TUTORIAL: Oscillators

rakon

Outline

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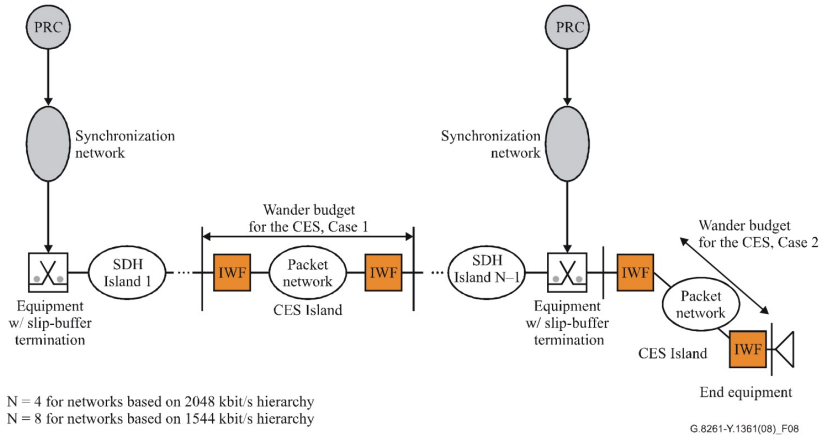
Oscillators

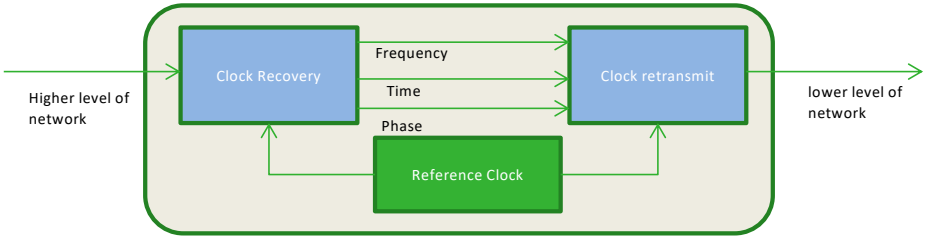
- Oscillator in synchronisation
- Oscillator fundamentals
- Oscillator selection for clocks

