Master Project

Implementation and Performance Analysis of Precision Time Protocol on Linux based System-On-Chip Platform

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Outline

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- Time Critical Actions
- Distributed Computing.
- Some financial services require highly accurate timekeeping by law.
- Scheduled operations.
- Logging.
- Power system protection
- Control and automation
- Data communication applications utilizing an Ethernet communications architecture.

Outline

Introduction

Available Solutions/Protocols

- NTP.

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- NTP.
- GPS.

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- NTP.
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- TTP and SERCOS:.

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- NTP.
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- TTP and SERCOS:.
- Precision Time Protocol (PTP-1588).

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Available Solutions/Protocols

- NTP.
- GPS.
- TTP and SERCOS:.
- Precision Time Protocol (PTP-1588). *Self-Organizing , **Sub-Microsecond level accuracy, ***Hardware assisted (Optional).

Outline

Introduction

Why this Project?

- Enabling Hardware timestamping capabilities of BeagleBone Black
- Analyzing the behavior of PTP implementation, with simulated load.
- Analysis of precision uncertainty.
- Maximum attainable accuracy.

Outline

Methodology

Tools and Technologies

- LinuxPTP (ptp4l, pmc and phy2sys).

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- stress-ng.

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- Beaglebone Black (SoC Platform).

Methodology

Tools and Technologies

- LinuxPTP (ptp4l, pmc and phy2sys).
- stress-ng.
- iPerf.
- Matlab.
- Beaglebone Black (SoC Platform). Supports Hardware Assisted PTP Implementation.

Outline

- Configuring a Linux kernel with PTP related options (CONFIG_PPS and PTP_1588_CLOCK).

Methodology

Establishing Test Environment

- Configuring a Linux kernel with PTP related options (CONFIG_PPS and PTP_1588_CLOCK).
- Installing and Configuring necessary tools.
  LinuxPTP
  Stress-ng
  iPerf
  Matlab

Outline

Methodology

Test Case scenarios

- Software Timestamping.

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- Hardware Timestamping.

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- Hardware Assisted Time Synchronization under Network Load.

Outline

Methodology

Data Collection and Presentation(Test Sheet)

Test ID	PTP Demon Config			Stress Test Config		Load distribution	Remarks
	Message Frequency	Filter 1	Filter 2	Load type	Intensity		
HwT1.1	1						Slave: HW , Master: SW
HwT1.2	1						Slave: SW , Master: HW
HwT1.3	1						Slave: HW , Master: HW
HwT1.4	8						
HwT1.5	8						log data: phc2sys + ptp4l
HwT1.6	8						log data: phc2sys
HwT1.7	8						log data: phc2sys + ptp4l
HwT1.8	8			CPU	50	Slave Only	
HwT1.9	8			CPU	50	Both	
HwT1.10	8			CPU	100	Slave Only	
HwT1.11	8			CPU	100	Both	
HwT1.12	8			I/O	–	Slave Only	
HwT1.13	8			I/O	–	Both	
HwT1.14	8			CPU	100	Slave Only	log data: phc2sys + ptp4l
HwT1.15	8			CPU	100	Both	log data: phc2sys + ptp4l
HwT1.16	8			I/O	–	Slave Only	log data: phc2sys + ptp4l
HwT1.17	8			I/O	–	Both	log data: phc2sys + ptp4l
HwT1.18	8			Network	1Mb	Source: Alien	
HwT1.19	8			Network	5Mb	Source: Alien	
HwT1.20	8			Network	10Mb	Source: Alien	
HwT1.21	8			Network	20Mb	Source: Alien	
HwT1.22	8			Network	50Mb	Source: Alien	

Methodology

Data Collection and Presentation (Log File)

C:\Users\Mudassar_\Desktop\master Project\PTP ----------DATA\New Data\Sw\SwT1.13\SwT1.13.txt - Notepad++

File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?

