APEX Embedded Artificial Intelligence Computer

User Manual

V2.3 2020.1



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Revisions

Revisions

Version v2.3

Revision	Date	Release Note
v1.0	2019/02/21	Initial release
v1.1	2019/3/8	Add Adayo GMSL Camera
v2.0	2019/4/27	Modify UART Port Modify DIP Switch
v2.2	2019/10/18	Restructure manual Add Setting Function
v2.3	2020/1/6	Change product name Add interface voltage

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Notice

Please read manual carefully before install, operate, or transport APEX

- Ensure that the correct power ange is being used before powering the device.
- Avoid hot plugging.
- Do not unplug APEX before shutting down the system.
- Do not use cables or connectors other than described in this manual.
- Do not use APEX near strong magnetic fields.
- Backup your data before transportation or APEX is idle.
- Recommend to transport APEX in its original packaging.

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Introduction

Apex

Apex is an embedded computing platform based on NVIDIA Jetson AGX Xavier. With waterproof and shockproof connectors and powerful computer vision processing capability, Apex is designed for autonomous machines, especially for outdoor environment use. Apex Xavier offers synchronization feature, which is essential for multi-sensor fusion. In addition, a variety of computer vision algorithm acceleration SDK are provided on Apex platform.

Included in the Box

- Apex ×1
- Power Supply with AC cord×1
- I/O Cable Assemblies×1
- 4G Antenna×2
- WiFi Antenna×2

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Specifications

Processor

Processor	NVIDIA Jetson AGX Xavier
CPU	8-core ARM v8.2 64-bit CPU
GPU	512-core Volta GPU
Memory	16GB 256-Bit LPDDR4
DL Accelerator	2×NV DLA Engines
Storage	32GB eMMC 5.1

I/O

	Interface	Quantity	Note
Network	Ethernet	1×8pin Waterproof Gigabit Ethernet port 1×RJ45 Gigabit Network port	Alternative RJ45 and waterproof port
	WIFI	1	2.4G/5.8G 300Mbps
Camera	Camera	8×CSI 1 Lane GMSL FAKRA Z TYPE	9V Transmission distance up to 15 meters
Video output	Video out	1×GMSL FAKRA Z TYPE	
	HDMI	1×HDMI 2.0 TYPE A	
USB	USB	2×USB 3.1 TYPE A 1×Micro USB	USB 5V, 1A Micro USB 5V, 0.5A
I/O	GPIO	5xGPIO	IN 0-12V, OUT 3.3V
	CAN	2	DB9 Terminal
	UART	1xDebug 2xTTL/RS232 2xRS232/422/485	DB9 Terminal TTL 3.3V
	SPI	1	3.3V
	I2C	1	3.3V
	I2S	1	3.3V
	Sync I/O	1xSYNC_IN 2xSYNC_OUT 2xSYNC_PPS	DB9 Terminal SYNC_IN 0-12V, SYNC_OUT 3.3V, SYNC_PPS 3.3V
User Expansion	TF	1xTF Slot	MicroSD card supported
	M.2	1×M.2 M Key 1×M.2 B Key	Full length NVME SSD 4G LTE
Function Key	Power KEY	1	Button
	Reset KEY	1	Button
	Recovery KEY	1	Button

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Power Supply

Power Sypply	Spec
Input Type	DC
Input Voltage	Wide input 12-50V DC
Typical consumption	30W

Mechanical

Mechanical	Spec
Dimensions (W×H×D)	245mm×68mm×172mm (I/O ports and mounting holes included) 213mm×68mm×143mm (I/O ports and mounting holes excluded)
Weight	2.2Kg

Environmental

Environmental	Spec
Operating Temperature	-20℃-70℃, 0.2~0.3m/s air flow[4]
Storage Temperature	-25℃-80℃
Storage Humidity	10%-90% non-condensing
Vibration	10Hz~200Hz 1m2/s3, 3 Axis 200Hz-500Hz 0.3m2/s3, 3 Axis[5]
Protection	IP67[6]

Certification

Certification	Status
CE	Passed
CCC, FCC, RoHS, SRRC	Processing

4. According to GB/T 2423-2008 Working frequency is subject to change after temperature reaches 60°C ↩

5. According to GB/T 4798.5-2007 ↩

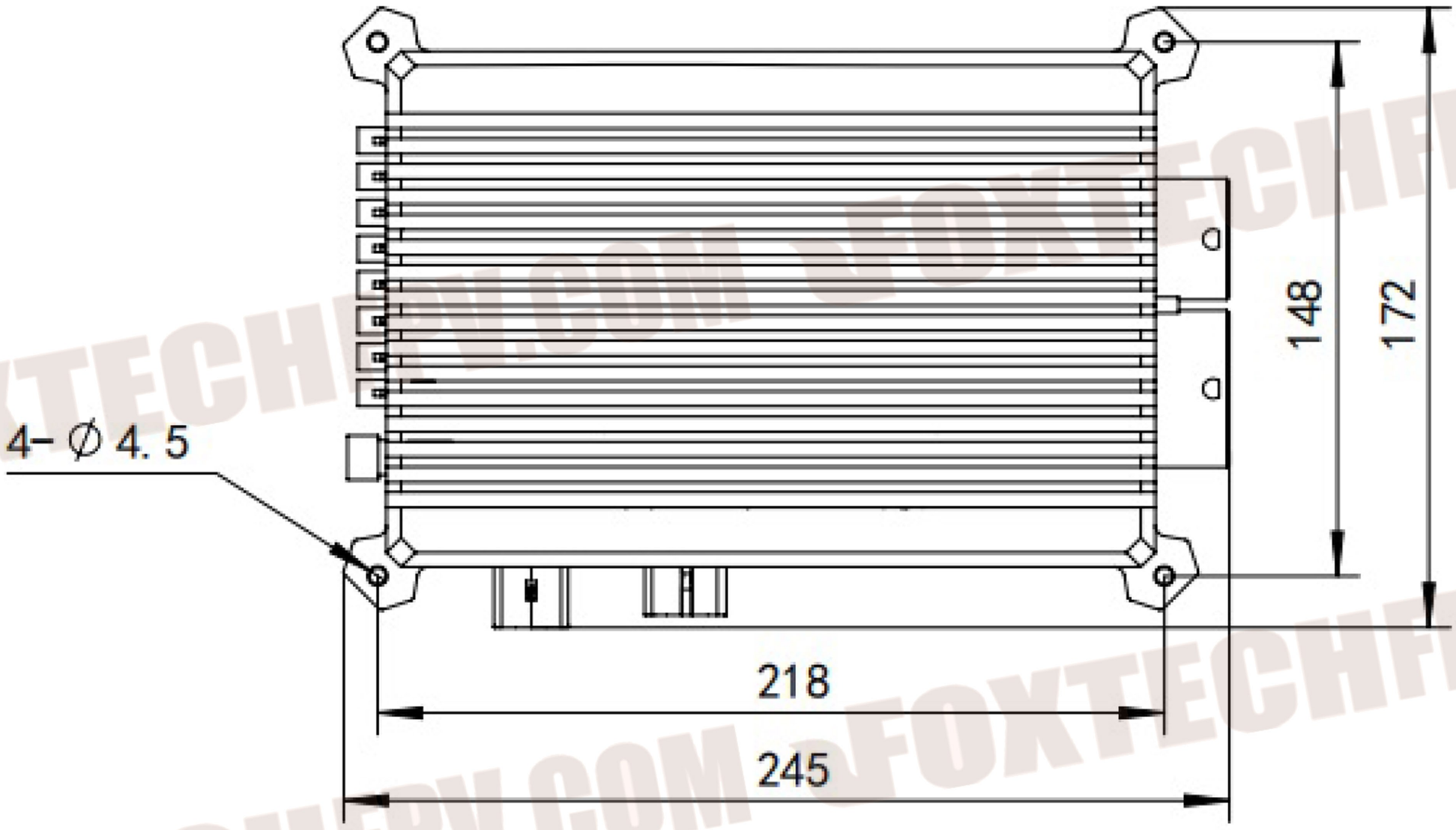
6. Professional I/O ports are IP67-rated. To achieve IP67 rating of Apex Xavier, please contact APEX for a second version of case design. ↩

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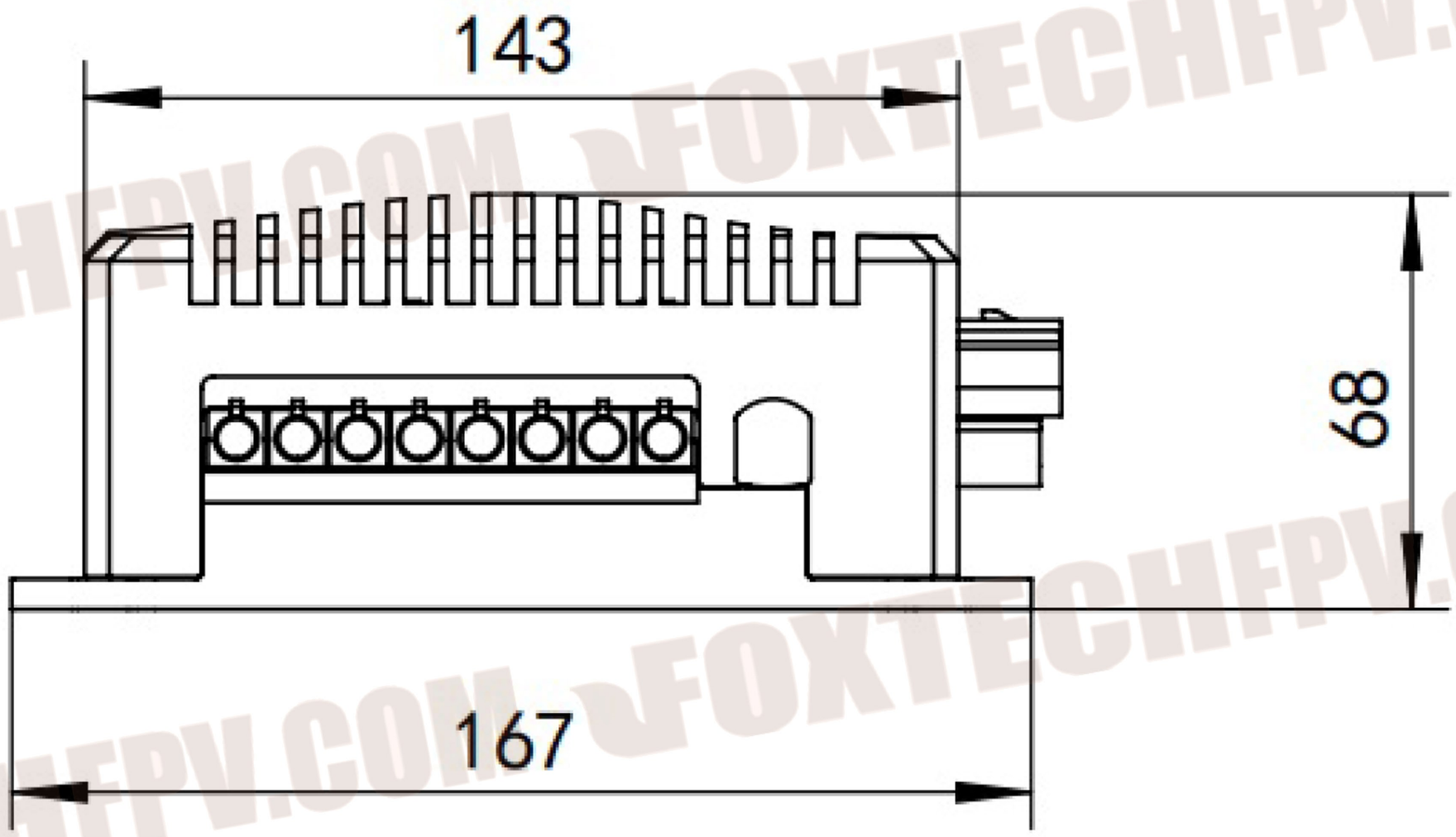
Install Dimension

Dimensions and mounting hole position as below:

Up view(Unit:mm)



Left view(Unit:mm)



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Service and Support

Support

APEX is glad to help you with any questions you may have about or product, or about the use of the technology for your application. The fastest way is sending us an email:support1@foxtechfpv.com. Or you could visit our developer forum: www.foxtechfpv.com for solutions.

Warranty

Warranty period: One year from the date of delivery.

Warranty content: Foxtech warrants the product manufactured by us to be free from defects in material and workmanship during warranty period. Please contact support1@foxtechfpv.com for return material authorization (RMA) prior to returning any items for repair or exchange. The product must be returned in its original packaging to prevent damage during shipping. Before returning any product for repair, it is recommended to back up your data and delete any confidential or personal data.

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Interfaces

Interfaces

Front panel

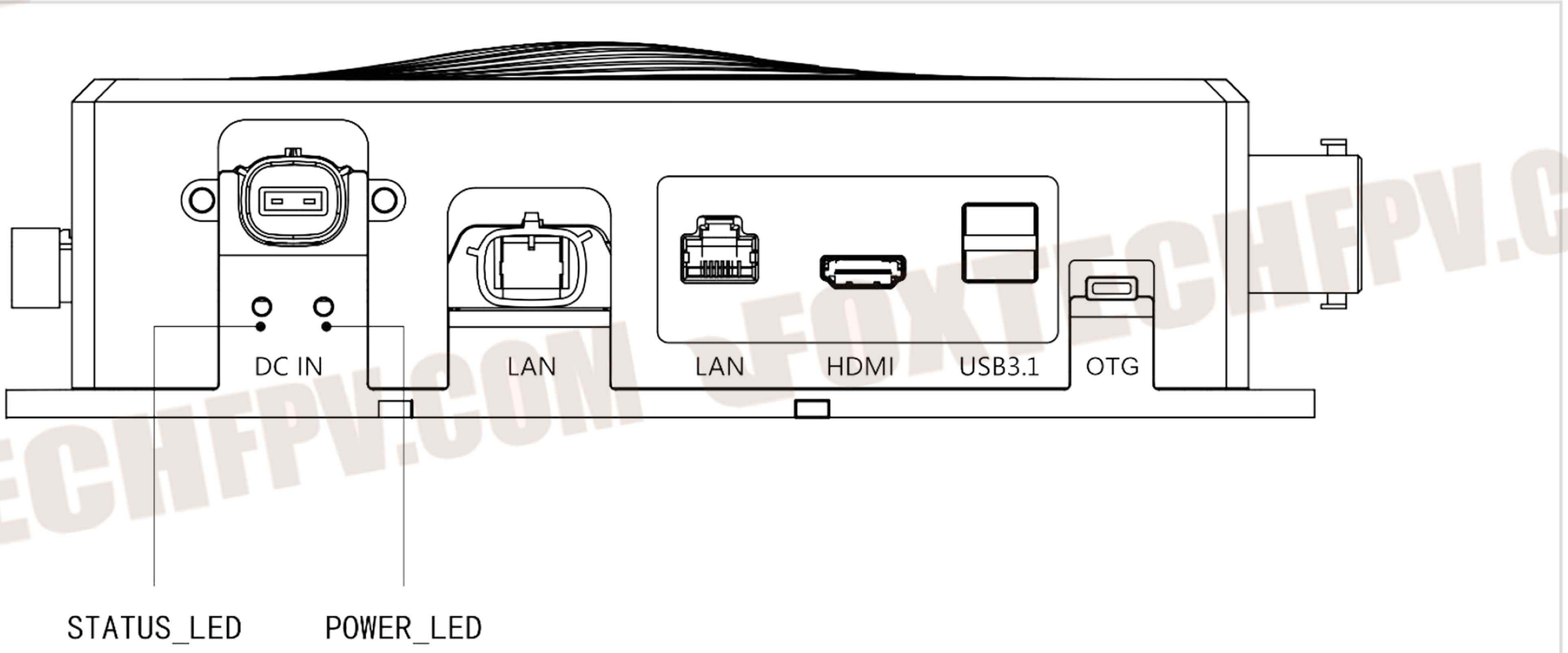
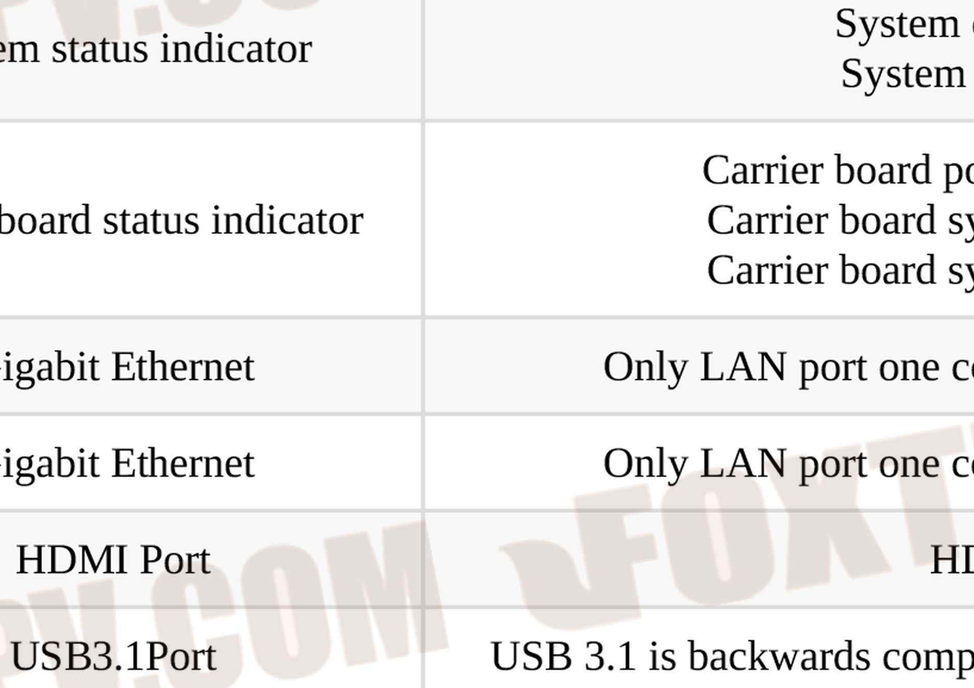


Figure Apex Front view

Interface	Name	Description
DC IN	Power interface	Power input voltage: 12-50V
STATUS_LED	System status indicator	System on: solid blue System off: solid red
POWER_LED	Carrier board status indicator	Carrier board power on: solid yellow Carrier board system on: solid white Carrier board system error: solid red
LAN(Waterproof)	Gigabit Ethernet	Only LAN port one could work at the same time
LAN(RJ45)	Gigabit Ethernet	Only LAN port one could work at the same time
HDMI	HDMI Port	HDMI 2.0
USB×2	USB3.1Port	USB 3.1 is backwards compatible with USB 3.0 and USB 2.0
Micro USB	Micro USB Port	Support USB OTG

