# Promira Serial Platform

The Promira Serial Platform with I$^2$C/SPI Active - Level 1 application allows developers to interface a host PC to a downstream embedded system environment and transfer serial messages using the I$^2$C and SPI protocols. Additionally, the I$^2$C and/or SPI pins can be used for general purpose signaling when the respective subsystem is not in use.

## Promira Serial Platform Features

- I$^2$C – Two-wire interface
  - Standard mode (100 kHz)
  - Fast-mode (400 kHz)
  - Fast-mode Plus (1 MHz)
  - Master and slave functionality
  - Master Bit Rate 1 kHz to 1.02 MHz
  - Slave Bit Rate 1 kHz to 500 kHz
- SPI – Four-wire serial communication protocol
  - Master and slave functionality
  - Master Bit Rate 31 kHz to 12.5 MHz
  - Slave Bit Rate 31 kHz to 8 MHz
  - Configurable slave select polarity for master mode
- GPIO – General Purpose Input/Output
  - General purpose signaling on I$^2$C and/or SPI pins
- Integrated Level Shifting
  - Target Power 5V or 3.3V
  - IO Power 0.9V - 3.45V
- Software
  - Windows, Linux, and Mac OS X compatible
  - Easy to integrate application interface
  - Upgradeable Firmware over USB

TOTAL PHASE

Supported products:

PROMIRA

Promira Serial Platform
User Manual v1.00

November 11, 2014

# 1 General Overview

The Promira Serial Platform with I$^2$C and SPI Active applications is a flexible, upgradeable development platform. It can serve as a drop-in replacement for the Aardvark I$^2$C/SPI Host Adapter. The Promira Serial Platform hardware has been designed to support many current and future serial interfaces. The Promira Serial Platform with I$^2$C and SPI Active applications connect to an analysis computer via Ethernet or Ethernet over USB. The applications installed on the Promira Serial Platform are field-updateable, field-upgradeable, and future-proof.

## 1.1 I$^2$C Background

### 1.1.1 I$^2$C History

When connecting multiple devices to a microcontroller, the address and data lines of each devices were conventionally connected individually. This would take up precious pins on the microcontroller, result in a lot of traces on the PCB, and require more components to connect everything together. This made these systems expensive to produce and susceptible to interference and noise.

To solve this problem, Philips developed Inter-IC bus, or I$^2$C, in the 1980s. I$^2$C is a low-bandwidth, short distance protocol for on board communications. All devices are connected through two wires: serial data (SDA) and serial clock (SCL).

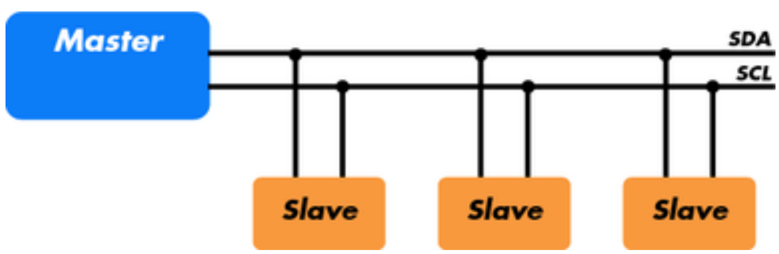



***Figure 1*** *: Sample I$^2$C Implementation. – Regardless of how many slave units are attached to the I$^2$C bus, there are only two signals connected to all of them. Consequently, there is additional overhead because an addressing mechanism is required for the master device to communicate with a specific slave device.*

Because all communication takes place on only two wires, all devices must have a unique address to identify it on the bus. Slave devices have a predefined address, but the lower bits of the address can be assigned to allow for multiples of the same devices on the bus.

### 1.1.2 I$^2$C Theory of Operation

I$^2$C has a master/slave protocol. The master initiates the communication. Here is a simplified description of the protocol. For precise details, please refer to the Philips I$^2$C specification. The sequence of events are as follows:

1. The master device issues a start condition. This condition informs all the slave devices to listen on the serial data line for their respective address.
2. The master device sends the address of the target slave device and a read/write flag.
3. The slave device with the matching address responds with an acknowledgment signal.
4. Communication proceeds between the master and the slave on the data bus. Both the master and slave can receive or transmit data depending on whether the communication is a read or write. The transmitter sends 8 bits of data to the receiver, which replies with a 1 bit acknowledgment.
5. When the communication is complete, the master issues a stop condition indicating that everything is done.

Figure 2 shows a sample bitstream of the I$^2$C protocol.

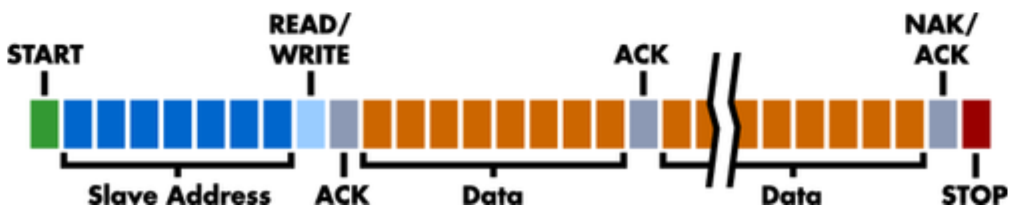



***Figure 2*** *: I$^2$C Protocol. – Since there are only two wires, this protocol includes the extra overhead of the addressing and acknowledgement mechanisms.*

### 1.1.3 I$^2$C Features

I$^2$C has many features other important features worth mentioning. It supports multiple data speeds: standard (100 kbps), fast (400 kbps), and high speed (3.4 Mbps) communications.

Other features include:

- Built-in collision detection,

- 10-bit Addressing,
- Multi-master support,
- Data broadcast (general call).

For more information about other features, see the references at the end of this section.

### 1.1.4 $I^2C$ Benefits and Drawbacks

Since only two wires are required, $I^2C$ is well suited for boards with many devices connected on the bus. This helps reduce the cost and complexity of the circuit as additional devices are added to the system.

Due to the presence of only two wires, there is additional complexity in handling the overhead of addressing and acknowledgments. This can be inefficient in simple configurations and a direct-link interface such as SPI might be preferred.

### 1.1.5 $I^2C$ References

- $I^2C$ bus – *NXP (Philips) Semiconductors Official $I^2C$ website*
- $I^2C$ (Inter-Integrated Circuit) Bus Technical Overview and Frequently Asked Questions – *Embedded Systems Academy*
- Introduction to $I^2C$ – *Embedded.com*
- $I^2C$ – *Open Directory Project Listing*

## 1.2 SPI Background

### 1.2.1 SPI History

SPI is a serial communication bus developed by Motorola. It is a full-duplex protocol which functions on a master-slave paradigm that is ideally suited to data streaming applications.

### 1.2.2 SPI Theory of Operation

SPI requires four signals: clock (SCLK), master output/slave input (MOSI), master input/slave output (MISO), slave select (SS).

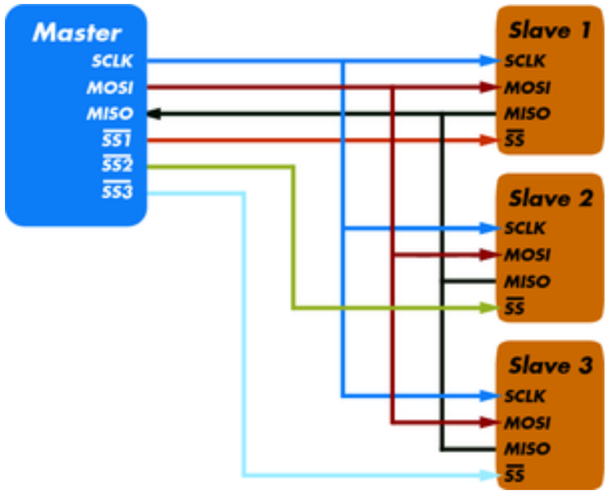



***Figure 3*** *: Sample SPI Implementation. – Each slave device requires a separate slave select signal (SS). This means that as devices are added, the circuit increases in complexity.*

Three signals are shared by all devices on the SPI bus: SCLK, MOSI and MISO. SCLK is generated by the master device and is used for synchronization. MOSI and MISO are the data lines. The direction of transfer is indicated by their names. Data is always transferred in both directions in SPI, but an SPI device interested in only transmitting data can choose to ignore the receive bytes. Likewise, a device only interested in the incoming bytes can transmit dummy bytes.

Each device has its own SS line. The master pulls low on a slaves SS line to select a device for communication.

The exchange itself has no pre-defined protocol. This makes it ideal for data-streaming applications. Data can be transferred at high speed, often into the range of the tens of megahertz. The flipside is that there is no acknowledgment, no flow control, and the master may not even be aware of the slave's presence.

### 1.2.3 SPI Modes

Although there is no protocol, the master and slave need to agree about the data frame for the exchange. The data frame is described by two parameters: clock polarity (CPOL) and clock phase (CPHA). Both parameters have two states which results in four possible combinations. These combinations are shown in figure 4.

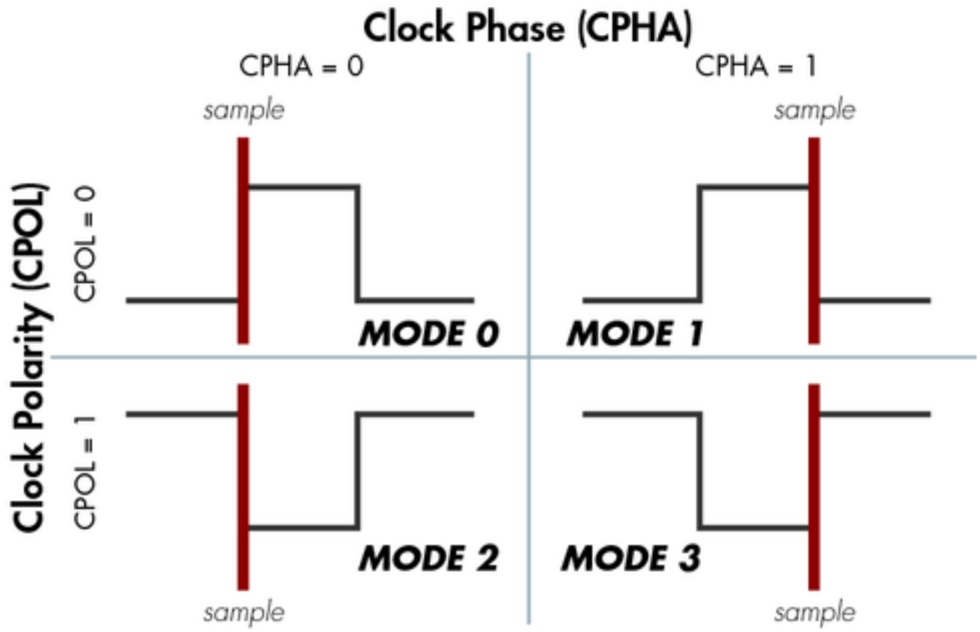



***Figure 4*** *: SPI Modes – The frame of the data exchange is described by two parameters, the clock polarity (CPOL) and the clock phase (CPHA). This diagram shows the four possible states for these parameters and the corresponding mode in SPI.*

### 1.2.4 SPI Benefits and Drawbacks

SPI is a very simple communication protocol. It does not have a specific high-level protocol which means that there is almost no overhead. Data can be shifted at very high rates in full duplex. This makes it very simple and efficient in a single-master single-slave scenario.

Because each slave needs its own SS, the number of traces required is n+3, where n is the number of SPI devices. This means increased board complexity when the number of slaves is increased.

### 1.2.5 SPI References

- Introduction to Serial Peripheral Interface – *Embedded.com*
- SPI – Serial Peripheral Interface

# 2 Hardware Specifications

## 2.1 Pinouts

### 2.1.1 Connector Specification

The Promira Serial Platform target connector is a standard 2x17 IDC male type connector 0.079x0.079″ (2x2 mm). The Promira Serial Platform target connector allows for up to a 34-pin ribbon cable and connector.

Two cables are provided with the Promira Serial Platform:

- 34-10 cable: A standard ribbon cable 0.039″ (1 mm) pitch that is 5.12″ (130mm) long with 2x17 IDC female 2x2mm (0.079x0.079) connector and 2x5 IDC female 2.54x2.54mm (0.10x0.10) connector. This provided target ribbon cable will mate with a standard keyed boxed header and is compatible with the Aardvark $I^2C$/SPI Host Adapter.
- 34-34 cable: A standard ribbon cable 0.039″ (1 mm) pitch that is 5.12″ (130mm) long with two 2x17 IDC female 2x2mm (0.079x0.079) connectors. This provided target ribbon cable will mate with a standard keyed boxed header.

### 2.1.2 Orientation

The pin order in the 2x5 IDC female connector in the provided target ribbon 34-10 cable is identical to the order used by the Aardvark $I^2C$/SPI Host Adapter. The brown line indicates the first position. When looking at your Promira Serial Platform and provided target ribbon cable in the upright position (figure 5), pin 1 is in the top left corner and pin 10 is in the bottom right corner.

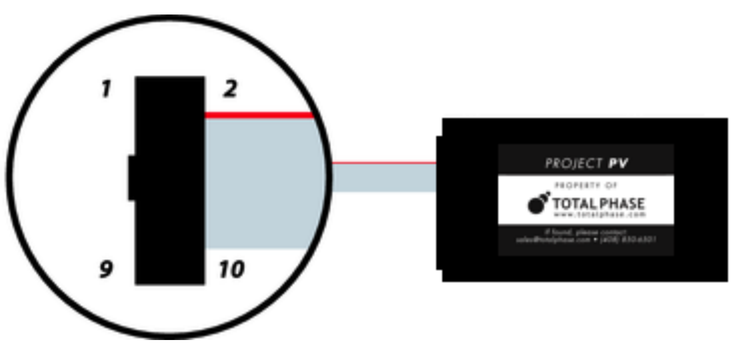



***Figure 5*** *: The Prmira platform in the upright position. –*
*Pin 1 is located in the upper left corner of the connector and*
*Pin 10 is located in the lower right corner of the connector.*

If you flip your Promira Serial Platform and provided target ribbon 34-10 cable over (figure 6) such that the text on the serial number label is in the proper upright position, the pin order is as shown in the following diagram.

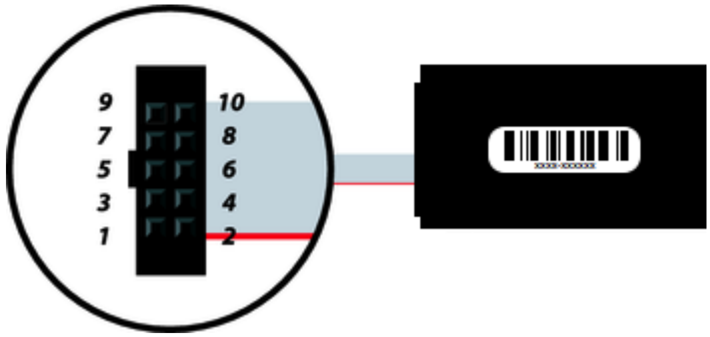



***Figure 6*** *: The Promira Serial Platform in the upside down position. – Pin 1 is located in the lower left corner of the 2x5 IDC female connector in the provided target ribbon 34-10 cable and Pin 10 is located in the upper right corner of this connector.*

### 2.1.3 Pin Description

**Table 1** : Pin Description - Target Connector

| **Pin** | **Symbol** | **Description** |
|---|---|---|
| 1 | SCL/ GPIO-00 | $I^2C$ Clock Signal. This clock line synchronizes communication between the master and slave. / GPIO-00 Signal. |
| 3 | SDA/ GPIO-01 | $I^2C$ Data Signal. This data line transfers data between the master and slave. / GPIO-01 Signal. |
| 7 | SCLK/ GPIO-03 | SPI Clock Signal. This clock line is driven by the SPI master and regulates the flow of the data bits. / GPIO-03 Signal. |
| 8 | MOSI/ GPIO-04 | SPI Master Out Slave In Signal. This data line supplies the output data from the master into the slave. / GPIO-04 Signal. |
| 5 | MISO/ GPIO-02 | SPI Master In Slave Out Signal. This data line supplies the output data from the slave to the master. / GPIO-02 Signal. |
| 9 | SS/GPIO-05 | SPI Slave Select (Chip Select) Signal. This control line allows slaves to be turned on and off via hardware control. / GPIO-05 Signal. |
| 4, 6 | Vtgt | Configurable Vcc Power Supply. No Connect/3.3 V/5 V. These Vcc pins are switched through the API or software GUI tool, and are used to power a downstream target, such as an $I^2C$/SPI EEPROM/flash. |

| | | |
|---|---|---|
| 22, 24 | IOVcc | Configurable Vcc IO level Power Supply. No Connect/0.9 V to 3.45 V. These Vcc IO pins are switched through the API or software GUI tool, and are used to power a downstream target, such as an I$^2$C/SPI EEPROM/flash. |
| 2, 10, 12, 16, 18, 28, 32, 34 | GND | Ground Connection. If the ground of the target system and the Promira Serial Platform are not connected together, then the signaling is entirely unpredictable and communication will likely be corrupted. |
| 11, 13, 14, 15, 17, 19, 21, 23, 25, 26, 27, 29, 31, 33 | Reserved | |

## 2.2 I$^2$C Signaling Characteristics

### 2.2.1 Speed

The Promira Serial Platform I$^2$C master can operate at a maximum bitrate of 1.02 MHz and supports many intermediate bitrates between 1 kHz and 1.02 MHz. The power-on default bitrate for the I$^2$C master unit is 100 kHz.

For slave functionality, the Promira Serial Platform can operate at any rate between 1 kHz and 500 kHz.

It is not possible to send bytes at a throughput of exactly 1/8 times the bitrate. The I$^2$C protocol requires that 9 bits are sent for every 8 bits of data. In addition, even though there is no inter-byte delay for the most part of the I$^2$C transaction, the Promira Serial Platform occasionally requires additional time to process the received bytes and set up the next portion of the transaction. In this case, delay is inserted on the I$^2$C bus.

