Ansys 2025 R2

POWERING INNOVATION THAT DRIVES HUMAN ADVANCEMENT

Getting Started with EMIT - Tutorial 7

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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 learning to create a detailed EMIT radio model from a typical manufacturer's specification sheet.

Key Concepts

- Interpreting manufacturers' specification sheets
- Creating detailed radio models

2 - Gathering Data

The first step in the radio modeling process is to gather as much data as possible on the radio's RF specifications. Some potential sources of this data are:

- Equipment manufacturer specification/data sheets
- Equipment user manuals
- Test and measurement data

For this example, we will create the radio based off a data sheet for a fictional, yet representative, radio from ABC Communications pictured below.

FREQUENCY RANGE:
2.0-29.999 MHz

NUMBER OF CHANNELS:
28,000

METHOD OF FREQUENCY CHANGE:
Automatic resonating power amplifier and antenna matching circuits.

POWER SOURCE:
Model A – 115 V, 400 cps, single phase
Model B – 208 V, 400 cps, 3 phase

POWER REQUIREMENTS:
Receive – 190 Watts
Transmit SSB – 850 Watts
Transmit AM – 1100 Watts

FREQUENCY STABILITY:
0.7 parts per million per month

NOMINAL CHANNEL SETTLING TIME:
6 seconds

AMBIENT TEMPERATURE RANGE:
-40°C to +70°C

AMBIENT HUMIDITY RANGE:
Up to 95% relative humidity

ALTITUDE RANGE:
Up to 30,000 feet

TRANSMITTING CHARACTERISTICS

RF POWER OUTPUT:
SSB – 400 Watts PEP
AM – 100 Watts Carrier

RF OUTPUT IMPEDANCE:
52 Ohms

VSWR:
Not to exceed 1.3:1

AUDIO INPUT IMPEDANCE:
100 Ohms unbalanced; 600 Ohms balanced

AUDIO FREQUENCY RESPONSE:
5 dB peak-to-valley ratio from 300-3000 Hz

DISTORTION:
SSB – 3rd order products down at least 30 dB.
AM – less than 20% at 85% modulation

RECEIVING CHARACTERISTICS

SENSITIVITY:
SSB – 1 uV for a 10 dB (S+N)/N ratio
AM – 3 uV modulated 30% at 1 kHz for a 6 dB (S+N)/N ratio

SELECTIVITY:
SSB – 2.85 kHz, 6 dB down; 6.0 kHz, 60 dB down
AM – 5.5 kHz, 6 dB down; 14 kHz, 60 dB down

AGC CHARACTERISTICS:
Maximum variation of audio output is 6 dB for signals from 10-100,000 uV. No overload below 1 V signal input

IF REJECTION:
80 dB minimum

AUDIO OUTPUT POWER:
100 mW into a 300 Ohm load

AUDIO DISTORTION:
Less than 10%

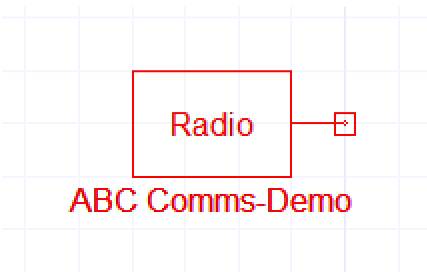
AUDIO FREQUENCY RESPONSE:
5 dB peak-to-valley ratio from 300-3000 Hz

ABC COMMUNICATIONS

3 - Adding the Radio

The next step in the radio modeling process is to add a new radio to the schematic. To do this, click the Radio icon in the ribbon area and select **New Radio**.