DC_IN Pin：



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Interfaces

Figure Apex DC_IN pin

Circuit	Description
1	V+
2	GND

LAN(Waterproof) Pin：

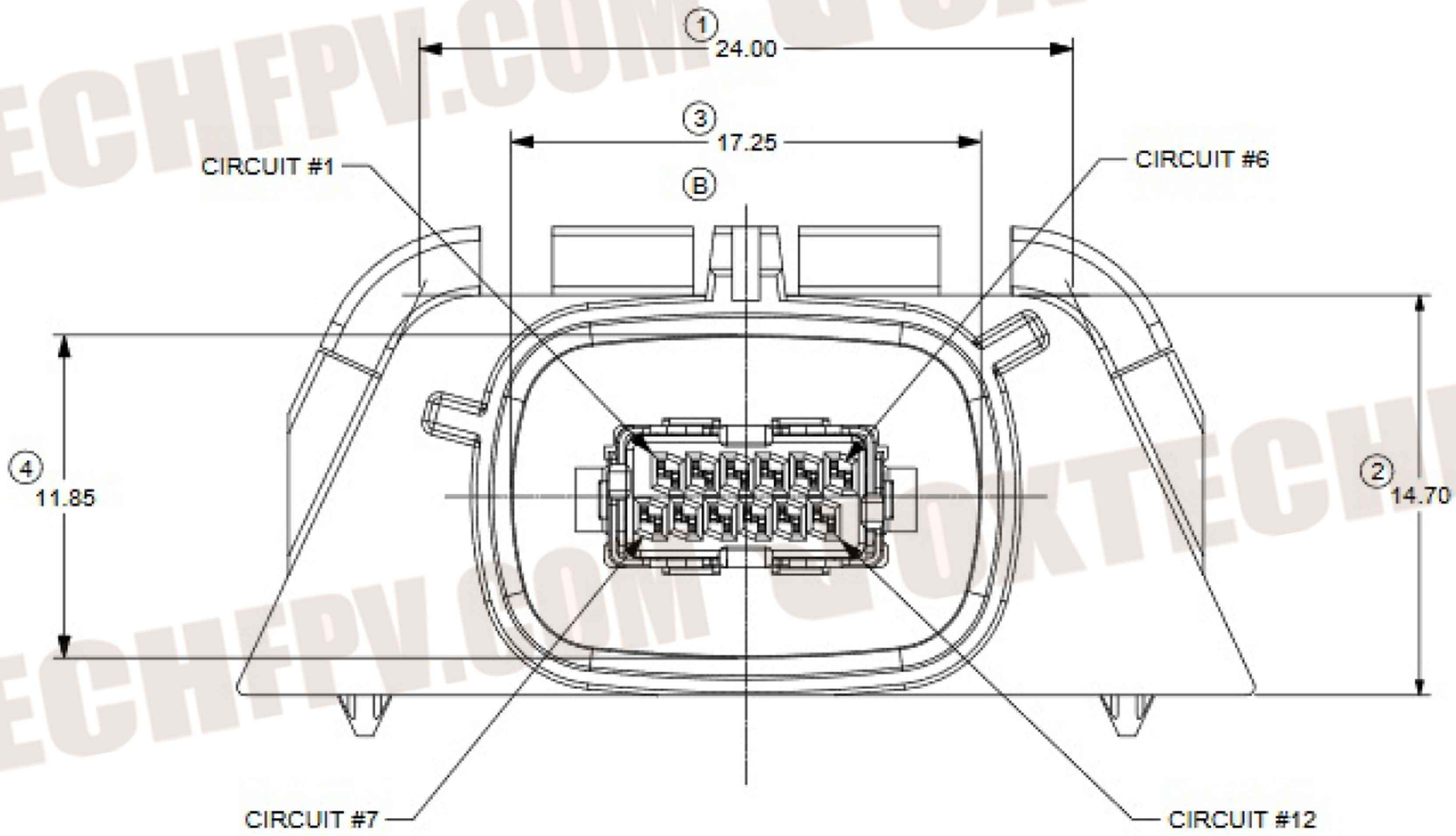


Figure LAN(Waterproof) Pin

Circuit	Description
1	MDI0+
2	MDI0-
3	MDI1+
4	MDI1-
5	MDI2+
6	MDI2-
7	MDI3+
8	MDI3-

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Left Panel

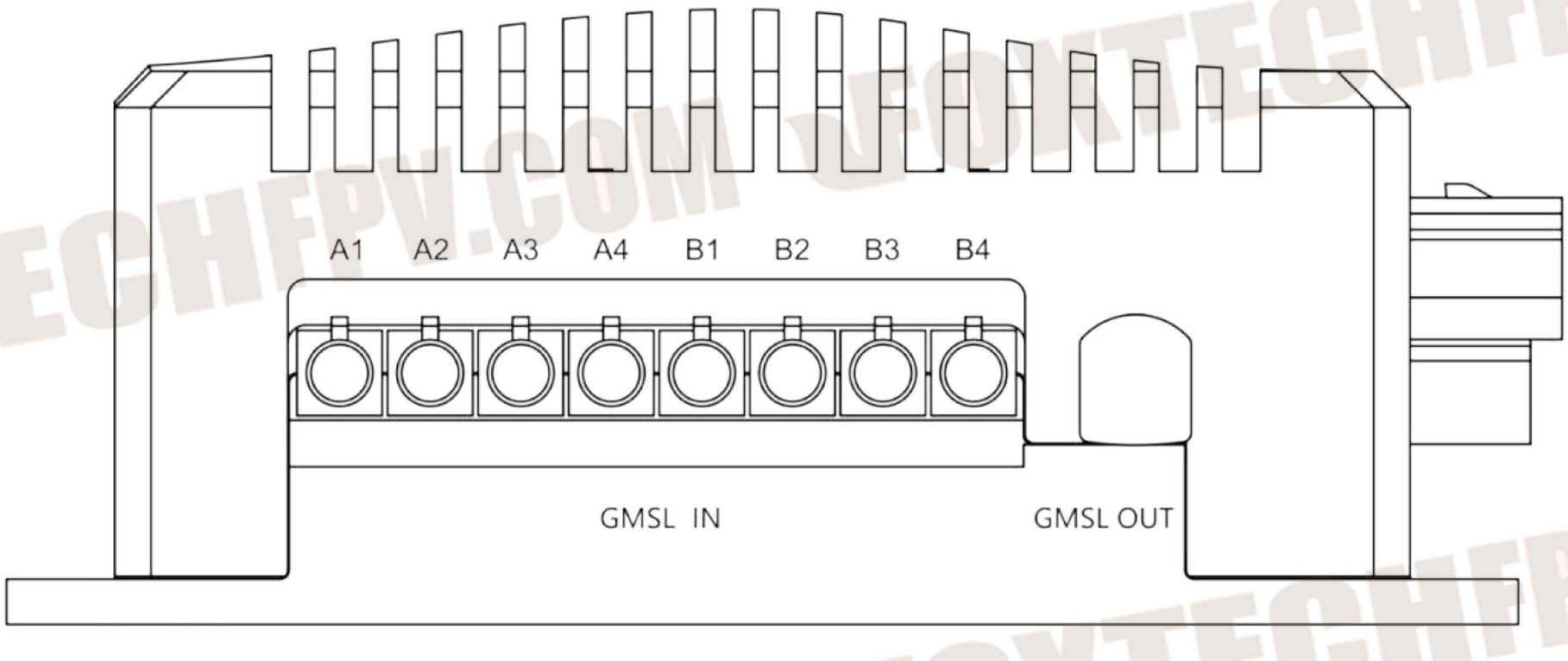


Figure Apex Left Panel

Interface	Name	Description
GMSL IN	GMSL in	Support 8 GMSL cameras(9v)
GMSL OUT	GMSL out	Support 1 GMSL display

GMSL OUT pin definition as follow:

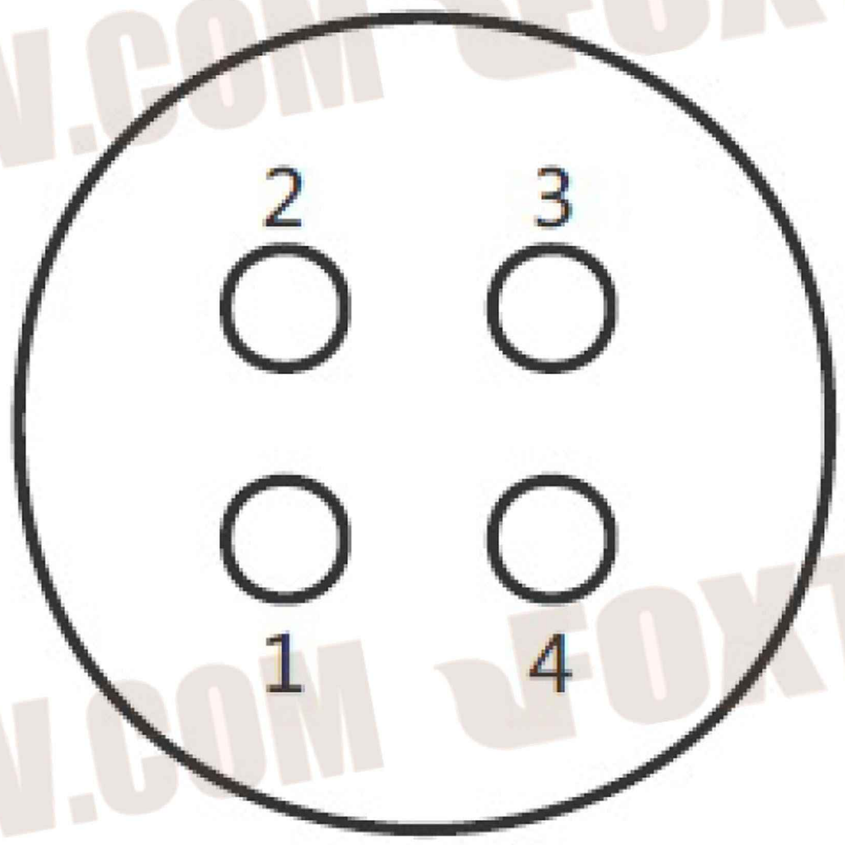


Figure Apex GMSL OUT pin

Circuit	Description
1	GMSL
2	GND
3	10.5V
4	GND

There is no restriction between two groups. When you connect cameras to a specific camera group, you must attach the cameras in sequential order: A1 to A4 or B1 to B4. Homogeneous camera types are required per camera group.

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Camera Mix	A1	A2	A3	A4	B1	B2	B3	B4
1 type a + 1 type b	●				●			
2 type a	●	●						
3 type a	●	●	●					
4 type a	●	●	●	●				
3 type a + 3 type b	●	●	●		●	●	●	
Device Node	/dev/video0				/dev/video1			

Right Panel

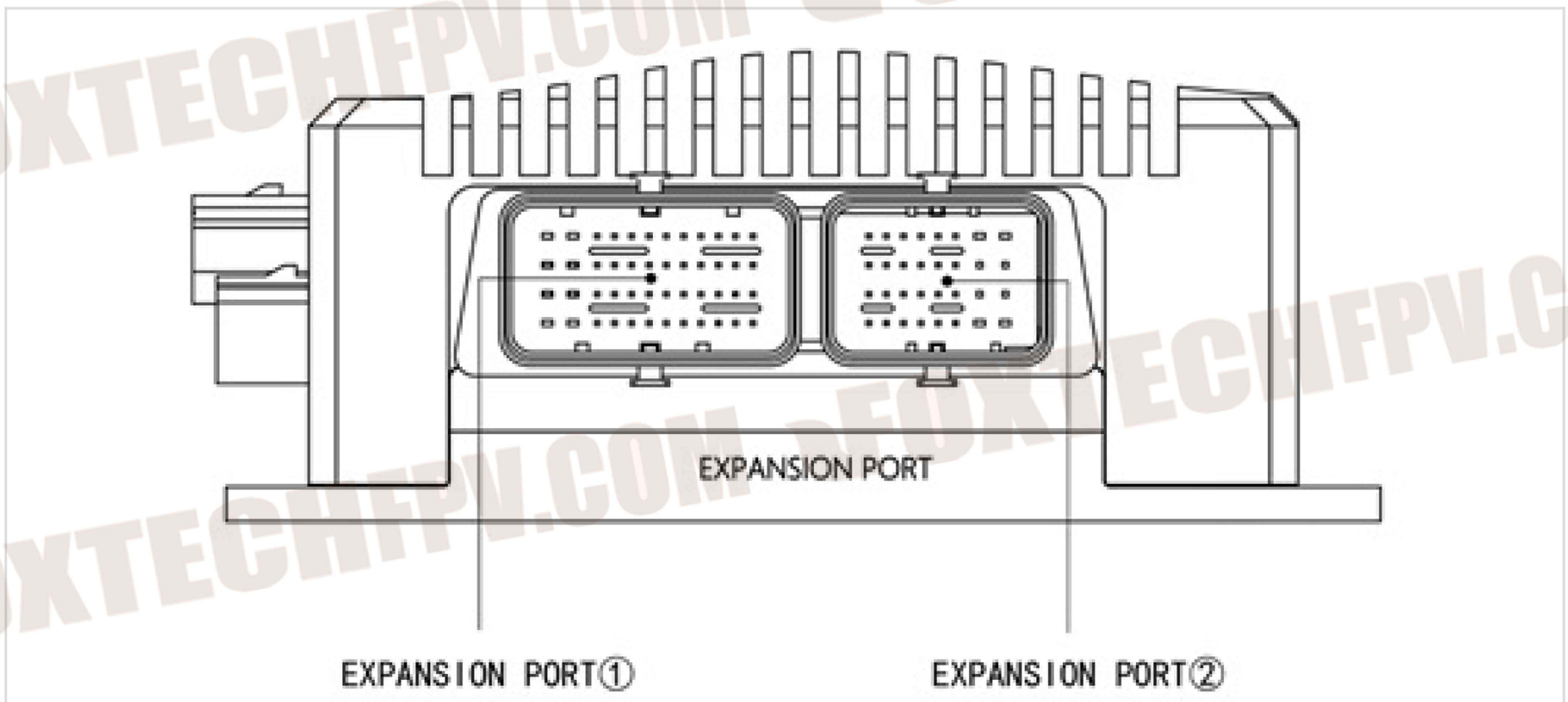


Figure Apex Right Panel

Interface	Name	Description
EXPANSION PORT①	I/O Expansion Port 1	1×DEBUG 2×TTL/232(TTL 3.3V) 2×232/422/485 2 × CAN 2×SYNC_PPS(3.3V) 1× SYNC_OUT(3.3V) 1×SYNC_IN(Logic High 1V-12V, Logic Low 0V-0.8V) 1 × POWER_ONKEY 1×FORCE_RECOVERY 1×RESET
EXPANSION PORT②	I/O Expansion Port 2	1×IIS(3.3V) 1×IIC(3.3V) 1×SPI(3.3V) 5×GPIO(For IN: Logic High 1V-12V, Logic Low 0V-0.8V. For OUT:3.3V)

I/O Expansion Port Pin Definitions

There are two I/O expansion ports at the right panel of Apex Xavier, as EXPANSION PORT ① and EXPANSION PORT ②：

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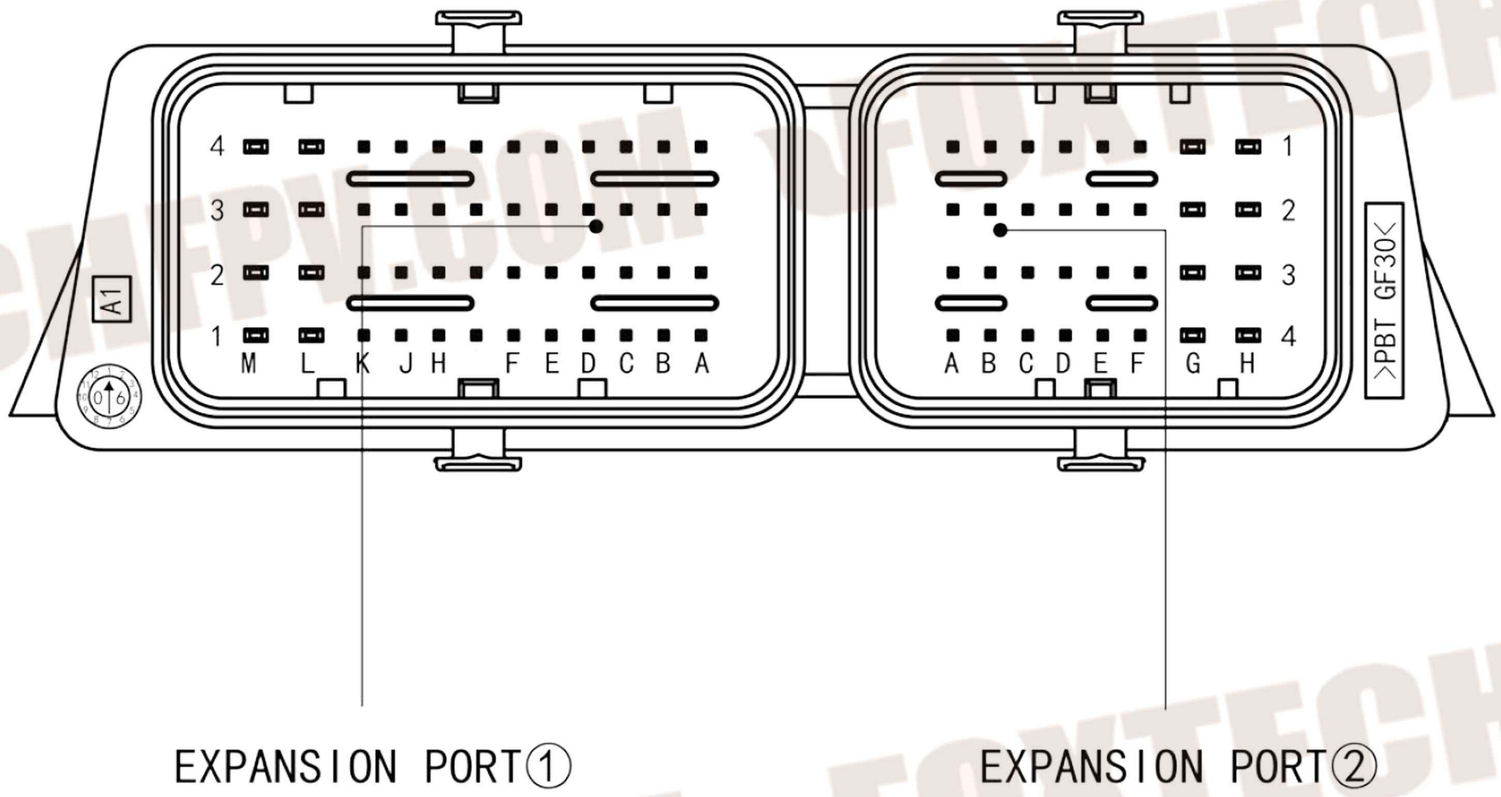


Figure I/O Expansion Ports

EXPANSION PORT ① Pin Assignments

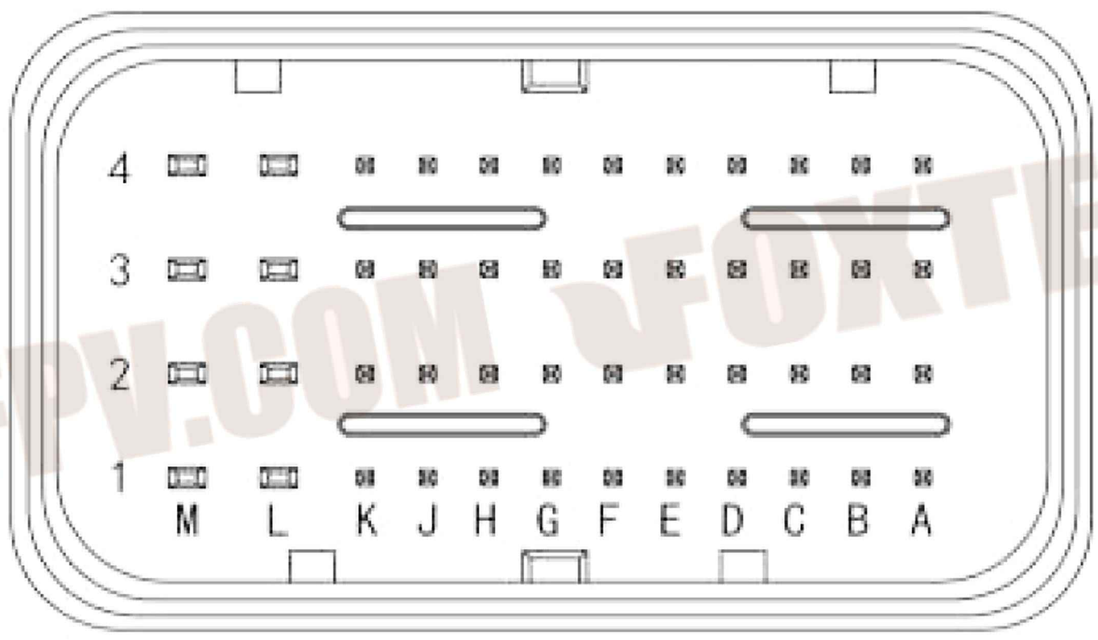


Figure EXPANSION PORT ①

Port Name	Pin	Definition	Description
UART(TTL/232)A DEBUG	G1	UART(TTL/232)A_RX	UART(TTL/232)A: TTL-RX/232-RX
	H1	UART(TTL/232)A_TX	UART(TTL/232)A: TTL-TX/232-TX
	J1	GND	Ground
UART(TTL/232)B	D1	UART(TTL/232)B_RX	UART(TTL/232)B: TTL-RX/232-RX
	E1	UART(TTL/232)B_TX	UART(TTL/232)B: TTL-TX/232-TX
	F1	GND	Ground
UART(TTL/232)C	B2	UART(TTL/232)C_RX	UART(TTL/232)C: TTL-RX/232-RX
	A2	UART(TTL/232)C_TX	UART(TTL/232)C: TTL-TX/232-TX
	A3	GND	Ground
UART(232/422/485)A	K1	UART(232_RX/485_A/422_T+)A	UART(232/422/485)A: 232_RX/485_A/422_T+
	L1	UART(232_TX/485_B/422_T-)A	UART(232/422/485)A: 232_TX/485_B/422_T-

