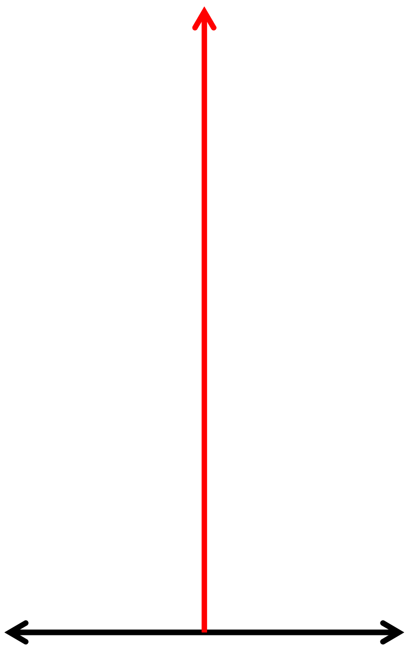
Time Holdover and Oscillator Requirements

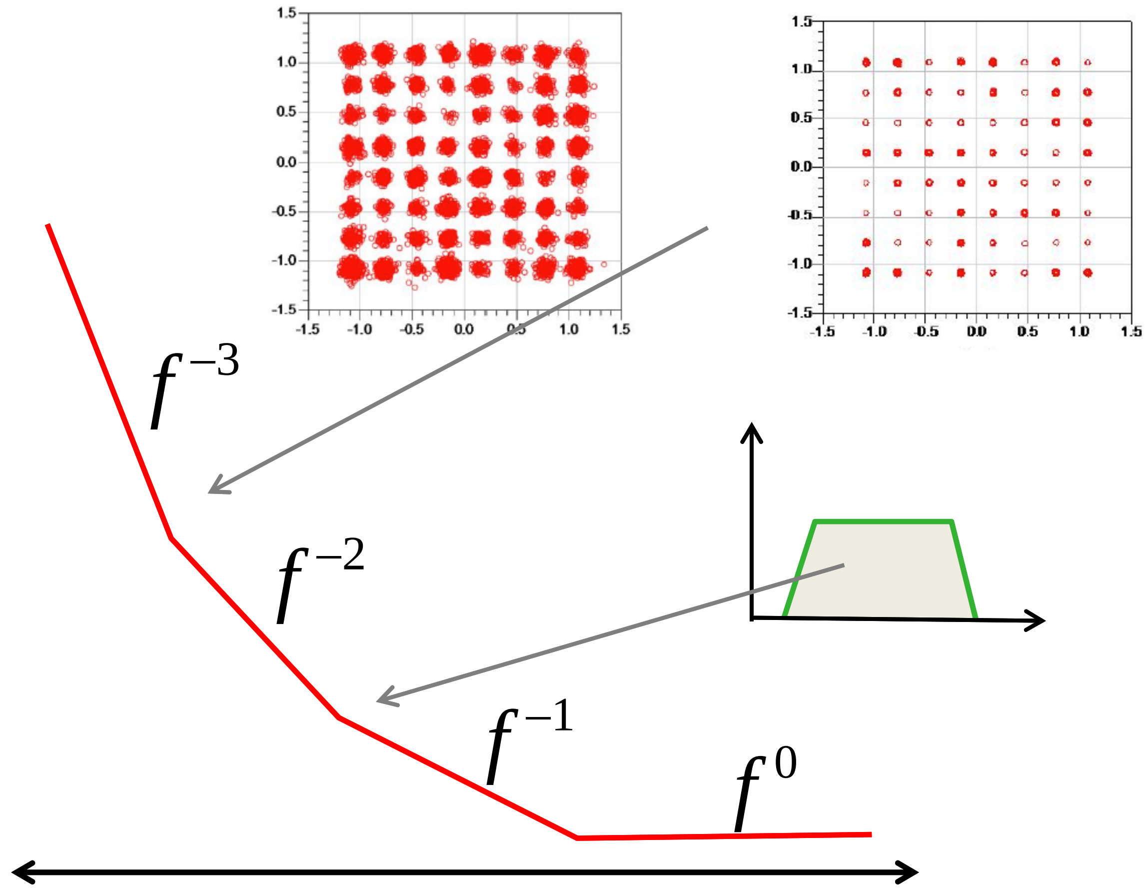
WSTS 2014

Telecommunications Global Positioning Space Defense

Oscillators

