Getting Started with EMIT - Tutorial 5

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Conventions Used in this Guide

Please take a moment to review how instructions and other useful information are presented in this documentation.

- Procedures are presented as numbered lists. A single bullet indicates that the procedure has only one step.
- Bold type is used for the following:
  - Keyboard entries that should be typed in their entirety exactly as shown. For example, "**copy file1**" means you must type the word **copy**, then type a space, and then type **file1**.
  - On-screen prompts and messages, names of options and text boxes, and menu commands. Menu commands are often separated by greater than signs (>). For example, "click **HFSS** > **Excitations** > **Assign** > **Wave Port**."
  - Labeled keys on the computer keyboard. For example, "Press **Enter**" means to press the key labeled **Enter**.
- Italic type is used for the following:
  - Emphasis.
  - The titles of publications.
  - Keyboard entries when a name or a variable must be typed in place of the words in italics. For example, "**copy** *filename*" means you must type the word **copy**, then type a space, and then type the name of the file.
- The plus sign (+) is used between keyboard keys to indicate that you should press the keys at the same time. For example, "Press Shift+F1" means to press the **Shift** key and, while holding it down, press the **F1** key also. You should always depress the modifier key or keys first (for example, Shift, Ctrl, Alt, or Ctrl+Shift), continue to hold it/them down, and then press the last key in the instruction.

Accessing Commands: *Ribbons, menu bars,* and *shortcut menus* are three methods that can be used to see what commands are available in the application.

- The *Ribbon* occupies the rectangular area at the top of the application window and contains multiple tabs. Each tab has relevant commands that are organized, grouped, and labeled. An example of a typical user interaction is as follows:

  "Click **Schematic** > **Line**"

This instruction means that you should click the **Line** command on the **Schematic** ribbon tab. An image of the command icon, or a partial view of the ribbon, is often included with the instruction.

- The *menu bar* (located above the ribbon) is a group of the main commands of an application arranged by category such File, Edit, View, Project, etc. An example of a typical user interaction is as follows:

  "On the **File** menu, click the **Open Examples** command" means you can click the **File** menu and then click **Open Examples** to launch the dialog box.

- Another alternative is to use the *shortcut menu* that appears when you click the right-mouse button. An example of a typical user interaction is as follows:

  “Right-click and select **Assign Excitation> Wave Port**” means when you click the right-mouse button with an object face selected, you can execute the excitation commands from the shortcut menu (and the corresponding sub-menus).

Getting Help: Ansys Technical Support

For information about Ansys Technical Support, go to the Ansys corporate Support website, http://www.ansys.com/Support. You can also contact your Ansys account manager in order to obtain this information.

All Ansys software files are ASCII text and can be sent conveniently by e-mail. When reporting difficulties, it is extremely helpful to include very specific information about what steps were taken or what stages the simulation reached, including software files as applicable. This allows more rapid and effective debugging.

Help Menu

To access help from the Help menu, click **Help** and select from the menu:

- **[product name] Help** - opens the contents of the help. This help includes the help for the product and its *Getting Started Guides*.
- **[product name] Scripting Help** - opens the contents of the *Scripting Guide*.
- **[product name] Getting Started Guides** - opens a topic that contains links to Getting Started Guides in the help system.

Context-Sensitive Help

To access help from the user interface, press **F1**. The help specific to the active product (design type) opens.

You can press **F1** while the cursor is pointing at a menu command or while a particular dialog box or dialog box tab is open. In this case, the help page associated with the command or open dialog box is displayed automatically.

Table of Contents

1 - Introduction

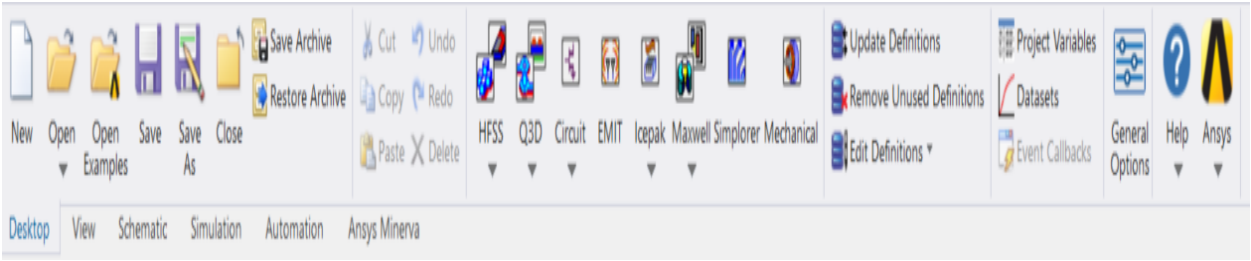
The focus of this tutorial is to demonstrate how to create a receiver susceptibility model. The susceptibility model will be defined based on the details of the WiFi 6 standard.