There can be extra overhead introduced by the operating system between calls to the Promira API. These delays will further reduce the overall throughput across multiple transactions. To achieve the fastest throughput, it is advisable to send as many bytes as possible in a single transaction (i.e., a single call to the Promira API).

### 2.2.2 Pull-up Resistors

There is a pull up resistor on each I$^2$C line (SCL, SDA). The lines are effectively pulled up to 0.9V-3.45V. The pull up resistor is 2.2K OHM for 2.2V - 3.45V I$^2$C signal level. The pull up resistor is 520 OHM for 1.2V - 2.2V I$^2$C signal level. The pull up resistor is 422 OHM for 0.9V - 1.2V I$^2$C signal level. If the Promira Serial Platform is connected to an I$^2$C bus that also includes pull-up resistors, the total pull-up current could be potentially larger. The I$^2$C specification allows for a maximum of 3 mA pull-up current on each I$^2$C line.

A good rule of thumb is that if a downstream $I^2C$ device can sink more than 5 mA of current, the protocol should operate properly. Stronger pull-up resistors and larger sink currents may be required for fast bitrates, especially if there is a large amount of capacitance on the bus. The Promira Serial Platform is able to sink approximately 10 mA per pin, so it is possible to have two Promira Serial Platforms communicate with each other as master and slave, with both devices pull-up resistors enabled.

Promira Serial Platform pull-up resistors can be switched and configured through the software GUI and API. Refer to the API section for more details.

### 2.2.3 $I^2C$ Clock Stretching

When the Promira Serial Platform is configured as an $I^2C$ master, it supports both inter-bit and inter-byte slave clock-stretching. If a slave device pulls SCL low during a transaction, the adapter will wait until SCL has been released before continuing with the transaction.

### 2.2.4 Known $I^2C$ Limitations

The Promira Serial Platform $I^2C$ master occasionally requires additional time to process the received bytes and set up the next bytes. In this case, delay is inserted on the $I^2C$ bus. Every Promira Serial Platform $I^2C$ master read transaction will have a delay before the last byte, and there may be additional delays between bytes during $I^2C$ master read and write.

The Promira Serial Platform can keep the slave functions enabled even while master operations are executed through the same adapter.

Multi-master is also supported: If there is a bus collision during data transmission and the Promira Serial Platform loses the bus, the transaction will be cut short and the host API will report that fewer bytes were transmitted than the requested number. This condition can be distinguished from the case in which the downstream slave cuts short the transmission by sending a NACK by using the function `ps_i2c_read`.

This constraint can be phrased in a different manner. Say that $I^2C$ master device **A** has a packet length of **X** bytes. If there is a second $I^2C$ master device **B**, that sends packets of length greater than **X** bytes, the first **X** bytes should never contain exactly the same data as the data sent by device **A**. Otherwise the results of the arbitration will be undefined.

This is a constraint found with most $I^2C$ master devices used in a multi-master environment.

# 2.3 SPI Signaling Characteristics

## 2.3.1 Speeds

The Prmira Platform SPI master can operate at bitrates between 31 kHz and 12.5 MHz. The power-on default bitrate is 992 kHz. The quoted bitrates are only achievable within each individual byte and does not extend across bytes. Even though there is no inter-byte delay for the most part of the SPI transaction, the Promira Serial Platform SPI master occasionally requires additional time to process the received bytes and set up the next bytes. In this case, a delay is inserted on the SPI bus. Every Promira Serial Platform SPI master transaction will have a delay of one half clock between the first byte and the second byte, and there may be additional delays between bytes on 128 byte boundaries.

The Promira Serial Platform SPI slave can operate at any bitrate from 31 KHz up to 8 MHz.

When the Promira Serial Platform is configured to act as an SPI slave, and the slave select is pulled high to indicate the end of a transaction, there is a data processing overhead of sending the transaction to the PC host. As such, if the SPI master sends a subsequent transaction in rapid succession to the Promira Platform slave, the data received by the Promira Serial Platform slave may be corrupted. There is no precise value for this minimum inter-transaction time, but a suggested spacing is approximately 100-200 µs.

See also section 2.3.3

## 2.3.2 Pin Driving

When the SPI interface is activated as a master, the slave select line (SS) is actively driven low. The MOSI and SCK lines are driven as appropriate for the SPI mode. After each transmission is complete, these lines are returned to a high impedance state. This feature allows the Promira Serial Platform, following a transaction as a master SPI device, to be then reconnected to another SPI environment as a slave. The Promira Platform will not fight the master lines in the new environment.

It is advisable that every slave also have passive pull-ups on the MOSI and SCK lines. These pull-up resistors can be relatively weak – 100k should be adequate.

As a slave, the MOSI, SCK, and SS lines are configured as an input and the MISO line is configured as an output. This configuration is held as long as the slave mode is enabled (see the API documentation later in the manual).

### 2.3.3 Known SPI Limitations

The Promira Serial Platform SPI master occasionally requires additional time to process the received bytes and set up the next bytes. In this case, a delay is inserted on the SPI bus. Every Promira Serial Platform SPI master transaction will have a delay of half clock between the first byte and the second byte, and there may be additional delays between bytes on 128 byte boundaries of 600 µs max. Over a large transfer, the average delay period is very low.

It is only possible to reliably send and receive transactions of 4 KiB or less as an SPI master or slave. This is due to operating system issues and the full-duplex nature of the SPI signaling.

## 2.4 USB 2.0 Compliance

The Promira Serial Platform is USB 2.0 compliant and will operate as a high speed (480 Mbps) device on a USB 2.0 hub or host controller. For additional information see table 15.

## 2.5 Physical Specifications

- Dimensions: W x D x L: 77.5 mm x 29.2 mm x 115.6 mm (3.05" x 1.15" x 4.55")
- Weight: 153 g (0.34 lbs)

# 3 Software

## 3.1 Compatibility

### 3.1.1 Overview

The Promira Serial Platform software is offered as a 32-bit or 64-bit Dynamic Linked Library (or shared object). The specific compatibility for each operating system is discussed below.

### 3.1.2 Windows Compatibility

The Promira Serial Platform software is compatible with 32-bit and 64-bit versions of Windows 7, and Windows 8/8.1.

Windows XP, Vista, 2000 and legacy 16-bit Windows 95/98/ME operating systems are not supported.

### 3.1.3 Linux Compatibility

The Promira Serial Platform software is compatible with all standard 32-bit and 64-bit distributions of Linux with kernel 2.6 and integrated USB support. When using the 32-bit library on a 64-bit distribution, the appropriate 32-bit system libraries are also required.

### 3.1.4 Mac OS X Compatibility

The Promira Serial Platform software is compatible with Intel versions of Mac OS X 10.5 Leopard, 10.6 Snow Leopard, 10.7 Lion, 10.8 Mountain Lion, and 10.9 Mavericks. Installation of the latest available update is recommended.

## 3.2 Connectivity

There are two ways to connect to the Promira Serial Platform: via USB or via Ethernet. No additional device drivers are required for using either method.

### 3.2.1 USB

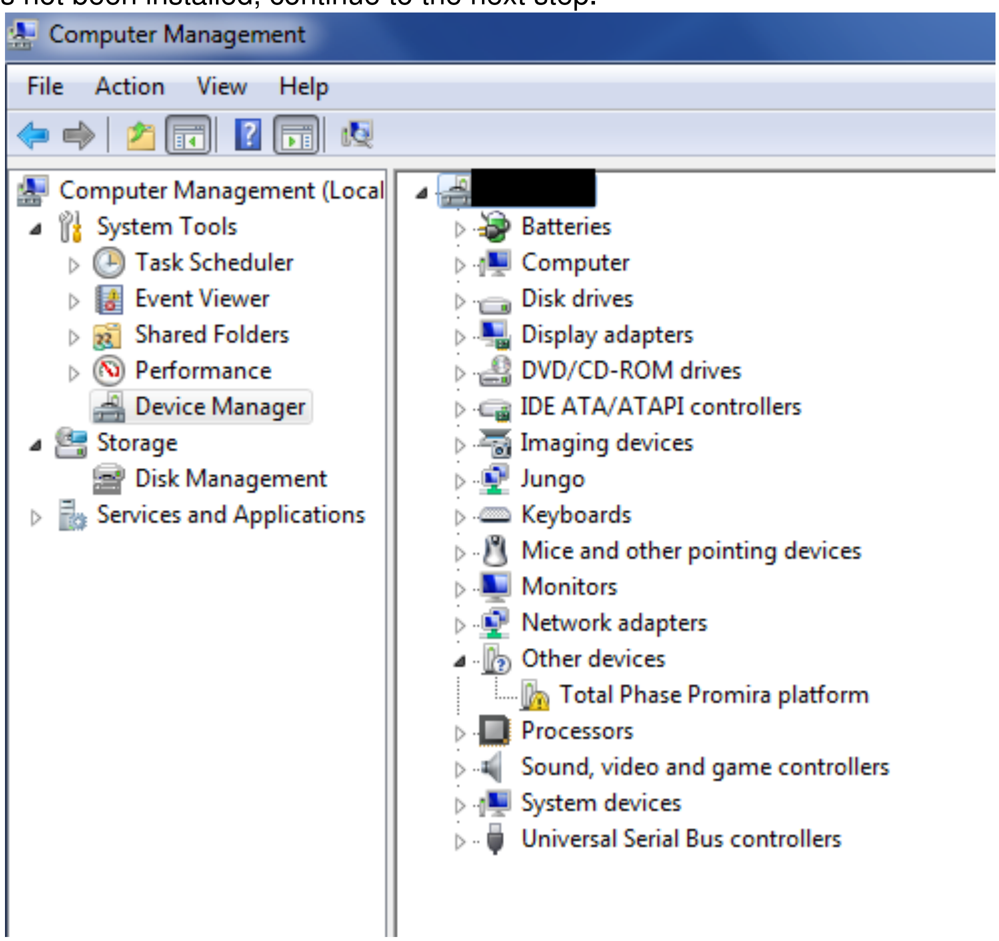
The Promira Serial Platform uses Ethernet over USB, which allows the host software to connect to the adapter via an IP address. To use this interface, connect the device to your PC with a USB cable and follow the instructions below to set up the connection on the PC.

For Ethernet over USB, the Promira Serial Platform is a DHCP server that dynamically distributes network configuration parameters, such as IP addresses for interfaces and services.

### Windows

1. Connect Promira to PC with USB cable.

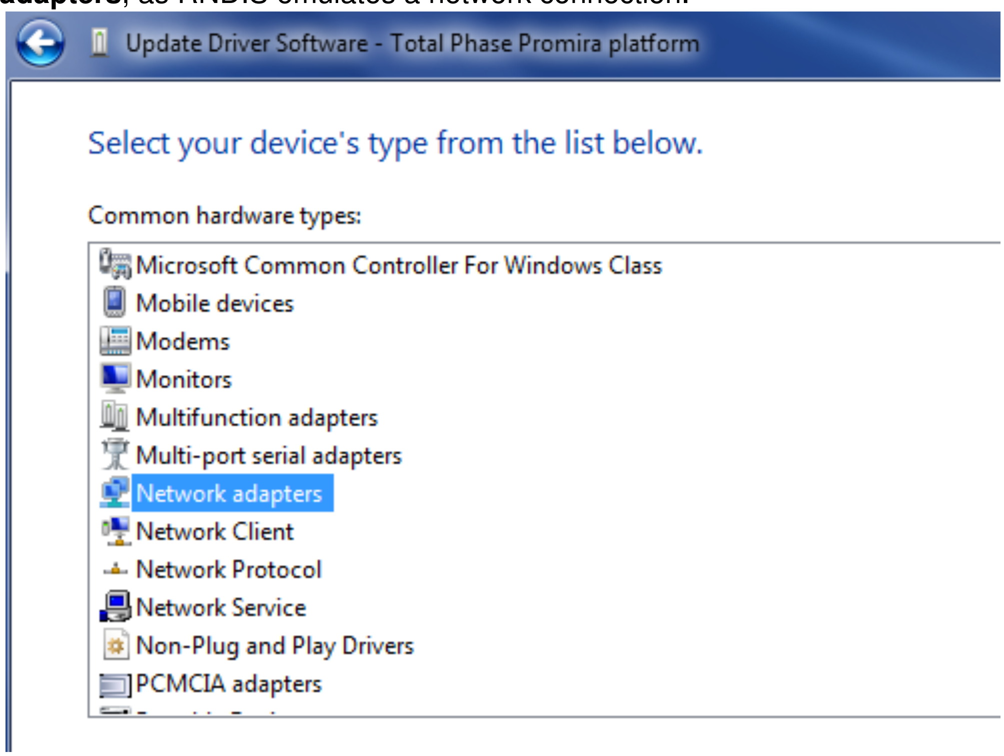
2. After the device is connected to the development PC, OS will automatically search for the RNDIS driver. To verify the drive is installed correctly, right click on **Computer** and select **Manage**. From **System Tools**, select **Device Manager**. It will show a list of devices currently connected with the development PC. If Total Phase Promira platform shows up with an exclamation mark implying that driver has not been installed, continue to the next step.



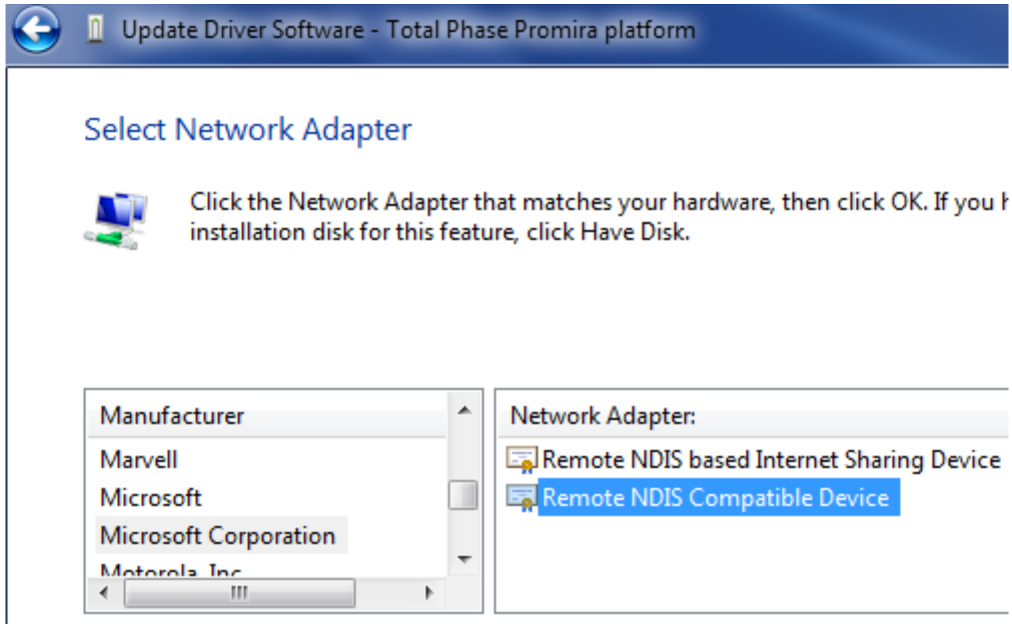

Otherwise, close this windows, skip RNDIS driver installation in the next step and continue to the following step.

3. Install RNDIS driver:

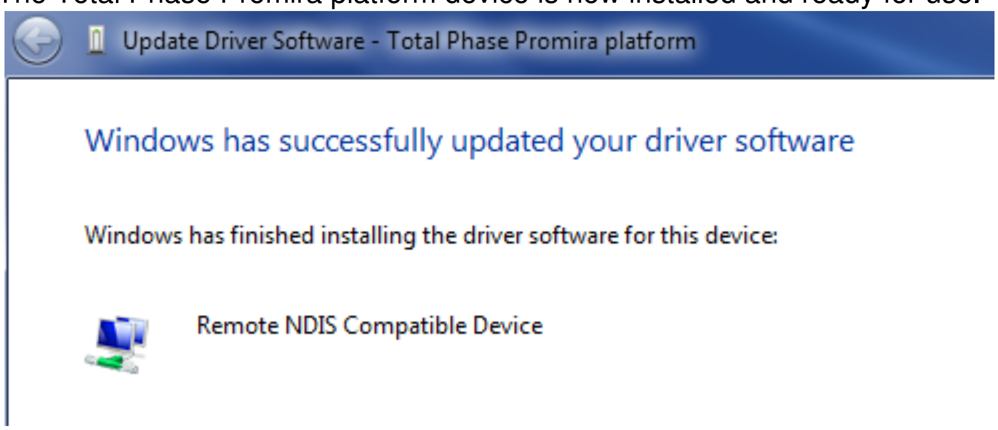
   - Right click on **Total Phase Promira platform** device and select **Update Driver Software...** When prompted to choose how to search for device driver software, choose **Browse my computer for driver software**.
   - **Browse for driver software on your computer** will come up. Select **Let me pick from a list of device drivers on my computer**.
   - A window will come up asking to select the device type. Select **Network adapters**, as RNDIS emulates a network connection.




   - In the **Select Network Adapter** window, select **Microsoft Corporation** from the **Manufacturer** list. Under the list of **Network Adapter:**, select **Remote NDIS compatible device**.




- The Total Phase Promira platform device is now installed and ready for use.




4. From the Start menu, select **Control Panel | Network and Internet | Network and Sharing Center.**
5. Select **Change adapter settings** on the left panel.
6. Right click on the **USB Ethernet/RNDIS Gadget** adapter, select **Properties**.

