

Functional Range

FL-1 - Load Balancing Relay



C&S Protection & Control Ltd.

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1. Introduction and application

FL1 is a micro-controller based unit for active and reactive load balancing. The display available on the front panel enables the user to know the status of connected generating sets. Micro-controller used in the unit makes it powerful enough to calculate the responses of the governor and AVR and auto-tune itself for optimum response.

The **FL1** is suitable for load balancing of up to four generating sets, the number of **FL1** required shall be same as that of number of generating sets (Refer fig 7.1,7.2,7.3); However load balancing between two generating sets can be achieved by using one **FL1** relay (With fixed master generating set).

The **FL1** can be employed for load management along with AMF unit NB2 and auto-synchronizer PSY2.

Note: Load management is possible only for two generating sets.

2. Features and characteristics

- Auto-tuning for achieving fast regulation with minimum oscillation.

Display of voltage, current, power factor frequency, active, reactive and apparent power,

LED indications for active-reactive load balancing, auto-manual mode and power ON.

Load dependent start/stop of slave generating set. (Applicable for two generating set only)

Selectable auto and manual mode of operation.

Ability to detect and indicate wrong CT polarities with auto reset facility.

Password security for parameter setting.

Wide setting range with fine steps.

Wide voltage range for auxiliary supply.

3. Design

3.1 Concept

Active load and reactive load sharing upto four generators. Load sharing among three or four generating sets can be achieved by using three or four **FL1** units respectively. However, a single **FL1** unit can do the load balancing between two generating sets (with fixed master generating set).

In case of two generating set operations, it is possible to configure start KVA and stop KVA for the slave generator; thus the unit extends the features from load balancing to load management. The load management for two generator operations can be achieved by using a single **FL1** relay (with fixed master generating set).

3.2 Operational states

The load balancing unit **FL1** has two operational states:

Passive state

Active state

Configuration of the unit can only be done in passive state. To enter in to the passive state auxiliary supply of **FL1** is to be switched on while pressing the reset button. Passive state is password protected (Default password: Press "ENTER/RP↑" key four times). Setting can only be changed after entering the correct password.

In active state, **FL1** displays the status of the connected generator and does the function of load balancing/management. On power ON the **FL1** goes in to active state.

3.3 Output relays

The **FL1** has six output relays. The function and the terminal arrangement of these relays (NO contacts) is as follows:

Relay Terminal function

- Relay 1: 1, 2 active power increment.
- Relay 2: 3, 4 active power decrement.
- Relay 3: 5, 6 reactive power increment.
- Relay 4: 7, 8 reactive power decrement.
- Relay 5: 9, 10 slave generator start.
- Relay 6: 11, 12 slave generator stop.

3.4 Inputs

3.4.1 CT connection

CT arrangement is shown in fig 7.1, 7.2 and 7.3. CT of both generators must be connected from the same phase.

3.4.2 PT connection

FL1 is only available in 230 V phase to neutral supply. PT connection must be made from the same supply from which CT inputs are connected.

3.4.3 Auxiliary Supply

FL1 has SMPS auxiliary supply, which can either be given from an AC source or DC source (For range please refer technical specification)

3.4.4 NO contacts

Function and the terminal arrangement of input contacts is as follows:

Contact 1: 19, 20 for synchronization over command.

Contact 2: 21, 22 for auto mode/manual mode selection.

Contact 3: 23, 24 for master selection logic

(For details refer fig 7.1, 7.2, and 7.3)

Contact 4: 25, 26 for master selection logic.

(For details refer Fig 7.1, 7.2, and 7.3)

3.5 Display

The load balancing unit **FL1** is equipped with 20X4 LCD display to provide the status of the Generating sets and various parameters of the Generating sets.

	KVA	KVAR	KW	PF	
G1	4 digit	4 digit	4 digit	4 digit	
G2	4 digit	4 digit	4 digit	4 digit	
IG1	4 digit			4 digit	IG2
V	4 digit			4 digit	Hz

“Active (Default) State Display”

3.6 LEDs

There are 7 LEDs on the front panel of **FL1**. These LEDs are used to indicate various operational states of **FL1**

The LEDs indicate the following

Active power increment

Active power decrement

Mode of operation: Auto

Mode of operation: Manual

Reactive power increment

Reactive power decrement

Power ON

3.7 Connections

The connection diagram for the load balancing unit **FL1** for two, three and four generating sets along with the master selection logic diagram shown in the Fig. 7.1, Fig. 7.2 and Fig. 7.3 respectively.

