WHITE PAPER

Rubidium Sync Holdover Ensures Mobile Service Availability

Abstract

This paper is designed to inform mobile network operators and their equipment suppliers of changes in synchronization requirements as networks advance through current and next generations of technology. In particular, it focuses on the need for superior holdover performance as sync specifications become more stringent and difficult to meet. Holdover allows continued service operation during an outage or impairment of the primary synchronization source. Typical crystal-based holdover solutions will provide a relatively short period for recovery of advanced services, while rubidium atomic clocks can meet the tight requirements of the new LTE-TDD base transceiver stations for 24 hours, and even longer for current generation 3G and 4G base stations.

Precise synchronization (sync) and timing are essential to mobile communications networks to ensure successful call signal handoff, proper transmission between base stations, transport of real-time services and compliance with radio frequency regulations. When timing or synchronization is lost, jitter and wander, packet loss and dropped frames can degrade Quality of Service (QoS) and have a negative impact on the end user experience. If individual base stations drift outside the specified frequencies, subscriber performance will be impacted by call interference, dropped calls and impaired data services. If telecommunications regulations such as E911 requirements are violated, the operator may incur additional expenses such as reporting outages and be subject to audits, in addition to possible fines and potential lawsuits.

Like all critical network functions, sync and timing solutions must be designed to perform even when there is a failure or outage of a primary network component. Holdover is the ability to keep the network sync-stabilized when the primary source of sync is disrupted or unavailable. In the event that timing or synchronization reference is lost, holdover helps protect revenue by ensuring continuous operation. Longer holdover periods enable more efficient operational response by increasing the amount of time the network can remain operational without requiring a truck roll. As cellular networks transition to 4G/LTE, rubidium atomic clocks provide the best performance solution for holdover, able to detect small errors in the primary sync signal before they begin to degrade the network. Base station equipment with an embedded rubidium atomic clock can maintain precise performance and support high QoS for longer periods than alternative holdover technologies.

Background

In traditional time division multiplex (TDM) digital telecommunications networks, sync was maintained by employing two types of synchronization elements, primary reference clocks (PRC), also known as a primary reference sources (PRS), and distribution clocks, to provide synchronization over a physical path. The PRC or PRS uses either a cesium oscillator or a global positioning system (GPS) to provide the reference signal for the synchronization of other clocks within the network. Sync distribution systems, called building integrated time supplies (BITS), synchronization supply units (SSU) or stand alone synchronization equipment (SASE), select one of the primary clock sources coming into a station as the active synchronization reference. Sync distribution systems provide synchronization outputs to all central office network elements. The reference signal is used to attenuate jitter and wander and maintain operation in holdover mode.

The transition from TDM to packet-based networks requires a change in the synchronization architecture as the TDM layer that inherently carried the sync signal is lost, and the sync signal is broken. Asynchronous Ethernet networks do not provide physical circuits between network elements. Consequently synchronization of base stations must be engineered into the packet backhaul using a packet timing technology such as IEEE 1588 (PTP) or provided by a GPS antenna and receiver at the cell site. In the event that timing or synchronization reference is lost, holdover becomes critical to ensure optimal network performance.

The Importance of Holdover

Regardless of the primary technology used to synchronize the packet-based network, rubidium technology can perform a critical function within the specified requirements of the base stations to support 4G/LTE services. To ensure continuous network operations, it is recommended that service providers deploy rubidium to ensure holdover for either a GPS or a PTP synched network.

In some base station deployments that are served by GPS receivers, where GPS signals are received only intermittently, such as inside buildings, underground and in downtown areas, holdover is crucial to the operation of base stations. Holdover technologies are also necessary to maintain sync during GPS outages caused by external events, such as in 2007 when the US Navy accidentally jammed GPS signals in the San Diego area. GPS is further compromised by criminals and vandals that can jam GPS signals with easily available GPS jammers, and environmental factors such as sun spots also contribute to GPS disruptions. The length of time any holdover technology can perform within the specification requirements of the base stations is critical. As any downtime affects customer satisfaction and some failures require a truck roll, having a full day or more rather than a few hours to recover has a significant effect on consumer quality of experience and on operational expenses.

Holdover Requirements and Technologies

Holdover is achieved by equipping cellular base transceiver stations (BTS) with oscillators or atomic clocks that temporarily holdover sync signals. Holdover periods can range from several hours to several days depending on the oscillator technology (crystal or rubidium), environmental factors (temperature and temperature variation), and the quality of the implementation (algorithms that account for and adapt to the effects of aging).

Holdover requirements vary depending on the type, complexity, and operator requirements. 4G/LTE time division duplex (TDD) networks have more stringent timing requirements than 2G/3G networks and some applications such as location based services and E911 impose even more exacting sync requirements in order to accurately locate the handset by triangulating from base stations.

