



Product Manual

Model 8060C Impedance Generators
Cold Noise-Parameter Measurements at Cryogenic Temperatures
Rev. 1 – June 15, 2019



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2. Introduction

Berkeley Nucleonics offers a cryogenic impedance generator (C-IGs) for “cold” noise-parameter measurements. Together with a proprietary impedance generation technique and a data processing algorithm, these compact impedance generators allow for fast and accurate measurement of noise parameters for a large number of frequencies.

The small size and fully electronic design permit noise-parameter measurements of packaged and on-wafer devices extending to low frequencies. On-board memory stores calibration data.

The C-IG consists of two parts: a room-temperature controller and a cryogenic temperature RF part. The two parts are connected with three low-frequency control lines.

This document describes the procedure for using impedance generators developed for the “cold” noise parameter extraction method.

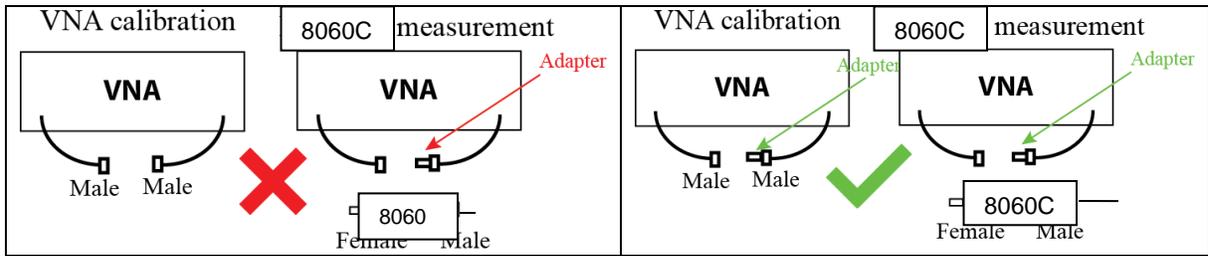
3. Dos and Don'ts

3.1 Use of adapters

When measuring S-parameters, calibration and measurement planes of the vector network analyzer (VNA) should be the same, i.e. if you need to use an adapter then for accurate measurements the network analyzer should be recalibrated to the adapter output plane.

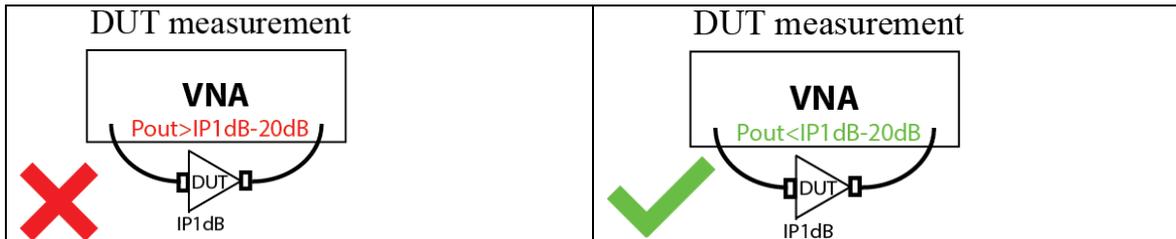


Fig. 1: Photograph of an 8060C Impedance Generator.