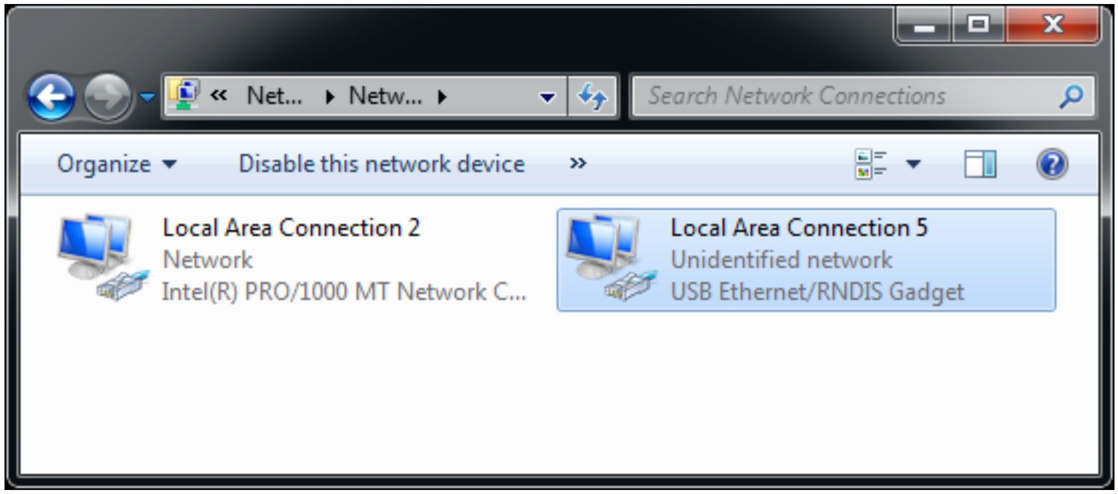



***Figure 7** : Windows Change adapter settings window.*

7. Double click on **Internet Protocol Version 4 (IPv4).**

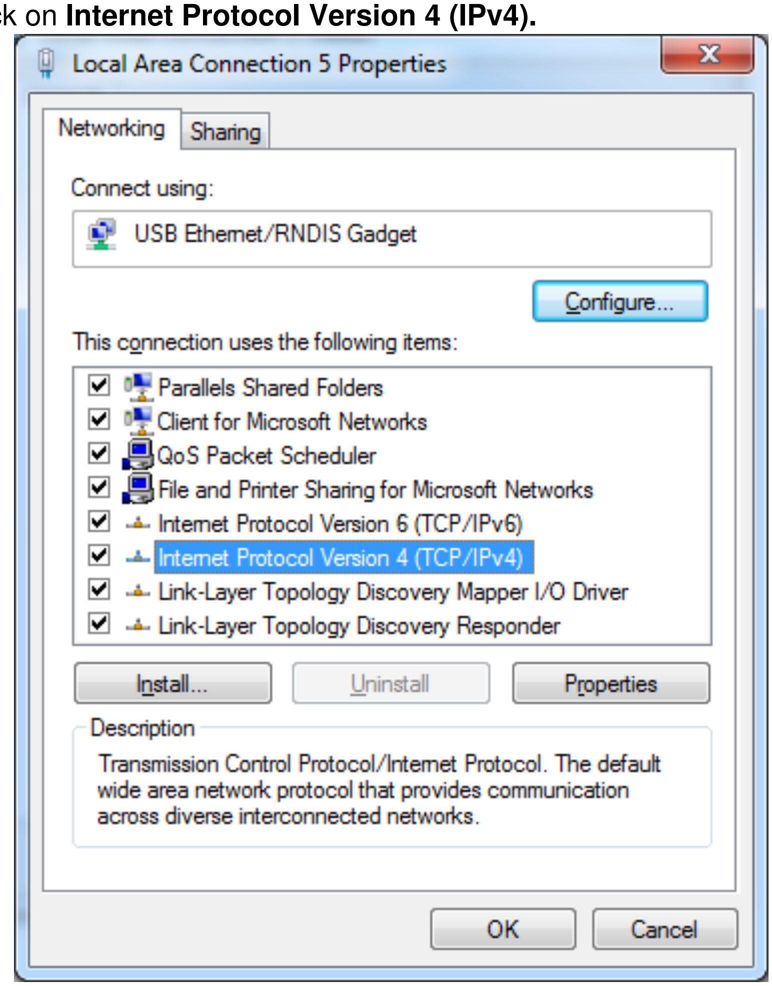


*Figure 8 : Windows Network Interface Properties dialog.*

8. Select **Obtain IP address automatically** and also select **Obtain DNS server address automatically**.

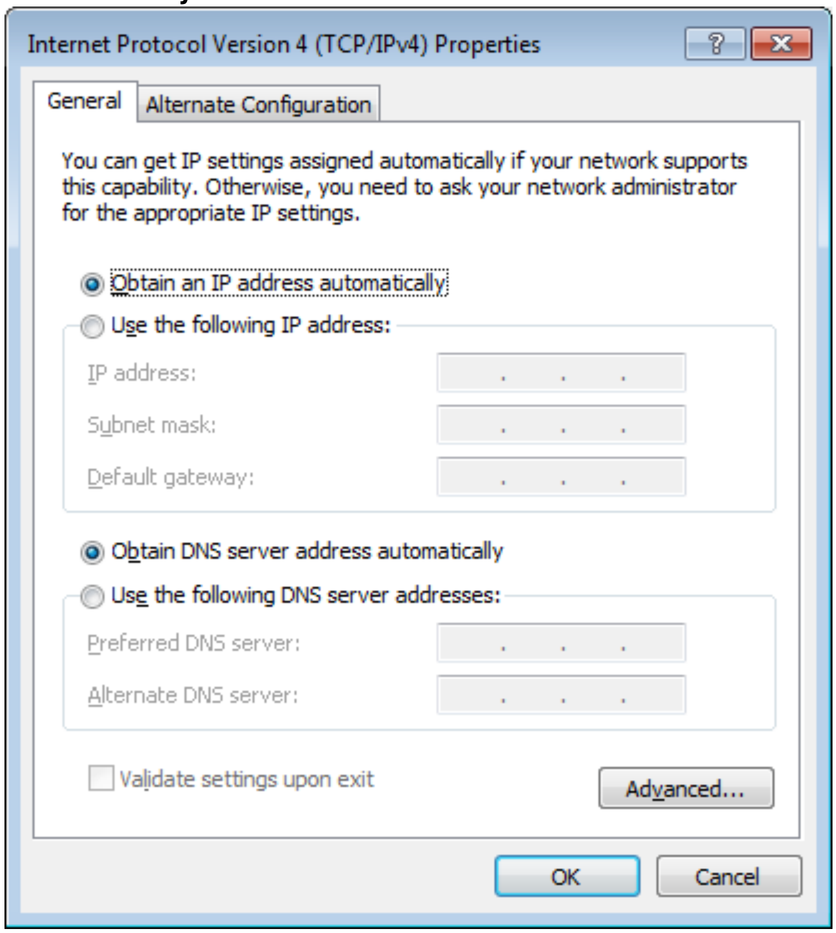



***Figure 9** : Windows IPv4 Properties dialog.*

9. Select **OK** and **Close** to dismiss the dialogs.

10. In order to make sure it is ready or to know the IP address of the Promira Serial Platform, right click on the **USB Ethernet/RNDIS Gadget** adapter, select **Status** and then select **Details...**. The IP address assigned to the network interface on the host PC is will be in the format of 10.x.x.x and is listed as the IPv4 Address. The IP address of the device will be at the preceding address. For example, the image below shows 10.1.0.2 for the host IP address. The device address will then be 10.1.0.1. This device address will also be displayed in the Control Center software and will be needed when connecting to the device using the API.

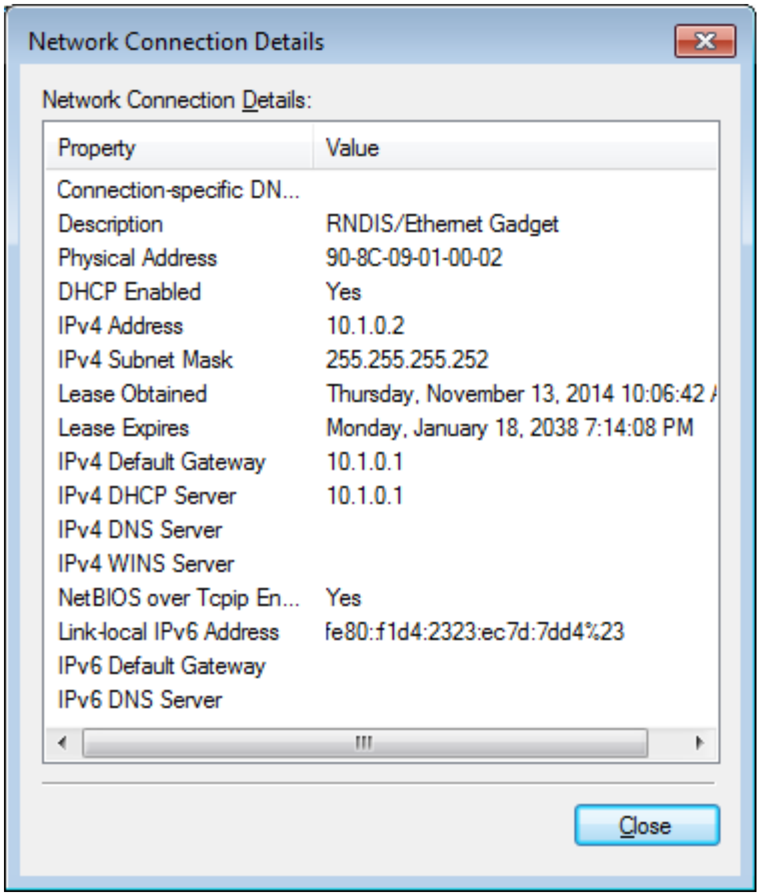



***Figure 10*** *: Windows Connection Details.*

11. Select **OK** and **Close** to dismiss the dialogs.

**Linux**

1. Download the Promira Serial Platform Linux support files from the website and follow the instructions in the README.txt file.
2. Connect Promira to PC with USB cable.
3. Use `ifconfig -a` to determine the network interface of Promira. If you do not recognize which one is the new interface, compare the lists from `ifconfig -a` before and after plugging in the device.

4. The Promira Serial Platform will be shown as tpp*x*.

**Mac OS X**

1. Connect Promira to PC with USB cable.
2. Select **Network** under **System Preferences.**
3. Select **Total Phase Promira Platform.**

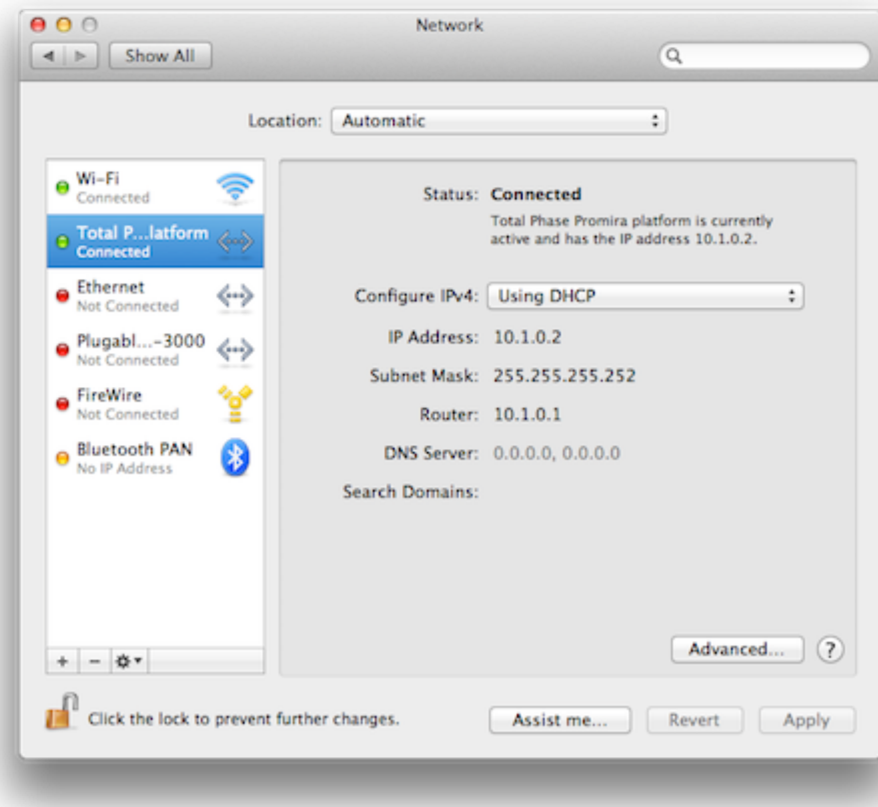



***Figure 11*** *: Mac OS X Network Preferences window.*

4. Select **Using DHCP** from the **Configure IPv4:** dropdown list box.

5. Select **Apply** to apply the changes.

### 3.2.2 Ethernet

Connecting via the Ethernet port provides a configurable interface to the Promira Serial Platform. The default IP address of the Ethernet interface is set to **192.168.11.1**. This address can be changed using the **promira** command-line application provided in the **util** folder in the Promira API package. See the README.txt file in the API package for more details.

## 3.3 Detecting IP addresses

To detect the IP addresses to which the Promira Serial Platforms are attached, use the `pm_find_devices` routine as described in following API documentation. Alternatively, the Control Center software can be used to list the available devices.

## 3.4 Dynamically Linked Library

The Promira requires the Promira DLL to operate and is only compatible with the Promira Serial Platform.

In addition to the Promira DLL, the Aardvark Compatibility DLL is provided to make the Aardvark API available for legacy and compatibility purposes.

### 3.4.2 DLL Location

Total Phase provides language bindings that can be integrated into any custom application. The default behavior of locating the Promira DLL and the Aardvark Compatibility DLL is dependent on the operating system platform and specific programming language environment. For example, for a C or C++ application, the following rules apply:

On a Windows system, this is as follows:

1. The directory from which the application binary was loaded.
2. The applications current directory.
3. 32-bit system directory (for a 32-bit application). Examples:
    - `c:\Windows\System32` [Windows 7/8 32-bit]
    - `c:\Windows\SysWow64` [Windows 7/8 64-bit]
4. 64-bit system directory (for a 64-bit application). Examples:
    - `C:\Windows\System32` [Windows 7/8 64-bit]

5. The Windows directory. (Ex: `c:\Windows` )
6. The directories listed in the PATH environment variable.

On a Linux system, this is as follows:

1. First, search for the shared object in the application binary path. If the `/proc` filesystem is not present, this step is skipped.
2. Next, search in the applications current working directory.
3. Search the paths explicitly specified in `LD_LIBRARY_PATH`.
4. Finally, check any system library paths as specified in `/etc/ld.so.conf` and cached in `/etc/ld.so.cache`.

On a Mac OS X system, this is as follows:

1. First, search for the shared object in the application binary path.
2. Next, search in the applications current working directory.
3. Search the paths explicitly specified in `DYLD_LIBRARY_PATH`.
4. Finally, check the /usr/lib and /usr/local/lib system library paths.

If the DLL is still not found, an error will be returned by the binding function. The error code is `PM_UNABLE_TO_LOAD_LIBRARY` for the management API and `PS_APP_UNABLE_TO_LOAD_LIBRARY` for the application API.

### 3.4.3 DLL Versioning

The Aardvark Compatibility DLL checks to ensure that the firmware of a given device is compatible. Each DLL revision is tagged as being compatible with firmware revisions greater than or equal to a certain version number. Likewise, each firmware version is tagged as being compatible with DLL revisions greater than or equal to a specific version number.

Here is an example.

```
DLL v1.20: compatible with Firmware >= v1.15
Firmware v1.30: compatible with DLL >= v1.20
```

Hence, the DLL is not compatible with any firmware less than version 1.15 and the firmware is not compatible with any DLL less than version 1.20. In this example, the version number constraints are satisfied and the DLL can safely connect to the target firmware without error. If there is a version mismatch, the API calls to open the device will fail. See the API documentation for further details.

## 3.5 Rosetta Language Bindings: API Integration into Custom Applications

### 3.5.1 Overview

The Promira Rosetta language bindings make integration of the Promira API into custom applications simple. Accessing Promira functionality simply requires function calls to the Promira API. This API is easy to understand, much like the ANSI C library functions, (e.g., there is no unnecessary entanglement with the Windows messaging subsystem like development kits for some other embedded tools).

First, choose the Rosetta bindings appropriate for the programming language. Different Rosetta bindings are included in the software download package available on the Total Phase website. Currently the following languages are supported: C/C++, Python. Next, follow the instructions for each language binding on how to integrate the bindings with your application build setup. As an example, the integration for the C language bindings is described below. (For information on how to integrate the bindings for other languages, please see the example code available for download on the Total Phase website.)

1. Include the `promira.h` and `promact_is.h` files in any C or C++ source module. The module may now use any API call listed in `promira.h` and `promact_is.h`.
2. Compile and link `promira.c` and `promact_is.c` with your application. Ensure that the include path for compilation also lists the directory in which `promira.h` and `promact_is.h` is located if the two files are not placed in the same directory.
3. Place the Promira DLL (promira.dll), included with the API software package, in the same directory as the application executable or in another directory such that it will be found by the previously described search rules.

### 3.5.2 Aardvark Compatibility

The Aardvark Compatibility Rosetta language bindings make it simple to integrate the Aardvark API into a custom application using the Promira Serial Platform. Similar to the Promira language bindings above, follow the instructions for each language binding on how to integrate the bindings with your application build setup. As an example, the integration for the C language bindings is described below.

1. Include the `aa_pm.h` file included with the API software package in any C or C++ source module. The module may now use any Aardvark API call listed in `aa_pm.h`.
2. Compile and link `aa_pm.c` with your application. Ensure that the include path for compilation also lists the directory in which `aa_pm.h` is located if the two files are not placed in the same directory.
3. Place the Promira DLL (promira.dll) and the Aardvark Compatibility DLL (aa_pm.dll), included with the API software package, in the same directory as the application executable or in another directory such that it will be found by the previously described search rules.

