TR-220
MULTIFUNCTION TEST SET

Transponder, TCAS, DME, TIS, and ADS-B Test Set
Operating and Maintenance Manual
Software Revision 3.40 and Later

REVISION

A	B	C	D	E	F	G	H	J	K	L	M	N
P	R	S	T	U	V	W	X	Y	Z			

01 July 2005

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Leading the AVIONICS TEST industry into the 21st Century!

NOTICE:

The information contained in this manual is subject to change without notice.

Tel-Instrument Electronics Corp. makes no warranty of any kind to this material, nor shall be liable including but not limited to, errors contained herein or for incidental or consequential damages in connection with the furnishings, performance, or use of this material.

PART NUMBER	VOLUMES INCLUDED	CHAPTERS INCLUDED
90008088-1	VOLUME 1	CHAPTERS I & II
90008088-2	VOLUMES 1 & 2	CHAPTERS I - VI

Chapter I – Introduction
Chapter II – Preparation for Use and Operation
Chapter III – Theory of Operation
Chapter IV – General Maintenance and Servicing Procedures
Chapter V – Schematics
Chapter VI – Illustrated Parts Catalog

Safety Precautions

The following are general safety precautions that are not related to a particular test or procedure. These are recommended procedures that all personnel must apply during many phases of operation and maintenance. It is assumed that the operator has general knowledge of electrical theory and the dangers associated with it.

1. When performing any of the preceding; thoroughly read and understand all procedures before actually performing them.

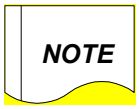
2. The various front panel connectors, switches, and controls specified can be located by referring to Figure 2-1 on page 2-3.

3. Take the time to learn the proper operation and function of the Test Set as outlined in Chapters 1, 2, and 3. Through knowledge of the Test Set and its capabilities greatly improves the time it takes to complete the tests.

4. Pay particular attention to **NOTES** and **WARNINGS** that may accompany some test and operational procedures.

WARNINGS

Alerts the operator to potential dangers associated with a particular test. Thoroughly understand the warning before proceeding to prevent a potentially dangerous situation or damage to the Test Set.



NOTES

Provides supplemental information that enhances the procedure or further explains in detail additional information to ensure understanding or proper operation.

5. Observe all standard safety procedures when working with live voltages. The potential for electric shock exists any time the Test Set is removed from its case.

6. DO-NOT service the unit or make adjustments alone. Always be in the presence of another person when working with live voltages.

7. Thoroughly inspect the equipment and the local area for potential hazards. Loose clothing and jewelry should be removed anytime the test set is being utilized or being serviced.

8. Be familiar with general first aid procedures and CPR (Cardiopulmonary Resuscitation). Contact your local Red Cross for more information.

9. Ensure the test equipment and the tools you utilize are in good operational condition and not damaged in any way.

10. Use only specified replacement parts as listed in the IPB. Failure to utilize factory approved parts may cause damage to personnel; the test set's, and possibly void the warranty.

ESD Safety and Protection

Many parts contained in the Test Set are sensitive to ESD (Electro-Static Discharge) damage. ESD can damage integrated circuits or semiconductors located within the Test Set. Only qualified personnel should service the Test Set to prevent damage. The following are guidelines to avoid ESD damage while still performing tests and or maintenance. These guidelines are meant only as a reminder, consult local directives and follow standard operating procedures before servicing, or repairing the Test Set.

- Wear a properly grounded wrist strap and remain in contact with an approved grounding point.
- Do not touch the connector pins or backplanes of ESD Sensitive circuits or parts.
- Ensure soldering irons are grounded before use.
- Do not remove any components or disconnect any connectors located in the Test Set with the power “ON”.
- Properly ground all test equipment being utilized. Refer to the test equipment operating manual for information.
- Place all removed components or parts in or on an approved conductive package.

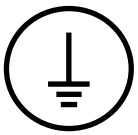
Most ESD devices or circuits and common points are readily identified utilizing several different methods. Below are some examples.

CE (IEC) Marking

The Following Symbols may be utilized in different locations throughout the Manual and are also located on and in the Test Set. Observe these warnings and markings and follow standard electrical safety anytime you utilize live circuits.

Caution

Alternating Current



Protective Conductor Terminal

Caution, risk of electrical shock

VOLUME 1

OPERATIONAL PROCEDURES

TR-220 TABLE OF CHANGES[1]

Date	REV	ECO	Page	Description
	Prelim.			Initial Release
07 Sep 03	A			Initial Release
15 July 04	B			Updated procedure explanations
16 Mar 05	C		2-5 & 6, 13, 17, 22, 43-46	Provided Detailed EHS and ADS setup and display info
01 Jul 05	D		Chapter 3-6	Added CHAPTERS 3, 4, 5, &6

[1] Changes are also denoted with a solid bar in the Left margin of each affected page.

Table of Contents

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

Appendix's

List of Illustrations (Figures)

List of Tables

CHAPTER I

INTRODUCTION

SECTION A

1.1 Scope of Manual

This manual is intended to familiarize the operator with the operating and maintenance procedures necessary to utilize the TR-220 Multifunction Test Set. Here-in after known as the T/S, Test Set, or TR-220.

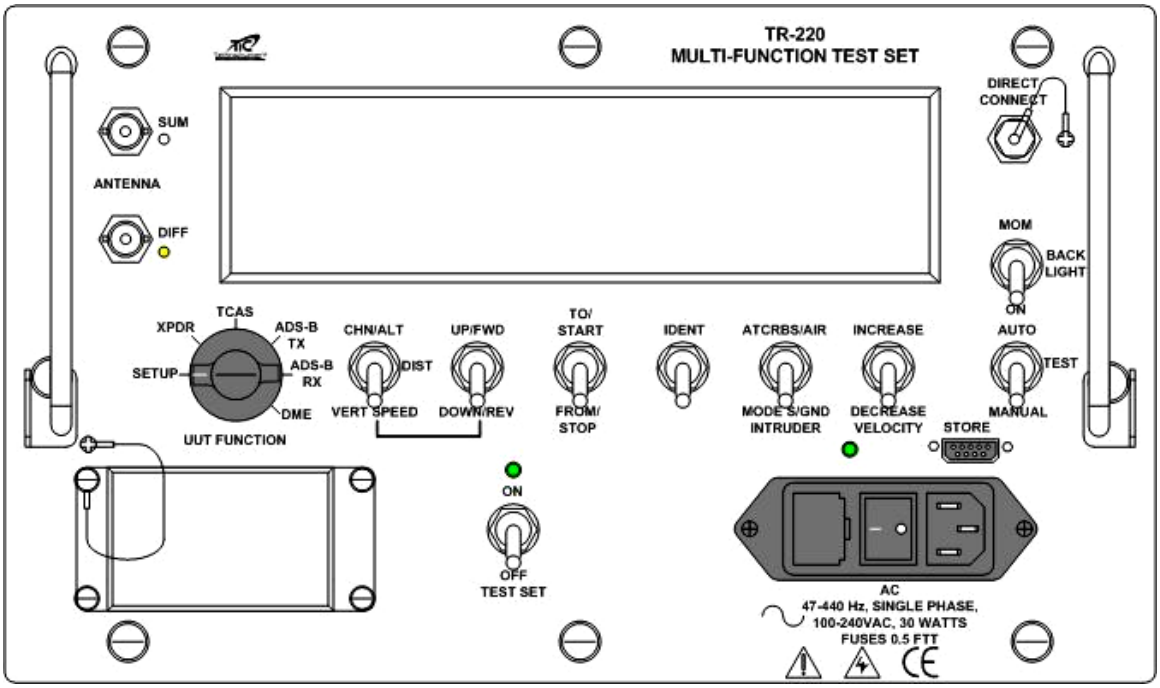


Figure 1-1

TR-220 Multifunction Test Set

1.2 Purpose and Function of the Equipment

The TR-220 Test Set tests airborne ATCRBS, MODE A/C, and MODE S transponders, TCAS I/II systems, DME equipment, and ADS-B and TIS Transponders. It is self-contained and battery operated that requires no direct hardware connection to the Unit Under Test (UUT).

For transponder testing, the Test Set simulates secondary radar to receive and radiate signals to the UUT from antennas supplied with the Test Set. For accurate power and frequency measurements, the Test Set can be directly connected to the UUT without the use of additional hardware.

For TIS testing, the Test Set transmits simulated Intruder Flight Data, which is then shown on the TIS display to verify results.

The Test Set will receive and Decode 1090 MHz ADS-B data including squitter type, airborne position, surface position, aircraft IDENT category, Airborne velocity, Latitude/Longitude, North/South velocity, and East/West Velocity. The **ADS-B TX** function allows the operator to receive, decode, and display ADS-B squitters. The **ADS-B RX** function permits the operator to simulate a 1090MHz squitter. The TR-220 can be configured to transmit an airborne or surface position squitter containing position, altitude, velocity, heading, aircraft category, flight ID, and Mode S address.

The simulation of an intruder aircraft converging on the Aircraft Under Test (AUT) accomplishes TCAS testing. The simulated target will be displayed on the TCAS display so the operator can ensure proper advisories.

DME tests simulate an aircraft at a simulated speed converging to or from a selected distance. By comparing the Test Set displayed distance to the DME under test display, the operator can confirm proper DME operation.

1.3 Regulatory Responsibilities

Effective April 6, 1987, The Federal Aviation Administration (FAA) has required certain tests be performed on transponders, both conventional ATCRBS and MODE S. In preparation for the installation of new air traffic control radar facilities, the FAA required new measurements to be performed on existing transponders and instituted required tests for MODE S transponders. FAR (Federal Aviation Regulation) Part 43, Maintenance, Preventive Maintenance, Rebuilding and Alteration section has been modified to reflect current technologies and improvements. Tel-Instruments has met all FAA requirements and recommends that the user of this type of equipment review the appropriate FAR or contact the manufacturer of their particular model of transponder to ensure that the current procedures and limitations are being correctly adhered to.

Eurocontrol has also incorporated new regulations for Mode S Elementary and Enhanced Surveillance. These requirements include Selective Identifiers for high-density traffic areas and will become mandatory beginning in May of 2003 for Elementary Surveillance and March 2005 for Enhanced Surveillance. The TR-220 Test Set has the capability to thoroughly test these new functions to comply with upcoming requirements. If you would like further information regarding these requirements, visit www.eurocontrol.int/.

1.4 Warranty

The Tel-Instrument Electronics Corporation warrants that each product it manufactures is free from defective material and workmanship for a period of two (2) years subject to the following terms and conditions. Tel-Instrument Electronics Corp. will remedy any such warranted defect subject to the following:

This warranty requires the unit to be delivered by the owner to Tel-Instrument intact for examination, with all transportation charges prepaid to the factory, within two (2) years from the date of sale to original purchaser. Tel-Instrument will solely determine when such defect exists.

This warranty does not extend to any of Tel products which have been subject to misuse, neglect, accident, improper installation, or used in violation of operating instructions. This warranty does not extend to units which have been repaired, calibrated, or altered in any way by a facility that is not approved, in writing, by Tel-Instrument Electronics Corp. to perform such work. This warranty does not apply to any product where the seals or serial number thereof has been removed, defaced or changed, nor to accessories not of our own manufacture.

Repair parts will be made available for a minimum period of five (5) years after the manufacture of this equipment has been discontinued.

This warranty is in lieu of all other warranties expressed or implied and all such other warranties are hereby expressly excluded. No representative or person is authorized to assume for us any other liability or warranty in connection with the sale of Tel's products.

This warranty does not cover or include batteries (batteries have a separate 90 day warranty).

Additional information with regard to the applications and maintenance of this equipment will be available from time to time.

1.4.1 Obtaining Warranty Service

In the event the Test Set may require service or repair that is included under the warranty provided with the Test Set; the following is necessary to ensure proper handling:

1. Contact Tel-Instrument Customer Support before shipping any Test Set back under a warranty condition.

   Tel-Instrument Electronics Corp. Customer Support can be reached by calling:

   - (201) 933-1600 (telephone)
   - (201) 933-7340 (fax)

2. The Customer Support Department will discuss the matter and if validated, issue an RMA (Return Material Authorization) number and form. Do not return any product without first receiving this authorization.
3. The Test Set must be returned with the completed RMA form. This will ensure prompt handling and expedited service.
4. Products must be returned in the Original Shipping Container (see Paragraph 1.4.1). If the original container is no longer available, please contact Tel-Instrument for guidance. Include in or on the shipping container the following information:

- RMA Form on top of the product
- The assigned RMA number written in bold letters on the outside of the shipping container
- Model, Serial Number, and specific details regarding the problem
- POC name, return address, telephone number, and email address

5. Freight Charges to the factory are the responsibility of the owner/operator. Tel-Instrument will provide return shipping if the problem is determined to be warranty covered.

1.4.2 Shipping and Packing the Test Set

1. Repackage the Test Set in the Original container utilizing the provided packing material. Do Not Ship the Test Set with out using a shipping container, this will prevent damage to the case and or finish during transit.

2. Wrap the Test set within plastic sheeting and firmly seat the Test Set in the original corner molds. Place all necessary documentation (RMA Form, POC, etc…), on top of the Test Set.

3. Utilize Package Tape and seal all seams. If the use of an industrial box stapler is used, be sure that they do not protrude through the box to prevent injury to personnel handling the package.

4. Firmly affix a shipping label and mail the Test Set to the following:

Tel-Instrument Electronics Corp.
728 Garden Street
Carlstadt, NJ 07072

Attn: Repair Department

SECTION B

EQUIPMENT DESCRIPTION

1.5 Specifications

Transponder Transmitter

Frequency	1030 MHz ± 10 kHz
Output Power	≥ 4dBm
Modes	A, C, S, ADS B TX/RX, and TIS

Transponder Receiver

Frequency	Frequency	1086.5 to 1093.5 MHz
	Accuracy	± 200 kHz
Power	Range	47 to 64 dBm
	Accuracy	± 2 dB (direct connect)
		± 3 dB (radiated)
Sensitivity	Range.	-50 to -87 dBm
	Accuracy	± 2 dB (direct connect)
		± 3 dB (radiated)
Reply Percent	Range	0 to 100%
	Accuracy	± 1%

DME

DME Receiver

Frequency	Frequency	Channel Freq +3.5 MHz
	Accuracy	± 200 kHz
Sensitivity	Range	< -35 dB

DME Transmitter

Frequency	Frequency	962 to 1213 MHz
	Accuracy	± 100 kHz
	Power	≥ 4 dB

TCAS

TCAS Transmitter

Frequency	1090 MHz ± 10 kHz
Output Power	≥ 4dB
Modes	C & S
Antenna Beamwidth….	15° Sum & Diff Ports
	30° Sum only

TCAS Receiver

Frequency	1026.5 to 1033.5 MHz
Power	47 to 64 dBm

Physical Characteristics

Packaging	MIL-PRF-28800 Style C
Size	14.5 x 9.4 x 6.5 inches
Weight.	20 pounds
Operating Temperature	-28° to +55° C
Battery Operation.	8 hours at a 20% Duty Cycle
AC Operation/Charging	100 – 240 VAC 47 – 440 Hz

1.6 Abbreviations, Acronyms and Glossary of Term[1]

A/A	Air to Air
A/A B	Air to Air Beacon
ac or AC	Alternating Current
A/D	Analog to Digital
ADS-B	Automatic Dependent Surveillance - Broadcast
Address	The unique code to which a MODE S transponder replies. This is not to be confused with the 4096 code used for identifying ATCRBS transponders. The address of a MODE S transponder is not alterable by the pilot or crew.
Altitude	The pressure altitude of the aircraft as transmitted by an ATCRBS or MODE S transponder. This information is obtained from an external sensor and transmitted to the transponder.
AM	Amplitude Modulation
ATCRBS	Air Traffic Control Radar Beacon System
ATCRBS/MODE S All Call	Interrogation that causes all ATCRBS/MODE S transponders to reply.
ATC	Air Traffic Control
AUT	Aircraft Under Test
BIT	Built in Test
Comm	Refers to the communications and data-link capability of a MODE S transponder. There are four (4) capabilities: No Comm, Comm A/B, Comm A/B/C and Comm A/B/C/D. The Comm. capability is displayed when the transponder is determined to be a MODE S.
CW	Continuous Wave
D/A	Digital to Analog
DAP	Downlinked Aircraft Parameter
dB	Decibel
dBm	Decibels above 1 milliwatt
dc or DC	Direct Current
DME	Distance Measuring Equipment
DPSK	Differential Phase Shift Keying. The method of modulation used for the selective MODE S uplink interrogations.
DF	Downlink Format. The format included in a MODE S transponder reply to an interrogation or squitter message that indicates the type of message.
ELM	Extended Length Messages
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FIFO	First In First Out
FREQ	Frequency
ft.	Feet
G/A	Ground to Air
Hz	Hertz
IF	Intermediate Frequency
IFF	Identify Friend or Foe
KHz	Kilohertz
kts.	Knots
LCD	Liquid Crystal Display
LED	Light Emitting Diode

[1] Further definitions may be found in the following reference books and documents: Helfrick, A.D. Principles of Avionics. Leesburg: Quality Books, 2000. RTCA/DO-181B. Minimum Operational Performance Standards for Air Traffic Control RADAR Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment. Washington D.C.: 1999. United States. Federal Aviation Administration. Federal Register Fed 3, 1987 FAA rules Part 91.

MODE S	A secondary radar system where transponders can be individually interrogated or selected (the “S” in MODE S) so that in a crowded air traffic area, the amount of interference or garble can be reduced to a minimum.
MHz	Megahertz
nmi.	Nautical mile
ns	Nanosecond
PAM	Pulse Amplitude Modulation
PDME	Precision Distance Measuring Equipment
PMCS	Preventative Maintenance Checks and Services
PPM	Pulses per Minute
PRF	Pulse Repetition Frequency
PW	Pulse Width
PWR	Power
RA	Resolution Advisories
Receiver Efficiency	The Test Set’s Measurement of valid replies received. Displayed as a Percentage.
Reply Codes	A transmitted response, from the airborne transponder, to an interrogation. Commercial transponders responses are designated as either ATCRBS/A where the reply includes the pilot selected 4096 ID code, or ATCRBS/C, where the reply includes the aircraft pressure altitude. These same responses for military transponders are designated as MODE 3A and MODE 3C. See Mode S for further information.
RF	Radio Frequency
RMS	Root Mean Square
R/T	Receiver Transmitter
SIF	Selective Identification Feature
SLS	Side Lobe Suppression. A pulse transmitted from an omni-directional antenna used as a reference level to prevent replies to interrogations received from the secondary radar antenna side lobes.
Squitter	The self-generated transmissions made by a MODE S transponder, not in reply to an interrogation, for the use of the collision avoidance system. And ADS-B Receivers and Transmitters.
SSR	Secondary Surveillance Radar
Surveillance Altitude	An interrogation that causes only the addressed MODE S transponder to reply.
Surveillance ID	An interrogation that causes only the addressed MODE S transponder to reply to its “4096” code.
TA	Traffic Advisories
TACAN	Tactical Air Navigation
TCAS	Traffic Alert and Collision Avoidance System
TIS	Traffic Information System
TX	Transmitter
UF	Uplink Format. The format in a MODE S interrogation that indicates the type of reply expected.
VORTAC	VOR and TACAN (co-located)
VOR	VHF Omni-Directional Range
VSWR	Voltage Standing Wave Ratio
WOW	Weight On Wheels
UUT	Unit Under Test
XPDR	Transponder
XPDR UT	Transponder Under Test
4096 Code	This refers to the octal number dialed into either an ATCRBS MODE A or MODE S transponder by the pilot. This is to be distinguished from the address of the MODE S transponder, which cannot be changed.

CHAPTER II

PREPARATION FOR USE AND OPERATION

SECTION A

GENERAL INFORMATION

2.1 General

This Chapter contains all necessary information on the initial unpacking, inspection, and set-up of the TR-220 Multifunction Test Set (Hereinafter called the TR-220, Test Set, or T/S).

2.2 Unpacking

When receiving the TR-220 for the first time, ensure that there is no damage to the shipping container. Carefully unpack the unit and save the shipping container in a safe location for shipping or extended storage.

Examine the unit for obvious signs of damage. Check all displays, switches, and connectors before utilizing the Test Set.

If any damage is found, DO NOT use the Test Set until a determination of the Test Sets functions can be assessed. Contact Tel-Instrument as soon as possible for further instructions.

The TR-220 Test Set batteries were installed and fully charged when shipped from the factory.

2.3 Installation

The Test Set is fully functional and ready to use from the factory. There are no installation procedures applicable.

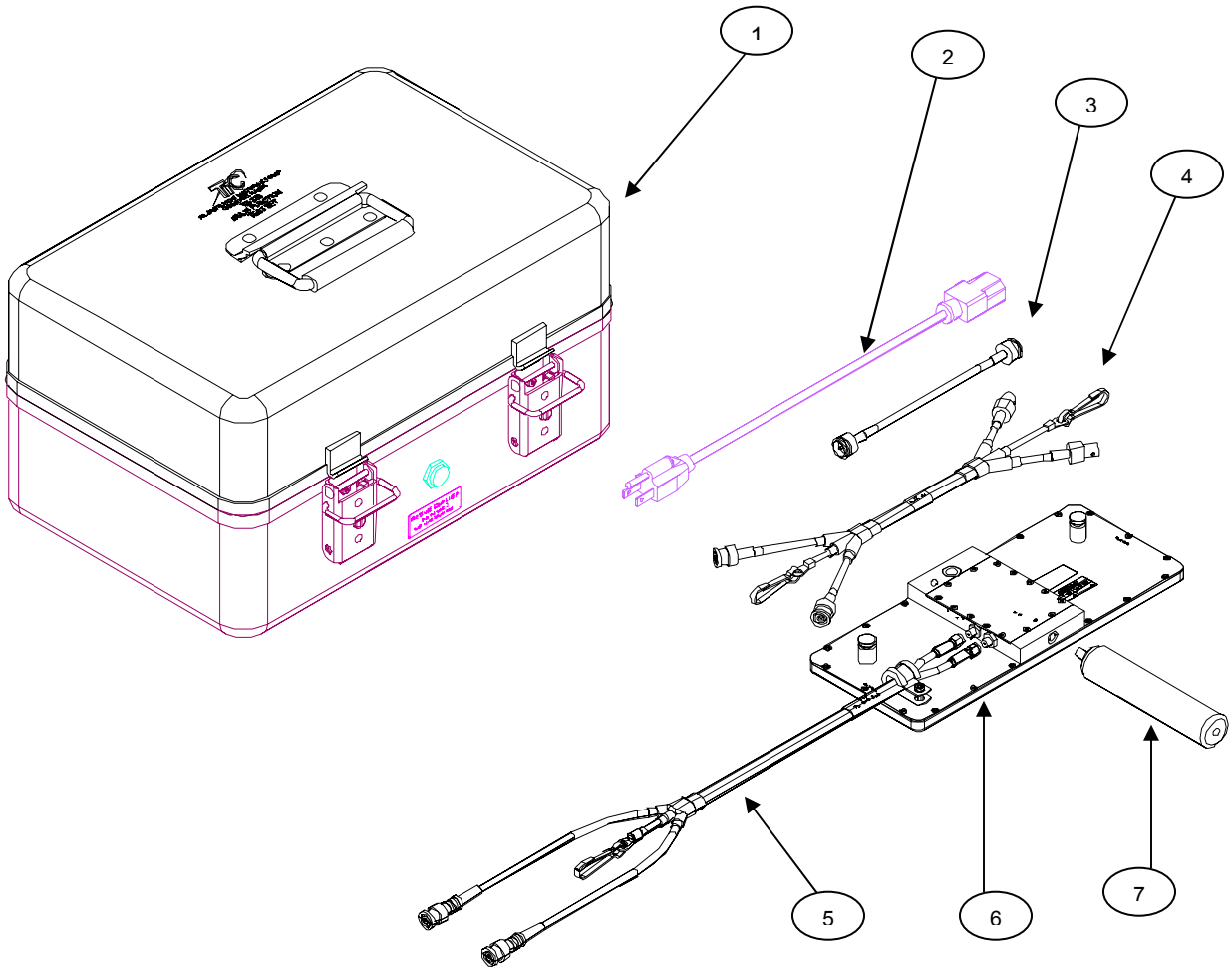
2.4 Accessories

Once opening the Test Set Cover, ensure all the accessories that were purchased with the Test Set are accounted for. The TR-220 comes standard with the following (See next page):

#	NOMENCLATURE	P/N	QTY
1	Test Set	90000088	1
2	Cable Assembly, AC Power Cord	75010025	1
3	Cable Assembly, Direct Connect	75010186	1
4	Extender Cable Assembly, Directional Antenna	75010078	1
5	Directional Antenna Cable Assembly	75010208-02	1
6	Directional Antenna Assembly	89001158-07	1
7	Directional Antenna Handle Assembly	88001002	1
X	TAP-200 Antenna Coupler		Optional
XX	TR-220 Manual (Not Shown)	90008088-1	1

TR-220 Accessories

Table 2-1



TR-220 Accessories

Figure 2-1

SECTION B

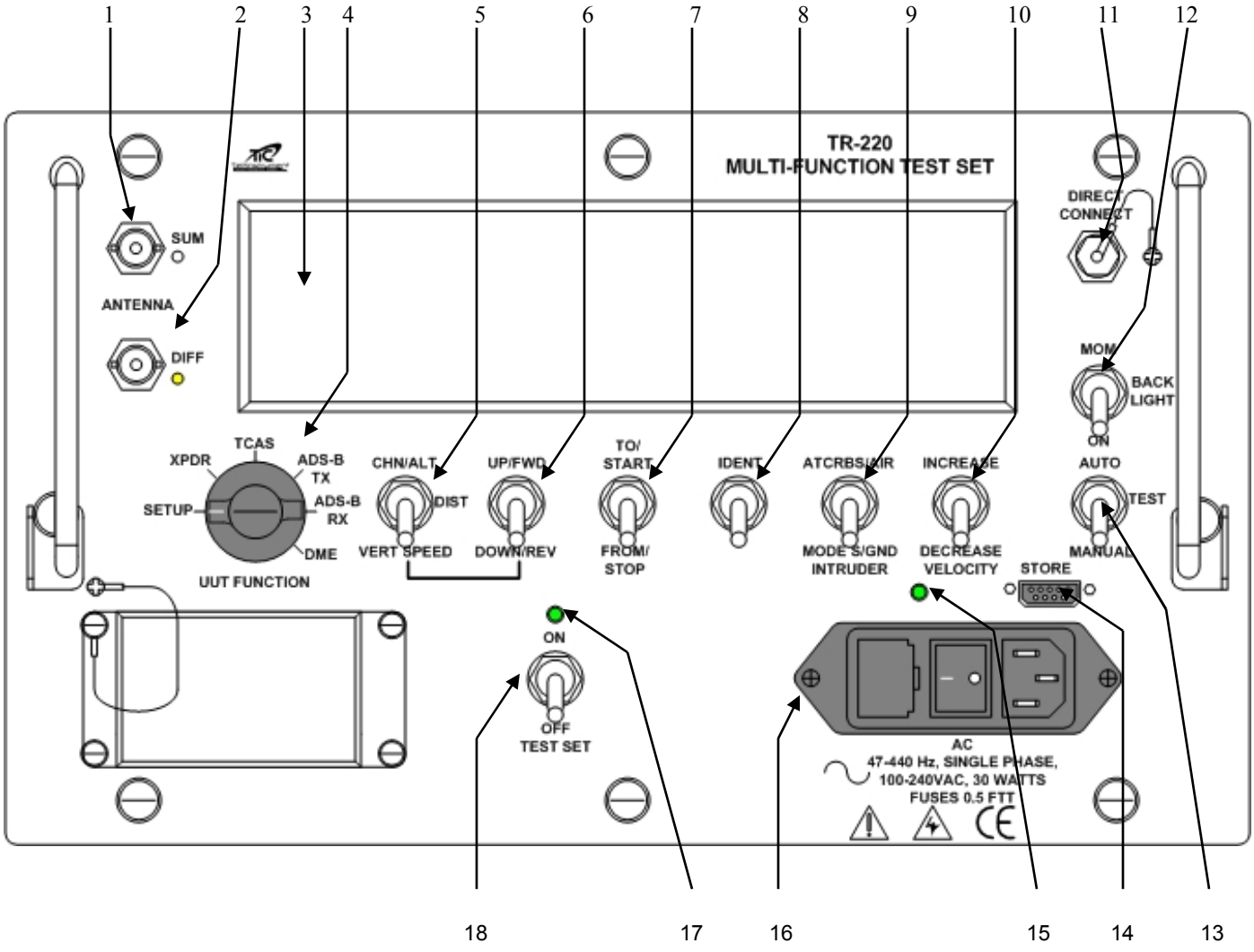
OPERATING CONTROLS, INDICATORS, AND CONNECTORS

2.5 General

This section covers location and function of the operating controls, indicators, and connectors. All controls, indicators, and connectors are located on the front panel of the Test Set.

2.6 Controls, Indicators, and Connectors

Figure 2-2 and Table 2-2 indicates the location and the function of each item on the front panel of the Test Set.



Controls, Indicators, and Connectors

Figure 2-2

FIG #	Control, Indicator, or Connector	(Table 2-2) FUNCTION
1	**SUM** Antenna Port	Provides Connection to the Directional Antenna Sum Connector and the optional TAP-135 Antenna Coupler.
2	**DIFF** Antenna Port	Provides Connection to the Directional Antenna Diff Connector
3	Data Display Window	Alpha/Numeric display (2 lines/20 characters) providing operational instructions, error messages, scenario progress, and test results.
4	**UUT FUNCTION** Switch	Provides access to Test Set Menus and Modes. **SETUP-** Set Antenna Gain, T/S Distance, TCAS Scenario Selection, Altitude, Velocity, and Vertical Speed and Distance, Power display (watts or dBm), Cable Loss, Mode S address, and Latitude and Longitude for ADS-B Functions. **XPDR-** Access ATCRBS and MODE S Transponder test menus. **TCAS-** Access TCAS intruder menus. **ADS-B TX-** Select ADS-B Transmitter Results. **ADS-B RX-** Select ADS-B, and TIS Functions. **DME-** Access DME Test menus.
5	**CHN/ALT, DIST, VERT SPEED** Switch	DME- Allows selection of DME Channels. Selectable from 108.0 MHZ in 50 KHz steps. Used in conjunction with **UP/FWD – DOWN/REV** switch.
		TCAS- Set Intruder altitude offset from 99,900' to 50,200' in 100' inc/ 50,175' to -9000' in 25' increments. Default is 0'. Used in conjunction with **UP/FWD – DOWN/REV** switch.
		TCAS- Intruder vertical speed in "feet per minute" (fpm) adjustable in 100' increments from +7500' to -7500'. Used in conjunction with **UP/FWD – DOWN/REV** switch.
6	**UP/FWD, DOWN/REV** Switch	Used in conjunction with **CHN/ALT, DIST, VERT SPEED** switch to vary parameters. Also used to set antenna gain and Test Set distance in **SETUP** mode.
7	**TO/START – FROM/STOP** Switch	Start and Stop TCAS Intruder scenarios and change DME To/From parameters.
8	**IDENT** Switch	Initiates a SPI Pulse for verification of transponder IDENT function.
9	**ATCRBS/AIR, MODE S /GND INTRUDER** Switch	Selects TCAS Intruder Type (MODE S or ATCRBS), and Air or Ground position.
10	**INCREASE/DECREASE VELOCITY**	Sets TCAS Intruder and DME speed velocities. Also utilized for ADS-B TX/RX Functions.
11	**Direct Connect** Port	For direct connection to a Transponder. Provides accurate RF Power, frequency and sensitivity measurements.
12	**MOM/BACK LIGHT/ON** Switch	Activates display backlighting either *"ON" or* momentarily.
13	**AUTO/TEST/MANUAL** Switch	Allows the operator to select an Automatic Sequence of Transponder tests or a Manual sequence. Initiates TCAS and DME scenarios. Hold AUTO key when Test Set power is turned "ON" to select CW operation. Use AUTO and MANUAL to advance through EHS and ADS-B tests.
14	**STORE** connector	RS-232 port for download of stored data to a PC.
15	Test Set charging indicator	Indicates to operator that the Test Set Batteries are charging
16	AC Power Panel	1. Provides connection to a 115 or 220 VAC power source. 2. AC "ON" / "OFF" switch for battery charging. 3. Fuse Cartridge.
17	**TEST SET ON/OFF** Switch	Turns Test Set "ON" and "OFF".
18	Power ON "LED"	Indicates to the operator that the Test Set is "ON".

SECTION C

OPERATING INSTRUCTIONS

2.7 General

The TR-220 is a self-contained instrument comprised of a Test Set mounted in a rugged case with a removable cover. The Test Set front panel contains all the switches necessary to test Transponders (ATCRBS and MODE S), ADS-B and TIS, DME and TCAS equipment. By the use of toggle switches and an easy to read display, the operator may quickly test, make accurate measurements and perform preprogrammed or manually selected TCAS scenarios. The directional antenna with an active LED display and optical sight are utilized for Transponder, DME, and TCAS tests. All accessories are stored in the Test Set case for easy storage and protection.

2.8 Battery Operation

The TR-220 Test Set is equipped with a rechargeable *Lead Acid* battery, capable of operating the Test Set using a 20% duty cycle for 8 hours at 77 degrees F (25 Degrees C). This represents a full day of typical testing on a single charge. When operating the Test Set in lower temperatures, the battery life will decrease slightly.

The operator will be able to utilize the Test Set until the batteries are nearly depleted. The unit may then be plugged into a standard 115 or 220 VAC / 47 to 440 HZ power source to continue testing. By observing a Duty Cycle (DC) of 20%, the Test Set batteries will begin regaining their charge while testing is in progress.

The TR-220 provides a low battery warning system to alert the operator when battery strength has been depleted to a point where testing may be interrupted. Several warning are displayed to warn the operator of this condition and to give them a warning that the batteries will require charging or supplemental AC power applied to complete extended testing.

As the battery capacity decreases, the Test Set will display the following:

```
Low Battery
Press AUTO to cont.
```

Toggle the **AUTO** switch to bypass the display and continue testing. Approximately 15 minutes of battery capacity is available. As the battery strength decreases, the display will indicate:

```
Low Battery
Recharge Required!
```

This indicates only several minutes of testing time is available. It is recommended that AC power be supplied to continue testing or testing halted at this point and the Test Set charged. Toggle the **AUTO** switch to bypass this warning. Further testing will result in the final warning:

```
Low Battery
SHUTTING DOWN
```

This warning cannot be bypassed, and AC power must be utilized or charging the battery is necessary.

It is strongly recommended that the batteries be charged for a short time each week, regardless if the Test Set has been utilized or not. A completely discharged battery will require approximately 16 hours to fully charge. Occasional charges of 16 hours on partially depleted batteries will have no adverse effects.

The current battery status display is available in the SETUP function.

```
Battery:    E■■■■■F
            Cont: AUTO
```

2.8.1 Auto Shutdown

To preserve battery strength, the TR-220 will automatically shut down after 20 minutes of inactivity. By toggling any switch during the 20 minutes will reset the timer allowing extended testing.

Shutdown will not occur when AC power is utilized as the source.

2.9 TR-220 Supplied Antenna

Standard equipment with the TR-220 is a Directional Antenna. The antenna, stored in the case cover, can either be hand held, tripod mounted, or directly mounted on the Test Set case. The Test Set also contains a direct connect cable for accurate power and frequency measurements (± 2 dB) when connected directly to the UUT. The Test Set has a built in 50 dB attenuator to prevent damage to the Test Set due to the High Power RF associated with Transponders.

2.9.1 Directional Antenna

The Directional Antenna is a printed circuit sandwiched between two opaque Lexan sheets.

1. Open and remove the TR-220 Test Set case cover. Release the two (2) push button holders

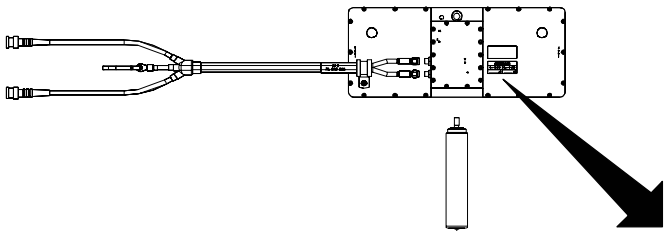
2. The Directional Antenna can be mounted on the case or be hand-held utilizing the supplied handle.

   2a. To mount the antenna to the case, simply slide the mounting Tabs (located on the back) into the slots located on the front of the Test Set Case.

   2b. To utilize the hand held method, attach the supplied handle to the bottom of the antenna and hand tighten only.

2c. You may also attach the antenna to a tripod, which will increase the stability due to high winds or hand movement thus increasing the lock on rate.

3. The operator must first set the proper Antenna Gain value into the Test Set memory. Turn the Test Set *"ON"* with the **UUT FUNCTION** switch in the **SETUP** position. Locate the *ANT GAIN* menu by toggling the **AUTO/MANUAL** switch. Enter the correct values that are affixed to the Directional Antenna (Figure 2-3) by using the **UP/FWD, DOWN/REV** switch. Ensure you enter both values, 1030 MHz and 1090 MHz. Once completed, turn *"OFF"* the Test Set. The values will remain in the Test Set memory. You will only need to reenter the values if the antenna is replaced or repaired.



Ant Gain 1030: +XXdB
Chg:Up/Dn Cont: AUTO

ANTENNA DATA	
Gain @ 1030	**Gain @ 1090**
-XX dB	**-XX dB**

Directional Antenna Gain

Figure 2-3

4. When using the handheld or tripod method, connect the extender cable supplied with the Test Set, ensuring to match the appropriate color-coded cables. Connect the opposite ends of the **ANTENNA SUM** & **DIFF** connectors on the Test Set front panel. If reversed, the Test Set will display a fault prompting the operator to check their antenna connections.

ANTENNA Connections
Missing or Reversed

5. Maintain a 10 to 170 ft. (3 to 50 meters) unobstructed path to the Aircraft Under Test (AUT), and point the Directional antenna to the appropriate antenna on the AUT.

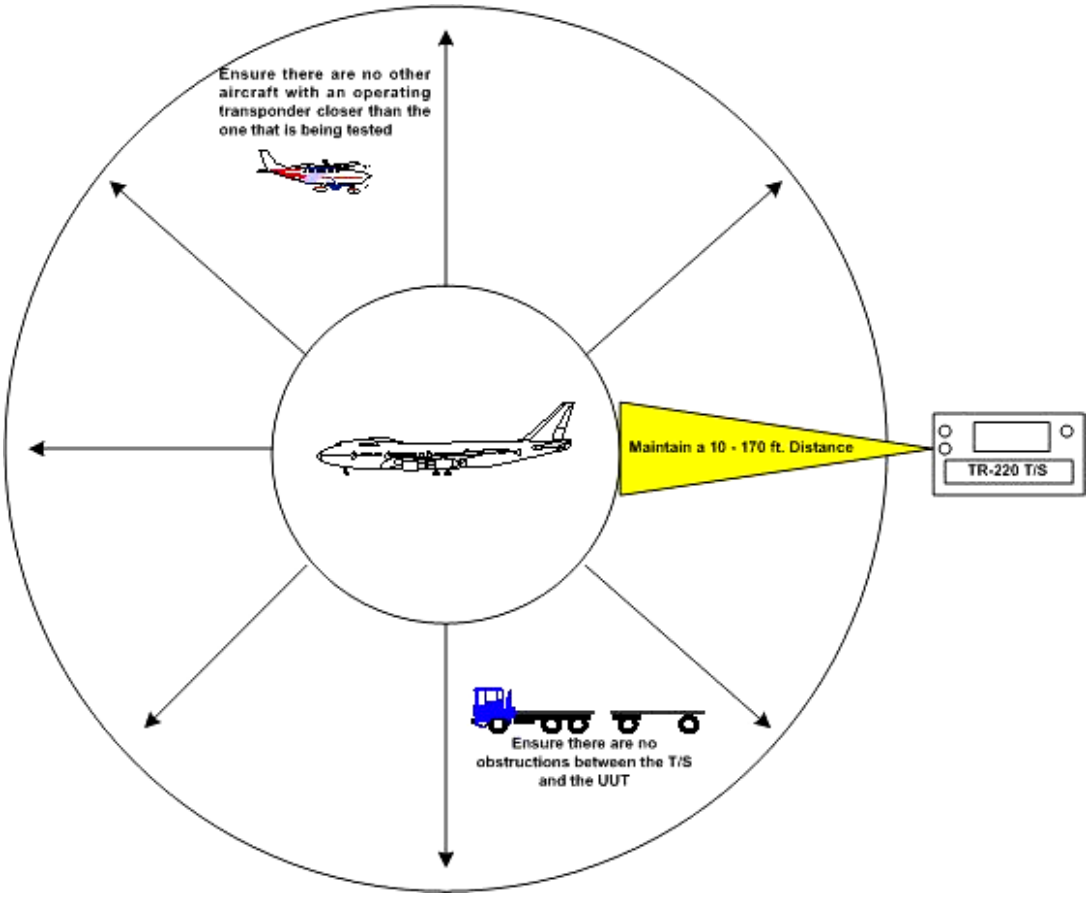
6. Turn the Test Set "ON" with the **UUT FUNCTION** switch in **SETUP**. Locate the *T/S Distance* menu by toggling the **AUTO** switch and insert the approximate distance measured from the Test Set to the AUT antenna by toggling the **UP/FWD, DOWN/REV** switch. With out turning the Test Set OFF, turn the **UUT FUNCTION** switch to the desired sequence of tests.

T/S Distance: 170 ft
Chg: Up/Dn Cont:Auto

7. The optical sight will have a blinking LED indicating the operator must turn the antenna slightly to gain a strong RF signal. A steady red LED signifies a good RF signal and the Test Set will commence testing. The operator may also observe the *TURN* indicator located on the display. By slowing turning the antenna, the *TURN* indicator will spin slower until a lock is obtained. At that point, the Test Set will display the appropriate display.

   NOTE: The TR-220 uses a software technique to narrow the beam width. When testing inside of a hanger, multi-path reflections can cause erroneous *TURN* indications. If unable to eliminate *TURN* message, remove antenna cable connection to DIFF port. This will not affect any test results.

8. Position the antenna with an unobstructed line to the UUT antenna. Ensure that the transmitter or receiver (RX/TX) that you are testing is significantly closer to the Test Set than another operating RX/TX; else, an undesired reply or erroneous and inaccurate results may occur.



Directional Antenna Setup

Figure 2-4

Measurements utilizing the Directional Antenna have an accuracy of ± 3 dB.

2.9.2 Direct Connect

The Direct Connect Cable, supplied with the Test Set, allows the operator to conduct transponder tests directly from the transponder under test. Utilizing the direct connect method eliminates possible antenna and cable losses and ensures the operator the transponder is operating at its full potential. The TR-220 has a built in 50 dB attenuator, thus eliminating the need to connect an external attenuator for power and frequency measurements. Simply connect the supplied cable from the test set to the transponder to be tested. Ensure that if your transponder has multiple antennas (diversity equipped), to terminate the second antenna to prevent damage to the transponder.

If you are not using the Direct Connect method, but the directional antenna method, you must install the supplied termination cap on the **DIRECT CONNECT** port. If it is not properly installed, the Test Set display will prompt the operator to remove the antenna.

Direct Connection REMOVE ANTENNA

Before testing utilizing the supplied Direct Connect cable, the operator must enter the appropriate cable loss to ensure accurate measurements.

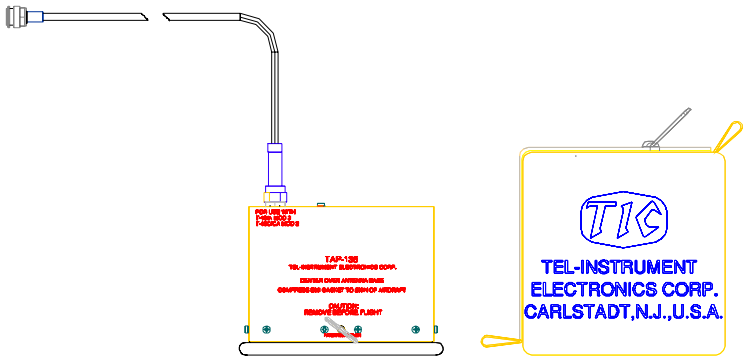
1. Access the ANT GAIN menu by turning the Test Set *"ON"* with the **UUT FUNCTION** switch in the **SETUP** position. Locate the *Cable Loss* menu by toggling the **AUTO/MANUAL** switch. Enter the correct values that are affixed to the supplied cable by using the **UP/FWD, DOWN/REV** switch. If you are using a different cable, it is important to know the cable loss value or inaccurate results will occur. Once completed, turn "OFF" the Test Set or toggle to **AUTO** switch. The value will remain in the Test Set memory. You will only need to reenter the value if another cable is utilized or it is repaired.

Cable Loss: 1.8 dB Chg: Up/Dn Cont:AUTO

Measurements utilizing the direct connect method have an accuracy of ± 2 dB.

2.9.3 TAP-200 Antenna Coupler (Optional)

The TR-220 can be used with the (optional) TAP-200 Anti Radiation Antenna Coupler for testing transponders (fig 2-5). The Antenna couplers provide a limited amount of attenuation, approximately 20 dB, to prevent the transmission of the transponder signal into the airspace above the aircraft under test. The Antenna Couplers may only be utilized on blade type antennas.



TAP-200 Coupler

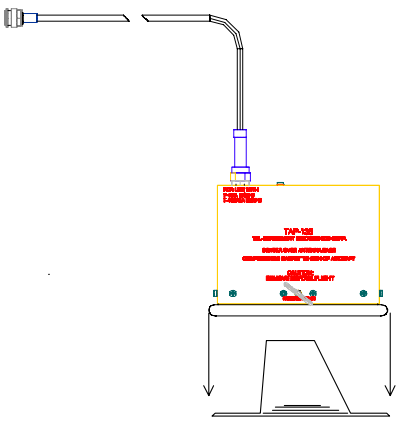
Figure 2-5

1. Connect the TAP-200 Cable to the TR-220 antenna **SUM** port.
2. Turn the test set **ON** by toggling the **ON/OFF** switch *Up* and turn the **UUT FUNCTION** switch to the **SETUP** position. Scroll to the Antenna Selection screen using the **AUTO/MANUAL** switch.

Antenna: TAP Chg:Up/Dn Cont:AUTO

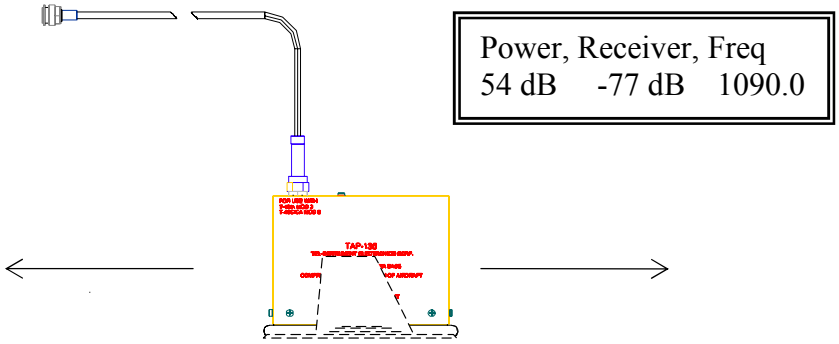
3. Use the UP/FWD-DOWN/REV switch to select *TAP*.
4. To install the coupler, pull the ring, which separates the spring-loaded clamp, and slide the coupler over the blade antenna. Ensure that the EMI gasket of the coupler is flush with the aircraft skin and that the coupler is centered over the antenna. Release the ring (fig 2-6).
5. Ensure that the coupler is centered over the antenna to be tested.
6. Due to the availability of numerous styles of antennas, slight adjust of the Coupler may be necessary to receive accurate measurements. If incorrect readings occur, re-position and ensure a snug fit on the antenna. Move the TAP-200 forward or back and double check a firm and snug seal on the aircraft surface (fig 2-7).
7. An accurate adjust of the couplers can be accomplished by advancing to the Manual Mode of tests *POWER, RECEIVER, FREQ* test page and adjusting the coupler for the maximum power out. Once adjusted, the operator can then restart the appropriate series of tests ensuring accurate results.

Center the TAP-200 as close to center as possible for the style of antenna being tested. If inaccurate results occur, reposition the coupler slightly forward or back and check for a snug flush fit until accurate measurements are displayed. Due to the many styles of antennas available, adjustments may be necessary.



TAP-200 Placement

Figure 2-6



TAP-200 Antenna Adjustment

Figure 2-7

.

8. Proceed with Transponder testing as outlined in paragraph 2.12 or 2.13

2.10 Initial Startup and Self-Test

When using the Test Set, it is advisable to have a fully charged battery. This will ensure all tests can be completed with no interruptions or loss of data.

1. Turn on the TR-220 by toggling the **ON/OFF** switch "UP". The green LED located above the switch will illuminate. Briefly, the Test Set display will indicate: Model number, current software version installed and total hours of operation.

Tel-Instrument TR-220 REV X.XX 00001 hrs

2. The Test Set will immediately commence a SELF TEST.

Self Test Testing . . .

The Self Test function is automatic, and will test the following components:

a. Digital Board
b. RF Maximum Power
c. RF Minimum Power
d. RF Board

If a failure is detected, a message indicating the failed component or test will be displayed. If no failures are detected, the result will be briefly displayed before moving to the initial start page of the selected tests.

Self Test PASS

3. Toggle the **BACKLIGHT** switch to the **MOM** position and verify the Test Set display backlighting illuminates. Release the switch and the backlighting will extinguish.

4. Turn the Test Set "OFF" by toggling the **ON/OFF** switch down. The display will be blank and the green LED will extinguish.

2.11 Transponder Test Sequence

The TR-220 T/S is capable of testing ATCRBS Mode A, Mode C and Mode S transponders. The operator may select between an *Automatic* series of tests and a *Manual* series of tests. Figure 2-8 outlines the sequence, in order, of tests conducted. The Test Set will determine the correct set of tests, either Mode A/C or Mode S upon receiving the transponder RF signal.

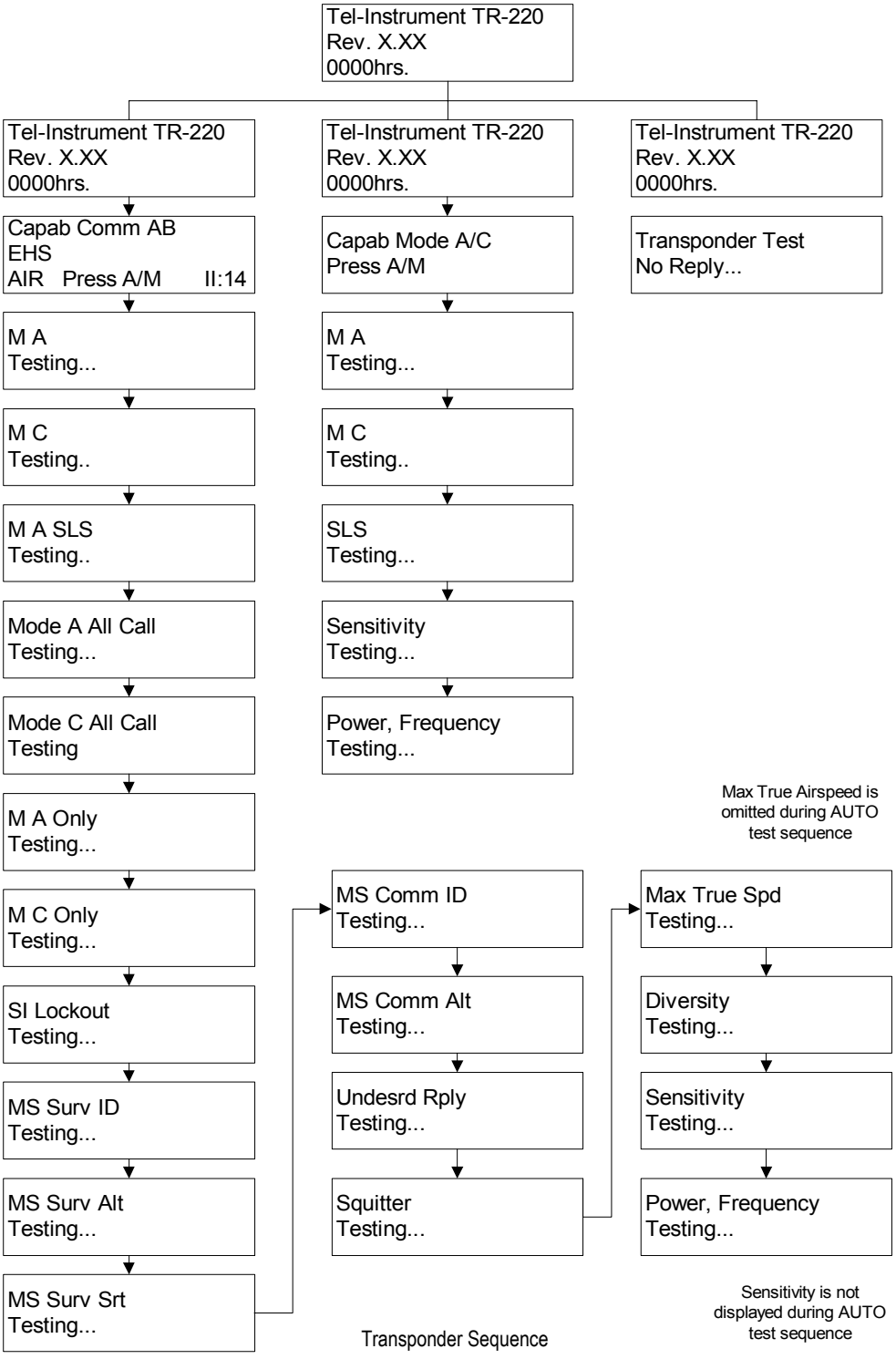


Figure 2-8

2.12 Transponder Manual Sequence of Tests

NOTE

All illustrations shown are for demonstration purposes. Though the test results may be typical, they are not meant to replace FAA guidelines and manufacturer recommendations.

When conducting tests in the *MANUAL* sequence, the operator initializes the sequence by toggling the **AUTO/TEST/MANUAL** switch to the **MANUAL** position. The Test Set then commences a series of tests and displays the individual results of each test (see figure 2-8) ending in the POWER, RECEIVER EFFICIENCY and FREQUENCY page. After each test is completed, the operator must toggle the **MANUAL** switch to advance to the next test in the series.

The *"IDENT"* feature of a transponder can only be tested during the *MANUAL* sequence of tests. See paragraph 2-14 for detailed instructions.

2.12.1 ATCRBS, Mode A/C Manual Testing

1. Utilize the procedures as outlined in paragraph 2.9 to select the preferred antenna method for the following tests.

2. Turn the Test Set "ON" by toggling the **ON/OFF** switch to the **ON** position. Ensure the green LED illuminates.

3. The Test Set commences the Self Test. "PASS" is displayed briefly if no failures are detected.

Self Test PASS

4. Turn the **UUT FUNCTION** switch to the **XPDR** position. The Test Set will automatically determine the transponder capability as being Mode A and/or C capable and display the appropriate start page.

Capab Mode A/C Press A/M

5. Toggle the **AUTO/TEST/MANUAL** switch to the **MANUAL** position to begin the sequence.

M A / Testing . . .

Mode A Test initialized.

M A 1234 100% 0.45–20.35– 0.45 PASS

Test Complete. Display indicates the UUT 4096 Octal Code (1234), Receiver Efficiency as a percentage (100%), Transponder Framing Pulse widths (0.45) and separation measured in .05 µs increments (20.35 µs).

6. To advance, toggle the **AUTO/TEST/MANUAL** switch to **MANUAL**. The next test in sequence will commence.

M C / Testing . . .

Mode C Test initialized.

M C 6520 10000’ 100% 0.45 – 20.35 – 0.45 PASS

Test Complete. Display indicates the UUT Altitude Gray Code (6520=1000’), Rcvr. Efficiency as a percentage (100%), Transponder Framing Pulse widths (0.45) and separation measured in .05 µs increments (20.35 µs).

7. To advance, toggle the **AUTO/TEST/MANUAL** switch to **MANUAL**. The next test in sequence will commence.

Mode A SLS T Testing . . .

Mode A SLS tests are initiated. The test set makes alternating interrogations with and without the SLS pulse.

SLS P1>P2 100% PASS P1=P2 0% PASS

When P1>P2 (SLS pulse at P1 - 9dB) the transponder reply efficiency should be greater than 99%. For P1=P3 (SLS) The transponder reply efficiency should be less than 1%

8. To advance, toggle the **AUTO/TEST/MANUAL** switch to **MANUAL**. The next test in sequence will commence.

Sensitivity Testing . . .

UUT Receiver sensitivity tests (MTL) for modes A and C are initiated.

A: -73.9dB C: -73.9dB Sens. A&C: PASS

Test Completed. Display indicates the UUT receiver sensitivity for mode A (-73.9db) and Mode C (-73.9dB) PASS is displayed when Mode A/C sensitivities are within 1dB.

9. To advance, toggle the **AUTO/TEST/MANUAL** switch to **MANUAL**. The next test in sequence will commence.

Power, Frequency / Testing . . .	UUT Power and Frequency Test is initialized.
Power, Frequency 54 dB 1090.0 MHz	Test Completed. Display indicates the UUT power (54 dB) and Frequency (1090.0) in MHz.

NOTE

Power measurements are measured in Watts or **dBm**. The Test Set only displays **dB** due to display restrictions. To change the display to indicate Watts, access the **SETUP** menu and toggle to the *Power in Watts* menu. Use the **UP/DOWN** toggle to make a selection.

END OF MODE A/C MANUAL TESTS

2.12.2 Mode S Manual Testing

1. Turn the Test Set "ON" by toggling the **ON/OFF** switch to the **ON** position. Ensure the green LED illuminates. Utilize the procedures as outlined in 2.9 to select the preferred antenna method for the following tests.

2. The Test Set commences the Self Test. "PASS" is displayed briefly if no failures are detected.

```
Self Test
PASS
```

3. Turn the **UUT FUNCTION** switch to the **XPDR** position. The Test Set will automatically determine the transponder capability as being Mode S capable and display the appropriate start page with the COMM A, B, C, & D capabilities also listed. The Test Set will display if the transponder reports it is capable of Enhanced Surveillance (EHS). The Test Set will display the Vertical Status (Air/Ground) and display the results of an Interrogation Identifier (14) test.

```
Capab Comm AB     EHS
AIR   Press A/M   II:14
```

4. Toggle the **AUTO/TEST/MANUAL** switch to the **MANUAL** position to begin the sequence:

```
M A                    /
Testing . . .
```

Mode A Test initialized.

```
M A 1234            100%
0.45–20.35– 0.45   PASS
```

Test Complete. Display indicates the UUT 4096 Octal Code (1234), Receiver Efficiency as a percentage (100%), Transponder Framing Pulse widths (0.45) and separation measured in .05 µs increments (20.35 µs).

5. To advance, toggle the **AUTO/TEST/MANUAL** switch to **MANUAL**. The next test in sequence will commence:

```
M C                    /
Testing . . .
```

Mode C Test initialized.

M C 6520 10000’ 100% 0.45-20.35-0.45 PASS

Test Complete. Display indicates the UUT Altitude Gray Code (6520=1000’), Rcvr. Efficiency as a percentage (100%), Transponder Framing Pulse widths (0.45) and separation measured in .05 µs increments (20.35 µs).

6. To advance, toggle the **AUTO/TEST/MANUAL** switch to **MANUAL**. The next test in sequence will commence:

Mode A SLS / Testing . . .

Mode A SLS tests are initiated. The test set makes alternating interrogations with and without the SLS pulse.

SLS P1>P2 100% PASS P1=P2 0% PASS

When P1>P2 (SLS pulse at P1 - 9dB) the transponder reply efficiency should be greater than 99%. For P1=P3 (SLS) The transponder reply efficiency should be less than 1%

7. To advance, toggle the **AUTO/TEST/MANUAL** switch to **MANUAL**. The next test in sequence will commence:

M A All Call / Testing . . .

Mode A All Call Test initialized. Transmits an M A All Call.

M A All Call / A02008 100%

Test Complete. Successful DF=11 reply will display the decoded aircraft address in Hexadecimal (A02008) and Receiver Efficiency as a percentage (100%).

8. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

M C All Call / Testing . . .

Mode 3C All Call Test initialized. Transmits a Mode 3C All Call.

M C All Call / A02008 100%

Test Complete. Successful DF=11 reply will display the decoded aircraft address in Hexadecimal (A02008) and Receiver Efficiency as a percentage (100%).

9. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

M A Only / Testing . . .

Mode A ONLY Test initialized. Test Set transmits an ATCRBS ONLY All-Call.

M A Only / PASS

A Mode S transponder will not reply to an ATCRBS Only All-Call. A *"PASS"* signifies the Mode S transponder did not respond.

10. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

M C Only / Testing . . .

Mode 3C ONLY Test initialized. Test Set transmits an ATCRBS ONLY All-Call.

M C Only / PASS

A Mode S transponder will not reply to an ATCRBS Only All-Call. A *"PASS"* signifies the Mode S transponder did not respond.

11. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

SI Lockout / Testing . . .

SI Lockout PASS 18 sec

The Test Set issues a SI Lockout command (37) and verifies that UUT will not respond for minimum of 3 seconds and maximum of 18 seconds.

12. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

M S Surv ID / Testing . . .

Mode S Surveillance Identity Test initialized. Test Set will transmit an UF=5 interrogation.

