Interferometric Residual Phase Noise Measurement System

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Lee Teng Internship Program

Advanced Photon Source
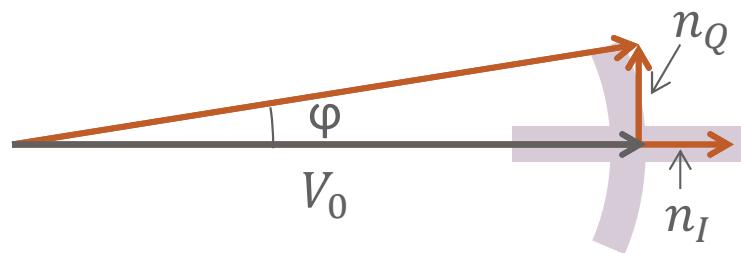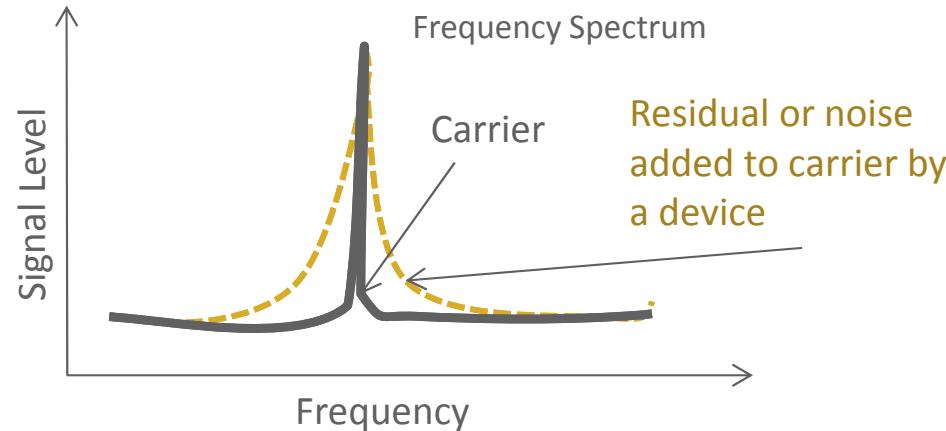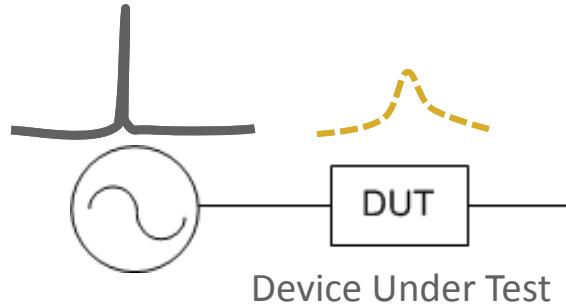
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Noise Characterization of Radio Frequency (RF) Devices
Phase & Amplitude noise of a RF Carrier

Device Under Test

Frequency Spectrum

Signal Level

Carrier

Residual or noise added to carrier by a device

Frequency

Polar

$$v(t) = V_0 \left[1 + \alpha(t)\right]\cos(\omega_0 t + \varphi(t))$$

$\alpha(t)$: amplitude noise

$\varphi(t)$: phase noise

Cartesian

$$v(t) = V_0 \cos(\omega_0 t) + n_I \cos(\omega_0 t) - n_Q \sin(\omega_0 t)$$
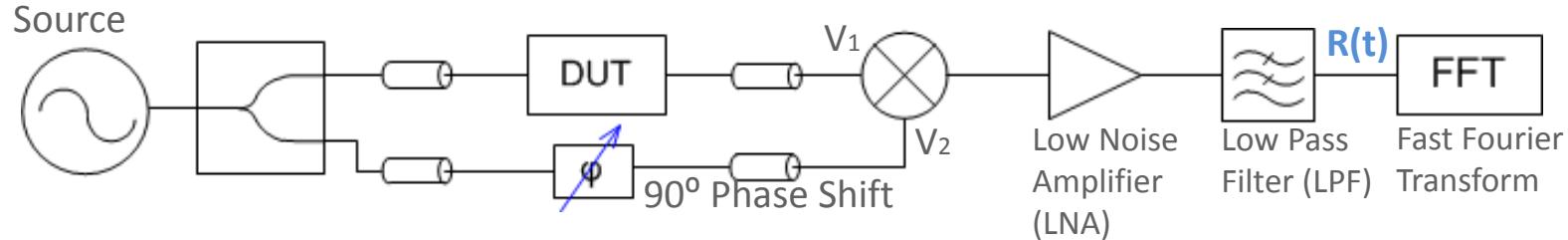
n_I: in-phase noise

n_Q: quadrature noise

When $\alpha(t), \varphi(t) \ll 1$

$$\alpha(t) \cong \frac{n_I}{V_0} \qquad \varphi(t) \cong \frac{n_Q}{V_0}$$

- Useful for characterizing noise added by a device or differential noise between devices (i.e. Short Pulse X-ray RF Cavities)

