MULTI-PURPOSE THRULINE® WATTMETER RF POWER ANALYST® MODEL 4391M

Operations Manual

Instruction Book Part Number 920-4391M Rev. G

The following are general safety precautions that are not necessarily related to any specific part or procedure, and do not necessarily appear elsewhere in this publication. These precautions must be thoroughly understood and apply to all phases of operation and maintenance.

Keep Away From Live Circuits

Operating personnel must at all times observe normal safety regulations. Do not replace components or make adjustments inside the equipment with high voltage turned on. To avoid casualties, always remove power.

Shock Hazard

Do not attempt to remove the RF transmission line while RF power is present. Radiated RF power is a potential health hazard. Observe general safety precautions for handling high voltage equipment. Always disconnect power before attempting any repairs.

Do Not Service or Adjust Alone

Under no circumstances should any person reach into an enclosure for the purpose of service or adjustment of equipment except in the presence of someone who is capable of rendering aid.

Chemical Hazard

Cleaning solvents for cleaning parts may be potentially dangerous. Avoid inhalation of fumes or prolonged contact with skin.

Safety Earth Ground

An uninterruptible earth safety ground must be supplied from the main power source to test instruments. Grounding one conductor of a two conductor power cable is not sufficient protection. Serious injury or death can occur if this grounding is not properly supplied.

Resuscitation

Personnel working with or near high voltages should be familiar with modern methods of resuscitation.

Safety Symbols

WARNING
Warning notes call attention to a procedure which, if not correctly performed, could result in personal injury.

CAUTION
Caution notes call attention to a procedure which, if not correctly performed, could result in damage to the instrument.

The caution symbol appears on the equipment indicating there is important information in the instruction manual regarding that particular area.

☞ NOTE: Calls attention to supplemental information

Fuse Replacement

Always use the same type and rating of fuse when replacing the fuse. Fuse information can be found in the parts list on page 69.

Warning Statements

The following safety warnings appear in the text where there is danger to operating and maintenance personnel, and are repeated here for emphasis.

WARNING

Use cleaning solvents in a well ventilated area. Avoid excessive inhalation of solvent fumes, since they can be toxic in heavy concentrations. Always wear eye protection and avoid skin contact with the solvent.

WARNING

Never attempt to connect or disconnect RF equipment from the transmission line while RF power is being applied. Leaking RF energy is a potential health hazard.

WARNING

Be sure that the power cable is unplugged before opening the wattmeter case. The power supply capacitor, C1 or C11 (depending upon model), can retain a dangerous charge that must be removed before touching. Always have another person standing by who is trained in electric shock first aid.

WARNING

For newer models (SN 074100063 and above) use nickel-metal hydride (NiMH) batteries only. DO NOT use nickel-cadmium (NiCAD) in these units. Failure to comply may result in damage to the batteries, damage to the instrument, and injury to personnel from battery chemicals.

WARNING

For SN 074100063 and above, use only Nickel Metal Hydride (NiMH) batteries that have a minimum capacity of 4500 milliamper hours (mAh). Do not install batteries that are not Nickel Metal Hydride. Do not install NiMH batteries that have less than 4500 mAh capacity. Failure to comply may result in damage to the batteries, damage to the instrument, and injury to personnel from battery chemicals.

Caution Statements

The following equipment cautions appear in the text whenever the equipment is in danger of damage, and are repeated here for emphasis.

CAUTION
Never apply RF power to the Model 4391M Wattmeter unless both line section sockets are filled with either an element or a dust plug. If an element is used it is advisable to place the element with the arrow at a 90° angle to the coaxial line.

CAUTION
Always be certain the 115/230 voltage selector is set to the proper voltage before ac power is applied.

CAUTION
Always disconnect AC power before opening the Model 4391 enclosure. Removal of at least one battery cell is also recommended when servicing the instrument.

CAUTION
Applying too much heat could damage the PC board.

CAUTION
This instrument contains static sensitive electronic components. Before opening or servicing the unit, make sure that you understand and practice electrostatic discharge component handling. Failure to comply may result in permanent damage to sensitive components.

CAUTION
Long-term storage of this instrument can affect battery performance and reduce battery life. Do not store the instrument for long periods of time without recharging the batteries (refer to page 20). Failure to comply may result in reduced battery charge and shortened battery life.

CAUTION
If the element cannot be fully inserted into the socket, do not force it. You might damage the element.

CAUTION
Internal batteries are connected. Remove one of the battery tubes before unsoldering wires connected to the Main PCB. Failure to comply may result in permanent equipment damage and severe shock to individuals.

USAGE

ANY USE OF THIS INSTRUMENT IN A MANNER NOT SPECIFIED BY THE MANUFACTURER MAY IMPAIR THE INSTRUMENT'S SAFETY PROTECTION.

USO

EL USO DE ESTE INSTRUMENTO DE MANERA NO ESPECIFICADA POR EL FABRICANTE, PUEDE ANULAR LA PROTECCIÓN DE SEGURIDAD DEL INSTRUMENTO.

BENUTZUNG

WIRD DAS GERÄT AUF ANDERE WEISE VERWENDET ALS VOM HERSTELLER BESCHRIEBEN, KANN DIE GERÄTESICHERHEIT BEEINTRÄCHTIGT WERDEN.

UTILISATION

TOUTE UTILISATION DE CET INSTRUMENT QUI N'EST PAS EXPLICITEMENT PRÉVUE PAR LE FABRICANT PEUT ENDOMMAGER LE DISPOSITIF DE PROTECTION DE L'INSTRUMENT.

IMPIEGO

QUALORA QUESTO STRUMENTO VENISSE UTILIZZATO IN MODO DIVERSO DA COME SPECIFICATO DAL PRODUTTORE LA PROZIONE DI SICUREZZA POTREBBE VENIRNE COMPROMESSA.

SERVICE

SERVICING INSTRUCTIONS ARE FOR USE BY SERVICE - TRAINED PERSONNEL ONLY. TO AVOID DANGEROUS ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING UNLESS QUALIFIED TO DO SO.

SERVICIO

LAS INSTRUCCIONES DE SERVICIO SON PARA USO EXCLUSIVO DEL PERSONAL DE SERVICIO CAPACITADO. PARA EVITAR EL PELIGRO DE DESCARGAS ELÉCTRICAS, NO REALICE NINGÚN SERVICIO A MENOS QUE ESTÉ CAPACITADO PARA HACERIO.

WARTUNG

ANWEISUNGEN FÜR DIE WARTUNG DES GERÄTES GELTEN NUR FÜR GESCHULTES FACHPERSONAL.

ZUR VERMEIDUNG GEFÄHRLICHE, ELEKTRISCHE SCHOCKS, SIND WARTUNGSARBEITEN AUSSCHLIEßLICH VON QUALIFIZIERTEM SERVICEPERSONAL DURCHZUFÜHREN.

ENTRENTIEN

L'EMPLOI DES INSTRUCTIONS D'ENTRETIEN DOIT ÊTRE RÉSERVÉ AU PERSONNEL FORMÉ AUX OPÉRATIONS D'ENTRETIEN. POUR

PRÉVENIR UN CHOC ÉLECTRIQUE DANGEREUX, NE PAS EFFECTUER D'ENTRETIEN SI L'ON N'A PAS ÉTÉ QUALIFIÉ POUR CE FAIRE.

UNITS ARE EQUIPPED WITH RECHAREABLE BATTERIES. THESE ARE TO BE REPLACED BY AUTHORIZED SERVICE PERSONNEL ONLY!!!

LAS UNIDADES VIENEN EQUIPADAS CON BATERIAS RECARGABLES. ¡¡¡Y SOLAMENTE EL PERSONAL DE SERVICIO AUTORIZADO PUEDE REEMPLAZARLAS!!!

GERÄTE SIND MIT WIEDER AUFLADBAREN BATTERIEN BESTÜCKT. BATTERIEN SIND NUR VON QUALIFIZIERTEM SERICE PERSONAL AUSZUWECHSELN!!!

CES DISPOSITIFS SONT ÉQUIPÉS DE BATTERIES RECHARGEABLES. SEUL LE PERSONNEL D'ENTRETIEN AUTORISÉ EST HABILITÉ À LES REMPLACER!

LE UNITÀ SONO DOTATE DI BATTERIE RICARICABILI, CHE DEVONO DA COME SPECIFICATO DAL PRODUTTORE LA PROTEZIONE DI SICUREZZA POTREBBE VENIRNE COMPROMESSA.

USE CORRECT VOLTAGE SETTING AND FUSE - SEE MANUAL.

UTILISER UNE TENSION ET UN FUSIBLE CORRECTS - CONSULTER LE MODE D'EMPLOI.

USE LA INSTALACION Y FUSIBLE DE VOLTAJE CORRECTO - VEA EL MANUAL.

AUSSCHLIESSLICH VORSCHRIFTSMÄSSIGE WECHSELSPANNUNGS-EINSTELLUNG UND SICHERUNG BENUTZEN - SIEHE DAZU HANDBUCH.

UTILLIZZARE TENSIONE E FUSIBLE ADATTI - FARE RIFERIMENTO AL MANUALE.

BE SURE THE 115/230V AC VOLTAGE SELECTOR IS SET TO THE PROPER LINE VOLTAGE, AND THE CORRECT AC LINE FUSE IS INSTALLED BEFORE AC POWER IS APPLIED.

S'ASSURER QUE LE SÉLECTEUR DE TENSION 115/230V C.A. EST BIEN RÉGLÉ POUR LA TENSION DU RÉSEAU ET QUE LE FUSIBLE DE LIGNE C.A. CORRECT EST EN PLACE AVANT DE METTRE SOUS TENSION C.A.

CERCIORESE QUE EL SELECTOR DE VOLTAJE DE 115/230V CA ESTE COLOCADO A LA LINEA DE VOLTAJE APROPIADA Y QUE EL FUSIBLE ESTE INSTALADO A LA LINEA CA ANTES DE APLICAR LA CORRIENTE ALTERNA.

VOR EINSCHALTEN DER WECHSELSTROMZUFUHR SICHERSTELLEN, DASS DER 115/230V WECHSELSPANNUNGS-SELEKTOR AUF DIE VORSCHRIFTSMÄSSIGE LEITUNGSSPANNUNG EINGESTELLT UND DIE RICHTIGE WECHSELSTROM-HAUPTSICHERUNG EINGESETZT IST.

PRIMA DI EROGARE CORRENTE, ASSICURARSI CHE IL SELETTORE DI VOLTAGGIO 115/230 V.C.A. SIA REGOLATO CORRETTAMENTE E CHE IL FUSIBLE ADATTO ALLA LINEA DI ALIMENTAZIONE C.A. SIA INSTALLATO.

RF VOLTAGE MAY BE PRESENT IN RF ELEMENT SOCKET - KEEP ELEMENT IN SOCKET DURING OPERATION.

DE LA TENSION H.F. PEAT ÊTRE PRÉSENTE DANS LA PRISE DE L'ÉLÉMENT H.F. - CONSERVER L'ÉLÉMENT DANS LA PRISE LORS DE L'EMPLOI.

HF-SPANNUNG KANN IN DER HF-ELEMENT-BUCHSE ANSTEHEN - ELEMENT WÄHREND DES BETRIEBS EINGESTÖPSELT LASSEN.

PUEDE HABER VOLTAJE RF EN EL ENCHUFE DEL ELEMENTO RF - MANTENGA EL ELEMENTO EN EL ENCHUFE DURANTE LA OPERACION.

IL PORTAELEMENTO RF PUÒ PRESENTARE VOLTAGGIO RF - TENERE L'ELEMENTO NELLA PRESA DURANTE IL FUNZIONAMENTO.

About This Manual

This instruction book is arranged so that essential information on safety is contained in the front of the book. Reading the Safety Precautions Section before operating the equipment is strongly advised.

The remainder of this manual is divided into Chapters and Sections. Figures and tables are numbered sequentially within each chapter.

Chapter Layout

Introduction

Introduces the external features and functions of the unit, equipment provided, and options available.

Theory of Operation

Describes the overall operation of the circuitry and the instrument functions.

Installation

Provides information about connecting the instrument to your equipment.

Operating Instructions

First time operators should read Chapter 1 - Introduction, Chapter 2 - Theory of Operation, and Chapter 3 - Installation, to get an overview of equipment capabilities and how to install it. Experienced operators can refer to Chapter 4 - Operating Instructions. All instructions necessary to operate the equipment, are contained in this section.

Maintenance

All personnel should be familiar with calibration and repair information found in Chapter 5 - Maintenance. If a failure should occur, the troubleshooting section will aid in isolating and repairing the failure.

Parts Lists

For location of major assemblies or parts refer to the part lists and associated drawings in Chapter 5 - Maintenance.

Changes to this Manual

We have made every effort to ensure this manual is accurate at the time of publication. If you should discover any errors or if you have suggestions for improving this manual, please send your comments to our factory. This manual may be periodically updated, when inquiring about updates to this manual refer to the part number and revision level on the title page.

Table of Contents

Chapter 1 **Introduction**

The Model 4391M is a multi-purpose Radio Frequency wattmeter designed around a microcomputer. A program stored in permanent memory controls the operation of the instrument at all times, permitting the detection and correction of various error sources and the refinement of the raw data produced by the directional detectors. The instrument can compute VSWR, amplitude modulation, and various decibel variables reducing the odds of error and making such measurements consistent or repeatable regardless of who makes the measurement.

Other benefits include extended range using standard elements in some modes of operation, continuous monitoring of maximum and minimum readings, a peaking aid, and error messages.

Because of its complexity, the proper use of the 4391M is not always obvious. For this reason it is strongly advised that this manual be read in its entirety before using the device.

Purpose and Function

The 4391M RF Power Analyst is an insertion type digital RF Directional Thruline® Wattmeter designed to measure peak or average power flow, load match, and amplitude modulation in 50 ohm coaxial transmission lines. It is intended for use with CW, AM, FM, SSB, TV, and Pulse modulation envelopes. The instrument directly reads PEP or CW power in watts, milliwatts, or kilowatts in 9 ranges from 2.5 to 1000 full scale forward power and 0.25 to 100 full scale reflected power depending on the Plug-in Element. In addition it reads SWR directly over the range of 1.00 to 99.99, percent modulation directly over the range of 0.0 to 99.9, and return loss over the range of 0 to 36.1 dB. For convenience, forward and reflected CW power can be displayed in dBm (dB above 1 milliwatt) from 6 dB above to 24 dB below nominal element range.

Power range and frequency band are determined by the Plug-in Elements used. Two switches on the front panel of the instrument are set by the user to correspond to the nominal power range of the forward element. The reflected element is assumed to have a nominal range one tenth that of the forward element.

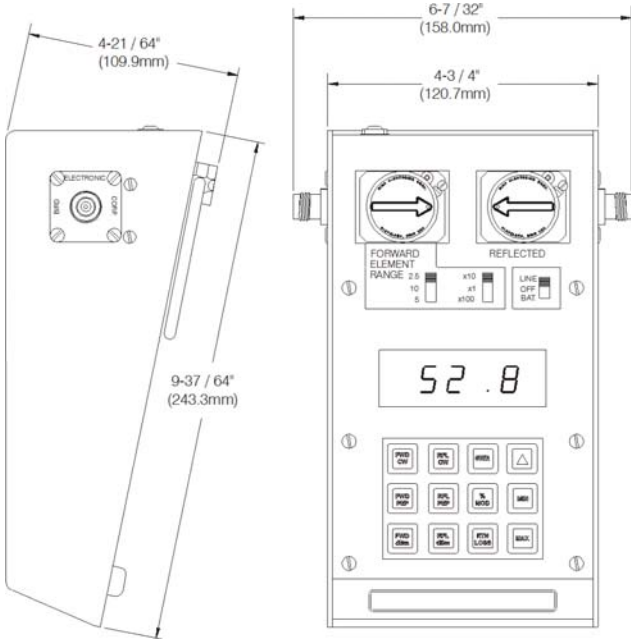
In any mode of operation, the instrument can recall from memory the lowest or highest reading taken or tell the operator whether the newest reading is less than, equal to, or greater than the previous reading.

Description

The instrument is housed in an aluminum case approximately 4-3/8 inches high by 9-5/8 inches deep by 6-1/4 inches wide (111 mm x 244 mm x 159 mm) including connections, see Figure 1. The line section is contained in the case and is not intended for removal. At each end of the line section are Bird Quick-Change type RF connectors which may be easily interchanged with any other Bird QC connector. See Bird Catalog for types available.

Operating power is derived from either rechargeable nickel-metal hydride (NiMH) batteries for SN 074100063 and above, or rechargeable nickel-cadmium (NiCAD) batteries for SN 074100062 and below inside the unit, It can also be powered from a 115/230 VAC power source connected to the unit through the power cord supplied with the unit.

Figure 1 Outline Drawing



Description of Operation

Figure 2 is a block diagram of the major functional parts of the Model 4391M RF Wattmeter. The Microcomputer integrated circuit shown, controls all the other portions of the instrument, which fall into two major groups.

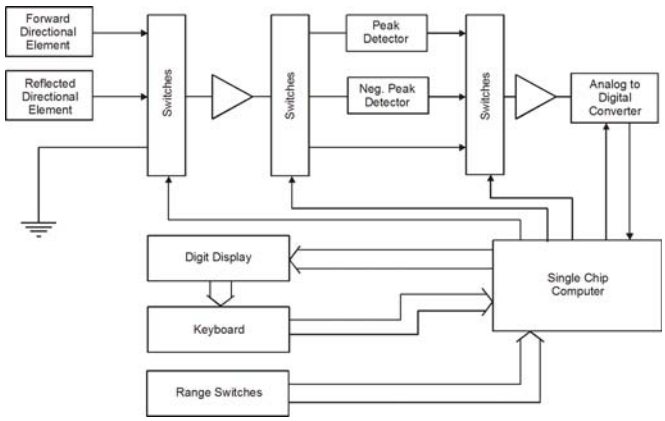
Keyboard, Range Switches, and Display Group

The keyboard and range switches serve only to pass information to the computer. The display, of course, returns information from the computer to the operator. The display, which is comprised of four seven-segment LED digits, is strobed digit by digit left to right at a rate of approximately one digit per millisecond. This serves to conserve battery power and drive circuitry while providing scanning for the columns of the keyboard. Each time a digit is strobed, the corresponding column of the keyboard is read and if a key is pressed, the computer puts the code for that key into a memory cell. The nine mode keys select which parameter is to be measured. The three modifier keys simply modify the way in which the result is displayed. The range selector switches identify to the computer the nominal full scale values of the elements used. They have no effect on input sensitivity, which is determined by the elements.

Elements, Analog Circuitry, and A/D Converter

These components are controlled by the computer. The Plug-in Elements in the line section provide low level positive voltages related to the instantaneous value of power (see Figure 3). The first group of solid state switches selects the forward element, the reflected element, or ground as the input to the preamplifier which boosts these signals to 0.1 to 2.0 volt range. The remaining switches shown as two groups direct the output of the preamp to the analog-to-digital converter either directly or through a peak or negative peak detector. The analog-to-digital converter converts the voltage to a 15 digit binary number.

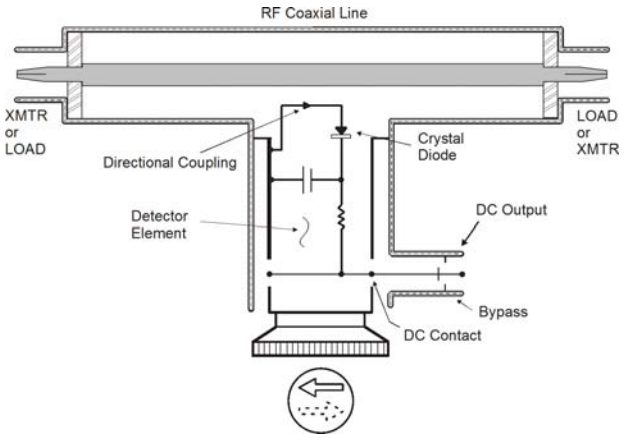
Figure 2 Circuit Block Diagram



Each reading output by the display is derived from up to three voltage readings using the circuitry described above. Once these voltages are measured, all remaining operations are performed within the computer chip as follows:

The voltages are corrected for error due to dc drift in the analog circuitry. Each voltage is converted to square root of power using stored data tables. These values are then combined mathematically to arrive at the final result in binary. This is used to update the registers containing the last value, the maximum value, or the minimum value as required. Finally, the result is converted to a decimal number and placed into a register from which the display driving routine operates.

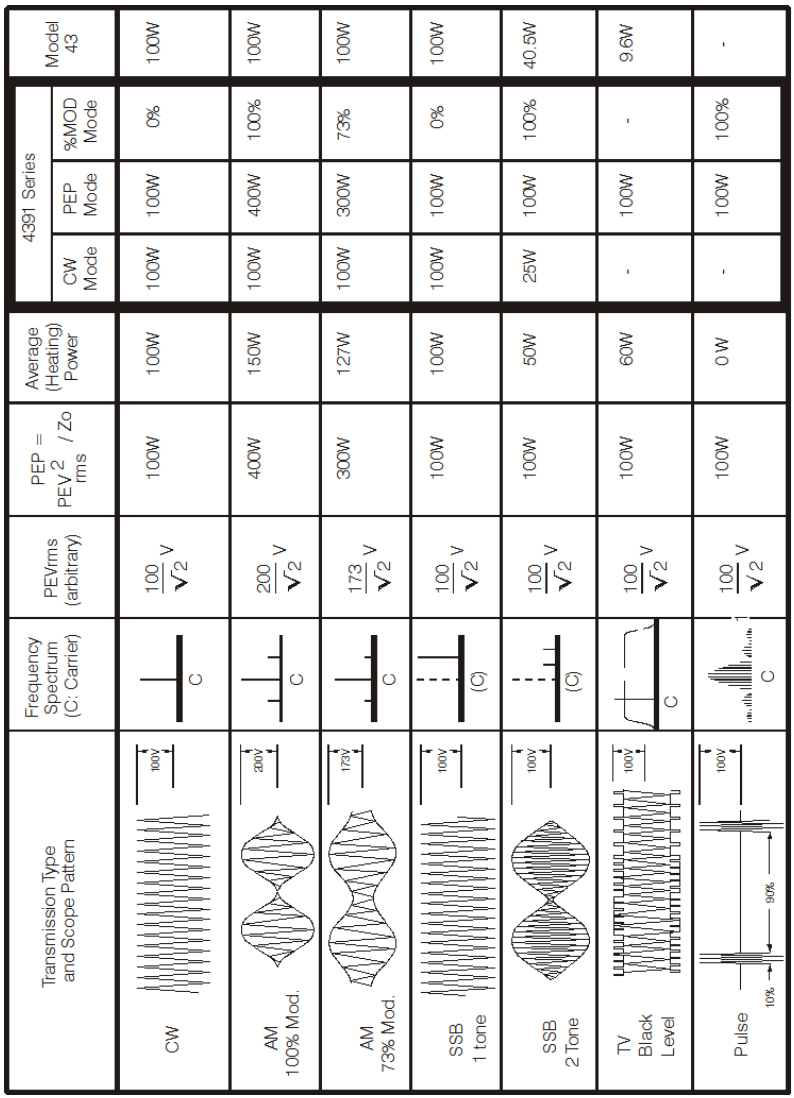
Figure 3 Plug-In Element Schematic Diagram



The coupling circuit that samples the travelling waves is in the Plug-in Element. The circuitry of the element and its relationship to the other components of the Thruline Wattmeter are illustrated in the schematic diagram. Energy will be produced in the coupling circuit of the element by both mutual inductance and capacitance from the travelling RF waves of the line section. The inductive currents will flow according to the direction of the travelling waves producing them. The capacitive portion of these currents is independent of the direction of the travelling waves. Therefore, assuming that the Plug-in Element remains stationary, the coupling currents produced from the waves of one direction will add in phase, and those produced from waves of the opposite direction will accordingly subtract in phase. The additive or “arrow” direction is assigned to the forward wave.

The electrical values of the element circuits are carefully balanced and designed so that current from the reverse wave will cancel the other almost completely. The result is directivity always higher than 25 dB, which means that the element is highly insensitive (nulled) to the REVERSE direction wave. Being highly directional, the Thruline element is sensitive (at one setting) only to one of the travelling waves that produce standing waves by interference. Thruline Wattmeter measurements are, therefore, independent of position along standing waves.

Figure 4 Readings with Various Envelopes



The Model 4391M RF Power Analyst is completely portable and very suitable for field or laboratory use. Its power is derived from either rechargeable nickel-metal hydride (NiMH) batteries for SN 074100063 and above, or rechargeable nickel-cadmium (NiCAD) batteries for SN 074100062 and below inside the unit, It can also be powered from a 115/230 VAC power source connected to the unit through the power cord supplied with the unit.

The batteries are shipped in a low charge state. It is, therefore, recommended that you charge the instrument for 16 hours before using it for continuous operation.

☞ Battery charging at temperatures greater than 45° C (113° F) can result in reduced operational time.

