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We are pleased to introduce our third quarterly newsletter —Time to Sync—your source for the latest Timing and Synchronization industry news, products, events, and more! Time to Sync keeps you connected and updates you with the latest news on high performance timing and synchronization products and solutions from Microsemi.

Microsemi offers a set of complementary product lines including enterprise network time servers, Power-over-Ethernet (PoE) midspan/injectors, Carrier Ethernet switches / PHYs and software, and equipment/data link security. We look forward to sharing some of these with you when available, while retaining focus of this newsletter to Timing and Synchronization.

Time to Sync is intended to be informative and educational, and to help you succeed! Please send us any comments or questions, including suggestions for future articles to timing@microsemi.com.

Technology and Product Updates

The Essentials on NTP vs. PTP

As the world is getting more inter-connected and computer networking more complex, the need for more precise time synchronization is becoming increasingly important. When we speak of time synchronization, two protocols that come to mind are Network Time Protocol (NTP), and the more recent Precise Time Protocol (PTP).

NTP is a proven technology in enterprise and IT/IS data centers where it is used to synchronize computer clocks in servers, workstations, and desktop machines. In the telecom industry, NTP has traditionally been deployed for billing, alarm management, and database synchronization in applications that only require sub-second accuracy.

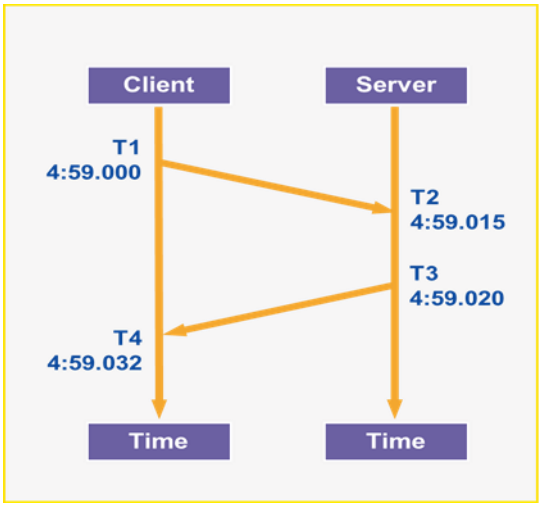

Figure 1 · **NTP Time Transfer**

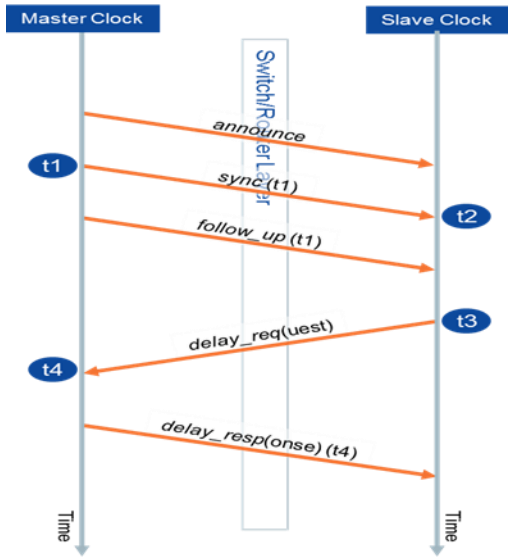

Figure 2 · **PTP Message Sequence**

PTP, often referred to as IEEE 1588, which is the standard this protocol defines, is an IP/Ethernet-based protocol for distributing time in a network from a master clock to one or more slave clocks. PTP typically provides a much higher level of accuracy through the use of hardware-assisted timestamping in both the Master and the Slave, and high-packet exchange rates between the Master and the Slave. PTP with hardware timestamping can typically achieve microsecond-level time transfer on a managed WAN.

PTP also offers great flexibility in the overall network architecture, which has led to the use of this protocol in a wide range of industries including telecommunications, defense, military, test and communication, power, industrial automation, and audio-visual systems.

Here are a few similarities between PTP and NTP:

- Both use timestamp-based timing signals.
- The timing signals in both are delivered over Ethernet.
- In both, performance is not defined by the protocol, but by the following:
  - Quality of the source clock
  - Update rate
  - Software stack delay in the server and the client
  - Holdover and servo control functions in the client
  - Number of hops, and types of hops (switches vs. routers)

The key differences between NTP and PTP are as follows:

- NTP is used to transfer time whereas PTP can be used to transfer time and frequency (and subject to the installation of the required additional components, even phase).
- NTP is generally implemented in software and PTP in hardware.
- In NTP, the client initiates the time transfer sequence whereas in PTP, the server initiates the sequence.

