



Application Note:
Motorola MTS4 Base Station T1 test
On the Freedom Communications System Analyzer

Application Note

Testing a MTS4 Tetra Base Station utilizing a Freedom Communication Technology Analyzer

This application note assumes the user has operational knowledge of both the R8100 and the Motorola MTS4 Base Station.

User of this document MUST also have a copy of the following Reference documentation:

Ref 1 :

Motorola document number: 6802800U74-AM

“MTS LITE, MTS2 and MTS 4 Installation, Configuration and basic Service Manual”

Screenshots in this document are based on an R8100 running **version 3.7 or greater**

When testing a Tetra Base Station, the R8100 must be configured with following options:

Tetra BS Mon Package (R8-TETRA_BSM)

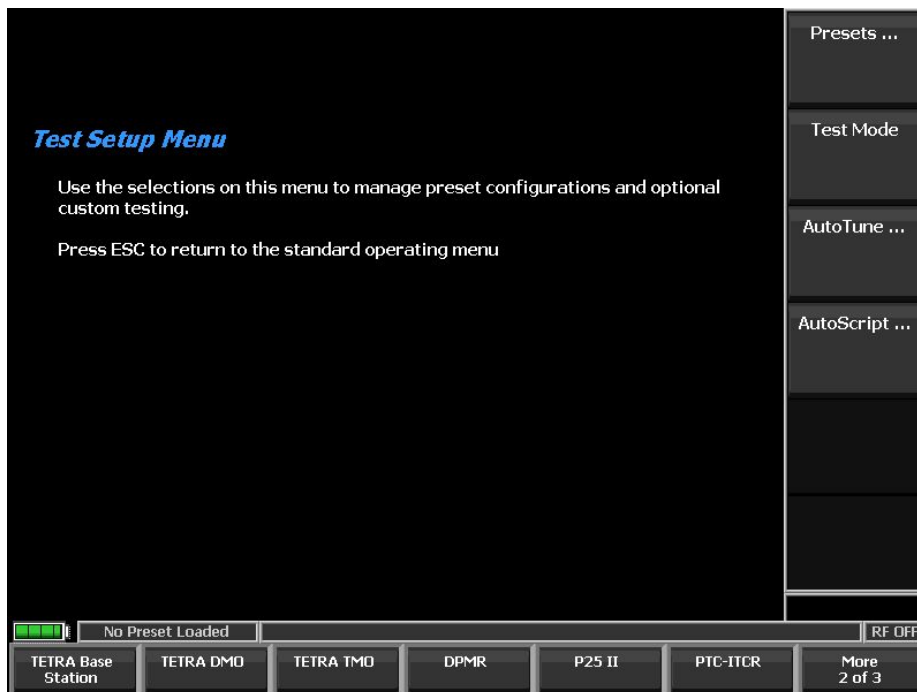
Tetra BSM T1 Test (R8-TETRA_BST1)

Also note: The Gen port output must operate down to -125dBm.

To accomplish this the test unit should be one of the following:

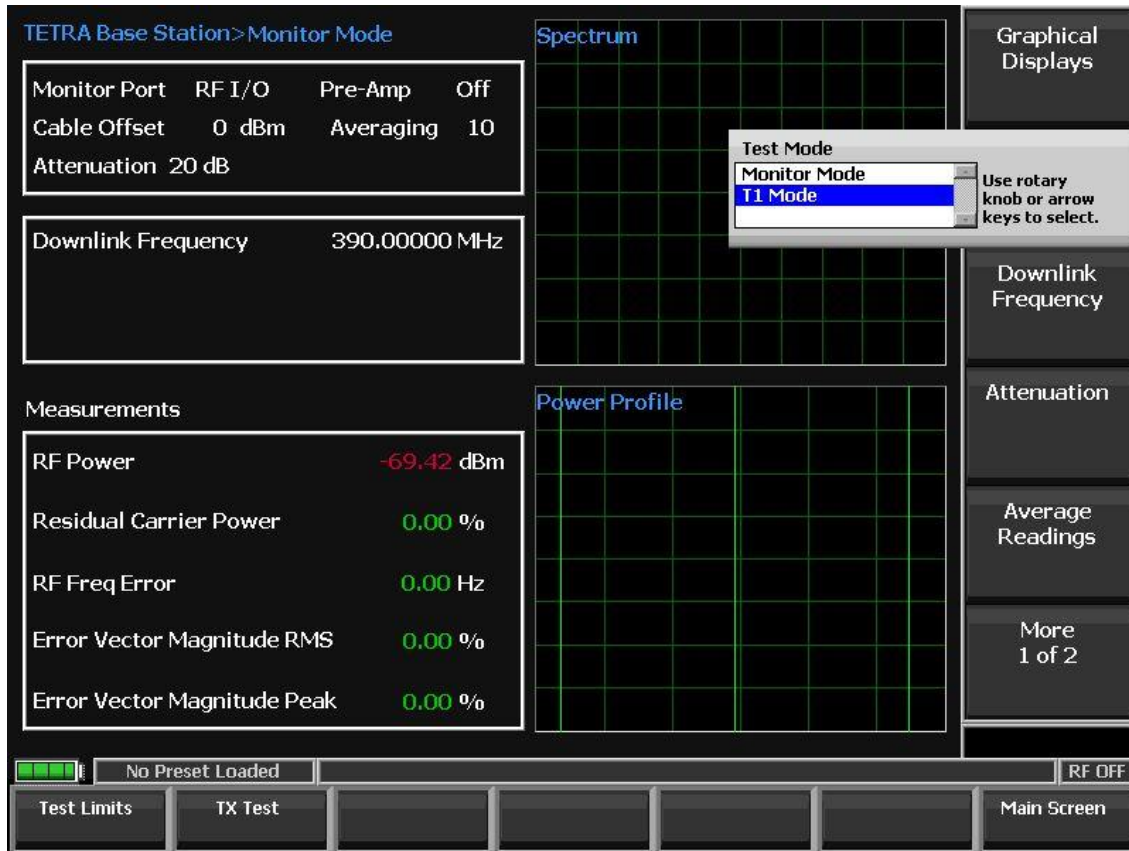
- A) FR8100
- B) R8000 or R8100 with the “Extended Gen OUT range” (R8-GEN_EXT) OPTION
- C) User has a 30dB attenuator to place on Gen port output

Power up the R8100 and select test mode “Tetra Base Station”



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After the R8100 switches to the "Tetra Base Station Mode" press the soft key "Test Mode" and select "T1 Mode"



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Testing a Motorola MTS4

All commands shown here for the Motorola Base Station are specific to this BS and are for demonstration purposes ONLY. It is important that technicians follow manufacturer's recommended procedures for power up and configuration of the base station.

This document discusses testing the Base Radio only.



Motorola MTS4 Base Station Rack

Note: there are 4 base radios in the MTS4



Base Radio -

NOTE separate TX and RX ports

Chapter 6 of Reference 1 - "Configuration and Testing" details the setup and overview of testing the MTS4 base radios.

NOTE: **The MTS MUST be taken out of service before performing the following sequence.**

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The following “section” numbers refer to chapters in the Reference 1 document.

Section 6.2.2 – Test Equipment

An R8100 with options “TETRA BS Mon Package” and “TETRA BSM T1 Test” will be utilized as the “TETRA Signal Generator” and “TETRA Analyzer” in place of the test equipment listed.

Section 6.5 – “Configuring and Verifying the Base Radio”

Follow Section 6.5 and forward along with changes specified below to verify the transmitter and receiver of the Base Radio.

Utilizing the Motorola DIMETRA BTS service software to communicate and control the Base Radio.

– connect serial interface to port B (Base radio RS232 interface)

Start BTS Service software

Establish connection to the MTS4 and log in.

Follow Motorola procedure to place the MTS4 into test mode.

