Signalcrafters
TECH, INC

OWNERS MANUAL

MODEL 70

COMPUTING POWER/SWR METER

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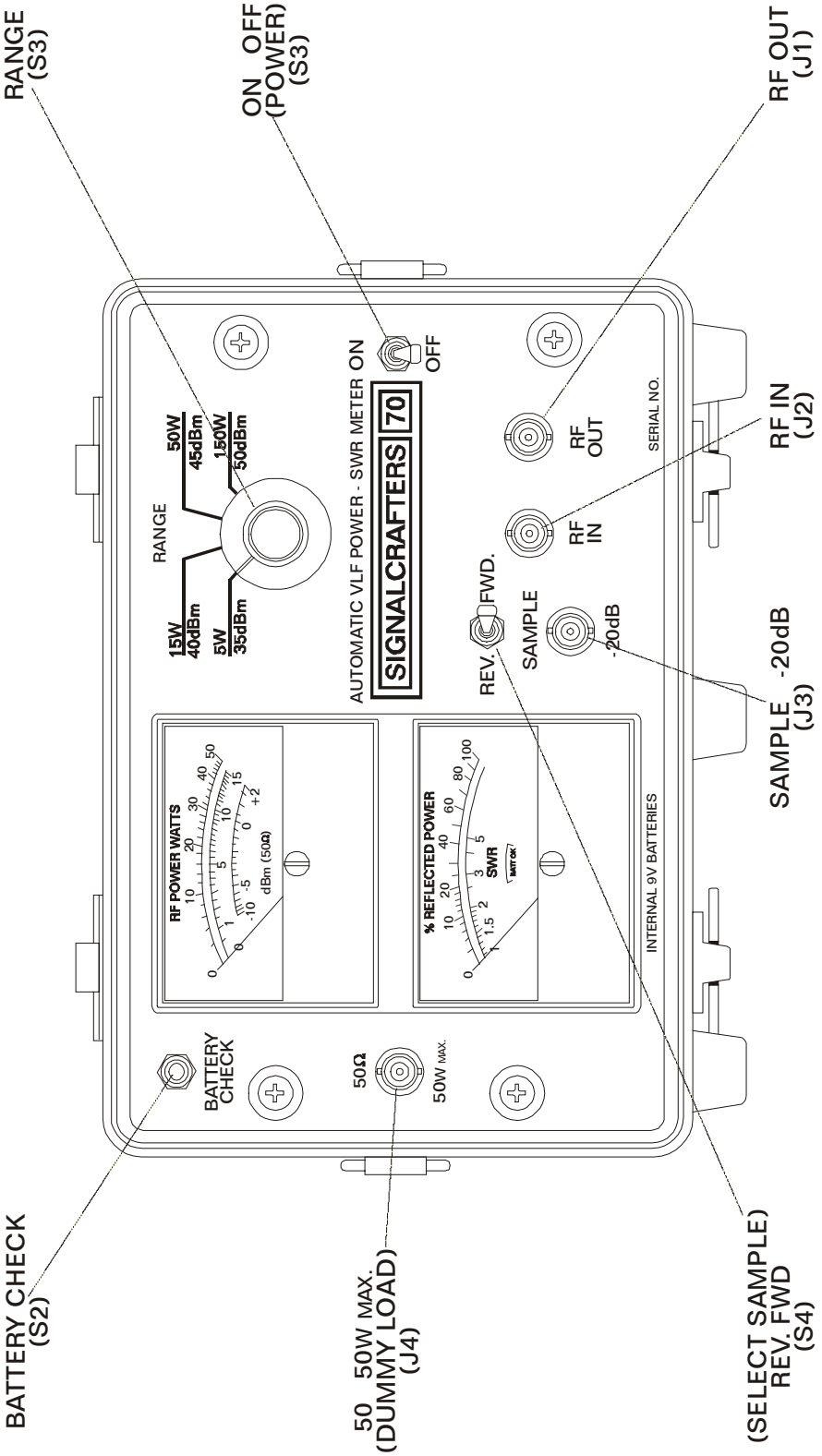


Model 70 PLC Computing Power/SWR Meter
Control Location
Figure 1

1. DESCRIPTION OF THE MODEL 70 PLC COMPUTING POWER / SWR METER

1.1 Overview

The Model 70 is a RF power meter and load mismatch measuring instrument designed for use in PLC systems in the frequency range of 10 kHz to 500 kHz. The Model 70 is calibrated for 50 ohm transmission lines but its use in 40 and 60 ohm systems introduces only minor errors.