Oscillators in synchronisation

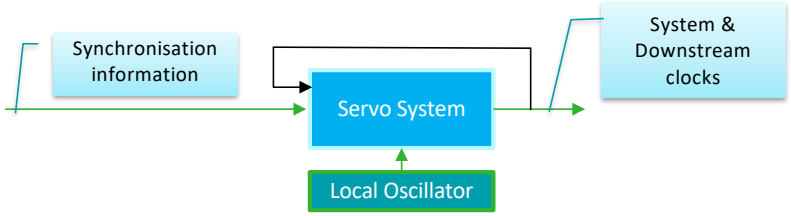
- **Synchronization is hierarchical**



- **Equipment Clocks “recover & retransmit”**

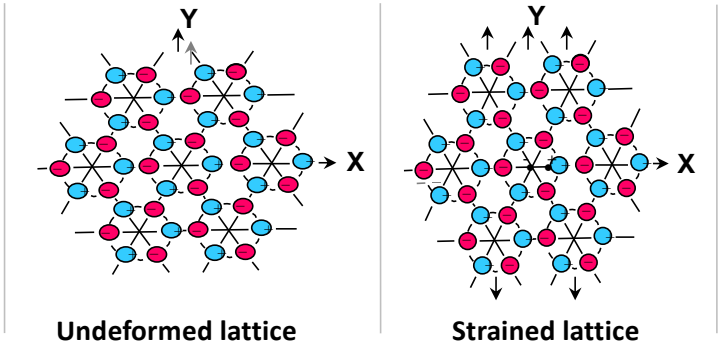


- **Oscillators on the clocks**

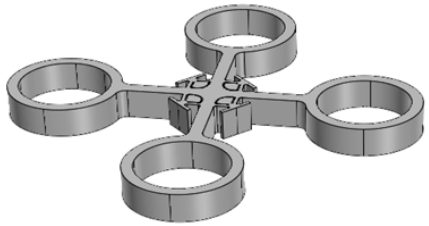


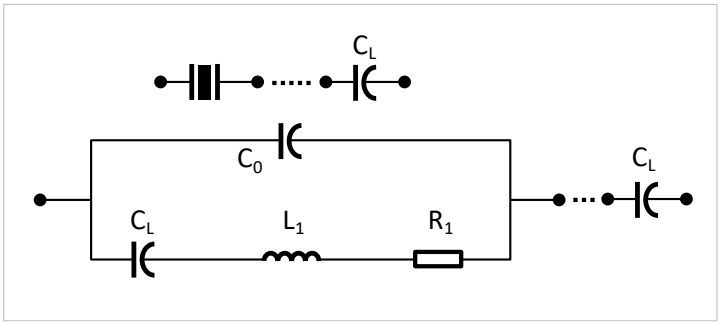
Oscillator technologies

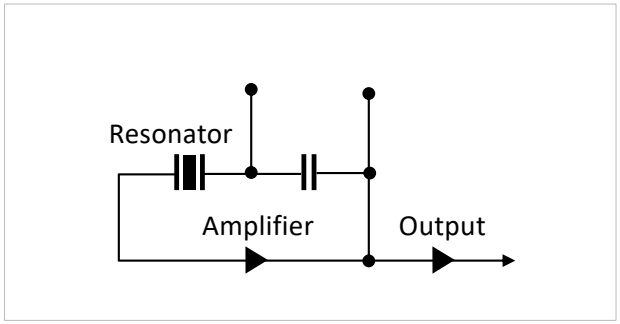
- **Piezo Electric effect in Quartz**



