

# TUTORIAL: Oscillators

Ullas Kumar (Rakon)



# Outline

## 1

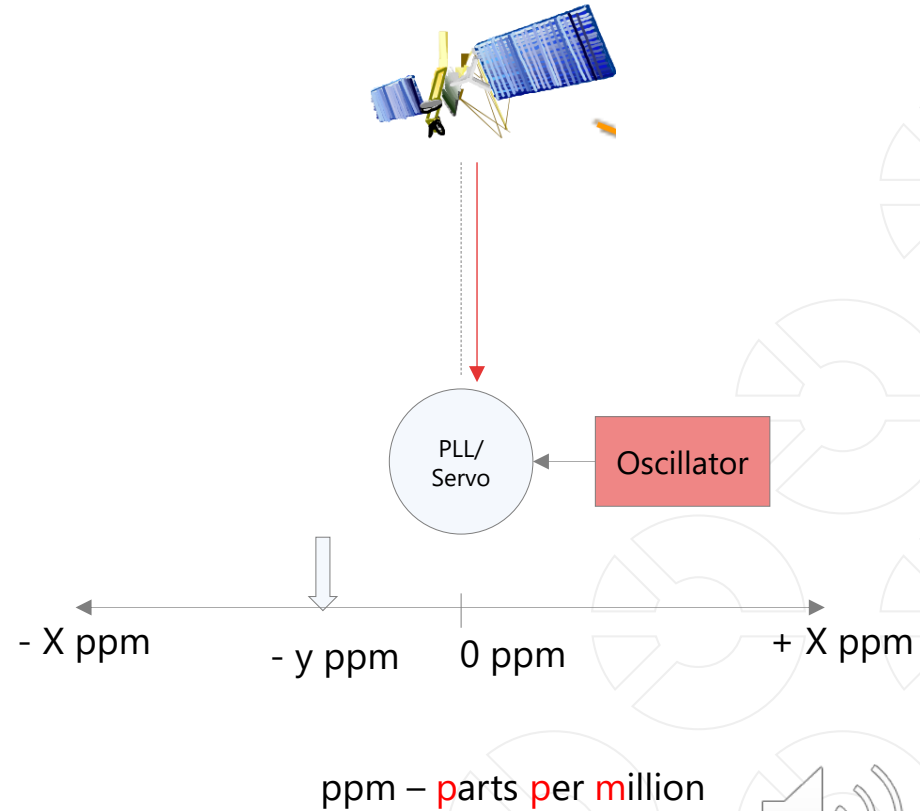
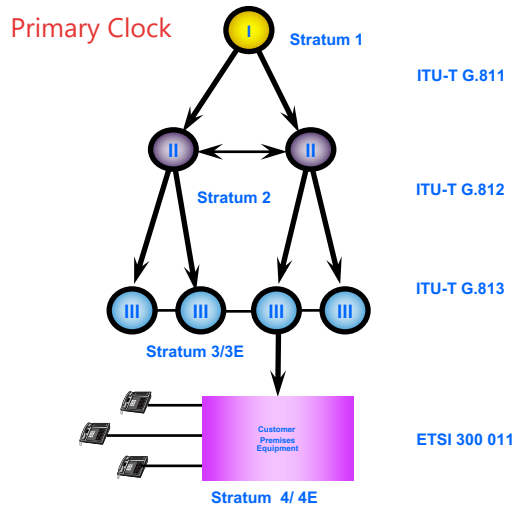
### Oscillators

- Oscillators in Synchronization
- Oscillator technologies
- Types of Oscillators
- Selection of Oscillators



