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## 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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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

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## Safety Precautions

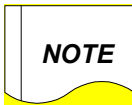
The following are general safety precautions that are not related to a particular test or procedure. These are recommended procedures that all personnel must apply during many phases of operation and maintenance. It is assumed that the operator has general knowledge of electrical theory and the dangers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

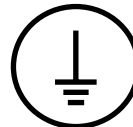
The Following Symbols may be utilized in different locations throughout the Manual and are also located on and in the Test Set. Observe these warnings and markings and follow standard electrical safety anytime you utilize live circuits.



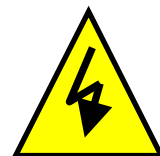
Caution



Alternating Current



Protective Conductor  
Terminal



Caution, risk of  
electrical shock

**VOLUME 1**  
**OPERATIONAL PROCEDURES**

TR-220 TABLE OF CHANGES<sup>1</sup>

Date	REV	ECO	Page	Description
07 Sep 03	Prelim. A			Initial Release 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

<sup>1</sup> Changes are also denoted with a solid bar in the Left margin of each affected page.

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# 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.

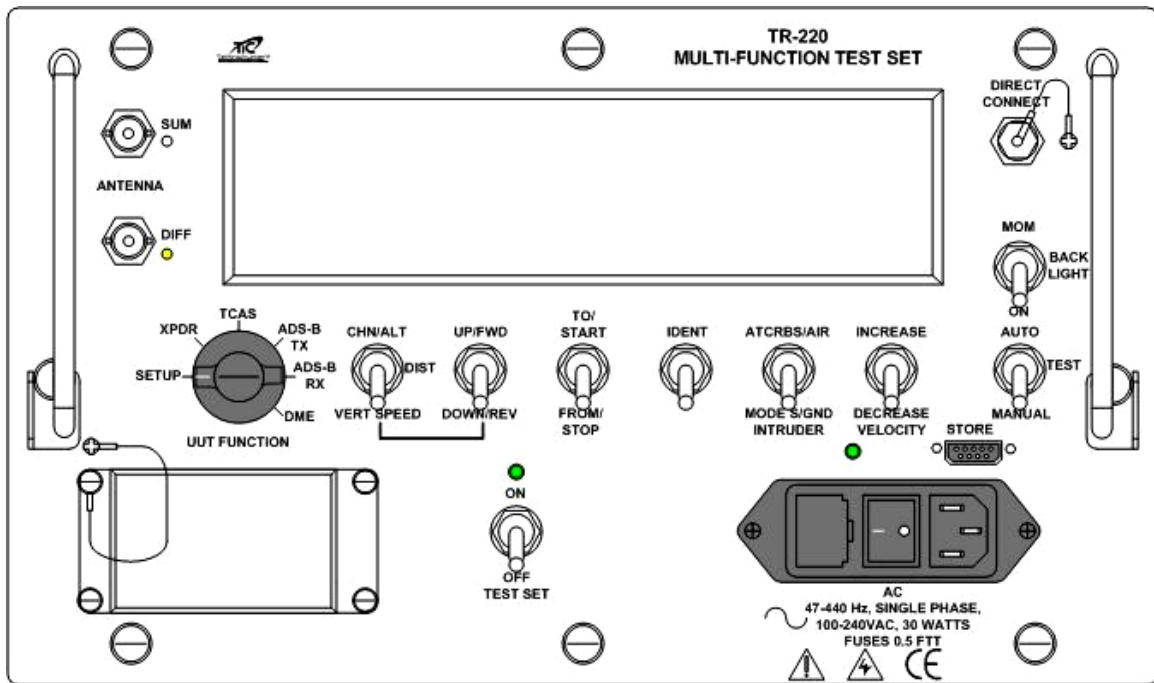


Figure 1-1

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/](http://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 $\pm$ 10 kHz
Output Power	$\geq$ 4dBm
Modes	A, C, S, ADS B TX/RX, and TIS

##### Transponder Receiver

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

#### DME

##### DME Receiver

Frequency	Frequency Accuracy	Channel Freq +3.5 MHz $\pm$ 200 kHz
Sensitivity	Range	< -35 dB

##### DME Transmitter

Frequency	Frequency Accuracy Power	962 to 1213 MHz $\pm$ 100 kHz $\geq$ 4 dB
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#### TCAS

##### TCAS Transmitter

Frequency	1090 MHz $\pm$ 10 kHz
Output Power	$\geq$ 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<sup>1</sup>

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

<sup>1</sup> 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.