### 3.5.3 Versioning

Since a new Promira DLL and Aardvark Compatibility DLL can be made available to an already compiled application, it is essential to ensure the compatibility of the Rosetta binding used by the application (e.g., `aa_pm.c` ) against the DLL loaded by the system. A system similar to the one employed for the DLL-Firmware cross-validation is used for the binding and DLL compatibility check.

Here is an example.

```
DLL v1.20: compatible with Binding >= v1.10
Binding v1.15: compatible with DLL >= v1.15
```

The above situation will pass the appropriate version checks. The compatibility check is performed within the binding. If there is a version mismatch, the API function will return an error code, `PS_APP_INCOMPATIBLE_LIBRARY`.

### 3.5.4 Customizations

While provided language bindings stubs are fully functional, it is possible to modify the code found within this file according to specific requirements imposed by the application designer.

For example, in the C bindings one can modify the DLL search and loading behavior to conform to a specific paradigm. See the comments in `promira.c` or `aa_pm.c` for more details.

# 4 Firmware

## 4.1 Field Upgrades

### 4.1.1 Upgrade Philosophy

The Promira Serial Platform is designed so that its internal firmware can be upgraded by the user, thereby allowing the inclusion of any performance enhancements or critical fixes available after the receipt of the device.

### 4.1.2 Upgrade Procedure

Please refer to the Control Center software user manual for the procedure to upgrade the firmware on the Promira Serial Platform.

# 5 API Documentation

## 5.1 Introduction

The Promira API documentation that follows is oriented toward the Promira Rosetta C bindings. The set of Promira API functions and their functionality is identical regardless of which Rosetta language binding is utilized. The only differences will be found in the calling convention of the functions. For further information on such differences please refer to the documentation that accompanies each language bindings in the Promira API Software distribution.

## 5.2 General Data Types

The following definitions are provided for convenience. All Promira data types are unsigned.

```
typedef unsigned char       u08;
typedef unsigned short      u16;
typedef unsigned int        u32;
typedef unsigned long long  u64;
typedef signed   char       s08;
typedef signed   short      s16;
typedef signed   int        s32;
typedef signed   long long  s64;
typedef float               f32;
```

## 5.3 Notes on Status Codes

Most of the Promira API functions can return a status or error code back to the caller. The complete list of status codes is provided at the end of this chapter. All of the error codes are assigned values less than 0, separating these responses from any numerical values returned by certain API functions.

Each API function can return one of two error codes with regard to the loading of the underlying Promira DLL, `PS_APP_UNABLE_TO_LOAD_LIBRARY` and `PS_APP_INCOMPATIBLE_LIBRARY`. If these status codes are received, refer to the previous sections in this manual that discuss the DLL and API integration of the Promira software. Furthermore, all API calls can potentially return the error `PS_APP_UNABLE_TO_LOAD_FUNCTION`. If this error is encountered, there is likely a serious version incompatibility that was not caught by the automatic version checking system. Where appropriate, compare the language binding versions (e.g., `PM_HEADER_VERSION` found in `promira.h` and `PM_CFILE_VERSION` found in `promira.c` or `PS_APP_HEADER_VERSION` found in `promact_is.h` and

PS_APP_CFILE_VERSION found in promact_is.c) to verify that there are no mismatches. Next, ensure that the Rosetta language binding (e.g., promira.c and promira.h or promact_is.c and promact_is.h) are from the same release as the Promira DLL. If all of these versions are synchronized and there are still problems, please contact Total Phase support for assistance.

Any API function that accepts any type of handle can return the error PS_APP_INVALID_HANDLE if the handle does not correspond to a valid instance that has already been opened or created. If this error is received, check the application code to ensure that the open or create command returned a valid handle and that this handle is not corrupted before being passed to the offending API function.

Finally, any function call that communicates with an Promira device can return the error PS_APP_COMMUNICATION_ERROR. This means that while the handle is valid and the communication channel is open, there was an error receiving the acknowledgment response from the Promira application. This can occur in situations where the incoming data stream has been saturated by asynchronously received messages an outgoing message is sent to the Promira application, but the incoming acknowledgment is dropped by the operating system as a result of the incoming USB receive buffer being full. The error signifies that it was not possible to guarantee that the connected Promira device has processed the host PC request, though it is likely that the requested action has been communicated to the Promira device and the response was simply lost. For example, if the slave functions are enabled and the incoming communication buffer is saturated, an API call to disable the slave may return PS_APP_COMMUNICATION_ERROR even though the slave has actually been disabled.

If either the $I^2C$ or SPI subsystems have been disabled by ps_app_configure, all other API functions that interact with $I^2C$ or SPI will return PS_I2C_NOT_ENABLED or PS_SPI_NOT_ENABLED, respectively.

These common status responses are not reiterated for each function. Only the error codes that are specific to each API function are described below.

All of the possible error codes, along with their values and status strings, are listed following the API documentation.

## 5.4 Application Management Interface

### 5.4.1 Application Management

#### Find Devices (pm_find_devices)

```
int pm_find_devices (int   num_devices,
                     u32 * devices);
```

*Get a list of IP addresses to which Promira adapters are attached.*

#### Arguments

| | |
|---|---|
| `num_devices` | maximum size of the array |
| `devices` | array into which the IP addresses are returned |

#### Return Value

This function returns the number of devices found, regardless of the array size.

#### Specific Error Codes

None.

#### Details

Each element of the array is 4 byte integer value represented IP address. For instance, "192.168.1.2" is 0x0201A8C0.

Two IP addresses to same device might be returned when both Ethernet and Ethernet over USB are enabled.

If the input array is NULL, it is not filled with any values.

If there are more devices than the array size (as specified by `num_devices`), only the first `num_devices` IP addresses will be written into the array.

### Find Devices (pm_find_devices_ext)

```
int pm_find_devices_ext (int   num_devices,
                         u16 * devices,
                         int   num_ids,
                         u32 * unique_ids
                         int   num_statuses
                         u32 * statues);
```

*Get a list of IP addresses and unique IDs to which Promira Serial Platforms are attached.*

#### Arguments

| | |
|---|---|
| `num_devices` | maximum number of IP addresses to return |
| `devices` | array into which the IP addresses are returned |
| `num_ids` | maximum number of unique IDs to return |
| `unique_ids` | array into which the unique IDs are returned |
| `num_statuses` | maximum number of statuses to return |

| | |
|---|---|
| `statuses` | array into which the statuses are returned |

**Return Value**

This function returns the number of devices found, regardless of the array sizes.

**Specific Error Codes**

`None.`

**Details**

This function is the same as `pm_find_devices()` except that is also returns the unique IDs of each Promira adapter. The IDs are guaranteed to be non-zero if valid.

The IDs are the unsigned integer representation of the 10-digit serial numbers.

The number of devices and IDs returned in each of their respective arrays is determined by the minimum of `num_devices`, `num_ids`, and `statuses`.

If status is PM_DEVICE_NOT_FREE, the device is in-use by another host and is not ready for connection.

### Open a Promira Serial Platform (pm_open)

```
Promira pm_open (const char * net_addr);
```

*Open a connection to a Promira Serial Platform.*

**Arguments**

| | |
|---|---|
| `net_addr` | net address of the Promira Serial Platform. It could be an IPv4 address or a host name. |

**Return Value**

This function returns a Promira handle, which is guaranteed to be greater than zero if valid.

**Specific Error Codes**

| | |
|---|---|
| `PM_UNABLE_TO_OPEN` | The specified net address is not connected to a Promira Serial Platform. |
| `PM_INCOMPATIBLE_DEVICE` | There is a version mismatch between the DLL and the firmware. The DLL is not of a sufficient version for interoperability with the firmware version or vice versa. |

#### Details

None.

### Close the Promira device (pm_close)

```
int pm_close (Promira promira);
```

*Close the connection to the Promira adapter.*

#### Arguments

| | |
|---|---|
| `promira` | handle of the connection to the Promira Serial Platform to be closed |

#### Return Value

The number of devices closed is returned on success. This will usually be 1.

#### Specific Error Codes

None.

#### Details

If the `promira` argument is zero, the function will attempt to close all possible handles, thereby closing all connections to Promira Serial Platforms. The total number of connections to Promira Serial Platforms closed is returned by the function.

### Launch an application (pm_load)

```
int pm_load (Promira      promira,
             const char * app_name);
```

*Launch an application.*

#### Arguments

| | |
|---|---|
| `promira` | handle of the connection to the Promira Serial Platform |
| `app_name` | application name to be launched |

#### Return Value

A Promira status code is returned with `PM_OK` on success.

#### Specific Error Codes

| | |
|---|---|
| PM_APP_NOT_FOUND | There is no application with the specified name. |
| PM_UNABLE_TO_LOAD_APP | Unable to load the application. |

**Details**

The Promira Serial Platform can have more than one application. Prior to the use of any subsystems in the application, it need to be launched.

The Promira Serial Platform with firmware version 0.65 or greater has one application and its name is "com.totalphase.promact_is".

### Get IP address (pm_query_net)

```
int pm_query_net (Promira promira,
                  int     ip_addr_len,
                  u08 *   ip_addr,
                  int     netmask_len,
                  u08 *   netmask);
```

*Get IP address and network mask for this Promira handle.*

**Arguments**

| | |
|---|---|
| promira | handle of the connection to the Promira Serial Platform |
| ip_addr_len | size of the array for IP address |
| ip_addr | array into which the IP address is returned |
| netmask_len | size of the array for network mask |
| netmask | array into which the network mask is returned |

**Return Value**

A Promira status code is returned with PM_OK on success.

**Specific Error Codes**

None.

**Details**

None.

### Configure IP address (pm_config_net)

```
int pm_config_net (Promira      promira,
                   const char * ip_addr,
```

```
const char * netmask);
```

*Configure the Ethernet network interface.*

**Arguments**

| | |
|---|---|
| `promira` | handle of the connection to the Promira Serial Platform |
| `ip_addr` | IP address string. |
| `netmask` | network mask string. |

**Return Value**

A Promira status code is returned with `PM_OK` on success.

**Specific Error Codes**

| | |
|---|---|
| `PM_NETCONFIG_ERROR` | Unable to configure network interface. |
| `PM_INVALID_IPADDR` | Invalid IP address. |
| `PM_INVALID_NETMASK` | Invalid network mask. |
| `PM_INVALID_SUBNET` | The `192.168.12.x` subnet is reserved. It is an error to configure the Ethernet interface to any address in this subnet. |

**Details**

Network interface can be configured by the `promira` utility (`promira.exe` or `promira`). See the section Ethernet for more detail.

# 5.5 General Application Interface

## 5.5.1 General Application

### Connect to the Application (ps_app_connect)

```
PromiraConnectionHandle ps_app_connect (const char * net_addr)
```

*Connect to the application launched by pm_load().*

**Arguments**

| | |
|---|---|
| `net_addr` | The net address of the Promira Serial Platform. It could be an IPv4 address or a host name. |

**Return Value**

This function returns a connection handle, which is guaranteed to be greater than zero if valid.

#### Specific Error Codes

| | |
|---|---|
| PS_APP_UNABLE_TO_OPEN | Unable to connect to the application. |
| PS_APP_UNABLE_TO_INIT_SUBSYSTEM | Failed to initialize one of subsystems ($I^2C$, SPI, or GPIO) in the Promira application. |

#### Details

More than one connection can be made to the application. Also note that the application can be shared by many user applications.

### Disconnect to the Application (ps_app_disconnect)

```
int ps_app_disconnect (PromiraConnectionHandle conn)
```

*Disconnect to the application.*

#### Arguments

| | |
|---|---|
| conn | handle of the connection to the application |

#### Return Value

The number of the connections to applications disconnected is returned on success. This will usually be 1.

#### Specific Error Codes

None.

#### Details

If the conn argument is zero, the function will attempt to disconnect all possible handles, thereby disconnecting all connected handles. The total number of handle disconnected is returned by the function.

### Version (ps_app_version)

```
int ps_app_version (PromiraChannelHandle channel,
                    PromiraAppVersion *  version);
```

*Return the version matrix for the application connected to the given handle.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `version` | pointer to pre-allocated structure |

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

`None.`

**Details**

The `PromiraAppVersion` structure describes the various version dependencies of application components. It can be used to determine which component caused an incompatibility error.

```
struct PromiraAppVersion {
  /* Software, firmware, and hardware versions. */
  u16 software;
  u16 firmware;
  u16 hardware;

  /* FW requires that SW must be >= this version. */
  u16 sw_req_by_fw;

  /* SW requires that FW must be >= this version. */
  u16 fw_req_by_sw;

  /* API requires that SW must be >= this version. */
  u16 api_req_by_sw;
};
```

If the handle is 0 or invalid, only `software`, `fw_req_by_sw`, and `api_req_by_sw` version are set.

### Sleep (ps_app_sleep_ms)

```
int ps_app_sleep_ms (u32 milliseconds);
```

*Sleep for given amount of time.*

#### Arguments

| | |
|---|---|
| `milliseconds` | number of milliseconds to sleep |

#### Return Value

This function returns the number of milliseconds slept.

#### Specific Error Codes

None.

#### Details

This function provides a convenient cross-platform function to sleep the current thread using standard operating system functions.

The accuracy of this function depends on the operating system scheduler. This function will return the number of milliseconds that were actually slept.

### Status String (ps_app_status_string)

```
const char *ps_app_status_string (int status);
```

*Return the status string for the given status code.*

#### Arguments

| | |
|---|---|
| `status` | status code returned by a Promira application function. |

#### Return Value

This function returns a human readable string that corresponds to status. If the code is not valid, it returns a NULL string.

#### Specific Error Codes

None.

#### Details

None.

### 5.5.2 Channel

#### Open a Channel (ps_channel_open)

```
PromiraChannelHandle ps_channel_open (PromiraConnectionHandle conn);
```

*Open a logical communication channel.*

**Arguments**

`conn` handle of the connection to the application

**Return Value**

This function returns a channel handle, which is guaranteed to be greater than zero if valid.

**Specific Error Codes**

`None.`

**Details**

Channel is a logical communication layer that talks to the application. All commands to the launched application will be executed through the specified channel.

#### Close the Channel (ps_channel_close)

```
int ps_channel_close (PromiraChannelHandle channel);
```

*Close the logical communication channel with the specified handle.*

**Arguments**

`channel` handle of the channel

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

`None.`

**Details**

None.

### 5.5.3 Queue

#### Create a Queue (ps_queue_create)

```
PromiraQueueHandle ps_queue_create (
                        PromiraConnectionHandle conn,
                        u08                     queue_type);
```

*Create a batch queue.*

**Arguments**

| | |
|---|---|
| `conn` | handle of the connection to the application |
| `queue_type` | type of queue. See Table 2 |

**Table 2** : `queue_type` enumerated types

| | |
|---|---|
| `PS_MODULE_ID_I2C_ACTIVE` | An $I^2C$ queue. |
| `PS_MODULE_ID_SPI_ACTIVE` | A SPI queue. |

**Return Value**

This function returns a queue handle, which is guaranteed to be greater than zero if valid.

**Specific Error Codes**

`None.`

**Details**

In order to use the Promira Serial Platform to send data across the bus at high speed, data and commands can be accumulated in a queue until a call is made to batch shift all of the queued data and commands.

The queue can contain only data or command to be sent over same type of the bus. For instance, any SPI data or command cannot be queued to an $I^2C$ queue.

#### Destroy the Queue (ps_queue_destroy)

```
int ps_queue_destroy (PromiraQueueHandle queue);
```

*Destroy the queue.*

**Arguments**

| | |
|---|---|
| `queue` | handle of the queue |

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

`None.`

**Details**

None.

### Clear the Queue (ps_queue_clear)

```
int ps_queue_clear (PromiraQueueHandle queue);
```

*Clear the batch queue.*

**Arguments**

| | |
|---|---|
| `queue` | handle of the queue |

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

`None.`

**Details**

All queued data and commands are removed from the queue.

### Queue a Delay in Milliseconds (ps_queue_delay_ms)

```
int ps_queue_delay_ms (PromiraQueueHandle queue,
                       int                milliseconds);
```

*Queue a delay value on the bus in units of milliseconds.*

**Arguments**

| | |
|---|---|
| `queue` | handle of the queue |
| `milliseconds` | amount of time for delay in milliseconds |

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

None.

**Details**

Queues `milliseconds` amount of delay on the bus.

### Queue a Sync Command (ps_queue_sync)

```
int ps_queue_sync (PromiraQueueHandle queue);
```

*Queue a sync command that waits all commands to be executed*

**Arguments**

| | |
|---|---|
| `queue` | handle of the queue |

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

None.

**Details**

The commands in queues to a single subsystem ($I^2C$, SPI, or GPIO) will be executed in order that command comes into the subsystem. However The commands in queues to multiple subsystems will be executed parallelly and cannot be guaranteed which one will be done first. This function is to wait all commands to be executed from all subsystems.

### Get a number of commands (ps_queue_size)

```
int ps_queue_size (PromiraQueueHandle queue);
```

*Get a number of commands in a queue.*

#### Arguments

| | |
|---|---|
| `queue` | handle of the queue |

#### Return Value

The number of command is the queue will be returned.

#### Specific Error Codes

`None.`

#### Details

None.

### Submit the Batch Shift (ps_queue_submit)

```
PromiraCollectHandle ps_queue_submit (
                          PromiraQueueHandle   queue,
                          PromiraChannelHandle channel,
                          u08                  ctrlId,
                          u08 *                queue_type);
```

*Perform the current batch queue.*

#### Arguments

| | |
|---|---|
| `queue` | handle of the queue |
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `queue_type` | type of queue |

#### Return Value

This function returns a collect handle, which is guaranteed to be greater than zero if valid.

