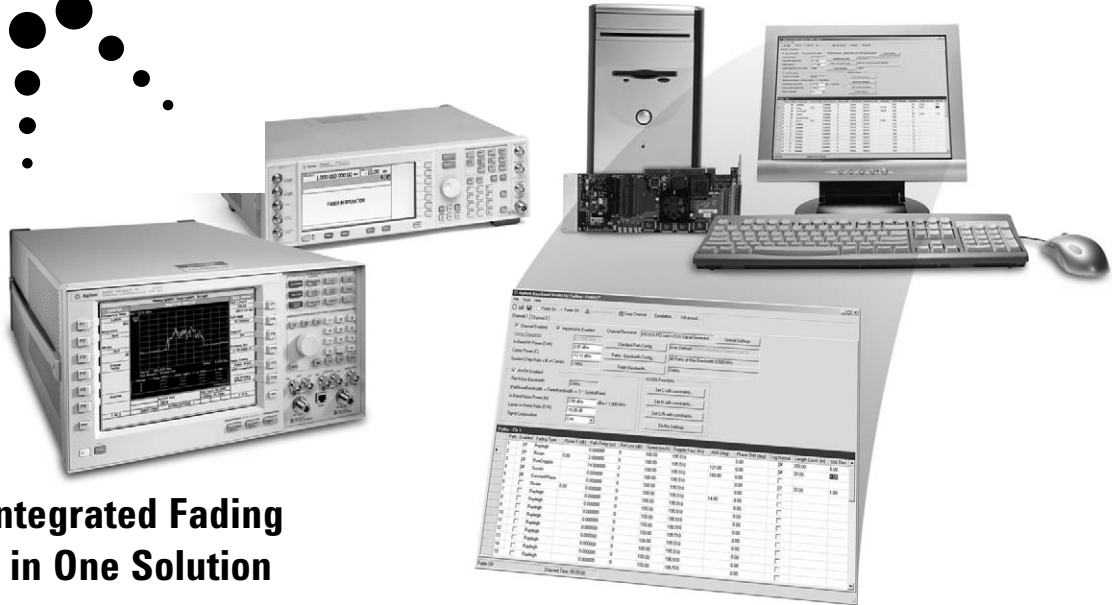


# Agilent N5115A Baseband Studio for Fading

## Technical Overview



## Digitally Integrated Fading and Noise in One Solution

N5115A Baseband Studio for fading is a powerful channel simulation tool for verifying communications receiver designs, such as cellular and wireless LAN, under real-world signal conditions. Achieve realistic channel simulation using multipath fading with the addition of AWGN, and simulate a diversity antenna or an interfering signal by adding a second channel. Preconfigured fading profiles for W-CDMA, HSDPA, COST 259, TD-SCDMA, cdma2000, cdmaOne 1xEV-DO, 1xEV-DV, GSM, EDGE, WLAN, and TETRA standards simplify initial setup, or you can choose user-defined fading profiles to meet your specific test needs.

The complete fading solution is comprised of the Baseband Studio for fading software that works with a PC equipped with the N5101A Baseband Studio PCI card and Agilent instruments capable of generating digital baseband signals. Baseband Studio for Fading currently supports the E4438C ESG vector signal generator and the E5515C wireless communications test set. The ESG creates digital baseband IQ signals using the internal signal creation personalities, PC-based Signal Studio software, or custom waveforms created by mathematical modeling tools such as Agilent's Advanced Design System (ADS) or MATLAB®. The E5515C creates digital baseband signals using either the cdma2000, 1xEV-DO, or W-CDMA lab applications. The ESG or E5515C sends these digital baseband signals to a PC equipped with the fading software and PCI card, where the software's PC-based interface is used to configure the channel simulation parameters. The baseband signal is faded digitally and then sent back to the ESG or E5515C for conversion to analog I/Q or RF.

