Short-Range Leakage Cancelation in FMCW Radar Transceivers

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Problem Statement
- FMCW radars suffer from permanent leakage from transmit into receive path
- In automotive application: Bumper reflections → short-range (SR) leakage
- Decorrelated phase noise (DPN) in IF domain causes sensitivity degradation

DPN Cross-Correlation Properties
- DPNs $\Delta \varphi_O(t)$ and $\Delta \varphi_S(t)$ are highly correlated when shifted by
  $$T_{\text{offset}} = -\frac{\tau_S - \tau_O}{2},$$
even if $\tau_O \ll \tau_S$.

System Model
- Introduce artificial on-chip target (OCT) to cancel SR leakage
- Choosing $\tau_O = \tau_S$ would lead to (ideally) perfect SR leakage cancelation
- However, delay lines cannot be realized in required range on MMIC

Short-Range Leakage Cancelation
1) Extraction of DPN from OCT IF signal
   $$\Delta \varphi_O[n] \approx \frac{\Delta A_o}{2} \cos(2\pi f_{\text{SFO}} \tau_O + \Phi_O) - \frac{\Delta A_S}{2} \sin(2\pi f_{\text{SFO}} \tau_O + \Phi_O)$$
2) Generation of SR leakage cancelation signal
   $$\hat{y}_S[n] = \frac{\Delta A_S}{2} \cos(2\pi f_{\text{SFO}} \tau_S + \Phi_S + \alpha_S \Delta \varphi_O[n])$$
   $$\alpha_S = \frac{\int_{-\infty}^{\infty} S_{yy}(f) \kappa_{\tau_S}(f) \left| H_L(f) \right|^2 e^{i2\pi f T_{\text{time}} \tau_S} df}{\int_{-\infty}^{\infty} S_{yy}(f) \kappa_{\tau_S}(f) \left| H_L(f) \right|^2 df}$$
3) Subtraction from received signal
   $$z[n] = y[n] - \hat{y}_S[n]$$