1998

PROGRAMMABLE

WATT-HOUR CALIBRATOR

Model 4700

Serial NOS:__________ __________

4701 4702

W A R R A N T Y

The ELECTRONIC DEVELOPMENT CORPORATION (E.D.C.) warrants to the original purchaser each instrument manufactured by them to be free from defects in material and workmanship. This warranty is limited to servicing, repairing and/or replacing any instrument or part thereof returned to the E.D.C. factory for that purpose in accordance with the instructions set forth below; and furthermore to repair or replace all materials, except tubes, fuses, transistors and other semiconductor devices which shall within one year of shipment to the original purchaser be returned to the E.D.C. factory and upon examination be deemed defective.

E.D.C. instruments may not be returned to the factory under the terms of this warranty without the prior authorization of the E.D.C. Service Department. All instruments returned to E.D.C. for service hereunder should be carefully packed and shipped. All transportation charges shall be paid by the purchaser.

EDC reserves the right to discontinue instruments without notice and to make changes to any instrument at any time without incurring any obligation to so modify instruments previously sold.

This warranty is expressly in lieu of all other obligations or liabilities on the part of EDC. No other person or persons is authorized to assume in the behalf of EDC any liability in the connection with the sale of its instruments.

> CAUTION: The instrument you have purchased is a precision instrument manufactured under exacting standards. Any attempts to repair, modify or otherwise tamper with the instrument by anyone other than an EDC employee or authorized representative may result in this warranty becoming void.

FACTORY SERVICE REQUEST
AND
AUTHORIZATION

WARRANTY SERVICE

Instruments may be returned only on prior authorization. Please obtain a RETURN AUTHORIZATION NUMBER either directly from the factory or from an authorized E.D.C. Representative. (See General Information below.)

CHARGEABLE REPAIRS

If requested, an estimate of charges will be submitted prior to repairs. We suggest that you request a RETURN AUTHORIZATION NUMBER to facilitate handling.

GENERAL INFORMATION

A) Please provide the following information in order to expedite the repair:

1) Indicate MODEL

2) Serial Number

3 Complete description of the trouble:

Symptoms, measurements taken, equipment used, lash-up procedures, attempted repairs, suspected location of failure and any other pertinent information.

B) Freight Charges must be PREPAID.

C) The RETURN AUTHORIZATION NUMBER should be noted on your documentation.

PACKING SUGGESTION

Although your E.D.C. instrument is built for laboratory, production environment and some field environment, it is NOT ruggedized. Therefore...

1. Be sure the carton is STRONG enough to carry the weight of the instrument, e.g. use double wall corrugation.

2. Be sure the carton is LARGE enough to allow for sufficient packing material, e.g., at least 2 inches all around the instrument. The packing material should be able to be compressed and then return to its approximate original volume.

3. For better handling, the shipment should always be by AIR FREIGHT (expect for short distances). You might use either UPS "blue label" or common air freight carrier, second day air.

   Please do not bounce it across the country in a truck. It may not hurt it, but it certainly is not going to do a laboratory instrument much good.

4. QUESTIONS? Just contact us. We will be pleased to help you.

1.0.0 DESCRIPTION AND SPECIFICATIONS

1.1.0 General Description

1.1.1 The EDC Model 4701A is a controller and voltage source which is used in conjunction with the E.D.C. Model 4702A current source.

1.1.2 The resultant two unit system forms a wattmeter or watt-hour meter calibrator with independent control of frequency, voltage amplitude, current amplitude and phase angle.

1.1.3 The system may be controlled manually with the 4701A front panel controls or via the IEEE-488 bus.

1.1.4 The 4701A accepts an optical pickup input for timing of a preset number of meter disk revolutions, or a TTL pulse input from an electronic watt-hour meter.

1.1.5 The system has a specified accuracy and is traceable cells to the National Institute of Standards and Technology.

1.1.6 The system is overload and short-circuit proof.

1.2.0 Output Specifications

1.2.1 FREQUENCY:

Setability:	50, 60 or 400 Hz
Accuracy:	±0.001%

1.2.2 VOLTAGE: (4701A)

Setability:	10x, 11x, 12x, 20x, 21x, 22x, 23x, 24x, 25x, 26x, 27x, or 48x volts. (Where x is an integer ranging from 0 to 10.)
Accuracy:	±0.05% of setting ± 01% of Full Scale. (Full Scale = 480V)
Power Output:	20 Watts minimum at any setting.

1.2.3 CURRENT: (4702A)

Setability: 100, 50, 30, 15, 10, 5, or 2.5 Amps or 10% of the above currents, or 0 current for the "Creep" test.

Accuracy: ±0.05% of setting ±.01% of full scale (Full scale = 100 A for 100% setting and (Full scale = 10 A for 10% setting).

Compliance Voltage:

10A Range - 5.0 VAC rms.

100A Range - 0.5 VAC rms.

Power Output: 50 Watts at full scale output. At other settings it is proportional to percentage of full scale, e.g. the power output at 50A on the 100A range is 25W.

1.2.4 PHASE ANGLE:

Setability: ±69° in 1° increments

Accuracy: ±.05°

1.2.5 Distortion: 0.5%

1.2.6 Load Regulation: 0.005%

1.2.7 Line Regulation: 0.0025%

1.3.0 General Specification

1.3.1 Power: Switch Selectable
115 or 230 V ±10% 50-60 Hz

		4701A	4702A
1.3.2	Power Consumption:	120 W	200 W
1.3.3	Net Weight:	20 lbs; 9.1 kg	42 lbs; 19.1 kg
1.3.4	Shipping Weight:	25 lbs; 11.3 kg	50 lbs; 22.7 kg
1.3.5	Dimensions:	19"w x 3½"h x 22½d 482 x 89 x 571.5mm	19"w x 7"h x 13.75"d 482 x 177 x 349mm

1.3.6 Temperature:
Calibration 23° ±1°C
Ambient 20° to 30°C
Operating Limit 10° to 50°
Storage -40° to 85°C

SECTION II

2.0.0 INSTALLATION

2.1.0 Mounting

The system is designed for mounting in a standard 19" rack. It is recommended that nylon washers be placed under the rack mounting screws to prevent scratching the mounting ears.

When rack mounting is required, use a rack support for each instrument. When the 4701A, watt-hour meter and current source are set one above the other, place the current source above the watt-hour meter for better ventilation.

2.2.0 Mating Connectors Normally Supplied With System

	Description	Qty	EDC Part No.
2.2.1	AC Power Cord	2	17251/CB117
2.2.2	Male 25 Pin "D" Interconnecting Cable	1	BMM6R/CB-122
2.2.3	100 Amp Male Connectors Red	1	PP250GR/CT216
	Mfr: Superior Electric Co. Blk	1	PP250GB/CT217
2.2.4	Voltage Output Connector	1	MS-3106A-14S-6P /CT124
2.2.5	Cable Clamp for Above	1	97-3057-6/CT122
2.2.6	Optical Pickup Cable Mount Socket MFR: Switchcraft	1	TA5FL/OD143

2.3.0 IEEE-488 BUS (GPIB) Cables

A one or two meter IEEE Std. 488 cable may be obtained from EDC. It is EDC part number 3045-1 or 3045-2.

