Hardware User Guide

V1.0.0

Intelligence at the speed of light™

Introduction

Thank you for choosing Cepton. Led by industry veterans with over 25 years of collective experience across a wide range of advanced lidar and imaging technologies, we aim to provide state-of-the-art, intelligent, lidar-based solutions for a range of markets such as autonomous driving, ADAS, intelligent traffic systems, security, crowd analytics, and industrial robotics.

Powered by our patented Micro Motion Technology (MMT™), this lidar sensor features a unique scan pattern to deliver dense and uniformly distributed point cloud for long-range and high-resolution 3D sensing – you should be able to see it soon, so enough advertising – let's get started!

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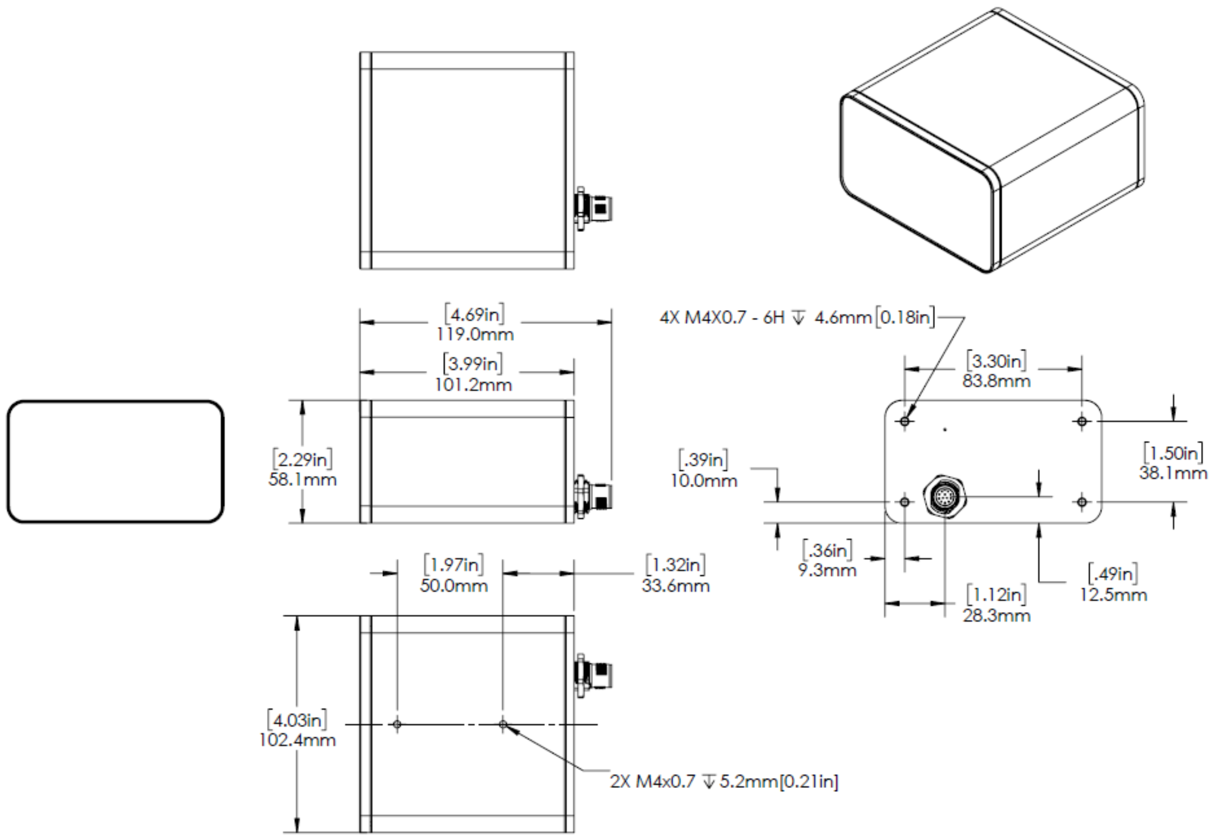
1. Mechanical Interface

