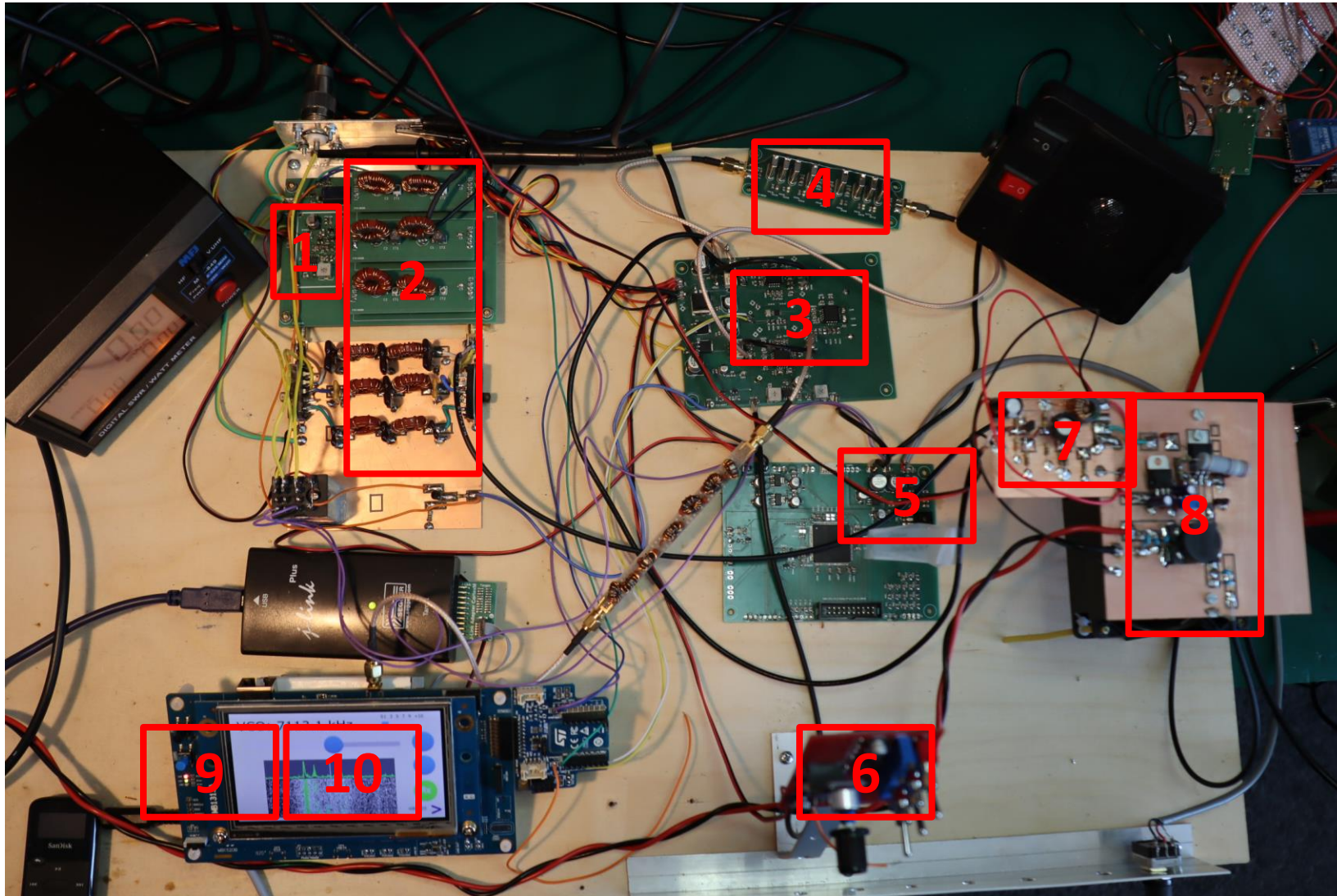


# The DIY super-het transceiver



1. Antenna amp
2. BP and LP filters
3. DDS and mixers
4. Crystal ladder filter
5. AF amp
6. Microphone amp and 2-tone gen.
7. PWR pre amp
8. PWR amp
9. Touch GFX
10. FFT

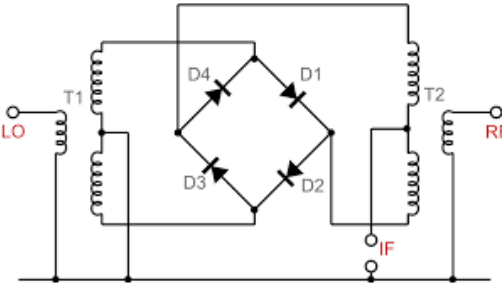
# Mixer basics

Multiplying two sine waves:

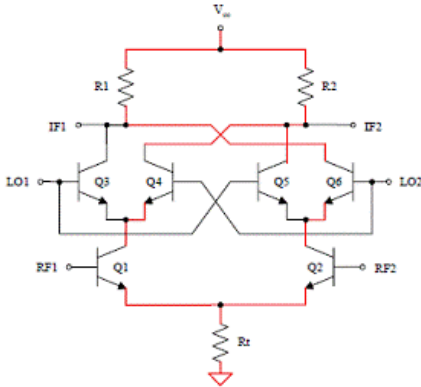
$$\sin(\omega_1 t) \cdot \sin(\omega_2 t) = \frac{1}{2} (\underbrace{\cos(\omega_1 t - \omega_2 t)}_{f1 - f2} - \underbrace{\cos(\omega_1 t + \omega_2 t)}_{f1 + f2})$$

Multiplying two signal in HF = mixing the signals

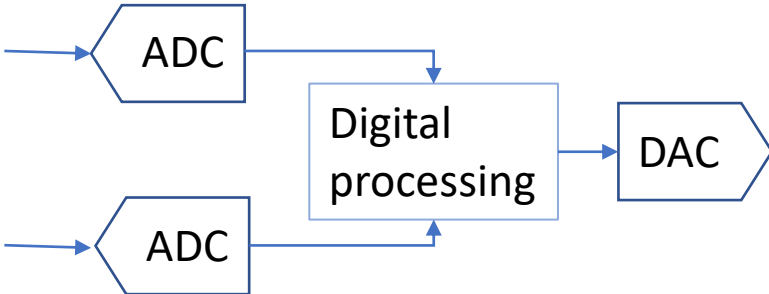
Diode ring mixer



double balanced BJT mixer



digital processing



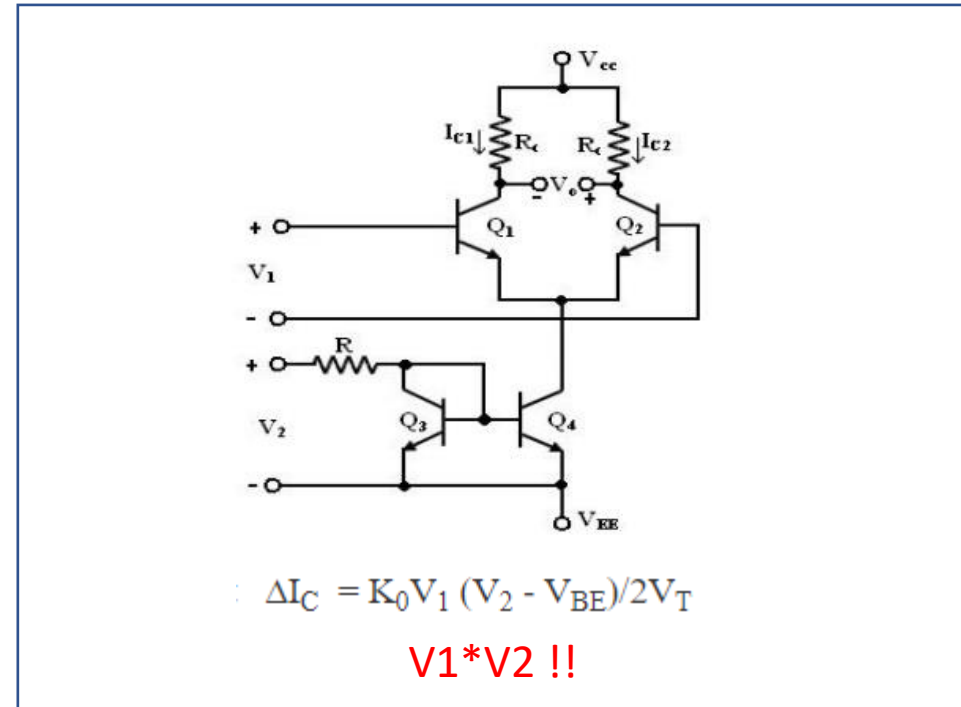
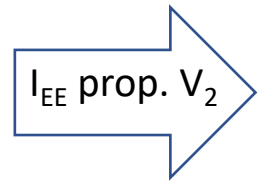
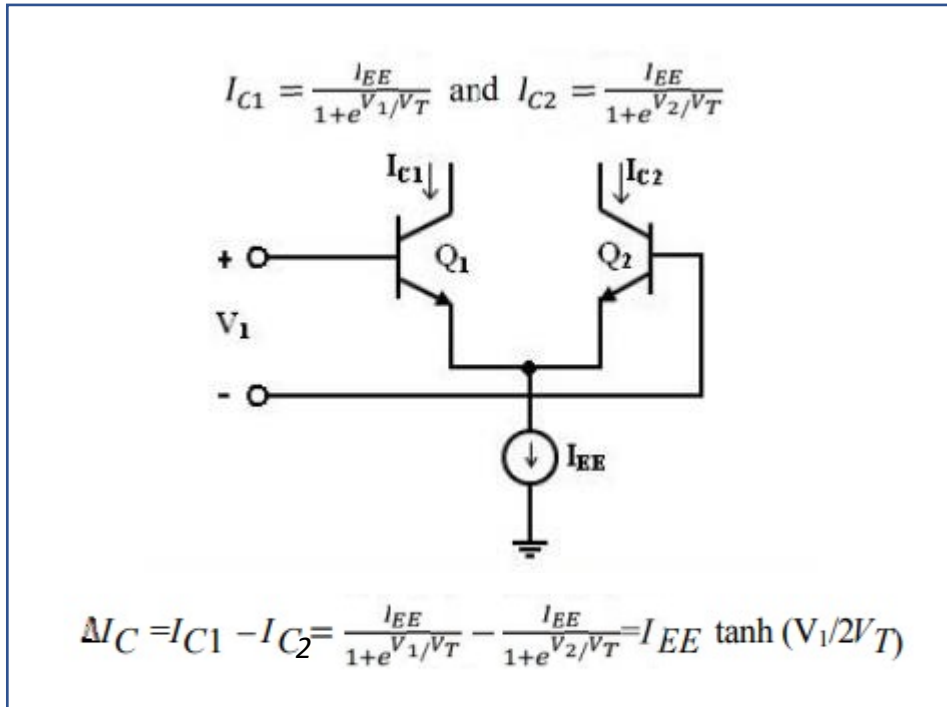
# A BJT can be used as a multiplier...