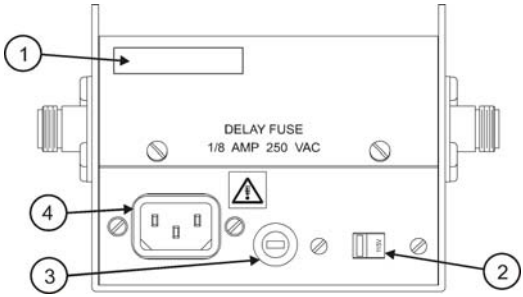
CAUTION
Long-term storage of this instrument can affect battery performance and reduce battery life. Do not store the instrument for long periods of time without recharging the batteries (refer to page 20). Failure to comply may result in reduced battery charge and shortened battery life.

Operating on AC Power

For ac power operation, the Model 4391M is simply connected to an AC receptacle using the line cord provided. The correct AC voltage is selected via a rear panel switch (Figure 5). The meter may be operated in this manner with the batteries removed if desired.

CAUTION
Always be certain the 115/230 voltage selector is set to the proper voltage before ac power is applied.

Figure 5 Rear Panel



Item No.	Description
Figure 5	
1	S/N Number Label
2	AC input voltage selector switch
3	Fuse holder
4	AC power cable connector

Connections

The Model 4391M contains a short section of rigid 50 ohm coaxial air dielectric transmission line. To make measurements relating to the travelling waves in a coaxial line, that line must be disconnected at some convenient point to permit the Model 4391M air line to be inserted.

Although the Model 4391M is normally supplied with two Female N-type connectors, a variety of easily interchangeable connectors are available to facilitate connecting to the user's system.

Once the Model 4391M is installed in the coaxial line, a Plug-in Element or a pair of Plug-in Elements must be selected which correspond to the frequency and power levels to be measured.

☞ NOTE: The instrument is shipped with dust plugs installed in the element sockets. Remove the dust plugs to insert elements.

In order to take full advantage of the Model 4391M's capabilities, two elements in a 10:1 ratio of power range should be used. If only one element is used, the other socket should be filled with a dust plug or a higher power element. Also, for greatest accuracy, the element(s) should be chosen having the lowest possible power range that will not result in over-ranging. Table 1 lists elements required for each mode of operation.

Table 1 Plug-In Elements Required

Mode	Forward	Reflected
FWD CW	✓	
RFL CW		✓
SWR	✓	✓*
FWD PEP	✓	
RFL PEP		✓
% MOD	✓	
FWD dBm	✓	
RFL dBm		✓
RTN Loss	✓	✓*

* The reflected element must have a nominal power range one tenth that of the forward element.

CAUTION
If the element cannot be fully inserted into the socket, do not force it. You might damage the element.

The higher power element is placed in the socket marked "FORWARD" and its arrow pointed in the direction of forward power flow (toward antenna or load). The lower power element is placed in the socket marked

"REFLECTED" and is normally pointed in the direction opposite to forward power flow. The elements are clamped in place by the hold-down catches on the face of the line section. These catches must be used to avoid error due to the element not contacting the bottom or seating plate of the socket. With the element(s) in place, set the range switches to correspond with the nominal power range of the elements. For example, if the forward element is a 5 watt element, the switches are set at 5 and x1. For a 250 watt element they are set at 2.5 and x100. Sometimes it is necessary to use milliwatts or kilowatts as the unit of measure. In other words, 1 watt becomes 10 x 100 milliwatts and 2500 watts becomes 2.5 x 1 kilowatts.

Operating Modes

The Model 4391M has nine modes of operation which are selected by pressing the mode keys momentarily. In addition, each mode has three output options selected by pressing the modifier keys. Detailed descriptions of the modes and output options follow.

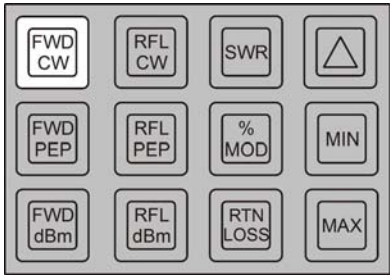
Reading Forward CW Power

For this measurement only a forward element is needed. Install the meter and element according to the preceding paragraphs and move the power switch to LINE or BAT depending on the power source desired. When powered up, the Model 4391M always goes into the forward CW power mode. If the unit is already operating, the forward CW power mode is selected by pressing the FWD CW key momentarily. If the applied power exceeds 120 percent of the range, two right-facing arrow heads (i.e., "greater-than" symbols) will be displayed. The operation of this error message does not depend on the correct setting of the range switches by the operator, nor will the meter or its elements be damaged if the switches are incorrectly set.

CAUTION
Never apply RF power to the Model 4391M Wattmeter unless both line section sockets are filled with either an element or a dust plug. If an element is used it is advisable to place the element with the arrow at a 90° angle to the coaxial line.

CAUTION
Always disconnect ac power before opening the Model 4391M enclosure. Removal of at least one battery cell is also recommended when servicing the instrument.

Figure 6 Forward Power (CW)



The Model 4391M arrives at values of CW power by a method quite different from analog meters such as the Model 43, also manufactured by Bird Electronic. While the two instruments will agree when the measured wave is of constant amplitude, AM or SSB waves will result in different indications (in the CW mode). This is because the analog instrument uses the inertia of the microammeter to "time-

average" the varying signal coming from the element, whereas the Model 4391M uses peak and negative peak detector circuits to measure peak and minimum square root of power and combines them using the equation:

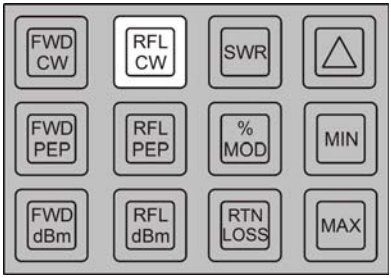
$$\text{CW POWER} = \left(\frac{\sqrt{\text{Peak Power}} + \sqrt{\text{Minimum Power}}}{2}\right)^2$$

With this technique, operation of CW mode is predictable regardless of envelope shape (see Figure 4).

Reading Reflected CW Power

Operation of the reflected CW power mode is identical to that for forward CW power described above with two exceptions: the readings are taken from the element in the socket marked "REFLECTED" and the range of the element is assumed to be 1/10 the range indicated by the range switches.

Figure 7 Reflected Power (CW)



Reading SWR

Two elements with a 10 to 1 power range ratio are required for this mode. Press the SWR key momentarily. If average forward power is between 10% and 120% of the scale and the average reflected power is less than 120% of the reflected element range, SWR will be displayed. If any of the above conditions are not met, an error message will be displayed. Two arrows pointing to the right — or "greater-than" symbols — indicate over-range, while two left-pointing arrows — or "less-than" symbols — indicate under-range or too little power. Refer to Table 2.

Figure 8 Standing Wave Ratio (SWR)

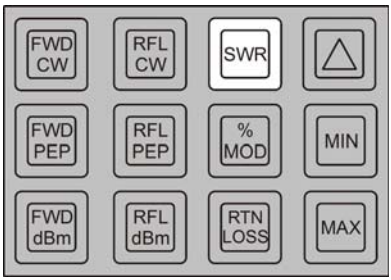


Table 2 Voltage Standing Wave Ratio (VSWR)

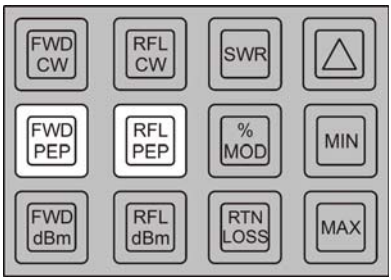
VSWR	Return Loss (dB)	Reflected Power %	VSWR	Return Loss (dB)	Reflected Power %
1.01	46.1	0.00	1.45	14.7	3.37
1.02	40.1	0.01	1.50	14.0	4.00
1.03	36.6	0.02	1.75	11.3	7.44
1.04	34.2	0.04	2.00	9.50	11.11
1.05	32.3	0.06	2.25	8.30	14.79
1.06	30.7	0.08	2.50	7.40	18.37
1.07	29.4	0.11	2.75	6.60	21.78
1.08	28.3	0.15	3.00	6.00	25.00
1.09	27.3	0.19	3.25	5.50	28.03
1.10	26.4	0.23	3.50	5.10	30.86
1.15	23.1	0.49	3.75	4.70	33.52
1.20	20.8	0.83	4.00	4.40	36.00
1.25	19.1	1.23	4.25	4.20	38.32
1.30	17.7	1.70	4.50	3.90	40.50
1.35	16.5	2.22	4.75	3.70	42.53
1.40	15.6	2.78	5.00	3.50	44.44

Measuring Peak Envelope Power

PEP power measurements are made in the same manner as CW power readings described above, except that the FWD PEP and RFL PEP buttons are pressed and the readings are displayed directly as peak power.

☞ NOTE: The accuracy of measurements made with modulation having a frequency, duty cycle, pulse width, or repetition rate outside the instrument range cannot be assured in any mode of operation.

Figure 9 Peak Envelope Power (PEP)



Measuring Amplitude Modulation

Only a forward element is required for this mode. Point the element in the direction of forward power and press % MOD. Modulation is displayed directly in percent, provided the average signal is above 10% and the PEP of the signal is below 400% of the element's nominal full scale. For specified accuracy, the average CW power levels must be greater than one-third of full scale. Modulation is calculated as follows:

$$\text{MODULATION} = \frac{\sqrt{\text{Peak Power}} - \sqrt{\text{Minimum Power}}}{\sqrt{\text{Peak Power}} + \sqrt{\text{Minumum Power}}} \times 100$$

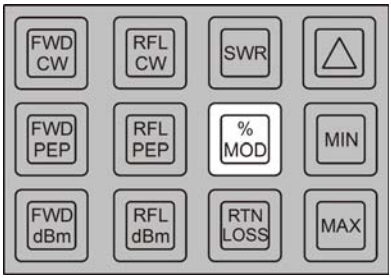
and is therefore limited to the range of 0 to 99.9 percent. Over-modulation will be indicated as 99.9 percent. Refer to Table 3.

Table 3 Amplitude Modulation

Peak / CW Power	% Modulation	Peak / CW Power	% Modulation
1.00	0	2.40	55
1.10	5	2.56	60
1.21	10	2.72	65
1.32	15	2.89	70
1.44	20	3.06	75
1.56	25	3.24	80
1.69	30	3.42	85
1.82	35	3.61	90
1.96	40	3.80	95
2.10	45	4.00	100
2.25	50		

Because of the threshold of the RF diode, a modulated signal which has a minimum power level below 0.3 percent of full scale will result in high modulation reading with uncertain accuracy.

Figure 10 Amplitude Modulation (%)



Measuring Power in dBm

Operation of the forward and reflected dBm modes is identical to the forward and reflected CW power modes, except that the resulting reading is converted to dB above 1 milliwatt before it is displayed. It should be noted that in doing this conversion, the range set on the slide switches is assumed to be watts rather than kilowatts or milliwatts. If it is not, 30.0 must be added to all dBm readings when the range is in kilowatts, or subtracted from all readings when it is in milliwatts. An error message is displayed if CW power is more than 24 dB below, or peak power is more than 6 dB above the nominal element range. Refer to Table 4.

Figure 11 CW Power in dBm

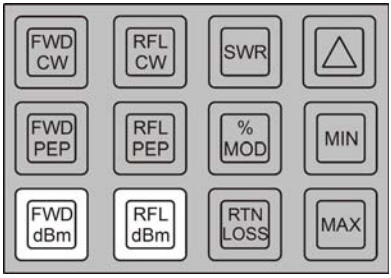


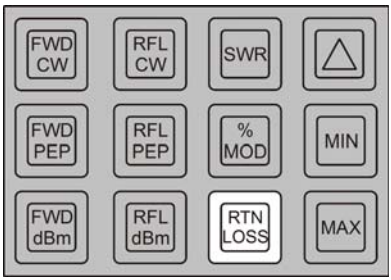
Table 4 Watts / dBm Equivalents

Power	dBm	Power	dBm
1 milliwatt	0	4 watts	36
10 milliwatts	10	10 watts	40
100 milliwatts	20	20 watts	43
1 watt	30	40 watts	46
2 watts	33	100 watts	50

Measuring Return Loss

The measurement of return loss is the same as that of SWR except that the result is displayed in dB. In other words a reading of 21.65 indicates that reflected power is 21.6 dB down from forward power.

Figure 12 Return Loss, Insertion Loss, or Attenuation



Insertion Loss or Attenuation

Attenuation or insertion loss can be measured directly using an external single port line section (P/N 4230-006-1), a dc feed-in adapter (P/N 4381-050), and a dc cable (P/N 3170-058-6). The Model 4391M is inserted at the source end of the device being measured. The second line section is inserted at the load end and its dc output is routed by the dc cable to the adapter inserted in the REFLECTED socket of the Model 4391M. Both elements are in this case pointed in the direction of forward power flow. If the two elements do not have a ten to one ratio, a correction factor must be added to or subtracted from the “return loss” reading see Table 5, depending on the ratio of the elements.

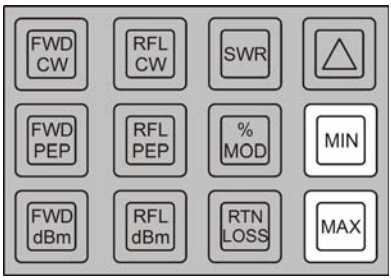
Table 5 Correction Factors

Ratio of Elements	Added dB	Ratio of Elements	Added dB
1:1	–10	100:1	10
2:1	–7	200:1	13
2.5:1	–6	250:1	14
4:1	–4	400:1	16
5:1	–3	500:1	17
10:1	0	1000:1	20
20:1	3	2000:1	23
25:1	4	2500:1	24
40:1	6	4000:1	26
50:1	7	5000:1	27

Monitoring Maximum and Minimum Readings

While operating in any of the modes described, the Model 4391M will continuously keep track of the highest and lowest reading obtained. This action begins after ten reading cycles to allow time for the peak detectors to settle from the previous mode. To recall the maximum or minimum reading, depress and hold the MAX or MIN key. When these keys are released, the meter goes back to displaying the current value of the parameter being measured. Recalling max or min does not stop the meter from continuing to monitor the current value and updating the minimum and maximum registers. To clear the minimum and maximum register, the mode key must be pressed again or a new mode selected. For example, if CW power deviations are monitored, the Model 4391M is installed as described at the beginning of this section and turned on, then the power source is turned on and allowed to stabilize. Once the system has stabilized, press FWD CW to clear the MAX and MIN registers. At any time during test the MAX and MIN keys can be used to recall the maximum and minimum values without affecting the test. However, pressing the FWD CW key or changing modes will clear the registers.

Figure 13 Maximum or Minimum Readings

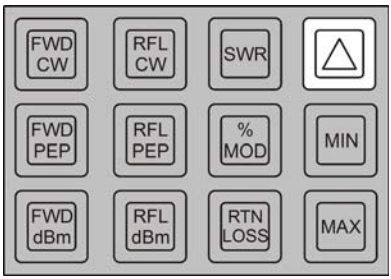


Using the Peaking Aid

The peaking aid is useful for making adjustments to optimize any of the parameters which the Model 4391M measures. After the mode is selected, press the delta (Δ) key momentarily. This blanks the least significant digit of the display, and replaces it with a right-facing arrow head if the

measured quantity is increasing or a left-facing arrow head if it is decreasing. If there is no change, the digit is left blank. To find a peak, begin making the adjustment in whichever direction produces a right-facing arrow and continue slowly in that direction until the arrow head turns around. At this point the peak has been reached. To check to make sure the peak has not been passed, press the MAX key to read the highest value read and release it to read the current value. The two should be the same. Desired minimum levels (e.g. of reflected power or of SWR) are found in a similar manner.

Figure 14 Peaking Aid (Δ)



Battery Safety

WARNING
For newer models (SN 074100063 and above) use nickel-metal hydride (NiMH) batteries only. DO NOT use nickel-cadmium (NiCAD) in these units. Failure to comply may result in damage to the batteries, damage to the instrument, and injury to personnel from battery chemicals.

Battery Care (SN 074100062 and below)

With average use, the nickel-cadmium batteries in the 4391M will power the unit for eight hours before needing recharged. The 4391M will maintain rated accuracy until all the decimal points light, indicating that recharging is required. To recharge, connect the AC power to the unit. This takes approximately 14 hours. To prolong the life of the batteries, it is recommended that they be allowed to discharge until the decimal points light periodically before recharging. If the batteries lose the ability to hold a charge they can be replaced with standard C-size nickel cadmium batteries. See Chapter 5 - Maintenance for important precautions regarding static electricity when opening the housing.

CAUTION
Always be certain the 115/230 voltage selector is set to the proper voltage before ac power is applied.

Battery Care (SN 074100063 and above)

With average use, the nickel-metal hydride batteries in the 4391M will power the unit for twelve hours before needing recharged. The 4391M will maintain rated accuracy until all the decimal points light, indicating that recharging is

required. To recharge, connect the AC power to the unit. This takes approximately 16 hours. To prolong the life of the batteries, it is recommended that they be allowed to discharge until the decimal points light periodically before recharging. If the batteries lose the ability to hold a charge they should be replaced with standard C-size nickel-metal hydride batteries. See Chapter 5 - Maintenance for important precautions regarding static electricity when opening the housing.

WARNING

For SN 074100063 and above, use only Nickel Metal Hydride (NiMH) batteries that have a minimum capacity of 4500 milliamper hours (mAh). Do not install batteries that are not Nickel Metal Hydride. Do not install NiMH batteries that have less than 4500 mAh capacity. Failure to comply may result in damage to the batteries, damage to the instrument, and injury to personnel from battery chemicals.

CAUTION

Long-term storage of this instrument can affect battery performance and reduce battery life. Do not store the instrument for long periods of time without recharging the batteries (refer to page 20). Failure to comply may result in reduced battery charge and shortened battery life.

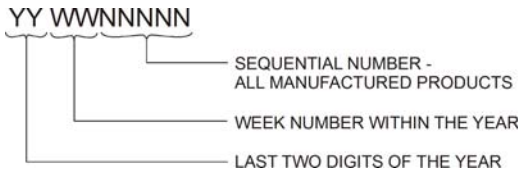
General

The 4391M RF Power Analyst was designed and built to provide many years of trouble free service. This section provides the information needed to prevent and correct equipment failure.

Unit Serial Numbering

Since the introduction of the 4391M product, there have been two different methods of serializing the instruments. The first is a five character serial number that is sequential for the 4391M product. With the five character format, serial number 01002 was manufactured *before* serial number 12115.

The second is a nine character serial number that is sequential for any given *week* of manufacturing for *all products* produced. This method includes the year, week, and a sequential number. The first two characters are the year, the second two characters are the week within that year, and the last five characters are a sequential number for products manufactured within that week. The following examples illustrate this method.



For the 15th week in the year 2001 and the 150th product manufactured, the serial number will be 011500150.

Example: 012505789 was manufactured *before* 035202019, and 074500017 was manufactured *after* 074007759.

Preventive Maintenance

To avoid unnecessary damage, always observe the following cautions:

1. The RF Power Analyst is a rugged and portable instrument intended for field use. However, it should not be unnecessarily exposed to extreme environmental conditions.
2. When not in use, store the RF Power Analyst in a carrying case, Check to see that the LINE/OFF/BATT switch is in the off position.
3. Charge the batteries for 16 hours prior to extended use of the RF Power Analyst. Refer to "Battery Care (SN 074100063 and above)" on page 17.

Cleaning and Inspection

Periodic inspection must be performed to ensure that the RF power analyst is always operational. Any damage noticed during inspection should be listed and repaired before use.

1. Visual inspect the equipment for loose or damaged parts.
2. Wipe any dust and dirt from the front panel and lower housing of the RF Power Analyst. Remove stubborn dirt with mild detergent and a soft cloth.

WARNING

Use cleaning solvents in a well ventilated area. Avoid excessive inhalation of solvent fumes, since they can be toxic in heavy concentrations. Always wear eye protection and avoid skin contact with the solvent.

3. Clean the inside of the line section bores using cotton swab stick dampened with alcohol or any acceptable cleaning fluid.
4. Visually inspect the RF connectors for any sign of wear or damage and replace if necessary. Clean the connectors with alcohol or any acceptable cleaning fluid.
5. Verify equipment operation using performance verification test in "Performance Verification Test" on page 21.

Long-term Storage

Do not store the instrument for long periods of time without recharging the batteries. When the instrument is stored for long periods of time without use, the batteries will loose their charge and also loose the ability to reach full charge when put into service. To restore the battery charge, perform a full charge according to the chart below:

Battery	Recharge Time
NiMH (SN 074100063 and above)	16 hours
NiCAD (SN 074100062 and below)	14 hours

If the batteries are not fully charged after that time, completely discharge the batteries then perform a full charge again. If necessary, repeat this discharge and charge cycle up to three times. If the batteries do not remain charged after three discharge-charge cycles, replace the batteries.

WARNING
For SN 074100063 and above, use only Nickel Metal Hydride (NiMH) batteries that have a minimum capacity of 4500 milliampere hours (mAh). Do not install batteries that are not Nickel Metal Hydride. Do not install NiMH batteries that have less than 4500 mAh capacity. Failure to comply may result in damage to the batteries, damage to the instrument, and injury to personnel from battery chemicals.

Performance Verification Test

The following test will determine if the RF Power Analyst's circuitry is operating properly. It is also used in equipment troubleshooting to isolate faults.

Table 6 Required Maintenance Equipment

Equipment	Recommended Model	Use		
		V	C	T
Function Generator	Hewlett Packard HP3325A	✓		✓
Calibrator/Source	Keithly Model 263	✓	✓	✓
Digital Multimeter	Hewlett Packard HP3455A	✓		✓
BNC T Connector	Kings No. KC-98-02	✓		✓
Cable Assembly (2 Required)	BNC to BNC (1 meter long)	✓	✓	✓
DC Feed-in Element (2 required)	Bird Electronic 4381-050	✓	✓	✓
V-Verification C-Calibration T-Troubleshooting				

Required Equipment

Refer to Table 6 for the test equipment needed to perform the verification test. This equipment is available at most calibration labs. If the exact equipment is not available, a similar item can be substituted with reduced confidence in the results.

Initial Setup

On a clean flat workspace perform the following setup procedure:

1. Plug one DC feed-in adapter into the FWD element socket on the RF Power Analyst and another into the RFL element socket.
2. Attach the BNC "T" adapter to the FWD DC feed-in adapter. Connect one end of a BNC to BNC cable assembly to the function generator output and the other to the BNC "T". Connect the multimeter to the remaining port on the BNC "T" adapter.
3. Connect a BNC to BNC cable assembly from the output of calibrator/source to the RFL DC feed-in adapter.
4. Set the RF Power Analyst range switches to the 10 and x10 positions. Connect AC power and place the LINE/OFF/BATT switch to the LINE setting.
5. Switch on the function generator and the Calibrator/Source. Allow the equipment to warm up.
6. Adjust the function generator to produce an 11.60 ±0.05 millivolt RMS signal at 1000 ±10 Hz. Adjust the generator controls to obtain 25.45 ±0.05 millivolt of DC offset.
7. Set the calibrator/source to output 10.04 ±0.04 microamps.

Test Procedure

Select each mode/range combination listed in Table 7. Compare the displayed values to the limits listed in the normal indication column. If the equipment fails any portion of this test, use the troubleshooting procures to isolate the fault and repair it.

Table 7 Performance Verification Test Results

MODE	Range Switch	Normal Indication
FWD CW	10 x 10	42.7 to 46.0 Watts
RFL CW	10 x 10	1.90 to 2.08 Watts
SWR	10 x 10	1.51 to 1.57
FWD PEP	5 x 100	485 to 512 Watts
RFL PEP	5 x 100	9.5 to 10.4 Watts
% MOD	5 x 100	49.0 to 51.0%
FWD dBm	2.5 x 1	30.2 to 30.6 dBm
RFL dBm	2.5 x 1	16.8 to 17.1 dBm
RTN LSS	2.5 x 1	13.2 to 3.7 dB

Calibration

The RF Power Analyst should be calibrated once each year or after any repair.

Required Equipment

Refer to Table 6 for test equipment needed to calibrate the RF Power Analyst. This equipment is available at most calibration labs. if the exact equipment is not available, a similar item can be substituted with reduced confidence in the results.

Initial Setup

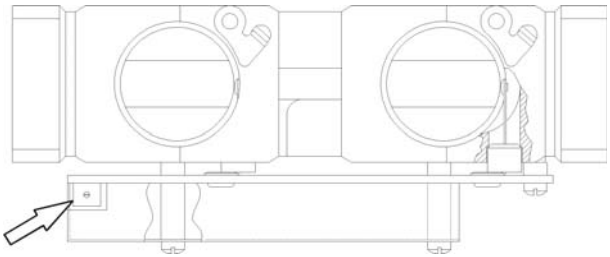
On a clean flat workspace perform the following setup procedure:

1. Remove the front panel from the lower housing assembly refer to “Front Panel Removal” on page 28.
2. Plug a DC feed-in adapter into the FWD element of the socket on the RF Power Analyst. Plug a metal dust plug into the RFL element socket.
3. Connect a BNC to BNC cable assembly from the output of calibrator/source to the DC feed-in adapater.
4. Set the RF Power Analyst range switches to the 10 and x100 positions. Connect AC power and place the LINE/OFF/BATT switch to the LINE setting.
5. Switch on the Calibrator/Source and let it warm up for at least one hour.
6. Set the Calibrator/Source to output 30 ±0.05 microamps.

