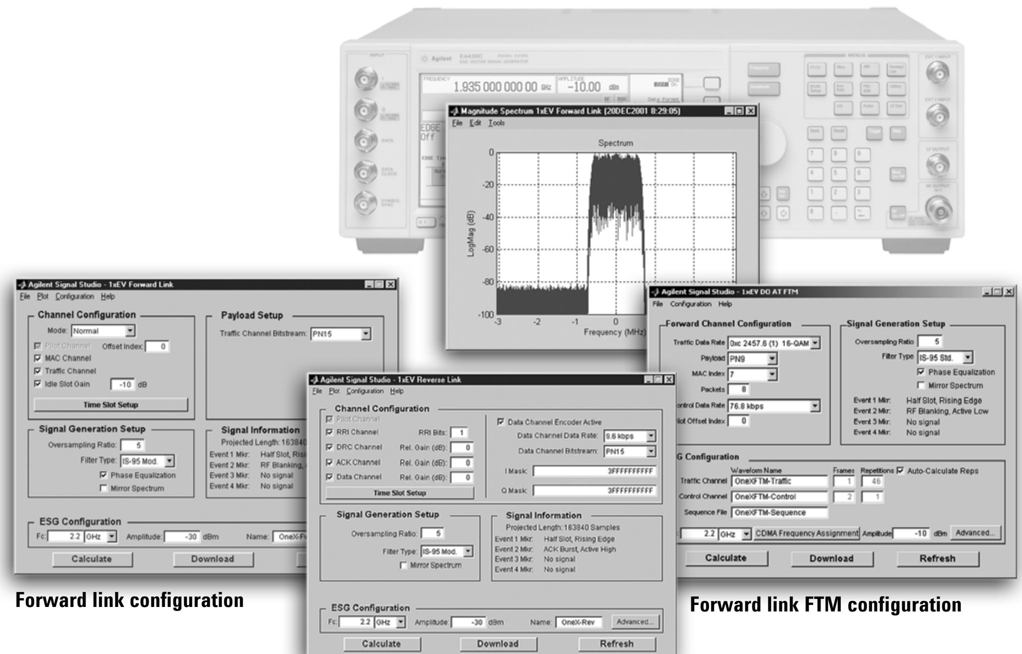
Agilent
1xEV-DO Signal Studio Software for the E4438C ESG Vector Signal Generator

Option 404
Application Note



Forward link configuration

Reverse link configuration

Forward link FTM configuration

Use Signal Studio to create 1xEV-DO forward and reverse link test signals

1xEV-DO Signal Studio software is a powerful tool for creating 1xEV-DO baseband I/Q waveforms for use with the Agilent E4438C ESG vector signal generator.

E4438C ESG main features

- Up to 32 Msample playback memory
- Optional 6 GB internal hard drive
- Digital hardware interpolation filters
- High-speed microprocessor
- Differential I/Q outputs
- 10B/T LAN or GPIB connectivity

1xEV-DO Signal Studio main features

- Quickly create 1xEV-DO frames
- Configure channels in each time slot
- Forward link channels
  - Pilot, MAC, and traffic
- Forward link FTM channels
  - Pilot, MAC, and traffic and control
  - Channel coding enables AT receiver PER analysis
- Reverse link channels
  - Pilot, MAC, ACK, and data
- Selectable baseband filtering
- Plot I/Q signals, spectrum, and CCDF curve

Agilent Technologies

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This product note is a self-guided tutorial describing the test signals that can be created with the 1xEV-DO Signal Studio software. This document is not meant to be a 1xEV technology tutorial. Basic knowledge of the forward and reverse link channel structure is required. For additional information on 1xEV technology, refer to the *References* section at the end of this document.

Software overview

The 1xEV-DO Signal Studio software is an intuitive Windows® based tool for configuring forward and reverse link 1xEV-DO frame structures. Unique physical channel configurations can be achieved in each time slot. The software calculates a custom baseband I/Q waveform file based on the 1xEV-DO frame configuration set by the user. Most waveforms take only a few seconds to build. The waveform file can then be downloaded to the ESG baseband generator for playback in arbitrary waveform mode.

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

After downloading the waveform file and instrument settings to the signal generator, the instrument automatically begins generating the 1xEV-DO RF signal. Local control of the signal generator is then re-enabled and instrument settings, like frequency and amplitude, can be modified from the signal generator's 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 baseband generator 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 recalculate and download the waveform to the signal generator for playback.

1xEV-DO software enhancement

Since its initial release, the 1xEV-DO Signal Studio software has been enhanced to provide a development and manufacturing solution for access terminal (AT) receiver tests. The enhancements are implemented in a separate 1xEV-DO Signal Studio configuration window (user interface), entitled *Forward Link FTM*.

Now there are three user interfaces provided with the 1xEV-DO Signal Studio software: the original forward link and reverse link interfaces, and the newer forward link factory test mode (FTM) interface. Each interface is available to download individually at **www.agilent.com/find/signalstudio**, and all three are enabled with the purchase of a single license key. If you currently have an ESG with the 1xEV-DO Signal Studio software enabled, the enhancements for AT receiver test are available free of charge; you only need to download the new forward link FTM user interface.

Ease of use

1xEV-DO Signal Studio software simplifies creating 1xEV-DO forward and reverse link test signals for use with the ESG. Instead of spending valuable time writing code to create a proprietary test signal, Signal Studio provides the ability to quickly configure a standards-based test signal via an intuitive graphical user interface. The Signal Studio 1xEV-DO frame configuration can easily be modified without rewriting code to create the desired test signal.

For quick and simple signal configuration, the 1xEV-DO Signal Studio software offers separate graphical user interfaces for the forward and reverse link directions. In addition, an FTM user interface is provided in the forward link direction specifically for testing AT receivers. Each user interface runs independently, so you may download all three or download only those needed to create signals for your application.

Component and transmitter test

The performance characteristics of 1xEV-DO components (including preamplifiers, combiners, filters and amplifiers) and transmitters are determined using a suitable stimulus. The 1xEV-DO Signal Studio software meets this need by providing statistically correct signals in both the forward and reverse link directions. Signal parameters, including the number of active channels and modulation type, can be modified to properly exercise components under a variety of crest factor conditions. Furthermore, CCDF curves may be plotted to verify the peak to average characteristics of the signals created with the forward link or reverse link user interfaces.

Note that the forward link interface is optimized for component and transmitter testing, while the forward link FTM interface is designed for access terminal receivers. The forward link interface provides configurable medium access channels (MAC) and the ability to plot the I/Q signals, spectrum, and CCDF curves. The forward link FTM interface provides full transport and physical layer channel coding required for testing receiver design and bit error rates.

Receiver test

In order to thoroughly test a receiver’s demodulation capabilities, a test signal with full channel coding is necessary. Full channel coding allows test engineers to determine if each functional stage of a receiver is operating correctly.

In the reverse link direction, the Signal Studio software provides full channel coding. This level of channel coding enables FER and BER testing on the signal received by the access network to verify performance.

In the forward link direction, the forward link FTM interface provides full channel coding. Both traffic and control channels are configurable in the forward link FTM window. Many channel parameters can be modified to stress receiver demodulation capabilities. The payload data in the physical layer packets is user-selectable to enable packet error rate (PER) analysis.

As indicated in Figure 2, the forward link interface does not provide full channel coding. Only the forward link FTM interface provides fully-coded forward link signals for AT receiver tests.

Signal structure

1xEV-DO frame structure

In 1xEV-DO systems, information is transmitted in frames, Figure 1. The total frame length is 26.67ms and each frame is divided equally into sixteen 1.666 ms time slots (1.2288 Mcps x 1.666 ms = 2048 chips per time slot). The frame structure is the same for both the forward and reverse link; however, the channel structure within the time slots is dependent upon the link direction.

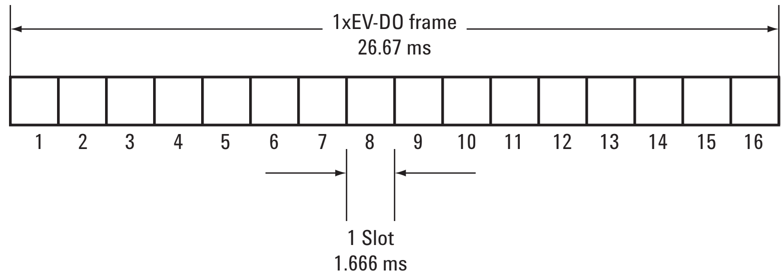

Figure 1. 1xEV-DO frame structure.

Connecting to the ESG

The Signal Studio software must be installed in a host computer prior to creating 1xEV-DO test signals. Before downloading 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* which can be found at: **www.agilent.com/find/signalstudio**.

Creating signals with the forward link interface

Forward link channel structure

The 1xEV-DO forward channel structure as implemented by the Signal Studio software is illustrated in Figure 2. The blocks highlighted in bold indicate frame configuration parameters that can be modified by the user. The blocks highlighted by dashed lines are not implemented in the Signal Studio software. All other blocks indicate fixed parameters that cannot be modified. For example, convolutional encoding, scrambling, and interleaving are not implemented in the forward traffic channel. Instead, the forward traffic channel bitstream is fed directly into the modulator block.

