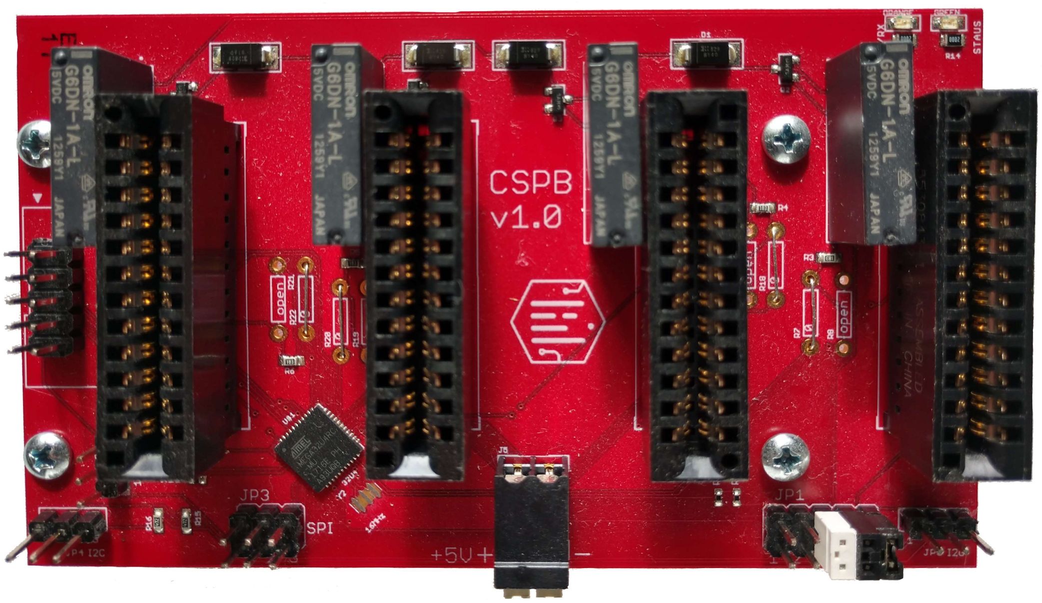
User Manual

Cluster System Power Board

Version 1.0



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Introduction

The Cluster System Power Board (CSPB) is a power distribution and control platform to simplify the construction of Single Board Computer Clusters. The power board is designed to allow for simple single cluster systems or complex multi board systems to be powered through one power supply and controlled from a single control module. Control of the power board is achieved via an i2c serial bus interface which can be chained across multiple power boards.

Functional Description

The CSPB is a micro-controller based power board that allows easy control of power to individual single board computers. Each power board can hold up to four single board computers that conform to the Raspberry Pi 40 pin IO connector standard.

The CSPB is controlled via an i2c serial interface which can be connected to any i2c capable module via the i2c bus connector. Slot 1 of the CSPB is also available as an i2c bus connection via jumper terminals. This allows slot 1 to be the i2c control module for the CSPB.

Because the CSPB is controlled via an i2c interface, power boards can be chained together to form larger cluster systems that can be powered from one power supply and managed from one controller module. Each CSPB can be configured with a unique i2c address.

The CSPB can power on or off each slot individually, allowing single board computers to be added or removed with out impacting the cluster. The CSPB can also be configured to power up individual slots during it’s initial power up sequence. During the initial power up sequence a slot power up delay can be programmed to help manage current draw on the power supply.

The CSPB supports software shutdown of individual slots. The CSPB will signal the single board computer to perform a shutdown and wait for a control line to change state before removing power to the slot. This function has a programmable time out to ensure power down is completed.

The CSPB supports querying of the slot power states and shutdown states through register reads. Both programmable register functions and readable register functions are describe in more detail in the Registers section on page 17.

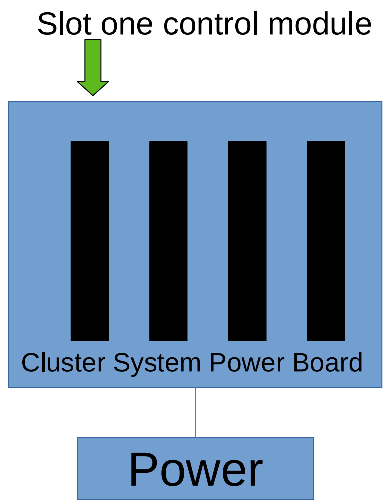
Jumper settings can be used to program default i2c addresses and i2c bus connections. Jumper settings are detailed in the Jumper Settings section on page 20.