Calibration Adjustment

Adjust potentiometer, R25, until the RF Power Analyst Displays 1000 ±5. Use the performance verification test, page 21, to verify correct operation of the RF Power Analyst.

Figure 15 Calibration Potentiometer, R25



Element Wiper Contact Adjustment

Occasionally, the element wipers must be adjusted to make a proper connection with the Plug-in Elements. If the wipers are recessed too far, use a small screwdriver to gently adjust them outward. Be careful not to bend them out so far as to interfere with insertion of the elements.

> CAUTION
> If the element cannot be fully inserted into the socket, do not force it. You might damage the element.

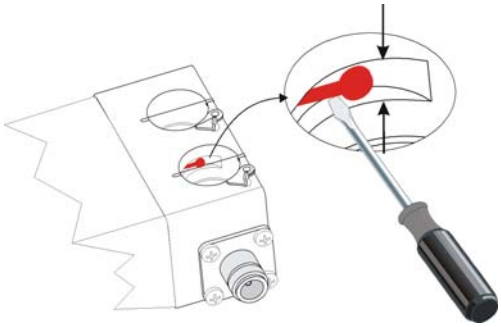
Continuous insertion or rotation of the element might cause a slight change in the position of the contact spring in the element socket. If the contact spring changes position, you might experience erratic power readings.

You can use a small screwdriver to adjust the position of the contact spring. Be careful not to bend the spring out so far that it interferes with insertion of the elements.

Perform the following steps to adjust the contact spring.

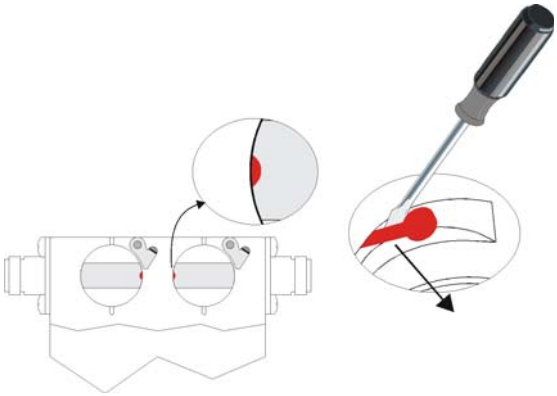
1. Using a small flat head screwdriver, place the flat side of the screwdriver behind the contact bar as indicated and bend the contact bar so that the contact rests in the center of the slot adjacent to the element socket (Figure 16).

Figure 16 Adjust Element Contact Up and Down



2. After centering the contact, bend it slightly toward the center of the element socket bore, so that the profile of the element contact is visible when viewing the element socket from the top of the socket bore (Figure 17).

Figure 17 Adjust Element Contact In and Out



3. If the contact is accidently moved too far into the element bore, the element will not slide into the socket. Move the contact back into the recessed area and repeat the process.

Troubleshooting

General

The troubleshooting instructions are intended to aid in isolation faults at a component/assembly level. This is accomplished through the use of a troubleshooting table and schematic diagrams.

First, locate the symptom(s) in the problem column of Table 8. In some cases the same fault can have more than one symptom and more than one possible remedy. Compare the possible causes until you arrive at a suspected fault. Once a fault has been isolated, repair or replace the defective components or assemblies.

☞ NOTE: Always recalibrate the RF Power Analyst after repairing the fault.

It is never possible to anticipate all types of failure. If a failure is not listed in troubleshooting or Table 8.

Table 8 Troubleshooting

PROBLEM	POSSIBLE CAUSE	REMEDY
Inaccurate power readings	RF Power Analyst uncalibrated	Recalibrate.
	Defective Plug-in Elements	Replace defective elements.
	Intermittent connection at the element wiper	Adjust the element wiper contact.
	Loose hold down catch	Readjust catch to hold element securely in place.
	Worn line section	Replace line section.
	Defect on Data Acquisition PC board assembly	Replace the PC board assembly (attached to line section). Refer to “Line Section Removal” on page 30.
High standing waves	Dirty Connectors	Clean the connectors.
	Worn or damaged connectors	Replace the connectors
	Foreign objects in line section	Remove object from the line section.
Short battery life	115/230V switch in wrong position	Set 115/230V switch to correct position.
	Damaged/worn batteries	Replace the batteries.
Will not operate from AC line	115/230V switch in wrong position	Set 115/230V switch to correct position.
	Blown fuse	Replace blown fuse.
	Defective line cord	Repair or replace.
Display indicates “0” Power	Element wiper not contacting the element	Readjust the element wiper to make good contact.
	Defective Plug-in Element	Replace Plug-In Element.
	Defect on Data Acquisition PC board assembly	Replace the PC board assembly (attached to line section). Refer to “Line Section Removal” on page 30.

PROBLEM	POSSIBLE CAUSE	REMEDY
One segment of a display does not light	Defective Display	Replace the display.
All decimal points stay lit	Low charge on the batteries	Recharge the batteries.
	Defect on Main PC board assembly.	Replace the Main circuit board assembly. Refer to “Main Printed Circuit (PC) Board Removal” on page 28.
Same segment on all displays doesn’t light	Defect on Main PC board assembly.	Replace the Main circuit board assembly. Refer to “Main Printed Circuit (PC) Board Removal” on page 28.
One or more keys do not function	Defect on Main PC board assembly.	Replace the Main circuit board assembly. Refer to “Main Printed Circuit (PC) Board Removal” on page 28.

Disassembly

WARNING
Be sure that the power cable is unplugged before opening the wattmeter case. The power supply capacitor, C1 or C11 (depending upon model), can retain a dangerous charge that must be removed before touching. Always have another person standing by who is trained in electric shock first aid.

CAUTION
This instrument contains static sensitive electronic components. Before opening or servicing the unit, make sure that you understand and practice electrostatic discharge component handling. Failure to comply may result in permanent damage to sensitive components.

Front Panel Removal

1. Disconnect instrument from AC power.
2. To remove the front panel, first loosen six phillips oval head screws (Figure 28, item 5) from side of lower housing.
3. Unscrew six phillips pan head screws (21) from top of panel.
4. Remove four pan head screws (12) and two lock washers (13) securing the front panel at the bottom and the back of the lower housing.
5. Lift the front panel from the rear. Be careful to clear the line section blocks and remove from the lower housing.
6. Remove pads (26) from toggle switches (S1, S2, and S3)

Main Printed Circuit (PC) Board Removal

SN 074100062 and below or SN 082700314 to 120801479

1. With the front panel removed (Refer to "Front Panel Removal" on page 28) unscrew four lower phillips oval head screws (Figure 28, item 5) and remove four countersunk lock washers (6).
2. Tilt the Main PC board assembly (7) up to expose its underside. Carefully cut and remove two shrink tubes (24) at switch (S3).

CAUTION
Internal batteries are connected. Remove one of the battery tubes before unsoldering wires connected to the Main PCB. Failure to comply may result in permanent equipment damage and severe shock to individuals.

3. Unsolder and remove the red and orange wires from the toggle switch (S3).
4. Unsolder and remove the brown wire from the Main PC Board assembly.
5. Unscrew remaining two phillips oval head screws (5) and remove two countersunk lock washers (6).
6. Disconnect cable assembly (8) at header (P1) and (27) from J3. Remove main PC board from lower housing assembly.

7. Unscrew four pan head screws (Figure 45, item 30) and remove supports (28) and (29). Remove the four lock washers (31).

SN 074100063 to SN 082700313

1. With the front panel removed (Refer to "Front Panel Removal" on page 28) unscrew four lower phillips oval head screws (Figure 29, item 4) and remove four countersunk lock washers (5).
2. Tilt the Main PC board assembly (Figure 30, item 6) up to expose its underside. Carefully cut and remove two shrink tubes (22) at switch (S3).

> CAUTION
> Internal batteries are connected. Remove one of the battery tubes before disconnecting wires connected to the Main PCB. Failure to comply may result in permanent equipment damage and severe shock to individuals.

3. Unsolder and remove the red and orange wires from the toggle switch (S3).
4. Unsolder and remove the brown wire from the Main PC Board assembly.
5. Unscrew remaining two phillips oval head screws (4) and remove two countersunk lock washers (5).
6. Disconnect cable assembly (7) at header (P1) and (27) from J3. Remove main PC board from lower housing assembly.
7. Unscrew three pan head screws (Figure 46, item 2). Remove the three lock washers (3).
8. Remove one pan head screw (10) and its lock washer (3) and remove supports (4) and (9).

☞ NOTE: There is a spacer (11) under the PCB that this screw passes through. Take care to keep it for reassembly.

SN 120801480 and above

1. With the front panel removed (Refer to "Front Panel Removal" on page 28) unscrew four lower phillips oval head screws (Figure 31, item 5) and remove four countersunk lock washers (6).
2. Tilt the Main PC board assembly (7) up to expose its underside.

> CAUTION
> Internal batteries are connected. Remove one of the battery tubes before unsoldering wires connected to the Main PCB. Failure to comply may result in permanent equipment damage and severe shock to individuals.

3. Carefully disconnect the power supply wire assembly (item 2) from the back side of the main PCBA..
4. Unscrew remaining two phillips oval head screws (5) and remove two countersunk lock washers (6).
5. Remove main PC board from lower housing assembly.
6. Unscrew four pan head screws (Figure 45, item 30) and remove supports (28) and (29). Remove the four lock washers (31).

Line Section Removal

(SN 01723 and below)

1. Remove the main printed circuit (PC) board. Refer to "SN 074100062 and below or SN 082700314 to 120801479" on page 28.
2. Unscrew eight pan head screws (Figure 28, item 10). Remove two "QC" connectors (9) by pulling away from the line section assembly (4).
3. Unscrew four pan head screws (23) that secure line section assembly to the lower housing. Remove four lock washers (22).
4. Using minimum pressure, spread apart the sides of the lower housing assembly just far enough to allow the line section assembly to be removed.
5. Unscrew two pan head screws (Figure 41, item 8) and remove cover (10) and two spacers (9) from the line section (1).
6. Disconnect the ribbon cable assembly from the PC board header (J1).
7. Unscrew two fillister head screws (5) and pull PC board assembly (2) away from the line section subassembly. Remove two spacers (4).
8. Remove keying beads (3) from the element wiper contacts on the PC board assembly.
9. Unscrew four fillister head screws (7). Remove two supports (6) from the line section subassembly.

(SN 01724 and above)

1. Remove the main printed circuit (PC) board. Refer to SN 074100062 and below or SN 082700314 to 120801479 on page 28.
2. Unscrew eight pan head screws (Figure 28, item 10). Remove two "QC" connectors (9) by pulling away from the line section assembly (4).
3. Unscrew four pan head screws (23) that secure line section assembly to the lower housing. Remove four lock washers (22).
4. Using minimum pressure, spread apart the sides of the lower housing assembly just far enough to allow the line section assembly to be removed.
5. Unscrew two 4-40 hex nuts (Figure 42 item 8) and remove cover (10) and two spacers (9) from the standoffs (12) on the line section (1).
6. Disconnect the ribbon cable assembly from the PC board header (J1).
7. Unscrew two fillister head screws (5) and pull PC board assembly (2) away from the line section subassembly. Remove two spacers (4), and unscrew two standoffs (12) with two lock washers (11).
8. Remove keying beads (3) from the element wiper contacts on the PC board assembly.
9. Unscrew four fillister head screws (7). Remove two supports (6) from the line section subassembly.

Transformer Assembly Removal (SN 074100062 and below)

1. Remove line section assembly from the lower housing. Refer to Line Section Removal, (SN 01723 and below) or (SN 01724 and above).
2. Unscrew two pan head screws (Figure 32, item 13) that secure the rear panel assembly (16) to the lower housing. Remove two lock washers (14).
3. Carefully cut shrink tubing (21) away from the wires on the voltage selector switch.
4. Unsolder and remove the four wires from the switch that connect to the transformer. Remove rear panel assembly.
5. Carefully cut the shrink tubing (18) and (19) away from the positive and negative terminals of battery holder (7).
6. Unsolder and remove the brown and red wires and the resistor lead (R16) from the battery holder terminals.
7. Unscrew two pan head screws (13) that secure the transformer assembly (12) to the lower housing. Remove two lock washers (14), two flat washers (20) and two elastic locknuts (15).

PC Board Power Supply Removal (SN 074100063 to 120801479)

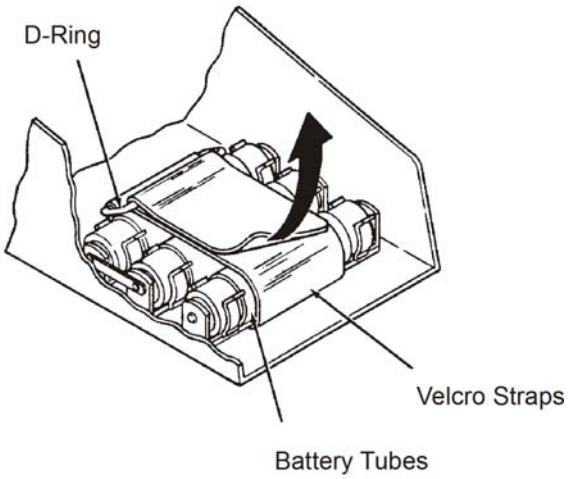
1. Remove line section assembly from the lower housing. Refer to Line Section Removal (SN 01724 and above).
2. Unscrew two pan head screws (Figure 33, item 4) and lock washers (5) that secure the rear panel assembly (3) to the lower housing.
3. Carefully cut shrink tubing (15) away from the wires on the voltage selector switch (Figure 33).
4. Unsolder and remove the four wires from the voltage selector switch to the PC board (6). Remove rear panel assembly.
5. Carefully cut the shrink tubing (14) away from the positive and negative terminals of battery holder (26).
6. Unsolder and remove the brown and red wires from the battery holder terminals.
7. Unscrew four screws (2) and lock washers (1) that secure the PC board assembly (6) to the lower housing.
8. Remove the PC board power supply assembly.

PC Board Power Supply Removal (SN 120801480 and above)

1. Remove line section assembly from the lower housing. Refer to Line Section Removal (SN 01724 and above).
2. Unscrew two pan head screws (Figure 34, item 3) and lock washers (4) that secure the rear panel assembly (5) to the lower housing.
3. Carefully pull away the wire quick disconnects on the voltage selector switch (5).
4. Remove rear panel assembly.
5. Carefully disconnect the power supply wire assembly (item 2) from the back side of the main PCBA.
6. Unscrew four screws (17) and lock washers (11) that secure the PC board assembly (2) to the lower housing.
7. Remove the PC board power supply assembly.

Repair

Figure 18 Battery Replacement



Repair is limited to replacing defective parts with new ones. Refer to Chapter 5 for a complete list of parts used in the RF Power Analyst. Use of parts not specified in the parts list is not recommended.

CAUTION

The RF Power Analyst contains MOS (metal oxide semiconductor) integrated circuits, which may be damaged by static electricity. Open the housing on a grounded conductive work surface and use standard antistatic precautions.

WARNING

Be sure that the power cable is unplugged before opening the wattmeter case. The power supply capacitor, C1 or C11 (depending upon model), can retain a dangerous charge that must be removed before touching. Always have another person standing by who is trained in electric shock first aid.

WARNING

For newer models (SN 074100063 and above) use nickel-metal hydride (NiMH) batteries only. DO NOT use nickel-cadmium (NiCAD) in these units. Failure to comply may result in damage to the batteries, damage to the instrument, and injury to personnel from battery chemicals.

WARNING
For SN 074100063 and above, use only Nickel Metal Hydride (NiMH) batteries that have a minimum capacity of 4500 milliamper hours (mAh). Do not install batteries that are not Nickel Metal Hydride. Do not install NiMH batteries that have less than 4500 mAh capacity. Failure to comply may result in damage to the batteries, damage to the instrument, and injury to personnel from battery chemicals.

Battery Replacement

1. With the front panel removed (Refer to "Front Panel Removal" on page 28) unscrew the lower front four of the six phillips oval head screws (Figure 28, page 54, item 5) and remove four countersunk lock washers (6). Loosen the two back screws (5).
2. Tilt the Main PC board assembly (7) up to expose the batteries.
3. Peel apart velcro strap (Figure 18). Remove six batteries and three battery tubes from the battery holder.
4. Install six new batteries and three battery tubes into the battery holder. Be sure to observe proper polarity.
5. Feed the loose end of the Velcro strap (Figure 18) through the D ring. Tighten the strap until the batteries are held firmly into place. Secure the strap by pressing it firmly into place.
6. Lower the PC board assembly and align the mounting holes. secure the PC board to the lower housing with four phillips oval head screws (5) and for countersunk lock washers (6). Tighten the two remaining screws.
7. Charge the batteries for 16 hours before using the RF Power Analyst. Refer to "Battery Care (SN 074100063 and above)" on page 17.

Reassembly

WARNING
Use cleaning solvents in a well ventilated area. Avoid excessive inhalation of solvent fumes, since they can be toxic in heavy concentrations. Always wear eye protection and avoid contact with the solvent.

CAUTION
The RF Power Analyst contains MOS (metal oxide semiconductor) integrated circuits, which may be damaged by static electricity. Open the housing on a grounded conductive work surface and use standard antistatic precautions.

Transformer Assembly Replacement (SN 074100062 and below)

1. Secure transformer assembly (Figure 32, item 12) into the lower housing with two pan head screws (13), two lock washers (14), two flat washers (20), and two new elastic locknuts (15). Do not reuse old locknuts.
2. Slip one shrink tube (19) over brown transformer wire and slide back away from end. Attach and solder brown transformer wire to the negative terminal of battery holder (7). Remove any residual flux and contaminants. Slide the tube over the connection and apply heat to shrink.
3. Slip one shrink tube (18) over both the red wire and the lead of the resistor (R16). Attach and solder both wires to the positive terminals of the battery holder. Remove any flux and contaminants. Slide the tube over the connection and apply heat to shrink.
4. Slide one shrink tube (21) over each of the fours wires from the transformer assembly (12) and slide back away from the ends. Attach and solder the wires to the terminals on the voltage selector switch (item 16, detail A). Remove any residual flux and contaminants. Slide the tubes over the connections and apply heat to shrink.
5. Attach the rear panel assembly (16) to the lower housing assembly using the two pan head screws (Figure 32, item 13) and lock washers (14).
6. Install the line section assembly into the lower housing. Refer to Line section reassembly, SN 01723 and below.

PC Board Power Supply Replacement (SN 074100063 to 120801479)

1. Install and secure the PC board power supply assembly to the lower housing using the four screws Figure 33, item (2) and lock washers (1).
2. Install shrink tubing (14) over both the brown and red wires then solder them to the battery holder terminals (26).
3. Install shrink tubing (15) over the four wires that connect to the voltage selector switch to the PC board (6) then solder the wires to the voltage selector switch (Figure 33, page 63, item 3, detail A).
4. Attach the rear panel assembly to the lower housing assembly using the two pan head screws (Figure 33, item 4) and lock washers (5).
5. Install the line section assembly to the lower housing. Refer to Line section reassembly SN 01724 and above.

PC Board Power Supply Replacement (SN 120801480 and above)

1. Install and secure the PC board power supply assembly to the lower housing using the four screws Figure 34, item (17) and lock washers (11).
2. Carefully connect the power supply wire assembly (item 2) to the back side of the main PCBA (Figure 31, item 7).
3. Connect the four wire disconnects to the voltage selector switch on the rear panel (Figure 34, item 5).
4. Attach the rear panel assembly to the lower housing assembly using the two pan head screws (Figure 34, item 3) and lock washers (4).
5. Attach the line section assembly to the lower housing. Refer to Line section reassembly SN 01724 and above.

Line section reassembly

SN 01723 and below

1. Attach two supports (Figure 41, item 6) to the line section subassembly (1) using four fillister head screws (7).
2. Install one keying bead (3) onto each element wiper contact of the printed circuit (PC) board assembly (2). Connect cable assembly to PC board header (J1).
3. Place this assembly on a flat surface with the flat side facing up. Position one spacer (Figure 41, item 4) over each of the four threaded holes. Gently lower the PC board assembly into place, lining up the four mounting holes with the threaded hole in the line section assembly. Screw two fillister screws (5) into holes 2 and 4.
4. Position two spacers (9) over the reaming mounting holes (1 and 3). Place cover (10) over PC board subassembly and secure with two pan head screws (8).
5. Gently spread apart the sides of the lower housing just far enough to allow installation of the line section assembly (Figure 28, item 4). Secure with four pan head screws (23) and four lock washers (22).
6. Install one connector (9) to each end of the line section and secure with four pan head screws (10)

SN 01724 and above

1. Attach two supports (Figure 42, item 6) to the line section subassembly (1) using four fillister head screws (7).
2. Install one keying bead (3) onto each element wiper contact of the printed circuit (PC) board assembly (2). Connect cable assembly (Figure 28, item 8) to PC board header (J1).
3. Place the assembly on a flat surface with the flat side facing up. Screw the two standoffs (Figure 42, item12), short end, with lock washers (11) into the two threaded holes nearest the socket bore. Position one spacer (4) over each of the two threaded holes. Gently lower the PC board assembly into place over the standoffs, lining up the two mounting holes with the threaded hole in the line section assembly. Screw two fillister screws (5) into holes 2 and 4.
4. Position two spacers (9) over the standoffs (12). Place cover (10) over PC board subassembly and secure with two 4-40 hex nuts with nylon inserts.

5. Gently spread apart the sides of the lower housing just far enough to allow installation of the line section assembly (Figure 28, item 4). Secure with four pan head screws (23) and four lock washers (22).
6. Install one connector (9) to each end of the line section and secure with four pan head screws (10)

Main printed Circuit (PC) Board Reassembly (SN 074100062 and below) or (SN 082700314 to 120801479)

1. Secure support (Figure 45, item 28) to the right side of the PC board sub assembly (1) with two pan head screws (30) and two lock washers (31). Be sure to line up the slot in the support with the tab of the voltage regulator (U11).

☞ NOTE: For SN 082700314 to 120801479, the PC board support (item 29) do not have a slot. Therefore no special alignment is required.

2. Attach support (29) to the left side of the PC board assembly with two pan head screws (30) and two lock washers (31).
3. Slide the PC board assembly into lower housing assembly. Align thee mounting holes on either side of the lower housing assembly with the three threaded holes in PC board supports. Fasten the PC board assembly at the top using two Phillips oval head screws (Figure 28, item 5) and two countersunk lock washers (6) but do not tighten. Connect cable assembly connector (8) to main PC board header (P1) and connector (27) to J3. Tilt board assembly up.
4. Slip one piece of shrink tubing (24), for each wire, over the end the red and orange wires and slide back away from the end.
5. Attach and solder the orange wire to the top terminal of toggle switch (S3) and the red wire to the bottom terminal. Clean the connections thoroughly to remove any flux and contaminants.
6. Slide the tubes over the connection and apply heat to shrink.
7. Insert the brown wire into the main PC board assembly and solder. Clean connection thoroughly to remove any flux and contaminants.
8. Reinstall the single battery that was removed during disassembly.
9. Lower the PC board assembly and align the remaining mounting holes. Secure the PC board to the lower housing with four phillips oval head screws (5) and four countersunk lock washers (6). Tighten all screws.

Main Printed Circuit (PC) Board Assembly (SN 074100063 to SN 082700313)

1. Insert spacer (Figure 46, item 11) between the PCB and PC board support (9) then secure the PCB to the support using one pan head screw (10) and its lock washer (3).
2. Using three pan head screws (2) and three lock washers (3), continue to assemble the PCB to the PC board supports (4) and (9).
3. Connect cable assembly connector (Figure , item 7) to header (P1) and connector (27) to J3 then insert the main PC board into the lower housing assembly.
4. Attach two phillips oval head screws (4) and two countersunk lock washers (5) to the end of the PC board sup-

ports nearest the line section then tilt the PCB up to expose the under side.

> CAUTION
> Internal batteries are connected. Remove one of the battery tubes before soldering wires to the Main PCB. Failure to comply may result in permanent equipment damage and severe shock to individuals.

5. Slide shrink tubing (22) over the red and orange wires that connect to the toggle switch (S3) then solder the wires and shrink the tubing.
6. Insert brown wire into the Main PC board assembly and solder. Clean connection thoroughly to remove any flux and contaminants.
7. Reinstall the single battery that was removed during disassembly.
8. Lower the PCB assembly then install four lower countersunk lock washers (5) and four phillips oval head screws (4).

Main Printed Circuit (PC) Board Assembly (SN 120801480 and above)

1. Secure the two PC board supports (Figure 45, item 29) to the PCB using four pan head screws (30) and four lock washers (31).
2. Connect cable assembly connector (Figure 31, item 8) to header (P1) and connector (2) to J1 on the back of the PCB. Then insert the main PC board into the lower housing assembly.
3. Attach two phillips oval head screws (5) and two countersunk lock washers (6) to the end of the PC board supports nearest the line section then tilt the PCB up to expose the under side.

> CAUTION
> Internal batteries are connected. Remove one of the battery tubes before soldering wires to the Main PCB. Failure to comply may result in permanent equipment damage and severe shock to individuals.

