered as R_{MAX}

R values can be determined through direct resistance measurements from the relay terminals, short-circuiting the main current transformer secondary. It is recommended to include these measurements in the protection set up guides.

R_E = 250 Ω, then the values of R_{MAX} should be:

$$R_{MAX} < \left(\frac{NTIX}{NTGL} \right)^2 * 250 * K_X$$

where:

$K_X = 2K/(1-K)$

NTIX: Transformation ratio of the auxiliary transformer

NTGL: Global transformation ratio.

As described in the K RESTRAINT PERCENTAGE MEASUREMENT, if the calculation of the required RS indicates a value above 250 Ω (maximum protection range), the K adjustment value will be increased, resulting in a modification of the protection sensitivity.

4.2.5. Adjustment of the Supervision Differential Unit

The supervision unit included in the differential protection is an overcurrent unit independently adjustable between 0.2 and 2 amps. Both the main differential unit and the supervision unit described must operate so that the bus differential relay may trip.

This unit has a double purpose. Firstly, it provides the relay with security, thus avoiding any false trips which may be produced in the case where one of its components should fail; and secondly, it makes it possible to limit the sensitivity of the protection (for example, if the protection operation is to be avoided in the case where the overcurrent transformer secondary circuit opens up) without modifying the restraint characteristics of the main unit.

Should there be no need to limit the relay sensitivity, the adjustment of this unit must be equal to the operation value of the main unit, determined be the selected K unit.

4.2.6. Protection Functions Incorporated in the DMS Module

4.2.6.1. Instantaneous Phase Voltage

Includes one instantaneous phase voltage units. Both are three-phase units:

Phase Undervoltage: 27∅ (3x27)

4.2.6.2. Ground Voltage with Harmonic Filtering

Ground Overvoltage (3V0) $64G_{A3rd}$ (instantaneous)

4.2.7. Change of Settings

It is possible to see the protection or control settings or to modify them manually, using the keyboard and display, or by means of a computer connected to any of the serial ports. To modify the settings by means of the keyboard, go to section "KEYBOARD AND DISPLAY". To modify the settings by computer, using the GE-LOCAL program, follow these steps:

- Make sure that the available connection cable coincides with the diagram shown in the figure, depending on whether the serial port of your computer is DB9 or DB25.
- Connect the cable between the relay (or modem) and the serial port of your computer.
- Run the GE-LOCAL software. For more details on the installation and use of the GE-LOCAL software see the GE-LOCAL instruction book.
- Make sure that the program's configuration parameters coincide with those of the SMOR unit. More specifically, the parameters on the configuration of the local MMI are the following:
    - COMMUNICATION SPEED (on the relay depending on whether communication is by local or remote port)
    - STOP BIT (on the relay depending on whether communication is by local or remote port)

To modify or view the unit's configuration parameters go to the configuration menu, corresponding to section "KEYBOARD AND DISPLAY".

When connecting to the unit, check that the relay number and password coincide with those which appear on the unit's configuration menu.

4.2.8. Settings' Tables

There are 3 settings tables stored in non-volatile memory, and these can be selected by settings or configurable inputs. There is also a set of independent settings, common to all the tables. The following categories contain the settings common to the 3 tables :

GENERAL
BREAKER COUPLER
ACTIVE TABLE
OSCILLOGRAPHY
FUNCTION PERMISSIONS

The remaining categories, shown below, contain the settings which can be selected independently for each of the 3 tables:

- **Function 27/64G (Voltage)**

It should be noted that in order to simplify setting the unit and for safety reasons, all settings connected with the configuration of the unit (configurable inputs and outputs, incident configuration and LEDs) have been removed from the keyboard/display and communications software. To carry out these configurations the GE-INTRO configuration software must be run.

The following table shows the settings common to all tables:

TABLE 2.1. Settings common to all tables

Common to all tables	Limits	Default	Interval
General Settings Group			
Relay status	In/out of service	Out of service	NA
Identification	20 ASCII characters	None	NA
Frequency	50 / 60 Hz	60 Hz	NA
Phase PT ratio Busbar 1	1-4000	1	1
Ground PT ratio Busbar 1	1-4000	1	1
Phase PT ratio Busbar 2	1-4000	1	1
Ground PT ratio Busbar 2	1-4000	1	1
Active table setting group			
Number of the active settings' table	1 - 3	1	1
Time for change to table 3	Reclose time-240s	60s	1s
Time for return from table 3	Safety time-1800s	120s	1s
Oscillography setting group			
Number of pre-fault cycles	2 - 10	2	1
Oscillography Pick-ups per function			
	Pick-up 27 P	Enabled	NA
	Pick-up 64G	Enabled	NA
	External Input Triggering	Enabled	NA
	Communication. Triggering.	Enabled	NA
	Pick-up 27 P	Enabled	NA
	Pick-up 64G	Enabled	NA
Function permission			
Function 27 P Permission	Not Permitted / / Permitted	Not Permitted	NA
Function 64G Permission	Not Permitted / / Permitted	Not Permitted	NA
Permitted Trips	Mask: NO/YES		
A: Trip 27 P	Enabled / Disabled	Disabled	NA
B. Trip 64G	Enabled / Disabled	Disabled	NA

The following table shows the settings that are independent for each table:

TABLE 2.2.. Independent settings for each table

Independent for each table	Limits	Default	Interval
Voltage Settings Group			
Undervoltage 27P Pick-up level	10 - 260 V	10V	1 V
Overvoltage 64G	3 - 100 V	100 V	1 V
	4. Voltage on both Busbars		

5. MEASURING, MONITORING AND ANALYSIS FUNCTIONS

5.1. MEASURING FUNCTIONS

DMS system has been designed to deal with up to 12 measured analog signals. These signals are fixed during the development of the specific DMS equipment at our factory, and may vary depending on the type of DMS relay; These measurements may be:

- Phase A, B and C currents, Neutral current.
- Phase to phase voltages.
- Frequency.
- etc.

User can get to these measurements by means of the two lines LCD display or using the graphical display of the relay (if available), or through a communication link, a PC and running the communication software GE_LOCAL.

5.2. SWITCHGEAR STATUS.

DMS equipment monitors the status of all the coupler switchgear items (circuit breaker, line switch, ground switch, Bus-bar switch, etc.) , by using the digital inputs configured by the user. The status of this different switchgear items (up to 7) can be checked by using the graphical LCD display (graphical MMI) in the front plate of the relay, or using a communication link, a PC and the GE_LOCAL communication software. In this way, it is very simple to monitor the status of the whole busbar.

5.3. VISUAL SIGNALING, LEDS.

It is available 1 green visual signaling (LEDs) in the front panel to show the module status.

5.4. SELF-CHECK FUNCTIONS FOR THE DMS.

DMS modules, due to its microprocessor based digital technology, includes self-checking functions, to guaranty the correct performance of the equipment, and its inhibition and alarm indication in case an internal error is detected.

There are start-up self-checking functions and run-time self-checking functions (making use of the microprocessors ‘idle time’ during system quiescent state). Self checks are performed on the internal power supply, program memory (ROM), work memory (RAM), oscillographic memory (RAM) and the settings and caliber memory (EEPROM).

Additionally, there is a hardware implemented test for the signaling LEDs. By using the TARGET RESET push button in the front panel of the relay, a test can be performed (all LEDs should light). Pushing and holding for more than 1 second will produce the resetting of all memorized LEDs.

5.5. ANALYSIS FUNCTIONS.

DMS module includes recording functions, as event recording and oscillographic recording, with a time tagging accuracy of 1 ms. In order to maintain the recorded information as well as the date and time in case the relay is switched off, there is a capacitor back up supply feature. This back up supply is intended for external power supply interruptions no longer than 24 hours.

Protection functions are independent on the other features of the system. There is a dedicated microprocessor to perform protection functions, and its operation is guarantied even in the lose of the communication board or any other part of the system.

5.6. EVENT RECORDER.

DMS modules keeps a record with the last 150 events detected by the protection functions. Events are generated by the protection module and have the following structure:

- Event name (descriptive text).
- Date and Time (1 ms resolution.)
- Present currents and voltages.
- Status of the module generating the event.

Example of a PC screen showing the list of events with the additional information stored for each event:

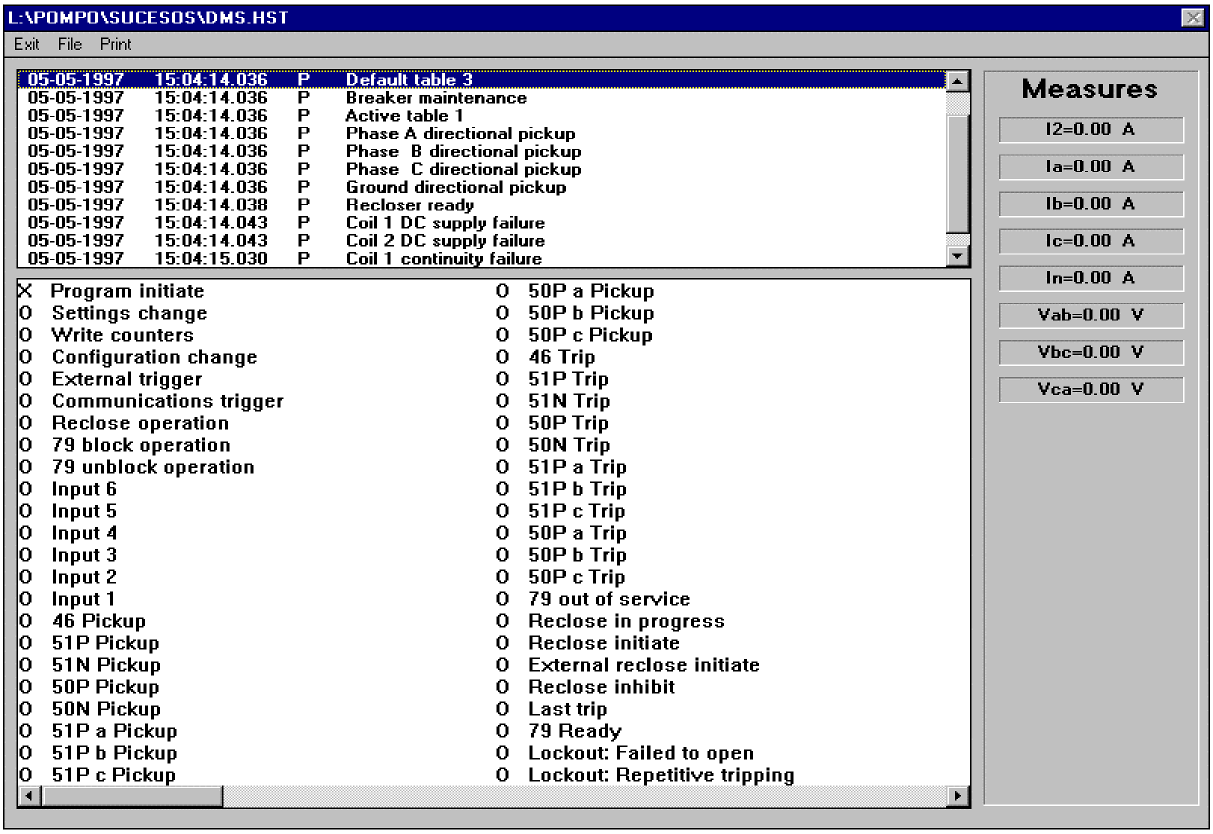


Figure 5.1 Event register.

The event register is stored on a EEPROM memory (permanent memory) and it is maintained even if power supply is lost (independently on the duration of the external power supply interruption).

Next follows an example of events that can be generated by a DMS module, depending on the functions it performs.

Table 5.1 Event list for DMS unit.

27		**Undervoltage**
	1	Bus Undervoltage Pick Up
	2	Bus 1 Undervoltage Pick Up
	3	Bus 2 Undervoltage Pick Up
	18	Phase A Undervoltage Pick Up
	19	Phase B Undervoltage Pick Up
	20	Phase C Undervoltage Pick Up
	21	Two Phase Undervoltage Pick Up
	22	Phases AB Undervoltage Pick Up
	23	Phases BC Undervoltage Pick Up
	24	Phases CA Undervoltage Pick Up
	25	Three Phase Undervoltage Pick Up
	26	64G pick up
	32	Phase Undervoltage Trip
	33	Single Phase Undervoltage Trip
	34	Phase A Undervoltage Trip
	35	Phase B Undervoltage Trip
	36	Phase C Undervoltage Trip
	37	Two Phase Undervoltage Trip
	38	Phases AB Undervoltage Trip
	39	Phases BC Undervoltage Trip
	40	Phases CA Undervoltage Trip
	41	Three Phase Undervoltage Trip
	42	64G Overvoltage trip
52		**Coupler Circuit Breaker**
	1	Circuit Breaker Closed
	2	Circuit Breaker Status undefined
	3	Circuit Breaker Closed
87B		Busbar trip
	1	Busbar 1 trip
	2	Busbar 2 trip
	3	Busbar 1 blocking signal
	4	Busbar 2 blocking signal
	5	Busbar 1 Alarm
	6	Busbar 2 Alarm
	7	Single busbar reduction
	8	Busbar 1 DC alarm
	9	Busbar 2 DC alarm
	10	Busbar 1 86 (closing blocking)
	11	Busbar 2 86 (closing blocking)
52BF		Breaker failure
	1	52 BF bay 1
	2	52 BF bay 2
	3	52 BF bay 3
	4	52 BF bay 4
	5	52 BF bay 5
	6	52 BF bay 6
	7	52 BF bay 7
	8	52 BF bay 8
	9	52 BF bay 9
	10	52 BF bay 10
	11	52 BF bay 11
	12	52 BF bay 12
	13	52 BF bay 13
	14	52 BF bay 14
	15	52 BF bay 15
	16	52 BF bay 16

	17	52 BF bay 17
	18	52 BF bay 18
	19	52 BF bay 19
	20	52 BF bay 20
	21	52 BF bay 21
	22	52 BF bay 22
	23	52 BF bay 23
	24	52 BF bay 24
BTR		Test Module
	1	Busbar 1 “ON”
	2	Busbar 1 “OFF”
	3	Busbar 1 “TEST”
	4	Busbar 2 “ON”
	5	Busbar 2 “OFF”
	6	Busbar 2 “TEST”

Associated with each event, the DMS module stores all the information available about the status of the module generating he event. See the follow table for an example of the information available for a protection module.

Table 5.2. Example of protection status

0.0 Program Initialization
0.1 Change of Settings
0.2 Counters modification
0.3 Configuration Change
0.4 External Trigger
0.5 Communication Trigger
3.0 Input #7, etc.
3.1 Input #6
3.2 Input #5
3.3 Input #4
3.4 Input #3
3.5 Input #2
3.6 Input #1
5.0 27 A Function Pick Up
5.1 27 B Function Pick Up
5.2 27 C Function Pick Up
5.4 64G Function Pick Up

.
.

5.7. ALARMS TREATMENT

DMS functions include Alarm generation and treatment functions. Alarms are relevant system operating conditions or status, as defined by the user, which are desired to be specially indicated or signaled by the DMS module.

It can be defined up to 32 different Alarms. To define an Alarm, the user may use all the information available in the status panel of the protection module and the status of the control module of the DMS module. 16 inputs OR gates may be used to define alarms.

Alarms will be shown at the graphical MMI display in the front panel of the relay, as soon as they are generated, tagged with date and time information. Alarms will also be transferred through the communication link to the Level 2 (Local Protection & Control Room) and Level 3 (Remote P&C Office, if available).

There are four different status for a given alarm:

- Active alarm and not acknowledged by the operator.
- Active alarm and acknowledged by the operator.
- Non active alarm and not acknowledged by the operator.
- Non active alarm and already acknowledged by the operator.

DMS module will present alarms in different formats depending on their status. The text message associated to an alarm, which will be also defined by the user, will appear in the graphical MMI in the front panel of the relay in one of the following formats: (also see the MMI chapter of this instruction book for a detailed description.)

- Active and not acknowledged : Dark Background, Blinking Text, with a star character.
- Active and acknowledged : Normal Steady Text, with a star character.
- Non active and not acknowledged : Dark Background, Steady Text, with a star character.
- Non active and acknowledged : Text disappears from LCD display.

This is:

- Dark background means NOT ACKNOWLEDGED.
- Star character means ACTIVE ALARM.

By using the keys around the graphical display, user may acknowledge a particular alarm (or all of them with a single key).

5.8. SIGNALING.

DMS module includes a different type of signaling function, which also generates date and time tagged signals.

In this case, signals are not shown in the local graphical MMI in the front panel of the module, but they are transferred by a communication link to Level 2 and 3 (if exists), and can be send to a local printer as they are generated. These signals do not need the treatment alarms need (acknowledging, etc.)

5.9. OSCILLOGRAPHY RECORDER

DMS protection functions keep four oscillography records, associated to the last four faults, or oscillography triggers, with 16 samples per cycle resolution. Each oscillography record has a fixed length of 66 cycles, with a configurable prefault, from 2 to 10 cycles. The exact content of an oscillography record depends on the DMS module model (if the relay has current inputs or not, etc.). In general, it will content the following information:

- 66 cycles of all analog inputs, currents (I_A, I_B, I_C, etc.), with 2 to 10 prefault cycles.

- Digital flags information, containing information as Protection functions Pick Ups, Trips, Drop Out, Activation of Inputs, Outputs, digital signals, etc.

- Date and Time.

- Causes that generated the oscillography record.

It can be configured the causes that can trigger the oscillography function, which functions or internal trips. Oscillography may also be triggered by an external input, and also by a command through the communication link.

Oscillography records are stored in RAM memory with a capacitor back up. This information will not be lost if the external power supply is lost for less than 24 hours. The oscillography records are taken from the relay using the GE_LOCAL communication software, and stored into a file in the COMTRADE (IEEE

C37.111-1991) standard format. These files can be visualized by the GE_OSC analysis software, or commercially available software like EXCEL, etc. importing the oscillography '.DAT' ASCII file.

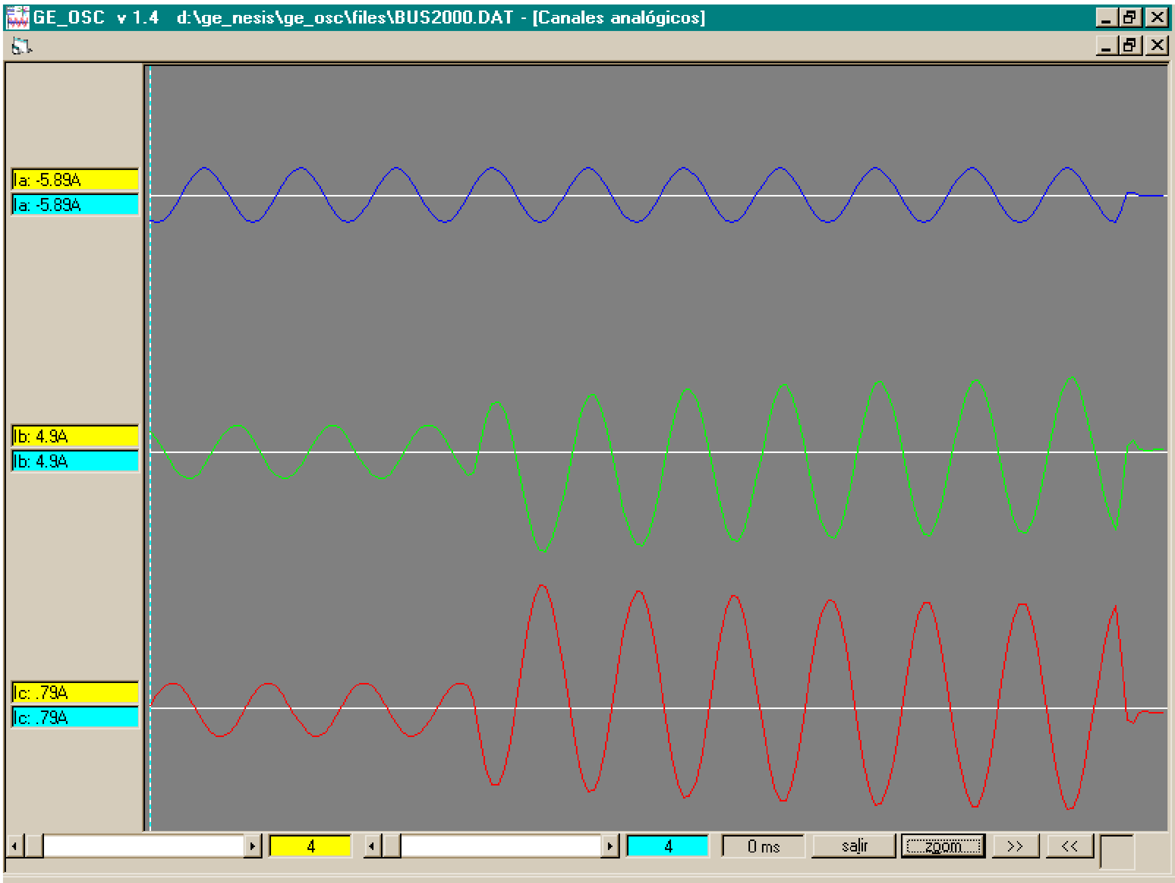


Figure 5.2 *GE_OSC analysis software*

GE_OSC has been designed to work with COMTRADE (IEEE C37.111-1991) Standard files, and allows the user to:

- Visualize analog channels recorded by the relay.
- Zoom in and out into these analog channels.
- Visualize digital channels recorded by the relay.
- Zoom in and out into these digital channels.
- Customize the presentations by template definition.
- Perform Phasor analysis, sample by sample, computing phase phasors and symmetrical components phasors.
- Access to advanced fault analysis tools designed by GE Power Management.

For further information refer to GE_OSC instruction book.

The COMTRADE format used for the DDS oscillography records is the IEEE Standard Common Format for Transient Data Exchange for Power Systems, IEEE C37.111-1991. This standard defines three different files for a given transient record:

1. **Data File**: ('.DAT' extension). This files contain all the analog values, sample by sample for each channel. These values must be integer numbers and the structure is the following:

n, tt, A1, A2, A3, ..., D1, D2, D3, ..., Dm

where:

n =	sample number.
tt =	time corresponding to the sample, in microseconds.
A1 .. Ak =	Integer number corresponding to the value of the sample, for each channel, from 1 to k analog channels.
D1 .. Dm =	1 or 0 digits, indicating the value of each digital channel, from 1 to m digital channels.

2. **Configuration channel**: ('.CFG' extension) This file contain the description of the data file contain, with this structure:

Identif., number
TT, nnA, nnD
nn, id, p, cccccc, uu, a, b, skew, min, max

nn, id, p, cccccc, uu, a, b, skew, min, max
nn, id, m

nn, id, m
freq.
nrates
sssss1, endsample1
sssss2, endsample2

sssss2, endsample2
mm/dd/yy, hh:mm:ss.ssssss
mm/dd/yy, hh:mm:ss.ssssss
Data file type

where :

Identif.:	Identification, Text.
number:	Identification, number.
TT:	Number of channels in data file.
nnA:	Number of analog channels in data file.
nnD:	Number of digital channels in data file.
nn:	Channel number.
id:	Channel identifier.
p:	Phase identifier.
cccccc:	Circuit/component being monitored.
uu:	Units (kV, etc.)
a:	Real number for the following equation:
b:	Real number for the following equation. Actual value recorded = a x integer number in data file + b
skew:	Real number to take into account the time difference between different channels in the same sample number.
min:	Integer number, minimum value of the corresponding channel.
max:	Integer number, maximum value of the corresponding channel.
m:	Normal status of each channel (for digital channel only).
freq.:	System frequency (50/60)
nrates:	Number of different sampling rates used in data file.
sssss1:	Sampling rate #1.
endsample1:	Last sample number taken at sample rate sssss1.
sssss2:	Sampling rate a #2.

endsample2:	Last sample number taken at sample rate sssss2.
etc.	
sssssn:	Sampling rate #n.
endsamplen:	Last sample number taken at sample rate sssssn.
mm:	Month
dd:	Day
yy:	Year
mm:	Minutes.
ss.ssssss:	Seconds.
Data File type:	ASCII or BINARY

3. **Header File:** ('.HDR' extension). This is a free format text file which contain additional information on the oscillography record. DMS module uses this file to store all the settings the relay was using at the moment the oscillography recorder war triggered. This is done in order to help analyze the performance of the protection functions.

6. CONTROL FUNCTIONS IN DMS MODULES

6.1. INTRODUCTION

DMS integrated system includes in the same equipment Protection functions (see corresponding chapter in this instruction book) and Control functions, which will be described in this chapter.

The Control Module in DMS comprises the following functions:

6.1.1. Switchgear Control Functions

This set of functions allows the user to:

- Configure (Design) the graphical display in the local MMI, in the front panel of the relay, by using the items of the DDS data base (circuit breaker, line switch, ground switch, etc.)
- Monitor the status of the switchgear defined, by means of the local graphical display in the front panel of the relay, or by using a communication link, a PC and the GE_LOCAL communication software.

6.1.2. Input and Output Configuration

- Define output contacts associated to each output signal defined in the internal logic, using 16 inputs OR gates and all the internal information available in the status panel of the DMS module.
- Define input contacts which are wanted to be used to define the internal logic.
- Define timers (if wanted) for the digital inputs.

6.1.3. Event Generation and Treatment

- Generation and treatment of two different user defined events: Alarms and Signaling.
- Define Alarms:
  - Alarm Text description.
  - when it has to be generated (using 16 inputs OR gates and all the information available in the status panel of the control and protection DMS modules.)
- Manage generated alarms, differing among four different alarm status:
  - Active alarm and acknowledged by the operator.
  - Active alarm and not acknowledged by the operator
  - Non active alarm and not acknowledged by the operator.
  - Non active alarm and acknowledge by the operator
- Define Signaling (same procedure as in alarms definition.)

6.1.4. Miscellaneous Control Functions.

- Measuring of present values of voltages, frequency, etc.

- Define logic circuits. There are 4 circuits available: the output of two of them is the output of an OR gate of 3 AND gates. The output of the other two is the output of an OR gate of 4 AND gates.

The above mentioned functions are configured by using a PC software and a communication link. GE_INTRO is the PC software designed to configure DMS protection functions. It is a Windows based program, and belong to the software package called GE_NESIS (GE_LOCAL, GE_INTRO and GE_OSC). Refer to the specific instruction book for a more detailed description of each program.

The configuration procedure using GE_INTRO is described in the following sections. For more details please refer to the GE_INTRO software instruction book.

6.2. CONFIGURATION PROCEDURE.

6.2.1. Digital Inputs Assignment.

User can define up to 42 digital inputs. There are four different groups of digital inputs: Switchgear status inputs (up to 16 inputs), Configurable Digital Inputs (up to 32 inputs), RTU inputs (up to 16 inputs), Pulse inputs (up to 4 inputs). User can define how many inputs of each type are needed for his application. Total number of inputs cannot exceed 42.

- **Switchgear Status Inputs**: The propose of these inputs is to let the DMS module know the status of the HV switchgear items and external equipment (-a and -b auxiliary contacts per HV switchgear item). These are level activated inputs (input must remain ON to define the status of the item). GE_INTRO will automatically prompt for external -a and -b contacts configuration for the user to define.

- **Configurable Digital Inputs**: These are generic inputs, which meaning and use must be defined by the user. These inputs, external contacts, are internally assigned to digital signals, which will be available anytime at the Control Status panel, for the user to define alarms, event, outputs, etc. User has to define an identification text for each input. As has been mentioned previously, these inputs, and all the internal signals are mapped into the control status panel, and user can use all this information to define alarms, events, outputs, etc. using 16 inputs OR gates. They can also be used to define the interlockings, failure conditions, success conditions, etc. Eight of these signals (the first 8) can be timed, between 0 and 60000 ms, this means that the relay will not consider the activation of the input until his associated timer has timed out. These inputs are also level activated inputs.

- **Pulse inputs**: Used to read pulses coming from external energy meters.

- **RTU inputs**: These are assigned to external contacts when control commands coming from a conventional RTU need to be used. RTU inputs are pulse inputs.

Following with the previous example, the **Switchgear Inputs** could be:

Switchgear input	**Control Input**
Control Block	-
Control Unblock	-
52-A	CI - 9
52-B	CI - 8
89E1-A	CI - 19
89E1-B	CI - 20
89E2-A	CI - 17
89E2-B	CI - 18

Note: CI is the generic denomination for Control Input. The external contacts associated to each CI are defined in the elementary diagram of each particular DMS module.

The list of switchgear inputs depends on the HV switchgear items defined in the previous section, cause GE_INTRO prompts automatically for two CI (-a and -b auxiliary contacts) for each HV switchgear item defined.

Configurable Digital Inputs could be:

Configurable Digital Inputs	Control Input	Temporization in ms
P.T. Secondary Protection Trip	CI - 1	0
87B Control Voltage Failure	CI - 2	0
52BF Control Voltage Failure	CI - 3	0
Oscillography in progress	CI - 7	0

Note: Same Control Input (and associated external contacts) could be used in different inputs definition. For example, 52/a and 52/b auxiliary contacts can be defined as HV Switchgear Status Inputs, to let DMS monitor the circuit breaker, and also can be defined as Configurable Digital Inputs, to be used in the internal logic defined later on by the user, to generate alarms, close outputs, etc.

6.2.2. Outputs Configuration.

The control Module of a DMS module can handle up to 24 user configurable outputs.

To define the outputs, user can use 16 inputs OR gates, and NOTs over all the information contained in the Control Status panel. The Control Status panel is divided into 10 groups with 16 control signals each. In the definition of the internal logic, using OR gates, all the signals going into the same OR gate must belong to the same Control group.

The Control Status panel is comprised of 160 control signals, which contain all the information related to the Control Module. Among other signals, user will find the status of every HV switchgear defined in section 4.2.1, the selection and output signals for each control action (open / close) defined in section 4.2.2, the configurable digital inputs defined in section 4.2.3, etc.

An example of a Control Status Panel, could be:

Control Signals Group #1

1. Program Initializing
2. Settings Change
3. Counters modification
4. New Events Recorded
5. New Signaling
6. Undefined
7. Undefined
8. Local / Remote
9. Time synchronization
10. Parallel EEPROM Alarm
11. Serial EEPROM Alarm
12. Default Caliber Alarm
13. Default General Settings Alarm
14. Default Command tables Alarm
15. Undefined
16. Power Supply Alarm

Control Signals Group #2

17. Control Blocked
18. Control Ready
19. Control Operating
20. Control, reclosing in progress
21. Control, Undervoltage
22. Control, Underfrequency
23. Undefined
24. Undefined
25. Waiting Operation Conditions
26. No Operation Conditions
27. Waiting Confirmation Comm.
28. Control Timer
29. Waiting Dwell Time
30. Waiting for success conditions.
31. Operation Completed
32. Operation not Completed

Control Signals Group #3

33. Control Block Input
34. Control Unblock Input
35. Undefined
36. Undefined
37. 52 Coupler Closed
38. 52 Coupler Open
39. 89E1 Open
40. 89E1 Closed
41. 89E2 Open
42. 89E2 Closed

Control Signals Group #4

43. Undefined
44. Undefined
45. Undefined
46. Undefined
47. Undefined
48. Undefined
49. Undefined
50. Undefined

51.Undefined
52.Undefined
53.Undefined
54.Undefined
55.Undefined
56.Undefined
57.Undefined
58.Undefined

Control Signals Group #5

59.Digital Input 7
60.Digital Input 8
61.Digital Input 11
62.Undefined
63.Digital Input 16

Control Signals Group #6

64.Control Voltage Failure
65.Signaling Voltage Failure
66.PT Secondary Protection Trip
67.Digital Input 24
68.Digital Input 25
69.Digital Input 26
70.Digital Input 27
71.Digital Input 28
72.Digital Input 29
73.Digital Input 30
74.Digital Input 31
75.Digital Input 32

Control Signals Group #7

76.Undefined
77.Undefined
78.Undefined
79.Undefined
80.Undefined
81.Undefined
82.Undefined
83.Undefined
84.Undefined
85.Undefined
86.Undefined
87.Undefined
88.Undefined
89.Undefined
90.Undefined
91.Undefined
92.Undefined
93.Undefined
94.Undefined

Control Signals Group #8

95.Undefined
96.Undefined
97.Undefined
98.Undefined
99.Undefined
100.Undefined
101.Undefined
102.Undefined
103.Undefined
104.Undefined
105.Undefined
106.Undefined
107.Undefined
108.Undefined
109.Undefined

Control Signals Group #9

110.Va1 < 50% VN
111.Vb1 < 50% VN
112.Vc1 < 50% VN
113.Va1 > 70% VN
114.Vb1 > 70% VN
115.Vc1 > 70% VN
116.Va2 < 50% VN
117.Vb2 < 50% VN
118.Vc2 < 50% VN
119.Va2 > 70% VN
120.Vb2 > 70% VN
121.Vc2 > 70% VN
122.VbB > 70% VN
123.Undefined
124.Undefined
125.Undefined
126.Undefined
127.Undefined
128.Undefined

Control Signals Group #10

129.Undefined
130.Undefined
131.Undefined
132.Undefined
133.Undefined
134.Undefined
135.Undefined
136.Undefined
137.Undefined
138.Undefined
139.Undefined

An example of control outputs could be:

Control Output Identification Text	Control Output
Local Mode	CO - 6
Oscillography record in progress	CO - 9
Remote Control	CO - 10
Critical Alarm	CO - 25
Control Voltage Alarm	CO - 26
PT Secondary Protection Trip	CO - 32

Note: CO means Control Output, the external contact numbers should be found in the elementary diagram of the specific DMS relay model.

6.2.3. Events Configuration.

48 different Events can be defined by the user into the Control Module of the DMS module.

16 inputs OR gates can be used during the configuration of these events. The input signals to these OR gates must be selected from the Control Status Panel, and all the inputs to one OR gate must belong to the same Control Signal Group. The activation of any one of those inputs will produce an output in the OR gate, and will generate an event. To deactivate the OR gate and the event, all of the inputs to the OR gate must be low.

User can assign a 32 character string (Identification Text) o each event.

Each event contains the following information:

- Identification Text.
- Alarm acknowledge mark (star character).
- Status of the signal generating the event (active or deactive)
- Date and time.

An example of events could be:

Event
52 Coupler Closed
52 Status Error
89-E1 Closed
89-E1 Status Error
89-E1 Open
89-E2 Closed
89-E2 Status Error
89-E2 Open
Control Voltage Failure
PT Secondary Protection Trip
52 Control Voltage Failure

6.2.4. Graphical Display Configuration.

It is possible for the user to configure the graphical display of the local MMI, in the front panel of the relay. User can configure the configuration of the switchgear monitoring screen and the measures screen of the LCD graphical display of the DMS module.

GE_INTRO, the configuration software for DMS protection functions, includes the capability for drawing the one-line drawing of the busbar, using several items from a item data base (circuit breaker, ground switch, line section, bus-bar section, etc.) and then, download the screen design to the DMS module through a serial communication link.

The measures screen can also be redesign and customize by the user at any time, using again the GE_INTRO software.

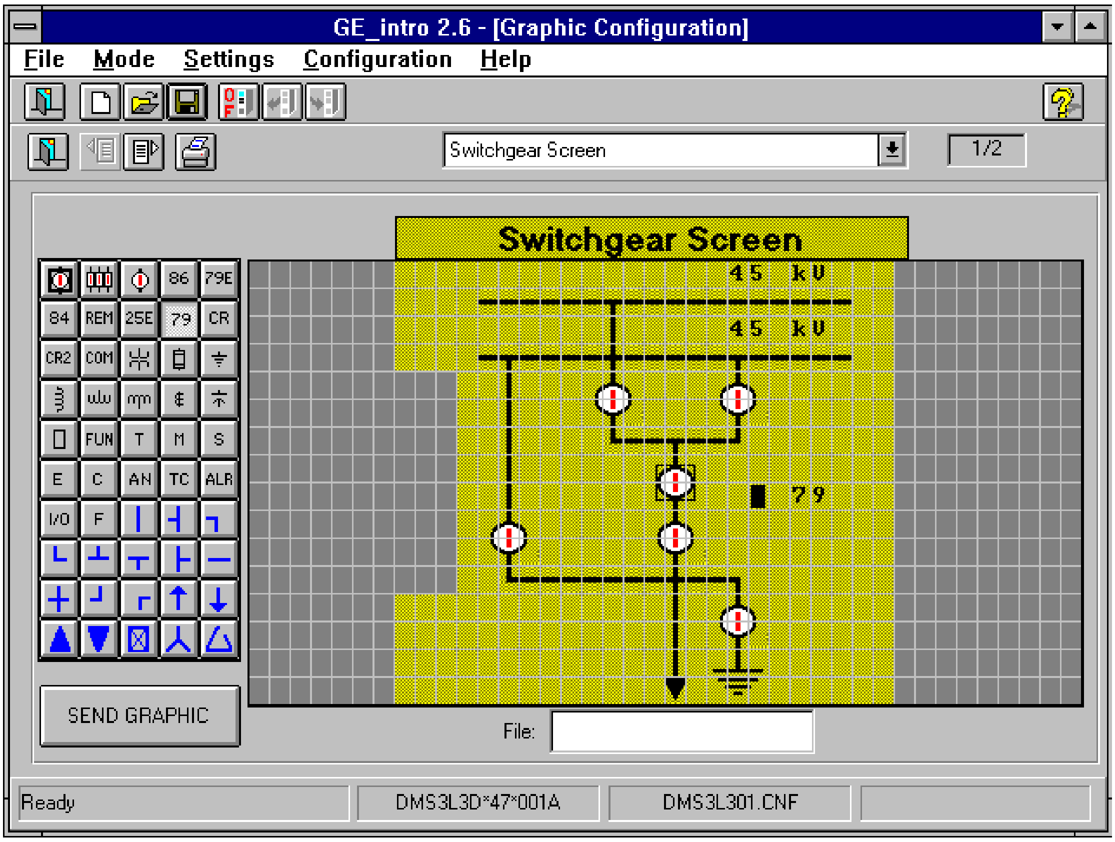


Figure 6.1 Graphic configuration (switchgear).

