GTS Processor Alignment Procedure

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1	6/28/2011	Experimental Release	------

Contents

1. Scope of Document

This document lists procedures for alignment of the following GTS Processor subassemblies:

GTS Processor 011-02571-( )

2. Related Documents

004-00558-00	GTS Processor System Minimum Performance Specification (MPS)
004-00558-01	GTS Processor Main Bd TX MPS
004-00558-02	GTS Processor Main Bd RX MPS
004-00558-03	GTS Processor Power Supply MPS
004-00558-04	GTS Processor Main Bd I/O MPS
004-00558-A0	GTS Processor System Ambient Only MPS
005-00630-01	GTS Processor Test Procedure
005-00630-02	GTS Processor Unit Environmental Qualification Form
005-00630-05	GTS Processor Theory of Operation
005-00630-06	GTS Processor Automatic Calibration Theory and Procedure
005-00630-07	GTS Processor Hardware Design Document
005-00630-09	GTS Processor Factory Calibration Theory and Procedure
006-A0262-00	SW, GTS Processor Install Tool
190-00587-50	GTS Processor Installation Manual
T00-00329-00	GTS Processor ATE/MNL Test Setup
T09-00117-00	GTS Processor ATE/Manual Test Prod Structure
T11-00166-00	Sub-Assy,GTS Processor Test Panel
T15-00166-00	Assy Drawing,GTS Processor Test Panel

3. Test Requirements

3.1 Hardware Equipment Required

The test equipment required for calibration and test of the GTS Processor units are listed in the table below.

DESCRIPTION	VENDOR / PART NUMBER	QTY
GTS 8XX ATE/MNL Test Setup	Garmin T00-00329-00 (Note 1)	1

Note 1: The setup for the Factory Calibration is at the discretion of the department performing the alignment as long as the setup is in compliance with 004-00558-00 GTS Processor System Minimum Performance Specification (MPS) the 005-00630-09 GTS Processor Factory Calibration Theory and Procedure and the 190-00587-50 GTS Processor Installation Manual.

3.2 Software Required

The test software required for calibration of the GTS Processor unit is listed in the table below.

DESCRIPTION	VENDOR / PART NUMBER	QTY
GTS Processor System Image	006-B1244-( )	1
GTS Processor Boot Image	006-B1244-B( )	1
GTS 8XX CLD Programming File	006-C0081-2( )	1
GTS 8XX IGRF MODEL PARAM MAG VAR	006-D0159-02	1

Region		
GTS Processor Audio Image	006-D0726-50	1
GTS Processor Region List	006-D2767-00	1
TestStand	T06-A0088-00	1
GTS 8XX SI Program	T06-A0217-00	1
GTS 8XX Panel Control Program	T06-A0218-00	1
Traffic Application	T06-A0219-10	1
GTS 8XX ATE Software	T06-A0154-00	1
GTS 8XX ATE Software, RX (TSO)	T06-A0154-80	1
GTS 8XX ATE Sequence Files (TSO)	T06-A0155-00	1
GTS 8XX Production ATE Sequence Files	T06-A0155-20	1
GTS 8XX ATE Sequence Files, RX (TSO)	T06-A0155-80	1
GTS 8XX ATE Limit Files (TSO)	T06-D0025-00	1
GTS Processor Production ATE Limit Files	T06-D0025-20	1
GTS Processor ATE Limit Files, RX (TSO)	T06-D0025-80	1

3.2.1 Software Installation Procedure

No intervention by the operator required.

4. Alignment Procedure

This procedure outlines the automated alignment procedure for GTS Processor Line Replaceable Units (LRU).

NOTE: The LDMOS FET manual alignment procedure outlined in section 4.3 MUST be completed before the automated alignment section.

4.1 GTS Processor Unit Level Alignment Overview

During the automated alignment, the Analog I/O of the unit Main Board is aligned at the initial Nominal (described below) or Ambient temperature only, and the remaining alignments shall be performed at three environmental temperature conditions in the order presented below.

Each of the 3 automated alignment routines shall be conducted on all individual GTS Processor LRU's in the order as presented in this document. Each of the 3 automated alignment routines shall be successfully completed in compliance with this document on all individual GTS Processor LRU's prior to any testing performed on any such appliance for the purpose of qualifying that appliance as being airworthy. Any appliance that has undergone repairs requiring the loosening, retightening or removal of the chassis screws securing the chassis sections shall have all 3 automated alignment routines performed in compliance with this document. If a failure occurs during one of the 3 automated alignment routines, and as long as loosening, retightening or removal of the chassis screws securing the chassis sections has not been performed, that particular automated alignment routine is allowed to be performed again followed by the automated alignment routine/routines that remain to be performed in order to complete the 3 automated alignment routines. If any of the 3 automated alignment routines is performed out of order, all 3 automated alignment routines shall be performed again in order.

Note

Except for the transition from Cold to Nominal or Hot temperatures, it is allowed to have the unit, or multiple units, powered up during the soak time in order to avoid additional time caused by the need to warm up the unit upon initialization of the test sequence. The unit shall be powered down prior to initiating the alignment sequence and shall not be powered down for a period of time exceeding 5 minutes prior to the unit being powered up by the ATE sequence. In such a case, and if available, a manual override of the ATE warm up period may be initiated by the operator.

4.1.1 Nominal (shall be performed first)

1. Expose unit to a Nominal temperature of +10º C ± 5º C for a minimum time period of 45 minutes with the unit powered ON to allow the unit temperature to stabilize. Maintain until Nominal alignment is complete.
2. Perform the Nominal alignment in compliance with Section 4.2.
3. Ensure unit power is either removed or cycled after Nominal alignment is completed.

4.1.2 Hot (shall be performed second)

1. Expose unit to a Hot temperature of +70º C ± 5º C for a minimum time period of 45 minutes with the unit powered ON to allow the unit temperature to stabilize. Maintain exposure until Hot alignment is complete.
2. Perform the Hot alignment in compliance with Section 4.2.
3. Ensure unit power is either removed or cycled after Hot alignment is completed.

4.1.3 Cold (shall be performed third)

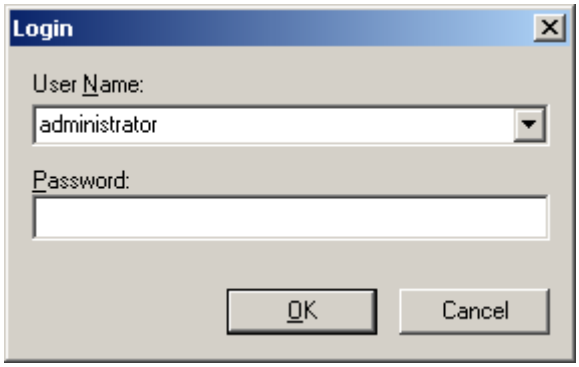
Note

During Cold, it may be necessary to apply purified alcohol on all connector contacts with either a clean cotton swab or clean non-shedding brush when changing units to avoid interrupted communications and RF functions between the UUT and test equipment.

