

Agilent Solution for radioOne™ Calibration

Application Note



Agilent Technologies

Table of Contents

- Traditional CDMA Mobile Station Architecture with Heterodyne Receiver 1**
- Latest CDMA Mobile Station Architecture with radioOne Technology 4**
- Effects of Second-Order Inter-Modulation in radioOne Architecture 6**
- Agilent Solution for radioOne Calibration 7**
 - Signal description 7
 - How to configure the test set to generate the required signals 8
 - Programming usage..... 10
- Conclusion 10**
- Appendix: Related References..... 11**

Traditional CDMA Mobile Station Architecture with Heterodyne Receiver

Traditional CDMA radios convert RF signals to and from baseband in multiple steps. In the receive path, it first converts the signal from RF to IF, then from IF to baseband. The transmitter converts the signal in the reverse order, from baseband to IF, then from IF to RF.

The well-known and most widely used receiver architecture is the heterodyne receiver, as depicted in Figure 1. This receiver employs one to multiple stages of an image-reject filter, a mixer, and a variable gain amplifier block. Due to the required high quality factors of the image reject mixers these are generally implemented off-chip. The drawback of implementing off-chip components, apart from the cost increase, is the increased power consumption. These blocks have to be driven with a characteristic impedance (typically 50 ohms). Driving signals at or near the RF frequency with such impedance requires power hungry driver blocks. Generally, the implementation of an increasing number of cascaded down conversion stages will also be reflected in the overall power consumption.

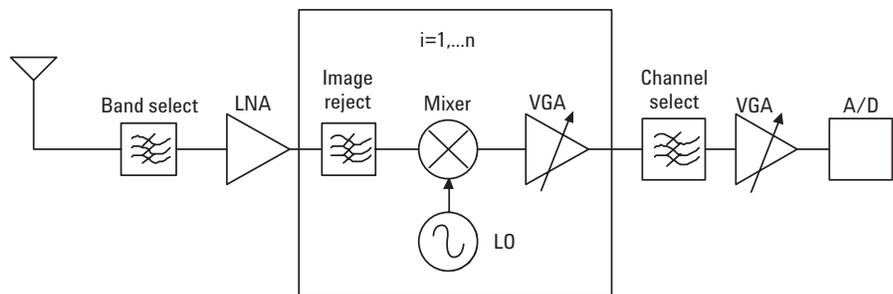


Figure 1. General diagram of the heterodyne receiver

Figure 2 shows a traditional CDMA mobile station based on the Qualcomm® 3300 series chipset, which implements a heterodyne receiver. For details, go to: http://www.cdmatech.com/solutions/products/cdmaone_is95_ab.jsp.