The Model 70 will safely handle CW powers of 100 watts over the PLC frequency range of 30 kHz to 500 kHz. Above 40 kHz, 150 watts is allowable. Below 30 kHz, the allowable power declines to 10 watts at 10 kHz.

In use the Model 70 is connected in series with the coaxial feed line between the PLC transmitter and the line tuner. When the PLC transmitter is keyed "on", the Model 70 will display forward power in watts and dBm on one front panel meter. The percent reflected power and standing wave ratio (SWR) are displayed on the other front panel meter.

The two displayed quantities are actually independent and the Model 70, because of its computing circuits, maintains this independence. The result is ease of measurement and complete "hands off" operation. There are no sensitivity or full scale meter adjustments to make during a tune-up procedure.

The internal analog computer computes the ratio of the reflected power to the forward power. Since this ratio relates directly to percent reflected power and SWR but is independent of the magnitude of either, no level or calibration adjustments are necessary.

2. USING THE MODEL 70

2.1 The Proper Hookup

Using the coaxial cables provided, connect the PLC transmitter output through the instrument to the line tuner. If the tuner is remotely located, it may be most convenient to make the hookup at the tuner site. Be sure that the transmitter output coaxial cable goes to the Model 70 **RF IN** connector. Likewise the cable from the **RF OUT** connector on the Model 70 must go to the input of the line tuner.

Be careful not to connect the PLC transmitter output to the **SAMPLE –20dB** connector. This output port can only tolerate about 100 mW of power before blowing a protective fuse. Once the fuse is blown the sample port is inoperative and the voltage sample feature is lost until the fuse is replaced. No other damage to the instrument occurs.

2.2 Making RF Power and SWR Measurements

The instrument is turned on with the toggle switch on the right side of the front panel. Press the **BATTERY CHECK** button to display the condition of the internal batteries.

Select a proper power range. It will be best if the forward power meter reads near the zero dB level on the power meter. This is by no means a requirement but the computing circuits for the SWR display are most accurate above –3.0 dB on any power range. As a practical matter however, any power indication between –10 dB and +2 dB on any range will provide full SWR computing with all of the accuracy necessary for tuning purposes.

At forward power levels below 2% of full scale on any power range the computing circuits are inhibited yielding a SWR reading of 1.0. This "squelch" circuit prevents improper SWR readings due to system noise when no significant forward power is being detected. Thus the threshold for full computing is about 100 mW on the 5 watt range.

Proper operation of the SWR computing can be checked by connecting the Model 70 output to the **50 Ω 50 W MAX** (dummy load). The SWR should read 1.0 when the PLC transmitter is operating

2.3 Making Tuner Adjustments

If the percent reflected power reads too high, readjustment of the line tuner is indicated. This is easily done by first adjusting the series inductor and then the matching transformer taps for a "% Reflected Power" reading. It is generally necessary to readjust the inductor setting since the settings of the matching transformer interact with the inductor tuning. It should only take a few minutes to adjust the tuner for optimum performance.

The adjustments normally require so little time using the Model 70 that calculating the tuner settings in advance is not justified.

2.4 Interpreting the Readings

During tuner adjustments it is normal for the forward power to change, sometimes a lot. This is because the load seen by the transmitter is altered as the tuning is done. The indicated forward power may in fact show a decrease as well as an increase during the tuning process. When the tuning is finished and a low percent reflected power is obtained, the transmitter is seeing very nearly its 50 ohm design load. At this point the forward power indicated by the Model 70 is accurate.

If after a good match is obtained the PLC transmitter power output is too low, the output tuning circuits of the transmitter may need adjustment. These adjustments will not affect the line tuner settings that have already been made. If a problem exists, it now has been isolated to the transmitter or possibly to the coaxial line feeding the tuner.