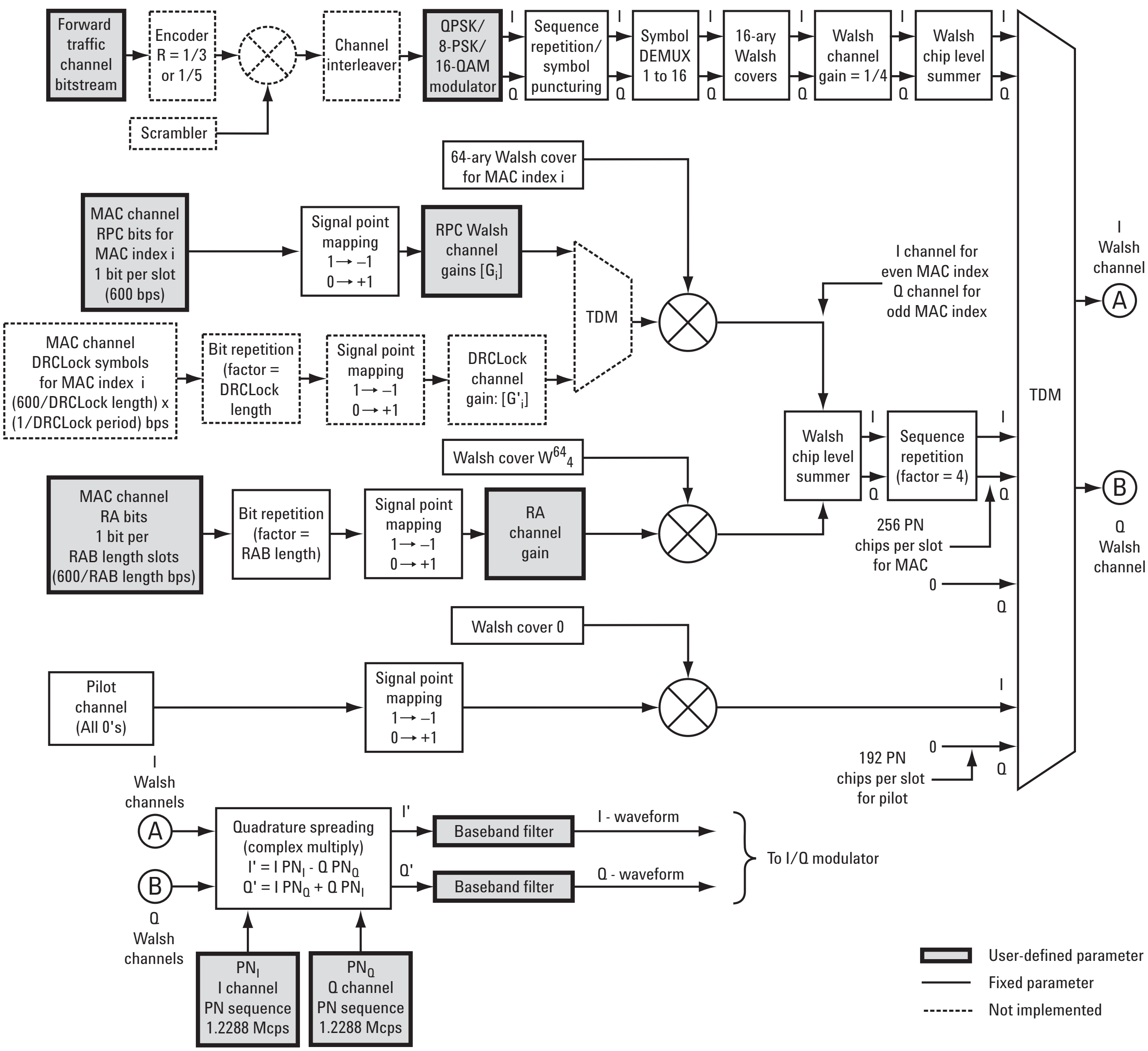

Figure 2. 1xEV-DO forward link channel structure as implemented by Signal Studio

Forward link frame configuration

The Signal Studio forward link user interface is divided into four menus: *Channel Configuration*, *Payload Setup*, *Signal Generation Setup*, and *ESG Configuration*. The mechanics of configuring the menus is simple and intuitive and will not be discussed in detail. The software provides pop-up help screens when the mouse pointer is placed directly over the item of interest.

A 1xEV-DO forward link waveform can be configured and downloaded to the ESG in four easy steps:

Step 1 - Configure the forward channels
Step 2 - Set up the signal generation parameters
Step 3 - Configure the ESG
Step 4 - Calculate and download

Step 1 Configure the forward channels

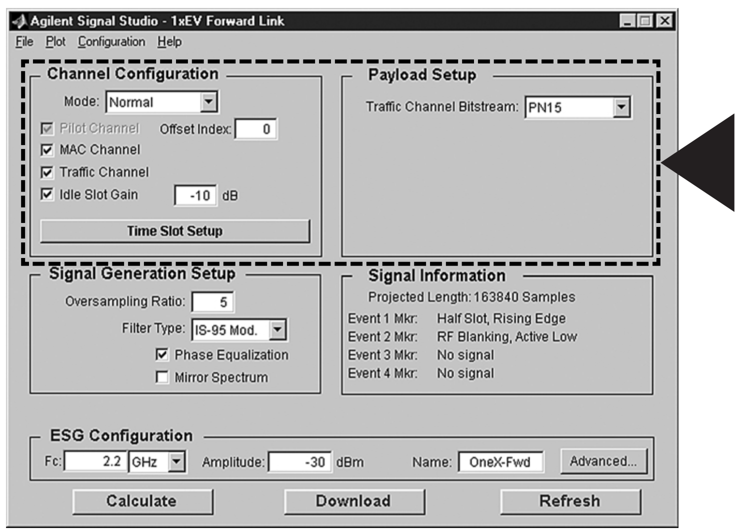

Figure 3. Forward link channel configuration and payload setup menus

The channel configuration and payload setup menus, outlined in Figure 3, provide an intuitive interface for constructing 1xEV-DO frames. The Signal Studio software provides two basic modes of operation: normal and continuous pilot.

Normal operating mode

In normal operating mode, a 1xEV-DO frame with custom channel configurations in each of the frame's 16 time slots can be configured. The following forward link channels are supported in normal operating mode: pilot channel, MAC channel, and traffic channel.

Pilot channel
The pilot channel is the default active channel in every frame and occurs as two distinct bursts in each time slot of the frame. It cannot be de-activated. The pilot channel's PN offset index, ranging from 0 to 511, can be set in the channel configuration menu. The PN offset of the pilot channel indicates the cell or sector of the transmitting access network.

Creating signals with the forward link interface

MAC and traffic channels

The MAC channel and traffic channel can each be activated or de-activated in the entire frame. Simply checking the box next to the MAC channel and traffic channel in the channel configuration menu optionally activates the channel for use in frame configuration. Once a MAC channel or traffic channel has been activated in the frame, further physical channel configuration can be implemented in each time slot. It is important to note that any channel configuration done at the time slot level is not implemented unless the channel is activated for use in the entire frame, as discussed above.

Active slots versus idle slots

In the forward link, physical channels are time division multiplexed in each of the frame's 16 time slots. If the pilot, MAC, and traffic channels are all active in a time slot, it is referred to as an active slot. When only the pilot and MAC channels are active in a time slot, it is referred to as an idle slot. The structure of both slot types is illustrated in Figure 4.

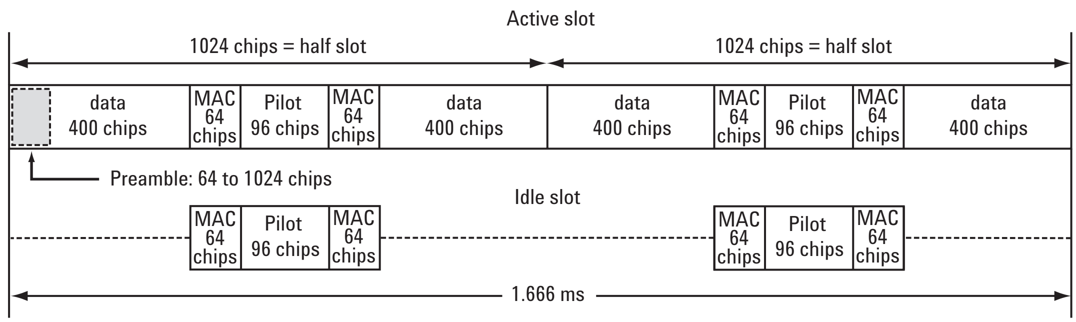

Figure 4. Forward link slot structures: active slot and idle slot.

Idle slot gain

During idle slot transmission, a large on/off power ratio requires that the access network power amplifier have extremely wide dynamic range. This is typically not the case. To address this issue, the software provides idle slot gain capability in the channel configuration menu. This parameter allows the noise level during the off time of the idle slot to be varied relative to the pilot channel. By varying the idle slot gain, the on/off power ratio can be set as needed to meet the transmission envelope mask requirements of the system. Optionally, the Idle slot gain parameter can be disabled. When disabled, RF blanking is automatically enabled. This results in a very large on/off power ratio during idle slot transmission.

Time slot setup

Selecting the time slot setup button in the channel configuration menu brings up a configuration table, Figure 5.

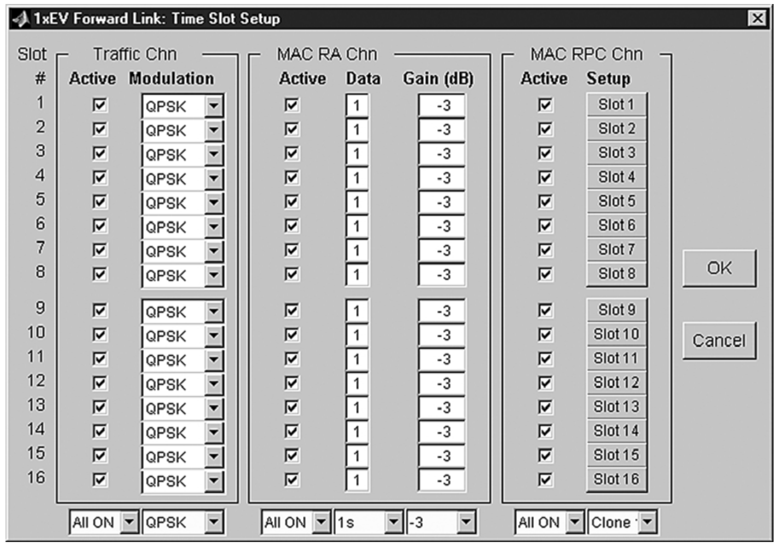

Figure 5. Forward link time slot setup table

The time slot setup configuration table is structured similar to a spreadsheet. Each row of the table represents one of the 16 time slots in a 1xEV-DO frame. The columns of the table are labeled and grouped as to which parameter they represent and what physical channel is being configured.

To simplify channel configuration, the bottom row of pull down menus provide fast edit capabilities. The channel parameter selected in a fast edit field is set in all 16 time slots (the entire column). This provides a quick alternative for configuring a generic forward link frame. To provide maximum flexibility, each channel parameter can still be individually configured in each time slot.