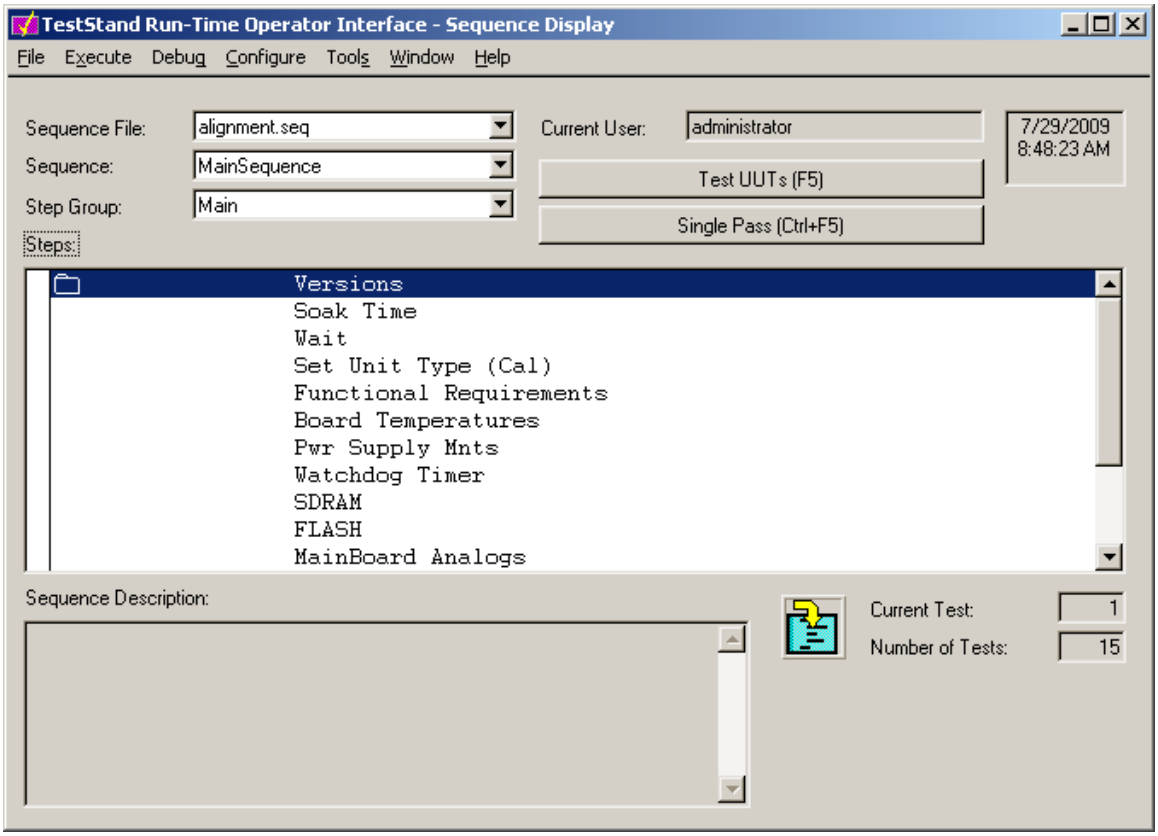
1. Expose unit to a Cold temperature of -55º C ± 5º C for a minimum time period of 45 minutes with the unit powered ON to allow the unit temperature to stabilize. Maintain until Cold alignment is complete.
2. Perform the Cold alignment in compliance with Section 4.2.
3. Ensure unit power is removed after Cold alignment is completed if transitioning to either Nominal or Hot temperature or cycled after Nominal alignment is completed in order to go directly into ATE performance test sequencing.

4.2 Automated Unit Alignment Sequence/ RF Factory Calibration Procedure

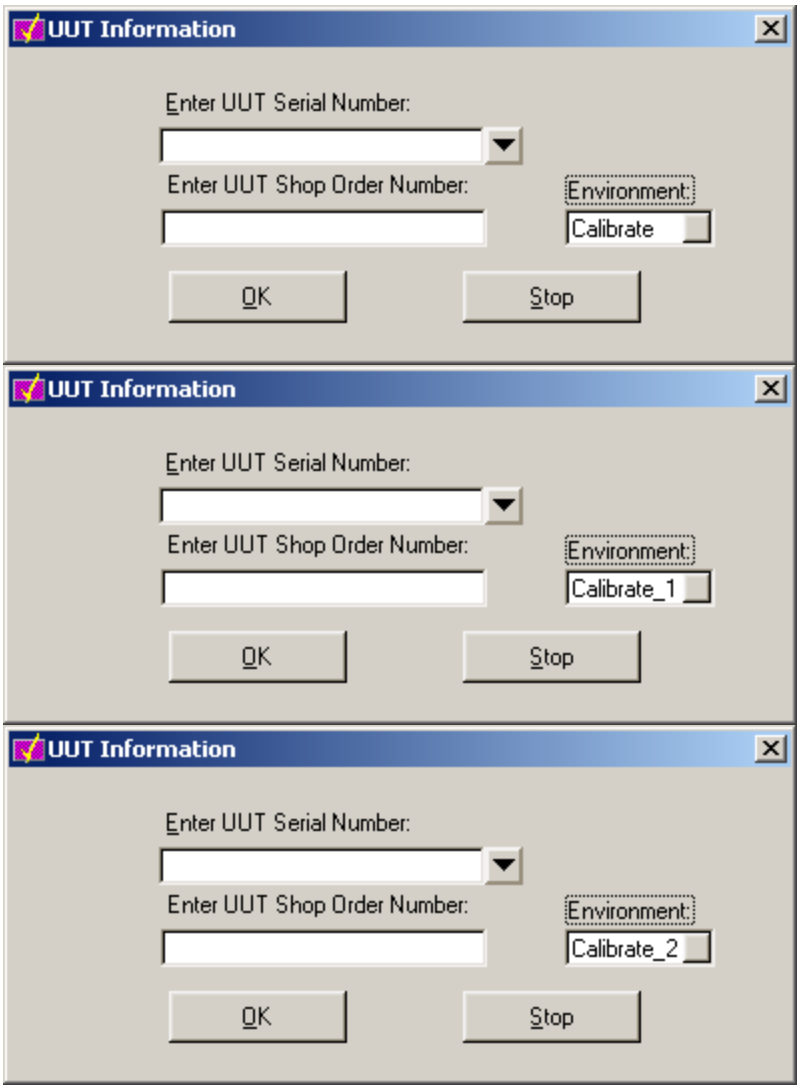
1. Ensure that the UUT power is OFF prior to initiating the ATE sequence.
2. Select correct alignment sequence file. There may be an icon on the desktop.
3. The login prompt will appear as shown below. Enter your name and password as required by process engineering.



4. The sequence display screen will appear. Click on the “Test UUT” button.



- Enter the UUT serial number, shop order number and environment
- **Nominal Calibration = Calibrate**
- **Hot Calibration = Calibrate_1**
- **Cold Calibration = Calibrate_2**



5. Click “OK”.

6. The automated alignment sequence will begin running. While the alignment is running a status screen will show the progression of the alignment.

