280/288 SERIES USERS' GUIDE

UG 3.2.2-280/288

DISCLAIMER

The greatest care has been taken to manufacture and calibrate your instrument. However, failure to install, set-up or operate the instrument according to its instructions may void the warranty.

WARNING

Ensure that all incoming AC power and other power sources are turned OFF before performing any work on the instrument. Failure to do so may result in serious (or even fatal) injury, and/or damage to equipment.

WARNING

Your instrument should only be opened by a duly authorized representative. The unit should only be opened in a full Anti-Static environment. Failure to do so may damage the electronics. Failure to do so voids the guarantee.

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1. GENERAL DESCRIPTION

The 280/288 Series are microprocessor-based, panel mounted instruments designed to simplify the measurement and management of electricity.

The 280/288 Series measure :

- RMS Voltage on each phase
- RMS Current on each phase
- Power (kW)
- Power Factor
- Consumption (kwh)

Displayed values are set according to potential transformer (if used) and current transformer ratios, via externally accessible DIP switches.
Optional measured values available:

- Frequency
- Ground (Earth) Leakage
- Apparent Power (kVA)
- Reactive Power (kVAr) and Energy (kVARh)
- Maximum Demand

Voltage is displayed line-to-line or line-to- neutral (DIP switch settable, see section 2.4.2).

The 288 Series, in addition to its measurement function, also allows control by the use of programmable set points on the following measured values (subject to model options):

- High Current
- High Voltage
- Low Voltage
- Low Power Factor
- High Power
- High Maximum Demand
- High Ground Leakage
- High Reactive Power (kVArh)
- High Apparent Power (kVA)

The instrument can also output one pulse per kWh or per 10 kWh, and with the appropriate options one pulse per kVArh or per 10 kVArh.

288 Series models have four relays, and can be user programmed to allocate any combination of set points to any of the relays.

Both the 280 and the 288 Series instruments can optionally have RS232 or RS422 communications, allowing them to be connected to printers, computers and central control rooms. The RS422 option also operates in multidrop mode, permitting up to 31 instruments to be connected to a single communications line.

Communications operate in either printer mode, where values are output at a user selected interval in printable format, or in computer mode, where a host computer polls the instrument in order to receive the values, or to examine or fix set points.

2. INSTALLATION AND SETUP

2.1 Mounting

The 280/288 Series are designed to be panel mounted. The dimensions of the cutout necessary are shown in Figure 1.

The instrument is positioned through the cutout and the two brackets then screwed to the back of the instrument as shown in Figure 2. Finally the four thrust screws are tightened against the panel in order to fix the instrument in place.

2.2 Location

The instrument should be mounted away from heat sources, in a dirt free environment. The ventilation holes at the back of the instrument should not be blocked. Although designed to operate in an electrically noisy environment, the instrument should not be placed near very high electric fields.

Figure 3 shows the position of the various terminals, connectors and DIP switches on the back of the instrument.

2.3 Wiring

WARNING

Ensure that all incoming AC power and other power sources are turned OFF before performing any work on the instrument. Failure to observe this practice can result in serious (or even fatal) injury and/or damage to equipment.

2.3.1 Power Source

The instrument is operated either by a factory set 185V-250V AC or a 95-135V AC 50/60Hz power source. Before connection check the label on the back of the instrument to ensure that you have been supplied with the correct voltage range for your requirements.

The live of the power source should be connected to terminal 14 and the neutral to terminal 13. The inputs are isolated from the measuring circuit, however the power source may be the same as the supply to be measured.

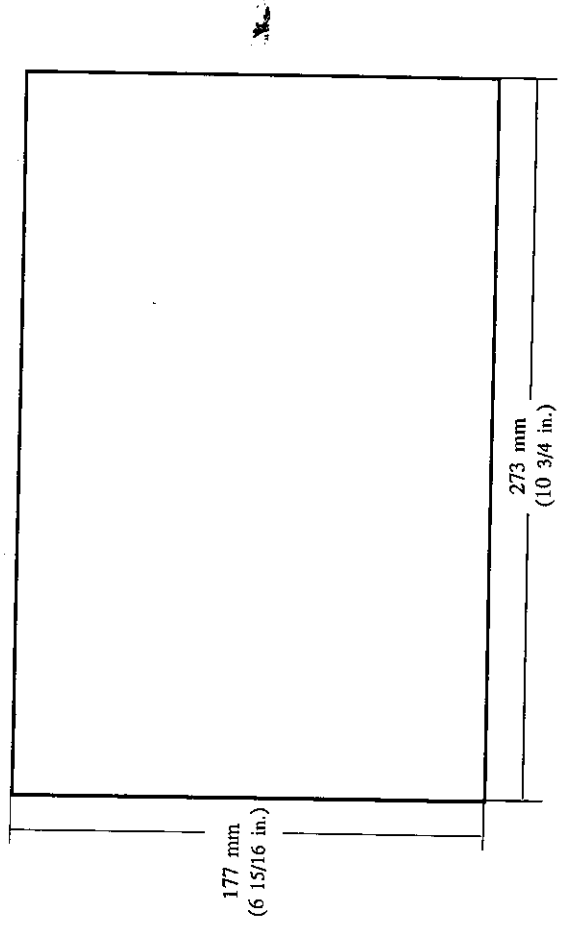


Figure 1 - Cut - Out

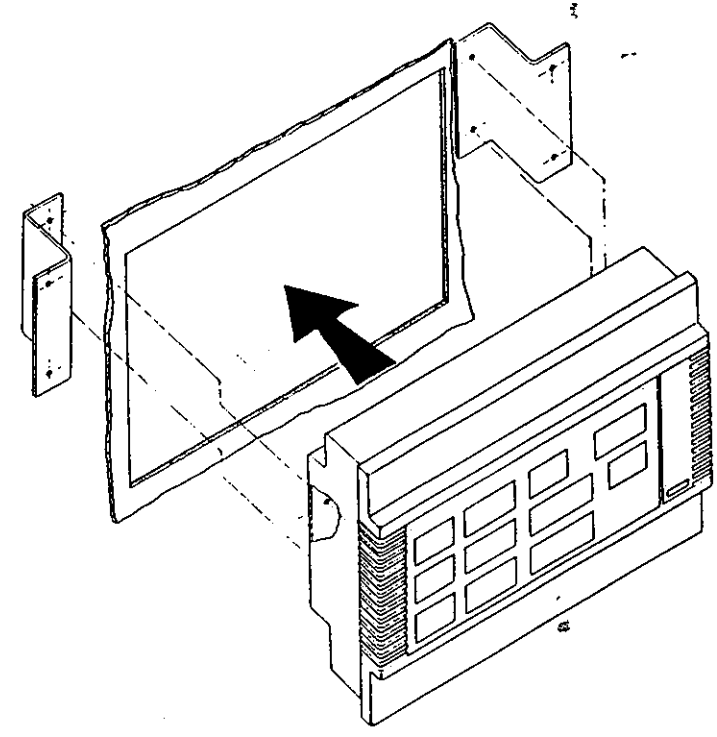


Figure 2 – Mounting

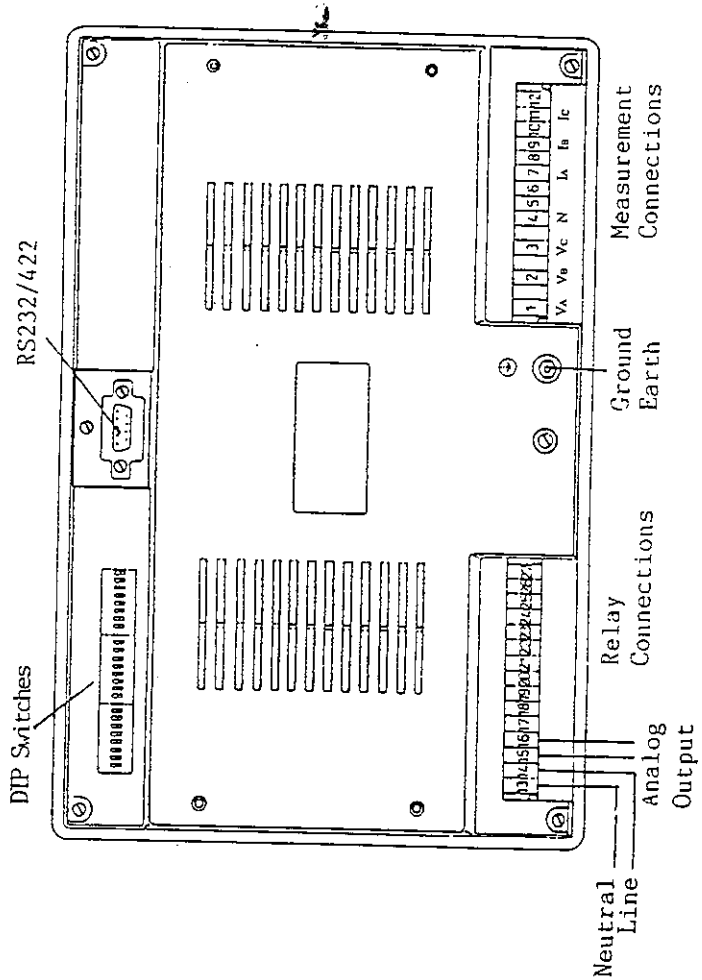


Figure 3 - Terminal and DIP Switch Locations

The chassis ground terminal must be connected to ground.