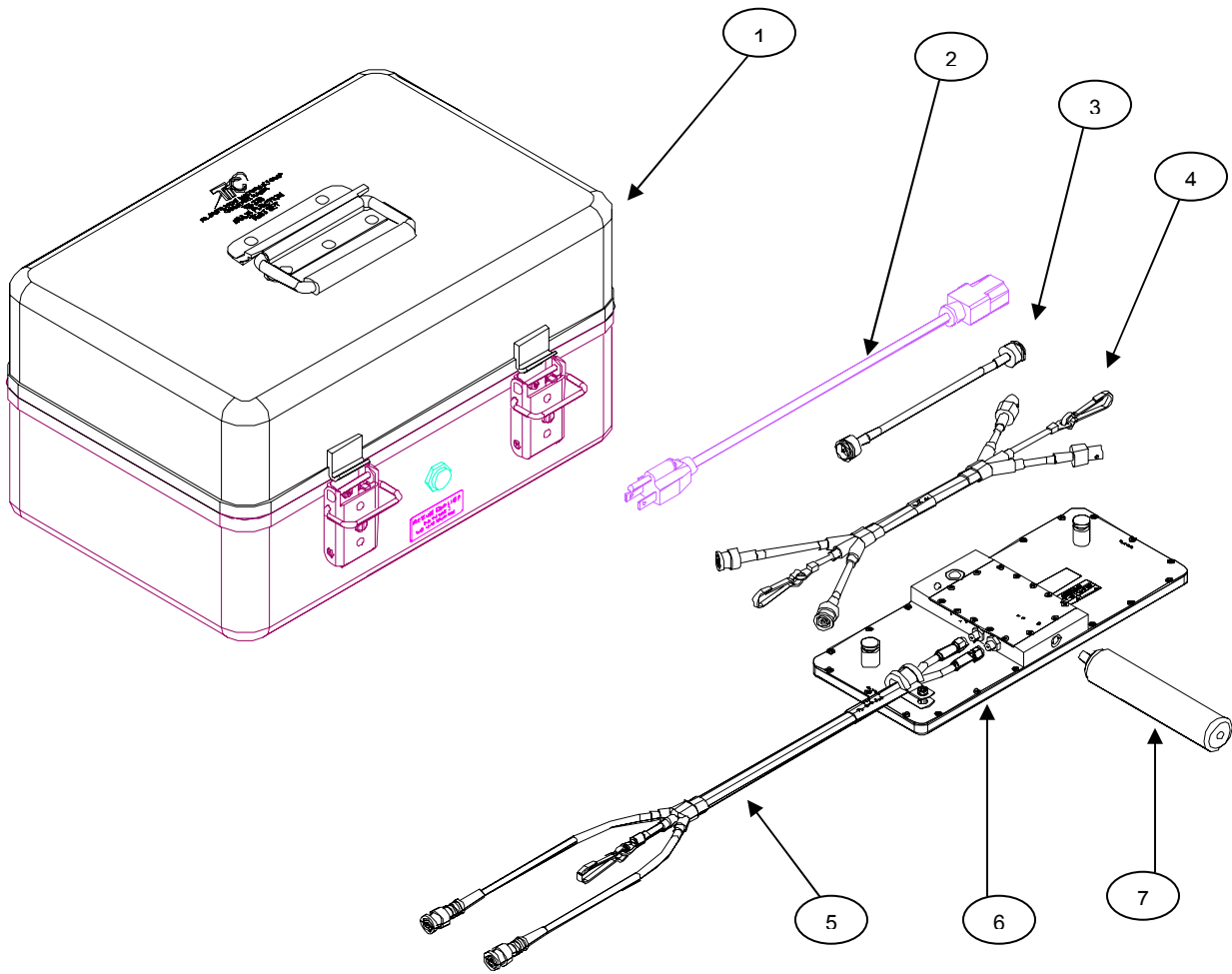
#### 2.4 Accessories

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

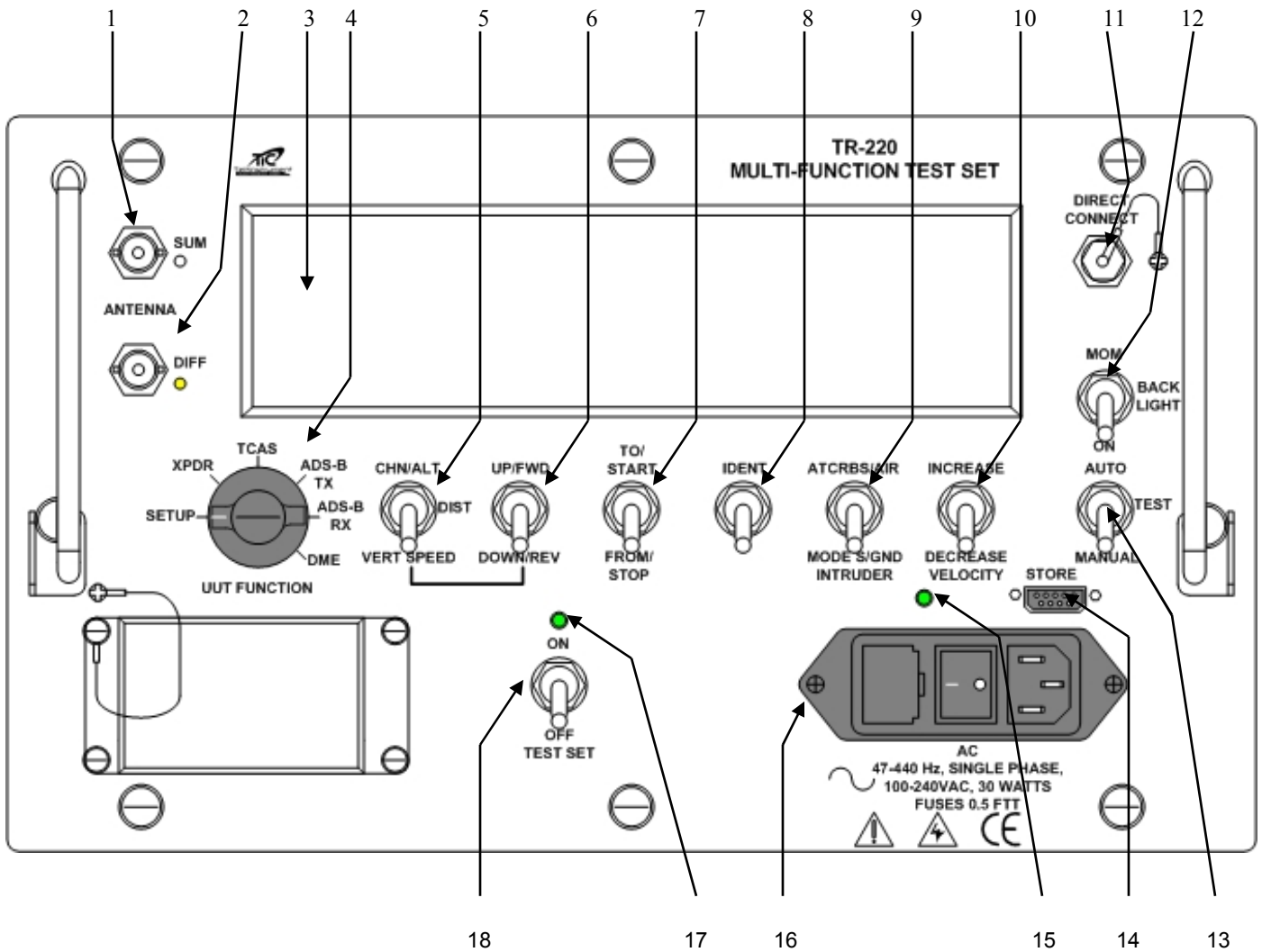
### OPERATING CONTROLS, INDICATORS, AND CONNECTORS