4.0 Working principle

4.1 Operating modes

The **FL1** has two mode of operation:

Auto mode

Manual mode

Terminals 21 and 22 are used for auto and manual mode selection.

Auto mode is selected by closing terminal 21 and 22. **FL1** enters into manual mode when terminal 21 and 22 are open. A switch can be connected across terminal 21 and 22 for auto/manual mode selection. Selected mode is displayed by LEDs on front panel.

Auto mode:

In auto mode **FL1** does the load balancing automatically based on settings and measurements, after receiving the Syn. Over command, provided that Slave Start command has already been issued. In auto mode pulse width is calculated by the unit depending on the power difference and response time of AVR and governor

Manual mode:

In manual mode the load balancing can be done with the help of four switches provided on the front panel.

The switch marked "Enter/RP↑" can be used to increase the reactive power of the selected slave generating set.

The switch marked "Reset/RP↓" can be used to decrease the reactive power of the selected slave generating set.

The switch marked "+/AP↑" can be used to increase the active power of the selected slave generating set.

The switch marked "-/AP↓" can be used to decrease the active power of the selected slave generating set.

The switches will become active as soon as manual mode is selected irrespective of Syn Over command. Thus, in manual mode user can also use these switches for voltage and frequency

control of generating set. Corresponding output contacts operate on pressing the respective push buttons and releases on release of push buttons.

4.2 Active and Reactive load sharing

The **FL1** does the load sharing for active power as well as reactive power simultaneously. The output contacts can be connected directly or through motorized potentiometer to the governor and AVR for active and reactive load sharing.

On power on the unit displays the measurement of the connected generators. In normal sequence of operation generator one (Master) will be switched on first, once the load on the master generator exceeds the set limit of Slave Start KVA, unit issue start command to Generator 2 (Slave).

After synchronization, syn. Over command is received by **FL1**; it starts balancing the load in accordance with the settings.

In beginning **FL1** sends fixed duration pulses to calculate the correction factor (Response time) of the system

In case the system fails to respond to the fixed pulses, **FL1** displays message on the LCD display as

'SYSTEM NOT RESPONDING FOR GOVERNOR CHANGE'/'SYSTEM NOT RESPONDING FOR AVR CHANGE'

The message can be acknowledged by pressing reset button, on pressing the button **FL1** restart sending the fixed pulses for calculating correction factor.

It is possible to do unequal percentage load sharing. Following equation is used for load sharing.

% Load shared by the slave generating set = {(% load shared by the slave generating set due to its KVA rating) + (+ ve tolerance in % load sharing) - (-ve tolerance in % load sharing)}.

Where % load shared by slave generating set due to its KVA rating

$$= (\text{Slave KVA} \times 100) / (\text{Slave KVA} + \text{Master KVA})$$

Example:

During load sharing between master generator and slave generator, if the slave generator is required to be de-rated of its actual load sharing, the following setting are adapted.

Master generator	:	1500KVA
Slave Generator	:	1000KVA
+ ve tolerance	:	1
-ve tolerance	:	11
Sensitivity	:	10%
Total plant load	:	1000KW

In this case, the master generator will take 700KW and on slave generator the load shall be 300KW \pm 10%. The **FL1** unit will not issue any pulse/command for active load sharing in slave generator between 270KW to 330KW.

To avoid continuous operation of load balancing commands, the relay sensitivity can be defined. Sensitivity indicates the dead operating zone.

Example:

Master kVA rating	:	500
Slave kVA rating	:	500
+ve tolerance	:	1
-ve tolerance	:	1
Sensitivity	:	10%
Total plant load	:	500KW

Load shared by the slave generating set will be 250KW \pm 10% i.e. the **FL1** unit will not issue any pulse/command for active load on slave generating set between 225KW to 275KW.

4.3 Load management

The **FL1** can also be employed for load management along with AMF relay NB2 and auto-synchronizer PSY2.

Load management facility is limited to two generator operation only.

The **FL1** continuously compare apparent power of the master generator with the set value of slave generator start KVA. When apparent power of master generator exceeds the set value of the start KVA and stays higher

for more than 10 Sec., the **FL1** issue a start command to the slave generating set. The start command/pulse is continuous latch type (for terminal no. please refer 6.2)

Once both the generators are synchronized, and syn. Over command is received, **FL1** starts function of load balancing.

