



EAN-GPIO and I2C

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 **CAUTION:** Alerts to a potential hazard that may result in personal injury, or an unsafe practice that causes damage to the equipment if not avoided

 **IMPORTANT:** Identifies crucial information that is important to setup and configuration procedures.

 *Used to emphasize points or reminds the user of something. Supplementary information that aids in the use or understanding of the equipment or subject that is not critical to system use*



1 Overview

This document covers how to configure GPIO lines to work with a custom ARM application that triggers the SightLine OEM to take a snapshot, or to be able to start a video recording using a button. It also covers how to send commands through the video processing boards for communicating with I²C devices. The ability to perform I²C read and write commands through SLA Command Protocol (**SLAI2CCommand**) has additionally been added in release 2.24.xx.

1.1 Additional Support Documentation

Additional Engineering Application Notes (EANs) can be found on the [Documentation](#) page of the SightLine Applications website.

The [Panel Plus User Guide](#) provides a complete overview of settings and dialog windows located in the Help menu of the Panel Plus application.

The Interface Command and Control (**IDD**) describes the native communications protocol used by the SightLine Applications product line. The IDD is also available as a PDF download on the [Documentation](#) page under Software Support Documentation.

1.2 SightLine Software Requirements

ⓘ IMPORTANT: The Panel Plus software version should match the firmware version running on the board.

1.2.1 Third Party Software

[Tera Term](#) (or PuTTY): SightLine recommends Tera Term for troubleshooting, debugging, and issuing commands on SightLine hardware.

2 GPIO Framework

GPIO	General Purpose Input/Output lines.
OEM	Main processing boards that have an ARM processor for supporting customer developed applications.
VideoTrack1500 VT3000_Release VT4000_Release	The SightLine primary application that runs on the ARM that handles command and control, acquisition, and video processing functionality.
SightLine Command and Control	Primary API for communicating with the OEM either through a serial port or Ethernet.
1500-AB	A bench-top interface board for working with the 1500-OEM that exposes the GPIO through headers pins.
3000-USB	Interface board for working with the 3000-OEM that exposes the GPIO through headers pins.
3000-IO	Main adapter board for working with the 3000-OEM board serial and Ethernet.



GPIO Framework notes:

The GPIO pins are available on the J4 (50 pin) connector on the 1500-OEM. This connector is also used to attach to a variety of digital camera input boards (Tau, Sony, Hitachi). If an external camera interface board is attached, then all GPIO pins may not be available. Consult with ICD-1500-Adapter-Boards for additional details.

The examples below refer to connector J10 of the 1500-AB board. This is functionally equivalent to the J4 connector of the 1500-OEM.

The GPIO pins are available on the J2, J3, and J4 connectors on the 3000-OEM. The examples below will often refer to the J3 and J5 connectors of the 3000-USB board attached to J2 of the 3000-OEM.

3 VIOSEL - Powering the 1500-OEM IO

The voltage level on all GPIO pins is set using VIOSEL. A voltage of 3.3V must be supplied to J10:46 (VIOSEL) to enable the GPIO. All GPIO output levels will follow VIOSEL. This must match the voltage output level (CMOS) of camera digital data, which is typically 3.3V.

3.3V and ground can be supplied from an external source or use the 3.3V power and GND available through the following points on the 1500-AB board:

- J9 Pin 10 (3.3V) and J9 Pin 12 (GND) [REV A and above]
- The test points labeled 3.3V and GND [Rev D].

Table 1: 1500-OEM IO Power and Ground

J10 Pin #	Signal Name	Values	Purpose
46	VIOSEL	1.8V, 2.5V, 3.3V	Sets voltage level for some GPIO
18	TAUDET	GND, NC, 1.8V	Enables or disables some GPIO
5	GND	Ground	
17	GND	Ground	
27	GND	Ground	
37	GND	Ground	
41	GND	Ground	
45	GND	Ground	
47	GND	Ground	
49	GND	Ground	



4 GPIO Connections

4.1 1500-AB

Five GPIO pins are available through headers on the 1500-AB boards.