#### 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	<b>SUM</b> Antenna Port	Provides Connection to the Directional Antenna Sum Connector and the optional TAP-135 Antenna Coupler.
2	<b>DIFF</b> 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	<b>UUT FUNCTION</b> Switch	Provides access to Test Set Menus and Modes. <b>SETUP</b> - 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. <b>XPDR</b> - Access ATCRBS and MODE S Transponder test menus. <b>TCAS</b> - Access TCAS intruder menus. <b>ADS-B TX</b> - Select ADS-B Transmitter Results. <b>ADS-B RX</b> - Select ADS-B, and TIS Functions. <b>DME</b> - Access DME Test menus.
5	<b>CHN/ALT, DIST, VERT SPEED</b> Switch	DME- Allows selection of DME Channels. Selectable from 108.0 MHZ in 50 KHz steps. Used in conjunction with <b>UP/FWD – DOWN/REV</b> 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 <b>UP/FWD – DOWN/REV</b> switch. TCAS- Intruder vertical speed in "feet per minute" (fpm) adjustable in 100' increments from +7500' to -7500'. Used in conjunction with <b>UP/FWD – DOWN/REV</b> switch.
6	<b>UP/FWD, DOWN/REV</b> Switch	Used in conjunction with <b>CHN/ALT, DIST, VERT SPEED</b> switch to vary parameters. Also used to set antenna gain and Test Set distance in <b>SETUP</b> mode.
7	<b>TO/START – FROM/STOP</b> Switch	Start and Stop TCAS Intruder scenarios and change DME To/From parameters.
8	<b>IDENT</b> Switch	Initiates a SPI Pulse for verification of transponder IDENT function.
9	<b>ATCRBS/AIR, MODE S /GND INTRUDER</b> Switch	Selects TCAS Intruder Type (MODE S or ATCRBS), and Air or Ground position.
10	<b>INCREASE/DECREASE VELOCITY</b>	Sets TCAS Intruder and DME speed velocities. Also utilized for ADS-B TX/RX Functions.
11	<b>Direct Connect</b> Port	For direct connection to a Transponder. Provides accurate RF Power, frequency and sensitivity measurements.
12	<b>MOM/BACK LIGHT/ON</b> Switch	Activates display backlighting either "ON" or momentarily.
13	<b>AUTO/TEST/MANUAL</b> 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	<b>STORE</b> 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	<b>TEST SET ON/OFF</b> 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

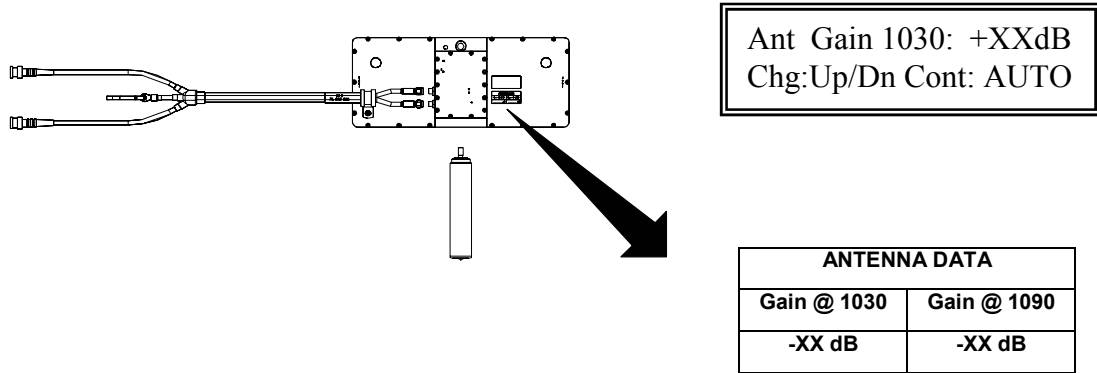
Standard equipment with the TR-220 is a Directional Antenna. The antenna, stored in the case cover, can either be hand held, tripod mounted, or directly mounted on the Test Set case. The Test Set also contains a direct connect cable for accurate power and frequency measurements ( $\pm 2$  dB) when connected 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.