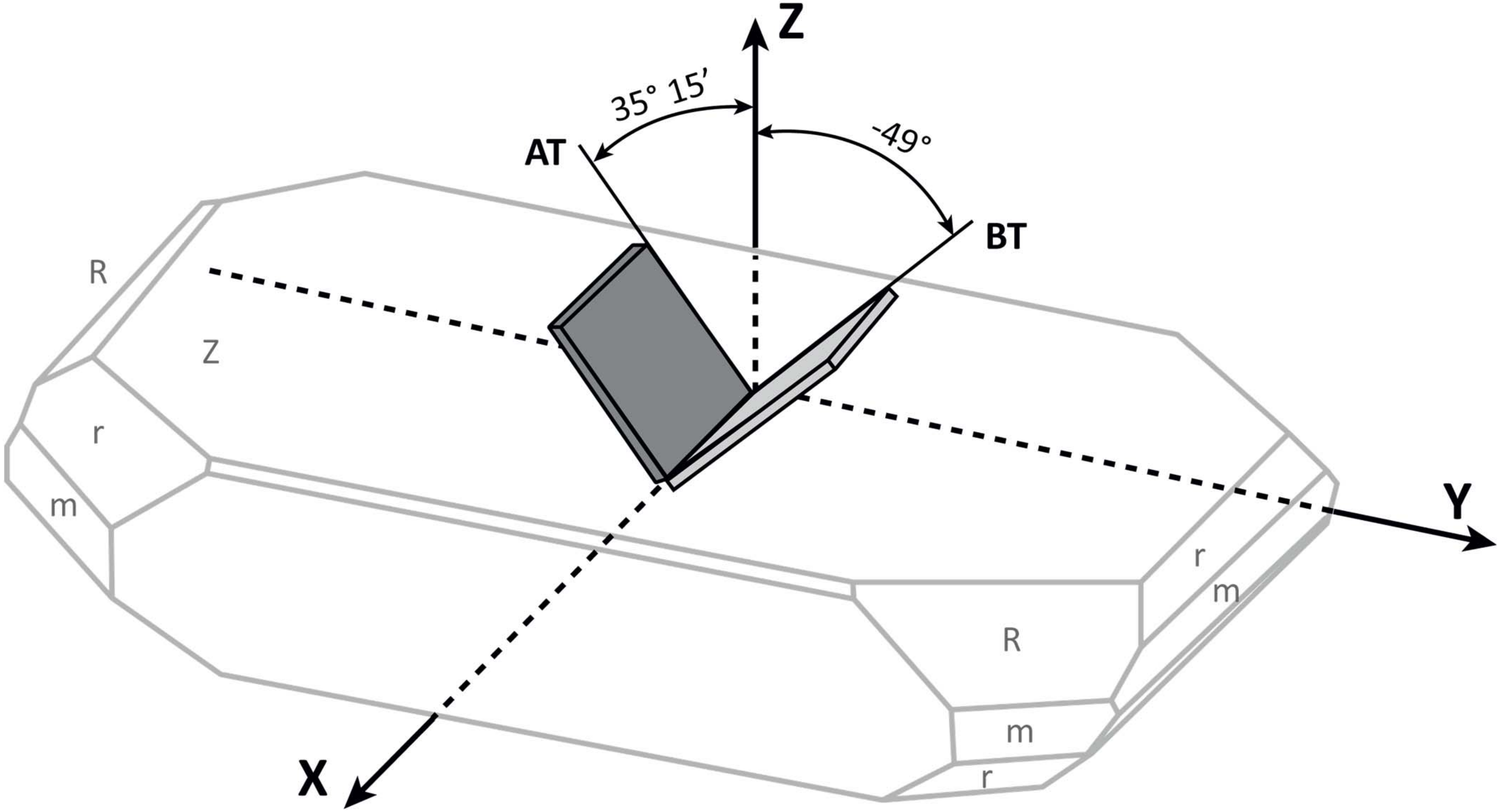


$$f(t) = f_0(t)$$

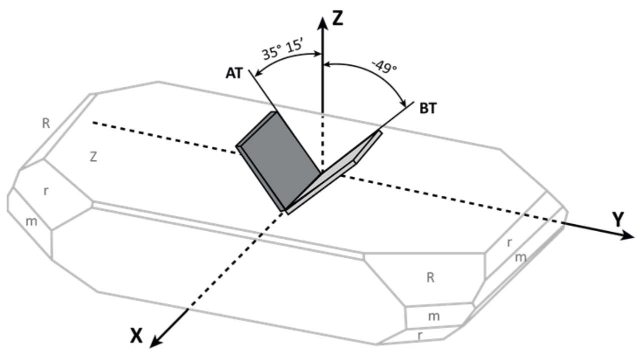


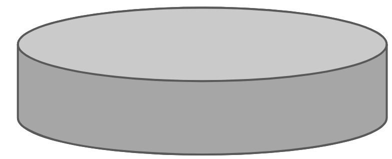
$$f(t) = f_0(t) + f_a(t^2) + f_{T,V,H,P,E}(t)$$

