Multi-Channel Signal Transmission over Fiber

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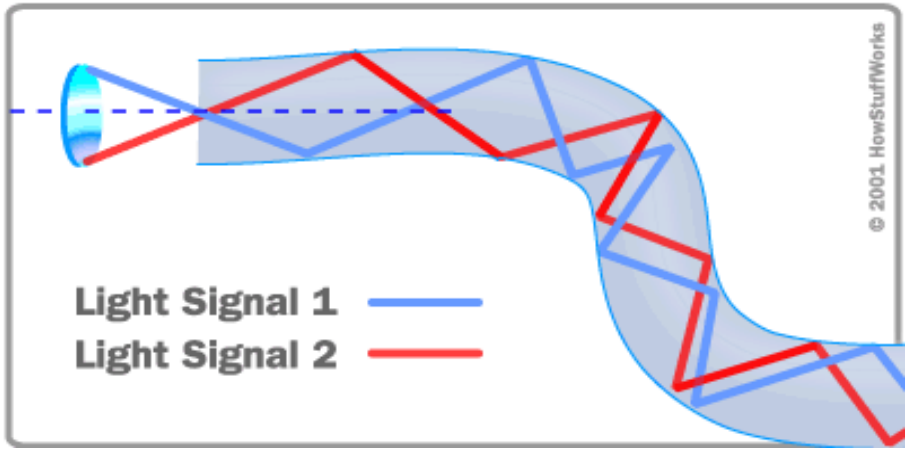
Design Goals

- FM modulate 3-4 different signals of potentially large bandwidth
- Transmit over fiber optic cable
- Receive and demodulate on the receiver with low distortion

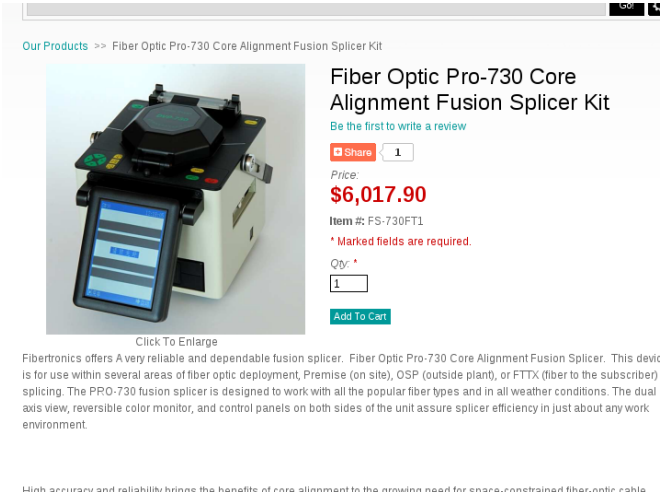
Why fiber?

- Less attenuation than copper
- Less noise than copper
- Doesn’t require as much reamplification

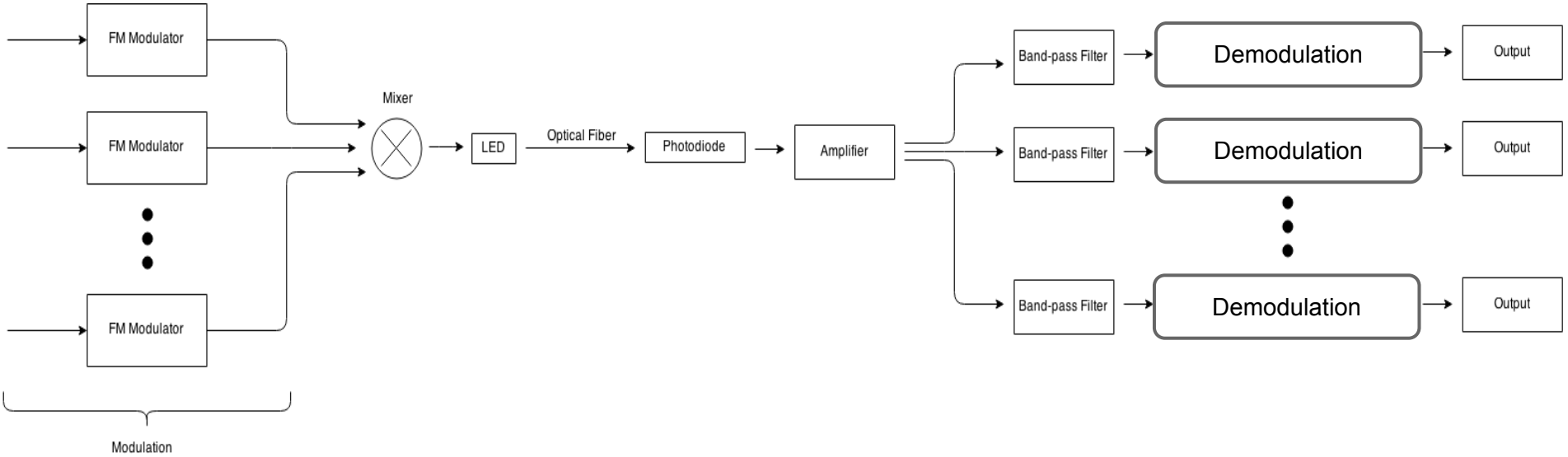


Why RF?

