## Subject: Typical RF System Budget Characteristics and Displays

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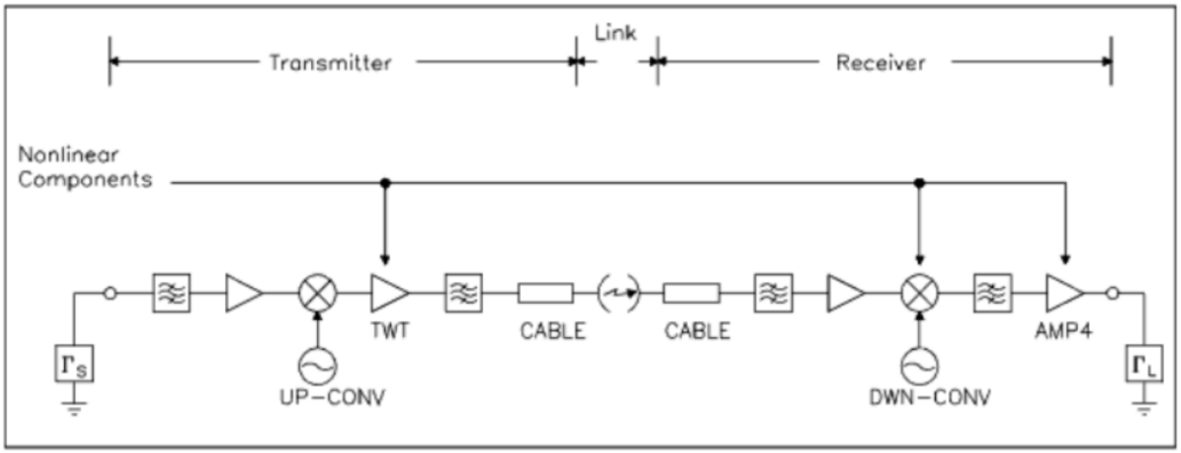
This paper discusses features on the web site: **https://www.serdesdesign.com/home/rf-system-budget-tool/**

The RF System Budget Analysis Tool analyzes an RF system that has a typical structure shown in this figure.




Where the RF system is defined by the cascade of two-port RF components, The components may be defined as S-Parameter data, filters, RF cables, gain or mixer components, Terrestrial links, or Satellite links,

See discussion in 'About the RF System Budget Analysis Tool'.

This section discusses typical RF system budget characteristics and displays. Let us know if you would like the tool enhanced with additional capability.

All RF system budget characteristics and displays are based on the measurements listed in **Meas...**

These measurements are defined in the Keysight documentation on the RF System Budget Analysis Tool, which John Baprawski wrote, at this Keysight web site:

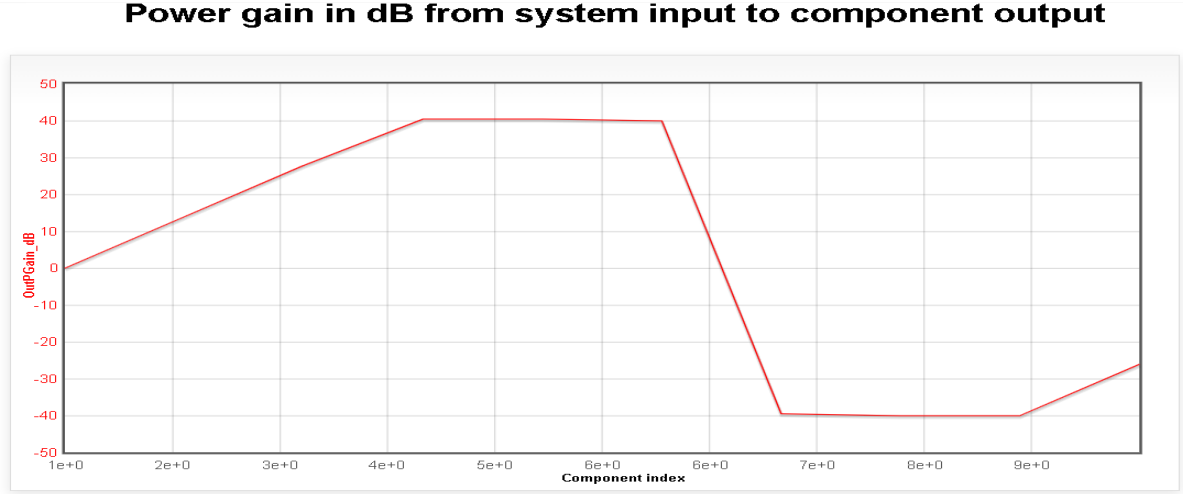
- https://edadownload.software.keysight.com/eedl/ads/2011_01/pdf/rfsysbudget.pdf
- Or, see the documentation at this alternate web site:
- https://mosses.pbworks.com/f/rfsysbudget.pdf