The location of the various terminals are shown in Fig. 3.

2.3.2 Voltage Input - Direct Measurement

2.3.2.1 3 wire sytems

Voltages up to 660V AC (line-to-line) may be connected directly to the instrument. The three lines are to be connected to terminals 1, 2 and 3, as in Figure 4.

2.3.2.2 4 wire systems

Wiring connections are as in Figure 5. Either line-to-neutral or line-to-line voltage can be displayed, according to the DIP switch settings (section 2.4).

THE VOLTAGE LINES SHOULD BE PROTECTED WITH FUSES OR CIRCUIT BREAKERS

2.3.3 Voltage Input - via P.T. Star (wye)

Configuration (4 wire systems)

For high voltage applications, the instrument can be connected via potential transformers in a star (or wye) configuration. The transformer secondaries must output a voltage of less than 660V AC line-to-line. The connections are shown in Figure 6.

Either line-to-line or line-to-neutral voltage can be displayed according the DIP switch settings (see section 2.4.3). The P.T. ratio is set via the front panel (see section 2.4.2) so that the instrument will display the correct voltage.

NOTE: Voltages above 999V are displayed in kilovolts, e.g. 1000V is displayed as 1.00. Voltages displayed in kilovolts include a decimal point.

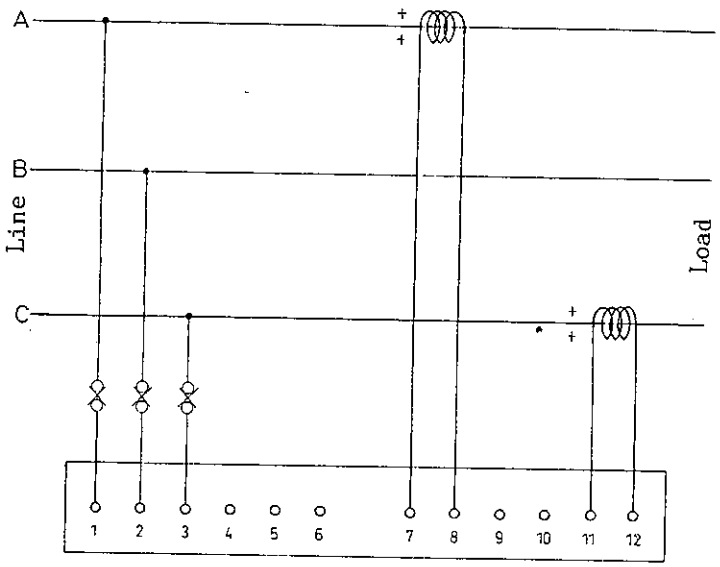


Figure 4 - Three wire system without potential transformers

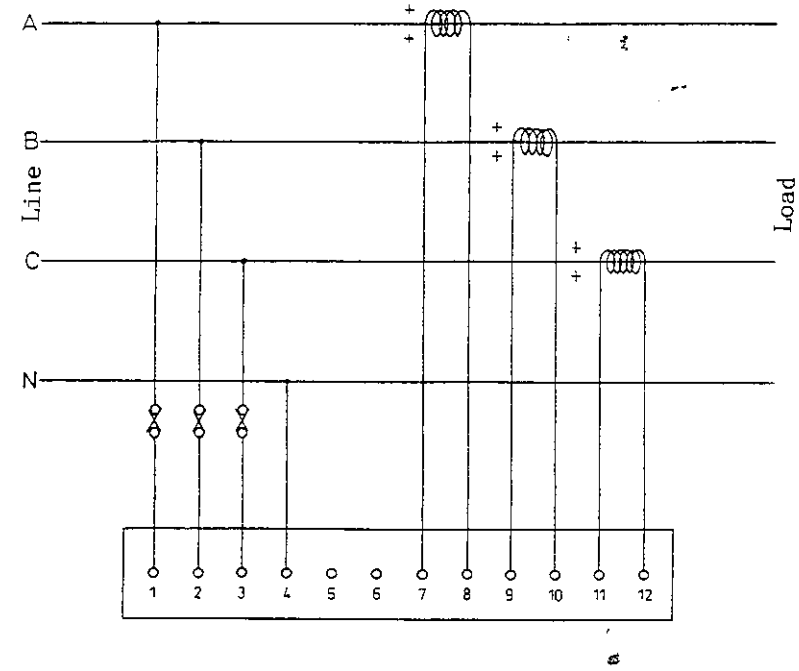


Figure 5 - Four wire system without potential transformers

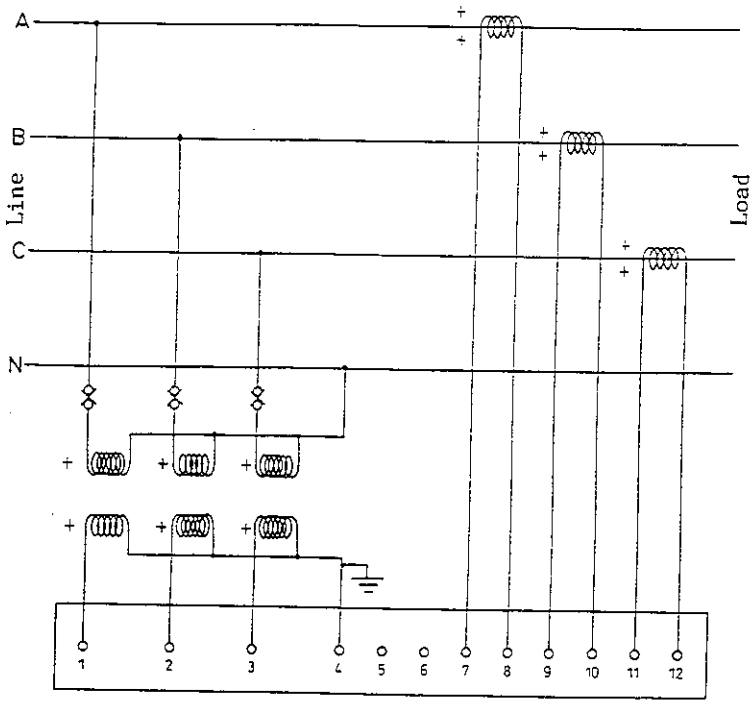


Figure 6 - Star (Wye) Connection with potential transformers

THE VOLTAGE LINES SHOULD BE PROTECTED WITH FUSES OR CIRCUIT BREAKERS.

2.3.4 Voltage Input - via P.T. Open Delta Configuration (3 wire systems)

For high voltage applications, the instrument can be connected via potential transformers in an open delta configuration. The transformer secondaries must output a voltage of less than 380V AC line-to-line. The connections are shown in Figure 7. Note that the connection to the middle phase and terminal 4 are grounded.

Open delta configuration is chosen by a DIP switch, as defined in section 2.4.3 Only line-to- line voltages are displayed.

The P.T. ratio is set via the front panel (see section 2.4.2), so that the instrument will display the correct voltage.

NOTE: Voltages above 999V are displayed in kilovolts with a decimal point.