- **MEMS**

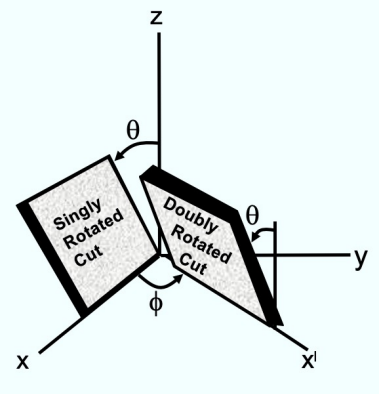


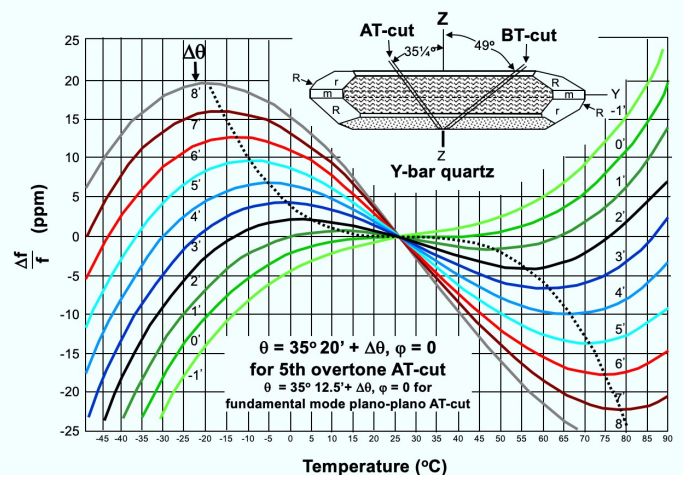


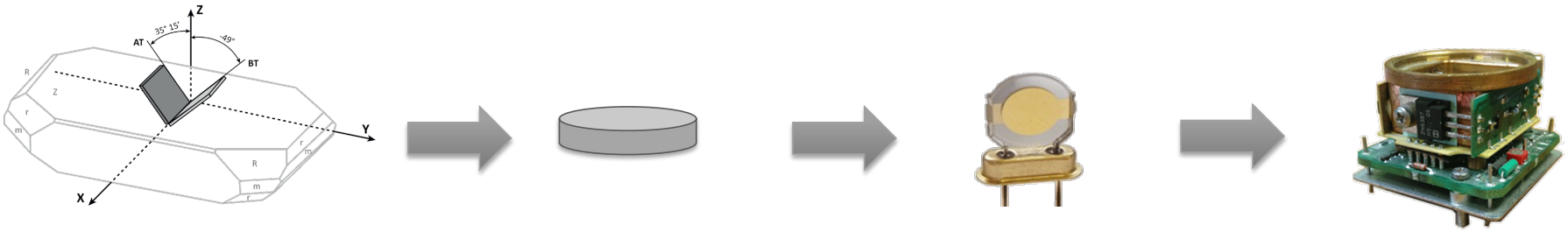


Ballato, “Doubly rotated thickness mode plate vibrators,” in Physical Acoustics, Vol. XIII, pp. 115-181, Academic Press, 1977.
John R. Vig Quartz Crystal Resonators and Oscillators For Frequency Control and Timing Applications - A Tutorial April 2012