The CSPB is power with 5.1V through a screwless spring loaded terminal block. The power circuit provides revers polarity protection.

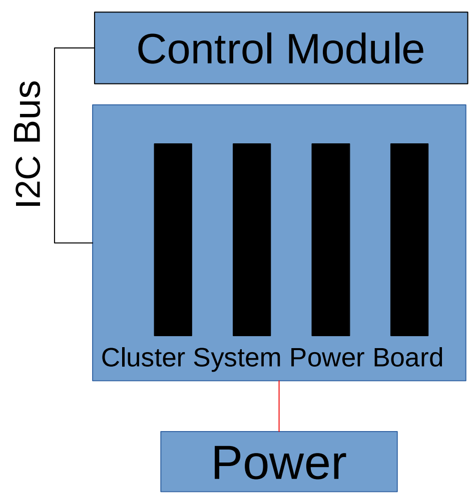
The CSPB has two LED indicators, one for active power to the board and a second to indicate micro-controller activity during command processing.

The CSPB can be mounted to a chassis or other mounting surface via the four 2.75mm mounting holes.

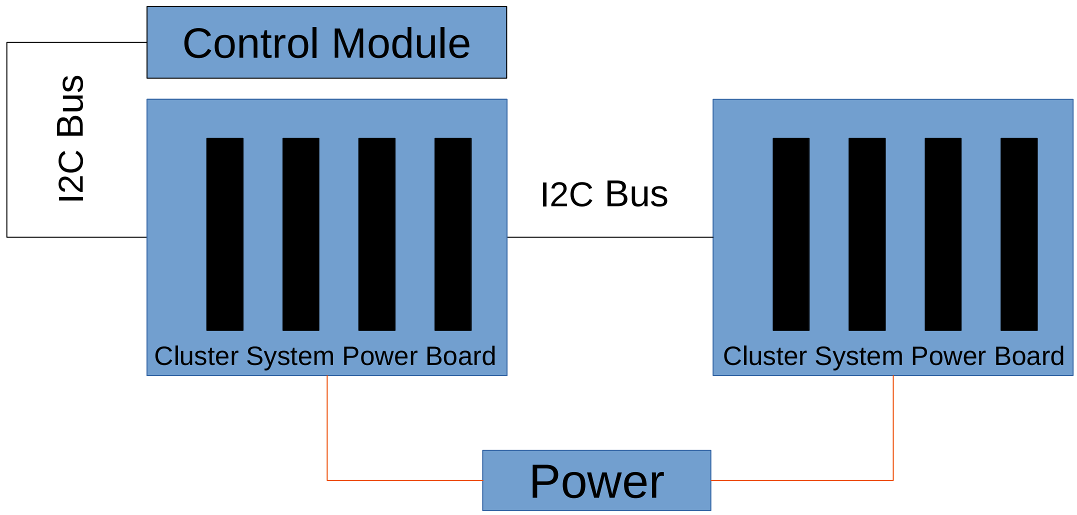
Typical Configurations:



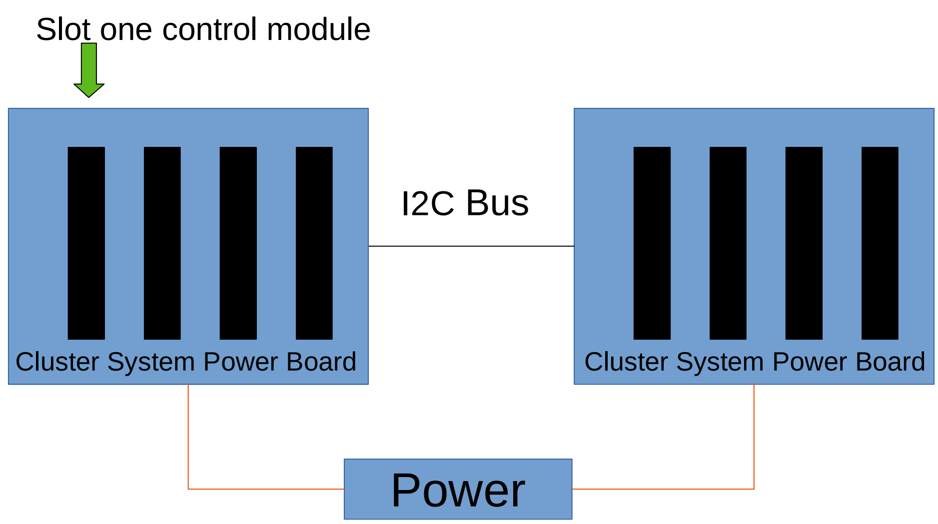
Drawing 1: Single CSPB with slot one control module



