6 Flicker Noise

1 Flicker Induced Phase Noise

Approaching the carrier, the slope of the phase noise spectrum in CMOS VCOs increases from –20 to –30 dB/decade. This is ascribed to the up conversion of flicker noise in FETs. The analysis presented in the previous chapter is reviewed to see if it explains this up conversion.

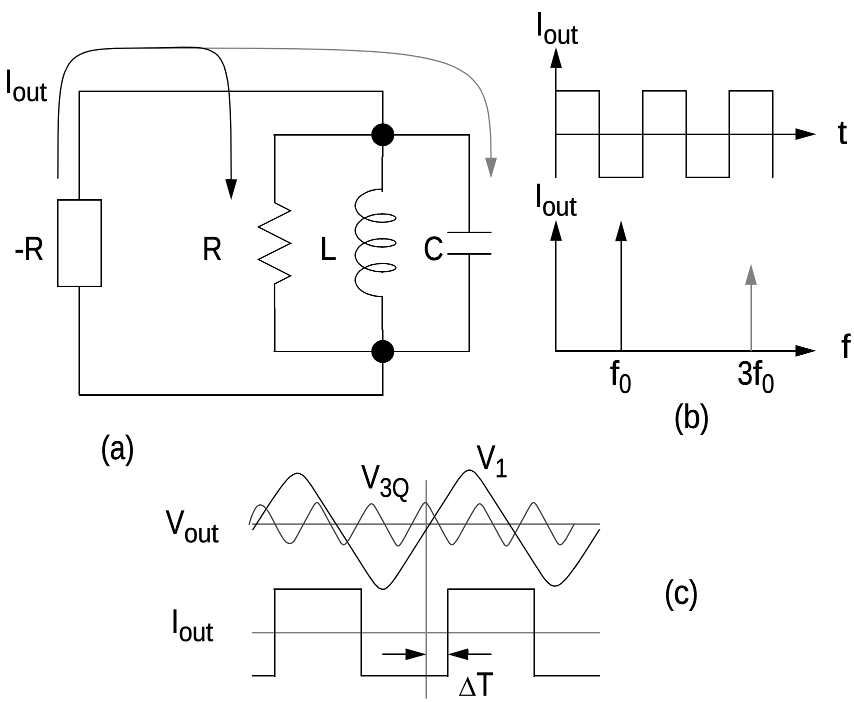
Flicker noise in the tail current source at a low frequency of ω_m indeed up converts to $\omega_0 \pm \omega_m$ and enters the resonator, but as AM, not PM noise. Therefore, in the absence of a high gain varactor to convert AM to FM [1], flicker noise in the tail current will not appear as phase noise. Next, consider flicker noise in the differential pair. The preceding analysis says that this modulates zero crossings, and injects a noise current into the resonator consisting of flicker noise sampled by an impulse train with frequency $2\omega_0$. Thus, noise originating at frequency ω_m produces currents at ω_m and at $2\omega_0 \pm \omega_m$. Both frequencies are strongly attenuated by the resonator, and neither explains flicker-induced phase noise at $\omega_0 \pm \omega_m$.

Therefore, the model presented so far predicts that none of the noise at low frequencies produces phase noise around the carrier. Yet measurements show that close to the carrier, there is up converted flicker noise, therefore there must be another mechanism.

2 FM Due to Modulated Frequency Content

Figure 1a shows a model of the oscillator where it is normally assumed that the negative resistance produces a sinusoidal current to compensate for the loss in the resonator. However, because the negative resistance is typically implemented with a non-linear circuit, this current is more like a square-wave, which is rich in harmonics, Figure 1b. Normally, these harmonics are neglected, but they must flow somewhere in the circuit and in fact at these high frequencies, the capacitor offers the lowest impedance path.

FIGURE 1 *The output current from the active circuit is a square wave, not a sine wave. The fundamental component flows into the loss resistance, while the high frequency harmonics flow into the capacitor, resulting in a shift between the zero crossings of the output voltage and the output current.*



As a result, the phase relationship between the zero crossings of the current and the voltage is upset, as shown in Figure 1c. This shift in phase due to harmonics produces a change in oscillation frequency given by (1), which was predicted by Groszkowski in 1933 [2].