The **FL1** monitors total apparent power of both generating sets and compare it with set value of stop KVA, when the total measured power goes below set value of Stop KVA, the **FL1** unit starts transferring the load from slave generating set to the master generating set.

A stop command is released from **FL1**, when the apparent power on slave generator is reduced to 10% of it's rated KVA.

Start command is also deactivated simultaneously.

The duration. of stop pulse is fixed to 1 Sec.

5.0 Settings

5.1 Setting procedure

Setting of **FL1** can be changed by using four push buttons available on front panel of **FL1**

Enter/RP \uparrow

Reset/RP \downarrow

+ /AP \uparrow

- /AP \downarrow

"Enter/RP \uparrow " push button is used for selection of parameters (sequence is listed in table 5.1) Once the parameter is selected the present set value appears on LCD display, which can be changed by pressing "+ /AP \uparrow " or "- /AP \downarrow " push buttons. "+ /AP \uparrow " push button is used to increment the value where as "- /AP \downarrow " push button is used for decrement.

The setting values in the **FL1** unit can only be changed in Passive state (refer article 3.2). After entering the valid password, it will ask to press the "Enter/RP \uparrow " push button by displaying <Enter>. After pressing push button first parameter is displayed on the LCD display. Sequence, setting range and steps of parameters is listed in table 5.1.

The set value of the corresponding parameter can be changed to increase or decrease by pressing, the “+ / AP↑” or “- / AP↓” push button respectively. If these switches are pressed continuously for some time, the step for the increment/decrement will change to 10 for 8 Sec. and thereafter it will be in the step of 100.

5.2 Setting range

Parameter	Ranges	Steps
Gen1 CT ratio Prim/Sec.	0-9999	1, 10, 100
Gen2CT ratio Prim/Sec.	0-9999	1, 10, 100
PT ratio Prim/Sec.	0.01-99.99	0.01, 0.1, 1.0
Generator 1 KVA	0-9999	1, 10, 100
Generator 2 KVA	0-9999	1, 10, 100
Slave start KVA>	0-9999	1, 10, 100
Slave stop KVA<	0-9999	1, 10, 100
Active load sharing Sensitivity %	0-100%	1, 10
Reactive load sharing Sensitivity %	0-100%	1, 10
Minimum pulse off time	0-100 Sec.	1, 10
GEN 3 CT ratio	0-9999	1, 10, 100
GEN 3 KVA	0-9999	1, 10, 100
GEN 4 CT ratio	0-9999	1, 10, 100
GEN 4 KVA	0-9999	1, 10, 100
+ ve tolerance in load sharing	0-100%	1, 10
- ve tolerance in load sharing	0-100%	1, 10
Select Slave Gen	1-4	1

Table : 5.1

6.0 Terminal detail

6.1 Terminal arrangement

The terminal arrangement of the **FL1** as shown in the table 5.2

Note: All CTs and PTs connections to the **FL1** unit must be from the same phase. The PT voltage connected to the relay must be phase to neutral 230 VAC voltage.

6.2 Terminal description

Terminal No.	Description
1, 2	Active power increment contact (Slave generating set)
3, 4	Active power decrement contact (Slave Generating set)
5, 6	Reactive power increment contact (Slave generating set)
7, 8	Reactive power decrement contact (Slave generating set)
9, 10	Slave generating set start contact
11, 12	Slave generating set stop contact
13, 14	CT input for master generating set
15, 16	CT input for slave generating set
17, 18	PT 230 VAC input supply from main bus.
19, 20	Synchronization over contact from synchronizing circuit breaker (CB)
21, 22	Auto mode/Manual mode selection switch
23, 24	Master selection logic input contact
25, 26	Master selection logic input contact
27, 28	Auxiliary voltage supply
29	Earth
30	Not used

Table : 5.2

7.0 Scheme

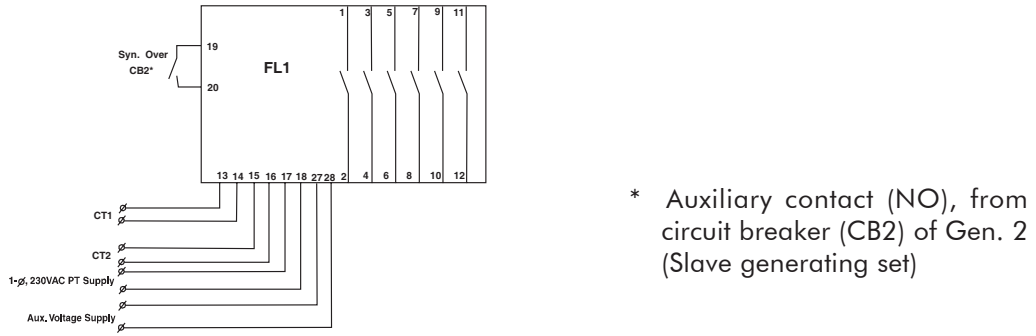


Fig. 7.1 Connection diagram, for 2 nos generating sets (with fixed master generating set).

