Application Note

Number 18/2005 Created: January 4, 2005

Holdover Autonomy of Synchronization Supply Units (SSU)

Oscilloquartz S.A., CH-2002 Neuchâtel 2, Switzerland,
Tel. +41 32 722 5555, Fax +41 32 722 5556, e-mail: osa@oscilloquartz.com

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 Clocks (PRC) and multiple synchronization routes from the PRC 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. Synchronization Supply Units (SSU) and Stand-alone Synchronization Equipment (SASE) 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 an SSU or SASE 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 in terms of frequency accuracy, jitter level and wander level measured at specific synchronization interfaces in the network. Synchronization interface performance is specified in ITU-T Rec. G.823, chapter 6, and in ETSI EN 300 462-3, chapter 7. Both the ITU-T and the ETSI documents contain exactly the same specifications. They specifiy different jitter and wander limits for four different synchronization interface types. The four interface types are 1) PRC output, 2) SSU output, 3) SEC output, and 4) PDH synchronization output. There are Network Limit specifications for jitter and for wander. The wander specifications are expressed in MTIE and in TDEV. As will be shown later, the calculation of the holdover autonomy of an SSU is based on the MTIE Network Limit for SSU output interfaces. This Network Limit is shown in Figure 1.

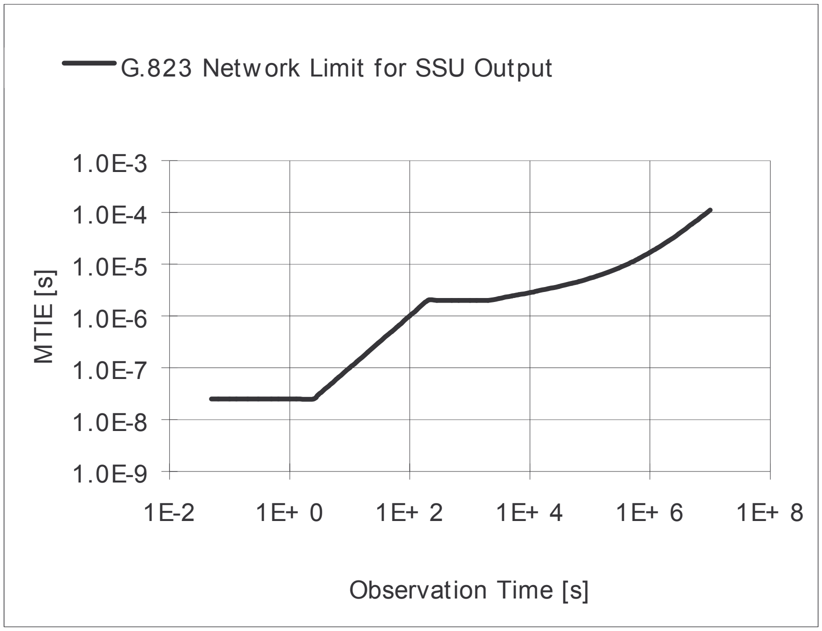

Figure 1: MTIE limits for DS-1 and OC-N reference interfaces under normal operating conditions

3 Definition: PRC Holdover Autonomy

Normally an SSU is locked to an input reference signal. If all input reference signals fail, the SSU enters holdover mode. In this operating mode the SSU's internal oscillator becomes the autonomous reference source. Oscillators used in SSUs 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 'PRC Holdover Autonomy Period'. This definition stemms from ITU-T Recommendation G.803, section III.6. Since the holdover performance of an oscillator depends on temperature conditions, the PRC 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 Network Limits and from the holdover performance of three oscillator types commonly used in Oscilloquartz products. The OCXO 8663 is a quartz crystal oscillator used mainly in SSU Type I applications (see ITU-T Rec. G.812). The BVA 8600 is a high-end electrode-less quartz crystal oscillator, whereas the Rb RMO is a rubidium oscillator. Both the BVA 8600 and the Rb RMO are mainly used mainly in SSU Type II applications (see ITU-T Rec. 812). Figures 2 to 6 show the holdover behaviour (expressed as an MTIE curve) of the three 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 SSU entered holdover mode[1]. The PRC Holdover Autonomy Period is equal to the Observation Time (horizontal axis) where the holdover curve crosses the G.823 Network Limit.