2.4.0 110/230 Line

2.4.1 A 110/230 line switch is located on the rear panel of each instrument, 4701 and 4702. Set the switch to the position correct for the line voltage the system will be connected to.

SECTION III

3.Ø.Ø SYSTEM OPERATION

3.1.Ø System Interconnections

The system is connected to the watt-hour meter under test as shown in FIG. 3.1.Ø.

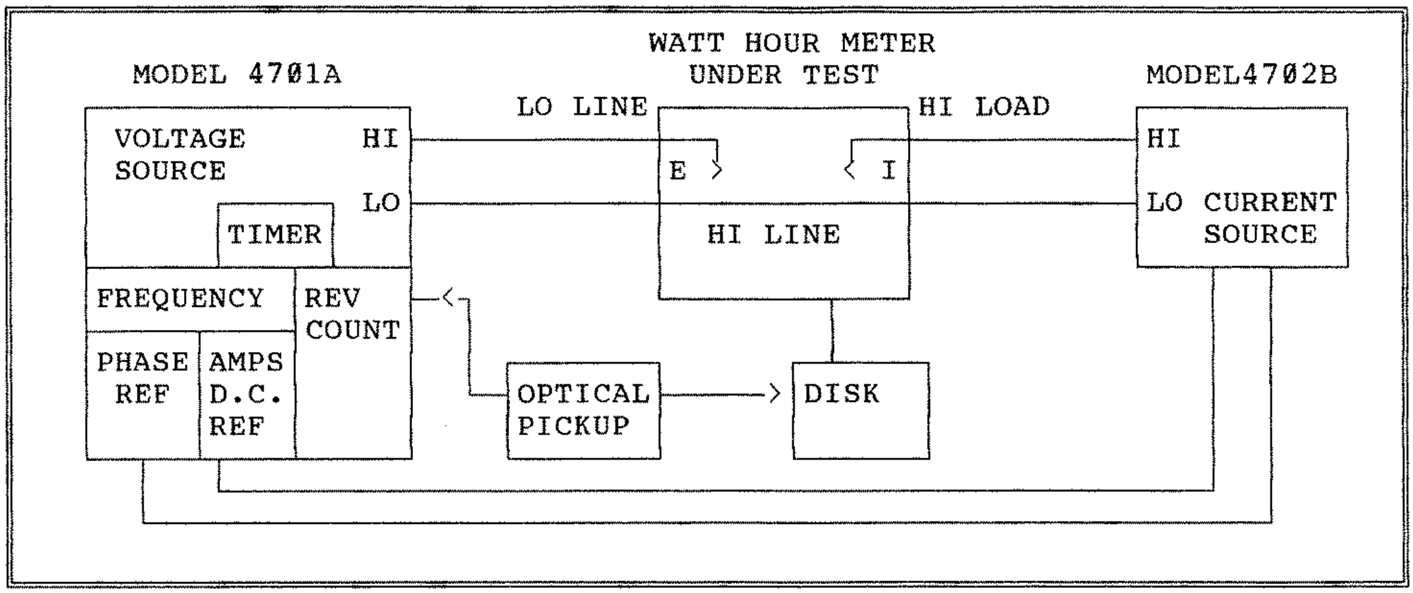


FIG 3.1.Ø

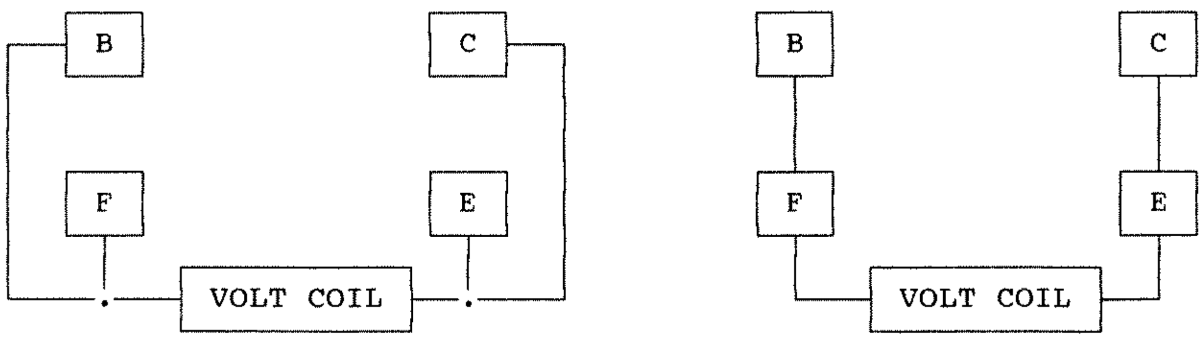
3.1.1. 4701A Voltage Output Connector

The connector pinout is:

A - Chassis Ground
B - HI Out
F - HI Sense
C - Lo Out
E - Lo Sense

If the voltage input of the watt-hour meter under test is high impedance, short pin B to pin F and short pin C to pin E. If the voltage input to the watt-hour meter under test draws appreciable current the remote sense capability should be used.

ONE OF THE CONFIGURATIONS SHOWN BELOW MUST BE USED.



A (FOUR WIRE BETWEEN 4701A AND LOAD) CORRECT FOR LARGE LOADS

FIG 3.1.1

B (TWO WIRE BETWEEN 4701A AND LOAD) CORRECT FOR SMALL LOADS INCORRECT FOR LARGE LOADS

NOTICE

THE SENSING CIRCUIT MUST BE COMPLETE. PLEASE REFER TO DRAWING 930727 IN THE REAR OF THIS MANUAL.

3.1.2 4702A Current Output Connections

3.1.2.1 High Current Connections

For 100% Amps settings, the large output terminals must be used. No. 1/0 AWG wire is suitable. The flexible welding cable is convenient for many applications.

3.1.2.2 Lo Current Connections

For 10% Amps settings, the small output terminals must be used. No. 18 AWG wire or larger is suitable for the lower currents.

CAUTION:
ONLY ONE SET OF OUTPUT TERMINALS MAY BE USED AT ONE TIME.

3.1.3 4701A to 4702A Interconnection

Interconnect the two units with the 25 pin male "D" cable provided with the system.

3.1.4 4701A Optical Trigger Input

A contact closure, a TTL level or an optically derived level may be used as a trigger. The system triggers on a high to low transition of the input. The mating cable mount socket is a Switchcraft No. TA5FL.

The pinout is shown below.

OPTICAL TRIGGER INPUT CONNECTOR (TA5FL) PINOUT

PIN 1 - INPUT
PIN 2 - +5 V
PIN 4 - DIGITAL GROUND

3.2.0 Front Panel Controls and Annunciators

All of the system front panel controls and annunciators are located on the 4701A except the 4702A power switch.

3.2.1 Power Switches

Rocker with indicator - one on each unit.

3.2.2 Reset - Run - Remote Switch

The RESET and RUN positions are local modes where the system is programmable by the other front panel controls. In the REMOTE position the system is programmable via the IEEE-488 Bus. In the remote mode the annunciator and indicators display the programmed values. The RESET positions resets the timer to zero. The next high to low transition on the trigger input will start the counter.

3.2.3 Disk Revolutions Switch

Settable from 1-12 with indicator. The third trigger input will start the counter counting real time in increments of 10 ms. After "N" disk revolutions the counter will stop.