### Key features

- ✓ Easily add AWGN
  - Digital accuracy in C/N
  - Hold C/N constant as you vary power
- ✓ Optimize number of paths and bandwidth
  - Up to 48 paths
  - Up to 30 MHz
- ✓ One or two channels
  - Simulate antenna diversity or interfering signals
- ✓ Simulate changing environments
  - Dynamically change path delay and path loss
  - Up to 5000 unique states
- ✓ A variety of profiles and setups
  - Rayleigh, Rician, Suzuki, log normal, and others
  - Predefined channel setups for WLAN, W-CDMA, cdma2000, GSM, and others
- ✓ Programmable control with built-in API

### Try before you buy

Go to [www.agilent.com/find/basebandstudio](http://www.agilent.com/find/basebandstudio) and download the Baseband Studio for fading software to your PC and evaluate the capabilities of the software. The Baseband PCI card and the Baseband Studio for fading license key is required to use the channel simulation capability with the E4438C ESG or the E5515C. The hardware and software can be ordered through your sales engineer or the nearest sales office, which can be found at: [www.agilent.com/find/assist](http://www.agilent.com/find/assist)



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# Channel Simulation To Test Under Real-World Signal Conditions

The signal conditions at the antenna of a wireless radio receiver are among the worst that a radio circuit designer will ever encounter. These fading conditions are the result of the transmitted wave propagating through the atmosphere to the receiver. In the ideal world the signal would follow one path and arrive at the receiver with little attenuation; however, the signal rarely takes one path. Instead, it is reflected, diffracted, and scattered from objects in the environment. These multiple paths add constructively, or destructively, causing random and rapid fluctuations in the received amplitude. If the transmitter or receiver is moving, the signal will also be spread in the frequency domain due to the Doppler effect. In addition to these multipath effects, there is a wide array of competing signals hitting the antenna, including atmospheric noise.

Modern communications receivers employ a broad range of techniques to combat these fading conditions, including antenna diversity, rake receivers, channel equalization, and data encoding and interleaving. Channel simulation is an essential part of the design and verification process to ensure the receiver is robust enough to provide reliable communications under fading conditions.

Baseband Studio for fading meets the needs for demanding channel simulation with the capability to simulate both large- and small-scale fading scenarios with wide bandwidths. The predefined fading profiles for cellular radio formats and WLAN, coupled with the easy-to-use AWGN features and dual channel capability, ensure quick and thorough evaluation of your receiver performance – all at a price that might surprise you.

## Fading with the E4438C ESG

Baseband Studio for fading coupled with the E4438C ESG vector signal generator offers R&D engineers the features needed to develop and debug today's high performance receivers while providing a flexible platform for tomorrow's needs. Take advantage of the ability to fade signals created using the ESG's built-in personalities and Agilent's comprehensive Signal Studio software suite. Need more flexibility? Access the ultimate in flexibility by fading your own custom waveforms created with Agilent ADS, MatLab®, C++, or your preferred signal modeling tool. Whether it's wide bandwidth fading or dual channel capability, the Baseband Studio fading solution can be configured to meet your need.

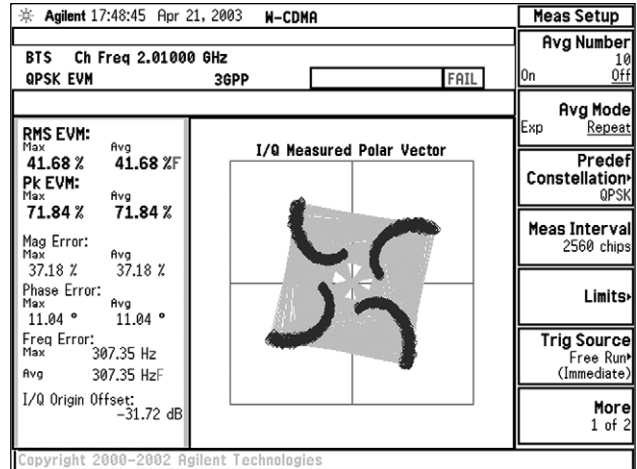


Figure 1. Can your receiver demodulate this? Constellation diagram of a single channel W-CDMA signal during a deep fade simulated with a Rayleigh distribution.

## Fading with the E5515C

Baseband Studio for fading coupled with the E5515C wireless communications test set offers a comprehensive cdma2000, 1xEV-DO, or W-CDMA RF protocol interface to simulate real network control with realistic fading conditions. The E5515C-based fading solution is ideal for engineers doing final RF qualification and verification of wireless terminals, off-loading the basic RF parametric and functional tests that often are the bottlenecks of larger conformance systems. Additionally, test uncertainty is minimized and since the same fader hardware is used with the E5515C and the ESG, the fading results obtained using the E5515C in final verification will correlate with results obtained using the ESG in early R&D. Now you can get your mobile handset to market more quickly with the confidence it will perform under real-world fading conditions.