Key Concepts

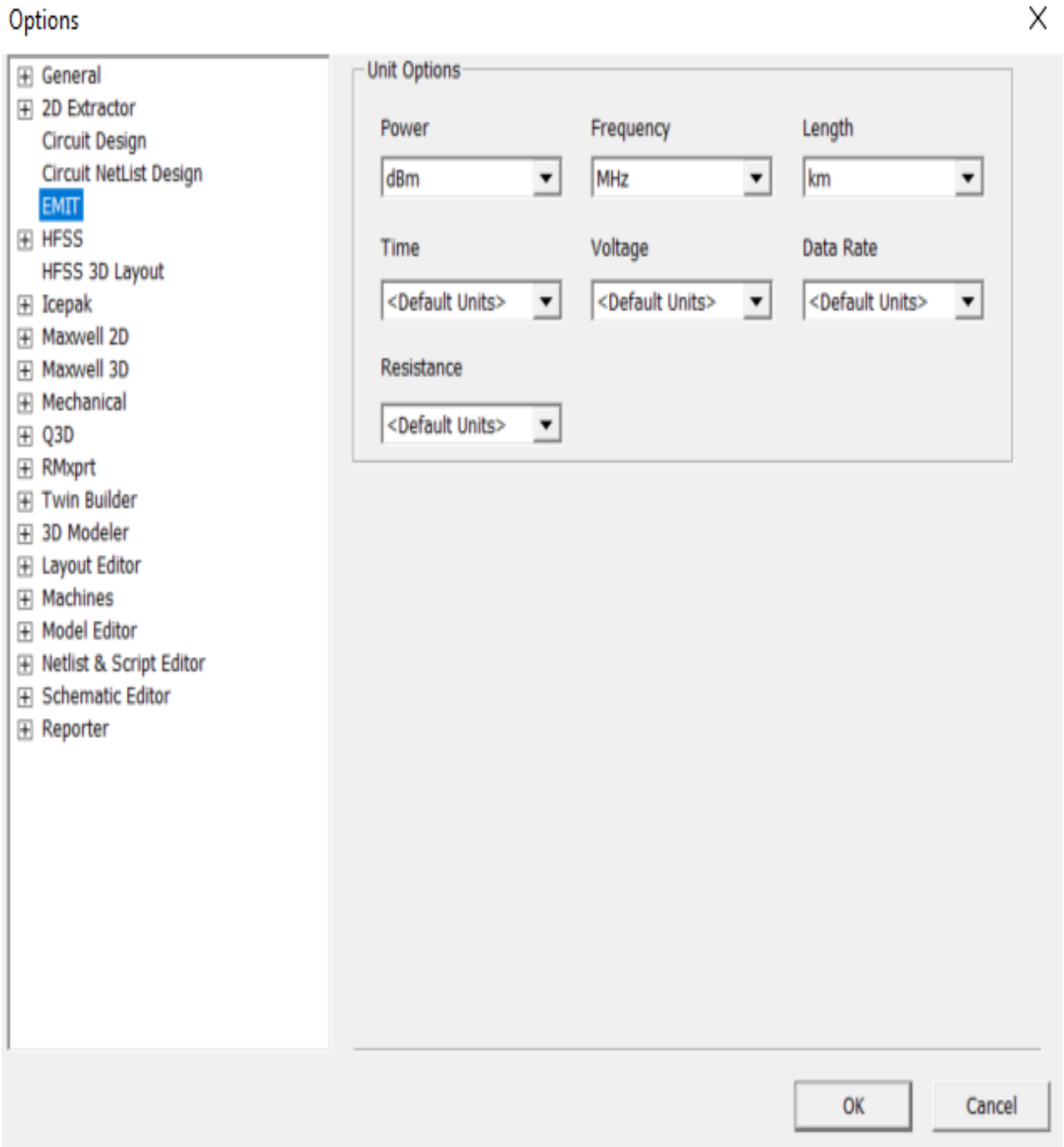
- Creating receiver susceptibility models
- Interpreting radio standards

2 - Add a Radio to an EMIT Design

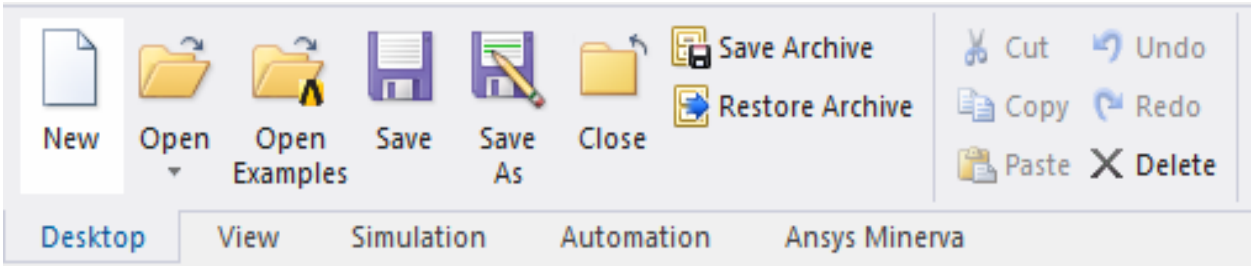
Before starting the tutorial, we will change the units used in EMIT to MHz, to better suit the frequency range that we will be using. To so do, select **General Options** from the right side of the ribbon area under the **Desktop** tab, as shown below.