- Wavelength Division Multiplexing is too expensive
- RF is common and well-understood



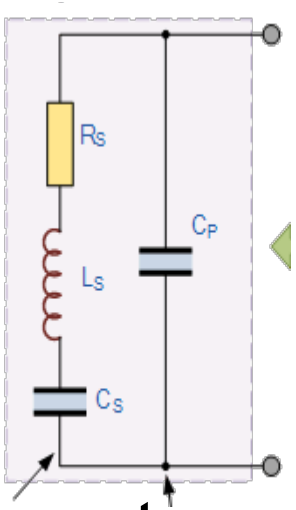
Block Diagram



Dividing the work

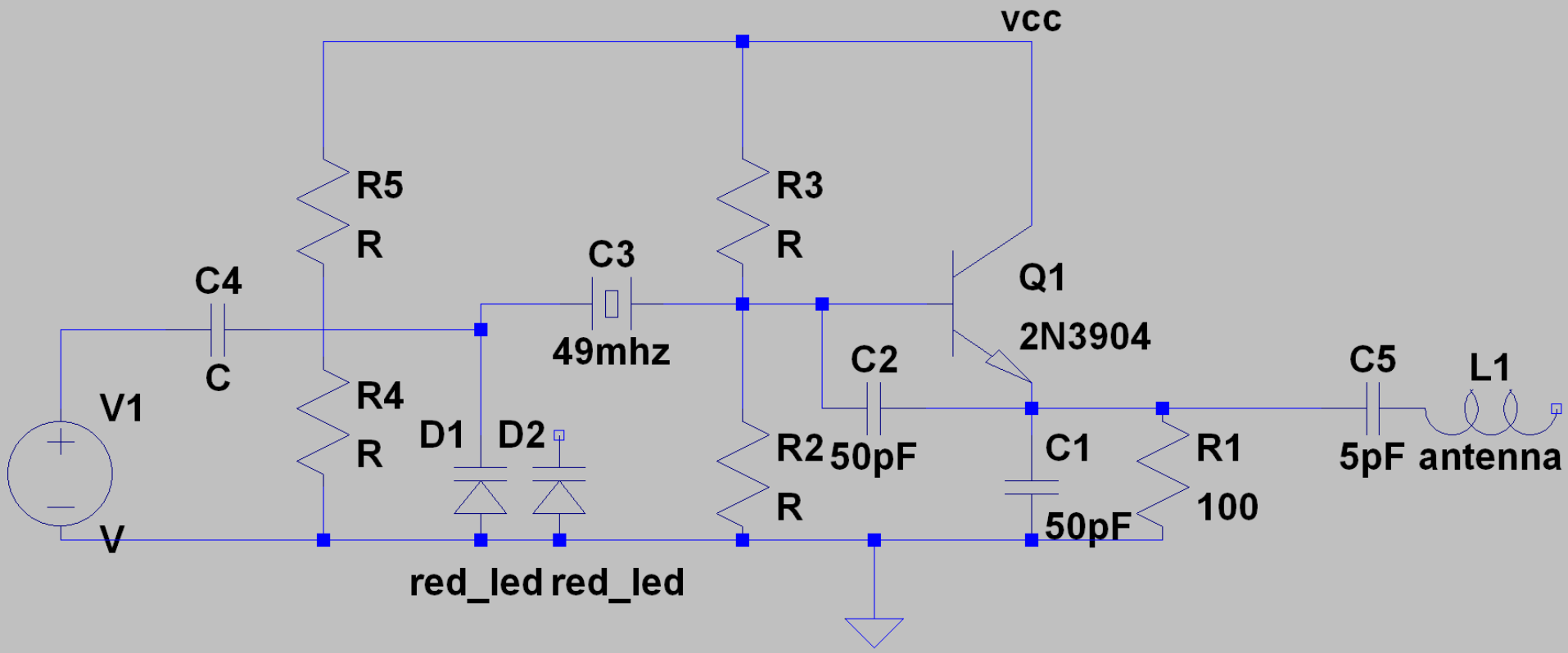
- Yanni: Modulation
- Max: Demodulation

Transmitting: FM Modulator



- VCXO (crystal based)
  - crystals have extremely high Q
  - reduces part count
  - act as tuned LC circuit
- Modulation and mixing happens in one step