$$I_C \approx I_S e^{V_{BE}/V_T}$$

BJT is a voltage dependent current-source → can be used as an amplifier

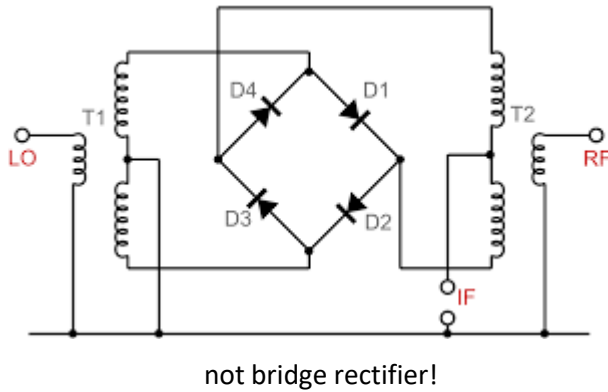
$V_T$  = thermal voltage; about 26mV at room temp.;  $kT/q$  ( $k$  = Boltzmann const.,  $T$  = temp.,  $q$  = charge of an electron)

$I_S$  = saturation current

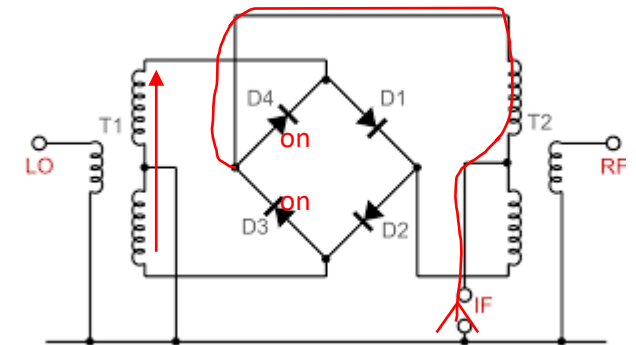
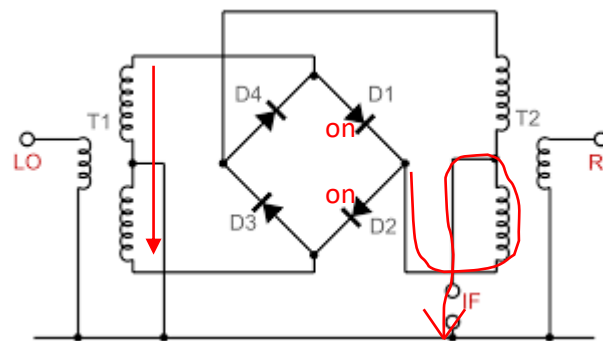
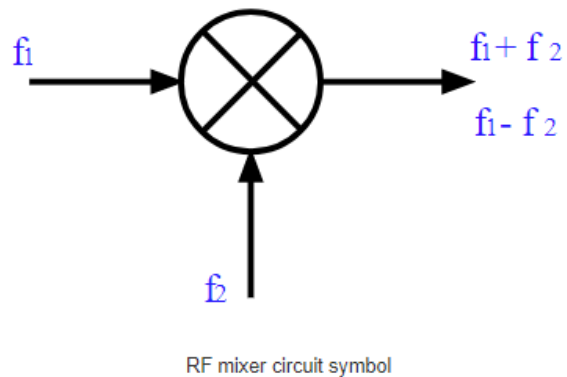


