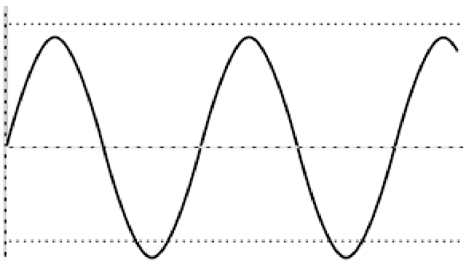
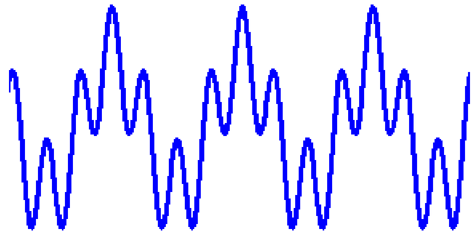
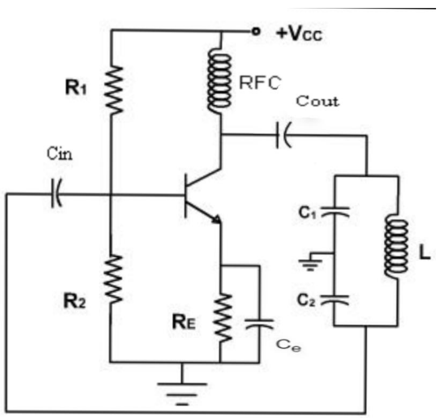
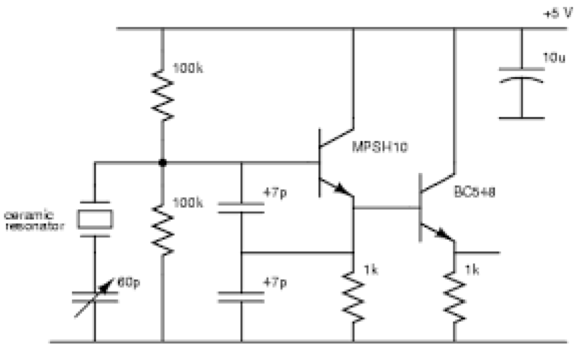
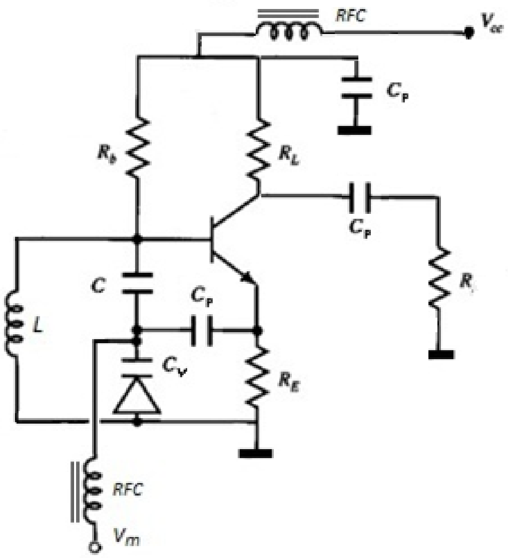
RF OSCILLATORS