7. When the alignment concludes, a result will be displayed. The following colored banners are used to show results:

    - Orange: Error (improper test setup detected)
    - Red: Test Failed (improper UUT performance)
    - Green: Test Passed (UUT aligned properly)
    - Blue: Terminated (Operator stopped test sequence)

8. PASS. Send unit to next operation.

9. FAIL. Print all failure data. Send UUT to troubleshoot for repair.

4.3 GTS Processor Manual Alignment

4.3.1 Overview

The 012-01805-00 GTS Processor TX High Power board is populated with variable capacitors on the drains of the LDMOS FETs in the amplifiers. These are used to optimally tune the LDMOS FETs to the maximum power output. The LMDOS FETs must be tuned before any automatic alignment is attempted, or the unit may not be able to meet the output power targets.

4.3.2 Equipment and Test Setup

Equipment should be set up similar to the GPA 65 alignment described in 005-00323-04 GTS 8XX Alignment Procedure. Refer to Appendix B GTS Processor Test and Measurement Equipment Initial Settings and Normalization and Appendix C GTS Processor Gigatronics 8542C and 80350A Zero Calibration, Offsets and Settings for equipment setup.

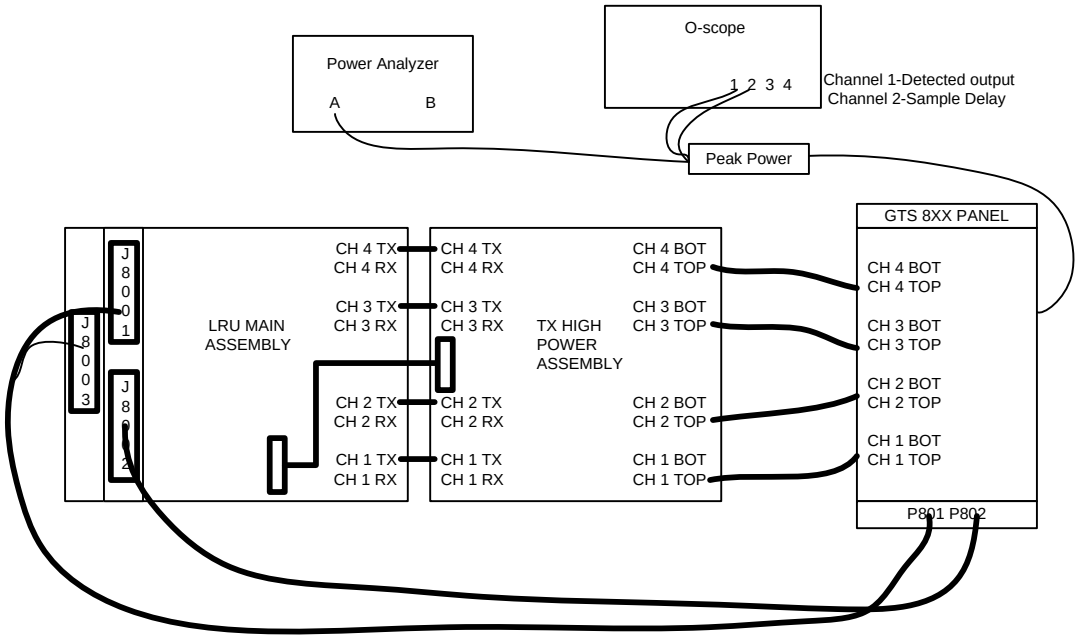


Figure 1 Equipment Setup for GTS Processor TX Alignment

4.3.3 Unit Setup

The variable capacitors on the LDMOS FET drains must be exposed to enable tuning. Remove the high power transmitter chassis from the main unit and set the main unit and high power transmitter assembly side by side. There are 8 P-SMP bullets that connect the transmit and receive RF signals to the main board from the high power transmitter. They will offer some resistance to disassembly, rock the assembly up and sideways carefully to disconnect them. Too much sideways force may break the tabs on the P-SMP bullets. There is also a 40 wire ribbon cable that connects the DC and control lines from the main board as well; this will fold out to enable connection while disassembled.

The metalized plastic cover over the high power transmitter board has openings through it to expose the variable capacitors, as shown in Figure 2. There are 4, one for each channel.

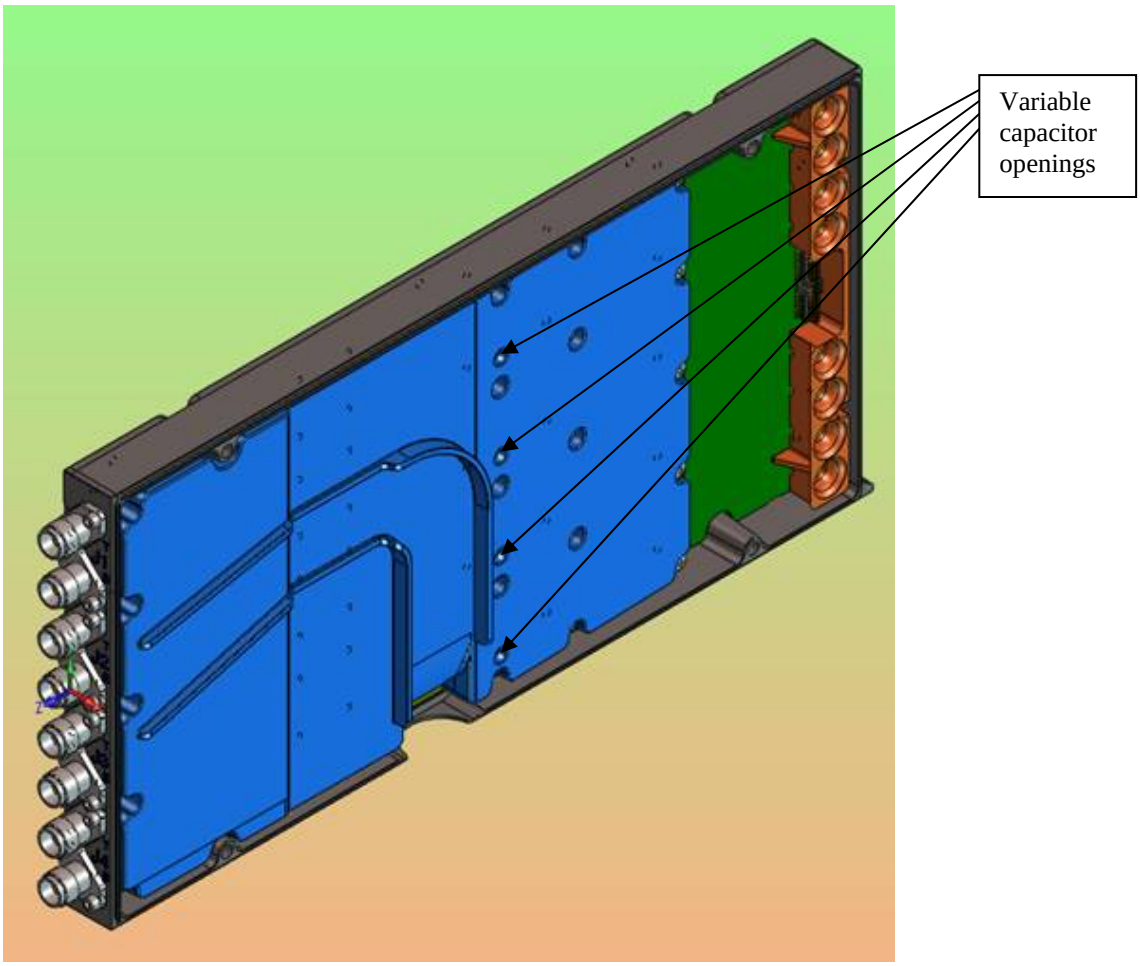


Figure 2. GTS Processor TX High Power Assembly

To enable transmitter tuning, the RF signals must be connected to the high power transmitter assembly while the unit is open. This requires a special receiver chassis. The normal receiver chassis on the unit assembly has holes too narrow to connect P-SMP connectorized cables between the main assembly and high power transmitter assembly.

