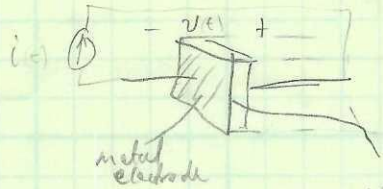
Crystal Osc (XO) & Voltage Controlled Crystal Osc (VCXO)

Frequency must normally be tightly controlled
Typical accuracy requirements

FM	$\ll \pm 200$ KHz @ 100 MHz	2000 ppm (0.2%)
NBFM (Cellular)	$\ll \pm 30$ KHz at 900 MHz!	33 ppm (0.0033%)

Can't achieve with standard components
Even if aligned, will drift $\approx \pm 25$ ppm/°C (or 0.1% for 50° change)
= 1 MHz out of 1 GHz

SOLN: Use Electro-acoustic Resonator!

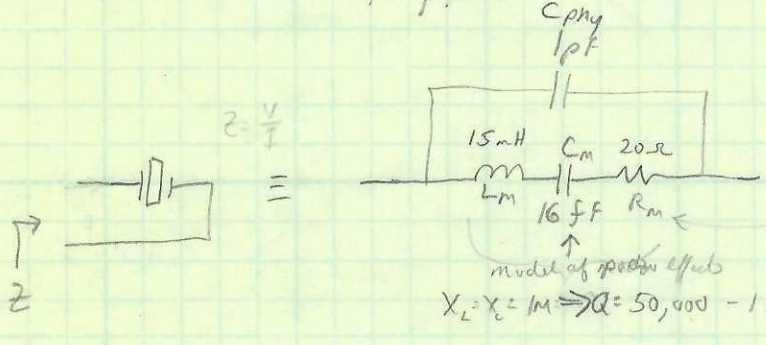


AC current ⇒ Voltage ⇒ E field ⇒ Stress ⇒ strain (delayed) ⇒ Voltage

Resonant when thickness = ½ acoustic wavelength, or 3/2, or 5/2, ...

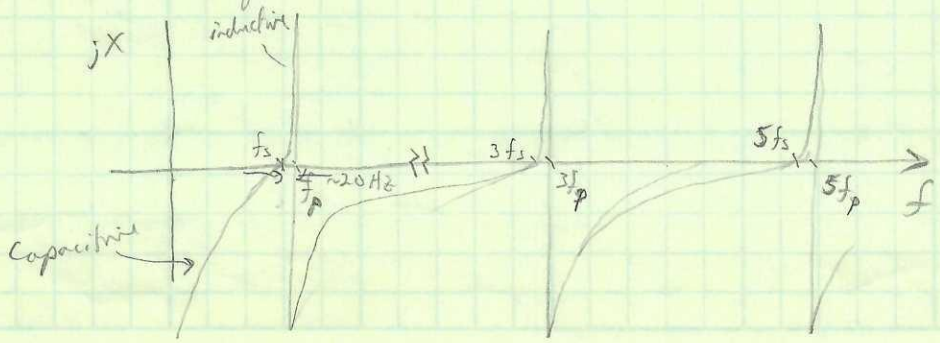
PASS OUT Crystals

Electrical model of I/V characteristic (fundamental resonance)

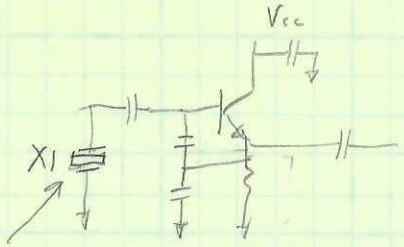


$X_L = X_C = 1M \Rightarrow Q = 50{,}000 - 100{,}000$

Reactance vs freq



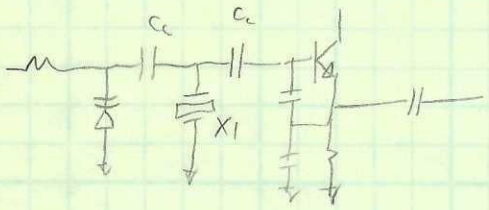
Stable Oscillators



ckt oscillates between f_s & f_p where X1 is inductive and reactance $X_L = X_{C_1 - C_2}$

Voltage Controlled Crystal Osc VCXO

Add varactor across crystal



Temperature Compensated XO (TCXO)

Add temp sensor and freq drift compensation ckt

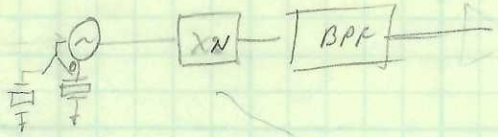
Result: f_o accurate to < 1 ppm over temperature!
(± 162 Hz at 162 MHz)

Problems

typically
fundamental f_o limited to < 50 MHz for crystal based oscillators

Can't "pull" f_o very far e.g. ± 1 kHz

Solns Frequency Synthesis

- 

Need lots of crystals to provide tuning

- Use as reference for PLL frequency synthesizer