BIDDLE
MEGGER®

Electrical Test Equipment
Measuring Instruments
Testing and
Training Services

AVO

AVO® ™

AVO INTERNATIONAL

multi-amp CORPORATION

4271 Bronze Way Dallas, Texas 75237-1088 U.S.A.
Ph. (214) 333-3201 Telex 163548 MULAM DL Fax (214) 333-3533

Multi-Amp Canada, 445 Finchdene Square, Scarborough, Ontario, M1X 1B7
Ph. (416) 298-6770 Telex 065-25453 Fax (416) 298-7214

INSTRUCTION MANUAL

For

DIGITAL PHASE ANGLE METER

MODEL PAM-275

It is essential that this instruction book be read thoroughly before putting the equipment in service.

Part Nº 12551
Rev. 1 8/15/91

IMPORTANT

The information and data contained within this instruction manual are proprietary with MULTI-AMP Corporation. The equipment described herein may be protected by one or more U.S. letters patent. MULTI-AMP specifically reserves to itself all rights to such proprietary information as well as all rights under any such patent, none of which is waived by the submission of this instruction manual to anyone.

The recipient, if a Government agency, acknowledges that this instruction book and the equipment described were procured with "Limited Rights" to technical data as described in ASPR 9-203 (b).

Part № 12551
Rev. 1 8/15/91

TABLE OF CONTENTS

Digital Display
0.0 to 359.9°

PAM-275R: Nonflickering, 0.6-in. (15-mm) LED numerals

PAM-275B: 0.5-in. (12-mm) LCD numerals

Isolation
Each input circuit is isolated from the other and from ground.

Input Frequency Range (specify one)
58 to 62 Hz **OR** 48 to 52 Hz

Current (both inputs)

Range	Accuracy	Resolution	Burden
0.05 – 2.0 A	±0.5°	0.1°	0.32 VA at 2 A
1.5 – 60 A			2.5 VA at 60 A

Useful down to 0.015 A and up to 120 A at reduced accuracy

Voltage (both inputs)

Range	Accuracy	Resolution	Burden
1 – 40 V	±0.5°	0.1°	4.7 kΩ
15 – 600 V			71 kΩ

Useful down to 0.25 V and up to 1200 V at reduced accuracy

Overload Capability
120 A for 1 min on high range
35 A for 1 min on low range
1200 V for 1 min on high range
120 V for 1 min on low range

Measurement Rate
Two measurements per second. Readings are held between measurements to avoid flickering.

Environmental
Temperature Range: 10 to 110° F (–12 to +43° C)

Warm-Up Time: Approx 1 min

Enclosure
The instrument is housed in a high-strength, molded suitcase-style case with carrying handle, removable hinged cover and lead compartment.

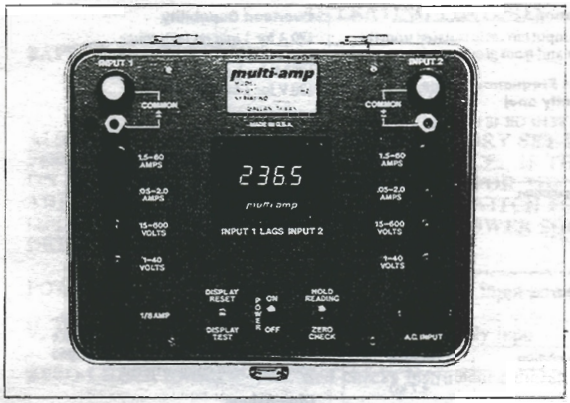
Dimensions (including removable cover)
8.5 H x 12 W x 90 D in.
216 H x 305 W x 229 D mm

Weight
12 lb (5.5 kg)

ORDERING INFORMATION

Item	Cat. No.
Model PAM-275 with:	
LCD Display 115-V, 60-Hz input	PAM-275B-115/60
LCD Display 230-V, 50-Hz input	PAM-275B-230/50
LED Display 115-V, 60-Hz input	PAM-275R-115/60
LED Display 230-V, 50-Hz input	PAM-275R-230/50

Item (Qty)	Cat. No.
Included Accessories	
Line cord (1)	6828
Fuses, 0.125, 250 V MDL (5)	981
Instructional manual (1)	9160
Optional Accessories	
Leads	
5 ft (1.5 m) (1 pr)	7933
Low-current, 5 ft (1.5 m) (1 pr)	7934
High-current, 5 ft (1.5 m) (1 pr)	7935



MULTI-AMP Model PAM-275

- **Reliable**
- **Rugged**
- **Easy-to-use**
- **Battery-operated**

Digital Phase Angle Meter

DESCRIPTION

The Multi-Amp® Model PAM-275 Digital Phase Angle Meter was designed specifically for electrical system applications. It is a battery-operated (rechargeable) or line-powered instrument. Incorporating two identical isolated input circuits, the unit permits precision measurements to be made of the phase angle relationship between two currents, two voltages or a voltage and a current.

APPLICATIONS

Model PAM-275 is commonly used in testing and calibrating protective relays, phasing out circuits, checking differential relay schemes, checking polyphase watthour and varhour meter installations and verifying the polarity of CTs and PTs.

FEATURES AND BENEFITS

- Direct digital reading
- Broadband current ranges
- Broadband potential ranges
- Excellent resolution
- Highly accurate
- Universal: measures I to I, E to E, E to I
- Long battery life
- Isolated input circuits
- Harmonic immunity: accurate reading with up to 30% harmonic distortion
- Not frequency-sensitive: accuracy not dependent on precise 50- or 60-Hertz inputs
- Rugged: Sturdy design provides years of typical field use.
- Out-of-range indication: automatic indication given when inputs are above or below rated ranges, eliminating need for instruments to monitor inputs
- Hold feature
- Not influenced by position

SPECIFICATIONS

Input (for battery recharging or line operation)

Nominal 115 or 230 V (switch-selected), 1 or 25 VA. Instrument may be used while battery is being recharged.

Battery Capacity

Minimum 8 hours of continuous usage on a single full charge. Low-battery condition is indicated by flashing decimals. Recharge time is twice the time used on battery power. The battery charger is built-in.

OPERATING FEATURES

SAFETY PRECAUTIONS

CAUTION

ALL UNITS ARE SHIPPED FROM THE FACTORY SET-UP FOR OPERATION FROM A NOMINAL 115 VOLT POWER SOURCE. IF THE UNIT IS TO BE USED ON A 230 VOLT SOURCE, IT IS NECESSARY FOR THE OPERATOR TO FIRST ADJUST THE POWER SOURCE SELECTOR SWITCH FOR 230 VOLT OPERATION. REFER TO "SELECTION OF POWER SOURCE" ON PAGE 1 FOR DETAILS.

POWER ON Switch	ON/OFF Switch for input power for logic and display.
1/8 Amp, 120/240 volts	Protects power supply input.
ZERO CHECK Switch	Self-checks instrument calibration.
HOLD READING Switch	Instrument will retain whatever measurement is being displayed when this switch is turned on.
DISPLAY RESET Switch	When toggled, the battery operation is reset for approximately five (5) additional minutes.
DISPLAY TEST Switch	All segments of each numeral are displayed (all 8's) to verify proper operation.

INPUT 1 & 2 Binding Posts

1.5 - 60 amps (Black)	High current input range.
0.05 - 2.0 amps (Black)	Low current input range.
15 - 600 volts (Red)	High potential input range.
1 - 40 volts (Red)	Low potential input range.
COMMON ± (White)	One side of the input signal (both current and potential) connects to either terminal.

INPUT 1 LAGS INPUT 2 Displays	Indicates phase angle in degrees.

SELECTION OF POWER SOURCE VOLTAGE:

All Model PAM-275 units are manufactured as dual voltage 120/240 volt units and are shipped from the factory with the power source VOLTAGE SELECTOR Switch set for nominal 120 volt operation. Power source voltage selection is adjustable by the use of a three-position slide switch. The switch has positions of 240/OFF/120.

The 240/OFF/120 Switch is located on the lower right side of the circuit board next to the transformer, with the 240 volt position to the top, the center position off, and the 120 volt position to the bottom. This switch is in the 120 volt position when shipped from the factory.

To obtain access to the power source VOLTAGE SELECTOR Switch, disconnect unit from source of power, remove instrument from case by loosening four mounting screws (next to INPUT Terminals) and lift chassis out of case. Remove the circuit board by removing the four mounting screws on the bottom of the chassis.

INPUT FUSES:

All units are shipped from the factory set up for nominal 120 volt operation. A $^1/_8$ ampere fuse is installed in the input fuse socket.

Five spare fuses are supplied with each new unit.

INPUT CIRCUITS:

Model PAM-275 measures and displays the phase angle relationship between two single phase ac signals applied to its input circuits.

Two identical input circuits are provided to facilitate measurements between two voltages, two currents or a voltage and a current. Each input circuit has binding posts for connecting the input signals. The two White binding posts labeled **COMMON** $\pm$ are used for both potential and current inputs. Although the two White binding posts are electrically the same point, the larger one should be used for currents in excess of 30 amperes. Either White binding post can be used as the common for potential inputs. Current inputs are applied to a White common binding post and the appropriate Black binding post as determined by the value of current. Potential inputs are applied to a White common binding post and the appropriate Red binding post as determined by the value of potential

DIGITAL DISPLAY:

The digital display indicates the phase angle in degrees that the signal applied to INPUT 1 lags the signal applied to INPUT 2.