1.1 Included Components

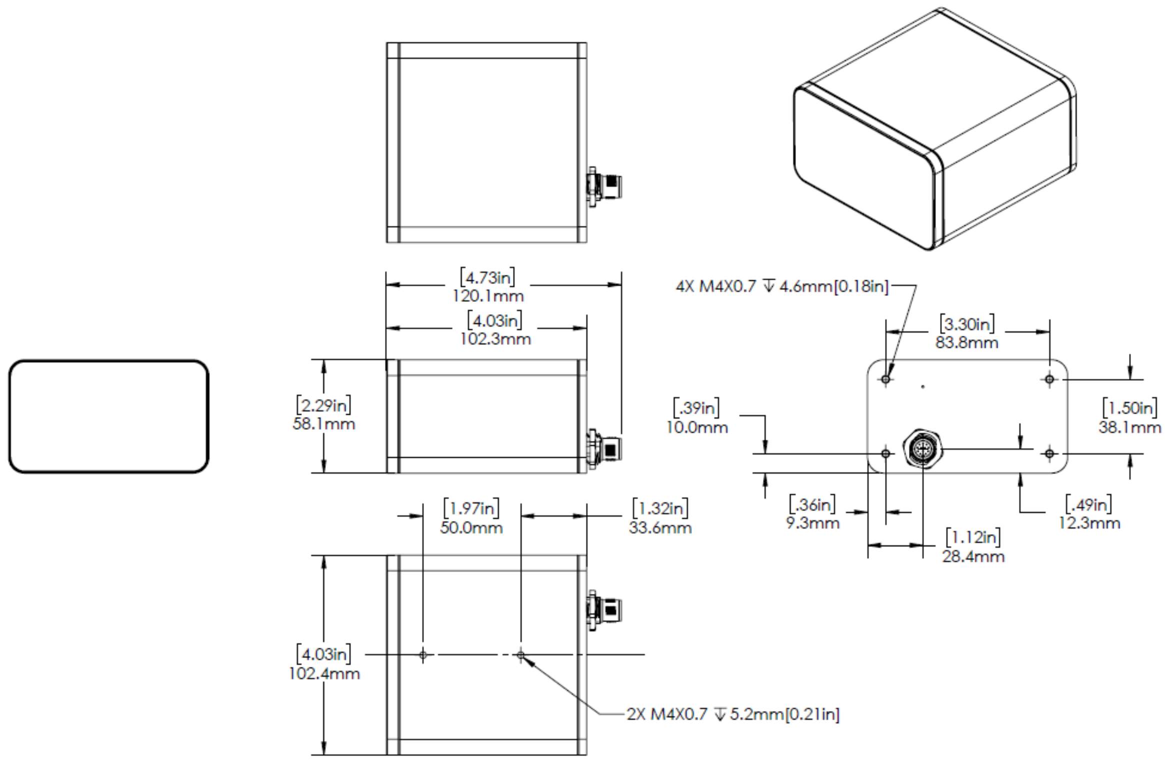
- Cepton Sensor: Vista-P / Vista-X / Vista-H Series
- M12 RJ45 Sensor Interface Cable (3m)
- Sensor 12v Power Supply

Figure 1. Cepton Lidar Sensor (left), M12 RJ45 Interface Cable (middle), 12v Power Supply (right)