Traffic channel

The traffic channel can be activated or de-activated in each of the 16 time slots. Additionally, a pull-down menu is provided to uniquely configure the traffic channel modulation type (QPSK, 8-PSK, or 16-QAM) in each time slot. The traffic channel modulation type is chosen based on the required rate of data transmission. The only traffic channel parameter not configured in the time slot setup table is the traffic channel bitstream. The bitstream can be set to all 0s, all 1s, alternating 01, alternating 10, PN9, or PN15 and is configured via a pull-down menu in the payload setup menu, Figure 3. The traffic channel bitstream is divided into each time slot with an active traffic channel for the entire frame. In the case of PN sequences, a continuous PN sequence is distributed across the time slots with an active traffic channel. After the last time slot with an active traffic channel has been filled with data, the PN sequence is truncated.

Creating signals with the forward link interface

MAC channels

The MAC channel in each time slot consists of the summation of multiple subchannels: reverse activity (RA) channel and up to 59 reverse power control (RPC) channels. The RA channel and each RPC channel are assigned a unique 64-ary Walsh cover. The RA channel and RPC channel 64-ary Walsh covers representing the information bit to be transmitted are Walsh summed.

The 1xEV-DO Signal Studio software does not implement the DRCLock channel as a MAC subchannel, Figure 2. This means that the RPC bits are not time-division multiplexed with DRCLock symbols as indicated in version 3.0 of the C.S0024 specification.

MAC reverse activity channel

The RA channel provides flow control information to the access terminal. In each of the frame's 16 time slots, the RA channel can be activated or de-activated, the information bit can be set to 0 or 1, and the channel gain (relative to the pilot channel) can be specified.

MAC reverse power control channel

The MAC RPC channel can also be optionally activated in each time slot. If the RPC channel is activated in a time slot, selecting the slot number button in the MAC RPC channel setup column produces a RPC setup table, Figure 6. The structure of the RPC Setup table is very similar to the time slot setup table discussed previously, except that there are 59 possible entries for each time slot.

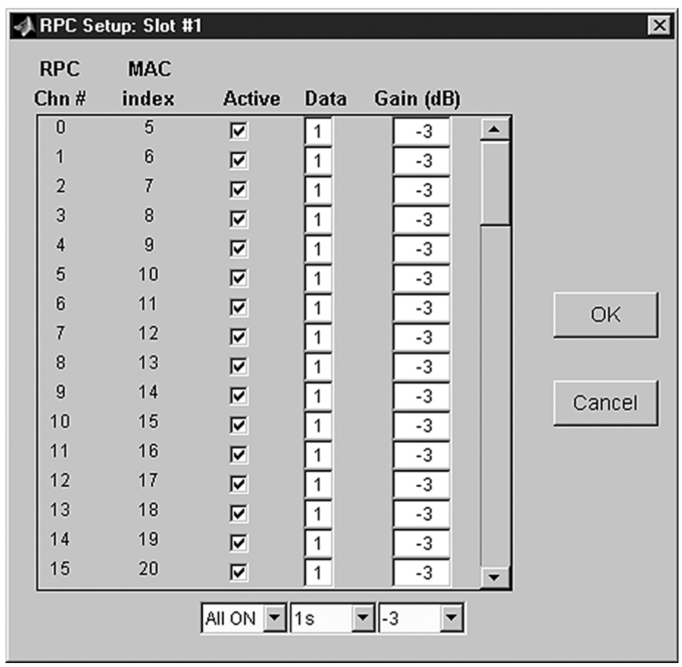

Figure 6. Forward link reverse power control setup table for slot #1

These 59 RPC channels can be individually configured for the selected time slot. Each channel that is activated will eventually be Walsh summed with the RA channel (if active) in the same time slot to make up the MAC channel. Each RPC channel carries a single power control data bit per time slot to a unique active access terminal. The access terminal will raise or lower power depending on whether a '0' or a '1' data bit is sent respectively. In the RPC setup table, the data bit for each active RPC channel can be individually defined. Additionally, the channel gain (relative to pilot channel) can be set via the pull-down menu for each active RPC channel.

Continuous pilot operating mode

The continuous pilot operating mode provides a fundamental test signal to be used as a troubleshooting tool to verify basic operation of the device under test. Instead of two pilot channel bursts occurring in each of the frame's 16 time slots, the pilot channel is continuously active during each frame time slot. As a result, the pilot channel is continuously active over the entire 1xEV-DO frame. In this mode of operation, the pilot channel is the only available channel type.

Step 2 Set up the signal generation parameters

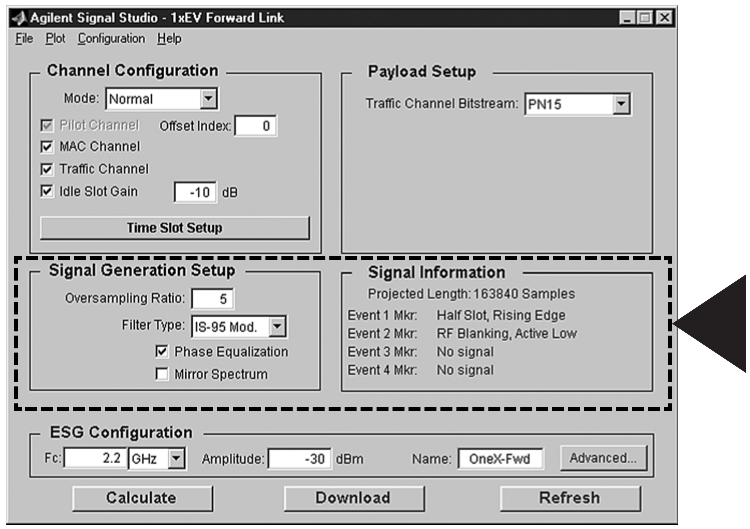

Figure 7. Forward link signal generation setup menu

The signal generation setup menu, boxed in Figure 7, provides a simple interface for defining the oversampling ratio, configuring the baseband filtering, and mirroring the RF spectrum.

Oversampling ratio

The oversampling ratio defines the number of samples calculated per I/Q symbol. Increasing the oversampling ratio of the constructed 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 when the ESG internal reconstruction filter is used.

Filter type

There are three filter selections available in the filter type pull-down menu: none, IS-95 standard, and IS-95 modified. The IS-95 modified filter provides improved adjacent channel performance compared to the IS-95 standard filter.

Phase equalization filtering can also be optionally activated in the forward link. The phase equalization filter acts as a pre-distortion filter to correct for delay distortion across the frequency band of interest.

Creating signals with the forward link interface

Mirror spectrum

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

Step 3 Configure the ESG

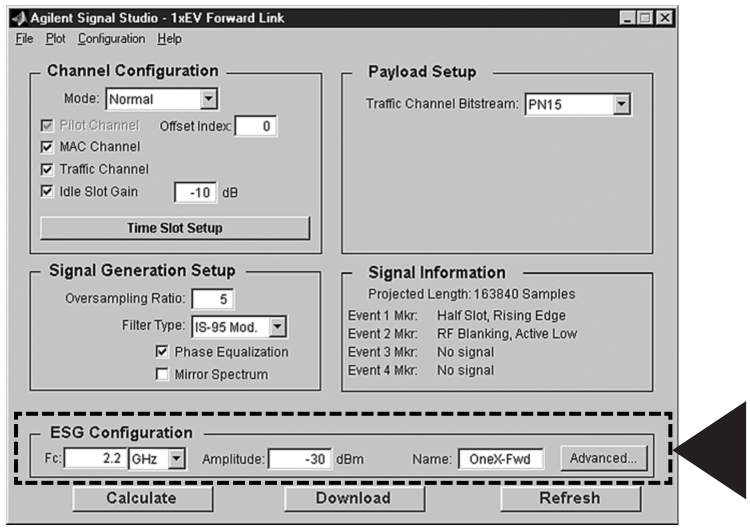

Figure 8. Forward link ESG configuration menu

In addition to the configured 1xEV-DO waveform, the Signal Studio software passes instrument settings to the ESG. These are defined in the ESG configuration menu, boxed in Figure 8.

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 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 unsupported 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.

Advanced settings

Additional ESG parameters can be accessed by selecting the advanced button in Figure 8. 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 User's Guide*.

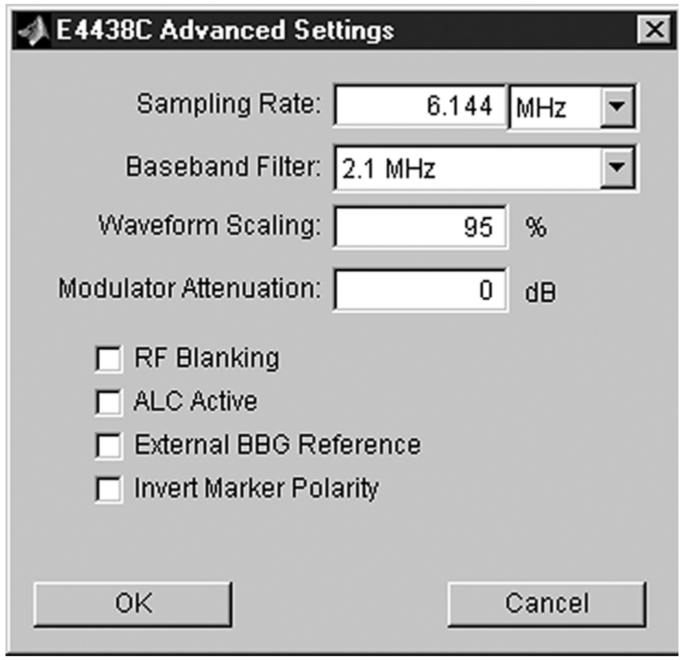

Figure 9. E4438C advanced settings menu

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.

Creating signals with the forward link interface

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 percent, some overshoot may occur; therefore the default setting is 95 percent. 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
RF blanking improves the signal quality when the MAC channel and/or traffic channel are de-activated in a time slot. It does so by increasing the on/off ratio of the forward link RF bursts. (Recall that the MAC channel and traffic channel are time division multiplexed in each forward link frame time slot.) The ESG event 2 marker is internally routed to provide the RF blanking signal.