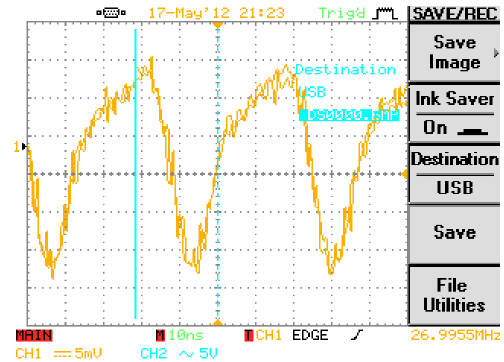


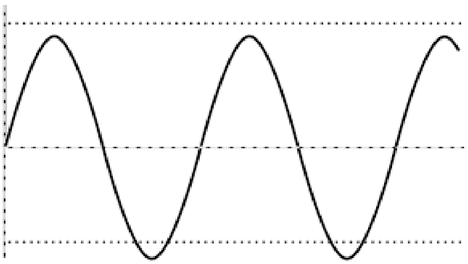




Eduard Bertran

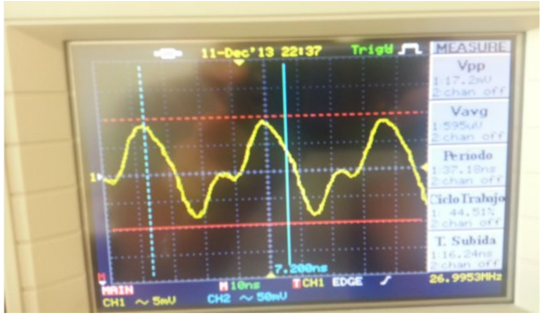
RF OSCILLATORS
Problem motivation

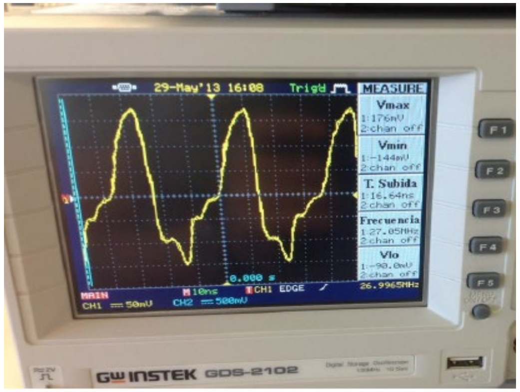




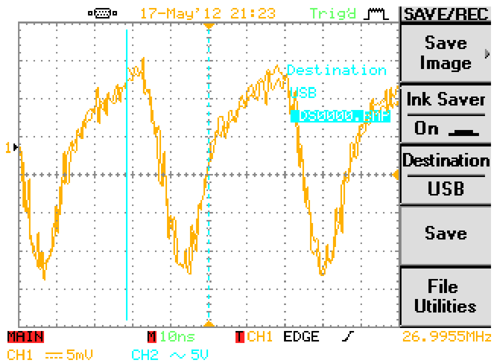
IDEALLY …

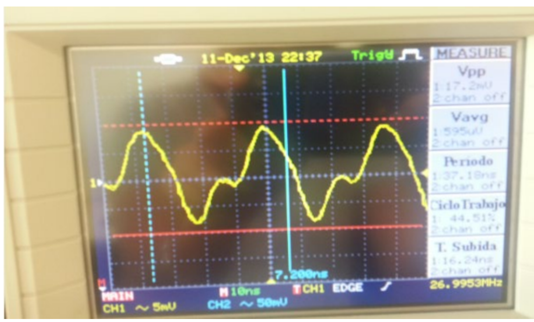
BUT…

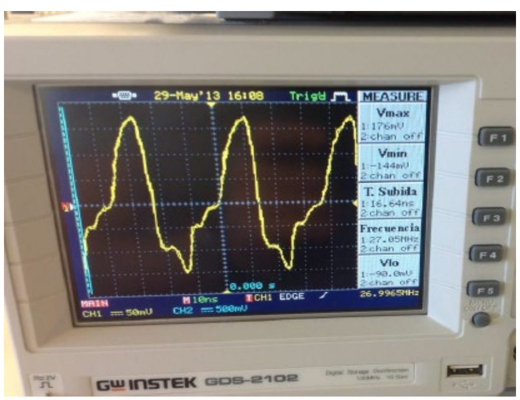


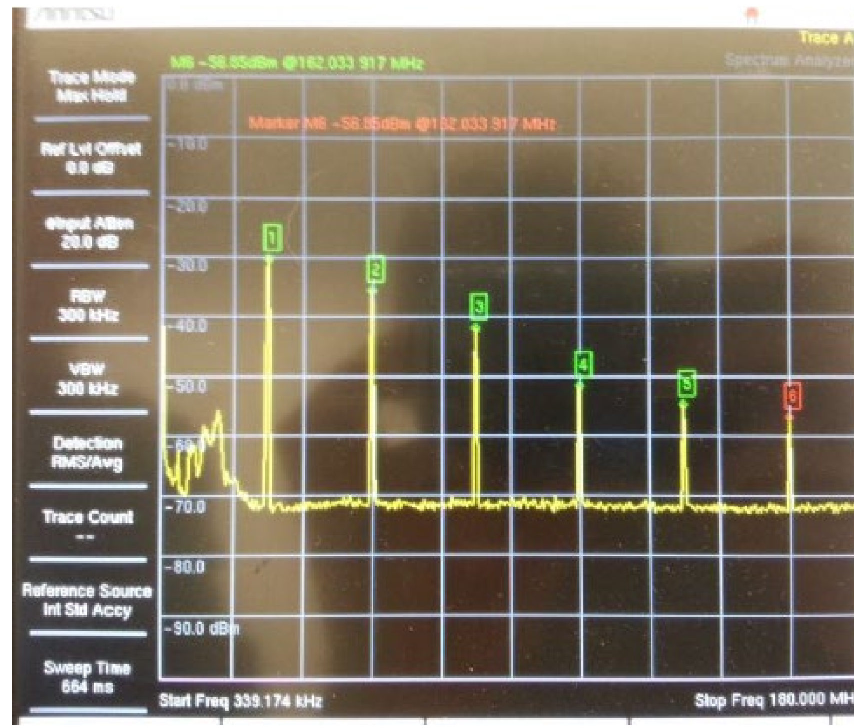


RF OSCILLATORS

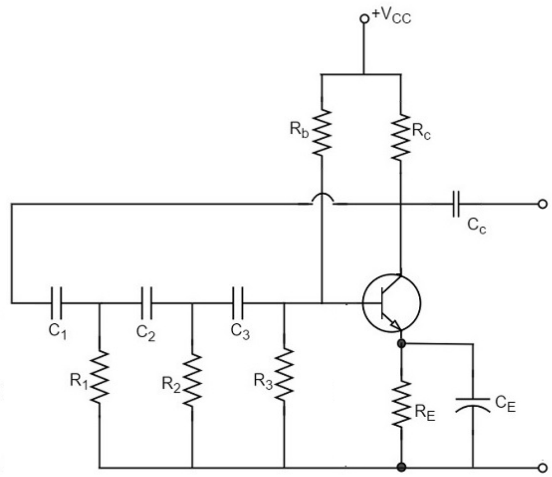






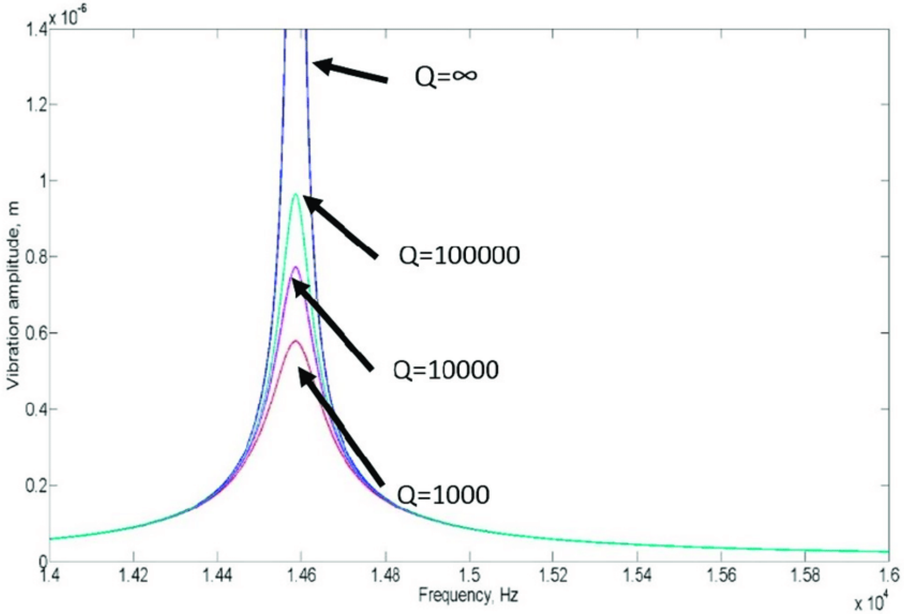


BASIC RF OSCILLATORS



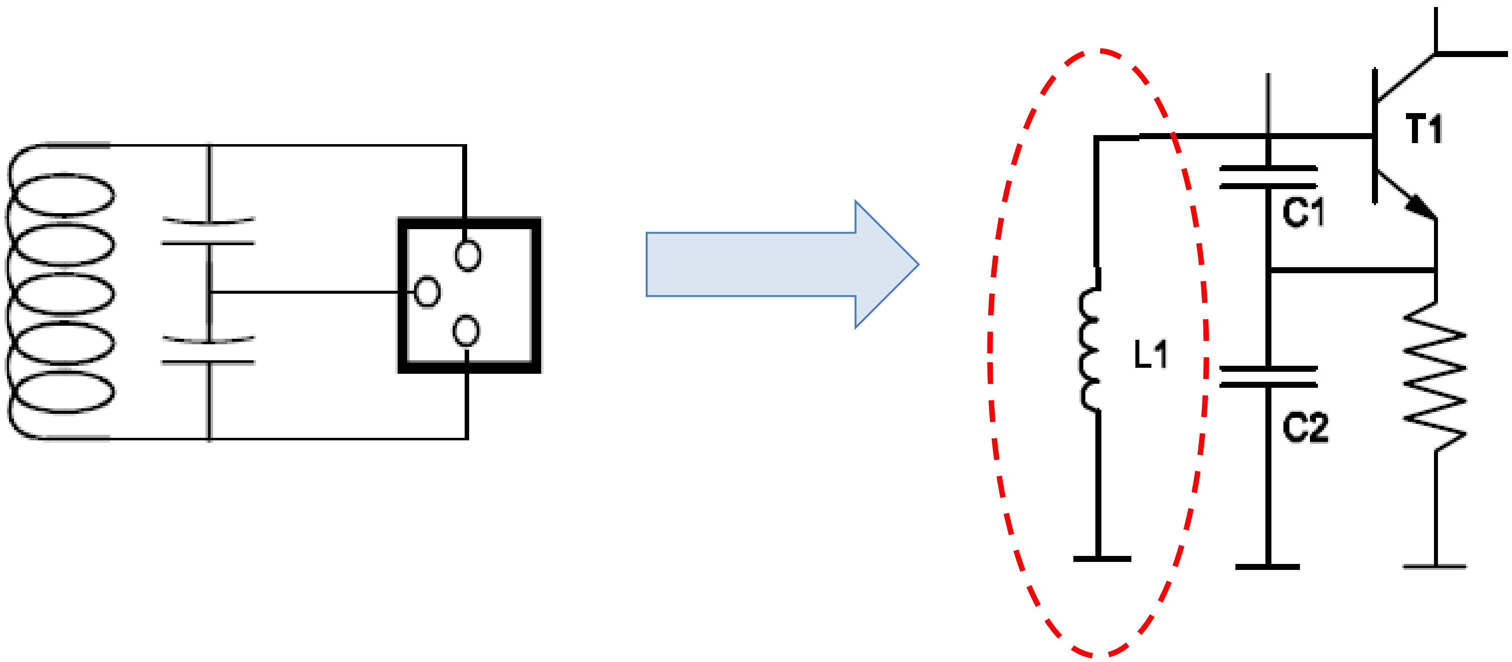
RC oscillators (phase shift) :

- Poor frequency selectivity.
- Low Q .
- Low frequency stability.
- Not too suitable for RF communication circuits.