THE VOLTAGE LINES SHOULD BE PROTECTED WITH FUSES OR CIRCUIT BREAKERS

2.3.5 Current Input

The instrument measures current via current transformers with 5 amp or 1 amp secondaries. This option is factory set, and before operation you should check the label on the back of the instrument to ensure that you have been supplied with the correct option.

The C.T.'s are connected as shown in Figure 4,5,6 and 7, depending on the type of voltage connection used. Note that for the open delta and 3 wire system configuration only two current transformers are required. If required, the return side of the current transformers (terminals 8, 10 and 12) may be grounded.

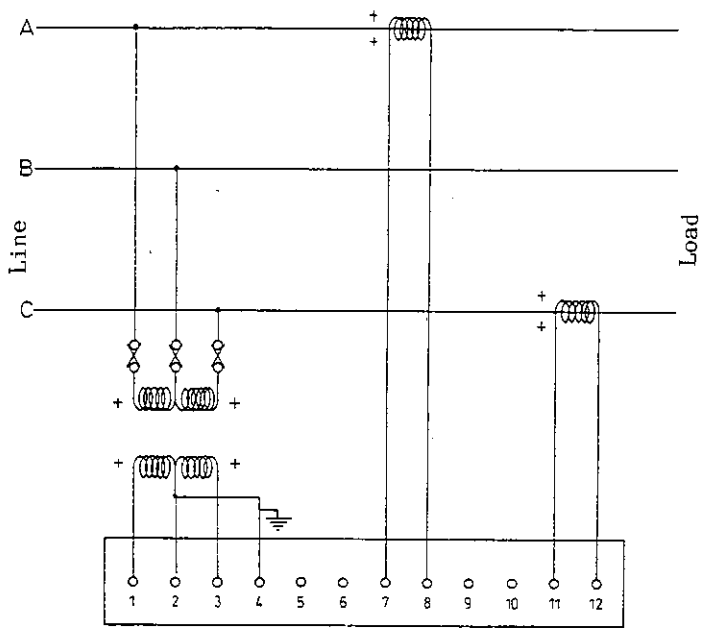


Figure 7 - Open Delta Connection with potential transformers

The C.T. ratio is set via the DIP switches, as defined in section 2.4, so that the instrument displays the actual current.

IMPORTANT: The C.T.'s must be connected in the correct order and with the correct polarity, as shown in the wiring diagrams for the instrument to operate properly. If after connection, the instrument displays a POWER FACTOR of close to zero, or zero, or POWER readings show unreasonable values, the polarity of the C.T. connections could possibly be wrong.

WARNING:

THE SECONDARY OF A CURRENT TRANSFORMER MUST NEVER BE OPEN CIRCUIT WHEN THE PRIMARY IS ENERGIZED. AN OPEN CIRCUIT CAN CAUSE HIGH VOLTAGES, TOGETHER WITH THE DANGER OF DAMAGE TO EQUIPMENT, FIRE AND POSSIBLY SERIOUS OR EVEN FATAL INJURY. FOR THIS REASON ENSURE THAT CURRENT TRANSFORMER WIRING IS SECURE, IF NECESSARY USING AN EXTERNAL STRAIN RELIEF TO REDUCE MECHANICAL STRAIN ON THE SCREW TERMINALS.

2.3.6 Ground Leakage Input (Optional)

A ground leakage current transformer with a 1000:1 ratio is connected to terminals 5 and 6, as in Figure 8. An actual ground leakage of 1 amp will result in an input of 1 mA to terminals 5 and 6. The full scale range is 0-5A (or 0-5mA after 1000:1 reduction).

2.3.7 Current Transformer Overload

The Instrument will withstand the following overload conditions from the current transformer secondaries:

7A RMS - continuous
100A RMS - 1 second

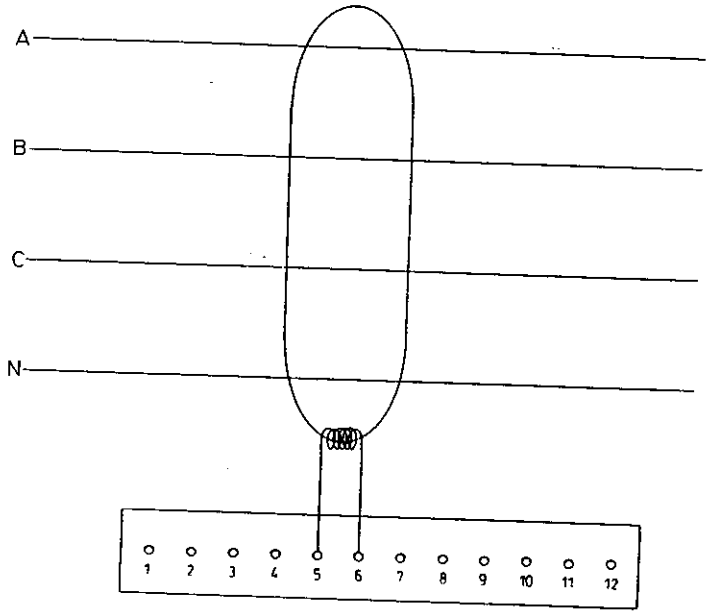


Figure 8 - Ground (Earth) Leakage

The CT burden for optimal accuracy must be of sufficient capacity to provide for the sum of all connected instrument burdens.

2.3.8 Maximum Demand- External Synchronization (Optional)

The period for maximum demand calculations can either be fixed internally (see section 4.1.8) or externally via a volt-free relay contact having minimum rating 24VDC, 0.5A. The relay is connected to terminals 5 and 6.

The relay contacts must be normally open. The start of a maximum demand period is signified by the contacts closing for at least 50ms.

The maximum demand period must be one minute or greater.

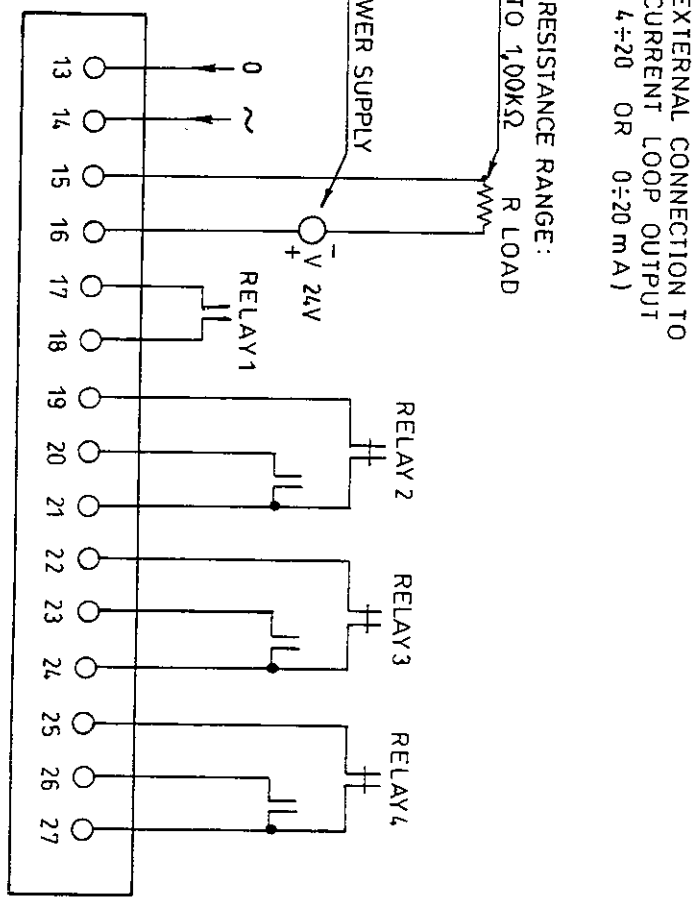
2.3.9 Alarms (288 Series only)

The 288 Series instruments have four relays. Relay 1 is a two-contact relay, and may be used for either set points or kWh pulsing. Relays 2, 3 and 4 are three-contact relays and are intended for set points only. See section 4 for a full description of set point programming. The terminals for relay wiring are shown in Figure 9.

Note: For the reactive power option (Model 288-4), relay 2 may be used for kVArh pulsing.

2.3.10 Communications (Optional)

RS232/422 communications are via a 9-pin female D-type connector at the rear of the instrument. Various protocol options are DIP switch selectable. A list of the options is given in section 2.4 and a full description of the software and hardware protocol is given in section 5.