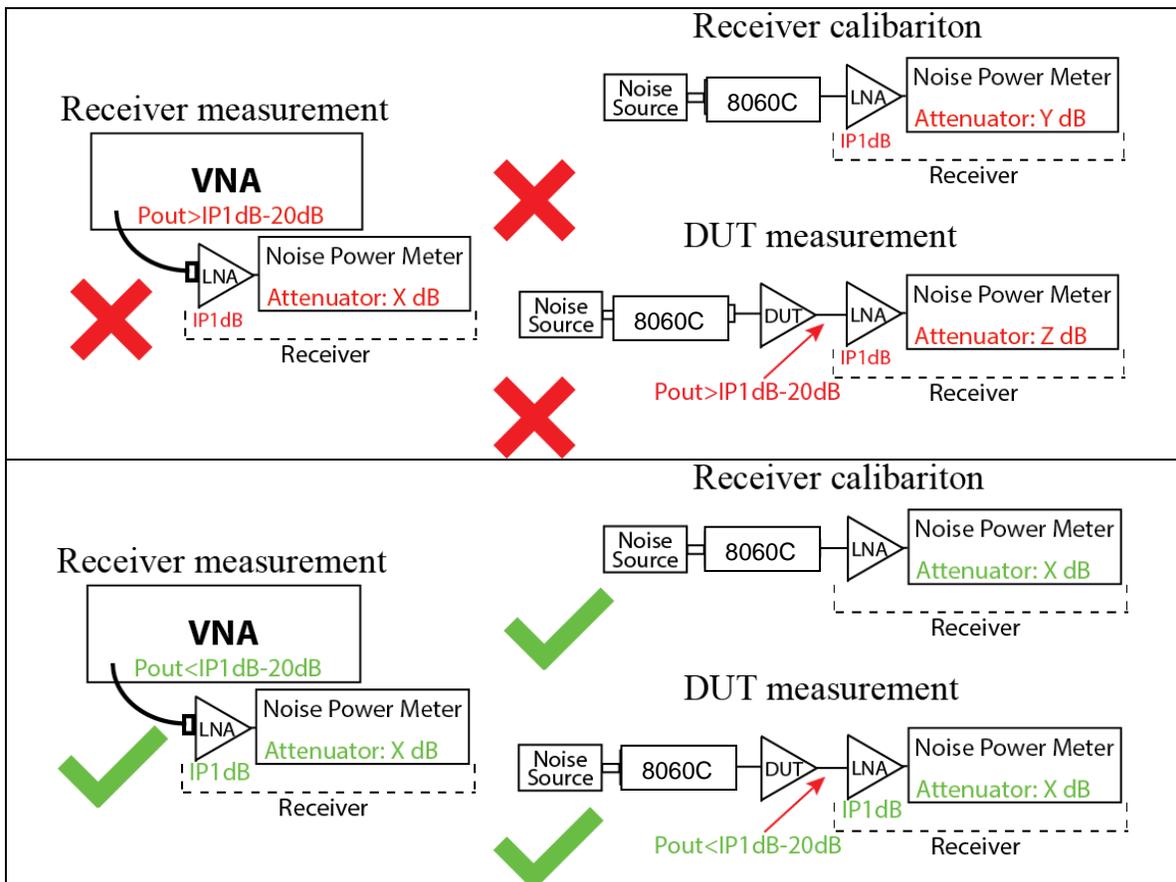
3.2 Gain saturation

Avoid saturating the DUT during its S-parameter measurements as that will result in measurement errors. At least 20dB back-off is recommended.



3.3 Receiver saturation and automatic attenuator control

Similar to the DUT measurements, avoid saturating receiver during calibration and the DUT measurements. Some receivers have automatic attenuation control. Care must be taken to have the same attenuator setting during the receiver calibration and the DUT measurement.



4. Impedance generator installation, functionality, and control

4.1 Installation

When first connected to a host computer via a USB 2.0, the Model 8060C is a composite device and appears as a mass storage device and as a COM device. For the COM device to work properly, appropriate drivers must be installed. Windows 10 is capable of installing these drivers automatically. For Windows 8 and Windows 7 computers, driver installation is performed with the following steps:

- Navigate to: Control Panel -> Device Manager
- Locate “Berkeley Nucleonics” device under “Other devices” and right click on it to select “Update Driver Software”
- Select “Browse my computer for driver software”
- Browse to as USB device labelled “8060C” and select an appropriate subdirector in directory “COM Drivers” and click “Next”
- A “Windows Security” window might pop-up, click on “Install this driver software anyway”
- The following window should inform of successful driver installation. Close this window.
- Berkeley Nucleonics’ Model 8060C should now appear as one of COM devices under “Ports (COM & LPT)” in the “Device Manager”. Record the COM port number for future use.
- Close “Device Manager” and “Control Panel”.
- Installation is complete.

