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PENTA-PLUS™ ANALYZER

CAT. NO. 835310

OPERATING AND INSTRUCTION MANUAL

A35310-802
P/N 835311
S/N 10240 & up
940425

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1. OPERATOR SAFETY

ATTENTION: READ THIS MANUAL BEFORE PROCEEDING WITH INSTALLATION AND OPERATING THE INSTRUMENT.

Sur demande, les directives sur la sécurité de l'opérateur sont disponibles en français.

1.1. DESCRIPTION

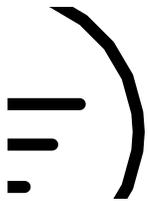
This instrument must be operated, used and serviced **ONLY** by trained, qualified personnel. Misuse of electrical instruments can result in personal injury and damage to the apparatus under test. Obey all applicable safety rules and regulations at all times.

Refer to the following sections of this manual for operating specifications and procedures.

1.2. EXPLANATION OF SAFETY SYMBOLS

Multi-Amp uses, where applicable, the following IEC 417 symbols on its instruments:

This symbol indicates that the operator of the instrument must refer to the instruction manual for further explanation and clarification.



Safety Ground Terminal. This terminal must be connected to an earth ground before making other connections to the instrument and prior to operating it.



This red symbol indicates that high voltage (i.e., any voltage equal or greater than 1000 Volts) is present on the terminal. Use extreme care.



This is the symbol for a sinusoidal AC voltage or current.

1.3. GROUNDING

Where a ground binding post or a grounding lead is provided on the instrument, it must be connected to an earth ground PRIOR to making any other connections.

WARNING: To avoid electric shock do not interrupt the connection to the protective safety ground.

1.4. POWER CORD AND FUSES

The power cord must be connected to a grounded supply system with proper electrical ratings, as indicated on the instrument.

In the case of detachable power cords, only the cord supplied or specified by Multi-Amp Canada should be used.

WARNING: TO AVOID ELECTRIC SHOCK ALWAYS DISCONNECT THE POWER CORD FROM THE SUPPLY CIRCUIT BEFORE SERVICING THE INSTRUMENT OR WHEN REPLACING A FUSE.



WARNING: ALL FUSES MUST BE REPLACED WITH THE SAME TYPE AND CURRENT AND VOLTAGE RATINGS. SHORT-CIRCUITING THE FUSEHOLDER IS PROHIBITED.

2. GENERAL INFORMATION

2.1. DESCRIPTION

The Multi-Amp® PENTA-PLUS ANALYZER (Model 835310) is a next generation portable battery/line operated multifunction instrument for measuring AC voltage, AC primary and secondary current, power, reactive power, phase angle and frequency of a single or three phase electrical system. PENTA-PLUS ANALYZER is easily configured to measure the amplitude and phase angle between any two voltage and current inputs. All measured quantities are displayed simultaneously on a large, easy-to-read graphic display.

The unique firmware in the PENTA-PLUS ANALYZER, combined with a built-in microprocessor-based timer, is designed specifically to facilitate the testing and commissioning of protective relay systems, including performing induction unit pick-up and timing tests. The internal timer responds to a variety of start and stop gates, including the application of AC or DC voltage, and opening or closing of dry contacts.

PENTA-PLUS ANALYZER is a menu driven instrument equipped with data-retention and data-logging capabilities, which allow the user to capture and save test results or transmit them to a PC on a pre-programmed time interval.

Other important features include accurate phase angle measurement at very low current levels and the high speed measurement mode.

2.2. APPLICATIONS

PENTA-PLUS ANALYZER is an ideal instrument for use in general electrical systems maintenance, in electrical machine repairs, in protective relay testing, or in monitoring power at the electrical service entrance

In the protective relay application area, PENTA-PLUS ANALYZER is designed to perform fast, accurate checking and testing of relay and meter installations, during their commissioning and for performing regular maintenance.

Also, combined with a source of voltage and/or current, PENTA-PLUS ANALYZER becomes an excellent tool for testing and calibrating virtually any type of protective relay.

2.3. FEATURES

- Battery and line operated, with an automatic built-in charger.
- Rugged, ergonomic and light plastic enclosure.
- 3 independent voltage and current channels, with a built-in timer.
- Specifically designed to facilitate protective relay testing.
- Simultaneously measures and displays voltage, current, phase angle, power, reactive power and frequency of single or three phase systems.
- Wide current and voltage operating ranges.
- Fast measurement mode, with up to 20 readings per second.
- Accurate phase angle measurement at low current levels.
- HOLD mode for freezing all readings.
- Auto-ranging to reduce test time, with manual over-ride.
- Independent frequency measurement on any two selected inputs.
- RS232 Data and parallel printer output ports.

2.4. ELECTRICAL SPECIFICATIONS

SPECIFICATIONS	
Input:	Line: 104-253 V, 50/60 Hz, 30 VA
Battery:	Internal, sealed lead-acid, rechargeable battery with an internal automatic charger. Safety features include Internal battery over-charging and charge exhaustion protection. Operation Time: 3-Hour continuous on full charge.
Voltage:	0 - 650 Volts (AC) in 9 ranges, with 0.1% resolution. Accuracy: $\pm 0.5\%$ of reading, from 3-650 Volts. Input impedance: 10 M Ω . Max input: 1000 Volts, from inputs to the chassis or between inputs.
Current:	0 - 100 Amperes (AC) in 11 ranges, with 0.1% resolution. Accuracy: $\pm 0.5\%$ of reading, from 0.05-100 Amperes. Burden at 5A: 0.1VA.
Phase Angle:	$\pm 0 - 360.0$ Degrees, with 0.1 degree resolution. Accuracy at 50/60 Hz: ± 0.4 Deg. for input levels above 3 Volts and 0.02 Amps, ± 2 deg. for input levels above 3 Volts or 0.002 Amps
Power:	$\pm 0 - 100$ KW in 6 ranges, with 0.1% resolution. Highest resolution is 0.001 Watt. Accuracy at 50/60 Hz: $\pm 0.6\%$ of VA.
Reactive Power:	$\pm 0 - 100$ KVAR in 6 ranges, with 0.1% resolution. Highest resolution is 0.001 VAR Accuracy at 50/60 Hz: $\pm 1\%$ of VA.
Frequency:	45 - 65 Hz, with 0.01 Hz resolution. Accuracy: ± 0.01 Hz
Time:	0.000 to 999.999 Seconds. Accuracy: ± 0.001 Seconds.
Start/Stop Inputs:	10 - 300 Volts (DC or AC), or dry contacts closure or opening. Input resistance: 1000 Ω Minimum.
Response Time:	Regular single-phase mode: 2 reading per second High Speed single-phase Mode: 20 readings per second Three-phase mode: 1 set of readings every 2.5 seconds.