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.

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 which lead to output power level errors. In these conditions, turning the ALC off and using the ESG power search feature can achieve better power level accuracy.

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
This field sets the polarity of the ESG event 1 and event 2 markers. As indicated in the Signal Information section of the forward link configuration window, the event 1 marker rising edge occurs on each half-slot boundary. When RF blanking is activated, the event 2 marker is internally routed to provide access to the RF blanking signal. Access to these signals is provided on the Event 1 and Event 2 ports on the rear panel of the ESG.

Step 4 Calculate and download

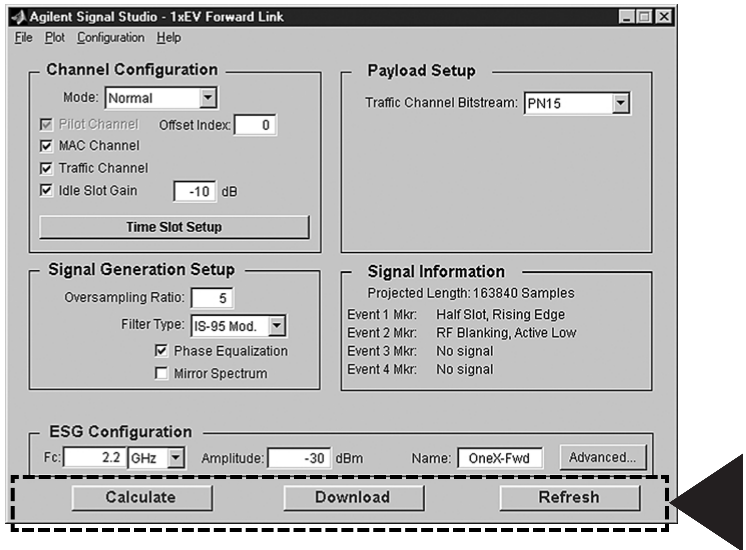

Figure 10. Forward link calculate and download menu

Once the waveform and ESG settings have been configured, the final step is to calculate the waveform and download it to the instrument, Figure 10.

Waveform calculation

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

Plotting I/Q signals, spectrum, and CCDF curves

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 window, Figure 11. The plot can be magnified using the zoom feature in the Tools pull-down menu at the top of the plot. 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.

Creating signals with the forward link interface

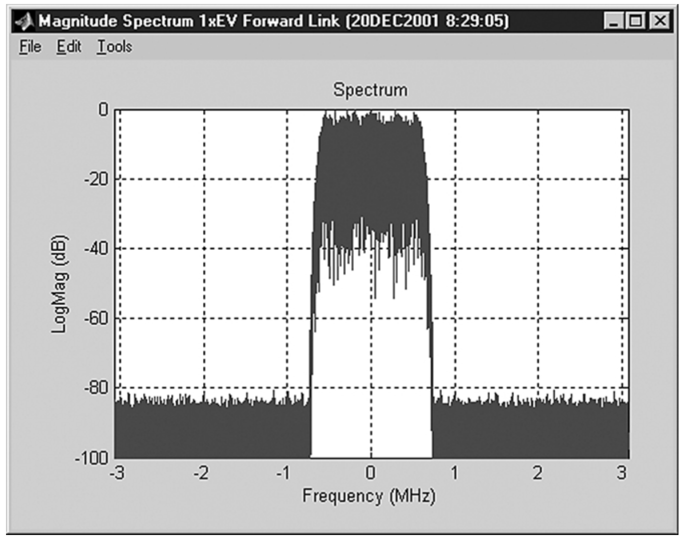

Figure 11. Spectrum plot of 1xEV-DO forward link I/Q waveform

Downloading to the ESG

Select the Download button, shown in Figure 10, to send the calculated I/Q waveform file representing the forward link frame and the signal generator setting to the instrument. The signal generator automatically begins producing the 1xEV-DO 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 shown in Figure 24. 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.

Saving software configurations

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 useful when complex frame configurations have been created in the software. From the menu keys at the top of the window shown in Figure 10, choose File → Save As, and then name the file and save it in the Agilent\Signal Studio\E4438C\OneXFwd directory. The software configuration can be recalled at any time by choosing the following menu options: File → Open, then the file name.

Saving waveforms in the ESG

After the calculated I/Q waveform has been downloaded to the signal generator for playback, it can be saved in the instrument's non-volatile memory for storage and recalled at any time 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, and sample rate will need to be reconfigured from the instrument's front panel when recalling waveforms from non-volatile memory for playback. Alternately, 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 *Agilent E4438C ESG Vector Signal Generator User's 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 1xEV-DO waveform files are configured and downloaded to the instrument, custom frame 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 *Agilent E4438C ESG Vector Signal Generator User's 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.

Creating signals with the reverse link interface

Reverse link channel structure

In the 1xEV-DO reverse link, physical channels are not time division multiplexed within each time slot. Instead, each frame time slot contains a complex summation of physical channels. The 1xEV-DO reverse channel structure as implemented by the Signal Studio software is shown in Figure 12. The blocks highlighted in bold indicate frame configuration parameters that can be modified by the user, whereas the blocks not highlighted indicate fixed parameters that are automatically implemented and cannot be modified. The reverse link signals created using the 1xEV-DO Signal Studio software are fully coded, meaning that all functional stages of the reverse channel structure are implemented.

Creating signals with the reverse link interface

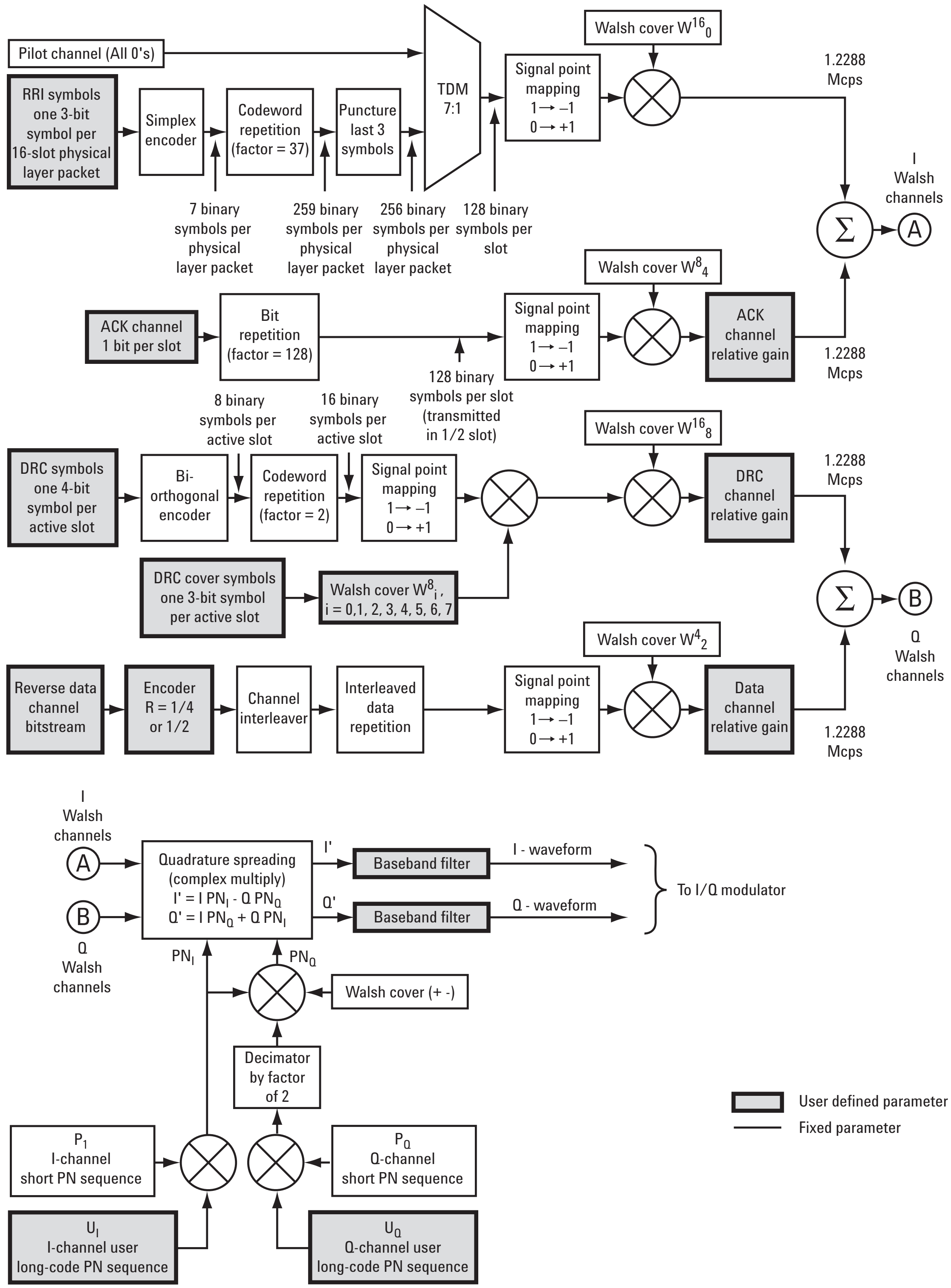

Figure 12. 1xEV-DO reverse link channel structure as implemented by Signal Studio

Reverse link frame configuration

Similar to the forward link, there are four basic steps to configuring a reverse link frame and generating the 1xEV-DO signal using the ESG:

Step 1 - Configure the reverse channels
Step 2 - Set up the signal generation parameters
Step 3 - Configure the ESG
Step 4 - Calculate and download

Only step 1 is significantly different from the four steps required to configure a forward link frame. As a result, steps 2 through 4 will not be discussed; instead, refer to the forward link frame configuration section of this document.