Transmitter Verification

Using Ref. 1 Section 6.5.4.2.1 – Transmitter Verification as reference:

Procedure:

- 1) Log on to the Test Application of the Base Radio.
See Logging on to the Test Application in Ref. 1 – Section 6.2.1.5.
- 2) Type power -otxch1 -a0 in the command line. This command dekeys the transmitter.
- 3) Replace the existing cable from the Base Radio TX connector with a test cable to the TX connector. Connect the other end of cable to the RF IN/OUT connector on the R8100 TETRA Analyzer.
- 4) Connect the 50 Ohm Coax cable from the 10 MHz REF IN/OUT connector of the R8100 TETRA Analyzer (on the side of the R8100) to the 10 MHz input connector on the Service Connector Box. By default, the R8100 is set to output 10Mhz ref.
- 5) Configure the R8100 Test Mode to “TETRA Base Station”. Then when in base station mode, select “Test mode” as T1 Mode.
- 6) **NOTICE:** The following commands key the transmitter. Make sure that transmission only occurs on licensed frequencies or into an RF dummy load. To ask for the current transmitter frequency, enter: freq -otxch1. To change the transmit frequency, enter:

· **for BR-Arch-1:** vco -otx_all -f<X>

· **for BR-Arch-2:** freq -otx_all -f<X>

where <X> is a transmit frequency. For example, to set the transmit frequency to

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410.0125 MHz, type vco -otx_all -f410.0125.

- 7) To key the transmitter with a TCH 7.2 channel type these three commands:

```
enable -otx_all son
```

```
ptm -orx_all -mTCH_72 -s15 -tNo_Trigger -d0
```

```
power -otxch1 -aXX
```

These commands set the transmitter to a specified power (in Watts) without altering any programmed parameters. For example, to key the Power Amplifier to 15W, type power -otxch1 -a15.

- 8) **NOTICE:** The measurement equipment setting for MCC = 0, MNC = 0 and BCC = 1
Burst Type: NCDB

On R8100 Selecting “Motorola MTS 1” under “BS OEM” under “T1 Test” will automatically provided the MCC = 0, MNC = 0, BCC = 1, Mode = Manual Receive, Type = TCH/7.2.

These settings can also be made manually, by setting “BS OEM” = User defined.

On the R8100 physical layer measurements of the transmitted Tetra signal can now be made.

The user can put a “Cable offset” into the R8100 to account for losses.

- 9) At the prompt, type these three commands:

meter -opa1 -mpa_pwr_fwd. This command returns the current value of forward power from the RF Power Amplifier.

meter -opa1 -mpa_pwr_re. This command returns the current value of reflected power from the RF Power Amplifier.

meter -opa1 -mpa_vswr. This command calculates the current Voltage Standing Wave Ratio (VSWR) from the RF Power Amplifier.

- 10) At the prompt, type: alarms -ofault_hndlr.

This command returns all active alarms of the Base Radio.

- 11) At the prompt, type: power -otxch1 —a0.

This command stops all transmitter activity.

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Example Transmit test setup and screen shots

Inside the MTS1 Test Application

==== Start Log File =====

```
> login -ufield
```

password:

```
field> power -otxch1 -a0          { Set output power level to zero (off) }
```

```
field>
```

```
field> freq -otxch1              { Request TX test frequency }
```

