

Fast Device Tune Measurement Solution for Calibrating W-CDMA Mobile Phones with the Agilent E6601A Wireless Communications Test Set

Application Note

Introduction

Continued consolidation and competition in the cell phone market has intensified manufacturing pressure to reduce cost of test. This has increased the need for test time improvements enabled by fast calibration techniques. These fast calibration techniques require unique chipset support capability in advanced test equipment. Such capability is realized in measurements like Agilent's Fast Device Tune, available in the Agilent Technologies E6601A and 8960 Wireless Communication Test Sets. Working together with chipset test mode software to synchronize with the mobile phone's test sequence, Fast Device Tune dramatically reduces test time for transmitter output power and receiver input level calibration. Measurement speed improvements are achieved with simultaneous calibration of transmitter and receiver performance across level and frequency in a single measurement sweep per frequency band.

This application note describes the Fast Device Tune measurement for calibrating W-CDMA mobile phones using the E6601A, Agilent's next generation test set optimized for manufacturing test. An overview of calibration, explanation of the measurement setup, tour of the Fast Device Tune application features, and programming example are all included.

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Calibrating Mobile Phones

Wireless device manufacturers are facing unprecedented pressures on operating margins. Commoditization of low-priced phones, increased demand for features in mid-range phones, and aggressive global competition are all factors keeping downward pressure on wireless device pricing. As a result, test costs have become a higher percentage of the overall manufacturing cost of a mobile phone. Manufacturers are making serious efforts to reduce these test costs. Reducing test time is one of the most effective ways to cut test costs in manufacturing. Transmitter and receiver calibration testing, which requires a large number of measurements, is a key process focus for test time reduction. Faster calibration techniques are helping by dramatically improving throughput in manufacturing test.

Responding to the need to reduce manufacturing test time, mobile phone chipset providers have been implementing a fast calibration technique that allows their chipset transmitter output power and receiver input level to be calibrated across level and frequency in a single frequency band sweep. The Fast Device Tune measurement in Agilent's E6601A and 8960 Wireless Communication Test Sets enables this solution and is supported in many of today's leading chipsets.

This application note describes the benefits of Fast Device Tune in more detail and how it is used with the Agilent E6601A test set.

Why is calibration testing so time consuming?

Calibrating a mobile phone requires a calibrated RF source and a calibrated RF measuring receiver with certain measurement capability. Call processing is not required, as calibration is a measurement-intensive, repetitive, and iterative process that requires test program control of the phone and the test set.

As a calibrated RF source, the test set provides a precise, expected level to the phone, which the phone then measures. This measurement is known as the received signal strength indication (RSSI). As a calibrated RF receiver, the test set makes critical power measurements to verify the output level of the phone meets regulatory and standards requirements, along with other modulation and spectral measurements frequently included to verify other performance parameters of the phone's transmitter, such as phase and frequency or out-of-channel emissions.

In mobile phone manufacturing, accurate calibration is imperative to ensure product quality and interoperability in operators' systems. Many channels (frequencies) and levels (power levels) are involved in the testing of today's multi-band and multi-format 2G/3G mobile phones. A typical W-CDMA calibration profile, for example, measures a mobile phone across two bands (800 to 1000 MHz and 1700 to 1990 MHz) with 15 channels in each band and 20 power levels at each channel. This adds up to 600 power measurements. Another 300 receiver measurements typically are made in each band. Thus, 1200 measurements in total are needed to calibrate the phone.

The traditional "set and measure" process involves setting the mobile phone to each channel and level, and then setting the test set's measuring receiver to the same channel to make the power measurement. The process is repeated on each channel until all calibration channels and levels have been measured and the calibration correction data is stored in the mobile phone. Next, the same "set and measure" process is carried out using the test set's RF source to provide calibrated levels for the mobile phone receiver's RSSI calibration. This method of W-CDMA device calibration might take over 150 seconds to complete—a long time in manufacturing terms. A large portion of this calibration time is communications overhead.

For each channel and level, the mobile phone must be set via a control interface and the test set must be set via GP-IB, LAN, or USB interface. The measurement data then must be read and calibration data stored into the mobile phone.

Reducing the number of measurements to speed up the calibration process is not always an option, however. Calibration of the transmitter output power affects maximum power, minimum power, power control, modulation quality, adjacent channel leakage, spectrum emissions, and battery life. Calibration of the receiver input level removes sources of uncertainty over the receiver's dynamic range to ensure proper operation in the wireless network, quality of reception, and accuracy. Since eliminating measurements is not always advisable, new techniques that improve the speed of the measurement process and reduce the communications overhead are needed. Agilent's Fast Device Tune measurement can reduce calibration test time by an order of magnitude; for example, from 150 to 15 seconds on the afore-mentioned W-CDMA calibration profile.

Agilent's contributions to fast calibration

Agilent has been working with manufacturers for many years to provide faster calibration techniques. In 1998, Agilent introduced the fastest Gaussian minimum shift keying (GMSK) power measurement in the industry with the ability to measure transmitted power at close to the GSM burst rate—a factor of 10 improvement over previous test sets.

The dynamic power measurement, introduced in 1999, improved the GMSK power measurement by an additional 50 percent by enabling power ramp measurements at the GSM frame rate at a single channel. Continued enhancements to the dynamic power measurement have added support for EDGE, W-CDMA and cdma2000® 1xRTT. The dynamic power measurement requires the mobile phone to provide a pre-defined test mode power ramp at each calibration channel, which helps reduce the communications overhead by measuring up to several hundred power levels in a single stepped sweep per channel.