Step 1 Configure the reverse channels

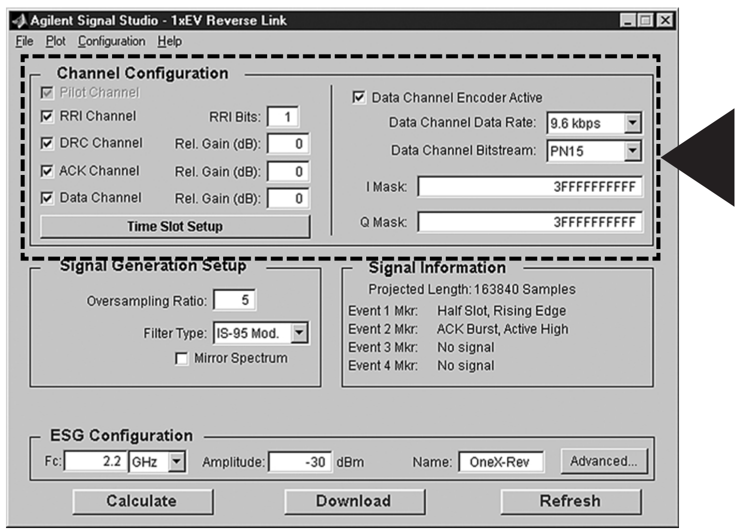

Figure 13. Reverse link channel configuration menu

The channel configuration menu, boxed in Figure 13, provides an easy-to-use graphical interface for constructing a 1xEV-DO frame with custom channel configurations in each of the frame's 16 time slots. The following reverse link channels are supported: pilot channel, reverse rate indicator (RRI) channel, data rate control (DRC) channel, acknowledgement (ACK) channel, and data channel.

Pilot channel and long-code mask

The pilot channel is the default active channel in every frame and appears in each time slot. Its configuration cannot be changed. The user long-code mask, which identifies distinct reverse traffic channels, is also set in the channel configuration menu.

Reverse rate indicator channel

The RRI channel can be optionally activated by checking the box in the channel configuration menu. When activated, it is time division multiplexed with the pilot channel. The RRI 3-bit symbol, representing the rate at which the data channel is transmitted, is defined in the RRI bits field. Valid entries are 0 through 7.

Data channel

The data channel can be optionally activated in the entire frame by checking the box in the channel configuration menu. When the data channel is activated, its relative gain with respect to the pilot channel can be specified. The data channel bitstream is selected in the channel configuration menu. Turbo encoding can also be optionally enabled. If encoding is enabled, the data channel data rate can be configured via the pull-down menu. The encoding rate (1/2 or 1/4) and symbol repetition factor are automatically configured depending on the selected data rate. In addition, when a data rate is selected, the RRI bits field in the channel configuration menu is automatically updated to represent the selected data rate. When active, the data channel is present in each of the frame's time slots.

Data rate control and acknowledgement channels

The DRC and/or ACK channel can each be optionally activated in the entire frame by checking the box in the channel configuration menu. If activated, the relative gain with respect to the pilot channel is specified in the channel configuration menu. Additional configuration can be accomplished by selecting the time slot setup button. It brings up a configuration table in which each row represents one of the 16 time slots in a 1xEV-DO frame. The columns of the table are labeled and grouped as to which parameter they represent and what physical channel is being configured, Figure 14. The bottom row of pull down menus provides fast edit capabilities to simplify frame configuration. The channel parameter specified in a fast edit field is set in all 16 time slots (the entire column).

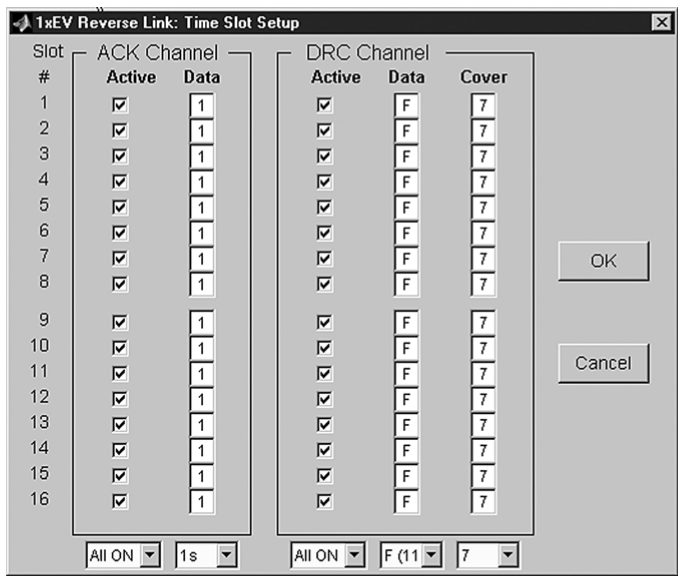

Figure 14. Reverse link time slot setup table

The ACK channel can be activated (or de-activated) in each time slot. In a 1xEV-DO system, a '0' bit (acknowledgement) is transmitted on the ACK channel if a forward traffic channel physical layer packet was successfully received from the access network. If the physical layer packet was not successfully received from the access network, a '1' bit (no acknowledgement) is transmitted. To simulate this, the information bit to be transmitted can be individually configured in each time slot with an active ACK channel.

The DRC channel is also optionally activated in each time slot. The 4-bit DRC value indicating the selected serving sector and the requested data rate on the forward traffic channel can be uniquely configured in each of the 16 time slots. Furthermore, the 8-ary Walsh cover can be individually configured in each time slot.

Creating signals with the forward link FTM interface

Forward link FTM channel structure

The 1xEV-DO forward channel structure as implemented by the Signal Studio forward link FTM interface is shown in Figure 15. The blocks highlighted in bold indicate user-defined frame configuration parameters that can be modified. The blocks that are not highlighted cannot be modified; they are based on the user-defined parameters and are automatically set by the Signal Studio software. The blocks highlighted with dashed lines are not implemented in the Signal Studio software. For example, channel coding is not implemented for MAC RA or MAC RPC bits. Instead, all zero I/Q symbols are fed into the time division multiplexer (TDM) block.

1xEV-DO physical layer packet structure

There are four forward link physical layer packet structures defined by the 1xEV-DO standard (Figure 16). An AT sends data rate control (DRC) requests to the access network to indicate the desired forward link data transmission rate, encoding rate, modulation type, and physical layer packet structure from the access network. The Signal Studio software automatically determines the correct packet structure when a traffic channel data rate (and DRC value) is selected in the forward channel configuration menu.

Creating signals with the forward link FTM interface

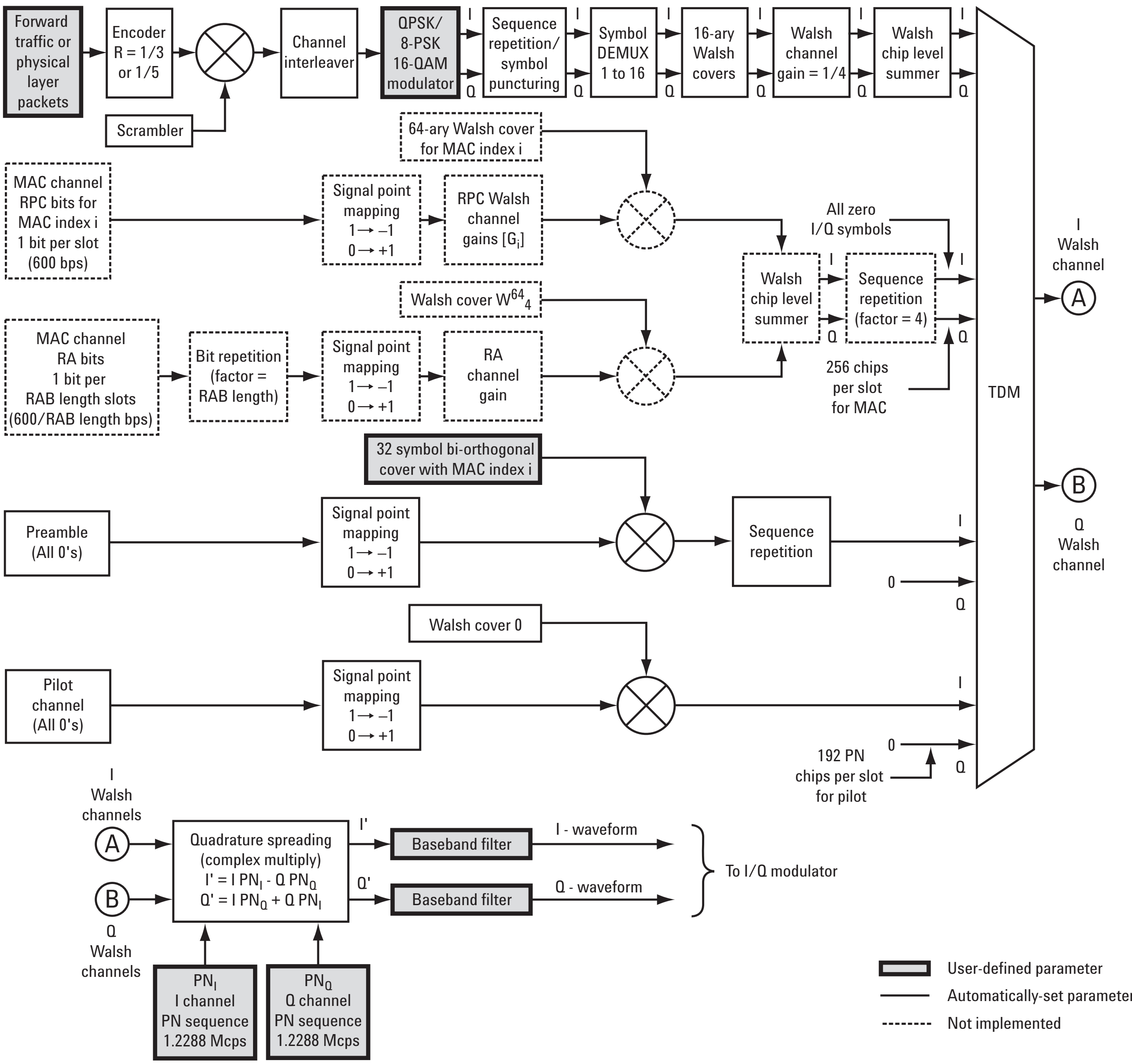

Figure 15. 1xEV-DO forward link FTM channel structure as implemented by Signal Studio