For further information please refer to the GE_INTRO instruction manual.

6.3. LOGIC DIAGRAMS

The logic diagrams corresponding to the control module of DMS protection functions are included in this section. These diagrams correspond to:

- Control Status Sequence.
- Control actions (Not applicable in this module. For other applications refers to the DDS Instruction manual)
- Switchgear Items Status Monitor.
- Control Status Assignment.

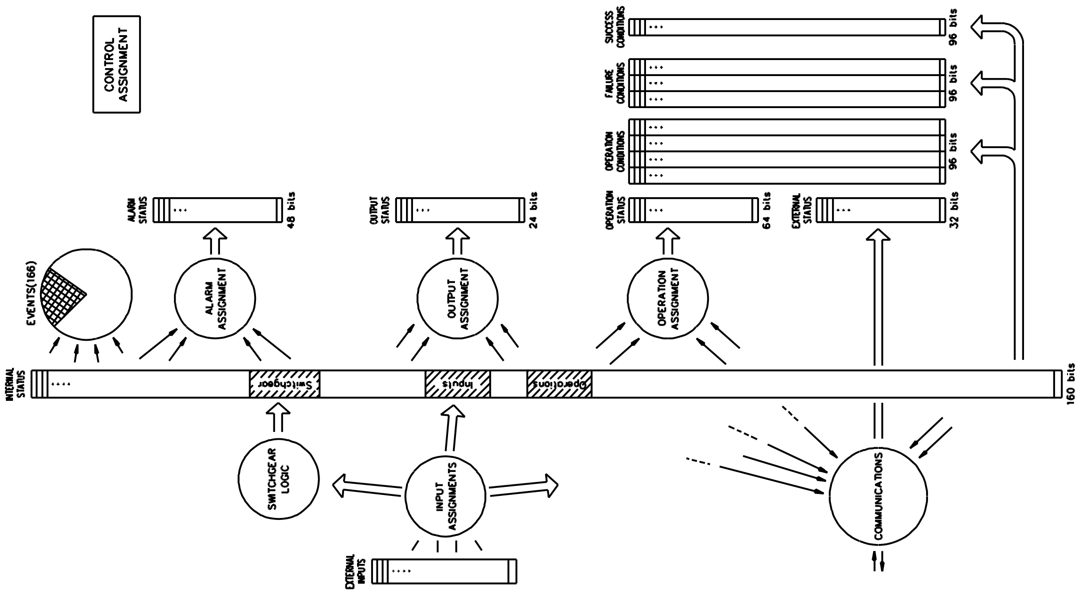


Figure 6.2 Status assignment.

7. HARDWARE DESCRIPTION

WARNING

The BUS2000 module incorporates electronic components that might be affected by electrostatic discharge currents flowing through certain components terminals. The main source of electrostatic discharges is human body, specially under low humidity conditions, with carpet floors or isolating shoes. If such conditions are present special care should be taken while manipulating BUS2000's modules and boards. Operators, before even touching any component, must make sure that their bodies are not charged by either touching a grounded surface or by using an antistatic grounded wrist bracelet.

The DDS (*) module architecture is of modular type, allowing to form, from a series of standard modules, protection and/or control racks, characterized by the software used in each concrete case (The level 1 modules are named DMS). This flexibility of the system allows each of the racks to adopt different configurations according to the functions included and the desired application.

The following hardware description is general, and includes those relevant aspects that are common to the different protection and/or control equipments included in the BUS2000 system.

(*) DDS is the system to integrate all the DMS modules (level 1) at Substation level, using the communication port of each module and doing the Integration by mean of a PC computer and a Software developed for this task (GE_POWER, GE_CONF).

7.1. CASES

BUS2000 systems are provided in complete cases. They are made up of standard 19 inches wide and four units high racks, fully wired to connecting blocks placed in the back. Connections between the different cases are achieved only from their connecting blocks.

All the auxiliary elements, such as stabilization resistors, supply resistors, etc, are provided by the factory in the cases, except for the intermediate adapting auxiliary transformers. These are provided separately for their set-up near the main transformers, or in the boards to which their secondary currents are wired for every position.

The cases are provided with a transparent front gate and a back gate, both removable for an easy access to the case during its installation.

Figure 19 shows the dimensions of the cases.

7.2. PANEL MOUNTED RACKS

The racks provided separately for the installation of BUS2000 board mounted systems are standard, 19 inches wide and their dimensions are shown in figure 18.

The external connections are provided in terminal blocks mounted in the rear part of the rack.

The front cover is made up of plastic material and fits over the case making pressure over a rubber joint located around the enclosure. This produces a tight proof sealing avoiding the entrance of dust. The resetting of the targets is achieved without having to take off the cover, through pushbuttons.

The modules provided with the various protection functions are assembled vertically on the racks. Several types of modules are available depending on their type of installation and extractability.

Name	Description	Modules
BBD	Single bus differential protection (6 positions) (figure 7.1)	3 DDF 1 DAL 1 DDI 1 DRD 3 DFI 1 DRS
BBR	Input and output modules for additional positions, Maximum:12 positions per rack.	6 DFI 2 DRS
BZC	latching auxiliary units for current switching in double bus systems. Maximum: 5 positions per	10 HLB100
DMS	Microprocessor monitoring module (figure 7.2)	
BTR	Optional test rack for single or double bus systems (figure 7.3)	1 DPR 2 HLB100 2 HLA100
BFR	Supervision and breaker failure overcurrent relay Maximum:5 positions per rack. (figure 7.4)	5 SFI 5 MFI
BAR	Accessory functions	1 DTE 6 HLB100

Figure 7.1 *BBD RACK*

Figure 7.2 *DMS RACK*

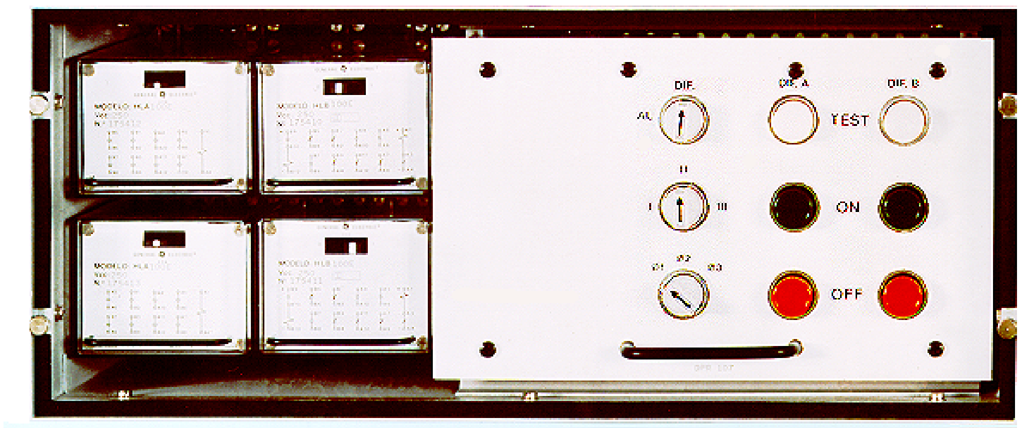


Figure 7.3 *BTR RACK*

Figure 7.4 *BAR RACK*

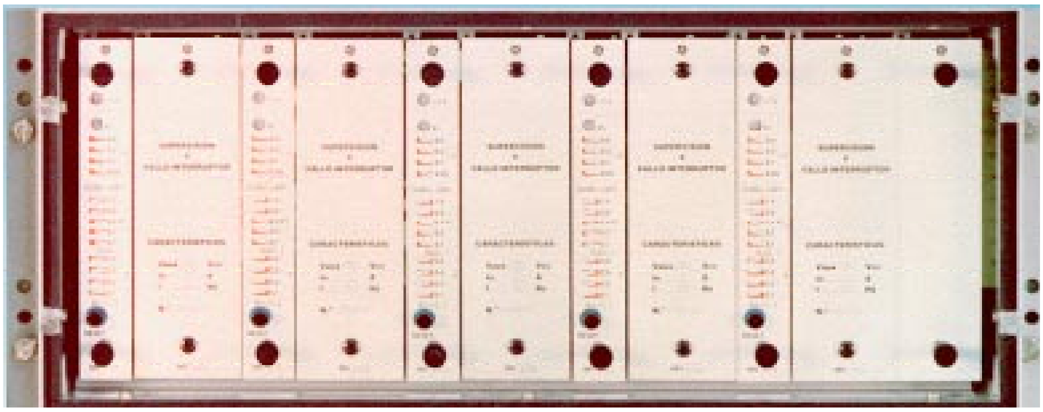


Figure 7.5 *BFR RACK*

7.3. MODULES

All the modules are identified by means of a number located in the front plate which specifies its function and characteristics.

The various configurations available in a bus protection system are carried out combining the number of modular components requested in order to obtain the whole of the desired functions and the number of input and output circuits requested. The BUS2000 is a flexible and modular system made up of the components described below.

The different types of modules are:

NAME	Description	Width inches	Draw-out
DDF	1 pole, differential unit board	1	YES
DAL	3 poles, alarm unit board	1	YES
DDI	Differential unit input module	2	NO
DRD	Differential unit output module	2	NO
DFI	2 lines input module	2	NO
DRS	6 lines tripping output module	2	NO
SFI	1 line breaker failure and supervision unit board	1	YES
MFI	1 line breaker failure and supervision output and input board	2	NO
DTE	Multifunctional module which gathers the followingfunctions: Reduction to single differential, coupling closing system, B.F. general tripping, permanent signaling of differential tripping.	6	NO
DPR	Testing unit module	9,5	NO
MDF	F.I. general tripping module (single bus)	1	NO
BPP	Signaling reset module	2	NO
DMS	Microprocessor based monitoring module with digital I/O, voltage analog inputs, communication port, IRIG-B and analog (low level input board.		

7.3.1. Printed Circuit Boards

Each module consists of a printed circuit board with a front plate mounted on it through two supports. Over this plate, there are two elements which fit into two nuts on the box that serve the purpose of pulling the module out of the rack or pushing it into it.

The electrical connections are made through a male connector which fits into a female connector located in the box.

7.3.2. Output Modules

They are similar to the printed circuit modules except for their structure which consists of a metal plate for the assembly of the output relays and other components. They also use a different connector.

7.3.3. Non- Removable Modules

They are used for assembling current transformers input transactors and other components.

They consist of a plate which supports their various components and several connecting blocks with the rest of the modules and with the system.

In order to remove these modules it is necessary to reach the rear part of the rack unscrewing its rear cover and removing the screws which hold the module as well as removing the connecting blocks. The module is drawn out though the front part of the rack. This operation has to be done with the protection system completely out of service and with its current inputs short-circuited.

7.3.4. Latching and Auxiliary Relays

They are unplugable with their own connection bases located and wired in the racks.

They are provided with their own transparent cover and are removed through the front part of the rack.

They must not be removed without having previously checked that the protection system is out of service and that their current inputs are short-circuited, given that their contacts may be part of the secondary circuit of the current intermediate transformers, which means that their removal could mean the opening of these circuits; this would cause the protection to trip or it would cause the operation of the alarm units, as well as possible permanent damage to the intermediate transformers.

7.3.5. Front Side Devices

Line current measuring terminals (FIG. 7)

They are located in the front plates of the restraint modules (DFI) . They consist of 2 or 3 rows of terminals according to the number of restraint inputs (2 maximum). The lower terminals correspond to the references of each phase and the upper terminals to the inputs in each line, per phase.

The a.c. voltage measured in these terminals corresponds to the current flowing through the line on the 1 A side.

Measuring terminals of the total restraint currents (FIG. 8)

They are located on the front plate of the differential module (DDI), in the upper row. The terminals in the lower row correspond to the reference, which is also common for the measurement of the differential currents.

The continuous voltage measured in these terminals correspond to 90% of the arithmetical sum of the currents of all the lines in the 1 A side.

Differential trip signaling (FIG. 9)

It is done by means of a red LED located in the front part of the boards in every differential single-phase unit.

It is a continuous signaling and the reset is carried out manually by means of a push-button located in the front part of the same board.

Signaling of operation of the alarm unit (FIG. 10)

It is done by means of three red LEDs (one for every phase) located in the front part of the board, in the alarm unit.

The signaling is continuous and the reset is achieved by means of a push-button placed in the front part of the board itself.

Operation level adjustment of the breaker failure unit (FIG. 11)

It is carried out by means of microswitches placed in the front part of the breaker failure board (SFI).

The minimum adjustment (all the microswitches placed at the left),is 0.2 A on the 1 A side, plus the number corresponding to every microswitch located to the right. The unit adjustment ranges from 0.2 to 3.3 A on the 1 A side, in 0.1 steps.

Operation time adjustment of the breaker failure unit (FIG. 11)

It is carried out by means of microswitches placed in the front part of the breaker failure board (SFI).

The minimum adjustment (all the microswitches placed at the left), is 0.2 s, plus the number corresponding to every microswitch, positioned to the right. The adjustment ranges from 0.1 to 1.6 s in 0.1 steps.

Operation level adjustment of the overcurrent unit (FIG. 11)

Two versions are available for the operation level of the overcurrent unit. In the first case, the level depends on the level adjustment of the breaker failure unit, and in the second the level is totally independent.

Dependent adjustment:

It is done by means of microswitches placed in the front part of the breaker failure board (SFI).

The minimum adjustment (all the microswitches placed at the left), is 0.25 times the adjustment of the breaker failure unit, plus the number corresponding to every microswitch, positioned to the right. The adjustment ranges from 0.25 to 1 time, in 0.05 steps.

Independent adjustment:

The same as the operation level adjustment of the breaker failure unit.

Bus coupling timer adjustment (FIG. 23)

It is done by means of microswitches placed in the front part of the switching module (MDF).

The minimum adjustment (all the microswitches placed at the left), is 0.2 s, plus the number corresponding to every microswitch, positioned to the right. The adjustment ranges from 0.2 to 1.7 s, in 0.1 steps.

Breaker failure trip signaling (FIG. 11)

It is done by means of a red LED placed in the front part of the boards, in every breaker failure unit.

This signaling is continuous and the reset is achieved manually through a push-button placed in the front part of the board.

Operation signaling of the overcurrent unit (FIG. 11)

It is done by means of a red LED placed in the front part of the boards, in every breaker failure unit.

This signaling is not continuous and stops signaling when the unit is reset.

7.3.6. Internal Adjustments

Percent slope adjustment (FIG. 12)

It is placed in the differential board (DDF) and it is achieved by means of a Cambion jumper. The range values are: 0.5, 0.6, 0.7, and 0.8

Differential overcurrent supervision adjustment (FIG. 12)

It is placed in the differential board (DDF) and it is achieved by means of a Cambion jumper. The range values are: 0.2, 0.3, 0.5, 0.8 , 1.0, 1.5 and 2.

Alarm operation time adjustment (FIG. 13)

It is placed in the alarm board (DAL) and it is achieved by means of the P1 potentiometer. It is adjusted at 10 s.

Failure pickup command seal in adjustment (fig. 14)

It is placed in the breaker failure board (SFI) and it is done by means of a jumper.

7.3.7. Factory Adjustments

DDF board (FIG. 12)

- P1 potentiometer: Differential unit operation level adjustment.
- P2 potentiometer: Differential unit operation time adjustment.
- P3 potentiometer: Differential unit recovering time adjustment.
- P4 potentiometer: Supervision unit operation level adjustment.
- P5 potentiometer: Supervision unit operation time adjustment.
- P6 potentiometer: Supervision unit fill-in time adjustment

DAL board (FIG. 13)

P1 potentiometer: Alarm unit recovering time adjustment.

SFI board (FIG. 14)

- P1 potentiometer: Breaker failure operation level adjustment.
- P2 potentiometer: Overcurrent unit operation level adjustment.
- P3 potentiometer: Overcurrent unit fill-in time adjustment.
- P4 potentiometer: Breaker failure unit fill-in time adjustment.
- P5 potentiometer: Overcurrent unit operation time adjustment

NOTE: The potentiometers described above are factory adjusted and it is not recommended to change their original adjustment positions.

7.3.8. Accessories

In systems provided separately, the following accessories are provided for installation inside the board:

7.3.8.1. Auxiliary Transformers

They are single phase units (three for every position and measuring unit) provided separately. Their dimensions and panel drilling are shown in figure 15.

7.3.8.2. Restabilization Resistors

One for each phase and measuring unit.

7.3.8.3. Non Linear Protection Elements Box

One for each measuring unit. A diagram box is shown in figure 16.

7.3.8.4. Power Supply Resistors Box

One for every differential rack and one for each breaker failure rack.

A diagram with the dimensions is shown in figure 16.

8. DMS MODULES

8.1. BOX CONSTRUCTION

The DMS modules are assembly in box of an standard 19'' rack four units high, manufactured in stainless steel and painted with gray epoxy resin. It is composed of a backbone structure, that includes the strips where all the modules and boards are connected, plus a rear plate with all the female connectors.

All the boxes have a surge ground connection terminal, essential not only in terms of safety but also on behavior against electromagnetic interference.

All the modules (described in a generic form in section 5.2) are of draw-out type, enabling easy maintenance and repair of the equipment.

The DMS also incorporates a plastic antitampering front cover. This cover keeps the relay sealed and provides a high protection against dust and water (IP51 index according to IEC 529). The use of a push-button allows access to the main functions without the need of removing the cover.

The front and rear views of a typical DMS equipment are shown on figures 32 to 34.

8.2. ELECTRICAL CONNECTIONS.

All the DMS electrical connections (voltage inputs and digital I/Os) are done through drawout terminal boards of 12 terminal blocks each located at the rear of the device.

Additionally to those terminal blocks, the DMS includes two communication ports. One front DB-9 port for local connection and another located on the rear nameplate, used for remote connection to the PC.

This second port may be used for point-to-point connection with a central computer in the substation by means of a multiplexer.

This second communication port may be, depending on the selected option, a RS232 with a DB-9 conector, a fiber optics (glass or plastic) conector or finally an RS-485.

In the rear plate are also included the terminal blocks for the time synchronization through a demodulated IRIG-B input.

8.3. INTERNAL CONSTRUCTION.

The internal architecture of the most general DMS modules, including protection and control functions, includes the following 4 units high drawout modules:

- Power Supply module.
- Magnetic Module (CT and VT analog inputs)
- Protection CPU board
- Communications CPU board.
- Control CPU board
- Digital inputs board.
- Digital outputs board.
- Digital inputs/outputs mixed board.
- Analog inputs board (coming from measurement transducers).

Each of these modules has a DIN type front connector for the connection to the internal communication bus. Also, in the case of having connections to the outside (Inputs, Outputs and power supply modules), the male part of the terminal block is incorporated. The female portion of the connector is located in the rear plate of the box. All these boards are inserted in the box perpendicularly to the rear plate.

Besides all these modules there are some other boards mounted in parallel to the front of the box. These boards are:

8.3.1. Internal bus board.

This is a PCB board that makes the connection between the digital inputs and the power supply through their front DIN connectors.

8.3.2. Front display board.

It is a PCB that includes the two LCD displays of the DMS protection and control equipments, the alphanumeric display for the protection management, and the graphic display for control management and visualization of events and measures, as well as its associated electronics, including the controls of brightness and contrast of the displays. Additionally, the board includes the front communications connector, the switch for local/remote operation selection of the control position and the bicolor LED indicator of the equipment status.

The front module is mechanically and solidly connected to the keypad board, the electrical connection is done through a flexible flat cable of 12 pins.

The subgroup formed by these two front boards (see figure 5.3) is connected to the rest of the relay through another flexible flat cable of 40 pins, connected itself to the front of the communications CPU.

8.3.3. Front keypad board

It is a printed board which is solidly joined to the front board of the display, as mentioned before, and supports the keypad for the protection operation (20 keys alpha-numeric and functional keypad that acts on the alpha-numeric display) The board also includes a transparent window for the display and for the control board in which the unit identification (model number and serial number) and its more relevant technical characteristics are included.

The group formed by both front boards is mechanically and electrically joined to the box by means of 4 screws placed at upper and lower part of the front. To get the access to the internal electronic modules of the relay the next steps must be followed (once the relay has been disconnected):

1. Remove the plastic cover.
2. Slack the fixed frontal screws till they are untied and only fixed by their fastening sleeve.
3. Let the front part fall softly till the flat cable, that is connected to the communications board, is accessible, and unfasten the extreme connected to this board.
4. Remove the frontal module.
5. Take out the internal bus board which fixes the different modules themselves.

If this process is followed, every relay module can be accessed in order to be taken out, maintained or replaced. In order to assembly the relay again, the procedure is the contrary, that is to say:

1. Make sure that every vertical drawout module has been correctly inserted.
2. Assembly the internal bus board which joins the different modules themselves by pressing from left to right every connector in order to be sure of their right insertion.
3. Connect the flat cable that connects the frontal module with the communications board.
4. Place the frontal module at its position and screw it on the box.
5. Cover again the relay with its protective cover.

8.4. IDENTIFICATION.

The identification label of the model is placed at the right of the alpha-numeric keypad. This label includes the model number, serial number and the most important nominal values (including nominal voltage and current, and DC power supply nominal voltage).

Terminal blocks placed at the rear cover are identified by black color serigraphy on the cover. Each of the terminals blocks are identified by a letter placed at the upper border of the cover close to the connector. This connector identification is assigned to the different connectors, beginning by A which corresponds to the connector placed on the right extreme (looking at the relay from the back).

In the terminals blocks, each of the 12 terminals of each block is identified from the top to the bottom by a number between 1 and 12 that is serigraphied on the cover close to each connector at the input side of the connection cables. The connector terminals for synchronization are identified by “IRIG-B” serigraphy and the terminals polarity is indicated by “+” and “-”.

For relays with fiber optics communications (plastic or crystal), transmission and reception connectors terminals are identified by TX and RX serigraphy respectively.

8.5. BOARDS

As indicated in the hardware general description, the DMS equipments have been designed taking as a basic criterion the creation and use of hardware boards common to the different functions. Customization to a required function is carried out using the protection/control software in the EPROM memories of the protection, control and communications CPU modules.

A series of hardware modules has been defined for this purpose, which can be used in any of the equipments, depending on the required application, with the only limitation of the 19’’ rack capacity to contain modules.

All the DMS protection and control modules include two sub-modules (one for protection and one for control), separated by the whole of the three CPU boards. Different box configurations are available, and can be identified by the number of rails (slots) available for inputs, outputs or mixed boards in the protection sub-module.

The three configurations available are characterized by:

- P0: Not available space for boards in the protection sub-module.
- P1: Available Space for only one board in the protection sub-module.
- P2: Available Space for two boards in the protection sub-module.

The most common architecture is P1, including the following typical distribution of modules (from left to right, watching from the front side of the equipment):

- Magnetic Module (analog inputs)
- Power supply module.
- Mixed protection inputs/outputs modules.
- Protection CPU
- Communications CPU
- Control CPU
- Analog Inputs
- Control Inputs
- Mixed control inputs/outputs (first module)
- Mixed control inputs/outputs (second module)
- Mixed control inputs/outputs (third module)
- Redundant Power supply module.

The hardware modularity provides advantages in several aspects:

- Greater reliability and experience accumulated in the hardware, because of this being common to all the equipments.
- Decrease of the number of different spare parts.
- Easy training for equipment maintenance and commissioning.

An additional aspect to emphasize is the separation of protection, communications and control functions in different CPU boards, each of them with its own dedicated 16 bit microprocessor.

This involves the following advantages:

- Higher processing capacity than architectures with a single microprocessor to support the protection and control functionality.
- The modification or improvement of one of the components does not involve modification of the whole assembly.
- Greater reliability. A failure in the communications or control hardware does not affect the protection functionality.

8.5.1. Magnetic Module.

Magnetic module takes voltage signals of the substation conventional transformers, and with these signals performs the following:

- It gives galvanic isolation to external signals by means of relay internal transformers.

- It makes suitable the external signals to the adequate voltage levels for the internal circuitry.

This module condition up to 8 analog signals, these being voltage or current signals. For this purpose, three types of internal transformers are available:

- Current transformers, for connection with external current transformers of secondary nominal current of 1 or 5 A. These modules are not used for the BUS2000.

- Voltage transformers, for connection with external voltage transformers of secondary nominal values of 110 V (phase-to-phase connection) or 110/√3 V (phase-to-ground connection).

- Ring CT´s for residual current signals or nominal values lower than 1 A. Not used with the BUS2000.

As these are protection transformers, where the dynamic range of the analog inputs is fundamental to avoid saturation, high range transformers are always used.

Anti-noise filters are another element of the module. As the magnetic module is connected to external switchgear signals, it can be affected by electromagnetic disturbance. In order to avoid their effect, anti-noise filters have been included in the transformers' primary (capacitors connected to chassis), as well as in the secondary (ferrites), so as to prevent disturbance from entering the equipment. These protection elements act as well as a barrier, preventing possible disturbances generated in the protection equipment to come out of this and affect the external equipment.

The last element included in the magnetic module consists of load resistors that convert the current signals in voltages, in the current signals case, and of resistive attenuators in the voltage signals case.

8.5.2. Protection CPU Processing Board.

This module is the main part of the equipment with reference to protection functions. The main functions are:

- Sampling of analog signals coming from magnetic module.
- Protection algorithm evaluation.
- Protection logic and auxiliary functions.
- Monitoring functions, events register, oscillography register, etc.
- Equipment self-check.

- Protection data communication to the communications CPU.

CPU module nucleus is a 16 bits microprocessor together with its auxiliary associated circuitry.

8.5.3. CPU Communications Board.

Communications CPU module nucleus is very similar to the protection CPU module, and it also consists of a 16 bits microprocessor together with the auxiliary electronic.

The main function of the communications CPU module is to maintain and control the communications in the following channels:

- Internal communication with the protection and control CPU modules.
- Local mode communication with a PC by the front communications port.
- Remote mode communication by rear communication port.
- Man-machine interface by means of keypads and displays.

8.5.4. Control CPU Board

This board is, at the hardware level, exactly the same as the protection CPU board, being differentiated only in the software contained in its EPROM memories.

The main functions carried out by the control board are the following:

- Control Measurement
- Monitoring and signaling of switchgear states
- Operations and interlocking of the switchgear equipment at the position level.

8.5.5. Digital Inputs Board.

The design of the DMS has been done for assuring the maximum capacity of inputs by board, maintaining at the same time the maximum reliability against electromagnetic disturbance. For this purpose, the standard board of inputs, identical for protection and control applications, includes 21 digital inputs divided into 3 groups of 7 inputs each one, with a common for each group of inputs.

Each of the board inputs has a resistive attenuate which adequates the external voltage battery levels (48 V, 125 V, ...) to the needs of the optocoupler that gives galvanic isolation to each input. As the majority of these inputs come from elements that are connected to the substation equipment, together with the resistive attenuate one passive filter is provided in order to get better behavior against electromagnetic perturbations.

Input modules (as well as the output ones), provide one selectable of 4 bits address, which allows to include up to 16 modules of each kind in the same DMS protection and control equipment.

8.5.6. Digital Outputs Board

Each of the DMS output boards includes 12 heavy duty relays, 16 Amperes nominal continuous capacity and 4000 VA breaking capacity or signaling, of continuos nominal capacity of 8 Amp. Each of these relays has an only contact (NC + NO). The contact of each relay can be set separately as normally close or normally open by jumpers (fixed by welding) placed on the board.

In every configuration the contacts are non potential contacts, without common elements and all of them have varistors between their terminals in order to protect them against overvoltages generated by the coils they are connected to. This provides a high immunity against electrical interferences.

8.5.7. Mixed Digital Inputs/outputs Boards

It includes the characteristics of the two previously mentioned boards. Each board includes 7 digital inputs, selectable by an internal jumper as an only group of 7 inputs with one common point or as two groups of 3 inputs with independent common points, and 8 digital outputs.

8.5.8. Analog Inputs Board (Measurement Transducers)

Each board includes 4 analog inputs, each one being able to be selected independently for the different defined range (+ /- 2.5mA, 0-1 mA, 0-5 mA, 4-20 mA ó + /- IOV).

8.5.9. Power Supply.

The Power Supply module includes the following functions:

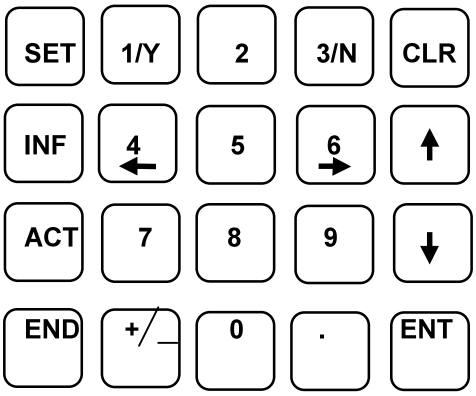
- Generation of the necessary voltages for the operation of the DMS modules circuitry, in this case 8V (subsequently regular to 5 V) for the logic, and 24 V for the tripping activation.
- Four relays, with the same characteristics as the ones included in the outputs board (2 relays for tripping functions and 2 relays for reclosing).
- A auxiliary relay for equipment alarm.
- Supervision Circuits for two trip and/or closing coils including voltage and current consumption supervision.

As regards the power supply board we should emphasize that:

- One passive filter is included in the power supply input in order to avoid any possible electromagnetic disturbances. A current limiter is also included in order to protect the power supply against unintentional groundings.
- The tripping relays are stronger (in capacity and in control operations life) than the normal ones used for similar protection equipment. Besides this, as the output contacts type can be configured, a high versatility is provided.
- The output circuits for feeding other boards are conditioned so that they can have several boards connected, being possible to switch the service from one board to another one in case of failure, increasing the reliability of the equipment.

9. KEYBOARD AND DISPLAY

Each DMS module has a 20 key keyboard and a 32 character liquid crystal display, which are distributed in two rows of 16 characters each. The layout of the keyboard can be seen in the following picture:



The keypad program uses menus to provide access to the different functions of the relay. These are divided into five big groups, each of them is accessed by means of a different key. These groups are the following:

Information : It gives data about the relay status. To access this menu, press the **INF** key.

Control Operations: It allows to synchronize the date and time of the relay and to do communications trigger. To access this menu, press the **ACT** key.

Settings: It allows to view and modify all the settings of the relay. To access this menu press the **SET** key.

Configuration Menu: It allows to access to the configuration of the relay, allowing the modification of communication baud rates, passwords, etc. To access this menu press **"7169"** (GE in ASCII code). In order to be able to access this menu, the relay must be in the main screen.

Single Key Menu: The DMS modules allows a simplified operating mode by pressing the **ENT** key. It is not necessary to remove the front cover to access to this mode.

In standby mode, each DMS module shows the following message:

- In the first line, the five first indicative letters of the DMS model, which allow to know its functionality.

- In the second line: GENERAL ELECTRIC.

For the example, the message in the screen is:

DMS3L1
GENERAL ELECTRIC

Here one of the last five groups must be selected. In order to select other group, you must return to this screen and press the corresponding key.

Once you are in a group, another one can not be selected without leaving first and going back to the standby screen. You can move inside a group by pressing **ENT, CLR**, ↑, ↓, ← y → keys. Their meanings are as follows:

ENT : To accept the option that appears on the screen at that moment. It is equivalent to go down one level in the tree menu.

CLR : To leave the option that appears on the screen at that moment. It is equivalent to go up one level in the tree menu.

↑/↓: Change the option. It is equivalent to a horizontal movement inside a menu. When the desired option appears on the screen, select it by pressing the **ENT** key.

←/→: Show the different possibilities of a particular setting. When the desired option appears on the screen, select it by pressing the **ENT** key.

9.1. TREE MENUS.

The DMS modules have different menus organized in levels. Level 0 is the standby screen. To access to level 1, a group key must be pressed (SET, INF, etc.). To move along a level ↑/↓ keys must be pressed. To go down to levels 2 and 3 **ENT** key must be pressed. To go up along the menu tree, **CLR** key must be pressed.

Level 1, depending on the selected group, provides the following information:

***TABLE 9.1**. Menu MMI. Description*

Group	Level 1	Description
SET	• SHOW PROTECTION SETTINGS • CHANGE PROTECTION SETTINGS • SHOW CONTROL SETTINGS • CHANGE CONTROL SETTINGS	• Show Protection settings • Change protection settings • Show control settings • Change control settings
	• CHANGE PROTECTION COUNTERS.	• Change protection counters
INF	• STATUS	• Show the DMS status
ACT	• DATE & HOUR • TRIGGER BY COMMUNICATION • RESET CURRENT MAXIMETER.	• Show the date and hour. • Start oscillography by communication • Reset the current maximeter
ENT **SET**	• Vab • Vag • FREQUENCY • DATE & HOUR	• Shoe the phase AB voltage in primary values. • Show the phase-to-ground (Vag) voltage in primary value. • Show the frequency in Hz • Set the date & hour
Configurat. unit **7169**	• BAUD REMOTE • STOP BITS • BAUD LOCAL • STOP BITS LOCAL • LOCAL SETTING • REMOTE SET • LOCAL COMMAND • REMOTE COMMAND • UNIT NUMBER • PASSWORD • t TIMEOUT	• Baud for remote communication • Stop Bits in remote communication • Baud for local communication • Stop Bits for local communication • Local settings enabled • Remote settings enabled • Local commands enabled • Remote commands enabled • Show the DMS number. • Password modification enabled • Timeout for communication

9.2. SETTINGS GROUP.

This group allows viewing and modifying DMS settings. It can be accessed by pressing the **SET** key when the DMS is in standby mode. The following message will be displayed:

VIEW
PROTECTION SETTINGS

Pushing the keys ↑ ↓ the following message will be displayed:

CHANGE
PROTECTION SETTINGS

DMS settings menu tree is represented in the following table. It is important to remember that in order to go down along the tree **ENT** key must be pressed, and that to go up the tree the **CLR** key should be pressed instead.

NOTE: The table shows a particular case, the DMS3L1 model; this means that those SETTINGS that depend on the functions present in the module, according to its functionality, will vary for different models (Permission x function, oscillography mask).

***TABLE 9.2**. Menu MMI. Ranges and Settings*

Level 1	Level 2	Level 3	Valid Range
• **SHOW PROTECTION SETTINGS** • **CHANGE PROTECTION SETTINGS**	• **GENERAL SETTINGS**	• DMS STATUS	• In service Out of service
		• NAME OF BUSBAR	• Alphanumeric chain of 20 characters
		• FREQUENCY	• 50 Hz 60 Hz
		• NOMINAL V PH-G	•
		• BUSBAR 1 PT RATIO	• 1 - 4.000 in 1 step
		• BUSBAR 2 PT RATIO	• 1 - 4.000 in 1 step
	• **ACTIVE SETTINGS** **OSCILLOGRAPHY MASK**	• ACTIVE SETTINGS	• 1-3
		• PICKUP 27A	• Enabled - Disabled
		• PICKUP 27B	• Enabled - Disabled
		• PICKUP 27C	• Enabled - Disabled
		• PICKUP 64G	• Enabled - Disabled
	FUNCTION X PERMISSION	• FUNCTION 27	• Permitted -
		•	• Non permitted
		• FUNCTION 64G	• Permitted - Non permitted
		• FUNCTION 27	• 10 - 260 V
		• FUNCTION 64G	• 3 - 100 V
		• LOST OF LOGIC	• Permitted - Blocked
• **SHOW CONTROL SETTINGS**	• **GENERAL SETTINGS**	• CONTROL	• In service - Out of service
		• FREQUENCY	• 50 Hz 60 Hz
		• RATIO PT BUSBAR 1	• 1 - 2.000 in 1 step
		• RATIO PT BUSBAR 2	• 1 - 2.000 in 1 step

Each DMS has a common group of settings for all the tables an another specific for each settings table. In the previous table we have only shown the settings related to table 1.

