Tune Example

Fig. 4. Simplified Tuning Loop.

The reference tuning loop uses a Gm cell in feedback as shown in simplified form in Fig. 4 [4]. A constant current $I_R$ is pushed into the Gm cell, producing a voltage $V_{o1} = I_R/g_m$. $\phi_1$ and $\phi_2$ are two non-overlapping clocks with frequency $f_{clock}$. During $\phi_1$, the capacitor $C_1$ is charged to $V_{o1}$. During $\phi_2$, the charge on $C_1$ is transferred to capacitor $C_H$. Also, a constant current $NI_R$ is drawn from $C_H$. The average value of the opamp output, $V_{o2}$, is used to tune the transconductance of the Gm cell.

When the loop reaches steady state, the charge injected onto $C_H$ by $C_1$ during $\phi_2$ equals the charge removed from $C_H$ by $NI_R$ in one clock period. Therefore $V_{o2}$ is periodic and $V_{o2}$ is constant. In steady state,

$$V_{o2} = \frac{I_R}{g_m}$$  \hspace{1cm} (1)

$$Q_{c1} = C_1 V_{o1} = N I_R T = Q_{c2}$$  \hspace{1cm} (2)

where $T = 1/f_{clock}$ is the clock period. Substituting $V_{o1} = I_R/g_m$ into (2) and simplifying gives

$$\frac{C_1}{S_m} = NT = \frac{N}{f_{clock}}$$  \hspace{1cm} (3)

where $g_m$ is the transconductance of the Gm cell. Hence, $C_1/g_m$ depends on the clock frequency $f_{clock}$, which is derived from a crystal oscillator, and $N$, the ratio of DC currents that can be accurately defined in a CMOS process.

A more detailed block diagram of the tuning loop is shown in Fig. 5. The clock frequency is 6.25MHz and the DC current ratio $N$ is 0.2. Using these values in (3), $C_1/g_m = 32\mu$A. If $C_1$ has the same nominal value as $C_2(=0.6\mu F)$ in the AC coupler, then $g_m = 18.4\mu A/V$. With $I_R \leq 5\mu A$ in Fig. 5, the nominal differential output voltage of the Gm cell is $\leq 0.53V$. To have a large $g_m$ tuning range, the Gm cell should allow an output swing of $>1.0V$.

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A 10.7-MHz 68-dB SNR CMOS Continuous-Time Filter with On-Chip Automatic Tuning

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