Time interval error 150 ns per 24 hours by the compact time keeping equipment.

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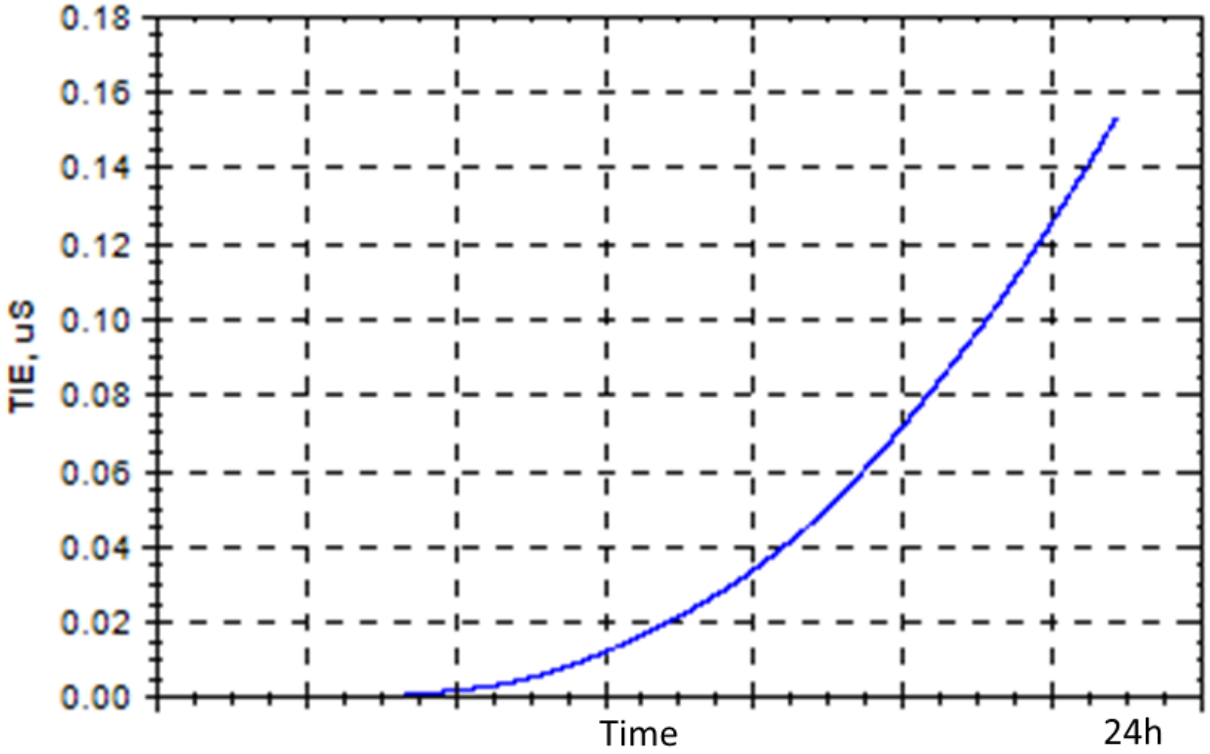
5G Requirements