2.5 Interference

There are a number of situations involving interfering signals that can and do make the adjustments difficult and sometimes confusing.

Incoming signals from the transmission line, either signals coupled to the line by crosstalk or signals being transmitted from the far end are interpreted as reflected power by the Model 70. This can lead to a high reflected power reading when that may not really be the case.

If the interfering signals are due to crosstalk between systems, selecting the next higher power range on the Model 70 is often helpful. Increasing the transmitter power when possible can often overpower the interfering signals as wall. In extreme cases a Frequency Selective Levelmeter connected to the **SAMPLE – 20dB** sampling port on the Model 70 will allow the measurements to be made. See the instructions in paragraph 3.2 for this type of measurement.

When the interfering signal is transmitted from the far end of the line, the best solution is to defeat the offending carrier. Lacking the ability to do this necessitates making the measurements during non-transmitting periods of the interfering carrier.

2.6 Short Lines vs. Long Lines

A properly tuned system has each transmission line terminated in its characteristic impedance. If this is not true there will be reflections and some loss of signal strength at the receiving end. The loss of signal may not be important but he mismatch can cause tuning problems at the transmitting end if the line has low losses.

Long lines with high losses effectively isolate the trans-mitting end from the receiving end. The effect is that matching adjustments at each end are largely independent. The result is that the tuner adjustments are easily done with the aid of the Model 70.

This is not necessarily the case with low loss short lines. If the receiving end is badly mismatched, almost no amount of tuning at the transmitting site will yield the desired result. What happens is that the signal reflects from the receiving end and cannot be tuned out by adjustments to the local line tuner. The solution is to alternately tune each end in order to obtain the best system match.Two Model 70 instruments are suggested for this operation as well as good communications between sites.

3. SPECIAL FEATURES

3.1 50 Ω 50 W MAX Dummy Load

A **50 Ω 50 W MAX** test load is available at the front panel. The load is intended for short time testing only, but is very useful for measuring the power output of the transmitter independent of the line tuner. It is always informative to compare this measurement with the power output measured with the tuner as the transmitter load. The two measurements should agree closely if the tuner has been properly adjusted.

It is often possible to isolate trouble in hybrids and long runs of coaxial cable by observing the percent reflected as each element in its turn is terminated in a known load. By observing the changes in power levels in dB along the transmission path between the transmitter and the line tuner, high loss elements in the system can easily be located.

3.2 Directional R.F. Voltage Sampling Port Sample –20dB

CAUTION!

Any signal applied to the voltage sampling **port SAMPLE –20 dB**, will upset the calibration of the Model 70 during normal operation.

Power in excess of 100 mW into this port will blow the internal protective fuse and disable the voltage sampling feature.

The voltage sampling port, **SAMPLE –20 dB** available on the front panel provides the user with a powerful measurement tool. The voltage at the connector is –20 dB from 50 ohms referred to the main line. A front panel switch **REV. FWD**. allows either the reflected or the forward voltage component on the line to be monitored with a Frequency Selective Levelmeter (Levelmeter). Using the features provided on most such instruments, the relative power level of the reflected and forward components are easily determined. The difference in dB between the reflected and forward readings noted on the Levelmeter is referred to as the return loss. Return loss in dB is related to percent reflected power by following equation:

$$\text{Return Loss [dB]} = [(10 \text{ Log } R) - 20]$$

Where R is the percent reflected power. A return loss of 6 dB equates to a SWR of 3.0 and a percent reflected power of 25%.

The tuner should be adjusted for the lowest possible return power and the return loss should be calculated. A practical tuning objective is 20 dB or more return loss.

The connection to the Levelmeter from the voltage sampling port, **SAMPLE –20 dB**, should be made with a short length of shielded cable. Two feet of RG58 cable has about the maximum capacitance allowable at 500 kHz. Longer lengths are acceptable at lower frequencies. The input impedance of the Levelmeter should be no less than 5,000 ohms. Impedances lower than 5,000 ohms will load the voltage sampling port too heavily and degrade the operation of the directional coupler in the Model 70.