LOW INPUT INDICATION:

If the magnitude of one of the inputs is below the rating of the input range being used, the display will flash. The input can be moved to the low range (if it is not already connected there) and the display will indicate the phase angle, provided that the input is within the rating of this range. However, if the input is below the minimum rating of the lowest range, the display will continue to flash. A reading can be obtained for inputs below the minimum rating, however, the error in measurement can be greater than that for inputs within the instrument's rated ranges.

HIGH INPUT INDICATION:

If the magnitude of one of the inputs is above the rating of the input range being used, the display will blink (flash on and off). The input can be moved to the high range (if it is not already connected there), and the display will stop blinking provided that the input is within the rating of this range. However, if the input is above the maximum rating of the highest range, the display will continue to blink. When the display blinks, the error in measurement can be greater than that for inputs within the instrument's rated range.

ACCURACY LEVELS:

Model PAM-275 is calibrated at the factory to measure the phase angle within rated accuracy for all input signals that are within the rated input ranges. On most units, if a low or high signal slightly outside the rated input ranges is applied, the meter will continue to accurately make its measurements. This is because the meter is factory calibrated to be within rated accuracy over the complete range at which it indicates without the display flashing.

HOLD READING FEATURE:

If it is desirable to retain the reading displayed, simply use the HOLD READING Switch. Whatever measurement is being displayed at the time this circuit is actuated, will be held until the switch is turned off. The reading is held even when the input signal is removed.

ZERO CHECK FEATURE:

Instrument calibration can be readily checked by use of the ZERO CHECK Switch.

To perform zero check, allow instrument to warm up for 10 minutes and then apply either approximately 5 amperes to the 1.5 - 60 amperes range of INPUT 2 or approximately 120 volts to the 15 - 600 volts range of INPUT 2. Connection to INPUT 1 is not required. Then turn the ZERO CHECK Switch on and the display should read between 359.8 and 0.2.

No adjustment is necessary if the reading is within these limits. Model PAM-275 is designed to minimize drifting, however, if zero check is outside these limits, the instrument can be recalibrated as follows:

1. Turn POWER Switch on and HOLD READING Switches OFF and disconnect all inputs, including the input line cord, from their source.
2. Remove the instrument from the case by removing the four mounting screws (next to the input terminals) and sliding the instrument out.
3. Place unit on table or bench top with its panel horizonal
4. Reconnect input line cord to the power source and turn POWER ON Switch ON.
5. Apply current or potential input to INPUT 2 as outlined above.
6. Turn ZERO CHECK Switch ON.
7. Locate and adjust trim pots R1 and R21 (Input 1 and 2) until display indicates between 359.8 and 0.2. These trim pots are located at the bottom left side of the board. No other adjustments should be made without contacting the factory.
8. Re-install instrument in its case.

OPERATION INSTRUCTIONS

THEORY OF OPERATION

The Model PAM-275 Digital Phase Angle Meter operates by measuring the elapsed time between the zero cross-over of Input 2 versus Input 1. The input signal of each input is filtered to minimize the harmonic distortion that may be present. The filtered sine wave is then converted to a square wave. The two square waves are compared by the logic circuit. The result of the comparison is a square wave pulse train, which is an accurate measurement of the elapsed zero cross-over between the two inputs. This pulse train is then converted by the logic circuit to a phase angle and displayed on the digital readout.

POWER CONNECTION AND TURN ON PROCEDURES:

1. Refer to Selection of Power Source Voltage on Page 1 before connecting instrument to a power source.

2. Check to insure POWER ON Switch is in the OFF position.

3. Connect the instrument to a suitable source of power. Check third wire in line cord to insure that the instrument is properly grounded to prevent any shock hazards.

4. Check to insure that the HOLD READING Switch is OFF. Turn POWER ON Switch ON.

5. Press Display Check Switch, all eights (888.8) should appear.

PHASE ANGLE MEASUREMENTS:

1. Connect either a current or potential to the appropriate binding posts of INPUT 1. Do not connect more than one input. For example, do not connect a current and a potential source simultaneously to INPUT 1.

2. Connect either a current or potential source to the appropriate binding posts of INPUT 2. Again, do not connect more than one source to INPUT 2.

CAUTION: Do not connect a potential source to the current input terminals.

3. Display will now indicate the phase angle that INPUT 1 lags INPUT 2. If display is blinking, a high or low level input is present or the battery is low. See Pages 2 and 3 for further details on LOW INPUT INDICATION, HIGH INPUT INDICATION and ACCURACY.

   NOTE: It is suggested to use color-coded test leads with the same color to the binding posts with the polarity marks.

OPERATION BELOW RANGE LIMITS:

The normal Model PAM-275 can be used for measuring phase angles below the meter's normal range limits.

In the lower current range 0.05-2.0 amperes, the Model PAM-275 can be used to measure phase angles with as little as 0.015 amperes input. In the lower voltage range 1-40 volts, the Model PAM-275 can be used to measure phase angles with as little as 0.25 volts input. However, the error in measurement will be greater than that for inputs within the instrument's rated ranges. When the magnitude of either the voltage or current drops below the lowest rating of the lowest input range, the display will flash zero (000.0).

OPERATION ABOVE RANGE LIMITS:

The Model PAM-275 may be used for measuring phase angles above the meter's normal range limits; however, it is not recommended.

In the upper current range 2-60 amperes, the Model PAM-275 may be used to measure phase angles with currents above 60 amperes input. In the upper voltage range 20-600 volts, the Model PAM-275 may be used to measure phase angles with voltages above 600 volts input. When the magnitude of either the current or voltage rises above the rating of the highest input range, the display will begin to flash on and off. In no case should an overload greater than 100% be applied to the meter. If a reading is still required, and the inputs are below the 100% overload limit, a reading may be obtained by connecting the inputs to the proper terminals. However, if an overload is applied for more than one minute, damage may result to the meter.

APPLICATIONS:

The phase angle meter has many uses. Certain terms will be used in this section which need to be defined.

1. Phase Angle is normally expressed in degrees. It is the angle between two sources, i.e., voltage leading or lagging current between 0° and 359.9°.

2. Power Factor is the cosine of the leading or lagging phase angle between a voltage and a current. It is either expressed as a decimal fraction or as a percent.

3. Power Factor Angle is the leading or lagging phase angle between the voltage and current.

   A. Determining Polarity of Current Transformers

   When current is induced into polarity of the primary of a current transformer, the current will flow out of polarity on the secondary, see Figure 1.

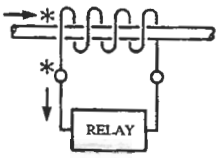


FIGURE 1: Direction of Secondary Current in a C. T.

Using a current transformer of known polarity. The current transformer of unknown polarity can be determined with a phase angle meter. Connect the two current transformers to the phase angle meter as shown in Figure 2.

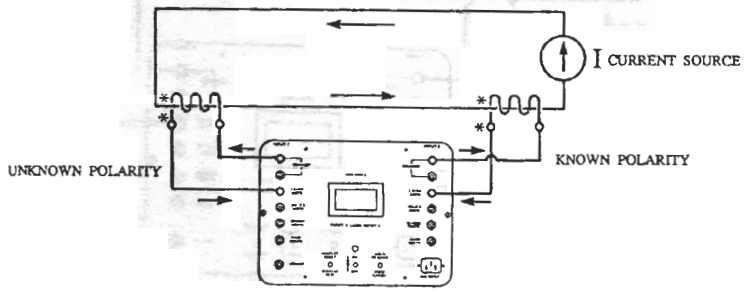


FIGURE 2: Determining Current Transformer Polarity

CAUTION: Do not open the secondary of the current transformers with the current source energized.

If the polarities are the same, a phase angle of zero degrees should be indicated. If a reading of 180 degrees is indicated, the polarity is opposite that of the known current transformer.

B. Determining the Power Factor Angle of an Inductive Circuit.

The current in a power system represents both real and reactive power. To determine how much of the current is being used to power an inductive load, connect the phase angle meter as shown in Figure 3. Note that the current lags the voltage in an inductive circuit, therefore, the current is supplied to INPUT 1. The phase angle displayed is the Power Factor Angle between the lagging current on INPUT 1 and the voltage on INPUT 2. If the load were a pure inductive load, the phase angle would be close to 90° or a Power Factor of 0% (cosine of 90° is 0.0).

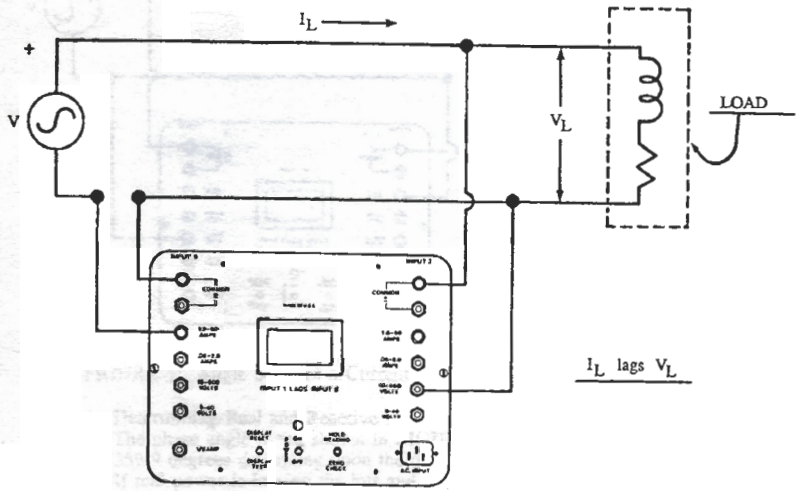


FIGURE 3: Angle between a Current and a Voltage (Induction Circuit).