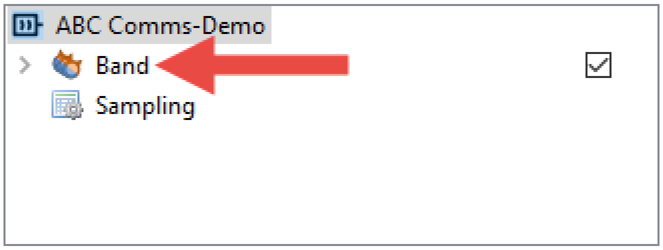
Rename the radio "ABC Comms-Demo" to change the way it displays in the schematic:

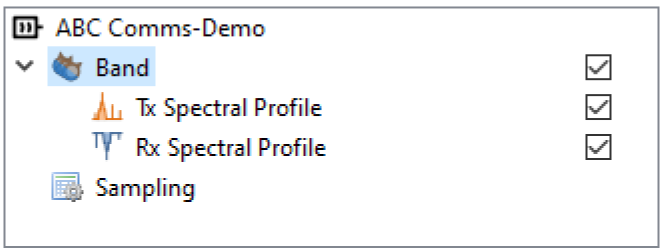


Double-click on the new radio component created in the schematic, or right-click and select **Configure** to open its **Radio Configuration** window. In the top left of this window is the node tree for the new radio. This makes it easier to identify the radio and quickly determine its functionality.

4 - Defining Operating Bands

Now that the radio has been created, we need to define the operating bands of the ABC Comms Radio. In EMIT, a Band is automatically added with a new radio, as shown below:





By default, this Band is capable of both transmitting and receiving. To configure it as a transmit only band you would deselect the Rx Spectral Profile node. To set it as a receive only band, you would deselect the Tx Spectral Profile node.

For this example, we will leave it as a Tx/Rx band.

Most of the radio specifications required to define the Tx Band are found in the spec sheet.

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Up to 30,000 feet

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RF OUTPUT IMPEDANCE:
52 Ohms

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Not to exceed 1.3:1

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100 Ohms unbalanced; 600 Ohms balanced

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Maximum variation of audio output is 6 dB for signals from 10-100,000 uV. No overload below 1 V signal input

IF REJECTION:
80 dB minimum

AUDIO OUTPUT POWER:
100 mW into a 300 Ohm load

AUDIO DISTORTION:
Less than 10%

AUDIO FREQUENCY RESPONSE:
5 dB peak-to-valley ratio from 300-3000 Hz

ABC COMMUNICATIONS

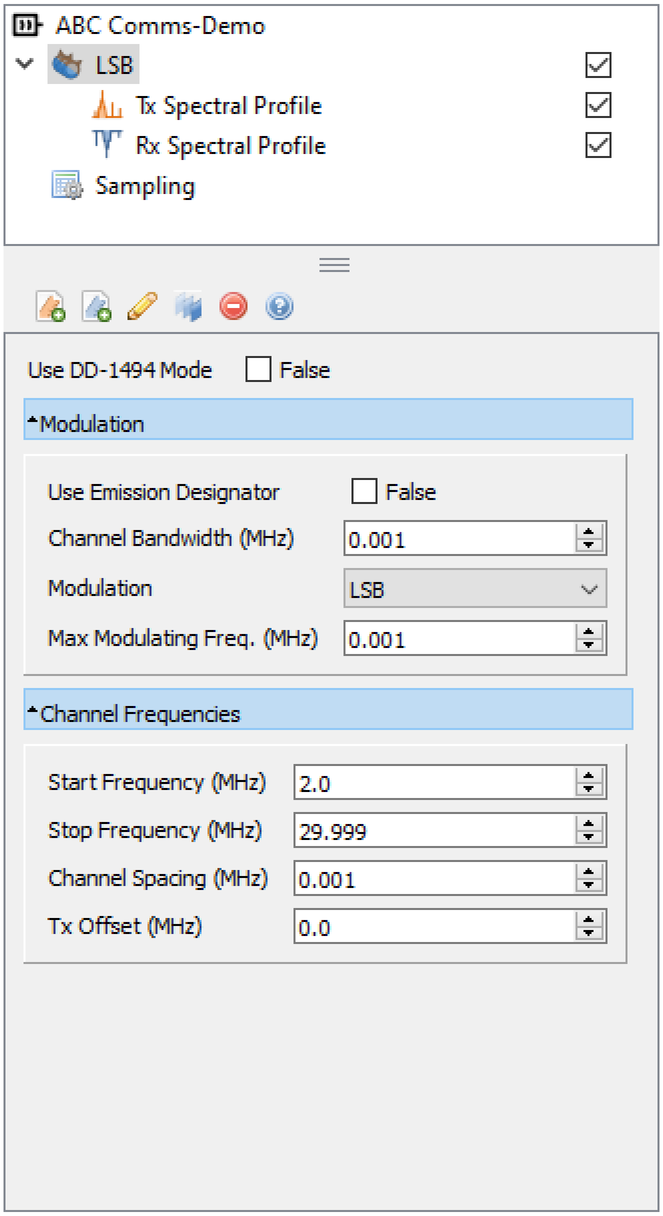
Under TRANSMITTING CHARACTERISTICS, the sheet states that the ABC Comms Radio uses both Single Sideband (SSB) modulation and Amplitude Modulation (AM). In EMIT, each modulation is modeled as a separate Tx/Rx band, so we will need at least 2 Tx bands and 2 Rx bands under the Radio node of our model.

