

Keysight Technologies

Flexible Digital Modulation Solution

Application Note



Introduction

Using the Keysight 33522B dual channel waveform generator and N9310A RF signal generator

Simple digital modulation signals, such as GFSK, are widely used in smart grid, near field communication (NFC), and many consumer electronics products. During the R&D or manufacturing process, it is necessary to generate digital modulation signals for RF receiver testing. As this application note explains, the Keysight Technologies, Inc. 33522B dual-channel waveform generator and N9310A RF signal generator provide an affordable alternative to using a vector signal generator. To demonstrate the solution's simplicity and flexibility, this paper will show how to generate a GFSK signal.

Preparations for Generating GFSK Signals

This section outlines the software and equipments necessary to generate a GFSK signal using this low-cost solution.

- Waveform editing software
This is used to edit the baseband waveform data for the Keysight 33522B waveform generator and to set up 33522B parameters, such as sampling rate and output level.

A *GFSK IQ Baseband Builder* is available for free downloading from the Keysight Web site. It was developed on MATLAB version 8.0.0.783 (R2012b), allowing the creation of GFSK baseband waveforms. The GFSK IQ Baseband Builder contains two files for you to use in the MATLAB environment:
 - *GFSK_N9310A_33522B_IQ.m* – Used to generate baseband waveform data and download it to the 33522B waveform generator
 - *Data.m* – Used to customize the I/Q baseband signal
- One Keysight 33522B waveform generator
This is a 30 MHz, dual channel waveform generator with exclusive *Trueform* signal generation technology. Once the waveform data is sent to the 33522B from the GFSK IQ Baseband Builder, it generates the I/Q signals for the RF signal generator. The 33522B contains 16 M of memory and an I/Q baseband signal player (Option MEM and Option IQP).
- One Keysight N9310A RF signal generator
This is a general purpose RF signal generator with a 9 kHz to 3 GHz frequency range and analog modulation as a standard configuration. It contains a 20 MHz bandwidth I/Q modulator (Option 001), enabling it to generate digital modulation signals with external I/Q baseband signals.

Configuring a Digital Modulation Solution

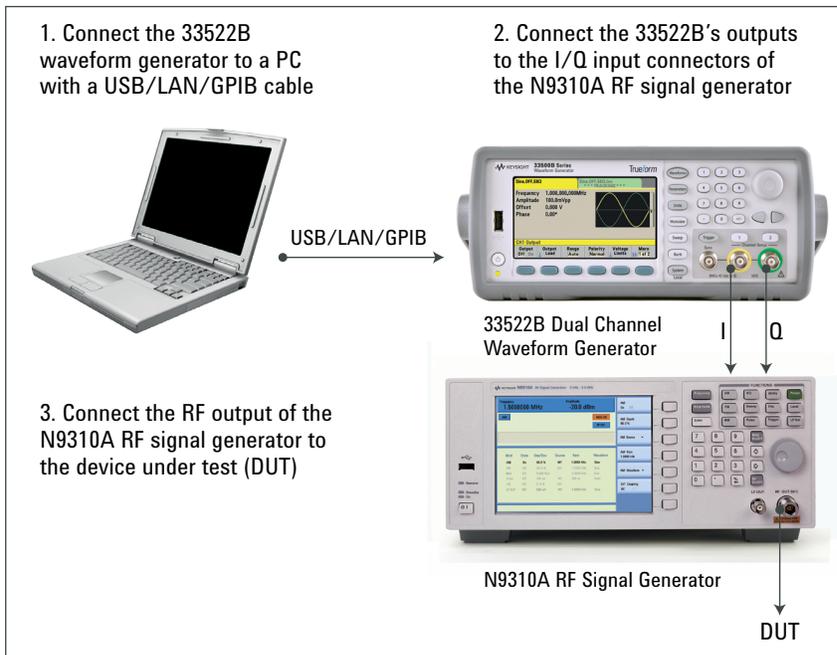


Figure 1. System setups for creating GFSK signals

Generating a GFSK signal

In the following demonstration, a 33522B waveform generator and N9310A RF signal generator will be used to generate a GFSK signal according to the parameters of TI's chipset CC1121, which is widely used in automatic meter reading (AMR), smart building, smart grid, and medical electronics.