4. Reinstall the single battery that was removed during disassembly.
5. Lower the PCB assembly then install four lower countersunk lock washers (6) and four phillips oval head screws (5).

Front Panel Reassembly

1. Place one pad (Figure 28, item 26) over the lever of each toggle switch (S1, S2, and S3).
2. Carefully lower front panel (11) onto the top of the lower housing assembly.
3. Fasten front panel assembly at the back and bottom of the lower housing assembly using four pan head screws (12) and two lock washers (13) with the two bottom screws.
4. Secure the top of the front panel with six Phillips pan head screws (21).
5. Tighten all six Phillips oval head screws (5) on either side of the lower housing assembly.

Customer Service

Any maintenance or service procedure beyond the scope of those in this chapter should be referred to a qualified service center.

If you need to return the unit for any reason, contact the Bird Service Center for a return authorization. All instruments returned must be shipped prepaid and to the attention of Bird Service Center.

Bird Service Center
30303 Aurora Road
Cleveland (Solon), Ohio 44139-2794
Phone: (440) 519-2298
Fax: (440) 519-2326
E-mail: bsc@bird-technologies.com

For the location of the Sales Office nearest you, give us a call or visit our Web site at:

http://www.bird-technologies.com

Figure 19 Power Supply and Main PC Board Schematic Diagram (SN **082700313** *and below)*

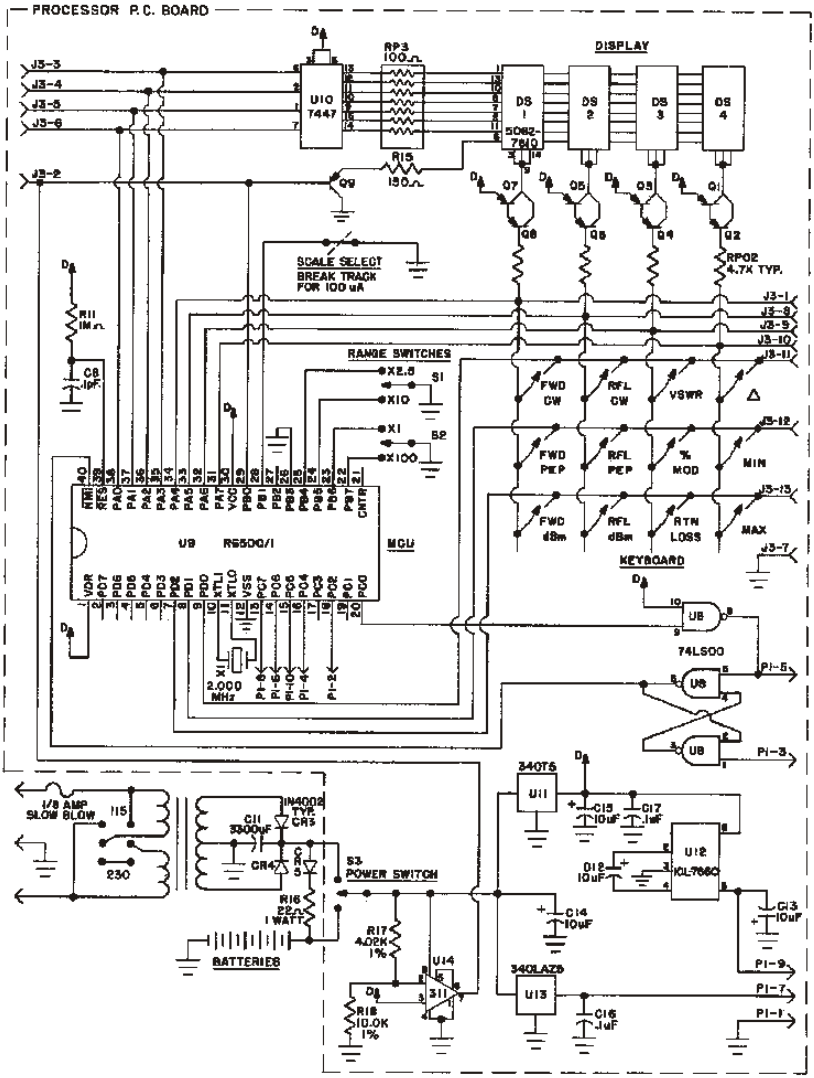
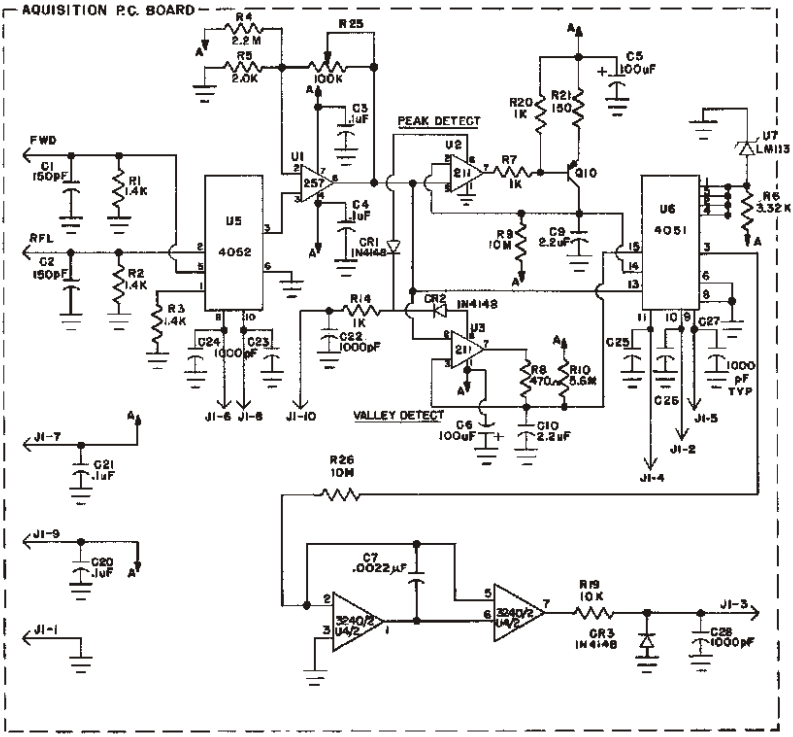


Figure 20 Acquisition PCB Schematic Diagram (SN 082700313 and below)



PINS NOT SHOWN

-5 ANALOG	GROUND	NOT CONNECTED
U1-4	U2-1	U1-1,5,8
U2-4	U5-4,6,8,11,12,13,14,15	U2-5
U3-1,4	U8-7,12,13	U3-5
U4-4	U9-12,26	U8-11
U5-7	U10-8	U9-2,3,4,5,6,17,19,21,27
U6-7		U10-4
		U12-1,6,7
+5 ANALOG	+5 DIGITAL	U14-5,6
U1-7	U8-14	
U2-8	U9-1,13	
U3-8	U10-16	
U4-8		
U5-16		
U6-16		

D = 5V DIGITAL SUPPLY

A = 5V ANALOG SUPPLY

A = -5V ANALOG SUPPLY

= GROUND

Figure 21 Processor PC Board Schematic Diagram (SN 074100063 to SN 082700313)

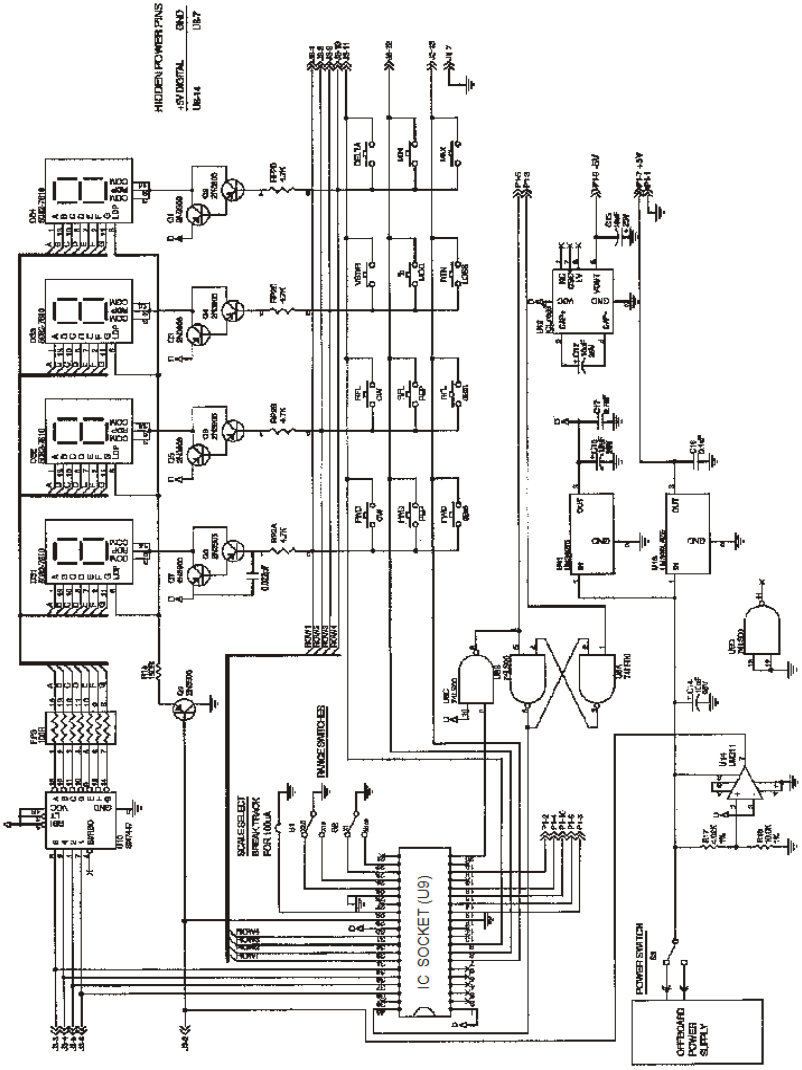


Figure 22 Microprocessor Auxiliary PC Board (SN ***074100063*** *to SN 082700313)*

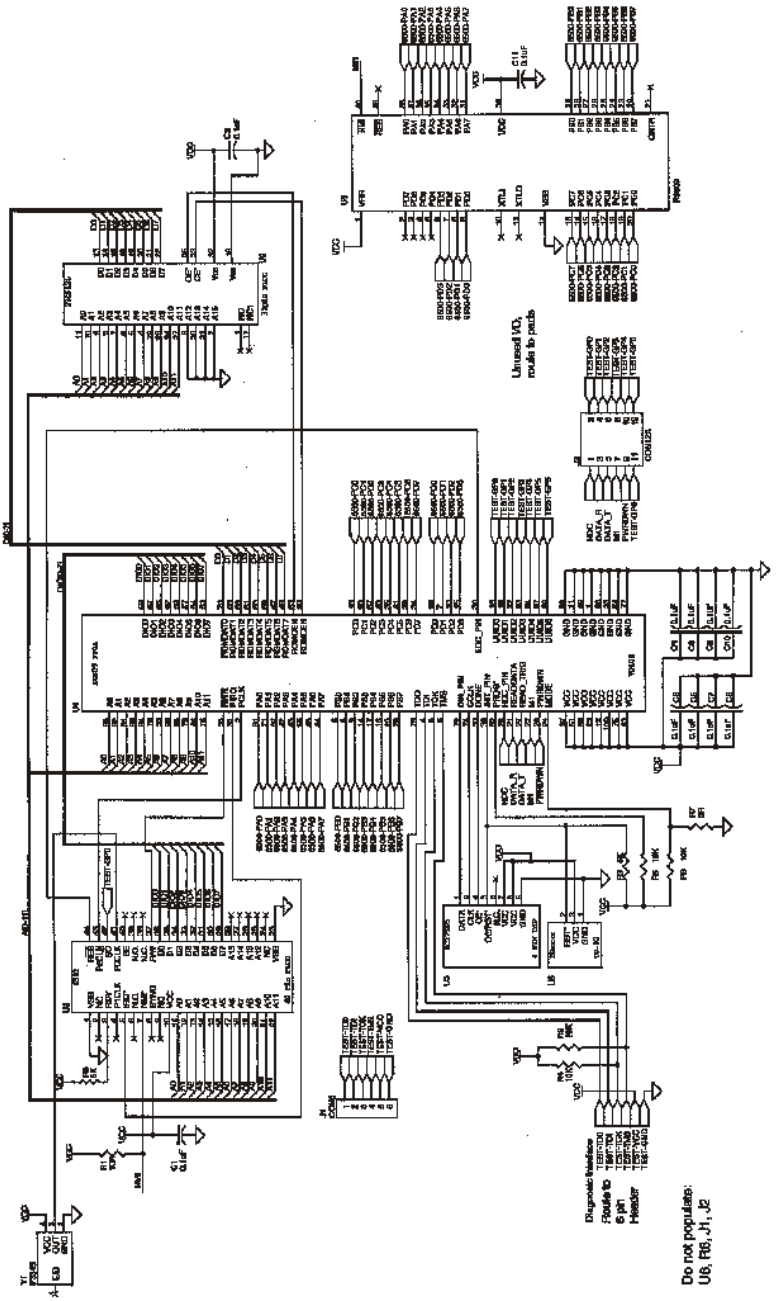


Figure 23 Power Supply PC Board (SN 074100063 to SN 120801479)

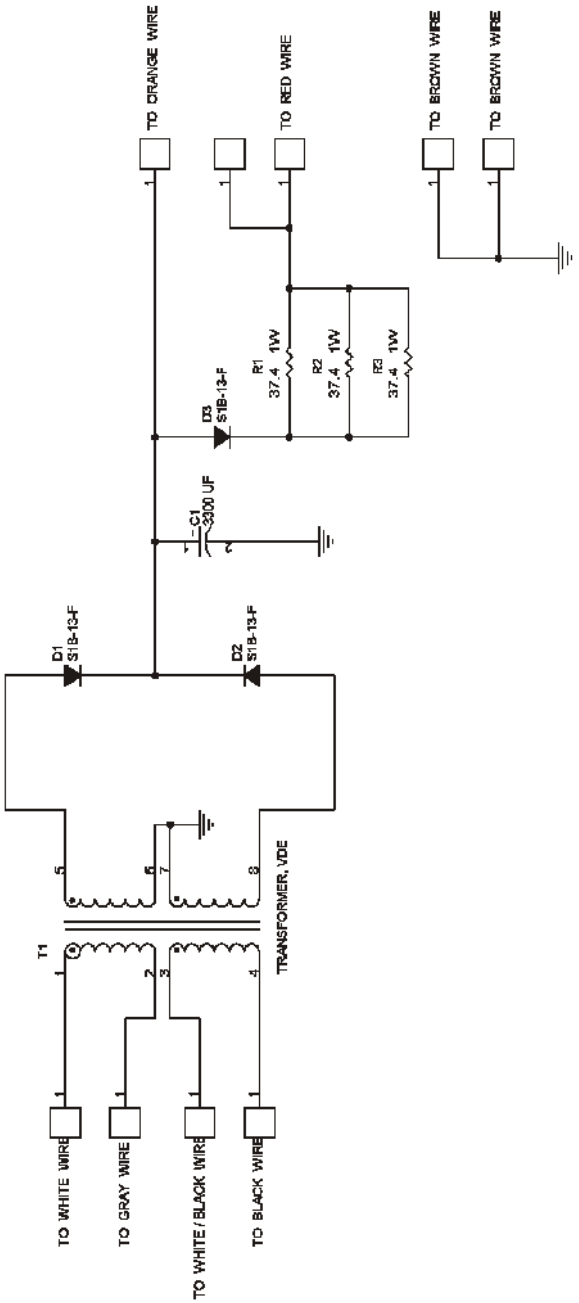


Figure 24 Acquisition PCB Schematic Diagram (SN 082700314 and above)

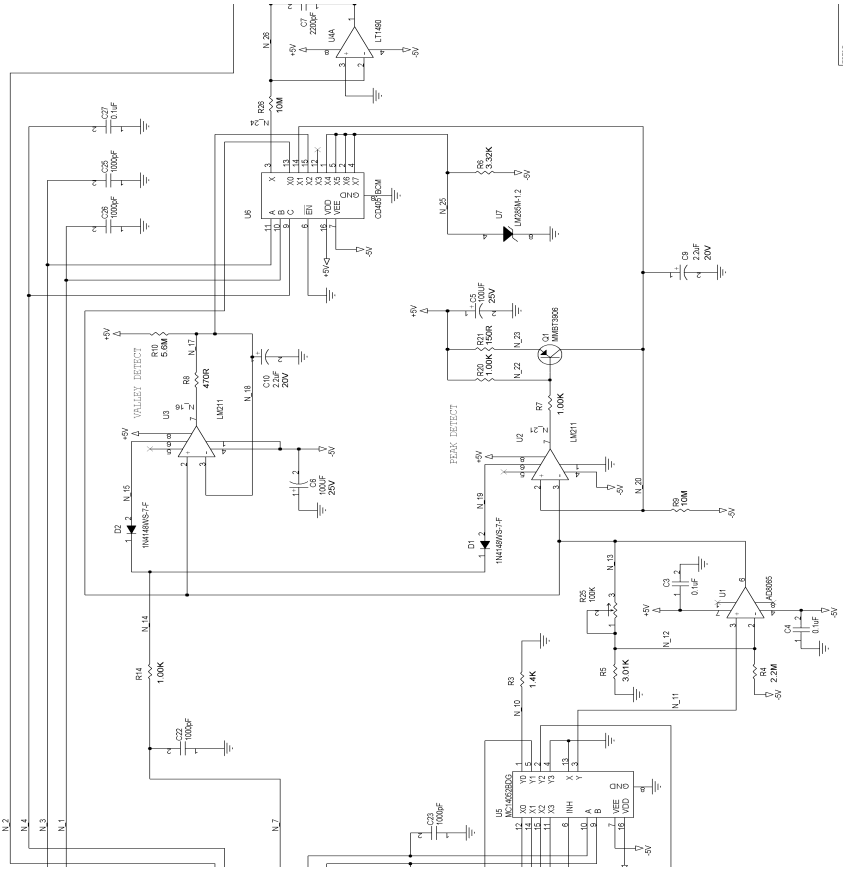


Figure 25 Processor PC Board Schematic Diagram (SN 082700314 to SN 120801479, sheet 1)

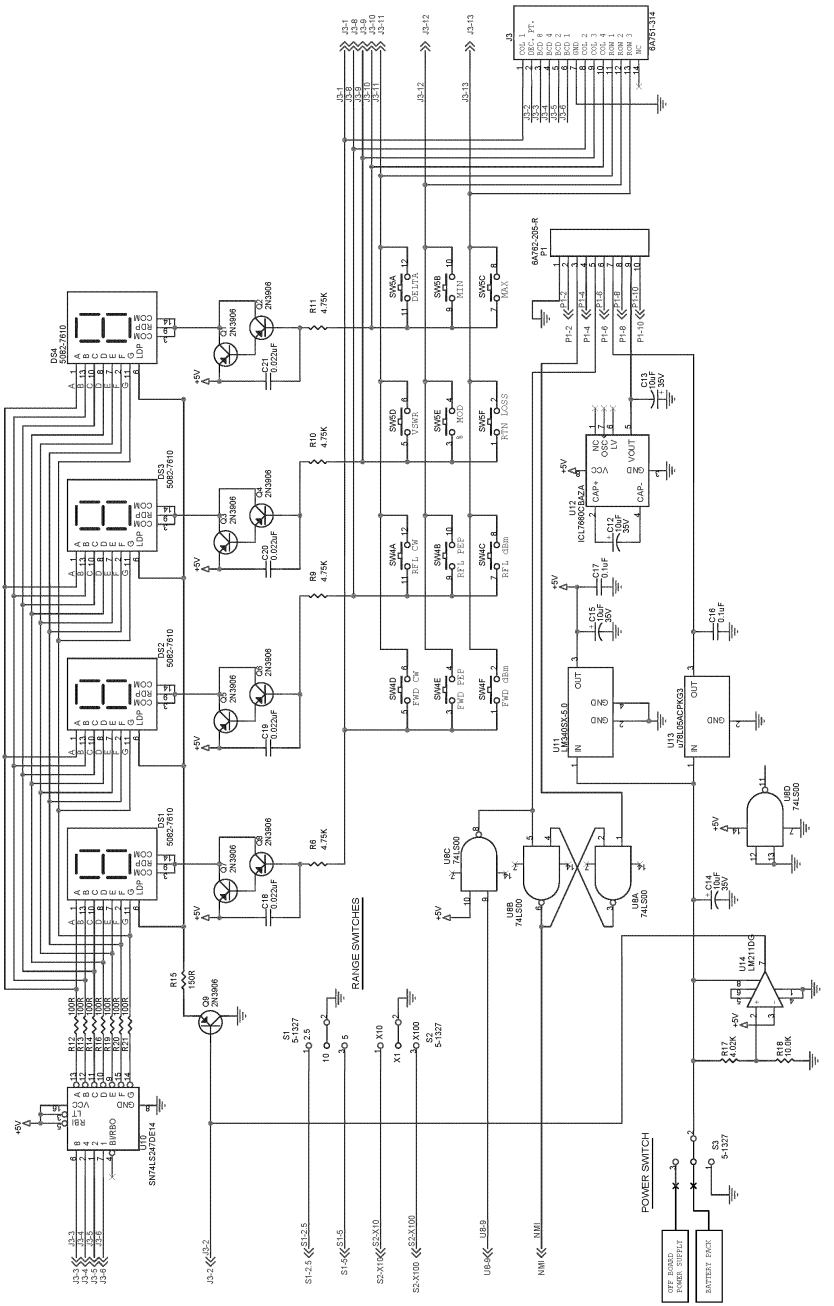


Figure 25 Processor PC Board Schematic Diagram (SN 082700314 to SN 120801470 sheet 2)

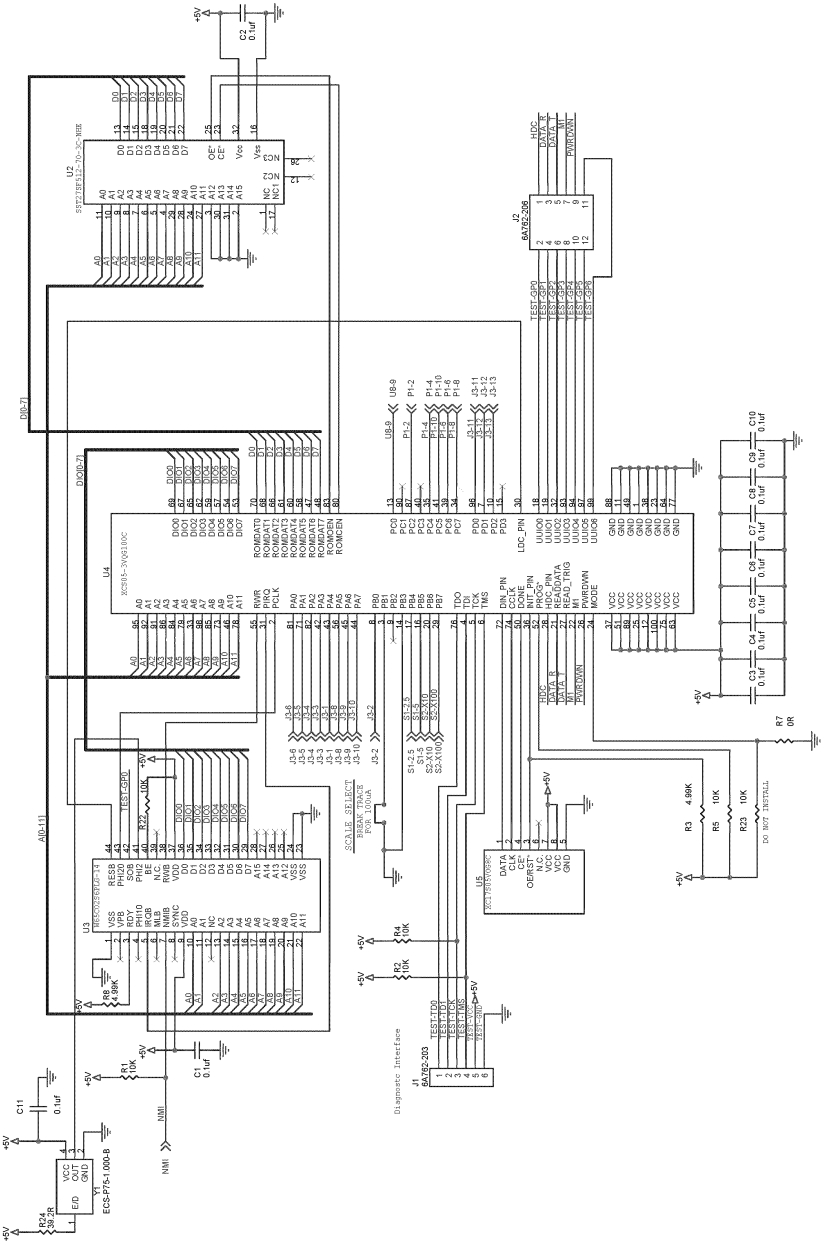


Figure 26 Processor PC Board Schematic Diagram (SN 120801480 and above, sheet 1)

