User's Guide
SLWU082–May 2012

TSW1400 Pattern Generators

The set of standalone user interfaces described in this document are used to expand the pattern generation capabilities of the TI High Speed Data Converter Pro software. A wide range of patterns can be generated and subsequently loaded into the TSW1400 with these user interfaces.

Section 1 of the document describes the steps for installing the Matlab Runtime Engine. In Section 2, loading custom patterns from a file into the High Speed Data Converter Pro is described and some user interfaces offered by TI for pattern generation are presented in Section 3.

This document covers the steps involved in loading externally generated patterns into the High Speed Data Converter Pro software. For information on loading patterns inside High Speed Data Converter Pro into the TSW1400 hardware, refer to the TSW1400 High Speed Data Capture/ Pattern Generator Card.

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1 Installing the MATLAB Runtime Engine

The user interfaces provided requires that Matlab Runtime Engine v7.16 is installed on the host pc. Install the runtime engine by double-clicking on the *MCRInstaller.exe* file located in the product folder. Let the self extractor complete .

1. When the *MATLAB Component Runtime 7.16* screen (Figure 1) displays, click *Next.*

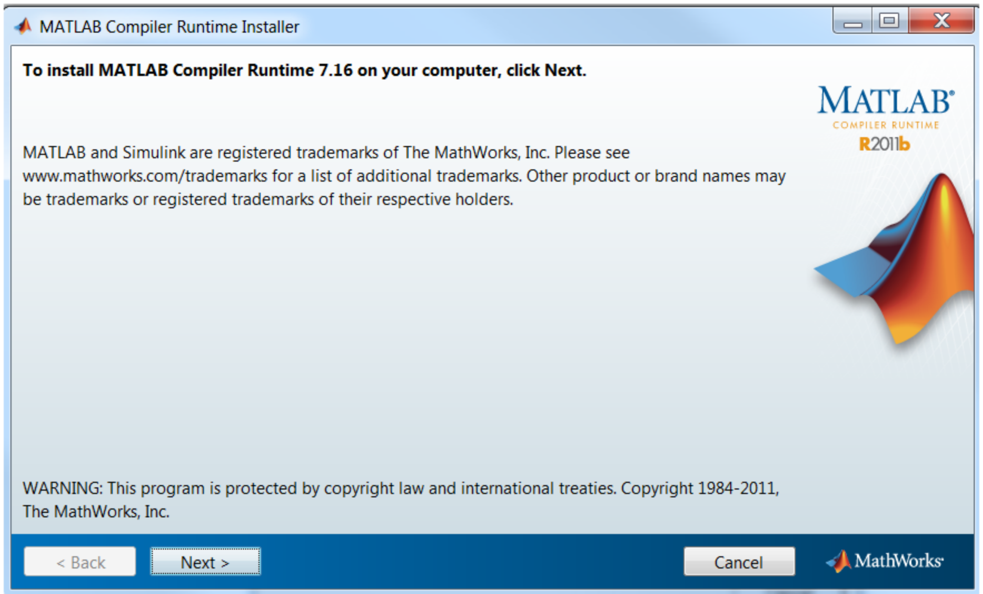

Figure 1. Installing the Matlab Runtime Engine

2. Follow the onscreen prompts to install the Runtime engine. If there are no errors, Figure 2 appears showing the progress of the installer.

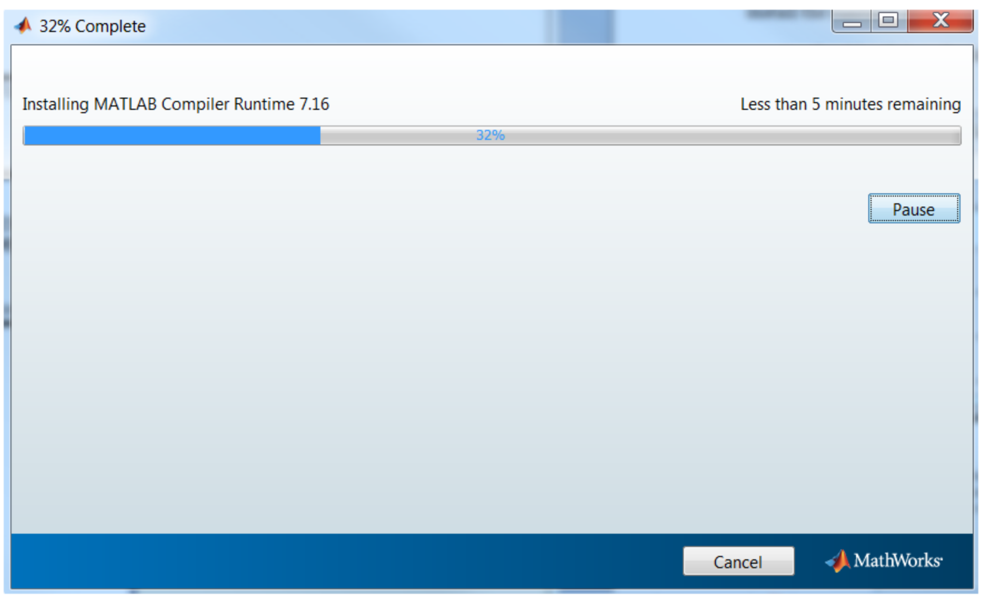

Figure 2. Installing the Matlab Runtime Engine (Progress bar)

2 Loading Custom Patterns into High Speed Data Converter Pro

Figure 3 shows the user interface of TI's High Speed Data Converter Pro software. Inside this user interface, channels refer to columns of data. Load a custom pattern by formatting the data into columns with each data column representing a separate channel. The columns can be delimited by either comma or space and the data file can be saved with a .txt extension.

- Load the pattern by clicking on **Load file to transfer into TSW1400** button and browse to the pattern file location.
- Ensure the spectrum is displayed correctly by entering the data rate used to generate the file.
- If complex FFT is selected, odd numbered columns (or channels) are treated as real data and even numbered columns (or channels) are treated as imaginary data.
- Ensure the data is formatted correctly when transmitting to the TSW1400 hardware by selecting the appropriate DAC option (offset binary or 2's complement).
- The data is transmitted to TSW1400 (after it has been loaded with the appropriate firmware) by clicking on the **Send** button. Please refer to TSW1400 High Speed Data Capture/ Pattern Generator Card for further instructions.

