

奥比模组多机同步方案

修订说明

V1.0	2024/11/12	首次发行
V1.1	2026/7/17	补充设计原理，测试方法和参考例程信息

1. 原理

Gemini 345Lg 设计了多机同步功能，是多个 3D 相机能够满足更多的需求。如增大相机的空间覆盖范围，提高有效帧率，利用多机同步功能拍摄更大视场角场景等。实现方案为硬件同步，硬件同步基于主控提供的脉冲硬件同步信号，需要主控端提供硬件同步管脚支持，同步精度较高。

2. 硬件设计

模组与主控相连均通过支持 GMSL2 协议的 FAKRA 接口同轴线缆。如需硬件同步功能，主控端需设计可周期性发送脉冲信号的 Fsync 同步管脚。通过解串、编串器转发到相机模组。

2.1 奥比模组设计

多台设备之间 RGB、Depth 和 IR 数据流数据流同步。多机同步通过 GMSL 链路中的 GPIO 引脚传输同步信号，主机输出高精度的触发信号，通过解串器和串行器的 GPIO 映射，将信号传输到从机。传输方式为星型拓扑（并联）。

星型拓扑由主机将信号传输给其余从机。当前连接方案下，Gemini 345Lg 仅支持做从机的多机同步方案，不支持做主机。仅支持在主控做主机的情况下进行多机同步。

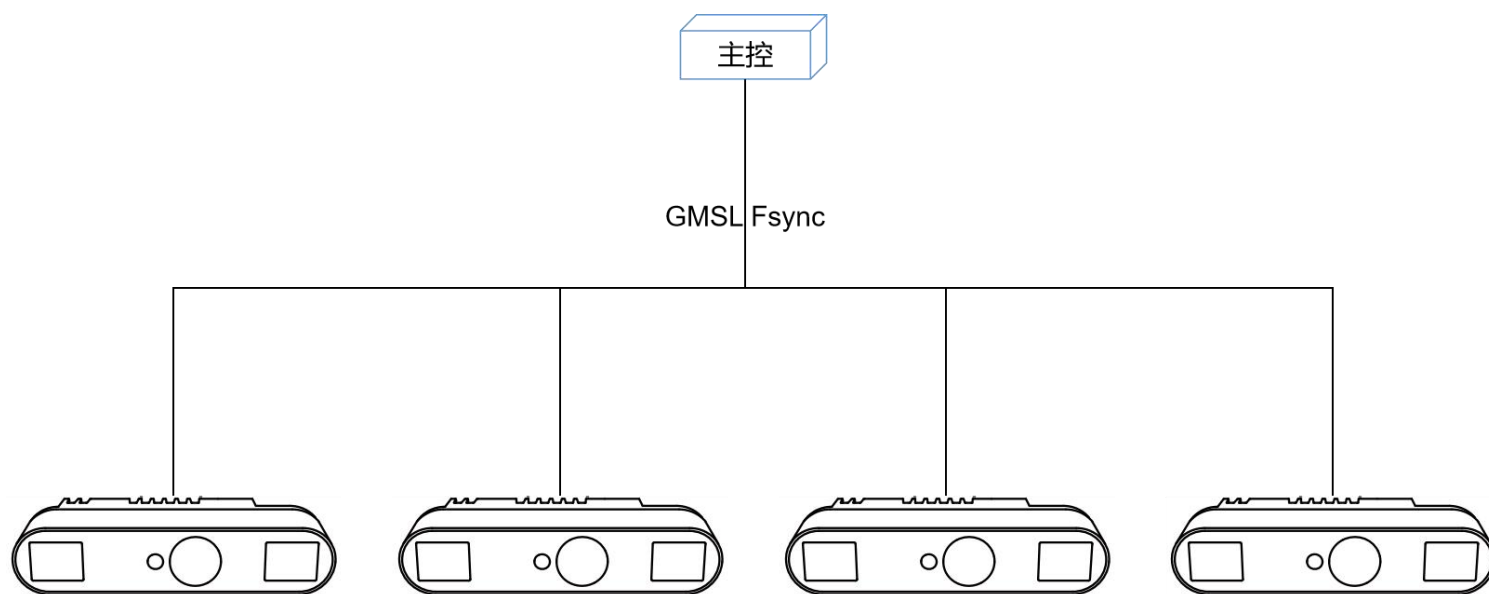
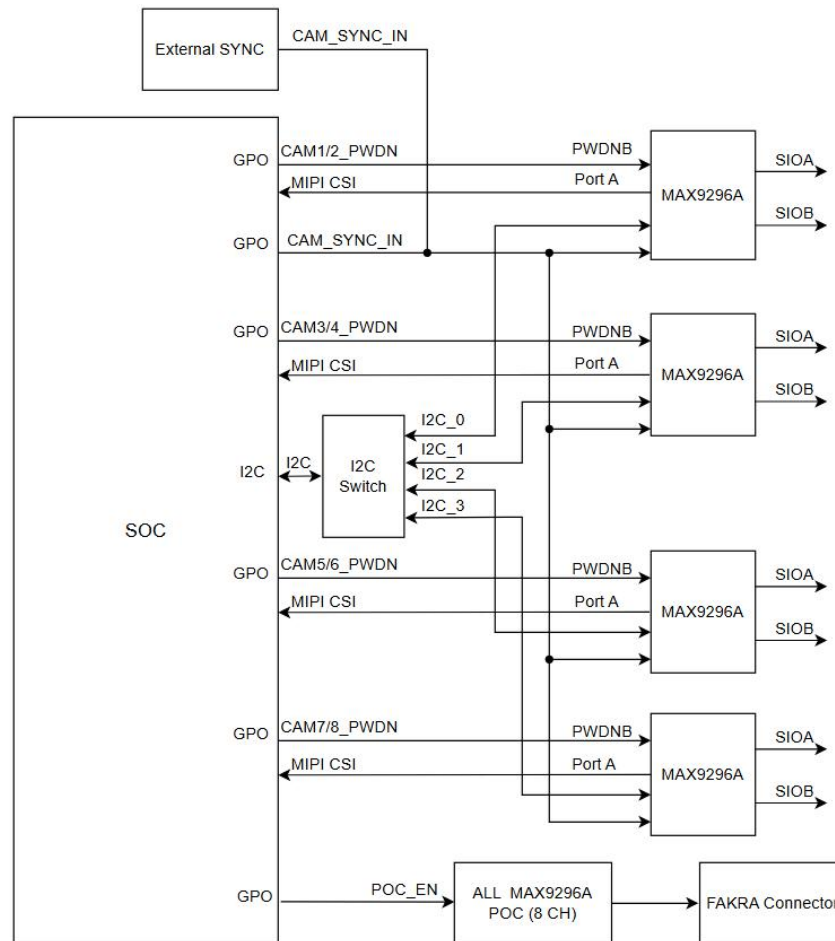