3.2.4 Standby Switch

In the standby mode the voltage and current outputs are shut off.

3.2.5 Volts Switches

The coarse switch selects the first two digits of 10x, 11x, 12x, 20x, 21x, 22x, 23x, 24x, 25x, 26x, 27x or 48x volts. The FINE switch selects x which is an integer ranging from 0 to 10. A 3 digit indicator displays the voltage.

3.2.6 Amps Switches

The SET switch selects 0.0, 2.5, 5, 10, 15, 30, 50 or 100 Amps. The % switch selects either 10% or 100% of the above values. A 3 digit indicator displays the amperage.

3.2.7 Phase Switches

The first two switches select a phase angle between 0° and 69°. The third switch determines whether the current lags or leads the voltage. A two digit indicator and a LEAD-LAG annunciator displays the selected settings.

3.2.8 Frequency Switch

The frequency may be set at 50, 60 or 400 Hz. An annunciator displays the selected frequency.

3.2.9 Mode Annunciator

An annunciator above the STANDBY switch displays SEC (seconds), and the mode, LOC (local), REM (remote), LLO (local lock out).

3.3.0 Remote Programming Via the IEEE-488 Bus (GPIB)

3.3.1 Introduction: The EDC model 4701A is compatible with the IEEE Std. 488/1978. The applicable reference publication is: IEEE Standard Digital Interface for Programmable Instrumentation (IEEE Std. 488/1978).

Publisher: The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street
New York, NY 10017

The <GP-IB> makes it possible for a user to connect various instruments and components together into a functional system. However, this system will not work without the proper software.

The operating system software offers a set of functions and commands which the user can assemble into a written program. Once written, the user's application program, in conjunction with the operation system software, will allow the various instruments on the <GP-IB> to generate signals, take measurements, and allow the instrument controller to manage the resulting information.

All commands sent over the <GP-IB> must be expressed in the controller's own language such as BASIC, FORTRAN, etc.

There are three steps that MUST be taken when using the <GP-IB> to make the system operate. The user MUST:

a. Understand what tasks must be performed.
b. Use the controller's language.
c. Know what kind of information the instruments are capable of exchanging.
d. READ THE CONTROLLER PROGRAMMING MANUAL THOROUGHLY!!!

3.3.2 The interface capabilities of the 4701A are SH1, AH1, T6, L4, SR1, RLØ, PP2, DCØ, DTØ, E1, (See para. 3.3.19 for PP2 exception.)

3.3.3 Interface Messages: The EDC 4701A will respond to the following interface messages:

"MLA". - My Listen Address. Upon receipt of this message, the instrument will enter its listener active state and be ready to accept a string of data bytes. ATN must be true.

"UNL". Unlisten. Upon receipt of this message, the instrument will enter its listener idle state and will not listen to any subsequent data byte strings. ATN must be true.

"IFC". Interface Clear. Upon receipt of this command the instrument will enter its listener idle state.

"Power-On" Clear. On "Power-On", and remote mode, the instrument will be in the listener idle state and its analog output will be Ø.

The instrument will also go to its listener idle state when in the local mode.

3.3.4 There are several groups of commands which the 47Ø1A will act upon, when received over the bus.

A. Normal messages to program the unit's output to a specified voltage and current.

B. Normal messages to program the unit's output to a specified frequency and phase angle.

C. Messages requesting specific responses on the condition of the 47Ø1.

D. Serial Poll in response to a SRQ.

E. Parallel Poll to indicate device status.

F. Interface Clear (IFC)

3.3.5 Setting the Instrument's Address: The EDC 4701A bus address is set with a "dip switch" located on the MPU board.

NOTE: THE BUS ADDRESS IS DISPLAYED UPON GOING FROM REMOTE TO LOCAL, AND THE DISPLAYED ADDRESS IS THE DEVICE NUMBER THE MODEL 4701A WILL RESPOND TO. HOWEVER, IF THE ADDRESS SWITCH IS CHANGED WHILE IN THE REMOTE MODE, THE DISPLAY WILL NOT INDICATE THE NEW ADDRESS, ALTHOUGH THE INSTRUMENT WILL NOW RESPOND TO THE NEW ADDRESS.

3.3.5.1 Use switches 1 through 5. They are arranged in BINARY code.

SW1 = Bit 1
SW2 = Bit 2
SW3 = Bit 4
SW4 = Bit 8
SW5 = Bit 16
ON = True
OFF = False
Binary numbers 0 through 30 are acceptable.

DO NOT SET ALL 5 SWITCHES TO "ON".

3.3.6 The output voltage amplitude and frequency of the Model 4701A are individually controlled over the bus, as are the amplitude and phase shift of the current output of the 4702. Simplified commands will program the outputs to the correct levels and frequency. The best range of voltage and current are selected, assuring the output will be at the level which gives the best performance.

3.3.7 When the Model 4701A is first placed into the remote mode, the outputs are reduced to zero and a complete message string must be sent across to set each parameter i.e.; Voltage, Current, and Frequency. Load will default to 100% or Heavy Load. Revolutions will be set at 1. Phase will default to 0°.

3.3.8 The data to be sent for the various functions are outlined in table 3.3.0.

3.3.9 A complete message string might look like this:

"E125A2D+55F060R009RU"

Which translates to:

125VAC,10amps,55°Leading,60Hz,9Revolutions,Run

3.3.10 To program the 4701A to execute an elapsed time test the bus message "RU" must be sent. Even though this message may be sent by itself, prior data must have been sent to set up the voltage, current, phase, load, frequency and number of revolutions.

3.3.11 The elapsed time count is stored in an elapsed time register and may be accessed over the bus with the "?ET" command. When the unit is placed in the TALK mode, it will respond with "ET=nnn.nnSECS". n =0-9.

3.3.12 Several other commands are available to permit the logging of the elapsed time reading with time and date of the test. See table 3.3.0.

3.3.13 The last elapsed time reading is stored in the elapsed time register, and may be read over the bus at any time prior to another elapsed time test.

3.3.14 Data Byte String Format. In general, the 4701A may be programmed by sending over one function, or several functions in the same data string. The separator is the alpha prefixes to each function, eliminating the need for delimiters within the string.

3.3.15 Each function is programmed with its ASCII identifier plus a quantity, with the exception of the CURRENT byte.

3.3.16 The CURRENT Byte is restricted to its alpha character plus a digit from 0 to 7. These digits represent the test currents available in the 4701A/4702A system. (See Table 3.3.16)

CURRENT BUS CODES

ASCII CHARACTER	100% AMPS OUT	10% AMPS OUT
0	0.0	0.0
1	2.5	.25
2	5.0	.50
3	10.0	1.0
4	15.0	1.5
5	30.0	3.0
6	50.0	5.0
7	100.0	10.0

TABLE 3.3.16

3.3.17 The output will change to a new value after receiving the end of message terminator.

NOTE: THE 4701A MUST RECEIVE AN END OF MESSAGE TERMINATOR TO ACT ON THE MESSAGE. IT WILL RECOGNIZE CR LF, LF, OR EOI SENT WITH THE LAST BYTE, AS A TERMINATOR.