# Noise Measurement Using Saturated Mixer
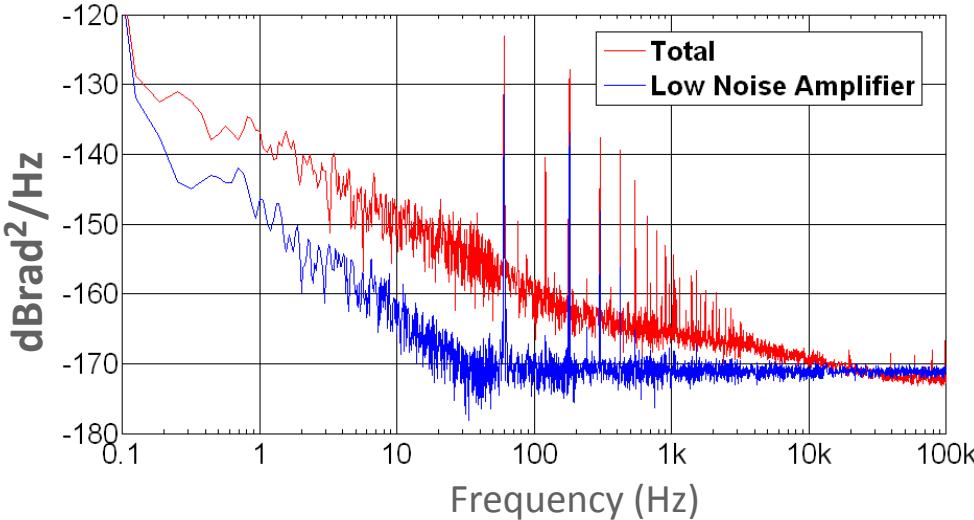
$$\mathbf{R}(t) = LPF\{V_1\cos(\omega_0 t + \varphi(t)) \times V_2\sin(\omega_0 t)\}$$
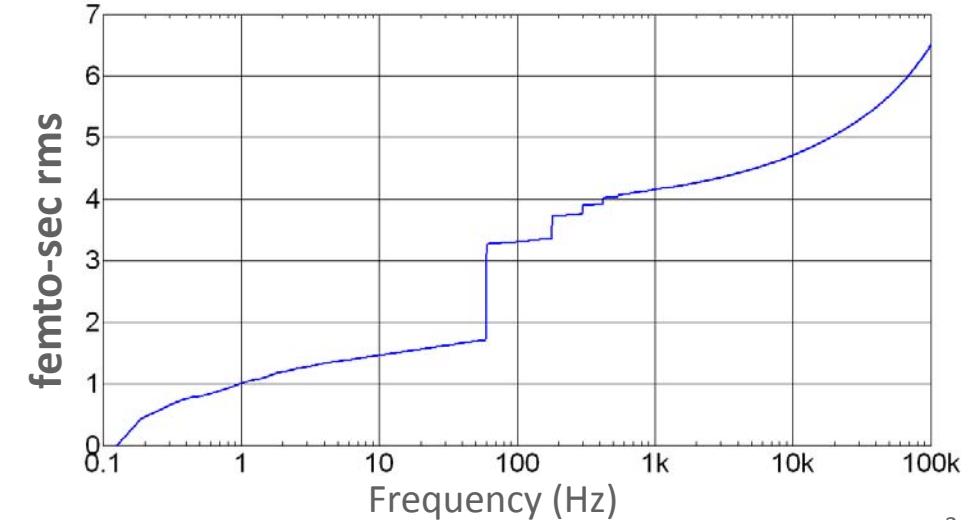
$$\cong k_\varphi\varphi(t) \quad (k_\varphi \cong 0.3\ \text{V/rad})$$