- General settings
- Circuit breaker
- Active table
- Oscillography mask

The rest of settings groups are applicable to each table independently, different groups being available for each table, e.g. function 46 T1,T2,T3, SETTINGS of the negative sequence function for each of the possible tables.

The procedure for changing any setting is as follows:

1. Press the SET key
2. Select the CHANGE SETTINGS. option
3. Select the desired setting in the menu.
4. Insert the value to be modified (or to select the desired one in the available list of SETTINGS with ← →).
5. Press the **ENT** key. If any other setting is to be modified, inside the same group, third and fifth steps must be repeated.
6. Press **END** key.
7. The DMS will ask for confirmation of the change showing in the screen the following message:

CONFIRM **Y / N**

8. To confirm the change, press the **1/Y** key. (otherwise press **3/N** key).
9. The DMS will show then the following message:

SETTINGS CHANGE **EXECUTED**

8. Press the **CLR** repeatedly to return to the standby mode.

If during the settings modification any range limit is exceeded, the relay will not accept the change and the following message will be displayed:

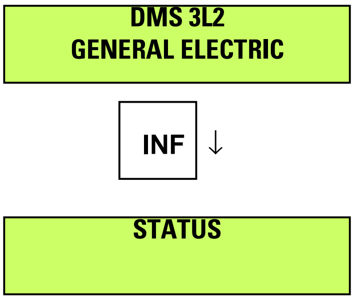
SETTINGS **OUT OF RANGE**

9.3. INFORMATION GROUP.

This group provides information related to the DMS internal status. To access to this group press the **INF** key from the main menu. The information group includes the following sub-groups:

- **Status.**

As in the settings group, to access this sub-group, you must press the **INF** key. After this action, we are in the level 1 of the menu. Once the sub-group is selected (in this case the only existing group) push the **ENT** key to see its contents, (going down to level 3). In this level, we can see the contents using the ↑ / ↓ keys. The exit of the information group is carried out pressing repeatedly the CLR key until the standby screen appears.



Status.

The DMS allows to visualize the status of various internal values. We go the status menu and press **ENT** key. Pressing the ↑ key we can move inside the status menu, obtaining the information of the following table:

TABLE 11.3. Information about the relay status

Screen	Possible values
MODEL DMS3***	According to the model
DATABASE	According to the model
PROTECTION VERSION	According to the model
CONTROL VERSION	According to the model
COMM. VERSION	According to the model
Vab Busbar 1	
Vbc Busbar 1	
Vca Busbar 1	
Vn1	
Vab Busbar 2	
Vbc Busbar 2	
Vca Busbar 2	
Vn2	
Nº OPENINGS	
PICKUP 27	YES - NO
PICKUP 64G	YES - NO
PROTECTION STATUS	IN SERVICE - OUT OF SERVICE
MODE	
ACTIVE GROUP	1: GROUP 1 2: GROUP 2 3: GROUP 3
STATUS 52 COUPLER	OPEN - CLOSE
LOCAL CONNECTION	IN SERVICE - OUT OF SERVICE
DATE AND TIME	
E2PROM COMM.	
COMMUNICATION SETTINGS	USER - DEFAULT

Screen	Possible values
PROTECTION LINK	YES - NO
CONTROL LINK	
EVENTS LEVEL 2	
DATE AND TIME	SHOW DATE AND TIME

9.4. CONTROL OPERATIONS GROUP.

This group allows to operate the circuit breaker from the keyboard, as well as to block, unblock the recloser and set the equipment time. To access this group, press the **ACT** key when the relay is in standby mode. When entering the operations menu, the first element of the menu appears and the following message is displayed:

ENTER
DATE / TIME

This indicates that the first element of the Operations menu is entering the date and time into the relay. Pressing the ↑ / ↓ keys the rest of elements of the Operations menu will appear. When the desired operation appears on the screen, press **ENT** key to select it.

In order to avoid not desired operations, the program will ask for confirmation of all of them. To confirm an operation, press the **1/Y** key and then **ENT**. To abort the operation, press **3/N** and then **ENT**. Pressing **CLR** when confirmation is requested, is equivalent to **3/N** and **ENT**, aborting the operation.

If the order is confirmed, the result of the operation will appear on the screen. Pressing **ENT** or **CLR** indistinctly the message is accepted and the screen returns to the operations menu.

As an example, this would be the procedure to open the circuit breaker starting from the operations menu:

ENTER DATE / TIME → **ENT** → **CONFIRM Y / N** → **1/Y** → **CARRIED OUT**

If the circuit breaker had not been opened, the result shown for the operation would have been "NOT CARRIED OUT"

The possible operations in the DMS are:

- Enter date/hour
- Communication Trigger
- Replacing int. maximeter

9.5. SINGLE KEY OPERATIONS.

The DMS allows a simplified way of operation, by using the **ENT** key. This mode allows to access different information about the DMS with no need to remove the external plastic cover. The operation consists of pressing repeatedly the **ENT** key. To access this mode we must start from the standby screen. The available information in this model of operation is shown in the following table, in its order of presentation.

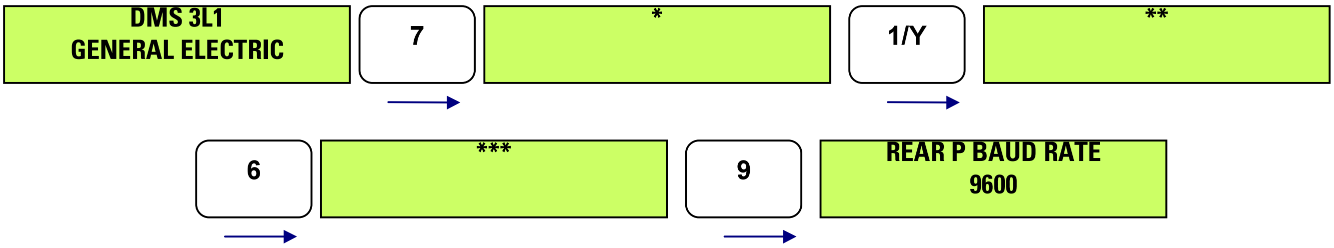
Magnitude
• Vab Busbar 1
• Vab Busbar 2
• PICKUP 27 Busbar 1
• PICKUP 64 G Busbar 1
• PICKUP 27 Busbar 2
• PICKUP 64 G Busbar 2
• PROTECTION STATUS
• ACTIVE GROUP
• STATUS 52 Coupler
• DATE AND TIME

9.6. CONFIGURATION MENU.

The DMS relay includes a configuration unit that can be accessed exclusively through the keypad. It is used to select how the relay will interact with the external environment.

The configuration unit is entered from the standby screen by entering a four digit numerical code. If the code is correct you will enter into the configuration menu, if not the relay will return to the standby screen.

The code is common to all DMS. It is not meant to be a password, but a simple measure of security to avoid accidental manipulation of the configuration. The code is **7169**, which was selected because it is the corresponding ASCII code for the initials GE. This is the way to access the configuration unit from the standby screen:



The value and meaning of the settings are as follows: (It is important to mention that to move in this group, ↑/↓ keys must be pressed).

- **REAR PORT BAUD RATE**: It is the baud rate that DMS relay uses to communicate with the remote end. The possible values for setting are between 1200 and 19,200 baud.

- **REAR PORT STOP BITS**: It is the number of bits added to each byte transmitted across the serial line. It is treated as a logical binary setting with the logical keys **1/Y** for 1, and **3/N** for 2.

- **FRONT PORT BAUD RATE**: It is the baud rate that DMS relay uses to communicate with the local end. The possible values for setting are between 1,200 and 19,200 baud.

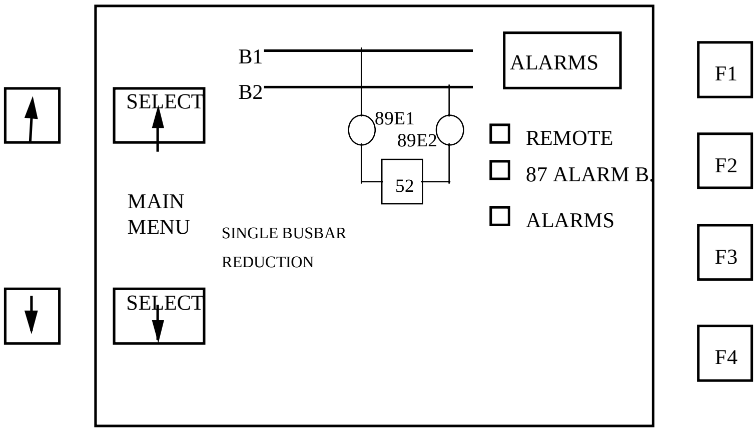
- **FRONT PORT STOP BITS**: They are the number of bits added to each byte transmitted across the serial line. It is treated as a logical binary setting with the logical keys **1/Y** for 1, and **3/N** for.

- **LOCAL SETTINGS**: Setting which enables/disables the settings change via local communication.
- **REMOTE SETTINGS**: Setting which enables/disables the settings change via remote communication.
- **LOCAL CONTROL**: Setting which enables/disables local mode control operations (computer directly connected).
- **REMOTE CONTROL**: Setting which enables/disables remote control operations (e.g. via modem).
- **UNIT NUMBER**: Each DMS is identified by a unit number which serves to identify the messages directed to it when there are several devices connected to the same communication network. This number may be between 1 and 255, both included.
- **PASSWORD**: The relay provides a password in order to prevent unauthorized personnel from communicating remotely with the relay through the use of GE_LOCAL communications software (which allows settings modifications or control operations). The password may only be viewed through the relay display and it consists of a number between 0 and 99999. The introduced password through GE_LOCAL must be identical to the relay password in order to permit the connection with it.
- **TIMEOUT t:** Maximum synchronization time in order not to produce “clock not set” alarm event

10. MIMIC OF THE POSITION

The DMS modules including protection and control functions, incorporate at the right side of the module a graphic display of 112 x 62 mm. Here it is shown a mimic of the position associated to this DMS module (circuit breakers, switch selectors and their status)

The standby mode screen is as follows:



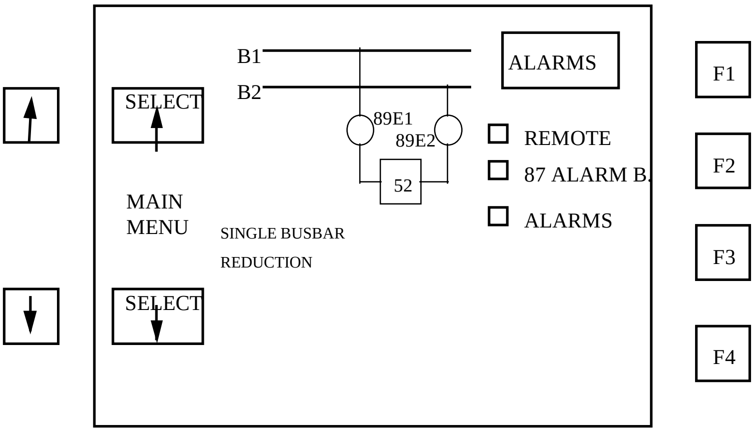
The keyboard for accessing the different screens and acting with the existing elements on a screen is situated at the left and right sides of the graphic display as follows:

- On the left side there are two keys with arrows, upward and downward. These keys are used to select the different elements in the screen.
- On the right there are several function keys F1, F2, F3, F4. Depending on the screen and on the operation we are performing, we will see on the display beside each function key, the operation it allows to perform. (e.g. In the above shown display, we find an “ALARMS” legend next to F1 key, which means that pressing this key we will move to the Alarms screen).

If after 15 minutes none of this keys is pressed, the display will be turned off automatically in order to avoid unnecessary consumption. When a key is pressed, it turns on again.

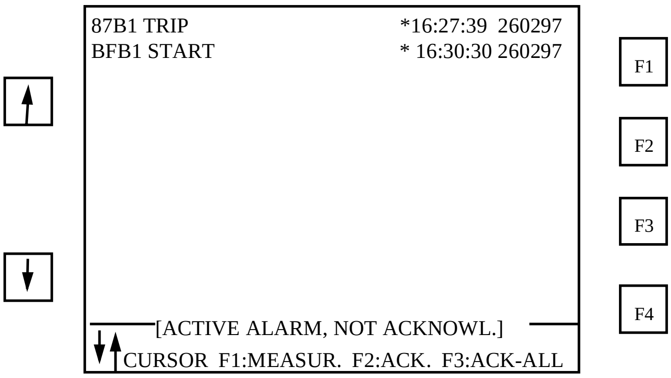
10.1. MAIN SCREEN

Here we will see the first screen or main screen that appears on the graphic display. This screen represents the mimic of the busbar or busbars with the situation of the arrangement: Single Busbar, Double Busbar operating independently, or Double Busbar in a Single Bus reduction. The representation only implies the Busbar and no the circuits connected to them.



10.2. ALARMS SCREEN

If we go from the main screen to the alarms screen pressing F1 key, as indicated on the main screen, the following picture will appear:



Here we can see a list of the alarms that have been produced in the substation. The maximum number of alarms is 12. Alarms are represented as follows:

- Alarm label, that is to say, associated text.
- Time when the alarm was produced.
- Alarm date.

When an alarm is produced, we will see on the screen the previous data with a dark blinking shadow. This blinking means that the alarm has not been “acknowledged”. For “recognizing” the alarm you must press F2 key, as indicated on the bottom of the screen. Once the alarm is acknowledged, the blinking shadow disappears, but the alarm will remain on the screen until the reason for its generation disappears.

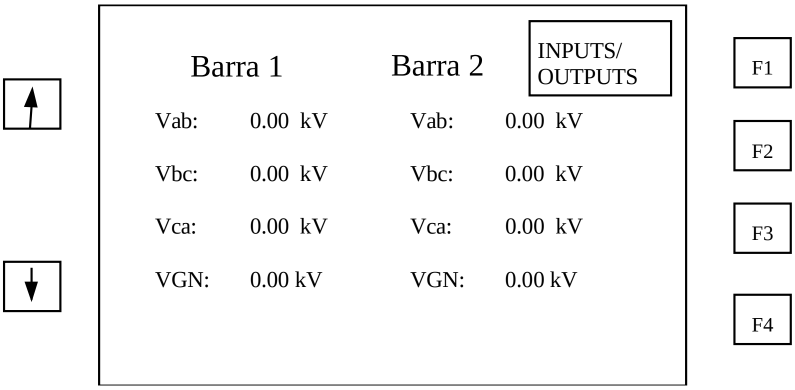
Now we can understand the text appearing at the bottom of the screen:: "ACTIVE ALARM, NOT ACKNOWLEDGED". When the alarm is acknowledged, the text changes to "ACTIVE ALARM".

The help text at the button of the screen shows the different actions to be carried out in that screen:

- The arrows are used to go from one alarm to another.
- Pressing F1 key, you will go to the measures screen.
- Pressing F2, the selected alarm is acknowledged. (When an alarm is selected, it changes color).
- Pressing F3, all the alarms are acknowledged automatically.

10.3. MEASURES SCREEN

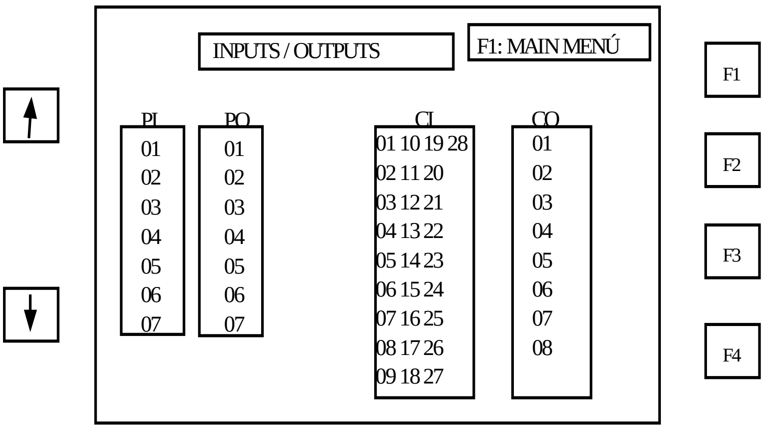
If we go from the alarms screen to the measures screen, the following screen will appear:



The presented values are those on the primary side. This screen will change according to the chosen DMS rack. e.g. the auxiliary services rack does not have any measure.

10.4. INPUTS AND OUTPUTS SCREEN

Pressing F1 key, we will go from the measures screen to the Inputs and Outputs screen. Here we can find the different inputs and outputs, that will appear separated by protection and control. The number of inputs/outputs is different depending on the DMS rack. The screen will be similar to the following:



Active inputs/outputs will appear with a dark shadow.

11. RECEIVING, HANDLING AND STORAGE

The systems are provided to the customer in a special packing unit that properly protects it during transportation, provided it is done under normal conditions.

Immediately after receiving the equipment, the customer should check if there is any evidence of the system having suffered damage during transportation. If injury or damage resulting from rough handling is evident, file a damage claim at once with the transportation company and promptly notify the factory.

Reasonable care should be exercised in unpacking the relay in order not to lose the accessories provided in the box.

If the equipment is not going to be installed immediately, it is convenient to store it in its original packing, in a place free from moisture and dust.

It is important to check that the inscription on the nameplate matches the data in the order.

11.1. ACCEPTANCE TESTS AND EQUIPMENT CALIBRATION

It is recommended, once the equipment is received, that a visual inspection and the tests given below be performed to make sure that the relay has not suffered any damage in transportation and the factory calibration has not been altered.

In the description of each test instructions for the calibration of every measuring unit are included. The units must only be readjusted if the values measured are beyond the indicated tolerance limits.

The tests described in chapter 12, can be carried out as installation or acceptance tests, depending on the criteria of the user. Since most users have different procedures for installation and acceptance tests, this section explains all the tests that can be performed on the systems.

12. ACCEPTANCE TESTS

12.1. VISUAL INSPECTION

Check that the model or models indicated in the plates match the data given in the order. Unpack the equipment and check there are no broken parts and no signs that the system has suffered any damage during transportation.

12.2. ELECTRIC TEST

General Considerations on the Power Supply Network and the Measuring Equipment

The bus protection equipments have been calibrated in the factory using a 50 and 60 Hz network with a minimum content of harmonics. In order to achieve consistent results, the tests must be carried out using a power supply network whose wave shape does not contain harmonics.

The dc. auxiliary infeed voltage used for tests must not be obtained with rectified a.c. because if this power supply is not properly smooth, it is possible the measuring units do not operate correctly due to possible voltage drops in the power source. Zener diodes, for example, may stop conducting because of power supply voltage drops. As general rule, the dc power supply must not have a ripple higher than 5%.

The ammeters and chronometers used must be calibrated and their precision must be better than that of the relay. The power supply network used in the tests must remain stable, mainly in the levels near the operation thresholds and during the whole operation time of the relay.

It is important to point out that the accuracy with which the test is performed depends on the network and on the instruments used. Functional tests performed with unsuitable power supply network and instruments are useful to check that the relay operates properly and therefore its operating characteristics are verified in an approximate manner. However, if the relay would be calibrated in these conditions, its operational characteristics would be outside the tolerance range values.

12.3. STABILIZATION RESISTORS TEST

- Check the value in ohms of the stabilization resistor for every phase.
- Adjust the resistors “correderas" to obtain the resistance value calculated for the operation, and check the value in ohms once the "correderas" bolts have been screwed.

12.4. AUXILIARY CURRENT TRANSFORMERS TEST

- Check the transformation ratio in the different taps, according to the model.
- Apply 300 Va.c. volts to the transformer secondary, with the primary opened and check that the current consumption ranges between 30 and 60 milliamperes.

12.5. PREVIOUS CHECK

According to drawing 226B6429H44 check out the following connections between cabinets:

1. Connect A and B and N terminal of each cabinet to their corresponding A and B and N terminal of the rest of the cabinet.(A1 to A1, B1 to B1, N1 to N1, A2 to A2...).
2. Connect X1 terminal of cabinet 1 to Y1 terminal of cabinet 2,
3. Connect X2 terminal of cabinet 1 to Y2 terminal of cabinet 2.
4. Connect X3 terminal of cabinet 1 to Y3 terminal of cabinet 2.
5. Connect X4 terminal of cabinet 1 to Y4 terminal of cabinet 2.
6. Connect X5 terminal of cabinet 1 to Y7 terminal of cabinet 2.
7. Connect X6 terminal of cabinet 1 to Y8 terminal of cabinet 2.
8. Connect X7 terminal of cabinet 1 to Y11 terminal of cabinet 2.
9. Connect X8 terminal of cabinet 1 to Y12 terminal of cabinet 2.
10. Connect X9 terminal of cabinet 1 to Y15 terminal of cabinet 2.
11. Connect X10 terminal of cabinet 1 to Y16 terminal of cabinet 2.
12. Connect X34 terminal of cabinet 1 to Y19 terminal of cabinet 2.
13. Connect X161 terminal of cabinet 1 to Y20 terminal of cabinet 2.
14. Connect X162 terminal of cabinet 1 to Y21 terminal of cabinet 2.
15. Connect X163 terminal of cabinet 1 to Y22 terminal of cabinet 2.
16. Connect X164 terminal of cabinet 1 to Y23 terminal of cabinet 2

Feed the equipment by connecting the positive of a dc voltage source to X1 borne, and the negative to X2 borne.

Make sure that there is also dc voltage in X5 (+), X6(-), in Y5(+), Y6(-), all the signaling LEDs on the differential (DDF) and alarm (DAL) boards are lit up after pressing the reset button.

Press also the reset buttons of the breaker failure boards (SFI) making sure that the breaker failure LED lights up, in all positions.

12.6. DIFFERENTIAL UNIT CHECK

12.6.1. Bus A

Set the latching relay corresponding to Bus A, in the line 7 (89AX/P7) to the ON position, that is, applied positive to P7- 15 and make a jump between P7-11 & P7-12.

Set the block latching relay corresponding to this differential to the ON position (3B/87A), check that X33-X34 is opened. The green light corresponding to bus A in the test box will be on. If not so, switch it on by pressing the green button.

Make a jumper between stabilization resistors and shorten U1 with U2.

12.6.1.1.Main Unit

Set the following adjustments in the differential boards:

-Slope: 0,5 (bridge on the left side of the board)

-Supervision: 0,2 (bridge on the right side of the board)

Apply current through terminals 23 and 26 of the position for phase 1, through 24 and 26 for phase 2, through 25 and 26 for phase 3 and check that in all 3 instances, the corresponding main units operate according to the following table:

SLOPE	PICKUP CURRENT
0.5	0.190 - 0.210
0.6	0.237 - 0.263
0.7	0.313 - 0.347
0.8	0.475 - 0.525

Also check that contact 1, 2 of the position closes. (if the alarm operates, the contact will open)

Each time the differential unit operates the following contacts will close: X29-X30, X31-X32, and alarm will appear in the display of the DMS module. These contacts will remind close until the reset button (place in cabinet 1 front panel) is pushed.

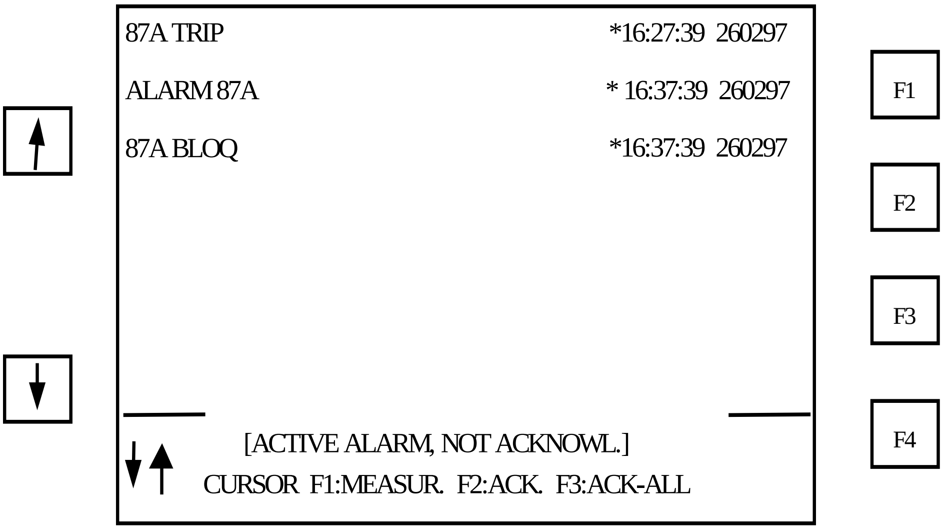


Figure 12.1 *Screen of alarms on the DMS "A".*

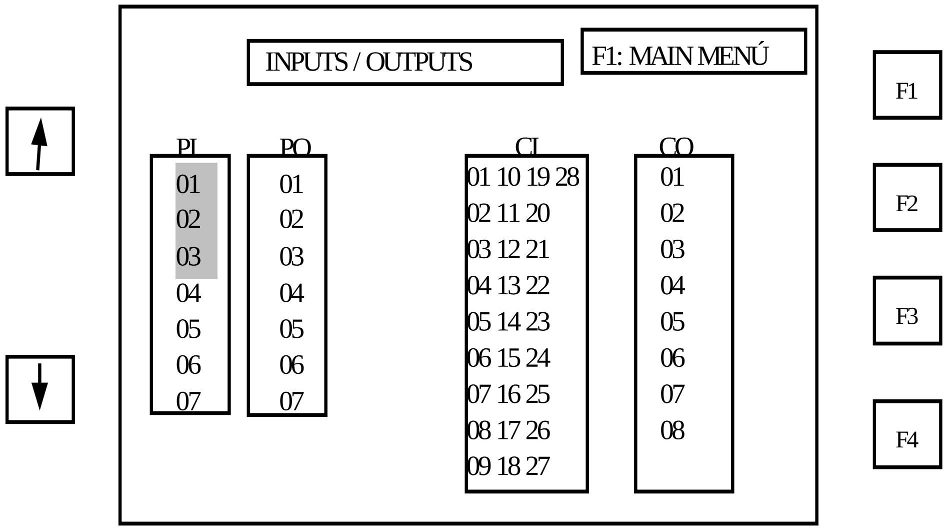


***Figure 12.2** Screen of Digital Inputs and Outputs Status on the DMS "A".*

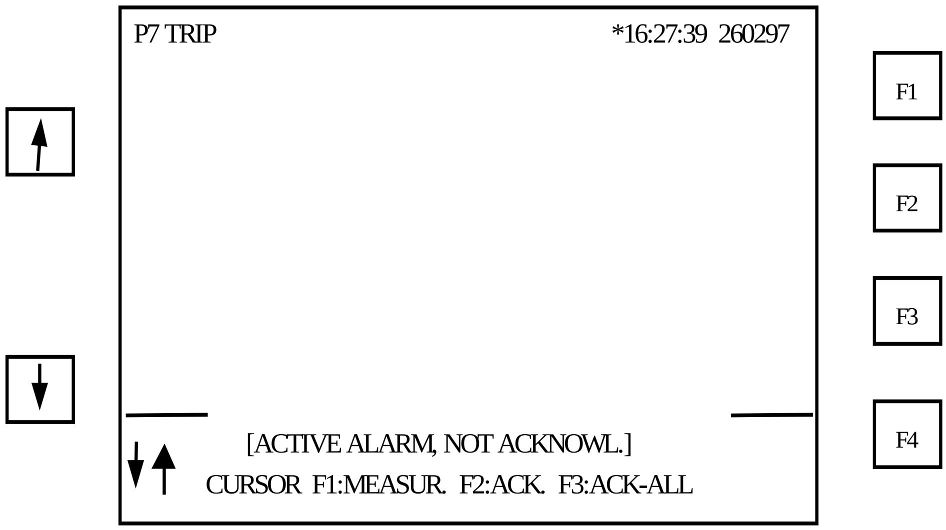


***Figure 12.3** Screen of alarms on the DMS "B".*

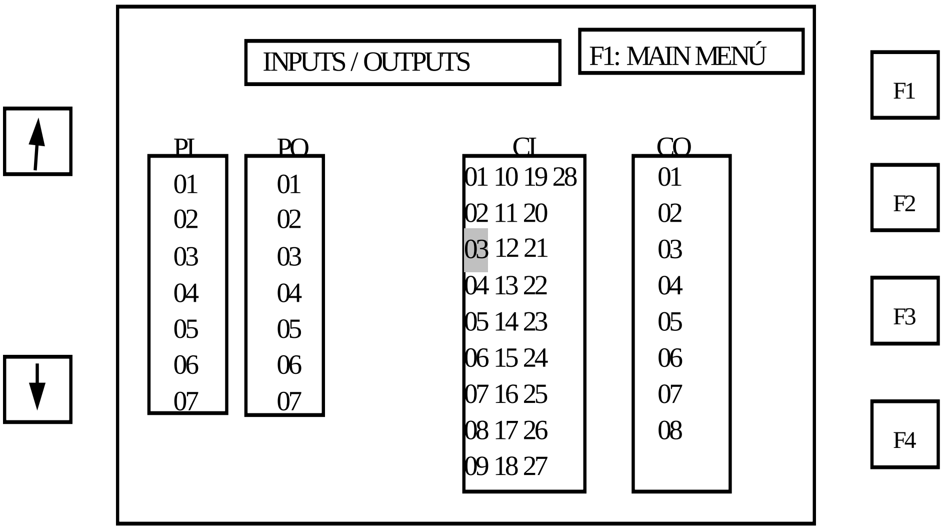


Figure 12.4 *Screen of Digital Inputs and Outputs Status on the DMS "B".*

NOTE: Should the alarm go off as a result from the current having been applied for over 10 s, the differential will be blocked and the corresponding red light in the test box will light up, and a message will show up on the alarm's screen. In such event, to proceed with the test, the differential should be reset by pressing the corresponding green button, and acknowledge the alarm to clear up the screen of the alarms.

12.6.1.2.Supervision Units

Set the following adjustments in the differential boards:

-Slope: 0,5 (bridge on the left side of the board)

-Supervision: 0,2 (bridge on the right side of the board)

Apply current through terminals 23 and 26 of the position for phase 1, through 24 and 26 for phase 2, through 25 and 26 for phase 3 and check that in all 3 instances, the corresponding supervision units operate according to the following table:

ADJUSTM. VALUE	PICKUP VALUE
0.2	0.190-0.210
0.3	0.285-0.315
0.5	0.475-0.525
0.8	0.760-0.840
1.0	0.950-1.050
1.5	1.425-1.575
2	1.900-2.100

Also check that contact 1, 2 of the position closes. (if the alarm operates, the contact will open)

Each time the differential unit operates the following contacts will close: X29-X30, X31-X32, and alarm will appear in the display of the DMS module. These contacts will remind close until the reset bottom (place in cabinet 1 front panel) is pushed.

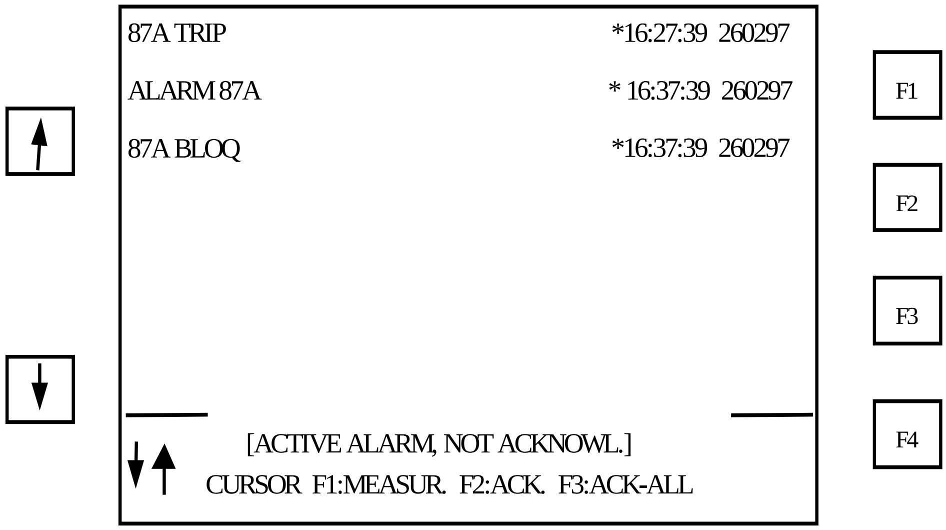


Figure 12.5 *Screen of alarms on DMS "A".*

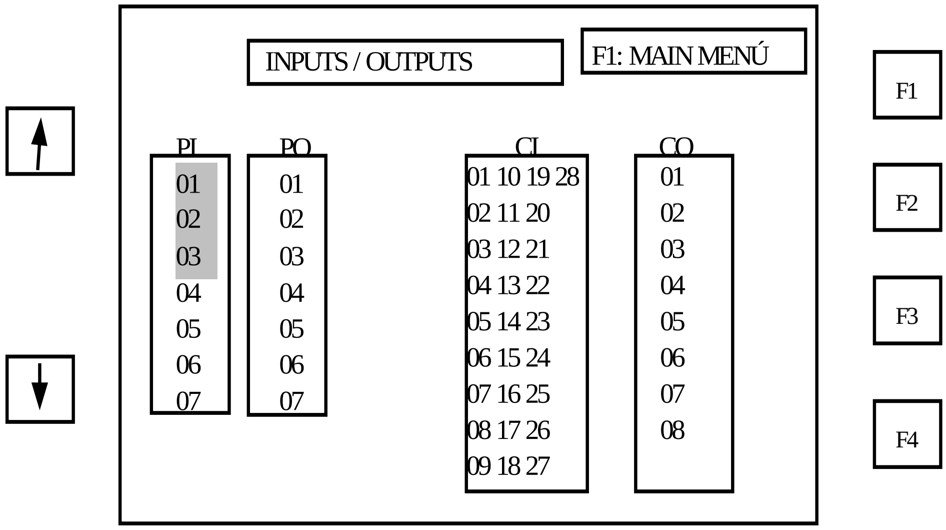


Figure 12.6 *Screen of Digital Inputs and Outputs Status on DMS "A".*

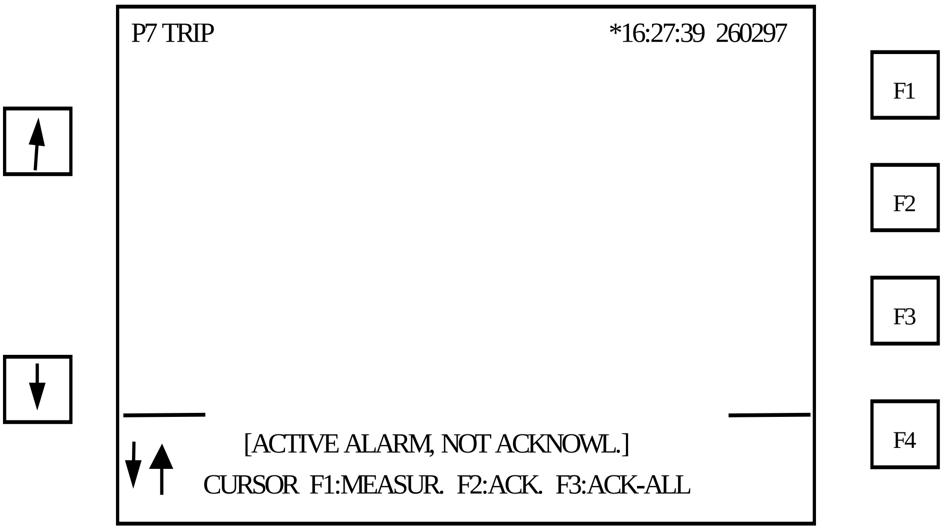


Figure 12.7 *Screen of alarms on the DMS "B".*

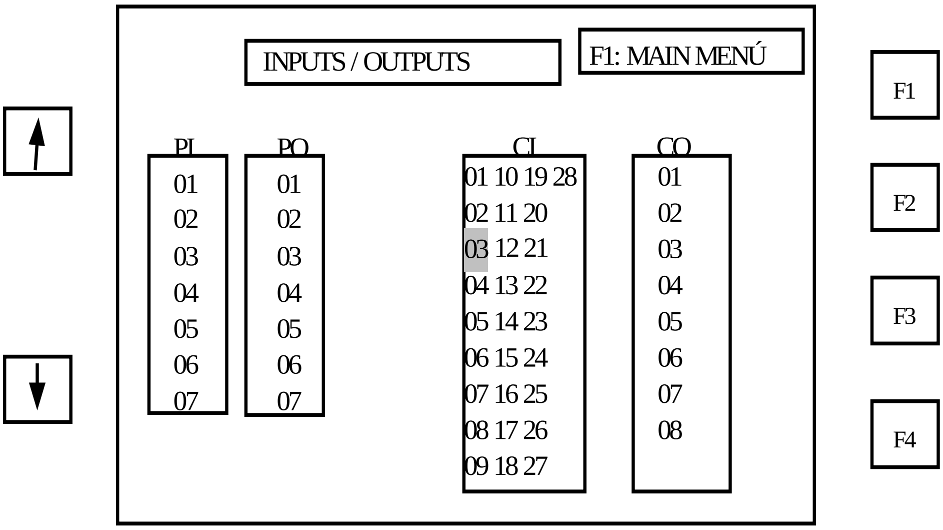


Figure 12.8 *Screen of Digital Inputs and Outputs Status on DMS "B".*

NOTE: Should the alarm go off as a result from the current having been applied for over 10 s, the differential will be blocked and the corresponding red light in the test box will light up, and a message will show up on the alarm's screen. In such event, to proceed with the test, the differential should be reset by pressing the corresponding green button, and acknowledge the alarm to clear up the screen of the alarms.