3.3.18 The EDC Model 4701A responds per IEEE 488 (GPIB)-1978 convention to a Serial Poll. A Serial Poll conducted in response to a SRQ sent to the 4701, will result in the 4701A transmitting over the bus the following status byte:

DI1-DI7 false, DI8 true

3.3.19 The EDC Model 4701A does not permit the Parallel Poll Configure, (PPC) command as implemented in the IEEE-488 (GPIB)-1978 convention. However, the unit may be configured by transmitting an ASCII "P", followed by the PPR byte. The EDC Model 4701A will respond to Parallel Polling from that point.

3.3.20 Talk Enable Modes. The controller may request specific status information from the EDC Model 4701. The messages to be sent to the EDC Model 4701A prior to sending an MTA are listed in table 3.3.2

3.3.21 Upon receipt of any of the above messages, and upon receipt of MTA, the EDC Model 4701A will respond with the appropriate information as listed in the table.

3.3.22 When the "what's wrong", (?), message is received, one of the following messages will be sent to the controller when the 4701A is placed in the talk mode.

"COMMAND ERROR"
"NOTHING WRONG"
"DATA ERROR"
"NO DATA PROGRAMMED"
"FREQUENCY ERROR"
"NO FREQUENCY DATA"
"VOLTAGE ERROR"
"NO VOLTAGE DATA"
"CURRENT ERROR"
"NO CURRENT DATA"

3.3.23 The "What's Wrong" request may be sent at any time, the EDC Model 4701A will respond with, "NOTHING WRONG" or one of the messages of Para 3.3.22. It is also used when the controller responds to an SRQ and the 4701A response signifies an error condition.

TALK MODES:

	TO READ:	SEND:	RESPONSE:
1.	VOLTS	?E	125VAC
2.	AMPS	?A	10AMPS
3.	FREQUENCY	?F	60HZ
4.	*WATTS	?W	
5.	*VARS	?V	
6.	ELAPSED TIME	?T	ET=987.65SECS
	6a. with TIME	?TT	AS 6 WITH TIME
	6b. with DATE	?TD	AS 6 WITH DATE
	6c. with D&T	?TC	AS 6 WITH DATE & TIME
7.	REVOLUTIONS	?R	REVS=100
8.	REAL TIME	?TI	10:25AM
9.	*% ERROR	?%	
10.	*Kh	?K	
11.	*SERIAL #	?SN	
12.	*MODEL	?MO	
13.	LAST MESSAGE OVER THE BUS	?LM	LAST STRING RECEIVED
14.	WHATS WRONG	?	SEE PARA. 3.3.22
15.	REPORT	?S	CURRENT DEVICE SETTINGS
16.	LEAD/LAG	?D	LEAD - LAG SETTINGS

TABLE 3.3.23

*= FOR FUTURE USE WITH KEYBOARD OPTION

3.4.0 Measurements With The System

The general Watt-Hour Meter equation is:

$$T = \frac{3600\, N\, K_h}{VI \cos\theta}$$

Where:

V is the voltage in volts.

I is the current in amperes.

θ is the phase angle.

cos θ is the power factor.

N is the number of disk revolutions.

K_h is the meter constant, and

T is the elapsed time in seconds.

If T_{th} is the theoretical elapsed time and T_{ob} is the observed elapsed time, then the meter error, E, is:

$$E = \frac{T_{th} - T_{ob}}{T_{th}} \times 100\%$$

For example: if K_h= 1, N = 1, V= 110 V, I = 10A and cos θ = ½, then:

$$T_{th} = \frac{3600}{1100 \times 1/2} = 6.55 \text{ sec.}$$

if T_{ob} = 6.62 sec., then:

$$E = \frac{6.55 - 6.62}{6.55} \times 100\% = -1.07\%$$

Or

1.07% SLOW

3.5.Ø Power Error As A Function Of The Phase Angle Error

The power is given by P = VI cos θ

Therefore:

$$\frac{dP}{d\theta} = -VI \sin\theta$$

or: dP = -VI sinθ dθ

or:

$$\frac{dP}{P} = \frac{-VI \sin\theta \, d\theta}{VI \cos\theta} = -\tan\theta \, d\theta$$

Percent error =

$$\frac{dP}{P} \times 100\% = -\tan\theta \, d\theta \times 100\%$$

At 6Ø°, the percent power error, for Ø.1° phase error =

$$\frac{-1.732 \times 0.1^{\circ} \times 2\pi \, RAD}{360^{\circ}} \times 100\% = 0.302\%$$

At Ø° a Ø.1° phase error would produce a negligible power error.

TABLE OF MAXIMUM POWER ERROR
AS A FUNCTION OF PHASE ANGLE ERROR
(Based on Phase Angle Error of 0.05° as specified)

1°	0.001523%	24°	0.038852%	47°	0.093579%
2°	0.003047%	25°	0.040691%	48°	0.096916%
3°	0.004573%	26°	0.042561%	49°	0.100386%
4°	0.006102%	27°	0.044463%	50°	0.103997%
5°	0.007634%	28°	0.046399%	51°	0.107762%
6°	0.009171%	29°	0.048371%	52°	0.111693%
7°	0.010714%	30°	0.050381%	53°	0.115803%
8°	0.012264%	31°	0.052433%	54°	0.120108%
9°	0.013821%	32°	0.054528%	55°	0.124626%
10°	0.015387%	33°	0.056669%	56°	0.129374%
11°	0.016962%	34°	0.058860%	57°	0.134375%
12°	0.018548%	35°	0.061103%	58°	0.139652%
13°	0.020146%	36°	0.063401%	59°	0.145232%
14°	0.021757%	37°	0.065758%	60°	0.151146%
15°	0.023382%	38°	0.068178%	61°	0.157429%
16°	0.025022%	39°	0.070665%	62°	0.164120%
17°	0.026679%	40°	0.073223%	63°	0.171266%
18°	0.028353%	41°	0.075857%	64°	0.178918%
19°	0.030047%	42°	0.078573%	65°	0.187139%
20°	0.031761%	43°	0.081375%	66°	0.195999%
21°	0.033497%	44°	0.084270%	67°	0.205582%
22°	0.035256%	45°	0.087264%	68°	0.215987%
23°	0.037041%	46°	0.090364%	69°	0.227332%

3.6.Ø IEEE-488 Bus Messages

IEEE488 BUS MESSAGES

TO PROGRAM	SEND ACROSS	EXAMPLE
1. VOLTAGE	Ennn	E125
2. CURRENT	An (n=Ø-7)	A3 (1ØAMPS)
3. LEAD/LAG	D±nn (nn=Ø-6Ø)	D 55 or D+55 or D-55
4. FREQUENCY	Fnnn (nn =5Ø,6Ø,4ØØ)	FØ6Ø
5. REVOLUTIONS	Rnn (nnn=1-19)	RØ9
6. TIME SET	TShhmmam/pm	TS1Ø25AM
7. DATE SET	DS=DAYddMMMyy	DS=TUE25AUG87
8. *SERIAL #	SN aaaaaaa	
9. *MODEL	MO aaaaaaaaa	
1Ø. *OPERATOR NAME	NA aaaaaaaaa	
11. RUN	RU	RU
12. RESET	RS	RS
13. ABORT	AB	AB
14. LOAD 1Ø%/1ØØ%	LL/HL	LL
PARALLEL POLL PPC	P	SEE PARA 3.3.19

TABLE 3.6.Ø

* FOR FUTURE USE WITH KEYBOARD OPTION.