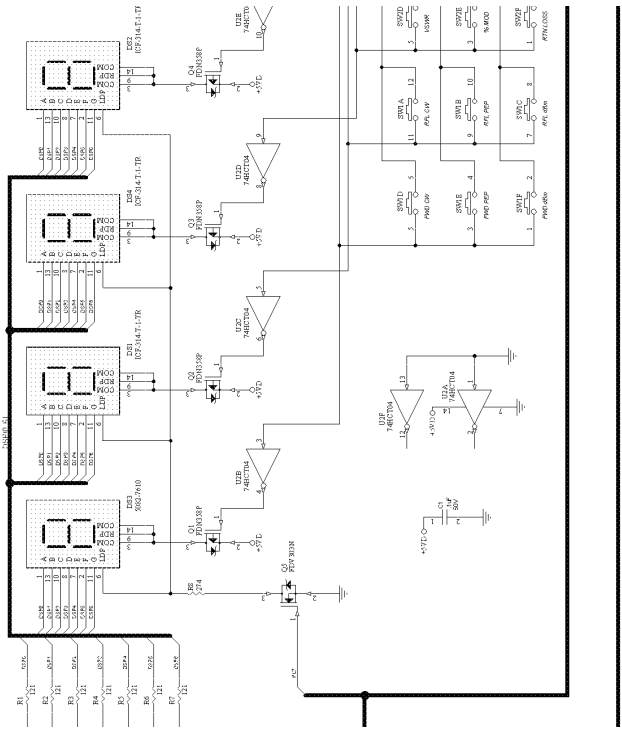


Figure 26 Processor PC Board Schematic Diagram (SN 120801480 and above, sheet 2)

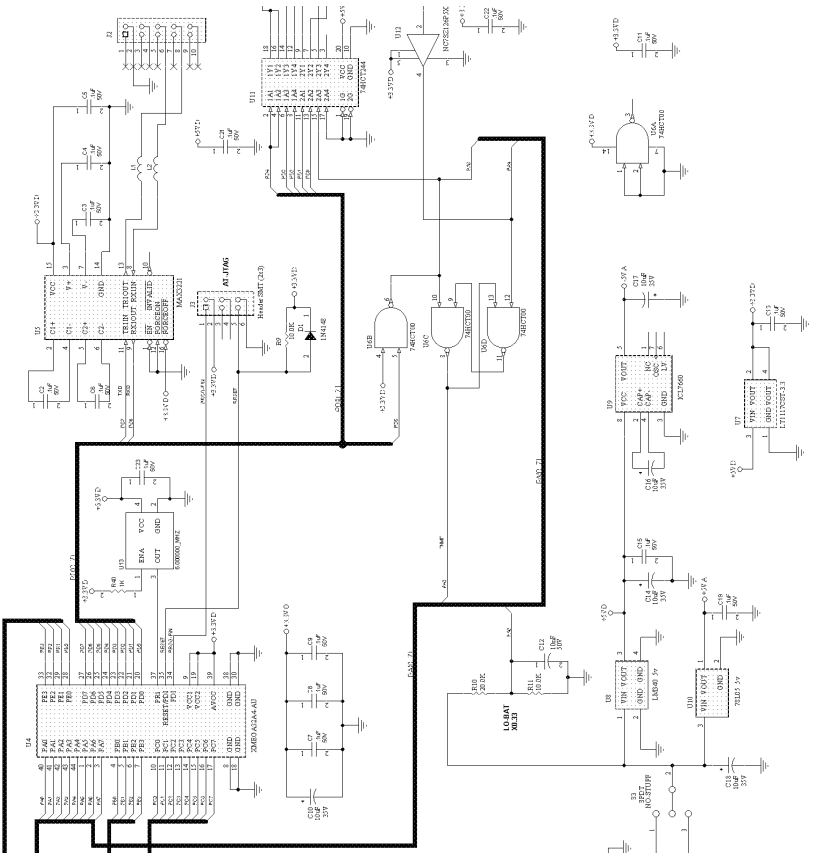
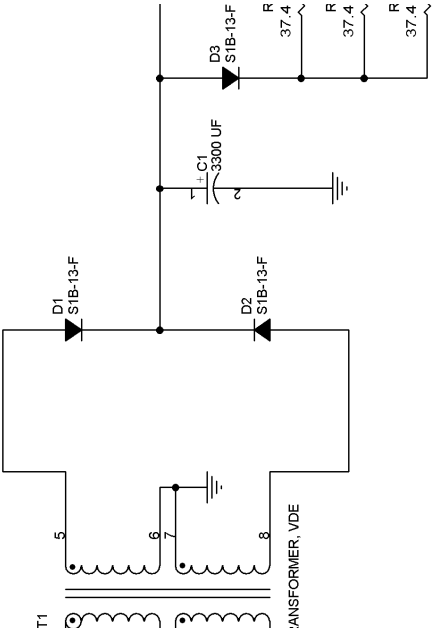


Figure 27 Power Supply PC Board (SN 120801480 and above)



Specifications

Measuring Medium	RF Transmission in 50 ohm lines
RF Power Range*	100 mW to 10 kW full scale using Bird Plug-in Elements. Accuracy not guaranteed with components not supplied by Bird
Usable Over-Range*	To 120% of scale on CW, PEP, SWR, and Return loss functions. To 400% of scale (PEP) on dBm and 0% modulation.
Frequency Range*	450 kHz to 2.3 GHz
Sampling Range	2-3 readings per second
Settling Time	10 seconds (worst case)†
Accuracy	
Power Readings	
CW	±7% of full scale
PEP	±8% of full scale
SWR	±10% of reading
% Modulation	±5%‡
Return Loss	±0.3 dB to corresponding SWR value
Impedance	50 ohms
Insertion SWR	1.05 max to 1000 MHz
Pulse Parameters (square pulses)	
Pulse Width	0.8 µsec. min.**
Repetition Rate	25 pps min.
Duty Cycle	0.01% min.
RF Line Connections	
Standard	Bird Quick Change "QC" Female N
Optional	Any Standard AN "QC" type
Temperature Range	
Operating	10°C to 45°C (50°F to 113°F)
Storage	-20°C to 45°C (-4°F to 113°F)
Input Power Requirements (SN 074100063 and above)	
Voltage	100-130 or 200-230 VAC (Switch Selectable) or 7.2 Vdc (internal battery)
Frequency	50-60 Hz
Power	6 Watts
Batteries	6-1.2 V NiMH C size (Rechargeable)
Battery Life	12 hours approx. (reduced after high temperture charging)
Input Power Requirements (SN 074100062 and below)	
Voltage	100-130 or 200-230 VAC (Switch Selectable) or 7.5 Vdc (internal battery)
Frequency	50-60 Hz
Power	6 Watts
Batteries	6-1.2 V Nicad C size (Rechargeable)
Battery Life	8 hours approx.
Weight	5-3/4 lb (2.6 kg)

* Frequency band and power range is determined by the Plug-in Elements selected. See Bird Catalog for availability. Some modes require two elements in a 10:1 power ratio.
† VSWR and return loss functions settle in less than 1 second.
‡ For CW power levels greater than one-third of full scale, accuracy of the percent modulation mode is 5% from 0 to 90% and +10% from 90 to 100%. Modulation frequency is 25 to 100,000 Hz; except for "A" and "B" elements: 25 to 20,000 Hz; and "H" elements: 25-10,000 Hz.
** For "A" and "B" elements the minimum pulse width is 1.5 microseconds. For "H" elements the minimum pulse width is 15 microseconds.

Parts List

General This section contains an illustrated list of all replacement parts for the 4391M RF power Analyst. Parts are grouped into major assemblies and subassemblies.

Parts Illustrations Illustrations of the RF Power Analyst provided at the end of this chapter show each component part and its relationship with the next higher assembly

Parts Lists Along with each illustration is a parts list showing all of the replaceable parts within that assembly or subassembly. If a part is found to be defective, and is not contained in these lists, it is not available for replacement, and the assembly to which it belongs must be replaced. The parts lists are broken down into the following column structure:

Index No. Numbers in this column identify the location of the part in an illustration. For example Index No. Figure 28-3 describes item 3 located within Figure 28.

Description The full name and descriptive data needed to identify and order replacement parts are contained within this column. The descriptions are indented to indicate relationship to the next higher assembly.

Cage Code Manufacturers of vendor items are identified in this column by Commercial and Government Entity (CAGE) code. A cross reference from mfg. code (CAGE) to name and address for vendors making 4391M parts is in the following table. A complete Cage code listing can be found in cataloging handbook H4-1.

MFG Part No. The original manufacturer's part number is contained in this column.

Qty This column indicates the quantity of each part used in the assembly but not necessarily the total quantity used in the unit.

☞ NOTE: Items without a listed part number are included in a higher level assembly and cannot be ordered as separate items.

CAGE Codes

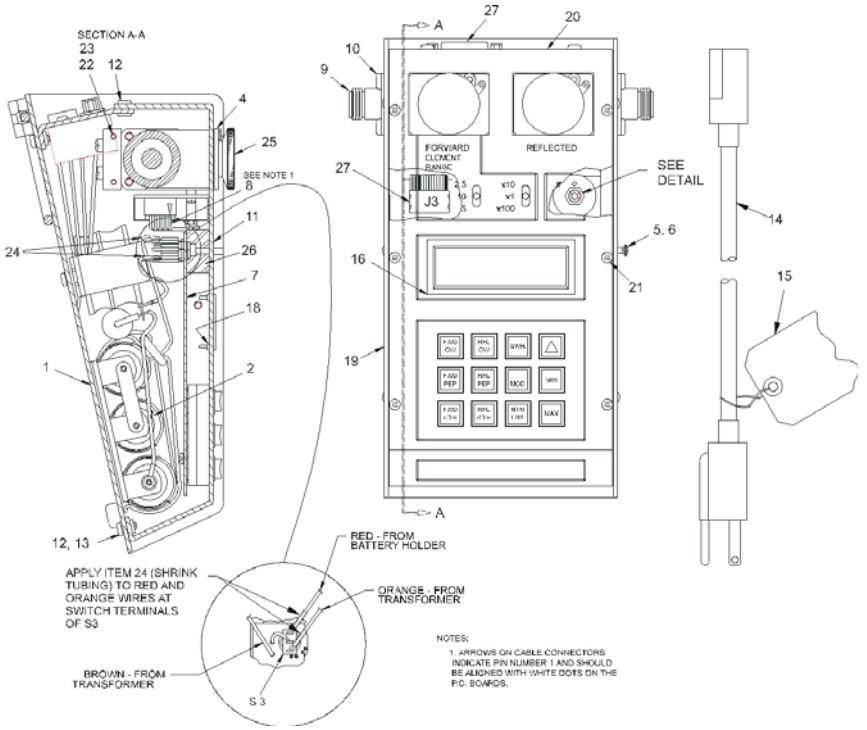
Code	Name and Address	Code	Name and Address
00779	Tyco Electronics Corp 2800 Fulling Mill Rd, Bldg-38 Middletown, PA 17057-3142	01884	Dearborn Electronics Inc. 1221 N US Highway 17/92 Longwood, FL 32750-3739
50139	Allen Bradley 1201 S 2nd St. Milwaukee, WI 53204-2496	09353	C & K Components, Inc 57 Stanley Ave Watertown, MA 02472-4802
05245	Corcom, Incorporated 620 S Butterfield Mundelein, IL 60060-9457	55680	Nichicon America Corp 927 E state Parkway Schaumburg, IL 60195-4526
05616	Cosmo Plastic Company 30201 Aurora Rd. Solon, OH 44139-2745	32997	Bourns Incorporated Trimpot Division 1200 Colombia Ave Riverside, CA 92507-2114

Code	Name and Address
27014	National Semiconductor Corp 2900 Semiconductor Dr Santa Clara, CA 95051-0606
80831	American Rivet Co, Inc. 11330 W Melrose St Franklin Park, IL 60131
18722	Haris Corp Semiconductor Sector 125 Crestwood Road Mountaintop, PA 18707-2189
2U635	Northern Engineering and Supply Co 27010 140th SE Kent, WA 98031
31433	Kemet Electronic Corp 2835 Kemet Way Simpsonville, SC 29681
53387	3M Co. 6801 River Place Blvd. Austin, TX 78726-4530
34371	Intersil Incorporated 1001 Murphy Ranch Rd. Santa Clara CA 95035
64013	Elna America Inc 153 E Savarona Way Carson, CA 90746-1406
70998	Bird Electronic Corp 30303 Aurora Road Solon, OH 44139-2794
70485	Atlantic India Rubber Works 1437 Kentucky Rt. 1428 Hagerholl, KY 41222-8646
70903	Belden Wire and Cable Co. 2200 US Highway 27 S Richmond, IN 47374-7437
06383	Panduit Corporation 17301 Ridgeland Tinley Park, IL 60477-3048
74861	Charles Industries Ltd 5600 Apollo Drive Rolling Meadows, Il 60008-4049
32559	Bivar Incorporated 4 Thomas Street Irvine, CA 92718-2512
71468	ITT Corp 666 E. Dyer Rd Santa Ana, CA 92705-5612
02690	Buckeye Rubber & Packing Co 23940 Mercantile Rd Cleveland, OH 44122-5989
0PJN9	Tyco Electronics / Nanonics M/S 38-77 P.O. Box 3608 Harrisburg, PA 17195
50434	Avago Technologies U.S. Inc. 350 W Trimble Rd San Jopse, CA 95131-1008
57771	Stimpson Company Inc 900 Sylvan Avenue Bayport, NY 11705-1012
81073	Grayhill Incorporated 561 Hillgrove Ave LaGrange, IL 60525-5914
59660	Tusonix Incorporated 7741 N business Park Dr Tucson, AZ 85740-7144
75915	Tracor Littlefuse Inc 800 E northwest Hwy Des Plaines, IL 60016-3049
9A204	3M Company 3M Ctr Bldg - 220 11-02 St Paul, MN 55144-1001
72982	Erie Specialty Products Inc 645 W 11th Street Erie, PA 16512
82389	Switch Craft Incorporated Sub of Raytheon Co 5555 N Elstron Ave Chicago, IL 60630-1314
91637	Vishay Dale Electronics Inc 1122 23rd St Columbus, NE 68601-3632
92194	Alpha Wire Corporation 711 Lidgerwood Ave Elizabeth, NJ 07207
0GPM7	NSK Industries, Inc. 4524 Hudson Dr. Stow, OH 44224
2M734	Panasonic Co. of North America One Panasonic Way 1F-6 Secaucus, NJ 07094-2917
56427	California Micro Devices Corp 215 Topaz St Milpitas, CA 95035-5430
3M927	Accurate Products Inc 4645 N Ravenswood Ave Chicago, IL 60640-4584
1JX75	Sumitomo Electric Interconnect 915 Armorlite Drive San Marcos, CA 92069
1G8B7	ECS Inc, International 1105 S. Ridgeview Olathe, KS 66062
5F520	Interpower Corporation 100 Interpower Ave Oskaloosa, IA 52577-1864

Code	Name and Address
61935	Schurter, Inc 447 Aviation Blvd Santa Rosa, CA 95403-1069
64155	Linear Technology Corp 1630 McCarthy Blvd Milpitas CA, 95035-7417
1BA54	Analog Devices 2209 Teal Ave Syracuse, NY 13206-1544
3EUW5	Harding Energy Inc One Energy Ctr Muskegon, MI 49441-5671
20462	Prem Magnetics Inc 3519 Chapel Hill Rd Johnsburg, IL 60050-2573
91833	Keystone Electronics Inc 3107 20th Rd Long Island City, NY 11105-2017
08779	Signal Transformer Co, Inc. 500 Bayview Ave Inwood, NY 11696-1702
4CTQ3	Don Ray 1150 White River Pkwy Dr Ste 505 Indianapolis, IN 46222
25905	Fall River Foundry Co. 670 S Main Fall River, WI 53932
4CYK1	Humiseal Division 128 1st St Pittsburgh, PA 15238
0LCG1	Texas Instruments 21550 Oxnard St, Ste 700 Woodland Hills, CA 91367
81855	EaglePicher Technologies LLC 1216 WEST C ST Joplin, MO 64801
6L334	Diodes, Inc. 8900 Winnetka Ave Northridge, CA 91324
SCT30	Fairchild 15/F Straight Block Ocean Cnt. 6 Canton Rd 99999
1ES66	Maxim Integrated Products, Inc. 120 San Gabreiel Dr. Sunnyvale, CA 94086
FAHD5	ON Semiconductor 14 R Paul MESPLE P.O. Box 1112 Toulouse, France 31000
68994	Xilinx Inc 2100 Logic Dr San Jose, CA 95124-3450
55322	SAMTEC 520 Park E. Blvd New Albany, IN 47151-1147
F4022	Vishay General Semiconductor 1999 Bd De La Madeleine P.O. Box 1159 Nice, France 06000
14936	General Semiconductor Inc 10 Melville Park Rd Mellville, NY 11747
1ZJG7	Glavin Industries Inc. 6835 Cochran Rd 44139-8004
7A088	Etched Metal Co. 30200 Solon Industrial Pkwy Solon, OH 44139
18310	Concord Electronics Corp. 30 Great Jones St New York, NY 10012-1115
0BZ86	Molex Electronics Ltd 85 Select Ave Scarborough, ON Canada M1V 4A9
52657	Panelgraphic Corp 10 Henderson Dr Caldwell, NJ 07006-6685
*	PN - W65C0256PLG-14 Western Design Center, Inc. 2166 E. Brown Rd Mesa, AZ 85213
6KUV2	AVX Corporation 1 AVX Blvd Fountain INN, SC 29644
34899	Fair-Rite Products Corp 1 Commerical Row Wallkill, NY 12589
1FN41	Atmel Corp. 2325 Orchard Pkwy San Jose, CA 95131

☞ ***** - *CAGE code not available. Individual part number listed for reference.*

Figure 28 RF Power Analyst, Model 4391M (SN 074100062 and below) or (SN 082700314 to 120801479)



Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 28	RF Power Analyst, Model 4391M	70998	4391-061	REF
-1	• RF Power Analyst, Subassembly (See Figure 32 for Breakdown)	70998	4391-002 (4391A002)*	1
-2	• Battery, NiMH, 1.2V (SN 082700314)	3EUW5 81855	HL-C4600 J-C4500	6
	• Battery, NiCAD, 1.2V (SN 074100062))	2M734	P-240C	6
-3	Not Used			
-4	• Line Section, Assembly (See Figure 41 or Figure 42 for Breakdown)	70998	4391-064	1
-5	• Screw, Machine, Phillips oval head, No. 4-40 1/4 in. lg sst		COML	6
-6	• Lock Washer, External tooth, countersunk No. 4 sst		COML	6
-7	• PC Board, MCU, Assembly (See Figure 43 and Figure 46* for Breakdown)	70998	4391-068 (4391B007)*	1
-8	• Cable PC Board, Assembly	70998	5-1531	1
-9	• Connector, Female N, Assembly	70998	4240-062	2

-10	• Screw, Machine, No. 8-32 1-4 in. lg, pan head, sst		COML	8
-11	• Panel, Assembly	70998	4391-066	1
-12	• Screw, Machine, pan head, No 6-32 5/16 in. lg, sst		COML	4
-13	• Lock Washer, Internal Tooth, No. 6 sst		COML	2
	• Cable, Power Cord, 115/230V, Assy	70903	17250	1
-14	• • Cord, Power Supply	70903	17250	1
-15	• • Tag, 230 V operation	70998	5-1792	1
-16	• Bezek, Display, molded	70998	4381-060	1
-17	• (not used)			
-18	• Fastener, Push nut	77122	PS 094032	6
-19	• Label, RF Directional Wattmeter	70998	4300B306-1	1
-20	• Label, Serial number (Specify serial number.))	70998	4381-063	1
-21	• Screw, Machine, phillips pan head No. 4-40, 1/4 in. lg, sst		COML	6
-22	• Lock Washer, Internal tooth, No. 4, sst		COML	4
-23	• Screw, Machine, pan head, No. 4-40, 1/4 in. lg, sst		COML	4
-24	• Shrink Tube, 1/8 in. ID, 1/2 in. lg	92194	FIT-221	2
-25	• Plug, Dust	70998	3610-031-01	2
-26	• PAD	70998	5-1948	3
-27	• Cable, I/O, Assembly	70998	4380-514	1

☞ *** -** *For SN 082700314 and above.*

Figure 29 RF Power Analyst, Model 4391M (SN 074100063 to SN 082700313, sheet 1)

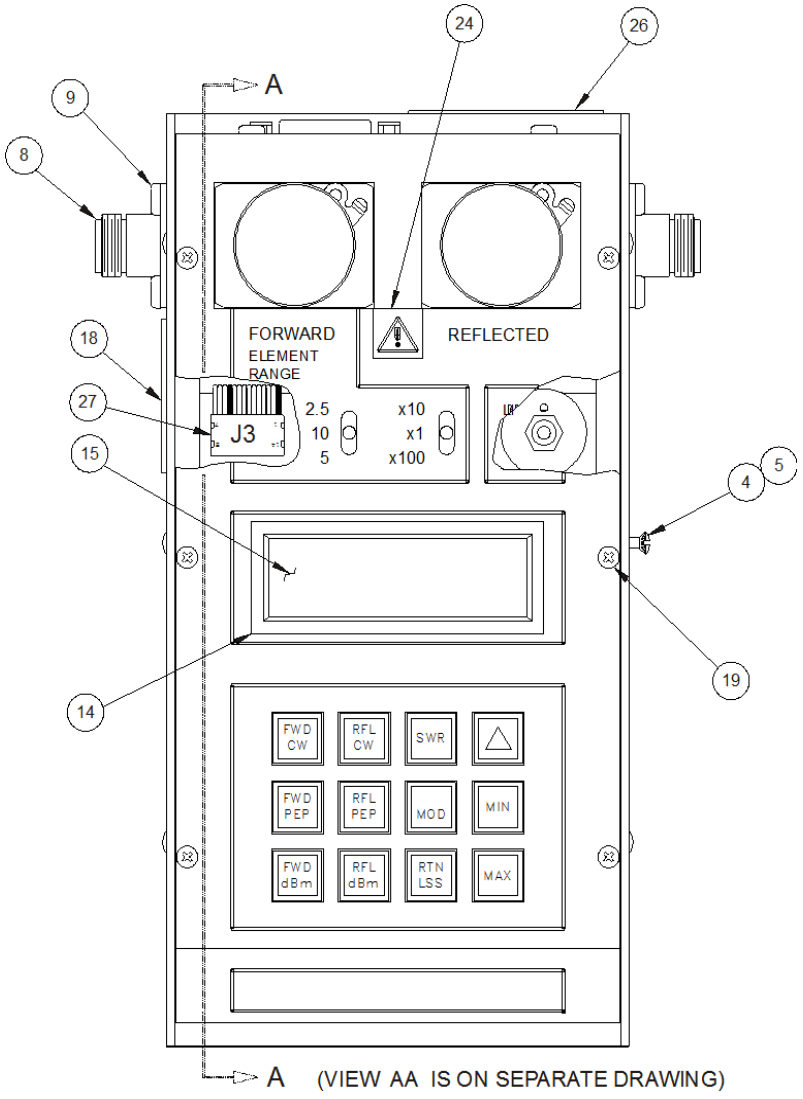
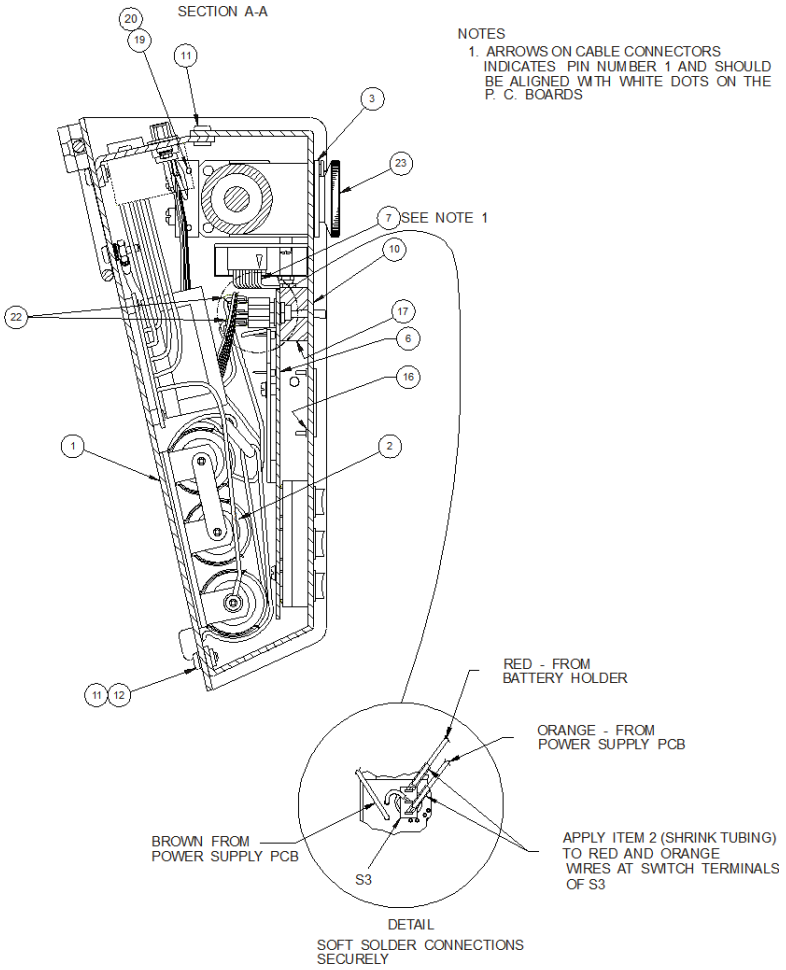