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	M1	UART(422_R+)A	UART(232/422/485)A: 422_R+
	M2	UART(422_R-)A	UART(232/422/485)A: 422_R-
	L2	GND	Ground
UART(232/422/485)B	G2	UART(232_RX/485_A/422_T+)B	UART(232/422/485)B: 232_RX/485_A/422_T+
	F2	UART(232_TX/485_B/422_T-)B	UART(232/422/485)B: 232_TX/485_B/422_T-
	E2	UART(422_R+)B	UART(232/422/485)B: 422-R+
	D2	UART(422_R-)B	UART(232/422/485)B: 422-R-
	C2	GND	Ground
CAN_A	B3	CAN_A_L	CAN_A Low
	C3	CAN_A_H	CAN_A High
CAN_B	D3	CAN_B_L	CAN_B Low
	E3	CAN_B_H	CAN_B High
PPS_A	A1	PPS_A_RX	PPS_A: TTL-RX/232-RX
	B1	PPS_A_TX	PPS_A: TTL-TX/232-TX
	C1	GND	Ground
	F3	PPS_A_SYNC	PPS_A_SYNC Pulse signal
	G3	GND	Ground
PPS_B	K2	PPS_B_RX	PPS_B: TTL-RX/232-RX
	J2	PPS_B_TX	PPS_B: TTL-TX/232-TX
	H2	GND	Ground
	H3	PPS_B_SYNC	PPS_B_SYNC Pulse signal
	J3	GND	Ground
SYNC_IO	K3	SYNC_IN	Sync in Signal
	L3	GND	Ground
	M3	SYNC_OUT	Sync out Signal
	M4	GND	Ground
	K4	GND	Ground
RESET	J4	RESET	Reset
RECOVERY	G4	FORCE_RECOVERY	Recovery
POWER	E4	POWER_ONKEY	Power
GND	H4	GND	Ground
	F4		
	D4		

[8]. UART(TTL/232)A is a DEBUG port, all TTL is 3.3V ↩

If you want to use GPS Sync function, please refer to the following instruction:

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Connect GPS NMEA Serial port to UART(TTL/232)B port of Apex Xavier(Baud 9600), device node is /dev/ttyUART_TTL_232_B

Connect GPS PPS Port to SYNC_IO PIN1of Apex Xavier, device node is /dev/miivii-sync-in-a

These two nodes above is occupied while GPS Sync function is available.

EXPANSION PORT ② Pin Assignment

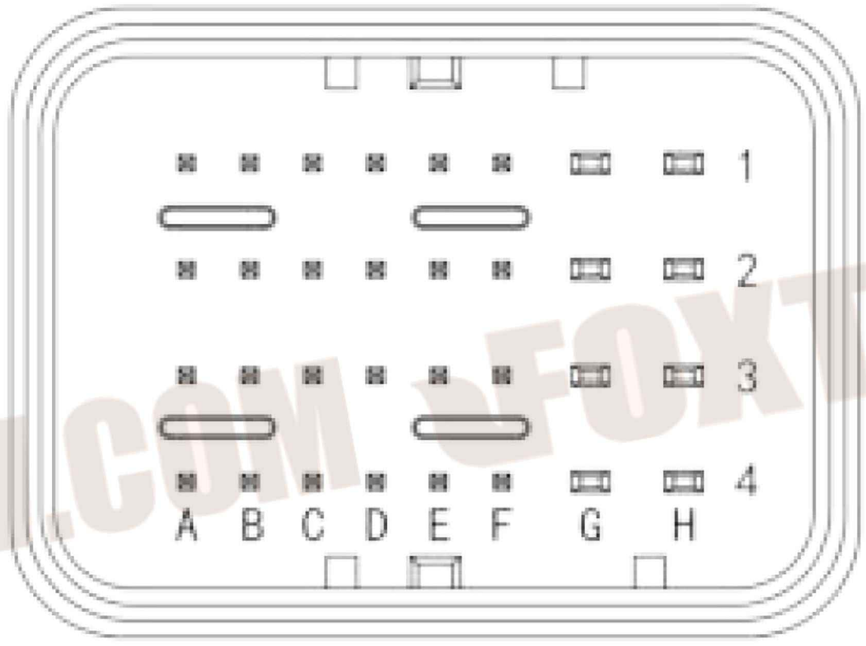


Figure EXPANSION PORT②

Port Name	Pin	Definition	Description
SPI Port	A4	SPI_SCK	SPI continuous serial clock
	B4	SPI_MISO	SPI master input slave output, or master in slave out
	C4	SPI_MOSI	SPI SPI master output slave input, or master out slave in
	D4	SPI_CS0	SPI slave select
	E4	GND	Ground
IIS Port	F4	IIS_MCLK05	IIS master clock
	G4	IIS_PWM01	IIS interrupt
	H4	IIS_SDIN	IIS serial data in
	H3	IIS_SDOUT	IIS serial data out
	G3	IIS_FS	IIS frame sync
	F3	IIS_CLK	IIS continuous serial clock
	E3	GND	Ground
IIC Port	D3	IIC_CLK	IIC serial clock
	C3	IIC_DAT	IIC serial data
	B3	GND	Ground
Audio Port	A3	IN1P	MIC Signal
	A2	AUD_HPOR	Right channel signal
	B2	AUD_HPOL	Left channel signal
	C2	GND	Ground
	D2	GPIO_A1	GPIO_IN

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GPIO Ports	F2	GPIO_B13	GPIO_OUT
	H2	GPIO_C24	
	G1	GPIO_D26	
	E1	GPIO_E33	
GND	E2	GND	Ground
	G2		
	H1		
	F1		
	D1		
	C1		
5V	B1	5V	5V

GPIO Pin Assignment

Port Name	Pin Number	GPIO	Default Setting	GPIO Export Value
GPIO	D2	GPIO_A	GPIO_IN	339
	F2	GPIO_B		433
	H2	GPIO_C	GPIO_OUT	387
	G1	GPIO_D		390
	E1	GPIO_E		413

Rear Panel

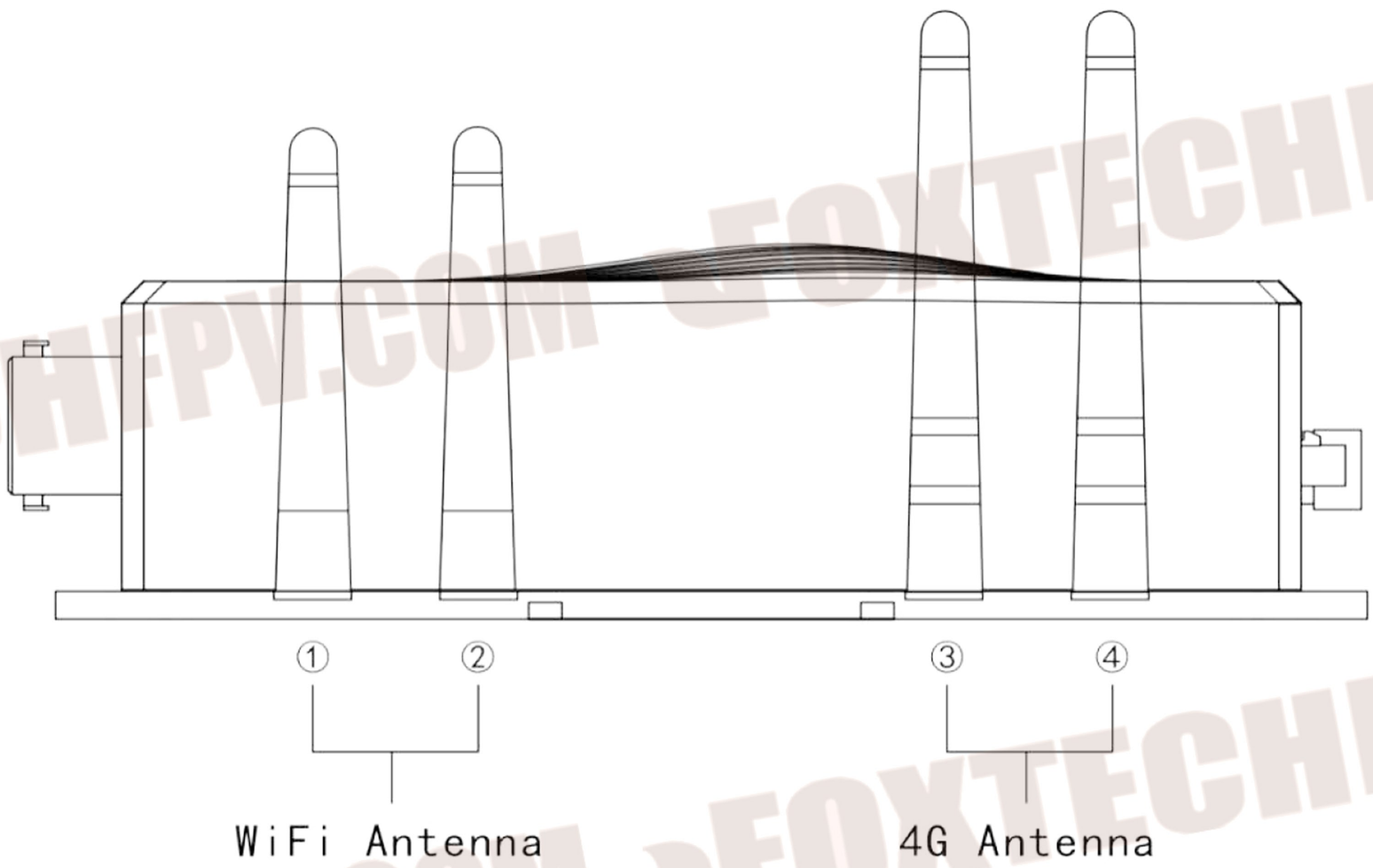


Figure Apex Rear Panel

Interface	Name	Description
①②	2.4G/5.8G WiFi Antenna connector	Connect to 2.4G/5.8G WiFiantenna
③④	4G Antenna connector	Connect to 4G antenna

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I/O Cable

Apex provides one I/O cable with 10 DB-9(DE-9) connectors and 3 buttons, as an extension of EXPANSION PORT ①

Number	Port	Quantity	Details
1	UART_TTL/232	3	Black DB9 connector
2	UART_232/422/485	2	Gray DB9 connector
3	CAN	2	White DB9 connector
4	PPS	2	Dark Blue DB9 connector
5	Sync I/O	2	Share one dark green DB9 connector
6	Button	3	1 RESET Button(White) 1 RECOVERY Button(Black) 1 POWER_ONKEY Button(Red)



Figure I/O Cable

UART(TTL/232)Ports and Pin Assignments

Apex provides 3 TTL/RS232 ports: UART(TTL/232)A, UART(TTL/232)B and UART(TTL/232)C. UART(TTL/232)A is for debugging use. Black DB9 connectors from I/O cable are shown as below:

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Figure UART(TTL/232) Cable and Connectors

3 UART(TTL/232) DP9 connectors pin assignments:

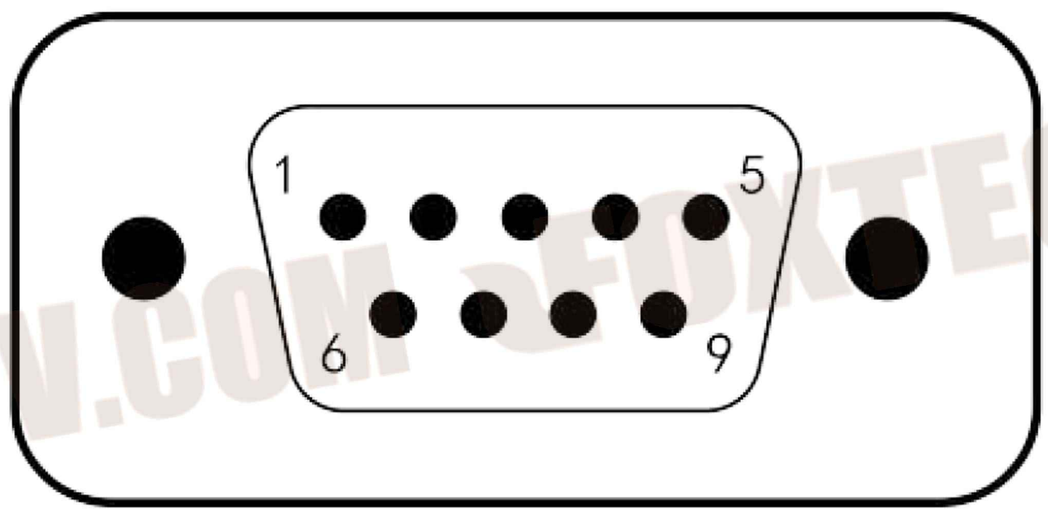


Figure UART(TTL/232) Pin

UART(TTL/232)A		UART(TTL/232)B		UART(TTL/232)C	
Pin	Signal	Pin	Signal	Pin	Signal
2	UART(TTL/232)A_RX	2	UART(TTL/232)B_RX	2	UART(TTL/232)C_RX
3	UART(TTL/232)A_TX	3	UART(TTL/232)B_TX	3	UART(TTL/232)C_TX
5	GND	5	GND	5	GND

UART(232/422/485) Ports and Pin Assignments

Apex provides 2 RS232/RS485/RS422ports: UART(232/485/422)A and UART(232/485/422)B. Gray DB9 connectors from I/O cable are shown as below:

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Figure UART(422/485) Cable and Connectors

2 UART(232/422/485) DP9 connectors pin assignments:

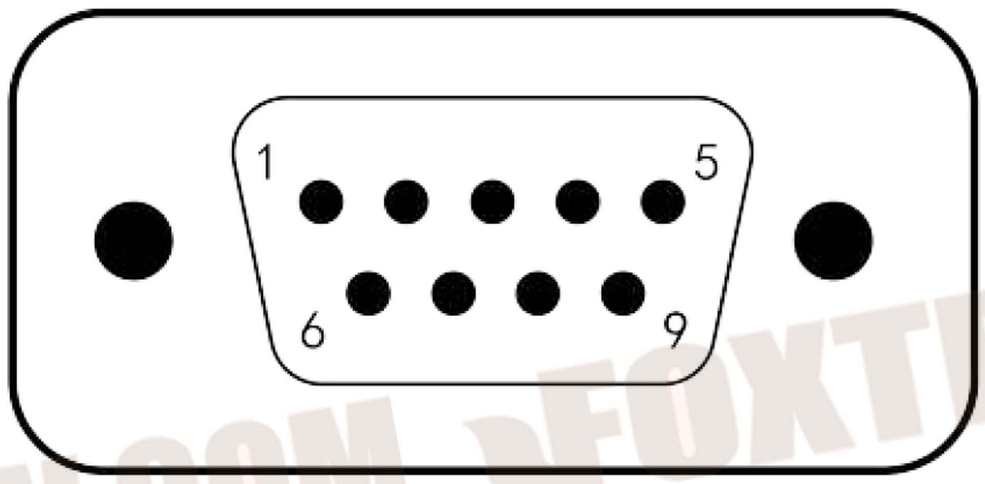


Figure UART(422/485) Pin

UART(232/422/485)A		**UART(232/422/485)B**	
Pin	Signal	Pin	Signal
2	UART(232_RX/485_A/422_T+)A	2	UART(232_RX/485_A/422_T+)B
3	UART(232_TX/485_B/422_T-)A	3	UART(232_TX/485_B/422_T-)B
5	GND	5	GND
6	UART(422_R-)A	6	UART(422_R-)B
7	UART(422_R+)A	7	UART(422_R+)B

Relation of UART Port and device node as follow:

Pin	**UART Port**	**Device Node**
1	UART(TTL/232)A	DEBUG
2	UART(TTL/232)B	ttyUART_TTL_232_B
3	UART(TTL/232)C	ttyUART_TTL_232_C
4	UART(232/422/485)A	ttyUART_232_422_485_A
5	UART(232/422/485)B	ttyUART_232_422_485_B

DIP switch for UART Ports:

Open Apex’s bottom cover, DIP switches are shown as below:

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Figure Apex DIP Switch

DIP switch settings are shown in the table below:

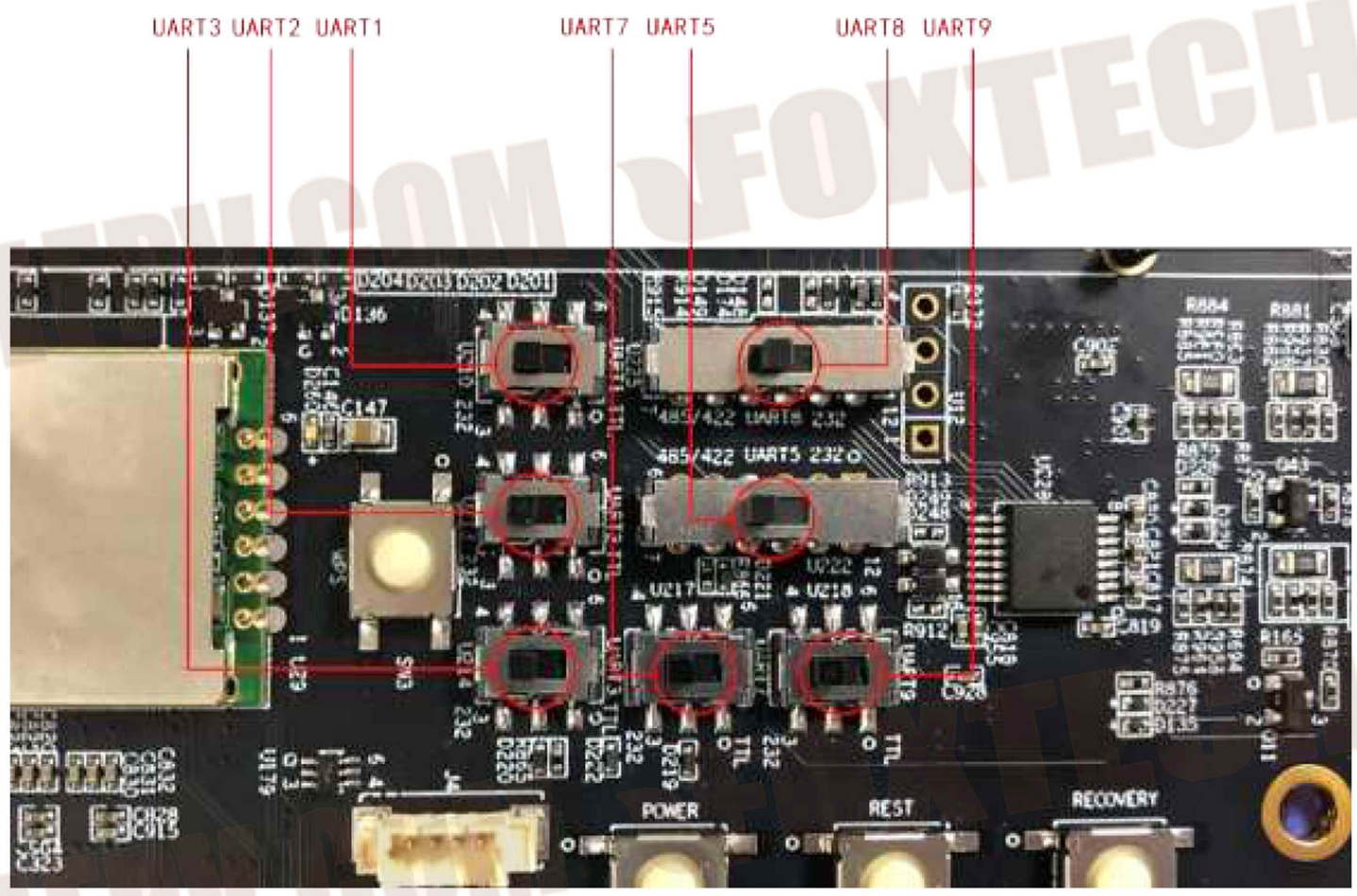


Figure DIP Switch Mapping

Number	UART Port	DIP Switch	DIP Switch Settings
1	PPS_A	UART1	1.For TTL signal: Switch to 'TTL’ 2.For 232 signal: Switch to '232' (default)
2	PPS_B	UART7	
3	UART(TTL/232)A	UART3	
4	UART(TTL/232)B	UART2	
5	UART(TTL/232)C	UART9	
6	UART(232/422/485)A	UART5	1.For 232 signal: Switch to '232' 2.For 422/485 signal: Switch to '422/485'(default)
7	UART(232/422/485)B	UART8	