4.Ø.Ø THEORY OF OPERATION

4.1.Ø Introduction - Refer to DWG B-419Ø

As shown on the block diagram the 47Ø1A/47Ø2A system forms an MPU controlled watt-hour meter calibrator with independent control of voltage amplitude, current amplitude, frequency and phase angle.

The system may be controlled manually with the 47Ø1A front panel controls or via the IEEE-488 bus.

The system accepts an optical pickup input for timing of a preset number of meter disk revolutions.

4.2.Ø 47Ø1A Theory Of Operation

The 47Ø1A is an MPU based controller and AC voltage source. It generates a DC reference voltage for control of the current amplitude, and also controls the current phase angle.

The theory of each 47Ø1A subsystem is discussed in sections 4.2.1 - 4.2.12.

4.2.1 Power Supply - Refer to Schematic B-42ØØC

4.2.1.1 The ± 22Ø V supplies are unregulated and are used to power the output stage. The Voltages are derived via RECT 8Ø4. Note that these voltages are with respect to P.A. out rather than ground referenced.

4.2.1.2 The ±15 V analog supplies are derived from RECT 8Ø3 and REG 8Ø9 and REG 81Ø. REG 8Ø9 drives REG 8Ø8 to provide the +5AN supply. This allows isolation between the analog and digital grounds.

4.2.1.3 The +5 V digital supply is derived from RECT 8Ø2 and REG 812.

4.2.2 Control Board - Refer to Schematics CB-4736, CB4737

4.2.2.1 The control board contains the manual switches, mode annunciators, and the alpha-numeric displays required for manual operation of the MODEL 4701.

4.2.2.2 The addresses of the alpha-numeric displays and the switches are decoded by U31, U36, U33 on the MPU Board. (See Schematic CB-4722).

4.2.2.3 Each of the fifteen(15) alpha-numeric displays has a unique address starting at 5001_{hex} and ending at $500f_{hex}$. When the MPU has decided that the data just received is different from the stored data, the displays are updated by reading into the display the new data to be displayed. The displays are ASCII coded, latched dot matrix types. Once the data has been loaded into a display, it is retained until new information is presented to the display.

4.2.2.4 Frequency, Local/Remote, Seconds, and Lead/LAG annunciators are turned on and off by U38 located on the MPU board.

4.2.2.5 The ten switches are connected to ICs U4, U8, U11, U12 and U16 which act as temporary registers. The output of these registers are continually read by the MPU when in the LOCAL mode.

4.2.3.0 Microprocessor Circuits - (Refer to Schematic CB-4721)

4.2.3.1 The functions of the EDC Model 4701A are under control of a 6502 microprocessor and its associated circuitry.

4.2.3.2 The basic timing of the EDC Model 4701A is set by the xtal controlled oscillator, operating at a frequency of 5.184 MHz.

4.2.3.3 U19 functions as the oscillator and output buffer for the 5.184 MHz oscillator.

4.2.3.4 The buffered oscillator output is sent to U20, where it is divided by four, and the 1.296 MHz becomes the clock frequency for the MPU. The 1.296 MHz output of U20 also goes to the I/O section where it is used as the reference clock for the 6840 timers.

4.2.3.5 U16, a UP supervisory circuit chip provides the necessary start-up and reset delay for the MPU.

4.2.3.6 U15 and U17 decode the high order bits of the address bus to enable the I/O registers and the memory locations used by the MPU.

4.2.3.7 U18 is 8k of ROM which contain the basic operating system software for the EDC MODEL 4701A. The ROM is located at EXXX and FXXX $_{hex}$. U21 a 4K RAM, contains the operating RAM locations. The RAM is located at 0XXX $_{hex}$.

4.2.3.8 U12F and U14A perform the read/write synchronization for the RAM.

4.2.3.10 The RAM locations for most of the data handling is done in "zero page" locations, in order to utilize the 6502's zero page handling advantages. This enhances the speed of operation of the EDC Model 4701A.

4.2.4 Input/Output Circuits - (Drawing CB-4722)

4.2.4.1 Data transfer between control circuits, the IEEE 488 bus, and the internal circuitry is handled by the input/output circuits.

4.2.4.2 The output frequency, and output amplitude pulse width signals are derived from timer/counters in the I/O section of the instrument.

4.2.4.3 Some of the amplitude and range functions are implemented through relay contacts. These relay coils are driven by the buffered output of U9, which is connected to the MPU data bus through latch, U11.

4.2.4.4 U27, one of two 6840 timers used in the EDC MODEL 4701A, provides the two pulse width signals, used to obtain the amplitude of the unit. The two signals generated are;"PQR", (the voltage amplitude), and "STU", (the current amplitude).

4.2.4.5 U26, the second 6840 timer provides the basic square wave reference signal frequency for the voltage oscillator, and also provides the phase shifted square wave reference for the oscillator driving the current source reference.

4.2.4.6 The control data that sets the various signal rates of the two timers are derived from the control panel in LOCAL mode, or the IEEE 488 bus in REMOTE.

4.2.4.7 Both real time and elapsed time functions are available in the Model 4701/4702 Watt Meter Calibration System. They are provided by U23, a real time chip IMC7170.

4.2.4.8 The timer circuit has lithium battery for backup. The projected battery life is in excess of 5 years.

4.2.4.9 In the normal mode of operation the timer provides hour and minute real time display to the front panel. The time may be displayed in either 12 Hr or 24 Hr mode, selectable over the bus.

4.2.4.10 For Watthour Meter testing, when the run configuration has been selected, the timer displays seconds to a resolution of 0.01 s. The maximum displayed elapsed time is 999.99 s.

4.2.4.11 Commands have been provided for setting the time over the IEEE-488 Bus.

4.2.4.12 Auxiliary Control Circuits -(Refer to Drawing CB-4723)

4.2.4.12.1 U28, a 6522 I/O chip interfaces with the Model 4702, and also provides the input for the optical pickup which senses the revolutions of the meter under test.

4.2.4.12.2 In local when the mode switch is placed in the RUN position, the rev count +1 is placed in the counting register of U28, the real time display is cleared to zeros.

4.2.4.12.3 When the first pulse from the optical pickup is received the .01 pulses from the counter U26,(CB-4722), increments the elapsed time registers and are displayed on the front panel.

4.2.4.12.4 Each successive input from the optical pickup decrements the counting register of U28. When the register decrements to zero the counting of the .Ø1 pulses cease, and the result is stored until another RUN is initiated.

4.2.4.12.5 In the REMOTE mode, the same sequence of events take place or receiving a RU message. However the elapsed time registers are cleared prior to the start of the test.

4.2.4.12.6 The elapsed time of the last test is stored in memory and may be recalled over the bus at any time prior to the start of a new test.

4.2.5 MPU-488 Interface - Refer to Schematic CB-4723.

4.2.5.1 The EDC Model 47Ø1A may be controlled from a remote location by an IEEE-488 controller over the IEEE-488 bus.

4.2.5.2 A unique bus address may be selected by the DIP switch located on the MPU board. Any address from Ø - 3Ø may be assigned to the unit. The setting of this switch is read and transferred to the MPU data bus by U32.

