2114 West 7th Street
Tempe, AZ 85281 USA
Voice +1.480.333.2200
E-mail sales@comtechefdata.com
Web www.comtechefdata.com

CDM-625 IEEE 1588v2 Precision Time Protocol (PTP) Performance

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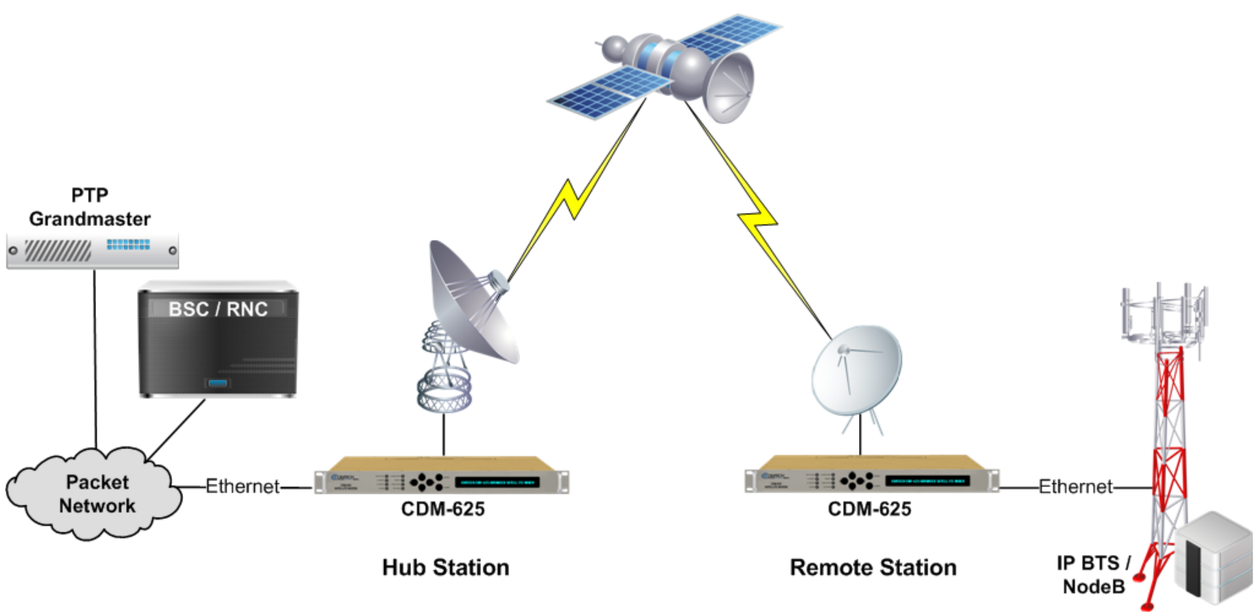
Mobile backhaul networks have traditionally been built using TDM technologies; in particular, PDH and SDH/ SONET microwave radios, low capacity SDH/SONET fiber rings, and copper-based E1/T1 leased lines. In order to support the evolution towards higher speed packet access, mobile operators are migrating backhaul to packet transport.

Ethernet, the commonly envisioned technology for backhaul, is inherently asynchronous. Network devices, such as BTS/NodeB/eNodeB, no longer have access to network timing that was traditionally provided by the TDM network. Newer mobile technologies also require time of day and phase synchronization in addition to frequency synchronization.

IEEE 1588v2 Precision Time Protocol (PTP) has emerged as the key network synchronization technology to synchronize frequency, time and phase over a packet network. Originally proposed by IEEE in 2002, a revised version was released in 2008. It is based on a hierarchical master-slave architecture where one or more grandmaster clocks provide synchronization for slave network nodes.

The CDM-625 Advanced Satellite Modem[1] is the first satellite modem to provide hardware support for PTP, thereby significantly improving the synchronization accuracy when backhauling over satellite. Based on satellite test results, the CDM-625 with hardware PTP support can improve timing accuracy by a factor of over 100,000 compared to the CDM-625 without hardware support for PTP.



[1] CDM-625 with Rev 2 HW and Base Modem FW 2.1.0 (or newer) provides native support for IEEE 1588v2 Precision Time Protocol.

PTP Protocol

PTP uses time stamped message exchange between the Master and the Slaves. The Slaves use the time stamps to calculate precise offset between Master and Slave to correct their local clock.