4.2 Functionality

The impedance generator is powered and controlled via a USB connection to a host computer. When connected to the computer and the drivers are installed, the Model 8060C appears as a COM port in the windows Device Manager. SCPI commands can be sent to control and configure the device. The following is a list of commands, which control the device:

setStateA: sets the C-IG into the thru state “A”

setStateB: set C-IG to impedance state “B”.

setStateC: set C-IG to impedance state “C”.

setStateD: set C-IG to impedance state “D”.

getIGtemperature: read C-IG temperature and output result in degrees Centigrade and a hexadecimal ADC code for troubleshooting. **(Only accurate at room temperatures.)**

getNStemperature: read noise source temperature and output result in degrees Centigrade and a hexadecimal ADC code for troubleshooting. If a noise source is not connected, the resultant temperature will be a large negative value, typically -61.45°C.

noiseSourceOn: Enables USB noise source (NoiseTech Microwave Devices only)

noiseSourceOff: Disabled USB noise source (NoiseTech Microwave Devices only)

setUpdateMode: Sets device in update mode. Requires hard reset by power cycling unit.

4.3 Control

This section shows examples of using Model 8060C device.

4.3.1 Putty

The quickest way to communicate with the device is by using Putty, which can be downloaded from <http://www.chiark.greenend.org.uk/~sgtatham/putty/latest.html>.

After Putty is downloaded and installed, it should be configured as follows:

- Click on “Serial” for Connection type
- Set “Serial line” to the COM port number (e.g., COM16) associated with Model 8060C in “Device Manager”
- Baud rate: 115200
- An example of the Putty configuration is shown in Fig. 2.

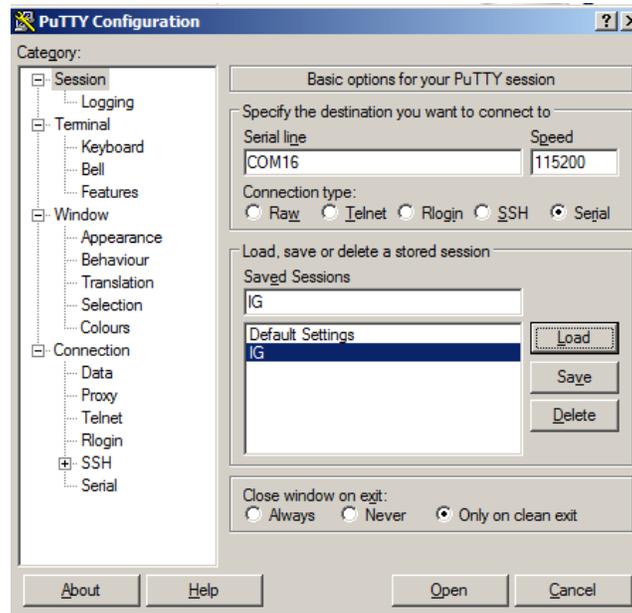


Fig. 2. Putty serial connection configuration.

- Navigate to “Terminal” category.
- Select: “auto wrap mode initially on”, “implicit CR in every LF”, “implicit LF in every CR”, and “Local echo: Force On”. See Fig. 3 for example.

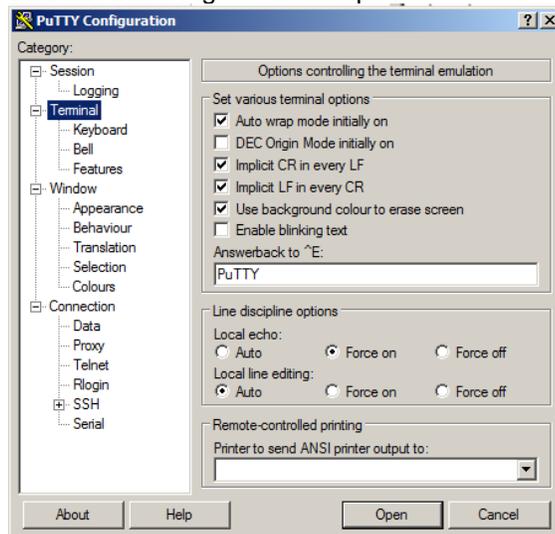


Fig. 3. Putty "Terminal" category configuration.

- Click “Open” to open the Model 8060C port in Putty.
- This opens a terminal window.
- Typing 8060C commands in the terminal window controls the device.
-

4.3.2 Matlab

Matlab can be used for communicating with the Model 8060C. Since other instruments can be also controlled through Matlab, an automated measurement system can be developed to perform noise parameter measurements. Contact Berkeley Nucleonics for advice and assistance with developing such a system.