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

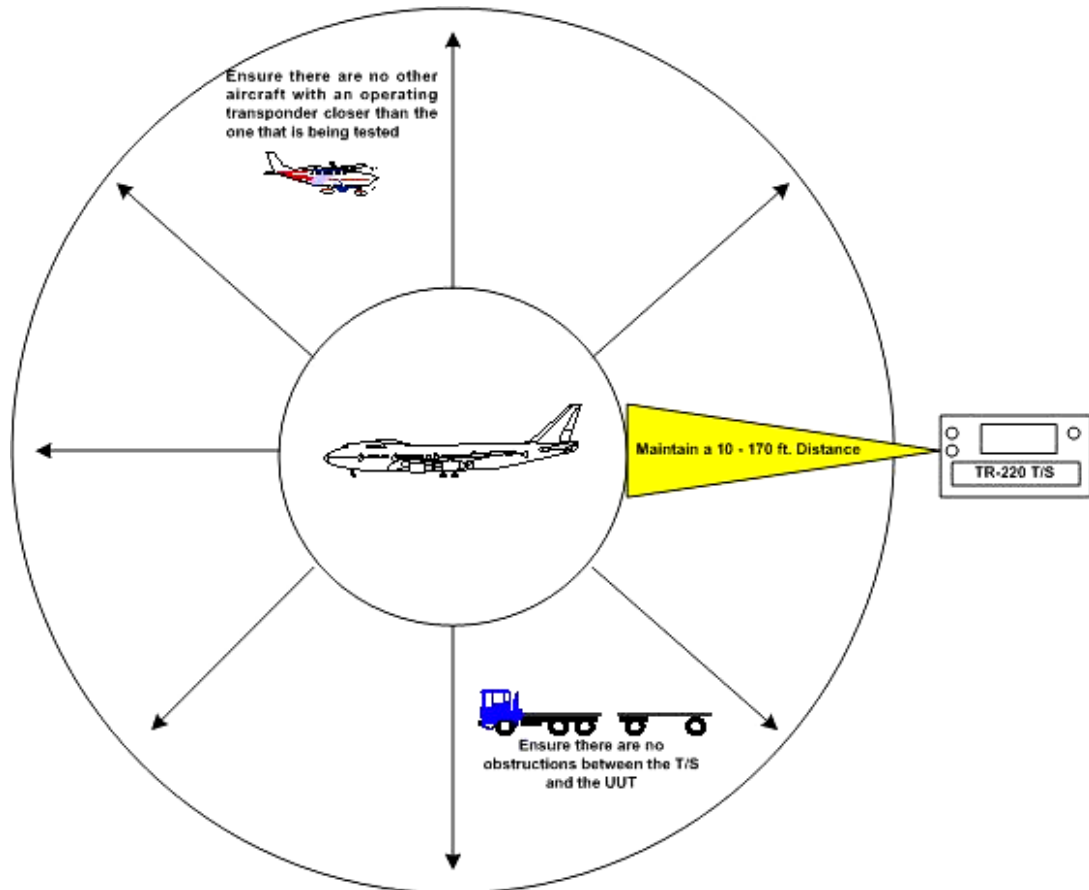
5. Maintain a 10 to 170 ft. (3 to 50 meters) unobstructed path to the Aircraft Under Test (AUT), and point the Directional antenna to the appropriate antenna on the AUT.
6. Turn the Test Set "ON" with the **UUT FUNCTION** switch in **SETUP**. Locate the **T/S Distance** menu by toggling the **AUTO** 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 slowly 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  $\pm 3$  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.

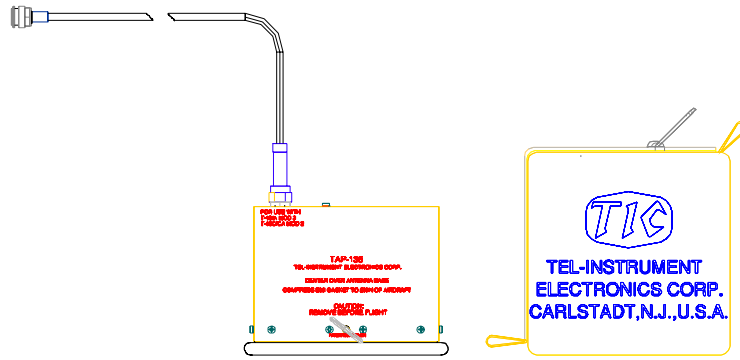
1. Access the ANT GAIN menu by turning the Test Set "ON" with the **UUT FUNCTION** switch in the **SETUP** position. Locate the *Cable Loss* menu by toggling the **AUTO/MANUAL** switch. Enter the correct values that are affixed to the supplied cable by using the **UP/FWD, DOWN/REV** switch. If you are 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  $\pm 2$  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

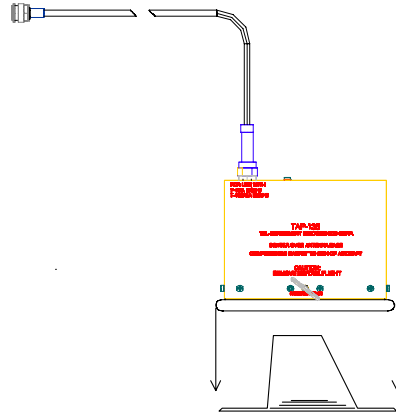
Figure 2-5

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

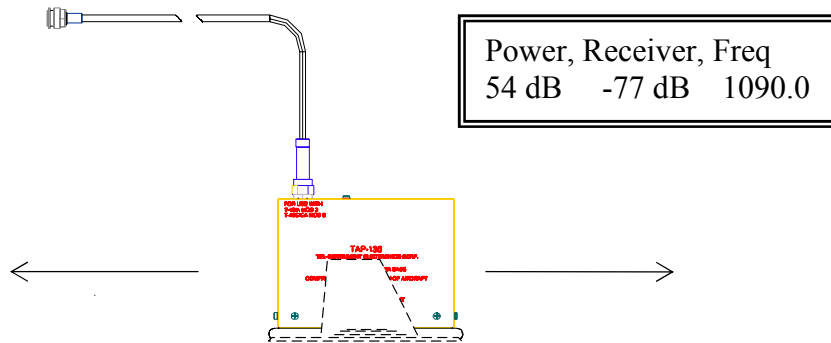
3. Use the UP/FWD-DOWN/REV switch to select *TAP*.
4. To install the coupler, pull the ring, which separates the spring-loaded clamp, and slide the coupler over the blade antenna. Ensure that the EMI gasket of the coupler is flush with the aircraft skin and that the coupler is centered over the antenna. 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.

