



POTENTIAL FIRMWARE FOR PRECISION TIME PROTOCOL

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PRECISION TIME PROTOCOL (PTP)

- IEEE standard to synchronize time.

First sync message & follow-up message from master to slave clock.

Offset = Send time at master –

Receipt time at slave

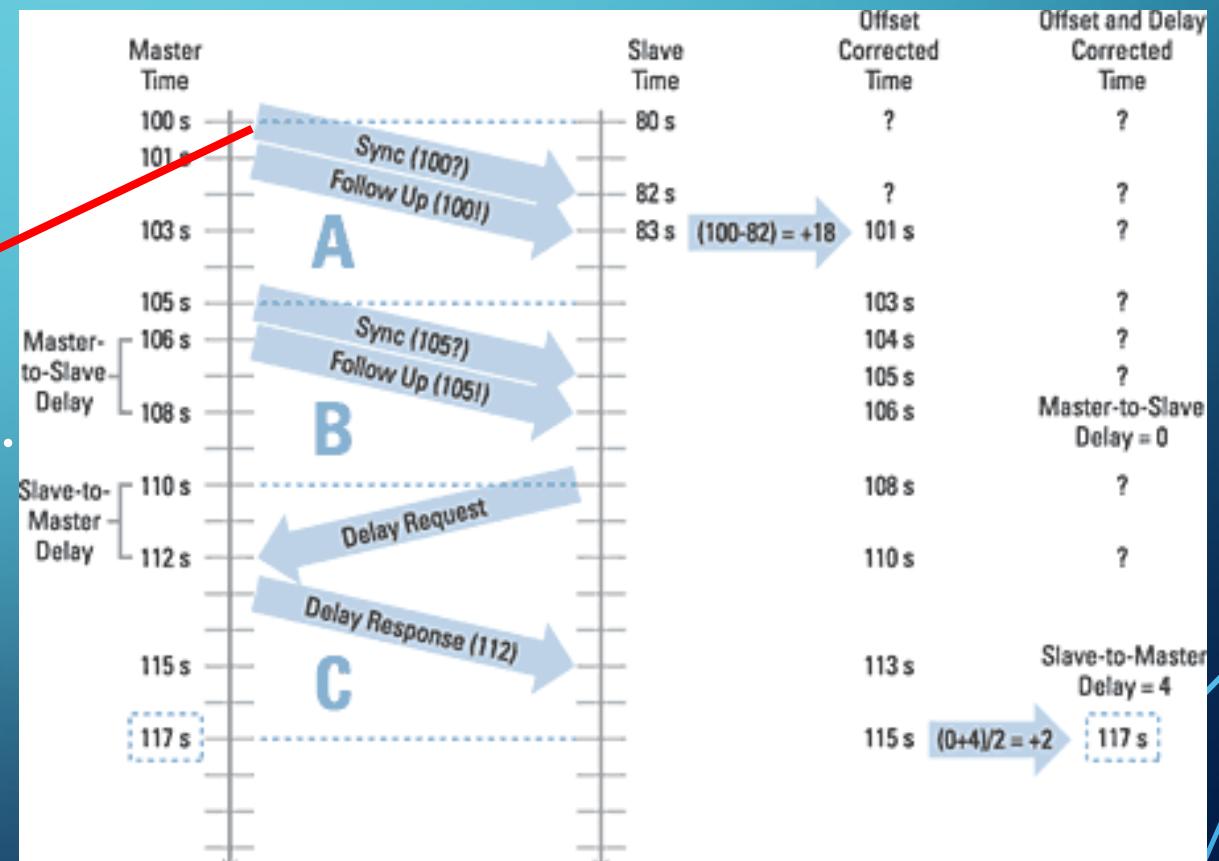
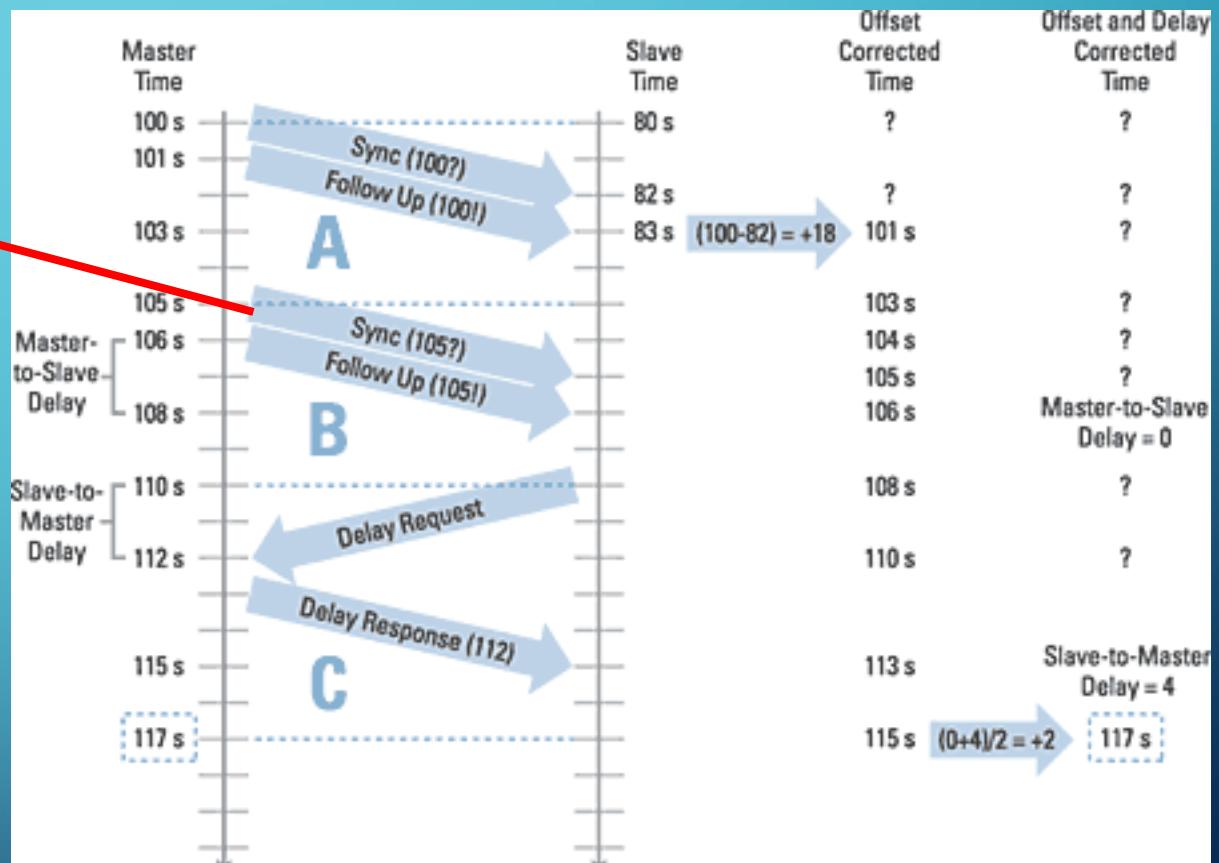


