OPERATING AND SERVICE MANUAL

DIGITAL WATT-AMMETER 1301

Topward

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LIST OF ILLUSTRATIONS

1301 SPECIFICATIONS

WATTS

RANGE	MAXIMUM READING	ACCURACY(12 months) 18°C-28°C (40Hz to 70Hz) ±(% rdg + digits)	MAXIMUM VOLTAGE	MAXIMUM CURRENT
20W	19.99	0.3% + 3d	299.9	200mA
200W	199.9	0.3% + 3d	299.9	2 A
2000W	1999	0.3% + 3d	299.9	20 A

Power Factor Response Capability: Zero to unity power factor, leading or lagging.

Shunt Resistance: 0.01Ω.
Settling Time: 2.5 seconds to within 2 digits of final reading.

AC VOLTAGE

RANGE	MAXIMUM READING	ACCURACY(12 months) 18°C-28°C (40Hz to 1KHz) ±(% rdg + digits)	INPUT RANGE MINIMUM	INPUT RANGE MAXIMUM	MAXIMUM ALLOWABLE INPUT
115V	199.9	0.25% + 2d	0V	199.9V	300V
230V	299.9	0.25% + 2d	100V	299.9V	300V

Input Impedance: Above 200KΩ.
Settling Time: 2.5 seconds to within 2 digits of final reading.

AC CURRENT

RANGE	MAXIMUM READING	ACCURACY(12 months) 18°C-28°C (40Hz to 1KHz) ±(% rdg + digits)*	MAXIMUM VOLTAGE BURDEN	SHUNT RESISTANCE
200mA	199.9	0.3% + 2 d (200Hz max)	0.25V	0.01Ω
2000mA	1999	0.3% + 2 d	0.25V	0.01Ω
20 A	19.99	0.3% + 2 d	0.25V	0.01Ω

* Above 200 counts.
Maximum Input: 35A peak, 20A RMS. (Circuit breaker protected at 20A RMS).
Crest Factor Response: 60:1 for minimum RMS input, liner decreasing to 3:1 for full scale RMS inputs.
Settling Time: 2.5 seconds to within 2 digits of final reading.

GENERAL

WATTS/AMPS READING: 3 automatic ranges-up at 2000, down range a 0.180.
MINIMUM INPUT: 10% of range for all true RMS responding converters.
ENVIRONMENT: Operating: 0°C to 55 C
0% to 80% relative humidity up to 40°C
Storage: -25°C to +65°C
POWER: 105-125 or 210-250 volts(switch selected), 90-110V available.
50-60Hz, 7 WATTS.
DIMENSIONS, WEIGHT: 85mm high x 235mm wide x 275mm deep
(3-1/2 in.x 9-1/4 in.x 10-3/4 in.)
NET WEIGHT: 1.5Kg. (3 lbs, 4 oz).

SECTION I — GENERAL INFORMATION

1-1 DESCRIPTION

1-2 Topward Model 1301 Auto Ranging Digital Watt-Ammeter was designed as an accurate, low-cost instrument to aid engineering, production test and quality assurance departments in the determination of product power consumption from AC power lines. The instrument features dual, independent digital displays. One provides a continuous display of the AC line voltage. The other is switch selectable to display true watts (EI cosθ) or true RMS current.

1-3 The Model 1301 provides a fast and convenient method of determining product efficiency, power factor and true RMS current while continuously monitoring the AC line voltage. Phase angle relationships may be accurately calculated through utilization of the displayed digital data.

1-4 The Model 1301 uses a unique four-quadrant complex waveform analog multiplier to derive a DC voltage level equivalent to the integrated product of the instantaneous value of line voltage and current. The developed DC voltage value is converted for presentation on a 3-1/2 digit display. Automatic ranging provides maximum resolution from 10 milliwatts to 1999 watts. True RMS current from 100 ua through 19.99 amperes with a crest factor of 3:1 may be monitored by selecting the current display with the front panel switch. A conventional 3-terminal power outlet is provided on the rear panel for ease of load connection for 115 volt applications. At time of order, and on request, the standard 15 ampere line cord connector and rear panel connectors of the 115V model will be replaced with 20 ampere, polarized connectors for use with appropriately wired outlets.