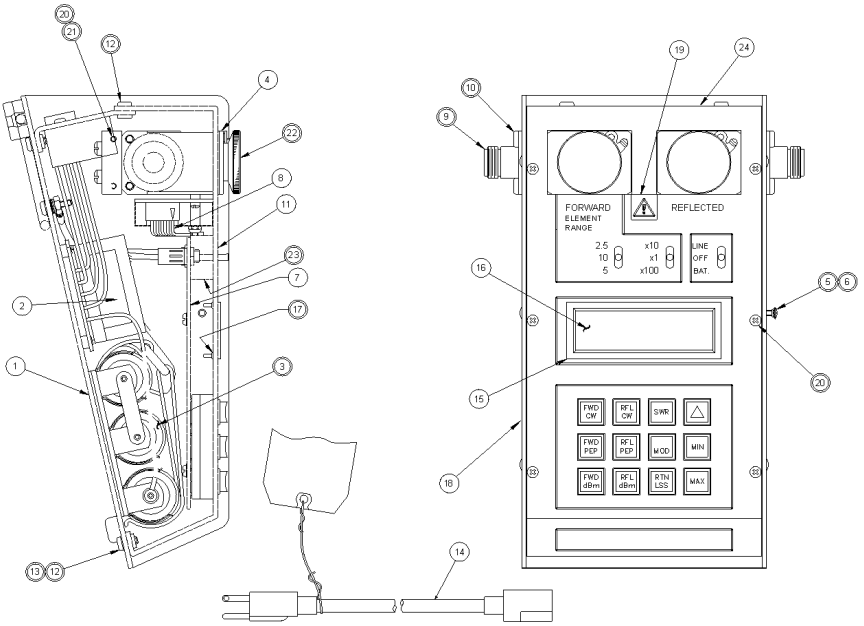
Figure 30 RF Power Analyst, Model 4391M (SN 074100063 to SN 082700313, sheet 2)



Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure and Figure 30	RF Power Analyst, Model 4391M	70998	4391-061	REF
1	• RF Power Analyst, Subassembly (See Figure 33 for Breakdown)	70998	4391A002	1
2	• Battery, NiMH, 1.2V	3EUW5 81855	HL-C4600 J-C4500	6
3	• Line Section, Assembly (See Figure 42 for Breakdown)	70998	4391-064	1
4	• Screw, Machine, Phillips oval head, No. 4-40 1/4 in. lg sst		COML	6

5	• Lock Washer, External tooth, countersunk No. 4 sst		COML	6
6	• PC Board, Assembly (See Table 46 for Breakdown)	70998	4391A007	1
7	•Cable PC Board, Assembly	70998	5-1531	1
8	• Connector, QC, F-N, Assembly	70998	4240-062	2
9	• Screw, Machine, No. 8-32 5/16 in. lg, pan head, sst		COML	8
10	• Panel, Assembly	70998	4391-066	1
11	• Screw, Machine, pan head, No 6-32 5/16 in. lg, sst		COML	4
12	• Lock Washer, Internal Tooth, No. 6 sst		COML	2
13	(not used)			
14	• Bezel, Display, molded	70998	4381-060	1
15	• Filter, Red	70998	4381-061	1
16	• Fastener, Push nut	77122	5-1076-2	6
17	• PAD, Polyester, Round	70998	5-1948	3
18	• Label, Nameplate	70998	5A2553	1
19	• Screw, Machine, phillips pan head No. 4-40, 1/4 in. lg, sst		COML	10
20	• Lock Washer, Internal tooth, No. 4, sst		COML	4
21	Not Used			
22	• Shrink Tube, 1/8" dia x 1/2" long	92194	FIT-221	2
23	• Plug, Dust	70998	3610-031	2
24	• Label	70998	5A2315-2	1
25	Not Used			
26	• Label, Serial number, Bar Code (Specify serial number)	70998	5A2593	1
27	• Cable, I/O, Assembly,	70998	4380-514	1
	•Book, Instruction (Not Shown)	70998	920-4391M	1

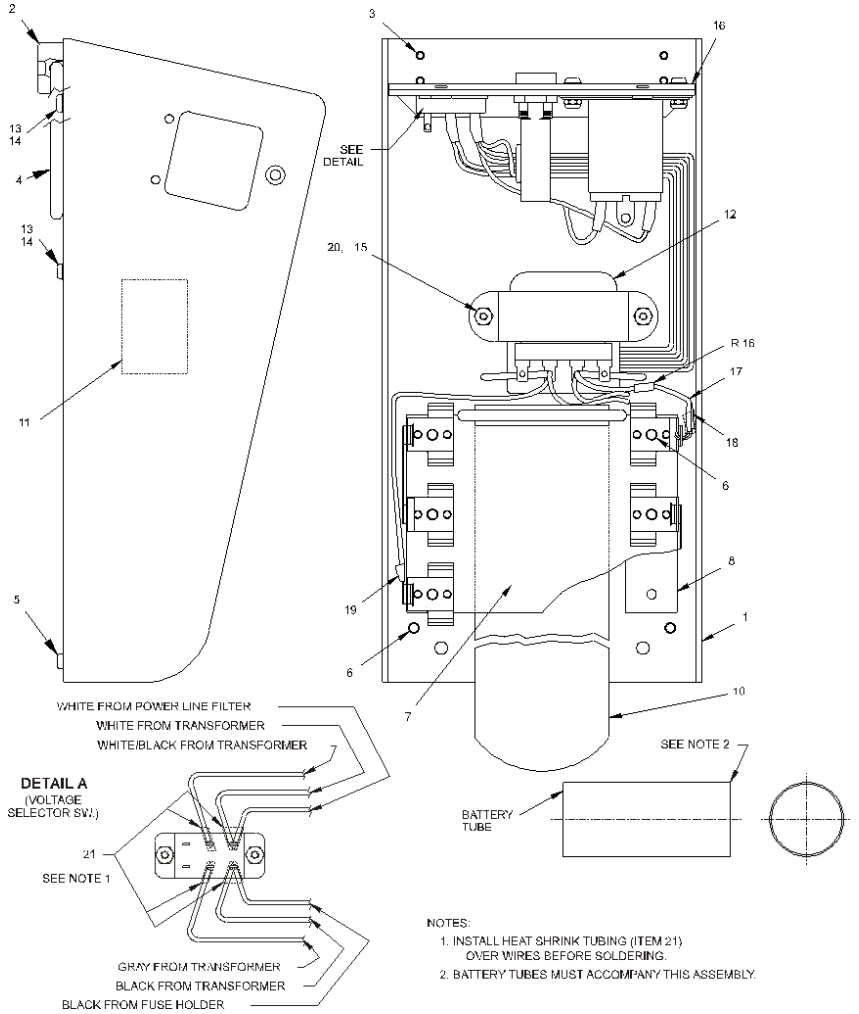
Figure 31 RF Power Analyst, Model 4391M (SN 120801480 and above)



Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
-1	RF Power Analyst, Subassembly	70998	4391B002	1
-2	• • Power Supply Assembly (part of 4391B002 assembly)			
-3	Battery, NiMH 1.2 V	3EUW5	5A1230	6
-4	Line Section Assembly	70998	4391-064	1
-5	#4-40 x 1/4 Phillips Oval HD MS, SS	70998	1112-0420-00	6
-6	#4 Ext Tooth C'Sink Lockwasher, SS	70998	1132-0109-00‘	6
-7	PC Board Assembly	70998	4391C007	1
-8	Cable, PC Board Assembly	70998	5-1531	1
-9	Connector, QC, F-N Assembly	70998	4240-062	2
-10	#8-32 x 5/16 Phillips Pan HD MS, SS	70998	1118-0513-00	8
-11	Panel Assembly	70998	4391B003	1
-12	#6-32 x 5/16 Phillips Pan HD MS, SS	70998	1116-0513-00	4
-13	#6 Internal Tooth Lockwasher, SS	70998	1132-0205-00	2
-14	Cable, Power Cord 115/230V Assembly	70998	4421-055	1
-15	Bezel, Molded	70998	4381-060	1
-16	Filter, Red	70998	4381-061	1
-17	Fastener, Push Nut	70998	5-1076-2	6
-18	Label, Nameplate	70998	5A2553	1
-19	Label, Warning	70998	5A2315-2	1
-20	#4-40 x 1/4 Phillips Pan HD MS, SS	70998	1112-0413-00	10

-21	#4 Internal Tooth Lockwasher, SS	70998	1132-0105-00	4
-22	Dust Plug	70998	3610-031-1	2
-23	Pad, Polyester, Round	70998	5-1948	3
-24	Label, S/N, Bar Code	70998	5A2593	1
-25	Instruction Book (Not Shown)	70998	920-4391M	1

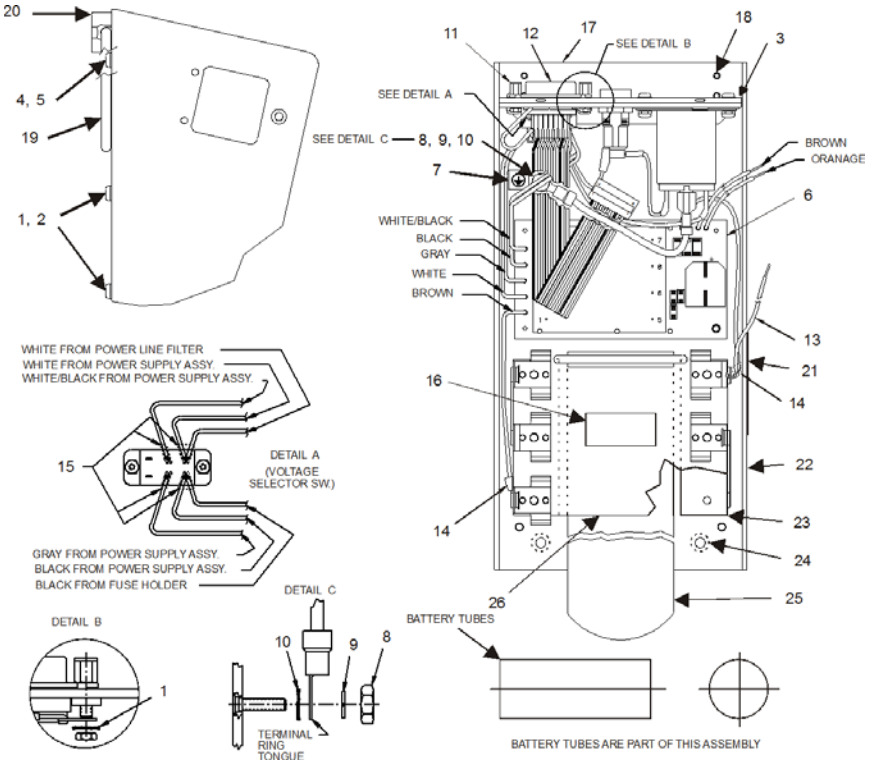
Figure 32 RF Power Analyst, Subassembly (SN 074100062 and below)



Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 32	RF Power Analyst, Subassembly	70998	4391-002	REF
	• Housing, Assembly	70998	4391-004	1
1	• • Housing, Lower (part of 4391-004 assembly)			
2	• • Foot, Detent (part of 4391-004 assembly)			
3	• • Rivet, Tubular (part of 4391-004 assembly)			

4	• • Bail, Tilt (part of 4391-004 assembly)			
5	• • Bumper, Foot (part of 4391-004 assembly)			
6	• • Rivet, Tubular (part of 4391-004 assembly)			
7	• • Battery Holder, Assembly (part of 4391-004 assembly) - includes battery tubes			
8	• • Spacer, Battery holder (part of 4391-004 assembly)			
9	(not used)			
10	• • Strap, Velcro (part of 4391-004 assembly)			
11	• • Label, Computing devices, mylar (part of 4391-004 assembly)			
12	• Transformer, Assembly (See Figure 38 for Breakdown)	70998	4391-020	1
13	• Screw, Machine, pan head, No. 6-32, 5/16 in. lg, sst		COML	4
14	• Lock Washer, Internal tooth, No. 6, sst		COML	4
15	• Locknut, Elastic, No. 6-32, sst		COML	2
16	• Rear Panel, Assembly (See Figure 38 for Breakdown)	70998	4391-017	1
17	• Electrical Wire, stranded No. 22GA., red vinyl insul.		COML	1
18	• Shrink Tube, 1/4 in. ID, 1 in. lg	92194	FIT-221	1
19	• Shrink Tube, 3/16 in. ID, 1/2 in. lg	92194	FIT-221	1
20	• Washer, Flat, No. 6, sst		COML	2
21	• Shrink Tube, 1/8 in. ID, 1/2 in. lg	92194	FIT-221	4

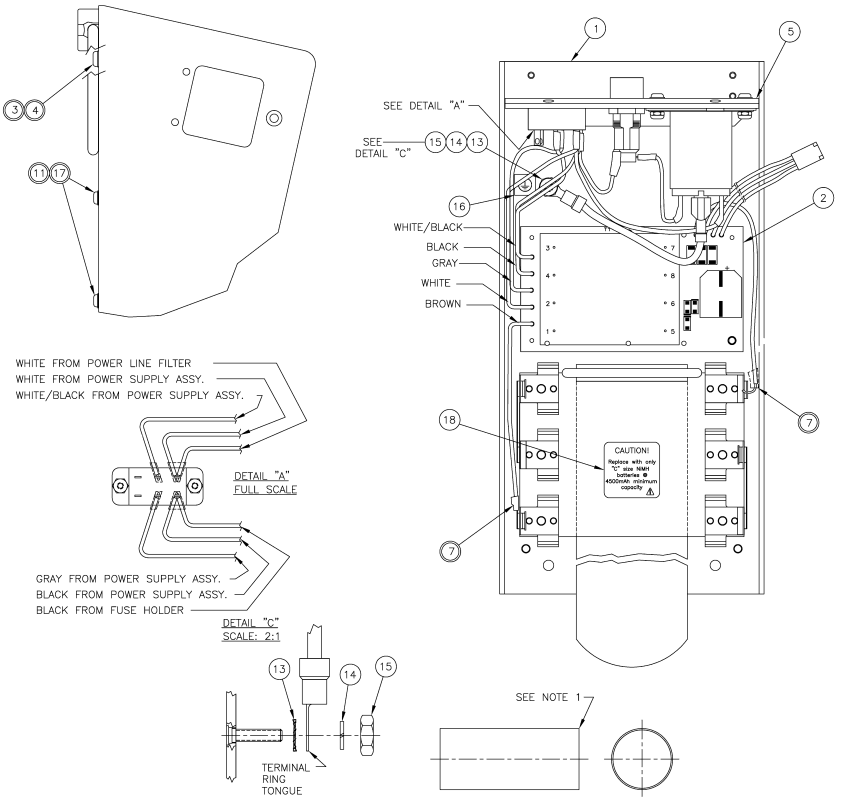
Figure 33 RF Power Analyst, Subassembly (SN 074100063 and above)



Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
	RF Power Analyst, Subassembly		4391A002	REF
1	• Lock Washer, Ext. tooth, No. 4, sst		COML	5
2	• Screw, Machine, pan head, No. 4-40, 3/8 in. lg, sst		COML	4
3	• Rear Panel, Assembly (See Figure 39 for Breakdown)	70998	4391A017	1
4	• Screw, Machine, pan head, No. 6-32, 5/16 in. lg, sst		COML	2
5	• Lock Washer, Internal tooth, No. 6, sst		COML	2
6	• Power Supply Assembly (See Figure 37 for Breakdown)	70998	4391A041	1
7	• Label	70998	5A2315-1	1
8	• Nut, Hex, No 6-32, sst		COML	1
9	• Lock Washer, Split, No. 6, sst		COML	1
10	• Lock Washer, Ext. tooth, No. 6, sst		COML	1
11	• Stand-off, Stud Mount	71468	5-1312	2
12	• Cable, I/O Assembly	70998	4380-514	1

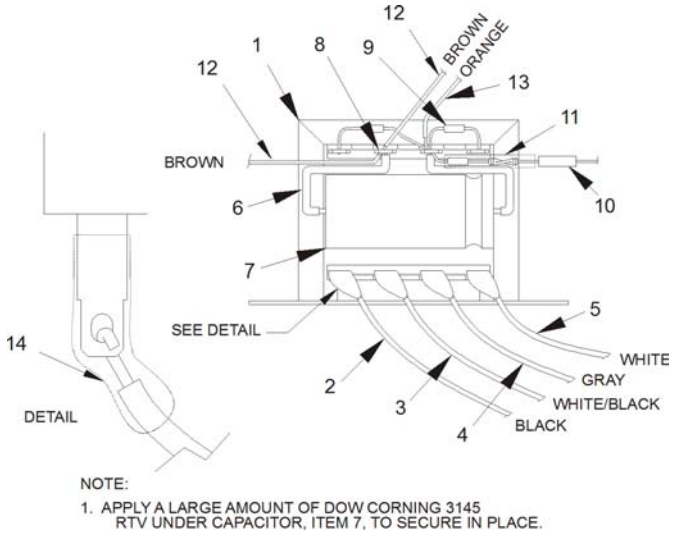
13	• Electrical Wire, stranded No. 22GA., red vinyl insul.		COML	1
14	• Shrink Tube, 3/16 in. ID, 1/2 in. lg	92194	FIT-221	2
15	• Shrink Tube, 1/8 in. ID, 1/2 in. lg	9‘2194	FIT-221	4
16	• Label, Caution	70998	5A2518-3	1
17	• Housing, Assembly	70998	4391A004	1
18	• • Rivet, Tubular (part of 4391A004 assembly)			
19	• • Bail, Tilt (part of 4391A004 assembly)			
20	• • Foot, Detent (part of 4391A004 assembly)			
21	• • Label, Computing devices, mylar (part of 4391A004 assembly)			
22	• • Housing, Lower (part of 4391A004 assembly)			
23	• • Spacer, Battery holder (part of 4391A004 assembly)			
24	• • Bumper, Stem (part of 4391A004 assembly)	77122	5-1388	2
25	• • Strap, Velcro (part of 4391A004 assembly)	70998	5-1958	1
26	• • Battery Holder, Assembly (part of 4391A004 assembly) - includes battery tubes			

Figure 34 RF Power Analyst Subassembly (SN 120801480 and above)



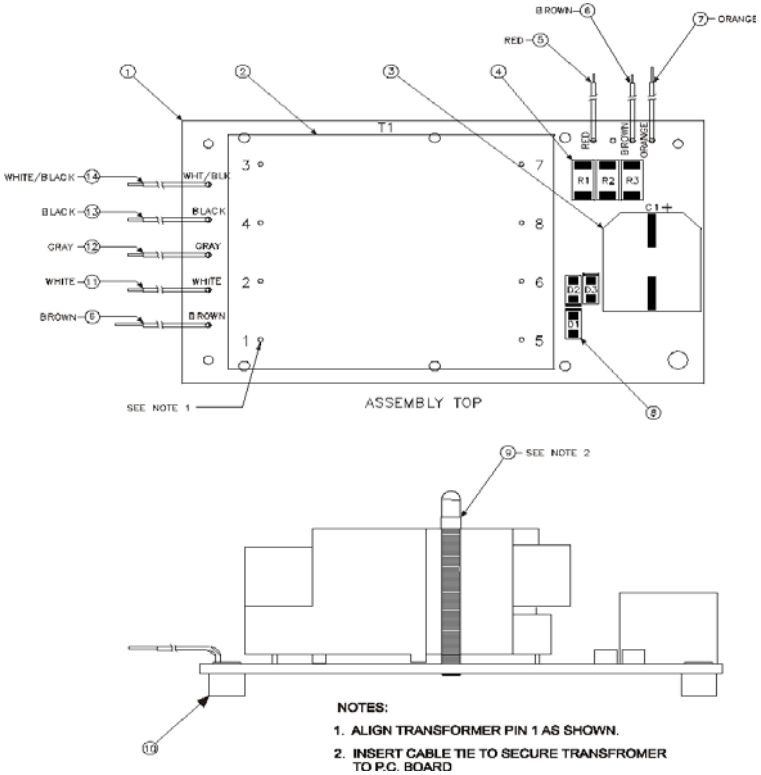
Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 33	RF Power Analyst, Subassembly	70998	4391B002	REF
1	Housing, Assembly	70998	4391A004	1
2	Power Supply Assembly	70998	4391B041	1
3	#6-32 x 5/16 Phill Pan Head Screws	70998	1116-0513-00	2
4	#6 Internal Locking Washer	70998	1132-0205-00	2
5	Panel Assembly	70998	4391B017	1
7	1/2" Shrink Tube	70998	5-566-3	2
11	#4 External Locking Washer	70998	1132-0106-00	4
13	#6 External Locking Washer	70998	1132-0206-00	1
14	#6 Split Locking Washer	70998	1132-0201-00	1
15	#6-32 Hex Nut	70998	1131-0200-00	1
16	Label	70998	5A2315-1	1
17	#4-40 x 3/8 Pan Head Screws	70998	1112-0613-00	4
18	Caution Label	70998	5A2518-3	1

Figure 35 Transformer Assembly



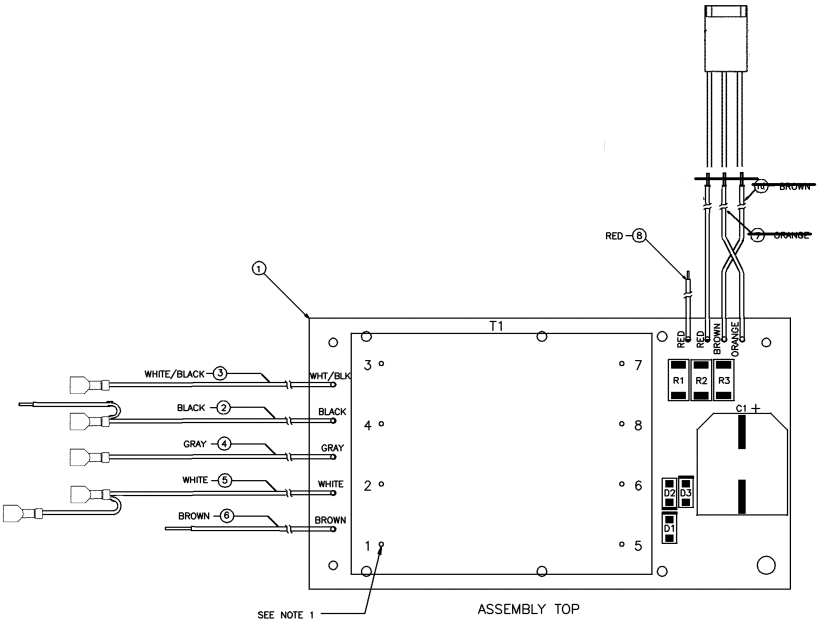
Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 38	Transformer, Assembly	70998	4391-020	REF
-1	• Transformer	08779	DP241-5-16	1
-2	• Electrical Wire, stranded tinned No. 22GA., balck vinyl insul.		COML	1
-3	• Electrical Wire, stranded tinned No. 22GA., black/white vinyl insul.		COML	1
-4	• Electrical Wire, stranded tinned No. 22GA., gray vinyl insul.		COML	1
-5	• Electrical Wire, stranded tinned No. 22GA., white vinyl insul.		COML	1
-6	• Tubing, Vinyl, 5/64 in. OD, 1 in. lg	9A204	No. 16 Temflex 105	2
-7	• Capacitor, Electrolytic, axial, 3300 uF (C11)	55680	TVX1C332M	1
-8	• Terminal, Transformer	05616	202	1
-9	• Diode, Rectifier (CR3, CR4, CR5)	14936	1N4002	3
-10	• Resistor, 22 Ohms, 5%, 1W (R16)	01121	RCR32	1
-11	• Shrinkable Tubing, teflon, 1 in. lg	92194	FIT-400-9	1
-12	• Electrical Wire, stranded No. 22GA., brown vinyl insul.		COML	1
-13	• Electrical Wire, stranded No. 22GA., orange vinyl insul.		COML	1
-14	• Shrink Tube, 3/16 in. ID, 1/2 in. lg	92194	FIT-221	4

Figure 36 Power Supply PCB Assembly (SN 074100063 to SN 120801479)