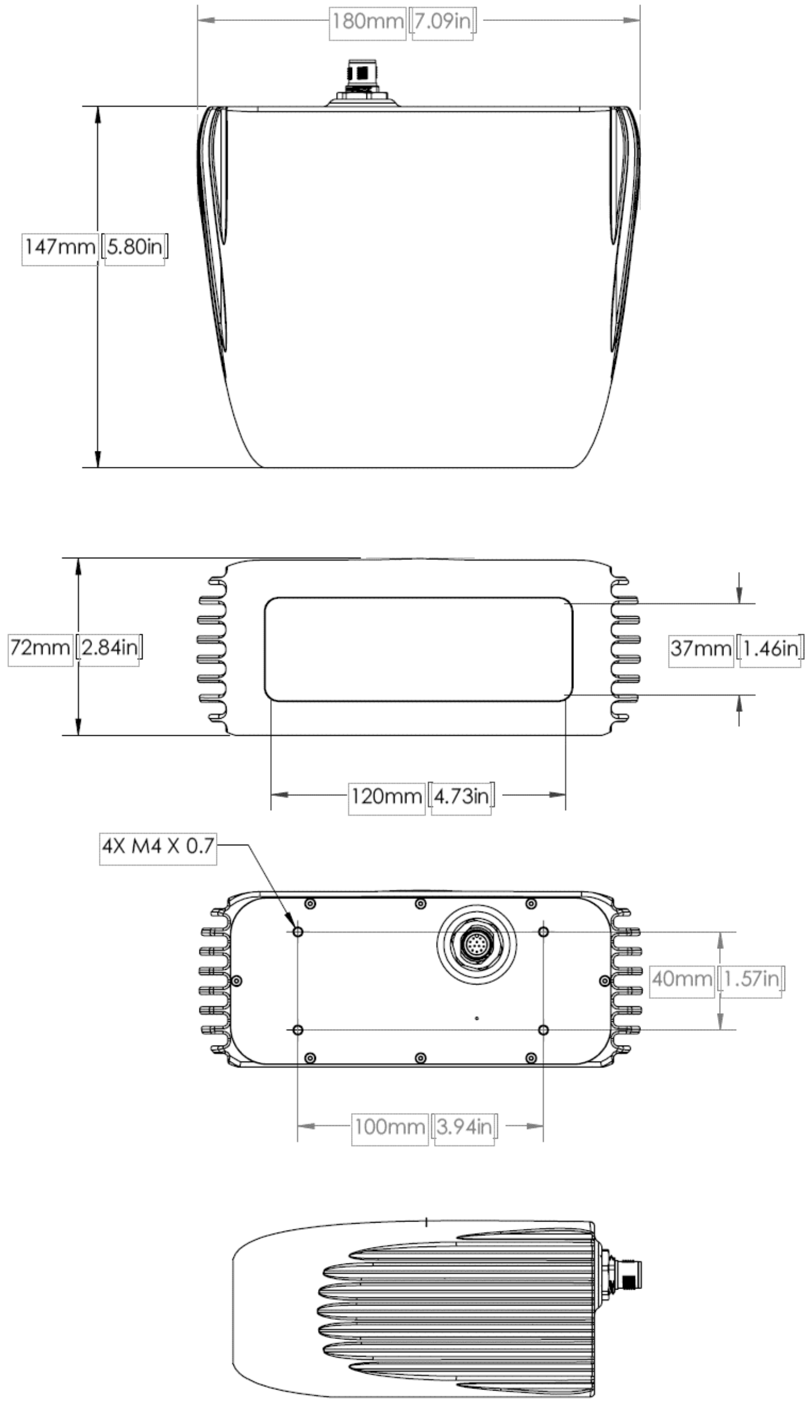
1.2 Exterior Dimension of Vista-P60, Sora-P60



1.3 Exterior Dimension of Vista-P90



1.4 Exterior Dimensions of Vista-X Series

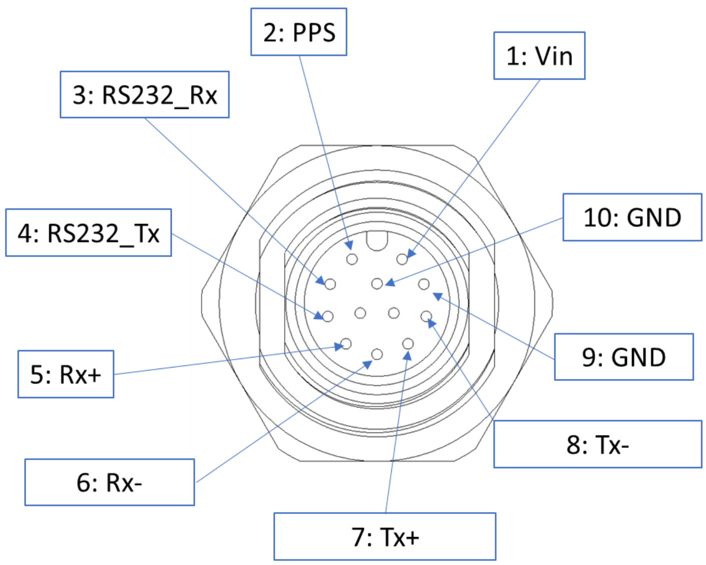


The Vista X sensor has 4 M4x07 mounting holes.