The input circuits of the Levelmeter must be configured for unbalanced and bridging operation. A terminated input configuration is in general a low impedance input of 600 ohms or less and thus must be avoided.

An easy check can be made to determine whether or not the Levelmeter connection is loading the voltage sampling port, **SAMPLE –20 dB**, too heavily. Place the Model 70 in operation with a carrier on the line. Note the readings on the Model 70. Connect and disconnect the Levelmeter to the voltage sampling port, **SAMPLE –20 dB**, and switch the reflected-forward toggle switch **REV. FWD**. back and forth as well. There should be no significant change in the Model 70 readings during this test. If there is, the load on the sample port is either too low in resistance or too high in capacitance or both.

The above mentioned method of adjusting a line tuner is much less convenient as compared to the fully automatic operation of the Model 70, but the method is very useful when interference is severe and/or the PLC transmitter power is less than 100 mW.
It is not necessary to have the Model 70 turned on for this operation since only passive circuits are used to obtain the directional voltage sample.

Most Levelmeters, such as the Rycom Levelmeters, have a selection of reference impedances. 50 ohms should be used if it is available. Add 20 dB to the level read on the Levelmeter to obtain the actual power level in dBm on the main 50 ohm coaxial line. If a 50 ohm reference selection is not available, a 75 ohm setting can be used. In this case add 21.76 dB to the level read on the Levelmeter to obtain the line level in dBm.

3.3 Multiple Carrier Response

It is sometimes necessary to adjust a line tuner for the best compromise match between two or more PLC transmitters closely spaced in frequency with the carriers combined onto one coaxial line. A special feature of the Model 70 is the ease with which this tuning can be accomplished.

First attempt to provide about equal power output from each of the transmitters. Then turn on all of the transmitters and adjust the line tuner for the lowest SWR reading obtainable. This method will provide the best compromise match over the band of frequencies.

In general the forward power reading during this multiple carrier operation will not be the sum of the input carrier powers. While the percent reflected power and SWR readings are quite reliable, the forward power readings are not. Forward power must be measured one carrier at a time. The meter is only calibrated for a single frequency signal. Multiple "tones" give erroneous readings. The computer in the Model 70 automatically corrects for these errors and displays the corrected computer SWR value.

4. MAINTENANCE

4.1 Batteries

The Model 70 is powered by two standard 9 volt transistor batteries. High quality units should be used for replacements. This should be done at any time that the battery check indicates low voltage.

In normal use the battery life should exceed one year. It is good practice to change the batteries each year to avoid any battery leakage problems

The batteries are located inside the instrument and can be reached by removing the four panel screws and carefully removing the instrument from the case.

4.2 Fuse Replacement

Two protective fuses are provided in the Model 70. One fuse (1.8 Amp) protects the voltage sample port against inadvertent application of power to the voltage sample connector. The other fuse (2 Amp) is in series with the main 50 ohm line to protect against excessive current transients. Both fuses are mounted behind the instrument panel and may be reached by removing the four panel mounting screws. The 2 Amp fuse is mounted near the BNC connector marked **RF OUT** and the 1/8 Amp fuse is near the connector marked **SAMPLE –20 dB**. Use only rosin core solder when replacing fuses.

4.3 Cleaning

The interior of the instrument should be blown free of dust and dirt from time to time. The case and front panel may be cleaned with a soft, damp cloth using a mild detergent. Use no solvents of any kind on or near the meter faces.

4.4 Calibration

Calibration of the Model 70 should not be attempted unless a well maintained standards facility is available. Instruments will be factory calibrated with a rapid turnaround.

Contact the factory for complete calibration instructions and equipment requirements if in-house calibration is required.

4.5 Repairs

Returns to the factory for repair should be prepaid and should include a short description of the trouble. Instruments will be repaired and recalibrated promptly after receipt of the instrument at the Signalcrafters factory.

Ship to (preferably via UPS):

Signalcrafters Tech, Inc.
57 Eagle Rock Avenue
East Hanover, NJ 07936
(973) 781-0880 or (800) 523-5815
FAX: (973) 781-9044

5. SPECIFICATIONS

RF POWER

Ranges: 0-5 watts (+25 to +37 dBm)
0-15 watts (+30 to +42 dBm)
0-50 watts (+35 to +47 dBm)
0-150 watts (+40 to +52 dBm)

Scales: 0-5 watts and 0-15 watts
-10 to +2 dB (50 ohm Reference).

