PmodACL Demo Reference Design

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Overview

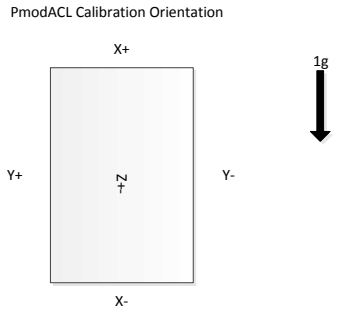
This project demonstrates the use of the pmodlib C library in conjunction with the PmodACL, PmodCLS, PmodCON3(Cerebot32MX7 Only), GWS S03N STD servo (or equivalent) and Cerebot32MX4/Cerebot32MX7 microcontroller to maintain the position of a servo rotor during rotation about the Z axis.

Functional Description

This project consists of chassis created to house the CerebotMX4/MX7, PmodACL, PmodCLS, and PmodCON3(MX7 only). Servo orientation is maintained by comparing the orientation of the PmodACL to an angle measured when prompted after calibration, this angle is known as surface normal and is perpendicular to the surface at the time of measurement. Rotating the chassis about the Z axis of the PmodACL will rotate the servo to maintain the initial surface normal angle. Degrees in radians for surface normal and current angle are displayed on the PmodCLS during operation. Servo movements are filtered using a rolling 20 point average which provides smooth servo movements. Without a rolling average, servo movements will be jittery due to constant adjustments as minor changes in angle are received from the PmodACL. Source code for the demo is located in the directory titled "PmodACL_Demo". This project was created using MPLAB IDE v8.80 and written entirely in C utilizing the Microchip and pmodlib libraries.

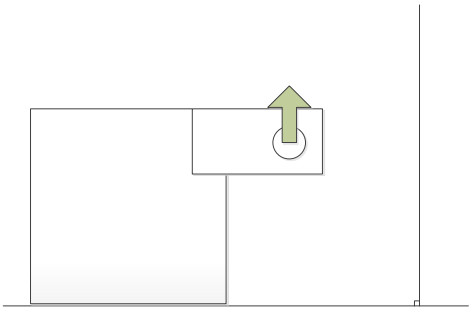
Operation

Once power is applied to the microcontroller "BTN1-Calibrate" will be displayed on the PmodCLS. Ensure the chassis is on a flat horizontal surface, then press BTN1. The goal is to exert 1g on the X axis during calibration to ensure accurate measurements during operation. See figure to the right for PmodACL orientation during calibration.

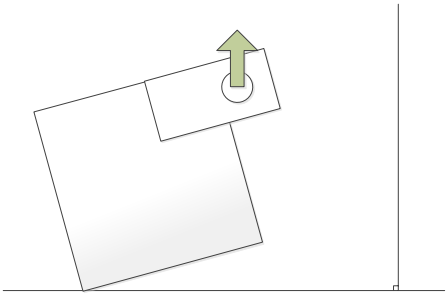


Once calibration has completed "BTN1-Set Normal" will be displayed on the PmodCLS. Tilt the chassis to the angle you want the servo to hold and press BTN1. Rotating the chassis about the PmodACL's Z axis will keep the servo positioned to the original surface normal angle. See figures below.