4.2.5.3 The address may also be changed over the bus. It should be noted however, upon shut down and subsequent turn-on, the EDC Model 47Ø1A will assume the address on the DIP switch.

4.2.5.4 U34 and U35 are bus transceivers. They permit proper isolation and impedance matching of the bus.

4.2.5.5 The bus transceivers connect directly to the 68488, U3Ø, which handles all the bus handshaking and protocol.

4.2.5.6 Utilizing the interrupt capabilities of the 68488, permits the MPU to deal with the internal functions of the 47Ø1A at a faster rate then it could if it had to monitor and handle all the IEEE-488 bus protocols.

4.2.5.7 In the LOCAL mode the EDC MODEL 4701A internal circuity does not respond to any activity on the IEEE-488 bus. When the unit is placed into the REMOTE mode, bus activity is monitored by the 68488, U30 and the MPU interrupt bus will respond to activity directed to the address of the EDC Model 4701A.

4.2.5.8 The EDC Model 4701A, (in the REMOTE mode), until receiving ar interrupt from the 68488, will monitor the LOCAL/REMOTE switch.

4.2.5.9 An IRQ from the 68488 tells the internal MPU that the controller chip, U30 has received a byte of data which has been sent to the unit's address. The EDC Model 4701A will now go to its DAC update routine.

4.2.6 Squarewave Reference Circuitry - Refer to Schematics CB-4721 and CB-4722.

4.2.6.1 U19 and associated circuitry form a buffered 5.184 MHz crystal oscillator. U20 divides this signal by 4 to generate the 1.296MHz clock.

4.2.6.2 The clock is fed into counter 3 of U26, where it is divided by an appropriate integer to produce a 50 Hz, 60 Hz, or 400 Hz squarewave. This signal is used as the squarewave reference for the phase locked loop in the sinewave oscillator.

4.2.7 Sinewave Oscillator - Refer to Schematic B-4195K.

4.2.7.1 Sinewave Phase Locked Loop

The following section is a description of the circuitry whict phase locks the sinewave oscillator to the squarewave reference.

4.2.7.1.1 The squarewave reference drives the reference input of phase comparator, Z710, via buffer U40, optoisolator U1, and buffer Z506C.

4.2.7.1.2 The sinewave output of Z701 is clipped by comparator Z709 anc drives the PCII input of Z710.

4.2.7.1.3 The PCII output of Z710 drives a lead-lag RC filter, which ir turn drives the gate of FET follower, Q720.

4.2.7.1.4 The source of Q720 drives the LED of the light variable resistor, U702. U702 is the frequency tuning element of the bridged-T oscillator, Z701.

4.2.7.1.5 K11 switches in larger capacitors in the bridged-T on 50 Hz and 60 Hz.

4.2.7.2 Sinewave Oscillator Amplitude Control Loop - (Refer to B-4195K)

The following section is a description of the circuitry which regulates the amplitude of the sinewave oscillator.

4.2.7.2.1 The sinewave output of Z701 is amplified by Z703 which drives the input of peak detector, Z704.

4.2.7.2.2 The output of Z704 drives the input of OTA, Z705. The +input of Z705 is driven by the sinewave plus an additional + bias. The output of Z705 is a positive going pulse of approximately 5% duty cycle, centered on the positive peak of the sinewave.

4.2.7.2.3 The output of Z705 drives the gating input of OTA, Z706. The - input of Z706 is driven by a +2.3 V D.C. reference voltage. The + input of Z706 is driven from the sinewave output of Z703. The current output pulse of Z706 is a measure of the deviation of the peak sinewave amplitude from its desired value.

4.2.7.2.4 The output of Z706 drives the error point of integrator, Z707. If the sinewave amplitude is too high, the integrator output will slew negatively, and vice-versa.

4.2.7.2.5 The output of Z707 drives the Y+ input of multiplier, Z708. Z708 controls the sinewave amplitude by regulating the gain from the output of Z701 back to its + input.

4.2.7.2.6 A sinewave out of lock signal is derived from Z710, pins 1 and 2, Z740 and Q750 drives the sinewave O/L light and the sinewave O/L input to V5 on schematic CB-4723.

4.2.8 PWM DACS - Refer to Schematic B-4193E.

4.2.8.1 Q510, Q511, and precision Zener diode D 530 form a 0 tc, + DC, voltage reference in the range of +6.1 V to +6.3 V.

4.2.8.2 The reference Zener voltage is resistively divided, and buffered by Z509 to provide a +2 V reference to the drains of Q522 and Q524.

4.2.8.3 The two DACS generate two +DC voltages in the range of 1 V - 10 V which are used as references in the voltage and current A.G.C. circuits.

4.2.8.4 If the desired volts DC reference is P.QR volts, counter A in the MPU/IO generates a squarewave with a duty cycle of PQR/1250. The squarewave is buffered by U4A, optoisolated by U2 and is fed via Z503A and Z503B to the gates of Q521 and Q522.

The +2 V reference is gated by Q521 and Q522, averaged by low pass filter Z504, and is applied to pin 3 of Z505. The voltage at pin 3 = 2PQR/1250.

Z505 is a non-inverting amplifier, with its gain set by appropriate feedback resistors. The output of Z505 is the Volts DC Reference.

4.2.8.5 If the desired Amps DC Reference is S.TU volts, counter A in the MPU/IO generates a squarewave with a duty cycle of STU/1250. This signal is buffered by VAC and optoisolated by V1. The amps DC reference is generated identically to the volts DC reference by Z503C, Z503D, Q523, Q524, Z508 and Z507.

4.2.9 Volts A.G.C. Circuitry - Refer to Schematic B-4194A.

4.2.9.1 The sinewave oscillator drives the input of the voltage controlled amplifier, (VCA). The VCA consists of Z611, Z612, U650 and associated circuitry.

4.2.9.2 The VCA control voltage is fed into the "+" input of Z611. The output of Z611 drives the LED of the Cds light variable resistor, U650. The LED current is sensed logarithmically by 4 diodes in series and is connected to the "-" input of Z611. This arrangement produces a gain which is approximately exponential with control voltage, minimizing the control voltage dynamic range required and compensates for varying characteristics of U650. A lower resistance of the CdS element of U650 produces a higher AC gain in the Z612 stage.

4.2.9.3 A rectifier, driven from the output stage, Z604 provides a current sink into the error point of the integrator, Z603. The DAC output provides a current source into the integrator error point. When the A.G.C. loop is in equilibrium, the source and sink currents are equal and opposite.

4.2.9.4 The output of the integrator drives the control voltage input of the VCA via auxiliary R-C filtering to minimize integrator ripple, which would produce VCA harmonic distortion.

4.2.9.5 When the output of Z603 is more than 12 volts negative, or more than 0.6 volts positive, threshold sensor Z620D is activated and sends an amplitude overload, (AOL) signal to the MPU.

4.2.9.6 A "crowbar" signal derived from the MPU/IO crowbars the sinewave input to the VCA and drives Z603 against its positive stop. When the crowbar is removed the output of the unit will slew to the correct value from near zero, rather than overshoot.

