

Virtual Instrument Aiming To Extend The Capabilities Of The Spectrum Analyzers

E. Lunca, A. Salceanu, S. Hanganu, C. Donciu

Faculty of Electrical Engineering, Bd. Dimitrie Mangeron 53,700050, Iasi, Romania,
+4032278683, +4032130054, {elunca, asalcean, hanganu, donciu}@ee.tuiasi.ro

Abstract-The paper presents a virtual instrument for measuring the insertion loss, signal-to-noise ratio, carrier-to-noise ratio and frequency response. Since most of the spectrum analyzers are equipped with a GPIB or RS-232 interface, here demonstrate that LabVIEW graphical environment represents the proper tool to develop such applications. Sometimes, instrument producers provide specific software, but using LabVIEW some additional costs can be eliminated by user developed software.

I. Test Setup and VI Description

A. Measuring the insertion loss

The most significant characteristic of a filter is the insertion loss, varying with frequency. It is defined as $20\log_{10}(E_1 / E_2)$, where E_1 is the output voltage of the signal source without the use of the filter, and E_2 is the corresponding output voltage with the filter in circuit [1].

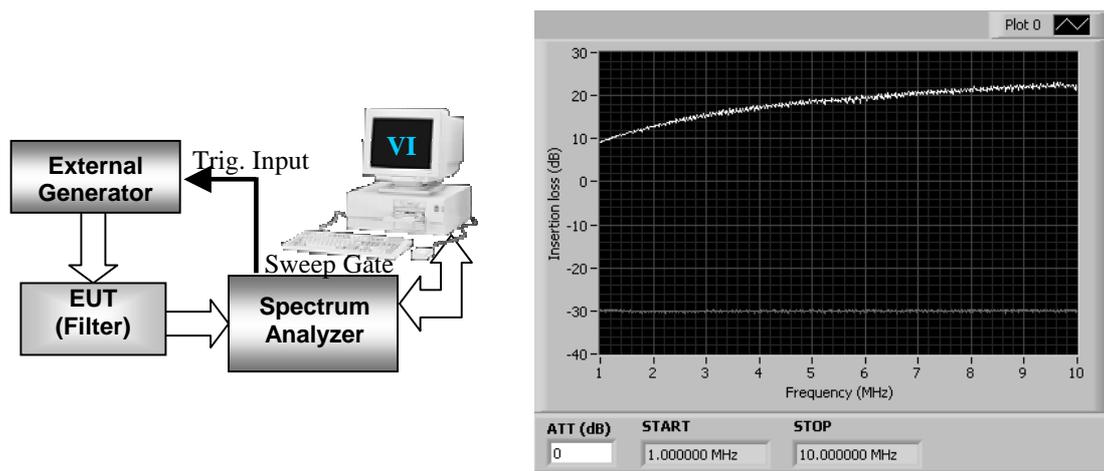


Figure 1. Measuring the insertion loss. Test setup and VI Graph

The virtual instrument communicates remotely with IFR 2398 spectrum analyzer through GPIB connection. To ensure a correct synchronization between spectrum analyzer and external programmable generator, the spectrum analyzer sweep gate signal will be applied to generator trigger input. The signal generator has to be put into linear sweep mode and the spectrum analyzer has to be put in a fast sweep mode (50 ms).

For insertion loss measurement, generator sweep parameters have to be compatible with the filter bandwidth and the spectrum analyzer characteristics [2]. The spectrum analyzer display must be put in MAX HOLD mode to obtain the result of all the sweeps corresponding to one single generator sweep. The VI calculates the insertion loss by using the following formula:

$$IL = P_1 (dBm) - P_2 (dBm) = 20\log_{10} \frac{E_1}{E_2} (dB), \quad (1)$$

where P_1 is the power in units of dBm displayed by spectrum analyzer without the use of the filter, and P_2 is the power in units of dBm displayed by spectrum analyzer, the filter being connected.

For this measurement the output level of signal generator has been settled at -30 dBm. The bottom plot in Figure 1 represents the power corresponding to direct connection between signal generator and spectrum analyzer. If desired, this plot may not be displayed. The top trace represents the insertion loss in units of dB as a difference between the power corresponding to direct connection and the power corresponding when the filter is inserted.