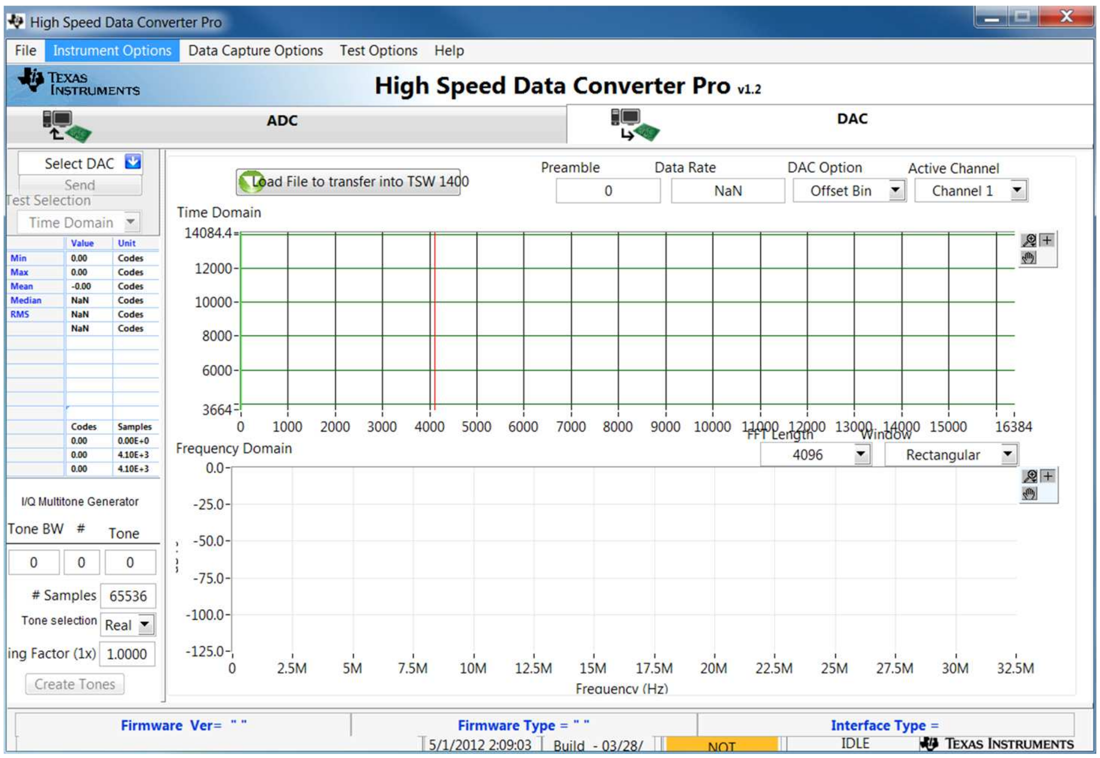

Figure 3. High Speed Data Converter Pro User Interface

3 Pattern Generators

The user interfaces offered by TI for pattern generation include MultiTonePattern, CommSignal, and LTE and MCGSM.

3.1 MultiTonePattern

The TSW1400_MultiTonePattern program can automatically generate a test pattern with single or multiple tones. The patterns can be complex or real. Figure 4 shows the TSW1400 MultiTonePattern user interface generating a pattern using the default settings, a vector size of 32767 (2^{15}-1) and clicking the **Generate and Save** button.

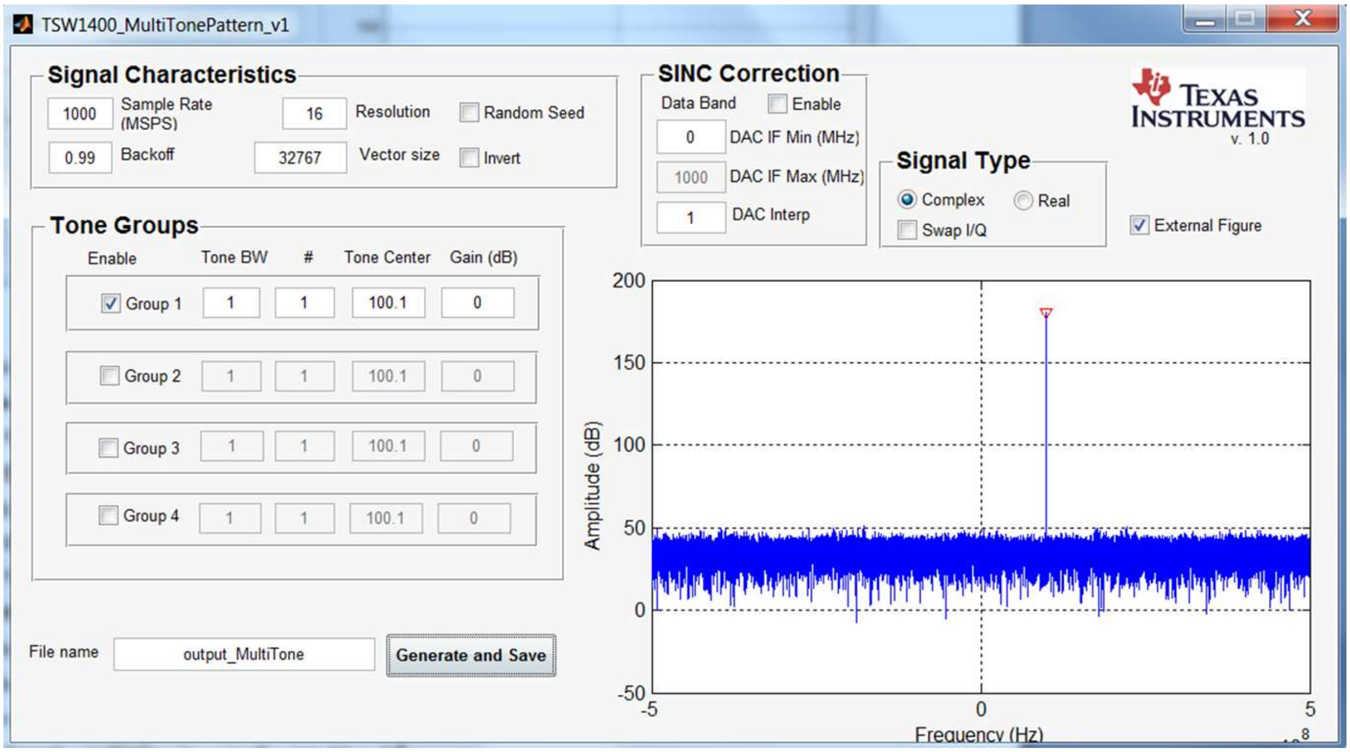

Figure 4. TSW1400 MultiTonePattern User Interface

The graphical user interface controls for the TSW1400 MultiTonePattern window divide into these areas:

Signal Characteristics area

- **Sample Rate (MHz):** sample rate of the pattern in MHz
- **Backoff:** linear backoff of the maximum signal from full scale. TI recommends using a value of less than 0.999 for the backoff.
- **Resolution:** number of bits of the pattern
- **Vector size:** number of vectors in the pattern
- **Random Seed:** selecting the Random Seed check box generates a different set of random phases each time the pattern is generated. If not selected, the exact same phases are used each time, and consequently the patterns are identical. In generating the multitonepattern, the phase of each tone is generated randomly to prevent aligning of the phase and generation of a very large peak-to-average ratio.
- **Invert:** multiplies (inverts) the signal by -1

Signal Type option

- **Complex:** signal is complex
- **Real:** signal is real

SINC Correction area

- **Enable:** enables SINC correction which applies a gradual increasing slope to compensate for the SINC rolloff of the HSDAC zero-order hold output
- **DAC IF Min (MHz):** DAC IF Min is the minimum frequency of the band at the DAC output. **DAC IF Max** is calculated automatically using the relation, IF MIN + Pattern Bandwidth. The data pattern has a bandwidth that is equal to the sample rate for a complex signal and half the sample rate for a real signal. With an interpolating DAC that includes mixer capabilities, this band is often interpolated and mixed to a higher frequency.
- **DAC Interp:** specifies the interpolation used in the HSDAC. Together with the pattern sample rate, this defines the DAC sample conversion rate and therefore the SINC roll-off effect.

Tone Groups area

There can be up to four groups of tones combined into the final pattern. The **Enable** check box is used to select each desired group. Each tone group is defined by the following input fields:

- **ToneBW:** total bandwidth (maximum frequency – minimum frequency) of the tone group. If there is only one tone in the group, the tone is at the **Tone Center** of the group and this parameter is ignored.
- **#:** number of tones in the group.
- **Tone Center:** center frequency of the tone in MHz. To avoid a pattern that is repetitive over a very short time scale, TI recommends setting this value slightly off from a round value. This is why 100.1 MHz is used rather than 100 MHz, which would repeat every 10 samples.
- **Gain (dB):** amplitude in dB of each tone in the group, relative to tones in other groups (not to full scale. NB: The backoff parameter in **Signal Characteristics** is used to set the power of the combined pattern relative to full scale). It is not the combined power of all the tones in the group, but for each tone. This can be a positive or negative value. If one group is set to 10 dB and a second group to –20dB, the power difference for a tone in the first group compared to a tone in the second group is 30 dB.

