RF Board Test & Alignment Procedure Outline
TP30-100102
Ver 4.3 2/16/99

Test Overview

Test goal is to determine if an RF board is operating correctly and to provide preliminary information regarding faults if they do occur. The RF board is tested by connecting it to a "golden" digital board (that is, one that has been fully testing and is deemed fully operational). The digital board will be connected to the RF board with a special test cable that will allow inspection and test of certain inter-board connections while the RF card is placed in a bed of nails. Additionally, the output of the RF card will be connected to test equipment under control of automated test software. Some RF tests are performed in sensitive areas and, at this time, do not have test points and therefore will require hand assisted testing.

The following test procedure should be followed in the order listed. All tests are considered to be pass/fail. If any test fails the units fails.

Equipment Needed

Power Supply
Adjustable 12 Volts, nominal regulated, 5 Amps current limit
Voltage meter
Current meter
Oscilloscope
LCR meter capable of measuring up to 10MHz
Antenna simulator load for PA/AAT
12 to 50 Ohm matching pad (20 watts at 30MHz)
RDS Encoder
150MHz signal generator for use with RDS signal
Must be able to modulate using external FM input at 7.5kHz peak deviation
2GHz .3pF FET Probe
2GHz spectrum analyzer with tracking generator
100MHz frequency counter with absolute accuracy to 1ppM at 10MHz
Special test cable with break out connections to connect Digital Board and RF board
Special test fixture including bed of nails.
Computer Pentium 133MHz with Windows 95 or better
Test control and analysis software
Test equipment control system and data acquisition system
“Golden” Digital Card

TEST Procedure Outline

Power Supply and power control.

Check to insure that the power rails are working.

Set current limit on input supply to 500mA.

- Enable the following three voltages by enabling power supply to digital board.

(This is done by applying power to the digital card JP11 with 13.6 Volts)

Input Voltage #1: 5V on Pins 5 and 6 of the inter-board connector
Input Voltage #2: 13.6 Volts on Pins 1,2,3,4 of the inter-board connector
Input Voltage #3: 5V on Pin 22 inter-board connector. (TCXO Power)

- Send command to turn everything off (GPS, PA, FM)
- Check that current draw is less than 150mA.
  Leave input voltages 1,2,3 on all the time after current is checked.
- Check: 5V +/- 10% on TP3
- Check: 13.6V +/- 10% on TP9
- Check: 5Volts +/- 10% on TP33 (TCXO_Power)
  The following lines are switched on by software.
- Send command to turn FM_ctrl power ON
- Check: 5V +/- 10% on TP38 FM_Power
- Send command to turn FM_ctrl power OFF
- Send command to turn tx_ctrl ON… ***Do not leave on for more than 60 seconds!***
- Check: Current < 1.5 amp
- Check: 5V +/- 10% on TP31 TX_Power
- Check: 13.6V +/- 10% on TP5 next to PA transformer
- Send command to turn tx_ctrl OFF
- Send command to turn FM_ctrl power ON
- Check: 5V +/- 10% on TP37 (near C168) and TP32 PLL_Power
- Send command to turn FM_ctrl power OFF
- Set 13.6V power supply current limit to 4 Amps

NOTE: All the following tests assume power is applied to digital board full time.

Check for proper System clock

The system clock will run most logic on the digital board. We must insure that the input levels are within CMOS levels.

- Check: level of 16.8MHz on pin 9 of the inter-board connector.
  Peak of signal must go above 3.5V
  Min should go below .7 Volts.

Align Clock Crystal

Our modulation relies on very tight frequency control. We must adjust the reference crystal to maintain accurate frequency control
(With TCXO power still on … leave on for rest of tests).

- Use a frequency counter to align crystal to within +/- 4Hz at 16.8MHz.
  Connection should be made at pin 9 on the Inter-Board connector.
  Frequency is adjusted by turning screw on U12.

Digital Logic

I2C (Subject to deletion)

- Send command to turn on FM power and leave on.
- Test I2C bus by running test routine that interfaces with A/D converter and
  RDS decoder.
  Read data from A/D converter and verify that result is a valid number
- Send command to set mode FM=off, RDS=on, HIU=on.
- Send command to set the FM frequency to desired frequency

- Verify ITU response RDS information (0x0D) locked, errors=0,quality=0.

Align VCO

Align VCO Inductor.

