

Cerebot Bluetooth Robot Reference Design

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Cerebot32MX4 Bluetooth Robot

Overview

This project demonstrates the use of the PmodLib C library in conjunction with the PmodHB5, PmodBT2 and Cerebot32MX4 microcontroller as a Bluetooth controlled robot. The companion project is the Cerebot32MX4 Bluetooth Robot Remote.

Functional Description

This project consists of a chassis built from the Robotic Starter kit, PmodBT2, PmodHB5 and Cerebot 32MX4 microcontroller. Commands are received through the PmodBT2 Bluetooth module, after which robot status (wheel RPM, VU bus battery voltage, FWD/REV direction) is transmitted to the remote.

Once power is applied to the microcontroller, Bluetooth module initialization begins. During this process the Bluetooth name of the robot is set to "CEREBOTROBOT" (configurable). Once complete, LD 1 on the board will illuminate; indicating the robot is ready and waiting for a new connection. LD1 - LD 4 will illuminate when a connection is made, and message processing begins (see Robot State Diagram and Communication Protocol). In the event Bluetooth connectivity is lost, the robot will enter the waiting state, set the duty cycle of the PWM for both PmodHB5 to 0%, leaving only LD1 illuminated.

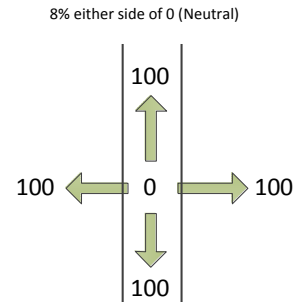
Bluetooth connection state is monitored by polling the STATUS pin of the PmodBT2, which is driven high when connected and low otherwise.

Source code for the robot is located in the directory titled "Cerebot Robot". The project was created using MPLAB IDE v8.80 and written entirely in C utilizing the Microchip C32 and PmodLib libraries.

Message Processing/Motion

Forward/Reverse speed values received are a percentage of the duty cycle, which is then applied to the pulse width modulation driving the enable pin on both the left and right PmodHB5s. If the Forward/Reverse direction received differs from the current direction of motion, the duty cycle will be set to zero until the RPM of both motors reaches zero. The direction bit will then be set and the new duty cycle applied. Left/Right speed values indicate the percentage of duty cycle to subtract from the left or right wheel depending on the Left/Right direction received. The effect of slowing one wheel down to facilitate a turn is called differential steering .

In an attempt to compensate for differences in motor RPM when traveling in a straight line, RPM values for both wheels are monitored and adjusted $\pm 0.5\%$ based on the RPM of the left wheel (used as reference). Adjustments occur only when the Left/Right duty cycle received is $< 8\%$ indicating a neutral position received from the remote control. The amount of adjustment applied is cumulative over time, and will not provide instantaneous course correction. Improvements on this method are left as an exercise for the programmer.



RPM is determined by sampling the quadrature encoding received from SensorA and SensorB of both PmodHB5s. RPM calculation is based on the number of state changes detected, four state changes equals one motor revolution. The driveshaft reduction ratio for motors included in the Robotic Starter Kit is 19:1, therefore internal motor rpm is further divided by 19 to supply driveshaft RPM. This value is transmitted to the remote.

Configuration

(All settings referenced in this section are in "cerebot_robot_remote.c")

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.

Bluetooth Communication - The Bluetooth name of the robot is a macro defined as BLUETOOTH_ROBOT_NAME and is used during inquiry to resolve the address of the robot by the remote. Additional Bluetooth parameters are set in initPmodBT2(), detailed explanations of these settings are available in the Roving Networks RN-42 Advanced User Manual.

Clock Rates:

Processor Freq: 80Mhz

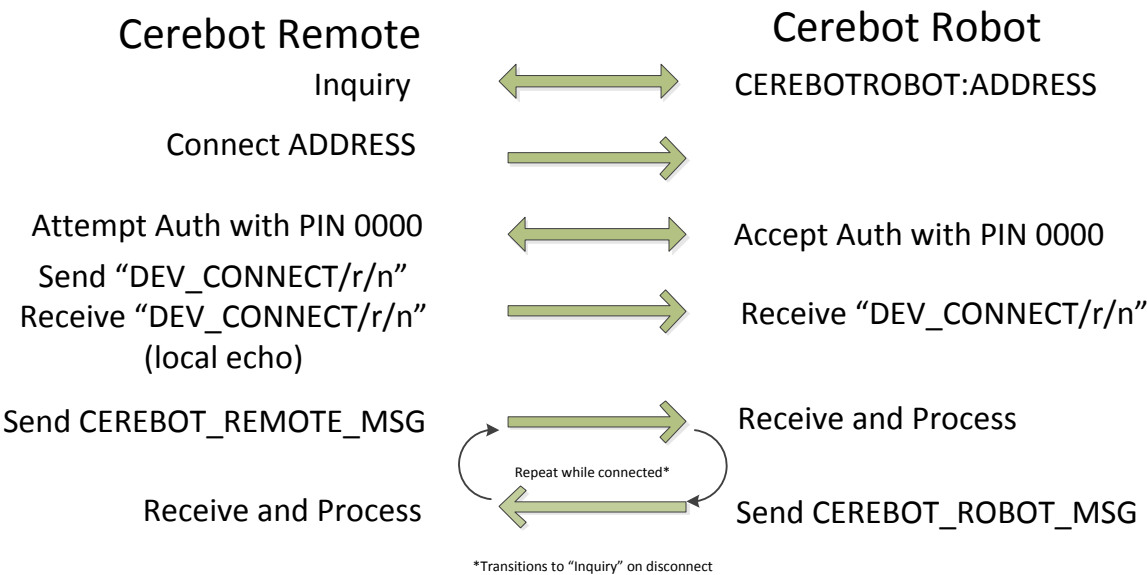
Peripheral Bus: 40Mhz

Port Bitrates:

UART2 - PmodBT2: 115200

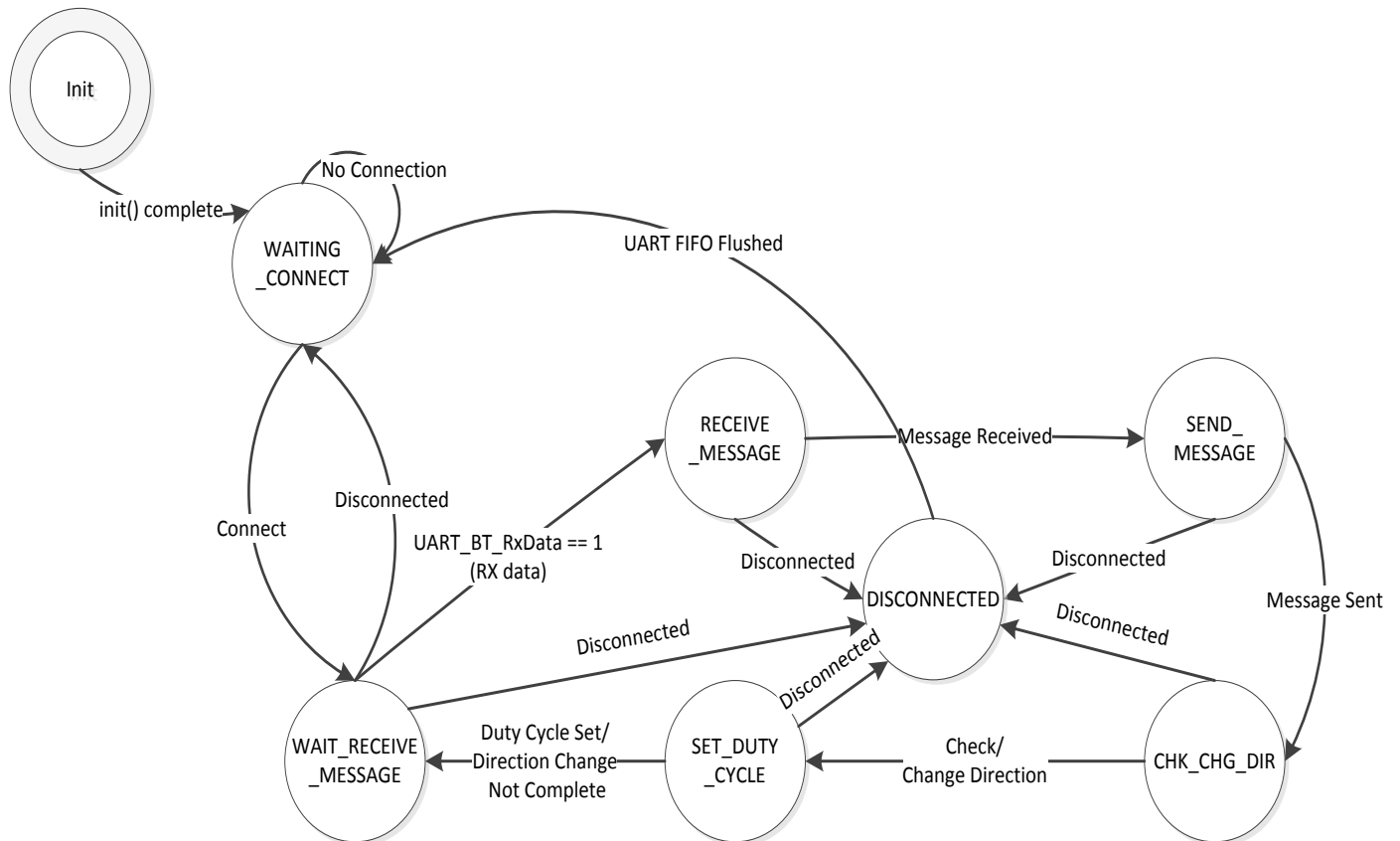
Communication Protocol :