C. Determining the Power Factor Angle of a Capacitive Circuit.

To determine how much of the current is being used to power a capacitive load, connect the phase angle meter as shown in Figure 4. Note that the current leads the voltage in a capacitive circuit, therefore, the current is supplied to INPUT 2 The phase angle displayed is the Power Factor Angle between the lagging voltage on INPUT I and the current on INPUT 2. If the load were a pure, capacitive load, the phase angle would be close to 270° or a Power Factor of 0% (cosine of 270° is, 0.0).

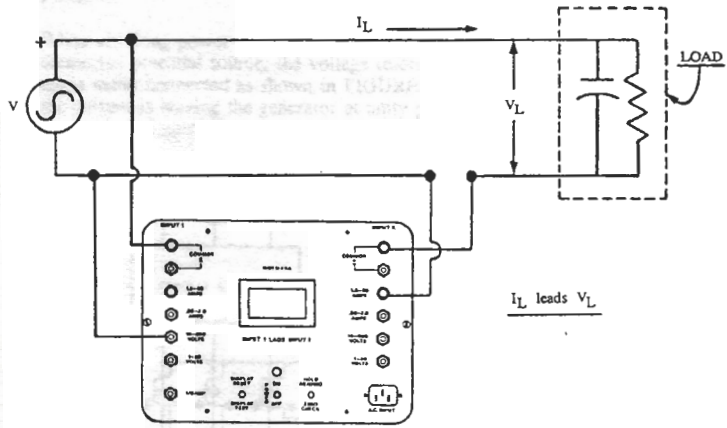


FIGURE 4: Angle between a Current and Voltage (Capacitive Circuit).

D. Determining Real and Reactive Power Flow in a Power System.
The phase angle meter shown in FIGURE 5, will read any angle from 0 to 359.9 degrees depending upon the direction of real and reactive power flow. If real power is leaving the bus and reactive is entering, the reading should be from 270° to 359.9°. If on the other hand, real power is entering and reactive is leaving the bus, the reading should be from 90° to 180° to 270°. If both real and reactive power are entering the bus, the reading should be from 180° to 270°. If both real and reactive power is leaving the bus, the meter should read from 0° to 90°.

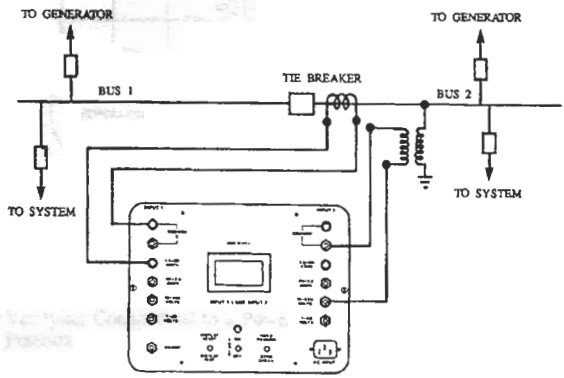


FIGURE 5: Determining Real and Reactive Power Flow

Part № 12551
Rev. 1 8/15/91

E. Verifying Connections to a Power Directional Relay with a Delta Connected Potential.

When checking power directional relays, or any three-phase relay with a Delta-connected potential source, the voltage reference is phase-shifted 30°. With the phase angle meter connected as shown in FIGURE 6, the meter will read 30° lagging when the current is leaving the generator at unity power factor.

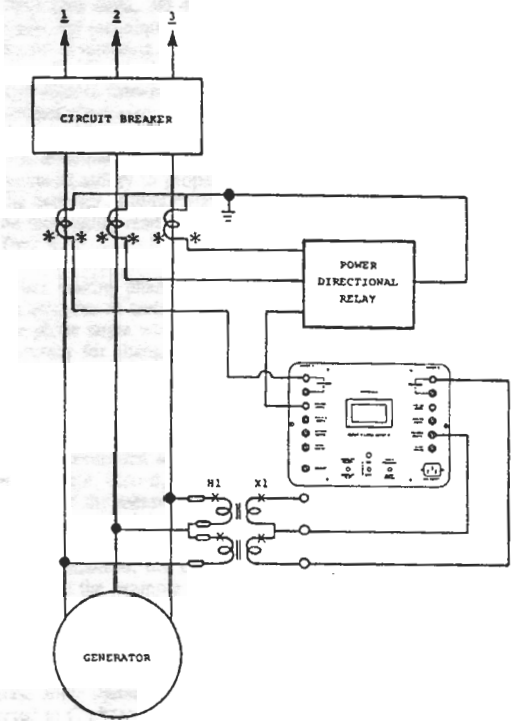


FIGURE 6: Verifying Connections to a Power Directional Relay With a Delta Connected Potential.

F. Verifying Connections to Transformer Rated Watthour Meters.

This section covers the use of the phase angle meter to check connections of transformer rated watthour meters. The procedure outlined provides a simple means where the average meter technician can easily and accurately check the connections of transformer rated watthour meters.

Three types of meters are shown:

3Ø 4 wire delta, 3Ø 4 wire Y, and 3Ø 3 wire 2 Element. There are other types, the techniques shown in this section may be modified to verify other forms of metering.

The vectors shown are plotted as conventional polar and are shown in a counter-clockwise rotation.

It is assumed that the operator of this equipment has the knowledge and technical ability to properly connect the meter as shown in the examples. If the operator is unfamiliar with the meter and its operation, it is suggested that he thoroughly read and understand the Operating Instructions beginning on Page 4.

When making phase angle measurements, it is suggested that the operator put an ammeter in series with the current leg to the phase angle meter. Measure the phase angle when the currents are about equal (this will insure higher accuracy for changing load conditions).

3Ø 4 WIRE Y 3 ELEMENT

Connect the phase angle meter to phase A, see FIGURE 7. Note, in this example the phase angle meter is shown connected to phase C for simplicity. After connecting the phase angle meter, measure the angle, record, and plot it as shown in FIGURE 8. Repeat the procedure for B and C phases. If the measurements and installation are correct, the potentials will be 120° apart.

If the load is closely balanced, the Power Factor can be determined by averaging the three angles together. As in the example, in FIGURE 8 the average of the three angles is 30°. The cosine of 30° is 0.87 or a Power Factor of 87%.

3 Ø WIRE 2 ELEMENT

Connect the phase angle meter as shown in FIGURE 9. In this example, the phase angle meter is connected to C phase for simplicity. Measure the potential vectors V_{A-B}, V_{B-C}, and V_{C-A} repeat the procedure for I_A. After the polar plot is completed, similar to Figure 10, plot a system delta diagram paralleling the original polar vectors, see Figure 11. The hypothetical V_{A-O} and V_{C-O} are established by bisecting the angles B-A-C. After and A-C-B. These vectors will be 30° away from the basic potential vectors and establish the unity power factor point for a 3 wire delta system. With a protractor, determine the angle between V_{A-O} and I_A and V_{C-O} and I_C. The cosine of the average of these two angles is the calculated power factor, see FIGURE 12.

3 Ø 4 WIRE DELTA 3 ELEMENT

Connect the phase angle meter as demonstrated in FIGURE 13. In FIGURE 13, the phase angle meter is connected to C phase for simplicity. Measure the potential vectors V_{A-B}, V_{B-C}, and V_{C-O} are established by bisecting the angles. These vectors will be 30° away from the basic potential vectors and establish the unity power factor point for a 4 wire delta system. With a protractor determine the angle between V_{A-O} and I_A, V_{B-O} and, and V_{C-O} I_B and I_C. The cosine of the average of these three angles is the calculated power factor, see FIGURE 16.