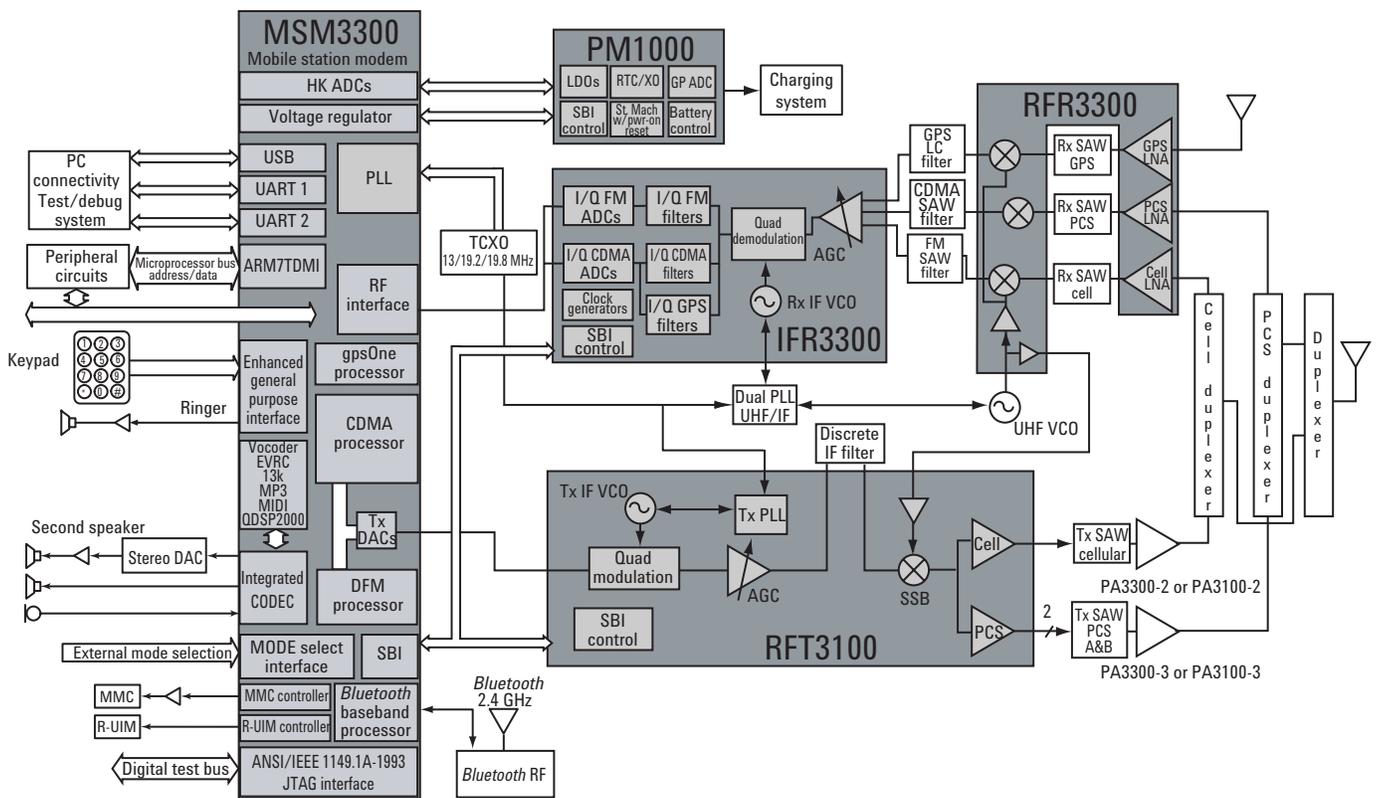


Figure 2. Traditional CDMA mobile station architecture with IF converter

- MSM3300: Mobile station (MS) modem
- RFT3100: Transmit processor (including baseband-to-IF and IF-to-RF)
- RFR3300: Receive processor (RF-to-IF)
- IFR3300: Receive processor (IF-to-baseband)
- PM1000: Power management ASIC

Latest CDMA Mobile Station Architecture with radioOne Technology

The radioOne solution offers a revolutionary technology for CDMA radios that use direct conversion, or zero intermediate frequency (ZIF) architecture for the wireless handset market.

The ZIF receiver, also known as a “homodyne” or “direct conversion” receiver, as depicted in Figure 3, has proven to be a good alternative to the previously described heterodyne receiver. In this architecture, the frequency of the local oscillator signal is equal to the carrier frequency. The fact that the wanted signal and the image signal are the same seriously relaxes the image rejection ratio requirements. The use of an off chip image reject filter is no longer required and hence the low noise amplifier (LNA) no longer needs to drive a 50-ohm load. The channel select filters of the heterodyne receiver are replaced by low-pass filters (LPFs) that can be implemented on chip. All these properties lead to an architecture with a reduced power consumption.

