User's and Programming Guide

HP ESG-D Series Option UN8 Signal Generators
Custom Digital Modulation

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Contents

Contents

Contents

Contents

1 Custom Digital Modulation

This guide describes the custom digital modualtion capability provided by the Real-Time I/Q Baseband Generator (Option UN8 required). This includes an overview of the Real-Time I/Q Baseband Generator, as well as information regarding the use of the custom modulation hardkeys and softkeys, functions, operations, a SCPI command reference, and a SCPI command cross-reference.

Overview

The Real-Time I/Q Baseband Generator enables you to shape the characteristics of a digitally modulated signal. You can use it to create both code- and time-domain multiple access signals. You can choose from a variety of modulation types, including QPSK, offset QPSK, BPSK, π/4DQPSK, 4-, 16-, 32-, 64-, and 256-QAM, as well as define your own MSK, FSK, and I/Q modulation types.

You can create and modify these custom modulation types using simple table editors, and store custom files to the signal generator's memory where they can be recalled on demand. Using the table editors, you can adjust the signal's data, frequency deviation, I value, Q value, phase deviation, bit rate, filter alpha, FIR coefficient and value, and symbol table offset. Also, with user-defined IQ and FSK modulations, you can design custom differential encoding schemes.

2 Using Functions

This chapter contains procedures that show you how to use some of the major functions of custom modulation (Option UN8 required).

Setting Up Internally-Generated Digital Modulation Using the Real-Time I/Q Baseband Generator

Using this procedure you will configure the signal generator to output a π/4DQPSK digitally-modulated signal with the following characteristics:

- Carrier frequency set to 1.894880 GHz
- Power level set to 0 dBm
- Timeslot 1 activated and configured as an Uplink Control 1 channel
- A fixed 4-bit repeating sequence selected as the data pattern for timeslot 1
- Timeslot 3 activated and configured as an Uplink Custom channel
- A repeating pattern of 4 1's and 4 0's selected as the data pattern for timeslot 3

Setting the Carrier Frequency

1. Press **Preset** to return the signal generator to the factory-defined instrument state.
2. Press the front panel **Frequency** key. Frequency becomes the active function and the normal preset value for frequency is displayed in the active entry area.
3. Enter 1.894880 GHz using the numeric keypad and pressing the **GHz** terminator softkey. The new carrier frequency is shown in the frequency area of the display.

   You should see: 1.894 880 000 00 GHz

Setting the Power Level

1. Press the front panel **Amplitude** key. Amplitude becomes the active function and the normal preset value for amplitude is displayed in the active entry area.
2. Enter 0 dBm using the numeric keypad and pressing the **dBm** terminator softkey. The new power level is shown in the amplitude area of the display.

   You should see: `0.00 dBm`

Selecting the Data Format

1. Press the front panel **Mode** key and then press **TDMA**, **TETRA** to select the TETRA communications standard.
2. Toggle the **Data Format Pattern Framed** softkey to **Framed**. When you select **Framed** for bursting the frame envelope, you will be transmitting framed data. This means that you will be bursting the timeslots that you have activated and there will be no RF carrier during the off timeslots. Notice that **Configure Timeslots** has become an active softkey.

Setting Up Timeslot 1

1. Observe the display and notice that the normal preset condition for timeslot #1 has the timeslot turned on and configured as an Uplink Normal traffic channel. Press the **Configure Timeslots** softkey. Next, look at the softkeys. The **Timeslot #** softkey shows that timeslot #1 is selected as the active timeslot. The **Timeslot Off On** softkey shows that timeslot #1 is turned on. Finally, the **Timeslot Type** softkey shows that timeslot #1 is configured as an Uplink Normal traffic channel.
2. Change the timeslot type to Uplink Control 1 timeslot by pressing the **Timeslot Type** softkey. Another menu of softkeys is displayed. Press **More (1 of 2)** and then press the **Up Control 1** softkey. You are automatically returned to the previous menu of softkeys. Notice that the **Timeslot Type** softkey has changed from **Up Normal** to **Up Control 1**. Also notice that the display shows timeslot #1 configured as an Uplink Control 1 timeslot.
3. Configure the data pattern for the timeslot by pressing **Configure Up Control 1**. Another menu of softkeys is displayed showing you choices for internal data generation or externally-supplied data patterns, either via the DATA connector or by downloading a binary file. Notice that the display has changed showing you a visual representation of the timeslot. Press the **Data** softkey.
4. Press **FIX4** to select a fixed 4-bit repeating sequence. The 4-bit data pattern becomes the active function and the normal preset value for FIX4 is displayed in the active entry area. Enter any binary sequence, such as 1010, using the numeric keypad and pressing the **Enter** terminator softkey. The new data pattern is displayed in the Data field near the bottom of the text area of the display.

   You should see: Data : 1010

   The data pattern is also displayed below the **FIX4** softkey.

Setting Up Timeslot 3

1. Press the front panel **Return** key twice to move to the preceding menu.
2. Select timeslot #3 as the active timeslot by pressing the **Timeslot #** softkey. Timeslot # becomes the active function and the current active timeslot (#1) is displayed in the active entry area. Press the up arrow key twice to increment the timeslot # to 3.
3. Turn on timeslot #3 by toggling the **Timeslot Off On** softkey from **Off** to **On**.
4. Change the timeslot type to an Uplink Custom timeslot by pressing the **Timeslot Type** softkey. Another menu of softkeys is displayed. Press the **Up Custom** softkey. You are automatically returned to the previous menu of softkeys. Notice that the **Timeslot Type** softkey has changed from **Up Normal** to **Up Custom**. Also notice that the display now shows timeslot #3 configured as an uplink custom timeslot.
5. Configure the data pattern for the timeslot by pressing **Configure Up Custom**. Another menu of softkeys is displayed that allows you to change the data pattern for the custom timeslot. Press **Other Patterns** and then press 4 1's & 4 0's to transmit a repeating sequence of four 1's followed by four 0's.

Turning On the TETRA Format and the Modulation

The signal generator is now configured to burst two uplink timeslots with a 0 dBm, π/4DQPSK digitally-modulated carrier at 1.894880 GHz. Follow these remaining steps to output the framed data.

1. Press **Return** once to move up one menu level until the first TETRA menu is displayed. (The first softkey in this menu is **TETRA Off On**.) Press the **TETRA Off On** softkey. The TETRA format toggles from **Off** to **On**. At this time the internal baseband generator will generate the internal data patterns that you have configured for timeslots 1 and 3. A message is displayed while this process is taking place. Notice, also, that the following display annunciators are turned on:
   - TETRA indicates that you have enabled the TETRA standard
   - I/Q indicates that I/Q modulation is being generated
   - ENVLP indicates that burst is activated for transmitting framed data
2. Press the front panel **RF On/Off** key to toggle RF on. Notice that the display annunciator changes from RF OFF to RF ON. The modulated signal is now available at the RF OUTPUT connector.

Table Editor Basics

Option UN8 provides several table editors that enable you to:

- map I/Q symbol positions (for details, see page 2-6)
- build a customized digital modulation (for details on using the FSK table editor, see page page 2-18)
- map custom differential encoding (for details, see page 2-28)
- create and modify FIR data filters (for details, see page 2-31)

While each of these table editors performs a different function, they are all used in basically the same way, and most of the table editors have several editing softkeys in common.

Common Edit Functions

Edit Item Enables you to use the front panel knob and arrow keys to edit the value of a selected entry. After highlighting the value you want to edit, select this softkey.

Insert Row Inserts a row for data below the currently selected row.

Delete Row Deletes the currently selected row of data.

Goto Row Displays a new page of softkeys so that you can quickly move to the first, middle, or last row of data. This is especially helpful in a large table, or when using the filter table editor mirror function.

Load Default Enables you to load default values into a table editor.

Restore Default Enables you to reset factory default values for the filter and the modulation type.

NOTE Restoring the default modulation effects the current settings in the I/Q table editor, the FSK table editor, and the Differential State table editor.

Load/Store Displays a new page of softkeys that enables you to load data from a stored file, save data to a file, or delete a stored file.

Delete All Rows Clears all data from a table.

CAUTION There is no “undo” command. Once you delete data from a table, you can not retrieve it.

Mapping Symbol Positions with the I/Q Table Editor

In modulation schemes defined by standards (for example, TDMA, GSM, and CDMA), symbols appear in default positions in the I/Q plane. The I/Q table editor provided in Option UN8 enables you to do the following:

- Create a unique mapping of symbols

  You can create a mapping that is not supplied as a default. You can also create a non-standard mapping; this is often necessary for a proprietary modulation scheme.

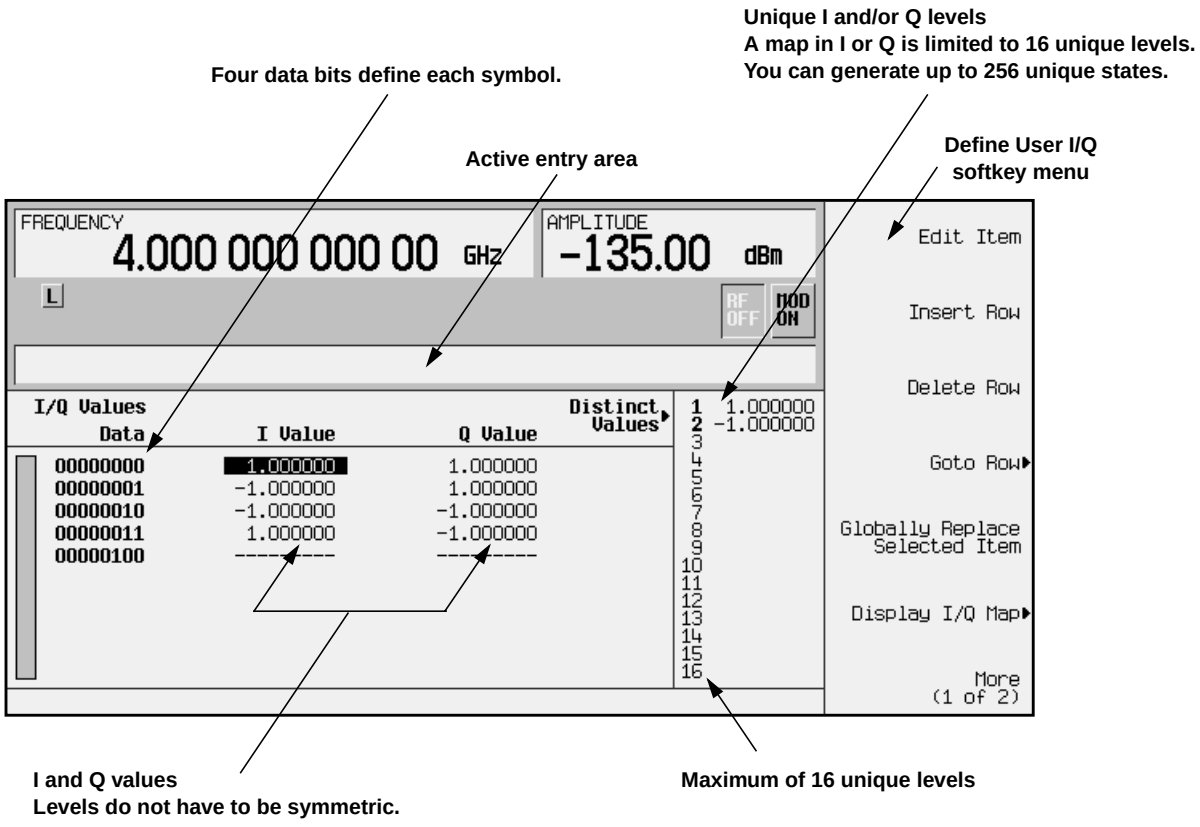
- Change the position of one or more symbols in a standard mapping

  This is often done to test the sensitivity of a receiver, or to create a symbol mapping that is similar to a default.

The examples in this section provide information on how to create an I/Q map (on page 2-7), how to edit a default map (on page 2-11), how to globally change a value in an I/Q table (on page 2-15), and how to use a stored custom I/Q map (on page 2-17).

Table Editor Basics

While the following examples provide information specific to the I/Q table editor (shown in the following figure), they do not go into detail on every possible way to edit information. The section "Table Editor Basics" on page 2-5 covers in detail many of the features common to most table editors.



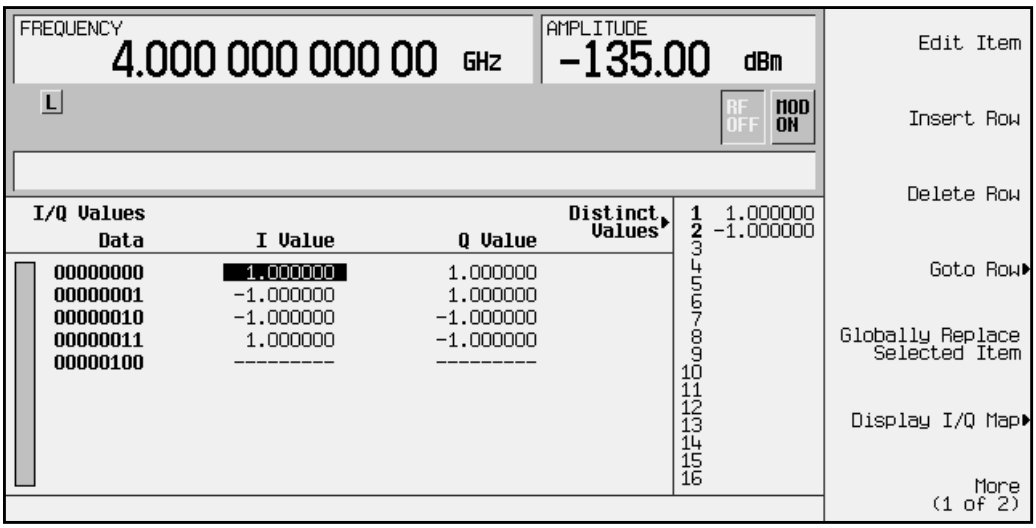
Creating a Symbol Map

Use the following procedure to create and store a 4-symbol unbalanced QPSK.

Accessing the I/Q Table Editor

1. Preset the signal generator.
2. Press the front panel **Mode** key.
3. In the softkey menu, press **Real Time I/Q BaseBand** (if this softkey does not appear, go to step 4).
4. To display the I/Q table editor, press **Custom**, **Modulation Type**, **Define User I/Q**.

   The following illustration of the I/Q table editor shows the data for a 4QAM I/Q map. The initial data you will see depends on what was last used in the instrument.



Clearing Data

When you create a new I/Q map (rather than editing existing data), it is often easier to start with an empty table. Use the following steps to clear existing data from the table editor.

1. Press the softkey **More (1 of 2)** to view the second page of softkeys.
2. Press **Delete All Rows**, **Confirm Delete of All Rows**. All data is removed from the table.
3. Press **More (2 of 2)** to return to the first page of softkeys.
4. Press **Display I/Q Map**. The data list is replaced by a blank I/Q state map.
5. To redisplay the list, press **Return**. As you enter data, you can toggle between the list and the map to visually check the entries.

Entering I and Q Values

Next you will enter the coordinates of each symbol. The position of a symbol is defined by a pair of values (one representing I and the other representing Q).

Table 2-1 I and Q Values for an Unbalanced QPSK

Symbol	Data Bits	I Value	Q Value
0	0000	0.500000	1.000000
1	0001	–0.500000	1.000000
2	0010	0.500000	–1.000000
3	0011	–0.500000	–1.000000

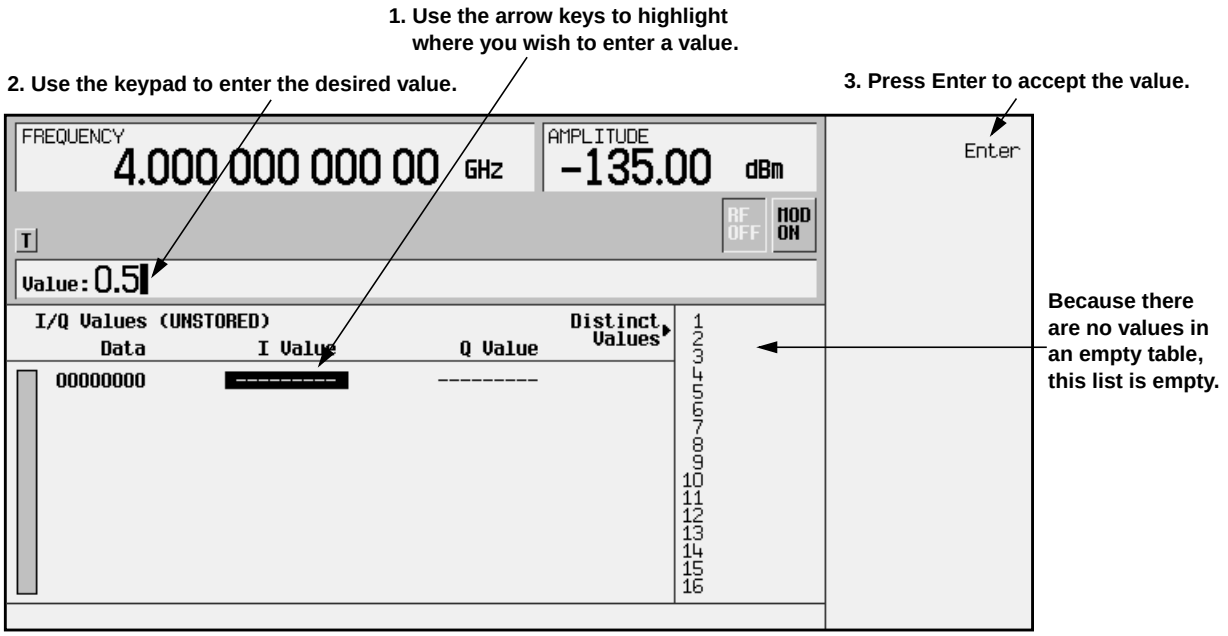
Both the 4QAM I/Q map shown on page 2-7, and the map you create in this example have four symbols. Please note, however, that the 4QAM I/Q map uses only *two* unique values (–1.0 and 1.0) to create those symbols, while this example uses the following *four* unique values: 0.5, 1.0, –0.5, and –1.0. It is not the number of values that defines how many symbols a map has, but how those values are combined.

NOTE The number of bits per symbol can be expressed using the following formula. Because the equation is a ceiling function, if the value of x contains a fraction, x is rounded up to the next whole number.

$$x = \lceil Log_2(y) \rceil$$

Where x = bits per symbol, and y = the number of I/Q states.

The following figure summarizes the process of entering values in the I/Q table editor. Detailed steps begin on the next page.



1. Note that the entry under `I Value` is highlighted. Use the numeric keypad to type the first I value from the table on page 2-8. You do not have to type the leading zero, or the zeros that follow the number 5.

   As you press the keys, the numbers display in the active entry area (if you make a mistake, use the backspace key and then retype).

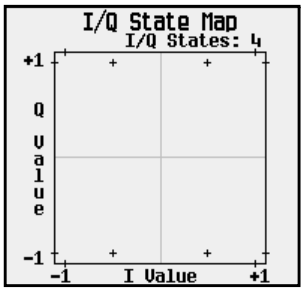
2. To accept the value, press the **Enter** softkey. Note that the I value updates, the highlight moves to the first Q entry (and provides a default value of 0), and an empty row of data appears below the first row.

   Also note that `0.000000` appears as the first entry in the list of Distinct Values, and that `0.500000` appears as the second entry.

NOTE The maximum number of distinct (unique) values that can appear in any I/Q map is 16. This is *not* the maximum number of I/Q entries; this is simply the maximum number of distinct values that you can use to create the entries. For example, if you load the default 256QAM map, you will see that 16 distinct values have been used to create far more than 16 I/Q entries.

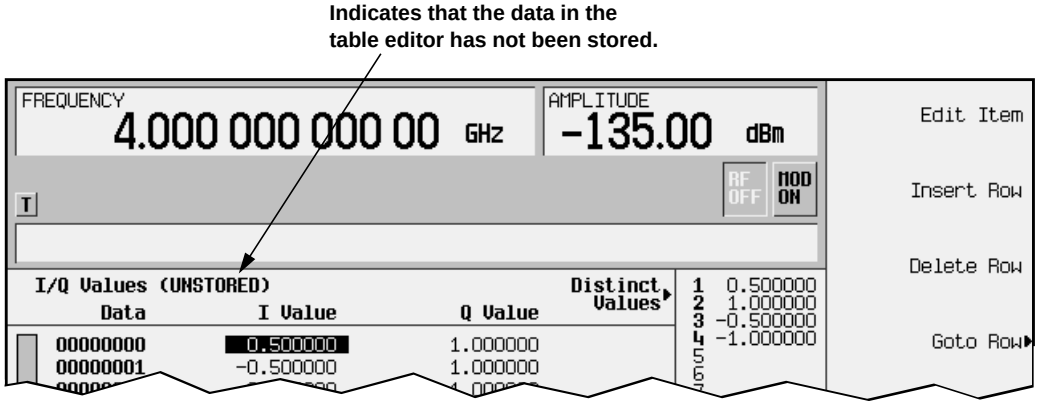
3. For the first `Q Value`, type 1, then press **Enter**. The Q value updates, and the highlight moves to the second I value. Now `0.500000` and `1.000000` are listed as the distinct values.

4. Enter the remaining I and Q values. Remember that you can view the I/Q map at any time (using the **Display I/Q Map** softkey, as described in "Clearing Data" on page 2-7). The figure to the right shows a completed constellation.



Storing the I/Q Map to Memory

Now that you have created a custom I/Q map, you can save it for future use. When the current table has not been stored, (UNSTORED) appears as shown in the following figure.



If you try to exit the table editor without storing, the signal generator displays the softkey:

Confirm Exit From Table Without Saving

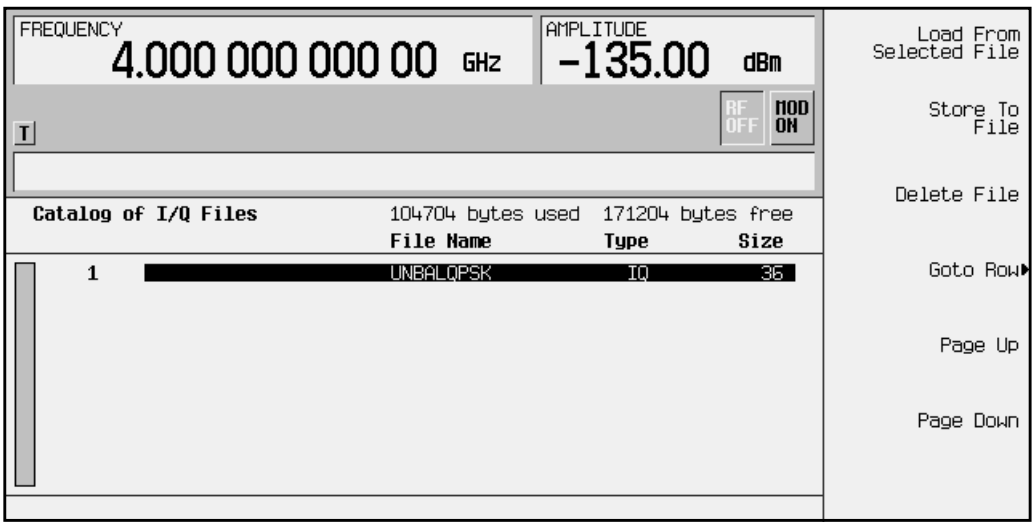
To exit *without* saving the table, select the softkey. If you do *not* want to exit without storing the table, press **Return**.

1. In the softkey menu, press **More 1 of 2**, **Load/Store**, **Store To File**. The catalog of I/Q files appears, which lists stored files, and amount of memory used and available (in bytes).
2. To name the file, press the softkey containing the desired character, then select the softkey with that character from the subsequent menu. For example, to begin naming the file UNBALQPSK, first press the **OPQRSTU** softkey, and then press the **U** softkey.

   Note that `U` is displayed in the active entry area following the `Store to:` text.

   Continue entering the characters for the file name until `UNBALQPSK` is displayed in the active entry area.
3. When the file name is complete, press **Enter**.

   The following figure shows the results of saving the I/Q file.



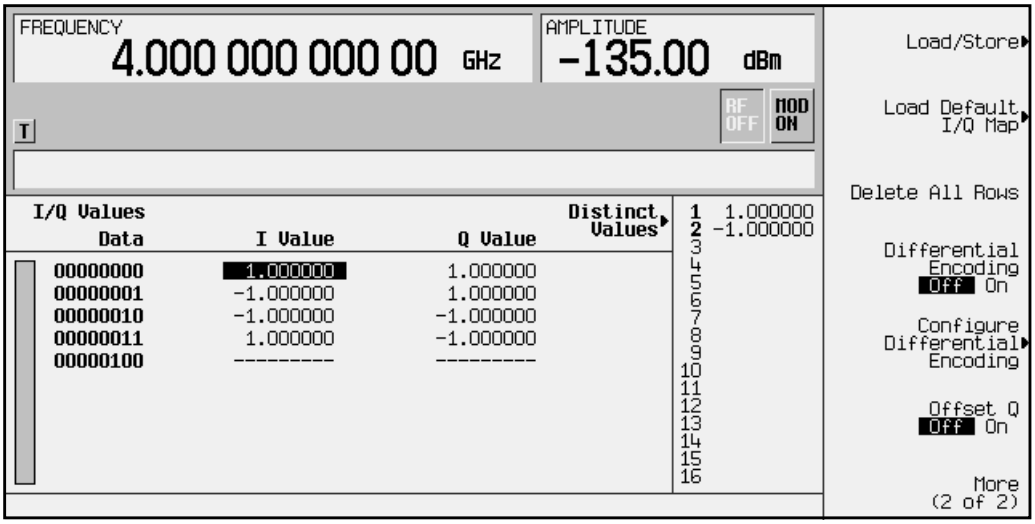
Moving an I/Q Symbol

You can manipulate symbol locations to simulate magnitude and phase errors. In this example, you will edit a 4QAM constellation to move one symbol closer to the origin.

Loading the 4QAM I/Q Map

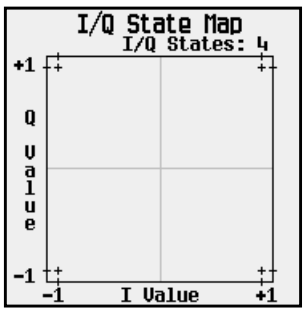
1. **Preset** the signal generator.
2. Press the front panel **Mode** key.
3. In the softkey menu, press **Real Time I/Q BaseBand** (if it appears), **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **QAM**, **4QAM**. The I/Q table editor displays the data for the 4QAM I/Q map.
4. Press **More (2 of 2)** to return to the first page of softkeys.

   The following illustration of the I/Q table editor shows the data for a 4QAM I/Q map.



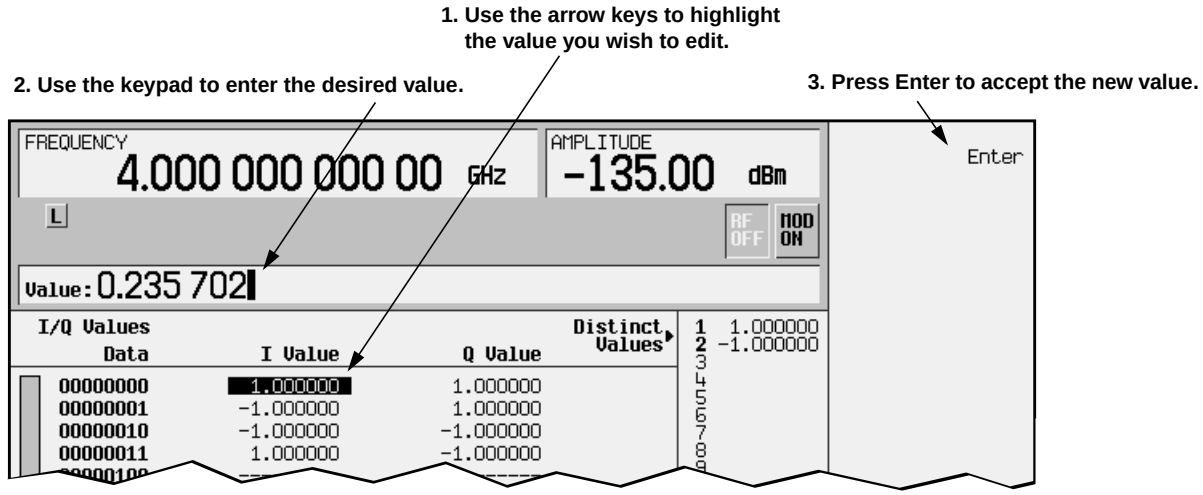
5. In the softkey menu, press **Display I/Q Map**. The data list is replaced by an I/Q state map (constellation diagram), as shown here.

   To redisplay the list, press **Return**. As you edit data, you can toggle between the list and the map to visually check the entries.



Editing I and Q Values

The following figure summarizes the process of editing values in the I/Q table editor. Detailed steps begin after the figure.



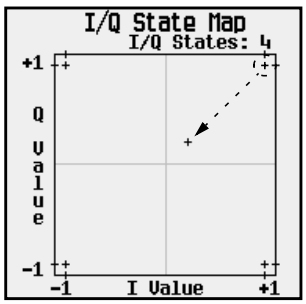
1. Note that the first I value is highlighted. Using the numeric keypad, type `0.235702`.

   As you press the keys, the numbers display in the active entry area (if you make a mistake, use the backspace key and then retype).

2. To accept the value, press the **Enter** softkey. Note that the I value updates, and the highlight moves to the first Q entry.

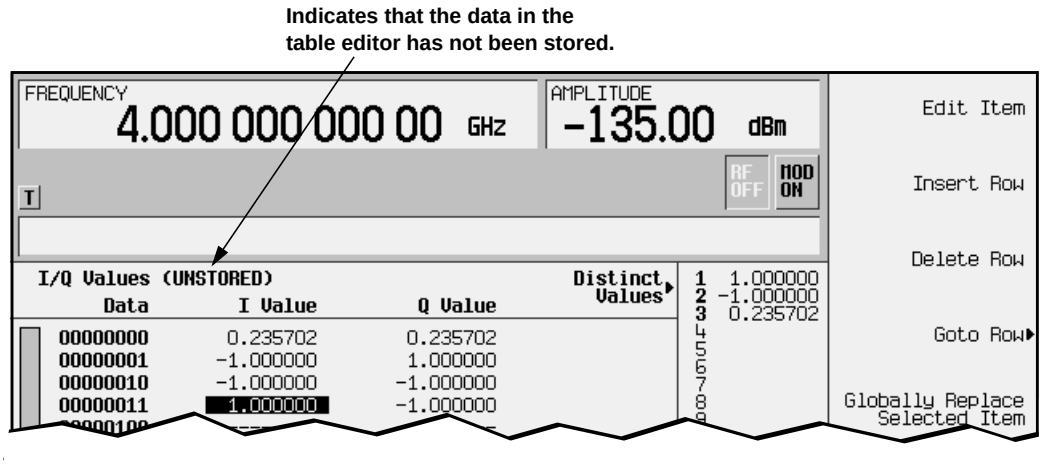
3. For the first Q entry, enter `0.235702` and press **Enter**.