Undo the bridges of the stabilization resistors and, applying current through the previous terminals. Check that both the alarms of the three phases operate with 28 mA (range: 27- 29mA) and that the red light of differential A goes off while the red light lights up.

Check as well that X35-X36 contact is closed and that there is no alarm on the DMS' display

Bear in mind that every time the alarm operates, the differential must be reset by pressing the corresponding green button.

Set the following adjustments in the differential boards of bus A:

-Slope: 0.8 (bridge on the left side of the board)

-Supervision: 1 (bridge on the right side of the board)

Remove jumpers from U1-U2, and P7-11 & P7-12.

12.6.2. Bus B

Set the latching relay corresponding to Bus B, he line 7 (89B/P7) to the ON position, that is, make a jumper between P7-11 & P7-14.

Set the BUSY/AB latching relay to the ON position, contact X45-X46 is closed. It will appear a message on the display of the DMS module. Apply positive to P7-13 and these contacts will open.

Set the block latching relay corresponding to this differential to the ON position (3B/87B), check that X41-X42 is opened. The green light corresponding to bus B in the test box should be lit up. If not so, light it up by pressing the green button.

Shorten the stabilization resistors and shorten U3 with U4.

12.6.2.1.Main Unit

Set the following adjustments in the differential boards:

-Slope: 0.5 (bridge on the left side of the board)

-Supervision: 0.2 (bridge on the right side of the board)

Apply current through terminals 23 and 26 of the position for phase 1; through 24 and 26 for phase 2; through 25 and 26 for phase 3 and check that in all three instances, the corresponding main units operate according to the following table:

SLOPE	PICKUP CURRENT
0.5	0.190 - 0.210
0.6	0.237 - 0.263
0.7	0.313 - 0.347
0.8	0.475 - 0.525

Check as well that contacts 1 and 2 of the position close. (if the alarm operates, the contact opens).

Each time the differential unit operates the following contacts will close: X37-X38, X39-X40, and alarm will appear in the display of the DMS module. These contacts will remind close until the reset bottom (place in cabinet 1 front panel) is pushed.

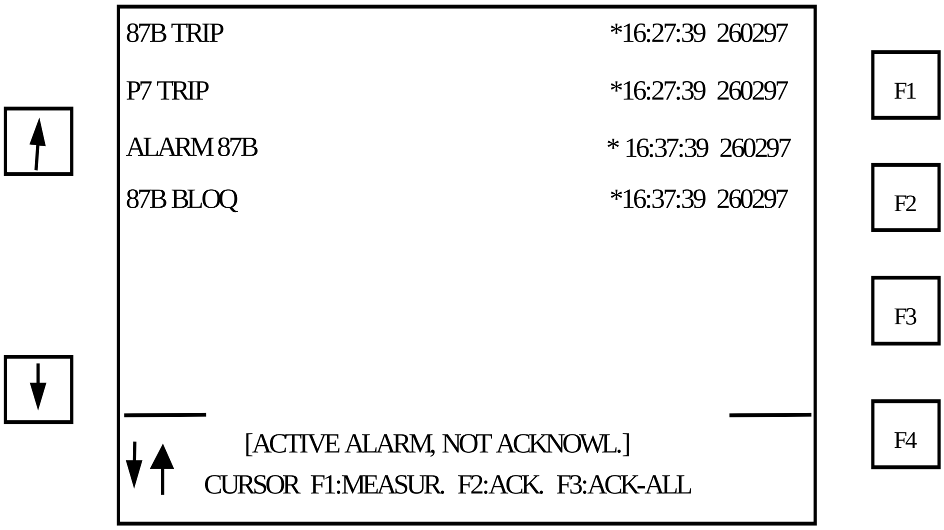


Figure 12.9 *Screen of alarms on the DMS "B".*

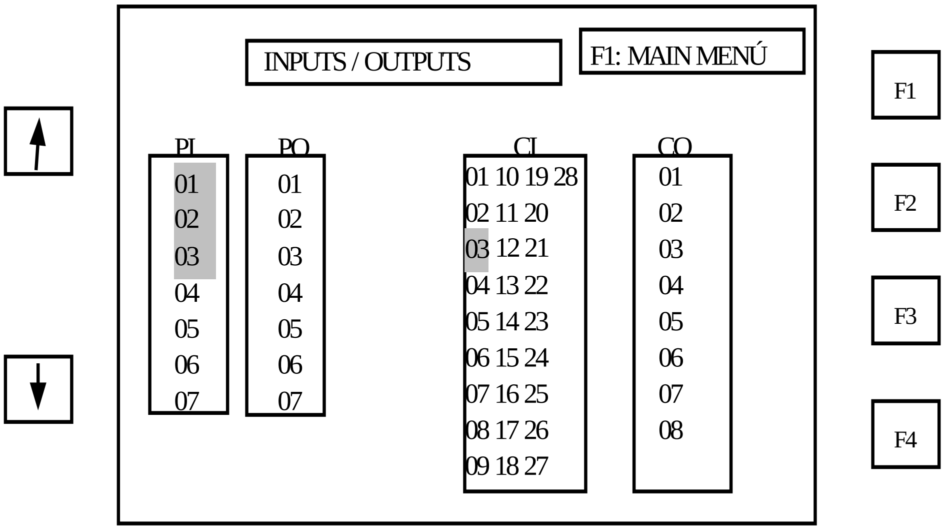


Figure 12.10 *Screen of Digital Inputs and Outputs Status on DMS "B".*

NOTE: Should the alarm go off as a result from the current having been applied for over 10 s, the differential will be blocked and the corresponding red light in the test box will light up, and a message will show up on the alarm's screen. In such event, to proceed with the test, the differential should be reset by pressing the corresponding green button, and acknowledge the alarm to clear up the screen of the alarms.

12.6.2.2.Supervision Units

Set the following adjustments in the differential boards:

-Slope: 0,5 (bridge on the left side of the board)

-Supervision: 0,2 (bridge on the right side of the board)

Apply current through terminals 23 and 26 of the position for phase 1, through 24 and 26 for phase 2, through 25 and 26 for phase 3 and check that in all 3 instances, the corresponding supervision units operate according to the following table:

ADJUSTM. VALUE	PICKUP VALUE
0.2	0.190-0.210
0.3	0.285-0.315
0.5	0.475-0.525
0.8	0.760-0.840
1.0	0.950-1.050
1.5	1.425-1.575
2	1.900-2.100

Also check that contact 1, 2 of the position closes. (if the alarm operates, the contact will open)

Each time the differential unit operates the following contacts will close: X37-X38, X39-X40, and alarm will appear in the display of the DMS module. These contacts will remind close until the reset bottom (place in cabinet 1 front panel) is pushed.

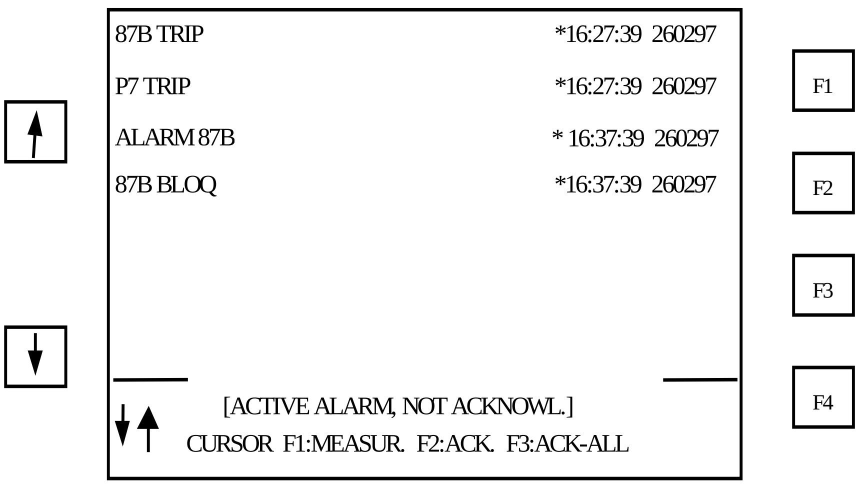


Figure 12.11 *Screen of alarms on the DMS “B”.*

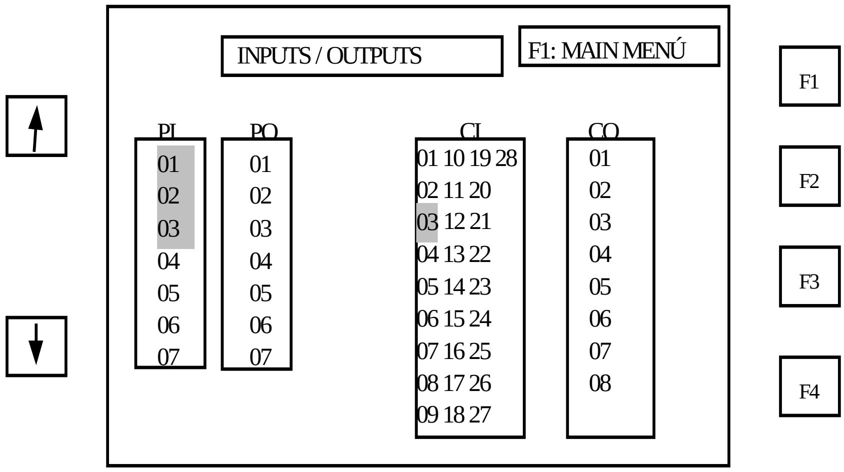


Figure 12.12 *Screen of Digital Inputs and Outputs Status on DMS "B".*

NOTE: Should the alarm go off as a result from the current having been applied for over 10 s, the differential will be blocked and the corresponding red light in the test box will light up, and a message will show up on the alarm's screen. In such event, to proceed with the test, the differential should be reset by pressing the corresponding green button, and acknowledge the alarm to clear up the screen of the alarms.

Undo the bridges of the stabilization resistors and applying current through the above terminals check that the alarms in all 3 phases operate with 28 mA (range: 27- 29mA); that the operation time is 10 s.(9.5, 10.5) and that the green target of the differential B goes off as the red target lights up.

Check as well that contact X43-X44 closes taking into account that every time the alarm operates the differential must be reset by pressing the corresponding green button.

Set the following adjustments to the differential boards of bus B:

Slope: 0.8 (bridge on the left side of the board)

Supervision: 1 (bridge on the right side of the board)

Remove jumpers from U3 and U4 , P7-11 and P7-14. Apply positive to P7-15.

12.7. DIFFERENTIAL TRIPPING OUTPUT CONTACTS TEST

This test has to be repeated for all positions and both bus bar.

Check that the contacts (see table 3: Differential output contacts and see table 4: lock out contacts) are open.

Connect the latching corresponding to bus bar A of the feeder being, simulating this situation in terminal blocks applying dc (+) to the corresponding terminal tested, see table 2: Bar connection & disconnection). Check that the lock out contact is closed (see table 4: lock out contacts).

Connect the corresponding bus bar differential. Put the corresponding jumper between terminals U1-U2 for Bar A and U3-U4 for Bar B. Apply 1,2 Amp to terminals (see table 1: Input current)

Check that when the differential trips, contacts (see table 3: Differential output contacts) are closed and the lock out contact is open (see table 4: lock out contacts).

NOTE: When the alarm starts, it will disconnect the tripping contacts but the lock out contacts will remind closed until the are reset (see drawing 226B6429H28):

- Pushing the button located in the BPP module (see cabinet front view 226B6430F15)
- Using the DMS contact, which can be activated applying +P to X73. (see drawing 226B6429F38)
- Using an external contact connected between X23-X24.

Check that when the blocking differential A, using its blocking unit (pushing the OFF button of the test block), and applying the previous current, the above mentioned contacts do not close.

Disconnect the latching corresponding to bus bar A, and connect the latching of bus bar B (this can be simulated in terminal blocks applying dc (+) to the corresponding terminals, see table 2: Bar connection and disconnection), and repeat the process.

Repeat the same procedure for phase 2 and for phase 3 (see table 1: Input current).

Repeat the same procedure for bus bar B, for each phase.

TABLE 1: input current for all positions

Phase A	Phase B	Phase C
23-26	24-26	25-26

TABLE 2: Bar connection and disconnection for all positions

BAR A		BAR B	
ON	OFF	ON	OFF
12	13	14	15

TABLE 3: DIFFERENTIAL TRIPPING OUTPUT CONTACTS

CONTACTS
1-2,3-4

TABLE 4: LOCK OUT CONTACTS

CONTACTS
5-6

12.8. BREAKER FAILURE AND 50 UNITS TEST

This test should be done for each one of the positions and both bus bar.

Check that the stabilization resistors are shortened.

Set the adjustment 50 of the position to 100% and BF to 0.9 A and the time of B.F. to 0.4 s, that is first step 100ms (all switches on SFI module should be on the left), second step 300ms (switches on DTE module, common for all positions).

Set up the latching relay of bus A (89AX/P) to the ON position (see table 2: Bar connection & disconnection) that of bus B (89BX/P) in the OFF position (see table 2: Bar connection & disconnection), put a jumper between terminals (see table 6: Compound blocking contacts), initiate the breaker failure protection by applying +P to the terminal (see table 4: Breaker failure initiation) of this position and apply 0.9 A of current through the corresponding terminals of this position (see table 1: Input current) and checking that:

- the differential does not trip;
- the 50 trips with 0.9 A;
- the B.F. trips with 0.9 A and at 0.4 s;
- When testing bar A check that there is voltage in X5 (+P) after 100ms (first step) and in X9 after 300ms (second step).
- When testing bar B check that there is voltage in X6 (+P) after 100ms (first step) and in X10 after 300ms (second step).
- Both leds are red;
- Contacts X25-X26 and X27-X28 are closed for Bar A and contacts X37-X38 and X39-X40 are closed for Bar B.
- the restraint measured in the corresponding terminal of the differential module is 0.9;
- contacts (see table 3: breaker failure tripping output contacts) of the position are closed;

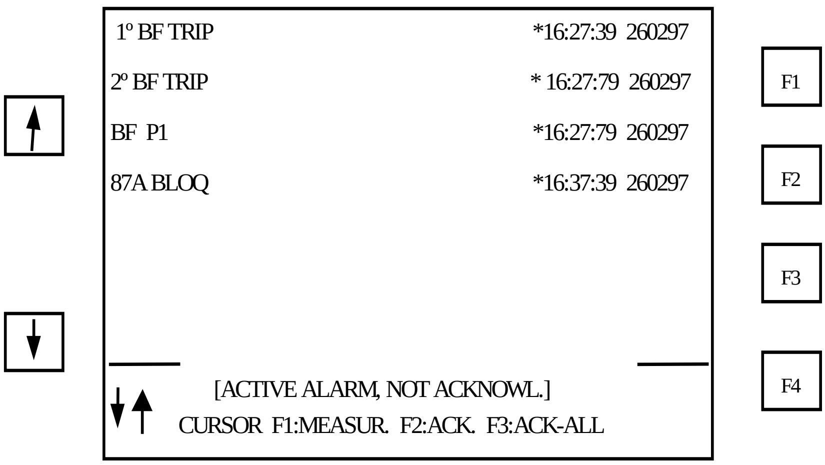


Figure 12.13 *Screen of alarms on the DMS “A” for position 1 on Bar A.*

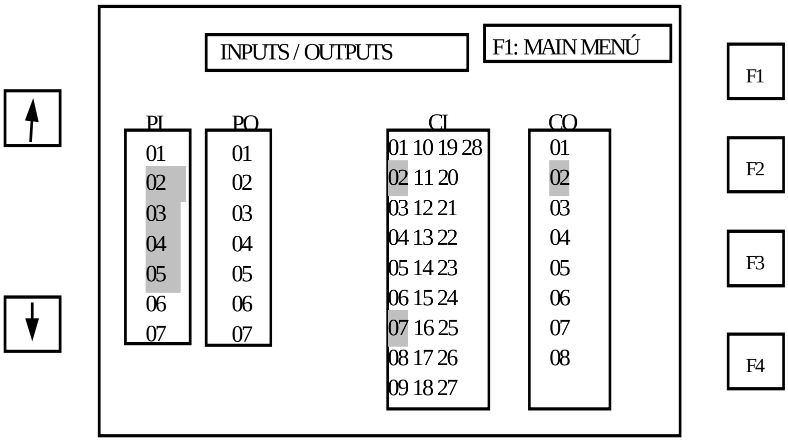


Figure 12.14 *Screen of Digital Inputs and Outputs Status on DMS "A" for position 1 on Bar A.*

Apply the same current through phase 2 (see table 1) and phase 3 (see phase 1).

Disconnect the latching relay of bus A (89AX/P) of the position tested, applying +P to terminal (see table 2: Bar connection & disconnection) of the position. Connect the latching relay of bus B (89BX/P) to the position, applying positive +P to terminal (see table 2: Bar connection & disconnection) of the position.

Set the line latching relays of the next position and repeat the whole process for every position. Repeat the above steps for bar B.

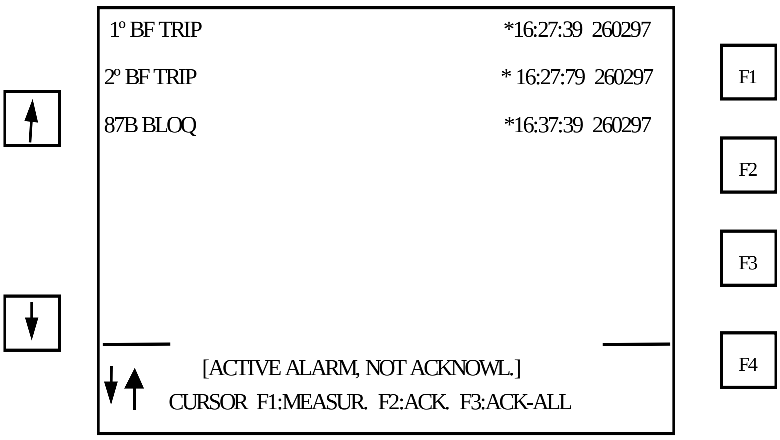


Figure 12.15 *Screen of alarms on the DMS "B" for position 1 on Bar B.*

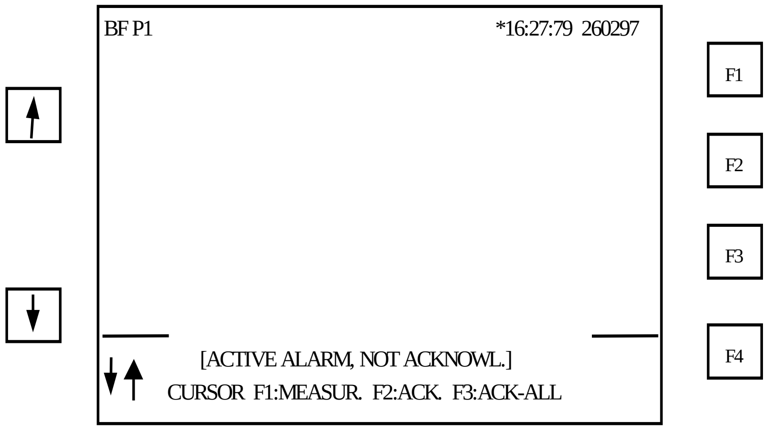


Figure 12.16 *Screen of alarms on the DMS "A" for position 1 on Bar B.*

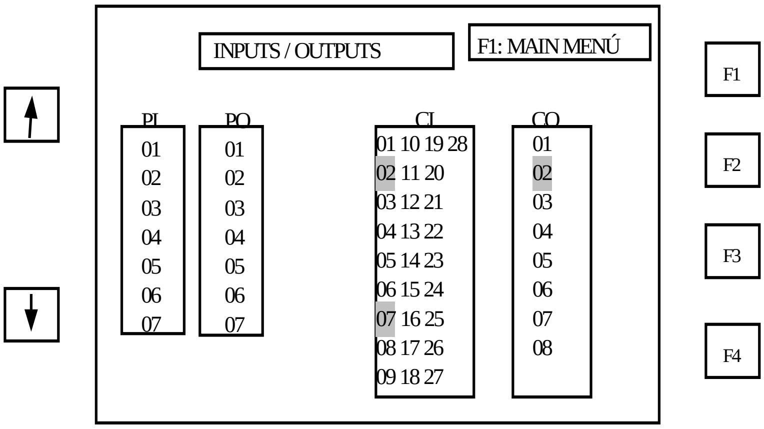


Figure 12.17 *Screen of Digital Inputs and Outputs Status on DMS "A" for position 1 on Bar B.*

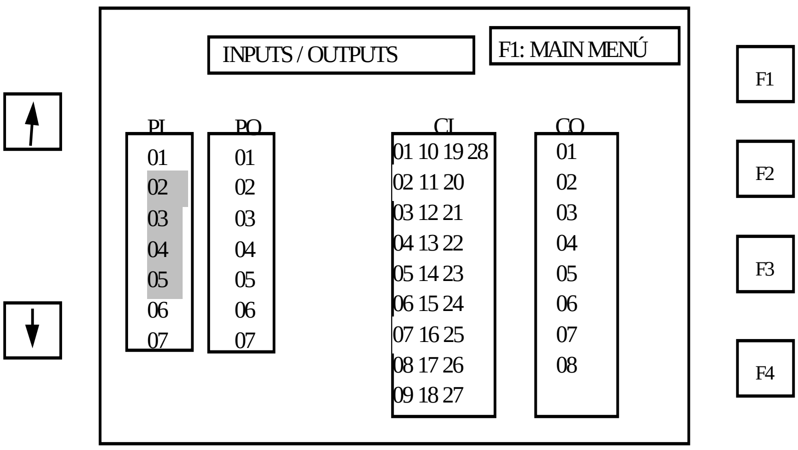


Figure 12.18 *Screen of Digital Inputs and Outputs Status on DMS "A" for position 1 on Bar B.*

TABLE 1: INPUT CURRENT FOR ALL POSITIONS

Phase A	Phase B	Phase C
23-26	24-26	25-26

TABLE 2: BAR CONNECTION & DISCONNECTION FOR ALL POSITIONS

BAR A		BAR B	
ON	OFF	ON	OFF
12	13	14	15

TABLE 3: BREAKER FAILURE TRIPPING OUTPUT CONTACTS

1st Step	2nd Step
9-10	1-2, 3-4

TABLE 4: BREAKER FAILURE INITIATION

Phase A	Phase B	Phase C	3 Phase
17	18	19	20

12.9. COUPLING DEVICE TEST

Set the three latching relays 52 EB/CS to the OFF position and connect them, applying +EB to terminal EB11, make sure that -EB is applied to terminal EB-13.

12.9.1. Bus A

Set the adjustment 50 of the coupling to 0.9 and set the time to 0.4 s that is:

1.- First step: 100 ms (SFI module).
2.- Second step: 300 ms (DTE module).

Remove the positive from EB11 to EB10. Apply current through EB23 and EB26, checking that:

- the differential does not trip.
- the 50 trips with 0.9 A.
- the restraint measured in the corresponding lead of the differential A is between 0.77-0.85.
- contacts EB1-EB, EB3-EB4, EB 9-EB10 and X25-X26, X27-X28 are closed.

Apply the same current through terminals EB24, EB26, checking as above (phase 2).

The same applies to terminals EB25, EB26 (phase 3).

12.9.2. Bus B

Successively, apply current (0.9 A) through EB27, EB30 (phase l), EB28, EB30 (phase 2), EB29, EB30 (phase 3) and check that in all three cases, the restraint measured in the corresponding terminal of the restraint module of differential B is between 0.77 and 0.85.

Check that the differential and the 50 + B.F. do not operate, making sure that contacts from EB1-EB2 EB3-EB4 EB 9-EB10 and X25-X26, X27-X2 are open.

Set the timer of the coupling to the maximum. Apply a jumper from the positive to terminal EB10. Apply 1.2 A through terminals EB27 and EB30, checking that:

- contact EB1, EB2 closes as soon as the differential trips and opens again after about 1 s.
- the three latching relays 52EB/CS are now in the reset position.
- the current is still closed by the above latching relays.

12.10. SWITCHING DEVICE TEST

Check that the stabilization resistance are shorten.

Set up the following adjustments to all the differential boards:

Slope: 0.8

Supervision: 0.5

Connect position 7 to bus B applying +P to terminals (see table 2: Bar connection & disconnection). The rest of the line latching relays must be in STANDBY position (0). If not so, apply positive to terminals (see table 2: Bar connection & disconnection), corresponding to the positions where there is a latching relay connected (1).

Apply 1 A through terminals (see table 1: Input current, phase A). Trip phase 1 of differential B.

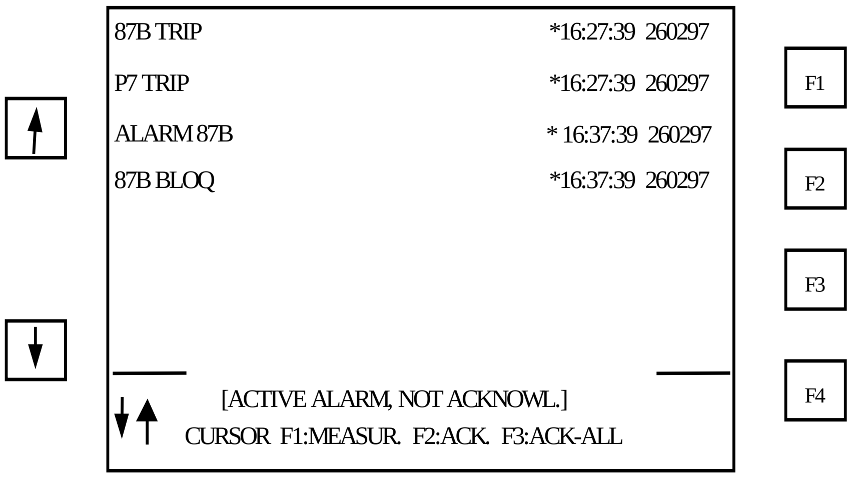


Figure 12.19 *Screen of alarms on the DMS "B".*

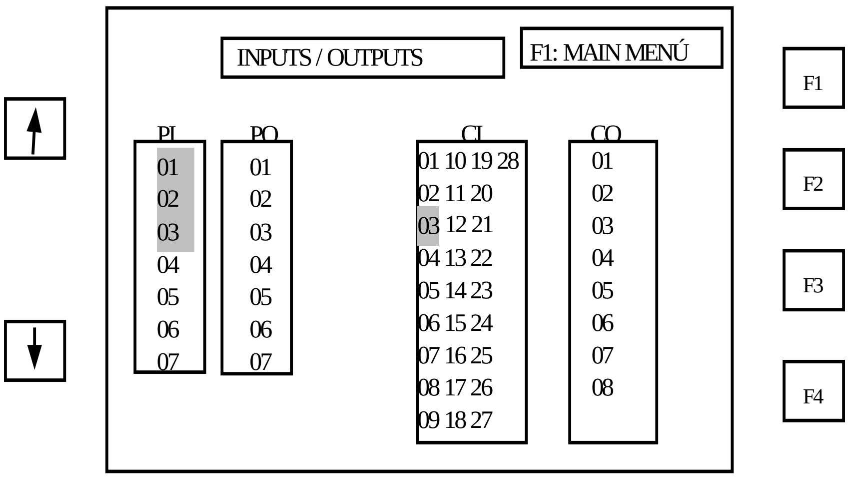


Figure 12.20 *Screen of Digital Inputs and Outputs Status on DMS "B".*

Apply Vdc between X11 (positive) and X12 (negative). In that moment, the three latching relays BUS/AB will operate (they go to 1); differential A trips, while differential B stops tripping.

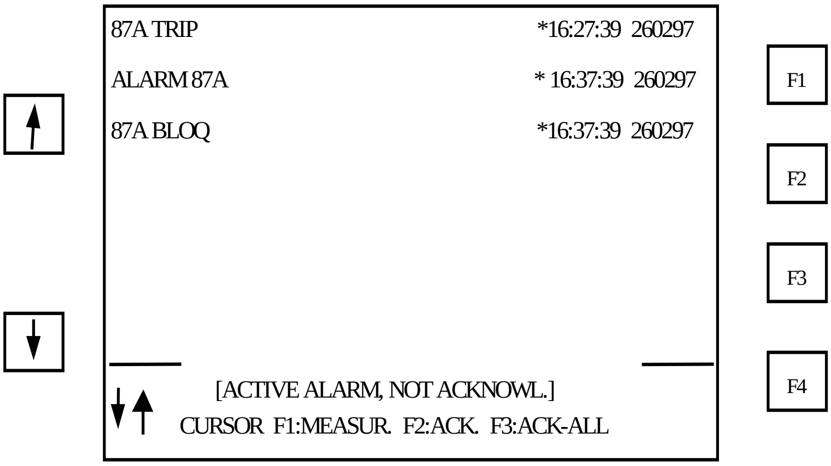


Figure 12.21 *Screen of alarms on the DMS "A".*

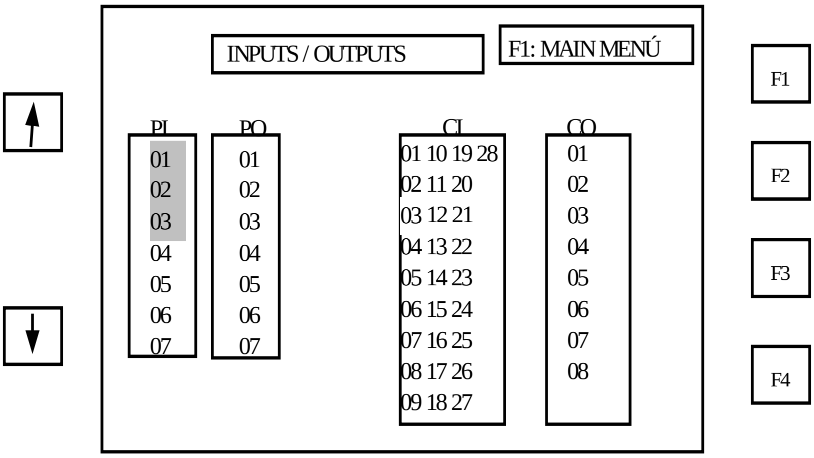


Figure 12.22 *Screen of Digital Inputs and Outputs Status on DMS "A".*

Acknowledge the alarms and some alarms will disappear from the screen of the DMS "B". Connect bus B pushing the green button on the test rack, and reset the DAL module and the DDF module of the phase under test.

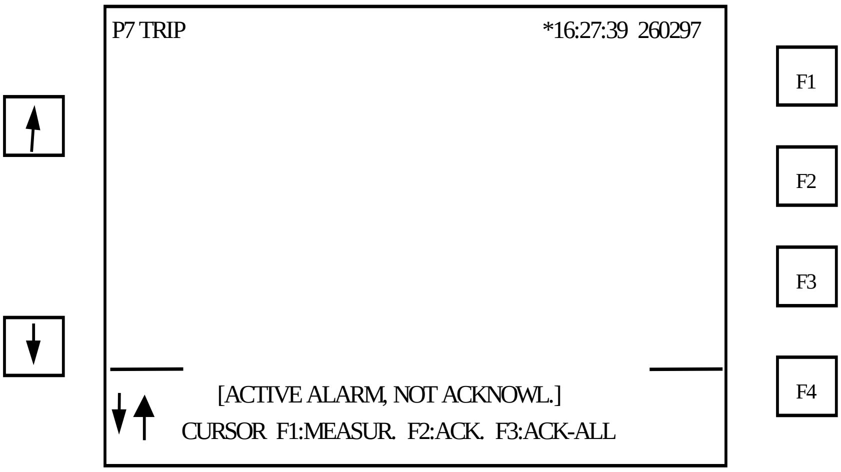


Figure 12.23 *Screen of alarms on the DMS "B".*

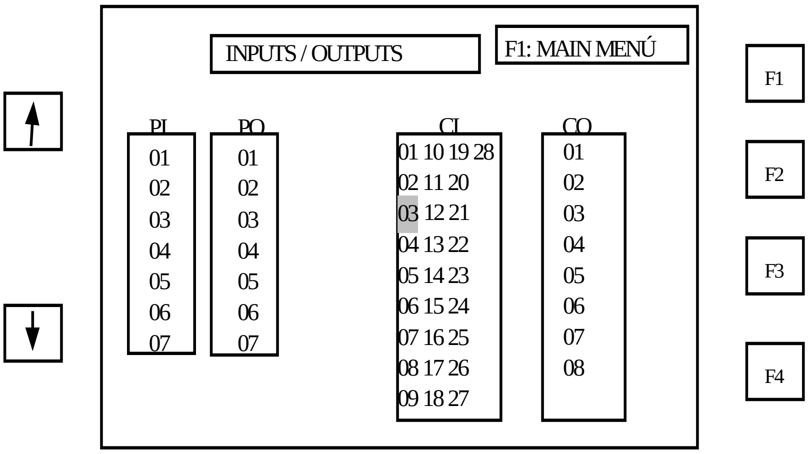


Figure 12.24 *Screen of Digital Inputs and Outputs Status on DMS "B".*

In such conditions, check by measuring in the leads of the differential module corresponding to bus A (phase 1) that the restraint is 0.9 Vdc and the differential is 0.9 Vdc. Bus B (phase 1) restraint and differential corresponding measures will be 0.

Disconnect direct current in terminals X11 (+) and X12 (-). In that moment, the three latching relays BUS/AB will operate (they go to O); differential B trips while differential A stops tripping.
In such conditions, check by measuring in the leads of the differential module corresponding to bus B (phase A) That the restraint is 0.9 Vdc and the differential is 0.9 Vdc. Bus A (phase A) restraint and differential corresponding measures will be 0.

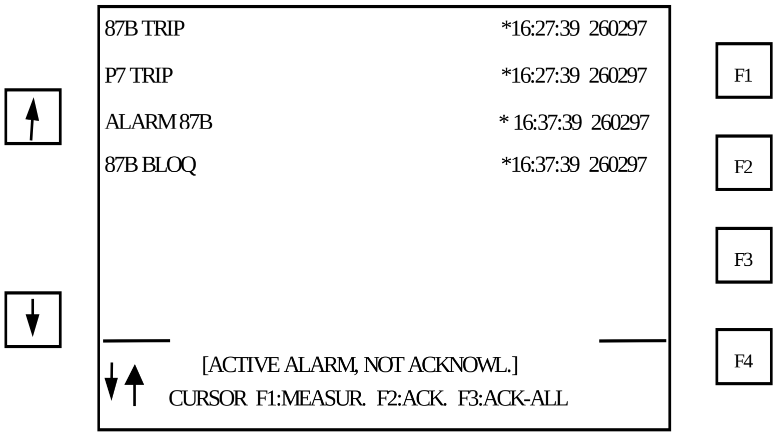


Figure 12.25 *Screen of alarms on the DMS "B".*

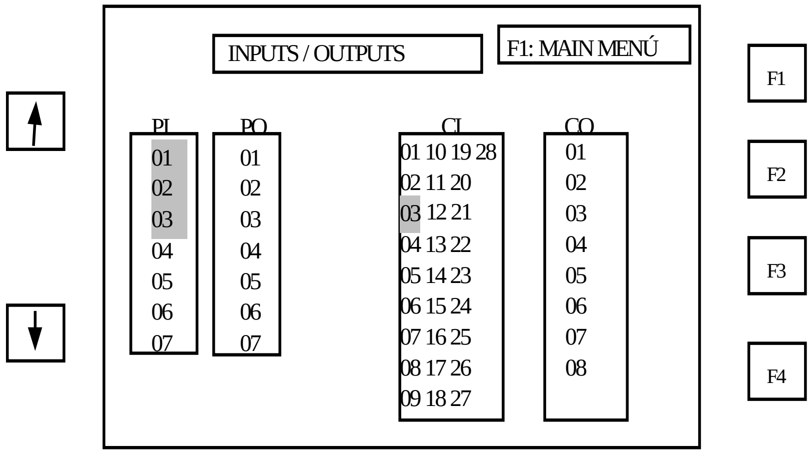


Figure 12.26 *Screen of Digital Inputs and Outputs Status on DMS "B".*

Acknowledge the alarms and some alarms will disappear from the screen of the DMS "A". Connect bus A pushing the green button on the test rack, and reset the DAL module and the DDF module of the phase under test.