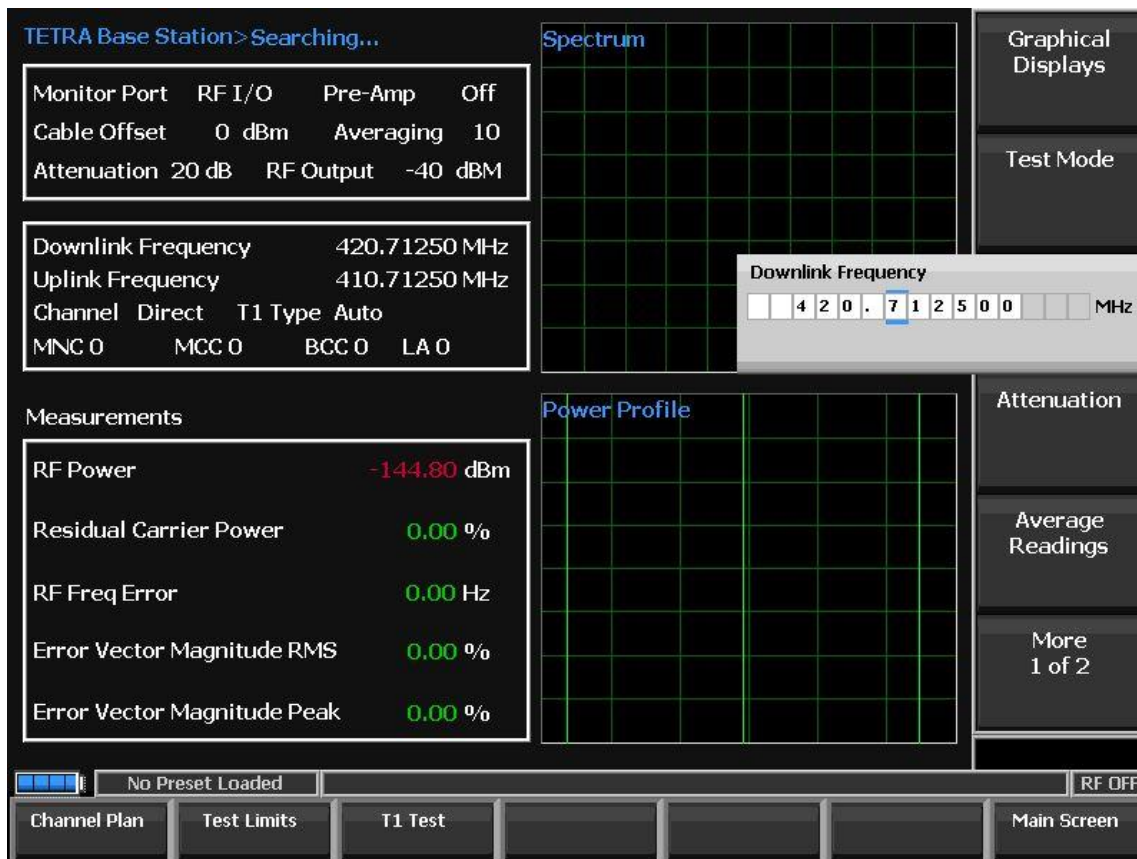
```
freq (txch1)=420.712500
```

```
field> freq -orxch1            { Request RX test frequency }
```

```
freq (rxch1)=410.712500
```

==== End Log File =====

On R8100 set the Downlink frequency to the transmit frequency of the Base Station



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Then hit the “T1 Test” button on bottom row and Hit the “BS OEM” key. Select “Motorola MTS 1”.



This choice presets the BCC = 1, and the Uplink single type to TCH/7.2.

BS TRANSMIT TEST

Now back on the MTS1

==== Start Log File =====

```
field> ptm -orx_all -mTCH_72 -s15 -tNo_Trigger -d0 { This command sets signal type}
```

```
field> enable -otx_all -son { This command enables the transmit channels}
```

```
field> power -otxch1 -a16 { This command sets TX output power to 16 watts }
```

EVENT: Train now

EVENT: Train now

==== End Log File =====

With the power on the R8100 can now be utilized to make measurements.

See next two screenshots.

If necessary, increase attenuation on R8100.

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TETRA Base Station>T1 Found>Connected

Monitor Port	RF I/O	Pre-Amp	Off
Attenuation	40 dB	Cable Offset	-0.3 dBm
Gen Port	RF I/O	RF Output	-70 dBm

Downlink Frequency	420.71250 MHz		
Uplink Frequency	410.71250 MHz		
Channel Direct	T1 Type TCH/7.2		
MNC 0	MCC 0	BCC 1	LA 0

Measurements	Averaging	10
RF Power	40.31 dBm	<div style="width: 100%; height: 10px; background-color: green;"></div>
Residual Carrier Power	0.56 %	<div style="width: 10%; height: 10px; background-color: green;"></div>
RF Freq Error	2.67 Hz	<div style="width: 5%; height: 10px; background-color: green;"></div>
Error Vector Magnitude RMS	3.09 %	<div style="width: 30%; height: 10px; background-color: green;"></div>
Error Vector Magnitude Peak	6.51 %	<div style="width: 35%; height: 10px; background-color: green;"></div>

Trajectories

Graphical Displays

Test Mode

Downlink Frequency

Attenuation

Average Readings

More 1 of 3

No Preset Loaded

RF ON

Main Screen

Detected Base Station Mode> T1 Test Running

Network Parameters

Downlink Frequency	420.71250 MHz	Channel Direct	MNC 0	BCC 1	
Uplink Frequency	410.71250 MHz	RF Level	-70 dBm	MCC 0	LA 0