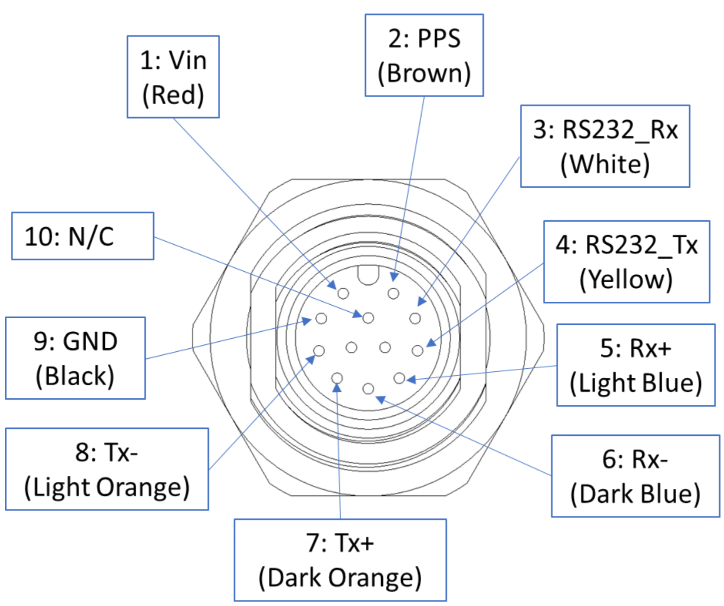
2. Electrical Interface

- M12 Male: Phoenix Contact 1404419
- M12 Female (straight): Phoenix Contact 1404420
- M12 Female (right angle): Phoenix Contact 1404423

2.1 Vista M12 Panel Male Connector Pinout



2.2 M12 Female Connector Pinout



2.3 M12 Female Interface Cable

Signal Name	Description	Pin Number	Direction
12v	Power	1	Input
PPS	Pulse Per Second Signal	2	Input
RS232_Rx	RS-232 Received Data	3	Input
RS232_Tx	RS-232 Transmit Data	4	Output
Rx+	Ethernet Rx+	5	N/A
Rx-	Ethernet Rx-	6	N/A
Tx+	Ethernet Tx+	7	N/A
Tx-	Ethernet Tx-	8	N/A
GND	Ground	9	Input
N/A	Not Connected	10	N/A
N/A	Not Connected	11	N/A
N/A	Not Connected	12	N/A

2.4 DB9 Female Interface (Cepton Lidar Sensor)

Signal Name	Description	Pin #	Direction
PPS	Pulse Per Second Signal	1	Input
RS232_Tx	RS-232 Transmit Data	2	Output
RS232_Rx	RS-232 Received Data	3	Input
N/A	Not Connected	4	N/A

GND	Ground	5	Input
N/A	Not Connected	6	N/A
N/A	Not Connected	7	N/A
N/A	Not Connected	8	N/A
N/A	Not Connected	9	N/A

2.5 DB9 Male Interface (GPS)

Signal Name	Description	Pin #	Direction
PPS	Pulse Per Second Signal	1	Output
RS232_Rx	RS-232 Received Data	2	Input
RS232_Tx	RS-232 Transmit Data	3	Output
GND	Ground	5	Output

2.6 RS-232 Signal Requirement

Property	Value
Logical 1 Voltage	-15V to -3V
Logical 0 Voltage	3V to 15V
Baud Rate	Configurable (from 300bps to 115200bps)
Data Bits	8
Stop Bit	1
Parity	None

2.7 PPS Signal Requirement

Property	Value
Frequency	1Hz
Voltage	1.8V - 5V
Polarity	Positive Polarity
Min Pulse Width	5µs
Min Interval between 2 Pulse	400ms

2.8 NMEA Sentence Requirement

Property	Value
Frequency	1Hz
Format	$GPRMC, GNRMC
NMEA 2.30 Mode	OFF

2.9 Timing Requirement

Property	Value
Min Interval between NMEA and PPS	10µs
Max Interval between NMEA and PPS	500ms

3. Drivers and Interface

3.1 Ethernet

The sensor will start sending packets via Ethernet as soon as the power is connected. The default sensor IP address is of the form 192.168.*.* , and it sends UDP broadcast packets on port 8808.