Drawing 2: Single CSPB with external control module



Drawing 3: Multiple CSPBs with external control module



Drawing 4: Multiple CSPBs with slot one control module

Hardware Description

Board Layout

The CSPB provides software controlled power distribution to the connected single board computers. There is a push terminal power connector for easy connection to a central power supply. LED indicators are provided for ‘power on’ and ‘board status’. Two i2c connectors are located at either end of the board and can be used to connect to a controller module and or to chain CSPB together is so desired. A jumper block is provided for configuring i2c bus connections and default address settings.

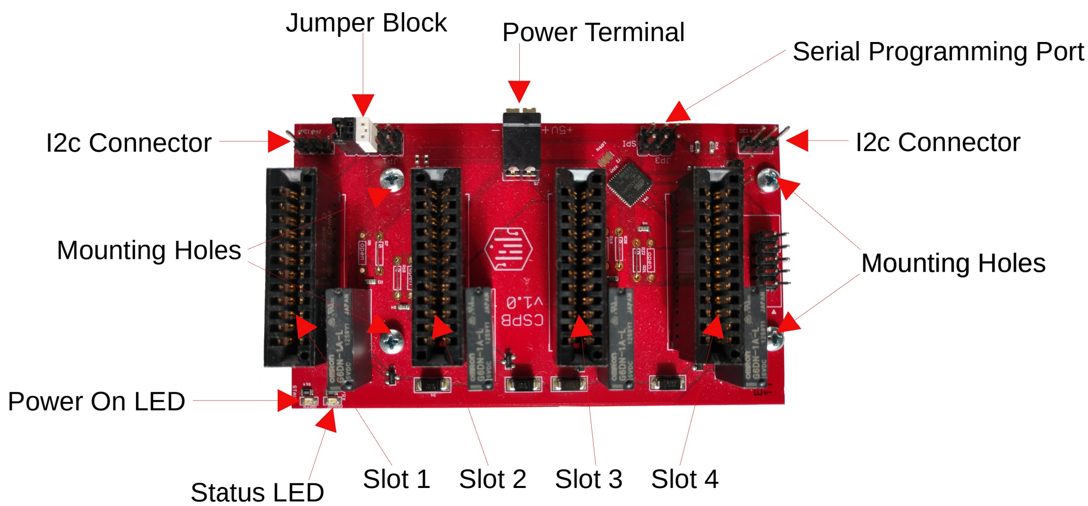


Figure 1: CSPB Board layout.

Power Specification

The power specification below were developed with the Raspberry Pi single board computer in mind, however other single board computers using the Raspberry Pi 40 pin header specification should also work.

Parameter	Value	Min	Max
Input Voltage[1]	5.1 V	4.75 V	5.25 V
Nominal Current	218 mA[2]		

1 The input voltage can vary according to the single board computer requirements.
2 This value does not include the current draw of the single board computers.

Dimensions

Figure 2: Dimensions and Mounting Holes.

Adapter Layout

The CSPB adapter board provides connection between the single board computer 40 pin header and the CSPB power slot. It provides signal leveling and a 2.5A thermal fuse current over draw protection to the single board computer. A slot power indicator is located at the front of the adapter board.