External Figure

When checked, a separate window displays the amplitude of the pattern in dB vs. frequency. For real patterns, only the positive frequency amplitudes display. A red, inverted triangle (Figure 4) identifies the largest amplitude tone. If there are multiple tones with the same power (Figure 5), the lowest frequency is identified with the triangle.

Generate and Save

This button creates the pattern. By default the generated pattern is saved as output_MultiTone.tsw in the same location as the executable.

3.1.1 MultiTonePattern Examples

Four Tone Groups Pattern Generation

This example describes how to generate a pattern and load it into High Speed Data Converter Pro. It illustrates the ability of the TSW1400 MultiTonePattern software to:

- Set different tone bandwidths
- Use positive and negative gains
- Employ a large number of tones

1. Set up the MultiTonePattern user interface as shown in (Figure 5). Change the sample rate to 500 MSPS and the Tone groups as shown in Figure 5. Keep the other parameters at their default values.
2. Generate the pattern by clicking the **Generate and Save** button. The GUI generates a file called output_MultiTone.tsw in the same folder as the executable.

   The amplitude spectral plot for this pattern displays as shown in Figure 5. The standard MATLAB figure control (magnifying glass) is used to zoom in on the displayed tone group and see the individual tones (Figure 6). To access this functionality, check External Figure before clicking on the **Generate and Save** button.

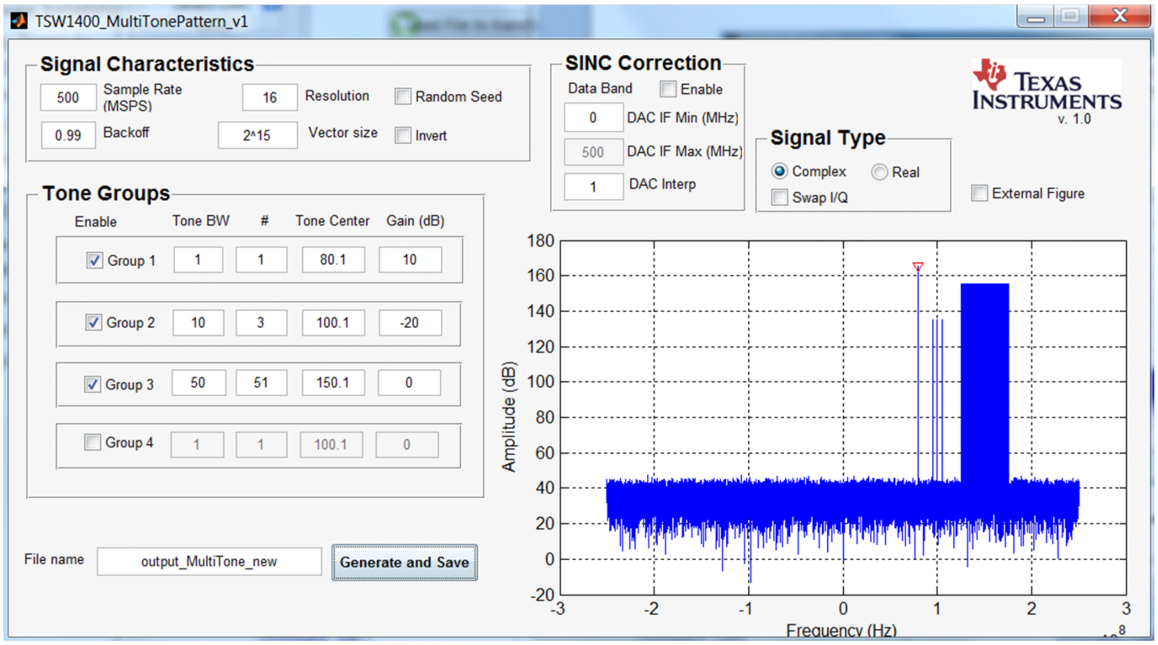

Figure 5. Generated Three Tone Group

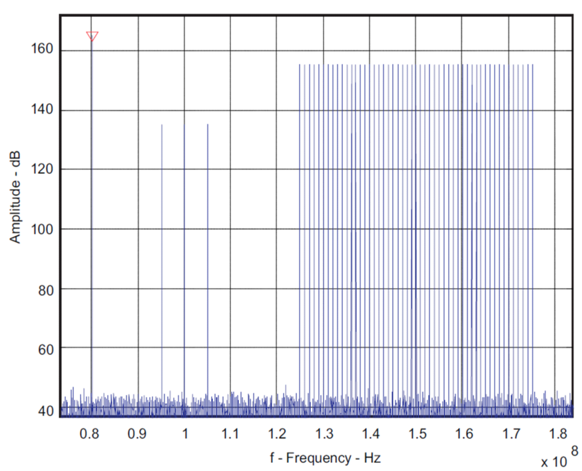

Figure 6. Magnified Spectral Plot of Three Tone Group

3. Inside High Speed Data Converter Pro, click on **Load file to transfer into TSW1400** and browse to the location of the file output_MultiTone.tsw generated in step 2
4. Enter the **Data Rate** (500 MHz) and DAC option (2's complement) as shown in Figure 7

The data can be transmitted to TSW1400 (after it has been loaded with the appropriate firmware) by clicking on the **Send** button. Please refer to TSW1400 High Speed Data Capture/ Pattern Generator Card for instructions.