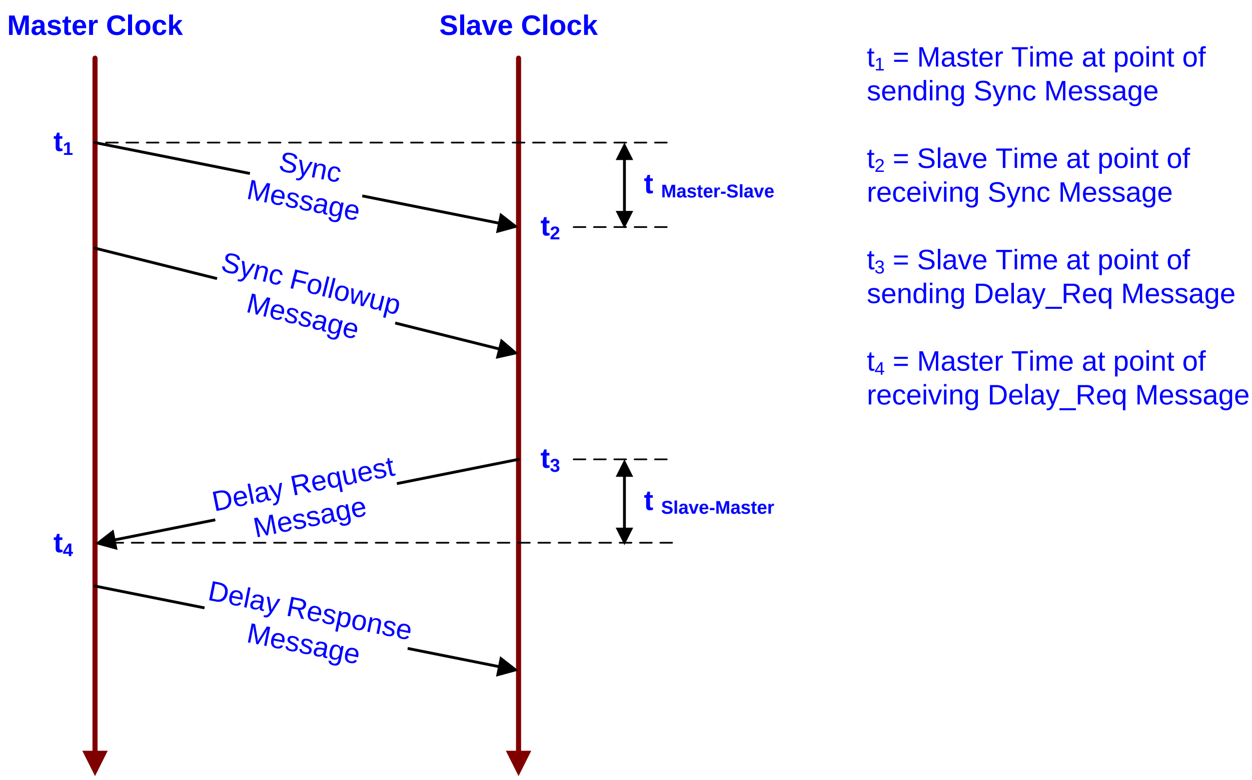


Figure 1. Precision Time Protocol Message Exchange

To calculate the offset between Master and Slave, both Master to Slave ($t_{Master\text{-}Slave}$) and Slave to Master ($t_{Slave\text{-}Master}$) path delay must be calculated. This requires 4 different time measurements:

t_1 is the precise Master Time of transmitting the Sync Message. This time is also sent in the Sync Followup Message (optional).

T_2 is the precise Slave Time of receiving Sync Message

Once Slave has t_1 and t_2, it can calculate $t_{Master\text{-}Slave} = t_2 - t_1$

t_3 is the precise Slave Time of transmitting the Delay Request Message.

T_4 is the precise Master Time of receiving the Delay Request Message. This time is sent in the Delay Response Message.

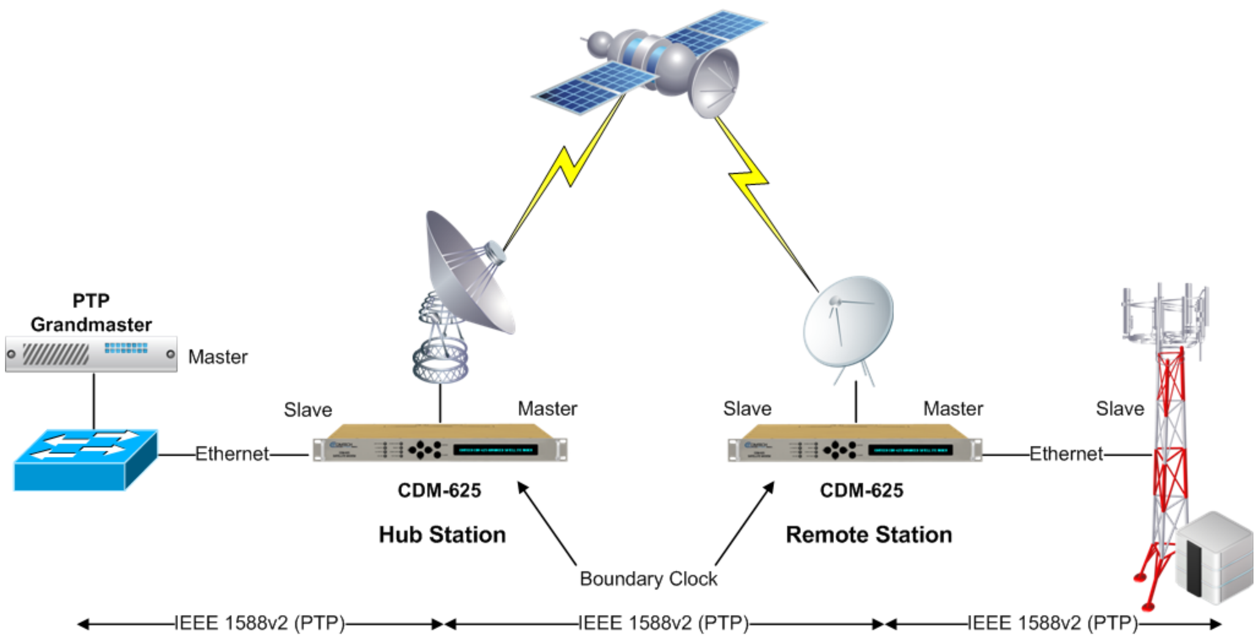
Once Slave has t_3 and t_4, it can calculate $t_{Slave\text{-}Master} = t4 - t3$