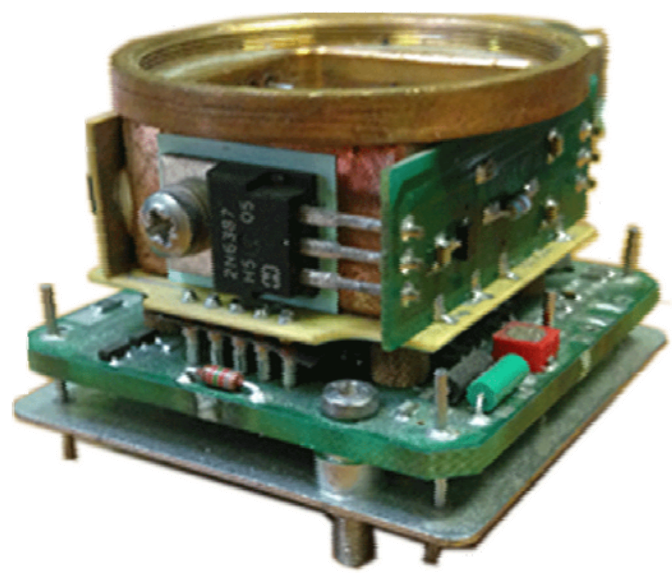
Construction



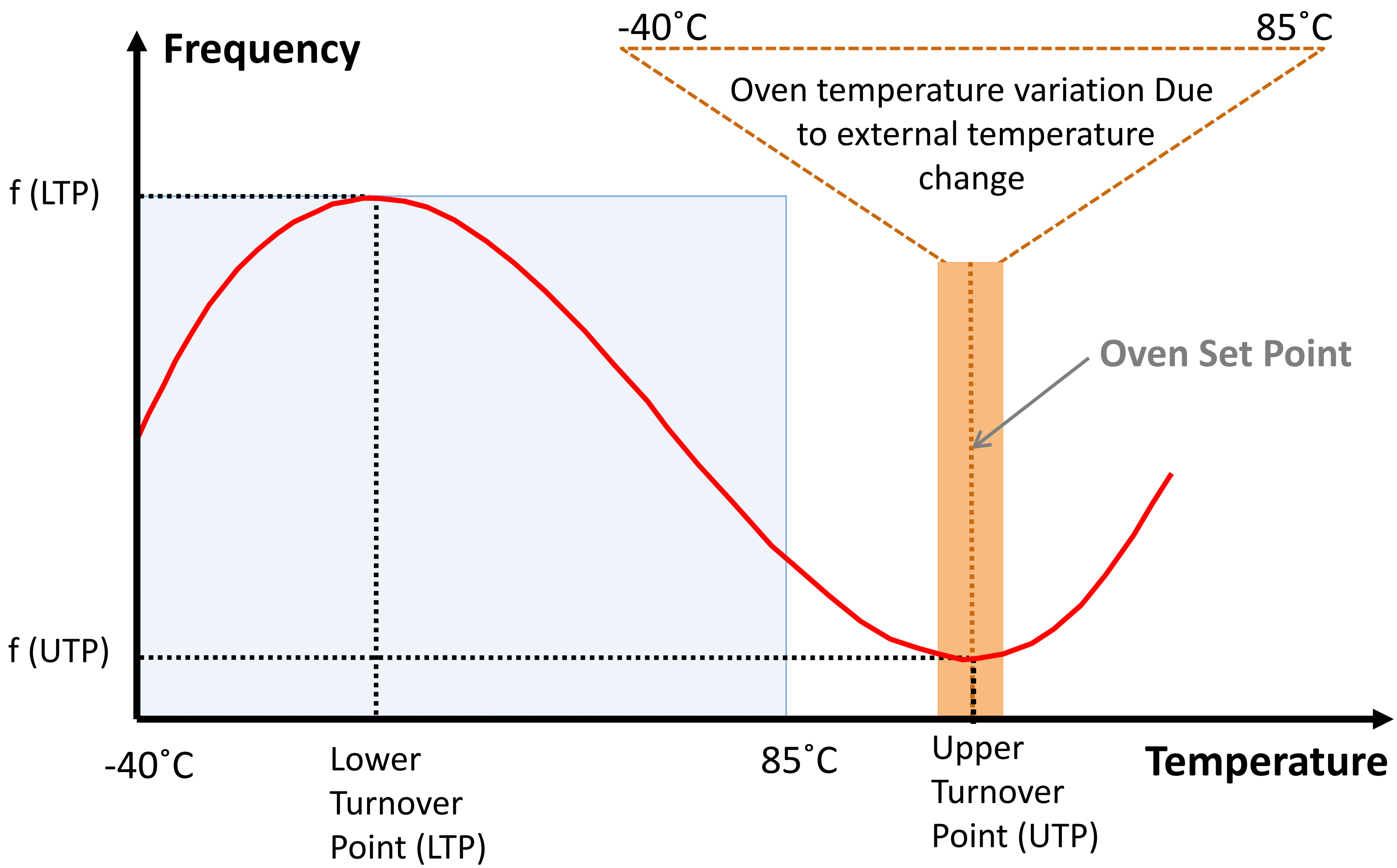
Construction





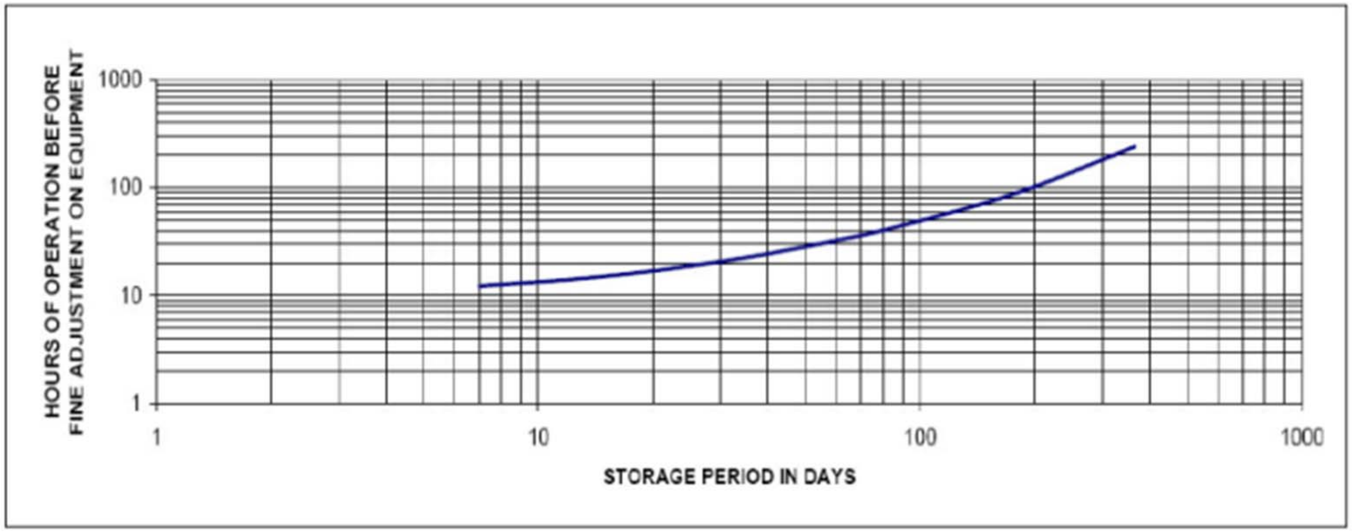


Oven Control

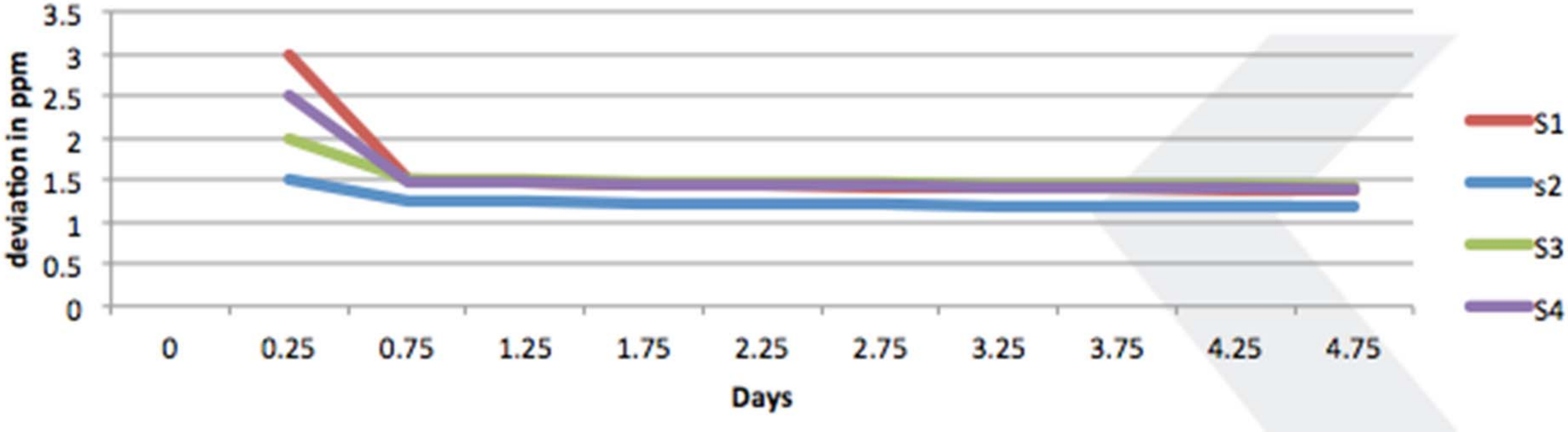