Accuracy: ±5% of full scale power into a 50 ohm load.

Frequency: 10 kHz to 500 kHz.

Response: ±0.1 dB over full frequency range.

Fuse Protection: 2 A between input and output

Power Limits: Signals into the Model 70 must not exceed the values shown:

FREQ (kHz)	Max Pwr (watts)
500	150
40	150
35	122
30	90
25	63
20	40
15	23
10	10

% REFLECTED POWER AND SWR

Ranges: 0-100% Reflected Power
1.0-5.0 Calibrated SWR.

Accuracy: ±10% at SWR = 3.0 for power levels between –10 dB and +2 dB on any power range.

±5% at SWR = 3.0 for a –1 dB power level, any power range.

INTERNAL BATTERIES

Snap Connector: 9 Volt transistor battery (two required).
NEDA 1604 (Eveready Type 216).

Expected Life: In excess of 1 year in normal use.

CONNECTORS

RF IN: BNC

RF OUT: BNC

50Ω 50W MAX: BNC (Dummy Load)

SAMPLE –20dB BNC (Voltage Sample)

DUMMY LOAD

BNC Connector: 50 ohm, 50 watt intermittent use.

Maximum ON time [minutes] = 50/Pwr.

Minimum OFF time = ON time x 5

VOLTAGE SAMPLE PORT

BNC Connector: Output level –20 dB ± 0.2 dB referred to the main line level.

Output impedance 50 ohms.

Forward / Reverse isolation greater than 30 dB

Fuse protection, 1/8 A

FRONT PANEL SWITCHES

Range: Four position rotary type.

On-Off: Toggle switch, closing cover pushes switch to OFF position..

REV. – FWD. Two position, toggle switch, selects Reverse or Forward, Voltage Sample at SAMPLE-20 dB connector.

BATTERY CHECK: Momentary push button.

SIZE

Overall: 23 cm x 15 cm x 21.5 cm high (9 in x 6 in x 8 ½ in high).

WEIGHT

Overall: 2.3 kg (5 lb) (less connecting cables)

ENVIRONMENT

Moisture: Splash proof with case closed.

Dust and Dirt: Sealed when closed. All internal switch components are sealed against intrustion by dust when in use.

Temperature: Storage: -40° to 66° C (-40° to +150° F).

Use: -23° to 50° C (-10° to +120° F).

Calibration Temp: 24° C (75° F).

CABLES PROVIDED

Qty 2 – 96 inch BNC to BNC, 50 ohm (RG58)