4. In the softkey menu, press **Display I/Q Map**. Note that one symbol has moved, as shown in the following figure.



Storing the I/Q Map to Memory

You can save this modified map for future use. When the current table has not been stored, (UNSTORED) appears as shown in the following figure.

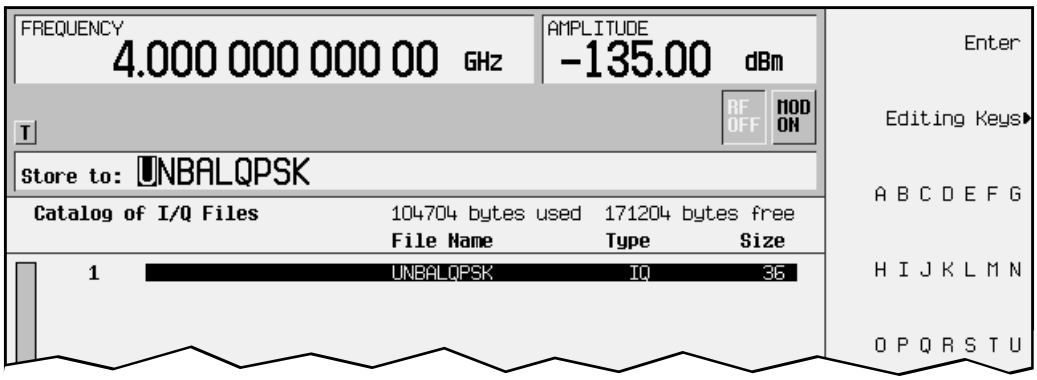


If you try to exit the table editor without storing, the signal generator displays the softkey:

`Confirm Exit From Table Without Saving`

To exit *without* saving the table, select the softkey. If you do *not* want to exit, press **Return**.

1. In the softkey menu, press **More 1 of 2**, **Load/Store**, **Store To File**. The catalog of I/Q files appears, which lists stored files, and amount of memory used and available (in bytes).
2. If there are already files in the catalog, the first file is selected, and its name appears in the active entry area, as shown in the following figure. If there are no files listed, go to step 3.

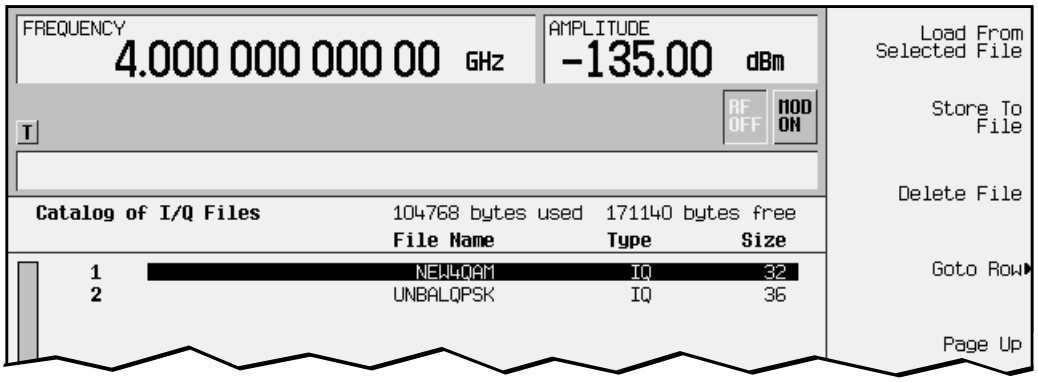


If an existing file is selected, press the **Editing Keys** softkey, then select **Clear Text**. The previous page of softkeys returns, and only a cursor appears in the active entry area following the `Store to:` text.

3. To name the file, press the softkey containing the desired character, then select the softkey with that character from the subsequent menu. For example, to begin naming the file NEW4QAM, first press the **HIJKLMN** softkey, and then press the **N** softkey.

   Note that `N` is displayed in the active entry area following the `Store to:` text. Continue entering the characters for the file name until `NEW4QAM` is displayed in the active entry area (use the numeric keypad for the number 4).

4. When the file name is complete, press **Enter**. The following figure shows the results of saving the I/Q file.



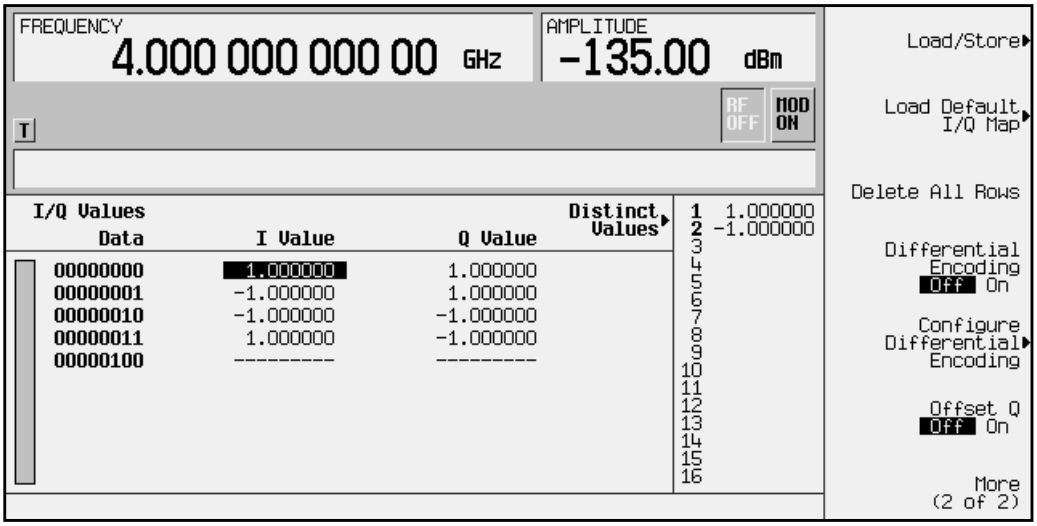
Globally Replacing an I/Q Value

When you want to change an I/Q value throughout the entire table, you can change the value once and have all occurrences of that value change to the new value. In this example, you will use the **Globally Replace Selected Item** command to globally replace I/Q values.

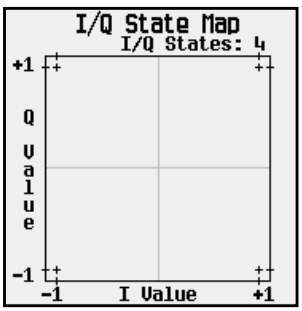
NOTE When using the **Globally Replace Selected Item** command, be sure that you want *all* occurrences of the selected value changed. Also, consider the order in which you change values. For example, if you want to change all current 0.5 values to 1.0, and all current 1.0 values to −0.75, change the 1.0 values first, or all values will end up as −0.75.

Loading the 4QAM I/Q Map

1. Preset the signal generator, then press the front panel **Mode** key.
2. In the softkey menu, press **Real Time I/Q BaseBand** (if it appears), **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **QAM**, **4QAM**. The I/Q table editor displays the data for the 4QAM I/Q map, as shown in the following illustration.



3. Press **More (2 of 2)** to return to the first page of softkeys, then press **Display I/Q Map**. The data list is replaced by an I/Q state map (constellation diagram), as shown at right. To redisplay the list, press **Return**. As you edit data, you can toggle between the list and the map to visually check the entries.

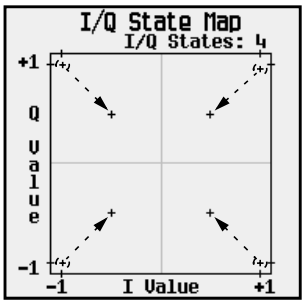


Globally Editing I and Q Values

1. Select any occurrence of the value `1.000000`, then select the softkey **Globally Replace Selected Item**.
2. Using the numeric keypad, type `0.5`, then press the **Enter** softkey.

   Note that all entries in the table that were originally `1.000000` now read `0.500000`.
3. Select any occurrence of the value `-1.000000`, then select the softkey **Globally Replace Selected Item**.
4. Using the numeric keypad, type `-0.5`, then press the **Enter** softkey.

   Note that all entries in the table that were originally `-1.000000` now read `-0.500000`.
5. In the softkey menu, press **Display I/Q Map**. Note that you have moved all of the symbols, as shown below.



Storing the I/Q Map to Memory

As described on page 2-13, you can save this modified map for future use (**Load/Store**, **Store To File**).

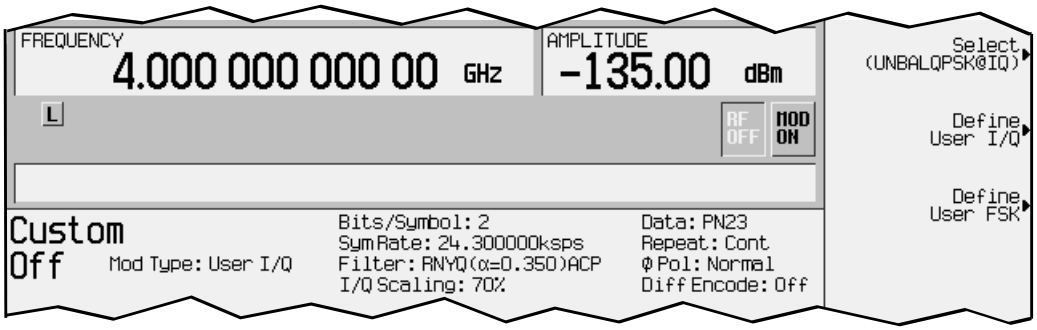
Using a Stored I/Q Map

Once you have created and stored a custom I/Q map, you can use that information as described in the following steps.

Selecting a Custom I/Q File

1. Press the front panel **Mode** key.
2. In the softkey menu, press **Real Time I/Q BaseBand** (if it appears), **Custom**.
3. To display the catalog of stored I/Q files, press **Modulation Type**, **Select**, **User I/Q**.
4. Highlight the file you want to use, then press **Load From Selected File**.

   The information from the file is loaded, and User I/Q is displayed as the `Mod Type`. Also note that **(<filename>@IQ)** appears below the **Select** softkey, as shown below.



Turning On a Custom Modulation

Once you have selected a custom modulation, use the following steps to turn it on.

1. Go to the Custom Modulation menu (**Mode**, **Real Time I/Q BaseBand** (if it appears), **Custom**).
2. In the Custom menu, press the softkey **Custom Off On** to highlight **On**.

   Note that, `Custom On` appears on the front panel, and the custom and I/Q annunciators turn on.
3. Press the front panel **Frequency** key and then set the desired frequency.
4. Press the front panel **Amplitude** hardkey and then set the desired amplitude.
5. If necessary, press the front panel **Mod On/Off** hardkey until the `MOD ON` annunciator appears. This applies the custom modulation to the carrier.
6. If the RF is not on (the `RF OFF` annunciator is on), press the front panel **RF On/Off** key. The display annunciator changes to `RF ON`, and the custom modulated signal is available at the RF OUTPUT connector.

Building a Customized FSK Modulation Using the FSK Table Editor

Use this procedure to create, store, and apply a customized continuous 4-level FSK signal. You will learn to do the following:

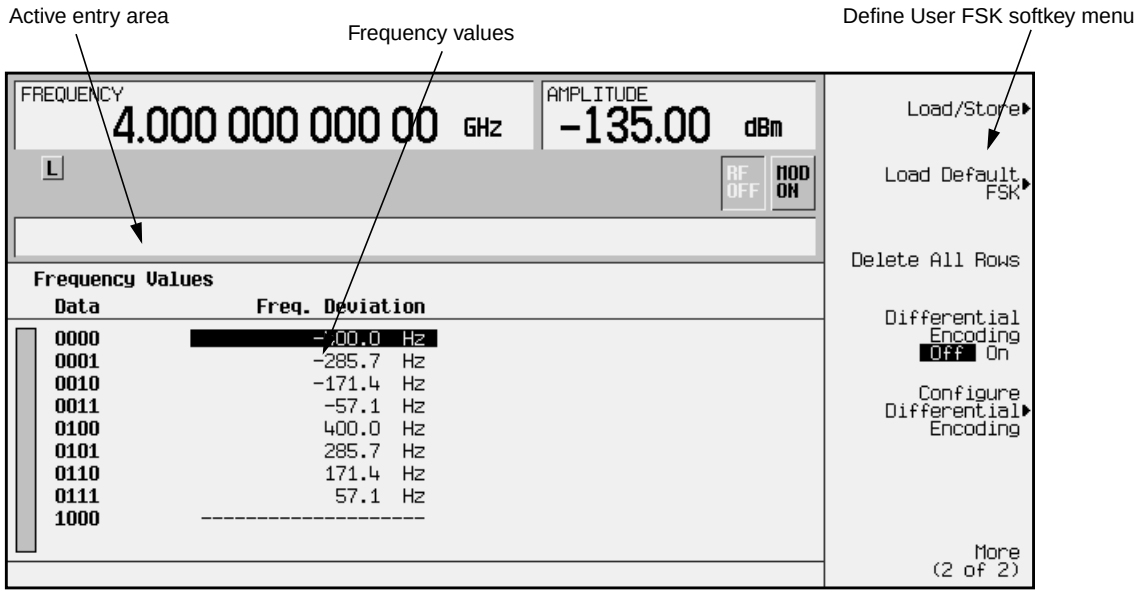
- Choose the Define User FSK setting
- Create a unique file of frequency deviations
- Store the custom FSK modulation to a file
- Load a stored file of frequency deviations
- Select a custom FSK file for use
- Turn on custom FSK modulation

Table Editor Basics

While the following examples provide information specific to the FSK table editor, they do not go into detail on every possible way to edit information. The section "Table Editor Basics" on page 2-5 covers in detail many of the features common to most table editors.

Choosing the Define User FSK Setting

1. Preset the signal generator to normal preset conditions.
2. Press the front panel **Mode** hardkey. (If you have multiple options installed in your signal generator, press the **Real Time I/Q BaseBand** softkey to select Option UN8.)
3. Press **Custom, Modulation Type, Define User FSK** to choose Custom Modulation and select the Define User FSK menu.
4. You will see a `Frequency Values` table with `Data` in the first column and `Freq. Deviation` in the second column. The following illustration of the FSK table editor shows the data for an 8-level FSK modulation. The initial data you see will depend on what was last used in the instrument.



Creating a Unique FSK File of Frequency Deviations

There are two methods for creating a custom FSK file. You can either define the frequency deviations using completely original data (see Using Original Data, below), or you can load and modify a default FSK pattern (see Modifying a Default FSK Pattern, below).

Using Original Data

Follow these instructions to create an example of an APCO25 C4FM customized continuous 4-level FSK signal with two bits per symbol.

NOTE The number of bits per symbol can be expressed using the following formula. Because the equation is a ceiling function, if the value of *x* contains a fraction, *x* is rounded up to the next whole number.

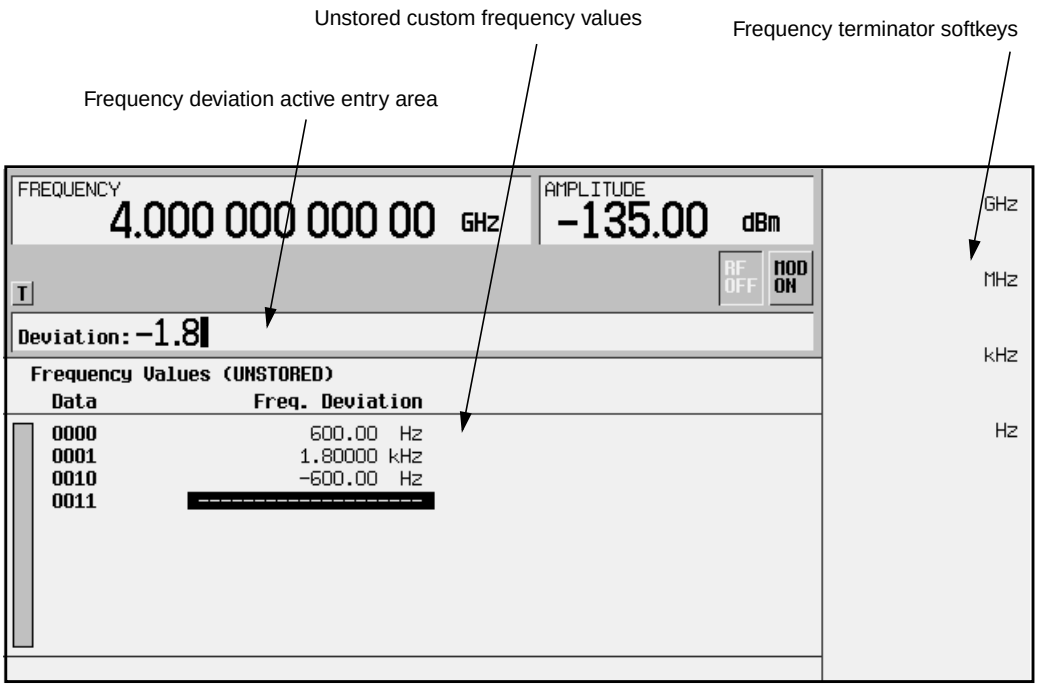
$$x = \lceil \mathrm{Log}_2(y) \rceil$$

Where *x* = bits per symbol, and *y* = the number of frequencies.

When you create new frequency values (rather than edit existing data), it is often easier to start with an empty table. To clear the existing frequency values from within the Define User FSK menu, press **More (1 of 2)**, **Delete All Rows**, **Confirm Delete Of All Rows**.

The following figure defines the areas of the display. As you enter frequency deviation values, the numbers will display in the active entry area (if you make a mistake, use the backspace key and then retype). Follow the steps below:

1. Enter the first frequency deviation value as follows:
   - Use the front panel numeric keypad to enter **600**.
   - Press the **Hz** terminator softkey to set the value at 600 Hz.
   - Notice that each time you enter a value, the Data column increments to the next binary number, up to a total of 16 data values (from binary 0000 to binary 1111).



2. Continue to use the numeric keypad and the appropriate terminator softkey to enter these frequency deviation values:

   - +1.8 kHz for data row `0001`
   - -600 Hz for data row `0010` (To designate a negative value, first press the **+/-** hardkey on the numeric keypad.)
   - -1.8 kHz for data row `0011`

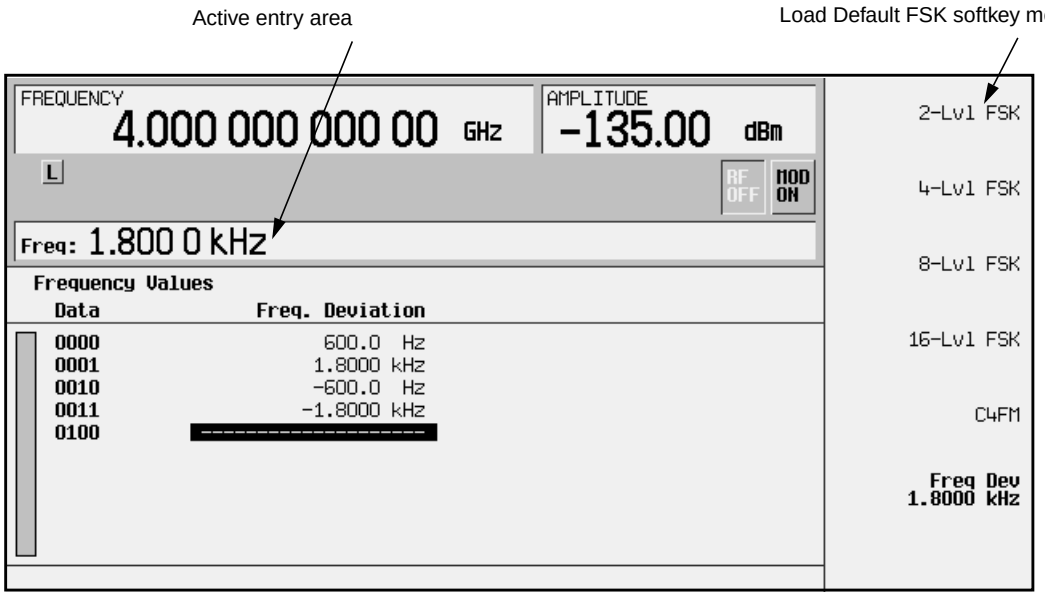
You have created an unstored file of frequency deviation values for your custom 4-level FSK file. To learn how to store the file, go to "Storing a Custom FSK Modulation to a File" on page 2-22. To learn how to modify a default FSK pattern, go to the next section.

Modifying a Default FSK Pattern

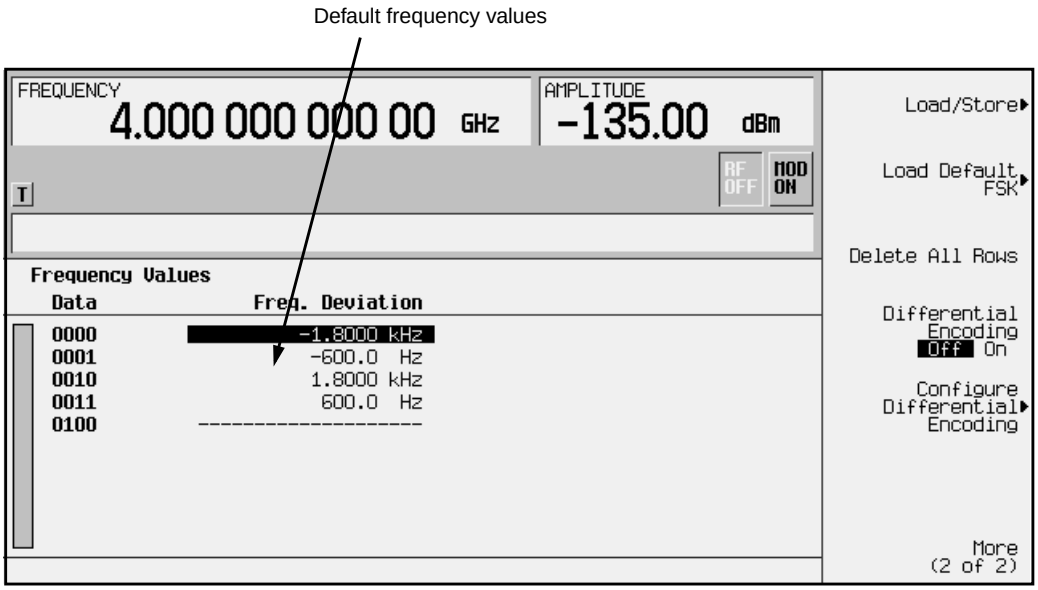
To add errors to a default modulation, load the default synchronous FSK modulation and then modify the existing frequency deviation values. If you choose to modify a default FSK modulation, you must first designate a frequency deviation value and then choose an FSK pattern. To modify a default 4-Lvl FSK pattern, follow these steps:

1. From the Define User FSK softkey menu, press **More (1 of 2)**, **Load Default FSK**.
2. Adjust the frequency deviation to `1.8 kHz`, by entering **1.8** on the numeric keypad and then pressing the **kHz** terminator softkey.

   You will see **1.8000 kHz** displayed in the `Freq:` active entry area of the display, and in bold under the **Freq Dev** softkey. See the following figure.



3. Press the **4-Lvl FSK** softkey. You will see the FSK table editor with the default Frequency Values displayed. See the following figure.



4. Use the up and down arrow keys or the front panel knob to highlight the frequency value for data row `0000`, then modify the first frequency deviation value as follows:
   - Press **More (2 of 2)**, **Edit Item**.
   - Turn the front panel knob to adjust the value to −1.810 kHz.
   - Press the **Enter** terminator softkey.
   - Notice that the highlight bar moves to data row `0001`.
5. Continue as in step four or use the numeric keypad and the appropriate terminator softkey to enter the following frequency deviation values:
   - −590 Hz for data row `0001` (To designate a negative value using the numeric keypad, first press the **+/-** hardkey.)
   - +1.805 kHz for data row `0010`
   - +610 Hz for data row `0011`

   You have created an unstored file of frequency deviation values for your custom 4-level FSK file. To learn how to store the file, go to the section, "Storing a Custom FSK Modulation to a File" on page 2-22.

Storing a Custom FSK Modulation to a File

Use this procedure to learn how to store a custom FSK modulation file to the instrument's memory catalog.

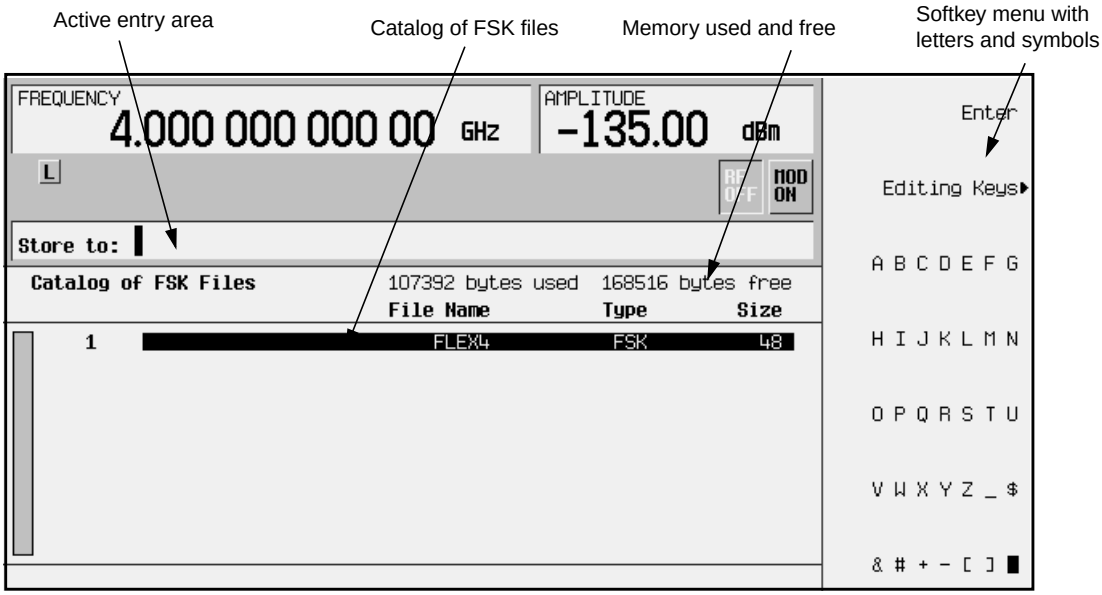
If you try to exit the table editor without storing, the signal generator displays the softkey:

Confirm Exit From Table Without Saving

To exit *without* saving the table, select this softkey. If you do *not* want to exit, press the **Return** hardkey.

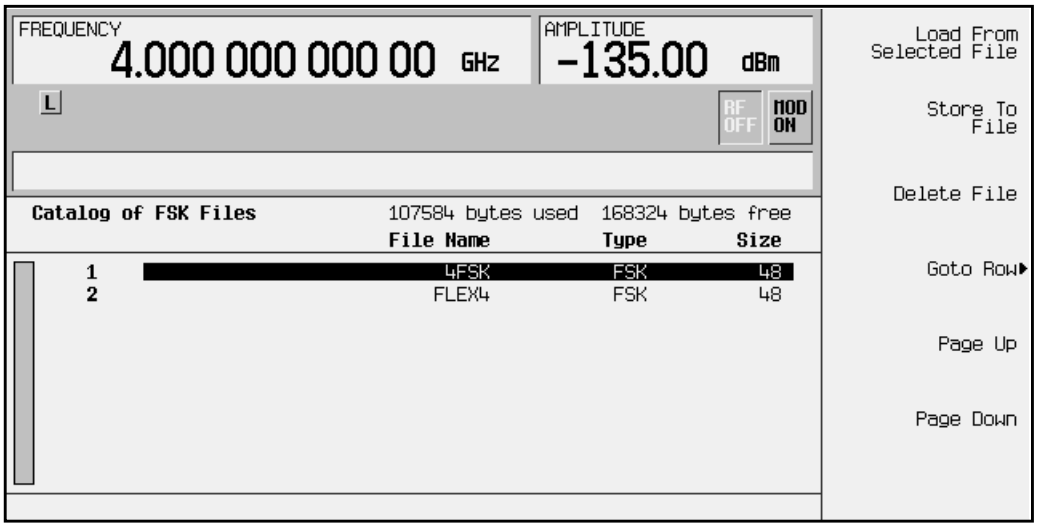
For this example, store the frequency deviations created in the previous procedure. If you have not yet created a custom FSK modulation, refer to the previous section, "Creating a Unique FSK File of Frequency Deviations" on page 2-19.

1. In the Define User FSK menu, choose **More (1 of 2)**, **Load/Store**. The catalog of stored FSK files appears. You will also see the amount of memory used and available (in bytes).
2. Press **Store To File**. A softkey menu appears that contains letters and symbols that you can use to name your file.
3. If an existing file is highlighted in the FSK Files catalog, its name appears in the `Store to:` active entry area. To clear the filename, press **Editing Keys**, **Clear Text**. The previous page of letter and symbol softkeys returns, and only a cursor appears in the active entry area.



4. For this example, you'll title the file 4FSK, since this signal is a continuous 4-level FSK. The file name is created by pressing numbers on the numeric keypad, or pressing the softkey containing the desired character, then selecting the softkey with that character from the subsequent menu. For example, press number **4** on the numeric keypad. Press the **ABCDEFG** softkey, then press **F**. Note that 4F is displayed in the active entry area following the `Store to:` text.
5. Continue entering the characters for the file name until 4FSK is displayed in the active entry area.
6. When the file name is complete, press the **Enter** terminator softkey.

You now have a file called 4FSK stored in the instrument's non-volatile memory. The following figure shows the results of saving the FSK file.