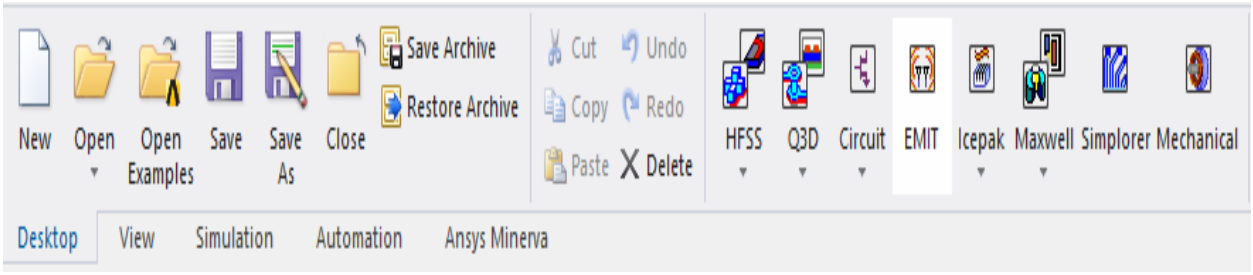
In the **Options** window, select EMIT from the list of categories and then under **Frequency** select MHz from the drop-down options. Click **OK** to save the change.



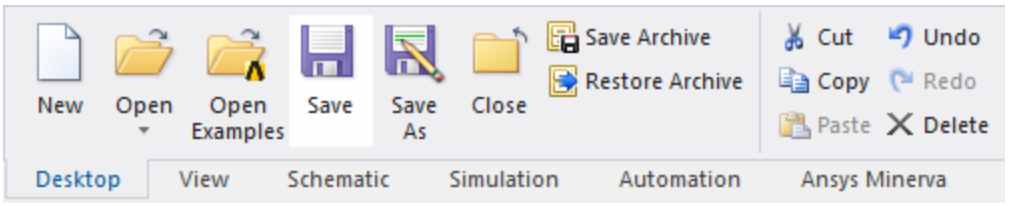
If you do not already have a new project open, create a new project by clicking **New** in the ribbon area under the **Desktop** tab.



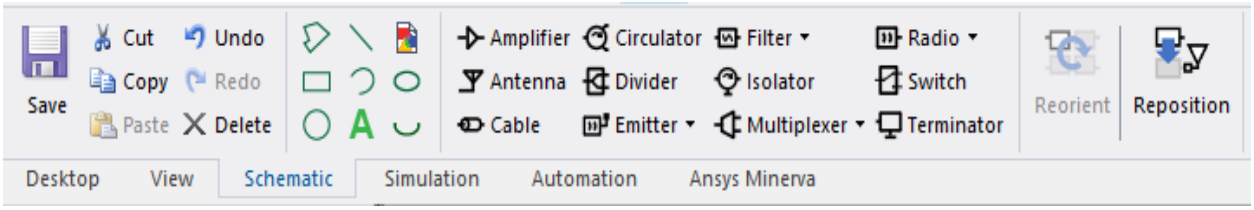
To add an **EMIT Design** to the new project, select **EMIT** from the ribbon area under the **Desktop** tab. This can also be done by right-clicking the project in the **Project Manager** window and selecting **Insert > Insert EMIT Design**.