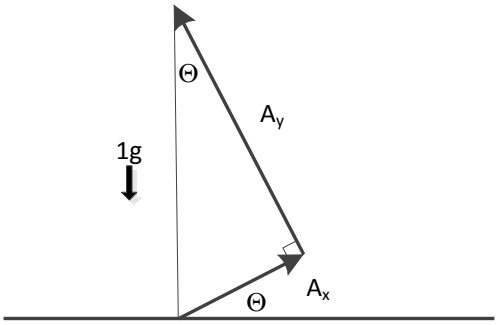
Set Surface Normal



Maintain Servo Position



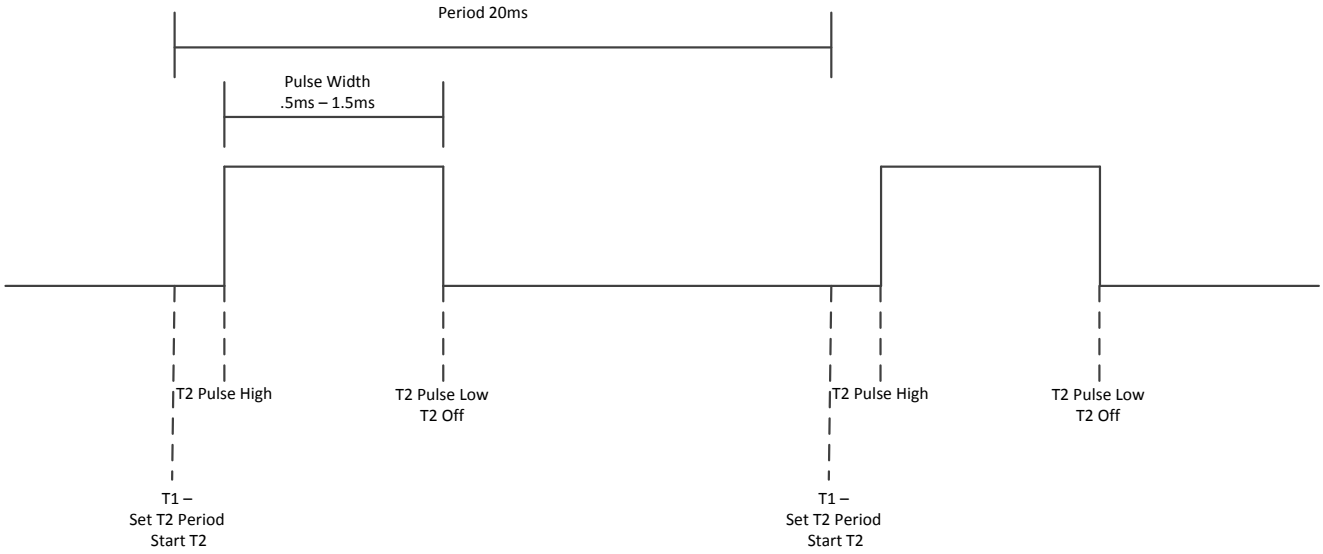
Angle Calculation



Tilt angle is calculated using the acceleration values from the X and Y axes received from the PmodACL. Using vector addition we create a right triangle whose hypotenuse if equal to 1g (adding X and Y acceleration vectors should always produce a resultant perpendicular to normal and equal 1g during static tilt). Using basic trigonometry we can see angle Θ is the arctan(A_x/A_y) in radians.

Pulse Width Modulation

Pulse width modulation for servo control is generated using two timers. Period length is controlled by Timer1 which fires every 20ms marking the start of a new period. The interrupt handler for Timer1 sets the next pulse state to HIGH, the period (pulse width) for Timer2 , resets Timer2's counter then enables it. Timer2 fires and drives the signal HIGH and sets the next pulse state to LOW, after one Timer2 period has expired the signal is driven low and Timer2 is disabled. When Timer1's period expires the process repeats.



Configuration
*All settings referenced in this section are in "PmodACL_Demo.c"

This project is designed to run on either the Cerebot32MX4 or Cerebot32MX7. Use of the MX7 requires the PmodCON3 for servo control. No additional configuration is required, conditional compilation will handle platform detection. The legacy libc library should be used with this project to support floating point string formatting. To access this setting go to Project->Build Options->Project, select the MPLAB PIC32 linker tab, select "Library Selection" in the categories combo box, check "Use Legacy libc" then click Ok.

Processor: configuration settings are located in the "PIC32 Configuration Settings" section.