B. Measuring signal-to-noise ratio

Figure 2 shows a signal-to-noise ratio measurement for an amplifying circuit. The bottom plot represents the reference noise floor when a 50 Ohm resistor is connected to the circuit input. If desired, this plot may not be displayed. The top plot represents the instantaneous power when a generator signal is applied to the circuit input. SNR, expressed in units of dB, will be calculated as 20 times the logarithm of the amplitudes ratio. For this measurement, the test frequency was fixed at 50.4 kHz.

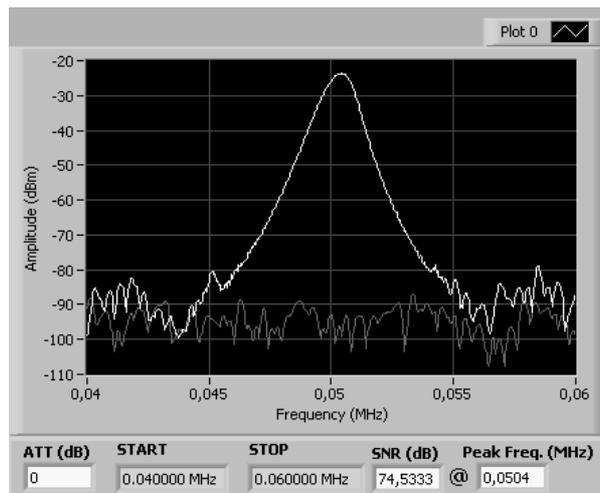


Figure 2. Measuring signal to noise ratio for an amplifying circuit

C. Measuring carrier to noise ratio

To measure the carrier to noise ratio, the spectrum analyzer is settled for desired carrier frequency and the virtual instrument displays the noise floor trace. Since the carrier input will be applied to the spectrum analyzer, CNR, expressed in units of dB, will be calculated as the ratio of the amplitude of the carrier to the amplitude of the noise.

D. Getting the frequency response

The frequency response refers to the gain and phase response of a circuit or other unit under test at all frequencies of interest [3]. The frequency response of a unit under test is measured by applying a stimulus to the unit, as shown in Figure 3, and computing the transfer function from the stimulus and response signals.

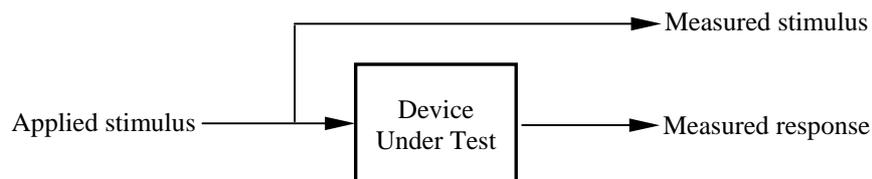


Figure 3. Configuration for frequency response measurement

Although the formal definition of frequency response includes both the gain and phase, in common usage, the frequency response often implies the magnitude (gain).

To achieve a good frequency response measurement, significant stimulus energy must be present in the frequency range of interest. Two common signals used are the chirp signal and a broadband noise signal. The chirp signal is a sinusoid swept from a start frequency to a stop frequency, thus generating energy across a given frequency range. Two noise signals having flat broadband frequency spectra are the white and pseudorandom noise [4].

However, the measurements are sensitive to impedance mismatches. The device under test is assumed to have $50\ \Omega$ input and output impedances. If this condition is not satisfied, there will be measurement errors due to unequal output from signal generator.

The effect of input impedance mismatch can be minimized by inserting an attenuator between the signal generator and the DUT, physically located close to the device under test. It is recommended a value of 6 dB or greater. For relatively high input impedance of the DUT, it is acceptable to replace the attenuator with a $50\ \Omega$ termination at the DUT input. If the DUT cannot drive the spectrum analyzer $50\ \Omega$ input, it is necessary to use an active probe [5]. By using an active probe, it will be possible to check the frequency response of the devices requiring a high impedance load, for example, crystal filters.

To get the frequency response, the measurement setup is similar with insertion loss test setup. The configuration parameters of spectrum analyzer and signal generator have to be also compatible with the bandwidth of the device under test. The spectrum analyzer must be put in MAX HOLD mode to obtain the result of all the sweeps corresponding to one single generator sweep.