图 2-1 多机同步系统连接示意图

实物连接图



解串板 FAKRA 接口上分别连接 Gemini 345Lg 相机模组，其中解串板设计必须满足解串芯片中多机同步管脚 (CAM_SYNC_IN) 连接到主控 GPO 或者外部同步模块 (External SYNC)。由于同步管脚时序要求较高，如使用主控 SOC 平台的 GPO，建议 PWM 方式使用。如使用外部同步模块，建议使用周期性、实时性较强平台。



如下表中表述了 Gemini 345Lg 模组编串模块内部多机同步与时间同步硬件管脚设计。

表 2-1 模组控制管脚说明

Pin 名称	I/O	定义	功能	解串需求优先级
MFP6	O	SYNC_IN	多机同步 SYNC_IN，串行芯片输出，模组 ASIC 输入信号，高脉冲有效，脉宽 $\geq 1\text{ms}$ 。	II 级，有多机同步需求时使用
MFP7	O	PPS	GPS 秒脉冲信号，高脉冲有效，脉宽 $\geq 1\text{ms}$ 。	II 级，有 GPS 授时同步需求时使用

USB 接口使用时候选用 SBU1 或者 SBU2 实现，建议如下图硬件实现，即 SBU2 连接到主控的控制管脚或者外部同步模块，如使用 USB 接口需要做单独防护设计（USB 密封盖实现 IP67 防护）。