In summary, both NTP and PTP have their own distinct place in the time synchronization space, each of them offering significant benefits to select applications. PTP, which utilizes standard network cabling, is well-positioned to economically fill a void between NTP and direct 1PPS timing synchronization, or the Inter Range Instrumentation Group (IRIG) timecode distribution that requires dedicated local hardware.

Easily Target High Growth Segments in Small Cell with IGM

IGM (Integrated GNSS Master) was announced in February 2015 with great anticipation. Uniquely designed with a small form factor, IGM provides precise timing for indoor small cells without requiring an external GPS antenna on the roof of a building.

Since its introduction, IGM has generated a lot of customer interest across the globe. More than 50 trials are being conducted, encompassing both mobile operators and small cell vendors. The strategy here is to make sure IGM interoperates with the majority of small cell product providers.

IGM supports the latest IEEE 1588 (PTP) profiles defined by International Telegraph Union – Telecommunications standardization school (ITU-T), and is an ideal product to deliver phase capabilities to small cells deployed indoors within an enterprise facility. It maximizes coverage and capacity, and is easy to install, with Plug and Play capabilities. It comes in both wall and ceiling versions, and therefore offers lot of flexibility in terms of the installation location.

Figure 3 · **IGM 1100i**

Figure 4 · **Integrated GNSS Master**

Small Cell Forum has recently confirmed that indoor installations and enterprise are the two main growth segments for small cells in the industry.

The industry feedback has been really encouraging so far:

- IGM was a finalist in a recent award ceremony held by Small Cell World Congress, and at the LTE World Summit.
- IGM was also featured in the Small Cell Magazine as the device to address the two high growth segments in the small cell industry – indoor installations and enterprise.

Lowering the overall cost of deployment is the key driving factor for the small cell industry, and IGM delivers exactly that, without compromising on performance. It is surely establishing itself as the product to consider. Microsemi has units available for demos and trials today.

For more information on IGM, visit our website to download the product brief.

Microsemi Quadruples Precision Time Protocol Client Capacity to Provide Leading Synchronization Performance to LTE Networks

The **TimeProvider** series features the industry's first offering of optimized synchronization solutions that deliver precise time from the core to the network edge, supporting the rapid transition to Ethernet mobile backhaul, and improving the mobile service experience for end users. With full support of ITU-approved PTP profiles for frequency and phase synchronization, and superior client capacity scalability, the **TimeProvider** series enables wireless operators to seamlessly migrate their networks forward to assure high quality service for LTE and small cell deployments.

The **TimeProvider** 2700/2300 clocks raise the bar for client capacity available from a single PTP GM device targeted at the LTE market, offering increased client capacity from 128 PTP clients to 512 PTP clients. The additional 8275.1 PTP phase profile support has been enabled with a new software update, which is ideal for customers in the communications market seeking to upgrade their LTE networks with the latest synchronization capabilities. Both upgrades are available on new as well as deployed **TimeProvider** 2700/2300 clocks, without additional hardware.

The additional G.8275.1 PTP profile for phase not only increases flexibility and utility, but is also supported by Microsemi's timing PTP chipsets, complementing other product offerings to deliver complete end-to-end timing solutions.

The 512-PTP client capacity capabilities of Microsemi devices meet the evolving client density requirements as LTE networks scale up with ever-increasing base station and small cell deployments worldwide. In contrast to alternative solutions available in the market that limit the PTP timing message rates at higher client counts, Microsemi devices can manage the increased client count at full PTP message rate, resulting in no potential compromise in end-to-end accuracy. With more Microsemi customers now requiring support for the G.8275.1 PTP profile for phase as they plan for LTE-TDD and LTE-A network deployments, the company's latest enhancement for the TP2300/2700 family will help ensure their networks are well-equipped for continued growth.

A Correction To Issue 2 of the Newsletter

The article titled "Why a Leap Second Was Added On 30 June, 2015" in Issue 2 of our newsletter (the November 2015 issue) incorrectly mentioned a day to consist of 84,000 seconds instead of 86,400 seconds.

Original (Printed) Version: Those who watched and tracked the June 30, 2015 leap second event were able to see a day with 86,401 seconds versus the usual 84,000 seconds.

Correct Version: Those who watched and tracked the June 30, 2015 leap second event were able to see a day with 86,401 seconds versus the usual 86,400 seconds.

We sincerely apologize for the error and thank the readers who brought this to our notice.

End Market Corner

Aerospace Testing Technology meets European Stock Trading

Aerospace test engineers have long known that things that move very fast need highly accurate and precise timing systems. If they don't collect enough data fast enough and with enough granularity, they can't make sense of what is happening, or more correctly, what happened.