Loading the Stored FSK File

Once you have created and stored a custom FSK modulation to a file, you can edit or redefine the unique modulation by loading the file from the instrument's memory. To load a previously stored FSK file, follow these instructions:

1. Preset the signal generator to normal preset conditions.
2. Press the **Mode** hardkey. (If you have multiple options installed in your signal generator, press the **Real Time I/Q BaseBand** softkey to select Option UN8.) Then press **Custom**, **Modulation Type**, **Define User FSK**, **More (1 of 2)**, **Load/Store**.

   The `Catalog of FSK Files` appears.
3. Use the up and down arrow keys or the front panel knob to highlight the file called `4FSK`. If there are many files in the FSK file catalog, the **Goto Row** softkeys can be helpful. See "Table Editor Basics" on page 2-5.
4. When the file is highlighted, press the **Load From Selected File** softkey. To confirm the file selection, press **Confirm Load From File**. If you change your mind, or want to choose a different file, press **Return**.
5. You will see the frequency values that you previously configured displayed in the User FSK table editor.

Selecting a Custom FSK File

Once you have created and stored a custom FSK modulation to a file, you can apply its unique characteristics for your custom modulation by selecting it. To select a custom FSK file, follow these instructions:

1. Preset the signal generator to normal preset conditions.
2. Press the **Mode** hardkey. (If you have multiple options installed in your signal generator, press the **Real Time I/Q BaseBand** softkey to select Option UN8.) Then press **Custom**, **Modulation Type**, **Select**, **User FSK**.

   The `Catalog of FSK Files` appears.
3. Use the up and down arrow keys or the front panel dial to highlight the file called `4FSK`. If there are many files in the FSK file catalog, the **Goto Row** softkeys can be helpful. See "Table Editor Basics" on page 2-5.
4. When the file is highlighted, press the **Select File** softkey.

   The display returns to the Modulation Type menu. Notice that **(4FSK@FSK)** is displayed under the **Select** softkey in the Modulation Type menu, and `Mod Type: User FSK` is displayed on the front panel display.

Turning On Custom FSK Modulation

Now you are ready to apply the custom FSK modulation. If you have not yet created and selected a custom FSK modulation, return to "Building a Customized FSK Modulation Using the FSK Table Editor" on page 2-18 and follow the instructions. If you have performed all of the previous steps, proceed with the following instructions.

1. Press the **Return** hardkey once to return to the Custom Modulation menu.
2. Press the **Custom Off On** softkey until **On** is highlighted.

   Notice that `Custom On` is displayed on the front panel and the following annunciators are enabled:

   - `Custom` indicates that you have enabled the Custom modulation
   - `I/Q` indicates that I/Q modulation is being generated
3. Press the front panel **Frequency** key.

   Frequency becomes the active function and the normal preset value for frequency is displayed in the active entry area.
4. Use the numeric keypad and press the **GHz** terminator softkey to enter the desired frequency, such as 1 GHZ.

   Notice that the new frequency is shown in the `FREQUENCY` area of the display:

   - `1.000 000 000 00 GHz`
5. Press the front panel **Amplitude** hardkey.

   Amplitude becomes the active function and the normal preset value for amplitude is displayed in the active entry area.
6. Use the numeric keypad and press the **dBm** terminator softkey to enter the desired amplitude, such as 0 dBM.

   Notice that the new power level is shown in the `AMPLITUDE` area of the display:

   - `0.00 dBm`
7. When the instrument is preset, modulation is On by default. If the `MOD ON` annunciator is not enabled, press the front panel **Mod On/Off** hardkey to display the annunciator and apply the custom FSK modulation to the carrier.
8. Press the front panel **RF On/Off** hardkey. Notice that the display annunciator changes from `RF OFF` to `RF ON`. The custom modulated FSK signal is now available at the RF OUTPUT connector.

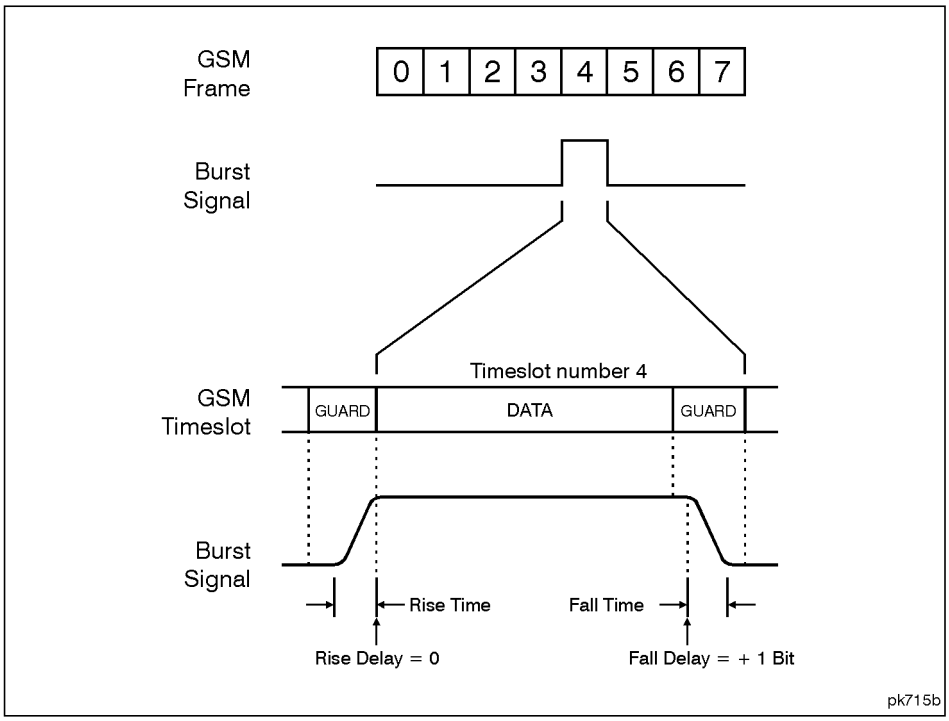
Customizing the Burst Shape

The Burst Shape feature allows you to customize burst shape rise and fall times and rise and fall delays.

Burst shape maximum rise and fall time values are affected by the following factors:

- the symbol rate
- the modulation type

When the rise and fall delays equal 0, the burst shape is attempting to synchronize the maximum burst shape power to the beginning of the first valid symbol and the ending of the last valid symbol of the timeslot. The following figure illustrates a bursted signal in a GSM frame with a rise delay of 0 and a fall delay of +1 bit.



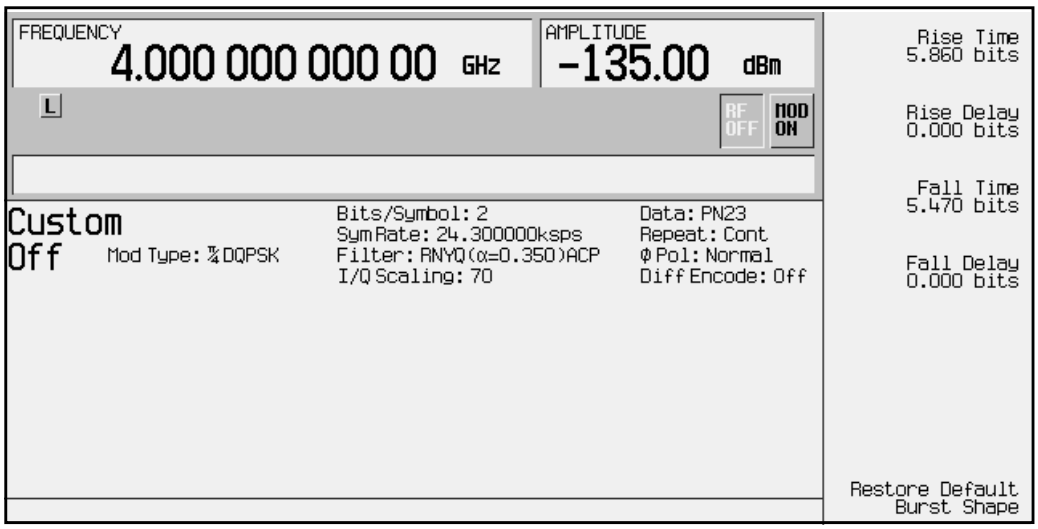
The ESG firmware computes optimum burst shape based on the settings you have chosen for modulation. You can further optimize burst shape by lining up the data portion with the modulation. For example, if you're designing a new modulation scheme, do the following:

- adjust the modulation and filtering to set the spectrum you want
- turn on framing
- adjust the burst rise and fall delay and rise and fall time for the timeslots

If you find that the Error Vector Magnitude (EVM) or Adjacent Channel Power (ACP) goes up when you turn bursting on, you can adjust the burst shape to assist with troubleshooting.

Use this procedure to adjust the burst shape:

1. Press the front panel **Mode** hardkey. (If you have multiple options installed in your signal generator, press the **Real Time I/Q BaseBand** softkey to select Option UN8.)
2. To choose the Burst Shape menu, press: **Custom**, **Burst Shape**.
   You will see a menu of softkeys for adjusting the rise and fall times and rise and fall delays of the burst shape. The default values are displayed in bits. There is also a softkey for restoring the default burst shape. See the following figure.



3. Press the following softkeys to adjust the burst shape:
   - Press the **Rise Time** softkey and enter a value on the numeric keypad, (for example, enter **5.0**) then press the **bits** terminator softkey.
   - Press the **Rise Delay** softkey and enter a value on the numeric keypad, (for example, enter **-3.5**) then press the **bits** terminator softkey.
   - Press the **Fall Time** and **Fall Delay** softkeys and enter values such as **5.0** and **3.6** respectively; then terminate each entry by pressing the **bits** terminator softkey.

Mapping Custom Differential Encoding

Differential encoding is a digital-encoding technique whereby a binary value is denoted by a signal *change* rather than a particular signal state. The signal generator is equipped with an editor that allows you to manipulate the differential state map associated with user-defined I/Q and user-defined FSK modulations. Using differential encoding, binary data can be encoded during the modulation process by way of transitions between states defined in the symbol table. Once the differential encoding has been configured, it is activated and applied to the current user-defined modulation.

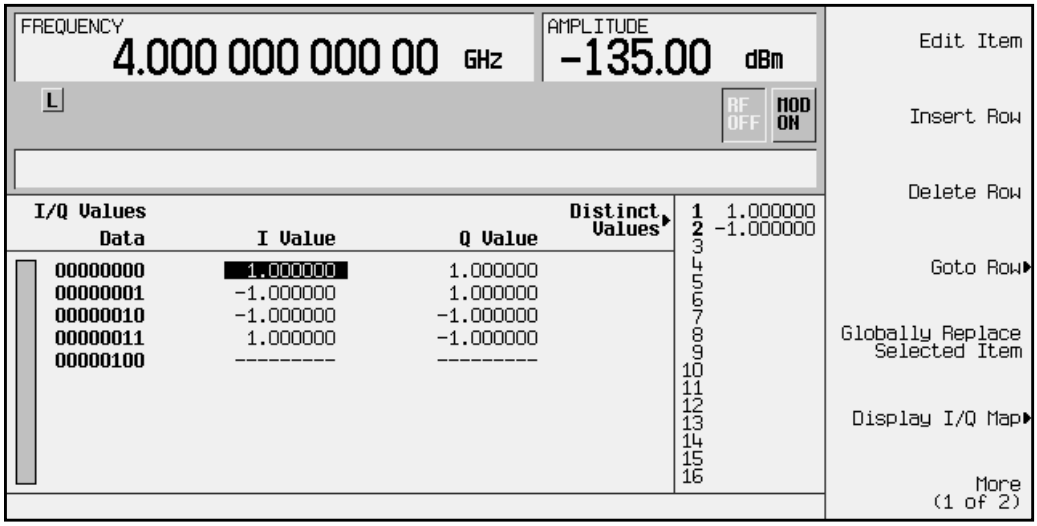
NOTE For a detailed explanation of differential encoding, refer to "Understanding Differential Encoding" on page 4-13.

Creating a User-Defined I/Q Modulation

Before you design a custom differential encoding scheme, you must first create a user-defined I/Q or FSK modulation. For the purposes of this example, you will create a user-defined 4QAM I/Q modulation from the signal generator's list of default I/Q maps.

1. Press **Mode**, **Real Time I/Q Base Band** (if this softkey appears), **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **QAM**, **4QAM**. This loads a default 4QAM I/Q modulation and displays it in the I/Q table editor.

   The default 4QAM I/Q modulation contains data that represent 4 symbols (00, 01, 10, and 11) mapped into the I/Q plane using 2 distinct values, 1.000000 and -1.000000. These 4 symbols will be traversed during the modulation process by the symbol table offset values associated with each symbol of data.

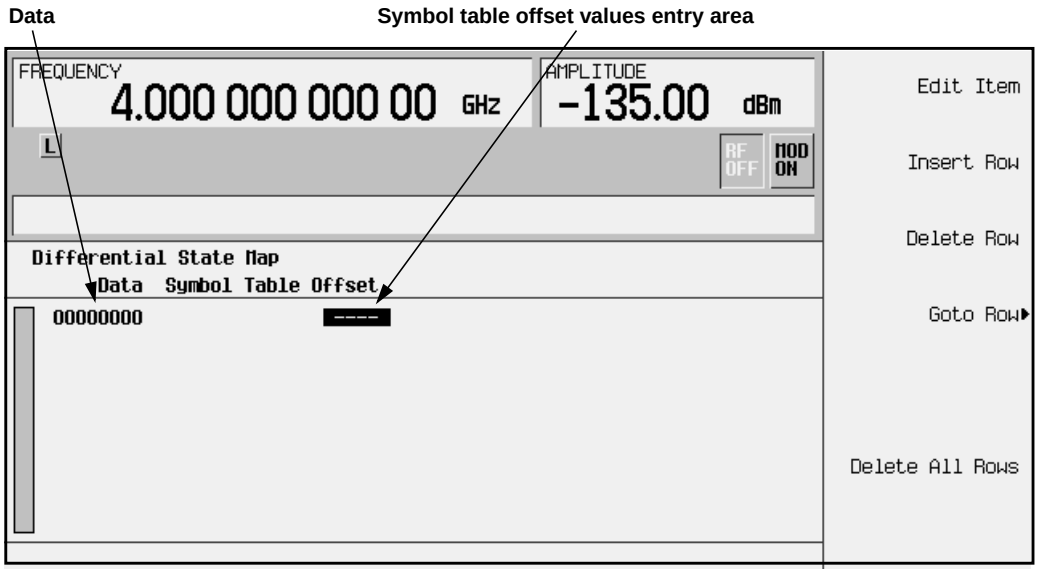


2. Press **More (1 of 2)**, **Configure Differential Encoding**. This opens the Differential State Map editor. You are now prepared to create a custom differential encoding for the user-defined default 4QAM I/Q modulation.

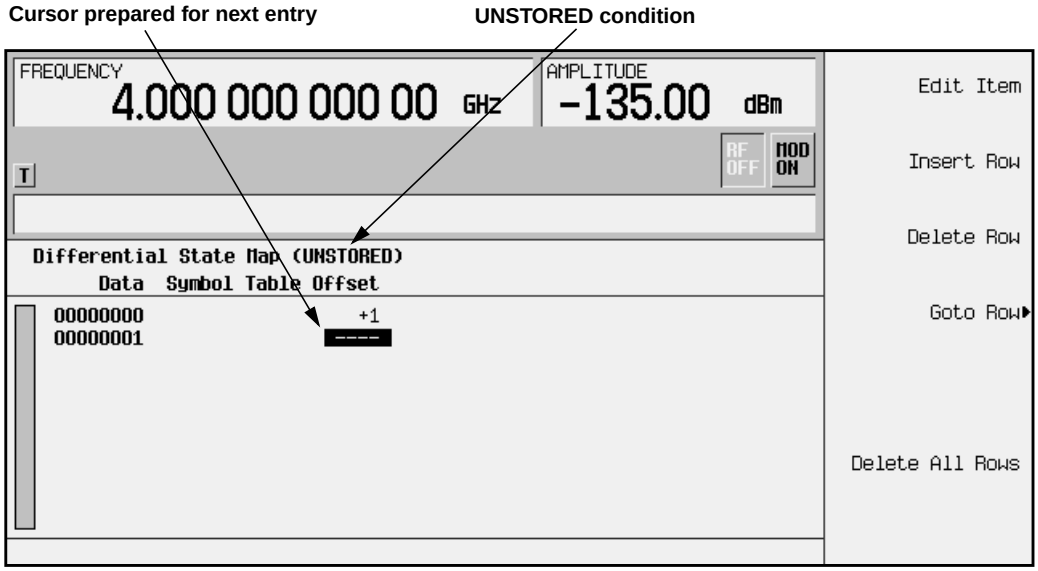
Editing the Differential State Map

The editor functions in the same manner as the I/Q and FSK table editors (explained in "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6 and "Building a Customized FSK Modulation Using the FSK Table Editor" on page 2-18). For an overview of basic table editing, see "Table Editor Basics" on page 2-5.

The following illustration shows the Differential State Map editor, along with the location of the data listing and the symbol table offset values entry area.



1. To encode the first symbol, add a symbol table offset of 1 by pressing **1**, **Enter**. This will rotate *forward* through the State Map by 1 value when a data value of 0 is modulated.



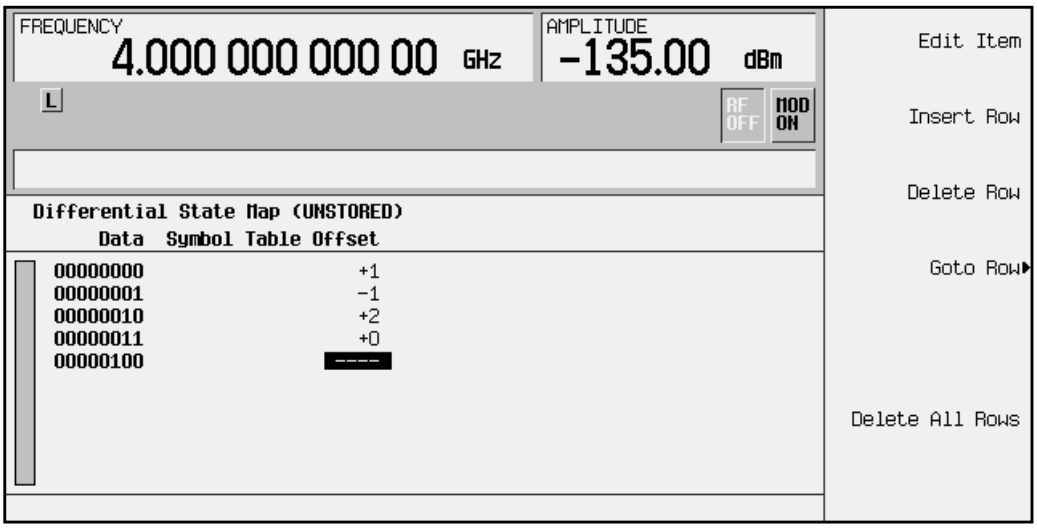
NOTE Notice that `(UNSTORED)` appears next to `Differential State Map` on the signal generator's display. Differential State Maps are associated with the user-defined modulation for which they were created. In order to save a custom Differential State Map, you must store the user-defined modulation for which it was designed. Otherwise the symbol table offset data will be purged when you press the **Confirm Exit From Table Without Saving** softkey when exiting from the I/Q or FSK table editor.

2. To encode the second symbol, add a symbol table offset of -1 by pressing **+/-**, **1**, **Enter**. This will rotate *backward* through the State Map by 1 value when a data value of 1 is modulated.

NOTE At this point, the modulation has one bit per symbol. For the first two data values (00000000 and 00000001) only the last bits (the 0 and the 1, respectively) are significant.

3. To encode the third symbol, add a symbol table offset of 2 by pressing **2**, **Enter**. This will rotate *forward* through the State Map by 2 values when a data value of 10 is modulated.
4. To encode the fourth symbol, add a symbol table offset of 0 by pressing **0**, **Enter**. This will *not* rotate through the State Map when a data value of 11 is modulated.

NOTE At this point, the modulation has two bits per symbol. For the data values 00000000, 00000001, 00000010, 00000011, the symbol values are 00, 01, 10 11 respectively.



5. Press **Return** to go back to the I/Q table editor.

Applying the Custom Differential Encoding

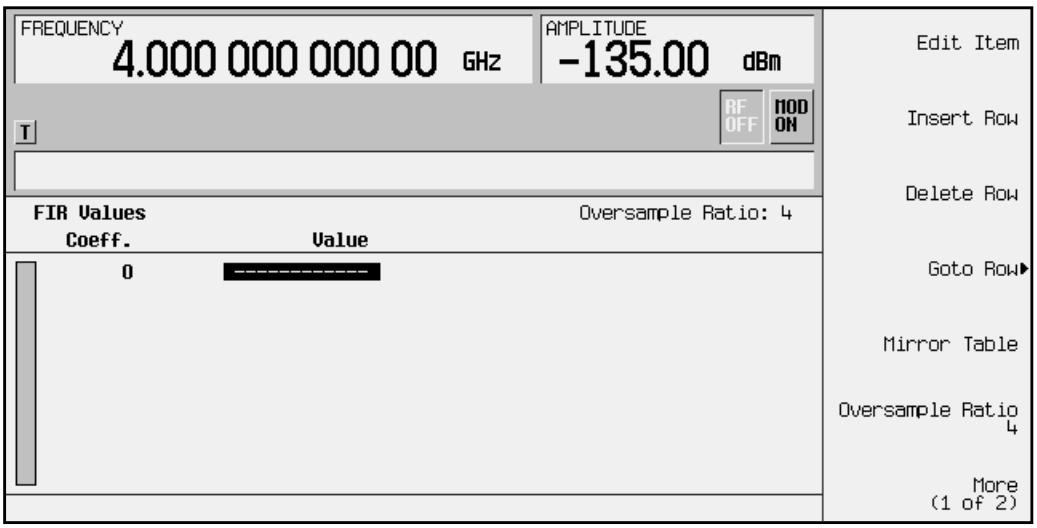
To apply the custom differential encoding to the user-defined 4QAM I/Q modulation, press **Differential Encoding Off On** until **On** is highlighted. The user-defined modulation will now be differentially encoded.

Creating a User-Defined FIR Filter Using the FIR Table Editor

Using this procedure you will create and store an 8-symbol, windowed sinc function filter with an oversample ratio of 4.

Accessing the Table Editor

1. Preset the signal generator to normal preset conditions.
2. Press the front panel **Mode** key.
3. If you have multiple options and the **Real Time I/Q BaseBand** softkey is visible, press it next.
4. Press **Custom**, **Filter**, **Define User FIR**. The FIR table editor should now be displayed. The following illustration shows the FIR table editor.

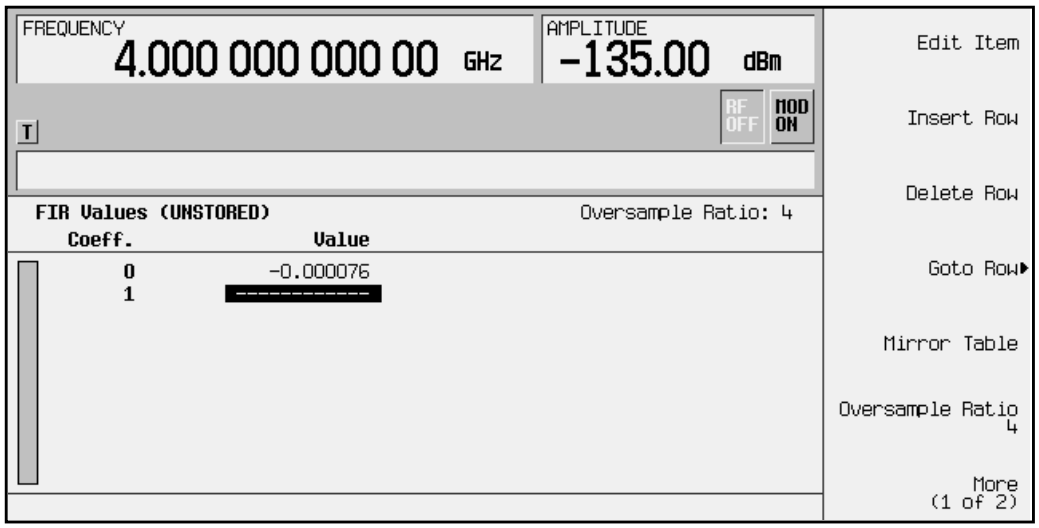


Entering the Coefficient Values

The FIR table editor creates a filter from values that you provide. In this example, the values you'll enter are listed after step 2.

1. Notice that the Value field for coefficient 0 is already highlighted. Use the numeric keypad to type the first value from the list. As you press the numeric keys, the numbers are displayed in the active entry area. (If you make a mistake, you can correct it using the backspace key.)

   Terminate your entry by pressing the **Enter** softkey. Notice that the value for coefficient 0 is now displayed in the Value field and a second row is automatically displayed with the Value field highlighted. (The following illustration shows the FIR table editor at this point in the process.)



2. Continue entering the coefficient values until all 16 are complete.

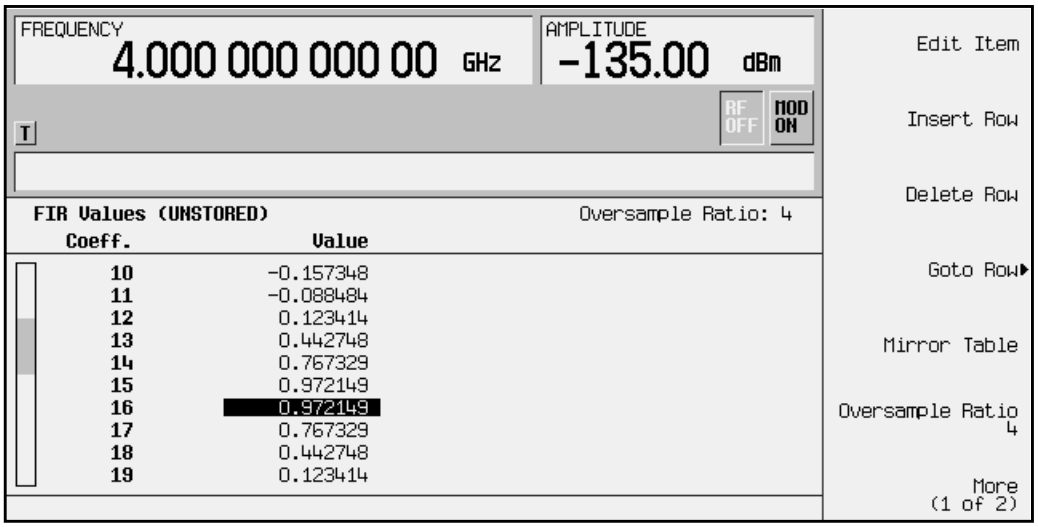
Coefficient	Value
0	–0.000076
1	–0.001747
2	–0.005144
3	–0.004424
4	0.007745
5	0.029610
6	0.043940
7	0.025852

Coefficient	Value
8	–0.035667
9	–0.116753
10	–0.157348
11	–0.088484
12	0.123414
13	0.442748
14	0.767329
15	0.972149

Duplicating the First 16 Coefficients Using Mirror Table

In a windowed sinc function filter, the second half of the coefficients are identical to the first half in reverse order. The signal generator provides a mirror table function that automatically duplicates the existing coefficient values in the reverse order.

1. Press the **Mirror Table** softkey. The last 16 coefficients are automatically generated and the first of these coefficients (number 16) is highlighted. The following illustration shows the display at this point in the process.



Setting the Oversample Ratio

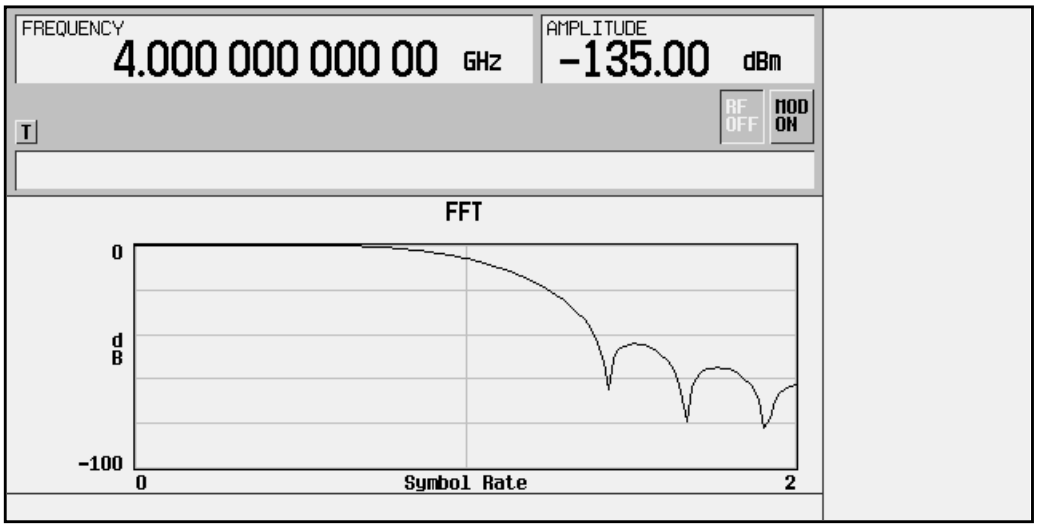
The oversample ratio (OSR) is the number of filter taps per symbol. Acceptable values range from 1 through 32, where the maximum combination of symbols and oversampling ratio allowed by the table editor is 1024. The instrument hardware, however, is actually limited to 32 symbols, an oversample ratio between 4 and 16, and 256 coefficients. So if you enter more than 32 symbols or 256 coefficients, the instrument will be unable to use the filter. If the oversample ratio is different from the internal, optimally selected one, then the filter will be resampled to the most optimal oversample ratio.

For this example, the desired OSR is 4, which is the default, so no action is necessary.

