OSCILLOQUARTZ
An ADVA Optical Networking Company

Holdover Autonomy of Timing Supply Generators and BITS Clocks

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Application Note

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Precision, Stability, Innovation, Support

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1 Introduction

Synchronization is a critical function for any telecommunications network. A failure of the synchronization supply can have severe consequences. Therefore synchronization networks must survive those failure conditions that may occur with a non-negligible probability. There are several means, by which the robustness of synchronization supply can be improved:

- Multiple Primary Reference Sources (PRS) and multiple synchronization routes from the PRS to sites and equipment; these routes should be geographically independent, so that link failures affect only one of the synchronization links, leaving secondary links intact.
- The capability of clocks to autonomously generate a sufficiently accurate synchronization signal when all incoming synchronization links have failed. This is called the holdover mode. Timing Supply Generators (TSG) are designed to provide highly accurate holdover synchronization which guarantees normal or nearly normal operation of the network for some time.

This Application Note deals with the following question: "For how long may a TSG stay in holdover mode while guaranteeing normal operation of equipment and systems it synchronizes?" The answer to this question gives important indications on how fast synchronization failures should be repaired.

2 Network Performance

The performance of a synchronization network is usually expressed as a wander level measured at specific synchronization interfaces in the network. Synchronization interface performance is specified in ANSI T1.101, chapter 7. ANSI T1.101 specifies different wander limits for two different reference interface types, i.e. for DS-1 and OC-N reference interfaces. Figure 1 shows the MTIE limits for normal operating conditions. The figure shows that the MTIE limits for the two interface types are equal for observation times above 280 seconds. ANSI T1.101 also specifies TVEV limits. And there are different specifications for normal operating conditions and degraded operating conditions. However, it is the MTIE limit for normal operating conditions which is used for calculating the so-called Holdover Autonomy.

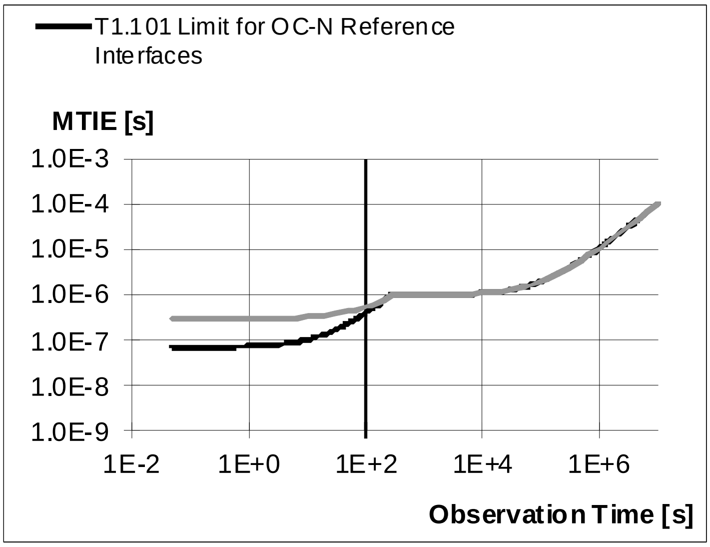

Figure 1: MTIE limits for DS-1 and OC-N reference interfaces under normal operating conditions

3 Definition: PRS Holdover Autonomy

Normally a TSG is locked to an input reference signal. If all input reference signals fail, the TSG enters holdover mode. In this operating mode the TSG's internal oscillator becomes the autonomous reference source. Oscillators used in TSGs are usually either quartz crystal oscillators or Rubidium oscillators. Their output frequency changes with time and is dependent on environmental temperature. As long as the resulting wander stays below the limits of Figure 1, the synchronized equipment and systems continue to operate normally. The interesting question is: "For what maximum holdover period is this the case?" This time period is called the 'PRS Holdover Autonomy Period'. Since the holdover performance of an oscillator depends on temperature conditions, the PRS Holdover Autonomy Period does also.

4 Holdover Autonomy of Oscilloquartz Products

The purpose of this Application Note is to describe the Holdover Autonomy of Oscilloquartz products under all kinds of temperature conditions. Figure 2 to 6 illustrate how Holdover Autonomy is derived from the MTIE limits and from the holdover performance of two oscillator types commonly used in Oscilloquartz products. The Rb RMO is a rubidium oscillator used in Stratum 2 TSGs. Figure 2 to 6 show the holdover behavior (expressed as an MTIE curve) of the two oscillators for different temperature conditions. Figure 2 is for constant temperature. The other 4 figures assume that temperature has changed by 2, 5, 10 or 20 °C since the instant in time when the TSG entered holdover mode[1]. The PRS Holdover Autonomy Period is equal to the Observation Time (horizontal axis) where the holdover curve crosses the T1.101 limit. In all five figures, the intersection occurs within that Observation Time range where the two limits for DS-1 and OC-N reference interfaces are equal. Hence the PRS Holdover Autonomy Period is the same for both reference interface types.