# Oscillators in Synchronization

- Local Reference in systems
- Synchronization is hierarchical

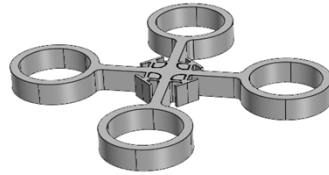


# Oscillator Technologies

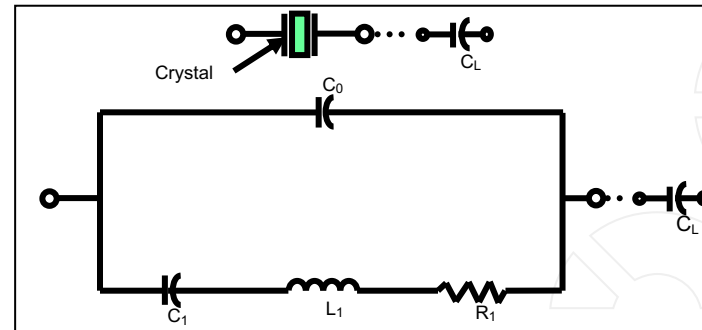
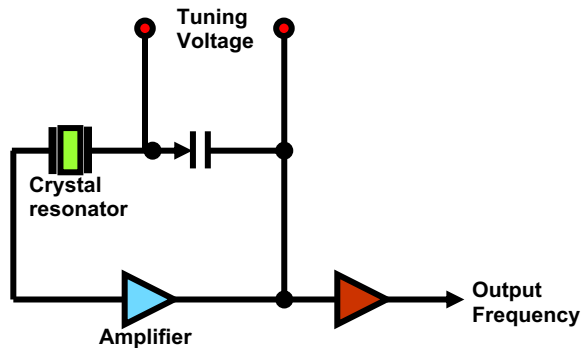
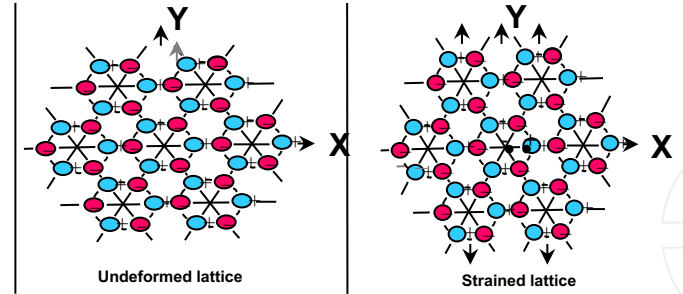
Various Technologies

Quartz based Oscillators

MEMS Oscillators

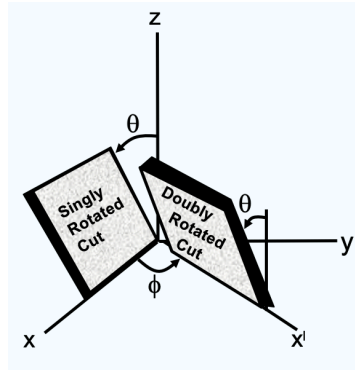


## Piezo Electric Effect

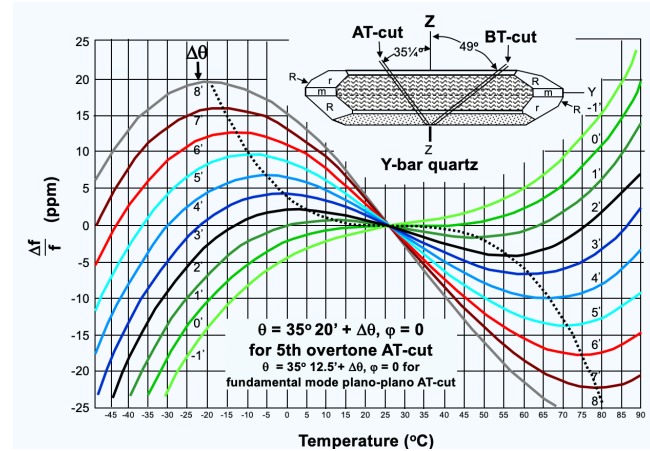
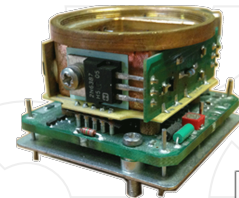
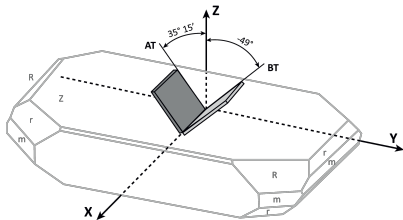


