Implementation Considerations for Holdover Functionality in Oscillator

Xiaochun Liu, Application Engineer

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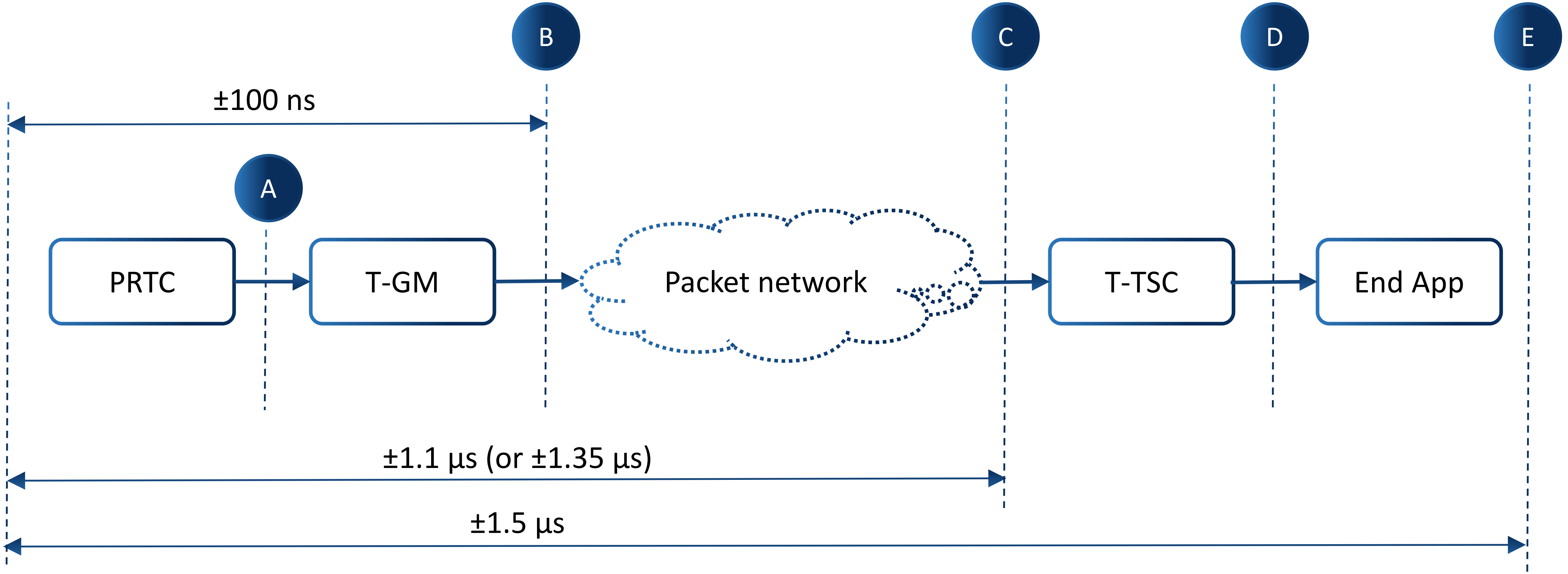