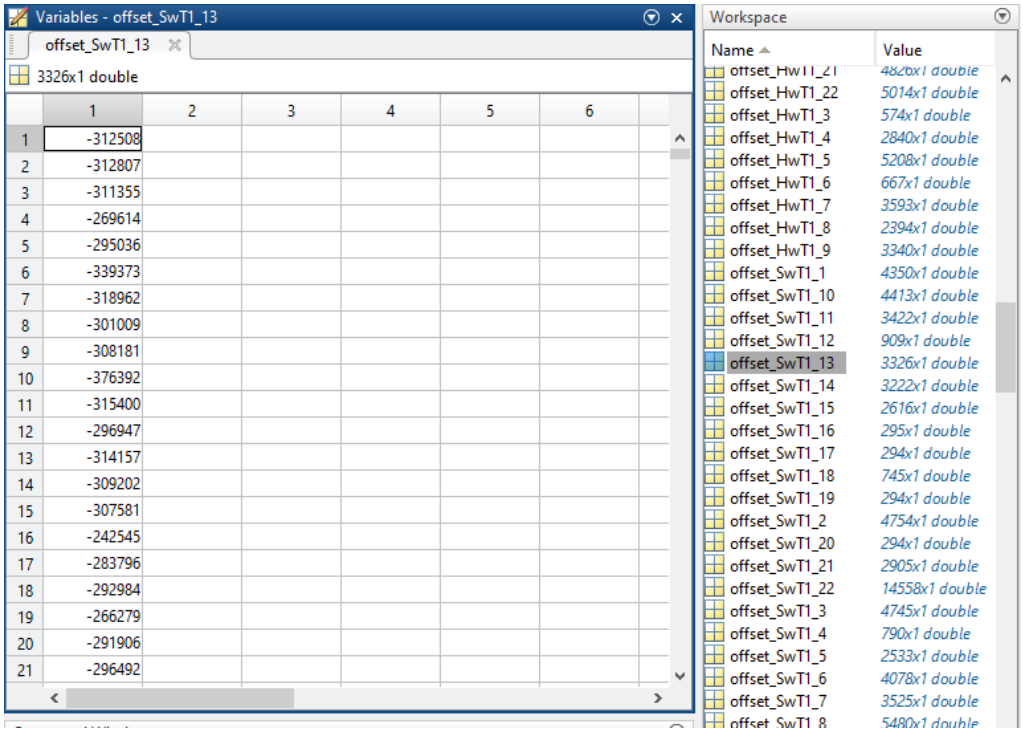
SwT1.13.txt

```
Dec 17 14:48:34 my-new-beaglebone-2 ptp4l: [569.989] master offset    -312508 s0 freq  +33516 path delay    106651
Dec 17 14:48:34 my-new-beaglebone-2 ptp4l: [570.115] master offset    -312807 s0 freq  +33516 path delay    106651
Dec 17 14:48:34 my-new-beaglebone-2 ptp4l: [570.240] master offset    -311355 s0 freq  +33516 path delay    106651
Dec 17 14:48:35 my-new-beaglebone-2 ptp4l: [570.365] master offset    -269614 s0 freq  +33516 path delay    106651
Dec 17 14:48:35 my-new-beaglebone-2 ptp4l: [570.490] master offset    -295036 s0 freq  +33516 path delay    106651
Dec 17 14:48:35 my-new-beaglebone-2 ptp4l: [570.615] master offset    -339373 s0 freq  +33516 path delay    106651
Dec 17 14:48:35 my-new-beaglebone-2 ptp4l: [570.740] master offset    -318962 s0 freq  +33516 path delay    106651
Dec 17 14:48:35 my-new-beaglebone-2 ptp4l: [570.865] master offset    -301009 s0 freq  +33516 path delay    106651
Dec 17 14:48:35 my-new-beaglebone-2 ptp4l: [570.991] master offset    -308181 s0 freq  +33516 path delay    106651
Dec 17 14:48:35 my-new-beaglebone-2 ptp4l: [571.115] master offset    -376392 s0 freq  +33516 path delay    107566
Dec 17 14:48:35 my-new-beaglebone-2 ptp4l: [571.241] master offset    -315400 s0 freq  +33516 path delay    107566
Dec 17 14:48:36 my-new-beaglebone-2 ptp4l: [571.366] master offset    -296947 s0 freq  +33516 path delay    107566
Dec 17 14:48:36 my-new-beaglebone-2 ptp4l: [571.491] master offset    -314157 s0 freq  +33516 path delay    108482
Dec 17 14:48:36 my-new-beaglebone-2 ptp4l: [571.616] master offset    -309202 s0 freq  +33516 path delay    108482
Dec 17 14:48:36 my-new-beaglebone-2 ptp4l: [571.741] master offset    -307581 s0 freq  +33516 path delay    108482
Dec 17 14:48:36 my-new-beaglebone-2 ptp4l: [571.867] master offset    -242545 s0 freq  +33516 path delay    108482
Dec 17 14:48:36 my-new-beaglebone-2 ptp4l: [571.992] master offset    -283796 s0 freq  +33516 path delay    108482
Dec 17 14:48:36 my-new-beaglebone-2 ptp4l: [572.117] master offset    -292984 s0 freq  +33516 path delay    108752
Dec 17 14:48:36 my-new-beaglebone-2 ptp4l: [572.242] master offset    -266279 s0 freq  +33516 path delay    108752
Dec 17 14:48:37 my-new-beaglebone-2 ptp4l: [572.367] master offset    -291906 s0 freq  +33516 path delay    108752
Dec 17 14:48:37 my-new-beaglebone-2 ptp4l: [572.493] master offset    -296492 s0 freq  +33516 path delay    108752
Dec 17 14:48:37 my-new-beaglebone-2 ptp4l: [572.618] master offset    -301785 s0 freq  +33516 path delay    108752
Dec 17 14:48:37 my-new-beaglebone-2 ptp4l: [572.743] master offset    -258412 s0 freq  +33516 path delay    108752
Dec 17 14:48:37 my-new-beaglebone-2 ptp4l: [572.868] master offset    -237081 s0 freq  +33516 path delay    108752
Dec 17 14:48:37 my-new-beaglebone-2 ptp4l: [572.993] master offset    -293413 s0 freq  +33516 path delay    108752
Dec 17 14:48:37 my-new-beaglebone-2 ptp4l: [573.118] master offset    -278082 s0 freq  +33516 path delay    108752
Dec 17 14:48:37 my-new-beaglebone-2 ptp4l: [573.243] master offset    -282957 s0 freq  +33516 path delay    108752
Dec 17 14:48:38 my-new-beaglebone-2 ptp4l: [573.369] master offset    -273251 s0 freq  +33516 path delay    108752
Dec 17 14:48:38 my-new-beaglebone-2 ptp4l: [573.494] master offset    -280333 s0 freq  +33516 path delay    108752
Dec 17 14:48:38 my-new-beaglebone-2 ptp4l: [573.619] master offset    -274458 s0 freq  +33516 path delay    108752
Dec 17 14:48:38 my-new-beaglebone-2 ptp4l: [573.744] master offset    -267791 s0 freq  +33516 path delay    108752
Dec 17 14:48:38 my-new-beaglebone-2 ptp4l: [573.869] master offset    -263104 s0 freq  +33516 path delay    108482
Dec 17 14:48:38 my-new-beaglebone-2 ptp4l: [573.994] master offset    -270561 s0 freq  +33516 path delay    108482
Dec 17 14:48:38 my-new-beaglebone-2 ptp4l: [574.119] master offset    -274935 s0 freq  +33516 path delay    108482
Dec 17 14:48:38 my-new-beaglebone-2 ptp4l: [574.245] master offset    -273310 s0 freq  +33516 path delay    108482
Dec 17 14:48:39 my-new-beaglebone-2 ptp4l: [574.370] master offset    -254351 s0 freq  +33516 path delay    108482
Dec 17 14:48:39 my-new-beaglebone-2 ptp4l: [574.495] master offset    -267473 s0 freq  +33516 path delay    108482
Dec 17 14:48:39 my-new-beaglebone-2 ptp4l: [574.620] master offset    -198432 s0 freq  +33516 path delay    108482
Dec 17 14:48:39 my-new-beaglebone-2 ptp4l: [574.745] master offset    -212345 s0 freq  +33516 path delay    108482
Dec 17 14:48:39 my-new-beaglebone-2 ptp4l: [574.870] master offset    -262800 s0 freq  +33516 path delay    108482
Dec 17 14:48:39 my-new-beaglebone-2 ptp4l: [574.995] master offset    -254755 s0 freq  +33516 path delay    108482
Dec 17 14:48:39 my-new-beaglebone-2 ptp4l: [575.120] master offset    -239961 s0 freq  +33516 path delay    108482
Dec 17 14:48:39 my-new-beaglebone-2 ptp4l: [575.246] master offset    -248084 s0 freq  +33516 path delay    108482
Dec 17 14:48:40 my-new-beaglebone-2 ptp4l: [575.371] master offset    -249748 s0 freq  +33516 path delay    108482
Dec 17 14:48:40 my-new-beaglebone-2 ptp4l: [575.496] master offset    -211119 s0 freq  +33516 path delay    108482
Dec 17 14:48:40 my-new-beaglebone-2 ptp4l: [575.621] master offset    -257112 s0 freq  +33516 path delay    109022
```