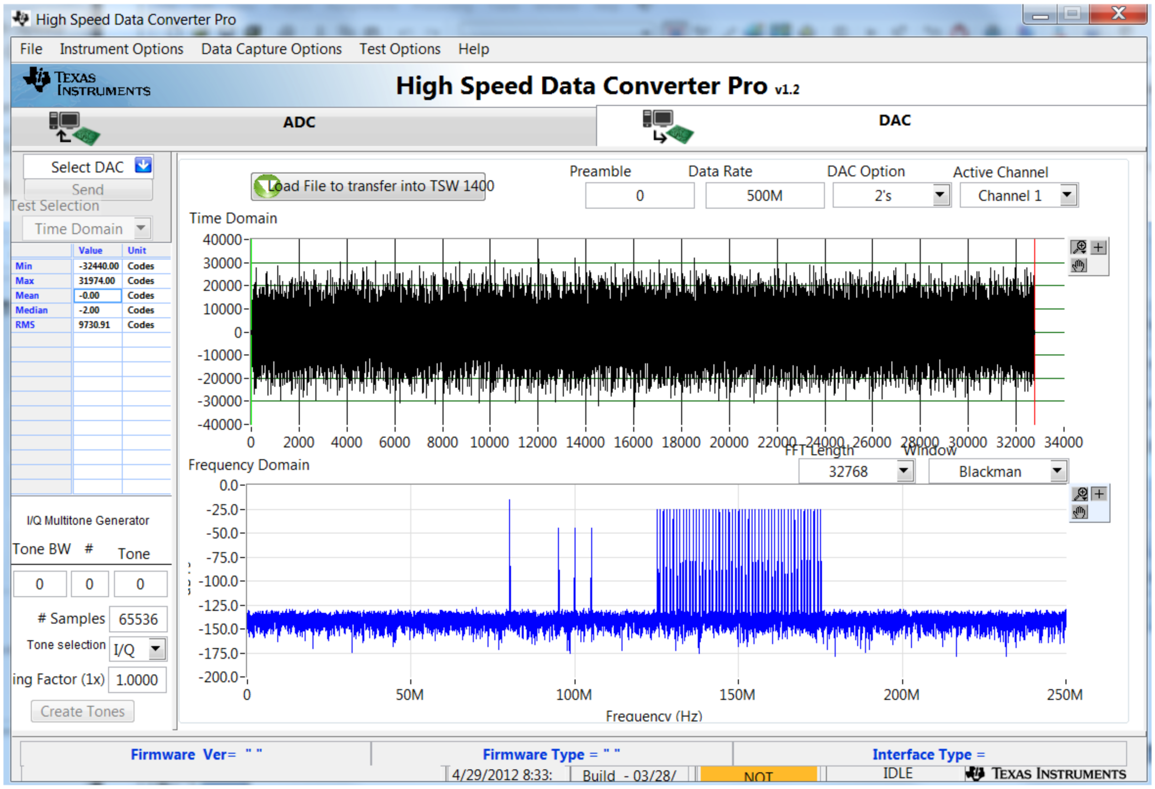

Figure 7. Three Tone Group Pattern Loaded Into High Speed Data Converter Pro

3.2 CommSignalPattern Software

The TSW1400 CommSignalPattern program automatically generates a test pattern for several modulated communications signals such as Wideband Code Division Multiple Access (WCDMA), Time Division - Synchronous Code-Division Multiple Access (TD-SCDMA), and a generic Quadrature Amplitude Modulation (QAM) signal. The patterns can be complex or real. Figure 8 shows the TSW1400 CommSignalPattern software user interface generating a pattern by using the default settings and clicking on the **Generate and Save** button.

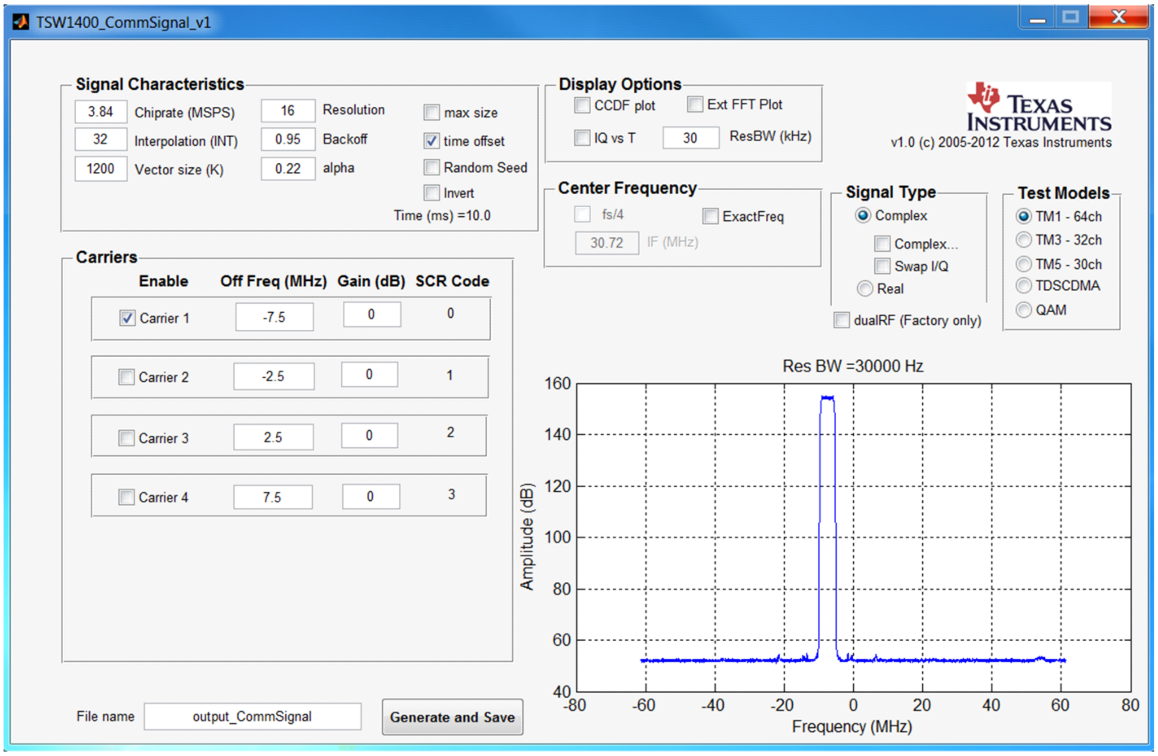

Figure 8. TSW1400 CommSignal User Interface

The graphical user interface controls for the CommSignalPattern window divide into these areas:

Test Models area

This section defines the chip or symbol data used for the pattern generation. The data for the WCDMA TM1, WCDMA TM3, WCDMA TM5, TD-SCDMA, and QAM test models were generated with the Agilent Advanced Digital System and typically demodulated with less than 0.3% of EVM.

- **TM1 – 64 ch:** WCDMA TM1 with 64 channels per 3GPP specification
- **TM3 – 32 ch:** WCDMA TM3 with 32 channels per 3GPP specification
- **TM5 – 30 ch:** WCDMA TM5 with 30 channels per 3GPP specification
- **TD-SCDMA:** TD-SCDMA Downlink signal with 16 user codes active
- **QAM:** Quadrature Amplitude Modulation

Signal Type area

- **Complex:** signal is complex
- **Complex IF:** select check box to modulate the combined group of carriers to a complex IF frequency using the values in the **Center Frequency** pane. When unchecked, the combined group of carriers is centered at 0 Hz.
- **Real:** signal is modulated to a real IF frequency according to the values in the **Center Frequency** pane.

Signal Characteristics area

- **Chiprate (MSPS):** chip or symbol rate of the baseband data in MSPS.
- **Interpolation (INT):** integer value of the oversample rate from the chip or symbol data. The final pattern data rate is the chip rate × Interpolation, for example, 3.84 MSPS × 32 = 122.88 MSPS.
- **Vector size (K):** number of K vectors in the pattern (× 1024)
- **Pilot Gain:** (TD-SCDMA test model only) linear gain of TD-SCDMA pilot relative to data. Typically used to reduce the peak power of the pilots, which can be quite large when several carriers are combined, as the pilots for each carrier add coherently.

- **Resolution:** number of bits in the pattern
- **Backoff:** linear backoff of the maximum signal from full scale. TI recommends using a value of 0.95 or less for the backoff.
- **Alpha:** RRC filter characteristic. Usually 0.22 for WCDMA and TD-SCDMA.
- **QAM width:** (QAM test model only) width in resolution of the square QAM constellation, equal to the square root of the number of constellation points. For example, QAM64 has a width of 8 and QAM256 has a width of 16.
- **Max size:** sets the vector to the largest size possible, which uses all the baseband vector symbols (or chips)
- **Time offset:** slightly offsets the WCDMA carriers in time by 1/(N × **Chiprate**), where N is the number of active carriers. This slightly reduces the PAR of a multicarrier signal. Displays only for TM1, TM3, TM5, or QAM test models.
- **Random Seed:** selecting the Random Seed check box generates a different set of random phases each time the pattern is generated. If not selected, the exact same phases are used each time, and therefore the patterns are identical. In generating the QAM patterns, the baseband symbol is generated randomly.
- **Invert:** multiplies (inverts) the signal by -1
- **Time (ms):** displays the total time of the pattern in milliseconds, which is the Vector size × 1024/**Chiprate**

Center Frequency area

This pane controls the center frequency of the group of carriers. Each carrier is offset from this center frequency by the **Offset Freq (MHz)** value in the Carriers area.