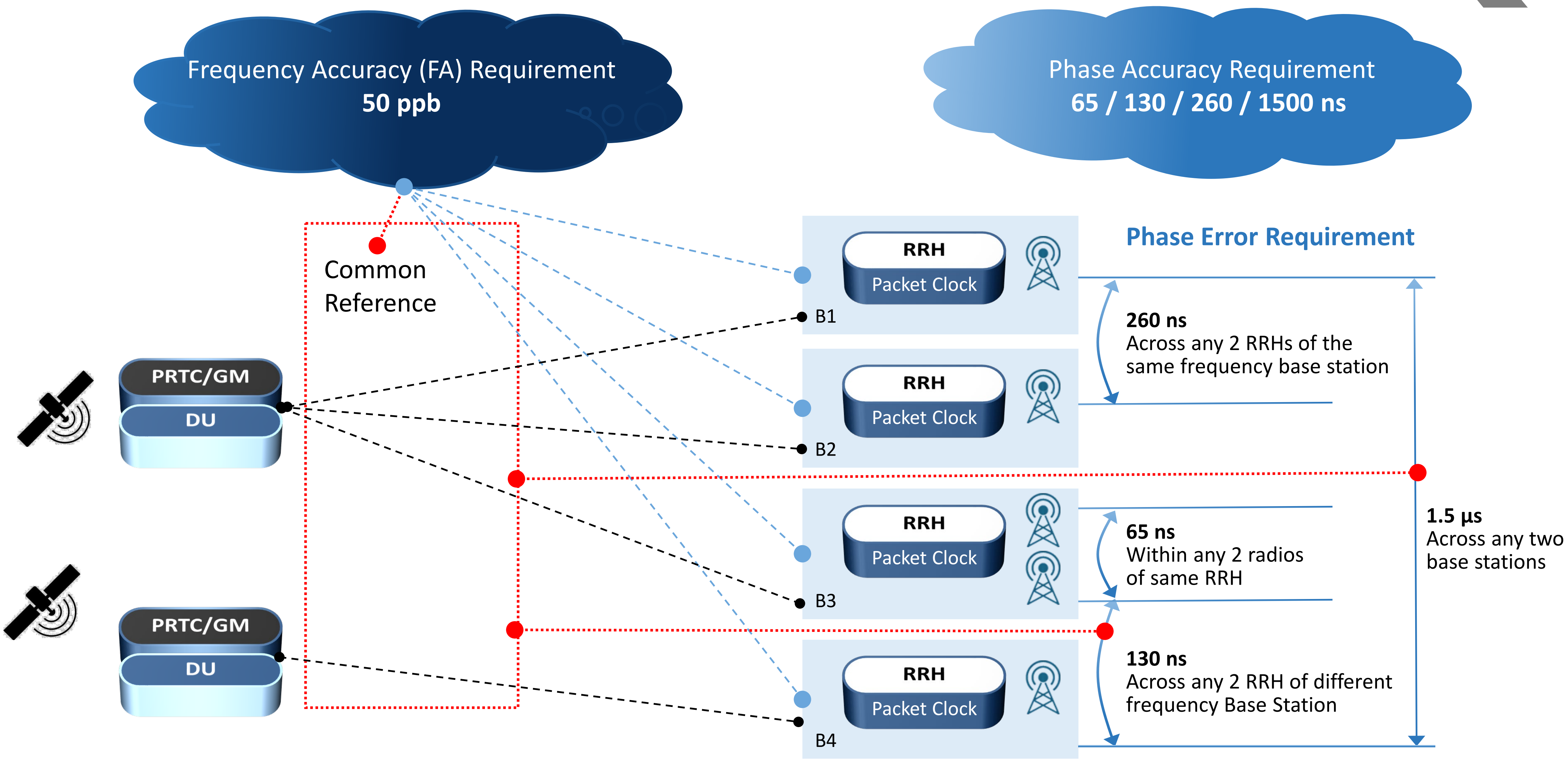
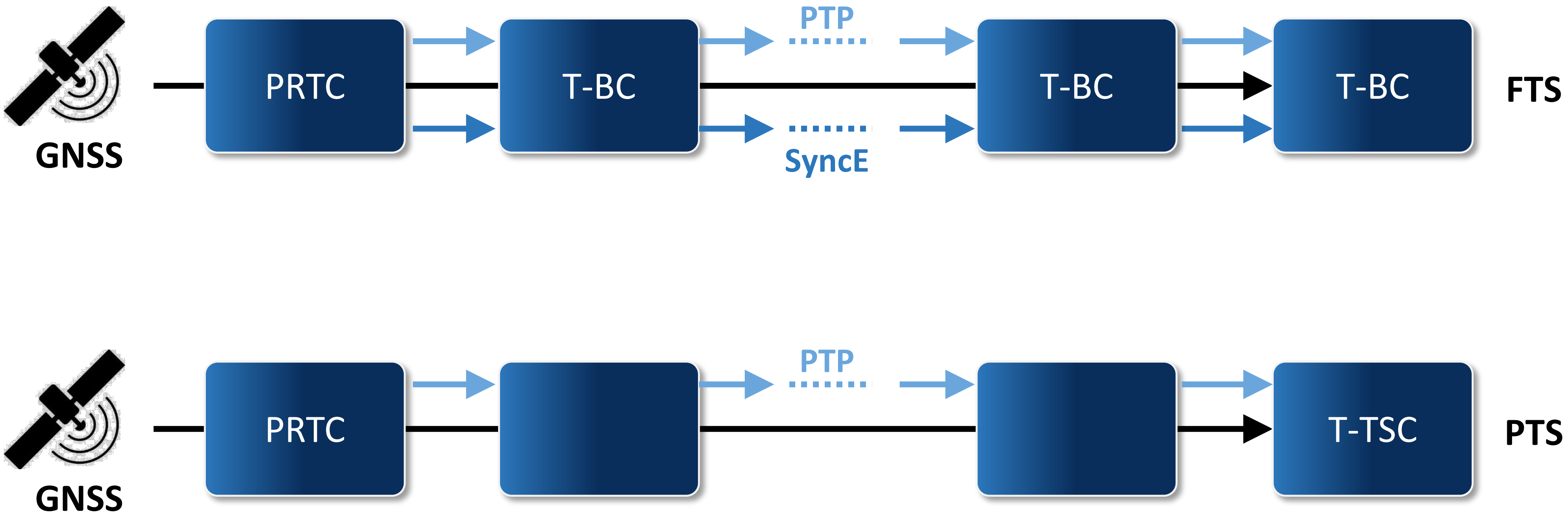
ITU Synchronization Reference Model



