DSP or QSP?

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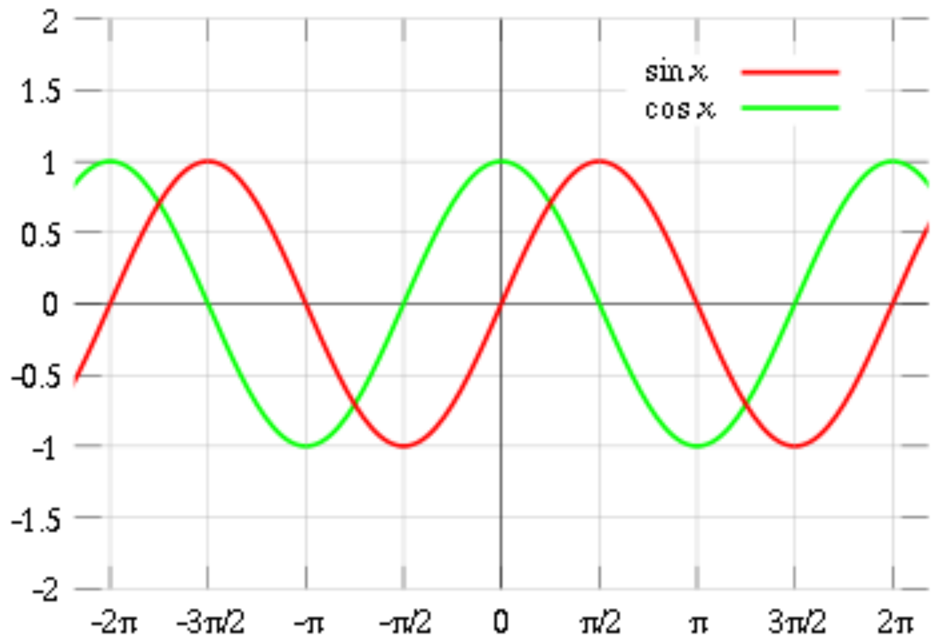
QSP?

- Will you relay a message?
- Nope - 'Quadrature Signal Processing'
- Ok, but why QSP?

Give me I and Q and I can demodulate anything.

- Gerald Youngblood K5SDR, Founder FlexRadio

Quadrature Signals



An arbitrary modulated sinusoidal

$$x(t) = A(t) \cdot \cos[\varpi_c t + \phi(t)]$$

can be decomposed into two orthogonal signals

$$x(t) = I(t) \cdot \cos[\varpi_c t] - Q(t) \cdot \sin[\varpi_c t]$$

where

I: In-Phase Component

$$I(t) = A(t) \cdot \cos[\phi(t)]$$

Q: Quadrature-Phase Component

$$Q(t) = A(t) \cdot \sin[\phi(t)]$$

Proof

$$x(t) = A(t)\cos[\varpi_c t+\phi(t)]$$

$$= A(t)\cos[\varpi_c t]\cos[\phi(t)] - A(t)\sin[\varpi_c t]\sin[\phi(t)]$$

via $\cos(\alpha+\beta) = \cos(\alpha)\cos(\beta) - \sin(\alpha)\sin(\beta)$

$$= [A(t)\cos[\phi(t)]]\bullet\cos[\varpi t] - [A(t)\sin[\phi(t)]]\bullet\sin[\varpi t]$$

$$= I(t)\bullet\cos[\varpi_c t] - Q(t)\bullet\sin[\varpi_c t]$$

To extract $I(t)$, multiply by $2\cos(\varpi_c t)$

$$y_I(t) = r(t)2\cos(\varpi_c t)$$

$$= [I(t)\cos[\varpi_c t] - Q(t)\sin[\varpi_c t]]2\cos(\varpi_c t)$$

$$= 2I(t)\cos[\varpi_c t]\cos(\varpi_c t) - 2Q(t)\sin[\varpi_c t]\cos(\varpi_c t)$$

$$= I(t)(1+\cos(2\varpi_c t)) - Q(t)\sin[2\varpi_c t]$$

via $\cos^2\theta=\frac{1}{2}(1+\cos 2\theta)$, $\sin\theta\cos\theta=\frac{1}{2}\sin 2\theta$

$$= I(t) + [I(t)\cos(2\varpi_c t) - Q(t)\sin[2\varpi_c t]]$$

Then apply low pass to remove $2\varpi_c t$ terms yielding

$$I(t)$$

To extract $Q(t)$, multiply by $-2\sin(\varpi_c t)$

$$y_Q(t) = r(t)[-2\sin(\varpi_c t)]$$

$$= [I(t)\cos[\varpi_c t] - Q(t)\sin[\varpi_c t]][-2\sin(\varpi_c t)]$$

$$= -2I(t)\cos[\varpi_c t]\sin(\varpi_c t) + 2Q(t)\sin[\varpi_c t]\sin(\varpi_c t)$$

