GE Consumer & Industrial

Multilin

DFF

Digital Frequency Relay
Instruction manual
GEK-106166F

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1. GENERAL DESCRIPTION AND APPLICATION

New technology has allowed a significant advance in the concept of integration between different components of the electrical system. The reasons for such integration are several:

- Reduce the investment in new equipment.
- Optimize the use of the existing installations.
- Improve the energy management system.

This integration of functions not only includes the switchgear protection and control devices, but also the monitoring elements, the alarm signalling equipment (with its associated treatment) and finally the analysis of all the available information (events, alarms, oscillography, load and demand profiles, etc.).

The DFF is a multi-microprocessor based protection relay used for frequency supervision in an electrical system.

Frequency variations originate from unbalance conditions between generation and load. The main reasons for this condition are:

- Inadequate load forecast or deficient generation capacity programming.
- Busbars, generator group or interconnection feeders trip.
- System splits into islands.

When the frequency variation is small, the unbalance condition will be corrected by the generator's regulator. In the case of big frequency variations, the regulator is not able to correct itself, and the frequency value will decrease with the danger of losing generation capacity.

If this underfrequency condition is not corrected, then a general blackout may occur.

In case of a shortage of generation capacity, the only possible way of recovering the stability of the system is through a selective load shedding scheme. The load disconnection is done when the frequency goes down below certain thresholds in order to provide adequate reaction time for the generators to recover via their speed regulators.

It is important to point out that when the frequency decreases quickly, relays operation based on the detection of underfrequency condition may not be enough to recover stability. In this case the load shedding scheme must also take into account the rate of change of frequency. This is done by calculating the frequency derivative over time. Loads are "shed" based not only on an absolute (static) underfrequency threshold, but also on the dynamic rate of change of frequency.

The DFF is mainly used in medium voltage and distribution substations as a selective load shedding scheme. By doing so, frequency recovers stability and potentially dangerous situations that might affect generators in other parts of the electrical system are avoided.

The DFF available functions are:

a) Protection

- Eight underfrequency units, settable as absolute or rate of change.
- Voltage unit to supervise frequency units.
- Undervoltage unit.
- Overvoltage unit.

b) Status/Actual Values

- Phase and ground voltage measurement.
- Frequency measurement.
- Frequency rate of change measurement.
- 17 LED indicators (16 of them user configurable).
- Self-checking and monitoring.

c) Post-Event Analysis

- Events Log.
- Oscillography: Waveform Capture or Frequency Trending.

d) Interfaces and Communications

The DFF has three communications ports:

- RS232 on the front panel
- RS232 on the rear
- Fiber Optic/RS485 option on the rear (selected by order code).

DFF support Software:

- **Communication software GE-LOCAL and DFFPC** (view and modify the protection settings, alarms, internal status, measurements, etc.)
- **Configuration software GE-INTRO** (configure the inputs, outputs, alarms and LEDs.)
- **Oscillography software GE-OSC** (view and analyze waveform captured data.) The oscillography is stored in a file in COMTRADE format (IEEE C37.111-1991 Standard).

These software packages are integral part of GE-NESIS software (General Electric NEtwork Substation Integration System).

2. OPERATING PRINCIPLES AND SETTINGS

DFF relay measures frequency by detecting the voltage zero crossings and measuring the time between them. When the frequency is detected to be below the setting, the relay starts counting for how many consecutive half-periods (semi cycles) it continues below the setting. There is a setting called "**SEMICYCLES SET**" to adjust the number of half-periods for the unit to pickup.

It is possible that the frequency transiently restores and goes above the underfrequency threshold. If this occurs, the DFF freezes the counter to pickup and starts counting the number of semi cycles to reset the unit. If the count of semi cycles to reset reaches the value set in the setting "**SEMICYCLES RESET**" then the unit is reset. On the other hand, if the frequency goes again below the threshold, the DFF will continue the count of semi cycles to set, from where it was left.
If the "**SEMI CYCLES SET**" count is reached the pickup signal of the unit is activated and the relay starts the count of the time delay set independently for each frequency unit.

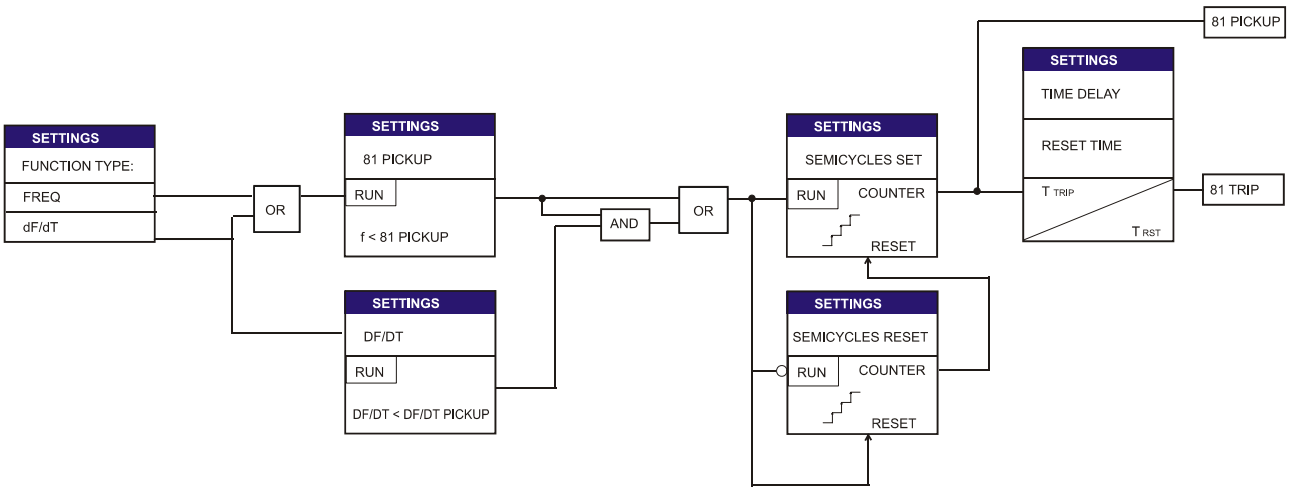
When the time delay expires, the trip signal of the unit is activated.

The "**SEMICYCLES SET**" and "**SEMICYCLES RESET**" settings are common for the eight frequency units.
The time delay (**TIME DELAY** and **RESET TIME**) are independent for each one of the eight units.

The relay provides the **PICKUP** signal and the **TRIP** signal for each one of the eight units as internal digital signals, to allow the user to configure the output contacts as required for each application.

GE INTRO software must be used to change the factory default configuration of output contacts or LEDs.

The following functional block diagram shows the operation of the relay, as described above, and shows the **PICKUP** and **TRIP** signals for each unit.



Drawing: 301A8000

FIGURE 2.1. DFF FUNCTIONAL BLOCK DIAGRAM

2.1 PROTECTION FUNCTIONS

2.1.1 FREQUENCY UNITS

The DFF relay incorporates 8 underfrequency units. All frequency units are supervised by a voltage unit that inhibits the frequency units in case the voltage decreases below the threshold.

The main settings for the frequency elements are:

GENERAL SETTINGS GROUP (Common to all Protection Functions of the relay)

Name	Limits	Default	Step
RELAY STATUS	NO SERV / IN SERV	NO SERV	N/A
FREQUENCY	50 / 60 Hz	50	N/A
NOMINAL VOLTAGE	90 – 220 Vac	90	1
INHIBIT V	40 – 110 %	40 %	1
SEMICYCLES SET	3 – 20	3	1
SEMICYCLES RESET	0 – 4	0	1
PHASE VT RATIO	1 – 4000	1000	1
GROUND VT RATIO	1 – 4000	1000	1

SETTINGS FOR EACH INDIVIDUAL FREQUENCY ELEMENT (for example 81 N1)

Name	Limits	Default	Step
FUNCTION TYPE	FREQ. Or dF/dT	FREQ.	N/A
81 PICKUP	40.00 – 70.00 Hz	50 Hz	0.01 Hz
TIME DELAY	0.00 - 60.00 s	1.00 s	0.01 s
dF/dT	-10.00 to -0.10 Hz/s	- 0.75 Hz/s	0.01 Hz/s
RESET TIME	0.00 - 600.00 s	0.00 s	0.01 s

***NOTE**: The measuring resolution of the DFF equipment is always better than 5 mHz. However to avoid fluctuations on the LCD display, the frequency is displayed in steps of 10 mHz. Measurements in 5 mHz steps are reflected on the oscillogram.*

GENERAL SETTINGS DESCRIPTION

- **RELAY STATUS**: The relay can be switched in or out of service (**NO SERV** / **IN SERV**)
- **FREQUENCY**: Defines the nominal frequency of the network (50 Hz / 60 Hz)
- **NOMINAL VOLTAGE**: Defines the secondary phase-phase Vac nominal voltage applied to the relay.
- **INHIBIT V**: The relay incorporates an inhibit voltage element with a user settable threshold **INHIBIT V**.
- **SEMICYCLES SET**: The DFF includes a counter that increments in semi cycles during an underfrequency situation. For example 5 semi cycles of 50Hz is equivalent to 50ms delay. This acts as a time delay to filter spurious variations in the input signal to the frequency unit. The counter is initially frozen if the frequency restores and it is reset by the operation of the **SEMICYCLES RESET** counter. This counter activates the Frequency Element pick up signal when the count exceeds the **SEMICYCLES SET** threshold.
- **SEMICYCLES RESET**: The DFF includes a counter that increments in semi cycles when the frequency restores. This counter resets the **SEMICYCLES SET** counter when the count exceeds the **SEMICYCLES RESET** threshold.
- **PHASE VT RATIO**: Defines the ratio of the HV phase voltage transformer.
- **GROUND VT RATIO**: Defines the ratio of the HV zero sequence voltage transformer.

SETTINGS FOR EACH INDIVIDUAL FREQUENCY ELEMENT (for example 81 N1)

- The **FUNCTION TYPE** setting adjusts the operation of the frequency unit as absolute frequency or rate of change of frequency (**df/dt**).
- The **81 PICKUP** is the pickup value for the unit if it is set as **FREQ** and for the underfrequency supervision element if it is set as **df/dt**.
- The **TIME DELAY** is the intentional time delay of the unit to produce a trip after pick up.
- **dF/dT** is the instantaneous value of the rate of change of frequency that will produce a trip if the **FUNCTION TYPE** is set as **df/dt**, and the supervision elements have operated.
- **RESET TIME** is the time the frequency units maintain the tripping signal after the condition that caused the trip has disappeared.

OPERATION IN FREQ MODE:

Select the setting **FUNCTION TYPE** as **FREQ**. (The setting value of **dF/dT** is now ignored). The operation time of this unit will depend on the setting of **TIME DELAY**. The pickup will occur once the adjusted “number of semi-cycles” expire, (common setting for all units), and the trip will take place when the time delay ends (note that tripping conditions should persist during all the time delay).

OPERATION IN DF/DT MODE:

To adjust a unit as rate of change select the setting **FUNCTION TYPE** as **dF/dT**.

In order to issue a trip in this operating mode the frequency has to be lower than the adjusted value in setting **81 PICKUP** AND the rate of change of frequency must be more negative than the setting value of dF/dT.

2.1.2 VOLTAGE UNITS

The DFF has 3 voltage units.

Inhibit voltage unit :

This unit supervises the phase voltage used for frequency calculation (phase B, of A**B**C). This unit is adjusted in the **GENERAL SETTINGS** menu as described above. It is set as a percentage of the nominal voltage. The range goes from 40 to 110 % of the nominal voltage (also adjustable). If the voltage measured in phase B goes below the setting, all frequency units will be inhibited.

Undervoltage unit :

This unit measures phase B voltage. The settings are as follows:

Name	Limits	Default	Step
27P PICKUP	20.00 – 110.00 Vac	50 Vac	0.01 Vac
TIME DELAY 27P	0.00 - 30.00 s	5 s	0.01 s
RESET TIME 27P	0 - 1200 s	0 s	1 s

- The **27P PICKUP** setting is the voltage operating value. If phase B measured voltage value goes below this setting, the unit picks up.
- The **TIME DELAY 27P** setting is the associated time delay for the undervoltage unit. The unit's trip takes place only after this time expires, taking into account that the voltage level must be lower than the setting during the course of the time delay.
- The **RESET TIME 27P** setting is the time that the unit maintains the tripping contacts closed once the trip command has been issued and the undervoltage condition has disappeared.

Overvoltage units :

This unit measures phase B voltage. The settings are as follows:

Name	Limits	Default	Step
PICKUP 59P	50.00 – 220.00 Vac	80 Vac	0.01 Vac
TIME DELAY 59P	0.00 – 30.00 s	5 s	0.01 s
RESET TIME 59P	0.00 – 30.00 s	0 s	0.01 s

- The **PICKUP 59P** setting is the voltage operating value. If phase B measured voltage value goes above this setting the unit picks up.

- The **TIME DELAY 59P** setting is the associated time delay for the overvoltage unit. The trip takes place only after this time expires. The voltage level must be higher than the setting during the course of the time delay.

- The **RESET TIME 59P** setting is the time that the unit maintains the tripping contacts closed once the trip command has been issued and the overvoltage condition has disappeared.

STATUS AND ACTUAL VALUES

2.2.1 MEASUREMENT

The DFF provides measurement values for:

- Three phase voltages
- One ground voltage
- Frequency
- Rate of change of frequency

The DFF calculates the fundamental frequency RMS voltage phasor for each phase and for ground. Measurement can be accessed through the local front display and from the **GE_LOCAL** or **DFFPC** communications software. All the values are affected by the external transformers´ ratio (**PHASE VT RATIO** and **GROUND VT RATIO** defined in **GENERAL SETTINGS**).

2.2.2 TARGET LEDS

In the DFF, a total of 17 LEDs are available, one bicolor LED (red/green)for the internal alarm function plus 16 red LED's configured as the table shown below.

LEDs configured for trip indication (9 to 16) include a memory feature, and they remain lit until the user presses the **TARGET RESET button for 3 seconds**.

The memory feature covers also for lost of Vdc auxiliary power.

There is a test facility for the LEDs, by pressing the **TARGET RESET** button for less than 3 seconds, all LED's will be lit without being reset.

The factory default configuration of the DFF is the following:

LED	DESCRIPTION	MEMORY	LED	DESCRIPTION	MEMORY
1	Pickup L1	NO	9	Trip L1	YES
2	Pickup L2	NO	10	Trip L2	YES

LED	DESCRIPTION	MEMORY	LED	DESCRIPTION	MEMORY
3	Pickup L3	NO	11	Trip L3	YES
4	Pickup L4	NO	12	Trip L4	YES
5	Pickup L5	NO	13	Trip L5	YES
6	Pickup L6	NO	14	Trip L6	YES
7	Pickup L7	NO	15	Trip L7	YES
8	Pickup L8	NO	16	Trip L8	YES

2.2.3 SELF-CHECKING AND DIAGNOSIS

The DFF includes self-checking and auto-diagnosis.

These tests are performed during the power-up process of the relay and during normal operation. They check the status of the power supply, ROM memory, RAM memory, oscillography memory and the EEPROM memory.

In case of an internal failure these functions detect the failure, disable the operation of the protection functions and warn the user by operating the ALARM contact (terminals C9-D9).

2.3 ANALYSIS FUNCTIONS

2.3.1 EVENT LOGS

The DFF relay has a circular log of the latest 144 events. Each event stores the following information:

- Date and time (1 msec resolution)
- Type of event
- Voltage
- Frequency
- dF/dT measurement
- Status of all internal digital signals (trips, pickups, inputs, outputs, etc.).

The events are stored in non-volatile EEPROM memory.

2.3.2 OSCILLOGRAPHY

There are two types of record selectable by the **OSCILLO TYPE** setting: **NORMAL** or **FREQ**.

NORMAL Type

The DFF unit can store up to 4 oscillography records, with a resolution of 16 samples per cycle. Each record has a maximum capacity of 99 cycles, and the number of pre-fault cycles is selectable between 2 and 10. Each record includes the following information:

- Waveforms of instantaneous samples of AC voltage inputs (V_A, V_B, V_C, V_N):
- Frequency value at instant of trigger.
- Digital channels indicating status of protection functions.
- Date and time.
- Trigger source.
- Active settings.

FREQ Type

The DFF unit stores up to 4 oscillography records, with a resolution of 2 samples per cycle. Each record has a maximum capacity of 1584 cycles, and the number of pre-fault cycles is selectable between 2 and 80. Each record includes the following information:

- Frequency trend computed every semi-cycle.
- Digital channels indicating status of protection functions.
- Date and time.
- Trigger source.
- Active settings.

To start an oscillography record, the user can set up to 24 signals that will act as a trigger. For details see **Chapter 2 - LIST OF SETTINGS**.

The waveforms are stored in a file in **COMTRADE** format (IEEE C37.111-1991 Standard).The oscillography record must be retrieved from the DFF relay by using **GE-LOCAL** or **DFFPC** communications software. They can be viewed through **GE-OSC** software or any program that can read **COMTRADE** files. They can also be imported from Microsoft EXCEL.

2.4 SETTING TABLES

The DFF provides three independent setting tables, TABLE 1, TABLE 2, TABLE 3, stored in non-volatile EEPROM memory. Only one table is active at one time.

There are some settings that are common for the three setting tables: **GENERAL SETTINGS, ACTIVE TABLE, OSCILLOGRAPHY MASK** and **FUNCTION PERMIT**. The rest of settings are independent for each table.

There is a setting called **ACTIVE TABLE** that defines which table is being applied.

There is another way of changing the active table. By using up to two digital inputs, called "**TABLE 0 SELECTION**" and "**TABLE 1 SELECTION**" up to four different (0 to 3) combinations are possible.

The selected combination is obtained from the following table:

Number	TABLE 1 SELECTION	TABLE 0 SELECTION	TABLE APPLIED
0	0	0	**ACTIVE TABLE** setting
1	0	1	1
2	1	0	2
3	1	1	3

***NOTE:** If any of the two digital inputs is active the "**ACTIVE TABLE**" setting is ignored*

2.5 INPUTS AND OUTPUTS

2.5.1 DIGITAL INPUTS

The DFF family of relays can have a variety of digital inputs. For details see ordering code in section 5 - **MODEL LIST**. The minimum number of inputs is 7 and the maximum is 14 (two groups of 7 Inputs each with a common terminal for each group). See chapter 4 for details on advanced configuration options.

2.5.2 OUTPUTS

The DFF family of relays provides a variety of digital outputs. For details see ordering code in section 5 - **MODEL LIST**. The minimum number of outputs is 13 and the maximum is 33. Four outputs are pre-assigned to the protection function trips and one for the internal alarm. See chapter 4 for details on advanced configuration options.