3 Ø 4 WIRE Y 3 ELEMENT

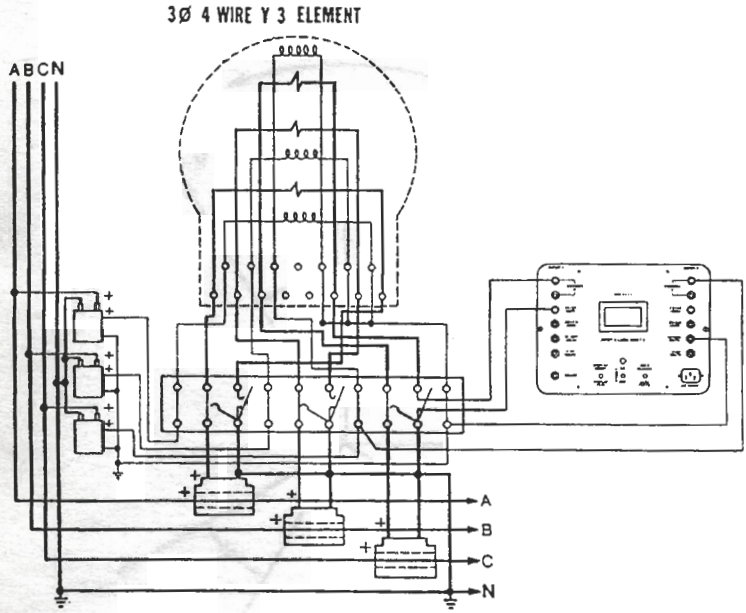


FIGURE 7: Verifying Connections of 3Ø 4 Wire Y 3 Element Meters

3 Ø 4 WIRE Y METER

IA	IB	IC
VA-N 28°	VB-N 30°	VC-N 32°
V-N 268°	VC-N 270°	VA-N 272°
VC-N 148°	VA-N 150°	VB-N 152°

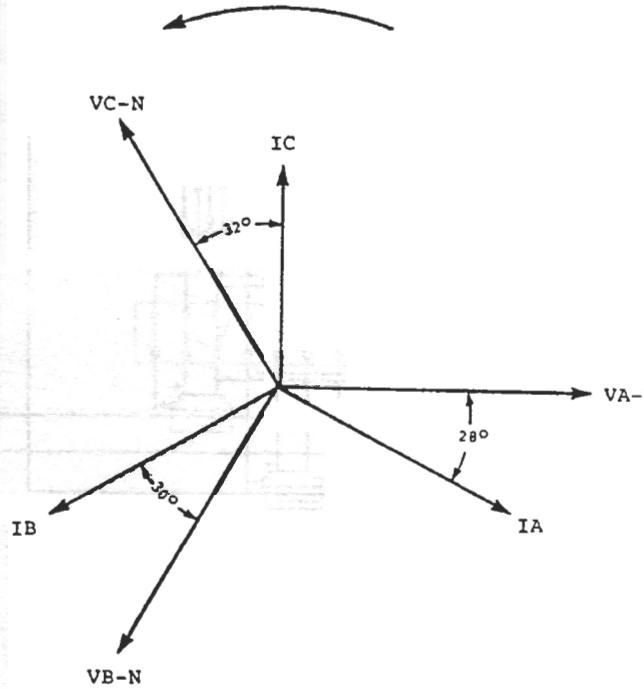


FIGURE 8

3 Ø 3 WIRE 2 ELEMENT

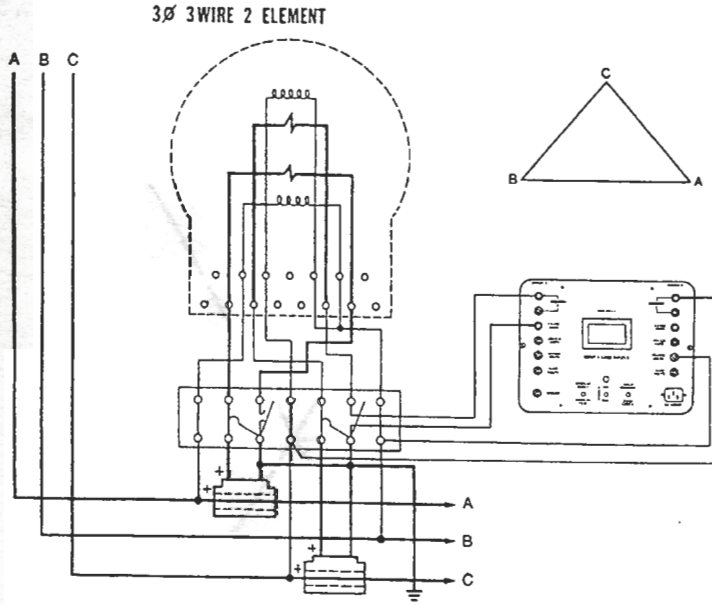


FIGURE 9

3 Ø 3 WIRE METER PHASE ANGLE VECTOR

PHASE ANGLE VECTOR

IA		IC	
VA-B	60°	VA-B	300°
VB-C	300°	VB-C	180°
VC-A	180°	VC-A	60°

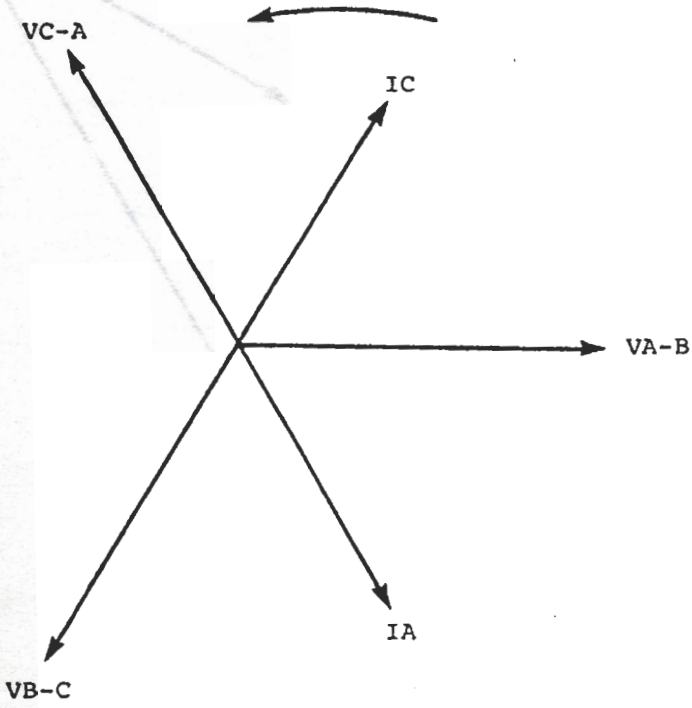


FIGURE 10

Part № 12551
Rev. 1 8/15/91

SYSTEM VECTOR

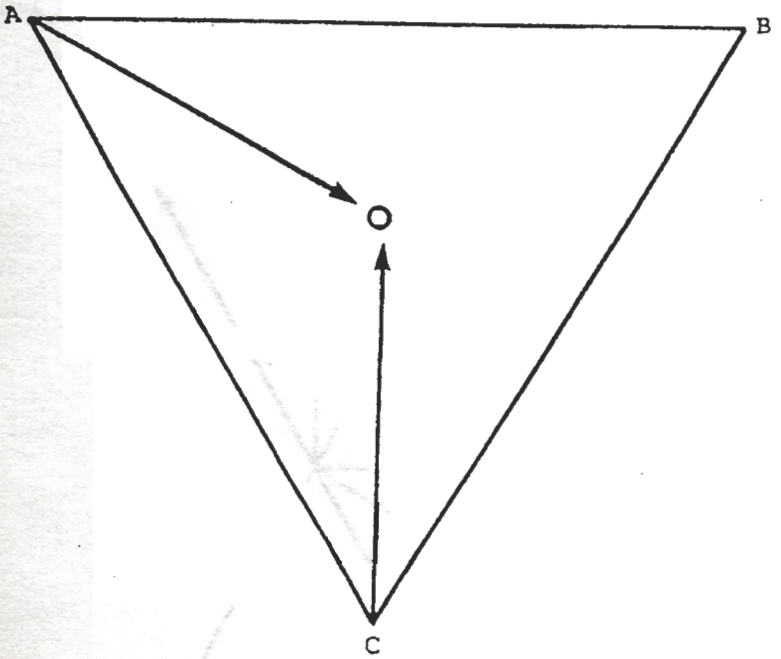


FIGURE 11

3 Ø 3 WIRE METER OVERLAYING SYSTEM VECTOR ON METER

PHASE ANGLE VECTOR

IA		IC	
VA-B	60°	VA-B	300°
VB-C	300°	VB-C	180°
VC-A	180°	VC-A	60°

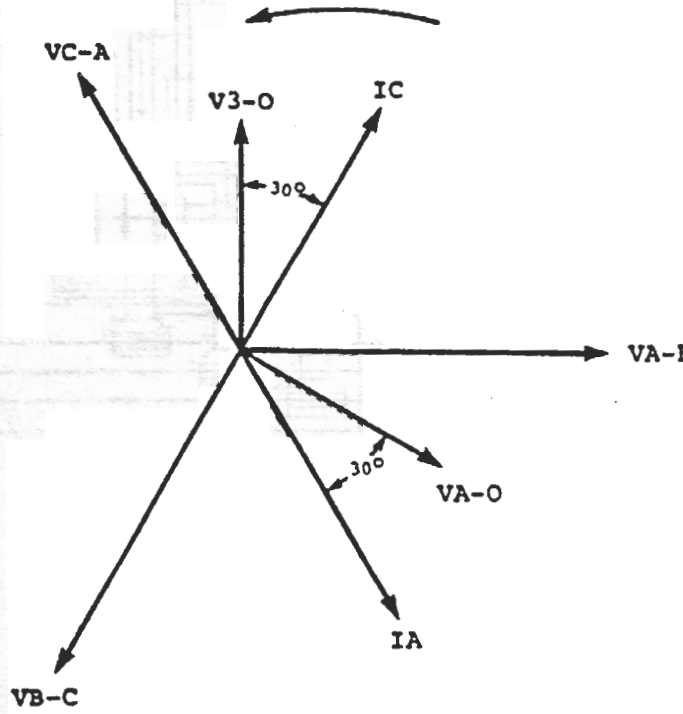


FIGURE 12

Part № 12551
Rev. 1 8/15/91

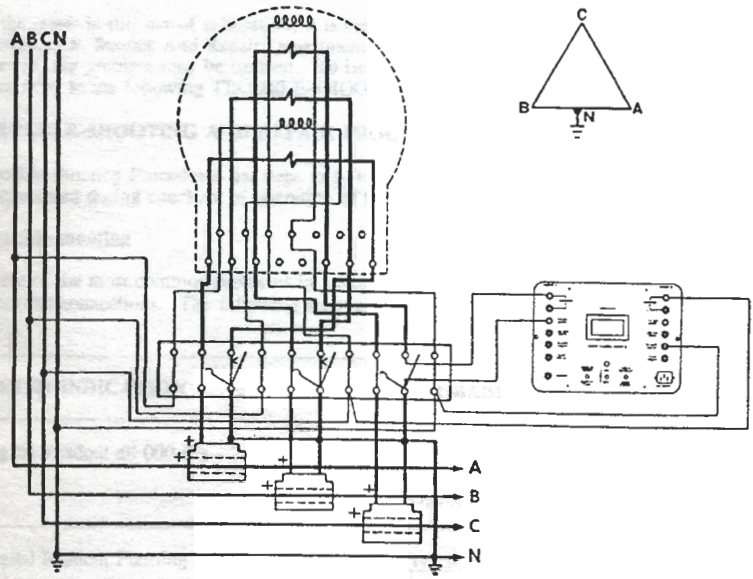


FIGURE 13: Verifying Connections of 3Ø 4 Wire Delta Meters

SERVICE DATA

CALIBRATION CHECK:

It is recommended that the Model PAM-275 be periodically tested to check calibration.