The following procedure may be better performed at an alignment station prior to assembly, as the alignment procedure requires some unit disassembly.

UUT setup:

1) Remove the receiver chassis from the main assembly.
2) Remove the 40 pin ribbon cable connection on the high power transmitter side.
3) Engineering will provide a special receiver chassis with the holes for the P-SMP cables drilled larger than normal.
4) Populate a 012-01911-00 GTS Processor Boost Supply and 012-01924-00 GTS Processor Interface board with ribbon cables onto this special receiver chassis.
5) Assemble the special receiver chassis onto the UUT's main assembly, taking care to align the pins on the Interface board with the main board.
6) On the high power transmitter assembly, it will be necessary to remove the clear plastic P-SMP bullet guide to enable cable connection.
7) Connect the 40 wire ribbon cable to the high power transmitter.
8) Line up the main assembly and high power transmitter assembly on the short side with the RF connections adjacent to each other.

9) Use about 6” long flexible cable with female P-SMP connectors on both ends to connect all 4 transmit signals from the main board to the high power transmitter assembly. The transmit connections are labeled on the high power transmitter board as CH1-TX, CH2-TX, CH3-TX, and CH4-TX corresponding to the appropriate channel.

Connect the main unit to the appropriate power and digital interface connectors. Connect the TNC RF connectors on the high power transmitter assembly to the panel—either dedicated RF cables built with TNC connectors or TNC adapters may be used.

4.3.4 Unit Power Up and Operation

Once the UUT is set up and all digital, RF connections are verified to be correct, open the GTS 8XX Panel program. Turn on unit power by selecting pwr 1 and pwr 2. Select ‘Top 1’ for the channel select, ‘8 dB’ for the pad. Unit should be drawing between 1.2 and 1.4 A at 28 V. If it is around 1-1.2 A instead, verify that the 40 pin ribbon cable is correctly connected between the main assembly and high power assembly; it adds around 200-300 mA at idle.

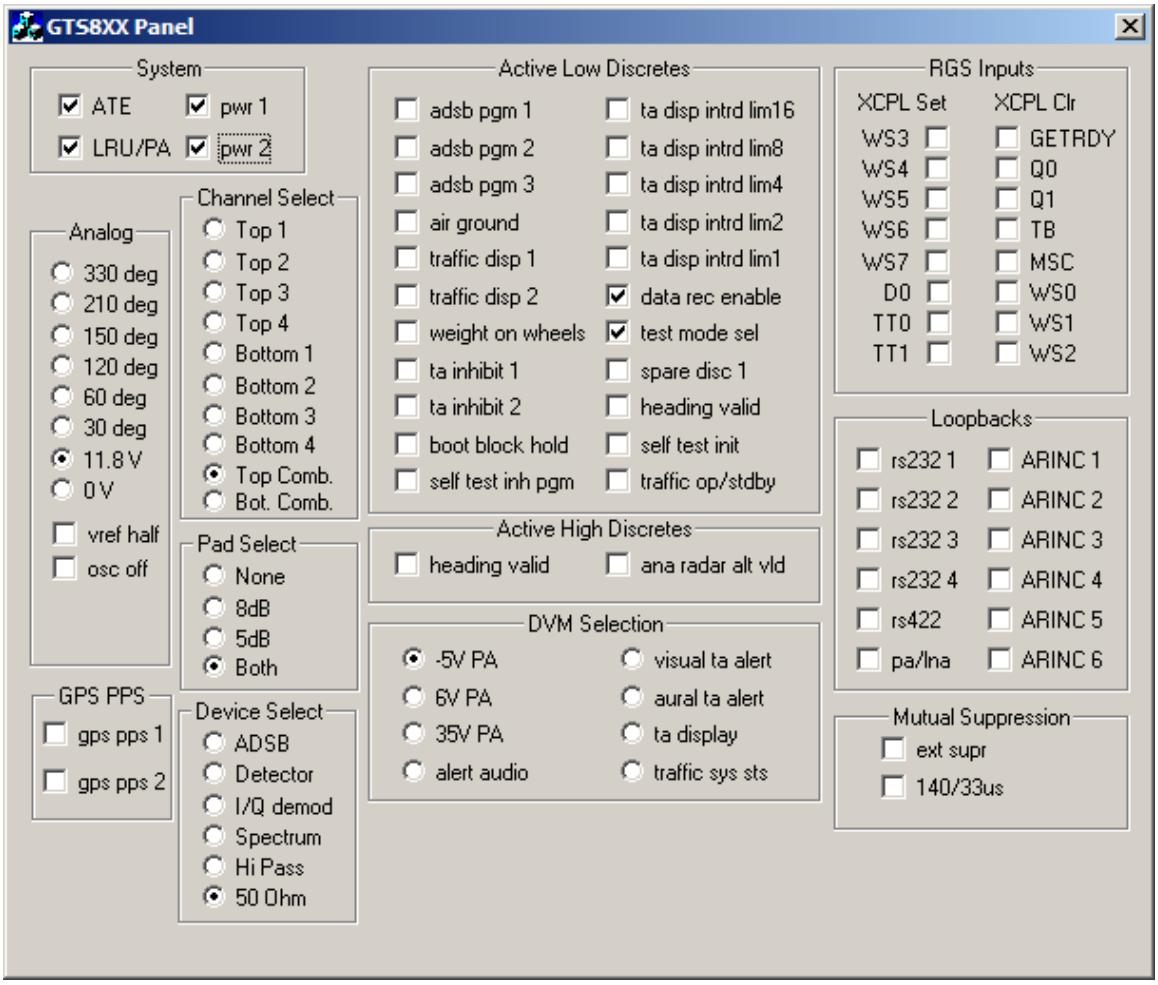


Figure 3. GTS 8XX Panel Program

1) Open the GTS 8XX SI program.
2) In Sys Mode window menu, select “Test”.
3) Select the Main I/O tab.
4) Verify all voltages are nominal per the readings, see Figure 3.