Since the specification sheet does not specify whether Lower Sideband (LSB) or Upper Sideband (USB) is used, we will model both as a worst case, which requires 3 Tx bands and 3 Rx bands.

We will begin by modeling the LSB radio band. Right-click the default **Band** and select **Rename**.

Rename this band "LSB".

Once the band is renamed, click it so that the property panel appears below it:



Modulation should always be set first because some of the parameters within the Band vary depending on the specific modulation selected. For this Band, select **LSB** from the modulation drop-down menu, then apply the following settings:

- Channel Bandwidth: 1 kHz.
- Max Modulating Frequency: 1 kHz.

The spec sheet does not specify the bandwidth of the modulating frequency, so we can assume that it is equal to the RF channel bandwidth (in this case, 1 kHz). This is a conservative approximation since a modulating frequency greater than this would result in significant adjacent channel interference due to the resulting overlap in the transmitted spectra.

Since the data sheet does not specify a Channel Bandwidth, we can set it to 1 kHz which is the maximum bandwidth that avoids adjacent channel interference and matches the transmitted bandwidth that is defined by a Max Modulating Frequency = 1 kHz. The final property panel for the LSB band is shown below.

Next, set the **Channel Frequencies**, per the spec sheet:

- Start Frequency: 2.0 MHz
- Stop Frequency: 29.999 MHz
- Channel Spacing: 0.001 MHz ((29.999 MHz - 2.0 MHz)/(28,000 channels))