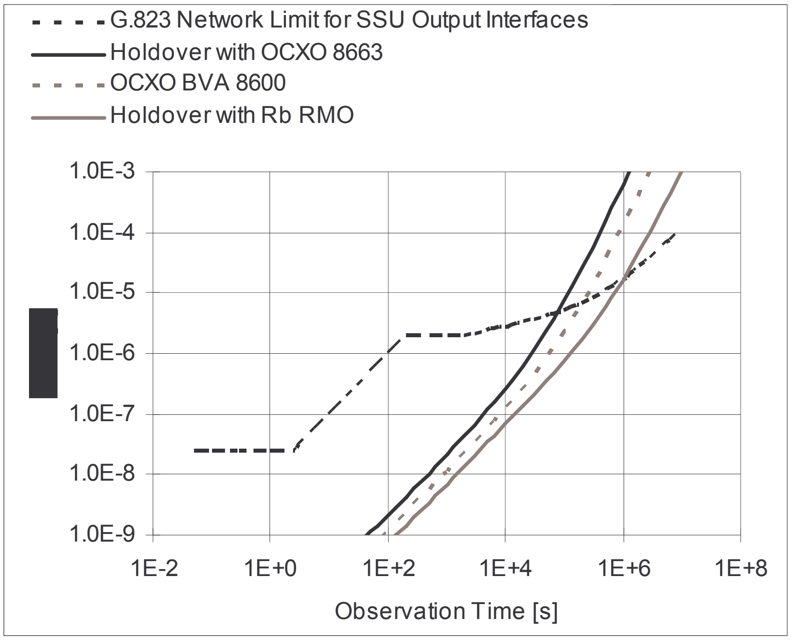

Figure 2: Holdover performance under constant temperature conditions

---

[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.