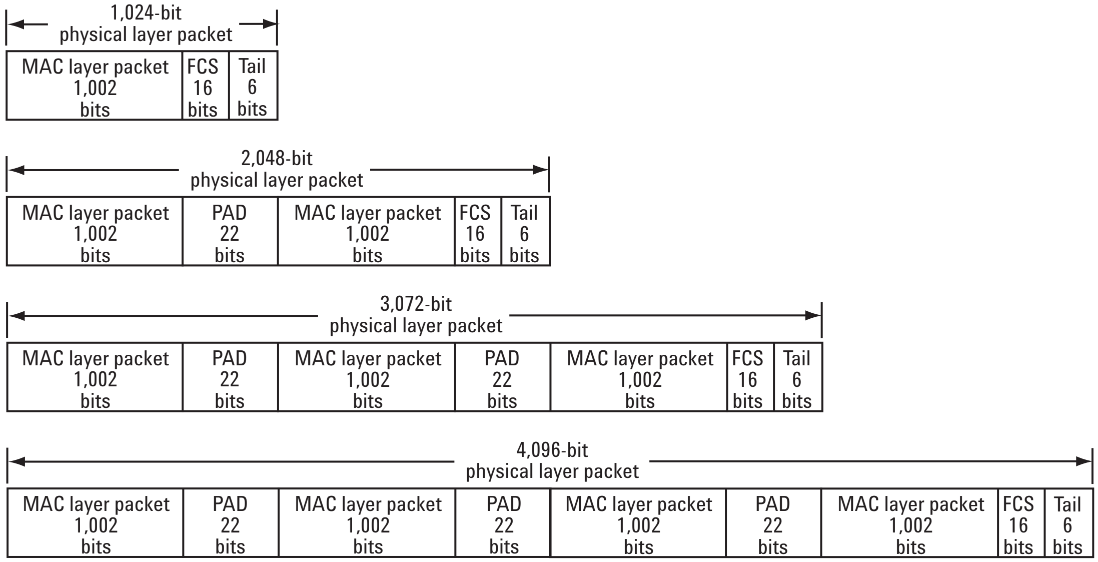

Figure 16. 1xEV-DO forward link physical layer packet structures

Forward link FTM frame structure

In 1xEV-DO systems, information is transmitted in frames, Figure 1. The Signal Studio software automatically determines the number of traffic and control frames required for the current forward link FTM configuration.

1xEV-DO slot structure

In the forward link, physical channels are time division multiplexed in each of the frame's 16 time slots, Figure 17. If the pilot, MAC, and traffic channels are all sent in a time slot, it is referred to as an active slot. When only the pilot and MAC channels are sent in a time slot, the time slot is referred to as an idle slot. Traffic or control channel physical layer packets are transmitted in the data portions of the 1xEV-DO slot. Multiple time slots may be required to accommodate a single packet transmission. The number of slots required to transmit a physical layer packet varies with DRC value, as indicated in the IS-856 standards. A table that relates DRC value to the number of slots a physical layer packet occupies is provided in Figure 19. When no physical layer packets are available to send, the access network transmits idle slots.

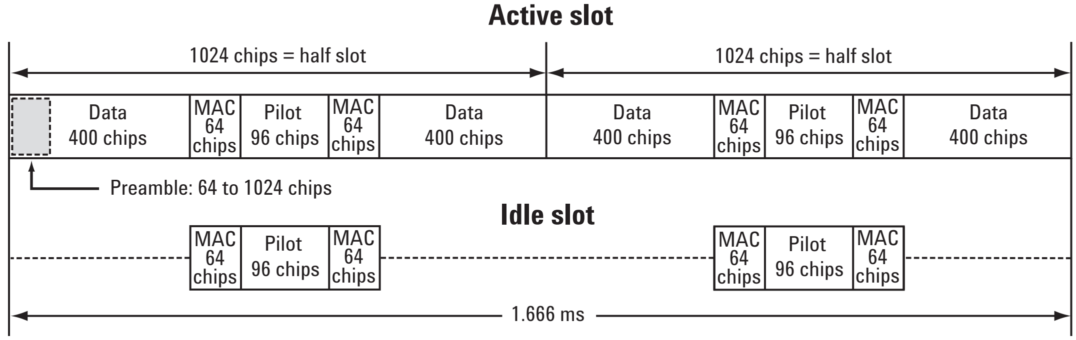

Figure 17. Forward link slot structures: active and idle slots

Creating signals with the forward link FTM interface

Forward link FTM frame configuration

The Signal Studio forward link FTM user interface is divided into three menus: forward channel configuration, signal generation setup, and ESG configuration. There are four basic steps to configuring a forward link FTM frame and generating the 1xEV-DO signal using the ESG:

Step 1 - Configure the forward channels
Step 2 - Set up the signal generation parameters
Step 3 - Configure the ESG
Step 4 - Calculate and download

Step 1 Configure the forward channels

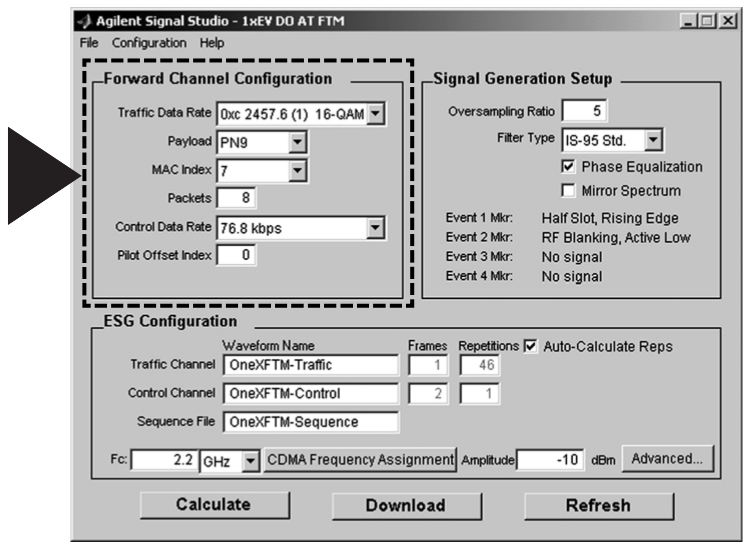

Figure 18. Forward channel configuration menu

The channel configuration menu, boxed in Figure 18, is used to set up fully coded traffic and control channels to transmit physical layer packets over the 1xEV-DO forward link. These signals can be used to analyze AT receiver packet error rate (PER) under various test conditions. The following forward link channels are supported: pilot, MAC, traffic and control.

Pilot channel

The pilot channel occurs as two distinct bursts in each time slot of the 1xEV-DO forward link frame. It cannot be de-activated. The pilot channel's pseudorandom noise (PN) offset index, ranging from 0 to 511, is set in the channel configuration menu. The PN offset of the pilot channel indicates the cell or sector of the transmitting access network.

MAC channel

The MAC channel coding is not implemented for FTM frames. Instead, all zero I/Q symbols are time division multiplexed into the MAC portion of each frame time slot.

Traffic channel

The number of physical layer packets to be transmitted over the traffic channel is a user-defined parameter. The preambles and physical layer packets are constructed based on the selected DRC value in the data rate pull-down menu. The preamble of each physical layer packet is coded with a 32-symbol bi-orthogonal cover derived from the MAC index that uniquely identifies the access terminal for which the physical layer packet is intended. The data transmitted during the MAC layer packet portion of the physical layer packet (Figure 16) is set in the payload pull-down menu.

The payload is a raw data sequence, not a formatted MAC layer packet. This level of signal coding is sufficient to verify physical layer receiver performance. When PN sequences are selected as the payload, a continuous PN sequence is distributed across the MAC layer packet portions of the total number of packets specified. After the last packet has been filled with data, the PN sequence is truncated. All zero data is transmitted during the pad portions of packet and standard-based frame check sequence (FCS) and tail bits are appended to the end of each packet. In the traffic data rate pull-down menu, you select from 12 traffic channel DRC values to set the data rate, encoding rate, and modulation type for the packet transmission. The table in Figure 19 lists the modulation characteristics and packet structures associated with specific DRC values.

DRC value	Data rate (kbps)	Encoding rate	Modulation type	Number of bits per packet	Number of slots per packet	Number of 32-chip preamble repetitions	Number of slots per preamble
0 x 1	38.4	1/5	QPSK	1,024	16	32	16
0 x 2	76.8	1/5	QPSK	1,024	8	16	8
0 x 3	153.6	1/5	QPSK	1,024	4	8	4
0 x 4	307.2	1/5	QPSK	1,024	2	4	2
0 x 5	614.4	1/3	QPSK	1,024	1	2	1
0 x 6	307.2	1/3	QPSK	2,048	4	4	4
0 x 7	614.4	1/3	QPSK	2,048	2	2	2
0 x 8	1,228.8	1/3	QPSK	2,048	1	2	1
0 x 9	921.6	1/3	8-PSK	3,072	2	2	2
0 x 10	1,843.2	1/3	8-PSK	3,072	1	2	1
0 x 11	1,228.8	1/3	16-QAM	4,096	2	2	2
0 x 12	2,457.6	1/3	16-QAM	4,096	1	2	1

Figure 19. 1xEV-DO DRC values and corresponding forward link modulation and packet parameters

Packets that occupy multiple frame slots are transmitted using four-slot interlacing. For example, as indicated in Figure 19, a single packet transmitted at 153.6 kbps occupies four frame time slots. If only one packet is selected for transmission, frame slots 1, 5, 9, and 13 are active while slots 2, 3, 4, 6, 7, 8, 10, 11, 12, 14, 15, and 16 are idle. On the other hand, if four packets are transmitted at 153.6 kbps, the first packet occupies frame slots 1, 5, 9, and 13, the second packet occupies slots 2, 6, 10, and 14, the third packet occupies slots 3, 7, 11, and 15, and the fourth packet occupies slots 4, 8, 12, and 16. If more than four packets are selected for transmission, additional frames are filled in a similar manner to accommodate the additional packets.