# Quartz Fundamentals

## Cuts of the crystal



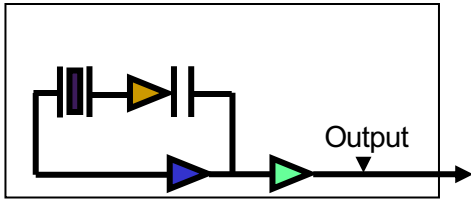
## Making of the oscillator



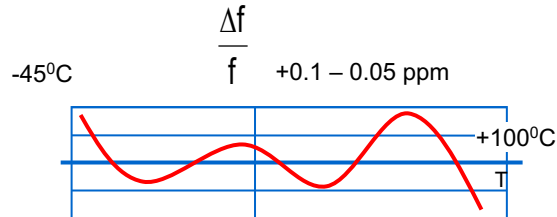
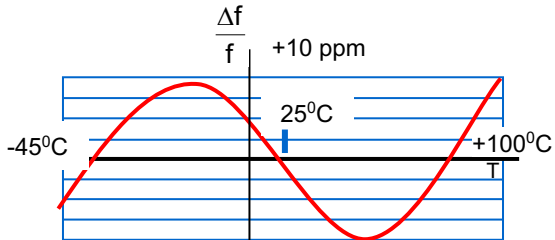
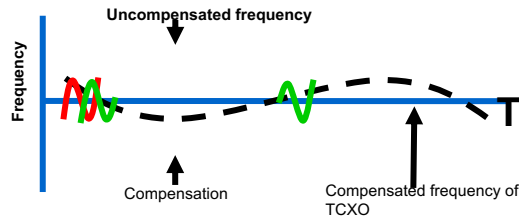
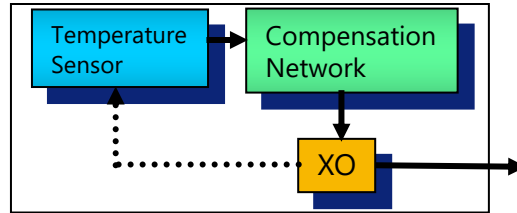
# Types of Oscillators

Oscillators are susceptible to temperature variations

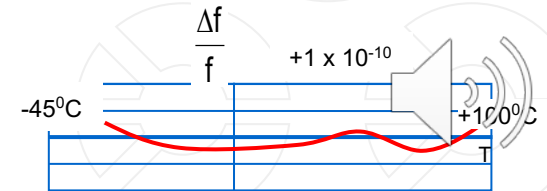
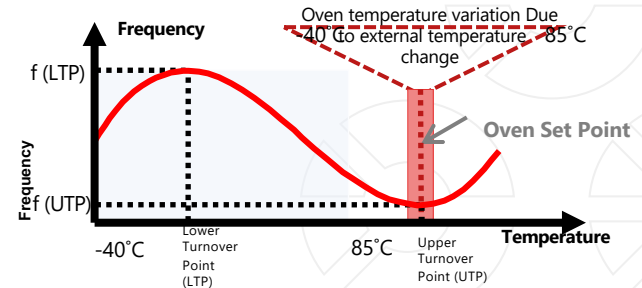
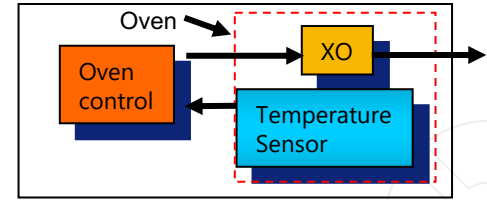
XOs



