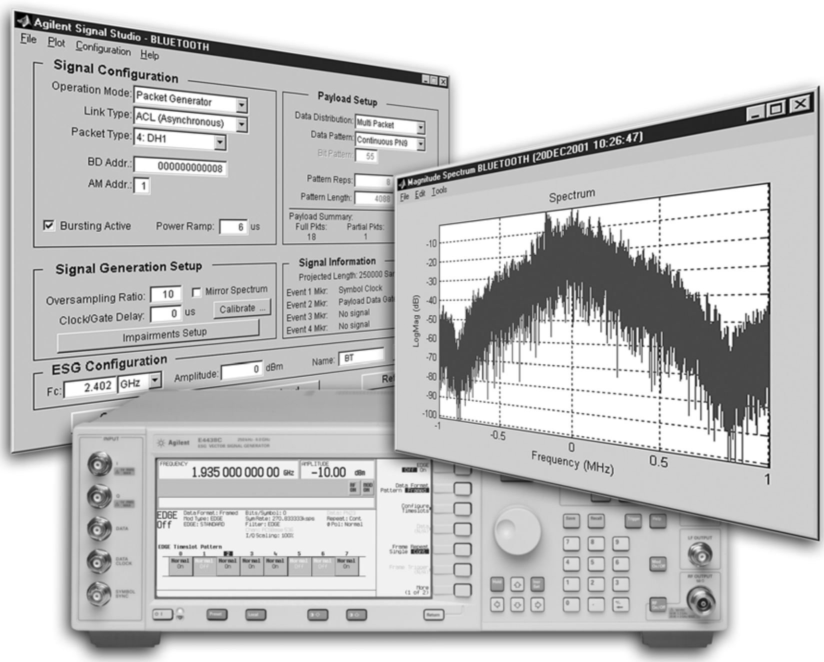
Agilent
Bluetooth™ Signal Studio Software for the E4438C ESG Vector Signal Generator

Option 406
Product Note



Use Signal Studio to create *Bluetooth* test signals

Bluetooth Signal Studio software is a powerful tool for creating *Bluetooth* baseband I/Q waveforms for use with the Agilent E4438C ESG Vector Signal Generator. Select from thirteen different packet types to configure, download and store the wave-forms in the ESG, and use the ESG flexible waveform sequencer to generate custom packet sequences.

E4438C ESG Vector Signal Generator main features

- 250 kHz to 1, 2, 3, 4, or 6 GHz frequency range
- Up to 32 Msamples waveform playback memory
- Up to 6 GByte non-volatile waveform storage
- Single-ended and differential I/Q outputs
- LAN and GPIB connectivity

Bluetooth Signal Studio software main features:

- Intuitive user interface
- Fully coded Bluetooth packets and Bluetooth modulated data streams
- Packet types: DH1, DH3, DH5, DM1, DM3, DM5, AUX1, HV1, HV2, HV3, NULL, POLL, ID
- Impairments: sinusoidal & linear frequency drift, frequency offset, symbol timing error, modulation index, AWGN
- Simplifies BER testing
- Plot BER vs. clock/gate delay
- Plot the I/Q signals and spectrum of the configured baseband waveform

Table of contents

This product note is a self-guided tutorial describing the test signals that can be created with the *Bluetooth* Signal Studio software. This document is not meant to be a *Bluetooth* technology tutorial. Basic knowledge of the *Bluetooth* radio specification is required. For additional information on Bluetooth technology, refer to the *References* section at the end of this document.

Software overview

The *Bluetooth* Signal Studio software is an intuitive Windows-based tool for configuring *Bluetooth* packets and *Bluetooth* modulated data streams. The software calculates an I/Q waveform file based on the *Bluetooth* signal configuration parameters set by the user. Most waveforms take only a few seconds to build. The waveform file can then be downloaded to the ESG internal baseband generator for playback in arbitrary waveform mode.

In addition to creating waveform files, the software provides configuration menus for key signal generator settings, including frequency and amplitude. The instrument settings, along with the I/Q waveform file, are passed to the ESG over the LAN or GPIB interface.

After downloading the waveform file and instrument settings to the signal generator, it automatically begins generating the *Bluetooth* modulated RF signal. Local control of the signal generator is then re-enabled and instrument settings, like frequency and amplitude, can be modified from the ESG front panel. The waveform files cannot be modified once they have been downloaded to the instrument.

The waveform files can be saved in the ESG non-volatile memory and recalled for playback at any time. In addition, the Signal Studio software configuration can be saved to the host computer's local hard drive and recalled at any time to re-calculate and download the waveform to the signal generator for playback.

Ease of use

Signal Studio simplifies creating *Bluetooth* test signals for use with ESG. Rather than spending valuable time coding *Bluetooth* packets at the bit level, use the software to create fully coded, standard-based *Bluetooth* packets and *Bluetooth* modulated data streams.

Intuitive user interface
Signals can be rapidly configured in an easy-to-use graphical software environment.

Thirteen fully coded *Bluetooth* packet types
The software provides thirteen different *Bluetooth* packet types to configure, including both voice and data packets. Because these packets are fully coded, demodulation and decoding capabilities of the DUT can be tested.

***Bluetooth* modulated data streams**
Continuous, non-bursted, non-packetized *Bluetooth* modulated data streams can be configured using the software. These signals are ideal for generating *Bluetooth* interference signals and basic test signals that do not require decoding to perform BER analysis.

Add signal impairments
Simulate a realistic *Bluetooth* device signal by adding frequency, modulation, and noise impairments to the signal when performing receiver tests.

Waveform sequencing
Take advantage of the ESG waveform playback memory (8 or 32 Msamples) to playback longer waveforms or create custom packet sequences. The *Bluetooth* Signal Studio software and the ESG built-in waveform sequencing capability combine to provide flexible generation of custom Bluetooth packet sequences.

Baseband and RF signals
Use the ESG single-ended and differential I/Q outputs to inject baseband signals in the transmit or receive paths of the device under test. Or drive the DUT using the ESG RF port tuned to the IF or carrier frequency of interest.

Simplified BER analysis
To facilitate receiver BER measurements on *Bluetooth* devices, an automated clock/gate delay calibration utility is provided in the software. Using the utility, the data, clock, and gate signal timing alignment at the input of the ESG internal BER analyzer can be easily determined and modified to attain accurate results.

Signal structure

This section provides a quick review of key *Bluetooth* signal characteristics. Additional information about the *Bluetooth* signal structure can be found in the Bluetooth *System Specification*.

Bluetooth modulation and transmission parameters

Modulation parameters	
Modulation type	FSK – Frequency Shift Keying
Baseband filtering	Gaussian, BT = 0.5
Maximum frequency deviation	140 – 175 kHz
Modulation index	0.28 – 0.35
Symbol rate	1 Msymbol/second
Transmission parameters	
Frequency band	2.4 GHz ISM band
Transmission scheme	TDD – Time Division Duplex
Spreading type	FHSS – Frequency Hopping Spread Spectrum
Number of channels	79
Channel spacing	1 MHz [f = 2.402 + k GHz, k = 0,1,2,...78]
Hop rate	1600 hops/second

Bluetooth transmission scheme

Time-division duplex

In *Bluetooth* systems, master and slave devices exchange information by alternating packet transmissions in time-division duplex, Figure 1. The master starts its transmission in even-numbered time slots only, and the slave starts its transmission in odd-numbered timeslots only.

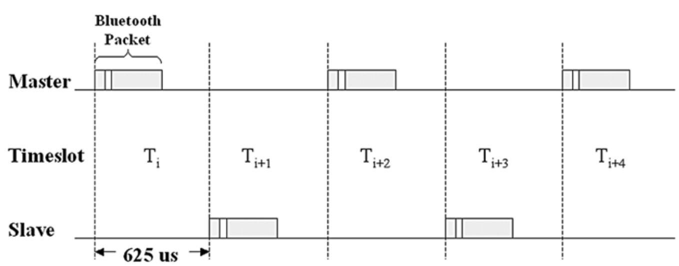


Figure 1. *Bluetooth* time-division duplex transmission scheme.

Frequency hopping

In normal operation, *Bluetooth* devices typically hop to a new carrier frequency each timeslot. However, when performing the majority of transmitter and receiver tests as indicated in the *Bluetooth* RF Test Specification, frequency hopping is disabled.

continued on page 5

Signal structure

Bluetooth **link types**

Two types of links can be established between *Bluetooth* devices:

Asynchronous Connection-Less (ACL) link

The ACL link is a point-to-multipoint link between the master and all slaves participating on the piconet. It is considered a packet-switched connection primarily intended for transmitting non-time sensitive information, like data. The fundamental packet length in *Bluetooth* systems occupies a single timeslot, as shown in Figure 1. Packets that occupy multiple timeslots are used to achieve increased data rates on the ACL link because they have larger user data fields.

Synchronous Connection-Oriented (SCO) link

The SCO link is a point-to-point link between the master and a single slave. It is considered a circuit-switched connection primarily intended for transmitting time sensitive information, like voice. All SCO link packets occupy a single timeslot; however, the packet transmission rate varies depending upon how much voice information is carried in the packet payload. The objective is to maintain a 64 kb/s link for voice transmission. However, because of the overhead associated with FEC coding, packets with FEC on the speech data must be transmitted at a faster rate than packets with no FEC to achieve an equivalent speech data rate (64 kb/s).

Bluetooth **packets**

Packet types

There are many different types of packets used to exchange information on a *Bluetooth* link. They can be generally categorized into three groups:

1. ACL link packets
2. SCO link packets
3. Control packets

Packet structure

All *Bluetooth* packet types are constructed based upon a standard packet structure, Figure 2. The standard packet structure consists of three fields: access code, header, and payload. In general, the access code and header fields carry overhead information necessary to communicate over a *Bluetooth* link and the payload field carries the user data to be exchanged. The amount of information contained within the payload field and degree of forward error correction (FEC) changes significantly depending upon the packet type.

Access code 72 bits	Header 54 bits	Payload 0 to 2744 bits

Figure 2. Standard *Bluetooth* packet structure.

Signal Studio software supports 13 different packet types, including both synchronous and asynchronous link type packets. The *Creating signals section* of this document provides additional detail about the structure of these packets and explains how to configure them using Signal Studio.

Connecting to the ESG

The Signal Studio software must be installed in a host computer prior to creating *Bluetooth* test signals. Before attempting to download waveforms to the instrument, verify that the host PC is communicating with the ESG. For additional information on connecting to the signal generator, refer to the *E4438C Signal Studio Installation Guide*, available on the website: **www.agilent.com/find/signalstudio**.

