Document:
Requirements Document for OCP-TAP Oscillator Classes

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Executive Summary

The Open Compute Project Foundation (OCP) was initiated in 2011 with a mission to apply the benefits of open source and open collaboration to hardware and rapidly increase the pace of innovation in, near and around the data center [1]. The OCP Time Appliances Project (TAP) is a special interest group for precision time synchronization in data centers whose vision is to share knowledge and create open-source specifications and reference designs for timing appliances [2]. To that end, this document specifies hardware requirements for different classes of oscillators used to implement time synchronization via IEEE 1588 Precision Time Protocol (PTP) [3] in the data center.

Revision History

Table 1. Revisions

Revision	Date	Description
0.1	August 24, 2021	Document created
0.11	September 9, 2021	Modified section 1
0.12	January 5, 2022	Change holdover from 1.5 us to 1.4 us to agree with OCP-TAP profile
0.13	January 6, 2022	Changed document name page 1, and minor grammatical changes.

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Introduction

Implementors needing to select oscillators for synchronizing networks in data centers face several challenges. Synchronization is a system-level requirement that is unclear how to satisfy by directly reading an oscillator datasheet. Differences in test methodologies between oscillator vendors can also complicate comparing products. For these reasons it can be difficult and time consuming to select oscillators, leading to inconsistent and unpredictable PTP performance in the network. This document specifies classes of oscillators for common data center use cases to make it easier and faster to compare and select oscillators with high confidence to achieve a given level of PTP performance.

1 Requirements for Class G1 Oscillator, Normative

Table 1. Standard data-center environment without synchronous Ethernet, see use case GM-A

Parameter	Symbol	Requirement
Ambient temperature (pick 1)	T_a1	-10°C to 70°C
	T_a2	0°C to 45°C
g-sensitivity	F_g	< 0.5 ppb/g
Frequency stability over temperature	F_stab	≤ ±0.5 ppb[1]
Frequency stability over temperature slope	dF/dT	≤ ±7 ppt/°C[2]
Allan deviation, Tau=100s	ADEV	≤9e-12
Daily aging	F_1d	≤ ±0.035 ppb/day[3]
Training time before entering holdover	t_h	< 12 hours
24-hour holdover	F_hold_24h	≤ ±1.4 µs in 24 hr[4]
1 hour holdover	F_hold_1h	≤ ±250 ns in 1 hr[4]
Jitter	J_pp	≤ 1 ns peak-peak[5]
Additional design requirements	ADR	List manufacturer recommendations[6]

[1] Measured with a linear continuous ramp of 1 °C/min. Daily aging is removed from the data before calculating frequency stability over temperature.

[2] A polynomial fit is recommended to remove high-frequency noise.

[3] Measured after compensating output frequency for aging, and within ±2.8°C over the full ambient temperature range.

[4] Measured with temperature profile provided in GM-A and starting temperatures of 5°C, 35°C and 55°C. See holdover test requirements document (TBD) for further details.

[5] Jitter is measured per ITU-T G.811.1 [4] for a 10 MHz output interface through a single pole band-pass filter with corner frequencies at 20 Hz and 100 kHz.

[6] When documenting compliance, oscillator manufacturers must list any additional test conditions or design requirements not specified herein and recommended by the manufacturer during operation that can significantly impact performance. This enables a customer to obtain the same performance as the manufacturer when compliance testing in the customer lab. For example, a manufacturer must document whether a part must be covered, if mechanical relief must be added to the mounting environment to reduce stress, airflow conditions, and any other design restrictions or test conditions that existed during the manufacturer's compliance testing for customers to achieve similar performance in their labs.

2 Conclusion

This document defines several classes of oscillators that enable time synchronization in the data center. Device and test specific requirements, where important, are also provided for each class of oscillator.

3 References

1. Refer to the OCP home page at https://opencompute.org
2. Refer to the OPC-TAP wiki page at https://www.opencompute.org/wiki/Time_Appliances_Project
3. IEEE 1588-2019 - IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems, https://standards.ieee.org/standard/1588-2019.html
4. ITU-T G.811.1, "Timing characteristics of enhanced primary reference clocks," August 2017.

4 License

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5 About Open Compute Foundation

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6 Appendix A. Example Use Cases

This appendix is not a requirement, but rather inspiration for developing the above requirements for oscillator class G1.

Table 2. Use case “GM-A” for a time card in an open Grandmaster for standard data center environment without synchronous Ethernet

Parameter	Requirement
Reference model	https://github.com/opencomputeproject/Time-Appliance-Project/tree/master/DC-Profile
Estimated volume per data center	10 units
Expected lifetime	10 years
Ambient temperature range	0°C to 45°C[7]
Temperature profile	1°C/min, soaking ramp any +/- 20°C window over full temp range (start at middle and soak, ramp to high and soak, ramp to middle and soak, ramp to low and soak, ramp to middle and repeat)
Airflow profile	Variable depending on traffic; typically, 10 to 200 cfm[6]
Relative humidity	10% to 85% noncondensing
Vibration	Per IEC78-2-(*), IEC721-3-(*) standards and levels (for transportation and handling and use in damp heat), with the following test requirements:[8] - Operation: 0.5g acceleration, 1.5mm amplitude, 5 to 500 Hz, 10 sweeps at 1 octave / minute per each of the three axes (one sweep is 5 to 500 to 5 Hz). - Non-Operating: 1g acceleration, 3mm amplitude, 5 to 500 Hz, 10 sweeps at 1 octave / minute per each of the three axes (one sweep is 5 to 500 to 5 Hz).
Shock	Per IEC78-2-(*), IEC721-3-(*) standards and levels (for transportation and handling and use in damp heat), with the following test requirements:[7]

[7] From OCP Minipack section 14.3 at https://www.opencompute.org/documents/minipack-ocp-specification-rev1-0-02102019-pdf

[8] Per OCP Tioga Pass server spec: https://www.opencompute.org/documents/facebook-2s-server-tioga-pass-specification, where operating means no electrical discontinuities during operation, and non-operating means no physical damage or limitation in functional capability shall occur during test.

	- Operating: 6g, half-sine 11ms, 5 shocks per each of the three axes - Non-operating: 12g, half-sine 11ms, 10 shocks per each of the three axes
Clock accuracy (absolute, locked to GPS)	250 ns, 100 ns, 25 ns[9]
Equipment clock accuracy	5 µs, 1 us, 100 ns - depending on application
Holdover	Equipment is fixed within 24 hrs. Stay within 1.5 µs in 24 hrs and 250 ns within 1 hr. Measured within +/-2.8C (per GR-1244) over operating temperature range.
Jitter	As specified in ITU-T G.811 for 10 MHz interface

[9] IEEE 1588 clock accuracy; time is accurate to within 100 ns, 25 ns, 10 ns (0x1F) via clock accuracy variance. In IEEE 1588 there's a PTPVAR calculated from TDEV (ITU converts TDEV to PTPVAR).

1 Appendix G. Acknowledgements

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