M S Surv ID / 1234 FS: AIR 100%

Test complete. A successful DF=5 Reply will display the aircraft 4096 Octal code (1234), Flight Status (Air), and Receiver Efficiency as a percentage.

NOTE

Possible Flight Status Codes are **AIR** (Airborne), **GND** (Ground), **AL/AR** (Alert/Airborne), **AL/GND** (Alert/Ground), **AL/SP** (Alert/SPI), and **SPI**.

13. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

M S Surv Alt / Testing . . .	Mode S Surveillance Altitude Test. Test Set will transmit an UF=4 interrogation.
M S Surv Alt / 10000' 100%	Test complete. A successful DF=4 Reply will display reported altitude (10000') and Receiver Efficiency as a percentage (100%).

14. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

M S Surv Srt / Testing. . .	Mode S Short Air to Air Surveillance Test. Test Set transmits a special short UF=0 interrogation.
USA: N107PP / A02008 VS:AIR 100% USA: N107PP / 50020010 VS:AIR 100%	Test complete. A Mode S transponder will reply in a DF=0 format. Alternating display will indicate the Country code (USA) and tail number, aircraft address in Hexadecimal (A02008) and Octal (50020010).

NOTE

Appendix A list available country codes. If the Test Set can not locate the country algorithm, "**??????**" will be displayed.

15. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

M S Comm Id / Testing . . .	Mode S Communication Identity Test. Test Set will transmit a COMM A/B transmission utilizing the UF=5/RR:18 field. This tests the transponders communication and data-link capabilities.
M S Comm Id / 1234 yyyyyyyy 100%	Test complete. A successful DF=21 Reply will display 4096 code (1234), Flight ID (yyyyyyyy) and Receiver efficiency as a percentage (100%).

16. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

M S Comm Alt / Testing . . .	Mode S Communication Altitude Test. Test Set will transmit a COMM A/B transmission utilizing the UF=4/RR:18 format. This tests the transponders communication and data-link capabilities.
M S Comm Alt / 10000' 100%	Test complete. A successful DF=20 Reply will display UUT Altitude (10000') and Receiver Efficiency as a percentage

17. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

Undesrd Rply / Testing . . .	Undesired Replies Test initialized. The Test Set will make randomly addressed interrogations.
Undesrd Rply / PASS	Test complete. If the UUT replies to any of the random interrogations, *"FAIL"* will be displayed. A *"PASS"* indicates the UUT did not reply as required. The test set uses a minimum of 3 random addresses to comply with FAR 43 App F.

18. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

Squitter / Testing . . .	The Test Set will not transmit interrogations but receive and process DF=11 and DF=17 extended replies.
ACQ: PASS 900 ms ADD: A02008 II:0	Test complete. Upon detection of the replies, the Test Set will display the interval time of the messages (if received) in milliseconds (900 ms). If either a DF=11 or DF=17 extended message is not acquired, *NOT DETECTED* will be displayed.
EXT: NOT DETECTED	
EXT: PASS 500 ms ADD: A02008 II:0	If and Extended Squitter "IS" detected, the following display indicating the interval time and address.

19. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

Max True Spd / Testing . . .	Test Set verifies the UUT airspeed code by transmitting an UF=0 interrogation.
Max True Spd / GT 300 & LE 600 kts	Test complete. The DF=0 will report the aircraft maximum cruising airspeed in the RI field of the DF=0 format.

NOTE

Eight possible RI field codes are available.
1) *NO Max airspeed data*, 2) *LE 75 knots* , 3) *GT 75 & LE 150 kts.*, 4) *GT 150 & LE 300 kts*, 5) *GT 300 & LE 600 kts*, 6) *GT 600 & LE 1200 kts*, 7) *GT 1200 kts*, *8) Not Assigned*.
GT denote “Greater Than”, LE denotes “Less than or Equal too”

20. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

Diversity / Testing . . .	Diversity Test initialized.
Diversity A02008 / PASS 26 dB Attn	Test complete. A *PASS* indicates that isolation relative to the active antenna is greater than 20 dB. and the actual isolation figure is displayed.

21. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

Sensitivity / Testing . . .	UUT Receiver sensitivity tests (MTL) for modes A and C are initiated.
A: -73.9dB C: -73.9dB Mode S: -74.4 dB PASS	Test Completed. Display indicates the UUT receiver sensitivity for mode A (-73.9db), Mode C (-73.9dB) and Mode S (-74.4dB). PASS is displayed when Mode A/C/S sensitivities are within 1dB.

22. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

Power, Frequency / Testing	UUT Power and Frequency tests for modes A and C are initiated.
Power, Frequency / 54 dBm 1090.0Mhz	Test completed. UUT transmitter power (54dBM) (shown in dBm or WATTS as selected in Set-up Menu) and UUT transmitter frequency in MHz.

END OF MODE S MANUAL TESTS

2.13 Transponder Automatic Sequence of Tests

When conducting tests in the *AUTO* sequence, the operator initializes the sequence by toggling the **AUTO/TEST/MANUAL** switch to the **AUTO** position. The Test Set then commences a series of tests without interruption (see figure 2-8) ending in the POWER, RECEIVER EFFICIENCY and FREQUENCY page. Test results will not be displayed unless a failure occurs. The operator can then override the failure and continue testing by toggling the **TEST** switch to the **AUTO** position.

NOTE

All illustrations shown are for demonstration purposes. Though the test results may be typical, they are not meant to replace FAA guidelines and manufacturer recommendations.

Before testing begins, ensure that you have read and fully understand the procedures preceding this section. By reviewing these sections, the operator can avoid erroneous and inaccurate results.

2.13.1 ATCRBS, Mode A/C Automatic Testing

1. Turn the Test Set "ON" by toggling the **ON/OFF** switch to the **ON** position. Ensure the green LED illuminates.

2. The Test Set commences the Self Test. "PASS" is displayed briefly if no failures are detected.

```
Self Test
PASS
```

3. Utilize the procedures as outlined in 2.9 to select the preferred antenna method for the following tests.

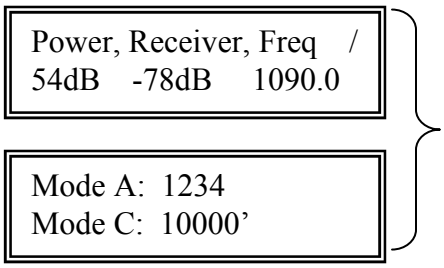
4. Turn the **UUT FUNCTION** switch to the **XPDR** position. The Test Set will automatically determine the transponder capability as being Mode A/C capable and display the appropriate start page.

```
Capab Mode A/C
Press A/M
```

5. Toggle the **AUTO/TEST/MANUAL** switch to the **AUTO** position. The Test Set will begin testing the transponder, without interruption, IAW figure 2-4. Each test will be displayed as "Testing . . ." but no results will be shown, until the Test Set as completed all tests.

```
M A                    /
Testing . . .
```

6. If no failures are detected, the Test Set will cease testing and display the following alternating display:

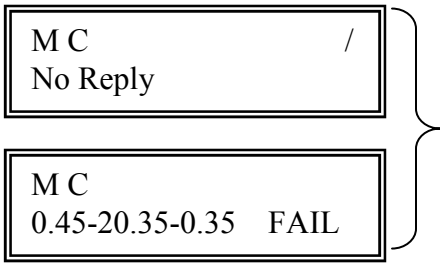


The final alternating display will indicate the UUT power (54dB), Receiver Sensitivity (-78dB), Frequency (1090.0), 4096 Octal Code (1234), and the UUT Altitude (10000') in 100 ft. increments.

NOTE

Power measurements are measured in Watts or **dBm**. The Test Set only displays **dB** due to display restrictions. To change the display to indicate Watts, access the **SETUP** menu and toggle to the *Power in Watts* menu. Use the **UP/DOWN** toggle to make a selection.

7. If a failure is detected during any test in the *Automatic* sequence, the Test Set will "STOP" at that test and display the failure along with the Framing Pulses, Pulse Width, and separation in µs.



Illustrate a Mode C failure. The first display indicates the failure, the second screen displays the Framing Pulse widths (0.45 & 0.35) and their separation (20.3) in µs.

8. The operator may override and advance to the next test in sequence by toggling the **AUTO/TEST/MANUAL** switch to the **AUTO** position. It is recommended that the operator determine the cause of the failure before advancing. Subsequent tests may be inaccurate or misleading.

9. The operator may also elect to repeat the failed test by toggling the **AUTO/TEST/MANUAL** switch to the **MANUAL** position.

END OF MODE A/C AUTOMATIC TESTS

2.13.2 Mode S Automatic Testing

1. Turn the Test Set "ON" by toggling the **ON/OFF** switch to the **ON** position. Ensure the green LED illuminates.

2. The Test Set commences the Self Test. "PASS" is displayed briefly if no failures are detected.

Self Test PASS

3. Utilize the procedures as outlined in 2.9 to select the preferred antenna method for the following tests.

4. Turn the **UUT FUNCTION** switch to the **XPDR** position. The Test Set will automatically determine the transponder capability as being Mode S capable and display the appropriate start page with the Communication capability of the Transponder (COMM NO, COMM AB, COMM ABCD).

Capab Comm AB EHS AIR Press A/M II:14

5. Toggle the **AUTO/TEST/MANUAL** switch to the **AUTO** position. The Test Set will begin testing the transponder, without interruption, IAW figure 2-7. Each test will be displayed as "TESTING . . ." but no results will be shown until the Test Set as completed all tests.

M A / Testing . . .

6. If no failures are detected, the Test Set will cease testing and display the following alternating display:

FID: yyyyyyy 10000' 54dB 1090.0MHz

H: A02008 O:50020010 1234 USA:N107PP

The final alternating display will indicate the transponder decoded *Flight ID Code* (FID: YYYYYYY), Aircraft altitude (10000'), UUT Power (54dB), Freq. (1090.0), aircraft address in both Hexadecimal and Octal (A02008, 50020010), and the Country code and tail number (USA:N107PP) if available.

NOTE

Appendix A lists available country codes. If the Test Set can not locate the country algorithm, "**??????**" will be displayed.

7. If a failure is detected during any test in the *Automatic* sequence, the Test Set will “STOP” at that test and display the failure along with the Framing Pulses-Pulse Width and separation in µs.

Illustrate a Squitter failure

8. The operator may override and advance to the next test in sequence by toggling the **AUTO/TEST/MANUAL** switch to the **AUTO** position. It is recommended that the operator determine the cause of the failure before advancing. Subsequent tests may be inaccurate or misleading.

9. The operator may also elect to repeat the failed test by toggling the **AUTO/TEST/MANUAL** switch to the **MANUAL** position.

END OF MODE S AUTOMATIC TESTS

2.14 Testing a Transponders "IDENT" Function

NOTE

The "*IDENT"* function can only be tested in the **Manual** mode of Tests in both Mode A/C and Mode S.

1. To test the *"IDENT"* feature of a transponder the operator may select the **Mode A** or the **M C Test** for the appropriate transponder (Mode A/C or Mode S).

```
M A                    /
Testing . . .
```

2. Allow the Test Set to complete the test.

```
M A 1234              100%
0.45–20.35– 0.45   PASS
```

3. Press the **IDENT** button or switch located on the transponder control panel or cockpit interface.

4. **IDENT** will be displayed for approximately 20 seconds to verify the receipt of the *SPI* pulse from the transponder.

```
M A 1234 IDENT  100%
0.45 — 20.35 — 0.45
```

5. The operator may now continue testing the transponder through the remainder of the tests.

END OF TRANSPONDER TESTS

2.15 TCAS Tests

The TR-220 Multifunction Test Set is capable of fully testing ATCRBS and Mode S, ACAS, TCAS I, and II systems (Traffic Alert and Collision Avoidance System). The operator is able to manually select a scenario or utilize the default scenario already preprogrammed in the Test Set Memory. When properly used, the Test Set will simulate an Intruder Aircraft converging on the position of the UUT. The operator may then observe the TCAS display to ensure the correct TA's (Traffic Advisory) and RA's (Resolution Advisory) occur on their display.

The Simulation is used with the Directional Antenna. This gives the operator the ability to move the Test Set to different locations and headings from the UUT.

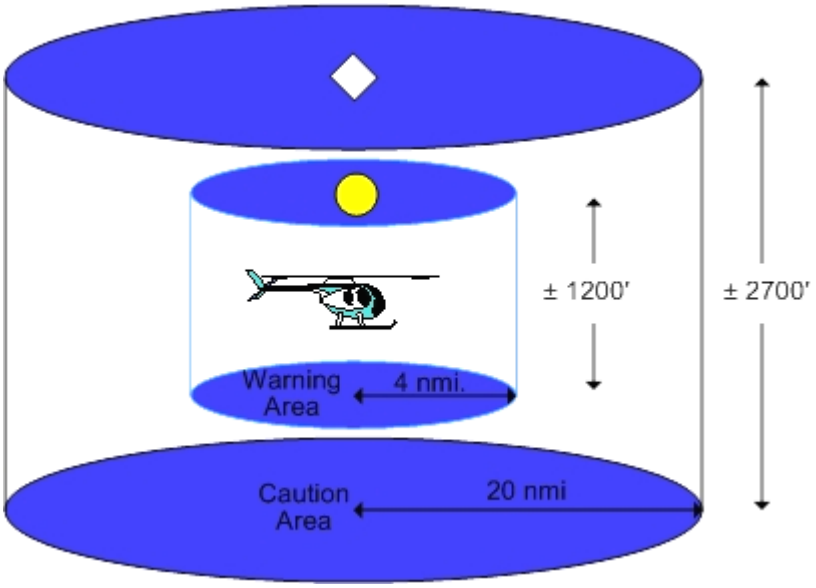
2.15.1 Typical TCAS Concepts

NOTE

All illustrations shown are for demonstration purposes. Though the test results may be typical, they are not meant to replace FAA guidelines and manufacturer recommendations.

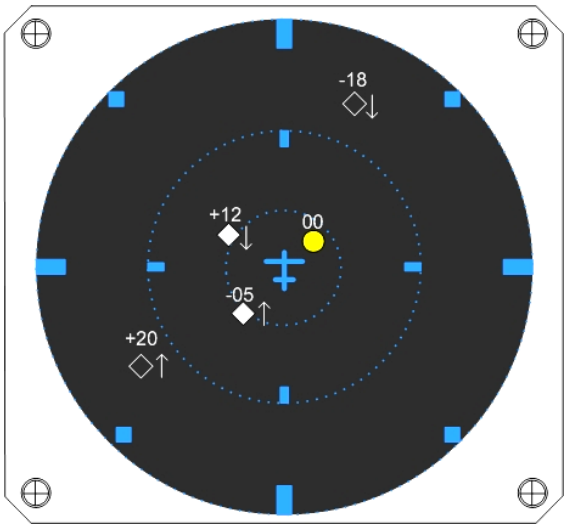
TCAS is a system, which provides situational awareness of the surrounding airspace of an aircraft to the pilot and crew. A TCAS establishes a volume of airspace around the aircraft. The size of the airspace is based on range, speed and altitude. By working in-conjunction with the aircraft Transponder system, the TCAS can determine the relative threat of an aircraft, issue visual and audible advisories to assist the crew in locating and/or take action to prevent a collision.

The perimeter of the *CAUTION AREA* is approximately 20 to 48 seconds to the time the intruder would enter the *WARNING AREA*. Refer to Figure 2-9.



Caution, Warning, and Collision Areas for a TCAS I System

Figure 2-9



A Solid Amber Circle indicates a **TA** (Traffic Alert), signifying a possible collision threat to your aircraft. Accompanied by a audible warning of "Traffic, Traffic"

A solid white diamond signifies a proximate traffic. Aircraft that are within 4nmi and ± 1200 feet altitude.

An open white diamond signifies other traffic within the selected range.

Numbers represent the intruder aircrafts relative altitude ± 100 ft levels from your aircraft.

The arrows indicate if the intruder aircraft is ascending or descending from your relative position.

Typical TCAS I Display

Figure 2-10

The perimeter of the *WARNING AREA* is approximately 15-35 seconds from entering the *COLLISION AREA (not depicted)*.

When an aircraft enters the *CAUTION AREA*, a "TA" (Traffic Advisory) is issued. This would consist of an audible and visual warning in the cockpit.

When an intruder enters the *COLLISION AREA*, the TCAS will issue a "RA" (Resolution Advisory). "RA's" consist of audible and visual warnings and possible instructions to avoid a collision.

A TCAS display will vary dependent on the manufacturer. Typically, a TCAS I system, as shown in figure 2-10, will display Traffic Advisories. A TCAS II System will be incorporated with a Vertical Speed Indicator (VSI), which will issue a RA, the pilots VSI will display a course of action to avoid a collision with an aircraft located in the COLLISION AREA.

2.15.2 TCAS Scenario Selection and Setup

1. To TR-220 must have the correct values entered to properly program an intruder to converge with the UUT aircraft. If the intruder scenario is incorrectly programmed, the operator may not receive the anticipated results.

2. Turn the Test Set "*ON*" and turn the **UUT FUNCTION** switch to **SETUP.**

3. Access the *TCAS Scenario* menu. The TR-220 has 10 preprogrammed intruder scenarios in its memory (see table 2-3). All TCAS Scenarios can be modified

and stored in the Test Set Memory. By toggling the **UP/FWD-DOWN/REV** switch, the operator can select the appropriate intruder scenario.

TCAS Scenario: 1 Chg:Up/Dn Cont: AUTO

4. After selecting a suitable scenario, the operator needs only to turn the **UUT FUNCTION** switch to the **TCAS** position to begin an intruder simulation. Proceed to paragraph 2.15.5 to continue with TCAS Tests. If the operator desires different parameters, continue with Step 5.

Scenario #	TCAS Start Distance	Start Altitude (Intruder)	Vertical Speed	Velocity
1	5 nmi.	2500 ft	0 fpm.	250 Kts.
2	5 nmi.	2500 ft	0 fpm.	250 Kts.
3	5 nmi.	2500 ft	0 fpm.	250 Kts.
4	5 nmi.	2500 ft	0 fpm.	250 Kts.
5	5 nmi.	2500 ft	0 fpm.	250 Kts.
6	5 nmi.	2500 ft	0 fpm.	250 Kts.
7	5 nmi.	2500 ft	0 fpm.	250 Kts.
8	5 nmi.	2500 ft	0 fpm.	250 Kts.
9	5 nmi.	2500 ft	0 fpm.	250 Kts.
10	5 nmi.	2500 ft	0 fpm.	250 Kts.

Preprogrammed (default) TCAS scenarios

Table 2-3

5. If the operator desires different parameters, Leave the **UUT FUNCTION** switch in the **SETUP** position and toggle the **AUTO** switch. The *Start Alt* menu will be displayed.

Start Alt: 2500’ Chg:Up/Dn Cont: AUTO

6. Toggle the **UP/FWD-DOWN/REV** switch to change the intruder’s start altitude. The Altitude can be changed from -1000 ft. to +99,900 ft. The altitude is adjustable in 25 ft. increments between -1000 ft. and 50,175 ft. and in 100 ft, increments above 52,000 ft. Hold the toggle switch either *UP* or *Down* for more than 5 seconds and the adjust speed will increase.

Start Alt: 10000’ Chg:Up/Dn Cont: AUTO

7. Toggle the **AUTO/TEST/MANUAL** switch to the **AUTO** position to advance to the *Velocity* menu. Utilize the **UP/FWD-DOWN/REV** switch to set the velocity to the desired setting. The *Velocity* is adjustable from 120Kts to 1200Kts.

Velocity: 180 nmi/h Chg:Up/Dn Cont: AUTO

8. Toggle the **AUTO/TEST/MANUAL** switch to the **AUTO** position to advance to the *Vert Speed* menu. Utilize the **UP/FWD-DOWN/REV** switch to set the vertical speed to the desired setting. The *Vert Speed* is adjustable from +7,500 fpm. to -7,500 fpm.

Vert Speed: +000 fpm Chg:Up/Dn Cont: AUTO

9. Toggle the **AUTO/TEST/MANUAL** switch to the **AUTO** position to advance to the *TCAS dist* menu. Set the distance of the intruder to the UUT by toggling the **UP/FWD-DOWN/REV** switch to the desired range. The range is adjustable from 1 nmi. to 50 nmi.

TCAS dist: 5 nmi Chg:Up/Dn Cont: AUTO

10. Toggle the **AUTO/TEST/MANUAL** switch to the *Mode S Addr* menu. The operator may change the Mode S address of the intruder aircraft. Switching the **switch** to **ALT** and then using the **UP/FWD-DOWN/REV** switch will enable the first two digits of the address to be changed. Switching to DIST and then to SPEED will enable the second tow digits and final two digits to be changed with the UP-DOWN switch respectively.

Mode S Addr: 3D8DFF Chg: Al/Ds/Sp-Up/Dn

By toggling the IDENT switch, the Mode S address will be decoded into the corresponding aircraft tail number where possible, or just show the country code for those countries that do not have an appropriate algorithm.

Mode S Addr: 3D8DFF DEU: D-GAAH

WARNING

Some Mode S Addresses may not be used. Ensure that the code you use is authorized in the country where the Test Set is being utilized. Tel-Instrument Corp. initially inserts **A00001** for the Mode S Address before shipping the Test Set.

When changing the Mode S address, utilize both the **CHN/ALT-DIST-VERT SPEED** and the **UP/FWD-DOWN/REV** switches.

11. Once all parameters have been set, turn the **UUT FUNCTION** switch to the **TCAS** position. The scenario is now held in the Test Set memory.

12. As a convenience, the following describes intruder scenarios and the correct parameters necessary to ensure a simulated convergence will occur.

The operator is able to select an infinite number of simulated Intruder scenarios. The TR-220 allows the user to select *Intruder Starting Altitude, Vertical Speed,* and *Distance* from target, and three preset *Velocities*. Table 2-4 describes each parameter and limitations.

PARAMETER	MIN AND MAX	NOTES
Intruder Velocity	120 – 1200 Kts.	10 KT. increments
Intruder Altitude	99,900 to -1000 ft.	50,200 to 99,900 in 100 ft increments -9000 to 51,175 ft in 25 ft increments
Vertical Speed	-7,500 to 7,500 fpm.	100 ft. increments
Intruder Distance	0 – 50 nmi.	1 nmi. increments

TCAS Intruder Parameters

Table 2-4

To select a scenario that will properly converge and intercept the UUT, the Aircraft altitude must be known. If any parameter is incorrectly entered, the intruder simulation may not intersect the UUT resulting in the operator not observing the intended display. The operator may utilize a Pitot Static Test Set to “Pump-Up” the aircraft altitude. It is recommended that this be accomplished before actual TCAS testing begins.

To correctly enter intruder parameters, utilize the following formula for reliable test results.

$$VS = \frac{(UUT - \text{Intruder Altitude}) \times \text{Velocity}}{\text{Intruder Distance} \times 60}$$

Assume the UUT Altitude is Pumped-up to 10,000 ft, Intruder Altitude set for 20,000 ft, Intruder Velocity is 600 kts and Intruder Distance is 20 nmi.

$$VS = \frac{(10{,}000 - 20{,}000) \times 600}{20 \times 60}$$

Complete the equation to find the correct Vertical Speed (VS) value to be entered.

$$VS = \frac{-6{,}000{,}000}{12000}$$

$$VS = -5000$$

The correct Vertical Speed variable is -5000 fpm.

Table 2-5 lists random TCAS Scenarios that will result in proper intruder convergence resulting in an RA and/or TA on the TCAS display.

Scenario #	UUT ALTITUDE (Pumped Up)	STARTING ALTITUDE	VELOCITY	TCAS DISTANCE	VERTICAL SPEED
1	-1000 ft.	2000 ft.	180 kts	10 nmi	-900 fpm
2	-500 ft.	1000 ft.	300 kts	15 nmi	-500 fpm
3	0 ft.	0 ft.	600 kts	20 nmi	0 fpm
4	500 ft.	1000 ft.	300 kts	25 nmi	-100 fpm
5	1000 ft.	3500 ft.	180 kts	25 nmi	-300 fpm
6	5000 ft.	4000 ft.	300 kts	25 nmi	200 fpm
7	7500 ft.	9500 ft.	600 kts	40nmi	-500 fpm
8	10,000 ft.	15,000 ft.	180 kts	50 nmi	-300 fpm
9	12,500 ft.	7500 ft.	300 kts	25 nmi	1000 fpm
10	15,000 ft.	30,000 ft.	600 kts	30 nmi	-5000 fpm
11	17,500 ft.	34,000 ft.	180 kts	15 nmi	-3300 fpm
12	20,000 ft.	10,000 ft.	300 kts	50 nmi	1000 fpm
13	25,000 ft.	41,500 ft.	600 kts	30 nmi	-5500 fpm
14	33,000 ft.	50,000 ft.	180 kts	30 nmi	-1700 fpm
15	42,000 ft.	15,000 ft.	300 kts	25 nmi	5400 fpm
16	49,000 ft.	31000 ft.	600 kts	45 nmi	4000 fpm
17	3000 ft.	5000 ft.	300 kts	25 nmi	-400 fpm
18	3500 ft.	2000 ft.	180 kts	45 nmi	-100 fpm
19	4500 ft.	2500 ft.	300 kts	50 nmi	200 fpm
20	7500 ft.	3000 ft.	600 kts	45 nmi	1000 fpm
21	8500 ft.	10,000 ft.	180 kts	15 nmi	-300 fpm
22	9000 ft.	15,000 ft.	300 kts	30 nmi	1000 fpm

Additional TCAS Intruder Scenarios

Table 2-5

2.15.3 Erasing the TCAS Scenario Memory

The TCAS memory can be restored to factory settings by the following procedures:

1. Place the **UUT FUNCTION** switch in the **SETUP** position.

2. Access the *TCAS Scenario* menu by toggling the **AUTO/TEST/MANUAL** switch.

TCAS Scenario: 1 Chg:Up/Dn Cont: AUTO

3. Toggle the **IDENT** switch "*UP*". The display shall revert to the *Reset Scenario* menu.

Reset Scenarios: MAN Cont Press AUTO

4. Toggle the **AUTO/TEST/MANUAL** switch to the **MANUAL** position. This will reset the operator-inserted scenarios and revert to the factory settings.

Default Scenarios Reset

2.15.4 Testing a TCAS Equipped Aircraft

1. Connect the Directional Antenna to the Test Set IAW Paragraph 2.9.1. The Directional Antenna is the only antenna that may be utilized for TCAS testing.

2. Turn the Test Set "*ON*" by toggling the **ON/OFF** switch to the **ON** position. Ensure the *GREEN* LED is illuminated.

3. Place the **UUT FUNCTION** switch in the **TCAS** position. The test set will first measure the TCAS transmitter power and frequency and the display will indicate the following

Power Frequency /
Listening . . .

4. After a few seconds, the display will indicate the following:

Power Frequency /
150W 1030.01Mhz

Power and Frequency measurements are approximate values and should be used for reference purposes only.

5. Press the **AUTO/TEST/MANUAL** switch to continue. The test set will next display the AUT Mode S address, transmitted via the TCAS system in a UF16 interrogation. The display will indicate the following

TCAS UF16 Md S Add:
3D8DFF

6. Press the **AUTO/TEST/MANUAL** switch to access the TCAS scenario selection screen and select the appropriate intruder scenario by using the **UP/FWD-DOWN/REV** switch. Paragraph 2.15.2 describes in detail correct procedures for initially programming and storing the TCAS scenarios.

NOTE

The following text utilizes Scenario 1, which is the default TCAS scenario. The parameters are as programmed in the example in para 2.15.2.

TCAS Test Mode S
Scen: 1, Press AUTO

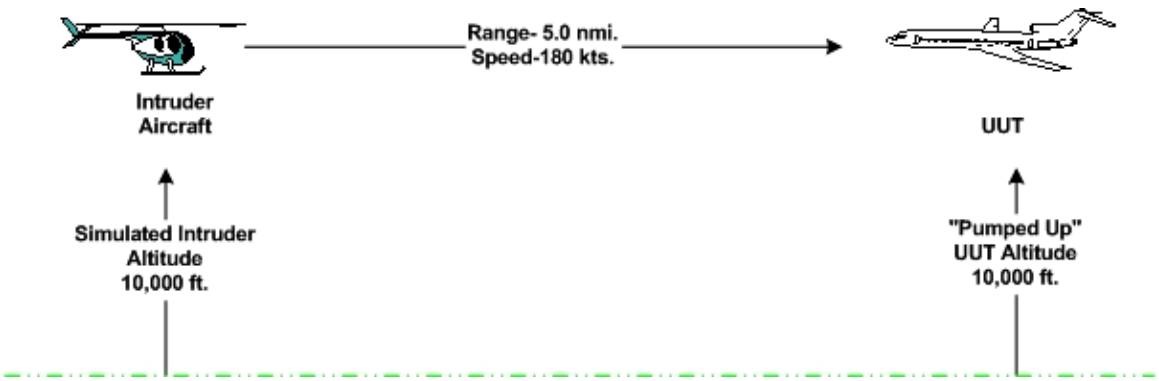
7. Simulate the UUT aircraft altitude to 10,000 ft by "Pumping Up" the aircraft with a Pitot Static test set

8. Select the Intruder velocity by toggling the **INCREASE-DECREASE VELOCITY** switch to the desired speed.

9. Select the intruder type, Mode S or ATCRBS using the ATCRBS/AIR-MODE S/GND switch. For TCAS I select ATCRBS and for TCAS II select Mode S.

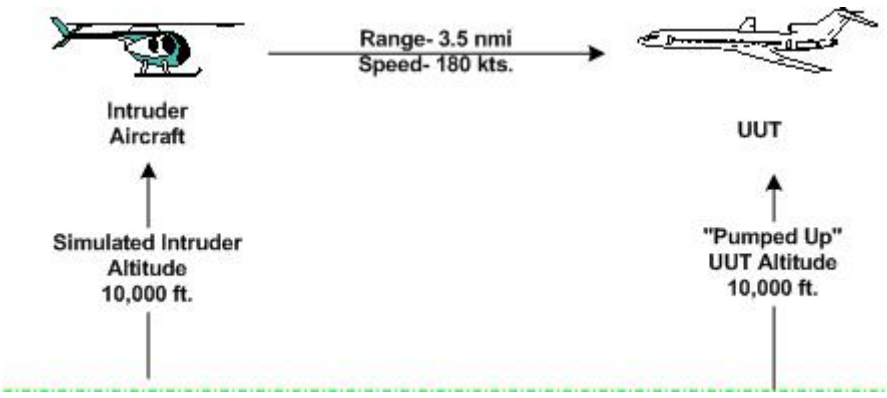
10. Toggle the **AUTO/TEST/MANUAL** switch to the **AUTO** position. The Test Set is now simulating an intruder aircraft at the selected position. **STP** indicates that the intruder is stopped at the initial position. Verify a display is annunciated on the UUT TCAS display. The display will indicate **ACQ** for a ATCRBS TCAS system. A Mode S TCAS system will initially show **ACQ** then change to indicate **TRK** once the correct *BIT* is received.

TRK 180 Kts 10000' /
5.0nm 000fpm STP

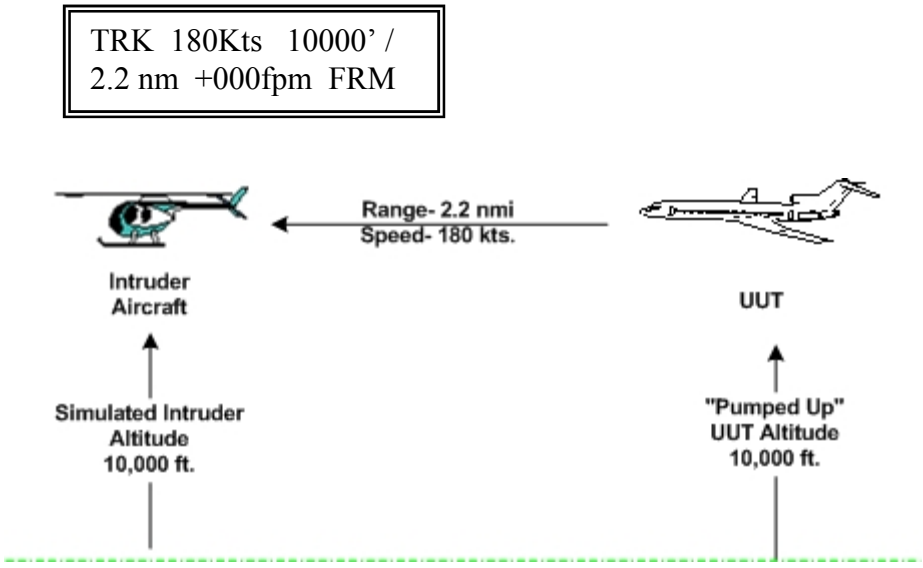


11. Toggle the **TO/START-FROM/STOP** switch to the **TO** position to commence the intruder convergence on the UUT. The Test Set display will indicate the altitude, range, velocity and climb rate (fpm) of the intruder simulation.

TRK 180Kts 10000' /
3.5 nm +000fpm TO



12. The operator may now observe the AUT TCAS display to ensure correct operation. Once the simulated intruder's range has reached 0 nmi, the Test Set will reverse the heading and return back to the start point. This will continue, back and forth, until the operator stops the simulation.



13. At any point during the simulation, the operator may STOP the intruder at any range. Toggle the **TO/START-FROM/STOP** switch twice to the **STOP** position. The intruder will stop and hold at that range. The operator now may move the Test Set to a different location around the AUT to check that correct azimuth information is being displayed on the TCAS display.

14. By selecting a starting altitude above or below the "Pumped UP" UUT altitude, the operator can simulate an intruder converging on the UUT from above or below the UUT. Table 2-5 lists several scenarios, which can be utilized for this purpose.

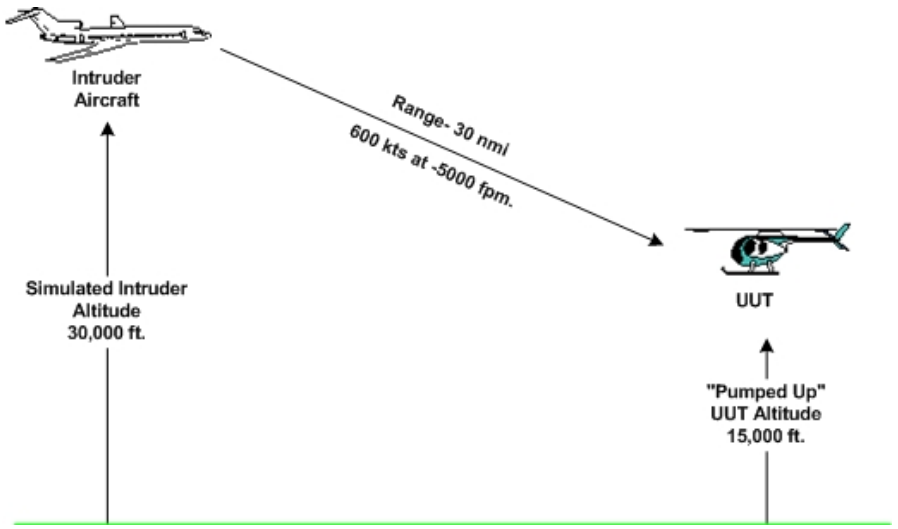
14a. For Example: Select Scenario #10.

Scenario #	UUT Altitude	Starting Altitude	Velocity	TCAS Distance	Vertical Speed
10	15000 ft.	30,000 ft.	600 kts	30 nmi	-5000 fpm

14b. Enter the values above in the *TCAS Scenario* Setup menus (Paragraph 2.15.2) and "Pump Up" the UUT aircraft to 15000 ft.

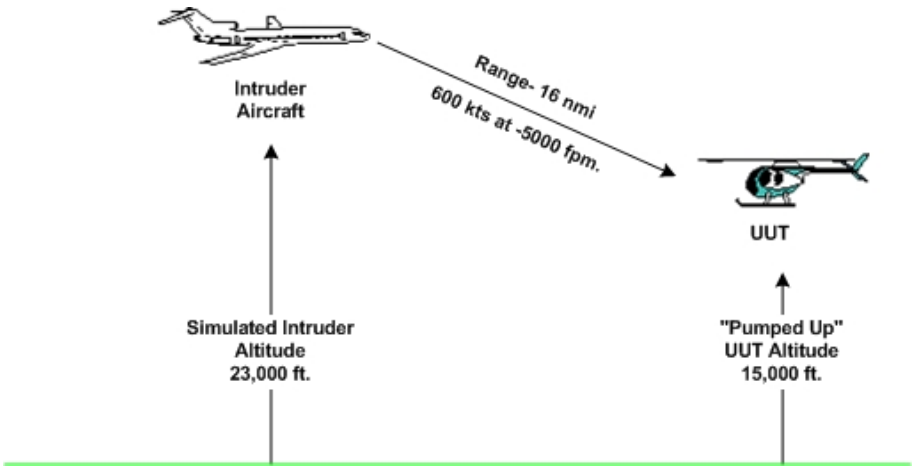
14c. Start the Intruder simulation as described in Paragraph 2.15.5.(11)

TRK 600Kts 30000' /
30 nm -5000fpm STP



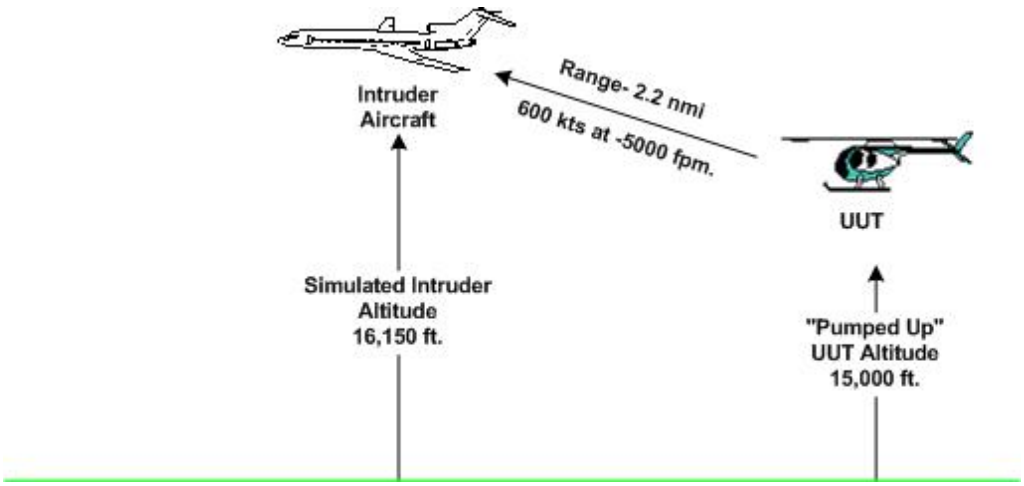
14d. As the simulated intruder approaches, the altitude will decrease to ensure a proper intersect of the targets.

TRK 600Kts 23000' /
15.9 nm -5000fpm TO



14e. Once the intruder has converged with the UUT, the simulation will reverse course and return to the original starting point.

TRK 600Kts 16150' /
2.1 nm -5000fpm FRM



15. It is possible to adjust the scenario parameters without changing the stored parameters within the *Setup Menu.* With the **UUT FUNCTION** switch in the TCAS position and with the TCAS scenario window displayed, proceed as follows:

TRK 600Kts 16150' /
2.1 nm -5000fpm STP

15a. Ensure that pressing the TO/STAR-FROM/STOP switch up twice and the display stop the scenario shows STP. (This is the only position, which allows temporary modification of the scenario parameters)

15b. By switching the **CHN/ALT-DIST-SPEED** switch to the relative positions, the altitude, distance and speed of the intruder can be adjusted with the UP-DOWN switch. Intruder velocity can be changed with the **INCREASE-DECREASE VELOCITY** switch. The scenario can now be run again with the modified parameters.

NOTE

Pressing AUTO to measure TCAS power and frequency or restarting the TCAS testing by moving the UUT Function switch will revert to the selected scenario parameters

END OF TCAS TESTS

2.16 DME Tests

The TR-220 is capable of selecting any of the DME frequencies of 108.0 – 117.95 MHz channels. The Test Set simulates a ground station at an operator selected range and velocity. When the operator initiates the test, the Test Set range, TO or FROM, will decrease to 0 nmi., and return back to the pre-selected range. The operator may also freeze the simulation at any point during the simulation.

The following paragraph will describe the procedure to properly conduct a test of a DME Receiver. The Directional Antenna is utilized for DME testing.

2.16.1 DME Setup

1. Connect the directional Antenna and follow the procedures as outlined in Paragraph 2.9.1.

2. Turn the Test Set *"ON"* by toggling the **ON/OFF** switch to the **ON** position. Verify the green LED is illuminated.

3. Select **DME** using the **UUT FUNCTION** switch and verify the following display: (note that DME velocity will be the last selected velocity).

108.00MHz 350K 0Hz
50.0nmi Ident Hold T

4. To select the appropriate frequency, place the **CHN/ALT-DIST-VERT SPEED** switch in the **CHN/ALT** position. Using the **UP/FWD-DOWN/REV** switch, select the desired DME channel. The operator may select any frequency from 108.00 to 117.95 MHz.

5. To select the range from the UUT, place the **CHN/ALT-DIST-VERT SPEED** switch in the **DIST** position and toggle the **UP/FWD-DOWN/REV** switch to the appropriate range. The Test Set range can be varied from 0 – 250 nmi, in 1 nmi increments (default distance is 50nmi).

6. Select the velocity of the scenario by toggling the **INCREASE-DECREASE VELOCITY** switch to **INCREASE** or **DECREASE** the AUT velocity (120-1200Kts in 10 Kt increments).

7. To begin testing, toggle the **TO/START-FROM/STOP** switch either *"UP"* or *"DOWN"*. By toggling the switch "*UP"*, the operator will select **TO** the AUT. The Test Set will begin decreasing the distance to the AUT at the selected velocity and display the UUT PRF in Hz.

108.00MHz 350K 18Hz
47.5nmi Ident ToT

8. At any point during the test, the operator may reverse the direction of the simulation by toggling the **TO/START-FROM/STOP** switch *"DOWN"* to the **FROM/STOP** position. The scenarios will then, stop and reverse direction. The *TO* display will change to *FROM* indicating FROM the AUT. The distance will track from the distance selected to zero nmi and back, repeatedly. The AUT DME indicator should be monitored to ensure correct distance and velocity measurements where applicable.

108.00MHz 350K 18Hz
48.0nmi Ident FromT

9. To halt the scenario at a selected distance, toggle the **TO/START-FROM/STOP** to the **FROM/STOP** position two times in succession. The simulation will stop at that distance and remain there until the **TO/START-FROM/STOP** switch is toggled to the **TO/START** position.

DME audio can be tested by listening to the AUT DME audio. The Test set will transmit appropriate Morse code station IDENT signal approximately every 40 seconds. The **IDENT** Tone can be switched OFF or ON by toggling the **IDENT** switch up.

To measure DME power and frequency, toggle the **AUTO/TEST/MANUAL** switch to the **AUTO** position. The test set listens for the DME transmissions.

Power FrequencyT
Listening . . .

12. The DME power and frequency will be displayed.

Power FrequencyT
55dbm 1041.0Mhz

END OF DME TESTS

2.17 Mode S Enhanced Surveillance

NOTE

All illustrations shown are for demonstration purposes. Though the test results may be typical, they are not meant to replace manufacturer recommendations or ACTUAL results

The TR-220 is capable of testing Mode S Transponders with Enhanced surveillance (EHS) capability. Access to the EHS menu is as follows:

If utilizing the Directional Antenna, select **SETUP** using the **UUT FUNCTION** switch and complete the procedures in paragraph 2.9.1. Utilize paragraph 2.9.2 if using the supplied direct connect cable.

1. Connect the antenna or direct connect cable as appropriate.

2. Turn the Test Set "ON" by toggling the **ON/OFF** switch to the **ON** position. Ensure the green LED illuminates.

3. The Test Set commences the Self-Test. "PASS" is displayed briefly if no failures are detected.

Self Test PASS

4. Turn the **UUT FUNCTION** switch to the **XPDR** position. The Test Set will automatically determine the transponder capability as being Mode S capable and display the appropriate start page with the COMM A, B, C & D capabilities also listed if applicable.

Capability COMM ABCD Press AUTO/MANUAL

5. Press the **TO/START-FROM/STOP** switch upwards to the **TO** position to access the *EHS* menu.

Mode S Enh. Surv. Using UF5/DF21 . . .

6. EHS testing can be carried out using 3 UF/DF combinations. Press the **UP-DOWN** switch to the "UP" position to select UF5/DF21, UF21/DF21, and the UF0/DF16 as applicable. The results displayed will be the same for each selection.

7. Press the **AUTO/TEST/MANUAL** switch to continue. The Roll angle will be displayed in degrees. Part of the BDS5 Track and Turn report.

```
BDS5 Roll Angle
 +90     D
```

8. Press **AUTO/TEST/MANUAL** to move to the next test. The True track angle will displayed in degrees and the Track Angle rate will be displayed in degrees per second. Part of the BDS5 Track and Turn report.

```
BDS5 True Trk Angle
An E120 D Rt  +  8    D/s
```

9. Press **AUTO/TEST/MANUAL** to move to the next test. The True Airspeed and Ground Speed will be displayed in Knots. Part of the BDS5 Track and Turn report.

```
BDS5 Tru ASpd     600K
      Gnd Speed   550K
```

10. Press **AUTO/TEST/MANUAL** to move to the next test. The Indicated Airspeed will be displayed in Knots, the Heading in degrees and the Mach number. Part of the BDS6 Heading and Speed report.

```
BDS6 Ind Aspd     600K
Hdg E120  D Mch 1.000
```

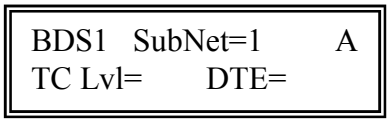
11. Press **AUTO/TEST/MANUAL** to move to the next test. The Barometric Altitude Rate and Inertial Vertical Velocity will be indicated in feet per minute. Part of the BDS6 Heading and Speed report.

```
BDS6 Balt      +6000'/M
In VertVel     +6000'/M
```

12. Press **AUTO/TEST/MANUAL** to move to the next tests Subsequent screens will display the values contained in registers BDS 1,0; 1,7; 1,8; and 1,9. The decoded register values are shown in Hexadecimal.

```
BDS 10 Datalink
10  00  00  80  E0  00  00
```

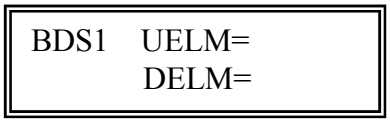
The TR-220 will decode and display parameters contained in the BDS 1,0 register. The parameters include, Mode S Subnet Network Number = “Sub Net=0” (Decode and display IAW with ICAO Annex X Volume 3 Sect. 5.2.9 (page 279) 0,1,2, 3, etc.); Transponder enhanced protocol indicator = “TC Lvl= 2-4” (Decode and display 0=2-4 and 1=5); DTE Sub address = “DTE= NO” (Decode and display 0=NO, 1=YES)

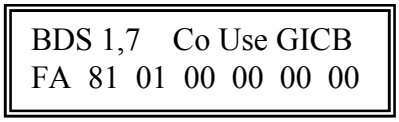


Mode S Specific Services Capability = “SPC SV CP=YES” (Decode and display 0=NO, 1=YES); Continuous Flag = “Cont Flg=NO” (Decode and display 0=NO, 1=YES); Surveillance Identifier = “SI=YES” (Decode and display 0=NO and 1=YES)

Aircraft Identification Capability = “Flt ID=YES (Decode and display 0=NO and 1=YES); Squitter Capability Subfield = “Sq=YES” (Decode and display 0=NO and 1=YES); Common usage GICB capability = “COM GICB=YES” (Decode and display 0=NO and 1=YES)

Uplink UELM capability = “UELM=NO” (0=NO, 1=1, 2=2, etc. ICAO Annex X Volume 3 Sect. 5.2.9 page 280); Downlink DELM capability =“DELM=NO” (0=NO, 1=1, 2=2, etc. ICAO Annex X Volume 3 Sect. 5.2.9 page 280)





13. Press **AUTO/TEST/MANUAL** to move to the next test. The display will indicate if TCAS has issued a Resolution Advisory. BDS3 ACAS Active Resolution Advisory.

NOTE

A second TR-220 may be necessary to simulate a TCAS intruder in order to cause the TCAS system to issue a Resolution Advisory

```
BDS Resolution Adv:
Active RA FFFFFF
```

14. Press **AUTO/TEST/MANUAL** to move to the next test. The display will indicate the Selected Altitude in feet. Part of the BDS4 Aircraft Intention report.

```
BDS4 FMC Alt 25000'
MCP/FCU Alt
```

Barometric Pressure Setting = "Press Set = 1015".0; Target Altitude Source = "Tgt Alt=UNK" (00=UNK, 01=ALT, 10=BOTH, 11=FMS); Status of Target Alt Source Bits = "Src=NO" (0=NO and 1=YES);

```
BDS4 Press Set=800.1mb
Tgt Alt= UNK Src=No
```

VNAV Mode = "VNAV=NA" (0=NA, 1=ACT); ALT Hold Mode = "ALT HD=NA (0=NA, 1=ACT; Approach Mode = "APRHL=NA" (0=NA and 1=ACT)

```
BDS4 VNAV = NA
Alt Hld= NA Appr= NA
```

END OF MODE S ENHANCED TESTS

2.18 ADS-B and TIS Testing

The TR-220 Test Set provides operators with the capability to test ADS-B and TIS functions that are now standard in many models of Transponders. This is an enhancement over standard MODE S transponder that provides operators with unique information previously not available.

2.18.1 ADS-B TX

NOTE

All illustrations shown are for demonstration purposes. Though the test results may be typical, they are not meant to replace manufacturer recommendations or ACTUAL results.

The TR-220 provides test capability for Mode S Transponders capable of DF17 Extended Squitters or ADS-B. The TR-220 ADS-B TX test can be accessed as follows.

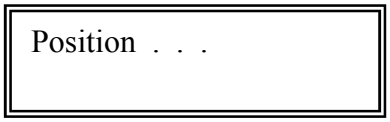
1. Utilize either the Direct Connect Method, Directional Antenna, or the optional TAP-200 for ADS-B and TIS Tests. Utilize paragraph 2.9 for instructions.

2. Turn the Test Set "*ON*" by toggling the **ON/OFF** switch to the **ON** position. Ensure the green LED illuminates.

3. The Test Set commences the Self-Test. "PASS" is displayed briefly if no failures are detected.

4. Turn the **UUT FUNCTION** switch to ADS-B TX. If no ADS-B squitters are received, the following screen will appear:

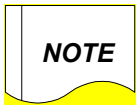
5. If a DF17 or DF18 squitter is detected, the display will show the following information. Use the **AUTO/TEST/MANUAL** switch to toggle between screens.



If the Transponder is in the Air and is transmitting a BDS 0,5 Extended Squitter Airborne Position Report, the following screen will be displayed:

Air 5200’ B 0.5s 39 17 51N 94 42 50W

The information displayed includes Squitter Type (Airborne), Altitude in Feet, Altitude Source (Barometric or GNSS), squitter period and encoded latitude and longitude.



For certain TR-220 functions, you must store the latitude/longitude of the test set in the SETUP FUNCTION. This is called the HOME POSITION. The latitude/longitude of the Test Set can be entered manually or automatically stored using the latitude/longitude information being transmitted by the aircraft under test. When you have the above screen displayed, press the IDENT switch, wait for the test set prompt and press the AUTO_TEST_MANUAL switch to MANUAL. This will store the latitude and longitude information in the test set HOME POSITION.

To set the Lat & Lon positional information into the TR-220, proceed as follows. Turn the test set **ON** with the **UUT FUNCTION** switch in the set up position.

Use the **AUTO/TEST/MANUAL** switch to scroll the display to the Lat/Lon screen

Latitude: Longitude: 39> 17 51N 94 42 50W

Use the **TO/START-FROM/STOP** switch to move the > cursor to the field which needs to be set and then use the **UP/FWD-DOWN/REV** switch to change the values to those desired.

If the Transponder is on the Surface (Ground) and is transmitting a BDS 0,6 Extended Squitter Surface Position Report, the following screen will be displayed. The information displayed includes Squitter Type (Surface), Movement in knots, Ground Track (True) in Degrees, squitter period, and encoded latitude and longitude. The proper decoding of the Surface Position requires that the test set latitude and longitude (HOME POSITION) is set to current position.

Gnd 1.0K +120D 5.0s 39 17 51N 94 42 50W

6. Press the **AUTO/TEST/MANUAL** switch to select the next screen:

Identification . . .

If the Transponder is transmitting a BDS 0,8 Extended Squitter Aircraft Identification and Type Report, the following screen will be displayed. The information displayed includes Aircraft Type, Squitter Period, and Flight ID.

Aircr. Cat: A2 5.0s Flight ID: T200ZC

7. Press the **AUTO/TEST/MANUAL** switch to select the next screen:

Airborne velocity

If the Transponder is Airborne (simulated) and is transmitting a BDS 0,9 Extended Squitter Airborne Velocity Report, the following screen will be displayed. The information displayed includes Velocity Type, East/West Velocity (knots), North/South Velocity (Knots), Geometric Height Difference between Barometric and GNSS Height (Feet), and Barometric or GNSS Vertical Rate (Up or Down in Feet/min).

Vel: 1 E 71K N 71K Hd: 125’ BVR: 600’

8. Press the **AUTO/TEST/MANUAL** switch to select the next screen:

Mode S Address . . .

The TR-220 will decode and display the Aircraft Mode S Address as shown in the following display. In addition, the TR-220 decodes and displays the Interrogator Identifier (II) field.

DF17 MS Addr:A40001 USA: N357NG II=0

9. Press the **AUTO/TEST/MANUAL** switch to select the next screen:

Latitude & Longitude

The TR-220 will display the encoded latitude and longitude information with more resolution. The display will indicate whether the information is from an Airborne Squitter (A) or Surface Position Squitter (G).

Lat: 39 17 51.30N Lon: 94 42 50.14W A

2.18.2 ADS-B RX

The TR-220 ADS-B RX Function allows transmission of the following information:

- Mode S Extended Squitter (DF17/DF18), Airborne or Surface Position, for 4 intruder aircraft.
- Traffic Information System (TIS) for 4 intruder aircraft

ADS-B Intruder simulations DF17/DF18 can be accessed as follows:

1. Turn the **UUT FUNCTION** switch to ADS-B RX and use the **AUTO/TEST/ MANUAL** switch to select the following screen.

4 DF17 Targets A00001 Airborne

2. Set the **ATCRBS/AIR-MODE S/GND** Intruder switch to Airborne or Ground.
3. Press the IDENT switch to select DF17 or DF18 target type.
4. Set a Mode S Address for the first intruder by selecting *SETUP* using the **UUT FUNCTION** and using the **AUTO/TEST/MANUAL** switch to select Mode S Address (The Mode S address for the other 3 targets will be incremented by 1). The TR-220 will transmit the DF17 or DF18 information for 4 intruder aircraft that have the following parameters when AIRBORNE intruder is selected:
    a. Altitude = 10,000 feet
    b. Distance = 10 miles from the test set **HOME POSITION**
    c. Velocity = 250 knots
    d. Target locations are NE, SE, SW, and NW of the test set **HOME POSITION**
    e. The Flight ID for the targets are TEL1, TEL2, TEL3, and TEL4

The TR-220 will transmit the DF17 or DF18 information for 4 intruder aircraft that have the following parameters when GND intruder is selected:

a. Distance = 1 mile from the test set **HOME POSITION**

b. Velocity = 5 knots

c. Target locations are NE, SE, SW, and NW of the test set **HOME POSITION**

d. The Flight ID for the targets are TEL1, TEL2, TEL3, and TEL4

TIS intruder simulations can be accessed as follows:

1. Select ADS-B RX on the TR-220 **UUT FUNCTION** switch
2. Use the **AUTO/TEST/MANUAL** switch to select the following screen:

3. The TR-220 will decode and display the Mode S Address of the Transponder under test.
4. The TR-220 will transmit Comm A (UF21) information for 4 intruders.

The transmitted information for the 4 intruders is as follows:

Target	Bearing	Range	Altitude	VS	Heading	Status
1	0	0.5	+200	LVL	0	TA
2	60	1.5	-500	CLB	45	TA
3	120	3.0	-1500	DES	-45	PA
4	240	5.0	+2000	LVL	90	PA

TIS Intruders

Table 2-6

END OF TIS TEST

2.19 RS-232 Download Procedures

The TR-220 contains memory to down load results received during the **AUTOMATIC** sequence of tests to a PC thru the use of the RS-232 port located on the front panel of the Test Set. Once downloaded, the information can be displayed in an Excel file to be viewed and saved for future reference. The following Tests and results are captured to the Test Set's memory:

1. **MODE A & SLS**
   Re: Mode A Reply, Mode A Code, MA SLS

2. **MODE C**
   Re: Mode C Reply, Mode C Altitude

3. **MODE A & SLS**
   MA SLS, P1 > P2, Reply, P1 = P2

4. **MODE A ALL CALL**
   Re: Mode A & C Reply, MA and C Address

5. MO**DE C ALL CALL**
   Re: MC & A Reply, Mode A & C Address

6. **MODE A ONLY**
   Re: Results

7. **MODE C ONLY**
   Re: Results

8. **MODE S SURVEILLANCE IDENTITY**
   Re: DF5 Reply, DF5 ID, DF5, Flight Status

9. **MODE S SI LOCKOUT**
   Re: Results

10. **MODE S SUVEILLANCE ALTITUDE**
    Re: DF4 Reply, DF4 Altitude, DF4 Flight Status

11. **MODE S SURVEILLANCE SHORT**
    Re: DF0 Reply, DF0 Altitude, DF0 VS, Tail Number

12. **MODE S COMM IDENTITY**
    Re: DF21 Reply, DF21 ID, DF21 Flight ID

13. **MODE S COMM ALTITUDE**
    Re: DF20 Reply, DF20 Altitude

14. **UNDESIRED REPLIES**
    Re: Results

15. **SQUITTER**
    Re: ACQ Per, ACQ Address, Ext PER, Extended Address

16. **DIVERSITY**
    Re: Results, Diversity Attenuation

17. **SENSITIVITY**
    MA, MC, & MS Sensitivity

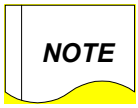
18. **POWER AND FREQUENCY**
    Re: Power (in dB), Power (in Watts), and Frequency

The Test Set Captures up to 32 series of tests, after capturing the 32th test, the Test Set will then begin overwriting the oldest captured data. The software required to download the stored information is part of the Test Set memory. No external software is required to be loaded onto the PC to accomplish the transfer.

Results are transferred via a RS-232 Cable (not supplied) to a COMM port on the computer at a 4800-baud rate. With the computer HyperTerminal, the data is downloaded as a comma delimited file, which can be opened in an Excel spreadsheet program. The operator may also choose to put it in another file of their choice.

2.19.1 Setting Up Your Computer for RS-232 Download

It is necessary to configure your computer to correctly display the data downloaded. Once this is accomplished, the operator can then sort the data in the excel file in any way they prefer. The TR-220 Test Set utilizes a Hyper Terminal Program that is part of the Microsoft Windows Operating System. If this is not installed on your computer, you can obtain the program from the Microsoft Website or from your Windows Software the was supplied with your Computer. The following describes a suggested way to configure your computer to properly display the data.



The following procedures are abbreviated and may not match your operating system exactly; contact your computer administrator or computer manufacturer for assistance.

1. Select *START* on the computer desktop.
2. Select *PROGRAMS.*
3. Select *ACCESSORIES.*
4. Select *COMMUNICATIONS.*
5. Select *HYPER TERMINAL.*
6. Enter a name for the Terminal Connection (e.g. – TR-220).
7. Select *CONNECT TO* and pick the correct COM port you will be utilizing on your computer. For most users, this will be *COM1*.
8. Set the Port Settings to the following.
   a. BIT PER SECOND – 4800
   b. DATA BITS – 8
   c. PARITY – None
   d. STOP BITS – 1
   e. FLOW CONTROL – Hardware
9. Select *APPLY*.
10. Select *OK*.

Close the Program. You have not created a permanent short cut configured for the TR-220 RS-232 download feature. You will not be required to repeat this procedure. When preparing to download data, select the TR-220 Hyper Terminal that should be located within the Hyper Terminal program selection dropdown.

2.19.2 Downloading the Data

Ensure the Test Set is **OFF** before connecting the Test Set to your computer.

1. Connect a standard RS-232 extension cable (not supplied) to the RS-232 connector located on the front panel of the Test Set and connect the other ends to the COM Port that was selected paragraph 2.15.1 step 7 (typically COM1).

2. On the computer, select the TR-220 Short Cut that was created in the paragraph 2.15.1.

3. Select *TRANSFER* from the Hyper-Terminal drop down menu.

4. Select CAPTURE TEXT and save the file to your desktop (recommended) and name the file to your preference but utilize a .csv extension (for example - Serial Number 2345Date.csv). Select *START*.

5. Press the **MANUAL** toggle switch on the Test Set to begin downloading the data and observe the following:

   TEL-INSTRUMENT
   Transferring Data . . .

   The data will download to the Hyper-Terminal program and can then be observed on the computer display. Once all of the data has been transferred, the Test Set will indicate:

   Output Completed
   Press MAN To Erase

   Select *TRANSFER* on the Hyper-Terminal drop-down menu, then *CAPTURE TEXT* and *STOP.* The data is now saved to the file. The operator may now choose to erase the stored data on the Test Set by toggling the **MANUAL** switch on the Test Set. Simply turn the Test Set *OFF* if you desire to keep the file in the memory.