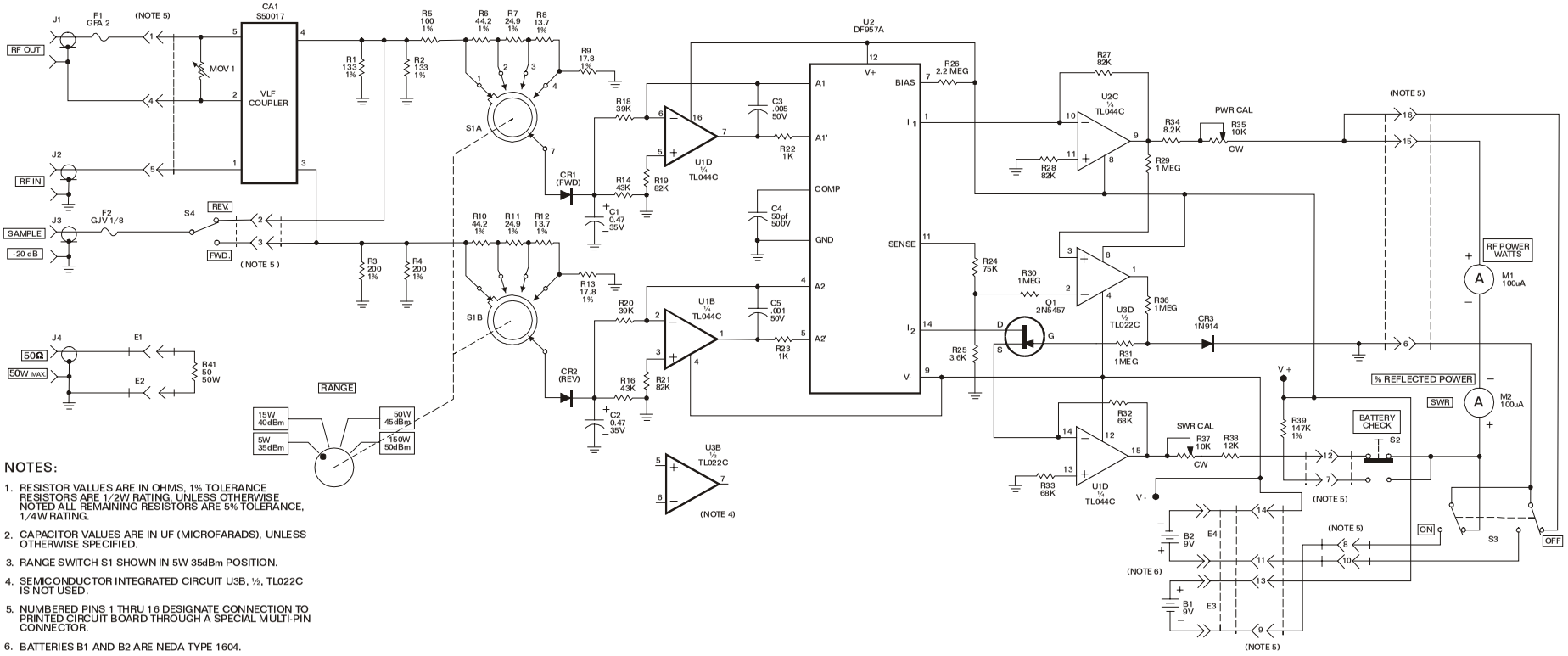
Qty 2 – BNC to Banana Plug Adapters
Qty 4 – Banana Plug to Alligator Clip Adapters

6. PARTS LIST SIGNALCRAFTERS MODEL 70

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION	QTY
B1, 2	60K0101	BATTERY, 9 VOLT, NEDA 1604	2
CA1	86D0051	SUB-ASSEMBLY MOD 70 COUPLER	1
CR1, 2	30A0001	DIODE, MD112 Ge POINT CONTACT	2
CR3	30A0005	DIODE, 1N914 SILICON	1
C1, 2	16C0273	Capacitor, Tantalum, 0.47 uF 20%, 35V	2
C3	16B0040	Capacitor, Disc Ceramic, 0.005 uF 100V	1
C4	16A0011	Capacitor, Disc Ceramic, 51 pF 50V	1
C5	16E0038	Capacitor, Disc Ceramic, 0.001 uF 100V	1
E1, 2	52K0736	Crimp, Red Ins ¼" F. Tab, 20-26 18RA-250F	2
P1, 2 (E3, 4)	60D0001	Connector, Battery w/leads -9V Neda 1604 72	2
F1	54G0020	Fuse, GFA-2 Amp, Pigtail	1
F2	54D0030	Fuse, GJV-1/8 Amp, Glass Tube	1
J1, 2, 3, 4	52A0029	Connector, Coaxial, UG1094A BNC Fem Jack	4
MOV1	30D0152	Varistor, 0180NA Metal Oxide	1
M1	42D0061	Custom Meter, Mod 70 RF PWR/dB	1
M2	42F0060	Custom Meter, Mod 70 SWR/BAT	1
Q1	30F0351	Transistor 2N5457 N Channel J-FET	1
R1, 2	10D3109	Resistor, MF, 133ohm 1% .5W RN60D 1330F	2
R3, 4	10D3126	Resistor, MF, 200ohm 1% .5W RN60D 2000F	2
R5	10A3097	Resistor, MF, 100ohm 1% .5W RN60D 1000F	1
R6, 10	10B3063	Resistor MF, 44.2ohm 1% .5W RN60D 44R2F	2
R7, 11	10G3039	Resistor MF 24.9ohm 1% .5W RN60D 24R9F	2
R8, 12	10G3014	Resistor MF 13.7ohm 1% .25W RN60D 13R7F	2
R9, 13	10B3025	Resistor MF 17.8ohm 1% .5W RN60D 17R8F	2
R14, 16	10B1660	Resistor, CF, 43K ohm 5% 0.25W	2
R15, 17		Not Assigned	
R18, 20	10C1659	Resistor, CF, 39K ohm 5% 0.25W	2
R19, 21, 27, 28	10D1667	Resistor, CF, 82K ohm 5% o.25W	4
R22, 23	10D1621	Resistor, CF, 1K ohm 5% 0.25 W	2
R24	10F1666	Resistor, CF, 75 OHM 5%, .025 W	1
R25	10C1634	Resistor, CF, 3.6K OHM 5%, 0.25 W	1
R26	10F1701	Resistor, CF, 2.2 Megohm 5% 0.25 W	1
R29, 30, 31, 36	10C1693	Resistor, CF, 1 Megohm 5%, 0.25 W	4
R32, 33	10K1665	Resistor, CF, 68K ohm 5% 0.25 W	2
R34	10B1643	Resistor, CF, 8.2K ohm 5% 0.25 W	1
R35, 37	12A0002	Trim Pot, 10K Cermet, 375Y103	2
R38	10B1647	Resistor, CF, 12K ohm 5% 0.25 W	1
R39	10K3401	Resistor MF 147Kohm 1% .5W RN60D 1473F	1
R40		NOT ASSIGNED	
R47	10D3901	Resistor WW NI 50ohm 5% 50W FST-50-50-NI-BKT	1
S1	44F0360	Custom Switch, Rotary, 73-8617	1
S2	44F0101	Switch Push Button SPDT w/blk shaft PB1-2PYZN	1