The stock trading industry faces the same challenge today. Only in this case, they're monitoring high-frequency trading (HFT). In HFT, trading data shows multiple order transactions with the same timestamp. Complicating matters, clocks differ between trading venues, makes it nearly impossible to track the very short lifetime of orders progressing through the system.

Speed in stock trading is nothing new, but markets are required to be fair, with regulators in place to take responsibility for errors due to oversight. Enter the recent September 2015 European Securities and Markets

Authority (ESMA) MiFID II regulations on clock accuracy and granularity in stock trading, and the need for accurate timestamping has become even more pertinent. Briefly, these regulations require select trading venues to improve order timestamp accuracy to 100 microseconds to UTC with a granularity of 1 microsecond. The regulations aim at:

- Ensuring accurate monitoring of orders throughout their lifetime, which can be significant in detecting and assessing potential market manipulation and front running behaviors, and
- Providing a way to reconstruct all events:
    - related to an order in an accurate time sequence and
    - over multiple trading venues at a consolidated level to be able to conduct effective cross-venue monitoring on market abuse

Aerospace instruments have long operated at the sub-100-microsecond level accuracy to UTC with 1 microsecond granularity to analyze test data. Microsemi's time and frequency products far exceed this requirement. Because the sub-100-microsecond level of accuracy is referenced to UTC, it can fulfill the cross-venue requirement (see the second sub-bullet above) as well, much like remote sensors gathering flight test data across the globe.

The stock trading industry already senses that they ultimately need to connect their systems to an external time source, like a GNSS referenced clock somewhere in the network. The caveat is that if for whatever reason the connection to GNSS is lost, they still must remain accurate to within 100 microseconds to UTC to continue trading. That's where atomic clocks come in.

Accurate atomic clocks, such as those built by Microsemi, are fully integrated into Microsemi time and frequency systems to keep the time accurate if the connection to GNSS is lost. These small atomic clocks have so little drift that if the GNSS connection is lost, it will be several weeks before the Microsemi clock synchronizing the trading system is off by 100 microseconds. This effectively buys ample time to address the connection issue while maintaining the clock accuracy required for trading operation compliance to the new rules.

So, while HFT pushes the limits of technology, regulators will push a new regulatory requirement for better oversight— the very accurate timestamp. Ask us today about our very accurate NTP/PTP time servers and how they can help you meet your timing requirements.

Revealing Deep Space Secrets with Atomic Clocks

Radio astronomy involves studying deep space to better understand planets, black holes, asteroids, and the universe as a whole. Researchers in this area of study use very large telescope systems to look far into the distant planets and stars to conduct their research efforts, which are very important for the long term health of planet Earth. Very-long-baseline interferometry (VLBI) and very-large-baseline arrays (VLBA) are popular techniques used for work in this area, which involves the use of sophisticated telescopes.

Figure 5 · **A Very Large Gate Array at one of the Research Facilities**

Atomic clock technologies are extensively used to support research efforts on VLBI and VLBA, as they provide very good stability, enabling multiple VLBA stations to perform as a single instrument. The synchronization of the widely dispersed telescopes enables higher resolution observations. Active hydrogen masers are the most preferred atomic clocks for VLBI/VLBA applications due to the stability specs that these masers offer (up to 10,000 seconds). The most important and challenging stability specs for VLBI research are the stability specs from 1-100 seconds, and Microsemi's active hydrogen masers successfully meet these specifications, offering an accuracy of 8E-14 at 1 second, 1.5E-14 at 10 seconds, and 4E-15 at 100 seconds. In addition, we offer very good low-phase noise outputs that are also critical to the radio frequency (RF) systems of the telescopes.

The maximum allowable time observation is limited by the visibility of all the participant laboratories in a simultaneous observation, usually limited by 1000 seconds or less, depending on the type of observation. The maximum expected duration of the observations determines the frequency stability (Allan deviation) required by the clock for the specified time window. Many renowned radio astronomy labs across the world are using Microsemi active hydrogen masers with GPS receivers and low-phase noise crystal oscillators in their research efforts.

Meet Our Precise Satellite Timing Module for Next-Generation Satellite Bus

Precision frequency sources are required for time keeping and metrology in communication and navigation satellites. The frequency sources for the satellites are typically quartz oscillators, and in rare instances where absolute accuracy is required, atomic clocks. Frequency sources can be used to establish a time base for each satellite, or for groups of satellites, typically with ground station support. All frequency sources are subject to change over time, usually referred to as drift or aging. As a result, the frequency and time must be adjusted remotely, a process that consumes effort, and often impacts the accuracy of the local time. Autonomous and accurate local frequency and time for individual satellites or for constellations of satellites, leads to a significant improvement in the system's capabilities.