[9]:Default switch for PPS ports and UART(TTL/232) ports is 232，default switch for UART(232/422/485) ports is 485/422

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CAN Ports and Pin Assignments

Apex provides 2 CAN ports: CAN_A and CAN_B. White DB9 connectors from I/O cable are shown as below:



Figure CAN Cable and Connectors

2 CAN connectors pin assignments：

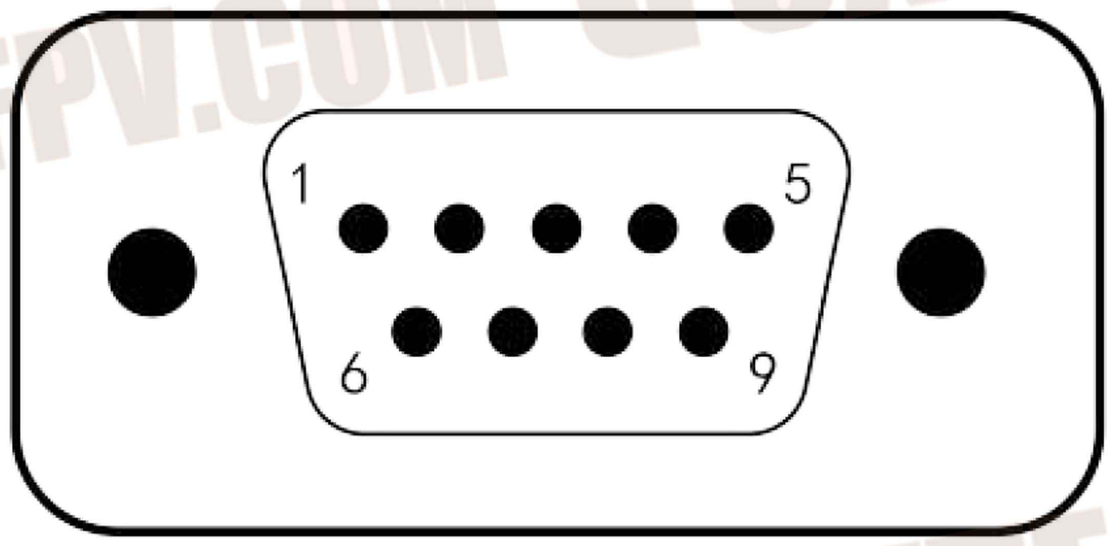


Figure CAN Pin

CAN_A		CAN_B	
Pin	Signal	Pin	Signal
2	CAN_A_L	2	CAN_B_L
7	CAN_A_H	7	CAN_B_H

PPS Ports and Pin Assignments

Apexprovides 2 PPS ports: PPS_A(115200 Bd) and PPS_B(9600 Bd). The blue DB9 connectors from I/O cable are shown as below:

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Figure PPS Cable and Connector

PPS_A(115200 Bd) and PPS_B(9600 Bd), Pin Assignments：

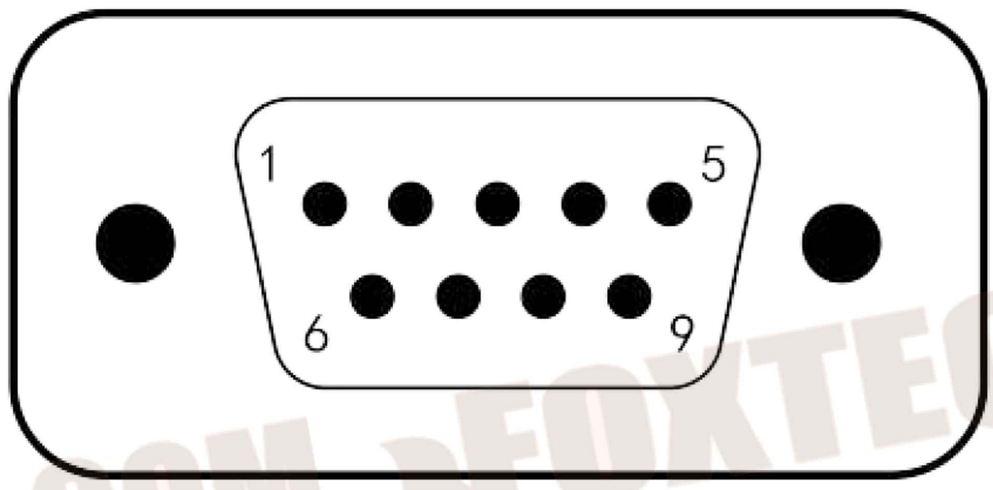


Figure PPS Pin

PPS_A		**PPS_B**	
Pin	Signal	Pin	Signal
1	GND	1	GND
2	PPS_A_RX	2	PPS_B_RX
3	PPS_A_TX	3	PPS_B_TX
5	GND	5	GND
6	PPS_A_SYNC	6	PPS_B_SYNC

SYNC Ports and Pin Assignments

Apex provides 2 sync I/O ports: Sync_out and Sync_in. They share the green DB9 connector from I/O cable:



Figure Sync IO Cable and Connector

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SYNC_IO DP9 connector pin assignments:：

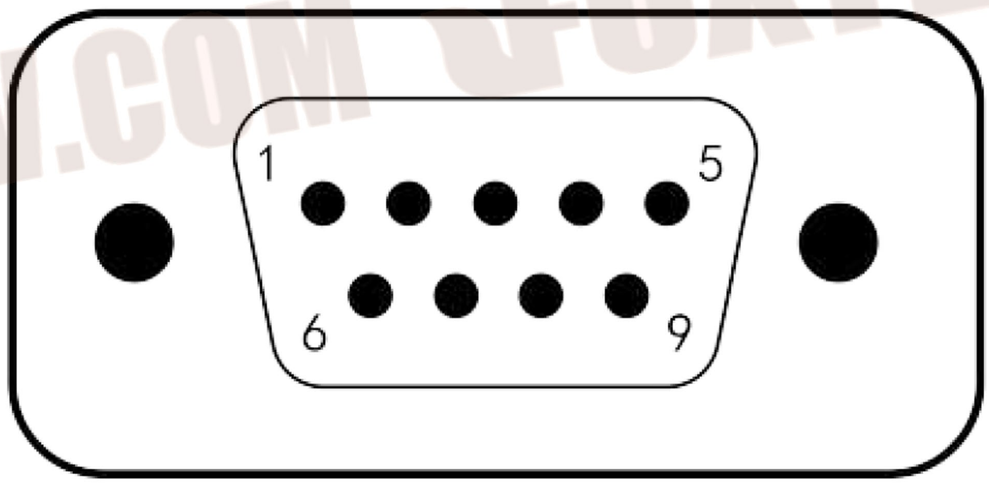


Figure Sync IO Pin

Synchronization Signal	
Pin	Signal
1	SYNC_IN_A
2	SYNC_OUT_A
3	NC
6	GND
7	GND
8	GND

Buttons

Apex provides 3 buttons: RESET, POWER_ONKEY and FORCE_RECOVERY.



Figure Function Buttons

Name	Function	Color
RESET	Restart	White
POWER_ONKEY	Power on	Red
FORCE_RECOVERY	Enter Recovery mode	Black

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Expansion

Apex provides expansion sockets for SSD, 4G module, TF card and SIM card. Remove screws on Apex's bottom cover as shown in below:

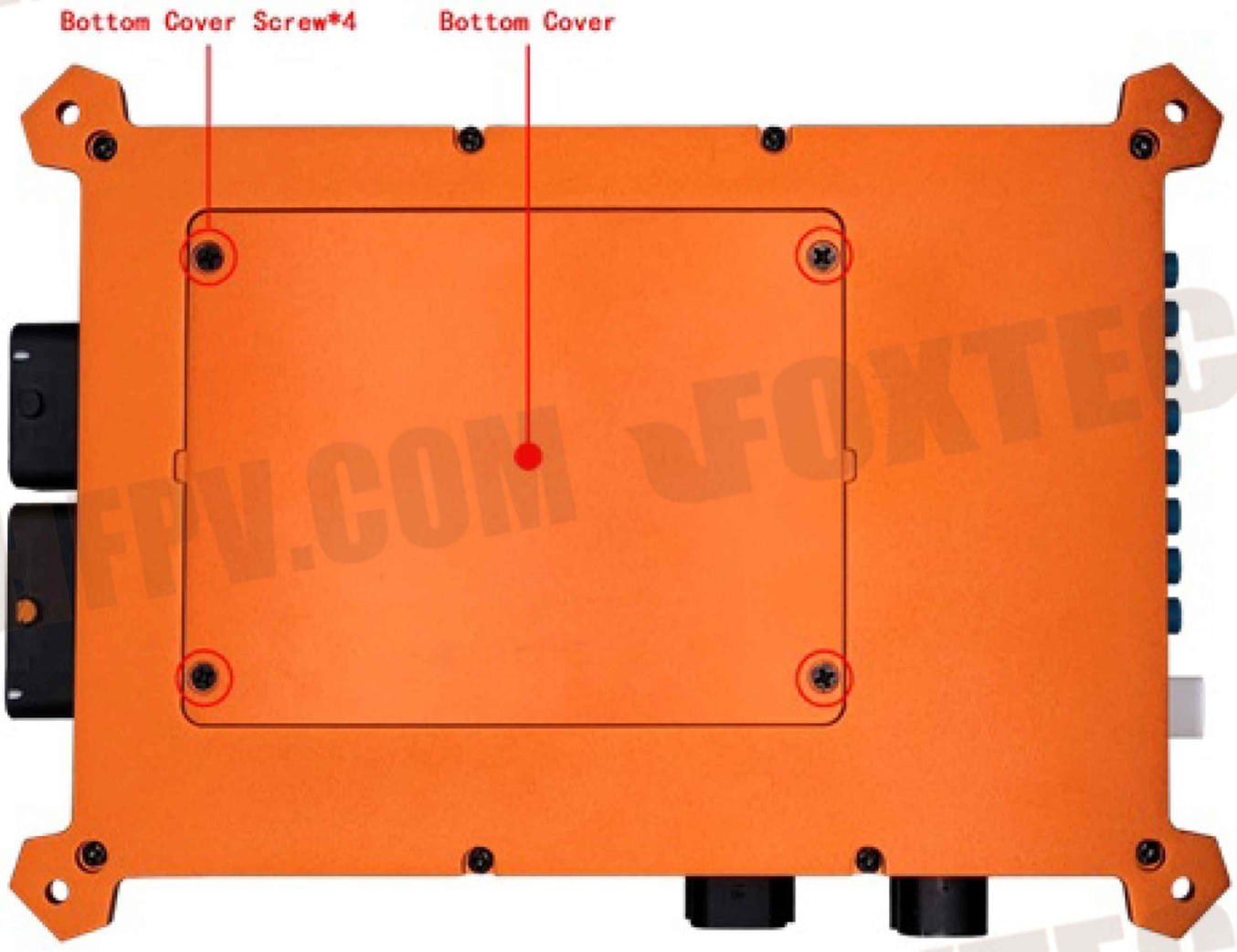


Figure Apex Xavier Button Cover

Expansion sockets are shown as below. After installation, SSD card and 4G module need to be screwed. Connect 4G antenna cable (attached to the board) to 4G module.

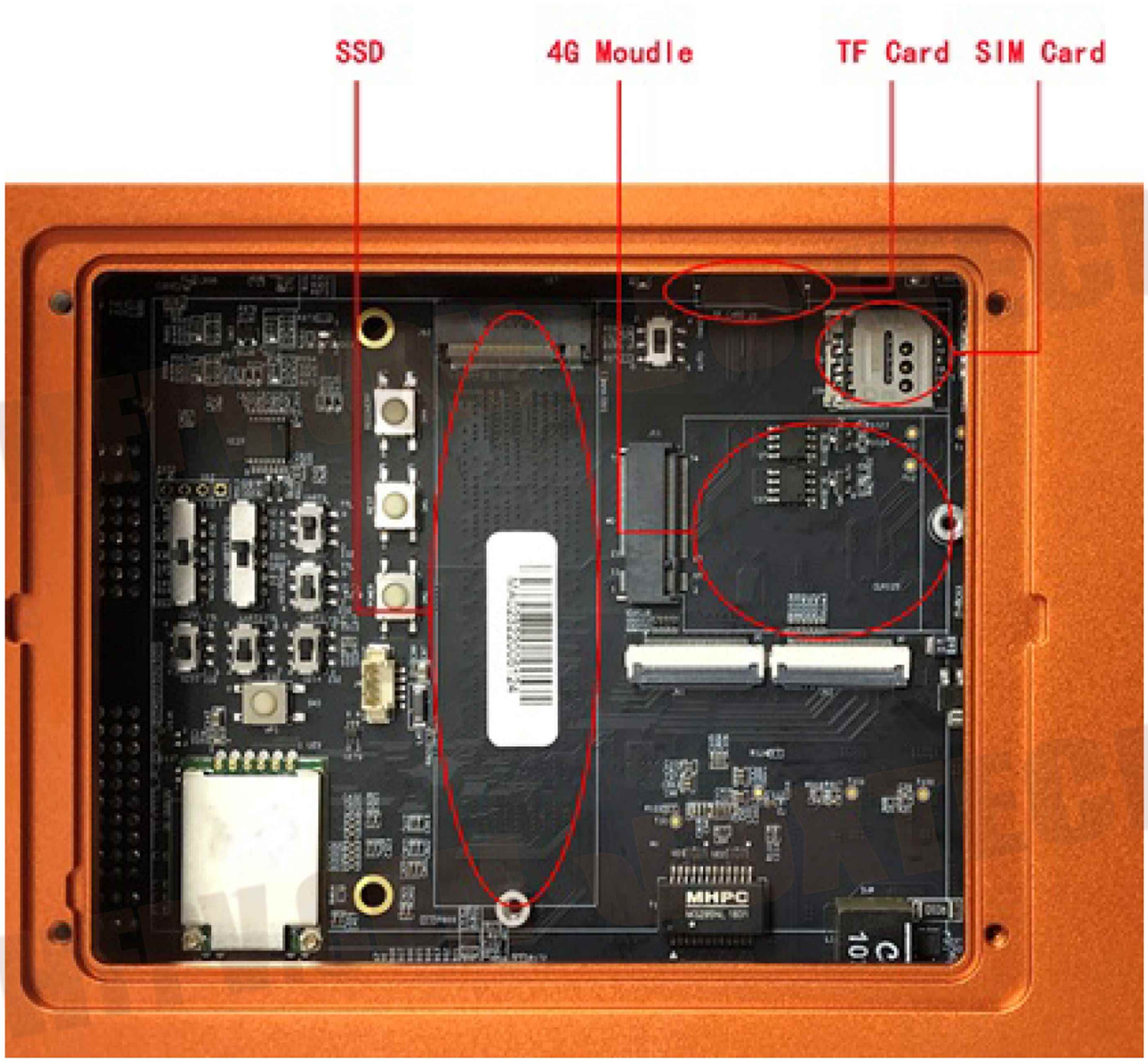


Figure Apex Expansion Sockets

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General Setting

System

APEX use Ubuntu system. Default username: nvidia default password: nvidia

Power on

Connect an external HDMI display to APEX HDMI port.

Connect a USB keyboard and mouse.

Connect the included AC adapter to power socket. Plug AC adapter into an appropriately rated electrical outlet.



Figure Startup

Power off: Use command $ sudo poweroff, or press and hold POWER_ONKEY button.

Reset: Use command $ sudo reboot, or press RESET button.

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APEX Setting

FOXTECH provides a setting program called APEX Setting. You can get access to basic information and settings through APEX Setting. Click the icon on upper right corner:

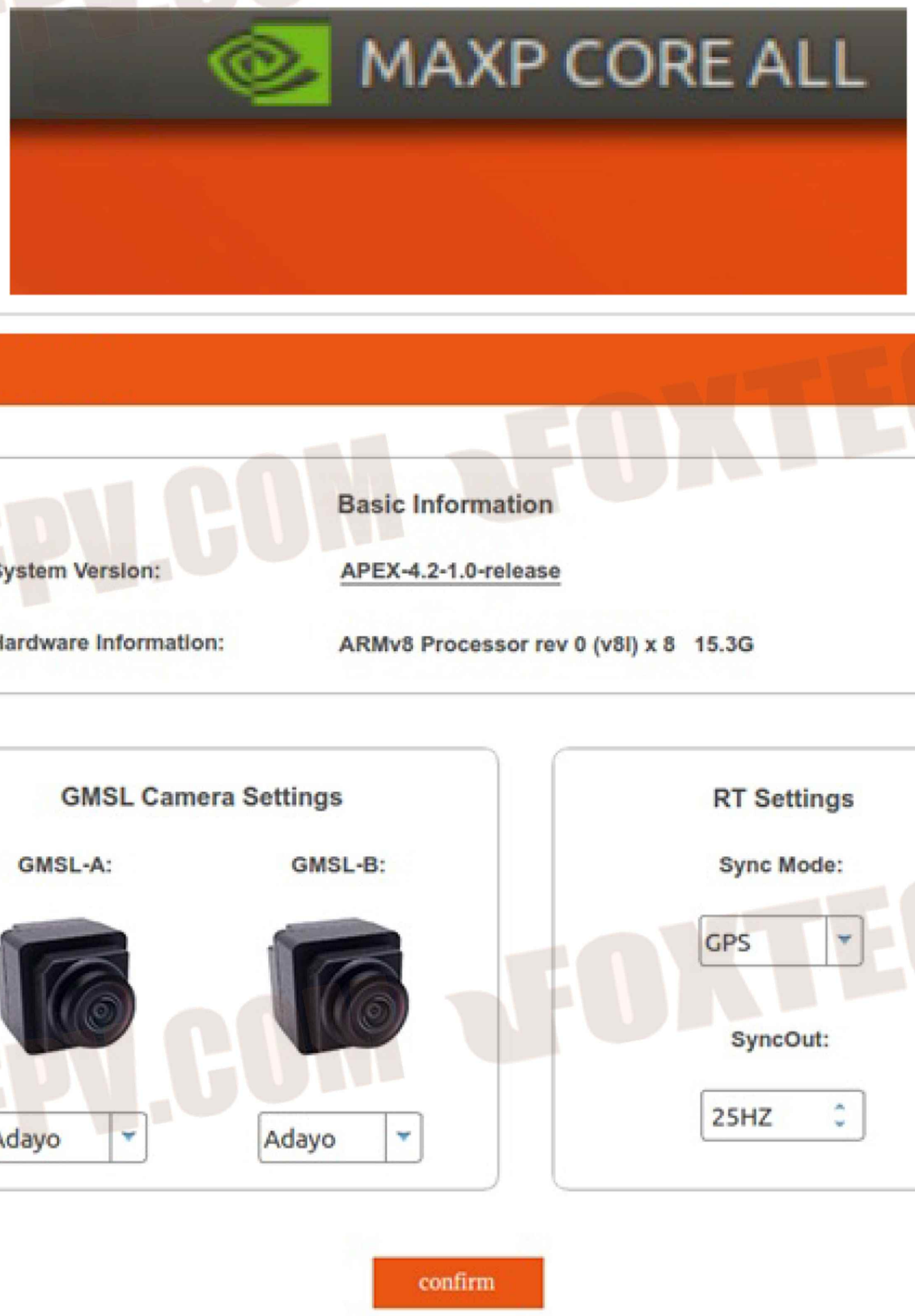


Figure Version Info

You can set up GMSL camera here. Apex has two groups of GMSL camera GMSL_A and GMSL_B, while S2Pro has only one group GMSL_A.