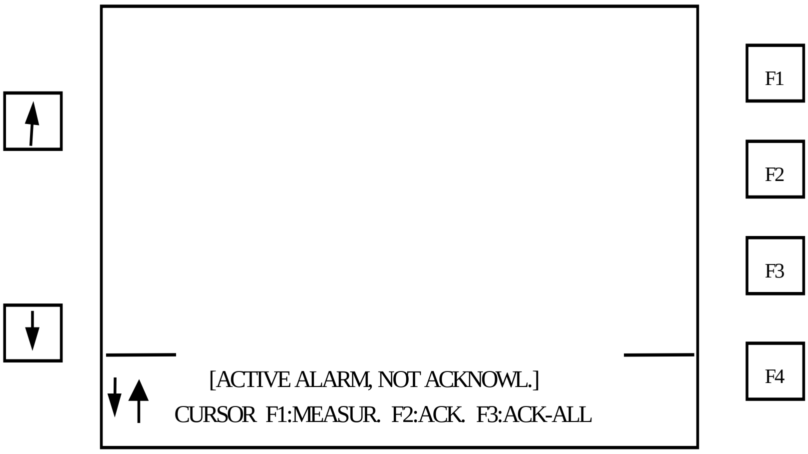


Figure 12.27 *Screen of alarms on the DMS "A".*

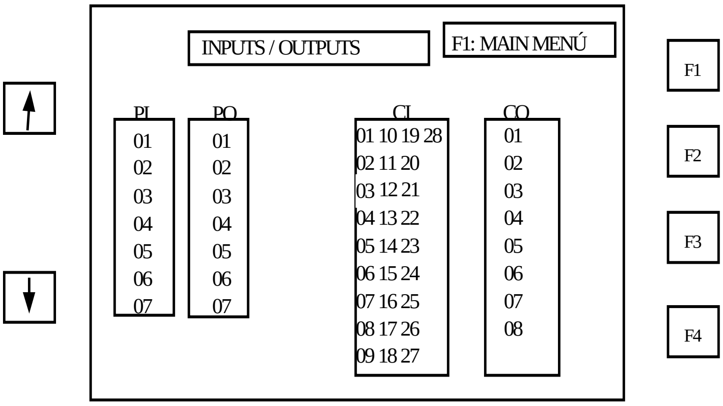


Figure 12.28 *Screen of Digital Inputs and Outputs Status on DMS "A".*

Remove the current applied to terminals (see table 1: Input current, phase A), applying it now, through terminals (see table 1: Input current, phase B). Repeat the same steps, taking into account that the one under test is phase B now.

Remove the current applied to terminals (see table 1: Input current, phase B), applying it now through terminals (see table 1: Input current, phase C). Repeat the same steps, taking into account that the one under test is phase C now.

Remove current and DC from X11 (+), X12 (-), when these terminals had it applied.

Connect the corresponding latching relay of bus A to the position 7, applying positive to terminal (see table 2: Bar connection & disconnection) (1). In that moment, having the bus B latching relay connected (1), the three BUS/AB latching relays will operate (they go to 1).

Disconnect bus A latching relay of position 7, applying positive to terminal (see table 2: Bar connection & disconnection). In that moment, the BUS/AB latching relays will operate again (they go to 0).

Remove the jumpers from the stabilization resistors.

12.11. TEST ELEMENT TEST

12.11.1.Ac and Switches Circuit

Set the AL-DIF switch to position DIF; the TAKES switch (I, II, III) to position II; and switch 01,02,03 to position 01.

Press the TEST button and check that the phase 1, corresponding to the pressed button, trips.

Set switch 01,02,03 to position 03. Press the TEST button and check that the phase 3, corresponding to the button pressed, trips.

Set switch AL-DIF to position DIF; the TAP switch (I, II, III) to position III and proceed with the same check , as above.

NOTE: to test position l of the switch, slope and supervision adjustments must be lowered.

Set AL-DIF switch to position AL; TAP switch (I, II, III) to any position; and 01,02,03 switch to position 01.

Press the TEST button and check that after 10 s., the alarm in phase 1, as well as the alarm corresponding to the button pressed, go off.

Set 01,02,03 switch to position 02. Press the TEST button and check that after 10 s., the phase 2 alarm of the differential corresponding to the button pressed, goes off.

Set 01,02,03 switch to the position 03. Press the TEST button and check that after 10 s., the phase 3 alarm of the differential corresponding to the button pressed, goes off.

12.11.2. On and Off Push-Buttons Check

Check that the differential can be connected and disconnected with the ON and OFF push-buttons; for this purpose, check the following:

When the green light of differential A is on, the latching relay 3B/87A will be in (1) whereas with the red one on , it will be in (0) .

Do the same check with the other differential and with its corresponding 3B/87B latching relay.

12.11.3. Test Memory Check

With the green light on, check that as you push the test button, the green light goes off as well as the red one, and the corresponding 3B latching relay goes to (1).

Also check that when releasing the TEST button everything is automatically reset.

Check that while doing the same but with the red light on, this light will stay on with or without pushing the button.

NOTE: Should any of the tests not be satisfactory, refer to UNITS CALIBRATION.

12.12. UNITS CALIBRATION

The units must only be readjusted if the values measured are beyond the indicated tolerance limits.

12.12.1. Main Units

Prior to the measure units calibration, the currents should be lead to the corresponding differential (double bus). For this purpose, a positive must be applied to terminals (see table 2: Bar connection & disconnection or differential A, and to terminals (see table 2: Bar connection & disconnection) for differential B. These terminals correspond to the position to be used for the carrying out of the test.

Before starting these tests, adjust the SUP. units of every differential board to 0.2 (Instruction Book FIG 20 back Cambion) and shorting the stabilization resistors.

Set the cambion slope (Instruction Book FIG 20 front Cambion) to 0.8. Apply 0.5 A through the leads corresponding to each phase, according to the above list, and adjust with P1 potentiometer of each board for the differential of the corresponding phase to operate with that value.

Check the rest of the pickup currents of each differential for each phase and for each of the rest of the slopes (Instruction Book FIG 20 front Cambion).

SLOPE	PICKUP CURRENT
0.5	0.190 - 0.210
0.6	0.237 - 0.263
0.7	0.313 - 0.347
0.8	0.475 - 0.525

The obtained value will be recorded in the corresponding box.

12.12.2. Supervision Units

Before starting with these tests, adjust the slope of the differential units to 0.5 (Instruction Book FIG 20 front Cambion), Check that the stabilization resistors are shorted.

Set the supervision of the differential boards to 0.5 (Instruction Book FIG 20. back Cambion). Apply 0.5 A through the leads corresponding to each phase, according to the above, and adjust with the P4 potentiometer of each board for the differential of the corresponding phase to operate with that value.

Check the rest of the pickup currents of each differential for each phase and for each of the rest of the adjustment values (Instruction Book FIG 20 back Cambion).

ADJUSTM. VALUE	PICKUP VALUE
0.2	0.190-0.210
0.3	0.285-0.315
0.5	0.475-0.525
0.8	0.760-0.840
1.0	0.950-1.050
1.5	1.425-1.575
2	1.900-2.100

The obtained value will be recorded in the corresponding box.

12.12.3. Alarm Unit Calibration

In order to carry out this test, remove the jumpers in the stabilization resistors.

Apply current through the same terminals as in the previous tests and check for every unit and phase the pickup values of the alarm units and their operation times.

The operation values will be approximately 28 mA and the operation time will be 10 s. If not, adjust with the P1 potentiometer of the alarm board.

NOTE: The terminals to be used for the STOP of the chronometer depend on the type and construction of the equipment.

Double bus. Bus A: terminals X35 - X36.

Double bus. Bus B: terminals X43 - X44.

The obtained value will be recorded in the corresponding box.

12.12.4. Overcurrent Units And Breaker Failure Calibration

12.12.4.1.Operation Level Calibration

Set the operation level adjustment of the breaker failure unit to 0.9A Set the unit operation time adjustment to the minimum (0.1 s).

Simulate the pickup of the unit and apply 0.9 A current by adjusting with potentiometer P1 of the board so that the unit may operate with that current (check with an oscilloscope that there are no pulses in D22 anode). Remember that it is timed.

Check the rest of the adjustable values. Operation time calibration.

Set the operation time adjustment of the breaker failure unit to 0.5 s and that of the operation level to 0.2 . Apply 0.5 A and adjust with the P5 potentiometer of the board so that the unit may operate en 0.5 s.

Check the rest of the adjustable values.

12.12.4.2. Overcurrent Unit Calibration

Set the adjustment of the overcurrent unit to 0.9 . Apply 0.9 A and adjust with the P2 potentiometer of the board so that the unit may operate with that value.

Check the rest of the adjustable values.

NOTE: Terminals for chronometer stop.

First step: X25-X26
Second step: X27-X28

Check that the model or models indicated in the plates match the data given in the order. Unpack the equipment and check there are no broken parts and no signs that the system has suffered any damage during transportation.

INTERNAL TEST PER POSITION OF BUSBAR DIFFERENTIAL PROTECTION

LOCATION:

VOLTAGE:

		DIF. TRIP	ALARM BLOCKING	B.F. TRIP.	50	V_L	V_D	V_R	SINGLE DIFF REDUCTION	OPEN SELECTOR	COMMENTS
POS											
	ϕ1										
	ϕ2										
	ϕ3										
POS											
	ϕ1										
	ϕ2										
	ϕ3										
POS											
	ϕ1										
	ϕ2										
	ϕ3										
POS											
	ϕ1										
	ϕ2										
	ϕ3										

MAIN RATIO:

LOCATION:

VOLTAGE:

	ALARM UNIT		DIFFERENTIAL SUPERVISION		DIFFERENTIAL UNIT	
	DIFF A	DIFF B	DIFF A	DIFF B	DIFF A	DIFF B
PHASE 1						
PHASE 2						
PHASE 3						
TIME						

	POSITION	POSITION	POSITION	POSITION	POSITION	POSITION	POSITION	POSITION	POSITION
50 (A)									
B.F. (A)									
B.F TIME									
LOOP RES. (Ω)									
MAIN CT RATIO									
AUX. CT RATIO									
DEDICATED SECONDARY									

12.13. DMS MODULE

In this section we will explain the different tests that allow verification of the complete functionality of a protection and/or control DMS equipment. For a given DMS equipment, only those tests corresponding to the functions included in it should be carried out, according to the table of application variables in the models selection guide.

The test instructions that follow correspond to the complete testing of a DMS3*** model.

12.13.1. Insulation Test

During the testing, the A12 terminal should be to connected to ground for security reasons. It must be verified that connection to ground exists in the terminal C12.

- Apply gradually 2500 volts between all the terminals of a group, connected among themselves, and the box, during a second.

12.14. COMMUNICATIONS

- Verifying that the 2 communication PORT of the DMS, allow communication with the relay.

- The communication parameters that will be adjusted to the PC as well as to the DMS are:

  Number of relay = 1
  Baud remote = 9600
  Baud local = 9600
  Bits stop remote = 1
  Bits stop local = 1

- Communicate with the relay through both ports using the GE-LOCAL software.

- Repeat the test for different speeds.

12.15. MEASUREMENTS

- Set the DMS as follows:

Ratio phases line =	1000
PT Ratio phases busbar =	1000
Frequency =	50 Hz

12.15.1. Voltages

- Enter the following voltage values to the DMS using the corresponding inputs (see the external connections diagram of the equipment in test):

Magnitude	Phase	1	2	3	4	5	6
Vab1 (V)	0º	0	1	10	50	100	200
Vbc1(V)	120º	0	1	10	50	100	200
VAC1 (V)	240º	0	1	10	50	100	200
Magnitude	Phase	1	2	3	4	5	6
Vab2 (V)	0º	0	1	10	50	100	200
Vbc2(V)	120º	0	1	10	50	100	200
VAC2 (V)	240º	0	1	10	50	100	200

- Verify that the DMS , measures Vab1, Vbc1, Vac1, Vab2, Vbc2, Vac2, with maximum error of 3%.

  - Repeat tests for 60 Hz (changing to 60 Hz the frequency setting in the general group).

12.15.2. Frequency Measurement

- Apply 100 V, 50 Hz for phase b1 and b2.

- Verify that the frequency measured by the equipment, is between 49.97 and 50.03 Hz.

MEASURING TEST FOR THE PROTECTION UNIT

FOR CONSIDERING FINISHED THE MEASURING TEST, FUNCTIONAL TESTS OF THE PROTECTION UNITS SHOULD BE CARRIED OUT IN ORDER TO ASSURE CORRECT MEASUREMENTS.

12.16. DIGITAL INPUTS

- This test should be carried out to values corresponding to +20% and -20% of the auxiliary voltage.

- Apply voltage to an input and check that the equipment detects its activation.
  (This can be done by associating one output relay with one input. Each time an input is activated the output relay will be operated too. Other way would be to associate one front LED to the activation of an input. This configuration can be done by means of GE_INTRO software).

- Repeat the test with the rest of protection and control Inputs.

12.17. OUTPUTS

12.17.1.Alarm Output Checking.

- Without applying auxiliary power supply, make sure that the alarm output contact is closed.
- Apply the auxiliary power supply voltage and make sure that there are no alarm conditions. For instance: protection out of service or all protection functions disabled. In such case, make sure that the alarm contact is opened..

12.17.2.Configurable Outputs Checking.

Make one of the configurable contacts close in one of the following ways:

- Configuring the outputs as protection unit pickups and producing one trip condition.
- Conditioning the output activation to an input activation.

Make sure that all the configurable relays close when the closing condition happens and open when this condition disappears.

NOTE 1: If the equipment does not include trip and closing contacts, points 1 and 2 will not be tested.

NOTE 2: If the equipment does not include a protection CPU, the outputs will be closed conditioned to the inputs performance.

12.17.3.Protection Functions

12.17.3.1.Minimum Voltage Unit (27)

- Set the DMS so that it trips for minimum voltage (27).

- Configure one of the outputs so that it is only activated by function 27.

- The test is carried out applying voltage to phases A, B and C successively. To those phases that are not being tested, a voltage should be applied over the tripping level, so that they do not act.

- In order to make sure that the relay trips, we will verify that all the trip relays are activated, as well as the contact configured as 27.

- Enter the following SETTINGS to the relay:
  -Pickup Value of the unit 27: 20 V

- Apply 21.5 V and verify that the DMS does not trip. Reduce the voltage gradually and verify that the DMS trips for a voltage of 20 V (with an admissible error of 5%).

- Verify that the time is between 0.010 and 0.015 s.

- Repeat the same test for the following settings:
  - Pickup Value of the unit 27: 110 V

- Apply 116 V and verify that the DMS does not trip. Reduce the voltage gradually and verify that the DMS trips for a voltage of 110 V (with an admissible error of 5%).

- Verify that the activation time is between 0.010 and 0.015 s.

12.17.3.2.Maximum Zero Sequence Unit (64G)

- Set the DMS so that it trips for MAXIMUM zero sequence voltage (64G).

- Configure one of the outputs so that it is only activated by function 64G.

- The test is carried out applying voltage to phases A, B and C successively. To those phases that are not being tested, a voltage should be applied over the tripping level, so that they do not act.

- In order to make sure that the relay trips, we will verify that all the trip relays are activated, as well as the contact configured as 64G.

- Enter the following SETTINGS to the relay:
  -Pickup Value of the unit 64G: 20 V

- Apply 18.5 V and verify that the DMS does not trip. Increase the voltage gradually and verify that the DMS trips for a voltage of 20 V (with an admissible error of 5%).

- Verify that the time is between 0.01 to 0.015 s.

- Repeat the same test for the following settings:
  - Pickup Value of the unit 64G: 110 V

- Apply 100 V and verify that the DMS does not trip. Increase the voltage gradually and verify that the DMS trips for a voltage of 110 V (with an admissible error of 5%).

- Verify that the activation time is between 0.010 and 0.015 s.

13. FINAL INSTALLATION & COMMISSIONING

13.1. SETPOINTS OF THE DIFFERENTIAL PROTECTION.

In each phase (A, B, C) there are two setpoints that must be accomplished

1. _The value of K_: If there is no high resistance consideration of loop or other, the value that it must of be adopted is that of K = 0.8. With this have a sensibility of 0.33 In.

2. _The value of the supervision circuit_:

- Value of the minimal short circuit current is inferior to In. The adjustment will be the minimum possible. In this way the sensibility will be determined by the value of K.
- Value of the minimal short circuit current is sensibly superior to In. The value of the supervision current, it is preferable to adjust it 1.5, to avoid the tripping of the protection in case of one of current circuits is broken or short-circuited, and thus to give the alarm unit time to act and block the trips. Evidently, in this last case the sensibility is determined by the supervision unit, but is earned in safety.

13.2. SETPOINTS OF THE BREAKER FAILURE

- _Current level adjustment_: The minimum level should be at least 150% of the maximum nominal current. Bear in mind that to calculate this value it must be considered the global ratio of the Substation or Power
- _Time setting_: This value must be inferior to the time set for zone 2 of the distance relays or of the backup protections of the power transformers. The value must also be higher than the trip time of the main protections (zone 1), plus the opening time of the associated breaker, plus a safety margin (i.e., if zone 2 is set to 500 mseg., the breaker failure will be adjusted in 300 mseg - have assumed a tripping time of distance relay in zone 1 of 30 mseg. and a breaker time of 80 mseg.).

13.3. INSTALLATION

All the units must be mounted in vertical surface which allows access to the front and rear sides of the equipment. It is not necessary to have access to the lateral surfaces of the equipment mounted.

13.4. PREVIOUS CHECK

Check that the equipment has not suffered any damage during transportation and that its characteristics and adjustments have not been altered

Check that the ratios of the auxiliary transformers are accurate according to the selected global ratio. (See figures from 226B6429H1 to 226B6429H8)

Measure for each line and phase the total impedance of the loop on the 1 A side, from the protection input leads, shorting the main transformer s secondary.

Check that the maximum value obtained in the measurements is less than:

$$R_{max} < (2K/1-K) *RE$$

Where:

Rmax: Max. resistance measured
RE: Stabilization resistance (250 Ω)
K: Adjusted slope

Leave the current circuits of the main transformers secondaries shorted until these currents are applied to the differential protection.

13.5. ARRANGEMENT AND PRELIMINARY LEADS

- Check that the values of each of the Stabilization Resistance measured 250 Ω.
- Short out the Stabilization Resistance.
- Disconnect the trips that go from the differential busbar protection and breaker failure protection, to the circuit breakers of the Substation or Power Plant. It should be done by disconnecting the physical elements (cables), or by the use of switching terminal boards .
- Check that all the leads are down except for the d.c. power supply X1(+)-X2 (-) and X7(+)-x8(-) for the control of the bar connection and disconnection of the feeders.
- Disconnect the two differentials through their OFF buttons.

13.6. TESTS WITHOUT LOAD

Carry out the acceptant test described in chapter 11.

Take into account that terminals mentioned in this chapter are referred to the set of drawings 226B6429. For each scheme, depending on the arrangement of the substation or power plant, and the needs of each utility, the identification and number of the terminals may defer from the ones that appear in 226B6429.

13.7. TESTS WITH LOAD

The objective of this test with real load, is to verify if the protection is correctly balanced: the sum of all the currents in the differential circuit is zero (0.0mV), and that all the polarities are correct.

This test uses the real currents that go through each circuit. Trips must be disconnected, for the differential units it will be enough to push the red button, but for the breaker failure protection check that all the tripping output terminals are brought down, so any mistake during the tests, will not cause a problem in the Substation.

Connect feeder by feeder to differential A and verify:

- The magnitude of the current of restrain is increasing and corresponds to the sum of the absolute values of all the currents connected to it.
- The differential current will increase or decrease weather the lines currents are compensated or not.
- The voltage (ac) measured at the front of the panel DFI is proportional to the input current.

Upon connecting the last circuit, the value of differential voltage must be of the order of 0.0 mV, 3 milivolt as maximum (upper values, indicate that there is a wrong connection). The alarm unit should be able to reset by pushing the reset button, the leds on the DAL module should be off.

Now transfer all the feeders, one by one to differential B following the same steps as above, and check the magnitudes of the current restrain and the differential current.

Upon connecting the last circuit, the value of differential voltage must be of the order of 0.0 mV, 3 milivolt as maximum (upper values, indicate that there is a wrong connection). The alarm unit should be able to reset by pushing the reset button, the leds on the DAL module should be off.

- Arrange the differential according to the actual arrangement of the Substation, and check that all the alarm unit can be reset (no led is on), and that the leds on the DDF modules are also off.

- Connect the two differentials through their ON buttons.
- Check that the only led that is on is the green one.
- Remove the jumpers from the Stabilizing Resistances.

-***NOTE***: The alarm units in the differentials will remain operated during installation, until all the currents are compensated.

For the measures of the voltage is sufficient the use of in digital multimeter with the range and precision of milivolt.

13.8. OPERATION CRITERIA

Please make sure that the short circuit of the stabilization resistances is disconnected before at the end of the tests.

A very extended criterion is not to connect immediately the trips, but to maintain this situation within a period enhance between 6 months to 1 year (depending on the weather conditions and the customs of the utility). This procedure is based on the importance of not having an undesired trip. Whose origin may be caused by various sources: mistake of some polarity in a current circuit, auxiliary contacts of disconnector switches that they do not are operating correctly, some loose cable, etc.). Therefore is preferred to have the protection in service under real operation environment during a period of test, but unable to trip, although it will give all the signals to the control panels.

Once this period has finished and the performance of the protection is considered as appropriated, the trips should be connected.

14. TESTS AND PERIODICAL MAINTENANCE

Given the importance of the protection relays in the operation of any equipment, a periodical test program is recommended.

The interval between periodical tests varies normally for different types of relays, types of equipments as well as the users' experience on periodical tests.

For systems which are not provided with testing equipment, it is recommended that the points described in CALIBRATION AND RECEIVING TESTS be checked every 1 or 2 years.

The optional equipment described in previous sections, allows for checking on the correct operation of the measure and alarm units and of the output elements, without having to remove the protection. In systems provided with testing equipment, this check can be carried out in short intervals, and does not require specialized personnel. In this case the frequency of the tests described in RECEIVING AND EQUIPMENT CALIBRATION can be reduced

15. FIGURES

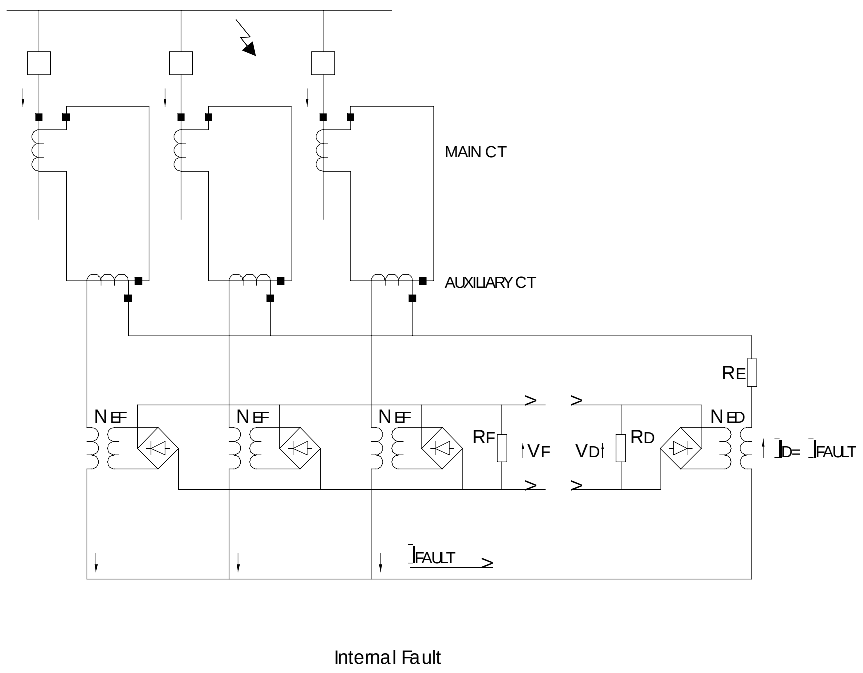


Figure 1*: Simple connection diagram for BUS 2000 differential protection* ***Internal fault****. (226B2211F1)*

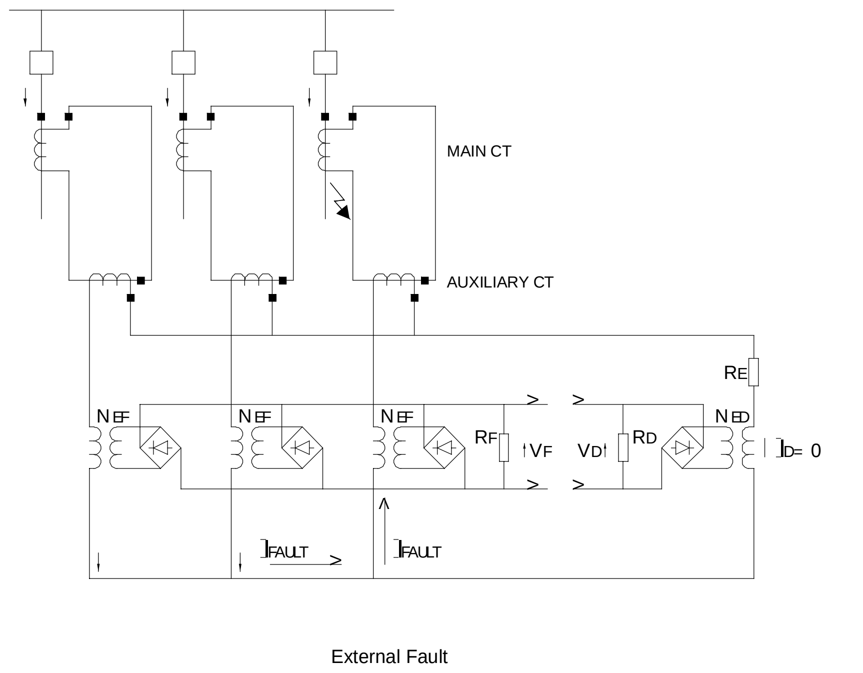


Figure 2*: Simple connection diagram for BUS 2000 differential protection.* ***External fault****. (226B2211F18)*

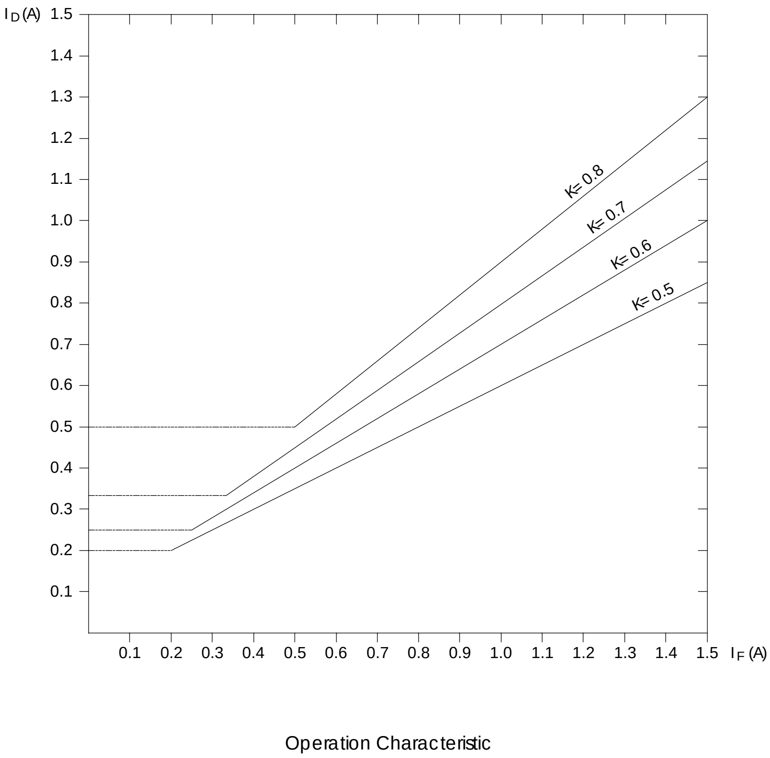


***Figure 3**: Operation characteristic. (226B2211F5)*

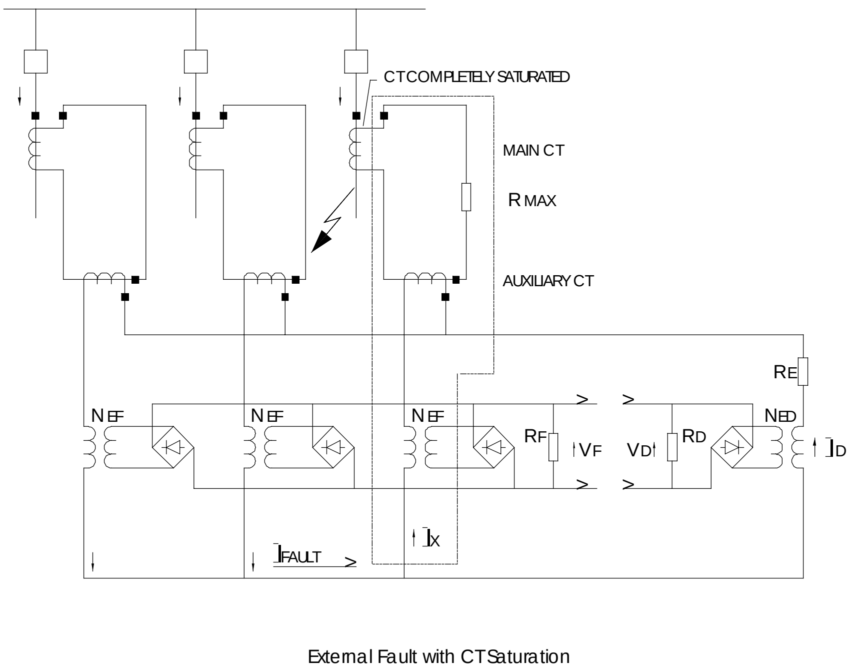


***Figure 4**: Simple connection diagram for BUS 2000 differential protection. **External fault with saturation core**. (226B2211F2)*

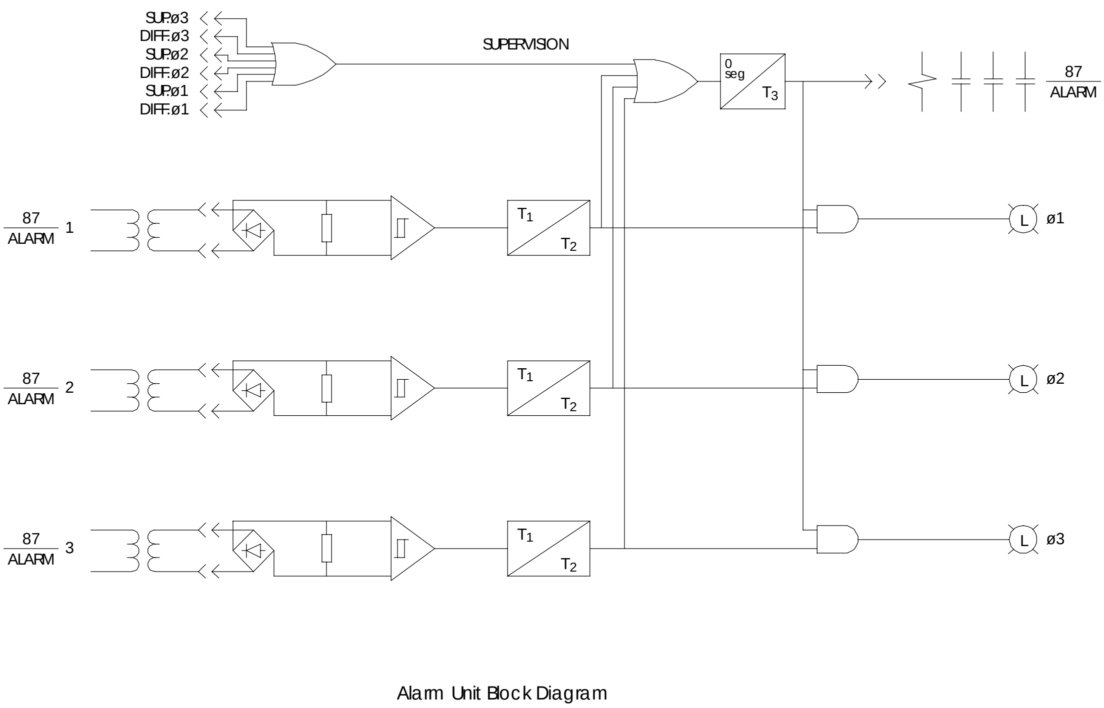


Figure 5*: Alarm unit block diagram. (226B2211F4)*

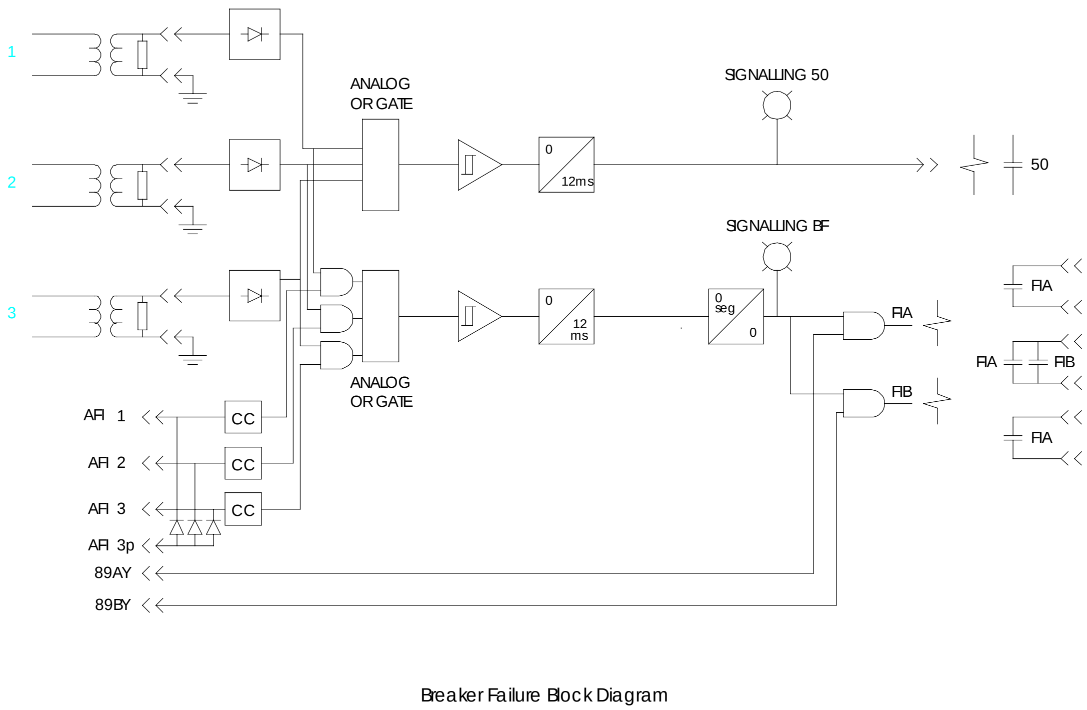
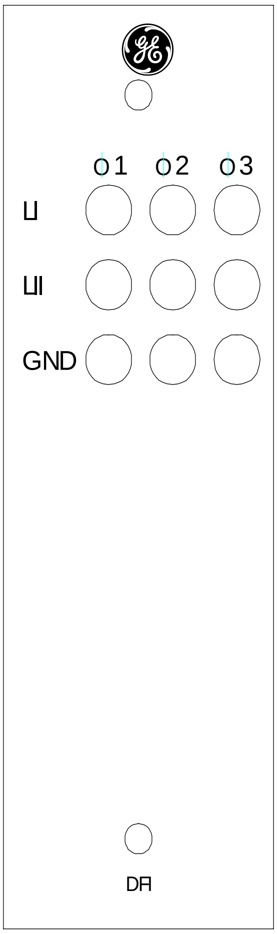
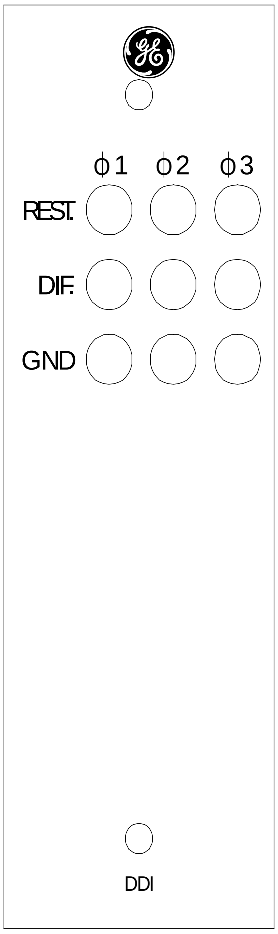