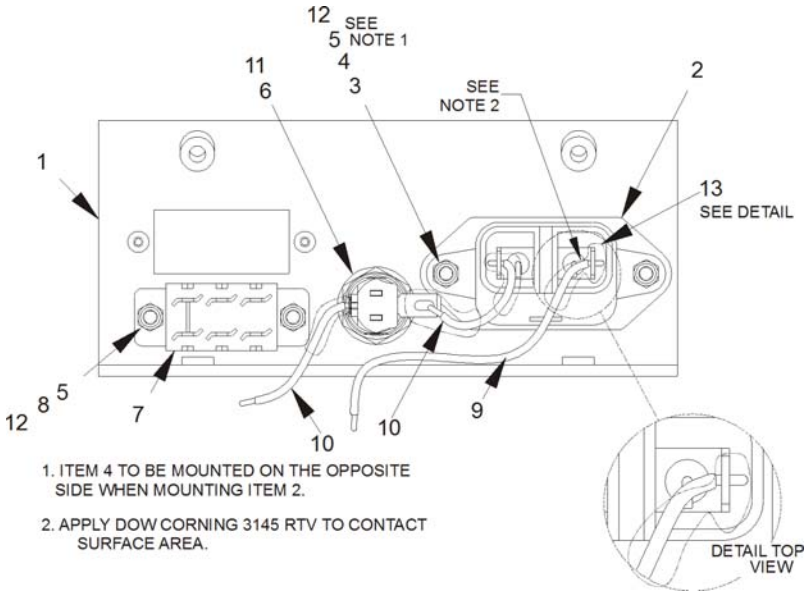
Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 36	Power Supply PCB, Subassembly	70998	4391A041	REF
1	• PCB, Power Supply	70998	4391A040	1
2	• T1, Transformer, VDE (T1)	20462	SPW-2302	1
3	• Capacitor, Electrolytic, 3300 µF, 20%, 25V (C1)	2M734	EEVFK1E332M	1
4	• Resistor, Chip, Thick Film, 37.4 Ohm, 1 W, 1%, 250V (R1, R2, R3)	GENRC	2512	3
5	• Wire Assembly, Red, 22 GA, 6 in.	70998	4386-004-21	1
6	• Wire Assembly, Brown, 22 GA, 6 in.	70998	4386-004-18	2
7	• Wire Assembly, Org, 22 GA, 5-1/4 in.	70998	4386-004-19	1
8	• D1, D2, D3, Diode, FM4002	F4022	S1B	3
9	• Cable Tie, 8 in.		COML	1
10	• Standoff, Swage Type			
11	• Wire Assembly, White, 22 GA, 8 in.	70998	4386-004-15	1
12	• Wire Assembly, Gray, 22 GA, 8 in.	70998	4386-004-16	1
13	• Wire Assembly, Black, 22 GA, 8 in.	70998	4386-004-14	1
14	• Wire Assembly, Wht/Blk, 22 GA, 8 in.	70998	4386-004-17	1

Figure 37 Power Supply PCB Assembly (SN 120801480 and above)



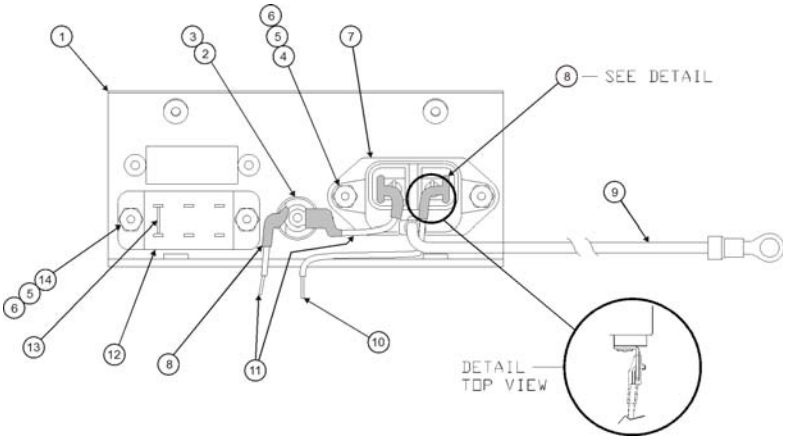
Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 32 and Figure	PC Board, Power Supply Assembly	70998	4391B041	REF
1	•	70998	4391A040	1
2	•	70998	4391B043-2	1
3	•	70998	4386-004-17	1
4	•	70998	4386-004-16	1
5	•	70998	4391B043-1	1
6	•	70998	4386-004-21	1
7	•	70998	5-1554-1	4
8	•	70998	5-1505-7	1
9	•	70998	5A2414-1	1
T1	•	70998	5A2414-1	1
R1,2,3	•	71468	6A310-37R4-F	3
C1	•	70998	6A436-332-M1EK	1
D1, 2,3	•	70998	6B1000-2	1
15	•	70998	4391B042	1

Figure 38 Rear Panel Assembly (SN 074100062 and below)



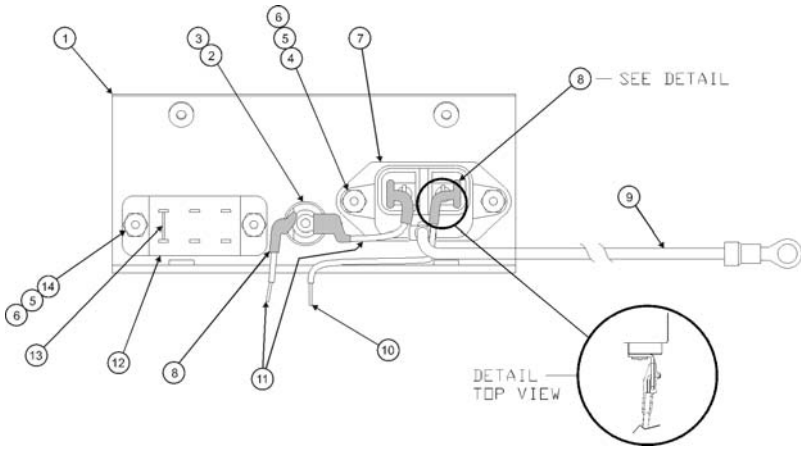
Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 38	Rear Panel, Assembly	70998	4391-017	REF
-1	• Rear Panel	70998	4391-023	1
-2	• Filter, Power Line	05245	1EEA1	1
-3	• Screw, Machine, pan head, No. 4-40, 7/16 in. lg, sst		COML	2
-4	• Lock Washer, internal tooth, No. 4, sst		COML	2
-5	• Lock Nut, Elastic, No 4-40, sst		COML	4
-6	• Fuse Holder, Panel, 3AG	75915	345-602L	1
-7	• Switch, slide, locking, DPDT (S4)	82389	46256LFR	1
-8	• Screw, Machine, pan head No. 4-40, 5/16 in. lg sst.		COML	2
-9	• Electrical Wire, stranded tinned No. 22GA., white vinyl insul.		COML	1
-10	• Electrical Wire, stranded tinned No. 22GA., black vinyl insul.		COML	2
-11	• Fuse, 3AG, 1/8 amp 250 volt (F1)	75915	313.125	1
-12	• Washer, Type B, flat, No.4, sst		COML	4
-13	• Shrink Tube, 1/8 in. ID, 1/2 in. lg	92194	FIT-221	2

Figure 39 Rear Panel Assembly (SN 074100063 to 120801479)



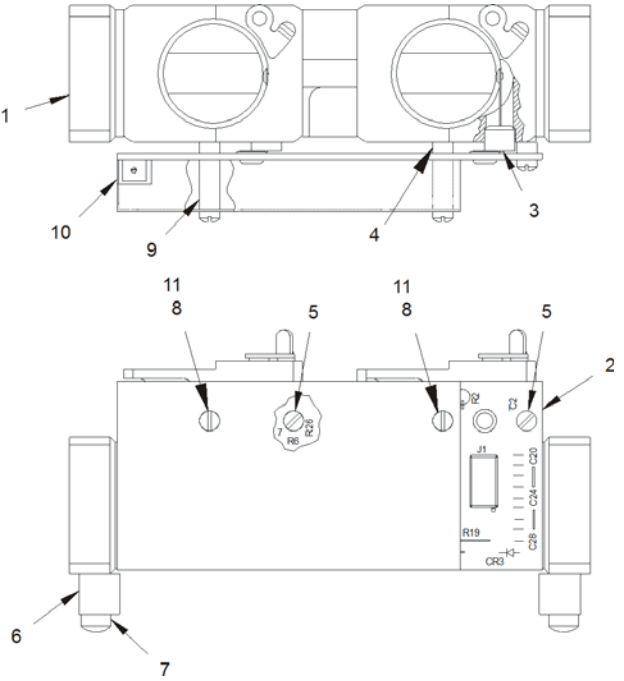
Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 39	Rear Panel, Assembly	70998	4391A017	REF
1	• Rear Panel	70998	4391A023	1
2	• Fuse, 5 x 22 mm, SLO-BLO, 1/8 amp 250 volt	75915	218.125	1
3	• Fuse Holder, Panel, 5 x 20 mm, Intl.	61935	FEF031.1081	1
4	• Screw, Machine, pan head, No. 4-40, 7/16 in. lg, sst		COML	2
5	• Nut, Hex, Nylon insert, No 4-40, sst		COML	4
6	• Washer, Type B, flat, No.4, sst		COML	4
7	• Filter, Power Line	05245	1EEA1	1
8	• Shrink Tube, 1/8 in. ID, 1/2 in. lg	92194	FIT-221	4
9	• Electrical Wire Assembly, stranded tinned No. 16GA., Grn/Yel vinyl insul.	70998	8578A035-12	1
10	• Electrical Wire Assembly, stranded tinned No. 22GA., white vinyl insul.	70998	4386-004-5	1
11	• Electrical Wire Assembly, stranded tinned No. 22GA., black vinyl insul.	70998	4386-004-12	2
12	• Switch, slide, locking, DPDT	00U24	83710030	1
13	• Electrical Wire, solid, tinned No. 22GA		COML	1
14	• Screw, Machine, pan head No. 4-40, 5/16 in. lg sst.		COML	2

Figure 40 Rear Panel Assembly (SN 120801480 and above)



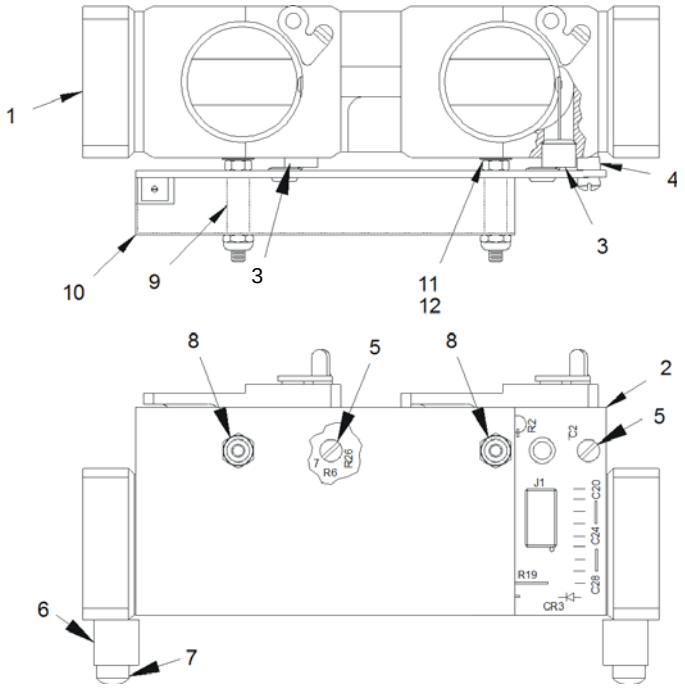
Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 40	Rear Panel, Assembly	70998	4391B017	REF
1	• Rear Panel	70998	4391B023	1
2	• Fuse, 5 x 22 mm, SLO-BLO, 1/8 amp 250 volt	75915	218.125	1
3	• Fuse Holder, Panel, 5 x 20 mm, Intl.	61935	FEF031.1081	1
4	• Screw, Machine, pan head, No. 4-40, 7/16 in. lg, sst		COML	2
5	• Nut, Hex, Nylon insert, No 4-40, sst		COML	4
6	• Washer, Type B, flat, No.4, sst		COML	4
7	• Filter, Power Line	05245	1EEA1	1
8	• Shrink Tube, 1/8 in. ID, 1/2 in. lg	92194	FIT-221	4
9	• Electrical Wire Assembly, stranded tinned No. 16GA., Grn/Yel vinyl insul.	70998	8578A035-12	1
10	• Electrical Wire Assembly, stranded tinned No. 22GA., white vinyl insul.	70998	4386-004-5	1
11	• Electrical Wire Assembly, stranded tinned No. 22GA., black vinyl insul.	70998	4386-004-12	2
12	• Switch, slide, locking, DPDT	00U24	83710030	1
13	• Electrical Wire, solid, tinned No. 22GA		COML	1
14	• Screw, Machine, pan head No. 4-40, 5/16 in. lg sst.		COML	2
	• Label (not shown)	70998	5A2315-2	1

Figure 41 Line Section Assembly (SN 01723 and below)



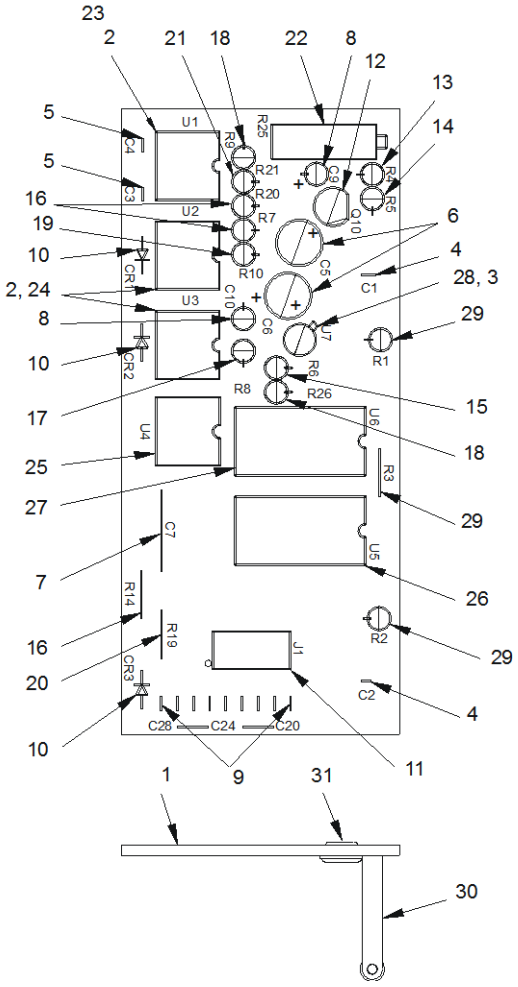
Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 41A	Line Section, Assembly	70998	4391-064	REF
-1	• Line Section, Subssembly	70998	4391-065	1
-2	• PC Board, Data Acquisition Assy (See Figure 43 for Breakdown)	70998	4391-062	1
-3	• Bead, Keying	70998	4391-026	2
-4	• Spacer	70998	4391-027	2
-5	• Screw, Machine, fillister head, No. 4-40, 1/4 in. lg, sst		COML	2
-6	• Support	70998	4381-029	2
-7	• Screw, Machine, fillister head, No. 8-32, 1/2 in. lg, sst		COML	4
-8	• Screw, Machine, fillister head, No. 4-40, 7/8 in. lg, sst		COML	2
-9	• Spacer	70998	4391-035-1	2
-10	• Cover, PC Board	70998	4391-034	1
-11	• Lock Washer, No. 4 internal sst		COML	2

Figure 42 Line Section Assembly (SN 01724 and above)



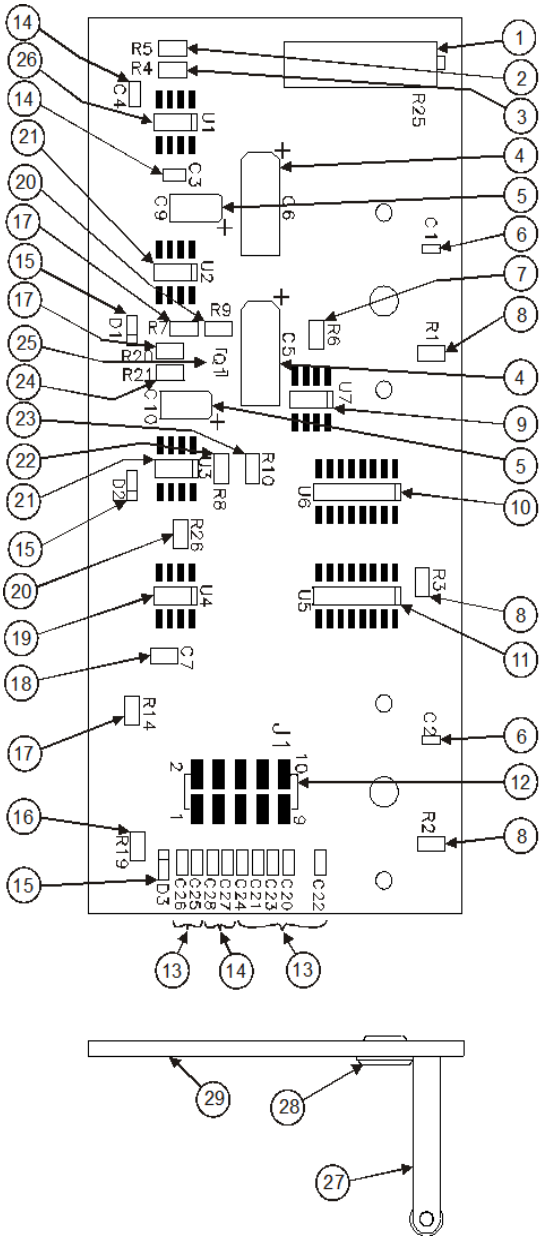
Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 41B	Line Section, Assembly	70998	4391-064	REF
-1	• Line Section, Subssembly	70998	4391-065	1
-2	• PC Board, Data Acquisition Assy (See Figure 43 or Figure 44 for Breakdown)	70998	4391-062	1
-3	• Bead, Keying	70998	4391-026	2
-4	• Spacer	70998	4391-027	2
-5	• Screw, Machine, fillister head, No. 4-40, 1/4 in. lg, sst		COML	2
-6	• Support	70998	4381-029	2
-7	• Screw, Machine, fillister head, No. 8-32, 1/2 in. lg, sst		COML	4
-8	• Hex Nut, with nylon insert, No. 4-40		1131-1013-00	2
-9	• Spacer	70998	4391-035-1	2
-10	• Cover, PC Board	70998	4391-034	1
-11	• Lock Washer, No. 4 internal sst		COML	2
-12	• Standoff, Threaded	70998	4391-038	2

Figure 43 Data Acquisition PC Board (SN 074100062 and below)



Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 43	PC Board, Data Acquisition	70998	4391-062	REF
	• PC Board, Subassembly	70998	4391-006	1
-1	• • PC Board, Acquisition	70998	4391-010	1
-2	• • Pad Mounting	32559	808-187	3
-3	• • Spacer, TO-18 Mount	32559	109-045	1
-4	• • Capacitor, Ceramic, 150 pF, 10%, 100V (C1, C2)	99942	CN15A 151K	2
-5	• • Capacitor, Ceramic, 0.1 uF, 20% 50V (C3, C4, C27, C28)	72982	RPE121Z5 U-104M	4
-6	• • Capacitor, Electrolytic, 100 uF, 20% (C5, C6)	2M734	ECEA1VU1 01	2
-7	• • Capacitor,Polypropylene, 2200 pF (C7)	74861	PP11.0022-1605	1
-8	• • Capacitor, Electrolytic, 2.2uF, (C9, C10)	01884	150D225X 90-15A2	2
-9	• • Capacitor, Ceramic, 1000 pF –0/+100% (C20 thru C26)	59660	Type SM	9
-10	• • Diode (CR1 thru CR3)	15238	1N4148	3
-11	• • Header, Male, I/O Pin	63878	929836-01	1
-12	• • Transistor, PNP (Q10)	27014	2N3906	1
-13	• • Resistor, 2.2M ohms, 5%, 1/4W (R4)	01121	Type CB	1
-14	• • Resistor, 3.0K ohms, 1%, 1/8W (R5)	91637	RN55D	1
-15	• • Resistor, 3.32K ohms, 1%, 1/8W (R6)	91637	RN55D	1
-16	• • Resistor, 1.0K ohms, 10%, 1/4W (R7, R14, R20)	01121	Type CB	2
-17	• • Resistor, 470 ohms, 2%, 1/4W (R8)	70998	5-546-3	1
-18	• • Resistor, 10M ohms, 5%, 1/4W (R9, R26)	01121	Type CB	2
-19	• • Resistor, 5.6M ohms, 10%, 1/4W (R10)	01121	Type CB	1
-20	• • Resistor, 10K ohms, 10%, 1/4W (R19)	01121	Type CB	1
-21	• • Resistor, 150 ohms, 5%, 1/4W (R21)	01121	Type CB	1
-22	• • Potentiometer,Cermet trimmer,100K Ohm	01121	94P104	1
-23	• • Integrated Circuit, OP Amp (U1)	27014	LF257H	1
-24	• • Integrated Circuit, Voltage Comparator (U2, U3)	27014	LM211H	2
-25	• • Integrated Circuit, OP Amp, Dual (U4)	18722	CA3240E	1
-26	• • Integrated Circuit, Analog Multiplexer (U5)	27014	4052B	1
-27	• • Integrated Circuit, Analog Multiplexer (U6)	27014	4051B	1
-28	• • Integrated Circuit, Precision Voltage Reference (U7)	27014	LM113H	1
-29	• • Resistor, 1.4K ohms, 1%, 1/8W (R1 thru R3) replace as a matched set	91637	RN55D	3
-30	• • Contact, DC	70998	4381-007	2
-31	• • Eyelet, Silver	57771	GS 5-5	2

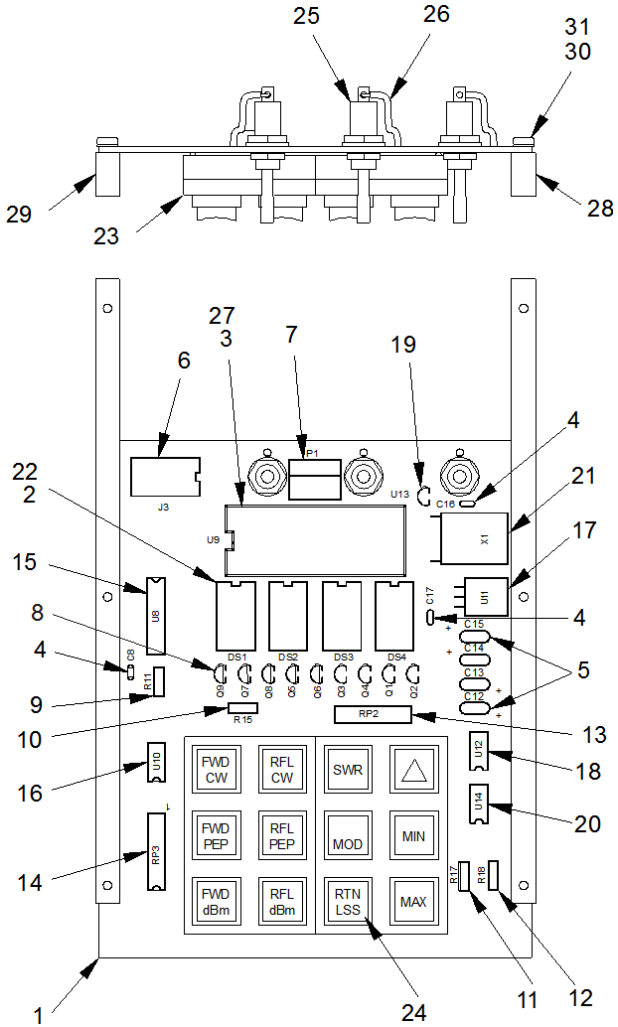
Figure 44 Data Acquisition PC Board (SN 074100063 and above)



Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 44	PC Board, Data Acquisition	70998	4391-062	REF
	• PC Board, Subassembly	70998	4391A006	1