#### Specific Error Codes

`None.`

#### Details

This function performs all of the accumulated commands in the queue and shifts them in order to the subsystem ($I^2C$ or SPI). After the operation completes, the batch queue is not cleared. Therefore, this function may be called repeatedly if the same sequence of commands is to be shifted across the bus multiple times.

When there are any batches uncollected, this function will return PS_APP_PENDING_ASYNC_CMD.

The queue_type tells what type of queue commands are executed.

This function is a block function and will be returned when first command of the queue is executed and host receives the response of first command with a collect handle. In order to receive the responses for the remained commands in queue, use the function ps_collect_resp.

If ps_queue_submit is called before all responses are collected, all uncollected responses of the previous queue will be discarded.

### Submit an Asynchronous Shift (ps_queue_async_submit)

```
int ps_queue_async_submit (PromiraQueueHandle   queue,
                           PromiraChannelHandle channel,
                           u08                  ctrlId);
```

*Submit the shift operations in the queue for asynchronous execution.*

#### Arguments

| | |
|---|---|
| queue | handle of the queue |
| channel | handle of the channel |
| ctrlId | index of the subsystem |

#### Return Value

A status code is returned with PS_APP_OK on success.

#### Specific Error Codes

None.

#### Details

This function will submit the current batch queue asynchronously. A temporary outgoing buffer will be created to store the batch queue. An internal incoming buffer will be also created to asynchronously capture the slave response data. The application programmer does not have to explicitly manage these two buffers. The function will immediately return after queuing this batch onto the Ethernet or the Ethernet over USB rather than waiting for the shift to complete.

At this point, the user application can submit another batch to the queue. This can be done immediately by submitting the same queue a second time without altering it the application simply needs to call `ps_queue_async_submit` again. Or, the user application may clear the queue and assemble a different batch all together or may append more commands. Any subsequent calls to `ps_queue_async_submit` will again create a temporary outgoing buffer and copy the current batch into it. Likewise, a temporary incoming buffer will also be created.

Note that the submitted batch should be sufficiently long (in real time) so that it does not complete before the user application can submit more batches (and also collect the first batch). This will allow the adjacent batches to shift with very little delay between them. How long to be safe? First, there is always the possibility that the user applications process could be scheduled out by the operating system before it has an opportunity to submit the subsequent batch. The operating system scheduler time slice may be as much as 10ms. Therefore, submitted batches should be long enough to bridge one, if not two, time slices. Second, if the user application is performing its own functions between the submission of two batches, the length of the batches should be long enough to accommodate the CPU time of those functions.

Keep in mind that there can significant memory overhead for each asynchronous batch:

1. Up to 8 times the size of the outgoing number of bytes. In the worst case, if there is only one byte in each command in a queue, the outgoing buffer is approximately 8 times of the number of bytes shifted out on the bus (this doesn't count SS# assert/deassert commands or intermediate delays) and there is potentially another factor of two due to kernel/user mode memory allocation. So if the user application shifts 10 KB out in one batch, the outgoing buffer overhead is approximately 80 KB in the worst case.
2. 8 times the size of the incoming buffer for each batch.

Hence, it is important to not queue many megabytes of batches with the asynchronous interface. Additionally, only a fixed number of batches can be submitted and be left pending prior to collection. This number is fixed to 256.

Finally, the asynchronous interface is only useful if the outgoing data of any asynchronous batch does not rely on the return data of a previous asynchronous batch.

### Collect an Asynchronous Shift (ps_queue_async_collect)

```
PromiraCollectHandle ps_queue_async_collect (
```

```
                              PromiraChannelHandle channel,
                              u08 *                queue_type);
```

*Collect a previously submitted asynchronous shift queue.*

**Arguments**

| | |
|---|---|
| `channel` | handle of channel |
| `queue_type` | type of queue |

**Return Value**

This function returns a collect handle, which is guaranteed to be greater than zero if valid.

**Specific Error Codes**

None.

**Details**

This function can be called at anytime after submitting a batch for asynchronous processing. It will block until the first command in the pending batch completes.

If `ps_channel_close` is called without collecting pending asynchronous batches, those batches will be canceled, even if they are in progress. All temporary buffers will be freed as well.

Note that this merely is a recommendation for use and developers can modify this procedure as it suits their own application requirements.

The application must keep full accounting of how many batches have been submitted and how many are collected during each step of the process. It is even possible that the application will not need multiple threads.

### 5.5.4 Collect

#### Collect the Response of the Command (ps_collect_resp)

```
int ps_collect_resp (PromiraCollectHandle collect,
                     u32 *                length,
                     u32 *                ret,
                     int                  timeout);
```

*Collect the response of one command from a previously submitted asynchronous shift queue with the associated collect handle.*

**Arguments**

| | |
|---|---|
| `collect` | handle of the collection |
| `length` | The actual number of bytes read |
| `ret` | The status code returned when it is executed separately |
| `timeout` | time to wait for the response |

**Return Value**

This function returns the identifier of the response read. See Table {{table.cmdid}}

**Table {{table.cmdid}}** : Identifier of the response

| | |
|---|---|
| `PS_I2C_CMD_BITRATE` | The response of $I^2C$ bitrate command.<br>`length` will be 0 and `ret` will be the actual bitrate set. |
| `PS_I2C_CMD_WRITE` | The response of $I^2C$ write command.<br>`length` will be 0 and `ret` will be $I^2C$ status code (see Table 7). In order to get the number of bytes written, use function `ps_collect_i2c_write`. |
| `PS_I2C_CMD_READ` | The response of $I^2C$ read command.<br>`length` will be the actual number of bytes read and `ret` will be $I^2C$ status code (see Table 7). In order to get data read, use function `ps_collect_i2c_read`. |
| `PS_SPI_CMD_BITRATE` | The response of SPI bitrate command.<br>`length` will be 0 and `ret` will be the actual bitrate set. |
| `PS_SPI_CMD_CONFIGURE` | The response of SPI configure command.<br>`length` and `ret` will be 0. |
| `PS_SPI_CMD_SS_POLARITY` | The response of SPI master SS polarity command.<br>`length` and `ret` will be 0. |
| `PS_SPI_CMD_WRITE` | The response of SPI write command.<br>`length` and `ret` will be the actual number of bytes read. In order to get data read, use function `ps_collect_spi_write`. |

**Specific Error Codes**

| | |
|---|---|
| `PS_APP_NO_MORE_TO_COLLECT` | Already collect all the responses for the command in the batch |

**Details**

It is also possible to ignore to receive the information come with either `length` or `ret` by passing NULL.

For some commands ($I^2C$ write/read or SPI write), additional function call is required to get data and the information.

Once `ps_collect_resp` gets called, the previous response is no longer available.

### 5.5.5 Configuration

#### Configure (ps_app_configure)

```
int ps_app_configure (PromiraChannelHandle channel,
                      PromiraAppConfig     config);
```

*Activate/deactivate individual subsystems ($I^2C$, SPI, GPIO).*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `config` | enumerated type specifying configuration. See Table 3 |

**Table 3** : `config` enumerated types

| | |
|---|---|
| PS_APP_CONFIG_GPIO | Configure all pins as GPIO. Disable both $I^2C$ and SPI. |
| PS_APP_CONFIG_SPI | Configure $I^2C$ pins as GPIO. Enable SPI. |
| PS_APP_CONFIG_I2C | Configure SPI pins as GPIO. Enable $I^2C$. |
| PS_APP_CONFIG_SPI\|PS_APP_CONFIG_I2C | Disable GPIO. Enable both $I^2C$ and SPI. |
| PS_APP_CONFIG_QUERY | Queries existing configuration (does not modify). |

**Return Value**

The current configuration on the application will be returned. The configuration will be described by the same values in `PromiraAppConfig`.

**Specific Error Codes**

`None.`

**Details**

If either the $I^2C$ or SPI subsystems have been disabled by this API call, all other API functions that interact with $I^2C$ or SPI will return `PS_APP_CONFIG_ERROR`.

If configurations are switched, the subsystem specific parameters will be preserved. For example if the SPI bitrate is set to 500 kHz and the SPI system is disabled and then enabled, the bitrate will remain at 500 kHz. This also holds for other parameters such as the SPI mode, SPI slave response, $I^2C$ bitrate, $I^2C$ slave response, etc.

However, if a subsystem is shut off, it will be restarted in a quiescent mode. That is to say, the $I^2C$ slave function will not be reactivated after re-enabling the $I^2C$ subsystem, even if the $I^2C$ slave function was active before first disabling the $I^2C$ subsystem.

**Target Power (ps_phy_target_power)**

```
int ps_phy_target_power (PromiraChannelHandle channel,
                         u08                  power_mask);
```

*Activate/deactivate target power pins 4, 6, 22 and 24.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `power_mask` | enumerated values specifying power pin state. See Table 5. |

**Table 5** : `power_mask` enumerated types

| | |
|---|---|
| `PS_PHY_TARGET_POWER_NONE` | Disable target power pins 4, 6, 22, 24. Pins 4, 6, 22, 24 at GND level. |
| `PS_PHY_TARGET_POWER_TGT1_5V` | Enable 5V on target power pins 4 and 6. |
| `PS_PHY_TARGET_POWER_TGT1_3V` | Enable 3.3V on target power pins 4 and 6. |
| `PS_PHY_TARGET_POWER_TGT2` | Enable target power pins 22 and 24 with the same voltage as the $I^2C$/SPI signals voltage level as programed by API function `ps_phy_level_shift`. The $I^2C$/SPI logic level can be programed to 0.9V to 3.45V. The precision level of the level shifter is approximately 0.015V. |
| `PS_PHY_TARGET_POWER_BOTH` | Enable 5V on target power pins 4 and 6, and enable target power pins 22 and 24 with the same voltage as the $I^2C$/SPI signals voltage level as programed by API function `ps_phy_level_shift`. |

| | |
|---|---|
| PS_PHY_TARGET_POWER_QUERY | Queries the target power pin state. |

**Return Value**

The current state of the target power pins will be returned. The configuration will be described by the same values as in the table above.

**Specific Error Codes**

None.

**Details**

None.

### Level Shift (ps_phy_level_shift)

```
f32 ps_phy_level_shift (PromiraChannelHandle channel,
                        f32                  level);
```

*Shift the logic level for all signal pins including target power pin 22 and 24.*

**Arguments**

| | |
|---|---|
| channel | handle of the channel |
| level | logic level from 0.9V to 3.45V |

**Return Value**

The Actual logic level on the Promira host adapter will be returned.

**Specific Error Codes**

None.

**Details**

The call with PS_PHY_LEVEL_SHIFT_QUERY returns existing configuration and does not modify.

# 5.6 $I^2C$ Interface

## 5.6.1 $I^2C$ Notes

1. It is not necessary to set the bitrate for the Promira $I^2C$ slave.
2. An $I^2C$ master operation read or write operation can be transacted while leaving the $I^2C$ slave functionality enabled. In a multi-master situation it is possible for the $I^2C$ subsystem to lose the bus during the slave addressing portion of the transaction. If the other master that wins the bus subsequently addresses this $I^2C$ subsystem slave address, the $I^2C$ subsystem will respond appropriately to the request using its slave mode capabilities.
3. It is always advisable to set the slave response before first enabling the slave. This ensures that valid data is sent to any requesting master.
4. It is not possible to receive messages larger than approximately 64 KiB-1 as a slave due to operating system limitations on the asynchronous incoming buffer. As such, one should not queue up more than 64 KiB-1 of total slave data between calls to the Promira API.
5. It is possible for the Promira $I^2C$ master to employ some of the advanced features of $I^2C$. This is accomplished by the `PromiraI2CFlags` argument type that is included in the `ps_i2c_read` and `ps_i2c_write` argument lists. The options in Table 6 are available can be logically ORed together to combine them for one operation.

**Table 6** : $I^2C$ Advanced Feature Options

| | |
|---|---|
| `PS_I2C_NO_FLAGS` | Request no options. |
| `PS_I2C_10_BIT_ADDR` | Request that the provided address is treated as a 10-bit address. The Promira $I^2C$ subsystem will follow the Philips $I^2C$ specification when transmitting the address. |
| `PS_I2C_COMBINED_FMT` | Request that the Philips combined format is followed during a $I^2C$ read operation. Please see the Philips specification for more details. This flag does not have any effect unless a master read operation is requested and the `PS_I2C_10_BIT_ADDR` is also set. |

| | |
|---|---|
| `PS_I2C_NO_STOP` | Request that no stop condition is issued on the I²C bus after the transaction completes. It is expected that the PC will follow up with a subsequent transaction at which point a repeated start will be issued on the bus. Eventually an I²C transaction must be issued without the "no stop" option so that a stop condition is issued and the bus is freed. |
| `PS_I2C_SIZED_READ` | See `ps_i2c_read` below. |
| `PS_I2C_SIZED_READ_EXTRA1` | See `ps_i2c_read` below. |

6. It is possible for the Promira I²C master to return an extended status code for master read and master write transactions. These codes are described in Table 7 and are returned by the `ps_i2c_read` and `ps_i2c_write` functions, as well as the analogous slave API functions.

**Table 7** : I²C Extended Status Code

| | |
|---|---|
| `PS_I2C_STATUS_BUS_ERROR` | A bus error has occurred. Transaction was aborted. |
| `PS_I2C_STATUS_SLA_ACK` | Bus arbitration was lost during master transaction; another master on the bus has successfully addressed this Promira Serial Platforms slave address. As a result, this Promira adapter has automatically switched to slave mode and is responding. |
| `PS_I2C_STATUS_SLA_NACK` | The Promira application failed to receive acknowledgment for the requested slave address during a master operation. |
| `PS_I2C_STATUS_DATA_NACK` | The last data byte in the transaction was not acknowledged by the slave. |
| `PS_I2C_STATUS_ARB_LOST` | Another master device on the bus was accessing the bus simultaneously with this Promira Serial Platform. That device won arbitration of the bus as per the I²C specification. |

| | |
|---|---|
| `PS_I2C_STATUS_BUS_LOCKED` | An I2C packet is in progress, and the time since the last I2C event executed or received on the bus has exceeded the bus lock timeout. This is most likely due to the clock line of the bus being held low by some other device, or due to the data line held low such that a start condition cannot be executed by the Promira application. The bus lock timeout can be configured using the `ps_i2c_bus_timeout` function. The Promira application resets its own I2C interface when a timeout is observed and no further action is taken on the bus. |
| `PS_I2C_STATUS_LAST_DATA_ACK` | When the I2C slave is configured with a fixed length transmit buffer, it will detach itself from the I2C bus after the buffer is fully transmitted. The I2C slave also expects that the last byte sent from this buffer is NACKed by the opposing master device. This status code is returned by the I2C slave (see Slave Write Statistics API) if the master device instead ACKs the last byte. The notification can be useful when debugging a third-party master device. |

These codes can provide hints as to why an impartial transaction was executed by the Promira Serial Platform. In the event that a bus error occurs while the Promira Serial Platform is idle and enabled as a slave (but not currently receiving a message), the adapter will return the bus error through the `ps_i2c_slave_read` function. The length of the message will be 0 bytes but the status code will reflect the bus error.

### 5.6.2 General I2C

#### Free bus (ps_i2c_free_bus)

```
int ps_i2c_pullup (PromiraChannelHandle channel,
                   u08                  ctrlId
                   u08                  pullup_mask);
```

*Activate/deactivate I2C pull-up resistors on SCL and SDAFree the I²C subsystem from a held.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `pullup_mask` | enumerated values specifying pullup state. See Table 8. |

**Table 8** : `pullup_mask` enumerated types

| | |
|---|---|
| `PS_I2C_PULLUP_NONE` | Disable SCL/SDA pull-up resistors |
| `PS_I2C_PULLUP_BOTH` | Enable SCL/SDA pull-up resistors |
| `PS_I2C_PULLUP_QUERY` | Queries the pull-up resistor state |

**Return Value**

The current state of the I²C pull-up resistors on the Aardvark adapter will be returned. The configuration will be described by the same values as in the table above.

**Specific Error Codes**

`None.`

**Details**

Both pull-up resistors are controlled together. Independent control is not supported. This function may be performed in any operation mode.

These pull-up resisters vary on the voltage level of SCL/SDA line which can be set by `ps_phy_level_shift`. See Table 9

**Table 9** : I²C pull-up resistor

| Range of voltage | Pull-up resistor |
|---|---|
| `<= 1.2V` | 389 ohm |
| `> 1.2V and <= 2.2V` | 520 ohm |
| `> 2.2V` | 1550 ohm |

### Free bus (ps_i2c_free_bus)

```
int ps_i2c_free_bus (PromiraChannelHandle channel,
```

```
                                    u08                 ctrlId);
```

*Free the $I^2C$ subsystem from a held bus condition (e.g., "no stop").*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

| | |
|---|---|
| `PS_I2C_BUS_ALREADY_FREE` | The bus was already free and no action was taken. |

**Details**

If the $I^2C$ subsystem had executed a master transaction and is holding the bus due to a previous `PS_I2C_NO_STOP` flag, this function will issue the stop command and free the bus. If the bus is already free, it will return the status code `PS_I2C_BUS_ALREADY_FREE`.

Similarly, if the $I^2C$ subsystem was placed into slave mode and in the middle of a slave transaction, this command will disconnect the slave from the bus, flush the last transfer, and re-enable the slave. Such a feature is useful if the Promira application was receiving bytes but then was forced to wait indefinitely on the bus because of the absence of the terminating stop command. After disabling the slave, any pending slave reception will be available to the host through the usual `ps_i2c_slave_write_stats` and `ps_i2c_slave_read` API calls.

The bus is always freed (i.e., a stop command is executed if necessary) and the slave functions are disabled at software opening and closing of the device.