Time Interval Error (TIE) per 24 hours – 150…400 nS



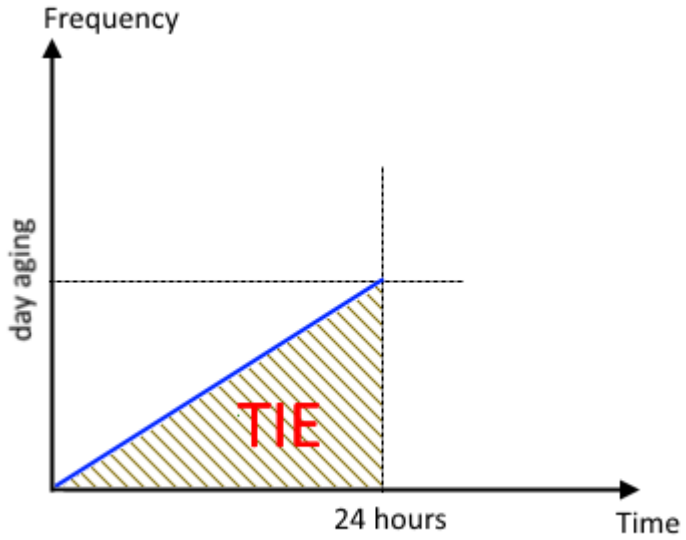
Rb

DOCXO

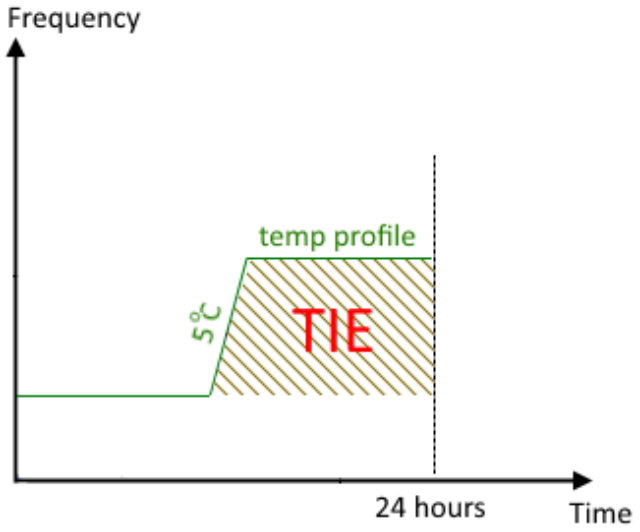
Could it be done?

TIE vs Frequency

Longterm stability (Aging)