- Frequency: 1 GHz
- Modulation format: GFSK
- Symbol rate: 50 kbps
- Deviation: 20 kHz
- BT: 0.5

Before you start, make sure your PC has the following software:

- Keysight IO Libraries Suite
www.keysight.com/find/iolib
- MATLAB software, with Instrument Control Toolbox and Signal Processing Toolbox
- GFSK IQ Baseband Builder

Note: In this section bold type refers to keys on the instrument. Text in [] refers to a softkeys found on the instrument's display. Information in an alternate typeface reflects information to be entered by the user.

Hints:

To define a specific baseband symbol, modify the 0/1 symbols in the data.m file.

When defining specific baseband symbols in MATLAB, using the data.m file:

- Remove the “%” symbols before the 0/1 and the expression “N=length (data)”
- Add “%” in front of the “N=1000” and “data=randi ([0,1], [N, 1])”

Getting Started

Step 1. Enter the GFSK IQ Baseband Builder and edit the GFSK baseband waveform using the GFSK_9310A_33522B_IQ.m

Note: The following three groups of parameters must be set before running it:

1. Baseband signal parameters:

- Symbol rate
- Peak deviation
- BT value of the gaussian filter

Example

```
%% GFSK Baseband Signal's parameters
symbolrate=50e3;      %GFSK's symbol rate
freq_dev=25e3;       %GFSK's frequency deviation
bt=0.5;              %3-dB bandwidth-symbol time
```

2. GFSK baseband symbol

- This demonstration leverages the 1,000 random GFSK symbols from the randi function of MATLAB.

Example

```
%% Transmitted data
% load data.m;          % import baseband symbol
% N=length(data);      % the number of GFSK symbol
N=1000;                % the number of GFSK symbol
data=randi([0,1],[N,1]); % Generate the random symbols
```

3. VISA address of the waveform generator

- Once the VISA address of the 33522B is correctly set up, the GFSK baseband waveform data will be sent to the memory of 33522 after running the GFSK_N9310A_33522B_IQ.m file. To determine the 33522B's VISA address in the system, refer to “Instrument I/O on this PC” in the Keysight Connect Export in the Keysight IO Libraries Suite.

Example

```
%% Send IQ data to arb
vAddress = ['USB0::0x0957::0x2C07::MY52800266::0::INSTR']; %build visa address
string to connect
```

Step 2. Run the GFSK_N9310A_33522B_IQ.m

Since the *GFSK_N9310A_33522B_IQ.m* previously set up the 33522B's output level, output On/Off, and other parameters, once the GFSK code in its memory is enabled it will generate the GFSK baseband signal.

Step 3. Set up the N9310A RF signal generator for the GFSK modulation

- Press Frequency > [1] > [GHz] to set up the carrier frequency at 1 GHz
- Press Amplitude > [-10] > [dBm] to set up the output level at -10 dBm
- Press I/Q > [I/Q On] to turn on the I/Q modulator
- Press RF On/Off to turn on the RF output

Once completed the GFSK signal can be verified with Keysight VSA software. Figure 2 shows that for this demonstration the FSK error is 2.7% and the deviation is 25.03 kHz.