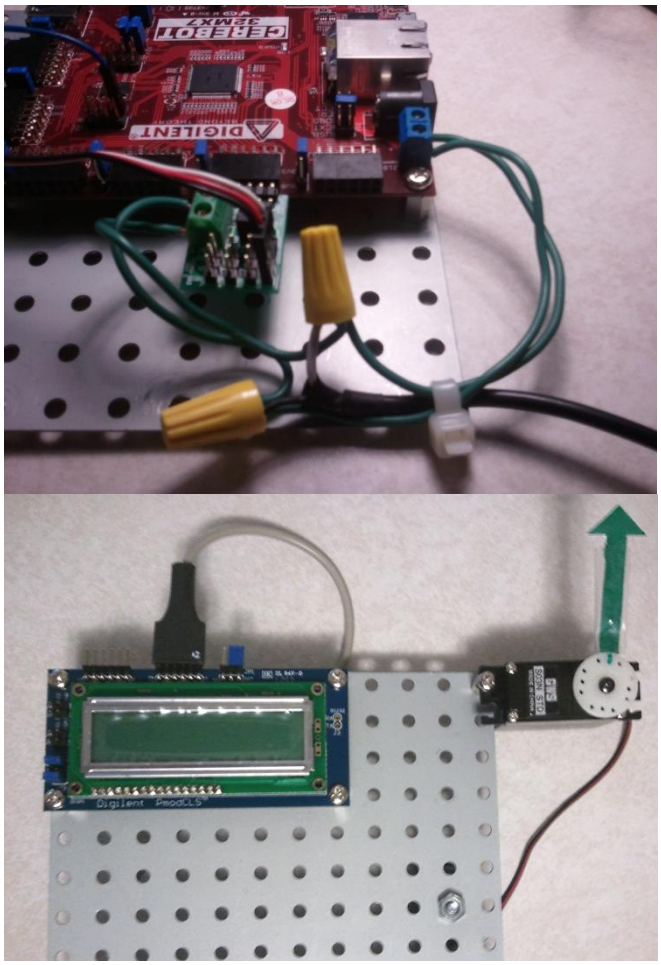
Pmod IO/Ports - IO ports/bits and channels have been defined as macros for easy configuration under //IO PORT/CHANNEL DEFINITIONS. Changes in hardware location must be reflected in this section.

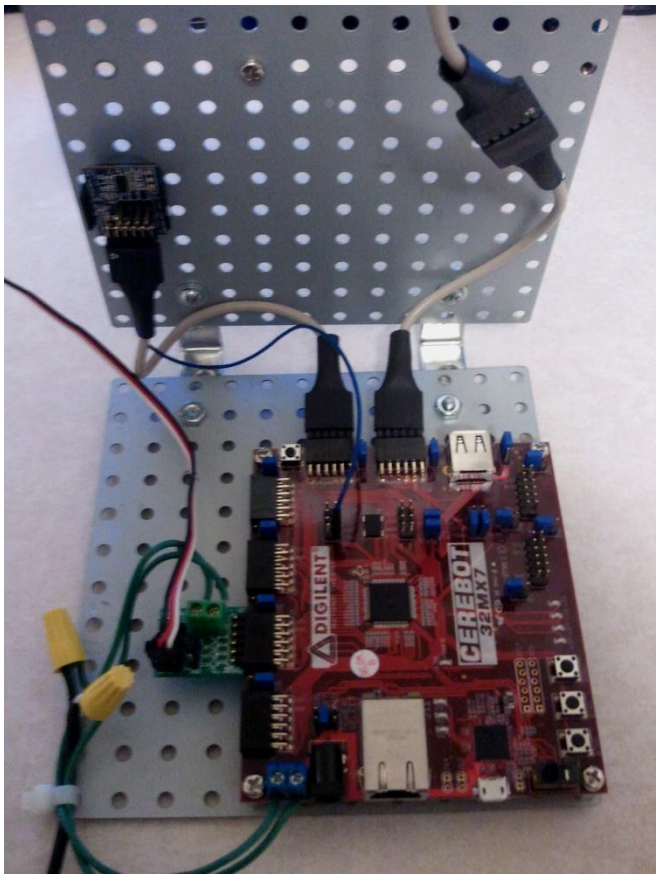
Clock Rates:
Processor Freq: 80Mhz
Peripheral Bus: 40Mhz