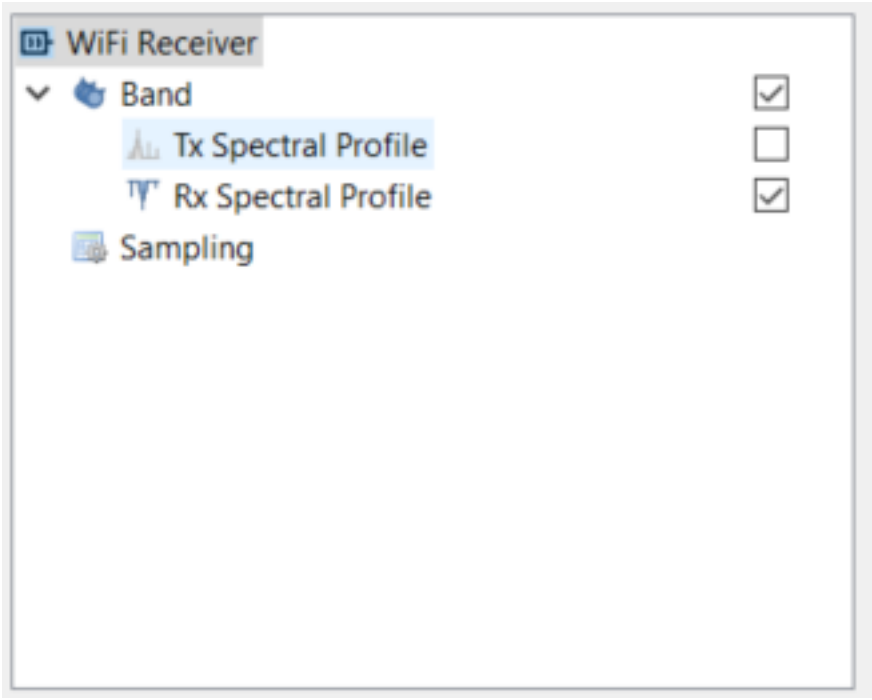
Save the project as "Tutorial 5" by pressing the **Save** icon in the ribbon area, shown below. We suggest that you save this to a folder somewhere in your user directory (as opposed to the EMIT installation directory, which is read-only).



This tutorial uses a single radio which will be configured as a receiver only. To add a radio to the design, click the **Radio > New Radio** icon in the **Schematic** tab of the ribbon toolbar.



To modify the radio, double-click on the new radio component, or right-click and select **Configure**. In the top left of the **Configuration** window, you can find the node tree for the new radio. Right-click on the node titled *New Radio* and select **Rename**. Set the name for the radio to **WiFi Receiver**. Next, expand the **Band** node and then deselect the **Tx Spectral Profile** node to disable the transmitting characteristics of the Band since we are only modeling the receive capabilities in this tutorial.