Impairments

Storage Impact on Oscillators

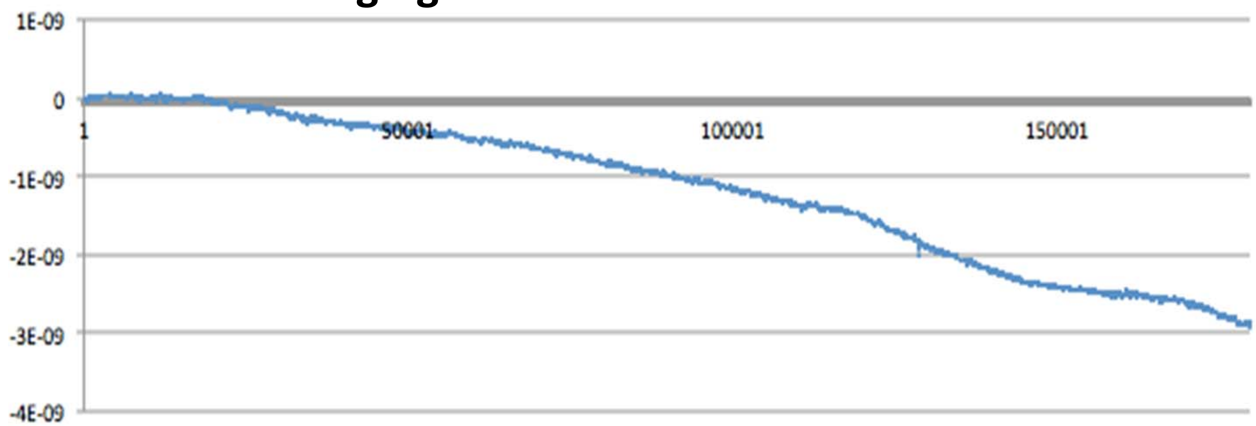


Reflow Impact on Oscillators

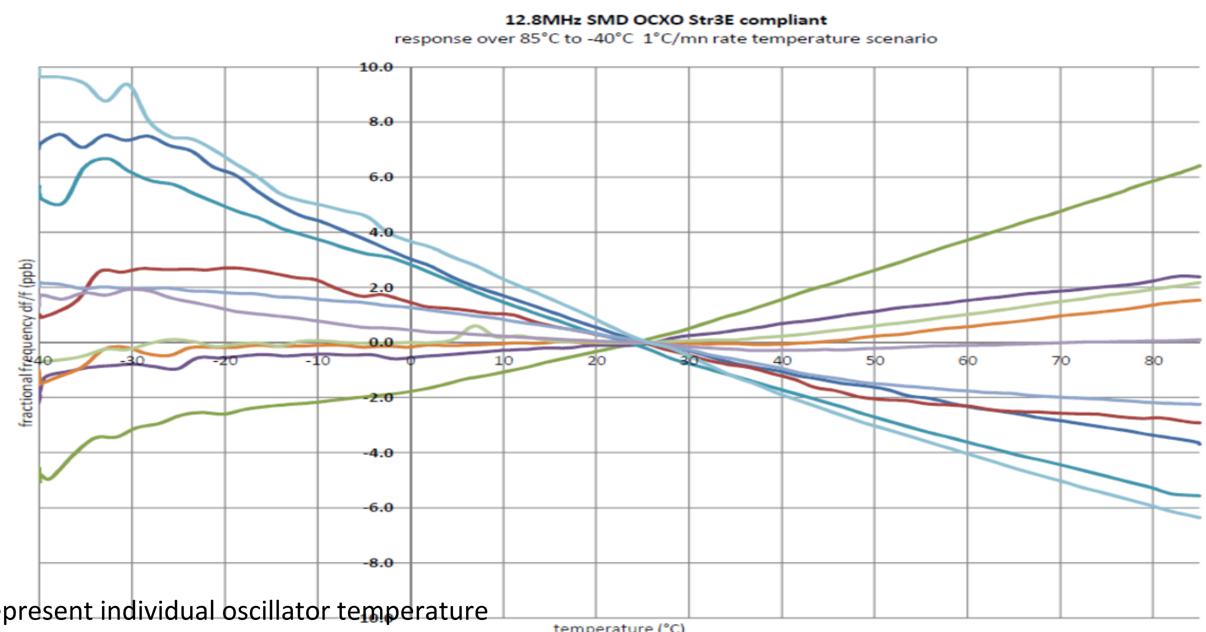


Impairments

Aging effect on Oscillators