On Ubuntu, it is necessary to assign a static IP address to the host computer's Ethernet interface (e.g. IP= 192.168.0.1 , Netmask= 255.255.0.0). This can be done through the NetworkManager GUI.

NOTE: *If the Ethernet end of the interface cable is not plugged in, the sensor will have a delayed start-up time. To prevent this, please make sure it is plugged in first before you power on the sensor.*

4. Time Synchronization

A GPS unit or MasterClock can be connected to the sensor to provide timestamp synchronization.

4.1 GPS

If a GPS device is connected, point timestamps are based on the GPS clock, otherwise they are based on the host computer's clock. The sensor listens for the NMEA sentence and the PPS (pulse per second) signal. The sensor does not use the location data from the GPS, but NMEA forwarding is enabled. The GPS is only used for timestamp synchronization. To connect your GPS device to our sensor, please review the cable pin-out in the Mechanical Interface section. Our standard sensor cable uses a DB9 female connector and is optional for your use. The recommended pulse length for the sensor to receive a PPS signal is 1 millisecond.

4.2 Time Sync Accuracy

NMEA input only

Your sensor will work without the PPS sync signal. However, connected only to NMEA, it can only achieve the time accuracy that the NMEA string provides. For example, if the timestamp in NMEA is in the format of HHMMSS.xx, the time synchronization can only achieve 10ms accuracy.

PPS input only

Your sensor will not respond to a PPS only input.

NMEA + PPS

This two-step synchronization will enable your sensor to have sub-microsecond accuracy.

4.3 PTP

Using PTP / IEEE 1588 which distributes a master clock over ethernet and tunes out the delay between the master clock and the end node.

Our sensor uses IEEE 1588v2, hardware timestamp based, peer-to-peer delay mechanism over layer 2, sync frequency 1Hz.

4.3.1 Quick Start PTP

See Appendix A: Implementing PTP for more advanced instructions.

1) Install PTP

```
sudo apt install linuxptp
sudo ptp4l -H -2 -P -i enp1s0
```

2) User Wireshark to check for PTP packets

3) Update /lib/system/system/ptp4l.service for start on reboot

```
[Unit]
Description=Precision Time Protocol (PTP) service

[Service]
Type=simple
ExecStart=/usr/sbin/ptp4l -H -2 -P -i enp1s0

[Install]
WantedBy=multi-user.target
```

4) Set sensors to Unicast mode by giving them a destination address other than 255.255.255.255

5) Check PTP tick box is ticked in CeptonViewer when connected to the sensor

6) Set target PC address to that setup on the sensors in 3)

5. Updating Firmware

Sensor firmware update capabilities will be available in the near future.

6. Troubleshooting

The CeptonViewer is a great tool to debug your sensor. It provides you rich sensor information for quick diagnostics, and the ability to quickly record the information to a pcap that can easily be shared with Cepton Support. Go to the link below to download the CeptonViewer.

https://github.com/ceptontech/cepton_sdk_redist/tree/master/setup

- Check to see if cables and connectors are fastened tightly. If the sensors ethernet cable is not connected to a host network before power is applied, the sensor may have a delayed start-up.
- Make sure the sensor is getting adequate power. You can use a voltmeter to check the M12 connector end. The sensor is mechanical, and a small vibration can be felt when the sensor is powered on.
- Firewall or Network/Adapter settings may be blocking network access.

Please contact support@cepton.com or submit a ticket through the **Cepton Help Center** if you have any technical questions. Do not attempt to open or repair the sensor yourself. It is prohibited by the terms to remove or open the product housing, inspect the internal of the product, reverse-engineer any part of the product, or permit any third party to do any of the foregoing.

7. Sensor Specifications

For product specifications, please contact Cepton Technologies to get access to datasheets.