Agilent's implementation of the phase and amplitude versus time (PAvT) measurement was introduced in 2005. With PAVT, manufacturers can calibrate non-linear power amplifiers to effectively produce a varying phase component—for example, an EGPRS 8PSK signal—so that they also can be used with the GMSK signal. This eliminates the need for a second power amplifier for GSM. The PAVT measurement increases the flexibility of the power measurement ramping capability and adds new phase and frequency measurements. These highly optimized measurement algorithms can be used only with a pulsed amplitude CW signal in the mobile phone's test mode. If a different signal type is needed for calibration, then an alternative method can be used in which the waveform is sampled directly and the raw polar or IQ data received is used to calculate the data needed to create the calibration factors.

Fast Device Tune is the latest and fastest in this progression of calibration test improvements, allowing the test set to make simultaneous transmitter output power level and receiver input level measurements across level and frequency in a single frequency band sweep. For chipsets that support Fast Device Tune, Agilent recommends this measurement as the fastest way to characterize power and RSSI over frequency range.

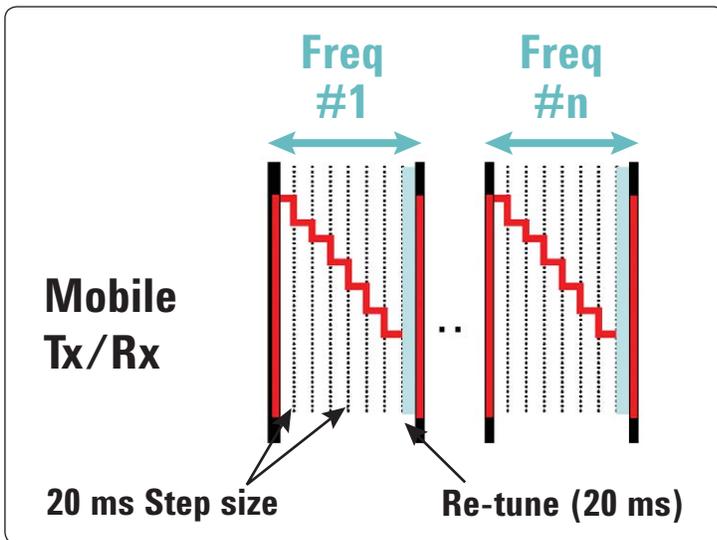


Figure 1. Fast Device Tune for W-CDMA phone calibration measures Tx power for each pre-defined 20 ms power step for a series of channels in a single frequency band.

Fast Device Tune Measurement Overview

The Fast Device Tune measurement in the Agilent E6601A and 8960 Wireless Communications Test Sets allows the simultaneous calibration of a mobile phone's transmitter output power and receiver input level across level and frequency in a single sweep per frequency band. Fast Device Tune is a combination of the dynamic power measurement, with simultaneous output level steps and frequency hopping.

The measurement is performed with the phone in a test mode. No call is established between the phone and the test set, and call processing capability in the test set is not required. The test mode, however, requires chipset support and software to cause the phone to output and receive at a series of frequencies and levels. The phone must transmit a predefined series of power steps at various uplink frequencies (channels) and simultaneously tune its receiver to perform measurements (such as RSSI) of the test set's signal at various downlink frequencies and power levels.

Mobile requirements

This type of calibration must be designed into the chipset software by the chipset provider and then implemented by the phone manufacturer during the phone calibration stage. A special set of mobile phone commands and a test-mode process are required to use Fast Device Tune.

Test set requirements

Fast Device Tune for the Agilent E6601A Wireless Communications Test Set is available today for W-CDMA calibration testing. The measurement is also available in the 8960 Wireless Communications Test Set for W-CDMA, cdma2000, and 1xEV-DO. The remainder of this application note focuses on the E6601A W-CDMA Fast Device Tune measurement.

The E6889A E6601 Application Features license set adds Fast Device Tune measurement capability to the E6601A running the E6832A W-CDMA Calibration Application. Note that the E6889A-1 Fast Device Tune measurement license must be selected. A W-CDMA configuration would therefore include the following elements:

- E6601A Wireless Communications Test Set
- E6890A General Purpose Application
- E6832A W-CDMA Calibration Application
- E6889A E6601 Application Features with E6889A-1 Fast Device Tune measurement

Various licensing options are available for both the E6832A and E6889A: perpetual, term (for periods of 1 to 12 months), and transportable.

Implementation

To implement the Fast Device Tune measurement solution, a connection is made between the RF output of the mobile phone and the RF in/out port of the test set. An intermediary controller running chipset calibration software is required to set up and control the Fast Device Tune measurement parameters and to control the mobile phone in transmitting its test signal waveform. Figure 2 illustrates a typical hardware configuration. Alternatively, the internal PC of the E6601A can be used as the controller and provide the serial interface to the phone as well. See Figure 3.



Figure 2. Diagram of the E6601A test set, mobile phone, and PC controller interconnections.

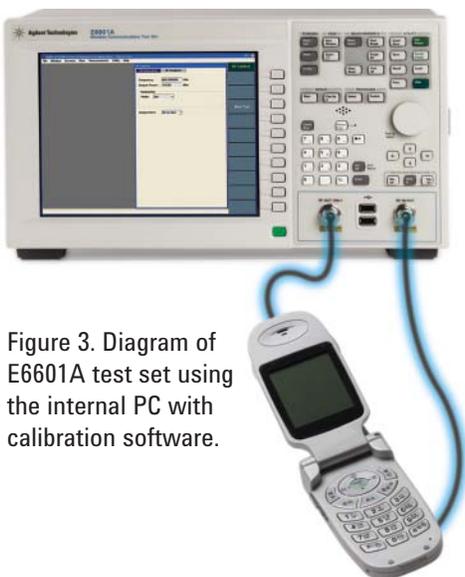


Figure 3. Diagram of E6601A test set using the internal PC with calibration software.