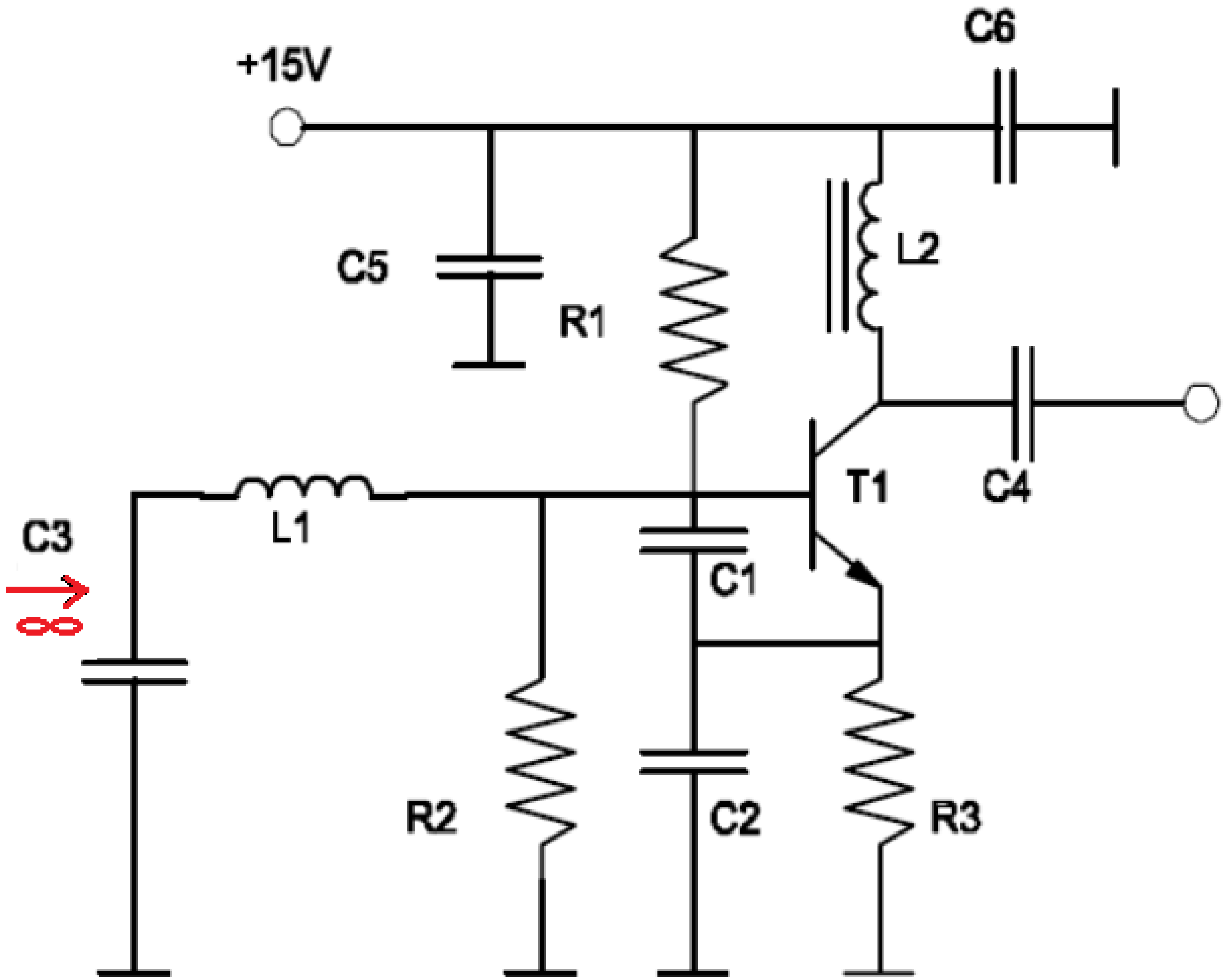
BASIC RF OSCILLATORS

COLPITTS

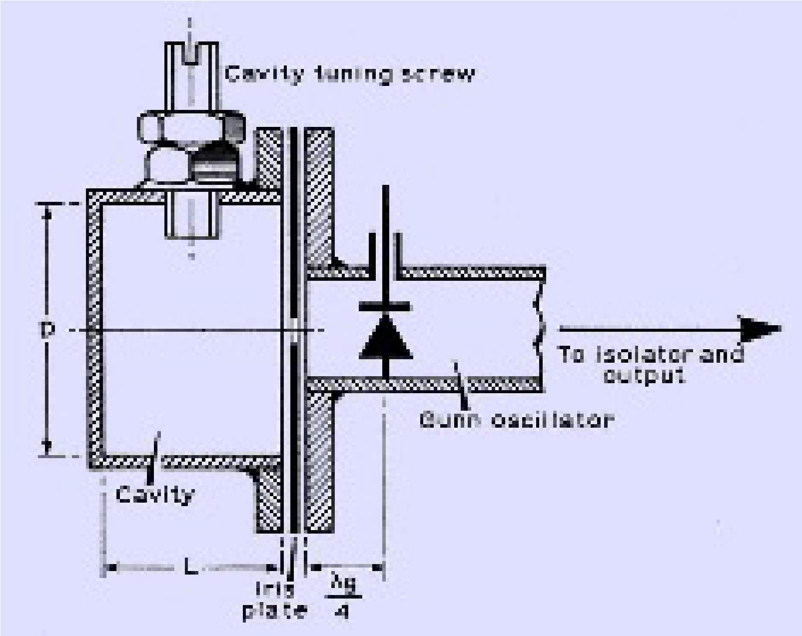


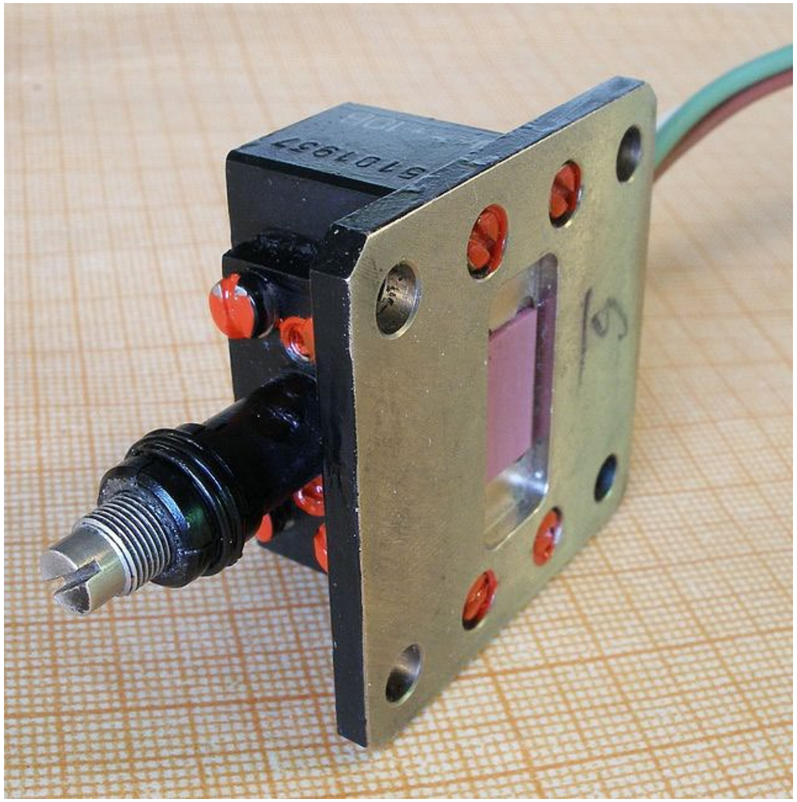
"artistic plot" : This inductor destroys the DC biasing of the transistor

COLPITTS



CAVITY OSCILLATORS





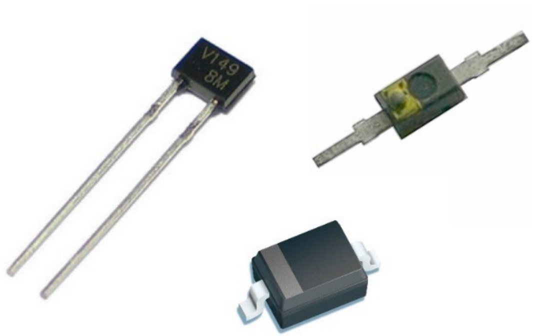
VARICAPS

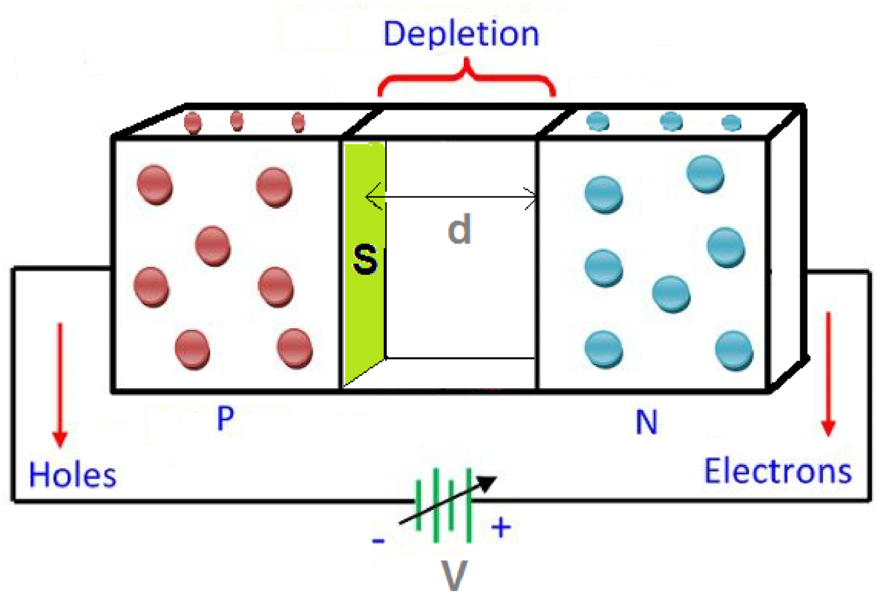
VOLTAGE CONTROLLED OSCILLATORS (VCO)

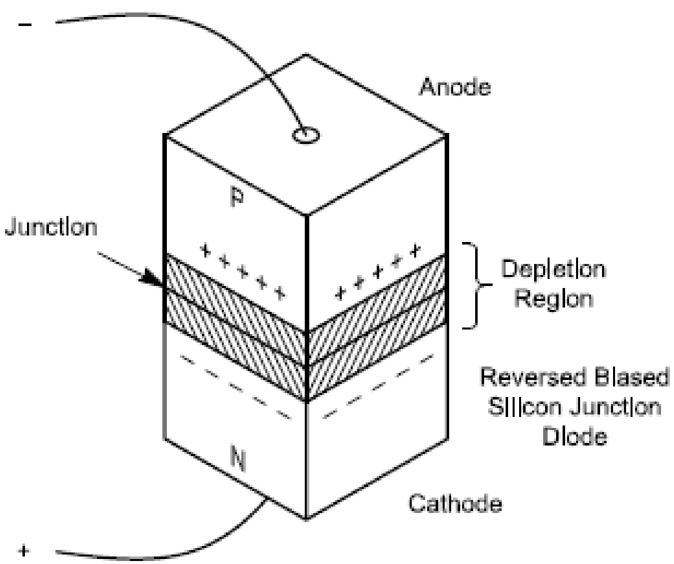
VARICAP (VARACTOR)

VARIable CAPacitance

(DO NOT CONFUSS with VARISTOR) !!