Frequency vs temperature stability



150 nS per 24 hours → ~3.5 E-12 per 24 hours

400 nS per 24 hours → ~9 E-12 per 24 hours

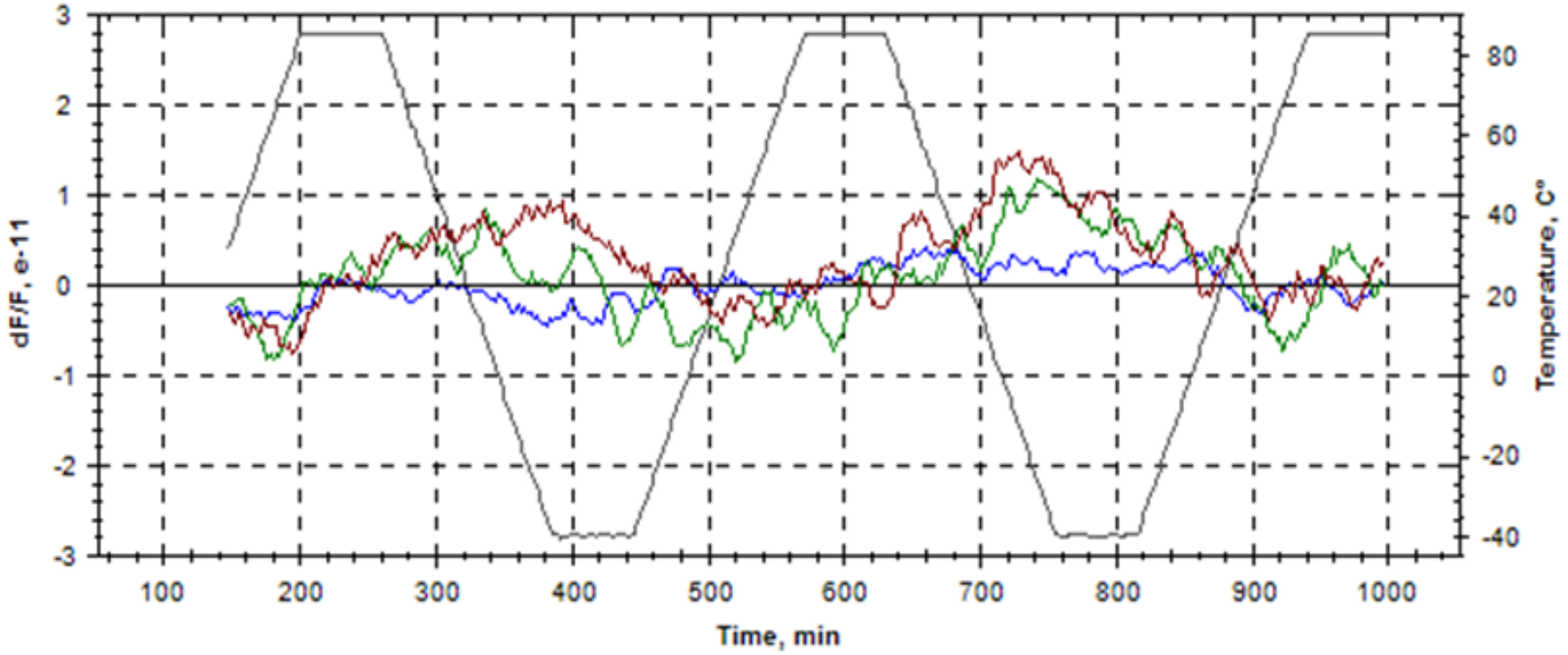
DOCXO

±5E-11/day
±1E-11 @ -20…+70°C
< 1E-12 ADEV 1sec

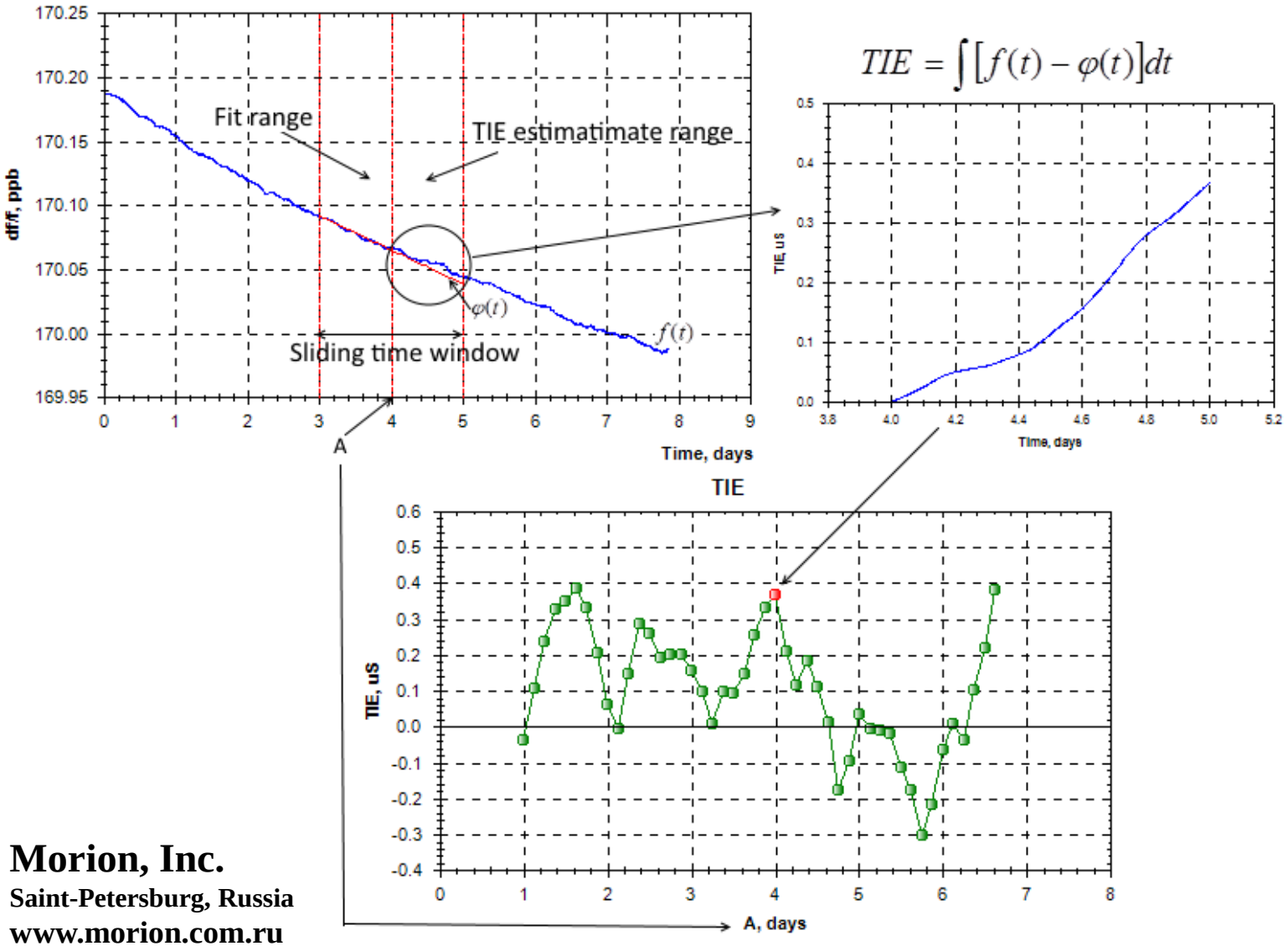
TIE per 24 hours*:
< 300ns at constant temperature
< 400ns ±5°C daily changed temperature