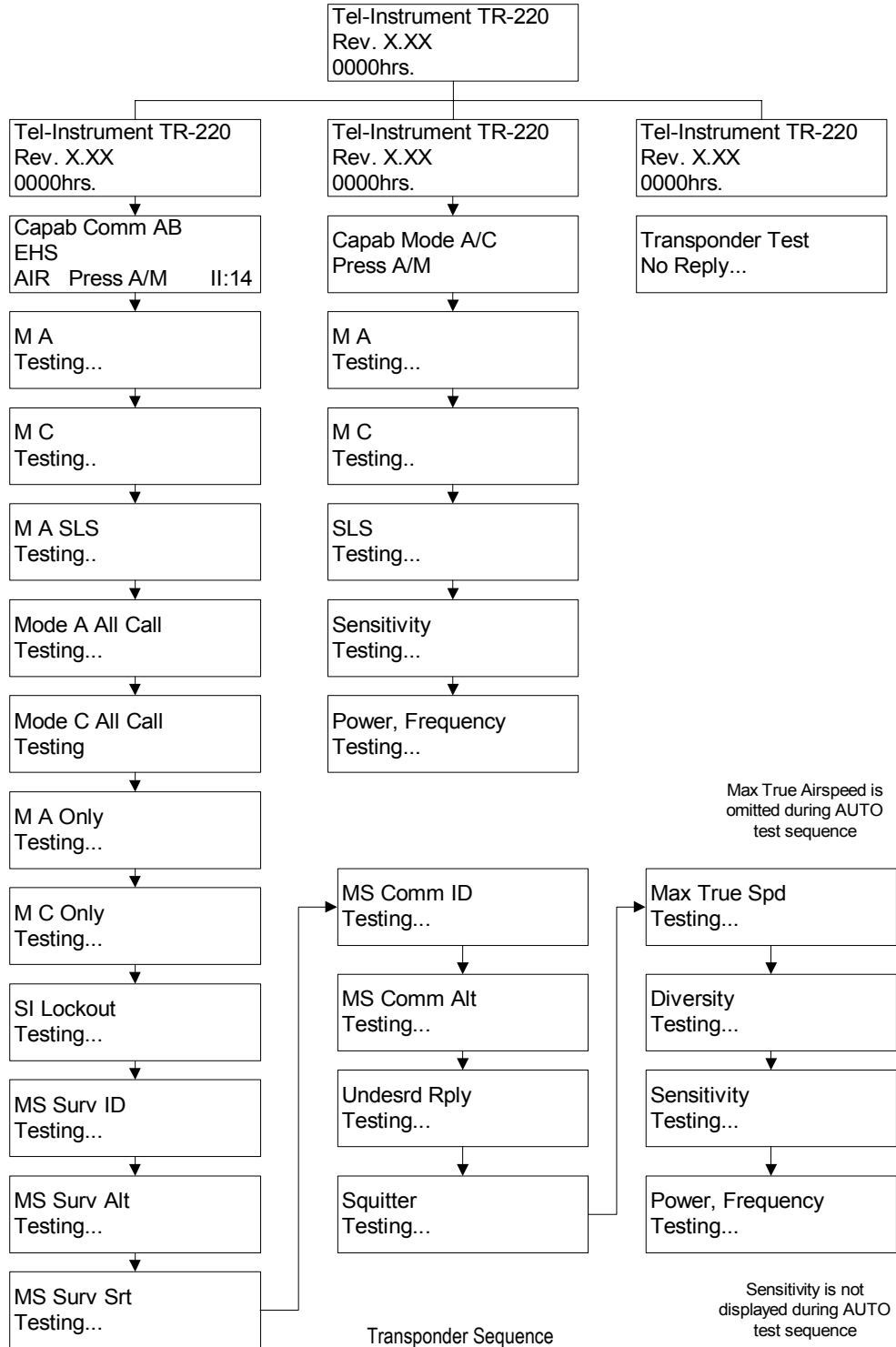
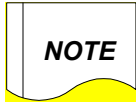


Figure 2-8

**2.12 Transponder Manual Sequence of Tests**



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.

MA 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.

MC                                    /  
Testing . . .

Mode C Test initialized.

MC 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.

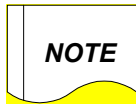
9. To advance, toggle the **AUTO/TEST/MANUAL** switch to **MANUAL**. The next test in sequence will commence.

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.



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



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  $\mu$ s increments (20.35  $\mu$ s).

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 ATRBS 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.

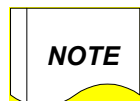
12. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

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.



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

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:

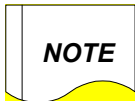
M S Surv Srt / Testing. . .
--------------------------------

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).



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

EXT: NOT DETECTED

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: PASS 500 ms  
ADD: A02008 II:0

If and Extended Squitter "IS" detected, the following display indicating the interval time and address.

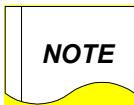
19. Toggle the **AUTO/TEST/MANUAL** switch to **MANUAL** to advance to the next sequence:

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.



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.

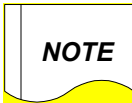
Power, Frequency /  
54 dBm 1090.0Mhz

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.