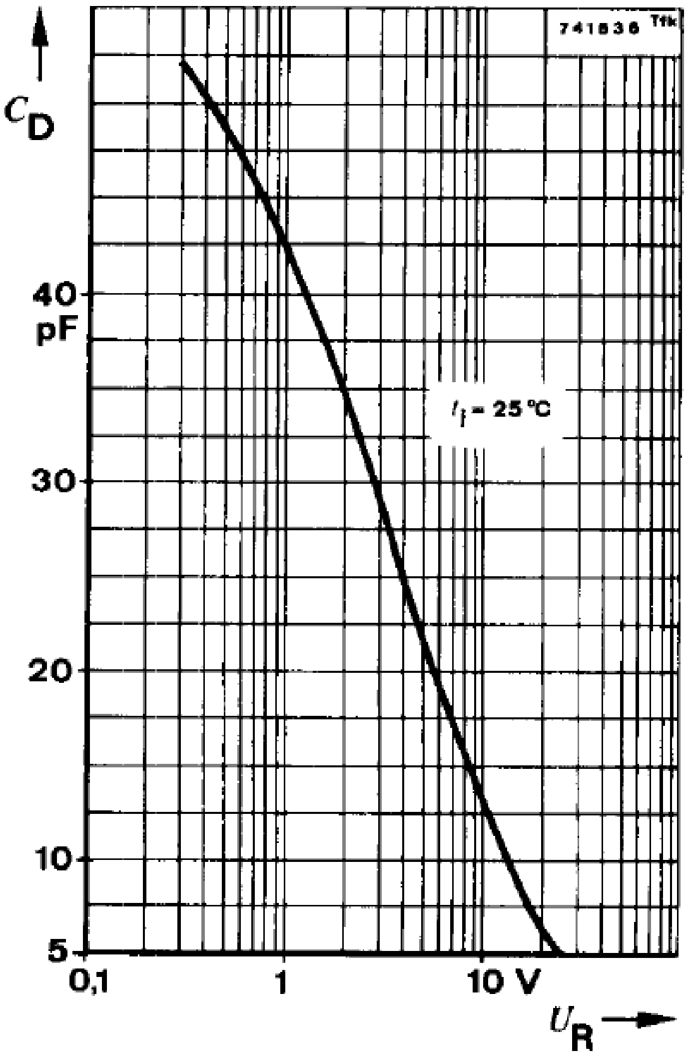


$$d \sim f(V)$$

$$C \sim \epsilon \frac{S}{d} \rightarrow \quad C \sim f(V)$$

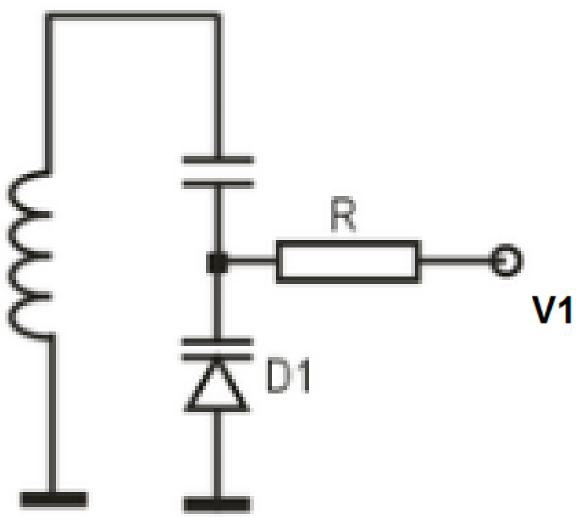
V reverse !

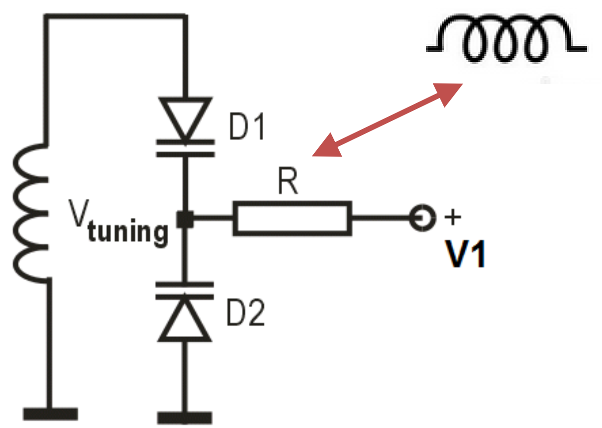
VARICAP (VARACTOR)



VCO
Voltage-Controlled Oscillator

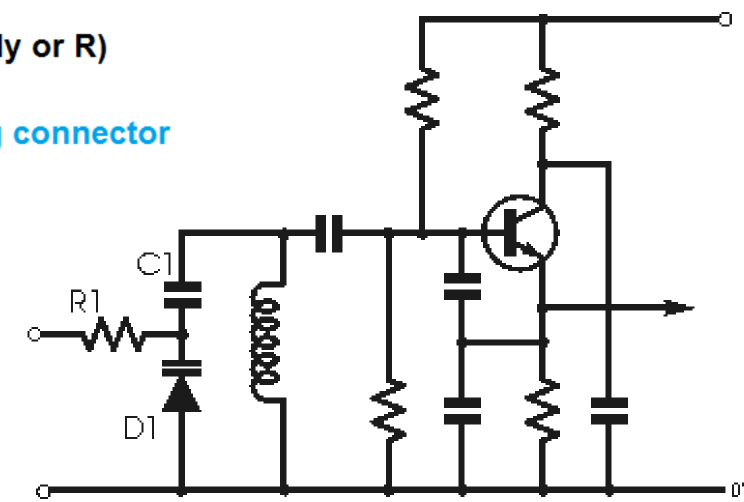
(not necessarily with a Varicap, but usual at RF frequencies



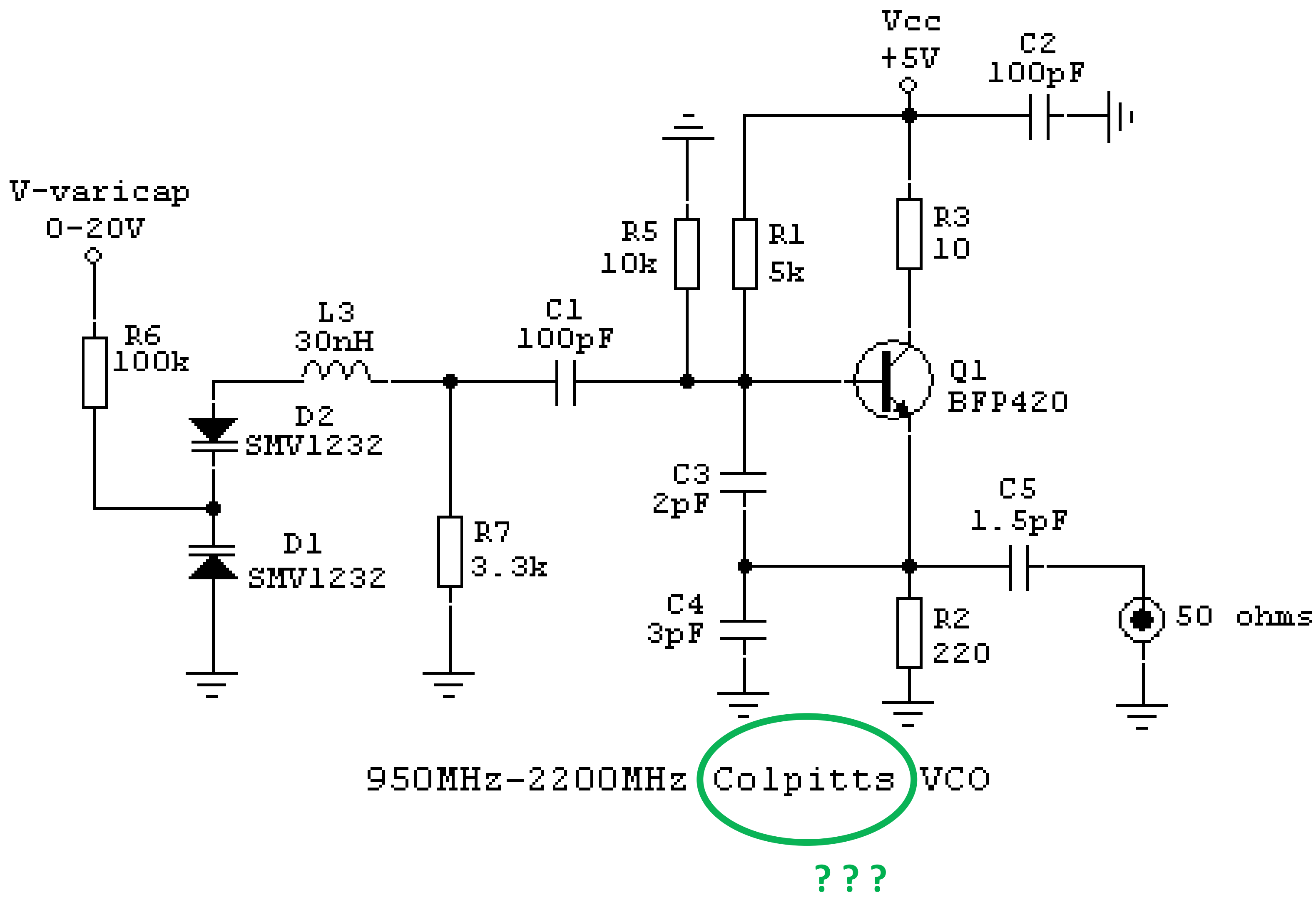


V1 = V_{tuning} (independently or R)

if R ⬆ , no signal loss through the tuning connector



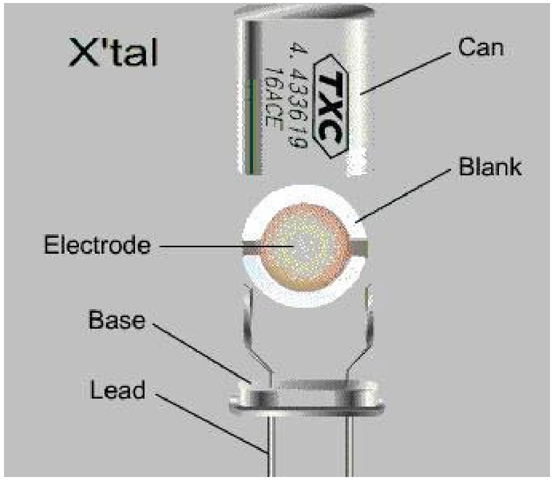
VARICAP (VARACTOR)

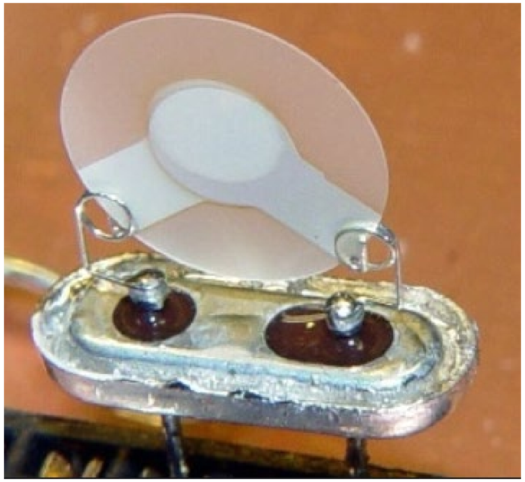


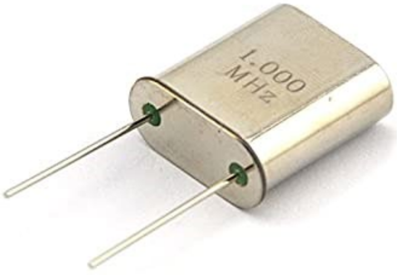
CRYSTAL OSCILLATOR

(Quartz Crystals)