Measurement description

The W-CDMA mobile phone's transmitter power sequence may include up to 400 steps (of 20 ms duration/step) and can span the whole dynamic range of the Tx power measurement. The levels can step up or down with varying magnitudes of change, as long as the first step in the sequence provides at least a 20 dB rise to trigger the measurement. The mobile phone may transmit the same power sequence at up to 400 frequencies in a single sweep with one sweep per band. The measurement allows a maximum of 400 steps in any configuration ($\text{step} \times \text{frequency} \leq 400$).

Once triggered, the Fast Device Tune measurement follows the pre-defined test mode sequence of the mobile as it amplitude- and frequency-hops. While following the transmitted signal sequence from the mobile (MS Tx), the test set can also synchronously transmit a W-CDMA-modulated downlink over a different, pre-defined frequency/amplitude calibration combination, which can be used to simultaneously calibrate the mobile phone's receiver (MS Rx). The MS Tx and MS Rx frequency/amplitude profiles are settable by the user, allowing up to 400 total steps each. The power measurement that is reported on each MS Tx step is compliant with the mean power measurement as defined in the 3GPP standard.

Putting the mobile phone into test mode allows it to transmit a predefined series of power steps at various frequencies (MS Tx frequency/power series) and, if necessary, to simultaneously tune its receiver to perform measurements of the test set's signal at various frequencies and power levels (MS Rx frequency/power series) to determine RSSI, for example. Figure 4 shows an example of both an MS Tx frequency/power series and an MS Rx frequency/power series.

This MS Rx frequency/power series must include the same number of power steps as the MS Tx frequency/power series (maximum 20 ms level steps \times frequencies = 400). These steps can be at any power level in the test set's RF output range (-110 to -20 dBm once the amplitude offsets are set). Because Fast Device Tune is done in test mode and not in a call, the MS Rx power sequence does not have to be in the same frequency band as the MS Tx power sequence. However, the number of frequencies in the MS Rx frequency sequence must match the number of frequency steps in the MS Tx frequency sequence.

Fast Device Tune also provides the option of turning off the RF generator on the test set and calibrating only the mobile phone's transmitter.

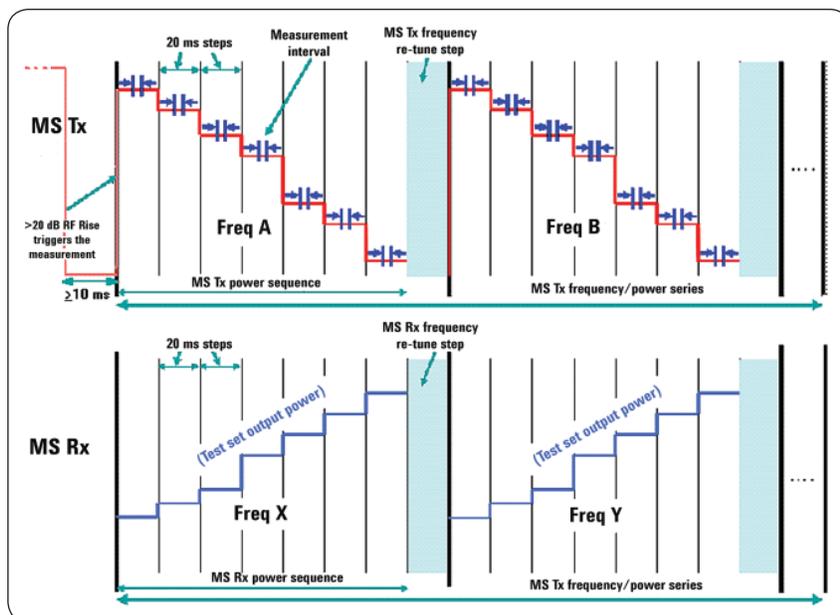


Figure 4. Example of the MS Tx and MS Rx frequency and power series for a Fast Device Tune measurement (step width = 20 ms).

Operating considerations

It is important to be aware that the Fast Device Tune measurement may re-range for every step in the MS Tx power sequence. To ensure that this process is not interrupted by other operations, Agilent recommends that no other GPIB commands be sent to the test set, or any front panel keys be pressed, until the measurement has completed. No additional measurements can be run at the same time as Fast Device Tune.

Note also that Fast Device Tune supports single mode only and does not support measurement averaging. It also does not perform auto-ranging, and it supports RF rise triggering only.

Application features

Fast Device Tune provides a set of application features accessed through the E6832A W-CDMA Calibration Application user interface. These features make it easy to set up and run the Fast Device Tune measurement and view the results. Several of these features are illustrated in Figure 5. Notice that “W-CDMA Fast Device Tune” is abbreviated as WFDT in this measurement screen.

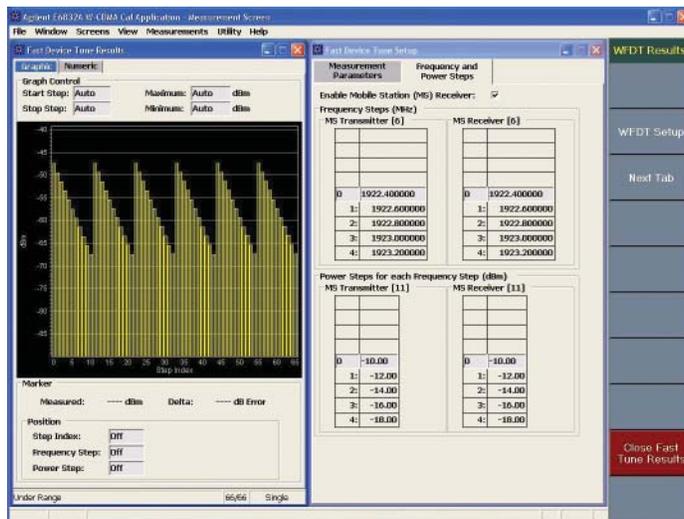


Figure 5. Application features such as a graphical display of measurement results (left) and numeric display of setup parameters (right) are part of the Fast Device Tune option.