FA and TAE Requirements in 5G Wireless Networks

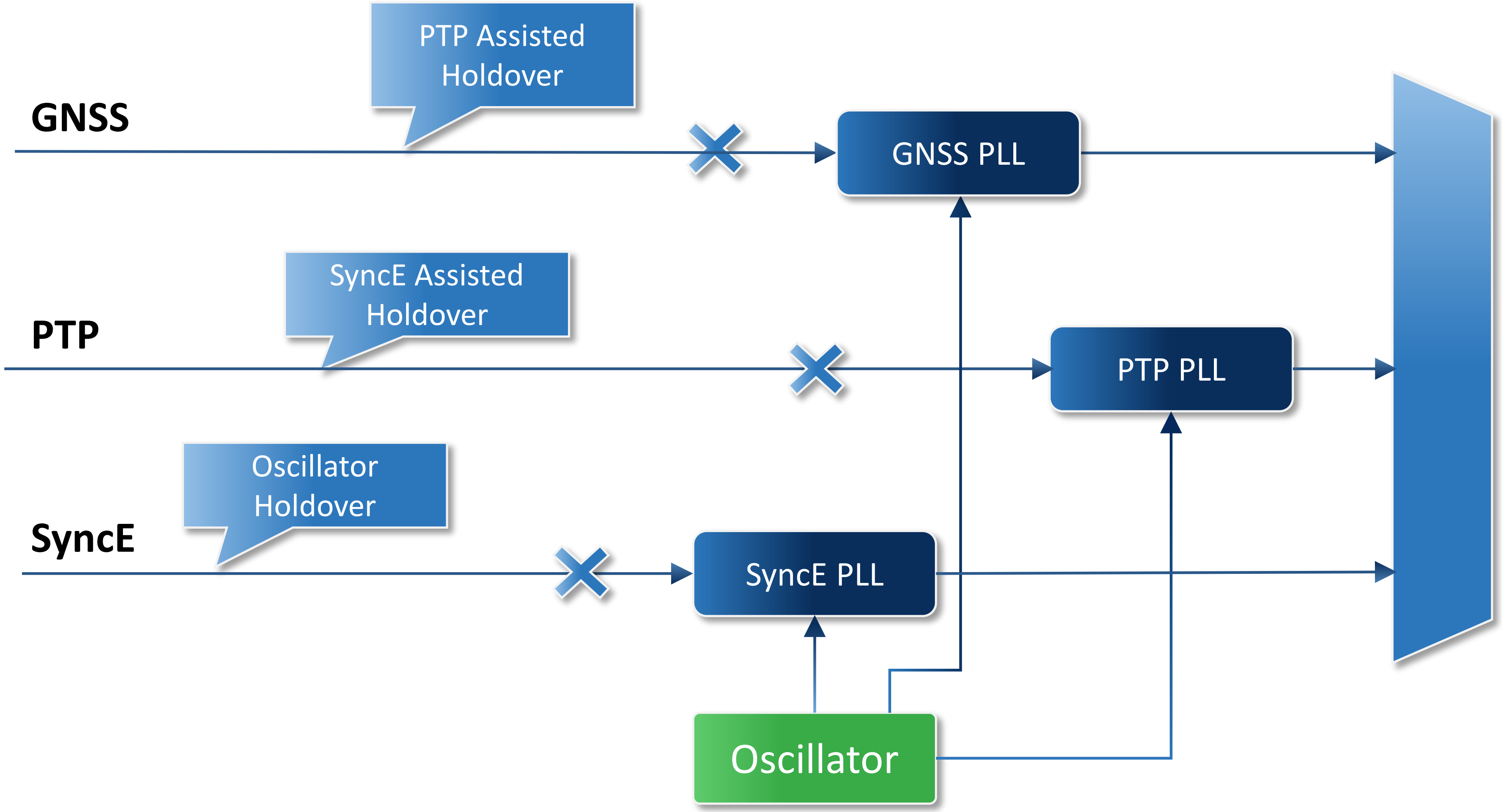


Timing Support Network



Holdover Scenarios

in Assisted Partial Timing Support (APTS) Clock



Overview of Methods for Holdover

Acknowledgement to Renesas Ottawa team for their contribution on this slide

Using a free-run oscillator

- SyncE frequency support for PTP
  - Assumes that the long term frequency offset of the SyncE reference is 0 ppm which can be confirmed via ESMC (SyncE quality levels)
- APTS with PTP connection modelling
  - Using GPS as the primary source of timing of the system
  - When GPS is available, characterizing the asymmetry in the PTP connection to use this when GPS is lost

Adding oscillator compensation

- OCXO/TCXO Learning for Long-Term Time Holdover
- Smart-OCXO Compensation for Long-Term Time Holdover