- **fs/4:** sets the center frequency exactly to the sample rate divided by 4, or Chip Rate × interpolation/4
- **ExactFreq:** uses the exact frequency specified in **IF (MHz)** and Carrier **Off Freq (MHz)**. When deselected, the frequency is rounded to the closest frequency that has a prime integer number of periods in the pattern time. When using the exact frequency, if there is not an integer number of periods in the pattern time, there may be a glitch in the pattern as it wraps from back to front. This is seen in the FFT display as skirts on the carrier (Figure 9). Typically this control is not selected.
- **IF (MHz):** center frequency for the carrier group. Note, this frequency is rounded to the lowest frequency that has an integer number of periods in the pattern time when **ExactFreq** is unchecked.

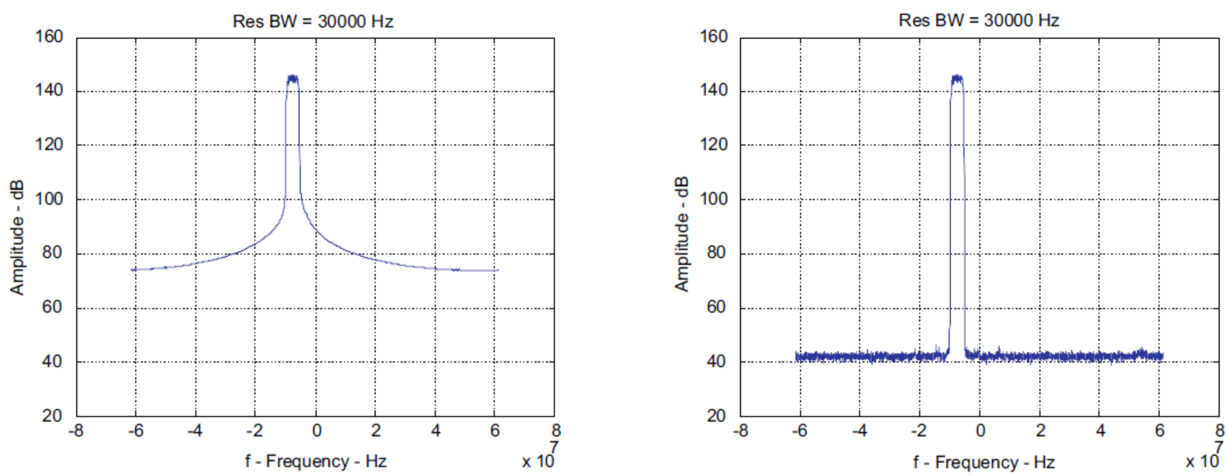

Figure 9. Comparison: Using Exact Frequency (Left) vs Using Rounded Frequency (Right)

Carriers area

There can be up to four carriers for WCMDA/QAM and six carriers for TD-SCDMA that are combined into the final pattern. The **Enable** check box is used to select individual carriers, which are described with these fields:

- **Off Freq (MHz):** offset frequency of the carrier in MHz from the center frequency. Note, this offset may be slightly shifted if the **ExactFreq** check box is not selected. When using the exact frequency, if there is not an integer number of period in the pattern time, there may be a glitch in the pattern as it wraps from back to front. This is seen in the FFT display as skirts on the carrier (Figure 9). Typically the rounded frequency is used.

- **Gain (dB):** amplitude in dB of each carrier relative to other carriers (not to full scale). The **Backoff** parameter in the Signal Characteristics pane is used to set the power of the combined pattern relative to full scale. The Gain can be a positive or negative value. If one carrier is set to 10 dB and a second carrier to –20 dB, the power difference between the first carrier and the second carrier is 30 dB.
- **SCR Code:** carrier SCR code that can be used to set up the demodulation properties in a spectrum analyzer.

Display Options area

- **CCDF plot:** displays the pattern CCDF in a separate window when selected. Note, the zero time (during the uplink slots) of the TD-SCDMA pattern is included in the average power, so for the TDD signal such as TD-SCDMA, the downlink average power is 2.2 dB [10log10(0.6)] higher than displayed when the ratio between DL and UL is 6:4. This ratio is subject to change during transmission, based on the standard.
- **IQ vs T:** displays the real and complex time series of the pattern in a separate window when selected
- **Ext FFT Plot:** displays the spectral plot in a separate window when selected. Use to save, copy, and print spectral plot output.
- **Res BW (kHz):** specifies the averaging window for the FFT plot, similar to the resolution bandwidth function of a spectrum analyzer

3.2.1 TSW1400 CommSignalPattern Examples

Two Carrier WCDMA TM1 Pattern

Generate an example two carrier, WCDMA TM1, complex baseband signal and load to High Speed Data Converter Pro Software with the following steps:

1. Select carriers at 2.5 and 7.5 MHz
2. Keep all the default values and select the **Enable** check boxes for **Carrier 3** and **Carrier 4** (Figure 10).
3. Select the **CCDF** and **Ext FFT** check boxes.
4. Click the **Generate and Save** button. The CCDF and FFT windows display the signal characteristics as shown in Figure 11 and Figure 12. Also the generated pattern is saved as output_CommSignal.tsw in the same folder as the executable.