6. Turn OFF the Test Set and disconnect the RS-232 cable.

2.19.3 Loading the Data to a Microsoft Excel File

1. Open up Microsoft Excel; do not double click on the file stored on the computers Desktop. Select *FILE* then *OPEN*. Locate the file on the Desktop (or wherever it was saved to) and open the file.

2. Depending on the edition of Microsoft Excel you currently have, the file may directly open and can then be organized as necessary. If the *IMPORT WIZARD* opens, follow step 3, if the file opened properly, skip to step 4.

3. If the *IMPORT FILE WIZARD* opens, select a *DELIMITED* file then click *NEXT. Select COMMA-DELIMITED* and deselect all others. Select *NEXT* and *FINISH.*

4. Once the file is loaded onto the Excel Spreadsheet, the operator can choose how to organize and display the information. By selecting “Auto Fit” options and selecting the appropriate Text, the operator can modify the spacing between each block. Refer to the Excel help file for further information.

CHAPTER III

THEORY OF OPERATION

3.1 General

The Test Set is comprised of four circuit boards which are controlled by and results displayed on the front panel. The Digital PCB interfaces with the Power Supply PCB and RF PCB and with the panel-mounted switches, connectors, and LCD display. An eight bit microprocessor is used to control the digital logic to perform the functions used to interact with the UUT.

The RF PCB generates the UUT stimulus signals and receives the UUT responses for measurement. The RF frequencies when transmitted are modulated by signals produced from the Digital PCB and passed to the antenna connector.

The connector on the front panel provides the power used to run the Test Set, charge the battery, and supply power and connection to the KIR/KIT encryption computers

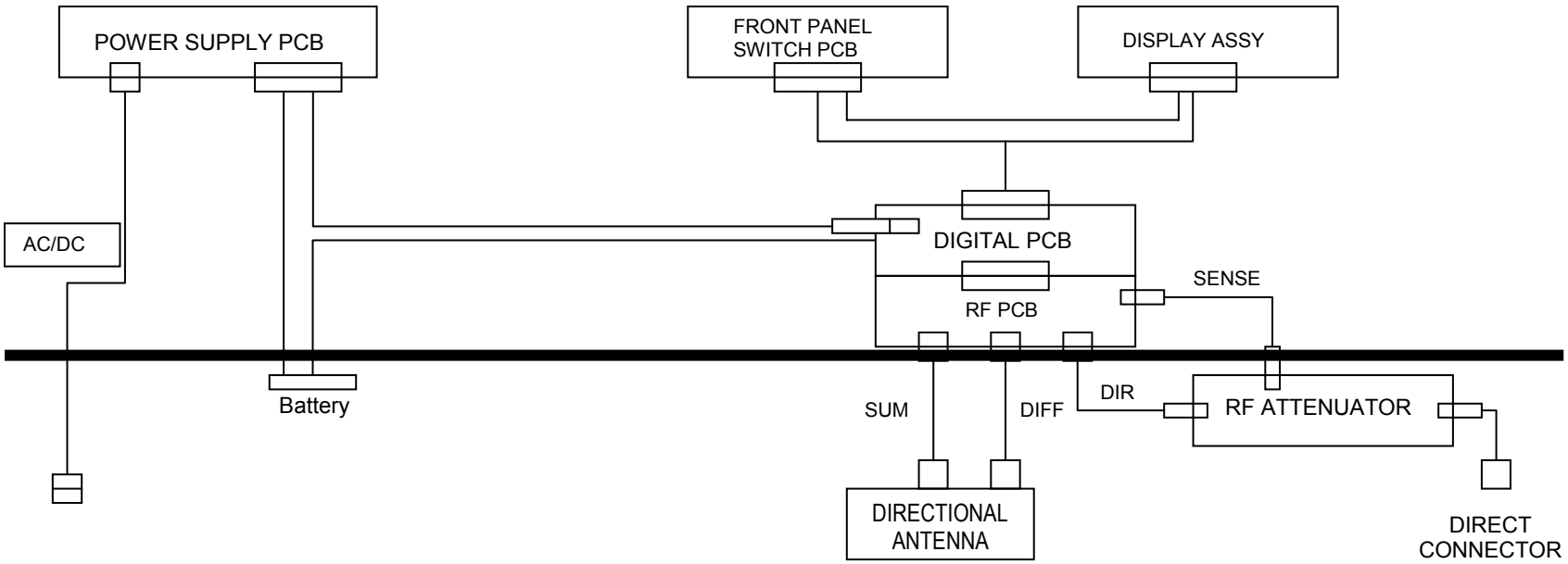
3.2 Subassemblies

The Test Set consists of the assemblies shown in Figure 3-1; the functions of these assemblies are contained in the following paragraphs:

Para	Subassembly	Function
3.3	Panel & Display Assembly	Operator Interface
3.4	RF PCB Assembly & Attenuator Assembly	Receive/Transmit
3.5	Digital PCB Assembly	Signal Generation/Processing
3.6	Power Supply PCB Assembly and Battery	Power Generation/Distribution
3.7	Case Assembly	Instrument Housing
3.8	over & Accessories Assembly	Accessories Housing
3.9	Directional Antenna Assembly	Antenna

3.3 Panel and Display Assembly

Operation of the Test Set is achieved with a user friendly panel which uses toggle and rotary switches coupled with an easy to read, large character, LCD display. The display has 2 lines of up to 20 characters, a character height of 0.5 inches, and is observable from a distance of ten feet in bright sunlight. The Test Set antenna, with an integral optical sight, can be mounted on the instrument case, hand held, or mounted on a tripod to be aimed at the aircraft antenna. The Test Set instrument can be hand held or hung by a neck strap to give hands free operation.



Test Set System Basic Functional Diagram

Figure 3-1

The Test Set is contained in a case with heavy wall construction and includes a pressure relief valve. The front panel has a continuous gasket and all front panel components are sealed. The Test Set has been designed to meet the environmental requirements of the PRTS specification. The front panel, which is the “backbone” of the unit, is made of 0.187 thick aluminum to which the EMI chassis is mounted. The RF and Digital PCB assemblies are installed inside the EMI chassis and are separated by a shielding plate. The RF PCB also has separate shields around the synthesizer and transmitter. Digital circuits are connected through two ribbon cables terminated with EMI filter connectors. The battery cavity is brazed to the front panel along with the Power Supply PCB assembly support plate brazed between them. When the panel is installed in the case, sockets on the back panel structure engage with guide pins mounted to the bottom of the case.

The Test Set was designed to withstand the rigors of weather and to operate in close proximity of aircraft. Normally operated with the cover removed, the Test Set will not be adversely affected by rain, salt air, or fumes. The cover stores all the ancillary items and, when closed.

3.4 RF PCB Assembly & Attenuator Assembly

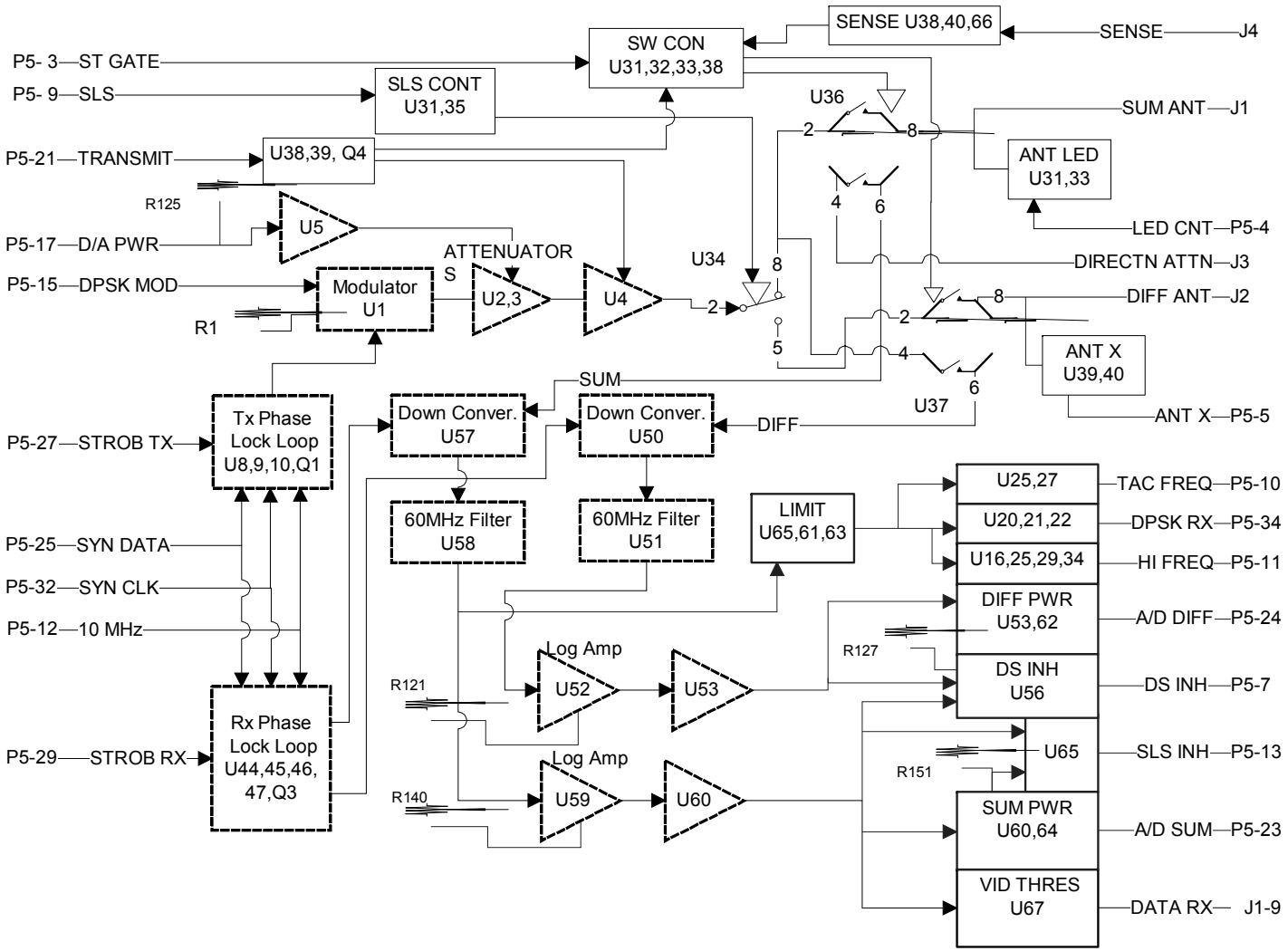
The RF PCB is connected to the Attenuator Assy. and then to the Direct Connect connector or the removable antenna through coax cables. The RF PCB is mounted in its own shielded enclosure that is connected directly to the Digital PCB and includes the transmitter, switching matrix, receiver and video processing. Figure 3-2 is the Test Set RF function diagram for both the transponder and interrogator test modes.

3.4.1 Transmitter

The transmitter phased locked loop (PLL), comprised of U8, U9, U10 and Q1 are capable of generating a 1030MHz signal for transponder testing and at 1090MHz, a signal for interrogator testing. The processor through the serial data bus controls the synthesizer U10 divide ratio. A portion of the oscillator signal is compared with the 10 MHz reference signal and generates an error voltage which is filtered by U8 and applied to the voltage controlled oscillator Q1. The 10 MHz reference signal is counted down (U29) from the 40MHz oscillator, U16, on the digital board.

3.4.2 Modulator

The double balanced mixer U1, amplitude and phase modulates the RF signal with the analog signal, DPSK MOD. This modulating signal is generated on the digital board. A balance resistor R1 is provided to compensate for the match between diodes in the balanced mixer. It needs to be adjusted for maximum P6 Flatness (In Mode S) ratio whenever U1 is replaced.



RF Functional Diagram

Figure 3-2

3.4.3 Gain Control

The peak modulated output transmitted level is capable of generating +7 dBm (at Sum Port) nominal and is stable to +/- 2 dB. Two voltage controlled RF amplifiers, U2 and U3 control it. A calibrated digital signal stored in the processor and converted to an analog signal using the D/A converter U8, located on the digital board, sets the gain of the RF amplifier. The output power is controlled over a range greater than 50 dB. The variable gain control amplifier is followed by a fixed gain (17dB) gated amplifier, U4.

3.4.4 Antennas, RF Switching, & Attenuator

The RF transmitter and receiver are connected thru the RF PCB mounted switching matrix and associated cables to either the antenna or thru a high power 50 dB attenuator directly connected to the UUT. The attenuator will dissipate peak powers up to 67 dBm allowing a direct connection between UUT and TR-220, without damage. A 10 foot RG-223/U coax with M39012/26-001 TNC connectors is provided for the direct connect testing.

When testing transponders, the transmitted P2 is switched to the difference antenna to generate an effective antenna Beamwidth of 20° (nominal). When testing transponders with the ISLS pulse present, the switch will not be activated and the resultant output level of P2 will be equal to P1 and P3. The magnitude of the signals received on the sum channel is scaled and are compared to the signals received on the difference channel to provide an effective receive Beamwidth of 10° (nominal).

The RF switches U34, U36 and U37, switch the modulated RF signal from the transmitter TR-220 to either the directional antenna, direct connect connector, or directly to the TR-220 receiver. The switching circuits also switch the received signal to the sum and difference receiver. When using the directional antenna during transponder testing, the side lobe suppression pulse P2 is switched by U34 to the difference antenna, while P1 and P3 are directed to the sum antenna. U36 and U37 are transfer switches. In the first state, Pin 2 is connected to Pin 8 and Pin 4 is connected to Pin 6 and in the second state, Pin 2 is connected to Pin 4 and Pin 8 is connected to Pin 6. U36-8 is connected to the sum port of the antenna, and Pin 6 is connected to the sum receiver. U37 pin 8 is connected to the difference port of the antenna and Pin 6 is connected to the difference receiver. The maximum rated input power to U36 and U37 from the antenna is +27 dBm continuous modulation (Antenna Port).

The signals controlling U40 are derived from a switch divider, which includes 10K termination for the direct connect connector. If the termination is connected, the directional antenna ports are active. If the termination is removed, direct connect is the active port. The signal SLS, derived on the digital board, controls U34 via U35 and U31 causing the P2 pulse to be directed to the difference antenna. A transmit/receive switch consisting of transfer switches U36 and U37 is controlled by the signal, TRANSMIT, and ST GATE, generated on the digital board.

3.4.5 Receiver

The receiver has a sensitivity of -50 dBm (nominal) and in testing has withstood greater than 1.6 watts/foot^2 peak pulsed power. The receiver consists of two mixers

(U50, U57), a local oscillator PLL (U44, 45, 46, 47), 2 band pass filters, two log amplifiers (U52, U59), a threshold comparator (U67), a sum and difference comparator (U56), a SLS detector and (P1/P2) comparator (U60, 64, 65, 66), a limiting amplifier (U55, 61, 63), a 60MHz discriminator frequency measuring circuit, a sum power measuring circuit (U60, 64), a difference power measuring circuit (U53, 62), and a DPSK demodulating circuit for Mode S.

The local oscillator PLL is identical to the transmitter PLL. It is set at 1030 MHz when testing transponders and 1090 MHz when testing interrogators. It is tuned in 100 kHz steps about the selected frequency for frequency measuring. The two mixers are double balanced and are connected thru the transfer switches to the sum and difference antennas.

The received sum and difference signals are mixed with the local oscillator output that produces a 60 MHz IF. The direct connect input is first attenuated by 50 dB and then follows the same path as the sum signal. The two log amplifiers, one for sum signals and one for difference signals, have a video output that is proportional to the log of the input over a range of 70 dB. The slope is adjusted (R121) so that the two amplifiers track over the range within +/-2dB.

The video sum signal out of the video amplifier U60 is connected to U67, a threshold circuit, to U56, a sum and difference comparator, and through U64, U60 to U65, SLS detector. Sample and hold amplifier U64, sum and difference comparator U65 are driven by the CPLD Digital PCB, which provides a 300 µsec sample pulse from DATA RX pulse. SLS INH accrues at P2 pulse time, blanks U64 to store P1 power level and activates U65 to hold the results of P1 and P2 comparison. If P2 is greater than -9dB of the P1 signal, the signal SLS INH will be high and will display that SLS is present.

The sum and difference video signals are applied to the sum and difference comparator U56. The difference signal is adjusted with R127 so that any signals within the center line of the difference antenna will be processed and those outside the ± 5 degrees will be inhibited. The signal DS INH will be high and will result in a display indicating "TURN". The operator must reposition the antenna until the "TURN" is no longer displayed.

3.4.6 Power, Frequency, & Sensitivity Measurement

The video signal from the sum and difference amplifiers (U53, 60) are stored in the sample-and-hold amplifiers and applied to the A/D converter on the digital board. The power measurement is provided by using a look up table in the processor.

The 60 MHz saturated signal out of the limiting amplifier (U55, 61, 63) is applied to the frequency discriminator U24 and to the DPSK demodulator (U20, 23, 21) through matching attenuators (20dB). The output of the frequency discriminator is compared in U26 whose output is either high or low depending on whether the signal out of the Log Amp is above or below 60MHz. The local oscillator will then be incremented in 0.1 MHz steps until the comparator changes state. At this point the offset of the local oscillator from nominal (1030, 1090 MHz) is the offset of the UUT transmitter and the frequency is calculated and displayed.

Sensitivity of the transponder under test is measured by increasing the RF power from minimum (U2, 3) until the percent response drops below 80%. The voltage provided by the D/A converter on the digital board is converted to power out by using a calibrated look-up table stored in the processor.

3.4.7 DPSK Demodulator

The DPSK demodulator receives a 60 MHz signal from the limiting amplifier. This signal is converted to 12 MHz by U20 and applied to discriminator U21 through delay line U23. The output of the phase discriminator compares the phase relationship of the direct signal and one that is delayed by 250 nsec. If the input changes phase, indicating a “1”, the comparator U22 will change state. The comparator U22 is enabled by DPSK PLS pulses from the digital board and its output is connected to the receiver FIFO on the digital board. The FIFO stores the information for evaluation by the processor.

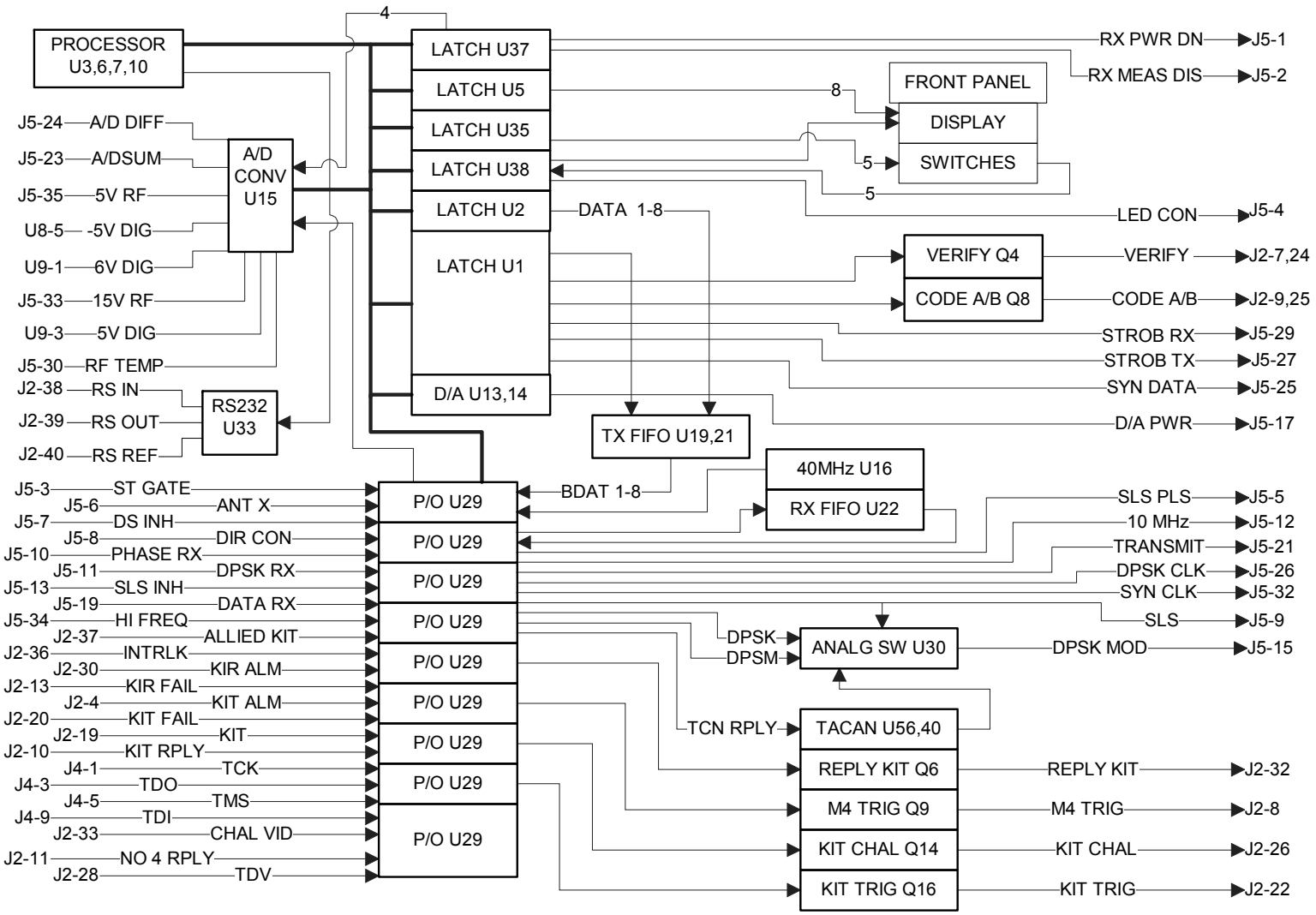
3.5 Digital PCB Assembly

The digital printed circuit board function diagram is shown in Figure 3-3.

3.5.1 Microprocessor Control Logic

The microprocessor U10 is an 8-bit CPU used to read and write instructions through hardware and firmware addressing. Special features of the 80C31 processor include extensive Boolean processing, 64 k byte programming memory address space, 64 k data memory address space, 32 bi-directional and individually addressable I/O lines, and two 16-bit timer/counters. A 12 MHz crystal clock, Y1, is used to synchronize the timing of the processing. Assembly language programming generates instructions, in the form of machine language to the processor, which are stored in U7. A high-speed 64K UV erasable and electrically reprogrammable CMOS EPROM, U7, is used for fast turn around and low power consumption. An 8 k RAM, U6, with battery backup is used to store accessible memory for the CPU interaction.

In order for the microprocessor to control the input/output signals, a 4-to-16 line decoder, with latch P/O U29, is utilized for memory address decoding and data routing applications. When the latch enable input, LE, is high, the outputs will change with the inputs. When LE goes low, the data on the select inputs are stored in the latches. The outputs of the decoder are used to select which register (U1, U2, U5, U35, U37, U38 or inside registers of U29) is selected. U1, U37, and U38 are used for various control functions, such as MODE 4 code select A or B, Mode-4 verification bit, strobes and data for the RF synthesizers and self-test functions.



Digital PCB Functional Diagram

Figure 3-3

3.5.2 Clock Frequencies & Range Counter

The 40 MHz crystal controlled clock controls all timing, except for CPU timing. 20MHz, 10 MHz and 4 MHz clock signals are produced from the 40 MHz clock by counters. The range counter is a pre-loadable 16 bit counter which is used in generating range delay in interrogator testing.

3.5.3 First-In/First-Out(FIFO)

Two FIFO's are used to transmit and receive data for all modes. The receive FIFO, U22, is used to receive the serial reply data from the UUT as well as self-test data. Once the data is received, it is unloaded by the CPU for analysis through one of the U29 registers.

The transmit FIFO, U19, is loaded by the CPU through U2 register. Once the transmit data is loaded in the FIFO, it is transmitted through U29 and under U29 control. The read rate of the FIFO sets the pulse shape and pulse spacing within the required tolerances. U30 transforms the transmitted data from digital form to levels suitable for RF modulation.

3.5.4 Operator Interface

Operation of the Test Set is achieved with a user friendly panel, with switches for ON/OFF and test mode controls and a heavy duty, large character, liquid crystal display. The display has two lines of characters, each with 20 symbols which are 0.5 inch high, an ON/OFF backlight control for night viewing, and can be read in direct sunlight from a distance of ten feet. The display viewing angles are +/- 30 degrees in both the up-down and left-right viewing directions. The information displayed includes the mode, the reply code, the UUT data, and Test Set status. To support UUT fault isolation, detailed test data from each step in the test sequence can also be displayed, at operator discretion. Refer to Section 2 for a complete description of the operating procedures and associated displays.

An optical sight permits the operator to aim at the desired UUT antenna. A LED, which is visible when viewing through the optical sight, is illuminated when test is in progress. The results of the test are displayed on the Test Set panel LCD display.

The Test Set can be handheld by the operator or supported by a neck strap. The antenna configuration allows the option of being handheld, mounted on the Test Set, or supported by a tripod using a fitting located at the unit's center of gravity.

3.5.5 Digital/Analog Converter

The digital to analog converter, U13 is loaded from the processor through the FIFO U13 and is used to control the transmitted RF power. The D/A converter are a 12 bit, 4096 levels, under processor control which will control the gain of two RF amplifiers. The gain can be controlled manually with a front panel control or automatically.

In the transponder automatic mode, the converter increases the RF output power until the transponder responds to more than 80% of the interrogations. At this time, the voltage level out of the converter is interpolated to the sensitivity of the UUT.

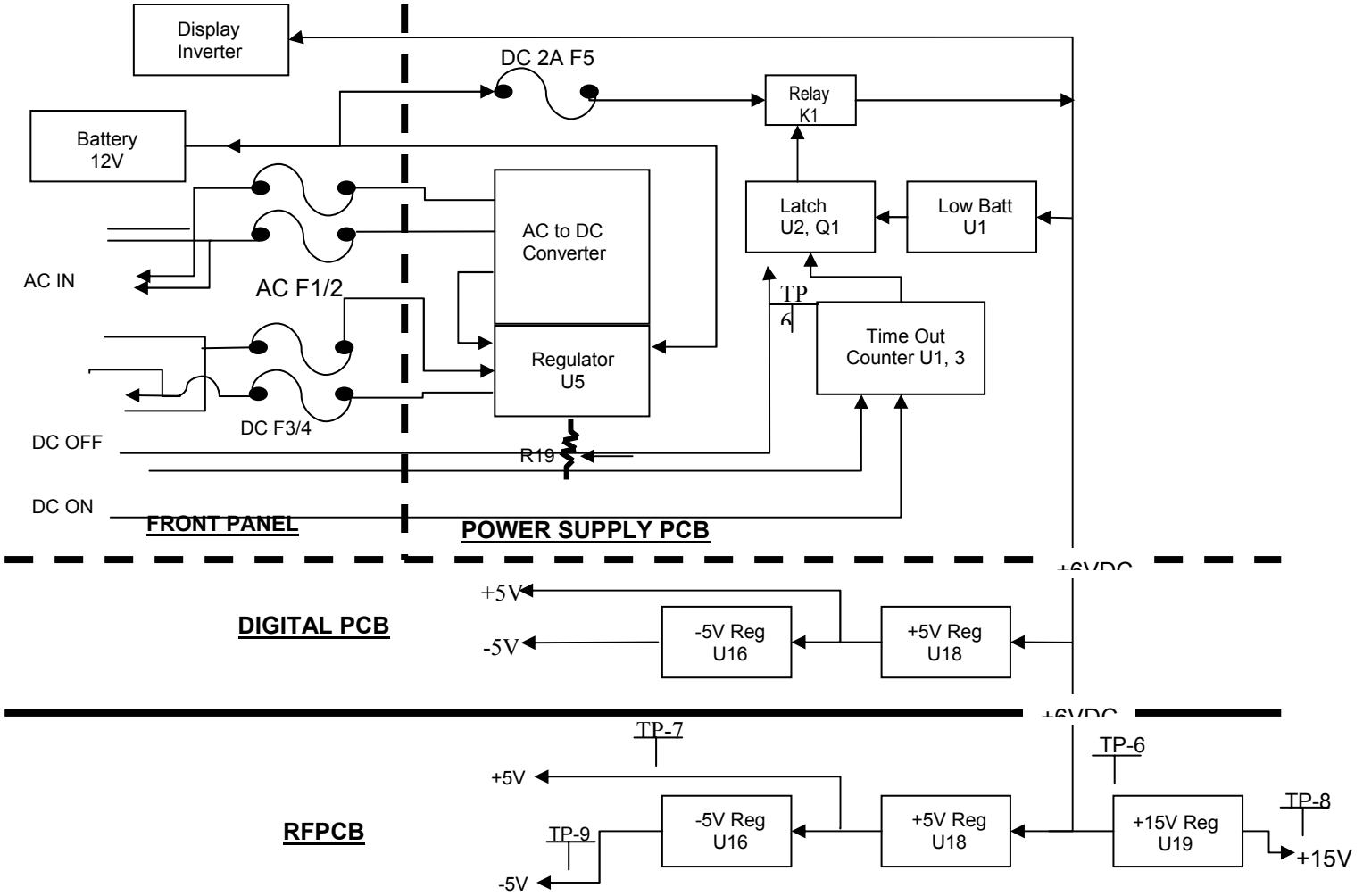
3.6 Power Supply PCB Assembly

3.6.1 Power Distribution

The power distribution is shown in the Power Distribution Function Diagram, Figure 3-4. The Test Set will operate from 115 - 230VAC, 50 to 400 Hz, from 28VDC, or from its own 6VDC internal battery. The Test Set has an internal battery charger, which operates from either the 28VDC or 115 - 230 VAC inputs. The Test Set can be operated and the battery charged at the same time. An input line filter is mounted to the input connector to filter out voltage spikes and RF interference.

When operating the Test Set on battery power, the battery voltage is monitored by the processor and a low voltage display is provided when the battery voltage reaches 5.8 volts. Under this condition, approximately 15 minutes of operating time are left. The Test Set will automatically turn OFF when the battery voltage is less than 5.4 volts to prevent deep discharge of the battery. The battery can be disconnected and replaced through the Test Set panel without erasing any stored codes or measured data.

The unit is capable of operating from the battery for 8 hours at a 20 percent duty cycle over the entire temperature range. At 25° C the unit will operate 8 hours at a 50 percent duty cycle.



Power Distribution

Figure 3-4

3.6.2 Power Functions

The power supply board, which will operate when energized by electrical systems, converts the AC or DC inputs to a nominal 6.5VDC which charges the battery and operates the system.

The battery voltage is provided to the Digital and RF PCBs. Two regulators, -5V (U8) and +5V (U9) and associated filters are located on the digital board provide DCV for the digital boards. Regulators U16, U18 and U19 on the RF board provide -5V, +5V and +15V respectively to the RF board circuits.

The power input is connected through the front panel: the AC ground is connected to the Test Set chassis and the four power lines, 2 AC and 2 DC, are switched with the PWR/CHG switch and fused with F1, 2, 3, and 4, located on the front panel. The AC supply and AC return are isolated from the Test Set by the transformer T1 that reduces the RMS voltage from 115VAC to 28 VAC. A series diode D9 in the 28VDC line protects the Test Set from reversing the 28VDC polarity and also removes the rectified voltage from the connected output pins.

3.6.3 Power Control

The Test Set control circuit consists of an OR Gate U2 connected as a latch turned on by momentarily turning the TEST switch to ON. An output high from the latch turns on Q1 that closes K1 providing 6 VDC to the Test Set. The Test Set is turned off in the following ways:

1) Momentarily turn the TEST SWITCH to the OFF position.

2) When the Test Set is battery operated and the battery drops below 5.4 volts, the TEST SET will turn off; the battery voltage is also monitored on the digital board, indicating to the operator when there is approximately 15 minutes of operating time remaining; it should be noted that the battery can be disconnected and replaced at any time without losing the stored code.

3) Shut down occurs after 15 minutes of non-use automatically; if the TEST switch is momentarily pressed to MANUAL or AUTO, the timer is reset; the timer is disabled whenever an external AC or DC source is connected to the Test Set.

3.6.4 Elapsed Time Indicator

The nonvolatile RAM on the digital board has a built-in real time clock supported by a battery with a 10 year life. Operating hours are retained in a non-volatile RAM and displayed when the Test Set is turned ON.

3.7 Case Assembly

The Test Set is housed in a case which is suitable for use in rugged environments. The case bottom contains the panel behind which are mounted the instrument SRA's. The case cover contains the accessories. The Test Set case bottom also contains the RF transmitter and receiver connected thru the RF PCB-mounted RF switching network and associated cables to

either the directional antenna or directly to the UUT. The direct connect UUT cable is 10 feet long, RG-223/U with TNC male connectors type M39012/26-001. All parts and attachments to the Test Set are safe from electro-static discharge.

3.8 Directional Antenna Assembly

The directional antenna is designed to be utilized in one of three test configurations:

1) Hand Held, for manual operator pointing at the target aircraft using the optical sighting device.

2) Tripod mounted, to be used as a remote antenna.

3) Mounted to the Test Set Case.

In all configurations, the remote antenna is connected to the Test Set by means of a pair of coax cables, sleeved together, one end of which are permanently fastened to the antenna structure with strain relief, and the other end connected to a pair of coax connectors on the Test Set panel. An extender cable is supplied for the hand held and tripod mounted configurations. Since the coax connectors can be interchanged, they are color coded. If they are interchanged a fault will be indicated on the display. The directional antenna is a micro strip rectangular probe-fed patch antenna generating a sum and difference pattern. The antenna assembly, without the detachable handle, is 5" x 10" x 2" and is enclosed in its own sealed radome. The optical sight has reticules at both ends for accurate pointing of the antenna boresight. The boresight scope also has a LED display indication of test activity to alert the operator of active test.

CHAPTER IV

GENERAL MAINTENANCE AND SERVICING INSTRUCTIONS

4.1 General

The use of the current generation of electronic components has dramatically decreased the cost of maintaining and calibrating test equipment. Tel has recommended an annual calibration and alignment interval and periodic checks to keep the TR-220 in operational condition. Performing preventative maintenance checks of the Test Set and Test Set verification checks if a failure is suspected will reduce down time by detecting and correcting potential problems at their onset. This chapter is broken down in three sections.

1. Routine Maintenance (Section A).
2. Test Set Verification and Acceptance Checks (Section B).
3. Annual Calibration and Alignment (Section C).

Routine Maintenance: By routinely cleaning and inspecting the TR-220 Test Set, the operator will be able to reduce down time due to unexpected failures. Routine Maintenance, as outlined in *Section A*, consists of checks and observations performed to maintain the Test Set in a serviceable and ready condition. They should be accomplished each time the Test Set is utilized and after extended storage.

Test Set Verification and Acceptance Checks: If the Test Set passes the Test Set Verification and Acceptance Check, a Calibration and Alignment is not necessary. This Test verifies all hardware related tests to ensure the Test Set is operating at manufacturers specifications.

If during normal operation a failure is suspected or unusual or erratic results are displayed, perform the procedures as listed in *Section B*. By conducting and verifying the Test Sets condition when abnormal results occur, the operator will be able to determine if the Test Set is malfunctioning or the UUT is at fault. Periodic checks will also alert the operator to possible problems and ensure the Test Set is in full operational condition before it is used.

If by completing the Test Set Verification and Acceptance Checks and the Test Set continues to exhibit unusual or erroneous information, the Test Set may require the Full Alignment as outlined in Section C.

Calibration and Alignment: A full Calibration and Alignment of the Test Set shall be performed under the following conditions:

1. Tel-Instrument Corporation recommends an Annual Test Set Verification Acceptance Check to determine if a Calibration or Alignment is necessary, and to ensure accurate test results and improved performance.

2. If any failure occurs or is suspected during *Routine* or *Test Set Verification Checks*, a full Calibration and Alignment shall be performed.

3. If any major assembly is replaced.

4. If during normal operation, the Test Set fails to meet any specification outlined in Chapter 1, Section B.

4.1.1 Safety Precautions

The following are general safety precautions that are not related to a particular test or procedure. These are recommended procedures that all personnel must apply during many phases of operation and maintenance. It is assumed that the operator has general knowledge of electrical theory and the dangers associated with it.

1. When performing any of the preceding tests thoroughly read and understand all procedures before actually performing them.

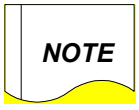
2. The various front panel connectors, switches, and controls specified can be located by referring to Figure 2-1 on page 2-3.

3. Take the time to learn the proper operation and function of the Test Set as outlined in Chapters 1, 2, and 3. Through knowledge of the Test Set and its capabilities greatly improves the time it takes to complete the tests.

4. Pay particular attention to **NOTES** and **WARNINGS** that may accompany some test procedures.

WARNINGS

Alerts the operator to potential dangers associated with a particular test. Thoroughly understand the warning before proceeding to prevent a potentially dangerous situation or damage to the Test Set.



NOTES

Provides supplemental information that enhances the test procedure.

5. Observe all standard safety procedures when working with live voltages. The potential for electric shock exists any time the Test Set is removed from its case.

6. DO-NOT service the unit or make adjustments alone. Always be in the presence of another person when working with live voltages.

7. Be familiar with general first aid procedures and CPR (Cardiopulmonary Resuscitation). Contact your local Red Cross for more information.

8. Ensure the test equipment and the tools you utilize are in good operational condition and not damaged in any way.

4.1.2 Preliminary Considerations

1. Test Equipment- Recommended test equipment is listed before each test. An equivalent type may be substituted in lieu of the listed equipment.

2. Environmental Considerations- Test and align the equipment in conditions similar to the conditions the Test Set will be utilized in.

3. Calibration Test Reports- Test reports are located in Appendix A & Appendix B. Make copies of the test reports before commencing alignment to properly log results.

4. The Test Set should be allowed to warm up for a period not to exceed 10 minutes before testing begins.

5. Always begin with a fully charged battery.

SECTION A

ROUTINE MAINTENANCE

4.2 General

By routinely cleaning and inspecting the TR-220 Test Set, the operator will be able to reduce down time due to unexpected failures. Routine Maintenance consists of checks and observations performed to maintain the Test Set in a serviceable and ready condition. They should be accomplished each time the Test Set is utilized and after extended storage.

Routine maintenance consists of the following:

1. Cleaning of the TR-220 Test Set exterior case.
2. Inspection of all connectors, cables and the Test Set assembly.
3. Inspection of the Hand Held Antenna and Connections.
4. Battery check and charging.

4.2.1 Cleaning Procedure

Keep the Test Set clean by removing any loose dirt, mildew or mild corrosion with a soft cloth moistened with warm water and a mild detergent. Do not spray any cleaning detergent or water directly on the Test Set. Ensure to dry off the Test Set with a Lint free cloth to remove all deposits and remaining cleaning solution. Strong cleaners and chemicals shall be avoided to prevent damage to the display, silk-screening, and switches.

4.2.2 Inspection of all Connectors, Cables, and Test Set Assembly

By inspecting the cables, connectors, and the Test Set periodically, potential inaccurate test results will be alleviated.

1. Check each cable for kinks, crushed insulation, frayed cables, and rusty connectors.
2. Check each antenna supplied with your Test Set for obvious signs of rust, dents and loose parts.
3. Inspect the Test Set case for signs of abuse. Large dents and cracked displays may render the Test Set inoperable.
4. Toggle and push each switch for proper operation. Sticking switches may result in erroneous test results.
5. Inspect for loose bolts, nuts, and screws; tighten if necessary.
6. Ensure all supplied antennas and cables are properly stowed when not in use.

4.2.3 Battery Check and Charging

Check the Lead Acid battery before each use to ensure a sufficient charge is available to complete the required tests. By charging the battery a few hours each week, you will keep the Lead Acid battery in a fully charged state ensuring a significant charge is available for extended testing. Follow the procedures in Paragraph 2.8 to fully charge the battery before calibrating the Test Set.

SECTION B

TEST SET VERIFICATION AND ACCEPTANCE CHECKS

4.3 General

These procedures will be performed on an Unopened Test Set, except where noted, by measuring inputs/outputs. If the Test Set results are not within tolerances, the Test Set will require a full Calibration and Alignment as outlined in *Section C*. The tests are broken down into individual sections to allow the operator to verify proper operation of individual functions when a discrepancy may arise or repair was accomplished.

4.3.1 Test Equipment Required

The following support equipment (or their equivalent) is necessary to perform the Test Set Verification and Acceptance Checks:

Name	Designation/Description
Oscilloscope	Infinium 54835A
Signal Generator	Hewlett Packard 8648B
Spectrum Analyzer	HP 8558B
Digital Voltmeter	Fluke 8000A
Oscilloscope	Hewlett Packard 54615B
Pulse Generator	Agilent 81101A
Crystal Detectors W/Load Resistor	Hewlett Packard P423B
Copy of Data Sheet (Appendix A)[1]	
Assorted Connectors and Adapters	
Assorted Cables with calibrated loss	

Support Equipment

Table 4-1

[1] To ensure accuracy and for simplicity, the Data Sheet is written and organized to reference each step by paragraph and step number. Make a photocopy, review and become familiar with the datasheet before beginning the tests.

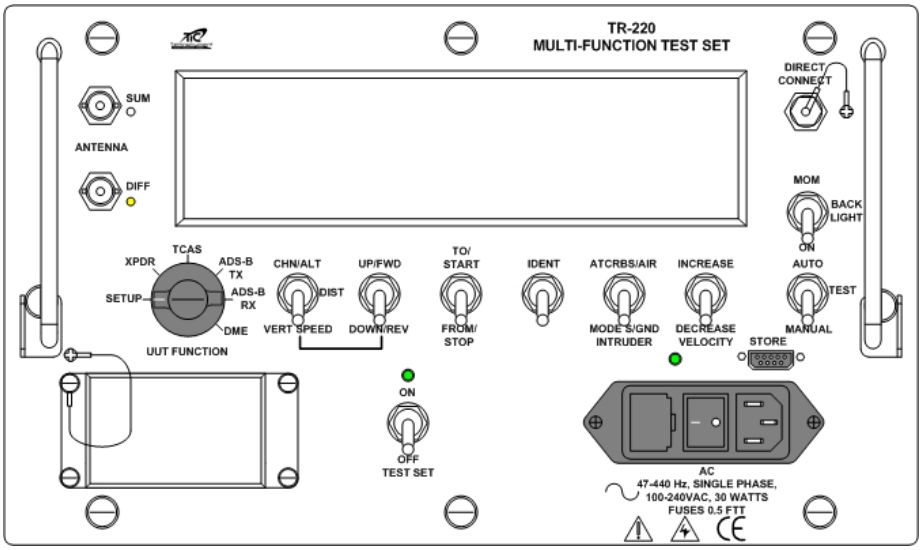
4.3.2 Test Set Initial Settings

Set the TR-220 front panel switches to the following positions before each test, unless otherwise instructed:

Function/Rotary Switch	Position
UUT FUNCTION	**XPDR**
CHNALT/DIST/VERT SPEED CODE/ALT – ATTEN	Centered
UP – DOWN/FWD – REV	Centered
TO/FROM – START/STOP	Centered
IDENT	Default
ATCRBS/AIR – MODE S GND	**ATCRBS/AIR**
INCREASE – DECREASE	Default
AUTO/TEST/MANUAL	Default
BACK LIGHT	Default
ON/OFF	**OFF**
Power Charge Rocker Switch	**OFF**
DIRECT CONNECT PORT	Termination Cap On
SUM – DIFF Connectors	Capped

Initial Settings

Table 4-2



Initial Settings

Figure 4-1

4.4 Display Operation, Self Test and Initial Start Verification

NOTE

Due to different Software revisions, displays and procedures may vary slightly.

NOTE

Pictured Test results in this procedure are for reference only. Due to numerous types of equivalent test equipment, your actual results may vary.

1. Connect the Test Set to an appropriate power source.
2. Turn the AC Rocker switch to the **ON** position and ensure that the green LED illuminates.
3. Turn the Test Set **ON/OFF** switch to the **ON** position and verify the green LED illuminates.
4. The TR-220 Self Test will initiate will be displayed **briefly**, verify the following:

Tel-Instrument TR-220 REV X.XX 00001 hrs	The Rev Level will display the current software installed. Hours will indicate the total hours the Test Set has been in operation.
Self Test Testing . . .	
Self Test PASS	
ANTENNA Connections Missing or reversed	The Test Set will Stop at this display.

5. The Test Set will indicate the current software version and total hours the Test Set has been "ON". Log this and the Self Test results on the Data Sheet.
6. Toggle the **BACKLIGHT** switch *down* and verify the backlighting remains illuminated.
7. Toggle the **BACKLIGHT** switch *Up* to the ***MOM*** position, hold momentarily, and release. Verify the backlighting illuminates briefly, and then extinguishes.
8. Turn the Test Set *"OFF"* by toggling the **ON/OFF** switch *down*. The Test Set will turn "*OFF".*

9. Disconnect the AC Power Cord and turn the Test Set back *"ON"* and ensure the Test Set turns "*OFF"* after approximately 15 minutes of inactivity (AC power not connected).

10. Remove the **DIRECT CONNECT** Termination Cap, Connect the Directional Antenna to the **SUM/DIFF** ports and turn the Test Set back "ON". Verify the following Display:

Direct Connection REMOVE ANTENNA

11. Remove the Directional Antenna and ensure that the Test set progresses to the following display:

TRANSPONDER test Press AUTO/MANUAL

12. Turn the Test Set "OFF".

4.4.1 Transponder, Transmitter/Frequency Verification Tests

These Tests will verify the Test Set RF output to ensure the Test Set is properly transmitting with the appropriate power at the correct frequency.

1. Set all Test Set Initial settings IAW Table 4-2.

2. Connect the Spectrum Analyzer to the Test Set **SUM** connector, ensure the **DIRECT CONNECT** termination Cap is installed.

NOTE

Any time that tests are conducted utilizing the **SUM and DIFF** ports and the Test Set is turned on, a message indicating "ANTENNA Connections Missing or reversed" may be displayed. To bypass this, simply short the center pin of the **DIFF** connector to advance.

3. Turn the Test Set *"ON"* with the **UUT FUNCTION** switch in the **SETUP** position. Locate the *ANT GAIN* menu by toggling the **AUTO/MANUAL** switch. Observe the Antenna gain menu and set the Antenna gain to **0 dB** for the 1030 and 1090 MHz positions. At the *CABLE LOSS* menu, set the cable loss also to **0 dB**.

   At the **T/S Distance Menu** page**,** set the distance for **25 ft** and select **AUTO**.

T/S Distance: 25 ft Chg:Up/Dn Cont: AUTO

Return the **UUT FUNCTION** switch to the **XPDR** position and turn the Test Set "*OFF".*

4. With the **FUNCTION SWITCH** in the **XPDR** position and turn the Test Set "ON" while holding *"Down"* the **TO/START – FROM/STOP** switches. This will disable the LED power and the display will briefly indicate this.

Antenna LED is OFF

5. Toggle the **AUTO/MANUAL** switch to **AUTO**. At the Transponder Test page, select the **MANUAL** Tests by toggling **AUTO/MANUAL** switch "Down" and continue to toggle down until reaching the *M A Menu* page.

TRANSPONDER test Press AUTO/MANUAL

M A No reply

Set the Spectrum Analyzer to the following positions:

Function	Setting
Frequency	1030 MHz
Span	0 MHz
Amplitude	0 dBm
Res BW	3 MHz
Video BW	3 MHz
Sweep	500 ms

Connect the **SUM** port to the Spectrum Analyzer. Measure the output power of the Test Set ensuring to add the cable loss from the **SUM** to the Spectrum Analyzer to the total. The output power shall be **7dBm / ± 2 dB**. *Note the actual reading on the Data sheet.*

6. Without turning Off the Test Set, disconnect the Spectrum Analyzer connector at the **SUM** port and connect it to the **DIFF** port.

Verify that the output power has reduced at least minimum of **20 dB** from that in step #5, remembering to take into account cable loss.

7. Select **SETUP** on the **UUT FUNCTION** switch and select the **T/S Distance Menu**: Set the distance to **35 feet**. Return the **UUT FUNCTION** switch to **XPDR** and return to the M A Test and ensure that the power is **9 db LOWER / ± 2 db** than what was measured at the **SUM** port Step 5.

8. Repeat the same procedure in Step 8, but set the *Distance Menu* to **75 feet**. Verify that the peak power off the **DIFF** port is **5 db LOWER / ± 2 db** than the **SUM** port measurement in Step 5.

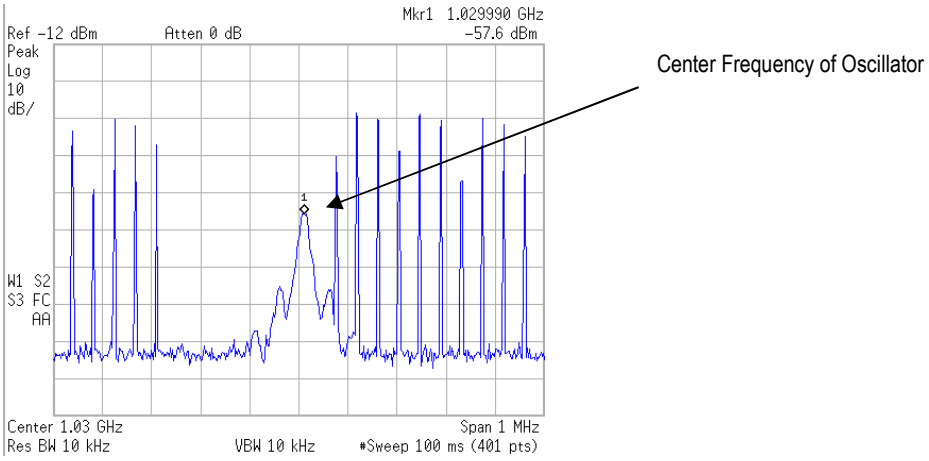
9. Remove the Spectrum Analyzer from the **DIFF** port and reattach it to the **SUM** port.

10. Turn the Test Set "OFF" and then back "ON" and return to the *MODE 3A Menu* Display.

11. Set the Spectrum Analyzer for the Following:

Function	Setting
Frequency	1030 MHz
Span	1 MHz
Amplitude	0 dBm
Res BW	10 kHz
Video BW	10 kHz
Sweep	100 ms

12. Measure the center frequency of the Spectrum Analyzer Display (Figure 4-2). Verify that the Center Frequency is **1030 MHz / ± 0.2 MHz**.



Transponder Output Frequency

Figure 4-2

13. Turn the Test Set *"OFF"* and disconnect test equipment.

4.4.2 TCAS Verification

These Tests will verify the Test Set TCAS modes are properly transmitting with the appropriate power at the correct frequency.

1. Set all Test Set Initial settings IAW Table 4-2.

2. Connect the Signal Generator output, to the Pulse "IN" connector on the rear of the Signal Generator. Set the Pulse Generator to the following:

   Adjust the Pulse Generator for 2 *Continuous Double Pulses* and the following (simulates a M3A Interrogation):

Function	Setting
Frequency	100 Hz
Dbl Delay	8.0 µs
Pulse Width	800 ns
Leading Edge Rise	5 ns
Amplitude	+4 V HI / + 0 V Low
Input Impedance	50Ω Out / 1 K In

   Adjust the Signal Generator to the following:

Function	Setting
Frequency	1030 MHz
Amplitude	0.00 dBm
Modulation	Pulse Modulated
Rear In	ON

3. Connect the output of the Pulse Generator directly to the **SUM** port of the Test Set. Place the Test Set **FUNCTION** switch in the **SETUP** position and turn the Test Set "*ON*".

4. At the Set Distance Menu, set the distance for 25 feet by toggling the **TO/FROM** switch. Toggle the **AUTO** switch UP when finished.

```
Set  Distance:        25 ft.
Chg:Up/Dn  Cont:  AUTO
```

5 Place the **FUNCTION** switch in **TCAS** and toggle the **AUTO/MANUAL** switch to **AUTO**.

```
Power              Frequency /
Listening . . .
```

Power	Frequency /
50 dBm	1030.0 MHz

Power	Frequency /
FAIL	

Results Shown are typical, your display may slightly vary. Output Power displayed is "don't care".

A *"FAIL"* display or incorrect frequency measurement is considered a fail.

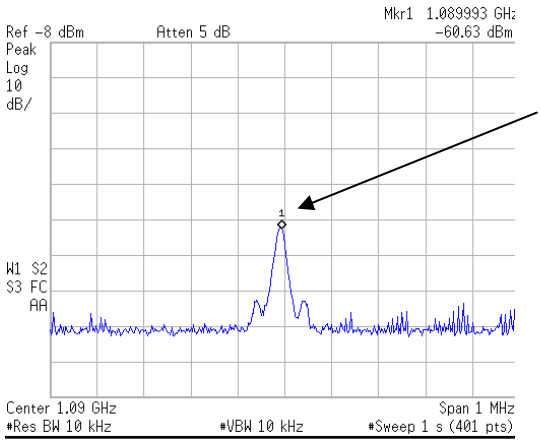
6. Vary the Frequency output of the Signal Generator in 0.1 MHz steps (1033.0 to 1027.0 MHz). Ensure that the displayed frequency follows ± 200 kHz at each step.

7. Set a Spectrum Analyzer for the Following:

Function	Setting
Frequency	1090 MHz
Span	1 MHz
Amplitude	-10 dBm (approx)
Res BW	10 kHz
Video BW	10 kHz
Sweep	1 sec

8. Disconnect the Signal generator from the **SUM** port. Connect a "T" connector to the **SUM** port and reconnect the Signal Generator, Connect the other output to the Spectrum Analyzer.

9. Measure the output frequency of the Test Set and ensure output is **1090 MHz ± 200 kHz** (See Figure 4-3). Turn the Test Set "OFF".



TCAS Output Frequency

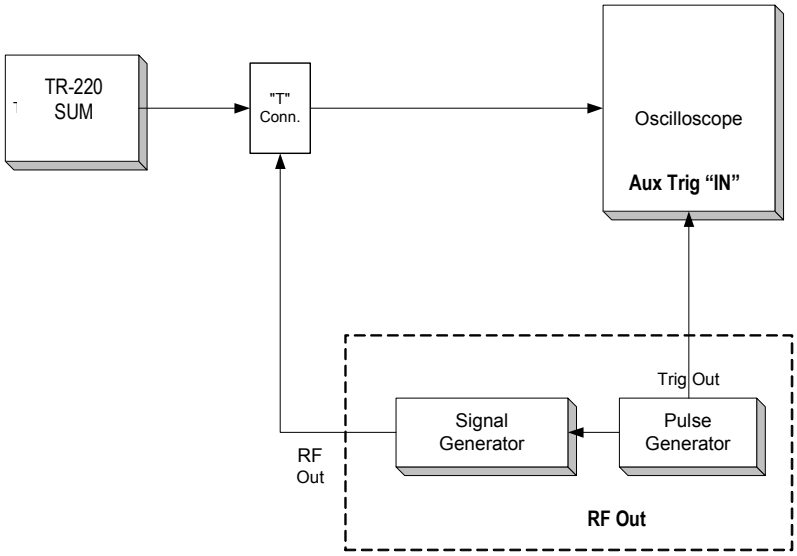
Figure 4-3

4.4.3 DME Verification

1. Set all Test Set Initial settings IAW Table 4-2 and connect the UUT to the Test Equipment IAW the following diagram.

NOTE

A crystal detector must be utilized at the input of the O'Scope to eliminate noise. If utilized, ensure that the LED function of the UUT is disabled before connecting the detector.



DME Test Se- up

Figure 4-4

Adjust the Pulse Generator for 2 *Continuous Double Pulses* and the following:

Function	Setting
Frequency	100 Hz
Delay	12 µs
Pulse Width	3.5 µs
Leading Edge Rise	5 ns
Amplitude	+4 V HI / + 0 V Low
Input Impedance	50Ω Out / 1 K In

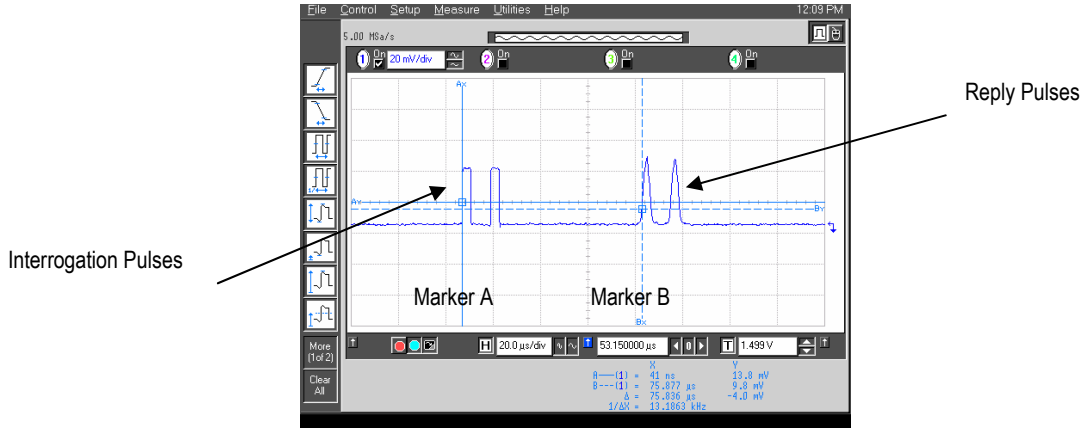
2. Connect the output of the Pulse Generator to the "*Pulse IN*" port of the Signal Generator. On the UUT, Select **DME** on the UUT using the **FUNCTION SWITCH** and turn the Test Set "*ON*" by holding the **TO/FROM** and **UP/DOWN** switches at the same time; this removes the LED power through the **SUM** port.

Select the Test Set Channel to108.00 MHz (17X) with a 2 nmi range. Set the Signal Gen. to 1041 MHz at 0 dB.

Adjust the O' Scope for the following:

Function	Setting
Horizontal	20µs
Vertical	50mV/Div
Trigger	Aux
Utilize the Auto Function for best results	

Observe on the scope the Interrogation Pulses and Reply Pulses (utilize the Averaging Mode if necessary).



DME Interrogation and Reply Pulses

Figure 4-5

Verify the following:

a. Each Interrogation Pulse is **3.5 µs / ± .5 µs** spaced **12.0 µs ± .5 µs**

.

b. Verify that the Test Set Reply Pulses spacing are **12 µs / ± .25 µs**.
c. Change the Test Set to **108.05** (17Y) and verify the spacing at **30 µs / ± .25 µs.**

Return the UUT to 108.00. Record the results on the data sheet.

3. DME Range Verification, utilizing the Infinium O' scope and markers. Place Marker "A" on the 50% rise of the first Interrogation Pulse. Place the Second Marker on the 50% rise of the first Reply pulse (See Figure 4-5). Measure the distance IAW with Table 4-3 changing the Test Set distance and frequency when needed:

	Range	DME 108.00		DME 108.05	Tolerance
		50 µs delay		**56 µs delay**	
a.	2	74.72 µsec	d.	80.72 µsec	± 6.18 µsec
b.	130	1656.66 µsec	e.	1662.66 µsec	± 6.18 µsec
c.	250	3140.00 µsec	f.	3146.00 µsec	± 6.18 µsec

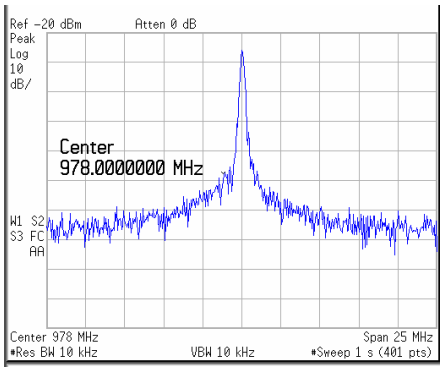
DME Range Verification

Table 4-3

4. DME Frequency verification is conducted by connecting the UUT **SUM** port to a Spectrum Analyzer. Turn on the UUT holding the **TO/FROM – START/STOP** and **UP/DOWN** Switches at the same time to disable the LED. Ensure Channel 108.00 MHz is selected. Set the Spectrum Analyzer to the following:

FUNCTION	SETTING
Frequency	978 MHz
Span	10 MHz
Amplitude	0 dBm
Res BW	10 kHz
Video	AUTO
Averaging	OFF
Sweep	1 sec

Verify a Center frequency of **<u>978 MHz / ± 0.5 MHz</u>** (Figure 4-6) and continue to test the frequency IAW Table 4-4.



DME Frequency

Figure 4-6

X Channels		Y Channels	
a.	108.00 MHz – 978 MHz	d.	108.05 MHz – 1104 MHz
b.	112.60 MHz – 1160 MHz	e.	112.65 MHz – 1034 MHz
c.	117.50 MHz – 1209 MHz	f.	117.55 MHz – 1083 MHz

DME Frequency Verification

Table 4-4

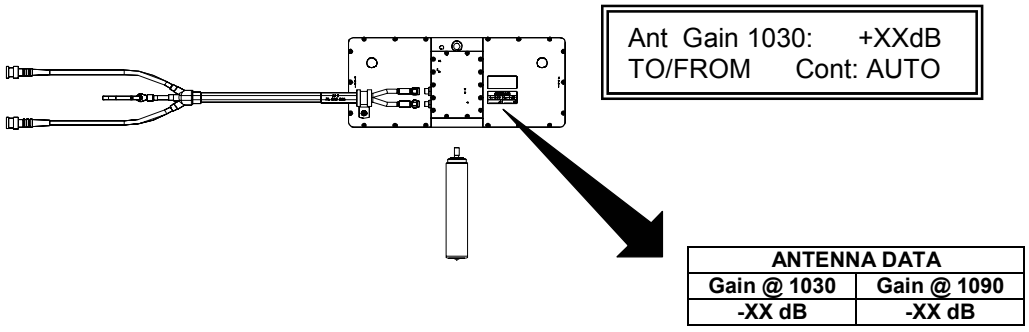
Log on the Data Sheet DME Frequency Test results.