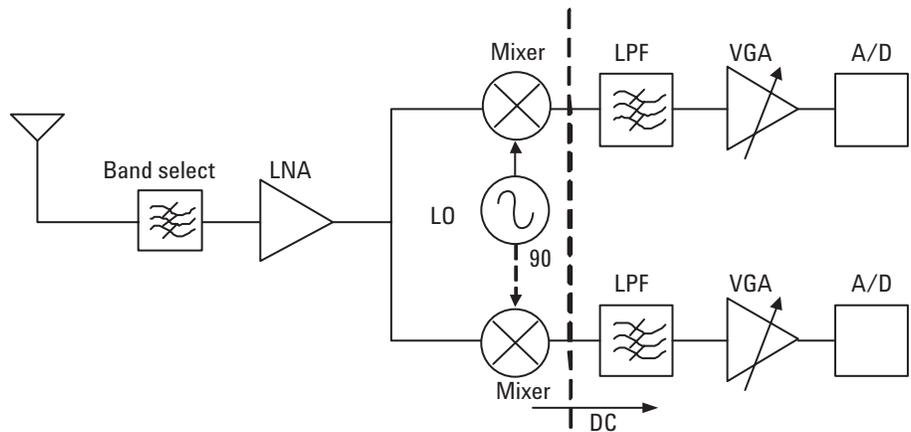


Figure 3. General diagram of the homodyne receiver

The ZIF architecture eliminates the need for IF components, including IF integrated circuits (ICs), IF surface acoustic wave (SAW) filters and IF voltage control oscillators (VCOs). The elimination of these parts reduces circuit board area and bill-of-materials costs, enabling more cost-effective multimode, multi-band handsets and other wireless devices.

Figure 4 shows a typical CDMA mobile station based on the Qualcomm 6000 series chipset, which implements the radioOne (ZIF) technology. For details, go to: http://www.cdmatech.com/solutions/pdf/msm6000_chipset.pdf.

