Short-Range Leakage Cancelation
in FMCW Radar Transceivers

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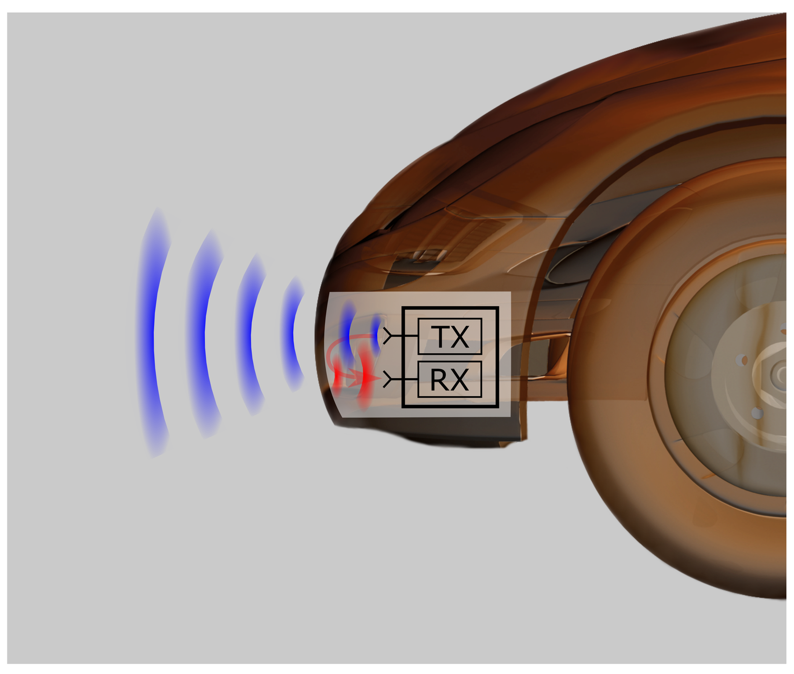
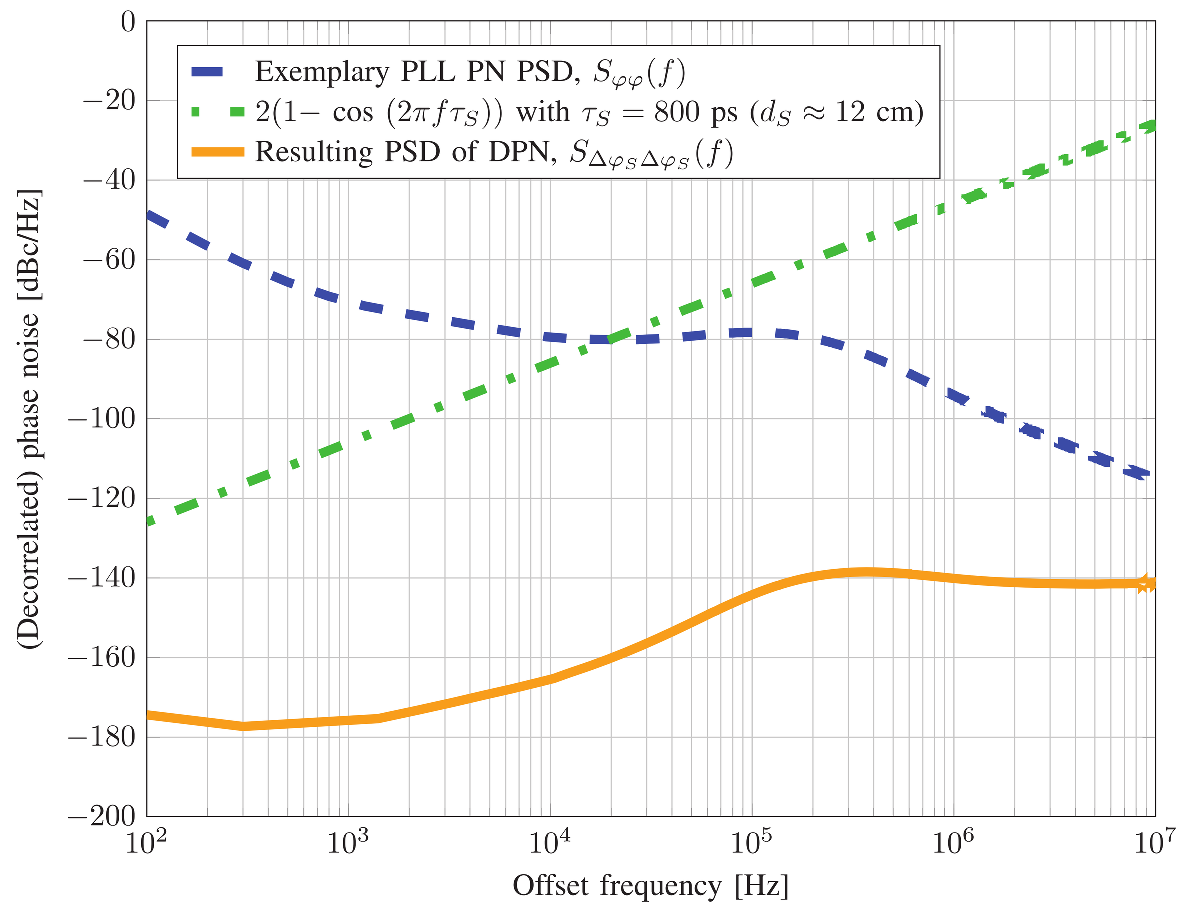
Problem Statement

