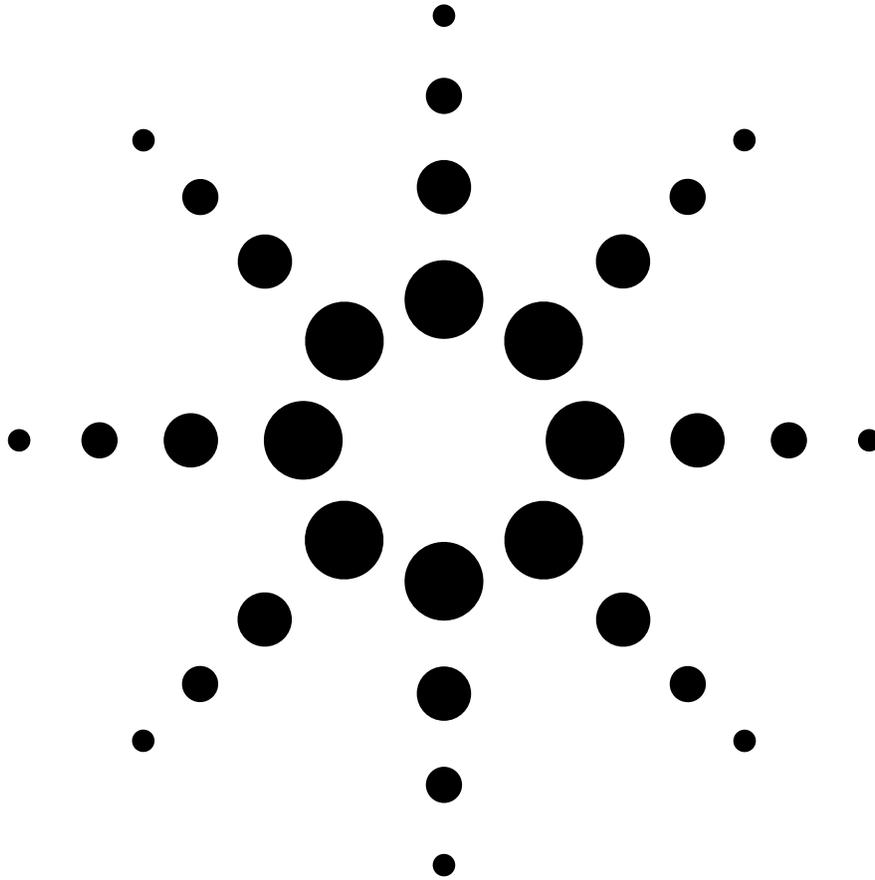


Agilent Technologies ESG Family/RF Signal Generators

Product Note



ESG Signal Generator/Option 201 Real-time IS-2000 Mobile Receiver Measurements



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Introduction

The recent 1999 CDMA Americas Congress marked the milestone of a decade of CDMA. Among the items highlighted were the exciting opportunities for CDMA in the new millennium. With the evolution toward 3G standards, CDMA is providing an even more exciting opportunity. CDMA leads the industry in providing the highest quality voice services and it is also leading the way in delivering wireless data services. Used by nearly 42 million worldwide, CDMA is the predominant global technology of choice for third generation (3G) services and devices.¹

Through its introduction of the ESG Option 201 real-time cdma2000² personality, Agilent Technologies is providing a significant advantage in signal generation for customers developing mobile receivers for the CDMA marketplace. The ESG Option 201 personality can be used to provide fully coded, multi-channel stimulus signals supporting both the IS-95 and IS-2000 (release 0) CDMA standards. These signals can be used to test receiver performance (frame error rates) and low-level protocol handling for CDMA products. Features include:

- a) Fully coded IS-95 signal package including pilot, sync, paging, and traffic channels.
- b) Fully coded IS-2000 signals including fundamental and supplemental channels at rates up to 307.2 kbps.
- c) Full control of the paging message stream (overhead and signaling messages).

This product note discusses features, setup, and applications for Agilent Technologies' ESG Option 201 Real-time cdma2000 personality. It is intended to provide R&D designers working on DSPs, ASICs, and other firmware components of IS-95 and IS-2000 mobile phones with techniques for testing and troubleshooting their receiver designs. The ESG Option 201 also provides designers with the ability to perform RF design characterization, and will provide manufacturing engineers with a suitable means of RF functional testing.

This product note assumes a working knowledge of CDMA and/or IS-2000. For supplemental information on CDMA and receiver measurements, please refer to the *Recommended Reading* section on page 25. Throughout the remainder of this document references are made to IS-2000; unless otherwise noted, the reader may assume that these references apply to IS-95 as well as IS-2000.

1. CDG (CDMA Development Group), www.cdg.org, *CDMA Moves Into The New Millennium; Leading Wireless Companies Highlight CDMA Milestones and Future at the CDMA Americas Congress*, San Francisco, CA, November 30, 1999.
2. cdma2000, also referred to as the IS-2000 standard, refers to the 3rd generation migration of cdmaOne, which incorporates backward compatibility with the IS-95 standard.

IS-2000 measurement background

Prior to the introduction of the ESG signal generator's Option 201 real-time cdma2000 personality, testing of IS-2000 mobile receivers was performed in a limited fashion using custom solutions or non real-time solutions such as arbitrary waveform generators.

Custom solutions had their downsides. They required significant time and effort to develop, they were typically complex and costly, and they provided only limited functionality and flexibility.

Arbitrary waveform generator solutions, such as the ESG Option 101 multi-carrier, multi-channel cdma2000 personality, have been used in the early stages of IS-2000 development to facilitate receiver design and test. Beyond the typical stimulus-response requirements of component test, arbitrary waveform generators also have the capability to simulate much of the coding required to verify receiver designs. Arbitrary waveform generators have been used to provide the first level of support in receiver test to ensure that receiver designs are demodulating and despreading properly.

The Option 201 real-time cdma2000 personality goes beyond these solutions by offering a second level of support to receiver design and verification. The added benefits of fully coded channels with complete long coding, the ability to utilize user-defined data, and the ability to make real time changes provide additional capabilities to accelerate the design process.

ESG Option 201 Real-time cdma2000 personality

The ESG's Option 201 personality provides a complete solution for testing of IS-2000 mobile receiver designs. This section provides an overview of the Option 201 real-time IS-2000 system. It also describes the Option 201 features.

Overview

The ESG with the Option 201 personality simulates a basestation transmitter to create a forward spread rate 1 (SR1) link for an IS-2000 mobile. The flexibility inherent in the ESG signal generator allows flexible channel configurations with individually adjustable power levels, customized user data, and customizable data rates. Radio configurations 1-5 (RC1-RC5) are supported. An IS-2000 RC4 forward traffic link, as supported by the personality, is shown below in Figure 1. Long and short coding, cyclic redundancy checks, convolutional encoding or turbo-coding, interleaving, power control, and complex scrambling are all supported. Paging, Sync, and Pilot channels are similarly supported.

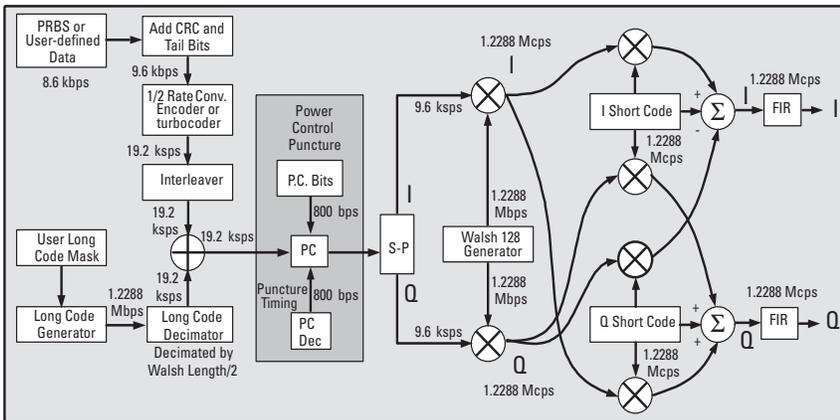


Figure 1. Forward coding path for an IS-2000 SR1 RC4 traffic channel

Because IS-2000 provides backward compatibility with IS-95 in RC1 and RC2 configurations, the Option 201 personality also supports the IS-95 standard.