1-5 The 1301 is designed to operte from selectable 115/230V AC independent of load power. The load voltage may be varied from 0 to 300 volts in two ranges; 0 to 199.9 and 100.0 to 299.9 Both input voltage and load are connected via a automatically switching circuit

1-6 20 AMPERE LOAD EXTENSION CORD

1-13 A 2-foot extension cord with 20 ampere capacity is available as an option. This allows the operator easy access to the rear connector by effecively bringing it around to the front work area.

SECTION II — INSTALLATION

2-1 INTRODUCTION

2-2 This section of the manual contains information for inspection and installation of the Model 1301 Digital Watt-Ammeter.

2-3 INITIAL INSPECTION

2-4 If the external shipping container shows evidence of in-transit damage, such damage should be immediately brought to the attention of the carrier and such damage noted on the bill of lading.

2-5 Unpack the instrument and retain the shipping container until the instrument has been inspected for possible damage in shipment. If in-shipment damage is observed, notify the carrier and obtain his authorization for repairs before returning the instrument to the factory. Where the external shipping container has shown evidence of damage in transit, but the instrument shows no external damage, it may be advisable to perform the calibration procedure of Section V to determine that the instrument has not incurred hidden damage.

2-6 POWER REQUIREMENTS

2-7 The instrument is shipped from the factory for operation from the power source voltage specified by the purchaser. The unit is available for operation at 115V, 15 Amps Max.; 115V, 20 Amps Max.; or 230V, 20 Amps Max. Connectors designed for 115V-20 amp (NEMA 5-20) operation use different blade configurations than connectors designed for 115V-15 amp operations.

The units operate from 50-60 Hz input. Units connected for 115V operation will operate at line voltages of 90 to 140 volts. Those configured for 230-volt operation will operate at line voltages of 180 to 260 volts. The power cord and rear panel connections are identified to assist the operator in properly connecting the unit and load to voltages and current sources for which they are rated.

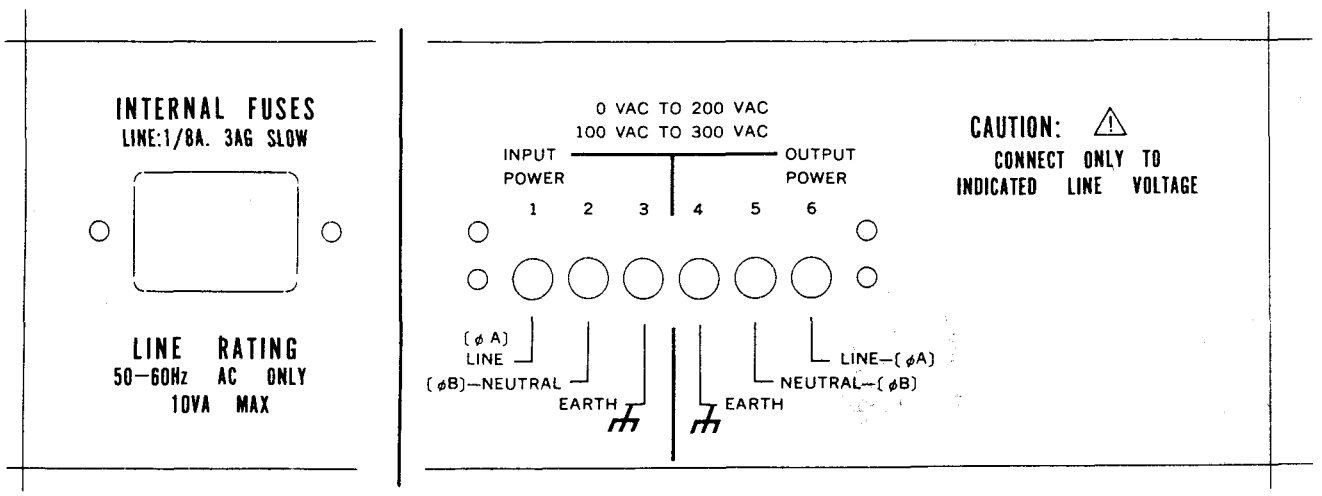


Figure 1. Rear Panel Connections.

SECTION III — OPERATION

3-1 INTRODUCTION

3-2 This section of the manual contains complete operating instructions for the Model 1301 Digital Watt-Ammeter.