A quick and easy calibration check can be made by following the ZERO CHECK procedures on Page 3. This calibration check will provide an easy and efficient test of the instrument's circuits. If out of calibration, follow the step by step calibration procedures on that page.

If the meter is still out of calibration, it is recommended that the meter be sent to Multi-Amp Corporation, Service And Repair Department for repair and recalibration. However, if desired, the problem may be isolated. To isolate the problem, it is recommended that the user refer to the following TROUBLE-SHOOTING AND REPAIR PROCEDURE.

TROUBLE-SHOOTING AND REPAIR PROCEDURE:

Trouble-shooting Procedures list steps to follow to locate the cause of abnormal conditions encountered during checkout or operation of the Model PAM-275.

Trouble-shooting

Some of the most common problems in making correct phase angle measurements are due to incorrect connections. The following are typical abnormal indications and probable causes.

METER INDICATION	PROBABLE CAUSE
Digital Readout all 000.0's	One or both units are below input range. Go to next lower range. Refer to Page 5, Operation Below Range Limits.
Digital Readout Flashing	WARNING OVERLOAD. One or both inputs are below or above range limits, disconnect inputs and refer to Page 5, Operation Above Limits, or the battery may need recharging.
Phase Angle appears to be 180° above or below expected value.	Polarity of either input is reversed. Reverse leads on one input.

Part № 12551
Rev. 1 8/15/91

Phase Angle appears to be grossly inaccurate	Connections to Input 1 and Input 2 have been reversed causing the lead and lag to be reversed. Reverse inputs, or the battery may need to be recharging.
The Digital Readout does not change	Check the Hold Reading Switch
Digital Readout Dim	Input voltage to the meter too low.
No Digital Readout	Check input fuses. Input voltage may be too low, refer to SELECTION OF POWER SOURCE INPUT, Page 2. Battery may be discharged.

If the problem is not external to the meter, it may be isolated internally by following the recommended repair procedures.

If a spare replacement printed circuit board is stocked, the following repair procedure should be followed:

1. Install a new printed circuit board, Assy PN 10275.
2. Check calibration of unit by following the Zero Check Procedure on Page 3.
3. If unit cannot be recalibrated, it is recommended the unit be returned with defective board to Multi-Amp Corporation, Service and Repair Department for repair and recalibration. See instructions on Page 23. For details.

If a spare replacement printed circuit board is not available, the following equipment will be required to isolate the defect.

1 ea. Millivoltmeter capable of measuring a voltage of 500 mvac rms with accuracy of $\pm$ 1%.

1 ea. D.C. voltmeter capable of measuring from 5-20 volts d.c. with an accuracy of $\pm$ 1%.

1 ea. Oscilloscope for observing waveform.

1 ea. Voltage source, see below.

1 ea. A. C. voltmeter capable of measuring up to 120 volts with an accuracy of $\pm$ 1%.

If the required equipment is not available or trained technical personnel are not available, it is recommended the unit be returned to the factory for repair and recalibration.

Additionally, before starting trouble-shooting repair procedure, it is recommended that if the test technician has not read the instruction manual, that he or she do so before starting repair procedures.

WARNING: Circuits will present a shock hazard during trouble-shooting procedure.

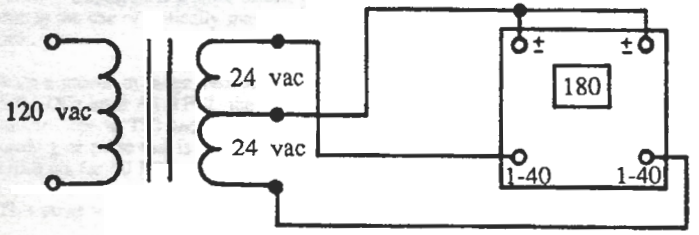
TESTING AC POWER SUPPLY AND ANALOG/LOGIC SECTION

1. Turn POWER ON Switch OFF. Check to insure HOLD READING Switch is in the OFF position. Disconnect the inputs and power line cord from their sources.

2. Remove the instrument from the case by loosening the two mounting screws from the case and lifting the instrument out.

3. Remove the printed circuit board and display assy from the chassis, do not remove the ribbon connector. Display module (assy) must be removed if extension cable is not available.

4. Connect the 1-40 volt terminals of Inputs 1 and 2 in parallel with A.C. voltage source, see below. **CAUTION: DO NOT connect the voltage source to the current terminals.**



180° Phase Shift Circuit

5. Connect the Model PAM-275 to a proper voltage source and switch POWER ON Switch to ON position.

6. Using the d.c. voltmeter, measure the voltage levels of the Power Supply, refer to schematic for pin numbers and proper voltage levels. If proper voltage levels are not present, Power Supply needs to be repaired. If proper voltage levels are present, proceed to next step.

TEST POINTS	MEASURE
TP6 (+) and TP10 (-)	+ 4.75 to + 5.25 VDC.
TP8 (+) and TP10 (-)	+ 14.50 to + 16.50 VDC.
TP9 (-) and TP10 (+)	- 14.50 to - 16.50 VDC.

NOTE: The ± voltages at TP8/TP9 (to TP10) must be within 0.5 VDC of each other.

7. With A-C test signal applied to input terminals, measure sine wave at TP1 and TP10

(ground) for input 2. Measure sine wave at TP2 and TP10 (ground) for input 1. The amplitudes of the sine wave signals should be approximately the amplitudes of the input signal times 0.2. For example, a 24 vac input on input 1 should produce a 4.8 VAC signal at TP2 (ground reference to TP10).

If the input signals are not present or if improper amplitude, check input transformers T1 and T2 for open windings or significant ohmic variance between the same circuits of the two transformers.

If the inputs signal levels at TP1 and TP2 appear normal proceed to the next step.

8. With signal applied as in step 7, check the voltage level at TP12. A voltage of less than + 1.0 VDC will indicate the proper signal range applied to the input. If this condition exists, proceed to the next step.

If the D.C. voltage level at TP12 is between + 1.0 and 5.2 VDC with in range signal applied to the input, there may be a filter or level detector circuit problem, (note the flashing display). If a filter circuit problem exists, field repair is not recommended due to the use of critically matched components selected during manufacture of the unit.

9. With a proper in range 180° signal applied as in step 7 and near ground (less than + 1.0 VDC) level AT TP12, the next check should be made at TP3. Connect the oscilloscope to TP3 and adjust for + 5VDC and 10 ms/div. the signal at TP3 is a count gate pulse that is positive going and will be approximately 8.3 ms for 60 HZ. (10.0 ms for 50 HZ).

This pulse will reoccur approximately every $^1/_2$ second.

If the pulse is present with correct logic level and pulse width, proceed to next step. If not, check circuitry associated with U15-U18 for normal integrated circuit operation as defined in IC manufacturer's data sheets.

10. The number displayed is a clock count recorded during the count gate pulse period described in step 9.

This clock is generated by a phase locked loop circuit synchronized with the input signal applied to input #2. The actual frequency measured at TP4 with a frequency counter will be 216 KHZ for 60 HZ, (180 KHZ for 50 HZ).

The period of the oscillation at TP4 if measured with an oscilloscope will be 4.63 us for 60 Hz, (5.56 us for 50 Hz). With the oscilloscope connected to TP15, one can observe the gated count as applied to the counter/display module.

If the count signal is correct at TP4 and TP15, proceed to step 11. If not, check the components associated to integrated circuits U11-14, U20 for proper operation.

11. The display options (LED or LCD) incorporate integrated circuitry not easily repaired in the field. If a display problem exits, check the ribbon cable for open circuits and the display for damaged components.

12. Switch OFF and disconnect voltage source from inputs 1 and 2.

TESTING BATTERY CHARGER

1. The battery charger is automatic in operation and depends upon the internal resistance of the battery to regulate the amount of charge required.

   NOTE: Beware of acid leakage from cracked or damaged battery. Replace cracked or damaged battery.

2. With A-C power cord connected and power switch OFF, measure terminal voltage of battery. Connect DC voltmeter (-) TP10 and (+) CATHODE OF D14. Terminal voltage of a **charged** battery should be between 5.25V and **6.3V.**

3. Switch power ON and battery charger should provide approximately 6.3 - 6.5V to the battery.

4. Under A-C power, the battery is disconnected from the system and is connected only to the charger. The charge current ranges from 10 MA to 200 MA, depending upon the condition of the battery.