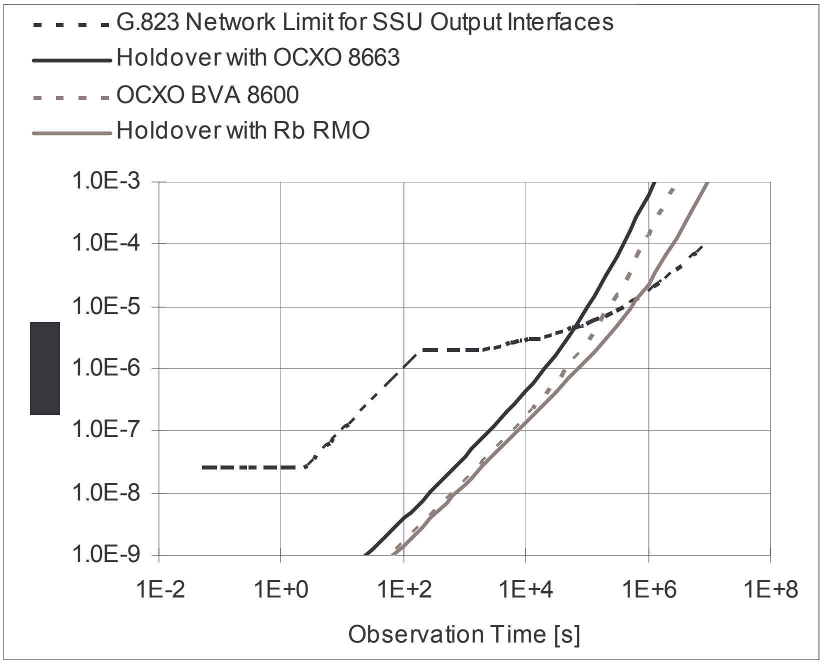

Figure 3: Holdover performance with 2 °C temperature variation

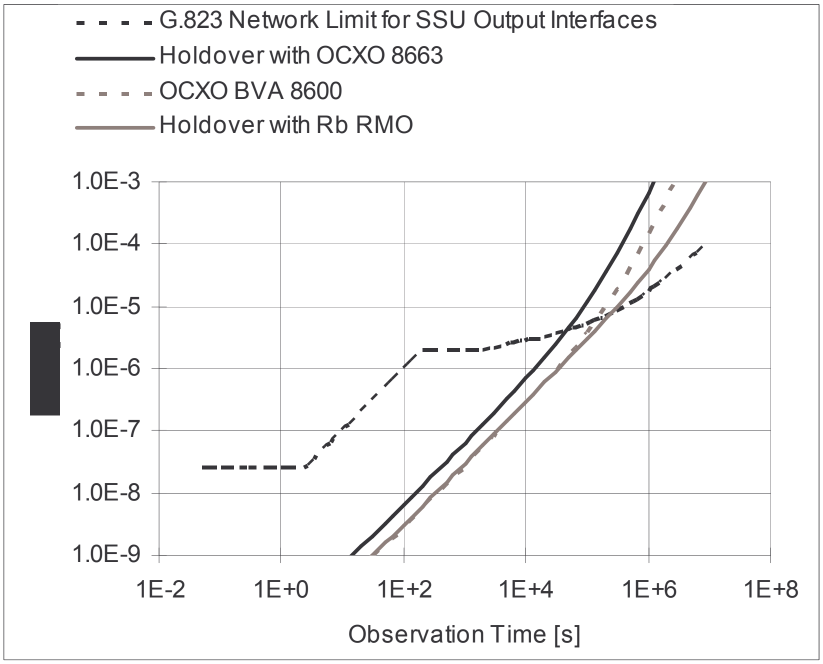

Figure 4: Holdover performance with 5 °C temperature variation

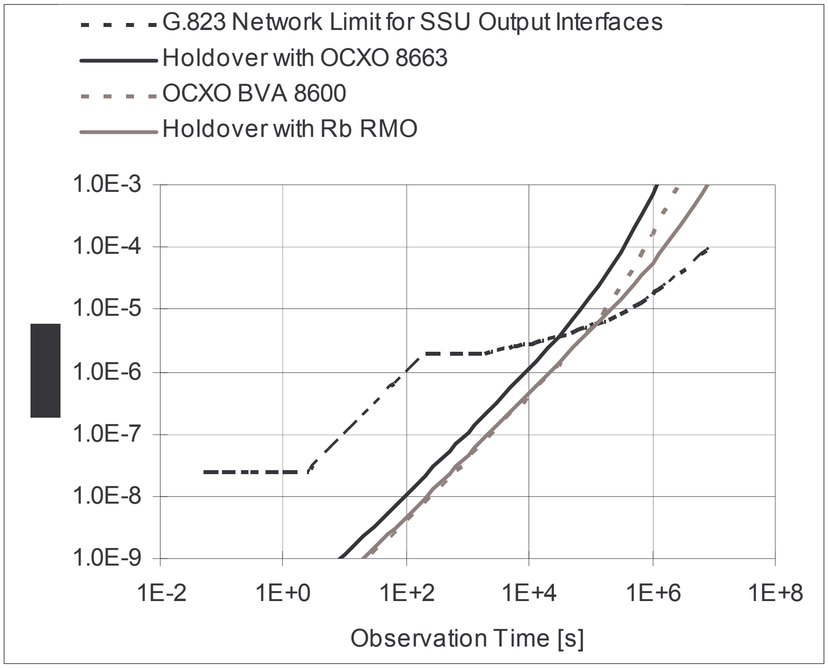

Figure 5: Holdover performance with 10 °C temperature variation

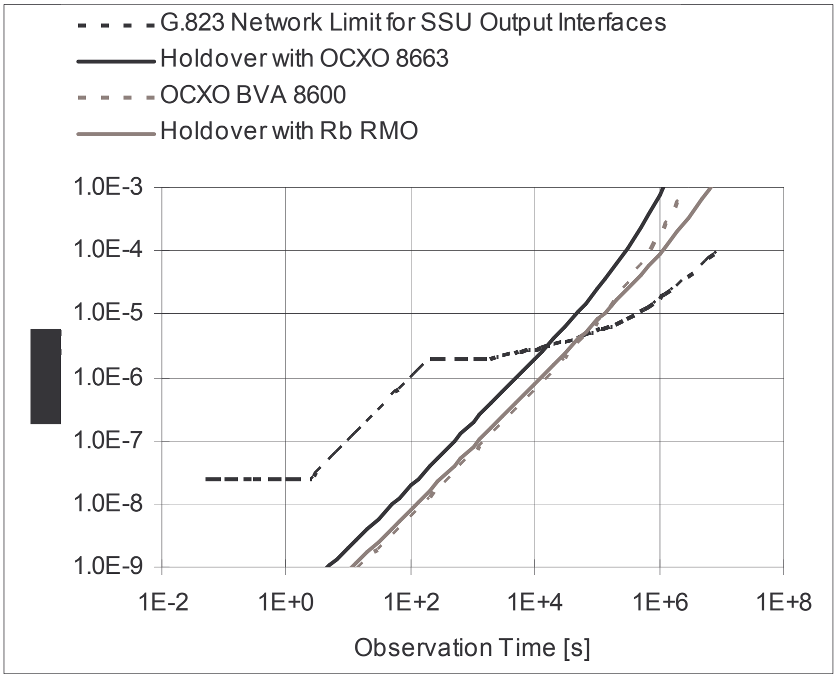

Figure 6: Holdover performance with 20 °C temperature variation

It 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 PRC 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 PRC Holdover Autonomy Periods for oscillators used in Oscilloquartz products, as a function of the magnitude of temperature variations[3]

Oscillator type	OCXO 8663	BVA 8600	Rb RMO
Const. temp.	21 hours	51 hours	9 days
2 °C	17 hours	46 hours	5.5 days
5 °C	13 hours	39 hours	2.8 days
10 °C	8.3 hours	31 hours	33 hours
20 °C	4.4 hours	19 hours	15 hours

5 Oscilloquartz Products

The oscillators OCXO 8663, BVA 8600 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, BVA 8600 and Rb RMO oscillators

Oscillatoquartz product	OCXO 8663	BVA 8600	Rb RMO
OSA 5548B SASE	X[4]	X	X
OSA 5581C GPS-SR	X		X
OSA 5240 GPS	X		X
OSA 5230 GPS	X	X	X
OSA 453x GPS	X		

6 Conclusion

The PRC 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

---