4.4.4 Final Checks

1. Place the Test Set Function Switch in the **SETUP** position.

2. Turn the Test Set *"ON"*. Locate the *ANT GAIN* menu by toggling the **AUTO/MANUAL** switch.

3. Locate the Hand-Held Antenna located in the Test Set cover. Find the Antenna Gains Label located on the back of the Antenna (Figure 4-7).



Directional Antenna Gain

Figure 4-7

4. Enter the correct gains for the appropriate frequencies as listed on the back of the antenna.

5. Turn the Test Set "OFF".

SECTION C

CALIBRATION AND ALIGNMENT

4.5 General and Frequency of Calibration

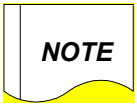
A full Calibration and Alignment of the Test Set shall be performed under the following conditions:

1. Tel-Instrument Corporation recommends an Annual Test Set Verification Acceptance Check to determine if a Calibration or Alignment is necessary, and to ensure accurate test results and improved performance.

2. If any failure occurs or is suspected during *Routine* or *Test Set Verification Acceptance Checks*, a full Calibration and Alignment shall be performed.

3. If any major assembly is replaced.

4. If during normal operation, the Test Set fails to meet any specification outlined in Chapter 1, Section B.



At any time during the Annual Calibration, the Test Fails to meet the correct specification and alignment of the Test Set fails to bring the unit within tolerance. The Test Set will require repair at the factory level. Contact Tel-Instrument Electronics Corp. for further guidance.

These procedures will be performed on an opened box to allow access to test points and alignment controls to align the Test Set to manufacturer's specifications. If these adjustments fail to return the Test Set to the specified parameters, the unit may require repair and additional maintenance. By utilizing the following procedures and referring to the schematics (Chapter VI), a qualified technician should be able to troubleshoot the problem. **Do not make adjustments for results that meet the specification**.

WARNING
Any time you are working with exposed wiring, the potential for electrical shock increases. Ensure all standard electrical safety procedures are strictly enforced to prevent injury.

Utilize APPENDIX B to log all data where indicated. The Appendix is conveniently labeled by Test and paragraph number to ensure that pertinent data is tracked and logged.

Utilize Figure 4-14 at the end of the Chapter for Locations of Test and Adjustment Points.

4.6 Test Equipment Required and Test Set Initial Settings

The following support equipment (or their equivalent) is necessary to perform the *Calibration and Alignment* of the TR-220Test Set.

Name	Designation/Description
Oscilloscope	Infinium 54835A
Signal Generator	Hewlett Packard 8648B
Spectrum Analyzer	Agilent E4401B
Digital Voltmeter	Fluke 8000A
Pulse Generator	Agilent 81101A
Crystal Detectors W/Load Resistor	Hewlett Packard P423B
RF Splitter	Mini-Circuits ZFSC-2-5
0-30 dB Attenuator (1 dB steps)	JFW, 50DR-010
0 – 1 dB (.1 dB steps)	JFW, 50R-249
Standard Digital Multimeter	
DC Power Supply	0 – 28 VDC
Copy of Data Sheet (Appendix B)[2]	
Assorted Connectors and Adapters	
Assorted Cables with calibrated loss	

Test Set Annual Calibration Equipment List

Table 4-5

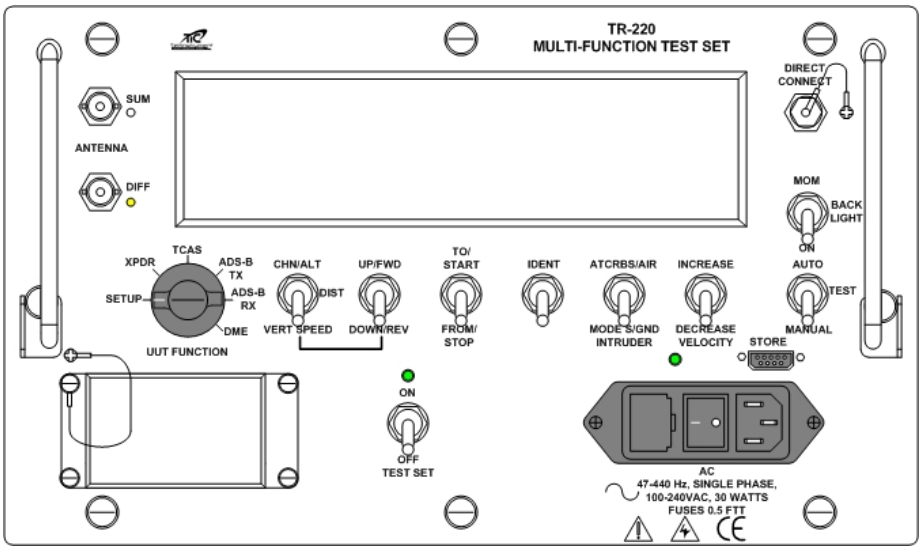
Set the TR-220 front panel switches to the following positions before each test, unless otherwise instructed:

Function/Rotary Switch	Position
UUT FUNCTION	**XPDR**
CHNALT/DIST/VERT SPEED CODE/ALT – ATTEN	Centered
UP – DOWN/FWD – REV	Centered
TO/FROM – START/STOP	Centered
IDENT	Default
ATCRBS/AIR – MODE S GND	**ATCRBS/AIR**
INCREASE – DECREASE	Default
AUTO/TEST/MANUAL	Default
BACK LIGHT	Default
ON/OFF	**OFF**
Power Charge Rocker Switch	**OFF**
DIRECT CONNECT PORT	Termination Cap On
SUM – DIFF Connectors	Capped

Initial Settings

Table 4-6

[2] To ensure accuracy and for simplicity, the Data Sheet is written and organized to reference each step by paragraph and step number. Make a photocopy, review and become familiar with the datasheet before beginning the tests.



Initial Settings

Figure 4-8

WARNING
Any time you are working with exposed wiring, the potential for electrical shock increases. Ensure all standard electrical safety procedures are strictly enforced to prevent possible injury.

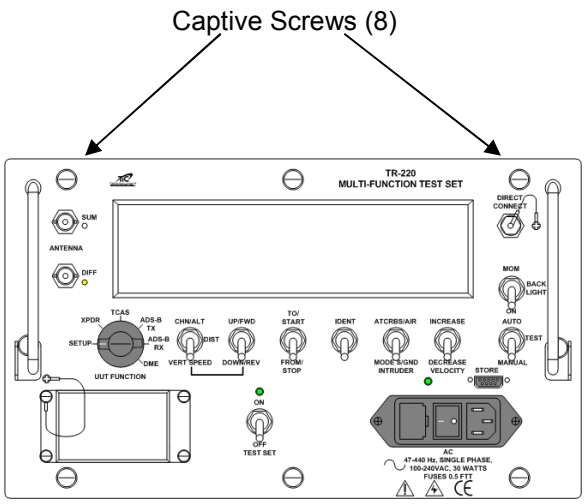
4.7 Disassembly of the Test Set and Procedures

The TR-220 Test Set was designed for ease of maintenance and access. Disassembly of the Test Set requires only the use of simple hand tools. Ensure that the tools that are utilized are in good working condition.

Electrostatic discharge may also pose a concern. When ever opening the Test Set, be sure to follow standard grounding principles. When ever a potential exists for static electricity to build, damage to the Test Set and the internal electronic components may result.

1. Remove the Test Set from the Case by loosening the eight (8) lock bolts located on the front panel of the Test Set (Figure 4-9). Do not remove the bolts as they are a captive type. Only loosen them enough to release their grip on the anchor nuts.

2. Grasp the Test Set Handles and slowly remove the Test Set assembly from the case. Ensure that you do not use force to pull the Test Set from the case; you may have to slightly angle the Test Set to allow for free movement of the assembly and attached hardware and cables.



Captive Screw Location

Figure 4-9

3. Access to the individual circuit boards is accomplished by removing the attaching hardware and covers. Ensure that all attaching cables and connectors remain attached and undue stress is not put on them.

4. Reassembly of the Test Set is accomplished by reversing the order of disassembly. Ensure that all of the connectors, cables and mounting hardware is tight and secure.

4.8 Calibration & Alignment

NOTE

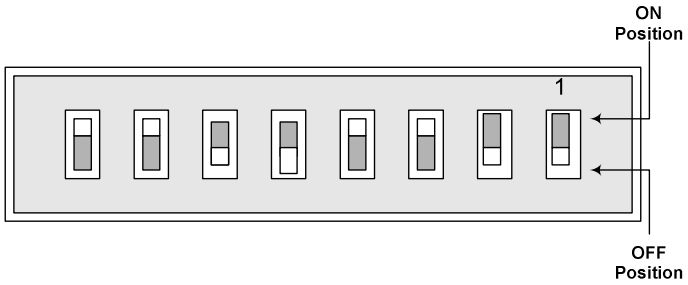
Due to different Software revisions, displays and procedures may vary slightly.

NOTE

Pictured Test results in this procedure are for reference only. Due to numerous types of test equipment, your actual results may differ slightly.

4.8.1 Sub-Assembly Adjustments

1. Gain Access to the TR-220 Digital PCB, locate U17 (Figure 4-10) and set position 1, 2, 5, 6 on the Dip Switch to “ON” and remaining switches to “OFF”. Ensure the **FUNCTION** switch is in the **XPDR** position and turn the Test Set “*ON*” while holding the **MANUAL** switch in the “*DOWN*” position, then release.



U-17

Figure 4-10

Record the **Installed CPLD Version** as shown on the display. Toggle the **TO** switch to advance to normal operation and turn the Test Set *"OFF"*.

2. Turn the Test Set *"ON"* while holding the **MANUAL** switch *"Down"*, place the **FUNCTION** switch in the **SETUP** position and observe the following:

NOTE

IF desired, the operator may ZERO the RAM. This would only be necessary if any major assembly has been replaced, or significant failure was detected during the Acceptance and Verification Checks.

Initialize RAM
INIT: Press Manual

3. Place the **FUNCTION** switch in **DME** to advance to the Clock reset page (user preference but typically completed when an update to software is installed at the factory.

Initialize RTC
INIT: MAN'L SKIP:AUTO

4. Turn the Test Set *"OFF"* and *"ON"* and place the **FUNCTION** switch to **SETUP**, and by using the on screen prompts change the setup values according to the following Table 4-7 (Following page). (Utilize the **UP/DOWN** and **TO/FROM** switches to make changes).

Turn the Test Set *"OFF"* when complete (Settings will be saved automatically).

PARAMETER	VALUE
TCAS Scenario	1
Start Alt	2500’
Velocity	250 nmi/h
Vert Speed	+000 fpm
TCAS dist	5 nmi
Mode S Address	A00001
Antenna	Hand-Held
Ant Gain 1030	0 dB
Ant Gain 1090	0 dB
T/S Distance	25 ft
Cable Loss	3.0 dB
Power in	dBm
Latitude: Longitude:	40 51 N 74 6 W

Initial Setup

Table 4-7

5. Place the **FUNCTION** switch in **XPDR**, remove the *Termination Cap* from the **DIRECT CONNECT** port, and turn the Test Set *“ON”*.

Tel-Instrument	TR-220
REV X.XX	00001 hrs

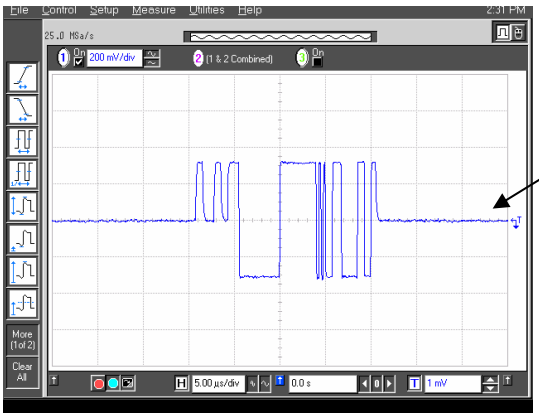
Self Test
Testing . . .

6. Log and Record the Test Set SW Version, then Turn the Test Set “OFF”.

7. Remove the Digital/RF boards from the Chassis to gain access to the attenuator. Disconnect the **ATT** connector located on the Attenuator Assembly. Connect an Oscilloscope directly to **TP-17**.

8. Turn the Test Set *“ON”* while holding the **MANUAL** switch *“Down”.* After the **CPLD** revision Screen is displayed, Toggle the **UP/FWD – DOWN/REV** switch *“Up”* and Observe the “*DPSK Test”* display.

9. Set your O’Scope to observe the following Display (Figure 4-11, following page) and ensure that the Base Line Voltage is set at **0 VDC / ± 2mv**.



DPSK Ripple Check

Figure 4-11

10. Adjust **R1** *ONLY IF NECESSARY*. Record the results and remove the O' Scope.

11. Turn the Test Set "*OFF*". Connect a Spectrum Analyzer directly to the same **ATT** port. Turn the Test Set back *"ON"* in the **XPDR** mode and access the Manual Sequence of transponder tests and advance to the **M A** test by toggling the **AUTO/MANUAL** switch "*Down*".

M A
No Reply

All information Shown is "Don't Care".

12. Set the Spectrum analyzer to the following initial settings and measure the output power at the **ATT** port (ensure to take in account any cable loss).

Function	Setting
Frequency	1030 MHz
Span	0 MHz
Amplitude	Approx 8 db
Res & Video BW	5 MHz
Sweep	1 sec
Scale per Div	1 dB

Verify **8 dbm / ± 0.2 dBm**. Adjust **R-125** on the RF board only if necessary. Turn the Test Set *"OFF"*, connect the **DIRECT CONNECT** termination cap and place a shorting plug on the Test Set **DIFF** connector.

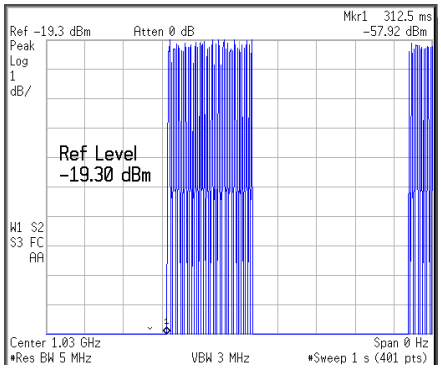
13. Disconnect the spectrum analyzer and connect it directly to the **SUM** port. Turn the Test Set back *"ON"* while holding the **FROM** switch *"Down"*. This disables the Antenna LED power.

Antenna LED is OFF

Advance once again to the *M A M*anual test by toggling the **AUTO/MANUAL** switch to **MANUAL**. Measure the power at the **SUM** port and ensure **7 dBm / ± 1 dBm**. Log this on the Data Sheet.

14. Move the Spectrum Analyzer to the **DIFF** port and terminate the **SUM** port. Turn the Test Set *"OFF"* and then back *"ON"*, at the *"Set Distance Menu"* page, set the distance for 25 feet, return to **XPDR** and advance to the *M A* test using the **MANUAL** switch.

    Verify that the Output Power at the **DIFF** port is **20 dB less** than at the **SUM** connector (See Figure 4-12) (Measured value in Step 13).



DIFF Power Measurements

Figure 4-12

15. Without turning the Test Set "*OFF"*, turn the **FUNCTION** switch to **SETUP***;* locate the **SET DISTANCE** menu and change the Distance from *25 ft* to *35 ft*. Return the **FUNCTION** switch to **XPDR** and advance back to the *Manual MA* test.

16. Verify that the output power at the **DIFF** port is now only **9 dB / ± 2 dB LOWER** than at the **SUM** port (Measured value in Step 13).

17. Without turning the Test Set "*OFF"*, turn the **FUNCTION** switch to **SETUP***;* locate the **SET DISTANCE** menu and change the Distance from 3*5 ft* to *75 ft*. Return the **FUNCTION** switch to **XPDR** and advance back to the *Manual MA* test.

18. Verify that the output power at the **DIFF** port is now only **5 dB / ± 2 dB LOWER** than at the **SUM** connector (Measured value in Step 13).

19. Turn the Test Set *"OFF"*, remove the load from the **DIRECT CONNECT** port and reconnect the spectrum analyzer to the **ATT** port.

20. Remove the cable from the **DIFF** port and turn the Test Set "*OFF*".

4.8.2 DAC Table (Transmit)

1. Remove the Termination Load from the **DIRECT CONNECT** port. Connect a Spectrum Analyzer to the **ATT** cable which is disconnected from the attenuator. Place the **FUNCTION** switch in the **TCAS** position and turn the Test Set back "*ON*" by holding the **MANUAL** switch down at the same time to enter the "*Calibrate TX POWER*" menu (the LED Power will automatically be removed).

TEST FUNCTIONS Calibrate TX POWER

NOTE

If the operator zeroized the RAM as in Paragraph 4.8.1, Step 2; the following display **MAY** be shown when ever turning the Test Set "ON" without entering a calibration mode. Advance to the next step by toggling the **AUTO** switch.

Self Test DAC table Xsum FAIL

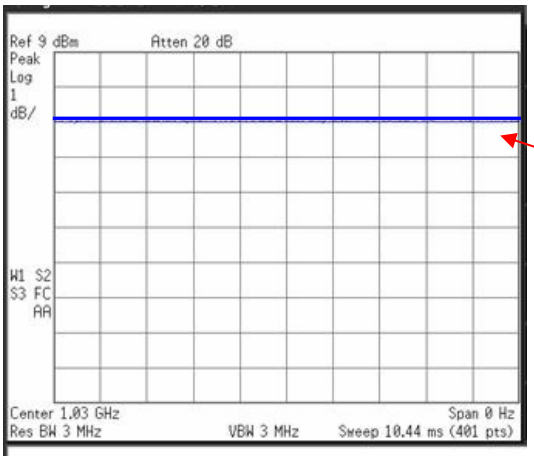
2. Toggle the **AUTO** switch and observe the following:

POWER CALIBRATION: -00 dB DAC=0000h

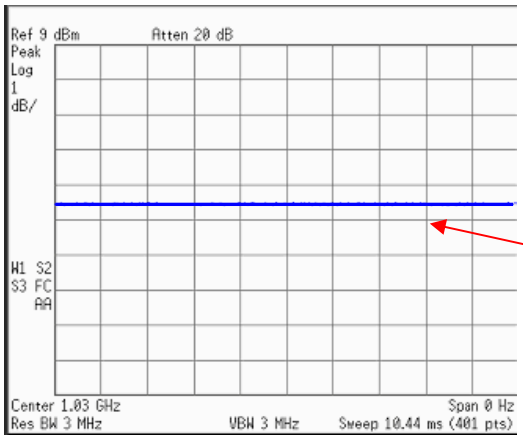
3. Set the Spectrum Analyzer to the following initial settings:

Function	Setting
Frequency	1030 MHz
Span	0 MHz
Amplitude	Approx 10 db
Res & Video BW	3 MHz
Sweep	50 ms
Scale per Div	1 dB

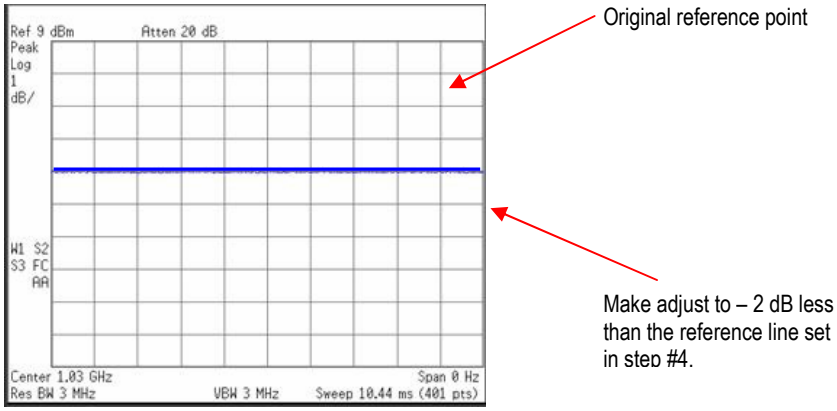
4. Observe a straight line power measurement. Adjust the Spectrum Analyzer so the measured pulse is even on any line. This will be the same reference line used for each measurement which ensures linear adjustments are made to the DAC table. The initial ***0 dB DAC setting of 0000h*** shall not be adjusted. After each adjustment, reposition the signal back to this same line before making another adjustment.



5. Toggle the **UP/DOWN** switch "*Down*". This will change the -00 dB display by -02 dB. The Spectrum Analyzer display will decrease by approx. -02 dB.



6. Utilize the **TO/FROM** to adjust the level in 1 dB steps and the **IDENT/EMERG** for 16 dB steps to place the spectrum Analyzer measurement -2 dB from the original reference. Test Sets Containing Software Version 3.43 or greater adjust the levels by utilizing the **TO/FROM** switch and the **CHN/ALT – DIST – VERT SPEED** switch to select 4 or 1 bit steps.



7. Readjust the Spectrum Analyzer to set the measured pulse back on the reference line as set up in Step #4. Toggle the **UP/DOWN** switch "*Down*" to advance to the next step (-04 dB). Continue to adjust the measurements in **– 2 dB steps to -48 dB**. Once complete, toggle the **AUTO** switch to save the DAC table to the Test Set RAM. Turn the Test Set "*OFF*".

During this Process, if you do not save by toggling the **AUTO** switch the data will not be saved and the DAC tables will have to be reset from the beginning.

Record on the data sheet each 2 dB step.

4.8.3 RX Gain Calibration

When In Diagnostic Mode, each time the Test Set is turned "*OFF*", then back "*ON*", the Test set may begin at the **INITIALIZE RAM** menu. Ensure you bypass this by toggling **AUTO**, or the DAC table will have to be reset.

1. Modulate a Signal Generator utilizing the Pulse Generator triggered by TP3 of the RF Board ensuring **0 dBm** at the output of the Signal Generator.

Function	Setting
Triggered Burst of 2 Single pulses	
Period	20.3 µs
Delay	12 µs
Pulse Width	450.0 ns
Leading Edge Rise	5 ns
Trailing Edge Rise	Lead E.
Amplitude	+4 V HI / + 0 V Low
Input Impedance	50Ω at 1 K In
Triggered by	Rising edge of ext In
Trigger Level	2.0 V / 10 k Ω

Set the Signal Generator to the Following:

Function	Setting
Frequency	1090 MHz
Modulation	Pulse Modulation
Input	Rear In
Output	0 dBm (measured at the cable end)

2. Disconnect the Spectrum Analyzer, and connect the Signal Generator to the **ATT** connector. Turn the Test Set back "*ON*" while holding the **IDENT** switch *"UP"*.

NOTE

Holding the **IDENT** switch "*UP"* when turning the Test Set "*ON"*, enables a 4 millisecond or 200 µsec (software dependent) receive window that ensures that the Test Set will *Hear* the simulated replies.

Advance to the Manual *M A* test by toggling the **MANUAL** switch down. Verify a *100% Reply* is observed on the Display.

```
M A
0000        100%        FAIL
```

SLS, FAIL, Ident, and EMERG may be seen, but have no effect and are *"Don't Care"* during the calibration. Display may differ dependent on Software installed.

3. Set the **FUNCTION** switch to the **ADS-B TX** position and turn the Test Set "*OFF"* then "*ON*" while holding the **MANUAL** switch "*Down*".

TEST FUNCTION:

Release the **MANUAL** switch to enter the "*Calibrate Receiver Gain Menu*".

Calibrate RX GAIN SUM: XXX DIFF: YYY

4. Adjust **R-143** (RF Board) until the Display indicates **210 / ±1.**

Calibrate RX GAIN SUM: 210 DIFF: YYY

5. Reduce the Signal Generator output by -25 dB. Adjust **R-140** (RF Board) until the Test Set indicates **145 / ±1.**

Calibrate RX GAIN SUM: 145 DIFF: XXX

6. Return the Signal Generator output to **0 dBm** level set in step #4, and verify that the display still measures **210 / ±1**.

   Repeat this procedure until both measurements can be obtained without adjustment.

7. Increase the Signal Generator 5 dB and verify that the display indicates **222 / ± 2**.

8. Turn the Test Set "*OFF*", select **XPDR** using the **FUNCTION** switch, then turn the Test Set back "*ON*" while holding the **IDENT** switch *"UP"*. Ensure 0 dB at the output of the signal generator Advance to the "POWER and FREQUENCY" Test in the MANUAL Mode of tests.

Power	Frequency
58 dB	1090.0 MHz

Ensure 58 dB is displayed ± 1 dB. All others "*Don't Care"*.

9. Set the Signal Generator Output to 0 dB, Test Set Display will indicate **53 dB ± 2.**

Power	Frequency
53 dB	1090.0 MHz

10. Vary the Output from +10 dBm to -20 dBm, and verify the display tracks accordingly **±1 dB** at each 1 dB step. Turn the Test Set "*OFF*" and disconnect the test equipment.

11. Reconnect the **ATT** connector back to the attenuator, connect a Spectrum Analyzer (set to the following initial settings) to the **DIRECT CONNECT** Port, turn the Test Set *"ON"* and advance to the *Manual M A* transponder test.

Function	Setting
Frequency	1030 MHz
Span	0 MHz
Amplitude	-40 dBm
Res BW	5 MHz
Video BW	3 MHz
Sweep	500 ms

12. Measure **- 42 dBm / ± 1 dB** (1030 MHz) taking into account any cable loss. Disconnect the Spectrum Analyzer.

13. Reconnect the Termination Load, back on to the **DIRECT CONNECT** port. Restart the Test Set while holding *"UP"* the **IDENT** switch. Advance to the *M A Manual* Transponder test.

14. Ensure that the Pulse Generator is still synchronized by the same procedures as outlined in Step #1. Connect the RF Splitter to the output of the Signal Generator. Set the Generator for 1090 MHz and amplitude at 0.0 ± 0.2 dBm as measured from both ends of the splitter one at a time using a Spectrum Analyzer.

NOTE

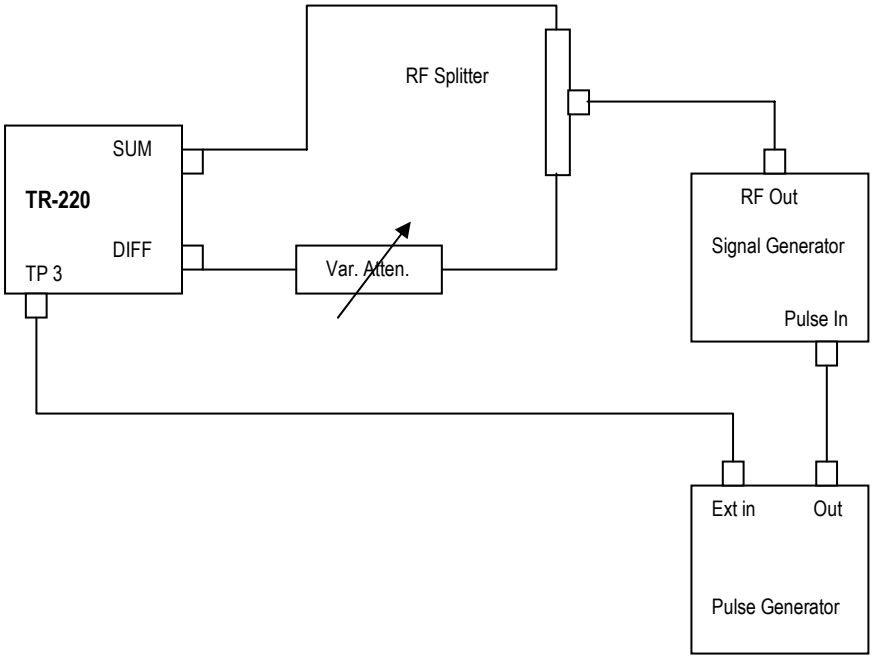
When measuring the two outputs of the splitter, it is necessary to terminate the end not being set with a 50 Ω load. The **SUM** or **DIFF** port may be utilized as the load. Setting the output at the end of the cable to 0 dBm must be done.

Turn "OFF" the Test Set, and connect *ONE* of the RF Splitter outputs to the **SUM** connector (See Figure 4-13, following page). This test is conducted without the Variable Attenuator.

15. Place the Test Set **FUNCTION** switch in the **XPDR** position, and turn *"ON"* the Test Set while holding *"UP"* the **IDENT** switch, then release. Continue to the Manual MA Test and observe a **100% reply**.

M A		
0000	100%	FAIL

SLS, FAIL, Ident, and EMERG may be seen, but have no effect and are *"Don't Care"* during the calibration. Display may differ dependent on Software installed.



SUM/DIFF Set-up

Figure 4-13

Turn the Test Set *"OFF"*, place the **FUNCTION** switch in **ADS-B TX;** connect the remanding Splitter output to the **DIFF** connector, and restart the Test Set while holding *"DOWN"* the **MANUAL** switch. Release the switch and observe the *"Calibrate RX Gain"* menu.

Calibrate RX GAIN			
SUM:	XXX	DIFF:	XXX

16. Adjust the Signal Generator output until the **SUM: XXX** is **202 / ± 2**. Adjust **R-124** (RF Board) until the **DIFF: YYY** on the Display indicates **240 / ± 2**.

17. Reduce the Signal Generator output by -25 dB. Verify that the **SUM: XXX** is **138 / ±2** and the **DIFF: XXX** is **175 / ± 2**. Adjust **R-121** (RF Board) if necessary.

18. Return the Signal Generator Output back + 25 dB and verify the **DIFF** and **SUM** readings are the same as measured in S**tep # 16, ±2**. If not, continue to adjust the measurements until no adjustment is necessary when toggling back and forth by 25 dB increments.

19. Turn the Test Set *"OFF"*, place the **FUNCTION** switch in the **XPDR** position. Turn the Test Set back *"ON"* while holding the **IDENT** switch *"UP"*. At the "*Set Distance Menu*", (Select **SETUP**, and return to **XPDR)**) select **35 ft**. Advance to the *Manual M A XPDR* test.

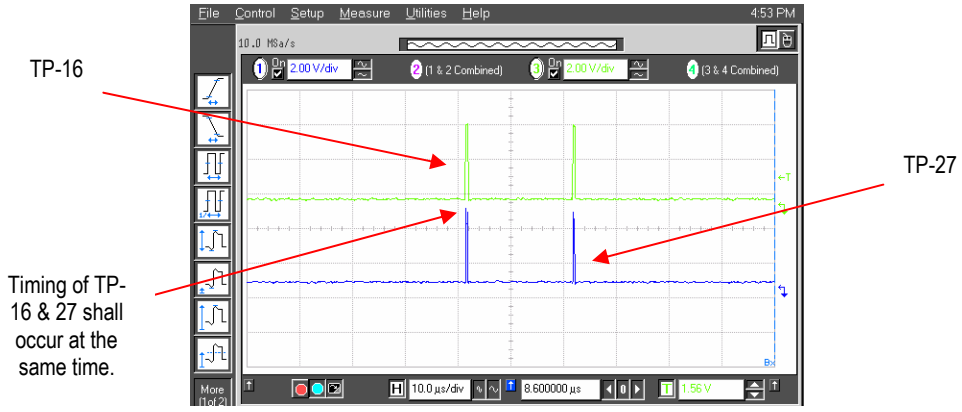
Set Distance: 35 ft. TO/FROM Cont: AUTO

20. Disconnect the **DIFF** connector and connect the variable attenuator (see Figure 4-13) between the RF Splitter and the **DIFF** Port. Verify that the output of the Signal Generator is set at -15 dBm / ± .2 dBm at the connection for the **SUM** port.

21. Adjust the variable Attenuator to provide a signal that is **10 dB / ± .2 dBm** less at the Diff port connector than at the **SUM** port connector.

22. Connect one oscilloscope probe and monitor **TP-16**. Connect another probe to **TP-27** and ensure that the signal at **TP-27** occurs at the same time as **TP-16** (Figure 4-14). If not there is possible interference from other equipment and the test may not be accurate.

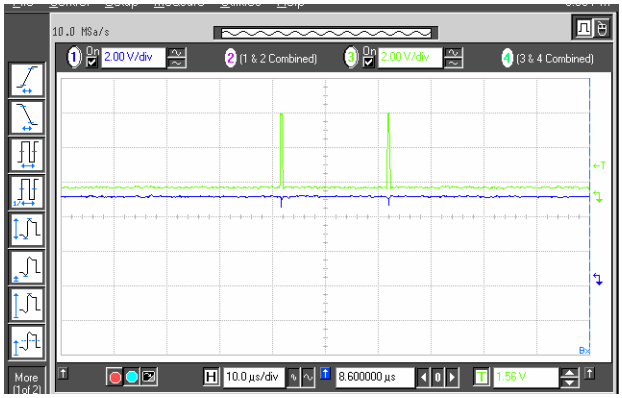
The Test Set Display should indicate **100% Reply**.



=TURN= Setup

Figure 4-14

23. Using **R-127** (RF Board), find the position where the **100% Reply** shown on the Test Set display changes to **=TURN=**. At **TP-27**, verify that the High/Low signal Changes State (Figure 4-15). This is a fine adjustment and care should be made to adjust this just to the point that the State of TP-27 changes.



M A =TURN= No Reply

Decrease the Variable Attenuator by 1 db, Verify that the pulses change state and the **=TURN=** display remains ON.

24. Increase the variable Attenuator by 2 dB, Verify that the =TURN= indicator message is OFF and that the signal at **TP-27 Changes State**. The Display will indicate 100% reply.

M A SLS 0000 100% FAIL

SLS, FAIL, and EMERG may be seen, but have no effect on the calibration.

25. Toggle the **SLEW UP/DOWN** switch **UP** to return to the *"Set Distance Menu"*. Change the distance to **25 ft.** and toggle the **AUTO** switch to return to the previous display. Verify that the **=TURN=** display now occurs at **6 / + 1 dB less** than at the level as seen in Step #24 by varying the attenuator ± 2 dB.

26. Turn "*OFF*" the Test Set, disconnect AC Power, and at DIP Switch U17, return all positions to **OFF** with the exception of Dip **Position #2;** which will remain **ON**.

Reassemble the RF and Digital boards back to the Test Set Chassis, leaving the Digital Board Cover OFF.

4.8.4 Power Supply Test

1. Remove the Front Panel Battery Cover and disconnect the Connection Terminals. Verify **7.2 VDC / ± 0.3 VDC** at the removed terminals.

   Disconnect the Power Supply.

2. Connect the Power supply to the Test Set Battery terminals and adjust for **6.5 VDC**. Monitor **TP3** (Power Supply) with a DVM; turn the Test Set "*ON*", readjust the Power Supply, if necessary, and advance to the Manual XPDR M A test.

3. Slowly decrease the Power Supply DC Voltage until the Test Set Display indicates:

LOW BATTERY Press AUTO to Continue

   The voltage of the Power Supply should indicate **5.6 VDC / ± .05 VDC**. Toggle the **AUTO/MANUAL** switch to **MANUAL** switch. Continue to lower the Power Supply to **5.4 VDC / ± .05 VDC**. Toggle the **MANUAL** switch once and the Display should not indicate "LOW BATTERY RECHARGE REQUIRED".

4. Continue the MA test by toggling **AUTO** and lower the power supply voltage to **5.2 VDC / ± .05 VDC.** Toggle the **AUTO/MANUAL** switch to **MANUAL** and the Test Set shall shut down.

5. Press and Hold the **TEST SET PWR** switch to "ON". The Test Set should indicate:

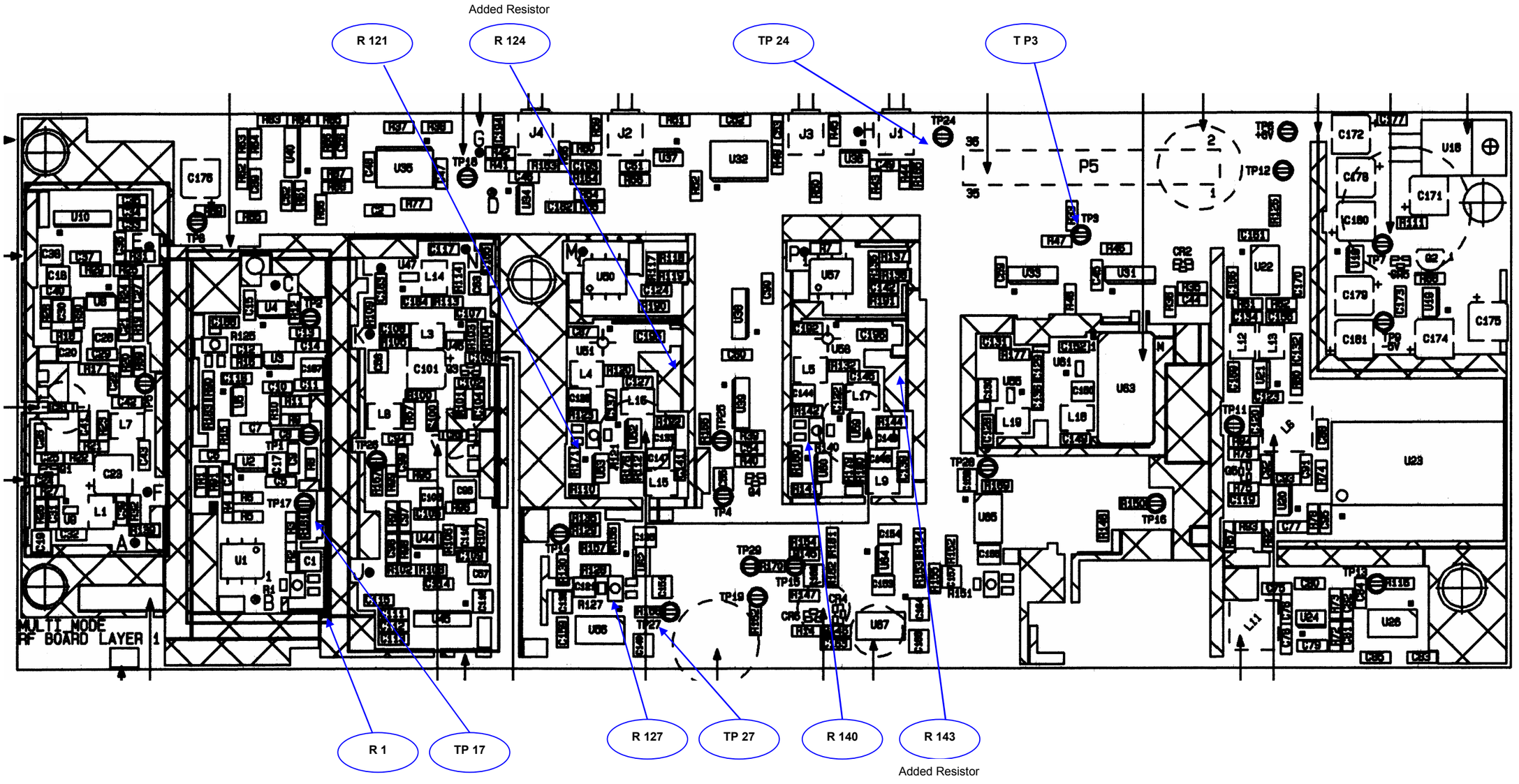
LOW BATTERY SHUTTING DOWN

   Release the toggle switch, the Test Set shall Shut OFF.

6. Reconnect the Battery leads and reassemble the Test Set back into the chassis and case.

4.8.5 Final Test

1. Conduct an **ACCEPTANCE and VERIFCATON Check IAW Section B**. This is the Final Test to ensure and verify proper operation and alignment. Log all results on the Data Sheet and maintain a copy in your records for future reference.

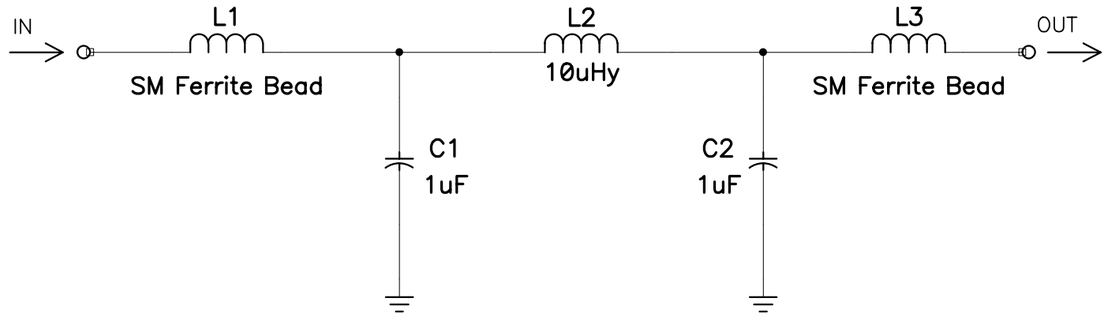


Test Point Locations

Figure 4-14

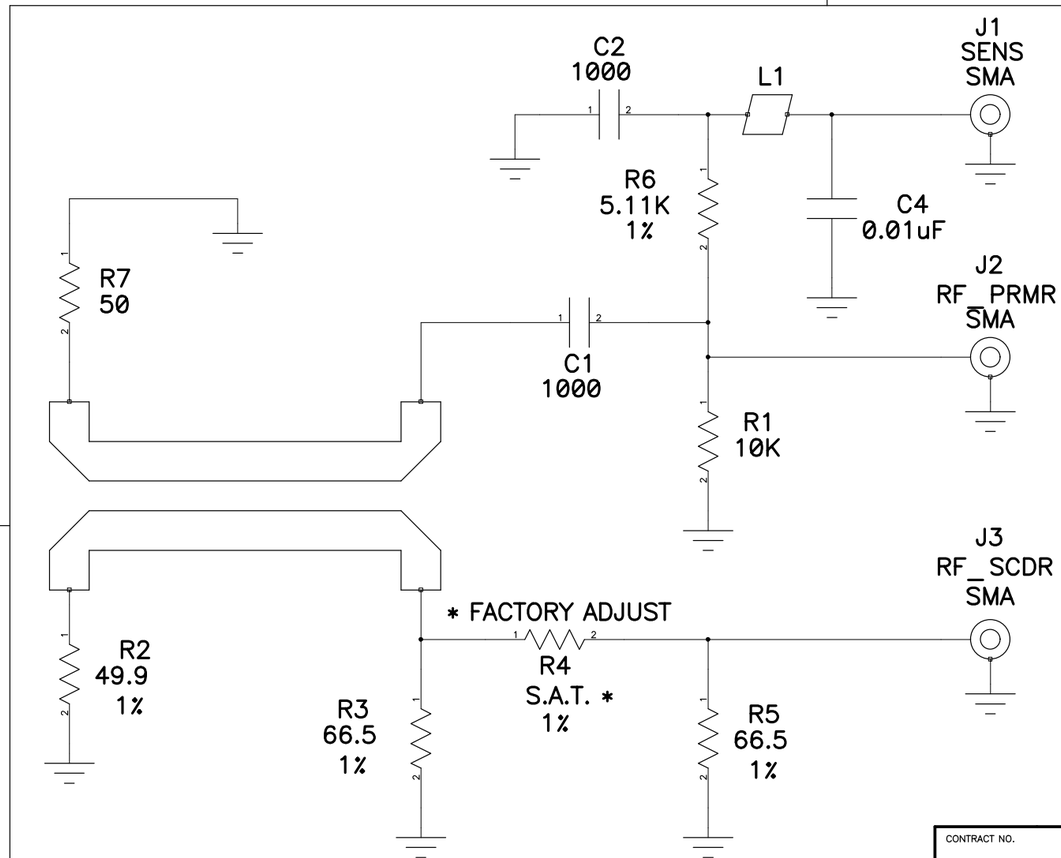
CHAPTER V

SCHEMATICS



	A	ERN 0002: INITIAL RELEASE	L.S.	4-4-00	JWW 4-4-00
	REV	DESCRIPTION	CHG INIT	DATE	APPROVED
	Title	SCHEMATIC DIAGRAM SENSE LINE FILTER PCB			
	Size B	Number 80 169 003			Rev A
Checked: JW 4-4-00	Date 3-23-00			Drawn by L.S.	
Issued: JW 4-4-00	Filename 80169003A.sch			Sheet 1 of 1	

Thu Jan 29, 2004 10:49:33



REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	ERN 0006: INITIAL RELEASE	6-29-00	J.W. 6-29-00
B	ECO 1648: R4 TO S.A.T.	020926	B.R. 020926

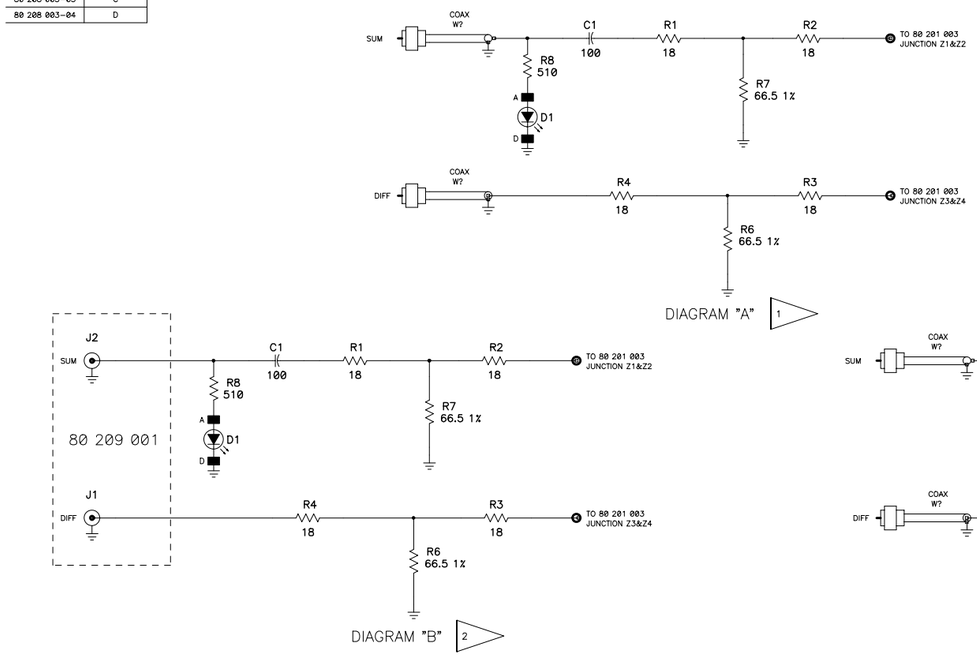
NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL CAPACITOR VALUES ARE IN PICOFARADS.
2. ALL RESISTORS ARE 1/4W 5%.

CONTRACT NO.		TEL-INSTRUMENT ELECTRONICS CORP.			
APPROVALS	DATE	SCHEMATIC DIAGRAM ATTENUATOR BOARD			
DRAWN L. SASS	6-29-00				
CHECKED L. SASS	7-6-00	SIZE B	FSCM NO. 92606	DWG. NO. 80 173 003	REV. B
ISSUED J. WALLACE	7-10-00	SCALE NTS	80173003B.SCH	SHEET 1 OF 1	

10:49:55 Thu Jan 29, 2004

PART NO.	DIAGRAM
80 208 003-01	A
80 208 003-02	B
80 208 003-03	C
80 208 003-04	D



1 SCHEMATIC DIAGRAM FOR 80208001-01

2 SCHEMATIC DIAGRAM FOR 80208001-02

3 SCHEMATIC DIAGRAM FOR 80208001-03

4 SCHEMATIC DIAGRAM FOR 80208001-04

REV	DESCRIPTION	CHG INIT	DATE	APPROVED
A	ECO1684-08: INITIAL RELEASE	L.S.	030310	M.G.

SCHEMATIC DIAGRAM
ANTENNA ATTENUATOR

80 208 003 A

Checked: M.G. 030310	030123	L. SASS	
Issued: B.R. 030310	80208003A.SCH	1	1
	Thu Jan 29, 2004 15:08:06		

PART NO.	DIAGRAM
80201003-01	"A"
80201003-02	"B"

REVISIONS				
REV.	DESCRIPTION	DATE	CHG INIT.	APPR
A	ERN 0038: INITIAL RELEASE	020719	SL	BR
B	ECO 1646-03 SCHEM CHG	020821	SL	BR
C	ECO 1684-03 MAKE TABULATION	030310	BR	BR

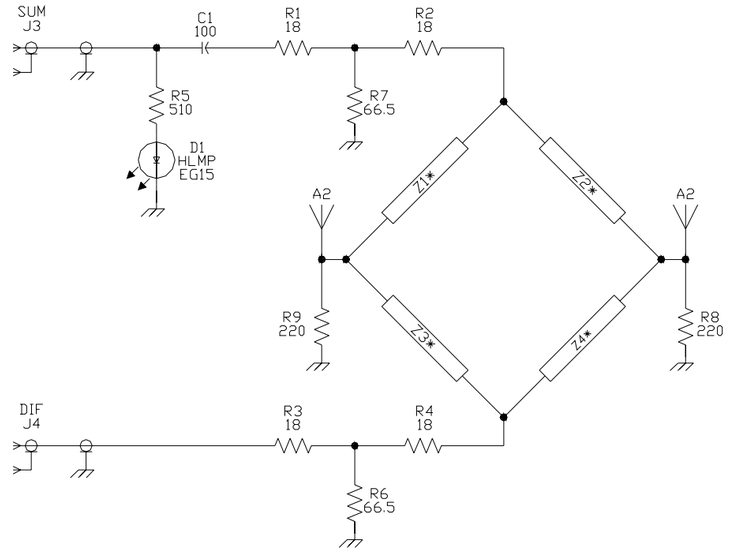


DIAGRAM "A" (2)

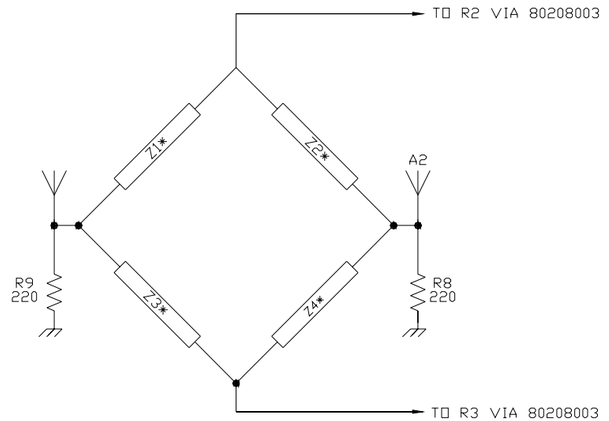


DIAGRAM "B" (3)

NOTES:

1. * INDICATES PCB FOIL COMPONENT.
2. (2) SCHEMATIC DIAGRAM FOR 80201001-01.
3. (3) SCHEMATIC DIAGRAM FOR 80201001-02 THRU 80201001-05.

SYSTEM CODE AN/APM-480		MATERIAL	UNLESS OTHERWISE SPECIFIED
		FINISH	DIMENSIONS ARE IN INCHES DECIMAL TOL 2 PLACE ±.01 3 PLACE ±.005 FRACTIONS ± 1/64 ANGLES ± 1° CHAMFERS ± 5°
80201001	90001059	TEL-INSTRUMENT ELECTRONICS CONFIDENTIAL THIS DOCUMENT CONTAINS PROPRIETARY INFORMATION AND SUCH INFORMATION MAY NOT BE DISCLOSED TO OTHERS FOR ANY PURPOSE, NOR USED FOR MANUFACTURING PURPOSES WITHOUT WRITTEN PERMISSION FROM TEL-INSTRUMENT ELECTRONICS CORP.	INTERPRET DRAWING IN ACCORDANCE WITH ANSI Y14.5M-1994
NEXT ASSY	USED ON		THIRD ANGLE PROJECTION
FIRST APPLICATION			

COMPUTER GENERATED ACAD DRAWING

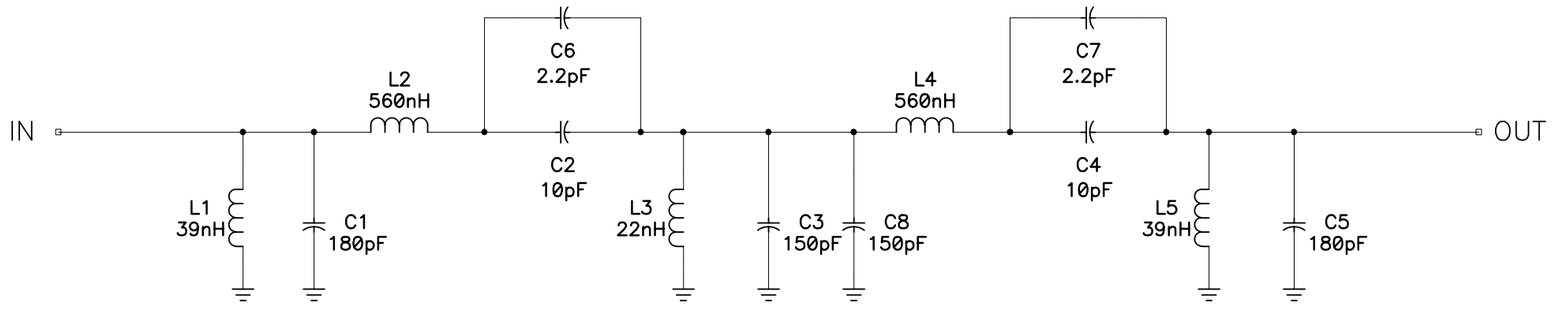
CONTRACT NO.		
RELEASE DATE		020725
DRAWN	SL	020719
CHK	BR	020719
ENGR	AK	020719
QA		
MFG		

Tel-Instrument Electronics Corp

SCHEMATIC DIAGRAM
DIRECTIONAL ANTENNA

SIZE	CAGE CODE	DWG. NO.	REV.
B	92606	80 201 003	C

SCALE NONE SHEET 1 OF 1



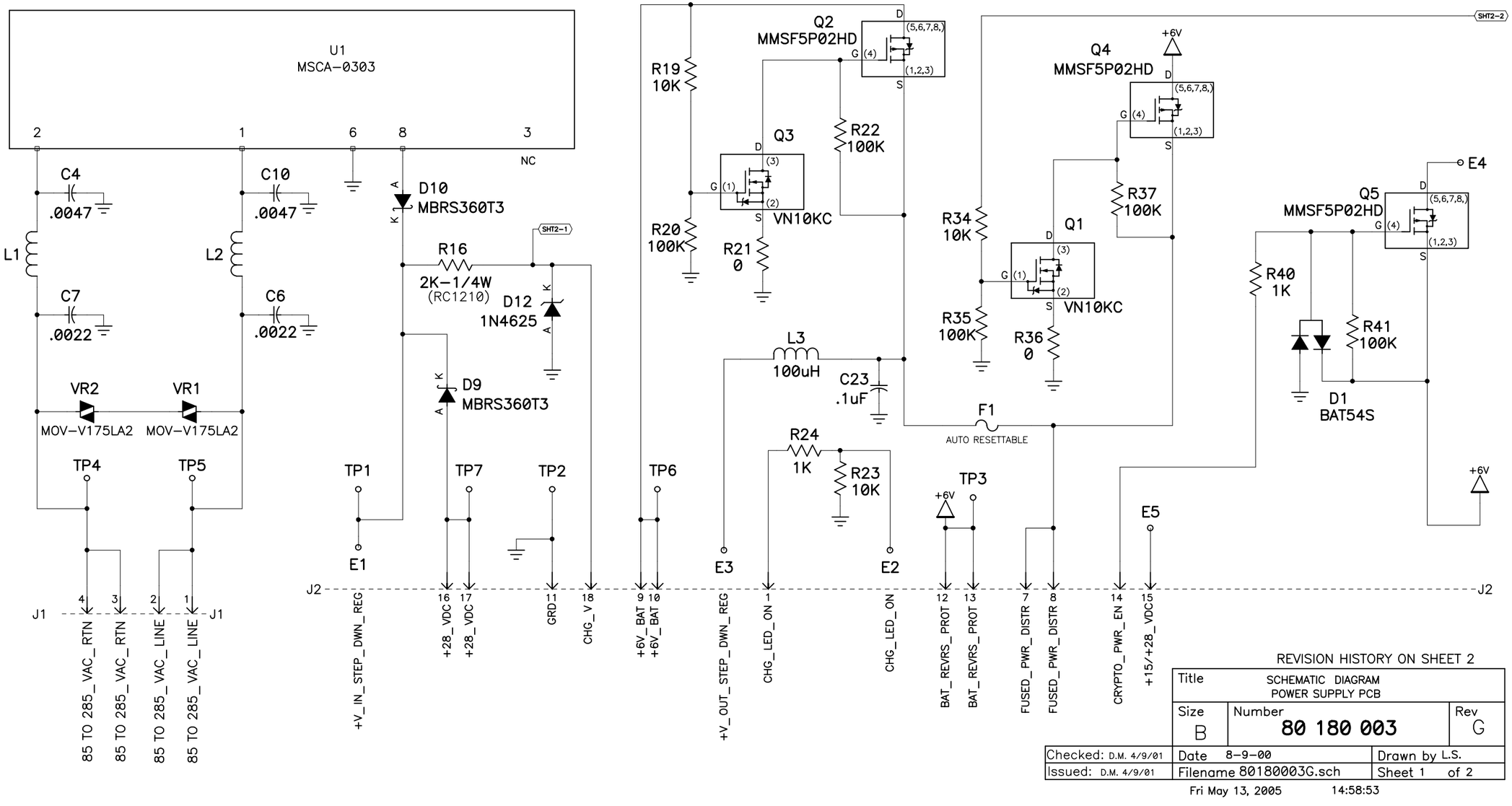
REV	DESCRIPTION	CHG INIT	DATE	APPROVED
A	ERN0058-03: INITIAL RELEASE	L.S.	030612	O.P. 030612

SCHEMATIC DIAGRAM
IF FILTER

80 212 003 A

Checked: O.P. 030612
Issued: D.M. 030612

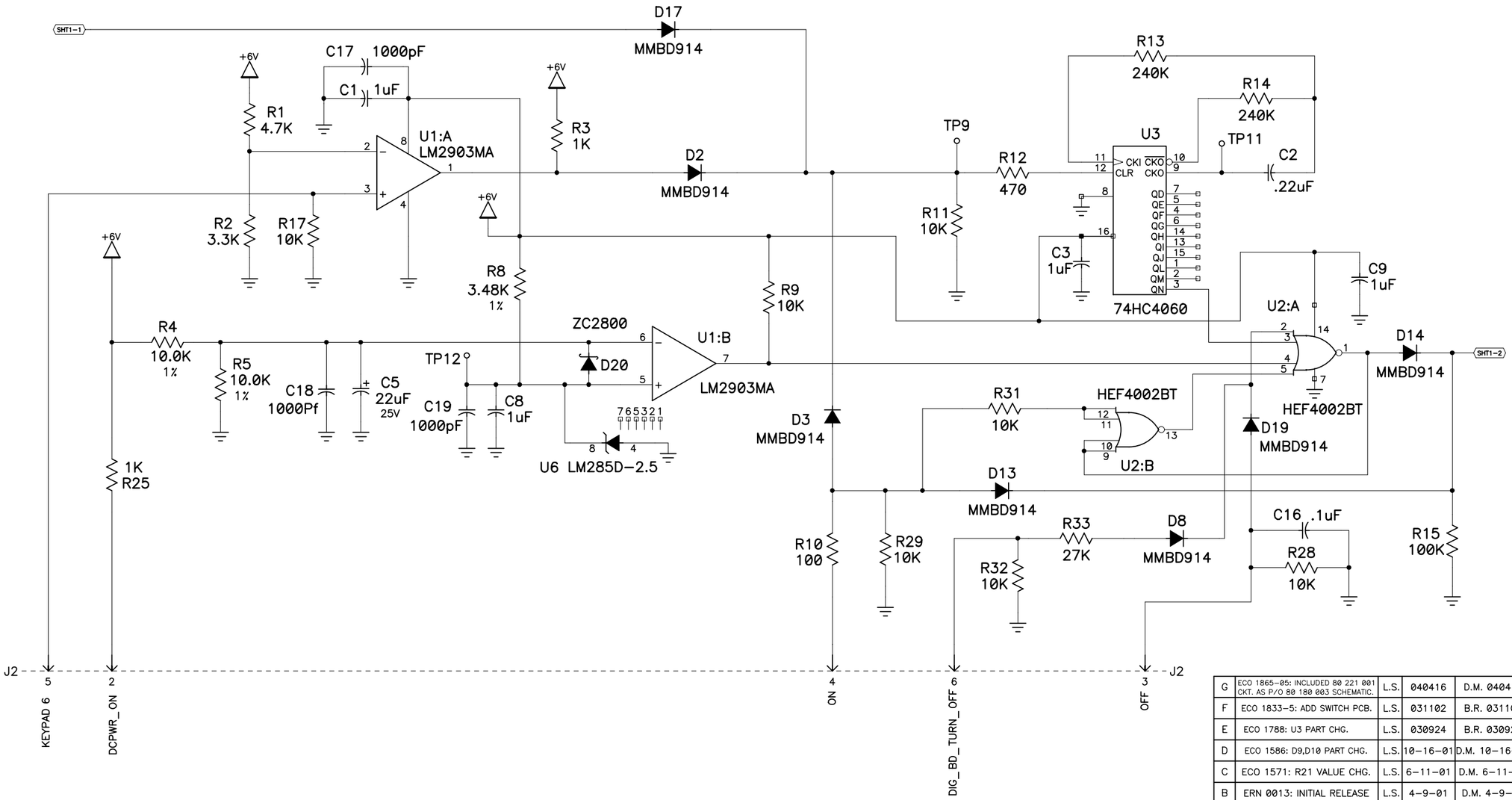
021210 L. SASS
80212003A.sch 1 1
10:50:16 Thu Jan 29, 2004



REVISION HISTORY ON SHEET 2

	Title: SCHEMATIC DIAGRAM POWER SUPPLY PCB	
	Size: B — Number: 80 180 003	Rev: G
Checked: D.M. 4/9/01	Date: 8–9–00	Drawn by: L.S.
Issued: D.M. 4/9/01	Filename: 80180003G.sch	Sheet 1 of 2

Fri May 13, 2005 14:58:53



REV	DESCRIPTION	CHG INIT	DATE	APPROVED
G	ECO 1865-05: INCLUDED 80 221 001 CKT. AS P/O 80 180 003 SCHEMATIC.	L.S.	040416	D.M. 040416
F	ECO 1833-5: ADD SWITCH PCB.	L.S.	031102	B.R. 031102
E	ECO 1788: U3 PART CHG.	L.S.	030924	B.R. 030924
D	ECO 1586: D9,D10 PART CHG.	L.S.	10-16-01	D.M. 10-16-01
C	ECO 1571: R21 VALUE CHG.	L.S.	6-11-01	D.M. 6-11-01
B	ERN 0013: INITIAL RELEASE	L.S.	4-9-01	D.M. 4-9-01

Title: SCHEMATIC DIAGRAM
POWER SUPPLY PCB

Size | Number: 80 180 003 | Rev: G

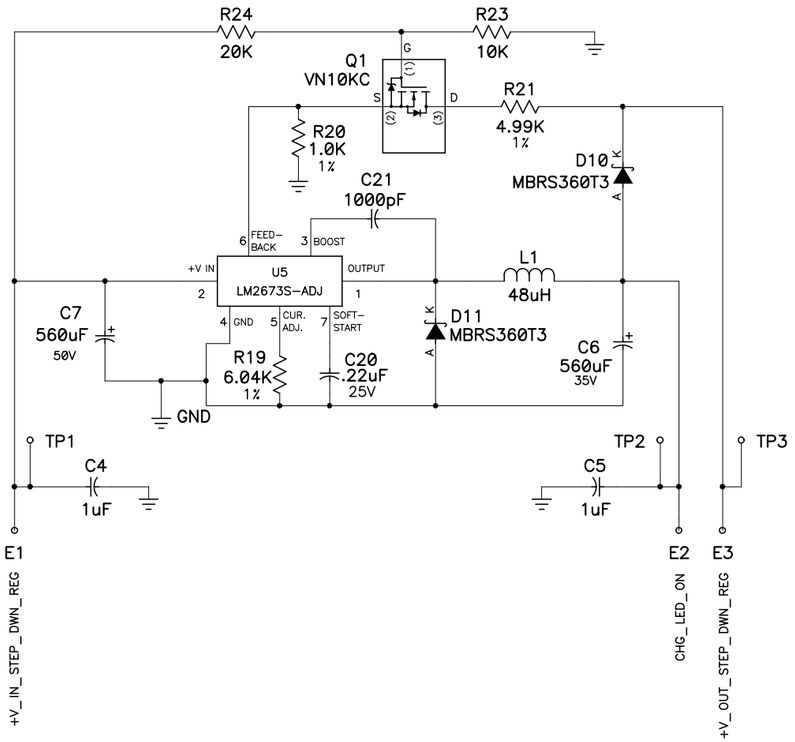
Checked: D.M. 4-9-01
Issued: D.M. 4-9-01

Date 9-8-00 | Drawn by L.S.

