



RIGOL

Test Solution

For RIGOL Quantitative
Measurement of the Effect of
Inserting a Frequency Converter
on SNR and BER



Application Notes

ANW01100-1220-0010

1 Introduction

The frequency converter can convert the input frequency to a higher or lower frequency band, commonly called the up frequency or down frequency. The mixer can mix the input signal with the local signal to acquire the sum or difference of the two signals or multiple signals. Thus converters and mixers are indispensable in RF circuits, and play an important role in the communication system, RF circuit design, signal processing, etc.

RF tests usually take various measurements on mixers and inverters, such as gain, gain flatness, group delay, phase compression and signal noise ratio (SNR).

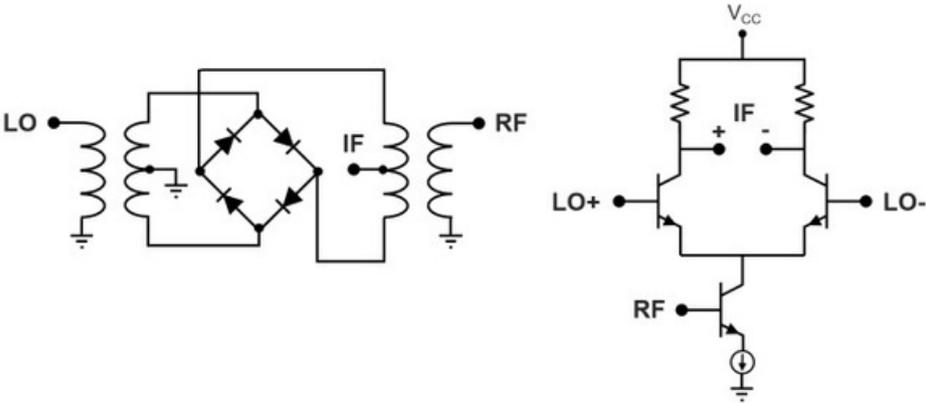


Figure 1.1 Passive Mixer and Active Mixer

2 Test Principle

When characterizing how a component or subsystem reduces the Signal-to-Noise Ratio (SNR) of the signal through the device, the Noise Factor (NF) measurement method in dB is usually used. The SNR degradation can be caused by the loss, extra noise from an active device, or a combination of the two. Noise Factor (or noise factor in linear) is defined as the ratio of the SNR at the input to the SNR at the output, which is also suitable for amplifiers and converters. For the ideal amplifier or converter, the output noise is equal to the input noise multiplied by the device gain, and the input terminal and output terminal will get the same SNR.

This test uses a converter from 0.95 GHz to 2.15 GHz, which requires a measurement chain with a stable SNR and BER. This stable connection scheme can be used to measure the effect on SNR and BER when inserting the device under test (converter and mixer). Therefore, the input SNR and the output SNR that through the converter should be determined. This test demonstrates how to measure the noise coefficient of a converter with RIGOL products.

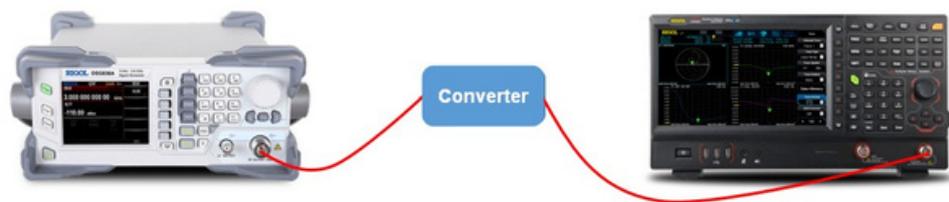


Figure 2.1 Connection Diagram of the Test on the Effect of Inserting a Converter on SNR and BER

The EVM is also measured to evaluate the error of the signal by calculating the vector difference between the actual transmitted signal and the ideal error-free reference signal, thus comprehensively measuring the amplitude error and phase error of the modulated signal. RIGOL's Vector Signal Analysis application software (VSA) can demodulate the output signals of the DUT in the time domain. The carrier of the test waveform is modulated with a certain number of symbols and a specific format. The software calculates the margin of error between the demodulated symbol and the ideal symbol. Then the error is normalized to the amplitude of the outermost symbol or the square root of the average symbol power. Then sum up the root mean square and combine all the symbol errors to get the overall EVM value.

The bite error rate test is carried out throughout the whole test, and the demodulated data is compared with the original data to get an accurate bit error rate value to evaluate the overall impact of the device on the bit error rate.

3 Test Challenges

1. Select the proper signal source for testing to ensure that the frequency range and power of the signal source meet the test requirements. The signal source needs to output a specific modulated signal and then carry out the noisy output.
2. The data processing is challenging. The output terminal processes and analyzes the data obtained from the test to compute the noise coefficient, and decodes the signal at the input terminal of the converter for the BER test and so on.
3. General measurement typically requires the error detector or signal analyzer, which is limited in application scenarios and relatively costly.

4 Solutions

RIGOL introduces solutions with DSG836A and RSA5065N to address the above difficulties. The DSG836A supports to modulate the signal on the transmitting terminal and add noise, while the RSA5065N on the receiving terminal can be used to measure other parameters such as EVM, SNR, bit error rate, and converter gain.

1. The input terminal generates the signal

The DSG836A has a 9 kHz to 3.6 GHz output frequency range, -110 dBm to +13 dBm output power range, which can generate various modulated signals for the converter.



Figure 4.1 DSG836A RF Signal Generator

The Ultra IQ Station software has multiple built-in digital modulations. Users can import the 0,1 meta data and then perform the IQ modulation. The signal is downloaded to the DSG IQ series signal source via the USB or LAN. The PC software also supports to import the .mat file, allowing to generate the IQ wavetable for complex signal by direct coding modulation by matlab. With the noise function of the PC software, users can accurately add noise to complete the SNR setting of the input signal.