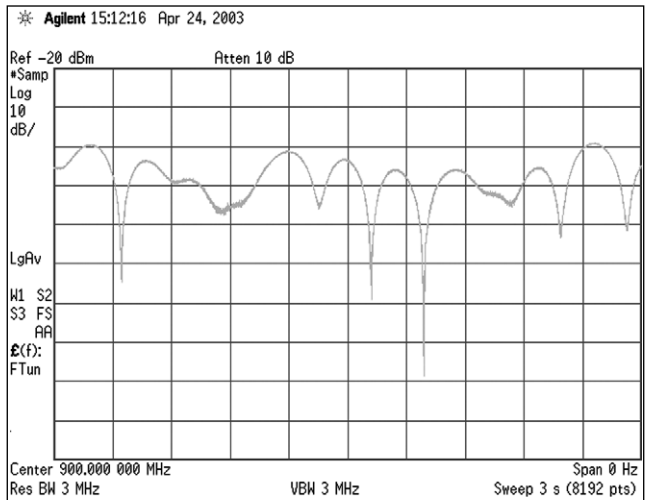


Figure 2. Will your receiver drop a call during a deep fade? Amplitude fluctuations experienced during Rayleigh fading of a single channel W-CDMA signal.

# Adding AWGN Has Never Been Easier or More Accurate

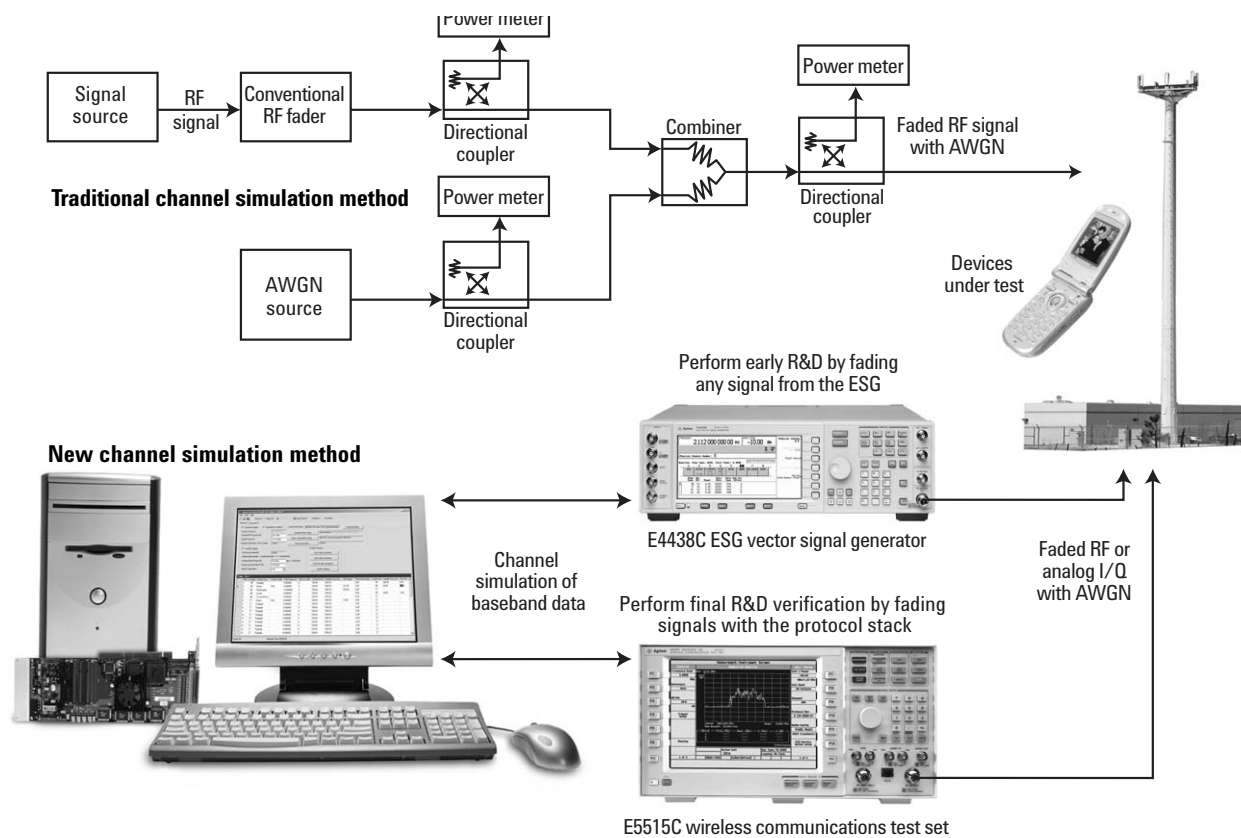


Figure 3. Reduce test time and equipment cost with a simplified setup for channel simulation.