Control channel

The control channel sends synchronization information to the access terminal. This channel allows the AT to acquire system time and the pilot channel PN offset. The modulation characteristics and physical layer packet structure for control channel transmissions are either DRC values 0 x 1 or 0 x 2. The control channel data rate, 38.4 or 76.8 kbps, is selected via the pull-down menu.

Creating signals with the forward link FTM interface

Step 2 Set up the signal generation parameters

The signal generation setup menu provides a simple interface for defining the oversampling ratio, configuring the baseband filtering, and inverting the Q channel. Refer to the forward link configuration section of this document (pages 6 through 12) for details on configuring the signal generation parameters.

Step 3 Configure the ESG

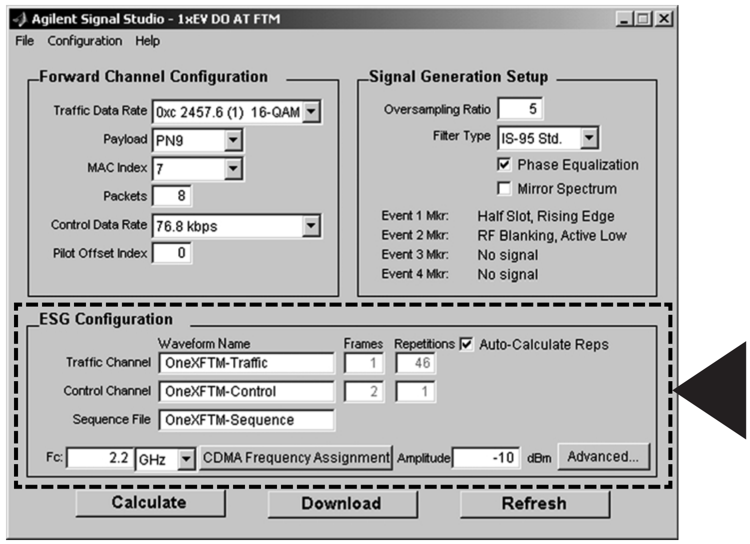

Figure 20. Forward link ESG configuration menu

In addition to the configured 1xEV-DO waveform, the Signal Studio software passes instrument settings to the ESG. These are defined in the ESG configuration menu, boxed in Figure 19. Configuring the ESG parameters is discussed in the forward link frame configuration section (pages 6 through 12). However, some additional features have been added to the forward link FTM user interface that are discussed below.

Frequency

The frequency field is used to set the frequency at which the ESG will generate the signal. To aid in setting the correct transmit frequency, a CDMA frequency assignment calculator is provided. Simply click the button, and select the frequency band and channel of interest to update the carrier frequency field.

Waveform name

Two independent waveforms are created by the Signal Studio forward link FTM interface. Each must have a unique waveform name. The first waveform consists of 1xEV-DO frames carrying the traffic channel and the second waveform consists of 1xEV-DO frames carrying the control channel. Sequencing of the traffic and control channel waveforms is set up directly in the ESG configuration menu. The sequence file must also be named. The alphanumeric text entered in the sequence file 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 unsupported 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.

Waveform repetitions

The software automatically sets the number of traffic waveform repetitions and control waveform repetitions when the Auto-Calculate Reps field is checked in the ESG configuration menu. If unchecked, the number of waveform repetitions for each can be manually entered. This provides the flexibility to set up custom ratios of traffic channel transmissions to control channel transmissions.

Step 4 Calculate and download

Once the waveform and ESG settings have been configured, the final step is to calculate the waveform and download it to the instrument. Refer to the forward link configuration section (pages 15 through 17) of this document for details on calculating, downloading, and saving waveforms.

Examples of basic measurements

The 1xEV-DO Signal Studio software, E4438C ESG vector signal generator and E4406A vector signal analyzer (VSA) combine to provide a powerful test solution for the development and manufacturing of 1xEV-DO products, Figure 21.

The VSA provides an optional 1xEV-DO test personality(**www.agilent.com/find/vsa**). It can also perform many fundamental RF tests in basic operating mode, including: channel power, adjacent channel power (ACP), complementary cumulative distribution function (CCDF), and power versus time (PVT).

To illustrate the ease with which these tests can be performed, two examples are given below: channel power and ACP. Following these, an example AT receiver test setup is shown in Figure 27.

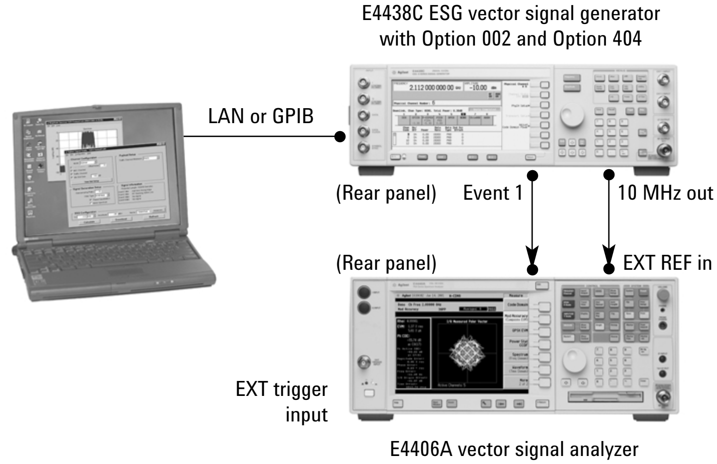

Figure 21. Connection diagram for downloading Signal Studio waveforms to the ESG vector signal generator and performing measurements using the Agilent E4406A vector signal analyzer

In the instructions below:
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.

Channel power

The channel power measurement is the average power in the frequency bandwidth of the signal and is typically defined as power integrated over the frequency band of interest. The channel power for a 1xEV-DO forward link frame with 16 active slots is measured below.

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

Set up the Signal Studio 1xEV-DO forward link for active slot transmission, Figure 22.

Set the channel configuration menu:
- Activate the MAC channel
- Activate the traffic channel
- Select PN9 for the forward traffic bitstream

Set the ESG configuration menu:
- Set the frequency to 1 GHz
- Set the amplitude to –10 dBm
- Enter "FWD-ACTIVE" in the waveform title field

To simplify the setup, the default Time Slot Setup and RPC channel configuration table settings are used.

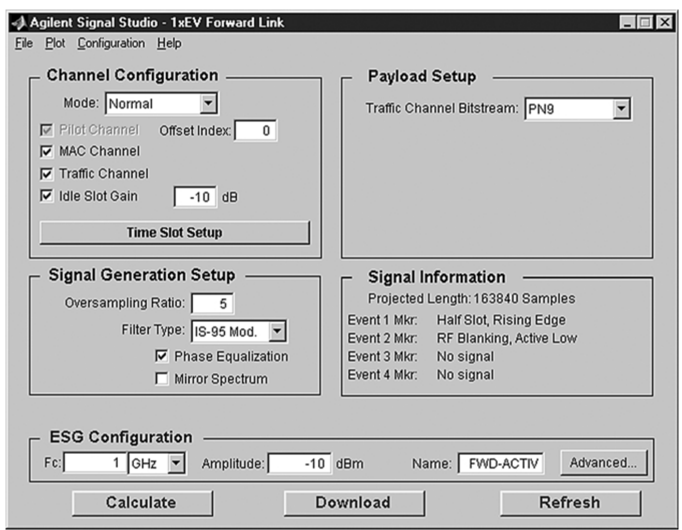

Figure 22. Signal Studio setup for generic active slot transmission

Calculate and download the 1xEV-DO forward link I/Q waveform to the ESG. The window shown in Figure 23 appears after a successful download.

Examples of basic measurements

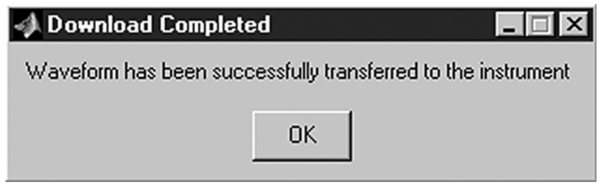

Figure 23. ESG successful waveform download indicator

The ESG is now generating the 1xEV-DO modulated RF signal.

Instructions: **E4438C ESG vector signal generator**	**Keystrokes:** **E4438C ESG vector signal generator**
Verify that active slot waveform is being generated, Figure 24.	[Mode] {Dual Arb}

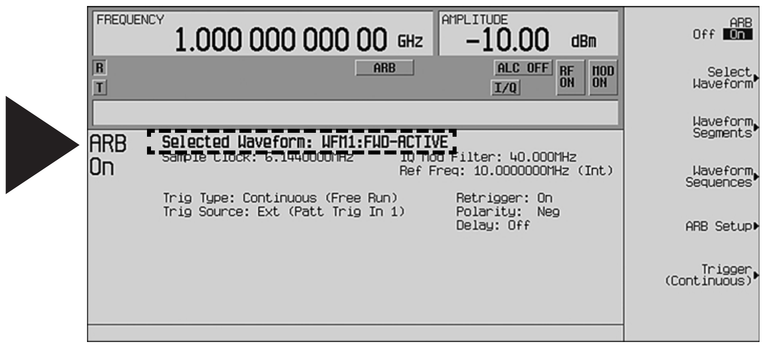

Figure 24. ESG dual arbitrary waveform generator user interface

Perform the channel power measurement using the VSA.

Instructions: **E4406A vector signal analyzer**	**Keystrokes:** **E4406A vector signal analyzer**
Preset the instrument	[Preset]
Make the channel power measurement	[Measure] {Channel Power}
Set the number of averages to 100, Figure 25.	[Meas Setup] {Avg Number} [100] [Enter] {Avg Mode Exp/Repeat}

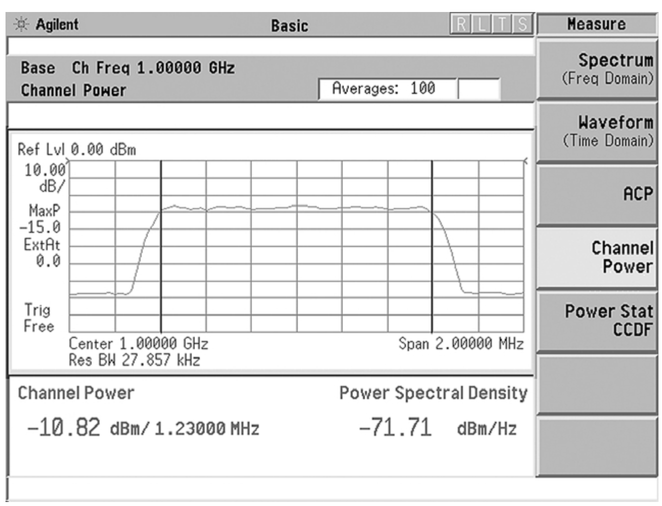

Figure 25. E4406A VSA channel power measurement

Adjacent channel power (ACP)

Using the same Signal Studio waveform configured for the channel power measurement, ACP can be measured for active slot transmission. The ACP measurement is typically defined as the ratio of the average power in the adjacent frequency channel to the average power in the transmitted frequency channel. ACP is usually measured at multiple offsets (adjacent and alternate channels).