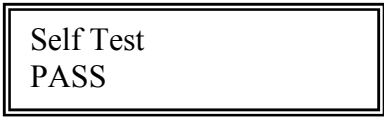


All illustrations shown are for demonstration purposes. Though the test results may be typical, they are not meant to replace FAA guidelines and manufacturer recommendations.

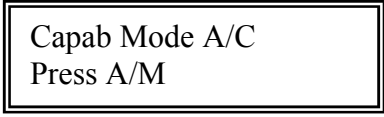
Before testing begins, ensure that you have read and fully understand the procedures preceding this section. By reviewing these sections, the operator can avoid erroneous and inaccurate results.

**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.



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.



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.

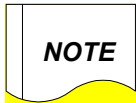


6. If no failures are detected, the Test Set will cease testing and display the following alternating display:

Power, Receiver, Freq /  
54dB -78dB 1090.0

Mode A: 1234  
Mode C: 10000'

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.



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  $\mu$ s.

MC /  
No Reply

MC  
0.45-20.35-0.35 FAIL

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  $\mu$ s.

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**



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  $\mu$ s.



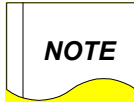
Illustrate a Squitter failure

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



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.

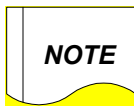
**END OF TRANSPONDER TESTS**

**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.

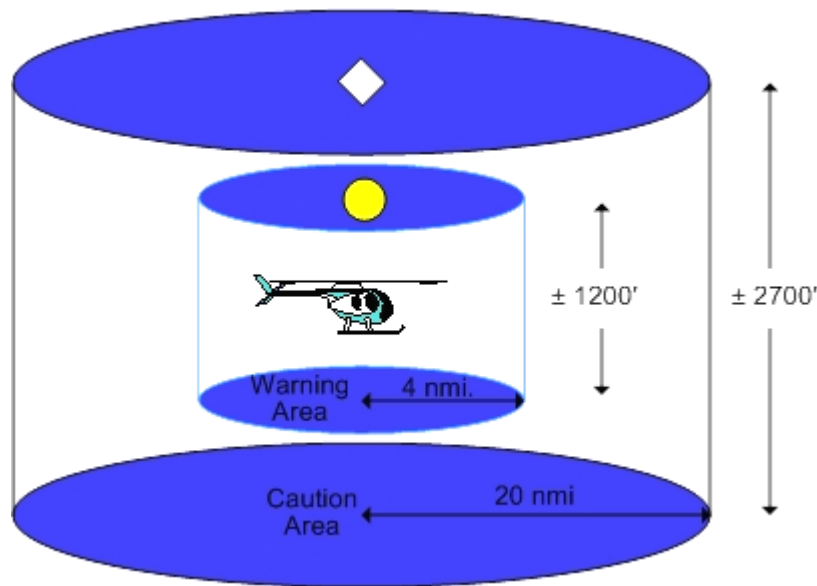
**2.15.1 Typical TCAS Concepts**



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.

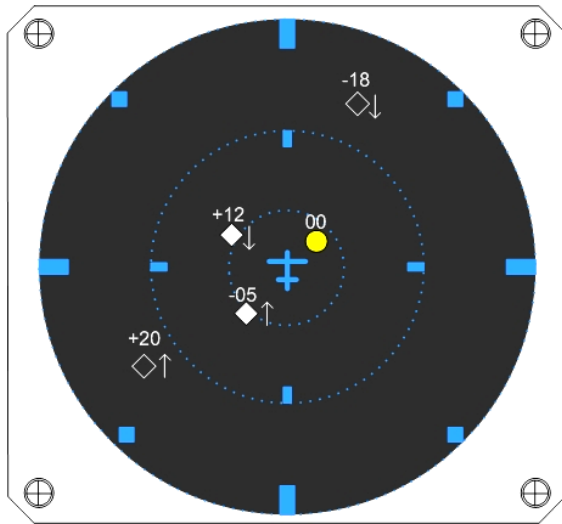
TCAS is a system, which provides situational awareness of the surrounding airspace of an aircraft to the pilot and crew. A TCAS establishes a volume of airspace around the aircraft. The size of the airspace is based on range, speed and altitude. By working in-conjunction with the aircraft Transponder 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  $\pm 1200$  feet altitude.
-  An open white diamond signifies other traffic within the selected range.
-  Numbers represent the intruder aircrafts relative altitude  $\pm 100$  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 two digits and final two digits to be changed with the **UP-DOWN** switch respectively.

Mode S Addr: 3D8DFF Chg: A/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:
3D8DFE

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**

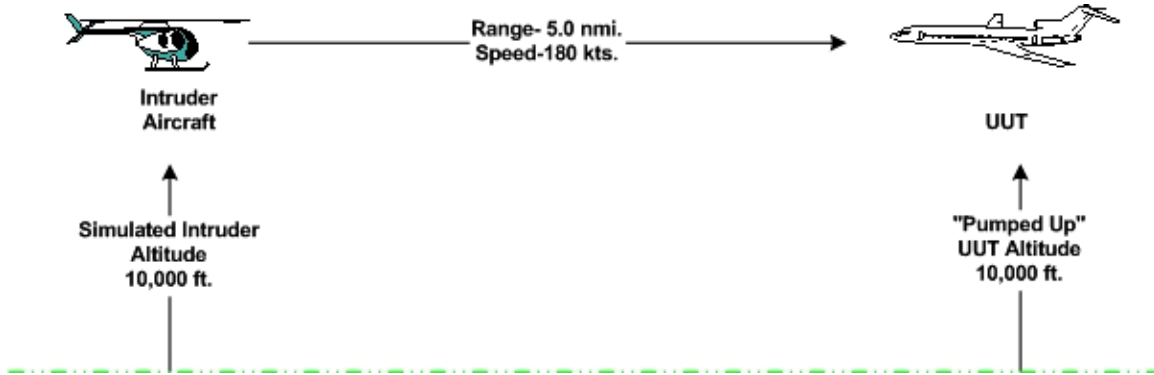
The following text utilizes Scenario 1, which is the default TCAS scenario. The parameters are as programmed in the example in para 2.15.2.
---

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.