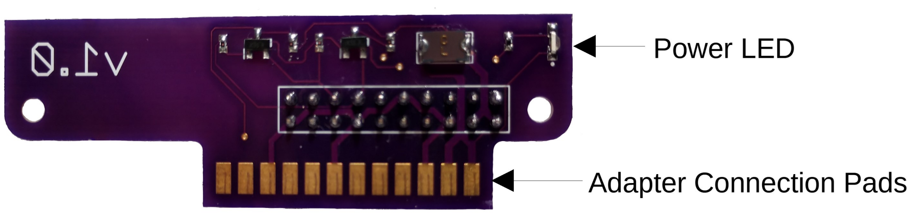


Figure 3: Adapter board layout.

I2c Connector Layout

There are two i2c connector on either side of the CSPB labeled JP4 and JP5. As seen in Figure 4, the connector pins are numbered from left to right starting with pin 1. The connector layout is as follows:

Table 1: i2c Connector Signals

Pin Number	Signal Name
1	Ground
2	SDA
3	SCL

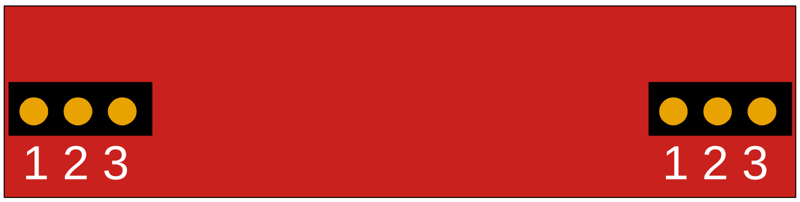


Figure 4: i2c Connectors

Component Assembly

To assemble a cluster system using the CSPB, first the adapter board must be attached to the single board computer. In Figure 5, a Raspberry Pi single board computer is shown in its proper orientation with respect to the adapter board and the CSPB. The adapter is placed over to the first 20 pins of the 40 pin single board computer header such that the power indicator is facing the front of the single board computer and the adapter connection pads are facing away from the single board computer. In the case of the Raspberry Pi, this will place the power adapter LED on the same side as the single board computer LEDs. A nut and bolt can now be inserted through the single board computer and adapter board mounting holes.

! **Warring**! It is necessary to connect the adapter board to the single board computer in the correct orientation. Failure to do so may result in damage to the single board computer and or the CSPB!

The adapter board with the single board computer attached, See Figure 6, is then inserted into the CSPB power slot such that the adapter power LED is facing the same side as the status indicators on the CSPB.

Warring! It is necessary to insert the adapter board to the CSPB in the correct orientation. Failure to do so may result in damage to the single board computer and or the CSPB!