Fig. A simplified diagram of Precision Time Protocol
(<http://www.ni.com/newsletter/50130/en/>)

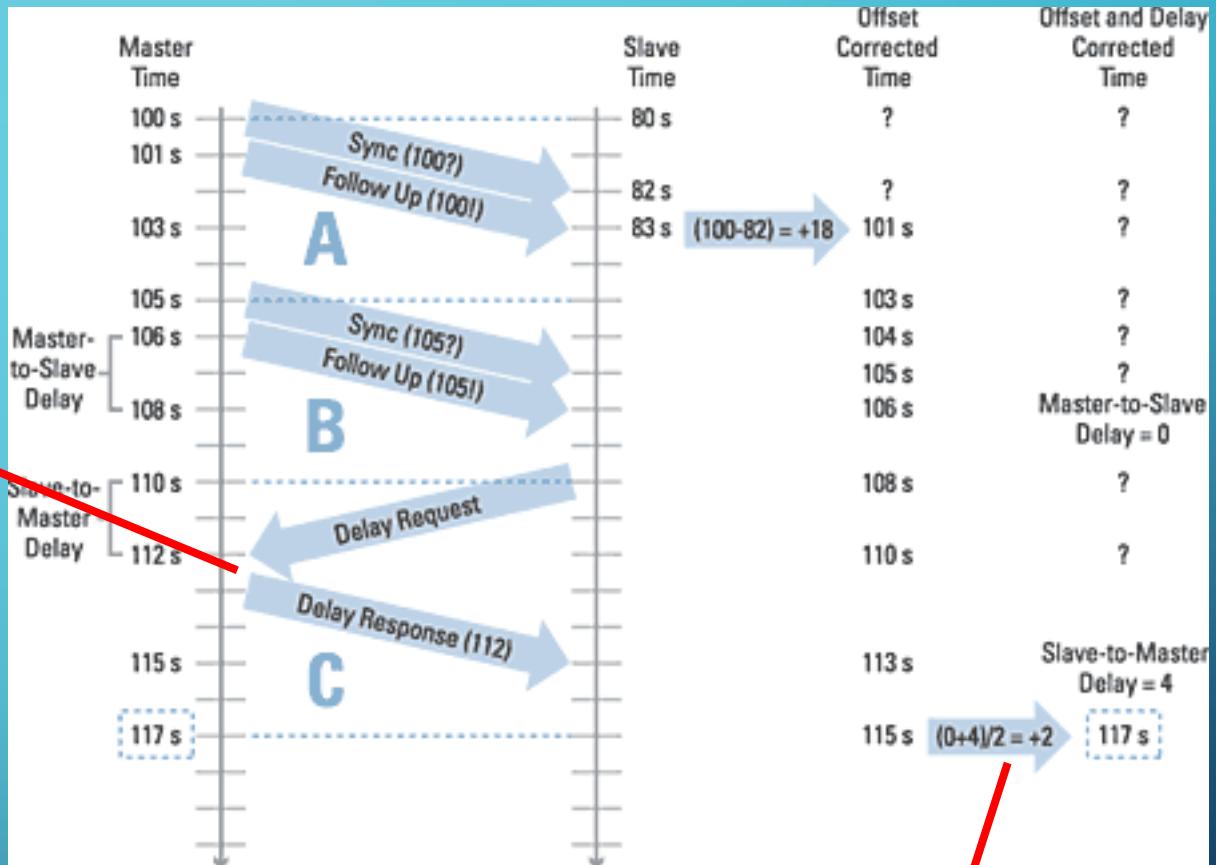
Second sync message
and follow-up calculates
the master-to-slave
delay.

Master-to-slave delay =
Send time at master –
Receipt time at slave
clock



Delay request and delay response messages calculate the slave-to-master delay.

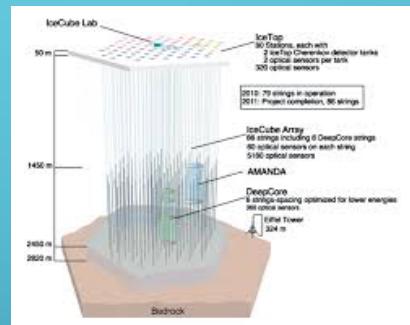
Slave-to-master delay =
Send time at slave clock –
Receipt time at master clock



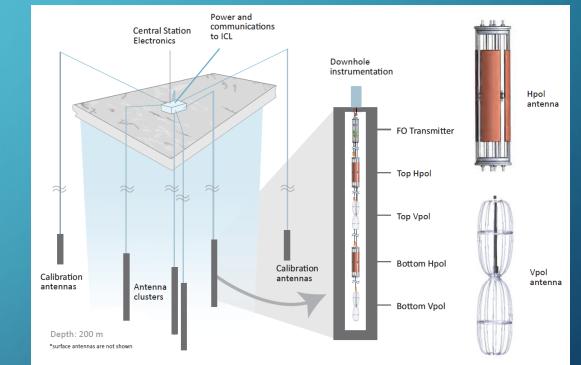
One way delay = (Master-to-slave delay + Slave-to-master delay)/2

IMPLICATIONS FOR THE USE OF PRECISION TIME PROTOCOL IN UHE EXPERIMENTS

- Potential to synchronize clocks of ARA and IceCube up to a few nanoseconds.
- Synchronization → Noise reduction.
- Also achieve synchronization between stations.