2.5. MECHANICAL AND ENVIRONMENTAL SPECIFICATIONS

Case Material:	High density Polyethylene
Dimensions:	356W x 267H x 229D millimetres (14W x 10.5H x 9D inches)
Weight	8.5 Kg (18.7 Lbs), approximately
Operating Temperature:	0°C to 40°C (32°F to 104°F)
Storage Temperature:	-20°C to 70°C (-4°F to 158°F)
Relative Humidity:	0 to 90%, NON-CONDENSING

.....2.6... ORDERING INFORMATION

.....	Cat. No.
.....PENTA-PLUS	835310

.....**The instrument is shipped complete with:**

..... Line cord, three wire, 120V	MC1495
..... Instruction Manual.....	835311

.....**The following optional accessories are available:**

..... Calibration Report	CAL-835310
..... Standard Potential Leads [set of 4, 2m]	835312
..... Fused Potential Leads [set of 4, 2m]	830213
..... 20-Amps Current Leads, States Plugs [set of 3, 1m]	835313
..... 20-Amp Current Leads, clips [set of 3, 1m]	835314
..... 100-Amp Current Leads [set of 3, 1m]	835315
..... 1000:1 Clamp-On Current Transformer	830312
..... 1000:5 Clamp-On Current Transformer	835318
..... 3000:1 Clamp-On Current Transformer	835319
..... 3000:5 Clamp-On Current Transformer	835320
..... Padded Soft Carrying Case	835316
..... Kodak Diconix 180si, Portable Ink-Jet Printer	K32099
..... Kodak 220 V/50 Hz Adaptor for the Printer	K05600
..... Kodak 240 V/50 Hz Adaptor for the Printer	K08192

.....2.7... CHANGES

..... Please note that this instrument is subject to continuous development and improvement. This instrument may therefore incorporate minor changes in detail from the information contained herein.

.....2.8... WARRANTY

..... **AVO** International warrant the equipment, sold by us or our authorized agents, to be free from defects in material and workmanship, reasonable wear and tear excluded, for a period of 12 months from date of shipment.

..... Warranty service will be performed on the equipment at the **AVO** International factory (unless the return of only a subassembly is authorized by **AVO** International) or, at **AVO** International's discretion, in the field. The customer shall prepay shipping charges for units returned to **AVO** International, and **AVO** International shall pay for the return of the required or replaced unit to the customer, repair or replace (at **AVO** International's option) the unit or subassembly provided that the Instrument has not been altered, modified or repaired by unauthorized personnel, and that our examination discloses to our satisfaction that any improper operation or failure was not the result of improper use, negligence or accident, exceeding environmental limits, or connecting the Instrument to incompatible equipment. The customer is asked to obtain return authorization from **AVO** International PRIOR TO returning a unit for service.

..... This warranty covers the cost of repairing or replacing faulty components at **AVO** International's option, but not the cost of travel and living expenses of service personnel for work completed in the field. Any field service trips will be subject to inspection of the **AVO** International service representative. If it is determined upon arrival that the repair is not covered by the Warranty, the customer must be prepared to cover the standard rates of the **AVO** International service representative(s) in addition to the cost of travel and living expenses of the service personnel.

..... The invoice for the full amount of the non-warranty repair will be submitted by the **AVO** International office upon the return of the service representative. The customer must remit the required payment immediately for all service work performed.

..... Products manufactured by **AVO** International Canada Limited to customer's specifications are warranted to be free from defects in material and workmanship and to conform to those specifications made a part of **AVO** International's quotation, or of a customer's Contract or Purchase Order. Inspection and acceptance shall be conclusive as to fulfilling this warranty, except as to fraud or

such gross mistakes as to amount to fraud.

..... SINCE **AVO** International HAS NO CONTROL OVER CONDITIONS OF USE, NO WARRANTY IS MADE OR IMPLIED AS TO SUITABILITY FOR CUSTOMER'S INTENDED USE BEYOND SUCH PERFORMANCE SPECIFICATIONS AS ARE MADE A PART OF **AVO** International'S QUOTATION, OR OF A CUSTOMER'S CONTRACT OR PURCHASE ORDER WHICH HAS BEEN APPROVED AND ACKNOWLEDGED BY **AVO** International. NO OTHER WARRANTY IS EITHER EXPRESSED OR IMPLIED. **AVO** International SHALL NOT BE LIABLE FOR CONSEQUENTIAL DAMAGES.

3. INSTALLATION

..... 3.1... UNPACKING AND INSPECTION

..... Prior to shipment this instrument was electrically tested and mechanically inspected to meet specifications and be free of mechanical defects.

..... After unpacking the instrument, visually inspect the instrument and accessories for damage. If evidence of damage is present, YOU must contact the carrier who transported the unit and file a claim in writing. The shipping container and packing material should be retained for inspection by the carrier's agent. Electrical operation per section 4 should be checked as soon as possible after shipment.

..... 3.2... PREPARATION FOR USE

..... THIS INSTRUMENT IS DESIGNED TO BE USED TO MEASURE POTENTIALLY LETHAL VOLTAGE AND CURRENT. It is highly recommended that the user familiarize himself with the controls, functions and features detailed in section 4 prior to use. ALL SAFETY PROCEDURES AND PRECAUTIONS MUST BE FOLLOWED WHEN OPERATING ON LINE WITH LETHAL VOLTAGES OF HIGH CAPACITY.