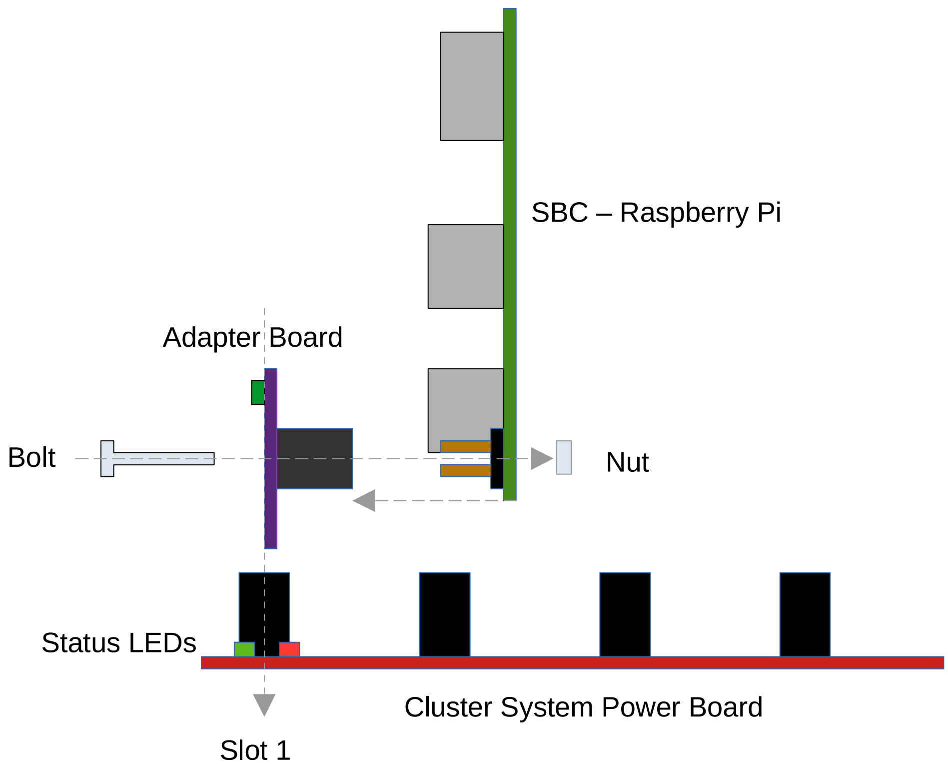


Figure 5: Component orientation.

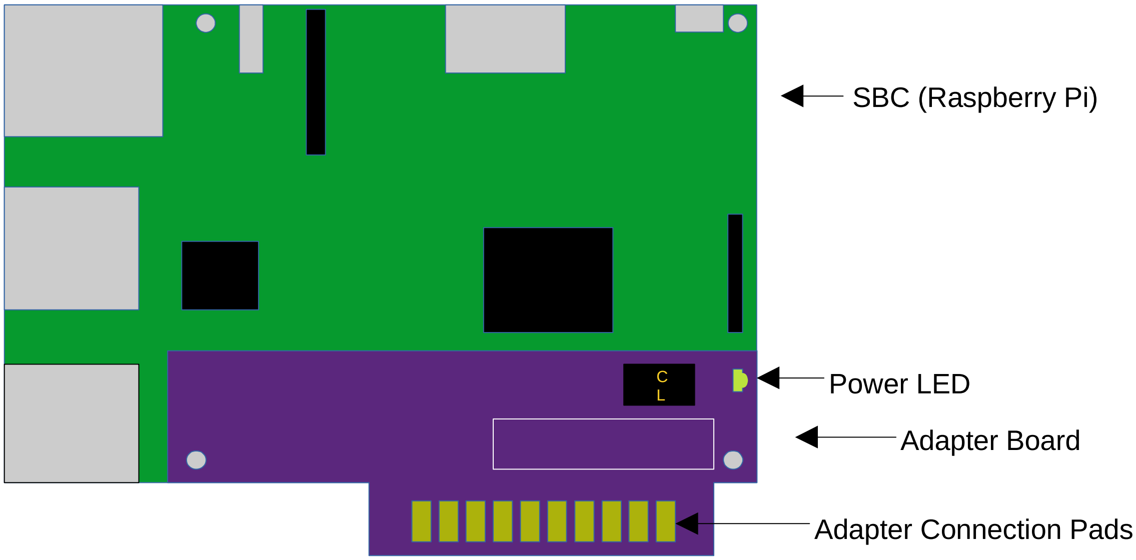


Figure 6: SBC with Adapter.

Command Summary

ASCII commands to control the function of the CSPB are sent to via the i2c buss interface. These commands support the slot power functions and read/writes of the data registers. Reading register data is accomplished through an i2c data request.

Function	**Command**	**Reply**
Shutdown	# *data*	
Signal Shutdown	$ *data*	
Set Power State	! *data*	
Write Register	W *register data*	
Set Read Register	*R*	*data*

Command Quick Reference

Table 2: Command Quick Reference

Command ASCII	Command Hex	Bytes	Data	Function	Response Bytes	Response Data
#	0x23	2	Slot state	Shutdown slot	-	-
$	0x24	2	Slot state	Signal Shutdown	-	-
!	0x21	2	Slot state	Set power state	-	-
W	0x57	3	Register Number Data	Write Register	-	-
R	0x52	2	Register Number	Set read register address	-	-

Command Set

Shutdown

Command	Bytes	Data	Function
#	2	*Slot State*	Instructs the CSPB to shutdown the specified slots. A bit value of one indicates a shutdown will be performed.

Description: The shutdown command affects all slots. The slot state is written to the cluster system power board. Each bit of the slot state value affects the corresponding slot. The current slot state can be obtained by reading the slot power register.