### Set Bus Lock Timeout (ps_i2c_bus_timeout)

```
int ps_i2c_bus_timeout (PromiraChannelHandle channel,
                        u08                  ctrlId,
                        u16                  timeout_ms);
```

*Set the $I^2C$ bus lock timeout in milliseconds.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |

| | |
|---|---|
| `ctrlId` | index of the subsystem |
| `timeout_ms` | the requested bus lock timeout in ms. |

**Return Value**

This function returns the actual timeout set.

**Specific Error Codes**

None.

**Details**

The power-on default timeout is 200ms. The minimum timeout value is 10ms and the maximum is 450ms. If a timeout value outside this range is passed to the API function, the timeout will be restricted. The exact timeout that is set can vary based on the resolution of the timer within the Promira application. The nominal timeout that was set is returned back by the API function.

If `timeout_ms` is 0, the function will return the bus lock timeout presently set on the Promira application and the bus lock timeout will be left unmodified.

If the bus is locked during the middle of any $I^2C$ transaction (master transmit, master receive, slave transmit, slave receive) the appropriate extended API function will return the status code `PS_I2C_STATUS_BUS_LOCKED` as described in the preceding Notes section. The bus lock timeout is measured between events on the $I^2C$ bus, where an event is a start condition, the completion of 9bits of data transfer, a repeated start condition, or a stop condition. For example, if a full 9 bits are not completed within the bus lock timeout (due to clock stretching or some other error), the bus lock error will be triggered.

Please note that once the Promira application detects a bus lock timeout, it will abort its $I^2C$ interface, even if the timeout condition is seen in the middle of a byte. When the Promira application is acting as an $I^2C$ mater device, this may result in only a partial byte being executed on the bus.

### 5.6.3 $I^2C$ Master

#### Set Bitrate (ps_i2c_bitrate)

```
int ps_i2c_bitrate (PromiraChannelHandle channel,
                    u08                  ctrlId,
                    int                  bitrate_khz);
```

*Set the $I^2C$ bitrate in kilohertz.*

#### Arguments

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `bitrate_khz` | the requested bitrate in khz. |

#### Return Value

This function returns the actual bitrate set.

#### Specific Error Codes

None.

#### Details

The power-on default bitrate is 100 kHz.

Only certain discrete bitrates are supported by the I²C master interface. As such, this actual bitrate set will be less than or equal to the requested bitrate.

If `bitrate_khz` is 0, the function will return the bitrate presently set on the I²C subsystem and the bitrate will be left unmodified.

### Queue a Set Bitrate (ps_queue_i2c_bitrate)

```
int ps_queue_i2c_bitrate (PromiraQueueHandle queue,
                          int                bitrate_khz);
```

*Queue the command that sets the I²C bitrate in kilohertz.*

#### Arguments

| | |
|---|---|
| `queue` | handle of the queue |
| `bitrate_khz` | the requested bitrate in khz. |

#### Return Value

A status code is returned with `PS_APP_OK` on success.

#### Specific Error Codes

None.

#### Details

This function queues the command, it will be executed when the function `ps_queue_submit` or `ps_queue_async_submit` is called.

The actual bitrate set will be returned with the function `ps_collect_resp` when collecting.

### Master Read (ps_i2c_read)

```
int ps_i2c_read (PromiraChannelHandle handle,
                 u08                  ctrlId,
                 u16                  slave_addr,
                 PromiraI2CFlags      flags,
                 u16                  num_bytes,
                 u08 *                data_in
                 u16 *                num_read);
```

*Read a stream of bytes from the I²C slave device.*

#### Arguments

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `slave_addr` | the slave from which to read |
| `flags` | special operations as described in "Notes" section and below |
| `num_bytes` | the number of bytes to read (maximum 65535) |
| `data_in` | array into which the data read are returned |
| `num_read` | the actual number of bytes read |

#### Return Value

Status code (see "Notes" section).

#### Specific Error Codes

| | |
|---|---|
| `PS_I2C_READ_ERROR` | There was an error reading from the Promira application. This is most likely a result of a communication error. |

#### Details

For ordinary 7-bit addressing, the lower 7 bits of `slave_addr` should correspond to the slave address. The topmost bits are ignored. The I²C subsystem will assemble the address along with the `R/W` bit after grabbing the bus. For 10-bit addressing, the lower 10 bits of `addr` should correspond to the slave address. The I²C subsystem will then assemble the address into the proper format as described in the Philips specification, namely by first issuing an write transaction on the bus to specify the 10-bit slave and then a read transaction to read the requested number of bytes. The initial write transaction can be skipped if the "Combined Format" feature is requested in conjunction with the 10-bit addressing functionality.

The `data_in` pointer should be allocated at least as large as `num_bytes`. When the `data_in` is NULL, this function discards the actual received bytes and returns only `num_read`. When the `num_read` is NULL, this function fills the actual received bytes, but doesn't return the number of bytes received.

It is possible to read zero bytes from the slave. In this case, `num_bytes` is set to `0` and the `data_in` argument is ignored (i.e., it can be 0 or point to invalid memory). However, due to the nature of the $I^2C$ protocol, it is not possible to address the slave and not request at least one byte. Therefore, one byte is actually received by the host, but is subsequently thrown away.

If the number of bytes read is zero, the following conditions are possible.

- The requested slave was not found.
- The requested slave is on the bus but refuses to acknowledge its address.
- The $I^2C$ subsystem was unable to seize the bus due to the presence of another $I^2C$ master. **Here, the arbitration was lost during the slave addressing phase – results can be unpredictable**.
- Zero bytes were requested from a slave. The slave acknowledged its address and returned 1 byte. That byte was dropped.

Ordinarily the number of bytes read, if not `0`, will equal the requested number of bytes. One special scenario in which this will not happen is if the $I^2C$ subsystem loses the bus during the data transmission due to the presence of another $I^2C$ master.

If the slave has fewer bytes to transmit than the number requested by the master, the slave will simply stop transmitting and the master will receive `0xff` for each remaining byte in the transmission. This behavior is in accordance with the $I^2C$ protocol.

Additionally, the `flags` argument can be used to specify a sized read operation. If the flag includes the value `PS_I2C_SIZED_READ`, the $I^2C$ subsystem will treat the first byte received from the slave as a packet length field. This length denotes the number of bytes that the slave has available for reading (not including the length byte itself). The $I^2C$ subsystem will continue to read the minimum of `num_bytes-1` and the length field. The length value must be greater than `0`. If it is equal to `0`, it will be treated as though it is `1`. In order to support protocols that include an optional checksum byte (e.g., SMBus) the flag can alternatively be set to `PS_I2C_SIZED_READ_EXTRA1`. In this case the I$^2$C subsystem will read one more data byte beyond the number specified by the length field.

The status code allows the user to discover specific events on the I$^2$C bus that would otherwise be transparent given only the number of bytes transacted. The "Notes" section describes the status codes.

For a master read operation, the `PS_I2C_STATUS_DATA_NACK` flag is not used since the acknowledgment of data bytes is predetermined by the master and the I$^2$C specification.

### Queue a Master Read (ps_queue_i2c_read)

```
int ps_queue_i2c_read (PromiraQueueHandle queue,
                       u16                slave_addr,
                       PromiraI2CFlags    flags,
                       u16                num_bytes);
```

*Queue a command that reads a stream of bytes from the I$^2$C slave device.*

#### Arguments

| | |
|---|---|
| `queue` | handle of the queue |
| `slave_addr` | the slave from which to read |
| `flags` | special operations as described in "Notes" section and below |
| `num_bytes` | the number of bytes to read (maximum 65535) |

#### Return Value

A status code is returned with `PS_APP_OK` on success.

#### Specific Error Codes

`None`

#### Details

This function queues the command, it will be executed when the function `ps_queue_submit` or `ps_queue_async_submit` is called.

The actual data read and the number of bytes read will be returned with the function `ps_collect_resp` and `ps_collect_i2c_read` when collecting.

### Collect a Master Read (ps_collect_i2c_read)

```
int ps_collect_i2c_read (PromiraCollectHandle collect,
                         u16                  num_bytes,
                         u08 *                data_in
                         u16 *                num_read);
```

*Collect the response of I²C master read.*

#### Arguments

| | |
|---|---|
| `collect` | handle of the collection |
| `num_bytes` | maximum size of the array |
| `data_in` | array into which the data read are returned |
| `num_read` | the actual number of bytes read |

#### Return Value

A status code is returned with `PS_APP_OK` on success.

#### Specific Error Codes

| | |
|---|---|
| `PS_APP_MISMATCHED_CMD` | The type of response is not `PS_I2C_CMD_READ`. |

#### Details

This function should be called right after the function `ps_collect_resp` returns `PS_I2C_CMD_READ`. Once the function `ps_collect_resp` is called again, then data for I²C read command will be discarded. However this function can be called many times before the function `ps_collect_resp` is called.

### Master Write (ps_i2c_write)

```
int ps_i2c_write (PromiraChannelHandle channel,
                  u08                  ctrlId,
                  u16                  slave_addr,
                  PromiraI2CFlags      flags,
                  u16                  num_bytes,
                  const u08 *          data_out,
                  u16 *                num_written);
```

*Write a stream of bytes to the I²C slave device.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `slave_addr` | the slave from which to write |
| `flags` | special operations as described in "Notes" section |
| `num_bytes` | the number of bytes to write (maximum 65535) |
| `data_out` | pointer to data |
| `num_written` | the actual number of bytes written |

**Return Value**

Status code (see "Notes" section).

**Specific Error Codes**

| | |
|---|---|
| `PS_I2C_WRITE_ERROR` | There was an error reading the acknowledgment from the Promira application. This is most likely a result of a communication error. |

**Details**

For ordinary 7-bit addressing, the lower 7 bits of `slave_addr` should correspond to the slave address. The topmost bits are ignored. The $I^2C$ subsystem will assemble the address along with the `R/W` bit after grabbing the bus. For 10-bit addressing, the lower 10 bits of `addr` should correspond to the slave address. The $I^2C$ subsystem will then assemble the address into the proper format as described in the Philips specification. There is a limitation that a maximum of only 65534 bytes can be written in a single transaction if the 10-bit addressing mode is used.

The `slave_addr 0x00` has been reserved in the $I^2C$ protocol specification for general call addressing. $I^2C$ slaves that are enabled to respond to a general call will acknowledge this address. The general call is not treated specially in the $I^2C$ master. The user of this API can manually assemble the first data byte if the hardware address programming feature with general call is required.

It is actually possible to write `0` bytes to the slave. The slave will be addressed and then the stop condition will be immediately transmitted by the $I^2C$ subsystem. No bytes are sent to the slave, so the `data_out` argument is ignored (i.e., it can be 0 or point to invalid memory).

If the number of bytes written is zero, the following conditions are possible.

- The requested slave was not found.

- The requested slave is on the bus but refuses to acknowledge its address.
- The I2C subsystem was unable to seize the bus due to the presence of another I2C master. **Here, the arbitration was lost during the slave addressing phase results can be unpredictable**.
- The slave was addressed and no bytes were written to it because `num_bytes` was set to `0`.

The number of bytes written can be less than the requested number of bytes in the transaction due to the following possibilities.

- The I2C subsystem loses the bus during the data transmission due to the presence of another I2C master.
- The slave refuses the reception of any more bytes.

The status code allows the user to discover specific events on the I2C bus that would otherwise be transparent given only the number of bytes transacted. The "Notes" section describes the status codes.

For a master write operation, the `PS_I2C_STATUS_DATA_NACK` flag can be useful in the following situation:

- Normally the I2C master will write to the slave until the slave issues a NACK or the requested number of bytes have been written.
- If the master has wishes to write 10 bytes, the I2C slave issues either an ACK or NACK on the tenth byte without affecting the total number of bytes transferred. The status code will distinguish the two scenarios. This status information could be useful for further communications with that particular slave device.

### Queue a Master Write (ps_i2c_read)

```
int ps_queue_i2c_write (PromiraQueueHandle queue,
                        u16                slave_addr,
                        PromiraI2CFlags    flags,
                        u16                num_bytes,
                        const u08 *        data_out);
```

*Queue a command that writes a stream of bytes to the I2C slave device.*

#### Arguments

| | |
|---|---|
| `queue` | handle of the queue |

| | |
|---|---|
| `slave_addr` | the slave from which to write |
| `flags` | special operations as described in "Notes" section |
| `num_bytes` | the number of bytes to write (maximum 65535) |
| `data_out` | pointer to data |

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

None

**Details**

This function queues the command, it will be executed when the function `ps_queue_submit` or `ps_queue_async_submit` is called.

The actual data written will be returned with the function `ps_collect_resp` and `ps_collect_i2c_write` when collecting.

### Collect a Master Write (ps_collect_i2c_write)

```
int ps_collect_i2c_read (PromiraCollectHandle collect,
                         u16 *                num_written);
```

*Collect the response of I²C master write.*

**Arguments**

| | |
|---|---|
| `collect` | handle of the collection |
| `num_written` | the actual number of bytes written |

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

| | |
|---|---|
| `PS_APP_MISMATCHED_CMD` | The type of response is not `PS_I2C_CMD_READ`. |

**Details**

This function should be called right after the function `ps_collect_resp` returns `PS_I2C_CMD_WRITE`. Once the function `ps_collect_resp` is called again, then data for I²C write command will be discarded. However this function can be called many times before the function `ps_collect_resp` is called.

### 5.6.4 $I^2C$ Slave

#### Slave Enable (ps_i2c_slave_enable)

```
int ps_i2c_slave_enable (PromiraChannelHandle channel,
                         u08                  ctrlId,
                         u08                  addr,
                         u16                  maxTxBytes,
                         u16                  maxRxBytes);
```

*Enable the $I^2C$ subsystem as an $I^2C$ slave device.*

**Arguments**

| | |
|---|---|
| channel | handle of the channel |
| ctrlId | index of the subsystem |
| addr | address of this slave |
| maxTxBytes | max number of bytes to transmit per transaction |
| maxRxBytes | max number of bytes to receive per transaction |

**Return Value**

A status code is returned with PS_APP_OK on success.

**Specific Error Codes**

None.

**Details**

The lower 7 bits of addr should correspond to the slave address of this $I^2C$ subsystem. If the topmost bit of addr is set, the slave will respond to a general call transmission by an $I^2C$ master. After having been addressed by a general call, the $I^2C$ slave treats the transaction no differently than a single slave communication. There is no support for the hardware address programming feature of the general call that is described in the $I^2C$ protocol specification since that capability is not needed for the Promira application.

If maxTxBytes is 0, there is no limit on the number of bytes that this slave will transmit per transaction. If it is non-zero, then the slave will stop transmitting bytes at the specified limit and subsequent bytes received by the master will be 0xff due to the bus pull-up resistors. The response that is transmitted by the slave is set through the ps_i2c_slave_set_response function described below. If the maximum is greater than the response (as set through i2cc_slave_set_response) the I²C slave will wrap the response string as many times as necessary to send the requested number of bytes.

If maxRxBytes is 0, the slave can receive an unlimited number of bytes from the master. However, if it is non-zero, the slave will send a not-acknowledge bit after the last byte that it accepts. The master should then release the bus. Even if the master does not stop transmitting, the slave will return the received data back to the host PC and then transition to a idle state, waiting to be addressed in a subsequent transaction.

It is never possible to *restrict* a transmit or receive to 0 bytes. Furthermore, once the slave is addressed by a master read operation it is always guaranteed to transmit at least 1 byte.

If a master transaction is executed after the slave features have been enabled, the slave features will remain enabled after the master transaction completes.

### Slave Disable (ps_i2c_slave_disable)

```
int ps_i2c_slave_disable (PromiraChannelHandle channel,
                          u08                  ctrlId);
```

*Disable the I²C subsystem as an I²C slave device.*

#### Arguments

| | |
|---|---|
| channel | handle of the channel |
| ctrlId | index of the subsystem |

#### Return Value

A status code is returned with PS_APP_OK on success.

#### Specific Error Codes

None.

#### Details

None.

### Slave Set Response (ps_i2c_slave_set_response)

```
int ps_i2c_slave_set_response (PromiraChannelHandle channel,
                               u08                  ctrlId,
                               u08                  num_bytes,
```

```
                                    const u08 *          data_out);
```

*Set the slave response in the event the $I^2C$ subsystem is put into slave mode and contacted by a master.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `num_bytes` | number of bytes for the slave response |
| `data_out` | pointer to the slave response |

**Return Value**

The number of bytes accepted by the $I^2C$ subsystem.

**Specific Error Codes**

`None.`

**Details**

The value of `num_bytes` must be greater than zero. If it is zero, the response string is undefined until this function is called with the correct parameters.

If more bytes are requested in a transaction, the response string will be wrapped as many times as necessary to complete the transaction.

The buffer space is 64 bytes.

### Asynchronous Polling (ps_i2c_slave_poll)

```
int ps_i2c_slave_poll (PromiraChannelHandle channel,
                       u08                  ctrlId,
                       int                  timeout);
```

*Check if there is any asynchronous data pending from the $I^2C$ subsystem.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `timeout` | timeout in milliseconds |

**Return Value**

A status code indicating which types of asynchronous messages are available for processing. See Table 10.

**Table 10** : Status code enumerated types

| | |
|---|---|
| `PS_I2C_SLAVE_NO_DATA` | No asynchronous data is available. |
| `PS_I2C_SLAVE_READ` | $I^2C$ slave read data is available. Use function `ps_i2c_slave_read` to get data. |
| `PS_I2C_SLAVE_WRITE` | $I^2C$ slave write stats are available. Use function `ps_i2c_slave_write_stats` to get data. |
| `PS_I2C_SLAVE_DATA_LOST` | $I^2C$ slave data lost stats are available. Use function `ps_i2c_slave_data_lost_stats` to get data. |

**Specific Error Codes**

`None.`

**Details**

Recall that, like all other Promira API functions, this function is not thread-safe.

If the timeout value is negative, the function will block indefinitely until data arrives. If the timeout value is 0, the function will perform a non-blocking check for pending asynchronous data.