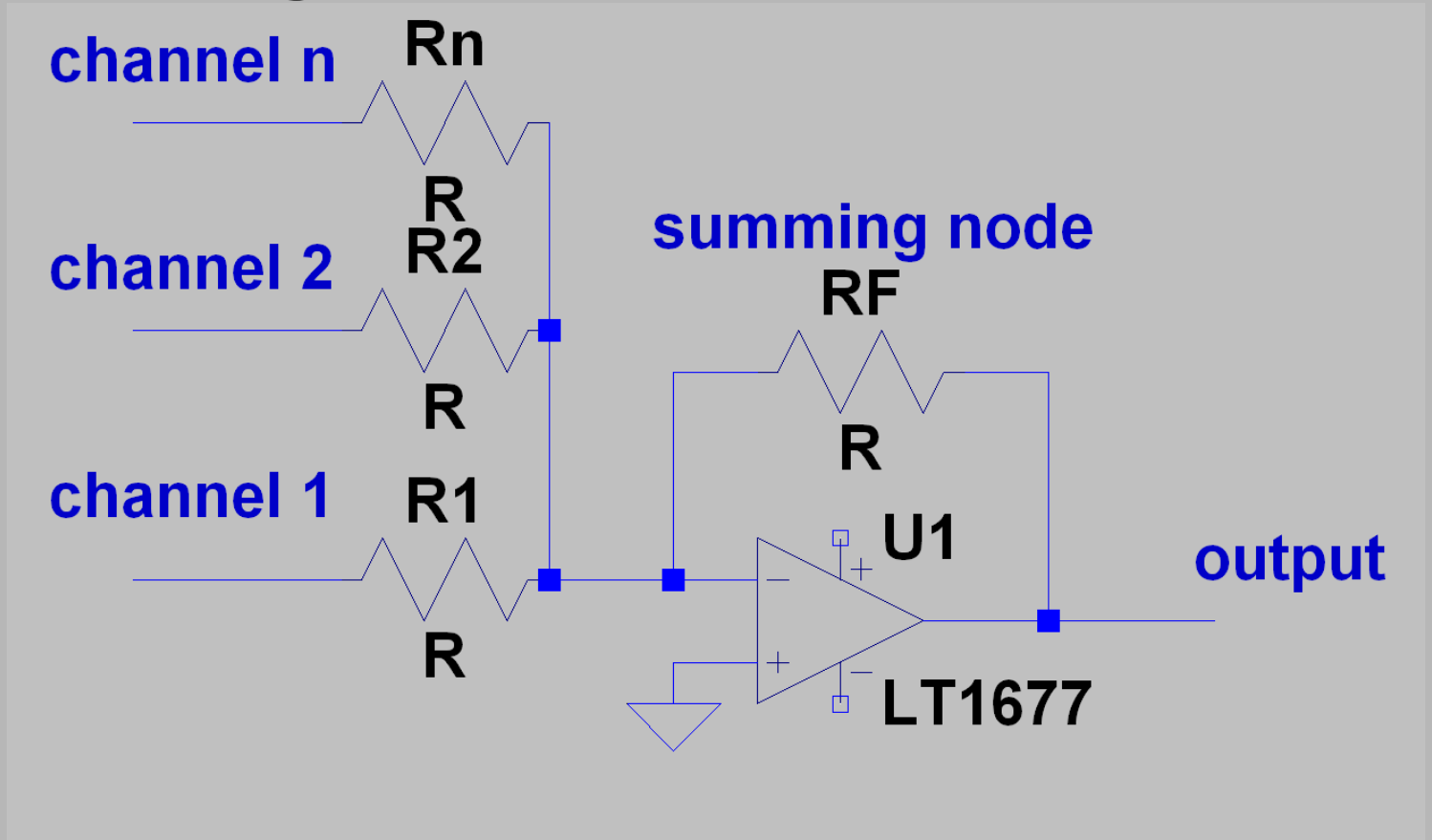
FM Modulator



Mixing the Outputs

- Fourier transform is linear so a simple op-amp adder circuit will suffice
- 1GHz GBW op-amp
  - when moving to a pcb, GBW in excess of 3GHz are easy to obtain in common footprints