Creating signals

This section describes how to configure and download *Bluetooth* signals to the ESG using the Signal Studio software. There are four basic steps:

Step 1 - Configure the *Bluetooth* signal
Step 2 - Setup the signal generation parameters
Step 3 - Configure the ESG
Step 4 - Calculate and download

Step 1 Configure the *Bluetooth* signal

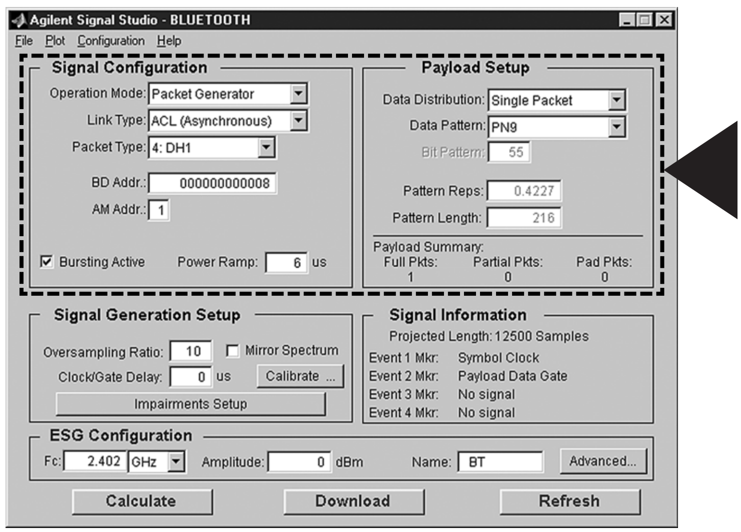


Figure 3. Signal configuration and payload setup menus.

The signal configuration and payload setup menus provide an intuitive interface for constructing *Bluetooth* modulated data streams and fully coded *Bluetooth* packets, (Figure 3). To distinguish the type of signal being configured, an **Operation Mode** pull-down menu is provided in the signal configuration menu, (Figure 4). Two modes of operation are available to choose from: data stream and packet generator.

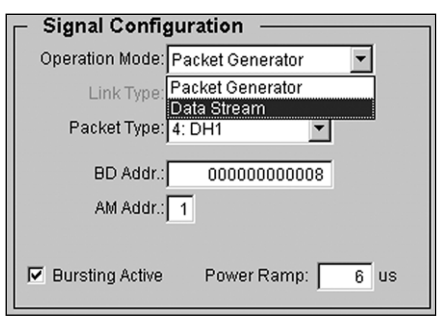


Figure 4. Operation mode pull-down menu.

continued on page 7

Creating signals

Data stream mode

When operating in data stream mode, a waveform comprised of a continuous non-bursted stream of data can be configured. This type of waveform is typically used as an interference signal or a basic test signal that doesn't require decoding to perform BER analysis. The signal configuration and payload setup menu parameters used to configure *Bluetooth* packet structures (link type, packet type, device address, etc.) are disabled in data stream operating mode. Only fields necessary to configure a non-bursted raw data stream can be modified.

To configure the data stream, select the desired data pattern in the payload setup menu. The length of the data stream can be defined by either setting the number of bits in the length field or setting the number of times the pattern is repeated in Repetitions field.

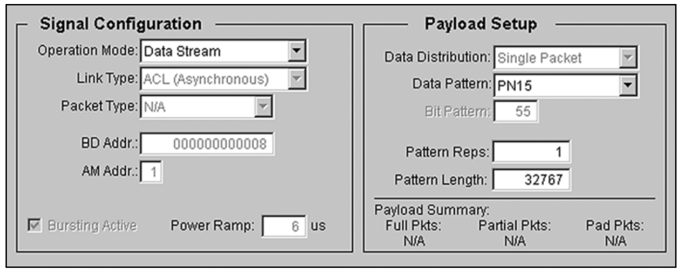


Figure 5. Setup for continuous PN15 *Bluetooth* modulated interference signal.

For example, to configure a continuous PN15 *Bluetooth* modulated interference signal, select PN15 in the data pattern pull-down menu and enter 1 in the pattern repetition field, Figure 5. Alternatively, 32767 could have been entered into the length field. When the repetitions field is modified, the length field is automatically updated, and vice versa. When downloaded to the ESG, the baseband generator will continuously repeat this data pattern during waveform playback.

Packet generator mode

When operating in packet generator mode, the software creates fully coded, standard-based *Bluetooth* packets. Table 1 provides a summary of the different packets that can be configured using the software.

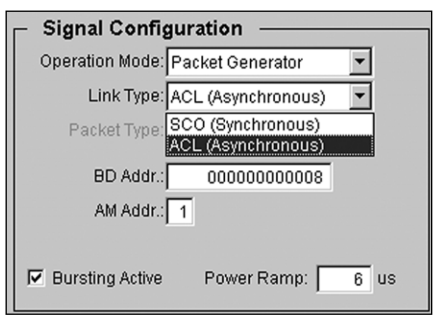


Figure 6. Link type pull-down menu.

To configure a packet, first set the link type pull-down menu to ACL or SCO, Figure 6. Then select the desired packet in the packet type pull-down menu. A different set of packets is available to choose from in the packet type pull-down menu depending on which link type is selected, see Table 1. Control packets are always available because they are common to both link types.

continued on page 8

Creating signals

Packet	Type				Description	Length (Slot)
	ACL	SCO	Control	Code ($b_3b_2b_1b_0$)		
DH1	•			0100	High data rate packet	1
DH3	•			1011	High data rate packet	3
DH5	•			1111	High data rate packet	5
DM1	•	•		0011	Medium data rate packet	1
DM3	•			1010	Medium data rate packet	3
DM5	•			1110	Medium data rate packet	5
AUX1	•			0001	Auxiliary packet	1
HV1		•		0101	High quality voice packet	1
HV2		•		0110	High quality voice packet	1
HV3		•		0111	High quality voice packet	1
NULL			•	0000	Null packet	1
POLL			•	0001	Poll packet	1
ID			•	n/a	Identification packet	1

Table 1. Summary of packet types that can be configured using *Bluetooth* Signal Studio software.

ACL and SCO packets

The Signal Studio software performs the all the necessary coding to create the selected packet type; including Forward Error Correction (FEC) and Cyclic Redundancy Check (CRC) for the header and payload fields when required. As a result, the process for configuring the different ACL and SCO packets is very similar. Only a few basic parameters need to be set so that the access code, header, and payload fields of the *Bluetooth* packet can be created.

Access code

The access code field is created based on the user-defined *Bluetooth* Device Address (BD ADDR). The BD ADDR is a unique 48-bit device address allocated to each *Bluetooth* transceiver. To configure the BD ADDR, enter a 48-bit device address in hexadecimal notation (most significant bit to least significant bit).

Header

The Header field is created using the type code of the selected packet type and the Active Member Address (AM ADDR) of the *Bluetooth* device for which the packet is intended. The AM ADDR is a 3-bit address used to distinguish between the active participating slaves on a piconet. To configure the AM ADDR, enter the 3-bit address in octal notation (most significant bit to least significant bit).

Payload

The structure of the payload field varies depending on which packet type is selected. Table 2 provides a summary of the payload field structure for all packet types supported by the software. Additional details regarding the packet structure can be found in the *Bluetooth System Specification*.

continued on page 9

Creating signals

Packet	Access code field	Header field	Payload field	Payload summary			
				Header (bytes)	User data (bytes)	FEC	CRC
DH1	•	•	•	1	0 to 27	no	yes
DH3	•	•	•	2	0 to 183	no	yes
DH5	•	•	•	2	0 to 339	no	yes
DM1	•	•	•	1	0 to 17	2/3	yes
DM3	•	•	•	2	0 to 121	2/3	yes
DM5	•	•	•	2	0 to 224	2/3	yes
AUX1	•	•	•	1	0 to 29	no	no
HV1	•	•	•	n/a	10	1/3	no
HV2	•	•	•	n/a	20	2/3	no
HV3	•	•	•	n/a	30	no	no
NULL	•	•					
POLL	•	•					
ID	•						

Table 2. Basic structure of the packets supported by *Bluetooth* Signal Studio software.

The payload setup menu offers a variety of custom payload data configurations for single and multi packet sequences. First select whether the data pattern is to be distributed into a single packet or over a multiple packet sequence using the data distribution pull-down menu.

Configuring a single packet

When single packet is selected (Figure 7), the software creates a waveform that consists of one *Bluetooth* packet. When downloaded to the ESG, the waveform is repeatedly played back resulting in a packet sequence comprised of identical packets.

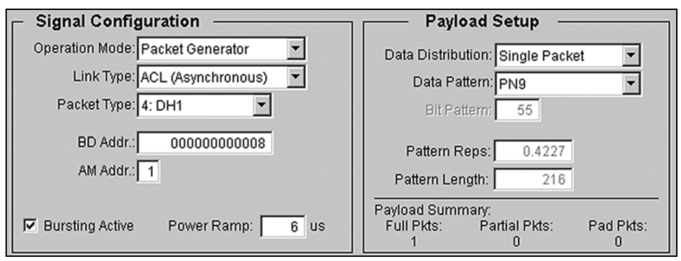


Figure 7. Example single packet setup.

The user data portion of the payload field, for the selected packet type, is filled to capacity with the data type selected in the data pattern pull-down menu. If PN data patterns are selected, the PN sequence is truncated after the maximum amount of user data has been placed in the packet.

The length and repetition fields are automatically updated as different packet types and data sequences are selected; however, these fields cannot be modified when single packet has been selected in the data distribution pull-down menu.

Configuring a multiple packet sequence

When multi packet is selected (Figure 8), the software creates a waveform that consists of a multiple packet sequence. A data pattern is distributed into the user data portion of each packet in the sequence. Once downloaded to the instrument, the signal generator repeatedly plays back the entire packet sequence. The net result is the ability to configure longer data sequences for analysis.

continued on page 10

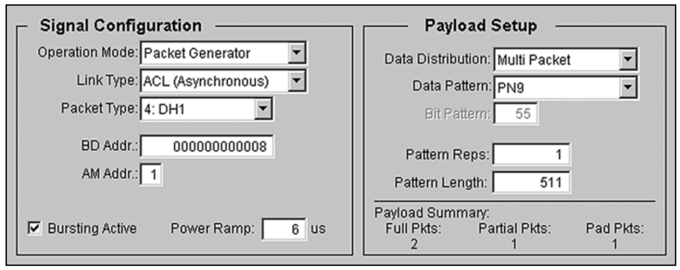


Figure 8. Example multi packet sequence setup.

The data type selected in the data pattern pull-down menu is spread over the user data portion of the packet sequence, Figure 9. The length of the data stream can be defined by either setting the number of bits in the length field or the number of times the pattern is repeated in repetitions field. When either of these fields is modified, the other is automatically updated. The number of packets required to accommodate the length and repetition field setting is automatically updated in the payload summary section of the menu.

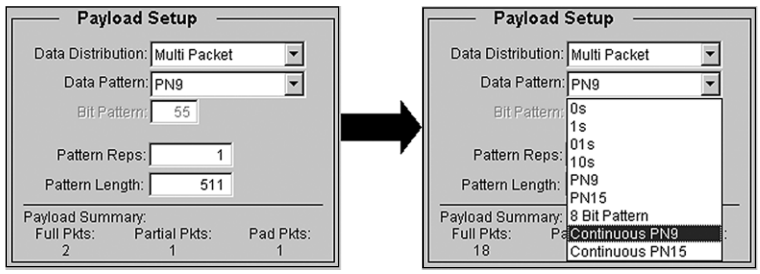


Figure 9. Data pattern pull-down menu.