The following shows an example code for controlling the Model 8060.

```

% Replace this COM port number in windows "Device Manager"
COM_port = 'COM16';

% Set Impedance Generator to State A (THRU)
s1 = serial(COM_port,'BaudRate',115200);
fopen(s1);
fprintf(s1,'setStateA');
fgets(s1) % Optional command to check on 8060C status.
fclose(s1);

% Set Impedance Generator to State B (THRU)
s1 = serial(COM_port,'BaudRate',115200);
fopen(s1);
fprintf(s1,'setStateB');
fgets(s1) % Optional command to check on 8060C status.
fclose(s1);

% Set Impedance Generator to State C (THRU)
s1 = serial(COM_port,'BaudRate',115200);
fopen(s1);
fprintf(s1,'setStateC');
fgets(s1) % Optional command to check on 8060C status.
fclose(s1);

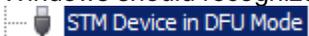
% Set Impedance Generator to State D (THRU)
s1 = serial(COM_port,'BaudRate',115200);
fopen(s1);
fprintf(s1,'setStateD');
fgets(s1) % Optional command to check on 8060C status.
fclose(s1);

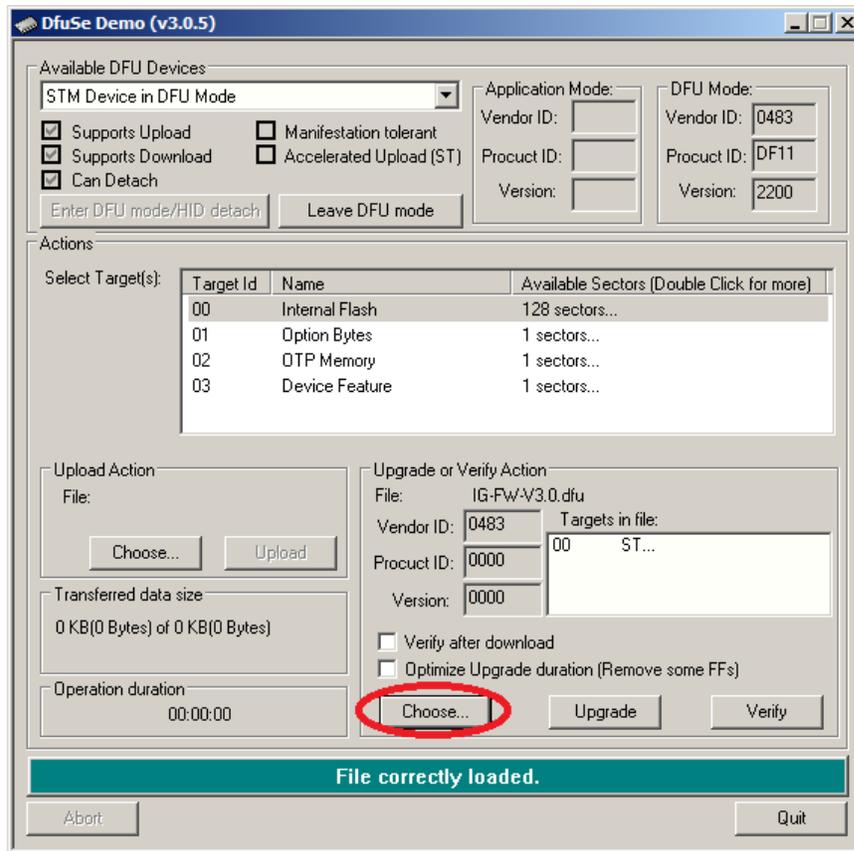
% Get Impedance generator Temperature (Celsius)
s1 = serial(COM_port,'BaudRate',115200);
fopen(s1);
fprintf(s1,'getIGtemperature');
IGtemperatureString = fgets(s1);
IGtemperatureString_value = strsplit(IGtemperatureString,',');
IGtemperature = str2num(IGtemperatureString_value{2});
fclose(s1);
disp(['8060C temperature is: ',num2str(IGtemperature),'C'])

% Get Noise Source generator Temperature (Celsius)(if attached)
s1 = serial(COM_port,'BaudRate',115200);
fopen(s1);
fprintf(s1,'getNSTemperature');
NSTemperatureString = fgets(s1);
NSTemperatureString_value = strsplit(NSTemperatureString,',');
NSTemperature = str2num(NSTemperatureString_value{2});
fclose(s1);
disp(['Noise source temperature is: ',num2str(NSTemperature),'C'])

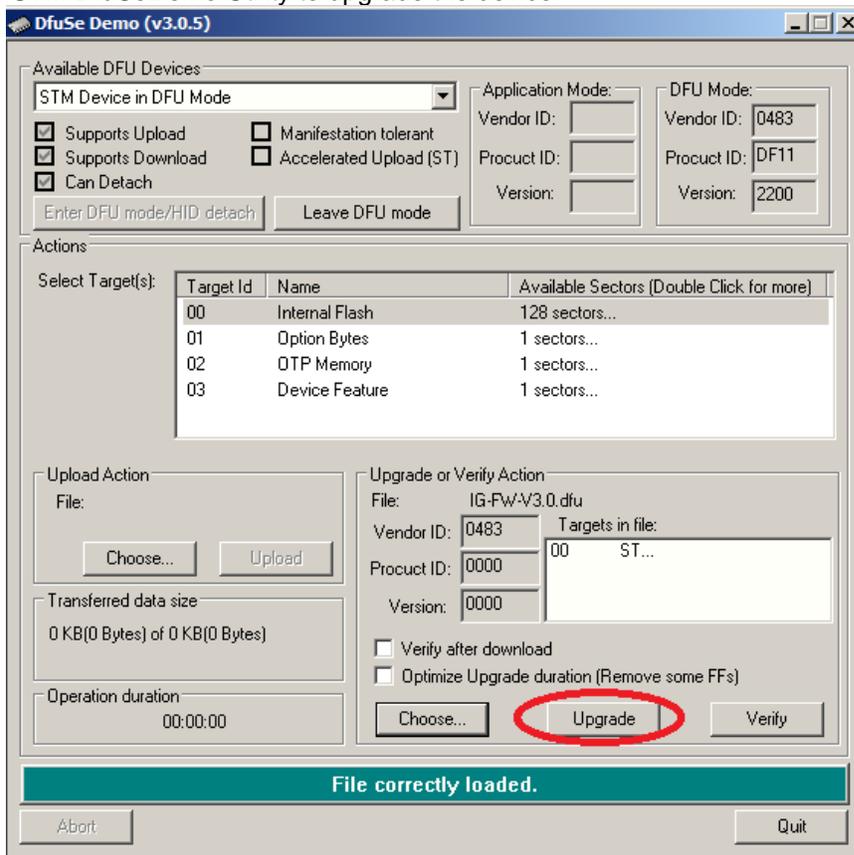
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4.4 Firmware Update

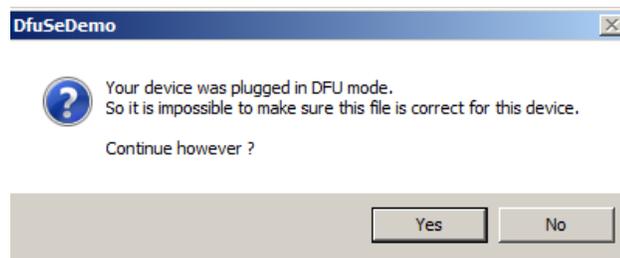
1. Connect to receiver through Putty (4.3.1).
