SECTION C

CALIBRATION AND ALIGNMENT

4.5 General and Frequency of Calibration

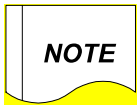
A full Calibration and Alignment of the Test Set shall be performed under the following conditions:

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

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

3. If any major assembly is replaced.

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



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

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

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

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

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

4.6 Test Equipment Required and Test Set Initial Settings

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

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

Test Set Annual Calibration Equipment List

Table 4-5

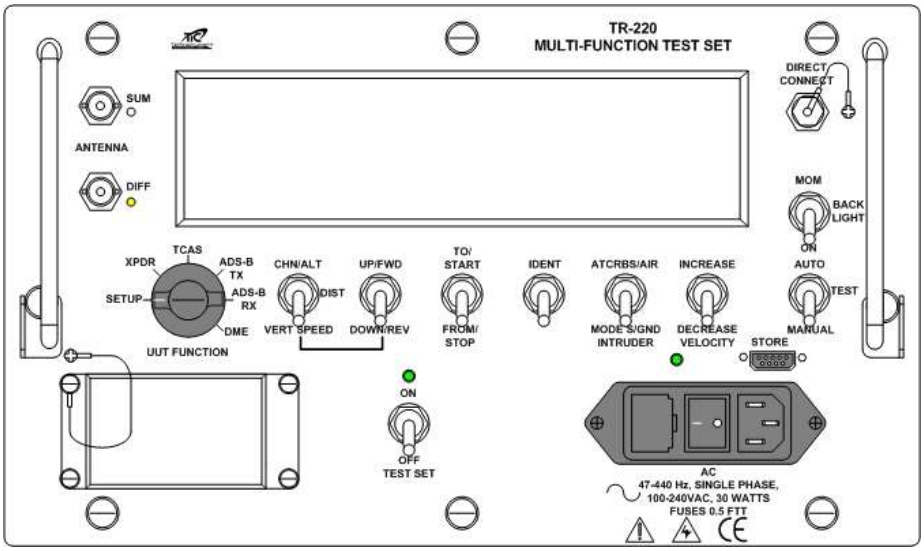
Set the TR-220 front panel switches to the following positions before each test, unless otherwise instructed:

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

Initial Settings

Table 4-6

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



Initial Settings

Figure 4-8

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

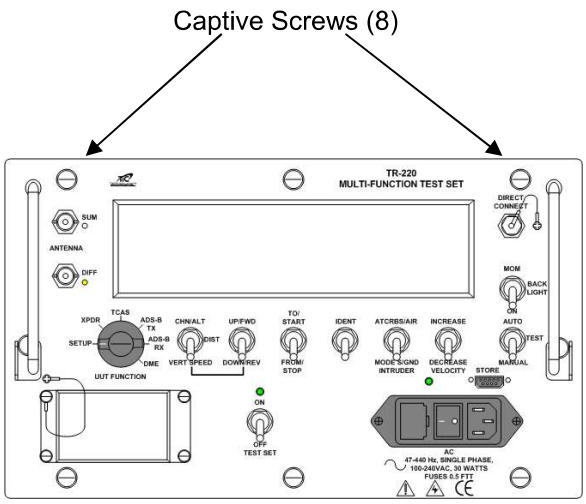
4.7 Disassembly of the Test Set and Procedures

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

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

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

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



Captive Screw Location

Figure 4-9

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

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

4.8 Calibration & Alignment

NOTE

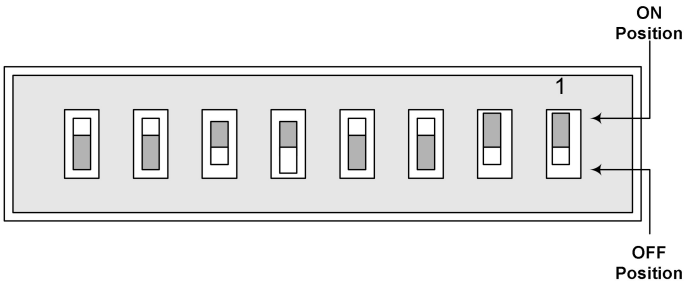
Due to different Software revisions, displays and procedures may vary slightly.

NOTE

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

4.8.1 Sub-Assembly Adjustments

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



U-17

Figure 4-10

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

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

NOTE

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

Initialize RAM
INIT: Press Manual

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

Initialize RTC
INIT: MAN'L SKIP:AUTO

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

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

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

Initial Setup

Table 4-7

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

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

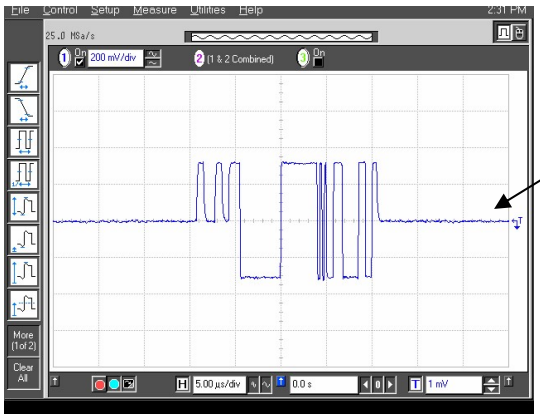
Self Test
Testing . . .