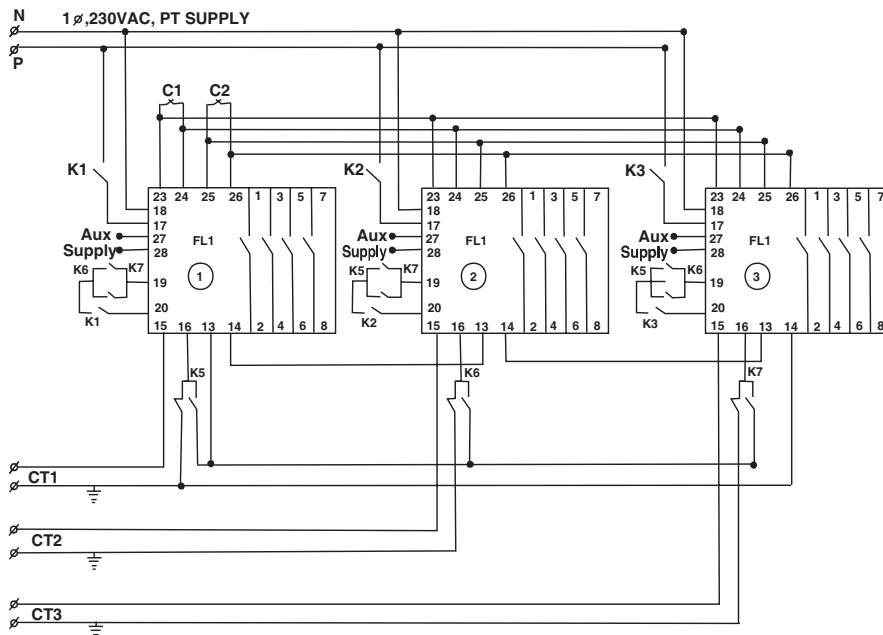
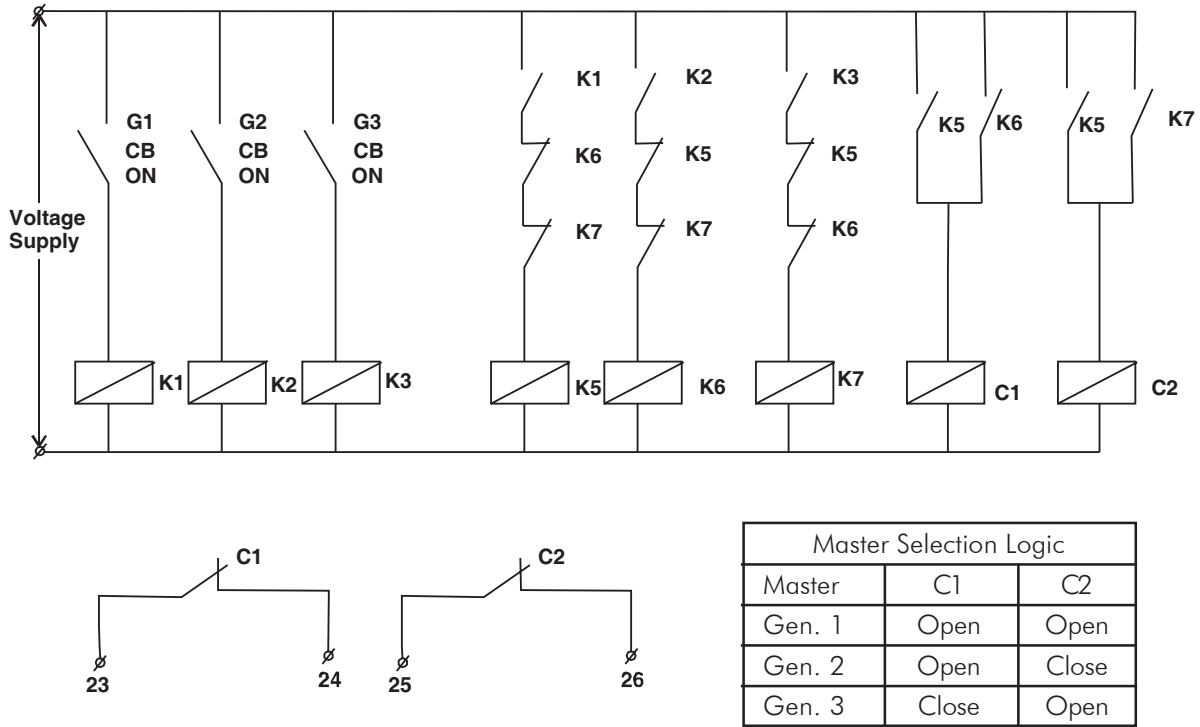
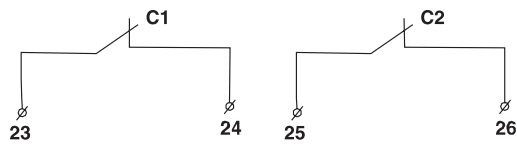
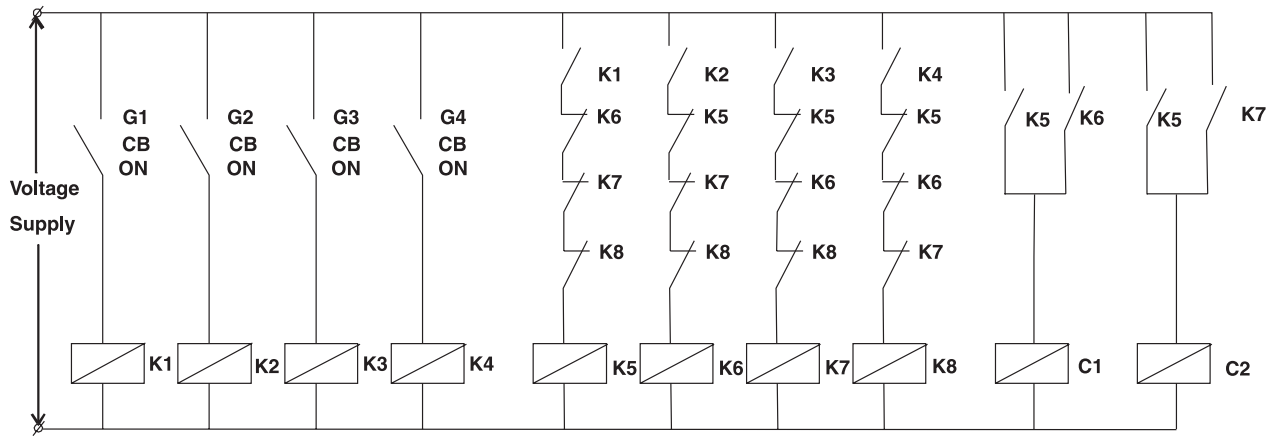