Port Bitrates:

UART	- PmodCLS:	9600
SPI	- PmodACL:	625000

Assembly:
The photos below show how the PmodACL Demo should look after assembly. Tables detailing the electrical connections of the different components are provided below the photos.



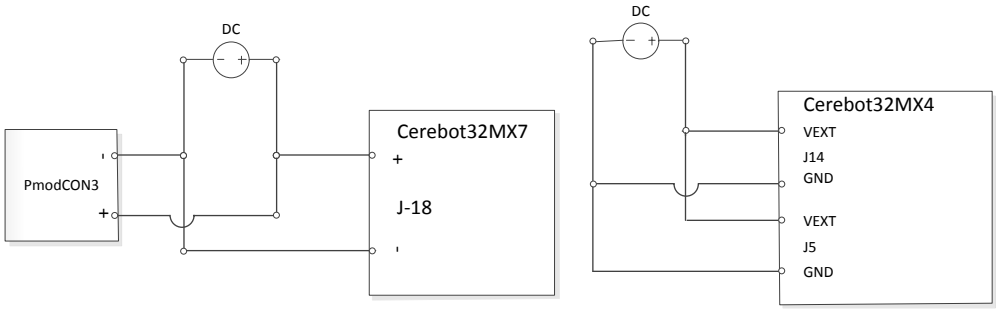


Servo/Pointer Installation:

All servo movements are offset by -20 degrees to ensure a range of motion suitable for its mounting position. When installing the pointer on the servo rotor, first power the system on and perform the calibration , the servo will then move to a position that is equivalent to surface normal with the microcontroller mounting plate as the referenced surface. Do not proceed until you have installed the servo pointer in a position perpendicular to the microcontroller mounting plate.

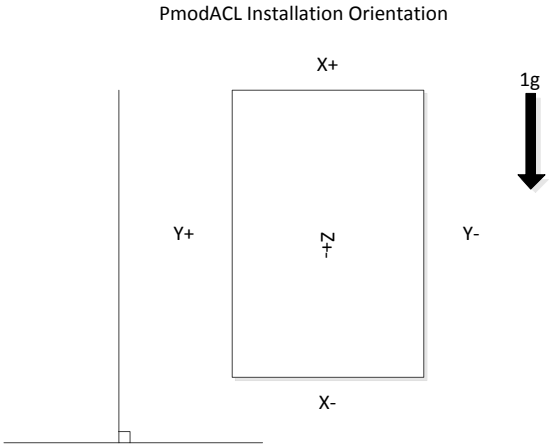
DC power configuration

Servo and board power are connected in parallel to the Coax Power Cable using wire nuts. See diagram below.



Accelerometer Installation:

The accelerometer must be mounted vertically as shown in the images above in the following configuration (X+ axis up)



Cerebot32MX7				
Header	Description	Connections		
JB	Servo Control	Pin	Peripheral Header	Peripheral Pin
		1	PmodCON3 - J1	1
		2	PmodCON3 - J1	4
		3	PmodCON3 - J1	3
		4	PmodCON3 - J1	2
		5	PmodCON3 - J1	5
		6	PmodCON3 - J1	6
JE	SPI - Accelerometer	Pin	Peripheral Header	Peripheral Pin
		1	PmodACL - J1	1
		2	PmodACL - J1	4
		3	PmodACL - J1	3
		4	PmodACL - J1	2
		5	PmodACL - J1	5
		6	PmodACL - J1	6
JF	UART - LCD status display	Pin	Peripheral Header	Peripheral Pin
		1	PmodCLS - J2	1
		2	PmodCLS - J2	4
		3	PmodCLS - J2	3
		4	PmodCLS - J2	2
		5	PmodCLS - J2	5
		6	PmodCLS - J2	6
J8	External Interrupt (MX7-INT3 ACL-INT1)	Pin	Peripheral Header	Peripheral Pin
		1	PmodACL - J1	8
J16	Power Source Selection	Shorting block installed on "External Power"		
J18	External Power	Pin	Peripheral Header	Peripheral Pin
		GND	Coax Power Cable	Black
		VEXT	Coax Power Cable	White