- Source phase noise ideally cancels

- Usually limited by LNA-mixer noise floor and cable vibration
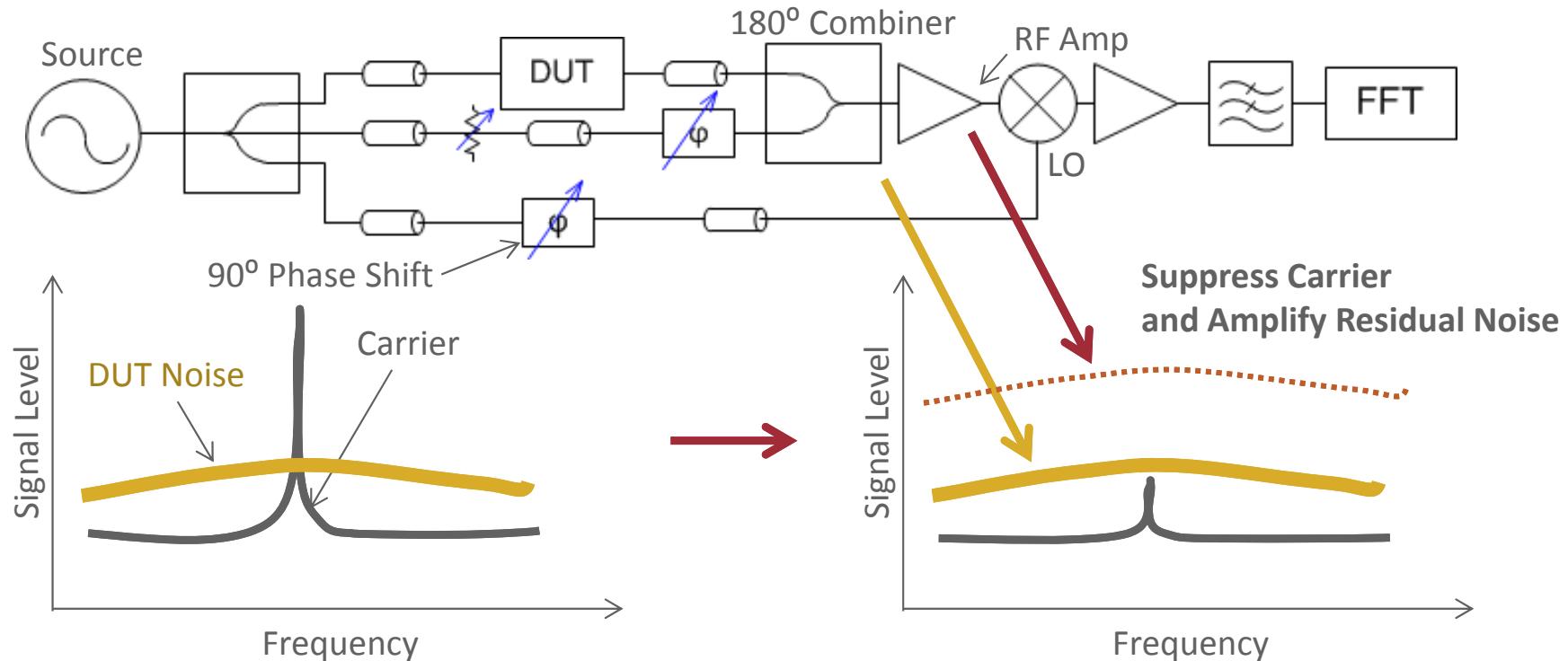
Phase Noise Power Spectral Density

Cumulative Integral
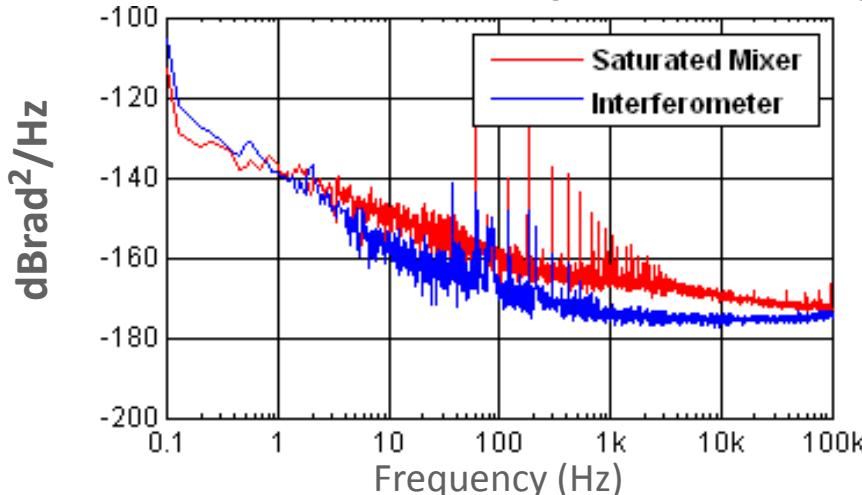
Interferometric Noise Measurement

- Increased sensitivity $k_\varphi \cong$ **18 V/rad** , Source noise cancels
- Usually limited by noise of RF Amp and cable vibration