Electronics of Radio (Supplement)

Notes on David Rutledge’s book

John Manferdelli
johnmanferdelli@hotmail.com

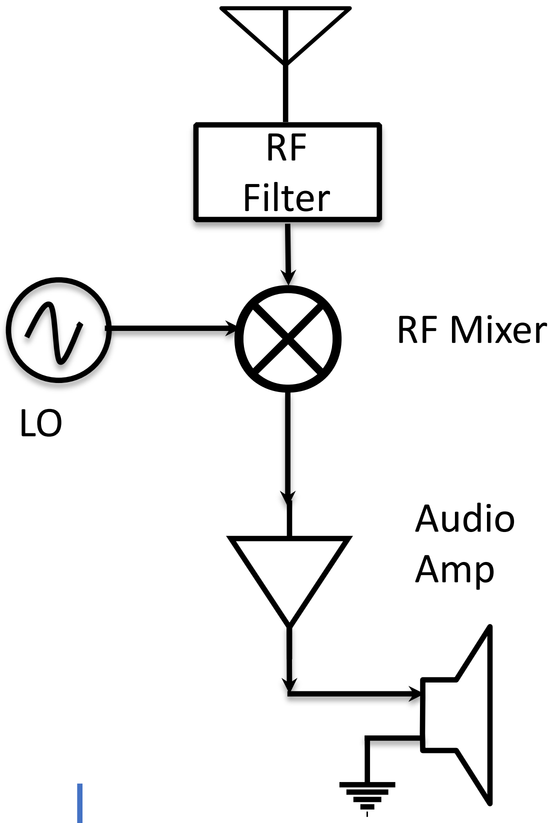
11062021 12:12

Modulation

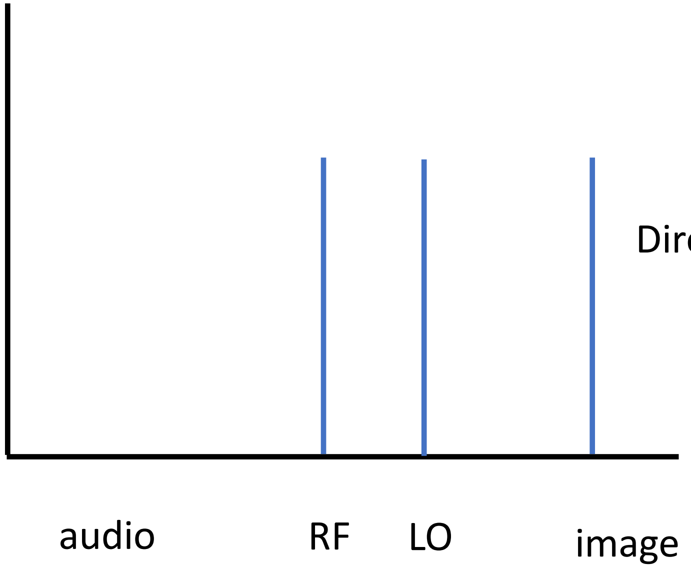
- AM: $V(t) = a(t)\cos(\omega_c t) + V_c\cos(\omega_c t)$
- FM: $V(t) = V_c\cos([\omega_c + a(t)]t)$
- FSK: $V(t) = V_c\cos(\omega_1 t)$, if 1 [mark]; $V_c\cos(\omega_0 t)$, if 0 [space]
- PSK: $V(t) = V_p\cos(\omega_c t)$, if 1; $-V_p\cos(\omega_c t)$, if 0 [space]
- Gain: $G = \frac{P_o}{P_i}$, Loss: $L = \frac{P_o}{P_{max}}$, Rejection: $\mathrm{R} = \frac{P_{max}}{P_{pb}}$,