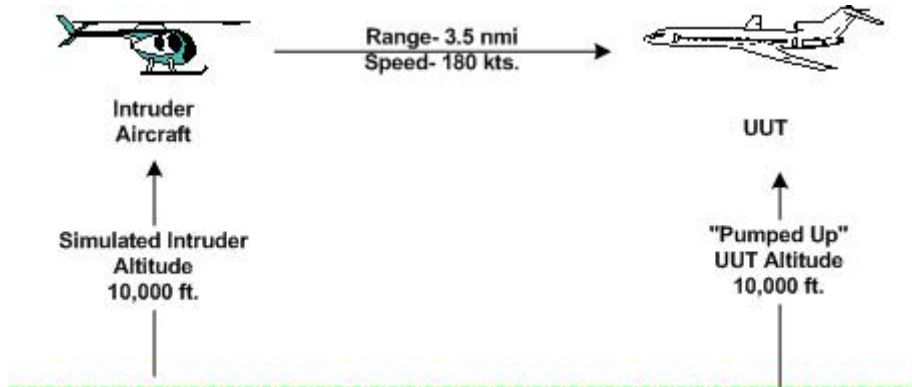
9. Select the intruder type, Mode S or ATCRBS using the ATCRBS/AIR-MODE S/GND switch. For TCAS I select ATCRBS and for TCAS II select Mode S.
10. Toggle the **AUTO/TEST/MANUAL** switch to the **AUTO** position. The Test Set is now simulating an intruder aircraft at the selected position. **STP** indicates 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



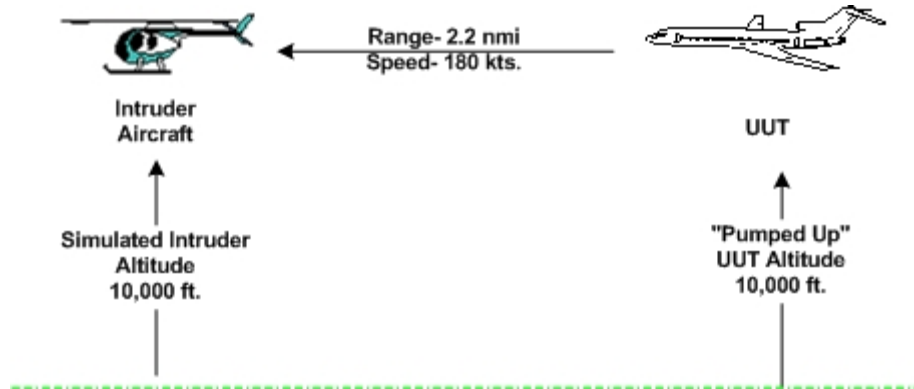
11. Toggle the **TO/START-FROM/STOP** switch to the **TO** position to commence the intruder convergence on the UUT. The Test Set display will indicate the altitude, range, velocity and climb rate (fpm) of the intruder simulation.

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.

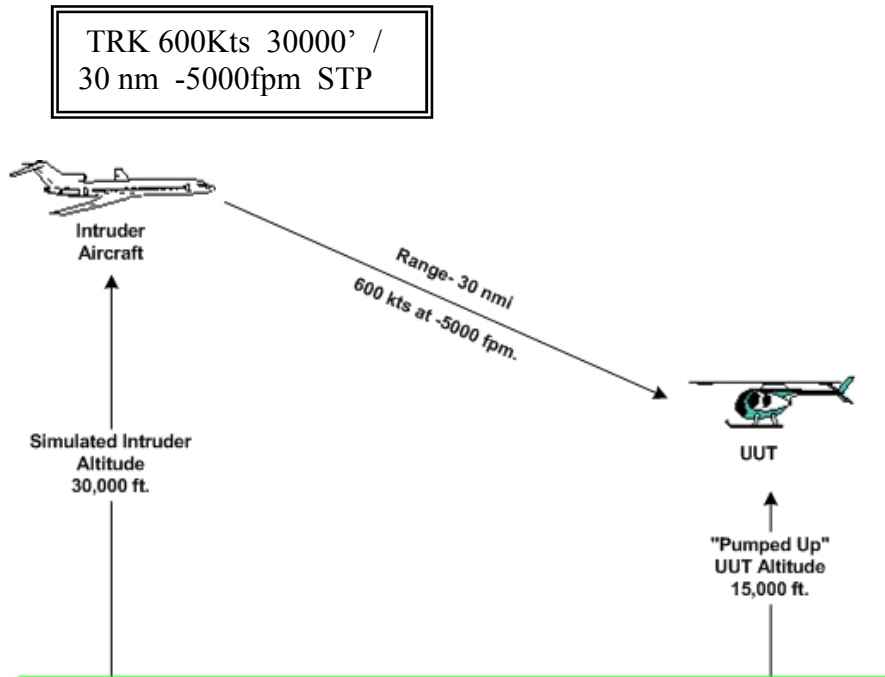
TRK 180Kts 10000' /  
2.2 nm +000fpm FRM