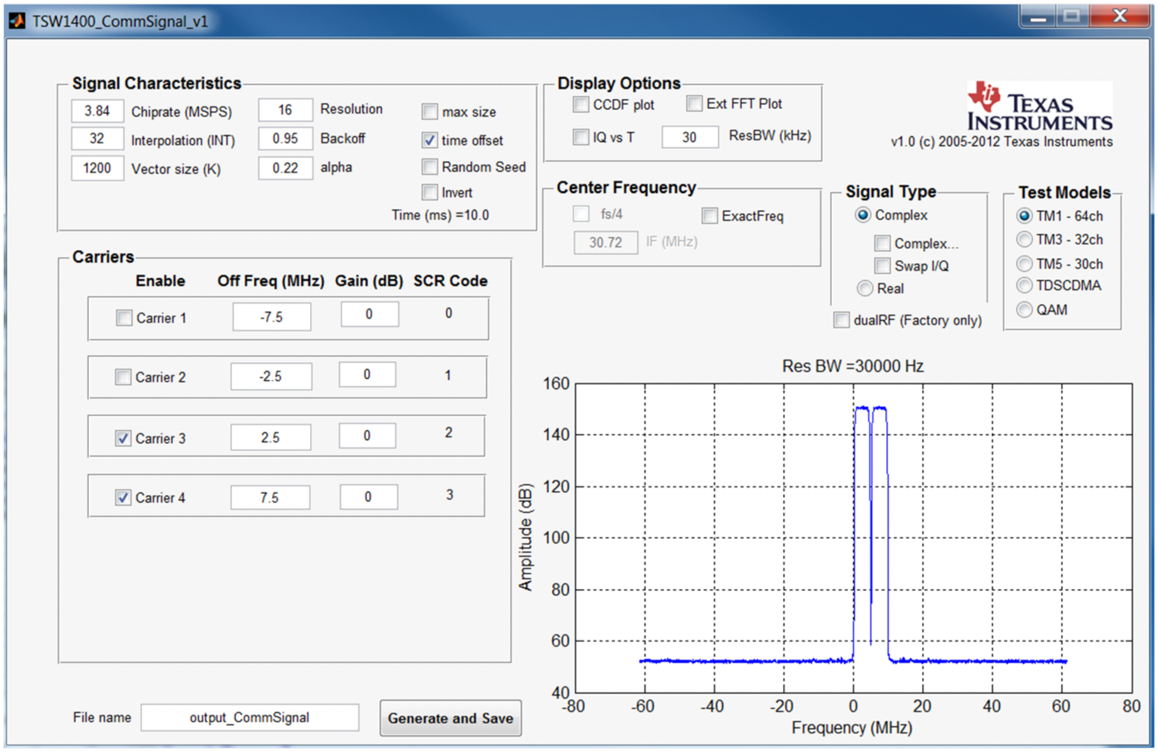

Figure 10. Two Carrier WCDMA TM1 pattern

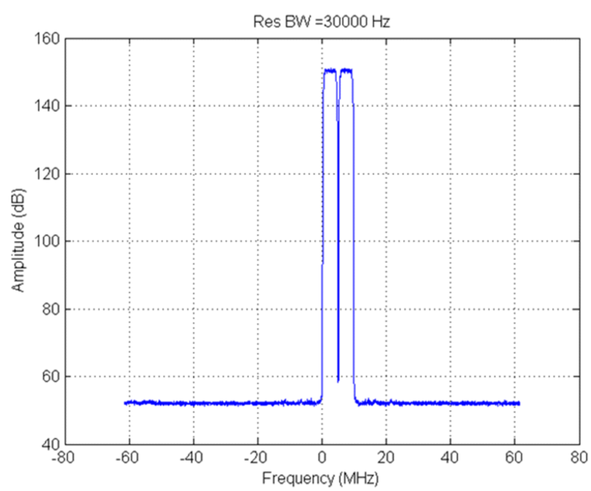

Figure 11. FFT of Two Carrier WCDMA TM1 Pattern

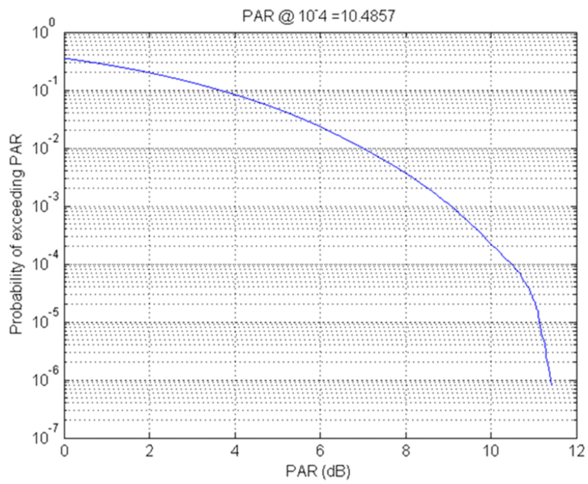

Figure 12. CCDF of Two Carrier WCDMA TM1 Pattern

5. In the High Speed Data Converter Pro window, click on **Load file to transfer into TSW1400** button and browse to the file output_commSignal.tsw generated in step 4.
6. Change the **Data Rate** to 122.88 MHz [i.e **Chiprate** (3.84M) × Interpolation (32)], DAC Option to 2's complement and Window to Blackman as shown in Figure 13.

The data can be transmitted to TSW1400 (after it has been loaded with the appropriate firmware) by clicking on the **Send** button. Please refer to TSW1400 High Speed Data Capture/ Pattern Generator Card for instructions.

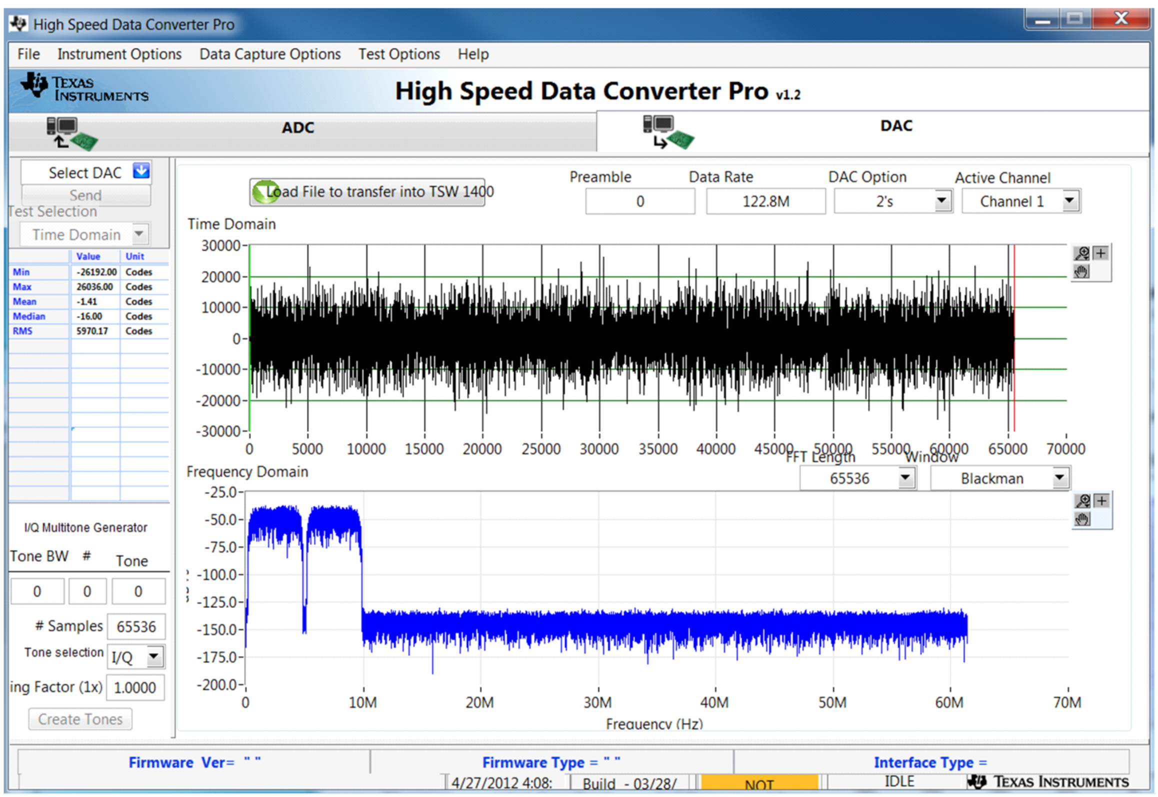

Figure 13. Two Carrier WCDMA TM1 Pattern Loaded Into High Speed Data Converter Pro

3.3 LTE

The TSW1400 LTE program generates multiple LTE baseband signal patterns at different bandwidths of 1.4, 3, 5, 10, 15, and 20 MHz. Each bandwidth has two test models, TM1.1 and TM3.1. TM1.1 is used for ACPR measurements, whereas TM3.1 is used to test EVM performance when using the LTE signal. Using the TSW3085 EVM, the patterns can be loaded in complex format through the LVDS connection between TSW1400 and TSW3085EVM.

