Crystal_Oscillator

Where To Find This Example

Select Help > Open Examples... from the menus and type either the example name listed above or one of the keywords below.

Or in Version 13 or higher you can open the project directly from this page using this button. Make sure to select the Enable Guided Help before clicking this button.

Open Install Example

Design Notes

CRYSTAL OSCILLATOR EXAMPLE

This example demonstrates a nonlinear oscillator simulation. The resonant structure uses a crystal resonator, and the negative impedance generator uses the ZETEX BFS17 bipolar transistor in a Clapp configuration. This example will demonstrate how the conditions required for oscillation are found using linear simulation. Then Harmonic Balance is used to determine the nonlinear characteristics of the oscillator. This example is specifically used to demonstrate that the oscillator capabilities in the AWR Design Environment work well, even when resonators have extremely high Q.

Overview

In this example, a crystal oscillator is simulated. The project illustrates how to analyze an oscillator using linear and nonlinear analysis. It is advisable to use linear analysis as a starting point. Nonlinear analysis can be used once the basic circuit design is understood and the approximate oscillator frequency has been determined. The first part of this example looks at the admittances of the two sections of the oscillator: the resonator, and the negative impedance generator. The oscillation frequency is predicted. The second part of the example, verifies the predicted oscillation frequency, as well as calculated the output properties and phase noise of the oscillator.

Step 1: Oscillator Linear Analysis

The first step in analyzing an oscillator is to look at the negative resistance generator and the resonator circuit to look for conditions for oscillation. Since this circuit does not have an explicit feedback loop it is easy to look at each network separately. The two schematics of interest are “Feedback_network” and “Resonator”. Both of them are used later in step 2 as subcircuits of “Crystal_Oscillator”. The “Feedback_network” schematic has the negative impedance generator and the “Resonator” schematic has the resonator structure using the crystal model. The approximate oscillation conditions occur when the sum of the susceptance for both networks is zero and the conductance is a negative value. The graph “Admittance” shows the individual contributions of the admittance and the graph “Total Admittance” shows the sum of these values, where the sum of the total admittances has been defined as the variable $y_{total}$ in the Output Equations. This graph shows that oscillation should occur slightly over 25 MHz.

A DC node voltage annotation has been added to the “Feedback Network” schematic to see that the circuit is biasing up correctly.

Step 2: Oscillator Nonlinear Analysis

Once the approximate oscillation conditions are known, the nonlinear oscillation conditions can be determined. The schematic “Crystal_Oscillator” uses hierarchy to hook together the two pieces of the circuit. At the node between the subcircuits, the OSCAPROBE element is attached to determine the nonlinear oscillation characteristics. The linear oscillation conditions help determine the $F_{start}$ and $F_{end}$ parameters (see the help for more details) on this model. Also the OSCNOISE block is used to specify phase noise simulations settings. With these two elements, the graphs “Phase Noise”, “Output Spectrum”, and “Output Waveform” are possible. Notice that this oscillator is oscillating right at 25 MHz.

Crystal Model

The Crystal Model is from John Vigs Tutorial "QUARTZ CRYSTAL RESONATORS AND OSCILLATORS" pg 3-20.

The Crystal Model requires a specification of the resonant frequency $F_s$, motional capacitance $C_1$, static capacitance $C_0$, and motional resistance $R_1$. The model will determine the motional inductance $L_1$ from other parameters. This is a linear model and does not include the overtones that occur in crystal resonators.

Schematic - Crystal_Oscillator
Graph - Phase Noise
Graph - Total Admittance