   NOTES: The battery is classified as a sealed 6 volt 4 amp/hour gel lead acid type. The recommended maximum discharge rate is 400 MA/hr. for 10 hours. The recommended charge rate is less than 200 MA for 20 hours (for a completely discharged battery). The typical float charge for a fully charged battery is about 5 - 10 MA.

   Whenever the A-C power is connected to the PAM-275, the battery charger is enabled. Regulator IC VR1 is set to supply the battery with the proper amount of current required to recharge the battery. However, the time required to actually recharge a battery depends on recharge limit.

   Regulator IC VR1 has an internal thermal cutout protection feature and cannot recharge a fully discharged battery at high ambient temperatures (over 130°).

   The temperature of regulator IC VR1 is a good indication of the battery charger operation (with A-C power cord installed). A warm or hot heat sink indicates a large recharge current. A cool heat sink usually indicates a small amount of charge current.

SERVICE AND REPAIR ORDER INSTRUCTIONS:

If factory service is required or desired, contact the factory for return instructions.

A Service & Repair Order (SRO) number will be assigned for proper handling of the unit when it arrives at the factory.

If desired, a letter with the number and instructions can be provided.

Provide the factory with model number, serial number, nature of the problem or service desired, return address, your name, and where you can be reached should the factory need to contact you.

A purchase order number, cost limit, billing, and return shipping instructions may also be provided if desired.

National Bureau of Standards traceable calibration and certification of two types is available, if desired, at additional cost.

Class One: A certificate is provided verifying the traceability and calibration of the equipment.

Class N: That which is required for nuclear power plants. A certificate of traceability and calibration along with "as found" and "as left" data are provided.

If an estimate is requested, provide the name and contact information of the person with approval/disapproval authority.

Pack the equipment appropriately to prevent damage during shipment. If a reusable crate or container is used, the unit will be returned in it if in suitable condition.

Put the SRO number on the address label of the shipping container for proper identification and faster handling.

NOTE: Ship the equipment *without* instruction manuals or nonessential items such as test leads, spare fuses, etc. These items are not needed to conduct repairs. *Do* ship the equipment with *all* interconnect cables, etc. which make the unit operational.

PREPARATION FOR RESHIPMENT

Save the shipping container that your unit came in. The shipping container your unit came in is designed to withstand the normal bumps and shocks of shipping via common commercial carrier. For example, you may wish to reship your unit to Multi-Amp for annual calibration certification.

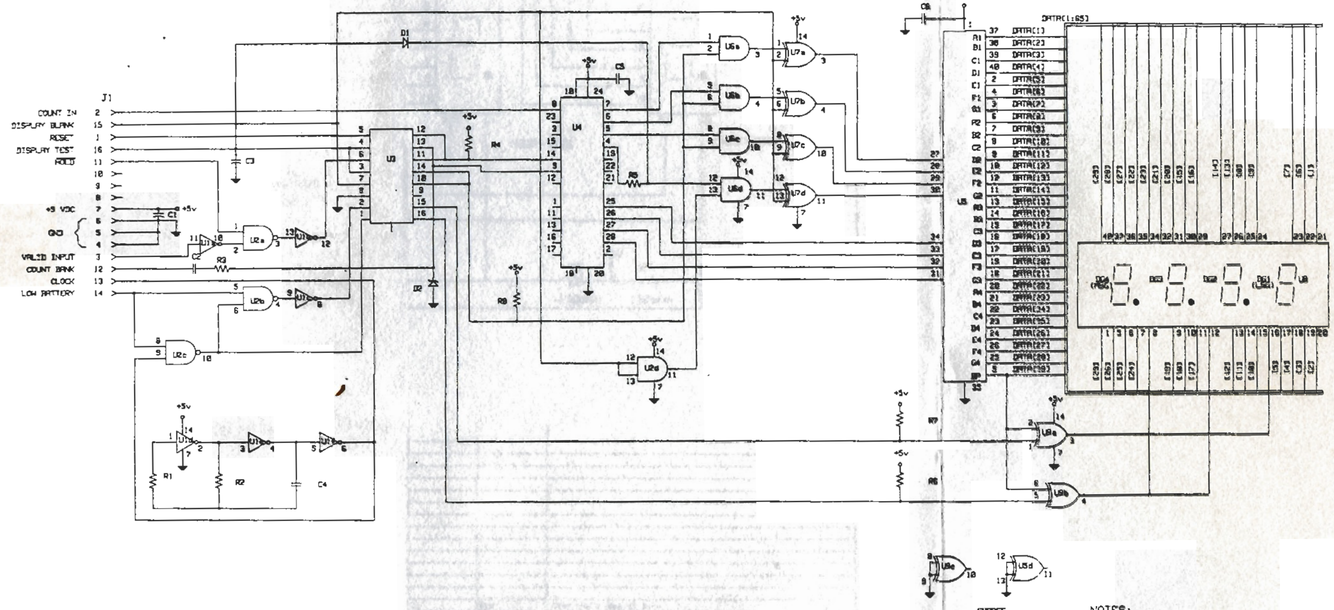
WARRANTY STATEMENT

Multi-Amp Corporation warrants to the original purchaser that the product is free from defects in material and workmanship for a period of one (1) year from date of shipment. This warranty is limited and shall not apply to equipment which has damage, or cause of defect, due to accident, negligence, unauthorized modifications, improper operation, faulty installation by purchaser, or improper service or repair by any person, company or corporation not authorized by the Multi-Amp Corporation.

Multi-Amp Corporation will, at its' option, either repair or replace those parts and/or materials that it deems to be defective. Any costs incurred by the purchaser for the repair or replacement of such parts and/or materials shall be the sole responsibility of the original purchaser.

THE ABOVE WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EITHER EXPRESSED OR IMPLIED ON THE PART OF THE MULTI-AMP CORPORATION, AND IN NO EVENT SHALL THE MULTI-AMP CORPORATION BE LIABLE FOR THE CONSEQUENTIAL DAMAGES DUE TO THE BREACH THEREOF.

DWG. NO. 21658D			
REVISIONS			
REV	ECN	DATE	REMARKS
1	18649	1/86	



NOTES:

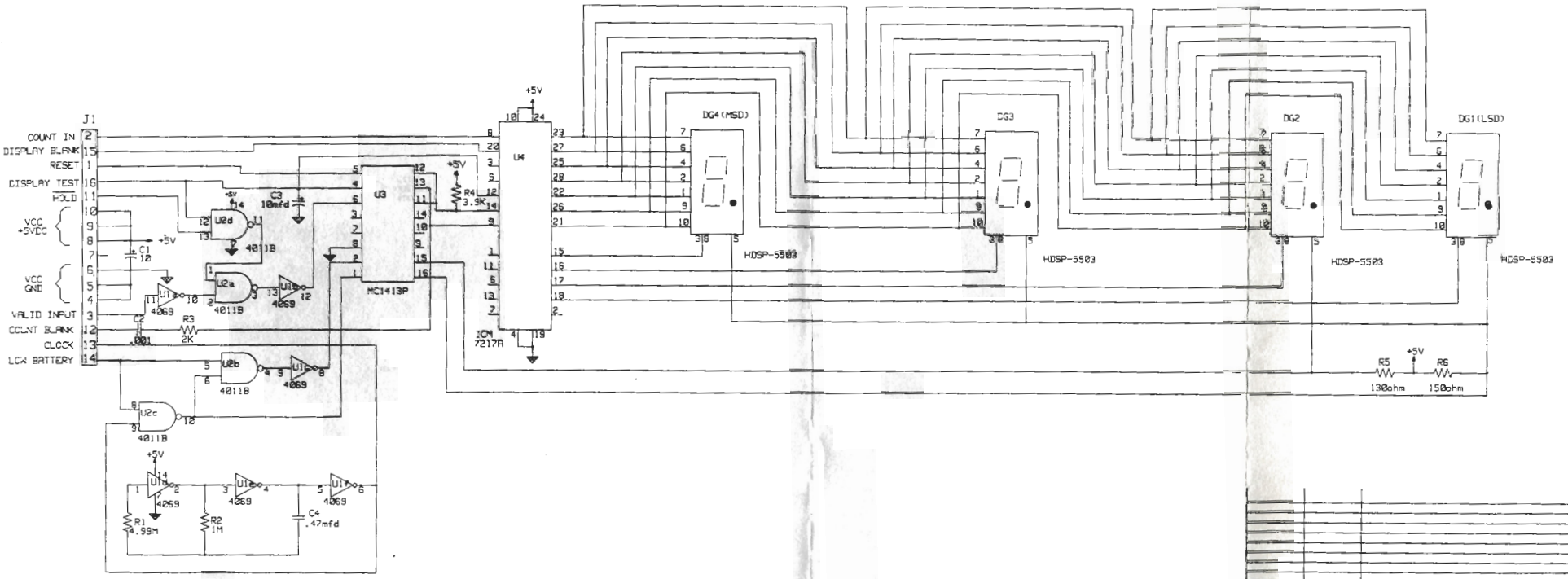
1. REF.: PCBD P/N - 21657CP
PCBD ASSY - 21658D
B/M - 21658MM