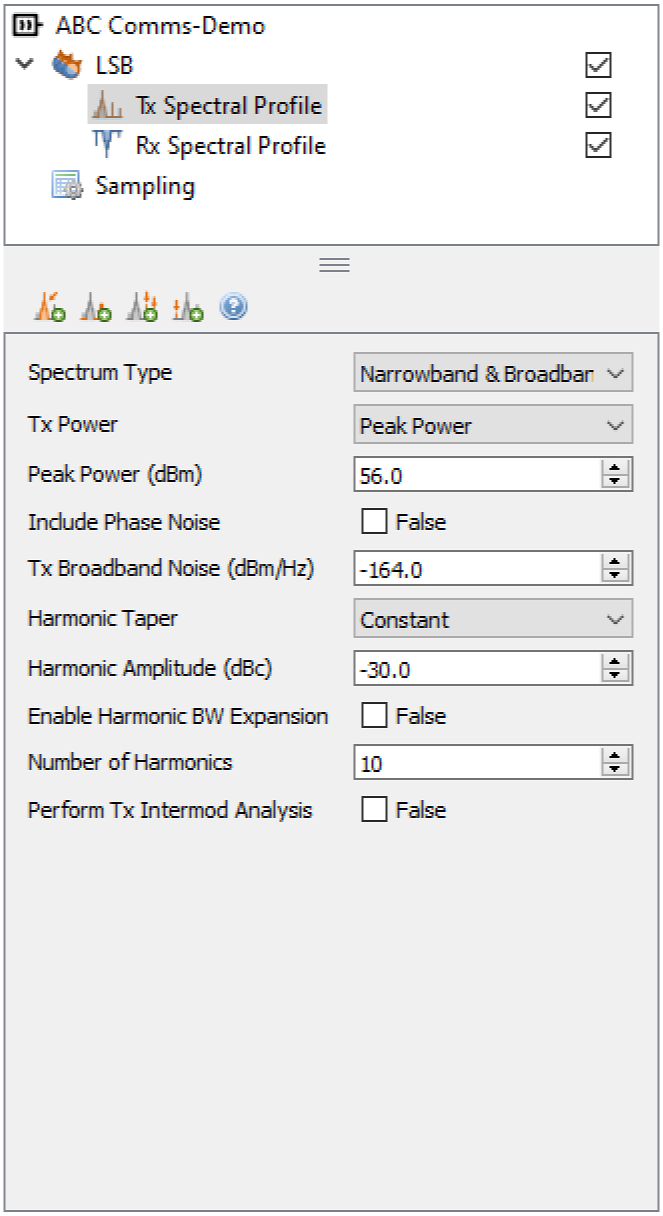
Click **Tx Spectral Profile** and continue entering parameters necessary to define our transmitted spectrum.

The parameters are:

- Spectrum Type: Narrowband & Broadband
- Tx Power: Peak Power
- Peak Power: 56 dBm
- Include Phase Noise: False
- Tx Broadband Noise: -164 dBm/Hz
- Harmonic Taper: Constant
- Harmonic Amplitude: -30 dBc
- Enable Harmonic BW Expansion: False
- Number of Harmonics: 10
- Perform Tx Intermod Analysis: False

From the spec sheet, the Peak Power of the ABC Comms radio using SSB modulation is 400 W (56 dBm). The Tx Broadband Noise of the transmitter can be calculated using ktF= -174+F [dBm] where k is the Boltzmann constant, T is the ambient temperature, and F is the transmitter noise figure. Assuming a transmitter noise figure of 10 dB (typical for high power transmitters), the Tx Broadband Noise is calculated to be -164 dBm/Hz.

The spec sheet states for SSB: "3rd order products down at least 30 dB." To err on the conservative side, we can set the Harmonic Taper to Constant via the drop-down menu and then set the Harmonic Amplitude to -30 dBc. This is a very conservative assumption since it is listed as a worst case for the 3rd order products only and the level of other (higher) products and harmonics is not specified. However, it provides a useful starting point which can be further refined as needed during the cosite analysis if EMIT predicts many false EMI issues due to the conservative estimate of these higher order harmonics or as higher fidelity data becomes available.



Now that all Tx parameters for the LSB modulation are set, it is time to set the Rx parameters.

Click **Rx Spectral Profile** to view options.