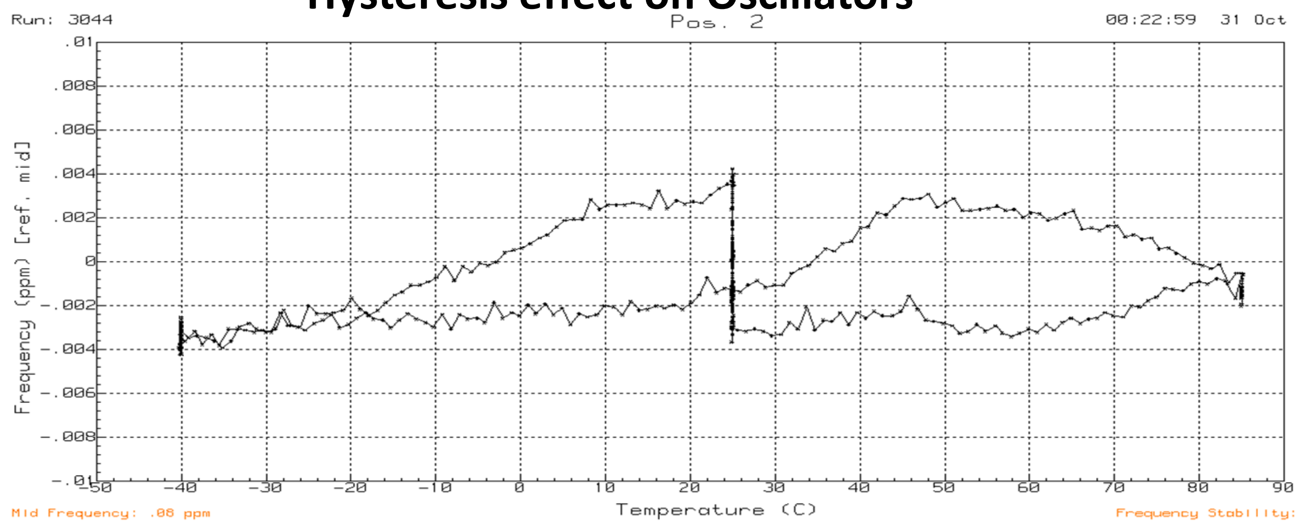
Temperature Effect on Oscillators



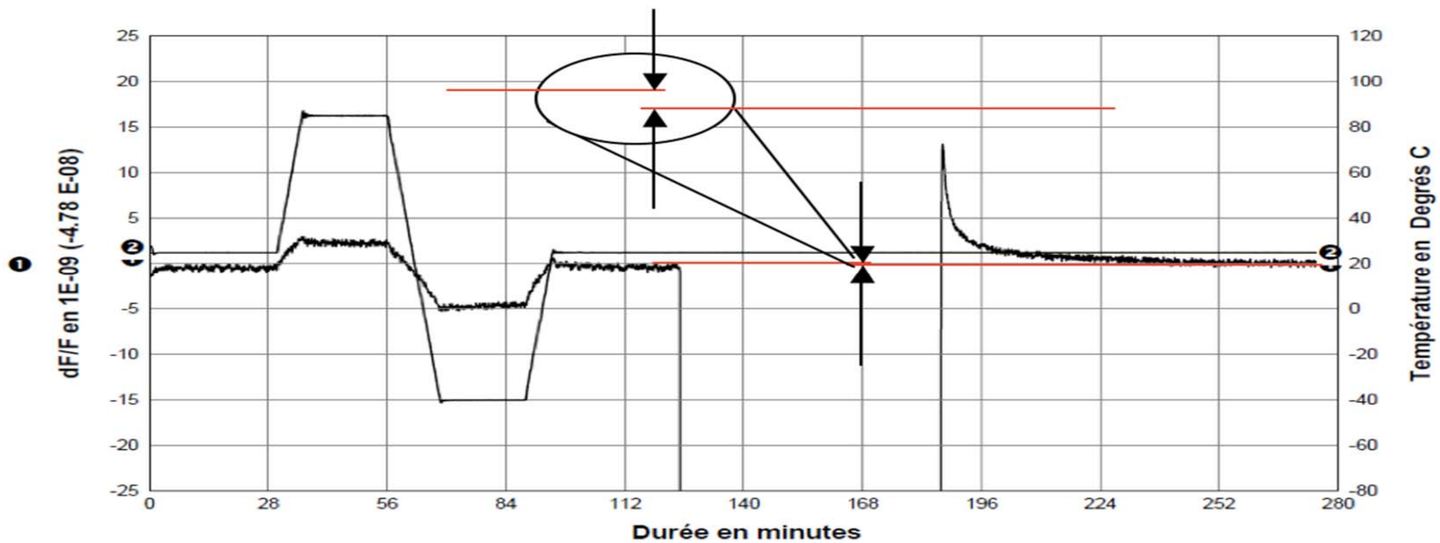
The different colours represent individual oscillator temperature behaviour in the same family of oscillators