Normal text file | length : 386.019 lines : 3.327 | Ln : 1 Col : 1 Sel : 0 | 0 | Windows (CR LF) | UTF-8 | INS

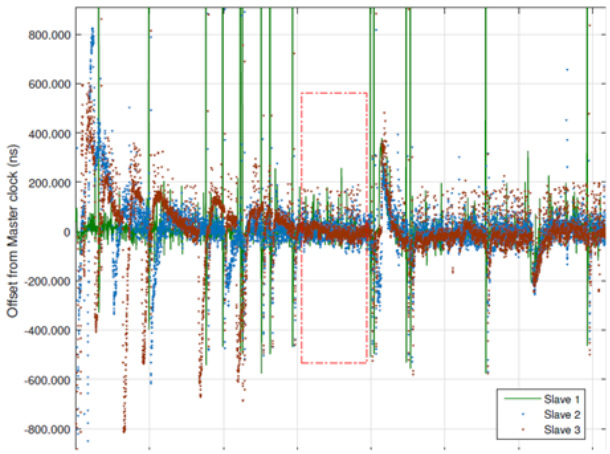
Methodology

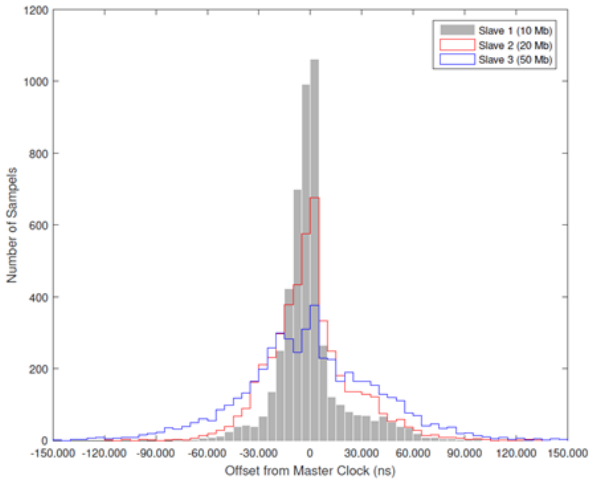
Data Collection and Presentation (Matlab Workspace)

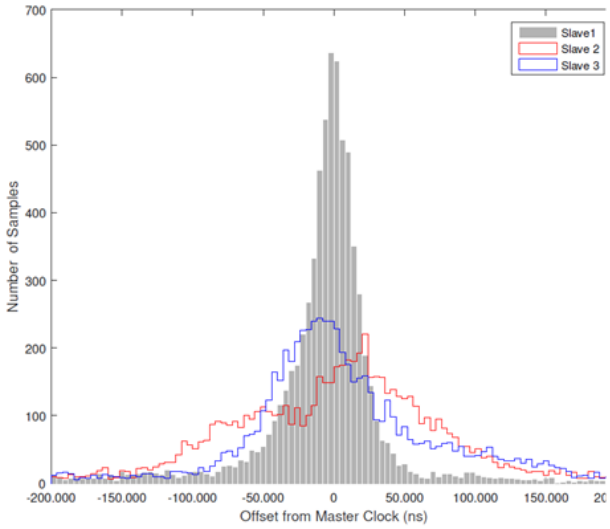


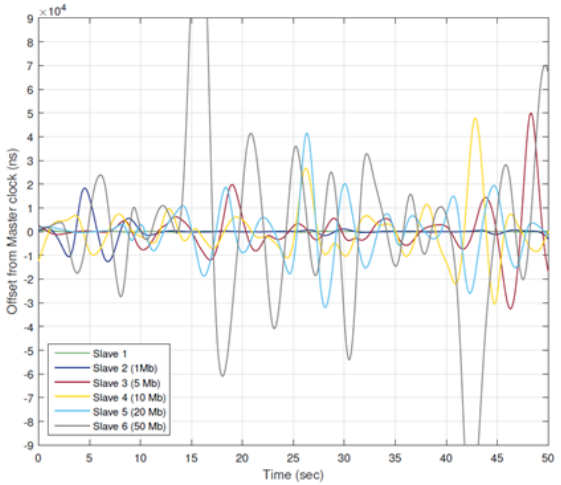
Methodology

Data Collection and Presentation (Data Presentation)