2. Issue command “setUpdateMode”.
3. Power cycle the unit (disconnect power and reconnect)
4. Windows should recognize the USB device as an STM device in bootloader mode

5. Use the STM DfuSeDemo Utility to upload the desired firmware (only .dfu files supported):



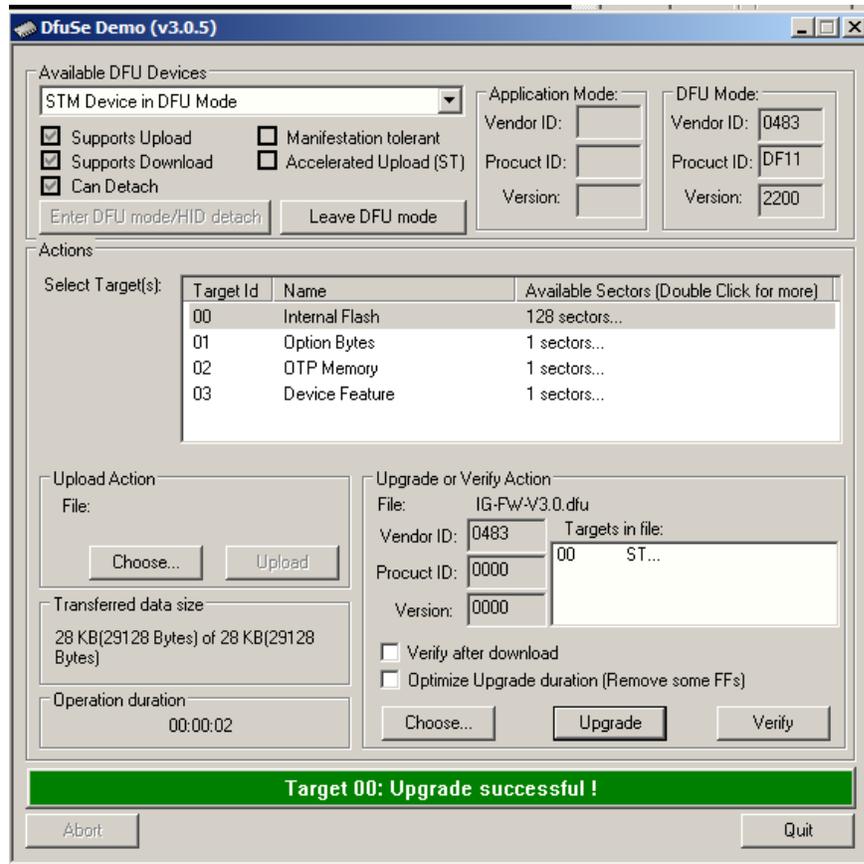
6. Use the STM DfuSeDemo Utility to upgrade the device:



7. Select Yes in the pop-up window:



8. If successful you should see the follow screen:



5. Noise parameter measurement procedure

The following procedure talks most about a calibration method. It should be understood that a device-under-test (DUT) measurement follows exactly the same procedure during which the DUT is placed at the calibration plane and the DUT noise parameters are corrected using the calibration data.

5.1 Required equipment

Noise parameters fully describe noise performance of a linear two-port device. To conduct noise parameter measurements the following equipment is required:

- Berkeley Nucleonics Model 8060C impedance generator (C-IG)
- Vector network analyzer (VNA) with an appropriate calibration kit
- Noise power meter (aka “receiver”). This can include a Noise Figure Analyzer (NFA) or a spectrum analyzer (SA) or a VNA, which is able to measure noise power, such as

Keysight’s PNA-X or Rohde and Schwarz ZVA, both with the noise figure measurement option. *Note: ZVA does not need a noise source and therefore the procedure described below is slightly different. Contact NoiseTech for a ZVA-specific measurement procedure.*

- Noise source (NS). An NS is used to measure the gain of the receiver. In case of a ZVA, NS is not required but an external power meter is used instead to calibrate the ZVA gain.
- Low noise amplifier (LNA) may be used at the input to the receiver to reduce receiver noise and improve measurement uncertainty.
- Appropriate RF cables