3-3 FRONT PANEL CONTROLS AND INDICATORS

3-4 There are Three switches on the front panel of the Model1301. The 20 ampere circuit breaker functions as load protection for the model1301, the power ON/OFF control for Model1301. Application of power to the instrument is indicated by lighting of the LINE VOLTAGE and LOAD displays. The other switch selects the indicating mode of the LOAD display. When in the WATTS position, the LED indicator adjacent to the WATTS legend is illuminated and the indication in the LOAD display is the true EI cos θ power to the load. When the switch is in the AMPS position, the LED indicator adjacent to the AMPS legend is illuminated and the indication in the LOAD display is the true RMS current flowing to the load. Each display is composed of 3½ seven-segment digits.

3-5 VOLTMETER

3-6 The LINE VOLTAGE display will show the line voltage at all times with 0.1 volt resolution regardless of the mode of the LOAD display. The Model 1301 operates from 0 to 199.9V AC and from 100.0 to 299.9 for load testing. The operating input voltage may be selected automatically.

3-7 AMMETER

3-8 To operate the Model 1301 in the AMPS mode, place the AMPS/WATTS switch in the AMPS position. The 3-1/2 digit LOAD display then indicates the current flowing to the load. There are three current ranges, 0.2A, 2A and 20A. Ranging is fully automatic. Whenever the input to the instrument is such that the indication would be 0180, or less (decimal point omitted), the instrument will automatically downrange. Whenever the input is such that the indication would be more than 1999, the instrument automatically upranges. If the maximum current of 19.99 amperes is exceeded, the display will blink until the load is removed or the current is reduced to within the instrument's range. If the indication is .0180 amperes, or less, the instrument is already operating in its lowest range (0.2A).

3-9 The foregoing paragraph was based on sinusoidal or near-sinusoidal waveforms. Under conditions of pulsing, or other complex waveforms with large crest factors, the instrument will uprange as necessary to maintain the input signal within the linear operating range of the internal amplifier. This insures that the display indication is in terms of the true RMS value of the measured current. Accuracy is not impaired. However, the reading resolution will be reduced. For example, if the true RMS value of a sinusoidal current is near 1.2 amperes, the display might indicate 1.212 amps. If the current is a high crest factor waveform, and it is necessary to uprange, the reading for the same RMS value would be 01.21. This feature is an invaluable aid to the test personnel as the leading zero to the left of the decimal point provides a recognizable indication that the current is other than near-sinusoidal and has a high crest factor, in the area of 3:1 or more.

3-10 WATTMETER

3-11 To operate the Model 1301 in the WATTS mode, the AMPS/WATTS switch is placed in the WATTS position. The LED indicator adjacent to the WATTS legend will illuminate to indicate the unit is operating in the WATTS mode. The LOAD display will then indicate the power, in watts, being delivered to the load. This is a true EI cosθ indication irrespective of the voltage or current waveforms. There are three power ranges; 20 watts, 200 watts and 2000 watts

which has ranges of 0.2, 2.0 and 20 kilowatts. Ranging in the power mode, as in the current mode, is completely automatic. Whenever the power to the load is such as to provide an indication of 0180, or less, the instrument will

automatically downrange. If the load power delivered would produce an indication of 1999, or more, the instrument will uprange. If the maximum of 1999 watts is exceeded, the display will blink until the load power is reduced to a value within the range of the instrument or the load is removed. If the indication is 01.80, or less, the instrument is operating in its lowest range, 20 watts.

3-12 As in the current mode of operation, the foregoing is applicable only when the current flowing to the load is near-sinusoidal. The autoranging system operates in an identical manner in the power mode as in the current mode. When the current is of a pulsing or complex nature, the peak detector will force an uprange to maintain the current amplifier in its linear operational region.

SECTION IV — FUNCTIONAL DESCRIPTION

4-1 GENERAL

4-2 This section of the manual provides a functional description of the Model 1301 Digital Watt-Ammeter referenced to the block diagram, Figure 2. The description provided in this section is intended to assist the engineer or technician in gaining a general understanding of the operation of the circuits of the Model 1301 without the necessity of a detailed circuit description. With the information provided in this section (and that of Section V, Calibration), routine maintenance during the initial one-year warranty period can be accomplished. Detailed warranty maintenance during this period will be accomplished at the factory.