Fundamentals

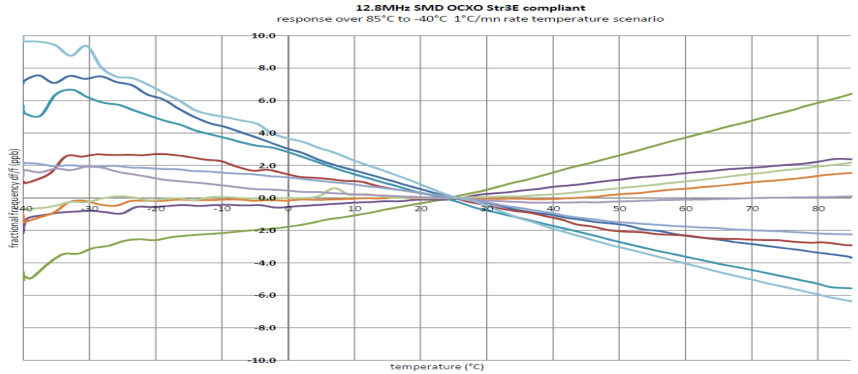




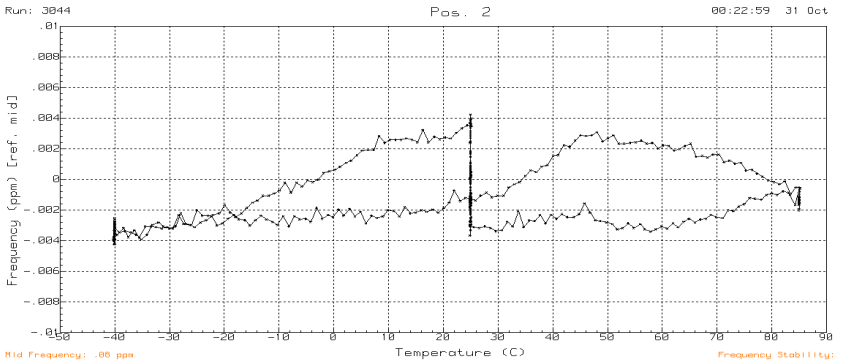


Influences on oscillators

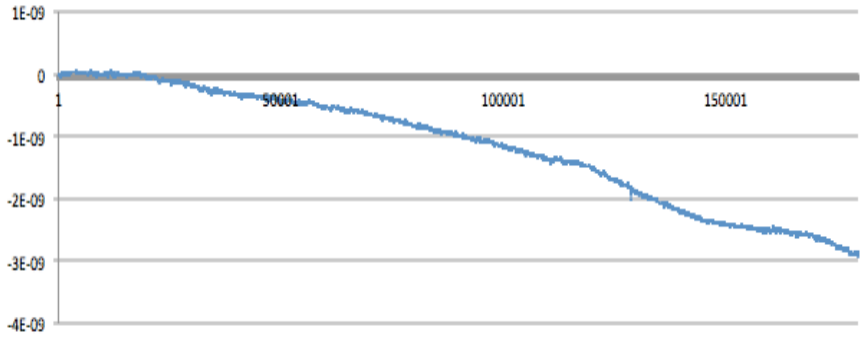
Temperature Effect



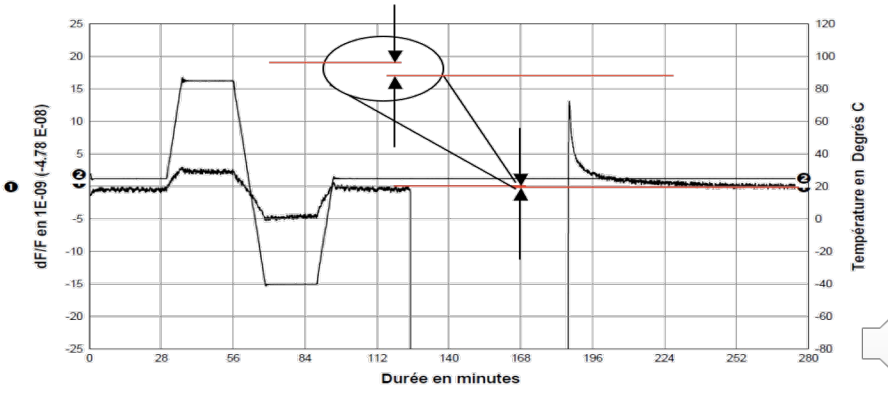
Hysteresis effect



Aging effect



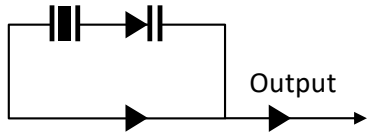
Retrace effect

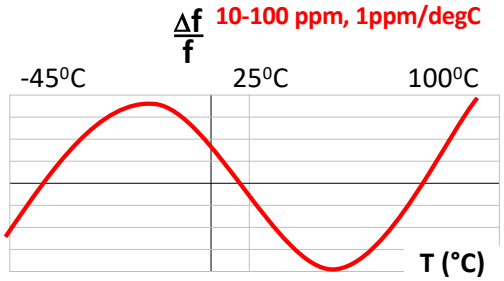


Improving oscillator stability

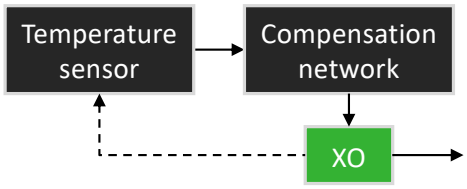
Oscillators are susceptible to temperature variations