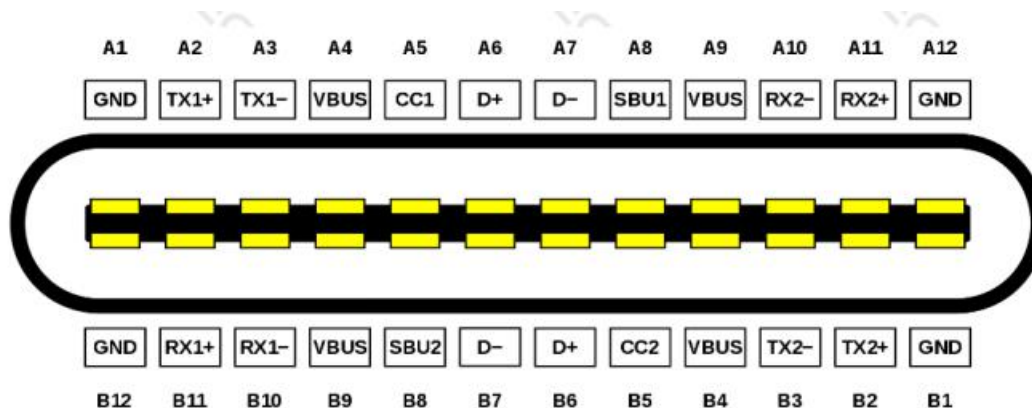
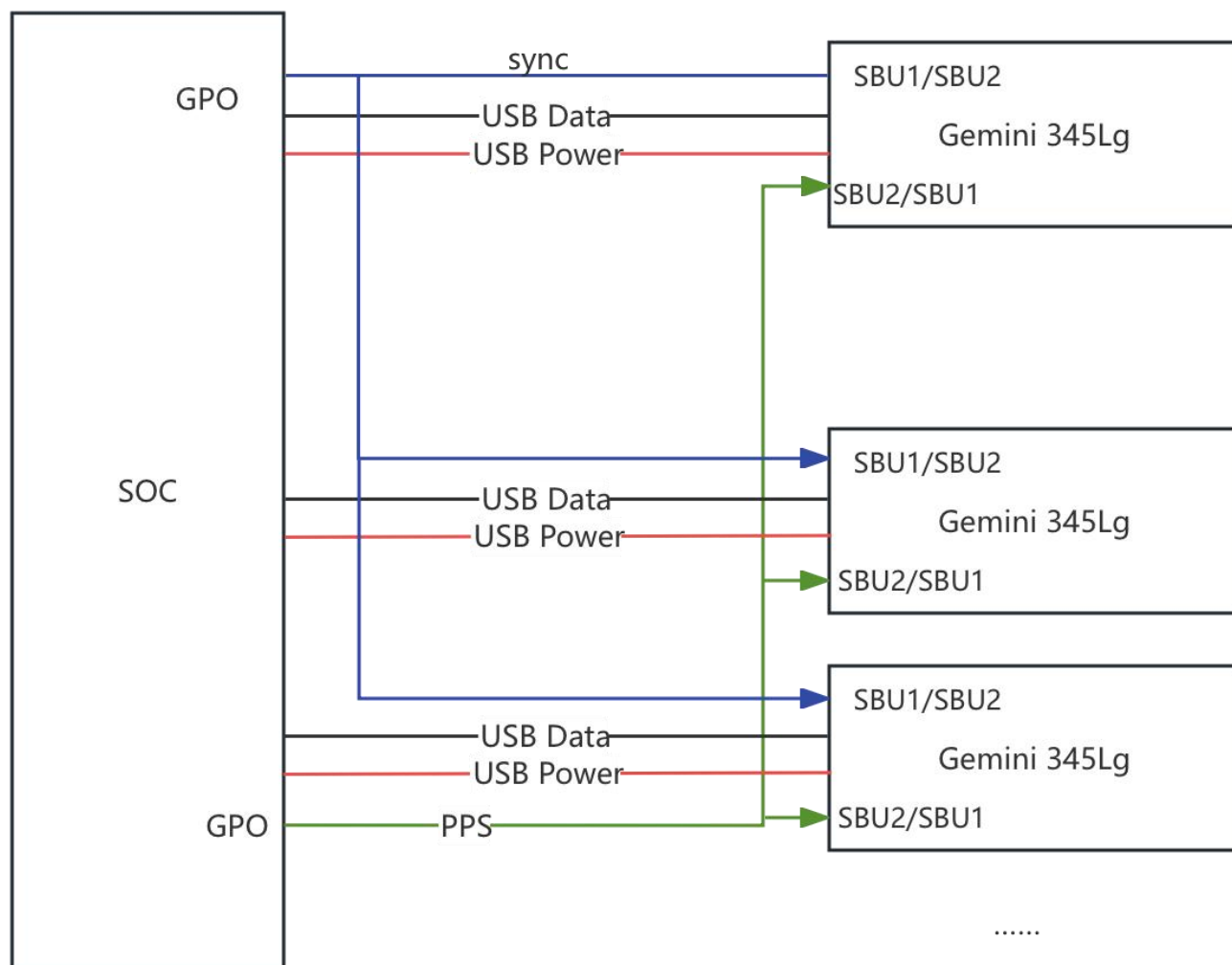


图 4-11-2 USB 接口图

表 4-11-2 DaBai AL USB 接口定义

pin	名称	功能描述	pin	名称	功能描述
A8	SBU1	sideband use, 3.3V, PPS(默认)	B8	SBU2	sideband use, 3.3V, SYNC_IN(默认)

具体硬件设计可以参考如下框图。由于目前相机模组为 Type-C，支持正反插，因此需要系统自动检测当前连接线束为正插还是反插。确定设置正确的 GPO 接口用于输出周期性 SYNC 信号。