4-3 POWER SUPPLIES

4-4 Power for the internal logic circuits is obtained from a power transformer, rectifier-filter system and regulators. In addition, a precision reference is obtained from the 5 volt logic supply. The reference supply furnishes an input to the voltmeter and current meter circuits to which the line voltage and current are compared.

4-5 VOLTMETER

4-6 The line voltage is sampled by a precision operational rectifier. The resultant DC voltage is passed through a dynamic filter before being applied to the DC voltmeter circuit. The VOLTS display is driven by a large scale integrated (LSI) circuit that compares the input DC to a precision reference voltage and develops the drive signals for the digit display selector and decoder/driver. The reading on the 3-1/2 digit display has a resolution of 0.1 volt. The displayed voltage is the average value of the line voltage calibrated in RMS.

4-7 The 115V AC model of the Digital Watt-Ammeter will operate with and display line voltages between 95 and 140. The 230V AC model will operate from 190 to 280 volts and line voltages between those limits will be displayed. As shown in the block diagram, the VOLTS voltmeter and its display do not enter into the power computations, but provide information on line voltage conditions to the operator. The displayed voltage is necessary to the calculation of phase angle and power factor.

4-8 AMMETER

4-9 A 0.01 ohm current shunt resistor in series with the power line neutral, provides the current sense input to the variable gain operational amplifier. The gain of the amplifier has three ranges that are controlled by the autoranging system. The output amplitude of the amplifier is maintained within the input limits of the true RMS converter. The converter develops a DC voltage proportional to the true RMS value of the amplifier output which is in direct relationship to the line current. In the AMPS mode, the output of the true RMS converter is applied to the LOAD display through the AMPS/WATTS selector. The IC and display circuit of the ammeter are similar to those employed in the VOLTS display and use a reference from the same source as that for the VOLTS display.

4-10 The ammeter circuit employs autoranging so that operation of the wattmeter is completely automatic. The LOAD display voltmeter IC used in the ammeter circuit has an overflow output that indicates that the applied input is beyond the measuring range of the IC. This output is used to command the autoranging system to uprange one step. The autoranging system output then reduces the gain of the variable gain amplifier to bring the output of the true RMS converter within range of the IC input. Current inputs that would cause a reading of 0180, or less, cause the autoranging system to downrange. There are three ranges of current; 0.2, 2 and 20 amperes. If the current exceeds 19.99 amperes, the system cannot uprange further. The display will read 19.99, but it will be blinking to indicate the overrange condition.

4-11 The Model 1301 is designed to provide true RMS current and true wattage (EI cos) readings with current and voltage waveforms that may be distorted severely compared to a sinusoidal waveform. In cases where peak currents are several times greater than the true RMS value, the input to the LOAD display may be within range, but the variable gain amplifier will be operating in its non-linear region. Therefore, the peak detector provides an input to the autoranging system that forces an uprange whenever the peak current is