Error Rates		BS T1 Information	
Downlink BER	0.000 %	Mode	Manual Receive
Downlink MBR	0.000 %	Type	TCH/7.2
Uplink BER	---,--- %	Loopback	Off
Uplink MER	---,--- %		

Test Results	Current	Min	Max	Average
RF Power dBm	40.314	40.305	40.318	40.312
Residual Carrier Power %	0.447	0.447	1.071	0.68
Frequency Error Hz	2.488	2.488	3.472	3.094
RMS Vector Error %	2.782	2.018	3.338	2.724
Peak Vector Error %	5.947	3.936	7.14	5.604

BS OEM

RF Output Level

Test Results

No Preset Loaded

RF ON

Main Screen

Application Note

Receiver Verification

This procedure provides commands and responses to verify proper operation of the Base Radio receiver path and is recommended after replacing a Base Radio. The Bit Error Rate (BER) measurement meets specifications at less than 0.01% (1.0e-02%) to pass the process.

Prerequisites: Take the Base Radio out of service.

Using Ref. 1 Section 6.5.4.3 – Receiver Verification as reference:

Using Ref. 1 Section 6.5.4.3.1 – Setting Up the Equipment for Receiver Verification

Using Ref. 1 Section 6.5.4.3.2 –Verifying the Receiver

NOTE: The R8100 does NOT support a hard wire timing pulse from the TETRA Base station. Instead the R8100 will align its slot timing to the TETRA Base Station by monitoring the transmission from the Base Station. So, in the following procedure, BOTH TX and RX of the Base Radio are utilized. It is recommended that the Transmitter testing above be setup and completed. Then without disconnecting any cables, move on to the BS Receiver test below.

Procedure:

Note: If the transmitter test above was just completed and connections are still made, then jump to procedure number 7 below.

- 1) Connect one end of the Service cable to the service computer.
- 2) Connect the other end of the Service cable to the BR Service Access port on the front panel of the BR.
- 3) Disconnect the existing cables from the Base Radio TX and RX connectors (or the connector corresponding to the receiver under test).
- 4) Connect a test cable to the TX and RX connectors.
- 5) Connect the other end of the TX test cable to the RF I/O on the R8100.
- 6) Connect the 50 Ohm Coax cable from the 10 MHz REF IN/OUT connector of the R8100 TETRA Analyzer (on the side of the R8100) to the 10 MHz input connector on the Service Connector Box. By default, the R8100 is set to output 10Mhz ref.
- 7) Connect the RX test cable to the Gen Port on the R8100 (Note: Software version must be 3.7 or higher to have TETRA signal output on the GEN PORT)
NOTE: IF the Test equipment **does not** have the “Extended GEN out range option” then place a 30dB attenuator between the Gen Port and RX port on Base station. In the test equipment go to “Settings”, “System Settings”, Set “RF level Offset” = ON and “RF Gen Out Offset” = -30 dB.
- 8) Enter the BR Test Application mode and login.
- 9) At the prompt,
 - type: freq -otxch1 to get the TX frequency
 - type: freq -orxch1 to get the RX frequency.

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Record the results. And Configure the R8100 Downlink Frequency to the BS TX frequency. Verify the R8100 Uplink frequency matches the BS RX frequency. If not, then verify channel plan configuration matches the base station configuration.

Note: All receivers within a single Base Radio have the same receive frequency.

10) Optional: If you need to change the TX or RX frequencies, enter the following commands:

```
freq -otx_all -f<X>
```

```
freq -orx_all -f<X>
```

where <X> is the frequency you want to set.

11) To key the transmitter with a TCH 7.2 channel type these three commands:

```
enable -otx_all son
```

```
ptm -orx_all -mTCH_72 -s15 -tNo_Trigger -d0
```

```
power -otxch1 -a1
```

These commands set the transmitter to 1 Watt power without altering any programmed parameters.

NOTICE: The measurement equipment setting for MCC = 0, MNC = 0 and BCC = 1
Burst Type: NCDB

On R8100 Selecting “Motorola MTS 1” under “BS OEM” under “T1 Test” will automatically provided the MCC = 0, MNC = 0, BCC = 1, Mode = Manual Receive, Type = TCH/7.2.

These settings can also be made manually, by setting “BS OEM” = User defined.