## Accuracy

Adding AWGN to a faded signal has often created problems in setting the desired carrier-to-noise ratio ( $C/N$ ) or the energy per bit to noise power spectral density ratio ( $E_b/N_0$ ). Traditional faders typically do not include a built-in AWGN generator, resulting in the need to combine two different RF signals to achieve the overall ratio. Baseband Studio for fading seamlessly integrates with the E4438C ESG or E5515C, eliminating calibration issues associated with traditional fading simulators. The baseband signal from the ESG or E5515C is sent to Baseband Studio for fading as a 16-bit digital signal. The multipath fading and AWGN are added to the original baseband data, all in the digital domain. The entire channel simulation process remains digital right up to the point where it is upconverted to RF. This results in exceptional  $C/N$  ratio accuracy because the uncertainty associated with adding analog signals has been eliminated.

## Simplicity

Adjust the value of the AWGN by simply entering the  $C/N$  or  $E_b/N_0$  value in the user interface. Setting the  $E_b/N_0$  parameters computes the correct AWGN level on a per-channel basis, and defines the ratio of energy transmitted on the channel to the overall noise power spectral density.

The software automatically queries the ESG or E5515C for the current power levels and data rates for the various channels. Baseband Studio for fading uses this information to precisely calculate the level of AWGN needed. The flat noise bandwidth of the added AWGN is automatically set to exceed the modulated carrier bandwidth simplifying AWGN setup.

When setting the level of AWGN you can hold  $C$ ,  $N$ ,  $C/N$ , or  $C+N$  constant, which makes receiver testing easier. For example, fix the  $C/N$  ratio as the carrier power changes, or fix the total received power as the  $C/N$  ratio varies. This holds the receiver front-end gain fixed, which is important for evaluating receiver performance under known conditions. Changing AWGN levels is also useful for testing the robustness of a particular channel for a given coding scheme.  $C/N$  and  $E_b/N_0$  can quickly be changed enabling the characterization of receiver performance over a continuum of AWGN levels, without having to readjust separate carrier and noise levels. Complicated noise summing is reduced to a few mouse clicks.

# Configure Fading Parameters to Meet Your Test Needs

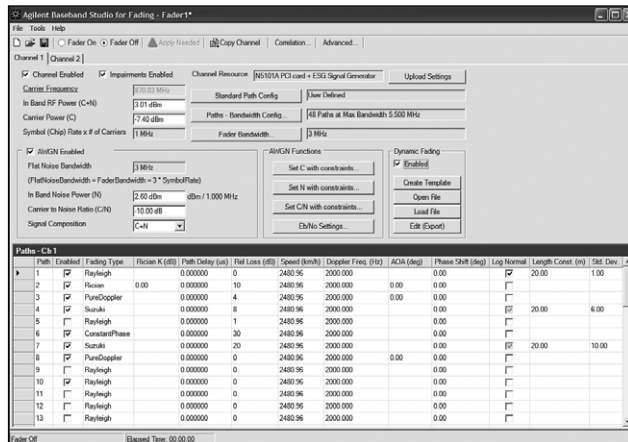


Figure 4. The PC-based interface of Baseband Studio for fading enables sophisticated channel simulation to be quickly and easily configured.

Additional path/bandwidth configuration available	Paths	RF 0.1 dB bandwidth (MHz)
<i>with Option 161</i>	9	30.0
	12	22.0
	15	17.0
<i>with Option 160</i>	18	13.0
	21	11.0
	24	11.0
	30	8.5
	36	6.5
	48	5.5

Table 1. Baseband Studio for fading allows you to optimize the bandwidth and the number of paths for your application when connected to an E4438C ESG.

## Optimize paths or bandwidth when using the ESG

There are two different bandwidth options available, either 17 MHz or 30 MHz, when using Baseband Studio for fading with the E4438C ESG. This lets you choose the level of performance you need, whether you are fading signals for cellular radio formats or WLAN applications. The exact bandwidth of the faded channel depends on the sample rate of the signal delivered to the software. Signals that are sampled at a higher rate will have a greater fading bandwidth available.