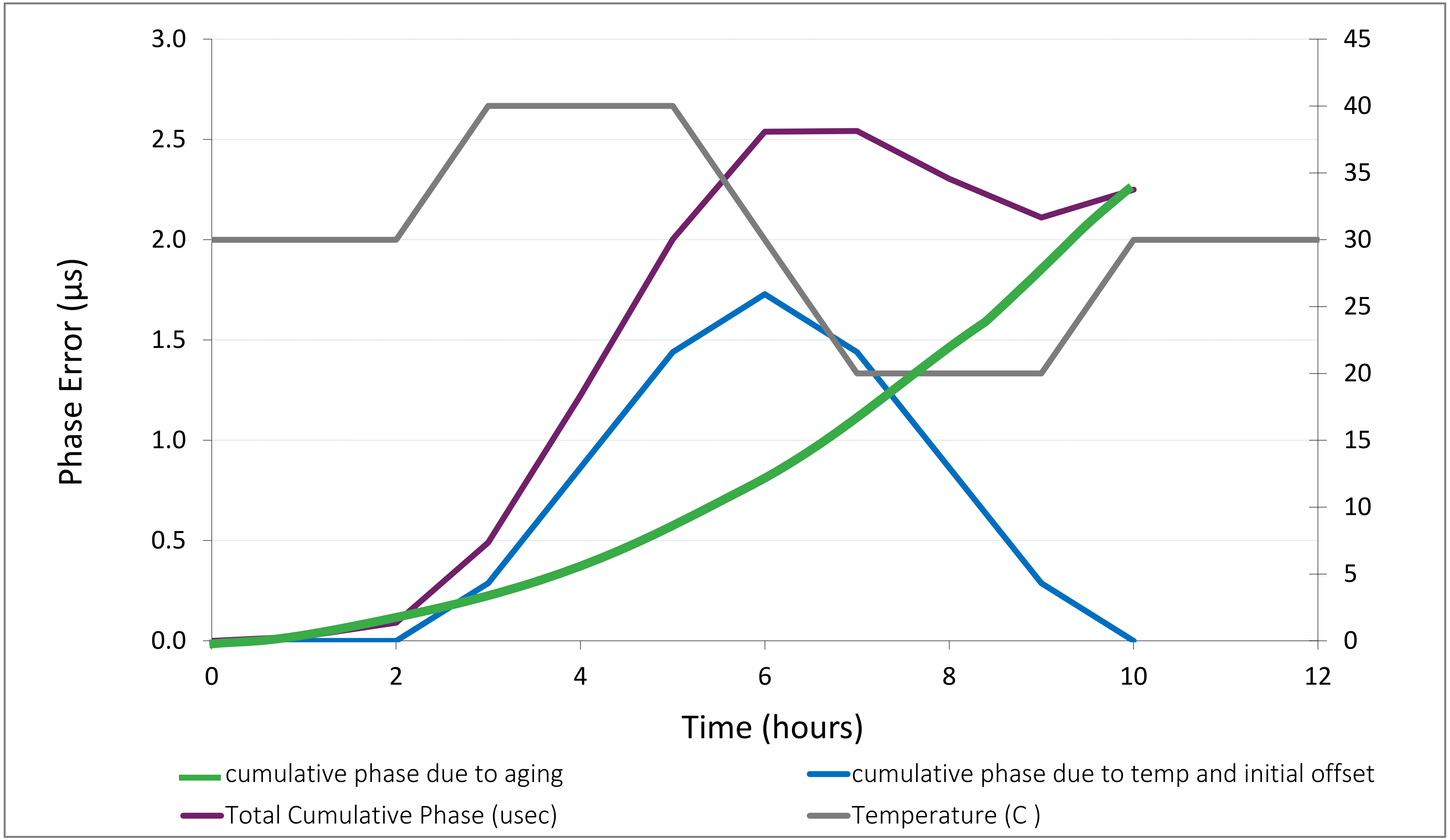
Model for Oscillator Holdover Performances

Phase Holdover at Time (t)

$$x(t) = x_0 + (f_0 + \Delta f_{env} + \Delta f_{RW})t + \frac{1}{2}\Delta f_{aging}\, t^2$$

- $\mathbf{x_o}$ = Initial phase offset
- $\mathbf{f_o}$ = The initial fractional frequency offset (ppb)
- $\mathbf{\Delta f_{env}}$ = Sum total of the changes in frequency (ppb) due to environmental factors (including temperature, input voltage, output loading, pressure, humidity, acceleration etc.)
- $\mathbf{\Delta f_{RW}}$ = Random frequency noise of oscillator
- $\Delta\mathbf{f_{aging}}$ = The long term change in frequency over time (ppb/day)