The menu structure of Option 201 shown in Figure 2 illustrates the flexibility and features of the system. The BTS Setup menu, shown in the bottom of the display, allows configuration of parameters common to all channels, while the Link Control softkey provides a separate configuration menu for individual channels.

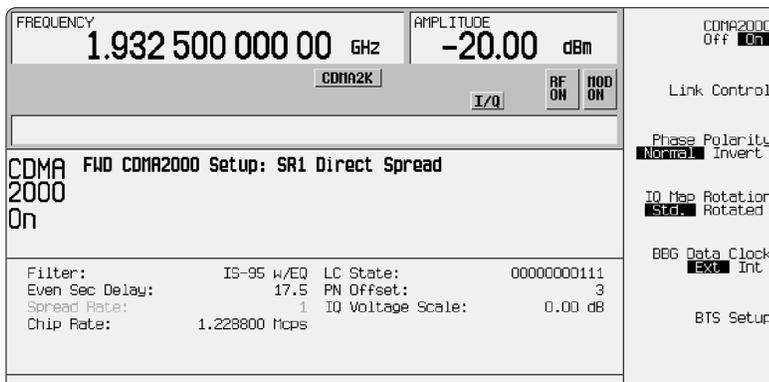


Figure 2. Screen printout of CDMA2000 menu

Key Features

Key features of the Option 201 personality are highlighted in Table 1 below. The 1-BOX column refers to the IS-95 solution that utilizes one ESG signal generator. The 2-BOX column refers to the IS-2000 solution that utilizes two ESG signal generators; this allows more complex signal structures as described in section in the two-box setup. Table 1 summarizes some differences between the one-box and two-box setups.

Table 1. Summary of key features

Description	1-BOX	2-BOX
• Fully coded IS-95 signal package including pilot, sync, paging, and traffic channels	●	●
• Fully coded IS-2000 signals including fundamental and supplemental channels at rates up to 307.2 kbps		●
• Full control of the paging message stream (overhead and signaling messages)	●	●
• Supports both convolutional and turbo coding	● 1	●
• User data insertion via user files or external data	●	●
• Variable chip rates, 50 Hz to 1.3 MHz	●	●
• Fully configurable sync channel base station parameters	●	●
• Pilot, Sync, Paging, and RC1-RC2 Fundamental (or OCNS) channels	●	●
• RC1-RC5 Fundamental and RC3-RC5 Supplemental channels	● 2	●

1. IS-95 modes do not support turbo coding.

2. One ESG can generate a group of channels including Pilot, Sync, Paging, and RC1-RC2 Fundamental or a group of channels including RC1-RC5 Fundamental and RC3-RC5 Supplemental channels. A single ESG cannot generate both groups of channels simultaneously.

ESG Option 201 IS-2000 Real-time receiver test setup

The Option 201 personality provides significant flexibility in its configuration. It may be configured as a one-box IS-95 setup or as a two-box IS-2000 setup. Since Option 201 is a real-time solution, it requires the Option UN8 Real-time I/Q Baseband Generator for its operation.¹ Below are descriptions of a one-box setup and a two-box setup with configuration examples.²

One-box setup

The one-box setup provides four IS-95 channels with real-time signal generation capability. This setup may be used to test IS-95 receiver designs. Figure 3 below provides the hardware configuration for the one-box setup. Using an ESG signal generator with options UN8 and 201, configure the hardware as shown in Figure 3. The one-box setup utilizes internal I/Q triggering. EVENT 1 provides an even second clock with a delay, which may be adjusted to align the frame timing with the RF output. *(Note: The delayed even second output provides a pulse every two seconds and is used for synchronizing test equipment.)* The 10 MHz Out is used as a frequency reference for additional test equipment, if needed.

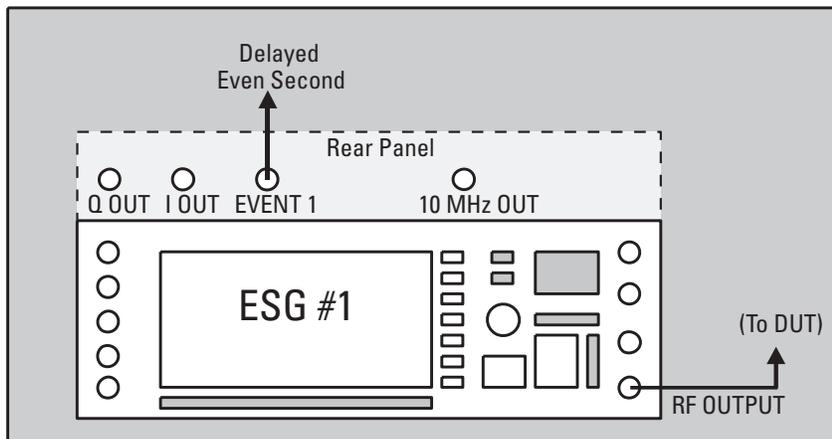


Figure 3. One-box configuration for mobile receiver test

1. Option UN8, revision C or higher is required. Firmware revision B.03.40 or higher is also required.
2. The configuration examples described in this document assume a factory preset condition in the ESG.

After configuring the hardware, follow the steps in Table 2 below to configure the instrument appropriately. In this example, Pilot, Sync, Traffic, and Paging channels are defined. For IS-95, the traffic channel may be defined as RC1 or RC2. This example is intended to illustrate a basic set-up from which the user can customize the instrument to meet his needs. Values in brackets [] are for example purposes only and the actual value should be determined by the user. Hard key selections are indicated by **bold** text.

Table 2. ESG instrument configuration for one-box setup

Parameter	Setting	Notes
Frequency	[900 MHz]	<i>Set to the appropriate center frequency of the carrier</i>
Amplitude	[-40 dBm]	<i>Set to the appropriate amplitude desired</i>
RF On/Off	On	
Mode / (Real-time I/Q BaseBand)		
CDMA		
Phase Polarity	Normal	
IQ Map Rotation	Std.	
BBG Data Clock	Int	
BTS Setup		<i>Use the arrows to navigate to adjust the BTS (Basestation Transceiver Station) Setup parameters.</i>
Filter	IS95 w/ EQ	<i>Set Filter to IS95 w/ EQ for either IS-95 or IS-2000</i>
Even Second Delay	17.5	<i>Set delay to 17.5 chips to align RF with the trigger.</i>
LC State	[0000000000]	<i>The LC (long code) State may be set to 0000000000 for no long code or to 0000000001 or another value to seed the long code.</i>
PN Offset	[0]	
IQ Voltage Scale	0.00 dB	
Return		<i>IQ Voltage Scale is set to zero for the one-box setup.</i>
Link Control		<i>From the Link Control menu, setup the channels as follows. Refer to Figure 4.</i>
Channel 1 (F-PICH) Setup:		<i>F-PICH (Forward Pilot Channel)</i>
Channel Number	1	
Channel State	On	
Channel Setup		<i>Use the arrows to navigate to adjust the Channel Setup parameters. Walsh Code for Pilot Channel is fixed at 0.</i>
Power	[-7.00 dB]	
Return		
Channel 2 (F-SYNCH) Setup:		<i>F-SYNCH (Forward Sync Channel)</i>
Channel Number	2	
Channel State	On	
Channel Setup		
Power	[-13.00 dB]	
Walsh Code	32	<i>The Sync channel uses Walsh code 32.</i>
Return		
Channel 3 (F-FCH) Setup:		<i>F-FCH (Forward Fundamental Traffic Channel)</i>
Channel Number	3	
Channel State	On	
Channel Setup		
Power	[-10.00 dB]	
Walsh Code	[8]	<i>Walsh code range for RC1 Fundamental is 0 – 63.</i>
Radio Config	[1]	
Return		
Channel 4 (F-PCH) Setup:		<i>F-PCH (Forward Paging Channel)</i>
Channel Number	4	
Channel State	On	
Channel Setup		
Power	[-10.00 dB]	
Walsh Code	[1]	<i>The initial paging channel is set to Walsh code 1.</i>
Return		
Channel Power Scaling:		<i>This step scales the power levels of the active channel so that they display the correct power levels being transmitted. The ratios are kept the same. If your total power is equal to 0.00 dB, then this step may be skipped. This feature is only used for the one-box solution.</i>
Channel Setup		
Adjust Code-Domain		
Power	Scale to 0 dB	
Return		
Return		
CDMA2000	On	<i>For the one-box setup, the I/Q is set to internal.</i>
I/Q	On	
I/Q Source	Int I/Q	

Figure 4 shows the Link Control menu on the ESG. This menu is used for channel configuration. Notice the effect of the channel power scaling on the individual channel power levels when scaled to 0 dB.