Fig. 7.2 Connection diagram for 3 nos. generating sets with master selection logic circuit.



Master Selection Logic		
Master	C1	C2
Gen. 1	Open	Open
Gen. 2	Open	Close
Gen. 3	Close	Open
Gen. 4	Close	Close

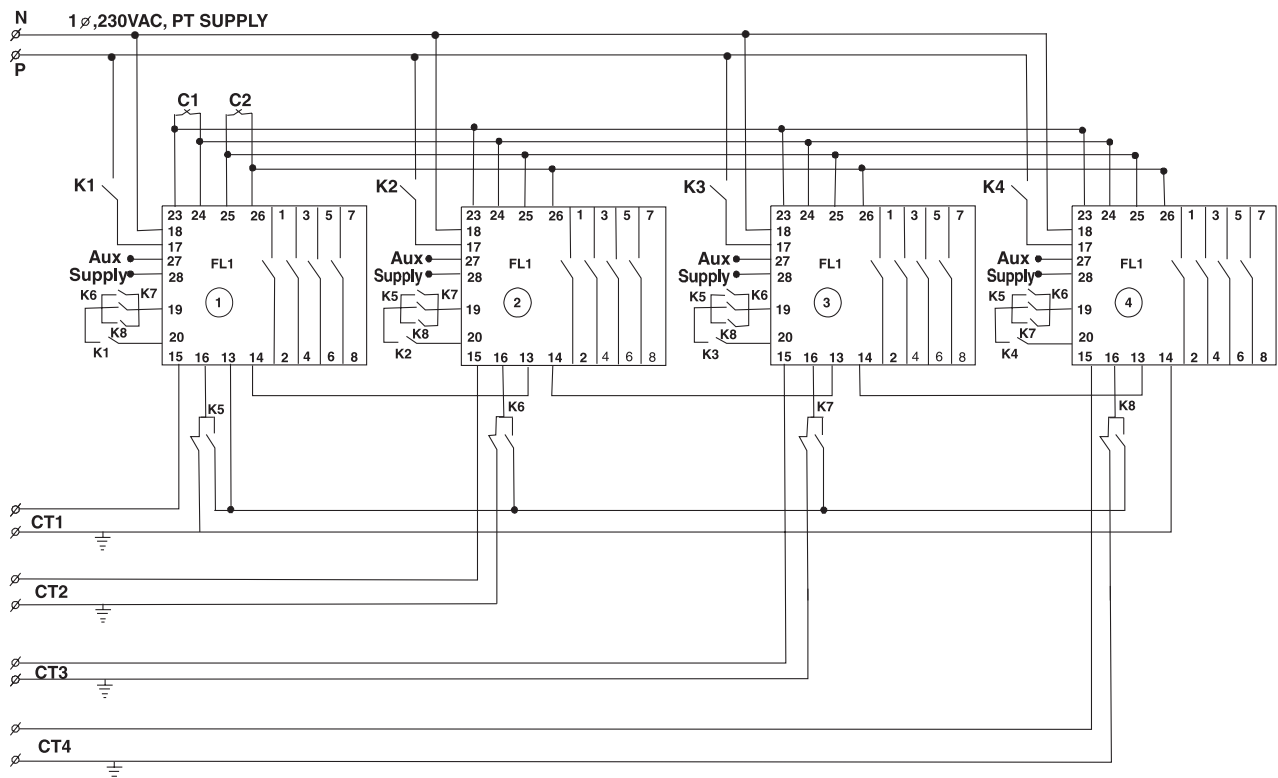
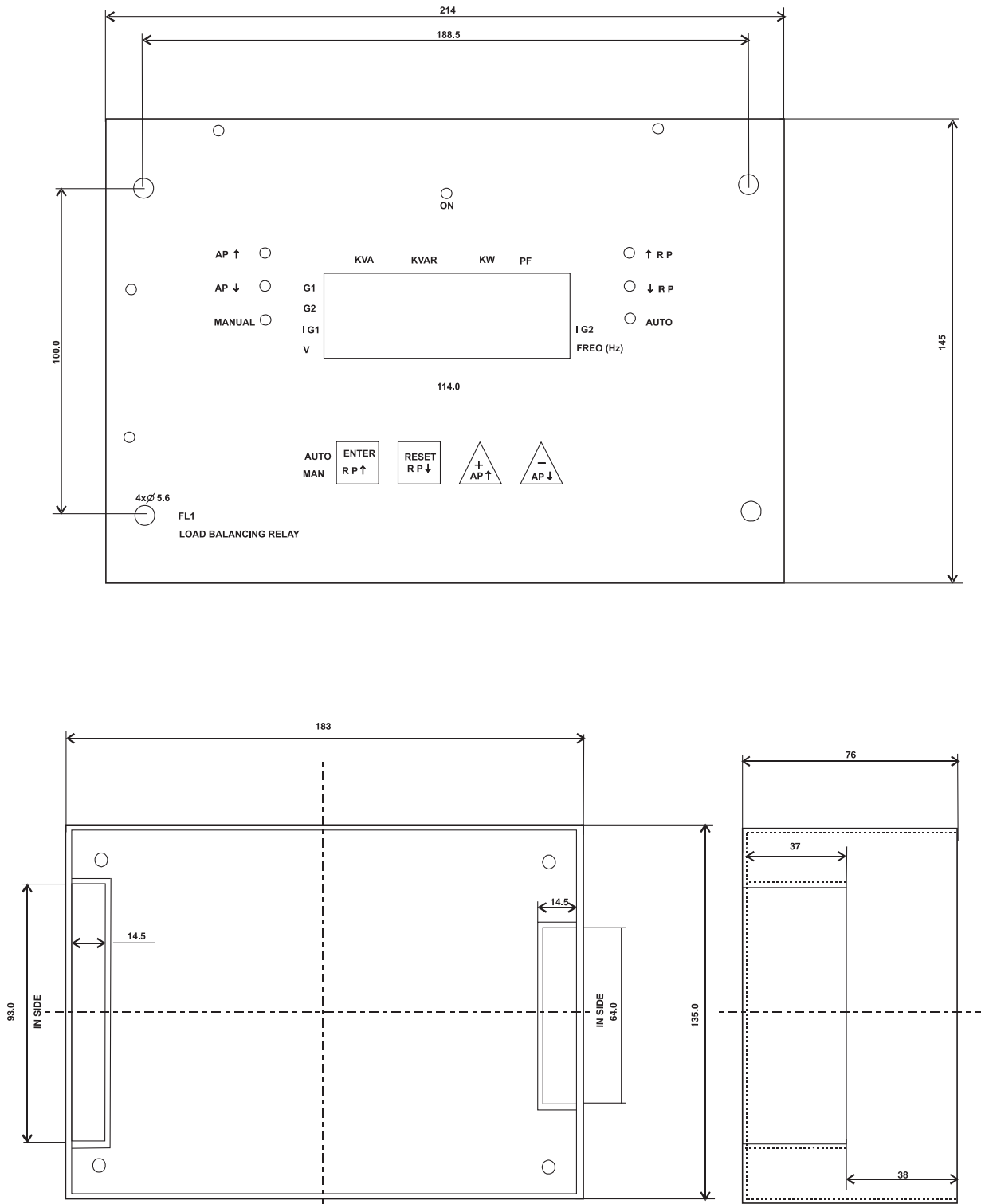