Holdover Performance with Oscillators



Implementation Considerations

- Compensation with the two key factors

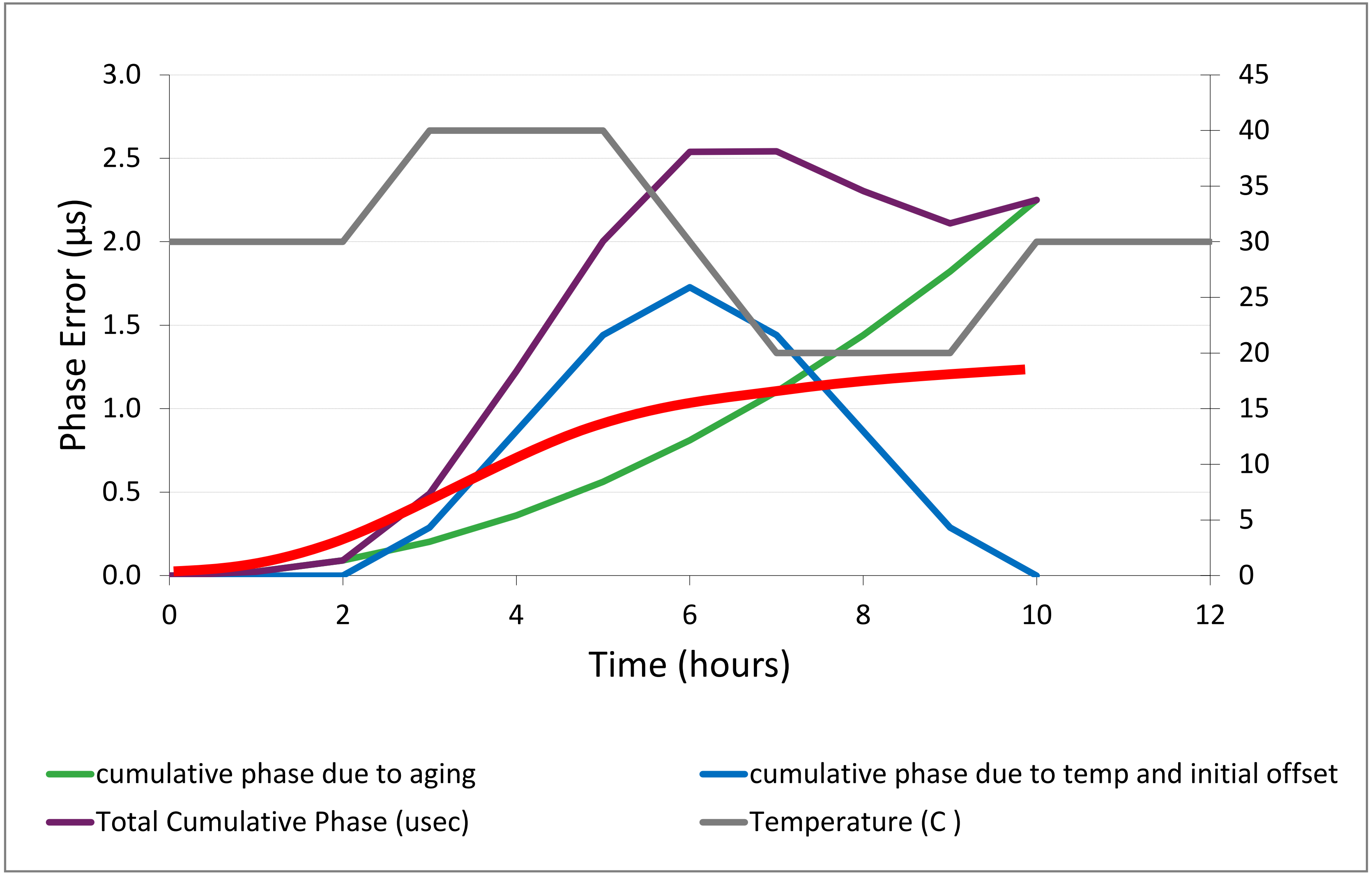
Temperature effect

Is linear: $\Delta f_{temp}\ t$