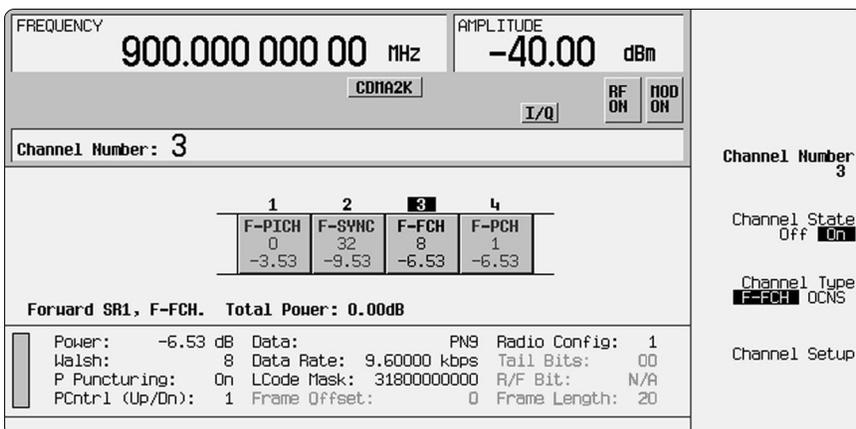


Figure 4. ESG Display for CDMA link control

After completing the instrument configuration, connect the RF Output of the ESG to a signal analyzer to view the signal, or to a CDMA mobile phone to establish communication. If connecting to a CDMA mobile phone, protocol must be established for call setup or the phone must be placed in test mode since the ESG does not support bi-directional protocol handling. Placing the mobile phone in test mode allows it to process messages without full handshaking.

A vector signal analyzer display of the one-box example is shown in Figure 5. This display illustrates that the code domain power levels shown on the ESG after power scaling match those shown on the vector signal analyzer.

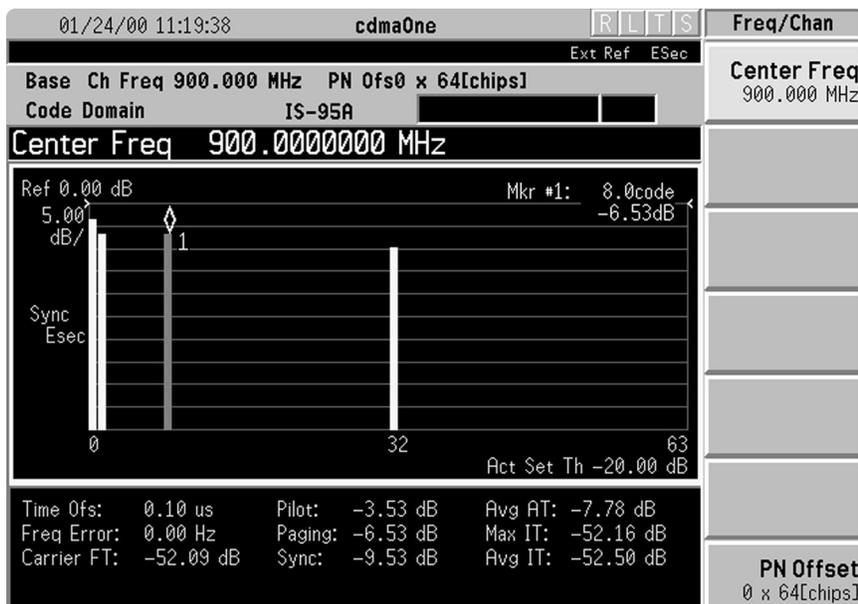


Figure 5. Agilent Technologies E4406A vector signal analyzer display of 4 code-domain channels from one-box example [Center Frequency = 900 MHz, Mode = cdmaOne, Measure = Code Domain, Avg Frames = Off, PN Offset = 0 x 64, Sync Type = Even Sec (Rear Trig In), Freq Ref = Ext]

Two-box setup

A two-box ESG Option 201 configuration is for situations where more real-time CDMA channels, power levels, or higher radio configurations are required than are available from a single ESG. In addition to the Pilot, Sync, Paging, and RC1 or RC2 traffic channel, a two-box setup provides two RC3, RC4 or RC5 traffic channels. The RC3, RC4 and RC5 traffic channels allow testing of IS-2000 receiver designs. *Note: The ESG Option 201 also supports the capability for a third RC3, RC4, or RC5 traffic channel with some limitations. If a third IS-2000 traffic channel is assigned, some I/Q distortion may be present.*

Figure 6 shows the basic architecture of the two-box solution. In this solution, each baseband generator has the capability to provide up to four IS-95 channels or up to three IS-2000 channels (refer to the note above regarding three IS-2000 channels). The I and Q outputs of the two baseband generators are summed together and fed into ESG #1 where amplitude and frequency control takes place. The RF output is provided by ESG #1. The RF output of ESG #2 is used solely to create the chip clock, which drives the baseband generators. Alternatively, an external function generator may be used to provide the chip clock.

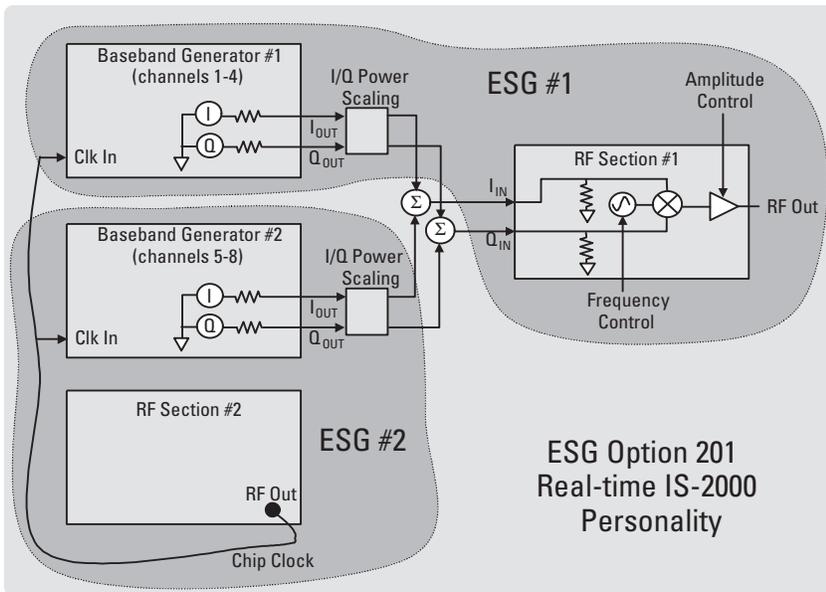
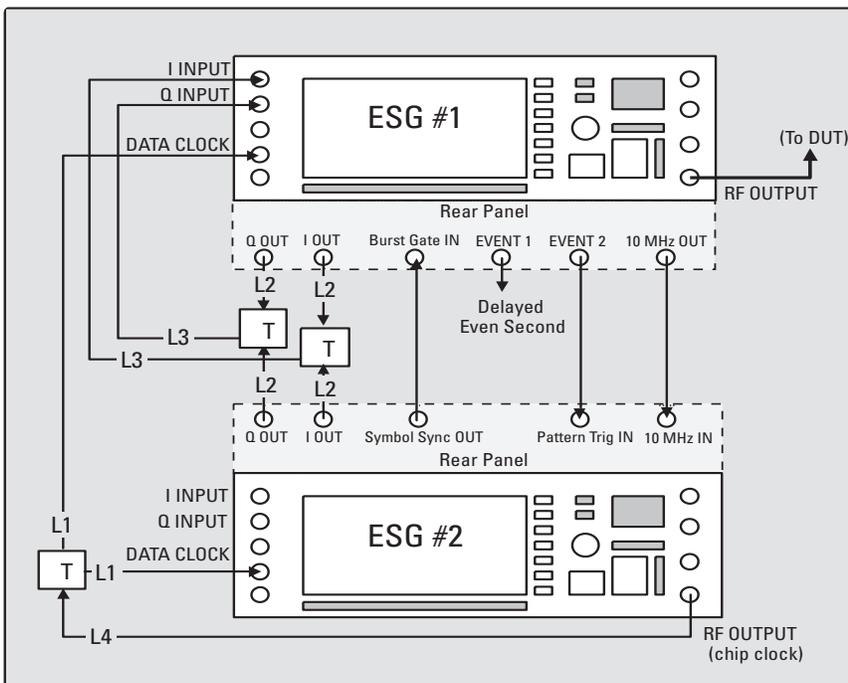