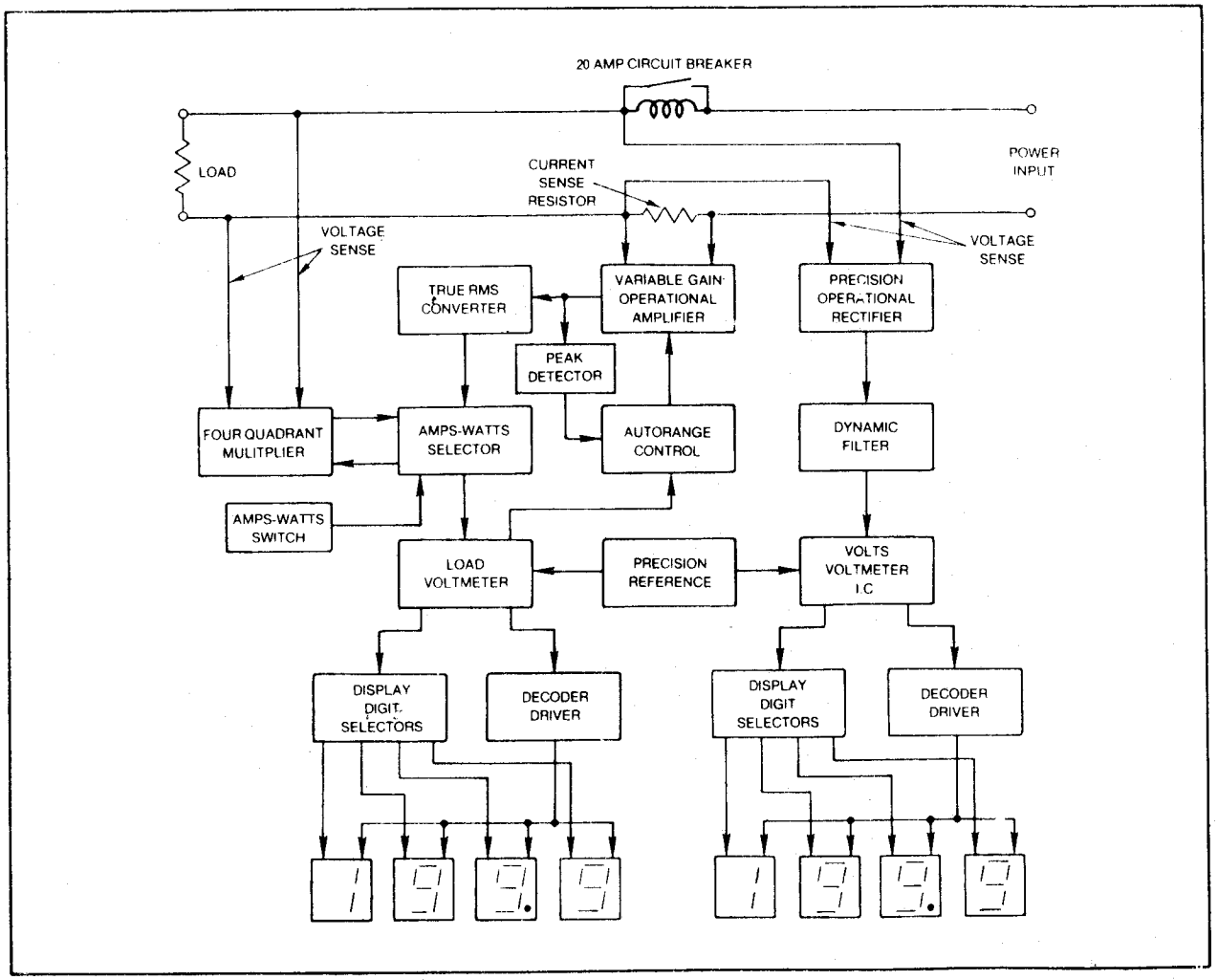


Figure 2. Block Diagram.

greater than 3.5 times the range. At the same time, it inhibits a downrange from being forced by the LOAD display input. Such a condition is indicated by a display reading of 01.00, for example, rather than 1.000, which would be the normal indication for a sinusoidal current.

4-12 WATTMETER

4-13 In the wattmeter mode, the DC output of the true RMS converter is removed from the LOAD display input and the output of the four-quadrant analog multiplier is connected to the LOAD display input. The analog multiplier multiplies the current input times the voltage input and provides a DC voltage output proportional to EI cos θ. This DC voltage is then applied to the LOAD display IC to produce the wattage reading. The analog multiplier is an integrated circuit configuration that permits the connection of non-linearty and auto-zero functions, thereby providing the high accuracy of the instrument in the wattmeter mode. The multiplier circuitry consists of IC9 (bilateral switch), IC10 (quad op amp), IC11 (quad NAND gate) and associated components. The individual sections of the multiple circuit devices are identified by the device designator and a digit suffix which corresponds to the output pin number, IC10-14, for example.

4-14 The circuit functions as follows (refer to Figure 3). The output voltage across the shunt is amplified by IC4. This is connected to one of the switch sections (SW1) of the bilateral switch (IC9). When the switch is closed, this voltage is applied to IC10-14, along with its associated components,

to form a low pass filter. The output of the filter is the voltage at its input if switch SW1 remains closed. If the switch is opened periodically, the output of the filter will be the input voltage times the mark/space ratio of the switch. For example, if the switch is closed 70 percent of the time and opened 30 percent of the time, with this sequence occurring at a rapid rate, the output of the filter will be 70 percent of the input voltage.