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION	QTY
S3	44F0003	Switch Togl DPDT w/long flat handl ST2-1F2YZN	1
S4	44B0001	Switch Togl SPDT w/short flat Handl ST1-1F1YZN	1
U1	32D0052	IC TL044CN Quad OP Amp	1
U2	34D0012	Custom IC DF-957A Power Meter Chip	1
U3	32F0051	IC TL022CP Dual OP Amp	1
MECHANICAL	74E0209	Custom Double Meter Shock Pad	1
MECHANICAL	74D0218	Custom Foam Washer, 9/16" OD-1/8" ID 3/16T H010	1
ASSY KIT	86K0053	Accessory Package w/96" Cables	1
		INCLUDES:	
	86C0064	96" BNC to BNC 50ohm (RG58) cable blk	1
	86A0065	96" BNC to BNC 50ohm (RG58) cable wht	1
	68F0030	BNC to Banana Plug Adapter	2
	52G0601	Clip, Alligator / Banana	1
	52E0602	Insulator, Red, for Alligator/Banana Clip	1
	52C0603	Insulator, Blk, for Alligator/Banana Clip	1
	52A0604	Insulator, Grn, for Alligator/Banana Clip	1

7. SCHEMATIC DIAGRAM



NOTES:

1. RESISTOR VALUES ARE IN OHMS, 1% TOLERANCE RESISTORS ARE 1/2W RATING, UNLESS OTHERWISE NOTED ALL REMAINING RESISTORS ARE 5% TOLERANCE, 1/4W RATING.
2. CAPACITOR VALUES ARE IN UF (MICROFARADS), UNLESS OTHERWISE SPECIFIED.
3. RANGE SWITCH S1 SHOWN IN 5W 35dBm POSITION.
4. SEMICONDUCTOR INTEGRATED CIRCUIT U3B, ½, TL022C IS NOT USED.
5. NUMBERED PINS 1 THRU 16 DESIGNATE CONNECTION TO PRINTED CIRCUIT BOARD THROUGH A SPECIAL MULTI-PIN CONNECTOR.
6. BATTERIES B1 AND B2 ARE NEDA TYPE 1604.

Model 70 PLC Computing Power/SWR Meter
Schematic Diagram
Figure 2