Modulation Mode	Description
ASK	ASK (1 bit/symbol)
PSK	Include BPSK (1 bit/symbol), QPSK (2 bits/symbol), 8PSK (3 bits/symbol), 8PSK EDGE (3 bits/symbol), OQPSK (2 bits/symbol), Pi/4DQPSK (2 bits/symbol) and Pi/8DBPSK (3 bits/symbol).
QAM	Include 16QAM (4 bits/symbol), 32QAM (5 bits/symbol), 64QAM (6 bits/symbol), 128QAM (7 bits/symbol) and 256QAM (8 bits/symbol).
FSK	Include 2FSK (1 bit/symbol), 4FSK (2 bits/symbol), 8FSK (3 bits/symbol), 16FSK (4 bits/symbol) and MSK (1 bit/symbol). The FSK Deviation box is displayed only when a FSK modulation mode is selected; at this point, you can click the box to input the FSK peak deviation.
User	Select the user-defined modulation mapping file (*.map file) as the modulation mapping source. When User is selected, the "Select map file" dialog box is displayed and you can select the user-defined *.map file in the corresponding directory. Then, click "OK" to load the file. At this point, the storage directory of the file loaded is displayed in the software user interface. In addition, you can also click Choose Map File to switch among the user-defined *.map files in different directories. Note: The number of rows in the data list of the *.map file loaded is 2^n ($n=0,1,2,\dots$) and the number of columns is 3 (wherein, the first column shows the row numbers, the second column shows the I data and the third column shows the Q data; the I data and Q data should be within -1 and 1). The format of the map file ($n=2$) is: 0,-0.2,-0.8 1,-0.4,-0.75 2,-0.2,0.5 3,-0.4,0.8 The values should be separated by commas.

Figure 4.2 DSG Modulation Mode

2.The signal test of the output terminal

RIGOL's RSA5065N is used to test the signal processed by the converter.

The RSA5065N real-time spectrum analyzer has a frequency range of 9 kHz to 6.5 GHz with noise floor as low as -165 dBm/Hz, available for measuring the small noise. It can be equipped with the optional VSA demodulation, accurately measuring the IQ modulation signal output by the converter to obtain the measurement parameters such as error rate, EVM, etc.

First configure the signal modulation parameters such as the modulation mode, code element, code rate, etc. and obtain the constellation diagram, demodulation results, spectral traces, etc. The measurement results include parameters such as EVM, SNR, etc.



Figure 4.3 QAM Signal Demodulation

Users can also obtain the error rate by importing the encoded data of the transmitting terminal to compare the decoded data with the imported data, as shown in the figure 4.4.



Figure 4.4 Signal Error Rate Test

Then modify the quality of the signal at the output terminal of the signal source by adding noise on the DSG PC software. Insert the frequency converter into the circuit and compare the signal quality before and after the insertion for testing.



Figure 4.5 16-QAM Signal After Adding Noise

The SNR becomes larger after modifying the quality of the input signal by adding the noise. Thus, it is easy to accurately quantify the impact of the device on the output signal under different SNR conditions.

3. Other parameter test of the frequency converter

The built-in vector network functionality of the RSA5065N also supports to test the converter gain, gain flatness, group delay, and gain and phase compression parameters.

5 Summary

The RIGOL DSG836A and RSA5065N ensure a stable measurement scheme with a stable SNR and BER, facilitating quantitative measurements of the effect of inserting the DUT (converter and mixer) on SNR and BER.

Boost Smart World and Technology Innovation

**Industrial Intelligent
Manufacturing**



Semiconductors



**Education &
Research**



Communication

System Integration



New Energy



- Cellular-5G/WIFI
- UWB/RFID/ ZIGBEE
- Digital Bus/Ethernet
- Optical Communication

- Digital/Analog/RF Chip
- Memory and MCU Chip
- Third-Generation Semiconductor
- Solar Photovoltaic Cells

- New Energy Automobile
- PV/Inverter
- Power Test
- Automotive Electronics

*Provide Testing and Measuring Products
and Solutions for Industry Customers*

HEADQUARTER

RIGOL TECHNOLOGIES CO., LTD.
No.8 Keling Road, New District,
Suzhou, Jiangsu, P.R.China
Tel: +86-400620002
Email: info@rigol.com

JAPAN

RIGOL JAPAN CO., LTD.
5F, 3-45-6, Minamitsuka, Toshima-Ku,
Tokyo, 170-0005, Japan
Tel: +81-3-6262-8932
Fax: +81-3-6262-8933
Email: info.jp@rigol.com

EUROPE

RIGOL TECHNOLOGIES EU GmbH
Carl-Benz-Str.11
82205 Gilching
Germany
Tel: +49(0)8105-27292-0
Email: info-europe@rigol.com

KOREA

RIGOL KOREA CO., LTD.
5F, 222, Gonghang-daero,
Gangseo-gu, Seoul, Republic of Korea
Tel: +82-2-6953-4466
Fax: +82-2-6953-4422
Email: info.kr@rigol.com

NORTH AMERICA

RIGOL TECHNOLOGIES, USA INC.
10220 SW Nimbus Ave.
Suite K-7
Portland, OR 97223
Tel: +1-877-4-RIGOL-1
Fax: +1-877-4-RIGOL-1
Email: info@rigol.com

**Gabriel Mancera Num.1537 Int. 102 Col.
Del Valle Delegación Benito Juárez C.P.
03100 Ciudad De México Teléfonos: (55)
5604-2654 ó (55) 7095-7546**

**WhatsApp: 222-790 1678 Correo:
ventas@kmoX.com.mx**

www.kmoX.com.mx