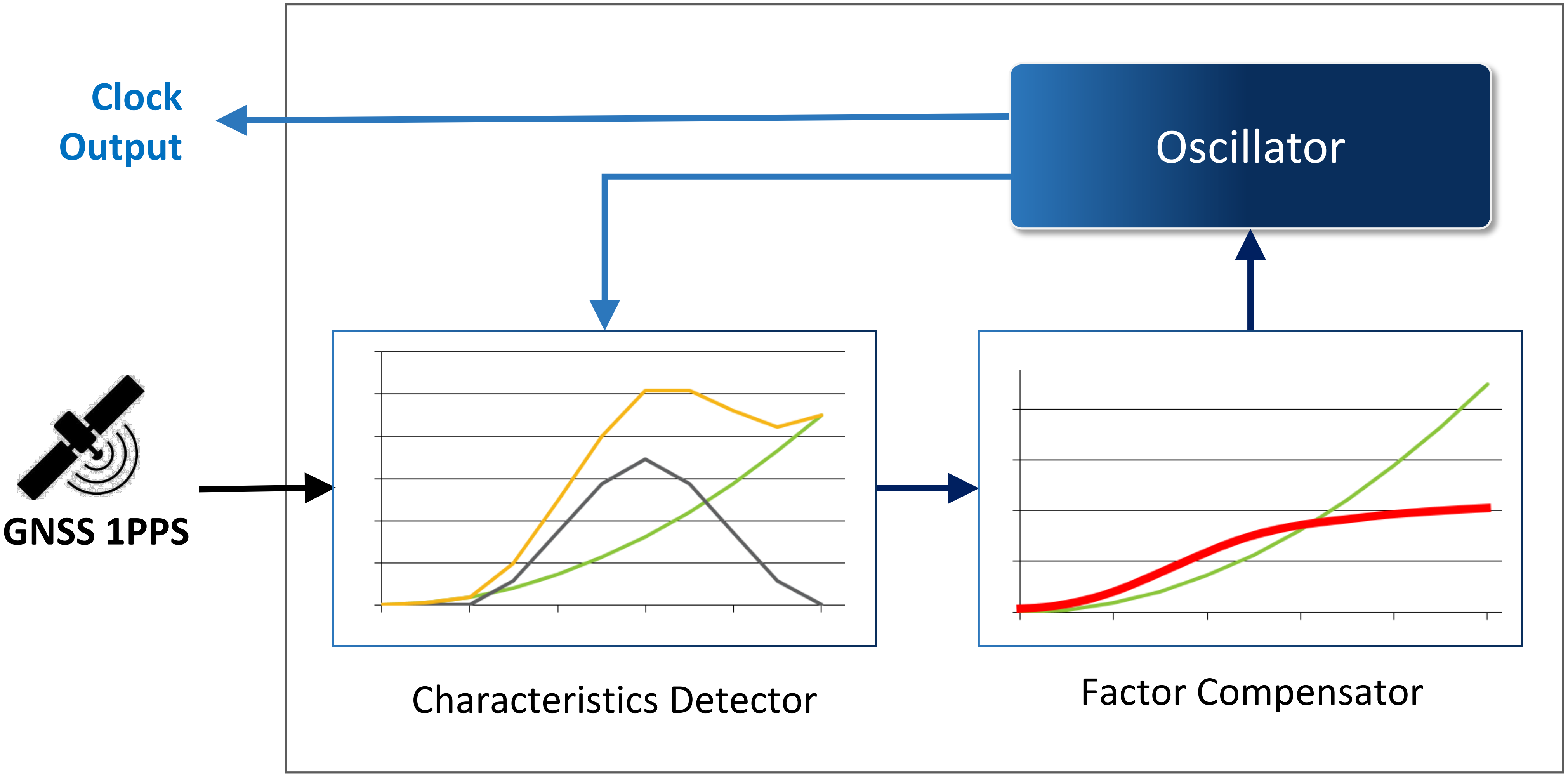
Aging effect

Is squared : $\frac{1}{2}\Delta f_{aging}\ t^2$

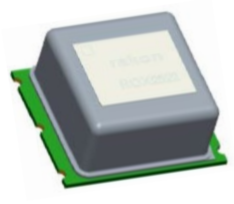
- Maintain the Cumulative Phase within 1.5 µs

