Product Manual for Dual SPDT Switch Matrix
Rev. 2 – November 24, 2020

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2. Introduction

NoiseTech Microwave ltd. (NoiseTech) has developed a switch matrix to reduce uncertainty in noise-parameter measurements and provide the ability to perform many repeated measurements. Once calibrated, many LNAs can be measured without the need for recalibration. The switch (SW) matrix consists of two independent USB-driven SPDT switches.
On-board memory stores the manual, technical specifications and can be used to store other information. The switch also comes with an optional cryogenic temperature sensor.
The switch can be used for other applications where wideband USB-controlled switches are needed.
The SW00160 frequency range is optimized for most commercial applications, such as WiFi, WiMax, LTE, 3G, 4G, 5G, Bluetooth wireless standards.

Fig. 1: Photograph of a C-SW00160 Switch Matrix.

This document describes the procedure for using the switch in a noise-parameter measurement system.

3. Switch installation, functionality, and control

3.1 Installation

When first connected to a host computer via a USB 2.0, SW00160 (or its cryogenic version C-SW00160) 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 “NoiseTech Microwaves Ltd” 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 “SW00160” 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.
- NoiseTech Microwave’s IG0160C 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.

3.2 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, IG0160C 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:

setStateV1C1: connect port V1 to C1

setStateN1C1: connect port N1 to C1.

setStateV2C2: connect port V2 to C2.

setStateN2C2: connect port N2 to C2.

getIGtemperature: read switch temperature and output result in Kelvin and a hexadecimal ADC code for troubleshooting.

getNStemperature: read noise source temperature and output result in degrees Centigrade and a hexadecimal ADC code for troubleshooting (only available for NoiseTech Microwave Devices only). 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.

3.3 Control

This section shows examples of using SW00160 device.

3.3.1 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 IG0160C in “Device Manager”
- Baud rate: 115200
- An example of the Putty configuration is shown in Fig. 2.

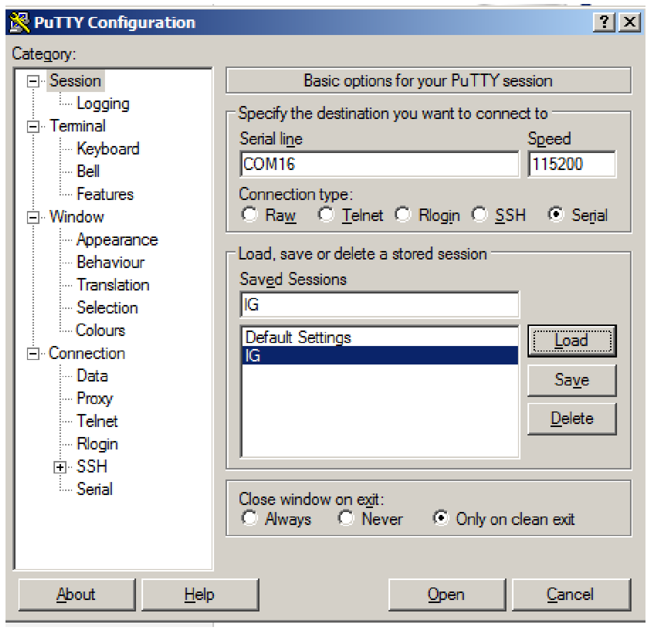


Fig. 2. Putty serial connection configuration.

- 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.

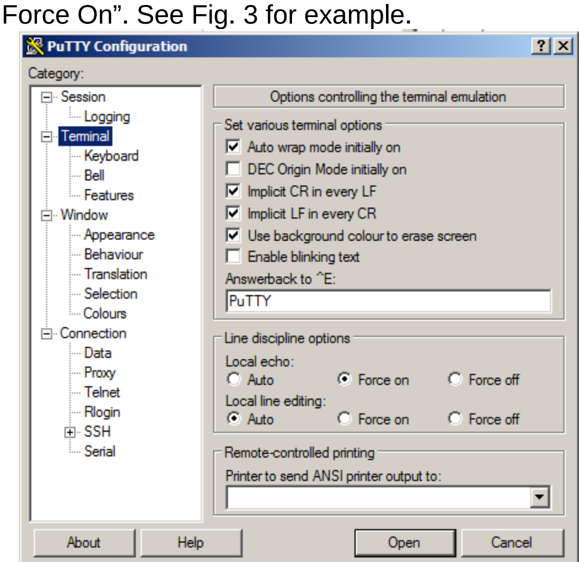


Fig. 3. Putty "Terminal" category configuration.

- Click “Open” to open the SW00160 port in Putty.
- This opens a terminal window.
- Typing SW00160 commands in the terminal window controls the device.

3.3.2 Matlab

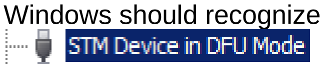
Matlab can be used for communicating with SW00160. Since other instruments can be also controlled through Matlab, an automated measurement system can be developed to perform noise parameter measurements. Contact NoiseTech Microwave for advice and assistance with developing such a system.

The following shows an example code for controlling SW00160.