Figure Set up GMSL Camera

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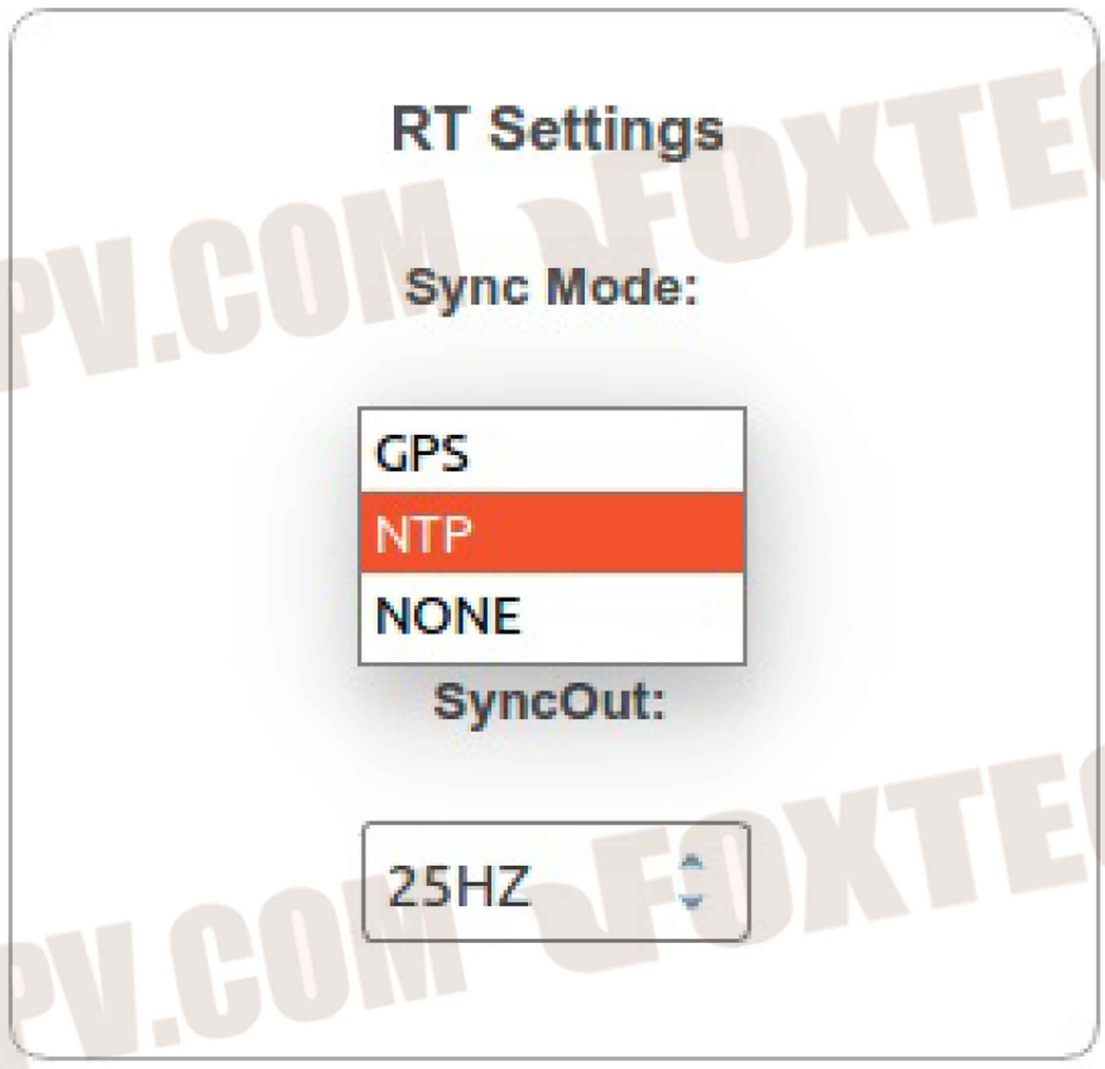


Figure Set Synchronization Mode

Default setting is NTP mode. APEX accept NTP service while set to this mode.

APEX accept GPS synchronization while set to GPS mode.

APEX cannot be synchronized nor synchronize other sensors while set to None mode.

You can also set Sync out frequency here, please note it is not GMSL frequency.

Finish setting and exit



Figure Finish setting

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Power Mode Setting

APEX has seven different power mode. You can set up power mode through the green NVIDIA icon on the upper right corner.

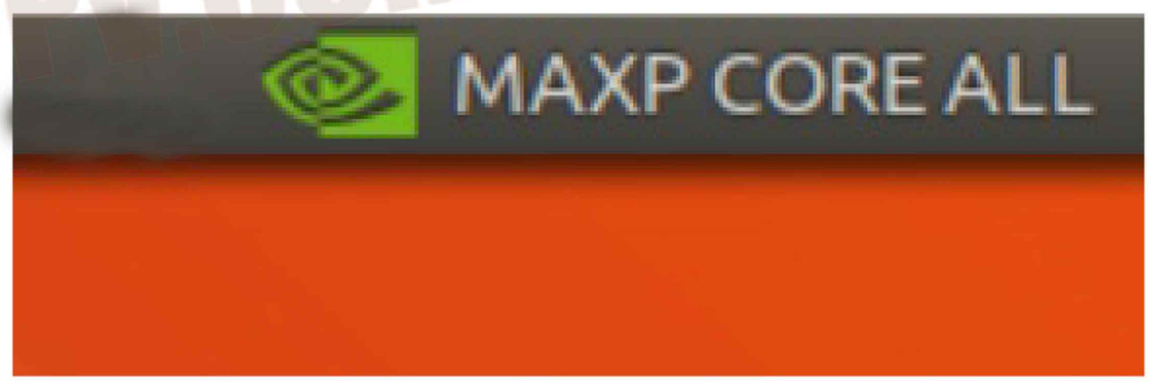


Figure Power mode Icon

The following table shows details of each model. Default mode of Apex is 3.

Mode Name	EDP	10W	15W	30W	30W	30W	30W
	MAXN	MODE_10W	MODE_15W	MODE_30W_ALL	MODE_30W_6CORE	MODE_30W_4CORE	MODE_30W_2CORE
Power Budget	n/a	10W	15W	30W	30W	30W	30W
Mode ID	0	1	2	3	4	5	6
Number of Online CPUs	8	2	4	8	6	4	2
CPU Maximal Frequency (MHz)	2265.6	1200	1200	1200	1450	1780	2100
GPU TPC	4	2	4	4	4	4	4
GPU Maximal Frequency (MHz)	1377	520	670	900	900	900	900
DLA Cores	2	2	2	2	2	2	2
DLA Maximal Frequency (MHz)	1395.2	550	750	1050	1050	1050	1050
Vision Accelerator (VA) cores	2	0	1	1	1	1	1
VA Maximal Frequency (MHz)	1088	0	550	760	760	760	760
Memory Maximal Frequency (MHz)	2133	1066	1333	1600	1600	1600	1600

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```
#check current mode
sudo nvpmodel -q verbose
# set to a certain mode
sudo nvpmodel -m [MODE ID]
#achieve best performance of current mode
sudo jetson_clocks
#check more info
sudo jetson_clocks --show
```

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IO

GPIO

Please change the code in <> to your GPIO export value

```
#switch to root
sudo su -
#set GPIO to high
echo 1 > /sys/class/gpio/<gpio339>/vlaue
#set GPIO to low
echo 0 > /sys/class/gpio/<gpio339>/vlaue
```

For auto config, write above commands to file `/etc/rc.local` .

UART

Open device node in /dev/. Then use stty command to set parameters. See stty command manual for details, please change the code in <> to your UART device node.

```
#config UART
$ sudo stty -F /dev/<ttyTHS1> speed 115200 cs8 -parenb -cstopb -echo
#send data through UART
$ sudo echo “miivii tty debug” > /dev/<ttyTHS1>
#receive data from UART
$ sudo cat /dev/<ttyTHS1>
```

CAN

Please check cansend.c and candump.c from https://github.com/linux-can/can-utils for instructions.

Test command:

```
sudo modprobe can

sudo modprobe can_raw

sudo modprobe mttcan

sudo ip link set can0 type can bitrate 1000000 dbitrate 1000000 berr-reporting on fd on

sudo ip link set up can0

sudo cansend can0 123\#abcdabcd

sudo candump can0

sudo ip -details -statistics link show can0

sudo ifconfig can0 down
```

CAN fd：

```
sudo modprobe can

sudo modprobe can_raw
```

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```
sudo modprobe mttcan

sudo ip link set can0 type can bitrate 500000 dbitrate 2000000 berr-reporting on fd on

sudo ip link set up can0

sudo cansend can0 213##011
```

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Expansion Setting

SSD Setting

```
#check ssd information
$sudo fdisk -lu
```

```
Disk /dev/mmcblk0boot1: 8 MiB, 8388608 bytes, 16384 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes


Disk /dev/mmcblk0boot0: 8 MiB, 8388608 bytes, 16384 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes


Disk /dev/nvme0n1: 232.9 GiB, 250059350016 bytes, 488397168 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0xd80dc8f5
nvidia@miivii-tegra:~$
```

Figure SSD Information

```
#Format SSD
$sudo mkfs -t ext4 /dev/nvme0n1
```

```
nvidia@miivii-tegra:~$ sudo mkfs -t ext4 /dev/nvme0n1
mke2fs 1.42.13 (17-May-2015)
Found a dos partition table in /dev/nvme0n1
Proceed anyway? (y,n) y
```

Figure Formatting SSD

```
#Check UUID
$sudo blkid /dev/nvme0n1
```

```
nvidia@miivii-tegra:~$ sudo blkid /dev/nvme0n1
/dev/nvme0n1: UUID="6e643050-77bb-40d3-97b4-7835fc016afb" TYPE="ext4"
nvidia@miivii-tegra:~$
```

Figure SSD UUID

```
#Auto mount
$UUID=6e643050-77bb-40d3-97b4-7835fc016afb
```

```
# Copyright (c) 2018, NVIDIA CORPORATION.  All rights reserved.
#
# NVIDIA CORPORATION and its licensors retain all intellectual property
# and proprietary rights in and to this software, related documentation
# and any modifications thereto.  Any use, reproduction, disclosure or
# distribution of this software and related documentation without an express
# license agreement from NVIDIA CORPORATION is strictly prohibited.
#
# /etc/fstab: static file system information.
#
# These are the filesystems that are always mounted on boot, you can
# override any of these by copying the appropriate line from this file into
# /etc/fstab and tweaking it as you see fit.  See fstab(5).
#
# <file system> <mount point>            <type>          <options>                                <dump> <pass>
/dev/root            /                    ext4           defaults                                    0 1
UUID=6e643050-77bb-40d3-97b4-7835fc016afb /home/nvidia/workspace/ ext4 defaults                      0 3
```

Figure Auto Mount Config

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Wireless Setting

WiFi Setting

Connect an external HDMI display to APEX HDMI port. Click the network icon in upper-right corner of the desktop. Find the name of your WiFi network and click on it. Enter your password and click ‘Connect’.



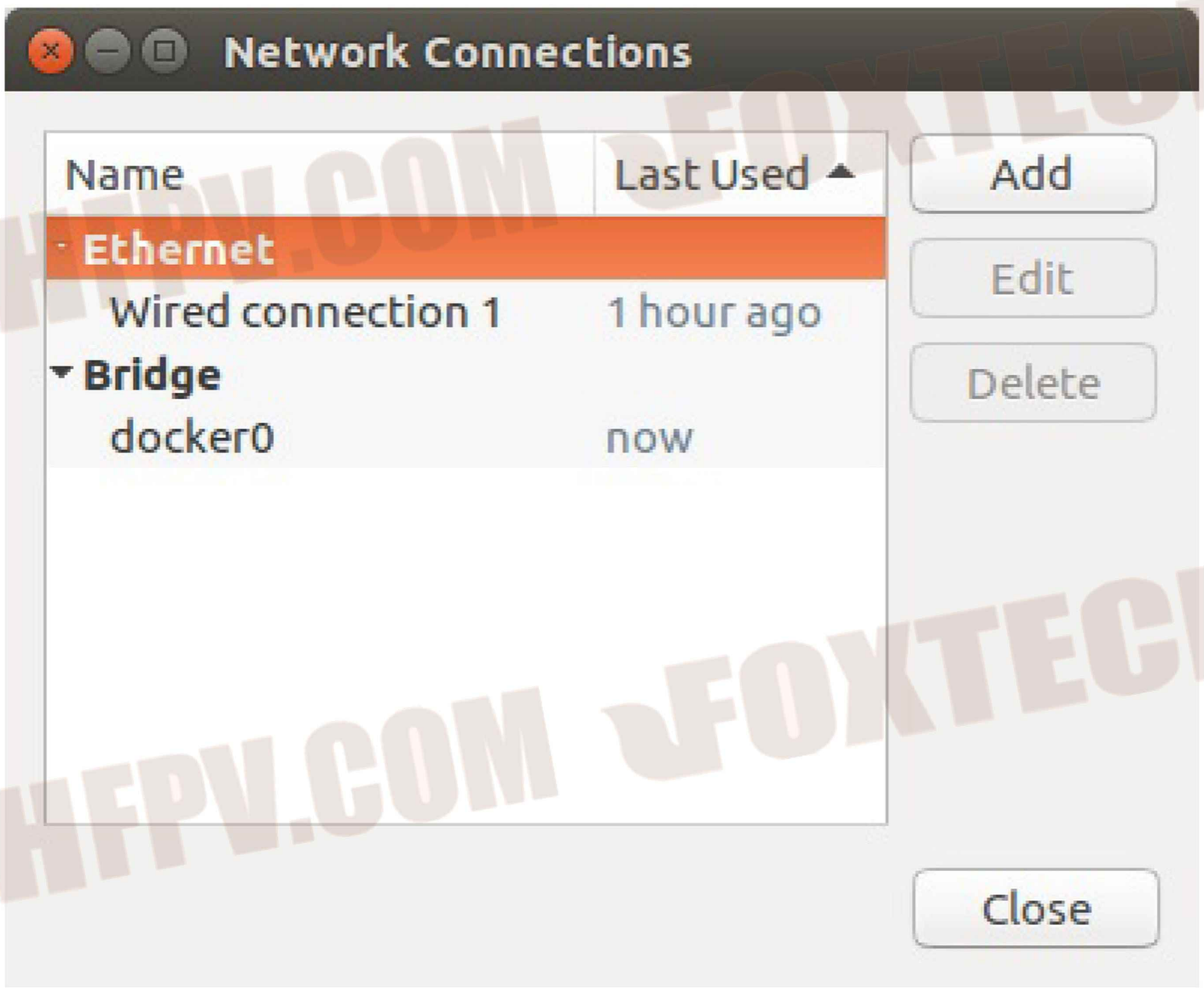
Figure WiFi Connection

4G Setting

4G module is not included in APEX package. Instructions for 4G module configuration are shown as below, using QUECTEL EM05 as an example. EM05 4G driver is included in APEX system. This SIM card could be detected automatically. There should be 4 devices under /dev/ttyUSB0~/dev/ttyUSB3.

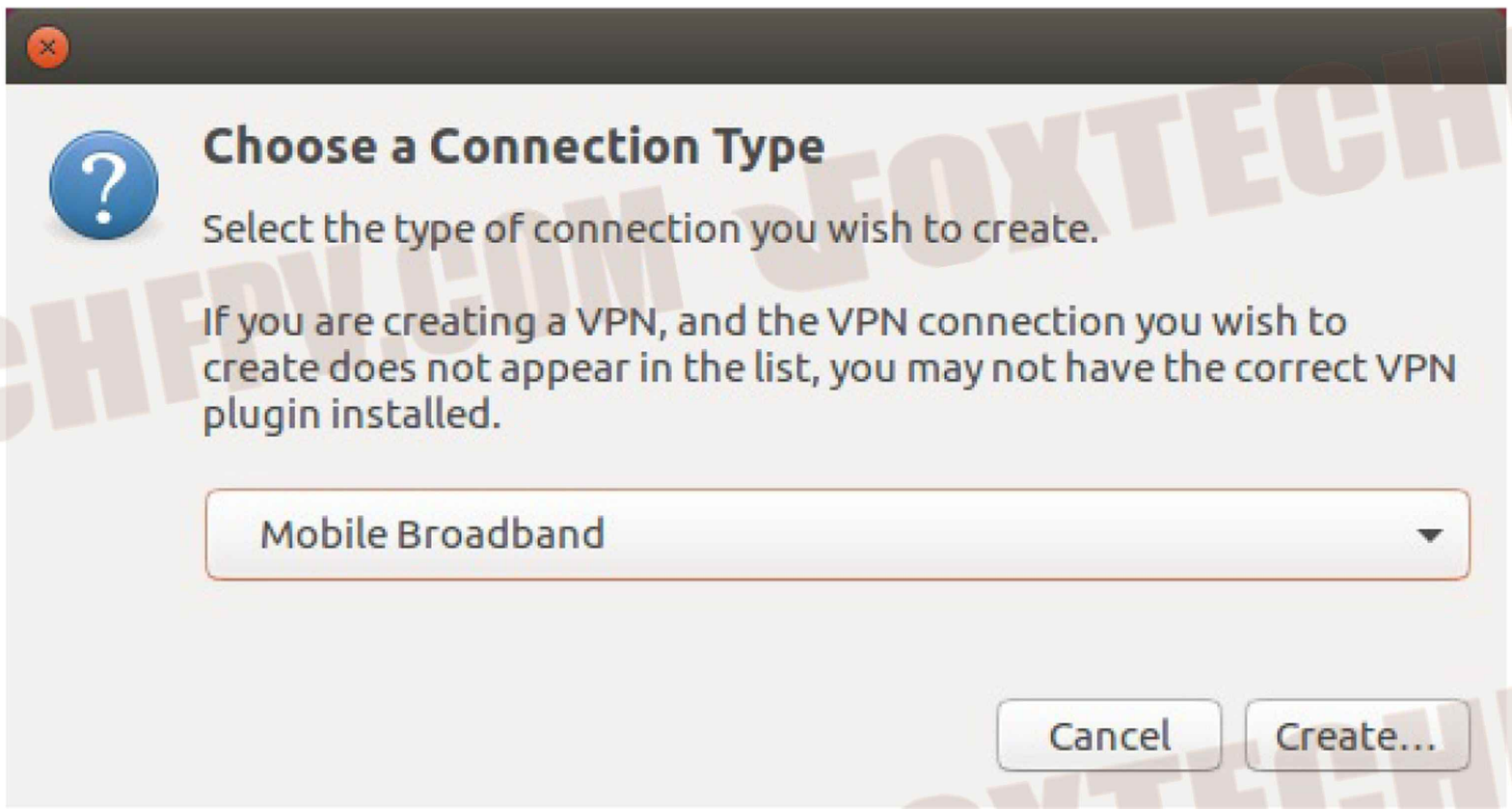
Users need to choose their own 4G LTE SIM card(note that mobile phone sim card and IOT sim card is supported, but IOT sim card requires further). Before getting started, please insert SIM card into sim socket.

Click the network icon in upper-right corner of the desktop. Find 'Edit Connections', then click 'add'.