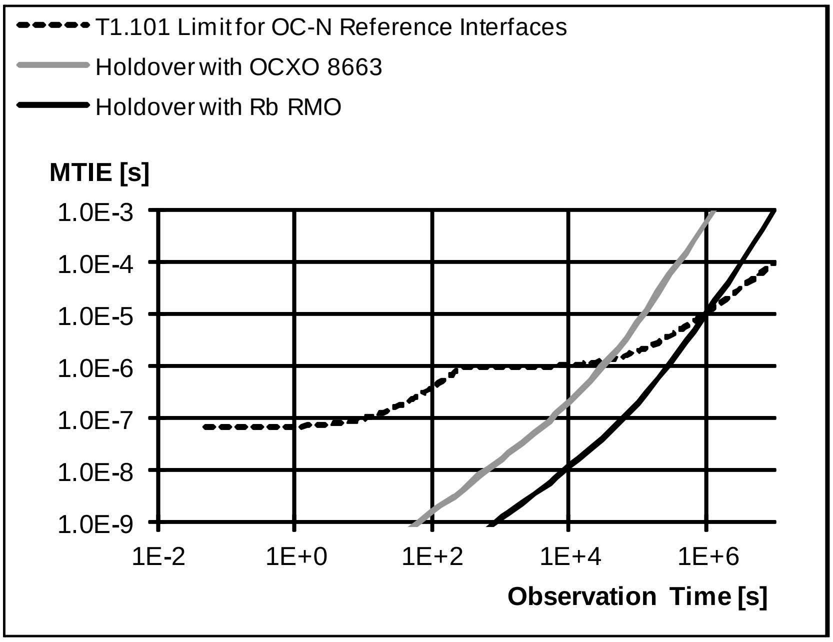

Figure 2: Holdover performance under constant temperature conditions

[1] For simplicity the calculations assume an abrupt temperature change occurring immediately after entry into holdover; this theoretical case is more severe than any other realistic scenario.