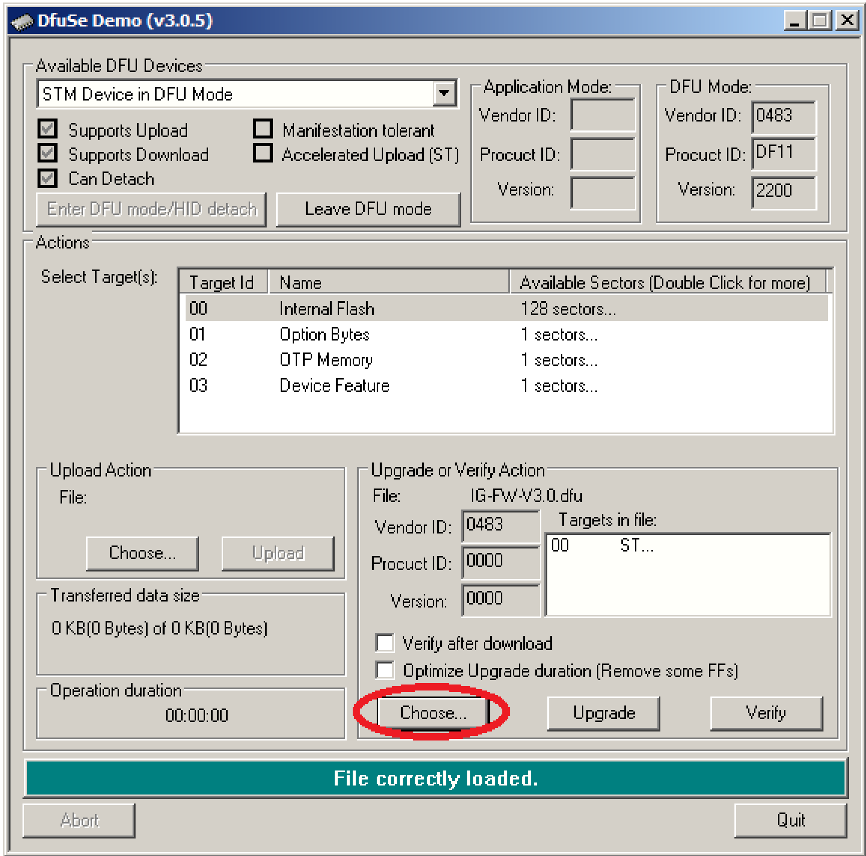
```
% Replace this COM port number in windows "Device Manager"
COM_port = 'COM16';
```

```
% Set SW00160 to connect port V1 to C1
s1 = serial(COM_port,'BaudRate',115200);
fopen(s1);
fprintf(s1,'setstatev1c1');
fgets(s1)     % Optional command to check on SW00160 status.
fclose(s1);

% Set SW00160 to connect port N1 to C1
s1 = serial(COM_port,'BaudRate',115200);
fopen(s1);
fprintf(s1,'setstaten1c1);
fgets(s1)     % Optional command to check on SW00160 status.
fclose(s1);

% Set SW00160 to connect port V2 to C2
s1 = serial(COM_port,'BaudRate',115200);
fopen(s1);
fprintf(s1,'setstatev2c2');
fgets(s1)     % Optional command to check on SW00160 status.
fclose(s1);

% Set SW00160 to connect port N2 to C2
s1 = serial(COM_port,'BaudRate',115200);
fopen(s1);
fprintf(s1,'setstaten2c2');
fgets(s1)     % Optional command to check on SW00160 status.
fclose(s1);

% Get switch temperature (Kelvin)
s1 = serial(COM_port,'BaudRate',115200);
fopen(s1);
fprintf(s1,'getIGtemperature');
IGtemperatureString = fgets(s1);
IGtemperatureString_value = strsplit(IGtemperatureString,' ');
IGtemperature = str2num(IGtemperatureString_value{3});
fclose(s1);
disp(['SW00160C temperature is: ',num2str(IGtemperature),'K'])

% 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'])
```

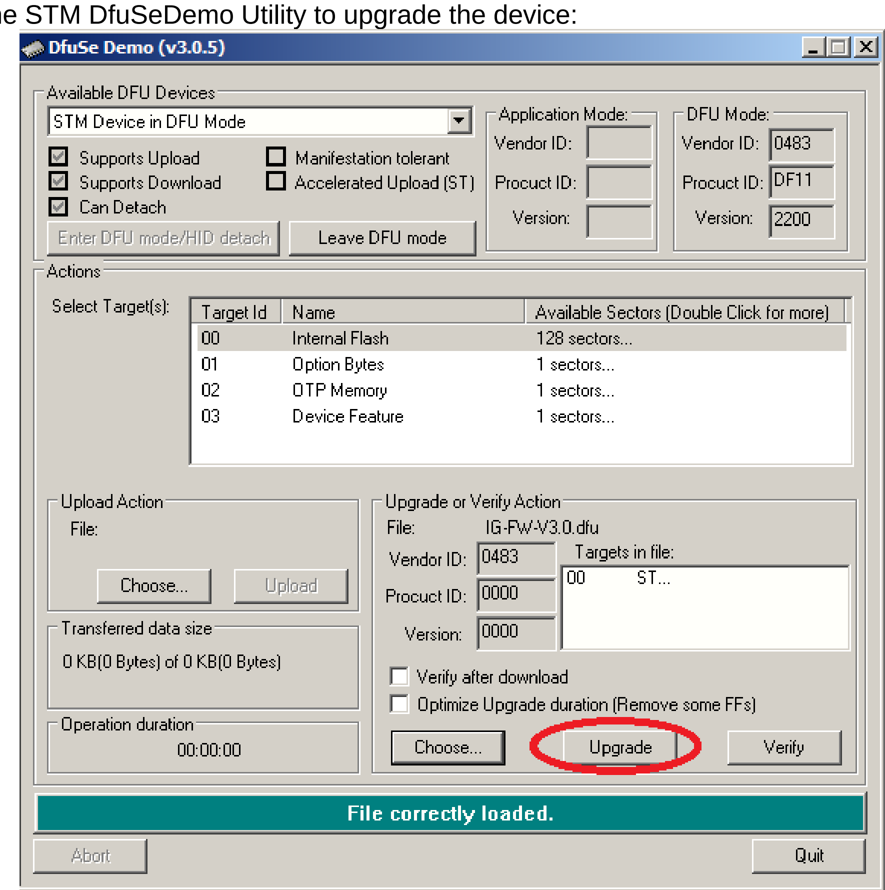
3.4 Firmware Update

1. Connect to receiver through Putty (3.3.1).
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
   

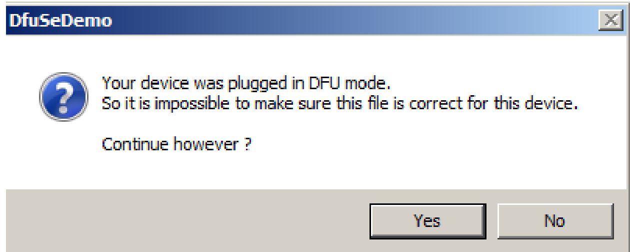
5. Use the STM DfuSeDemo Utility to upload the desired firmware (only .dfu files supported):



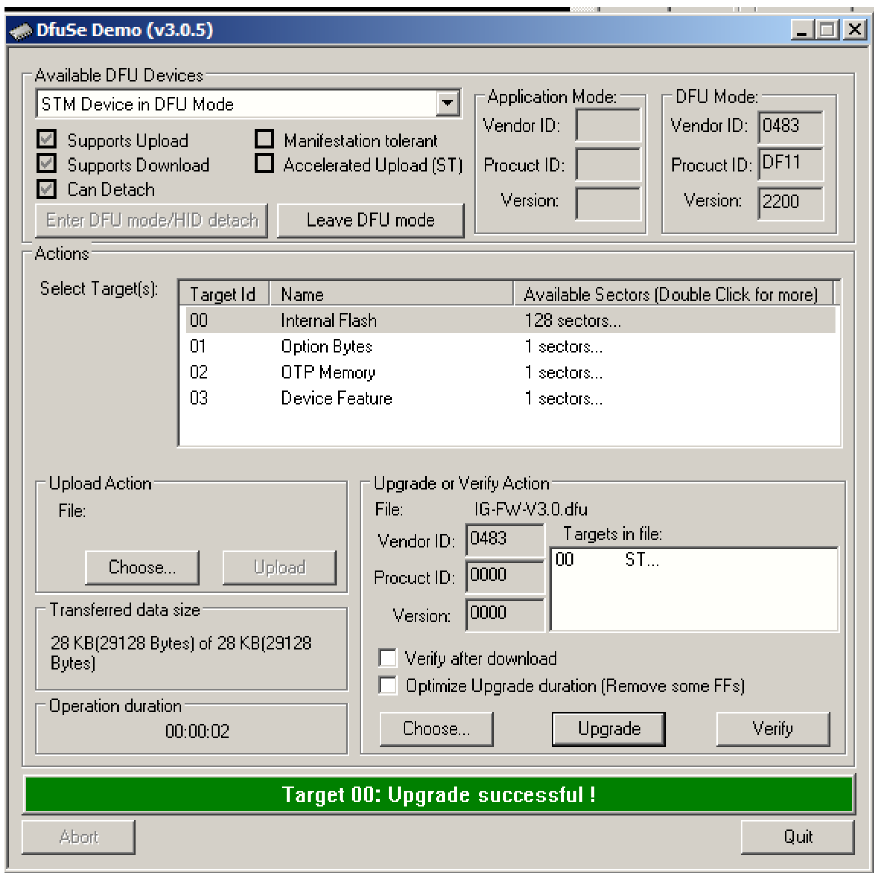
6. Use the STM DfuSeDemo Utility to upgrade the device:



7. Select Yes in the pop-up window:



8. If successful you should see the follow screen:

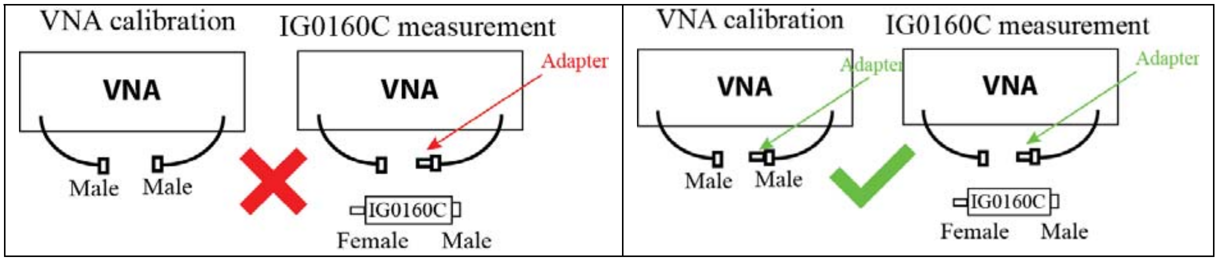


4. Dos and Don’ts when measuring noise parameters

This section stresses the importance of proper calibration and measurement procedure on the quality of the noise-parameter measurements.

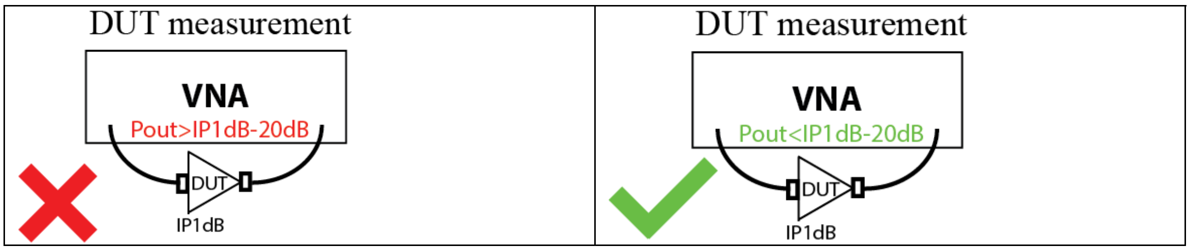
4.1 Use of adapters

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.



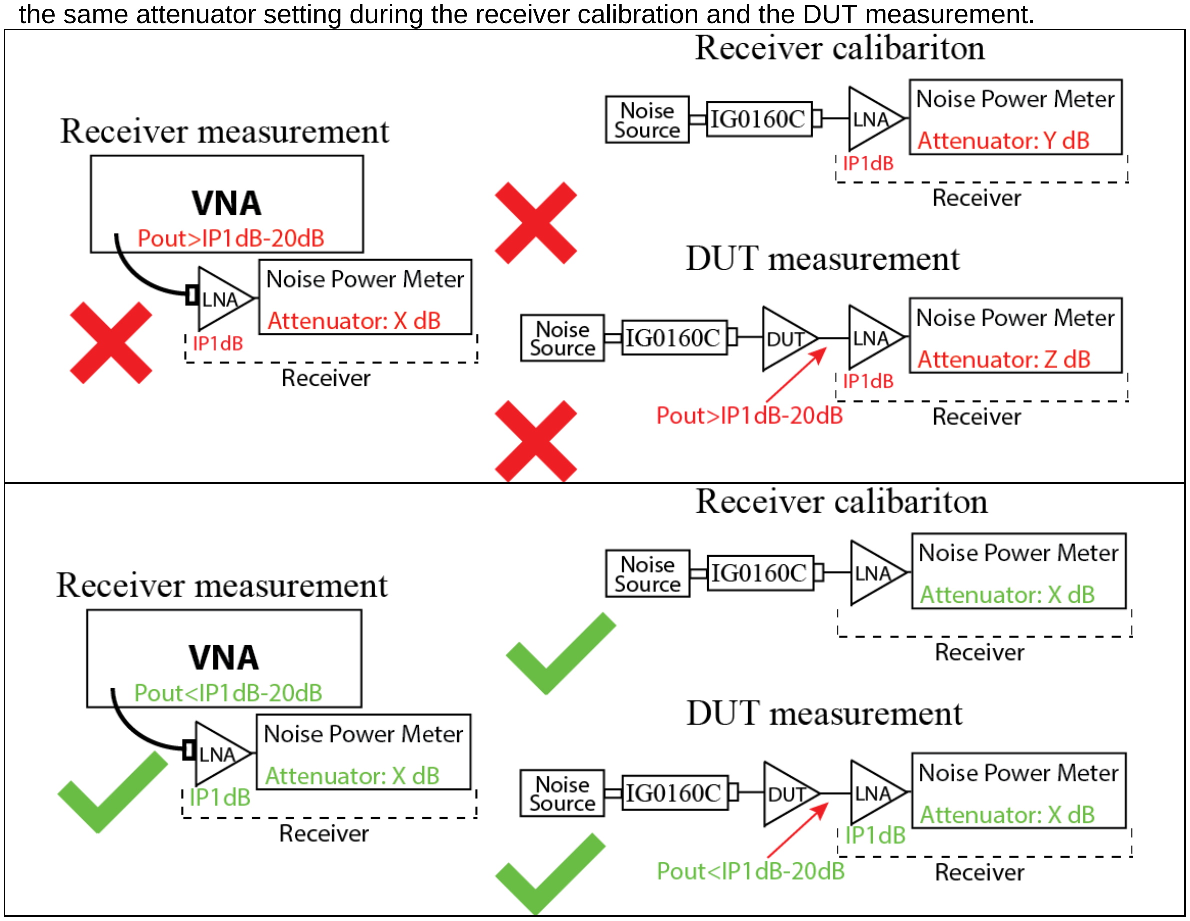
4.2 Gain saturation

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



4.3 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.



5. Noise parameter measurement procedure

Please contact NoiseTech or visit NoiseTechMircowaves.com to obtain IG0160C manual that describes the noise parameter measurements. The following procedure only shows how SW00160 may be used to as part of the noise parameter measurements.