On the R8100 physical layer measurements of the transmitted Tetra signal can now be made.

The user can put a “Cable offset” into the R8100 to account for losses.

12) Verify the Downlink BER on the T1 Test Screen is 0.000 %. If so then continue. If not verify that BS is transmitting and the network settings in R8100 (MCC, MNC, BCC) are correct.

13) Set the R8100 RF Output level to -90 dBm.

14) Set the R8100 Gen Port to “GEN OUT”

15) Type sge -orx_all -son and press ENTER to enable system gain alignment.

16) At the prompt, type: enable -orxch1 -dbr1 -son.

This command enables the receiver branch under test and should enable br1, br2, or br3 respectively depending on the branches that you are testing.

17) Type ppr -orxch1 -a3 -r1 to analyze the received RF signal quality of the Base Radio.

This command output 1 report based on 3 averages.

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The Sync Location should be around 1000 and BER should be 0.000.

If BER is NOT 0.000% then at Main Screen (Tetra MODE) – find “SYNC” software key on vertical keys and select SYNC.

After SYNC type “ppr -orxch1 -a3 -r1” and view results.

18) Set the R8100 RF Output level to -118 dBm.

19) Type “ppr -orxch1 -a1000 -r1”

This command output 1 report based on 10000 averages.

Record the results.

Step example:

Receiver Number = 1 2 3

SGC Attenuation (dB) = 0 0 0

Sync. Location (1/10 us) = 1058 1058 1058

Sync. Amplitude (dB) = -81 -81 -81

Total Bits/Msgs = 86400 86400 86400

Bits/Msgs in Error = 2186 2214 2251

BER/MER (%) = 2.530092 2.562500 2.605324

RSSI (dBm) = -118 -118 -119

20) Type ppr -orxch1 -a1 -r200 to check for small peaks of interference. Record the results.

21) Repeat step 19 through step 20 for all receiver branches.

22) Disconnect the equipment.

23) Repeat procedure for all remaining Base Radios.

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Example BS RECEIVE TEST

```
==== Start Log File =====
field> freq -otxch1                { Read TX frequency}
freq (txch1)=420.712500
field> freq -orxch1                { Read RX frequency}
freq (rxch1)=410.712500
field> enable -otx_all -son        { Enable transmitter }
field> ptm -orx_all -mTCH_72 -s15 -tNo_Trigger -d0    { Set transmit type }
field> power -otxch1 -a1          { Set output power to 1 watt }
EVENT: Train now
EVENT: Train now
field> sge -orx_all -son          { Set gain state of receiver }
State=on
field>
field> enable -orxch1 -dbr1 -son   { enable receive channel 1)
field>
field> ppr -orxch1 -a3 -r1        { output performance data from DSP – 3 averages 1 report}
Receiver Number      =1    2    3
SGC Attenuation (dB) =0    0    0
Sync. Location (1/10 us) =3280  80  0
Sync. Amplitude (dB)  =-58  -87  -97
Total Bits/Msgs      =1296  1296  1296
Bits/Msgs in Error   =587   618   648
BER/MER (%)          =45.293209 47.685184 50.000000
```