- A computer connected to the C-IG via a USB port and running software that controls the C-IG.

5.2 Measurement process

A block diagram of the measurement setup is shown in Fig. 4.

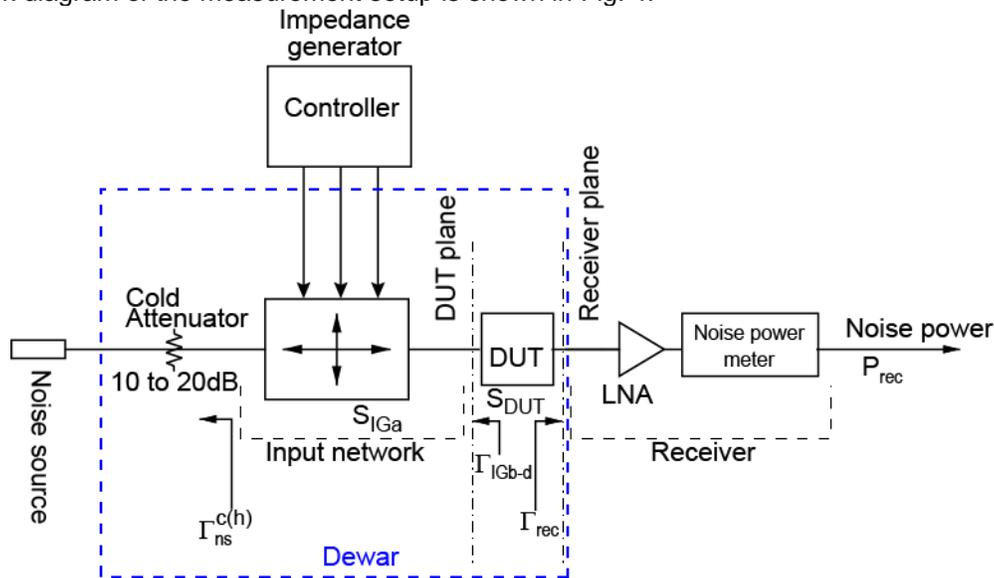


Fig. 4. Block diagram of the noise-parameter measurement system.

The following is a general procedure for calibrating the receiver by measuring its noise parameter. All steps are performed over the required frequency range. It is suggested to perform of large number measurements for adequate averaging, especially for noise-power measurements. (*If a VNA is used as a receiver, please contact Berkeley Nucleonics for an updated procedure.*)

Berkeley Nucleonics offers a Dual SPDT switch matrix can reduce the number of calibration steps. For more information and for a different measurement procedure please contact Berkeley Nucleonics.

“Cold-attenuator” measurement setup is shown in Fig. 4. Other measurement options are available. Some measurements can be performed at room temperature. Please contact Berkeley Nucleonics for more information.

- Step 1 Calibrate VNA for S-parameter measurement.
- Step 2 Measure the DUT S-parameters (S_{DUT}) and save in a touchstone-format file.
- Step 3 Measure the reflection coefficient of the receiver (Γ_{rec}) and save in a touchstone-format file.
- Step 4 **(Optional step)** Measure¹ reflection coefficients (Γ_{ns}^c and Γ_{ns}^h) of the NS in its ON state (a.k.a. Hot state) and OFF state (a.k.a. Cold state) and save in touchstone-format files.

- Step 5 Measure² two port S-parameters (S_{IGa}) of the C-IG in state “A”, and the output reflection coefficients (Γ_{IGb} , Γ_{IGc} , and Γ_{IGd}) of the C-IG in its states “B”, “C”, and “D”. Save S-parameters in touchstone-format files.
- Step 6 Connect the output of C-IG to the input of the receiver (i.e. as in Fig. 4 but with the DUT replaced by a thru). Set the C-IG to its state “A”. For both the ON state and the OFF state of the NS, measure noise powers with the receiver ($P_{rec,cal}$) and the NS temperature³ (T_{NS}). Save measurements in appropriate files.