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:

- NoiseTech’s C-IG0160C impedance generator (IG)
- NoiseTech’s C-SW00160 or SW00160 dual SPDT switch matrix (Switch)
- 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 and is often recommended at the input to the receiver to reduce receiver noise and improve measurement uncertainty.
- Appropriate RF cables
- A computer connected to the IG and the Switch via a USB port and running software that controls the IG and the Switch.

5.2 Measurement process

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

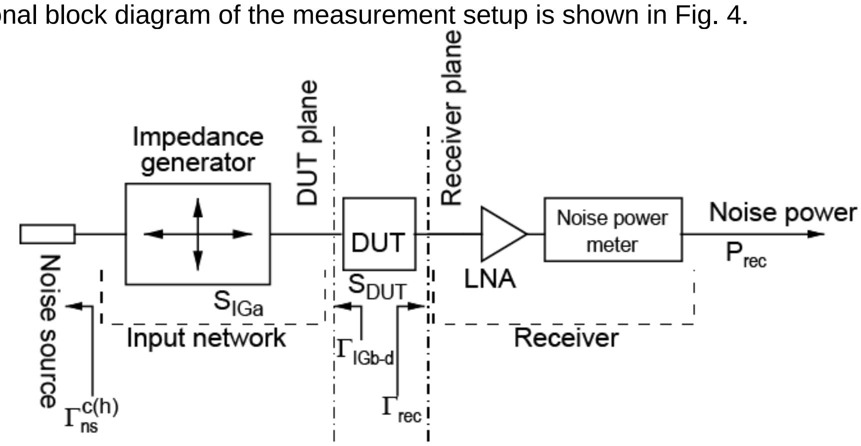


Fig. 4. Block diagram of the noise-parameter measurement system.

When using the Switch, the block diagram is modified as shown in Fig. 5.

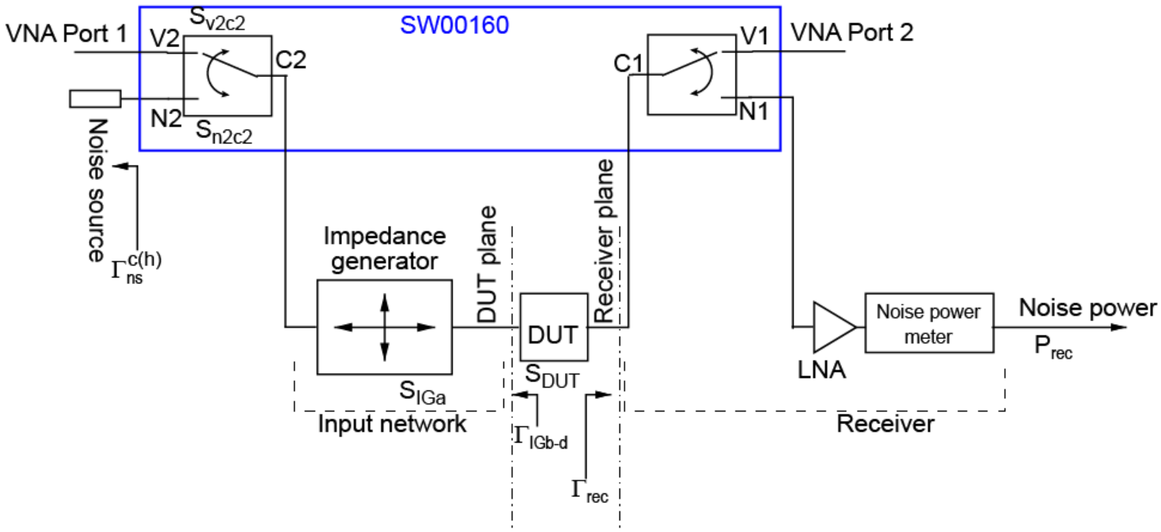


Fig. 5. Block diagram of the noise-parameter measurement system with the Switch is used. <u>Note that the two internal switches of SW00160 can be interchanged as desired, i.e. the V1N1C1 switch can be connected in place of the V2N2C2 switch and vice versa.</u>

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 large number measurements for adequate averaging, especially for noise-power measurements. (*If a VNA is used as a receiver, please contact NoiseTech for an updated procedure.)*

<u>The following descriptions assume SW00160 is connected as in Fig. 5. However, the two internal switches can be swapped as required to simplify the setup.</u>

A block diagram of the cryogenic measurement setup is shown in Fig. 6.

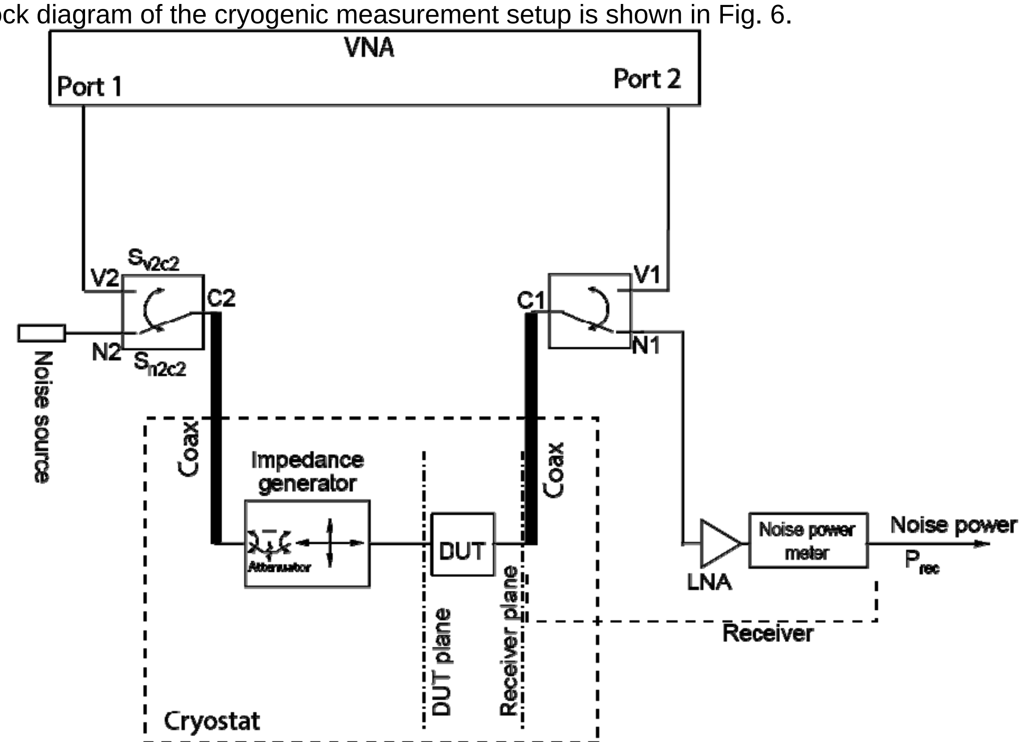


Fig. 6. Block diagram of the noise-parameter measurement system.