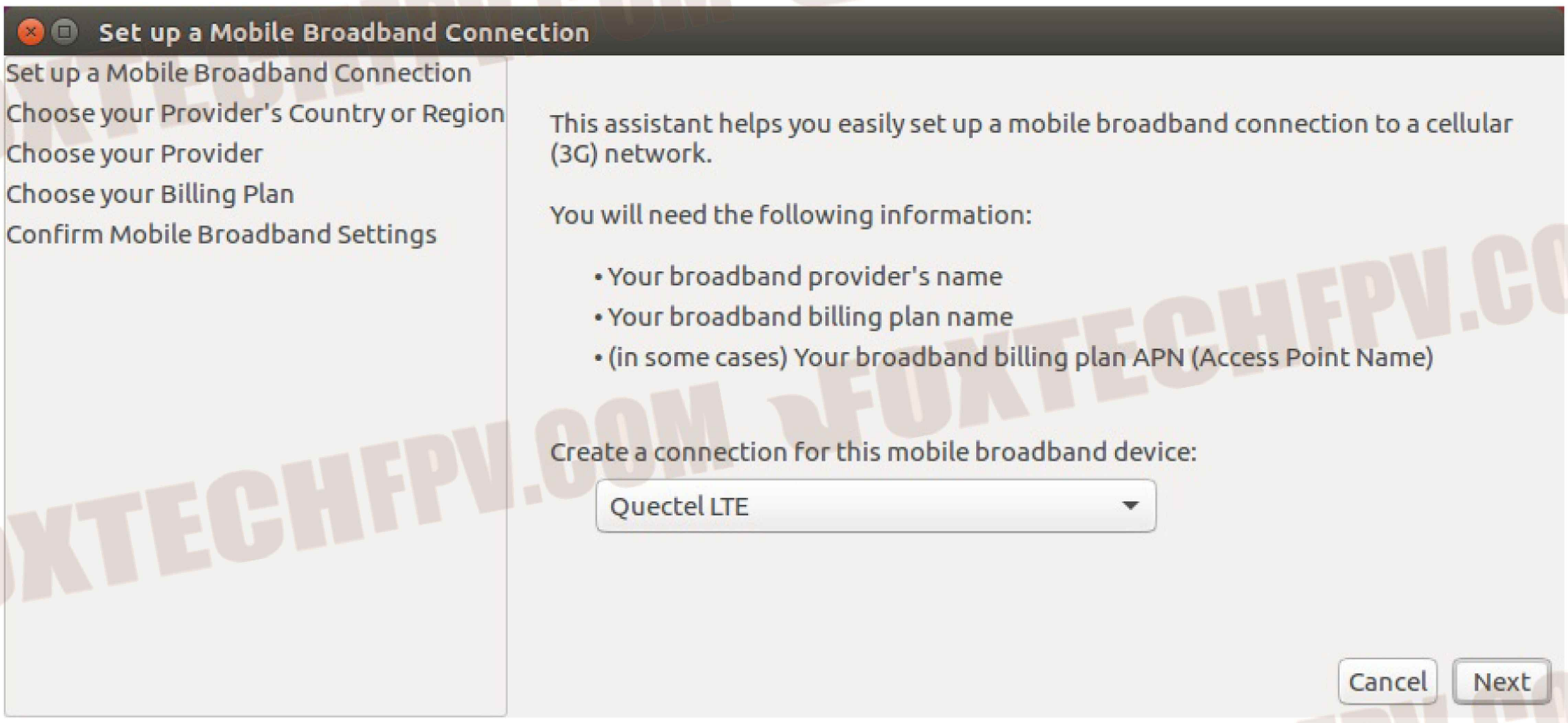


Change connection type to 'Mobile Broadband'

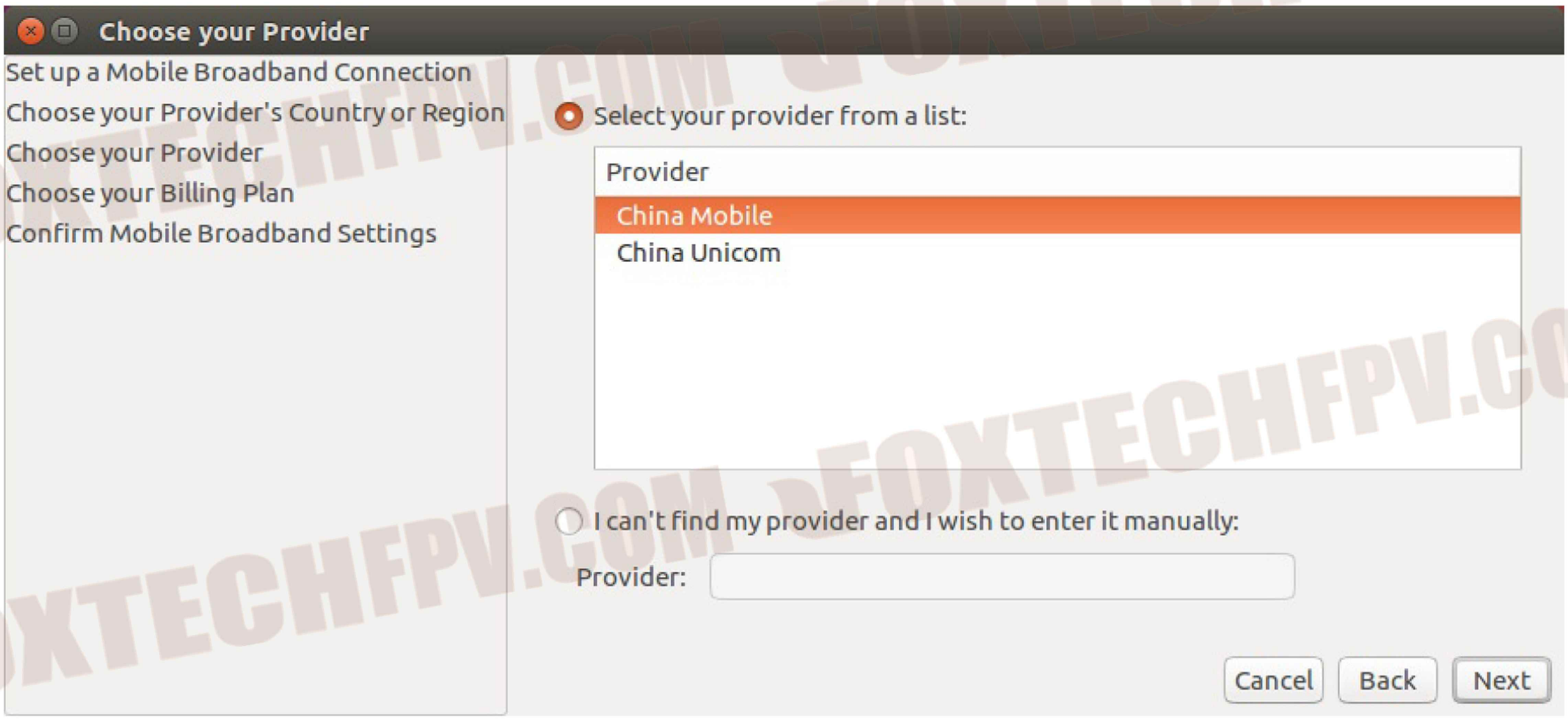
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Next

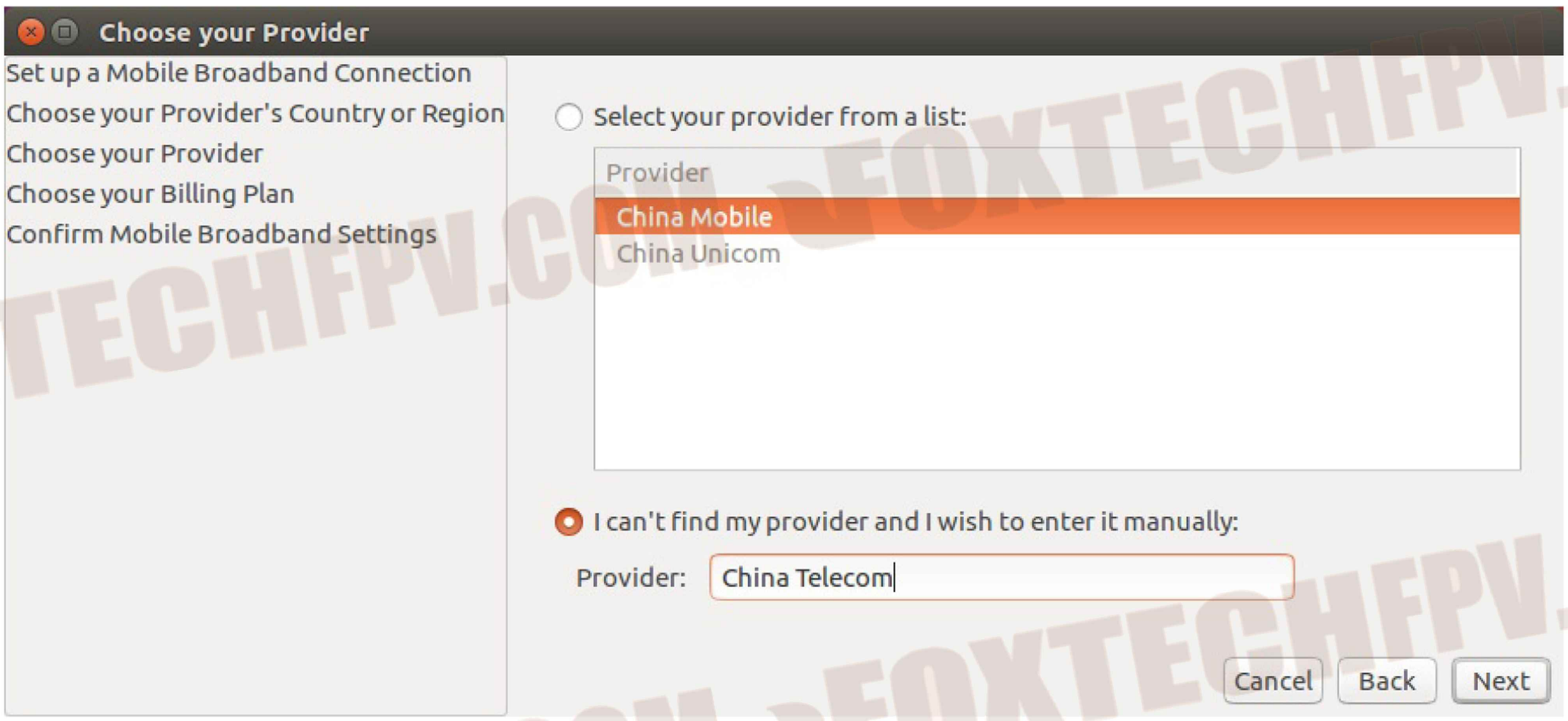


Change country to 'China'. Then choose network provider.



If your network provider is not included in the list, then enter it manually.

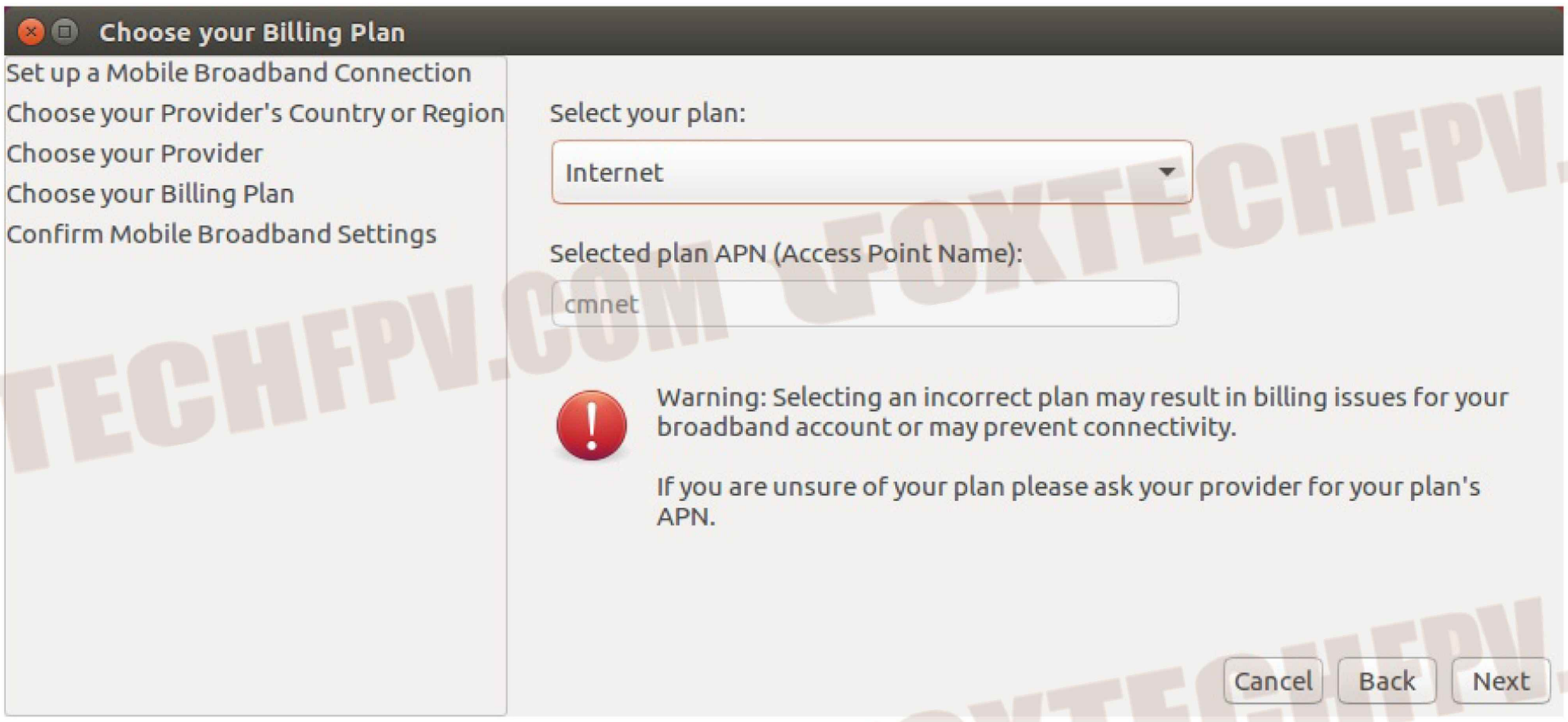
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Choose your Plan

China Mobile choose 'Internet'，China Unicom and China Telecom choose default

APN settings: China Mobile: cmnet; China Unicom: 3gnet; China Telecom: ctnet

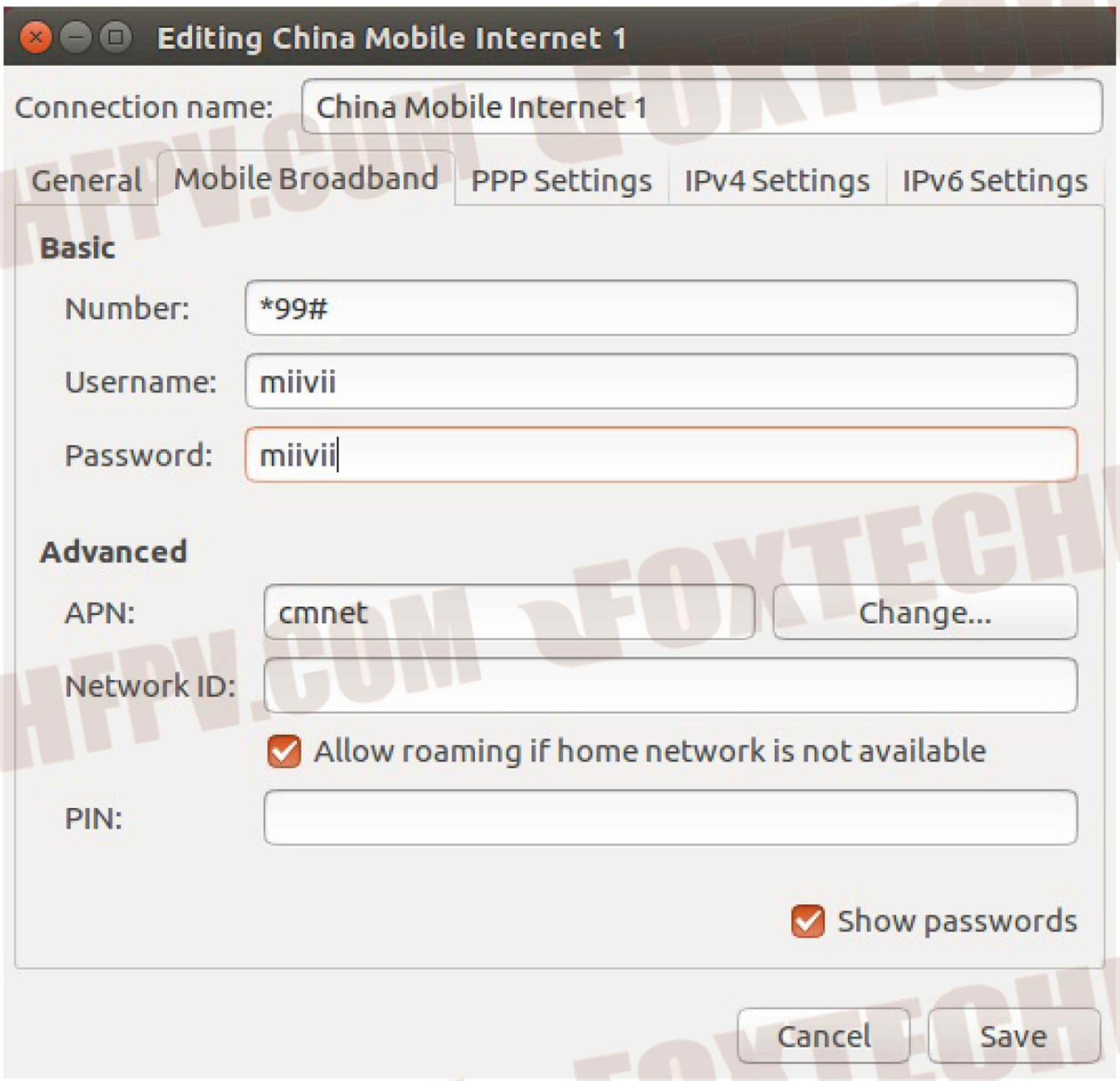


Check entire settings, then click 'Apply'

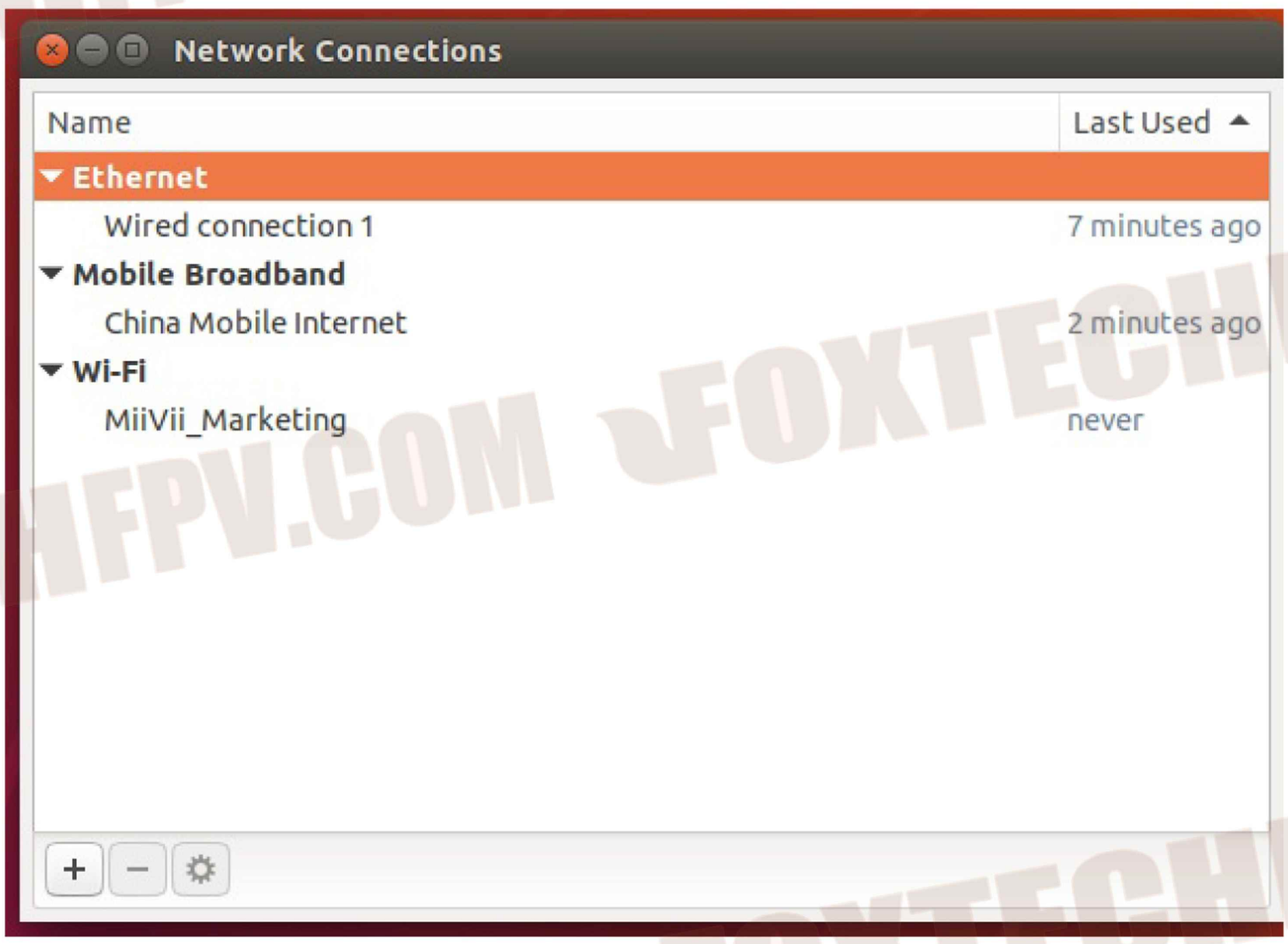


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Enter username and password, click 'save'