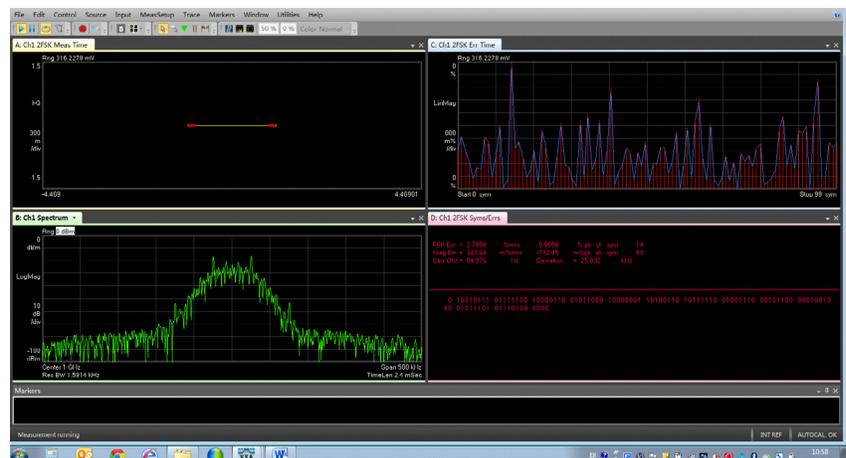


Figure 2. Verifying the GFSK signal with Keysight VSA software



Hint:

In the 33522B waveform generator, its sample rate = symbol rate × OF (over sampling factor). In this demonstration, the symbol rate is set as 50 kbps, and the OF is set as 64, therefore, the sample rate should be set as 3.2 Msa/s.

Reusing the GFSK Waveform Data

After running `GFSK_N9310A_33522B_IQ.m`, a .csv file for the GFSK waveform data will be created: `GFSK_SymbolRateXkbps_FreqDevYkHz.csv`, in which the X refers to symbol rate and Y refers to deviation value. This .csv file can be copied and reused with other 33522B waveform generators, making it easier to produce the desired GFSK baseband signals during manual operations.

To reuse the GFSK waveform on other 33522B waveform generators:

Step 1. Import the GFSK waveform data to the 33522B waveform generator

1. Copy the `GFSK_SymbolRate50kbps_FreqDev25kHz.csv` to a Flash memory device
2. Insert the Flash memory device into the USB port on the 33522B's front panel
3. Load the waveform data from the Flash memory device:
 - Press [Arb] > [Arbs ↓] > [Import Data ↓] > [Select Data File]
 - Rotate the knob to highlight External, and press the button to the right and under the knob
 - Rotate the knob to highlight the waveform data file `GFSK_SymbolRate50kbps_FreqDev25kHz.csv`, and press [Select] and [Single]
 - Press [IQ] > [Next →] > [Import Data]
 - When the 33522B displays “Importing data file...” and “Do you want to load the file?”, press [Yes] to load the waveform data file `GFSK_SymbolRate50kbps_FreqDev25kHz.csv`

Step 2. Manually set up the 33522B parameters

- Set up the sample rate
 - Press [Sample rate] > [3.2] > [Msa/s]
- Set up the amplitude
 - Press [Amplitude] > [1] > {Vpp}

Step 3. Enable the GFSK baseband signal output

- Press [1] of [Channel Setup] > [Output] > [On], to enable the GFSK baseband signal output from the 33522B waveform generator

Conclusion

The combination of the Keysight 33522B waveform generator and Keysight N9310A RF signal generator is a flexible, reliable, and low cost solution to address digital modulation needs. This solution leverages the *GFSK IQ Baseband Builder* mentioned in this application note and supports developing custom waveforms for other modulation formats.

Ordering Information

Model/Option	Description
Keysight 33522B	30 MHz, dual channel waveform generator
33522B-MEM	16 M memory
33522B-IQP	I/Q baseband signal player
Keysight N9310A	RF signal generator, 9 kHz to 3 GHz
N9310A-001	I/Q modulator, 20 MHz

References

- *Complex Modulation Generation with Low-Cost Arbitrary Waveform Generators*
 - *Keysight's Trueform Architecture for Wireless Applications*, white paper, literature number 5991-1100EN
- *Simply the Generation of High-Quality IQ signals*, application note, literature number 5991-1048EN



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