Table 2: 1500-AB Rev J J11 Pin

J11 Pin #	Signal Name	Voltage Level	Default Direction	TAUDET	
				Enable	Disable
13	GPIO172	VIOSEL	Input	NC (PULLUP)	GND
14	GPIO173	VIOSEL	Input		
15	GPIO174	VIOSEL	Input		
16	GPIO175	VIOSEL	Input		
17	GPIO178	3.3V	Input	NA	NA

GPIO144 and 145 are also available at 3.3V as test points on 1500-AB REV J board (see [Figure 2](#)).

GPIO172 is used as a receiver enable signal for some camera adapter boards. These include the 1500-Sony board and the 1500-CL board.

4.2 1500-OEM (Rev E)

The following additional GPIOs are available on J5.

Table 3: 1500-OEM (Rev E) J5 Pin

J5 Pin #	Signal Name	Voltage Level	Default Direction	TAUDET	
				Enable	Disable
9	GPIO145	1.8V	Input	NA	NA
12	GPIO144	1.8V	Input	NA	NA

4.3 3000-USB

Six GPIO are available on the 3000-USB board through the 3-pin header pins (J3 and J5). The GPIO default as inputs. These can be changed in the software application (see [Linux Hardware Configuration](#)).

Table 4: 3000-USB J3 Pin

J3 Pin #	Signal Name	Voltage Level	Default Direction	TAUDET	
				Enable	Disable
1	GPIO16	3.3V	Input	NC (PULLUP)	GND
2	GPIO22	3.3V	Input		
3	GPIO24	3.3V	Input		

Table 5: 3000-USB J5 Pin

J5 Pin #	Signal Name	Voltage Level	Default Direction	TAUDET	
				Enable	Disable
1	GPIO17	3.3V	Input	NC (PULLUP)	GND
2	GPIO23	3.3V	Input		
3	GPIO28	3.3V	Input		



4.4 4000-OEM

Table 6: 4000-OEM J2 Pin

J2 Pin #	Signal Name	Voltage Level	Default Direction	TAUDET	
				Enable	Disable
4	GPIO7_USER	3.3V	Input		
5	GPIO8_USER	3.3V	Input		

Table 7: 4000-OEM J25 Pin

J25 Pin #	Signal Name	Voltage Level	Default Direction	TAUDET	
				Enable	Disable
7	GPIO6_USER	3.3V	Input		

4.5 4000-MIPI

Table 8: 4000-OEM J25 Pin

J25 Pin #	Signal Name	Voltage Level	Default Direction	TAUDET	
				Enable	Disable
7	GPIO6_USER	3.3V	Input		