The fading software supports a minimum of 15 paths for a 17 MHz bandwidth and 9 paths for a 30 MHz bandwidth to meet your most demanding fading needs. A unique processing algorithm in the Baseband Studio PCI card enables more paths to be available if the maximum fading bandwidth is not required for a particular application. Up to 48 paths can be realized for narrow bandwidth applications. For ESG applications, Baseband Studio for fading will display the available paths/bandwidth configurations based on the sample rate of the signal.

## Choose the number of paths when using the E5515C

The fader bandwidth is optimized for cdma2000, 1xEV-DO and W-CDMA when using Baseband Studio for fading with the E5515C wireless communications test set. The bandwidth is fixed at 6.144 MHz for the W-CDMA lab application and provides up to 24 paths. The bandwidth is fixed at 1.966 MHz for the cdma2000 and 1xEV-DO lab applications and provides up to 48 paths.

## Simulate dynamically changing environments

In real-world situations the receiver is often moving through a particular environment. As the receiver moves by various buildings, trees, and other objects the path length from the transmitter to the receiver changes. Additionally, the received signal level is modified by the reflection coefficient of the objects the signal encounters. Baseband Studio for fading simulates these real-world scenarios by dynamically changing the path delay and path attenuation as a function of time. Up to 5000 unique path delay and path attenuation states, with user-definable dwell times, can be configured for the first six paths in the user interface. Each fading state is programmed into a Microsoft® Excel spreadsheet, enabling user-definable algorithms to generate the delay and attenuation information. A simple Excel spreadsheet template can be accessed from the user interface to enable quick configuration of the fading data.

Note: dual channel fading is not supported with the E5515C.

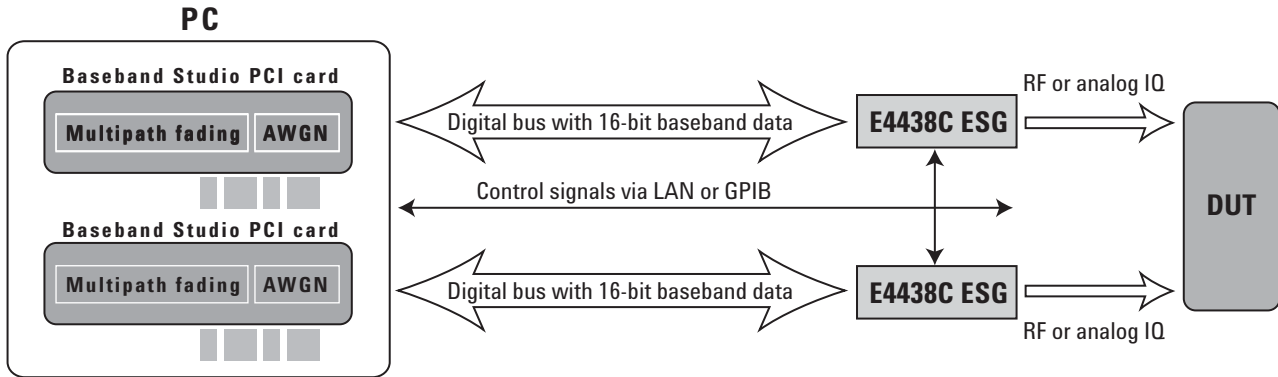


Figure 5. System block diagram of Baseband Studio for fading in a dual channel configuration when used with the E4438C ESG.

### One- or two-channel fading

Baseband Studio for fading supports an optional independently faded channel for testing transmitter or receiver diversity or for simulating an interfering signal. This requires the PC to have two Baseband Studio PCI cards so it can fade a baseband signal from a second E4438C ESG. The correlation between the channels can be specified in the user interface to simulate the distance between the two antennas. The PCI card automatically synchronizes the clocks of both ESGs to ensure accuracy of the transmitted signal. *Note:* dual channel fading is not supported with the E5515C.

### A variety of predefined fading profiles

The ability to simulate different fading profiles is essential for evaluating receiver performance in a variety of environments. Baseband Studio for fading can simulate both small scale and large scale fading models or combinations of the two. This enables the simulation of rapid signal fluctuations, due to small movements of the receiver, and slow changes in average power, caused by shadowing effects of distant objects. The PC-based user interface makes configuring simulation quick and easy.