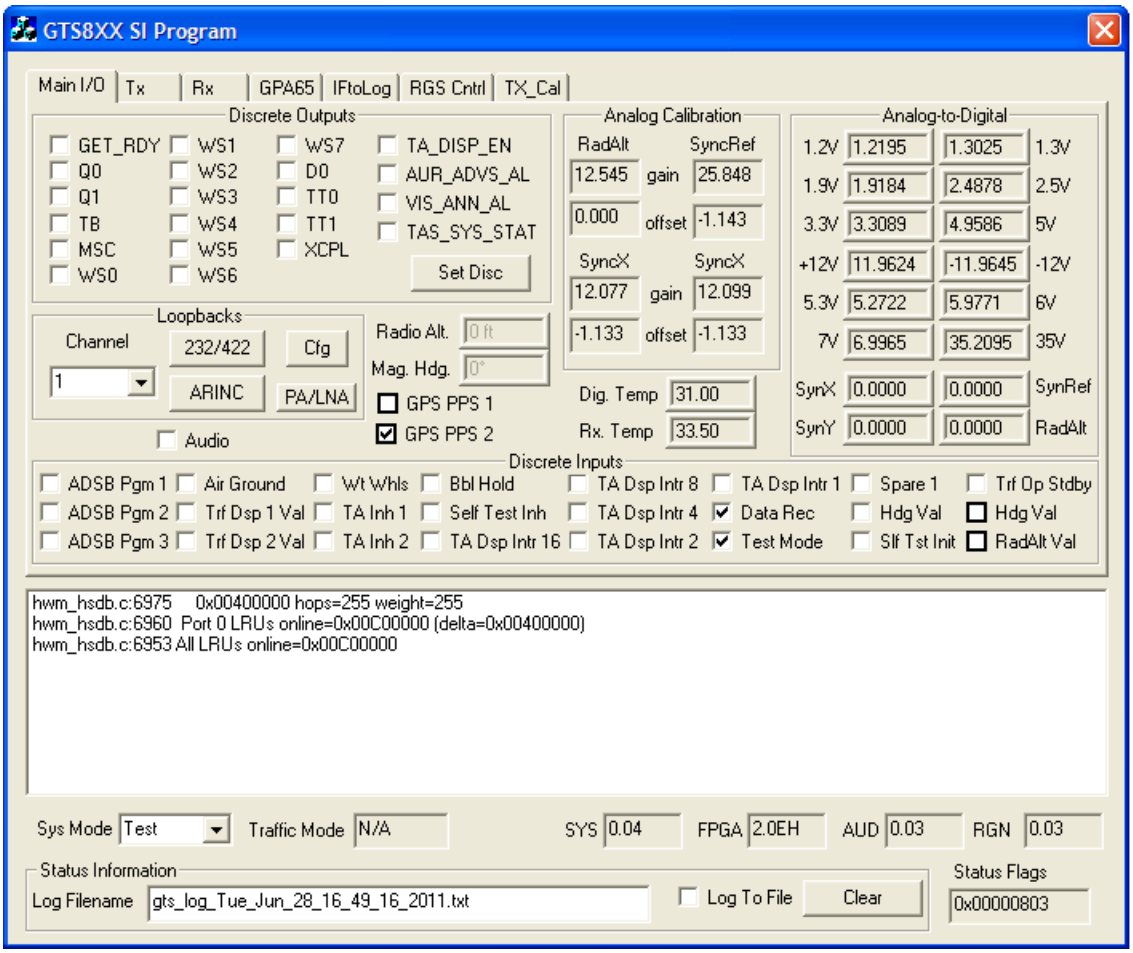


Figure 4. GTS 8XX SI Tool with good power readings

5) Select the TX tab.
6) Under Intrr Properties, Set ‘S1 Pwr (dB)’ and ‘P1 Pwr (dB)’ to 0.
7) Ensure the GTS panel program has selected Channel 1 for the channel select, 8 dB for the pad.
8) Under Intrr Tst Mode, Select ‘Mode-C 1’ in the roll box.
9) Click the ‘Test TX’ button.
10) Pulses should appear on the detected output of the oscilloscope screen, and power readings on the power analyzer.
11) Turn the variable capacitor on channel 1 clockwise, and the pulse should increase in power.
12) Find the peak transmit power (should be greater than 52 dBm with the proper offset).
13) Disable transmissions by selecting Intrr Tst Mode to ‘None’ and click the Test Tx button.
14) Switch the panel to channel 2-4, iterating steps 8-12 for each channel.
15) If all channels are greater than 52 dBm after tuning, reassemble with UUT’s own receiver chassis and components. Alignment is finished.
16) If a channel does not meet greater than 52 dBm output, or if transmissions fail, the unit requires troubleshooting to fix.