**using aging compensation*

DOCXO. Frequency vs Temperature



DOCXO. Longterm stability

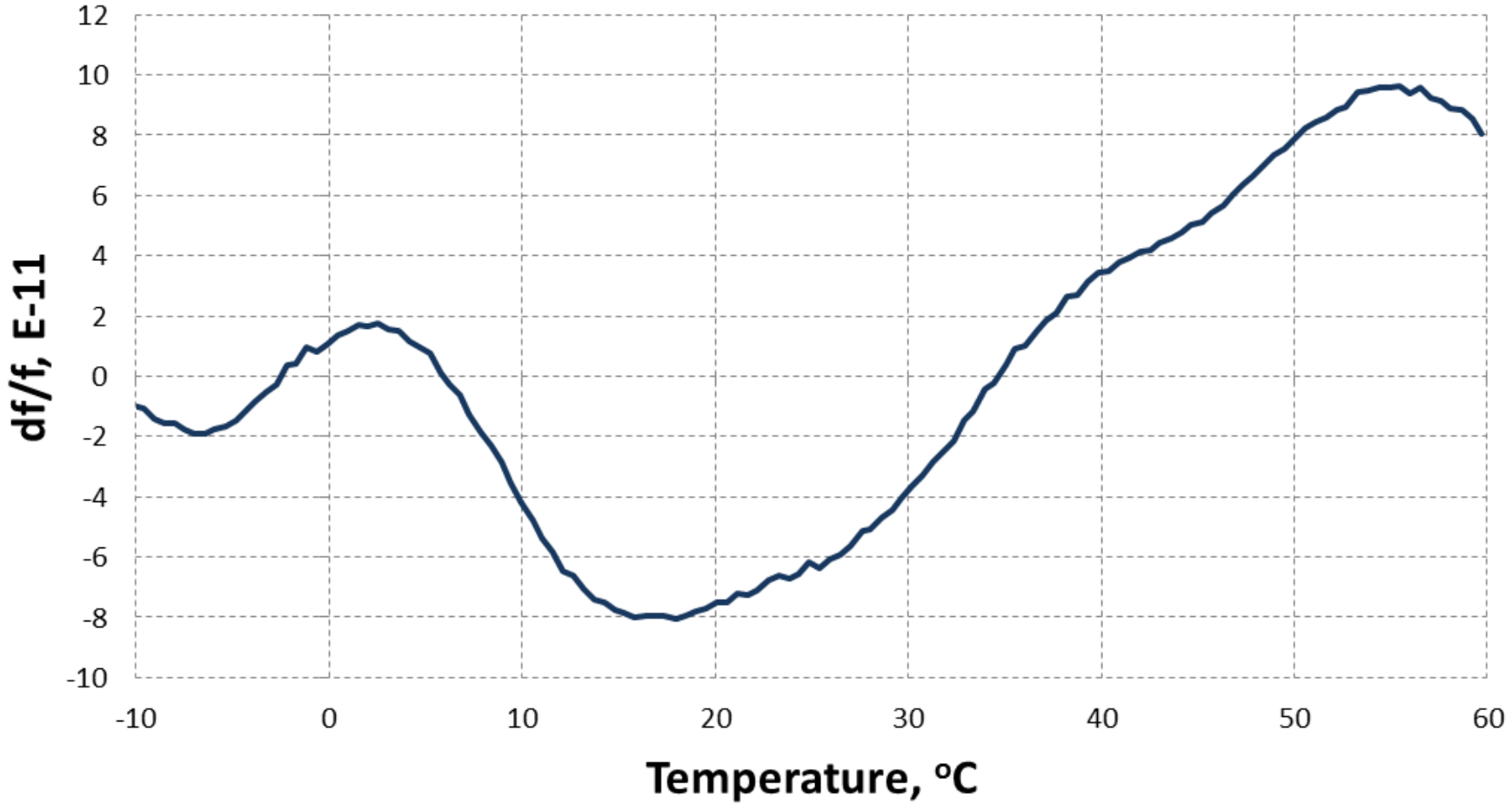


Rubidium

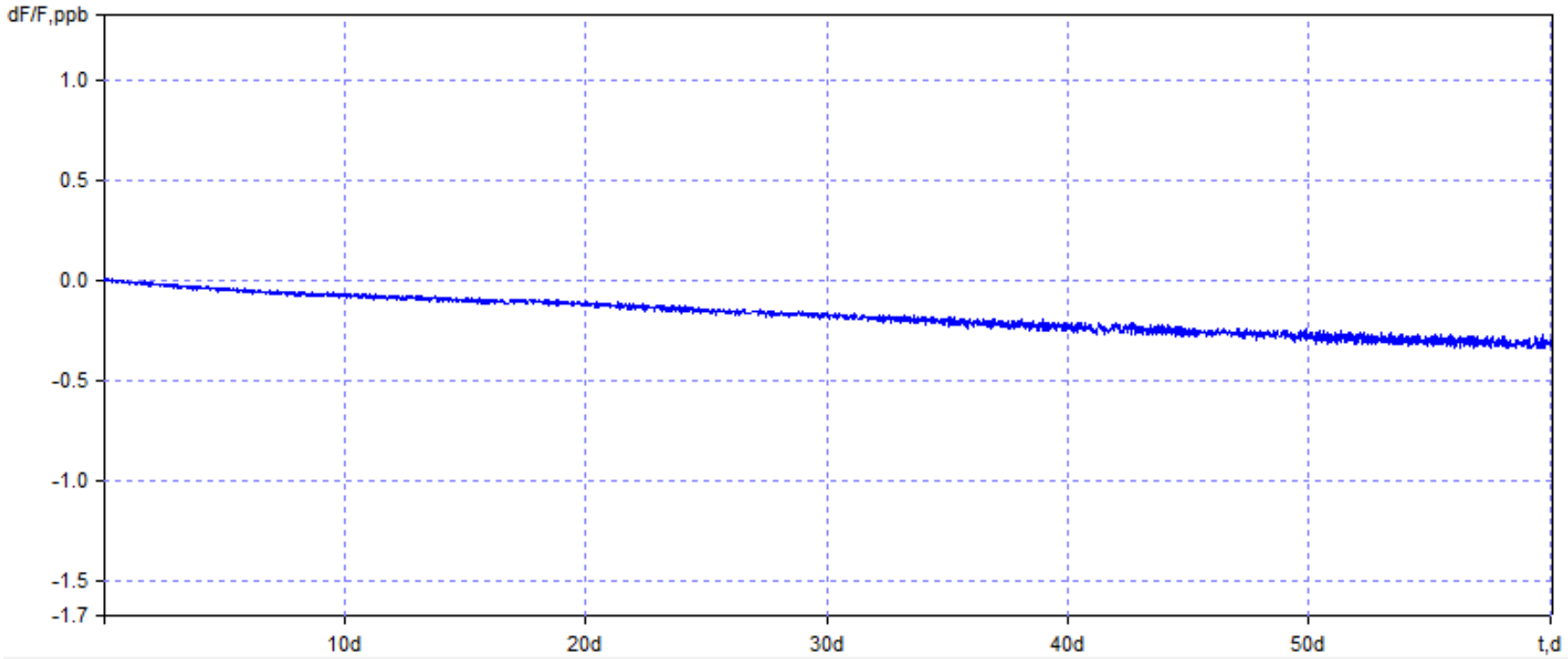
±4E-12/day
±1E-10 @ -5…+55°C
< 1.4E-11 ADEV 1sec

TIE per 24 hours:
< 100ns at constant temperature
< 500ns ±5°C daily changed temperature