2.4 System Configuration

The instrument has two DIP switch blocks for the selection of user-settable options. A third DIP switch block is included when the RS232/422 option is installed. The DIP switches are accessible at the back of the instrument at the top left hand corner. The DIP switches are numbered as shown in Figure 10.

2.4.1 C.T. Ratios

DIP switch block 1 selects the current transformer ratios.

C.T. Ratio		**Block 1 Switch Number**				
5A	**1A**	**1**	**2**	**3**	**4**	**5**
30:5	6:1	OFF	OFF	OFF	OFF	OFF
40:5	8:1	OFF	OFF	OFF	OFF	ON
50:5	10:1	OFF	OFF	OFF	ON	OFF
60:5	12:1	OFF	OFF	OFF	ON	ON
80:5	16:1	OFF	OFF	ON	OFF	OFF
100:5	20:1	OFF	OFF	ON	OFF	ON
120:5	24:1	OFF	OFF	ON	ON	OFF
150:5	30:1	OFF	OFF	ON	ON	ON
200:5	40:1	OFF	ON	OFF	OFF	OFF
250:5	50:1	OFF	ON	OFF	OFF	ON
300:5	60:1	OFF	ON	OFF	ON	OFF
400:5	80:1	OFF	ON	OFF	ON	ON
500:5	100:1	OFF	ON	ON	OFF	OFF
600:5	120:1	OFF	ON	ON	OFF	ON
700:5	140:1	OFF	ON	ON	ON	OFF
750:5	150:1	OFF	ON	ON	ON	ON
800:5	160:1	ON	OFF	OFF	OFF	OFF
1000:5	200:1	ON	OFF	OFF	OFF	ON
1200:5	240:1	ON	OFF	OFF	ON	OFF
1500:5	300:1	ON	OFF	OFF	ON	ON
1600:5	320:1	ON	OFF	ON	OFF	OFF
2000:5	400:1	ON	OFF	ON	OFF	ON
2500:5	500:1	ON	OFF	ON	ON	OFF

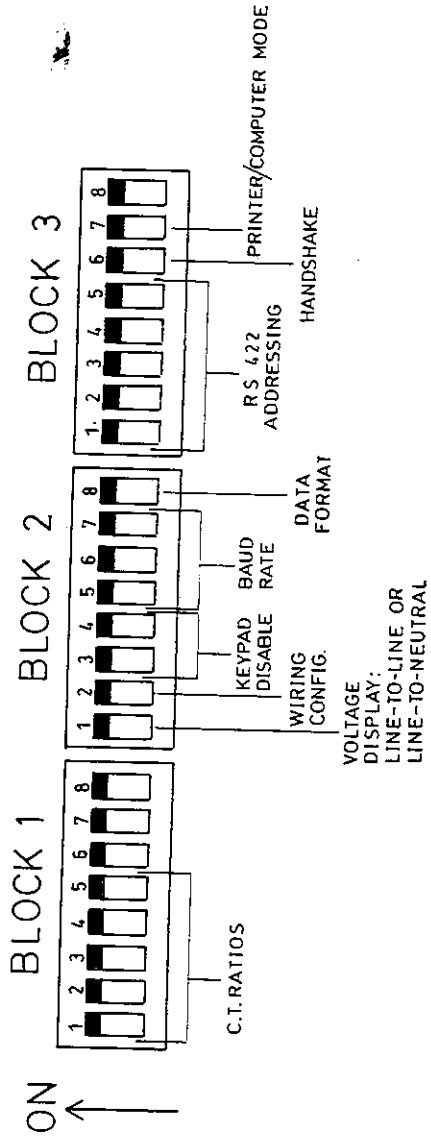


Figure 10 - DIP Switch Blocks

C.T. Ratio		Block 1 Switch Number				
5A	**1A**	**1**	**2**	**3**	**4**	**5**
3000:5	600:1	ON	OFF	ON	ON	ON
4000:5	800:1	ON	ON	OFF	OFF	OFF
5000:5	1000:1	ON	ON	OFF	OFF	ON
5000:5	1200:1	ON	ON	OFF	ON	OFF
5000:5	1500:1	ON	ON	OFF	ON	ON
5000:5	2000:1	ON	ON	ON	OFF	OFF
5000:5	3000:1	ON	ON	ON	OFF	ON

2.4.2 P.T. Ratios

P.T. ratios are user selectable via the front panel. Choices range between 1.0 and 2000, in 0.1 steps. For example, if the P.T. being used has a ratio of 6.6 kV:110V, then the user would program a ratio of 60.0 (i.e., 6600 / 110 = 60.0).

Programming P.T. ratios

1. Press the SELECT key to put the instrument into Programming Mode. An alphanumeric character will appear in the middle voltage window. Depending on the series and model of the instrument, possible values appearing in that window may be: 1, 2, 3, 4, A, P, Pr, or Pt.

2. Use the UP/DOWN arrow keys to scroll through the values until the characters "Pt." appear in the middle voltage window.

3. By pressing the SELECT key, the decimal point following "Pt" will disappear. Use the UP/DOWN arrow keys to scroll through P.T. ratios from 1.0 to 200.0, which appear in the middle display on the right side of the instrument. Once the appropriate value appears, press the RESET KWH key. The reappearance of the decimal point after "Pt" indicates that the P.T. ratio has been set.

4. Use the UP/DOWN arrow keys to select an additional parameter to be programmed or press the RESET KWH key to exit programming and return to operational mode.

2.4.3 DIP-Switch Block 2

DIP switch block 2 selects the voltage display and wiring options and the push button disable options.

The four combinations of switches 1 & 2 are:

Block 2 Switch		Wiring Diagram	Description
1	2		
OFF	OFF	Fig 5 or 6	4-wire; line to line voltage
ON	OFF	Fig 5 or 6	4-wire; line to neutral voltage
OFF	ON	Fig 4	3-wire direct connection
ON	ON	Fig 7	3-wire open delta connection

Block 2, Switch 3

OFF - RESET kWh Push Button enabled
ON - RESET kWh Push Button disabled

For the reactive power models (280-2 and 280-4, this switch also disables the RESET kVArh button. For the maximum demand models (280-3 and 288-5), this switch also disables RESET Maximum Demand.

Block 2, Switch 4

OFF - Set Point Programming enabled
ON - Set Point Programming disabled

For the maximum demand models (280-3 and 288-5), this switch also disables maximum demand period programming.

Baud Rate (Communications Option)

Baud Rate	Block 2 Switch Number		
	5	6	7
110	OFF	OFF	OFF
300	OFF	OFF	ON
1200	OFF	ON	ON
2400	ON	OFF	OFF
4800	ON	OFF	ON
9600	ON	ON	OFF
9600	ON	ON	ON

Block 2, Switch 8 (Communications Option)

OFF - Data format: 7 bit even parity
ON - Data Format: 8 bit no parity

2.4.4 DIP-Switch Block 3 (Communications option only)

RS-422 Address	Block 3 Switch Number				
	1	2	3	4	5
0	OFF	OFF	OFF	OFF	OFF
1	OFF	OFF	OFF	OFF	ON
2	OFF	OFF	OFF	ON	OFF
3	OFF	OFF	OFF	ON	ON
4	OFF	OFF	ON	OFF	OFF
5	OFF	OFF	ON	OFF	ON
6	OFF	OFF	ON	ON	OFF
7	OFF	OFF	ON	ON	ON
8	OFF	ON	OFF	OFF	OFF
9	OFF	ON	OFF	OFF	ON
10	OFF	ON	OFF	ON	OFF
11	OFF	ON	OFF	ON	ON
12	OFF	ON	ON	OFF	OFF
13	OFF	ON	ON	OFF	ON
14	OFF	ON	ON	ON	OFF
15	OFF	ON	ON	ON	ON
16	ON	OFF	OFF	OFF	OFF
17	ON	OFF	OFF	OFF	ON
18	ON	OFF	OFF	ON	OFF
19	ON	OFF	OFF	ON	ON
20	ON	OFF	ON	OFF	OFF
21	ON	OFF	ON	OFF	ON
22	ON	OFF	ON	ON	OFF
23	ON	OFF	ON	ON	ON
24	ON	ON	OFF	OFF	OFF
25	ON	ON	OFF	OFF	ON
26	ON	ON	OFF	ON	OFF
27	ON	ON	OFF	ON	ON
28	ON	ON	ON	OFF	OFF
29	ON	ON	ON	OFF	ON
30	ON	ON	ON	ON	OFF
31	ON	ON	ON	ON	ON

Block 3, Switch 6 (Communications Option)

OFF - Handshake: XON/XOFF
ON - Handshake: DTR/CTS

Block 3, Switch 7 (Communications Option)

OFF - Printer Mode
ON - Computer Mode

3. FRONT PANEL-DISPLAYS AND OPERATION

The front panel consists of :

* Displays
* Push Buttons

3.1 Displays

The displays are formed from seven-segment LEDS. The numbers displayed are updated twice a second.