IceCube



Clock synchronization using PTP

FIRMWARE FOR PRECISION TIME PROTOCOL

- Microcontroller on the ARA DAQ needs to be programmed to recognize PTP packets and forward them on to the output pin.
- Precision Time Protocol daemon (PTPd): open source, software-only implementation of PTP.

TIVA TM4C1294
MICROCONTROLLER

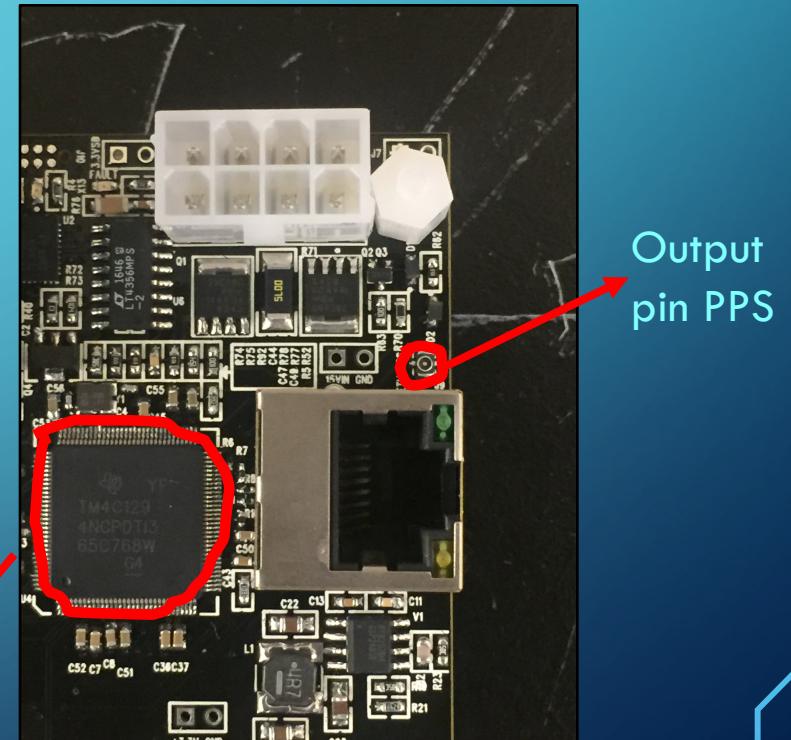


Fig. Hardware for PTP on the ARA Smart Power Data Acquisition board.

DESIGN

- Clock Servo
 - Data path from protocol to clock.
 - Calculates & filters offset, delay and inputs them to the Proportional-Integral (PI) Controller.
 - The PI controller disciplines the clock.