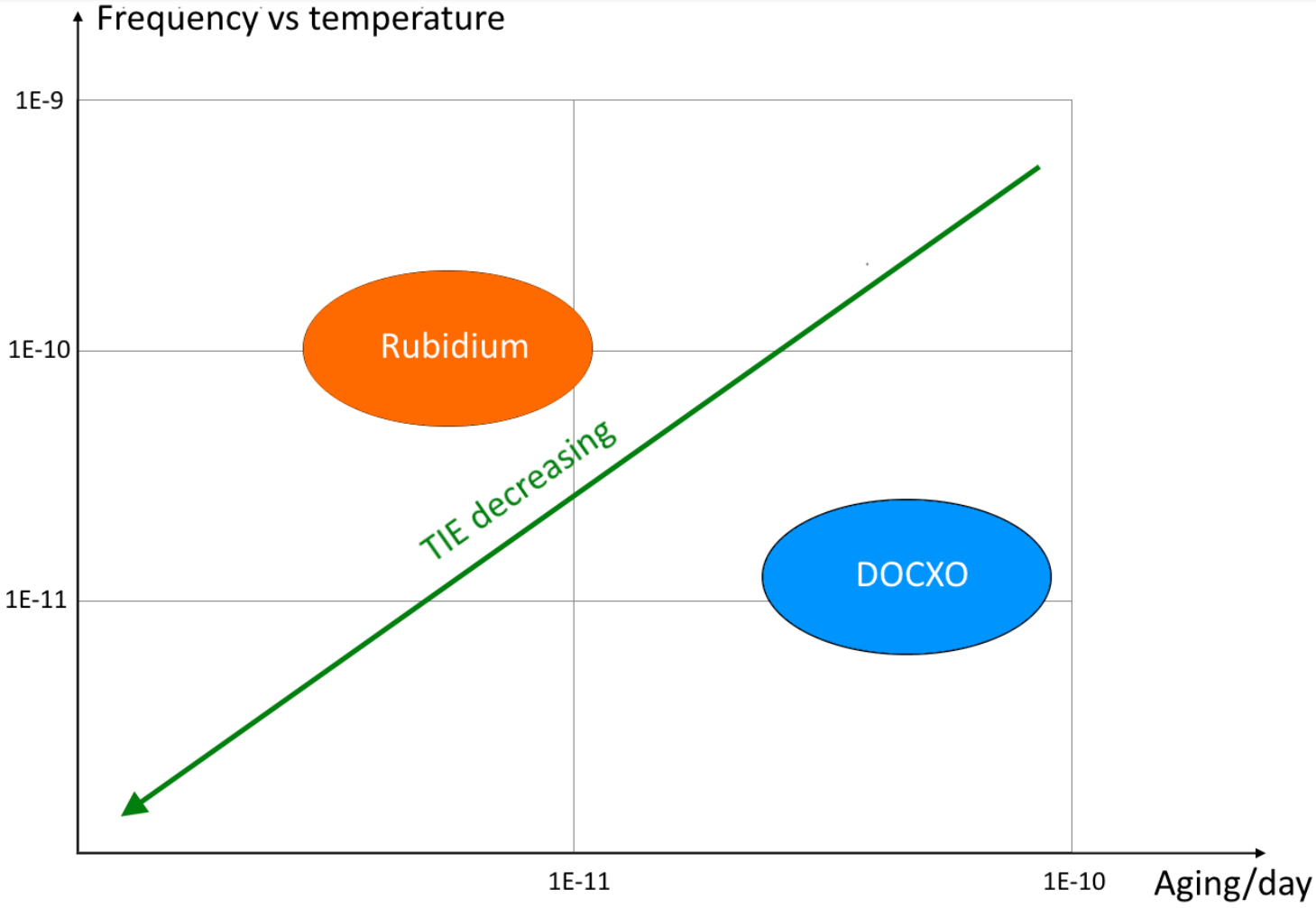
Rubidium. Frequency vs Temperature



Rubidium. Longterm stability

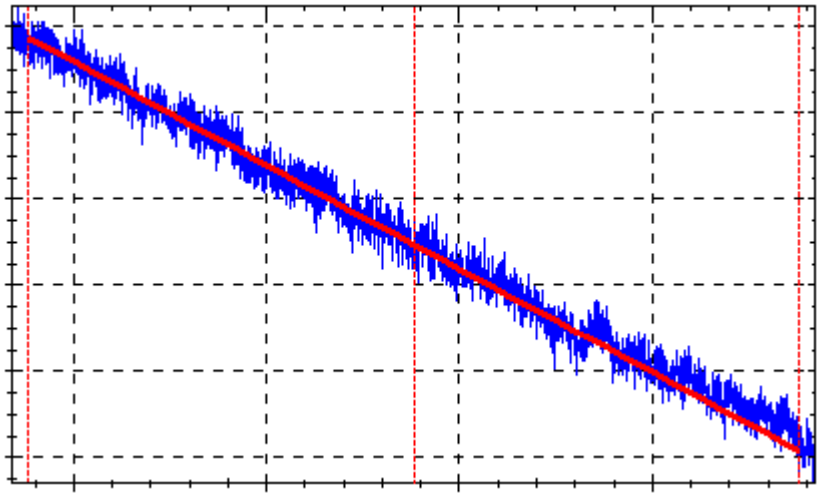


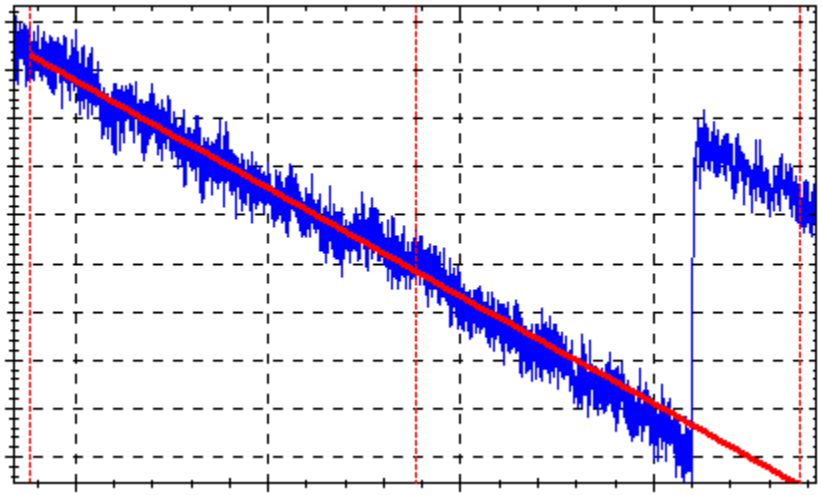