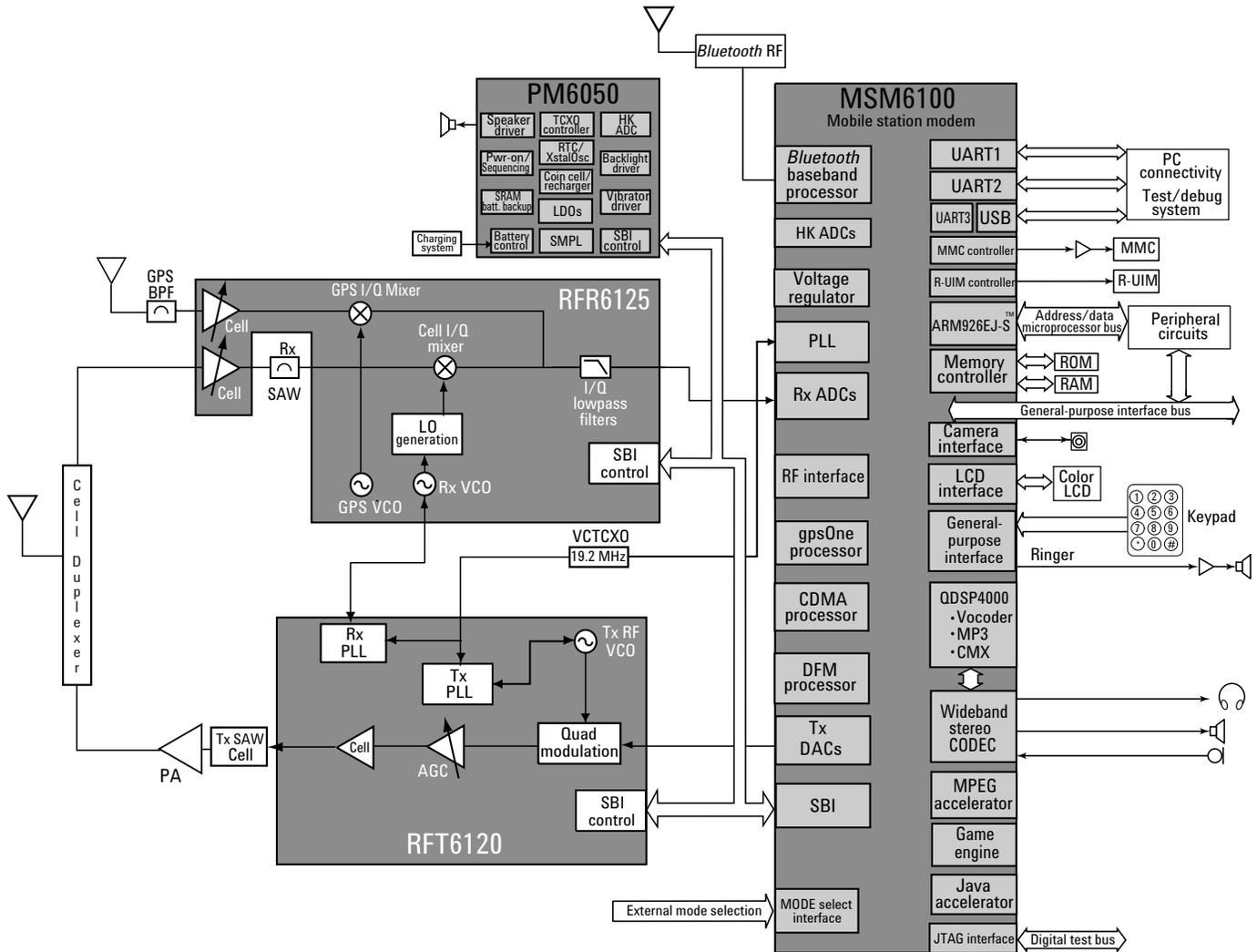


Figure 4. CDMA MS architecture with radioOne technology

- MSM6100: Mobile station modem
- RFR6125: RF-to-baseband receive processor
- RFT6120: Baseband-to-RF transmit processor

Effects of Second-Order Intermodulation in radioOne Architecture

The radioOne technology brings a lot of merits to the wireless handset market as mentioned in the previous section of this document, “*Latest CDMA Mobile Station Architecture with radioOne Technology.*” As a tradeoff, radioOne architecture (ZIF) does have peculiar issues.

There are many technical challenges with the ZIF architecture to include second-order inter-modulation (IM2). IM2, due to self-mixing in the down-conversion mixers, causes an unwanted signal to appear at the output of the mixer stage, corrupting the down converted signal as depicted in Figure 5.

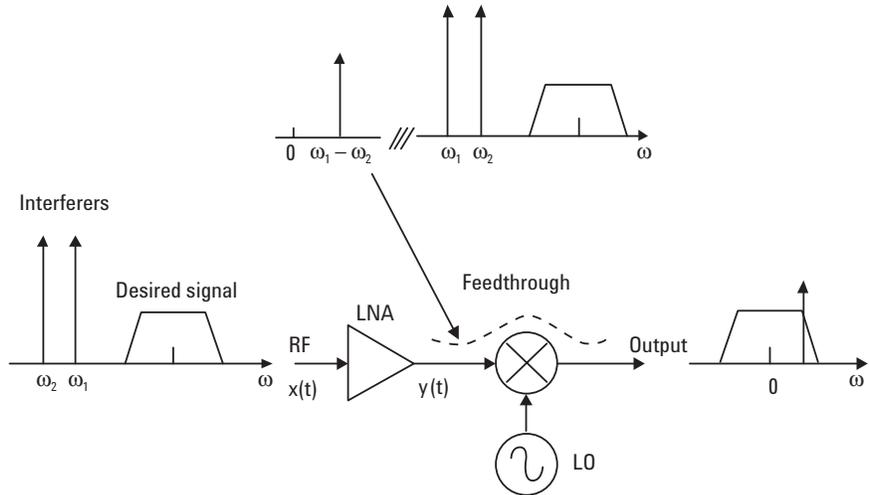


Figure 5. Second-order distortion on ZIF architecture

- Input signal is $x(t) = A_1 \cos \omega_1 t + A_2 \cos \omega_2 t$
- LNA output signal is $y(t) = \alpha_1 x(t) + \alpha_2 x(t)^2$
- $y(t)$ contains a term $\alpha_2 A_1 A_2 \cos(\omega_1 - \omega_2)t$, which is a low-frequency beat signal generated by two high-frequency interferers in the presence of IM2.
- Since the mixer includes feedthrough, the IM2 signal appears at the output with no frequency translation

To minimize the impact of second-order distortion on the radioOne architecture, an interference simulator is required to calibrate the mobile stations that use radioOne architecture.

Agilent Solution for radioOne Calibration

The Agilent 8960 test set provides two types of amplitude modulated signals, AM (fixed 56% amplitude modulation) or DSB-SC (dual side-band suppressed carrier). These signals are used for calibrating the IM2 of the mobile stations that use Qualcomm's radioOne chipset, without the need of an additional instrument.