The availability of time through Global Navigation Satellite Systems (GNSS) allows for adjustment of the local time of a system by means of one pulse-per-second (1PPS). The use of Kalman filtering to steer high-

performance crystal oscillators provides high accuracy and stability while ensuring long term performance of the GNSS on-board atomic clocks. Microsemi has developed a space-borne product that leverages heritage space-ovenized oscillators and advanced Kalman filter algorithms which have demonstrated exceptional performance for 1PPS in both steered and un-steered conditions.

For more information on Microsemi's Satellite Timing module, click here or visit our website.

Microsemi Events

Summary

ISPCS (Beijing, China)

Microsemi made its presence felt at the IEEE Symposium on Precision Clock Synchronization (ISPCS) for Measurement, Control and Communication, where we demonstrated the interoperability of our innovative IEEE 1588 products and technologies. The product in focus was IGM-1100i, a groundbreaking solution focused on reducing deployment costs for indoor small cell precise synchronization. Microsemi was the Gold promotional partner for the event, and received good response.

ITSF (Edinburg, Scotland)

The International Telecom Sync Forum (ITSF) conference, organized by the most influential forum in the time and synchronization domain, presented high quality content discussing the latest technologies in the industry. Microsemi was the Diamond sponsor for the event. We hosted a booth at the conference, and presented a few technical papers including:

- Coherent Network Primary Reference Time Clocks (cnPRTC) Simulation and Test Results
- Ethernet Time Transfer through a U.S. Commercial Optical Telecommunications Network
- Metrics and Limits for G.8271.2 Unaware Phase Networks

We also ran IGM110i demonstrations successfully with full indoor reception.

LTE North America 2015 (Dallas, Texas)

The 8th Annual LTE North America summit was the industry's meeting point to discuss the present and future of cellular networks in the region. We presented on the challenges associated with small cell deployment, and critical problems associated with traditional GPS installations.

Microsemi also conducted demonstrations for the IGM 1100i and the TP2700. The demonstrations around IGM were very received with a lot of interest.

Upcoming Events

PTTI (Monterey, California) - Jan 26 to 28, 2016

The Precise Time and Time Interval Systems and Applications (PTTI) meeting is an annual conference sponsored by the Institute of Navigation (ION). It consists of a technical program designed to:

- Disseminate and coordinate PTTI information at the user level
- Review present and future PTTI requirements
- Educate the government, industry engineers, technicians, and managers about precise time and frequency technology and associated problems, and
- Provide an opportunity for active exchange of information on the new technologies associated with PTTI

Visit us at booth number #16 to know more about our offerings.

Latest Collateral

White Paper: GPS Everywhere vs. Synchronization Systems

The timing division of Microsemi released a white paper on the challenges and benefits associated with system synchronization (1588 PTP telecom profile) for various types of access equipment (small cell, macrocell, picocell, etc.), versus those associated with GPS Everywhere. The paper provides a complete techno-commercial analysis that includes various scenarios that can cause GPS outage, and the behavior of the two technologies in these scenarios. The analysis also covers aspects such as installation challenges and total cost of ownership.

Download the paper at: http://www.microsemi.com/document-portal/doc_download/135662-gps-everywhere-versus-synchronization-systems-challenges-and-benefits

Webinar (GPS World): Timing, Time Transfer and Synchronization: New Applications and Techniques

Microsemi partnered with GPS World at the Timing and Synchronization webinar conducted by Market Insights. The partnership included a detailed session on the recently released SyncSystem 4380A, the benefits offered by the product, and the specific applications that can be targeted in metrology, defense, communications, and aerospace.

For more information on the webinar, please visit the webcast link here.

Microsemi in the News

- Microsemi Expands its IEEE 1588 Embedded Solution with Standards-compliant Telecom Profile for Phase to Address Stringent Synchronization Requirements for 4G/LTE
- Microsemi Introduces Complete Power Profile-Compliant Solution to Address Growing Demand for Synchronization of Smart Grids and Synchrophasors
- Microsemi Wins "Public Outstanding Technology Company" and "Enterprise Hardware & Device" Awards at Orange County Tech Alliance's 22nd Annual High-Tech Innovation Awards

Microsemi new product press releases can be viewed at http://investor.microsemi.com/releases.

Microsemi Corporate Headquarters
One Enterprise, Aliso Viejo,
CA 92656 USA

Within the USA: +1 (800) 713-4113
Outside the USA: +1 (949) 380-6100
Sales: +1 (949) 380-6136
Fax: +1 (949) 215-4996

E-mail: sales.support@microsemi.com