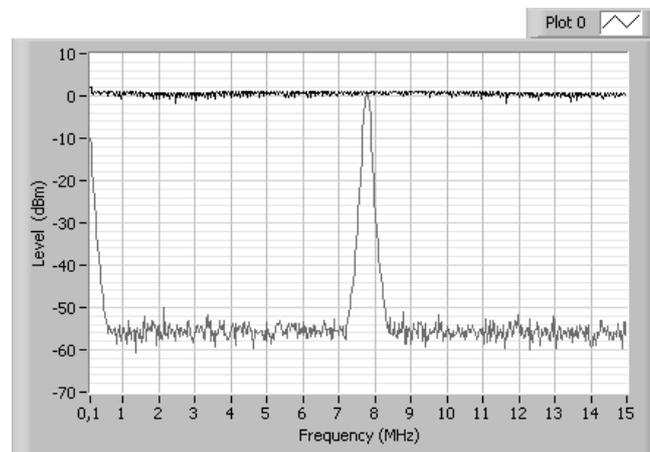


Figure 4. An instantaneous power spectrum of the chirp signal and max hold values for a complete generator sweep

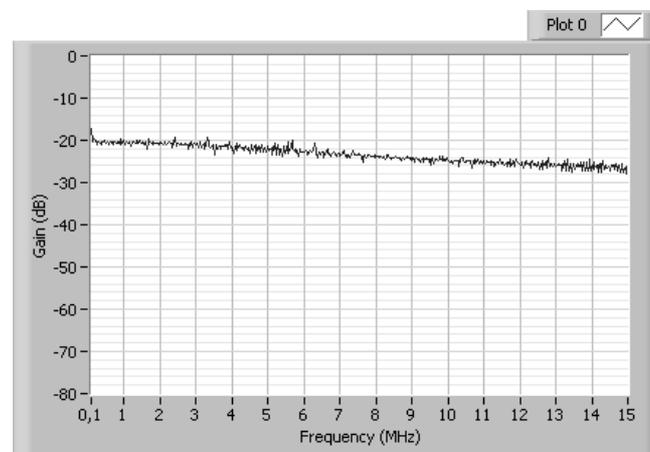


Figure 5. Measuring the gain for an amplifier in frequency bandwidth from 100 kHz to 15 MHz

For measurements, we used the amplifier included in a millivoltmeter, excited by a sinusoid swept from 100 kHz to 15 MHz. The chirp signal level has been settled at 0.8 dBm. The bottom plot in Figure 4 represents an instantaneous power spectrum when the chirp signal from generator is directly applied to the spectrum analyzer input. The top plot represents the max hold values for a complete generator sweep.

Figure 5 represents the gain response, expressed in units of dB, with the amplifier connected between programmable generator and spectrum analyzer.

II. Conclusions

The here presented paper describes a LabVIEW instrument based on IFR 2398 spectrum analyzers characteristics, allowing a considerable extension of its capabilities. Measurements on amplifiers, converters, filters can be performed in a simple way, covering a large frequency range.

Acknowledgements

This work was financed and developed in the framework of Romanian CNCSIS TD program, code 193, and Romanian CNCSIS Bd program, code 7.

References

- [1] Alexandru Salceanu, Mihai Cretu, Constantin Sarmasanu, *Noises and Interferences in Measuring Circuitry*, CERMI, Iasi, 1999.
- [2] Jean Noel Payen, Marc Schweizer, "External tracking generator for 239X", *Application Note*, Aeroflex Inc., Issue 1, 09/03.
- [3] National Instruments, "Measurement Encyclopedia – Frequency response".
- [4] Michael Cerna, Audrey F. Harvey, "The fundamentals of FFT-Based Signal Analysis and Measurement", *Application Note 041*, National Instruments, July 2000.
- [5] Jeffrey Austen, "Network Measurements using the HP 4195A Network Analyzer", 2000.
- [6] IFR Americas, Inc., "Spectrum Analyzer 2398 – Operation Manual".
- [7] IFR Americas, Inc., "Spectrum Analyzer 2398 – Programming Manual".