5 1500-AB Board Setup

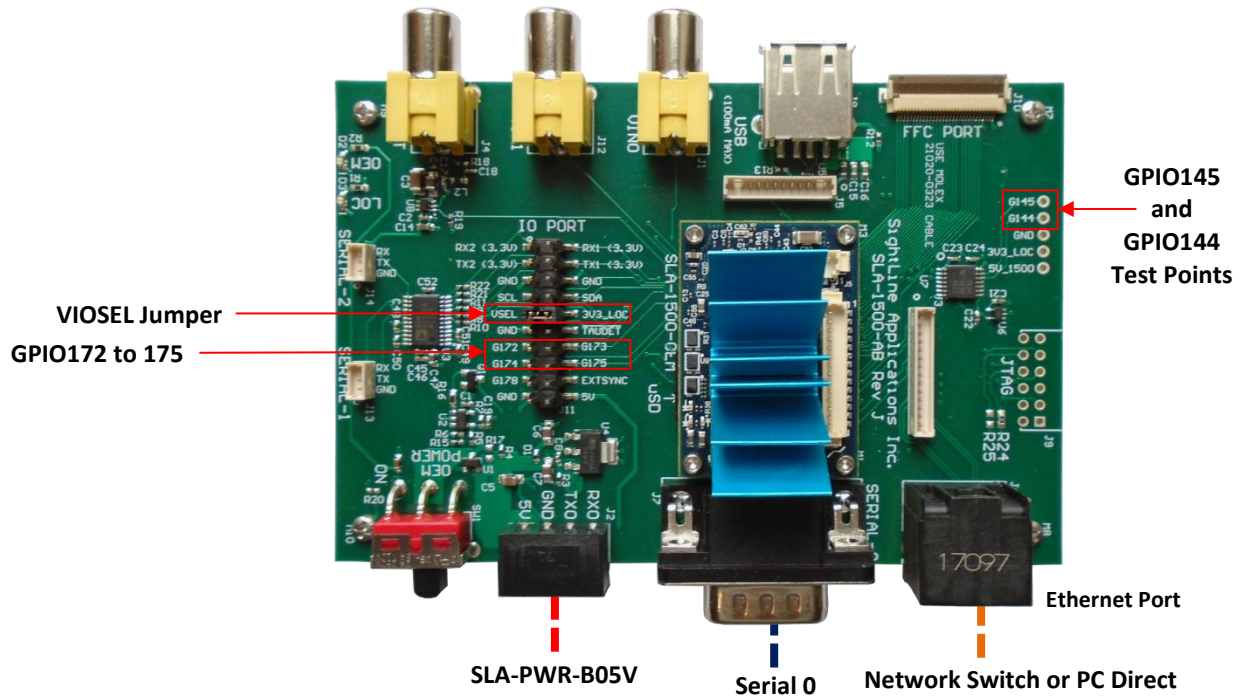


Figure 1: 1500-AB (Rev J) + 1500-OEM (Rev E) GPIO Setup



6 3000-USB Board Setup

Connect the 3000-USB board to the 3000-OEM board.

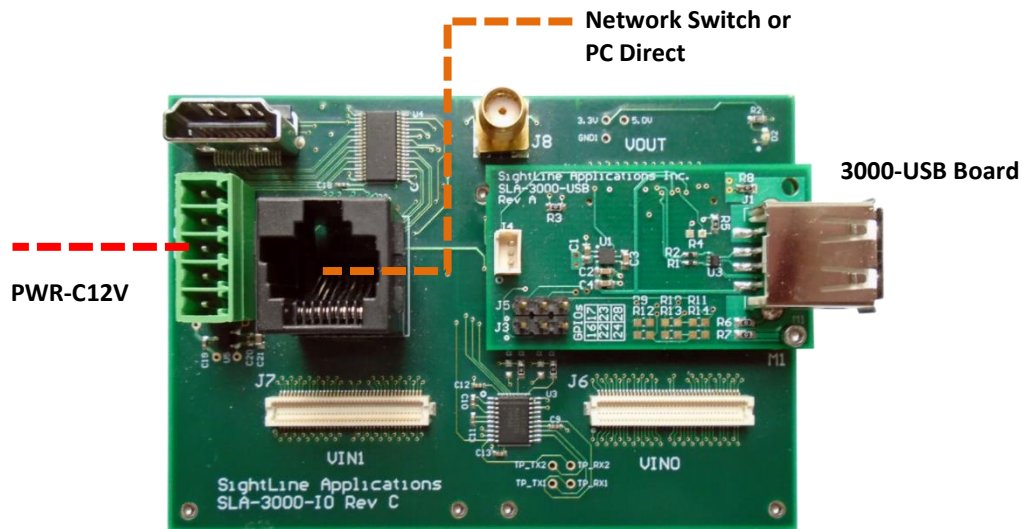


Figure 2: 3000-OEM + 3000-IO + 3000-USB

7 4000-OEM Pins

Table 9: Connector J2 Serial Port / GPIO

Pin	Signal	Description
1	GND	
4	TX1	3.3V TTL
5	RX1	3.3V TTL
6	GPIO_459	GPIO (4000-OEM schematic net name GPIO7_USER)
7	GPIO_460	GPIO (4000-OEM schematic net name GPIO8_USER)