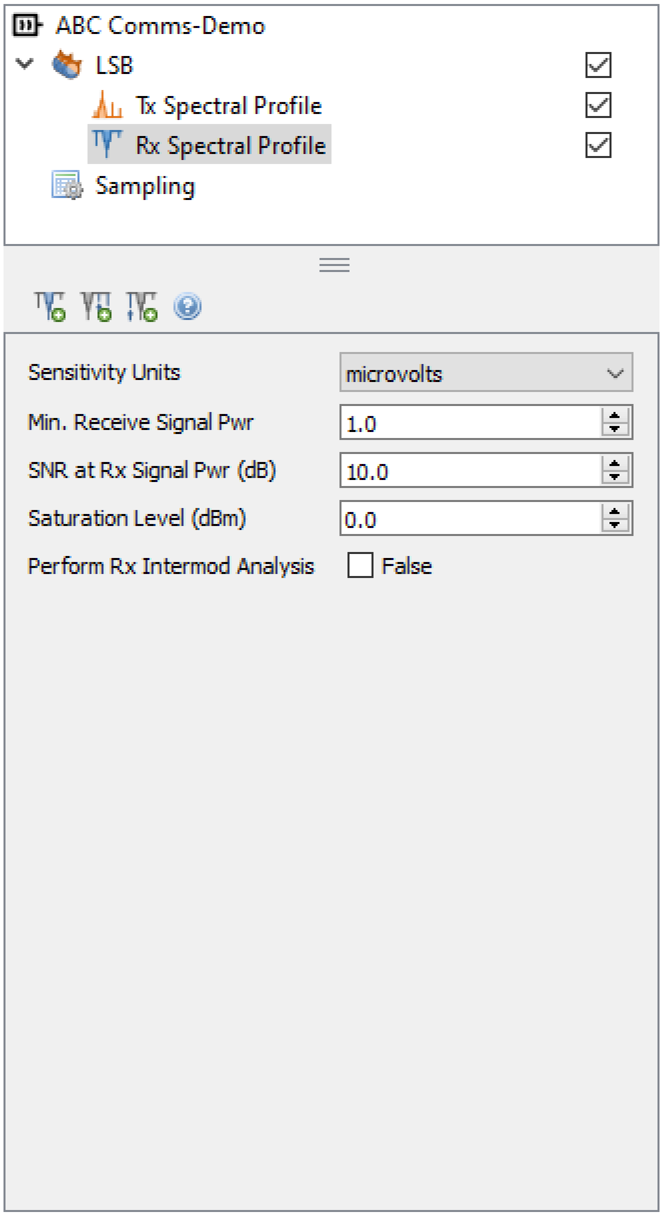
Apply the following settings:

- Sensitivity Units: μV
- Min. Receive Signal Power: 1 μV
- SNR at Rx Signal Power: 10 dB

- Saturation Level (dBm): 0 dBm
- Perform Rx Intermod Analysis: False

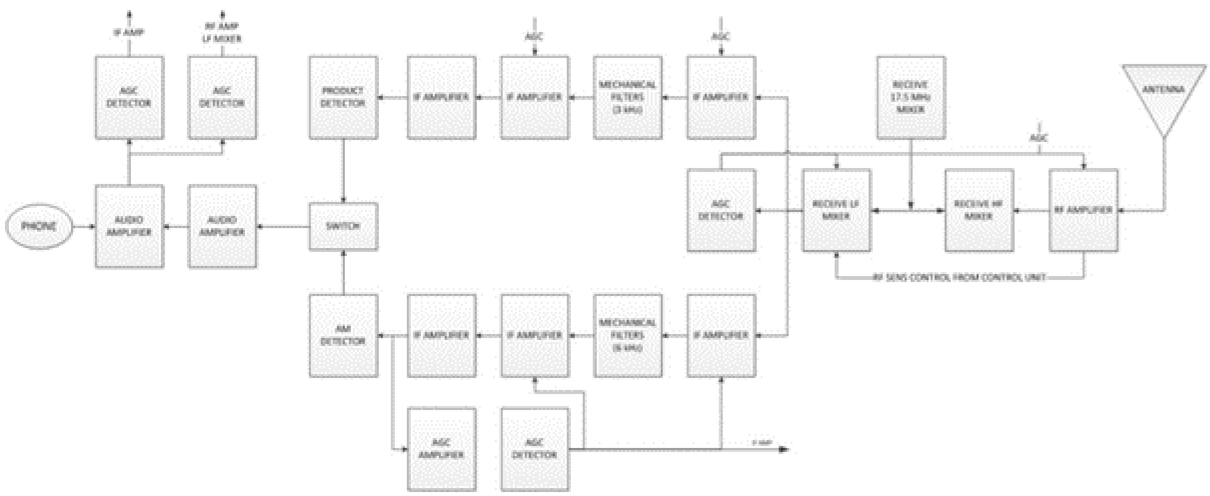
Referring to our spec sheet, under RECEIVING CHARACTERISTICS, the sensitivity of the SSB modulation is specified as "1 µV for a 10 dB (S+N/N) ratio." The (S+N/N) ratio is equivalent to the SNR at Rx Signal Pwr field in EMIT so this value should be set to 10 dB. By default, EMIT expects the units for Minimum Receive Signal Power (i.e. sensitivity) to be specified in dBm. To change the units, so we don't need to manually convert the sensitivity to dBm, select microvolts from the drop-down menu for Sensitivity Units and then specify the Minimum Receive Signal Power as 1 µV.