Displaying a Graphical Representation of the Filter

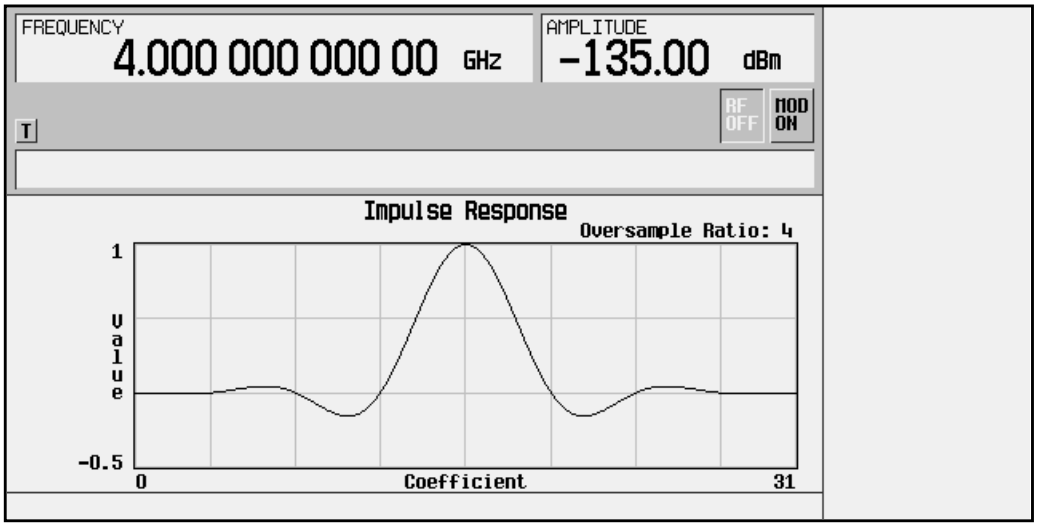
The signal generator has the capability of graphically displaying the filter in both time and frequency dimensions.

1. To view the filter frequency response (calculated using a fast Fourier transform), press **More (1 of 2)**, **Display FFT**. The following graph will be displayed:



2. To return to the menu keys, press **Return**.

3. Display the filter impulse response in time by pressing **Display Impulse Response**. The following graph will be displayed:

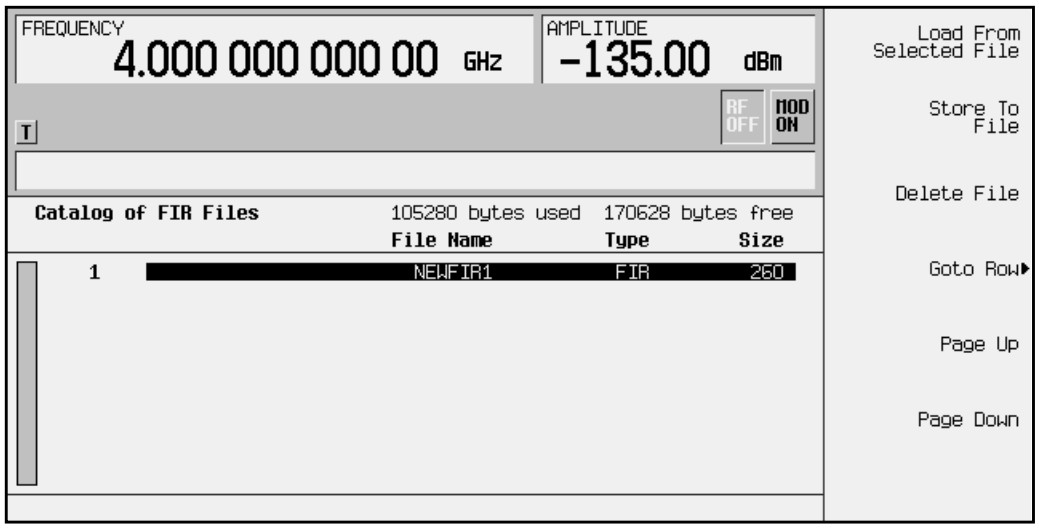


4. To return to the menu keys, press **Return**.

Storing the Filter to Memory

The filter is now complete and can be stored to non-volatile memory for future use. At any time you can check the information at the top of the FIR table editor to determine whether the current table has been stored. Your current table should display the following text: `FIR Values (UNSTORED)`. If you attempt to exit the table editor mode without first storing to a file, the signal generator will first prompt you to confirm that you want to exit without storing to a file. If you do *not* want to exit after all, press **Return**. To store the file, perform the following steps.

1. Press **Load/Store**, **Store To File**. The catalog of FIR files is displayed along with the amount of memory available.
2. For this example, you'll title the file NEWFIR1. The file name is created by pressing the softkey containing the desired character, then selecting the softkey with that character from the subsequent menu. For example, press the **HIJKLMN** softkey. Then press the bottom softkey, **N**. `N` is displayed in the active entry area following the `Store to:` text.
3. Continue entering the characters for the file name until `NEWFIR1` is displayed in the active entry area. (Use the numeric keypad to enter the number 1.)
4. Press **Enter** when the file name is complete. The contents of the current FIR table editor are stored to a file in non-volatile memory. The following illustration shows the display:



The NEWFIR1 file is the first file name listed. (If you have previously stored other FIR files, additional file names will be listed below NEWFIR1.) The file type is FIR and the size of the file is 260 bytes. The amount of memory used is also displayed. The number of files that can be saved depends on the size of the files and the amount of memory used. Memory is also shared by instrument state files and list sweep files.

This filter can now be used to customize a modulation or it can be used as a basis for a new filter design. (Refer to the additional filter examples in this chapter.)

Modifying an FIR Filter Using the FIR Table Editor

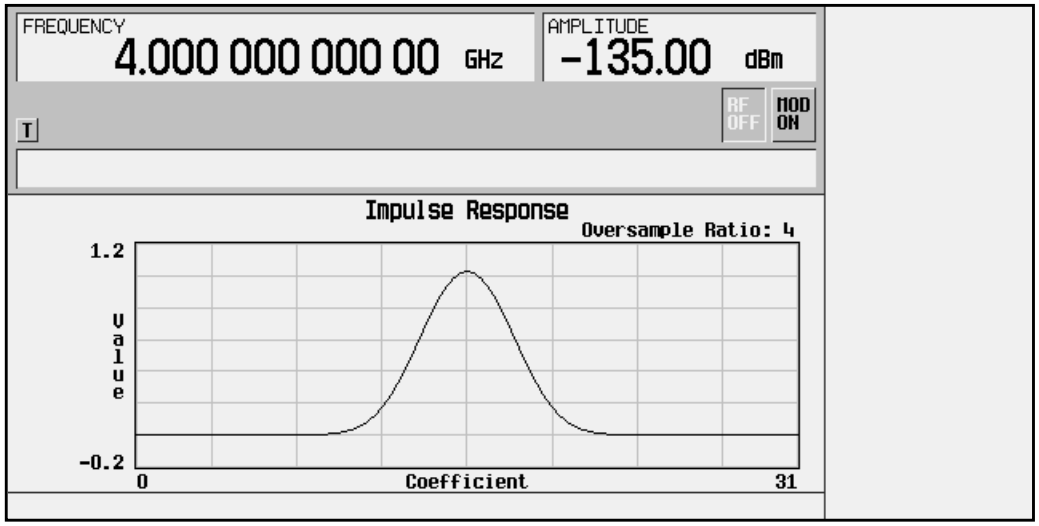
FIR filters stored in signal generator memory can easily be modified using the FIR table editor. You can load the FIR table editor with coefficient values from user-defined FIR files stored in the signal generator's memory, or from one of the default FIR filters. Then you can modify the values, and store the new files. In this example, you'll load the FIR table editor with the values for a default Gaussian filter and then modify it.

Loading the Default Gaussian FIR File

1. Preset the signal generator to normal preset conditions.
2. Press the front panel **Mode** key.
3. If you have multiple options and the **Real Time I/Q Baseband** softkey is visible, press it next.
4. To select the Gaussian filter, press **Custom**, **Filter**, **Define User FIR**, **More (1 of 2)**, **Load Default FIR**, **Gaussian**.
5. Set the filter BbT to 0.300 (if **Filter BbT** is not already set to this value): Press **Filter BbT** and rotate the front panel knob until 0.300 is displayed.
6. Set the number of filter symbols to 8 (if **Filter Symbols** is not already set to this value): Press **Filter Symbols** and rotate the front panel knob until 8 is displayed.
7. Press **Generate**. The FIR table editor should now contain the coefficient values for the specified Gaussian filter.

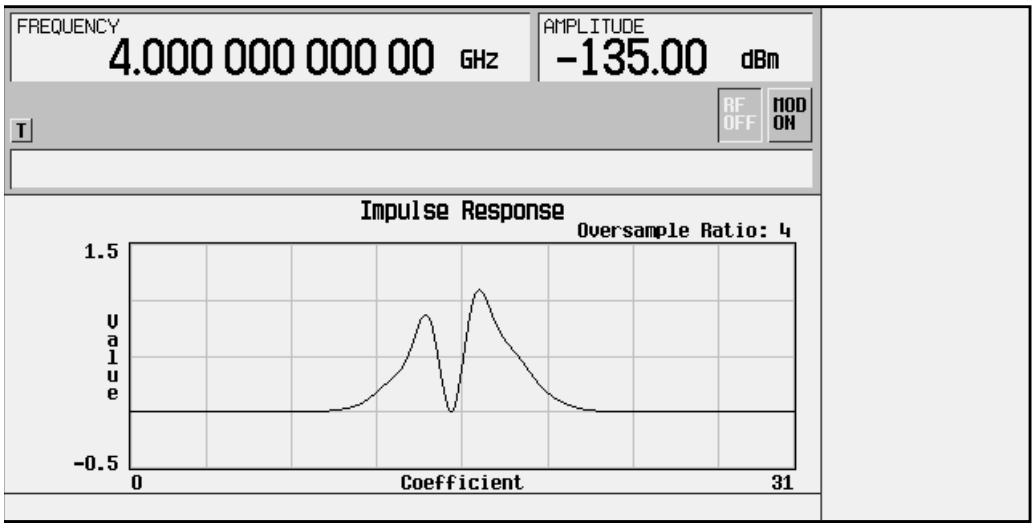
NOTE The actual oversample ratio during modulation is automatically selected by the instrument. A value between 4 and 16 is chosen dependent on the symbol rate, the number of bits per symbol of the modulation type, and the number of symbols.

8. Press **Display Impulse Response** for a graphic representation of the filter impulse response as shown on the following page:
9. To return to the menu keys, press **Return**.



Modifying the Coefficients

1. The value for coefficient 0 should be highlighted. Use the front panel knob to scroll down until coefficient 15 is highlighted.
2. Press **0**, **Enter** to change the value of the coefficient to 0.
3. Press **Display Impulse Response** to see the effects of the change:



   Notice that the graphic display can provide a useful troubleshooting tool (in this case indicating a missing coefficient value for a proper Gaussian response).

4. To return to the menu keys, press **Return**.
5. In addition to changing existing values, you can also insert and delete rows of coefficients and change the oversample ratio. Press **More (2 of 2)** to access these softkeys.
6. Change coefficient 15 back to its original value.
   a. Use the front panel knob to highlight row 15.
   b. Press **1**, **Enter**.

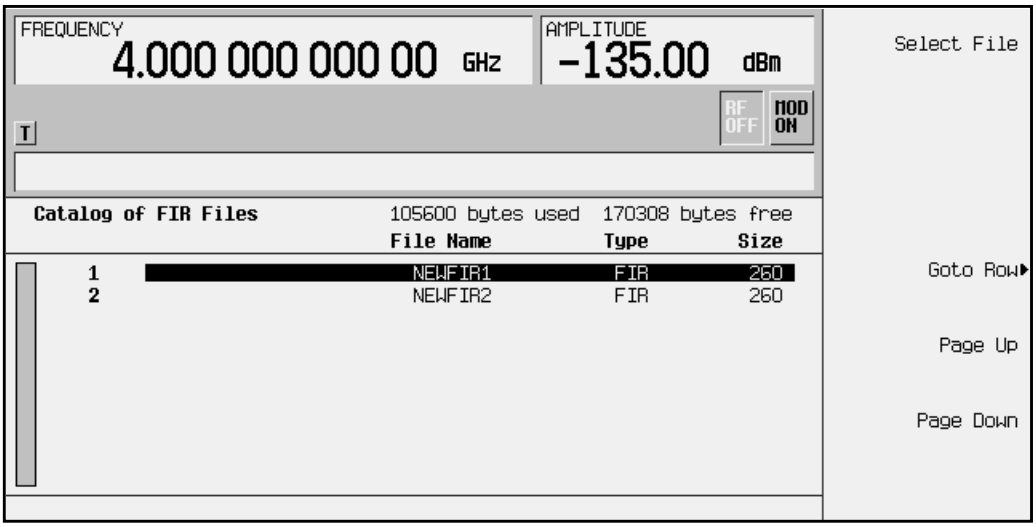
Storing the Filter to Memory

1. Press **More 1 of 2**, **Load/Store**, **Store To File**. The catalog of FIR files is displayed along with the amount of memory available.
2. Name the file NEWFIR2.
3. Press **Enter** when the file name is complete. The contents of the current FIR table editor are stored to a file in non-volatile memory, and the catalog of FIR files is updated to show the new file.

Applying a User-Defined FIR Filter to a Custom Modulation State

Custom FIR filters can be created using the FIR table editor feature or they can be created externally and downloaded into signal generator memory. Once the filter is stored in memory, it can be selected for use with your custom modulation state. This example requires that at least one FIR file be already stored in memory. For an example of creating and storing an FIR filter, see "Creating a User-Defined FIR Filter Using the FIR Table Editor", earlier in this chapter.

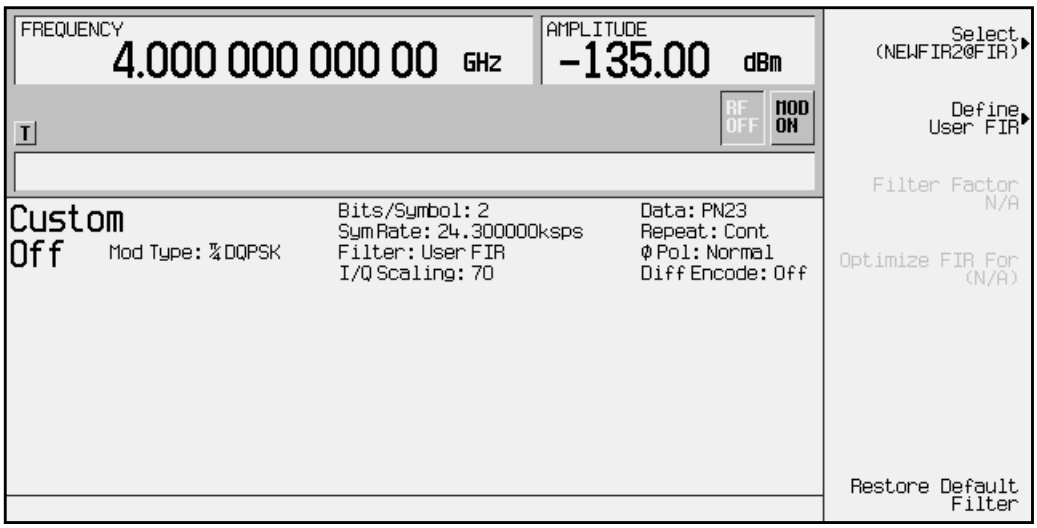
1. Preset the signal generator to normal preset conditions.
2. Press the front panel **Mode** key.
3. If you have multiple options and the **Real Time I/Q Baseband** softkey is visible, press it next.
4. Press **Custom**, **Filter**, **Select**, **User FIR**. The catalog of FIR files should now be displayed. The following illustration shows an example of the catalog.



In this example there are two FIR files listed: NEWFIR1, and NEWFIR2. (These files were created in the previous examples.)

5. Scroll down in the list until the desired filter is highlighted. In this example, NEWFIR2 is the desired filter. You can use the front-panel knob or the arrow keys as well as the GoTo Row function.

6. Press **Select File**. The highlighted filter is now selected for use in your custom modulation state. The following illustration shows our example displayed.



The filter you selected is NEWFIR2. You can see the name displayed below the **Select** softkey (at the top and right). In the Filter field, near the left of the display, **User FIR** is displayed to indicate that a user-defined FIR filter has been selected.

Once you have set the other modulation parameters to your satisfaction, turn on Custom and the RF output and your user-defined filter is in use.

NOTE The actual oversample ratio during modulation is automatically selected by the instrument. A value between 4 and 16 is chosen dependent on the symbol rate, the number of bits per symbol of the modulation type, and the number of symbols.

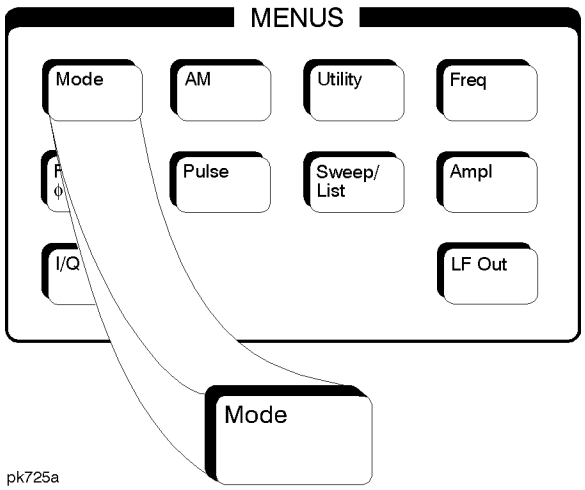
3 Softkey Reference

The following section describes briefly the **Mode** hardkey, and explains the associated softkeys that are used to activate functions specific to custom modulation (Option UN8 required).

Mode Key

Pressing the front panel **Mode** key accesses a menu of softkeys which allow you to create custom digital modulation (described in this manual) and to generate existing TDMA standards, including DECT, GSM, NADC, PDC, PHS, and TETRA (described in the companion manuals). If you have multiple options and the **Real Time I/Q Baseband** softkey is visible, press it and then press **Custom** to access the custom modulation menu. If you have only Option UN8, after pressing the **Mode** hardkey, your first menu is the **Custom** and **TDMA** softkeys. This chapter assumes that the **Custom** and **TDMA** softkeys are in the first menu.

The softkeys in this section are described in alphabetical order. The SCPI commands that duplicate these softkeys remotely are also provided in this section.



Custom

Pressing this softkey accesses a menu of softkeys for creating custom digital modulation. The custom modulation generator provides generic symbol building, variable symbol rates, and variable filter capabilities. You can define your own modulation by selecting an existing modulation type or creating your own unique modulation. You can select from several existing filters or create your own filter. You can also set the symbol rate and define the burst shape. The softkeys that implement these capabilities are described in this section in alphabetical order.

%

Press this softkey to indicate acceptance of the edited I/Q Scaling value (1.0 to 9999.0%).

Softkey Location: Press **Mode**, **Custom**, **(More 1 of 2)**, **Configure Hardware**, **I/Q Scaling**, **%** (this softkey appears after you edit the I/Q Scaling value)

π/4 DQPSK

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Press this softkey to select π/4 DQPSK (π/4 Differential Quadrature Phase Shift Keying) for modulating a continuous stream of the selected data pattern. π/4DQPSK modulation transmits data at the rate of 2 bits per symbol. Notice that the modulation selection is shown in the text area of the display in the `Mod Type` field and also under the **Select** and **PSK** softkeys in the Modulation Type menus.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **PSK**, **π/4 DQPSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] P4QPSK
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Loading an I/Q Map

Press this softkey to load a π/4 DQPSK (π/4 Differential Quadrature Phase Shift Keying) I/Q map into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **PSK**, **π/4 DQPSK**

2-Lvl FSK

This softkey appears in two different situations. To select an FSK pattern to use as your modulation, press the softkeys listed under "Selecting an FSK Modulation," below. To load a default FSK pattern into the FSK table editor and modify it, press the softkeys listed under "Modifying an FSK Pattern" below.

Selecting an FSK Modulation

Press this softkey to select 2-Level FSK (Frequency Shift Keying) for modulating a continuous stream of your selected data pattern. 2-Lvl FSK modulation transmits data at the rate of 1 bit per symbol. Notice that your modulation selection is shown in the text area of the display in the `Mod Type` field and under the **Select** softkey in the Modulation Type menu.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **FSK**, **2-Lvl FSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] FSK2
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Modifying an FSK Pattern

Press this softkey to load a 2-Level FSK (Frequency Shift Keying) modulation pattern into the FSK table editor. 2-Lvl FSK modulation transmits data at the rate of 1 bit per symbol. For details on using the FSK table editor, see "Building a Customized FSK Modulation Using the FSK Table Editor" on page 2-18.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User FSK**, **More (1 of 2)**, **Load Default FSK**, **2-Lvl FSK**

4 1's & 4 0's

Press this softkey to select a binary data pattern that consists of four ones followed by four zeroes. If you have selected **4 1's & 4 0's**, both the **Data** and the **Other Patterns** softkeys will show this selection. In addition, `P4` (where "P" refers to Pattern and "4" refers to four ones and four zeroes) is displayed in the `Data` field in the top line of the text area of the display.

Softkey Location: Press **Mode**, **Custom**, **Data**, **Other Patterns**, **4 1's & 4 0's**

Status after Normal Preset: PN23

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DATA P4
[:SOURce]:RADio:CUSTom:DATA?
```

4-Lvl FSK

This softkey appears in two different situations. To select an FSK pattern to use as your modulation, press the softkeys listed under "Selecting an FSK Modulation," below. To load a default FSK pattern into the FSK table editor and modify it, press the softkeys listed under "Modifying an FSK Pattern," below.

Selecting an FSK Modulation

Press this softkey to select 4-Level FSK (Frequency Shift Keying) for modulating a continuous stream of your selected data pattern. 4-Lvl FSK modulation transmits data at the rate of 2 bits per symbol. Notice that your modulation selection is shown in the text area of the display in the `Mod Type` field and under the **Select** softkey in the Modulation Type menu.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **FSK**, **4-Lvl FSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] FSK4
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Modifying an FSK Pattern

Press this softkey to load a 4-Level FSK (Frequency Shift Keying) modulation pattern into the FSK table editor. 4-Lvl FSK modulation transmits data at the rate of 2 bits per symbol. For details on using the FSK table editor, see "Building a Customized FSK Modulation Using the FSK Table Editor" on page 2-18.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User FSK**, **More (1 of 2)**, **Load Default FSK**, **4-Lvl FSK**

4QAM

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Press this softkey to select 4QAM (4-state Quadrature Amplitude Modulation) for modulating a continuous stream of the selected data pattern. 4QAM modulation transmits data at the rate of 2 bits per symbol. Notice that the modulation selection is shown in the text area of the display in the `Mod Type` field, and also under the **Select** and **QAM** softkeys in the Modulation Type menu.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **QAM**, **4QAM**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] QAM4
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Loading an I/Q Map

Press this softkey to load a 4QAM (4-state Quadrature Amplitude Modulation) I/Q map into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **QAM**, **4QAM**

8 1's & 8 0's

Press this softkey to select a binary data pattern that consists of eight ones followed by eight zeroes. If you have selected **8 1's & 8 0's**, both the **Data** and the **Other Patterns** softkeys will show this selection. In addition, `P8` (where "P" refers to Pattern and "8" refers to eight ones and eight zeroes) is displayed in the `Data` field in the top line of the text area of the display.

Softkey Location: Press **Mode**, **Custom**, **Data**, **Other Patterns**, **8 1's & 8 0's**

Status after Normal Preset: PN23

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DATA P8
[:SOURce]:RADio:CUSTom:DATA?
```

8-Lvl FSK

This softkey appears in two different situations. To select an FSK pattern to use as your modulation, press the softkeys listed under "Selecting an FSK Modulation," below. To load a default FSK pattern into the FSK table editor and modify it, press the softkeys listed under "Modifying an FSK Pattern," below.

Selecting an FSK Modulation

Press this softkey to select 8-Level FSK (Frequency Shift Keying) for modulating a continuous stream of your selected data pattern. 8-Lvl FSK modulation transmits data at the rate of 3 bits per symbol. Notice that your modulation selection is shown in the text area of the display in the `Mod Type` field and under the **Select** softkey in the Modulation Type menu.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **FSK**, **8-Lvl FSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] FSK8
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Modifying an FSK Pattern

Press this softkey to load a 8-Level FSK (Frequency Shift Keying) modulation pattern into the FSK table editor. 8-Lvl FSK modulation transmits data at the rate of 3 bits per symbol. For details on using the FSK table editor, see "Building a Customized FSK Modulation Using the FSK Table Editor" on page 2-18.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User FSK**, **More (1 of 2)**, **Load Default FSK**, **8-Lvl FSK**

8PSK

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Press this softkey to select 8PSK (8-state Phase Shift Keying) for modulating a continuous stream of the selected data pattern. 8PSK modulation transmits data at the rate of 3 bits per symbol. Notice that the modulation selection is shown in the text area of the display in the `Mod Type` field and also under the **Select** and **PSK** softkeys in the Modulation Type menus.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **PSK**, **8PSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] PSK8
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Loading an I/Q Map

Press this softkey to load a 8PSK (8-state Phase Shift Keying) I/Q map into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **PSK**, **8PSK**

16 1's & 16 0's

Press this softkey to select a binary data pattern that consists of sixteen ones followed by sixteen zeroes. If you have selected **16 1's & 16 0's**, both the **Data** and the **Other Patterns** softkeys will show this selection. In addition, `P16` (where "P" refers to Pattern and "16" refers to sixteen ones and sixteen zeroes) is displayed in the `Data` field in the top line of the text area of the display.

Softkey Location: Press **Mode**, **Custom**, **Data**, **Other Patterns**, **16 1's & 16 0's**

Status after Normal Preset: PN23

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DATA P16
[:SOURce]:RADio:CUSTom:DATA?
```

16-Lvl FSK

This softkey appears in two different situations. To select an FSK pattern to use as your modulation, press the softkeys listed under "Selecting an FSK Modulation," below. To load a default FSK pattern into the FSK table editor and modify it, press the softkeys listed under "Modifying an FSK Pattern," below.

Selecting an FSK Modulation

Press this softkey to select 16-Level FSK (Frequency Shift Keying) for modulating a continuous stream of your selected data pattern. 16-Lvl FSK modulation transmits data at the rate of 4 bits per symbol. Notice that your modulation selection is shown in the text area of the display in the `Mod Type` field and under the **Select** softkey in the Modulation Type menu.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **FSK**, **16-Lvl FSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] FSK16
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Modifying an FSK Pattern

Press this softkey to load a 16-Level FSK (Frequency Shift Keying) modulation pattern into the FSK table editor. 16-Lvl FSK modulation transmits data at the rate of 4 bits per symbol. For details on using the FSK table editor, see "Building a Customized FSK Modulation Using the FSK Table Editor" on page 2-18.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User FSK**, **More (1 of 2)**, **Load Default FSK**, **16-Lvl FSK**

16PSK

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Press this softkey to select 16PSK (16-state Phase Shift Keying) for modulating a continuous stream of the selected data pattern. 16PSK modulation transmits data at the rate of 4 bits per symbol. Notice that the modulation selection is shown in the text area of the display in the `Mod Type` field and also under the **Select** and **PSK** softkeys in the Modulation Type menus.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **PSK**, **16PSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] PSK16
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Loading an I/Q Map

Press this softkey to load a 16PSK (16-state Phase Shift Keying) I/Q map into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **PSK**, **16PSK**

16QAM

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Press this softkey to select 16QAM (16-state Quadrature Amplitude Modulation) for modulating a continuous stream of the selected data pattern. 16QAM modulation transmits data at the rate of 4 bits per symbol. Notice that the modulation selection is shown in the text area of the display in the `Mod Type` field and also under the **Select** and **QAM** softkeys in the Modulation Type menus.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **QAM**, **16QAM**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] QAM16
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Loading an I/Q Map

Press this softkey to load a 16QAM (16-state Quadrature Amplitude Modulation) I/Q map into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **QAM**, **16QAM**

32 1's & 32 0's

Press this softkey to select a binary data pattern that consists of thirty-two ones followed by thirty-two zeroes. If you have selected **32 1's & 32 0's**, both the **Data** and the **Other Patterns** softkeys will show this selection. In addition, `P32` (where "P" refers to Pattern and "32" refers to thirty-two ones and thirty-two zeroes) is displayed in the `Data` field in the top line of the text area of the display.

Softkey Location: Press **Mode**, **Custom**, **Data**, **Other Patterns**, **32 1's & 32 0's**

Status after Normal Preset: PN23

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DATA P32
[:SOURce]:RADio:CUSTom:DATA?
```

32QAM

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Press this softkey to select 32QAM (32-state Quadrature Amplitude Modulation) for modulating a continuous stream of the selected data pattern. 32QAM modulation transmits data at the rate of 5 bits per symbol. Notice that the modulation selection is shown in the text area of the display in the `Mod Type` field and also under the Select and **QAM** softkeys in the Modulation Type menus.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **QAM**, **32QAM**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] QAM32
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Loading an I/Q Map

Press this softkey to load a 32QAM (32-state Quadrature Amplitude Modulation) I/Q map into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **QAM**, **32QAM**

64 1's & 64 0's

Press this softkey to select a binary data pattern that consists of sixty-four ones followed by sixty-four zeroes. If you have selected **64 1's & 64 0's**, both the **Data** and the **Other Patterns** softkeys will show this selection. In addition, `P64` (where "P" refers to Pattern and "64" refers to sixty-four ones and sixty-four zeroes) is displayed in the `Data` field in the top line of the text area of the display.

Softkey Location: Press **Mode**, **Custom**, **Data**, **Other Patterns**, **64 1's & 64 0's**

Status after Normal Preset: PN23

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DATA P64
[:SOURce]:RADio:CUSTom:DATA?
```

64QAM

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Press this softkey to select 64QAM (64-state Quadrature Amplitude Modulation) for modulating a continuous stream of the selected data pattern. 64QAM modulation transmits data at the rate of 6 bits per symbol. Notice that the modulation selection is shown in the text area of the display in the Mod Type field and also under the **Select** and **QAM** softkeys in the Modulation Type menus.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **QAM**, **64QAM**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] QAM64
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Loading an I/Q Map

Press this softkey to load a 64QAM (64-state Quadrature Amplitude Modulation) I/Q map into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **QAM**, **64QAM**

256QAM

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Press this softkey to select 256QAM (256-state Quadrature Amplitude Modulation) for modulating a continuous stream of the selected data pattern. 256QAM modulation transmits data at the rate of 8 bits per symbol. Notice that the modulation selection is shown in the text area of the display in the `Mod Type` field and also under the **Select** and **QAM** softkeys in the Modulation Type menus.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **QAM**, **256QAM**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] QAM256
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Loading an I/Q Map

Press this softkey to load a 256QAM (256-state Quadrature Amplitude Modulation) I/Q map into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **QAM**, **256QAM**

All Timeslots

Press this softkey to set the external trigger EVENT 1 output to the beginning of every timeslot.

Softkey Location: Press **Mode**, **Custom**, **More (1 of 2)**, **Sync Out**, **Begin Timeslot**

Status after Normal Preset: Begin Pattern

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:SOUT ALL
[:SOURce]:RADio:CUSTom:SOUT?
```

Begin Pattern

Press this softkey to set the external trigger EVENT 1 output to the beginning of a pattern or frame.