Table 10: Connector J25 Extra Serial / GPIO

Pin	Signal	Description
1	GND	
2	TX0	3.3V TTL
3	RX0	3.3V TTL
4	GND	
5	TX3	3.3V TTL
6	RX3	3.3V TTL
7	GPIO_458	GPIO (4000-OEM schematic net name GPIO6_USER)
8	GPIO_125	Default MCU_PB3 Open Drain (Heater control). APQ_GPIO_125 optional w/ resistor load for fan, etc.



8 4000-MIPI Pins

All signals at 3.3V levels.

Table 11: Connector J2 IO Connector

Pin	Description	Pin	Description
1	Ground	5	Serial TX7
2	Serial TX4	6	Serial RX7
3	Serial RX4	7	GPIO6
4	Ground	8	GPIO13 (Open drain FET), 1A Max

9 GPIO Circuit and Requirements

9.1 GPIO Level Translators and Output Impedance

GPIO signal levels are voltage translated to match VIOSEL. To allow GPIOs to be used as both inputs and outputs bi-directional voltage translators are used. SightLine hardware currently uses Texas Instruments TXB0104 voltage translators with automatic direction sensing.

Texas Instruments provides a comprehensive [guide](#) to working with the TXB output.

The TXB chip has an output impedance of 4K ohm. This chip is intended to have a very weak output drive (~2ma), with the intention that an external device with a stronger drive can overcome this weak drive and reverse the direction of the translator. This allows GPIOs to work as inputs and outputs without separate I/O direction select lines.

External hardware attached to this output must have an input impedance of 50K ohm or higher. This is due to the weak drive and resultant bidirectional nature. Input capacitance of external hardware must be less than 70Pf. The capacitance requirement can mean short wire lengths. Issues have been reported using scope probes in 1X mode vs 10X mode (10X has higher impedance than 1X).

For external circuitry that has low input impedance a MOSFET should be part of the design. This provides high input impedance to the TXB and proper drive levels for external circuitry.

Chose a MOSFET that meets the voltage and current needs of the external circuitry with a $V_{gs(th)}$ max that is less than the VIOSEL voltage (typically VIOSEL= 3.3V). $V_{gs(th)}$ is the voltage at which the MOSFET will start to turn on. We recommend choosing a $V_{gs(th)}$ less than 3.3V, e.g., 2V.

The max and min specs show possible variances among individual devices. In this case choosing the max value is the best option.



9.2 GPIO Input

Button closure

Requires an external pullup resistor

VCC = VIOSEL (or 3.3V for GPIO178)

R1 \approx 1 K ohm

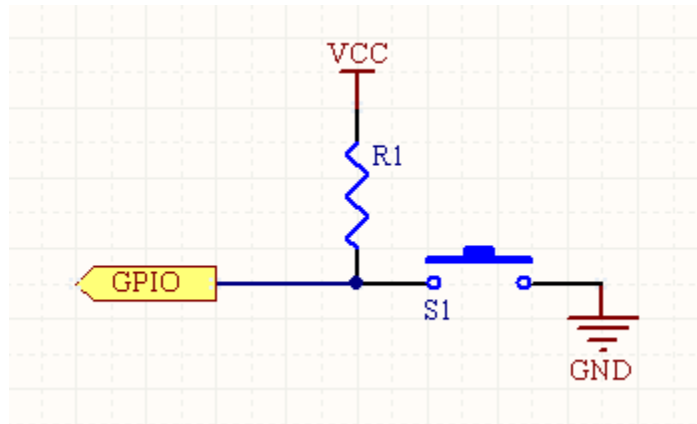


Figure 3: Push Button GPIO

9.3 GPIO Output

Drives LED

Requires an external circuit

VCC = VIOSEL (or 3.3V for GPIO178)

R1 \approx 500 ohm (depends on LED)