Signal description

In CW operating mode, the test set operates like a signal generator. It can provide either an AM (fixed 56% amplitude modulation) or DSB-SC modulated signal, as depicted in Figure 6.

- The output power of the modulated signal (either AM or DSB-SC) is determined by the cell power setting. For details, see *“How to Configure the Test Set to Generate the Required Signal”* later in this document.
- The output frequency of the modulated signal is adjusted by changing the RF Gen Freq. For details, see *“How to Configure the Test Set to Generate the Required Signal”* later in this document.
 - With the AM signal selected, the RF Gen Freq setting represents the center frequency of the signal (f_c).
 - With the DSB-SC signal selected, the RF Gen Freq setting represents the frequency of the lower sideband signal (f_L). The upper sideband (f_H) is 20 kHz above the RF Gen Freq setting, that is $f_H = f_L + 20$ kHz.

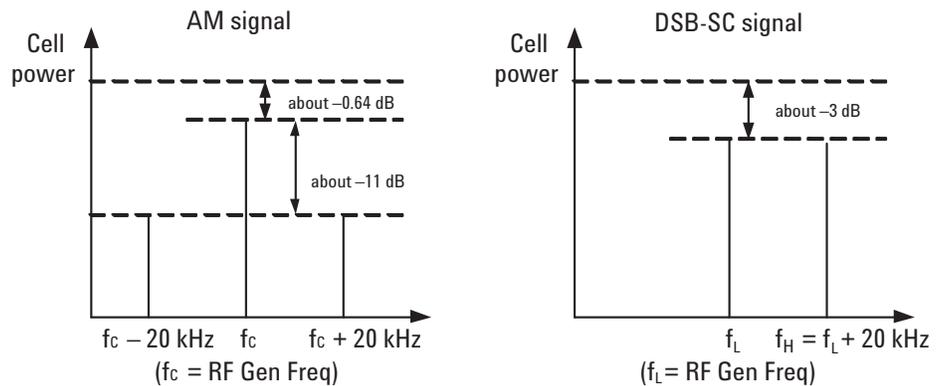


Figure 6. AM signal and DSB-SC signal in 8960 for radioOne calibration

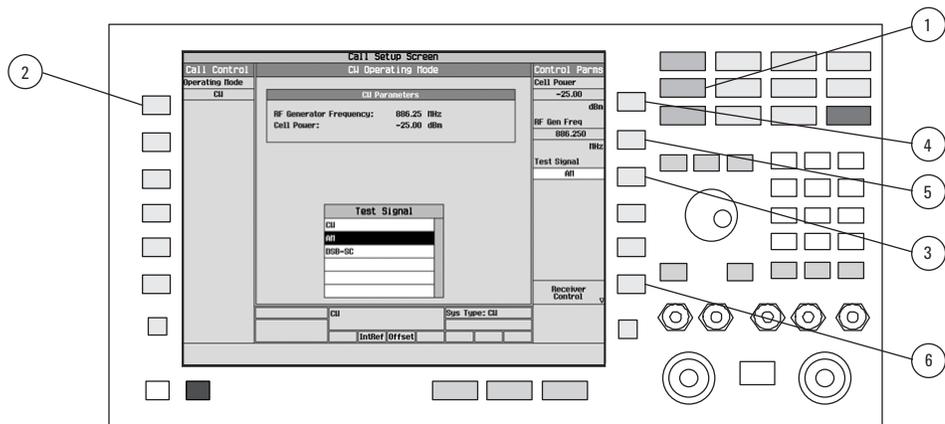
How to configure the test set to generate the required signals

Example 1: AM signal

For example, to make the IM2 calibration on the mobile stations that use Qualcomm's radioOne chipset, if you require an AM modulated carrier (see Figure 6) with the following characteristics at the input to the mobile station's antenna:

- The modulation tone is sinusoidal, the frequency is 20 kHz, and the AM modulation depth is 56%.
- The carrier signal's frequency (f_c) is offset from the Rx reference frequency by 5.0 MHz. For example, if the reference signal is at the frequency of 881.52 MHz (cellular band, channel 384), the carrier signal's frequency (f_c) should be 886.52 MHz.
- The signal strength is -25 dBm at the antenna's input.