- FMCW radars suffers 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



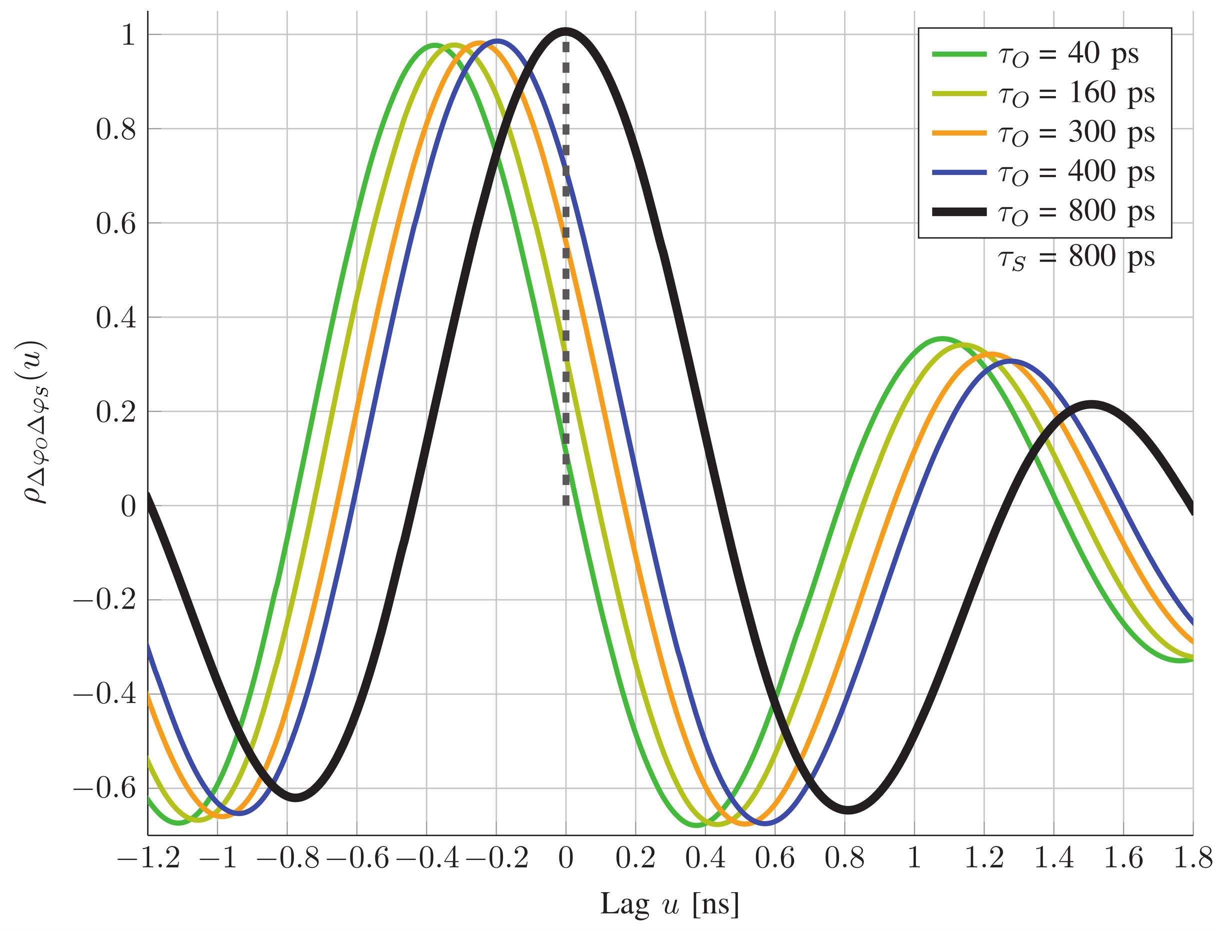


DPN Cross-Correlation Properties

- DPNs $\Delta\varphi_O(t)$ and $\Delta\varphi_S(t)$ are highly correlated when shifted by