<table>
<tr><th colspan="3">Cerebot32MX4</th></tr>
<tr><th>Header</th><th>Description</th><th>Connections</th></tr>
<tr><td>JB</td><td>SPI - Accelerometer</td><td>
<table>
<tr><th>Pin</th><th>Peripheral Header</th><th>Peripheral Pin</th></tr>
<tr><td>1</td><td>PmodACL - J1</td><td>1</td></tr>
<tr><td>2</td><td>PmodACL - J1</td><td>4</td></tr>
<tr><td>3</td><td>PmodACL - J1</td><td>3</td></tr>
<tr><td>4</td><td>PmodACL - J1</td><td>2</td></tr>
<tr><td>5</td><td>PmodACL - J1</td><td>5</td></tr>
<tr><td>6</td><td>PmodACL - J1</td><td>6</td></tr>
</table>
</td></tr>
<tr><td>JH</td><td>UART - LCD status display</td><td>
<table>
<tr><th>Pin</th><th>Peripheral Header</th><th>Peripheral Pin</th></tr>
<tr><td>1</td><td>PmodCLS - J2</td><td>1</td></tr>
<tr><td>2</td><td>PmodCLS - J2</td><td>4</td></tr>
<tr><td>3</td><td>PmodCLS - J2</td><td>3</td></tr>
<tr><td>4</td><td>PmodCLS - J2</td><td>2</td></tr>
<tr><td>5</td><td>PmodCLS - J2</td><td>5</td></tr>
<tr><td>6</td><td>PmodCLS - J2</td><td>6</td></tr>
</table>
</td></tr>
<tr><td>J5</td><td>External Power (VS BUS)</td><td>
<table>
<tr><th>Pin</th><th>Peripheral Header</th><th>Peripheral Pin</th></tr>
<tr><td>GND</td><td>Coax Power Cable</td><td>Black</td></tr>
<tr><td>VEXT</td><td>Coax Power Cable</td><td>White</td></tr>
</table>
</td></tr>
<tr><td>J6</td><td>External Interrupt</td><td>
<table>
<tr><th>Pin</th><th>Peripheral Header</th><th>Peripheral Pin</th></tr>
<tr><td>1</td><td>PmodACL - J1</td><td>8</td></tr>
</table>
</td></tr>
<tr><td>J12</td><td>Power Source Selection</td><td>Shorting block installed on "External Power"</td></tr>
<tr><td>J14</td><td>External Power (VU BUS)</td><td>
<table>
<tr><th>Pin</th><th>Peripheral Header</th><th>Peripheral Pin</th></tr>
<tr><td>GND</td><td>Coax Power Cable</td><td>Black</td></tr>
<tr><td>VEXT</td><td>Coax Power Cable</td><td>White</td></tr>
</table>
</td></tr>
<tr><td>JP1</td><td>Disconnect VS Bus from VU Bus</td><td>Shorting block removed.</td></tr>
<tr><td>S1</td><td>Servo Control</td><td>
<table>
<tr><th>Pin</th><th>Peripheral Header</th><th>Peripheral Pin</th></tr>
<tr><td>SIG</td><td>Servo - GWS SO3N STD</td><td>White</td></tr>
<tr><td>VS</td><td>Servo - GWS SO3N STD</td><td>Red</td></tr>
<tr><td>GND</td><td>Servo - GWS SO3N STD</td><td>Black</td></tr>
</table>
</td></tr>
</table>