The supported fading profiles include

- Rayleigh – small-scale multipath scattering
- Rician – Rayleigh with a direct ray
- log normal – large scale free space path loss
- Suzuki – Rayleigh with log normal
- pure Doppler – frequency shift due to motion
- Constant phase – change phase and delay of a path

Also available are predefined setups for common cellular formats that simplify test preparation. These profiles can be modified to provide custom configurations for simulating specific environments. The unique 3GPP W-CDMA moving propagation and birth-death fading profiles are also included as predefined setups.

### Utilize the Microsoft .NET-based API

Use the Microsoft® .NET-based application-programming interface (API) to configure channel simulation directly from your test executive rather than from the Baseband Studio for fading graphical user interface. The entire channel simulation process can be automated in your own programming environment. The software's built-in Help system provides Microsoft .Net programming examples. These programming examples can be easily leveraged to minimize the programming and automation learning curve.

### Reduce Your Cost of Test

Baseband Studio for fading reduces capital equipment costs and saves test time compared to conventional fading techniques. The scalable architecture of the fading software enables you to select only the performance you need. Conventional channel simulation solutions often require costly analog upconversion and downconversion stages. Baseband Studio for fading uses an all-digital, PC-based method that does not require complex integration of test equipment.

# Features and Specifications<sup>1</sup>

Multipath fading	E4438C ESG vector signal generator	E5515C wireless communications test set
<b>RF specifications<sup>1</sup></b>		
RF bandwidth <sup>2</sup> , maximum		
Option 160	17 MHz	W-CDMA 6.144 MHz; cdma2000 or 1xEV-DO 1.966 MHz
Option 161	30 MHz	N/A
Maximum paths per channel		
Option 160	Between 15 and 48 paths <sup>3</sup>	W-CDMA up to 24; cdma2000 or 1xEV-DO up to 48
Option 161	Between 9 and 48 paths <sup>3</sup>	N/A
Number of channels <sup>4</sup>	1 or 2	1
Carrier feed-through	-55 dBc typical <sup>5</sup>	-47 dBc typical <sup>6</sup>
<b>Signal input/output</b>		
Available inputs <sup>7</sup>	Any signal generated with the E4438C-601/602 internal baseband generator <sup>8</sup> including user generated ARB files or signals generated with the E5515C wireless communications test set using the cdma2000, 1xEV-DO, or W-CDMA lab applications.	
Available outputs	Faded analog I/Q or RF	Faded analog I/Q or RF
<b>Channel simulation</b>		
Simulation method	Filtered noise	Filtered noise
Spectral shape	3 dB, 6 dB, or flat	3 dB, 6 dB, or flat
Fading types	Rayleigh, Rician, log normal, Suzuki, pure Doppler, or constant phase	
Rayleigh distribution		
Deviation from CPDF	0.5 dB from 10 to -30 dB of mean power level	0.5 dB from 10 to -30 dB of mean power level
Rician distribution		
Power ratio (k) range	-60 to 60 dB	-60 to 60 dB
Direct ray angle of arrival range	0 to 360 °	0 to 360 °
Log-normal and Suzuki distributions		
Local constant	1 to 400 m	1 to 400 m
Standard deviation	0 to 12 dB	0 to 12 dB
Path delay	0 to 10 ms	0 to 10 ms
Resolution	< 1 ns	< 1 ns
Accuracy	0.4 ns + 0.2% of path delay	< 40 ns
Phase shift	0 to 360 °	0 to 360 °
Path loss	0 to 99 dB	0 to 99 dB
Resolution	0.01 dB	0.01 dB
Accuracy	0.1 dB	0.1 dB
Doppler shift	0 or 0.3 Hz to 2.4 kHz	Maximum Doppler shift limited to 1900 Hz
Accuracy	< 0.05%	for cdma2000 or 1xEV-DO

- Listed specifications are characteristics. These specifications describe performance distribution derived from measurements where the nominal proportion is typically greater than 50%, e.g. 50% of instruments will meet or exceed the described nominal values
- The RF channel simulation bandwidth is dependent upon sample rate and the number of paths selected. The software displays the available paths/bandwidth configurations based on the current settings. The flatness and rolloff characteristics of the source used for upconversion are added to the final RF output. The bandwidth is measured 0.1 dB down from the carrier.
- The number of paths can be increased up to a maximum of 48 if the full RF bandwidth is not required.
- Dual channel mode requires a two E4438C ESGs, two N5105A Baseband Studio PCI cards, and two sets of options for the Baseband Studio for fading software.
- Measured under the following condition: After an IQ calibration for a constant amplitude signal at the top of a fade for a single path of Rayleigh fading. Carrier feedthrough will degrade as the crest factor of the modulation signal or fading increases.
- Measured under the following conditions: After an IQ calibration for a cdma2000, 1xEV-DO, or W-CDMA signal at the top of a fade for single path of Rayleigh fading. Carrier feedthrough will degrade as the fading crest factor increases.
- RF, analog I/Q, and digital I/Q inputs are not supported.
- E4438C-403 calibrated noise personality and E4438C-409 GPS personality are not supported with Baseband Studio for fading. The internal E5515C AWGN is also not supported with fading. To add AWGN to a faded signal order N5115A-168.

