Effect of Jitter on Radio Performance

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1 Recap

- A jittery LO signal $v_{\mathrm{LO}}(t, \theta_j)$ can be modeled as an ideal signal $v_{\mathrm{LO}}(t)$ with an additive noise term $v_{nj}(t)$

$$v_{\mathrm{LO}}(t, \theta_j) = v_{\mathrm{LO}}(t) + v_{nj}(t) \tag{1}$$

- The average power of the jitter component $\overline{v_{nj}^2(t)}$ is proportional to the LO signal power $\overline{v_{\mathrm{LO}}^2(t)}$

$$\overline{v_{nj}^2(t)} = \overline{v_{\mathrm{LO}}^2(t)} \cdot \theta_{j,rms}^2 \tag{2}$$

where $\theta_{j,rms}$ is the rms phase noise of the signal.

- The signal-to-noise ratio (SNR) of the LO signal is then given by

$$SNR_{\mathrm{LO}} = \frac{1}{\theta_{j,rms}^2} \tag{3}$$

$$\theta_{j,rms}^2 = 2 \int_{\Delta\omega_0}^{\Delta\omega_0 + BW} L_\theta(\Delta\omega) d\Delta\omega \tag{4}$$

where $L_\theta(\Delta\omega)$ is the single-side band (SSB) phase noise power spectral density (PSD) normalized to the power of the desired LO harmonic, BW is the baseband bandwidth of the signal, and $\Delta\omega_0$ is the offset between the desired LO harmonic and the center of our signal bandwidth. end

2 Frequency Translation

A radio transceiver employs a mixer to up-convert a baseband signal to radio frequency (RF) signal in a transmitter, and vice versa in a receiver.

Mixing is simply a process of multiplication, where the desired signal and LO signal are multiplied.

$$v_{out}(t) = v_{in}(t) \cdot v_{\mathrm{LO}}(t, \theta_j) \tag{5}$$

$$v_{out}(t) \approx v_{in}(t) \cdot \Big(v_{\mathrm{LO}}(t) + v_{nj}(t)\Big) \tag{6}$$

$$\overline{v_{out}^2(t)} \approx \overline{v_{in}^2(t)\, v_{\mathrm{LO}}^2(t)} + \overline{v_{in}^2(t)\, v_{nj}^2(t)} \tag{7}$$

$$\overline{v_{nj}^2(t)} = \overline{v_{\mathrm{LO}}^2(t)} \cdot \overline{\theta_j^2(t)} = \overline{v_{\mathrm{LO}}^2(t)} \cdot \theta_{j,rms}^2 \tag{8}$$

$$\overline{v_{out}^2(t)} \approx \overline{v_{in}^2(t)}\, \overline{v_{\mathrm{LO}}^2(t)} + \overline{v_{in}^2(t)}\, \overline{v_{nj}^2(t)} \tag{9}$$

$$\overline{v_{out}^2(t)} \approx \overline{v_{in}^2(t)}\, \overline{v_{\mathrm{LO}}^2(t)} + \overline{v_{in}^2(t)}\, \overline{v_{\mathrm{LO}}^2(t)}\, \overline{v_{nj}^2(t)} \tag{10}$$

$$\overline{v_{out}^2(t)} \approx \overline{v_{in}^2(t)}\, \overline{v_{\mathrm{LO}}^2(t)} + \overline{v_{in}^2(t)}\, \overline{v_{\mathrm{LO}}^2(t)}\, \theta_{j,rms}^2 \tag{11}$$

$$SNR_{out} = SNR_{\mathrm{LO}} \approx \frac{1}{\theta_{j,rms}^2} \tag{12}$$

3 Sampling