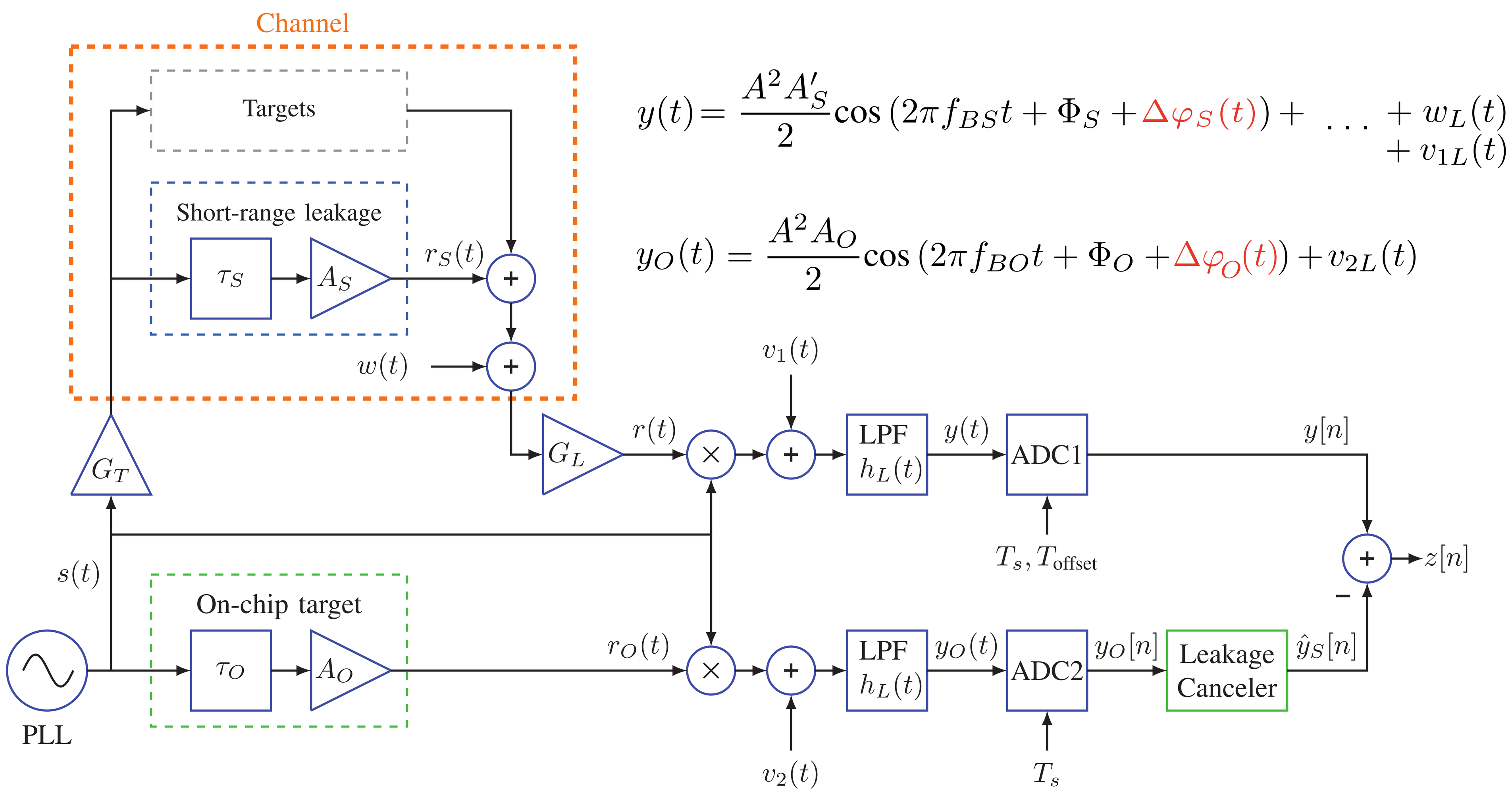
$$T_{\text{offset}} = -\frac{\tau_S - \tau_O}{2},$$

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



$$y(t) = \frac{A^2 A_S'}{2}\cos\left(2\pi f_{BS} t + \Phi_S + \Delta\varphi_S(t)\right) + \ldots + w_L(t) + v_{1L}(t)$$

$$y_O(t) = \frac{A^2 A_O}{2}\cos\left(2\pi f_{BO} t + \Phi_O + \Delta\varphi_O(t)\right) + v_{2L}(t)$$

Short-Range Leakage Cancelation

1) Extraction of DPN from OCT IF signal

$$\Delta\varphi_O[n] \approx \frac{\frac{A^2 A_O}{2}\cos(2\pi f_{BO} n T_s + \Phi_O) - y_O[n] + v_{2L}[nT_s]}{\frac{A^2 A_O}{2}\sin(2\pi f_{BO} n T_s + \Phi_O)}$$

2) Generation of SR leakage cancelation signal

$$\hat{y}_S[n] = \frac{A^2 \hat{A}_S'}{2}\cos(2\pi \hat{f}_{BS} n T_s + \hat{\Phi}_S + \alpha_L\,\Delta\varphi_O[n])$$

$$\alpha_L = \frac{\int_{-\infty}^{\infty} S_{\varphi\varphi}(f)\,\kappa_{\tau_O\tau_S}(f)\,|H_L(f)|^2\,e^{j2\pi f T_{\text{offset}}}\,df}{\int_{-\infty}^{\infty} S_{\varphi\varphi}(f)\,\kappa_{\tau_O}(f)\,|H_L(f)|^2\,df}$$

3) Subtraction from received signal

$$z[n] = y[n] - \hat{y}_S[n]$$

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