This function sends a command to collect all slave data to $I^2C$ subsystem and saves it $I^2C$ asynchronous slave queue. If there is any slave data in the queue, then it returns the type of first slave data.

One can employ the following technique to guarantee that all pending asynchronous slave data have been captured during each service cycle:

1. Call the polling function with a specified timeout.
2. If the polling function indicates that there is data available, call the appropriate service function once for each type of data that is available.
3. Next, call the polling function with a 0 timeout.
4. Call the appropriate service function once for each type of data that is available.
5. Repeat steps 3 and 4 until the polling function reports that there is no data available.

### Slave Write Statistics (ps_i2c_slave_write_stats)

```
int ps_i2c_slave_write_stats (PromiraChannelHandle channel,
                              u08                  ctrlId,
                              u08 *                addr,
                              u16 *                num_written);
```

*Return number of bytes written from a previous Promira I²C slave to I²C master transmission.*

#### Arguments

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `addr` | the address to which the sent message was received |
| `num_written` | the number of bytes written by the slave |

#### Return Value

Status code (see "Notes" section).

#### Specific Error Codes

| | |
|---|---|
| `PS_I2C_SLAVE_TIMEOUT` | There was no recent slave transmission. |
| `PS_I2C_SLAVE_READ_ERROR` | This slave data is not I²C slave write. |

#### Details

The transmission of bytes from the Promira slave, when it is configured as an I²C slave, is asynchronous with respect to the PC host software. Hence, there could be multiple responses queued up from previous write transactions.

The only possible status code is `PS_I2C_STATUS_BUS_ERROR` which can occur when an illegal START, STOP, or RESTART condition appears on the bus during a transaction. In this case the `num_written` may not exactly reflect the number of bytes written by the slave. It can be off by `1`.

### Slave Read (ps_i2c_slave_read)

```
int ps_i2c_slave_read (PromiraChannelHandle channel,
                       u08                  ctrlId,
                       u08 *                addr,
                       u16                  num_bytes,
                       u08 *                data_in
```

```
u16 *                    num_read);
```

*Read the bytes from an I²C slave reception.*

#### Arguments

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `addr` | the address to which the received message was sent |
| `num_bytes` | the maximum size of the data buffer |
| `data_in` | array into which the data read are returned |
| `num_read` | the actual number of bytes read by the slave |

#### Return Value

Status code (see "Notes" section).

#### Specific Error Codes

| | |
|---|---|
| `PS_I2C_SLAVE_TIMEOUT` | There was no recent slave transmission. |
| `PS_I2C_DROPPED_EXCESS_BYTES` | The msg was larger than num_bytes. |
| `PS_I2C_SLAVE_READ_ERROR` | This slave data is not I²C slave read. |

#### Details

If the message was directed to this specific slave, `*addr` will be set to the value of this slaves address. However, this slave may have received this message through a general call addressing. In this case, `*addr` will be `0x80` instead of its own address.

The num_bytes parameter specifies the size of the memory pointed to by data. It is possible, however, that the received slave message exceeds this length. In such a situation, `PS_PS_I2C_DROPPED_EXCESS_BYTES` is returned, meaning that `num_bytes` was placed into data but the remaining bytes were discarded

There is no cause for alarm if the number of bytes read is less than `num_bytes`. This simply indicates that the incoming message was short.

The reception of bytes by the Promira slave, when it is configured as an I²C slave, is asynchronous with respect to the PC host software. Hence, there could be multiple responses queued up from previous transactions.

The only possible status code is `PS_I2C_STATUS_BUS_ERROR` which can occur when an illegal START, STOP, or RESTART condition appears on the bus during a transaction.

#### Slave Data Lost Statistics (ps_i2c_slave_data_lost_stats)

```
int ps_i2c_slave_data_lost_stats (PromiraChannelHandle channel,
                                  u08                  ctrlId);
```

*Return number of slave read/write lost from a previous Promira I²C slave to I²C master transmission.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |

**Return Value**

The function returns the number of I²C slave read/write

**Specific Error Codes**

| | |
|---|---|
| `PS_I2C_SLAVE_TIMEOUT` | There was no recent slave transmission. |
| `PS_I2C_SLAVE_READ_ERROR` | This slave data is not I²C slave data lost. |

**Details**

There are two asynchronous slave queues, one in the host and the other is in the device. When the capacity of both queues is all 255. If the number of slave data exceeds 255 in the device, I²C slave read/write is counted as lost and returns back to the host.

## 5.7 SPI Interface

### 5.7.1 SPI Notes

1. The SPI master and slave must both be configured to use the same bit protocol (mode).
2. It is not necessary to set the bitrate for the Promira SPI slave.
3. An SPI master operation read or write operation can be transacted while leaving the SPI slave functionality enabled. During the master transaction, the slave will be temporarily deactivated. Once the master transaction is complete, the slave will be automatically reactivated.

4. It is always advisable to set the slave response before first enabling the slave. This ensures that valid data is sent to any requesting master.

5. It is not possible to receive messages larger than approximately 64 KiB-1 as a slave due to operating system limitations on the asynchronous incoming buffer. As such, one should not queue up more than 64 KiB-1 of total slave data between calls to the Promira API.

6. It is not possible to send messages larger than approximately 64 KiB-1 as a master due to operating system limitations on the asynchronous incoming buffer. The SPI is full-duplex so there must be enough buffer space to accommodate the slave response when sending as a master.

7. Sending zero bytes as an SPI master will simply toggle the slave select line for 5-10 µs.

### 5.7.2 General SPI

#### Configure (ps_spi_configure)

```
int ps_spi_configure (PromiraChannelHandle channel,
                      u08                  ctrlId,
                      PromiraSpiPolarity   polarity,
                      PromiraSpiPhase      phase,
                      PromiraSpiBitorder   bitorder);
```

*Configure the SPI master or slave interface.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `polarity` | `PS_SPI_POL_RISING_FALLING` or `PS_SPI_POL_FALLING_RISING` |
| `phase` | `PS_SPI_PHASE_SAMPLE_SETUP` or `PS_SPI_PHASE_SETUP_SAMPLE` |
| `bitorder` | `PS_SPI_BITORDER_MSB` or `PS_SPI_BITORDER_LSB` |

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

`None.`

**Details**

These configuration parameters specify how to clock the bits that are sent and received on the Promira SPI interface.

The polarity option specifies which transition constitutes the leading edge and which transition is the falling edge. For example, `PS_SPI_POL_RISING_FALLING` would configure the SPI to idle the SCLK clock line low. The clock would then transition low-to-high on the leading edge and high-to-low on the trailing edge.

The phase option determines whether to sample or setup on the leading edge. For example, `PS_SPI_PHASE_SAMPLE_SETUP` would configure the SPI to sample on the leading edge and setup on the trailing edge.

The bitorder option is used to indicate whether LSB or MSB is shifted first.

The pair ( `PS_SPI_POL_FALLING_RISING`, `PS_SPI_PHASE_SETUP_SAMPLE` ) would correspond to mode 3 in the figure found in the "SPI Background" chapter.

### 5.7.3 SPI Master

#### Set Bitrate (ps_spi_bitrate)

```
int ps_spi_bitrate (PromiraChannelHandle channel,
                    u08                  ctrlId,
                    int                  bitrate_khz);
```

*Set the SPI bitrate in kilohertz.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `bitrate_khz` | the requested bitrate in khz. |

**Return Value**

This function returns the actual bitrate set.

**Specific Error Codes**

`None.`

**Details**

The power-on default bitrate is 1000 kHz.

Only certain discrete bitrates are supported by the SPI subsystem. As such, this actual bitrate set will be less than or equal to the requested bitrate unless the requested value is less than 125 kHz, in which case the SPI subsystem will default to 125 kHz.

If `bitrate_khz` is 0, the function will return the bitrate presently set on the Promira application and the bitrate will be left unmodified.

### Queue a Set Bitrate (ps_spi_bitrate)

```
int ps_queue_spi_bitrate (PromiraQueueHandle queue,
                          int                bitrate_khz);
```

*Queue the command that sets the SPI bitrate in kilohertz.*

#### Arguments

| | |
|---|---|
| `queue` | handle of the queue |
| `bitrate_khz` | the requested bitrate in khz. |

#### Return Value

A status code is returned with `PS_APP_OK` on success.

#### Specific Error Codes

`None.`

#### Details

This function queues the command, it will be executed when the function `ps_queue_submit` or `ps_queue_async_submit` is called.

The actual bitrate set will be returned with the function `ps_collect_resp` when collecting.

### Set Slave Select Polarity (ps_spi_master_ss_polarity)

```
int ps_spi_master_ss_polarity (PromiraChannelHandle channel,
                               u08                  ctrlId,
                               PromiraSpiSSPolarity polarity);
```

*Change the output polarity on the SS line.*

#### Arguments

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `polarity` | `PS_SPI_SS_ACTIVE_LOW` or `PS_SPI_SS_ACTIVE_HIGH` |

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

`None.`

**Details**

This function only affects the SPI master functions on the SPI subsystem. When configured as an SPI slave, the SPI subsystem will always be setup with SS as active low.

### Queue a Set Slave Select Polarity (ps_spi_master_ss_polarity)

```
int ps_queue_spi_master_ss_polarity (
                                PromiraQueueHandle   queue,
                                PromiraSpiSSPolarity polarity);
```

*Queue the command that changes the output polarity on the SS line.*

**Arguments**

| | |
|---|---|
| `queue` | handle of the queue |
| `polarity` | `PS_SPI_SS_ACTIVE_LOW` or `PS_SPI_SS_ACTIVE_HIGH` |

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

`None.`

**Details**

This function queues the command, it will be executed when the function `ps_queue_submit` or `ps_queue_async_submit` is called.

### Master Write/Read (ps_spi_write)

```
int ps_spi_write (PromiraChannelHandle channel,
```

```
                              u08                   ctrlId,
                              u16                   out_num_bytes,
                              const u08 *           data_out,
                              u16                   in_num_bytes,
                              u08 *                 data_in);
```

*Write a stream of bytes to the downstream SPI slave device and read back the full-duplex response.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `out_num_bytes` | number of bytes to send |
| `data_out` | pointer to the bytes to transmit out |
| `in_num_bytes` | number of bytes to receive |
| `data_in` | array into which the data read are returned |

**Return Value**

This function returns the total number of bytes read from the slave which normally will be the same as the number of bytes written to the slave. See below for how this value relates to `in_num_bytes`.

**Specific Error Codes**

| | |
|---|---|
| `PS_SPI_WRITE_ERROR` | There was an error writing to the Promira application. This is most likely a result of a communication error. Make sure that `out_num_bytes` is less than 64 KiB-1. |

**Details**

Due to the full-duplex nature of the SPI protocol, for every byte written to the slave, one byte is also received. The SPI subsystem will always receive the same number of bytes that it sends out (barring any error). This is the return value mentioned above. The user has the option of saving all, some, or none of those received bytes by varying the size of `in_num_bytes`.

This function will always write out the number of bytes defined by `out_num_bytes` from the memory pointed to by `data_out`. When `out_num_bytes` is larger than `in_num_bytes`, `data_in` is completely filled and any extra bytes are dropped. When `out_num_bytes` is less than `in_num_bytes`, all the received bytes are saved and `data_in` is only partially filled.

The `data_in` pointer should reference memory that is at least allocated to the size specified by `in_num_bytes`. If `data_in` is NULL, then data received will be discarded.

If `out_num_bytes` is `0`, no bytes will be written to the slave. However, the slave select line will be dropped for 5-10 µs. This can be useful in sending a signal to a downstream SPI slave without actually sending any bytes. For example, if an SPI slave has tied the slave select to an interrupt line and it sees the line is toggled without any bytes sent, it can interpret the action as a command to prepare its firmware for an subsequent reception of bytes. If `out_num_bytes` is `0`, `data_out`, `data_in`, and `in_num_bytes` can be set to `0`.

If the return value of this function is less than `out_num_bytes`, there was an error. SPI is a bit-blasting scheme where the master does not even know if there is a slave on the other end of the transmission. Therefore, it is always expected that the master will send the entire length of the transaction.

An error will likely occur if the number of bytes sent is significantly greater than 64 KiB-1. This function cannot reliably execute larger transfers due to the buffering issues explained in the "Software | Application Notes" section. Only a partial number of bytes will be sent to the slave and only a partial number will be received from the slave; it is quite possible that these numbers will not be equal. The size of the partial response is returned by this function and any received data up to `in_num_bytes` will be in the memory pointed to by `data_in`. Note that the last few bytes of the response may be corrupted as well.

### Queue a Master Write/Read (ps_queue_spi_write)

```
int ps_queue_spi_write (PromiraQueueHandle queue,
                        u16                out_num_bytes,
                        const u08 *        data_out);
```

*Queue the command that writes a stream of bytes to the downstream SPI slave device and reads back the full-duplex response.*

#### Arguments

| | |
|---|---|
| `queue` | handle of the queue |
| `out_num_bytes` | number of bytes to send |
| `data_out` | pointer to the bytes to transmit out |

#### Return Value

A status code is returned with `PS_APP_OK` on success.

#### Specific Error Codes

None.

#### Details

This function queues the command, it will be executed when the function `ps_queue_submit` or `ps_queue_async_submit` is called.

The actual data read and the number of bytes read will be returned with the function `ps_collect_resp` and `ps_collect_spi_write` when collecting.

### Collect a Master Write/Read (ps_collect_spi_write)

```
int ps_collect_spi_write (PromiraCollectHandle collect,
                          u16                  in_num_bytes,
                          u08 *                data_in);
```

*Collect the response of SPI master read.*

#### Arguments

| | |
|---|---|
| `collect` | handle of the collection |
| `in_num_bytes` | number of bytes to receive |
| `data_in` | array into which the data read are returned |

#### Return Value

This function returns the total number of bytes read from the slave which normally will be the same as the number of bytes written to the slave. See below for how this value relates to `in_num_bytes`.

#### Specific Error Codes

| | |
|---|---|
| `PS_APP_MISMATCHED_CMD` | The type of response is not `PS_SPI_CMD_WRITE`. |

#### Details

This function should be called right after the function `ps_collect_resp` returns `PS_SPI_CMD_WRITE`. Once the function `ps_collect_resp` is called again, then data for SPI write/read command will be discarded. However this function can be called many times before the function `ps_collect_resp` is called.

### 5.7.4 SPI Slave

#### Slave Enable (ps_spi_slave_enable)

```
int ps_spi_slave_enable (PromiraChannelHandle channel,
                         u08                  ctrlId);
```

*Enable the SPI subsystem as an SPI slave device.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

`None.`

**Details**

None.

#### Slave Disable (ps_spi_slave_disable)

```
int ps_spi_slave_disable (PromiraChannelHandle channel,
                          u08                  ctrlId);
```

*Disable the SPI subsystem as an SPI slave device.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

`None.`

**Details**

None.

### Slave Set Response (ps_spi_slave_set_response)

```
int ps_spi_slave_set_response (PromiraChannelHandle channel,
                               u08                  ctrlId,
                               u08                  num_bytes,
                               const u08 *          data_out);
```

*Set the slave response in the event the SPI subsystem is put into slave mode and contacted by a master.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `num_bytes` | number of bytes for the slave response |
| `data_out` | pointer to the slave response |

**Return Value**

The number of bytes accepted by the SPI subsystem for the response.

**Specific Error Codes**

`None.`

**Details**

The value of `num_bytes` must be greater than zero. If it is zero, the response string is undefined until this function is called with the correct parameters.

Due to limited buffer space on the SPI subsystem, the device may only accept a portion of the intended response. If the value returned by this function is less than `num_bytes` the SPI subsystem has dropped the remainder of the bytes.

If more bytes are requested in a transaction, the response string will be wrapped as many times as necessary to complete the transaction.

The buffer space will nominally be 64 bytes but may change depending on firmware revision.

### Asynchronous Polling (ps_spi_slave_poll)

```
int ps_spi_slave_poll (PromiraChannelHandle channel,
                       u08                  ctrlId,
                       int                  timeout);
```

*Check if there is any asynchronous slave data pending from the SPI subsystem.*

#### Arguments

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `timeout` | timeout in milliseconds |

#### Return Value

A status code indicating which types of asynchronous messages are available for processing. See Table 10.

**Table 10** : Status code enumerated types

| | |
|---|---|
| `PS_SPI_SLAVE_NO_DATA` | No asynchronous slave data is available. |
| `PS_SPI_SLAVE_DATA` | SPI slave read data is available. Use `ps_spi_slave_read` to get data. |
| `PS_SPI_SLAVE_DATA_LOST` | SPI slave data lost stats are available. Use `ps_spi_slave_data_lost_stats` to get data. |

#### Specific Error Codes

`None.`

#### Details

This function is alike the function `ps_i2c_slave_poll`. However the SPI slave data is separately handled and saved in the SPI asynchronous queue.

### Slave Read (ps_spi_slave_read)

```
int ps_spi_slave_read (PromiraChannelHandle channel,
                       u08                  ctrlId,
```

```
                                u16                   num_bytes,
                                u08 *                 data_in);
```

*Read the bytes from an SPI slave reception.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |
| `num_bytes` | the maximum size of the data buffer |
| `data_in` | array into which the data read are returned |

**Return Value**

This function returns the number of bytes read asynchronously.

**Specific Error Codes**

| | |
|---|---|
| `PS_SPI_SLAVE_TIMEOUT` | There was no recent slave transmission. |
| `PS_SPI_DROPPED_EXCESS_BYTES` | The data was larger than num_bytes. |
| `PS_SPI_SLAVE_READ_ERROR` | The slave data is not SPI slave data lost. |

**Details**

The `num_bytes` parameter specifies the size of the memory pointed to by data. It is possible, however, that the received slave message exceeds this length. In such a situation, `PS_SPI_DROPPED_EXCESS_BYTES` is returned, meaning that num_bytes was placed into data but the remaining bytes were discarded.