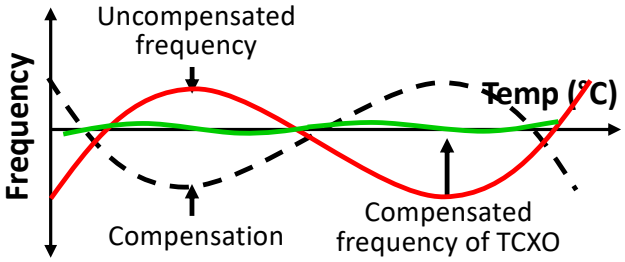
XOs

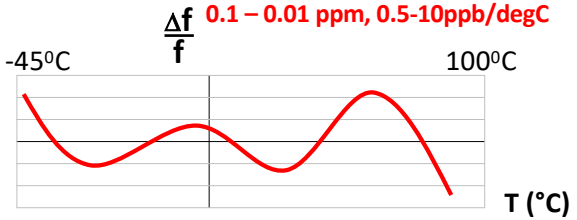




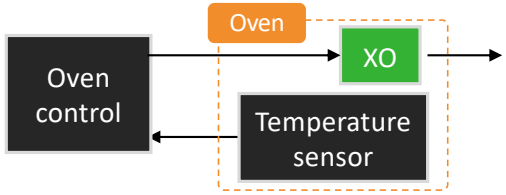
TCXOs – temperature compensation

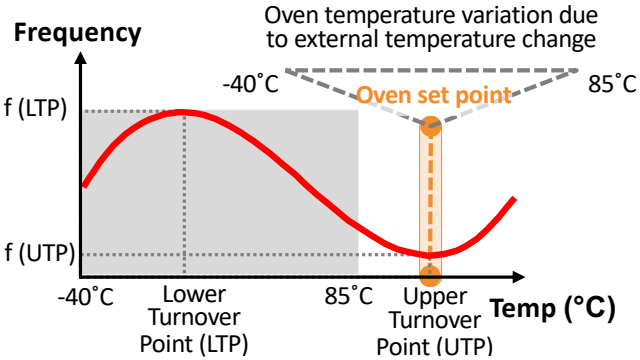


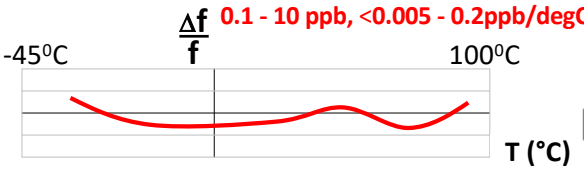