Thanks to Blake Gray Ph.D., Director of Engineering /Silicon Creations LLC for the use of their Keysight Advanced Design System (ADS RF Budget System Analysis Tool for testing my current copy of this tool against the ADS copy.

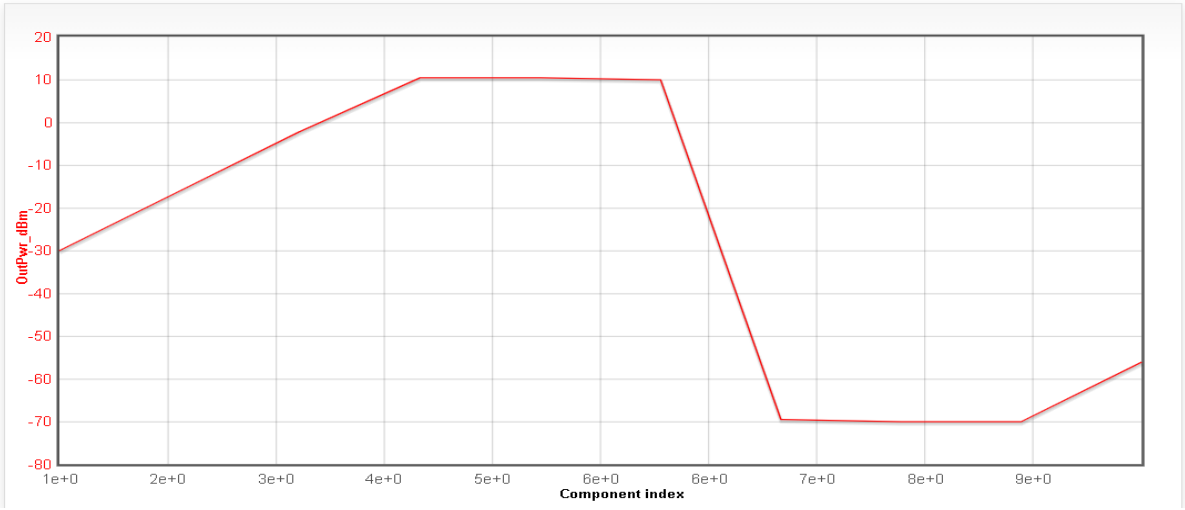
## Example RF System Measurement Displays

A typical RF system shown in the above block diagram has a transmit RF section, a link, and a receive RF section.