- Step 7 Repeat Step 6 for states “B”, “C”, and “D”, while keeping the NS OFF. Save measurements in appropriate files.
- Step 8 Insert the DUT between the output of C-IG and the receiver.
- Step 9 With NS set to OFF, set C-IG to its four states and measure noise power ($P_{rec,meas}$) with the receiver. Save results in appropriate files.
- Step 10 Extract noise parameters using measured data. An example Matlab code for performing such extraction is included on 8060C for user reference.

¹ Because the attenuator is large and the noise source reflection coefficient is typically very low, Γ_{ns}^c and Γ_{ns}^h are expected to be very similar and very small. In this case Step 4 can be omitted by assigning $\Gamma_{ns}^c=0$ and $\Gamma_{ns}^h=0$.

² The attenuator could be considered to be a part of the C-IG. In this case the Excess Noise Ratio (ENR) of the noise source is used as is. Otherwise, the ENR needs to be corrected by the attenuator value.

³ Different noise-source manufacturers have different definitions for ENR [3]. Since often ENR is a function of the ambient temperature, the ambient temperature should be taken into account when extracting noise parameters.

6. References

- [1] “System and method for measuring wideband noise parameters using an impedance generator,” U.S. Patent Application No. 62/364,458
- [2] M. Himmelfarb and L. Belostotski, "On Impedance-Pattern Selection for Noise Parameter Measurement," *IEEE Transactions on Microwave Theory and Techniques*, vol. 64, no. 1, pp. 258-270, January, 2016.
- [3] L. Belostotski and J. W. Haslett, "Evaluation of Tuner-Based Noise-Parameter Extraction Methods for Very Low Noise Amplifiers," *IEEE Transactions on Microwave Theory and Techniques*, vol. 58, no. 1, pp. 236-250, Jan. 2010.

7. Revision notes