The user payload of each packet in the sequence is filled to capacity with the selected data pattern if possible. When the length of the data pattern is selected such that it is not divisible by an integral number of packet payloads, a packet with a partial payload is generated to accommodate the remaining portion of the data pattern. This packet is then appended to the sequence of full packets.

Note: The user payload portion of a *Bluetooth* packet must be filled with an integral number of data bytes. Zeroes are appended to the selected data pattern if the length of the sequence does not end on an integer number of user data bytes for the selected packet type.

Two packet sequence presets, continuous PN9 and continuous PN15, are provided in the data pattern pull-down menu when multi packet is selected, Figure 9. These presets are intended to simplify the setup process when configuring a packet sequence with continuous PN data distributed over the user data portion of each packet payload. When continuous PN9 or PN15 is selected in the data pattern pull-down menu, the software automatically configures the length and repetitions fields, Figure 10. The number of packets required to accommodate the selected continuous PN pattern is also automatically determined and updated in the *Payload summary section*.

continued on page 11

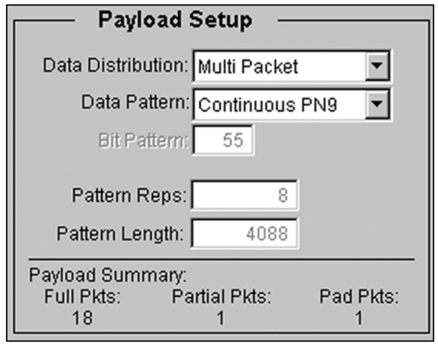


Figure 10. Payload setup for a multi packet sequence with continuous PN9 user data.

Payload summary section

Full packets – Number of packets with user payload filled to capacity.

Partial packets – Because the user payload portion of each packet is filled to capacity if possible, the number of partial packets appended to the end of a packet sequence will always be zero or one.

Pad packets – When the software creates a multiple packet sequence, the sequence bit in the header field is toggled after each packet transmission in the sequence. This indicates to the *Bluetooth* device that the incoming packet is not a re-transmitted packet. To maintain an alternating sequence bit when the waveform is repeatedly played back, an even number of packets must be generated. If the data pattern length is set such that an odd number of packets are required to send the data, then a pad packet is appended to the end of the packet sequence. The pad packet has no payload and is only generated in this circumstance to accommodate the alternating sequence bit.

Control packets – As indicated in Table 2, the ID, NULL, and POLL packets do not contain a payload field. As a result, the payload setup menu is disabled when one of these packet types is selected in the packet type pull-down menu.

NULL and POLL packets are composed of an access code and header field (126-bit fixed length). When configuring NULL and POLL packets, only the BD ADDR and AM ADDR need to be set.

The ID packet is comprised of only an access code (68-bit fixed length). Because the ID packet does not contain header and payload fields, only the BD ADDR needs to be configured.

Bursting – In packet generator mode, bursting can be enabled or disabled in the signal configuration menu. When enabled, the packet transmission timing of the test signal adheres to the *Bluetooth* TDD slot structure for the selected packet type. A summary of the transmission rates for each the packet types supported by the software is provided in Figure 11.

continued on page 12

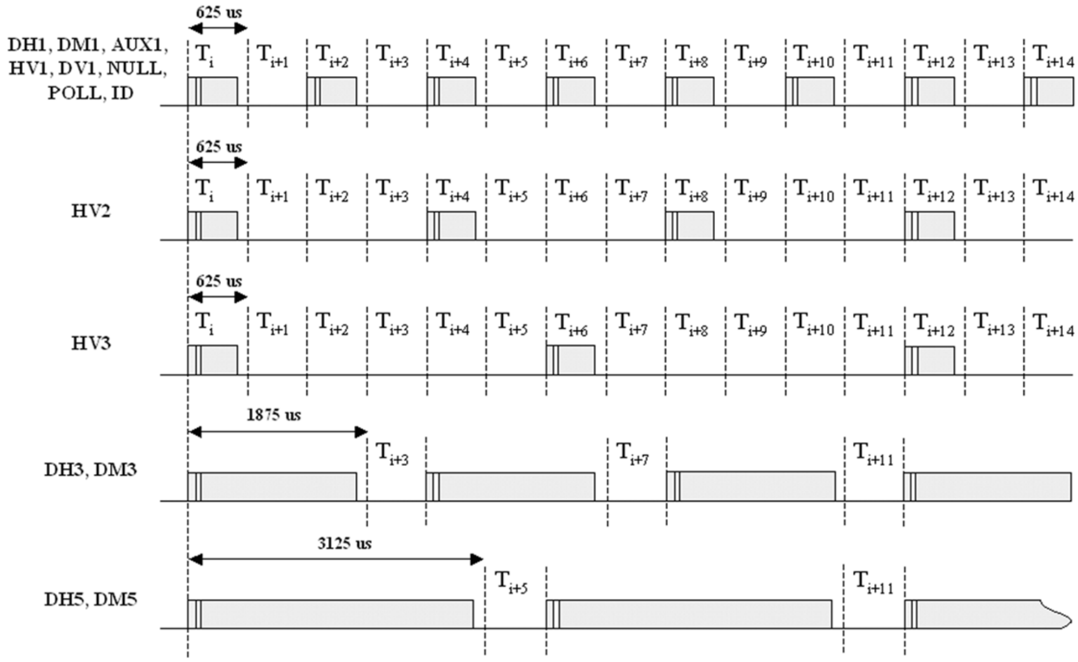


Figure 11. Bursted transmission timing relationships for different packet types.

At the beginning and end of a packet transmission, the ESG ramps power following a user defined burst profile. The burst profile is defined by setting the number of microseconds, prior to the first symbol transmission, over which the carrier frequency is ramped from idle power to transmit power, Figure 12. The same burst profile is used to transition the carrier from transmit power level to idle power level after the last symbol of the packet has been transmitted.

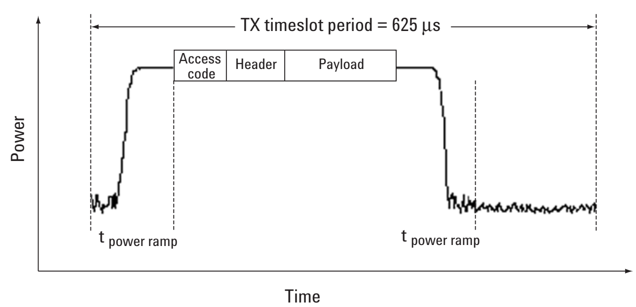


Figure 12. Burst profile of a single slot packet transmission.

A reference burst profile for signal generator test signals is indicated in the Bluetooth RF test specification. This reference is used as the default burst profile setting for signals created using the *Bluetooth* Signal Studio software. To deviate from the reference burst profile, modify the Power Ramp field. Keep in mind that as the rise/fall time of the bursted signal is decreased, the amount of spectral splatter due to bursting is increased.

When bursting is disabled, the ESG transmits concatenated packets with no power ramping. The effect of disabling bursted transmission is shown in Figure 13. Notice that there is no off time between packets when bursted packet transmission is disabled. This concept can be extended to all the packet types shown in Figure 11. This non-bursted transmission structure is similar to data stream mode; however, in data stream mode there is no packet structure associated with the data transmission.

continued on page 13

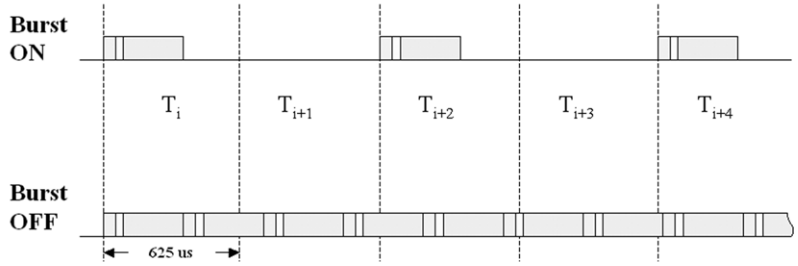


Figure 13. Bursted and non-bursted single slot packet transmission.

Step 2 Setup the signal generation parameters

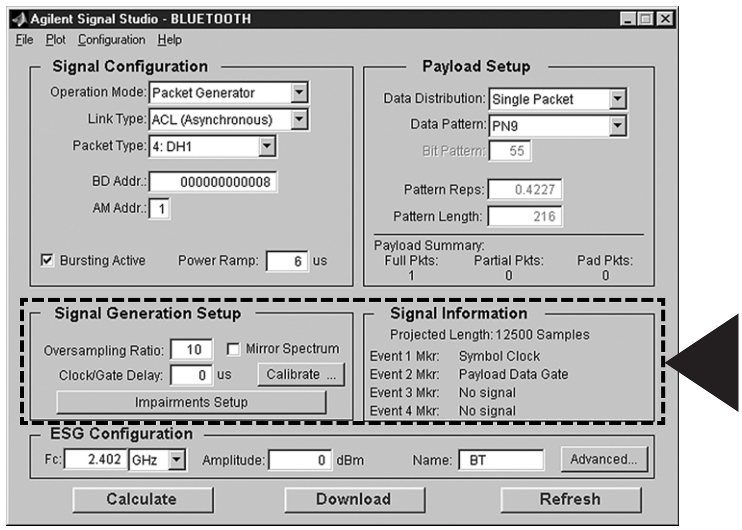


Figure 14. Signal Generation Setup and signal information menus.

The signal generation setup menu, boxed in Figure 14, provides a simple interface for defining the oversampling ratio, mirroring the spectrum, delaying clock and gate signals, and adding signal impairments.

Oversampling ratio

The oversampling ratio defines the number of samples calculated per I/Q symbol. Increasing the oversampling ratio of the signal increases the separation of the sampling images from the desired signal. This allows for better image rejection by the baseband reconstruction filter. However, the improved image rejection comes with a price. Increasing the oversampling ratio increases the waveform calculation time and file size. Notice that the projected file length in the signal information section is updated as the oversampling ratio setting is increased. The default setting is sufficient for most applications. Additional benefits of modifying the oversampling ratio are discussed in the *Clock/gate delay* section.

Mirror spectrum

Enabling the mirror spectrum feature inverts the Q channel, resulting in a mirrored spectrum. As a signal normally propagates through the different functional blocks of a receiver, for example the mixer block, the signal spectrum may be reversed. Using this feature facilitates realistic testing of receiver functional blocks that would normally be presented with a mirrored spectrum signal.

continued on page 14

Clock and gate signals

The Signal Studio software makes use of the ESG markers to generate clock and gate signals along with the configured waveform. These signals are necessary to perform BER analysis on *Bluetooth* packets and data streams using the ESG internal BER analyzer.