Figure 6*: Block diagram for current supervision and breaker failure units: three pole triping. (226B2211F7)*



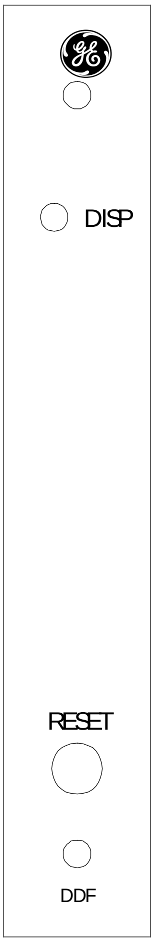
Restrain Module Front View



Differential Module Front View

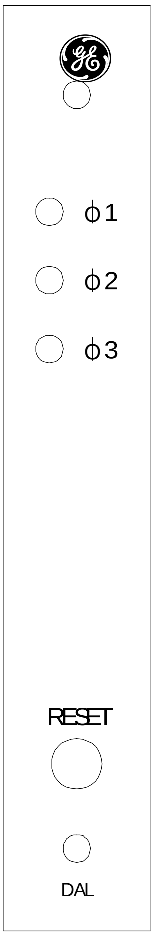
Figure 7: *Restrain module front view. (226B2211F15)*

Figure 8: *Differential module front view. (226B2211F14)*



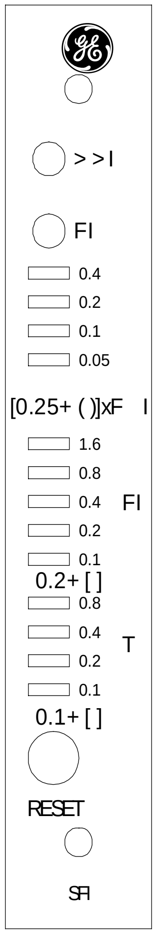
Differential Board Front View

Figure 9:*Differential Board front view. (226B2211F12)*



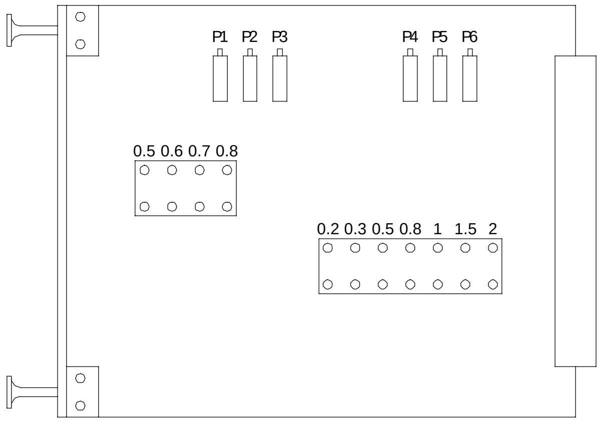
Alarm Board Front View

Figure 10:*Alarm Board front view. (226B2211F10)*



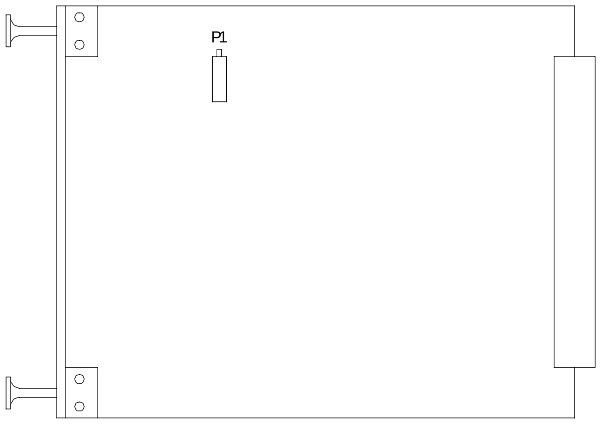
Breaker Failure Board Front View

Figure 11:*Breaker Failure Board front view. (226B2211F16)*



Differential Board - Internal Adjustments

Figure 12*:Differential Board internal adjustments. (226B2211F13)*



Alarm Board - Internal Adjustments

Figure 13*:Alarm Board internal adjustments. (226B2211F11)*

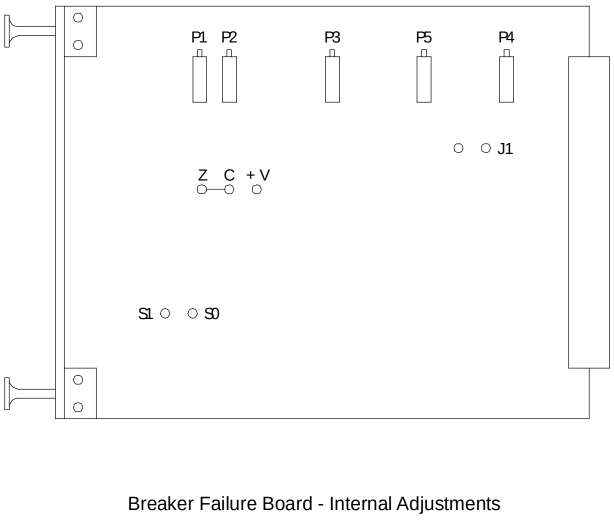


***Figure 14**:Differential Board internal adjustments. (226B2211F17)*

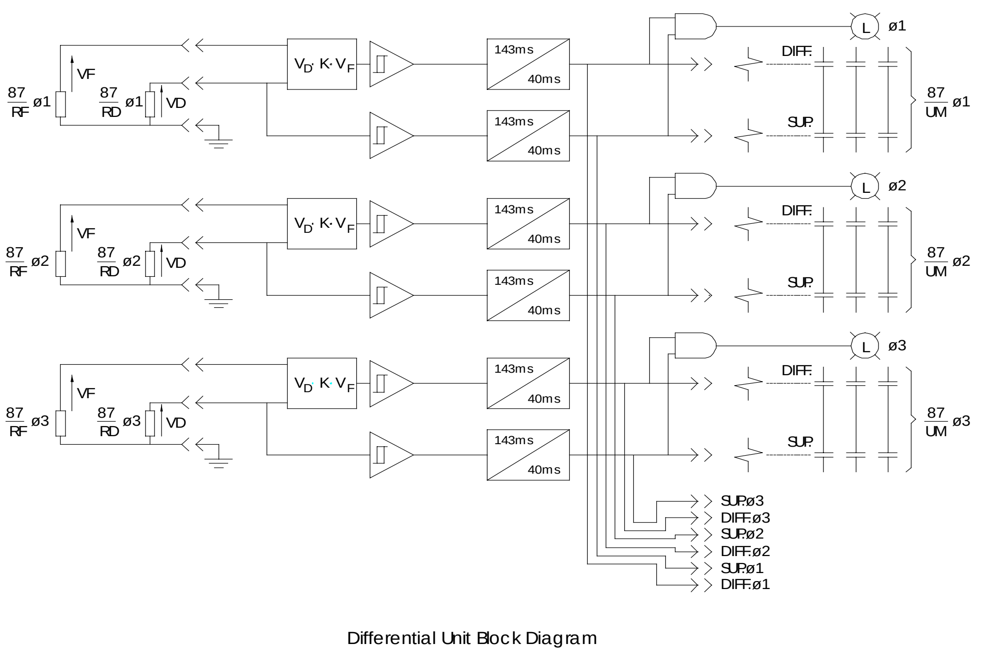


***Figure 15**:Differential Unit Block Diagram. (226B2211F3)*

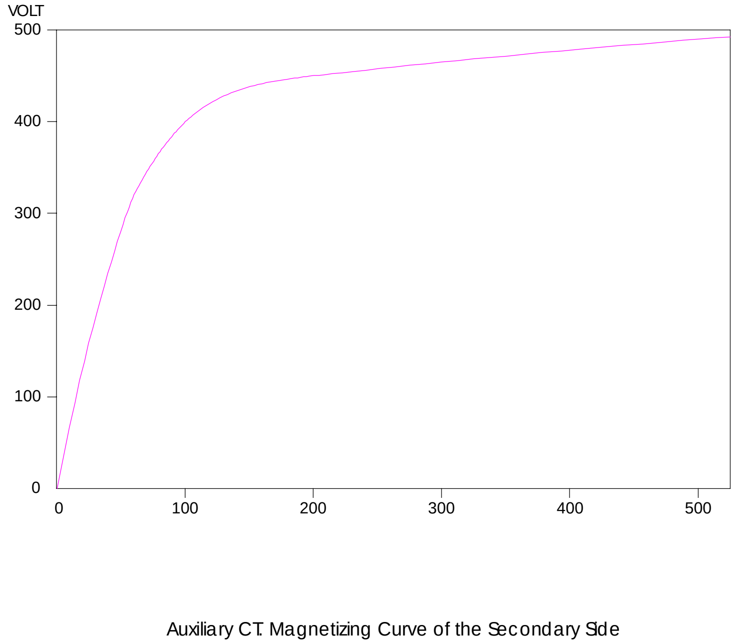
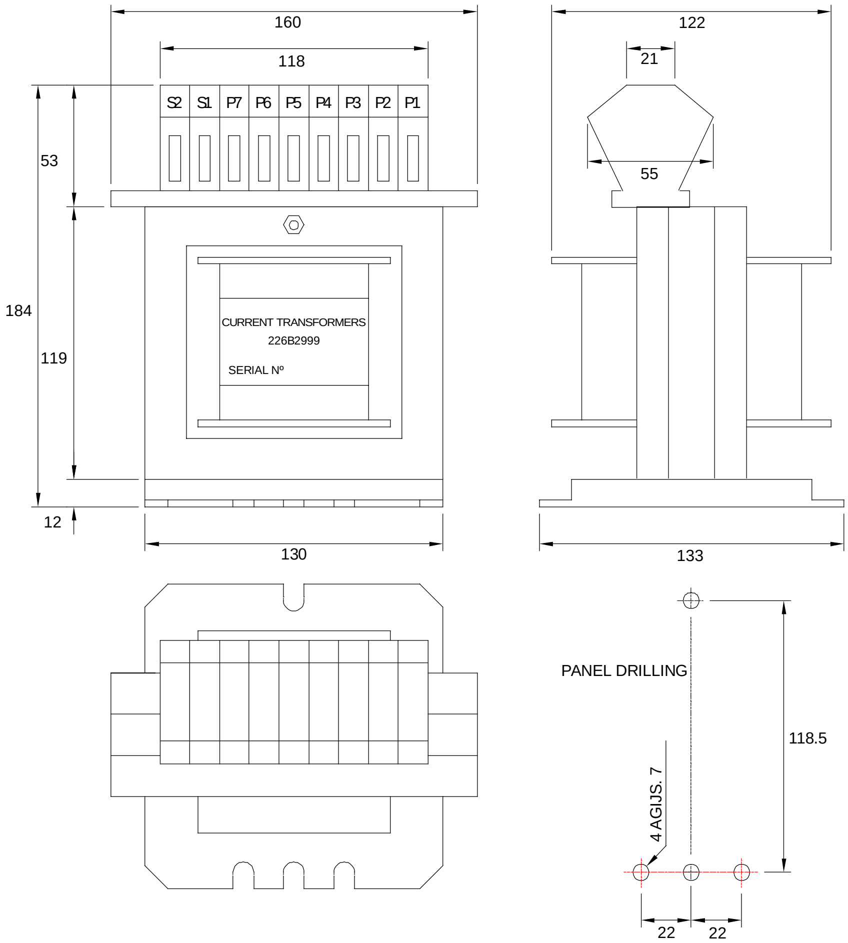


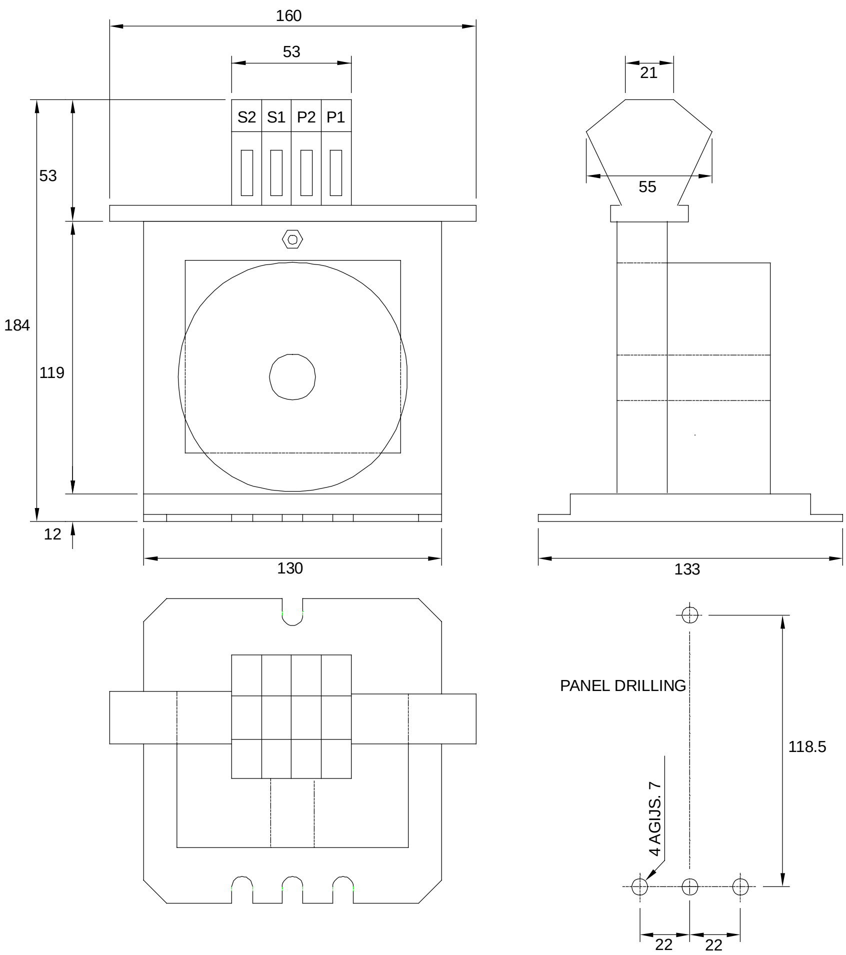
Figure 16*:CT Magnetizing Curve of the secondary side. (226B2211F6)*

16. DIMENSIONS



Auxiliary current transformer dimensions

Figure 17*:Auxiliary current transformer's. (226B2211F9)*



Oscillography Auxiliary current transformer dimensions

Figure 18*:Osciloghaphy Auxiliary current transformer. (226B2211F22)*

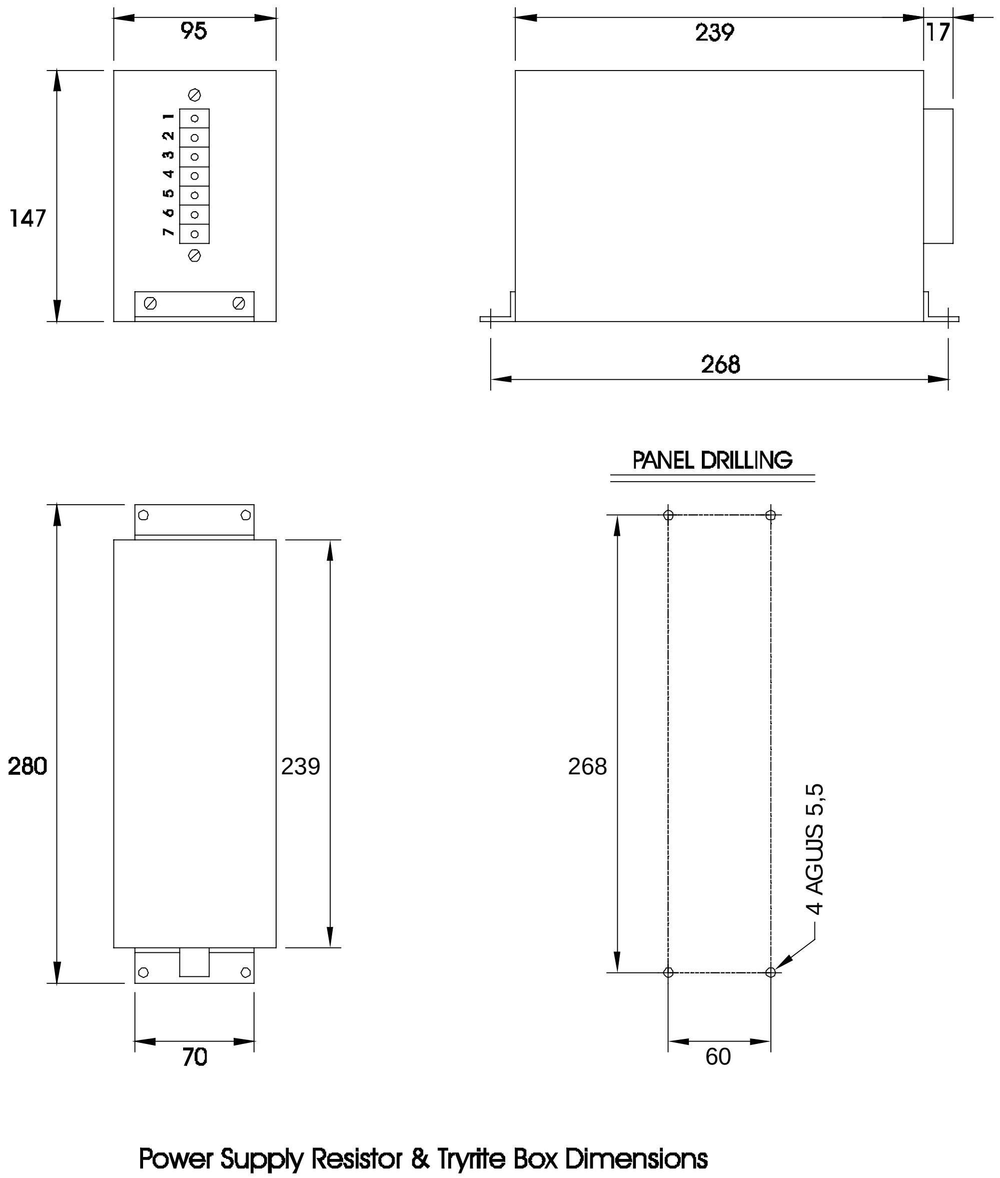


Figure 19*:Power Supply or Thyrite boxs . (226B2211F18)*

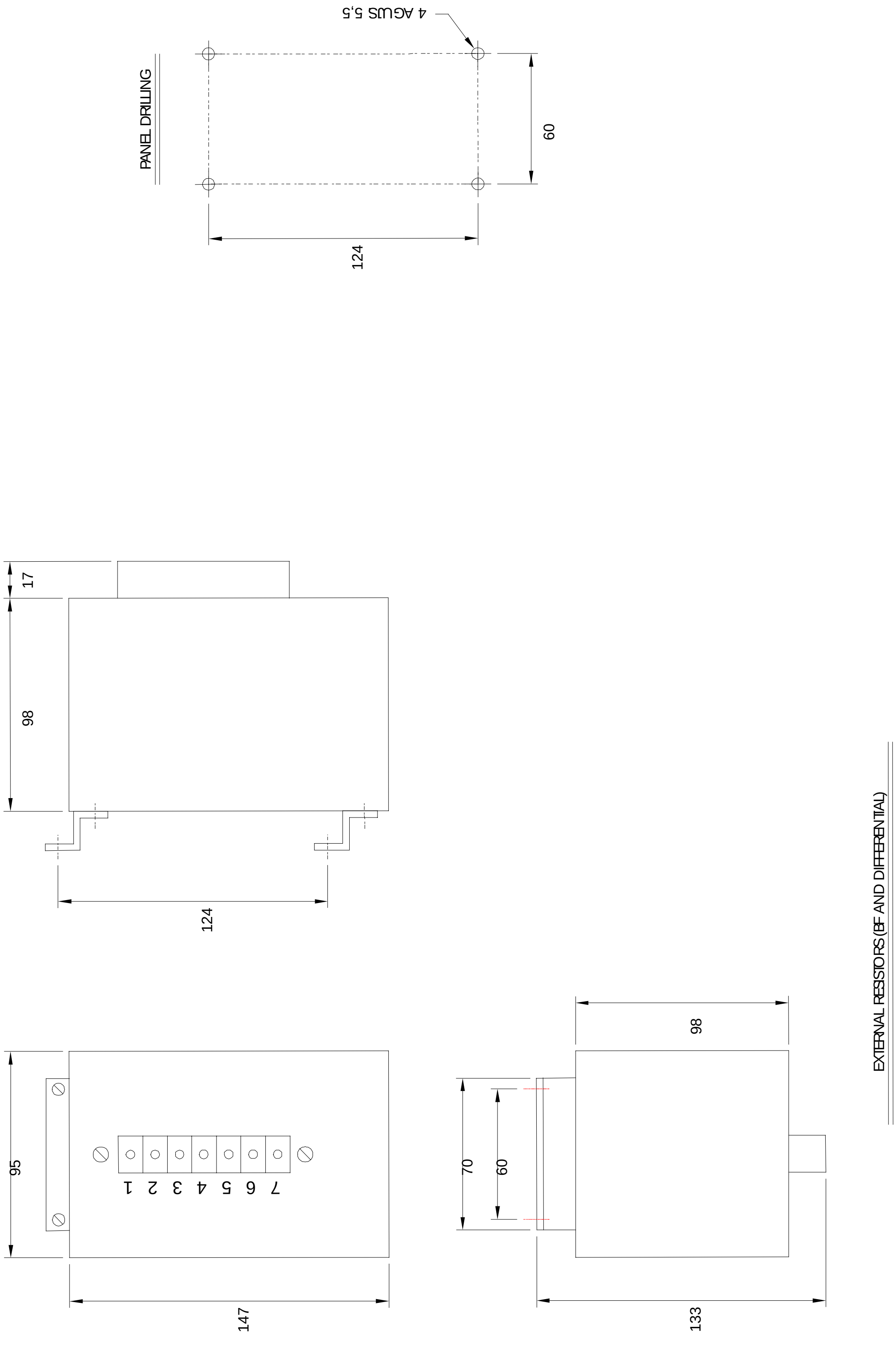


***Figure 20**: Breaker block diagram . (226B2211F23)*

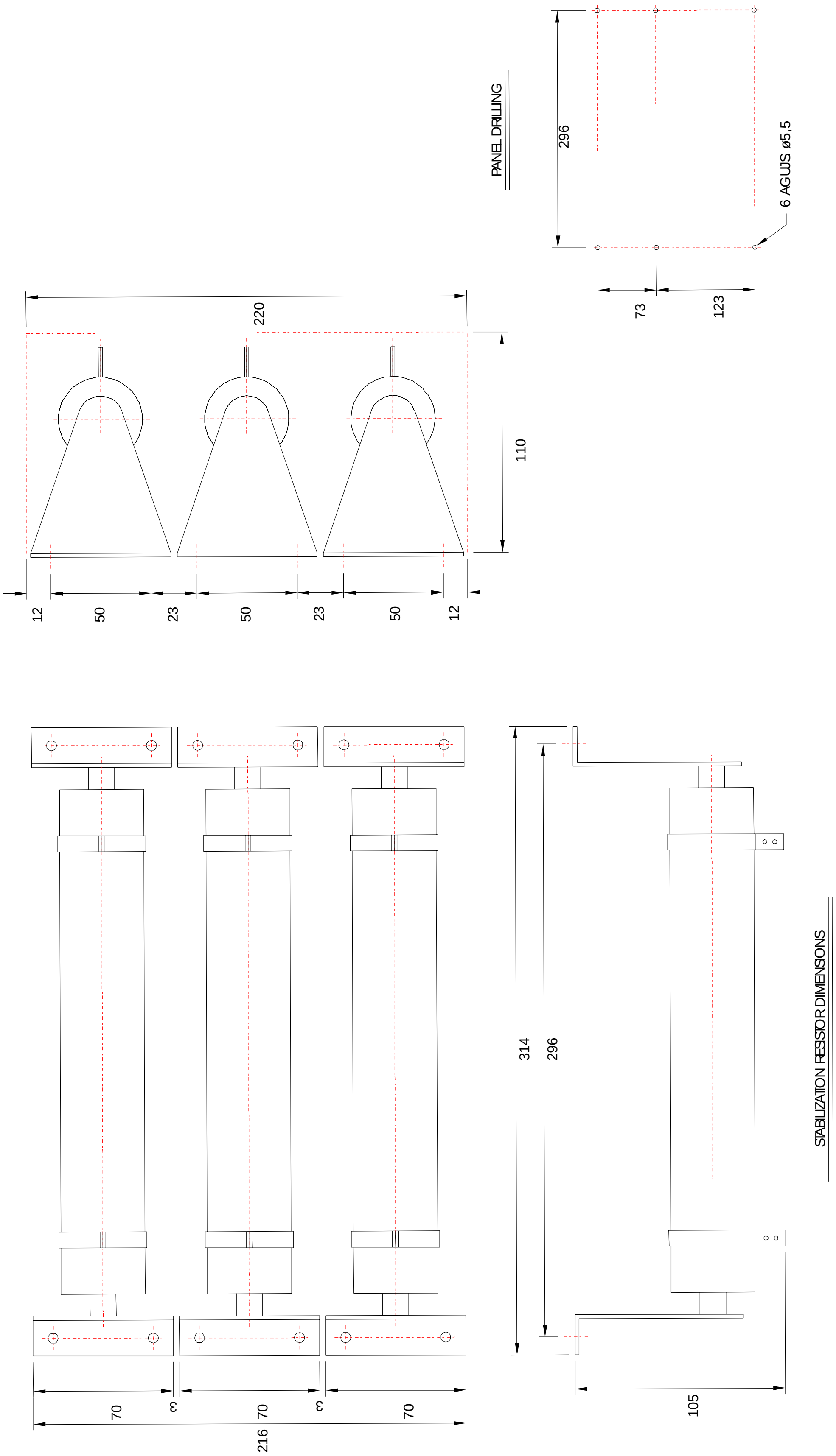


***Figure 21**: Stabilization resistor dimensions . (226B2211F24)*

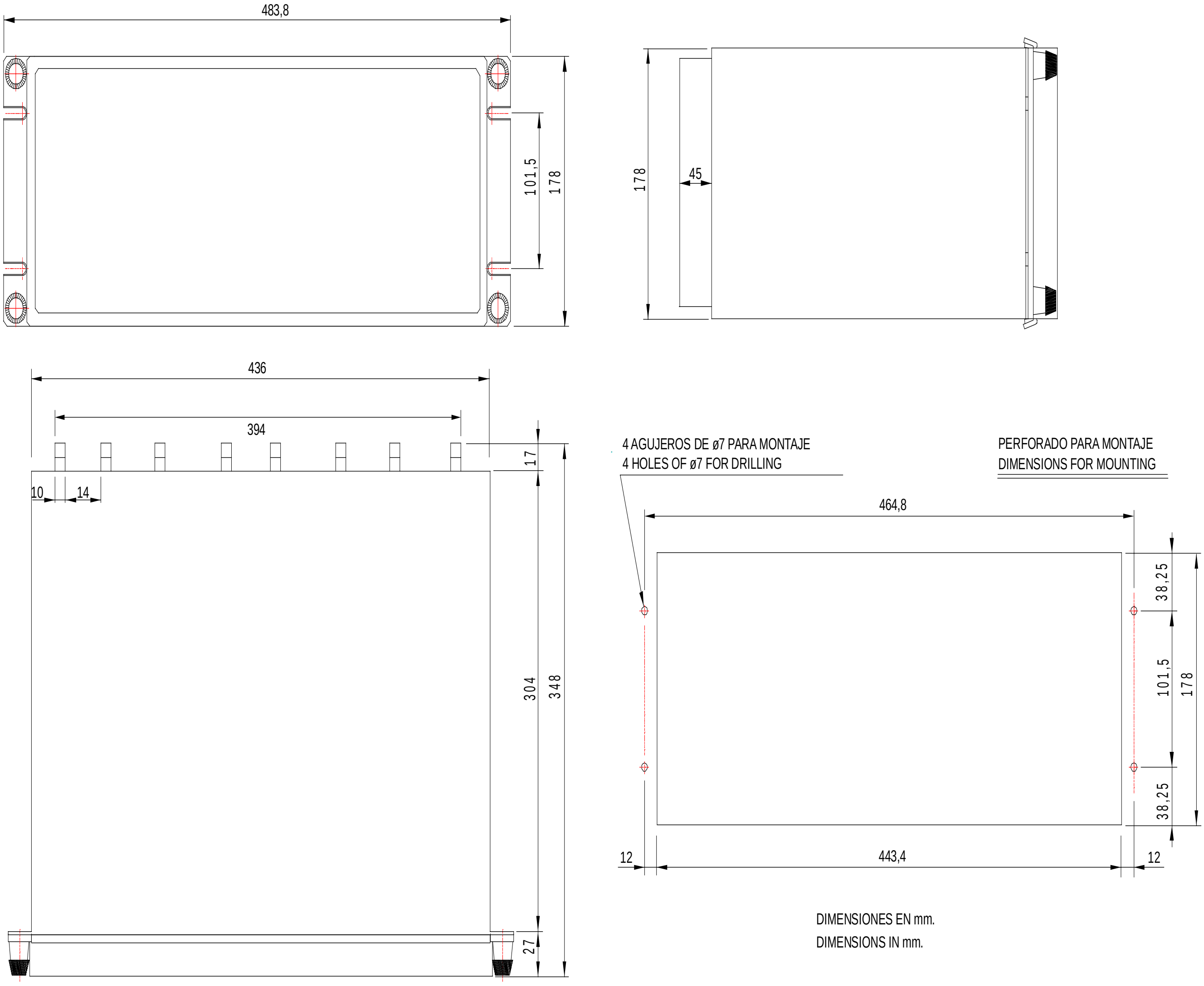


***Figure 22** Rack . (226B2211F20)*

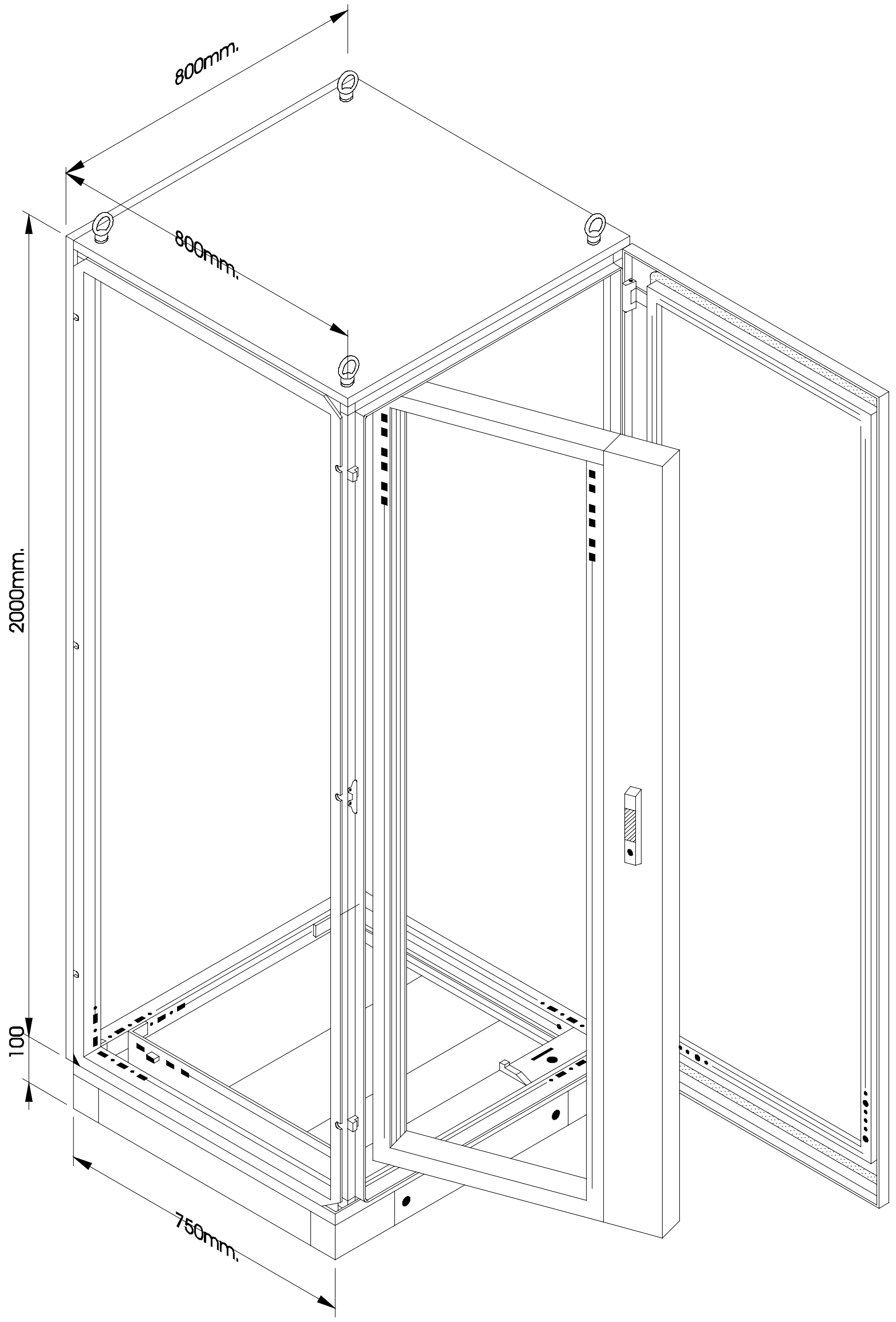
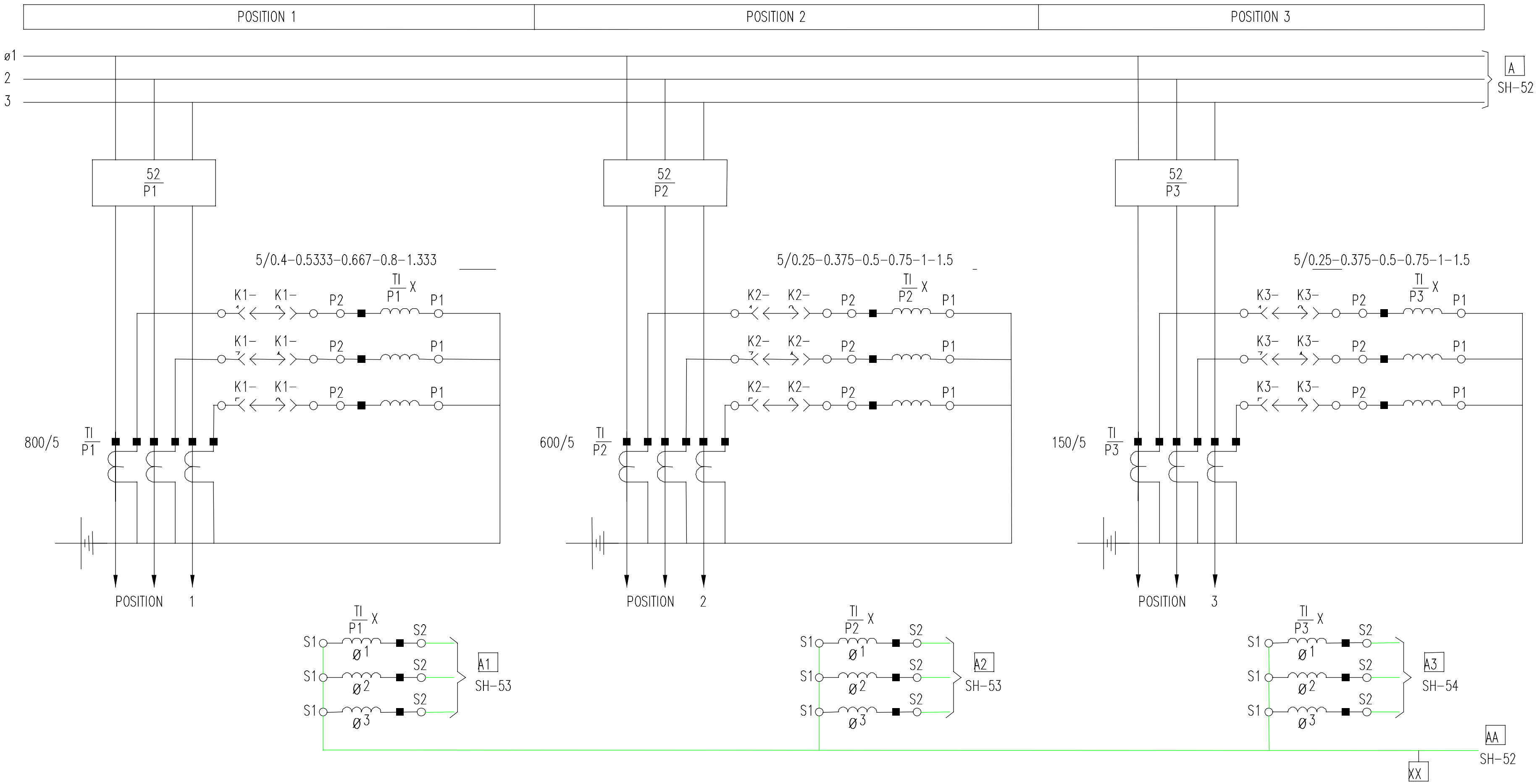