Impairments

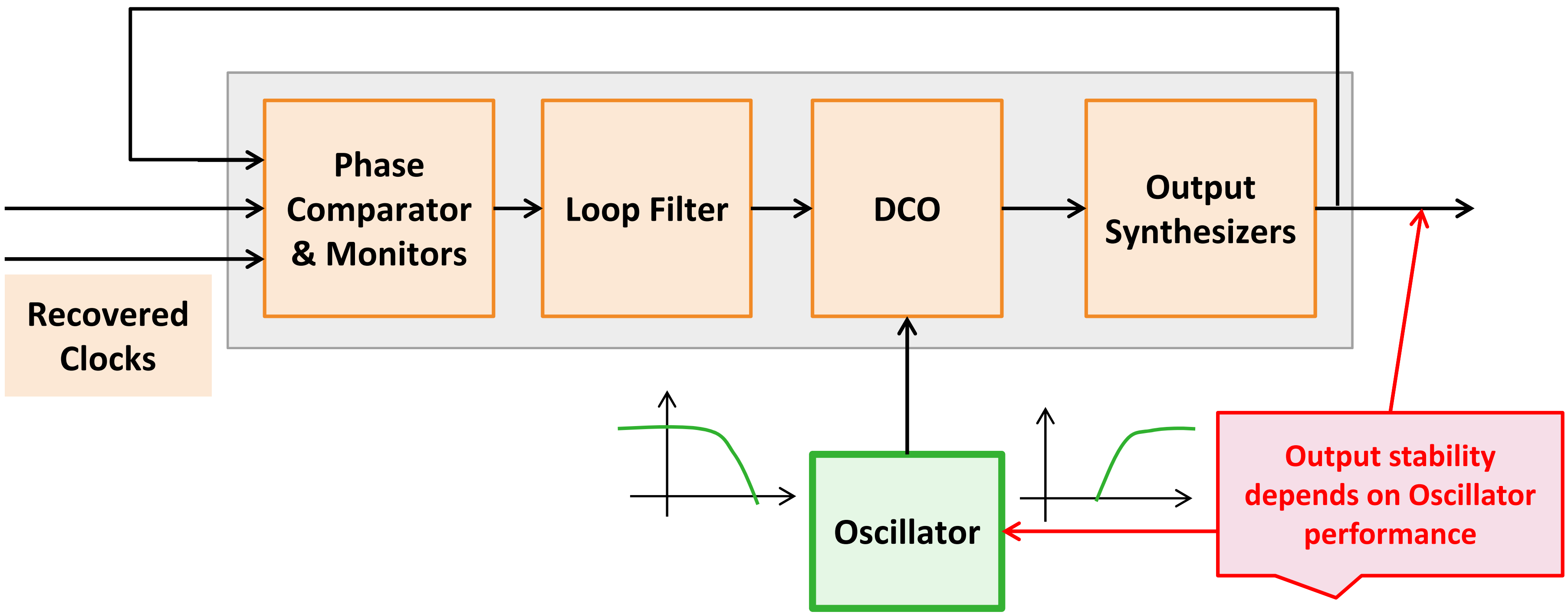
Hysteresis effect on Oscillators



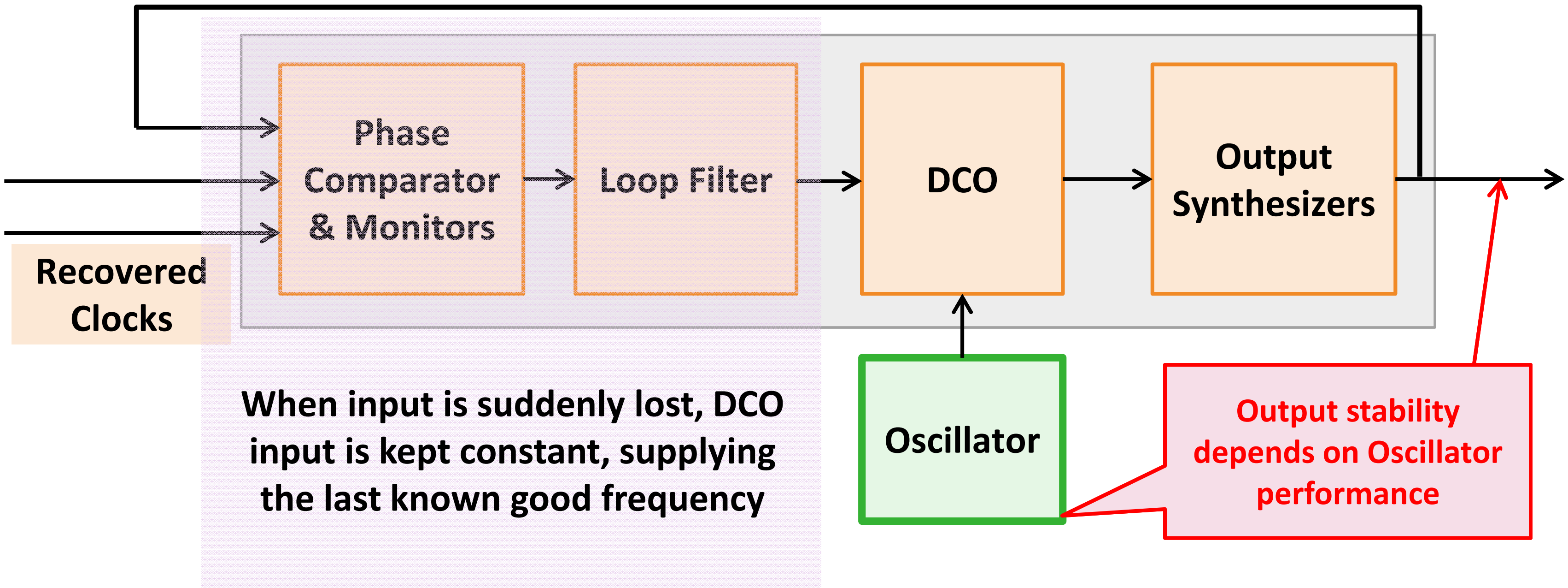
Retrace effect on Oscillators



Impact of Oscillator on a Loop



Holdover Operation



Example

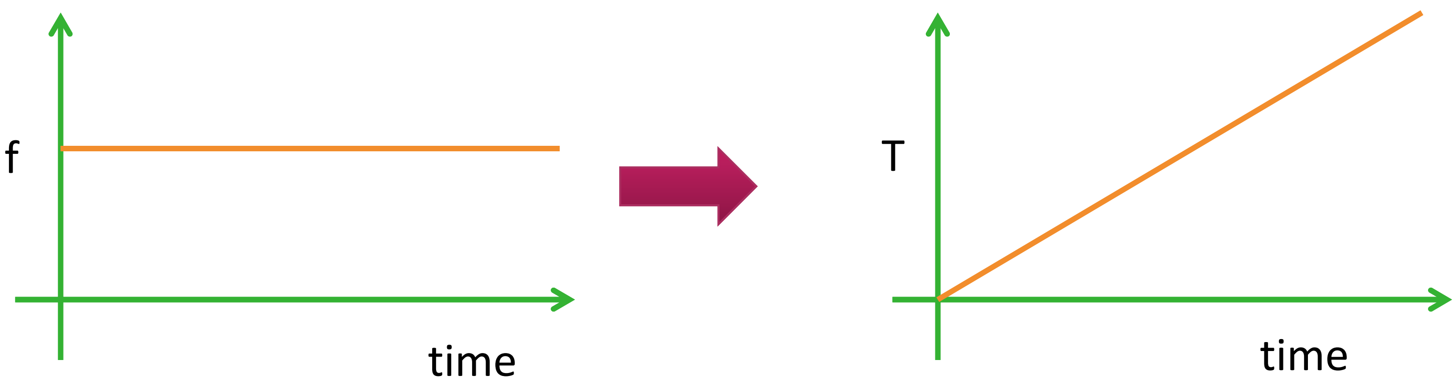
Initial holdover accuracy	±50 ppb	Best case system accuracy
Initial phase jump	± 120 ns	Occurs because of entry to holdover
Oscillator temperature stability	± 2 ppm	Usually -40 to +85 °C
Oscillator Aging	± 100 ppb/24hrs	
Other effects (Vss, load, etc.)	± 100 ppb/24hrs	

Application Requirements

- 1.5us requirement for LTE TDD base stations
- <0.5us for LTE-A and positioning applications

- GNSS based systems are vulnerable
- GNSS failure situations of 72 hours envisioned