Graphical display – The graphical display provides pan/zoom, markers, and other features. As is typical with graphical measurements, the graphical display can be manipulated using a drag-style “zoom.” Drag a box (from upper left to lower right) around a single power step in the graph to zoom in and see fine detail of the result. “Pan” the result by holding down the right mouse key and moving the waveform around. Zoom back out by clicking and dragging from the lower right to upper left.

The marker feature has the ability to display frequency in addition to power levels. Right-click in the Position/Step Index field of the Fast Device Tune Results window to turn the marker on. The Step Index setting moves the marker from one power step to the next across the entire range (Figure 6). Make direct entries or highlight the entry area and then use the up/down arrows to step across the measurement results one step at a time. The Frequency Step setting is used to quickly jump across frequencies, skipping the power levels for one single frequency. Power Step quickly covers the levels within one set frequency.

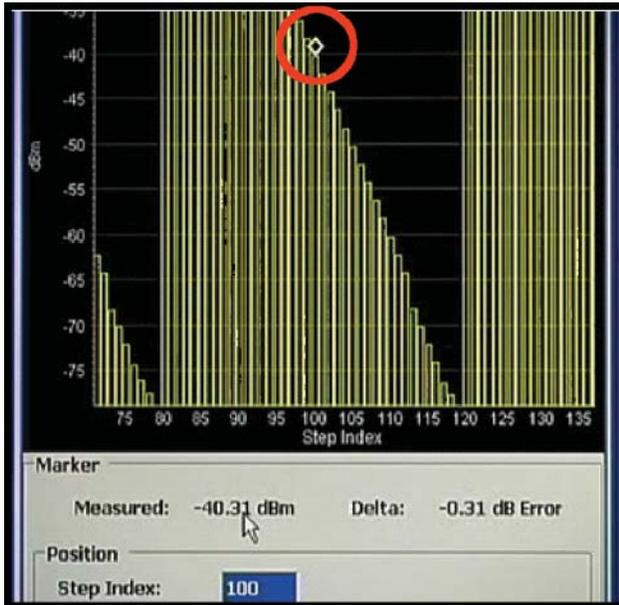


Figure 6. The Step Index setting moves the marker from one power step to the next across the range.

Numeric display – the “Numeric” tab at the top left side of the measurement window switches the graphical display to a numeric display; in this case a table of measured values for the frequencies and the levels of each frequency tested. This tabular data can be helpful particularly in an “over range” or “under range” situation, as it can be used to quickly compare actual levels to expected levels. (See “Troubleshooting,” page 14.)

Step	Frequency	Power		
		Measured	Expected	Delta
	MHz	dBm	dBm	dB Error
0	1922.400000	-14.99	-15.00	0.01
1		-19.99	-20.00	0.01
2		-24.99	-25.00	0.01
3		-29.99	-30.00	0.01
4		-34.99	-35.00	0.01
5		-39.99	-40.00	0.01
6		-44.99	-45.00	0.01
7		-49.99	-50.00	0.01
8		-54.99	-55.00	0.01
9		-59.99	-60.00	0.01
10		-64.99	-65.00	0.01
11		-69.99	-70.00	0.01
12		-74.99	-75.00	0.01
13		-79.99	-80.00	0.01
14		-84.99	-85.00	0.01
15		-89.99	-90.00	0.01
16		-94.99	-95.00	0.01
17		-99.99	-100.00	0.01

Figure 7. The Numeric display presents measured values in a tabular format.

Power Samples mode – a Power Samples feature shows the actual sampled data from the measurement. On the “Measurement Parameters” tab of the Fast Device Tune Setup window, click the “Enable Power Samples” box in the dynamic power setup (Figure 8, upper right).

Initiate a new measurement, and the actual power samples are displayed mapped to the graphical results (Figure 8, below). This feature is especially helpful in setting up the measurement as it can be used to verify that the trigger delay value is starting the measurement once the burst has ramped up fully. “Power Samples” mode also can be used to check whether the interval is too long, allowing the power to drop and affect the result, or if the signal levels are “walking” (becoming increasingly out of synchronization) over the duration of the measurement.