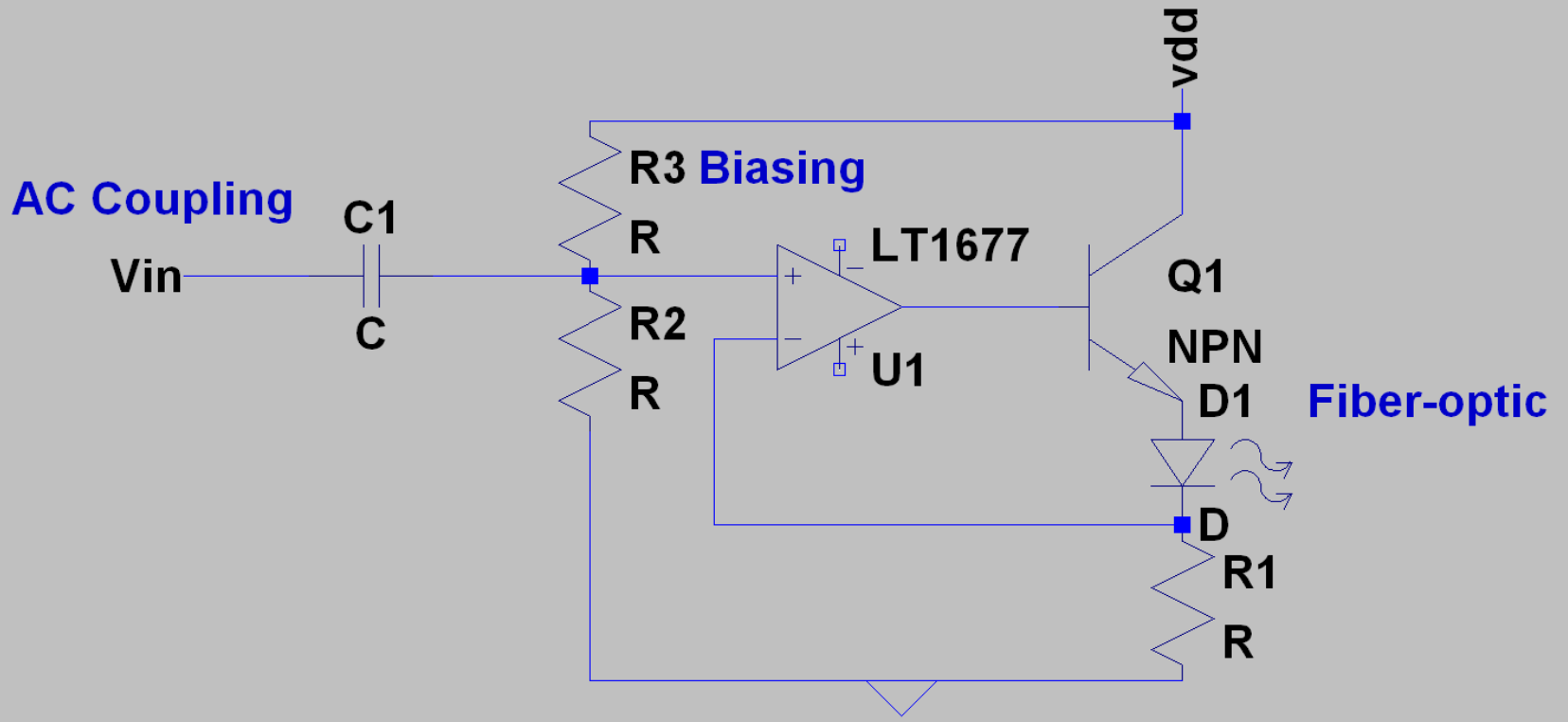
Summing Amp


channel n
Rn
R
channel 2
R2
R
channel 1
R1
R
summing node
RF
R
U1
output
LT1677

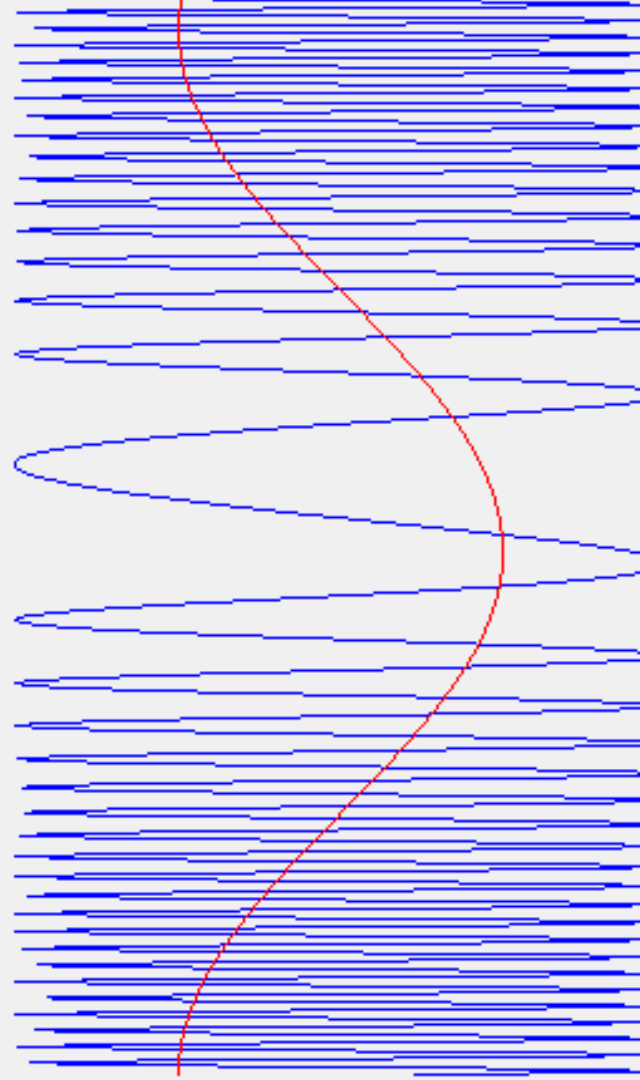
Transmitting Mixed Signals

- Transmitter is LED, those run on current sources
- Make a VCCS
  - wrap feedback around a transistor