..... 3.3... REPACKING AND SHIPMENT

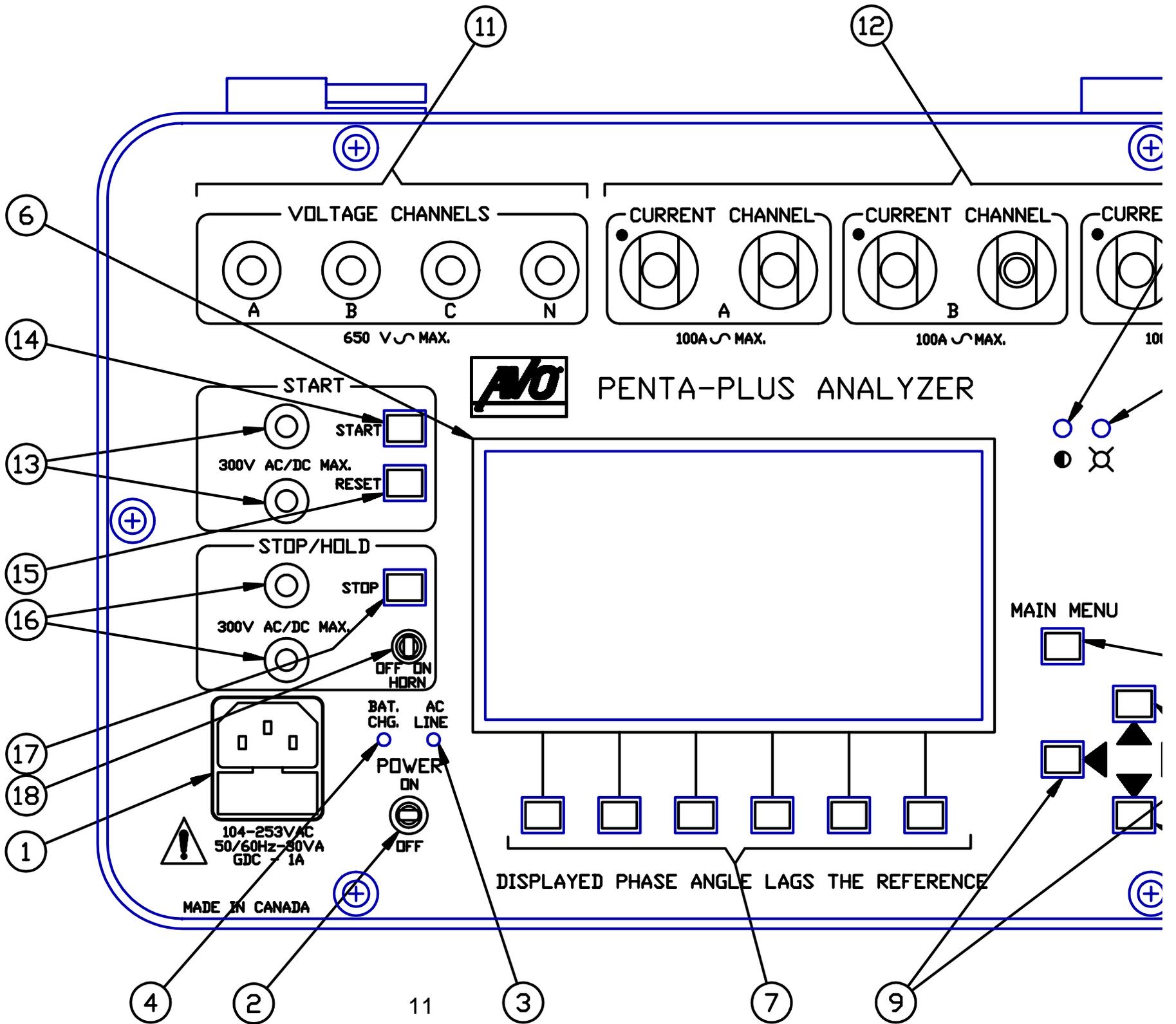
..... To insure proper shipment of this instrument, it is recommended that the original reusable container and packing material be retained. If being returned for calibration or service, please attach a card to the instrument specifying the owner, model and serial number and service required.

4. OPERATING INSTRUCTIONS

..... 4.1... PANEL CONTROLS AND OPERATING FUNCTIONS

..... Refer to FIGURE 4-1. for the following panel controls.

- 1..... LINE INPUT SOCKET: This is the main input for the PENTA-PLUS, and should be connected to a suitable line receptacle, using the provided line cord. The input socket also contains the protection fuse. Replace with type GDC, 1 Amps, 250 Volts only.
- 2..... MAIN POWER SWITCH: Bring the switch to the mid position and then momentarily flip upward to activate the instrument.
- 3..... AC LINE INDICATOR: This LED will illuminate when the input plug is connected to a live line power. The LED also acts as a low-battery indicator. As the battery charge becomes low (25% or lower), this LED will flash at a constant rate.
- 4..... BATTERY CHARGED INDICATOR: This LED will illuminate when the internal battery is charged to 90% (or higher) of its full capacity.
- 5..... PROTECTIVE GROUND TERMINAL: The safety protective chassis ground connection for the instrument. This terminal is internally connected to the U ground.
- 6..... DISPLAY: The display is a high-resolution graphic LCD.
- 7..... FUNCTION KEYS: These pushbuttons are operated in conjunction with the display. The display provides indication of key function. Function of each key varies with each screen.
- 8..... MAIN MENU KEY: When depressed, the PENTA-PLUS will return to the main menu.
- 9..... LEFT/RIGHT CURSOR KEYS: The cursor keys allow the operator to move, in the left and right directions, to different fields on the screen.
- 10.... UP/DOWN CURSOR KEYS: The cursor keys allow the operator to move, in the up and down directions, to different fields on the screen.



..... FIGURE 4-1.FRONT PANEL OF THE PENTA-PLUS

- 11.....VOLTAGE INPUTS: The single or polyphase voltages are connected to these binding posts, as labelled.
- 12.....CURRENT INPUTS: Three independent current circuits may be connected to these binding posts. The correct polarity, for the phase angle measurement purposes, is indicated by the red terminal and a black dot.
- 13.....START INPUTS: Interval timer start binding post connections. Also used to start the measurement.
- 14.....START KEY: This key is used to start the interval timer and the measurement.
- 15.....RESET KEY: This key is used to reset the meter in certain measuring screens.
- 16.....STOP INPUTS: Interval timer stop binding post connections. Also can be used to stop/hold the measurement.
- 17.....STOP KEY: This key is used to stop the timer or stop/hold the measurement.
- 18.....HORN TOGGLE SWITCH: This key will enable or disable the horn on the STOP contact inputs. Once enabled, a horn is sounded if a continuity is detected across the STOP binding posts. This feature is useful for performing minimum pick-up test on protective relays.
- 19.....RS232 OUTPUT PORT: This unidirectional port is provided for transmitting the test results to an external PC or a data terminal.
- 20.....PARALLEL PRINTER PORT: The printer port can be connected to a Centronics compatible parallel printer, for printing the test results.
- 21.....DISPLAY CONTRAST CONTROL: Turning this recessed screw will change the contrast of the display.
- 22.....DISPLAY BACK-LIGHT SWITCH: This switch controls the display back-light. In low ambient light conditions, the back-light allows the operator to see the display. If not

needed, the back-light should be turned off to preserve the battery.