2.2 平台端设计建议

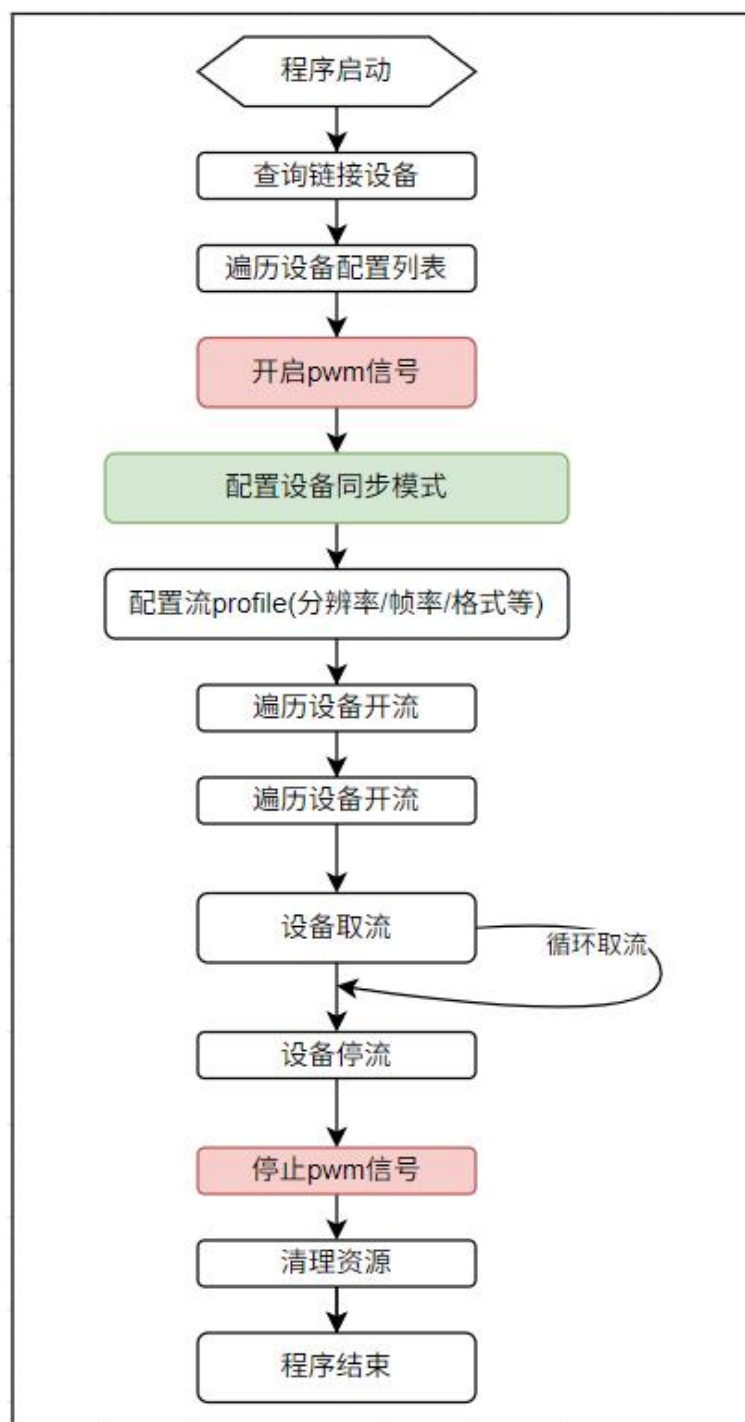
建议平台接硬件的 PWM 作为同步触发信号 F_{sync} 的产生源，可以保证信号波动较小满足 sensor 的要求，不要使用普通的 GPIO 通过高精度定时器去控制，因为 Linux 不是实时操作系统信号波动会比较大。

针对 GMSL 接口，同步触发信号 IO 需要连接到 MAX9296 支持 GPIO 功能或者 GPI 功能的 MFPx 引脚，如 MFP0 / MFP5/ MFP6/MFP10 这几个引脚都是奥比验证过的引脚。

针对 USB 接口使用，同步触发信号 IO 需要连接到主控的 GPO 管脚，GPO 管脚作为 SYNC 信号连接到模组的 SBU1/SBU2，SYNC 信号要求周期性以及电平 3.3V。

3. 软件设计

3.1 多机同步软件接口调用流程框图



3.2 关键事项

- 1) 注意如使能 pwm 特定频率信号触发多机视频同步输出(pwm 频率需要根据视频帧率对应)

软件配置硬件多机同步触发模式

- 2) OB_MULTI_DEVICE_SYNC_MODE_SECONDARY

- 3) 使用多机同步，所有的模组 RGB、Depth、IR 的帧率必须是一样的。

- 4) 同步信号精度要求：

GMSL 接口详细参考例程：multi_devices_sync_gmsltrigger

USB 接口详细参考例程：advanced.multi_devices_sync

该 sample 会调用/dev/camsync 字符 PWM 驱动硬件触发，pwm 信号会同时触发多个相机出流；

同步信号配置调整建议：

V1.8.00 及更早版本：建议配置周期为 $T+30\mu s$ ，精度保持在 $(T+20\mu s, T+40\mu s)$ 。

V1.8.01 及之后版本：建议配置周期为 T ，精度保持在 $(T-10\mu s, T+10\mu s)$ 。

4. GMSL 测试方法

4.1 硬件连接

硬件设备：解串板-奥比测试解串板及配套电源； 主控-AGX 平台及配套电源； 模组-4pcs Gemini 345Lg 模组；
线材-4pcs 6Gbps GMSL 线。

4.2 测试步骤

1. 安装对应 GMSL 驱动：

各平台+解串器+模组搭配的驱动安装说明如下：

```
# AGX_Orin + G335Lg: if use FG96_8CH_GMSL_V2 Dser board and use PWM01 generate multi-camera synchronization signals.  
sh copy_to_target_agx_orin_fg96.sh
```

```
# AGX_Orin + G335Lg: if use Leopard LI-JAG-ADP-GMSL2-8CH Dser board and use PWM01 generate multi-camera synchronization signals.  
sh copy_to_target_agx_orin_leopard.sh
```

```
# AGX_Orin + G335Lg: if use ADVANTECH MIC-FG-8G Dser board and use PWM01 generate multi-camera synchronization signals.  
sh copy_to_target_agx_orin_mic_fg_8g.sh
```

```
# AGX_Orin + G335Lg: if use CTI Dser board and use PWM01 generate multi-camera synchronization signals.  
sh copy_to_target_agx_orin_cti.sh
```

```
# AGX_Orin + G335Lg: if use XC Dser board and use hrtimer generate multi-camera synchronization signals.  
sh copy_to_target_agx_orin_xc.sh
```

```
# AGX_Orin + G345Lg: if use FG96_8CH_GMSL_V2 Dser board and use PWM01 generate multi-camera synchronization signals.  
sh copy_to_target_agx_orin_nomtd_fg96.sh
```

```
# AGX_Orin + G345Lg: if use XC Dser board and use hrtimer generate multi-camera synchronization signals.  
sh copy_to_target_agx_orin_nomtd_xc.sh
```

```
# Orin_NX + G335Lg: if use FG96_2CH_V2 Dser board and use pwm8 generate multi-camera synchronization signals.  
sh copy_to_target_orin_nx_fg96.sh
```