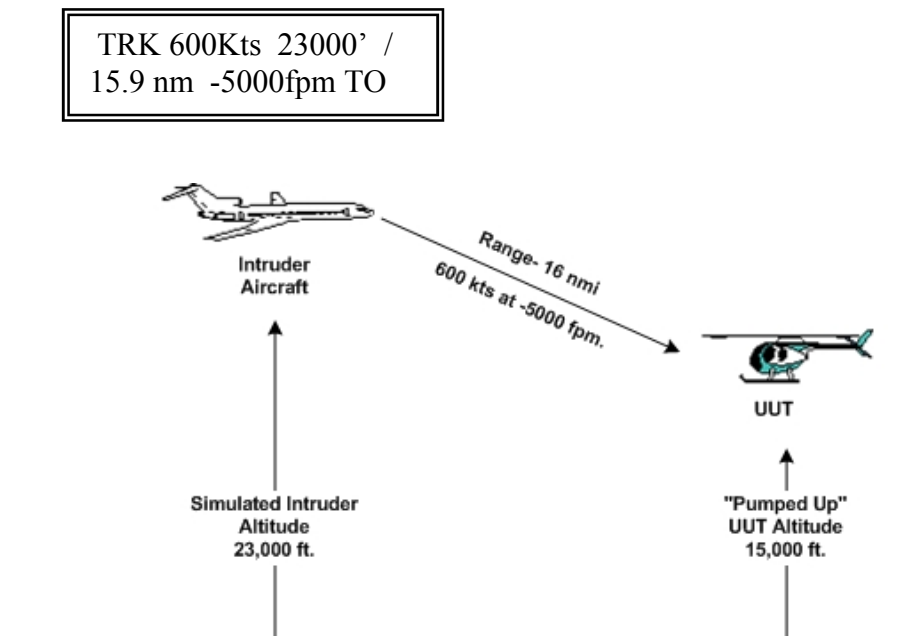
13. At any point during the simulation, the operator may STOP the intruder at any range. Toggle the **TO/START-FROM/STOP** switch twice to the **STOP** position. The intruder will stop and hold at that range. The operator now may move the Test Set to a different location around the AUT to check that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

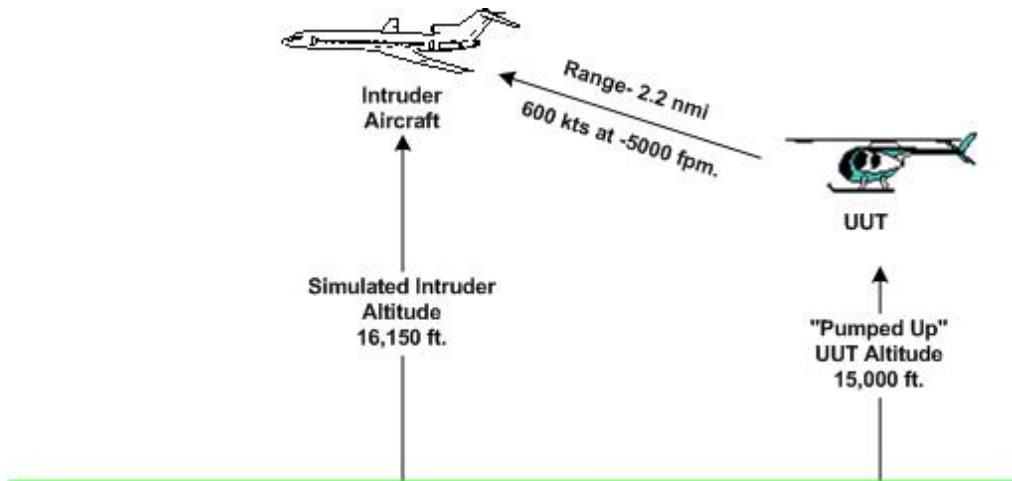


14d. As the simulated intruder approaches, the altitude will decrease to ensure a proper intersect of the targets.



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.

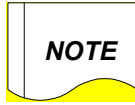
Power	FrequencyT
Listening . . .	

12. The DME power and frequency will be displayed.

Power	FrequencyT
55dbm	1041.0Mhz

**END OF DME TESTS**

## 2.17 Mode S Enhanced Surveillance



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 be 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 <sup>3</sup> /M In VertVel +6000 <sup>3</sup> /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)

BDS1	SubNet=1	A
	TC Lvl=	DTE=

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)

BDS1	SPC SV CP=
	Cont Flg= SI=

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)

BDS1	Flt ID=
	Sq= COM GICB=

Uplink UELM capability = "UELML=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)

BDS1	UELML=
	DELM=

BDS 1,7	Co Use GICB
FA	81 01 00 00 00 00

BDS 1,8	MS Sp Sv GICB
00 00 00	81 C0 81 F0

BDS 1,9	MS Sp Sv GICB
00 00 80	00 80 00 80

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)

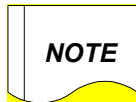
BDS4 VNAV = NA  
Alt Hld= NA Appr= NA

**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



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.

Self Test  
PASS

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

DF-17/18 Message  
Decoding

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.

Position . . .

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.



**NOTE**

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:
- Altitude = 10,000 feet
  - Distance = 10 miles from the test set **HOME POSITION**
  - Velocity = 250 knots
  - Target locations are NE, SE, SW, and NW of the test set **HOME POSITION**
  - 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 download 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:

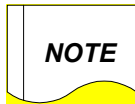
1. **MODE A & SLS**  
Re: Mode A Reply, Mode A Code, MA SLS
2. **MODE C**  
Re: Mode C Reply, Mode C Altitude
3. **MODE A & SLS**  
MA SLS, P1 > P2, Reply, P1 = P2
4. **MODE A ALL CALL**  
Re: Mode A & C Reply, MA and C Address
5. **MODE C ALL CALL**  
Re: MC & A Reply, Mode A & C Address
6. **MODE A 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.