Follow the procedures below to configure the test set in CW operating mode, select the AM signal for output, set the cell power to -25 dBm, and set the RF Gen Freq to the desired carrier signal's frequency (f_c) (for example, set to 886.52 MHz).



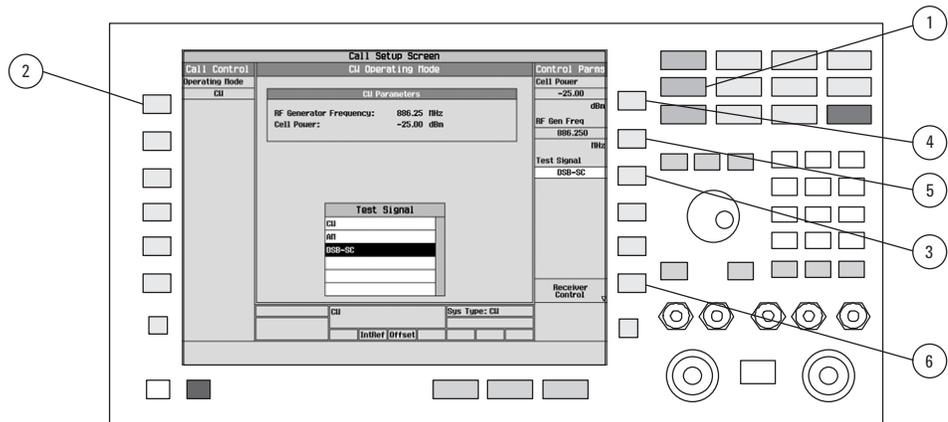
1. Press the **CALL SETUP** key.
2. Select **Operating Mode (F1)** and set the operating mode to **CW**.
3. Select **Test Signal (F9)**, then select **AM** from the menu and confirm the selection by selecting **Yes** in the dialog box.
Note: Changing the test signal requires several seconds to complete.
4. Select **Cell Power (F7)**, enter the desired value (for example, -25 dBm/1.23 MHz) by using the data entry keys and press the knob.
5. Select **RF Gen Freq (F8)**, enter the desired value (for example, 886.52 MHz) by using the data entry keys and press the knob.
6. (Optional) Select **Receiver Control (F12)** and manually set the test set's receiver control parameters (such as expected CW power, measurement receiver frequency, and reverse link receiver frequency) to the desired values.

Example 2: DSB-SC signal

For example, to make the IM2 calibration on the mobile stations that use Qualcomm's radioOne chipset, if you require a DSB-SC modulated signal (as shown in Figure 6) with the following characteristics at the input to the mobile station's antenna:

- The upper sideband (f_H) of the DSB-SC signal is offset from the lower sideband (f_L) by 20 kHz.
- The lower sideband (f_L) of the DSB-SC signal is offset from the receiver (Rx) reference frequency by 5.0 MHz. For example, if the reference signal is at the frequency of 881.52 MHz (cellular band, channel 384), the lower sideband (f_L) of the DSB-SC signal should be at the frequency of 886.52 MHz.
- The signal strength is -25 dBm at the antenna's input.

Follow the procedures below to configure the test set in continuous wave (CW) operating mode, select the DSB-SC signal for output, set the cell power to -25 dBm, and set the RF Gen Freq to the lower sideband frequency (f_L) of the desired DSB-SC signal (for example, set to 886.52 MHz).



1. Press the **CALL SETUP** key.
2. Select **Operating Mode (F1)** and set the operating mode to CW.
3. Select **Test Signal (F9)**, then select **DSB-SC** from the menu and confirm the selection by selecting **Yes** in the dialog box.
Note: Changing the test signal requires several seconds to complete.
4. Select **Cell Power (F7)**, enter the desired value (for example, -25 dBm/1.23 MHz) by using the data entry keys and press the knob.
5. Select **RF Gen Freq (F8)**, enter the desired value for the lower sideband of the DSB-SC signal (for example, 886.52 MHz) by using the data entry keys and press the knob.
6. (Optional) Select **Receiver Control (F12)** and manually set the test set's receiver control parameters (such as expected CW power, measurement receiver frequency, and reverse link receiver frequency) to the desired values.