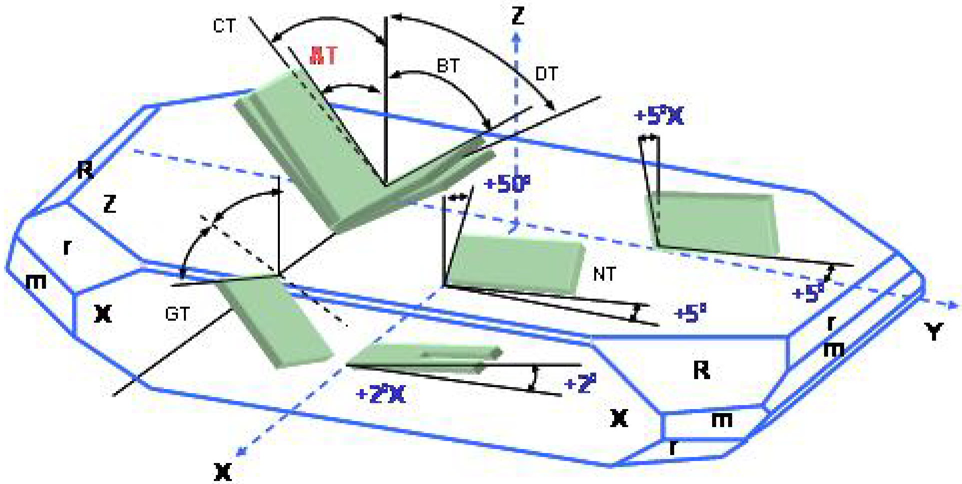
QUARTZ *CRYSTAL OSCILLATOR*

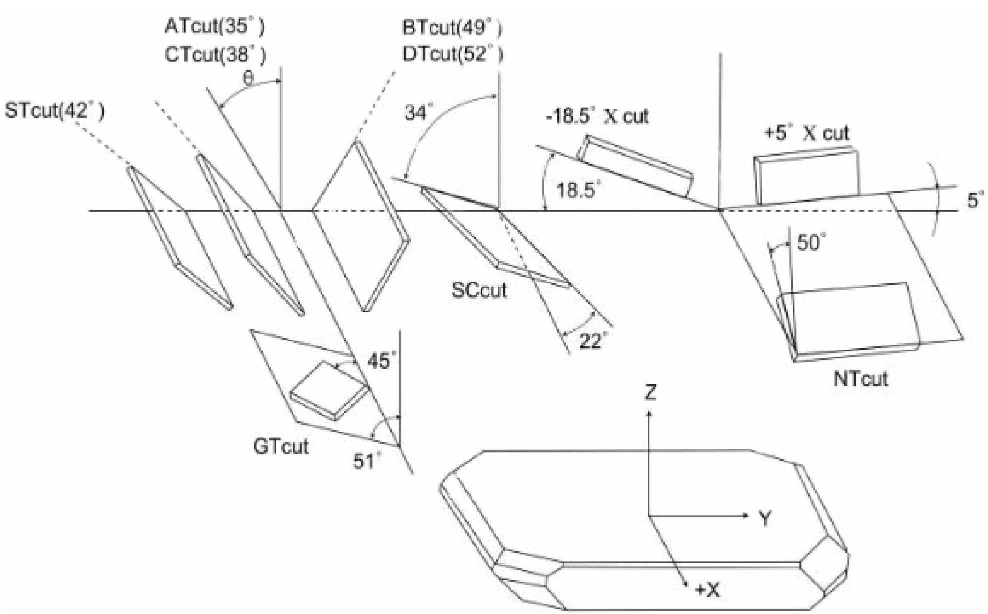


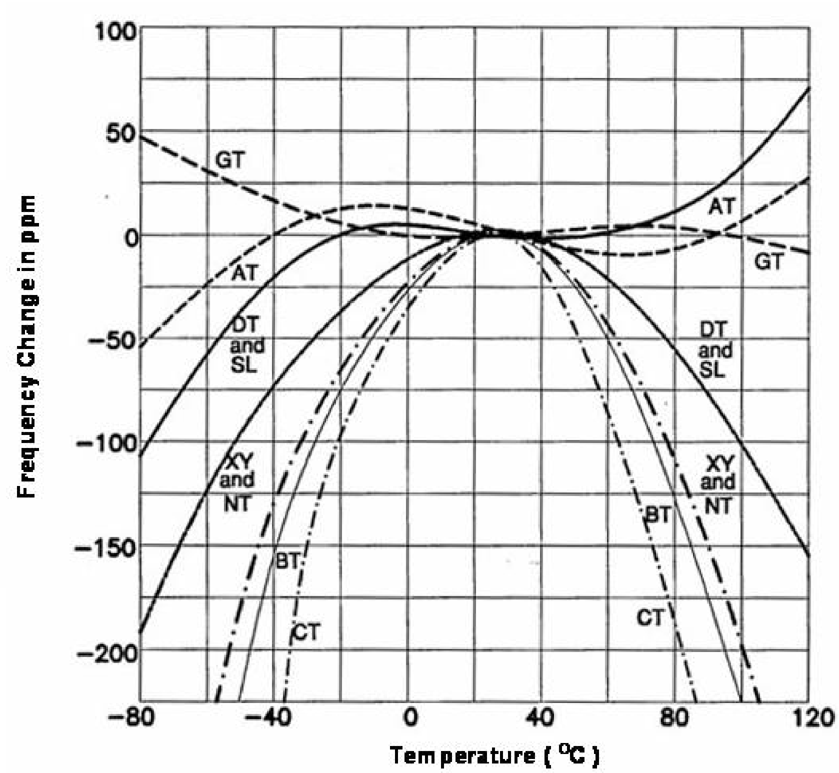




QUARTZ *CRYSTAL OSCILLATOR*

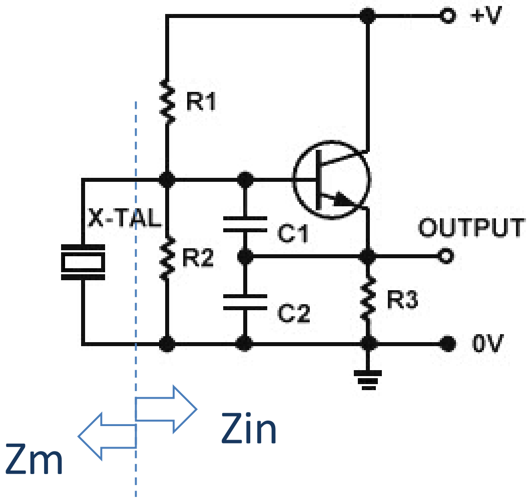


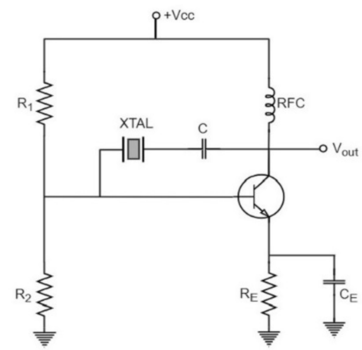




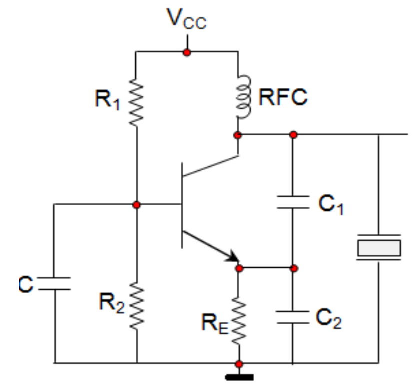
VARICAP (VARACTOR)

Colpitts Crystal Oscillators

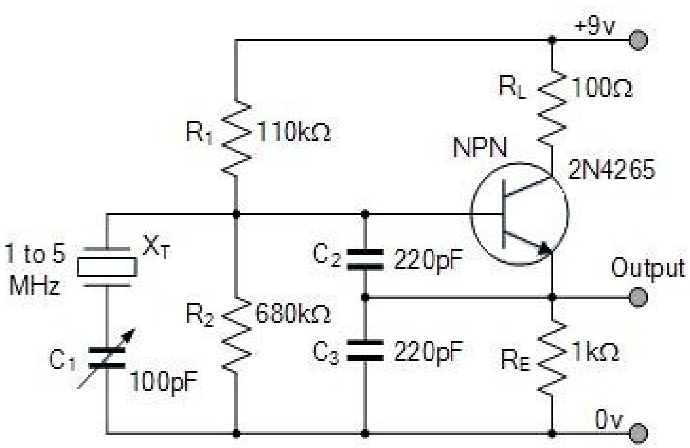




Series resonance



Parallel resonance



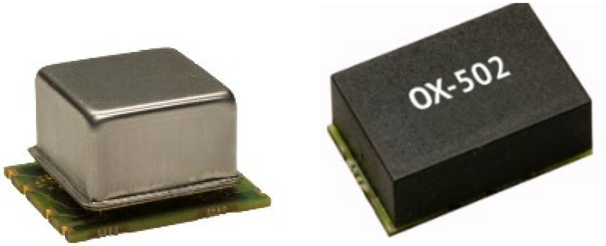
On supplying the power to the oscillator, the amplitude of the oscillations increases until a point where the **NONLINEAR** amplifier sets the loop gain to unity (Barkhausen gain requirement). The frequency will self-adjust (series or parallel resonance) so as to facilitate the crystal to present a reactance to the circuit to fulfill the Barkhausen phase requirement (so, not all the circuits with two poles in the imaginary axis are oscillators in practice).