PmodCLS

Header	Description	Connections
J2	UART Communication	See tables below
JP2	Mode Selection	REV E: MD0 = shorted, MD1 = open, MD2 = shorted REV D: MD0 = open, MD1 = shorted, MD2 = open

Pin	Peripheral Header	Peripheral Pin
1	Cerebot 32MX7 - JF	1
2	Cerebot 32MX7 - JF	2
3	Cerebot 32MX7 - JF	3
4	Cerebot 32MX7 - JF	4
5	Cerebot 32MX7 - JF	5
6	Cerebot 32MX7 - JF	6

Pin	Peripheral Header	Peripheral Pin
1	Cerebot 32MX4 - JH	1
2	Cerebot 32MX4 - JH	2
3	Cerebot 32MX4 - JH	3
4	Cerebot 32MX4 - JH	4
5	Cerebot 32MX4 - JH	5
6	Cerebot 32MX4 - JH	6

PmodACL

Header	Description	Connections
J1	SPI Communication /Interrupt	See tables below

Pin	Peripheral Header	Peripheral Pin
1	Cerebot 32MX7 - JE	1
2	Cerebot 32MX7 - JE	2
3	Cerebot 32MX7 - JE	3
4	Cerebot 32MX7 - JE	4
5	Cerebot 32MX7 - JE	5
6	Cerebot 32MX7 - JE	6
8	Cerebot 32MX7 - J8	1

Pin	Peripheral Header	Peripheral Pin
1	Cerebot 32MX4 - JB	1
2	Cerebot 32MX4 - JB	2
3	Cerebot 32MX4 - JB	3
4	Cerebot 32MX4 - JB	4
5	Cerebot 32MX4 - JB	5
6	Cerebot 32MX4 - JB	6
8	Cerebot 32MX4 - J6	1

PmodCON3

Header	Description	Connections

J1	SPI Communication /Interrupt	Pin	Peripheral Header	Peripheral Pin
		1	Cerebot 32MX7 - JB	1
		2	Cerebot 32MX7 - JB	2
		3	Cerebot 32MX7 - JB	3
		4	Cerebot 32MX7 - JB	4
		5	Cerebot 32MX7 - JB	5
		6	Cerebot 32MX7 - JB	6

J2	Servo Control	Pin	Peripheral Header	Peripheral Pin
		SIG	Servo - GWS SO3N STD	White
		VS	Servo - GWS SO3N STD	Red
		GND	Servo - GWS SO3N STD	Black

J6	Servo Power	Pin	Peripheral Header	Peripheral Pin
		+	Coax Power Cable	Black
		-	Coax Power Cable	White

Servo - GWS SO3N STD

Header	Description	Connections

J1	Position Signal/Power	Pin	Peripheral Header	Peripheral Pin
		White	PmodCon3 - J2	SIG
		Red	PmodCon3 - J2	VS
		Black	PmodCon3 - J2	GND

Pin	Peripheral Header	Peripheral Pin
White	Cerebot32MX4 - S1	SIG
Red	Cerebot32MX4 - S1	VS
Black	Cerebot32MX4 - S1	GND

Parts List

Digilent

(1) Cerebot32MX7 or Cerebot32MX4
(1) PmodACL
(1) PmodCLS
(1) PmodCON3 (Cerebot32MX7 only)
(3) 6 Pin Cable Connector
(3) 6 Pin Header & Gender Changer
(1) 1 Pin MTE Cable
(2) Base Plate Expansion Kit
(1) GWS Servo Kit
(3) Standoffs (contains 4ea)
(1) Coax Power Cable
(1) Pmod Clip

Hardware Store
(2) 90 degree angle brackets
(4) 5" (length) insulated wire
(2) Wire Nuts