Figure 6. ESG Option 201 two-box architecture

The physical hardware configuration for the two-box setup is shown in Figure 7. Two ESG signal generators, each with options UN8 and 201, are required. ESG #1 is used to generate the Pilot, Sync, OCNS, and Paging channels. ESG #2 provides the Traffic channels and the 1.2288 MHz chip clock that drives the data clock for both ESGs with matched delays; the Data Clock input clips the RF to TTL levels (refer to the note regarding cable lengths in Figure 7.)

The I and Q outputs for the channel data are summed together with T-connectors; splitters/combiners are not required since mismatch is not significant. Each ESG's I/Q power levels are independent of each other; refer to the section titled Power Mapping Procedure for more information on this.

System synchronization between ESG #1 and ESG #2 uses two external connections. In the first connection, EVENT 2 of ESG #1 provides a system reset to the ESG #2 PATTERN TRIG IN. Any change in the state of ESG #1 requiring a reset of long code and channel frame timing will generate a system reset and re-sync both ESG's. For the second connection, the even second output from ESG #2's SYMBOL SYNC OUT is connected to ESG #1's BURST GATE IN. If ESG #1 detects a misalignment of the even second output from ESG #2 with its internal even second clock, then a system sync output will be generated by ESG #1 to re-synchronize both ESGs. Additionally, as with the one-box setup, EVENT 1 provides a variable Delayed Even Second clock for synchronizing other equipment.



Note: Matched short cable lengths (i.e. L1 = L1; L2 = L2; L3 = L3) are important to reduce phase difference. L4 should also be kept very short.

Figure 7. Two-box configuration for mobile receiver test

Similar to the example for the one-box setup, on page 12, an example is provided for a two-box setup. This example provides a Pilot, Synch, OCNS, and Paging channel, as well as a Fundamental RC4 traffic channel, and a Supplemental RC4 traffic channel.

After configuring the hardware appropriately for the two-box setup, follow the steps in Table 3 and Table 4 below to configure the instruments. Table 3 is for the configuration of ESG #1 and Table 4 is for the configuration of ESG #2. Values in brackets [] are for example purposes only and the actual value should be determined by the user. Hard key selections are indicated by **Bold** text. Note: The LC (Long Code) State and the PN Offset of both ESGs must match.

Table 3. ESG #1 instrument configuration for two-box setup

Parameter	Setting	Notes
Frequency	[900 MHz]	Set to the appropriate center frequency of the carrier.
Amplitude	[-40 dBm]	Set to the appropriate amplitude desired.
Ampl		
ALC	On	ALC is the Amplitude Level Control.
RF On/Off	On	
Mode / (Real-time I/Q BaseBand)		
CDMA		
Phase Polarity	Normal	
IQ Map Rotation	Std.	
BBG Data Clock	Ext	Ensure that the BBG Data Clock is set to Ext.
BTS Setup		Use the arrows to navigate to adjust the BTS (Basestation Transceiver Station) Setup parameters.
Filter	IS95 w/ EQ	Set Filter to IS95 w/ EQ for either IS-95 or IS-2000
Even Sec Delay	17.5	Set delay to 17.5 chips to align RF with trigger.
LC State	[00000000001]	The LC (long code) State may be set to 00000000000 for no long code or to 00000000001 or another value to seed the long code.
PN Offset	[0]	
Return		
Link Control		From the Link Control menu, setup the channels as follows. Refer to Figure 4.
Channel 1 (F-PICH) Setup:		F-PICH (Forward Pilot Channel)
Channel Number	1	
Channel State	On	
Channel Setup		Use the arrows to navigate to adjust the Channel Setup parameters. Walsh Code for Pilot Channel is fixed at 0.
Power	[-7.00 dB]	
Return		
Channel 2 (F-SYNCH) Setup:		F-SYNCH (Forward Sync Channel)
Channel Number	2	
Channel State	On	
Channel Setup		
Power	[-13.00 dB]	
Walsh Code	32	Walsh code range for Sync is 0 – 63; typically 32.
Return		
Channel 3 (OCNS) Setup:		OCNS (Orthogonal Channel Noise Simulator)
Channel Number	3	
Channel Type	OCNS	OCNS is optional and can be used to generate orthogonal noise into the system. It may be used as fill-in power so that the total relative power equals 0 dB.
Channel State	On	
Channel Setup		
Power	[-3.46 dB]	
Walsh Code	[57]	Refer to the Power Mapping Procedure for details on setting this parameter.
Return		
Channel 4 (F-PCH) Setup:		F-PCH (Forward Paging Channel)
Channel Number	4	
Channel State	On	
Channel Setup		
Power	[-10.00 dB]	
Walsh Code	[1]	Select a Walsh Code between 1-7 for Paging.
Return		
CDMA2000	On	
I/Q	On	For the two-box setup, the External I/Q input is used.
I/Q Source	Ext I/Q	
Utility		Note: If the Signal Polarity Setup menu is not available, this step can be skipped.
Instrument Adjustments		
Signal Polarity Setup		
Data Clock Polarity	Pos	Confirm that the Clock Polarity is set to Positive.

Table 4. ESG #2 instrument configuration for two-box setup

Parameter	Setting	Notes
Frequency	1.2288 MHz	Set the frequency to 1.2288 MHz for the Chip Clock. The amplitude is set to maximum and the Amplitude Level Control is turned off in order to provide near TTL voltages to drive the Data Clock.
Amplitude	20 dBm	
Ampl		
ALC	Off	
Mod On/Off	Off	
RF On/Off	On	
Mode / (Real-time I/Q BaseBand)		The I/Q phase polarity is reversed because the RF is below 250 MHz, the harmonic mixing transition point. The internal I/Q path has an automatic phase inversion, but the external I/Q path must be set manually. Ensure that the BBG Data Clock is set to Ext.
CDMA		
Phase Polarity	Invert	
IQ Map Rotation	Std.	
BBG Data Clock	Ext	
BTS Setup		Use the arrows to navigate to adjust the BTS (Basestation Transceiver Station) Setup parameters. Set Filter to IS95 w/ EQ for either IS-95 or IS-2000 Set delay to 17.5 chips to align RF with the trigger. The LC (long code) State may be set to 0000000000 for no long code or to 0000000001 or another value to seed the long code.
Filter	IS95 w/ EQ	
Even Second Delay	17.5	
LC State	[0000000001]	
PN Offset	[0]	
Return		
Link Control		From the Link Control menu, set up the channels as follows. Refer to Figure 4.
Channel 1 (F-PICH) Setup:		F-PICH (Forward Pilot Channel)
Channel Number	1	
Channel State	Off	
Channel 2 (F-SCH #2) Setup:		Second F-SCH (Forward Supplemental Channel)
Channel Number	2	
Channel Type	F-SCH	
Channel State	Of	
Channel 3 (F-FCH) Setup:		F-FCH (Forward Fundamental Traffic Channel)
Channel Number	3	
Channel State	On	
Channel Setup		
Power	[-10.00 dB]	
Walsh Code	[10]	Manually check to make sure the Walsh Code doesn't conflict with the Walsh Codes on ESG #1.
Radio Config	[4]	
Return		
Channel 4 (F-SCH #1) Setup:		First F-SCH (Forward Supplemental Channel) Note: Channel 2 may alternatively be configured as a supplemental channel.
Channel Number	4	
Channel Type	F-SCH	
Channel State	On	
Channel Setup		
Power	[-10.00 dB]	
Walsh Code	[4]	The Supplemental's Walsh code range varies based upon the RC and data rate. Manually check to make sure the Walsh Code doesn't conflict with the Walsh Codes on ESG #1.
Radio Config	[4]	
Data Rate	[153.600 kbps]	
Return		
Return		
CDMA2000	On	
Utility		Note: If the Signal Polarity Setup menu is not available, this step can be skipped. Confirm that the Clock Polarity is set to Positive.
Instrument Adjustments		
Signal Polarity Setup		
Data Clock Polarity	Pos	

Once the instruments have been properly configured, power mapping must be performed to align the power levels of the channels between the two ESGs appropriately. This is required since the two ESGs are not aware of each other's power level. To perform power mapping, refer to the end of this section.