Direct conversion receivers

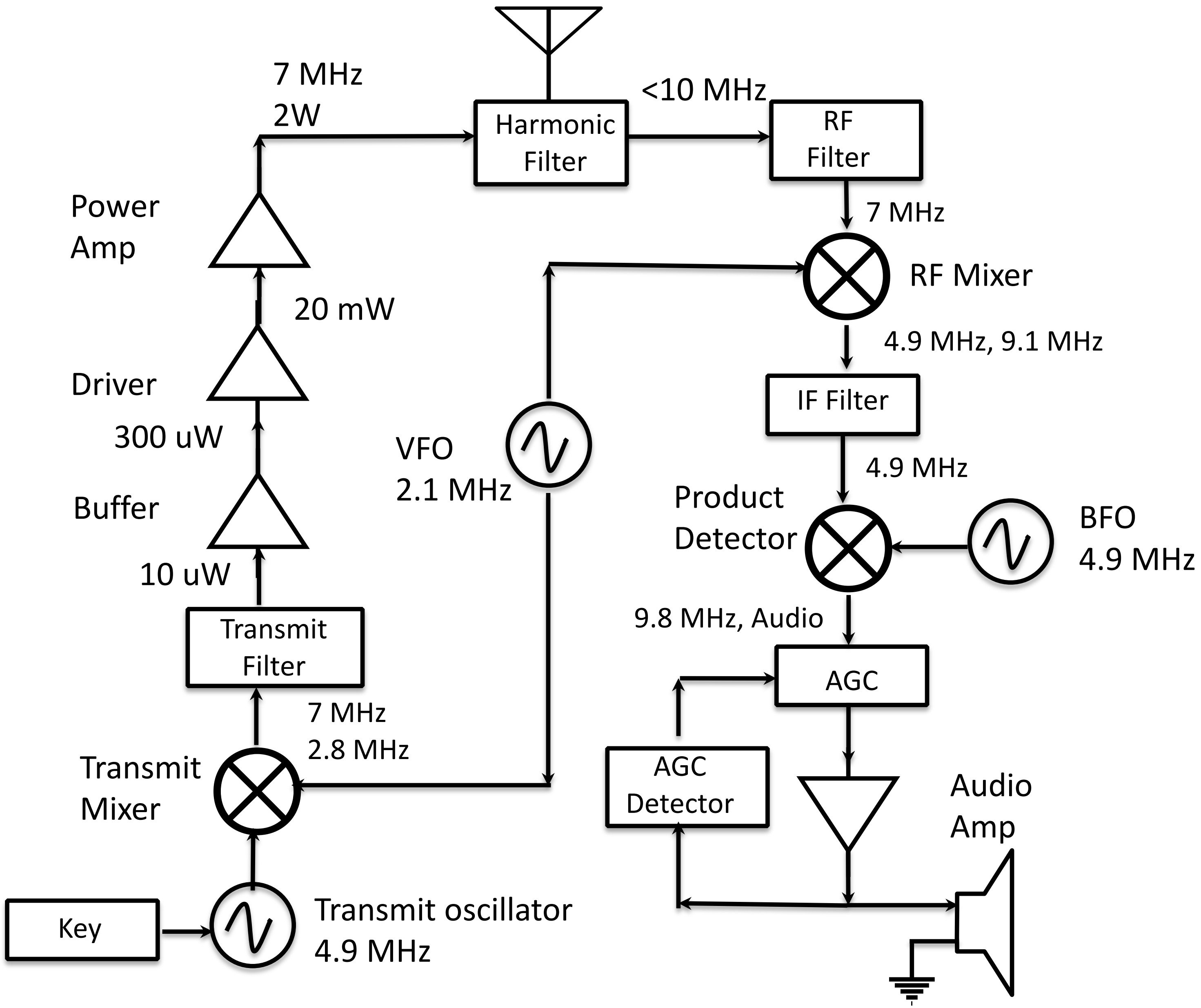
- Mixer
  - $V(t) = \cos(\omega_1 t)\cos(\omega_2 t) = \frac{1}{2}[\cos((\omega_1 + \omega_2)t) + \cos((\omega_1 - \omega_2)t)]$
- Image frequency
  - $\omega_{vi} = \omega_{LO} + \omega_a$
  - $\omega_{rf} = \omega_{LO} - \omega_a$
- RF filter removes image
- Downside:
  - Not tunable