- 1.5us for 24 hours translates to stability of 3e-11 !

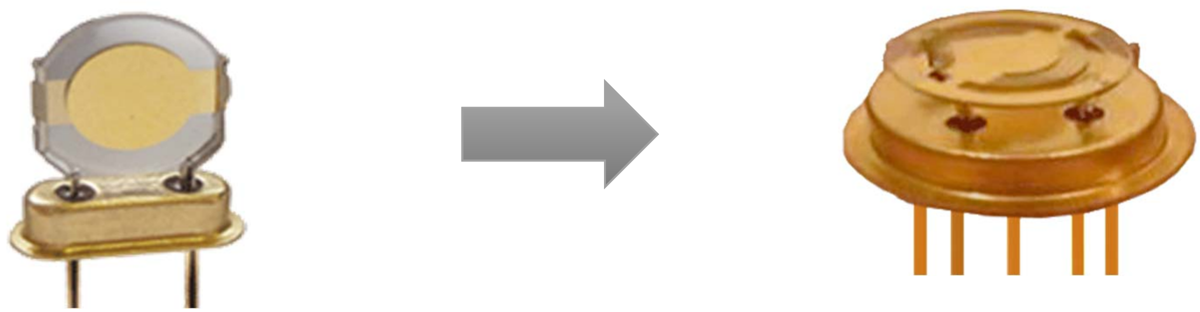


Improving holdover => Improving Stability

- Crystal related improvements
- Mechanical improvements
- Using System Supports
- Enhancing Control loops and Electronics
- Other Environmental effect related Controls

Crystal & Mechanical Enhacements

- Crystal enhancements



- Improving Mechanical Structures
- Thermal isolation improvements

Compensation & Enhancements

- Aging control
- Thermal self control
- Hysteresis Control
- Supply Voltage variation control
- Temperature effects of Frequency variation control

Control Enhancements

- Fine granularities for controls
- Precise sensor requirements
- Higher order prediction algorithms
- Phase noise impact with active components