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 a large number of measurements for adequate averaging, especially for noise-power measurements. (*If a VNA is used as a receiver, please contact NoiseTech for an updated procedure.)*

NoiseTech’s C-SW00160 Dual SPDT switch matrix is shown in Fig. 6 to speed up the measurement procedure. For more information and for a different measurement procedure please contact NoiseTech or download C-SW00160 Manual from NoiseTechMicrowaves.com.

“Cold-attenuator” measurement setup is shown in Fig. 6. Other measurement options are available. Some measurements can be performed at room temperature. Please contact NoiseTech for more information.

5.2.1 Before measurement starts:

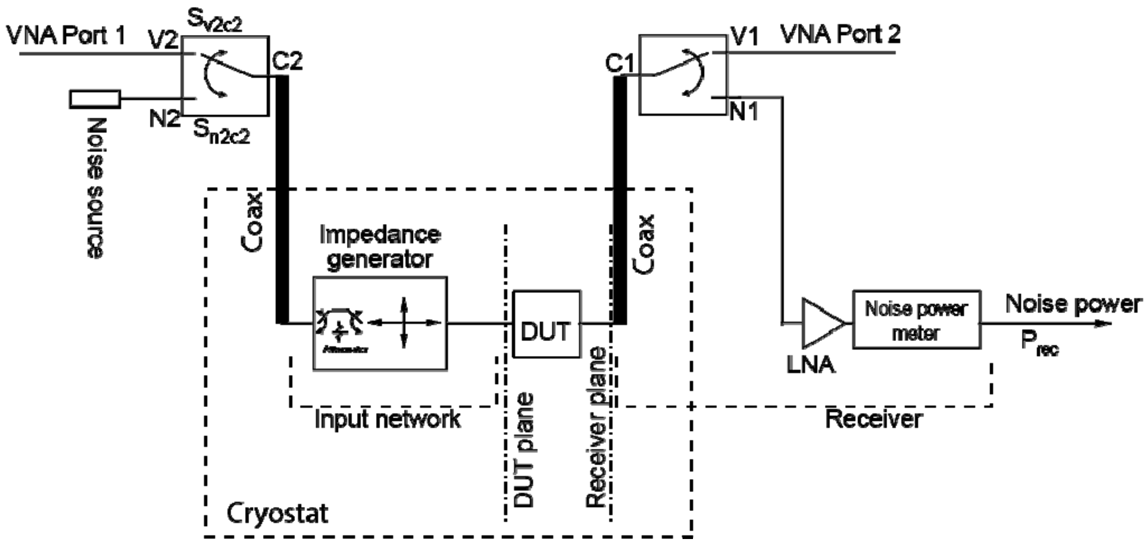
- It is suggested to make the DUT have a Female input port and Male output port by adding an adapter at the DUT output. It is not necessary to have all DUTs like that, but for demonstration purposes, this makes steps more straightforward. We can later show what to do when DUT has other ports.
- Setup VNA cables so that Port 1 has a Male port and Port 2 has a Female Port.
- Setup Switch 1 to have C1 as Female, V1 as Male, N1 and either Male or Female
- Setup Switch 2 to have C2 as Male, N1 as Female, and V1 as Female port
- Input Coax transition cable: the room temperature port is Female, the cryogenic port Male
- Output Coax transition cable: the room temperature port is Male, the cryogenic port Female
- Setup a “Measurements” directory where the measured data is placed. This directory is expected in the last step of the process. If another directory is used, modify the last script to grab the data from the correct directory.

5.2.2 Cryogenic noise-parameter measurement

Note: Example Matlab code is supplied with the switch

For cryogenic measurements, the switch can be placed either in the cryostat or external to the cryostat. NoiseTech switches can be used in either location, but it is often preferred to have the switch placed outside the cryostat as that configuration
- reduces the number of coaxial cables entering the cryostat
- enables easier changes to the setup without the need to warm up
- reduces the thermal load on the cryostat
- reduces the required size of the cryostat.

The measurement system that uses a cold-attenuator measurement method is depicted below



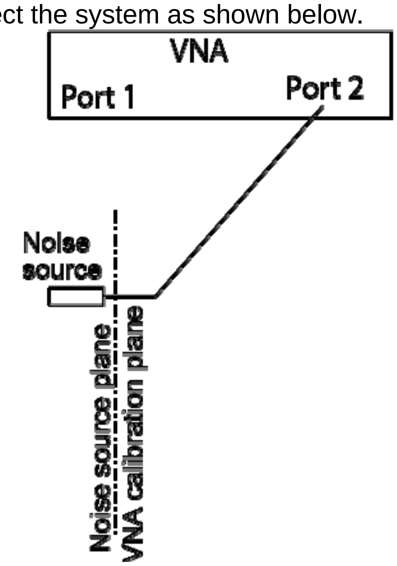
The following describes the calibration and measurement steps.
Note that for all steps, the VNA is calibrated once with the calibration plane being at the ends of the coax cables connected to the VNA.

5.2.2.1 Calibration

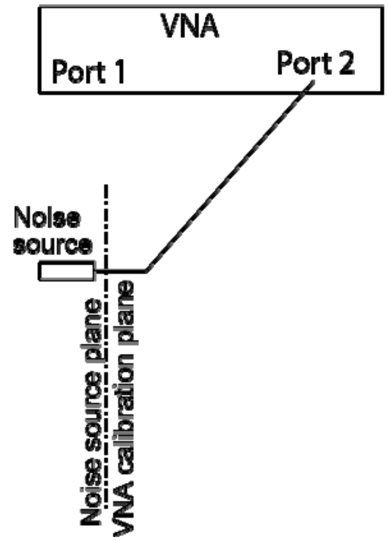
Step #1: Measure S-parameters of “Coax” cables

Step #2: Measure noise source reflection[1] coefficient when the noise source is OFF.

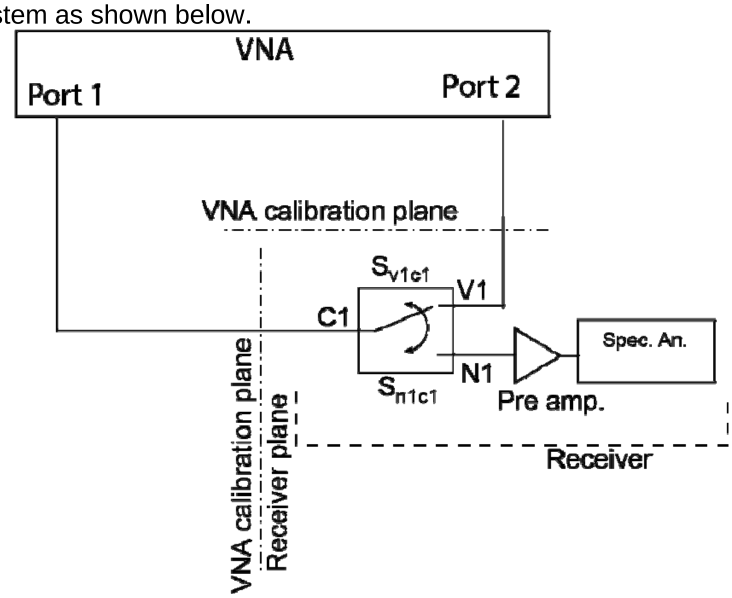
Connect the system as shown below.