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RSSI (dBm) =-91 -121 -160

field> ppr -orxch1 -a3 -r1 { Select "SYNC" on R8100 and check receive again }

Receiver Number =1 2 3

SGC Attenuation (dB) =0 0 0

Sync. Location (1/10 us) =707 625 0

Sync. Amplitude (dB) =-53 -83 -97

Total Bits/Msgs =1296 1296 1296

Bits/Msgs in Error =0 121 648

BER/MER (%) =0.000000 9.336419 50.000000

RSSI (dBm) =-91 -120 -160

==== End Log File =====

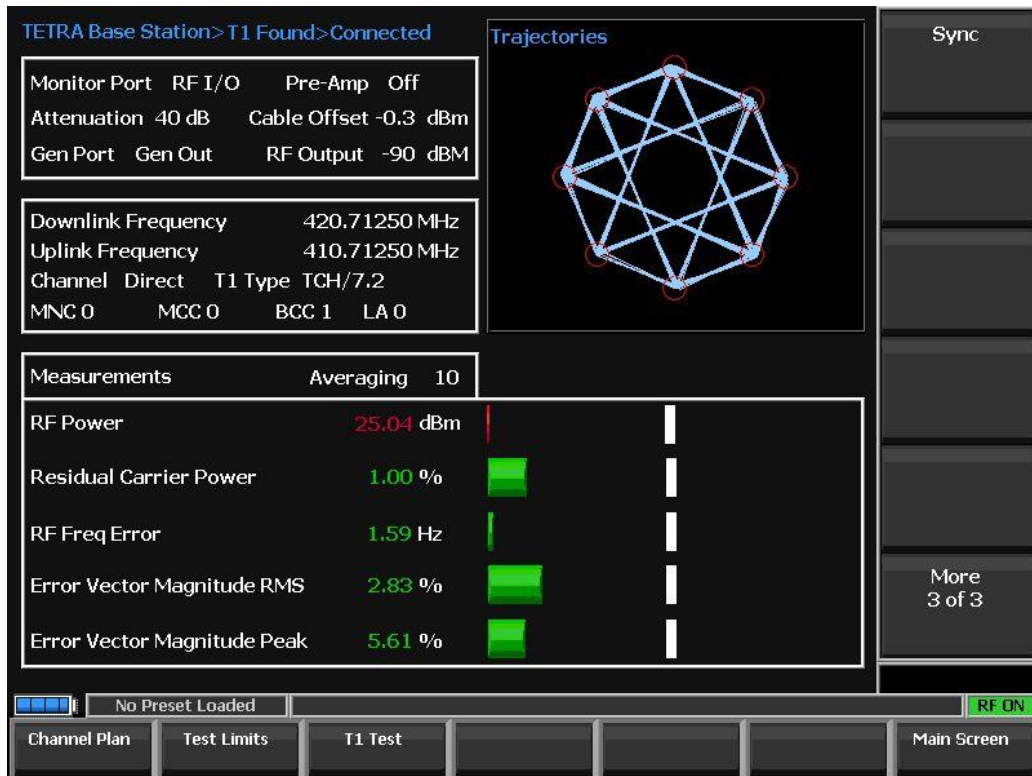
On the R8100 – the output power to the Base Station is set at -90 dBm.

Note the report results above and see that the sync location is 3280 1/10 us off, and a BER of 45.2% is reported. The Motorola manual for this test indicates that sync location should be less than 1000.

Go to R8100 user interface and on main screen 3 of 3 press the "SYNC" button. (See screen shot below). The R8100 will execute synchronization to the transmit from the Base station.

After SYNC, recheck the receive performance and find sync location at 707 and BER at 0.000.

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Then on the R8100 lowering the output power and recheck measurements on the MST4 until the expected BRE is found.

Test shown below shows dropping level to -118 dBm.

==== Start Log File =====

```
field> ppr -orxch1 -a1000 -r1          { performance data from DSP - 1000 averages 1 report}
Receiver Number      =1    2    3
SGC Attenuation (dB) =0    0    0
Sync. Location (1/10 us) =726  2354  0
Sync. Amplitude (dB) =-81  -93  -97
Total Bits/Msgs     =432000 432000 432000
Bits/Msgs in Error  =7412  199901 216000
BER/MER (%)         =1.715741 46.273380 50.000000
RSSI (dBm)          =-118  -127  -160
```

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==== End Log File =====

This is end of test.

Shut down power on MTS4.

==== Start Log File =====

field>

field> power -otxch1 -a1 0

field>

==== End Log File =====

Verifying and Tuning the Receiver RSSI Levels

The RSSI level affects the sensitivity of the interference alarm.

If the RSSI levels are off in the receiver testing it is important that the levels be adjusted for best operation. Follow the instructions found in Section 6.5.4.3.3 of Ref. 1 to accomplish this but utilize the receiver path setup and test configuration found in **Receiver Verification** above in place of external frame triggering setup used in the MTS4 document.

Conclusion

This application note has described an example of testing a specific Tetra Base Station utilizing an R8100 configured with the "Tetra BS Mon Package" and the "Tetra BSM T1 Test" option. This basic procedure can be utilized for any Tetra Base Station, but the user must follow the specific setup and test commands supplied by the manufacture of the base station under test.

All MTS test commands utilized here are specific to MOTOROLA and are shown here only for demonstration.