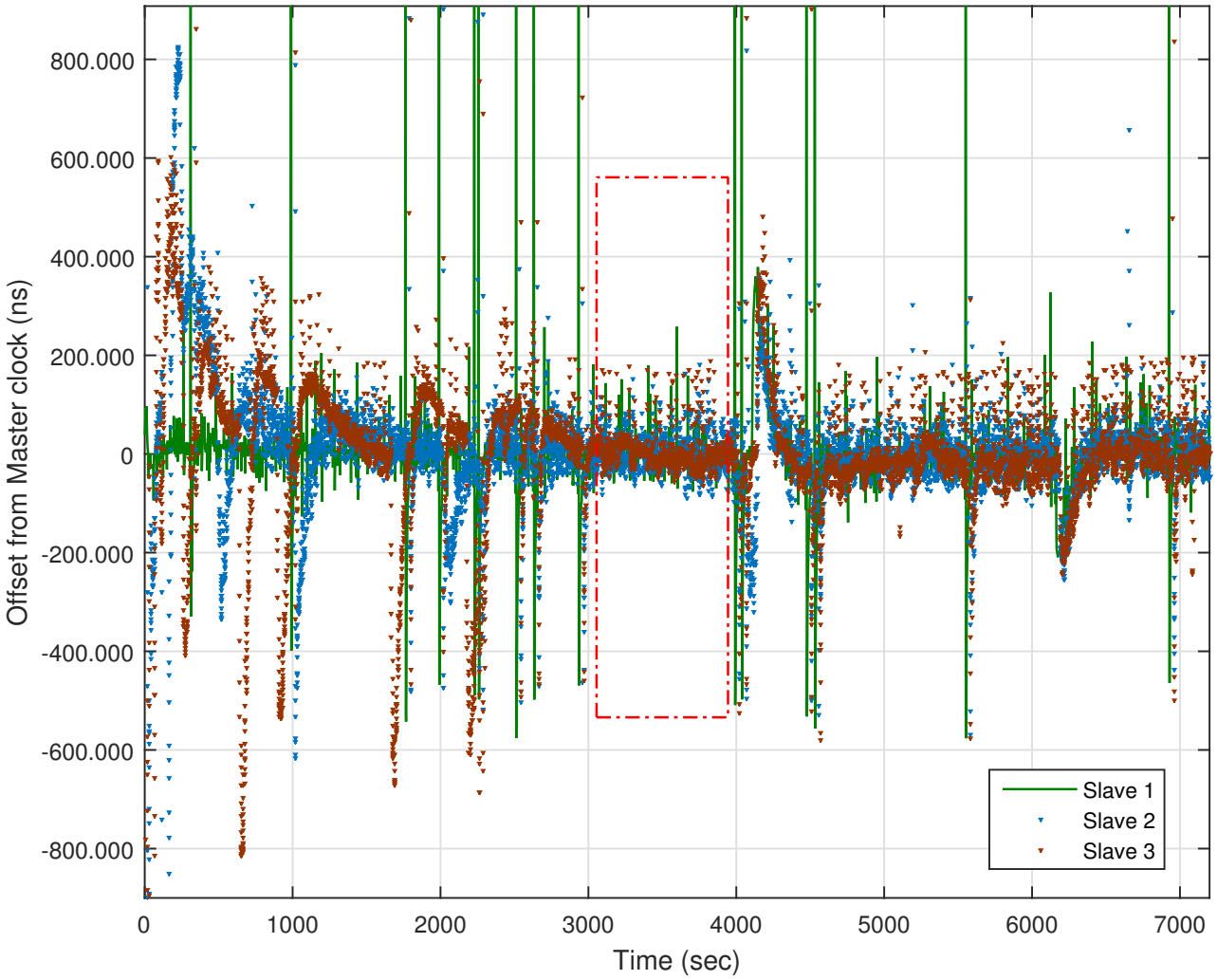






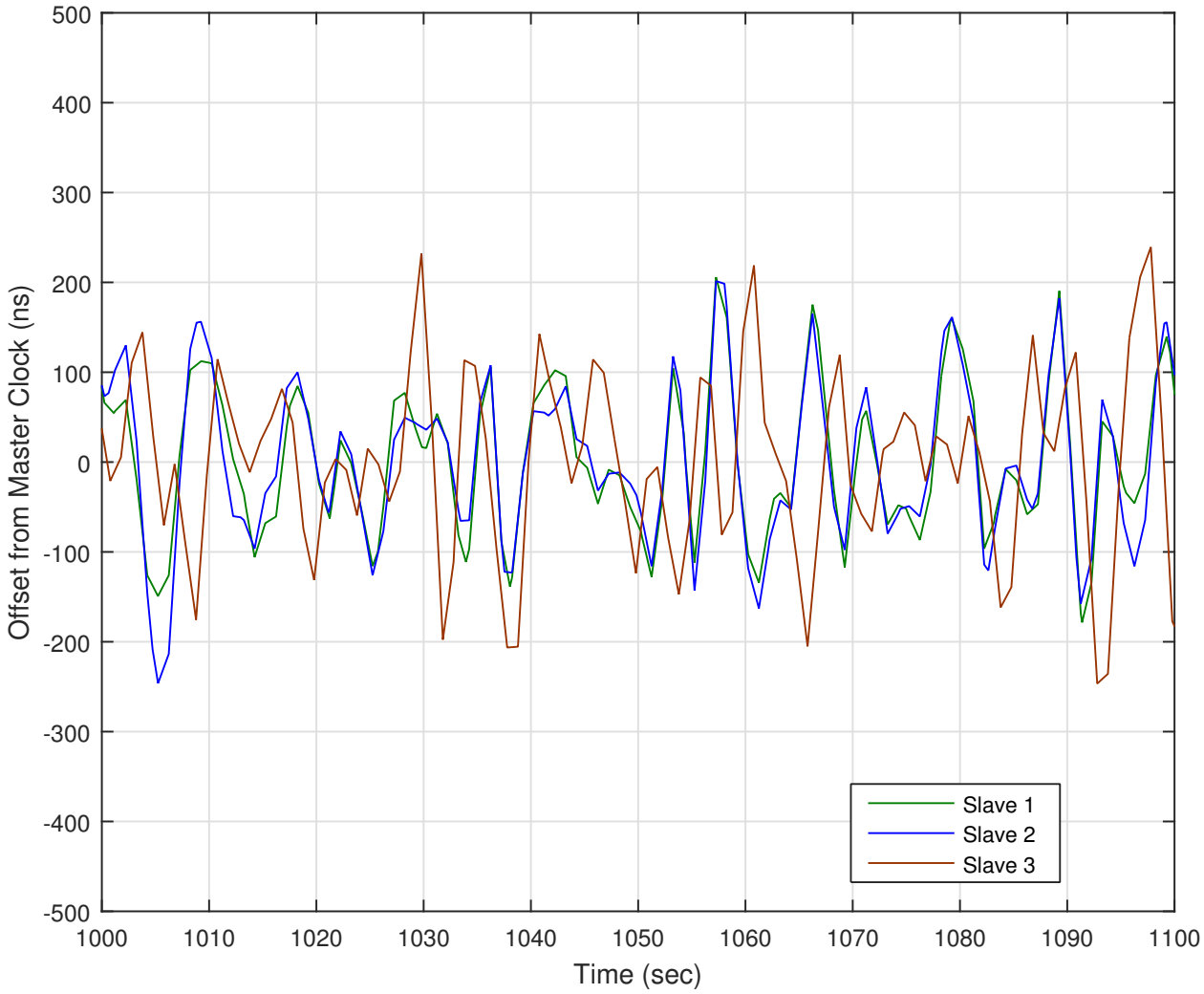
Results/Demo

Software Timestamping based Time Synchronization