Diagram of a VCCS

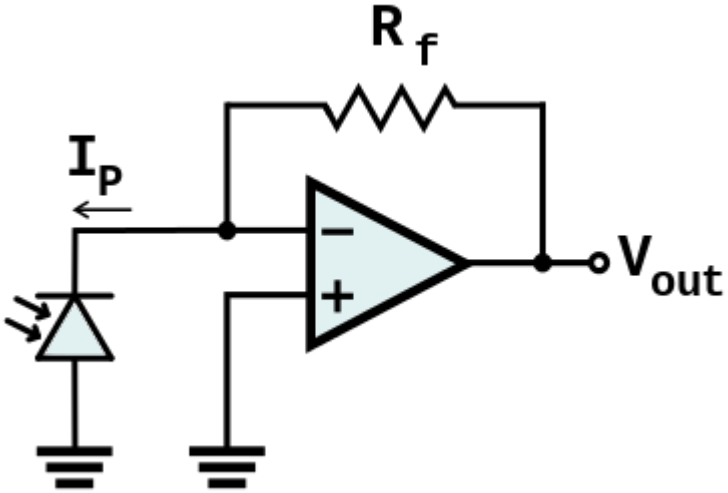


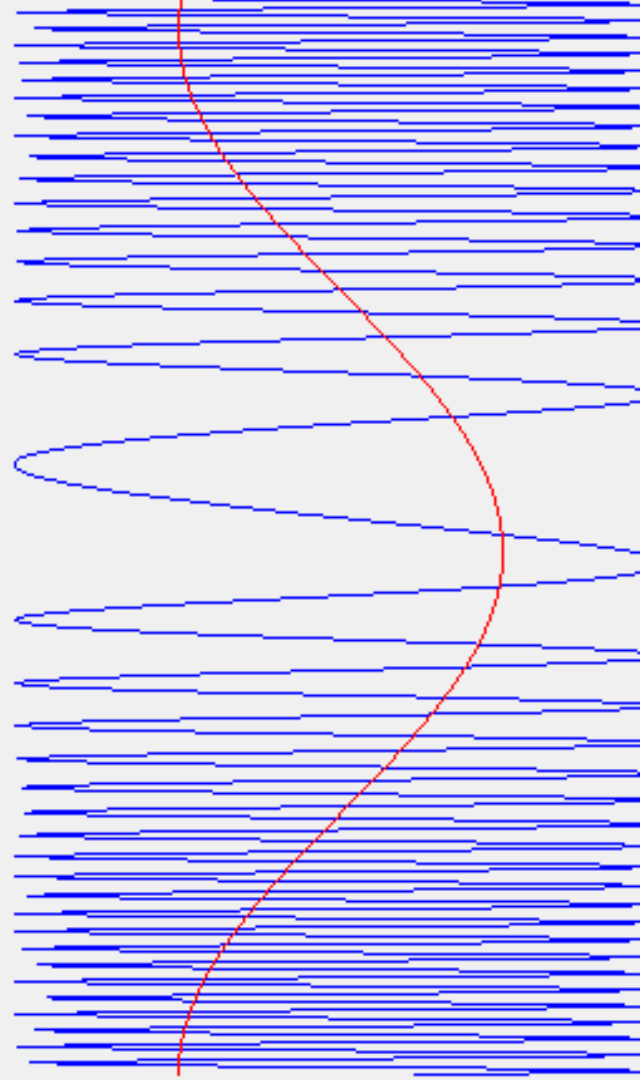
Receiving/Demodulation



Photodiode -> Voltage

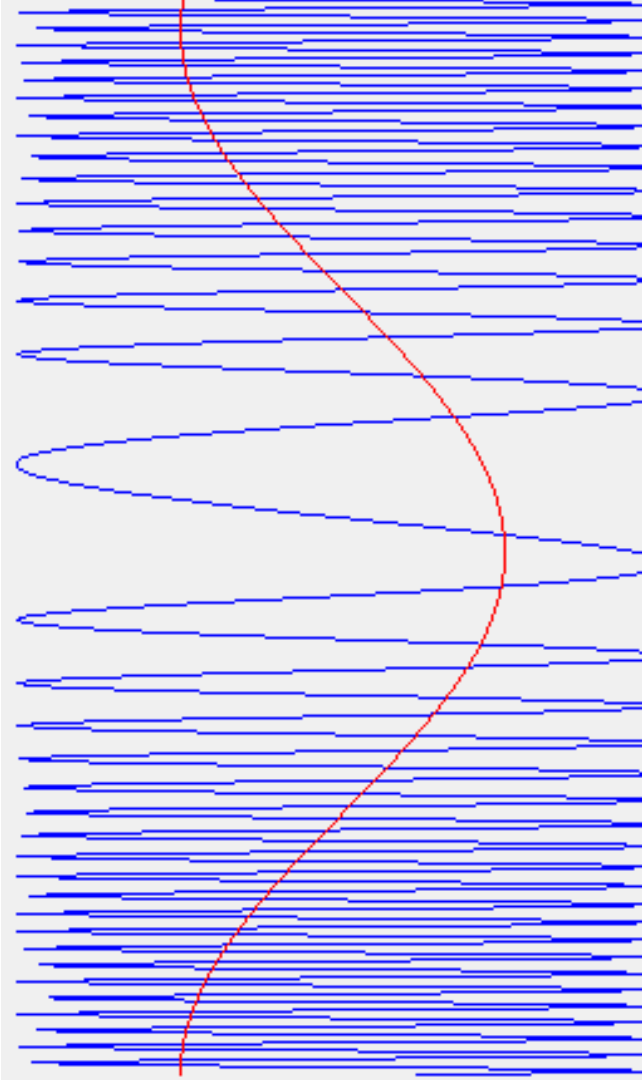
- Transimpedance amp
- (we've all seen this)





Receiving

- Many ways to demod FM
  - Quadrature demodulation
  - Slope detection
    - Superheterodyne receiver
    - Super regenerative receiver
    - Op-amp differentiation
  - Phase locked loop (PLL)



Why does differentiation work?

$$A\sin(2\pi f_c t + \beta sin(2\pi f_m t)).$$

$$\frac{d}{dt}.$$

$$A[\text{stuff}]\cos(2\pi f_m t)\sin(2\pi f_c t + \beta sin(2\pi f_m t)).$$

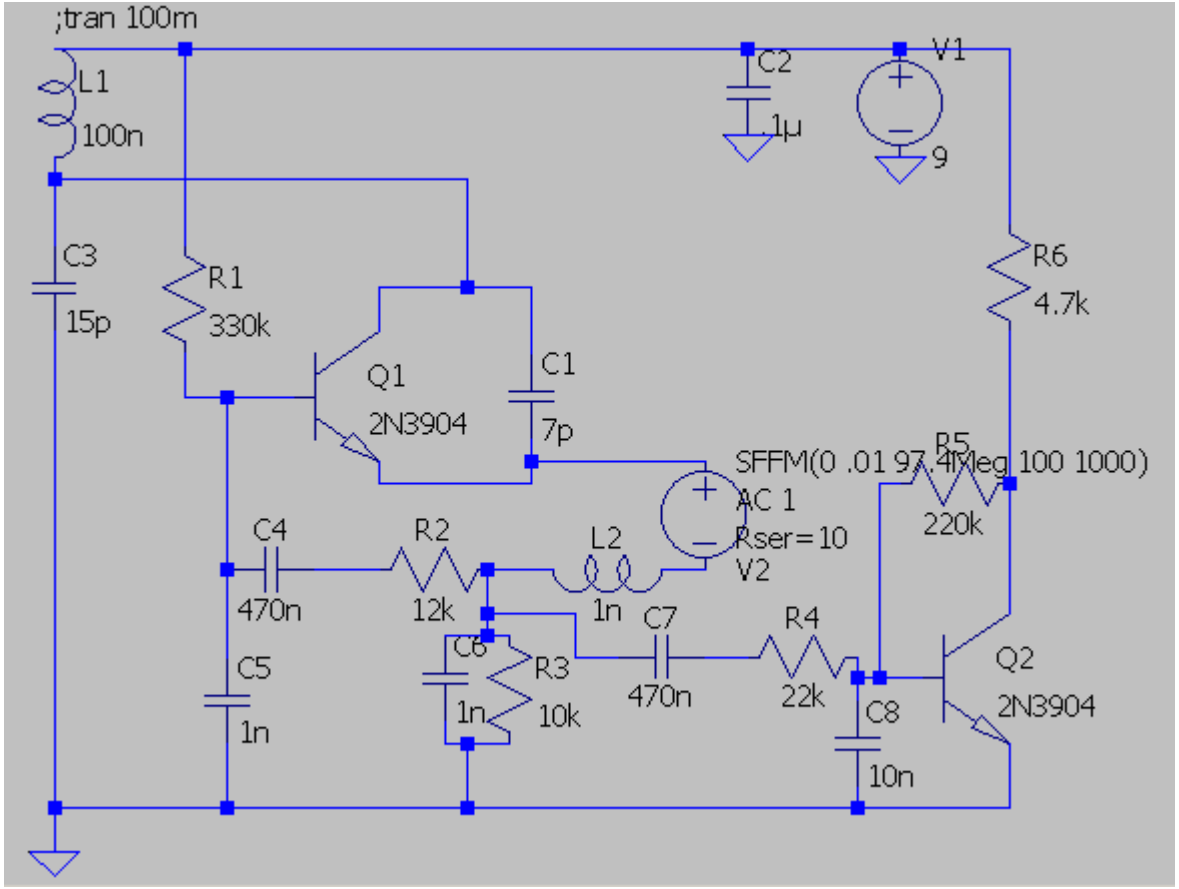
Why does differentiation work?