..... 4.2. SAFETY CONSIDERATIONS

..... The measuring terminals of this instrument can be connected to lethal voltages and hazardous current circuits. Professional organizations using this instrument will normally have safety procedures covering such installations and users will be trained to follow them. Notwithstanding these conditions, certain precautions should be followed when using this instrument.

- 1.....The chassis ground connection should always be firmly attached to the system ground bus, even when an AC line cord is used.
- 2.....Connections should be established to the potential and current terminals before the measuring circuit is energized.
- 3.....The use of potential leads containing high rupture fuses is recommended in high KVA circuits.
- 4.....All current terminals should be tightly fastened, to avoid dangerous terminal voltages and preclude ohmic heating at high currents.

..... 4.3... USING THE INTERNAL BATTERY

..... This instrument is equipped with an internal rechargeable sealed lead-acid battery. The battery will typically provide up to 3 hours of continuous operation on full charge. The battery is protected against over-charging and charge exhaustion.

..... The internal charger will automatically charge the battery when the line power is applied to the instrument. When the battery is 90% charged, the 'battery charged' LED illuminates. The instrument can be used while the battery is being charged.

..... The AC LINE LED also acts as low-battery indicator. This LED will flash at a constant rate, once the battery charge drops below 25%.

..... In order to prolong the life of the battery and ensure optimum

performance, the following procedure should be observed:

- 1..... Charge the battery overnight after using the instrument for a short time or after a whole day.
- 2..... Charge the instrument at least once a month, if it is stored unused, or store it connected to a power line.
- 3..... If the battery condition has been allowed to deteriorate due to lack of attention, charge it for a period of up to one week to allow the charger to recover the condition of the battery.

..... 4.4... GENERAL OPERATING INSTRUCTIONS

..... The following is a general procedure for operating the PENTA-PLUS.

- 1..... Connect the front panel protective safety ground binding post to a good earth ground. This is recommended even if the AC power cord is used.
- 2..... If the AC power is used, connect the provided AC power cord to a suitable supply. The PENTA-PLUS is equipped with a wide input range power supply and therefore can be operated from 104 to 253 Volts (AC), 50 or 60 Hertz.
- 3..... Turn on the instrument by toggling the power switch to its mid- position and flipping it to its momentary upper position. The instrument should display the main menu.
- 4..... Make the proper connections to the voltage and/or current channel inputs. Connections should be established to the potential and current terminals before the measuring circuit is energized.
- 6..... Proceed with the actual test as described in the following sections.

..... 4.5... SINGLE-PHASE OPERATION

..... The single-phase operation mode is intended for measuring a single voltage and current, two voltages or two currents. This mode features a quick input selection menu, which enables the

operator to measure various quantities in a single- or poly-phase installation.

..... Note that the displayed phase angle lags the reference input.

..... 4.5.1. SELECTING THE INPUT CHANNELS

..... 1. Select the **SINGLE-PHASE** configuration from the main menu, by pressing the corresponding function key. The following should appear on the display.

<h1>SINGLE PHASE MODE</h1>					
USE THE FUNCTION KEYS TO SELECT					
V_{AN} & I_A	V_{AB} & V_{CN}	I_A & I_B	OTHER INPUTS	HIGH SPEED CAPTR	MAX HOLD

..... 2. From the single-phase screen, select the input channels required. The following quick selections are provided for convenience:

..... - **Van & Ia** For one-voltage and one-current measurements. The voltage is applied between the A and N voltage terminals, and the current is applied to the A current terminals.

..... - **Vab & Vcn** For two-voltages measurements. The first voltage is applied between the A and B voltage

terminals, and the second voltage is applied between the C and N terminals.

..... **la & lb** For two-currents measurements. The first current is applied to the A current terminals, and the second current is applied to the B current terminals.

..... Press the corresponding function key to activate the measurement on any of the above selections.

..... If inputs other than the ones listed above are required, press the **OTHER INPUTS** function key. The instrument will display the following:

VAN ■ VAN					
VBN □ VBN ■					
VCN □ VCN □					
VAB. □ VAB.					
VBC. □ VBC.					
VCA. □ VCA.					
IA □ IA..... □					
IB □ IB..... □					
IC □ IC..... □					
SELECT INPUT 1		SELECT INPUT 2			MEAS

..... 3. Use the **SELECT INPUT 1** followed by **SELECT INPUT 2** function keys to configure the measurements. Note that certain combinations of input 1 and 2 are not possible. The instrument automatically disables these combinations.

..... 4. Press the **MEAS** function key to activate the measurement.

..... 4.5.2.THE MEASURING FUNCTIONS

$V_{AN} = \dots\dots 0.000 \dots\dots$ VOLTS $\dots\dots 0.00$ Hz $I_A = .0.000 \dots\dots$ AMPS $\dots\dots 0.00$ HZ PHASE =.. 0.000 \dots\dots DEG POWER =. 0.000 \dots\dots WATTS VAR =..... 0.000 \dots\dots VARS <p style="text-align: right;">RANGE: 10V.. 200 MA</p>					
PRINTER DISAB.	RS232 DISAB.	SAVE RESULT	RMS AVG FILTER	RANGE: AUTO MANUAL	ESC

..... 1. Anytime during the course of measurement, the serial and/or parallel (i.e., printer) transmission can be activated.

..... In order to activate the transmission, make the appropriate connection to the PRINTER and RS232 terminals. Refer to section 4.13. for more details.

..... Press the **PRINT** and/or **RS232** function keys to initiate the transmission. If the instrument can establish proper communication with the external device, the **ENABLE** indicator, in the **PRINT** or **RS232** function boxes will illuminate.

..... To terminate the transmission, press the **PRINT** and/or **RS232** function keys again.

..... Note that the activating both serial and parallel transmission may degrade the update rate of the instrument.

..... 2. If the timed data transmission has been activated, pressing **PRINT** or **RS232**, as described in step 1, will initiate the timed transmission. Please refer to section 4.11. for information on timed data

transmission.

-3. The **STOP** inputs or key can be used to hold readings on display. To reactivate the measurement, use the **START** inputs or key.

..... The **START** or **STOP** inputs respond to a change of state. This change may be a dry contact opening or closure, or the initial application of an A.C. or DC Voltage. The input terminals are isolated from the chassis ground and are independent of signal polarity.
-4. To save the measurements, it is recommended to hold the display, as described in item 3. first, and then press **SAVE RESULTS** function key.

..... Pressing this key will pop up the ID TAG NUMBER sub-screen. This number is tagged to the saved data, for future reference. If no specific ID tag number is required, press the **CONTINUE** function key. All saved data are time and date stamped.

