



# NoiseTech Microwaves Ltd.

Product Manual for Dual SPDT Switch Matrix  
Rev. 1 – June 13, 2019

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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 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 degrees Centigrade and a hexadecimal ADC code for troubleshooting. (Not applicable for C-SW00160)

**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

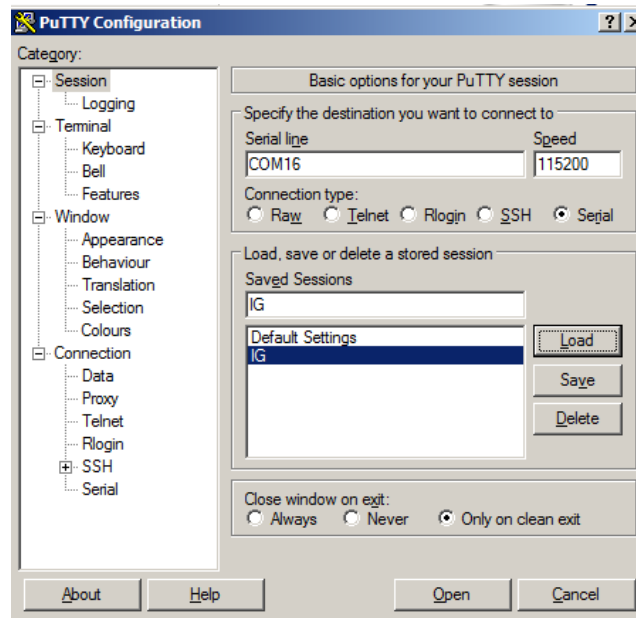
This section shows examples of using SW00160 device.

#### 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>.

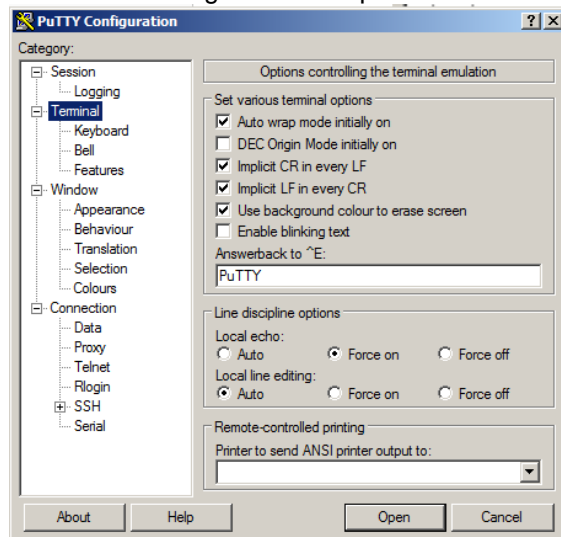
After Putty is downloaded and installed, it should be configured as follows:

- 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"
```

```
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```

```

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);

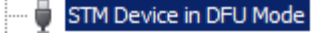
% Set SW00160 to connect port N2 to C2
s1 = serial(COM_port,'BaudRate',115200);
fopen(s1);
fprintf(s1,'setstaten2c2');
fgets(s1) % Optional command to check on SW00160 status.
fclose(s1);

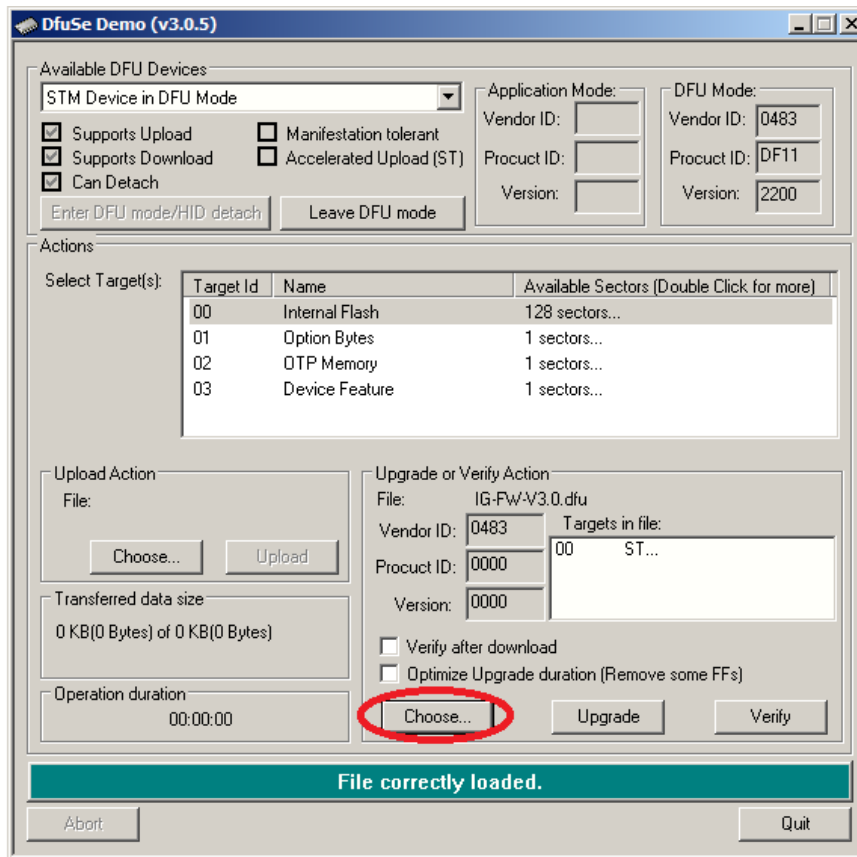
% Get Impedance generator Temperature (Celsius)
s1 = serial(COM_port,'BaudRate',115200);
fopen(s1);
fprintf(s1,'getIGtemperature');
IGtemperatureString = fgets(s1);
IGtemperatureString_value = strsplit(IGtemperatureString,',');
IGtemperature = str2num(IGtemperatureString_value{2});
fclose(s1);
disp(['IG0160C 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'])

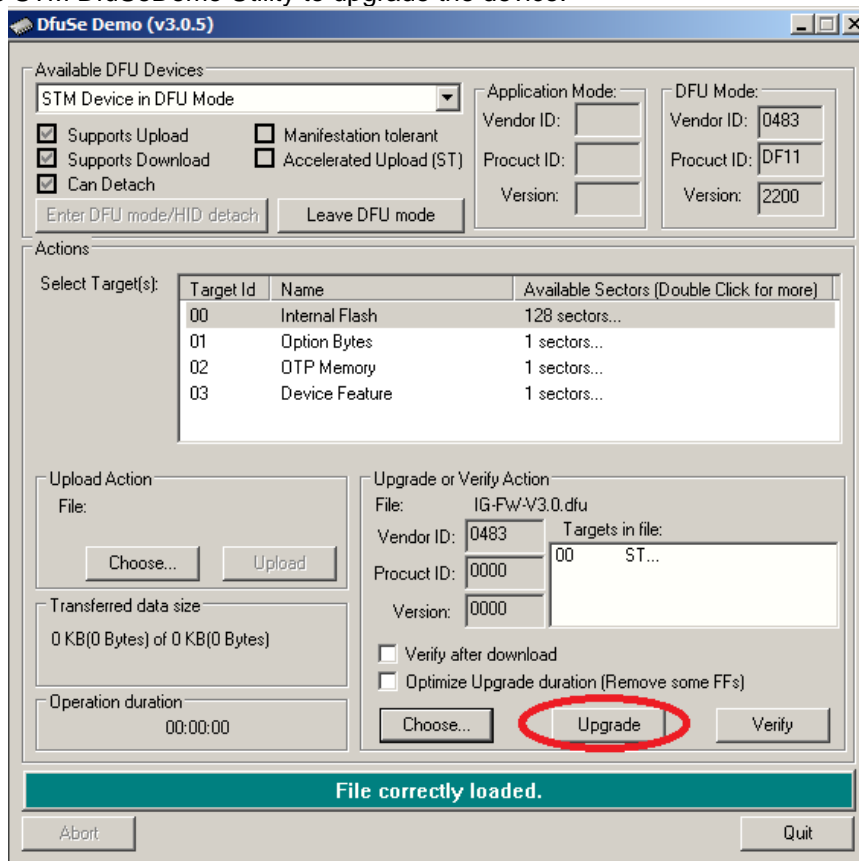
```