Filename 80180003G.sch | Sheet 2 of 2

Fri May 13, 2005 14:59:07

HIGHEST REFERENCE DESIGNATONS USED							
C21	D11	E3	L1	Q1	R24	TP3	U5
REFERENCE DESIGNATONS NOT USED							
C1–C3 C8–C19	D1–D9				R1–R18		U1–U4



NOTES:

1. UNLESS OTHERWISE SPECIFIED RESISTOR VALUES ARE IN OHMS. CAPACITANCE VALUES ARE IN MICROFARADS.
2. ALL INTERGRATED CIRCUITS ARE IDENTIFIED BY GENERIC PART TYPE FOR REFERENCE ONLY.

REV	DESCRIPTION	CHG INIT	DATE	APPROVED
B	ECO 1715: ADD Q1, R23, R24	L.S.	030429	BR
A	ERN 0028: INITIAL RELEASE	L.S.	020319	BR

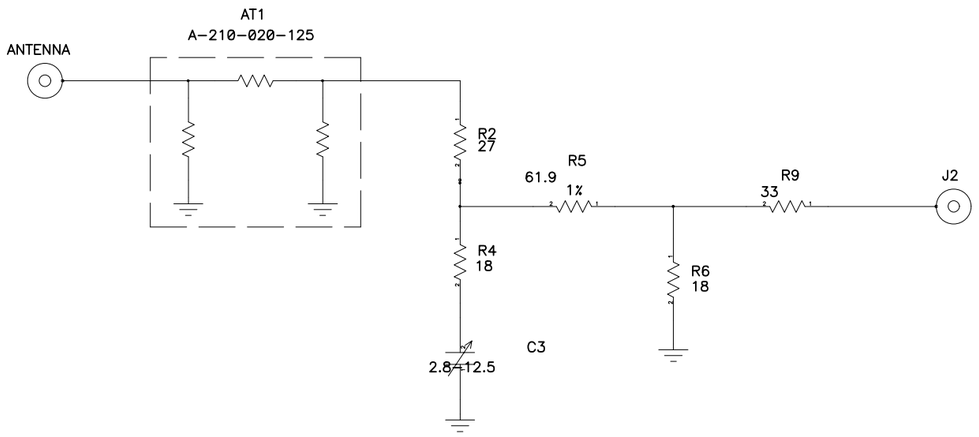
SCHEMATIC DIAGRAM
REGULATOR PCB

80 191 003 | B

Checked: BR
Issued: 020319

8–24–01 L.S.
80191003B.sch 1 1
Fri May 13, 2005 14:58:10

	REVISIONS		
REV	DESCRIPTION	DATE	APPRVD
A	ECO 1621–60:INITIAL REL.	020329	WR
B	ECO 1868–59:REMOVE TAP–135 FROM TITLE BLOCK.	040507	DM



NOTES:
UNLESS OTHERWISE SPECIFIED:

1. RESISTOR VALUES ARE IN OHMS.
2. CAPACITOR VALUES ARE IN PICOFARADS.

80198001	TR–210
80198001	TR–220
80198001	T–48A
80198001	T–48
80198001	T–49CA
80198001	T–49C
NEXT ASSY	USED ON
APPLICATION	

CONTRACT NO.

APPROVALS	DATE
DRAWN D.MCMAHON	020329
CHECKED WR	020329
ISSUED	

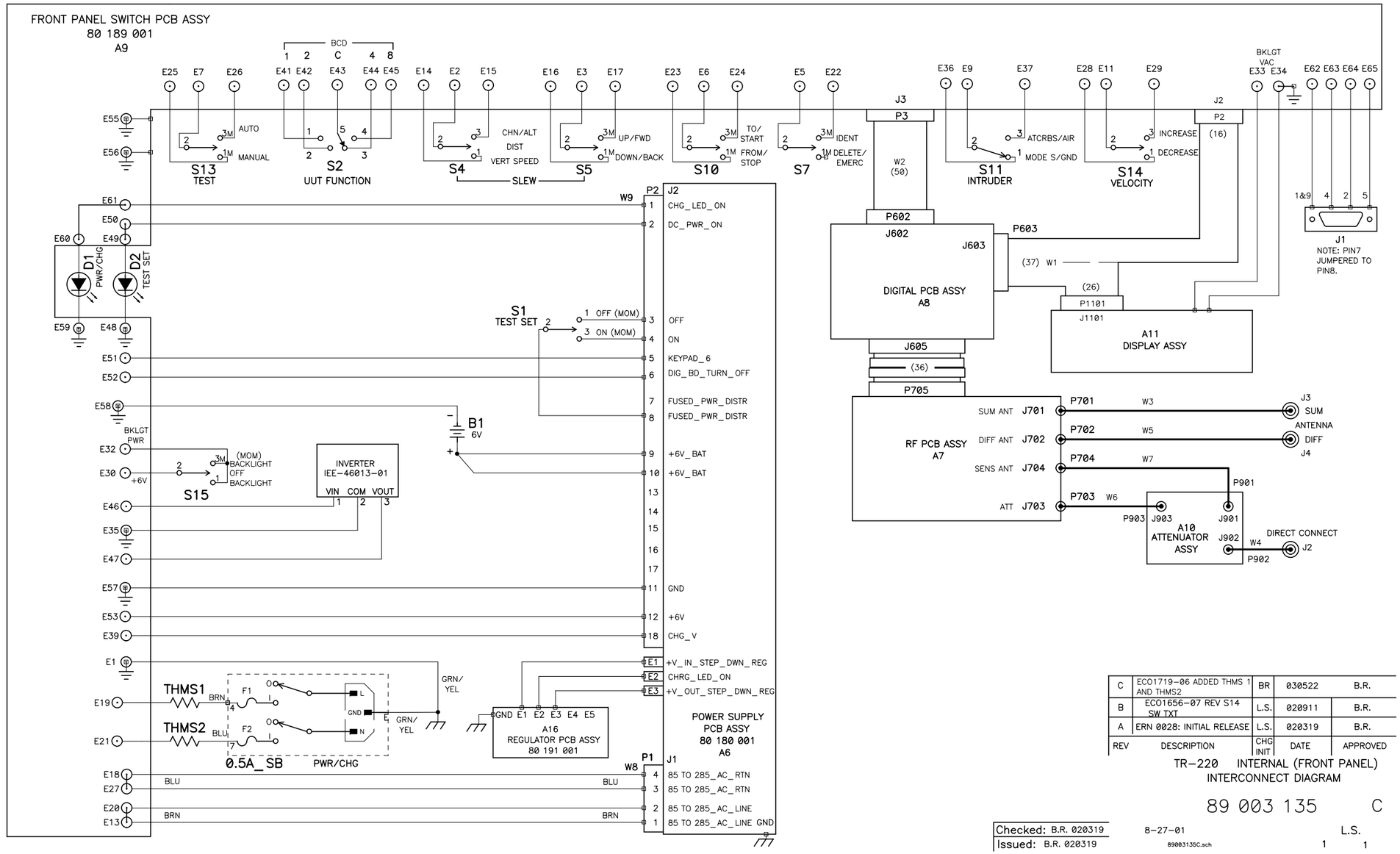
TEL–INSTRUMENT ELEC. CORP.

SCHEMATIC DIAGRAM
ANTI–RADIATION HAT
(10 FT. CABLE)

SIZE	FSCM NO.	DWG. NO.	REV
B	92606	80198003	B

SCALE NONE SHEET OF 1

TR-220 INTERNAL (FRONT PANEL) INTERCONNECT



REV	DESCRIPTION	CHG INIT	DATE	APPROVED
C	ECO1719-06 ADDED THMS 1 AND THMS2	BR	030522	B.R.
B	ECO1656-07 REV S14 SW TXT	L.S.	020911	B.R.
A	ERN 0028: INITIAL RELEASE	L.S.	020319	B.R.

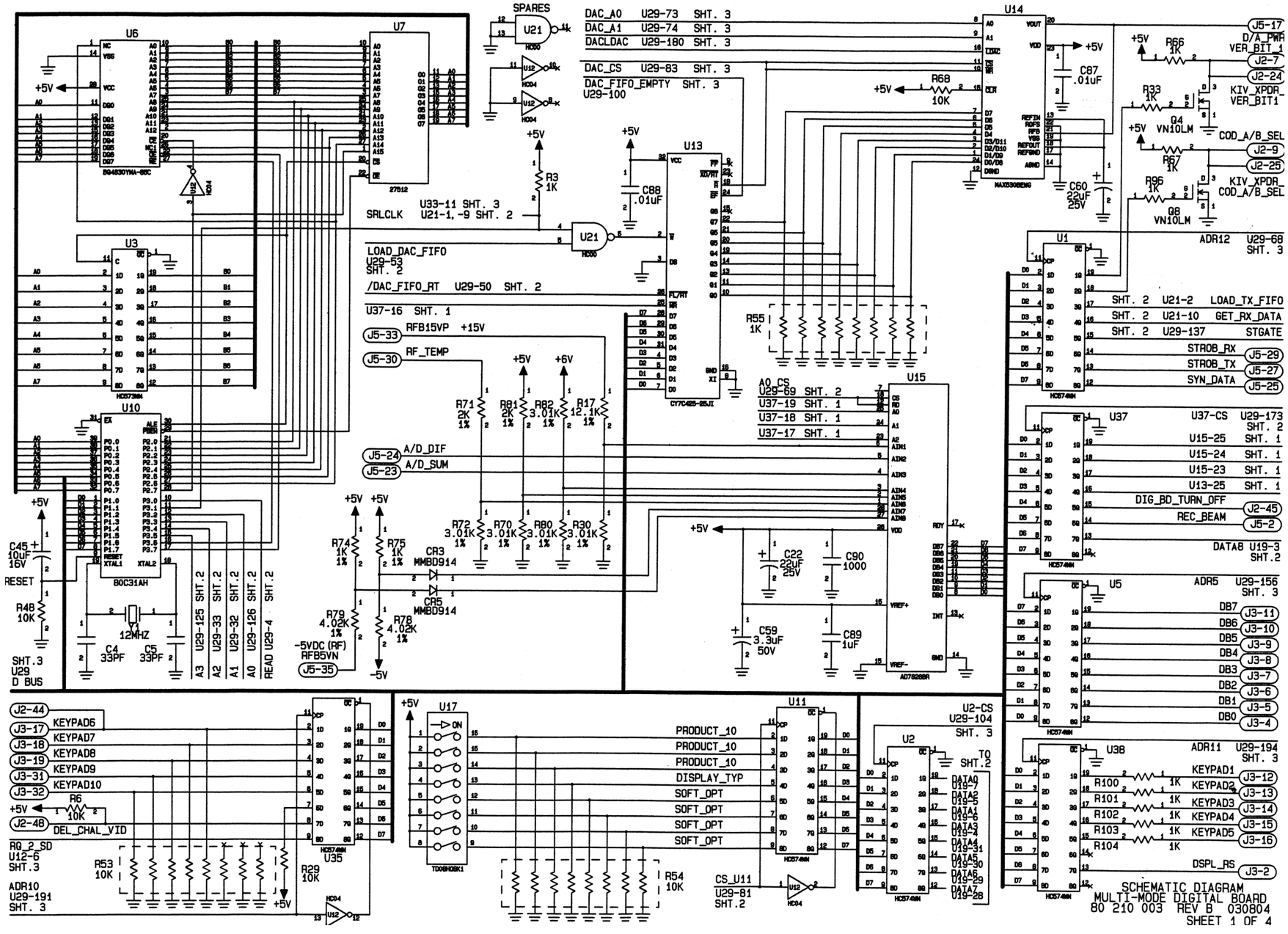
TR-220 INTERNAL (FRONT PANEL) INTERCONNECT DIAGRAM

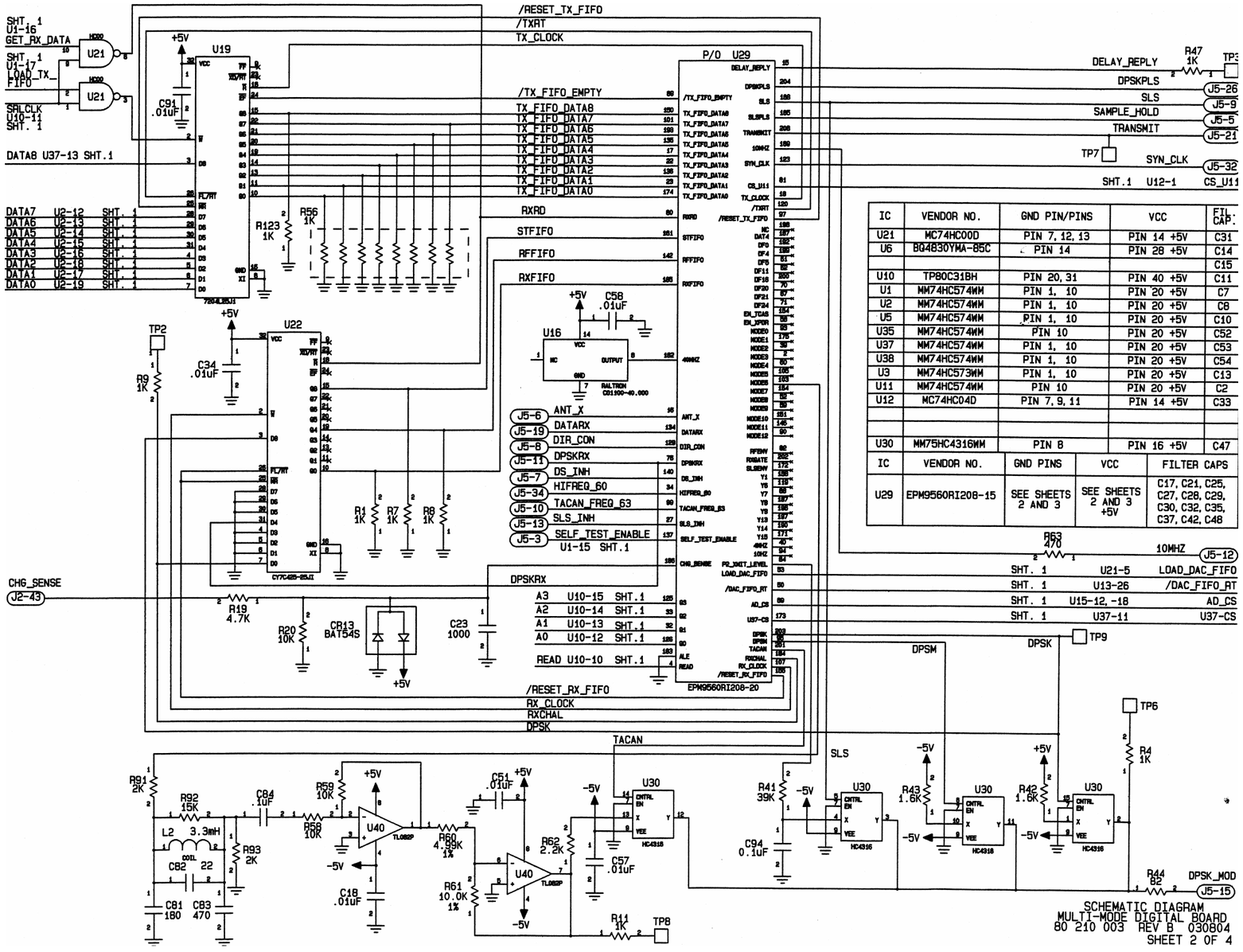
89 003 135 C

Checked: B.R. 020319
Issued: B.R. 020319

8-27-01
89003135C.sch
Fri May 13, 2005 14:57:16

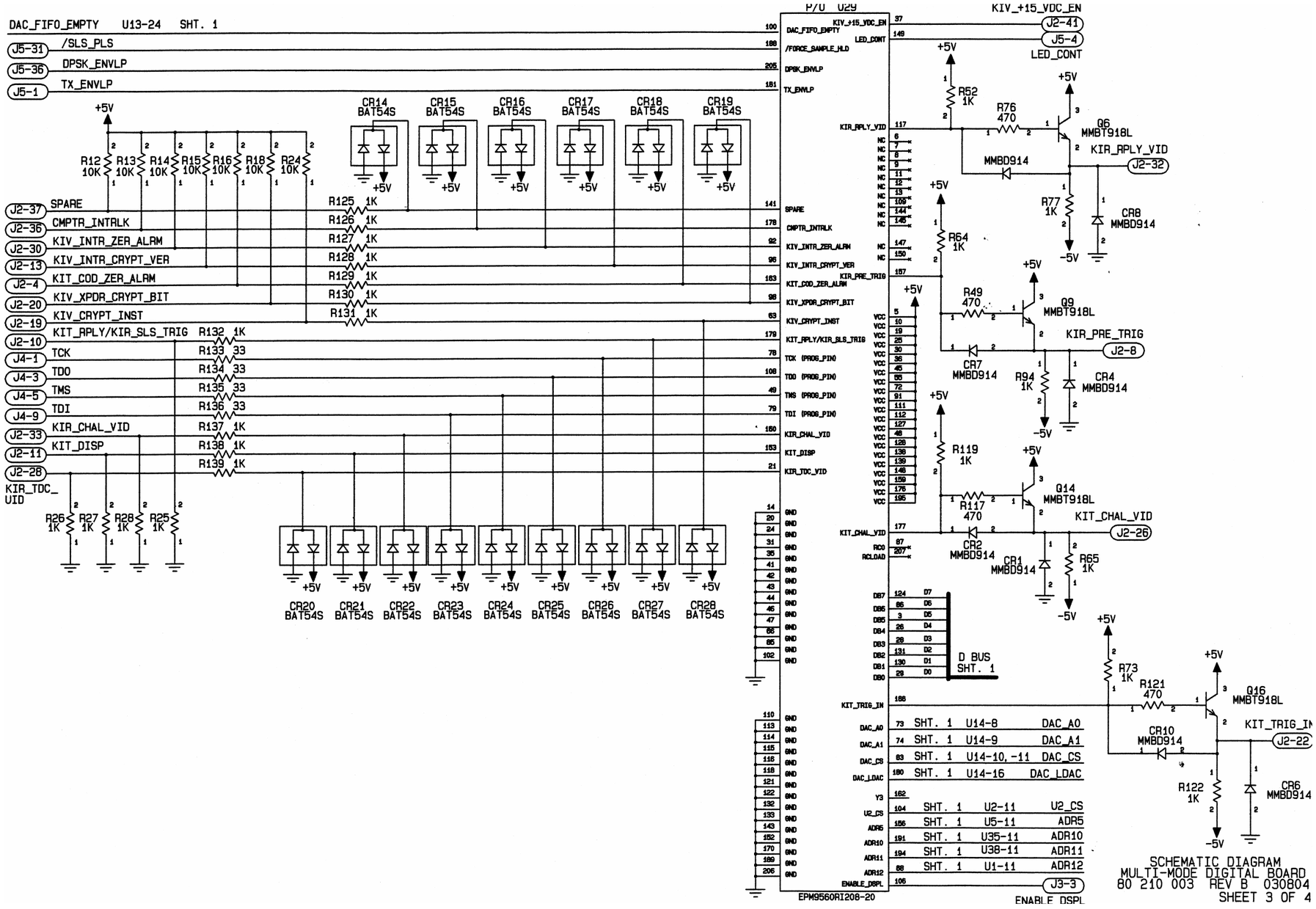
L.S.
1 1

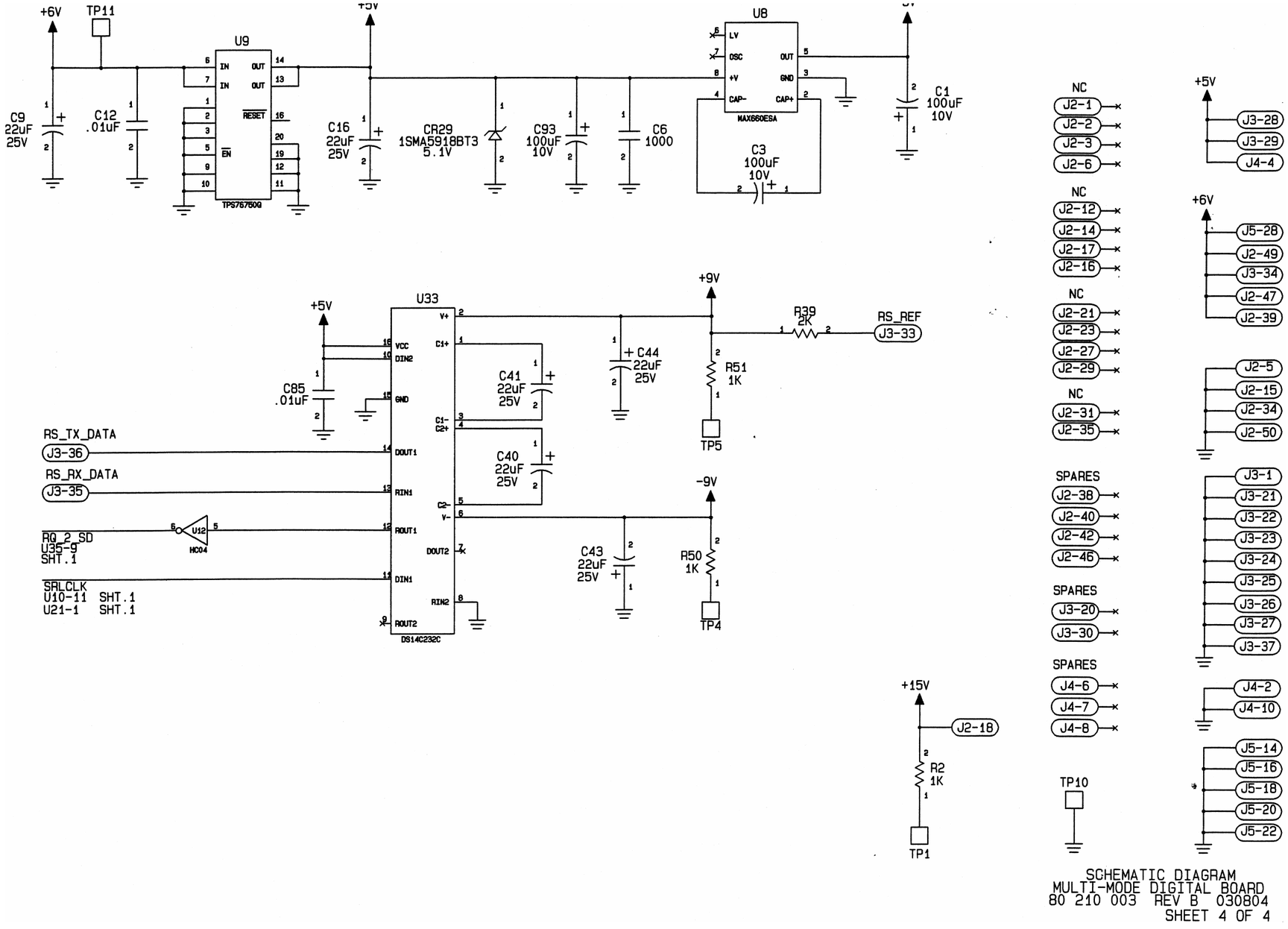

SPARES
DAC_A0 U29-73 SHT. 3
DAC_A1 U29-74 SHT. 3
DACLDAC U29-180 SHT. 3
DAC_CS U29-83 SHT. 3
DAC_FIFO_EMPTY SHT. 3
U29-100
U33-11 SHT. 3
SRLCLK U21-1, -9 SHT. 2
LOAD_DAC_FIFO
U29-53
SHT. 2
/DAC_FIFO_RT U29-50 SHT. 2
U37-16 SHT. 1
RFB15VP +15V
RF_TEMP
A/D_DIF
A/D_SUM
-5VDC (RF)
RFB5VN
A0 CS
U29-69 SHT. 2
U37-19 SHT. 1
U37-18 SHT. 1
U37-17 SHT. 1
ADR12 U29-68
SHT. 3
SHT. 2 U21-2 LOAD_TX_FIFO
SHT. 2 U21-10 GET_RX_DATA
SHT. 2 U29-137 STGATE
STROB_RX
STROB_TX
SYN_DATA
U37-CS U29-173
SHT. 2
U15-25 SHT. 1
U15-24 SHT. 1
U15-23 SHT. 1
U13-25 SHT. 1
DIG_BD_TURN_OFF
REC_BEAM
DATA8 U19-3
SHT.2
ADR5 U29-156
SHT. 3
ADR11 U29-194
SHT. 3
U2-CS
U29-104
SHT. 3
TO
SHT.2
CS_U11
U29-81
SHT.2
RQ_2_SD
U12-6
SHT.3
ADR10
U29-191
SHT. 3
SHT.3
U29
D BUS
SCHEMATIC DIAGRAM
MULTI-MODE DIGITAL BOARD
80 210 003 REV B 030804
SHEET 1 OF 4



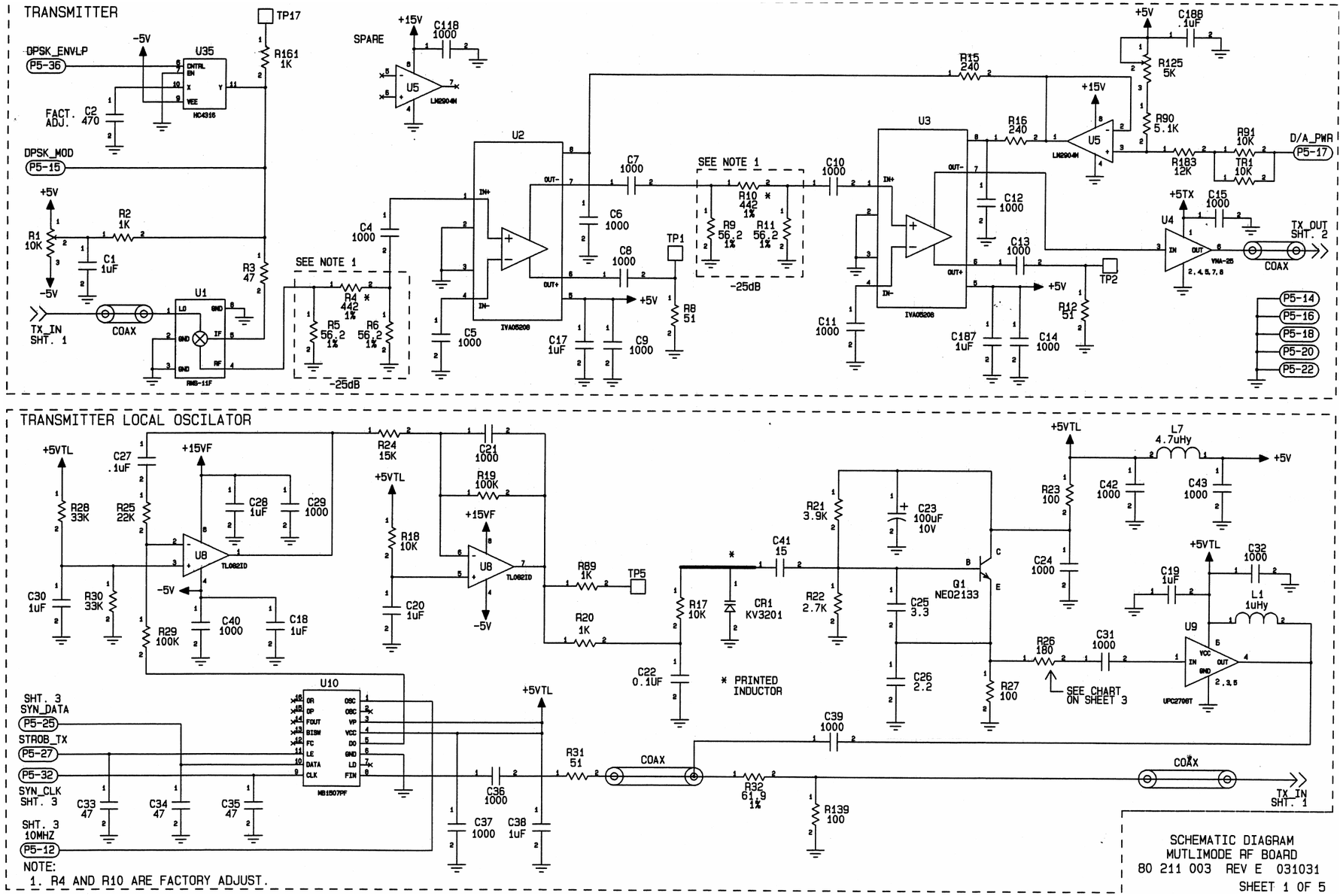
IC	VENDOR NO.	GND PIN/PINS	VCC	FIL CAP:
U21	MC74HC00D	PIN 7, 12, 13	PIN 14 +5V	C31
U6	BQ4830YMA-85C	PIN 14	PIN 28 +5V	C14
				C15
U10	TP80C31BH	PIN 20, 31	PIN 40 +5V	C11
U1	MM74HC574WM	PIN 1, 10	PIN 20 +5V	C7
U2	MM74HC574WM	PIN 1, 10	PIN 20 +5V	C8
U5	MM74HC574WM	PIN 1, 10	PIN 20 +5V	C10
U35	MM74HC574WM	PIN 10	PIN 20 +5V	C52
U37	MM74HC574WM	PIN 1, 10	PIN 20 +5V	C53
U38	MM74HC574WM	PIN 1, 10	PIN 20 +5V	C54
U3	MM74HC573WM	PIN 1, 10	PIN 20 +5V	C13
U11	MM74HC574WM	PIN 10	PIN 20 +5V	C2
U12	MC74HC04D	PIN 7, 9, 11	PIN 14 +5V	C33
U30	MM75HC4316WM	PIN 8	PIN 16 +5V	C47

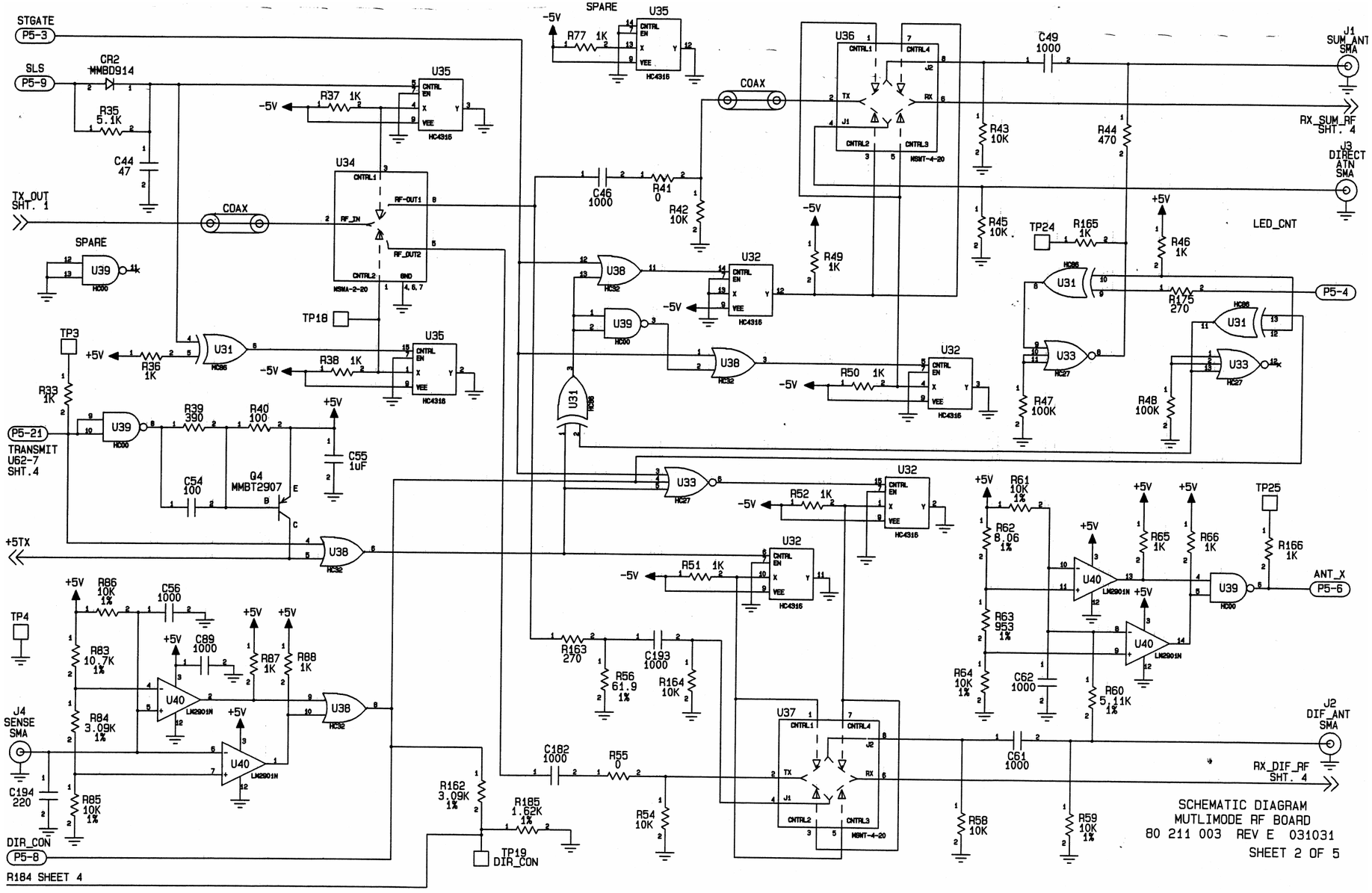
IC	VENDOR NO.	GND PINS	VCC	FILTER CAPS
U29	EPM9560RI208-15	SEE SHEETS 2 AND 3	SEE SHEETS 2 AND 3 +5V	C17, C21, C25, C27, C28, C29, C30, C32, C35, C37, C42, C48

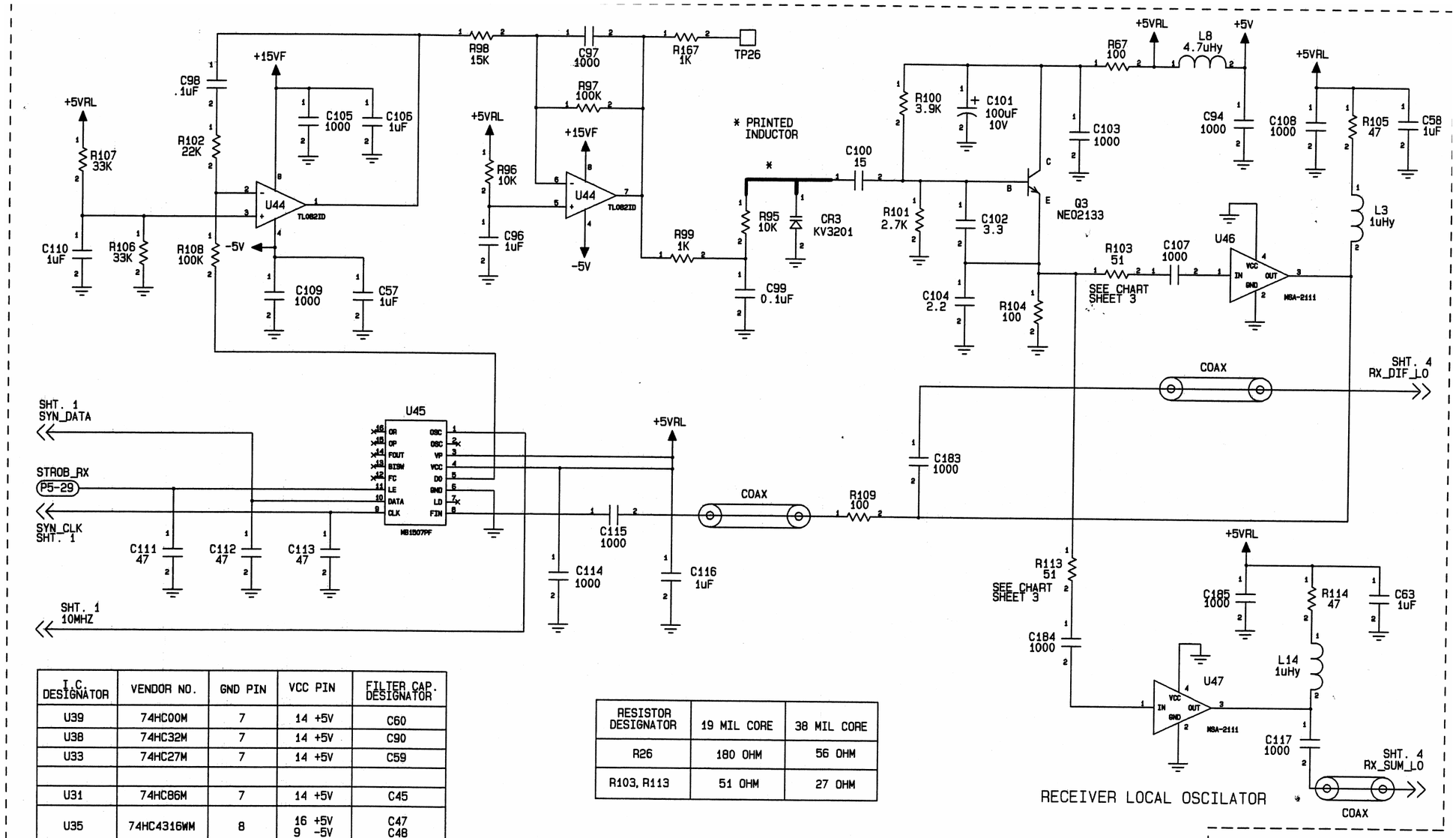

DAC_FIFO_EMPTY U13-24 SHT. 1
J5-31 /SLS_PLS
J5-36 DPSK_ENVLP
J5-1 TX_ENVLP
J2-37 SPARE
J2-36 CMPTR_INTRLK
J2-30 KIV_INTR_ZER_ALARM
J2-13 KIV_INTR_CRYPT_VER
J2-4 KIT_COD_ZER_ALARM
J2-20 KIV_XPDR_CRYPT_BIT
J2-19 KIV_CRYPT_INST
J2-10 KIT_RPLY/KIR_SLS_TRIG
J4-1 TCK
J4-3 TDO
J4-5 TMS
J4-9 TDI
J2-33 KIR_CHAL_VID
J2-11 KIT_DISP
J2-28 KIR_TDC_VID
R12 10K
R13 10K
R14 10K
R15 10K
R16 10K
R18 10K
R24 10K
R125 1K
R126 1K
R127 1K
R128 1K
R129 1K
R130 1K
R131 1K
R132 1K
R133 33
R134 33
R135 33
R136 33
R137 1K
R138 1K
R139 1K
R26 1K
R27 1K
R28 1K
R25 1K
CR14 BAT54S
CR15 BAT54S
CR16 BAT54S
CR17 BAT54S
CR18 BAT54S
CR19 BAT54S
CR20 BAT54S
CR21 BAT54S
CR22 BAT54S
CR23 BAT54S
CR24 BAT54S
CR25 BAT54S
CR26 BAT54S
CR27 BAT54S
CR28 BAT54S
+5V
P/O U29
EPM9560RI208-20
KIV_+15_VDC_EN
J2-41
J5-4
LED_CONT
R52 1K
R76 470
Q6 MMBT918L
KIR_RPLY_VID
J2-32
MMBD914
R77 1K
CR8 MMBD914
-5V
R64 1K
R49 470
Q9 MMBT918L
KIR_PRE_TRIG
J2-8
CR7 MMBD914
R94 1K
CR4 MMBD914
R119 1K
Q14 MMBT918L
R117 470
KIT_CHAL_VID
J2-26
CR2 MMBD914
CR1 MMBD914
R65 1K
D BUS SHT. 1
R73 1K
R121 470
Q16 MMBT918L
KIT_TRIG_IN
J2-22
CR10 MMBD914
R122 1K
CR6 MMBD914
DAC_A0 73 SHT. 1 U14-8 DAC_A0
DAC_A1 74 SHT. 1 U14-9 DAC_A1
DAC_CS 83 SHT. 1 U14-10, -11 DAC_CS
DAC_LDAC 180 SHT. 1 U14-16 DAC_LDAC
U2_CS 104 SHT. 1 U2-11 U2_CS
ADR5 156 SHT. 1 U5-11 ADR5
ADR10 191 SHT. 1 U35-11 ADR10
ADR11 194 SHT. 1 U38-11 ADR11
ADR12 88 SHT. 1 U1-11 ADR12
ENABLE_DSPL J3-3
SCHEMATIC DIAGRAM
MULTI-MODE DIGITAL BOARD
80 210 003 REV B 030804
SHEET 3 OF 4



SCHEMATIC DIAGRAM
MULTI-MODE DIGITAL BOARD
80 210 003 REV B 030804
SHEET 4 OF 4


TRANSMITTER
TP17
R161 1K
DPSK_ENVLP
P5-36
-5V
U35
CNTRL EN
X
Y
VEE
HC4316
FACT. ADJ.
C2 470
DPSK_MOD
P5-15
+5V
R2 1K
R1 10K
C1 1uF
-5V
R3 47
TX_IN SHT. 1
COAX
U1
LO
GND
IF
RF
RMS-11F
SEE NOTE 1
R4 * 442 1%
R5 56.2 1%
R6 56.2 1%
-25dB
SPARE
+15V
C118 1000
U5
LM290-N
C4 1000
U2
IN+
IN-
OUT-
OUT+
IVA05208
C7 1000
C6 1000
C8 1000
TP1
C5 1000
C17 1uF
C9 1000
R8 51
SEE NOTE 1
R10 * 442 1%
R9 56.2 1%
R11 56.2 1%
-25dB
C10 1000
U3
C11 1000
C187 1uF
C14 1000
R12 51
TP2
R15 240
R16 240
C12 1000
C13 1000
+5V
C188 .1uF
R125 5K
R90 5.1K
R91 10K
R183 12K
TR1 10K
D/A_PWR
P5-17
+5TX
C15 1000
U4
VNA-25
TX_OUT SHT. 2
COAX
P5-14
P5-16
P5-18
P5-20
P5-22
TRANSMITTER LOCAL OSCILATOR
+5VTL
C27 .1uF
+15VF
R28 33K
R25 22K
C28 1uF
C29 1000
U8
TL082ID
C30 1uF
R30 33K
R29 100K
C40 1000
C18 1uF
R24 15K
C21 1000
R19 100K
R18 10K
C20 1uF
R89 1K
TP5
R20 1K
C22 0.1UF
R17 10K
CR1 KV3201
C41 15
R21 3.9K
R22 2.7K
C23 100uF 10V
Q1 NE02133
C25 3.3
C26 2.2
R27 100
C24 1000
R23 100
C42 1000
C43 1000
L7 4.7uHy
C19 1uF
C32 1000
L1 1uHy
U9
VCC
GND
UPC2706T
R26 180
C31 1000
SEE CHART ON SHEET 3
* PRINTED INDUCTOR
U10
SHT. 3 SYN_DATA
P5-25
STROB_TX
P5-27
P5-32
SYN_CLK SHT. 3
SHT. 3 10MHZ
P5-12
C33 47
C34 47
C35 47
MB1507PF
C36 1000
C37 1000
C38 1uF
R31 51
C39 1000
R32 61.9 1%
R139 100
NOTE:
1. R4 AND R10 ARE FACTORY ADJUST.
SCHEMATIC DIAGRAM
MUTLIMODE RF BOARD
80 211 003 REV E 031031
SHEET 1 OF 5

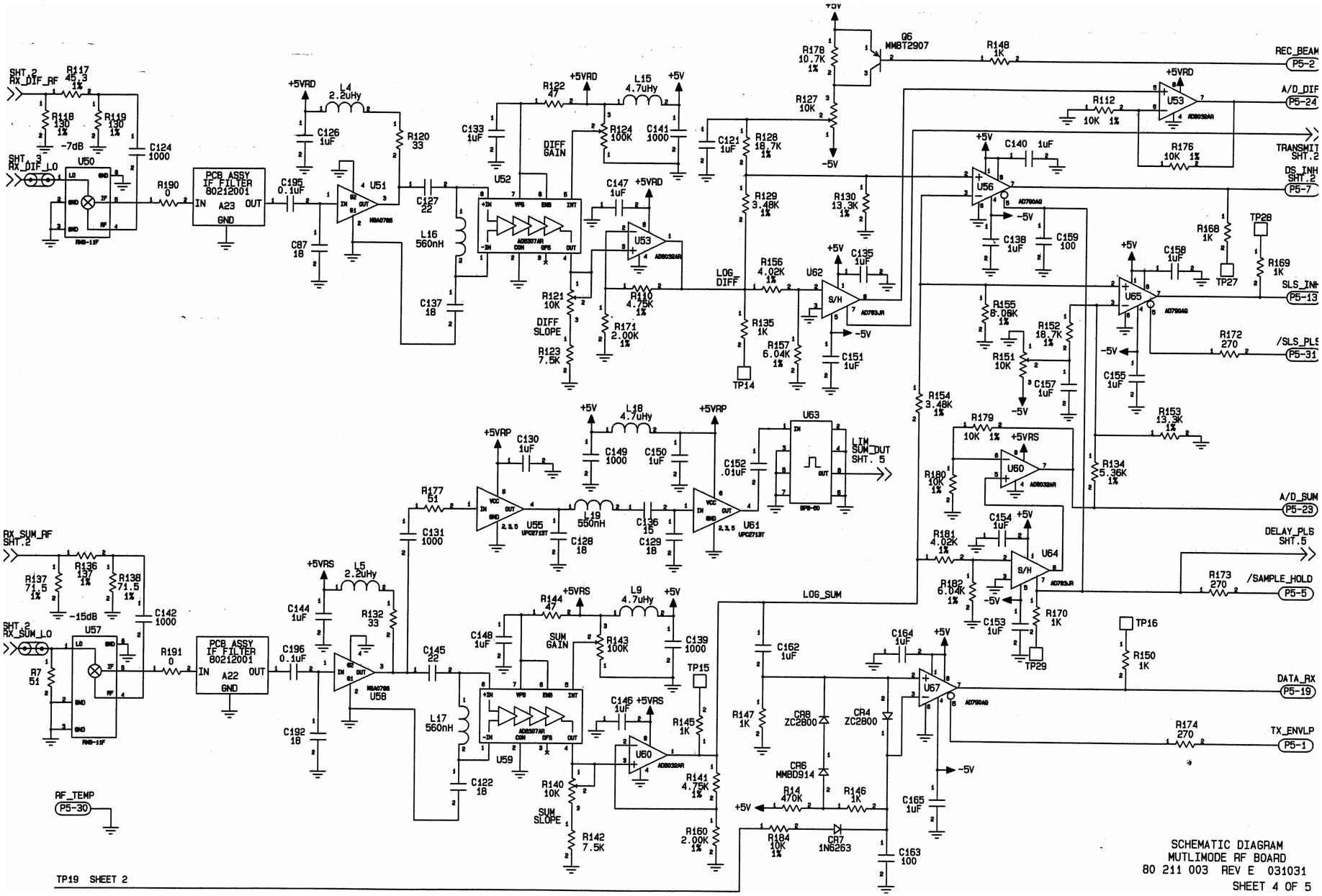

STGATE
P5-3
SLS
P5-9
CR2
MMBD914
R35
5.1K
C44
47
TX_OUT
SHT. 1
COAX
SPARE
U39
HC00
TP3
+5V
R36
1K
U31
HC86
R33
1K
P5-21
TRANSMIT
U62-7
SHT.4
R39
390
R40
100
C54
100
Q4
MMBT2907
C55
1uF
+5TX
U38
HC32
U34
CNTRL1
RF_IN
RF-OUT1
RF_OUT2
CNTRL2
GND
MSWA-2-20
4, 6, 7
TP18
U35
CNTRL EN
X
Y
VEE
HC4316
R37 1K
R38 1K
-5V
SPARE
R77 1K
C46
1000
R41
0
R42
10K
U36
CNTRL1
CNTRL4
CNTRL2
CNTRL3
TX
RX
J1
J2
MSWT-4-20
C49
1000
J1
SUM_ANT
SMA
RX_SUM_RF
SHT. 4
J3
DIRECT
ATN
SMA
R43
10K
R44
470
R45
10K
TP24
R165
1K
+5V
R46
1K
LED_CNT
P5-4
R175
270
U33
HC27
R47
100K
R48
100K
R49
1K
U32
R50 1K
R51 1K
R52 1K
U37
R61
10K
1%
R62
8.06
1%
R63
953
1%
R64
10K
1%
R65
1K
R66
1K
TP25
R166
1K
ANT_X
P5-6
U40
LM2901N
C62
1000
R60
5.11K
1%
C61
1000
J2
DIF_ANT
SMA
RX_DIF_RF
SHT. 4
R58
10K
R59
10K
1%
R163
270
C193
1000
R56
61.9
1%
R164
10K
C182
1000
R55
0
R54
10K
R162
3.09K
1%
R185
1.62K
1%
TP19
DIR_CON
J4
SENSE
SMA
C194
220
DIR_CON
P5-8
R184 SHEET 4
R86
10K
1%
C56
1000
C89
1000
R87
1K
R88
1K
R83
10.7K
1%
R84
3.09K
1%
R85
10K
1%
SCHEMATIC DIAGRAM
MUTLIMODE RF BOARD
80 211 003 REV E 031031
SHEET 2 OF 5

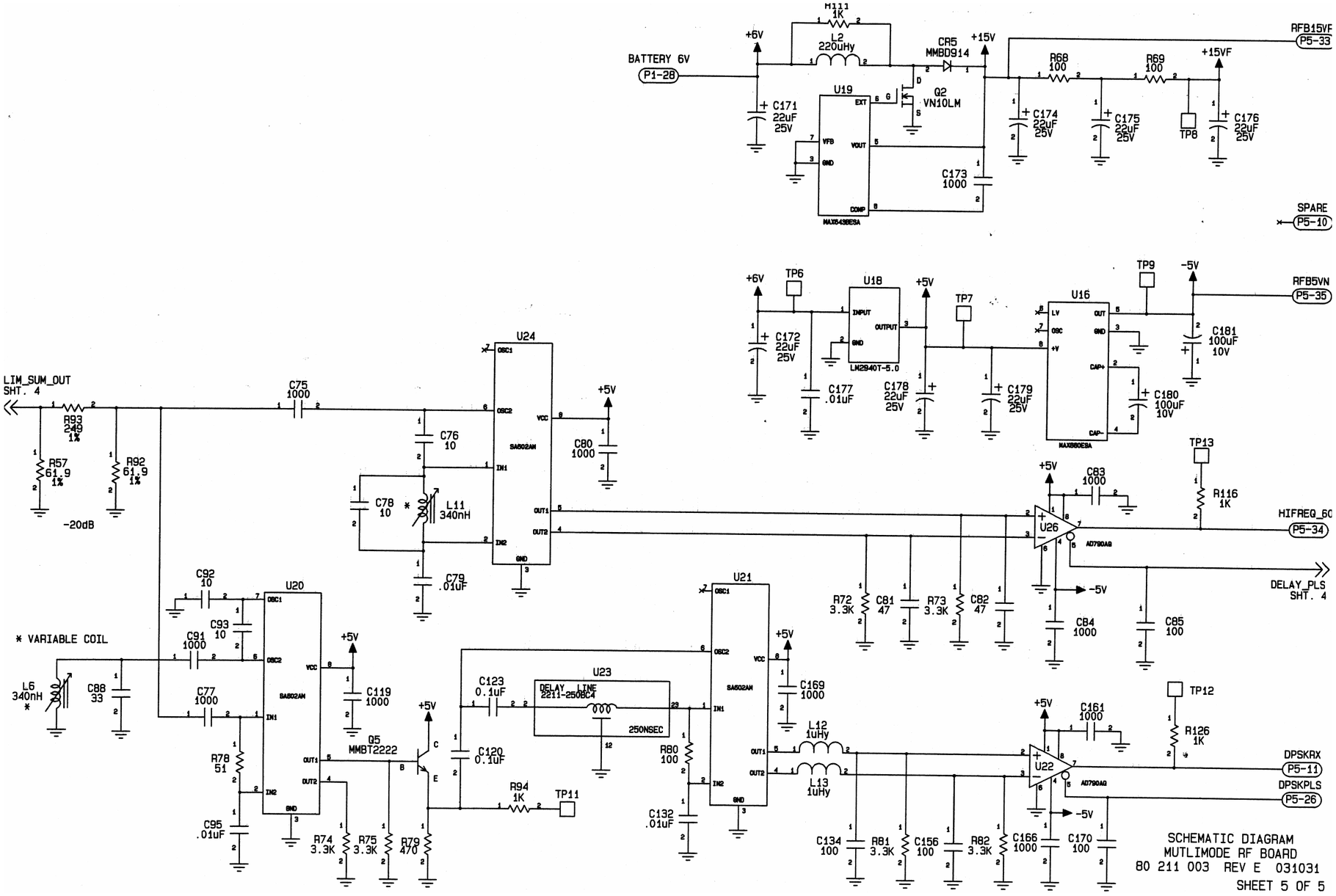


I.C. DESIGNATOR	VENDOR NO.	GND PIN	VCC PIN	FILTER CAP. DESIGNATOR
U39	74HC00M	7	14 +5V	C60
U38	74HC32M	7	14 +5V	C90
U33	74HC27M	7	14 +5V	C59
U31	74HC86M	7	14 +5V	C45
U35	74HC4316WM	8	16 +5V 9 -5V	C47 C48
U32	74HC4316WM	8	16 +5V 9 -5V	C52 C53

RESISTOR DESIGNATOR	19 MIL CORE	38 MIL CORE
R26	180 OHM	56 OHM
R103, R113	51 OHM	27 OHM

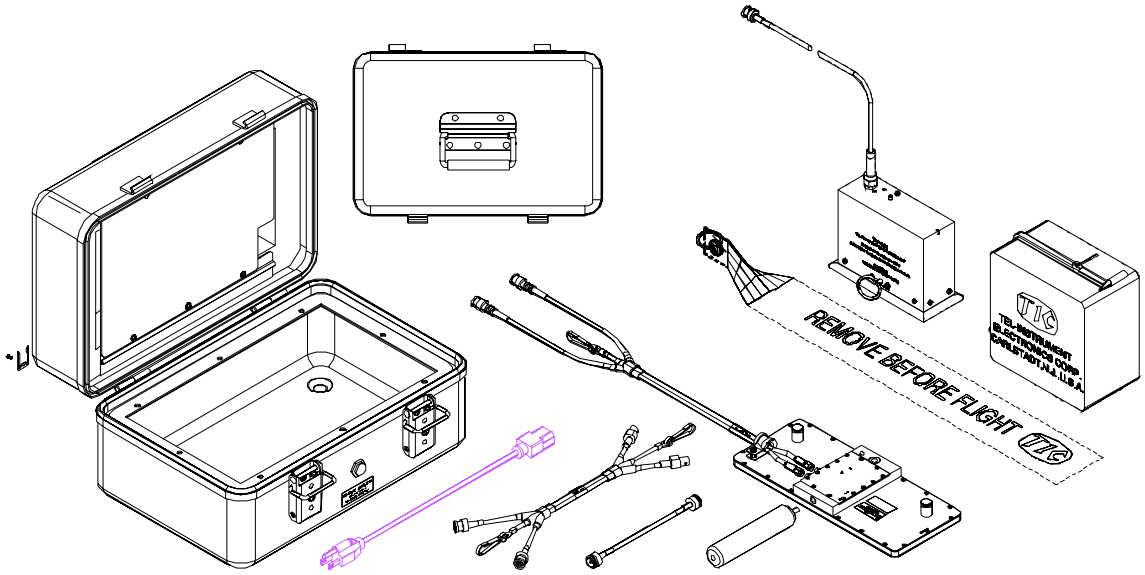
SCHEMATIC DIAGRAM
MUTLIMODE RF BOARD
80 211 003 REV E 031031
SHEET 3 OF 5


SHT.2 RX_DIF_RF
SHT.3 RX_DIF_LO
R117 45.3 1%
R118 130 1%
R119 130 1%
-7dB
U50
RMS-15F
C124 1000
R190 0
PCB ASSY IF FILTER 80212001
IN A23 OUT
GND
C195 0.1uF
C87 18
+5VRD
L4 2.2uHy
C126 1uF
U51
HSA0705
R120 33
C127 22
L16 560nH
C137 18
C133 1uF
R122 47
DIFF GAIN
U52
AD8307AR
R124 100K
L15 4.7uHy
C141 1000
C147 1uF
U53
AD8032AR
R121 10K
DIFF SLOPE
R123 7.5K
R110 4.75K 1%
R171 2.00K 1%
Q6 MMBT2907
R178 10.7K 1%
R127 10K
-5V
C121 1uF
R128 18.7K 1%
R129 3.48K 1%
R130 13.3K 1%
LOG DIFF
R156 4.02K 1%
U62
S/H
AD783JR
C135 1uF
R135 1K
TP14
R157 6.04K 1%
C151 1uF
R148 1K
REC_BEAM P5-2
A/D_DIF P5-24
TRANSMIT SHT.2
DS_INH SHT.2 P5-7
R112 10K 1%
R176 10K 1%
C140 1uF
U56
AD790AQ
C138 1uF
C159 100
R168 1K
TP28
TP27
R169 1K
SLS_INH P5-13
C158 1uF
U65
R155 8.06K 1%
R152 18.7K 1%
R151 10K
C157 1uF
R172 270
/SLS_PLS P5-31
C155 1uF
R153 13.3K 1%
R154 3.48K 1%
R179 10K 1%
+5VRS
U60
AD8032AR
R180 10K 1%
R134 5.36K 1%
A/D_SUM P5-23
C154 1uF
R181 4.02K 1%
U64
R182 6.04K 1%
C153 1uF
TP29
R170 1K
R173 270
/SAMPLE_HOLD P5-5
DELAY_PLS SHT.5
LOG_SUM
C162 1uF
C164 1uF
U67
TP16
R150 1K
DATA_RX P5-19
R174 270
TX_ENVLP P5-1
CR8 ZC2800
CR4 ZC2800
CR6 MMBD914
R14 470K
R146 1K
R147 1K
C165 1uF
C163 100
R184 10K 1%
CR7 1N6263
+5VRP
C130 1uF
L18 4.7uHy
C149 1000
C150 1uF
U63
LIM SUM_OUT SHT. 5
C152 .01uF
R177 51
C131 1000
U55 UPG2713T
L19 550nH
C128 18
C136 15
C129 18
U61 UPG2713T
SHT.2 RX_SUM_RF
R137 71.5 1%
R136 137 1%
R138 71.5 1%
-15dB
C142 1000
SHT.2 RX_SUM_LO
U57
R7 51
R191 0
PCB ASSY IF FILTER 80212001
IN A22 OUT
GND
C196 0.1uF
C192 18
+5VRS
L5 2.2uHy
C144 1uF
R132 33
U58
C145 22
L17 560nH
C122 18
U59
R144 47
SUM GAIN
L9 4.7uHy
C148 1uF
R143 100K
C139 1000
TP15
C146 1uF
R145 1K
U60
R140 10K
SUM SLOPE
R142 7.5K
R141 4.75K 1%
R160 2.00K 1%
RF_TEMP P5-30
TP19 SHEET 2
SCHEMATIC DIAGRAM
MUTLIMODE RF BOARD
80 211 003 REV E 031031
SHEET 4 OF 5


R111
1K
+6V
L2
220uHy
CR5
MMBD914
+15V
RFB15VF
P5-33
BATTERY 6V
P1-28
U19
Q2
VN10LM
R68
100
R69
100
+15VF
C171
22uF
25V
C174
22uF
25V
C175
22uF
25V
TP8
C176
22uF
25V
C173
1000
MAX643BESA
SPARE
P5-10
+6V
TP6
U18
+5V
TP7
U16
TP9
-5V
RFB5VN
P5-35
C172
22uF
25V
LM2940T-5.0
C177
.01uF
C178
22uF
25V
C179
22uF
25V
MAX860ESA
C181
100uF
10V
C180
100uF
10V
TP13
+5V
C83
1000
R116
1K
HIFREQ_6C
P5-34
U26
AD790AB
-5V
DELAY_PLS
SHT. 4
C84
1000
C85
100
LIM_SUM_OUT
SHT. 4
C75
1000
U24
SA602AN
C76
10
C78
10
L11
340nH
C79
.01uF
C80
1000
R93
249
1%
R57
61.9
1%
R92
61.9
1%
-20dB
R72
3.3K
C81
47
R73
3.3K
C82
47
C92
10
U20
C93
10
C91
1000
* VARIABLE COIL
L6
340nH
*
C88
33
C77
1000
C119
1000
R78
51
C95
.01uF
Q5
MMBT2222
R74
3.3K
R75
3.3K
R79
470
C123
0.1uF
U23
DELAY LINE
2211-250BC4
000
250NSEC
C120
0.1uF
R94
1K
TP11
U21
C169
1000
R80
100
C132
.01uF
L12
1uHy
L13
1uHy
TP12
C161
1000
R126
1K
DPSKRX
P5-11
DPSKPLS
P5-26
U22
AD790AQ
C134
100
R81
3.3K
C156
100
R82
3.3K
C166
1000
C170
100
SCHEMATIC DIAGRAM
MUTLIMODE RF BOARD
80 211 003 REV E 031031
SHEET 5 OF 5

CHAPTER VI

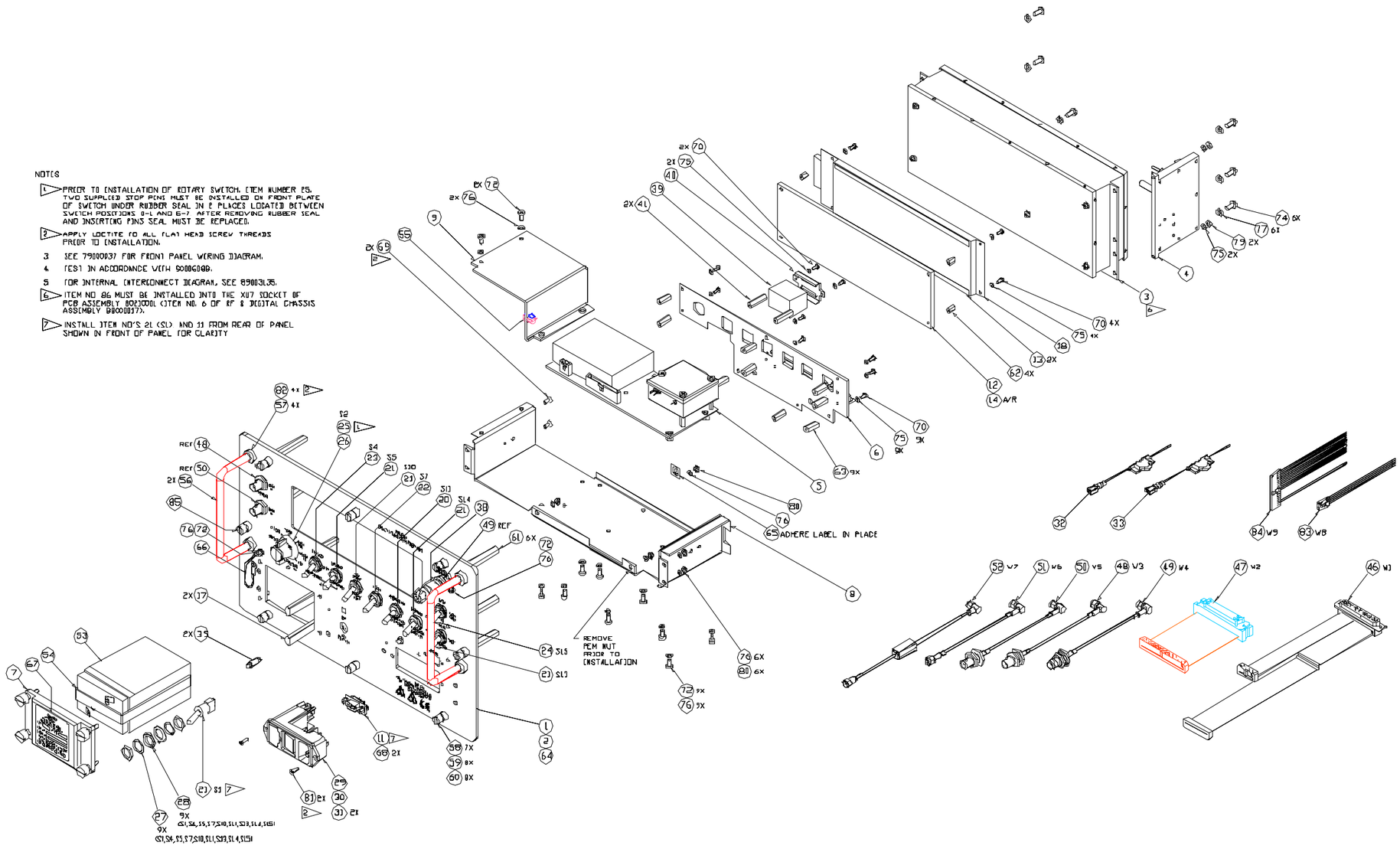
ILLUSTRATED PARTS BREAKDOWN
PARTS LIST



TR-220 Test Set and Accessories

Figure 6-1

TR-220 Test Set & Accessories				90 000 088		
#	QTY	Tel Desig.	Nomenclature	Ref Designator	Resource	Vendor P/N
	1	**75010186**	CABLE ASSY, DIRECT CONNECT			
	1	**75010025**	CABLE ASSY, AC POWER CORD			
	1	**75010078**	EXTENDER CABLE ASSY., DIRECTIONAL ANTENNA			
	1	**75010208-02**	DIRECTIONAL ANTENNA CABLE ASSEMBLY			
	1	**89001158-07**	DIRECTIONAL ANTENNA ASSEMBLY			
	1	**88001002**	DIRECTIONAL ANTENNA HANDLE ASSEMBLY			
	1	**89000166**	ANTI-RADIATION COUPLER ASSY, TAP-200 (10 FT.)			