2.6 MAN MACHINE INTERFACE (MMI).

The DFF relay includes a 20-button keypad with a two-line LCD display (16 characters per line). The background of the LCD is back lit by LEDs. The contrast can be adjusted through a trimmer accessible behind the front board.

Through this interface, the user can change settings, visualize actual values, etc. Refer to **KEYPAD AND DISPLAY** section.

2.7 REMOTE COMMUNICATIONS

The relay has up to 3 serial communications ports. PORT 1 is accessible at the front of the relay PORTs 2 and 3 are accessed at the rear of the relay.

There are different models depending on the physical media of connector PORT 2 (RS-232, RS-485 or fiber optics). See ordering code at section 5 - **MODEL LIST**.

The connector for PORT1 has priority over connector port2 and is selected once DCD signal (Data Carrier Detect) is activated. See figure 8 for required connections. Use the cable configuration described in the figure or use a standard direct RS-232 cable (no crossings) and a standard Null-Modem adaptor.

PORTS 1 and 2 are fully independent and can be used at the same time. PORT 3 is switched with PORT 1.

The relay is in local communication when using either the MMI or the front port.

Both local and remote communication can be active at the same time, however the possibility of changing settings or performing control operations is limited only to the communication mode with higher priority (local mode). The other channel then will only have access to read the information.

Once the local communication is interrupted, either by the disconnection of port 1 connector or by returning the MMI to the initial screen (done manually pressing **CLR** key or automatically after 15 minutes without any button being pressed), the remote communication mode recovers its lost privileges of being able to change settings or perform control operations.

3. SETTINGS

Setting can be viewed and modified in different ways: through the keypad and display or through a computer connected to a serial port. In order to modify settings manually please refer to section 9 “**KEYPAD AND DISPLAY**”.

The DFF relay has three independent setting tables, TABLE 1, TABLE 2, TABLE 3, stored in non-volatile EEPROM memory. The active table is selected through the **ACTIVE TABLE** setting or with the **TABLE 0 SELECTION** or **TABLE 1 SELECTION** digital inputs. The following groups of settings are common to the three tables:

- **GENERAL SETTINGS**
- **ACTIVE TABLE SETTING**
- **OSCILLOGRAPHY MASK**
- **FUNCTION PERMIT**

The settings that can be selected independently for each table are:

- **27P** - Undervoltage unit
- **59P** - Overvoltage unit
- **81N1** - Underfrequency unit or dF/dT
- **81 N2** - Underfrequency unit or dF/dT
- **81N3** - Underfrequency unit or dF/dT
- **81N4** - Underfrequency unit or dF/dT
- **81N5** - Underfrequency unit or dF/dT
- **81N6** - Underfrequency unit or dF/dT
- **81N7** - Underfrequency unit or dF/dT
- **81N8** - Underfrequency unit or dF/dT

The following tables contain a complete list of the DFF settings common for the three tables, with their associated ranges, units and steps. The column called **DEFAULT** shows the factory default settings:

Table III . Common settings for all tables

Setting type	DESCRIPTION	RANGE	Factory Default	Step
GENERAL SETTINGS				
RELAY STATUS	Put the relay IN or OUT of service	NO SERV / IN SERV	NO SERV	N/A
FREQUENCY	Nominal frequency	50 / 60 Hz	50 Hz	N/A
IDENTIFICATION (can only be changed via a PC)	Alphanumeric string of 20 characters	N/A	Identification	N/A
NOMINAL VOLTAGE	Nominal ph-ph voltage	90 - 220 Vac	90 Vac	1 V
INHIBIT V	voltage inhibition of frequency functions	40 - 110 %	40 %	1 %
SEMICYCLES SET	Number of semi-cycles for the frequency units operation	3 - 20	3	1
SEMICYCLES RESET	Number of reset cycles for the frequency units reset	0-4	0	1
PHASE VT RATIO	VT phase ratio	1 - 4000	1000	1
GROUND VT RATIO	VT ground ratio	1 - 4000	1000	1
ACTIVE TABLE SETTING	**DESCRIPTION**	**RANGE**	**Factory Default**	**Step**
ACTIVE TABLE	Activates a table of settings	1 - 3	1	1
FUNCTION PERMIT	**DESCRIPTION**	**RANGE**	**Factory Default**	**Step**
27P FUNCTION	To enable 27P	Enabled / Disabled	Disabled	N/A
59P FUNCTION	To enable 59P	Enabled / Disabled	Disabled	N/A
81N1 FUNCTION	To enable 81N1	Enabled / Disabled	Disabled	N/A
81N2 FUNCTION	To enable 81N2	Enabled / Disabled	Disabled	N/A
81N3 FUNCTION	To enable 81N3	Enabled / Disabled	Disabled	N/A
81N4 FUNCTION	To enable 81N4	Enabled / Disabled	Disabled	N/A
81N5 FUNCTION	To enable 81N5	Enabled / Disabled	Disabled	N/A
81N6 FUNCTION	To enable 81N6	Enabled / Disabled	Disabled	N/A
81N7 FUNCTION	To enable 81N7	Enabled / Disabled	Disabled	N/A

Setting type	DESCRIPTION	RANGE	Factory Default	Step
81N8 FUNCTION	To enable 81N8	Enabled / Disabled	Disabled	N/A
27P TRIP	To enable 27P TRIP	YES/NO	YES	N/A
59P TRIP	To enable 59P TRIP	YES/NO	YES	N/A
81N1 TRIP	To enable 81N1 TRIP	YES/NO	YES	N/A
81N2 TRIP	To enable 81N2 TRIP	YES/NO	YES	N/A
81N3 TRIP	To enable 81N3 TRIP	YES/NO	YES	N/A
81N4 TRIP	To enable 81N4 TRIP	YES/NO	YES	N/A
81N5 TRIP	To enable 81N5 TRIP	YES/NO	YES	N/A
81N6 TRIP	To enable 81N6 TRIP	YES/NO	YES	N/A
81N7 TRIP	To enable 81N7 TRIP	YES/NO	YES	N/A
81N8 TRIP	To enable 81N8 TRIP	YES/NO	YES	N/A
OSCILLOGRAPHY MASK	**DESCRIPTION**	**RANGE**	**Factory Default**	**Step**
TYPE OF OSCILLO	Define type of oscillo. Voltage Waveforms/Frequency Trending	NORMAL/FREQ	NORMAL	N/A
PREFAULT CYCLES	Number of prefault cycles	2- 10 (NORMAL) 2-80 (FREQ)	4	1
81N1 PICKUP	81N1 PU triggers oscillography	YES/NO	YES	N/A
81N2 PICKUP	81N2 PU triggers oscillography	YES/NO	YES	N/A
81N3 PICKUP	81N3 PU triggers oscillography	YES/NO	YES	N/A
81N4 PICKUP	81N4 PU triggers oscillography	YES/NO	YES	N/A
81N5 PICKUP	81N5 PU triggers oscillography	YES/NO	YES	N/A
81N6 PICKUP	81N6 PU triggers oscillography	YES/NO	YES	N/A
81N7 PICKUP	81N7 PU triggers oscillography	YES/NO	YES	N/A
81N8 PICKUP	81N8 PU triggers oscillography	YES/NO	YES	N/A
81N1 TRIP	81N1 TRIP triggers oscillography	YES/NO	YES	N/A
81N2 TRIP	81N2 TRIP triggers oscillography	YES/NO	YES	N/A
81N3 TRIP	81N3 TRIP triggers oscillography	YES/NO	YES	N/A
81N4 TRIP	81N4 TRIP triggers oscillography	YES/NO	YES	N/A
81N5 TRIP	81N5 TRIP triggers oscillography	YES/NO	YES	N/A
81N6 TRIP	81N6 TRIP triggers oscillography	YES/NO	YES	N/A
81N7 TRIP	81N7 TRIP triggers oscillography	YES/NO	YES	N/A
81N8 TRIP	81N8 TRIP triggers oscillography	YES/NO	YES	N/A
27P PICKUP	27P PU triggers oscillography	YES/NO	YES	N/A

Setting type	DESCRIPTION	RANGE	Factory Default	Step
59P PICKUP	59P PU triggers oscillography	YES/NO	YES	N/A
INPUT TRIGGER	INPUT triggers oscillography	YES/NO	YES	N/A
COMMUNICATIONS TRIGGER	PC or MMI can trigger oscillography	YES/NO	YES	N/A
27P TRIP	27P TRIP triggers oscillography	YES/NO	YES	N/A
59P TRIP	59P TRIP triggers oscillography	YES/NO	YES	N/A

Table IV. INDEPENDENT SETTINGS FOR EACH TABLE (TABLE 1, TABLE 2, TABLE 3)

Setting type	DESCRIPTION	RANGE	Factory Default	Step
27P FUNCTION	UNDERVOLTAGE			
27P PICKUP	27P Pickup	20 to 110 Vac	50	1 Vac
TIME DELAY 27P	Operating time	0 to 30 s	5	0.01 s
RESET TIME 27P	Reset time after fault disappears	0 to 1200 s	0	1 s
59P FUNCTION	OVERVOLTAGE			
59P PICKUP	59P Pickup	50 to 220 Vac	80	1 Vac
TIME DELAY 59P	Operating time	0 to 30 s	5	0.01 s
RESET TIME 59P	Reset time after fault disappears	0 – 30 s	0	0.01 s
81NX FUNCTIONS *	FREQUENCY			
FUNCTION TYPE	Type: Freq. or Rate of change	FREQ / dF/dT	FREQ	N/A
81 PICKUP	81 Pickup	40 to 70 Hz	50 Hz	0.01 Hz
TIME DELAY	Operating time	0 to 60 s	1.00 s	0.01 s
DF/DT	Rate of Change	-0.1 to -10 Hz/s	-1 Hz/s	0.01 Hz/s
RESET TIME	Reset time after fault disappears	0 to 600 s	0	0.01 s

- **8 independent frequency units are provided within each table, 81N1, 81N2, 81N3, 81N4, 81N5, 81N6, 81N7 and 81N8.**

4. EQUIPMENT CONFIGURATION

The DFF is a microprocessor-based relay that samples analog inputs, processes them by means of internal algorithms and activates outputs accordingly. Most of the relay information may be accessed by the user in order to create special configurations of inputs, outputs and LEDs, using AND, OR and NOT logical gates. The DFF presents this information as “Internal Status”, which is a set of logical Boolean states of all the internal variables available inside the relay. Each variable may be a “0” or a “1”. As an example, one internal state is the pickup of a frequency unit. If this unit operates as underfrequency, its internal state will be “1”. This value can be configured to close an output contact or lit an LED.

In the same way if one digital input is activated, its “internal state” goes to “1”, and it can be configured also to close an output contact or to lit an LED.

The DFF device has two different types of internal states:

- Protection internal states.
- General and communication internal states.

The following tables show the list of the internal signals available.

TABLE I. PROTECTION INTERNAL STATES

	Internal States		Internal States		Internal States		Internal States
0	Program Initiation	40	F1 Trip	80	Output 13	120	
1	Settings change	41	F2 Trip	81	Output 14	121	
2		42	F3 Trip	82	Output 15	122	
3	Configuration change	43	F4 Trip	83	Output 16	123	
4	External trigger	44	F5 Trip	84	Output 17	124	
5	Communications trigger	45	F6 Trip	85	Output 18	125	
6		46	F7 Trip	86	Output 19	126	
7		47	F8 Trip	87	Output 20	127	
8		48	27 Pickup	88	Output 21	128	
9		49	59 Pickup	89	Output 22	129	
10		50		90	Output 23	130	
11		51		91	Output 24	131	
12		52		92	Output 25	132	
13		53		93	Output 26	133	
14		54		94	Output 27	134	
15		55		95	Output 28	135	
16	Input 14	56	27 Trip	96		136	
17	Input 13	57	59 Trip	97	Parallel E2PROM Alarm	137	
18	Input 12	58		98	Serial E2PROM Alarm	138	
19	Input 11	59		99	Out of order	139	
20	Input 10	60		100	Default general settings	140	
21	Input 9	61		101	Table 1 default settings	141	
22	Input 8	62		102	Table 2 default settings	142	
23		63		103	Table 3 default settings	143	
24	Input 7	64	Output 1	104	Trip contact	144	AND1
25	Input 6	65	Output 2	105	Table 1 active	145	AND2
26	Input 5	66	Output 3	106	Table 2 active	146	AND3
27	Input 4	67	Output 4	107	Table 3 active	147	AND4
28	Input 3	68	Output 5	108	Trips disabled	148	AND5
29	Input 2	69	Output 6	109		149	AND6
30	Input 1	70		110		150	AND7
31		71		111	New events	151	AND8
32	F1 Pickup	72	Output 7	112		152	AND9
33	F2 Pickup	73	Output 8	113		153	AND10
34	F3 Pickup	74	Output 9	114		154	AND11
35	F4 Pickup	75	Output 10	115		155	AND12
36	F5 Pickup	76	Output 11	116		156	AND13
37	F6 Pickup	77	Output 12	117		157	AND14
38	F7 Pickup	78		118		158	AND15
39	F8 Pickup	79		119		159	AND16

***NOTE**: This table shows the internal states for model DFF1000, with 14 inputs and 33 outputs. Models DFF1001 (7 inputs and 25 outputs) and DFF1002 (7 inputs and 13 outputs) will show the associated states in blank.*

TABLE II. COMMUNICATIONS INTERNAL STATES

	Internal States		Internal States		Internal States		Internal States
0	Mode: Remote (1) Local (0)	20		40		60	
1	Rear Connection	21		41		61	
2	Front Connection	22		42		62	
3		23		43		63	
4		24	Protection link	44		64	LED 1
5		25	Control link	45		65	LED 2
6		26		46		66	LED 3
7		27		47		67	LED 4
8		28		48		68	LED 5
9		29		49		69	LED 6
10		30		50		70	LED 7
11		31		51		71	LED 8
12		32	New events	52		72	LED 9
13		33		53		73	LED 10
14		34		54		74	LED 11
15		35		55		75	LED 12
16	Time/date alarm	36		56		76	LED 13
17		37		57		77	LED 14
18	Serial EEPROM alarm	38		58		78	LED 15
19	System Settings	39		59		79	LED 16

The configuration of the DFF protection system is done by means of GE_INTRO software (instruction book GEK-105594A)

4.1 INPUTS CONFIGURATION

Each of the 14 or 7 configurable Inputs (depending on the model) can have any of the following options:

- Input non-active
- External Trigger (Pulse)
- Table 0 selection (Level)
- Table 1 selection (Level)
- Frequency trips block (Level)
- Voltage trips block (Level)
- Complete protection trips block (Level)

Description:

- **Non active**: Generic meaning, to be used in user application.
- **External Trigger** (Pulse): This input is activated by a pulse and triggers the oscillography unit to capture the analog waveforms at that moment.
- **Table 0 selection 0** (Level): This input is active while there is Vdc applied to the input. It is used to change the active setting table. Please refer to section 2.5 for further details.
- **Table 1 selection** (Level): Same as above.
- **Frequency trips block** (Level): This input is active while there is Vdc applied to the input. It is used to block the operation of all frequency units.
- **Voltage trips block** (Level): This input is active while there is Vdc applied to the input. It is used to block the operation of all voltage units.
- **Complete protection trip block** (Level): This input is active while there is Vdc applied to the input. It is used to block the operation of all protection units.

4.2 OUTPUTS CONFIGURATION

The DFF protection system provides 28, 20 or 8 user configurable outputs (depending on the model) plus five non-programmable factory configured ones. These outputs are referred as SP1, SP2, etc.

Any of the internal states of the DFF (shown in table I) can be configured to close one of these programmable outputs. The operation of the output can be associated either to the activation or deactivation of those internal states. Following the same rules described in previous sections, logic circuits can be done with the outputs, using OR, AND and NOT gates.

To configure protection output number 14 as the logic AND of digital input number 1 and the undervoltage trip these steps should be followed:

- Configure input number 1 as non-active.
- Configure AND number 1 output as the activation of input number 1.
- In the same screen configure AND number 2 output as the trip of the undervoltage unit.
- In the same screen configure AND number 3 as the logic AND of AND number 1 and number 2 gates.
- In the output configuration screen, assign output number 14 as the activation of AND number 3.

4.3 LEDS CONFIGURATION

The DFF system includes 16 user configurable LEDs. Those LEDs can be associated to internal protection events and also to internal communication events. One LED, once activated, may blink or remain steady depending on how it has been configured. There is also the choice of providing memory to an LED, this means that it will remain lit even in the case the condition that activated it disappears.

In order to configure an LED it is necessary to first configure one internal state to a protection or communication event. Once this is done, the LED must be configured to be driven by that protection or communication event.

To program LED number 12 to be lit when the undervoltage function trips, the following procedure should be followed:

- In the Settings/Protection/ Events Menu configure “Protection Event Number 1” to the undervoltage function trip.
- In the Settings/General Configuration/LEDs Menu assign LED number 12 to “Protection Event Number 1”.

5. TECHNICAL CHARACTERISTICS

5.1 MODEL LIST / ORDERING CODE

POSITION	DFF	1	-	-	-	-	C	-	-	0	0	2	A	-	DESCRIPTION
5															**Comm. Protocols**
			0												P1, P2: Mlink
			2												P1: Mlink ; P2: ModBus RTU
6															**Type of system**
				0											19'' rack
				1											½ 19'' rack
7															**Inputs/Outputs**
					0										14 inputs / 33 outputs (not available for ½ rack model)
					1										7 inputs / 25 outputs
					2										7 inputs / 13 outputs
					3										14 inputs / 20 outputs (not available for ½ rack model)
8															**Communications. Rear Ports**
															P2: RS232
						1									P2: 1mm Plastic FO + P3: RS232
						2									P2: 62,5/125 glass FO+ P3: RS232
						3									P2 : RS485+ P3 : RS232
						4									P2, P3: Plastic F.O. 2 ports & 2 connectos P2 integrable, P3 commuted
10															**Digital Inputs- Nominal voltage**
								0							48-125 Vdc
								1							110-250 Vdc
11															**Power Supply**
									G						48-125 Vdc
									H						110-250 Vdc.
15													**A**		**Revision Level**
16															**Language**
														-	Spanish
														I	English
														F	French

5.2 TECHNICAL CHARACTERISTICS

MECHANICAL

- Protection IP51 (according to IEC 529).
- Local MMI with LCD display (2 rows of 16 characters each) and 20-button keypad.
- 19 " rack – 4U high version
  - Up to 10 Rear terminal blocks with 12 terminals each.
  - Dimensions: 437 x 200 x 176 mm.
  - Weight: Net 12 kg. Shipping 13 kg
- ½ 19'' rack – 4U high version:
  - Up to 8 Rear terminal blocks with 12 terminals each.
  - Dimensions: 222 x 200 x 176 mm
  - Weight: Net 10 kg. Shipping 12 kg.