Example:

Shutdown slot 1: #1 (binary 0001)

Shutdown slot 3: #4 (binary 0100)

Shutdown slot 1 and 3: #5 (binary 0101)

Signal Shutdown

Command	Bytes	Data	Function
$	2	*Slot State*	Instructs the CSPB to signal a shutdown to the specified slots. A bit value of one indicates that the signaling will be performed.

Description: The signal shutdown command affects all slots. The slot state is written to the cluster system power board. Each bit of the slot state value affects the corresponding slot.

Example:

Signal Shutdown on slot 1: $1 (binary 0001)

Signal Shutdown on slot 3: $4 (binary 0100)

Signal Shutdown on slot 1 and 3: $5 (binary 0101)

Power

Command	Bytes	Data	Function
!	2	*Slot State*	Instructs the CSPB to set the slot power state for each slot

Description: The power command affects all slots. The slot state is written to the cluster system power board. Each bit of the slot state value affects the corresponding slot. To change the state of one slot with out affecting the other slots, the current slot state is required. The current slot state can be obtained by reading the slot power register.

Example:

Shutdown slot 1: #1 (binary 0001)

Shutdown slot 3: #4 (binary 0100)

Shutdown slot 1 and 3: #5 (binary 0101)

Write Register

Command	Bytes	Data	Function
W	3	*Register Number, Data Byte*	Writes the data byte to the specified register address.

Description: The write register command will one byte the the specified register address. See the register address table for defined register addresses.

Example:

Write 15 to the i2c address register (0): W015

Set Read Register

Command	Bytes	Data	Function
R	2	*Register Number*	Set the read register in the CSPB.

Description: The set read register command will set a pointer on the CSPB to the specified register number. A subsequent i2c read will return the byte data in that register.

Example:

Set the read register pointer in the CSPB to register 0, the i2c boot address: R0

A i2c byte data request will now return the data byte in register 0.

Registers

The CSPB has several programmable function registers and two readable state registers. These registers are accessed through the Read Register and Write Register commands describe in the Command Set section on page 14.

Table 3 provides a summery of the register addresses and functions.

Table 3: Register Addresses

Register Address	Bit	Default Value Hexadecimal	Default Value Decimal	Function
0	0-7	0x30	48	i2c bus address
1	0	0x01	1	Slot 1 boot on power up
	1	0x01	1	Slot 2 boot on power up
	2	0x01	1	Slot 3 boot on power up
	3	0x01	1	Slot 4 boot on power up
	4	0x00	0	Reserved for future use.
	5	0x00	0	Reserved for future use.
	6	0x00	0	Reserved for future use.
	7	0x00	0	Reserved for future use.
2	0	0x00	0	Slot 1 i2c master indicator
	1-7	0x00	0	Reserved for future use.
3	0-7	0x64	100	Power up delay in 20 milliseconds increments
4	0-7	0x32	50	Power down signal duration in 20 millisecond increments
5	0-7	0x0A	10	Shutdown timeout in seconds
6-255	0-7	0xFF	255	Reserved for future use.
128	0-7	0x00	0	Monitor line state values for each slot
129	0-7	0x00	0	Power state values for each slot

Note: Registers 128 and 129 are read only.

Register Details

0 - i2c Address

This register contains the i2c address of the CSPB upon power up. It is user programmable to any valid i2c address in the range of decimal 9-255. The default is decimal 48. Attempting to program addresses below decimal 9 are ignored.

1 - Power up on boot

The first 4 bits of this programmable register indicate which slots will be powered on during the CSPB initial power up sequence. The least significant bit maps to slot 1. The default value is decimal 15 (binary 00001111). A 1 indicates that power will be applied. The last 4 bits are reserved for future use.

2 - Miscellaneous

This programmable register contains miscellaneous function values. The first bit can be set to 1 to indicate that slot one on the CSPB contains the i2c controller module. Bit one is optional and is defaulted to 0.

The next seven bits are reserved for future use.

3 - Slot power up delay

This programmable register contains the slot power up delay in 20 millisecond increments. During the initial CSPB power up sequence, each slot can be powered on. The power up delay can be used to introduce a delay between the application of power to each slot so as to reduce current loads on the power supply. The default is 100, which results in a two second delay between the application of power to each slot.