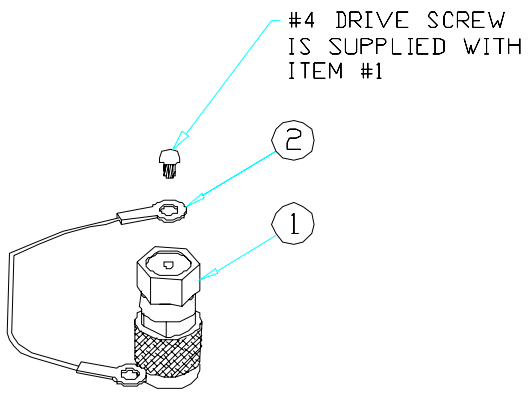
TR-220 Front Panel Assembly

Figure 6-2

Front Panel Assembly				89 000 135		
#	QTY	Tel Desig.	Nomenclature	Ref Designator	Resource	Vendor P/N
1	1	**61060051**	FRONT PANEL			
2	1	**57005039**	SILK SCREEN, FRONT PANEL			
3	1	**88000017**	CHASSIS ASSY	A4		
4	1	**89001077**	ATTENUATOR ASSY	A10		
5	1	**88000028**	POWER SUPPLY ASSY	A5		
6	1	**80189000**	PCB ASSY, FRONT PANEL SWITCH BOARD	A9		
7	1	**88000018**	BATTERY COVER ASSY	A15		
8	1	**62020071**	BRACKET, FRONT PANEL			
9	1	**62020072**	BRACKET, BATTERY			
10						
11	1	**48000113**	CONNECTOR, SUB D TYPE, 9 PIN		AMP	747905-2
12	1	**43015003**	FILTER, DISPLAY			
13	2	**31000011**	TAPE, FOAM, 1/4" X 8"		3M	4032
14	AR	**31010001**	SILICONE SEALANT, RTV			
15						
16						
17	2	**31016005**	TRIM MOLDING, ADHESIVE BACKED			
18	1	**45010001**	LCD DISPLAY		IEE	03857-03-040
19						
20	1	**46027520**	SWITCH, TOGGLE, SPDT	S11	C&K	7101-TCWZQE
21	5	**46027516**	SWITCH, TOGGLE, SPDT	S1, S5, S10, S13, S14	C&K	7105-TCWZQE
22	1	**46027517**	SWITCH, TOGGLE, SPDT	S7	C&K	7108-TCWZQE
23	1	**46027526**	SWITCH, TOGGLE, SPDT	S4	C&K	7103-TCWZQE
24	1	**46027521**	SWITCH, TOGGLE, SPDT	S15	C&K	7107-TCWZQE
25	1	**46020019**	SWITCH, ROTARY	S2	GRAYHILL	26ASD45-01-1-AJS
26	1	**57025023**	KNOB	S2	MS91528-1II1B	MS91528-1II1B
27	9	**52063004**	WASHER (.477 ID)	S1,S4,S5,S7,S10 ,S11,S13-S15	ASMCO	396-.020-SS-0
28	9	**52063003**	WASHER, SEALING, SWITCH	S1,S4,S5,S7,S10 ,S11,S13-S15	MFS	60064
29	1	**48035010**	AC RECEPTACLE		SCHURTER	KD14.110 1.151
30	1	**48035008**	FUSE DRAWER		SCHURTER	4303.2401
31	2	**45100026**	FUSE, 500mA/250V, SUPER TIME LAG		SCHURTER	34.504
32	1	**88000034**	ASSEMBLY, THERMISTOR (BLUE)			
33	1	**88000035**	ASSEMBLY, THERMISTOR (BROWN)			
34						
35	2	**45001015**	LED INDICATOR, SNAP-IN (GREEN)		DIALIGHT	559-2201-007

Front Panel Assembly				89 000 135		
#	QTY	Tel Desig.	Nomenclature	Ref Designator	Resource	Vendor P/N
38	1	**88001014**	TERMINATION ASSY	A14		
39	1	**48072001**	INVERTER		IEE	46013-01
40	1	**62020075**	BRACKET, INVERTER			
41	2	**52400053**	STANDOFF, FEMALE, 1/4 HEX X 15/16 LG		RAF	2111-440-SS-20
42						
43						
44						
45						
46	1	**75010165**	CABLE ASSY, DIGITAL/PANEL DISPLAY	W1		
47	1	**75010166**	CABLE ASSY, DIGITAL/F.P. SWITCH PCB	W2		
48	1	**75010075**	CABLE ASSY, RF/ANTENNA (SUM)	W3		
49	1	**75010079**	CABLE ASSY, ATTEN/DIRECT CONNECT	W4		
50	1	**75010081**	CABLE ASSY, RF/ANTENNA (DIFF)	W5		
51	1	**75010082**	CABLE ASSY, ANTENNUATOR/RF	W6		
52	1	**75010142**	CABLE ASSY, SENSE LINE FILTER	W7		
53	1	**48071006**	BATTERY			
54	1	**55008006**	BELT, BATTERY		McMASTER-CARR	6082K33-12
55	1	**55001007**	STRAIN RELIEF, BLACK		HEYCO	1017
56	2	**56025007**	HANDLE		VEMALINE PROD.	BZ130-1
57	2	**31020035**	FERRULE		PROMPTUS	288-09ALC
58	7	**50400002**	SCREW, CAPTIVE			
59	8	**52061001**	"O" RING		McMAS OR ASMCO	9464K11 OR #AS568A-006
60	8	**50500002**	RETAINER			
61	6	**52400054**	STANDOFF, FEMALE, 5/16 HEX X 2.688 LG		ASMCO	1240H-SS 2.688-12
62	4	**52400008**	STANDOFF, FEMALE, 1/4 HEX X 5/16 LG		RAF	2101-440-SS-20
63	9	**52400052**	STANDOFF, FEMALE, 1/4 HEX X 5/8 LG		RAF	2106-440-SS-20
64	1	**55082017**	GASKET, PANEL		TECKNIT	89-01080
65	1	**57031011**	LABEL, SAFTY FUNCTION		PANDUIT	PESC-H-EC
66	1	**55008004**	STRAP, ATTACHING		GLENAIR	G3.5-05
67	1	**57030017**	NAMEPLATE			

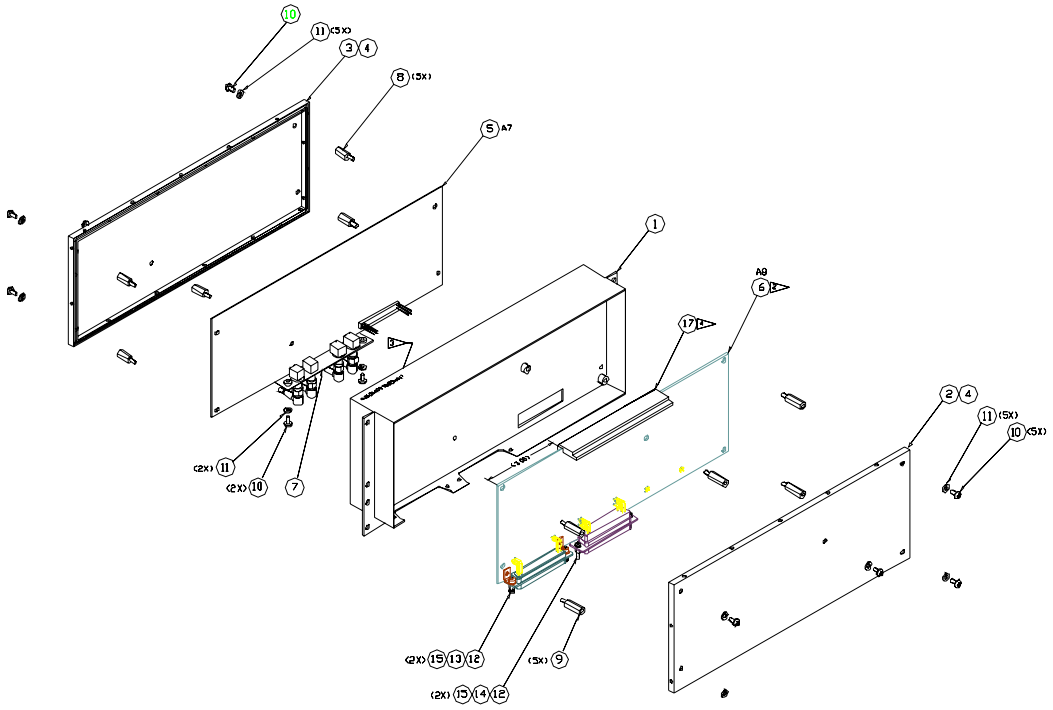
#	QTY	Tel Desig.	Nomenclature	Ref Designator	Resource	Vendor P/N
68	2	**52400049**	3/16 HEX JACK SCREW		RAF	4750-3
69	2	**50120005**	SCREW, FLAT HD, #6-32 X .31 LG		MS24693-C25	MS24693-C25
70	13	**50110007**	SCREW, PAN HD, #4-40 X .25 LG		MS51957-13	MS51957-13
71						
72	13	**50110001**	SCREW, PAN HD, #6-32 X .31 LG		MS51957-27	MS51957-27
73						
74	6	**50110013**	SCREW, PAN HD, #8-32 X .38 LG		MS51957-43	MS51957-43
75	17	**52020002**	WASHER, LOCK, #4		MS35338-135	MS35338-135
76	20	**52020001**	WASHER, LOCK, #6		MS35338-136	MS35338-136
77	6	**52020003**	WASHER, LOCK, #8		MS35338-137	MS35338-137
78						
79	2	**53010011**	NUT, HEX, EXTRA SMALL PATTERN #4-40		TOWER	4CNESS
80	7	**53010001**	NUT, HEX, #6-32		MS35649-264	MS35649-264
81	2	**50140015**	SCREW, FLAT HD, 82 DEG., #4-40 X .38 LG		MS51959-15	MS51959-15
82	4	**50140014**	SCREW, FLAT HD, 82 DEG., #8-32 X .50 LG		MS51959-45	MS51959-45
83	1	**75010163**	CABLE ASSY, POWER SUPPLY (4 PINS)	W8		
84	1	**75010193**	CABLE ASSY, POWER SUPPLY (18 PINS)	W9		
85	1	**50400004**	CAPTIVE SCREW			
86	1	**48077022-21**	PROGRAMMED MEMORY			
86	1	**40200104**	IC PROM, ERASABLE			
87	1	**48078006-02**	CPLD, PROGRAMMABLE			
		90006088	TEST PROCEDURE, COMPOSITE			
		79000037	WIRING DIAGRAM, FRONT PANEL			
		89003135	INTERCONNECT DIAGRAM, INTERNAL			



Termination Cap

Figure 6-3

Termination Cap				88 001 014		
#	**QTY**	**Tel Desig.**	**Nomenclature**	**Ref Designator**	**Resource**	**Vendor P/N**
1	1	**43003001**	TERMINATION CAP, 9.386K		ALAN	9400T-1940
2	1	**55008004**	STRAP, ATTACHING			



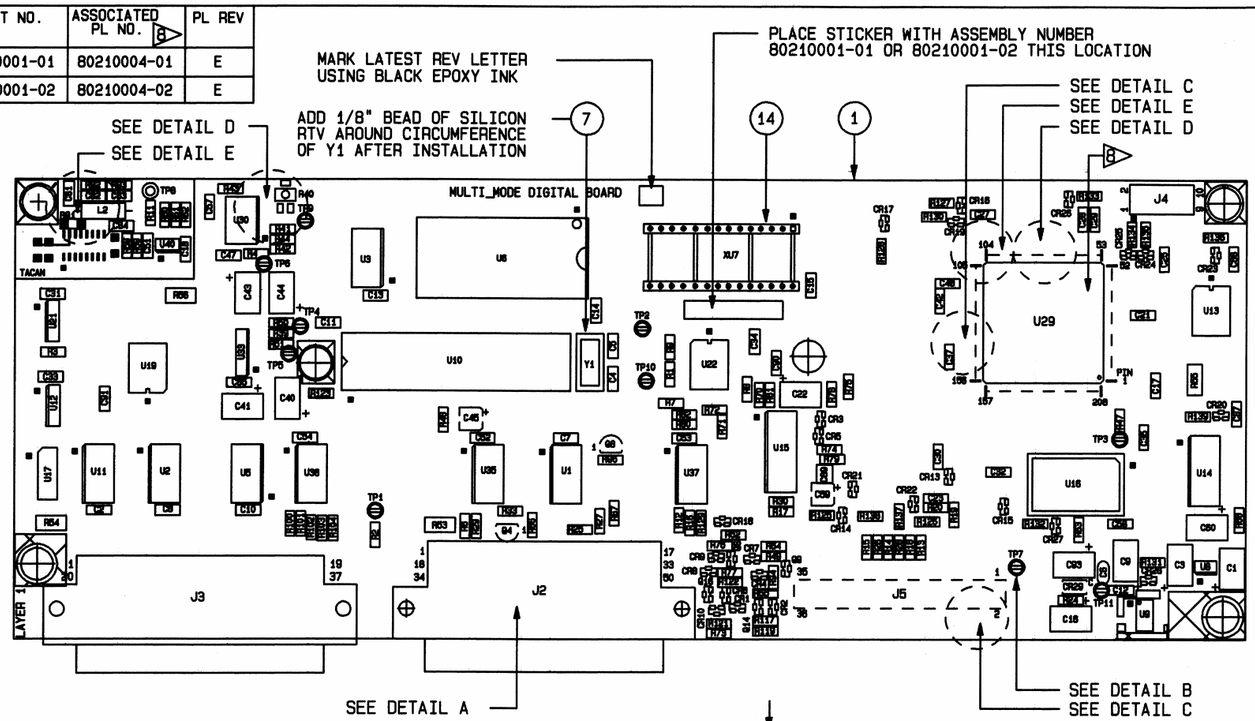
RF Digital Chassis

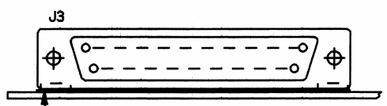
Figure 6-4

RF/Digital Chassis				88 000 017		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	1	**62000033**	CHASSIS, RF/DIGITAL			
2	1	**62040037**	COVER, DIGITAL CHASSIS			
3	1	**62040038**	COVER, RF CHASSIS			
4	AR	**55060001**	SHIELD, SPIRAL		SPIRA	SS-06
5	1	**80211001**	PCB ASSY, MULTIMODE RF BOARD			
6	1	**80210001**	PCB ASSY, MULTIMODE DIGITAL BOARD			
7	1	**62070052**	PLATE, SMA			
8	5	**52400029**	STANDOFF, MALE/FEMALE		RAF	4534-632-SS-20
9	5	**52400030**	STANDOFF, MALE/FEMALE		RAF	4537-632-SS-20
10	12	**50110015**	SCREW, PAN HD, #6-32 X .25 LG			MS51957-26
11	12	**52020001**	WASHER, LOCK, #6			MS35338-136
12	4	**52400032**	STANDOFF, 3/16 HEX, "D" CONN		RAF	4750-2
13	2	**50110021**	SCREW, PAN HD, #4-40 X .125 LG			MS51957-11
14	2	**50110008**	SCREW, PAN HD, #4-40 X .19 LG			MS51957-12
15	4	**52020002**	WASHER, LOCK, #4			MS35338-135
16						
17	1	**31004012**	STIFFENER BOARD			

PART NO.	ASSOCIATED PL NO.	PL REV
80210001-01	80210004-01	E
80210001-02	80210004-02	E

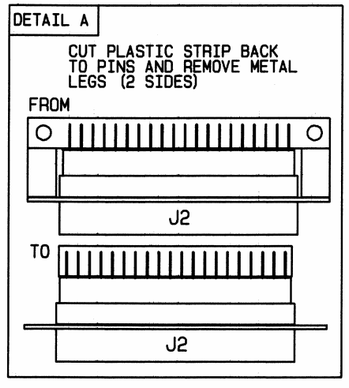
REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
D	ECO 1820: UPDATE PL REV BOX (ADDED -01 AND -02). UPDATE USED ON APPLICATION BLOCK.	031031	W.R.
E	ECO 1821: UPDATE PL REV BOX	031031	W.R.

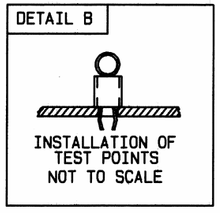


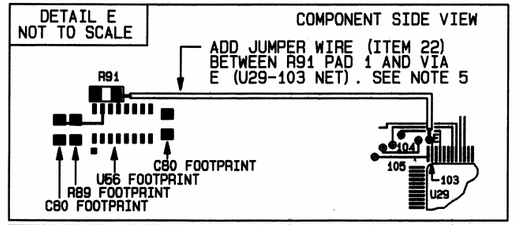


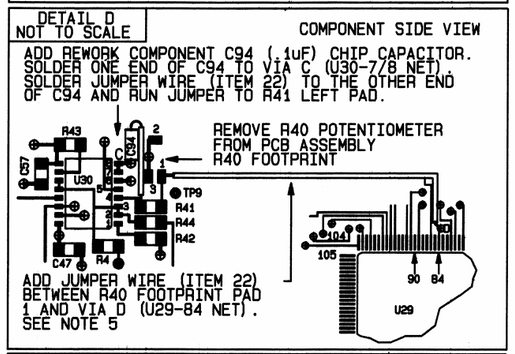
NOTES:

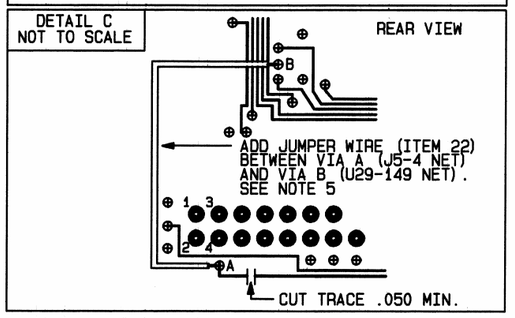
1. REFER TO TIC DOCUMENT ID 20 QP 002-APPENDIX A (SQR1 THROUGH SQR10) FOR SUPPLIER QUALITY REQUIREMENTS.
2. SEE ASSOCIATED PARTS LIST 80 210 004.
3. REFER TO CONFIGURATION CHART FOR CURRENT REVISION LEVEL OF PCB ASSEMBLY AND REVISION LEVELS OF RELATED DETAILS.
4. FR4, .062 THICK
5. SPOT CEMENT JUMPER WIRES (ITEM 22) TO PCB EVERY INCH ON GREATER THAN 1 INCH LENGTH.
6. FOR SCHEMATIC DIAGRAM SEE 80 210 003.
7. TEST IN ACCORDANCE WITH 80 210 006.
8. INSTALL U29 PER ASSOCIATED PARTS LIST.











80210001-01	89000083	T-47NC
80210001-01	89000085	T-47NH/NR
80210001-01	88000017	T-47SC
80210001-01	88000017	T-47SH
80210001-01	88000017	T-47G
80210001-02	88000031	TR-210
80210001-02	88000031	TR-220C
80210001-02	88000031	TR-220H
ASSY NUMBER	NEXT ASSY	USED ON
APPLICATION		

MATERIAL: COPPER CLAD GLASS EPOXY FR4 .062 THK.

FINISH

CONTRACT NO.

APPROVALS		DATE
DRAWN	D. McMAHON	021018
CHECKED	W.R	021018
ISSUED	W.R	021018

TEL-INSTRUMENT ELEC. CORP.

PCB ASSEMBLY
MULTI_MODE DIGITAL BOARD

SIZE	FSCM NO.	DWG. NO.	REV
D	92606	80210001-( )	E
SCALE NTS			SHEET 1 OF 1

Multimode Digital Board

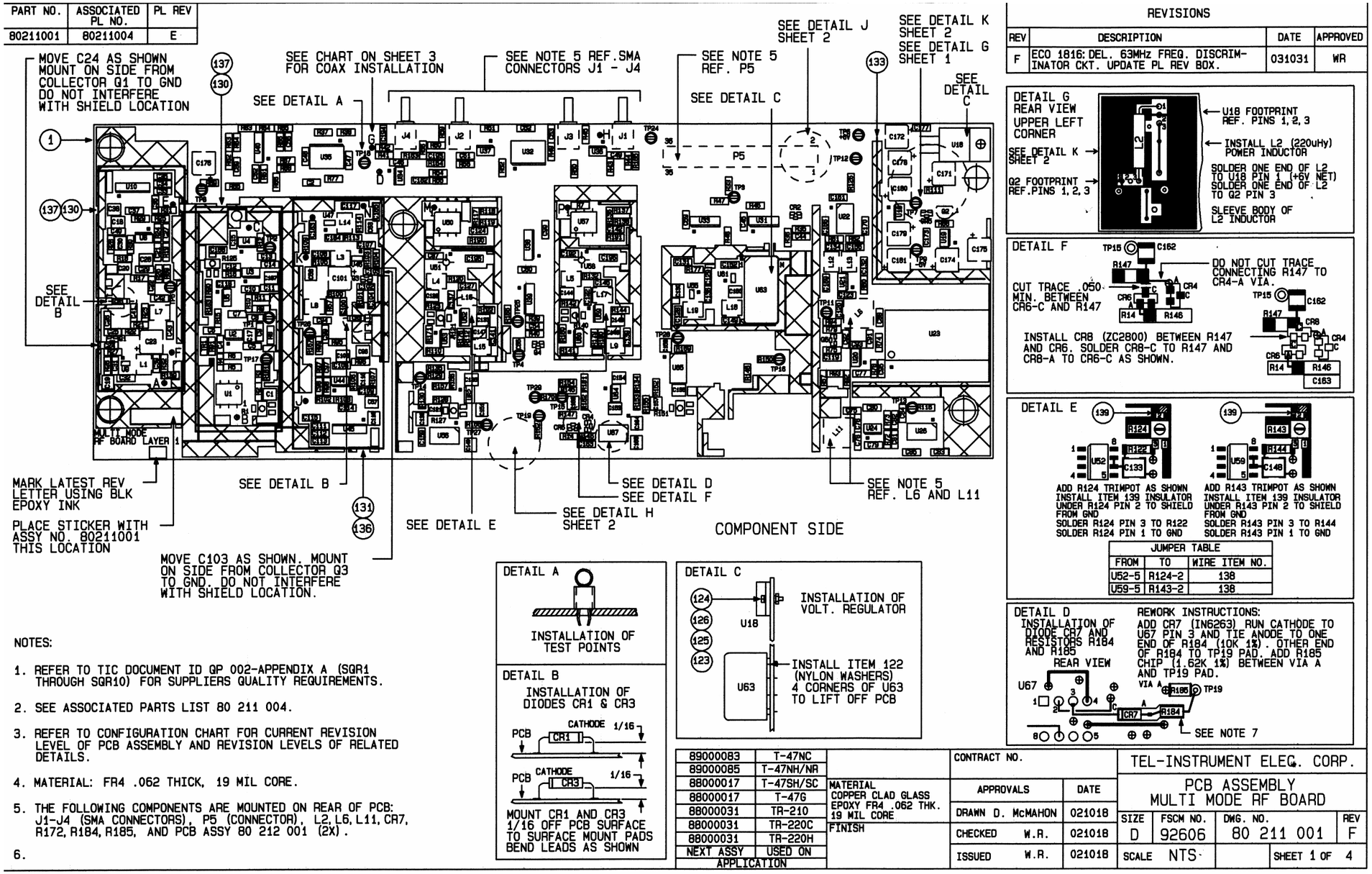
Figure 6-5

Multimode Digital PCB				80 210 001		
#	QTY	Tel Desig.	Nomenclature	Ref Designator	Resource	Vendor P/N
1	1	**80111002**	PCB DRILLING AND FABRICATION (REV B)			
2	1	**48000055**	CONNECTOR. HEADER, 36 PIN	J5	SAMTEC	SSW-118-01-G-D
3	1	**48000033**	CONNECTOR RT. ANGLE, 37 PIN	J3	AMP	FCC17-C37PC-44B
4	1	**48000054**	CONNECTOR RT. ANGLE, 50 PIN	J2	AMP	747497-4
5	1	**48000022**	CONNECTOR, HEADER, 10 PIN	J4	SPECTRUM	842-800-560-010
6	1	**40040016**	CRYSTAL, 12MHz	Y1		
7	1	**55080002**	CRYSTAL MOUNT	XY1		
8	1	**48075008**	CRYSTAL OSCILLATOR, 40MHz	U16	RALTRON	CO1025-40.000
9	1	**46025003**	8 PIN DIP SWITCH-SM	U17	C & K	TD08H0SK1
10						
11	1	**40200027**	I.C.	U10	INTEL	TP80C31BH-1
12						
13						
14	1	**48064006**	SOCKET, IC., 28 PIN	XU7	AUGAT	528-AG11D-ES
15	1	**48078006-01**	CPLD, PROGRAMMABLE	U29		
15	1	**40201137**	IC-PLD-SM; 208 PIN	U29	ALTERA	EPM9560RI208-20
16						
17	1	**40201138**	IC-SM	U6	BENCHMARQ	BQ4830YMA-85
18	1	**40200111**	I.C.	U15	ANALOG DEVICES	AD7828BR
19	1	**40201105**	IC-SM	U33	NAT'L SEMI	DS14C232C
20	1	**40201136**	IC-SM	U8	MAXIM	MAX660ESA
21	1	**40201139**	IC-SM		OLYMPIC	461-4
22	A/R	**72628001**	WIRE, KYNAR, INSULATED 28 AWG.	U9	TEXAS INST.	TPS76750QPWP
23	1	**56060019**	VOLT. REGULATOR; SM	U21	NAT'L SEMI	MC74HC00D
24	1	**40201038**	IC-SM	U12	FAIRCHILD	MC74HC04D
25	1	**40201019**	IC-SM			
26						
27	1	**40201011**	IC-SM			
28						
29	1	**40201014**	IC-SM	U1, U2, U5, U35, U37, U38, U11	FAIRCHILD	MM74HC574WM
30	7	**40201013**	IC-SM	U19, U13, U22	IDT	7204L25J1

Multimode Digital PCB				80 210 001		
#	QTY	Tel Desig.	Nomenclature	Ref Designator	Resource	Vendor P/N
31	3	**40201153**	IC-SM-FIFO	U40	TEXAS INST.	TL082CD
32	1	**40201008**	IC-SM	CR13-CR28	VISHAY	BAT54S
33	16	**40010044**	DIODE-SM (DUAL)	CR29	MOTOROLA	1SMA5918BT3
34	1	**40010045**	DIODE-SM 5.1V ZENER	CR1-CR10	FAIRCHILD	MMBD914
35	10	**40010014**	DIODE-SM			
36						
37	11	**55025008**	TERMINAL, POST	TP1-TP11	COMP. CORP	TP-105-01-09
38	1	**43011029**	INDUCTOR, 3.3uhy	L2	NYTRONICS	WEE-3300
39	2	**40001012**	TRANSISTOR	Q4, Q8	SILICONIX	VN10LM
40						
41	4	**40001017**	TRANSISTOR-SM	Q6, Q9, Q14, Q16	FAIRCHILD	MMBT918L
42						
43						
44						
45						
46	2	**41150002**	RES. CHIP, ARRAY 742-10K	R53, R54	DIGI-KEY	742C163103JCT-ND
47	2	**41150001**	RES. CHIP, ARRAY 742-1K	R55, R56	DIGI-KEY	742C163102JCT-ND
48	14	**41160015**	RES. CHIP; RC1206; 10K	R6, R12-R16, R18, R20, R24, R29, R48, R58, R59, R68		
49	1	**41160013**	RES. CHIP; RC1206; 4.7K	R19		
50	1	**41160096**	RES. CHIP; RC1206; 39K	R41		
51	44	**41160003**	RES. CHIP; RC1206; 1K	R1-R4, R7-R9, R11, R25-R28, R33, R47, R50-R52, R64-R67, R94, R96, R100-R104, R73, R77, R119, R122, R123, R125-R132, R137-R139		
52	1	**41160041**	RES. CHIP; RC1206; 15K	R92		
53	3	**41160030**	RES. CHIP; RC1206; 2K	R39, R91, R93		
54	1	**41160008**	RES. CHIP; RC1206; 2.2K	R62		
55	1	**41160029**	RES. CHIP; RC1206; 3.3K	R89		
56	5	**41160021**	RES. CHIP; RC1206; 470 OHMS	R49, R63, R76, R117, R121		
57	4	**41160007**	RES. CHIP; RC1206; 33 OHMS	R133-R136		
58	1	**41160032**	RES. CHIP; RC1206; 82 OHMS	R44		
59	2	**41160077**	RES. CHIP; RC1206; 1.6K	R42, R43		

Multimode Digital PCB				80 210 001		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
60	1	**41101260**	RES. CHIP; RC1206, MF 1%; 4.99K	R60		
61	A/R	**31006001**	TAPE, ISULATING			KAPTON
62	2	**41101222**	RES. CHIP; RC1206, MF 1%; 2K	R71, R81		
63	1	**41101289**	RES. CHIP; RC1206, MF 1%; 10.0K	R61		
64	2	**41101251**	RES. CHIP; RC1206, MF 1%; 4.02K	R78, R79		
65	5	**41101239**	RES. CHIP; RC1206, MF 1%; 3.01K	R30, R70, R72, R80, R82		
66	2	**41101193**	RES. CHIP; RC1206, MF 1%; 1K	R74, R75		
67	1	**41101297**	RES. CHIP; RC1206, MF 1%; 12.1K	R17		
68	3	**42025037**	CAP. CHIP; CC1206, NPO; 1000pF	C23, C80, C90		
69	1	**42026001**	CAP. CHIP; CC1210; 1uF	C89		
70	1	**42025033**	CAP. CHIP; CC1206; NPO; 470pF	C83		
71	2	**42025019**	CAP. CHIP; CC1206, NPO; 33pF	C4, C5		
72	1	**42025028**	CAP. CHIP; CC1206; 180 pF	C81		
73	1	**42100006**		C6		
73					LEMET (ALT)	C322C102KIR5CA
74	37	**42020001**	1	C2, C7, C8, C10-15, C17, C18, C21, C25, C27-35, C37, C42, C47, C48, C51-54, C57, C58, C85-87, C88, C99		
75	8	**42480009**	CAP. TANT-SM; 22uF/25V;	C9, C16, C22, C40, C41, C43, C44, C60	PANASONIC	ECS-T1ED226R
	ALT				AVX (ALT)	TAJ-D-226K-025R
76	1	**42185019**	CAP. ALUM ELECT-SM; 3.3uF/50V	C59	PANASONIC	ECE-V1HV3R3SR
77	3	**42480008**	CAP. TANT-SM; 100uF/10V	C1, C3, C93		TAJD107K010R
78	1	**42185030**	CAP. ALUM ELECT-SM; 10uF/16V	C45		ECE-V1CA100R
79	1	**50110009**	SCREW, PAN HD. 4-40X5/16 LG.			MS51597-14
80	1	**52020002**	WASHER, LOCK NO. 4			MS35338-135

Multimode Digital PCB				80 210 001		
#	**Qty**	**Tel Desig.**	**Nomenclature**	**Ref Desig.**	**Resource**	**Vendor P/N**
81	1	**52010002**	WASHER, FLAT NO. 4			MS15794-804
82	1	**53010002**	NUT, HEX NO. 4			MS35649-244
83	2	**42020014**	CAP. CHIP; CC1206; X7R; 22pF	C82		
84	1	**42020013**	CAP. CHIP; CC1206; X7R; .1uF	C84, C94		
85	A/R	**31010005**	WIRE TACKING ADHESIVE			TAKPAK 444
		80210003				



NOTES:

1. REFER TO TIC DOCUMENT ID QP 002-APPENDIX A (SQR1 THROUGH SQR10) FOR SUPPLIERS QUALITY REQUIREMENTS.
2. SEE ASSOCIATED PARTS LIST 80 211 004.
3. REFER TO CONFIGURATION CHART FOR CURRENT REVISION LEVEL OF PCB ASSEMBLY AND REVISION LEVELS OF RELATED DETAILS.
4. MATERIAL: FR4 .062 THICK, 19 MIL CORE.
5. THE FOLLOWING COMPONENTS ARE MOUNTED ON REAR OF PCB: J1-J4 (SMA CONNECTORS), P5 (CONNECTOR), L2, L6, L11, CR7, R172, R184, R185, AND PCB ASSY 80 212 001 (2X).
6.

89000083	T-47NC
89000085	T-47NH/NR
88000017	T-47SH/SC
88000017	T-47G
88000031	TR-210
88000031	TR-220C
88000031	TR-220H
NEXT ASSY	USED ON
APPLICATION	

MATERIAL: COPPER CLAD GLASS EPOXY FR4 .062 THK. 19 MIL CORE

FINISH

CONTRACT NO.

APPROVALS		DATE
DRAWN	D. McMAHON	021018
CHECKED	W.R.	021018
ISSUED	W.R.	021018

TEL-INSTRUMENT ELEC. CORP.

PCB ASSEMBLY
MULTI MODE RF BOARD

SIZE	FSCM NO.	DWG. NO.	REV
D	92606	80 211 001	F

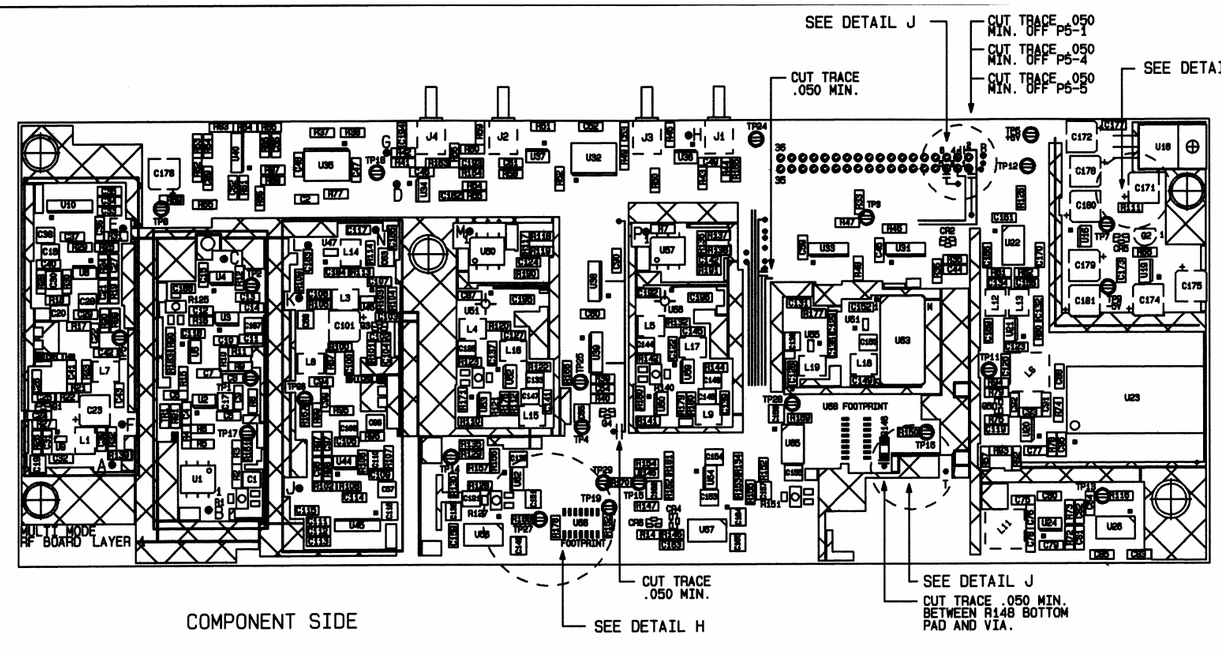
SCALE NTS · SHEET 1 OF 4

REVISIONS

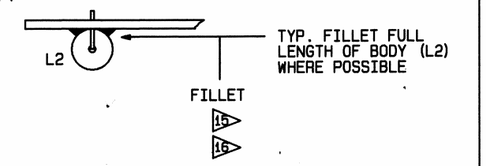
REV	DESCRIPTION	DATE	APPROVED
F	ECO 1816: DEL. 63MHz FREQ. DISCRIMINATOR CKT. UPDATE PL REV BOX.	031031	WR

JUMPER TABLE		
FROM	TO	WIRE ITEM NO.
U52-5	R124-2	138
U59-5	R143-2	138

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
	SEE SHEET 1		

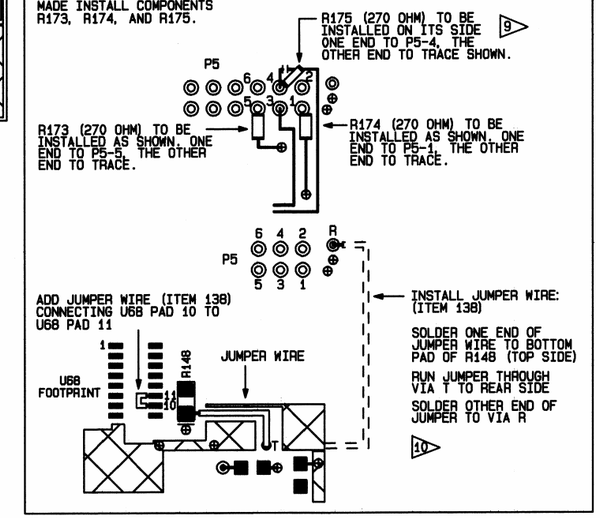


DETAIL K
REAR VIEW
NOT TO SCALE

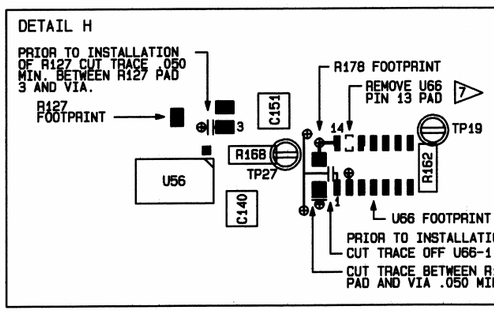


DETAIL J

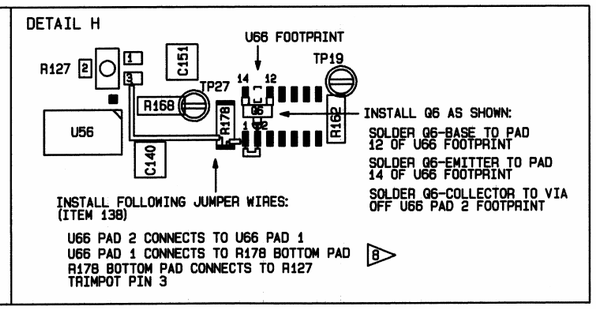
AFTER TRACE CUTS ARE MADE INSTALL COMPONENTS R173, R174, AND R175.



DETAIL H



DETAIL H



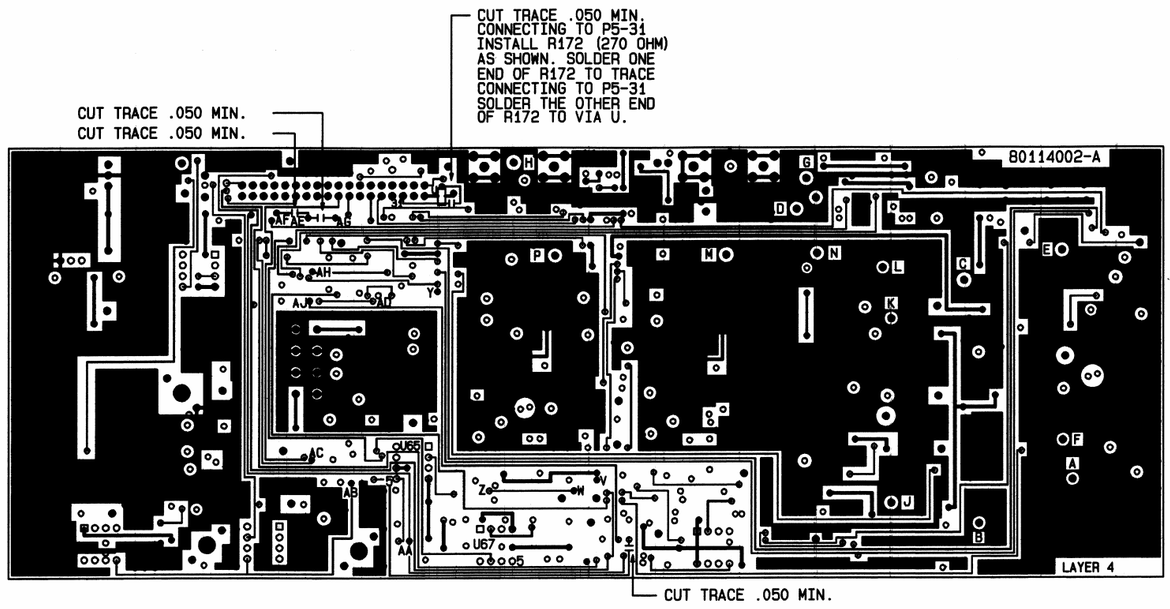
NOTES:

7. U66-13 PAD MUST BE REMOVED FOR PROPER INSTALLATION OF Q6 (TRANSISTOR). REFER TO DETAIL H.
8. SOLDER JUMPER WIRES (ITEM 138) TO FOUR PADS AS SHOWN. REFER TO DETAIL H.
9. COMPONENT R175 SHOULD BE INSTALLED ON IT'S SIDE AS SHOWN.
10. JUMPER WIRE (ITEM 138) MUST PASS THROUGH VIA T TO ALLOW FOR CONNECTION FROM COMPONENT SIDE TO SOLDER (REAR) SIDE.
15. AFTER PRELIMINARY FUNCTIONAL TEST, STAKE COMPONENT AS SHOWN USING A FILLET OF RTV ITEM 134 OR EQUIVALENT. ALL COMPONENT LEADS MUST BE FREE OF STAKING.
16. TYPICAL STAKING OF AXIAL LEADED COMPONENTS, SEE COMPONENT FOR LOCATION AND APPROXIMATE LENGTH OF FILLET.

CONTRACT NO.		TEL-INSTRUMENT ELEC. CORP.				
		PCB ASSEMBLY MULTI MODE RF BOARD				
APPROVALS	DATE	SIZE	FSCM NO.	DWG. NO.		REV
DRAWN D. McMAHON	030804	D	92606	80 211 001		F
CHECKED WR	030804	SCALE NTS			SHEET 2 OF 4	
ISSUED WR	030804					

Multimode RF Board
(2 of 4)
Figure 6-6b

	REVISIONS		
REV	DESCRIPTION	DATE	APPROVED
	SEE SHEET 1		



SOLDER SIDE

NOTES:

11 SPOT CEMENT JUMPER WIRES AND COAX CABLES TO PCB USING ITEM 129. SPOT CEMENT APPROXIMATELY EVERY INCH ON GREATER THAN ONE INCH LENGTH.

12 INSTALL JUMPER WIRES AND COAX CABLES ACCORDING TO TABLE POINT TO POINT DIRECTIONS.

11 12

COAX TABLE			
FROM	TO	LOCATION	COAX
HOLE "A"	HOLE "B"	SOLDER SIDE	ITEM 47
HOLE "C"	HOLE "D"	SOLDER SIDE	ITEM 47
HOLE "E"	HOLE "F"	SOLDER SIDE	ITEM 47
HOLE "G"	HOLE "H"	SOLDER SIDE	ITEM 47
HOLE "J"	HOLE "K"	SOLDER SIDE	ITEM 47
HOLE "L"	HOLE "M"	SOLDER SIDE	ITEM 47
HOLE "N"	HOLE "P"	SOLDER SIDE	ITEM 47

11 12

JUMPER WIRE TABLE			
FROM	TO	LOCATION	COAX
VIA "V"	VIA "W"	SOLDER SIDE	ITEM 138
U67-5	VIA "Y"	SOLDER SIDE	ITEM 138
VIA "Z"	VIA "AA"	SOLDER SIDE	ITEM 138
VIA "AA"	VIA "AB"	SOLDER SIDE	ITEM 138
VIA "AC"	U65-5	SOLDER SIDE	ITEM 138
VIA "AD"	VIA "AE"	SOLDER SIDE	ITEM 138
VIA "AF"	VIA "AG"	SOLDER SIDE	ITEM 138
VIA "AH"	VIA "AJ"	SOLDER SIDE	ITEM 138

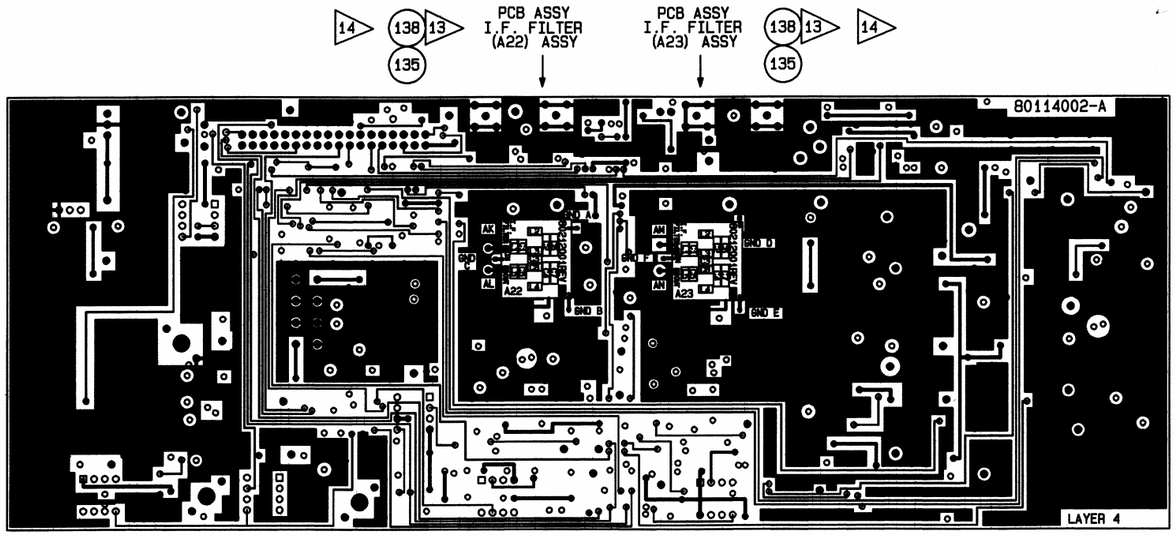
CONTRACT NO.		TEL-INSTRUMENT ELEC. CORP.			
		PCB ASSEMBLY MULTI MODE RF BOARD			
APPROVALS	DATE	SIZE	FSCM NO.	DWG. NO.	REV
DRAWN D.McMAHON	030804	D	92606	80 211 001	F
CHECKED WR	030804	SCALE NTS		SHEET 3 OF 4	
ISSUED WR	030804				

Multimode RF Board
(3 of 4)
Figure 6-6c

JUMPER WIRE TABLE			
FROM I.F FILTER PCB 80 212 001 (A22)	TO RF PCB 80 211 001	LOCATION	WIRE
GND A	GND PLANE	SOLDER SIDE	ITEM 138
GND B	GND PLANE	SOLDER SIDE	ITEM 138
GND C	GND PLANE	SOLDER SIDE	ITEM 138
IN	VIA "AK"	SOLDER SIDE	ITEM 138
OUT	THRU VIA "AL" TO C196 PAD	COMPONENT SIDE	ITEM 138

JUMPER WIRE TABLE			
FROM I.F FILTER PCB 80 212 001 (A23)	TO RF PCB 80 211 001	LOCATION	WIRE
GND D	GND PLANE	SOLDER SIDE	ITEM 138
GND E	GND PLANE	SOLDER SIDE	ITEM 138
GND F	GND PLANE	SOLDER SIDE	ITEM 138
IN	VIA "AM"	SOLDER SIDE	ITEM 138
OUT	THRU VIA "AN" TO C195 PAD	COMPONENT SIDE	ITEM 138

	REVISIONS		
REV	DESCRIPTION	DATE	APPROVED
	SEE SHEET 1		



NOTES:

13 PRIOR TO INSTALLATION OF I.F. FILTER PCB ASSY'S (A22 AND A23) 80212001 ITEM 135, DRILL OUT VIA'S LABELED "AL" AND "AN". DRILL OUT USING .052 DIAMETER DRILL. INSTALL JUMPER WIRES PER JUMPER WIRE TABLE. INSULATION MUST BE REMOVED ON ALL JUMPER WIRES USED ON THE I.F. FILTER BOARDS (A22 AND A23) EXCEPT THE WIRES GOING TO VIA'S THAT ARE LABELED "AL" AND "AN". THE WIRES THAT GO TO VIA'S "AL" AND "AN" MUST PASS THROUGH HOLE ON REAR OF PCB TO COMPONENT SIDE. INSULATION MUST STAY ON THESE WIRES ONLY.

14 APPLY A THIN LAYER OF ADHESIVE CEMENT (ITEM 132) BETWEEN RF PCB 80 211 001 AND I.F. FILTER PCB'S 80 212 001. (2 PLACES ASSY'S A22 AND A23).