(FM power should still be on)

- Send command to tune the receiver to 97.5 MHz
- Adjust L41 (VCO inductor) to obtain 2.0V +/- 25 mV on “diode tune” TP39

Check for oscillations in preamp. (For first 1000 units only)

- Set spectrum analyzer to:
  - Start 300MHz
  - End 3GHz
  - RBW auto
- Use High BW (FCI constructed) passive probe to check C109 pad that connects with C108
- Check that all signals are below -50dBm except the fundamental VCO signal
- Check closely for oscillations at 1.8GHz

Align FM band select filters.

- Send command to tune the receiver to 87.5 MHz

Set Spectrum Analyzer to

- Start 88.1MHz
- End 108MHz
- RBW auto

- Probe pin 1 of U16 with FET Probe.
- Set tracking generator to –30dBm and apply to HF/FM port
- Adjust L43, L44, L47, and L51 (varactor BPF inductors) for maximum signal level on pin 1 U16
- Send command to set RX to 87.5 MHz and record diode tune test point voltage TP39. Should be greater than 0.5V and less than 2V.
- Send command to set RX to 108 MHz and record diode tune test point voltage. Should be greater than 3V and less than 4.5V.

Check RF Level

- Set PLL to 101.940740 MHz (RX power still on) by sending command to set HF modulator frequency=0
- Input to ADS9850 on pin 9 should be greater than 2Volts P-P (USE FET PROBE)

Check phase noise

- Set Spectrum Analyzer to (Subject to deletion)
  - Center 101.1MHz
  - Span 20KHz
  - RBW 300Hz
- Using a FET probe check C109 pad that connects to C108 *(Note test point was not included because 5 pF is enough to hinder performance and no more stray capacitance can be added to this portion of the circuit. Note: c109 is a DNP)*
- Check that all signals are -40dBc relative to the fundamental at 101.1MHz

Check for spurs. (Subject to Deletion)

- Set spectrum analyzer to the following settings.
  - Center 101.1MHz
  - Span 20MHz
  - RBW auto
- Check C109 Pad Near bottom of board with FET probe
- Check that all signals are -38dBc relative to the fundamental at 101.1MHz

Check PLL lock time. (Subject to Deletion)

- Set the receiver to scan the FM band. Watch TP-39 using AC couple on a digital oscilloscope. Set to AC coupling, 20mV per div, and 10ms per div. Trig at 30mV.
- Send command to set operational mode with FM=on, RDS=on, HIU=on.

- Check that switching time is less than 10ms. (rise time)

Check VCO startup. (Subject to Deletion)

- Set spectrum analyzer to the following settings.
  Start 88.1MHz
  End 118MHz
  RBW auto
- Send message to apply power to VCO by enabling FM_ctrl
- Send message to initialize PLL to 100MHz (FM freq = 89.3)
- Verify 100MHz output is at C109 with 20dBmV using FET Probe.
  Repeat power cycle 5 times.

Align quadrature tank.

- Input a –80 dBm 97.5 MHz FM signal to the receiver. Set the FM modulation to 1 kHz modulation frequency, 100 kHz deviation.
  Signal should be injected at HF/FM port.
- Set RX to 97.5
- Adjust L55 (quadrature inductor) for maximum 1 kHz audio output. Should be greater than 150 mV p-p on TP41

Check RDS operation with RF Input

- Tune the receiver to 87.5 MHz
- Input a –100 dBm, 87.5 MHz RDS signal to the receiver. Set the RDS deviation to 10% of full broadcast FM (75kHz) or 7.5KHz +/-100Hz using known RDS input data source.
- Verify the RDS data is correct at the receiver output verified by uP and digital card interface. (software test)
- Send command to set operational mode with FM=on, RDS=on, HIU=on.
- Verify ITU response RDS information (0x0D) has locked, errors=0, quality=0.
- Tune the receiver to 97.5 MHz
- Input a –100 dBm, 97.5 MHz RDS signal to the receiver. Set the RDS deviation to 7.5kHz, using known data sequence(s).
- Verify the RDS data is correct at the receiver output.
  (Software Test)
- Verify ITU response RDS information (0x0D) has locked, errors=0, quality=0.
- Tune the receiver to 108 MHz
- Input a –100 dBm, 108 MHz RDS signal to the receiver. Set the RDS deviation to 7.5KHz, using known data sequence(s).
- Verify the RDS data is correct at the receiver output
  (Software Test)
- Verify ITU response RDS information (0x0D) has locked, errors=0, quality=0.

PA Power Test

Note: Use a 12 ohm load with short cable (less than 6 Inches for this test)
Note: Test Setup includes a digital card that has been "characterized" to the antenna at least once
Note: Low Power Setting should be set to 7
Note: For all PA tests FM scanning mode must be disabled.