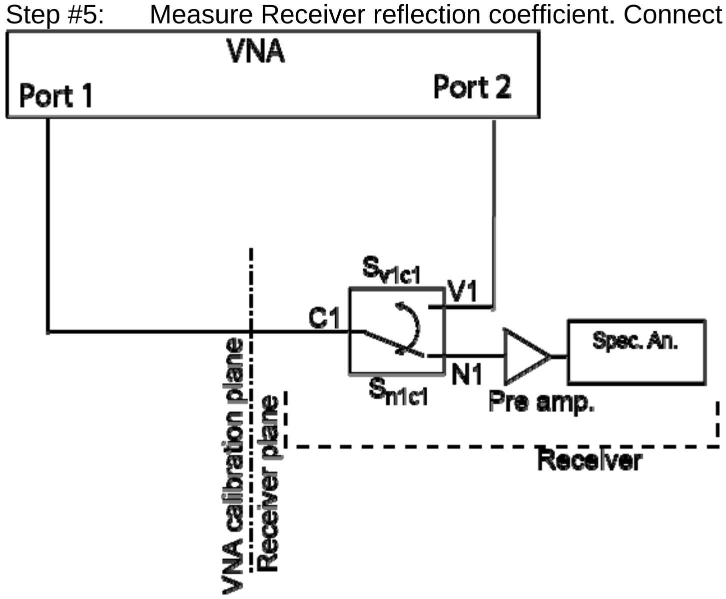
Step #3: Measure noise source reflection[1] coefficient when the noise source is ON.



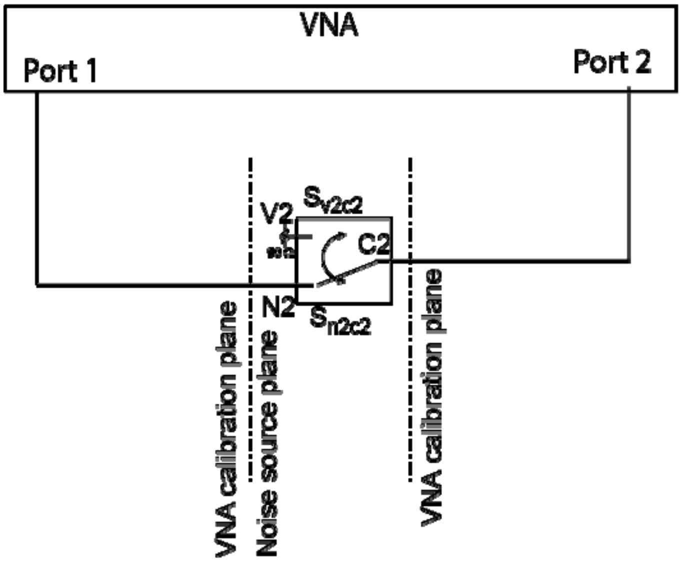
Step #4: Measure Switch v1c1 path. If the switch is not used, this step is skipped. Connect the system as shown below.



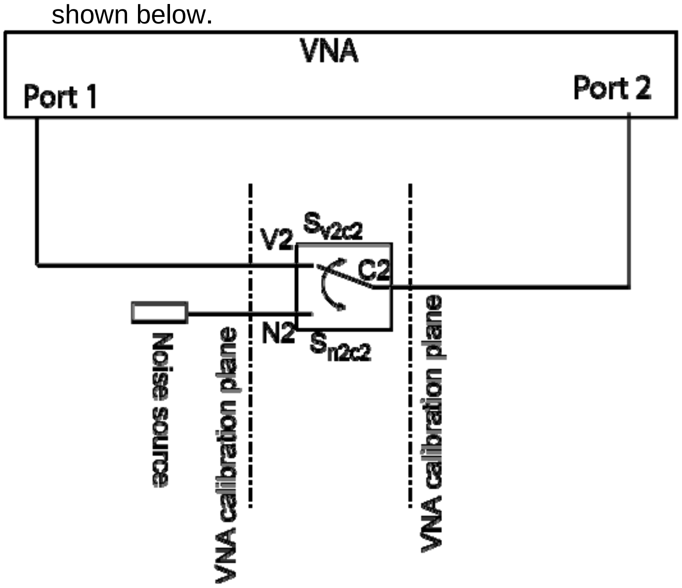
Step #5: Measure Receiver reflection coefficient. Connect the system as shown below.



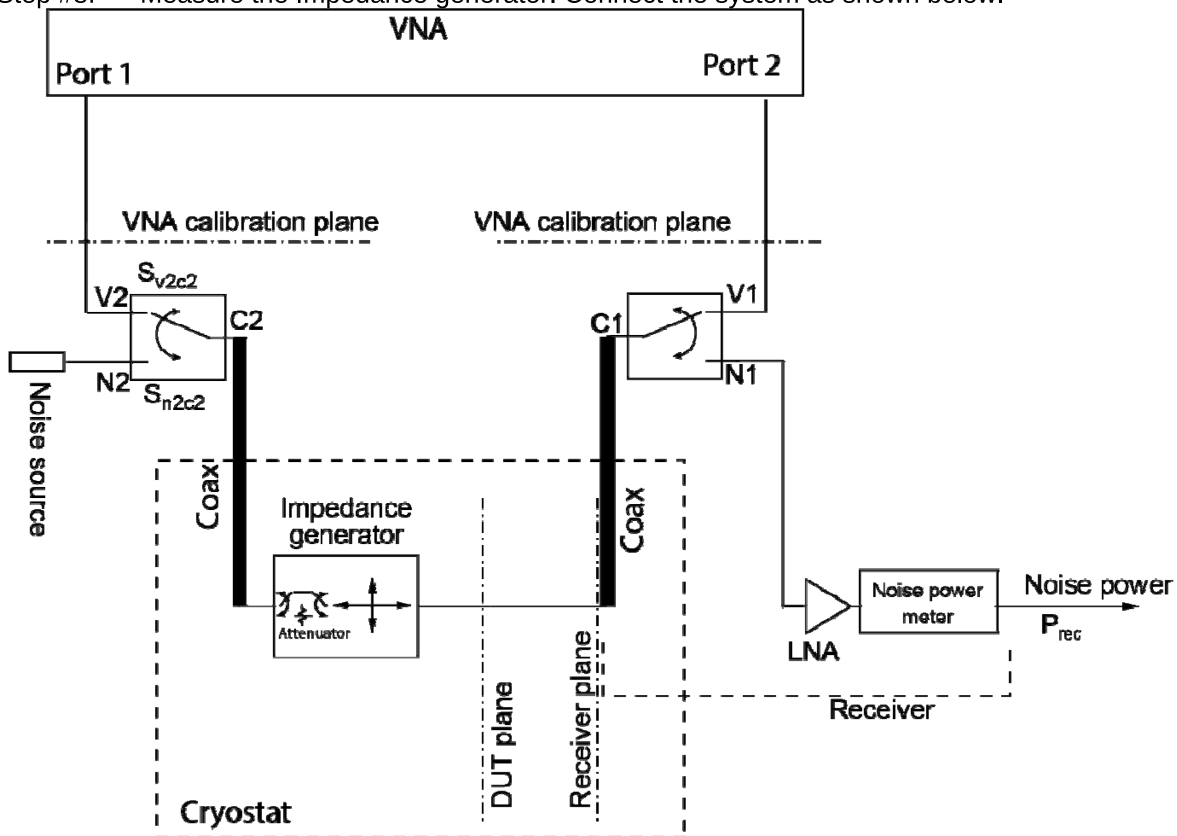
Step #6: Measure Noise Path of the input Switch in state n2c2. Connect the system as shown below.