- FM -> Envelope
- Envelope -> Diode -> LPF
- Nyquist’s Theorem
- Must sample at twice the highest frequency component

Super Regenerative Receivers

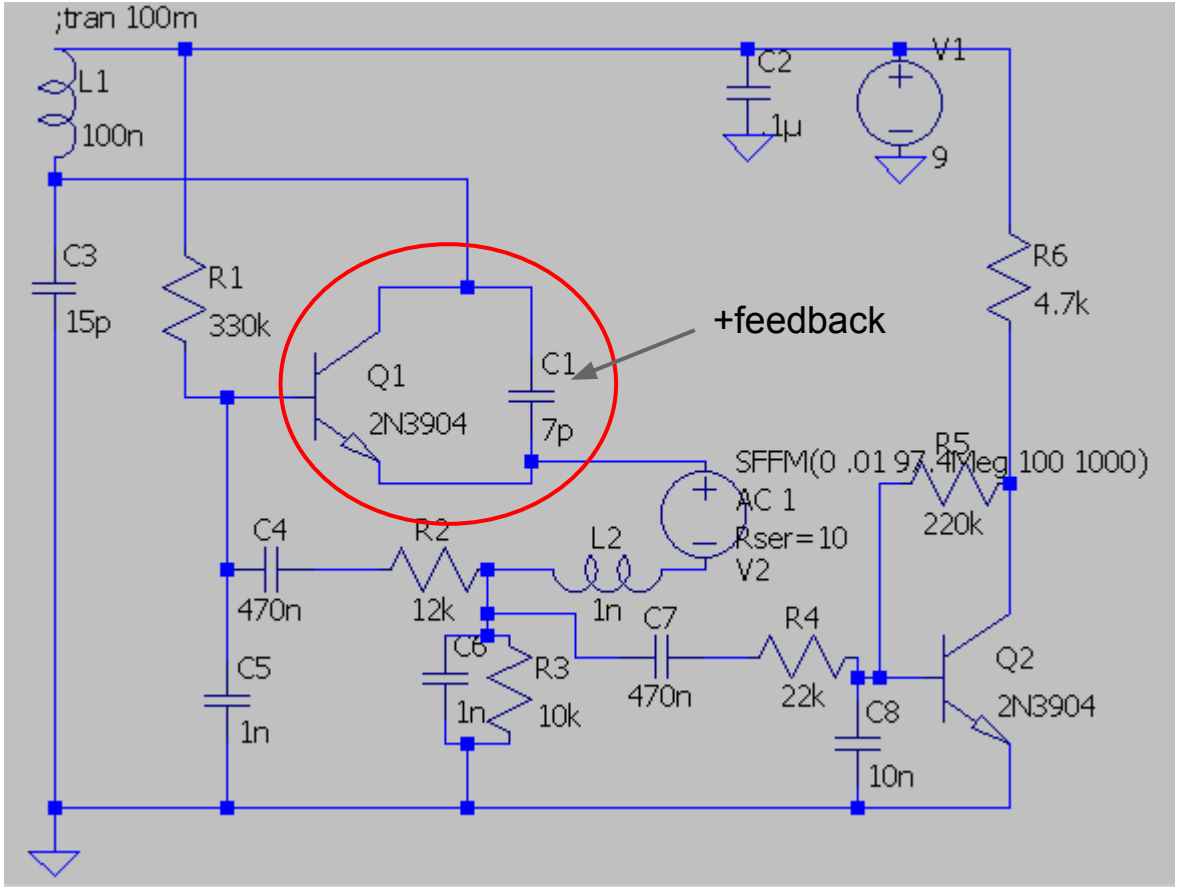
- Transistor with positive feedback
- Slope detection
- Amplify and demodulate in one step
- Popular ~1915
- Generally replaced by superhet receivers

Regenerative Receiver



(Thanks, ke3ij!)