4.2.10 Output Stage - Refer to Schematic B-4192B.

4.2.10.1 The output of Z612A drives the inverting input of Z401.

4.2.10.2 The output of Z401 drives the high voltage output stage consisting of Q410 and Q411. Notice that the ±220 volt supplies are referenced to the output of the amplifier. This arrangement eliminates the need for a high voltage intermediate state. Q414 and Q415 provide current limiting.

4.2.10.3 Amplitude ranging is controlled by relays K1 and K2 by switching in the appropriate output transformer taps.

4.2.11 Amps Phase Shifter - Refer to Schematics B-4190, B-4196C, B-4198B, B-4195G and B-4211D.

4.2.11.1 The voltage output is divided and drives pre-amplifier Z806, which drives comparator Z803. The purpose of Z806 is to make the phase independent of voltage.

4.2.11.2 As will be discussed in section 4.3.2 a voltage in phase with the current appears at the output of Z10 on the 4702A. This signal drives pre-amplifier Z816, which drives comparator Z813. The purpose of Z816 is to make the phase independent of current.

4.2.11.3 The output of Z8Ø3 drives a programmable monostable multivibrator consisting of Z8Ø4, Z8Ø5 and associated components. This arrangement enables the phase for each of the three frequencies to be trimmed. The falling edge of the output of Z8Ø3 is delayed and drives G1 of V26 via buffer Z5Ø6C and optoisolator V6. A squarewave's falling edge, delayed by an integral number of clock cycles, depending on the desired phase, appears at Ø1 of V26.

4.2.11.4 O1 of U26 drives RES1 and CLK2 of Z731 via inverter U12D, Buffer U4B, and Optoisolator U3.

4.2.11.5 The output of Z813 drives CLK1 and RES2 of Z731.

4.2.11.6 The sinewave oscillator drives Z727 an "all-pass" filter to produce approximately 9Ø° lead.

4.2.11.7 Z728 and U73Ø comprise a variable "all-pass" filter which can be tuned from approximately Ø - 18Ø° lag.

4.2.11.8 Depending on the sign of the phase error, Z731 either sources or sinks current from the capacitor on the gate of Q732. Q732 regulates the LED current in U73Ø which tunes the variable "all-pass" filter for no phase error. When there is no phase error, Q2 goes low, and Q1 goes high and Z731 assumes an inert "tri-state" mode.

4.2.11.9 The output of Z728 is buffered by Z733 which drives an R-C network which produces a lead at 4ØØ Hz relative to 6Ø Hz. The output of the R-C network is the sinewave reference to the 47Ø2A. The lead R-C network compensates for a lag in the 47Ø2A output transformer.

4.2.12 Optical Pickup Circuitry - Refer to Schematic B-4212D.

4.2.12.1 The input connector is a Switchcraft #TB5M. The mating connector is a SWITCHCRAFT # TA5FL.

4.2.12.2 +2Ø Volts is brought to drive the LED in a reflective sensor such as the Banner CV1. The sensor output interfaces with the MPU via Z125.

4.3.0 4702A Theory of Operation - Refer to Schematics B-4210 and B-4211.

The 4702A is a slave unit to the 4701A. It generates an AC current proportional to the +DC reference provided by the 4701A. The 4701A also provides an A.C. reference, and digital inputs to drive relays. The 4702A sends back a phase reference and an overload signal to the 4701A. The theory of each 4702A subsystem is discussed in sections 4.3.1 - 4.3.4.

4.3.1 Power supply - Refer to Schematic B-4210E.

A MDA 2502 rectifier and 2 - 6900 ufd/75 V capacitors, form a ±50 V power supply for the power amplifier. An MDA 202 rectifier, 2-680 ufd/63 V capacitors, 7815 and 7915 regulators form a +30 V supply for the relays, and ±15 V for the operational amplifiers.

4.3.2 Control Circuitry - Refer to Schematic B-4210E.

4.3.2.1 TTL levels from the 4701A drive the standby-operate and range relays.

4.3.2.2 Z6 is a comparator which detects an overcurrent in one of the output transistors, or Z6 being against its negative stop. When one of these conditions is detected, the output of Z6 will go positive, turning on Q5 which sends an overload signal back to the 4701A.

4.3.3 Amps A.G.C. Circuitry - Refer to Schematic B-4211D.

4.3.3.1 The sinewave reference from the 4701A drives the input of the VCA. The VCA consists of Z1, Z4, V10 and associated circuitry. It operates identically to the VCA described in section 4.2.9.2.

4.3.3.2 The output current is sensed by one of the sense resistors R10 or R100 depending upon which set of output terminals is used. This voltage is amplified by the differential amplifier Z9 and is buffered by Z10. The output of Z10 provides a phase reference to the 4701A and drives a rectifier, Z3.

4.3.3.3 The rectifier provides a current sink into the error point of the integrator, Z2. The "+" DC reference voltage from the 4701A provides a current source into the integrator error point. When the A.G.C. loop is in equilibrium, the source and sink currents are equal and opposite. The output of the integrator drives the control voltage input of the VCA, the "+" input of Z4.

4.3.3.4 A "crowbar" signal derived from the MPU/IO crowbars the sinewave input to the VCA and drives Z2 against its positive stop. When the crowbar is removed, the output of the 4702A will slew to the correct value from near zero, rather than overshoot.

4.3.4 Output Stage - Refer to Schematic B-4211D.

4.3.4.1 The output of the VCA drives the inverting input of Z5.

The output of Z5 drives the output stage consisting of Q1 and Q2. Notice that the ±50 volt supplies are referenced to the output of the amplifier. This arrangement eliminates the need for a high voltage intermediate stage.

4.3.4.2 Amplitude ranging is controlled by K12 by switching in a different calibration potentiometer for each range.

SECTION V

5.Ø.Ø	CALIBRATION	
5.1.Ø	Required Equipment	
5.1.1	AC-DC DVM	Hewlett Packard Model 3458A
5.1.2	Phasemeter	Clarke-Hess Model 6ØØØ or equivalent
5.1.3	Frequency Counter	Philips Model PM6667
5.1.4	Active Current Transformer	Jamb Industries Model CT1ØØØ
5.1.5	Precision Current	Holt Instrument Labs P/N 81667-Ø5Shunt .1 AMP, 1Ø Ω
5.1.6	Precision 4-Wire Ø.1Ω Resistor	Leeds & Northrup
5.1.7	Precision 1Hz TTL Squareware Source (Frequency Accuracy .Ø1%	

5.2.Ø 4701A CALIBRATION - REFER TO DRAWINGS CB-4741 & B-4274

Turn R42Ø all the way counterclockwise before proceeding and install output connector jumpers. The STANDBY switch should be in the downward (OPERATE) position for the following calibration procedure.

5.2.1 Frequency Calibration - Refer to Drawing CB-4741.

Connect a frequency counter between PIN 9 of U2Ø and ground(J3 Pin 2). Adjust C22 for a reading of 1,296,ØØØ ±5 Hz.

Connect the frequency counter between TP71Ø and ground. Check frequency accuracy on 5Ø Hz, 6Ø Hz and 4ØØ Hz by varying the front panel frequency switch. Frequencies should be within ±Ø.ØØ1%.