8. Laser Specifications

Class	Class 1 per IEC 60825-1:2014 Maximum laser power: 5.25E-08 J (IEC 60825-1:2014, condition 3)
Type of Laser	Semiconductor diode
Wavelength	904 nm (20° C)
Radiation Mode	Pulse
Pulse Repetition Rate	1KHz < repetition rate < 100KHz
Pulse Width	1 nsec < pulse width < 100 nsec
Average Power	< 10 mWatt
Peak Power	< 200 Watt
Output Power per Pulse	< 1 E-6 J

9. Appendix A: Implementing PTP

This section explains in more detail how to setup PTP to work with our sensors.

9.1 Equipment Required

- Cepton sensors with PTP capability
- Cepton sensor cables
- A network switch which passes PTP packets and supports hardware packet timing (see Appendix 2)
- A PTP Server capable of acting as a Grand Master Clock source (See appendix 1)
- RJ45 Ethernet cables for Cepton Edge Box and demo computer

9.2 PTP Server Setup

A PTP Server / Grand Master Clock source is used to give a common clock to synchronize all the sensors the network. This example uses the Nvidia Jetson TX2 board which features an ARM processor capable of running full Ubuntu.

Install Ubuntu 16.04 or 18.04 on the server.

Set the Ethernet Interface ip address to match the network being used and the netmask to 255.255.0.0 or /16. Which in this case results in 192.168.0.0/16.

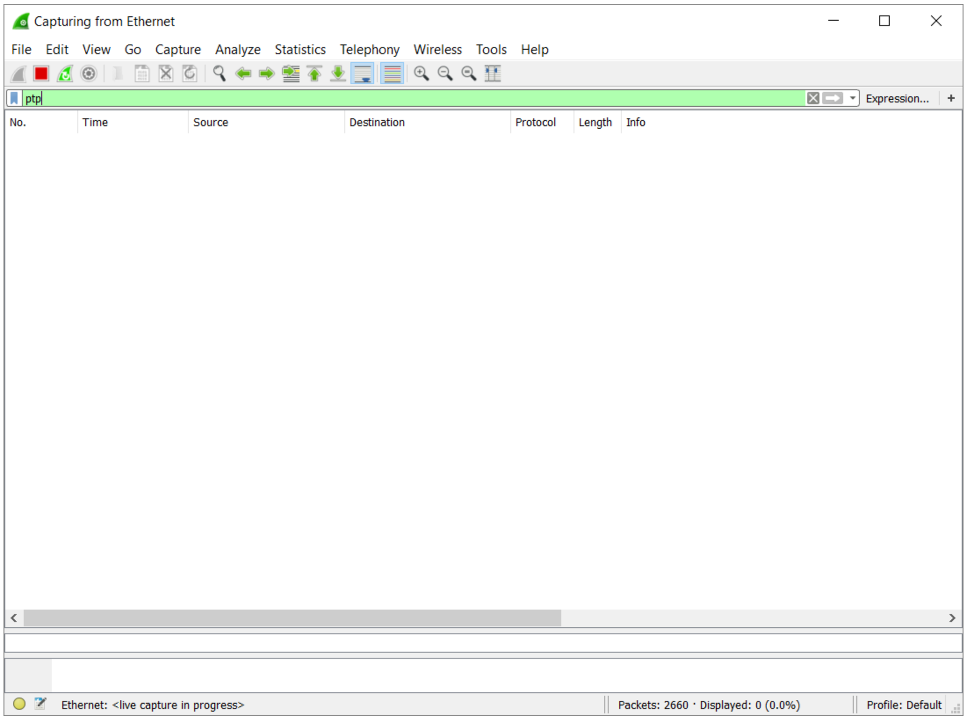
Install ptp4l as follows (internet connection required):

```
sudo apt install linuxptp
sudo ptp4l -H -2 -P -i [ethernet interface name]
```