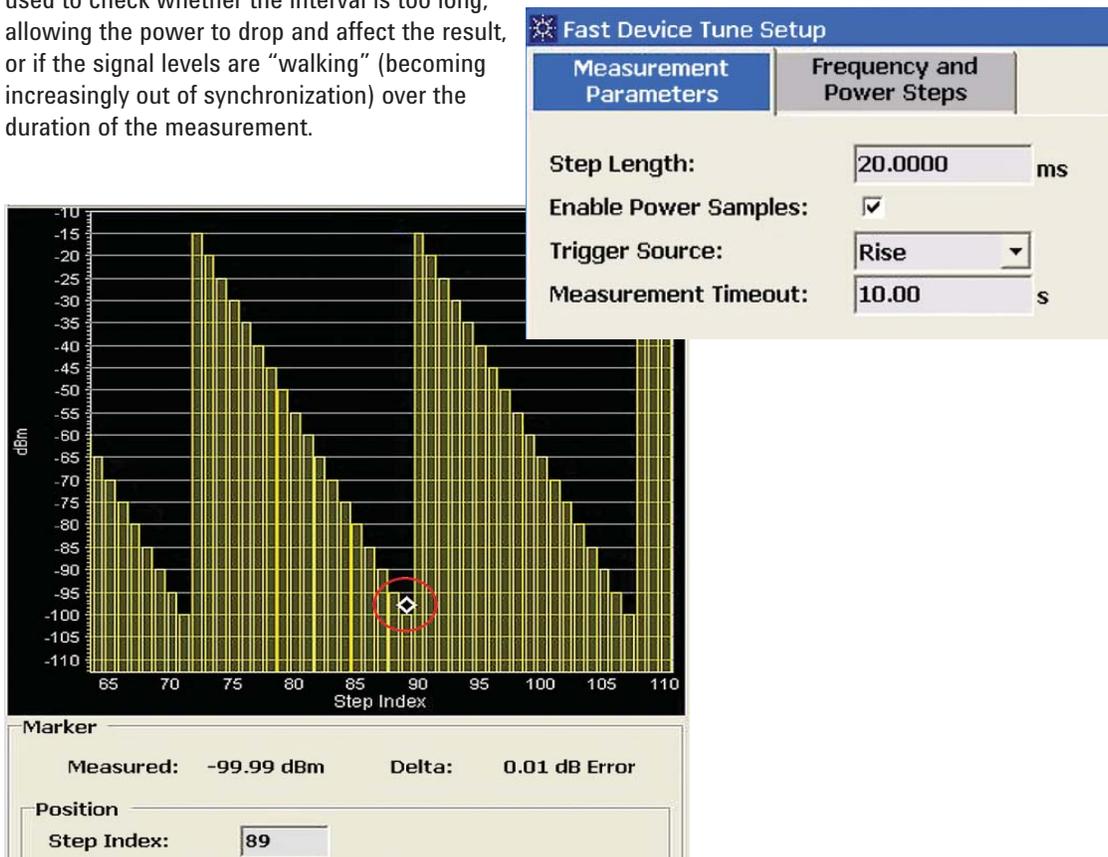


Figure 8. Enable Power Samples mode from the Fast Device Tune Setup window (upper right). The power samples are mapped to the graphical results (page 13).

Measurement results

The E6601A test set returns the following results for the Fast Device Tune measurement. See Figure 9.

Integrity indicator – A result of “Normal” indicates that the measurement suite completed successfully without error and the result is accurate.

MS transmitter power results (for all steps) – Gives the values for all measured power levels during the Fast Device Tune measurement.

MS transmitter power result (for a specified step) – Gives the value for any specific power/frequency step.

Measurement step progress count – Gives the number of steps that have been completed in a single measurement. The progress count is updated approximately every 50 steps until all the measurements complete.

Number of frequency steps – Gives the number of frequency steps in the measurement.

Number of power levels – Gives the number of power levels in the measurement.

Number of power results – Gives the number of measured MS Tx power results.

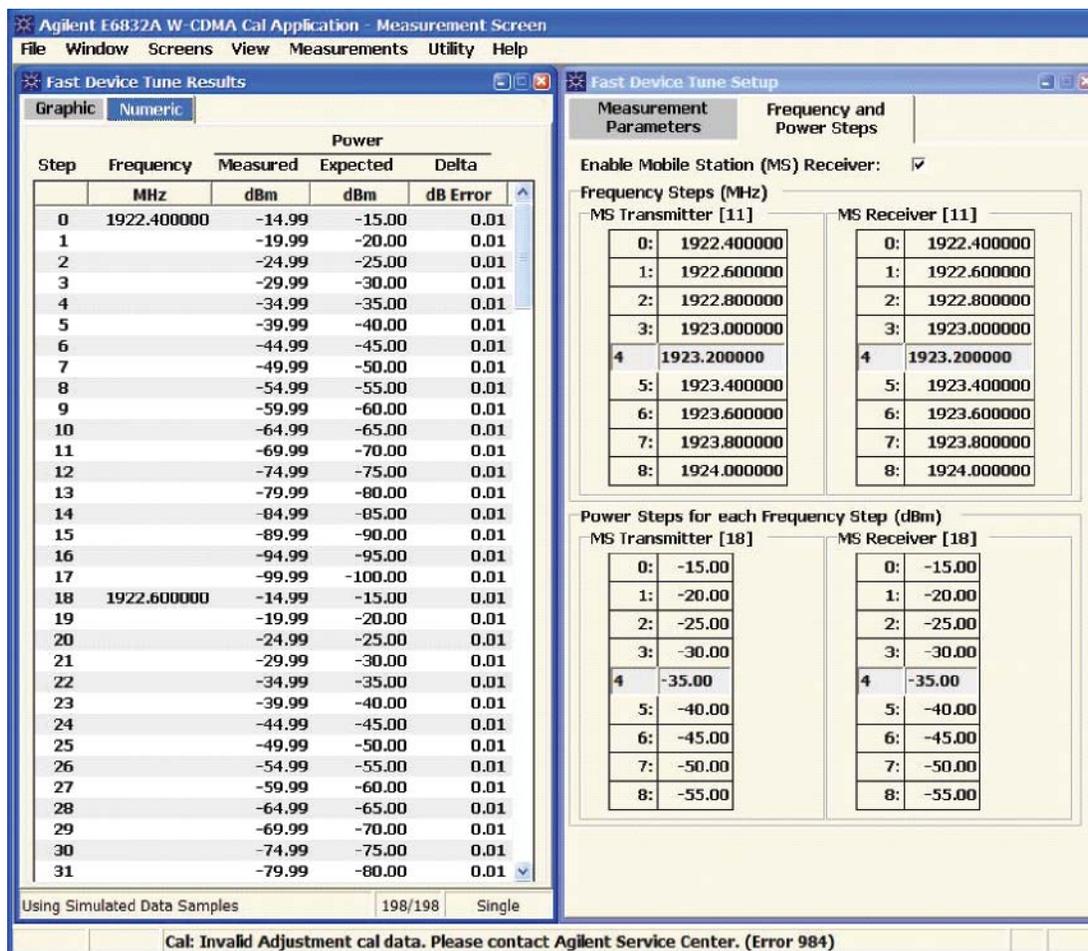


Figure 9. Measurement results for frequency and power steps are shown in the numeric display.