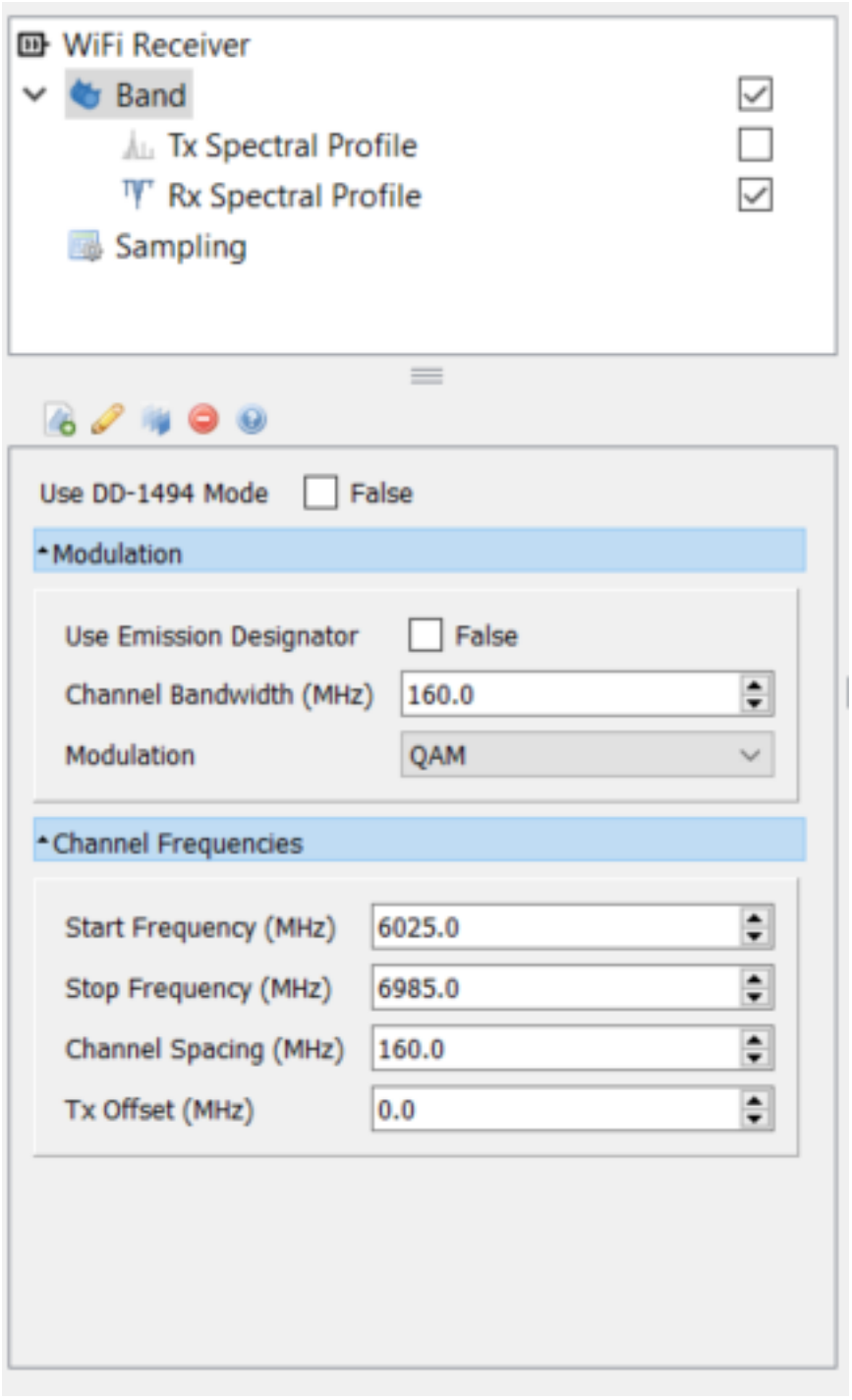


3 - Configure the Band Characteristics

We will be referring to the 802.11ax-2021 standard for much of this tutorial. A copy of the standard can be downloaded from the IEEE Xplore website, but we will also include references to the data required from the standard. For simplicity, we will only be modeling the parameters required for the highest data rate. That is, the 160 MHz channels with 1024-QAM and a 5/6 coding rate. Section 27.5 of the standard shows the mappings between the modulation and coding to the data rate. EMIT's **Commercial Unlicensed Systems** library also contains a WiFi 6 radio model that includes all of the defined modulation and coding combinations for both the 5 GHz and 6 GHz operating bands.

The **Band** level characteristics of a radio typically apply to both the transmitter and receiver. These are parameters that need to be synchronized between the Tx and Rx for communication to occur such as the operating channels and the modulation scheme. For this tutorial, we are going to focus on the highest speed channels which use 160 MHz of bandwidth and operate in the 6 GHz frequency band. A good list of the channels can be found here, but there are many other online sites that also list them. The first 6 Ghz channel with a 160 MHz bandwidth is centered at 6.025 GHz and the final channel in the band is centered at 6.985 GHz.

With the data above, we can fully define the **Band** of the receiver as shown below.



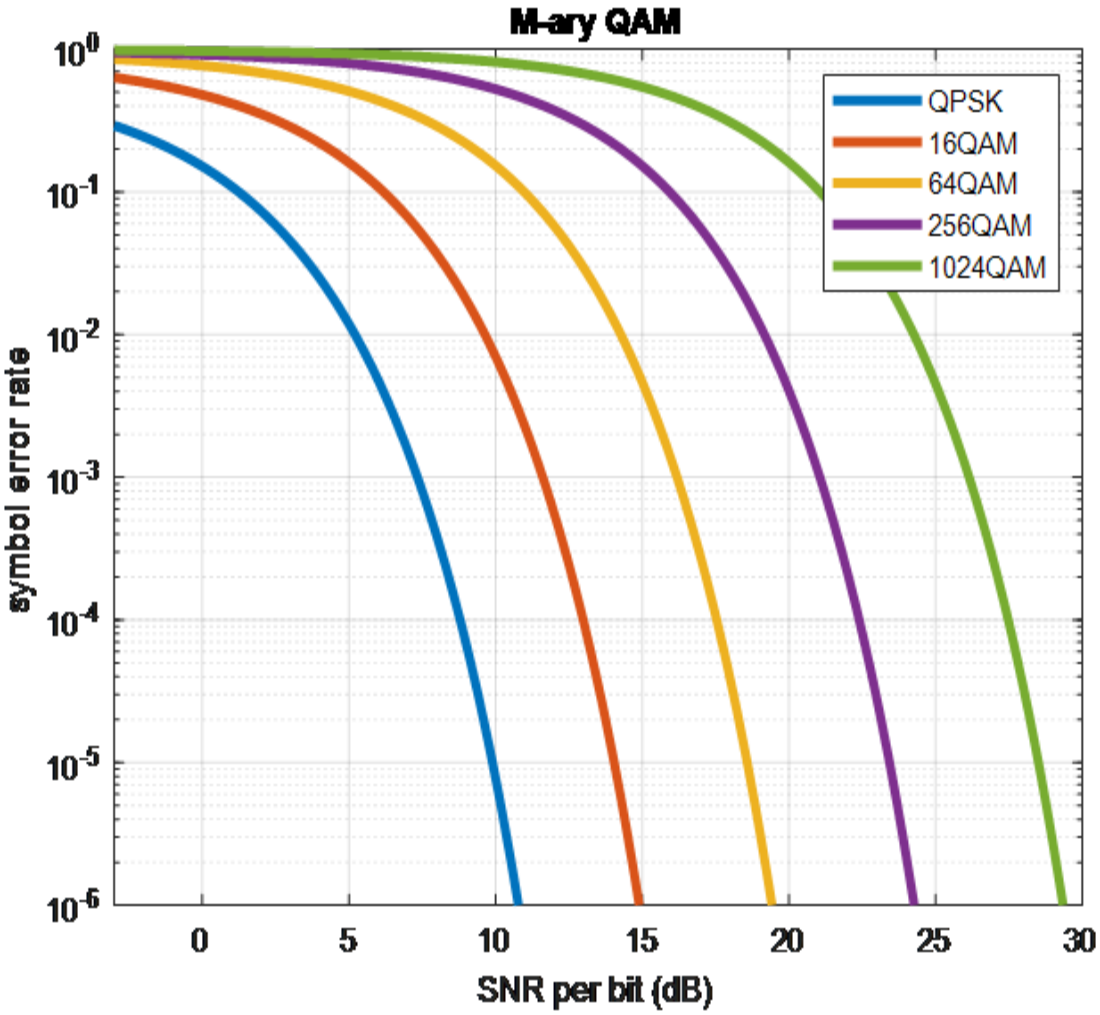
4 - Configure the Rx Spectral Profile Characteristics