### 3.4 Firmware Update

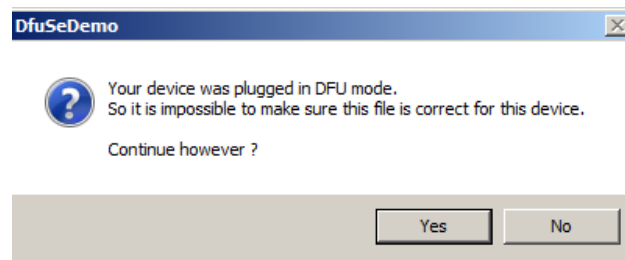
1. Connect to receiver through Putty (3.3.1).
2. Issue command “setUpdateMode”.
3. Power cycle the unit (disconnect power and reconnect)
4. Windows should recognize the USB device as an STM device in bootloader mode  

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



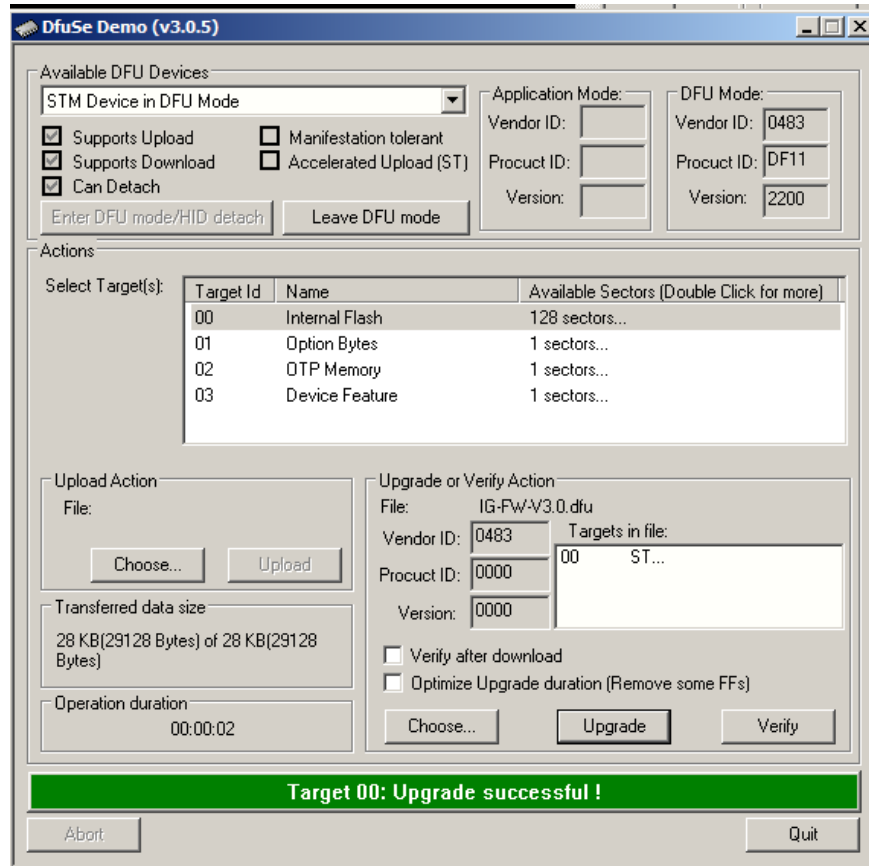
6. Use the STM DfuSeDemo Utility to upgrade the device:



7. Select Yes in the pop-up window:



8. If successful you should see the follow screen:

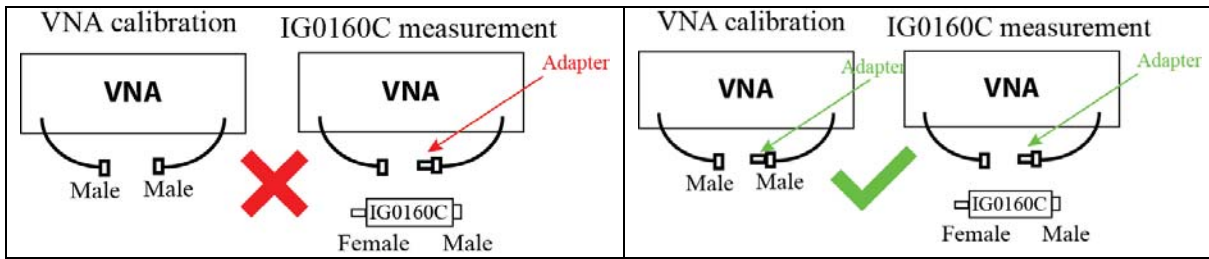


## 4. Dos and Don'ts when measuring noise parameters

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

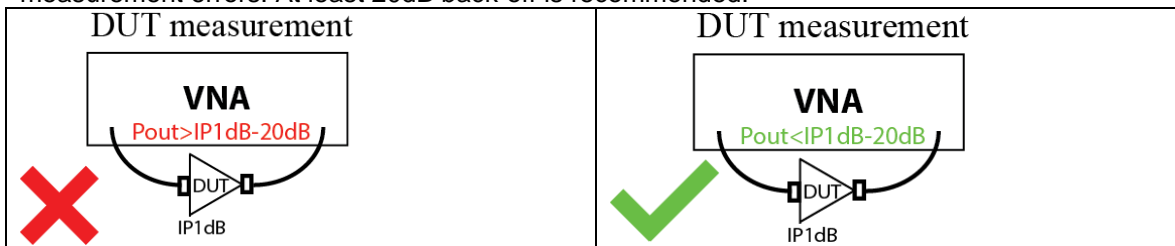
### 4.1 Use of adapters

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.



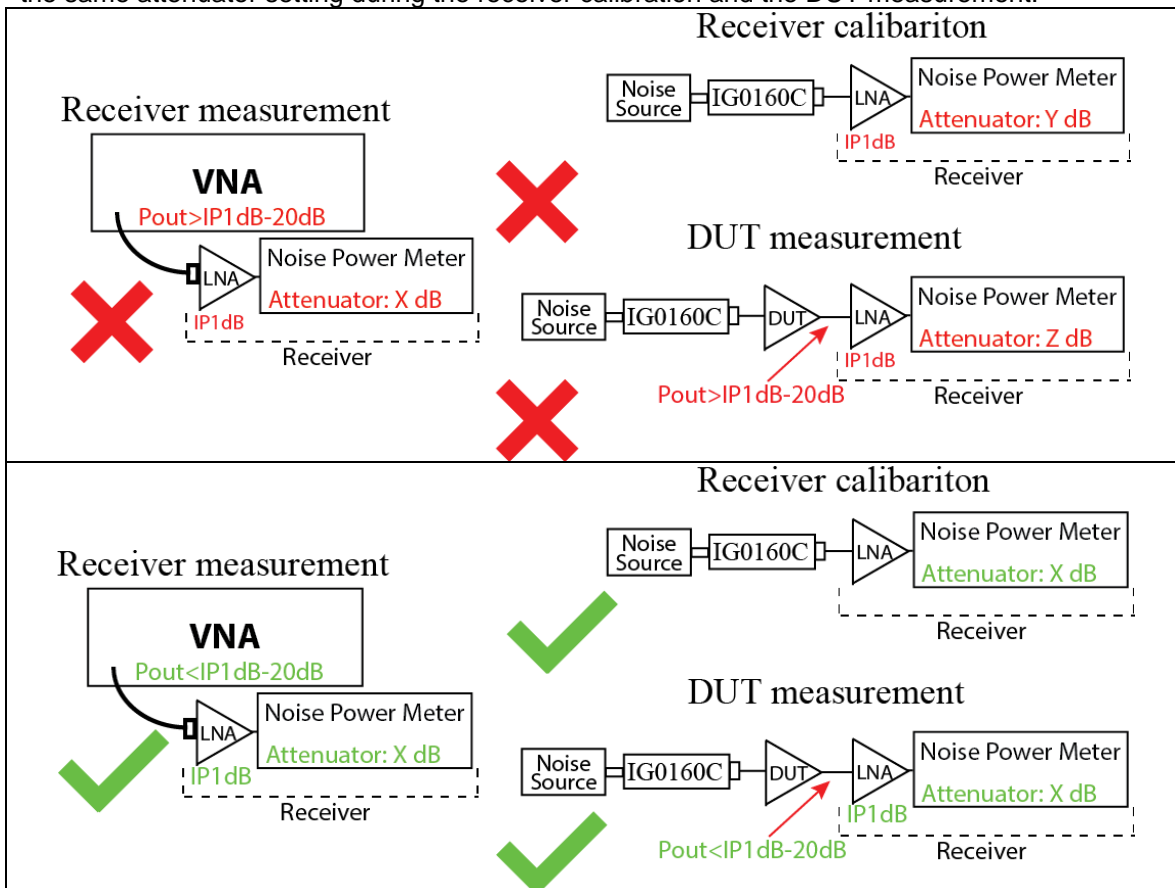
### 4.2 Gain saturation

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 [NoiseTechMicrowaves.com](http://NoiseTechMicrowaves.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.