Channel simulation (continued)	E4438C ESG vector signal generator	E5515C wireless communications test set
Vehicle speed	0, or $V_{\min} = \frac{180 \times 10^6}{f_{RF}} \frac{m}{s}$ $V_{\max} = \frac{7.2 \times 10^{11}}{f_{RF}} \frac{m}{s}$	0, or $V_{\min} = \frac{180 \times 10^6}{f_{RF}} \frac{m}{s}$ $V_{\max} = \frac{5.7 \times 10^{11}}{f_{RF}} \frac{m}{s}$ (cdma2000 or 1xEV-DO) $V_{\max} = \frac{7.2 \times 10^{11}}{f_{RF}} \frac{m}{s}$ (W-CDMA)
Resolution	0.1 km/h, m/s, mph	0.1 km/h, m/s, mph
Correlation	0 to 1 for each path between channels 1 and 2	N/A
Predefined settings	W-CDMA, HSPDA, COST 259, TD-SCDMA, cdma2000, cdmaOne, 1xEV, GSM, EDGE, WLAN, and TETRA	
3GPP W-CDMA tests	Birth-death propagation and moving propagation	Birth-death propagation and moving propagation
Dynamic Fading		
Number dynamic paths <sup>1</sup>	Up to 6	NA
Number of states	1 to 5000	NA
Dwell time per state	10 ms to 1000 s	NA
Path delay	0 to 10 ms	NA
Path loss	0 to 99 dB	NA
<b>AWGN specifications</b>	<b>E4438C ESG vector signal generator</b>	<b>E5515C wireless communications test set</b>
Carrier to noise ratio accuracy <sup>2</sup>	0.3 dB	0.3 dB
Bandwidth	Up to a maximum of 17 MHz with Option 160; Up to a maximum of 30 MHz with Option 161	W-CDMA 6.144 MHz; cdma2000 or 1xEV-DO 1.966 MHz
Crest factor		
9 maximum paths	12 dB minimum	15 dB minimum
≥12 maximum paths	15 dB minimum	15 dB minimum
Randomness	89 bit pseudo-random sequence with a repetition period greater than 3 billion years	
C/N	-30 to 30 dB	W-CDMA ±10 dB; cdma2000 or 1xEV-DO ±20 dB <sup>3</sup>
Resolution	0.01 dB	0.01 dB
Hold one of the following constant as another of these quantities is varied	C/N, C, N, or C+N	C/N, C, N, or C+N
$E_b/N_o, E_c/N_o, E_b/N_t$	-30 to 30 dB	cdma2000 or 1xEV-DO; ±40 dB for $E_b/N_t$ <sup>3</sup>
Resolution	0.01 dB	cdma2000 or 1xEV-DO; 0.01 dB for $E_b/N_t$
Hold one of the following constant as $E_b/N_o, E_c/N_o,$ or $E_b/N_t$ is varied	C, N, or C+N	C, N, or C+N

1. Additional paths beyond the first six can be enabled, however, they are not dynamically faded.
2. Not including the effects of carrier feedthrough. Measured with one path of constant fading.
3. Range depends on channel configuration.