1	• • Potentiometer, Trimmer, 100K Ohm, 20 Turn (R25)	GENRC	43P	1
2	• • Resistor, Chip, 3.01K ohms, 1%, 1/8W, 150V, Thick Film (R5)	GENRC	0805	1
3	• • Resistor, Chip, 2.2M ohms, 5%, 1/8W, Thick Film, 150V (R4)	GENRC	0805	1
4	• • Capacitor, Tantalum, 100 uF, 20%, 10V, Low ESR (C5, C6)	31433	3216	2
5	• • Capacitor, Chip Tantalum Electrolytic, 2.2uF, 10%, 20V (C9, C10)	31433	Size 'A' (3216 mm)	2
6	• • Capacitor, Ceramic Chip, 150 pF, 5%, 25V, NPO (C1, C2)	GENRC	0402	2
7	• • Resistor, Chip, 3.32K ohms, 1%, 1/8W, 150V, Thick Film (R6)	GENRC	0805	1
8	• • Resistor, Chip, 1.4K ohms, 0.1%, 1/10W (R1 thru R3) replace as a matched set	GENRC	0705/0805	3
9	• • Diode, Voltage Reference, 1.2V (U7)	27014	LM285D	1
10	• • IC, 8-Channel Multiplexer, (U6)	GENRC	4051B	1
11	• • IC, 4-Channel Multiplexer, (U5)	GENRC	4052B	1
12	• • Header, Male, 5 x 10 Pin (J1)		COML	1
13	• • Capacitor, Ceramic Chip, 1000 pF, 10%, 50V, X7R (C20 thru C26)	GENRC	0603	7
14	• • Capacitor, Ceramic Chip, 0.1 uF, 10% 50V, X7R (C3, C4, C27, C28)	GENRC	0603	4
15	• • Diode, Fast Switching, (D1 thru D3)	GENRC	1N4148	3
16	• • Resistor, Chip, 10K ohms, 1%, 1/8W, 150V, Thick Film (R19)	GENRC	0805	1
17	• • Resistor, Chip, 1.0K ohms, 1%, 1/8W, 150V, Thick Film (R7, R14, R20)	GENRC	0805	2
18	• • Capacitor, Film Chip, 2200 pF, 2%, 16V (C7)	2M734	0805	1
19	• • IC, OP Amp, U4)	64155	LT1490CS8	1
20	• • Resistor, Chip, 10M ohms, 5%, 1/8W, 150V, Thick Film (R9, R26)	GENRC	0805	2
21	• • IC, Voltage Comparator, (U2, U3)	FAHD5	LM211D	2
22	• • Resistor, Chip, 470 ohms, 5%, 1/8W, 150V, Thick Film (R8)	GENRC	0805	1
23	• • Resistor, Chip, 5.6M ohms, 5%, 1/84W, 150V, Thick Film (R10)	GENRC	0805	1
24	• • Resistor, Chip, 150 ohms, 1%, 1/8W, 150V, Thick Film (R21)	GENRC	0805	1
25	• • Transistor, PNP, (Q1)	GENRC	3906	1
26	• • IC OP Amp, Single, 145 MHz, (U1)	1BA54	AD8065ARZ	1
27	• • Contact, DC	70998	4381-007	2
28	• • Eyelet, Silver	57771	5-1224-2	2
29	• • PC Board, Acquisition, Unpopulated	70998	4391A010	1

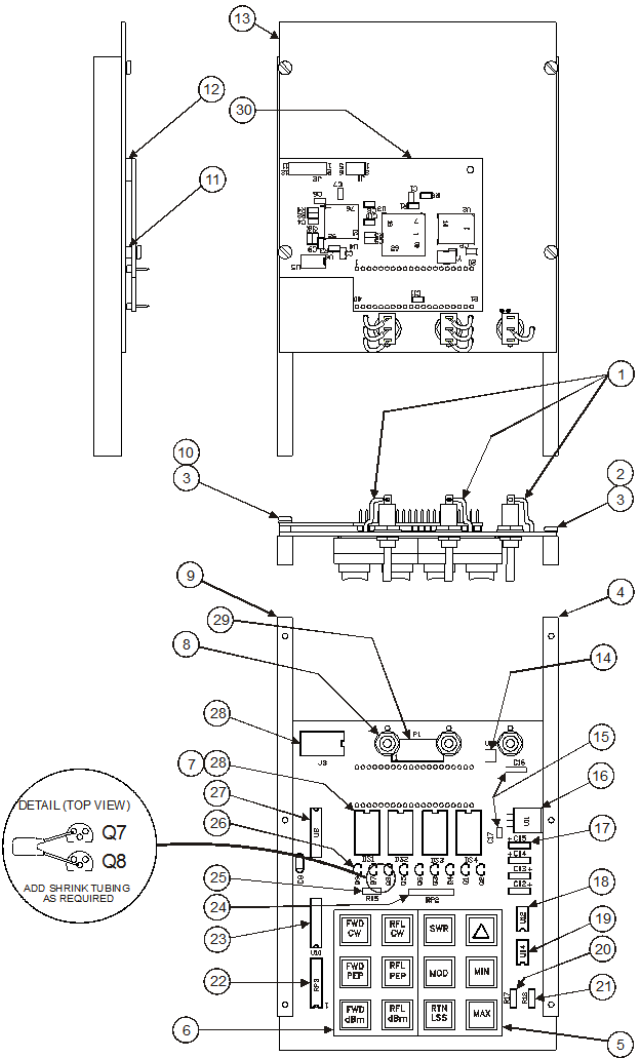
Figure 45 MCU PC Board Assembly (SN 074100062 and below)



Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 45	PC Board, MCU, Assembly	70998	4391-068	REF
	• PC Board, MCU, Subassembly	70998	4391-063	1
	• • PC Board, MCU, Subassembly	70998	4391-008	1
-1	• • • PC Board, MCU	70998	4391-011	1
-2	• • • Socket, Low profile, 14 pin DIP	91506	514-AG10D	4
-3	• • • Socket, Low profile, 40 pin DIP	00779	640379-1	1
-4	• • • Capacitor, Ceramic, 0.1 uF, 20%, (C8, C16, C17)	72982	REP121Z5U 104M	3
-5	• • • Capacitor, 10 uF (C12 thru C15)	31433	T322C106M0 15AS	4

-6	• • • Socket, Low profile, DIP (J3)	91506	514-AG10D	1
-7	• • • Header, Male, right angle (P1)	70998	4391-030	1
-8	• • • Transistor PNP (Q1 thru Q9)	27014	2N3906	9
-9	• • • Resistor, 1M ohms, 5% 1/4W (R11)	01121	Type CB	1
-10	• • • Resistor, 150 ohms, 5% 1/4W (R15)	01121	Type CB	1
-11	• • • Resistor, 4.02K ohms, 1% 1/8W (R17)	91637	RN55d	1
-12	• • • Resistor, 4.02K ohms, 1% 1/8W (R17)	91637	RN55d	1
-13	• • • Resistor Network, 4.7K ohms, SIP (RP2)	32997	4380R-102-472	1
-14	• • • Resistor Network, 100 ohms, DIP (RP3)	32997	4114R-001-101	1
-15	• • • Integrated Circuit, NAND Gate, quad (U8)	27014	74LS00	1
-16	• • • Integrated Circuit, Decoder/Driver, Seven segment (U10)	27014	7447A	1
-17	• • • Integrated Circuit, Voltage regulator (U11)	27014	LM340T5	1
-18	• • • Integrated Circuit, Voltage converter, CMOS (U12)	32293	ICL7660CPA	1
-19	• • • Integrated Circuit, Voltage regulator (U13)	27014	LM340LAZ-5.0	1
-20	• • • Integrated Circuit, Voltage comparator (U14)	27014	LM311N	1
-21	• • • Crystal, Microprocessor, 2.00 MHz (X1)	2U635	MPC33	1
-22	• • Display, LED (DS1 thru DS4)	50434	5082-7610	4
-23	• • Switch, Pushbutton (S5)	81073	82-601-81	2
-24	• • Legend, keyboard	70998	4386-012	1
-25	• • Switch, Toggle, SPDT (S1 thru S3)	09353	7103-L2Y-ZQ	3
-26	• • Electrical Wire, No. 22GA., solid copper, yellow PVC insul., 1 in. long		COML	1
-27	• • Integrated Circuits, Masked Microprocessors, NMOS (U9)	70998	4381-035	1
-28	• • Support, PC Board	70998	4391-024	1
-29	• • Support, PC Board	70998	4391-025	1
-30	• Screw, Machine, pan head, No. 4-40, 1/4 in. lg, sst		COML	4
-31	• Lock Washer, Split, No. 4, sst		COML	4

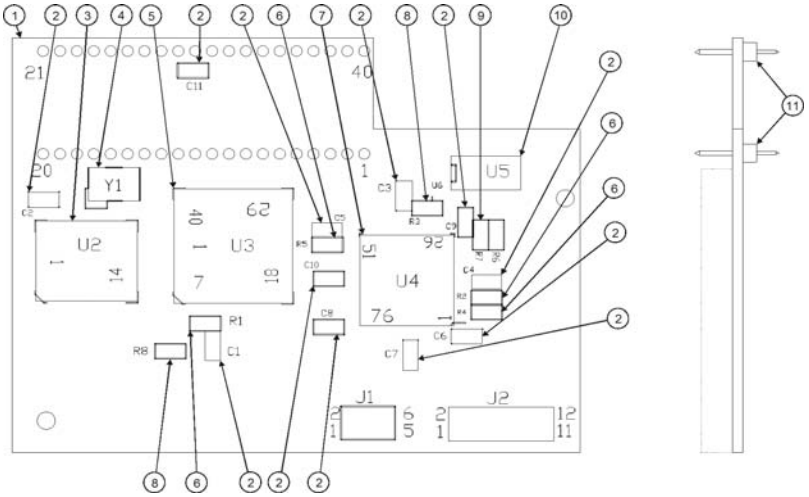
Figure 46 MCU PC Board Assembly (SN 074100063 to 082700313)



Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 46	PC Board, MCU, Assembly	70998	4391A007	REF
1	• Electrical Wire, Assembly No. 22GA., solid copper 0.060 in dia., yellow PVC insul., 1 in. long	70998	4386-004-22	7
2	• Screw, Machine, pan head, No. 4-40, 1/4 in. lg, sst		COML	3
3	• Lock Washer, Split, No. 4, sst		COML	4

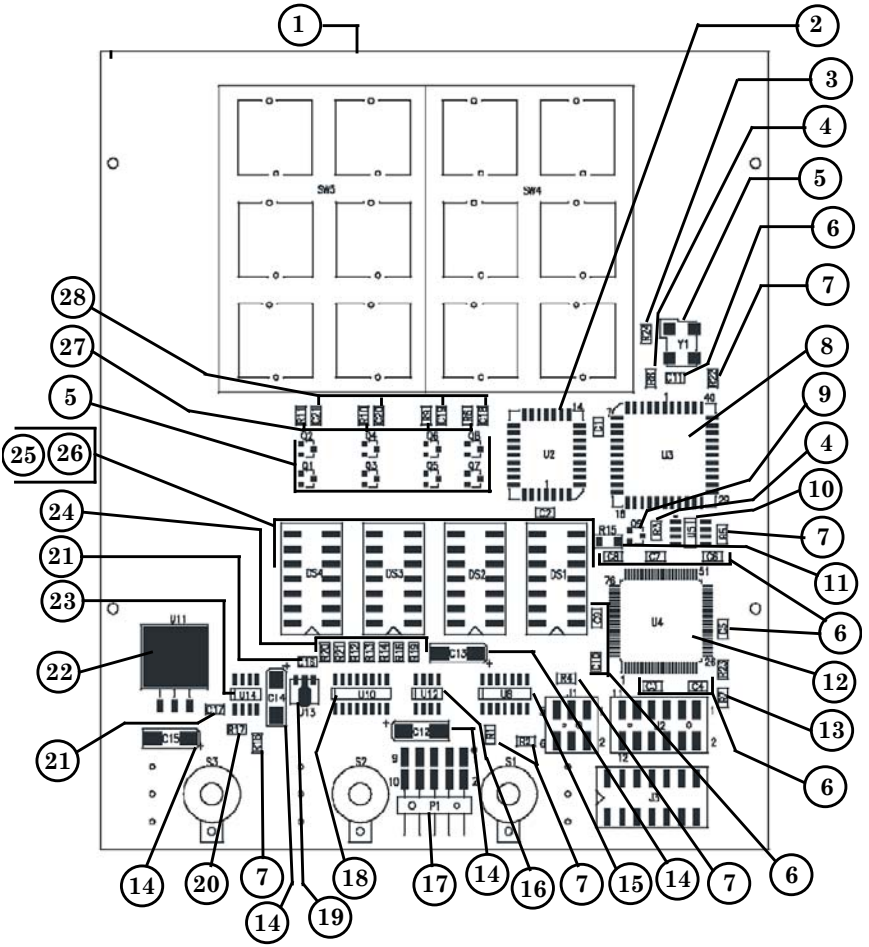
4	• Support, PC Board	70998	4391-024	1
5	• Switch, Pushbutton	81073	5-1277-2	1
6	• Switch, Pushbutton	81073	5-1277-1	1
7	• Display, LED (DS1 thru DS4)	50434	5082-7610	4
8	• Switch, Toggle, SPDT (S1 thru S3)	09353	7103L2YZQE	3
9	• Support, PC Board	70998	4391-025	1
10	• Screw, Machine, pan head, No. 4-40, 7/16 in. lg, sst		COML	1
11	• Spacer	70998	4391-027	
12	• Gasket, Neoprene, Self Adhesive, 3/8 " wide x 1/16" thick	02690	5-1052-3	1
13	• PC Board, Pre-assembly	70998	4391A008	1
13	• • PC Board, MCU	70998	4391-011	1
14	• • Integrated Circuit, Voltage regulator (U13)	27014	LM340LAZ-5.0	1
15	• • Capacitor, Ceramic, 0.1 uF, 20%, 50V (C16, C17)	72982	REP121Z5U 104M	2
16	• • Integrated Circuit, Voltage regulator (U11)	27014	LM340T5	1
17	• • Capacitor, Tant., 10 uF, 20%, 25V, (C12 thru C15)	31433	T322C106M0 25AS	4
18	• • Integrated Circuit, Voltage converter, CMOS (U12)	32293	ICL7660CPA	1
19	• • Integrated Circuit, Voltage comparator (U14)	27014	LM311N	1
20	• • Resistor, Metal Film, 4.02K ohms, 1% 1/4W (R17)	91637	RN55d	1
21	• • Resistor, Metal Film, 10K ohms, 1% 1/4W (R18)	91637	RN55d	1
22	• • Resistor Network, 100 ohms, DIP (RP3)	32997	4114R-001-101	1
23	• • Integrated Circuit, Decoder/Driver, Seven segment (U10)	27014	7447A	1
24	• • Resistor Network, 4.7K ohms, SIP (RP2)	32997	4380R-102-472	1
25	• • Resistor, Metal Film, 150 ohms, 5% 1/4W (R15)		RN60D	1
26	• • Transistor PNP (Q1 thru Q9)	27014	2N3906	9
27	• • Integrated Circuit, NAND Gate, quad (U8)	27014	74LS00	1
28	• • Socket, Low profile, 14 pin DIP (DS1-DS4, J3)	91506	514-AG10D	5
29	• • Header, Male, right angle (P1)	70998	4391-030	1
30	• PC Board, Aux. Processor, Assy (see Figure 47)	70998	4381A035	1
(detail)	• • Capacitor, Ceramic, 0.022 uF, 10%, 50V (across Q7 and Q8, see drawing detail)	GERNC	X7R	1

Figure 47 Microprocessor Daughter PCB (SN 074100063 to SN 082700313)



Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 45	PC Board, Aux. Processor, Assembly	70998	4381A035	REF
1	• PC Board, Pre-assembly, Unpopulated	70998	4381A067	1
2	• Capacitor, Ceramic Chip, 0.1 uF, 20%, 25V, (C1 - C11)	GENRC	0805	11
3	• Integrated Circuit, Memory (U2)	70998	4381A090-2	1
4	• Oscillator, Crystal, 2.00 MHz (Y1)	1G8B7	ECS-P75-1.000-B	1
5	• Integrated Circuit, CMOS (U3)	56427	65SC02	1
6	• Resistor, Chip, Thick Film, 10.0K ohms, 1% 1/8W, 150V (R1, R2, R4, R5)	GENRC	0805	4
7	• Integrated Circuit, Field Programmable Gate Array (FPGA) (U4)	68994	XCS05-3VQ100C	1
8	• Resistor, Chip, Thick Film, 4.99K ohms, 1% 1/8W, 150V (R3, R8)	GENRC	0805	2
9	• Resistor, Chip, Thick Film, 150 ohms, 5%, 1/8W, 150V (R7)	GENRC	0805	1
10	• Integrated Circuit, EEPROM (U5)	70998	4381A070-1	1
11	• Header, Male	55322	TSF-120-01-T-S	2

Figure 48 Main Board Assembly (SN 082700314 to SN 120801479)

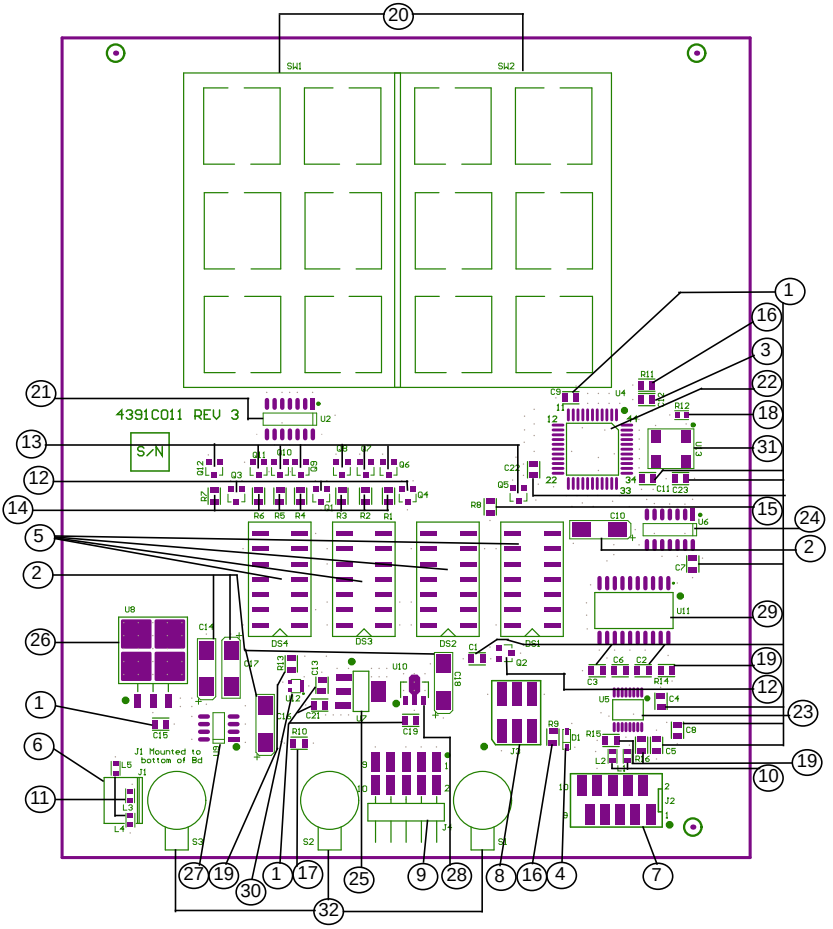


Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
Figure 48	PC Board Assembly	70998	4391B008	REF
1	• PC Board, Pre-assembly, Unpopulated	70998	4391A011	1
2	• Integrated Circuit, Memory / Programmed	70998	4381A090-2	1
3	• Resistor,Chip 39.2 1	GENRC	0805	1
4	• Resistor,Chip 4.99K	GENRC	0805	2
5	• Oscillator, Program	1G8B7	ECS-P75-1. 000-B	1
6	• Capacitor, Ceramic .1uF, 25V	GENRC	0805	11
7	• Resistor,Chip 10.0K	GENRC	0805	6
8	• Integrated Circuit, Microprocessor	*	W65CO256PLG-14	1
9	• Transistor-PNP #3906	FAHD5	MMBT3906LT	9

Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
10	• Integrated Circuit, EEPROM / Programmed	70998	4381B070-1	1
11	• Resistor,Chip 150 1%	GENRC	0805	1
12	• Integrated Circuit, FP GA	68994	XC505-3VQ100C	1
13	• Resistor,Chip 0 5% 0	GENRC	0805	1
14	• Capacitor,Tantchip 10uF, 35V	GENRC	6032	4
15	• Integrated Circuit, 2-Input NAND gat	0LCG1	74LS00	1
16	• Integrated Circuit, DC-DC Converter	34371	IRC7660CBAZ	1
17	• Connector, Header.1	55322	TSM-105-01-T-DH-P	1
18	• Integrated Circuit, Decoder/Driver,	0LCG1	74LS247D	1
19	• Voltage Regulator 5.	0LCG1	uA78L05ACPK	1
20	• Resistor,Chip 4.02K	GENRC	0805	1
21	• Capacitor, Ceramic C	GENRC	0805	2
22	• Integrated Circuit, Regulator	27014	LM340S-5.0	1
23	• Integrated Circuit, Voltage Comparat	FAH05	LM211D	1
24	• Resistor,Chip 100 1%	GENRC	0805	4
25	• LED Display	50434	5082-7610	3
26	• Socket, Integrated Circuit	55322	ICF-314-T-I-TR	5
27	• Resistor,Chip 4.75K	GENRC	0805	4
28	• Capacitor, Ceramic C	GENRC	0805	4

☞ ***** - *CAGE Code not available. For company contact information, refer to chart on page 51.*

Figure 49 Main Board Assembly (SN 120801480 and above)



Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
1	Capacitor, Ceramic Chip 0.1uF 10% 0805 50V X7R	70998	6A406-104-KR1H	16
2	Capacitor, Tantalum Chip 10uF 20% Electrolytic C/ TANT 35V	6KUV2	TAJD106M035RNJ	5
3	CAPACITOR, CERAMIC CHIP 0.01uF, 10% 0805, 50V, X7R	2M734	ECJ-2VB1H103K	1
4	Diode, Fast Switching, #4148	6L334	1N4148WS-7-F	1
5	CONNECTOR, SOCKET SMT	55322 50434	5082-7610, ICF-314-T-1-TR	4
6	Connector, Header Friction Lock Vertical 3 position	70998	6A822-10-1	1
7	Connector, Header	00779	1-188275-0	1

Index No.	Description 1 2 3	CAGE Code	Mfg Part No.	Qty
8	Connector, Header SMT Vertical, 6 pos (2x3) .100 x .100, .025 sq pin	55322	TSM-103-01-L-DV-P	1
9	Connector, Header	55322	TSM-105-01-T-DH-P	1
10	Filter, Chip Bead EMI 0603	34899	2506031027Y0	2
11	Filter, Chip Bead EMI 0603	34899	2506033017Z0	3
12	TRANSISTOR, FET P-CHANNEL POWER	SCT30	FDN358P	4
13	TRANSISTOR, FET, N-CHANNEL	SCT30	FDV303N	8
14	Resistor,Chip 121 1% 0805 150V 1/ 8W,Thick Film	70998	6A306-1210-F	7
15	Resistor,Chip 274 1% 0805 150V 1/ 8W Thick Film	70998	6A306-2740-F	1
16	Resistor,Chip 10.0K 1% 0805 150V 1/ 8W Thick Film	70998	6A306-1002-F	2
17	Resistor, Chip 30.1K 1% 0805 150V 1/8W Thick Film	70998	6A306-3012-F	1
18	Resistor,Chip 1K 1% 0603 50V 1/ 10W Thick Film	70998	6A304-1001-F	1
19	Resistor,Chip 20.0K 1% 0805 150V 1/ 8W Thick Film	70998	6A306-2002-F	4
20	2X3 KEY PAD	09353	82-601-81	2
21	IC, Hex Inverter (7404)	SCT30	MM74HCT04MTCX	1
22	IC, Microcontroller, 8-bit w/flash	1FN41	XMEGA32A4-AU	1
23	IC, Tranceiver RS-232, w/ Shutdown, 3-5.5V	1ES66	MAX3221EUE+	1
24	IC,Quad Nand Gate 74HCT00 SO-14 PKG OR 150 MIL	70998	6A2000-4	1
25	IC, Regulator 3.3V	0LCG1	TLV1117-33CDCY	1
26	IC, Regulator	27014	LM340SX-5.0/ NOPB	1
27	IC, Voltage Converter Positive to Negative #7660	34371	ICL7660CBAZA-T	1
28	Voltage Regulator 5.0V SOT-89	0LCG1	UA78L05ACPK	1
29	IC,Octal Buffrs/ Line Drv #74244 W/ 3-State Outputs	0LCG1	74HCT244DWR	1
30	C Buffer Uhs Single 3-State SC-70-5	SCT30	NC7SZ126P5X	1
31	Oscillator, Clock 2.000000MHz	1G8B7	ECS-P73-2.000-B	1
32	Switch, Toggle SPST	09353	7103L1YZQE 7103L2YZQE	3

Limited Warranty

All products manufactured by Seller are warranted to be free from defects in material and workmanship for a period of one (1) year, unless otherwise specified, from date of shipment and to conform to applicable specifications, drawings, blueprints and/or samples. Seller's sole obligation under these warranties shall be to issue credit, repair or replace any item or part thereof which is proved to be other than as warranted; no allowance shall be made for any labor charges of Buyer for replacement of parts, adjustment or repairs, or any other work, unless such charges are authorized in advance by Seller.

If Seller's products are claimed to be defective in material or workmanship or not to conform to specifications, drawings, blueprints and/or samples, Seller shall, upon prompt notice thereof, either examine the products where they are located or issue shipping instructions for return to Seller (transportation charges prepaid by Buyer). In the event any of our products are proved to be other than as warranted, transportation costs (cheapest way) to and from Seller's plant, will be borne by Seller and reimbursement or credit will be made for amounts so expended by Buyer. Every such claim for breach of these warranties shall be deemed to be waived by Buyer unless made in writing within ten (10) days from the date of discovery of the defect.

The above warranties shall not extend to any products or parts thereof which have been subjected to any misuse or neglect, damaged by accident, rendered defective by reason of improper installation or by the performance of repairs or alterations outside of our plant, and shall not apply to any goods or parts thereof furnished by Buyer or acquired from others at Buyer's request and/or to Buyer's specifications. Routine (regularly required) calibration is not covered under this limited warranty. In addition, Seller's warranties do not extend to the failure of tubes, transistors, fuses and batteries, or to other equipment and parts manufactured by others except to the extent of the original manufacturer's warranty to Seller.

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