Fig. 7.3 Connection diagram, for 4 nos. generating sets with master selection logic circuit.

8.0 Dimensional diagram

The dimensional details of the load balancing unit FL1 are shown in the Fig. 8.1



All dimensions are in mm.

Fig. 8.1 Dimensional Diagram

9.0 Technical data

9.1 General data

Type	: FL1
Design	: Flush panel mounting
Duty	: Continuous operation
Maintenance	: None

9.2 Measuring input circuits

Nominal voltage	: Single phase 230 VAC (Phase to neutral)
Nominal current	: 1 A/5A
Nominal frequency	: 50 Hz
Auxiliary supply	: 16-270VAC/16-360VDC
Burden (C.T.)	: <1VA

9.3 Common data

Connecting leads	: 2.5 mm ²
Insulation	: as per IS 3231
Operation indicator	: LED, LCD
Mounting	: Wall mounting
Output contacts	: 6 change over contacts
Contacts rating	: Max. 1250VA, 230VAC
Display	: 20 X 4 LCD
Weight	: Approx. 2 Kg

10.0 Order form

Load balancing relay	FL1	
Rated current		
1A		1
5A		5

Technical data subject to change without notice.



BASIC RANGE

- Micro-controller based compact economical design
- DIN rail mounted
- Status indication via LED
- Step-less settings through front potentiometer



HIGHTECH RANGE

- Microprocessor based numerical protection
- Event & fault recording
- RS 485 communication
- Bright alpha-numeric display



INTEGRATED RANGE

- Complete numeric protection, solution for sub-station in association with TEAM-ARTECHE, Spain
- Distance protection
- Comprehensive transformer protection –
 - a. Three winding transformer
 - b. Two winding transformer
- Multi-functional relay: variety of protection combination

For further information, please contact :

CSPC

C&S Protection & Control Ltd.

44, Okhla Indl. Estate, New Delhi-110020, Ph.: 011-55602414, 26319465-66 Fax: 011-55602413 email: cspc@controlsindia.com

Marketing Office : DELHI : Ph.: 55602414, 26319465-66 Fax: 55602413 CHANDIGARH : Ph. 2776154, 2776151, 2726153 Fax: 2726154
KOLKATA : Ph. 24549607-08 Fax: 24549371 MUMBAI : Ph.: 24114727-28 Fax : 24126631 PUNE : Ph.: 5444822-824, Fax: 5410820,
AHMEDABAD : Ph.: 65841425, 6589132 Fax : 6589132 BANGALORE : Ph.: 5586147, 5323582, 5594939 Fax: 5582796,
CHENNAI : Ph.: 26426475, 26426572 Fax: 26411972 HYDERABAD : Ph.: 27813003, 55332304 Fax: 27812987