The next parameter on the property panel is the Saturation Level, which is seldom specified by manufacturers. It is recommended that for most applications a saturation level of 0 dBm be used as a conservative estimate, but this may not always be accurate. This is based on experience and knowledge of the typical IF amplifiers that are often found in a receiver front-end which are usually the driving force behind the maximum RF signal input level (i.e., Rx saturation level).

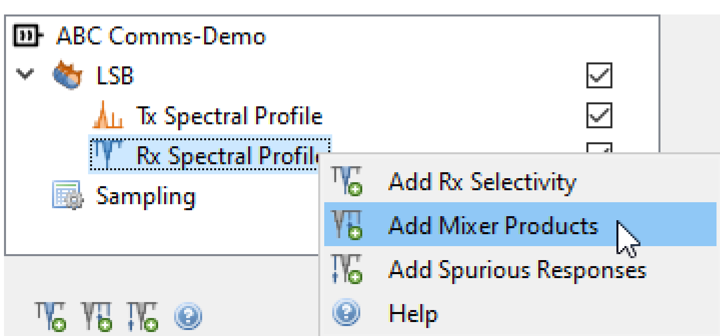

ABC Comms-Demo
LSB
Tx Spectral Profile
Rx Spectral Profile
Sampling
Sensitivity Units
microvolts
Min. Receive Signal Pwr
1.0
SNR at Rx Signal Pwr (dB)
10.0
Saturation Level (dBm)
0.0
Perform Rx Intermod Analysis
False

5 - Adding Mixer Products

If we had no further information on the receiver's performance, we could stop here and have a relatively accurate model of our receiver for use in cosite interference analyses. However, the spec sheet also contains a functional block diagram. Careful examination of this diagram shows that the receiver's first intermediate frequency (IF) is specified as 17.5 MHz. This enables us to model the receiver's mixer products, which are typically more susceptible to interference than all other frequencies except for the tuned RF channel. This is because unwanted signals occurring at these mixer product frequencies can be translated to the baseband frequency within the receiver's front-end.



To model the ABC Comms radio Rx mixer products, right-click the Rx Spectral Profile and select **Add Mixer Products**.



This creates a child node for the Rx Spectral Profile, called **Mixer Products**.

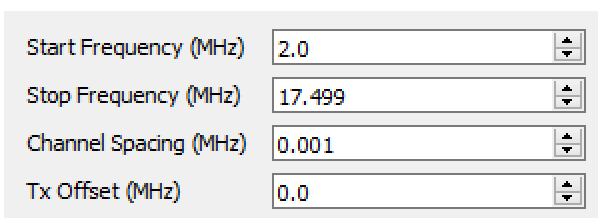
Specify its settings as follows (explanation below):

- Mixer Product Taper: Constant
- Mixer Product Susceptibility: 80 dBc
- Image Rejection: 80 dBc
- Maximum RF Harmonic Order: 3
- Maximum LO Harmonic Order: 3
- Mixing Mode: LO Above Tuned RF Frequency
- 1st IF Frequency: 17.5 MHz
- Mixer Product Table Units: Absolute