..... To change the ID number, use the left/right cursor keys to move from one digit to the next. To change the digit use the up/down cursor keys. Press **CONTINUE** function key to enter the number and save the data.
-5. The instrument automatically defaults to true **RMS** measurement. To Change the measurement mode to **AVERAGE** or **FILTERED-AVERAGE**, press the corresponding function key. The selected mode is highlighted.
-6. The instrument will default to automatic ranging. If manual override is desired. Proceed as follows:

..... - Press **RANGE** function key. The **MANUAL** ranging will be highlighted.
..... - The voltage range will be highlighted.
..... - Use up/down cursor keys to change the range.
..... - Use left/right cursor keys to move to current

range.

..... - Use up/down cursor keys to change the range.

..... Please refer to section 4.7. if an external clamp-on current transformer is used.

..... 7. To switch back to automatic ranging, press the **RANGE** function key again. The **AUTO** ranging will be highlighted.

..... 8. The input shown on the top of the display is the reference input, for phase angle measurement purposes.

..... 9. Pressing **ESC** function key, will return the user to the single-phase input selection screen.

..... 4.5.3. SINGLE-PHASE MAX-HOLD FEATURE

..... The single phase operating mode is equipped with a max-hold feature. In this mode the ammeter or voltmeter (whichever selected) holds the maximum RMS value of the input current or voltage. This mode is useful for performing instantaneous tests on protective relays. Note that this feature is also available in the TIMER screen.

..... 1. Select the **SINGLE-PHASE** configuration from the main menu, by pressing the corresponding function key.

..... 2. From the single-phase screen, select **MAX HOLD**, by pressing the corresponding function key.

..... The following display will appear:

MAX-HOLD SCREEN

..... **VAN = VOLTS**
..... **IA = AMPS**

PRINTER DISAB.	RS232 DISAB.	SAVE RESULTS	I _A V _{AN} V _{AN} & I _A	60 Hz 50 Hz	ESC
-------------------	-----------------	-----------------	---	----------------	-----

..... 3..... Select either **I_a** (i.e., ammeter) or **V_{an}** (i.e., voltmeter), or both, by using the corresponding function key. The instrument default to I_a.

..... 4..... Use the up/down cursor keys to select the correct range. Automatic ranging feature is not available in this mode.

..... 5..... Once the measuring circuit is activated, the meter would hold the highest RMS value of the input signal. To reset the meter, press the **RESET** switch.

..... 6..... All other functions (i.e., PRINT, RS232 and SAVE RESULTS) are as described in section 4.5.2..

..... 7..... Pressing **ESC** function key, will return the user to the single-phase input selection screen.

..... 4.6... THREE-PHASE OPERATION

..... The three-phase operation mode is intended for measuring all 3-phase quantities in a delta or wye installation. Please note that the displayed phase angle lags the input, marked as the reference on the display.

..... 4.6.1.SELECTING THE CONFIGURATION

..... Select the **THREE PHASE WYE** or the **THREE PHASE**

DELTA configuration from the main menu, by pressing the corresponding function key. The instrument will immediately go into the measuring screen.

..... 4.6.2.THE MEASURING FUNCTIONS

59.99 Hz						A	B	C	WYE
V..						.....0.000	.0.000	.0.000	
REF 0dq ...						..... @ 0.0	..... @ 0.0		
A..						.....0.000	.0.000	.0.000	
.....						@ 0.0	..... @ 0.0	..... @ 0.0	
W.						.....0.000	.0.000	.0.000	
VAR						0.000	0.000	0.000	
						RANGE:	5V	100mA	
PRINTER DISAB.	RS232 DISAB.	SAVE RESULTS	RMS AVG FILTER	RANGE: AUTO MANUAL	CHANGE REF				

..... 1. Anytime during the course of measurement, the serial and/or parallel (i.e., printer) transmission can be activated.

..... In order to activate the transmission, make the appropriate connection to the PRINTER and RS232 terminals. Refer to section 4.13. for more details.

..... Press the **PRINT** and/or **RS232** function keys to initiate the transmission. If the instrument can establish proper communication with the external device, the **ENABLE** indicator, in the **PRINT** or **RS232** function boxes will illuminate.

..... To terminate the transmission, press the **PRINT** and/or **RS232** function keys again.

..... Note that the activating both serial and parallel transmission may degrade the update rate of the instrument.

-2. If the timed data transmission has been activated, pressing **PRINT** or **RS232**, as described in step 1, will initiate the timed transmission. Please refer to section 4.11. for information on timed data transmission.
-3. The **STOP** inputs or key can be used to hold readings on display. To reactivate the measurement, use the **START** inputs or key.
- The **START** or **STOP** inputs respond to a change of state. This change may be a dry contact opening or closure, or the initial application of an AC or DC Voltage. The input terminals are isolated from the chassis ground and are independent of signal polarity.
-4. To save the measurements, it is recommended to hold the display, as described in item 3. first, and then press **SAVE RESULTS** function key.
- Pressing this key will pop up the ID TAG NUMBER sub-screen. This number is tagged to the saved data, for future reference. If no specific ID tag number is required, press the **CONTINUE** function key. All saved data are time and date stamped.
- To change the ID number, use the left/right cursor keys to move from one digit to the next. To change the digit use the up/down cursor keys. Press **CONTINUE** function key to enter the number and save the data.
-5. The instrument automatically defaults to true **RMS** measurement. To Change the measurement mode to **AVERAGE** or **FILTERED-AVERAGE**, press the corresponding function key. The selected mode is highlighted.
-6. The instrument will default to automatic ranging. If manual override is desired. Proceed as follows:
- - Press **RANGE** function key. The **MANUAL** ranging will be highlighted.

- -..... The voltage range will be highlighted.
- -..... Use up/down cursor keys to change the range.
- -..... Use left/right cursor keys to move to current range.
- -..... Use up/down cursor keys to change the range.

..... Please refer to section 4.7. if an external clamp-on current transformer is used.

.....7. To switch back to automatic ranging, press the **RANGE** function key again. The **AUTO** ranging will be highlighted.

.....8. Pressing **ESC** function key, will return the user to the single-phase input selection screen.

.....9. Phase A voltage input is taken as the reference for phase angle measurement. The operator may change the reference to either phase B or phase C voltage, by pressing the corresponding function key.

..... 4.7... CLAMP-ON CURRENT TRANSFORMER OPERATION

..... For application requiring direct measurement of primary current, four different optional clamp-on current transformers are offered with this instrument. These clamp-ons provide ratios of 1000:1, 1000:5, 3000:1 and 3000:5.