Regenerative Receiver



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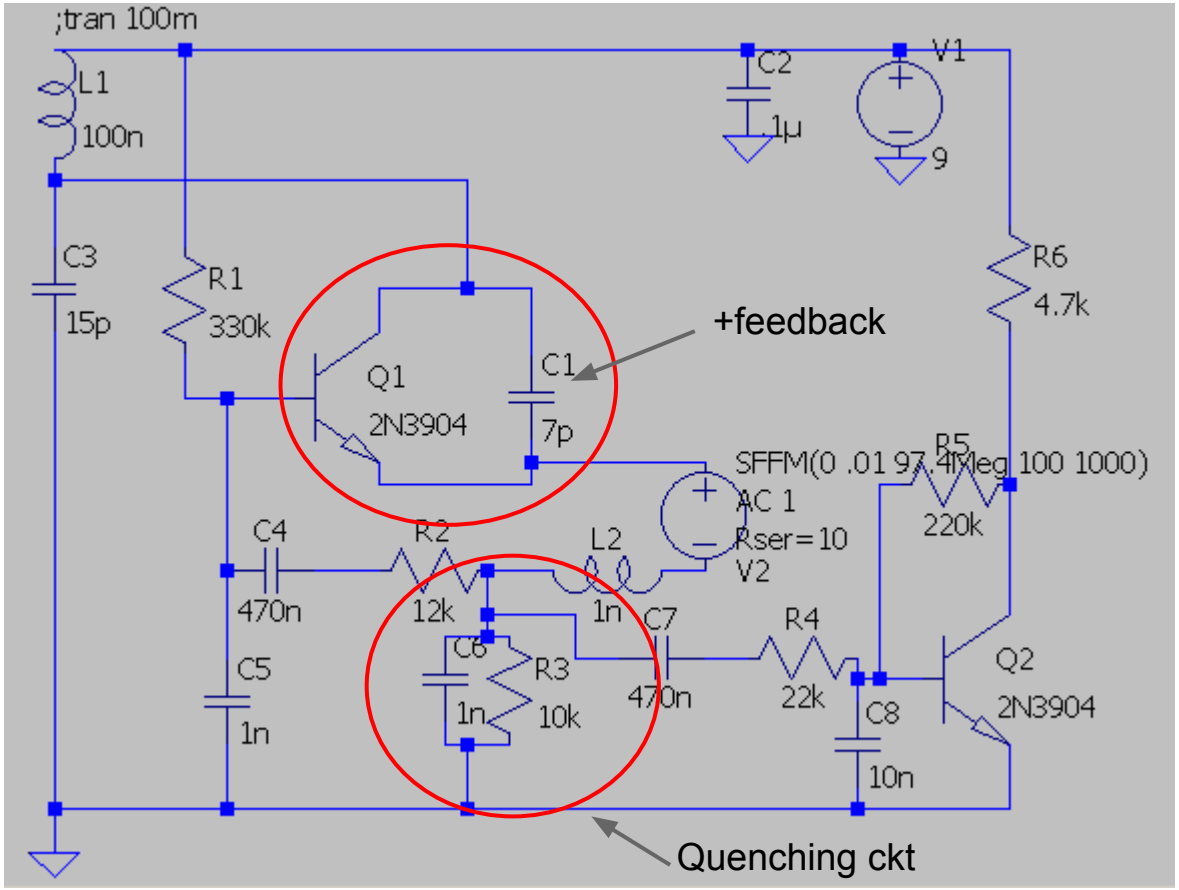
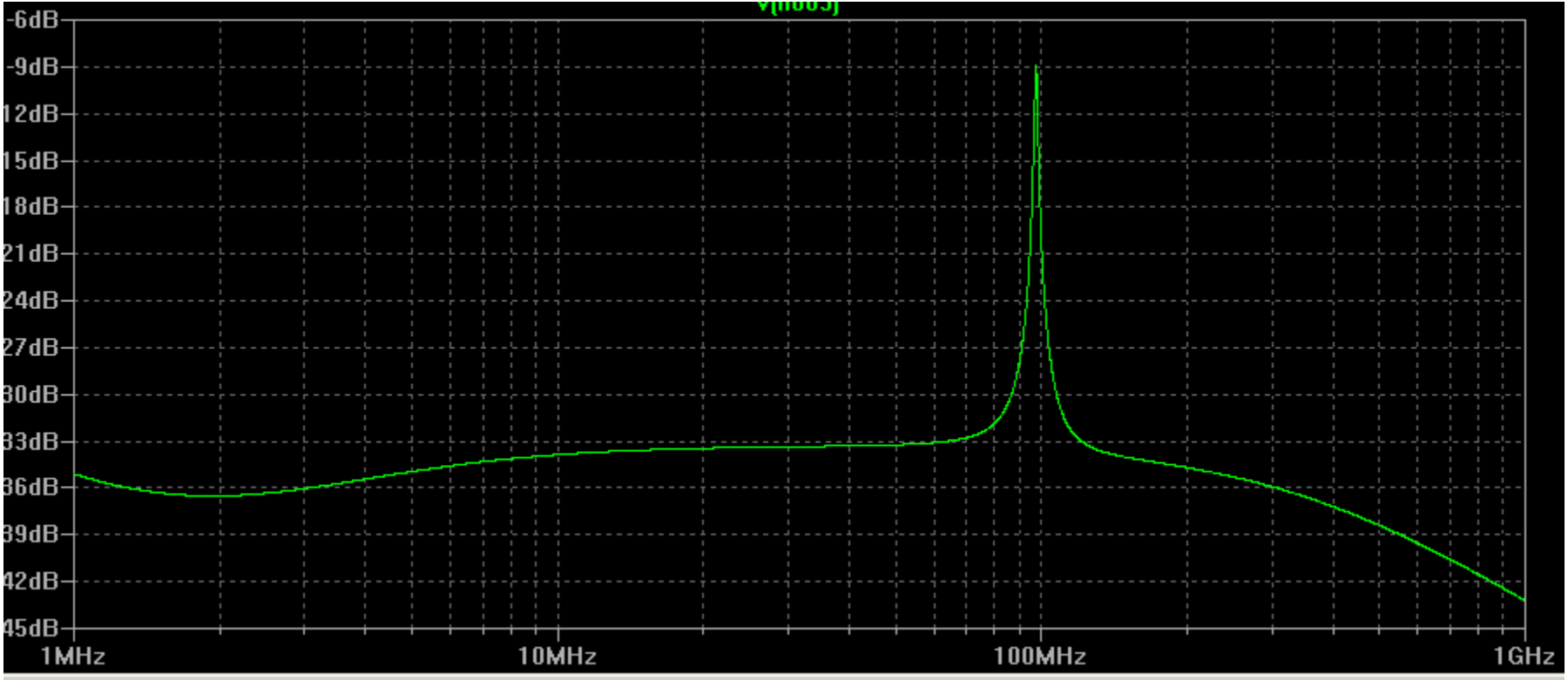
Regenerative Receiver