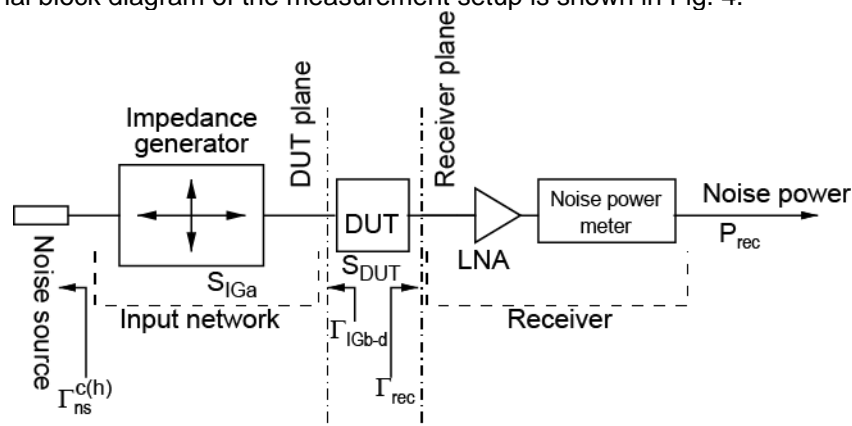
### 5.1 Required equipment

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

- NoiseTech’s IG0160C impedance generator (IG)
- NoiseTech’s 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

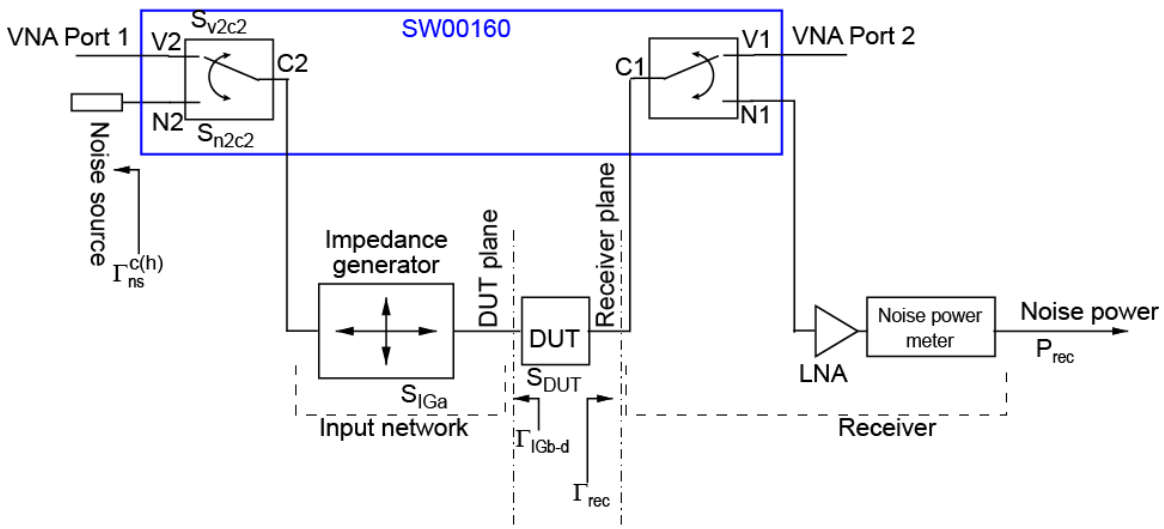
A conventional block diagram of the measurement setup is shown in Fig. 4.



**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. 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.**

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 NoiseTech for an updated procedure.)

There are different approaches to measurements. Two approaches are described next. Contact NoiseTech if such approach is not applicable for a particular system configuration.

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.