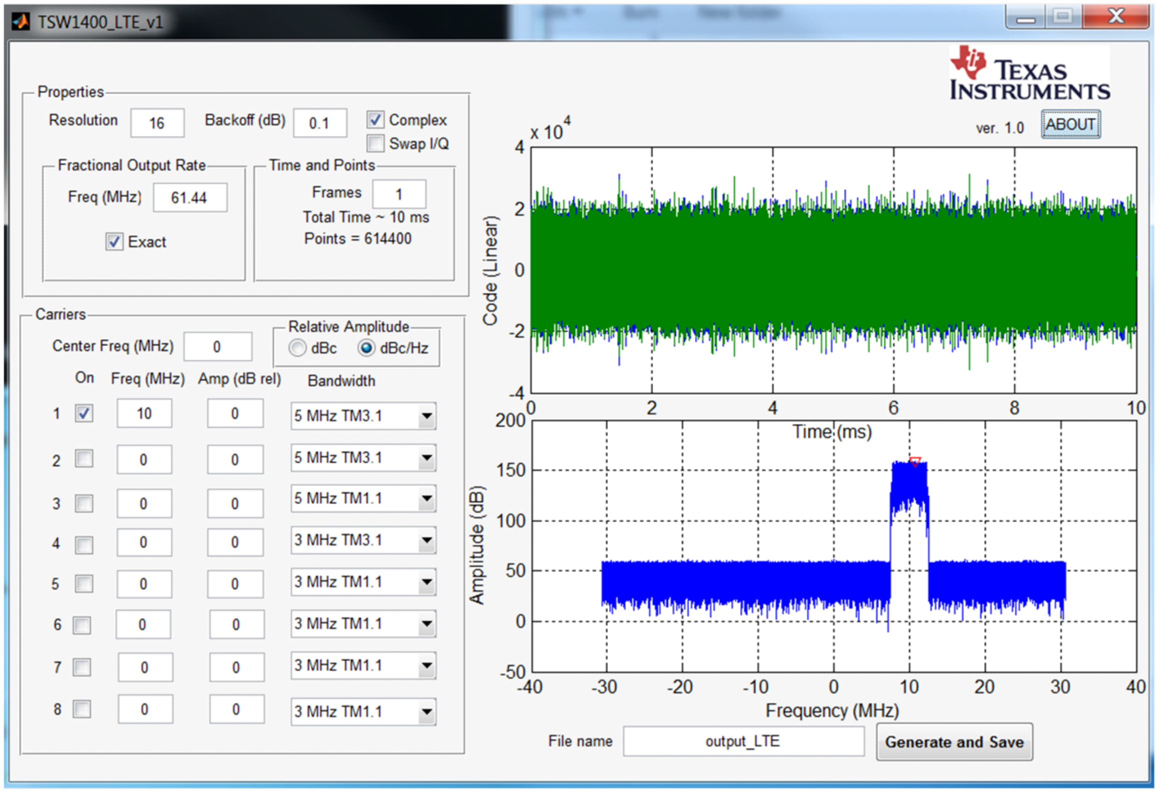

Figure 14. TSW1400 LTE User Interface

The GUI controls for TSW1400 LTE pattern generator are divided into these sections:

- **Properties area**
  - **Resolution:** number of bits of the pattern
  - **Backoff:** linear backoff of the maximum signal from full scale
- **Fractional Output Rate area**
  - **Freq. :** DAC sampling rate divided by the interpolation factor. Sets the rate at which the pattern is loaded to the DAC for correct timing
  - **Frames:** Window of samples
- **Carrier area**
  - **Center Freq. :** The location of the baseband signal
  - **Relative Amplitude:** Unit of measurement
  - **1–8 Selection:** LTE baseband signal characteristics, with options for selecting location, amplitude, and bandwidth of the signal

3.3.1 TSW1400 LTE Example

This example describes how to generate patterns with the LTE GUI and load them into High Speed Data Converter Pro.

1. Set up the interface for TSW1400_LTE as shown in Figure 14.
2. Click on the **Generate and Save** button to create the LTE pattern. The generated pattern is saved as output_LTE.tsw in the same folder as the executable.
3. Inside High Speed Data Converter Pro, click on **Load file to transfer into TSW1400** and browse to the location of the file output_LTE.tsw generated in step 2.
4. Enter the **Data Rate** (61.44 MHz) and DAC option (2's complement) as shown in Figure 15.

The data can be transmitted to TSW1400 (after it has been loaded with the appropriate firmware) by clicking on the **Send** button. Please refer to TSW1400 High Speed Data Capture/ Pattern Generator Card for instructions.

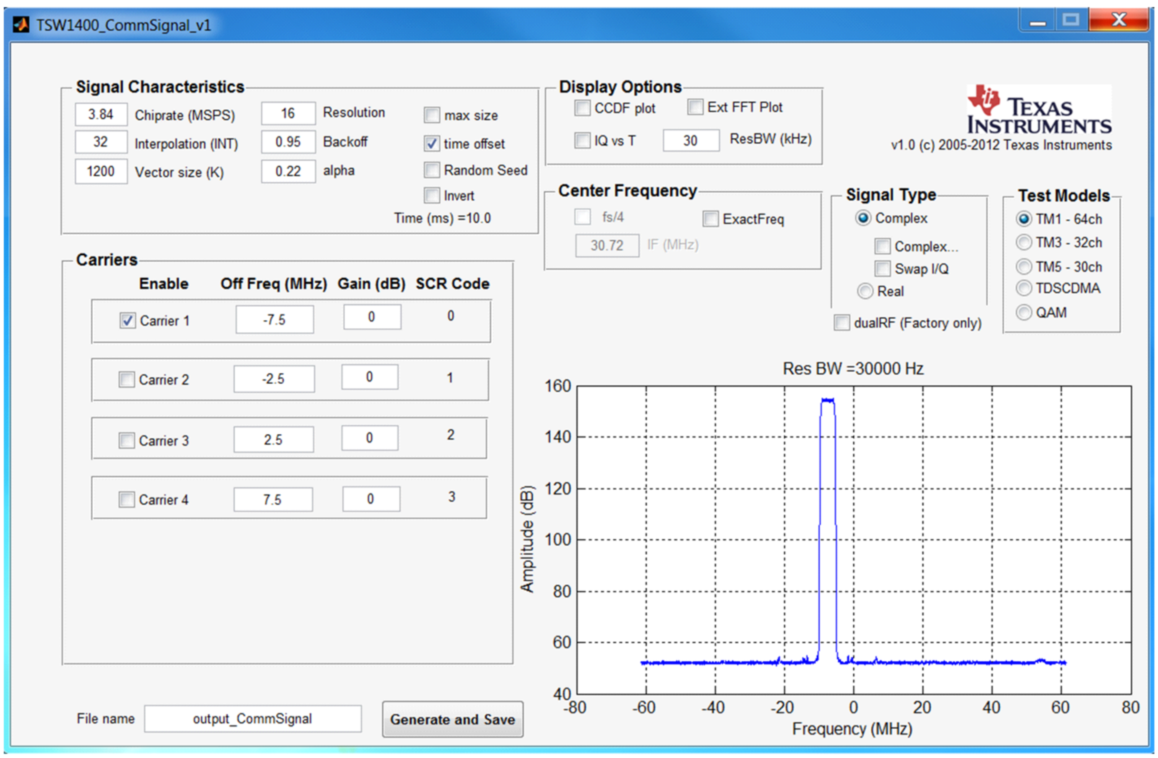

Figure 15. Generated LTE Pattern Loaded Into High Speed Data Converter Pro

3.4 *MCGSM*

The TSW1400 MCGSM user interface is used to generate multicarrier standard and edge GSM signals. The front panel divides into the following areas:

Properties

- **Resolution:** number of bits of the pattern
- **Backoff:** linear backoff of the maximum signal from full scale. TI recommends using a value of less than 0.999 for the backoff.
- **Complex:** signal is complex
- **Swap I/Q:** interchanges the I and Q data when signal is complex
- **Interpolation:** integer value of the oversample rate from the chip or symbol data (chip rate is fixed at 270.833 kHz for GSM). The final pattern data rate is thus 270.833 kHz × Interpolation. The interpolation value can be specified as an integer or as a fraction

  - **Integer:** specifies the interpolation as an integer
  - **Fractional**
    - **M:** when selected the user can specify the desired final data rate for the GSM signal. The user interface automatically calculates the required interpolation needed.
    - **M/N:** specifies the interpolation as a fraction (for example, the ratio of M to N)

Carriers

- **Center Freq:** this pane controls the center frequency of the group of carriers. Each carrier is offset from this center frequency by the value of **Freq (MHz)** in the signals area.
- **Slot Hopping**
  - **Enable:** enables slot hopping
  - **Spacing:** specifies the desired spacing for slot hopping
- **Signals**
  - **On:** selects a signal to generate. Up to 8 signals can be generated
  - **Freq. :** specifies the frequency offset of the selected signal form the center frequency (**Center Freq**)
  - **Amp:** specifies the amplitude in dB of the selected signal
  - **EDGE:** specifies if the signal generated is standard or edge GSM

3.4.1 MCGSM Example

This example shows how to generate a GSM signal using the TSW1400 MCGSM pattern generator and subsequently load it into High Speed Data Converter Pro software.