Connect the RF OUTPUT of ESG #1 to a signal analyzer to view the signal, or to a CDMA mobile phone to establish communication. If connecting to a CDMA mobile phone, protocol must be established for call setup or the phone must be placed in test mode to allow it to process messages without full handshaking.

Figure 8 shows the vector signal analyzer display of the two-box example defined in Table 3 and Table 4 with the expected code channels as follows:

Channel	RC	Data Rate	Walsh Set	Walsh Code
Pilot	-	-	-	0
Sync	-	-	-	32
Paging	-	-	-	1
OCNS	-	-	-	57
Fundamental	RC4	9.6 kbps	128-bit	10
Supplemental	RC4	153.6 kbps	4-bit	4

Note that the code domain power levels shown on the ESG after power mapping match those shown on the signal analyzer.

Note that the high data rate supplemental traffic channel at Walsh code 4 occupies additional code space.

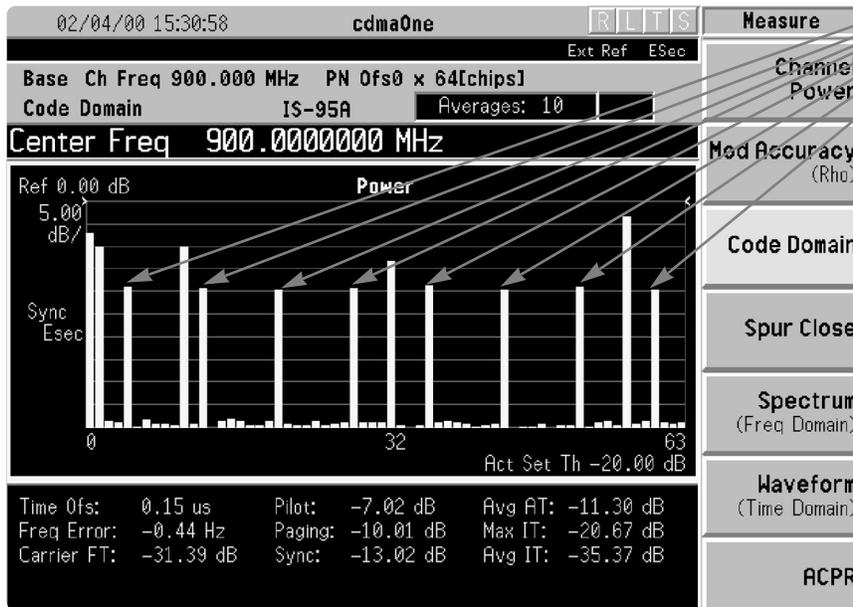


Figure 8. Agilent Technologies E4406A vector signal analyzer display of code-domain channels from two-box example [Center Frequency = 900 MHz, Mode = cdmaOne, Measure = Code Domain, Avg Frames = 10, PN Offset = 0 x 64, Sync Type = Even Sec (Rear Trig In), Freq Ref = Ext]

It is possible to generate a third RC3, RC4 or RC5 traffic channel from ESG #2. In the Link Control menu, channel 2 may be toggled to F-SCH for a second supplemental traffic channel. If three RC3, RC4 or RC5 traffic channels are selected, a "Code Power Err" message will appear with a value of error listed. This means that some of the symbols will have an error associated with them and the code domain will exhibit some artifacts. This is a result of system limitations. For situations where the user is not concerned about power deviation this may be acceptable and will allow an additional channel to be configured. I/Q map rotation provides another alternative (see inset).

Power mapping procedure

The power mapping procedure defines the process for mapping or aligning the channel powers between the two instruments. This procedure must be followed for the two-box configuration each time the power level settings are modified. The I/Q Voltage Scale adjusts the power ratio between the two ESGs. The channel power scaling, or the use of the OCNS channel, adjusts the individual channel power levels to match their true values.¹

To determine the appropriate power mapping levels, calculations may be performed manually as defined in the ESG Option 201 User's Guide, or they may be determined with the Excel® spreadsheet which is included with the ESG Family Signal Generators Option 201 Real-time cdma2000 Personality User's and Programming Guide. The spreadsheet is also available on the ESG website at <http://www.agilent.com/find/powermap>. The Excel spreadsheet method is preferable due to ease of use. The inputs to the spreadsheet are the desired levels for each of the code channels. The outputs from the spreadsheet are the settings for I/Q Voltage Scale and also the updated settings for the channel power levels or the OCNS, if used.

I/Q Map Rotation

The ESG also allows a 45° rotation of the I/Q map to alleviate the "Code Power Err" problem. Rotating the I/Q map on both boxes changes the I/Q map so three RC3, RC4 or RC5 traffic channels may be supported on the second box; but then only two channels may be supported on the first ESG without creating power deviations. As an example, an F-PICH and an F-SYNCH channel could be configured on ESG #1 and an F-FCH and two F-SCH channels could be configured on ESG #2.

1. The total power in the channels should equal 0 dB or 100%. This may be accomplished by adjusting the levels of each active channel to equal 0 dB or by adding an OCNS channel to make up for the short-fall to achieve 0 dB.

Table 5 shows a sample of the Excel spreadsheet used for power mapping. This example uses OCNS.

Table 5. Agilent ESG Option 201 power scaling worksheet, V2.11

		Enter desired powers in this column and into the ESG (Blank for Off)	Enter these calculated results into the ESG				
	Channel #	Powers (dB)	IQ Voltage Scale (dB)	Percentage Power in Column C	Voltage (V)	Total Voltage per box	Percent IQ Voltage per box (dB)
Box #1	Pilot	-7.00	0.00	0.199526	0.446684	1.657868	-1.40
	2	-13.00		0.050119	0.223872		
	3			0.000000	0.000000		
	4	-10.00		0.100000	0.316228		
OCNS Power is calculated automatically so that total power is 0 dB.	OCNS	-3.46		0.450355	0.671085		
Box #2	1		-4.19	0.000000	0.000000	0.632456	-5.59
	2			0.000000	0.000000		
	3	-10.00		0.100000	0.316228		
	4	-10.00		0.100000	0.316228		
OCNS Power is calculated automatically so that total power is 0 dB.	OCNS			0.000000	0.000000		
OCNS in Box #	1						
Total Power (dB)	0.00						
Total Voltage	2.290324						

Power Mapping requires the user to edit the OCNS or channel power levels in the instruments and to modify the I/Q Voltage Scale setting. Table 6 shows an example Power Mapping illustration that matches the data in Table 5 for both ESGs.

Table 6. Power mapping instrument configuration for ESG #1 and ESG #2

Parameter	Setting for ESG #1	Setting for ESG #2
Mode / (Real-time I/Q BaseBand) CDMA		
BTS Setup I/Q Voltage Scale Return	[0.00 dB]	[-4.19 dB]
Link Control Channel Number	1	1
Channel Setup Power	[-7.00 dB]	[not applicable]
Channel Number	2	2
Channel Setup Power	[-13.00 dB]	[not applicable]
Channel Number	3	3
Channel Setup Power	[-3.46 dB]	[-10.00 dB]
Channel Number	4	4
Channel Setup Power	[-10.00 dB]	[-10.00 dB]

Real-time IS-2000 measurements

This section provides an overview of various IS-95 and IS-2000 forward link (e.g. mobile receiver) measurements which may be performed with the ESG's Real-time Receiver Test personality.

