EENG 385 - Electronic Devices and Circuits
Frequency Domain: Active Filters
How To: Build a Bode Plot Using Frequency Sweep Method

How To: Bode Plot via FRA

You will now have the Keysight oscilloscopes generate a Bode plot using a built-in function called frequency response analysis (FRA). In order to do this, the oscilloscope must provide the device under test (DUT) sine waves of varying frequency through the function generator output shown in Figure 1. Sine the oscilloscope must compare the amplitude and phase of the input and output, a copy of the function generator goes to channel 1 of the oscilloscope and channel 2 measures the output.

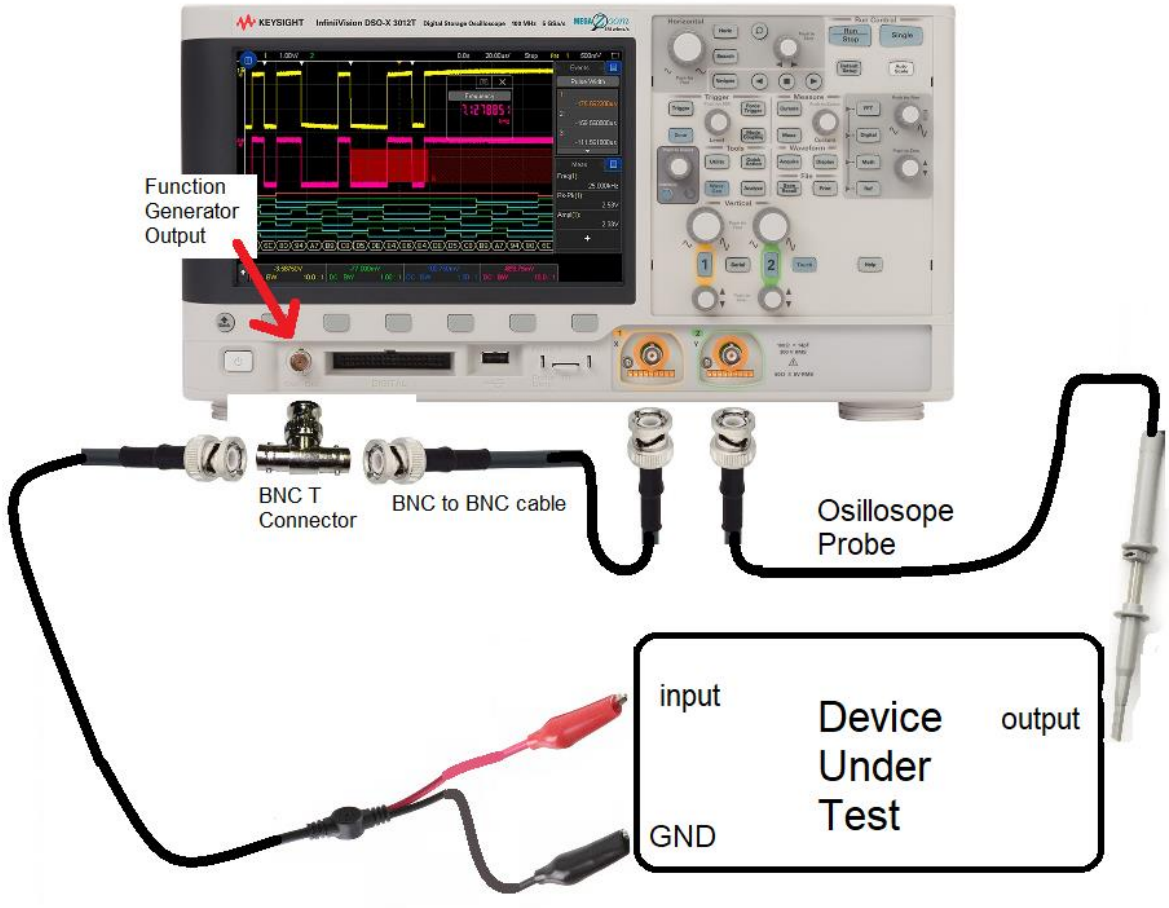

Figure 1: Setup of the Keysight Infinivision 3012T oscilloscope needed to generate a Bode plot using the frequency response analysis tool of the oscilloscope.

Oscilloscope setup for level shifter

Generating a Bode plot for the level shifter is fairly straight forward. Start by configuring your audio board as follows:

- Install the female end of a male/female jumper wire onto the INPUT LEVEL pin, red circle in Figure 3.
- Install the female end of a male/female jumper wire onto the OUTPUT LEVEL pin, upper orange circle in Figure 3.

Now it's time to use the FRA function to generate a Bode plot for the level-shifter or filter.

- Press the Analysis button (just above the Ch2 vertical scale knob)
- Press the Features softkey and select FRA
- Make sure the setup tab (gear icon) is selected
    - Frequency Mode — Sweep
    - Frequency (Start, Stop) — 10Hz — 47kHz
    - Points per decade — 10
    - Source (Input, Output) — 1 — 2
    - WaveGen — 200mVpp — 50Ω
- Press Run Analysis. The screen displays the input and output waveform as data is bring collected.
- The graph tab should auto select and display the Bode Plot for the DUT.