$$= -I(t)\sin(2\varpi_c t) + Q(t)(1-\cos[2\varpi_c t])$$

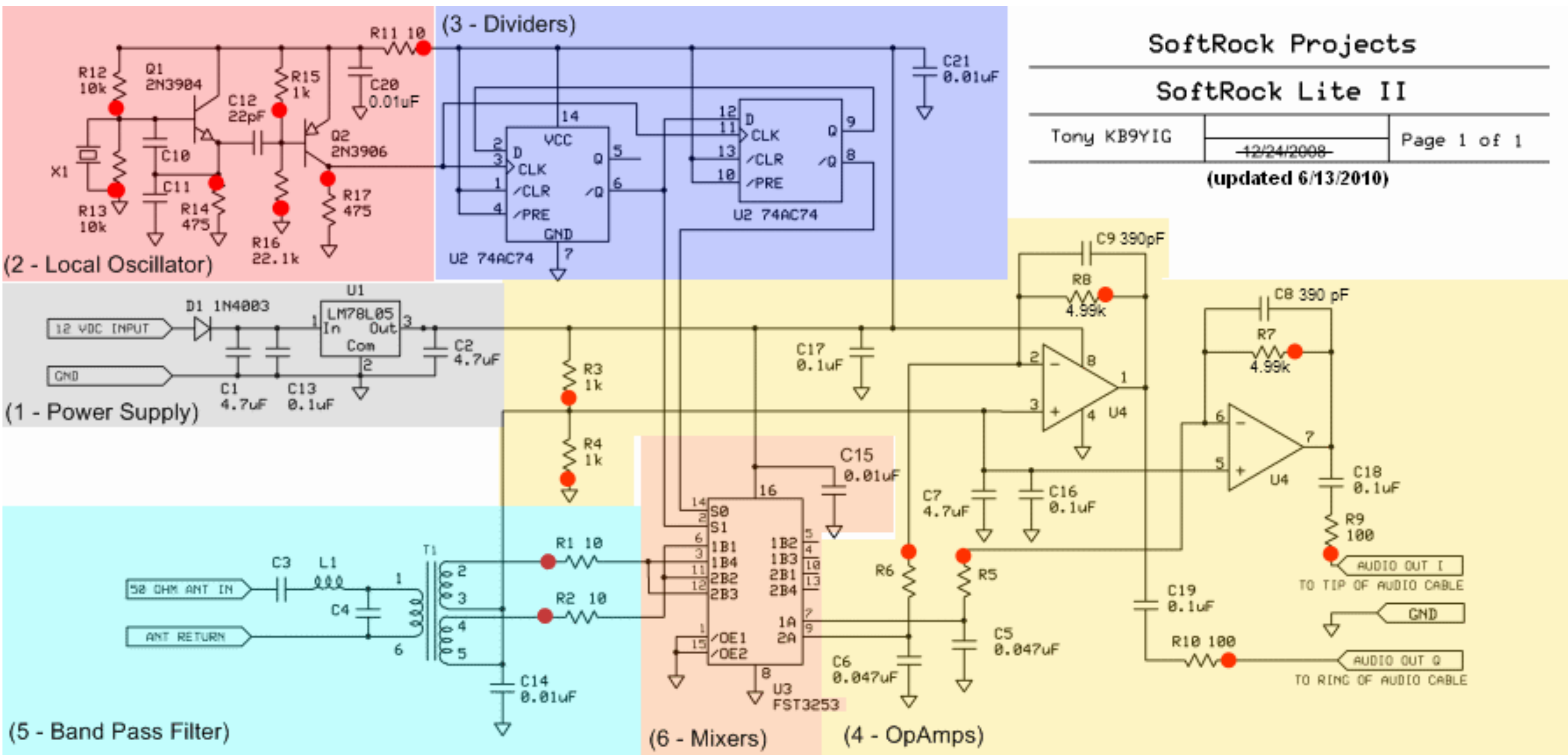
via $\cos\theta\sin\theta=\frac{1}{2}\sin2\theta$, $\sin^2\theta=\frac{1}{2}(1-\cos2\theta)$

$$= Q(t) - [I(t)\sin(2\varpi_c t) + Q(t)\cos[2\varpi_c t]]$$

Then apply low pass to remove $2\varpi_c t$ terms yielding

$$Q(t)$$

SoftRock II and Ensemble II use nearly identical Quadrature Sample Detectors (QSDs) based on Tayloe Detector



Topics for next session

- Weaver versus Tayloe Detectors
- More Math
  - Introduction to Complex Numbers
  - Euler's Formula
- What happens inside PowerSDR?