Quadrature Signal processing
ES 442 – Spring 2016

Polar to Rectangular Conversion

Project signal to "I" and "Q" axes

Q-Value

I-Value

0 deg
Fourier Transforms of $\sin(\omega t)$ and $\cos(\omega t)$

$$\cos(2\pi f_o t) = \frac{e^{j2\pi f_o t}}{2} + \frac{e^{-j2\pi f_o t}}{2}$$

$$\sin(2\pi f_o t) = j\frac{e^{-j2\pi f_o t}}{2} - j\frac{e^{j2\pi f_o t}}{2}$$

Note: $+j$ corresponds to $e^{j(\pi/2)}$

$-j$ corresponds to $e^{-j(\pi/2)}$
A Complex Exponential Consists of $\sin(\omega t)$ and $\cos(\omega t)$

$$e^{j2\pi f_0 t} = \cos(2\pi f_0 t) + j\sin(2\pi f_0 t)$$

Note:  
$+j$ corresponds to $e^{j(\pi/2)}$  
$-j$ corresponds to $e^{-j(\pi/2)}$
Quadrature Amplitude Modulation Transmitter & Receiver

(1) Both transmitter and receiver use two sinusoidal signals in quadrature to modulate and demodulate I and Q inputs.

(2) The LO signal in the receiver must have identical frequency and phase as the LO signal in the transmitter.
Phase-Shift Method – SSB Transmitter

Should be -90° phase shift and \( \sin(\omega_c t) \).
Phase-Shift Method for Generating SSB

A -90° phase shift requires clockwise rotation in complex plane
**Weaver SSB Transmitter**

**Note:** Two -90° rotations are needed for one of the sidebands to be cancelled.

**Note:** LO1 and LO2 are not equal.
\[
\begin{align*}
    i_t(t) &= i(t) \cos(2\pi f_0 t + 0^\circ) \\
    q_t(t) &= q(t) \cos(2\pi f_0 t + 90^\circ) = q(t) \sin(2\pi f_0 t) \\
    y_t(t) &= \sqrt{i^2(t) + q^2(t)} \cos(2\pi f_0 t + \theta(t)) \\
    \text{where } \theta(t) &= \tan^{-1} q(t) / i(t) \\
    -180^\circ &< \theta < 180^\circ
\end{align*}
\]
Digital I/Q Modulation
Anticipating our coverage of digital communication systems

- I/Q signals take on discrete values at discrete time instants corresponding to digital data