# Ordering Information

## Baseband Studio for fading configuration

Model/option	Description	Notes
N5101A	Baseband Studio PCI card	Required <sup>1</sup>
N5115A <sup>2</sup>	Baseband Studio for fading	Required
N5115A-160	One fading channel with up to 17 MHz RF BW	Required <sup>1</sup>
N5115A-161	One fading channel with extension from 17 up to 30 MHz RF BW	Optional bandwidth extension when using the ESG <sup>1</sup>
N5115A-168	Add AWGN to a fading channel	Recommended <sup>1</sup>
N5115A-170	ESG fading connectivity for one fading channel	N5115A-170 or N5115A-172 is required <sup>1</sup>
N5115A-172	E5515C fading connectivity for one fading channel	N5115A-170 or N5115A-172 is required <sup>1</sup>
N5115AK-161	Upgrade fading RF BW from 17 to 30 MHz	
N5115AK-168	Upgrade to add AWGN noise to a fading channel	
N5115AK-170	Upgrade to add ESG fading connectivity for one fading channel	
N5115AK-172	Upgrade to add E5515C fading connectivity for one fading channel	

## Recommended ESG configuration

Model/option	Description	Notes
E4438C	ESG vector signal generator	Firmware C.03.40 or later required
E4438C-506	250 kHz to 6 GHz frequency range	Can substitute E4438C-501, -502, -503 or -504 (lower frequencies)
E4438C-UNJ	Enhanced phase noise performance	Only required for option 506
E4438C-005	6 GB hard drive	Recommended
E4438C-602 <sup>3</sup>	Internal baseband generator, 64 MSa	Can substitute E4438C-601 (8 MSa)

Supported applications: Any application that utilizes the baseband generator, including internal personalities<sup>4</sup> and the Signal Studio applications.

## Recommended E5515C configuration

Model/option	Description	Notes
E5515C	Wireless communications test set	Required
E5515C-003	Flexible link subsystem	Required
E5515CU-185	Protocol processor / DSP upgrade	Required when E6703C is used
E5515CU-504	HW upgrade kit to fading capability for E5515C	Required
E6702B	cdma lab application	One of the following required: E6702B, E6703C, E6706A
E6706A	1xEV-DO lab application	One of the following required: E6702B, E6703C, E6706A
E6703C	W-CDMA lab application	One of the following required: E6702B, E6703C, E6706A
N5880A	cdma2000/IS-95/AMPS enhanced wireless test manager	Optional for automating system
N5882A	W-CDMA enhanced wireless test manager <sup>4</sup>	Optional for automating system

Supported applications: Either the E6702B, E6703B, or the E6706A Lab Applications<sup>4</sup>

## PC configuration<sup>5</sup>

	Minimum configuration
PC class	600 MHz Pentium® III
Memory	256 MB, minimum; 512 recommended
Hard drive space	145 MB
Required free slots	2 slots for each Baseband Studio PCI card
Operating system	Windows® 2000, service pack 2 or 3 or Windows XP with service pack 1
Software	Microsoft® Excel 2000 or later if dynamic fading feature is used

- Two are required for dual channel capability with the ESG. Dual channel capability is not supported with the E5515C.
- Baseband Studio for fading is not currently compatible with the N5102A Baseband Studio digital signal interface module or N5110A Baseband Studio for waveform capture and playback.
- Replacement kits for E4438C-001 and -002 are E4438CK-601 and -602.
- E4438C-403 calibrated noise personality and E4438C-409 GPS personality are not supported with Baseband Studio for fading. The internal E5515C AWGN is also not supported with fading. To add AWGN to a faded signal order N5115A-168.
- Agilent does not supply a PC with the Baseband Studio products.

# Additional Resources

## Web

[www.agilent.com/find/basebandstudio](http://www.agilent.com/find/basebandstudio)

[www.agilent.com/find/signalstudio](http://www.agilent.com/find/signalstudio)

[www.agilent.com/find/esg](http://www.agilent.com/find/esg)

[www.agilent.com/find/8960devicedesign](http://www.agilent.com/find/8960devicedesign)

## Literature

*Baseband Studio for Waveform Capture and Playback,*  
Technical Overview  
Literature no. 5989-2095EN

*Baseband Studio Digital Signal Interface Module,*  
Technical Overview  
Literature no. 5988-9495EN

*E4438C ESG Vector Signal Generator, Brochure*  
Literature no. 5988-3935EN

*E4438C ESG Vector Signal Generator, Data Sheet*  
Literature no. 5988-4039EN

*E4438C ESG Vector Signal Generator, Configuration Guide*  
Literature no. 5988-4085EN

*E5515C Wireless Communications Test set, Brochure*  
Literature no. 5988-0573EN

*E6702B CDMA Lab Application, Data Sheet*  
Literature no. 5988-6180EN

*E6703C WCDMA Lab Application, Data Sheet*  
Literature no. 5989-0248EN

*E5515C Wireless Communications Test Set,*  
Upgrade Configuration Guide  
Literature no. 5988-1986EN



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