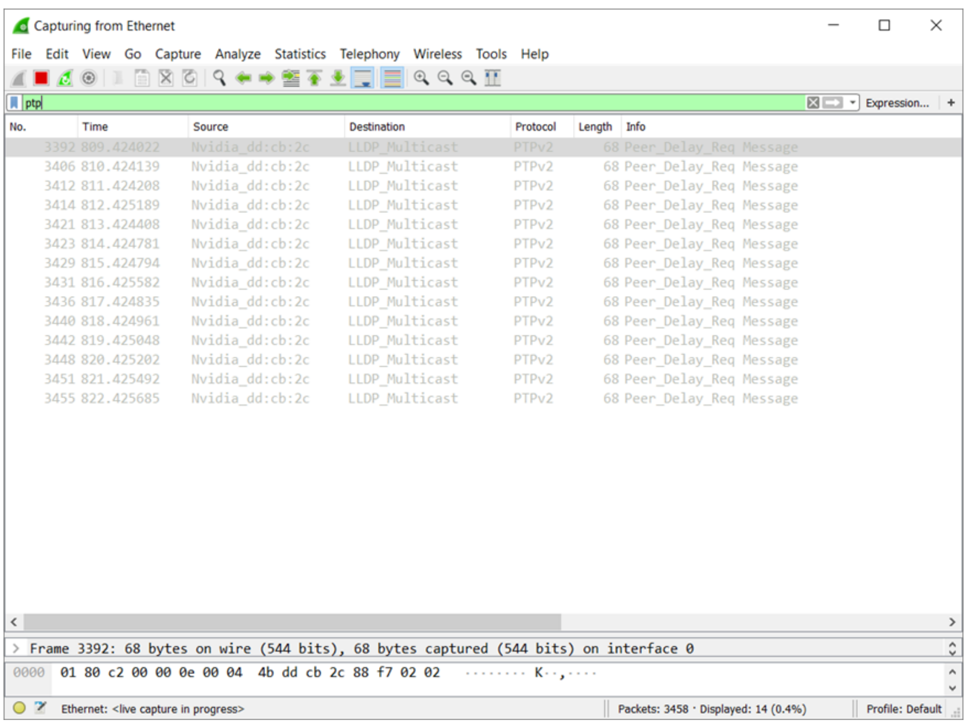
In this case the interface name is enp1s0 giving

```
sudo ptp4l -H -2 -P -i enp1s0
```

To ensure that the PTP server is working, use Wireshark with the filter “ptp”. Before the command is given to start the PTP server nothing will be shown.



After the PTP server is started you will see PTP messages coming from the server.



9.3 Setting the PTP server to start from power up

The PTP server must restart when power is cycled on the server. To make this happen, edit the file /lib/system/system/ptp4l.service and change the command line used to start ptp4l to `sudo ptp4l -H -2 -P -i enp1s0` the file will look something like this before the change

```
[Unit]
Description=Precision Time Protocol (PTP) service

[Service]
Type=simple
ExecStart=/usr/sbin/ptp4l -f /etc/linuxptp/ptp4l.conf -i eth0

[Install]
WantedBy=multi-user.target
```

And this after

```
[Unit]
Description=Precision Time Protocol (PTP) service

[Service]
Type=simple
ExecStart=/usr/sbin/ptp4l -f /etc/linuxptp/ptp4l.conf -i eth0

[Install]
WantedBy=multi-user.target
```

Where enp1s0 is the ethernet interface where the PTP timing output is required.

9.4 Sensor Setup

If there are more than 3 sensors on the network, the sensors should be set for unicast operation. This is accomplished by setting a destination network address of something other than 255.255.255.255.

Note that as the sensor is in unicast mode to be able to see it in CeptonViewer it will have to be running on the computer which has the destination address set in the sensor. In addition, if no point cloud is seen on the target computer, then there is probably already an application that's consuming the unicast UDP data stream from port 8808. To fix this, either stop the application that's using port 8808 or change the port used by the sensors. (See appendix 3).

9.5 Check that the sensor sees the PTP packets

In CeptonViewer, check the sensors point cloud and check that the sensor is receiving and locking to PTP by clicking on the 'Sensor' button under found under the 'General' button. This will display information about the selected sensor. There is a tick box for PTP and it should be ticked. If you have more than one sensor connected, you can select another sensor by click on the colored button with the sensor serial number.

The PTP system is now running.