4-15 The ratio of the switch closed time to opened time is controlled by IC10-1, IC10-7, IC11-11 and IC11-10. The input of IC10-1 is connected to the voltage at the load that is to be measured. As this voltage varies, IC10 and IC11 control the time that switch SW1 is closed.

4-16 IC11-11 is used as a buffer amplifier and drives switch section SW1 of the bi-lateral switch. Since switch section SW2 of the switch is driven by IC11-10, it is the complement of IC11-11. This causes switch SW1 to be closed when switch SW2 is open and vice versa. The purpose of switch SW2 is to connect IC10-8 to the input of the low pass filter whenever switch SW1 is open. During this time a correction voltage is applied to the filter to compensate for DC offset drift in the multiplier circuitry.

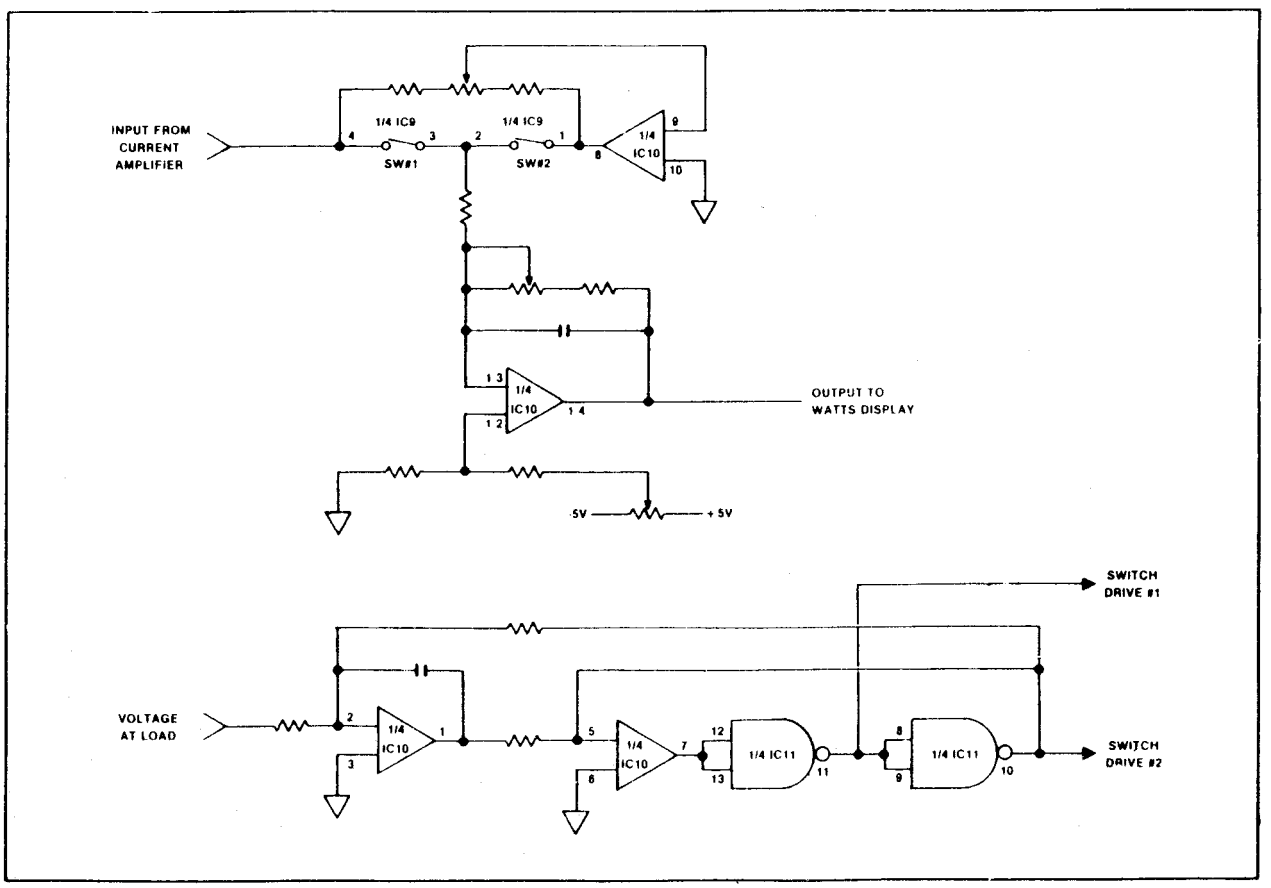


Figure 3. Simplified Circuit Diagram, Multiplier Circuit.