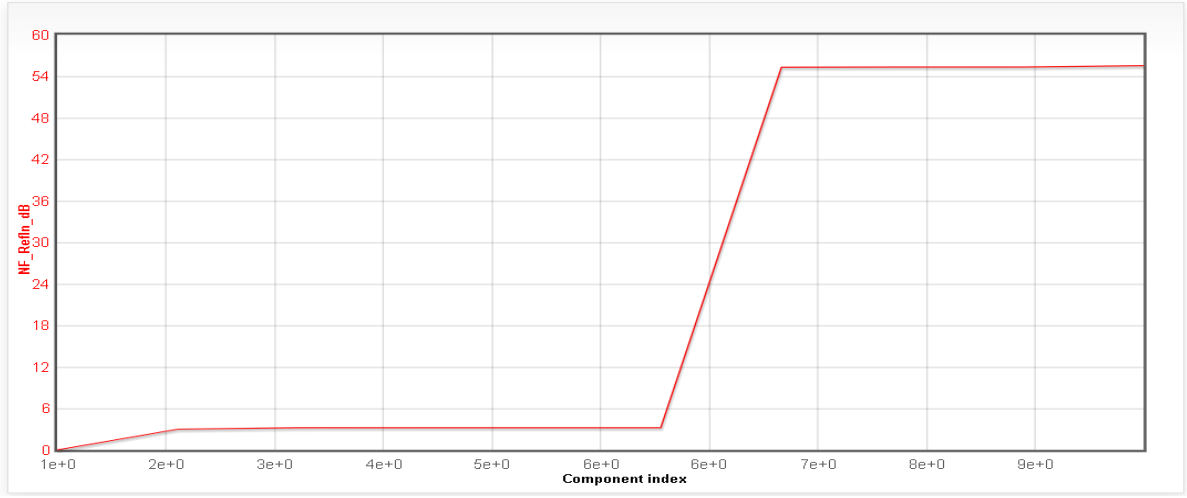
For the default RF system, here are the resultant displays.



## Power in dBm at component output



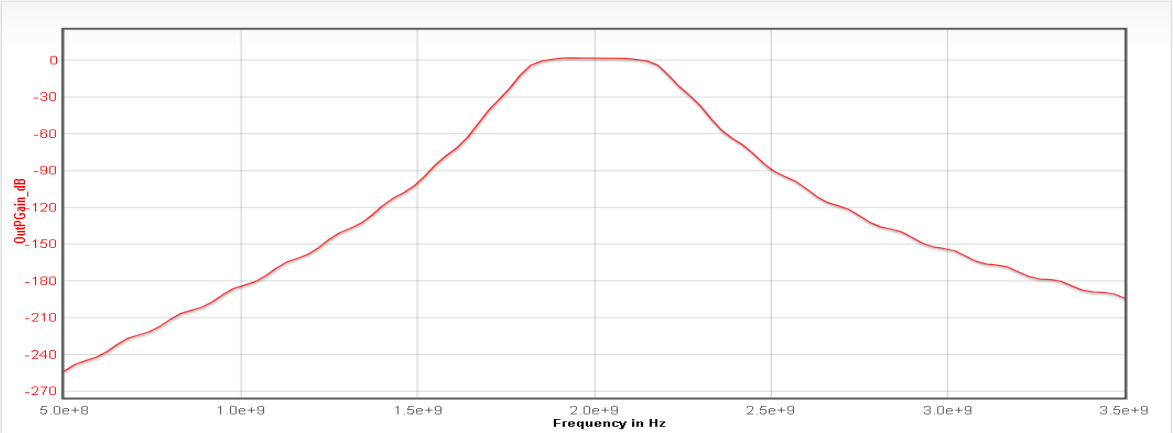

## Noise figure in dB from system input to component output



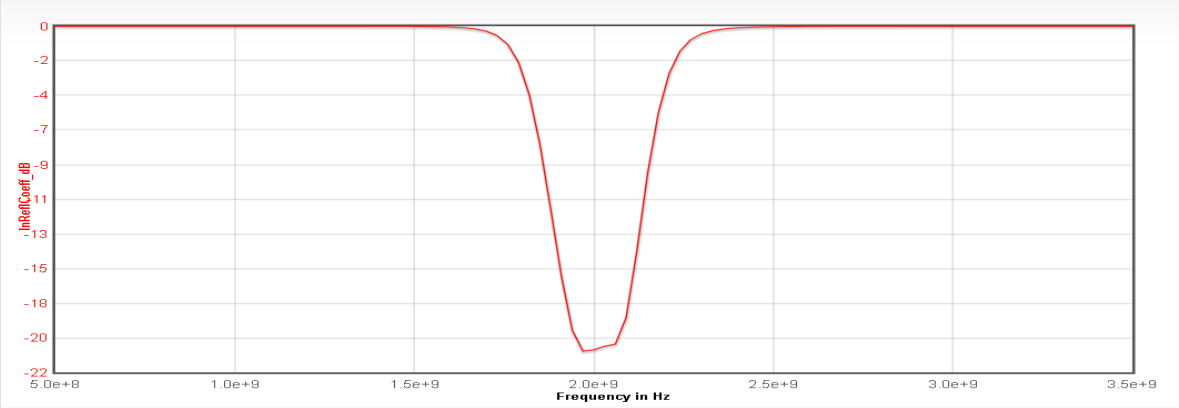
Additional displays are available based on user selection from the above measurement list.