REF. DES.	PART NO.	DESCRIPTION	QTY.
U8	10389	DISPLAY LCD PAM275B	1
U3	8069	IC MC1413 TRANS ARRAY DARL	1
U4	8284	IC CMOS ICM7217IJI	1
U1	5351	IC CMOS 4069 HEX INVERT	1
U5	5342	IC CMOS 7211 4DIG DRIVER LCD	1
U6	5336	IC CMOS 4081B QUAD 2 IN AND	1
U7,9	5333	IC CMOS 4070B QUAD EXC OR	2
U2	4971	IC CMOS 4011 QUAD 2 IN NAND	1
D2	7984	DIODE Z 4.7V 0.5W 1N750A	1
D1	3997	DIODE 1N4448	1
C5,6	3602	CAP MFD 0.01 50V CERAMIC	2
C2	8323	CAP MFD 0.001 10% 200V POLY	1
C4	71057	CAP MFD 0.47 10% 20V POLY	1
C1,3	5358	CAP MFD 10.0 20% 20V TANT	2
R1	9183	RES M 4.99 1% 1/4W	1
R4-R8	7961	RES K 3.9 5% 1/4W	5
R2	3920	RES M 1.0 1% 1/4W	1
R3	3480	RES K 2 1% 1/4 W	1
J1	5377	CONN MOLEX 4094/16P M	1

TOLERANCES UNLESS NOTED
3 PLACE DEC. ± .005
2 PLACE DEC. ± .02
FRACTIONS ± 1/32
HOLES THRU 1/2" DIA. +.004 -.000
ANGLES ±0°30'

multi-amp
Electrical Sciences, Inc.
4271 Bronze Way
Dallas, Texas 75237 U.S.A.
Telephone (214) 333-3201
TWX 910-861-9052

DWN. RJ PARRISH	APPD. [signature]	SCALE NONE	
CHKD.	DATE 4/2/86	SH. 1 OF 1	
TITLE SCHEM. LCD DISPLAY PAM 275			
PART NO. 10392	DWG. NO. 21658D		REV 1



NOTE:

1. REFERENCE ASS'Y DRAWING 19981C
   REFERENCE ASS'Y BILL OF MATERIAL 19982BM

DWG. NO.	19968D		
REVISIONS			
REV	ECN	DATE	REMARKS
1	17283	2/14/85	
2	17468	5/17/85	REDRAWN
3	17558	6/26/85	SEE ECN
4	18148	8/12/85	SEE ECN

ITEM	PART NO.	DESCRIPTION	QTY.
J1	9329	CONN MOLEX 4804/16 PIN	1
DS1-4	9818	DISPLAY HDSP-5503 COMMON CATHODE	4
U1	9951	IC 4011B DUAL NAND	1
U2	9871	IC 4011B QUAD 2-IN NAND	1
U3	8868	IC MC1413P HIGH VOLTAGE ARRAY	1
U4	8798	IC ICM 7217B	1
R6	3436	RES 150 OHM 1% 1/4 W	1
R5	5574	RES 130 OHM 1% 1/4 W	1
R4	7961	RES 3.9K OHM 5% 1/4 W	1
R3	3488	RES 2K OHM 1% 1/4 W	1
R2	3528	RES 1M OHM 1% 1/4 W	1
R1	5183	RES 4.99M OHM 1% 1/4 W	1
C1,C3	5358	CAP 10MFD 20V TANT	2
C2	8323	CAP .001MFD 28V POLY	1
C4	21857	CAP .47mfd 28V POLY	1

TOLERANCES UNLESS NOTED
2 PLACE DEC. ± .005
3 PLACE DEC. ± .002
FRACTIONS ± 1/32
HOLES THRU 1/2" DIA. +.004 -.000
ANGLES ±0° 30'

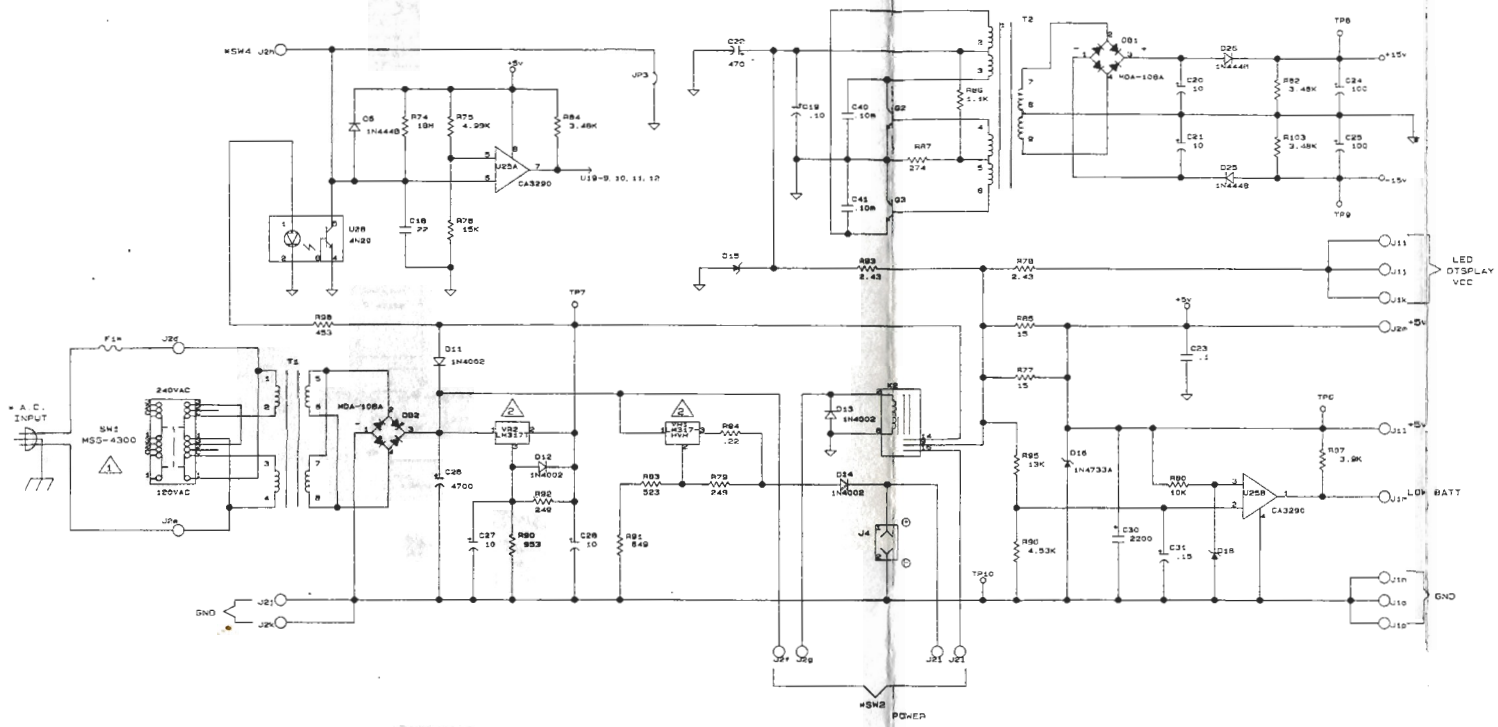
MULTI-AMP

Electrical Sciences, Inc. (214) 323-3281
4271 BRIDGE WAY DALLAS, TEXAS 75237

DWN. R.J. Parrish
CHKD.
APPD.
DATE 8/11/85
SCALE NONE
SH. 1 OF 1

TITLE SCHEMATIC-LED DISPLAY /COUNTER
ASS'Y-PRM275

PART NO.	DWG. NO.	REV
9927	19968D	4



Notes

REF. 205798M
205620 ASY. DWG

* REFERENCE TO COMPONENTS NOT MOUNTED ON PCB

1. SW1 SWITCH POSITION MUST BE SELECTED PRIOR TO APPLICATION OF A.C. POWER SWITCH POSITION #2 IS "OFF" SHOWN IN "120V" POSITION.
2. HEAT SINK REQUIRED.
3. INSTALL JUMPER JP3 TO DEFEAT DISPLAY TIMER.