2. 安装完成后，再运行一遍 reconnect.sh 脚本，后续每次重新连接相机均需运行该脚本。

```
orbbe@ubuntu: ~/Desktop/MB2402/gmsl-driver-jetson-v1.2....
orbbe@ubuntu:~/Desktop/MB2402/gmsl-driver-jetson-v1.2.01(JP6.0)$ sh '/home/orbb
c/Desktop/MB2402/gmsl-driver-jetson-v1.2.01(JP6.0)/copy_to_target_agx_orin_nomt
_fg96.sh'
[sudo] password for orbbe:
bakckup tegra-camera.ko
bakckup videodev.ko
bakckup capture-ivc.ko
bakckup nvhost-nvcsi-t194.ko
Modified /boot/extlinux/extlinux.conf to add following DTBO entries:
/boot/tegra234-p3737-camera-g300-overlay.dtbo
Reboot system to reconfigure.
orbbe@ubuntu:~/Desktop/MB2402/gmsl-driver-jetson-v1.2.01(JP6.0)$ sh reconnect.s
et.sh
Files g300 has loaded,unload g300
rmmod: ERROR: Module obc_max9296 is not currently loaded
rmmod: ERROR: Module obc_max96712 is not currently loaded
reconnect g300
orbbe@ubuntu:~/Desktop/MB2402/gmsl-driver-jetson-v1.2.01(JP6.0)$
```

备注：如系统执行自动驱动加载，无需处理。

3. 多机同步 sample 参考 sdk 包中示例 sample 如下 3.advanced.multi_devices_sync 目录

sdk 包 bin 目录测试程序 ./ObMultiDeviceSyncViewer

测试执行需要注意修改 配置多机同步工具配置文件：MultiDeviceSyncConfig.json

1).配置四台机器为从机 OB_MULTI_DEVICE_SYNC_MODE_SECONDARY;

2).注意配置链接模组的 SN 号

```
{
  "require": false,
  "sn": "CH4815D001F",
  "syncConfig": {
    "syncMode": "OB_MULTI_DEVICE_SYNC_MODE_SECONDARY",
    "depthDelayUs": 0,
    "colorDelayUs": 0,
    "trigger2ImageDelayUs": 0,
    "triggerOutEnable": false,
    "triggerOutDelayUs": 0
  },
  "timestampReset": {
    "enable": false,
    "enableResetTime": false,
    "delayTimeUs": 0,
    "triggerOutEnable": false
  }
},
```

详细释义如下描述。

```
{
    "sn": "CL2LC2P0089", // device serial number
    "syncConfig": { // 详细信息请参考 ObTypes.h 文件内的 OBMultiDeviceSyncConfig 结构体定义和说明
        "syncMode": "OB_MULTI_DEVICE_SYNC_MODE_SECONDARY", // 同步模式配置, 常用模式:
        "OB_MULTI_DEVICE_SYNC_MODE_PRIMARY, OB_MULTI_DEVICE_SYNC_MODE_SECONDARY,
        OB_MULTI_DEVICE_SYNC_MODE_SECONDARY_SYNCED", 在 include\libobsensor\h\ObTypes.h 中定义的枚举
        "depthDelayUs": 0, // ir/depth/tof 触发信号输入延时, 单位微秒;
        "colorDelayUs": 0, // rgb 触发信号输入延时, 单位微秒
        "trigger2ImageDelayUs": 0, // 触发信号输入到捕获图像的延时, 单位微秒
        "triggerOutEnable": false, // 设备触发信号输出延迟的使能开关
        "triggerOutDelayUs": 0, // 设备触发信号输出延时, 单位微秒
    }
}
```

3).硬件触发信号配置说明

执行上面测试多机同步 sample 如果配置测试从机如 SECONDARY 模式需要先把如下 pwm 硬件触发信号程序跑起来。

```
sudo ./MultiDeviceSyncGmslTrigger
```

```
root@qcs6490-odk:/tmp/123/install/Example/bin# ./MultiDeviceSyncGmslTrigger
Please select options:
-----
0 --> config GMSL SOC PWM trigger Source. Set trigger fps:
1 --> start Trigger
2 --> stop Trigger
3 --> exit
-----
input select item: 0

Enter FPS (frames per second) (for example: 3000): 3000
Setting FPS to 3000...
Please select options:
-----
0 --> config GMSL SOC PWM trigger Source. Set trigger fps:
1 --> start Trigger
2 --> stop Trigger
3 --> exit
-----
input select item: 1

Error: open /dev/camsync failed
Failed to start trigger.
start pwm source Triggersync...

Please select options:
-----
0 --> config GMSL SOC PWM trigger Source. Set trigger fps:
1 --> start Trigger
2 --> stop Trigger
3 --> exit
-----
input select item: █
```