- Send command to set operational mode with FM=off, HIU=on.
- Set D/A converter to low power but do not apply 12V (PA power disabled)
- Verify voltage at TP22 is 0.080Volts +/- 20mV
- Set PA to high power
- Verify voltage at TP22 is 1Volt +/- 100mV

The PA circuit has the ability to regulate the current used by the RF power amplifier. This circuit must be checked to insure proper operation. We need to set the current for low power while changing the 12 input from 11V to 16 Volts.

Low Power

- Set PA to Low Power
- Set NCO to 12MHz
- Perform an Autotune
- Turn PA ON

Check that the low power setting draws no more than 1500mA

- Set spectrum analyzer to the following settings.

  Start 3MHz
  End 53MHz
  Span 20MHz
  RBW auto

Check Spectrum analyzer for output power level is -9dBm +/- 1dB

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- Verify PA output level at 11,13.6 and 16 Volts is 2.5dBm +/- 1dB
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- Note: New Matching pad has 37.5dB loss for a 40dBm input the spectrum analyzer should read 2.5dB.
- Verify PA output level is -2.5dBm +/- 1dB with 13.6 DC power input and NCO to set to the following frequencies 5,10,15,20 and 25MHz.
- TURN PA OFF

High Power (Sweep)

- Set NCO to 12MHz
- Autotune
- Turn PA on
- Check that the high power setting draws no more than 3.3A.
- Check spectrum analyzer for output power level is 5dBm+/- 1dB
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- Verify PA output level at 11,13.6 and 16 Volts is -9dBm +/- 1dB
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- Verify PA output level is -9dBm +/- 1dB with 13.6 DC power input and NCO to set to the following frequencies 5,10,15,20 and 25MHz.
- Note: DO NOT LET PA OVERHEAT
- Turn PA OFF

PA power sense circuit (Final Assembly Only)

- Turn on PA
- Set PA to low power
- Set NCO to 10MHz
- Autotune
- Set relays for forward power reading
- Read A/D converter for forward power.
- Verify ITU response Msg Type= Automatic Antenna Tuner VSWR Measurement (0x03)

- Turn PA OFF

Check output harmonic content.

- Connect antenna simulation load to the ITU HF/FM connector
- Set NCO to 3.2MHz
- Turn PA ON
- Set PA to high power
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- Set spectrum analyzer to the following settings.

  Start 3MHz
  End 53MHz
  Span 20MHz
  RBW auto
- Read level of 3000kHz signal with spectrum analyzer
- Read level of 2nd harmonic of original signal
- Read level of 3rd harmonic of original signal
- Verify all signals are below 45dbc

Note for:	3.2MHZ	6.4MHz	12.8MHz
2nd	–25dBc	-30dBc	-35dBc
3rd	–25dBc	-30dBc	-40dBc

- Repeat with NCO set to 6.4MHz
- Repeat with NCO set to 12.8MHz
- Turn PA OFF

Check AAT performance

Check the proper installation of reactive components on the circuit using a reactance meter on the HF output port. Every inductor step should be double the last. For example adding in number 2 inductor while removing number 1 inductor should result in a 20 nH change. Removing 2 and adding 3 should result in 40nH difference.

Inductors
#1=L53, #2=L54, #3=L52, #4=L50, #5=L49, #6=L38, #7=L31, #8=L29, #9=L32, #10=L30, #11=L25
Capacitors
#1=C158, #2=C157, #3=C156, #4=C132, #5=C124, #6=C120, #7=C97, #8=C84, #9=C85, #10=C87, #11=C86

- NCO set to zero.
- Set PA to low power
- PA ON
- Check system input current is below 1Amp.
- Set up AAT for transformer 2
- Sense circuit enabled
- Set to inductors
- Short all inductors.

Allow inductor #1Measure inductanceShort inductor #1

- Allow inductor #2
- Measure inductance. Insure twice as much as #1 within 10%
- Short inductor #2
- Allow inductor #3
- Measure inductance. Insure twice as much as #2 within 10%
- Short inductor #3
- Continue to the last inductor.
- Repeat for capacitors. (Note Capacitors are opposite polarity on relay settings)
- Reset AAT

Check five transformers for proper operation.