9.6 Selecting PTP Server Hardware

A server that can be used as the PTP Grand Master clock server must support packet timestamping in hardware. To find out if a device has hardware packet time stamping use the `ethtool -T <network interface>` command in Ubuntu:

```
nvidia@perception_box:~$ ethtool -T enp1s0
Time stamping parameters for enp1s0:
Capabilities:
        hardware-transmit     (SOF_TIMESTAMPING_TX_HARDWARE)
        software-transmit     (SOF_TIMESTAMPING_TX_SOFTWARE)
        hardware-receive      (SOF_TIMESTAMPING_RX_HARDWARE)
        software-receive      (SOF_TIMESTAMPING_RX_SOFTWARE)
        software-system-clock (SOF_TIMESTAMPING_SOFTWARE)
        hardware-raw-clock    (SOF_TIMESTAMPING_RAW_HARDWARE)
PTP Hardware Clock: 1
Hardware Transmit Timestamp Modes:
        off                   (HWTSTAMP_TX_OFF)
        on                    (HWTSTAMP_TX_ON)
Hardware Receive Filter Modes:
        none                  (HWTSTAMP_FILTER_NONE)
        all                   (HWTSTAMP_FILTER_ALL)
        ptpv1-l4-sync         (HWTSTAMP_FILTER_PTP_V1_L4_SYNC)
        ptpv1-l4-delay-req    (HWTSTAMP_FILTER_PTP_V1_L4_DELAY_REQ)
        ptpv2-l4-sync         (HWTSTAMP_FILTER_PTP_V2_L4_SYNC)
        ptpv2-l4-delay-req    (HWTSTAMP_FILTER_PTP_V2_L4_DELAY_REQ)
        ptpv2-l2-sync         (HWTSTAMP_FILTER_PTP_V2_L2_SYNC)
        ptpv2-l2-delay-req    (HWTSTAMP_FILTER_PTP_V2_L2_DELAY_REQ)
        ptpv2-event           (HWTSTAMP_FILTER_PTP_V2_EVENT)
        ptpv2-sync            (HWTSTAMP_FILTER_PTP_V2_SYNC)
        ptpv2-delay-req       (HWTSTAMP_FILTER_PTP_V2_DELAY_REQ)
```

The following must be present in the command output for the device to work as a PTP server with the accuracy required for this application.

```
SOF_TIMESTAMPING_RAW_HARDWARE
SOF_TIMESTAMPING_TX_HARDWARE
SOF_TIMESTAMPING_RX_HARDWARE
```

As they are in the above example which is a Nvidia Jetson TX2 board.

9.7 Selecting a Network Switch for PTP Compatibility

The Network switch used to connect all the elements together (Sensors, PTP Server & Computer running the application which consumes the point cloud) must support IEEE 802.1as and parts of IEEE 1588. One example of a switch which supports the necessary parts of these standards is the Netgear GS724Tv4 (Manual). The switch must have the relevant IEE 1588 / IEEE 802.1as features enabled through the purchase and application of an AVB licence (Audio Video Bridging) NetGear PN GS724TAV-20000S.

Safety & Legal Notices

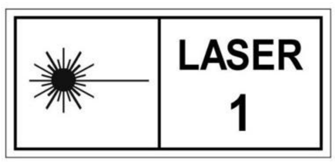
CAUTION! All Cepton lidar sensors are sealed units. To reduce risks of laser radiation and electric shock, and to avoid violating the warranty, do not open the sensor body.

Operating Safety

1. **Read** – All safety and operating instructions should be read before the product is operated.
2. **Retain** – All safety and operating instructions should be retained for future reference.
3. **Follow** – All warnings and operating instructions on the product.
4. **Service** – The user should not attempt to modify or service the product beyond what is described in the operating instructions.

Physical Safety

Contact your service representative for all repair issues or questions about safety if there are visible defects or damage to the Cepton lidar sensor. Refer all service and repairs to authorized support and service representatives.



Laser Safety

The Cepton lidar sensor is designed Class 1 eye safe during all procedures of operation, having satisfied IEC AEL and MPE emission requirements per IEC 60825-1 Ed 3 2014.

CE Compliances

The Cepton lidar sensor complies with the essential requirements of the relevant European health, safety and environmental production legislation as stated in the Harmonized Standards, which are the technical specifications established by European standards agencies.

IP67 Compliance

The Cepton lidar sensor passed Water and Dirt/Dust Ingress Tests in compliance with the IEC 60529 IP67 specification.

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Contact & Support

- **Contact Information**

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- **Support**

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