Systems Engineering

Oscillators

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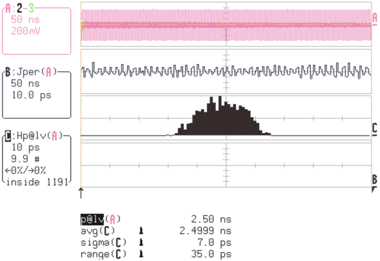
Oscillators

- Objective: generate a pure tone $A(\cos \omega t + \phi)$
- (or a square wave)
- Oscillation frequency
- Frequency drift
- Oscillator jitter
- Power
- Fixed or variable-frequency
- Dependence of frequency (ppm) with
  - Power supply
  - Load variations
  - Age
  - ...

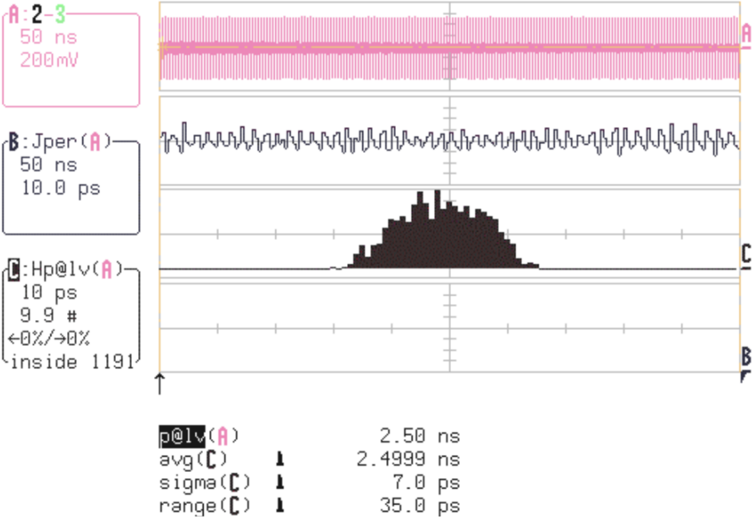
Oscillator Stability

- Long-term stability: ppm
- Short-term stability: jitter



Source: Cardinal Components Inc. A.N. 1006

Jitter in the time-domain

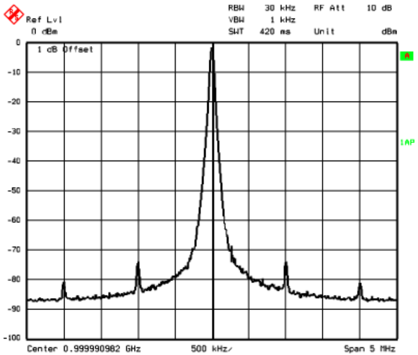


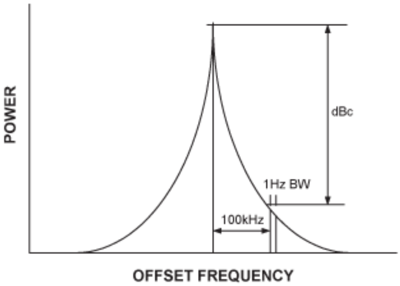
Source: Cardinal Components Inc. A.N. 1006

Jitter in the frequency-domain

Phase Noise

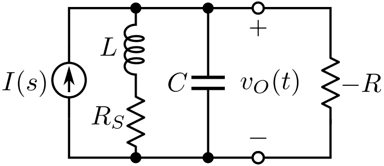
- Phase Noise (dBc @ 100 kHz)
- Different phase-noise profiles

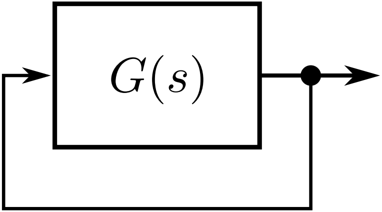




Oscillator Theory

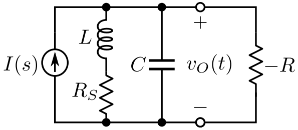
- Negative resistance approach
- Unity feedback approach
- Both approaches are exactly equivalent
  - But some circuit structures are easier to understand with one or the other