- Select transformer #1
- Enable sense circuit
- Set LCR meter to 3MHz
- Insure resistance input component is near 24 ohms. +/- 5 Ohms
- Enable transformer 2
- Insure resistance is 12 ohms. +/-3 Ohms
- Enable transformer 3
- Insure resistance is 6 ohms. +/- 2 Ohms
- Enable transformer 4
- Insure resistance is 3 ohms. +/- 1 Ohm
- Enable transformer 5
- Insure resistance is 1.5 ohms. +/- .5 Ohms

Appendix

Hex strings for messages in this document:

Turn PA or TX_CTRL power off [F5,A1,0C,00,54,E2,F6]
Turn PA or TX_CTRL power on [F5,A1,0C,01,95,22,F6]
Turn GPS power off [F5,A1,18,00,5B,E2,F6]
Turn GPS power on [F5,A1,18,01,9A,22,F6]
Turn FM_CTRL or RX power off [F5,A1,19,00,5A,72,F6]
Turn FM_CTRL or RX power on [F5,A1,19,01,9B,B2,F6]
Select PA low power setting (attenuation on) [F5,A1,07,01,92,12,F6]
Select PA high power setting (attenuation off) [F5,A1,07,00,53,D2,F6]
Select HF/FM = HF [F5,A1,0B,01,97,12,F6]
Select HF/FM = FM [F5,A1,0B,00,56,D2,F6]
Set HF modulator frequency to zero Hz [F5,A1,06,00,00,00,00,91,71,F6]
Set HF modulator frequency to 3MHz [F5,A1,06,C0,C6,2D,00,50,1C,F6]
Set HF modulator frequency to 6.4MHz [F5,A1,06,00,A8,61,00,39,01,F6]
Set HF modulator frequency to 10MHz [F5,A1,06,80,96,98,00,33,5D,F6]
Set HF modulator frequency to 13MHz [F5,A1,06,40,5D,C6,00,46,C3,F6]
Set HF modulator frequency to 25MHz [F5,A1,06,40,78,7D,01,E4,38,F6]
Set FM frequency to 87.5MHz [F5,A1,14,6B,03,00,00,C5,56,F6]
Set FM frequency to 89.3MHz [F5,A1,14,7D,03,00,00,C1,1E,F6]
Set FM frequency to 97.5MHz [F5,A1,14,CF,03,00,00,E6,66,F6]
Set FM frequency to 108.0MHz [F5,A1,14,38,04,00,00,65,D3,F6]
Read AAT A/D converter [F5,A1,08,78,56,F6]
Set Xfmr T1 [F5,A1,0A,00,57,42,F6]
Set Xfmr T2 [F5,A1,0A,01,96,82,F6]
Set Xfmr T3 [F5,A1,0A,02,D6,83,F6]
Set Xfmr T4 [F5,A1,0A,03,17,43,F6]
Set Xfmr T5 [F5,A1,0A,04,56,81,F6]
Turn all relays off [F5,A1,13,00,00,00,00,9C,B2,F6]
Turn on relay 0 [F5,A1,13,01,00,00,00,9D,4E,F6]
Turn on relay 1 [F5,A1,13,02,00,00,00,9D,0A,F6]
Turn on relay 2 [F5,A1,13,04,00,00,00,9D,82,F6]
Turn on relay 3 [F5,A1,13,08,00,00,00,9E,D2,F6]
Turn on relay 4 [F5,A1,13,10,00,00,00,98,72,F6]
Turn on relay 5 [F5,A1,13,20,00,00,00,97,72,F6]
Turn on relay 6 [F5,A1,13,40,00,00,00,89,72,F6]
Turn on relay 7 [F5,A1,13,80,00,00,00,B5,72,F6]
Turn on relay 8 [F5,A1,13,00,01,00,00,CD,72,F6]
Turn on relay 9 [F5,A1,13,00,02,00,00,3D,72,F6]
Turn on relay 10 [F5,A1,13,00,04,00,00,DD,73,F6]
Turn on relay 11 [F5,A1,13,00,08,00,00,1D,70,F6]
Turn on relay 12 [F5,A1,13,00,10,00,00,9D,77,F6]
Turn on relay 13 [F5,A1,13,00,20,00,00,9D,78,F6]
Turn on relay 14 [F5,A1,13,00,40,00,00,9D,66,F6]
Turn on relay 15 [F5,A1,13,00,80,00,00,9D,5A,F6]
Turn on relay 16 [F5,A1,13,00,00,01,00,9D,22,F6]
Turn on relay 17 [F5,A1,13,00,00,02,00,9D,D2,F6]
Turn on relay 18 [F5,A1,13,00,00,04,00,9E,72,F6]
Turn on relay 19 [F5,A1,13,00,00,08,00,9B,72,F6]
Set relays to pass power [F5,A1,13,F0,0F,F0,0F,0C,00,99,96,F6]
Opmode set RDS on, HIU on [F5,A1,03,22,D1,0B,F6]
Opmode set RDS, FM and HIU on [F5,A1,03,23,10,CB,F6]
Opmode set HIU on only [F5,A1,03,02,D0,D3,F6]