Holdover performance



DOCXO improvements

Longterm stability. Frequency jumps



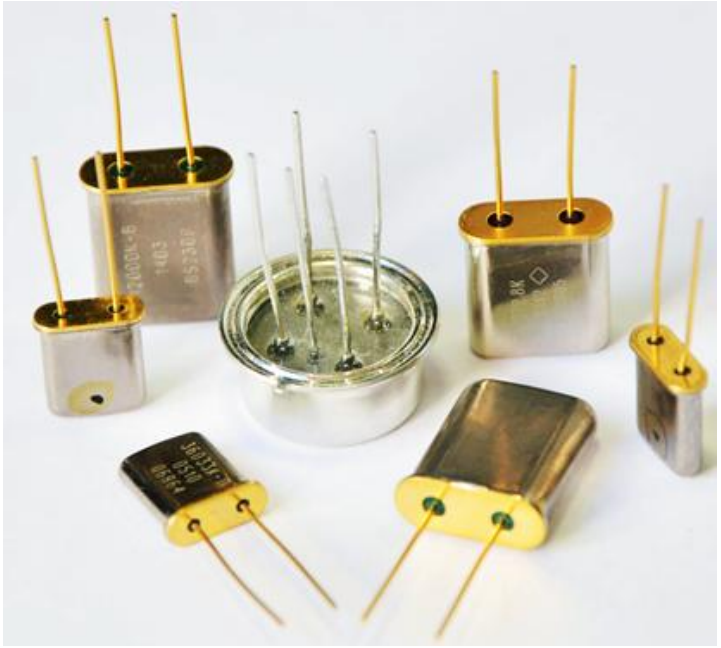


- Purity of quartz crystals
- High quartz overtone
- Using high stability reference