..... There are two manners in which the clamp-ons can be utilized:

..... 1..... Measuring Primary current, watts and vars in a single- or three-phase installation.

..... 2..... Verifying the ratios of CTs, used in relaying and metering installations.

..... The following sections detail the operation for each of these applications.

..... 4.7.1.MEASURING PRIMARY CURRENT

..... 1. For this application, connect the clamp-on CT(s)

directly to the current channel terminals on the front panel. Up to three clamp-ons can be used for three-phase applications. Note that the CTs are only rated for 600 Volts class circuits.

.....2. Proceed with the selection, as detailed in sections 4.5. and 4.6..

.....3. To select the clamp-on ratio on the measuring screen, proceed as follows:

.....- Press **RANGE** function key. The **MANUAL** ranging will be highlighted.

.....- The voltage range will be highlighted.

.....- Use left/right cursor keys to move to current range.

.....- Use up/down cursor keys to change the range. Select the correct range (i.e., **1000:1**, or **1000:5**, or **3000:1**, or **3000:5**).

.....4. All measuring functions are explained in sections 4.5.2. and 4.6.2.

..... 4.7.2. VERIFYING THE RATIOS OF CTs

.....1. For this application, connect the clamp-on CT directly to the phase A current channel terminals on the front panel. Connect the secondary of the CT under test to the phase B current channel terminals.

.....2. Select the **SINGLE-PHASE** configuration from the main menu, by pressing the corresponding function key. The following should appear on the display.

SINGLE PHASE MODE

USE THE FUNCTION KEYS TO SELECT

V_{AN} & I_A	V_{AB} & V_{CN}	I_A & I_B	OTHER INPUTS	HIGH SPEED CAPTR	MAX HOLD
------------------------	---------------------------	---------------------	-----------------	------------------------	-------------

.....3. From the single-phase screen, select **Ia & Ib**, by pressing the corresponding function key. The measurement will be activated.

I_A =..... 0.000 AMPS .. 0.000 Hz I_B =..... 0.000 AMPS .. 0.000 Hz PHASE =..... 0.000 DEG					
..... RANGE: 1000:5 6A					
PRINTER DISAB.	RS232 DISAB.	SAVE RESULT	RMS AVG FILTER	RANGE: AUTO MANUAL	ESC

.....4. The instrument will default to automatic ranging. Change the range to manual and select the correct range as follows:

- - Press **RANGE** function key. The **MANUAL** ranging will be highlighted.
 - - The current range will be highlighted (for Ia).
 - - Use up/down cursor keys to change the range. Select either **1000:1**, **1000:5**, **3000:1** or **3000:5**, depending the clamp-on used.
 - - Use left/right cursor keys to move to the second current range.
 - - Use up/down cursor keys to change the range. The 6A is the optimal range for CTs with 5A secondaries.
- 5. All measuring functions are as explained in sections 4.5.2.

..... 4.8... HIGH-SPEED SINGLE-PHASE CAPTURE MODE

..... In the normal single-phase operating mode the instrument updates the readings twice every second. For applications requiring faster update rate, such as measuring currents and voltages of short duration, a high-speed capture mode is available. In this mode the update speed is 20 times every second. The high speed mode of operation works in conjunction with the START and STOP circuitry, allowing the user to capture 3-seconds of test results, in a controlled manner.

..... **NOTE:** For the fastest results when using the high speed single phase mode it is recommended that the **Int Sync** options be chosen

..... 1..... **SYNC:** Due to the high-speed operation in this mode a synchronizing signal is required for proper operation. The following selection of the SYNC signals are available:

- - An externally applied voltage to Vab terminals (voltage channel A and B).
- - An externally applied current to Ia terminals (current channel A).
- - An internal 50 or 60 Hz SYNC

..... The frequency of the SYNC and the input signals must be the same. The external SYNC should be a steady signal

and be present prior to the start of measurement. Use one of the internal SYNC sources if an external source is not available.

..... 2.....CAPTURE MODES: Two capture modes are available:

.....-.....AFTER-START: in this mode 3 seconds of data is captured after the measurement is initiated. Use the START inputs or key to initiate the measurement. The measurement will automatically abort 3-seconds after it is started.

.....-.....BEFORE-STOP: in this mode 3 seconds of data is captured before the measurement is terminated. In this mode the START inputs or key is used to initiate the test and the STOP inputs or key is used to terminate the test.

..... 4.8.1.THE MEASURING FUNCTIONS

.....1.Select the **SINGLE-PHASE** configuration from the main menu, by pressing the corresponding function key.

.....2.Select **HIGH SPEED CAPTR** from the single phase screen. The following will appear:

<p>INPUT 1 (REF).. INPUT 2.....SYNC.....CAPTURE MODE V_{AB}..... I_A.....EXT. V_{AB}.....BEFORE-STOP </p> <p>.....1..... CHANGE INPUTS, IF REQUIRED. 2..... SET CAPTURE MODE. 3..... CHANGE RANGE, IF REQUIRED. 4..... APPLY EXT SYNC SOURCE PRIOR TO MEASUREMENT. 5..... ARM CAPTURE CIRCUIT 6..... USE THE START INPUTS TO INITIATE TEST.</p>					
CHANGE INPUT		CAPTR MODE	ARM	VIEW DATA	ESC

..... Note that the information on top of the screen indicates the default conditions for this mode. The condensed operating instructions for this mode is also shown on this display.

.....3. To change the input channels press the **CHANGE INPUT** function key. The following display will appear:

..... INPUT 1 (REF) .. INPUT 2 SYNC					
..... V_{AB}.....	.....I_A.....	.....EXT. V_{AB}			
..... V_{AB}.....	.....V_{CN}.....	.....EXT. V_{AB}			
..... I_A.....	.....I_C.....	.....EXT. I_A			
..... I_A.....	.....V_{CN}.....	.....EXT. I_A			
..... V_{AB}.....	.....I_A.....	.....INT. 60Hz			
..... I_A.....	.....V_{BA}.....	.....INT. 60Hz			
..... V_{AB}.....	.....I_A.....	.....INT. 50Hz			
..... I_A.....	.....V_{AB}.....	.....INT. 50Hz			
					CONTIN

..... Use the up/down cursor keys to highlight and select the configuration required. Please note that the input 1 is marked as the reference for phase angle measurement purposes. The first four selections require an external SYNC signal. The last four utilize an internal 50 or 60 Hz SYNC source.

..... To enter the new configuration and return to the previous screen, press **CONTIN** function key.