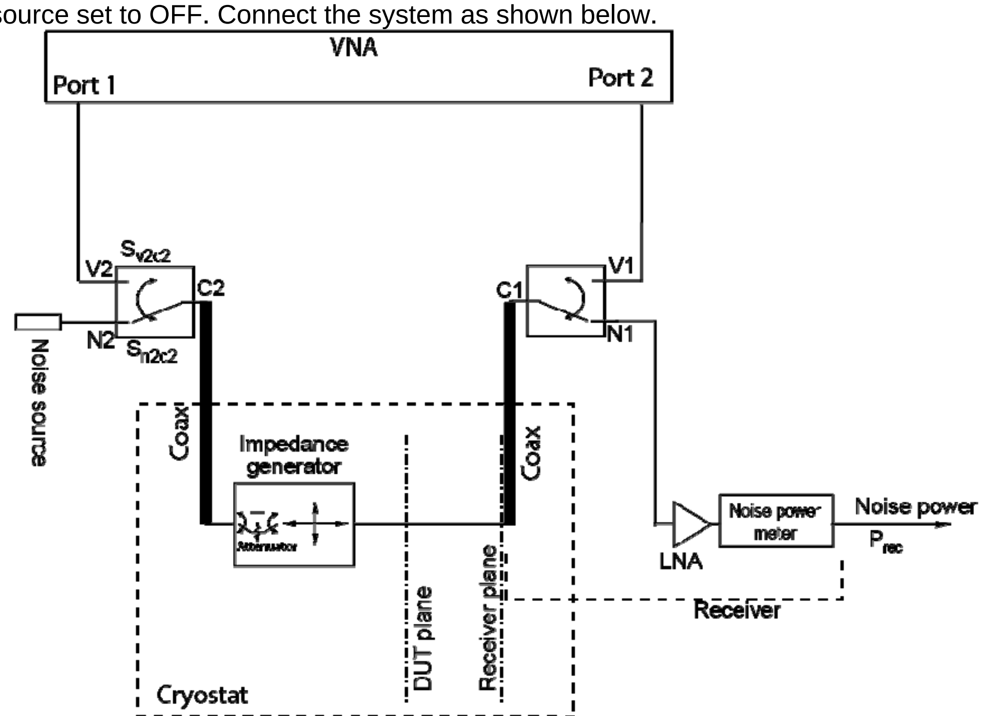
Step #7: Measure VNA Path of the input Switch in state v2c2. Connect the system as shown below.



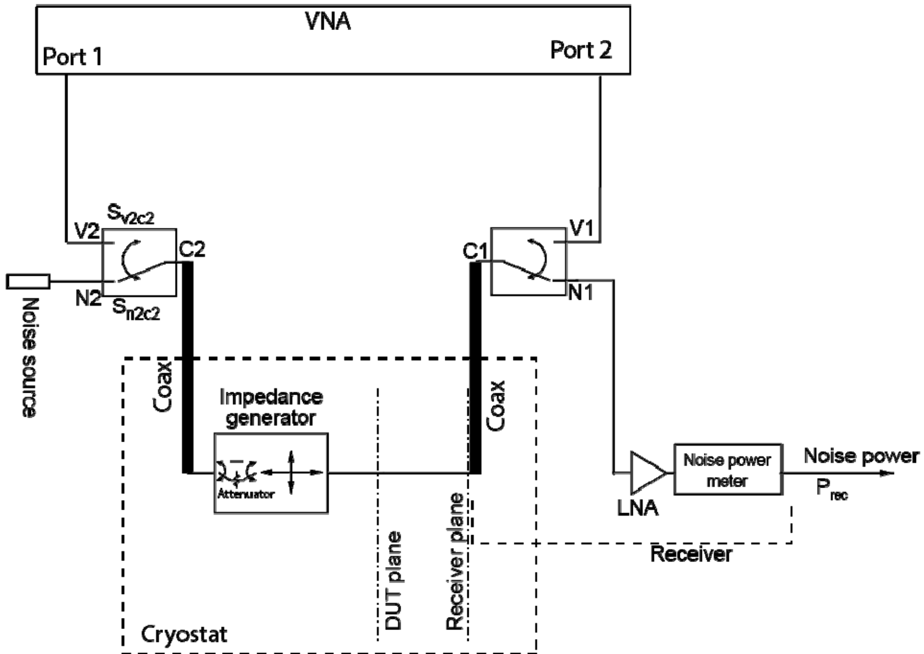
Step #8: Measure the Impedance generator. Connect the system as shown below.



Step #9: Measure noise power and switch and IG temperatures with the Receiver with the noise source set to OFF. Connect the system as shown below.