Measurement overview

The ESG Option 201 Real-time cdma2000 personality provides the capability of performing numerous measurements on a mobile receiver including RF performance and protocol-handling capability. This section describes some of these tests. The section on Frame Error Rate Measurements provides a list of standard RF receiver measurements that are typically performed on CDMA systems. The section titled Functional Testing of Algorithm Decoding provides examples of protocol testing which may be performed.

Frame Error Rate (FER), Block Error Rate (BLER), and Bit Error Rate (BER) Parametric Measurements

Frame error rate and block error rate measurements characterize the performance of the RF receiver under various interference conditions to ensure adequate operation in real-life environments. FER provides a ratio of the number of frames received with CRC errors to those without errors. Various FER tests are specified for IS-95 and IS-2000 RF testing including the following:

- Sensitivity and dynamic range
- Adjacent channel interference
- Fading and multi-path distortions
- Single tone desensitization
- Intermodulation spurious response attenuation

Similarly, BLER tests utilize the phone or external test equipment to maintain an account of erased blocks. FER and BLER tests are widely used and are beneficial in design characterization, verification, and RF functional testing in manufacturing.

Additionally, bit error rate measurements may be used for design characterization and provide additional bit error information.

FER measurement setup

The measurement setup is relatively consistent for the various FER and BER measurements. A generic measurement setup is shown below in Figure 9. Supplementary equipment will vary between the various tests and may include one or more interference sources and/or fading equipment. Note that the computer control system may also be used to control the ESG signal generators for automated channel setup and instrument configuration.

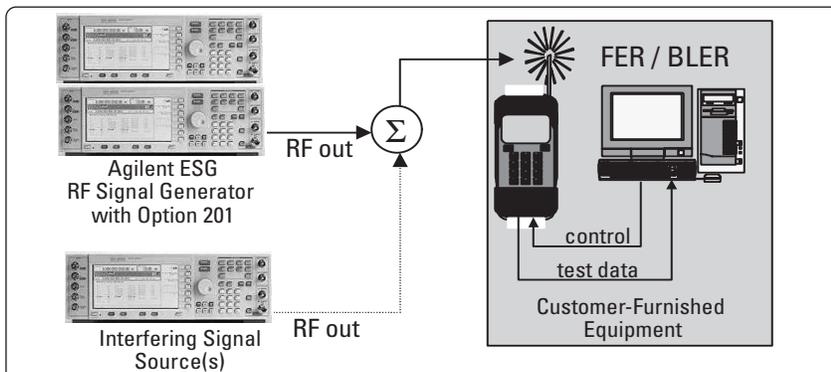


Figure 9. FER / BLER measurement setup

After setting up the equipment, the ESG Option 201 system is configured as discussed earlier in section 3 of this document. At this point, a signal will be present at the ESG's RF output. The signal generated by the ESG will appear to the mobile phone as a basestation signal. It is the phone's duty, at this point, to synchronize to the signal and read the overhead channels. The synchronization process consists of the following steps:

- 1) Mobile receiver acquires the ESG Pilot
- 2) Mobile receiver acquires and decodes the Sync channel
- 3) Mobile receiver acquires and monitors the Paging channel

After synchronization has been completed, the phone is placed in test mode and test mode commands are issued by the user. The mobile receiver is instructed, via test mode, to listen for a specific RC traffic channel on a specific Walsh code (e.g. RC2, F-FCH, Walsh code 47). The mobile set then begins decoding the specified traffic channel and is requested, once again via test mode, to report the number of frames in error.

Once this general measurement procedure has been established, the various FER tests may be performed.

Sensitivity and dynamic range

The sensitivity measurement provides the minimum power level at the receiver that results in a FER, which does not exceed a specified value.

For example, the test would determine the power level required to achieve less than 0.5% FER. Sensitivity helps characterize a receiver's ability to demodulate a low-level signal. Sensitivity is a key measure of merit in receiver design because a receiver that has higher sensitivity will receive signals more accurately and require less power from the basestation.

Similarly, the receiver's dynamic range is the input power range over which the FER does not exceed a specific value.

Adjacent channel interference

The adjacent channel interference FER test is a variation on sensitivity in which the sensitivity of the receiver is measured in the presence of an adjacent channel signal.

Fading and multi-path distortions

In this test, fading and multi-path distortions are applied to the signal source and the sensitivity of the receiver is measured under varying distortion conditions. A channel simulator is used to induce the fading and multi-path distortions. This test is very critical for receiver design since fading and multi-path are major obstacles which real-life receivers must overcome.

Single tone desensitization

This test measures the ability of the receiver to receive a signal in the presence of a single tone at a given frequency offset away from its center frequency. FER provides the measure of merit.

This test is important because it determines the receiver's ability to resolve its signal in the presence of an interfering tone.

Test Mode

In order to perform the tests defined herein, the mobile device is required to have a test mode which will allow it to deviate from the normal handshaking requirements and go into a manual control mode. The mobile device can then be controlled by a computer.

Intermodulation spurious response attenuation

This test measures the ability of the receiver to receive a signal in the presence of two interfering CW tones, which produce intermodulation products in the band of the desired CDMA signal. FER provides the measure of merit.

This test is important because intermodulation signals are common in CDMA systems and this test measures the receiver's tolerance to this interference.

Bit Error Rate (BER) tests

Optionally, bit error rate testing may also be performed provided that the phone can provide layer 1 baseband decoding. This is illustrated in Figure 10. In this method, the ESG provides either a known data pattern or pseudo-random data (PN9 or PN15) which the BER tester can recognize. The phone decodes the data and provides the de-framed PN9 or PN15 data via a test connector, which is fed back to the ESG for BER measurements.

The ESG must be equipped with the option UN7, Internal Bit Error Rate Analyzer.

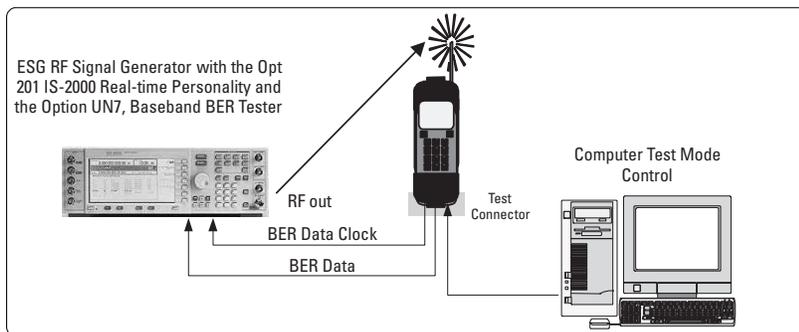


Figure 10. BER measurement setup

Functional testing of algorithm decoding

Various functionality tests may be performed to verify the operation of the mobile receiver and its supporting firmware. These tests include, but are not limited to, the following:

- Unidirectional messaging and protocol development
- Unidirectional paging channel protocol development
- Flexible diagnostic tests for firmware
- Functional tests on single and multiple channels
- Response to power control data

Test setup configurations vary, but essentially will include an ESG Option 201 personality, a mobile receiver, control and/or measurement equipment, and interconnections. An example is shown at the end of this section.

Messaging and protocol development, unidirectional

Messaging and protocol may be verified by sending user-defined data to the mobile receiver and analyzing how the firmware and hardware components respond to the transmitted data. Unidirectional implies the one-way transmission from the ESG signal generator to a mobile phone receiver.

This design activity assists with debugging and helps ensure the reliability and stability of the mobile set. The ability to easily verify messaging and protocol will result in reduced development time.

Paging channel protocol development, unidirectional

Paging channel protocol development is a subset of messaging and protocol development. The ESG Option 201 personality provides fine control of the paging channel allowing insertion of asynchronous paging messages. This allows the ESG to communicate to the mobile receiver in essentially the same way a basestation would. This simplifies the development and verification of paging commands.

Flexible diagnostic tests for firmware

The flexibility of the Option 201 personality allows testing of various portions of the firmware. Testing with all Walsh code and long code combinations, all data rates, convolutional and turbo coding, and other parameters available to the user helps to ensure that the phone receives the signals properly under each configuration.

This is very useful in regression testing to make sure that previously working functions do not break when new features or capabilities are added to the phone.