The next step is to define the receiver specific parameters. We will start with the receiver's **minimum input level sensitivity** or the **Min. Received Signal Power**. This is the weakest signal that the receiver can detect and properly decode and is defined in the following table. For a 160 MHz channel using R=5/6 and 1024-QAM, the *Minimum Sensitivity = - 43 dBm.*

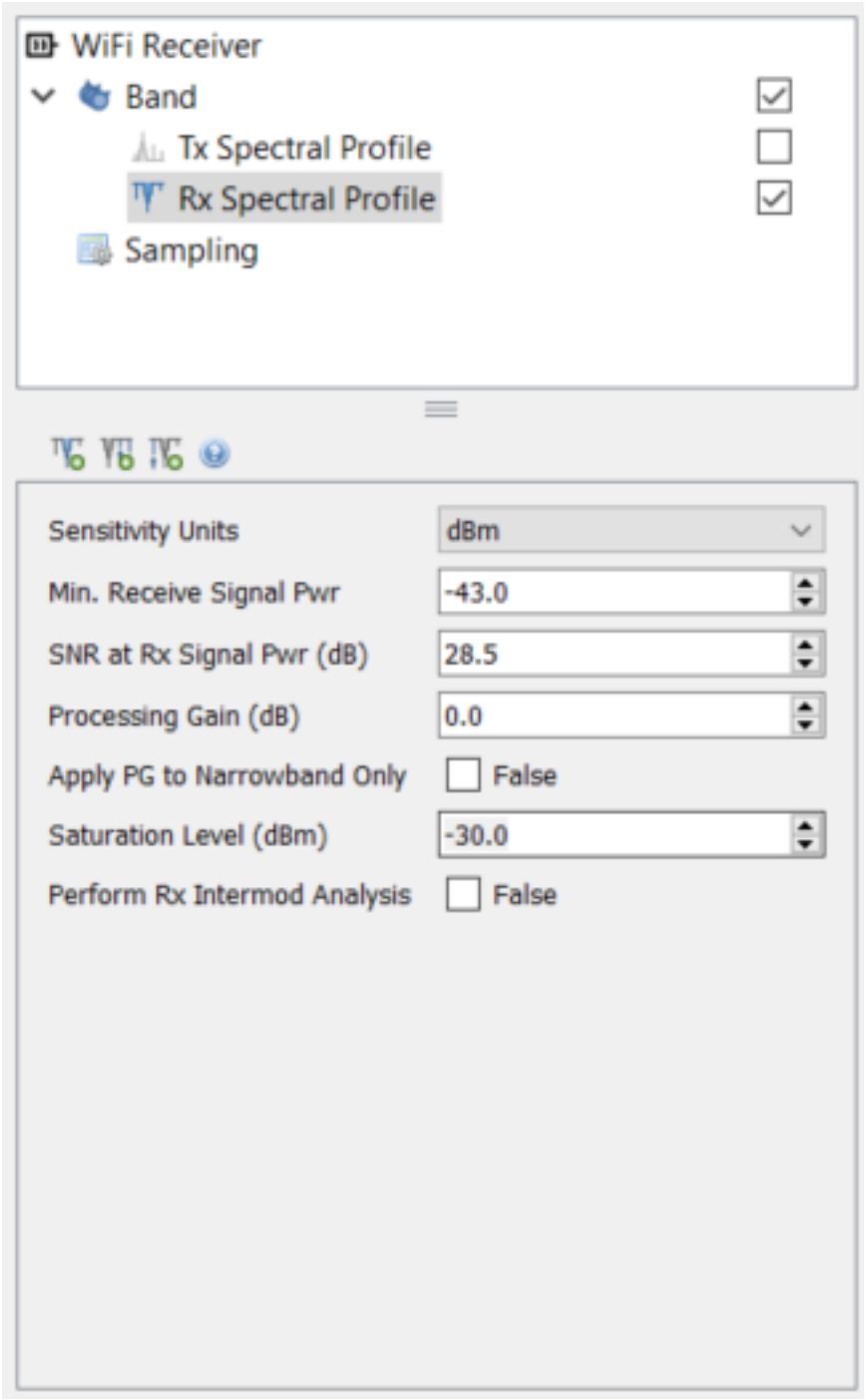
Receiver minimum input level sensitivity