There is no cause for alarm if the number of bytes read is less than `num_bytes`. This simply indicates that the incoming message was short.

The reception of bytes by the SPI subsystem, when it is configured as an SPI slave, is asynchronous with respect to the PC host software. Hence, there could be multiple responses queued up from previous write transactions.

The SPI API does not include a function that is analogous to the $I^2C$ function `ps_i2c_slave_write_stats`. Since SPI is a full-duplex standard, the slave writes to the master whenever it receives bytes from the master. Hence, a received message from `ps_i2c_slave_read` implies that an equal number of bytes were sent to the master.

### Slave Data Lost Statistics (ps_spi_slave_data_lost_stats)

```
int ps_spi_slave_data_lost_stats (PromiraChannelHandle channel,
```

```
                                             u08              ctrlId);
```

*Return number of slave read/write lost from a previous Promira SPI slave to SPI master transmission.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `ctrlId` | index of the subsystem |

**Return Value**

The function returns the number of SPI slave read/write

**Specific Error Codes**

| | |
|---|---|
| `PS_SPI_SLAVE_READ_ERROR` | The slave data is not SPI slave data lost. |

**Details**

There are two asynchronous slave queues, one in the host and the other is in the device. When the capacity of both queues is all 255. If the number of slave data exceeds 255 in the device, SPI slave read/write is counted as lost and returns back to the host.

# 5.8 GPIO Interface

## 5.8.1 GPIO Notes

1. The following enumerated type maps the named lines on the Promira $I^2C$/SPI output cable to bit positions in the GPIO API. All GPIO API functions will index these lines through a single 8-bit masked value. Thus, each bit position in the mask can be referred back its corresponding line through the mapping described below.

**Table 12** : `PromiraGpioBits` : enumerated type of line locations in bit mask

| | | | |
|---|---|---|---|
| `PS_GPIO_SCL` | Pin 1 | `0x01` | $I^2C$ SCL line |
| `PS_GPIO_SDA` | Pin 3 | `0x02` | $I^2C$ SDA line |
| `PS_GPIO_MISO` | Pin 5 | `0x04` | SPI MISO line |
| `PS_GPIO_SCK` | Pin 7 | `0x08` | SPI SCK line |
| `PS_GPIO_MOSI` | Pin 8 | `0x10` | SPI MOSI line |
| `PS_GPIO_SS` | Pin 9 | `0x20` | SPI SS line |

2. There is no check in the GPIO API calls to see if a particular GPIO line is enabled in the current configuration. If a line is not enabled for GPIO, the get function will simply return `0` for those bits. Another example is if one changes the GPIO directions for $I^2C$ lines while the $I^2C$ subsystem is still active. These new direction values will be cached and will automatically be activate if a later call to `ps_app_configure` disables the $I^2C$ subsystem and enables GPIO for the $I^2C$ lines. The same type of behavior holds for `ps_gpio_set`.
3. Additionally, for lines that are not configured as inputs, a change in the GPIO line using `ps_gpio_set` will be cached and will take effect the next time the line is active and configured as an input.
4. On the Promira application launching, directions default to all input. Also the GPIO subsystem is off by default. It must be activated by using `ps_app_configure`.

### 5.8.2 GPIO Interface

#### Direction (ps_gpio_direction)

```
int ps_gpio_direction (PromiraChannelHandle channel,
                       u32                  direction_mask);
```

*Change the direction of the GPIO lines between input and output directions.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `direction_mask` | each bit corresponds to the physical line as given by `GpioBits`. If a line's bit is `0`, the line is configured as an input. Otherwise it will be an output. |

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

`None.`

**Details**

None.

#### Get (ps_gpio_get)

```
int ps_gpio_get (PromiraChannelHandle channel);
```

*Get the value of current GPIO inputs.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |

**Return Value**

An integer value, organized as a bitmask in the fashion described by `GpioBits`. Any line that is logic high will have a its corresponding bit active. If the line is logic low the bit will not be active in the bit mask.

**Specific Error Codes**

None.

**Details**

A line's bit position in the mask will be `0` if it is configured as an output or if it corresponds to a subsystem that is still active.

### Set (ps_gpio_set)

```
int ps_gpio_set (PromiraChannelHandle channel,
                 u32                  value);
```

*Set the value of current GPIO outputs.*

**Arguments**

| | |
|---|---|
| `channel` | handle of the channel |
| `value` | a bitmask specifying which outputs should be set to logic high and which should be set to logic low. |

**Return Value**

A status code is returned with `PS_APP_OK` on success.

**Specific Error Codes**

None.

**Details**

If a line is configured as an input or not activated for GPIO, the output value will be cached. The next time the line is an output and activated for GPIO, the output value previously set will automatically take effect.

### Change (ps_gpio_change)

```
int ps_gpio_change (PromiraChannelHandle channel,
                    u16                  timeout_ms);
```

*Block until there is a change on the GPIO input lines.*

#### Arguments

| | |
|---|---|
| `channel` | handle of the channel |
| `timeout_ms` | time to wait for a change in milliseconds |

#### Return Value

The current state of the GPIO input lines.

#### Specific Error Codes

None.

#### Details

The function will return either when a change has occurred or the timeout expires. Pins configured for $I^2C$ or SPI will be ignored. Pins configured as outputs will be ignored. The timeout, specified in milliseconds, has a precision of approximately 2 ms. The maximum allowable timeout is approximately 60 seconds. If the timeout expires, this function will return the current state of the GPIO lines. It is the applications responsibility to save the old value of the lines and determine if there is a change based on the return value of this function.

The function `ps_gpio_change` will return immediately with the current value of the GPIO lines for the first invocation after any of the following functions are called: `ps_app_configure`, `ps_gpio_direction`.

## 5.9 Error Codes

**Table 13** : Promira API Error Codes

| Literal Name | Value | ps_app_status_string() return value |
|---|---|---|
| PS_APP_OK | 0 | ok |
| PS_APP_UNABLE_TO_LOAD_LIBRARY | -1 | unable to load library |
| PS_APP_UNABLE_TO_LOAD_DRIVER | -2 | unable to load USB driver |

| | | |
|---|---|---|
| PS_APP_UNABLE_TO_LOAD_FUNCTION | -3 | unable to load binding function |
| PS_APP_INCOMPATIBLE_LIBRARY | -4 | incompatible library version |
| PS_APP_INCOMPATIBLE_DEVICE | -5 | incompatible device version |
| PS_APP_COMMUNICATION_ERROR | -6 | communication error |
| PS_APP_UNABLE_TO_OPEN | -7 | unable to open device |
| PS_APP_UNABLE_TO_CLOSE | -8 | unable to close device |
| PS_APP_INVALID_HANDLE | -9 | invalid device handle |
| PS_APP_CONFIG_ERROR | -10 | configuration error |
| PS_APP_MEMORY_ALLOC_ERROR | -11 | unable to allocate memory |
| PS_APP_UNABLE_TO_INIT_SUBSYSTEM | -12 | unable to initialize subsystem |
| PS_APP_INVALID_LICENSE | -13 | invalid license |
| PS_APP_PENDING_ASYNC_CMD | -30 | pending respones to collect |
| PS_APP_TIMEOUT | -31 | timeout to collect a response |
| PS_APP_CONNECTION_LOST | -32 | connection lost |
| PS_APP_CONNECTION_FULL | -33 | too many connections |
| PS_APP_QUEUE_FULL | -50 | queue is full |
| PS_APP_QUEUE_INVALID_CMD_TYPE | -51 | invalid command to be added |
| PS_APP_QUEUE_EMPTY | -52 | no command to send |
| PS_APP_NO_MORE_TO_COLLECT | -80 | no more response to collect |
| PS_APP_UNKNOWN_CMD | -81 | unknown response received |
| PS_APP_MISMATCHED_CMD | -82 | response doesn't match with the command |
| PS_I2C_NOT_AVAILABLE | -100 | i2c feature not available |
| PS_I2C_NOT_ENABLED | -101 | i2c not enabled |
| PS_I2C_READ_ERROR | -102 | i2c read error |
| PS_I2C_WRITE_ERROR | -103 | i2c write error |
| PS_I2C_SLAVE_BAD_CONFIG | -104 | i2c slave enable bad config |
| PS_I2C_SLAVE_READ_ERROR | -105 | i2c slave read error |
| PS_I2C_SLAVE_TIMEOUT | -106 | i2c slave timeout |
| PS_I2C_DROPPED_EXCESS_BYTES | -107 | i2c slave dropped excess bytes |
| PS_I2C_BUS_ALREADY_FREE | -108 | i2c bus already free |
| PS_SPI_NOT_AVAILBLE | -200 | spi feature not available |
| PS_SPI_NOT_ENABLED | -201 | spi not enabled |
| PS_SPI_WRITE_ERROR | -202 | spi write error |
| PS_SPI_SLAVE_READ_ERROR | -203 | spi slave read error |

| | | |
|---|---|---|
| PS_SPI_SLAVE_TIMEOUT | -204 | spi slave timeout |
| PS_SPI_DROPPED_EXCESS_BYTES | -205 | spi slave dropped excess bytes |

# 6 Electrical Specifications

## 6.1 DC Characteristics

**Table 14** : Absolute Maximum Ratings

| Pin | Symbol | Conditions | Min | Max | Units |
|---|---|---|---|---|---|
| 1, 3, 9 | SCL/GPIO-00, SDA/GPIO-01, SS/GPIO-05 | | -0.5 | 5.5 | V |
| 5, 7, 8 | MISO/GPIO-02, SCK/GPIO-03, MOSI/GPIO-04 | | -0.5 | 4.6 | V |

**Table 15** : Operating Conditions

| Symbol | Description | Conditions & Notes | Min | Max | Units |
|---|---|---|---|---|---|
| Ta | Ambient Operating Temperature | | 10 (50) | 35 (95) | C (F) |
| Icore | Core Current Consumption | (1) | | 500 | mA |

Notes:

(1) The core current consumption includes the current consumption for the entire internal Promira platform, but does not include the outputs current consumption.

**Table 16** : DC Characteristics

| Pin | Symbol | Conditions and Notes | Min | Max | Units |
|---|---|---|---|---|---|
| 4, 6 | Vtgt | | 3.3 | 5 | V |
| 22, 24 | IOVcc | | 0.9 | 3.45 | V |
| 1, 3, 9 | SCL/GPIO-00, SDA/GPIO-01, SS/GPIO-05 | (1) | 0.9 | 3.45 | V |
| 5, 7, 8 | MISO/GPIO-02, SCK/GPIO-03, MOSI/GPIO-04 | (1) | 0.9 | 3.45 | V |
| 4, 6 | Vtgt | (2) | | 50 | mA |
| 22, 24 | IOVcc | (2) | | 50 | mA |
| 1, 3, 9 | SCL/GPIO-00, SDA/GPIO-01, SS/GPIO-05 | (3) | | 10 | mA |
| 5, 7, 8 | MISO/GPIO-02, SCK/GPIO-03, MOSI/GPIO-04 | (3) | | 10 | mA |

Notes:

(1) The Level shifter precision is approximately 0.015V.

(2) Option 1: Two pins have 50 mA each. Option 2: One pin has 100 mA, and one pin has 0 mA. Etc. Total current consumption on both pins should not exceed 100 mA.

(3) Option 1: Six pins have 10 mA each. Option 2: One pin has 60 mA, and the other five pins have 0 mA. Etc. Total current consumption on all six pins should not exceed 60 mA.

**Table 17** : Current Consumption Calculation Example

| Pin | Symbol | Description | Conditions & Notes | Max per pin | Max per all pins | Units |
|---|---|---|---|---|---|---|
| NA | Icore | Core Current Consumption | (1) | 500 | 500 | mA |
| 4, 6 | Vtgt | Configurable VCC Power Supply | (2) | 50 | 100 | mA |
| 22, 24 | IOVcc | Configurable VCC IO Level Power Supply | (2) | 50 | 100 | mA |
| 1, 3, 5, 7, 8, 9 | SCL/GPIO-00, SDA/ GPIO-01, MISO/GPIO-02, SCK/GPIO-03, MOSI/ GPIO-04, SS/GPIO-05 | I2C/SPI Signals | (3) | 10 | 60 | mA |
| | Total Current Consumption For Promira Core and Outputs | | (4) | | 760 | mA |

Notes:

(1) The core current consumption includes the current consumption for the entire internal Promira platform, but does not include the outputs current consumption.

(2) Option 1: Two pins have 50 mA each. Option 2: One pin has 100 mA, and one pin has 0 mA. Etc. Total current consumption on both pins should not exceed 100 mA.

(3) Option 1: Six pins have 10 mA each. Option 2: One pin has 60 mA, and the other five pins have 0 mA. Etc. Total current consumption on all six pins should not exceed 60 mA.

(4) If the total current consumption for the Promira platform core and outputs is over 500 mA, then USB 3.0 port and USB 2.0 cable or Total Phase external AC adapter should be used. USB 3.0 port supplies up to 900 mA. USB 2.0 port supplies up to 500 mA. Total Phase external AC adapter supplies up to 1.2 A. In this example the total current

consumption for the Promira platform core and outputs is 760 mA, therefor USB 3.0 port and USB 2.0 cable or Total Phase external AC adapter should be used.

# 6.2 AC Characteristics

## 6.2.1 SPI AC Characteristics

**Table 18 (*)** : SPI Timing Parameters

| Symbol | Parameter | Min | Max | Units |
|---|---|---|---|---|
| $t_1$ | SS# assertion to first clock | 0.5 | 20 (*) | µs |
| $t_2$ | Last clock to SS# deassertion | 1 | 70 (*) | µs |
| $t_p$ | Clock period (clk) | 80 | 10000 | ns |
| $t_d$ | Setup time (Master) | 0 | 0.05 | µs |
| $t_d$ | Setup time (Slave) | 0 | n/a | µs |
| $t_b$ | Time between start of bytes (Slave) | 8 | n/a | clk |

(*) - See also section 2.3.3.

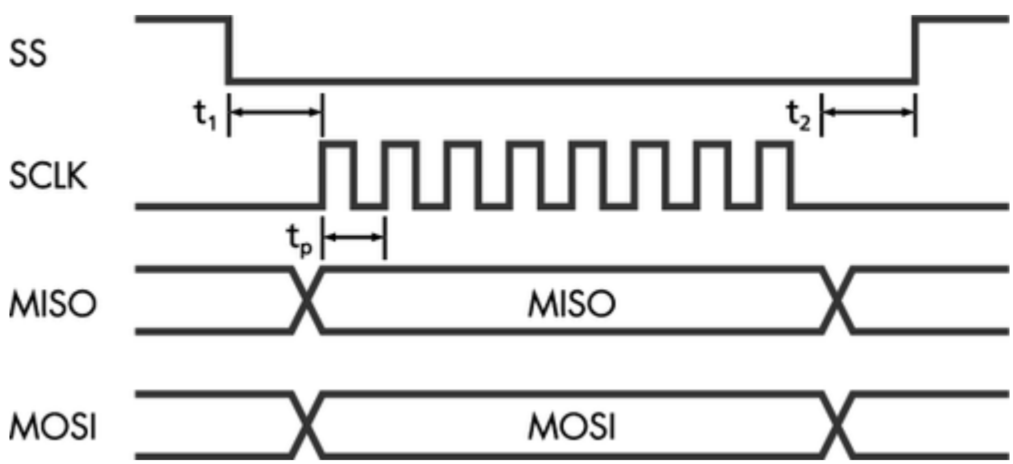



***Figure 12** : SPI Waveform*

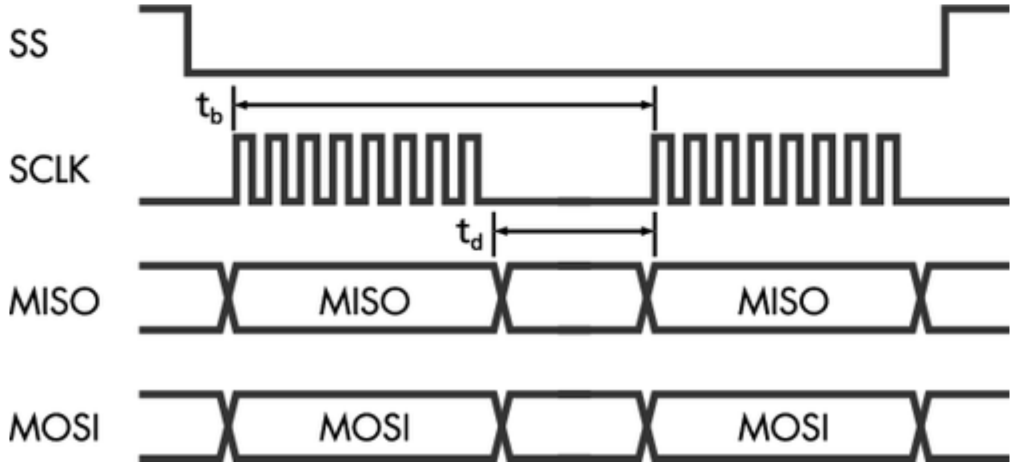



***Figure 13*** *: SPI Byte Timing*

# 6.3 Signal Ratings

## 6.3.1 Logic High Levels

All signal levels are nominally 0.9-3.45 volts (+/- 10%) logic high. The Promira Serial Platform is also compatible with devices with 5V $I^2C$/SPI signals level.

## 6.3.2 ESD protection

The Promira Serial Platform has built-in electrostatic discharge protection to prevent damage to the unit from high voltage static electricity.

## 6.3.3 Input Current

All $I^2C$/SPI inputs (except for SPI SS signal) are high-impedance, and their input current is approximately 1 µA. SS signal has 10k Ohm pull-up resistor. When SS signal is used as input, its input current is approximately 1 &micro.

# 7 Legal / Contact

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