上面示例运行 MultiDeviceSyncGmslTrigger, 输入 0 配置对应数据流的帧率, 若帧率为 30, 则输入 3000.。然后再输入 1 开启同步信号

4). 运行多机同步工具内的 ObMultiDeviceSyncViewer，第一次运行 0，后续运行均可输入 1

```
libavutil.so.56
libavutil.so.56.31.100
libopencv_core.so.4.2
libopencv_core.so.4.2.0
libopencv_highgui.so.4.2
libopencv_highgui.so.4.2.0
positec@tegra-ubuntu:~/Desktop/123/ObMultiDeviceSyncViewer_v1.3.20_Linux_aarch64_20250331074109
[sudo] password for positec: p/123/ObMultiDeviceSyncViewer_v1.3.20_Linux_aarch64_20250331074109
OBMultiDeviceSyncViewer version: 1.3.20
argc: 1
Please select options:
0 --> config devices
1 --> start stream
input: 0
```

启动运行后如下所示:

```
test@test: ~/Desktop/mb2402/ObMultiDeviceSyncViewer_v1.3.20_Linux_aarch64_20250331074109
ING
le=OB_MULTI_DEVICE_SYNC_MODE_SECONDARY
le=OB_MULTI_DEVICE_SYNC_MODE_SECONDARY
le=OB_MULTI_DEVICE_SYNC_MODE_SECONDARY
le=OB_MULTI_DEVICE_SYNC_MODE_SECONDARY
eviceSyncConfig.json already init.
ty!!!
SyncConfig.json 'devicePid'(0X0000), result device list size: 4
t host system. Select the first device in streamDeviceList as a primary device. sn: CH4815D0023
0000P, sensorType: OB_SENSOR_COLOR, deviceIndex: 1, isPrimaryDevice: 0
OR_COLOR, profile={width=1280, height=720, format=YUYV, fps=20}
0000P, sensorType: OB_SENSOR_DEPTH, deviceIndex: 1, isPrimaryDevice: 0
OR_DEPTH, alignMode=ALIGN_DISABLE
OR_DEPTH, profile={width=640, height=480, format=8, fps=20}
timestamp=1744686715363, system timestamp=1744686715194
timestamp=1744686715413, system timestamp=1744686715244
timestamp=1744686715463, system timestamp=1744686715294
timestamp=1744686715513, system timestamp=1744686715344
timestamp=1744686715563, system timestamp=1744686715394
timestamp=1744686715613, system timestamp=1744686715444
timestamp=1744686715663, system timestamp=1744686715494
timestamp=1744686715713, system timestamp=1744686715544
```

5). 在数据流预览界面按 S 键进行手动授时，按 C 键进行存图。若无存图需求，在窗口界面观察时间戳差异亦可。以上数据显示 0-3 不同模组，输出图像数据类型，对应帧索引以及时间戳。

