# Oscillator Carrier phase compensation using Kalman tracking

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In practice, Oscillator won't produce carrier with accurate frequency fc, but within a small interval around fc. Hence, there is always a small frequency mismatch between carrier frequency from receiver's local oscillator and transmitter carrier frequency. This causes the received symbol to get shifted by some phase (not magnitude). This phase have to be compensated before decoding.

The phase in each time 'n' is. Where $\Delta\emptyset$ is due to frequency mismatch $\Delta f$. (2*pi*$\Delta f$). Phase noise $\Delta\emptyset$ is modeled as Gaussian iid noise in each time n.

- mean=0
- variance= 4*pi*$\Delta f_{3dB}$ /fs
- fs- symbol frequency
- $\Delta f_{3dB}$ is the 3db half power frequency of local oscillator at receiver.

$$\phi(n) = \phi(n-1) + \Delta\phi.$$

The received symbol is (we are considering symbol level model. Without phase compensation in front -end of Rx, we get this symbol)

r(n)= $(s(n) \star h(n))e^{j\phi(n)} + \xi(n)$

After decoding data, we cancel out the data, channel part by dividing. Channel is known at Rx. This is the equation of our interest.

$$y(n) = r(n)/\hat{a}(n) \approx \underbrace{\exp\left(j\phi(n)\right)}_{D(\cdot)} + \frac{\xi(n)}{\hat{a}(n)}.$$

We try to estimate the phase, from this non linear equation. Kalman filter is used for estimation in linear functions only. So here Unscented Kalman is used, which transforms the non-linear into a some form of linear by weighted sum of different extrapolated samples around the input.