5.2.1.1 Connect the precision 1Hz. Source between pin 1 (H1) and pin 4 (Gnd) of the optical pickup female connector. Set Disk Revs to 1.

Set the Reset-Run-Remote switch to Reset and then to Run. Coarsely adjust C3Ø for an elapsed time reading of 1.ØØ Sec. Set Disk Revs to 12. Fine tune C3Ø for an elapsed time reading of 12.ØØ Sec.

The real time clock may need to be set. See Table 3.3.2.

5.2.2 PWM DAC Calibration - Refer to Drawing B-4274.

Set SW 600 to the D.C. CAL position.

5.2.2.1 Connect a D.C. DVM across the reference zener. Adjust R510 so that the voltage equals the voltage on the tag.

5.2.2.2 Remove the voltage output connector to break the connection between pins C & E (low out & low sen). Connect a D.C. DVM between SG and PG (across the 100 Ω resistor near the reference zener). Adjust R520 for a null reading. Remove DVM and reconnect pins C and E of the output connector.

5.2.2.3 Connect a D.C. DVM between TP510 and Zener ground, ZG. Adjust R511 for a reading of +2 V ±100 μV.

5.2.2.4 Connect a D.C. DVM between TP501 and ZG.

5.2.2.5 Set the front panel voltage switches to 480 V. Adjust R513 for a reading of +4.8 V.

5.2.2.6 Set the front panel voltage switches to 100 V. Adjust R512 for a reading of +1.0 V.

5.2.2.7 Repeat the 5.2.2.5 - 5.2.2.6 sequence several times if necessary as R512 and R513 are interacting.

5.2.2.8 Check the D.C. voltage at TP501 for the following AC voltage settings.

AC VOLTAGE SETTING	VOLTAGE D.C.	D.C. ERROR µV ALLOWABLE .025% of SETTING
100	1.00	250
101	1.01	253
102	1.02	255
103	1.03	258
104	1.04	260
105	1.05	263
106	1.06	265
107	1.07	268
108	1.08	270
109	1.09	273
X=10 10X 110	1.10	275
110	1.10	275
120	1.20	300
200	2.00	500
210	2.10	525
220	2.20	550
230	2.30	575
240	2.40	600
250	2.50	625
260	2.60	650
270	2.70	675
480	4.80	1200

5.2.2.9 Connect a D.C. DVM between TP502 and ZG. Set Current Range to 100%.

5.2.2.10 Set the front panel current switches to 100 A. Adjust R515 from a reading of +10 V.

5.2.2.11 Set the front panel current switches to 2.5A. Adjust R514 for a reading of +0.25 V.

5.2.2.12 Repeat the 5.2.2.10 - 5.2.2.11 sequence several times if necessary as R514 and R515 are interacting.

5.2.2.13 Check the D.C. voltage at TP502 for the following AC current settings.

AC CURRENT SETTING	%SETTING	DC VOLTAGE
0(CREEP) .25	10	0.25
.50	10	.5
1.0	10	1.0
1.5	10	1.5
3.0	10	3.0
5.0	10	5.0
10.0	10	10.0
0(CREEP) 2.5	100	02.5
5.0	100	5.0
10.0	100	10.0
15.0	100	1.5
30.0	100	3.0
50.0	100	5.0
100.00	100	10.0

5.2.3 Output Calibration - Refer to Drawing B-4274B.

SW600 should be in the DC CAL position for D.C. adjustments, and in OPERATE for AC adjustments.

5.2.3.1 Output Calibration, DC Adjustments

5.2.3.1.1 Output Stage Idle Current Adjustment

Connect a DC DVM between TP401 and TP400, analog ground. Adjust R420 for a reading of 12 mVdc.

5.2.3.1.2 Rectifier Zero Adjustment

Connect a DC DVM between TP660 and ZG. Adjust R610 for a null reading.

5.2.3.1.3 Integrator Zero Adjustment

Connect a DC DVM between TP670 and ZG. Adjust R620 for a null reading.

5.2.3.2 Output Calibration, AC Adjustments

Set SW600 to OPERATE. Connect an AC DVM to the output terminals. Set the front panel voltage switches to 480 V. Adjust R650 for a reading of 480 V. Set the front panel voltage switches to 100 V. Adjust R620 for a reading of 100 V. Repeat the R650-R620 sequence several times if necessary, as the R's are interacting. Check the AC voltage output for the following settings:

AC VOLTAGE SETTING	ALLOWABLE AC ERROR, mV
100	50
110	55
120	60
200	100
210	105
220	110
230	115
240	120
250	125
260	130
270	135
480	240

5.3.0 4702A Calibration - Refer to Drawing B-4251.

5.3.1 4702A Current Output Calibration - Refer to Drawing B-4251.

5.3.1.1 Output Stage Idle Current Adjustment.

Place the system in STANDBY by using the 4701A front panel STANDBY switch. Connect a DC DVM between TP10 and TP11, ground. Adjust R1 for a reading of 16 mV.

5.3.1.2 Rectifier Zero Adjustment

Connect a DVM between TP9 and TP8, ground. Adjust R2 for a null reading.

5.3.1.3 Connect a one turn loop from the 4702A 100Amp output terminals through the sense transformer of the CT1000. Connect the Holt 10Ω shunt to the output of the CT1000. Connect the A.C. DVM across the output terminals of the 10Ω shunt. Place the unit in operate and dial up 50Amps on the 4701A. Adjust R5 for a reading of 1 Volt. Dial down to 5Amps. Adjust R3 for a reading of 100mV. Repeat the R5-R3 sequence several times if necessary as the R's are interacting.

Connect the 10 A output of the 4702A to the input of the 4-wire 0.1Ω resistor. Connect the A.C. DVM to its output terminals. Adjust R4 for a reading of 1 Volt.

5.4.0 Phase Calibration - Refer to Drawing B-4274B.

Place the system in STANDBY. Dial up 60 Hz, 100 V, 100%, 100 A and 60° lag. Place a short across the 100 Amp output terminals. Connect the A input of the phasemeter to the voltage output of the 4701A through an appropriate attenuator so as not to exceed its input voltage limit. Connect the B input of the phasemeter to TP7. Place the system in OPERATE.

Note phase reading for 100 A setting. Dial down to 5 A. Adjust R801 for the same phase reading. Go back to the 100 A setting. Repeat the procedure several times to get identical phase readings for the 100 A and 5 A settings. Set voltage to 480 V. Note the phase reading. Dial down to 100 V. Adjust R800 for the same reading. Go back to the 480 V setting. Repeat the procedure several times to get identical phase readings for the 480 V and 100 V settings.

Alternately switch between 10 A and 0.5 A. Adjust R801 so that the phase readings are identical. Alternately switch between 100 V and 480 V. Adjust R800 so that the phase readings are identical.

Adjust R805 for a reading of 60°. Change frequency to 60 Hz and adjust R806 for a reading of 60°. Change frequency to 400 Hz and adjust R804 for a reading of 60°. Check for phase accuracy at the following points: 0°, 11°, 22°, 33°, 44°, 55°, 66°, 67°, 68°, 69°, lead and lag, for all three frequencies.

6.0.0 TROUBLESHOOTING

6.1.0 Current may be distorted due to diode effect in output connectors.