Values displayed are:

Value	Format	Notes
Voltage - A or Voltage - AB	XXX (Volts) or X.XX (kV) or XX.X (kV)	**Block 2** **Switch 1** ON : Voltage A OFF :Voltage AB
Voltage - B or Voltage - BC	XXX (Volts) or X.XX (kV) or XX.X (kV)	**Block 2** **Switch 1** ON : Voltage B OFF :Voltage BC
Voltage - C or Voltage - CA	XXX (Volts) or X.XX (kV) or XX.X (kV)	**Block 2** **Switch 1** ON : Voltage C OFF :Voltage CA
Current - A Current - B Current - C	XXXX (Amps) XXXX (Amps) XXXX (Amps)	
Power Factor	±X.XX	Power weighted 3 phase average current lag is + current lead is -

Value	Format	Notes
Power	XXXXX (kW) or XXX.XX (MW) or XXXX.X (MW) or XXXXX. (MW)	
Consumption	XXXXX (kWh) or XXX.XX (MWh) or XXXX.X (MWh) or XXXXX. (MWh)	
Ground Leakage	XXXX (mA)	Option
Frequency	XX.X (Hz)	Option
Apparent Power	XXX (kVA) or X.XX (MVA) or XX.X (MVA) or XXX. (MVA)	Option; Replaces Power Factor
Reactive Power	XXX (kVAr) or X.XX (MVAr) or XX.X (MVAr) or XXX. (MVAr)	Option; Replaces Ground Leakage
Reactive Energy	XXXXX ((kVArh) XXX.XX (MVArh) or XXXX.X (MVArh) or XXXXX. (MVArh)	Option Replaces Power

3.2 Front Panel Keypad

RESET KWH

When pressed continuously for more than two seconds, the kWh value displayed is reset to zero. This push button is disabled when DIP switch block 2, switch number 3 is set to ON.

SELECT, UP-ARROW, DOWN-ARROW

These push buttons are used for programming. A full description of their use is given in sections: 2.4.2 - P.T. Ratios, 4 - Set Points/Max. Demand Period, and 5.4.4.1 - Print Intervals. Programming can be disabled when DIP switch block 2, switch number 4 is set to ON.

RESET KVARH (models 280-2 and 288-4 only)

When pressed continuously for more than two seconds, the kVArh value displayed is reset to zero. This push button is disabled when DIP switch block 2, switch number 3 is set to ON.

DISPLAY MAX DEMAND

While this key is pressed maximum demand is displayed in place of instantaneous power.

RESET MAX DEMAND (models 280-3 and 288-5 only)

When pressed continuously for more than two seconds, the maximum demand value displayed is reset to zero. This push button is disabled when DIP switch block 2, switch number 3 is set to ON.

4. SET POINTS

4.1 Programming the Set Points

Set point limits are programmed using the push buttons on the front panel. All values are stored in non-volatile memory and are saved in the event of a power failure.

During the programming process the monitored values continue to be measured even though they are not displayed. If the communications option is present, values will continue to be transmitted.

Front panel programming can be disabled when DIP switch block 2, switch number 4 is set to ON.

The following steps are used to choose the set points:

4.1.1 Press the SELECT key to put the instrument into Programming Mode. The first relay number (1) will be displayed in the middle voltage (phase B) display and all other windows will display their respective set point limits. Pressing the UP OR DOWN keys will cause the relay number to change between 1, 2, 3 and 4.

4.1.2 Pressing the SELECT key again will confirm the choice of relay to be programmed, and will allow the High Voltage set point to be altered. The present High Voltage set point will be displayed in the upper voltage (phase A) display. TheUP OR DOWN keys can then be used to alter the set point.

Every time the UP OR DOWN key is pressed the set point will be changed by one digit. When the key is pressed for more than two seconds continuously, the set point will change continuously at an accelerated rate. If the key is pressed for more than ten seconds then the set point will change at an even faster rate. As soon as the key is released, and then pressed again, the set point will again change by one digit.

By this method of fine and coarse adjustment, the set point required can be reached quickly, but accurately.

The set point can be cancelled by pressing the UP OR DOWN arrows simultaneously. Once cancelled, the set point limit is shown as dots, instead of digits. A cancelled set point can be reinstated by pressing the up or down arrow.

Pressing the SELECT key again will confirm the chosen set point limit value, and will display the present delay (as long as the set point was not cancelled). This can then be altered with the UP OR DOWN keys. If the set point was cancelled then the effect, if this key is pressed, is as in 4.1.3 below.

4.1.3 Pressing the SELECT key again will confirm the set point delay chosen, and will allow the Low Voltage set point to be set. The upper voltage window (phase A) is blanked out and the present Low Voltage limit is displayed in the lower voltage window (phase C). The set point can then be changed in the same way, as for the High Voltage set point.

4.1.4 In this way all the set points can be altered using the SELECT key to step through all the parameters.

4.1.5 Pressing the RESET KWH key after a set point or set points have been examined or changed will return programming to the relay change level as in 4.1.1 above. Note that this action operates only when the set point delay is being displayed, so that it is not possible to alter a set point level without at least examining the set point delay.

Pressing the RESET KWH key again will return the instrument to the normal operational display.

4.1.6 When relay 1 is displayed, the kWh window can also be accessed to alter the kWh pulsing parameter, either 1 or 10 kWh per pulse.

4.1.7 The Reactive Power model (288-4) allows relay 2 to be used for kVArh pulsing. Accessing the kVArh window permits either 1 or 10 kVArh per pulse to be set.

4.1.8 The Maximum Demand models (280-3 and 288-5) allow the maximum demand period (1, 2, 5, 10, 15, 20, 30 or 60 minutes) to be programmed. Alternately, the unit can be programmed to allow an external pulse input to define the demand period.

4.1.8.1 For the 280-3 pressing the SELECT key will display the letter 'P' in the middle voltage window. Pressing the SELECT key again will display the period in the power window (all other windows go blank). The period may then be altered with the ARROW keys.

Possible time periods are: 1, 2, 5, 10, 15, 20, 30 or 60 minutes. After the number 60 the letter 'E' will appear. Choose the desired time period or the letter 'E' if using external synchronization. Pressing the RESET KWH key twice returns the instrument to monitor mode.

4.1.8.2 For the 288-5, high accumulating maximum demand set point replaces high power. Pressing the SELECT key first displays relay 1 in the middle voltage window. Pressing the UP OR DOWN arrow keys allows the user to page through the relay numbers; the letter 'P' will appear after relay 4, also displaying the maximum demand period in the Power window. See Section 4.1.8.1 for programming details.

4.1.8.2.1 The maximum demand set point is for 'accumulating maximum demand' during the current period. For example, for a power level of 100kW, and a period of 15 minutes, if a set point of 50kW is fixed, the alarm will be set 7.5 minutes after the start of the maximum demand period.

4.1.8.2.2 When external synchronization is used, the set point will operate correctly only after the first demand period has been completed.

4.1.9 See section 6 for programming the analog output option.

5. COMMUNICATIONS

5.1 General

The serial interface option is a powerful extension of the instrument's capacity, facilitating direct interface with other computer equipment for data logging, process control and remote programming. It is supplied under the -R2 and -R4 ordering options.

5.2 Transmission Standards

5.2.1 RS232. This is basically a two wire system in which one wire is held at ground potential, while the other is switched. It is susceptible to noise and may be used for distances up to 10 metres. However, it may be possible to extend this range, using lower transmission rates and shielded cabling.