SECTION V — MAINTENANCE

5-1 INTRODUCTION

5-2 This section contains the maintenance information for the Topward Model 1301 Series Digital Watt-Ammeters. Included in this section are the required test equipment list and calibration procedures.

5-3 REQUIRED TEST EQUIPMENT

5-4 The test equipment required for maintenance and calibration of the Topward Model 1301 Series Digtial Watt-Ammeters is listed below:

AC Voltage Source
Precision Current Source Valhalla Model 2500E
Dekavider with 10K Input Impedance
10:1 Step Down Transformer

5-5 CALIBRATION PROCEDURE

5-6 The following procedure should be performed on a routine basis to insure that the instrument remains within calibration limits. The calibration procedure should be performed before returning the unit to service after repairs have been accomplished that involve any of the accuracy determining components.

NOTE

Calibration adjustments and locations are identified in the Assembly Diagram of Figure 5-1.

5-7 Connect the voltage output from the AC voltage source to the power input on the Model 1301 No output load should be connected to the Model 1301

5-8 Set the AC voltage source output to zero. Adjust R78 for desired indication.

02001603J5-9 Set the AC voltage source to 50 Hz and select the desired output voltage 115V. Adjust R35 for the desired indication.

5-10 Apply 230V AC. Adjust R63 for desired indication.

5-11 Connect the output of the Model 2500E current source as follows:

OUTPUT HI to LINE NEUTRAL OUTPUT
OUTPUT LO to LINE NEUTRAL INPUT

5-12 Connect the input of the 2500E to the output of the Dekavider. Connect the output of the AC voltage source to the input of the Dekavider.

5-13 Set the Dekavider output to zero. Connect a DVM to the output of the Dekavider. Set the Dekavider output voltage to 1V AC. Monitor and adjust the Dekavider as needed to maintain 1V AC Set the 2500E output to 100 milliamperes.

5-14 Set the front panel AMPS/WATTS selecto switch to the AMPS position.

5-15 Adjust R4 for an indication of 0.1000 amps.

5-16 Set the Model 2500E to output to 1.000(amps.

5-17 Adjust R3 for an indication of 1.000 amps.

5-18 Set the Model 2500E output to 10.000 amps

5-19 Adjust R2 for an indication of 10.00 amps.

5-20 Set the Model 2500E output to zero.

5-21 Select the WATTS function on the Mode 1301

5-22 Connect a FLOATING DVM to IC4, pin 6.

5-23 Vary R20 for + 1V and – 1V DC indication o the DVM and set R77 for less than a 2-digit chang in the WATTS reading.

5-24 Set R20 for a reading of less than + 0.1V D(on the DVM. Disconnect the DVM.