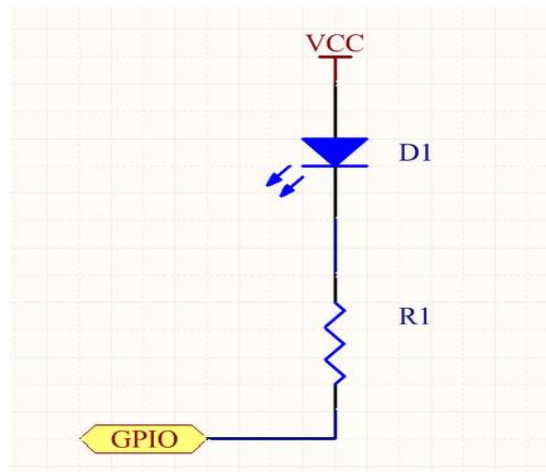


Figure 4: GPIO Drives LED

10 Testing GPIO

GPIO can be exercised from the Linux command line. This is useful when testing the GPIO circuit.

10.1 Configure GPIO for Output

```
echo 175 > /sys/class/gpio/export
cat /sys/class/gpio/gpio175/direction
echo out >
/sys/class/gpio/gpio175/direction
echo "0" >
/sys/class/gpio/gpio175/active_low
echo "0" > /sys/class/gpio/gpio175/value
echo "1" > /sys/class/gpio/gpio175/value
```




10.2 Configure GPIO for Input

```
echo 175 > /sys/class/gpio/export
cat /sys/class/gpio/gpio175/direction
echo "in" >
/sys/class/gpio/gpio175/direction
echo "0" >
/sys/class/gpio/gpio175/active_low
echo "both" >
/sys/class/gpio/gpio175/edge
for (( ; ; ))
do
    cat /sys/class/gpio/gpio175/value
done
```

11 GPIO Example Application

An example Linux application is available as part of the [ARM Processor Code Examples](#).

11.1 SLAGPIO\gpioMain2017

A Visual Studio 2017 project which generates a PC console application (gpioMain.exe) that does the following:

- Communicates with SightLine hardware using the [SightLine Command and Control](#) protocol over Ethernet.
- Reads and reports current microSD card video record status.
- Toggles video recording on/off with the F1 function key.
- Intended as an easy way of understanding and debugging the SightLine Command and Control and connections to SightLine hardware. Uses the same main code/threads/objects as all the Linux example applications.
- Application requires changing the IP address `#define IPADDR_VIDEOTRACK 192.168.1.107` to match the IP address of the SightLine hardware. This can be determined by connecting Panel Plus to the SightLine hardware and then reading the IP address from the lower left corner of the application.

11.2 GPIO Linux Application

A Code Composer Studio 5 project. Details of installation and compiling are in the [EAN-ARM Application Development](#) document.

GPIO requires Ubuntu Linux image *UbuntuSLA_2_21.7z* or higher. The 1500-OEM requires installation of VideoTrack1500 application 2.21 or higher. The 3000-OEM requires the VT3000_Release application 2.22 or higher.

Code is common with the PC application, except for the implementation of the *GPIOCtrl* class, which uses Linux GPIO pins as opposed to the F1 key.



The application uses the following GPIO pins by default:

1500-OEM

- GPIO178 (input) - video record toggle.
- GPIO174 (input) - Initiate a single JPEG snapshot. Snapshot settings must be setup and persisted using the Panel Plus application.
- GPIO175 (output) - Display video record status on an LED.

3000-OEM

- GPIO16 (input) - video record toggle.
- GPIO22 (input) - Initiate a single JPEG snapshot. Snapshot settings must be setup and persisted using the Panel Plus application.
- GPIO24 (output) - Display record status on an LED.

12 Linux Hardware Configuration

Once the GPIO Linux application has been customized, it must be setup to run in parallel with the VideoTrackXXX application on the SightLine hardware. This requires modifying the `/etc/rc.d/rc.local` file on the 1500-OEM or similar scripts on the other OEM platforms.