..... 4..... Pressing the **CAPTR MODE** function key will change the capture mode from AFTER-START to BEFORE-STOP and vice versa, as previously explained. Note the capture mode is shown on the top right hand corner of the display.

- 5..... Only manual ranging is available in this mode of operation. Set the proper voltage and current range prior to the measurement:
- - The voltage range should be highlighted.
 - - Use up/down cursor keys to change the range.
 - - Use left/right cursor keys to move to current range.
 - - Use up/down cursor keys to change the range.
- 6..... If an external SYNC source is selected, it should be present at this point. We recommend a 120V input for voltage and 5A input for current. Note that the correct range is selected (step 5.).
- 7..... Once all the connection to the instrument are made, press the **ARM** function key to arm the capture circuitry.
- 8..... Use the **START** inputs or key to initiate the test. If a **BEFORE STOP** mode of operation is selected, a **STOP** signal is required to terminate the test. In a **AFTER-START** mode, the test is automatically terminated three seconds after it is started.
- The **START** or **STOP** inputs respond to a change of state. This change may be a dry contact opening or closure, or the initial application of an AC or DC Voltage. The input terminals are isolated from the chassis ground and are independent of signal polarity.
- 9..... Once the data has been captured, use the **PAGE UP** or **PAGE DOWN** function keys to scroll through pages of data. There are a total of six pages.
- 10..... In order to activate the transmission of the captured data to an external printer or PC, make the appropriate connection to the **PRINTER** and **RS232** terminals. Refer to section 4.13. for more details.
- Press the **PRINT** and/or **RS232** function keys to initiate the transmission. All six pages of captured data will be transmitted.
- 11..... To save the data press **SAVE RESULTS** function key.

..... Pressing this key will pop up the ID TAG NUMBER sub-screen. This number is tagged to the saved data, for future reference. If no specific ID tag number is required, press the **CONTINUE** function key. All saved data are time and date stamped.

..... To change the ID number, use the left/right cursor keys to move from one digit to the next. To change the digit use the up/down cursor keys. Press **CONTINUE** function key to enter the number.

..... 12..... Press **ESC** to return to the previous screen.

..... 4.9... TIMER/RELAY OPERATION

..... The PENTA-PLUS is equipped with an internal timer, primarily intended for performing timing tests on protective relays and circuit breakers. The timer is equipped with a sensing circuitry that responds to a change of state. This change may be a contact opening or closing, or the initial application of an AC or DC Voltage, or removal of a DC voltage. The input terminals are isolated from the chassis ground and are independent of signal polarity.

..... 4.9.1.MODES OF OPERATION

..... There are three independent modes built into the TIMER/RELAY operation:

..... 1. **CONTINUOUS MODE:** In this mode the timer is disabled, but the voltmeter or ammeter is operating continuously. This mode of operation, in conjunction with the **STOP** terminals, can be used to verify minimum pick-up on protective relays. Note that the **STOP** inputs act as a continuity detector in this mode.

..... 2. **TIMER MODE:** In this mode the timer is armed and triggered using the **START** inputs or key. The ammeter or voltmeter is also running continuously. The timer can be stopped using the **STOP** terminals or key. The reading of the ammeter or voltmeter freezes when the timer stops.

..... This mode is useful for performing timing test on protective relays.

.....3. MAX HOLD MODE: In this mode of operation, the timer is disabled. The ammeter or voltmeter holds the maximum RMS value of the input current or voltage. This mode is useful for performing instantaneous tests on protective relays.

..... 4.9.2.THE MEASURING FUNCTIONS

.....1. Select the **TIMER/RELAY** from the main menu, by pressing the corresponding function key.

..... VAN = VOLTS					
..... IA = AMPS					
..... TIME= SEC.... 0.000 Hz					
..... CYCLES =					
VIEW RESULTS	CONT. MAXHLD TIMER	SAVE RESULTS	IA VAN VAN & IA	60 Hz 50 Hz	ESC

.....2. Select the mode of operation, as described in the pervious section, using the appropriate function key. CONTINUOUS is the default mode.

.....3. Select either **Ia** (i.e., ammeter) or **Van** (i.e., voltmeter), or both, by using the corresponding function key. The instrument defaults to Ia.

.....4. Note that only manual ranging is available for this mode of operation. Use the up/down cursor keys to change the range.

.....5. In the CONTINUOUS MODE the timer is disabled,

but the voltmeter or ammeter is operating continuously. The **STOP** inputs act as a continuity detector for testing minimum pick-up on protective relays. When a continuity is detected, a horn will sound. Use the horn toggle switch to disable the horn, if not required.

-6. In the **TIMER MODE** the timer is armed and triggered using the **START** inputs or key. The ammeter or voltmeter is also running continuously. The timer can be stopped using the **STOP** terminals or key. The reading of the ammeter or voltmeter freezes when the timer stops.
- The **START / STOP** inputs are equipped with a sensing circuitry that responds to a change of state. This change may be a contact opening or closing, or the initial application of an AC or DC Voltage, or removal of a DC voltage. The input terminals are isolated from the chassis ground and are independent of signal polarity.
-7. In the **MAX HOLD** mode, once the measuring circuit is activated, the meter would hold the highest RMS value of the input signal. To reset the meter, press **RESET**.
-8. Press the **SAVE RESULTS** to temporarily save the content of the display in a buffer. This information then can be permanently saved under **VIEW RESULTS** screen.
-9. Press **VIEW RESULTS** to view the data in the temporary buffer.
-10. ... In the view results screen, use the **PAGE UP** or **PAGE DOWN** function keys to scroll through the data.
-11. ... The **PRINT** or **RS232** function keys can also be used to transmit the data to a printer or a PC. In order to activate the transmission of the data to an external printer or PC, make the appropriate connection to the **PRINTER** and **RS232** terminals.

Refer to section 4.13. for more details.

..... Press the **PRINT** and/or **RS232** function keys to initiate the transmission.

..... 12. ... To save the data press **SAVE RESULTS** function key.

..... Pressing this key will pop up the ID TAG NUMBER sub-screen. This number is tagged to the saved data, for future reference. If no specific ID tag number is required, press the **CONTINUE** function key. All saved data are time and date stamped.

..... To change the ID number, use the left/right cursor keys to move from one digit to the next. To change the digit use the up/down cursor keys. Press **CONTINUE** function key to enter the number.

..... 13. ... Press **ESC** to return to the previous screen.