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

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

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

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



DPSK Ripple Check

Figure 4-11

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

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

M A
No Reply

All information Shown is "Don't Care".

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

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

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

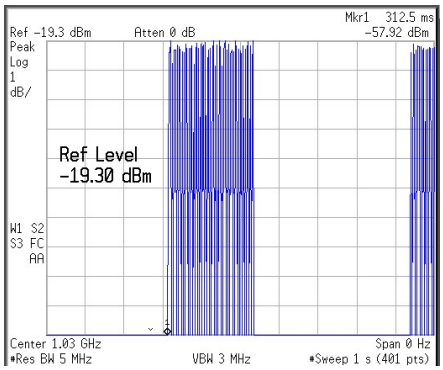
13. Disconnect the spectrum analyzer and connect it directly to the **SUM** port. Turn the Test Set back *"ON"* while holding the **FROM** switch *"Down"*. This disables the Antenna LED power.

Antenna LED is OFF

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

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

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



DIFF Power Measurements

Figure 4-12

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

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

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

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

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

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

4.8.2 DAC Table (Transmit)

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

TEST FUNCTIONS Calibrate TX POWER

NOTE

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

Self Test DAC table Xsum FAIL

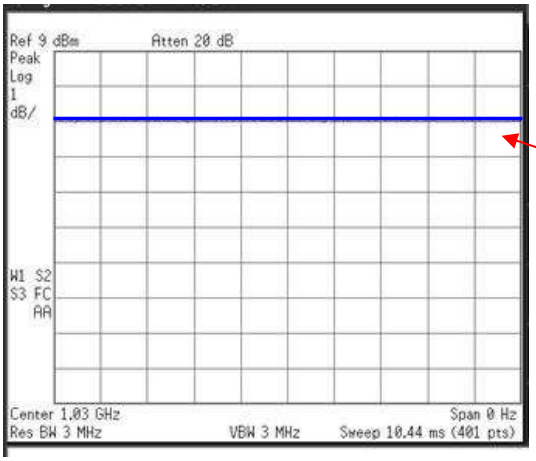
2. Toggle the **AUTO** switch and observe the following:

POWER CALIBRATION: -00 dB DAC=0000h

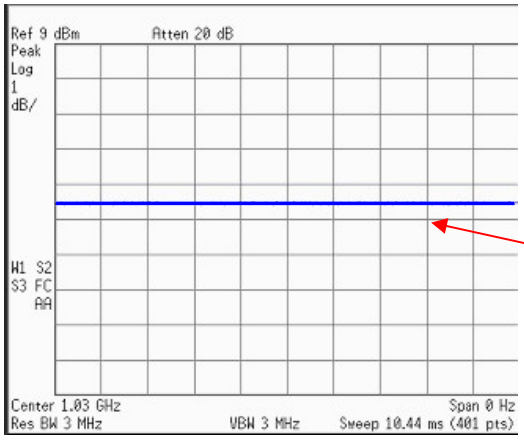
3. Set the Spectrum Analyzer to the following initial settings:

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

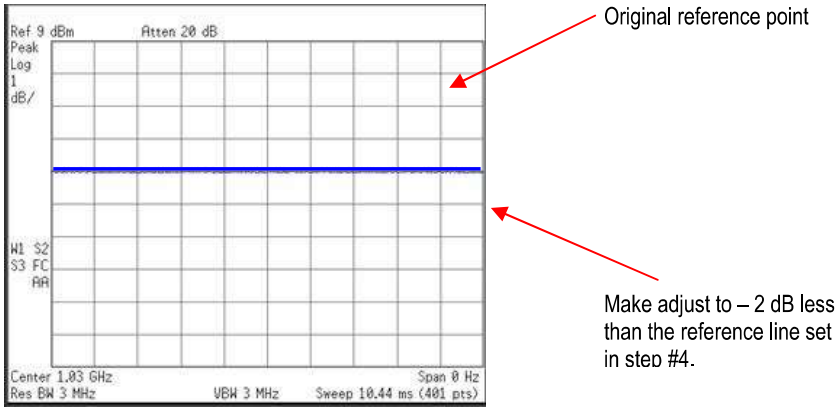
4. Observe a straight line power measurement. Adjust the Spectrum Analyzer so the measured pulse is even on any line. This will be the same reference line used for each measurement which ensures linear adjustments are made to the DAC table. The initial ***0 dB DAC setting of 0000h*** shall not be adjusted.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



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



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



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

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

Record on the data sheet each 2 dB step.