Troubleshooting

Problems with the Fast Device Tune measurement often are caused by setup errors. Triggering issues, over-range or under-range conditions, and certain integrity indicators are most common.

Over-range and under-range conditions – Any step within the Fast Device Tune measurement can be over-range or under-range. The affected steps are flagged in the dB error column of the numeric results display. Also, the over-range or under-range condition is indicated at the bottom of the graphical display (Figure 10).

Any reading greater than ± 9 dB in the dB error column is over-range or under-range. If the measurement results show unexpected values, the cause may be misaligned signals. Agilent recommends the following steps:

- Turn on the Enable Power Samples Display and re-run the measurement
- On the test set's front panel, observe and compare the measured power samples to the expected power samples on the graphic tab of the Fast Device Tune results window.

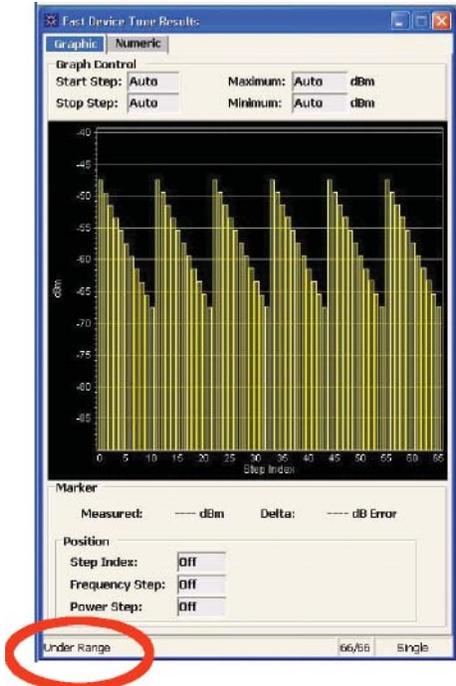


Figure 10. An under-range condition is indicated at the bottom of the graphical display.

Triggering issues – If the measurement is not triggering properly, Agilent recommends the following steps:

- Ensure that the signal is within the capture range, which is +9 dB from the expected power (plus the amplitude offsets). The expected power is the level entered into the "Frequency and Power Steps" configuration table.
- Ensure that the INITiate:WFDtuned:ARMed? query has returned a "1" before triggering the measurement.

Parameter error (integrity indicator 21) – This error can result from unequally sized MS Tx and MS Rx frequency sequence settings or unequally sized MS Tx and MS Rx power sequence settings. The error also can be caused by frequency and power sequence settings that are too large.

Sampler memory overflow (integrity indicator 41) or state machine overflow (integrity indicator 42) can result when other programs are running on the test set, including background utilities controlled by the Microsoft® Windows XP® operating system. All unnecessary programs should be closed during Fast Device Tune measurements.

Programming the Fast Device Tune Measurement

The following programming example illustrates a typical automated procedure using the command interface provided in the Fast Device Tune measurement solution.

Program flow

A procedure that can be used to make a Fast Device Tune measurement is described below and illustrated in Figure 11. Prior to executing the measurement, connect the mobile phone to the test set and put the mobile phone into a suitable test mode. Also, connect the mobile phone's digital control port to a PC controller to facilitate starting the test mode.

Instrument setup

- Load and configure the E6832A W-CDMA Calibration Application.
- Set the expected measurement output power in the RF generator.
- Set the expected measurement frequency in the RF analyzer.

Fast Device Tune measurement setup

- Configure the mobile phone to measure the test set's signal at least 900 μ s after the start of each step, to allow the test set's source to settle to the specified limits.
- Set up the Fast Device Tune measurement parameters "Measurement Timeout" and "Enable Power Samples" as needed using the SETup:WFDTune commands. *Note that the step "Enable power samples" will significantly slow reporting of the Fast Device Tune measurement results.* It is recommended that this step be used only for measurement troubleshooting.
- Set up the and frequency and power sequences as needed using the SETup:WFDTune commands.

Initiate and fetch the Fast Device Tune measurement

- Use the INITiate:WFDTune[:ON] command to start the measurement.
- Use the INITiate:WFDTune:ARMed? query to determine if the measurement is armed and ready to be triggered.
- Order the mobile phone to start transmitting its MS Tx frequency/power series (the MS should then increase its output power by at least 20 dB to reach the first step in the series, which triggers the measurement with an RF rise).
- Use the FETCH:WFDTune? commands to obtain the measurement results.