CONTRACT NO.		TEL-INSTRUMENT ELEC. CORP.			
		PCB ASSEMBLY, MULTI MODE RF BOARD			
APPROVALS	DATE	SIZE	FSCM NO.	DWG. NO.	REV
DRAWN D.MCMAHON	030804	D	92606	80 211 001	F
CHECKED WR	030804	SCALE NTS		SHEET 4 OF 4	
ISSUED WR	030804				

Multimode RF Board
(4 of 4)
Figure 6-6d

Multimode RF PCB				80 211 001		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	1	**80114002**	PCB Drill and Fab. RF			
2	5	**40200113**	Comparator, AD790AQ, DIP	U22, U26, U56, U65, U67	Analog Devices	AD790AQ
3	1	**40201142**	Delay Line, 250 nSec	U23	Data Delay Dev.	250NSEC 2211-250BC4
4	1	**40201139**	Regulator, -5VDC, MAX660ESA, SO-8	U16	Maxim	MAX660ESA
5	2	**40201143**	Op-Amp, Dual TL082ID, SO-8	U8, U44		TL082ID
6	1	**40201144**	Regulator, +15VDC, MAX643BESA, SO-8	U19	Maxim	MAX643BESA
7	2	**40201084**	Strathesizer, MB1507PF, SO-16	U10, U45		MB1507PF
8						
9	3	**40201145**	Freq. Discr, SA602AM, SO-8	U20, U21, U24		SA602AM
10	2	**40201149**	Log Amp, AD307AR SO-8	U52, U59	Analog Devices	AD8307AR
11	2	**40201088**	RF Amp, UPC2713T, SO-8	U55, U61	NEC	UPC2713T
12	2	**40201150**	Op-Amp, Dual AD8032AR, SO-8	U53, U60	Analog Devices	AD8032AR
13	1	**40201113**	RF Amp, VNA-25, SO-8	U4	Mini-Circuits	VNA-25
14	1	**40201114**	RF Switch, MSWA-2-20, SO-8	U34	Mini-Circuits	MSWA-2-20
15	2	**40201115**	RF Switch, MSWT-4-20, SO-8	U36, U37	Mini-Circuits	MSWT-4-20
16	1	**40201116**	Comparator, Quad, LM2901N, SO-8	U40		LM2901M
17	2	**40201112**	IF Amp, IVA-05208, SO-8	U2, U3	Hewlett Packard	IVA-05208
18	2	**40201011**	Switch, CMOS, MM74HC4516WM, SO-16	U32, U35		MM74HC4316WM
19	2	**40201117**	Sample & Hold, AD783JR, SO-8	U62, U64	Analog Devices	AD783JR
20	1	**40201038**	Nand, Quad, 74HC00M, SO-14	U39		74HC00M
21	3	**40201086**	MIXER, RMS-11F	U1, U50, U57	Mini-Circuits	RMS-11F
22	1	**56060006**	Regulator, SUDC, LM2940T-5.0	U18	National Semi.	LM2940T-5.0
23						
24	2	**40201128**	RF Amp, MSA0786	U51, U58	Hewlett Packard	MSA0786
25	2	**40201132**	RF Amp, MSA2111	U46, U47	Hewlett Packard	MSA2111
26	1	**40201147**	RF Amp, UPC2708T	U9	NEC	UPC2708T
27	1	**40200112**	FILTER, 60MHz, PBP-60	U63	Mini-Circuits	PBP-60
28	1	**40201047**	Op Amp, Dual, LM-2904, SO-8	U5		LM2904M
29	1	**40201005**	XOR, Quad, 2 input, 74HC86M, SO-14	U31		74HC86M
30	1	**40201053**	NOR, Triple, 3 input, 74HC27M, SO-14	U33		74HC27M

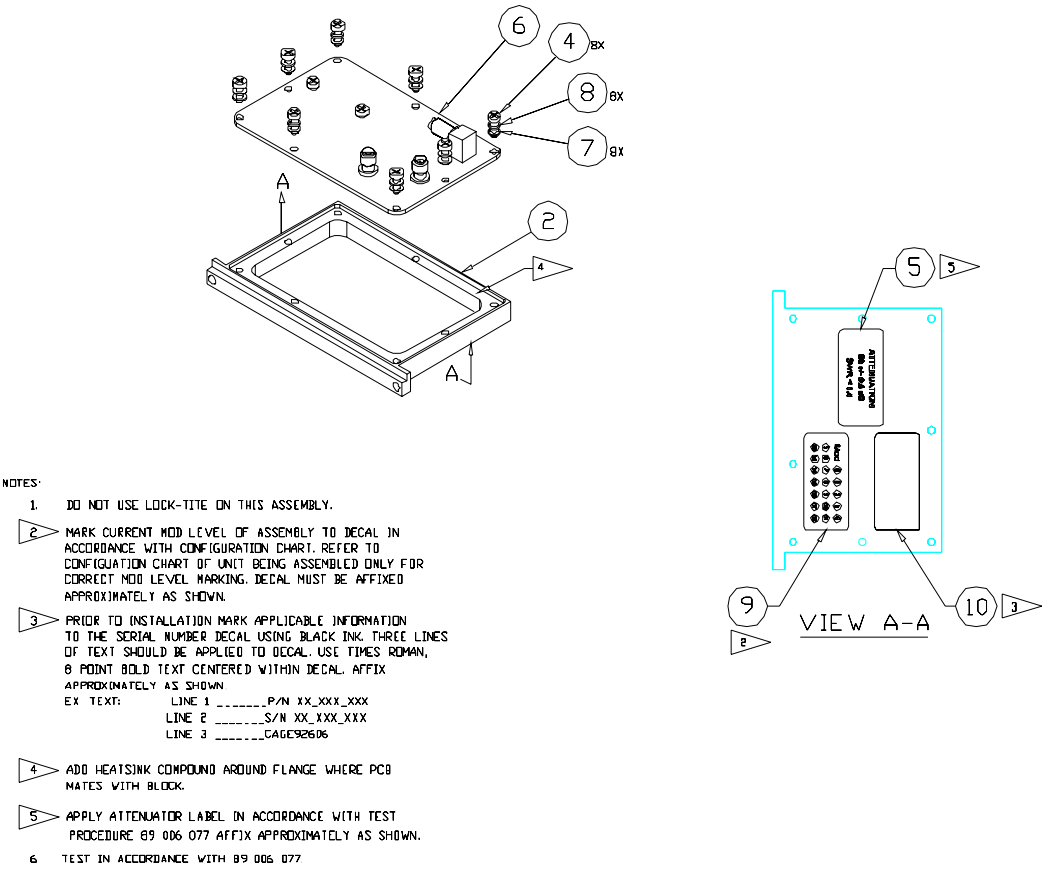
Multimode RF PCB				80 211 001		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
31	2	**40001013**	Transistor, RF, NPN, NE02133, Sot-23	Q1, Q3	NEC	NE02133
32	1	**40001012**	Transistor, MOSFET, VN10LM	Q2		VN10LM
33	2	**40001014**	Transistor, PNP, MMBT2907, Sot-23	Q4, Q6		MMBT2907A
34	1	**40001011**	Transistor, NPN, MMBT2222A, Sot-23	Q5		MMBT2222A
35	3	**40010014**	Diode, SM, MMBD914, Sot-23	CR2, CR5, CR6		MMBD914
36	2	**40010011**	Diode, Varactor, PF, KV3201	CR1, CR3		KV3201
37	2	**40010016**	Diode, Shotky, ZC2800, Sot-23	CR4,CR8		ZC2800
38	3	**43011057**	Inductor-SM; .56uHy	L16, L17, L19	Toko	300NS-R56M
39	4	**48000056**	Connector-SMA, Female	J1-J4	E.F. Johnson	142-0701-501
40	1	**48000065**	Connector; 36 pin	P5	Samtec	ZSS-118-03-G-D-715
41	24	**55025008**	Terminal	TP1-TP9,TP11-TP19,TP24-TP29	Component Corp	TP-105-01-09
42	2	**43011053**	Inductor Variable; 340nHy	L6, L11	Standex	957106J2
43	2	**43011047**	Inductor-SM; 2.2uHy	L4, L5	Toko	300LS-2R2K
44	5	**43011019**	Inductor-SM; 1uHy	L1, L3, L12, L13, L14	Toko	300LS-1R0K
45	1	**43011078**	Inductor-SM; 220uHy	L2	Delevan	2474-29L
46	5	**43011031**	Inductor-SM; 4.7uHy	L7, L8, L9, L15, L18	Toko	300LS-4R7K
47	A/R	**71110006**	Cable Coax		Olympic	53284
48	1	**42025029**	Cap Chip NPO CC1206; 220pF	C194		
49	7	**42480009**	Cap -Tant-SM; 22uF/25V	C171-172, C174-176,C178-179	Panasonic	ECS-T1ED226R
50	70	**42025037**	Cap Chip NPO CC1206; 1000pF	C4-15,C21,C24,C29,C31-32, C36-37,C39,C40,C42-43, C45-49,C52-53,C56,C59-C62, C75,C77,C80, C83-84,C89,C90-91,C94,C97, C103,C105,C107-109, C114-115,C117-119,C124, C131,C139,C141-142,C149, C161,C166,C169,C173, C182-185,C193		
51	4	**42025013**	Cap Chip NPO CC1206; 10pF	C76,C78, C92-C93		

Multimode RF PCB				80 211 001		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
52	9	**42020013**	Cap Chip X7R CC1206; 0.1uF	C22,C27,C98-99,C120, C123,C188, C195, C196		
53	3	**42025015**	Cap Chip NPO CC1206; 15pF	C41, C100, C136		
54	5	**42020001**	Cap Chip X7R CC1206; 0.01uF	C79,C95,C132,C152,C177		
55	7	**42025025**	Cap Chip NPO CC1206; 100pF	C54,C85,C134,C156,C159, C163,C170		
56	2	**42025007**	Cap Chip NPO CC1206; 3.3pF	C25, C102		
57	2	**42025005**	Cap Chip NPO CC1206; 2.2pF	C26, C104		
58	9	**42025021**	Cap Chip NPO CC1206; 47pF	C33-35,C44,C81-82, C111-113		
59	38	**42026001**	Cap Chip X7R CC1210; 1uF	C1,C17-20,C28,C30,C38, C55,C57-58,C63, C96,C106,C110,C116, C121,C126,C130,C133,C135, C138,C140,C144,C146-148, C150,C151, C153-155, C157-158,C162,C164-165, C187		
60	1	**42025019**	Cap Chip NPO CC1206; 33pF	C88		
61	6	**42025016**	Cap Chip NPO CC1206; 18pF	C87, C122, C128, C129, C137, C192		
62	2	**42025017**	Cap Chip NPO CC1206; 22pF	C127, C145		
63						
64						
65	1	**41050009**	Potentiometer-SM; 5K	R125	Bourns	3314G-1-502E
66	1	**40010007**	Diode, Shottky	CR7		1N6263
67	5	**41050010**	Potentiometer-SM; 10K	R1,R121,R127,R140,R151	Bourns	3314G-1-103E
68	2	**41050013**	Potentiometer-SM; 100K	R124, R143	Bourns	3314G-1-104E
69	1	**41163001**	Thermistor-SM; 10K	TR1	Tone Metric	060412-6011-84-C1
70	1	**41000033**	Res. MF 1%, 10K RN55C1002F	R184		
71	1	**41101064**	Res. Chip 1% RC1206; 45.3 Ohm	R117		
72	1	**41101213**	Res. Chip 1% RC1206; 1.62K	R185		
73						
74	1	**41101261**	Res. Chip 1% RC1206; 5.11K	R60		
75	1	**41101191**	Res. Chip 1% RC1206; 953 Ohm	R63		

Multimode RF PCB				80 211 001		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
76	1	**41101110**	Res. Chip 1% RC1206; 137 Ohm	R136		
77	2	**41101108**	Res. Chip 1% RC1206; 130 Ohm	R118, R119		
78	2	**41101240**	Res. Chip 1% RC1206; 3.09K	R84, R162		
79	2	**41101292**	Res. Chip 1% RC1206; 10.7K	R83, R178		
80	2	**41101301**	Res. Chip 1% RC1206; 13.3K	R130, R153		
81	9	**41101289**	Res. Chip 1% RC1206; 10.0K	R59,R61,R64,R85-86,R112, R176,R179-180		
82	2	**41101159**	Res. Chip 1% RC1206; 442 Ohm	R4, R10		
83	2	**41101083**	Res. Chip 1% RC1206; 71.5 Ohm	R137, R138		
84	2	**41101315**	Res. Chip 1% RC1206; 18.7K	R128, R152		
85						
86	2	**41101251**	Res. Chip 1% RC1206; 4.02K	R156, R181		
87	2	**41101268**	Res. Chip 1% RC1206; 6.04K	R157, R182		
88	2	**41101280**	Res. Chip 1% RC1206; 8.06K	R62, R155		
89	1	**41101263**	Res. Chip 1% RC1206; 5.36K	R134		
90	1	**41101135**	Res. Chip 1% RC1206; 249 Ohm	R93		
91	4	**41101077**	Res. Chip 1% RC1206; 61.9 Ohm	R32, R56, R57, R92		
92	2	**41101245**	Res. Chip 1% RC1206; 3.48K	R129, R154		
93	4	**41101073**	Res. Chip 1% RC1206; 56.2 Ohm	R5, R6, R9, R11		
94	2	**41101258**	Res. Chip 1% RC1206; 4.75K	R110, R141		
95	2	**41101222**	Res. Chip 1% RC1206; 2.00K	R160, R171		
96	2	**41160045**	Res. Chip 5% RC1206; 240 Ohm	R15, R16		
97	2	**41160021**	Res. Chip 5% RC1206; 470 Ohm	R44, R79		
98	1	**41160070**	Res. Chip 5% RC1206; 390 Ohm	R39		

Multimode RF PCB				80 211 001		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
99						
100	5	**41160062**	Res. Chip 5% RC1206; 47 Ohm	R3,R105,R114,R122,R144		
101	2	**41160086**	Res. Chip 5% RC1206; 7.5K	R123, R142		
102	1	**41160006**	Res. Chip 5% RC1206; 180 Ohm	R26		
103	1	**41160036**	Res. Chip 5% RC1206; 470K	R14		
104						
105	2	**41160004**	Res. Chip 5% RC1206; 2.7K	R22, R101		
106	2	**41160007**	Res. Chip 5% RC1206; 33 Ohm	R120, R132		
107	10	**41160011**	Res. Chip 5% RC1206; 100 Ohm	R23, R27, R40, R67-R69, R80, R104, R109, R139		
108	5	**41160001**	Res. Chip 5% RC1206; 270 Ohm	R163, R172-R175		
109	4	**41160042**	Res. Chip 5% RC1206; 33K	R28, R30, R106, R107		
110	8	**41160043**	Res. Chip 5% RC1206; 51 Ohm	R7,R8,R12,R31,R78,R103,R113,R177		
111	4	**41160145**	Res. Chip 5% RC1206; 0 Ohm	R41, R55, R190, R191		
112	6	**41160025**	Res. Chip 5% RC1206; 100K	R19,R29,R47,R48,R97,R108		
113	2	**41160041**	Res. Chip 5% RC1206; 15K	R24, R98		
114	2	**41160047**	Res. Chip 5% RC1206; 22K	R25, R102		
115	2	**41160022**	Res. Chip 5% RC1206; 3.9K	R21, R100		
116						
117	11	**41160015**	Res. Chip 5% RC1206; 10K	R17-18,R42-43,R45,R54,R58, R91,R95-96, R164		
118	35	**41160003**	Res. Chip 5% RC1206; 1K	R2,R20,R33,R36-38,R46, R49-52,R65,R66,R77, R87-89,R94,R99,R111,R116, R126,R135,R145-148, R150,R161,R165-170		
119	2	**41160082**	Res. Chip 5% RC1206; 5.1K	R35, R90		
120	6	**41160029**	Res. Chip 5% RC1206; 3.3K	R72-R75, R81, R82		
121	4	**42480008**	Cap-Tant-SM; 100uF/10V	C23, C101, C180, C181	AVX	TAJD107K010R
122	4	**52062002**	Washer, Nylon		Seastrom	5610-214-20
123	1	**53010002**	Nut, Hex No.4			MS35649-244

Multimode RF PCB				80 211 001		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
124	1	**50110009**	Screw, P.H. 4-40 X 5/16 LG			MS51957-14
125	1	**52010002**	Washer, Flat, No. 4			MS15795-804
126	1	**52020002**	Washer, Lock, No. 4			MS35338-135
127	1	**41160089**	Res. Chip 5% RC1206; 12K	R183		
128	1	**42025033**	Cap Chip NPO CC1206; 470pF	C2		
129	AR	**31010005**	Adhesive, Wire Tacking		Loctite	TAK-PAK 444
130	2	**31020085**	Shield Isolation			
131	1	**31020084**	Shield Isolation			
132	AR	**31010001**	Adhesive, Silicone, RTV		Dow Corning	732
133	1	**31020086**	Shield Isolation			
134	AR	**31010011**	RTV, Silicone		Loctite	5145
135	2	**80212001**	Pcb Assembly, I.F. Filter			
136	1	**62040040**	Cover, Shield Isolation			
137	2	**62040039**	Cover, Shield Isolation			
138	AR	**72628001**	Wire, Kynar, Insulated, 28 AWG		Olympic	461-4
139	AR	**31006002**	Tape, Low Static Polymide Film		3M	5149
140	1	**40201078**	OR; Quad, 2 Input; MC74HC32M; SO-14	U38		
141	AR	**80211006**	TP, Multimode RF PCB			



NOTES:

1. DO NOT USE LOCK-TITE ON THIS ASSEMBLY.
2. MARK CURRENT MOD LEVEL OF ASSEMBLY TO DECAL IN ACCORDANCE WITH CONFIGURATION CHART. REFER TO CONFIGUATION CHART OF UNIT BEING ASSEMBLED ONLY FOR CORRECT MOD LEVEL MARKING. DECAL MUST BE AFFIXED APPROXIMATELY AS SHOWN.
3. PRIOR TO INSTALLATION MARK APPLICABLE INFORMATION TO THE SERIAL NUMBER DECAL USING BLACK INK. THREE LINES OF TEXT SHOULD BE APPLIED TO DECAL. USE TIMES ROMAN, 8 POINT BOLD TEXT CENTERED WITHIN DECAL. AFFIX APPROXIMATELY AS SHOWN
   EX TEXT: LINE 1 _____P/N XX_XXX_XXX
   LINE 2 _____S/N XX_XXX_XXX
   LINE 3 _____CAGE92606
4. ADD HEATSINK COMPOUND AROUND FLANGE WHERE PCB MATES WITH BLOCK.
5. APPLY ATTENUATOR LABEL IN ACCORDANCE WITH TEST PROCEDURE 89 006 077 AFFIX APPROXIMATELY AS SHOWN.
6. TEST IN ACCORDANCE WITH 89 006 077

Attenuator Assembly

Figure 6-7

Attenuator Assembly				89 001 077		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1						
2	1	**65000019**	BLOCK ATTENUATOR			
3						
4	8	**50110009**	SCREW, PAN HD. 4-40 X 5/16			MS51957-14
5	1	**57031020**	DECAL, ATTENUATOR			
6	1	**80173001**	PCB ASSEMBLY, ATTENUATOR BOARD			
7	8	**52010007**	FLAT WASHER			NAS620C-4L
8	8	**52020002**	WASHER, SPLIT-LOCK NO. 4			MS35338-135
9	1	**57031021**	DECAL, MOD			
10	1	**57030013**	DECAL, SERIAL NO.			

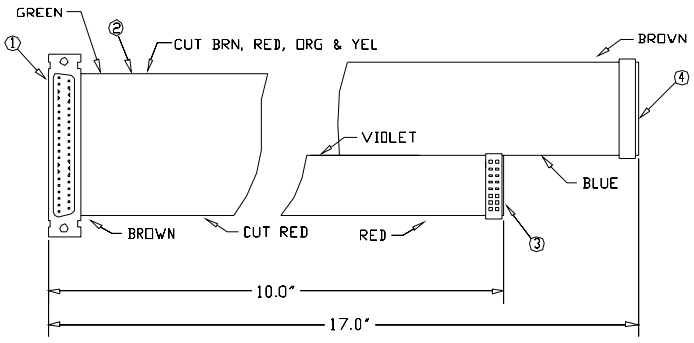
Attenuator PCB Assembly

(Drawing unavailable)

Attenuator PCB				80 173 001		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1						
2	1	**80173002**	Drilling and Fabrication (REV A)			
3	1	**41130016**	Resistor Power; Termination;50 Ohm	R7	RF Power	RFP-250-50TC
4	2	**42025037**	Cap Chip, NPO; CC1206; 1000PF	C1, C2		
5	1	**41160015**	Res Chip 5%; RC1206; 10K	R1		
6	1	**41101261**	Res Chip 1%; RC1206; 5.11K	R6		
7	1	**41101068**	Res Chip 1%; RC1206; 49.9 Ohm	R2		
8	2	**48040052**	Connector-SMA; Straight (.200 Foot print)	J1, J2	E.F. Johnson	142-0701-231
9	1	**48040059**	Connector-SMA; Right Angle (.200 Foot print)	J3	E.F. Johnson	142-0701-301
10	2	**41161009-80**	Res Chip 1%; RC0805; 66.5 Ohm	R3, R5		
11	1	**41101118**	Res Chip 1%; RC1206; 165 Ohm	R4 S.A.T.		
11	**SUB**	**41101117**	Res Chip 1%; RC1206; 162 Ohm	R4 S.A.T.		
11	**SUB**	**41101119**	Res Chip 1%; RC1206; 169 Ohm	R4 S.A.T.		
11	**SUB**	**41101120**	Res Chip 1%; RC1206; 174 Ohm	R4 S.A.T.		
11	**SUB**	**41110121**	Res Chip 1%; RC1206; 178 Ohm	R4 S.A.T.		
11	**SUB**	**41101122**	Res Chip 1%; RC1206; 182 Ohm	R4 S.A.T.		
11	**SUB**	**41101123**	Res Chip 1%; RC1206; 187 Ohm	R4 S.A.T.		
11	**SUB**	**41101124**	Res Chip 1%; RC1206; 191 Ohm	R4 S.A.T.		
12	1	**42020001**	Cap. Chip, X7R, CC1206, 0.01uF	C4		
13	1	**48065005**	Ferrite Chip	L1	Steward	MI1206K900R-00
14	2	**50110009**	Screw, Pan Hd. 4-40 X 5/16 Lg.			MS51957-14
15	2	**52010007**	Washer, Flat , Small Pattern No. 4			NAS620C-4L
16	2	**52020002**	Washer, Splitlock No. 4			MS35338-135
17	2	**53010011**	Nut, Hex, Extra Small Pattern No.4		Tower Fasterners	4CNESS

#	ITEM #1	CABLE WIRE	ITEM #4	ITEM #3
1	--	BRN	1	--
2	--	RED	2	--
3	--	ORG	3	--
4	--	YEL	4	--
5	1	GRN	5	--
6	20	BLU	6	--
7	2	VIO	7	--
8	21	GRY	8	--
9	3	WHT	9	--
10	22	BLK	10	--
11	4	BRN	11	--
12	23	RED	12	--
13	5	ORG	13	--
14	24	YEL	14	--
15	6	GRN	15	--
16	25	BLU	16	--
17	7	VIO	17	--
18	26	GRY	18	--
19	8	WHT	19	--
20	27	BLK	20	--
21	9	BRN	21	--
22	28	RED	22	--
23	10	ORG	23	--
24	29	YEL	24	--
25	11	GRN	25	--
26	30	BLU	26	--
27	12	VIO	--	1
28	31	GRY	--	2
29	13	WHT	--	3
30	32	BLK	--	4
31	14	BRN	--	5
32	33	RED	--	6
33	15	ORG	--	7
34	34	YEL	--	8
35	16	GRN	--	9
36	35	BLU	--	10
37	17	VIO	--	11
38	36	GRY	--	12
39	18	WHT	--	13
40	37	BLK	--	14
41	19	BRN	--	15
42	--	RED	--	16

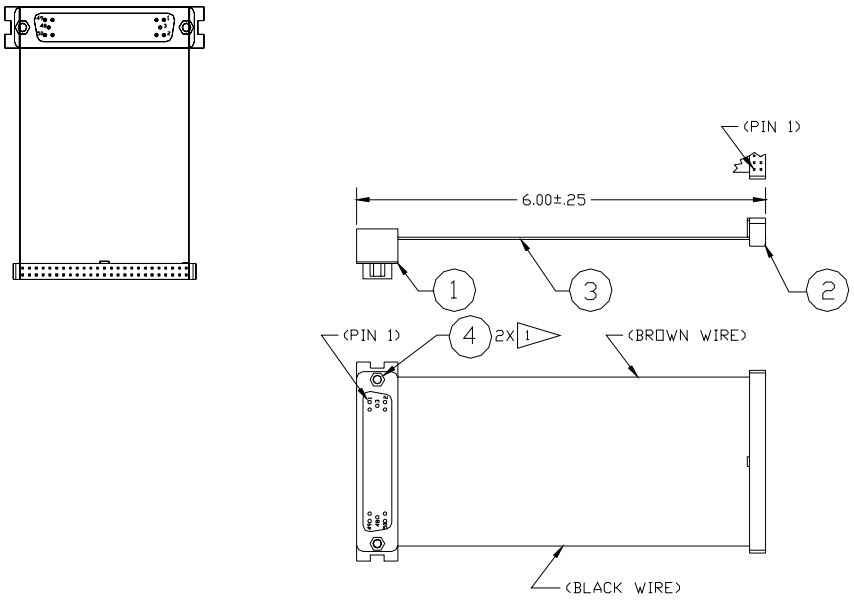
NOTES:
1 DISCARD WIRES ORANGES THRU BLACK (43-50)
2. SEE ASSOCIATED PARTS LIST 75 010 165



Cable Assembly, Dig/Panel Display

Figure 6-8

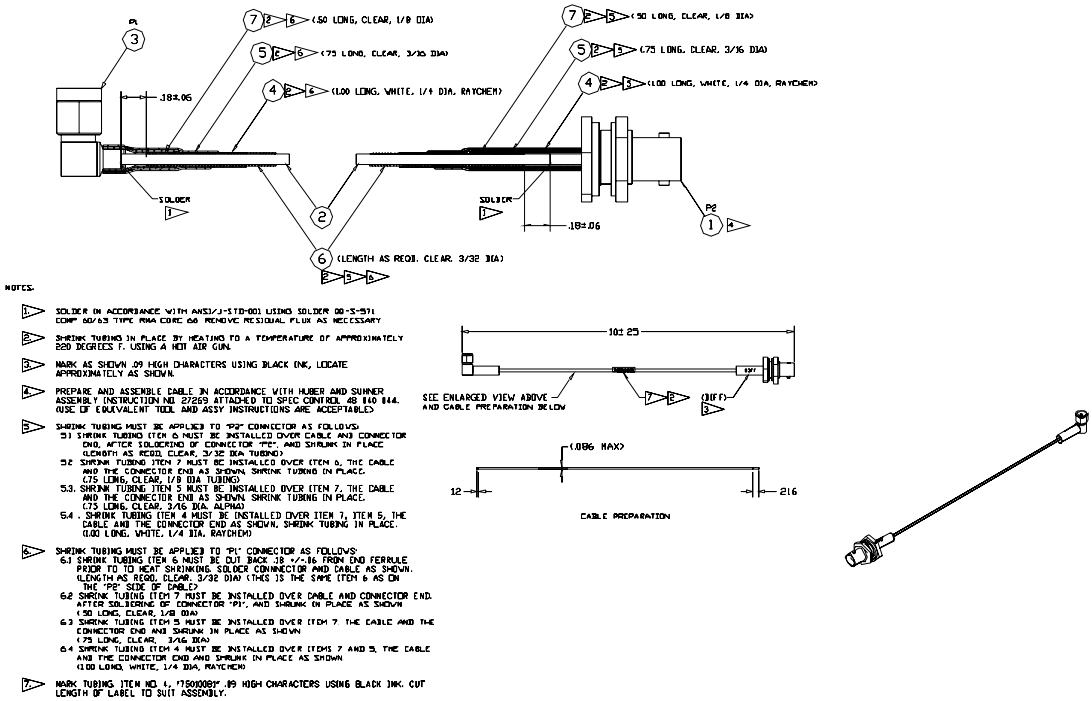
Cable Assembly, Dig/Panel Display				75 010 165		
#	**Qty**	**Tel Desig.**	**Nomenclature**	**Ref Desig.**	**Resource**	**Vendor P/N**
1	1	**48 000 039**	CONNECTOR, 37 PIN		AMP #747303-1	
2	A/R	**75 000 019**	CABLE, FLAT, 50 CONDUCTORS		3M #3302-50	
3	1	**48 000 059**	CONNECTOR, 16 PIN		T&B #622-1600	
4	1	**48 000 016**	CONNECTOR, 26 PIN		T&B #622-2630	



Cable Assembly, Dig/FP Switch PCB

Figure 6-9

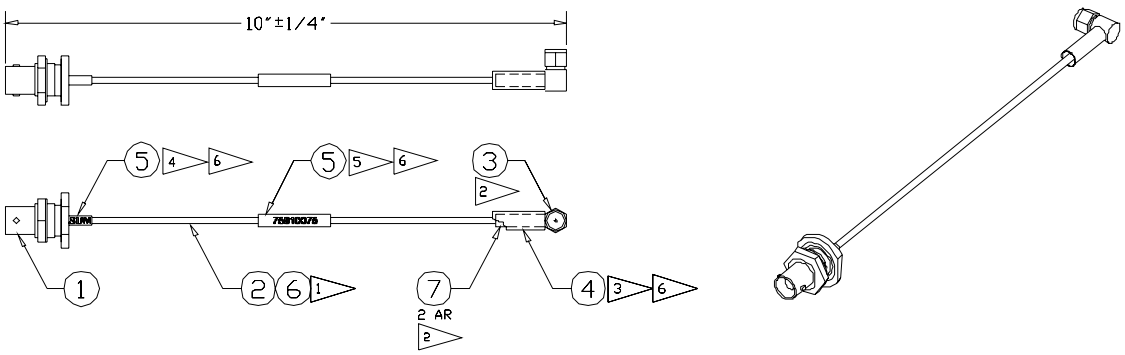
Cable Assembly, Dig/FP Switch PCB				75 010 166		
#	**Qty**	**Tel Desig.**	**Nomenclature**	**Ref Desig.**	**Resource**	**Vendor P/N**
1	1	**48000069**	CONNECTOR, RIBBON, 50 PIN		AMP	746789-1
2	1	**48000068**	CONNECTOR, RIBBON, 50 PIN		AMP	111564-4
3	AR	**75000019**	CABLE, 50 COND., 28 AWG		3M	3302-50
4	2	**52400032**	JACKSCREW, 4-40, 3/16 HEX X 3/16 LG.		RAF	4750-2



Cable Assembly, RF/Antenna Diff

Figure 6-10

Cable Assembly, RF/Antenna DIFF				75 010 081		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	1	**48040043**	CONNECTOR, BNC		HUBER-SUHNER	24BNC-50-2-20
2	AR	**71111002**	WIRE, COAX		HUBER-SUHNER	EZ-FLEX-086
3	1	**48040045**	CONNECTOR, RT. ANGLE, SMA		HUBER-SUHNER	16SMA-50-2-3
4	AR	**73000009**	SHRINK TUBING, CLEAR, 1" LG.		ALPHA	FIT-221-3/16
5	AR	**73000019**	SHRINK TUBING, WHITE, 1" LG.		RAYCHEM	TMS-SCE-1/4-2.0-9
6	AR	**73000008**	SHRINK TUBING, CLEAR, 3/32		ALPHA	FIT-221-3/32
7	AR	**73000010**	SHRINK TUBING, CLEAR, 1/8		ALPHA	FIT-221-1/8
	AR	**SN60/63**	SOFT SOLDER			QQ-S-571



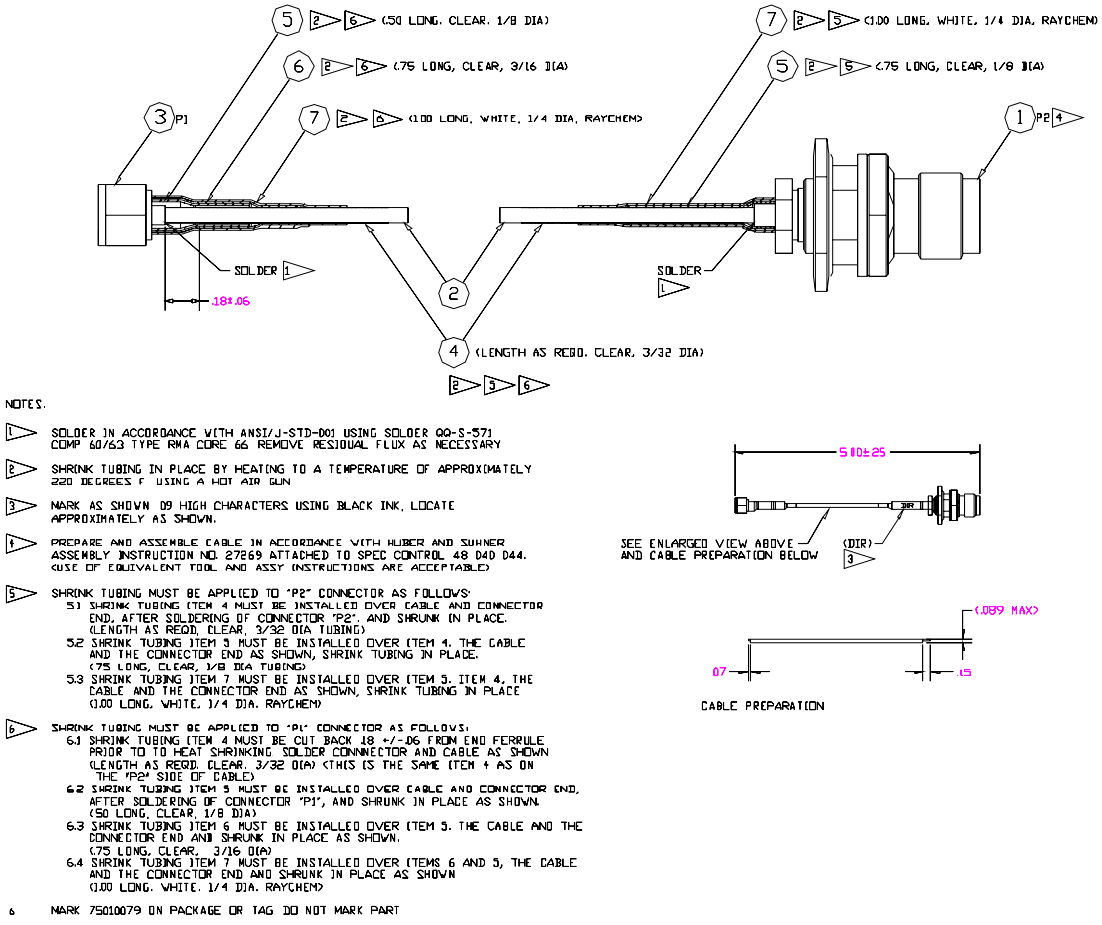
NOTES:

1. SHRINK TUBING (ITEM NUMBER 6) SHOULD BE INSTALLED OVER THE ENTIRE LENGTH OF CABLE (ITEM NUMBER 2) AND CONNECTOR ENDS OF CONNECTORS (ITEM NUMBERS 1 AND 3) SHRINK TUBING IN PLACE BY HEATING TO A TEMPERATURE OF APPROXIMATELY 220°F USING A HOT AIR GUN.
2. INSTALL TWO PIECES OF SHRINK TUBING (ITEM NO. 7) OVER FERRULE OF CONNECTOR (ITEM NO. 3). FIRST INSTALL A .50 INCH LONG PIECE OF SHRINK TUBING (ITEM NO. 7) OVER FERRULE AND SHRINK IN PLACE BY HEATING TO A TEMPERATURE OF APPROXIMATELY 220°F USING A HOT AIR GUN. INSTALL THE SECOND PIECE OF SHRINK TUBING (ITEM NO. 7) APPROXIMATELY .43 INCH LONG OVER THE .50 INCH LONG PIECE. SHRINK TUBING IN PLACE BY HEATING TO A TEMPERATURE OF APPROXIMATELY 220°F USING A HOT AIR GUN.
3. PLACE SHRINK TUBING (ITEM NO. 4) OVER ITEM NUMBERS 6 AND 7.
4. MARK SHRINK TUBING (ITEM NO. 5) "SUM" .08 HIGH CHARACTERS USING BLACK INK. INSTALL OVER ITEM NO. 6 AT CONNECTOR ITEM 1.
5. MARK SHRINK TUBING "75010075" .08 HIGH CHARACTERS USING BLACK INK. INSTALL AFTER ASSEMBLY OF ALL OTHER ITEMS. CUT LENGTH OF LABEL TO SUIT ASSEMBLY.
6. SHRINK TUBING IN PLACE BY HEATING TO A TEMPERATURE OF APPROXIMATELY 220°F USING A HOT AIR GUN.

Cable Assembly, RF/Antenna (SUM)

Figure 6-11

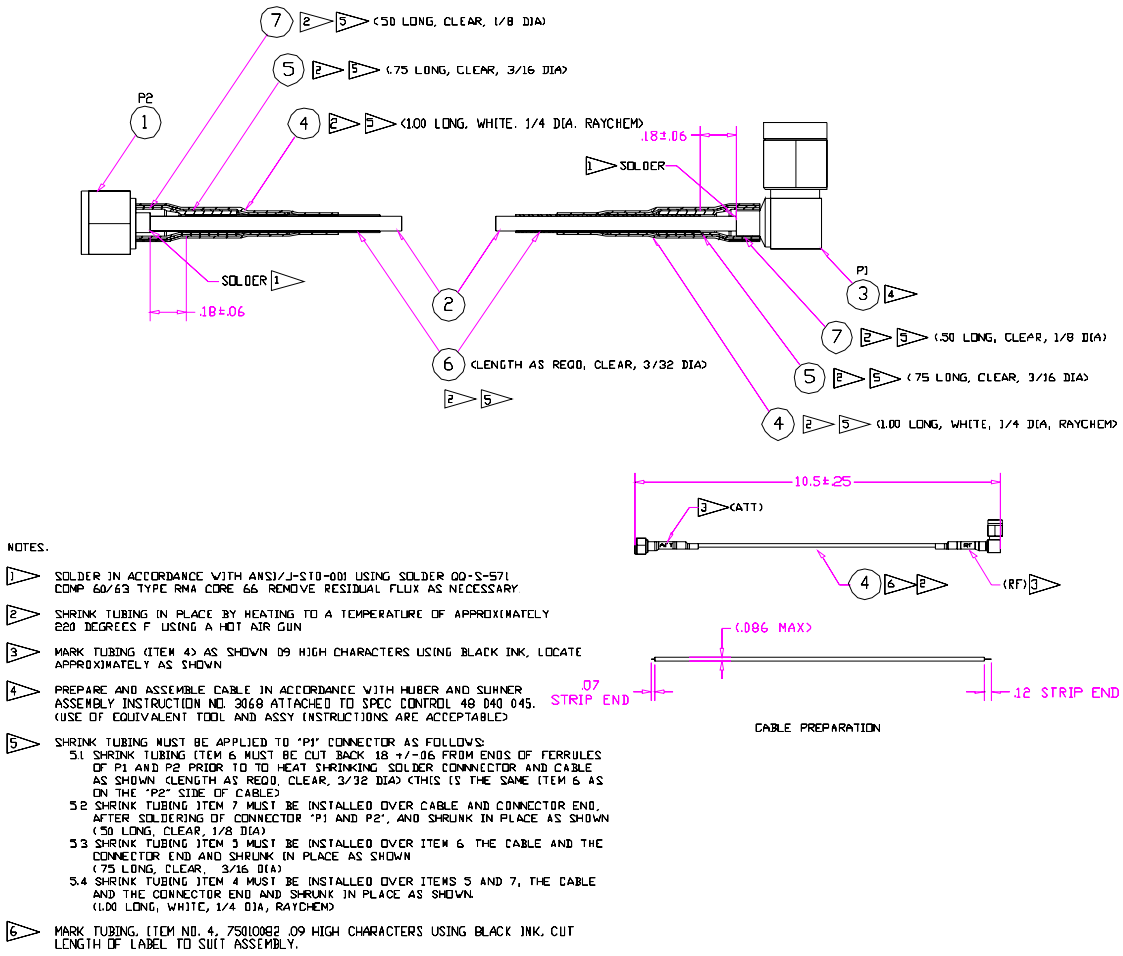
Cable Assembly, RF/Antenna SUM				75 010 075		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	1	**48040043**	CONNECTOR, BNC		HUBER-SUHNER	24BNC-50-2-20
2	AR	**71111002**	WIRE, COAX		HUBER-SUHNER	EZ-FLEX-086
3	1	**48040045**	CONNECTOR, RIGHT ANGLE, SMA		HUBER-SUHNER	16SMA-50-2-3
4	1	**73000012**	SHRINK TUBING, WHITE 1" LG.		ALPHA	FIT-221-3/16 WHITE
5	1	**73000019**	SHRINK TUBING, WHITE 1" LG.		RAYCHEM	TMS-SCE-1/4-2.0-9
6	AR	**73000008**	SHRINK TUBING, CLEAR, 3/32		ALPHA	FIT-221-3/32
7	AR	**73000010**	SHRINK TUBING, CLEAR, 1/8		ALPHA	FIT-221-1/8



Antenna/DIR Connect Cable Assembly

Figure 6-12

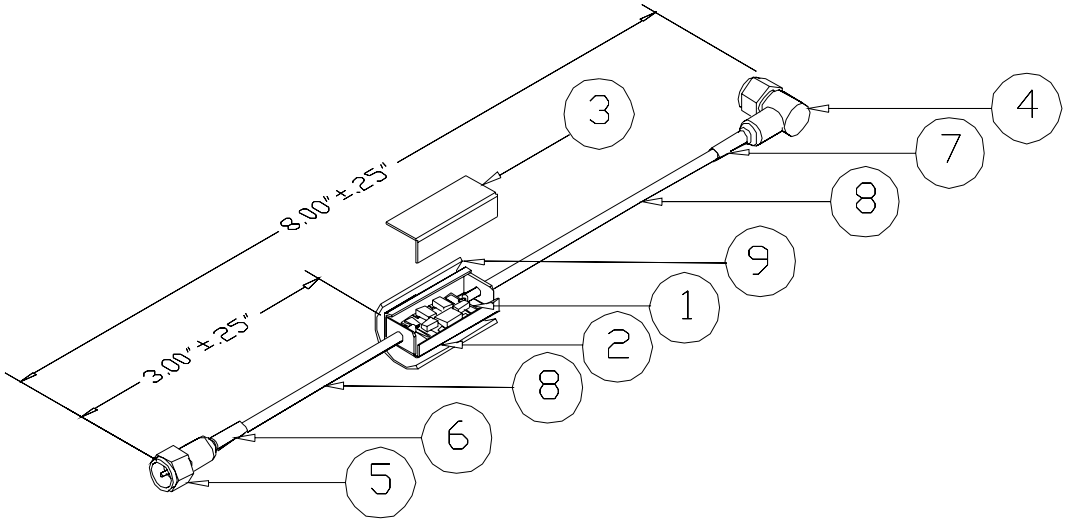
Antenna/DIR Connect Cable Assy				75 010 079		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	1	**48040044**	CONNECTOR, TNC		SUHNER	24TNC-50-2-31
2	AR	**71111002**	CABLE, COAX		EZ FORM CORP	EZ-FLEX-086
3	1	**48040040**	CONNECTOR, SMA		EFJ	142-0693-001
4	AR	**73000008**	SHRINK TUBING, CLEAR		ALPHA	FIT-221-3/32
5	AR	**73000010**	SHRINK TUBING, CLEAR		ALPHA	FIT-221-1/8
6	AR	**73000009**	SHRINK TUBING, WHITE		ALPHA	FIT-221-3/16
7	AR	**73000019**	SHRINK TUBING, WHITE		RAYCHEM	TMS-SCE-1/4-2.0-9
	AR	**SN60-63**	SOFT SOLDER			QQ-S-571



Attenuator/RF Cable Assembly

Figure 6-13

Attenuator/RF Cable Assembly				75 010 082		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	1	**48040040**	CONNECTOR, STRAIGHT		E.F. JOHNSON	142-0693-001
2	AR	**71111002**	WIRE, COAX		HUBER-SUHNER	E-Z-FLEX086
3	1	**48040045**	CONNECTOR, RIGHT ANGLE, SMA		HUBER-SUHNER	16SMA-50-2-3
4	1	**73000019**	SHRINK TUBING, WHITE, 1" LONG		RAYCHEM	TMS-SCE-1/4-2.0-9
5	AR	**73000009**	SHRINK TUBING, CLEAR 3/16		ALPHA	FIT-221-3/16
6	AR	**73000008**	SHRINK TUBING, CLEAR, 3/32		ALPHA	FIT-221-3/32
7	AR	**73000010**	SHRINK TUBING, CLEAR, 1/8		ALPHA	FIT-221-1/8
	AR	**SN60-63**	SOFT SOLDER			QQ-S-571



Cable Assembly, Sense Line

Figure 6-14

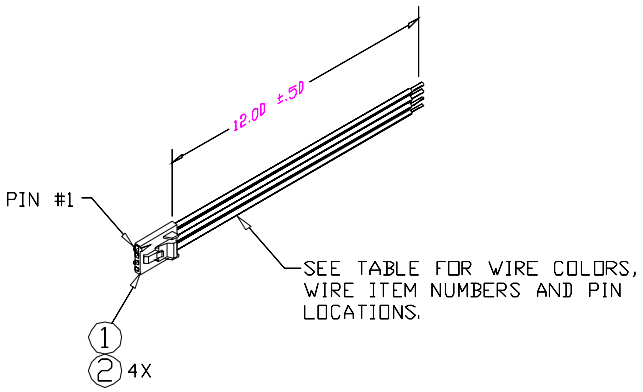
Cable Assembly, Sense Line				75 010 142		
#	**Qty**	**Tel Desig.**	**Nomenclature**	**Ref Desig.**	**Resource**	**Vendor P/N**
1	1	**80169001**	SENSE FILTER PCB ASSEMBLY	A26		
2	1	**31020096**	BOX, SENSE FILTER			
3	1	**62040050**	COVER, SENSE FILTER			
4	1	**48040045**	CONNECTOR, RIGHT ANGLE, SMA	J2	HUBER-SUHNER	16SMA-50-2-3
5	1	**48040040**	CONNECTOR, STRAIGHT, SMA	J1	E.F. JOHNSON	142-0693-001
6	1	**73000018**	SHRINK TUBING, WHITE, 1" LG.		RAYCHEM	TMS-SCE-3/16-2.0-9
7	1	**73000012**	SHRINK TUBING, WHITE, 1" LG.		ALPHA	FIT-221-3/16 WHITE
8	AR	**71111003**	WIRE, COAX		HUBER-SUHNER	S-FORM 86 FEP
9	AR	**73000011**	SHRINK TUBING, BLACK, 1-1/2" LG.		ALPHA	FIT-221-1/2 BLACK

Sense Line Filter

(Drawing unavailable)

Sense Line Filter				80 169 001		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	1	**80169002**	PCB Drilling and Fabrication (Rev A.)			
2	2	**48065005**	Ferrite Chip, SM	L1, L3	Steward	#MI1206K900R-00
3	1	**43011020**	Inductor, SM 10 uHy +/-10%	L2	TOKO	#300LS-100K
4	2	**42026001**	Cap, Chip, CC1210 Z5U; 1uF	C1,C2		

PIN NO.	WIRE COLOR	WIRE ITEM NO.
1	BRN	3
2	BRN	3
3	BLU	4
4	BLU	4



NOTES:

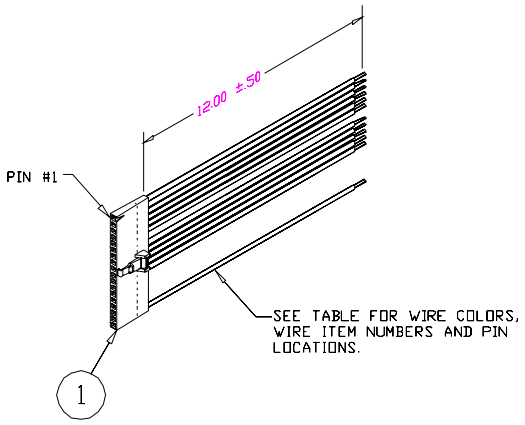
1. SEE ASSOCIATED PARTS LIST 75 010 163.

Cable Assembly, Power Supply

Figure 6-15

Cable Assembly, Power Supply				75 010 163		
#	**Qty**	**Tel Desig.**	**Nomenclature**	**Ref Desig.**	**Resource**	**Vendor P/N**
1	1	**48 000 089**	CONNECTOR, RECEPT, ASSY, SINGLE ROW		AMP	#104257-3
2	4	**46 053 002**	CONTACT, RECEPTACLE		AMP	#104480-8
3	AR	**72 722 002**	WIRE, TEFLON INSUL, 22 AWG, BRN		OLYMPIC	#307-1
4	AR	**72 722 007**	WIRE, TEFLON INSUL, 22 AWG, BLU		OLYMPIC	#307-6

PIN NO.	WIRE COLOR	WIRE ITEM NO.
1	WHT/GRY	12
2	WHT/VIO	11
3	WHT/GRN	10
4	WHT/YEL	9
5	WHT/ORN	8
6	WHT	7
7	NOT USED	–
8	VIO	6
9	RED	3
10	RED	3
11	BLK	2
12	GRN	5
13	NOT USED	–
14	NOT USED	–
15	NOT USED	–
16	NOT USED	–
17	NOT USED	–
18	ORN	4



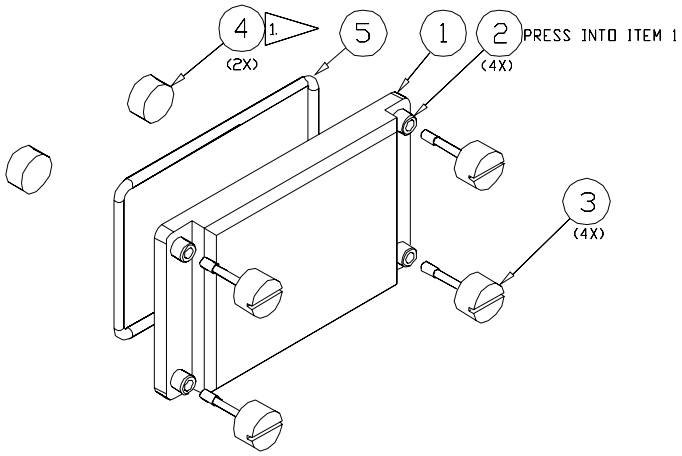
NOTES:

1. SEE ASSOCIATED PARTS LIST 75 010 193.

Power Supply Cable, 18 Pin

Figure 6-16

Power Supply Cable, 18 Pin				75 010 193		
#	**Qty**	**Tel Desig.**	**Nomenclature**	**Ref Desig.**	**Resource**	**Vendor P/N**
1	1	**48000074**	CONNECTOR, RECEPT, ASSY, SINGLE ROW		AMP	#1-103644-7
2	AR	**72722001**	WIRE, TEFLON INSUL, 22 AWG, BLK		OLYMPIC	#307-0
3	AR	**72722003**	WIRE, TEFLON INSUL, 22 AWG, RED		OLYMPIC	#307-2
4	AR	**72722004**	WIRE, TEFLON INSUL, 22 AWG, ORN		OLYMPIC	#307-3
5	AR	**72722006**	WIRE, TEFLON INSUL, 22 AWG, GRN		OLYMPIC	#307-5
6	AR	**72722008**	WIRE, TEFLON INSUL, 22 AWG, VIO		OLYMPIC	#307-7
7	AR	**72722010**	WIRE, TEFLON INSUL, 22 AWG, WHT		OLYMPIC	#307-9
8	AR	**72722014**	WIRE, TEFLON INSUL, 22 AWG, WHT/ORN		OLYMPIC	#307-93
9	AR	**72722015**	WIRE, TEFLON INSUL, 22 AWG, WHT/YEL		OLYMPIC	#307-94
10	AR	**72722016**	WIRE, TEFLON INSUL, 22 AWG, WHT/GRN		OLYMPIC	#307-95
11	AR	**72722018**	WIRE, TEFLON INSUL, 22 AWG, WHT/VIO		OLYMPIC	#307-97
12	AR	**72722019**	WIRE, TEFLON INSUL, 22 AWG, WHT/GRY		OLYMPIC	#307-98



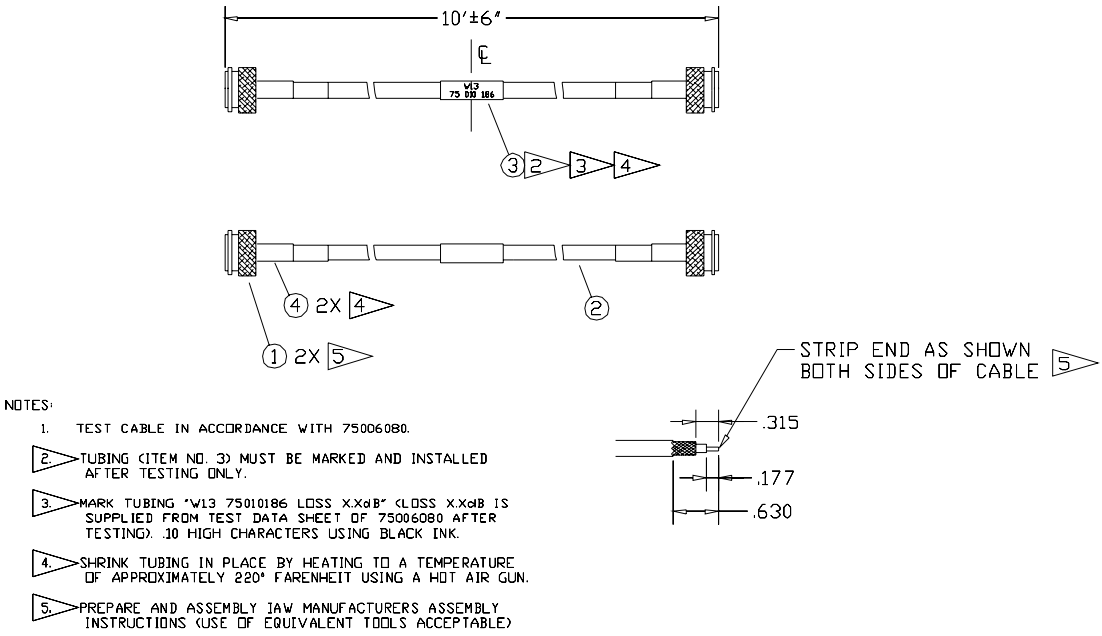
NOTES:

1. ADHERE TO ENDS OF CENTER STRUT APPROX .50 FROM INSIDE EDGE TO CENTER OF BUMPER, EACH SIDE.

Battery Cover Assembly

Figure 6-17

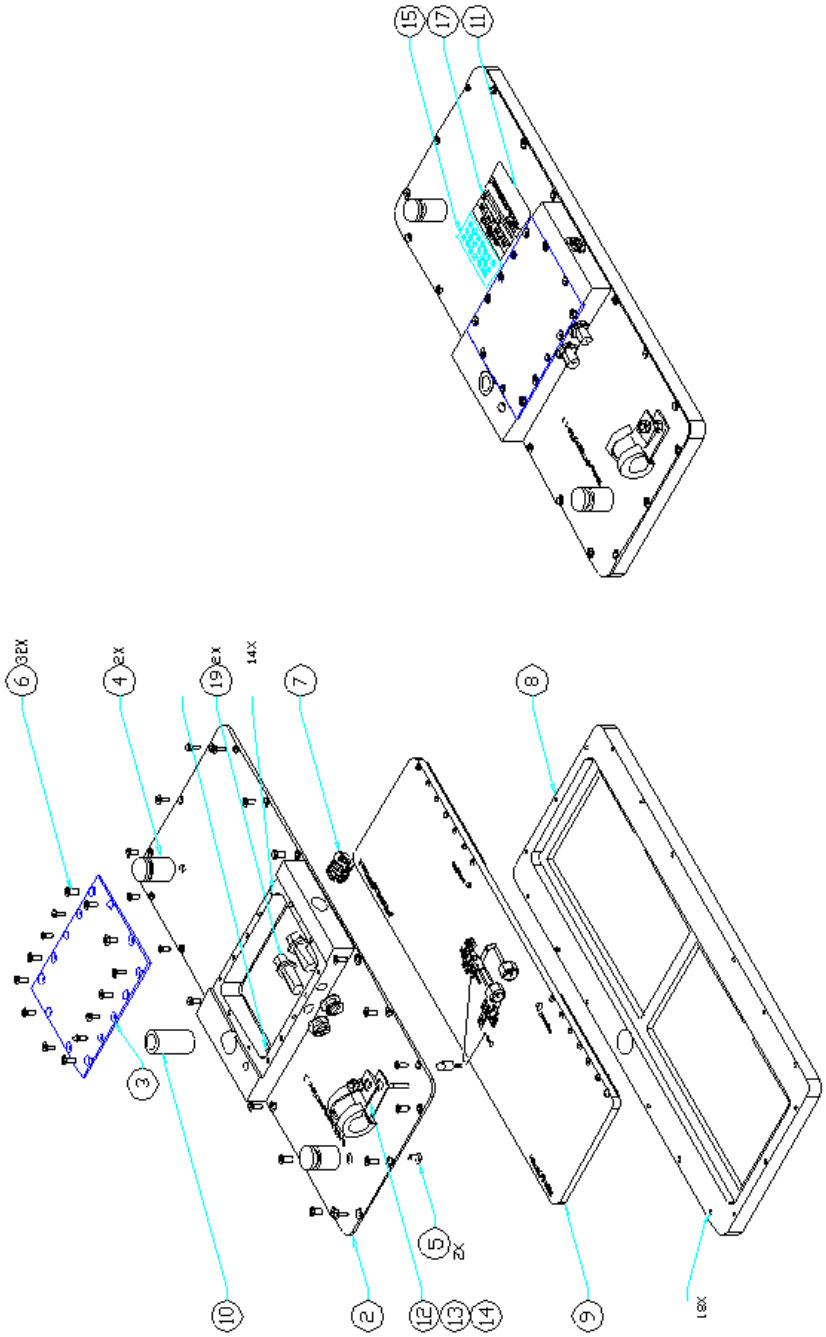
Battery Cover Assembly				75 010 029		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	1	**62040061**	COVER, BATTERY			
2	4	**50500001**	RETAINER, CAPTIVE		ASMCO	#400006SS12
3	4	**50400003**	SCREW, CAPTIVE		ASMCO	#702-.7505512
4	2	**31016010**	BUMPER, ROUND, SELF ADHESIVE		McMASTER-CARR	#9723K15
5	1	**55082026**	GASKET, LEAD BATTERY			



Direct Connect Cable Assembly

Figure 6-18

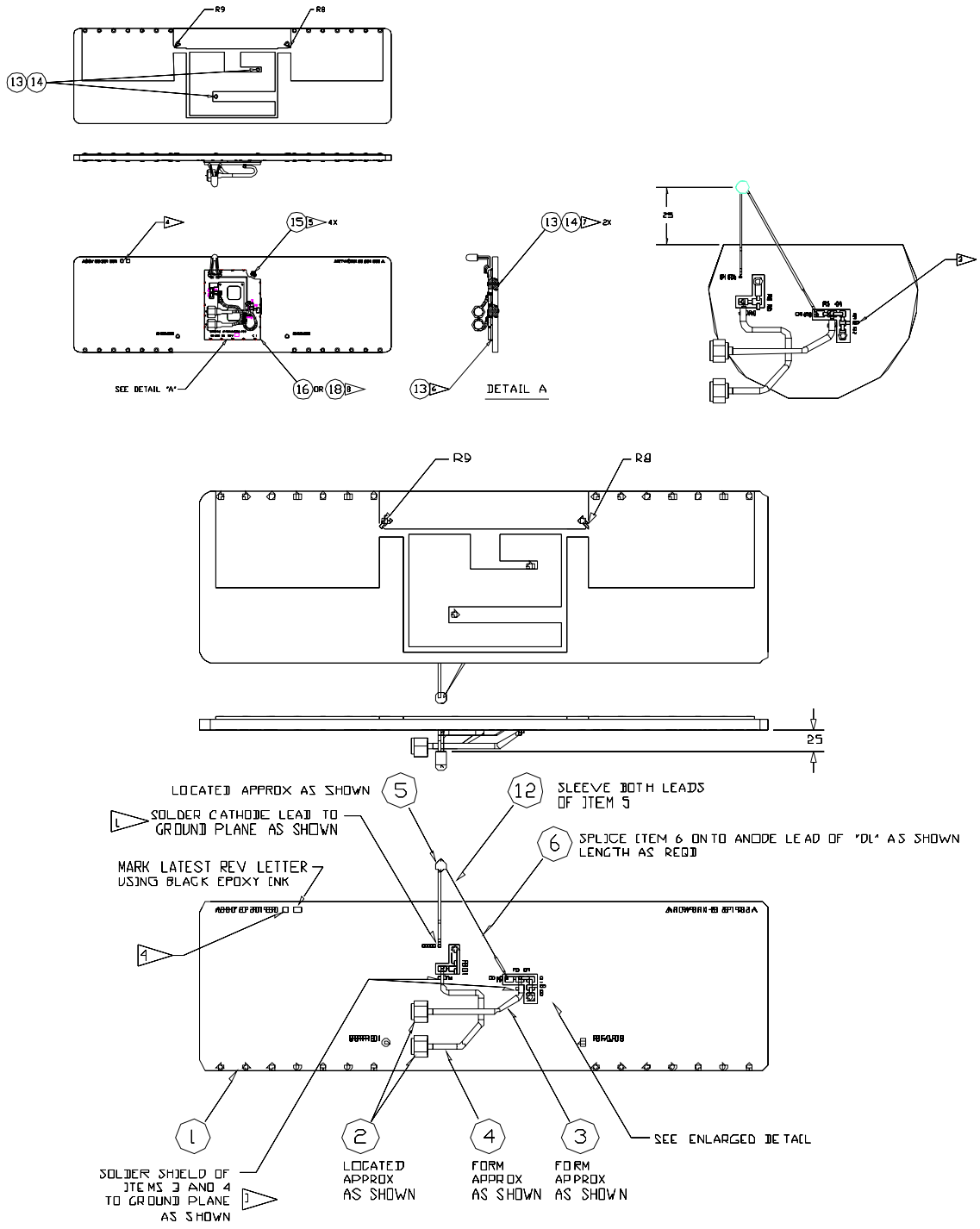
Direct Connect Cable Assembly				**75 010 186**		
#	**Qty**	**Tel Desig.**	**Nomenclature**	**Ref Desig.**	**Resource**	**Vendor P/N**
1	2	**48040055**	CONNECTOR, CRIMP, TNC		HUBER-SUHNER	11TNC-50-3-115/133NE
2	10'	**71110005**	WIRE, COAXIAL, RG-223/U		OLYMPIC	6273
3	1	**73000021**	PRINTABLE HEAT SHRINK, WHITE		RAYCHEM	TMS-SCE-3/4-2.0-9
4	2"	**73000006**	SHRINK TUBING		ALPHA	FIT-221-1/4
		75006080	TEST PROCEDURE, DIRECT CONNECT RF CABLE			



Directional Antenna Assembly

Figure 6-19

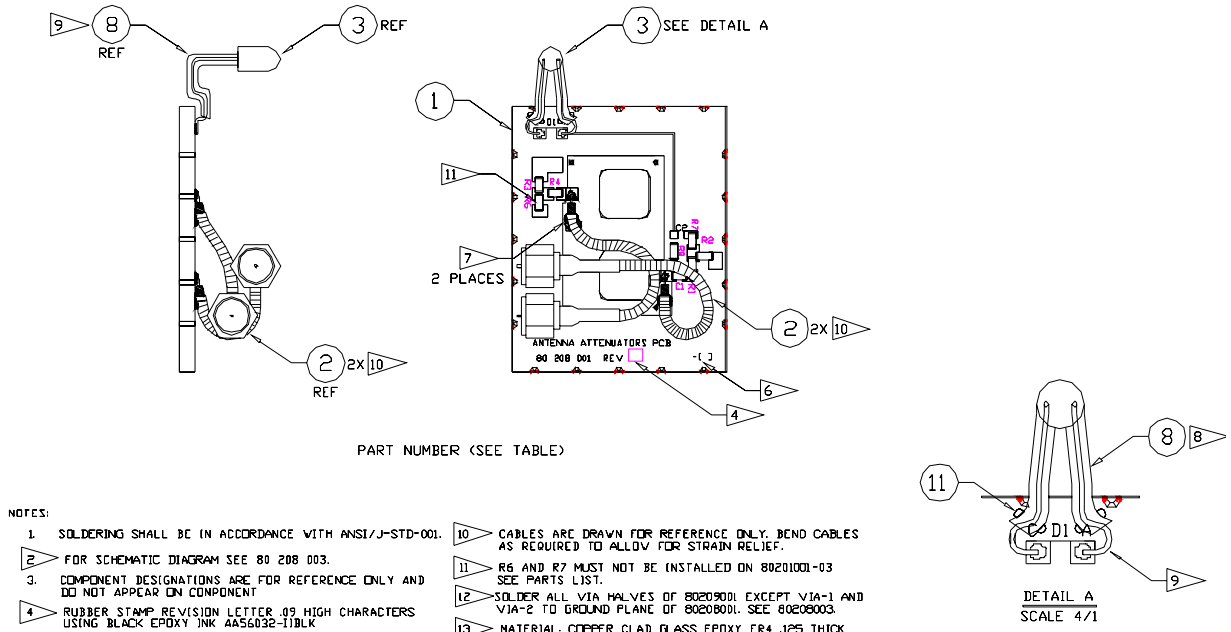
Directional Antenna Assembly				89 001 158 07		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	AR	**BLK**	INK MARKING EPOXY			AA56032-IBLK
2	1	**62070037**	BACK PLATE ANTENNA-DIP BRAZE			
3	1	**65000020**	COVER, ANTENNA			
4	2	**65000021**	STANDOFF, ANTENNA			
5	2	**50140001**	SCREW, FLAT HD. 6-32 X 3/8 82 DEGREE			MS51959-28
6	32	**50140010**	SCREW, FLAT HD. 3-48 X 1/4 82 DEGREE		McMASTER-CARR	91771A092
7	1	**50600001**	INSERT, THREADED		McMASTER-CARR	90247A012
8	1	**31008001**	RADOME ANTENNA			
9	1	**80201001-01**	PCB ASSEMBLY, DIRECTIONAL ANTENNA	A14		
9	1	**80201001-02**	PCB ASSEMBLY, DIRECTIONAL ANTENNA			
9	1	**80201001-04**	PCB ASSEMBLY, DIRECTIONAL ANTENNA			
9	1	**89000104**	PCB ASSEMBLY, DIRECTIONAL ANTENNA			
10	1	**52100004**	SIGHT			
11	1	**57030013**	DECAL, SERIAL NUMBER			
12	1	**56000010**	CLAMP, CABLE		McMASTER-CARR	3225T63
13	1	**52010001**	WASHER, FLAT NO. 6			MS15795-805
14	1	**53200004**	LOCK NUT W/NYLON NO. 6		TOWER	6CNNMS
15	1	**57031021**	DECAL, MOD			
16	AR	**31010001**	RTV SILICONE ADHESIVE		DOW CORNING	732
17	1	**57031007**	LABEL, DATA			
18	AR	**31010006**	LOCTITE		LOCTITE	454
19	2	**48040046**	CONNECTOR, SMA		EF JOHNSON	142-0901-401
20	AR	**31010008**	SIL-711, NON CORROSIVE ADHESIVE		MASTERBOND	SIL-711