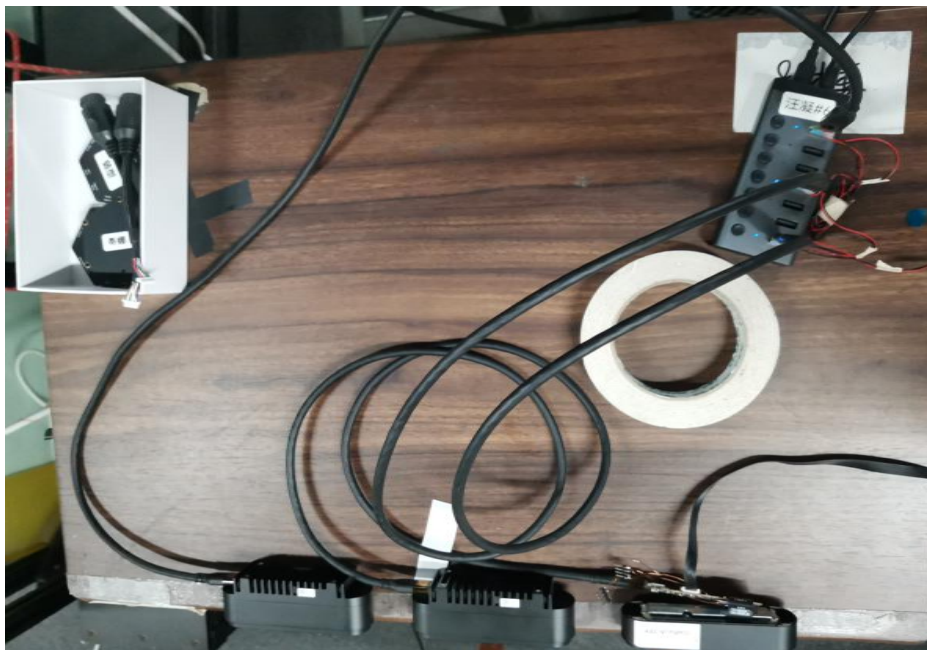


```
1, irLeft frame index=1973, timestamp=1753339852181 ms, global timestamp=1753339852310 ms, system timestamp=1753339852200 ms
0, irLeft frame index=1413, timestamp=1753339852181 ms, global timestamp=1753339852253 ms, system timestamp=1753339852206 ms
2, irLeft frame index=1812, timestamp=1753339852181 ms, global timestamp=1753339852477 ms, system timestamp=1753339852207 ms
1, depth frame index=1513, timestamp=1753339852181 ms, global timestamp=1753339852310 ms, system timestamp=1753339852213 ms
2, depth frame index=1138, timestamp=1753339852181 ms, global timestamp=1753339852477 ms, system timestamp=1753339852219 ms
3, depth frame index=1109, timestamp=1753339852181 ms, global timestamp=1753339852419 ms, system timestamp=1753339852213 ms
0, depth frame index=1498, timestamp=1753339852181 ms, global timestamp=1753339852253 ms, system timestamp=1753339852213 ms
2, color frame index=1870, timestamp=1753339852181 ms, global timestamp=1753339852477 ms, system timestamp=1753339852213 ms
1, color frame index=1997, timestamp=1753339852181 ms, global timestamp=1753339852477 ms, system timestamp=1753339852219 ms
0, color frame index=1528, timestamp=1753339852181 ms, global timestamp=1753339852310 ms, system timestamp=1753339852219 ms
3, color frame index=1742, timestamp=1753339852181 ms, global timestamp=1753339852253 ms, system timestamp=1753339852219 ms
1, irLeft frame index=1929, timestamp=1753339852215 ms, global timestamp=1753339852419 ms, system timestamp=1753339852219 ms
2, irLeft frame index=1675, timestamp=1753339852214 ms, global timestamp=1753339852343 ms, system timestamp=1753339852240 ms
3, irLeft frame index=1803, timestamp=1753339852214 ms, global timestamp=1753339852452 ms, system timestamp=1753339852240 ms
0, irLeft frame index=1464, timestamp=1753339852214 ms, global timestamp=1753339852510 ms, system timestamp=1753339852240 ms
1, depth frame index=1964, timestamp=1753339852215 ms, global timestamp=1753339852287 ms, system timestamp=1753339852240 ms
3, depth frame index=1710, timestamp=1753339852214 ms, global timestamp=1753339852343 ms, system timestamp=1753339852246 ms
0, depth frame index=1499, timestamp=1753339852214 ms, global timestamp=1753339852452 ms, system timestamp=1753339852246 ms
2, depth frame index=1839, timestamp=1753339852214 ms, global timestamp=1753339852287 ms, system timestamp=1753339852246 ms
3, color frame index=1743, timestamp=1753339852214 ms, global timestamp=1753339852510 ms, system timestamp=1753339852246 ms
1, color frame index=1998, timestamp=1753339852215 ms, global timestamp=1753339852452 ms, system timestamp=1753339852253 ms
2, color frame index=1871, timestamp=1753339852214 ms, global timestamp=1753339852343 ms, system timestamp=1753339852253 ms
0, color frame index=1529, timestamp=1753339852214 ms, global timestamp=1753339852510 ms, system timestamp=1753339852253 ms
3, irLeft frame index=1676, timestamp=1753339852248 ms, global timestamp=1753339852287 ms, system timestamp=1753339852253 ms
2, irLeft frame index=1804, timestamp=1753339852248 ms, global timestamp=1753339852486 ms, system timestamp=1753339852273 ms
0, irLeft frame index=1465, timestamp=1753339852248 ms, global timestamp=1753339852544 ms, system timestamp=1753339852273 ms
1, irLeft frame index=1930, timestamp=1753339852248 ms, global timestamp=1753339852320 ms, system timestamp=1753339852273 ms
2, depth frame index=1840, timestamp=1753339852248 ms, global timestamp=1753339852377 ms, system timestamp=1753339852273 ms
1, depth frame index=1965, timestamp=1753339852248 ms, global timestamp=1753339852544 ms, system timestamp=1753339852279 ms
3, depth frame index=1711, timestamp=1753339852248 ms, global timestamp=1753339852377 ms, system timestamp=1753339852279 ms
0, depth frame index=1400, timestamp=1753339852248 ms, global timestamp=1753339852486 ms, system timestamp=1753339852279 ms
2, color frame index=1444, timestamp=1753339852248 ms, global timestamp=1753339852320 ms, system timestamp=1753339852280 ms
1, color frame index=1172, timestamp=1753339852248 ms, global timestamp=1753339852486 ms, system timestamp=1753339852286 ms
0, color frame index=1130, timestamp=1753339852248 ms, global timestamp=1753339852544 ms, system timestamp=1753339852286 ms
3, irLeft frame index=1477, timestamp=1753339852281 ms, global timestamp=1753339852377 ms, system timestamp=1753339852286 ms
2, irLeft frame index=1605, timestamp=1753339852281 ms, global timestamp=1753339852320 ms, system timestamp=1753339852286 ms
1, irLeft frame index=1411, timestamp=1753339852281 ms, global timestamp=1753339852353 ms, system timestamp=1753339852306 ms
2, depth frame index=1811, timestamp=1753339852281 ms, global timestamp=1753339852519 ms, system timestamp=1753339852306 ms
0, depth frame index=1510, timestamp=1753339852281 ms, global timestamp=1753339852577 ms, system timestamp=1753339852307 ms
1, depth frame index=1911, timestamp=1753339852281 ms, global timestamp=1753339852410 ms, system timestamp=1753339852307 ms
3, depth frame index=1710, timestamp=1753339852281 ms, global timestamp=1753339852577 ms, system timestamp=1753339852313 ms
1, color frame index=1510, timestamp=1753339852281 ms, global timestamp=1753339852353 ms, system timestamp=1753339852313 ms
2, color frame index=1712, timestamp=1753339852281 ms, global timestamp=1753339852410 ms, system timestamp=1753339852313 ms
0, color frame index=1510, timestamp=1753339852281 ms, global timestamp=1753339852519 ms, system timestamp=1753339852313 ms
3, color frame index=1715, timestamp=1753339852281 ms, global timestamp=1753339852410 ms, system timestamp=1753339852320 ms
2, color frame index=1515, timestamp=1753339852281 ms, global timestamp=1753339852353 ms, system timestamp=1753339852320 ms
```