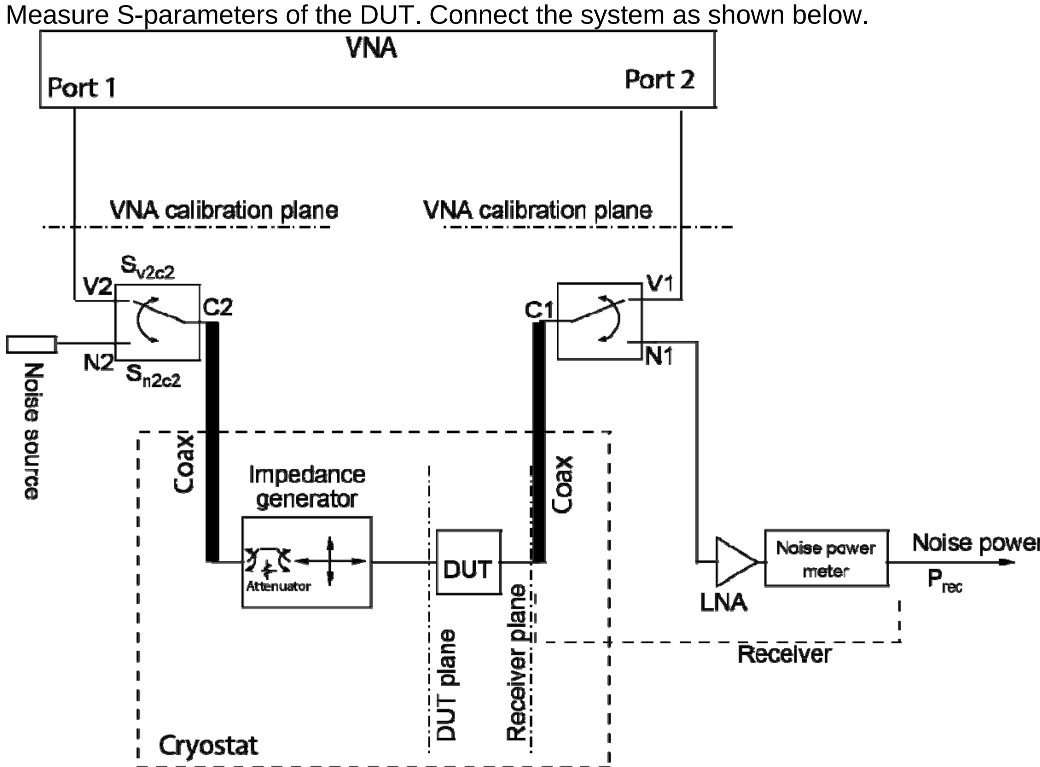


Step #10: Measure noise power with the Receiver with the noise source set to ON. Connect the system as shown below.

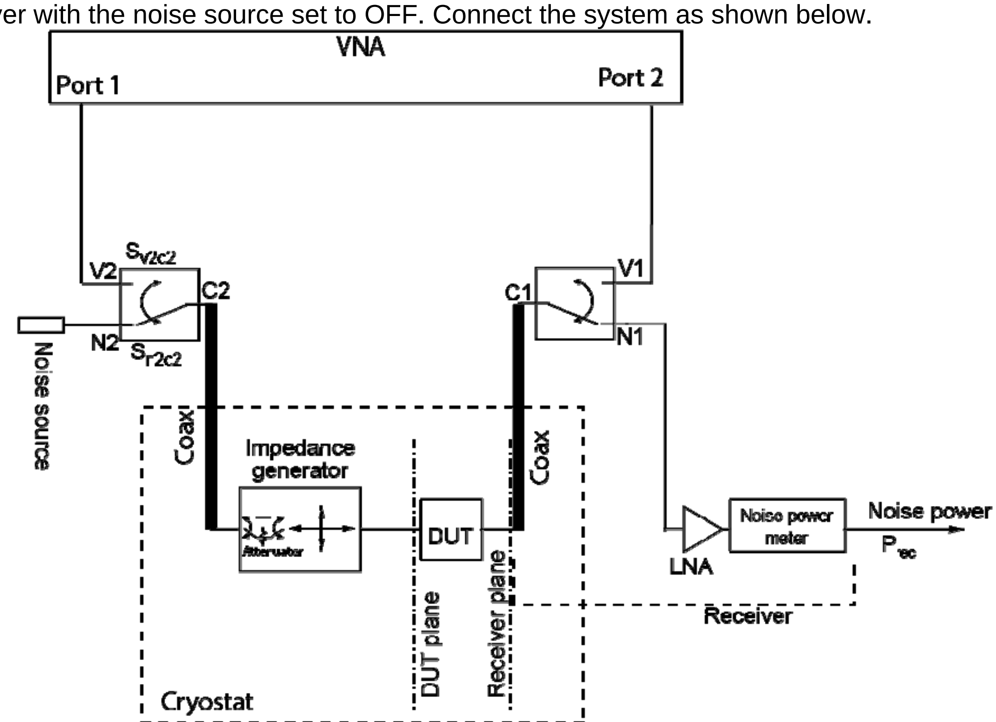


5.2.2.2 DUT Measurement

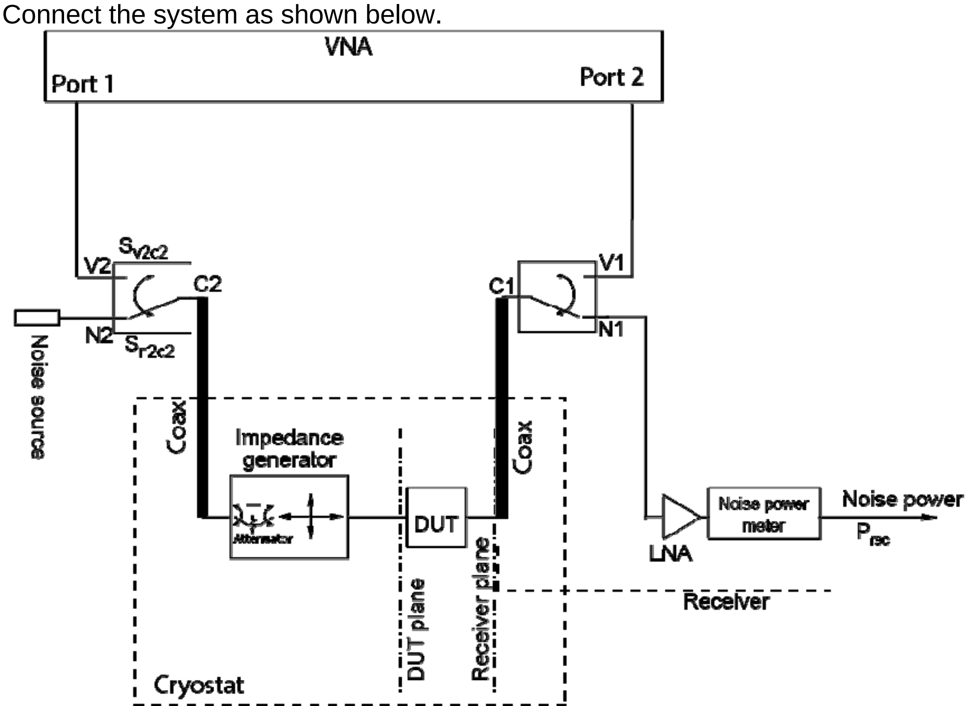
Step #11: Measure S-parameters of the DUT. Connect the system as shown below.



Step #12: Measure the physical temperatures and noise power of the DUT with the Receiver with the noise source set to OFF. Connect the system as shown below.



Step #13: Measure the noise power of the DUT with the Receiver with the noise source set to ON. Connect the system as shown below.



Step #14: Calculate noise parameters of the DUT.

Step #15: Repeat steps 12 to 14 to measure different DUTs.

[1] Because the attenuator is large and the noise source reflection coefficient is typically very low, the noise source reflection coefficients are expected to be very similar and very small. In this case Step #2 and Step #3 can be omitted by assigning reflection coefficients of 0.

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.

7. Revision notes

Nov 24, 2020: Updated the photo
Nov 24, 2020: Updated the switch temperature measurement code
Nov 24, 2020: Updated the measurement procedure