Directional Antenna/PCB (Not all Parts are shown)

Figure 6-20

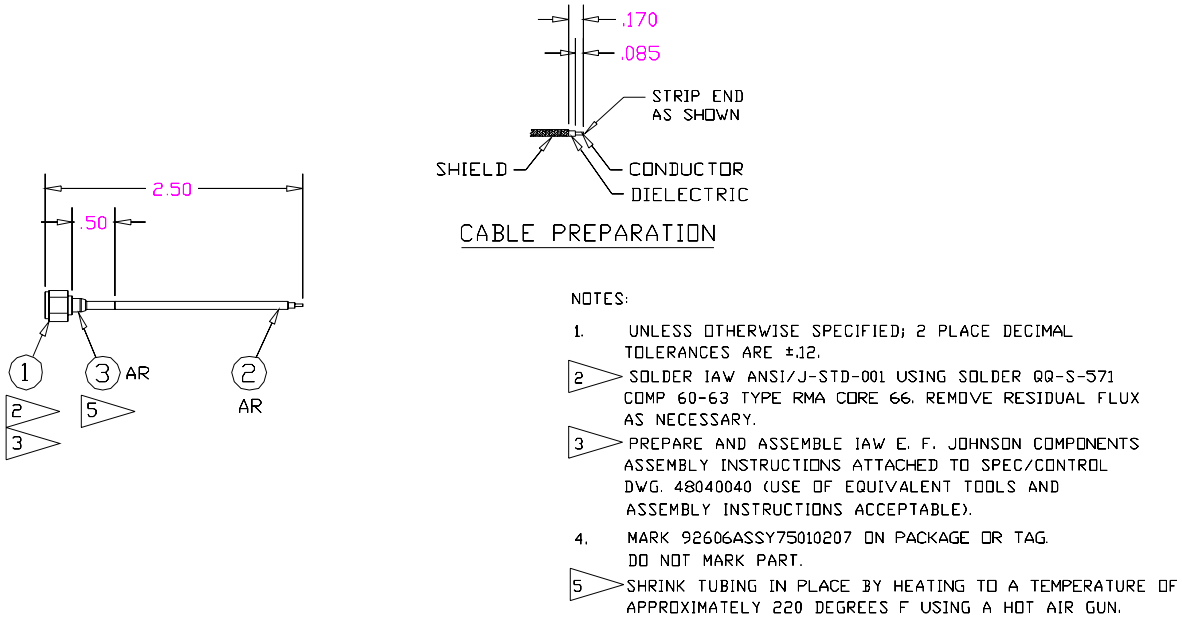
Directional Antenna PCB				80 201 001 04		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	1	**80201002**	DRILLING AND FABRICATION			
2	2	**48040040**	CONNECTOR, SMA		EFJ	142-0693-001
3	1	**71111002**	WIRE, SEMI-RIGID COAX, 2.5" LONG		EZ- FORM CORP	EZ-FLEX-086
4	1	**71111002**	WIRE, SEMI-RIGID COAX, 3.0" LONG		EZ- FORM CORP	EZ-FLEX-086
5	1	**45001013**	LAMP -LED (RED)	D1	AGILENT	HLMP-EG15-RU000
6	AR	**70000001**	WIRE, ELECT., SOLID COND.,TIN. COPPER, #24 AWG		ALPHA	299
7	1	**42025025**	CAP CHIP, NPO, CC1206, 100pF	C1		
8	4	**41161001-32**	RES CHIP, 5%, RC0805, 18 OHMS	R1, R2, R3, R4	PANASONIC	ERJ-6GEYJ180V
9	1	**41161001-67**	RES CHIP, 5%, RC0805, 510 OHMS	R5	PANASONIC	ERJ-6GEYJ511V
10	2	**41161009-80**	RES CHIP, 5%, RC0805, 66.5 OHMS	R6, R7	PANASONIC	ERJ-6ENF66R5V
11	2	**41161001-58**	RES CHIP, 5%, RC0805, 220 OHMS	R8, R9	PANASONIC	ERJ-6GEYJ221V
12	AR	**73000033**	TUBING,TEFLON, #22 AWG, CLEAR		ALPHA	TFT-200-22
13	AR	**SN60-63**	SOFT SOLDER			QQ-S-571
14	AR	**72001007**	20 AWG TINNED COPPER BUS WIRE		OLYMPIC	755
15	AR	**31010004**	LOCTITE			



Antenna Attenuator PCB

Figure 6-21

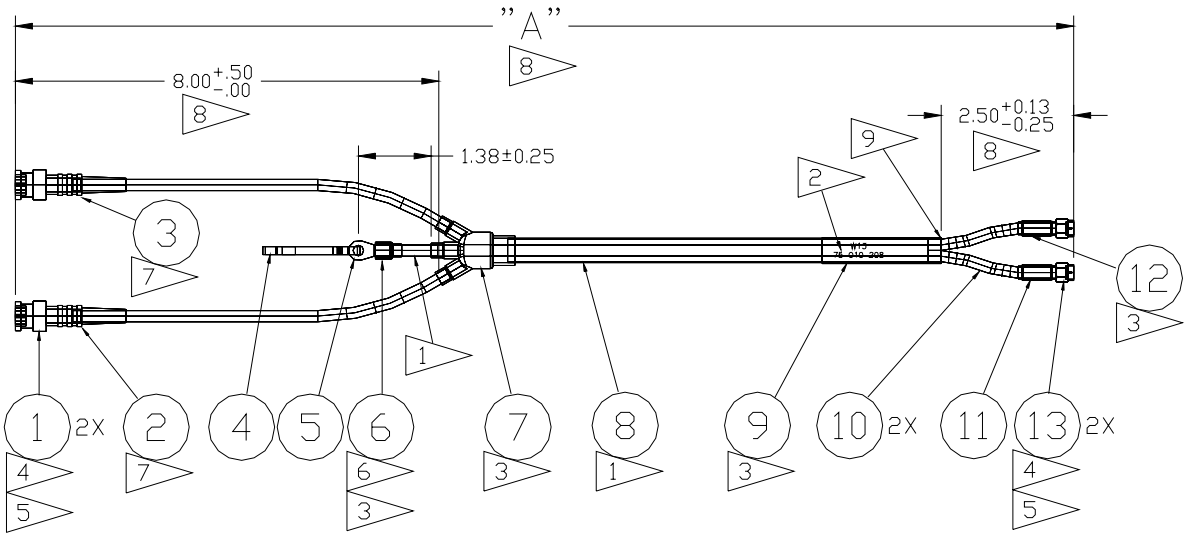
Antenna Atten, PCB Assembly				80 208 001-03		
#	**Qty**	**Tel Desig.**	**Nomenclature**	**Ref Desig.**	**Resource**	**Vendor P/N**
1	1	**80208002**	DRILLING AND FABRICATION			
2	2	**75010207**	CABLE ASSEMBLY, RF			
3	1	**45001013**	LAMP -LED (RED)	D1	AGILENT	HLMP-EG15-RU000
4	1	**42025025**	CAP CHIP, NPO, CC1206, 100pF	C1		
5	4	**41161001-01**	RES, CHIP, 5%, 0805, 0 OHMS	R1, R2, R3, R4	PANASONIC	ERJ-6GEYJ0R0V
6	1	**41161001-67**	RES CHIP, 5%, RC0805, 510 OHMS	R8	PANASONIC	ERJ-6GEYJ511V
8	AR	**73000033**	TUBING,TEFLON, #22 AWG, CLEAR		ALPHA	
9	AR	**SN60-63**	SOFT SOLDER			QQ-S-571
10	AR	**73000010**	3/16" HEAT SHRINK, CLEAR		ALPHA	FIT-221-1/8 CLEAR
11	AR	**31010006**	TAC-PAC 454		LOCTITE	454
13	1	**80208003**	ANTENNA ATTENUATOR SCHEMATIC DIAGRAM			



Cable Assembly RF

Figure 6-22

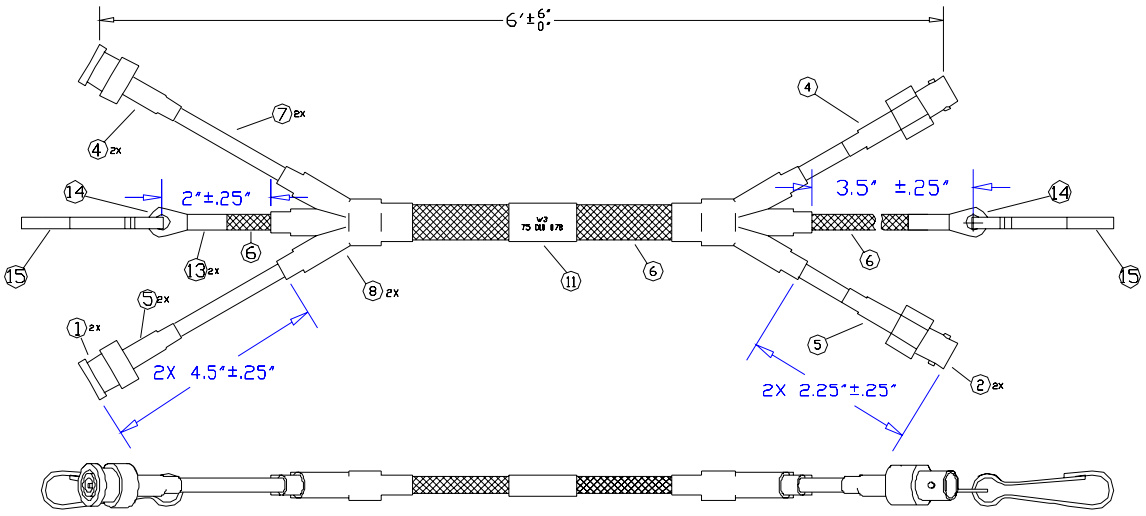
Cable Assembly, RF				75 010 207		
#	**Qty**	**Tel Desig.**	**Nomenclature**	**Ref Desig.**	**Resource**	**Vendor P/N**
1	2	**48040040**	CONNECTOR, SMA, STRAIGHT		E. F. JOHNSON	142-0693-001
2	AR	**71111002**	WIRE, SEMI-RIGID COAX		EZ-FORM CORP	EZ-FLEX-086
3	AR	**73000009**	SHRINK TUBING, CLEAR, 3/16		ALPHA	FIT-221-3/16
4	AR	**SN-60-63**	SOLDER			QQ-S-571



Directional Antenna Cable Assembly

Figure 6-23

Directional Antenna Cable Assy.		75 010 208 02				
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	2	**48040066**	Connector, BNC, Male		Huber-Suhner	11BNC-50-3-16/133NE
2	1	**73000035**	Taper Sleeve, Yellow		Huber-Suhner	78Z-4-3-5
3	1	**73000036**	Taper Sleeve, White		Huber-Suhner	78Z-9-3-5
4	1	**49000001**	Snap-Hook		Baron Manuf.	7340-1 3/4" (McMaster 3960T)
5	1	**55006003**	Crimp-On		McMaster	69405K57
6	AR	**73000006**	Shrink Tubing, Black, 1/4" Dia		Alpha	FIT-221-1/4
7	1	**73000004**	Shrink 3-Way Sleeve		Hellerman	306-1
8	AR	**73000005**	Braided, Expandable Sleeving		Teckflex	FLEXO-PET-1/4
9	1	**56001001**	Label, 1/2" White			
10	AR	**71110005**	Wire, Coax, RG223/U		Olympic	6273
11	AR	**73000003**	Shrink Tubing, Yellow, 1/4" Dia		Alpha	FIT-221-1/4
12	AR	**73000002**	Shrink Tubing, White, 1/4" Dia		Alpha	FIT-221-1/4
13	2	**48040067**	Connector, SMA, Male		Huber-Suhner	11SMA-50-3-6/111NE
		75006080	Test Procedure, Direct Connect RF Cable			

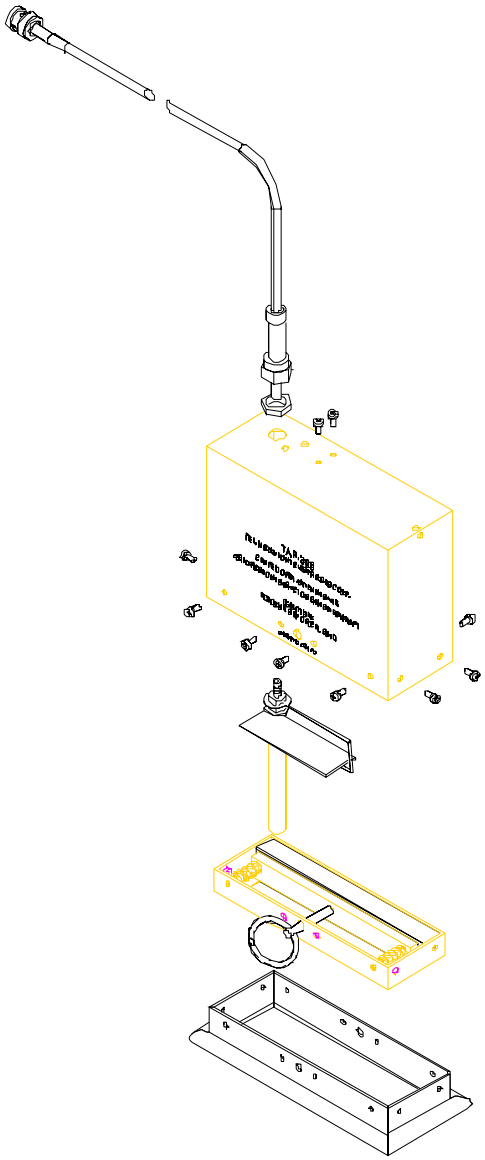


NOTES:
1.
2. ITEM 6- BRAID CONTINUOUS THRU 3-WAY SLEEVE

Directional Antenna Extension Cable Assembly

Figure 6-24

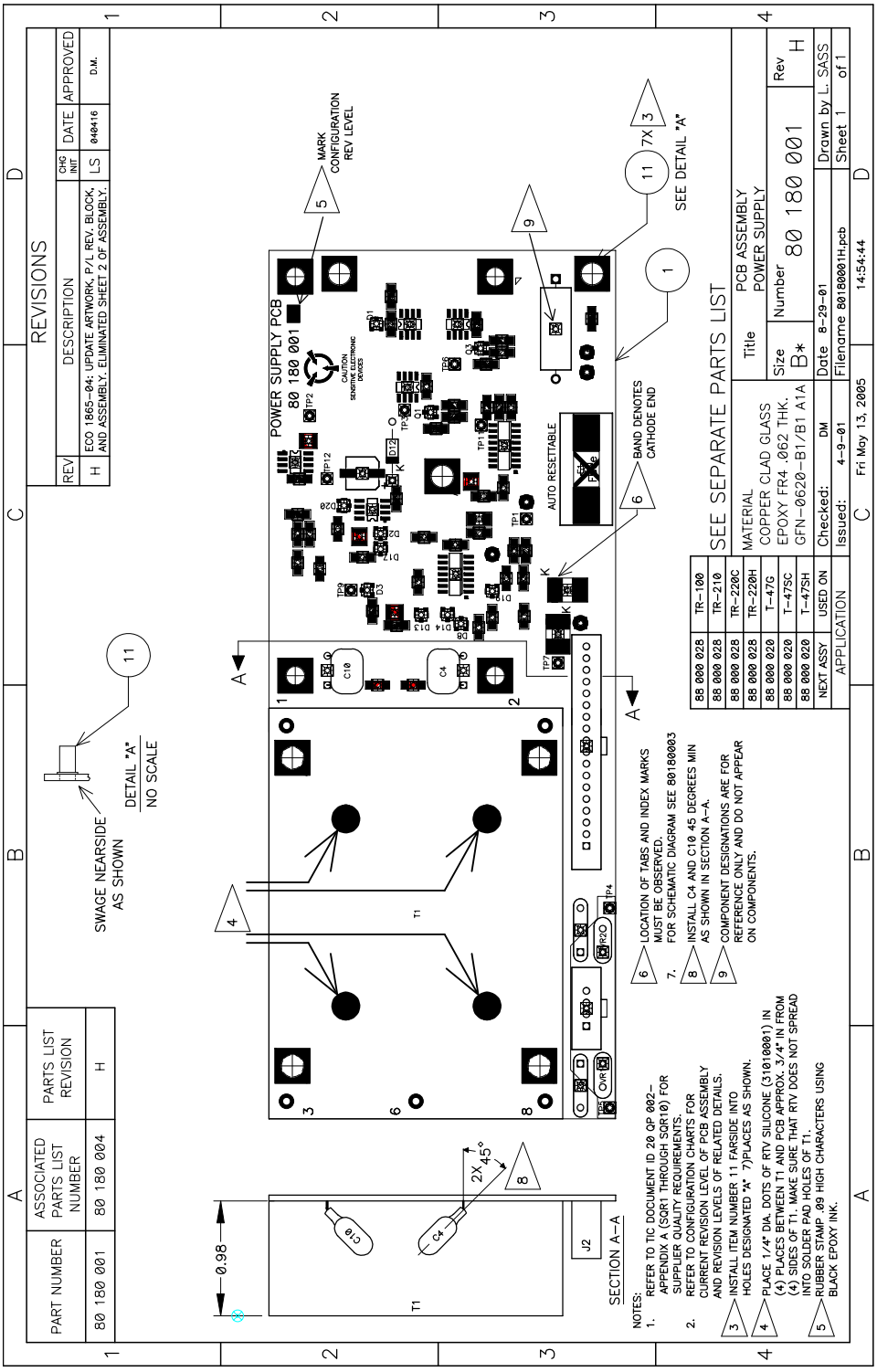
Directional Antenna Extension Cable Assy.				75 010 078		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	2	**48040038**	Conn., Straight BNC Plug		Amphenol	31-320
2	2	**48040039**	Conn., Straight BNC Jack		Amphenol	36800, USE with Crimp Sleeve 31-1357-2G
3						
4	1.5"	**73000002**	Shrink Tubing, White		Alpha	71-94-5226-6953
5	1.5"	**73000003**	Shrink Tubing, Yellow		Alpha	71-94-5226-6428
6	A/R	**73000005**	Braided EXP. Sleeve		Teckflex	Flexo-pet-1/4
7	12.5'	**71110005**	Cable, Coax, RG223U			RG-223/U
8	2	**73000004**	Shrink 3-way Sleeve		Hellermann	306-1
9						
10						
11	1	**56001001**	Cable Tie/Text			
12	1	**55006002**	Crimp-on		McMaster-Carr	69405K56
13	2"	**73000006**	Shrink Tubing, Black		Alpha	FIT-221-1/4
14	2	**55006003**	Crimp-on		McMaster-Carr	69405K57
15	2	**49000001**	Snap Hook		Baron Mfg.	7340-1-3/4" (MCM #3960T5)



TAP-200 Assembly

Figure 6-25

TAP-200 Assembly				89 000 166		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	1	**64050014**	CAN			
2	1	**64050015**	FRAME, INNER			
3	13	**52020002**	WASHER, LOCK, #4			MS35338-135
4	2	**50110002**	SCREW, PAN HEAD, #4-40 X 1/2" LONG			MS51957-17
5	11	**50110009**	SCREW, PAN HEAD, #4-40 X 5/16" LONG			MS51957-14
6						
7	1	**40030006**	ANTENNA, TUBE ASSEMBLY			
8	1	**80198001**	PCB ASSEMBLY, ARC			
9	1	**64030023**	POUCH (OPTIONAL)			
10	1	**48040066**	CONNECTOR, COAXIAL, BNC MALE		HUBER-SUHNER	11BNC-50-3-16-3
11	10'	**71111001**	WIRE, COAXIAL, FLEXIBLE		BELDEN	8262 OR EQUIVALENT
12	1	**48040033**	CONNECTOR, COAX, 1/2 HEX		AMPHENOL	31-1356-2G
13	1	**31020071**	FERRULE, CRIMP SLEEVE			
14	2	**55082007**	GASKET, RF FILTER, LARGE			
15	2	**55082009**	GASKET, RF FILTER, SMALL			
16	AR	**31010002**	ADHESIVE		3M	1300 YELLOW
17	2	**55082010**	GASKET, DURO 50, 1/2" X 1/4"			
18	1	**62070026**	PLATE, FIXED, PHENOLIC			
19	1	**62070027**	PLATE, MOVABLE, PHENOLIC			
20	2	**53700002**	RING, KEY		WORTH	KR-4-Z
21	1	**51009002**	ROD, PULL			
22	2	**52400017**	STANDOFF, 3/16" HEX		RAF	4515-440-SS-40
23	1	**31016001**	STREAMER, WARNING		AUW	30042
24	1	**55001002**	STRAIN RELIEF, MODIFIED		HEYCO	3237 (MODIFIED)
25	2	**56023001**	SPRING		ASSOCIATED	C0300-030-1000-S
26	1	**55010004**	LUG, GROUND		ZIERICK	334-.375-.020
27	1	**57005074**	SILKSCREEN, TAP-200			
		89006145	TEST PROCEDURE, ANTI-RADIATION COUPLER			

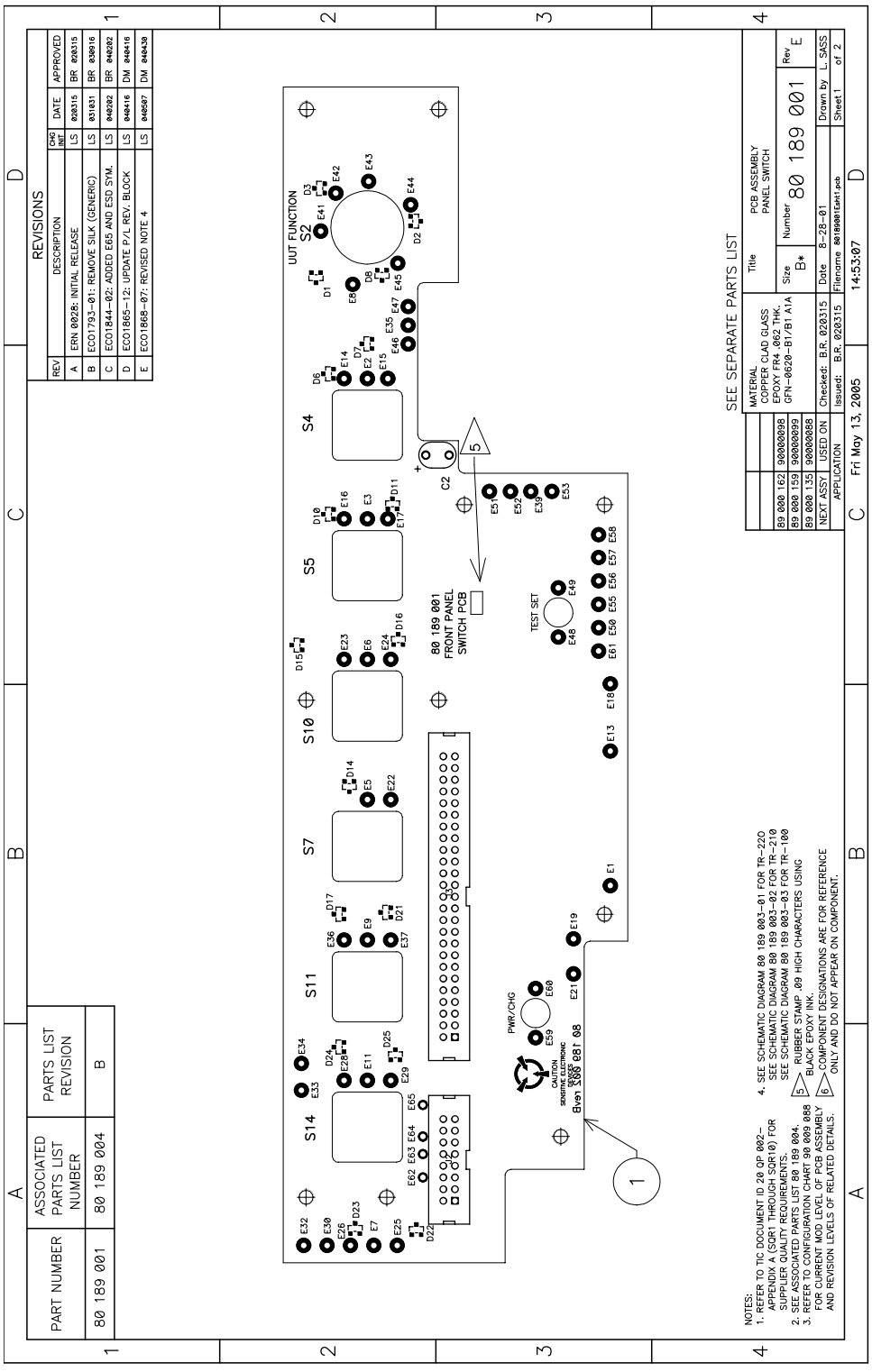


PCB Power Supply

Figure 6-26

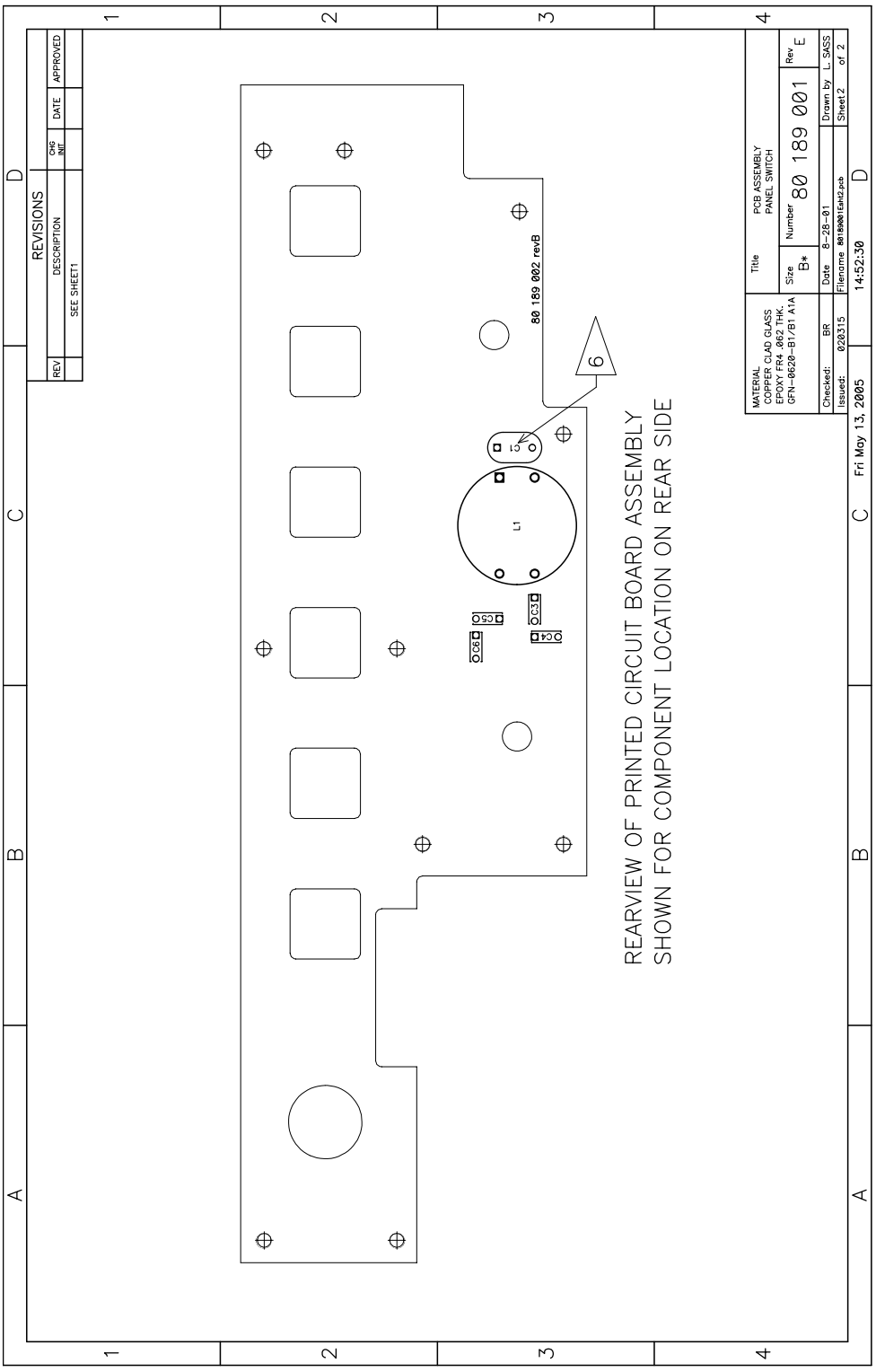
PCB Assembly, Power Supply				80 180 001		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	1	**80180002**	PCB Drilling and Fabrication	U3	Fairchild Philips Texas Inst.	MM74HC4060M 74HC4060 CD74HC4060M
2	1 ALT ALT	**40201071**	I.C.-SM	U2	Philips	HEF4002BT
3	1	**40201154**	Nor Gate 4002-SM	U1	Philips	LM2903D
4	1	**40201023**	Comparator 2903-SM	VR1,VR2	Harris	V175LA2
5	2	**42230002**	Varistor (MOV)	C4,C10	Sprague	30LVSD47
6	2	**42100002**	Cap.,Cerm. Disc 4700pF, 250V	C6,C7	Sprague	440LD22
7	2	**42100004**	Cap.,Cerm. Disc .0022uF/250V	T1	Astrodyne	MSCA-0303
8	1	**48092003**	Converter, AC/DC	J2	AMP	1-103670-7
9	1	**48000066**	CONN., 18 PIN	J1	AMP	103670-3
10	1	**55050010**	CONN., HEADER, 4 POS. SIN. ROW	N/A	RAF	7829-632-B-SS-20
11	7	**52300005**	FASTENER	TP1-TP9,TP11,TP12	Comp. Corp	TP-105-01-09
12	10	**55025008**	TERMINAL	U6	Texas Inst.	LM285D-2.5
13	1	**40201157**	I.C.-SM DIODE-285 (2.5V)	U6	ON Semi.	LM285D-2.5
14	ALT	**40201157**	I.C.-SM DIODE-285 (2.5V)	F1	Schurter	PFST.200
15	1	**45100024**	Fuse-Strap, Resettable	C1, C3, C8, C9		
16	4	**42026001**	CAP. CHIP; CC1210 Z5U; 1uF	C2		
17	1	**42020065**	CAP. CHIP; CC1206 X7R; .22uF/25V	C16, C23		
18	2	**42020013**	CAP. CHIP; CC1206 X7R; 0.1uF	C17, C18, C19	Panasonic	ECE-V1EA220P
19	3	**42025037**	CAP. CHIP; CC1206 NPO; 1000pF	C5		
20	1	**42185036**	CAP. ALUM-ELECT-SM; 22uF/25V			
21				R16		
22	1	**41165002**	RES. CHIP; RC1210 5%; 2K	R1		
23	1	**41160013**	RES. CHIP; RC1206 5%; 4.7K	R15, R20, R22, R35, R37, R41		
24	6	**41160025**	RES. CHIP; RC1206 5%; 100K	R13, R14		
25	2	**41160035**	RES. CHIP; RC1206 5%; 240K	R3, R24, R25, R40		
26	4	**41160003**	RES. CHIP; RC1206 5%; 1K	R9, R11, R17, R19, R23, R28, R29, R31, R32, R34		
27	10	**41160015**	RES. CHIP; RC1206 5%; 10K	R4, R5		

PCB Assembly, Power Supply				80 180 001		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
28	1	**41160011**	RES. CHIP; RC1206 5%; 100 Ohms	R10		
29	1	**41160029**	RES. CHIP; RC1206; 5%; 3.3K	R2		
30	1	**41101245**	RES. CHIP; RC1206; 1%; 3.48K	R8		
31	1	**41160021**	RES. CHIP; RC1206; 470 Ohms	R12		
32	1	**41160024**	RES. CHIP; RC1206; 5% 27K	R33		
33	2	**40001030**	TRANSISTOR-SM	Q1, Q3	Vishay	VN10KC
34	3	**40001031**	TRANSISTOR-SM	Q2, Q4, Q5	Motorola	MMSF5P02HD
35	1	**43011059**	INDUCTOR; 100uHy	L3	RENCO	RL-1284-100
36	2	**40010036**	DIODE 360-SM	D9, D10	MOTOROLA	MBRS360T3
37	1	**40010037**	DIODE 4625-(5.1V)	D12	MOTOROLA	1N4625
38	7	**40010014**	DIODE 914-SM	D2,D3,D8,D13,D14,D17,D19	NAT'L SEMI.	MMBD914
39	1	**40010016**	DIODE 2800-SM	D20	SCHOTTKY	ZC2800
40	2	**48065005**	Chip, Ferrite	L1,L2	STEWARD	MI1206K900R-00
41	2	**41160145**	RES. CHIP, RC1206: 0 OHMS	R21, R36		
42	AR	**31010001**	SILICONE ADHESIVE (RTV)		DOW CORNING	732



Panel Switch Assembly

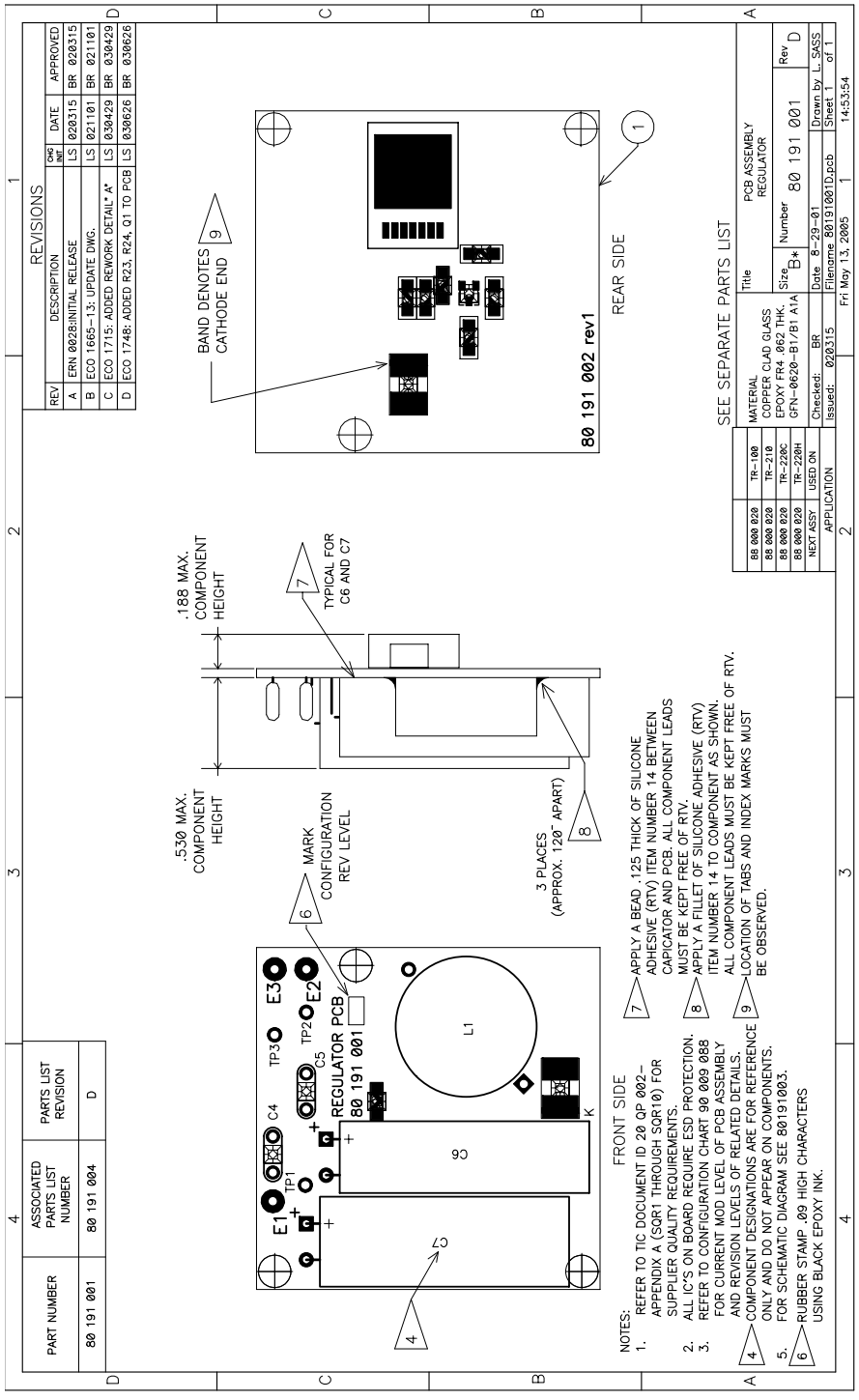
Figure 6-27 (a)



Panel Switch Assembly

Figure 6-27 (b)

Panel Switch Assembly				80 189 001		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	1	**80189002**	DRILLING AND FABRICATION	J2	AMP/TYCO	6-1437063-3
2	1	**55050019**	HEADER, 16 POS., DOUBLE ROW, LATCHING	J3	AMP/TYCO	104313-9
3	1	**55050007**	HEADER, 50 POS., DOUBLE ROW	D1-D3, D6-D8, D10, D11, D14-D17, D21-25	NAT'L SEMI.	MMBD914
4	17	**40010014**	DIODE-SM	L1	RENCO	RL-6010-2.2-6.0
5	1	**43013005**	INDUCTOR, TOROID 2.2mH	C2	SPRAGUE	199D107X9020FE2
6	1	**42470021**	CAP., TANT., 100uF/20V	C1	PANASONIC	ECK-DRS101MBY
7	1	**42100005**	CAP., CERM. DISC 100pF/400V	C3-C6	ELCON	ECR152GJ
8	4	**42250008**	CAP., POLYCARB .0015uF/250V	J2	AMP/TYCO	6-1437063-3



PCB Assembly, Regulator

Figure 6-28

PCB Assembly, Regulator				80 191 001		
#	Qty	Tel Desig.	Nomenclature	Ref Desig.	Resource	Vendor P/N
1	1	**80191002**	PCB DRILLING AND FABRICATION (REV A.)			
2	1	**56060021**	VOLTAGE REGULATOR-SM	U5	NAT'L SEMI.	LM2673S-ADJ
3	3	**55025008**	TERMINAL	TP1-TP3	COMP. CORP.	TP-105-01-09
4	2	**42000032**	CAPACITOR, CERM 1uF/50V	C4, C5	PANASONIC	ECU-S1H105KBB
5	1	**42020065**	CAPACITOR, CHIP; CC1206 X75; .22uF/25V	C20		
6	1	**42025037**	CAPACITOR, CHIP; CC1206 NPO; 1000pF	C21		
7	1	**42190024**	CAPACITOR, ALUM-ELECT.; 560uF/50V	C7	PANASONIC	EEU-FC1H561B
8	1	**42190023**	CAPACITOR, ALUM-ELECT.; 560uF/35V	C6	PANASONIC	ECA-1VFQ561L
9	1	**41101193**	RESISTOR, CHIP; RC1206 1%; 1.0K	R20		
10	1	**41101260**	RESISTOR, CHIP; RC1206 1%; 4.99K	R21		
11	1	**41101268**	RESISTOR, CHIP; RC1206 1%; 6.04K	R19		
12	1	**43013003**	INDUCTOR; 48uHY	L1	RENCO	RL-6100-48-3-H3(HORIZONTAL)
13	2	**40010036**	DIODE 360-SM	D10, D11		MBRS360T3
14	AR	**31010001**	SILICONE ADHESIVE (RTV)		DOW CORNING	732
15		**80191003**	SCHEMATIC DIAGRAM			
16	1	**41101289**	RESISTOR, CHIP: RC1206 1%; 10.0K	R23		
17	1	**41101318**	RESISTOR, CHIP: RC1206 1%; 20.0K	R24		
18	1	**40001030**	TRANSISTOR-SM, SOT-23, N-CHANNEL	Q1	VISHAY	VN10KC
19	AR	**72722001**	WIRE, TEFLON, 22AWG, BLACK		OLYMPIC	307-0

APPENDIX A

TR-220 Test Set Verification and Acceptance Checks Data Sheet

DATE	
Model	
Serial #	
Technician	

4.4 Display Operation, Self Test, and Initial Start Verification				
Step #	**Test Description**	**Expected Value** Log the result	**Result** Circle	**Initial**
2	**PWR/CHG**, Verify Green LED	LIT	PASS FAIL	
3	**ON/OFF**, Verify Green LED	LIT	PASS FAIL	
5	Self Test	PASS	PASS FAIL	
	Verify Current Software	Rev		
	Total Test Set Hours	Hours		
6	Backlighting, Constant	Illuminated	PASS FAIL	
7	Backlighting, Momentary	Momentarily Illuminated	PASS FAIL	
9	Auto Shut Off	15 Minutes ± 2 Min	PASS FAIL	
10	Verify "Direct Connect" Display	Displayed	PASS FAIL	
		Displayed	PASS FAIL	
11	Display Returns	"Transponder Test"	PASS FAIL	

4.4.1 Transponder, Transmitter/Frequency Verification Tests				
Step #	**Test Description, Expected Value**	**Measured Value** Log the result	**Result** Circle	**Initial**
5	XPDR Power Out, SUM Port **5 to 9 dBm**	dBm	PASS FAIL	
6	Power Out, DIFF Port **Min 20 dB Lower**	dBm	PASS FAIL	
7	Power Out, DIFF Port, 35 Feet **9 dB ± 2 dBm, Lower than Step 5**	dBm	PASS FAIL	
8	Power Out, DIFF Port, 75 Feet **5 dB ± 2 dBm, Lower than Step 5**	dBm	PASS FAIL	
12	Frequency **1030 MHz / ± 0.2 MHz**	MHz	PASS FAIL	

4.4.2 TCAS Verification				
Step #	**Test Description, Expected Value**	**Measured Value** Log the result	**Result** Circle	**Initial**
5	Verify Interrogator Display "Power & Frequency" are displayed	Checked	PASS FAIL	
6	Vary Frequency Measurements **1033 to 1027 MHz ± .2 MHz**	Checked	PASS FAIL	
9	TCAS Output Frequency **1090 MHZ ± 200 kHz**	MHz	PASS FAIL	

4.4.3 DME Verification				
Step #	**Test Description, Expected Value**	**Measured Value** Log the result	**Result** Circle	**Initial**
2	a. Interrogation Pulse Width **3 to 4 µs**	µs	PASS FAIL	
	b. Reply Pulse Spacing **11.75 to 12. 25 µs**	µs	PASS FAIL	
	c. Interrogation Pulse Width, Y **29.75 to 30.25 µs**	µs	PASS FAIL	
3	a. DME 108.00 MHz, Range 2 **74.72 µsec / ± 6.18 µsec**	µs	PASS FAIL	
	b. DME 108.00 MHz, Range 130 **1656.66 µsec / ± 6.18 µsec**	µs	PASS FAIL	
	c. DME 108.00 MHz, Range 300 **3757.700 µsec / ± 6.18 µsec**	µs	PASS FAIL	
	d. DME 108.05 MHz, Range 2 **80.72 µsec / ± 6.18 µsec**	µs	PASS FAIL	
	e. DME 108.05 MHz, Range 130 **1662.66 µsec / ± 6.18 µsec**	µs	PASS FAIL	
	f. DME 108.05 MHz, Range 300 **3763.700 µsec / ± 6.18 µsec**	µs	PASS FAIL	
4	a. DME Frequency 108.00 MHz **978 MHz / ± 0.5 MHz**	MHz	PASS FAIL	
	b. DME Frequency 112.60 MHz **1160 MHz / ± 0.5 MHz**	MHz	PASS FAIL	
	c. DME Frequency 117.50 MHz **1209 MHz / ± 0.5 MHz**	MHz	PASS FAIL	
	d. DME Frequency 108.05 MHz **1104 MHz / ± 0.5 MHz**	MHz	PASS FAIL	
	e. DME Frequency 112.65 MHz **1034 MHz / ± 0.5 MHz**	MHz	PASS FAIL	
	f. DME Frequency 117.55 MHz **1083 MHz / ± 0.5 MHz**	MHz	PASS FAIL	

4.4.4 Antenna Gain				
Step #	**Test Description, Expected Value**	**Measured Value** Log the result	**Result** Circle	**Initial**
4	1030 MHz Antenna Gain Set	Checked		
	1090 MHz Antenna Gain Set	Checked		

DATE	
PASS/FAIL	
Technician	

FAILED TEST RESULTS LOG			
Step #	**Failed Test**	**Value Measured**	**Initial**

Unit Disposition - _____

APPENDIX B

TR-220 Test Set Calibration and Alignment Data Sheet

4.8.1 Sub Assembly Adjustments				
Step #	**Test Description**	**Specification**	**Initial Result**	**Final Adjusted (If applicable)**
1	Record CPLD Version		Version	
6	Record Software Revision		Revision	
10	DPSK Base Line Voltage	0 V ± 2 mv	mv	mv
12	**ATT** Peak Power	8 / ± 0.2 dBm	dBm	dBm
13	**SUM** port Peak Power	7 / ± 1 dBm	dBm	dBm
14	Peak Power at **DIFF**, 25 ft.	Power Diff > 20 dB	dB	dB
16	Peak Power at **DIFF**, 35 ft.	Power Diff -9 / ± 2 dB	dB	dB
18	Peak Power at **DIFF**, 75 ft.	Power Diff -5 / ± 2 dB	dB	dB

4.8.2 DAC Table Adjustments				
Step #	**Test Description**	**Specification**	**Initial Result**	**Final Adjusted (If applicable)**
7	**DAC TABLE**	2	Hex Value	Hex Value
	DAC TABLE	4	Hex Value	Hex Value
	DAC TABLE	6	Hex Value	Hex Value
	DAC TABLE	8	Hex Value	Hex Value
	DAC TABLE	10	Hex Value	Hex Value
	DAC TABLE	12	Hex Value	Hex Value
	DAC TABLE	14	Hex Value	Hex Value
	DAC TABLE	16	Hex Value	Hex Value
	DAC TABLE	18	Hex Value	Hex Value
	DAC TABLE	20	Hex Value	Hex Value
	DAC TABLE	22	Hex Value	Hex Value
	DAC TABLE	24	Hex Value	Hex Value
	DAC TABLE	26	Hex Value	Hex Value
	DAC TABLE	28	Hex Value	Hex Value
	DAC TABLE	30	Hex Value	Hex Value
	DAC TABLE	32	Hex Value	Hex Value
	DAC TABLE	34	Hex Value	Hex Value
	DAC TABLE	36	Hex Value	Hex Value
	DAC TABLE	38	Hex Value	Hex Value
	DAC TABLE	40	Hex Value	Hex Value
	DAC TABLE	42	Hex Value	Hex Value
	DAC TABLE	44	Hex Value	Hex Value
	DAC TABLE	46	Hex Value	Hex Value
	DAC TABLE	48	Hex Value	Hex Value

4.8.3 Receiver Gain				
Step #	**Test Description**	**Specification**	**Initial Result**	**Final Adjusted (If applicable)**
2	Verify 100% Reply	100%	Verify	
4	Receiver Gain SUM / 0 dBm	210 / ± 1		
5	Receiver Gain SUM / -25 dBm	145 / ± 1		
6	Receiver Gain SUM / 0 dBm	210 / ± 1		
7	Receiver Gain SUM / + 5 dBm	222 / ± 1		
8	Power Measurement Display	58 dB		
9	Power Measurement Display	53 dB		
10	Output Tracking +10 to -20	Tracks ± 1dB	Verify	
12	Direct Connect Out	- 42 dBm / 1 dB	dBm	dBm
16	Receiver Gain DIFF	240 / ± 2		
17	Receiver Gain DIFF / – 25 dB	175 / ± 2		
18	Receiver Gain Verification	Verify		
23	DIFF/SUM @ 35 ft	Verify Pulse State Change	Check	Check
24	DIFF/SUM @ 35 ft	Verify Pulse State Change at 2 dB less	Check	Check
25	DIFF/SUM @ 25 ft	Verify Pulse State Change at 6 dB / ± 1	dB	dB

4.8.4 Power Supply Test				
Step #	**Test Description**	**Specification**	**Initial Result**	**Final Adjusted (If applicable)**
1	Power Supply Voltage at Batter Leads	7.2 VDC / ± 0.3 VDC	VDC	
3	Low Battery Display	5.6 VDC / ± .05 VDC	VDC	
	NO Low Battery Display	5.4 VDC / ± .05 VDC	VDC	
4	Test Set Shuts Down	5.2 VDC / ± .05 VDC		
5	"LOW BATTERY SHUTTING DOWN"	Verify Display	Checked	

4.8.5 Acceptance and Verification Check FINAL STEP				
Step #	**Test Description**	**Specification**	**Initial Result**	**Final Adjusted (If applicable)**
1	Complete Acceptance and Verification Test	PASS		PASS FAIL

Date of Calibration	
Technician	
Signature or Stamp	

FAILED TEST RESULTS LOG			
Step #	**Failed Test**	**Value Measured**	**Initial**

Unit Disposition - _____

APPENDIX C

TR-220/210/211 Series of Test Sets

TAP-200 Calibration Procedures

1.0 PURPOSE

To Provide Owner and Operators of TR-220 and TR-210 Test Sets additional information and procedures to test and verify the TAP-200 Antenna Coupler.

The TAP-200, which is available in both 10' and 50' lengths, is available as an optional accessory and the following procedures are applicable to both.

2.0 EQUIPMENT REQUIRED

The following equipment list is necessary to calibrate and certify the TAP-200.

a) *Agilent 8757D, Scalar Network Analyzer, or equivalent*

b) L-Band Transponder antenna mounted on a 3'x3' metallic base

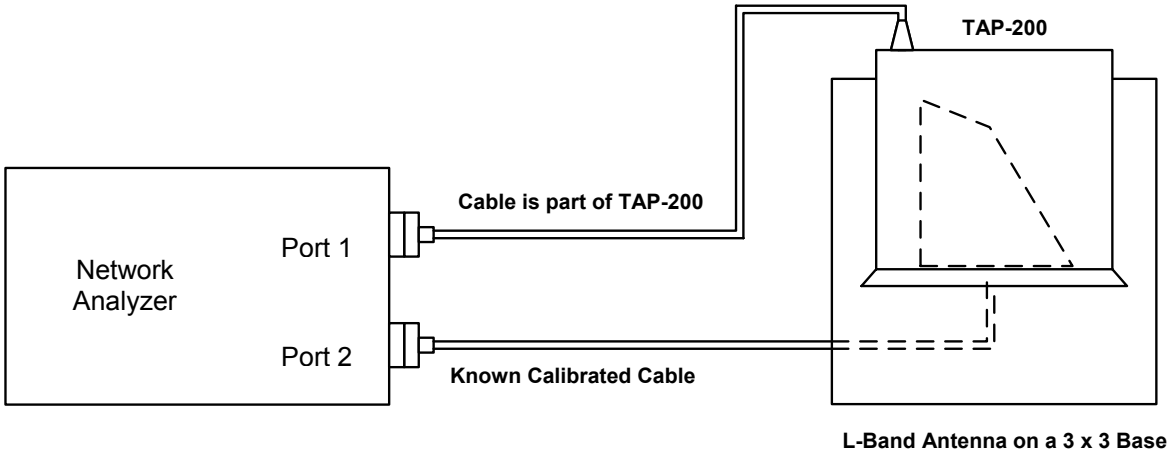
c) An assortment of connector adapters

d) Plastic, non metallic, tuning tools

Please refer to your Maintenance Manual which will detail Safety concerns, disassembly procedures, and drawings that may assist the operator/technician in completing these tests.

3.0 PROCEDURES

1. Connect the TAP-200 to a Network Analyzer and L-BAND Antenna IAW Figure A-1.



TAP-200 Calibration Setup

Figure A-1

2. Ensure that the TAP-200 is centered and flush to the base directly over the L-Band Antenna.

3. Set the Network Analyzer to the following:

Start Frequency	1020.0 MHz
Stop Frequency	1100.0 MHz
Scale Ref. Level	-50 dB (Take into account calibrated cable)
Ref. Position	5
Scale/Div	1.0 dB
Power Level	10 dBm
Averaging	"ON"
Marker 1	1030.0 MHz
Marker 2	1090.0 MHz

4. Observe a display similar to Figure A-2. Patterns may vary slightly.

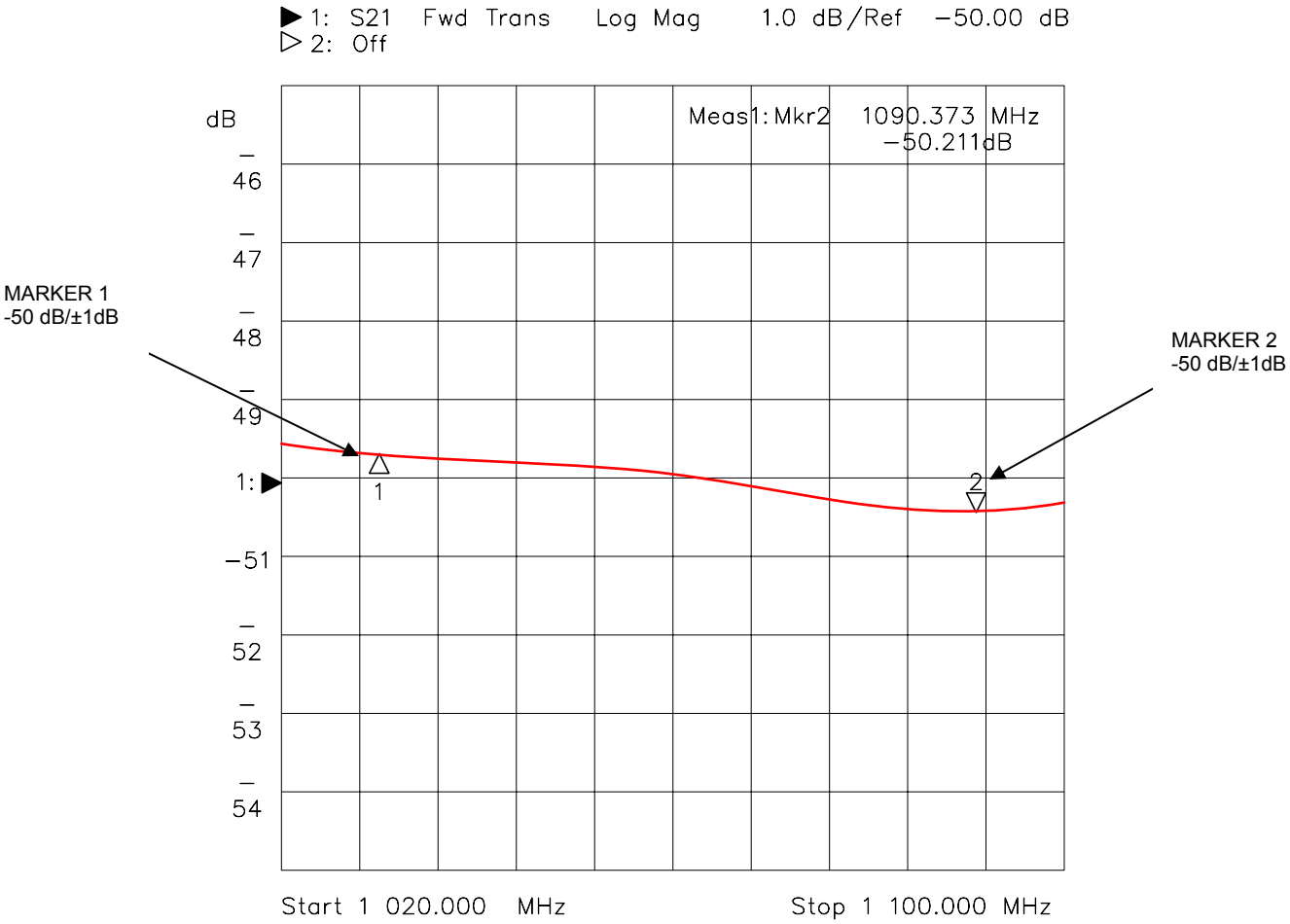
NOTE

Do not make an adjust if the measured display is in specification

5. Adjust **C4** (located on top of the TAP-200) so that the displayed measurement can be adjusted in an approx ± 3 dB. There is two positions in which **C4** might provide results. Select the location which provides the minimal slope and allows smooth adjustability around its range.

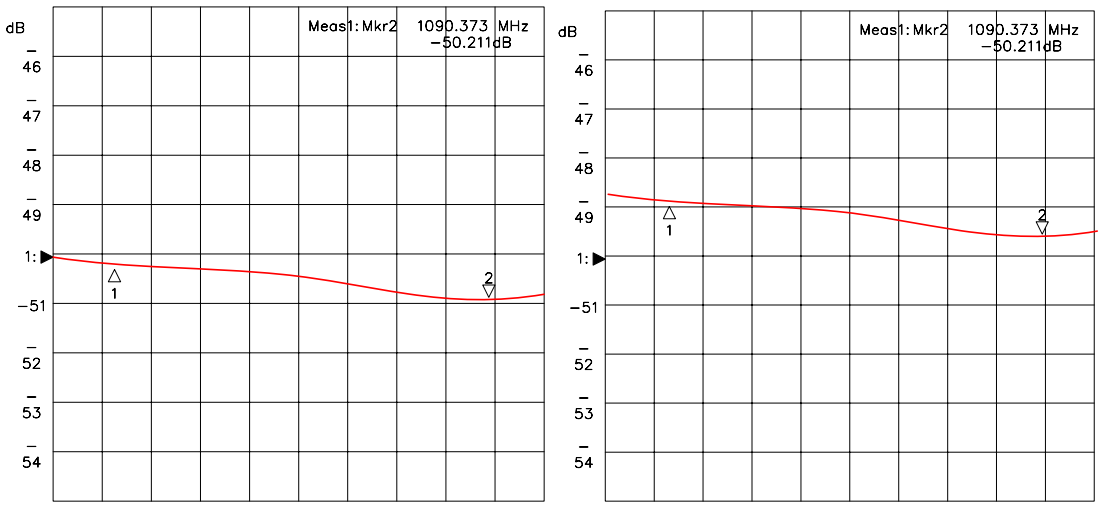
6. Fine tune **C4** so that at *MARKER 1,* the display is at -50 dB/± 1 dB, at the same time, *MARKER 2* is also at -50 dB/± 1 dB (see Figure A-3). Ensure that the cable loss from Port 2 to the L Band antenna was accounted for. Variations in the displayed measurement are not linear. Do not adjust the measurement in the center, only at the markers.

7. Record the results on the Data sheet as provided at the end of this supplement and seal the adjustment access for **C-4** to provide dust and rain protection.

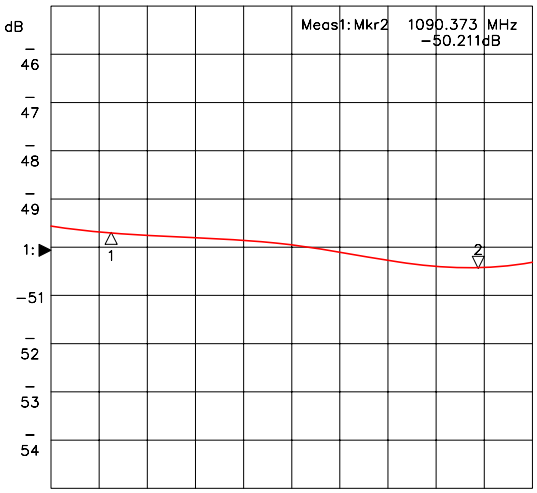


TAP-200 Network Analyzer Display

Figure A-2



INCORRECTLY ADJUSTED



CORRECT

TAP-200 Adjustment Examples

Figure A-3

TAP-200 Calibration/Verification Check Data Sheet

DATE	
Model	
Serial #	
Technician	

3.0 TAP-200 Adjustment				
Step #	**Test Description**	**Expected/Measured Value** Log the result	**Final Adjusted**	**Initial**
6	Marker A -50dB / ± 1 dB	dB	dB	
6	Marker B -50dB / ± 1 dB	dB	dB	

FAILED TEST RESULTS LOG			
Step #	**Failed Test**	**Value Measured**	**Initial**

Unit Disposition - _____