Modulation		Rate (*R*)	Minimum sensitivity (20 MHz PPDU) (dBm)	Minimum sensitivity (40 MHz PPDU) (dBm)	Minimum sensitivity (80 MHz PPDU) (dBm)	Minimum sensitivity (160 MHz or 80+80 MHz PPDU) (dBm)
Without DCM	With DCM					
N/A	BPSK	1/2	–82	–79	–76	–73
BPSK	QPSK	1/2	–82	–79	–76	–73
QPSK	16-QAM	1/2	–79	–76	–73	–70
QPSK	16-QAM	3/4	–77	–74	–71	–68
16-QAM	N/A	1/2	–74	–71	–68	–65
16-QAM	N/A	3/4	–70	–67	–64	–61
64-QAM	N/A	2/3	–66	–63	–60	–57
64-QAM	N/A	3/4	–65	–62	–59	–56
64-QAM	N/A	5/6	–64	–61	–58	–55
256-QAM	N/A	3/4	–59	–56	–53	–50
256-QAM	N/A	5/6	–57	–54	–51	–48
1024-QAM	N/A	3/4	–54	–51	–48	–45
1024-QAM	N/A	5/6	–52	–49	–46	–43

Next, we need to know the required signal-to-noise ratio (SNR) for 1024-QAM. For a symbol error rate of 10^{-5}, 1024-QAM requires $SNR \cong 28.5\ dB$. The **Processing Gain** of a receiver is dependent on the actual implementation of the hardware and is thus not specified in the standard. For this tutorial, we will set the *Processing Gain = 0 dB*.



Finally, for the **Rx Spectral Profile**, we need to define the **Saturation Level** or the receiver's **maximum input level**. Input power levels greater than this level will typically overload the receiver and/or lead to significant intermodulation products in the receiver's front end which degrades the performance of the receiver and can be a significant source of interference. The **maximum input level** for WiFi 6 is defined as -30 dBm in the 6 GHz band in section 27.3.20.5 of the standard. The final **Rx Spectral Profile** parameters should be defined as shown below.



5 - Defining Receiver Selectivity

At this point our receiver model meets the minimum requirements of what is needed for a preliminary desense analysis. However, most standards typically provide some additional information that can further refine the model and improve the accuracy of the results. For receivers, this additional information is typically called the **adjacent channel rejection** and the **nonadjacent channel rejection** and is modeled in EMIT as **Receiver Selectivity**.