FREQUENCY MEASUREMENTS

- Accuracy: ±100 PPM at 20°C
- Repeatability: ±50 PPM
- Temperature error: ±35 PPM from -20°C to +55°C
- Ageing: ±5 PPM according to MIL-C3098F
- Hysteresis: 0.04 Hz

When a stable frequency generator is used. For instance the EPOCH20 in 50 or 60 Hz mode.

ELECTRICAL CHARACTERISTICS

- Frequency: 50 or 60 Hz
- Nominal Voltage: 90 - 220 Vac (phase-phase)
- Power Supply: 48 - 125 Vdc or 100 - 250 Vdc ± 20% (see ordering code/model list)
- Digital Inputs nominal voltage: 48-125, 110-220 Vdc (see ordering code/model list)

- AC Voltage inputs Un = 220/%3
  - Continuous rating: 2 x Un
  - 1 min rating: 3.5 x Un
- Temperature:
  - Operation: -20°C to +55°C
  - Storage: -40°C to +70°C
- Humidity: Up to 95% without condensation
-
- Tripping contacts:
  - Nominal Voltage, maximum operating voltage: 250 / 440 Vac
  - Continuous current / make and carry. 16 / 25
  - Breaking capacity 4000 VA
  - Mechanical life 3 x 10E6 operations
- Burdens:
  - Voltage circuit: 0.2 VA for Un = 90 Vac
  - DC burden: 12 W
  - Per energized digital input: 8 mA (1 W Vaux = 125 Vdc)

COMMUNICATIONS

- Mode: Half duplex.
- Speed: 1200 to 115200 bauds
- Physical media:

RS232 (ports 1, 3)

- Plastic fiber optics (port 2 Optional, see ordering code/model list)

Connector type : HFBR-4516

Typical emitted power : -8dBm

Receiver sensitivity : -39dBm

Wavelength: 660 nm

- Glass fiber optics (port 2 Optional, see ordering code/model list)

Connector type : STA

Typical emitted power: -17.5 dBm

Receiver sensitivity: -24.5 dBm

Wavelength : 820 nm.

- RS485 (port 2 optional, see ordering code/model list)

STANDARDS

The DFF complies with the IEC relay standards, including also GE dielectric strength test and the European directive of Electromagnetic Compatibility (89/336) for CE marking.

It also fulfills low voltage European directives and standards ANSI C37.90, IEC 255-5, IEC 255-6 e IEC 68.

Test	Standard	Class
• Dielectric Strength (Insulation)	IEC 255-5	2kV 50/60 Hz 1 minute
• Impulse voltage withstand	IEC 255-5	5 kV, 0.5 J
• 1 MHz Interference test	IEC 255-22-1	III
• Electrostatic discharge	IEC 255-22-2 EN 61000-4-2	IV 8 kV
• Interference test withstand	IEC 255-22-3	III
• Electromagnetic fields	ENV 50140	10 V/m
• Electromagnetic fields. Common mode.	ENV 50141	10 V/m
• Electromagnetic fields. Frequency modulated.	ENV 50204	10 V/m
• Fast transient	IEC 255-22-4 EN 61000-4-4	IV
• Magnetic fields at industrial frequency	EN 61000-4-8	30 A/m
• Radio frequency emission	EN 55011	B

6. HARDWARE DESCRIPTION

The DFF incorporates electronic components that might be affected by electrostatic discharge currents flowing through certain component terminals. The main source of electrostatic discharges is the human body, especially under low humidity conditions with carpet floors or isolating shoes. If such conditions are present special care should be taken while manipulating DFF´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.

6.1 MECHANICAL CONSTRUCTION

6.1.1 CASE CONSTRUCTION.

The DFF case is a standard 19" (or ½ 19'') rack, 4U high, manufactured in stainless steel and painted with black epoxy resin. It is composed of a four-sided wrapper, which includes the modules/printed circuit guides, plus a rear plate with all the terminal blocks.

The case has a surge ground connection terminal, essential not only in terms of safety, but also for behavior against electromagnetic interference.

All the modules can be withdrawn, enabling easy maintenance and repair.

The DFF has a polycarbonate front cover. This keeps the relay sealed, providing protection against dust and water (IP51 index according IEC 529). The use of a push-button allows access to the main functions without the need for removing the cover.

The front and rear views of both versions of DFF are shown on list of figures at the end of the manual.

6.1.2 ELECTRICAL CONNECTIONS.

DC power and AC electrical connections are made through 12-way terminal blocks located at the rear of the case.

The DFF includes up to three communication ports. One in the front for local connection and the others located on the rear plate, used for remote connection.

6.1.3 INTERNAL CONSTRUCTION.

The internal architecture of the DFF is composed of the following drawout modules:

- Power supply module.
- Magnetic module (AC voltage inputs).
- Protection CPU module.
- Communications CPU module.
- Up to 3 Modules for the digital Inputs and Outputs. (see ordering code/model list for options)

Each of these modules has a DIN type front connector for the connection to the internal communication bus.

The following boards are mounted behind and in parallel to the front plate.

- Internal bus board.

Interconnects all the modules through their front DIN connectors.

- Front display board.

This PCB includes the display, the 16 LEDs, the communication port connector and the two-color LED.

The front display board is mechanically and solidly connected to the keypad board with the electrical connections made through a flexible 12-way flat cable.

These two front boards are connected to the rest of the relay through a 40-way flexible flat cable, which connects to the front of the communications CPU.

- Front keypad board.

This board supports the 20 key keypad and has a transparent window for the LCD display.

The group formed by both front boards is mechanically fixed to the case by 4 captive screws.

Accessing internal modules

1. Remove the plastic cover.
2. Undo the 4 captive front screws (located in the 4 corners).
3. Lower the front plate carefully until the 40-way flat cable is accessible, and pull out the connector in the communication CPU.
4. Remove the front module.
5. Take out the internal bus board, which interconnects the modules.

Relay modules can now be accessed and withdrawn, maintained or replaced. In order to re-assemble the relay, follow steps 1 to 5 in reverse order, making sure that all modules are in their correct location and that all connectors are fully inserted.

6.1.4 IDENTIFICATION.

The identification label of the model is located at the right of the keypad. This label includes the model number, serial number and the most important nominal values.

Terminal blocks placed at the rear plate are identified by black lettering. Each of the terminals blocks are identified by a letter printed at the top, close to the connector. The code uses letters of the alphabet beginning with A at the right hand edge of the case when viewed from the rear.

The 12 terminals of each block are identified by a number between 1 and 12 that is printed on the rear plate close to each connector The numbers run from 1 at the top to 12 at the bottom. The IRIG-B terminals are identified by the “+” and “-“ sign.

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

6.1.5 MAGNETIC MODULE.

The magnetic module connects the substation voltage signals to the relay providing galvanic isolation by means of internal transformers and reduces the voltage levels for the internal circuitry.

As the magnetic module connects to HV equipment it must be capable of withstanding electromagnetic disturbances. To avoid this effect, the relay has filters in the primary side of the transformer and in the secondary side.

6.1.6 PROTECTION CPU MODULE

This module performs the following functions:

- Samples the analog signals from the magnetic module.
- Evaluates protection algorithms.
- Performs protection and auxiliary functions.
- Carries out monitoring functions, events logs, oscillography, etc.
- Equipment auto-diagnostic.
- Sends protection data to the communications CPU.

6.1.7 COMMUNICATIONS CPU MODULE.

~~The main functions of the communications CPU module are as follows:~~

- Communicate internally with the protection CPU module.

- Communicate locally with a PC by the front communications port.
- Communicate remotely by the rear communication ports.
- Handle the Man-machine interface, i.e. the keypad and display.

6.1.8 INPUT MODULE.

The DFF design takes maximum care in assuring reliability against electromagnetic disturbances.

Each input has a resistive attenuator which reduces the external voltage battery levels (48 V, 125 V, ...) to match the levels of the optocoupler. The optocoupler gives galvanic isolation to each input and greatly enhances the performance against electromagnetic perturbations.

6.1.9 OUTPUT MODULE.

Each module has 12 heavy-duty relays with duties as listed in section 5.2. The alarm relay has one normally closed contact. All of the relays have one normally open contact each. The contacts are potential free.

6.1.10 POWER SUPPLY.

The power supply module includes the following:

- DC-DC converter that converts the external battery power supply voltage to the electronic circuitry voltage (8Vdc and 24Vdc).
- Four tripping relays, with contact duties as defined in section 5.2.
- One equipment alarm relay.
- One passive filter to suppress electromagnetic disturbances.
- One current limiter to protect the power supply against unintentional grounding.

7. ACCEPTANCE TESTS

7.1 VISUAL CHECK

Unpack the relay and make sure that there are no broken parts and no signs that the relay has been damaged during transportation.

Make sure that all the screws are well tightened and the terminal blocks are not damaged.

Make sure that the device model number shown on the front plate matches with the ordered model.

7.2 CONNECTION AND NECESSARY EQUIPMENT

Equipment needed:

- 1 Vdc power supply
- 1 Vac voltage source
- 1 multimeter

Connect the relay as shown in the external connection diagram.

Power supply must be connected to D11 (Positive) and C11 (Negative) terminals at rated value.

Due to safety reasons, the ground terminal must be connected.

7.3 INSULATION TESTS.

Interconnect the terminals as shown in the table below. Each set of terminals defines a group.

Gradually apply 2000Vac between each group and ground, during one second.

Gradually apply 2000Vac between groups, during one second.

Isolated groups are as follows:

MODEL DFF1x00

GROUP	RELAY TERMINALS	TYPE
G1	A7..A10, B7..B10	Voltage
G2	C5..C9, D5..D9	Trips
G3	C11, D11	Power Supply
G4	E1.. E4, F1..F4	Inputs
G5	E5..12, F5..12	Outputs
G6	J1..12, K1..12	Outputs
G7	R1..4, I1..4	Inputs
G8	R5..12, I5..12	Outputs

MODEL DFF1x01

GROUP	RELAY TERMINALS	TYPE
G1	A7..A10, B7..B10	Voltage
G2	C5..C9, D5..D9	Trips
G3	C11, D11	Power Supply
G4	E1.. E4, F1..F4	Inputs
G5	E5..12, F5..12	Outputs
G6	J1..12, K1..12	Outputs

MODEL DFF1x02

GROUP	RELAY TERMINALS	TYPE
G1	A7..A10, B7..B10	Voltage
G2	C5..C9, D5..D9	Trips
G3	C11, D11	Power Supply
G4	J1.. J4, K1..K4	Inputs
G5	J5..J12, K5..K12	Outputs

MODEL DFF1x11 (half rack)

GROUP	RELAY TERMINALS	TYPE
G1	A7..A10, B7..B10	Voltage
G2	C5..C9, D5..D9	Trips
G3	C11, D11	Power Supply
G4	E1.. E4, F1..F4	Inputs
G5	E5..E12, F5..E12	Outputs
G6	G1..G12, H1..H12	Outputs

MODEL DFF1x12 (half rack)

GROUP	RELAY TERMINALS	TYPE
G1	A7..A10, B7..B10	Voltage
G2	C5..C9, D5..D9	Trips
G3	C11, D11	Power Supply
G4	E1.. E4, F1..F4	Inputs
G5	E5..E12, F5..F12	Outputs

7.4 POWER SUPPLY

For safety reasons, A12 terminal must be grounded during functional tests.

Apply nominal voltage to the relay, then adjust to minimum, then maximum. For each voltage check that the ALARM relay is open when it is powered and close when it is not powered.

Note: The Alarm Output also closes when the relay is out-of-service (**STATUS** setting in the **GENERAL SETTINGS** menu) or if being **IN SERVICE**, there is no protection unit enabled to trip. At least one protection unit must be enabled, and its trip permitted.

To perform this test, first set the relay to **IN SERV**ice, under the **GENERAL SETTINGS/STATUS** menu, and enable at least one function, permitting its operation under **FUNCTION PERMIT** menu, and its trip permission under the same menu.

7.5 VOLTAGE MEASUREMENT

Set the VT ratios to the following values (**GENERAL SETTINGS**) :

- PHASE VT RATIO : 1000
- GROUND VT RATIO : 1000
- FREQUENCY : 50 Hz

Apply the following voltages:

Value	1	2	3	4	5	6
Va (Vac)	5	10	50	100	150	200
Vb (Vac)	5	10	50	100	150	200
Vc (Vac)	5	10	50	100	150	200
Vn (Vac)	5	10	50	100	150	200

Using the LCD and keypad check that the equipment measures with an accuracy better than 5 % of the applied voltage.

Modify the nominal frequency setting and repeat the test at 60 Hz.

7.6 FREQUENCY MEASUREMENT.

***Note**: Frequency measurements are done by applying voltage to phase B Input terminals A9-A10.*

Using the LCD and keypad check that the frequency measurement error is not higher than 0.01 Hz for the following frequency and voltage values:

- Voltages: 50,150 and 250 Vac
- Frequencies: 40, 50, 55, 60 and 70 Hz

Check that when a fixed frequency is applied, the frequency variation is not higher than 0.01 Hz when voltage is modified between 50, 150 and 250 Vac.

7.7 DIGITAL INPUT CHECKS.

Apply DC nominal voltage (see model list) then adjust by +/-20%.

Apply voltage to an input and check that the relay detects its activation. Use **GE_LOCAL** or **DFFPC** communication software, **INPUTS & OUTPUTS** menu, to monitor the status of inputs as they are being tested.

7.8 OUTPUT CHECKS.

1. Trip Output checks.

- Enable all the protection functions.
- Enable the trips.
- Force the operation of one underfrequency function injecting a voltage at a frequency below the set value.
- Check if trip contacts (TRIP1, TRIP2, TRIP3, TRIP4) are closed while the trip condition is present, and reset when this condition disappears.

2. Alarm Output checks.

- Switch off the Vdc power supply, and check if the alarm output contact is closed.
- Switch on the Vdc auxiliary power supply and check if alarm contact is open.

Note: The Alarm Output also closes when the relay is out-of-service (**STATUS** setting in the **GENERAL SETTINGS** menu) or if being **IN SERVICE**, there is no protection unit enabled to trip. At least one protection unit must be enabled, and its trip permitted.

To perform this test, first set the relay to **IN SERV**ice, under the **GENERAL SETTINGS/STATUS** menu, and enable at least one function, permitting its operation under **FUNCTION PERMIT** menu, and its trip permission under the same menu.

3. Configurable Outputs checks.

Force the closing of each output and check that they operate properly.

To force the operation of the outputs follow one of the following procedures:

- Simulate an underfrequency condition so the relay closes the corresponding output.
- Configure outputs to close when one particular input is energized. Energize the corresponding input and check if outputs close. (GE INTRO software must be used to change the configuration of inputs and outputs)

7.9 COMMUNICATIONS PORTS CHECKS.

Connect the relay to the PC using a communication cable.

(Communication cable configuration is shown in the list of figures at the end of this manual. Use this cable configuration or use a standard direct RS232 cable (no crossings) and a standard Null-Modem adaptor)¡

Set in DFF relay and in the PC the following communication parameters:

- Number of relay = 1
- DFF rear port baud rate = 9600
- DFF front port baud rate = 9600
- DFF rear port stop bits = 1
- DFF local port stop bits = 1

By using **GE_LOCAL** or **DFFPC** communications software establish the connection and check the relay communicates through all communications ports.

7.10 KEYPAD, DISPLAY AND LED CHECKS.

Press Target Reset button and verify that all the LEDs are lit.

Press the appropriate keys and verify that the following messages are displayed:

Start from the main screen:

DFF
GENERAL ELECTRIC

KEYS	LCD MESSAGES
< SET >	VIEW PROTECTION SETTINGS
< CLR >	DFF GENERAL ELECTRIC
< INF >	STATUS
< ENT >	MODEL
< ↑ >	DATA BASE
< ↓ >	MODEL
< CLR >	STATUS
< CLR >	DFF GENERAL ELECTRIC
< ACT >	SET DATE/TIME
< CLR >	DFF GENERAL ELECTRIC
<7169>	REAR PORT BAUD RATE
< ↑ >	REAR PORT STOP BITS

Clear the display by pressing the **CLR** key.

7.11 CONTROL OPERATIONS.

1. Time setting.

Set date and time of the relay and verify the proper operation.

To set date and time use the **SET DATE/TIME** menu in the ACTions menu. To enter into this menu press **ACT** key from the main display showing **DFF - GENERAL ELECTRIC**.

2. Communications Trigger.

Apply an AC voltage to any phase and trigger the oscillography capture using the **ACT** – **COMM TRIGGER** command. Retrieve the oscillography register using **GE_LOCAL** or **DFFPC** software and display the record using **GE_OSC** software package. Verify that the captured waveform fits with the applied voltage signal.

7.12 INHIBIT VOLTAGE CHECK.

***NOTE**: Tests must be done with phase B.*

***NOMINAL VOLTAGE** setting is phase-to-phase voltage.*

Injected voltages are phase-to-ground.

- Set the relay ***NOMINAL FREQUENCY*** to nominal frequency (50 or 60 Hz).
- Set one frequency unit as absolute threshold and set the operating value to 110% of nominal frequency.

- Set nominal voltage to 90 Vac (***NOMINAL VOLTAGE*** setting is phase-to-phase voltage).
- Set inhibition voltage to 40 % (0.4x90V = 36Vph-ph = 20.8Vph-gnd).
- Provide a 10Vac voltage signal on phase B terminals, at nominal frequency.
- Check that the unit trips with 22 Vac and does not trip with 19 Vac
- Set inhibition voltage to 110 % (1.1x90V = 99Vph-ph = 57Vph-gnd).
- Check that the unit trips with 61 Vac and does not trip with 54 Vac.
- Set nominal voltage to 220 Vac.
- Set inhibition voltage to 40 % (0.4x220V = 88Vph-ph = 50.8Vph-gnd).
- Check that the unit trips with 54 Vac and does not trip with 48 Vac.
- Set inhibition voltage to 110 % (1.1x220V = 242Vph-ph = 139.7Vph-gnd).
- Check that the unit trips with 150 Vac and does not trip with 132 Vac

7.13 VOLTAGE FUNCTION CHECKS.

***NOTES**: Voltage functions operate on phase B voltage. For undervoltage tests, initial voltage must be 10% higher than trip voltage setting, and for overvoltage tests initial voltage must be 10% lower.*

1. 27P UNDERVOLTAGE FUNCTION CHECKS

Set 27 function as follows:

27P PICKUP : 20 Vac

TIME DELAY 27P : 0 s.

RESET TIME 27P: 0 s.