A symbol clock is generated on the ESG event 1 port for all waveforms created using the *Bluetooth* Signal Studio software. Because *Bluetooth* is 2-level FSK modulated (1 bit/symbol), the symbol clock can be used to indicate the bit rate of the incoming data sequence to the ESG internal BER analyzer. When operating in packet generator mode, a payload data gate signal is also provided on the ESG Event 2 port. This gate signal is used to recover continuous PN9 payload data from an incoming *Bluetooth* packet sequence for BER analysis. Refer to the *Basic measurements* section for a detailed example of how these signals are used to perform BER analysis.

Clock/gate delay

When clock and gate signals generated by the ESG are used to perform BER analysis, it is important to realize that the test signal transmitted by the ESG experiences a propagation delay through the device under test. As a result, the demodulated loopback signal must be realigned in time with the clock and gate signals at the input of the BER analyzer, Figure 15. Delay control over the clock and gate signals is provided by the software to enable realignment with the test signal at the input of the BER analyzer.

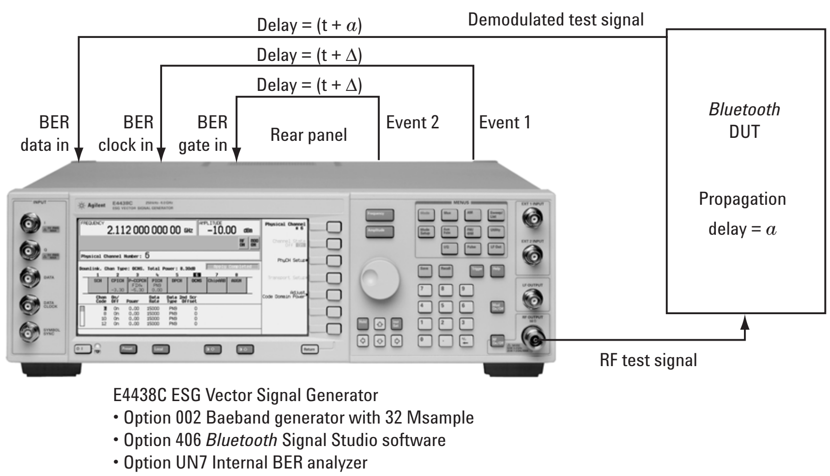


Figure 15. To perform BER analysis using this measurement setup, the clock/gate delay setting (Δ) must be equal to the propagation delay the test signal experiences through the Bluetooth device (a).

If the propagation delay characteristics for the device under test are known, enter the delay value in the clock/gate delay field during waveform configuration. The clock and gate signals associated with the waveform will be delayed by the indicated amount during waveform playback. The resolution of the clock/gate delay parameter is directly coupled to the oversampling ratio setting. It can be determined by dividing the symbol period (1 μs) by the oversampling ratio. To increase the incremental delay resolution, increase the oversampling ratio of the configured waveform. When doing so, remember that increasing the oversampling ratio also increases the projected length of the waveform.

continued on page 15

Creating signals

Clock/gate delay calibration

If the delay parameter is unknown, leave the default value (0 µs) in the clock/gate delay field and finish configuring the waveform. After the waveform has been calculated, the automated clock/gate delay calibration utility can be used to determine the delay characteristics of the device under test.

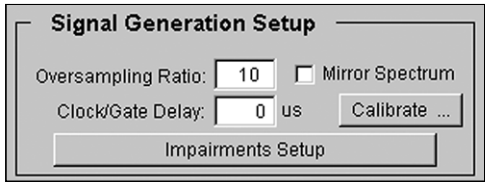


Figure 16. Signal generation setup menu.

After the waveform has been downloaded to the ESG, select the calibrate button in the signal generation setup menu (Figure 16) to bring up the clock/gate delay calibration utility (Figure 17). Once configured, the calibration utility generates a plot of BER vs. clock/gate delay. From the plot, the correct clock gate delay setting to realign the signals at the input of the BER analyzer can be determined.

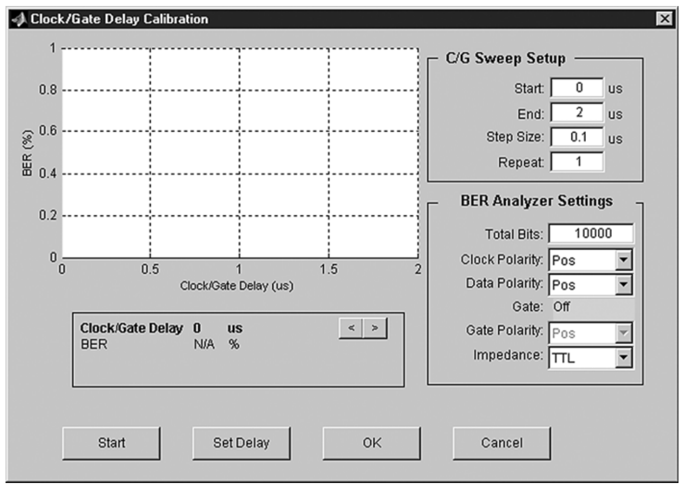


Figure 17. Clock/gate delay calibration utility.

The clock/gate sweep setup menu is used to configure the calibration utility, Figure 18. Enter the clock/gate delay range in the start and end fields. Typical propagation delay through a *Bluetooth* device ranges from 1 to 10 µs; however, depending on the test setup, longer delays are possible.

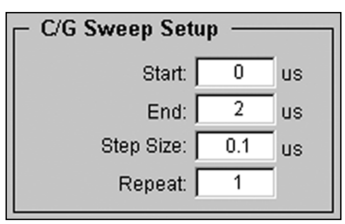


Figure 18. Clock/Gate Sweep Setup menu.

continued on page 16

The incremental delay step at which BER tests are performed is set in the step size field. The resolution of this field is also directly coupled to the oversampling ratio setting as described previously. The repeat field is used to set the number of BER test iterations for each clock/gate delay increment. When this field is set to 2 or greater, the BER results are plotted on the graph for each iteration of the measurement. By increasing the number of BER test repetitions, it can easily be determined if repeatable results are achievable.

The ESG internal BER analyzer settings required to perform the clock/gate delay calibration are also configured remotely using the Signal Studio software, Figure 19. The total number of data bits to be analyzed at each delay increment is set in the total bits field. The gate signal is automatically enabled in packet generator mode and disabled in data stream mode. The default polarity of the clock, data, and gate signals is set to positive. This is the correct setting for the basic measurement setup and should not be modified unless there is a need to do so in a particular application.

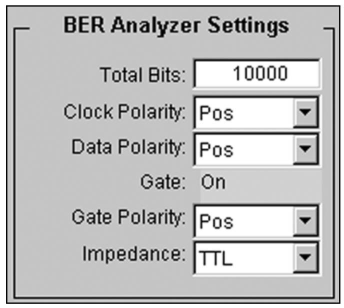


Figure 19. ESG internal BER analyzer setup menu.

Once configured, initiate the BER test sequence by pressing the start button. A plot of BER vs. clock/gate delay will be incrementally filled in as each BER test in the sweep is completed. With no impairments added to the signal, a delay that results in 0% BER should be achievable.

After the plot has been generated, a marker is automatically placed at the clock/gate delay setting with the minimum BER test results. The results section directly below the graph is updated to reflect the marker position. The arrow buttons can be used to incrementally move the marker to other points on the curve. The clock/gate delay setting and corresponding BER are continuously updated in the results section as the marker is moved across the graph. If the Repeat field is set to 2 or greater, the minimum, maximum, and average BER is provided in the results section for each clock/gate delay increment.

An example plot is provided in Figure 20. In this case, the repetitions field was set to 3. The dots indicate the individual results for each clock/gate delay increment (note that some results overlap). The triangles are placed at the average BER for each clock/gate delay increment.

continued on page 17

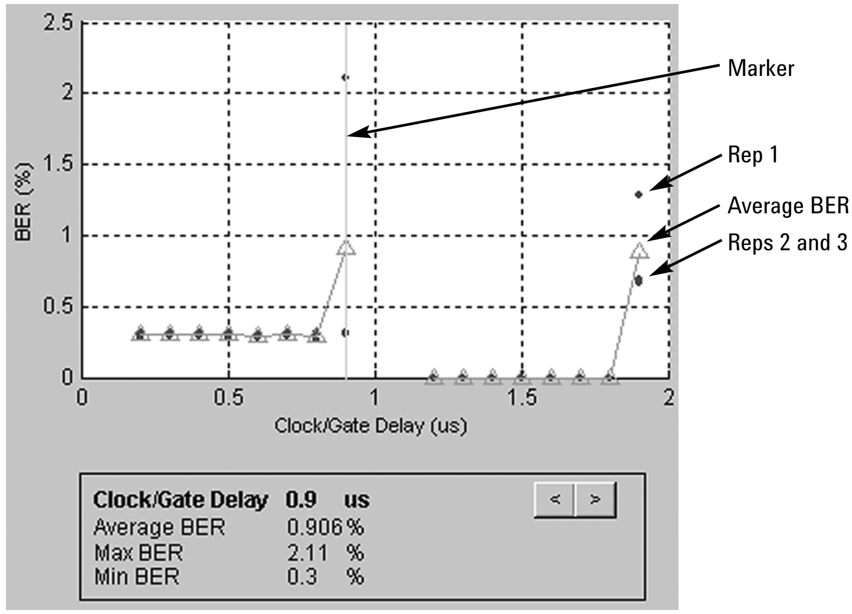


Figure 20. Plot of BER vs. clock/gate delay with repetitions field set to 3.

When the set delay button is selected, the delay setting of the current marker location is returned to the clock/gate delay field in the signal generation setup menu. As a result, it is important to remember to return the marker to the delay setting that yields the minimum BER test results prior to pressing the set delay button.

After pressing the set delay button, select the OK button to close the clock/gate delay calibration utility and return to the main user interface. The BER calibration can be aborted at any time by pressing the cancel button.

An example is provided in the Basic Measurements section of this document that details the measurement setup and procedure for performing clock/gate delay calibration.

Marker rotate SCPI command

To adjust the clock/gate signal delay, the Signal Studio software sends a marker rotate SCPI command to the ESG baseband generator. The marker rotate feature currently only exists in the *Bluetooth* Signal Studio software. There is no equivalent soft key available in the ESG dual arb menu. The marker rotate SCPI command can also be used when setting up custom SCPI based test routines. The command and description are provided below for reference.

Marker rotate
[:SOURce]:RADio:ARB:MARKer:ROTate “filename”, <rotate_count>.
The marker rotate SCPI command shifts the I/Q waveform markers by the indicated number of samples in the rotate_count field. The shift is based on the current position of the markers. The rotate_count cannot exceed +/- (number of sample points - 1).

continued on page 18

Creating signals

Signal impairments

The Signal Studio software provides a straightforward graphical menu for adding impairments to the *Bluetooth* signal. In general, the impairments are derived from the frequency and modulation tolerances specified for *Bluetooth* transmitters. Adding these impairments enables the evaluation of receiver performance with signals realistically anticipated from *Bluetooth* transmitters. All impairments required by the *Bluetooth* RF Test Specification to perform single- and multi-slot sensitivity tests are provided in the *Bluetooth* Signal Studio software.