If the frequency sweep was enabled (EnableFSweep = 1) in the SetupOptions, then these default displays are available where in this example the FSweepBW = 3 GHz and the FSweepNumPts = 101.

**Output power gain in dB vs Output Frequency**

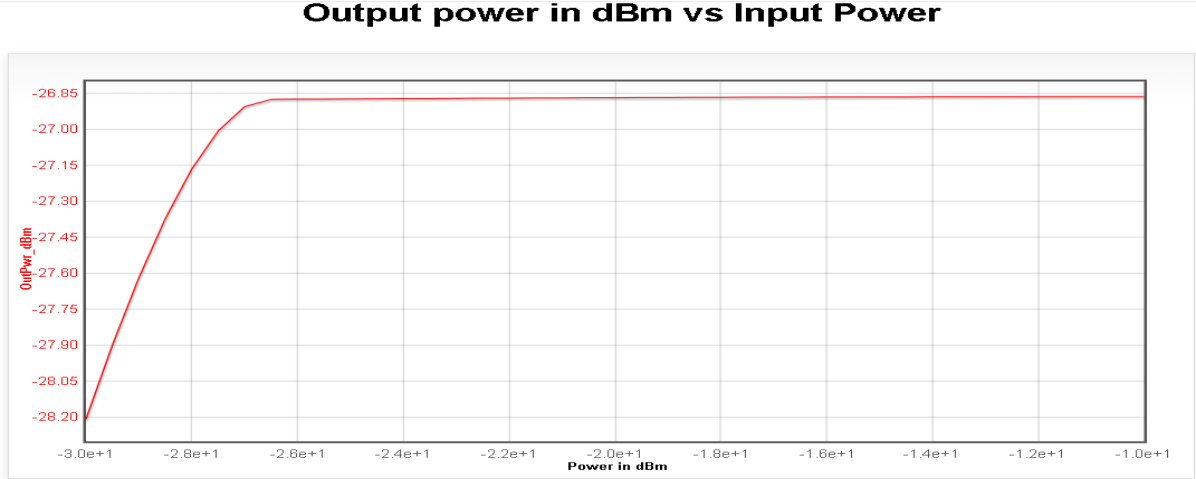



**Input reflection coefficient in dB vs Input Frequency**



Additional FSweep displays are available based on user selection from the above measurement list.

If the power sweep was enabled (EnablePSweep = 1) in the SetupOptions, then these default displays are available where in this example the PSweepMin = -30 dBm, PSweepMax =  -10 dBm and the PSweepNumPts = 41.




Additional PSweep displays are available based on user selection from the above measurement list.

## Viewing RF System Budget Analysis Data in an Excel Spreadsheet

The data for th RF system budget analysis is collected into a file named “RF_<Analysis_name> _RF_Budget.csv where <Analysis_name> is the used entered name for that field at the top of the tool.

On Linux:

The csv file can be downloaded after a successful “Run” using the button:

| | |
|---|---|
| Download Budget Data File | Download |

On Windows when the user has downloaded and installed the RF System Budget Analysis Tool on their Windows PC.:

The CSV file is located in the users 'include' directory:

- C:\RFSystemsDesign\user-<num>\channel-analysis-tool\analysis\include, when <num> is the assigned user number.