Decrease the voltage and check that the relay trips with 19.4 Vac and drops out with 21.6 Vac

Modify the 27P PICKUP to 65 Vac

Decrease the voltage and check that the relay trips with 63.05 Vac and drops out with 70.2 Vac

Modify the 27P PICKUP to 110 Vac

Decrease the voltage and check that the relay trips with 106.7 Vac and drops out with 118.8 Vac

2. 59P OVERVOLTAGE FUNCTION CHECKS

Set 59P function as follows:

59P PICKUP: 50 Vac

TIME DELAY 59P: 0 s.

RESET TIME 59P: 0 s.

Increase the voltage and check that the relay trips with 51.5 Vac and drops out with 46 Vac

Modify the 59P PICKUP to 135 Vac

Increase the voltage and check that the relay trips with 139.05 Vac and drops out with 124.2 Vac

Modify the 59P PICKUP to 220 Vac

Increase the voltage and check that the relay trips with 226.6 Vac and drops out with 202.4 Vac.

7.14 FREQUENCY UNITS CHECKS.

1. Absolute threshold checks

Configure the frequency units as "**FREQ**" with the following settings:

Unit 1 : 49 Hz

Unit 2 : 48 Hz

Unit 3 : 47 Hz

Unit 4 : 46 Hz

Unit 5 : 45 Hz

Unit 6 : 44 Hz

Unit 7 : 43 Hz

Unit 8 : 42 Hz

Decrease the frequency gradually and check that each unit has an error margin not higher than 0.01 Hz.

2. Rate of change of Frequency checking.

Configure the frequency units as "df / dt" with the following settings:

Unit 1 : - 0.1 Hz/s

Unit 2 : - 0.2 Hz/s

Unit 3 : - 0.5 Hz/s

Unit 4 : - 1 Hz/s

Unit 5 : - 1.5 Hz/s

Unit 6 : - 2 Hz/s

Unit 7 : - 5 Hz/s

Unit 8 : - 10 Hz/s

Set all units to the same frequency supervision level.

Test each Frequency Unit simulating frequency variations, decreasing ramps, with rates of change of frequency more negative than the setting of the unit under test. Check that each unit operates with an error margin not higher than 0.1 Hz/s.

8. INSTALLATION AND MAINTENANCE

8.1 RECEPTION, OPERATION AND STORAGE.

DFF relays are supplied to the customer in a special package, which adequately protects it during transportation, as long as this is performed in normal conditions. Immediately after receiving the relay, the customer should check whether it shows any signs of transportation damage. If it is apparent that the relay has been damaged by inappropriate handling, it must be immediately advised in writing to the carrier, and the damage must be reported to the manufacturer.

For unpacking the relay, normal care should be taken in order not to lose the screws, documents and other auxiliary elements also supplied in the carton box.

If the relay is not going to be installed immediately, it is recommended to store it in its original package, and keep it in a dry, dust free and metal particles free place.

8.2 INSTALLATION

The place where the relay is to be installed must be clean, dry, free of dust and vibrations, and well illuminated to facilitate inspection and tests.

The relay must be mounted on a vertical surface. Check the list of figures at the end of the manual for the drilling diagram in order to do the panel cut out

As DFF design is based on state-of-the-art digital technology and the manufacturing is done under severe control conditions with sophisticated high accuracy equipment, it is completely unnecessary to recalibrate the relay.

8.3 GROUND CONNECTION FOR SAFETY AND PERTURBATION REMOVAL.

A12 ground terminal (see figure 6) must be connected to ground in order to get a right operation of the perturbation removal filters included in the system. For securing the maximum protection, this connection must be as short as possible (preferably 25 cm or less). In this way, the capacitors internally connected between outputs and ground deflect the high frequency perturbations directly to ground without crossing the electronic circuits, so that these circuits are perfectly protected.

Besides, safety of the staff that handles the relay is guaranteed by means of this connection, as the whole chassis is grounded.

8.4 MAINTENANCE

Due to the primary role that protection relays have in any installation, it is recommended that a periodic test program is followed. The intervals between these tests vary depending on the application, as well as on the experience and customs of the user. DFF provides self-diagnosis functions that allow to immediately detect failures of the circuitry with the only help of the keyboard and the display. Although this self-diagnosis capability does not reduce the average time between failures, it increases the availability of the protection thanks to the possibility of drastic reduction of the failure detection.

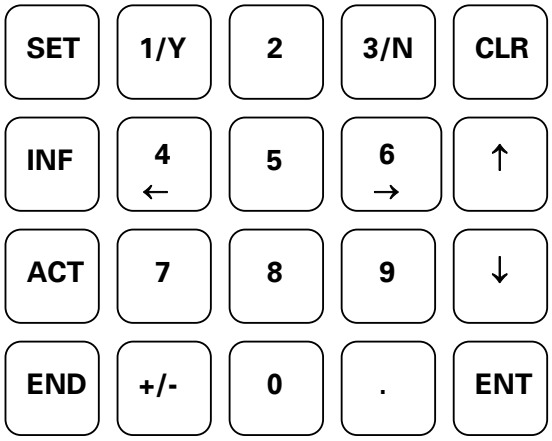
The group of tests that can be done to verify the whole operability of DFF equipment is deeply described in **ACCEPTANCE TESTS** chapter

The majority of the protection and communication functions are integrated in two different EPROM based programs, because of this the rate of failures is significantly lower to the ones of previous designs (electromechanical or static analog relays). Besides this there is no need of relay recalibration after years of use.

Possible failures of the communication microprocessor do not affect to the protection functions, which are implemented by means of a dedicated microprocessor.

9. KEYPAD AND DISPLAY

DFF relay has a 20-key keypad and a 32-character LCD (Liquid Crystal Display), which are distributed in two rows of 16 characters each. The layout of the keypad is displayed in the following figure:



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 provides 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 manually trigger the oscillography. 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 the following sequence of key strokes: **"7" "1" "6" "9"** (ASCII codes for "G" "E", "71" "69"). In order to be able to access this menu, the relay must be in the main screen.

***Single Key Menu*:** The DFF relay 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 the standby mode, the following message is displayed:

DFF
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 cannot be selected without quitting first and going back to the standby screen. You can move inside a group by pressing **ENT, CLR**, ↑, ↓, ← and → 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.

9.1 TREE MENUS.

The DFF relay has different menus organized in levels. Level 0 is the standby screen. To access to level 1, a group key must be pressed (**SET, INF, ACT**). 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:

Group	Level 1	Description
SET	• VIEW PROTECTION SETTINGS • MODIFY PROTECTION SETTINGS	• View settings • Modify settings
INF	• STATUS	• View device status
ACT	• SET DATE/TIME • COMMUNICATIONS TRIGGER	• Set date and time • Oscillography trigger
ENT	• Va • Vb • Vc • Vn • Frequency • dF/dT • PROTECTION STATUS • ACTIVE TABLE • DATE/TIME	• Primary side phase A voltage value (kV) • Primary side phase B voltage value (kV) • Primary side phase C voltage value (kV) • Primary side ground voltage value (kV) • Frequency value • rate of change of Frequency value • Protection in or out of service • Active settings table • Date and time
7169	• NETWORK BAUD RATE • NETWORK STOP BITS • LOCAL PORT BAUD RATE • LOCAL PORT STOP BITS • LOCAL SETT • REMOTE SETT • LOCAL CONTROL • REMOTE CONTROL • UNIT NUMBER • PASSWORD • TIMEOUT t	• Rear port communications baud rate • Rear port stop bits • Front port communications baud rate • Front port stop bits • Local settings change enabled • Remote settings change enabled • Local control operations enabled • Remote control operations enabled • Relay unit number • Relay password • Maximum time between two consecutive synchronization commands received from a central computer in order not to produce “clock not set” alarm event. If the relay is not going to be receiving regular synch commands set this value to 0

9.2 SETTINGS MENU GROUP.

The DFF relay has some settings groups common to all tables but other groups are particular for each settings table.

The common settings are the following ones:

- GENERAL SETTINGS
- ACTIVE TABLE
- OSCILLOGRAPHY MASK
- FUNCTION PERMIT

The rest of the setting groups are independent for each of the setting tables.

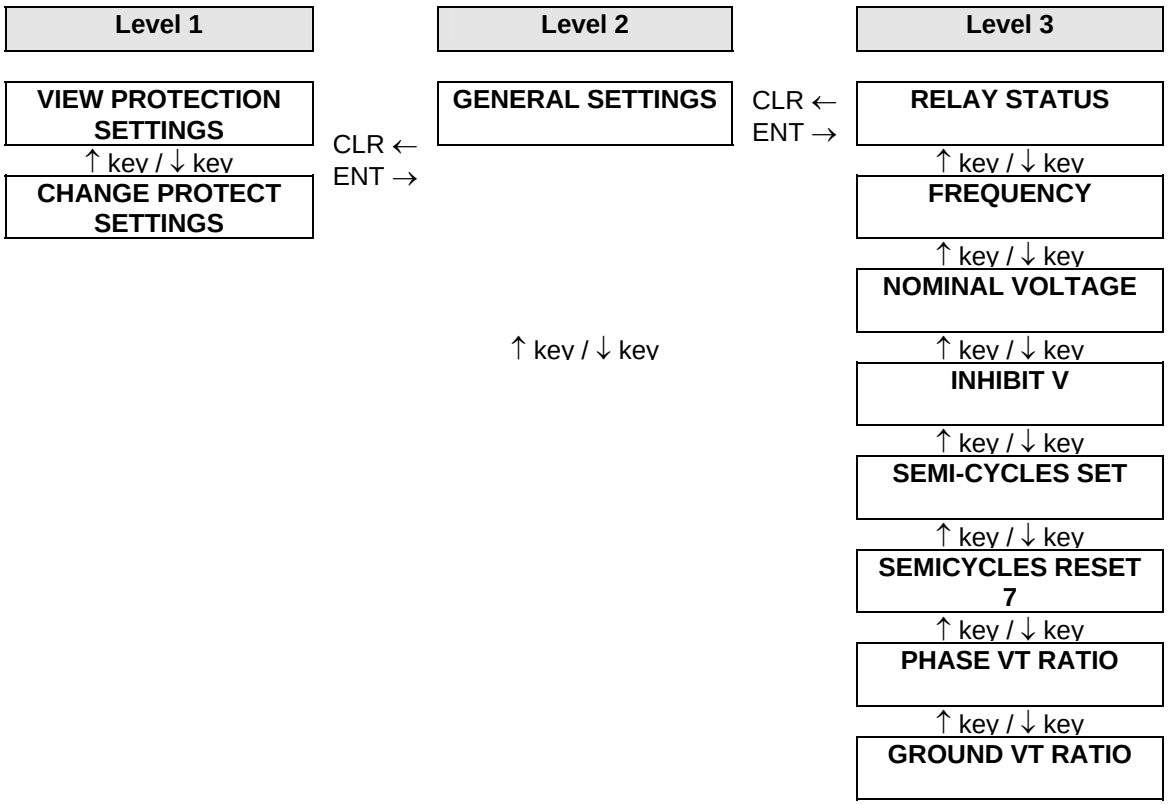
This menu group allows the user to view and modify the DFF's settings. To access this group, the **SET** key must be pressed when the DFF is in the standby mode, showing **DFF - GENERAL ELECTRIC**. The following message will be displayed:

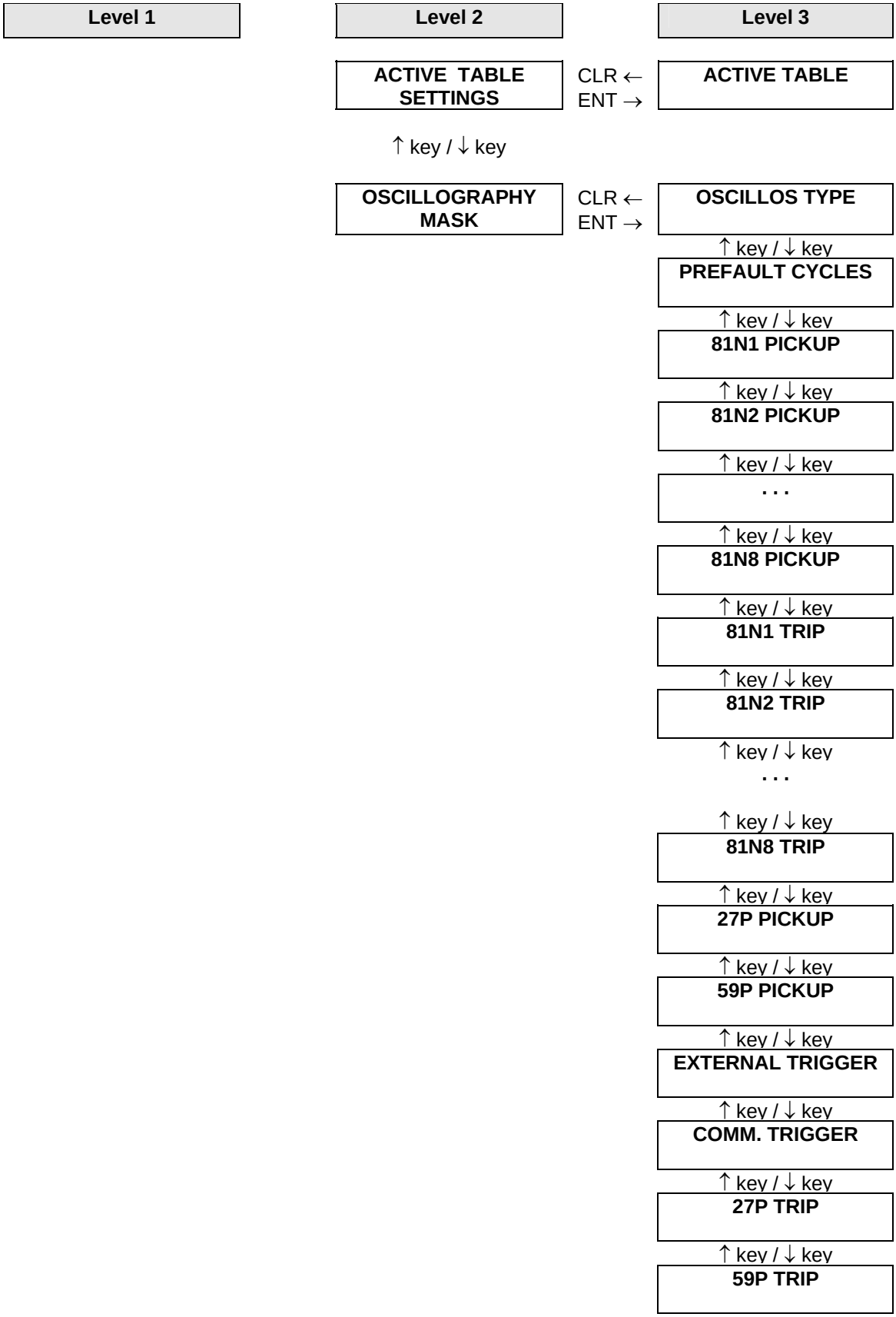
VIEW PROTECTION SETTINGS

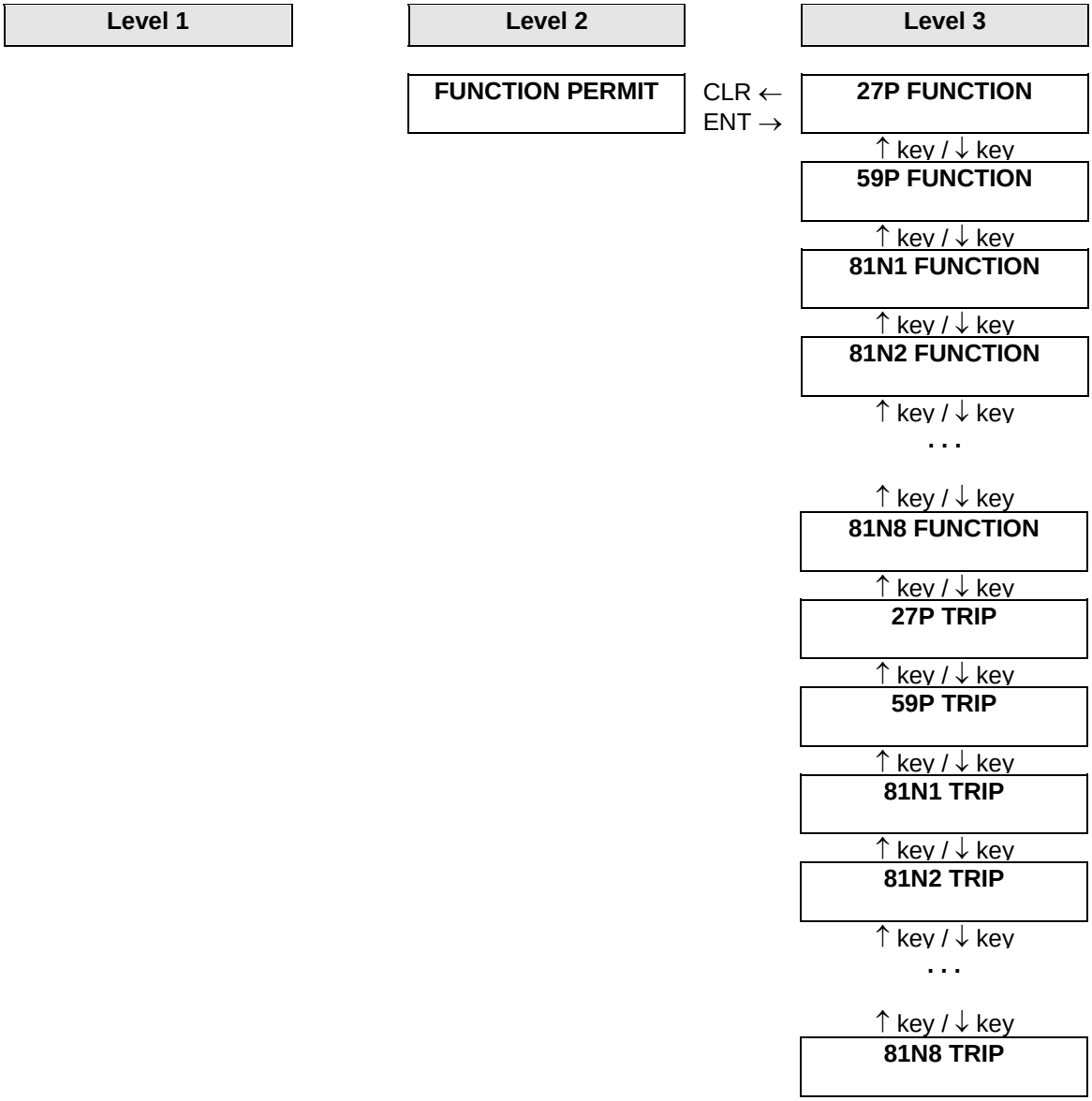
Pressing either the ↑/↓ keys, the following message will be displayed:

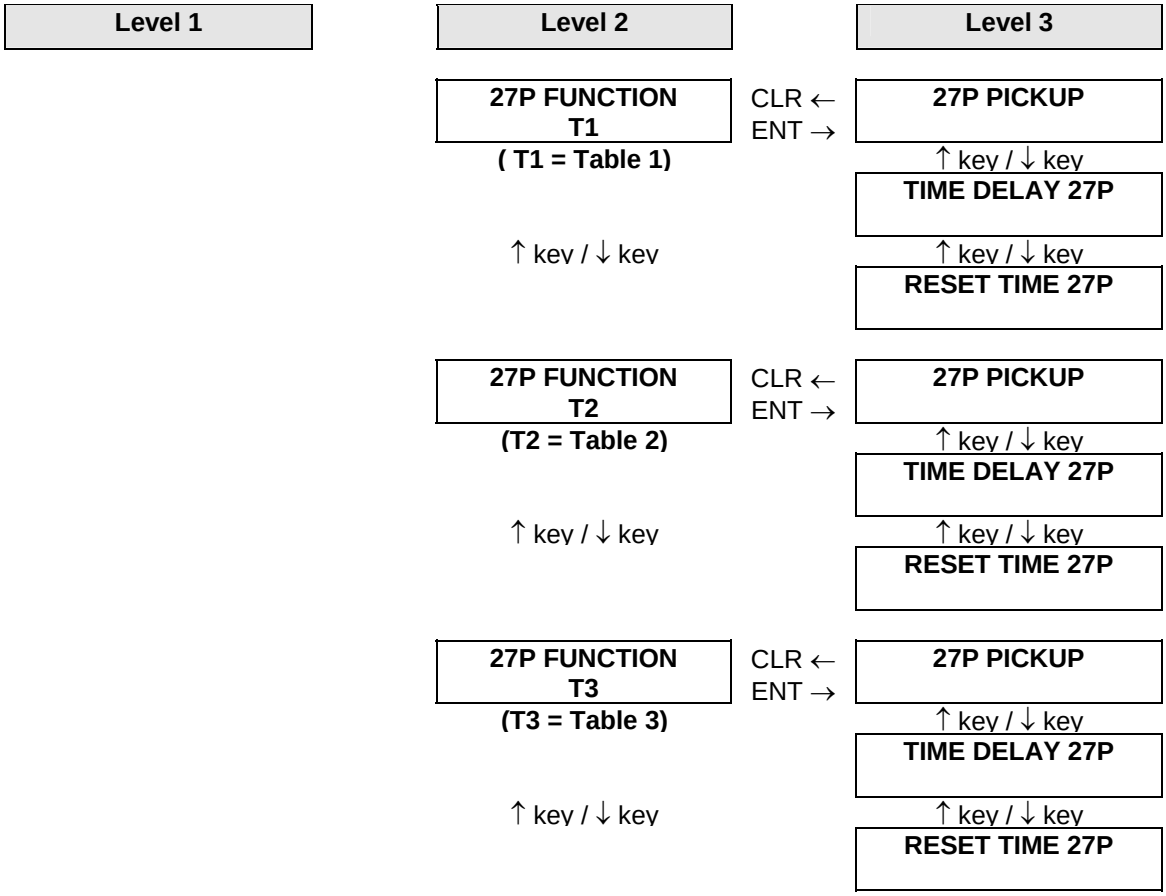
CHANGE PROTECT SETTINGS

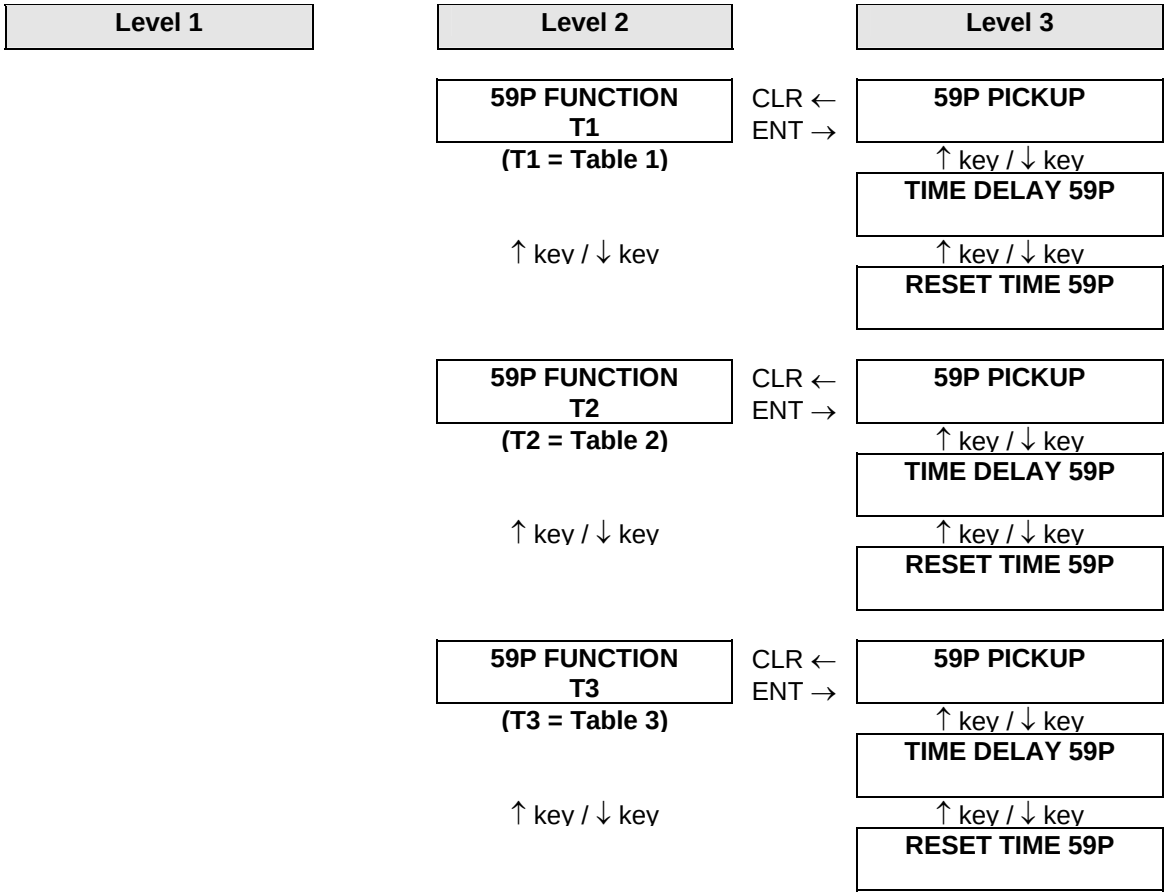
DFF settings menu tree is represented in the following table. It is important to remember that in order to go into the tree (go from Level 1 to Level 2) **ENT** key must be pressed, and that to come out of the tree (go from Level 2 to Level 1) the **CLR** key must be pressed.

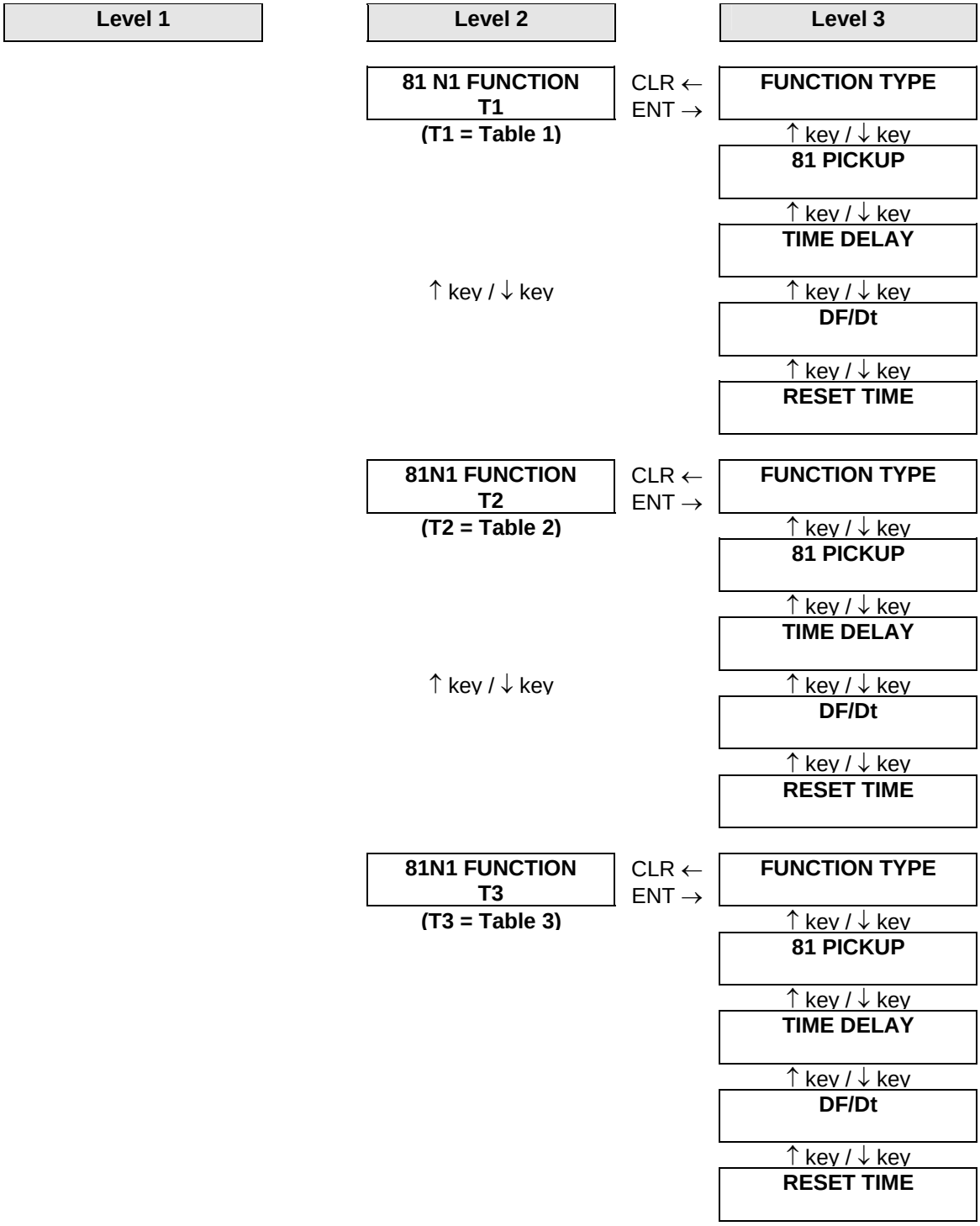

Level 1
Level 2
Level 3
VIEW PROTECTION SETTINGS
↑ key / ↓ key
CHANGE PROTECT SETTINGS
CLR ←
ENT →
GENERAL SETTINGS
↑ key / ↓ key
CLR ←
ENT →
RELAY STATUS
↑ key / ↓ key
FREQUENCY
↑ key / ↓ key
NOMINAL VOLTAGE
↑ key / ↓ key
INHIBIT V
↑ key / ↓ key
SEMI-CYCLES SET
↑ key / ↓ key
SEMICYCLES RESET 7
↑ key / ↓ key
PHASE VT RATIO
↑ key / ↓ key
GROUND VT RATIO


Level 1
Level 2
Level 3
ACTIVE TABLE SETTINGS
CLR ←
ENT →
ACTIVE TABLE
↑ key / ↓ key
OSCILLOGRAPHY MASK
CLR ←
ENT →
OSCILLOS TYPE
↑ key / ↓ key
PREFAULT CYCLES
↑ key / ↓ key
81N1 PICKUP
↑ key / ↓ key
81N2 PICKUP
↑ key / ↓ key
. . .
↑ key / ↓ key
81N8 PICKUP
↑ key / ↓ key
81N1 TRIP
↑ key / ↓ key
81N2 TRIP
↑ key / ↓ key
. . .
↑ key / ↓ key
81N8 TRIP
↑ key / ↓ key
27P PICKUP
↑ key / ↓ key
59P PICKUP
↑ key / ↓ key
EXTERNAL TRIGGER
↑ key / ↓ key
COMM. TRIGGER
↑ key / ↓ key
27P TRIP
↑ key / ↓ key
59P TRIP


Level 1
Level 2
Level 3
FUNCTION PERMIT
CLR ←
ENT →
27P FUNCTION
↑ key / ↓ key
59P FUNCTION
↑ key / ↓ key
81N1 FUNCTION
↑ key / ↓ key
81N2 FUNCTION
↑ key / ↓ key
. . .
↑ key / ↓ key
81N8 FUNCTION
↑ key / ↓ key
27P TRIP
↑ key / ↓ key
59P TRIP
↑ key / ↓ key
81N1 TRIP
↑ key / ↓ key
81N2 TRIP
↑ key / ↓ key
. . .
↑ key / ↓ key
81N8 TRIP


Level 1
Level 2
Level 3
27P FUNCTION T1
(T1 = Table 1)
CLR ←
ENT →
27P PICKUP
↑ key / ↓ key
TIME DELAY 27P
↑ key / ↓ key
RESET TIME 27P
↑ key / ↓ key
27P FUNCTION T2
(T2 = Table 2)
CLR ←
ENT →
27P PICKUP
↑ key / ↓ key
TIME DELAY 27P
↑ key / ↓ key
RESET TIME 27P
↑ key / ↓ key
27P FUNCTION T3
(T3 = Table 3)
CLR ←
ENT →
27P PICKUP
↑ key / ↓ key
TIME DELAY 27P
↑ key / ↓ key
RESET TIME 27P
↑ key / ↓ key


Level 1
Level 2
Level 3
59P FUNCTION T1
(T1 = Table 1)
CLR ←
ENT →
59P PICKUP
↑ key / ↓ key
TIME DELAY 59P
↑ key / ↓ key
RESET TIME 59P
↑ key / ↓ key
59P FUNCTION T2
(T2 = Table 2)
CLR ←
ENT →
59P PICKUP
↑ key / ↓ key
TIME DELAY 59P
↑ key / ↓ key
RESET TIME 59P
↑ key / ↓ key
59P FUNCTION T3
(T3 = Table 3)
CLR ←
ENT →
59P PICKUP
↑ key / ↓ key
TIME DELAY 59P
↑ key / ↓ key
RESET TIME 59P
↑ key / ↓ key



THESE SCREENS ARE REPEATED 8 TIMES TO COVER THE 8 FREQUENCY UNITS INCLUDED IN DFF

9.2.1 ENTERING SETTINGS MANUALLY

In order to modify a setting, the following steps must be followed:

1. Press the **SET** key.
2. Select **MODIFY PROTECTION SETTINGS** option.
3. Select the desired setting in the menu (see menu tree).
4. Press the value to be modified (for the **BAUD RATE** setting select the desired one in the available settings list with ← / →).
5. Press the **ENT** key. If any other setting is to be modified, inside the same group, steps 3 to 5 inclusive must be repeated.
6. Press **END** key.

The relay will ask for confirmation of the change and the following message will be displayed:

CONFIRM? (Y/N)

7. To confirm the change, press **1/Y** key . (Otherwise press **3/N** key).
8. Now the following message will be displayed:

SETTINGS CHANGE EXECUTED

9. Press the **CLR** key repeatedly in order to return to the standby mode:

DFF GENERAL ELECTRIC

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

SETTING OUT OF RANGE

Some settings do not require to enter a value through the keypad. They are just a selection of an option among several possibilities. In that case, the different options can be displayed by using ←/→ keys.

9.3 INFORMATION GROUP.

This group provides information related to the DFF internal states. To access this option, press the **INF** key and the following message will be displayed:

DFF GENERAL ELECTRIC	INF →	STATUS

By pressing the **ENT** key the status menu is accessed. With the ↑ and ↓ keys the following states are shown:

State	Description
MODEL	Model type
PROT VERSION	Protection program version
COM VERSION	Communications program version
Va	Phase A voltage
Vb	Phase B voltage
Vc	Phase C voltage
Vn	Ground voltage
FREQUENCY	Frequency
dF/dT	Rate of Change of Frequency
F1 PICKUP	Underfrequency unit 1 pickup
F2 PICKUP	Underfrequency unit 2 pickup
F3 PICKUP	Underfrequency unit 3 pickup
F4 PICKUP	Underfrequency unit 4 pickup
F5 PICKUP	Underfrequency unit 5 pickup
F6 PICKUP	Underfrequency unit 6 pickup
F7 PICKUP	Underfrequency unit 7 pickup
F8 PICKUP	Underfrequency unit 8 pickup
27 PICKUP	Undervoltage unit pickup
59 PICKUP	Overvoltage unit pickup
PROTECTION STATUS	Protection in service/out of service
ACTIVE TABLE	Active table number (1-3)
LOCAL CONN	Local connection
DATE/TIME (CORRECT)	Date and time correctly (or incorrectly) synchronized
COMM E2PROM (CORRECT)	Error (or absence of error) in communications e2prom
COMM SETT (USER)	Communications settings (Default or User)
PROTEC LINK.	Protection and communication link
DATE&TIME	Date and time

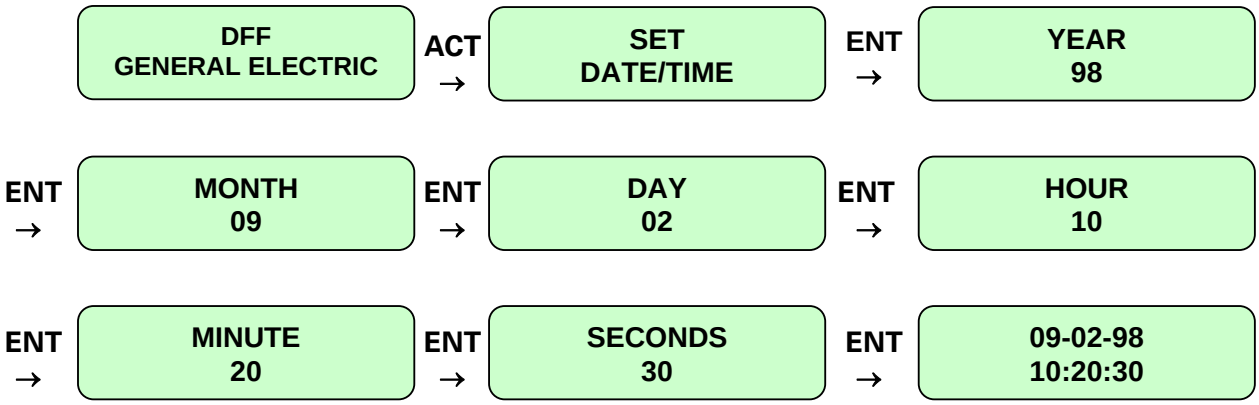
9.4 CONTROL OPERATIONS GROUP.