Messages sent/received via serial communication through the PmodBT2 utilize structs CEREBOT_REMOTE_MSG and CEREBOT_ROBOT_MSG located in "cerebot_robot_remote_types.h" .



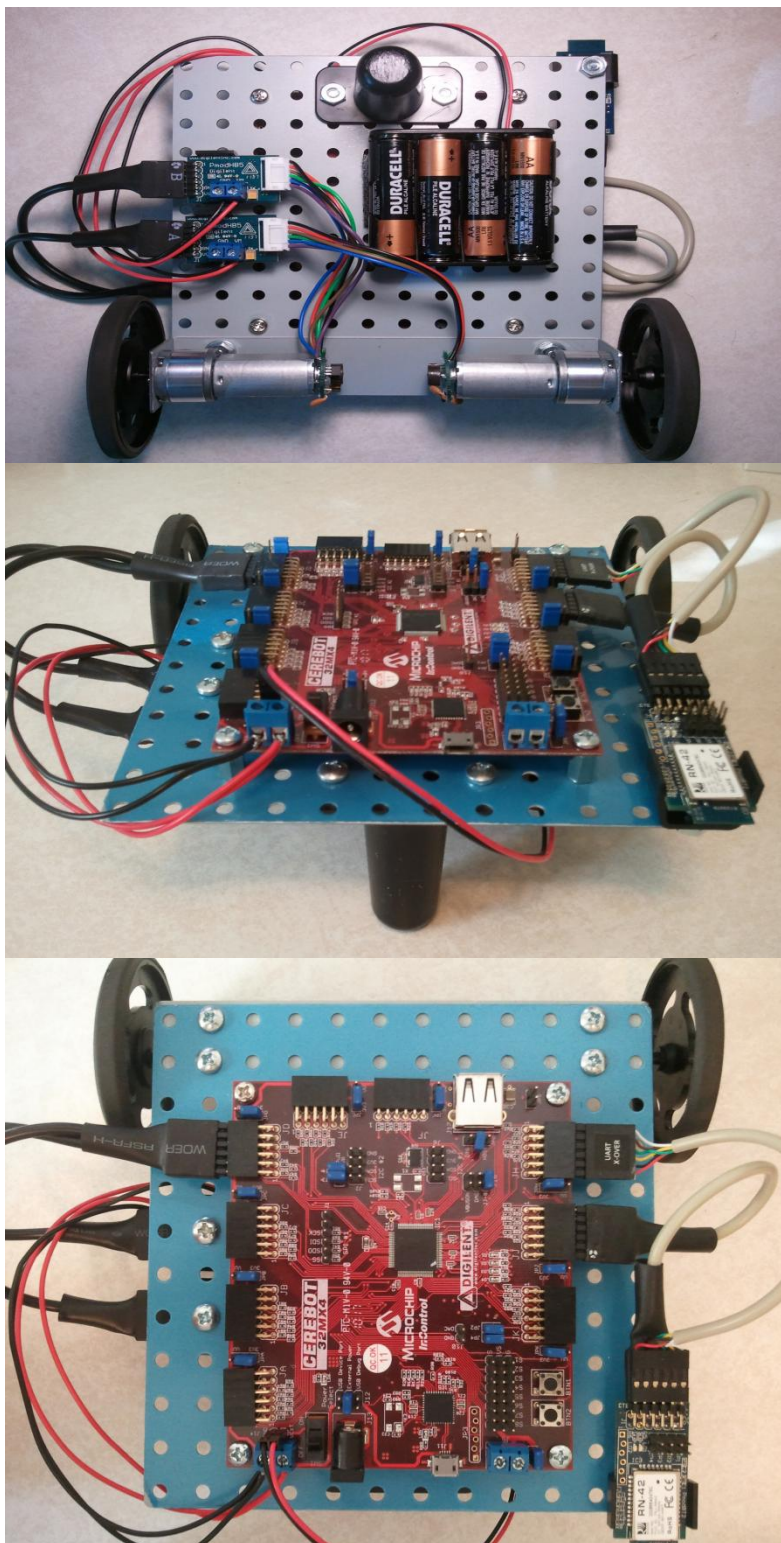
Robot State Diagram:

The following state transition diagram represents the main program loop of the robot keying on specific events that trigger a transition from one state to the next. State names line up with states present in appTask() prefixed with STATE_.