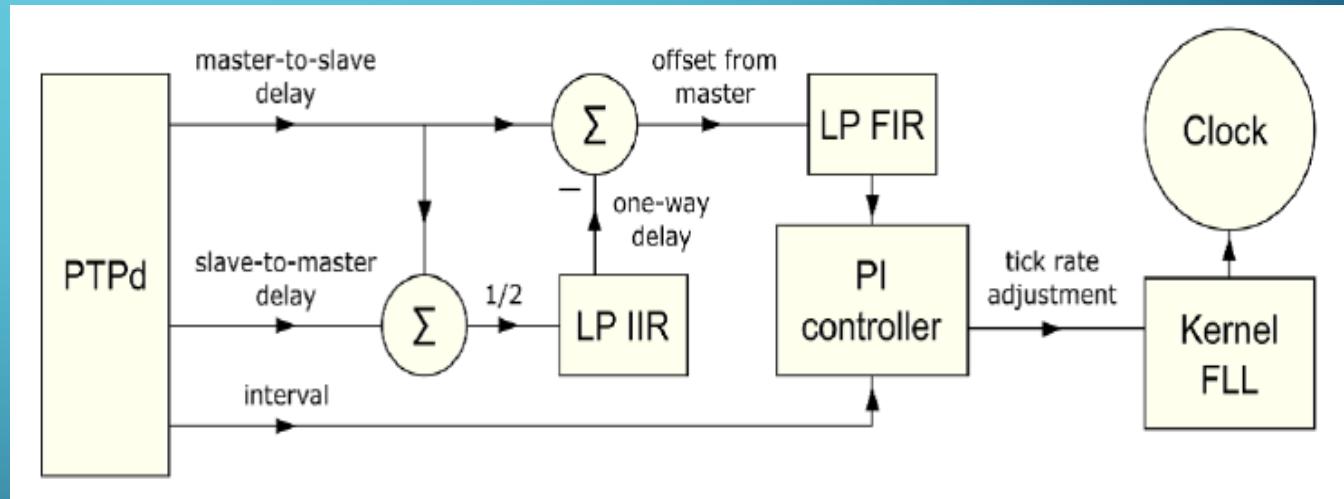
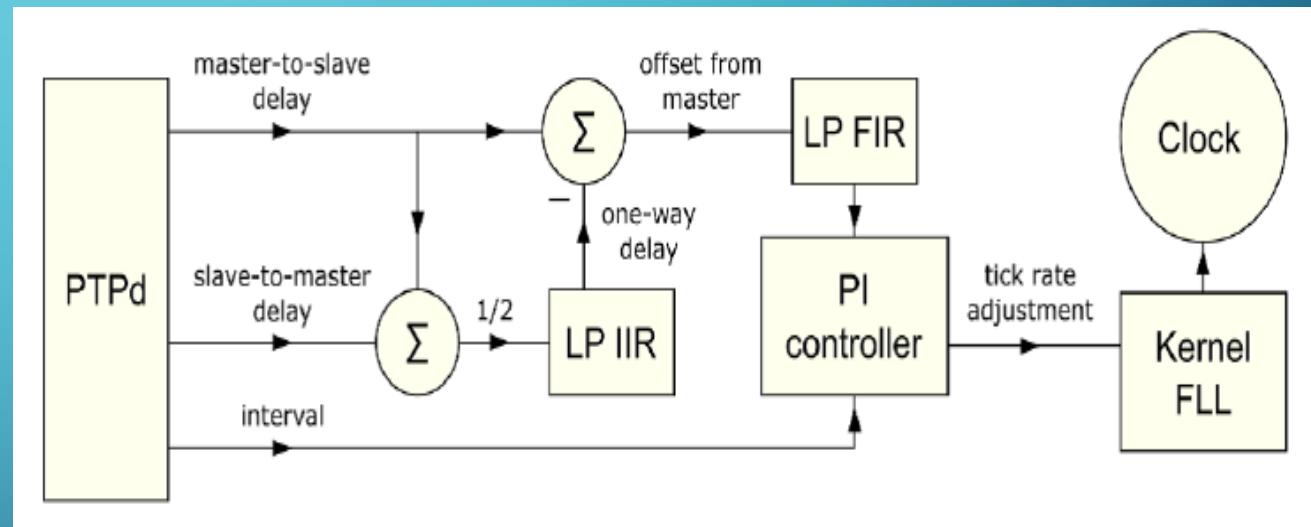


Fig. Diagram of the Clock Servo
(Correll, Kendall, Nick Barendt and
Michael Branicky's paper, 2005)

DESIGN

- PI CONTROLLER
 - Corrects the local lock by correcting both the time error & rate error.
 - Time error: difference in times between master and slave.
 - Rate error: difference in tick rates between the clocks.



CONSTRAINTS FOR USING PTP DAEMON

- Relies on Linux environment.
- Software-only implementation.
- Lesser coordination on medium time scales due to jitter in offset estimation as seen in the Allan variance plots.
- More suitable for stable network topologies or in other words, dynamic stiffness functionality is not present.

SUMMARY

- Time synchronization b/w ARA and IceCube can help reduce thermal noise by allowing us to look at shorter time intervals.
- Microcontroller in ADAQ needs to be programmed to recognize and forward PTP signals.
- PTPd is a software-only implementation which could be used to program microcontroller.
- Several constraints with PTPd: lesser coordination on medium time scales and the need for stable network topology.

REFERENCES

- Correll, Kendall, Nick Barendt, and Michael Branicky. "Design considerations for software only implementations of the IEEE 1588 precision time protocol." *Conference on IEEE*. Vol. 1588. 2005.