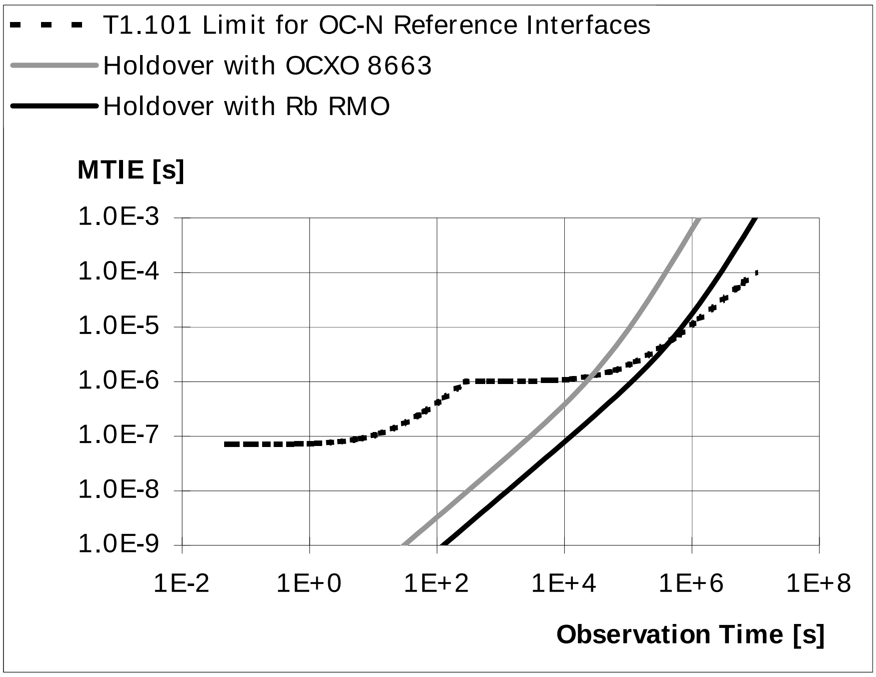

Figure 3: Holdover performance with 2 °C temperature variation

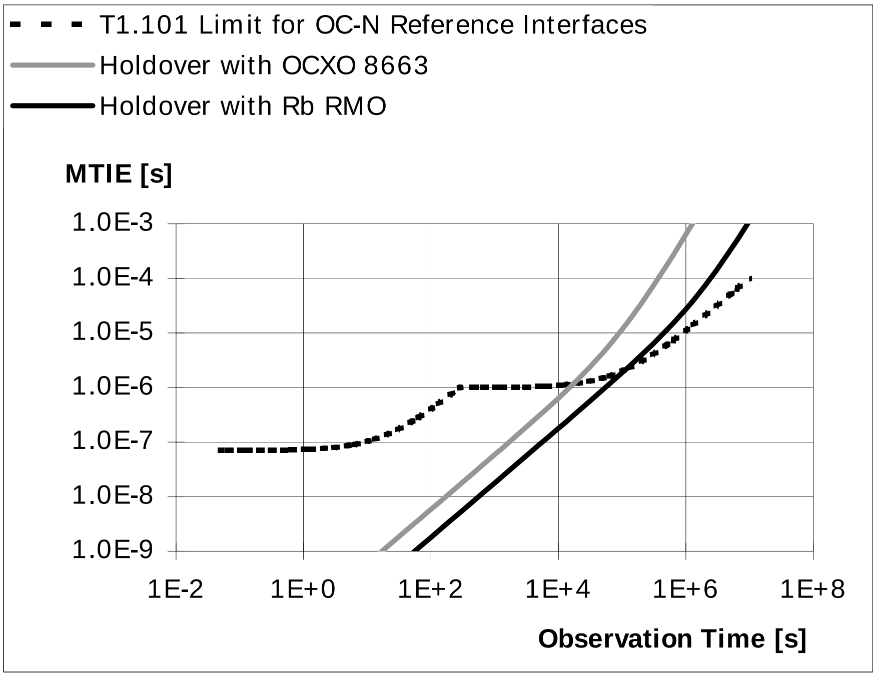

Figure 4: Holdover performance with 5 °C temperature variation

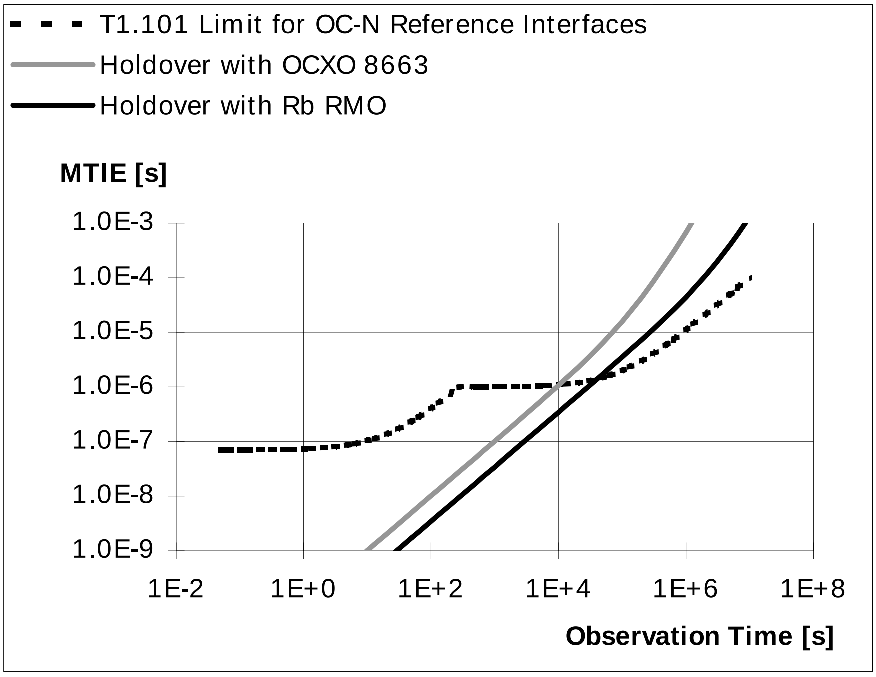

Figure 5: Holdover performance with 10 °C temperature variation

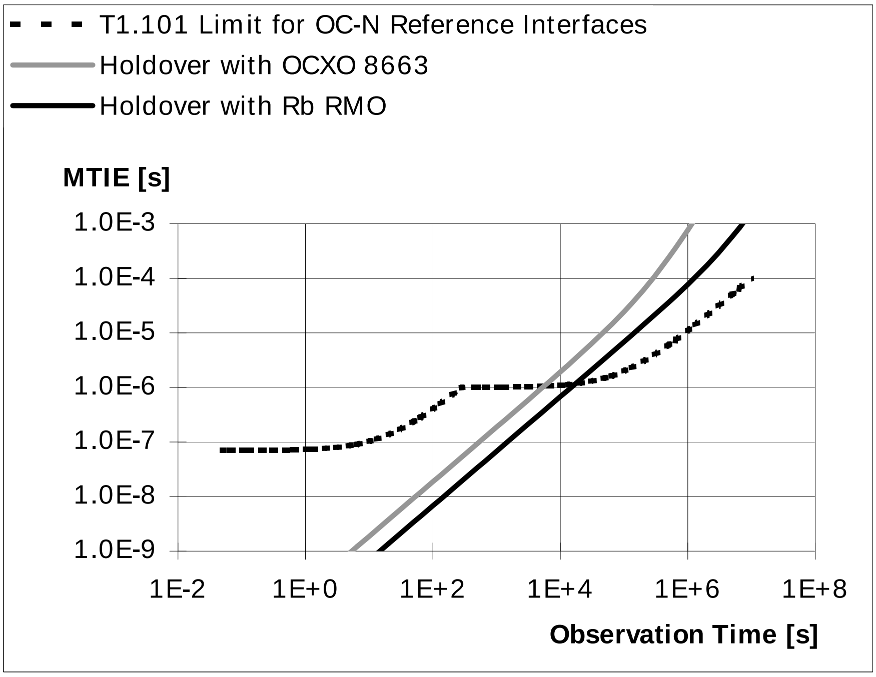

Figure 6: Holdover performance with 20 °C temperature variation

In is important to note that the holdover curves depicted in the figures are calculated from the manufacturer's guaranteed holdover performance specifications[1]. Measured holdover performance is always better than the specified performance. It follows, that the Holdover Autonomy values derived from the figures are not just typical, but implicitly guaranteed[2] values. Table 1 gives a summary of the PRS Holdover Autonomy Periods. When comparing with values published elsewhere, one should remember that typical Holdover Autonomy Periods can be 100 % to 200 % better than the calculated values of Table 1.

Table 1: Guaranteed PRS Holdover Autonomy Periods for oscillators used in Oscilloquartz products, as a function of the magnitude of temperature variations[3]

Oscillator type	OCXO 8663	Rb RMO
Const. temp.	12 hours	12 days
2 °C	7.5 hours	5.3 days
5 °C	5 hours	1.4 days
10 °C	2.8 hours	11 hours
20 °C	1.6 hours	4.7 hours

5 Oscilloquartz Products

The oscillators OCXO 8663 and Rb RMO are used in many Oscilloquartz synchronization products. Table 2 shows which oscillators are available in which product.

Table 2: Oscilloquartz product types containing the OCXO 8663 and Rb RMO oscillators

Oscillator product	OCXO 8663	Rb RMO
OSA 5548B SASE	X	X
OSA 5581C GPS-SR	X	X
OSA 5240 GPS	X	X
OSA 453x GPS	X	