5.2.2 RS422. This is a balanced system, which is less susceptible to electrical noise, permitting reliable transmission for distances up to 1000 metres.

This standard also allows multidrop mode, i.e. one host computer can be connected with several instruments on a single serial communication line.

5.3 Connector Pinout

The serial interface connector is a standard 'D' type 9 pin female plug-in connector, located at the top centre of the back of the instrument. The connections to the plug are as follows:

Pin	Name	Function
1	0V	Common
2	TXD	Transmit data
3	RXD	Receive data
4	DTR	Data terminal ready
5	CTS	Clear to send
6	NTXD	Transmit data

Pin	Name	Function
7	NRXD	Receive data
8	NDTR	Data terminal ready
9	NCTS	Clear to send

Pins 1 - 5 are used for RS232 transmission
Pins 1 - 9 are used for RS422 transmission

5.4 Communication Format

5.4.1 Baud Rate

Baud Rate	Block 2 Switch Number		
	5	6	7
110	OFF	OFF	OFF
300	OFF	OFF	ON
1200	OFF	ON	ON
2400	ON	OFF	OFF
4800	ON	OFF	ON
9600	ON	ON	OFF
9600	ON	ON	ON

5.4.2 Data format

DIP switch block 2, switch number 8

OFF - Data format: 7 bit even parity
ON - Data Format: 8 bit no parity

1 start bit, 1 stop bit - fixed

5.4.3 Communication Handshake

DIP switch block 3, switch number 6

OFF - Handshake: XON/XOFF
ON - Handshake: DTR/CTS

5.4.3.1 XON/XOFF

Sending an XOFF signal disables transmission, while sending an XON signal re-enables transmission.

5.4.3.2 DTR/CTS

The DTR output is held high while the instrument is able to receive data, and transmission is disabled while the CTS input is low.

5.4.4 Communication Mode

The instrument can communicate with either a printer or computer. In PRINTER MODE, the instrument sends data to a printer or computer at user selectable intervals, while in COMPUTER MODE communications are bi-directional. The choice of mode is DIP switch selectable.

DIP switch block 3, switch number 7
OFF - Printer Mode
ON - Computer Mode

5.4.4.1 Printer mode

The instrument sends a fixed format printed report at a user defined interval every: 1, 2, 5, 10, 15, 20, 30, or 60 minutes. Make sure that the communications parameters for the instrument and printer are compatible (See sections 5.4.1 - 5.4.3 for parameter settings). After resetting the instrument, the value headings will be printed on the first line, while intiial readings will be printed on the second line. Consequent readings will be printed every "n" minutes as specified by the user.

Programming Print Intervals

1. Press the SELECT key to put the instrument into Programming Mode. An alphanumeric character will appear in the middle voltage window. Depending on the series and model of the instrument, possible values appearing in that window may be: 1, 2, 3, 4, A, P, Pr, or Pt.

2. Use the UP/DOWN arrow keys to scroll through the values until the characters "Pr." appear in the middle voltage window.

3. By pressing the SELECT key, the decimal point following "Pr" will disappear. Use the UP/DOWN arrow keys to scroll through possible print intervals of: 1, 2, 5, 10, 15, 20, 30, or 60 minutes. Once the appropriate value appears press the RESET KWH key. The reappearance of the decimal point after "Pr" indicates that the print interval has been set.

4. Use the UP/DOWN arrow keys to select an additional parameter to be programmed or press the RESET KWH key to exit programming and return to operational mode.

This table describes the format of the report:

V1	**V2**	**V3**	**A1**	**A2**	**A3**
NNN	NNN	NNN	NNNN	NNNN	NNNN

PF	**KW**	**KWH**	**KVA***	**KVAR***
N.NN	NNNNN	NNNNN	NNN	NNN

KVARH*	**MAX DEM ***	**HZ ***	**GL ***
NNNNN	NNNNN	NN.N	NNNN

* Optional values

5.4.4.2 Computer mode

In computer mode the instrument uses a two-way communication protocol. The communication works on a master-slave basis, where the instrument is the slave, i.e. all messages are initiated by the host computer.

5.4.4.2.1 Software protocol. All messages conform to the following protocol :

The protocol is designed to consist only of printable characters.

Field 1 -
Synchronization character - one or more "!" characters.

Field 2 -
Message Length - Three characters, between "000" and "999" representing the number of bytes in the message body, address and message length fields.

Field 3 -
Address (Used for RS-422) Two characters, between "00" and "99".

NOTE : FOR RS232 COMMUNICATIONS, THIS FIELD MUST ALWAYS BE '00'.

Field 4 -
Message type - Code representing type of request sent by host.

Field 5 -
Message Body - All characters must be in the range HEX22 to HEX7E.

Field 6 -
Checksum. The checksum is calculated in a 2 byte word for the message length, address, message type and message body, and is designed to produce a one byte checksum in the range HEX22 to HEX7D. The checksum is:

(sum of (each byte - HEX22)) modulo HEX5C + HEX22

Field 7 -
Trailer. Carriage return and/or line feed.

Fields 3 and 4 of replies are always the same as in the request message.

5.4.4.2.2 Message Types. The host computer may send the following three message types :

5.4.4.2.2.1 Data Request

HOST REQUEST

Message Type - '0'
Message Body - none

REPLY

Message Body -

Field	Offset	Length in Bytes	Description
1	0	4	Voltage - A
2	4	4	Voltage - B
3	8	4	Voltage - C
4	12	5	Current - A
5	17	5	Current - B
6	22	5	Current - C
7	27	6	Power - A
8	33	6	Power - B
9	39	6	Power - C
10	45	4	Power Factor - A
11	49	4	Power Factor - B
12	53	4	Power Factor - C
13	57	6	Total True Power
14	63	4	Power Factor - Average
15	67	6	Consumption
16	73	5	Ground Leakage *
17	78	4	Frequency *
18	82	6	Reactive Power -A
19	88	6	Reactive Power -B *
20	94	6	Reactive Power -C *
21	100	6	Apparent Power-A *
22	106	6	Apparent Power-B *
23	112	6	Apparent Power-C *
24	118	6	Reactive Energy *
25	124	6	Total Reactive Power
26	130	6	Total Apparent Power
27	136	6	Max. Demand
28	142	6	Max. Demand (Spare)

* Available on appropriate instrument models. If the field is not supported it is filled with zeros (HEX30).

5.4.4.2.2.2 Examine Set Point

HOST REQUEST

Message Type - '1'

Message Body -

Field No	No of Bytes	Contents	Description
1	1	'1'..'4'	Relay Number
2	2	*	Set Point Number

REPLY

Message Body -

Field No	No of Bytes	Contents	Description
1	1	'1'..'4'	Relay Number
2	2	*	Set Point Number
3	4	'NN.N'	Set Point Delay
4	2,4 or 6	*	Set Point Limit

Field 3 is filled with '/', when the Set Point is not allocated.

5.4.4.2.2.3 Change Set Point

HOST REQUEST

Message Type - '2'

Message Body -

Field No	No of Bytes	Contents	Description
1	1	'1'..'4'	Relay Number
2	2	*	Set Point Number
3	4	'NN.N'	Set Point Delay
4	2,4 or 6	*	Set Point Limit

To cancel the Set Point, field 3 has to be filled with the '/' character.

REPLY

Message Body -

Field No	No of Bytes	Contents	Description
1	1	'1'..'4'	Relay Number
2	2	*	Set Point Number
3	4	'NN.N'	Set Point Delay
4	2,4 or 6	*	Set Point Limit

* NOTE - Set Point numbers and Limit lengths

Set Point No.	Set Point	Limit Length (Bytes)
1	High Voltage	4:'0NNN' or 'N.NN' or 'NN.N'
2	Low Voltage	4:'0NNN' or 'N.NN' or 'N.NN'
3	High Current	4: 'NNNN'
4	High Power or Max. Dem.	6: '0NNNNN' or 'NNN.NN'
5	Low P.F	4: 'N.NN'
6	High G.L	4: 'NNNN'
7	kWh Pulsing	2: '01' or '10'
8	High Reactive Power	4: '0NNN' or 'N.NN' or 'NN.N'
9	High Apparent Power	4: '0NNN' or 'N.NN' or 'NN.N'

Set Point No.	Set Point	Limit Length (Bytes)
10	kVArh pulsing	2: 01 or 10
11	Max. Demand Period	2: 01, 02, 10, 15, 30 or 60

where 'N' is in range '0'..'9'

Error Replies :

The instrument will send the following error messages in response to incorrect host requests:

Message Body -

'XK' - Parameters being set
'XP' - Invalid Set Point Value
'XF' - Invalid Message Format or Checksum
'XM' - Invalid Request Type

5.4.5 Multidrop Mode (RS422)

RS422 communications allow one host computer to access up to 31 instruments on a single communications line. The host computer accesses each instrument individually using the address field of the communications protocol. Address values of '01' to '31' are valid. (Address '00' must be given for a single unit using RS422 Protocol).