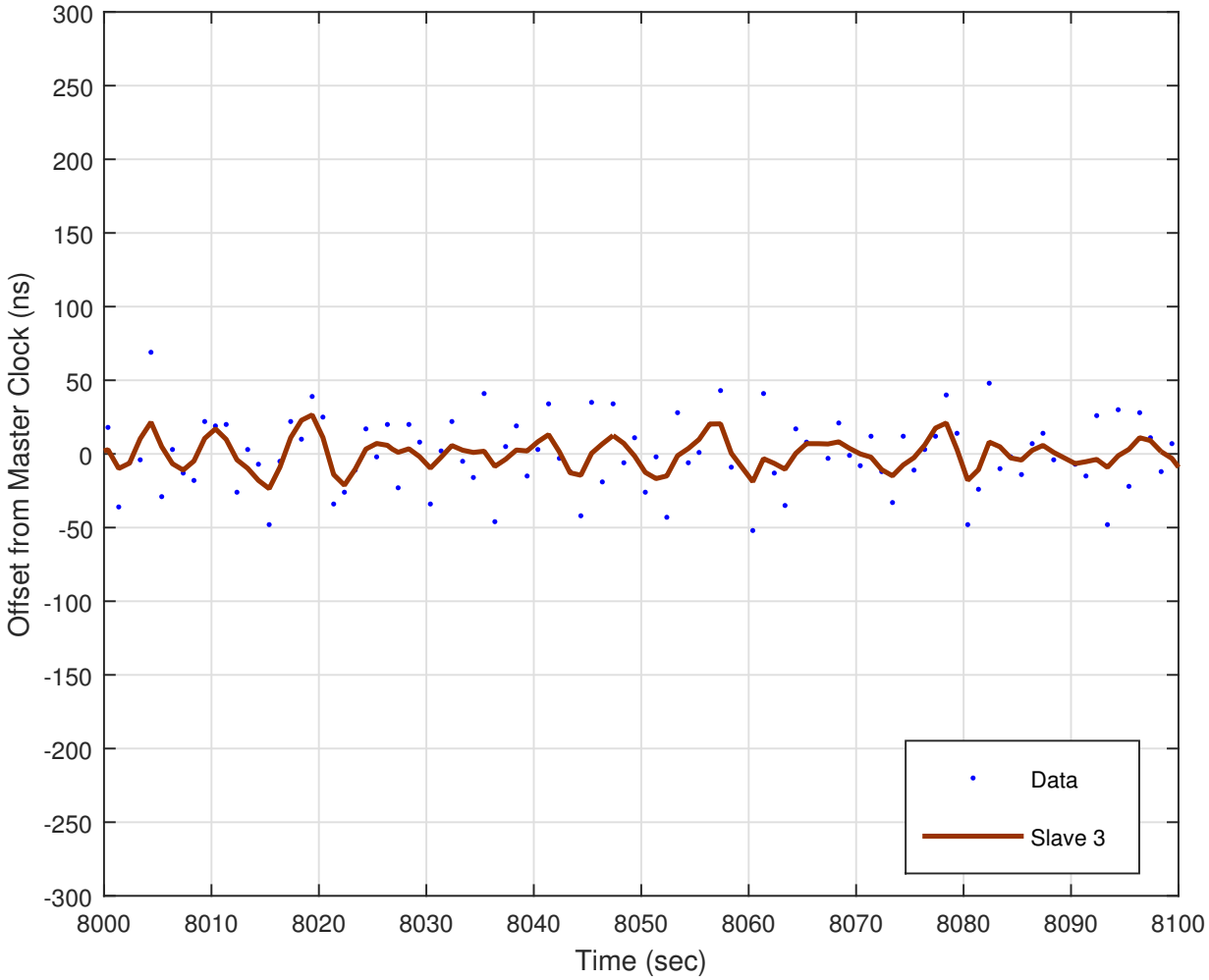
Results/Demo

Hardware Timestamping based Time Synchronization (Multiple Slaves)