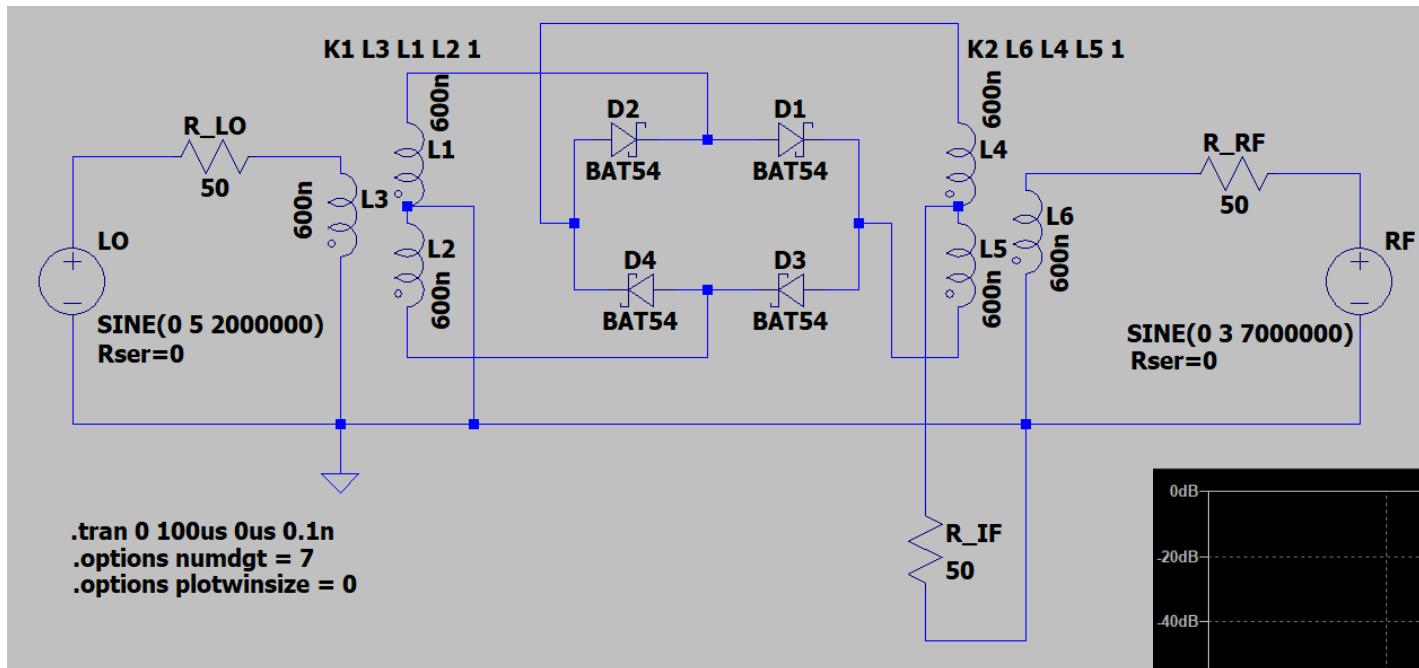
2 quadrant to 4 quadrant -> Gilbert Cell