Offset from Master to Slave = $(t_{Master\text{-}Slave} - t_{Slave\text{-}Master}) / 2$

CDM-625 PTP Operation

The CDM-625 supports hardware time stamping at ingress and egress ports for maximum accuracy. This eliminates delay variation due to buffering. The CDM-625 is designed to operate as a boundary clock. A PTP boundary clock interfaces separate PTP domains intercepting and processing all PTP messages. Synchronization process is as follows:

- Near side CDM-625 synchronizes its LAN port to the Grandmaster clock (PTP domain)
- WAN port synchronizes to the LAN port
- Far side WAN port synchronizes to the near side WAN port (PTP domain)
- Far side LAN port synchronizes to Far side WAN port
- Slave device synchronizes to Far side LAN port (PTP domain)



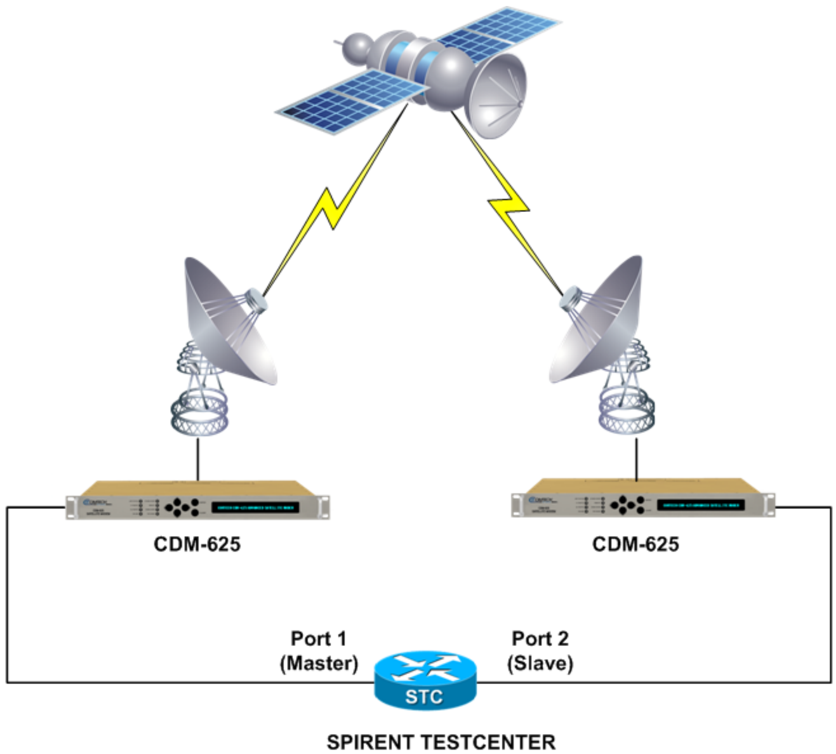
Performance Test Results

The CDM-625's built-in hardware and software support for PTP makes it possible to achieve unprecedented synchronization accuracy over satellite when operating in packet mode. Extensive tests were conducted over satellite to benchmark PTP performance.

The test setup was as follows:

RF Frequency	Ku-band
FEC	QPSK TPC 3/4
BER	1.0E-7
Operational Mode	Base Modem layer 2 Switch without IP sub-mux or overhead channel[2]

[2] PTP may not be available with certain configurations.



For each test, sufficient time was provided for PTP Slave to reach steady state. Measured test results are as follows:

Modem PTP Status	Modem WAN Data Rate	Traffic - Ethernet Ingress	Measured Timing Accuracy	Comments
Disabled	1 Mbps	No traffic	± 100 µs	With PTP feature disabled, PTP performance is highly dependent on WAN capacity and ingress traffic and deteriorates rapidly with increasing traffic.
Disabled	1 Mbps	500 kbps	± 15 ms	
Disabled	1 Mbps	1 Mbps	± 50 ms	
Disabled	1 Mbps	2 Mbps	PTP slave could not synchronize	
Enabled	1 Mbps	1 Mbps	± 150 ns	CDM-625 PTP performance is independent of traffic.
Enabled	1 Mbps	25 Mbps	± 150 ns	

Summary

CDM-625 with PTP support enables 2G and 3G mobile backhaul over satellite with unprecedented synchronization accuracy when operating over a packet network.

For more information, please contact our sales team:

sales@comtechefdata.com **+1.480.333.2200** **+1.480.333.2540**