[1] Assumption: before entering holdover mode, the SSU was locked for at least 12 hours to a reference which is itself within G.823 Network Limits for SEC or PDH synchronization 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.

[4] Actually OCXO 8665G, a variation of the OCXO 8663

Autonomy is a crucial factor for deciding where to deploy what type of SSU. Visibly Type II SSUs 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 SSUs.

7 Bibliography

[1] ITU-T; *Recommendation G.823, The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy*; Geneva; March 2000.

[2] ITU-T; *Recommendation G.803, Architecture of transport networks based on the synchronous digital hierarchy (SDH)*; Geneva; March 2000.

[3] ETSI; *EN 300 462-3-1, The control of jitter and wander within synchronization networks*; Sophia Antipolis; May 1998.

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

8 Abbreviations

Table 2: Abbreviations used in this Application Note

ETSI	European Telecommunications Standards Institute
ITU-T	International Telecommunication Union, Telecommunication Standardization Sector
MTIE	Maximum Time Interval Error
OCXO	Oven Crystal Quartz Oscillator
PDH	Plesiochronous Digital Hierarchy
PRC	Primary Reference Clock
Rb	Rubidium
SASE	Stand-alone Synchronization Equipment
SEC	SDH Equipment Clock
SDH	Synchronous Digital Hierarchy
SSU	Synchronization Supply Unit
TDEV	Time Deviation