# Diode Ring Double Balanced Mixer



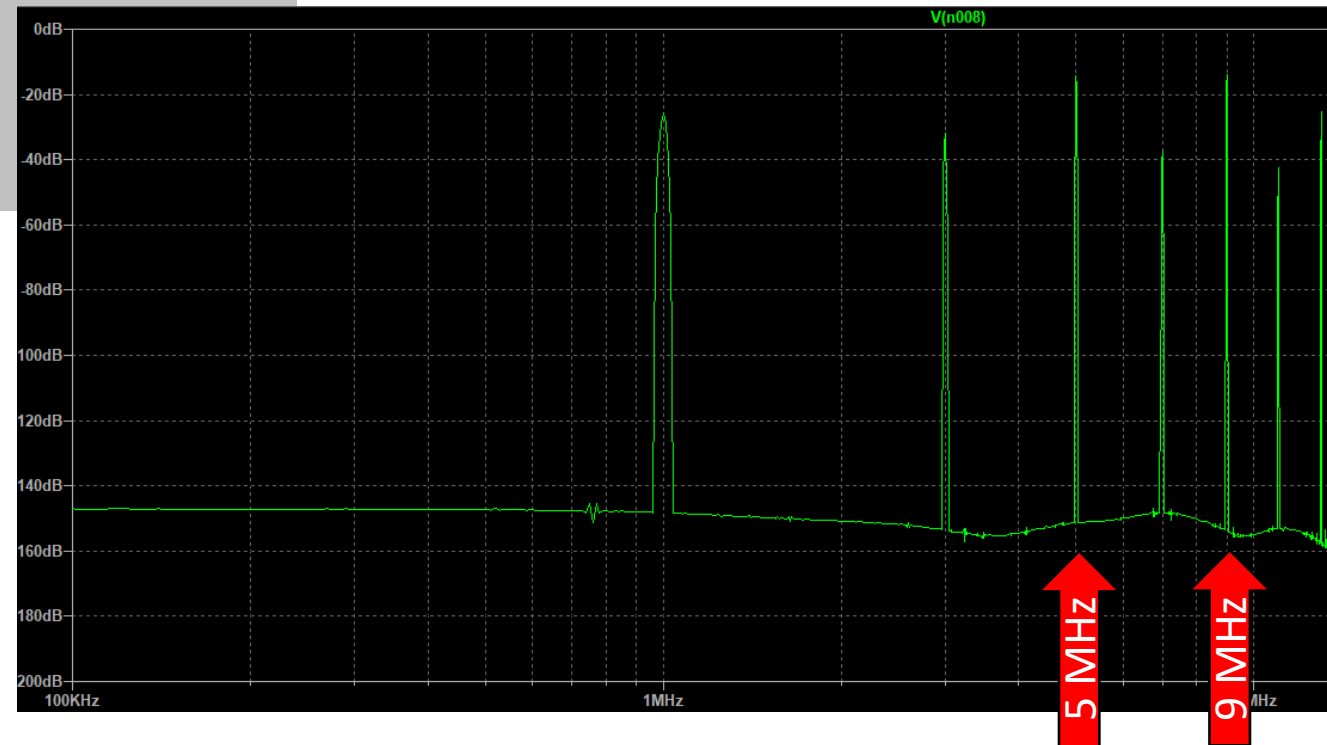
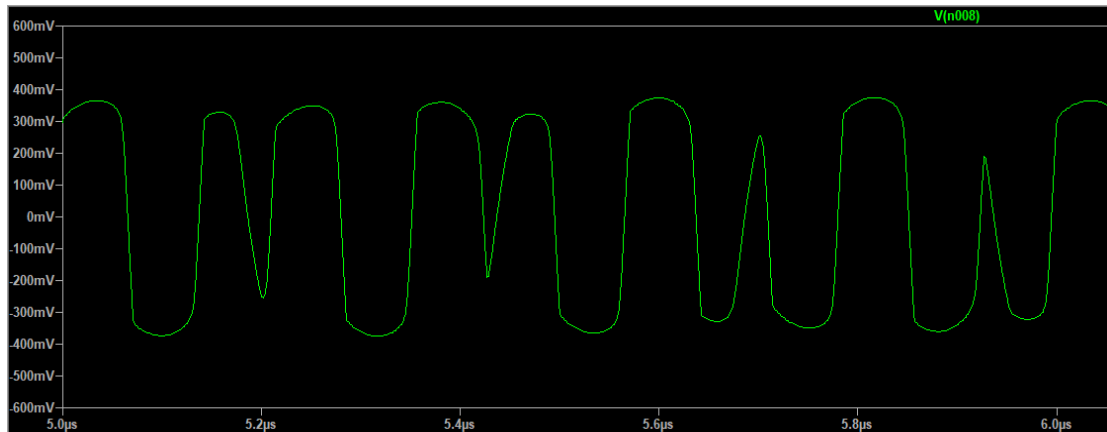
- Diodes used as switches
- Usually, schottky diodes used for lower forward voltage of 0.3V, low on resistor and good high freq. response
- Choose 20dB higher signal on LO vs. RF to drive the diodes from LO
- LO must be  $> 7\text{dBm}$
- Analog switches can be used as well





# LT Spice Simulation

- LO = 2MHz, RF = 7MHz
- IF = 9MHz and 5MHz



# Mixer in GNU radio