Clicking the impairments setup button in the signal generation setup menu brings up the impairment configuration menu, Figure 21. Each impairment can be enabled or disabled using the box to the left of the desired impairment.

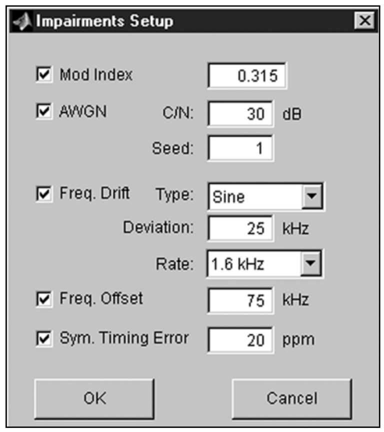


Figure 21. Impairments setup menu.

Carrier frequency offset

This impairment adds a static error to the transmission frequency. It is used to simulate a *Bluetooth* device transmitting at a frequency slightly offset from the specified carrier.

Carrier frequency drift

This impairment adds a dynamic error to the transmission frequency. It is used to simulate a *Bluetooth* device's carrier frequency varying during the transmission of a packet. The frequency drift impairment repeats at the beginning of each timeslot, and occurs across a period of time equal to the duration of the packet. Figure 22 illustrates the carrier frequency drift impairment for a single-slot packet. This concept can be extended to multi-slot packets as well. The maximum frequency drift deviation is user defined. The software provides two types of carrier frequency drift, linear and sinusoidal.

Linear drift
When linear drift is selected, the carrier frequency deviates from the center carrier frequency in a positive or negative linear direction, depending on the drift deviation setting. For example, a drift deviation setting of -15 kHz would cause the carrier frequency to drift in a linear fashion from zero to 15 kHz below the intended carrier frequency.

Sinusoidal drift
When sine drift is selected, the carrier frequency drifts above and below its designated center carrier frequency in a sinusoidal fashion. The sinusoidal drift rate is defined in the Rate pull-down menu.

- Single slot packet, drift rate = 1.6 kHz
- Three slot packet, drift rate = 500 Hz
- Five slot packet, drift rate = 300 Hz

Since packets are slightly shorter than the number of timeslots they occupy, they are not fully impaired by the second half of the drift cycle. Therefore, it is recommended that separate positive and negative drift impairment cases are tested by changing the drift deviation setting (for example, 25 kHz and -25 kHz).

continued on page 19

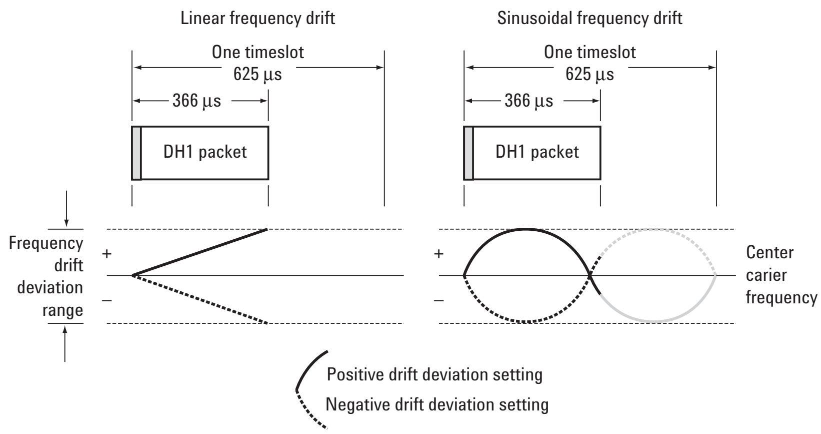


Figure 22. Linear and sinusoidal carrier frequency drift impairment.

Modulation index

The modulation index is the ratio of peak-to-peak frequency deviation to the bit rate. Modifying this parameter impairs the peak-to-peak frequency deviation only.

Symbol timing error

This impairment varies the symbol rate of the *Bluetooth* signal. Adding this impairment adjusts the standard 1 Msymbol/second rate by the set amount.

Additive White Gaussian Noise (AWGN)

This impairment adds noise to the *Bluetooth* signal. Although not required by the *Bluetooth* RF test specification, this impairment enables the simulation of non-ideal environments for receiver performance evaluation. The carrier to noise ratio and the noise seed are user defined. The noise seed initializes the 16-bit shift register used for noise generation. When repeating measurements, using the same noise seed for each measurement iteration increases the probability of replicating test results.

continued on page 20

Step 3 Configure the ESG

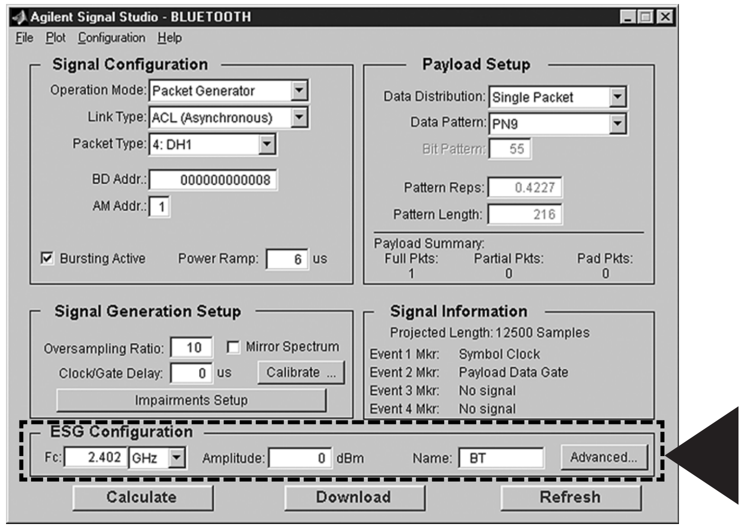


Figure 23. ESG configuration menu.

In addition to the configured *Bluetooth* waveform, the Signal Studio software passes instrument settings to the ESG. These are defined in the ESG configuration menu, boxed in Figure 23.

Basic settings

There are three fundamental ESG settings that must be defined prior to downloading the waveform to the instrument.

Frequency
This field is used to set the frequency at which the ESG will generate the signal.

Amplitude
This field is used to set the power at which the ESG will generate the signal.

Waveform name
The alphanumeric text entered in the Name field will appear in the ESG user interface after the waveform file is downloaded to the instrument. The ESG only recognizes waveforms that are named using the following alphanumeric characters:

- A thru Z
- 0 thru 9
- $ & _ # + - [ ]

If un-supported alphanumeric characters are used to name the waveform, the ESG will generate a file name not found error (Error: -256) when the waveform is downloaded to the instrument. There is a 20-character maximum name length for waveform files.

continued on page 21

Advanced settings

Additional ESG parameters can be accessed by selecting the advanced button in Figure 23. Typically, these parameters should not be modified unless there is a specific reason to do so. A brief description is provided below and additional information on these parameters can be found in the *E4438C ESG Vector Signal Generator Users Guide*.

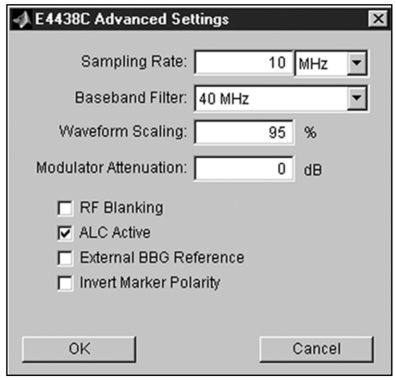


Figure 24. E4438C Advanced settings menu.

Sampling rate
This parameter is automatically set when the oversampling ratio is defined in the signal generation setup menu. It is the rate at which the waveform I/Q samples are read from the baseband generator memory during playback.

Baseband filter
The ESG provides three baseband filters [2.1 MHz, 40 MHz, and 50 MHz (through)]. The bandwidth of the baseband signal (1/2 the RF bandwidth) dictates the minimum reconstruction filter bandwidth to be used. Depending on the oversampling ratio and where the image frequencies appear, a wider bandwidth reconstruction filter may be selected.

Waveform scaling
The waveform scaling parameter is used to reduce the overshoot associated with the DAC interpolation filter. At 100%, some overshoot may occur; therefore the default setting is 95%. Further scaling may help to decrease DAC over-range occurrences.

Modulator attenuation
The modulator attenuation parameter is used to reduce the signal level driving the I/Q modulation block. Adjusting the attenuation may reduce signal distortion and improve the overall dynamic range. The recommended setting is 10 dB attenuation.

RF blanking
When enabled, RF blanking improves the signal quality by increasing the on/off ratio of the RF bursts. The ESG Event 2 marker is internally routed to provide the RF blanking signal. When RF blanking is active, the ALC is enabled only for the RF burst duration and disabled otherwise.

Note: When RF blanking is enabled, the marker polarity must be set to positive or the wanted RF signal will be blanked resulting in no RF output from the ESG.
Note 2: When RF blanking is enabled, the payload gate signal is no longer generated on the Event 2 port.

ALC active
When enabled, the automatic level control (ALC) constantly monitors and controls the RF output power of the ESG. There are some modulation conditions, which the ALC circuit cannot handle properly. For example, when RF blanking is disabled, DH3 and DH5 packets experience slight amplitude variation during the packet transmission. This is due to the ALC trying to correct for the bursted transmission. In these conditions, turning the ALC off and using the ESG power search feature can achieve better power level accuracy.

continued on page 22

External BBG reference
The ESG baseband generator uses an internal reference clock as its time base. Alternatively, an external reference clock can be used as the time base by selecting External BBG reference. If an external reference is used, it should be connected to the ESG prior to downloading waveform and instrument settings.

Invert marker polarity
Selecting invert marker polarity changes the polarity of the ESG event 1 and event 2 markers from positive to negative. The event 1 marker is used to generate the symbol clock and the event 2 marker is used to generate the payload data gate. Both signals are TTL level. Access to these signals is provided on the rear panel of the ESG. The default setting, positive, is correct if the marker signals are directly routed to the ESG internal BER analyzer clock and gate in ports.