Section of code that needs modified:

```
if [ -f slStabTrackOMAP.out ]; then
    #./VideoTrack1500 -S0 0 -Q -CAPTURE
    sony_720p &
    #sleep 10
    #./SLAGimbal &
    ./VideoTrack1500 -Q &
```

Modify code to:

```
if [ -f slStabTrackOMAP.out ];
then
    ./VideoTrack1500 -Q &
    sleep 20
    ./SLAGPIO1500 &
```

The -Q option runs VideoTrack1500 in quiet mode. The sleep command is to let the command and control processing begin.

A similar change should be made to the `/home/root/sla3000_init.sh` file on the 3000-OEM.

13 Configuring I²C

This section describes how to login into SightLine hardware using [Tera Term](#) and read/write data to support I²C devices using Linux commands. It also provides simple example C code that reads/writes I²C data.

For testing and system configuration, read and write commands I²C commands can be performed through the SLA Command Protocol (SLA I²C Command, release 2.24). Details on command structure and examples of I²C read/write operations are included in the [IDD](#).

Login:

1. Open the Tera Term application.
2. From the main menu go to *File » New Connection*.



3. Enter the IP address of the OEM board and click *OK*.

4. Enter the Username (*root*) and password (*root*), and then click *OK*. If prompted to key cache, click *Yes* (or *OK*).

For the 4000-OEM, username, and password (passphrase) are *slroot*.

5. At the command prompt, use the following commands when working with the I²C bus:

- *i2cdetect* - Lists devices on the bus
- *i2cget* - Read registers from the I²C device
- *i2cset* - Write registers on the I²C device

13.1 I²C Linux Commands

Listing I²C buses:

```
root@sla3000:~# i2cdetect -l
i2c-1  i2c          OMAP I2C adapter          I2C adapter
i2c-4  i2c          OMAP I2C adapter          I2C adapter
root@sla3000:~#
```

Listing I²C devices on the bus:

```
root@sla3000:~# i2cdetect -a -r -y 1
00:  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
10:  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
20:  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
30:  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
40:  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
50:  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
60:  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
70:  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
root@sla3000:~#
```



Reading values:

```
root@sla3000:~# i2cget -f -y 1 0x68 0x75
0x92
root@sla3000:~#
```

Writing values:

```
root@sla3000:~# i2cget -f -y 1 0x68 0x6c
0x00
root@sla3000:~# i2cset -f -y 1 0x68 0x6c 0x05
root@sla3000:~# i2cget -f -y 1 0x68 0x6c
0x05
root@sla3000:~#
```

13.2 Changing I²C Clock Speed - 4000-OEM / 4000-MIPI-IN

The I²C clock speeds on both the 4000-OEM and 4000-MIPI-IN can be increased from the default 400KHz to 1MHz using the **SystemValue (0x92)** command and dialog in Panel Plus.

1. Connect to 4000-OEM within Panel Plus.
2. From the Panel Plus main menu » *Configure* » *System Value*.
3. Check the *Persist* checkbox so changes are persisted through parameter saves and subsequent restarts.
4. Enter System Values:
 - a. *0x300* in the field for *Value0* if setting I²C -1 on 4000-OEM.
 - b. *0x3000000* in the field for *value0* if setting I²C -3 on 4000-MIPI-IN.
 - c. *0x3000300* in the field for *value0* if setting both I²C -1 and i2C-3 at the same time.
5. Click *Send*.
6. Main menu » *Parameters* » *Save to Board*. Main menu » *Reset* » *Board*.
7. After the system reboots reconnect to the board.
8. Verify the system value change took effect:
 - a. Use Tera Term to establish an SSH session to the target hardware.
 - b. Send command for I²C-1 and verify output.

```
slroot@ ~
SD> xxd /proc/device-tree/soc/i2c@0075b6000/clock-frequency
00000000: 000f 4240 ..B@
```