..... 4.10. DATA VIEW

..... PENTA-PLUS is equipped with a non-volatile internal memory for saving the test data. The **VIEW SAVED DATA** features allows the user to retrieve the save data for download to an external device. The capacity of the internal memory and the type number used are as follows:

.....	TYPE #	CONTENT	CAPACITY
-------	-------	---------------	-------	----------------	-------	-------	-----------------

.....	TYPE 1	Single Phase data	100 sets
-------	-------	--------	------	-------------------	-------	-------	----------

.....	TYPE 2	Three Phase data	100 sets
-------	-------	--------	------	------------------	-------	-------	----------

.....	TYPE 3	Max-Hold data	100 sets
-------	-------	--------	------	---------------	-------	-------	----------

.....	TYPE 4	Timer data	18 sets
-------	-------	--------	------	------------	-------	-------	---------

.....	TYPE 5	High Speed Capture data	8 sets
-------	-------	--------	------	-------------------------	-------	-------	--------

..... If different type numbers are saved, the capacity for each type will decrease.

..... In order to view a set of data which has already been saved, proceed as follows:

..... 1..... Select **VIEW SAVED DATA** from the main menu. The

following will appear on the display:

FILE .	DATE.....	TIME	USER ID...	TYPE	
1.....	94-05-15...	12:19:33....	00000001 .	4	
2.....	94-05-15...	12:22:33....	00000002 .	4	
END OF DIRECTORY					
PRINT DIR.	RS232 DIR.	PRINT ALL FILES	CLEAR ALL	PAGE DOWN	VIEW DATA

..... A directory containing all saved data will be shown.

..... 2..... To print or transmit the list of all files in the directory to a printer or a PC, use the **PRINT DIR.** or **RS232 DIR.** function keys. Refer to section 4.13. for more details.

..... 3..... **PRINT ALL FILES** function key will print the contents of all saved data in the directory.

..... 4..... To clear all saved files in the directory, press the **CLEAR ALL** function key.

..... 5..... To scroll through all files use the up/down cursor keys. To scroll through all pages of the directory (if more than one) use the **PAGE DOWN** function key.

..... 6..... To view the content of the highlighted press the **VIEW DATA** function key.

..... Each individual file can be printed or transmitted once it is viewed.

..... 4.11. TIMED DATA TRANSMISSION

..... For normal single-phase or three-phase measurement the instrument can be configured so that the test results are

transmitted to an external PC and/or printer on a regular pre-programmed time interval. The interval is programmable from 1 to 59 minutes. For instance, if a 5 minute interval is selected, the operator can connect the instrument to a printer, enable the print function from the single or three phase measuring screens and print the measured quantities every 5 minutes.

..... The following procedure details the programming of this function:

- 1..... Select **MORE** from the main menu. Select **DATA TRANS INTRVL** from the second menu, by pressing the appropriate function key.
- 2..... Use the left/right cursor keys to select the digit and the up/down to change the number.
- 3..... Press the **DISABL ENABLE** function key to enable this function.
- 4..... Press **ESC** to exit.
- 5..... To activate this function enable either the **PRINT** or **RS232** functions from the single- or three-phase measuring screens.

..... 4.12. SETTING THE CLOCK AND DATE

..... The PENTA-PLUS is equipped with an internal real-time clock and date, used to stamp the saved data. In order to change the clock and/or date settings proceed as follows:

- 1..... Select **MORE** from the main menu. Select **TIME&DATE** from the second menu, by pressing the appropriate function key.
- 2..... Use the left/right cursor keys to move to the appropriate field (i.e., year, month, day, hour, minutes, seconds).
- 3..... Use the up/down cursor keys to change the numbers, as required.
- 4..... To save the new time and/or date press **UPDATE DATE/TIME** function key.

..... 5..... To exit without saving the changes, skip step 4. and press the **ESC** function key.

..... 4.13. PERIPHERAL OPERATION

..... 4.13.1. PRINTER PORT

..... The printer port is located on the front panel of the instrument, and uses a 25-pin delta receptacle. The instrument employs the Centronics protocol and therefore can be directly connected to any compatible dot matrix printer.

..... Printer port connector pin-out is shown in TABLE 4-1..

..... TABLE 4-1..... CENTRONICS PRINTER PORT PIN-OUT

PIN NUMBER	DESIGNATION	SIGNAL DIRECTION
1	STROBE	OUTPUT
2	DATA BIT 0	OUTPUT
3	DATA BIT 1	OUTPUT
4	DATA BIT 2	OUTPUT
5	DATA BIT 3	OUTPUT
6	DATA BIT 4	OUTPUT
7	DATA BIT 5	OUTPUT
8	DATA BIT 6	OUTPUT
9	DATA BIT 7 (MSB)	OUTPUT
10	ACKNOWLEDGE	INPUT
11	BUSY	INPUT
19-25	SIGNAL GROUND	-----

Other pins are not used.

..... 4.13.2. RS232 SERIAL DATA PORT

..... The serial port is located on the front panel of the instrument, and uses a 9-pin delta plug. The ASCII encoded characters are transmitted at the 4800 baud rate, with one start bit, 8 data bits, 1 stop bit, and no parity.

..... The serial port can be directly interfaced to a terminal, a compatible serial data acquisition system or COM ports on any personal computer. Commonly used software programs such as Windows Terminal or PROCOMM can be used to collect the data from the instrument.

..... The pin out of the 9-pin delta plug is shown in TABLE 4-2.. Please note the data transmission is unidirectional. **PENTA-PLUS utilizes the null modem configuration for communicating to a personal computer.**

..... TABLE 4-2..... RS232 CONNECTOR PIN-OUT

PIN NUMBER	DESIGNATION	FUNCTION
2	TxD	Transmit Data
3	RxD	Receive Data
5	GND	Signal Ground
7	CTS	Clear To Send
8	RTS	Request To Send

Other pins are not used.

5. SERVICE AND MAINTENANCE

..... The components and techniques used by **AVO** International are mostly standard and readily understood by competent, trained technicians. Some calibration and set-up procedures, however, are very difficult to perform in the field without the test jigs and accurate standards available to factory personnel. Customer repair and calibration are not recommended.

..... Please contact your **AVO** International representative should service or calibration be required. The North American addresses and phone numbers are shown below:

.....	180 Middlefield Road..	.....	4271 Bronze Way
.....	Scarborough, ON M1S 4M6 .	.....	Dallas, TX 75237-1088
.....	Canada .....	.....	U.S.A.
.....	Phone:	(416)298-6770....	..... Phone:..... (214)333-3201
.....	Fax:..	..... (416)298-7214....	..... Fax: (214)333-3533