4 - Slot power down signal duration

This programmable register contains the duration of the power down signal in 20 millisecond increments. The power down signal is applied to a single board computer to trigger a software shutdown of the computer. The default value is 50 which results in a 1 second duration.

5 - Slot shutdown timeout

This programmable register contain the power down timeout value in seconds. When a shutdown command is issued, the CSPB will monitor the single board computer shutdown line for a state transition. If this transition is not seen within the timeout period, the CSPB will remove power from the slot after the timeout period has expired. This prevents an infinite power down time. The default is 10 seconds.

128 - Monitor line State

The first 4 bits of this read only register contain the monitor line state of each slot. The least significant bit maps to slot 1. This register can be used query the monitor line for a given slot to determine monitor line state transitions. A 1 indicates a high state and a 0 indicates a low state. The last 4 bits are not used.

129 - Slot Power State

The first 4 bits of this read only register contain the power state of each slot. The least significant bit maps to slot 1. This register can be used query the power state for a given slot. A 1 indicates that power is on and 0 indicates that power is off. A binary value of 0001111 would indicate that power is applied to all 4 slots. The last 4 bits are not used.

Jumper Settings

Jumper Number	Function	Setting
1	Default i2c Address	Use i2c address 0x30, decimal 48
2	Alternate i2c Address	Use i2c address 0x15, decimal 21
3	i2c SDA connector	Connect to Slot 1 SDA line
4	i2c SCL connector	Connect to Slot 1 SCL line
5	I2c 3.3v connector	Connect i2c 3.3V source

Jumper Description

Jumper 1

Short this jumper to ignore the programmed i2c address and use the decimal 48 address. This jumper takes precedence over jumper 2.

Jumper 2

Short this jumper to ignore the programmed i2c address and use the decimal 21 address.

Jumper 3

Short this jumper to connect the i2c SDA line on slot one to the i2c SCL bus line. To use slot one as the CSPB control module, jumpers 4 and 5 must also be shorted.

Jumper 4

Short this header to connect the i2c SCL line on slot one to the i2c SCL bus line. To use slot one as the CSPB control module, jumpers 3 and 5 must also be shorted.

Jumper 5

Short this jumper to connect the 3.3V line on slot one to the i2c 3.3V source line. To use slot one as the CSPB control module, jumpers 3 and 4 must also be shorted.

Configuring the single board computer (Raspberry Pi)

The following configuration example is based on a Raspberry Pi single board computer loaded with the Raspbian Buster OS. Other single board computers may require different configuration settings or methods to achieve the desired default port behavior. In this example, the default port behavior is as follows:

- BCM GPIO port 22 shall be set high (3.3V) upon boot up of the single board computer.
- BCM GPIO port 22 shall be set low (0V) upon shutdown completion of the single board computer.
- BCM GPIO port 27 shall be set as an input in the low state. A high (3.3V) signal by the CSPB shall indicate that the single board computer should shutdown.

This default port behavior can be configured by adding the following lines to the end of the **/boot/config.txt** file

```
# On boot up, set GPIO22 to be an output with a value of 1 which is 3.3V.  (This is BCM pin Number)
gpio=22=op,dh

# Set a shutdown signal on GPIO27 with a transition from low to high.
dtoverlay=gpio-shutdown,gpio_pin=27,active_low=0,gpio_pull=up

# Drive the Monitor pin low at power off.
dtoverlay=gpio-poweroff,gpiopin=22,active_low
```

Python Software

There are two python PIP packages available as examples of interfacing with the CSPB hardware. The first is the cspb package that contains a basic hardware driver and the second is the cspb-tools package which contains a rudimentary graphical user interface. Both packages were developed with the Raspberry Pi Raspbian operating system as the intended operating environment.

cspb Package

The cspb PIP package contains a basic hardware driver for the cluster system power board. It uses the smbus package for low level data communications across the i2c bus. It can be imported in to your python code to control the power board functions.