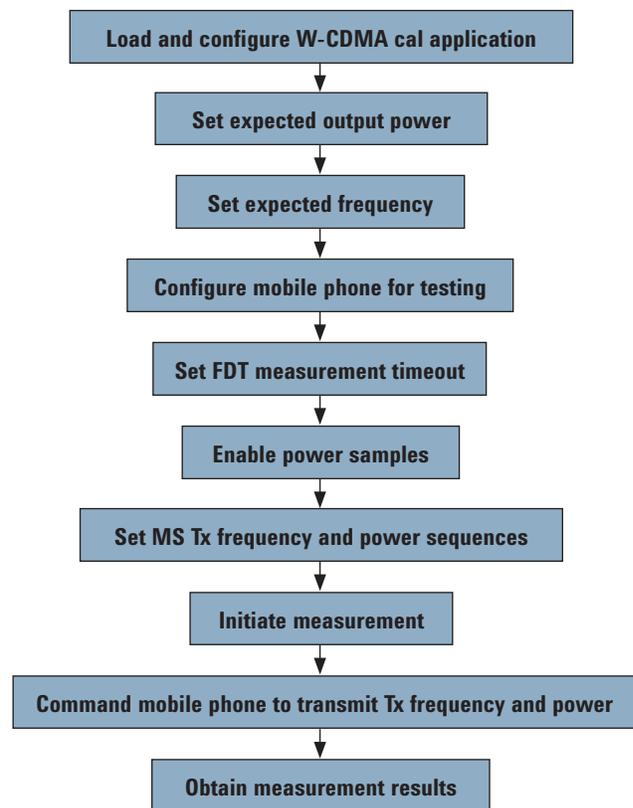


Figure 11. Example of a procedure used to make a W-CDMA Fast Device Tune measurement.

Programming example

The following programming example illustrates the automated use of the E6601A test set. This example is written in Visual Basic®, which is a common choice for automating wireless test systems. Other languages, such as Visual C++® and Agilent VEE, can also be used based on the

same programming principles. The example makes use of the communication capability provided by the VISA COM drivers that are part of the Agilent IO Libraries Suite. This suite is provided pre-installed on every E6601A produced by Agilent Technologies. The VISA COM library supports a wide variety of hardware and operating systems. For more information, see the IO Libraries web page at www.agilent.com/find/iolib.

```
Option Explicit On
Option Strict On
Imports Ivi.Visa.Interop
Module modFastDeviceTune

    Public Sub FastDeviceTune()

        ' This programming example assumes the wireless device is connected to the test set,
        ' and in a suitable test mode.

        Dim ResManager As New ResourceManager
        Dim TestSet As New FormattedIO488
        Dim FetchWFDTResults As Array
        Dim FrequencyTXResults As Array
        Dim TXFreqSequence As Array
        Dim TXPowerSequence As Array
        Dim RXFreqSequence As Array
        Dim RXPowerSequence As Array
        Dim X As Integer = 0
        Dim Y As Integer = 0
        Dim MeasurementReady As Integer

    Try

        ' Open the connection to the test set
        TestSet.IO = CType(ResManager.Open("GPIB0 ::14::INSTR"), IMessage)

        ' Clear the interface buffer.
        TestSet.IO.Clear()
        Console.WriteLine(ControlChars.NewLine & "Measuring Fast Device Tune...")

        '***Set up measurement parameters***

        ' Set VISA timeout to 15 seconds. This timeout should be longer than the
        ' following measurement timeout value.
        TestSet.IO.Timeout = 15000

        ' Set Fast Device Tune timeout to 10 seconds.
        TestSet.WriteString("SETup:WFDTune:TIMEout 10S")

        '***Set up Frequency and Power Steps***

        'Set the MS TX Frequency value array and query the number of elements
        ' for error checking.
        TestSet.WriteString("SETup:WFDTune:MS:TX:FREQuency:STEP 1852.4E6,
            1870.4E6, 1886.4E6, 1902.4E6")
        TestSet.WriteString("SETup:WFDTune:MS:TX:FREQuency:STEP:COUNT?")
        TXFreqSequence = CType(TestSet.ReadList, Array)

    End Try

    End Sub

End Module
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' Set the MS TX Power Level array and query the number of elements for
  error checking.
TestSet.WriteString("SETup:WFDTune:MS:TX:POWer:STEP 16,12,8,4,0,-4,
  -8,-12,-16,-20")
TestSet.WriteString("SETup:WFDTune:MS:TX:POWer:STEP:COUNT?")
TXPowerSequence = CType(TestSet.ReadList, Array)

' Set the MS RX Frequency value array and query the number of elements
  for error checking.
TestSet.WriteString("SETup:WFDTune:MS:RX:FREQuency:STEP 1932.4E6,
  1950.4E6, 1966.4E6, 1982.4E6")

TestSet.WriteString("SETup:WFDTune:MS:RX:FREQuency:STEP:COUNT?")
RXFreqSequence = CType(TestSet.ReadList, Array)

' Set the MS RX Power Levels array and query the number of elements for
  error checking.
' (The last seven are "dummy" values.)
TestSet.WriteString("SETup:WFDTune:MS:RX:POWer:STEP -80, -60, -40, -60,
  -60, -60, -60, -60, -60,-60")
TestSet.WriteString("SETup:WFDTune:MS:RX:POWer:STEP:COUNT?")
RXPowerSequence = CType(TestSet.ReadList, Array)

' The following if statement compares the size of the power arrays and
  frequency arrays.
If (TXPowerSequence.Length <> RXPowerSequence.Length) Then
  Console.WriteLine("The Fast Device Tune Measurement requires that the
    number of MS TX Power Levels is the same as the number of MS RX Power
    Levels before it will initiate the measurement.")
ElseIf TXFreqSequence.Length <> RXFreqSequence.Length Then
  Console.WriteLine("The Fast Device Tune Measurement requires that
    the number of MS TX Frequency values is the same as the number of MS
    RX Frequency values before it will initiate the measurement.")
ElseIf (TXPowerSequence.Length * TXFreqSequence.Length > 400) Then
  Console.WriteLine("The Fast Device Tune Measurement requires that
    the product of the number of MS Frequency values multiplied by the
    number of MS RX Power Levels be less than 400.")
End If

'***INITiate and FETCh measurements***

' Initiate Fast Device Tune.
TestSet.WriteString("INITiate:WFDTune")

ARM: 'Query the test set to see if the measurement is armed and ready to be triggerd.
TestSet.WriteString("INITiate:WFDTune:ARMed?")

'Fetch the result of the armed query.
MeasurementReady = CInt(TestSet.ReadNumber)

' This if statement makes sure the measurement is armed before continuing.
If MeasurementReady = 0 Then
  GoTo ARM
ElseIf MeasurementReady = 1 Then
  'Order the MS to begin transmission of its MS TX Frequency/Power Series.
  'Be sure that your mobile is properly configured to measure the MS/RX
  Frequency/Power series and
  'transmit the MS TX Frequency Power Series defined in the test set.
  'The width of the first power step must be at least half of the power
  step size and should

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    'increase its output power by at least a 20 dB RF rise to reach the
    first step in the series,
    'to trigger the measurement).
    Console.WriteLine(ControlChars.NewLine & "Command your mobile to
    transmit the calibration waveform.")

    'Fetch the Measured Results.
    TestSet.WriteString("FETCh:WFDTune?")
    FetchWFDTResults = CType(TestSet.ReadList(), Array)

    '***Print measurement results***

    Console.WriteLine(ControlChars.NewLine & "Fast Device Tune Results:")
    Console.WriteLine("Integrity Indicator = " & CStr(FetchWFDTResults.
    GetValue(0)))
    Console.WriteLine("Number of Frequency Steps = " &
    CStr(FetchWFDTResults.GetValue(1)))
    Console.WriteLine("Number of Power Levels = " &
    CStr(FetchWFDTResults.GetValue(2)))
    Console.WriteLine("Number of Power Results = " &
    CStr(FetchWFDTResults.GetValue(3)))
    Console.WriteLine("MS TX Power Results")

    'Query the MS TX Frequencies and assign them to an array to be
    printed with the power levels.
    TestSet.WriteString("SETup:WFDTune:MS:TX:FREQuency:STEP?")
    FrequencyTXResults = CType(TestSet.ReadList(), Array)

    'This For loop prints the Frequency, then the power levels measured
    at that frequency for every
    'frequency step.
    For X = 4 To FetchWFDTResults.Length - 1
        If (X - 4) Mod 10 = 0 Then
            Console.WriteLine("MS TX Power Levels when the Frequency (Hz) is:
            " & CStr(FrequencyTXResults.GetValue(Y)))
            Y = Y + 1
        End If
        Console.WriteLine(CStr(FetchWFDTResults.GetValue(X)))
    Next X
    Console.WriteLine(ControlChars.NewLine & "Fast Device Tune
    Measurement Complete.")
    End If

    'Display any errors that occur while this program is ran.
    Catch ex As Exception
    MessageBox.Show("The following error occurred in the Fast Device
    Tune measurement: " & ControlChars.CrLf & ex.Message, "Program
    Error", MessageBoxButtons.OK, MessageBoxIcon.Error)
    End Try

    '***Post test clean up***

    ' Turn the Fast Device Tune measurement off.
    TestSet.WriteString("INITiate:WFDTune:OFF")
    ' Close IO interface to test set
    TestSet.IO.Close()
    End Sub
End Module