TCXOs – Temperature compensation

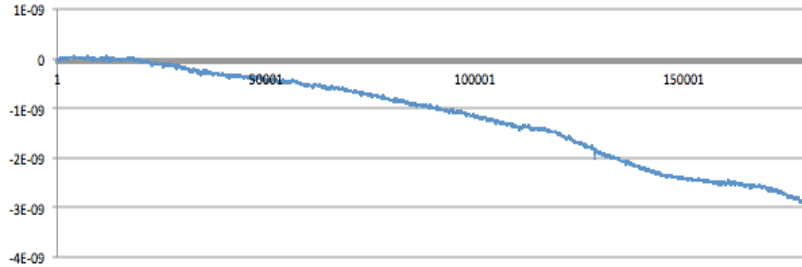


OXCOS- Oven control

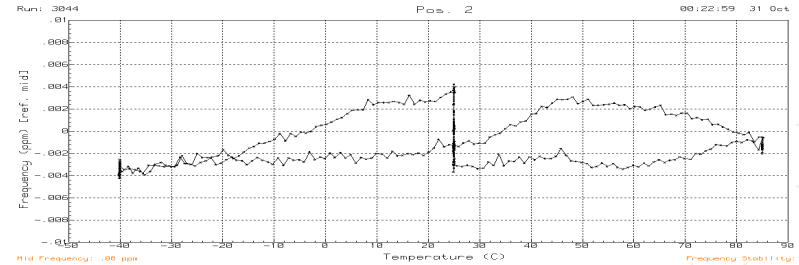


# Influences on Oscillators

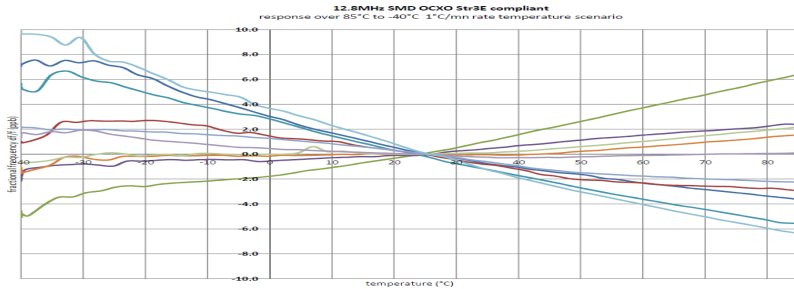
## Aging effect



## Hysteresis effect



## Temperature Effect

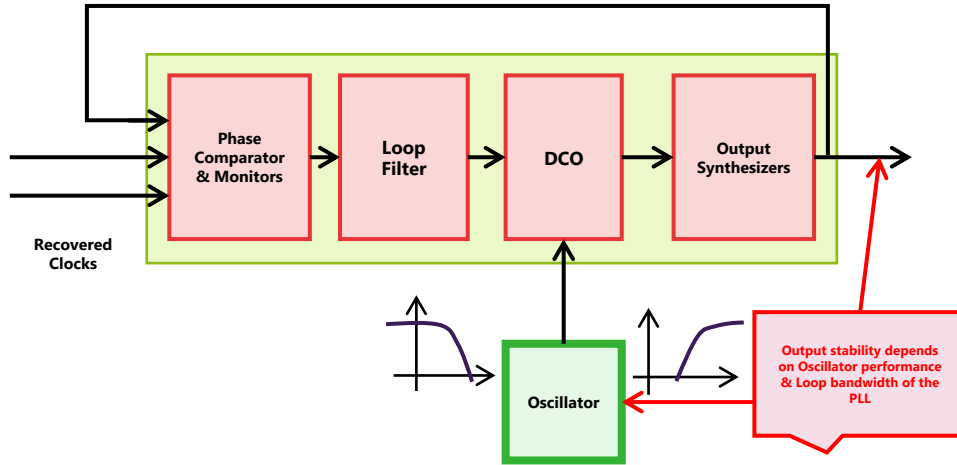


## Retrace effect



# Oscillator Selection for Clocks

## Servo Model



## Impact of Oscillators

Oscillators present a high pass effect to the output

As the loop bandwidths become narrower, output corrections are more infrequent

Variations on the reference oscillator reflect at the output

Loop Bandwidth	10-100Hz	1-10Hz	0.1Hz – 1Hz	10mHz – 100mHz	1mHz	<1mHz
Recommended Oscillator Temperature Stability	500ppb-1ppm	100-300ppb	50-100ppb	20-50ppb	5-10ppb	1-5ppb





# Oscillator selection

Oscillator requirements are based on

- Free Run -> Overall oscillator stability for 10/15/20 years, all causes included
- Loop bandwidth -> Support for loop bandwidth at required output error, at constant temperature and at variable temperature
- Frequency Vs Temperature performance -> This forms part of the wander generation and holdover requirement of the standards
- Ageing performance -> This forms part of the wander generation and holdover requirement specifications
- Phase noise, Temperature sensitivity, Allan deviation, shock & vibration performance -> Other oscillator effects depending on the application.

# Summary

Oscillators are fundamental building blocks of clocks

Quartz based oscillators produce clean and stable clocks, other technologies like MEMS are also used

Temperature compensation and oven control and methods used to improve stability of clocks

As the loop bandwidth of the systems decrease, higher stability oscillators to be used to have a certain level of output stability

Wander generation and holdover and key aspects of oscillator selection in systems