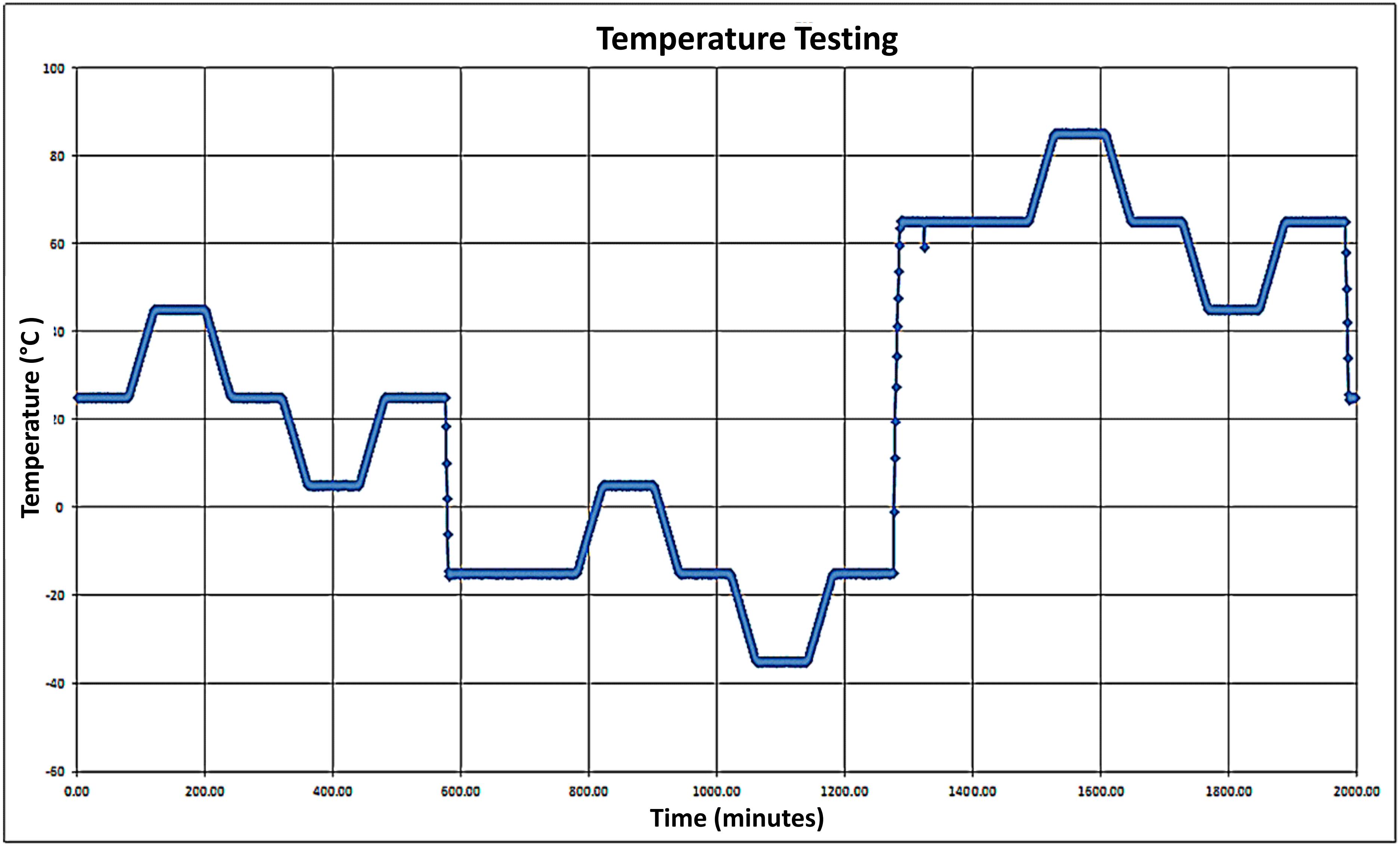
System Effects

- Reducing effects due to gravity, vibration & shock
- Minimizing radiation effects
- Resisting environmental effects – Humidity & Pressure

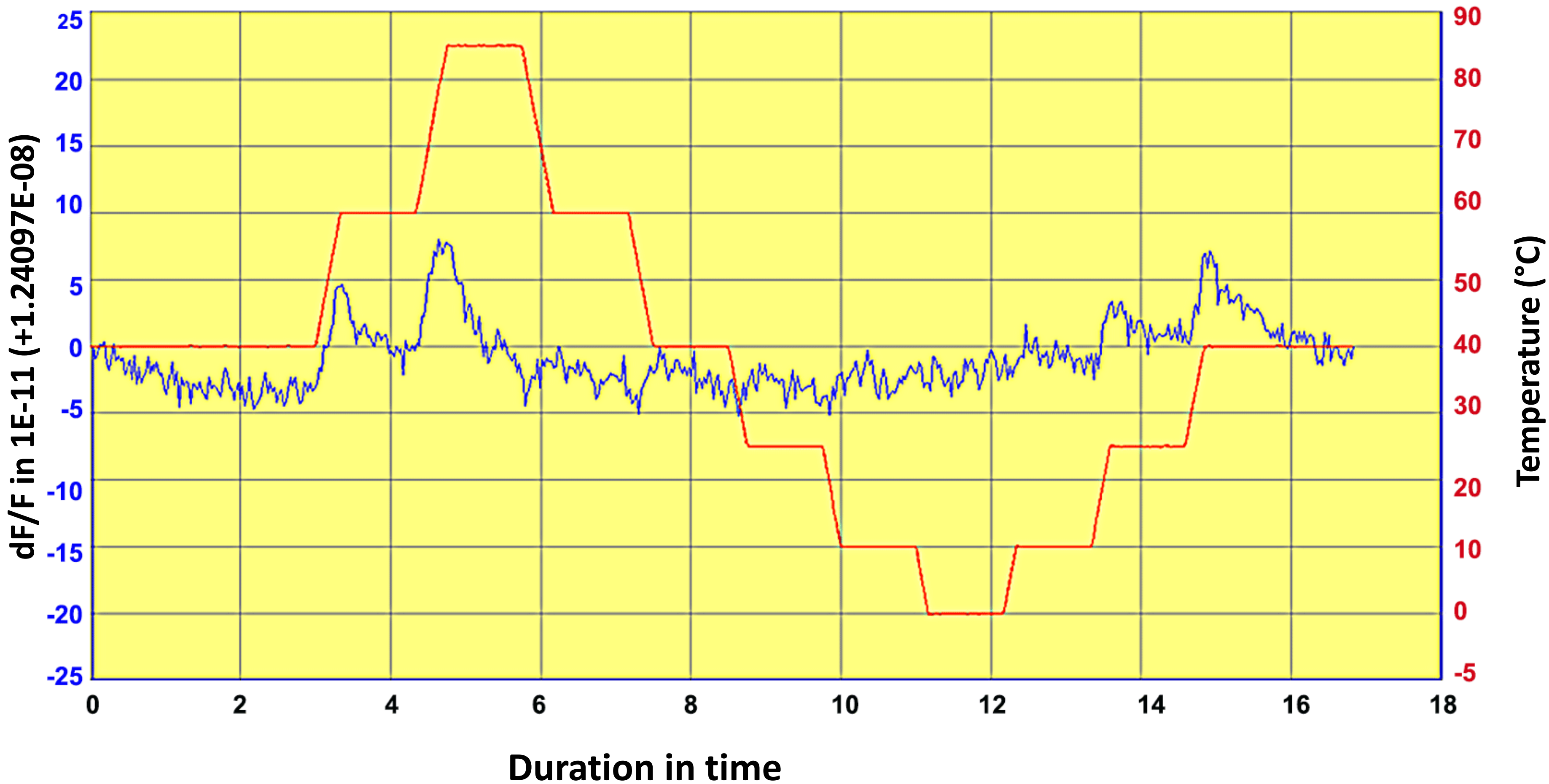
Testing Challenges

- **Measured aging on individual oscillators**
- **Zero Gap testing**
- **Improvements for production benches**
  - Measurement accuracy
  - Continuous measurements
- **Temperature profiles for testing**

Temperature Testing of Sync



Sample Performances



Summary

- Long term time holdover is desired but challenging
- Crystal based oscillators - Hurdles in compensation
- High stability oscillators pose testing challenges

References

- Contributions of Dr. Nigel Hardy, Vincent Candelier, Cyril Datan, Principle R & D Engineers at Rakon
- Various ITU-T documents
- Various documents published by NIST
- J.R Vig; Quartz Crystal Resonators and oscillators for frequency control and timing applications

rakon

synchronising connectivity