This group allows to set the date and the time of the relay as well as to produce an oscillography trigger.

To access to control operations group, the **ACT** key must be pressed (from the standby screen). These are the available control operations:

- Set date and time.
- Communications trigger.

To change date and time, the following steps must be followed:



***NOTE** : To modify the numeric value that is displayed, press **CLR** key to delete it.*

The execution of the **OSCILLOGRAPHY TRIGGER** order causes the start of the oscillography register.

9.5 SINGLE KEY OPERATIONS.

The DFF relay allows a simplified operation mode through the use of the **ENT** key. This mode allows access to various relay information without the necessity to remove the transparent plastic cover. The operation mode consists of repeatedly pressing the **ENT** key. To access this mode the relay must be in standby. The available information in this operation mode is shown in the following table in the order that it is displayed.

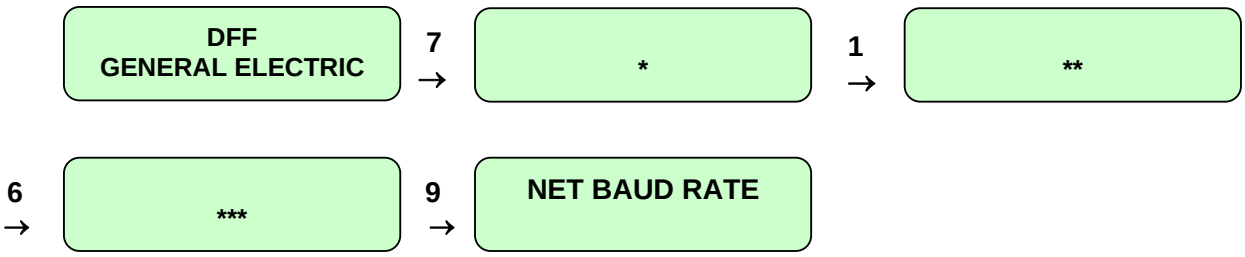
MAGNITUDES	DESCRIPTION
Va	phase A primary voltage value (kV)
Vb	phase B primary voltage value (kV)
Vc	phase C primary voltage value (kV)
Vn	ground primary voltage value (kV)
Frequency	frequency value (Hz)
dF/Dt	rate of change of frequency (Hz/s)
PROTECTION STATUS	protection 'in' or 'out of service'
ACTIVE TABLE	active settings table
DATE/TIME	date and time

9.6 COMMUNICATIONS MENU.

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

The configuration unit is entered from the standby screen by entering a four digit numerical code (sequence of key strokes). If the code is correct the LCD will show the configuration menu, if not the relay will return to the standby screen.

The code is common to all DFF relays. It is not meant to be a password, but a simple measure of security to avoid accidental manipulation of the configuration. The code is "**7" "1" "6" "9",** which was selected because it is the corresponding ASCII code for the initials GE ("G"="71", "E"="69"). This is the step by step sequence of displays to access the communications menu from the standby screen:



The settings are as follows: (to move in this group, ↑/↓ keys must be pressed).

- ***NET BAUD RATE***: The baud rate used in the remote communication port at the rear. The possible values for setting are between 1,200 and 115,200 baud.

- ***NET STOP BITS***: Number of bits added to each byte transmitted across the serial line (remote comm. port). It is treated as a logical binary setting with the logical key **1/Y** for 1, and key **3/N** for 2.
- ***LOCAL BAUD RATE****:* The baud rate used in the local communication port at the front. The possible values for setting are between 1,200 and 115,200 baud.

- ***LOCAL STOP BITS***: Number of bits added to each byte transmitted across the serial line (local comm. port). It is treated as a logical binary setting with the logical key **1/Y** for 1, and key **3/N** for 2.

- ***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 control operations.
- ***REMOTE CONTROL***: Setting which enables/disables remote control operations.
- ***UNIT NUMBER***: When there are several devices connected to the same communication network each DFF is identified by a unit number that serves to identify the messages directed to it. Range: 1 to 255.

- ***PASSWORD***: The relay provides a password in order to prevent unauthorized personnel from communicating remotely with the relay through the use of **GE_LOCAL** or DFFPC communications software. 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** or **DFFPC** must be identical to the relay password in order to permit the change of settings and the control operations.
- ***TIMEOUT t*:** Maximum time between two consecutive synchronization commands received from the PC in order not to produce “clock not set” alarm event. If no regular synchronization commands are to be received then enter 0 in this setting.