As the mobile network technology advances, higher synchronization accuracy is required. GSM and UMTS require frequency sync accuracy of 16 ppb (parts per billion) at the transport interfaces, with no requirement for phase synchronization. CDMA 2000 adds a phase sync requirement of ± 3 to 10 microsecond (µs), and 4G/LTE TDD stations require phase synchronization ± 1.5 µs accuracy. (Figure 1)

Application	Frequency Transport / Air Interface	Phase
GSM	16 ppb / 50 ppb	none
UMTS	16 ppb / 50 ppb	none
CDMA2000	16 ppb / 50 ppb	± 3-10 µs
LTE FDD	16 ppb / 50 ppb	none
LTE TDD	16 ppb / 50 ppb	± 1.5 µs

Figure 1: Synchronization Requirements

The most commonly used holdover source is an oven controlled crystal oscillator (OCXO) which has historically met the needs of GMS/UMTS and CDMA networks. Looking forward, rubidium atomic clocks are a better solution, delivering a much higher level of performance and precision with longer holdover periods. As a benchmark for typical implementations: rubidium can hold 1.5 microseconds accuracy for up to 24 hours in targeted base station temperature environments, while crystal oscillators ensure only 8 microseconds for up to 24 hours under the same conditions. (Figure 2)

	Accuracy	Holdover Period
Crystal OCXO	± 8 µs	24 hours
Rubidium Atomic Clock	± 1.5 µs	24 hours

Figure 2: 24 Hour Holdover Performance

Even for 2G/3G environments where the accuracy requirements are not as stringent, rubidium provides a significant advantage as the much longer holdover period can save weekend or nighttime truck rolls.

It must be noted that different grades of oscillators deliver varying holdover performance, which of course will also vary in cost. The design implementation can also have significant impact; for example a software algorithm can compensate for accuracy changes due to the aging of the oscillator. Figure 3 presents a comparison of drift over time for oven controlled crystal oscillators versus a rubidium atomic clock. The point is that under similar environmental circumstances and within the price/performance ranges targeted for base stations, rubidium provides holdover performance significantly better than crystal oscillators.

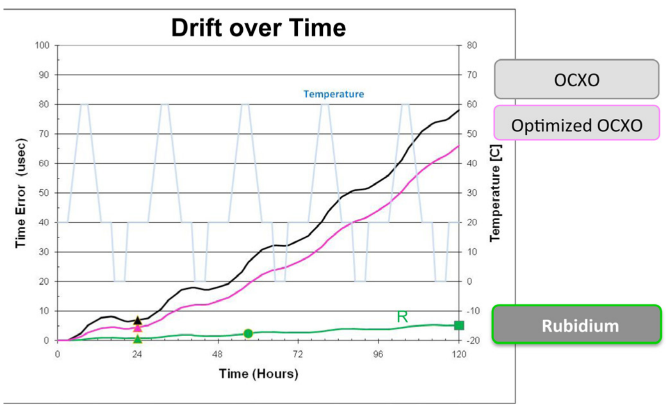

Figure 3: Drift Over Time

Other important factors favoring rubidium holdover technology are:

1. The latest rubidium miniature atomic clocks are the same size and form factor as OCXO devices used for holdover, making it easy to embed in equipment designs.
2. Innovation has yielded lower power consumption, and power performance will continue to improve.
3. And most importantly, costs for rubidium clocks are on a steep decline: five years ago prices were double what they were two years ago, and technical innovation continues the downward trend today.

Sync and Holdover Technology for the Future

Carrier service availability has always relied on redundancy and backup solutions to meet the expectations of their customers. A reliable end-to-end synchronization solution for a packet-based network requires the use of a primary sync source (either IEEE-1588 PTP or GPS) and an embedded rubidium atomic clock at the base station. Sophisticated algorithms adaptively manage GPS and other sync signal sources to provide improved accuracy and stability in the sync output. In this solution, multiple technologies aid one another to extend the holdover time of rubidium and allow installation of base stations in locations that were not practical in the past. This approach has been tested for deployment and is ready for carriers to include in 4G/LTE build out plans. (Figure 4)

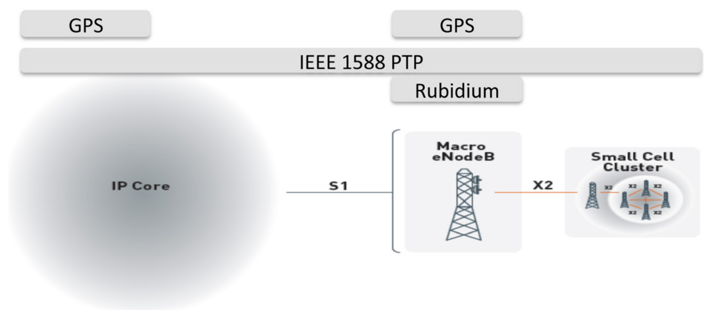

Figure 4: Multiple Sync Technologies for 4G/LTE Build Out

Conclusion

With the evolution of mobile networks to 4G/LTE, the requirements for synchronization become more stringent with the advancement of tighter phase requirements. To meet the phase requirements on 1.5 µs and ensure continuous network operations, rubidium atomic clocks are required to deliver network holdover and protect the network when the sync signal is lost. Performance, cost and ease of implementation have come together to make rubidium atomic clocks for base transceiver stations an increasingly attractive value.

For more information on the Microsemi portfolio of Rubidium products, visit us at: www.microsemi.com/mac

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