- c. Send command for I²C-3 and verify output.

```
slroot@ ~
SD> xxd /proc/device-tree/soc/i2c@0075ba000/clock-frequency
00000000: 000f 4240 ..B@
```

Table 12: I2C Clock Frequency Output

Hex	Decimal	Frequency
0x00061a80	400,000 Hz	400 kHz
0x00f4240	1,000,000 Hz	1MHz



13.3 3000-OEM I²C Connectors

Table 13: 3000-OEM I²C Connectors

Connector	Common Name	I ² C Bus	Bus Speed
J2	Vout	I ² C-1	400 kHz
J3	Vin0 (Camera 0)	I ² C-1	400 kHz
J4	Vin1 (Camera 2)	I ² C-4	400 kHz

13.4 I²C Slave Addressing

In device specifications I²C addresses are sometimes specified as 7-bit or 8-bit. In the examples shown in the I²C section, the I²C address is 0x68, which is 7-bits. The 8-bit address would be $0x68 \ll 1 == 0xD0$. This is because the bottom bit in the slave address is a read/write indicator.

If you are having trouble reading or writing to the I²C device, try $\gg 1$ (divide by 2 in hex) in the slave address.

All references to slave address in this document (including sample code) refer to the 7-bit slave address.



Figure 5: Slave Address

- ✓ Verify the I²C device is powered up.
- ✓ Check that the SDA and SCL are connected correctly between the SightLine hardware and the target device.
- ✓ Check the bus speed of the target device. 3000-OEM I²C bus runs at 400 kHz.
- ✓ SightLine hardware I²C bus runs at 3.3V levels.
- ✓ There are multiple I²C buses exposed by the SightLine Hardware. Verify the I²C device is connected to the correct bus.

13.5 Example Linux Code

This section illustrates a simple example of using a Linux driver to read and write bytes from an I²C device.

Example of calling the code:

```
u8 buf[2] = {0x28, 0x04};
int ret = SLI2cSet(buf, 2, 2, 0x5D); //
returns -1 on failure, 0 on success
```

**Example code:**

```
#include <fcntl.h>
#include <unistd.h>
#include <sys/ioctl.h>
#include <stdio.h>
#include <linux/i2c-dev.h>
#include <linux/i2c.h>
```

```
int I2cGet(unsigned char *buf, long
nbytes, unsigned char bus, unsigned char
addr)
{
    char fname[20];
    sprintf(fname, "/dev/i2c-%d", bus);
    int file;
    if((file = open(fname, O_RDWR)) < 0) {
        printf("failed to open %s\n", fname);
        return -1 ;
    }
```

```
    if(ioctl(file, I2C_SLAVE, addr) < 0) {
        printf("Failed to access device
0x%x\n", addr);
        close(file);
        return -1 ;
    }
```

```
    if(read(file, buf, nbytes) != nbytes) {
        printf("Failed to read from %s
(%d)\n", fname, bus);
        close(file);
        return -1;
    }
    close(file);
    return 0;
}
```

```
int I2cSet(unsigned char *buf, long
nbytes, unsigned char bus, unsigned char
addr)
{
    char fname[20];
    sprintf(fname, "/dev/i2c-%d", bus);
    int file;
    if((file = open(fname, O_RDWR)) < 0) {
        printf("failed to open %s\n", fname);
        return -1;
    }
```



```
    if(ioctl(file, I2C_SLAVE_FORCE, addr) <
0) {
    printf("Failed to access device
0x%x\n", addr);
    close(file);
    return -1;
    }
```

```
    if(write(file, buf, nbytes) != nbytes) {
    printf("Failed to write to %s (%d)\n",
fname, bus);
    close(file);
    return -1;
    }
    close(file);
    return 0;
}
```

14 Questions and Additional Support

questions and additional support, please contact [Support](#). Additional support documentation and Engineering Application Notes (EANs) can be found on the [Documentation](#) page of the SightLine Applications website.