10. FIGURES

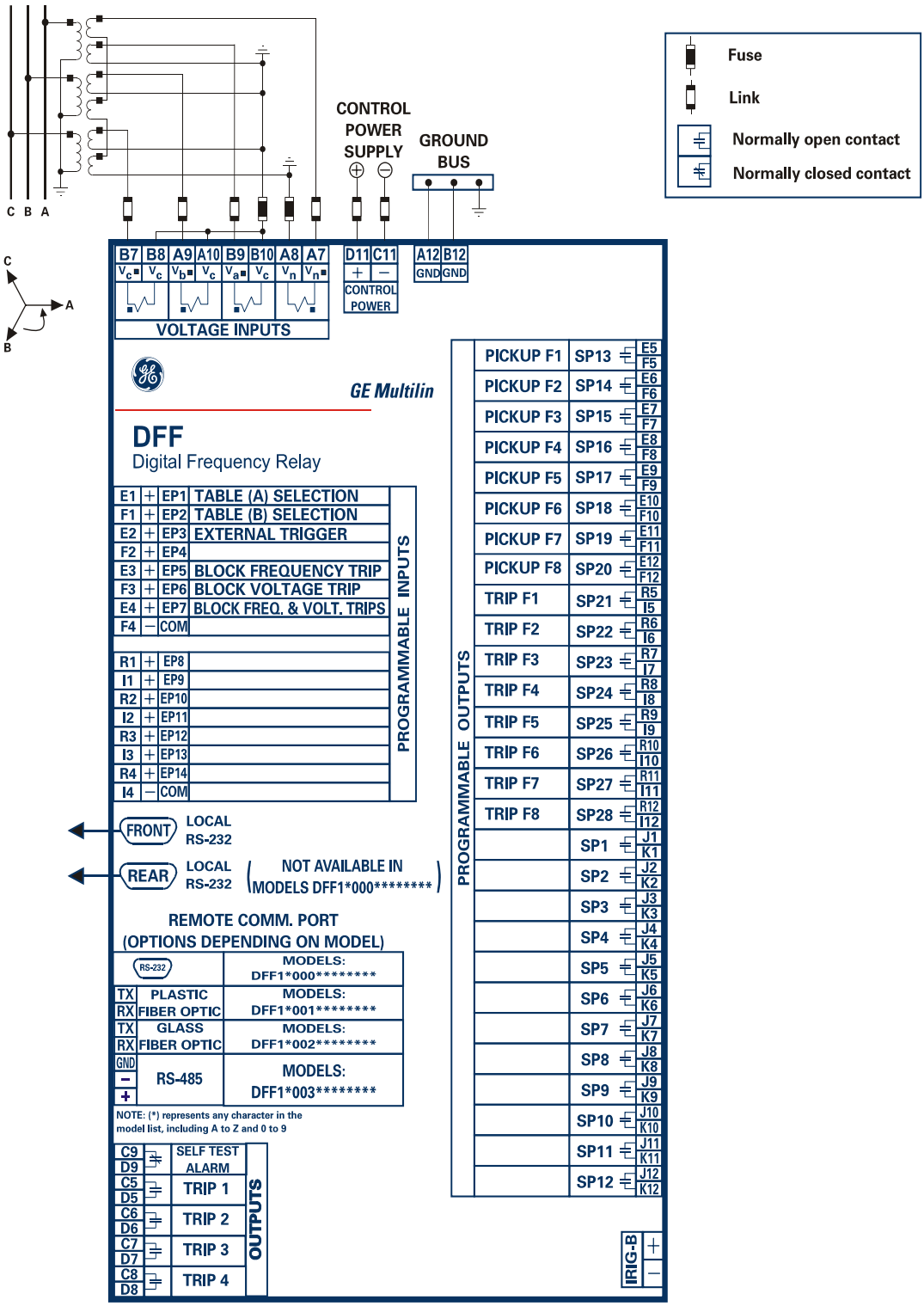


Figure 1: *External Connections for DFF1000 model*

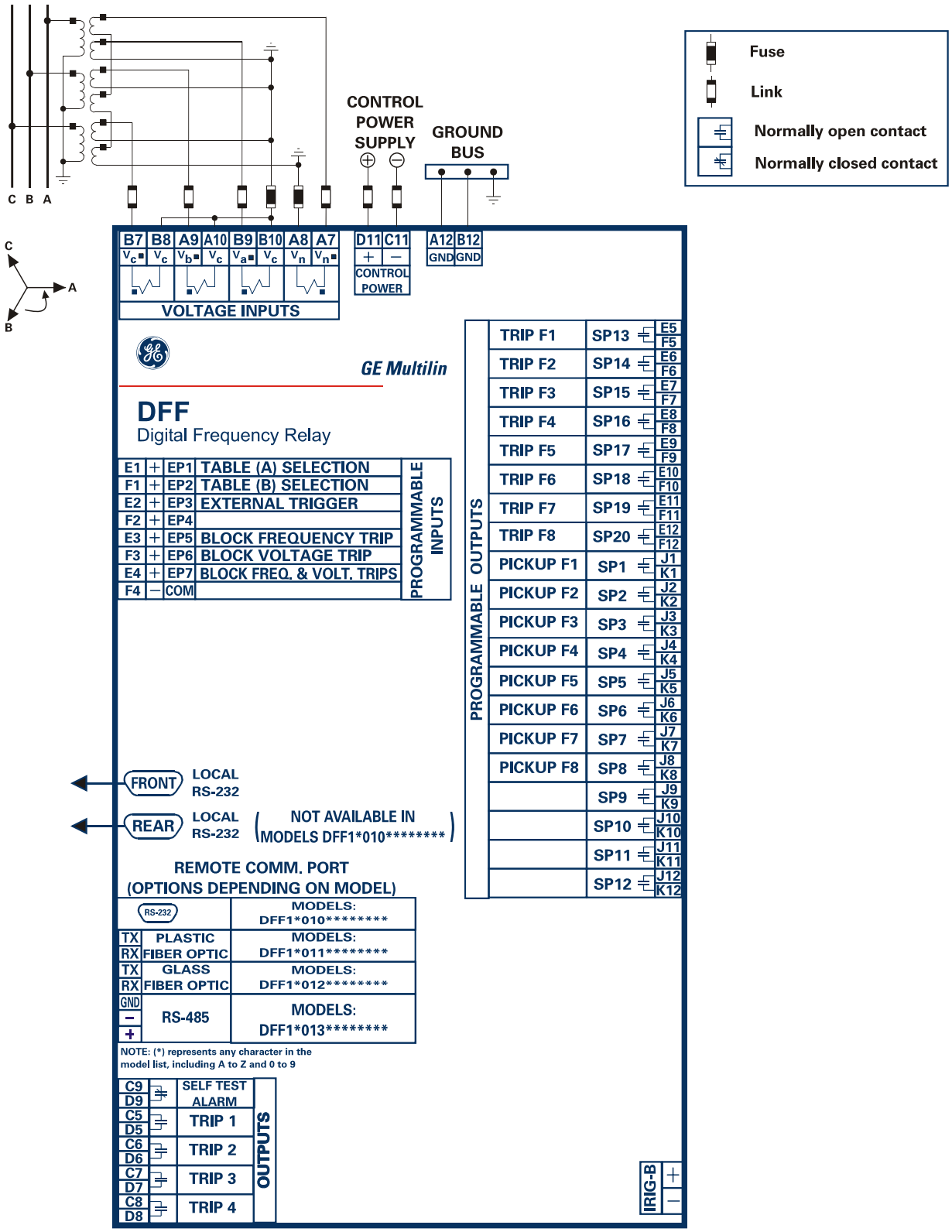


Figure 2: *External Connections for DFF1001 model*

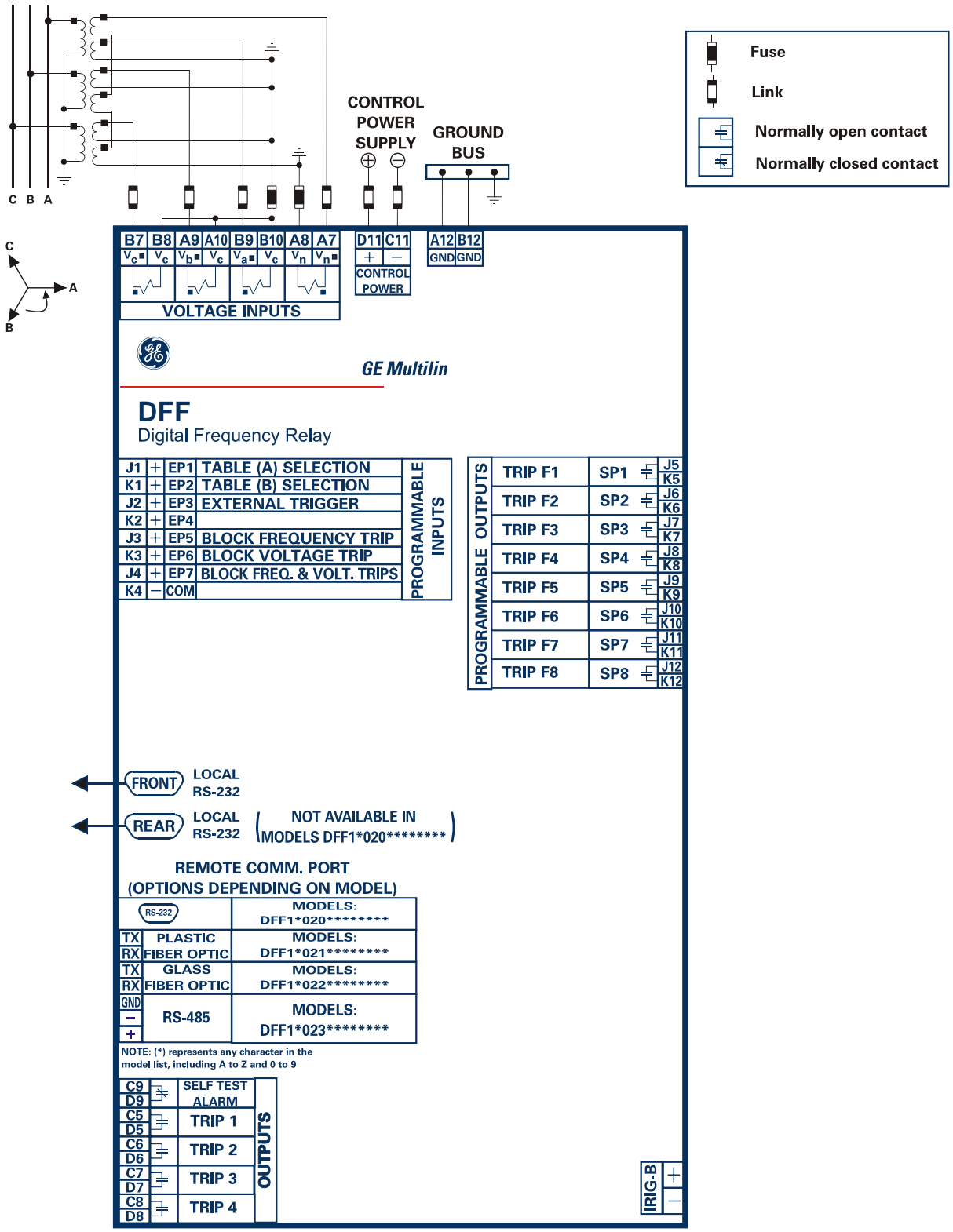


Figure 3: *External Connections for DFF1002 model*

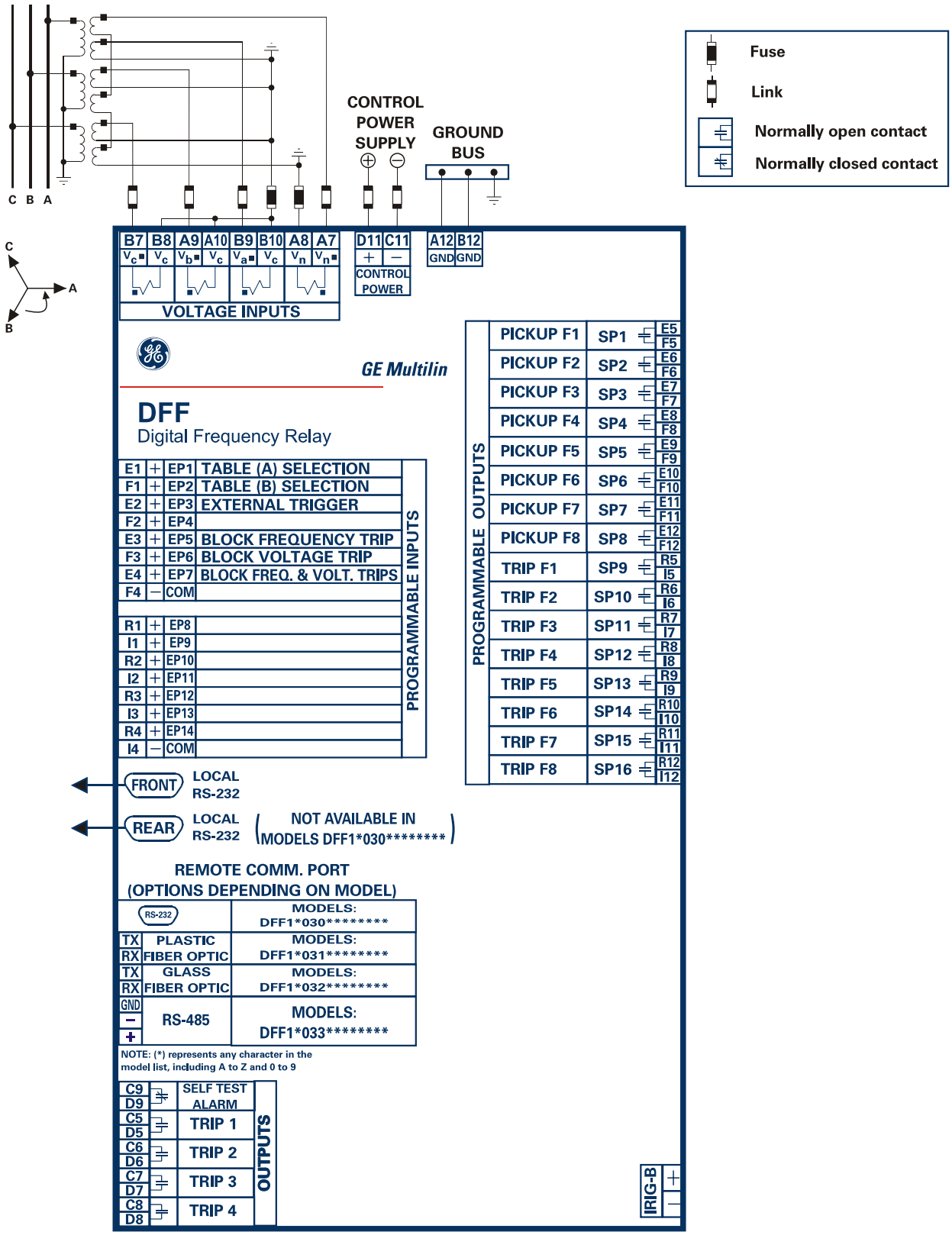


Figure 4: *External Connections for DFF1003 model*

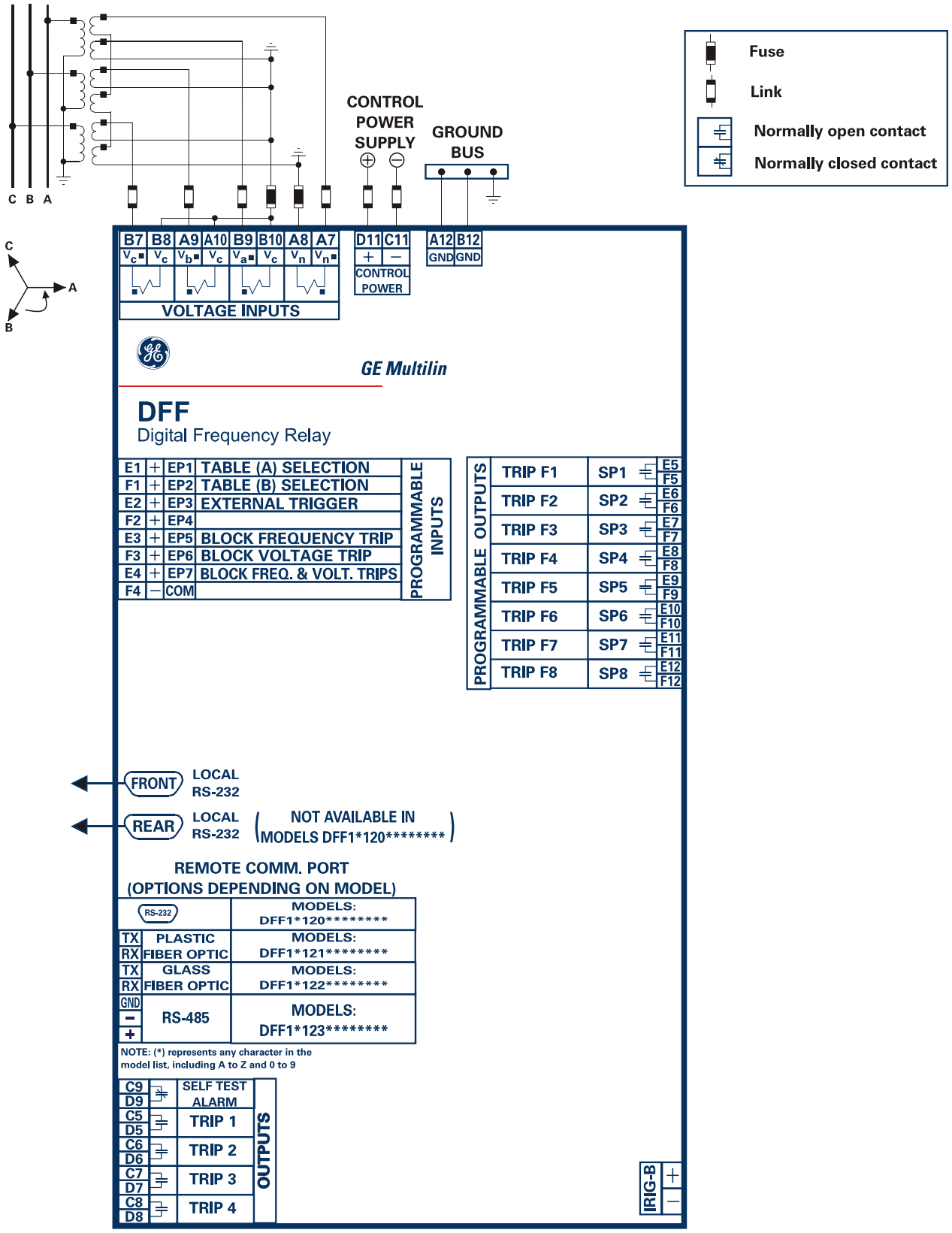


Figure 5: *External Connections for DFF 1012 model*

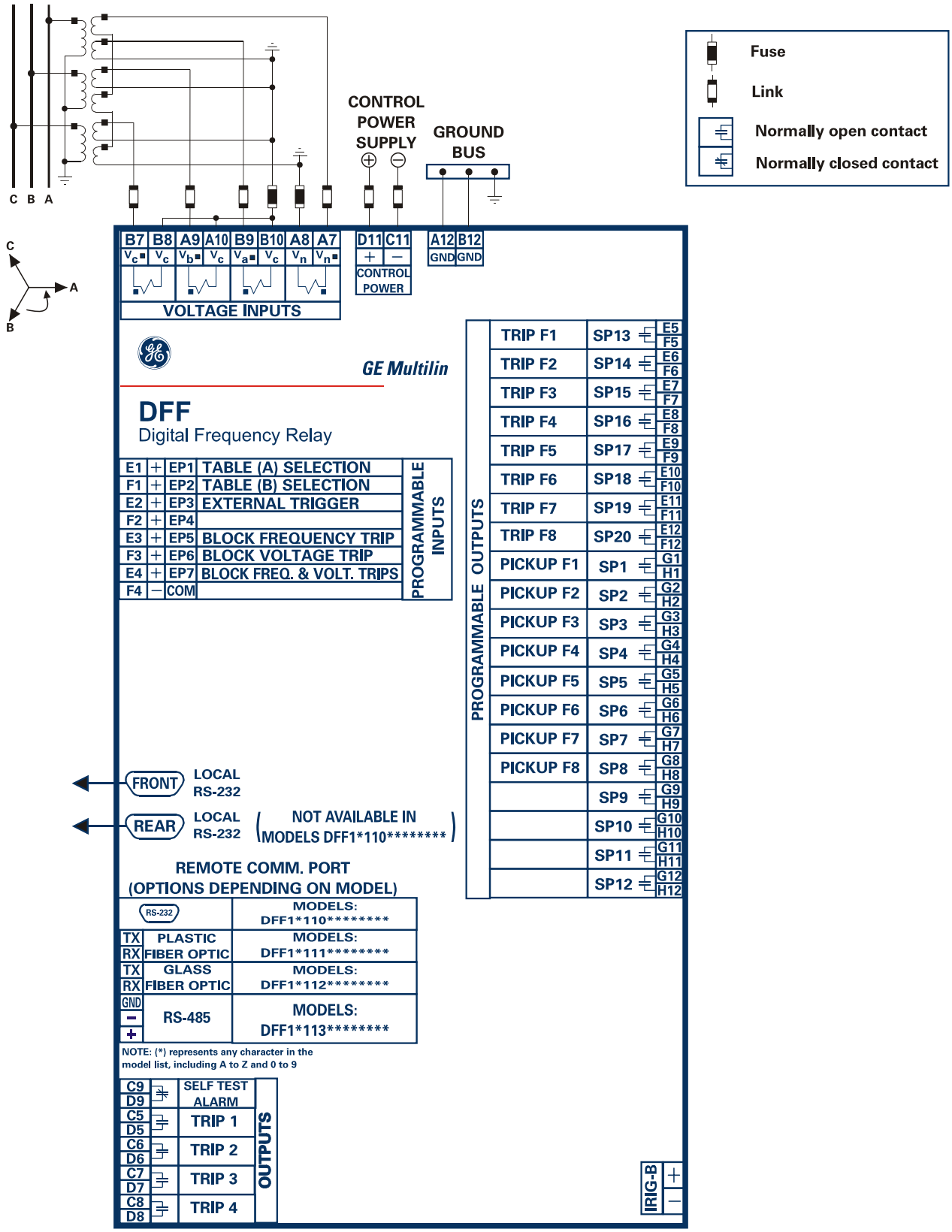


Figure 6: *External Connections for DFF 1011 model*

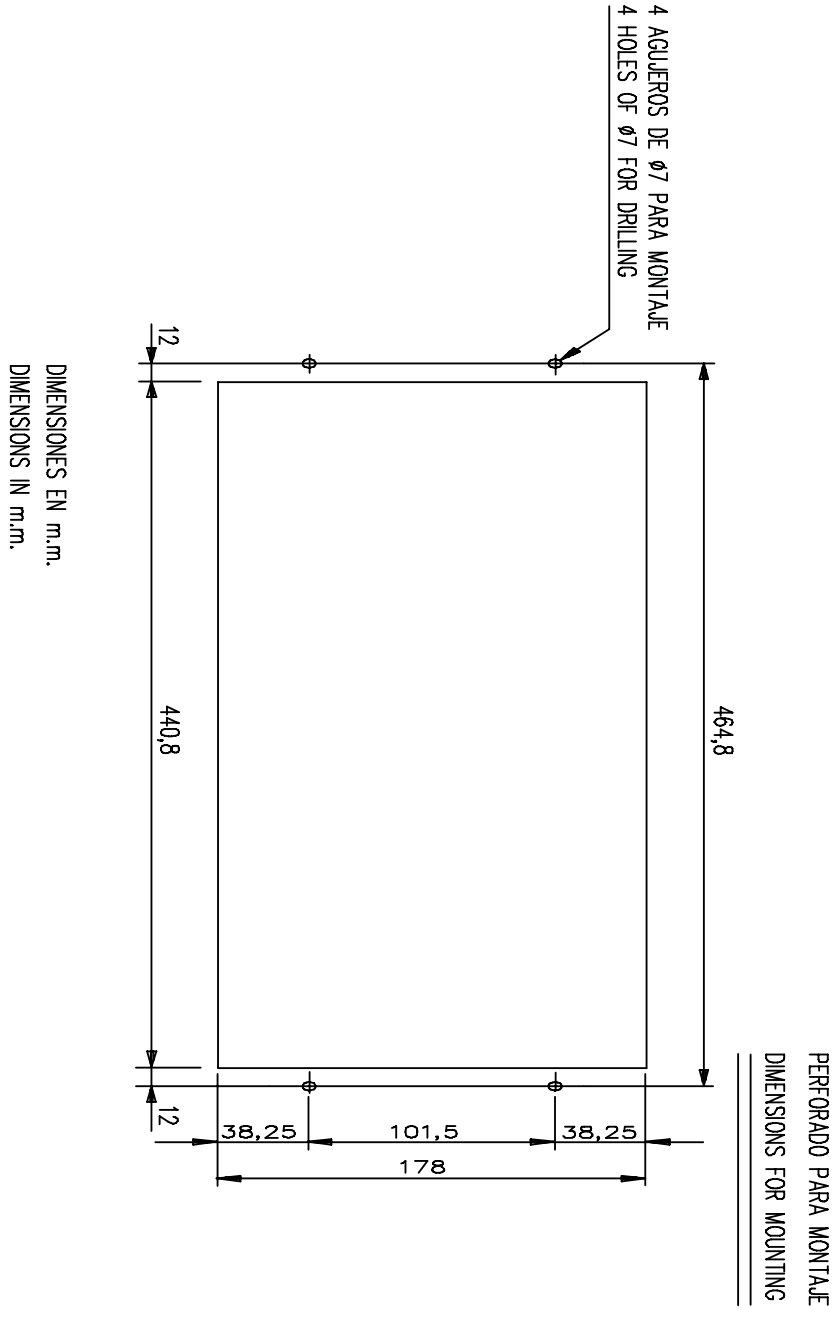
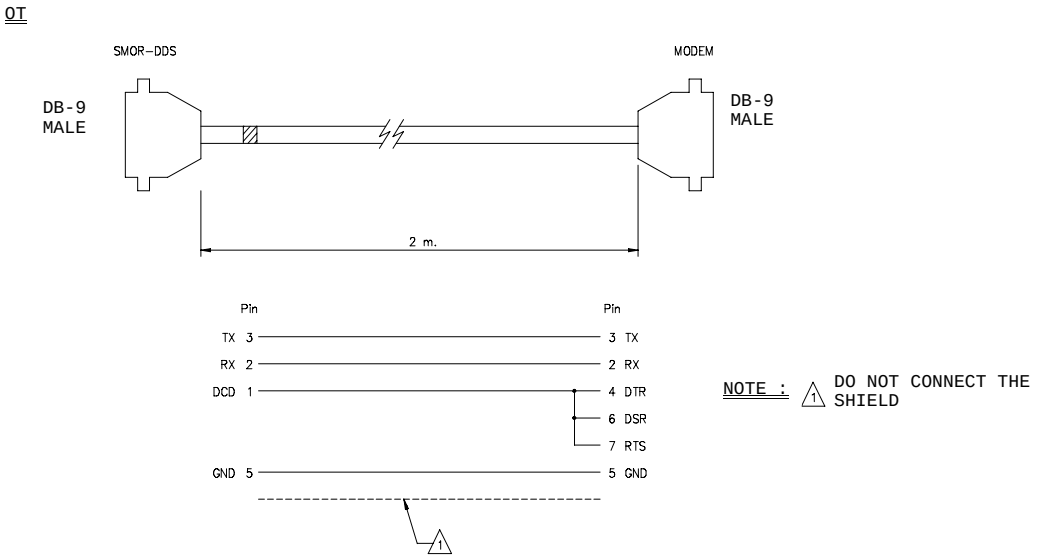


Figure 7: *Panel Mounting for 19" rack models*

Relay to Modem connection. Direct/through cable, no crossing.



Relay to computer connection (standard null modem)

It is recommended to use a direct cable with an standard Null Modem connector at one end.