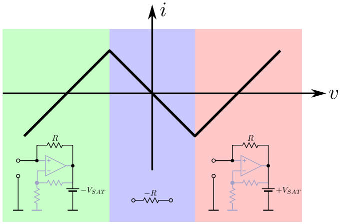


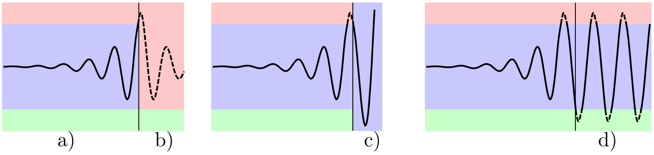


Negative resistance oscillators

- Negative resistance approach

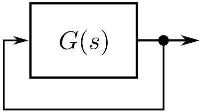






Feedback oscillators

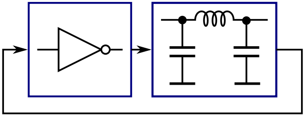
- $G(\omega) = 1$ approach



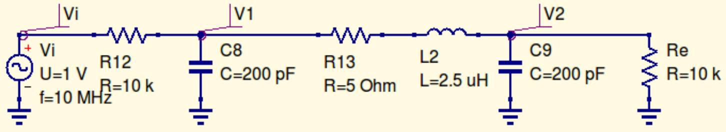
- These are two (!) conditions:
  - Magnitude $= 1$
  - Phase $= 0$

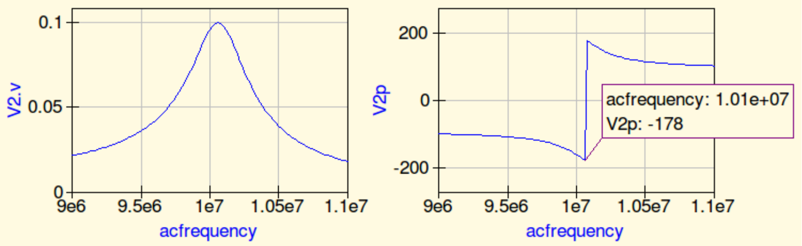
Feedback oscillators

- A popular approach with inverting gain element



- Detailed circuit analysis



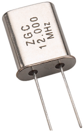


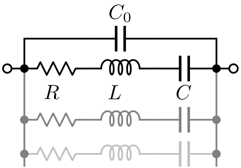
Resonators

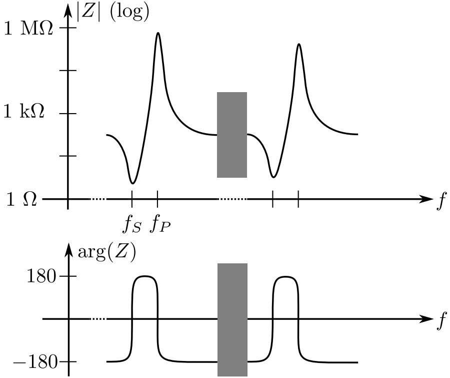
- LC circuits
  - $Q \sim 50$
  - Bad stability
- Ceramic resonators
  - $Q \sim 50$
  - stability 500 ppm
- Crystals
  - $Q \sim 50000$
  - stability better than 20 ppm
- Others
  - Transmission lines
  - Ceramic coaxial resonators
  - Cavities
  - ...

Crystals

- Piezoelectric material
- AT-cut



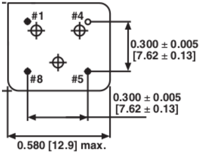


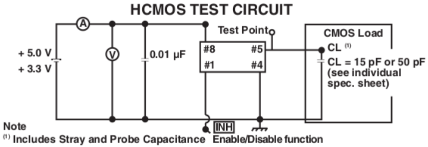


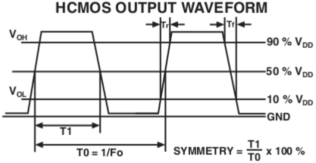
Crystals

- Equivalent circuit 10 MHz crystal
  - R=12 Ω. C=24 fF, C0=6 pF L=105 mH
  - Q=50000
- Equivalent circuit 12 MHz crystal
  - R=10 Ω, C=9 fF, C0=4 pF, L=19 mH
  - Q=130000

Crystal modules







ENABLE/DISABLE FUNCTION	
INPUT (PIN 1)	OUTPUT (PIN 5)
OPEN	ENABLE
$V_{IH} \geq 2.2\ V_{DC}$	ENABLE

PIN	CONNECTION
#1	N.C.
#4	GND
#5	OUTPUT
#8	V_{DD}