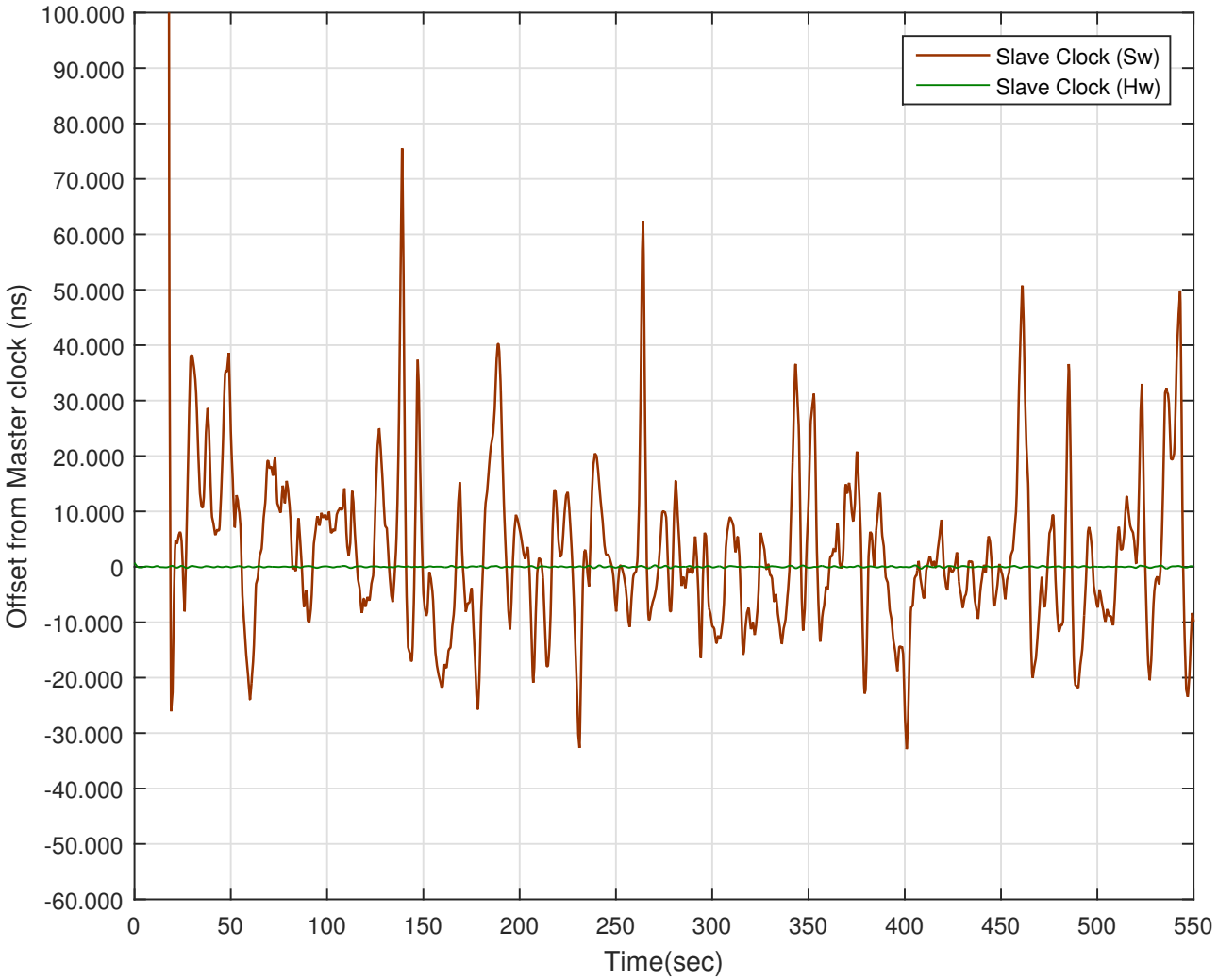
Results/Demo

Hardware Timestamping based Time Synchronization (Single Slave)