Multidrop mode works as follows; all the instruments on the communication line monitor every host request.

However only the instrument with the address in the address field of the request will reply, placing its address in the address field of the reply.

The address is fixed by DIP switch block 3 as below :

RS-422 Address	Block 3 Switch Number				
	1	2	3	4	5
0	OFF	OFF	OFF	OFF	OFF
1	OFF	OFF	OFF	OFF	ON
2	OFF	OFF	OFF	ON	OFF
3	OFF	OFF	OFF	ON	ON
4	OFF	OFF	ON	OFF	OFF
5	OFF	OFF	ON	OFF	ON
6	OFF	OFF	ON	ON	OFF
7	OFF	OFF	ON	ON	ON
8	OFF	ON	OFF	OFF	OFF
9	OFF	ON	OFF	OFF	ON
10	OFF	ON	OFF	ON	OFF
11	OFF	ON	OFF	ON	ON
12	OFF	ON	ON	OFF	OFF
13	OFF	ON	ON	OFF	ON
14	OFF	ON	ON	ON	OFF
15	OFF	ON	ON	ON	ON
16	ON	OFF	OFF	OFF	OFF
17	ON	OFF	OFF	OFF	ON
18	ON	OFF	OFF	ON	OFF
19	ON	OFF	OFF	ON	ON
20	ON	OFF	ON	OFF	OFF
21	ON	OFF	ON	OFF	ON
22	ON	OFF	ON	ON	OFF
23	ON	OFF	ON	ON	ON
24	ON	ON	OFF	OFF	OFF
25	ON	ON	OFF	OFF	ON
26	ON	ON	OFF	ON	OFF
27	ON	ON	OFF	ON	ON
28	ON	ON	ON	OFF	OFF
29	ON	ON	ON	OFF	ON
30	ON	ON	ON	ON	OFF
31	ON	ON	ON	ON	ON

Every instrument on the line must have a unique address. As noted above address '00' is used for RS232 communications, and RS422 communication for a single unit system. The address '00' must NOT be used for multiph units using RS422 multidrop mode.

6. ANALOG OUTPUT (Optional)

The A0 option (0-20mA) and the A4 option (4-20mA) provide an analog output which can be programmed to represent any displayed value. The output is passive and requires a 24 volt DC external power source. It is connected to terminals 15 and 16 (see Fig. 9).

6.1 Wiring for 4-20 mA / 0-20 mA Output

The analog output is passive and therefore requires an external source to power the current loop. The negative side must be connected to terminal 15 and the positive side to terminal 16 of the Relay Terminal Block. See figure 9 (Section 2.3.9) of the Users' Guide for the position of these terminals. The current loop resistance must be in the range 0-1.35 kohm

6.2 Programming

For 280 models, pressing the SELECT key will display the letter 'A' in the middle voltage window

For 288 models, pressing the SELECT key and then the UP OR DOWN arrow key will bring the letter 'A' to the middle voltage window.

If a second 'A' appears, then this signifies which parameter is allocated to the analog output. To cancel the current allocation, press SELECT, causing all the 'dots'to disappear, and then press UP and Down simultaneously, causing the 'A' to be replaced with 'dots'.
At this point pressing the SELECT key causes the 'dots' to move from one parameter to the next. Once the 'dots' are at the required parameter, pressing the UP key will allocate this parameter, displaying an 'A'.
Pressing the RESET KWH key twice returns the display to the monitor mode.

6.3 Measured Values equivalent to 4-20 mA / 0-20 mA Output

The following table gives the value ranges of the 4-20 mA and 0-20 mA ouput for each parameter

Parameter	Value	4-20mA	0-20 mA
VOLTAGE (No Potential Transformer)	0 V 660 V	4 mA 20 mA	0 mA 20 mA
VOLTAGE (Using a Potential Transformer)	0 V (144/x) * y Where x is the secondary and y is the primary of the P.T. ratio.	4 mA 20 mA	0 mA 20 mA
CURRENT (For all Current Transformer ratios)	0 A 120% * x Where x is the primary of the C.T. ratio.	4 mA 20 mA	0 mA 20 mA
POWER FACTOR	-0.00 -0.50 1.00 0.50 0.00	4 mA 8 mA 12 mA 16 mA 20 mA	0 mA 5 mA 10 mA 15 mA 20 mA
POWER (kW)	0 kW V * I * n kW Where V and I are defined according to the P.T. and C.T. ratios; while n=2 for line to line measurement, and n=3 for line to neutral measurement.	4 mA 20 mA	0 mA 20 mA
MAXIMUM DEMAND	See Power		
FREQUENCY	45 Hz 65 Hz	4 mA 20 mA	0 mA 20 mA

Parameter	Value	4-20mA	0-20 mA
GROUND LEAKAGE	0 mA 6000 mA	4 mA 20 mA	0 mA 20 mA
KVA	See Power		
KVAR	V * I * n kVAr Where V and I are defined according to the P.T. and C.T. ratios; while n= -2 for line to line measurement, and n= -3 for line to neutral measurement.	4 mA	0 mA
	0 kVAr V * I * n kW Where V and I are defined according to the P.T. and C.T. ratios; while n=2 for line to line measurement, and n=3 for line to neutral measurement.	12 mA 20 mA	10 mA 20 mA

EXAMPLES (for 4-20 mA):

1. VOLTAGE - Using a P.T. ratio of 2400:120 V

P.T. secondary = 120; P.T. primary = 2400, using the above formula:

(144 / 120) * 2400 = 2880, therefore

0 V = 4 mA
2880 V = 20 mA

2. CURRENT - Using a C.T. ratio of 1000:5 A

C.T. primary = 1000, using the above formula:
120% * 1000 = 1200, therefore

0 A = 4 mA
1200 A = 20 mA

3. POWER - Using a P.T. ratio of 2400:120 V, and a C.T. ratio of 1000:5 A on a line to neutral system.

Using ex.s 1 and 2, V = 2880; I = 1200; n = 3 for line to neutral measurement, using the above forumula:

2880 * 1200 * 3 = 10,368,000 W = 10,368 kW, therefore

0 kW = 4 mA
10,368 kW = 20 mA

6.4 Communication

6.4.1 Examine analog output allocations

Host request
Message Type - '1'
Message Body -

Field No.	No. of Bytes	Contents	Description
1	1	'A'	see
2	2	Parameter No.	Table
3	4	'00.0' or '////'	*
4	1	'0'	

6.4.2 Change Analog Output Allocation

HOST REQUEST
Massage Type - '2'
Message Body

Field No.	No. of Bytes	Contents	Description
1	1	'A'	
2	2	Parameter No.	See Table
3	4	'00.0' or '////'	*
4	3	'136'	

REPLY
Message Body

Field No.	No. of Bytes	Contents	Description
1	1	'A'	
2	2	Parameter No.	See Table
3	4	'00.0' or '////'	*
4	3	'136'	

* '00.0' Analog Output allocated to this parameter.
'////' Analog Output not allocated to this parameter.

Parameter	Parameter No.
Voltage 1	21
Voltage 2	22
Voltage 3	23
Current 1	24
Current 2	25
Current 3	26
App. Power	27
Power Factor	28
Reactive Power	29
Active Power	30
Accumulated Max. Demand	31
Ground Leakage	32
Frequency	34

7. SELF TESTS

When the instrument is turned on, or is reset as a result of its internal self-checks, certain numbers are displayed on all the LED digits.

An error code, which gives the reason for the reset, is displayed for two seconds.

