C_I is the I channel conversion loss factor, C_Q is the Q channel conversion loss factor, θ_R is the I-axis phase rotation in radians, B_I is the I channel DC offset in volts, B_Q is the Q channel DC offset in volts, and θ_E is the quadrature phase error in radians.

When the LO and RF frequencies are not equal, θ_R can be set to 0 to simplify (5) and (6):

$$\hat{I}(t) = C_I I(t) + B_I \quad (7)$$

$$\hat{Q}(t) = C_Q(\cos\theta_E Q(t) - \sin\theta_E I(t)) + B_Q \quad (8)$$

θ_R is only important in applications when the phase difference between the RF and LO signals must be known (i.e. phase detector).

Example: Apply a 12 GHz CW LO signal at +5 dBm and a 12.001 GHz CW RF signal at -2 dBm. To estimate the AD110140B's $\hat{I}(t)$ and $\hat{Q}(t)$ signals, start by determining all the parameters in (7) and (8).

C_I and C_Q are determined by the conversion loss and amplitude imbalance of the AD110140B. From the datasheet's typical performance plots at 12 GHz, use 8.8 dB conversion loss and -0.21 dB amplitude imbalance to find C_I and C_Q :

$$\frac{C_I + C_Q}{2} = 10^{(-8.8/20)} = 0.3631 \quad (9)$$

$$20\log(\frac{C_Q}{C_I}) = -0.21 \quad (10)$$

$$C_I = 0.3675 \qquad C_Q = 0.3587 \quad (11), (12)$$

Quadrature phase error and DC offsets are also obtained from the typical performance plots at 12 GHz:

$$\theta_E = -1.5 Deg. = -0.026 Radians \quad (13)$$

$$B_I = -0.005V \qquad B_Q = -0.004V \quad (14), (15)$$

The next step in estimating $\hat{I}(t)$ and $\hat{Q}(t)$ is to calculate the ideal $I(t)$ and $Q(t)$ from the RF input signal. Given that the RF signal frequency is 1 kHz greater than the LO frequency, $I(t)$ and $Q(t)$ define an upper sideband tone of 1 kHz having a constant amplitude of:

$$\frac{A^2}{0.1} = 10^{(-2.0/10)} \quad (16)$$

$$A = 0.2512V \quad (17)$$

From (3) and (17) we know:

$$I(t) = 0.1776\cos(2\pi 1000t) \quad (18)$$

and

$$Q(t) = 0.1776\sin(2\pi 1000t) \quad (19)$$

The final step in estimating $\hat{I}(t)$ and $\hat{Q}(t)$, the demodulator's real I and Q outputs signals, is to insert (11), (12), (13), (14), (15), (18), and (19) into (7) and (8) giving the final result:

$$\hat{I}(t) = 0.065\cos(2\pi 1000t) - 0.005$$

$$\hat{Q}(t) = 0.064\sin(2\pi 1000t - 0.026) - 0.004$$

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