4.8.3 RX Gain Calibration

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

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

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

Set the Signal Generator to the Following:

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

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

NOTE

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

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

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

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

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

TEST FUNCTION:

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

Calibrate RX GAIN SUM: XXX DIFF: YYY

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

Calibrate RX GAIN SUM: 210 DIFF: YYY

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

Calibrate RX GAIN SUM: 145 DIFF: XXX

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

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

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

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

Power	Frequency
58 dB	1090.0 MHz

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

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

Power	Frequency
53 dB	1090.0 MHz

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

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

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

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

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

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

NOTE

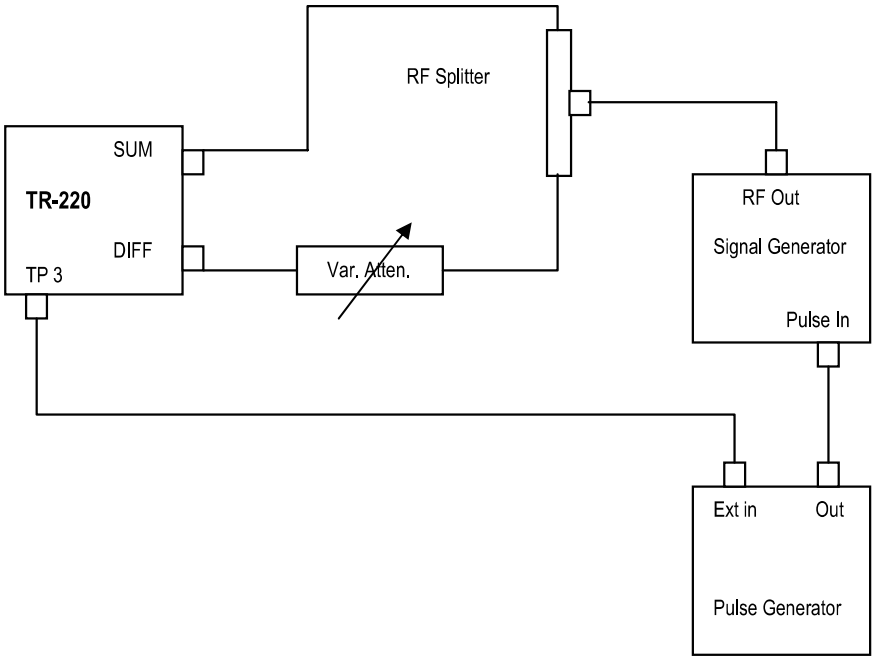
When measuring the two outputs of the splitter, it is necessary to terminate the end not being set with a 50 Ω load. The **SUM** or **DIFF** port may be utilized as the load. Setting the output at the end of the cable to 0 dBm must be done.

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

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

M A		
0000	100%	FAIL

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



SUM/DIFF Set-up

Figure 4-13

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

Calibrate RX GAIN			
SUM:	XXX	DIFF:	XXX

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

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

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

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

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

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

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

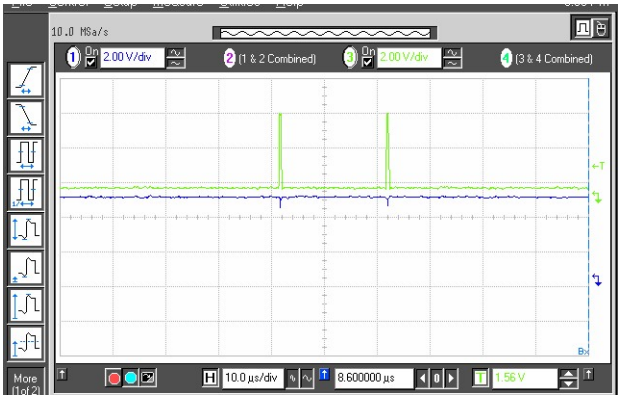
22. Connect one oscilloscope probe and monitor **TP-16**. Connect another probe to **TP-27** and ensure that the signal at **TP-27** occurs at the same time as **TP-16** (Figure 4-14). If not there is possible interference from other equipment and the test may not be accurate.

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

=TURN= Setup

Figure 4-14

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



M A	=TURN=
No Reply	

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

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

M A	SLS
0000	100% FAIL

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

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

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

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

4.8.4 Power Supply Test

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

   Disconnect the Power Supply.

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

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

LOW BATTERY Press AUTO to Continue

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

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

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

LOW BATTERY SHUTTING DOWN

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

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

4.8.5 Final Test

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