Functional tests on single and multiple channels

Functional call setup tests may be performed to make sure decoding algorithms in the DSP are working properly. The test has the various Pilot, Sync and Paging channels set up and confirms that the mobile receiver is able to properly establish communication with them. The channels may be set up starting with single channels and progress to a complete multi-channel call to systematically verify the operation of the receiver.

This basic operational test functions as a design validation step. The ability to try out one channel at a time helps isolate design issues. An external fading simulator may be added to verify operation in the midst of fading.

Response to power control data¹

The ESG Option 201 personality has a feature that allows a user-definable power control sequence. When on, power puncturing occurs to cause the mobile phone's power level to step up a specified amount and then drop back down as shown in Figure 11. The number of steps may be defined.

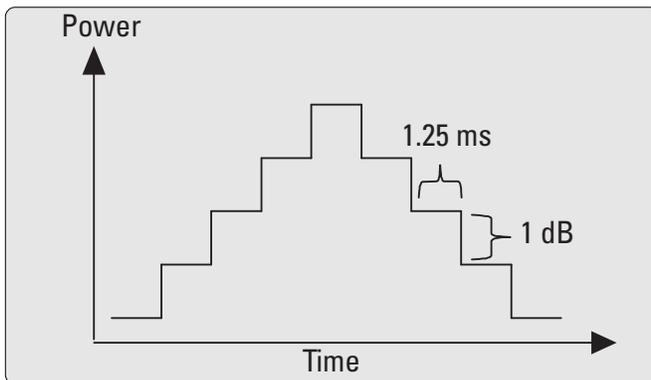


Figure 11. Power control with power puncturing set to 4 Up/Dn

1. In Option 201, power control bits are always transmitted at the same power level as the data bits at all data rates.

This allows the power and response of the mobile phone's power control system to be monitored. Figure 12 shows a simulation of the power response of a mobile phone as would be viewed on a signal analyzer.

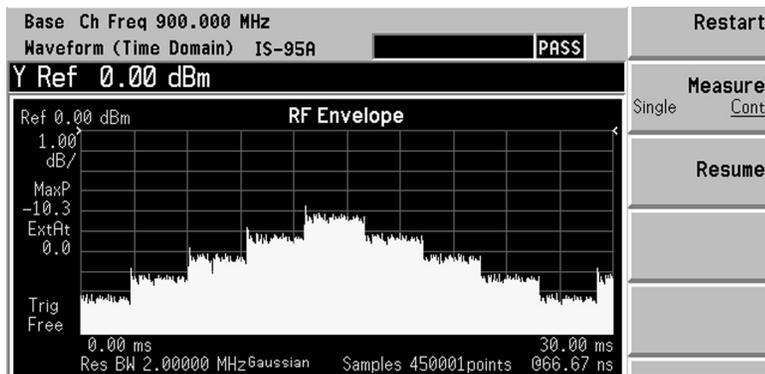


Figure 12. Power control display simulation
 [Center Frequency = 900 MHz, Mode = cdmaOne, Measure = Waveform(Time Domain), Sweep Time = 30 ms, Res BW = 2 MHz, Scale/Div = 1.00 dB, Ref Value = 0.00 dBm]

Demonstration example

A demonstration example of a functional test setup is shown in Figure 13. This example utilizes the ESG Option 201 personality and an Agilent Technologies E7473A CDMA drive test system. (Note that the E7473A CDMA drive test system is not part of the ESG Option 201, but may be purchased separately.) Once configured, the drive test system is able to monitor the signals generated by the ESG. Details such as pilot channel power, sync messages, and paging messages may be observed.

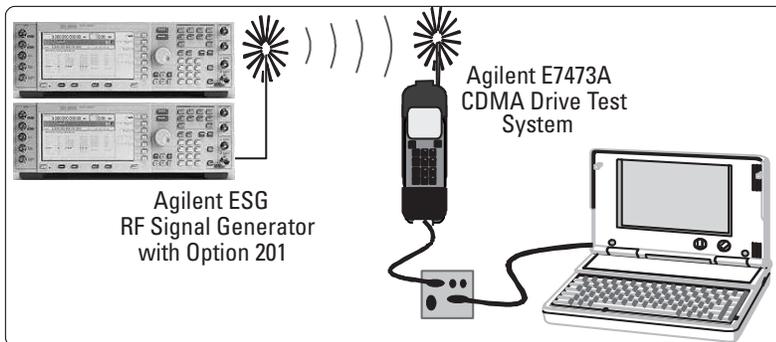


Figure 13. Demo setup example for functional testing

A mobile phone is connected to the drive test system and configured by defining the hardware project, the mobile phone, and the appropriate port. For details on drive test configuration, refer to the drive test user's guide.

Once the drive test has been configured to match the mobile phone, the ESG Option 201 personality must also be configured appropriately, as follows:

- Frequency set to frequency of mobile phone
- Amplitude set to an appropriate level, such as -20 dBm
- Pilot channel configured
- Sync channel and appropriate Sync type configured
- Paging channel configured
- Fundamental traffic channel(s) may be configured, optionally
- Other parameters, such as PN Offset, may be varied as desired

Once the ESG has been appropriately configured, the drive test software may be run. With the phone turned on, load the drive test software and select the appropriate project. Click on the collection softkey, and then on the icons titled phone virtual front panel and the messages virtual front panel. The drive test software should now be ready. By turning the phone off, then on, it will quickly synchronize to the ESG and display the sync and paging messages as shown in Figure 14. The computer display windows show the transmitter's signal strength, as well as the stream of messages and contents being received.

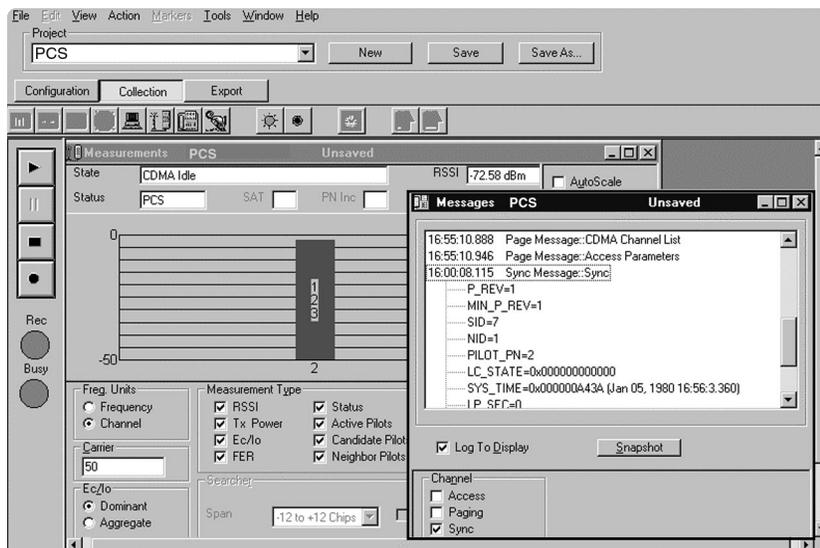


Figure 14. Screen shot from E7473A CDMA Drive test system monitoring the ESG Pilot, Sync, and paging channels

Optionally, to test the receiver's ability to track multiple basestations, two ESGs may each be independently configured as IS-95 basestations with Pilot, Sync, Traffic, and Paging channels. The mobile phone would be expected to keep track of both basestations and select the appropriate one with the stronger Pilot signal. The Sync message from the mobile phone would indicate the selection.

Appendix A-Specifications

Real-time cdma2000 personality, Option 201

Description

Option 201 is a firmware personality built upon the internal real-time I/Q baseband generator (Option UN8). This option will generate fully coded IS-2000 signals (phase 1) for mobile receiver test and provide the stimulus for frame or bit error tests, and functional tests of the mobile unit's protocol handling. It is backward compatible with IS-95 systems using Radio Configurations 1 or 2. Option 201 also provides forward link signals according to the TS-B-2000 version of the IS-2000 standard.