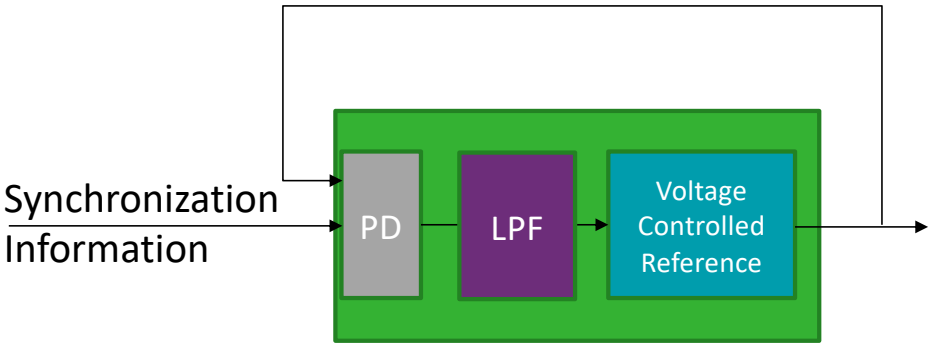
OCXOs – oven control

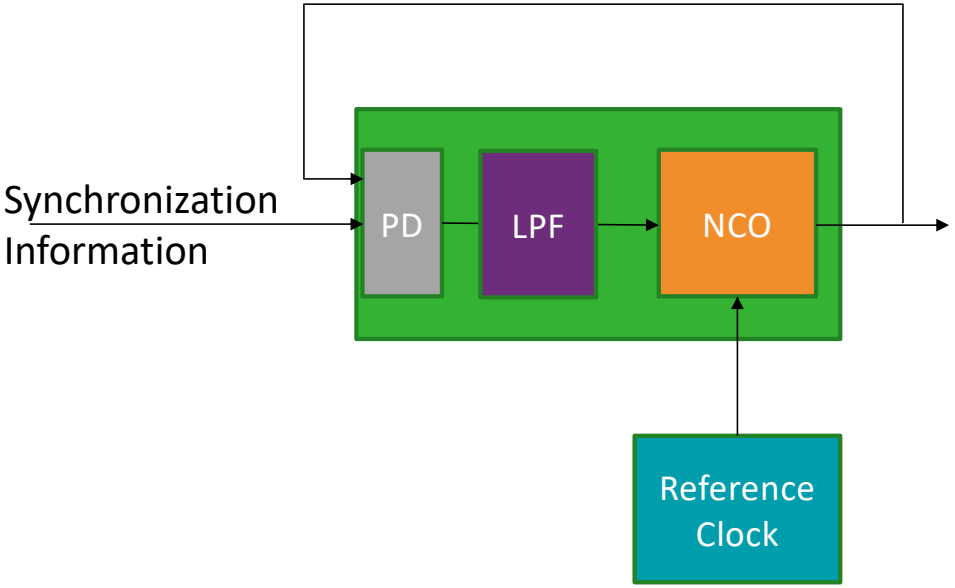






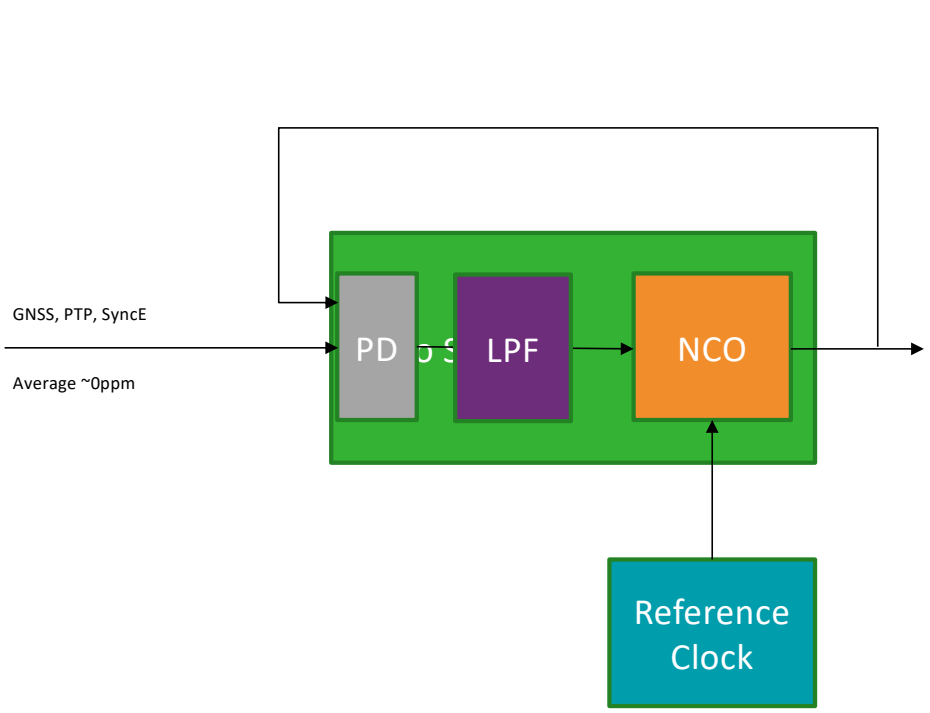
Implementation of servos

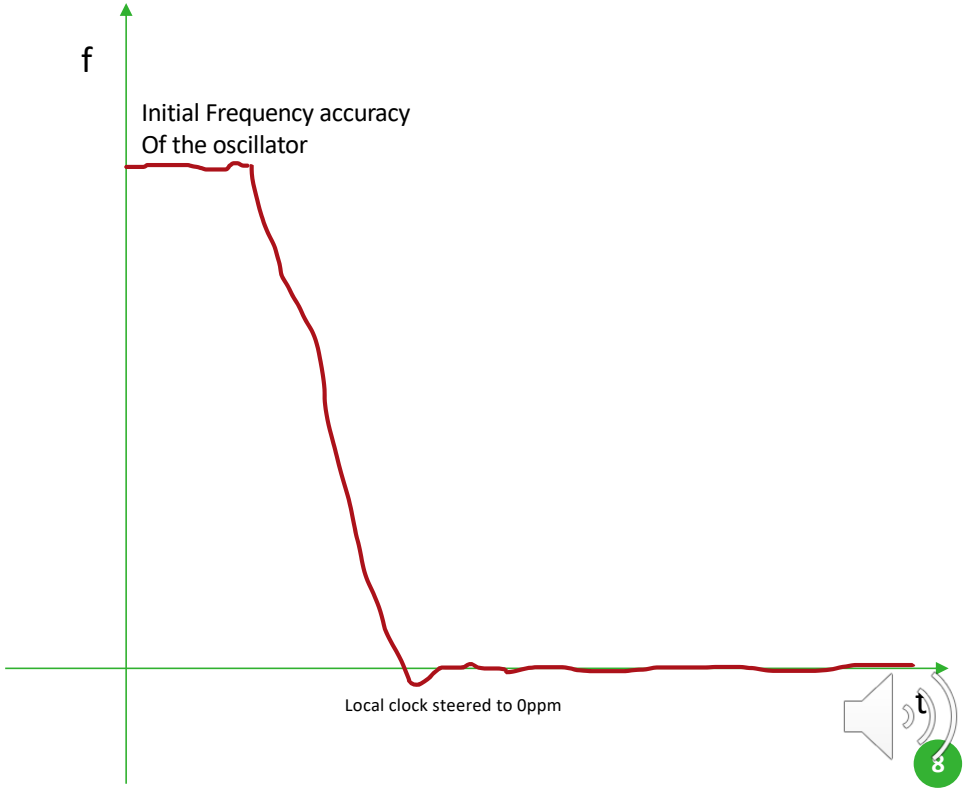




How does clocks work!