The desired operating frequency of **the parallel resonant crystal is often set 100 ppm or so above the series resonant frequency;** if the oscillator stability is better than 100 ppm the resonance can be tuned with a capacitance.

FREQUENCY STABILITY

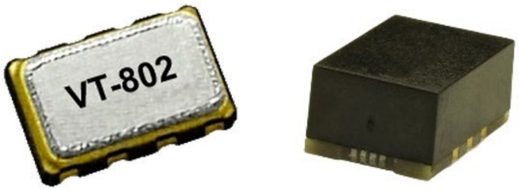
FREQUENCY STABILITY

CONTROLLED CRYSTAL OSCILLATORS



Oven Controlled Crystal Oscillators (OCXO)

Typical Temperature Stability: *±1 x 10-7 to ±1 x 10-9*
Typical aging rate: *±2 x 10-7/year to ±2 x 10-8/year*
Typical Power Consumption: *1.5 Watts to 2.0 Watts*



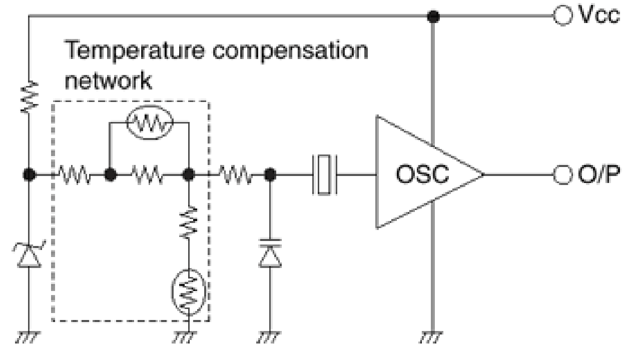
Temperature Controlled Crystal Oscillators (TCXO)

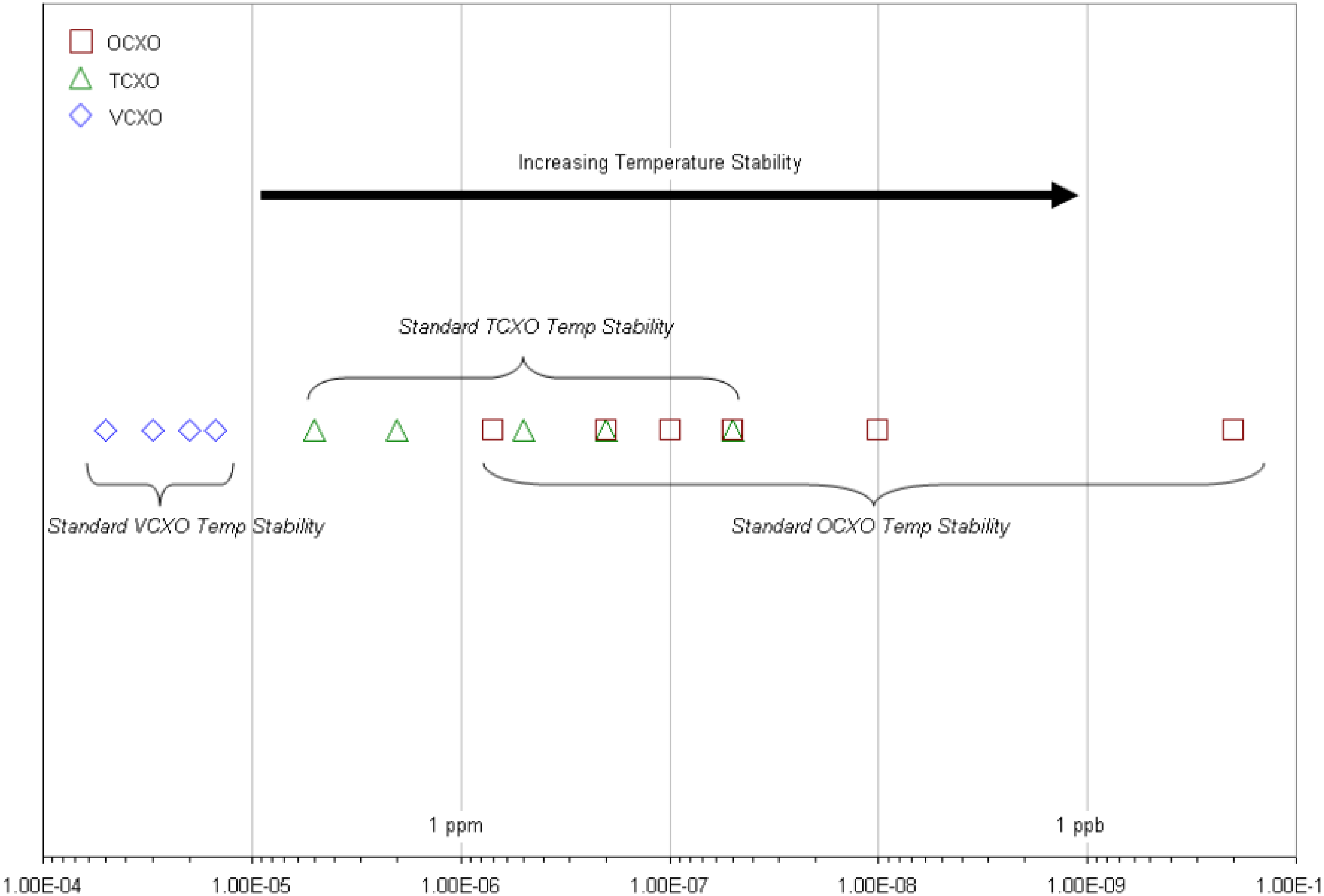
Typical Temperature Stability: *±0.20 ppm to ±2.0 ppm*
Typical aging rate: *±0.50 ppm/year to ±2 ppm/year*

Voltage Controlled Crystal Oscillators (VCXO)

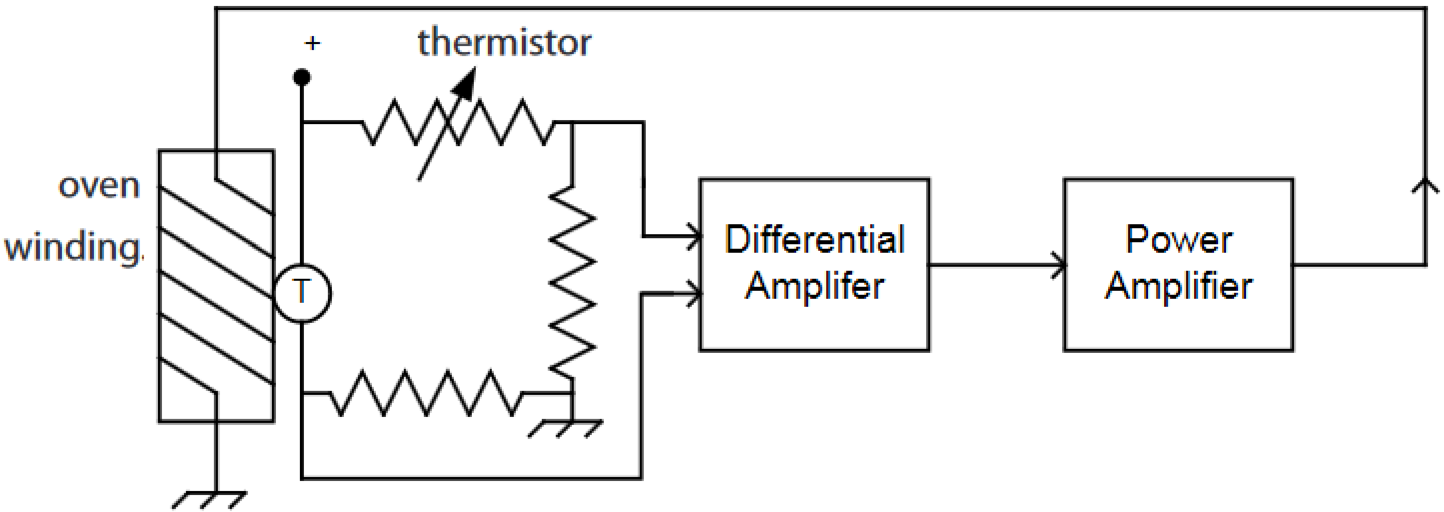
Typical deviation ranges: *±10 ppm to as much as ±2000 ppm.*
Typical aging rate: *±1 ppm/year to ±5 pp/year*

	Clock Oscillator	TCXO	OCXO
0°C to 70°C	±10 ppm	±0.5 ppm	±0.003 ppm
-20°C to 70°C	±25 ppm	±0.5 ppm	±0.003 ppm
-40°C to 85°C	±30 ppm	±1 ppm	±0.02 ppm
-55°C to 125°C	±50 ppm	N/A	N/A




OCXO
TCXO
VCXO
Increasing Temperature Stability
Standard TCXO Temp Stability
Standard VCXO Temp Stability
Standard OCXO Temp Stability
1 ppm
1 ppb
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10

Oven Controlled Crystal Oscillator (OCXO)



FREQUENCY STABILITY

TEMPERATURE COEFFICIENT

parts per million (ppm)

.01 % = 100 PPM
.005% = 50 PPM
.001 % = 10 PPM

ppm/°C

$\Delta f = k\,(f_o \cdot \Delta \mathrm{T})$, k = ppm/ºC , T= temp in ºC

example:

$\boldsymbol{DATA}$:

$\boldsymbol{nominal\ frequency = 20\ MHz,}$

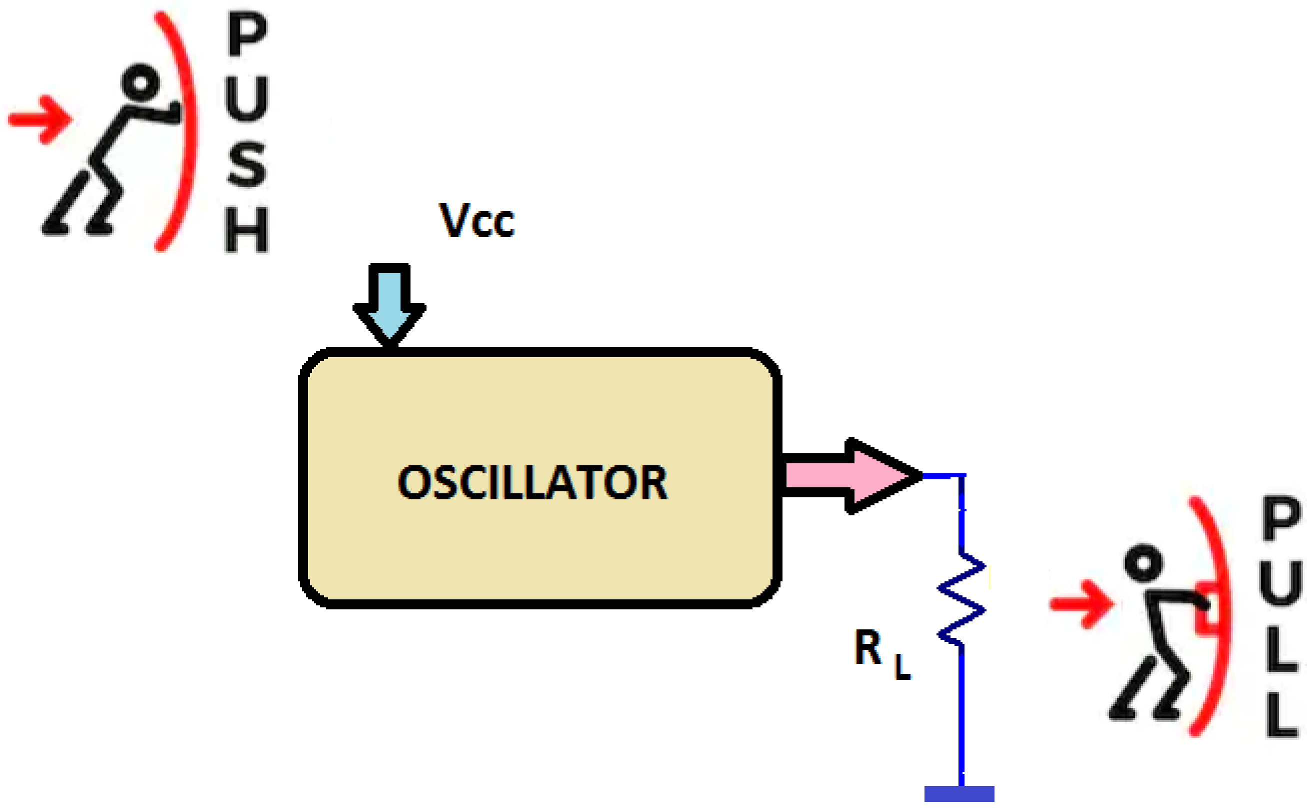
k= 32 ppm /ºC

$\Delta T = +10\ ^{\circ}C$ (+ = temperature increment)

$\Delta f = 32 \cdot 20 \cdot 10 = 6400$ Hz

FREQUENCY STABILITY

PUSHING and PULLING

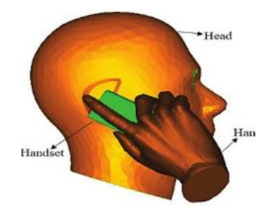


FREQUENCY STABILITY

PUSHING and PULLING

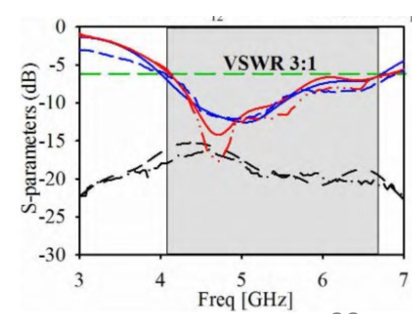
PUSHING: Sensitivity of the output frequency to **SUPPLY VOLTAGE** changes.
Hz/V or Hz/mV. May a positive or negative value.
Specially relevant in mobile equipment, battery operated

PULLING: Sensitivity of the output frequency to the **OUTPUT IMPEDANCE.**
Not often specified in ohms (!). Instead, it more used a parameter related with the separation between the actual impedance and the ideal one (matching impedance).



" less than X Hz at *VSWR* = Y"
"no more than X kHx at Y dB ***return loss***"

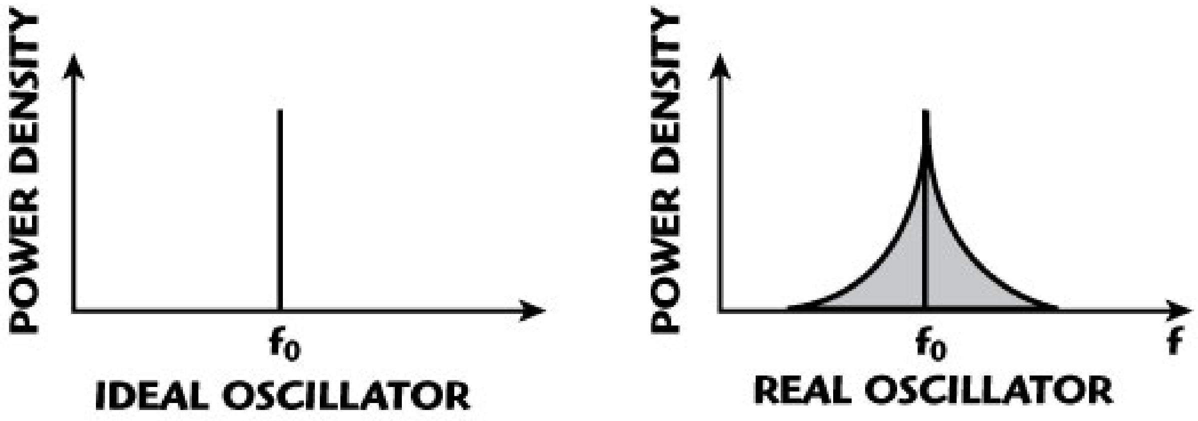
Specially relevant in mobile equipment, specially regarding the antenna impedance which depends on the mobile terminal environment

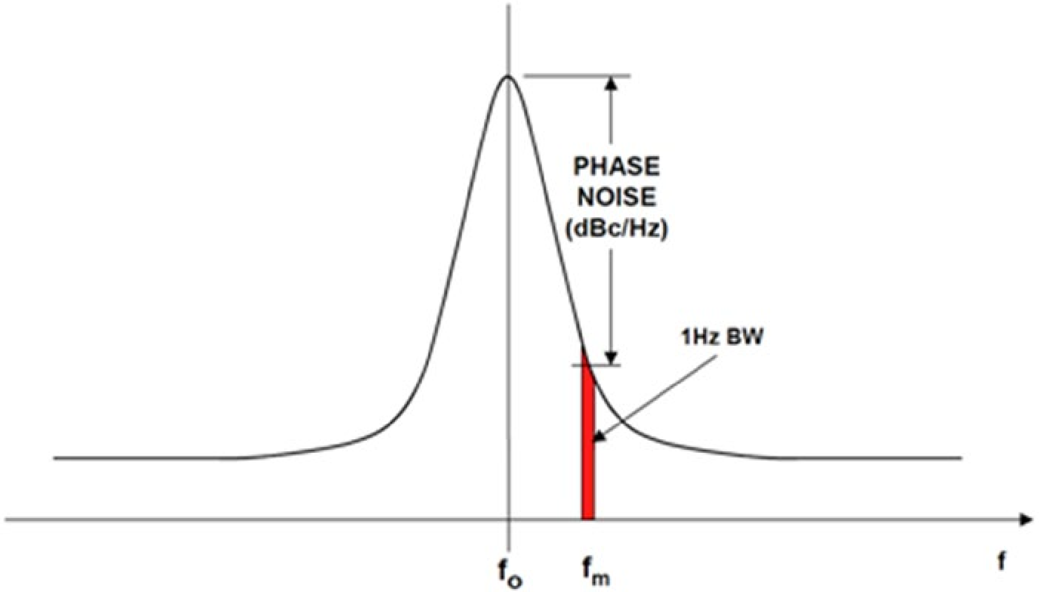


(VSWR , return loss… are concepts seen in the parallel course of OESC.)