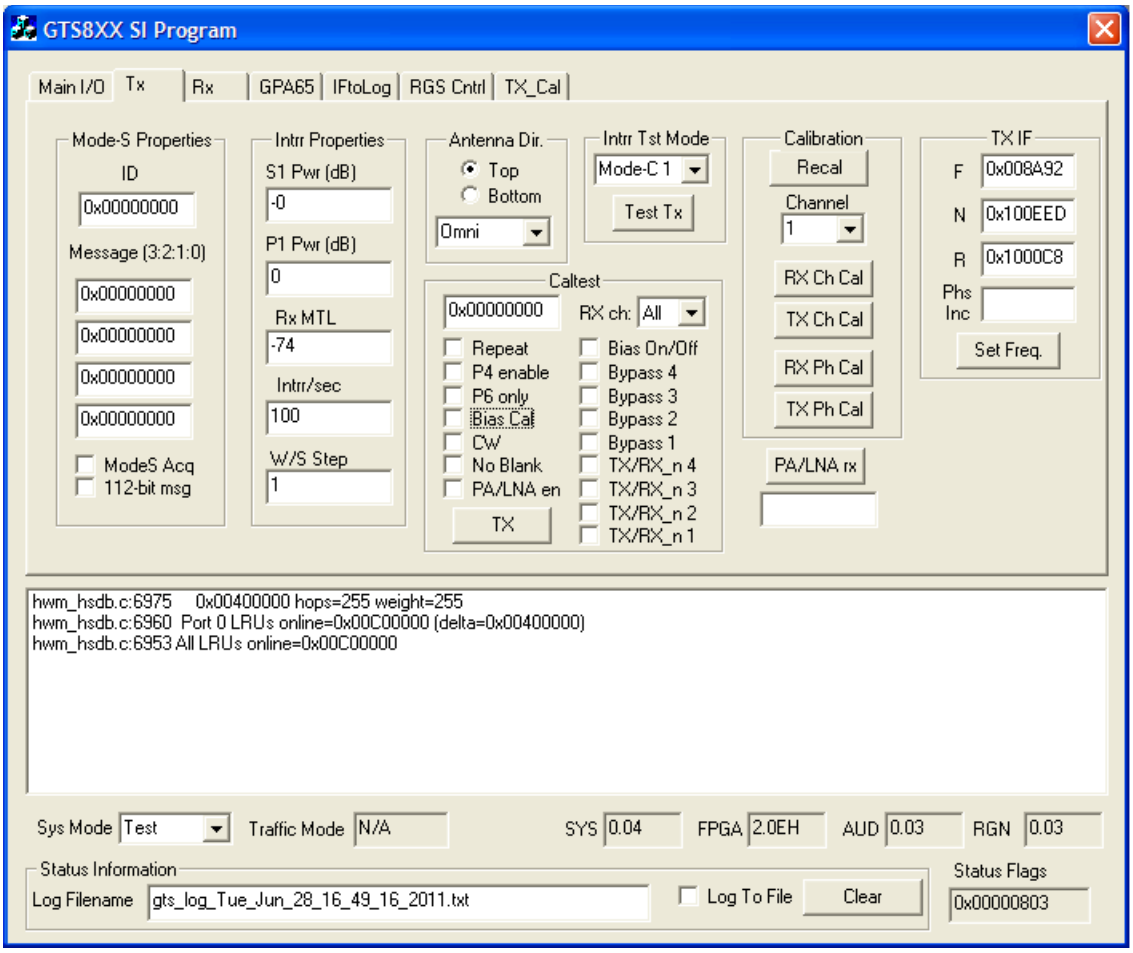


Figure 5 GTS 8XX SI Tool TX Setup

Appendix A Main Board I/O Alignment

NOTE

The Main Board I/O Alignment consists of only an analog inputs alignment as described in this document, and is performed by automated means requiring no operator intervention during the normal process of Factory Calibration sequencing. This automated alignment occurs one time only during the Nominal or Ambient Factory Calibration routine and is not performed at either Hot or Cold.

Analog Inputs Alignment Requirements

NOTE: This alignment procedure must be executed and pass before test series {ANA01XX}, {ANA02XX}, and {ANA03XX} in the GTS Main Board I/O MPS GPN 004-00558-04 are attempted.

1. Apply the **26 VRMS AC Reference Input** signal to the Heading Reference input (J8002, pins 63 and 64) while applying the **11.8 VRMS AC Calibration and Test Input** signal (in phase) to the Heading X (J8002, pins 41 and 42) and Heading Y (J8002, pins 44 and 45) inputs. Measure the Heading Reference ADC value.
2. Apply the **13 VRMS AC Calibration Input** signal to the Heading Reference input while applying the **11.8 VRMS AC Calibration and Test Input** signal (in phase) to the Heading X and Heading Y inputs. Measure the Heading Reference ADC value.
3. {ALN0001, 2} Calculate the alignment gain and alignment offset values of the Heading Reference input in VRMS/Volt and Volts, respectively, as a function of the ADC readings between the 26 VRMS level and 13 VRMS level.
4. {ALN0003, 4} Apply the **26 VRMS AC Reference Input** signal to the Heading Reference input. Apply 0 VRMS to the Heading X input and Heading Y input. Measure the Heading X and Heading Y ADC values. Set the negative of these values as the Heading X and Heading Y alignment offset voltages, respectively.
5. {ALN0005, 6} Apply the **26 VRMS AC Reference Input** signal to the Heading Reference input. Apply the **11.8 VRMS AC Calibration and Test Input** signal (in phase) to the Heading X and Heading Y inputs, and again measure the Heading X and Heading Y ADC values. Calculate the alignment gain values of the Heading X and Heading Y inputs in VRMS/V as a function of the ADC readings between the 0 VRMS levels and 11.8 VRMS levels.
6. {ALN0007} Input 0 VDC between the Radar Altimeter “HI” and “LO” inputs (J8002, pins 71 and 72). Allow the circuit to settle. Measure the Radar Altimeter ADC value. Set the negative of this value as the Radar Altimeter alignment offset voltage.
7. {ALN0008} Input 30 VDC between the Radar Altimeter “HI” and “LO” inputs. Allow the circuit to settle. Measure the Radar Altimeter ADC value. Calculate the alignment gain value of the Radar Altimeter input in VDC/V as a function of the ADC readings between the 0 VDC level and 30 VDC level.

Test Name	Analog Inputs Alignment Requirements
Acceptance Criteria	{ALN0001} 24.8 <= Heading Reference alignment gain <= 27.0 {ALN0002} -1.18 V <= Heading Reference alignment offset <= -1.13 V {ALN0003} -1.17 V <= Heading X alignment offset <= -1.12 V {ALN0004} -1.17 V <= Heading Y alignment offset <= -1.12 V {ALN0005} 11.7 <= Heading X alignment gain <= 12.3 {ALN0006} 11.7 <= Heading Y alignment gain <= 12.3 {ALN0007} -0.005 V <= Radar Altimeter alignment offset <= 0 V {ALN0008} 12.1 <= Radar Altimeter alignment gain <= 12.4

Appendix B GTS Processor Test and Measurement Equipment Initial Settings and Normalization

GTS 8XX Test Panel Initial Settings

The GTS 8XX Test Panel will be controlled by the GTS 8XX Panel program except prior to the alignment and post alignment; only the following settings on the panel are necessary in order to ensure that power to the LRU is off when not subordinate to the GTS 8XX Panel program:

Note

A +28VDC power supply with the capacity to supply an instantaneous 9 amps as a minimum must be connected to the panel and supplying power in order for the test panel to deliver power to the LRU and to do so without current limiting and actuating a crowbar effect.

1. PANEL power on/off switch: ON

2. UNIT PWR "pwr 1" and "pwr 2" on/off switches: OFF

Primary O-scope Settings

1. Both O-scope 1 and 2 all channels:
    a. Input Impedance: 50 ohms
    b. Bandwidth: Full
    c. DC Coupling

2. Set O-scope 1 to monitor PA/LNA detected output signal
    a. O-scope CH 1 Peak Power Sensor Detected Output (black cable)
        1. Volts Per Division: 100mV
        2. Time Per Division: 400nS
        3. Suggested trigger level for making measurement: 300mV
        4. Suggested delay for making measurement: 300nS
    b. O-scope CH 2 Peak Power Sensor Sample Delay (white cable)
        1. Volts Per Division: 1.0V
        2. Time Per Division: 400nS
        3. Use CH 1 as trigger source when displaying signal.
    c. O-scope CH 3 X10 probe

Note

Verify that probe compensation has been adequately performed prior to making measurements.

1. Volts per Division: 1.0V
2. Time Per Division: 20uS
3. Suggested trigger level for making measurement: 2.0V
4. Suggested delay for measurement: 58.34uS

NOTE

For O-scope #1 measurements of bias pulses, the bandwidth of the O-scope may need to be narrowed to 20Mhz and the ground reference horizontal marker will have to be adjusted just into the top of the trace noise and the peak horizontal marker will have to be adjusted just into the top of the trace noise to achieve an accurate enough measurement to be at or just below the maximum pulse amplitude. Refer to the following figures for the expected long and short bias pulses with markers.