For example, for the default RF system, the CSV file will have 114 lines of data with these top 20 lines.

| | | |
|---|---|---|
| 1 | Filter | |
| 2 | Amplifier | |
| 3 | Mixer | |
| 4 | Amplifier | |
| 5 | Filter | |
| 6 | Cable | |
| 7 | Link | |
| 8 | Cable | |
| 9 | Filter | |
| 10 | Amplifier | |
| 11 | Mixer | |
| 12 | Filter | |
| 13 | Amplifier | |
| 14 | SystemInN0_dBm | -173.975 |
| 15 | SystemInNPwr_dBm | -173.975 |
| 16 | SystemInP1dB_dBm | -31.4406 |
| 17 | SystemInSOI_dBm | 1000 |
| 18 | SystemInTOI_dBm | -21.8272 |
| 19 | SystemNF_dB | 55.5296 |
| 20 | SystemOutN0_dBm | -115.225 |

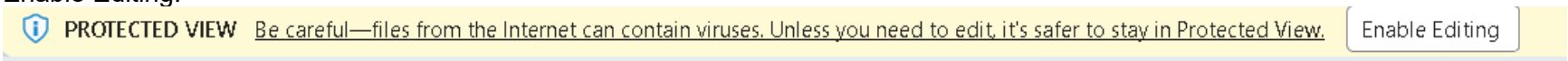
On Windows:

This data can be automatically graphed in Microsoft Excel on a Windows PC after downloading the SetUp_Budget_Sheets.xlsm using the download button:

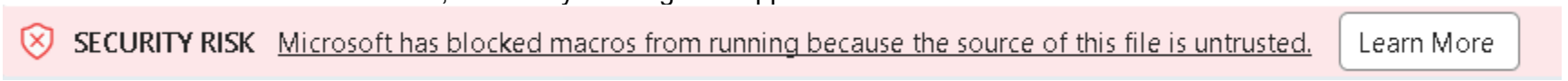
| | |
|---|---|
| Download Excel xls File | Download |

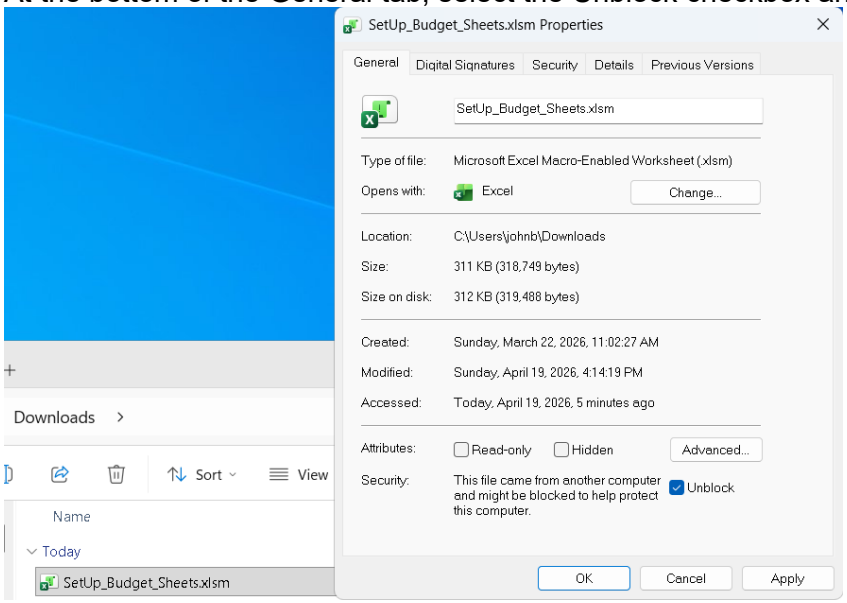
When SetUp_Budget_Sheets.xlsm is opened the first time:

- Enable Editing:



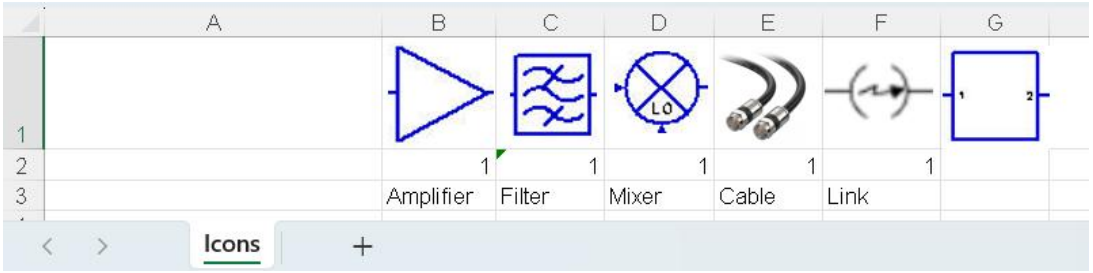

- Since this Excel file contains a Macro, a Security message will appear:



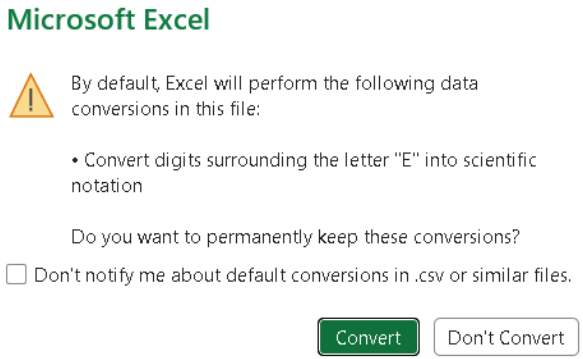

- To enable the Macro, do the following:
  - Open Windows File Explorer and go to the folder where you saved the file.
  - Right-click the file and choose Properties from the context menu.
  - At the bottom of the General tab, select the Unblock checkbox and select OK.
  - 


The SetUp_Budget_Sheets.xlsm file can now be used with the RF budget data.

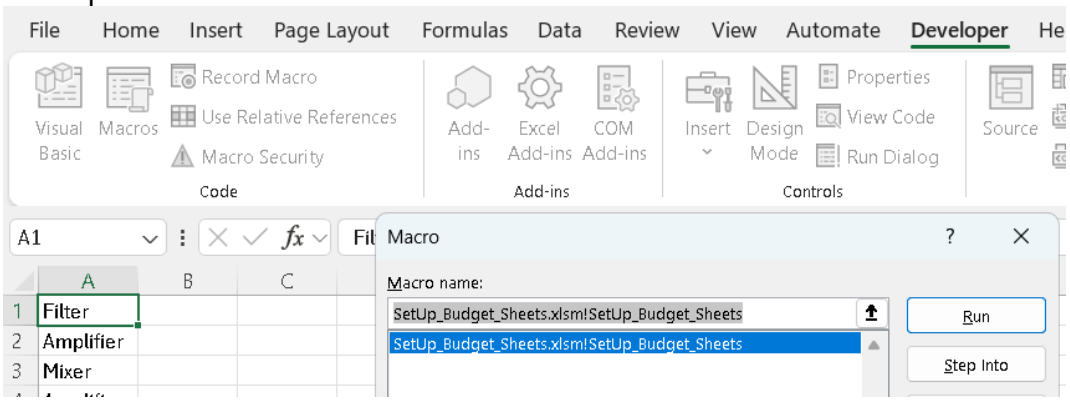
Open the SetUp_Budget_Sheets.xlsm file in Excel.




Open the RF budget CSV file in Excel. Excel will prompt to convert the scientific notation. Select 'Convert".