Direct conversion



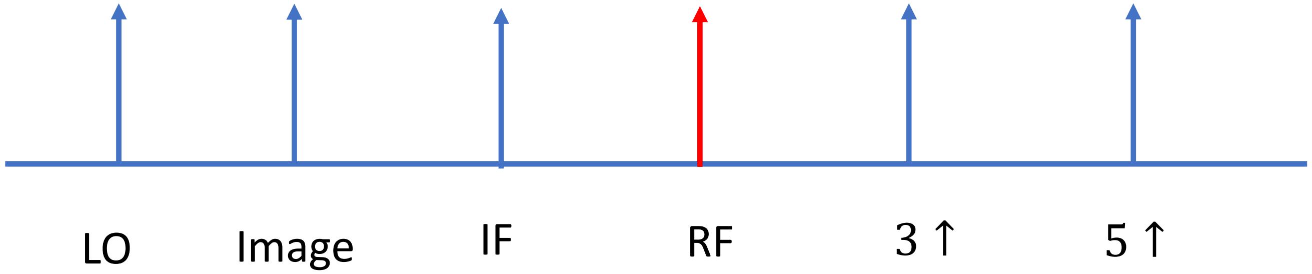
Norcal 40A



7 MHz
2W
Harmonic
Filter
<10 MHz
RF
Filter
7 MHz
Power
Amp
RF Mixer
20 mW
4.9 MHz, 9.1 MHz
Driver
IF Filter
300 uW
VFO
2.1 MHz
4.9 MHz
Product
Detector
BFO
4.9 MHz
Buffer
10 uW
Transmit
Filter
9.8 MHz, Audio
AGC
7 MHz
2.8 MHz
Transmit
Mixer
AGC
Detector
Audio
Amp
Key
Transmit oscillator
4.9 MHz

Mixers

- $V_{lo}(t)$ is a square wave with period ω_{lo}. Expanding this in a Fourier series, we get:
- $V_{lo}(t) = \frac{4}{\pi}(\cos(\omega_{lo}t) - \frac{\cos(3\omega_{lo}t)}{3} + \frac{\cos(5\omega_{lo}t)}{5} \dots)$, $V_{rf}(t) = V_{rf}\cos(\omega_{rf}t)$
- $V_{lo}(t)V_{rf}(t) = \frac{2V_{rf}}{\pi}(\cos(\omega_{-}t) - \frac{\cos(3\omega_{-}t)}{3} + \frac{\cos(5\omega_{-}t)}{5} \dots) + \frac{2V_{rf}}{\pi}(\cos(\omega_{+}t) - \frac{\cos(3\omega_{+}t)}{3} + \frac{\cos(5\omega_{+}t)}{5} \dots)$
- $\omega_{+} = \omega_{lo} + \omega_{rf}$ and $\omega_{-} = |\omega_{lo} - \omega_{rf}|$
- We define $\omega_{k+} = (k\omega_{lo} + \omega_{rf})$ and $\omega_{k-} = |k\omega_{lo} - \omega_{rf}|$ and $V_{k+}(t) = \frac{2V_{rf}}{k\pi}\cos(\omega_{k+}t)$ and $V_{k-}(t) = \frac{2V_{rf}}{k\pi}\cos(\omega_{k-}t)$
- $\omega_i = \omega_{if} - \omega_{lo}$ and $\omega_{if} = \omega_{if} + \omega_i$, ω_i is a spurious signal. ω_{k+} and ω_{k-} are the spurs from the kth harmonic



Phasors

- $V(t) = RI(t)$
- $V(t) = L\dot{I}(t)$
- $I(t) = C\dot{V}(t)$
- Suppose $V(t) = Acos(\omega t + \theta)$ and $\mathrm{I}(t) = Bcos(\omega t + \phi)$. If $\phi > \theta$, we say the current leads the voltage.
- $V(t) = Re(e^{j(\omega t+\theta)})$, and $\mathrm{I}(t) = Re(e^{j(\omega t+\phi)})$
- Now define $V = Ae^{j\theta}$ and $I = Be^{j\phi}$, so $|V| = A$, $|I| = B$, $\angle V = \theta$, and $\angle I = \phi$. V and I are called phasors and do not include time. Note that $V(t) = Re(Ve^{j\omega t})$ and $\mathrm{I}(t) = Re\left(Ie^{j\omega t}\right)$.
- Note that $I = CVj\omega$, for a capacitor and $V = LIj\omega$, for an inductor

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