```

Programming example results

This program returns the following results:

- Fast Device Tune integrity indicator
- Number of frequency steps
- Number of power steps
- Number of power results
- MS Tx power results

These results are grouped by frequency. A sample output from this programming example is shown below:

```
Measuring Fast Device Tune...
Command your mobile to transmit the
calibration waveform.
Fast Device Tune Results:
Integrity Indicator = 0
Number of Frequency Steps = 4
Number of Power Levels = 10
Number of Power Results = 40
MS TX Power Results
MS TX Power Levels when the Frequency (Hz)
is: 1852400000
15.82862
11.57644
7.07968
2.454624
-1.281671
-5.108028
-10.49541
-13.33077
-17.75223
-22.32819
MS TX Power Levels when the Frequency (Hz)
is: 1870400000
17.71036
13.54132
9.092502
4.495572
0.7686377
-3.022201
-8.401796
-11.21253
-15.6125
-20.20369
MS TX Power Levels when the Frequency (Hz)
is: 1886400000
18.04979
13.89712
9.466404
4.772737
1.188457
-2.619997
-7.983655
-10.79959
-15.20029
-19.79635
```

```
MS TX Power Levels when the Frequency (Hz)
is: 1902400000
17.30778
13.2036
8.842636
4.246554
0.6216635
-3.16222
-8.539176
-11.37039
-15.74968
-20.34672
Fast Device Tune Measurement Complete.
```

Verification of calibration data

At the end of a calibration profile, it is common practice to run some type of verification tests on the newly obtained calibration factors. The extent of testing and procedures used can vary considerably depending on the manufacturer's intent. Final testing usually provides the most extensive verification of the calibration data.

Conclusion

Compared to "traditional" calibration measurement techniques, the Fast Device Tune measurement on the Agilent E6601A and 8960 improves Tx power and Rx RSSI test time during the calibration of a mobile phone by up to an order of magnitude. Agilent is working with chipset manufacturers to ensure test mode support of Fast Device Tune for all leading chipsets so that more users can take advantage of this major improvement to wireless test.

The E6601A Fast Device Tune implementation takes this powerful test capability and adds a flexible manual user interface for easier setup, troubleshooting, and implementation. The addition of a "power samples" mode in particular is a useful troubleshooting and measurement start-up tool.

The combination of measurement flexibility, dynamic range, graphical display, and "power samples" capability enables Fast Device Tune on the E6601A to provide significantly faster mobile phone calibration times with no sacrifice in measurement accuracy or repeatability for maximum calibration throughput.

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