To save the image on the screen

- [Save/Recall] → Save → Format → 24-bit Bitmap image (*.bmp)
- [Save/Recall] → Save → Press to Save

Oscilloscope setup for low pass filter

The process of using the FRA function to measure the low pass filter is complicated by the fact that the sin wave generated by the oscilloscopes function generator are centered round 0V and swing through positive and negative voltages (it does not have a DC offset adjustment). This is a problem because the Low Pass Filter is powered by 0-5V and any negative voltage swings in the input are clipped to 0V. This would cause massive distortion of the input and ruin the resulting Bode plots.

In order to address this, you will have to send the function generator output from the oscilloscope through the level shifter (adding a DC offset to the sin waves) and then feed the level shifter output to the Low Pass Filter as shown in Figure 2.

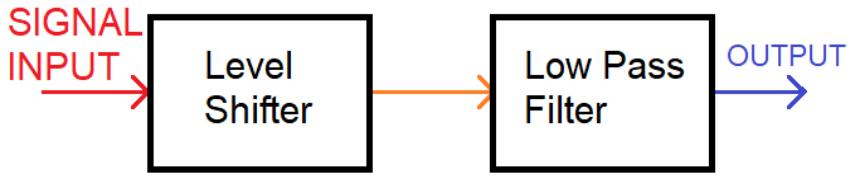

Figure 2: Circuit setup to add a DC offset to the sin waves.

To do this configure your audio board as follows:

- Install female/female jumper wire between the OUTUT LEVEL to INPUT LPF pins, orange lines in Figure 3.
- Install the female end of a male/female jumper wire onto the INPUT LEVEL pin, red line in Figure 3.
- Install the female end of a male/female jumper wire onto the OUTPUT LPF pin, blue line in Figure 3.
- Adjust the level potentiometer to 2.0V. You should use an oscilloscope to verify the input sin waves re not being clipped or have done this in the previous FRA test.

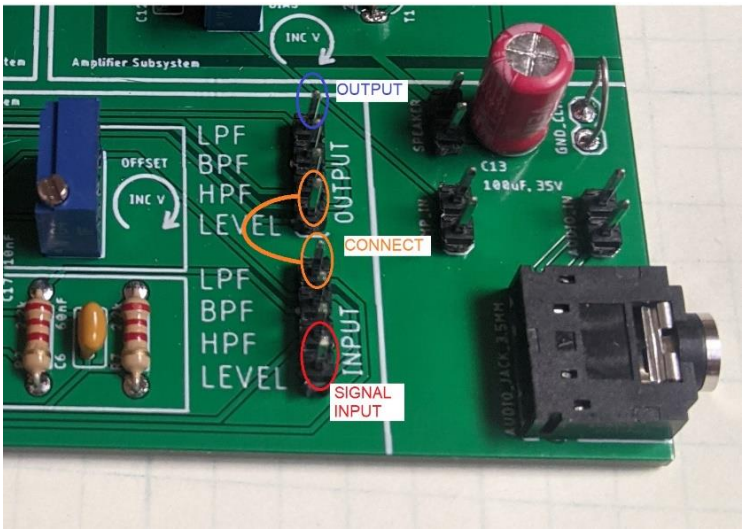

Figure 3: Board connections to insert the level-shifter into the signal path of the low apss filter.

Once you have verified that your board is configured correctly, it's time to use the FRA function to generate a Bode plot for the low pass filter using the same setup in the previous section.

The graph tab should auto select and display the Bode Plot for the audio amplifier similar to the one shown in Figure 4.

Figure 4: The Bode plot generated by the FRA tool of the Infinivision 3012T oscilloscope or the low pass filter.

Oscilloscope setup for high pass filter

Since the high pass filter has a DC blocking capacitor on the input and offsets its inputs to 2.5V, there is no need to insert the level shifter in series with the HPF as we did with the LPF. The upshot of this is that in order to build a Bode plot for the HPF, setup the oscilloscope the same way that you set it up for the level shifter. The exception being that you send the function generator input into the HP input and take the output of the HP output header pin.

Oscilloscope setup for band pass filter

Since the band pass filter does not have a DC blocking capacitor you need to insert the level shifter in series with the BPF the same as we did with the LPF. To do this configure your audio board as follows (with some creative re-interpretation of Figure 3.

- Install female/female jumper wire between the OUTUT LEVEL to INPUT BPF pins, orange lines in Figure 3.
- Install the female end of a male/female jumper wire onto the INPUT LEVEL pin, red line in Figure 3.
- Install the female end of a male/female jumper wire onto the OUTPUT BPF pin, blue line in Figure 3.
- Adjust the level potentiometer to 2.0V. You should use an oscilloscope to verify the input sin waves re not being clipped or have done this in the previous FRA test.