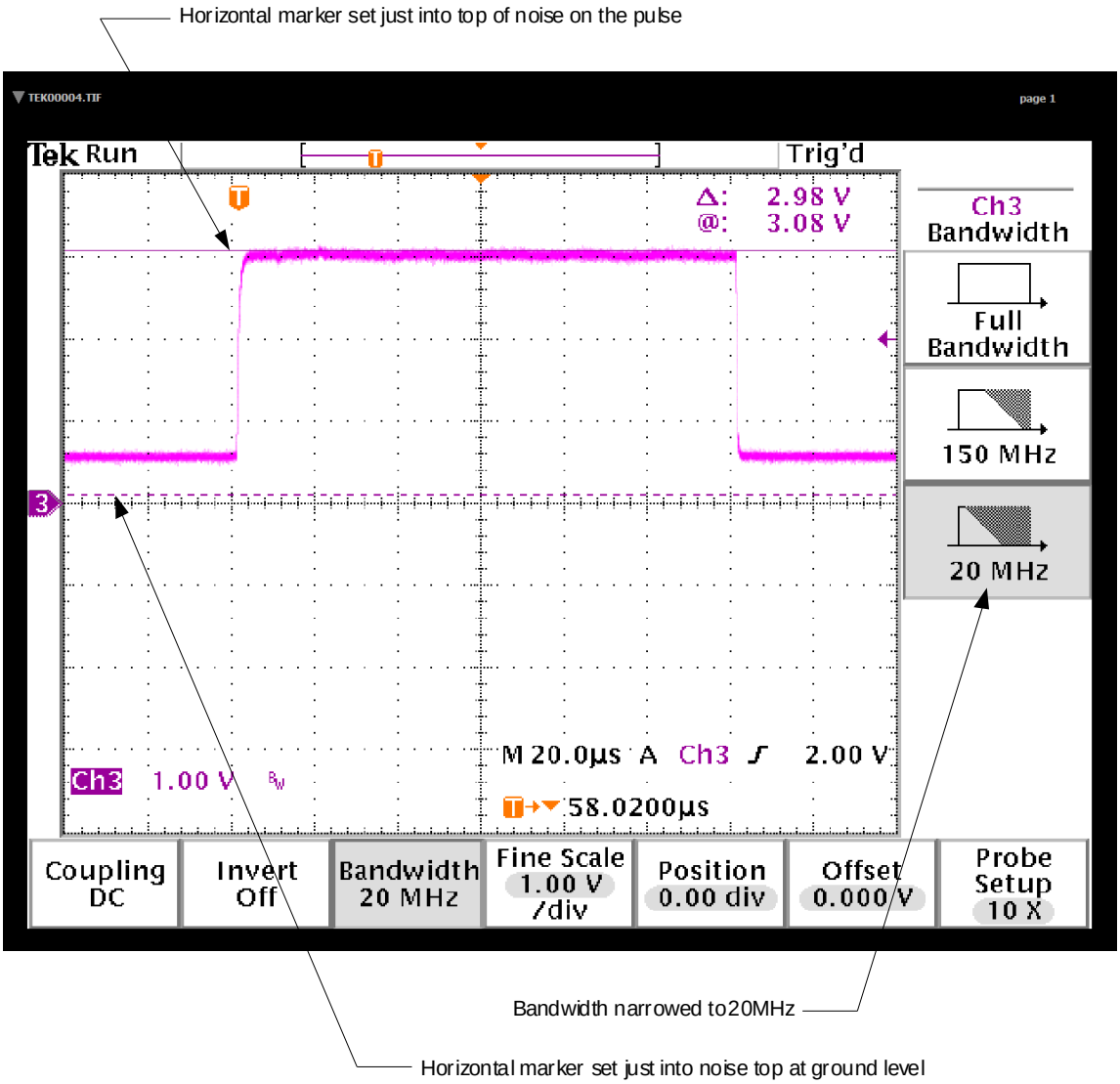


Figure B-1 Long Bias Cal Pulse Measurement

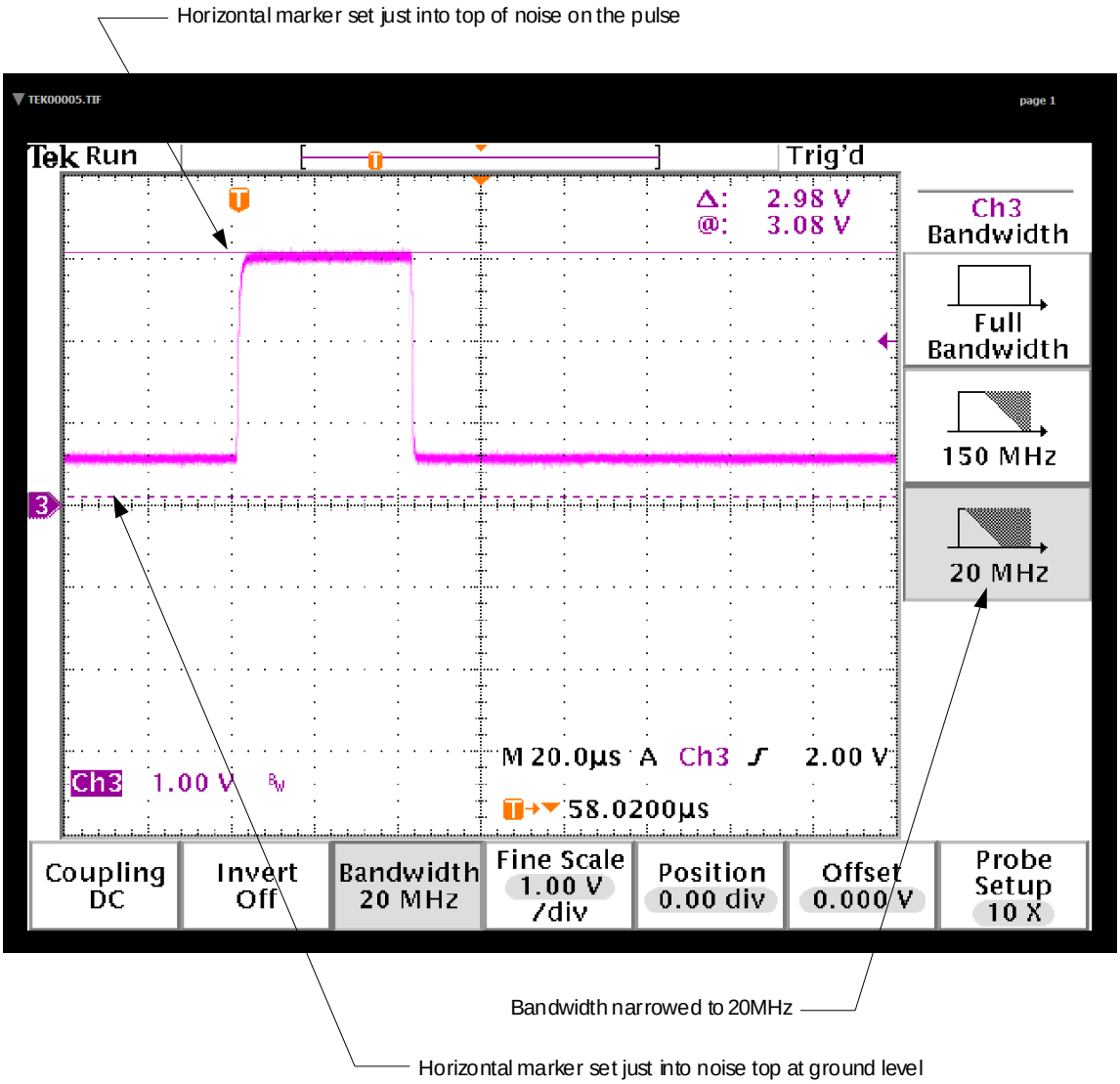


Figure B-2 Short Bias Pulse Measurement

3. Set O-scope #2 to monitor LRU detected output signal
    a. O-scope CH 1 Peak Power Sensor Detected Output (black cable)
        1. Volts Per Division: 200mV
        2. Time Per Division: 200nS
        3. Suggested trigger level for making measurement: 560mV
        4. Suggested delay for making measurement: 300nS
    b. O-scope CH 2 Peak Power Sensor Sample Delay (white cable)
        1. Volts Per Division: 1.0V
        2. Time Per Division: 268nS
        3. Use CH 1 as trigger source when displaying signal.