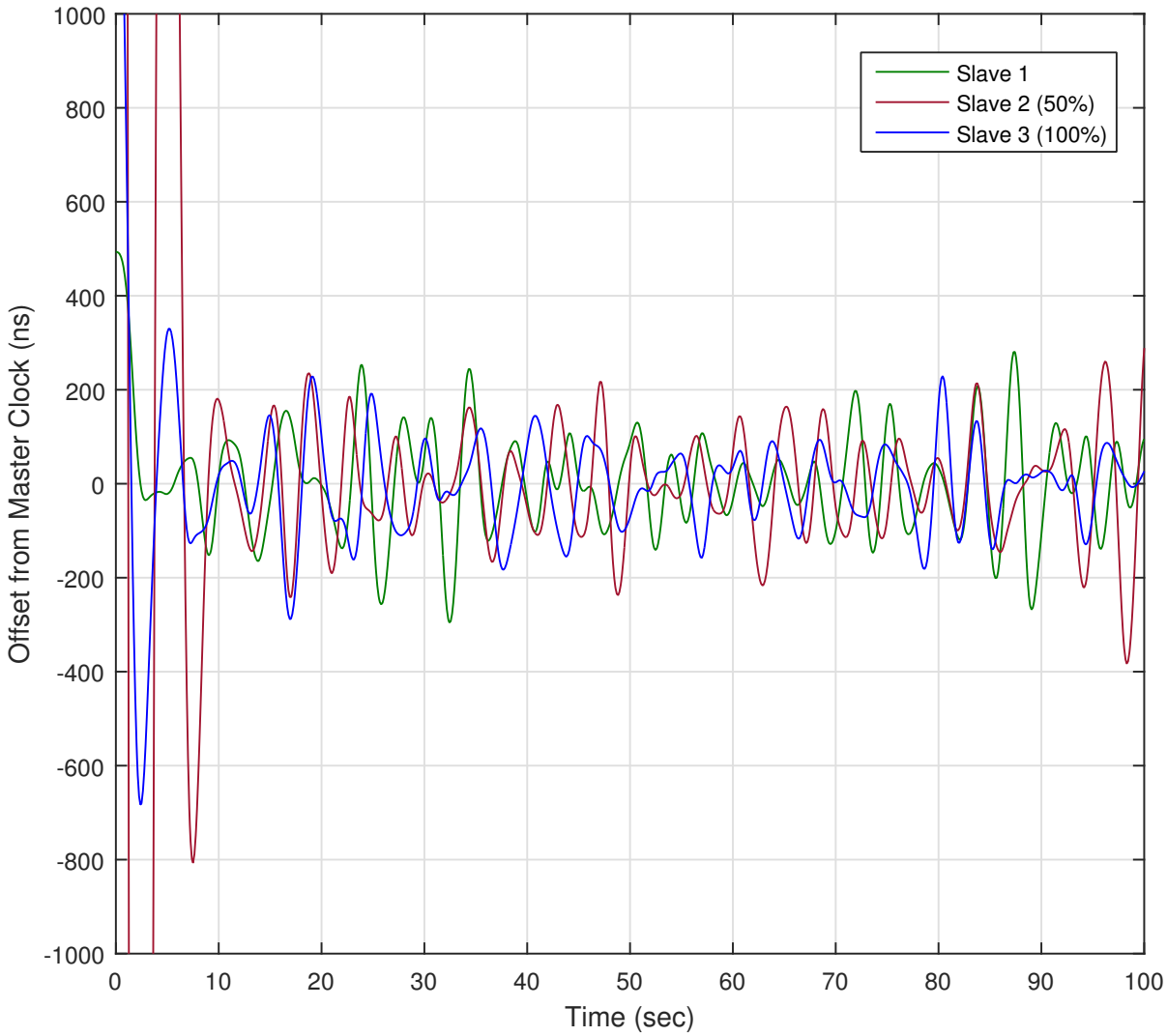
Results/Demo

Comparison of Hardware and Software based Time Synchronization



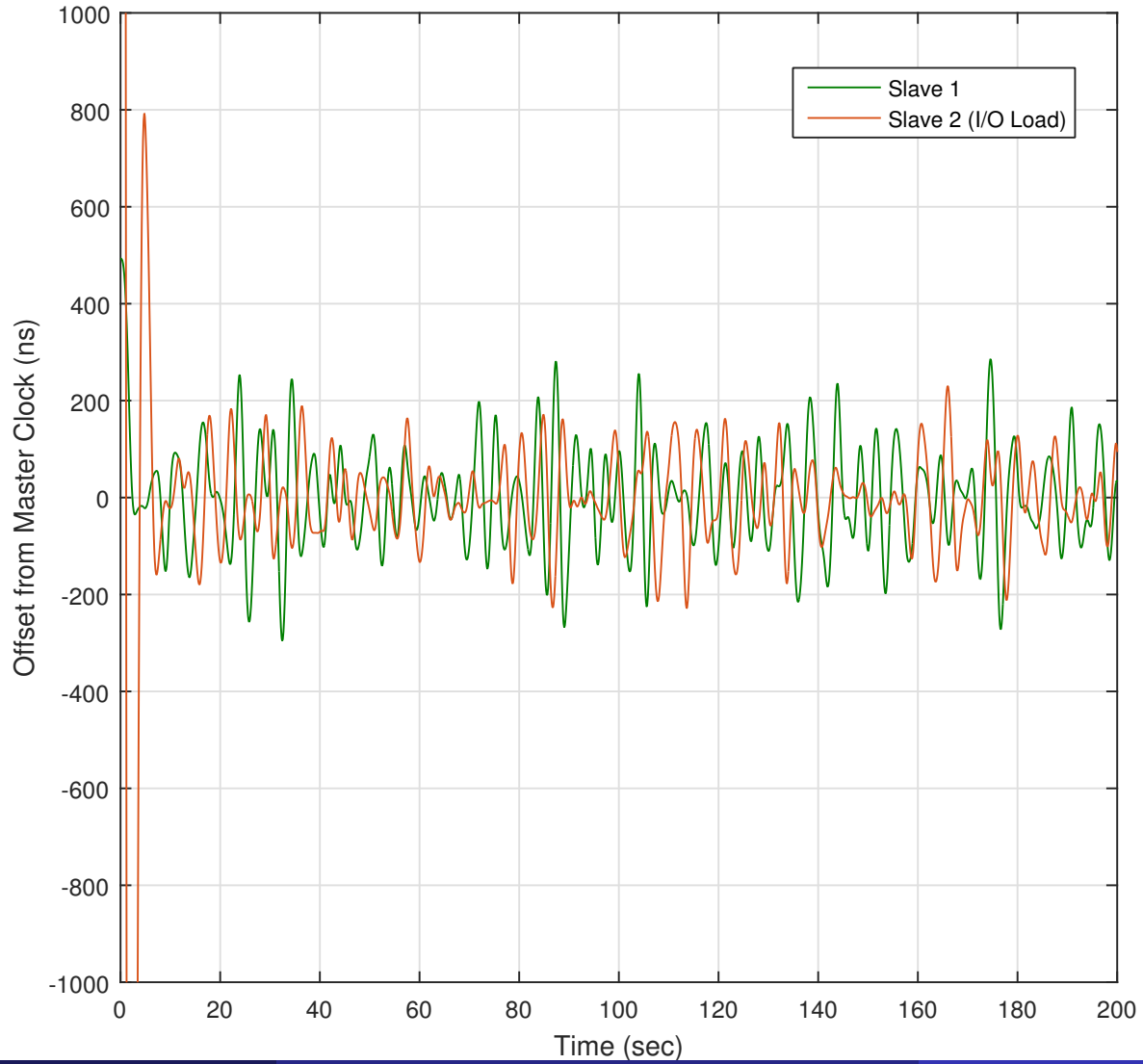
Results/Demo

Hardware Assisted Time Synchronization under CPU Load



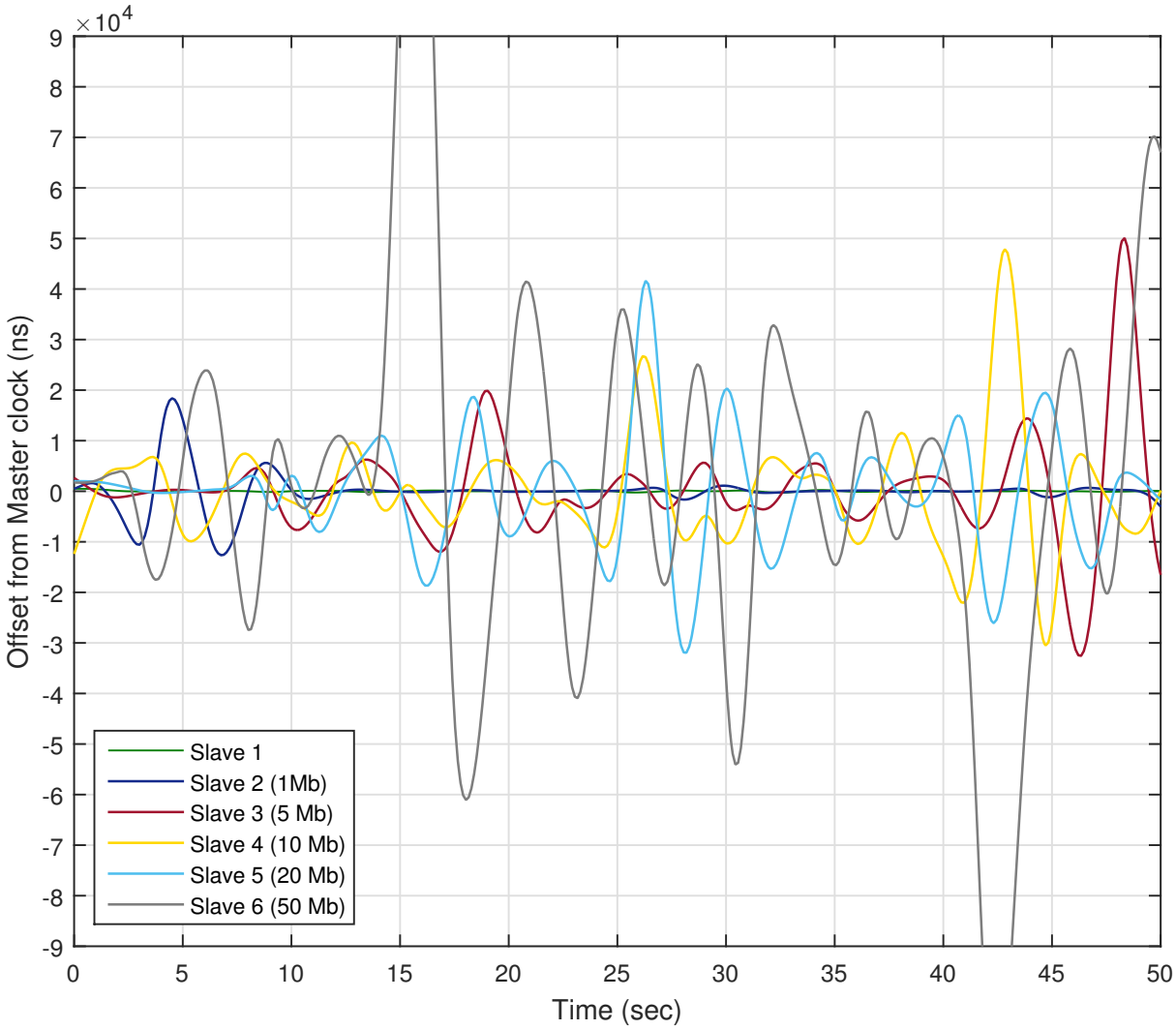
Results/Demo

Hardware Assisted Time Synchronization under I/O Load



Results/Demo

Hardware Assisted Time Synchronization under Network Load



Summary

- In Software only solutions,the average offset of slave clocks remained between $\pm$ 0.5ms
- In Hardware based implementations, the accuracy of $\pm$ 200ns was frequently achieved.
- In load case scenarios, apparently network traffic based tests showed some considerable effects.

References I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IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.
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