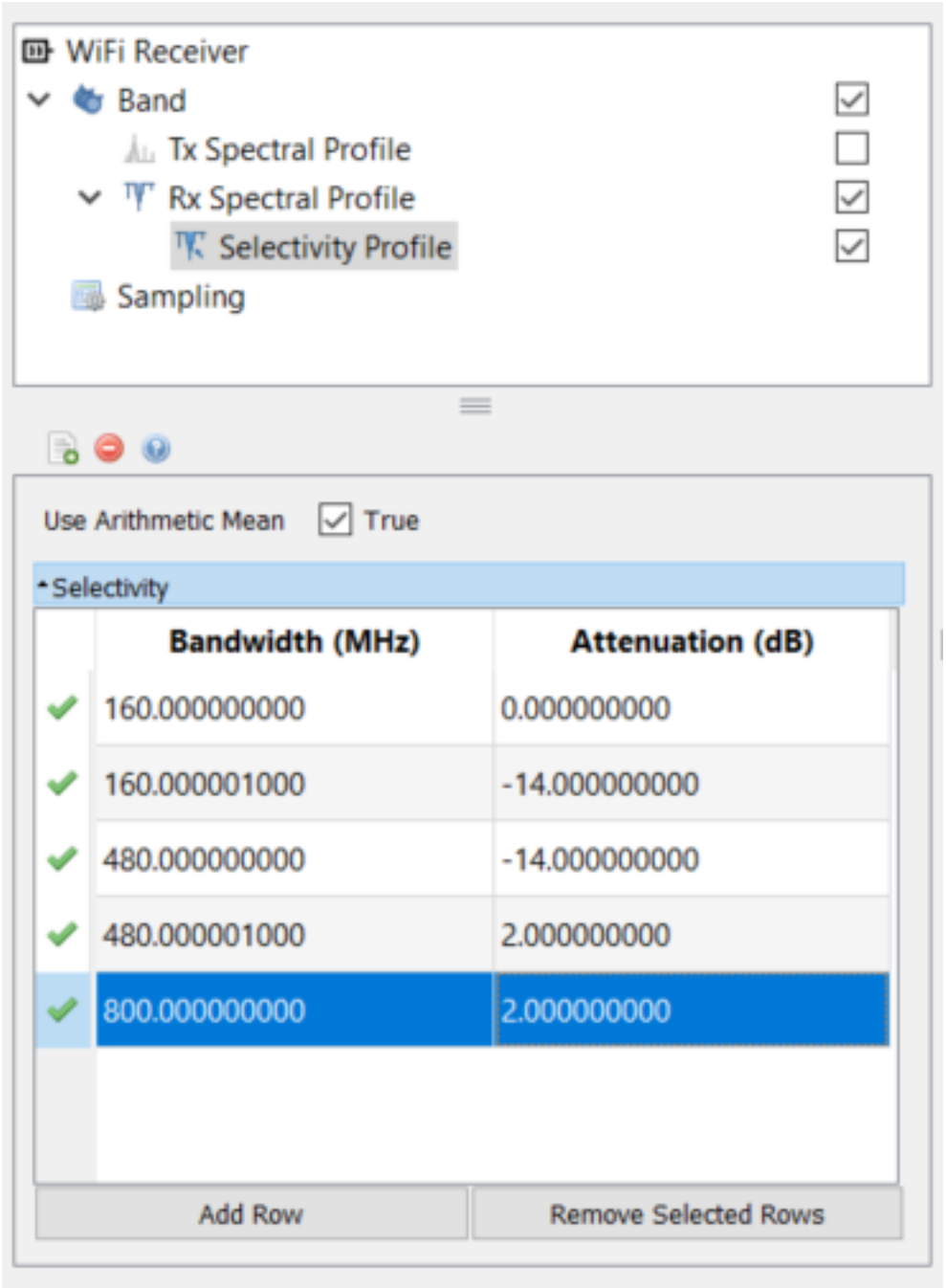
To add a **Selectivity** model to our receiver model, right-click on the **Rx Spectral Profile** node and select **Add Rx Selectivity** or press the  icon in the **Rx Spectral Profile's** property panel. The standard defines the adjacent and nonadjacent channel rejection criteria in sections 27.3.20.3 and 27.3.20.4, respectively, and a summary is specified in the following table.

Minimum required adjacent and nonadjacent channel rejection levels

Modulation		Rate (*R*)	Adjacent channel rejection (dB)		Nonadjacent channel rejection (dB)	
Without DCM	With DCM		20/40/80/160 MHz channel	80+80 MHz channel	20/40/80/160 MHz channel	80+80 MHz channel
N/A	BPSK	1/2	16	13	32	29
BPSK	QPSK	1/2	16	13	32	29
QPSK	16-QAM	1/2	13	10	29	26
QPSK	16-QAM	3/4	11	8	27	24
16-QAM	N/A	1/2	8	5	24	21
16-QAM	N/A	3/4	4	1	20	17
64-QAM	N/A	2/3	0	–3	16	13
64-QAM	N/A	3/4	–1	–4	15	12
64-QAM	N/A	5/6	–2	–5	14	11
256-QAM	N/A	3/4	–7	–10	9	6
256-QAM	N/A	5/6	–9	–12	7	4
1024-QAM	N/A	3/4	–12	–15	4	1
1024-QAM	N/A	5/6	–14	–17	2	–1

In the property panel of the **Selectivity** node, click to "Add Row". The first row simply defines the tuned channel bandwidth, in this case 160 MHz with 0 dB attenuation. Since this table defines the adjacent channel and one additional channel, we will add four more rows to the **Selectivity** profile. Two rows are need for each channel to specify the end points of the bandwidth and

create a rectangular channel shape (that is, constant rejection across the entire channel). The standard specifies that each adjacent channel is spaced by **W MHz** where **W** is the bandwidth of the channel. EMIT will center the bandwidths about the tuned channel so we need the 1st adjacent channel bandwidth to include the channel bandwidth (W) plus the bandwidth of one channel **above** and one channel **below** making the total bandwidth of the 1st adjacent channel = 3W. Similarly, the total bandwidth of the 2nd adjacent channel includes the channel bandwidth and two channels both above and below the tuned channel, resulting in a total bandwidth equal to 5W. Additionally, the attenuation values for each of these rows are -14 dB and +2 dB, respectively. For the 160 MHz channel bandwidth, the Selectivity bandwidths become 480 MHz and 800 MHz, respectively.



Note that *Use Arithmetic Mean* = TRUE. This centers the bandwidths about the tuned channel using the arithmetic mean, whereas deselecting **Use Arithmetic Mean** will use the geometric mean to center the selectivity bandwidths.

EMIT's receiver model can also include spurious responses and mixer products, but these parameters are dependent on the specific design and implementation of the receiver architecture

and are thus not included in the standard. A plot of the final receiver susceptibility model is shown below.