Appendix C GTS Processor Gigatronics 8542C and 80350A Zero Calibration, Offsets and Settings

Caution

Ensure power meter power is off prior to disconnecting or connecting sensor cables. Do not disconnect or connect sensor cables when the power meter is powered on in order to avoid possible damage to both the power meter and sensor and to ensure that the power meter is able to set a correct state for the sensor type.

1. Ensure that the Peak Power Sensor cable assemblies for CH A and CH B are properly connected to the Power Meter and no PAD is connected to either of the sensor inputs.

2. Power up the power meter.

3. Verify the following:
    a. Front panel A Mode light is illuminated.
    b. Front panel B Mode light is illuminated.
    c. Disregard additional illuminated lights until settings are completed.

4. Depress front panel dB/mW button to display measurements in dBm.

5. Depress front panel FREQ button and set both A and B frequency corrections to 0.050 (GHz) and depress ENTER.
    a. Verify front panel A Mode and B Mode lamps are not lit.

POWER METER SETUP

6. Depress front panel MENU and depress up or down arrow until MEAS SETUP MENU is displayed.
    a. Depress up arrow until AVERAGE is displayed.
    b. ENTER
    c. Depress up or down arrow on both AVG A and AVG B until both are set to Auto.
    d. ENTER
    e. MENU, ENTER, up or down arrow until OFFSET is displayed, ENTER.
    f. Enter offsets for Channels A and B according to Appendix D Measurement of Test Set RF Line Insertion Loss for PPA Offsets worksheet values. Record Channel A and Channel B OFFSET values on a sticker and attach to the Power Meter in a conspicuous location.
    g. MENU, ENTER, up or down arrow until RESOLUTION is displayed, ENTER.
    h. Use up or down arrow to select Top or Bot and left and right arrows to set a resolution for “X.XX” places. ENTER.
    i. MENU, ENTER, up or down arrow until PEAK HOLD is displayed, ENTER.
    j. Ensure “UNAVAILABLE” is displayed. ENTER.
    k. MENU, ENTER, up or down arrow until CREST FACTOR is displayed, ENTER.
    l. Ensure “UNAVAILABLE” is displayed. ENTER.
    m. MENU, ENTER, up or down arrow until MIN/MAX is displayed, ENTER.
    n. Depress up or down button until OFF is displayed. ENTER.
    o. MENU, ENTER, up or down arrow until LIMITS is displayed, ENTER.
    p. Depress up or down button until OFF is displayed for both TopLine and BotLine.

ENTER.

q. MENU, ENTER, up or down arrow until dB/mW SETUP is displayed, ENTER.
r. Depress left or right button until Log is displayed for both Top Line and Bot Line. Enter.
s. MENU, ENTER, up or down arrow until REL SETUP is displayed, ENTER.
t. Depress left or right button until ON is displayed for both Top Line and Bot Line. Enter.
u. Disregard ADVANCED MENU

POWER METER SETUP COMPLETE

PEAK POWER SENSOR SETUP

7. Depress front panel MENU and depress up or down arrow until SENSOR SETUP is displayed. ENTER.
    a. Depress left or right arrow to select A or B. Both A and B will have the same settings, so perform the following for both A and B.
    b. ENTER
    c. Set Trig Mode X (A or B) is displayed. Use left or right arrow keys to select Int. ENTER.
    d. Set Trig Level X (A or B) is displayed. Use up or down arrow keys to select 0.00dBm. ENTER
    e. Set Samp Delay X (A or B) is displayed. Use up or down arrow keys to select 0.0nS. ENTER.
    e. Use up or down arrows to Set DLY Offset to 480.0nS (A and B both same):
    f. ENTER
    g. Configuration may be stored in memory as necessary. Store/Recall 1. (S1 measurement) Trig. Mode = INT. Set Trig Level = 0 dBm. Set Sample Delay = 0 nsec. DLY Offset = 480 nsec.
    h. Use up or down arrows to Set DLY Offset to 2.480 nS (A and B both same):
    i. ENTER
    j. Configuration may be stored in memory as necessary. Store/Recall 2. (P1 measurement) Trig. Mode = INT. Set Trig Level = 0 dBm. Set Sample Delay = 0 nsec. DLY Offset = 2.480 nsec.

8. Verify on the power meter display that both A and B MODE lights indicate only PEAK and OFFSET on. All other MODE indicator lights should be off.

PEAK POWER SENSOR SETUP COMPLETE

PEAK POWER SENSOR CALIBRATION ZERO

9. Connect the Type N end of peak power sensor A to the CALIBRATOR Type N jack on the power meter panel.

10. Depress ZERO CAL on the power meter panel and wait until the routine is complete. If a failure occurs, the display will notify the user; and if it is successful, it will automatically go into the measurement display.

11. Disconnect peak power sensor A from power meter.

12. Perform Steps 9, 10 and 11 for sensor B.

THIS COMPLETES THE GIGATRONICS 8542C and 80350A ZERO CALIBRATION, OFFSETS and SETTINGS

Appendix D GTS Processor Suggested Equipment

Note

The list provided is neither complete nor definitive, and the department performing the alignment and measurements may choose to use equipment other than what is presented as long as measurement integrity is maintained and potential damage to equipment is minimized.

QTY	
1	Agilent 8753ES Network Analyzer
1	Agilent 85033D Calibration Kit
2	3.5mm Female to 3.5mm Male adaptor
1	3.5 mm Female to TNC Male adaptor
1	3.5mm Male to TNC Male adaptor
1	TNC Female to Female barrel connector
1	Megaphase P/N TM18-7931-36M Network Analyzer Cable
1	Megaphase P/N TM18-7932-36M Network Analyzer Cable
1	5/16 Maury Microwave Corp.Model 8799A (8 in/lb) torque wrench
1	5/16 Maury Microwave Corp.Model 8799D1 (5 in/lb) torque wrench
1	5/16 combination wrench
1	1/4 combination wrench
1	Topward 6306A Power Supply
1	Gigatronics 8542C Universal Power Meter
1	SOLA S7 28V 6A Power Supply
1	Hewlett Packard 34401A Multimeter
1	Garmin T11-00166-00 ATE/Test Panel
2	Tektornix TDS3034B Oscillocope
1	Fluke 187 Multimeter
1	Hewlett Packard 8562E Spectrum Analyzer
2	Weinschel Model 1 (1Kw PK @ 5uS) 10dB attenuator (or 1 20dB attenuator)
1	Weinschel Model 33-10-34 (5Kw PK @ 5uS) 30dB attenuator