Step 4 Calculate and download

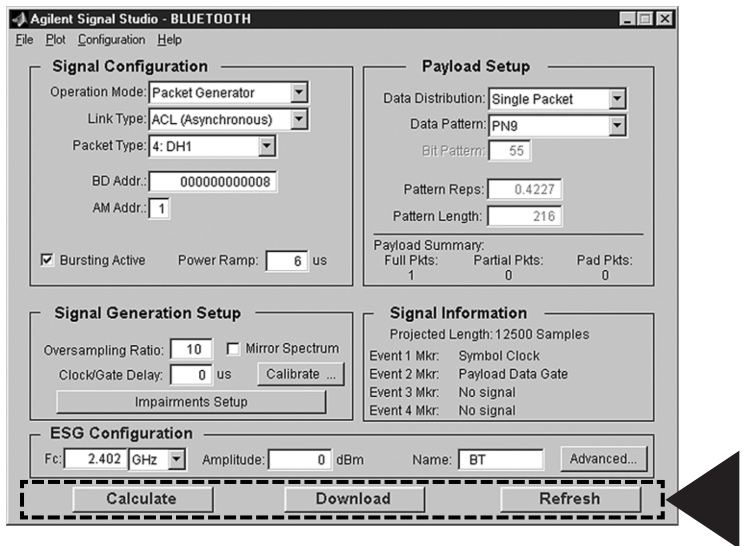


Figure 25. Calculate, download, and refresh functions.

Once the waveform and ESG settings have been configured, the final step is to calculate the waveform and download it to the instrument, Figure 25.

Calculating waveforms

To initiate waveform calculation, select the calculate button. The software will generate an I/Q waveform file in accordance with the current signal configuration. Waveform calculation typically takes only a few seconds.

Plotting waveforms

After the I/Q waveform has been calculated, the Signal Studio software can generate a plot of the baseband spectrum, I/Q waveforms, and CCDF curve. To plot the spectrum, choose Plot → Spectrum from the menu keys at the top of the main user interface window, Figure 25. The plot can be magnified using the zoom feature in the Tools pull-down menu at the top of the plot, Figure 26. Simply select the zoom feature and use the mouse pointer to select the section of the plot to be affected. Plots of the I/Q waveforms and CCDF curve can be generated in a similar manner.

continued on page 23

Creating signals

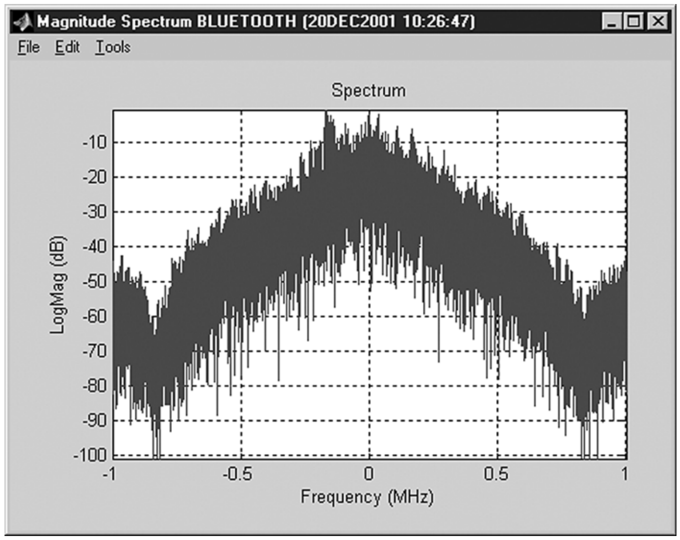
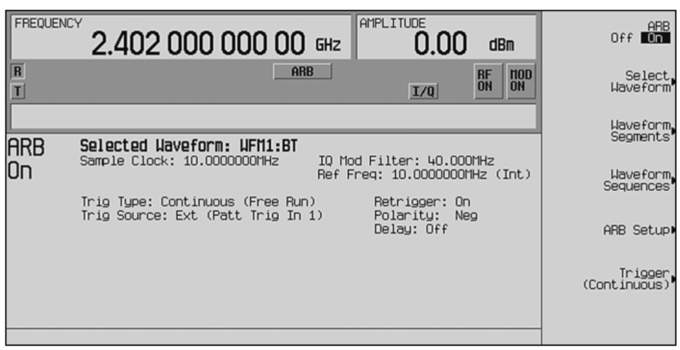


Figure 26. Spectrum plot of the *Bluetooth* I/Q waveform.

Downloading waveforms

Select the download button, Figure 25, to send the calculated I/Q waveform file and the signal generator setting to the instrument. The signal generator automatically begins producing the *Bluetooth* modulated RF signal. Local control of the instrument is then re-enabled and signal generator settings can be modified from the instrument's front panel. If the instrument is in its initial start-up state or in another personality prior to downloading a waveform from Signal Studio, it may be helpful (but not necessary) to set the ESG into dual arb mode. This will reduce confusion after the waveform has been downloaded to the signal generator, because the waveform name and state of the instrument is clearly labeled in the dual arb user interface (see Figure 27). Only the instrument settings can be modified from the signal generator's front panel, the waveform files cannot be modified once they have been downloaded to the instrument.



continued on page 24

Creating signals

Saving the Signal Studio setup

The Signal Studio software configuration can be saved to the host computer's local hard drive. The configuration can then be recalled at any time to re-calculate and download the waveform to the signal generator. This is especially useful when complex packet configurations have been created in the software. From the menu keys at the top of the window in Figure 25, choose File → Save As, and then name the file and save it in the Agilent\Signal Studio\E4438C\Bt directory. The software configuration can be recalled anytime by choosing the following menu options: File → Open, then the file name.

Saving waveforms

After the calculated I/Q waveform has been downloaded to the signal generator for playback, it can be saved in the ESG non-volatile memory for storage and recalled at anytime for playback. Note that the instrument states are not stored in non-volatile memory along with the waveform. As a result, the ESG settings like frequency, amplitude, filter setting, ALC setting and sample rate will need to be reconfigured from the instrument's front panel when recalling waveforms from non-volatile memory for playback. Alternatively, when the waveform is initially downloaded to the instrument, the ESG instrument states can be saved using the SAVE hard key on the ESG front panel. The instrument state can then be recalled prior to selecting the desired waveform from non-volatile memory for playback. For more information on saving waveforms to the instrument, refer to the *E4438C ESG Vector Signal Generator Users Guide*. The I/Q waveform files created by the Signal Studio software cannot be stored outside the instrument.

Sequencing waveforms

The ESG baseband generator is capable of sequencing several waveform segments. If multiple *Bluetooth* waveform files are configured and downloaded to the instrument, custom packet sequences can be created. Setting up waveform sequences is accomplished through the ESG dual arb user interface, not in the Signal Studio software. For more information on setting up waveform sequencing, refer to the *E4438C ESG Vector Signal Generator Users Guide*.

Refresh

The refresh function is used to update ESG configuration parameters, like frequency and amplitude, without recalculating the waveform. For example, after the waveform has been downloaded to the instrument, the Frequency field can then be modified. To initiate the change, select the refresh button, and a SCPI command is sent to the ESG to modify the frequency setting.

Receiver measurements

The *Bluetooth* RF test specification outlines several test scenarios under which receiver performance must be verified. Theses tests are intended to ensure that receivers in all *Bluetooth* devices meet a minimum performance criterion. A general overview of the *Bluetooth* receiver test cases can be found in *Application Note 1333-1:* Bluetooth *RF Measurement Fundamentals*.

ESG BER analysis capability

When performing *Bluetooth* receiver measurements, bit-error-rate (BER) is used as a gauge to verify compliant operation. This section describes the ESG vector signal generator's BER analysis capabilities.

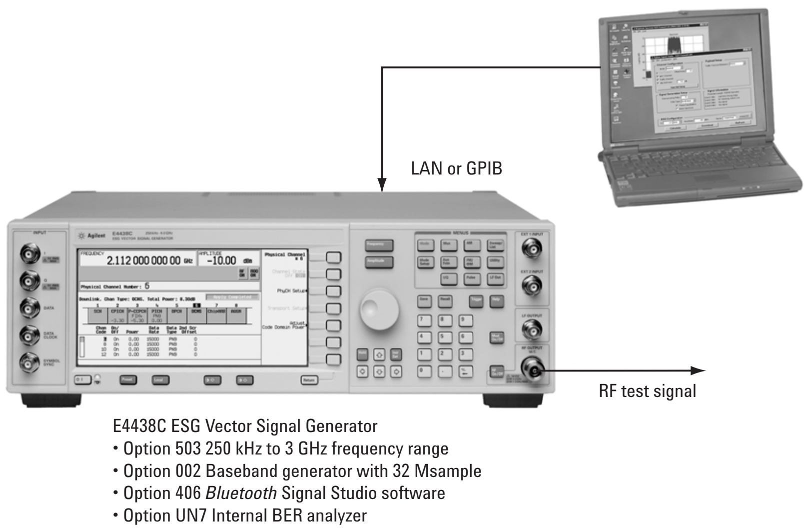


Figure 28. ESG configuration required to perform *Bluetooth* BER analysis.

The ESG internal BER analyzer is capable of analyzing framed and unframed continuous PN9, PN11, PN15, PN20, and PN23 baseband data sequences only. Performing BER analysis on unframed data requires two signals (data and clock) while framed data requires three signals (data, clock, and gate). The clock signal is used to indicate the bit rate of the incoming data sequence to the BER analyzer. The gate signal is used to enable the BER analyzer only when the continuous PN9 or PN15 baseband data portion of a frame is present for analysis. When performing *Bluetooth* BER measurements, the gate signal is used to recover the continuous PN9 payload data portion of a *Bluetooth* packet sequence. Figure 28 indicates the required ESG configuration to perform BER analysis on *Bluetooth* signals generated by Signal Studio.

BER measurement setup

The ESG does not establish a link with a *Bluetooth* device; however, different BER measurement setups can still be achieved on *Bluetooth* devices that internally implement various test modes. These test modes do not require a link to be established. The most common are the "continuous receive" test modes and a "loopback" test modes. Measurement setups for both are discussed below.

"Continuous receive" operating mode

A *Bluetooth* device in "continuous receive" operating mode must provide access to the demodulated *Bluetooth* signal in order to perform BER measurements. Access is typically provided at the FM demodulator or baseband processor output. The ESG BER analyzer data input impedance is TTL compatible. If the recovered baseband signal is not a TTL level signal, then external circuitry is required to convert the recovered baseband signal to TTL level.

An example BER measurement setup is illustrated in Figure 29. In this setup, the ESG is configured to provide a *Bluetooth* modulated RF signal using Signal Studio. The RF test signal consists of a sequence of *Bluetooth* modulated DH1 packets with continuous PN9 payload data.