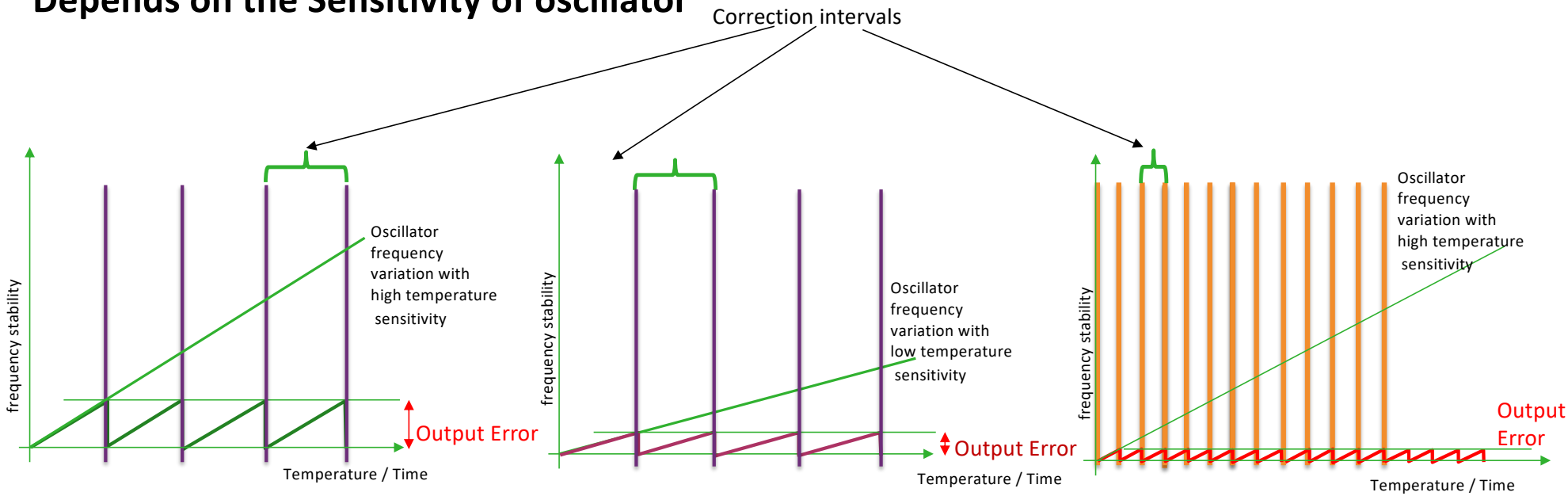
Local clocks are steered with information from higher layers





Noise generation of the system

Depends on the Sensitivity of oscillator



Loop bandwidth	10 – 100 Hz	1 – 10 Hz	0.1 – 1 Hz	10 – 100 mHz	1 mHz	<1 mHz
Recommended temperature stability	0.5 – 1 ppm	0.1 – 0.3 ppm	0.05 – 0.1 ppm	20 – 50 ppb	5 – 10 ppb	1 – 5 ppb
Temperature Sensitivity	10-20ppb/degC	5-10ppb/degC	1-5ppb/degC	0.2-0.5ppb/degC	0.1-0.2ppb/degC	<1ppb/degC

Oscillator selection

Oscillator requirements are based on

- **Free Run →**
  - Overall oscillator stability for 10/15/20 years, all causes included
- **Noise Generation →**
  - FvT & sensitivity
- **Holdover →**
  - Ability to hold the frequency/phase of the clock
  - Depends primarily on sensitivity & ageing
- **Other effects impacting application performance →**
  - Phase noise, shock & vibration

Summary

- Oscillators are fundamental building blocks of clocks
- 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
- Freerun, wander generation and holdover and key aspects of oscillator selection in systems