Select Developers > Macros > Run:

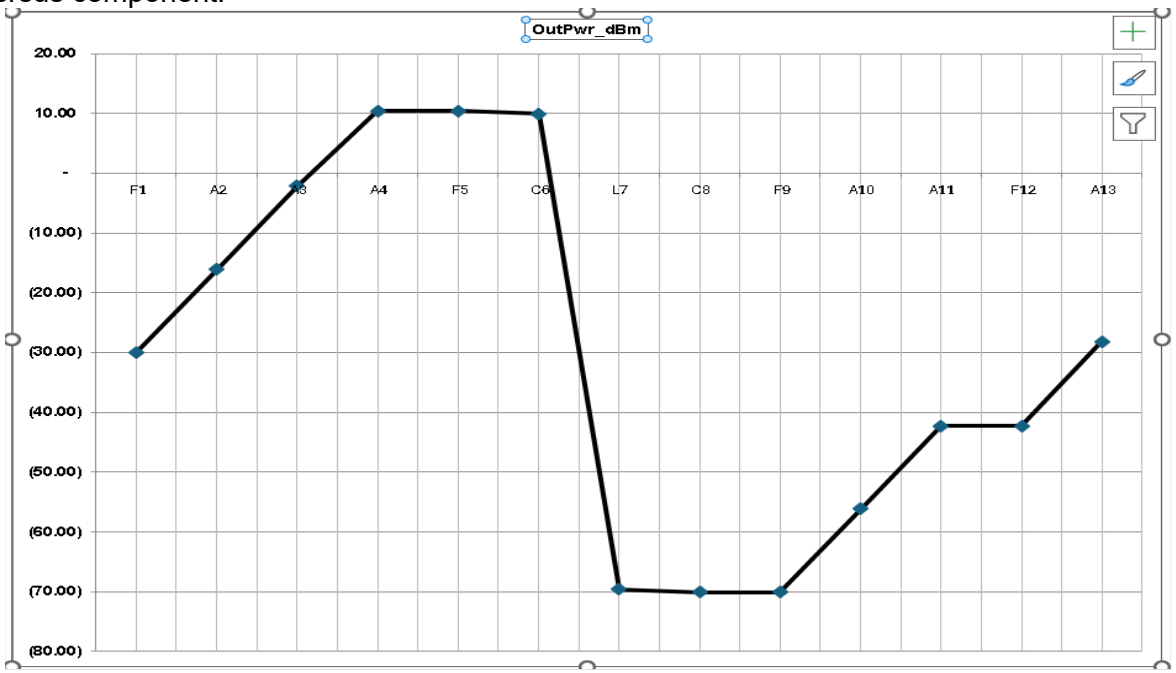


After the Macro is Run, the 'Cascade_Meas' sheet will appear showing a table for the 13 components in this default example and their associated measurement values:

| A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Meas_Name** | **F1** | **A2** | **A3** | **A4** | **F5** | **C6** | **L7** | **C8** | **F9** | **A10** | **A11** | **F12** | **A13** |
| Cmp_Ctrb_SysNF_NoImage_dB | 0.00 | 3.00 | 0.09 | 0.00 | 0.00 | 0.00 | 49.20 | 0.02 | (0.00) | 0.18 | 0.01 | 0.00 | 0.00 |
| Cmp_Ctrb_SysTOI_dB | - | - | - | 38.43 | - | - | - | - | - | - | 0.00 | - | 0.17 |
| Cmp_LS_GainChange_dB | (0.00) | 0.00 | (0.01) | (1.42) | - | - | (0.00) | (0.00) | 0.00 | (0.00) | (0.00) | 0.00 | (0.00) |
| Cmp_NF_dB | 0.00 | 3.00 | 3.00 | 3.00 | 0.00 | 0.49 | 93.65 | 0.49 | 0.00 | 3.00 | 3.00 | 0.00 | 3.00 |

For this default table, there are 73 lines.

Other tab in the CSV file will show a graph for each of the measurements. For example, here is the graph for the Output Power in dBm versus component.




This graph coincides with line 57 in the table.

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2 | **Meas_Name** | **F1** | **A2** | **A3** | **A4** | **F5** | **C6** | **L7** | **C8** | **F9** | **A10** | **A11** | **F12** | **A13** |
| 57 | **OutPwr_dBm** | (30.04) | (16.11) | (2.18) | 10.40 | 10.40 | 9.90 | (69.57) | (70.06) | (70.06) | (56.13) | (42.24) | (42.24) | (28.21) |

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