1. Enable signals 1 and 2 and set their corresponding frequencies to -5 and 5 MHz, respectively. Set the carrier frequency to 20 MHz and keep all other values at the default as shown in Figure 16.
2. Click on the **Generate and Save** button to create the signal. The signal is automatically saved as output_MCGSM.tsw in the same directory as the executable. The default name (output_MCGSM) can be changed if desired.
3. Inside High Speed Data Converter Pro, click on **Load File to transfer into TSW1400** and browse to the file output_MCGSM created in step 2.
4. To generate the correct spectrum, set the **Data Rate** to 104 MHz [that is, data rate = 207.833 kHz × interpolation (384) = 104 MHz]. Also set the DAC option to 2’s complement and the window to Blackman.

The data can be transmitted to TSW1400 (after it has been loaded with the appropriate firmware) by clicking on the **Send** button. Please refer to the TSW1400 High Speed Data Capture/ Pattern Generator Card for further instructions.

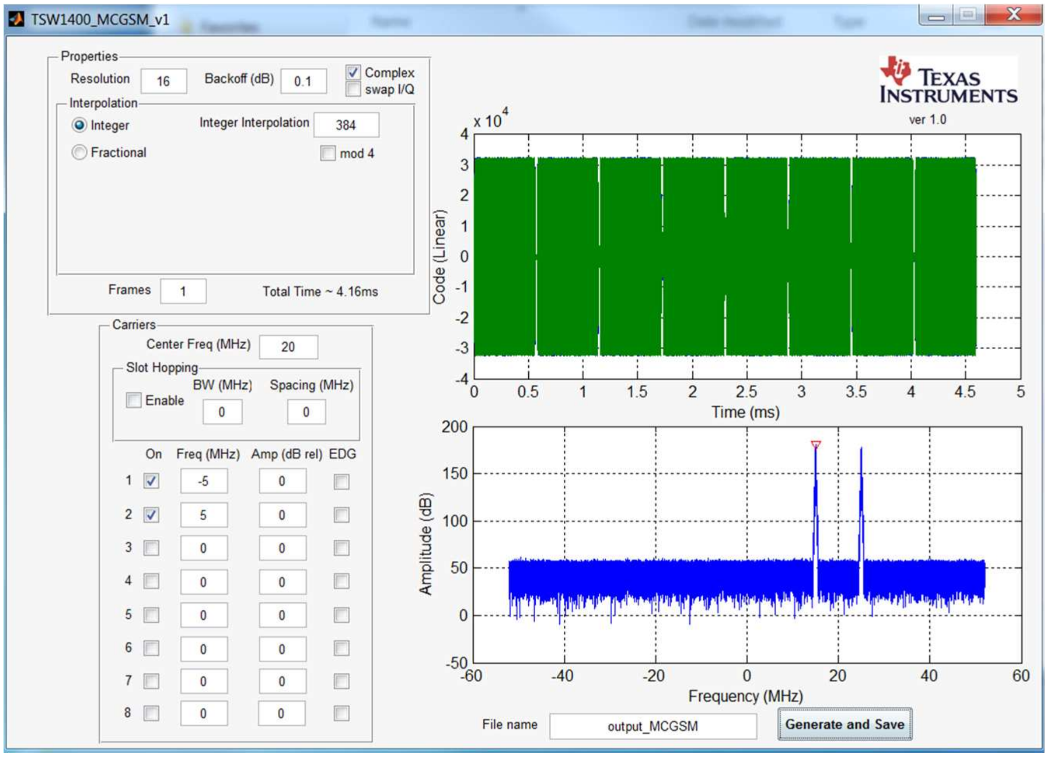

Figure 16. TSW1400 MCGSM Pattern Generator User Interface

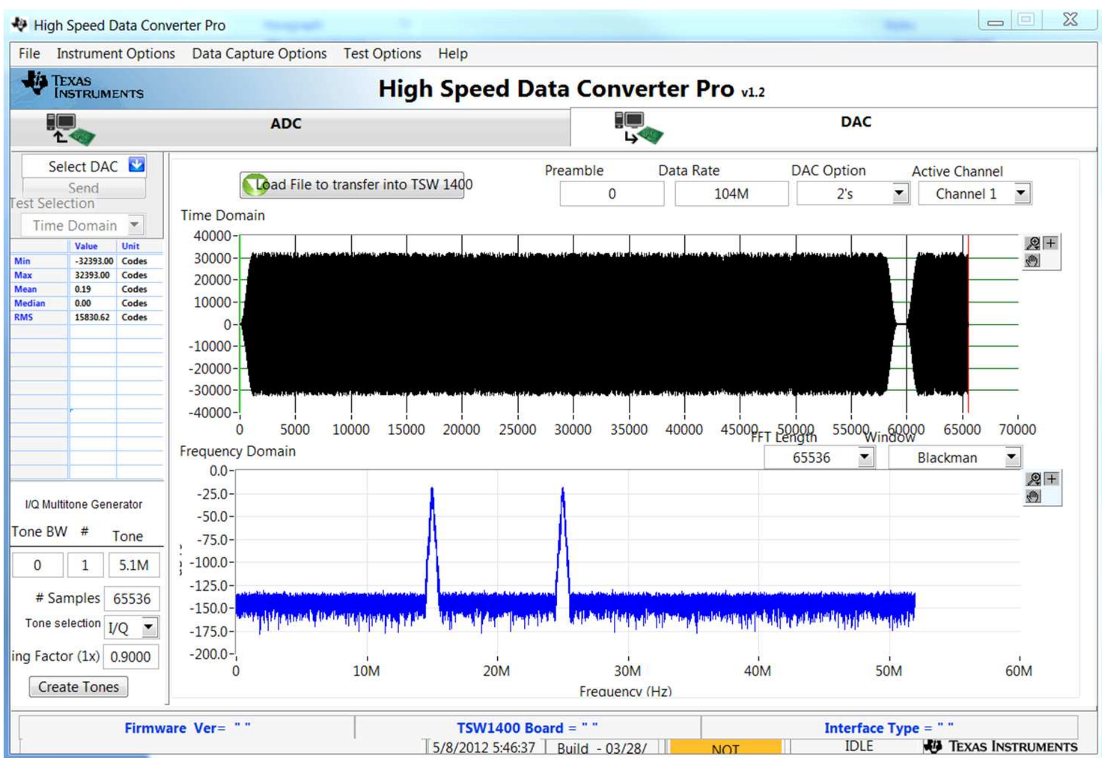

Figure 17. Generated MCGSM Pattern Loaded Into High Speed Data Converter Pro

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