Softkey Location: Press **Mode**, **Custom**, **More (1 of 2)**, **Sync Out**, **Begin Pattern**

Status after Normal Preset: Begin Pattern

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:SOUT FRAME
[:SOURce]:RADio:CUSTom:SOUT?
```

Begin Timeslot

Press this softkey to set the external trigger EVENT 1 output to the beginning of the specified timeslot.

Softkey Location: Press **Mode**, **Custom**, **More (1 of 2)**, **Sync Out**, **Begin Timeslot**

Status after Normal Preset: Begin Pattern

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:SOUT SLOT <value>
[:SOURce]:RADio:CUSTom:SOUT?
```

BBG Data Clock Ext Int

Press this softkey to select the internal data clock for the base band generator or to select an externally-supplied data clock. A data clock or symbol clock input must be supplied when external mode is selected. For more information on input and output signals, refer to the user's guide in the standard manual set.

Softkey Location: Press **Mode**, **Custom**, **More (1 of 2)**, **Configure Hardware**, **BBG Data Clock Ext Int**

Status after Normal Preset: Int

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:BBClock INT[1]|EXT[1]
[:SOURce]:RADio:CUSTom:BBClock?
```

BPSK

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Press this softkey to select BPSK (Binary Phase Shift Keying) modulation for modulating a continuous stream of the selected data pattern. BPSK modulation transmits data at the rate of 1 bit per symbol. Notice that the modulation selection is shown in the text area of the display in the `Mod Type` field and also under the **Select** and **PSK** softkeys in the Modulation Type menus.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **PSK**, **BPSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] BPSK
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Loading an I/Q Map

Press this softkey to load a BPSK (Binary Phase Shift Keying) modulation I/Q map into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **PSK**, **BPSK**

Burst Shape

Press this softkey to select the Burst Shape menu of softkeys. Once selected, you can program the number of bits for the rise and fall time and the rise and fall delay of the burst shape. You can also restore the default burst shape available at instrument preset condition.

Softkey Location: Press **Mode**, **Custom**, **Burst Shape**

Bus

Press this softkey to use the HP-IB as the pattern trigger for a single output of your unframed data pattern. Once selected, you can trigger a single event at any time by sending a trigger command over HP-IB (*TRG) or by asserting the HP-IB GET (group execute trigger) line. Notice that `Bus` is displayed under the **Pattern Trigger** softkey.

Softkey Location: Press **Mode**, **Custom**, **More (1 of 2)**, **Pattern Repeat Single**, **Pattern Trigger**, **Bus**

Pattern Repeat and Pattern Trigger functions are *not* available if you use either a PN data sequence, or an external data source.

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:TRIGger [SOURce] BUS
[:SOURce]:RADio:CUSTom:TRIGger [SOURce]?
```

C4FM

This softkey appears in two different situations. To select a C4FM FSK pattern to use as your modulation, press the softkeys listed under "Selecting an FSK Modulation," below. To load a default C4FM FSK pattern into the FSK table editor and modify it, press the softkeys listed under "Modifying an FSK Pattern," below.

Selecting an FSK Modulation

Press this softkey to select C4FM for modulating a continuous stream of your selected data pattern. C4FM is an APCO 25-compliant, 4-level FSK (Frequency Shift Keying) modulation that transmits data at the rate of 2 bits per symbol. Notice that your modulation selection is shown in the text area of the display in the `Mod Type` field and under the **Select** softkey in the Modulation Type menu.

APCO 25 (Association of Public-Safety Communications Officials - International, Inc., Project 25) is a standard setting initiative for public-safety communications.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **FSK**, **C4FM**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] C4FM
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Modifying an FSK Pattern

Press this softkey to load a C4FM FSK (Frequency Shift Keying) modulation pattern into the FSK table editor. C4FM FSK modulation transmits data at the rate of 2 bits per symbol. For details on using the FSK table editor, see "Building a Customized FSK Modulation Using the FSK Table Editor" on page 2-18.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User FSK**, **More (1 of 2)**, **Load Default FSK**, **C4FM**

Configure Differential Encoding

Press this softkey to display a menu and editor (a Differential State Map) for creating user-defined differential encoding for the user-defined modulation table being edited. Use this table to enter the Symbol Table Offset for each binary data bit.

For a detailed explanation of differential encoding, see "Understanding Differential Encoding" on page 4-13.

For information on using the Differential State Map editor, see "Mapping Custom Differential Encoding" on page 2-28.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Configure Differential Encoding**

Or press **Mode**, **Custom**, **Modulation Type**, **User FSK**, **More (1 of 2)**, **Configure Differential Encoding**

SCPI Commands:

```
:MEMory:DATA:FSK "<file name>",num_states,f0,f0,...
[,diff_state,num_diff_states,diff0,diff1,...]
```

```
:MEMory:DATA:UIQ "<file name>",offsetQ,num_states,i0,q0,
i1,q1,...[,diff_state,num_diff_states,diff0,diff1,...]
```

Configure Hardware

Pressing this softkey reveals a menu that allows you to select a particular hardware configuration to meet your specific needs. You may configure any of the following hardware options:

Set the external data clock to normal or symbol.

Set the baseband generator clock to external or internal.

Softkey Location: Press **Mode**, **Custom**, **More (1 of 2)**, **Configure Hardware**

Custom Off On

Press this softkey to toggle the operating state of the Real Time I/Q BaseBand Generator between on and off. Setting **Custom Off On** to **On** sets up the internal hardware to allow you to customize your own data patterns. You may choose between defined modulation types and filters or create your own custom modulation formats for transmitting a continuous stream of your unframed data pattern.

Softkey Location: Press **Mode**, **Custom**, **Custom Off On**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom[:STATe] ON|OFF|1|0
[:SOURce]:RADio:CUSTom[:STATe]?
```

D8PSK

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Press this softkey to select D8PSK (Differential 8-state Phase Shift Keying) for modulating a continuous stream of the selected data pattern. D8PSK modulation transmits data at the rate of 3 bits per symbol. Notice that the modulation selection is shown in the text area of the display in the `Mod Type` field and also under the **Select** and **PSK** softkeys in the Modulation Type menus.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **PSK**, **D8PSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] D8PSK
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Loading an I/Q Map

Press this softkey to load a D8PSK (Differential 8-state Phase Shift Keying) I/Q map into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **PSK**, **D8PSK**

Data

Press this softkey to display a menu of choices for internal data generation (pseudorandom bit patterns, fixed 4-bit repeating sequences, set patterns of ones and zeroes) or you can choose to supply your own data (download a binary file or input data using the DATA INPUT connector).

Pattern Repeat and Pattern Trigger functions are *not* available if you use either a PN data sequence, or an external data source.

Softkey Location: Press **Mode**, **Custom**, **Data**

Status after Normal Preset: PN23

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DATA PN9|PN11|PN15|PN20|PN23|FIX4|
"<file name>"|EXT|P4|P8|P16|P32|P64

[:SOURce]:RADio:CUSTom:DATA?
```

Define User FIR

Press this softkey to access a table editor for creating and modifying FIR filters. The FIR table editor allows a maximum filter length of 1024 taps (32 symbols with a maximum oversampling ratio of 32). The instrument hardware, however, is actually limited to 32 symbols, an oversample ratio between 4 and 16, and 256 coefficients. So if you enter more than 32 symbols or 256 coefficients, the instrument will be unable to use the filter. If the oversample ratio is different from the internal, optimally selected one, the filter will be resampled to the most optimal oversample ratio. Examples of using the FIR table editor are provided in the "Using Functions" chapter.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Define User FIR**

SCPI Commands:

```
:MEMory:DATA:FIR "<file name>",osr,coefficient
{,coefficient}

:MEMory:DATA:FIR? "<file name>"
```

Define User FSK

Pressing this softkey displays the FSK table editor, where you can define custom asymmetric (or symmetric) FSK modulation patterns. The FSK table editor enables you to define a frequency deviation and load a default symmetric FSK pattern (2-Lvl, 4-Lvl, 8-Lvl, 16-Lvl, or C4FM) or create a modulation pattern based on user-defined frequency values.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User FSK**

SCPI Commands:

```
:MEMory:DATA:FSK "<file name>",num_states,f0,f1,...
[,diff_state,num_diff_states,diff0,diff1,...]
```

Define User I/Q

Pressing this softkey displays the I/Q table editor, where you can directly define symbol positions. The I/Q table editor enables you to create custom constellation diagrams that you can save to an I/Q file catalog (see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6).

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**

SCPI Commands:

```
:MEMory:DATA:IQ "<file name>",offsetQ,num_states,i0,q0,
i1,q1,...[,diff_state,num_diff_states,diff0,diff1,...]
```

Delete All Rows

Press this softkey to erase the current table values. Be careful with this softkey, because there is no “undo” key.

Delete All Rows is located in the table editor menus.

Delete File

Pressing this softkey will delete the highlighted file from the displayed catalog.

Delete File is located in the catalogs of files.

Delete Row

Press this softkey to delete the highlighted row in a table editor.

Delete Row is located in the table editor menus.

Diff Data Encode Off On

Press this softkey to change the operational state of the signal generator's differential data encoding.

For a detailed explanation of differential data encoding, see “Understanding Differential Data Encoding” on page 4-17.

Softkey Location: Press **Mode**, **Custom**, **More (1 of 2)**, **Diff Data Encode Off On**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DENCode ON|OFF|1|0
[:SOURce]:RADio:CUSTom:DENCode?
```

Differential Encoding Off On

Press this softkey to change the operational state of the user-defined Differential Encoding.

For a detailed explanation of differential encoding, see "Understanding Differential Encoding" on page 4-13.

For information on using the Differential State Map editor, see "Mapping Custom Differential Encoding" on page 2-28.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Differential Encoding Off On**

Or press **Mode**, **Custom**, **Modulation Type**, **Define User FSK**, **More (1 of 2)**, **Differential Encoding Off On**

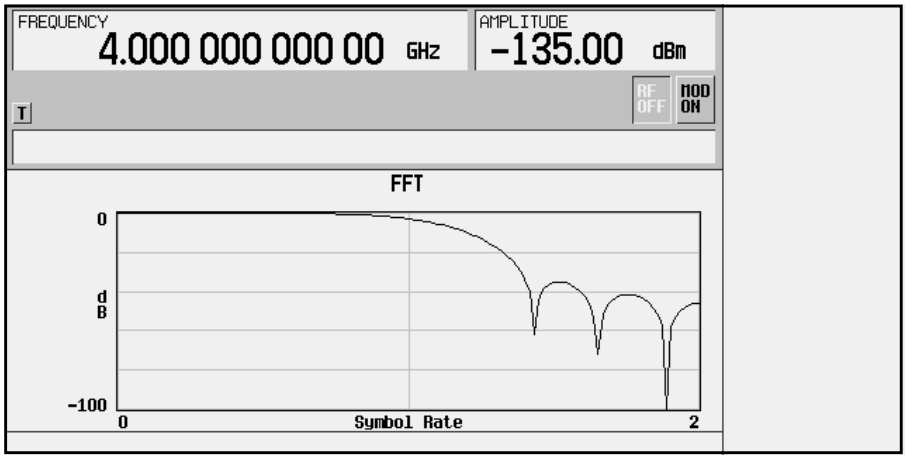
SCPI Commands:

```
:MEMory:DATA:FSK "<file name>",num_states,f0,f1,...
[,diff_state,num_diff_states,diff0,diff1,...]
```

```
:MEMory:DATA:IQ "<file name>",offsetQ,num_states,i0,q0,
i1,q1,...[,diff_state,num_diff_states,diff0,diff1,...]
```

Display FFT

Press this softkey to display a graphical representation of the filter frequency response (calculated using a fast Fourier transform). The following is an example of the frequency response of a root Nyquist filter with an oversample ratio of 4.

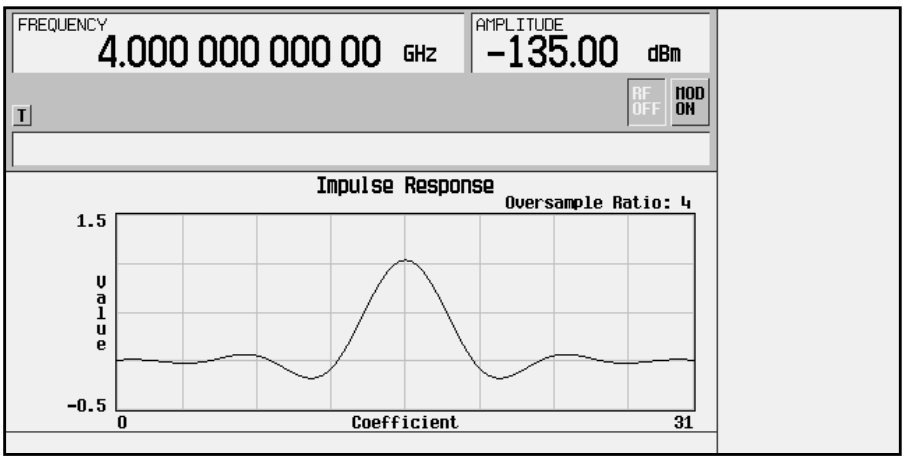


To return to the FIR table editor and the menu keys, press **Return**.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Define User FIR**, **More (1 of 2)**, **Load Default FIR**, **Root Nyquist**, (or any other filter selection), **Generate**, **Display FFT**

Display Impulse Response

Press this softkey to display a graphical representation of the filter impulse response in time. The following is an example of the impulse response of a root Nyquist filter with an oversample ratio of 4.



To return to the FIR table editor and the menu keys, press **Return**.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Define User FIR**, **More (1 of 2)**, **Load Default FIR**, **Root Nyquist**, (or any other filter selection), **Generate**, **Display Impulse Response**

Display I/Q Map

Pressing this softkey displays an I/Q constellation map diagram of the current set of I/Q points. You can use this display as you create or modify a constellation map in the I/Q table editor (as described in "Clearing Data" on page 2-7).

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **Display I/Q Map**

Edit Item

Press this softkey to select the highlighted value for editing in the current table editor. After you select the item this way, you can use the front panel RPG and arrow keys to edit the value.

Edit Item is located in table editor menus.

Ext

There are two keys called **Ext**. In the Data menu, pressing **Ext** selects an external user signal as the modulating data stream. With **Ext** selected, you should apply the data signal to the DATA INPUT connector.

Notice that Ext is also displayed under the **Pattern Trigger** softkey. In this menu, selecting **Ext** allows you to trigger an event with a signal applied to the TRIGGER IN connector.

Softkey Location: Press **Mode**, **Custom**, **Data**, **Ext**

Or press **Mode**, **Custom**, **More (1 of 2)**, **Pattern Repeat Single**, **Pattern Trigger**, **Ext**

Pattern Repeat and Pattern Trigger functions are *not* available if you use either a PN data sequence, or an external data source.

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DATA EXT
[:SOURce]:RADio:CUSTom:DATA?
[:SOURce]:RADio:CUSTom:TRIGger[SOURce] EXT
[:SOURce]:RADio:CUSTom:TRIGger[SOURce]?
```

Ext Data Clock Normal Symbol

Press this softkey to toggle the external data clock use between **Normal** and **Symbol**. When you select **Normal**, you must supply a signal (either a clock or a pulse) to the DATA CLOCK INPUT connector to clock the DATA and SYMBOL SYNC signals. (An unlock will occur if external data is selected and these signals are not supplied.) When you select **Symbol**, no signal is required at the DATA CLOCK INPUT connector. Instead, the data is clocked on both the rising and falling edges of the SYMBOL SYNC signal.

Softkey Location: Press **Mode**, **Custom**, **More (1 of 2)**, **Configure Hardware**, **Ext Data Clock Normal Symbol**

Status after Normal Preset: Normal

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:EDClock SYMBol|NORMal
[:SOURce]:RADio:CUSTom:EDClock?
```

Ext Delay Bits

Press this softkey to specify the number of bits for the external trigger delay. When **Ext Delay Off On** is set to **On**, a value greater than 0 will delay the transmission of the triggered data after the external trigger event by the number of bits specified. To enter a new value, rotate the front panel knob until the desired value is displayed, use the up and down arrow keys, or enter the value using the numeric keypad and press the **Enter** terminator softkey. The range of values allowed is 0 through 65,535 bits. This softkey is inactive until the trigger selection is set to **Ext**.

Softkey Location: Press **Mode**, **Custom**, **More (1 of 2)**, **Pattern Repeat Single**, **Pattern Trigger**, **Ext**, **Ext Delay Bits**

Pattern Repeat and Pattern Trigger functions are *not* available if you use either a PN data sequence, or an external data source.

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:TRIGger[SOURce]:EXTernal
:DELay <value>

[:SOURce]:RADio:CUSTom:TRIGger[SOURce]:EXTernal:DELay?
```

Ext Delay Off On

Press this softkey to toggle the external trigger delay on and off. When this function is turned on, the transmission of the triggered data will be delayed after the external trigger event by the number of bits specified by the **Ext Delay Bits** softkey. This softkey is inactive until the trigger selection is set to **Ext**.

Softkey Location: Press **Mode**, **Custom**, **More (1 of 2)**, **Pattern Repeat Single**, **Pattern Trigger**, **Ext**, **Ext Delay Off On**

Pattern Repeat and Pattern Trigger functions are *not* available if you use either a PN data sequence, or an external data source.

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:TRIGger{SOURce]:EXTernal:DELay
:STATe ON|OFF|1|0

[:SOURce]:RADio:CUSTom:TRIGger{SOURce]:EXTernal:DELay
:STATe?
```

Fall Delay

Press this softkey to edit the burst shape fall delay. The default value is 0.000 bits. To change it, press this softkey and enter a new value (minimum and maximum values depend upon modulation type and symbol rate). Use the front panel knob, up and down arrow keys, or enter a value using the numeric keypad; then press the **bits** terminator softkey.

Softkey Location: Press **Mode**, **Custom**, **Burst Shape**, **Fall Delay**

Status after Normal Preset: 0.000

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FALL:DELay <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FALL:DELay?
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FDELay <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FDELay?
```

Fall Time

Press this softkey to edit the burst shape fall time. The default value is 5.47 bits. To change it, press this softkey and enter a new value (minimum and maximum values depend upon modulation type and symbol rate). Use the front panel knob, up and down arrow keys, or enter a value using the numeric keypad; then press the **bits** terminator softkey.

Softkey Location: Press **Mode**, **Custom**, **Burst Shape**, **Fall Time**

Status after Normal Preset: 5.470

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FALL:TIME <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FALL:TIME?
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FTIMe <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FTIMe?
```

Filter

Press this softkey to access menus for selecting a filter type, restoring the default filter, and for defining a unique FIR filter. The Filter menu also lets you adjust the filter alpha (when Nyquist or root Nyquist filters are selected) or bandwidth time product (for Gaussian filters). In addition, you can also optimize the filter for the best EVM or ACP.

Softkey Location: Press **Mode**, **Custom**, **Filter**

Filter Alpha

Press this softkey to change the FIR filter's alpha parameter in either the Filter menu or the Load Default FIR menus.

In the Filter menu, the **Filter Alpha** softkey changes the alpha parameter of the selected root Nyquist or Nyquist filter. To enter a new value, rotate the front-panel knob until the desired value is displayed, use the up and down arrow keys, or enter the value using the numeric keypad and press the **Enter** terminator softkey. The range of values allowed is 0.000 through 1.000.

This key only appears *after* choosing a root Nyquist or Nyquist filter. If a Gaussian filter is in use, you will see **Filter BbT**. If any other filter is in use, this key is replaced with a greyed-out key labeled **Filter Factor N/A**.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Filter Alpha**

Status after Normal Preset: 0.350

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:ALPHa <value>
[:SOURce]:RADio:CUSTom:ALPHa?
```

In the Load Default FIR menus, the **Filter Alpha** softkey changes the alpha parameter of the root Nyquist or Nyquist filter coefficients loaded into the FIR table editor. After entering the alpha value, press **Generate** to modify the filter coefficients in the table editor.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Define User FIR**, **More (1 of 2)**, **Load Default FIR**, **Root Nyquist** (or **Nyquist**), **Filter Alpha**

Status after Normal Preset: 0.350

Filter BbT

Press this softkey to change the bandwidth-multiplied-by-bit-time (BbT) filter parameter in either the Filter menu or the Load Default FIR menu.

In the Filter menu, the **Filter BbT** softkey changes the BbT parameter of the selected Gaussian filter. To enter a new value, rotate the front-panel knob until the desired value is displayed, use the up and down arrow keys, or enter the value using the numeric keypad and press the **Enter** terminator softkey. The range of values allowed is 0.100 through 1.000.

This key only appears *after* choosing a Gaussian filter. If a root Nyquist or Nyquist filter is in use, you will see **Filter Alpha**. If any other filter is in use, this key is replaced with a greyed-out key labeled **Filter Factor N/A**.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Select**, **Gaussian**, **Filter BbT**

Status after Normal Preset: 0.500

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:BBT <value>
[:SOURce]:RADio:CUSTom:BBT?
```

In the Load Default FIR menu, the **Filter BbT** softkey changes the BbT parameter of the Gaussian filter coefficients loaded into the FIR table editor. After entering the BbT value, press **Generate** to modify the filter coefficients in the table editor.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Define User FIR**, **More (1 of 2)**, **Load Default FIR**, **Gaussian**, **Filter BbT**

Status after Normal Preset: 0.300

Filter Factor N/A

This grayed-out softkey is displayed when a filter is in use that does not contain an adjustable alpha or BbT parameter (such as the rectangle filter or a user-defined FIR filter). This softkey changes to either **Filter Alpha** or **Filter BbT** if the appropriate root Nyquist, Nyquist, or Gaussian filter is selected for use.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Select**, **More (1 of 2)**, **Rectangle** (or select a User FIR file), **Filter Factor N/A**

Filter Symbols

Press this softkey to define the number of symbols for the filter to be loaded into the FIR table editor. The FIR table editor allows a maximum filter length of 1024 coefficients with a maximum oversample ratio of 32 and a maximum of 32 symbols. If you create an FIR filter with greater than 16 symbols, however, the maximum symbol rate will be decreased by half. To change the number of symbols, rotate the front-panel knob until the desired value is displayed, use the up and down arrow keys, or enter the value using the numeric keypad and press the **Enter** terminator softkey. The range of values allowed is 1 through 32.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Define User FIR**, **More (1 of 2)**, **Load Default FIR**, **Root Nyquist** (or **Nyquist**, **Gaussian**, or **Rectangle**), **Filter Symbols**

Status after Normal Preset: 8

FIX4

Press this softkey to select a 4-bit repeating sequence data pattern. Press **FIX4** and the 4-bit pattern becomes the active function. Enter your desired 4-bit pattern using the front panel knob, up and down arrow keys, or enter the value using the numeric keypad and press the **Enter** terminator softkey. Notice that your selected 4-bit pattern is displayed in the `Data` field in the top line of the text area of the display.

Softkey Location: Press **Mode**, **Custom**, **Data**, **FIX4**

Status after Normal Preset: PN23

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DATA FIX4
[:SOURce]:RADio:CUSTom:DATA?
[:SOURce]:RADio:CUSTom:DATA:FIX 4 <0-15>
[:SOURce]:RADio:CUSTom:DATA:FIX 4?
```

Freq Dev

This softkey appears in two different situations. To select symmetric FSK frequency deviation, press the softkeys listed under "Selecting an FSK Modulation," below. To load a default FSK pattern into the FSK table editor and modify the frequency deviation, press the softkeys listed under "Modifying an FSK Pattern," below.

Selecting an FSK Modulation

Press this softkey to select symmetric FSK frequency deviation. The default frequency deviation is 400 Hz. To change it, press this softkey and enter the desired value (0 Hz is the minimum value; the maximum value depends upon the symbol rate). Use the front panel knob, up and down arrow keys, or enter a value using the numeric keypad; then press the **GHz**, **MHz**, **kHz**, or **Hz** terminator softkey. Notice that the modulation selection is displayed under the **Select** softkey and the frequency deviation is displayed under the **FSK** softkey in the Modulation Type menus.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **FSK**, **Freq Dev**

Status after Normal Preset: 400.00 Hz

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation:FSK[:DEViation]
<val><unit>

[:SOURce]:RADio:CUSTom:MODulation:FSK[:DEViation]?
```

Modifying an FSK Pattern

Press this softkey to define a custom frequency deviation convention in the FSK table editor. The default frequency deviation is 400 Hz. For details on using the FSK table editor, see "Building a Customized FSK Modulation Using the FSK Table Editor" on page 2-18.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User FSK**, **More (1 of 2)**, **Load Default FSK**, **Freq Dev**

FSK

Pressing this softkey accesses a menu of FSK (Frequency Shift Keying) modulation types for modulating a continuous stream of your selected data pattern. You can choose between 2-Lvl FSK, 4-Lvl FSK, 8-Lvl FSK, 16-Lvl FSK, and C4FM; you can also change the default frequency deviation.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **FSK**

Gaussian

Press this softkey to select the Gaussian pre-modulation filter in either the Select (filter) menu or the Load Default FIR menu.

In the Select (filter) menu, pressing the **Gaussian** softkey selects this FIR filter for use in your custom modulation setup. The default filter bandwidth-multiplied-by-bit time product (BbT) is automatically set to 0.500. You can change the filter BbT to any value between 0.100 and 1.000 by pressing the **Filter BbT** softkey.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Select**, **Gaussian**

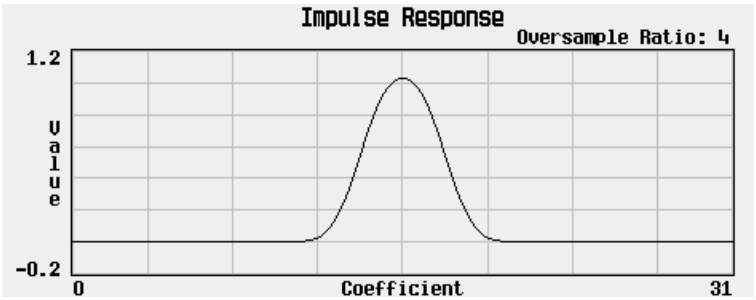
SCPI Commands:

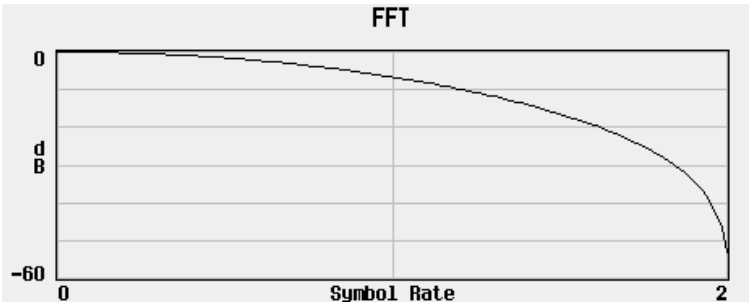
```
[:SOURce]:RADio:CUSTom:FILTer GAUSsian
[:SOURce]:RADio:CUSTom:FILTer?
```

In the Load Default FIR menu, pressing the **Gaussian** softkey followed by **Generate** loads the FIR table editor with the coefficient values for the Gaussian filter. The filter BbT and number of filter symbols are defined with the softkeys in this menu. If you change either parameter after loading the filter coefficients, press the **Generate** softkey again to reload the FIR table.

The impulse response and the frequency response of the default Gaussian filter with a BbT of 0.500 and an oversample ratio of 4 are shown in the graphs on the following page.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Define User FIR**, **More (1 of 2)**, **Load Default FIR**, **Gaussian**





Globally Replace Selected Item

Press this softkey, found in the Define User I/Q menu, to globally replace the selected value throughout the data table. For instance, if you have defined a Q Value of -1, and wish to change it to +1, highlight the -1 value and select Globally Replace Selected Item. All values of -1 (in both the I and the Q column) will be replaced with a value of +1.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **Globally Replace Selected Item**

Goto Row

Press this softkey to display softkeys that enable you to select a row or page in a table or list of items.

Goto Row is located in the table editor menus and in the catalogs of files.

Goto Bottom Row

Press this softkey to move the selection bar to the bottom row in the current table or list of items.

Goto Bottom Row is located in the table editor menus and in the catalogs of files.

Goto Middle Row

Press this softkey to move the selection bar to the middle row in the current table or list of items.

Goto Middle Row is located in the table editor menus and in the catalogs of files.

Goto Top Row

Press this softkey to move the selection bar to the top row in the current table or list of items.

Goto Top Row is located in the table editor menus and in the catalogs of files.

Gray Coded QPSK

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Press this softkey to select Gray Coded QPSK (Quadrature Phase Shift Keying) for modulating a continuous stream of your selected data pattern. Gray Coded QPSK modulation transmits data at the rate of 2 bits per symbol. The constellations for this modulation type are designed so that the symbols differ by only one bit between transitions. Notice that your modulation selection is shown in the text area of the display in the `Mod Type` field and also under the **Select**, **PSK**, and **QPSK and OQPSK** softkeys in the Modulation Type menus.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **PSK**, **QPSK and OQPSK**, **Gray Coded QPSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] GRAYQPSK
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Loading an I/Q Map

Press this softkey to load a Gray Coded QPSK (Quadrature Phase Shift Keying) I/Q map into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **PSK**, **QPSK and OQPSK**, **Gray Coded QPSK**

Insert Row

Press this softkey to insert a new row directly above the highlighted row in the currently active table.

Insert Row is located in the table editor menus.

I/Q Scaling

Use this softkey to adjust the amplitude of the I/Q outputs (for better ACP). This adjustment is not available if you are using MSK or FSK modulation. The range is 1 through 10000%.

Softkey Location: Press **Mode**, **Custom**, **(More 1 of 2)**, **Configure Hardware**, **I/Q Scaling**

Status after Normal Preset: 70%

IS95 OQPSK

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Press this softkey to select IS95 OQPSK (Offset Quadrature Phase Shift Keying) for modulating a continuous stream of your selected data pattern. IS95 OQPSK modulation transmits data at the rate of 2 bits per symbol. Notice that your modulation selection is shown in the text area of the display in the `Mod Type` field and also under the **Select**, **QPSK and OQPSK**, and **PSK** softkeys in the Modulation Type menus.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **PSK**, **QPSK and OQPSK**, **IS95 OQPSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] IS95OQPSK
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Loading an I/Q Map

Press this softkey to load an IS95 OQPSK (Offset Quadrature Phase Shift Keying) I/Q map into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type, Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **PSK**, **QPSK and OQPSK**, **IS95 OQPSK**

IS95 QPSK

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Press this softkey to select IS95 QPSK (Quadrature Phase Shift Keying) for modulating a continuous stream of your selected data pattern. IS95 QPSK modulation transmits data at the rate of 2 bits per symbol. Notice that your modulation selection is shown in the text area of the display in the `Mod Type` field and also under the **Select**, **QPSK and OQPSK**, and **PSK** softkeys in the Modulation Type menus.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **PSK**, **QPSK and OQPSK**, **IS95 QPSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] IS95QPSK
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Loading an I/Q Map

Press this softkey to load an IS95 QPSK (Quadrature Phase Shift Keying) I/Q map into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **PSK**, **QPSK and OQPSK**, **IS95 QPSK**

Load/Store

Press this softkey to display a menu for loading tables from, and storing tables to, non-volatile memory. Non-volatile memory enables you to retain files for future use after an instrument power cycle.

Load/Store is located in the table editor menus.

Load Default FIR

Press this softkey to access a menu for automatically filling the FIR table editor with coefficient values from pre-defined filters such as root Nyquist, Nyquist, Gaussian and Rectangle. The default filter parameters can also be selected in this menu allowing you to choose the filter alpha or BbT and the number of filter symbols.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Define User FIR**, **More (1 of 2)**, **Load Default FIR**

Load Default FSK

Press this softkey to select a default symmetric FSK modulation. You can select from 2-Lvl, 4-Lvl, 8-Lvl, 16-Lvl FSK, or C4FM and configure the frequency deviation for the FSK modulation selected.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User FSK**, **More (1 of 2)**, **Load Default FSK**

Load Default I/Q Map

Press this softkey to select a standard I/Q mapping from a set of either PSK or QAM modulations.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**

Load From Selected File

Press this softkey to replace the current information in a table editor with the information in the highlighted file.

Load From Selected File is located in each of the catalogs of files.

Mirror Table

Press this softkey to mirror the FIR table entries such that the table doubles in size and the values in the top half of the table are duplicated in the bottom half of the table in reverse order.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Define User FIR**, **Mirror Table**

Modulation Type

Pressing this softkey accesses a menu that enables you to customize the current modulation type. You can define the modulation format, build a symbol mapping, or change the symbol table offset.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**

Status after Normal Preset: π/4 DQPSK

SCPI Commands:

```
[:SOURce]:RADio:PHS:MODulation[:TYPE] BPSK|QPSK|IS95QPSK|
GRAYQPSK|OQPSK|IS95OQPSK|P4DQPSK|PSK8|PSK16|D8PSK|MSK
|FSK2|FSK4|FSK8|FSK16|C4FM|QAM4|QAM16|QAM32|QAM64|QAM256|
UIQ|UFSK
```

```
[:SOURce]:RADio:PHS:MODulation[:TYPE]?
```

More

When there are more softkeys in a given menu than can be displayed at one time, **More (1 of 2)** appears as the last softkey. Select this softkey to see the next page of softkeys.

To return to the first page of softkeys from the second page, select the **More (2 of 2)** softkey. Do *not* press the **Return** hardkey. **Return** displays the previous *menu*, not the previous page in a menu.

MSK

Press this softkey to select MSK (Minimum Shift Keying) modulation for modulating a continuous stream of your selected data pattern. MSK modulation transmits data at the rate of 1 bit per symbol. When you select MSK, Notice that your modulation selection is shown in the text area of the display in the Mod Type field and also under the **Select** softkey in the Modulation Type menu. The phase deviation appears under the **MSK** softkey in the Modulation Type menu.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **MSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] MSK
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Nyquist

Press this softkey to select the Nyquist (raised cosine) pre-modulation filter in either the Select (filter) menu or the Load Default FIR menu.

In the Select (filter) menu, pressing the **Nyquist** softkey selects this FIR filter for use in your custom modulation setup. The default filter alpha is automatically set to 0.350. You can change the filter alpha to any value between 0 and 1 by pressing the **Filter Alpha** softkey.

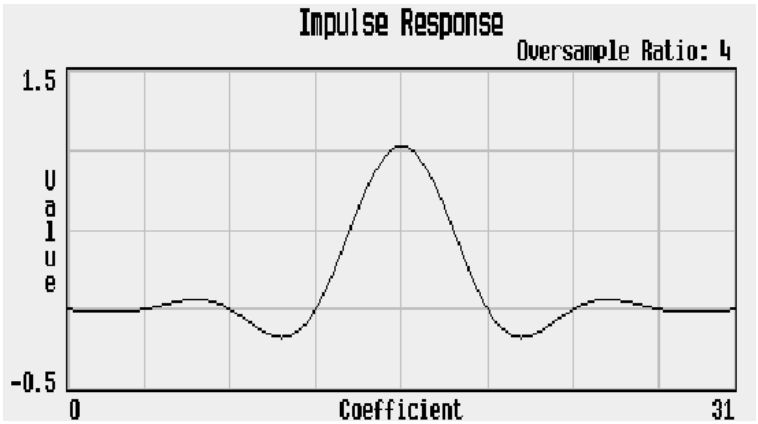
Softkey Location: Press **Mode**, **Custom**, **Filter**, **Select**, **Nyquist**

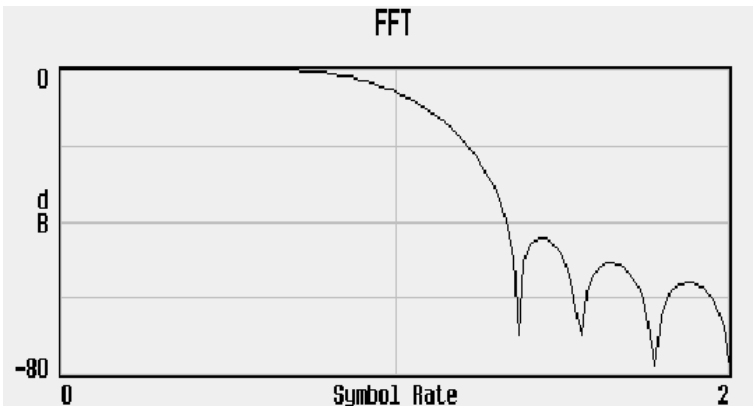
SCPI Commands:

```
[:SOURce]:RADio:CUSTom:FILTer NYQuist
[:SOURce]:RADio:CUSTom:FILTer?
```

In the Load Default FIR menu, pressing the **Nyquist** softkey followed by **Generate** loads the FIR table editor with the coefficient values for the Nyquist filter. The filter alpha and number of filter symbols are defined with the softkeys in this menu. If you change either parameter after loading the filter coefficients, press the **Generate** softkey again to reload the FIR table. The impulse response and the frequency response of a Nyquist filter with an alpha of 0.350 and an oversample ratio of 4 are shown in the graphs below.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Define User FIR**, **More (1 of 2)**, **Load Default FIR**, **Nyquist**





Offset Q Off On

Press this softkey to change the operational state of the user I/Q offset Q, which defines whether the Q output is delayed by 1/2 symbol from the I output.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User IQ**, **More (1 of 2)**, **Offset Q Off On**

Status after Normal Preset: Off

SCPI Commands:

```
:MEMory:DATA:UIQ "<file name>",offsetQ,num_states,i0,q0,
i1,q1,...[,diff_state,num_diff_states,diff0,diff1,...]
```

Optimize FIR For EVM ACP

Press this softkey to optimize the filter for minimized error vector magnitude (select EVM) or to minimized adjacent channel power (select ACP). The EVM selection provides the most ideal passband. The ACP selection improves stopband rejection. This feature only applies to root Nyquist, and Nyquist filters. The softkey is grayed out when any other filter is selected.

Status after Normal Preset: ACP

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Optimize FIR For EVM ACP**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:CHANnel EVM|ACP
[:SOURce]:RADio:CUSTom:CHANnel?
```

OQPSK

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Press this softkey to select OQPSK (Offset Quadrature Phase Shift Keying) for modulating a continuous stream of your selected data pattern. OQPSK modulation transmits data at the rate of 2 bits per symbol. Notice that your modulation selection is shown in the text area of the display in the `Mod Type` field and also under the **Select**, **QPSK and OQPSK**, and **PSK** softkeys in the Modulation Type menus.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **PSK**, **QPSK and OQPSK**, **OQPSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] OQPSK
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Loading an I/Q Map

Press this softkey to load a OQPSK (Offset Quadrature Phase Shift Keying) I/Q map into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **PSK**, **QPSK and OQPSK**, **OQPSK**

Other Patterns

Pressing this softkey reveals a menu of data pattern selections. Each of the selections in this menu is a pattern of equal quantities of ones and zeroes (such as four ones and four zeroes). If you have selected one of these data patterns, the selection will be displayed in the **Other Patterns** softkey and also in the **Data** softkey.

Softkey Location: Press **Mode**, **Custom**, **Data**, **Other Patterns**

Oversample Ratio

Press this softkey to identify the oversample ratio for your user-defined FIR filter. Acceptable values range from 1 to 32. The oversample ratio may, however, be resampled by the instrument to a value from 4 through 16 based on the values set for the number of symbols, the symbol rate, and the number of bits per symbol of the modulation type. Generally, the higher the symbol rate, the lower the oversample ratio allowed. The following table describes the maximum oversample ratio allowed for each modulation type:

Modulation Type	BPS	Maximum OSR	
		≤ 16 Symbols	> 16 Symbols
BPSK MSK 2-LVL FSK	1	16	8
QPSK IS95 QPSK ISAT QPSK OQPSK IS95 OQPSK	2	16	8
8PSK D8PSK 8-LVL FSK	3	15	6
16PSK 16QAM	4	16	8
32QAM	5	15	5
64QAM	6	15	6
	7	14	7
256QAM	8	16	8

Status after Normal Preset: 4

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Define User FIR**, **Oversample Ratio**

Page Down

Pressing this softkey displays the next page of entries.
Page Down is located in the table editor menus and in the catalogs of files.

Page Up

Pressing this softkey displays the previous page of entries.
Page Up is located in the table editor menus and in the catalogs of files.

Pattern Repeat Single Cont

Press this softkey to toggle the data pattern repeat from single to continuous. Notice that your selection appears after Repeat in the text display. After preset, the instrument default is continuous. Toggling pattern repeat to single, enables the **Pattern Trigger** softkey.

Pattern Repeat and Pattern Trigger functions are *not* available if you use either a PN data sequence, or an external data source.

Softkey Location: Press **Mode**, **Custom**, **More (1 of 2)**, **Pattern Repeat Single Cont**

Status after Normal Preset: Continuous

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:REPeat SINGle|CONTinuous
[:SOURce]:RADio:CUSTom:REPeat?
```

Pattern Trigger

Press this softkey to display a menu of keys for selecting the triggering for the modulating signal. Pattern triggering is only allowed if the **Pattern Repeat Single Cont** softkey is set to single mode. The choices are Trigger Key, Bus, and Ext. If you have selected one of these data patterns, the selection appears under the **Pattern Trigger** softkey.

Pattern Repeat and Pattern Trigger functions are *not* available if you use either a PN data sequence, or an external data source.

Softkey Location: Press **Mode**, **Custom**, **More (1 of 2)**, **Pattern Repeat Single**, **Pattern Trigger**

Phase Dev

Press this softkey to select the MSK (Minimum Shift Keying) phase deviation. The default is 90˚. To change it, press this softkey and enter the desired value (from 0˚ to 100˚) using the front panel knob, up and down arrow keys, or enter the value using the numeric keypad; then press the **deg** terminator softkey. Notice that the phase deviation appears under the **MSK** softkey in the Modulation Type menu.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **MSK**, **Phase Dev**

Status after Normal Preset: 90.0 deg

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation:MSK[:PHASe] <val><unit>
[:SOURce]:RADio:CUSTom:MODulation:MSK[:PHASe]?
```

Phase Polarity Normal Invert

Press this softkey to reverse the direction of rotation of the phase modulation vector. When you choose **Invert**, the in-phase component will lag the quadrature-phase component by 90° in the resulting modulation. The inverted selection also applies to the I OUT and Q OUT signals.

Phase Encoding

The phase encoding rules define the phase mapping of modulation data on a constellation. The following table and constellation diagrams describe the normal and inverted modes of phase modulation.

	Data	
Phase	Normal (I, Q)	Inverted (I, Q)
π/4	(0, 0)	(0, 1)
3π/4	(1, 0)	(1, 1)
-3π/4	(1, 1)	(1, 0)
-π/4	(0, 1)	(0, 0)

Softkey Location: Press **Mode**, **Custom, More (1 of 2)**, **Phase Polarity Normal Invert**

Status after Normal Preset: Normal

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:POLarity[:ALL] NORMal|INVerted
[:SOURce]:RADio:CUSTom:POLarity[:ALL]?
```

PN11

Press this softkey to select an internally-generated PN11 pseudorandom bit pattern. Notice that `PN11` is displayed in the `Data` field in the top line of the text area of the display.

Softkey Location: Press **Mode**, **Custom**, **Data**, **PN Sequence**, **PN11**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DATA PN11
[:SOURce]:RADio:CUSTom:DATA?
```

PN15

Press this softkey to select an internally-generated PN15 pseudorandom bit pattern. Notice that PN15 is displayed in the Data field in the top line of the text area of the display.

Softkey Location: Press **Mode**, **Custom**, **Data**, **PN Sequence**, **PN15**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DATA PN15
[:SOURce]:RADio:CUSTom:DATA?
```

PN20

Press this softkey to select an internally-generated PN20 pseudorandom bit pattern. Notice that PN20 is displayed in the Data field in the top line of the text area of the display.

Softkey Location: Press **Mode**, **Custom**, **Data**, **PN Sequence**, **PN20**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DATA PN20
[:SOURce]:RADio:CUSTom:DATA?
```

PN23

Press this softkey to select an internally-generated PN23 pseudorandom bit pattern. Notice that PN23 is displayed in the Data field in the top line of the text area of the display.

Softkey Location: Press **Mode**, **Custom**, **Data**, **PN Sequence**, **PN23**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DATA PN23
[:SOURce]:RADio:CUSTom:DATA?
```

PN9

Press this softkey to select an internally-generated PN9 pseudorandom bit pattern. Notice that PN9 is displayed in the Data field in the top line of the text area of the display.

Softkey Location: Press **Mode**, **Custom**, **Data**, **PN Sequence**, **PN9**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DATA PN9
[:SOURce]:RADio:CUSTom:DATA?
```

PN Sequence

Press this softkey to display a menu of choices for pseudorandom internal data generation.

Softkey Location: Press **Mode**, **Custom**, **Data**, **PN Sequence**

Status after Normal Preset: PN23

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DATA PN9|PN11|PN15|PN20|PN23|FIX4|
“<file name>”|EXT|P4|P8|P16|P32|P64

[:SOURce]:RADio:CUSTom:DATA?
```

PSK

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Pressing this softkey displays a menu of PSK (Phase Shift Keying) modulation types for modulating a continuous stream of the selected data pattern. You can choose from QPSK and OQPSK, BPSK, π/4 DQPSK, 8PSK,16PSK, and D8PSK.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **PSK**

Loading an I/Q Map

Pressing this softkey displays a menu of PSK (Phase Shift Keying) modulation types that you can load into the I/Q table editor. For details on editing I/Q maps, see “Mapping Symbol Positions with the I/Q Table Editor” on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **PSK**

QAM

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Pressing this softkey displays a menu of QAM (Quadrature Amplitude Modulation) modulation types for modulating a continuous stream of the selected data pattern. You can choose from 4QAM, 16QAM, 32QAM, 64QAM, and 256QAM.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **QAM**

Loading an I/Q Map

Pressing this softkey displays a menu of QAM (Quadrature Amplitude Modulation) modulation types that you can load into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **QAM**

QPSK

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor (see "Loading an I/Q Map," on the top of the next page).

Selecting a Modulation

Press this softkey to select QPSK (Quadrature Phase Shift Keying) for modulating a continuous stream of your selected data pattern. QPSK modulation transmits data at the rate of 2 bits per symbol. Notice that your modulation selection is shown in the text area of the display in the `Mod Type` field and also under the **Select**, **QPSK and OQPSK**, and **PSK** softkeys in the Modulation Type menus.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **PSK**, **QPSK and OQPSK**, **QPSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] QPSK
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

Loading an I/Q Map

Press this softkey to load a QPSK (Quadrature Phase Shift Keying) I/Q map into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **PSK**, **QPSK and OQPSK**, **QPSK**

QPSK and OQPSK

This softkey appears in two different situations, enabling you to either select a modulation, or load an I/Q map into the I/Q table editor.

Selecting a Modulation

Pressing this softkey displays a menu of QPSK (Quadrature Phase Shift Keying) and OQPSK (Offset Quadrature Phase Shift Keying) modulation types for modulating a continuous stream of the selected data pattern. You can choose from QPSK, IS95 QPSK, Gray Coded QPSK, OQPSK, and IS95 OQPSK.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **PSK**, **QPSK and OQPSK**

Loading an I/Q Map

Pressing this softkey displays a menu of QPSK (Quadrature Phase Shift Keying) and OQPSK (Offset Quadrature Phase Shift Keying) modulation types that you can load into the I/Q table editor. For details on editing I/Q maps, see "Mapping Symbol Positions with the I/Q Table Editor" on page 2-6.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **PSK**, **QPSK and OQPSK**

Rectangle

Press this softkey to select the one-symbol wide rectangle pre-modulation filter in either the Select (filter) menu or the Load Default FIR menu.

In the Select (filter) menu, pressing the **Rectangle** softkey selects this FIR filter for use in your custom modulation setup.

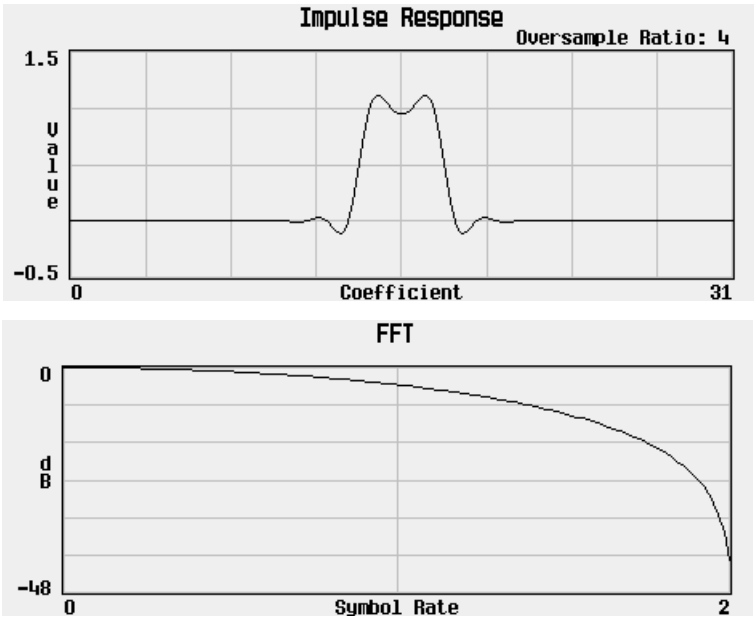
Softkey Location: Press **Mode**, **Custom**, **Filter**, **Select**, **More (1 of 2)**, **Rectangle**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:FILTer RECTangle
[:SOURce]:RADio:CUSTom:FILTer?
```

In the Load Default FIR menu, pressing the **Rectangle** softkey followed by **Generate** loads the FIR table editor with the coefficient values for the rectangle filter. The number of filter symbols are defined with the **Filter Symbols** softkey in this menu. The default is a one-symbol wide rectangle in an eight-symbol wide filter. If you change the number of symbols after loading the filter coefficients, press the **Generate** softkey again to reload the FIR table.

The impulse response and the frequency response of the default rectangle filter are shown in the following graphs:



Softkey Location: Press **Mode**, **Custom**, **Filter**, **Define User FIR**, **More (1 of 2)**, **Load Default FIR**, **Rectangle**

Restore Default Filter

Press this softkey to replace the current FIR filter with the default filter (root Nyquist $\alpha = 0.350$).

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Restore Default Filter**

Restore Default Burst Shape

Press this softkey to reset the burst parameters to their default values (rise time = 5.860 bits, rise delay = 0.000 bits, fall time = 5.470 bits, fall delay = 0.000 bits). This softkey is a convenience feature for quickly resetting the burst parameters. You can also change each of the burst characteristics individually by using the **Rise Time**, **Rise Delay**, **Fall Time**, and **Fall Delay** softkeys in this menu.

Softkey Location: Press **Mode**, **Custom**, **Burst Shape**, **Restore Default Burst Shape**

Restore Default Modulation Type

Press this softkey to restore the default modulation type for the format currently selected. For a custom format, π/4 DQPSK is the default modulation type.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Restore Default Modulation Type**

Restore Default Symbol Rate

Press this softkey to reset the transmission symbol rate to the default value (24.300 ksps). This softkey is a convenience feature for quickly resetting the symbol rate. You can also change the symbol rate by pressing the **Symbol Rate** softkey.

Status after Normal Preset: 24.300 ksps

Softkey Location: Press **Mode**, **Custom**, **Symbol Rate**, **Restore Default Symbol Rate**

Rise Delay

Press this softkey to edit the burst shape rise delay. Default is 0.000 bits. To change it, press this softkey and enter a new value (minimum and maximum values depend upon modulation type and symbol rate). Use the front panel knob, up and down arrow keys, or enter a value using the numeric keypad; then press the **bits** terminator softkey.

Softkey Location: Press **Mode**, **Custom**, **Burst Shape**, **Rise Delay**

Status after Normal Preset: 0.000

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RISE:DELay <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RISE:DELay?
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RDELay <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RDELay?
```

Rise Time

Press this softkey to edit the burst shape rise time. The default value is 5.860 bits. To change it, press this softkey and enter a new value (minimum and maximum values depend upon modulation type and symbol rate). Use the front panel knob, up and down arrow keys, or enter a value using the numeric keypad; then press the **bits** terminator softkey.

Softkey Location: Press **Mode**, **Custom**, **Burst Shape**, **Rise Time**

Status after Normal Preset: 5.860

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RISE:TIME <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RISE:TIME?
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RTIMe <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RTIMe?
```

Root Nyquist

Press this softkey to select the root Nyquist (root-raised cosine) pre-modulation filter in either the Select (filter) menu or the Load Default FIR menu.

In the Select (filter) menu, pressing the **Root Nyquist** softkey selects this FIR filter for use in your custom modulation setup. The default filter alpha is automatically set to 0.350. You can change the filter alpha to any value between 0 and 1 by pressing the **Filter Alpha** softkey.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Select**, **Root Nyquist**

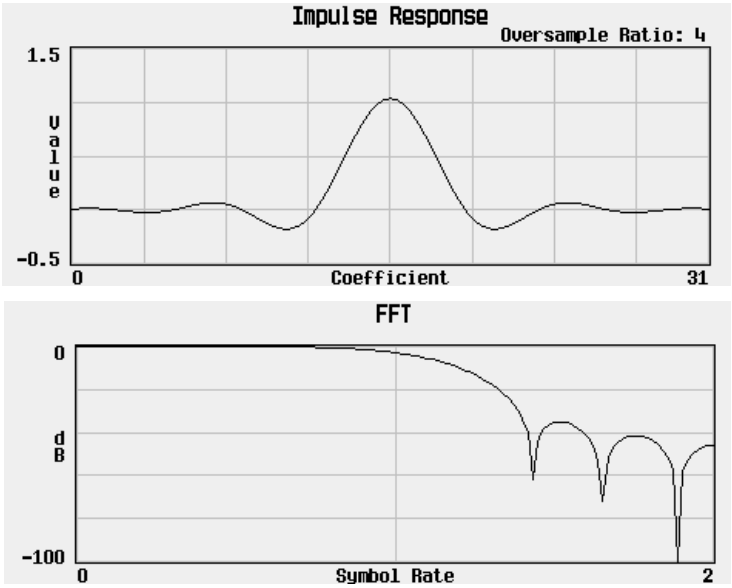
SCPI Commands:

```
[:SOURce]:RADio:CUSTom:FILTer RNYQuist
[:SOURce]:RADio:CUSTom:FILTer?
```

In the Load Default FIR menu, pressing the **Root Nyquist** softkey followed by **Generate** loads the FIR table editor with the coefficient values for the Nyquist filter. The filter alpha and number of filter symbols are defined with the softkeys in this menu. If you change either parameter after loading the filter coefficients, press the **Generate** softkey again to reload the FIR table.

The impulse response and the frequency response of a root Nyquist filter with an alpha of 0.350 and an oversample ratio of 4 are shown in the following graphs.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Define User FIR**, **More (1 of 2)**, **Load Default FIR**, **Root Nyquist**



Select

There are two softkeys named Select, one in the Filter menu and one in the Modulation type menu. In the Filter menu, you can select a pre-modulation filter type; in the Modulation type menu, you can select a modulation.

Selecting a Filter

In the Filter menu, press this softkey to access a menu for selecting the pre-modulation filter type. The pre-defined choices are root Nyquist, Nyquist, Gaussian, and Rectangle. In addition to the pre-defined filters, you can access the catalog of files stored in the signal generator memory. You can select any filter that you have either created externally and downloaded into memory, or that you have created internally in the Define User FIR menu and then subsequently stored.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Select**

Status after Normal Preset: Root Nyquist

SCPI Commands:

```
[:SOURce]:RADio[:NADC]:FILTer RNYQuist|NYQuist|
GAUSsian|RECTangle|"<file name>"

[:SOURce]:RADio[:NADC]:FILTer?
```

Selecting a Modulation

In the Modulation Type menu, press this softkey to accesses a menu for defining the modulation type. The choices are PSK, MSK, FSK, QAM, User I/Q and User FSK. In addition to the pre-defined modulations, you can access a catalog of FSK or I/Q files stored in the signal generator memory, where you can select a modulation that you have created and stored in either the Define User FSK or Define User I/Q menu.

Status after Normal Preset: p/4 DQPSK

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**

Select File

Press this softkey to select a file in the displayed catalog of binary files. To make your selection, scroll through the list using the front panel knob or up and down arrow keys until the desired file is highlighted; then press **Select File**. If you select a custom file as a data pattern for modulated transmissions, `UserFile` appears in the `Data` field of the text display. If you select a custom file as the modulation type, UserFile appears in the `Mod Type` field of the text display.

Select File is located in each of the catalogs of files.

Store To File

Press this softkey to store the selected custom configuration to a file in non-volatile memory for later recall and use.

Store To File is located in each of the catalogs of files.

Symbol Rate

Press this softkey to set the transmission symbol rate. The default symbol rate is 24.300 ksps. To change it, enter the desired value using the front panel knob, up and down arrow keys, or enter the value using the numeric keypad; then press the **Msps**, **ksps**, or **sps** terminator softkey. Values range from 50.000 sps through 12.500000000 Msps but will vary depending on the modulation type.

Softkey Location: Press **Mode**, **Custom**, **Symbol Rate**, **Symbol Rate**

Status after Normal Preset: 24.300 ksps

SCPI Commands:

The BRATe SCPI command sets the bit rate. The bit rate is adjusted to reflect symbol rate dependent on the number of bits per symbol for the modulation type.

```
[:SOURce]:RADio:CUSTom:SRATe <value>
[:SOURce]:RADio:CUSTom:SRATe?
[:SOURce]:RADio:CUSTom:BRATe <value>
[:SOURce]:RADio:CUSTom:BRATe?
```

Sync Out

Press this softkey to select a synchronization location within the data pattern. A synchronization signal is provided at the EVENT 1 connector.

Softkey Location: Press **Mode**, **Custom**, **More (1 of 2)**, **Sync Out**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:SOUT FRAME|SLOT|ALL
[:SOURce]:RADio:CUSTom:SOUT?
```

Sync Out Offset

Press this softkey to set an offset from the synchronization location. The offset can be as large as the number of bits in the timeslot selected in the Sync Out menu.

Softkey Location: Press **Mode**, **Custom**, **More (1 of 2)**, **Sync Out**, **Sync Out Offset**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:SOUT:OFFSet <value>
[:SOURce]:RADio:CUSTom:SOUT:OFFSet?
```

Trigger Key

Press this softkey to select the front panel **Trigger** key as the pattern trigger for a single output of an unframed modulated data transmission (**Data Format Pattern Framed** is set to **Pattern**). Once selected, you can trigger a single event at any time by pressing the **Trigger** key. Notice that `Trigger Key` is displayed under the **Pattern Trigger** softkey.

Softkey Location: Press **Mode**, **Custom**, **Pattern Repeat Single**, **Pattern Trigger**, **Trigger Key**

Pattern Repeat and Pattern Trigger functions are *not* available if you use either a PN data sequence, or an external data source.

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:TRIGger[SOURce] KEY
[:SOURce]:RADio:CUSTom:TRIGger[SOURce]?
```

User File

Press this softkey to display the catalog of binary files stored in the signal generator's memory. You can select a custom file from this catalog for your data pattern. Scroll through the listed files and when your selection is highlighted, press the **Select File** softkey. Notice that `User File` is shown in the `Data` field of the display.

Softkey Location: Press **Mode**, **Custom**, **Data**, **User File**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:DATA "<file name>"
[:SOURce]:RADio:CUSTom:DATA?
```

User FIR

Press this softkey to display the catalog of FIR filter files stored in the signal generator's memory. You can select a custom filter from this catalog for your pre-modulation filter. Scroll through the listed files and when your selection is highlighted, press the **Select File** softkey. Notice that `User FIR` is shown in the `Filter` field of the display and the file name is listed in the second line of the **Select** softkey.

Softkey Location: Press **Mode**, **Custom**, **Filter**, **Select**, **User FIR**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:FILTer "<file name>"
[:SOURce]:RADio:CUSTom:FILTer?
```

User FSK

Press this softkey to display the catalog of FSK files stored in the signal generator's memory. You can select a custom file from this catalog for your FSK modulation. Scroll through the listed files until your selection is highlighted, then press the **Select File** softkey. Notice that `User FSK` is shown in the `Mod Type` field of the display and **User FSK** appears in bold, along with the selected file name, in the Select Modulation Type sub-menu.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **User FSK**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation:UFSK "<file name>"
[:SOURce]:RADio:CUSTom:MODulation:UFSK?
[:SOURce]:RADio:CUSTom:MODulation:[:TYPE] UFSK
[:SOURce]:RADio:CUSTom:MODulation:[:TYPE]?
```

User I/Q

Press this softkey to display the catalog of I/Q files where you can select a prestored configuration to use for the modulation type. Scroll through the listed files and when your selection is highlighted, press **Select File.** Notice that `User I/Q` is shown in the `Mod Type` field of the display, and **User I/Q** appears in bold in the Select Modulation Type sub-menu.