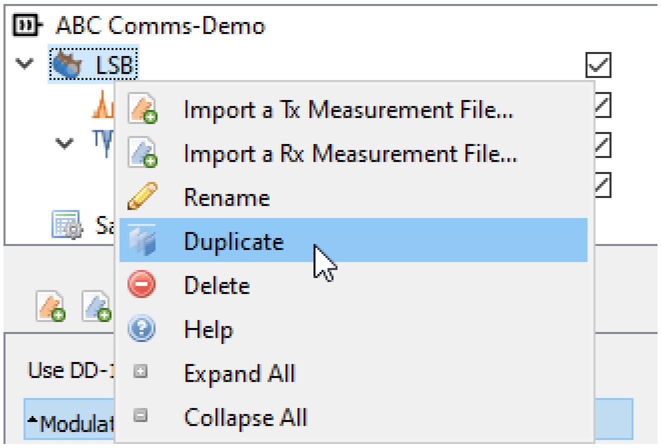
Mixer Product Susceptibility and Image Rejection should be set to 80 dBc since the IF image rejection is specified as "80 dB minimum." The default values for the RF and LO harmonic orders typically provide sufficient fidelity since higher order products are usually much less susceptible.

Per the specifications, the IF frequency is 17.5 MHz, which is directly in the middle of the operating band (i.e. the start/stop channel frequencies). This would render the Mixing Mode invalid because 17.5 MHz is both above and below half of the RF channels. The simplest way to mitigate this is to split the LSB band into 2 separate bands: one that operates from 2.0-17.499 MHz and another that operates from 17.5-29.999 MHz.

To accomplish this, return to the **LSB** settings and set the **Stop Frequency** of the band currently being modeled to 17.499 MHz. Note that the Mixing Mode for this band is "LO Above Tuned (RF) Frequency."



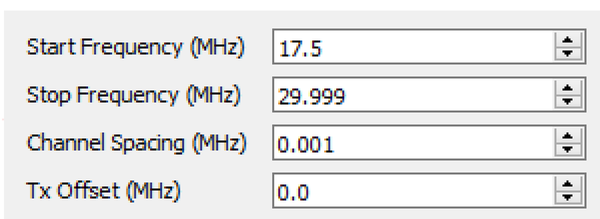
Next, right-click the **LSB** band and select **Duplicate**.



This creates a second LSB, labeled **LSB 2**, with the same settings as the first.

For **LSB 2** change the settings to:

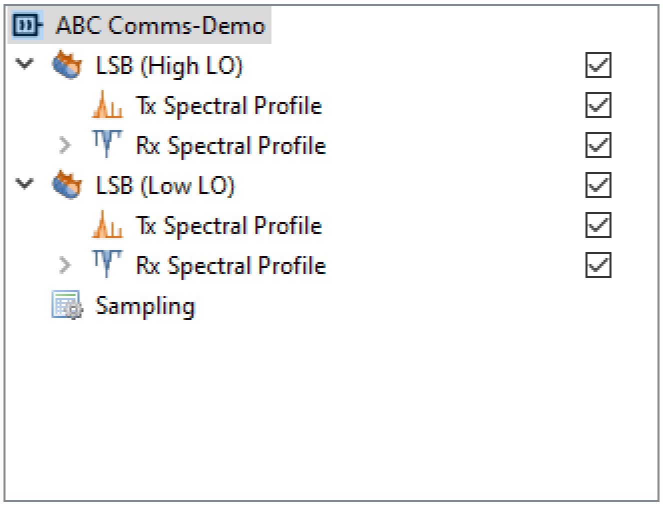
- Start Frequency: 17.5 MHz
- Stop Frequency: 29.999 MHz



Under **LSB 2**, click **Mixer Products**.

Set the **Mixing Mode** of the duplicated band to **LO Below Tuned (RF) Frequency**.