Perform the ACP measurement using the VSA.

Instructions: **E4406A vector signal analyzer**	**Keystrokes:** **E4406A vector signal analyzer**
Preset the instrument	[Preset]
Make the ACP measurement, Figure 26.	[Measure] {ACP}

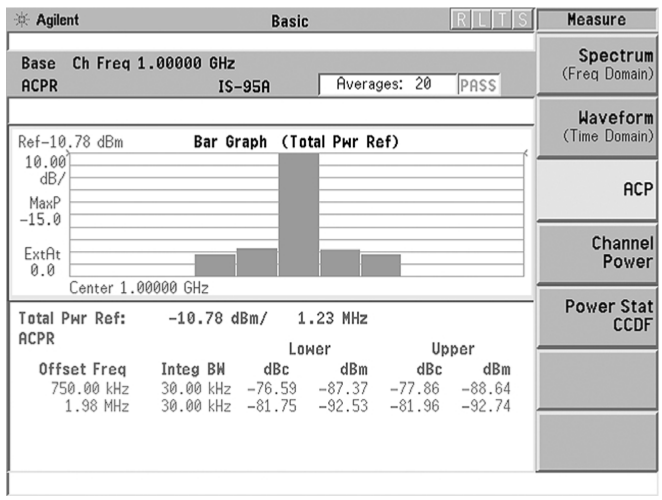

Figure 26. ACP bar graph for 1xEV-DO active slot transmission

AT receiver test setup

The E4438C ESG vector signal generator with the 1xEV-DO Signal Studio software forward link FTM interface provides a fully coded forward link signal for access terminal (AT) receiver test. A typical test setup is shown in Figure 27. The PC controller is required to initiate factory test mode in the AT, step the AT through the call setup process (such as acquire pilot, acquire sync, and demodulate traffic channel), and perform PER analysis on the received signal from the ESG.

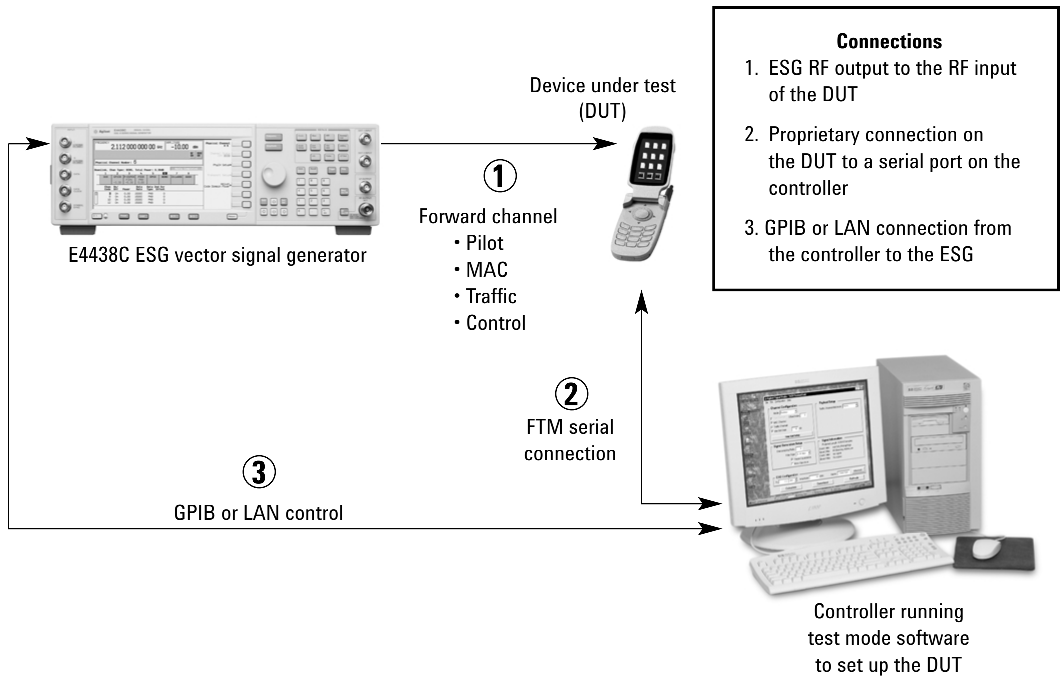

Figure 27. Typical measurement setup to perform AT receiver measurements

In Figure 27, the ESG provides a fully coded forward link signal for analysis. The controller is responsible for initiating FTM in the AT, stepping it through the call setup process, and performing PER measurements on the received signal.

1xEV-DO Signal Studio software features[1]

Forward link	
Pilot channel	PN offset index: 0 to 511 Selectable mode: continuous or bursted
MAC channels	
Reverse activity	Data: 0 or 1 Gain relative to pilot: -30 dB to +30 dB
Reverse power control	Data: 0 or 1 Gain relative to pilot: -30 dB to +30 dB
Traffic channel	Data bitstream: 0s, 1s, 01s, 10s, PN9, PN15 Modulation type: QPSK, 8-PSK, 16-QAM
Idle slot gain	Noise level relative to pilot: 0 dB to –80 dB
Filter types	Rectangular, IS-95 standard, IS-95 modified (improved ACP), phase equalization
Oversampling ratio	Valid range: 2 to 30

Forward link FTM (factory test mode)	
Pilot channel	PN offset index: 0 to 511
MAC channels	I/Q data: all zeroes
Traffic channel	Number of packets: 1 to 32 Preamble MAC index: 5 to 63 Packet payload: 0s, 1s, 01s, 10s, PN9, PN15 Data rate: 38.4, 76.8, 153.6, 307.2, 614.4, 921.6, 1228.8, 1843.2, 2457.6 kbps Encoding rate: 1/5 or 1/3 (automatically set) Modulation types: QPSK, 8-PSK, 16-QAM
Control channel	Data rate: 38.4 and 76.8 kbps
Filter types	Rectangular, IS-95 standard, IS-95 modified (improved ACP), phase equalization
Oversampling ratio	Valid range: 2 to 30

Reverse link	
Pilot channel	
Reverse rate indicator channel	Data: 0 to 7 Octal
Data rate control channel	Data: 0 to F Hexadecimal Walsh cover Index: 0 to 7 Gain relative to pilot: -30 dB to +30 dB
Data channel	Data bitstream: 0s, 1s, 01s, 10s, PN9, PN15 Data rate: 9.6, 19.2, 38.4, 76.8, 153.6 kbps Encoding rate: 1/4 rate @ 9.6, 19.2, 38.4, 76.8 kbps 1/2 rate @ 153.6 kbps Modulation type: BPSK
I & Q Mask (42-bit)	Valid range: 00000000000 to 3FFFFFFFFFF
Filter types	Rectangular, IS-95 standard, IS-95 modified (improved ACP)
Oversampling ratio	Valid range: 2 to 30

1. Features subject to change.

Acronym list

1xEV	cdma2000 1x evolution
1xEV-DO	cdma2000 1x evolution for data only
8-PSK	8-ary phase-shift keying
16-QAM	16-level quadrature amplitude modulation
ACK	Acknowledgement
ACP	Adjacent channel power
AT	Access terminal
BER	Bit error rate
CCDF	Complementary cumulative distribution function
dBm	Decibels relative to 1 milliwatt
DRC	Data rate control
FER	Frame error rate
FTM	Factory test mode
GHz	Gigahertz
GPIB	General purpose interface board
IF	Intermediate frequency
MAC	Medium access control
NAK	No acknowledgement
PER	Packet error rate
PN	Pseudorandom noise
PN9	Pseudorandom noise of period 2^9-1
PN15	Pseudorandom noise of period 2^{15}-1
QPSK	Quadrature phase-shift keying
RA	Reverse activity
RF	Radio frequency
RPC	Reverse power control
RRI	Reverse rate indicator
VSA	Vector signal analyzer

Additional literature

E4438C Signal Studio Installation Guide
Available at: **www.agilent.com/find/signalstudio**
Agilent 1xEV-DO Signal Studio Software for the E4438C ESG Vector Signal Generator - Product Overview
Literature number 5988-5459EN

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

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

References

Third Generation Partnership Project 2 (3GPP2). *cdma2000 High Rate Packet Data Air Interface Specification.* C.S0024 version 3.0 (TIA/EIA/IS-856). December 2001.

Third Generation Partnership Project 2 (3GPP2). *Recommended Minimum Performance Standards for cdma2000 High Rate Packet Data Access Terminal.* C.S0033 version 1.0. December 2001.

Third Generation Partnership Project 2 (3GPP2). *Recommended Minimum Performance Standards for cdma2000 High Rate Packet Data Access Network.* C.S0032 version 1.0. December 2001.

Telecommunication Industry Association (TIA) and Electronics Industry Association (EIA). *Test Application Specification (TAS) for High Rate Packet Data Air Interface.* TIA/EIA/IS-890. July 2001.

For more information or to obtain these standards and specifications visit **www.3GPP2.com** or **www.tiaonline.org**.

Ordering information

1xEV-DO Signal Studio Software is option E4438C-404 for the Agilent E4438C ESG vector signal generator. The Signal Studio software requires that the ESG is equipped with the optional baseband generator (option E4438C-001 or E4438C-002).

Try before you buy!

Go to **www.agilent.com/find/signalstudio** and download Signal Studio 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 vector signal generator. 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: option E4438CK-404.

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