Softkey Location: Press **Mode**, **Custom**, **Modulation Type**, **Select**, **User I/Q**

SCPI Commands:

```
[:SOURce]:RADio:CUSTom:MODulation:UIQ "<file name>"
[:SOURce]:RADio:CUSTom:MODulation:UIQ?
[:SOURce]:RADio:CUSTom:MODulation:[:TYPE] UIQ
[:SOURce]:RADio:CUSTom:MODulation:[:TYPE]?
```

TDMA

Pressing this softkey reveals a menu of softkeys for generating data patterns that are formatted into a framed structure (where the data bits are located in fields defined by the individual TDMA protocols) or for generating just the data pattern where the data sequence can be output a single time or repeatedly. Refer to the user's and programming guides for the individual TDMA protocols.

4 Operation

This section contains theory of operation that will help you learn how to use the custom modulation functionality.

Digital Modulation Input/Output Relationships

The baseband generator's clock can be internally or externally supplied, and the external data clock can be set to a normal bit clock or a symbol clock. Combinations of these selections will affect the inputs required and the outputs available as shown in Table 4-1.

NOTE With Option 1EM, all connectors are located on the rear panel.

Table 4-1 Pattern Data Mode

Front Panel Settings			Front Panel Inputs			Rear Panel Outputs		
Data	**BBG Data CLK**	**Ext Data Clock**	**DATA CLK**	**SYMB SYNC**	**DATA**	**DATA CLK OUT**	**SYMB SYNC OUT**	**DATA OUT**
Int	Int	NA	NA	NA	NA	Internal Bit Clock	Internal Symbol Clock	Internally Generated Data
Int	Ext	Normal	User's Bit Clock	NA	NA	Internal Bit Clock	Internal Symbol Clock	Internally Generated Data
Int	Ext	Symbol	User's Symbol Clock	NA	NA	Internal Bit Clock	Internal Symbol Clock	Internally Generated Data
Ext	Int	NA	NA	User's Symbol Clock [1]	User's Ext Data[1]	Internal Bit Clock	User's Symbol Clock	User's External Data
Ext	Ext	Normal	User's Bit Clock	User's Symbol Clock	User's Ext Data	Internal Bit Clock	User's Symbol Clock	User's External Data
Ext	Ext	Symbol	User's Symbol Clock [2]	User's Symbol Clock[2]	User's Ext Data	Internal Bit Clock	User's Symbol Clock	User's External Data

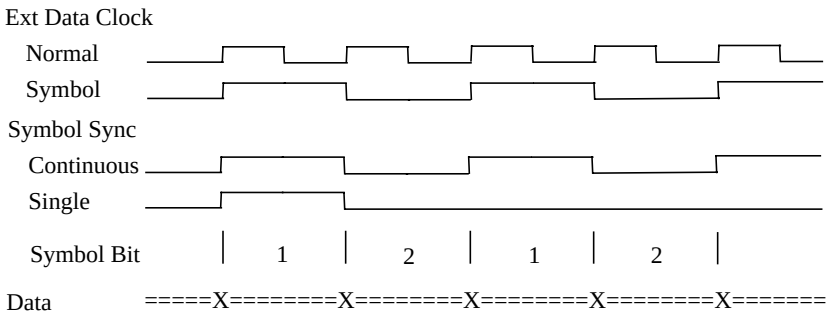
1. The front panel SYMBOL SYNC and DATA inputs must be clocked by the internal bit clock output from the rear panel DATA CLK OUT.
2. When the user's symbol clock is supplied to the DATA CLOCK input, it must also be supplied to the SYMBOL SYNC input by means of a tee.

Data Clock Timing Patterns

The following timing diagram shows the following information:

- external DATA CLOCK INPUT signal in normal and symbol modes
- SYMBOL SYNC INPUT signal in continuous and single modes
- symbol bits (2 bits per symbol)
- DATA INPUT pattern

Notice that the data should change (zero to one or one to zero) on the rising edge of the data clock and the data must be stable on the falling edge of the data clock.



where X is data transition; = is data valid 0 or 1

Alternate Amplitude and Alternate Timeslot Amplitude Control (Option UNA only)

The Alternate Amplitude Control feature comprises two separate subsystems, Alternate Amplitude and Alternate Timeslot Amplitude. The Alternate Amplitude Control subsystem provides the user with the capability of toggling the RF output power between a main amplitude and a definable alternate amplitude. The Alternate Timeslot Amplitude subsystem provides the capability of having different power levels on the transmitting digital data stream during framed data or non-framed external data.

Analog instruments with the Alternate Amplitude Control Option UNA are equipped with only the Alternate Amplitude subsystem. Digital instruments with baseband generators (Option UN8) have both Alternate Amplitude and Alternate Timeslot Amplitude subsystems.

NOTE The two subsystems can operate independently or coupled depended on the configuration. Similar to data generation and I/Q Burst control, the firmware provides the most intuitive approach to signal coupling, but when necessary, the user can override all firmware couplings.

Table 4-2 Summary of Firmware Couplings

Mode State	Pattern/Framed Data	Alt State	Alt Trigger	RF Output	General Comments
OFF	N/A	ON	EXT	Main and Delta Toggling	Must supply trigger input to TRIGGER IN rear panel BNC
OFF	N/A	ON	MAN	Main and Delta Toggling	Use softkey or remote command to toggle the RF
OFF	N/A	ON	INT	Main Only	INT trigger source has no effect when MODE off
ON	Int Pattern	OFF	N/A	Main or Delta (Manual Control)	Can manually turn on ALT and manually toggle RF
ON	Ext Pattern	ON	INT	Main and Delta toggling	Must supply trigger input to ALT PWR IN rear panel BNC
ON	Frame (all timeslots OFF)	OFF	N/A	No RF	Alternate amplitude has no meaning when all timeslots are off
ON	Frame (at least one timeslot on with no delta selection)	OFF	N/A	Main power during on timeslot	Alternate amplitude is off to avoid power drift when none of the timeslots are using Delta Amplitude.
ON	Frame (at least one timeslot ON with delta selection)	ON	INT	Assigned MAIN or DELTA power as selected	

For instruments with Option UN8, the alternate amplitude state is turned off to stabilize the circuitry and avoid subtle power drifting if a TDMA format is on and either all timeslots are off, or none of the timeslots turned on use alternate amplitude.

During non-framed/continuous EXT data transmission, alternate state is turned on (a signal must be provided at the ALT PWR IN rear panel BNC trigger input) to allow the capability of alternating the RF output power to the transmitting pattern. During these transmissions, the trigger rate determines the duration of the toggling amplitude. This can be useful in applications where external data, clock and symbol signals are provided for external framing. By providing a ALT PWR IN trigger in signal, different amplitudes can be positioned on the transmitting pattern, similar to the alternate timeslot amplitude effect with internal framing.

For analog instruments, the INT trigger source selection has no effect and this softkey is grayed out.

For instruments with Option UN8, unless a TDMA format or a custom pattern modulation is turned on, the baseband generator does not function and the INT trigger source selection for alternate amplitude trigger has no effect.

Viewing Files Stored in the Memory Catalog

You can use the memory catalog to view the files that have been stored to the source's mass memory. You can list all of the files, or have them displayed by file type.

1. Switch on the instrument's line power.
2. If the instrument is in remote mode, first press the **Local** key to return the instrument to local control. Press **Utility** (located in the MENUS section of the instrument's front panel).
3. Press **Memory Catalog**.
4. Press **Catalog Type**.

   If you do not wish to review the FIR catalog, continue with step 5.

   To view the files in the FIR catalog, press **FIR**. You can use the appropriate softkeys in this menu to copy, rename, and delete specific files, or to delete all the files within the FIR directory. When you are finished, press **Catalog Type**.
5. To view arbitrary waveform generator-related files, press **ARB Catalog Types**.

   - Press **Seq** to review all of the existing sequence files in the sequence memory. Sequence files hold information such as waveform file names, number of repetitions, and playing order.
   - Press **ARB** to review all of the existing arbitrary waveform generator waveform files in volatile ARB memory.
   - Press **NVARB** to review all of the existing arbitrary waveform generator waveform files in NVARB memory.
   - Press **CDMA** to review all of the existing CDMA files in NVARB memory.

For all arbitrary waveform generator catalog types, you can use the appropriate softkeys to rename or delete specific files, or delete all of the files present in a specific catalog directory. In addition, the Sequence and CDMA directories contain a **Copy File** softkey that allows you to copy and rename a specific file.

You can also view the waveform files in ARB and NVARB memory by pressing **Mode**, **Dual ARB**, **Waveform Segments**.

User File Applications

Digital Modulation Data Programming with User Files Remote

Use the following SCPI command line to enter a user file for remote programming of the source's digital modulation:

```
:MMEM:DATA "<file name>"
```

Sample Command Line

A sample command line:

```
:MMEM:DATA "<file name>",#ABC
```

`"<file name>"` the file name

`A` the number of numeric digits to follow in B.

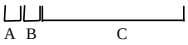
`B` specifies the number of data bytes in C.

`C` the digital modulation data.

Example 1

In the following example, the data bytes are in ASCII.

```
:MMEM:DATA "NEWDATAFILE",#1912SA4D789
```



`"NEWDATAFILE"` the file name

`1` defines the number of numeric digits to follow in B. After the #, this number points to the single digit 9 which defines the number of bytes of modulation data. (This variable is represented by A in the sample command line.)

`9` reserves the 9 data digits (12SA4D789) that indicate the bytes (in ASCII) that are stored in the modulation data (C). This variable is represented by B in the sample command line.

`12SA4D789` the digital modulation data in ASCII. This variable is represented by C in the sample command line.

Example 2

In the following example, the data bytes are in ASCII.

```
:MMEM:DATA "NEWDATAFILE1",#21012&A%4D789
                          A B      C
```

"NEWDATAFILE1" the file name

2	defines the number of numeric digits to follow in B. After the #, this number points to the double digit 10 which defines the number of bytes of modulation data. This variable is represented by A in the sample command line.
10	reserves the 10 data digits (12&A%4D789) that indicate the bytes (in ASCII) that are stored in the modulation data (C). This variable is represented by B in the sample command line.
12&A%4D789	the digital modulation data in ASCII. This variable is represented by C in the sample command line.

NOTE A user file must contain enough data to fill the entire field(s) for which it is selected. If a user file containing a data pattern with less than the required number of bits is selected, the resulting signal will not be usable. For example, if you want to fill the data field of an uplink normal TETRA burst, the user file must contain at least 432 bits of data. If the data is downloaded using ASCII characters (which represent one byte of data per character), you must enter 54 bytes of data. The six least-significant bits of the 54th byte will be truncated.

Querying the User File's Digital Modulation Data

Use the following SCPI command line to query a digital modulation user file:

```
:MMEM:DATA?"<file name>"
```

Sample Command Line

A sample command line:

```
:MMEM:DATA?"<file name>"
```

`"<file name>"` the file name

Example 1

In the following example, the data bytes are returned in ASCII.

```
:MMEM:DATA?"NEWDATAFILE"
```

`"NEWDATAFILE"` the file name

The data will be returned in the same #ABC format used in the earlier sample: #1912SA4D789 (in ASCII).

Example 2

In the following example, the data bytes are in ASCII.

```
:MMEM:DATA?"DATAFILE1"
```

`"DATAFILE1"` the file name

The data be returned in the same #ABC format used in the earlier sample: #21012&A%4D789 (in ASCII).

Reviewing User Files in the Memory Catalog

The memory catalog can be used to review the existing user files and any new files that have been transferred to the source's mass memory. To review the memory catalog:

1. Switch the source's line power on.
2. Press **Utility** (located in the MENUS section of the instrument's front panel). If the instrument is in remote mode, first press the **Local** key to return the instrument to local control.
3. Press **Memory Catalog**.
4. Press **All** to review all the files in the system.
5. Press **Binary** to review all of the existing binary files.

User File Example Programs

The following user file example programs are provided to help you understand how to apply basic SCPI concepts. Example Programs 1 through 4 were created in HP Basic (version 6.0). Example Program 5, which provides the same function as Example Program 4, is written in the C programming language.

Example Program 1, Send a File and Data to the Source's User File Directory

```
10 Sig_gen=719
20 LOCAL Sig_gen
30 CLEAR Sig_gen
40 CLEAR SCREEN
50 OUTPUT Sig_gen;"*RST"
60 OUTPUT Sig_gen;":MMEM:DATA ""DATAFILE"",#1912SA4D789"
70 END
```

Example Program 2, Query a File and Data in the Source's User File Directory

```
10 DIM A$[10000]
20 Sig_gen=719
30 LOCAL Sig_gen
40 CLEAR Sig_gen


50 CLEAR SCREEN
60 OUTPUT Sig_gen;"*RST"
70 OUTPUT Sig_gen;":MMEM:DATA?""DATAFILE"""
80 ENTER Sig_gen;A$
90 PRINT A$
100 END
```

Example Program 3, Create a TETRA User File

```
10 Sig_gen=719
20 LOCAL Sig_gen
30 CLEAR Sig_gen
40 CLEAR SCREEN
50 OUTPUT Sig_gen;”*RST”
60 OUTPUT Sig_gen;”RADIO:TETRa ON”
70 OUTPUT Sig_gen;”RADIO:TETRa:BURST:STATE ON”
80 OUTPUT Sig_gen;”RADIO:TETRa:SLOT1:STATE ON”
90 OUTPUT Sig_gen;”RADIO:TETRa:SLOT1:NORMAL”
100 OUTPUT Sig_gen;”RADIO:TETRa:SLOT1:UNORMAL “datafile””
110 END
```

Example Program 4, Upload User Data Using Integer Arrays to the Source’s User File Directory

```
10 DATA 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
20 DATA 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 30 INTEGER
A(1:15), B(1:15)
40 READ A(*)
50 OUTPUT 719 USING “K, 15(B) “;”MMEM:DATA ““TESTDATA””,#215”,A(*)
60 OUTPUT 719;”:MMEM:DATA?””TESTDATA””””
70 DIM A$[4]
80 ENTER &!( USING “K, 30(B)”;A$,B(*)
90 PRINT A$, B(*)
100 END
```

Example Program 5, Upload User Data Using Integer Arrays to the Source’s User File Directory (C Language Version)

```
#include <stdio.h>

#include <string.h>

/*

* The following routine must be substituted for one in the user's
HPIB library.

*/

extern write_hpib(int address, int size, unsigned char* data);

/* HPIB Port Address

*/

#define HPIB_ADDRESS 719

/* SCPI string token for loading data into instrument */

#define FILE_LOAD_SCPI_TOKEN "MMEM:DATA \"%s\",#%d%s"

/* File name to create int the instrument*/

#define FILE_NAME "Newdatafile"

/*

* The following is the binary data to load into the instrument. For this example
the data * is incremental, and in general would be more random. This data can also
be read from * a file by the programmer. This data is similar to the Basic example
(Example Program 4).

*/
```

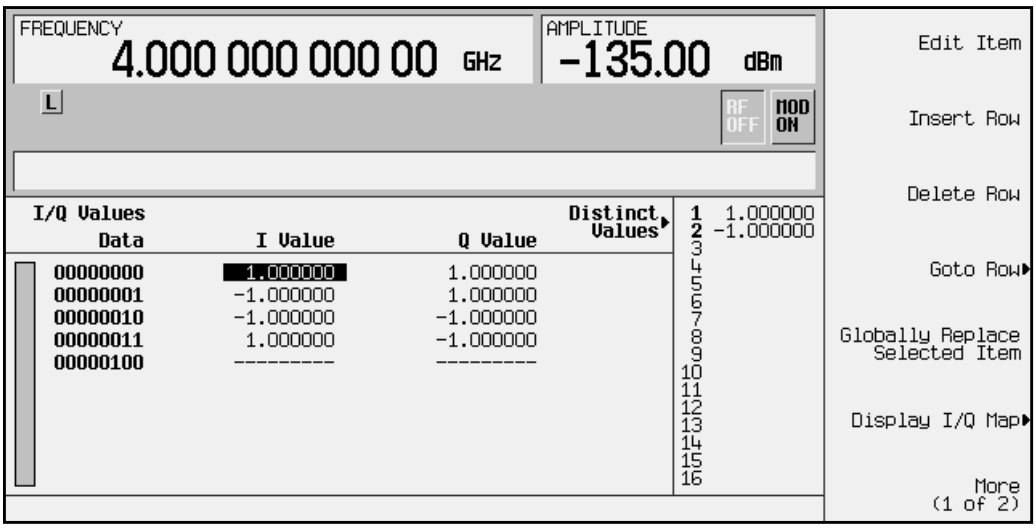
```
unsigned char db[] = {
1,2,3,4,5,6,7,8,9,10,11,12,13,14
15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31
};
int
main(void)
{
int db_size= sizeof(db)/sizeof(unsigned char);
char token_string[128];
char db_size_string[64];
int db_size_string_length;
unsigned char data_buffer[512];

sprintf(db_size_string, "%d", db_size);
db_size_string_length=strlen(db_size_string);
sprintf(token_string,
  FILE_LOAD_SCPI_TOKEN,
  FILE_NAME,
  db_size_string_length,
  db_size_string);
memcpy(data_buffer, token_string, strlen(token_string));
memcpy(data_buffer+strlen(token_string), db, db_size);
write_hpib(HPIB_ADDRESS, strlen(token_string)+db_size,
data_buffer);
return 0;
}
```

Understanding Differential Encoding

Differential encoding is a digital-encoding technique whereby a binary value is denoted by a signal change rather than a particular signal state. Using differential encoding, binary data in any user-defined I/Q or FSK modulation can be encoded during the modulation process via symbol table offsets defined in the Differential State Map.

For example, consider the signal generator's default 4QAM I/Q modulation. (To see an I/Q State Map of this modulation, press **Mode**, **Real Time BaseBand** (if this key appears), **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **QAM**, **4QAM**.) With a user-defined modulation based on the default 4QAM template, the I/Q State Map contains data that represent 4 symbols (00, 01, 10, and 11) mapped into the I/Q plane using 2 distinct values, 1.000000 and -1.000000. These 4 symbols can be differentially encoded during the modulation process by assigning symbol table offset values associated with each data value. The following illustration shows the 4QAM modulation in the I/Q State Map table editor.

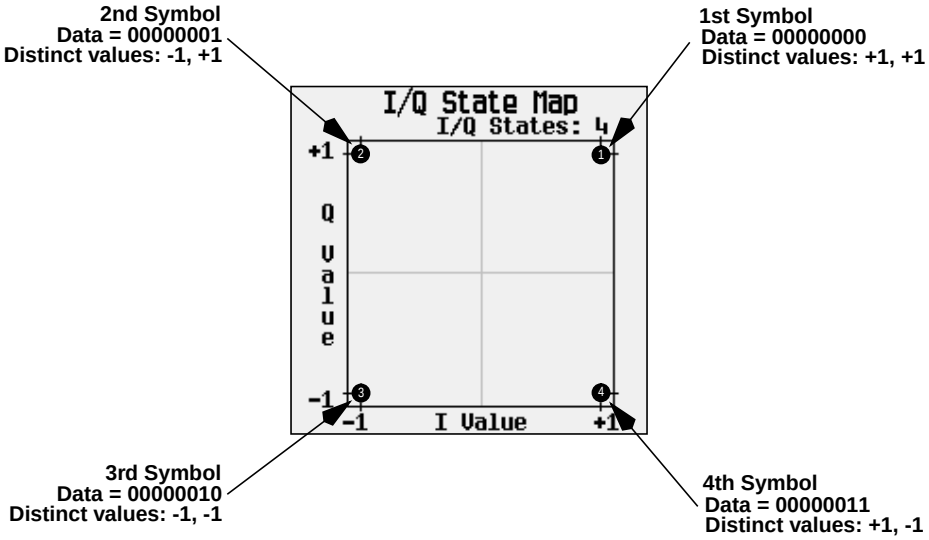


NOTE The number of bits per symbol can be expressed using the following formula. Because the equation is a ceiling function, if the value of *x* contains a fraction, *x* is rounded up to the next whole number.

$$x = \lceil Log_2(y) \rceil$$

Where *x* = bits per symbol, and *y* = the number of differential states.

The following illustration shows a 4QAM modulation I/Q State Map. (To see the map on the signal generator, press **Mode**, **Real Time BaseBand** (if this key appears), **Custom**, **Modulation Type**, **Define User I/Q**, **More (1 of 2)**, **Load Default I/Q Map**, **QAM**, **4QAM**, **More (2 of 2)**, **Display I/Q Map**.)

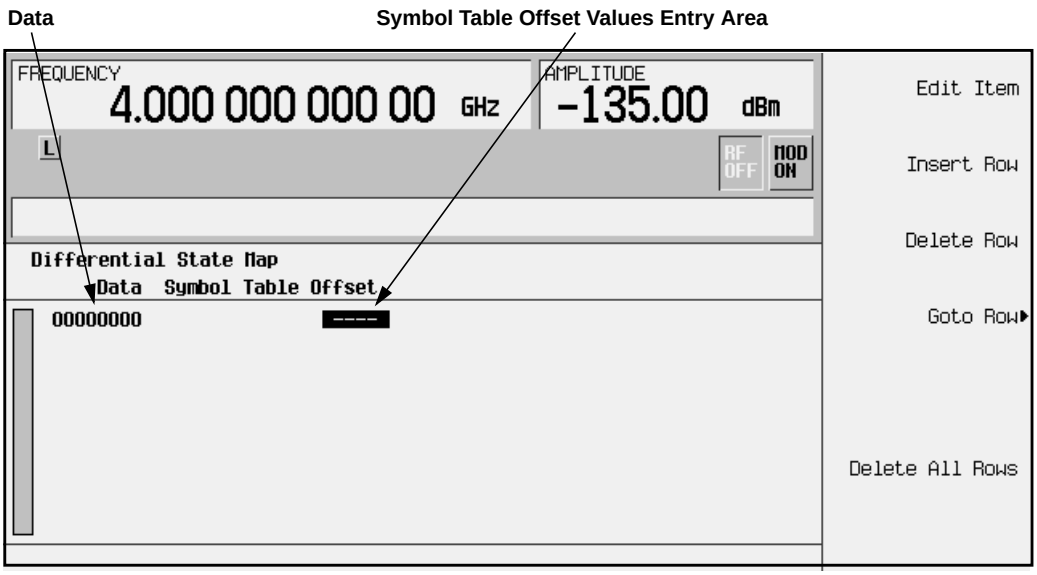


How Differential Encoding Works

Differential encoding employs offsets in the symbol table to encode user-defined modulation schemes. The Differential State Map editor is used to introduce symbol table offset values which in turn cause transitions through the I/Q State Map based on their associated data value. Whenever a data value is modulated, the offset value stored in the Differential State Map is used to encode the data by transitioning through the I/Q State Map in a direction and distance defined by the symbol table offset value.

Understanding The Differential State Map Editor

Pressing **Configure Differential Encoding** opens the Differential State Map editor. At this point, you see the data for the 1st symbol (00000000) and the cursor prepared to accept an offset value.



Entering a value of +1 will cause a 1-state forward transition through the I/Q State Map, as shown in the following illustration.

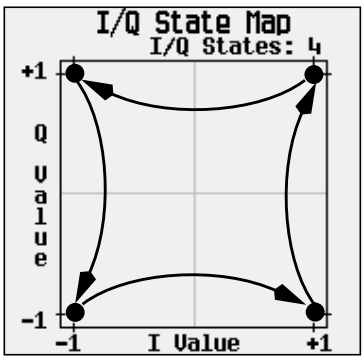
NOTE The following I/Q State Map illustrations show all of the possible state transitions using a particular symbol table offset value. The actual state-to-state transition would depend upon which state the modulation had started in.

Entering the following values in the Differential State Map, and pressing **Return**, **Differential Encoding Off On** until **On** is highlighted, differentially encodes the user-defined I/Q or FSK modulation that is present in the I/Q State Map.

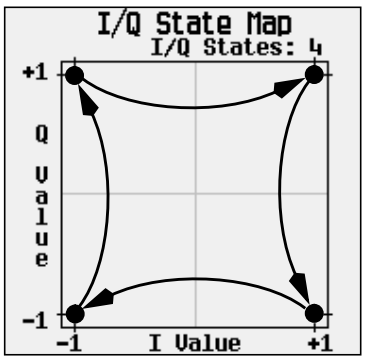
- For data 00000001, enter -1.
- For data 00000010, enter 2.
- For data 00000011, enter 0.

These symbol table offsets will result in one of the transitions shown in the following illustrations.

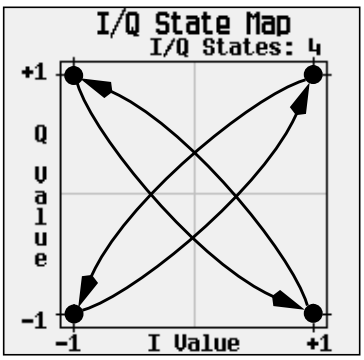
Data Value 00000000 with Symbol Table Offset +1 transition 1 state forward



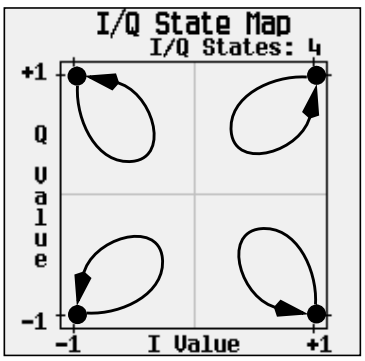
Data Value 00000001 with Symbol Table Offset -1 transition 1 state backward



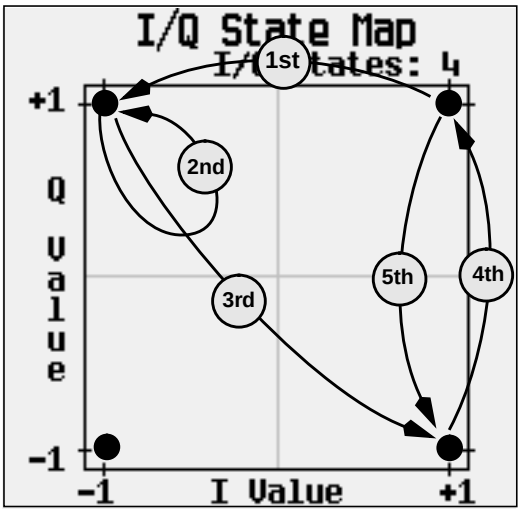
Data Value 00000010 with Symbol Table Offset +2 transition 2 states forward

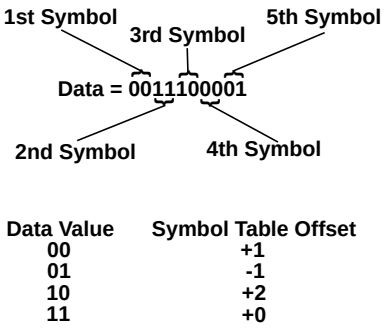


Data Value 00000011 with Symbol Table Offset +0 no transition



When applied to the user-defined default 4QAM I/Q map, starting from the 1st symbol (data 00), the differential encoding transitions for the data stream (in 2-bit symbols) 0011100001 appear in the following illustration.





Data Value	Symbol Table Offset
00	+1
01	-1
10	+2
11	+0

As you can see from the previous illustration, the 1st and 4th symbols, having the same data value (00), produce the same state transition (forward 1 state). In differential encoding, symbol values do not define location; they define the direction and distance of a *transition* through the I/Q State Map.

Understanding Differential Data Encoding

In digital modulation formats such as GSM, digital data (1's and 0's) are encoded, modulated onto a carrier frequency and subsequently transmitted to a receiver. In contrast to differential encoding (described on page 2-30), differential *data* encoding modifies the data stream *prior* to I/Q mapping. Where differential encoding encodes the raw data by using symbol table offset values to manipulate I/Q mapping at the point of modulation, differential data encoding uses *the transition from one bit value to another* to encode the raw data.

How Differential Data Encoding Works

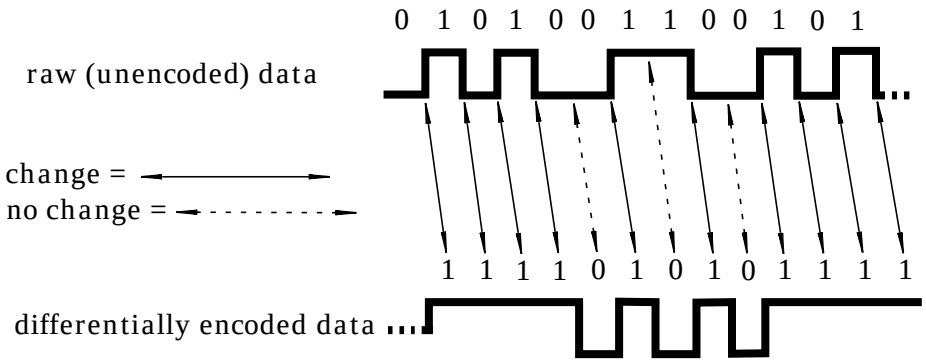
Differential data encoding modifies the raw digitized data by creating a secondary, encoded data stream that is defined by *changes* in the digital state, from 1 to 0 or from 0 to 1, of the raw data stream. This differentially encoded data stream is then modulated and transmitted.

In differential data encoding, a *change* in a raw data bit's digital state, from 1 to 0 or from 0 to 1, produces a 1 in the encoded data stream. *No change* in digital state from one bit to the next, in other words a bit with a value of 1 followed by another bit with a value of 1 or a bit with a value of 0 followed by the same, produces a 0 in the encoded data. For instance, differentially encoding the data stream containing 01010011001010 renders 1111010101111.

Differential data encoding can be described by the following equation:

$$transmittedbit(i) = databit(i-1) \oplus databit(i)$$

For a bit-by-bit illustration of the encoding process, see the following illustration.



How to Access and Apply Differential Data Encoding

You can apply differential data encoding to a custom modulation by pressing **Mode**, **Real Time I/Q BaseBand** (if this key is present), **Custom**, **More (1 of 2)**, **Diff Data Encode Off On** until **On** is highlighted.

You can apply differential data encoding to a GSM modulation by pressing **Mode**, **Real Time I/Q BaseBand** (if this key is present), **TDMA**, **GSM**, **More (1 of 2)**, **Modify Standard**, **Diff Data Encode Off On** until **On** is highlighted.