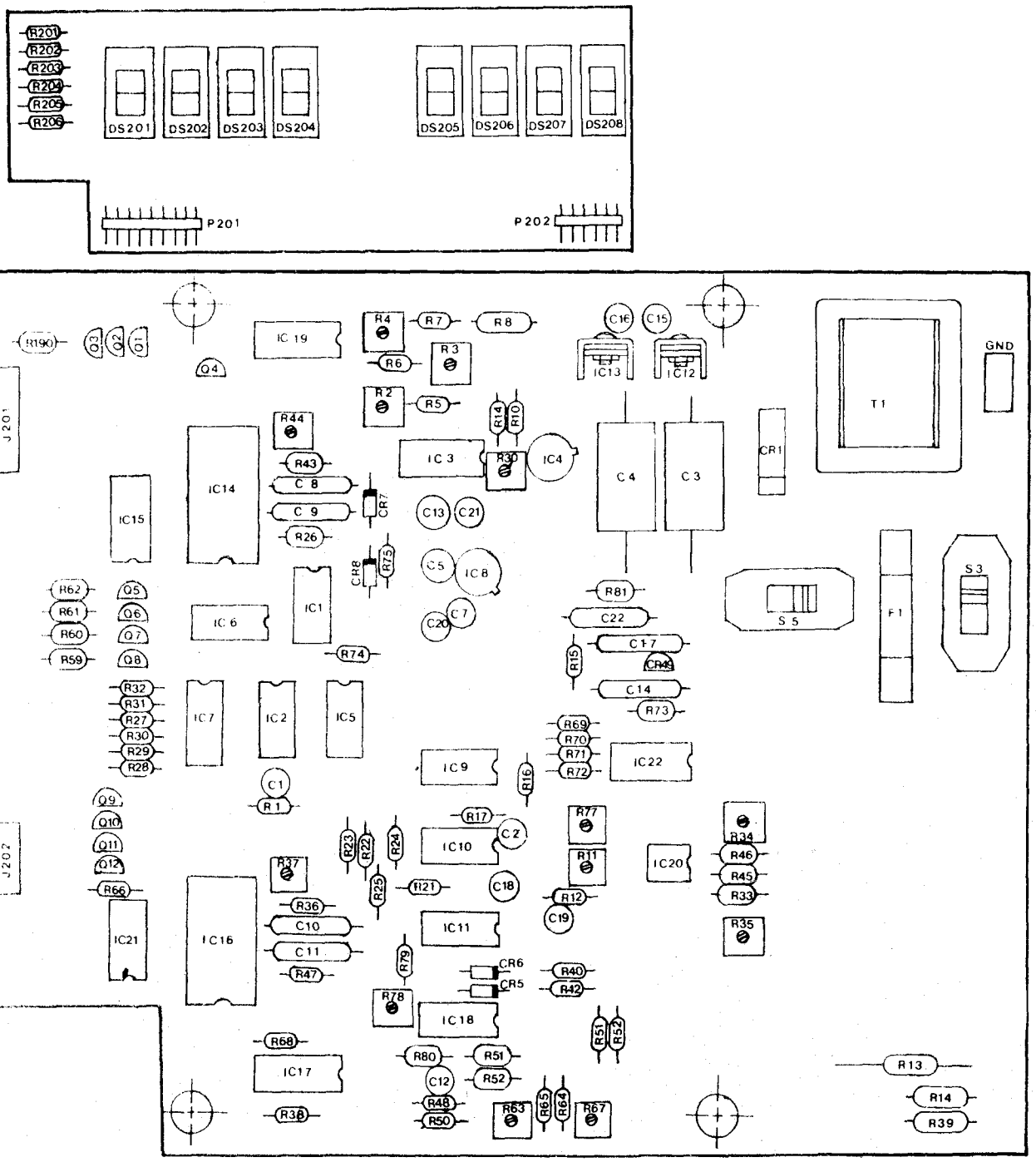
5-25 Adjust R67 for an indication of 00.00 on th WATTS display.

5-26 Set the Model 2500E output to 1.0000 amps.

5-27 Adjust R11 for the same indication on the WATTS display that is on the VOLTAGE display.

5-28 R34 need not be adjusted unless R2, R3 and R4 are outside their dynamic range.

5-29 R36 and R44 control the clock frequency of the two A-D converters and need not be adjusted on a routine basis.


R201
R202
R203
R204
R205
R206
DS201
DS202
DS203
DS204
DS205
DS206
DS207
DS208
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P202
R190
Q3
Q2
Q1
Q4
IC19
R4
R7
R8
R6
R3
C16
C15
IC13
IC12
GND
T1
J201
R2
R5
R14
R10
R44
R43
IC3
R30
IC4
C4
C3
CR1
IC14
C8
C9
R26
CR7
C13
C21
IC15
CR8
R75
C5
IC8
R62
R61
R60
R59
Q5
Q6
Q7
Q8
IC6
IC1
R74
R81
C22
C17
CR49
R15
C14
R73
S5
F1
S3
R32
R31
R27
R30
R29
R28
IC7
IC2
IC5
C20
C7
R69
R70
R71
R72
IC22
IC9
R16
C1
R1
Q9
Q10
Q11
Q12
R66
J202
R17
R77
R34
R23
R22
R24
IC10
C2
R11
IC20
R46
R45
R33
R37
R25
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R12
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CR6
CR5
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R42
R78
IC18
R51
R52
R68
IC17
R80
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C12
R52
R48
R50
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R38
R13
R14
R39