Click the network icon in upper-right corner of the desktop. Then connect to your network. If you need auto connection, please edit Network connections:



Select 'General', then check 'Automatically connect to this network when it is available'

Reset APEX , you can automatically connect to 4G network

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Synchronization Function

Sync Introduction

Apex provides 3 ways to synchronize sensor input data: PPS, Sync in and Sync out. Synchronization error is within 1μs. (Error estimation method is attached to the end of this section)

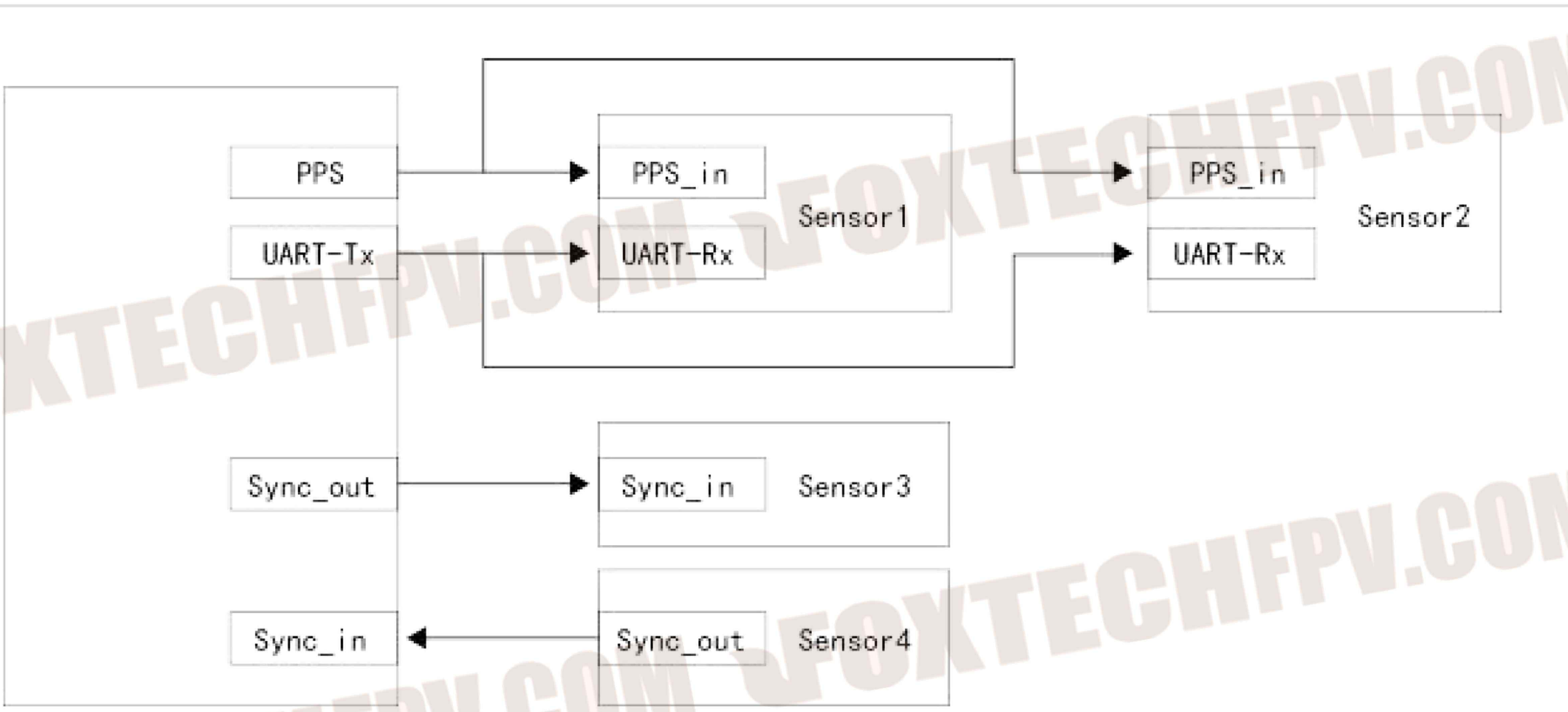


Figure Sync Fearure Schematic

Sync Function

PPS Sync Method

APEX generates PPS(Pulse width: 50ms). The NMEA GPRMC message is sent through PPS port. NMEA message example:

```
$GPRMC,060249.000,A,3949.63046,N,11616.48565,E,0.296,,291118,,,A*4d
```

'060249.000' represents 'Time of fix 06:02:49 UTC'. Receiving PPS signal and GPRMC message, sensors which support PPS synchronization, could synchronize their internal clock with system time. Together with the timestamp, sensor data is sent to Apex , so that Apex receives the data acquisition time.

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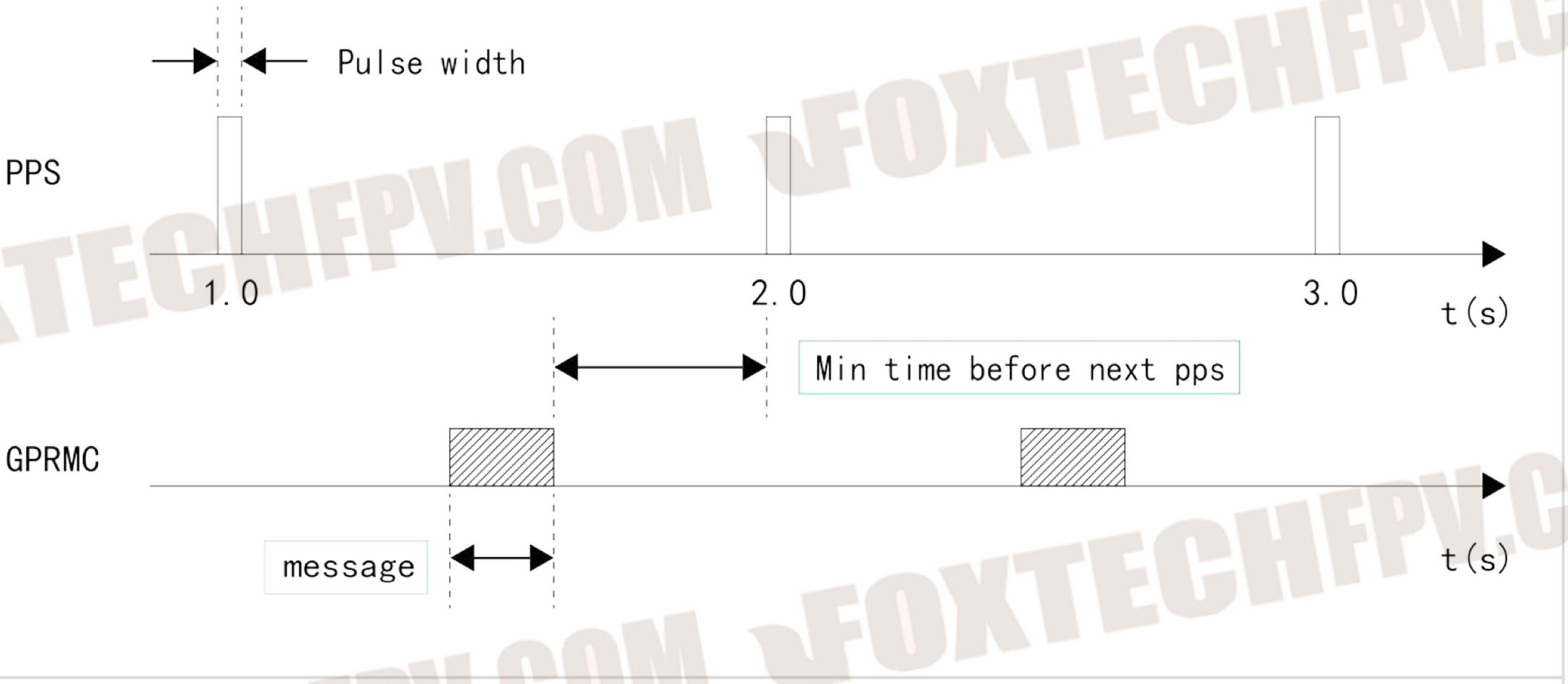


Figure PPS Sync Method Schematic

Synchronization verification (RS-LiDar-16 sensor):

When the sensor connects with Apex using only data wire, device ROS Node sends hardware timestamp to the system, which is determined by sensor's internal clock. As shown below, there is a big difference between hardware timestamp and system time.

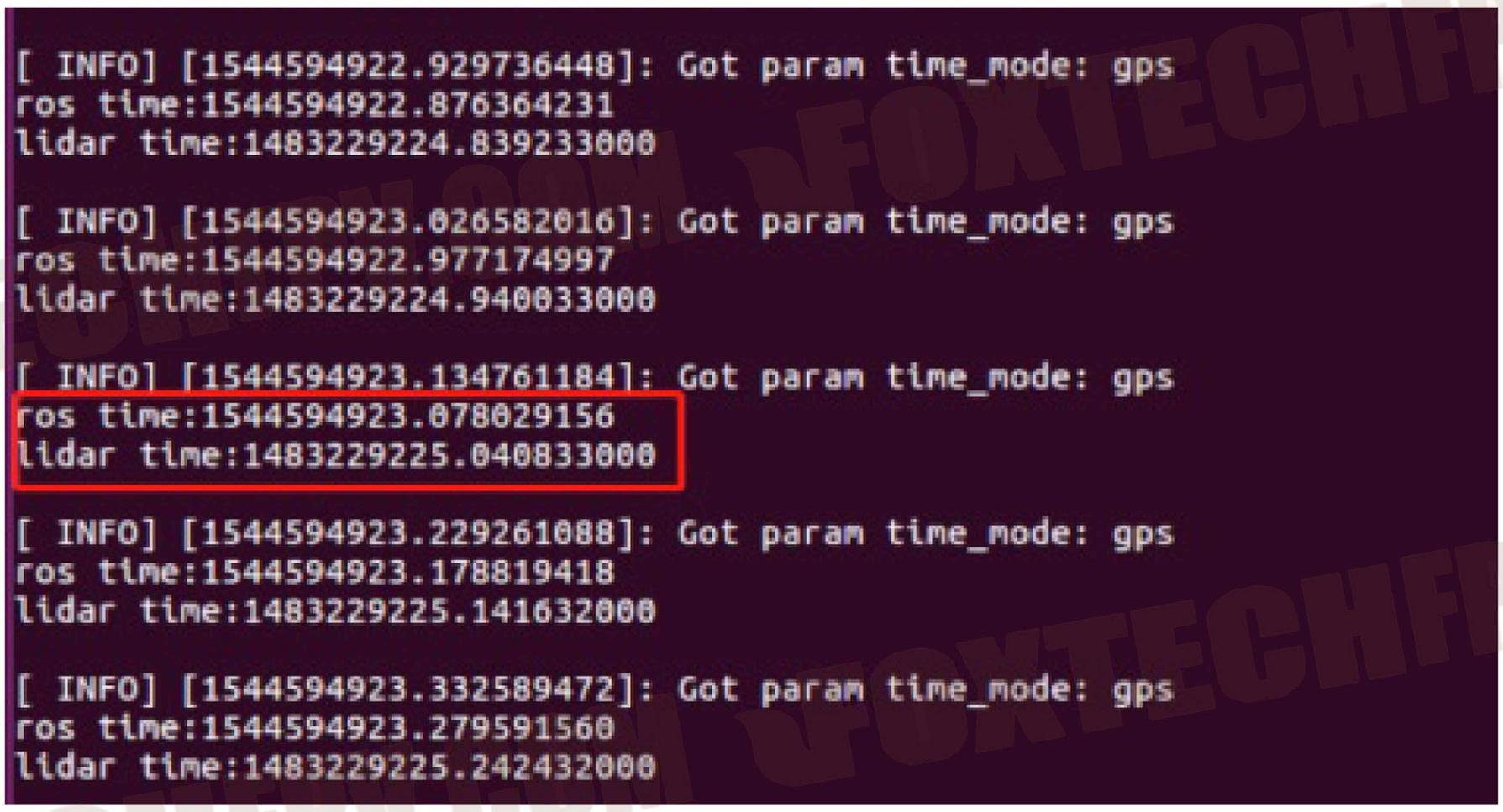
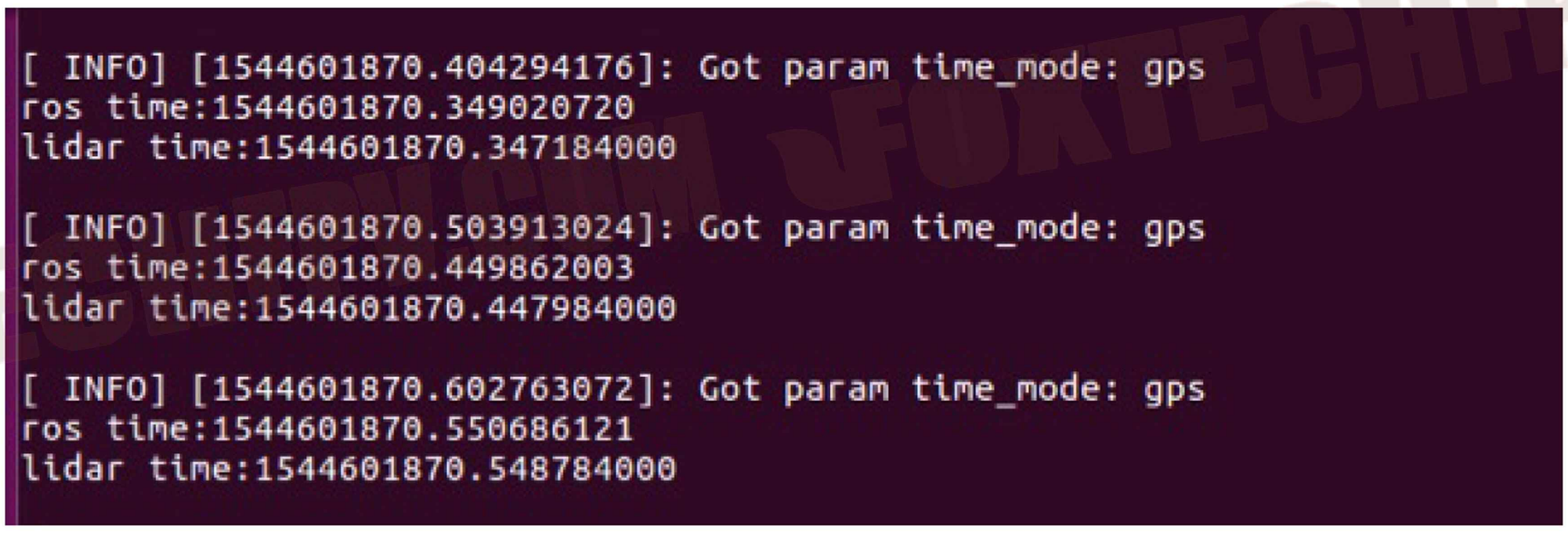


Figure Comparison of Lidar Time and ROS time without Synchronization

After connecting the sensor with Apex PPS_SYNC and PPS_TX pin, the sensor's internal clock is synchronized with system time. Comparing the hardware timestamp and system time, when the difference is less than 100ms, it means PPS synchronization is functional.



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Sync out Method

Apex could generate one 1-30Hz signal (Pulse width: 5ms) through its sync-out pin. This signal is received by sensors as trigger signal for data acquisition. Meanwhile, Apex records the moment of this signal's rising edge. After data acquisition, Apex associates received data with the trigger signal's rising edge moment as data timestamp. Thus, Apex system obtains data acquisition time.

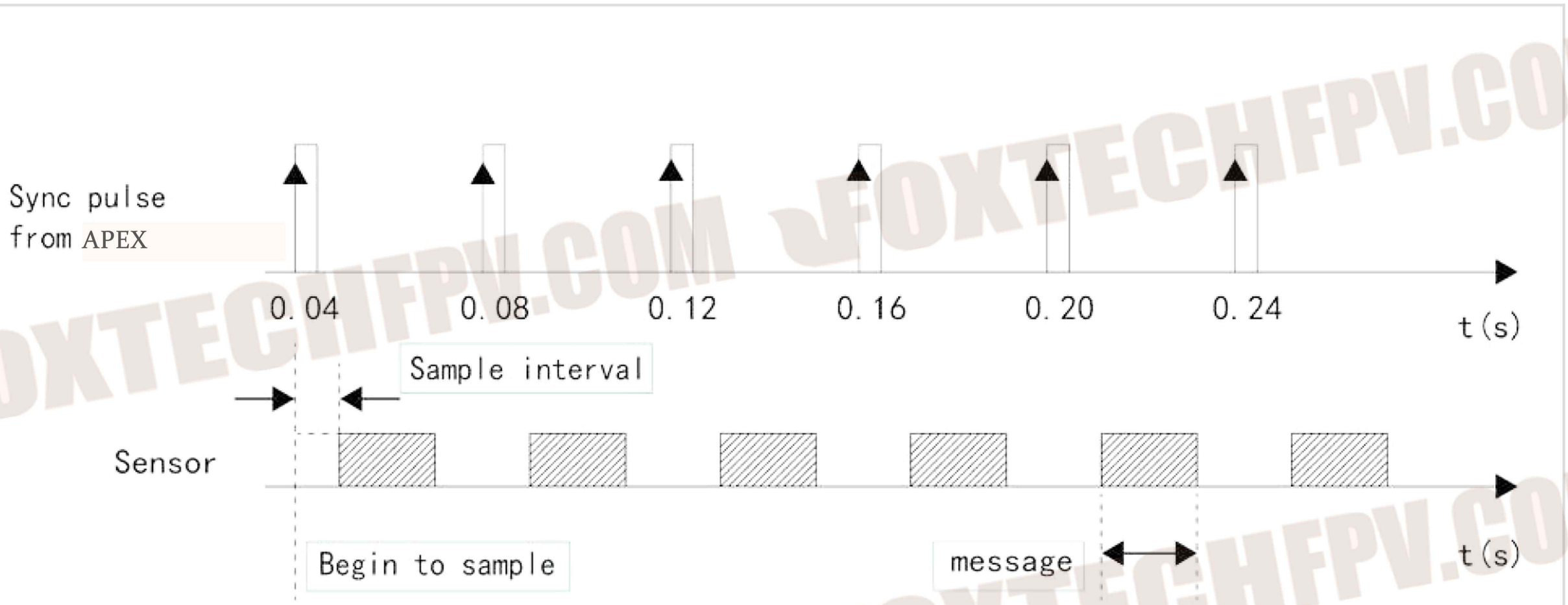


Figure Sync out Method Schematic (25Hz)

Also, Apex provides sync-out feature for GMSL interface. See GMSL Camera Section for details.

Synchronization Verification

Set the sensor to external sync configuration. By recording ROS bags, check whether the sensor trigger signal equals to your setting or not. If the difference is within 1Hz, it means sync-out method is functional.