5 Remote Programming

This chapter contains a brief overview of the Standard Commands for Programmable Instruments (SCPI) programming language (including a command syntax description) and a listing of all of the custom modulation generator subsystem SCPI commands in alphabetical order. The descriptions include syntax requirements, ranges, restrictions, query responses, and status at *RST.

Getting Started with SCPI

This section includes some basic reference material for the Standard Commands for Programmable Instruments language (SCPI). For more detailed information, see the Programming Guide.

Understanding Common Terms

The following terms are used throughout the remainder of this chapter.

Controller — A controller is any computer used to communicate with a SCPI instrument. A controller can be a personal computer, a minicomputer, or a plug-in card in a card cage. Some intelligent instruments can also function as controllers.

Instrument — An instrument is any device that implements SCPI. Most instruments are electronic measurement or stimulus devices, but this is not a requirement. Similarly, most instruments use an HP-IB or RS-232 interface for communication. The same concepts apply regardless of the instrument function or the type of interface used.

Program Message — A program message is a combination of one or more properly formatted SCPI commands. Program messages always go from a controller to an instrument. Program messages tell the instrument how to make measurements and output signals.

Response Message — A response message is a collection of data in specific SCPI formats. Response messages always go from an instrument to a controller or listening instrument. Response messages tell the controller about the internal state of the instrument and about measured values.

Command — A command is an instruction in SCPI. You combine commands to form messages that control instruments. In general, a command consists of mnemonics (keywords), parameters, and punctuation.

Query — A query is a special type of command. Queries instruct the instrument to make response data available to the controller. Query mnemonics always end with a question mark.

Standard Notation

This section uses several forms of notation that have specific meaning:

Command Mnemonics — Many commands have both a long and a short form and you must use either one or the other (SCPI does not accept a combination of the two). Consider the FREQuency command, for example. The short form is FREQ

and the long form is FREQUENCY. This notation type is a shorthand to document both the long and short form of commands. SCPI is not case sensitive, so fREquEnCy is just as valid as FREQUENCY, but FREQ and FREQUENCY are the only valid forms of the FREQuency command.

Angle Brackets

Angle brackets indicate that the word or words enclosed represent something other than themselves. For example, <new line> represents the ASCII character with the decimal value 10. Similarly, <END> means that EOI is asserted on the HP-IB interface. Words in angle brackets have much more rigidly defined meaning than words shown in ordinary text. For example, this section uses the word "message" to talk about messages generally. But the bracketed words <program message> indicate a precisely defined element of SCPI. If you need them, you can find the exact definitions of words such as <program message> in a syntax diagram.

More About Commands

Query and Event Commands

You can query any value that you can set. For example, the presence of the signal generator FREQuency:OFFSet command implies that a FREQuency:OFFSet? also exists. If you see a command ending with a question mark, it is a query-only command. Some commands are events and cannot be queried. An event has no corresponding setting if it causes something to happen inside the instrument at a particular instant.

Implied Commands

Implied commands appear in square brackets. If you send a subcommand immediately preceding an implied command, but do not send the implied command, the instrument assumes you intend to use the implied command and behaves just as if you had sent it. Notice that this means that the instrument expects you to include any parameters required by the implied command. The following example illustrates equivalent ways to program the signal generator using explicit and implied commands.

Example signal generator commands with and without an implied command:

`FREQuency[:CW] 500 MHz`	using explicit commands
`FREQuency 500 MHz`	using implied commands

Optional Parameters

Optional parameter names are enclosed in square brackets. If you do not send a value for an optional parameter, the instrument chooses a default value. The instrument's command dictionary documents the values used for optional parameters.

Command Syntax

Following the heading for each programming command entry is a syntax statement showing the proper syntax for the command. An example syntax statement is shown here:

```
POWer[:LEVel] MAXimum|MIN
```

Syntax statements read from left to right. In this example, the :LEVel portion of the statement immediately follows the POWer portion of the statement with no separating space. A separating space is legal only between the command and its argument. In this example, the portion following the [:LEVel] portion of the statement is the argument. Additional conventions used in the syntax statements are defined as follows:

- Italics are used to symbolize a program code parameter or query response.
- ::= means “is defined as.”
- | (vertical bar) indicates a choice of one element from a list. For example, <A>|<B> indicates <A> or <B> but not both.
- [] (square brackets) indicate that the enclosed items are optional.
- Upper-case lettering indicates that the upper-case portion of the command is the minimum required for the command. For example, in the command FREQuency, FREQ is the minimum requirement.
- Lower-case lettering indicates that the lower-case portion of the command is optional; it can either be included with the upper-case portion of the command or omitted. For example, in the command FREQuency, either FREQ, or FREQUENCY is correct.
- ? after a subsystem command indicates that the command is a query.

CUSTOM Subsystem SCPI Command Reference

The CUSTOM subsystem SCPI commands are used to set the controls and the parameters associated with custom modulation via a remote controller.

Baseband Data Clock Input Configuration

```
[:SOURce]:RADio:CUSTom:BBCLock INT[1]|EXT[1]
[:SOURce]:RADio:CUSTom:BBCLock?
```

This command sets the data (bit) clock input to the baseband generator board to either Internal or External. This command is independent in each mode and works for both non-burst (continuous) and burst modes. This allows for a matrix of selections between burst/non-burst, internal/external data generation, internal/external data clock, and external bit/symbol data clock.

`INT[1]` Selects the instrument's internal data clock.

`EXT[1]` Selects an external data clock input.

Status after Normal Preset or *RST: Internal

Burst Shape Configuration

Fall Delay

```
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FALL:DELay <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FALL:DELay?
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FDELay <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FDELay?
```

This command sets the burst shape fall delay.

Range: minimum and maximum values depend upon modulation type and symbol rate.

Status after Normal Preset or *RST: 0.000

Fall Time

```
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FALL:TIME <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FALL:TIME?
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FTIMe <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FTIMe?
```

This command sets the burst shape fall time.

Range: minimum and maximum values depend upon modulation type and symbol rate.

Status after Normal Preset or *RST: 5.470

Rise Delay

```
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RDELay <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RDELay?
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RISE:DELay <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RISE:DELay?
```

This command sets the burst shape rise delay.

Range: minimum and maximum values depend upon modulation type and symbol rate.

Status after Normal Preset or *RST: 0.000

Rise Time

```
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RISE:TIME <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RISE:TIME?
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RTIMe <value>
[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RTIMe?
```

This command sets the burst shape rise time.

Range: minimum and maximum values depend upon modulation type and symbol rate.

Status after Normal Preset or *RST: 5.860

Custom State

```
[:SOURce]:RADio:CUSTom[:STATe] ON|OFF|1|0
[:SOURce]:RADio:CUSTom[:STATe]?
```

This command toggles the custom modulation. Options: `On (1)` or `Off (0)`.

Status after Normal Preset or *RST: Off

Data Configuration

```
[:SOURce]:RADio:CUSTom:DATA PN9|PN11|PN15|PN20|PN23|FIX4|
"<file name>"|EXT|P4|P8|P16|P32|P64
[:SOURce]:RADio:CUSTom:DATA?
```

This command sets a data pattern for unframed transmission. Options are as follows:

`PN9`	Pseudorandom bit pattern
`PN11`	Pseudorandom bit pattern
`PN15`	Pseudorandom bit pattern
`PN20`	Pseudorandom bit pattern
`PN23`	Pseudorandom bit pattern
`FIX4`	4-bit repeating sequence data pattern
`"<file name>"`	A file in the catalog of binary files
`Ext`	External input data pattern
`P4`	Four 1's and four 0's
`P8`	Eight 1's and eight 0's
`P16`	Sixteen 1's and sixteen 0's
`P32`	Thirty-two 1's and thirty-two 0's
`P64`	Sixty-four 1's and sixty-four 0's

NOTE Pattern Repeat and Pattern Trigger functions are *not* available if you use either a PN data sequence, or an external data source.

Status after Normal Preset or *RST: PN23

FIX4 Configuration

```
[:SOURce]:RADio:CUSTom:DATA:FIX4 <0-15>
[:SOURce]:RADio:CUSTom:DATA:FIX4?
```

This command sets the value of the data field FIX4.

Status at Normal Preset or *RST: 0000 (binary).

Diff Data Encode

```
[:SOURce]:RADio:CUSTom:DENCode ON|OFF|1|0
[:SOURce]:RADio:CUSTom:DENCode?
```

This command controls the operational state of the differential data encoding.

For a detailed explanation of differential data encoding, see "Understanding Differential Data Encoding" on page 4-17.

Differential Encoding

```
:MEMory:DATA:FSK <"filename">,num_states,f0,f1,...
[,diff_state,num_diff_states,diff0,diff1,...]
```

```
:MEMory:DATA:IQ <"filename">,offsetQ,num_states,i0,q0,i1,q1,...
[,diff_state,num_diff_states,diff0,diff1,...]
```

The user-defined FSK modulation and user-defined I/Q modulation SCPI commands contain the differential encoding information. Before designing a differential encoding scheme, you must first define the FSK or I/Q modulation to be encoded. The actual differential encoding-related input appears bolded in the command listing above.

This command line enables you to define the differential encoding criteria.

`diff_state`	Toggle for differential encoding. (ON | OFF | 1 | 0)
`num_diff_states`	The number of differential states (0 through 256)
`diff0`	Value of first differential state (an integer value from -128 through +127)
`diff1`	Value of second differential state (an integer value from -128 through +127)

External Data Clock Configuration

```
[:SOURce]:RADio:CUSTom:EDCLock SYMBol|NORMal
[:SOURce]:RADio:CUSTom:EDCLock?
```

This command sets the external data clock use. The options are as follows:

`Normal`	You must supply a signal to the DATA CLOCK INPUT connector to clock the DATA and SYMBOL SYNC signals.
`Symbol`	No signal is required at the DATA CLOCK INPUT connector. Instead, the data is clocked on both the rising and falling edges of the SYMBOL SYNC signal.

This is a persistent state that is set to Normal at the factory.

External Delay Configuration

Toggling State

```
[:SOURce]:RADio:CUSTom:TRIGger[:SOURce]:EXTernal:DELay:STATe ON|OFF|1|0
[:SOURce]:RADio:CUSTom:TRIGger[:SOURce]:EXTernal:DELay:STATe?
```

Setting Delay Bits

```
[:SOURce]:RADio:CUSTom:TRIGger[:SOURce]:EXTernal:DELay <value>
[:SOURce]:RADio:CUSTom:TRIGger[:SOURce]:EXTernal:DELay?
```

Filter Alpha, Nyquist, or Root Nyquist

```
[:SOURce]:RADio:CUSTom:ALPHa <value>
[:SOURce]:RADio:CUSTom:ALPHa?
```

This command changes the Nyquist or root Nyquist filter's alpha value. The acceptable range for the variable <value> is 0.000 through 1.000.

This command is effective only *after* choosing a root Nyquist or Nyquist filter. It does not have an effect on other types of filters.

At *RST, this value is set to 0.350.

Filter BbT, Gaussian

```
[:SOURce]:RADio:CUSTom:BBT <value>
[:SOURce]:RADio:CUSTom:BBT?
```

This command changes the bandwidth-multiplied-by-bit-time (BbT) filter parameter. The acceptable range for the variable <value> is 0.100 through 1.000.

This command is effective only *after* choosing a Gaussian filter. It does not have an effect on other types of filters.

At *RST, this value is set to 0.500.

Filter Selection

```
[:SOURce]:RADio:CUSTom:FILter RNYQuist|NYQuist|GAUSsian|
RECTangle|“<file name>”

[:SOURce]:RADio:CUSTom:FILter?
```

This command selects the pre-modulation filter type. The choices are:

- `RNYQuist` - Root Nyquist filter
- `NYQuist` - Nyquist filter
- `GAUSsian` - Gaussian filter
- `RECTangle` - Rectangle filter
- `“<file name>”` - Any filter file that you have either created externally and downloaded into memory, or that you have created internally in the Define User FIR menu and then subsequently stored.

At *RST, this value is set to root Nyquist.

Filter Optimization

```
[:SOURce]:RADio:CUSTom:CHANnel EVM|ACP
[:SOURce]:RADio:CUSTom:CHANnel?
```

This command is used to optimize the filter for minimized error vector magnitude (select EVM) or for minimized adjacent channel power (select ACP). The EVM selection provides the most ideal passband. The ACP selection improves stopband rejection. This feature only applies to root Nyquist and Nyquist filters. The softkey is grayed out when any other filter is selected.

At *RST, this value is set to ACP.

I/Q Scaling

```
[:SOURce]:RADio:CUSTom:IQ:SCALe <value>
[:SOURce]:RADio:CUSTom:IQ:SCALe?
```

This command sets the amplitude of the I/Q outputs for better ACP. This command has no effect with MSK or FSK modulation.

Range: 1 through 10000 At *RST, this value is set to: 70

Modulation Configuration

Modulation Type

```
[:SOURce]:RADio:CUSTom:MODulation[:TYPE] BPSK|QPSK|IS95QPSK|GRAYQPSK|OQPSK|
IS95OQPSK|P4DQPSK|PSK8|PSK16|D8PSK|MSK|FSK2|FSK4|FSK8|FSK16|C4FM|QAM4|QAM16|
QAM32|QAM64|QAM256|UIQ|UFSK
[:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
```

This command sets the custom modulation to one of the available formats.

At *RST, this value is set to: P4DQPSK

Selecting a Custom FSK or I/Q Modulation File

UFSK “<file name>” defines the prestored FSK file that you want to use.

```
[:SOURce]:RADio:CUSTom:MODulation:UFSK “<file name>”
[:SOURce]:RADio:CUSTom:MODulation:UFSK?
```

This information is held in memory until you send the command that selects user FSK as the modulation type.

```
[:SOURce]:RADio:CUSTom:MODulation:TYPE UFSK
```

UIQ “<file name>” defines the prestored I/Q file that you want to use.

```
[:SOURce]:RADio:CUSTom:MODulation:UIQ “<file name>”
[:SOURce]:RADio:CUSTom:MODulation:UIQ?
```

This information is held in memory until you send the command that selects user I/Q as the modulation type.

```
[:SOURce]:RADio:CUSTom:MODulation:TYPE UIQ
```

Creating a Custom FSK Modulation

```
:MEMory:DATA:FSK "<file name>",num_states,f0,f1,...
[,diff_state,num_diff_states,diff0,diff1,...]
```

This command enables you to define and store a custom FSK file.

`"<file name>"` The name under which to store the defined FSK information

`num_states` Number of frequency states (2 through 16)

`f0` Value of the first frequency

`f1` Value of the second frequency

`diff_state` Toggle for differential encoding. (ON | OFF | 1 | 0)

`num_diff_states` The number of differential states (0 through 256)

`diff0` Value of first differential state (an integer value from -128 through +127)

`diff1` Value of 2nd differential state (an integer value from -128 through +127)

Example

The following example creates and stores a four–level FSK file named 4FSK that has four states (frequencies) of -2 kHz, -1 kHz, 2 kHz, 1 kHz. Differential encoding is toggled ON, and there are two differential states: 1 and 0.

```
:MEM:DATA:FSK "4FSK",4,-2 kHz,-1 kHz,2 kHz,1 kHz,ON,2,1,0
```

Creating a Custom I/Q Modulation

```
:MEMory:DATA:IQ "<file name>",offsetQ,num_states,i0,q0,i1,q1,...
[,diff_state,num_diff_states,diff0,diff1,...]
```

This command enables you to define and store a custom I/Q file.

`"<file name>"` The name under which to store the defined I/Q information

`offsetQ` Whether the Q output is delayed by 1/2 symbol from the I output (OFF | ON | 0 | 1)

`num_states` Number of symbols (2 through 256)

`i0` I value of first symbol (-1 through +1)

`q0` Q value of first symbol (-1 through +1)

`diff_state` Toggle for differential encoding. (ON | OFF | 1 | 0)

`num_diff_states` The number of differential states (0 through 256)

`diff0` Value of first differential state (an integer value from -128 through +127)

`diff1` Value of 2nd differential state (an integer value from -128 through +127)

Example

The following example creates and stores a two-symbol I/Q file named testBPSK that has offset Q turned on.

```
:MEM:DATA:IQ "testBPSK",1,2,1,0,0,0
```

FSK Frequency Deviation

```
[:SOURce]:RADio:CUSTom:MODulation:FSK[:DEViation] <val><unit>
[:SOURce]:RADio:CUSTom:MODulation:FSK[:DEViation]?
```

This command selects symmetric FSK frequency deviation; to define an asymmetric or different convention than the default, see "Creating a Custom FSK Modulation" on page 5-11.

Range: 0 Hz is the minimum value; the maximum value depends upon the symbol rate.

At *RST, this value is set to: 400.0 Hz

MSK Phase Deviation

```
[:SOURce]:RADio:CUSTom:MODulation:MSK[:PHASe] <val><unit>
[:SOURce]:RADio:CUSTom:MODulation:MSK[:PHASe]?
```

This command selects MSK phase deviation.

Range: 0 to 100 degrees.

At *RST, this value is set to: 90.00 degrees

Pattern Repeat

```
[:SOURce]:RADio:CUSTom:REPeat SINGle|CONTinuous
[:SOURce]:RADio:CUSTom:REPeat?
```

Pattern Repeat is *not* available with either a PN data sequence, or an external data source.

Pattern Trigger Source Configuration

```
[:SOURce]:RADio:CUSTom:TRIGger[:SOURce] KEY|EXT|BUS
[:SOURce]:RADio:CUSTom:TRIGger[:SOURce]?
```

Pattern Trigger is *not* available with either a PN data sequence, or an external data source.

Phase Polarity

```
[:SOURce]:RADio:CUSTom:POLarity[:ALL] NORMal|INVerted
[:SOURce]:RADio:CUSTom:POLarity[:ALL]?
```

This command sets the direction of rotation of the phase modulation vector. The options are as follows:

`Normal`	Normal phase polarity.
`Inverted`	The in-phase component will lag the quadrature-phase component by 90° in the resulting modulation. The inverted selection also applies to the I OUT and Q OUT signals.

At *RST, this value is set to: Normal

Symbol Rate

```
[:SOURce]:RADio:CUSTom:SRATe <value>
[:SOURce]:RADio:CUSTom:SRATe?
[:SOURce]:RADio:CUSTom:BRATe <value>
[:SOURce]:RADio:CUSTom:BRATe?
```

This command sets the transmission symbol rate.

At *RST, this value is set to: 24.300000 ksps

Sync Out Configuration

```
[:SOURce]:RADio:CUSTom:SOUT FRAME|SLOT|ALL
[:SOURce]:RADio:CUSTom:SOUT?
```

Begin Timeslot

```
[:SOURce]:RADio:CUSTom:SOUT SLOT <value>
```

Sync Out Offset

```
[:SOURce]:RADio:CUSTom:SOUT OFFSet <value>
[:SOURce]:RADio:CUSTom:SOUT OFFSET?
```

User FIR Definition

```
:MEMory:DATA:FIR "<file name>",osr,coefficient{,coefficient}
:MEMory:DATA:FIR? "<file name>"
```

This command is used to define User FIR filters. The instrument hardware is limited to filters with a maximum length of 32 symbols, an oversample ratio between 4 and 16, and 256 coefficients. If your filter has more than 32 symbols or 256 coefficients, the instrument will be unable to use the filter. If the oversample ratio is different from the internal optimally selected one, the filter will be resampled to the optimal possible oversample ratio.

6 Programming Command Cross–Reference

This section lists custom modulation hardkeys and softkeys and their corresponding SCPI commands. For a complete list of the signal generator's hardkeys and softkeys and their corresponding SCPI commands, refer to the main programming guide.

Table 6-1 Mode – Custom Softkeys

Key	SCPI Command
π/4DPSK	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] P4DQPSK
2–Lvl FSK	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] FSK2
4 1's & 4 0's	[:SOURce]:RADio:CUSTom:DATA P4
4–Lvl FSK	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] FSK4
4QAM	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] QAM4
8 1's & 8 0's	[:SOURce]:RADio:CUSTom:DATA P8
8–Lvl FSK	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] FSK8
8PSK	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] PSK8
16 1's & 16 0's	[:SOURce]:RADio:CUSTom:DATA P16
16–Lvl FSK	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] FSK16
16PSK	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] PSK16
16QAM	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] QAM16
32 1's & 32 0's	[:SOURce]:RADio:CUSTom:DATA P32
32QAM	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] QAM32
64 1's & 64 0's	[:SOURce]:RADio:CUSTom:DATA P64
64QAM	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] QAM64
256QAM	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] QAM256
All Timeslots	[:SOURce]:RADio:CUSTom:SOUT ALL [:SOURce]:RADio:CUSTom:SOUT?
BBG Data Clock Ext Int	[:SOURce]:RADio:CUSTom:BBCLock INT[1]|EXT[1] [:SOURce]:RADio:CUSTom:BBCLock?
Begin Pattern	[:SOURce]:RADio:CUSTom:SOUT FRAME [:SOURce]:RADio:CUSTom:SOUT?
Begin Timeslot	[:SOURce]:RADio:CUSTom:SOUT SLOT <value> [:SOURce]:RADio:CUSTom:SOUT?
BPSK	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] BPSK
Bus	[:SOURce]:RADio:CUSTom:TRIGger[:SOURce] BUS
C4FM	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] C4FM

Key	SCPI Command
Configure Differential Encoding	:MEMory:DATA:FSK “<file name>”,num_states,f0, f1,...[,diff_state,num_diff_states,diff0,diff1,...] :MEMory:DATA:IQ “<file name>”,offsetQ,num_states,i0, q0,i1,q1,...[,diff_state,num_diff_states,diff0, diff1,...]
Custom Off On	[:SOURce]:RADio:CUSTom[:STATe] ON|OFF|1|0 [:SOURce]:RADio:CUSTom[:STATe]?
D8PSK	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] D8PSK
Data	[:SOURce]:RADio:CUSTom:DATA PN9|PN11|PN15|PN20|PN23| FIX4|“<file name>”|EXT|P4|P8|P16|P32|P64 [:SOURce]:RADio:CUSTom:DATA?
Define User FIR	:MEMory:DATA:FIR “<file name>”,osr,coefficient {,coefficient} :MEMory:DATA:FIR?
Define User FSK	:MEMory:DATA:FSK “<file name>”,num_states,f0, f1,...[,diff_state,num_diff_states,diff0,diff1,...]
Define User I/Q	:MEMory:DATA:IQ “<file name>”,offsetQ,num_states,i0, q0,i1,q1,...[,diff_state,num_diff_states,diff0, diff1,...]
Diff Data Encode Off On	[:SOURce]:RADio:CUSTom:DENCode ON|OFF|1|0 [:SOURce]:RADio:CUSTom:DENCode?
Differential Encoding Off On	:MEMory:DATA:FSK “<file name>”,num_states,f0, f1,...[,diff_state,num_diff_states,diff0,diff1,...] :MEMory:DATA:IQ “<file name>”,offsetQ,num_states,i0, q0,i1,q1,...[,diff_state,num_diff_states,diff0, diff1,...]
EXT	[:SOURce]:RADio:CUSTom:DATA EXT [:SOURce]:RADio:CUSTom:TRIGger[:SOURce] EXT
Ext Data Clock Normal Symbol	[:SOURce]:RADio:CUSTom:EDCLock SYMBol|NORMal [:SOURce]:RADio:CUSTom:EDCLock?
Ext Delay Off On	[:SOURce]:RADio:CUSTom:TRIGger[:SOURce]:EXTernal:DELay :STATe ON|OFF|1|0 [:SOURce]:RADio:CUSTom:TRIGger[:SOURce]:EXTernal:DELay :STATe?

Key	SCPI Command
Ext Delay Bits	[:SOURce]:RADio:CUSTom:TRIGger[:SOURce]:EXTernal:DELay <value> [:SOURce]:RADio:CUSTom:TRIGger[:SOURce]:EXTernal:DELay?
Fall Delay	[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FALL:DELay <value> [:SOURce]:RADio:CUSTom:BURSt:SHAPe:FALL:DELay? [:SOURce]:RADio:CUSTom:BURSt:SHAPe:FDELay <value> [:SOURce]:RADio:CUSTom:BURSt:SHAPe:FDELay?
Fall Time	[:SOURce]:RADio:CUSTom:BURSt:SHAPe:FALL:TIME <value> [:SOURce]:RADio:CUSTom:BURSt:SHAPe:FALL:TIME? [:SOURce]:RADio:CUSTom:BURSt:SHAPe:FTIMe <value> [:SOURce]:RADio:CUSTom:BURSt:SHAPe:FTIMe?
Filter Alpha	[:SOURce]:RADio:CUSTom:ALPHa <value> [:SOURce]:RADio:CUSTom:ALPHa?
Filter BbT	[:SOURce]:RADio:CUSTom:BBT <value> [:SOURce]:RADio:CUSTom:BBT?
FIX4	[:SOURce]:RADio:CUSTom:DATA:FIX4 <0–15> [:SOURce]:RADio:CUSTom:DATA:FIX4?
Freq Dev	[:SOURce]:RADio:CUSTom:MODulation:FSK[:DEViation] <val><unit> [:SOURce]:RADio:CUSTom:MODulation:FSK[:DEViation]?
Gaussian	[:SOURce]:RADio:CUSTom:FILTer GAUSsian [:SOURce]:RADio:CUSTom:FILTer?
Gray Coded QPSK	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] GRAYQPSK
I/Q Scaling	[:SOURce]:RADio:CUSTom:IQ:SCALe <value> [:SOURce]:RADio:CUSTom:IQ:SCALe?
IS95 OQPSK	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] IS95OQPSK
IS95 QPSK	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] IS95QPSK
Modulation Type	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] BPSK|QPSK| IS95QPSK|GRAYQPSK|OQPSK|IS95OQPSK|P4DQPSK|PSK8|PSK16| D8PSK|MSK|FSK2|FSK4|FSK8|FSK16|C4FM|QAM4|QAM16|QAM32| QAM64|QAM256|UIQ|UFSK [:SOURce]:RADio:CUSTom:MODulation[:TYPE]?
MSK	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] MSK
Nyquist	[:SOURce]:RADio:CUSTom:FILTer NYQuist [:SOURce]:RADio:CUSTom:FILTer?

Key	SCPI Command
Offset Q Off On	:MEMory:DATA:IQ “<file name>”,offsetQ,num_states,i0, q0,i1,q1,...[,diff_state,num_diff_states,diff0, diff1,...]
Optimize FIR For EVM ACP	[:SOURce]:RADio:CUSTom:CHANnel EVM|ACP [:SOURce]:RADio:CUSTom:CHANnel?
OQPSK	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] OQPSK
Pattern Repeat Single Cont	[:SOURce]:RADio:CUSTom:REPeat SINGle|CONTinuous [:SOURce]:RADio:CUSTom:REPeat?
Pattern Trigger	[:SOURce]:RADio:CUSTom:TRIGger[:SOURce] KEY|EXT|BUS [:SOURce]:RADio:CUSTom:TRIGger[:SOURce]?
Phase Dev	[:SOURce]:RADio:CUSTom:MODulation:MSK[:PHASe] <val><unit> [:SOURce]:RADio:CUSTom:MODulation:MSK[:PHASe]?
Phase Polarity Normal Invert	[:SOURce]:RADio:CUSTom:POLarity[:ALL] NORMal|INVerted [:SOURce]:RADio:CUSTom:POLarity[:ALL]?
PN9	[:SOURce]:RADio:CUSTom:DATA PN9
PN11	[:SOURce]:RADio:CUSTom:DATA PN11
PN15	[:SOURce]:RADio:CUSTom:DATA PN15
PN20	[:SOURce]:RADio:CUSTom:DATA PN20
PN23	[:SOURce]:RADio:CUSTom:DATA PN23
QPSK	[:SOURce]:RADio:CUSTom:MODulation[:TYPE] QPSK
Rectangle	[:SOURce]:RADio:CUSTom:FILTer RECTangle [:SOURce]:RADio:CUSTom:FILTer?
Rise Delay	[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RDELay <value> [:SOURce]:RADio:CUSTom:BURSt:SHAPe:RDELay? [:SOURce]:RADio:CUSTom:BURSt:SHAPe:RISE:DELay <value> [:SOURce]:RADio:CUSTom:BURSt:SHAPe:RISE:DELay?
Rise Time	[:SOURce]:RADio:CUSTom:BURSt:SHAPe:RISE:TIME <value> [:SOURce]:RADio:CUSTom:BURSt:SHAPe:RISE:TIME? [:SOURce]:RADio:CUSTom:BURSt:SHAPe:RTIMe <value> [:SOURce]:RADio:CUSTom:BURSt:SHAPe:RTIMe?
Root Nyquist	[:SOURce]:RADio:CUSTom:FILTer RNYQuist [:SOURce]:RADio:CUSTom:FILTer?
Select	[:SOURce]:RADio:CUSTom:FILTer RNYQuist|NYQuist| GAUSsian|RECTangle|“<user FIR>” [:SOURce]:RADio:CUSTom:FILTer?

Key	SCPI Command
Select File	[:SOURce]:RADio:Custom:DATA “<file name>”
Symbol Rate	[:SOURce]:RADio:CUSTom:BRATe <value> [:SOURce]:RADio:CUSTom:BRATe? [:SOURce]:RADio:CUSTom:SRATe <value> [:SOURce]:RADio:CUSTom:SRATe?
Sync Out	[:SOURce]:RADio:CUSTom:SOUT FRAME|SLOT|ALL [:SOURce]:RADio:CUSTom:SOUT?
Sync Out Offset	[:SOURce]:RADio:CUSTom:SOUT OFFSet <value> [:SOURce]:RADio:CUSTom:SOUT:OFFSet?
Trigger Key	[:SOURce]:RADio:CUSTom:TRIGger[:SOURce] KEY
User FIR	[:SOURce]:RADio:CUSTom:FILTer “<file name>” [:SOURce]:RADio:CUSTom:FILTer?
User FSK	[:SOURce]:RADio:CUSTom:MODulation:UFSK “<file name>” [:SOURce]:RADio:CUSTom:MODulation:UFSK? [:SOURce]:RADio:CUSTom:MODulation[:TYPE] UFSK
User I/Q	[:SOURce]:RADio:CUSTom:MODulation:UIQ “<file name>” [:SOURce]:RADio:CUSTom:MODulation:UIQ? [:SOURce]:RADio:CUSTom:MODulation[:TYPE] UIQ

Index

Index

W