5. USB 测试方法

5.1 硬件连接

如下图所示连接方式，使用特制 USB 线束，其中同步信号连接到主控同步信号，USB 供电与数据连接到 USB HUB，主控同步信号连接到 PWM 模式同步信号发生器，USB 数据连接到 PC。



5.2 测试步骤

1. 相机配置设置为 slave 模式：OB_MULTI_DEVICE_SYNC_MODE_SECONDARY



```
"devices": [  
  {  
    "require": true,  
    "sn": "DBA00000038",  
    "syncConfig": {  
      "syncMode": "OB_MULTI_DEVICE_SYNC_MODE_PRIMARY",  
      "depthDelayUs": 0,  
      "colorDelayUs": 0,  
      "trigger2ImageDelayUs": 0,  
      "triggerOutEnable": true,  
      "triggerOutDelayUs": 0  
    },  
    "timestampReset": {  
      "enable": false,  
      "enableResetTime": true,  
      "delayTimeUs": 0,  
      "triggerOutEnable": true  
    }  
  },  
  {  
    "require": true,  
    "sn": "CH9F84D003J",  
    "syncConfig": {  
      "syncMode": "OB_MULTI_DEVICE_SYNC_MODE_SECONDARY",  
      "depthDelayUs": 0,  
      "colorDelayUs": 0,  
      "trigger2ImageDelayUs": 0,  
      "triggerOutEnable": true,  
      "triggerOutDelayUs": 0  
    },  
    "timestampReset": {  
      "enable": false,  
      "enableResetTime": true,  
      "delayTimeUs": 0,  
      "triggerOutEnable": false  
    }  
  },  
  {  
    "require": true,  
    "sn": "CH9F84D002Y",  
    "syncConfig": {  
      "syncMode": "OB_MULTI_DEVICE_SYNC_MODE_SECONDARY",  
      "depthDelayUs": 0,  
      "colorDelayUs": 0,  
      "trigger2ImageDelayUs": 0,  
      "triggerOutEnable": true,  
      "triggerOutDelayUs": 0  
    },  
    "timestampReset": {  
      "enable": false,  
      "enableResetTime": true,  
      "delayTimeUs": 0,  
      "triggerOutEnable": false  
    }  
  }  
]
```

2. 运行测试工具：ObMultiDeviceSyncViewer
3. 读取 sensor Timestamp，如下读取记录数据。

RGB MJPEG	DEPTH Y16	设备		Group 1					
				RGB	DEPTH	单机 DEPTH&RGB 同步	多机DEPTH&RGB同步		
				time Stamp	time Stamp	时间戳偏 差	RGB时 间戳偏	DEPT H时间	RGB流水灯 位置偏差
1280*720 20fps	640*480 20fps	Slave 1	#0P	1748507257941	1748507257941	0	1	1	2
		Slave 2	#IB	1748507257941	1748507257941	0			
		Slave 3	#1F	1748507257940	1748507257940	0			
		Slave 4	#23	1748507257941	1748507257941	0			
1280*720 10fps	640*480 10fps	Slave 1	#0P	1748507055759	1748507055759	0	0	0	1
		Slave 2	#IB	1748507055759	1748507055759	0			
		Slave 3	#1F	1748507055759	1748507055759	0			
		Slave 4	#23	1748507055759	1748507055759	0			
1280*720 30fps	640*480 30fps	Slave 1	#0P	1748506819980	1748506819980	0	1	1	1
		Slave 2	#IB	1748506819980	1748506819980	0			
		Slave 3	#1F	1748506819980	1748506819980	0			
		Slave 4	#23	1748506819981	1748506819981	0			
1280*720 15fps	640*480 15fps	Slave 1	#0P	1748506552767	1748506552767	0	1	1	1
		Slave 2	#IB	1748506552768	1748506552768	0			
		Slave 3	#1F	1748506552767	1748506552767	0			
		Slave 4	#23	1748506552768	1748506552768	0			

综合以上 GMSL 接口和 USB 接口实验，根据实验数据记录满足单目组多传感器同步，曝光时间差异<1ms；多模组同步，曝光时间差异<5ms。其中记录曝光时间 rgb 是第一行曝光结束时间，ir 为曝光结束时间。