#### **Approach #1 (Example Matlab code supplied):**

- Step 1 Calibrate VNA for S-parameter measurement (the VNA output power can be high as this calibration is used to measure passive parts). Measure 2-port S-parameters between N1 of the Switch and the IG output (DUT plane).
- Step 2 Using the same calibration measure reflection coefficient  $\Gamma_{ns}^c$  of the NS in its OFF state (a.k.a. Cold state) and save in touchstone-format files
- Step 3 Repeat Step 2 to measure reflection coefficient  $\Gamma_{ns}^h$  of the NS in the ON state (a.k.a. Hot state) and save in touchstone-format files.
- Step 4 Perform 1-port calibration on Port 1 of the VNA with the Switch (V2C2 state) and IG connected to Port 1. Measure reflection coefficient at Receiver plane with the in Switch N1C1 state.
- Step 5 Perform 1-port calibration<sup>1</sup> on Port 2 of the VNA with the Switch (V1C1 state) connected to Port 2. Measure reflection coefficients of the IG in states A, B, C, and D at the DUT plane with the NS is set to OFF.
- Step 6 Repeat Step 5 for the IG state A with the NS set to ON.
- Step 7 Replace the DUT in Fig. 5 with an insertable THRU, set the Switch to N1C1 and N2C2 states, set NS to OFF. Measure noise power with the receiver at all four IG states and record the IG temperature ( $T_{IG}$ ), and, if available, and the temperature of the NS temperature ( $T_{NS}$ ).
- Step 8 Repeat Step 7 for IG state A with the NS set to ON.
- Step 9 Perform 2-port VNA calibration<sup>1</sup> at the DUT plane and Receiver plane with the IG in the A state and the Switch in the V1C1 and V2C2 states. Place the DUT in the system

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as in Fig. 5 and measure its S-parameters. Save S-parameters in a touchstone-format file.

- Step 10 Repeat Step 7 but with the DUT placed in the system.
- Step 11 Repeat Step 8 but with the DUT placed in the system.
- Step 12 Extract noise parameters using measured data. An example Matlab code for performing such extraction is included on IG0160C for user reference.

### Approach #2 (Requires a TRL calibration code and TRL standards)

- Step 1 Calibrate VNA for S-parameter measurement (the VNA output power can be high as this calibration is used to measure passive parts).
- Step 2 Measure S-parameters of Switch V2C2 path ( $S_{v2c2}$ ) and Switch N2C2 path ( $S_{n2c2}$ ) and save in touchstone-format file.
- Step 3 Measure reflection coefficients ( $\Gamma_{ns}^c$  and  $\Gamma_{ns}^h$ ) 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 4 Connect the system as in Fig. 5. Do not insert the DUT.
- Step 5 Perform a TRL calibration between the DUT plane and the receiver plane. Calibrate the VNA between the DUT plane and the Receiver plane with the Switch set to V1C1 and V2C2 states and the IG set to state A. This step can be performed with either a user-supplied TRL code<sup>2</sup> or with a VNA. The latter requires the ability to compare calibration parameters of this step and of Step 1. As the result of this step, 2-port S-parameters of the IG in State A are obtained.
- Step 6 Set the IG to state A and the Switch to V2C2 and N1C1 states. Measure the reflection coefficient of the receiver ( $\Gamma_{rec}$ ) and save in a touchstone-format file.
- Step 7 Set the Switch to states N2C2 and V1C1, set NS to OFF and measure the output reflection coefficients ( $\Gamma_{IGa}$ ,  $\Gamma_{IGb}$ ,  $\Gamma_{IGc}$ , and  $\Gamma_{IGd}$ ) of the IG in its states "A", "B", "C", and "D". Save S-parameters in touchstone-format files.
- Step 8 Repeat Step 7 for IG state A and the NS is set to ON.
- Step 9 Connect the output of IG to the input of the receiver (i.e. as in Fig. 5 but with the DUT replaced by a thru). Set the Switch to N1C1 and N2C2 states. Set the IG to its state "A". For both the ON state and the OFF state of the NS, measure noise powers with the receiver ( $P_{rec,cal}$ ), the IG temperature ( $T_{IG}$ ), and, if available, the NS temperature ( $T_{NS}$ ). Save measurements in appropriate files.
- Step 10 Repeat Step 9 for states "B", "C", and "D", while keeping the NS OFF. Save measurements in appropriate files.
- Step 11 Insert the DUT between the output of IG and the receiver.
- Step 12 With the Switch set to V1C1 and V2C2 states and the calibration from Step 5, measure the DUT S-parameters ( $S_{DUT}$ ) and save in a touchstone-format file.
- Step 13 With NS set to OFF, and the Switch set to N1C1 and N2C2 states, set IG to its four states and measure noise power ( $P_{rec,meas}$ ) with the receiver. Save results in appropriate files.
- Step 14 Extract noise parameters using measured data.

<sup>1</sup>The VNA output power should be low enough to avoid compression of the DUT and the receiver.

<sup>2</sup> If a TRL code is not available, contact NoiseTech for a sample of such code.

## 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

NoiseTech Microwaves Ltd. ([www.NoiseTechMicrowaves.com](http://www.NoiseTechMicrowaves.com))

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