Channel types generated

Up to four channels simultaneously, of any of the following

- Pilot
- Paging
- Sync
- F-Fundamental
- F-Supplemental
- OCNS

Global controls across all channels

Channel Power	0 to -40 dB
Filter	IS95, IS95 w/eq, IS95 mod, IS95 mod w/eq, IS2000 SR3 direct spread, Root Nyquist, Nyquist, Gaussian, User defined FIR, Rectangle, APCO 25 C4FM
Spread rate	1
PN offset	0-511
Chip Rate	50Hz-1.3MHz
Even second delay	0.5 to 128 chips
I/Q voltage scale	0 to -40 dB
Code domain power	Equal powers or scale to 0 dB

Pilot channel

Walsh	0 (non-adjustable)
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Sync channel

Walsh	0 to 63
Data	Free editing of the following fields: SID, NID, F-synch type, Sys_Time, PRAT, LTM_Off, Msg_Type, P_REV, MIN_P_REV, LP_SEC, DAYLT, Cdma Freq, ext Cdma freq, and Reserved

Paging channel

Walsh	0 to 63
Data	Default paging message or Userfile
Long Code Mask	0-3FFFFFFFFh
Rate	4.8 or 9.6 kbps

Fundamental channel

Radio Config.	1 to 5
Walsh	0 to 63
Data Rate	1.2 to 14.4 kbps, depending on radio configuration PN9, PN15,
Data	Userfile, External serial data, or predefined bit patterns
Long Code Mask	0-3FFFFFFFFh
Power Control	N up/down, "N" may be set from 1 to 80
Power Puncture	On/Off
Frame Offset	0 (non-adjustable)
Frame Length	20ms (non-adjustable)

Supplemental channel

Same channel configuration as Fundamental, except

Radio Config.	3 to 5
Walsh	0-63, depending on RC and Data Rate
Data Rate	19.2 to 307.2 kbps, depending on radio configuration
Turbo Coding	May be selected for data rates from 28.8 to 153.6kbps
Power Control	not provided
Power Puncture	not provided

OCNS channel

Walsh	0 to 63
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Inputs

External data	Can be selected for one channel, either fundamental or supplemental
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Outputs

various timing signals such as chip clock and even second

Appendix B – Terms and definitions

ASIC – Application Specific Integrated Circuit
AWGN – Additive White Gaussian Noise
BBG – Base Band Generator
BER – Bit Error Rate
BLER – Block Error Rate
BTS – Base Transceiver Station
CDMA – Code Division Multiple Access multiplexing scheme
cdmaOne™ – Brand name that describes a complete wireless system incorporating the IS-95 CDMA air interface.
cdma2000 – The name identifying the TIA standard for third generation technology that is an evolutionary outgrowth of cdmaOne with a seamless migration path to 3G features and services. See also IS-2000.
CRC – Cyclic Redundancy Check
DAYLT – DAYLight savings time, Sync channel message
dB – deciBel; a ratio in Log base 10
dBm – deciBel milliwatts, a measure of power expressed in terms of its ratio (in dB) to one milliwatt
DSP – Digital Signal Processor
Delayed Even Second – Delay for the even second clock pulse.
Even Second Clock – A clock pulse sent out every two seconds to synchronize the clock rate of the basestation to external equipment.
FER – Frame Error Rate
Forward Path – Refers to the base-to-mobile link
F-FCH – Forward Fundamental traffic CHannel; primary traffic channel for voice and low-speed data.
F-PCH – Forward Paging CHannel which is the digital control channel for the forward link. The first paging channel is always assigned to Walsh code 1. When additional paging channels are required, Walsh codes 2 – 7 are used.
F-PICH – Forward Pilot CHannel used by all mobiles as a coherent phase reference and as a means to identify cells from each other. The Pilot channel uses Walsh code 0.
F-SYNCH – Forward Sync CHannel; transmits time of day information for clock alignment. The Synch channel always uses Walsh code 32.
F-SCH – Forward Supplemental traffic CHannel provides additional bandwidth for high-speed data.
IS-95 – Interim Standard 1995 for US Code Division Multiple Access.
IS-95A – TIA standard document that defines the common air interface for IS-95.
IS-2000 – 3rd Generation version of IS-95 standard which incorporates backwards compatibility with IS-95.
LPSEC – LeaP SEcOnDs, Sync channel message.
LTM_Off – Local TiMe Offset, Sync channel message which provides the offset of the local time from the system time.
Msg_Type – Message Type, Sync channel message.
MC – Multi-Carrier
MINPREV – Minimum Protocol REVision level, Sync channel message.
NID – Network IDentification, Sync channel message.
OCNS – Orthogonal Channel Noise Simulator
OTD – Orthogonal Transmit Diversity
PN Offset – Pseudo-random Number Offset which are time offsets in the short sequence code assigned to each basestation to uniquely identify them.
PRAT – Paging channel data RATE, Sync channel message which provides the data rate used by the paging channels in the system.
PREV – Protocol REVision level, Sync channel message
QOF – Quasi-Orthogonal Function
RC – Radio Configuration
RF – Radio Frequency
RSSI – Receive Signal Strength Indication
SID – System IDentification, Sync channel message.
Sys_Time – System Time, Sync channel message.
SR – Spreading Rate
TIA – Telecommunications Industry Association
Walsh Code – Orthogonal codes which are assigned uniquely to each user in a cell.

Recommended reading

1. *Performing cdma2000 Measurements Today*, Agilent Technologies Application Note 1325, literature number 5968-5858E.
2. *Understanding CDMA Measurements for Basestations and Their Components*, Agilent Technologies Application Note 1311, literature number 5968-0953E.
3. *Testing and Troubleshooting Digital RF Communications Receiver Designs*, Agilent Technologies Application Note 1314, literature number 5968-3579E.
4. *HPSK Spreading for 3G*, Agilent Technologies Application Note 1335, literature number 5968-8438E.
5. Agilent Technologies 3G web site: <http://www.agilent.com/find/3g>.

Related literature

1. *ESG Family of RF Digital and Analog Signal Generators brochure*, Agilent Technologies, literature number 5968-4313E.
2. *ESG Family RF Signal Generators Configuration Guide*, Agilent Technologies, literature number 5965-4973E.
3. *ESG Family RF Signal Generators Specifications*, Agilent Technologies, literature number 5968-3096E.
4. *E4406A VSA-Series Transmitter Tester*, Agilent Technologies, literature number 5966-4762E.
5. *HP Wireless CDMA Solutions*, Agilent Technologies, literature number 5966-3058E.
6. *Agilent Technologies ESG Family Signal Generators Option 201 cdma2000 Personality User's and Programming Guide*, Agilent Technologies, literature number E4400-90386.

References

1. TR45 Recommended Minimum Performance Standards for Dual-Mode Spread Spectrum Mobile Stations, Telecommunications Industry Association, SP-4383, June 16, 1999.
2. *TIA/EIA Interim Standard, Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System*, TIA/EIA/IS-95-A, Telecommunications Industry Association, May 1995.
3. *CDMA Terminology and Definitions*, CDG Web site: http://www.cdg.org/tech/cdma_term.html, December 23, 1999.
4. *Concepts of CDMA – Advanced Training Version*, 5th Revision, Hewlett-Packard Company, 1997.
5. *Concepts of cdma2000 – An Early Overview*, Revision 1.8, Hewlett-Packard Company, 1998.

Ordering information

The ESG Option 201 personality can be ordered with a new ESG, or through an upgrade. The upgrade kit is Option 251. The upgrade kit may be downloaded and activated by purchasing a license key. The serial number of the unit as well as the Host ID number must be supplied. This personality requires firmware B.03.40 or higher. It also requires the Real-time I/Q Baseband Generator, option UN8 revision C or higher. For option UN8 revision information on your ESG, refer to ESG's utility menu and select Instrument Info, then Options Info. (A hardware upgrade is available for customers with older option UN8 boards.)

Recommended accessory list for the two-box ESG Option 201 configuration:

Qty	Description	Part Number
10	30 cm 50 Ω coaxial cable with two BNC (m) connectors	8120-1838
3	122 cm 50 Ω coaxial cable with two BNC (m) connectors	8120-1840
2	Type-N (m) to BNC (f) standard 50 Ω adapters	E9635A
3	Right-angle BNC standard 50 Ω adapter	E9620A
3	BNC (f) to BNC (f) standard 50 Ω adapters	E9622A
3	BNC tee (m) (f) (f) standard 50 Ω adapters	E9625A

For more information on the Agilent Technologies ESG Signal generator or Option 201, visit our web site at: <http://www.agilent.com/find/esg>.

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