Installation

To install the package on a Raspbian OS:

```
pip install cspb
```

Example usage

Example 1: To shutdown all power slots

```
from cspb.CSPB import CSPB

i2c_bus_number = 1
i2c_device_address = 21
cspb = CSPB(i2c_bus_number, i2c_device_address)
cspb.shutdown(#ff)
```

csb-tools Package

The cspb-tools package contains a rudimentary graphical user interface that allows for control and programming of the cluster system power board. It uses the cspb python package for communications with the power board. This user interface was developed with the Raspberry Pi Raspbian operating system as its intended operating environment.

Installation

To install the package on a Raspbian OS:

```
pip install cspb-tools
```

Running the user interface

```
run_cspb_gui
```

User Interface Description

The CSPB Power tab, see Figure 7, in the CSPB Control Center software can send one of 3 commands to the CSPB.

Each command as selected buy the radio button is analogous to the commands described in the Command Set section on page 14. Placing a check in the check box of a given slot will send a value 1 in the command for that slot. The current power state is displayed in the box to the right of the slot number.

The command will be sent to the board located on the selected i2c bus at the specified i2c address.

The command will effect all slots. Therefore care should be taken to ensure that power is not inadvertently removed from slots that may need to remain on. This is especially true if the CSPB control module is configured in slot 1.

The CSPB Registers tab, see Figure 8, can be used to read and write values to the specific registers. Reading current register values is accomplished by simply selecting the Read button. Writing a value to a register is accomplished by placing a check in the Enable check box for the associated register and adding a value to be written in the accompanying value box. When the Write button is selected, all enabled fields are written.

Figure 7: CSPB Power Tab.

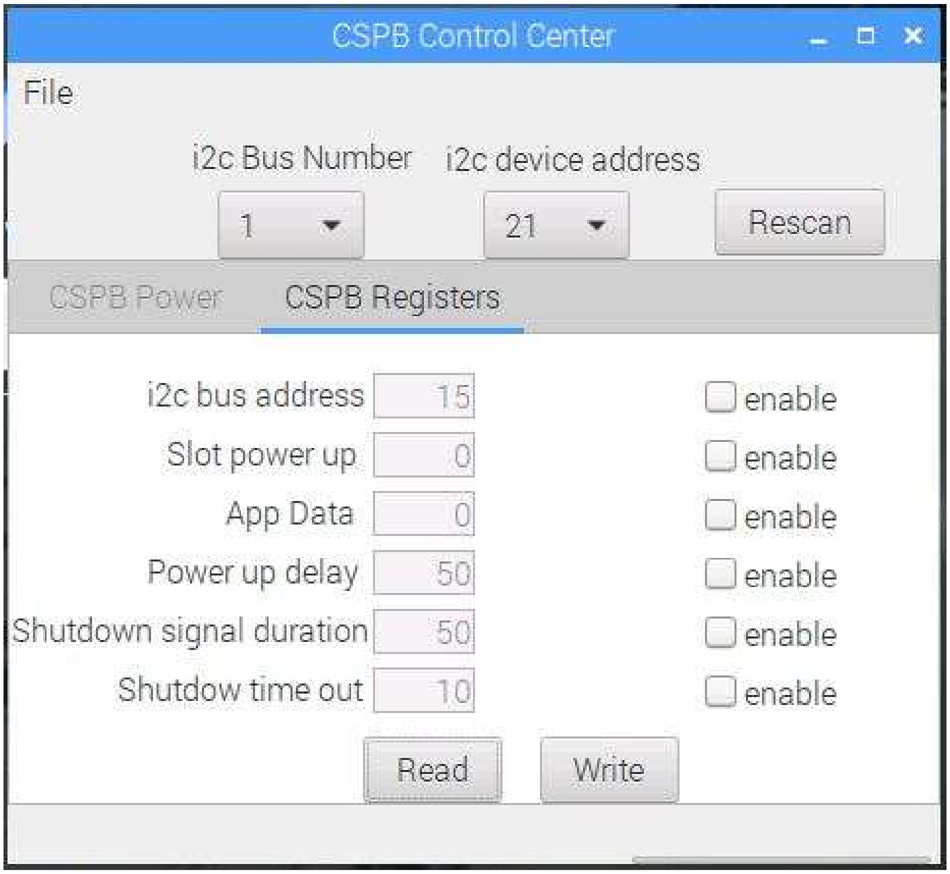


Figure 8: CSPB Registers tab