Guidelines for Integrating Livox LiDARs with GNSS-INS

Document Release History		
Date	**Release**	**Change Description**
2019/1/29	V1.0.0	Initial release

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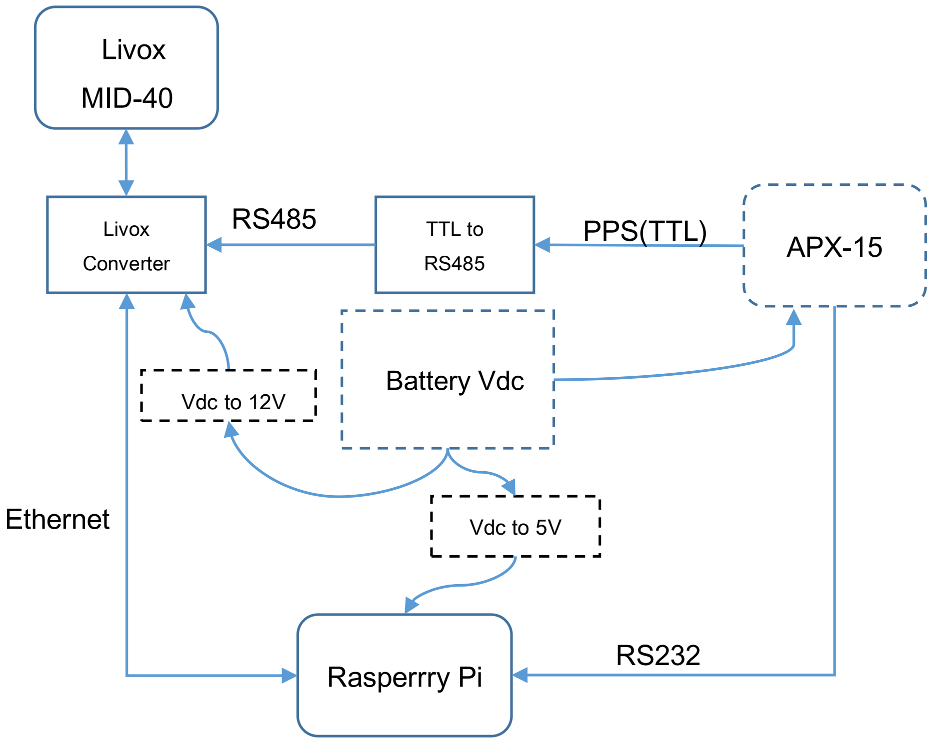
1. Background

With their high performance, Livox LiDARs can be used in a variety of applications including autonomous driving, UAVs, high precision mapping. Among these applications, it is a common practice to fuse the LiDAR point cloud data with a GNSS-INS system to compensate any motion during the data collection. In this document, we provide a guideline for users to integrate Livox LiDARs to a GNSS-INS system. We will take two GNSS-INS modules as explanatory examples: APX-15 and uINS Module.

2. List of Devices

1. Livox MID-40
2. Livox Converter
3. APX-15 module
4. TTL-RS485 Converter
5. Onboard Computer with SD card(Raspberry Pi 3 B+)
6. DC-DC Converter(Ouput:12V, 10A for Livox LiDAR)
7. DC-DC Converter(Output:5V, 3A for Raspberry Pi)

3. System Blockdiagram



Remarks:

1、 The required voltage range for Livox MID-40, Raspberry Pi, and APX-15 are 10~16V, 5V and 8~32V, respectively. DC-DC converters with proper output voltage level are needed in case Vdc is not in the respective range.
2、 The PPS output of APX-15 is in TTL level, while the PPS input of Livox MID-40 is RS485. A TTL-RS485 Converter is needed to convert the signal level.
3、 Livox MID-40 transmits point cloud data to Raspberry Pi via Ethernet port.
4、 APX-15 transmits pose data to Raspberry Pi via RS232 port.
5、 Raspberry Pi supports SD cards for data storage.
6、 GPS antenna of the APX-15 should be placed at proper locations to avoid interference from other modules.

4. Time Synchronization

Once powered on, APX-15 will sample and process pose (position and attitude) data at a given rate, the data are packed with the GPS time and sent to the Raspberry Pi via the RS232 port. Meanwhile, the APX-15 transmits one pulse per second and the rising edge of each pulse (the rising edge) occurs at every integer seconds (i.e., 1 sec, 2 sec, 3 sec…).

A Livox LiDAR sends data packets to Raspberry Pi via the Ethernet port at 1kHz (1000 data packets per second). Each data packet has a timestamp, 100 points data, and status information (the manual of Livox MID-40). The timestamp indicates the time (in nano-seconds) of the first data point within this packet from the rising edge of the most recent pulse occurs on the LiDAR PPS port. As the LiDAR samples points at a regular time period (10us for MID40 and each of the three units within a MID100), the timestamp for each point within a packet could be inferred from the timestamp of the first point.

Assume the GPS time is time T_A ms within week W_A , and the timestamp in a Livox LiDAR data packet is T ms , below pseudo codes show how to align the time-line of point data from Livox LiDARs to that of APX-15. In below pseudo codes, W_L denotes the week number of the timestamp of the point cloud data packet and T_L denotes the time in ms within that week.

T_{Ams} = T_A mod 1000

T_{As} = FlOOR (T_A / 1000)

IF | T_A – T | < 500 **THEN**

$T_L = T_{As}$ *1000 + T

WL = WA

ELSE IF T_{Ams} > T **THEN**

$T_L = (T_{As} + 1)$ * 1000 + T

IF T_L > 7 * 24 * 3600 *1000 **THEN**

T_L = T

$W_L = W_A + 1$

ELSE IF T_{Ams} < T **THEN**

$T_L = (T_{As} - 1)$ *1000 + T

IF T_L < 0 **THEN**

T_L = 7 * 24 * 3599*1000 + T

$W_L = W_A - 1$