Sync in Method

Sensors with sync-in mode could generate a signal at the beginning of data acquisition. Apex receives this signal and records its rising edge moment. After data acquisition, Apex associates received data with the signal's rising edge moment as data timestamp. Thus, Apex system obtains data acquisition time.

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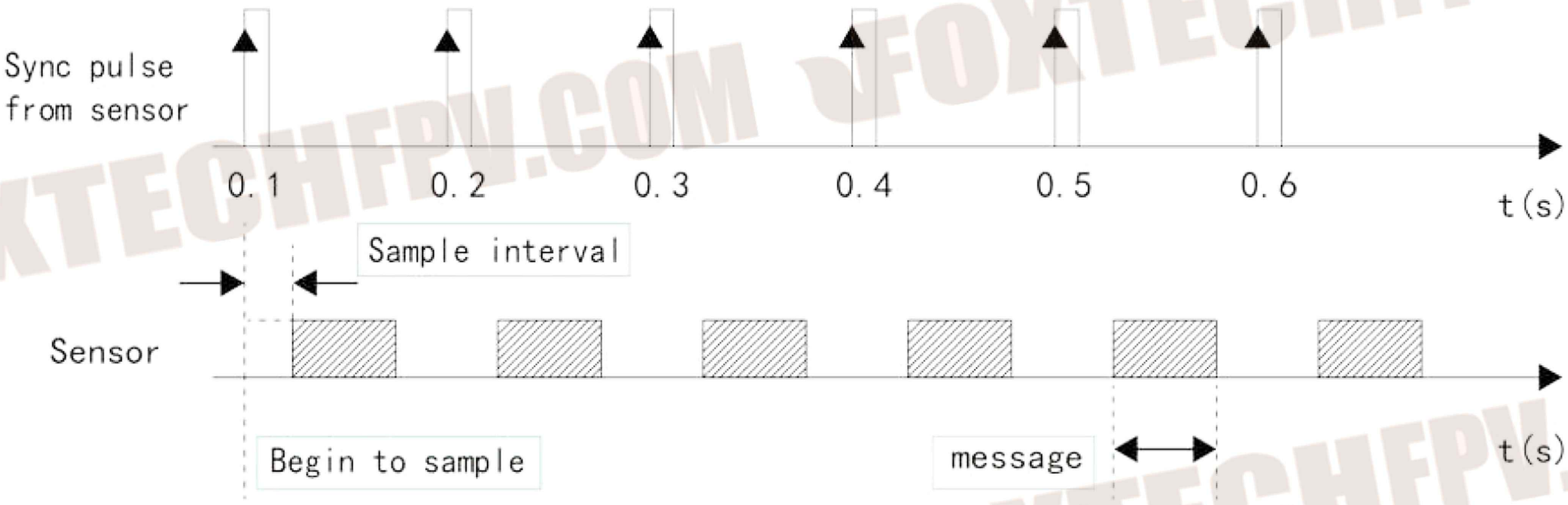


Figure Sync in Method Schematic (10Hz)

Synchronization Verification:

Print the signal's timestamp received by SYNC_IN pin. Compare this timestamp with system time of frame received (ros::time::now). If the difference is less than 100 ms, it means sync-in method is functional.

Synchronization error estimation

Measure PPS signal duration with oscilloscope

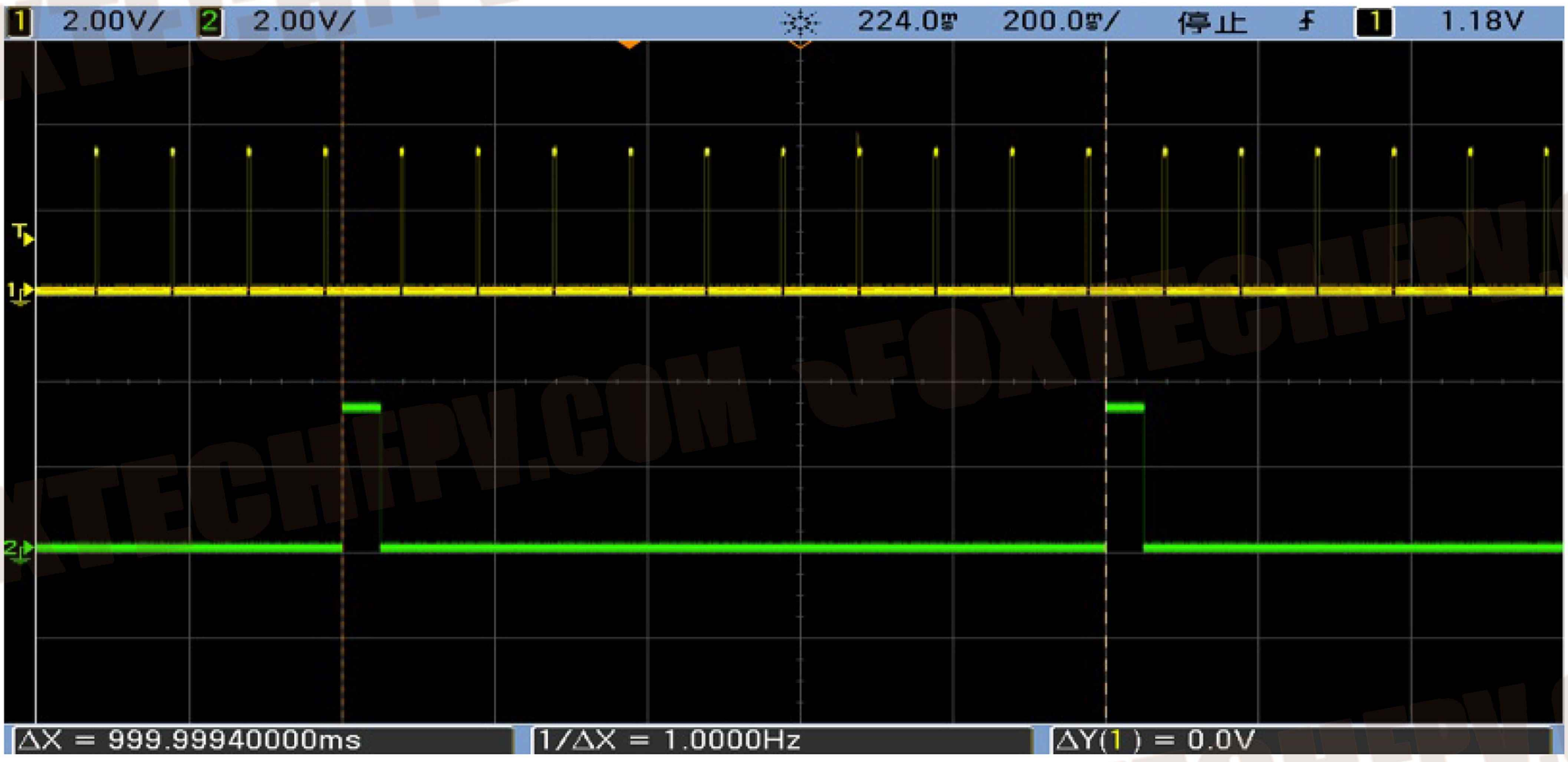


Figure PPS Signal Duration

	Theoretical Value(μs)	Measurement Result(μs)	Error（μs）
PPS	1000000	999999.4	0.6

Measure sync-out signal duration with oscilloscope

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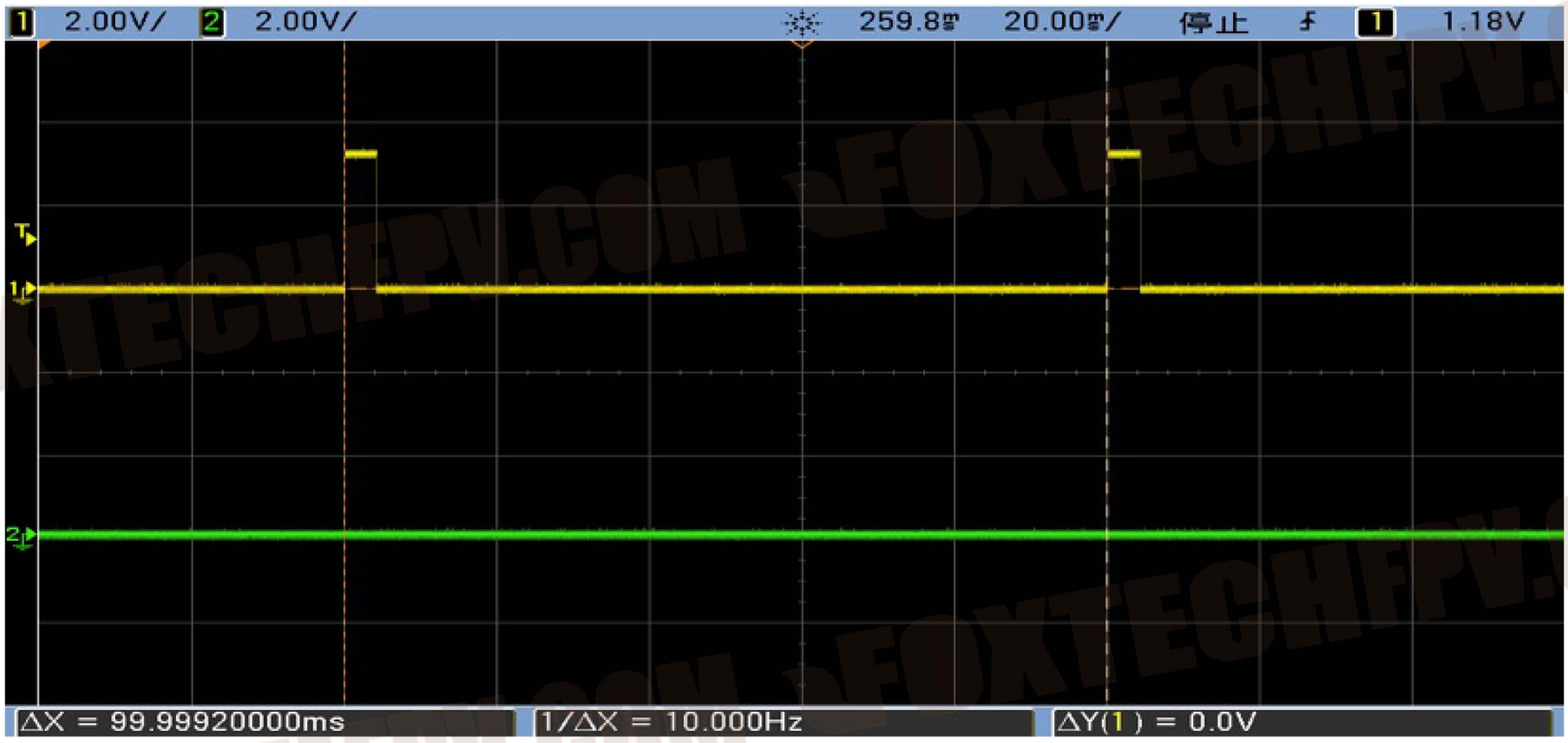


Figure Sync-out Signal Duration (10Hz)

	Theoretical Value（μs）	Measured Value（μs）	Error（μs）
Sync out	100000	99999.2	0.8

Evaluate synchronization feature by measuring timestamp jitter

Sample code to calculate timestamp jitter

`APEX` provides sample code for users to evaluate the synchronization feature.

```
#navigate to the following directory
cd /opt/miivii/feature/sync_test/bin
#evaluate sync-out method performance
./sync_out_test
#evaluate sync-in method performance
./sync_in_test
#evaluate pps synchronization method performance
./pps_test
```

Sync out jitter measurement

Sample code(sync_out_test) could run real-time analytics on the received timestamp. Time interval, frequency, max deviation and standard deviation are printed out.

```
You are checking the sync out mode
Time interval: the interval between two frames
Frequency measured : the Frequency measured by the Time interval
Max deviation : the difference between the maximum and the average
standard deviation : calculated by statistical data
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 32(ns) standard deviation: 9.055385
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 32(ns) standard deviation: 9.055385
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 32(ns) standard deviation: 9.055385
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 32(ns) standard deviation: 9.055385
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 32(ns) standard deviation: 9.055385
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 32(ns) standard deviation: 9.055385
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 32(ns) standard deviation: 9.055385
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 32(ns) standard deviation: 9.055385
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 32(ns) standard deviation: 9.055385
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 32(ns) standard deviation: 9.055385
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 32(ns) standard deviation: 9.055385
```

Figure Sync out Test Result

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Sync in jitter measurement

Connect an external signal with fixed frequency to APEX SYNC_IN pin. Run sample code (sync_in_test) for real-time analytics on the received timestamp.

APEX SYNC_OUT pin could be used as an 25Hz external signal to connect with SYNC_IN pin



Figure Sync Pin Connection Schematic

```
You are checking the sync in mode,pleale check the connecting line
Time interval: the interval between two franes
Frequency measured : the Frequency measured by the Time interval
Max deviation : the difference between the maximum and the average
standard deviation : calculated by statistical data
Time interval: 39999999(ns) Frequency measured: 25.000001(hz)  Max deviation: 193(ns) standard deviation: 76.583288
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 193(ns) standard deviation: 65.984847
Time interval: 39999999(ns) Frequency measured: 25.000001(hz)  Max deviation: 193(ns) standard deviation: 71.700767
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 193(ns) standard deviation: 71.693793
Time interval: 39999999(ns) Frequency measured: 25.000001(hz)  Max deviation: 193(ns) standard deviation: 69.942834
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 193(ns) standard deviation: 61.269895
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 193(ns) standard deviation: 68.673139
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 193(ns) standard deviation: 70.115299
Time interval: 39999999(ns) Frequency measured: 25.000001(hz)  Max deviation: 193(ns) standard deviation: 66.143783
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 193(ns) standard deviation: 77.051931
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 193(ns) standard deviation: 67.535176
```

Figure Sync-in Jitter Test Result

PPS jitter measurement

Connect APEX PPS pin and SYNC_IN pin. Run sample code (pps_test) for real-time analytics on the received timestamp.

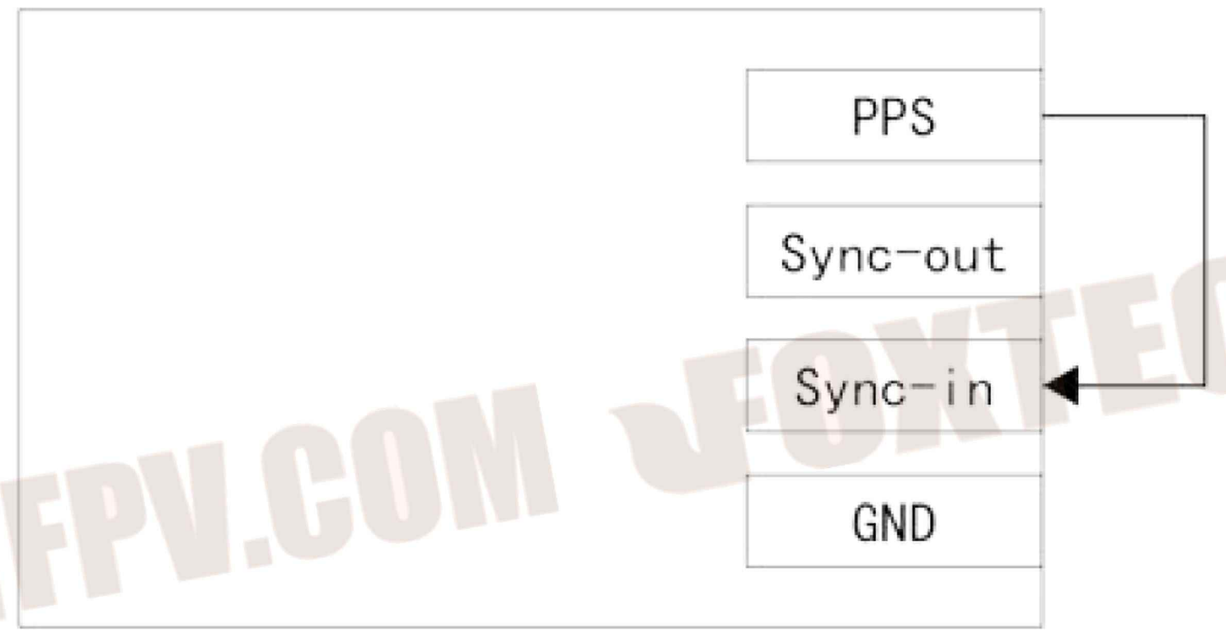


Figure Sync Pin Connection Schematic

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```
You are checking the sync in mode,pleale check the connecting line
Time interval: the interval between two frames
Frequency measured : the Frequency measured by the Time interval
Max deviation : the difference between the maximum and the average
standard deviation : calculated by statistical data
Time interval: 39999999(ns) Frequency measured: 25.000001(hz)  Max deviation: 193(ns) standard deviation: 76.583288
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 193(ns) standard deviation: 65.984847
Time interval: 39999999(ns) Frequency measured: 25.000001(hz)  Max deviation: 193(ns) standard deviation: 71.700767
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 193(ns) standard deviation: 71.693793
Time interval: 39999999(ns) Frequency measured: 25.000001(hz)  Max deviation: 193(ns) standard deviation: 69.942834
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 193(ns) standard deviation: 61.269895
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 193(ns) standard deviation: 68.673139
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 193(ns) standard deviation: 78.115299
Time interval: 39999999(ns) Frequency measured: 25.000001(hz)  Max deviation: 193(ns) standard deviation: 66.143783
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 193(ns) standard deviation: 77.051931
Time interval: 40000000(ns) Frequency measured: 25.000000(hz)  Max deviation: 193(ns) standard deviation: 67.535176
```

Figure PPS Test Result

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GMSL Function

GMSL

- GMSL Sync is triggered by one sync signal with frequency of 25Hz,you can set up frequency from 14Hz to 30Hz in gmsl SDK.
- MAXIM GMSL can drive a cable length of 15 meters.
- Support 8-Bit YUV format video with resolution of 1280×720@25, 1280×728@25, 1280×800@25 and 1280×1080@25.
- Support following GMSL camera brand and model:
-
    - **Entron** : S001A190CM0A，S001A105CM0A，S001A065CM0A，S001A038CM0A，F001R182CM0S，F001R120CM0S，F001R100CM0S，F001R060CM0S，F001R028CM0S
    - **Calmcar**: CA20205201，CA30212801，CA30211201，CA10219201
    - **Adayo**: C1A201，C1A203，C1A204
    - **Sensing**：SG1-AR0143-H030，SG1-AR0143-H059，SG1-AR0143-H125，SG1-AR0143-H197

Connection

Please refer to 'Interfaces'

Camera Setup

Please set up your GMSL camera in Setting before use.

Video Output

offers egl_demo and opencv_demo for gmsl video output. Please refer to opt/miivii/features/gmsl_camera

Demo code[13] :

```
#Complie
cp -ravf /opt/ SDK /features ~/
cd ~/features/gmsl_camera
make -j;

#Execuate with only one camera pluged
./bin/4cameras_egl_demo -d /dev/video0 -s 1280x720
./bin/8cameras_egl_demo -d /dev/video0 -s 1280x720
./bin/cameras_opencv_demo -d /dev/video0 -s 1280x720 -r 25
```

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Figure GMSL Output

[13]. parameters are defined by camera resolution. For , n is the number of connected cameras; WxH is video resolution. For instance, when two 1280x720 cameras are connected, parameters should be set at <2560x720>. When connected to different camera group, /dev/videoX should be set as /dev/video0 or /dev/video1. ↩

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Demo and application

APEX offers several demo code:

Algorithm: APEX offers human, vehicle, bicycle detection. Please refer to opt/ SDK /features/algorithm

Acceleration SDK: APEX provides acceleration SDK based on Yolo v3. Please refer to opt/ SDK /features/ accelerator

ROS demo: APEX offers ROS DEMO. Please refer to opt/miivii/ros_demo

Among them, miivii_msgs is the message rule of ROS. miivii_gmsl is the ROS node of GMSL camer. miivii_detector is the ROS node of object detection.

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Appendix

Exception Handling

If bug occurs to you while developing, please check DEBUG log first:

Step 1: Find the position of DEBUG port in 'Interfaces'

Step 2: Connect DEBUG port with a PC using a RS232-USB cable

Step 3: Download Serial debugging tool in the PC, set Baud to 115200

Step 4: Check DEBUG log

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