It also makes sense to rename the bands to something more distinctive. Right-click the bands to rename LSB to "LSB (High LO)" and LSB 2 to "LSB (Low LO)".

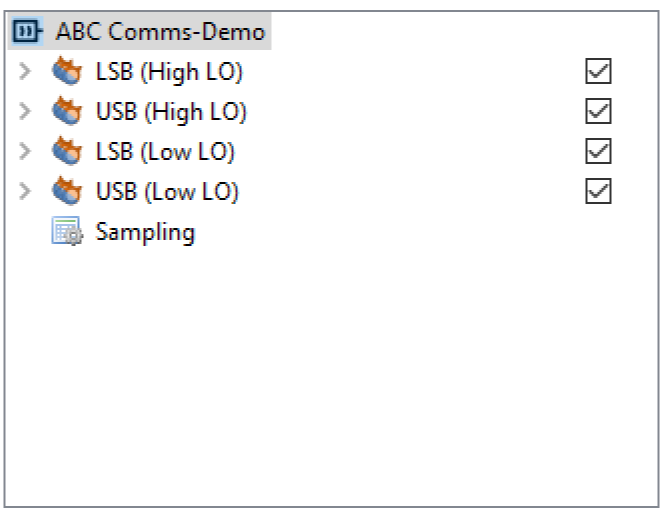


We can now quickly define two Bands for the USB modulation by duplicating the LSB bands and changing the modulation type to USB via the drop-down menu.

Right-click **LSB (High LO)** and select **Duplicate**. Rename it to "USB (High LO)." From the **Modulation** drop-down menu, select **USB**.

Right-click **LSB (Low LO)** and select **Duplicate**. Rename it to "USB (Low LO)." From the **Modulation** drop-down menu, select **USB**.

This is the only change required and the need to model USB is due to the assumption that the specified SSB modulation can be either LSB or USB, which may not always be the case.



A similar procedure can be followed to define the AM Band as well.

Duplicate **LSB (High LO)** and rename it **AM (High LO)**.

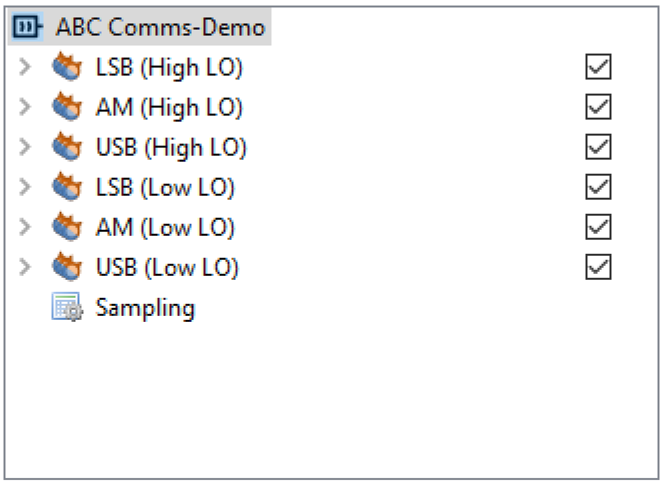
Duplicate **LSB (Low LO)** and rename it **AM (Low LO)**.

Adjust the settings for each AM band so that:

- Tx Spectral Profile Peak Power: 100W (50 dBm)
- Rx Spectral Profile Sensitivity: 3 μV (-97.6 dBm)
- SNR at Rx Signal Power: 6 dB

All the other parameters remain the same.

There are now 6 bands due to the 3 different modulations modeled (AM, LSB, USB) and the need to split each of the modulations into 2 separate bands due to the IF frequency being in the center of the operating band.



Our ABC Comms radio model is now fully created based on the provided spec sheet. The only remaining task is to define the Sampling for the ABC Comms radio. In EMIT, a radio's Sampling is specific to the individual project or scenario and thus is not dependent on the spec sheet data.

For details on how to define the Sampling, refer to previous tutorials.