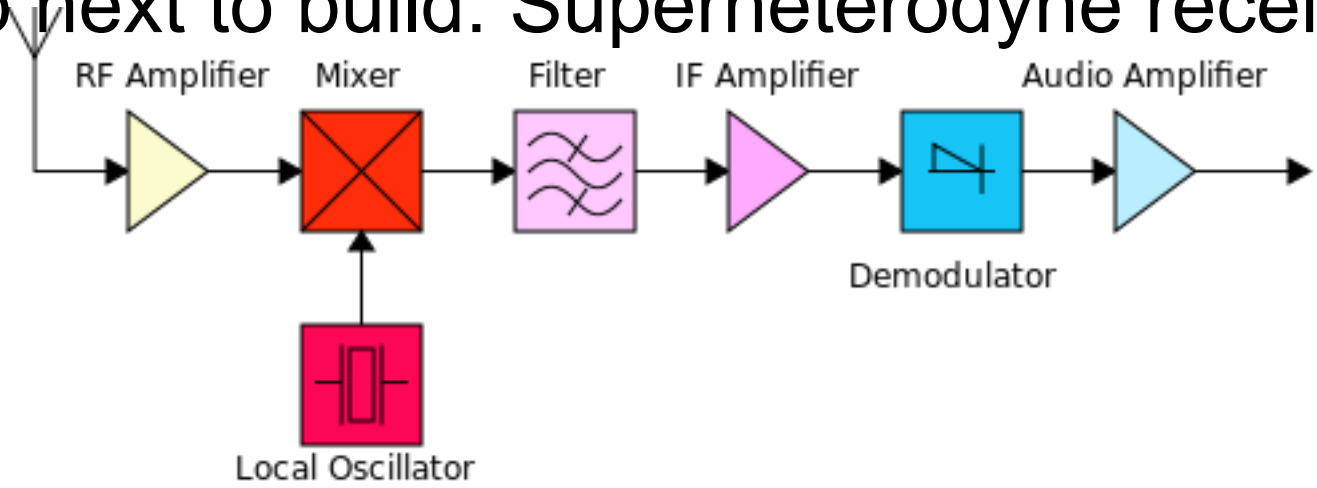
(Thanks, ke3ij!)

Frequency Analysis (LTSpice)



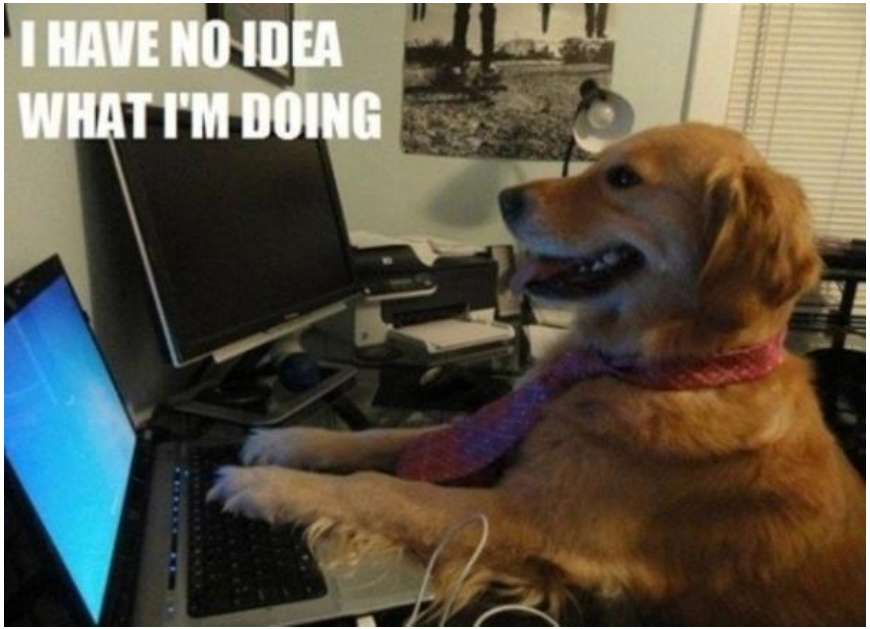
Super Regenerative Receivers

- Not optimal for this application (best at WFM)
- Up next to build: Superheterodyne receiver



DEMO!

- Tune in to 49.9 MHz FM
- Pirate radio



Timeline

This week:

- Build more receiving circuits, pick what works best, try to maximize SNR
- Replace radio with fiberoptic

Next week:

- Nail down our mixing technique
- Design and order boards, assemble

Then -> Checkoffs:

- ***Debug!***