The error codes are:

1	ROM Error
2	RAM Error
3	Watch Dog Timer Reset
4	Sampling Interrupt Failure
5	Program Malfunction
6	Built-In-Test Failure
8	Power Down (Normal)

If the instrument resets itself continuously, (this can be seen by the error code and '8's being displayed for several seconds) then the instrument has a hardware fault. Frequent resetting may be the result of excessive electrical noise in the region of the instrument.

8. SPECIFICATIONS

8.1 Displayed Values (Displays will vary according to particular model):

8.1.1 Voltage - Three phases displayed simultaneously, either line-to-line or line-to- neutral (DIP switch settable).

Input: Direct (up to 660V line-to-line) or via P.T.

Accuracy: ± 0.5% of reading &
± 0.25% of full scale &
± 1 digit in range 10% to 100% of full scale

Resolution: 1 Volt up to 999 V
0.01 KV in range 1 kV to 9.99 kV
0.1 KV in range 10 kV to 99.9 kV

Crest Factor: Direct voltage (peak-to-peak)
less than 1850 V

Frequency: 45 Hz to 65 Hz

Burden: < 0.3VA

8.1.2 Current - Three phases displayed simultaneously

Input: Input from Current Transformers with either 5A or 1A secondary output is (C.T. output is factory set and must be indicated upon order).

Accuracy: ± 0.5% of reading &
± 0.25% of full scale &
± 1 digit in range of 10% to 120% of full scale This does not include inaccuracies introduced by the user's external C.T.'s.

Resolution: 1 amp

Crest Factor: Current (peak-to-peak)17 A for 5A C.T.
3.4 A for 1A C.T.

Burden: < 0.3VA

8.1.3 Power - Displayed in Kilowatts or Megawatts.

Input: Calculated from instantaneous voltage and current values

Accuracy: ± 1% of reading &
± 0.5% of full scale volt-amps &
± 1 digit for Power Factor in range
|PF| > 0.5

Resolution: 1 KW in range 0 to 99999 kW
.01 MW in range 100.00 to 999.99 MW
.1 MW in range 1000.0 to 9999.9 MW
1 MW in range 10000. to 99999. MW

For reactive power models (280-2 and 288-4) power is displayed with only 3 significant digits.

8.1.4 Power Factor

Accuracy: ± 2% of reading &
± 1 digit in the range |PF| > 0.5

Range: 1.00 to + 0.00 (Current Lag)
1.00 to - 0.00 (Current Lead)

Resolution: 0.01

8.1.5 Consumption - Displayed in Kilowatt Hours/ Megawatt Hours Input: Calculated from Power.

Accuracy: As for Power.

Resolution: 1 KWH in range 0 to 99999 KWH
.01 MWH in range 100.00 to 999.99 MWH
.1 MWH in range 1000.0 to 9999.9 MWH
1 MWH in range 10000. to 99999. MWH

8.1.6 Frequency Displayed in Hertz.

Input: Calculated from voltage waveforms.

Accuracy: ± 0.3% of reading &
± 1 digit assuming sinusoidal voltage waveform.

Resolution: 0.1 Hz

Range: 45 Hz to 65 Hz

8.1.7 Ground Leakage Displayed in Milliamps.

Input: From 1000:1 Ground Leakage C.T. giving full scale output of 5mA.

Accuracy: ± 2.0% of reading &
± 0.5% of full scale &
± 1 digit

Resolution: 1 mA

Range: 0 to 9999 mA

8.1.8 Reactive Power Displayed in kVAr/MVAr

Input: Calculated from instantaneous voltage and current values.

Accuracy: ± 1% of reading &
± 0.5% of full scale volt-amps &
± 1 digit for Power Factor in the range |PF| < 0.9

Resolution: 1kVAr in range 0 to 999 kVAr
.01 MVAr in range 1.00 to 9.99 MVAr
.1M VAr in range 10.0 to 99.9 MVAr
1 MVAR in range 100. to 999. MVAr

8.1.9 Apparent Power Displayed in kVA/MVA

Input: Calculated from active and reactive power.

Accuracy: ± 1.5% of reading &
± 0.5% of full scale volt-amps &
± 1 digit in the rane |PF| > 0.5

Resolution: 1 kVA in range: 0 to 999 kVA
.01 MVA in range 1.00 to 9.99 MVA
.1 MVA in range 10.0 to 99.9 MVA
1 MVA in range 100. to 999. MVA

8.1.10 Reactive Energy - Displayed in Kilovar Hours/Megavar Hours.

Input: Calculated from Reactive Power.

Accuracy: As for Reactive Power.

Resolution: 1kVArh in range 0 to 99999 kVArh
.01 MVArh in range 100.00 to 999.99MVArh
.1 MVArh in range 1000.0 to 9999.9 MVArh
1 MVArh in range 10000. to 99999. MVArh

8.1.11 Maximum Demand - Displayed in Kilowatts/ Megawatts

Definition: The average power during the demand period. The highest value since the previous reset is displayed. The Set Point for model 288-5 is on the accumulating maximum demand during the current demand period.

Demand periods are selectable at 1, 2, 5, 10, 15, 20, 30 and 60 minutes or can be synchronized via an external pulse.

Accuracy, range and resolution: As for Power.

8.2 Programmable Set Points (288 Series Only)

Limits defined via the keypad on the front panel for the following values:

High current (on any phase)
High voltage (on any phase)
Low voltage (on any phase)
Low power factor
High power
High ground leakage*
High reactive power*
High apparent power*
High maximum demand*

* Available only on appropriate models.

8.3 Relays (288 Series Only)

8.3.1 Ratings :

3 relays rated at 250V AC 5A 3 contacts.
1 relay rated at 200V DC 0.5A 2 contacts.

Each of the programmable set points can be allocated to any of the 4 relays, except for KWH pulsing which must be allocated to the 0.5 amp relay.

8.3.2 Delay for each set point is defined via the keypad on the front panel. The delay may be set in the range 0.1 seconds to 99.9 seconds in 0.1 second steps, according to the value displayed in the specific window.

8.3.3 KWH Pulsing is available for interface with PLC's or other electronic devices.

Pulsing options are as follows:

1 pulse per 1 kWh or 1 pulse per 10 kWh.

Contacts closed for 100 ms and open for 100 ms each pulse.

8.3.4 Optionally kVArh Pulsing is available in addition to kWh Pulsing for interface with PLC's or other electronic devices. Pulsing options are as follows:

1 pulse per 1 kVArh or 1 pulse per 10 kVArh.

Contacts closed for 100 ms and open for 100 ms each pulse.

8.4 Communications (Optional on all models)

8.4.1 RS232 or RS422 Protocol; 9-pin female D-type connector

8.4.2 Analog Output, 0 - 20 mA or 4 - 20 mA

8.5 Power Supply

185 V to 250 V AC
or 95 V to 135 V AC
50 Hz/60 Hz
20 W

8.6 Displays

Simultaneous presentation of all values on seven segment LED numeric displays, updated twice per second. Ranges will match Current Transformer and Potential Transformer ratios.

8.7 Tolerances

Operating Temperature: 0 degrees to 50 degrees C
(32 degrees to 122 degress F)
Storage Temperature: -40 degrees to 70 degrees C
(-40 degrees to 158 degrees F)

The instrument should not be stored or operated in direct sunlight.

Humidity: 0 to 90% non-condensing

8.8 Standards

UL Recognised, File No., to E129258.

All units conform to the following standards:

BSI 4743
CSA C22.2 No. 14
FCC 15J-A
IEC 348
UL 1244
VDE 0411
VDE 0871-B

9. WARRANTY

The Seller offers a 12 month functional warranty for faulty workmanship or parts, from date of despatch from factory. This warranty is on a return to factory basis. Consult your local distributor.

The Seller does not accept liability for any damage caused by instrument malfunction.

The Seller accepts no responsibility that the instrument is suitable for the application for which purchased.

Failure to install, set-up or operate the instrument according to its instructions may void the warranty.

Your instrument should only be opened by a duly authorized representative. The unit should only be opened in a full Anti-Static environment. Failure to do so may damage the electronics. Failure to do so voids the guarantee.

NOTE: These instructions do not purport to cover all possible contingencies that may arise during the installation, operation or maintenance of the instrument. If further information is required, your representative or local distributor should be contacted.

For further information on this instrument, contact your local distributor.