FREQUENCY STABILITY

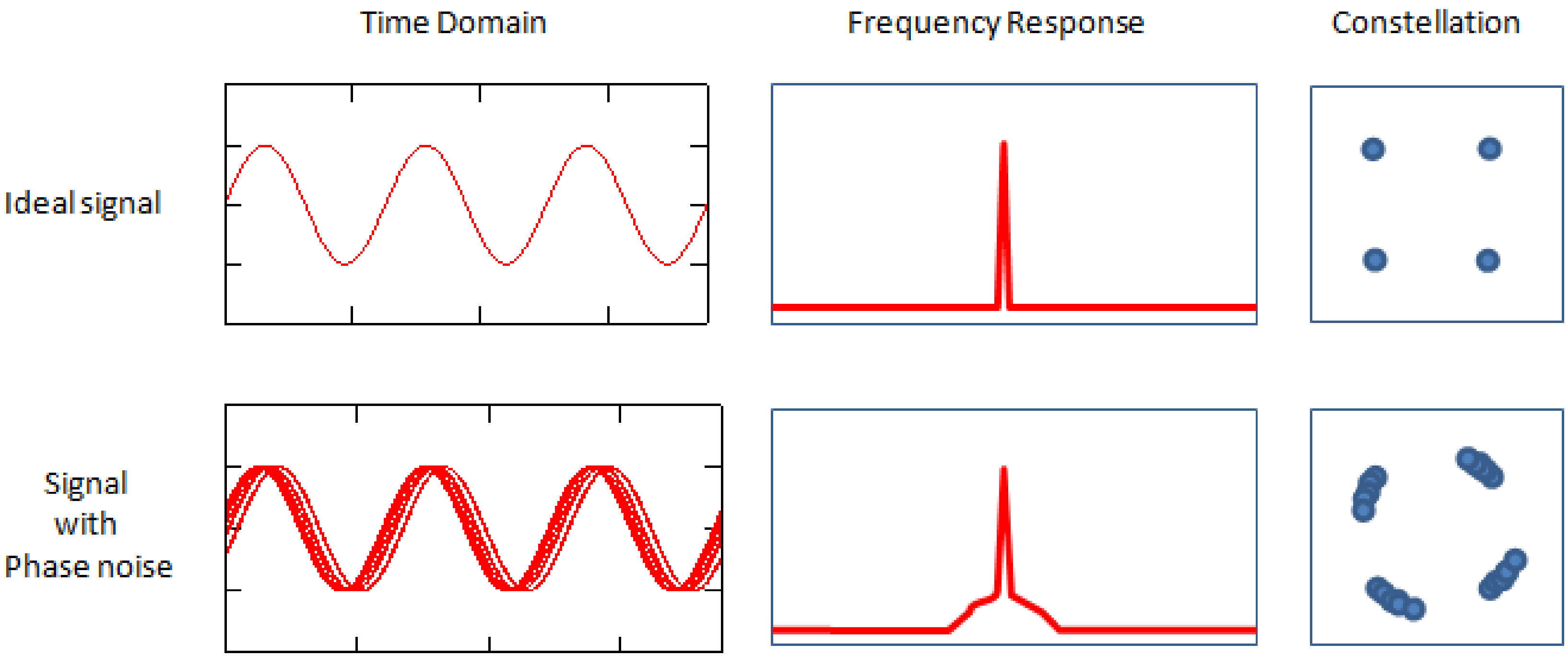
PHASE NOISE





FREQUENCY STABILITY

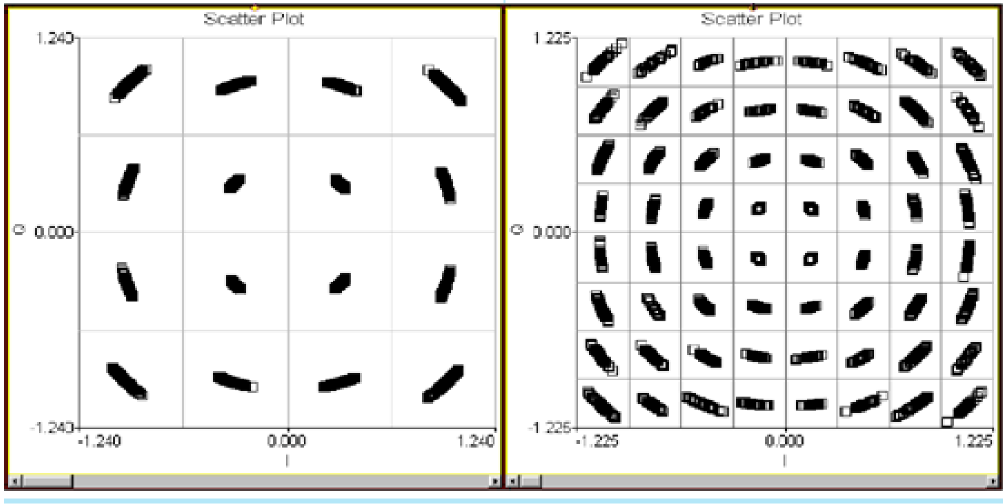
PHASE NOISE EFFECTS



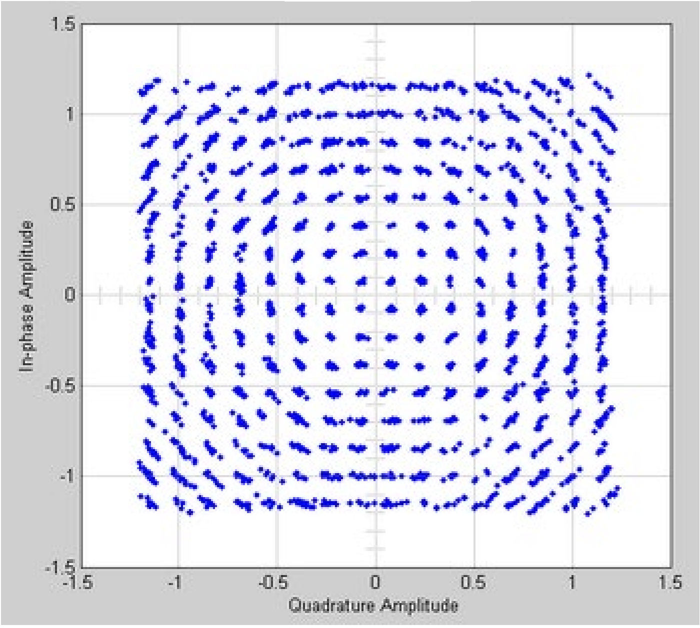
FREQUENCY STABILITY

NOISE EFFECTS

16-QAM and 64-QAM

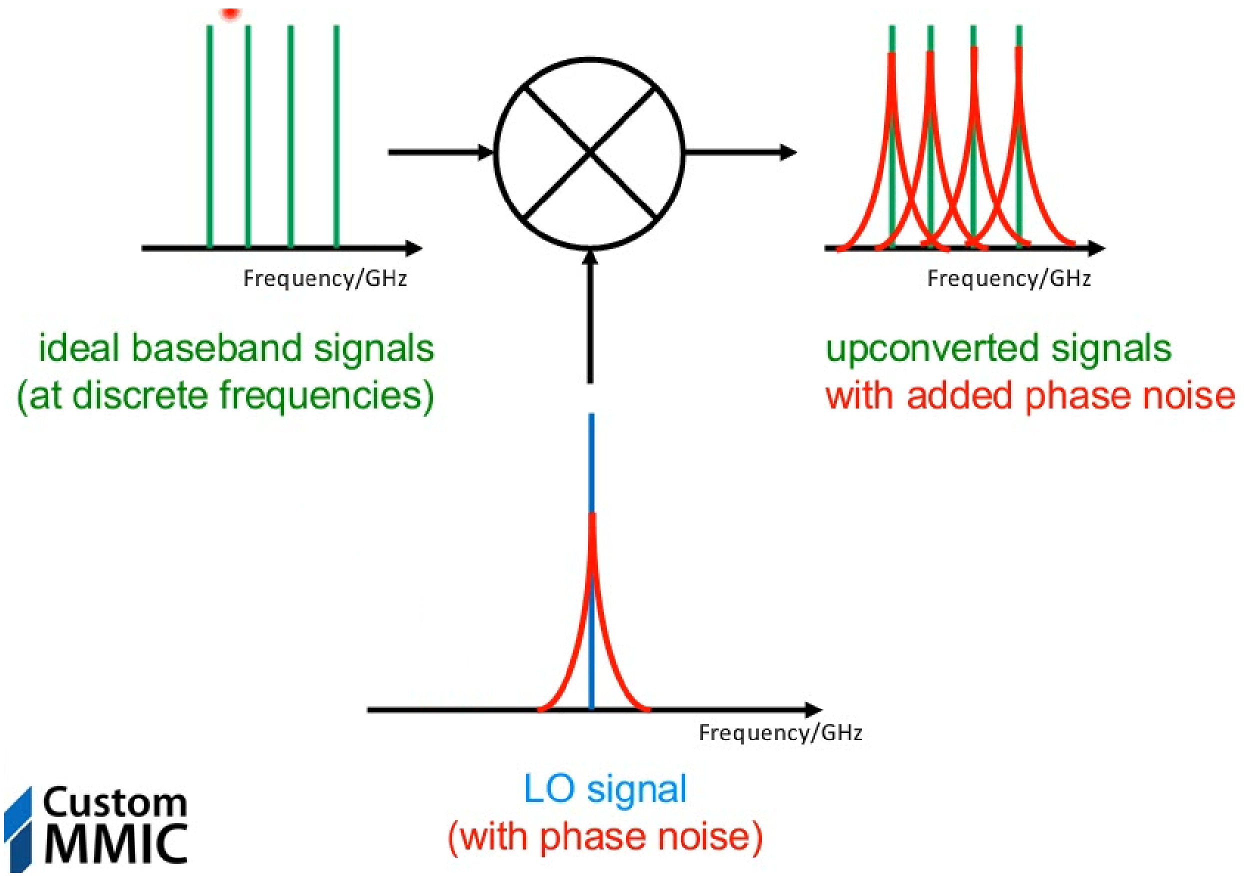


256-QAM



FREQUENCY STABILITY

PHASE NOISE EFFECTS



Custom MMIC

FREQUENCY STABILITY

PHASE NOISE EFFECTS