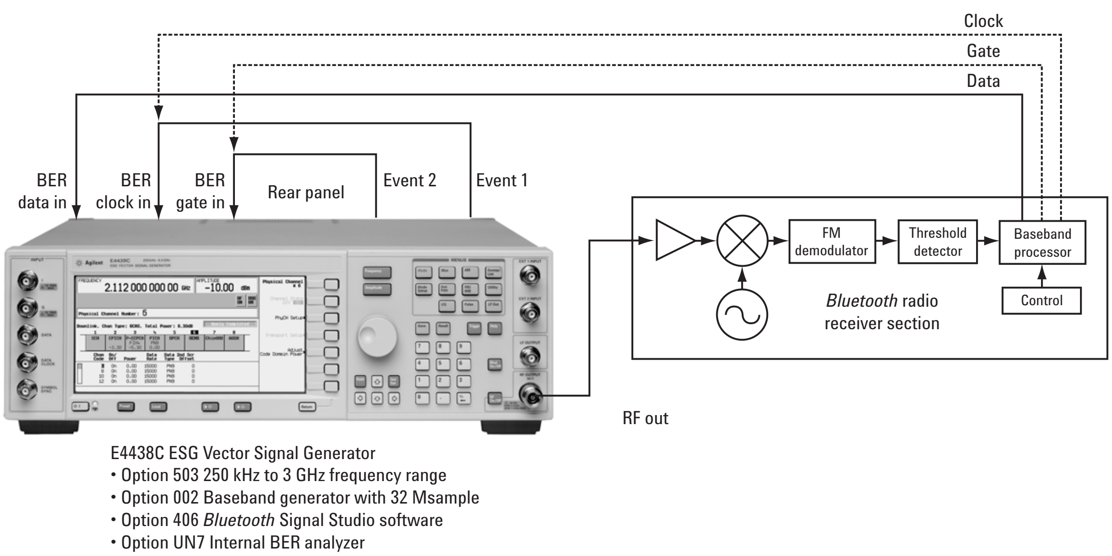


Figure 29. BER test setup for a *Bluetooth* device in "continuous receive" operating mode.
Note: Dashed lines indicate alternate configurations.

continued on page 27

Basic measurements

The *Bluetooth* receiver demodulates the signal transmitted by the ESG and provides access to the *Bluetooth* baseband signal (packets or continuous data stream) at the baseband processor output. This signal (assumed TTL level) is routed to the ESG internal BER analyzer data input.

If recovered clock and gate signals are also available from the *Bluetooth* device's baseband processor, these signals should be used to perform the BER analysis. Using these signals provides a more functional test of receiver clock recovery capability. Furthermore, these signals have experienced the same propagation delay as the demodulated *Bluetooth* signal. Hence, they do not need to be realigned at the input of the BER analyzer.

If the *Bluetooth* device does not provide the clock or gate signal, the clock and gate signals generated by the ESG can be used to perform the BER analysis. The delay setting found using the Signal Studio clock/gate delay calibration feature should be used to realign the clock/gate signals generated by the ESG with the demodulated *Bluetooth* signal at the input of the BER analyzer.

"Loopback" operating mode

The ESG is not capable of demodulating a *Bluetooth* RF signal. Therefore, to perform BER analysis on a *Bluetooth* device operating in a "loopback" test mode, additional equipment is required to demodulate the *Bluetooth* RF loopback signal. In the test setup shown in Figure 30, the ESG Vector Signal Generator and ESA-E series spectrum analyzer combine to provide a powerful BER test solution for *Bluetooth* devices operating in "loopback" mode.

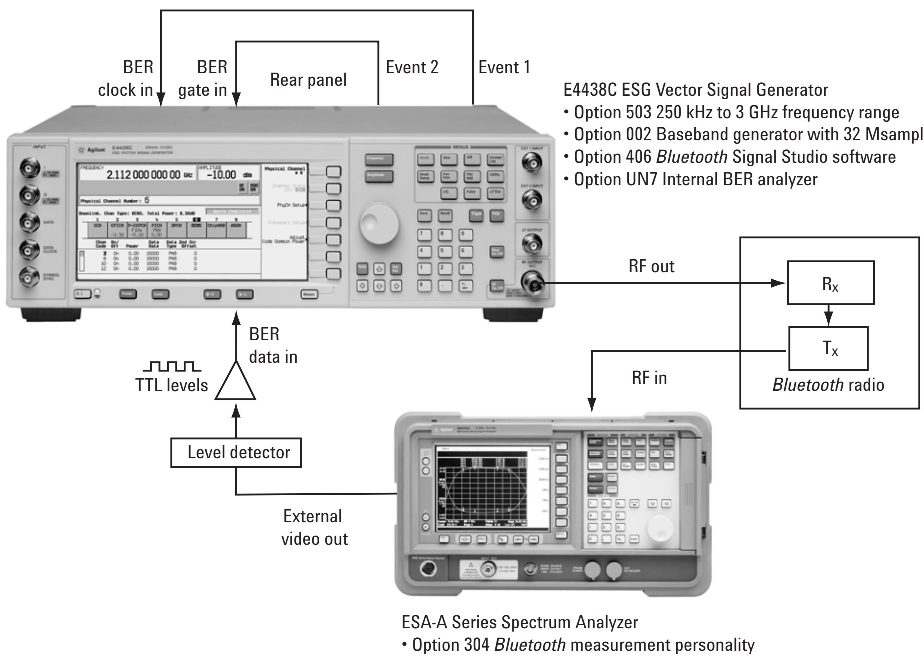


Figure 30. BER test setup for a *Bluetooth* device operating in "loopback" mode.

continued on page 28

Basic measurements

In this example, the ESG is configured to provide a *Bluetooth* modulated RF signal using the Signal Studio software. The RF test signal consists of a sequence of *Bluetooth* modulated DH1 packets with continuous PN9 payload data.

In "loopback" mode, the *Bluetooth* device receives, demodulates, and decodes the RF signal transmitted by the ESG. The device then re-transmits the recovered continuous PN9 payload data in the same packet type that it received from the ESG. The *Bluetooth* device's internal test mode must be capable of this operation to perform BER analysis in this configuration.

The ESA-E series spectrum analyzer with the *Bluetooth* measurement personality is used to receive and demodulate the RF loopback signal from the *Bluetooth* device. Access to the demodulated signal is provided on the External Video Out port of the ESA-E. Because this signal is not TTL level, external circuitry is required to condition the signal to TTL level prior to feeding it to the ESG internal BER analyzer.

The clock and gate signals generated by the ESG are used to recover the continuous PN9 payload data portion of the *Bluetooth* packet for BER analysis. The delay setting found using the Signal Studio clock/gate delay calibration feature should be used to realign the clock/gate signals with the demodulated *Bluetooth* signal at the input of the BER analyzer.

BER measurement example – Clock/gate delay calibration

This example illustrates the procedure for performing clock/gate delay calibration using Signal Studio. In this example, the measurement setup illustrated in Figure 31 is used. This is very similar to the test setup illustrated in Figure 29; however, for demonstration purposes, the Agilent ESA series spectrum analyzer (with the *Bluetooth* measurement personality) is used to demodulate the *Bluetooth* signal generated by the ESG instead of an actual *Bluetooth* receiver.

Note: The ESA does not decode the *Bluetooth* signal. Therefore, packets that implement FEC on the payload data portion of the packet should not be used in this test setup.

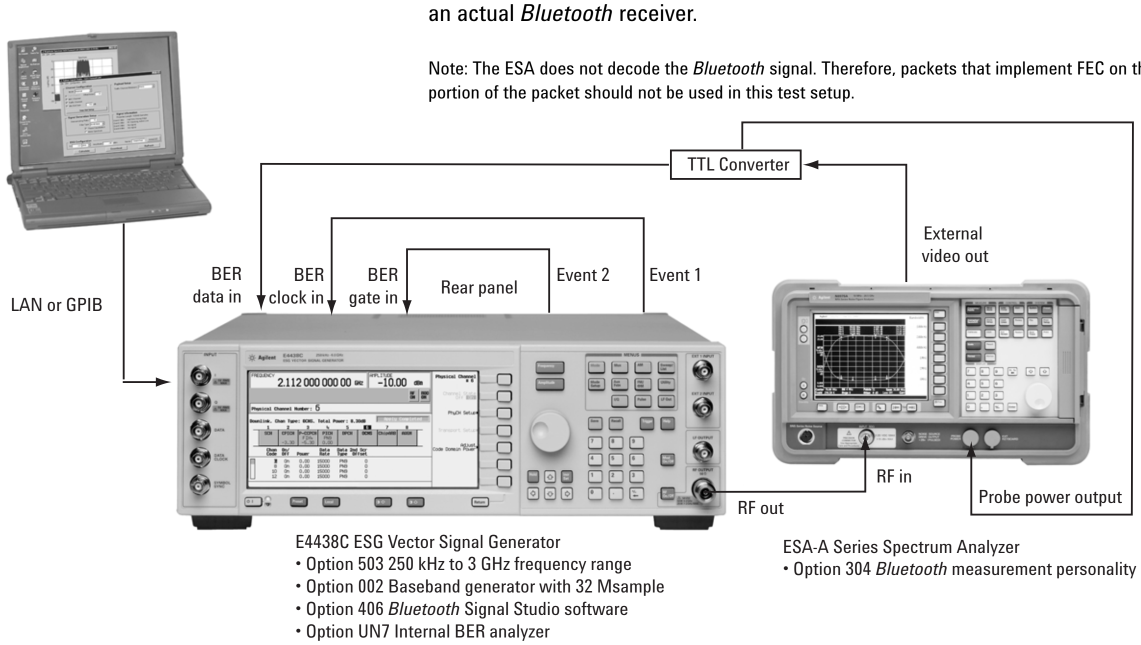


Figure 31. Example BER measurement setup using the ESA to demodulate the *Bluetooth* signal generated by the ESG.

continued on page 29

Instrument instructions for performing measurements:
Keystrokes surrounded by [ ] indicate hard keys located on the instrument front panel.
Keystrokes surrounded by { } indicate soft keys located on the right side of the display.

Procedure

1. Connect the test setup as shown in Figure 31 and preset the ESG.

Instructions: **E4438C ESG vector signal generator**	**Keystrokes:** **E4438C ESG vector signal generator**
Preset the instrument	[Preset]

2. Configure the ESA to demodulate the Bluetooth signal generated by the ESG.

Instructions: **E4402B ESA**	**Keystrokes:** **E4402B ESA**
Preset the instrument	[Preset]
Set the frequency to *Bluetooth* channel #1 (2.402 GHz)	[Frequency] [2.402] {GHz}
Set the span to 0 Hz	[Span] {Zero Span}
Set the resolution bandwidth to 5 MHz	[BW/Avg] {Resolution BW} [5] {MHz}
Set the video bandwidth to 3 MHz	{Video BW} [3] {MHz}
Set the sweep time to 40 us	[Sweep] {Sweep Time} [40] {us}
Set the trigger to continuous	[Trig] {Free Run}
Turn auto alignments off Note: If Auto-Alignments is not turned off, additional bit errors will occur when the ESA-E re-calibrates the IF, because the Ext. video out signal is temporarily interrupted.	[System] {Alignments} {Auto Align} {Off}
Turn FM demodulation on	[Det/Demod] {Demod} {FM}

3. Use Signal Studio to configure a DH1 multi packet sequence that contains continuous PN9 data distributed over the user payload portion of the packet sequence, Figure 32. Do not add impairments to the signal when performing the initial calibration. Once configured, select the calculate button.