Figure 23 *Cabine**t** . (226B2211F21)*

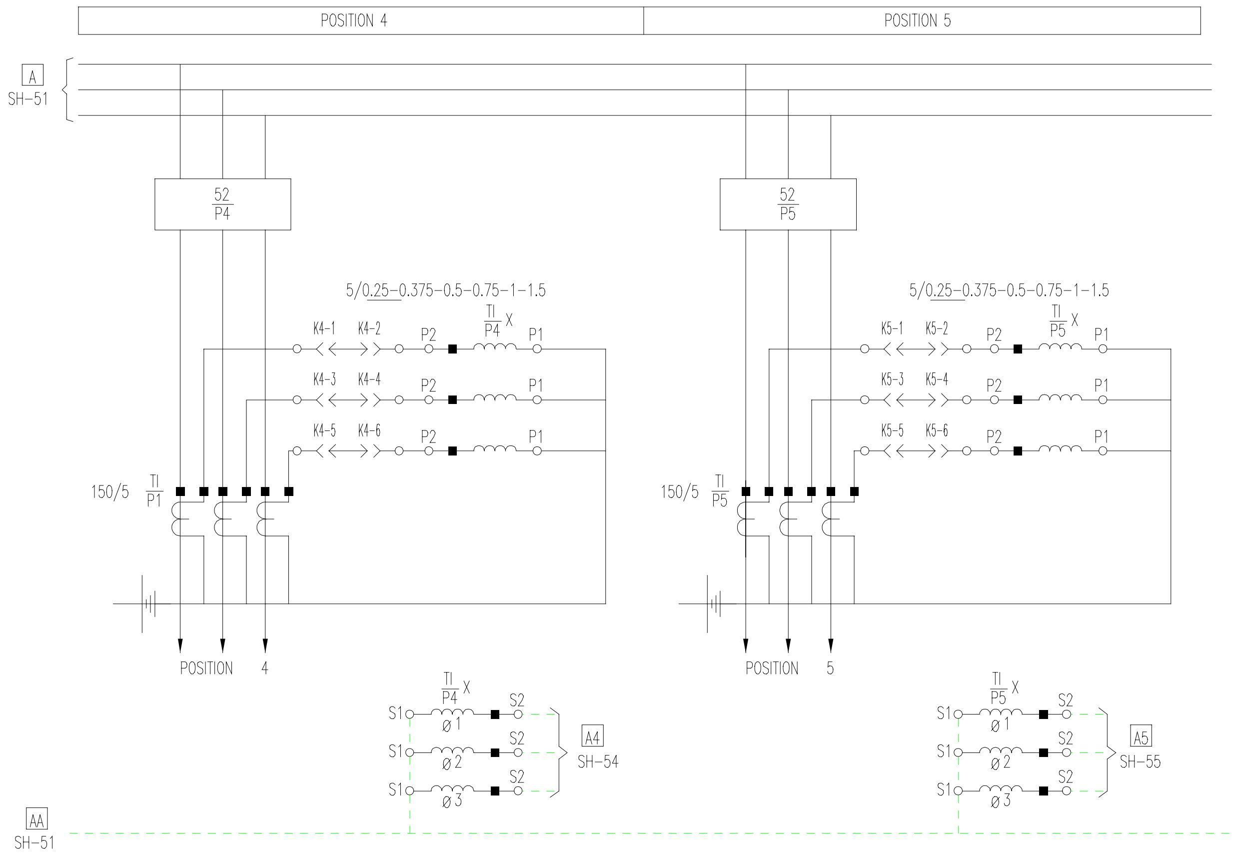
17. SCHEMATICS

This set of drawings represent an imaginary substation (based on real cases) with a double bus bar arrangement with eight feeders plus a bus coupler (226B6429). This scheme includes some of the optional features that can be provided under request:

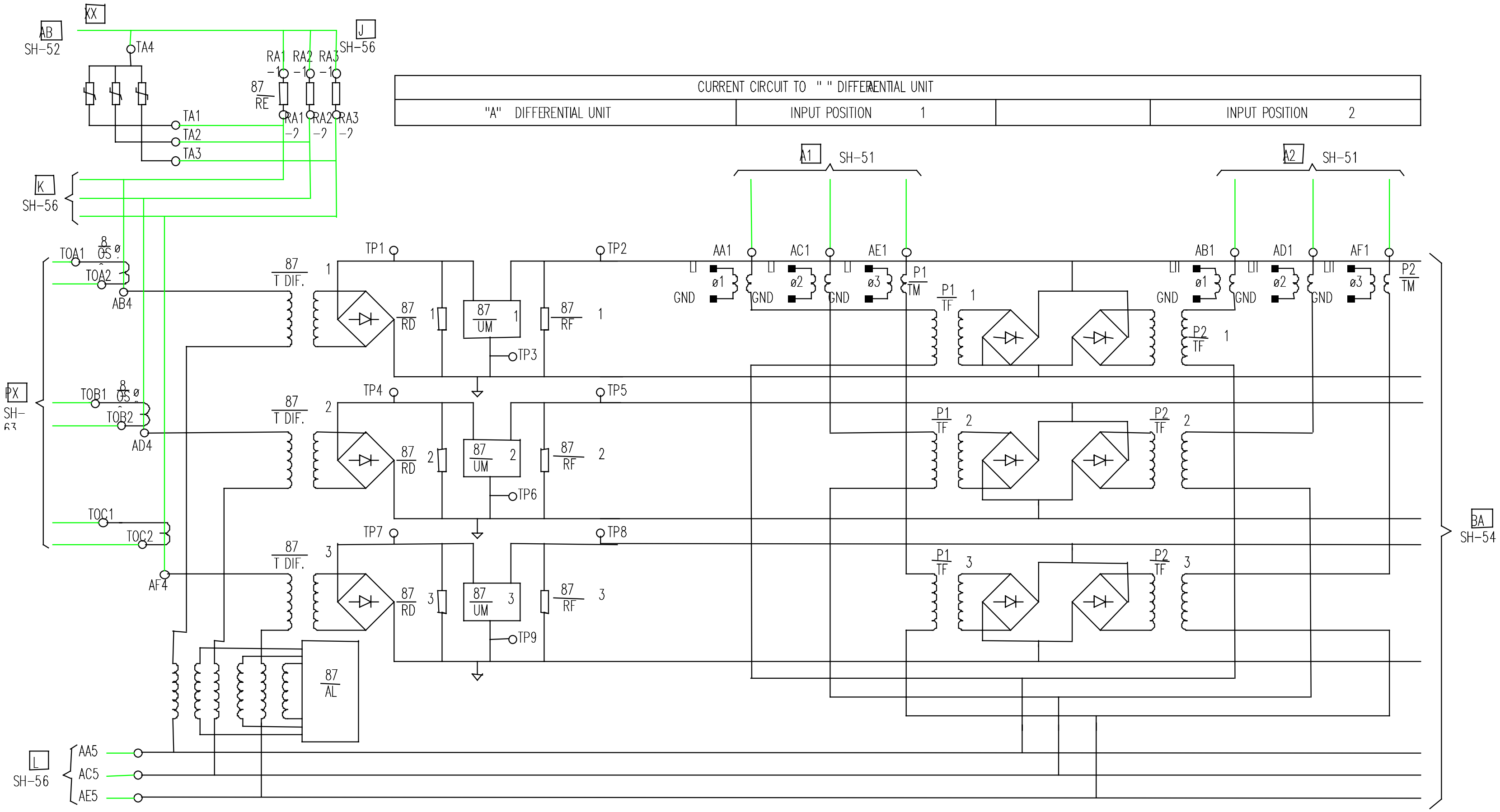
- Test rack.
- PK: test blocks located in the current input.
- PK: test blocks located in the tripping output contacts.
- 86 lock out contacts
- Breaker failure with two steps
- Undervoltage supervision. (27)



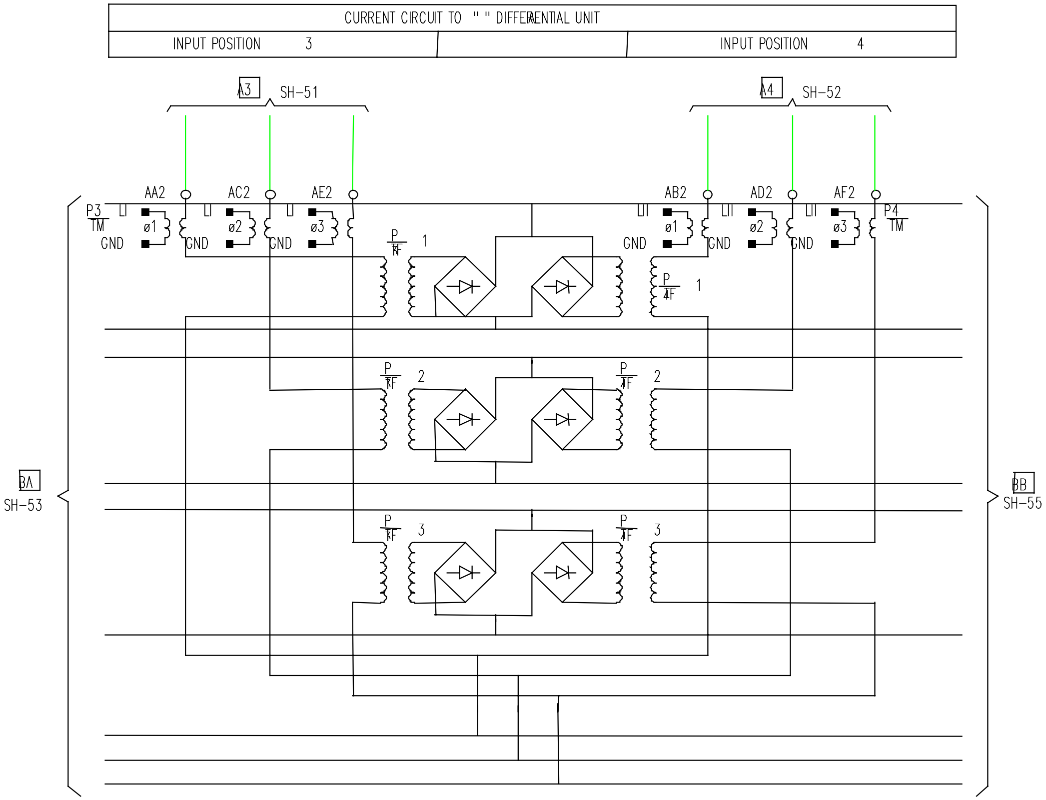
Position 1, 2, 3 – Three line current diagram (B6429F51)



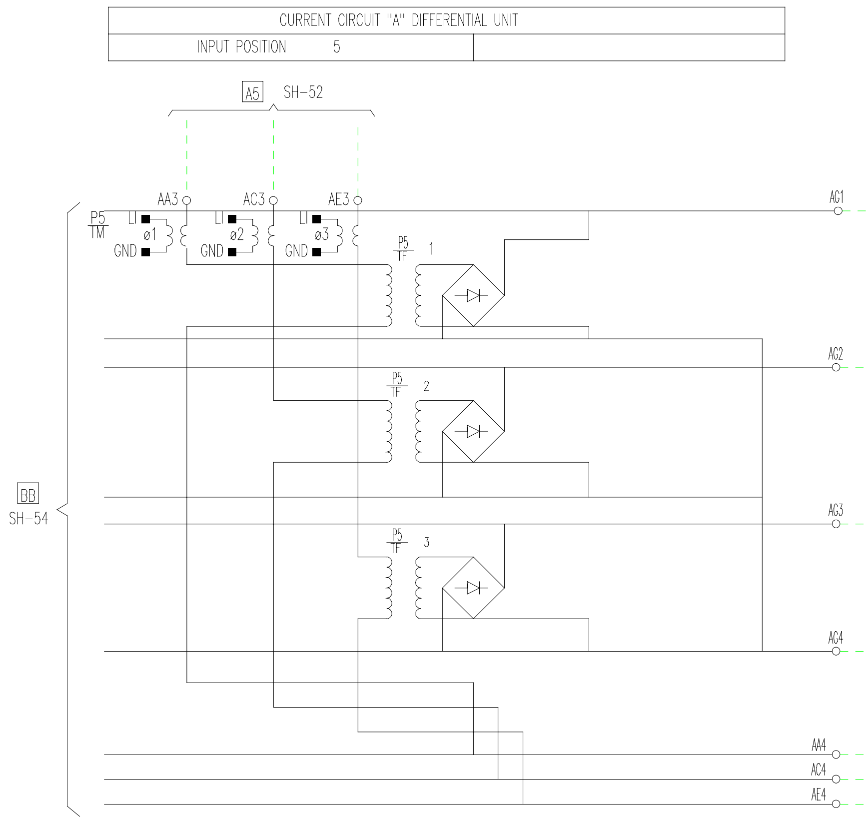
Position 4, 5 – Three line current diagram (B6429F52)



Current circuit to “A” Differential Unit Current Input P1, P2 (B6429F53)

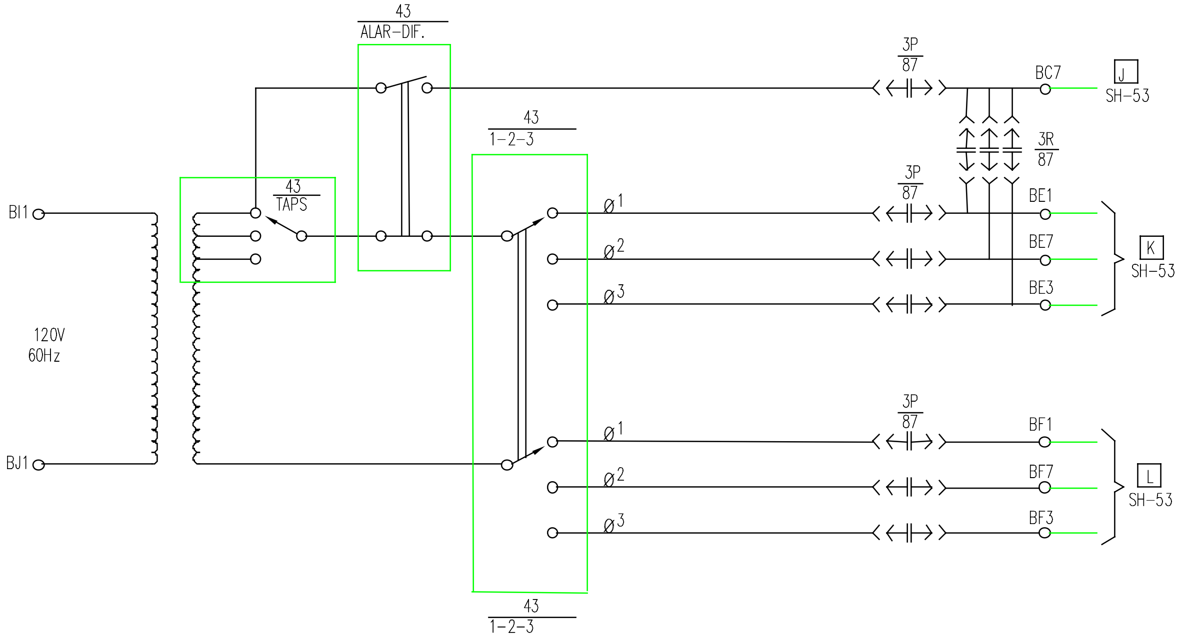


Current Circuit to “A” Differential Current Input P3, P4 (B6429F54)

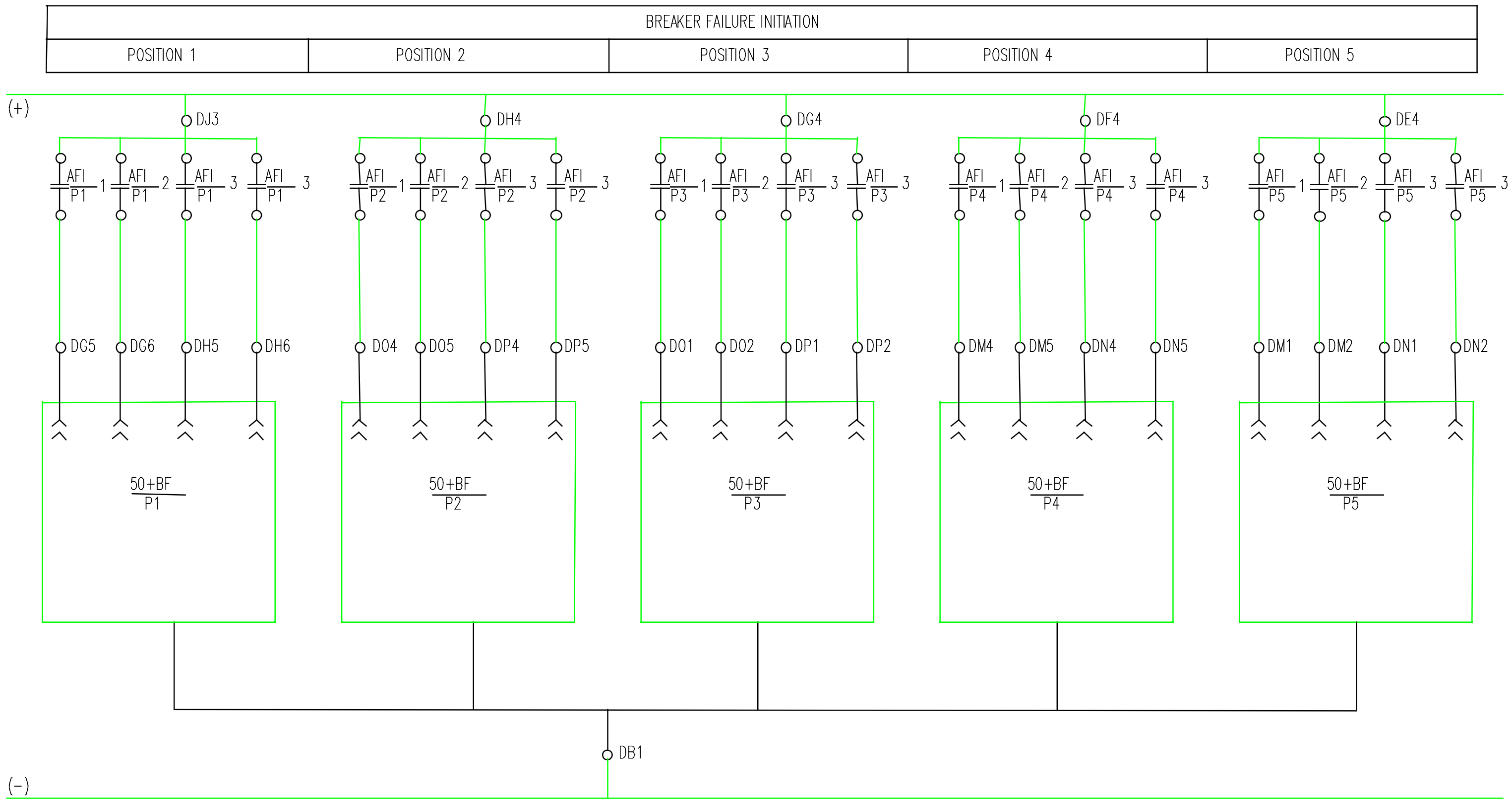


Current Circuit to "A" Differential Unit, Current Input P5 (B6429F55)

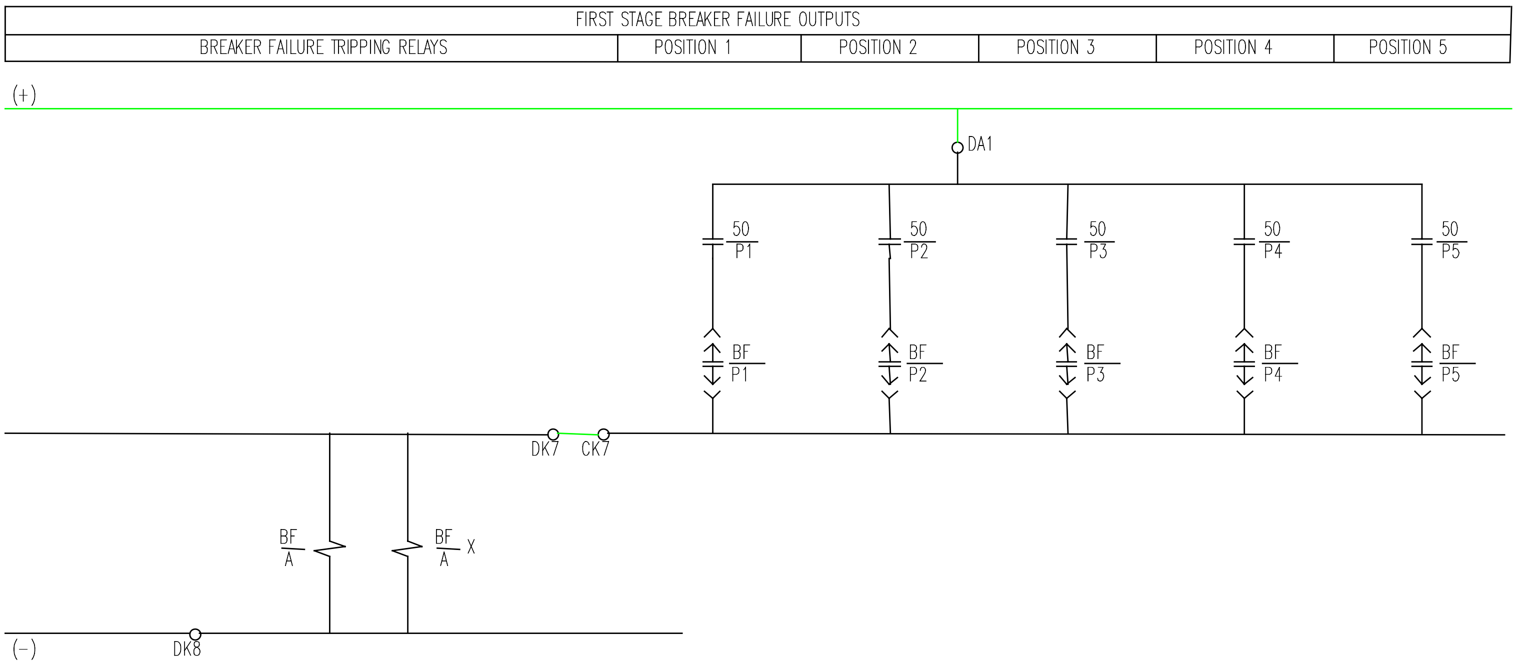
TEST AUXILIARY TRANSFORMER	SELECTION SW.			TEST SELECTOR CONTACTS AND SHORTING AUXILIARY DEVICE CONTACTS
	TRANSFORMER TAPS	ALARM TEST DIF. UNIT TEST	TEST 1-2-3	



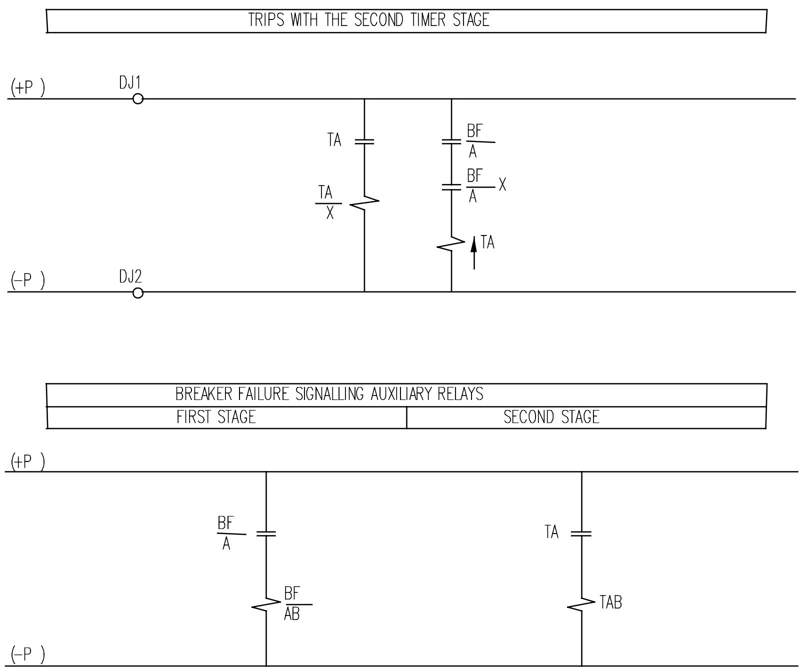
Test Unit (B6429F56)



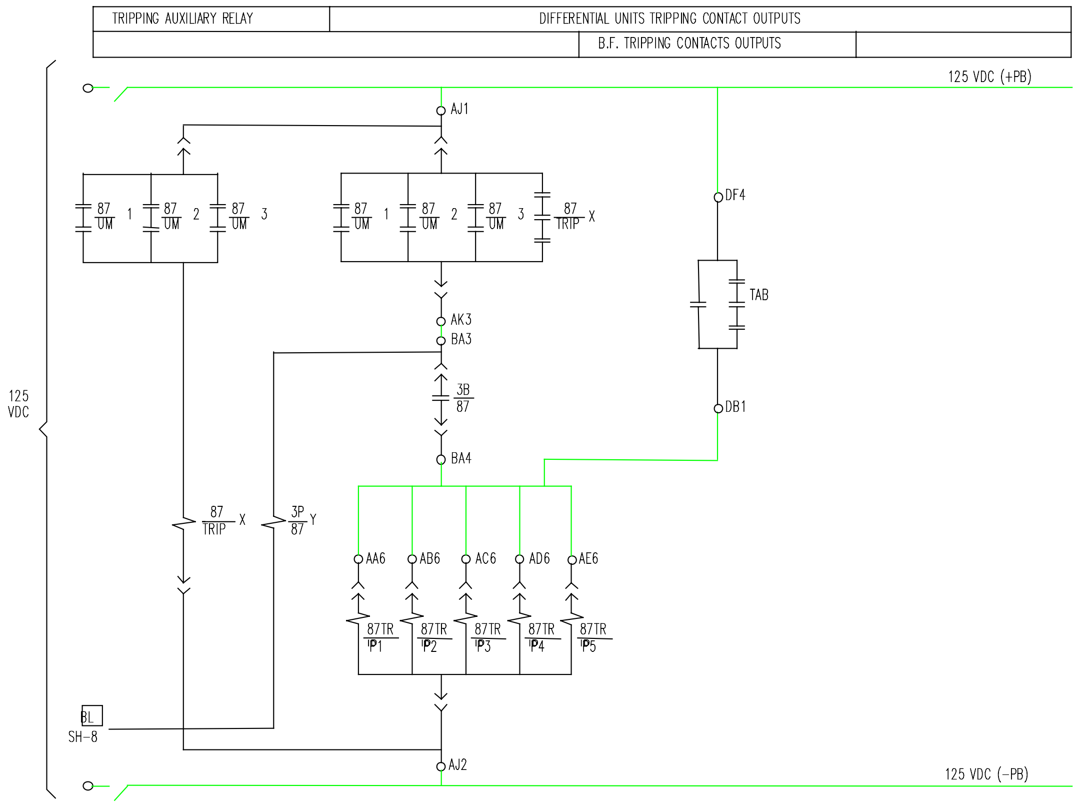
First stage breaker failure initiation Positions P1, P2, P3, P4, P5 (B6429F57)



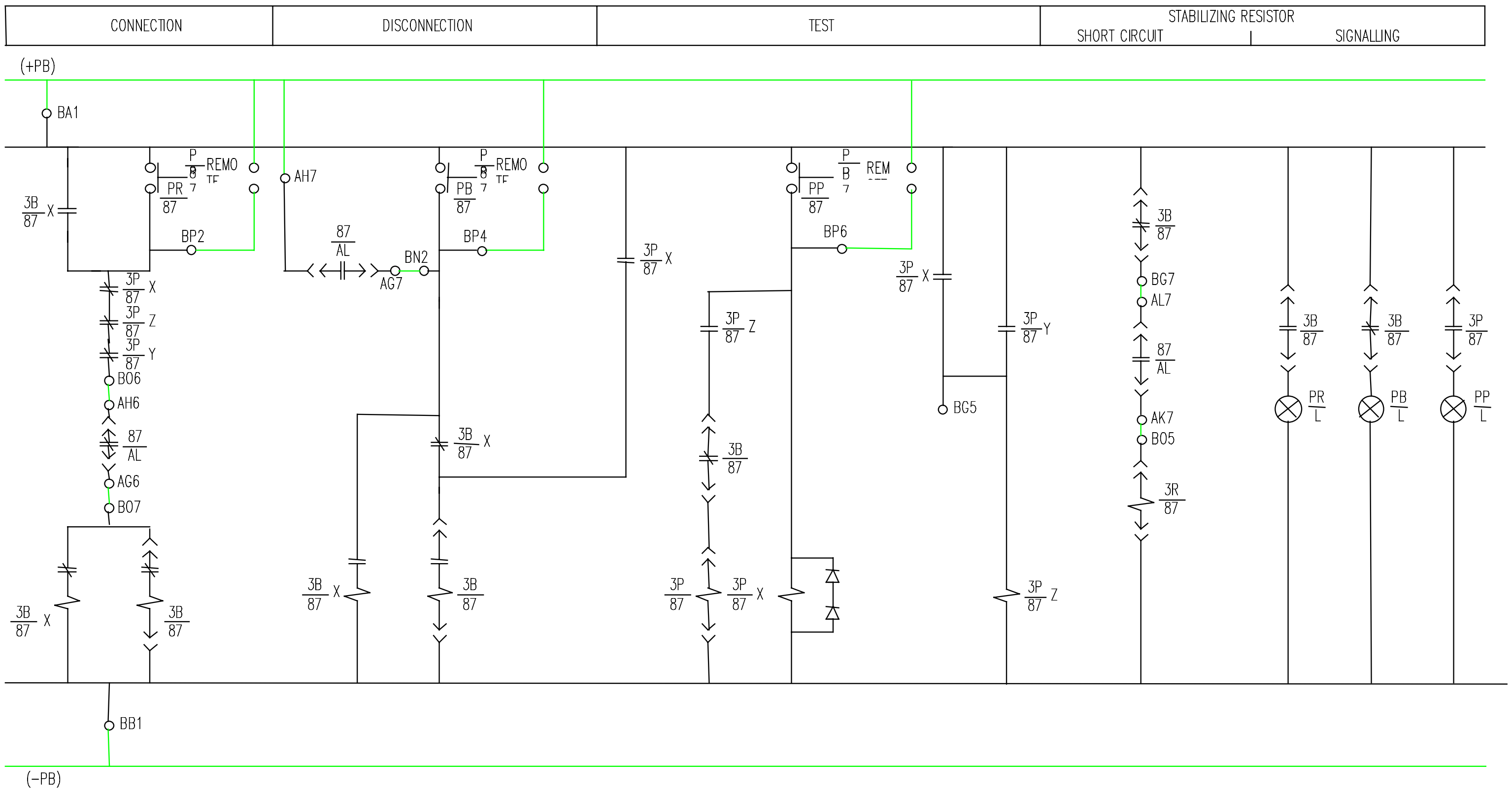
First stage breaker failure tripping contact outputs (B6429F58)



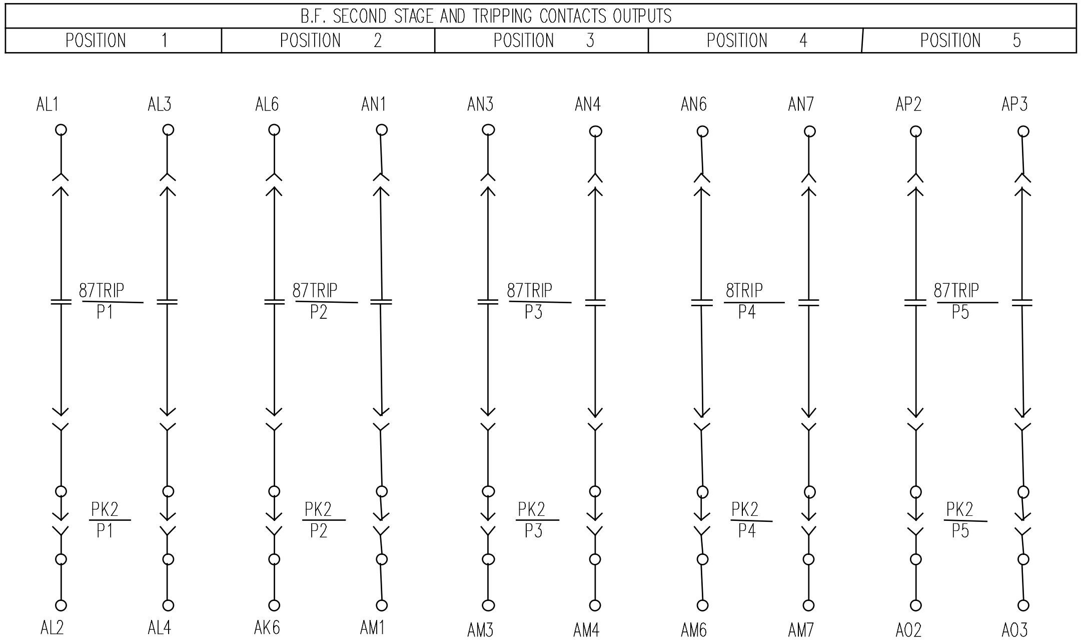
Second stage breaker failure tripping and signaling (B6429F59)



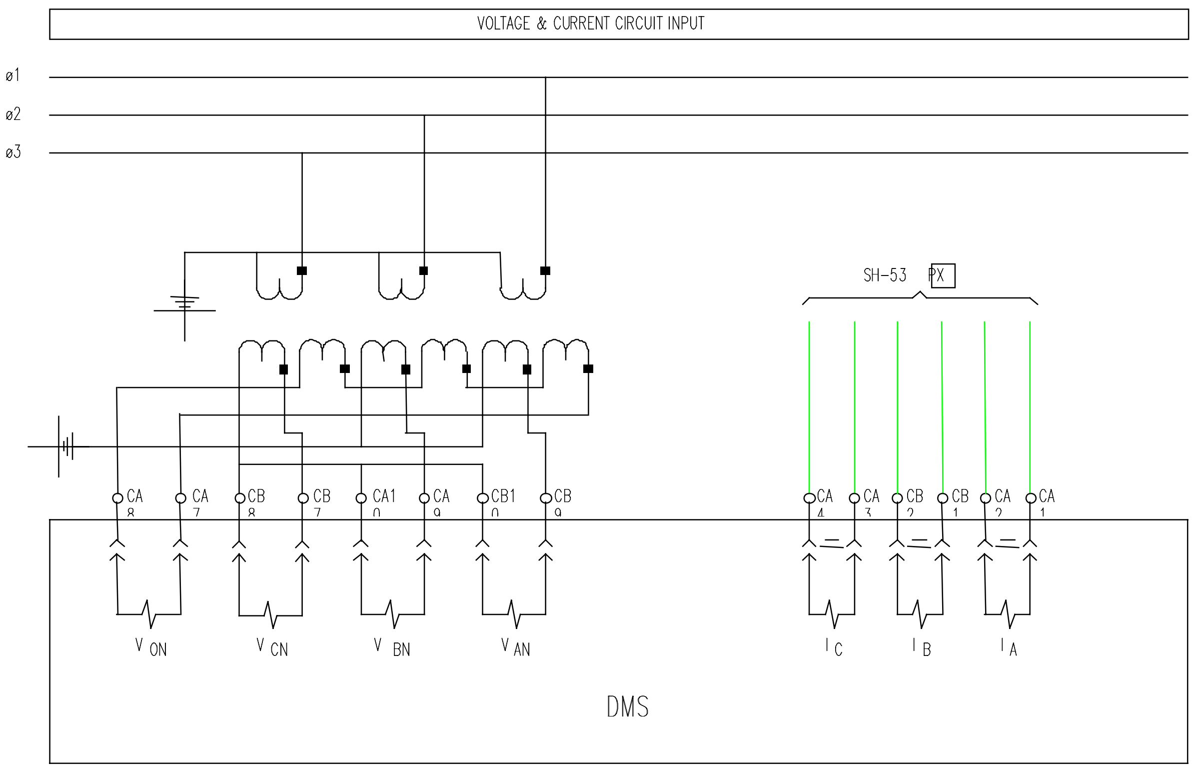
Differential units tripping contact outputs – Positions P1, P2, P3, P4, P5 (B6429F60)