9	20704	02/88
9	22936	09/90
10	24638	08/92
12		05/94

DWG. NO. 20470D

REVISIONS

REV.	ECN	DATE
1	14621	01/84
2	15064	03/84
3	15566	09/84
4	XXXXX	02/85
5	17510	06/85
6	18842	02/86
7	20704	11/87

AVO MULTI-AMP CORPORATION
(214) 333-3201
4271 BRONZE WAY DALLAS, TEXAS 75237

ENGR. APPD. DATE

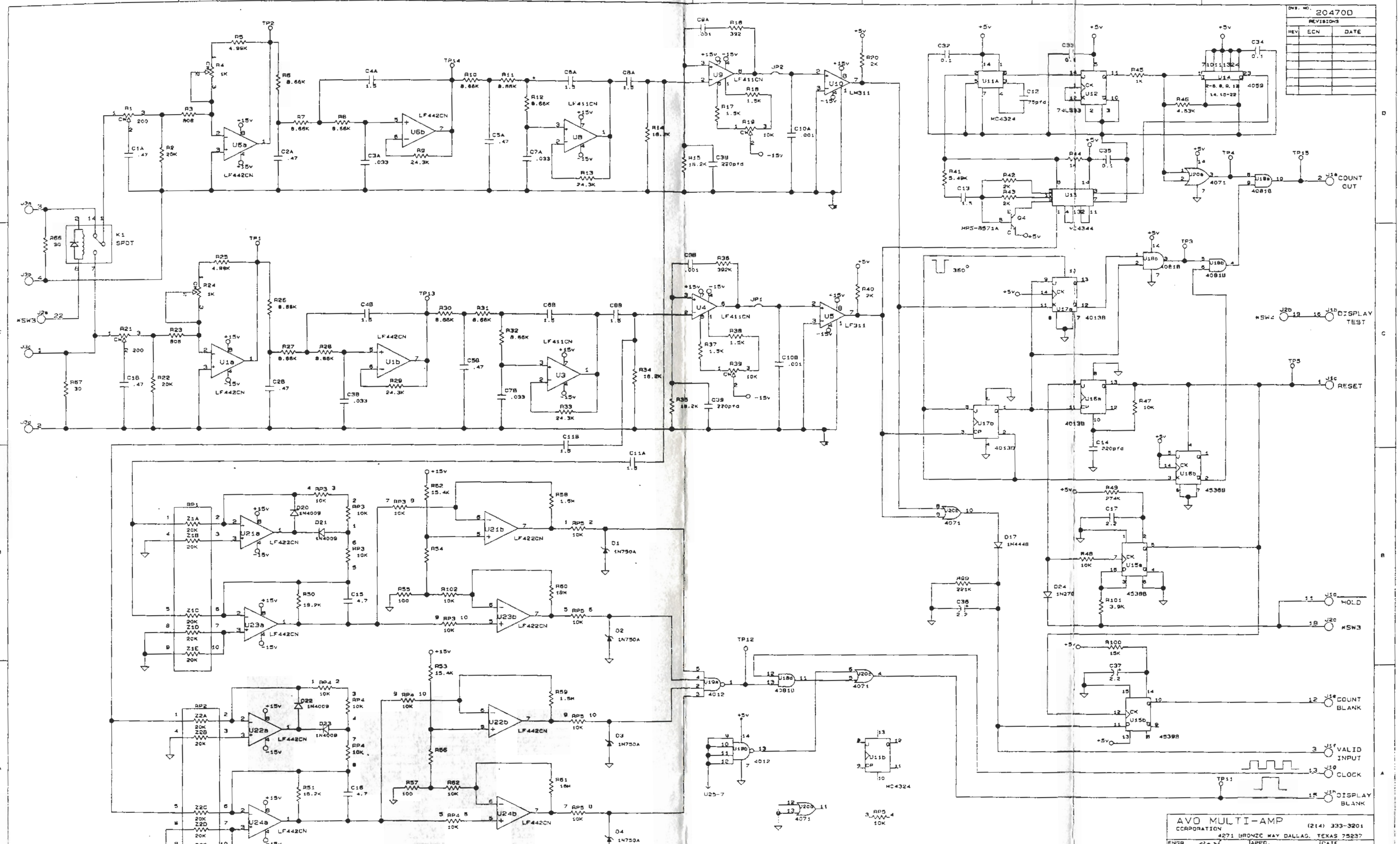
TITLE SCHEMATIC - PAM 275

SHEET 1 OF 2

PART NO. 10275

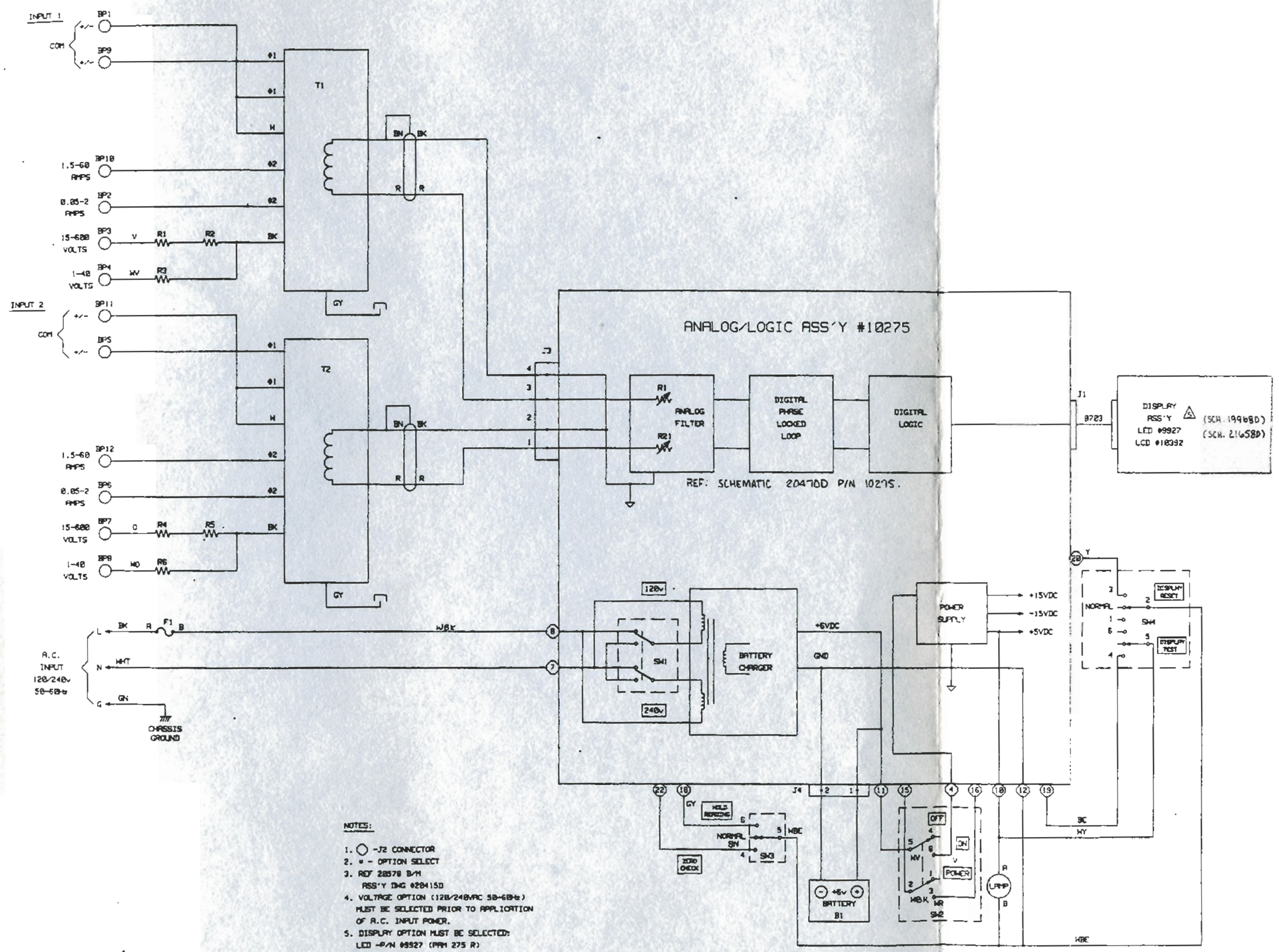
DWG. NO. 20470D

REV. 13



AVO MULTI-AMP CORPORATION
(214) 333-3201
4271 BRONZE WAY DALLAS, TEXAS 75237

ENGR.	APPD.	DATE
TITLE SCHEMATIC - PAM 275		SHEET 2 OF 2
PART NO. 10275	DWG. NO. 204700	REV. 13



NOTES:

1. ◯ -J2 CONNECTOR
2. * - OPTION SELECT
3. REF 20578 B/M ASS'Y DWG #20415D
4. VOLTAGE OPTION (120/240VAC 50-60Hz) MUST BE SELECTED PRIOR TO APPLICATION OF A.C. INPUT POWER.
5. DISPLAY OPTION MUST BE SELECTED: LED -P/N #9927 (PAM 275 R) LCD -P/N #10392 (PAM 275 B)

DWG. NO. 21269D		
REVISIONS		
REV	ECN	DATE
1	17636	7/11/85
2		REDRAW
3	15828	9/13/94

ITEM	PART NO.	DESCRIPTION	QTY.
	8703	CABLE ASS'Y, 16 CONDUCTOR RIBBON	1
SW3	8864	SWITCH DPDT ON/OFF/(ON)	1
SW4	8862	SWITCH DPDT (ON)/OFF/(ON)	1
SW2	8863	SWITCH DPDT ON/NONE/ON	1
B1	10357	BATTERY, 6VDC 4.0 A/HR.	1
LAMP	5356	LED ASSY-RED 5V	1
REF	10275	ANALOG/LOGIC PCBD ASSY	1
R1,R2,R4,R5	71011	RES. 34k OHM 1% 5W	4
R3,R6	3088	RES. 2.5k OHM 1% 3W	2
* REF	10392	DISPLAY ASS'Y, LCD	1
* REF	9927	DISPLAY ASS'Y, LED	1
T1,T2	8684	TRANSF INPUT	2
F1	7443	FUSE, 0.125A 250V MDL	1

TOLERANCES UNLESS NOTED
DECIMAL ±.010
FRACTIONS ±1/32
HOLES THRU 1/2" DIA
ANGLES ±0° 30'

multi-amp CORPORATION
4271 BRONZE WAY DALLAS, TEXAS 75237 (214) 333-3201

DWN. TP | APPD. | SCALE NONE
CHKD. | DATE | SH. 1 OF 1

TITLE: SCHEMATIC PAM 275 R/B

PART NO. PAM 275 R/B | DWG. NO. 21269D | REV 3