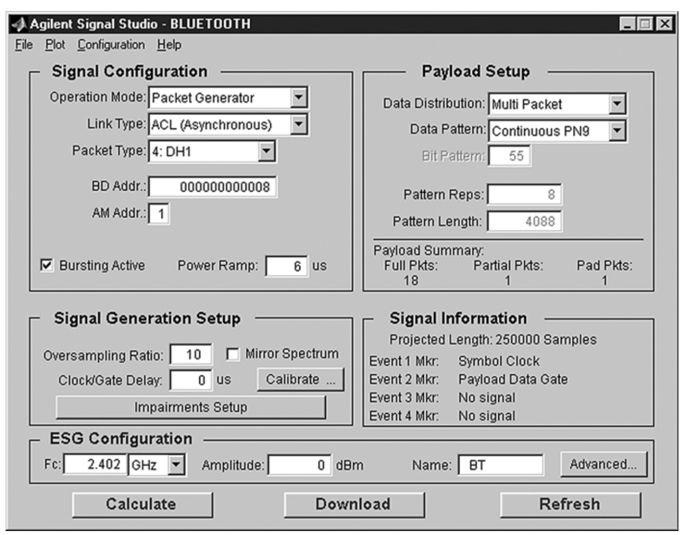


Figure 32. Signal Studio configured to create a DH1 multi packet sequence with continuous PN9 data spread over the user payload portion of the sequence.

continued on page 30

Basic measurements

4. Use the calibrate utility to determine the signal propagation delay through the ESA. Select the calibrate button in Figure 33. The calculated waveform is automatically downloaded to the ESG and the calibration utility is initiated.

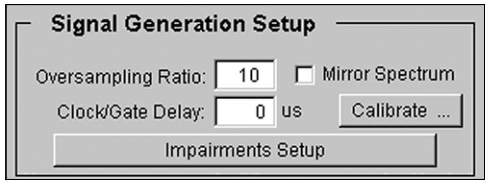


Figure 33. Signal generation setup menu.

5. Configure the automated clock/gate delay calibration utility, Figure 34. In this example, the clock/gate sweep end field is set to 10 us. Default values are used for the remaining configuration fields.

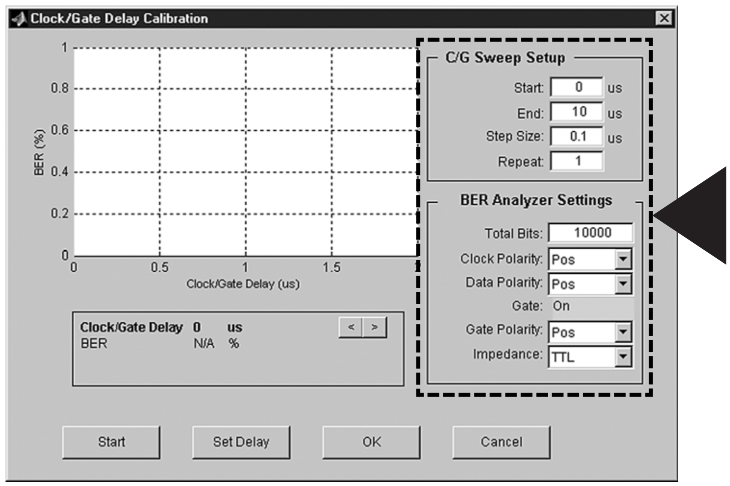


Figure 34. Clock/gate delay calibration utility setup.

6. Once configured, select the Start button to generate the plot of BER vs. clock/gate delay. The plot points are incrementally filled in as each test iteration is completed.

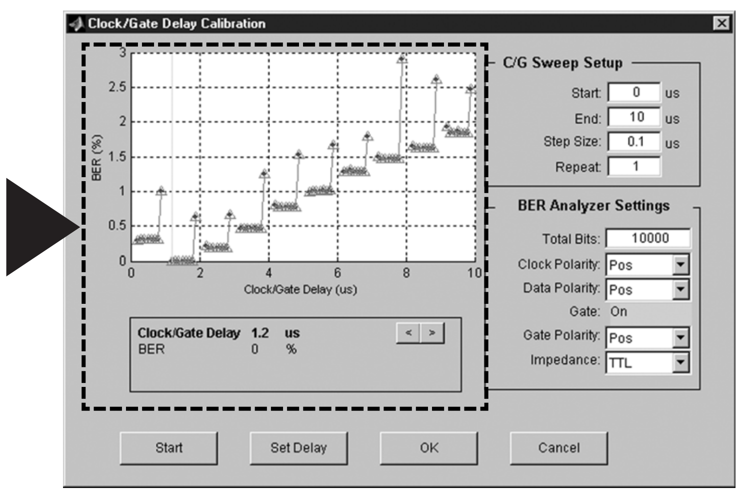


Figure 35. BER vs. clock/gate delay calibration results.

continued on page 31

7. After the plot has been generated, a marker is automatically placed at the clock/gate delay setting that yields the minimum BER, Figure 35. Notice that the plot looks similar to a step function. With no impairments added to the signal, there is a range of approximately 1/2 a symbol period that yields the same BER results. In this case, the marker is placed at the first BER minimum. When impairments are added to the signal, the plot no longer looks like a step function. Instead, it looks like a series of parabolas, from which a true minimum can be found. By initially performing the calibration without impairments added to the signal, the clock/gate delay range for optimum BER can easily be determined. As a result, when later performing clock/gate delay calibration on an impaired signal, the sweep range can be adjusted accordingly to decrease test time.

8. Place the marker at the desired clock/gate delay setting using the arrow buttons and select the set delay button. Then select the OK button. The clock/gate delay setting associated with the current marker location is returned to the clock/gate delay field (Figure 36) in the signal generation setup menu and the calibration utility is closed.

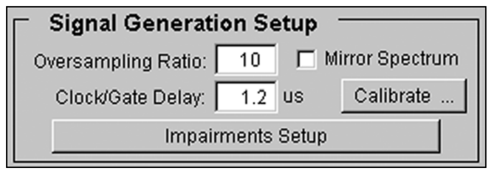


Figure 36. Signal generation setup menu with clock/gate delay setting returned from the calibration utility.

9. To apply the optimum clock/gate delay setting returned from the calibration utility to the configured waveform, re-calculate and download the waveform to the ESG.

As demonstrated, the calibration utility removes the trial and error uncertainty when determining the optimum clock/gate delay setting for performing BER test on *Bluetooth* devices.

Bluetooth *Signal Studio software features*

Data streams	0s, 1s, 01s, 10s, 8-bit pattern, PN9, PN15
Packet types	
ACL	DH1, DH3, DH5, DM1, DM3, DM5, AUX1
SCO	HV1, HV2, HV3, DM1
Control	NULL, POLL, ID
***Bluetooth* device address**	Valid range: 0000 0000 0000 to FFFF FFFF FFFF Hex
Active member address	Valid range: 0 to 7
Payload data patterns	0s, 1s, 01s, 10s, 8-bit pattern, PN9, PN15
Burst power ramp	Valid range: 1 to 10 us per power ramp Resolution: 1 us
Impairments	
Frequency offset	Valid range: -100 kHz to +100 kHz Resolution: 1 kHz
Frequency drift:	
Linear	Valid range: -100 kHz to +100 kHz Resolution: 1 kHz
Sinusoidal	Valid range: -100 kHz to +100 kHz Resolution: 1 kHz Rate: 300 Hz, 500 Hz, 1.6 kHz
Modulation index	Valid range: 0.250 to 0.400 Resolution: 0.001
Symbol timing error	Valid range: -50 ppm to 50 ppm Resolution: 1 ppm
AWGN	C/N valid range: +10 dB to +40 dB Resolution: 1 dB Seed valid range: 1 to 65535
Clock and gate delay	Valid range: 0 to 100 us Resolution: (1us / oversampling ratio)
Oversampling ratio	Valid range: 2 to 20

Acronym list

ACL	Asynchronous Connection-Less
ACP	Adjacent Channel Power
AM ADDR	Active Member Address
AWGN	Additive White Gaussian Noise
BD ADDR	*Bluetooth* Device Address
BER	Bit Error Rate
BT	Bandwidth Time product
CCDF	Complementary Cumulative Distribution Function
CRC	Cyclic Redundancy Check
DAC	Digital/Analog Converter
DUT	Device Under Test
dBm	Decibels relative to 1 milliwatt
FEC	Forward Error Correction
FHSS	Frequency Hopping Spread Spectrum
FSK	Frequency Shift Keying
GFSK	Gaussian Filtered Frequency Shift Keying
GPIB	General Purpose Interface Board
IF	Intermediate Frequency
I/Q	Inphase/Quadrature
ISM	Industrial, Scientific, and Medical
PC	Personal Computer
PN	Pseudorandom Noise
PN9	Pseudorandom Noise of period 2^9-1
PN15	Pseudorandom Noise of period 2^{15}-1
RF	Radio Frequency
SCO	Synchronous Connection-Oriented
TDD	Time-Division Duplex
TTL	Transistor-Transistor Logic
VSA	Vector Signal Analyzer

Related Agilent literature

E4438C Signal Studio Installation Guide
Available at: **www.agilent.com/find/signalstudio**

Agilent E4438C ESG Vector Signal Generator - Data Sheet
Literature number 5988-4039EN

Agilent E4438C ESG Vector Signal Generator - Configuration Guide
Literature number 5988-4085EN

Measuring Bit Error Rate Using the ESG-D Series RF Signal Generators, Option UN7
Literature number 5966-4097E

Bluetooth *Signal Studio Software for the E4438C ESG Vector Signal Generator, Option 406 - Product Overview*
Literature number 5988-5458EN

Bluetooth *RF Measurement Fundamentals, Application Note 1333-1*
Literature number 5988-3760EN

Bluetooth R*F Testing – The Right Tests For The Radio, White Paper,*
www.agilent.com/find/bluetooth

Verifying Bluetooth *Baseband Signals Using Mixed-Signal Oscilloscopes, Application Note*
Literature number 5988-2181EN

Investigating Bluetooth *Modules: The First Step in Enabling Your Device with a Wireless Link, Application Note*
Literature number 5988-2417EN

Agilent Technologies - Bluetooth *Technology Portal,*
www.agilent.com/find/bluetooth

References

Specification of the Bluetooth *System, Version 1.1*

Bluetooth *RF Test Specification, Version 1.1*

Ordering information

Bluetooth Signal Studio software is Option 406 for the Agilent E4438C ESG Vector Signal Generator. The Signal Studio software requires that the ESG is equipped with the optional baseband generator (Option 001 or 002).

Try before you buy!

Go to **www.agilent.com/find/signalstudio** and download *Bluetooth* Signal Studio software to your PC. Only the signal configuration and plotting capabilities of the software can be evaluated. A license key is required to load the waveforms created by the software into the ESG. The license key can be ordered through your sales engineer or local sales office, which can be found at **www.agilent.com/find/assist**.

Upgrade kits

If you currently own an E4438C ESG Vector Signal Generator and are interested in obtaining an upgrade kit only (license key), order: E4438CK Option 406.

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