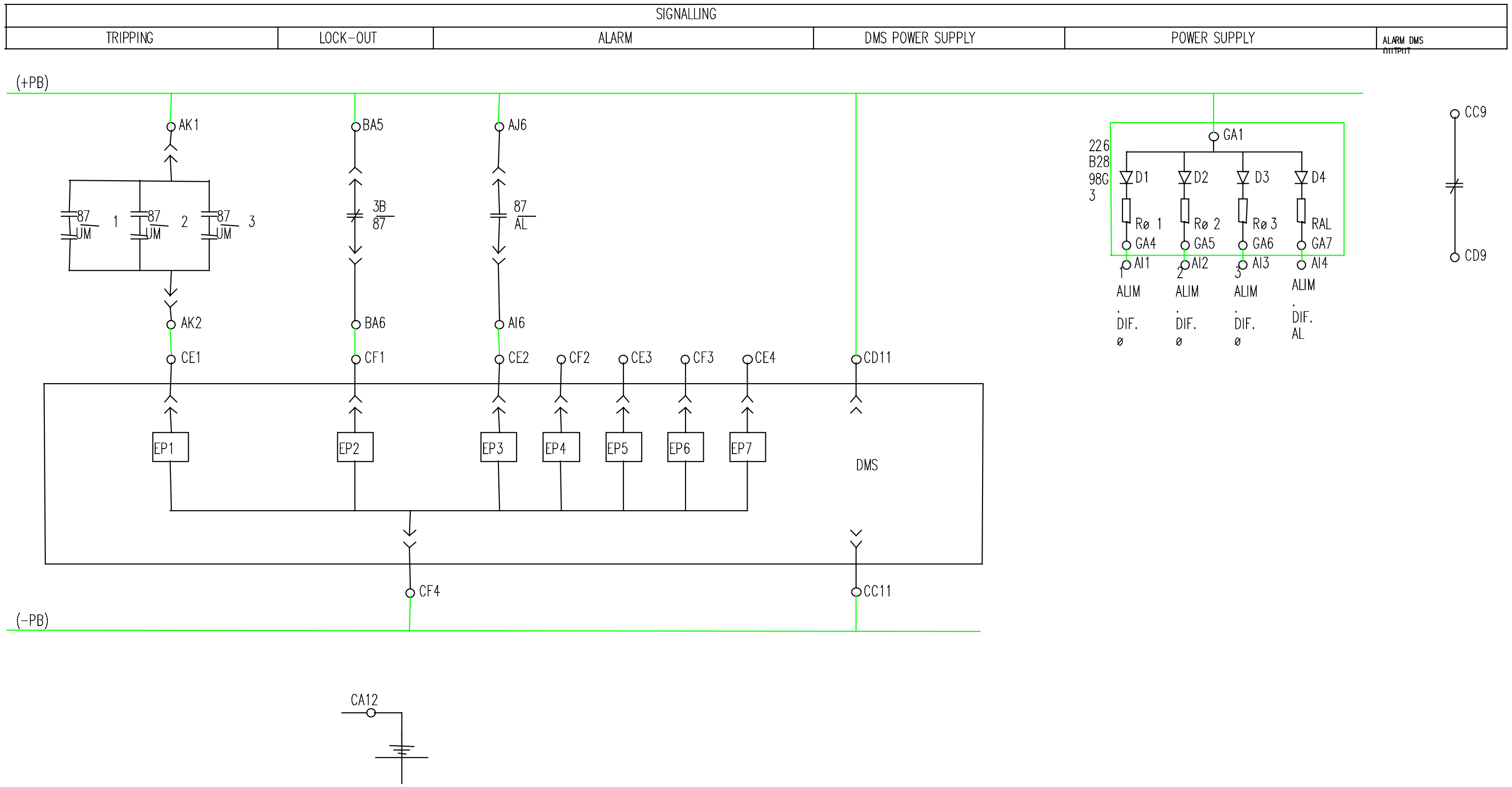
Differential unit A connection, disconnection and test (B6429F61)



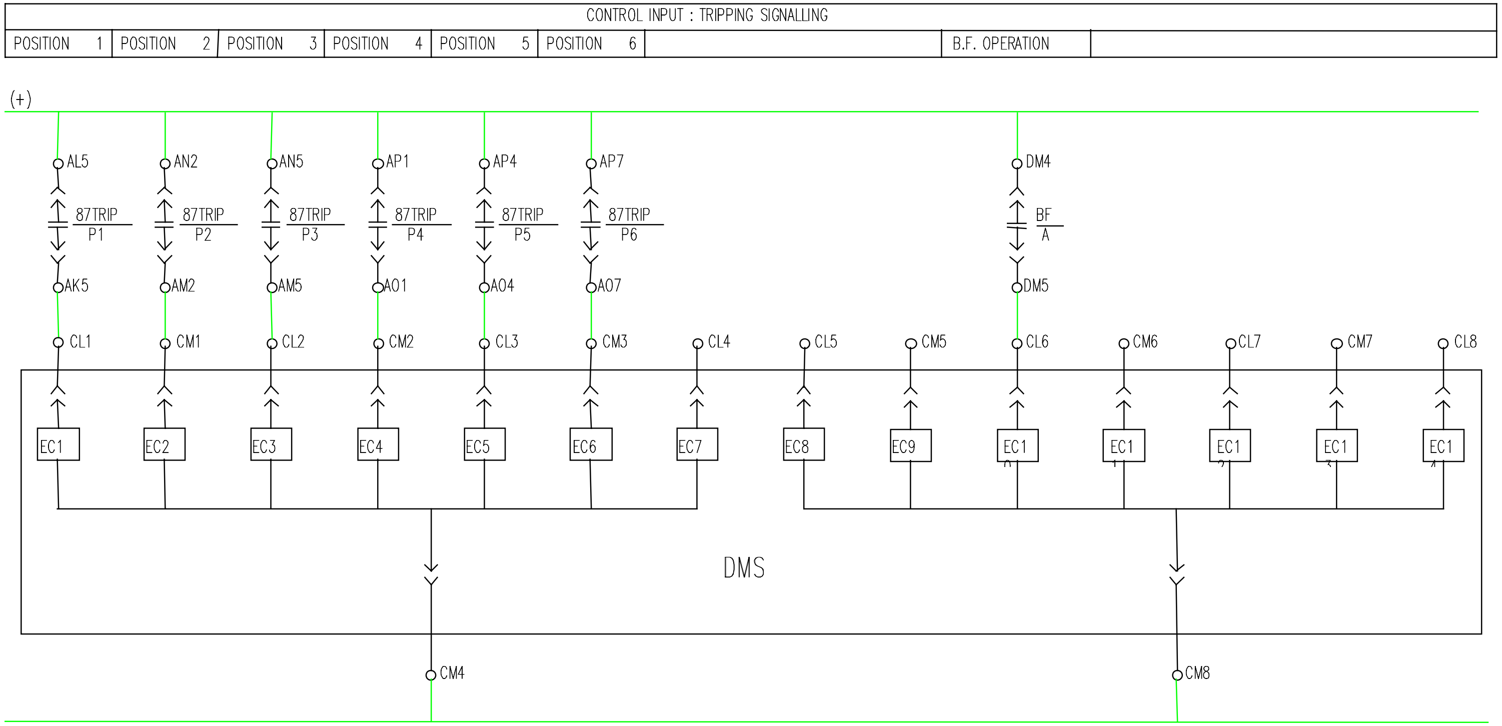
Tripping Contact Outputs P1, P2, P3, P4, P5 (B6429F62)



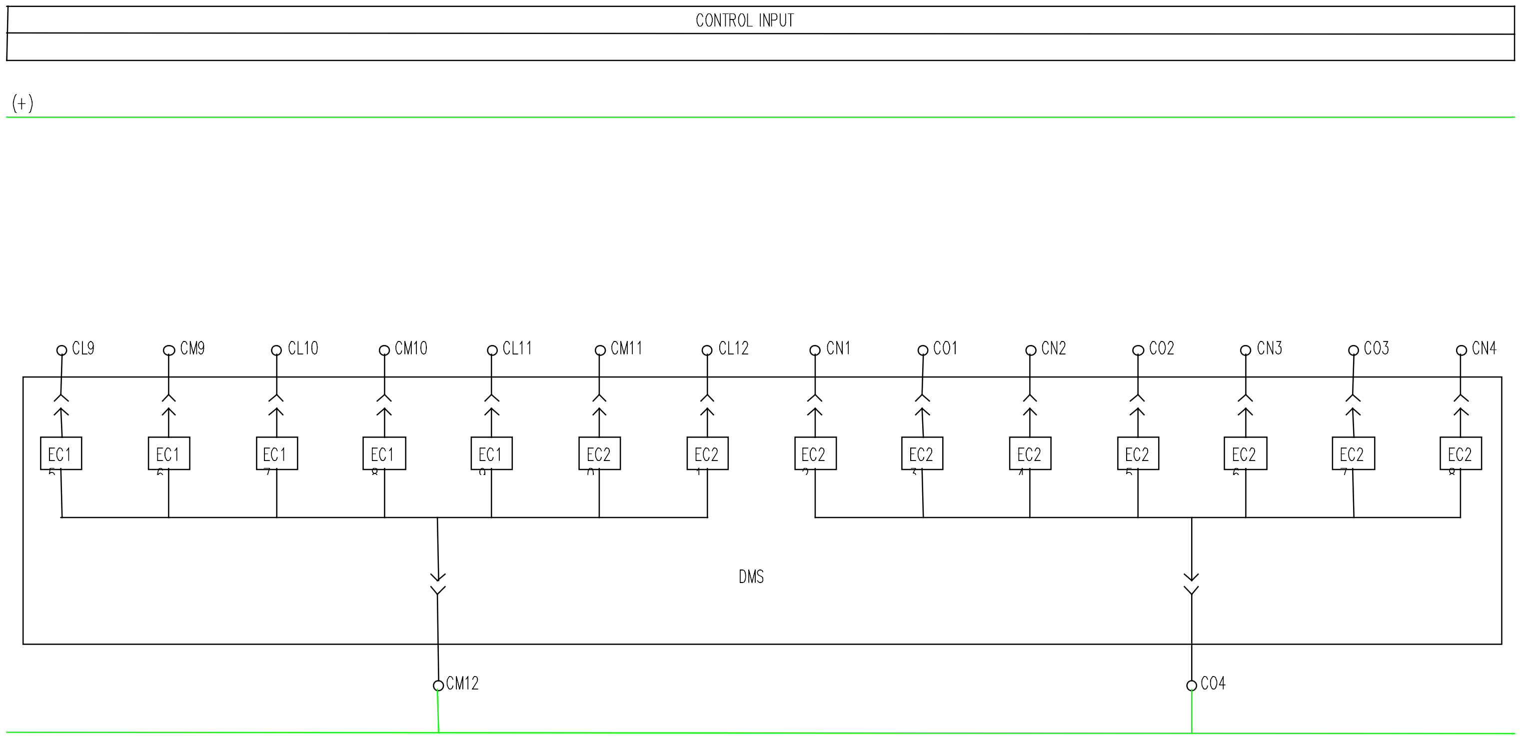
Three line current and voltage diagram (B6429F63)



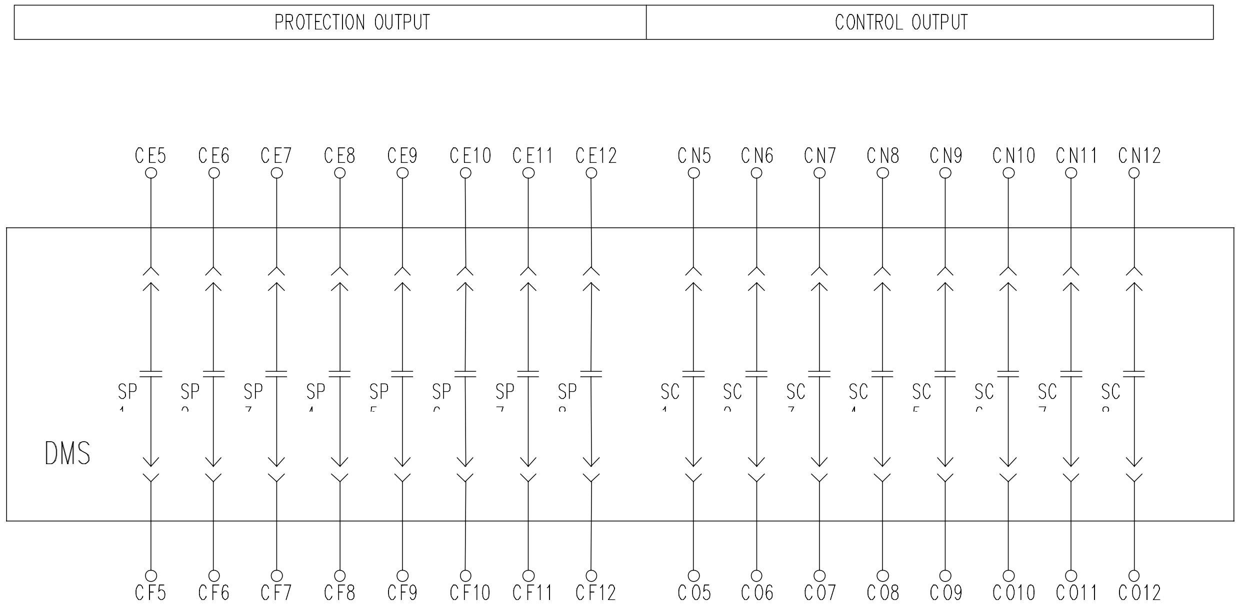
Input signaling to the DMS unit (B6429F64)



DMS Control Input (B6429F65)



DMS Control Input (B6429F66)



Protection Output & Control Output (B6429F67)

LEGEND

FUNCTIONAL UNIT		DEVICE TYPE	DESCRIPTION
52/ P1....P5		BREAKER	BREAKER/BUS COUPLER, POSITIONS P1....P5
TI/P1....P5		MAIN CT	MAIN CURRENT TRANSFORMER / POSITIONS P1....P5
TI AUX / P1....P5		TRANSFORMER 226B2999	AUXILIARY CURRENT TRANSFORMER / POSITIONS P1....P5
87A-87B (1), (2), (3)		BUS1000	DIFFERENTIAL RELAY ZONES A, B PHASES 1, 2, 3
	RE	BUS1000	STABILIZING RESISTOR
	T. DIF	BUS1000	DIFFERENTIAL CIRCUIT INPUT CURRENT TRANSFORMER
	AL	BUS1000	ALARM UNIT
	RD	BUS1000	DIFFERENTIAL VOLTAGE RESISTOR
	RF	BUS1000	RESTRAINT VOLTAGE RESISTOR
	TRIP	BUS1000	BREAKER FAILURE UNIT
TP1....TP9		TERMINAL	DIFFERENTIAL AND RESTRAINT VOLTAGE TESTING POINTS (FOR MEASURING
EB, P1.....P5/TF		DFI	RESTRAINT TRANSF. BUS COUPLER POSITIONS P1....P5 (INPUT MODULE)
43/ ALARM-DIFF.		TEST UNIT DPR	SELECTOR SWITCH OF ALARM DIFF. TEST
43/ TAPS		TEST UNIT DPR	SELECTOR SWITCH OF TAP SELECTION
43/ 1-2-3		TEST UNIT DPR	SELECTOR SWITCH OF PHASE SELECTION
BFA+50/EB		MFI	B.F. & OVERCURRENT SUPERVISION RELAYS / BUS COUPLER
AFI1, AFIAFI2, AFIAFI3 / P1....P5 AFI3		EXTERNAL CONTACT	BREAKER FAILURE INITIATION P1...P5
BF / A		DTE	BREAKER FAILURE FIRST STAGE ZONES A-B
BFA /X		DTE	AUXILIARY OF BF /A
50 / P1....P5		MFI	OVERCURRENT SUPERVISION CONTACT POSITONS P1....P5
87X/TRIP 1, 2, 3		DRD	DIFFERENTIAL UNIT TRIPPING CONTACT
87Y / TRIP		DRD	AUXILIARIES OF 87A /TRIP
3B / 87		LATCHING RELAY	LOCKOUT RELAY 3B/87A
87 TRIP / P1....P5		DRS	TRIPPING RELAY
PR / 87 A – 87 B		TEST UNIT	CONNECTION SWITCH
PB / 87 A – 87 B		TEST UNIT	DISCONNECTION SWITCH
PP / 87 A – 87 B		TEST UNIT	TEST SWITCH

FUNCTIONAL UNIT	DEVICE TYPE	DESCRIPTION
3BX / 87 A – 87 B	TEST UNIT	AUXILIARY OF 3B / 87
3PX, 3PY, 3PZ / 87 A	TEST UNIT	AUXILIARY OF 3P / 87A
3PX, 3PY, 3PZ / 87 B	TEST UNIT	AUXILIARY OF 3P / 87B
PPY/ 87A-87B-87C	TEST UNIT	AUXILIARY OF PP/87A, 87B
PR, PB, PP /L	TEST UNIT	CONNECTION DISCONNECTION TEST LAMPS
BF / P1....P5	SFI	BREAKER FAILURE POSITIONS P1....P5
87X / TRIP	DRD	AUXILIARY DIFFERENTIAL RELAY
SP1....SP8	DMS	PROTECTION OUTPUTS
SC1....SC8	DMS	CONTROL OUTPUTS

NOTE:

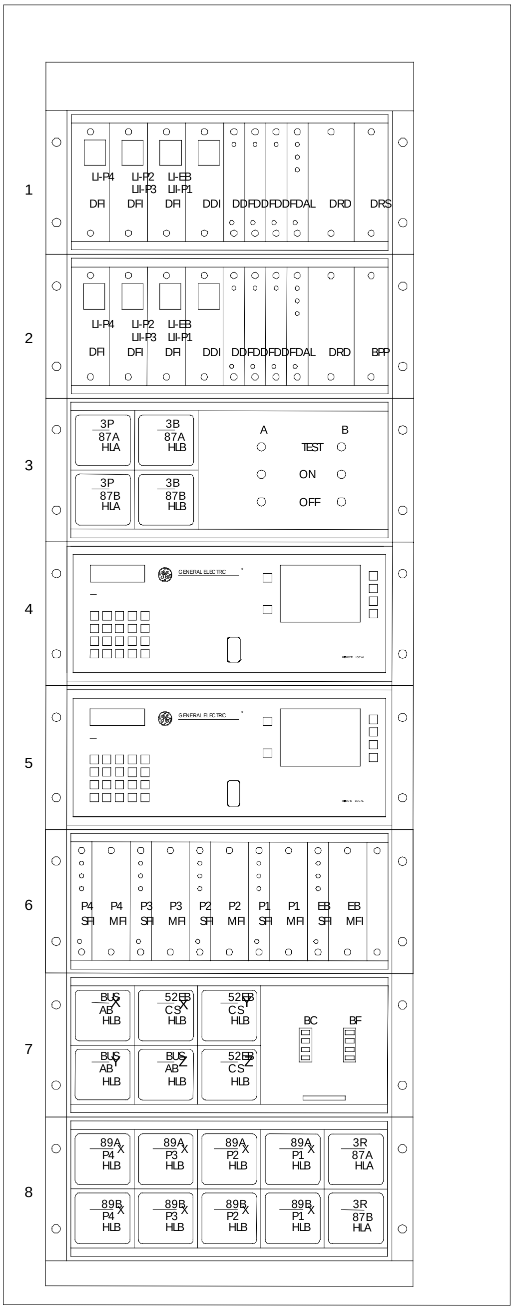
TERMINAL BLOCKS BEGINNING WITH “**A**” BELONG TO DIFFERENTIAL RACK A BBD 156
TERMINAL BLOCKS BEGINNING WITH “**B**” BELONG TO TEST RACK BTR 111
TERMINAL BLOCKS BEGINNING WITH “**C**” BELONG TO AUXILIARY RACK (DMS3LSD4MB001A)
TERMINAL BLOCKS BEGINNING WITH “**D**” BELONG TO BREAKER FAILURE
TERMINAL BLOCKS BEGINNING WITH “**K**” BELONG TO TEST BLOCK
TERMINAL BLOCKS BEGINNING WITH “**Y**” BELONG TO POWER SUPPLY RESISTOR BOX. DIF A
TERMINAL BLOCKS BEGINNING WITH “**T**” BELONG TO THYRITES BOX
TERMINAL BLOCKS BEGINNING WITH “**R**” BELONG TO STABILIZING RESISTOR

18. CABINET'S FRONT AND INSIDE VIEW

The BUS2000 represented in the scheme is housed in three cabinets. The auxiliary CT are located in the third cabinet.

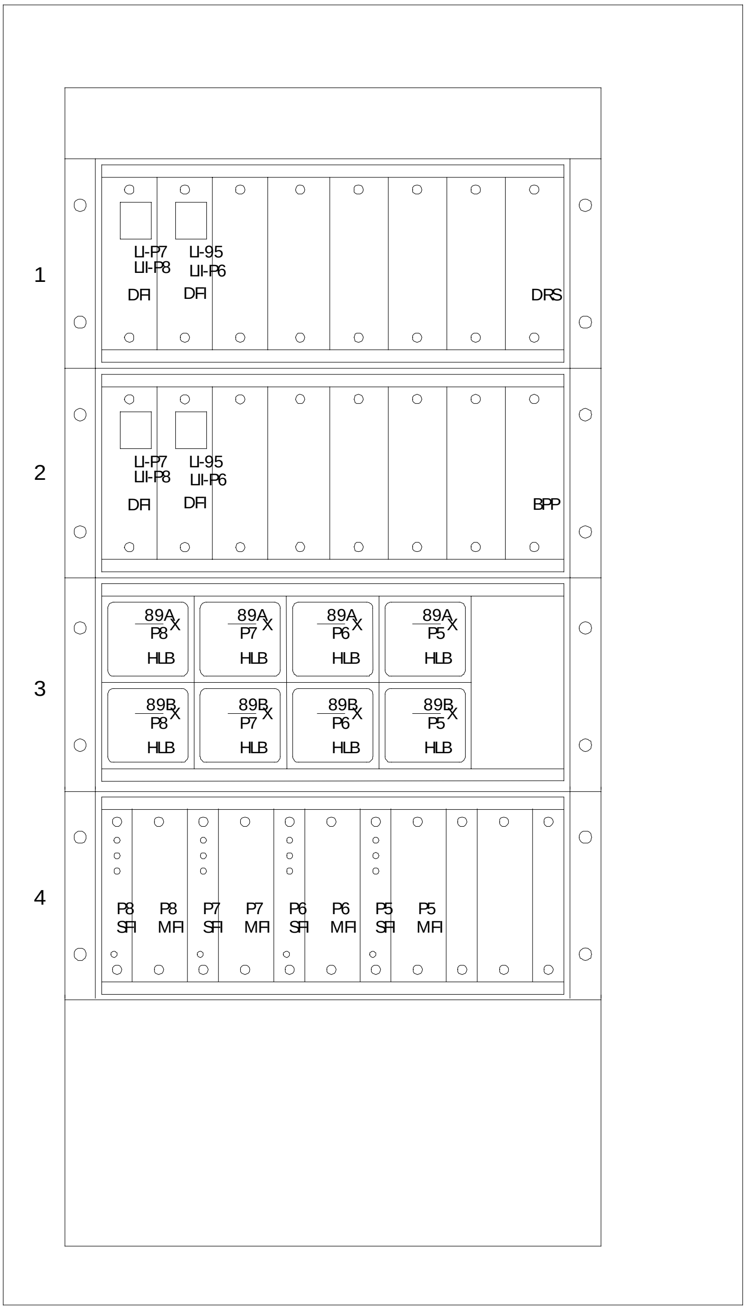
1st Cabinet Front View (226B6430F15)
2nd Cabinet Front View (226B6430F16)

1st Cabinet Inside View (189C3170F86)
2nd Cabinet Inside View (189C3170F87)
3rd Cabinet Inside View (189C3170F88)



1. ZONE A DIFFERENTIAL RACK
2. ZONE B DIFFERENTIAL RACK
3. TEST RACK (ZONES A & B)
4. DMS "A"
5. DMS "B"
6. BREAKER FAILURE RACK
7. ACCESORY FUNCTIONS RACK (BUS COUPLER A & B)
8. LATCHING RELAYS FOR CURRENTS SELECTION AND STABILIZING RESISTORS SHORTING AUXILIARY DEVICES

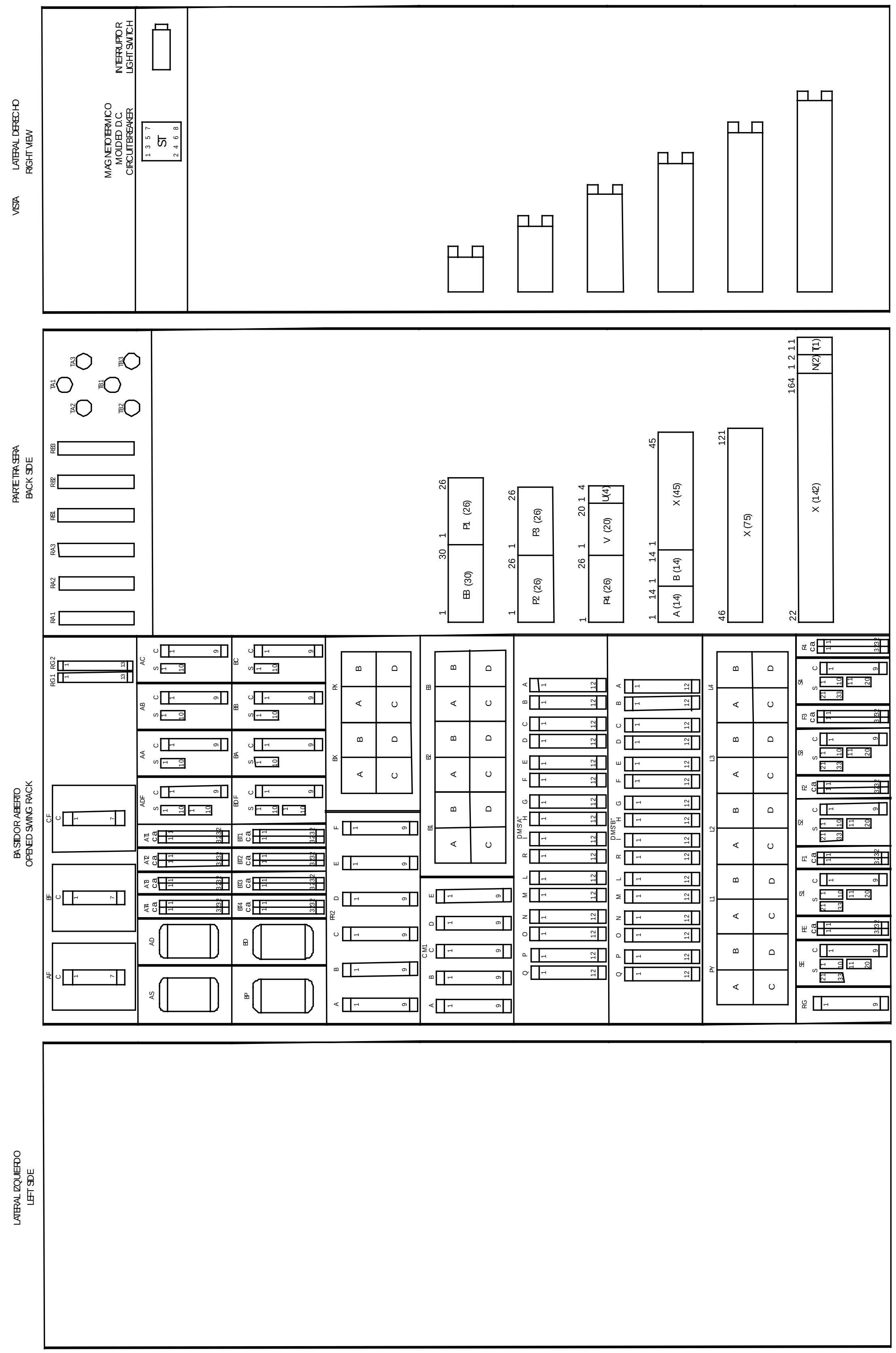
1st Cabinet Front View (226B6430F15)



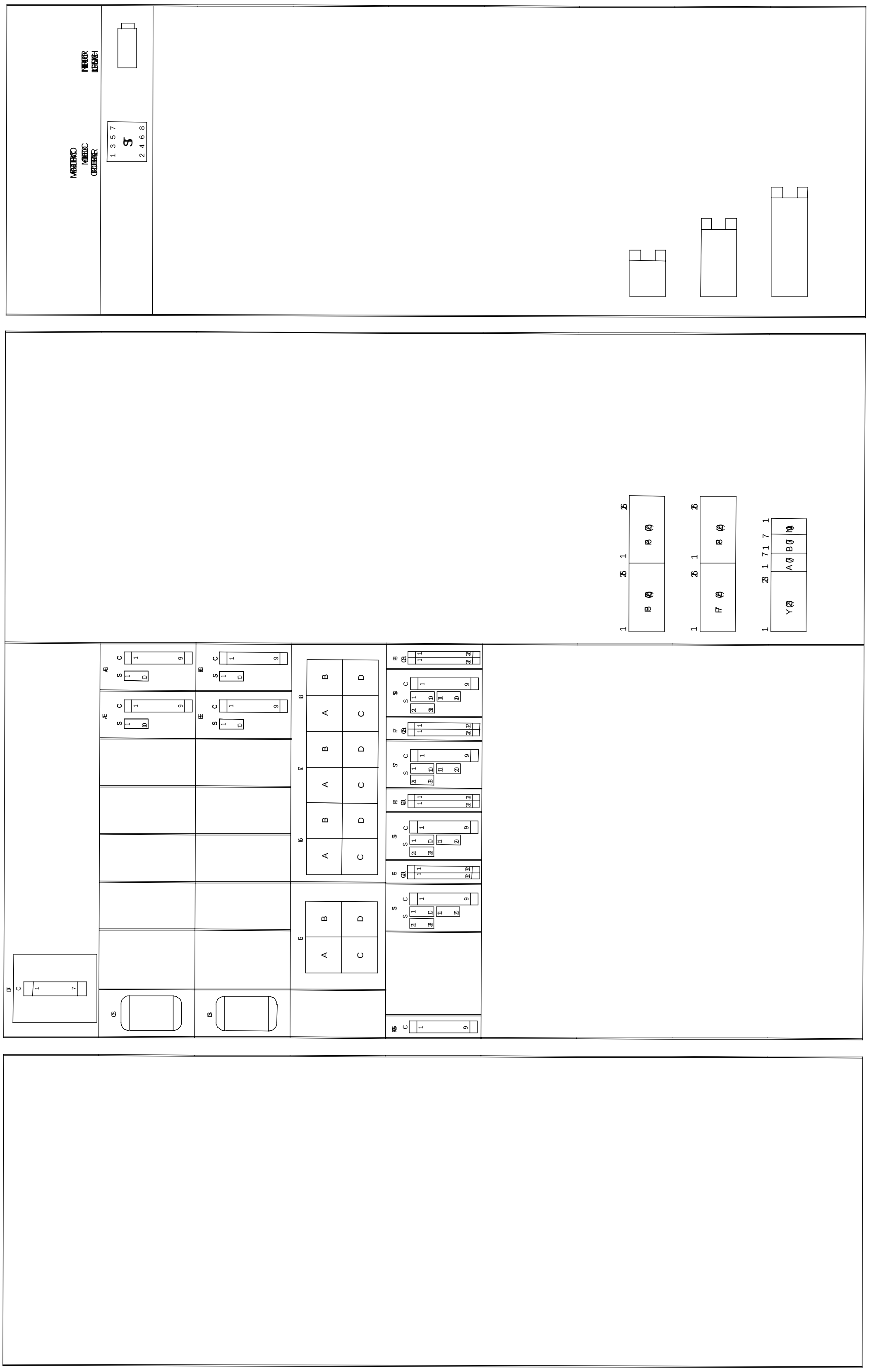
1. ZONE A ADDITIONAL LINES INPUT RACK.
2. ZONE B ADDITIONAL LINES INPUT RACK.
3. LATCHING RELAYS FOR CURRENT SELECTION RACK.
4. BREAKER FAILURE RACK.

2nd Cabinet Front View (226B6430F16)

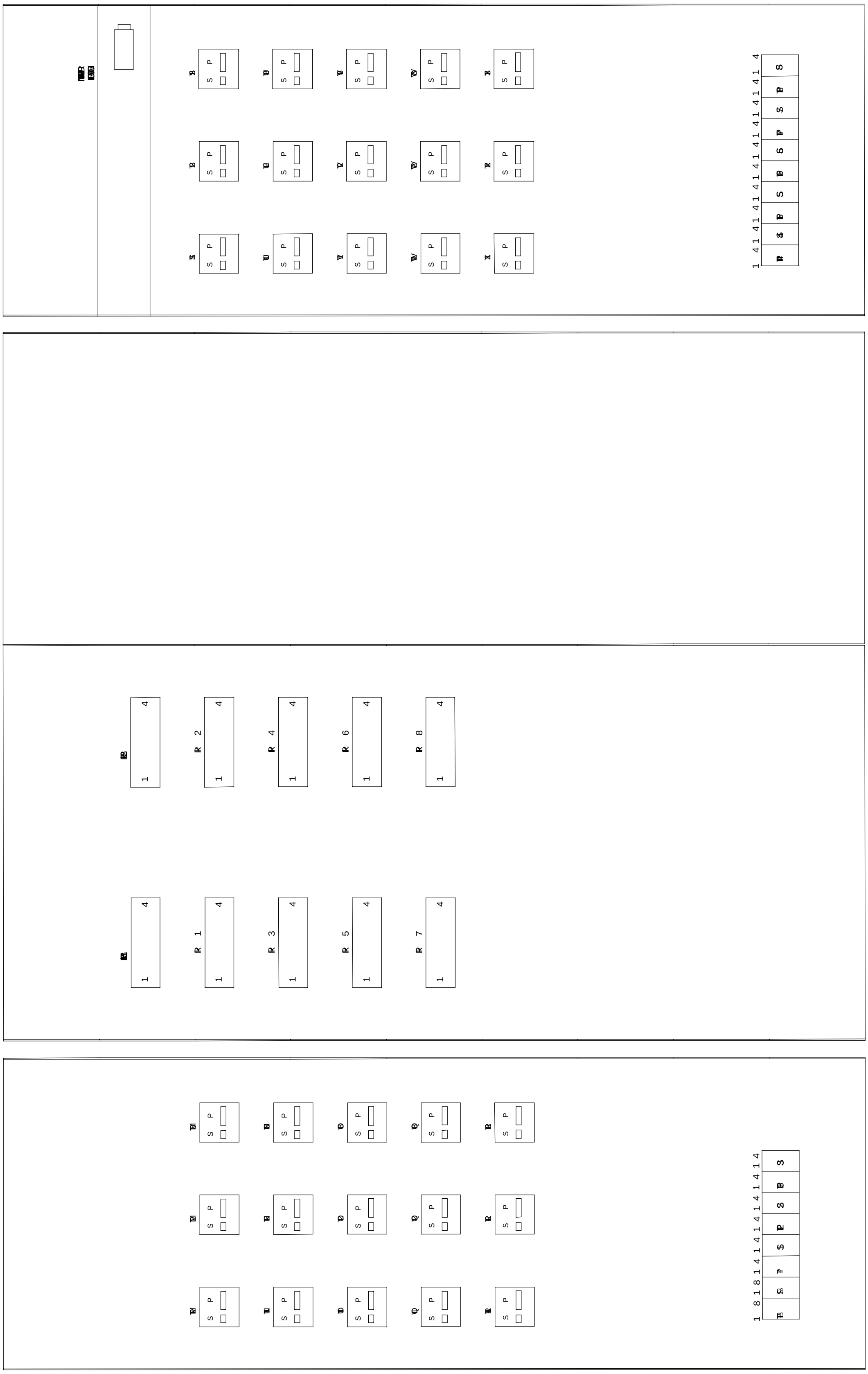
18. CABINETS FRONT AND INSIDE VIEW



1st Cabinet Inside View (189C3170F86)



2nd Cabinet Inside View (189C3170F87)



3rd Cabinet Inside View (189C3170F88)