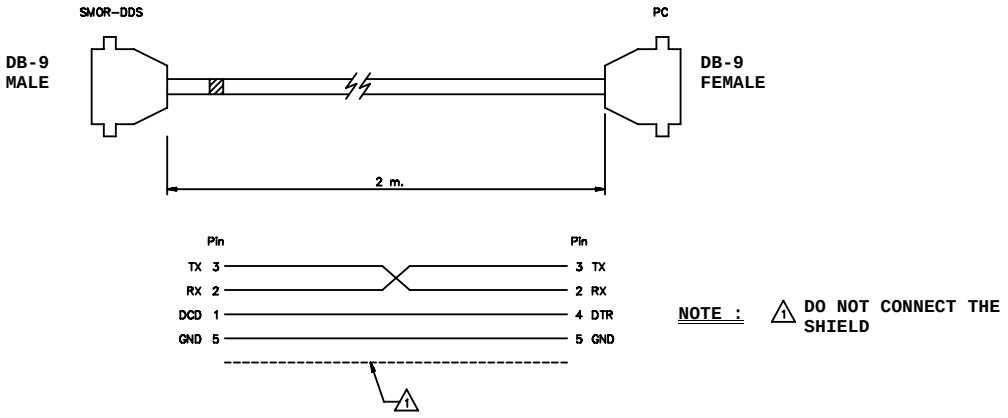


Figure 8. *RS-232 Connection*

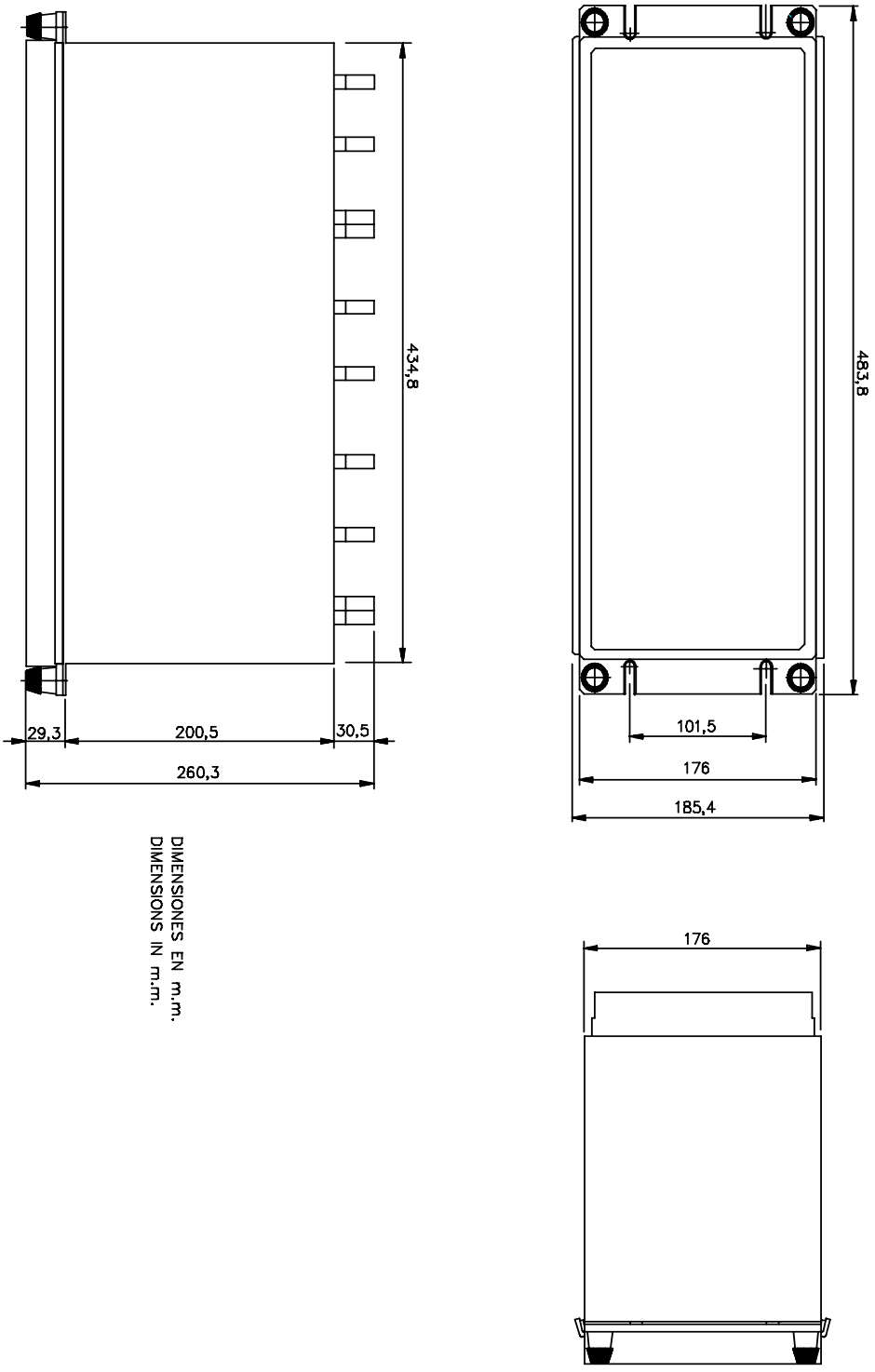


Figure 9: *Dimensions diagram for 19 rack models*

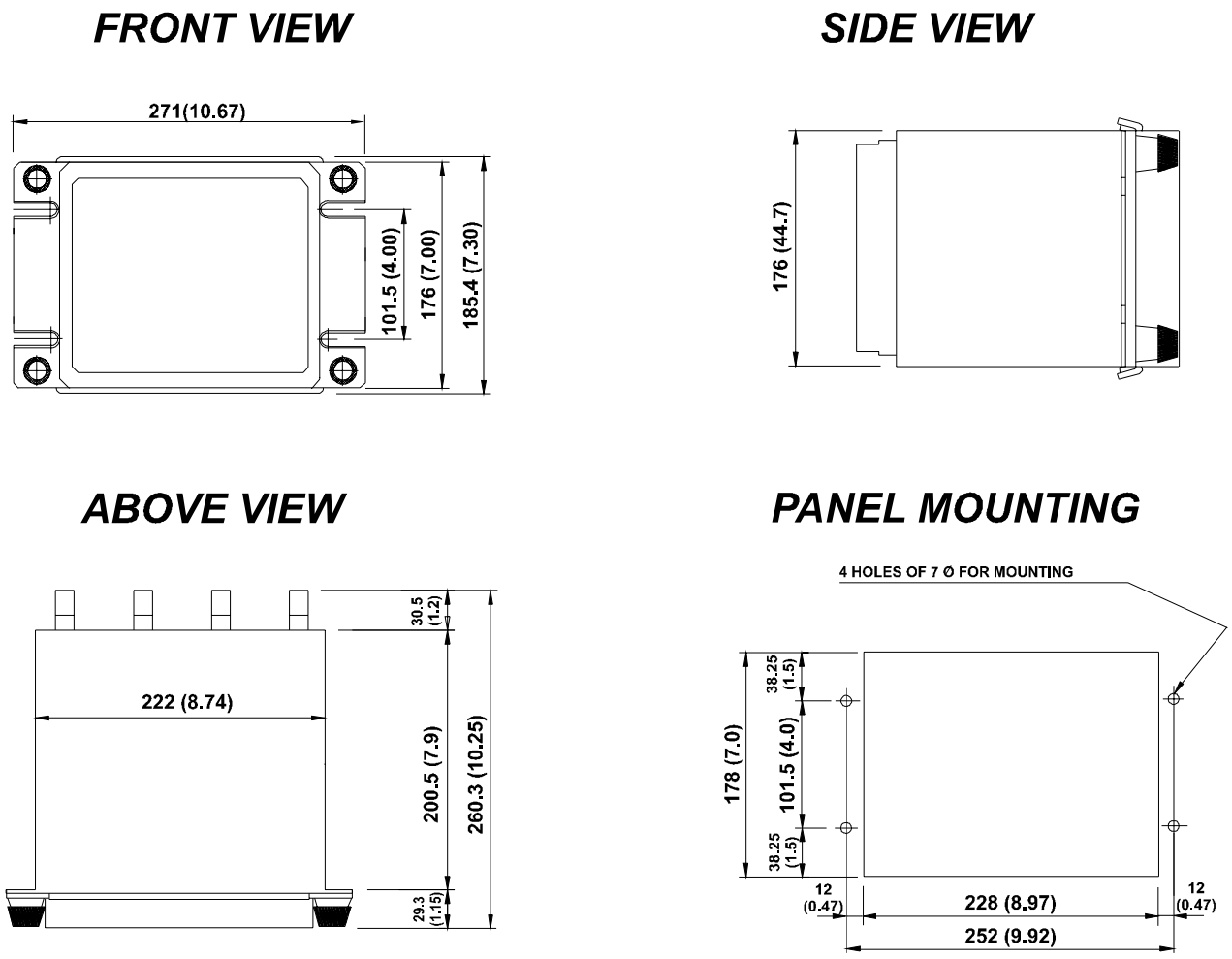


***Figure 10** : Dimensions Diagram for ½ rack models*

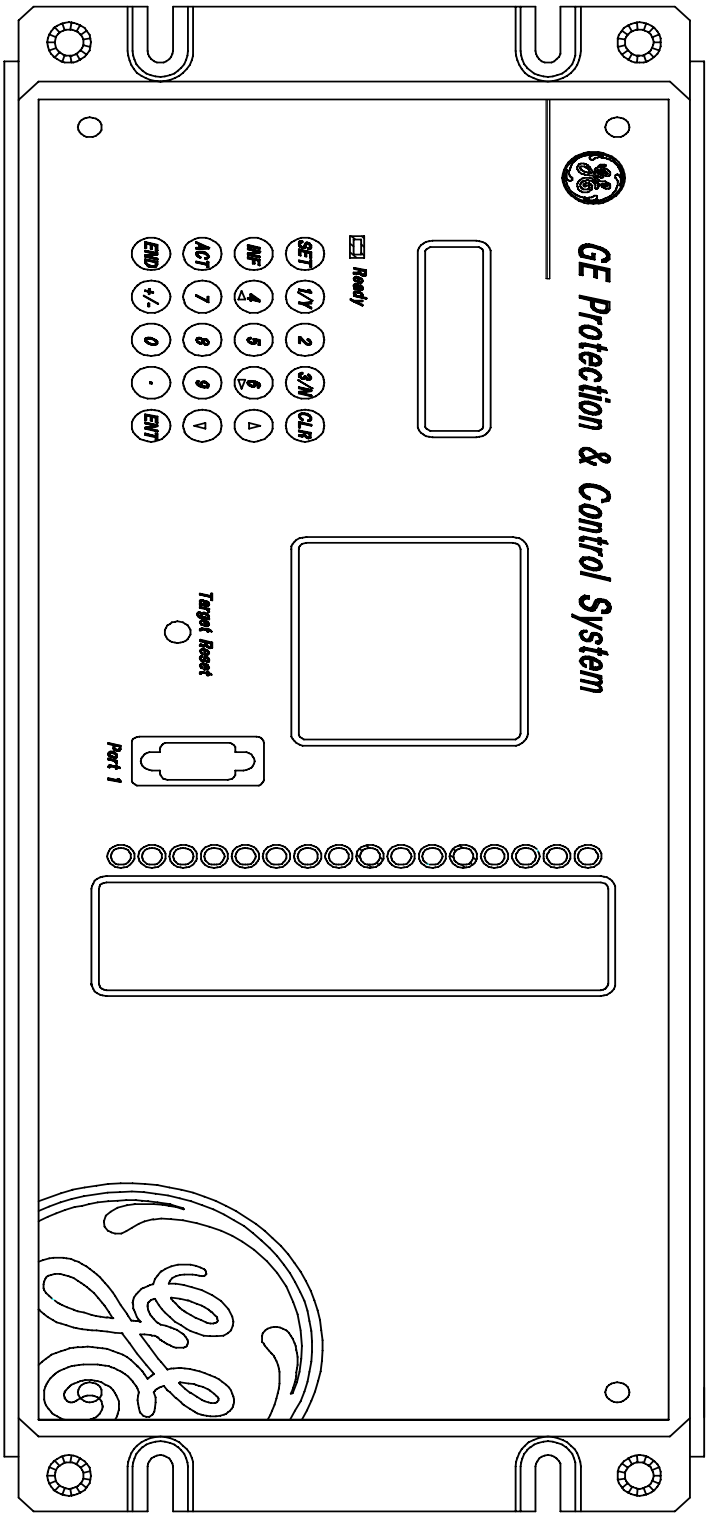


Figure 11: *Front View for 19" rack models*

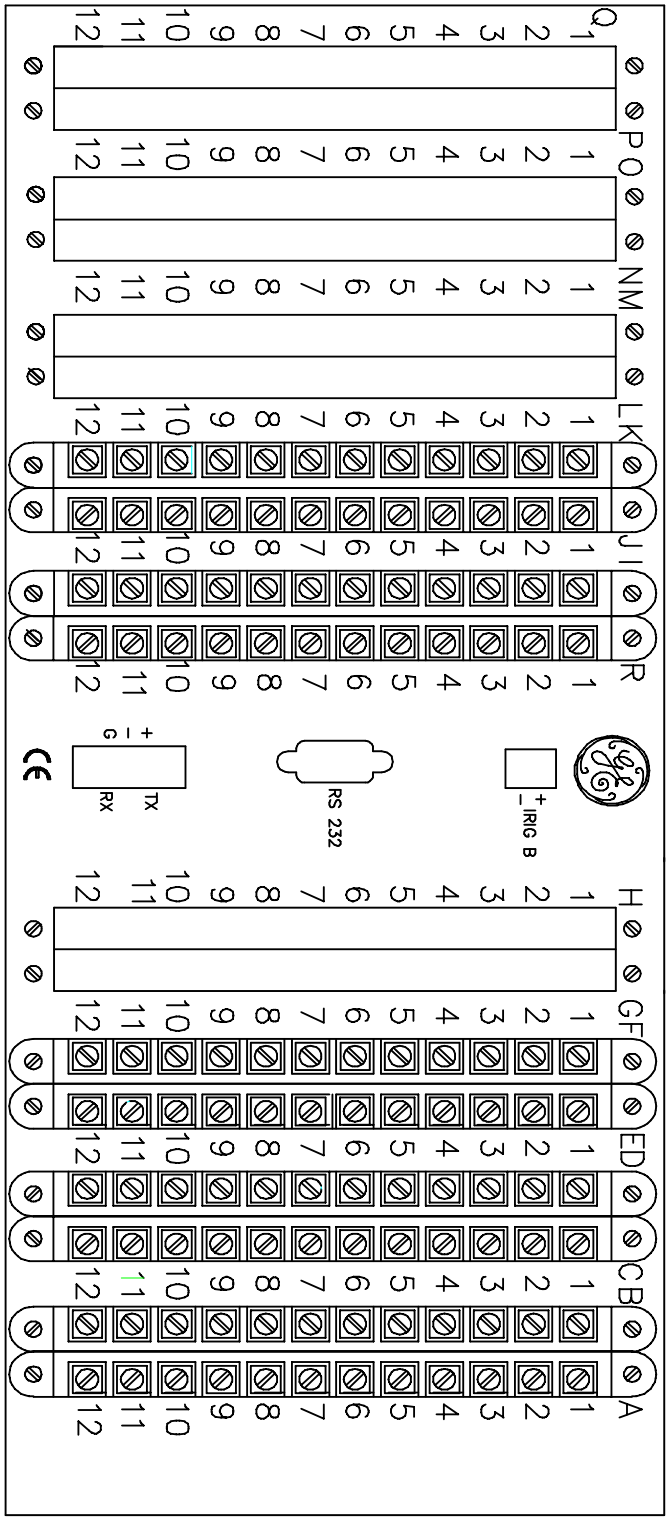


Figure 12: *Rear View for 19" rack model*

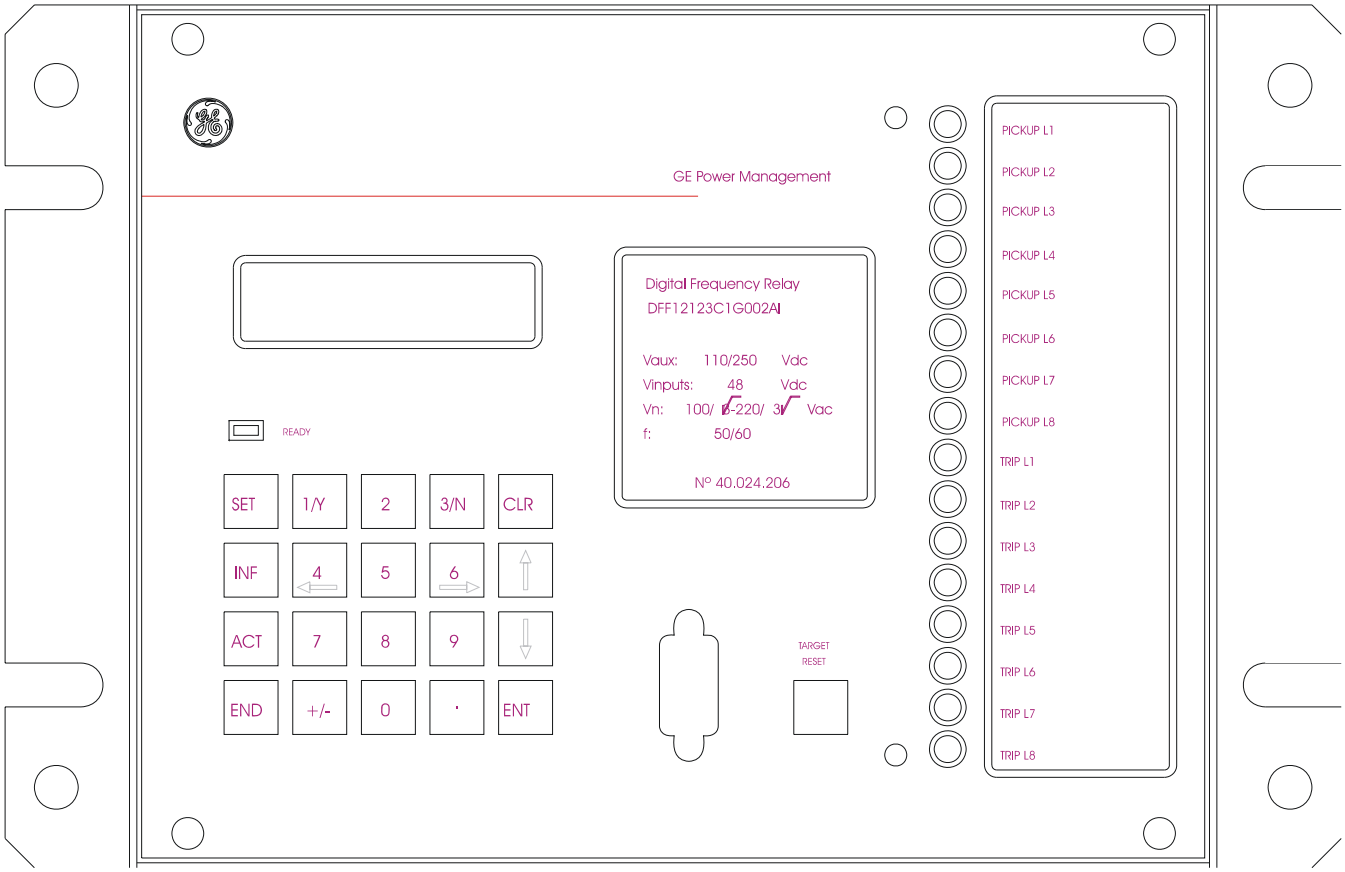


***Figure 13**: Front View for ½ rack models (B2213F3)*

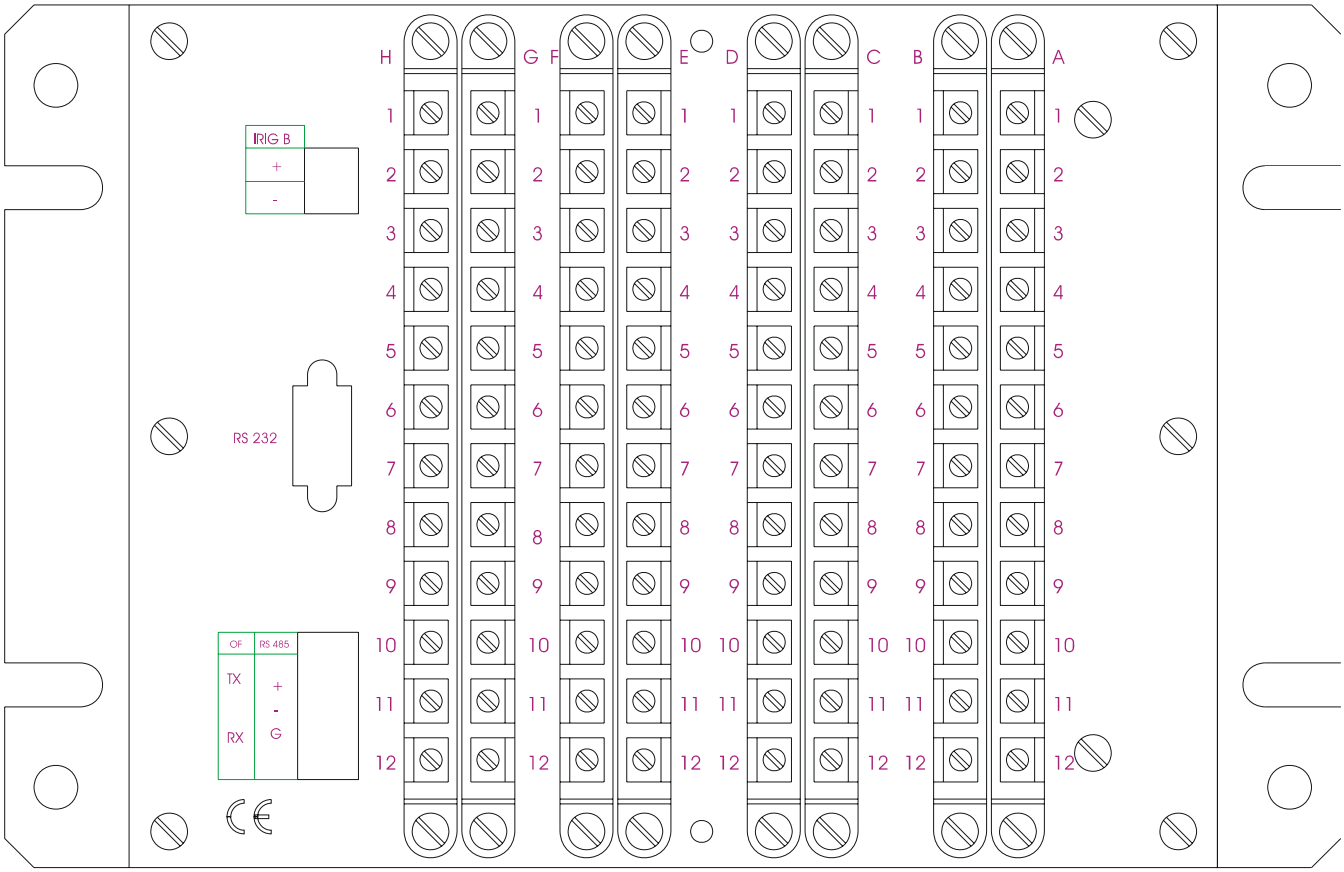


Figure 14: *Rear View for ½ rack models (B2213F2)*