[1] Assumption: before entering holdover mode, the TSG was locked for at least 8 hours to a reference which is itself within T1.101 performance limits for DS-1 interfaces

[2] Under the above assumptions

[3] For simplicity the calculations assume an abrupt temperature change occurring immediately after entry into holdover; this theoretical case is more severe than any other realistic scenario.

6 Conclusion

The PRS Holdover Autonomy Periods given in this Application Note are important for the design and for the operation & maintenance of any synchronization network. During the design phase Holdover Autonomy is a crucial factor for deciding where to deploy what kind of TSG or BITS clock. Visibly Stratum 2 clocks provide the best holdover protection. They should be installed in sites where the amount of traffic affected by synchronization link failures is high, or where repair times are long (e.g. remote sites), or where there is only one incoming synchronization reference available. On the other hand, knowing the Holdover Autonomy helps in planning operation & maintenance procedures which best fit the autonomy provided by the deployed TSGs or BITS clocks.

7 Bibliography

[1] ANSI; *T1.101-1999, American National Standard for Telecommunications - Synchronization Interface Standard*; Washington D.C.; 1999.

[2] St. Bregni; *Synchronization of Digital Telecommunications Networks*; John Wiley & Sons, Chichester; 2002.

8 Abbreviations

Table 3: Abbreviations used in this Application Note

ANSI	American National Standards institute
BITS	Building Integrated Timing Supply
DS-1	Digital Signal level 1
OC-N	Optical Carrier level n
OCXO	Oven Crystal Quartz Oscillator
Rib	Rubidium
SSU	Synchronization Supply Unit
TSG	Timing Supply Generator