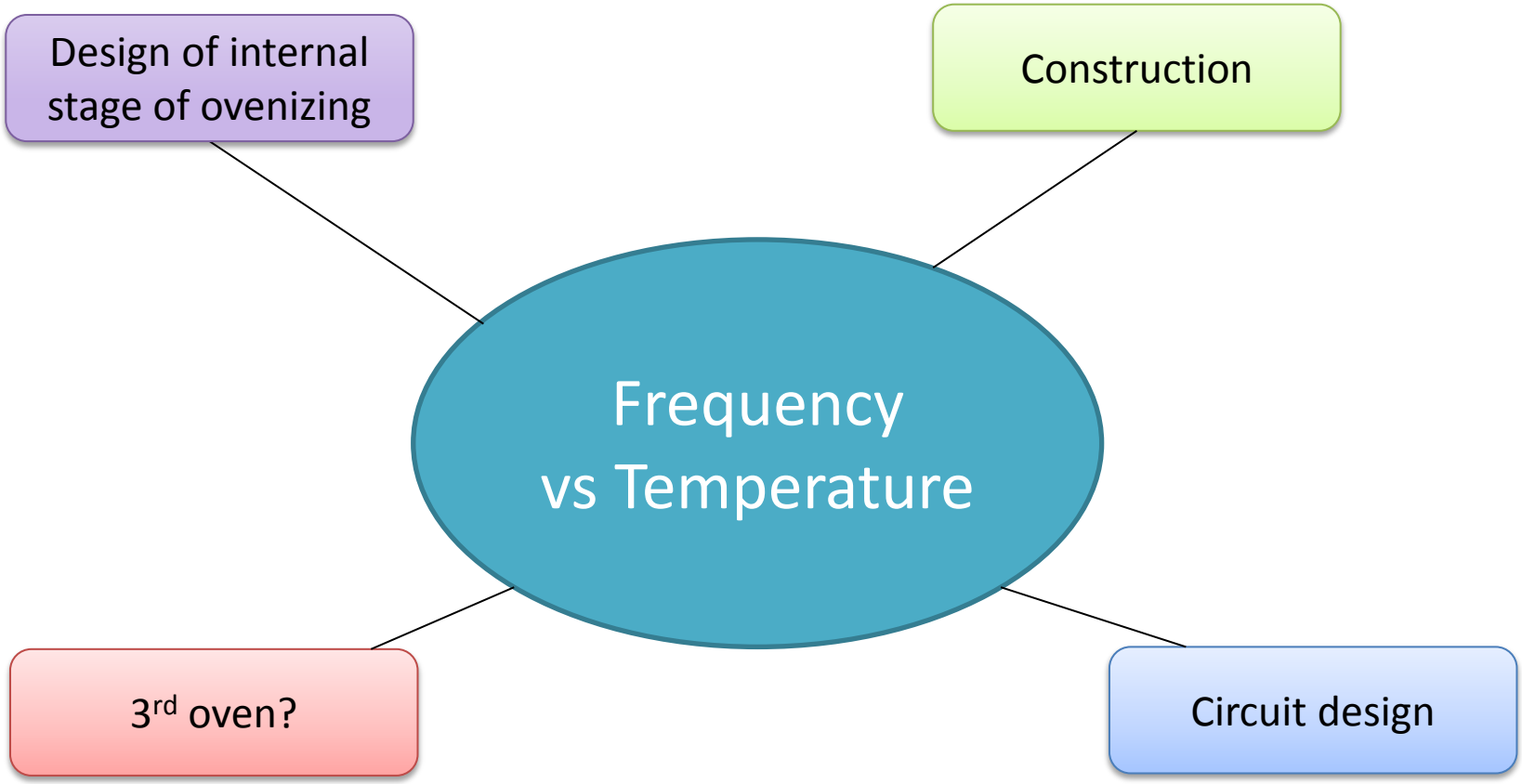
DOCXO improvements

Quartz crystals

- Using crystals without tuning
- Quartz blank polishing
- Holders



DOCXO improvements



Rubidium improvements

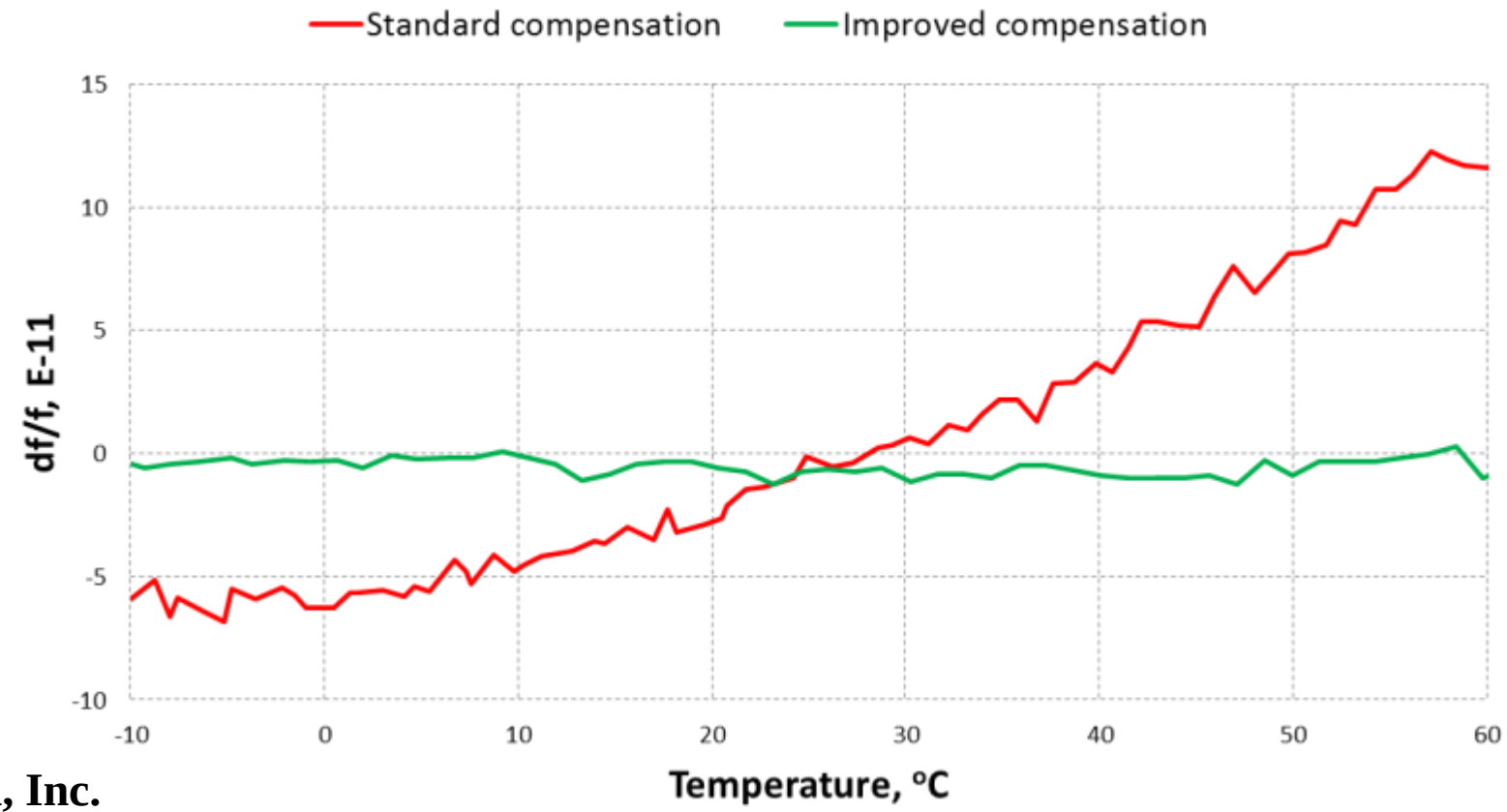
Frequency vs Temperature

- Design:
  - Construction
  - Heat distribution
  - Using new materials

Rubidium improvements

Frequency vs temperature

- Temperature compensation



±1E-11!

Conclusions

- DOCXO can meet tight requirements for TIE per 24 hours < 400 ns both at constant temperature and when it slightly changed ±5°C. Aging compensation is needed.
  - *Ways to improve: quartz crystals, circuit design, construction.*

- Rubidium oscillators can meet very tight requirement for TIE per 24 hours < 100 ns at constant temperature. But they are very sensitive to temperature changes, so at ±5°C daily changes TIE performance degraded to 500 ns.
  - *Ways to improve: temperature compensation , construction.*

Thanks for your attention!

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