Programming usage

Use the following commands to:

- Set the test set to CW operating mode:
CALL:OPERating:MODE CW
- Set the test set to output the AM test signal:
CALL:WAVEform:TYPE:CW AM
- Set the test set to output the DSB-SC test signal:
CALL:WAVEform:TYPE:CW DSB
- Set the cell power to -25 dBm:
CALL:POWer -25
- Set the RF generator frequency to 886.52 MHz:
CALL:RFGenerator:FREQuency 886.52 MHZ

Conclusion

The radioOne solution offers a revolutionary technology for the wireless handset market, which enables more cost-effective multimode, multi-band handsets and other wireless devices. Due to the impact of IM2 on ZIF architecture, the wireless devices using ZIF architecture must be calibrated to guarantee the receiver properly demodulates the desired CDMA signal. The Agilent 8960 test set provides the required signal sources, which has better phase noise characteristics and allows for the IM2 calibration without additional signal generator instruments.

Appendix: Related references

- *RF Microelectronics*; Behzad Razavi, Prentice Hall Communications Engineering and Emerging Technologies Series; 2 ISBN 0-13-887571-5.
- *Qualcomm radioOne information*:
<http://www.cdmatech.com/solutions/products/radioone.jsp>.
- *Agilent Technologies 8960 Series 10 Web page*:
<http://www.agilent.com/find/8960>.

Agilent Technologies' Test and Measurement Support, Services, and Assistance
Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Support is available for at least five years beyond the production life of the product. Two concepts underlie Agilent's overall support policy: "Our Promise" and "Your Advantage."

Our Promise

Our Promise means your Agilent test and measurement equipment will meet its advertised performance and functionality. When you are choosing new equipment, we will help you with product information, including realistic performance specifications and practical recommendations from experienced test engineers. When you use Agilent equipment, we can verify that it works properly, help with product operation, and provide basic measurement assistance for the use of specified capabilities, at no extra cost upon request. Many self-help tools are available.

Your Advantage

Your Advantage means that Agilent offers a wide range of additional expert test and measurement services, which you can purchase according to your unique technical and business needs. Solve problems efficiently and gain a competitive edge by contracting with us for calibration, extra-cost upgrades, out-of-warranty repairs, and onsite education and training, as well as design, system integration, project management, and other professional engineering services. Experienced Agilent engineers and technicians worldwide can help you maximize your productivity, optimize the return on investment of your Agilent instruments and systems, and obtain dependable measurement accuracy for the life of those products.



Agilent Email Updates

www.agilent.com/find/emailupdates

Get the latest information on the products and applications you select.

Agilent T&M Software and Connectivity

Agilent's Test and Measurement software and connectivity products, solutions and developer network allows you to take time out of connecting your instruments to your computer with tools based on PC standards, so you can focus on your tasks, not on your connections. Visit www.agilent.com/find/connectivity for more information.

By internet, phone, or fax, get assistance with all your test & measurement needs

Phone or Fax

United States:

(tel) 800 452 4844

Canada:

(tel) 877 894 4414

(fax) 905 282 6495

China:

(tel) 800 810 0189

(fax) 800 820 2816

Europe:

(tel) (31 20) 547 2323

(fax) (31 20) 547 2390

Japan:

(tel) (81) 426 56 7832

(fax) (81) 426 56 7840

Korea:

(tel) (82 2) 2004 5004

(fax) (82 2) 2004 5115

Latin America:

(tel) (305) 269 7500

(fax) (305) 269 7599

Taiwan:

(tel) 0800 047 866

(fax) 0800 286 331

Other Asia Pacific Countries:

(tel) (65) 6375 8100

(fax) (65) 6836 0252

Email: tm_asia@agilent.com

Online Assistance:

www.agilent.com/find/assist

Product specifications and descriptions in this document subject to change without notice.

radioOne is a trademark and Qualcomm is a registered trademark of Qualcomm, Inc.

Bluetooth™ is a trademark owned by Bluetooth SIG, Inc., U.S.A. and licensed to Agilent Technologies, Inc.

© Agilent Technologies, Inc. 2003
Printed in USA *October 7, 2003*
5988-9973EN



Agilent Technologies