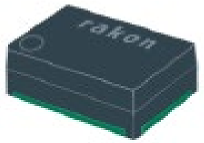


Holdover Implementation in Oscillator



Oscillators Product with Holdover



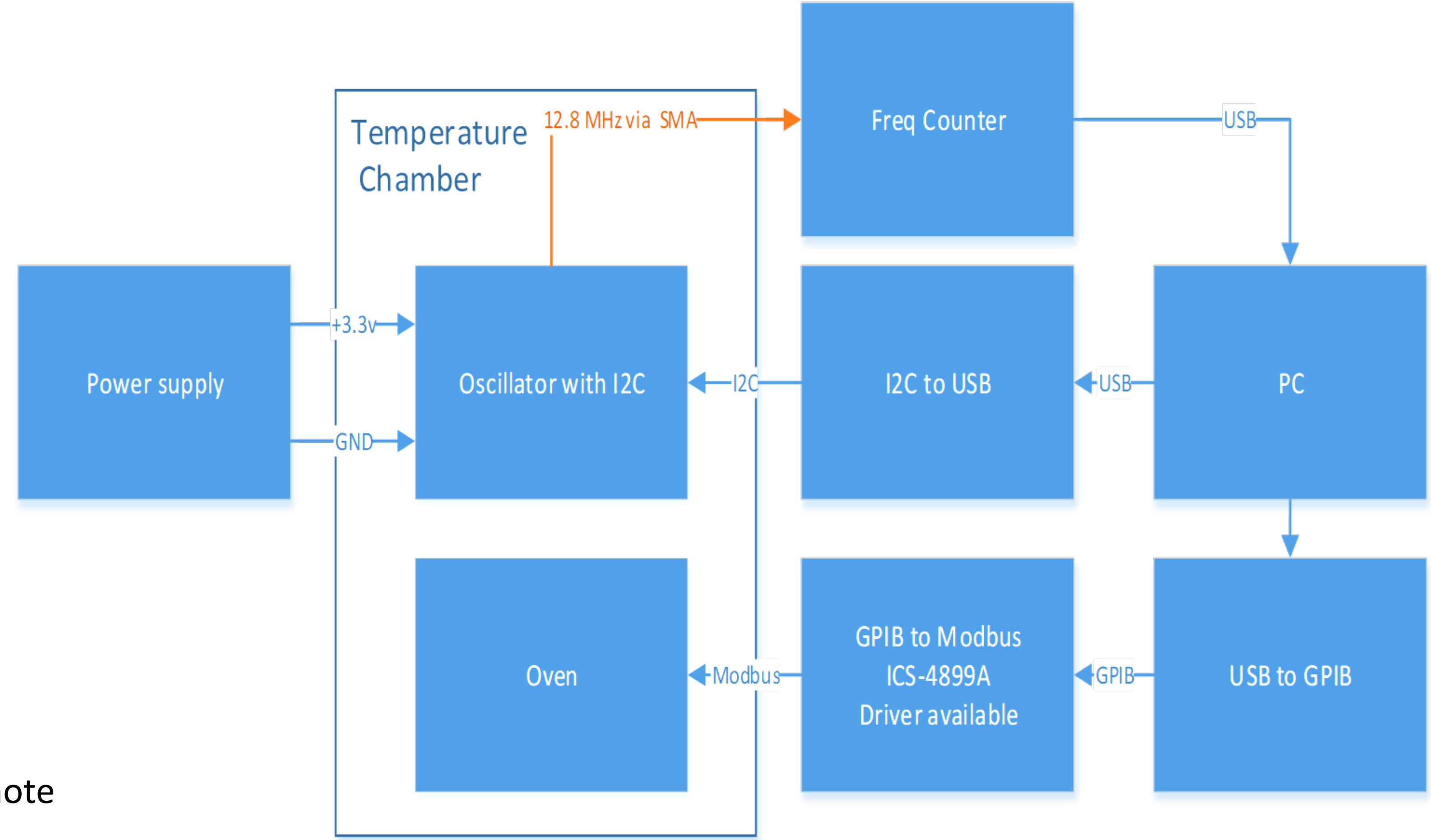


Oscillator Type	Smart OCXO	OCXO	OCXO	OCXO
Form Factor	25 x 22 mm	14 x 9 mm	14 x 9 mm	14 x 9 mm
Holdover	24 hours	~8 hours	~5 hours	~5 hours
Aging	0.2 ppb/day	10.3 ppb/day	0.5 ppb/day	1 ppb/day
Temperature Sensitivity	0.5 ppb	0.75 ppb	2 ppb	3 ppb

Smart OCXO example – Lab test

Acknowledgement to Renesas Ottawa's contribution on the lab test designs and sharing the results

- Retrieve the frequency variation model coefficients from the OCXO
- Configure a temperature chamber with a standard ramp from 25 to 85°C to -40 to 25°C with maximum change of 1°C/min
- During the temperature ramp
- Monitor the internal temperature of the OCXO and the output frequency
- Calculate the frequency adjustment based on the model provided by the manufacturer
- Estimate phase holdover performance from fractional frequency offset



For more information see the Renesas App note

"ClockMatrix Oscillator Compensation"

https://www.renesas.com/us/en/document/apn/clockmatrix-oscillator-compensation

www.rakon.com