Assembly:

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



The table below details the electrical connections between the different components of the robot. All jumpers are in their default positions except J12 & J18 which are detailed below.

Cerebot 32MX4				
Header	Description	Connections		
JD	Left Motor	Pin	Peripheral Header	Peripheral Pin
		1	PmodHB5 - J1	1
		2	PmodHB5 - J1	2
		3	PmodHB5 - J1	3
		4	PmodHB5 - J1	4
		5	PmodHB5 - J1	5
		6	PmodHB5 - J1	6
JD	Right Motor	Pin	Peripheral Header	Peripheral Pin
		7	PmodHB5 - J1	1
		8	PmodHB5 - J1	2
		9	PmodHB5 - J1	3
		10	PmodHB5 - J1	4
		11	PmodHB5 - J1	5
		12	PmodHB5 - J1	6
JH	Bluetooth UART Connection (Using UART X-Over Cable)	Pin	Peripheral Header	Peripheral Pin
		1	PmodBT2 - J1	1
		2	PmodBT2 - J1	4
		3	PmodBT2 - J1	3
		4	PmodBT2 - J1	2
		5	PmodBT2 - J1	5
		6	PmodBT2 - J1	6
JJ	Bluetooth Connection and Status	Pin	Peripheral Header	Peripheral Pin
		1	PmodBT2 - J1	7
		2	PmodBT2 - J1	8
		3	PmodBT2 - J1	9
		4	PmodBT2 - J1	10
		5	PmodBT2 - J1	11
		6	PmodBT2 - J1	12
J12	Power Select	Shorting Block Installed on "External Power"		
J14	External Power (Battery Holder)	Pin	Peripheral Header	Peripheral Pin
		GND	Battery	Black
		VEXT	Battery	Red
J18	HBridge Power	HB5 Left Motor		
		Pin	Peripheral Header	Peripheral Pin
		GND	J3	GND
		VEXT	Battery	VM
		HB5 Right Motor		
		Pin	Peripheral Header	Peripheral Pin
		GND	J3	GND
		VEXT	Battery	VM
JP4	VU Bus Voltage Monitor	Shorting Block Installed		

PmodBT2				
Header	Description	Connections		
J1	Bluetooth UART Connection (Using UART X-Over Cable)/ Bluetooth Connection and Status	Pin	Peripheral Header	Peripheral Pin
		1	Cerebot 32MX4 - JH	1
		2	Cerebot 32MX4 - JH	4
		3	Cerebot 32MX4 - JH	3
		4	Cerebot 32MX4 - JH	2
		5	Cerebot 32MX4 - JH	5
		6	Cerebot 32MX4 - JH	6
		7	Cerebot 32MX4 - JJ	1
		8	Cerebot 32MX4 - JJ	2
		9	Cerebot 32MX4 - JJ	3
		10	Cerebot 32MX4 - JJ	4
		11	Cerebot 32MX4 - JJ	5
		12	Cerebot 32MX4 - JJ	6
JP1 - 4	See PmodBT2 Reference Manual	Open		

PmodHB5(Left Motor)				
Header	Description	Connections		
J1	Left Motor to Cerebot 32MX4 Connection	Pin	Peripheral Header	Peripheral Pin
		1	Cerebot 32MX4 - JD	1
		2	Cerebot 32MX4 - JD	2
		3	Cerebot 32MX4 - JD	3
		4	Cerebot 32MX4 - JD	4
		5	Cerebot 32MX4 - JD	5
		6	Cerebot 32MX4 - JD	6
J2	Left Motor	Connected to Left Motor		
J3	Motor Power	Pin	Peripheral Header	Peripheral Pin
		GND	Cerebot 32MX4 - J18	GND
		VM	Cerebot 32MX4 - J18	VEXT

PmodHB5(Right Motor)				
Header	Description	Connections		
J1	Right Motor to Cerebot 32MX4 Connection	Pin	Peripheral Header	Peripheral Pin
		1	Cerebot 32MX4 - JD	7
		2	Cerebot 32MX4 - JD	8
		3	Cerebot 32MX4 - JD	9
		4	Cerebot 32MX4 - JD	10
		5	Cerebot 32MX4 - JD	11
		6	Cerebot 32MX4 - JD	12
J2	Right Motor	Connected to Right Motor		
J3	Motor Power	Pin	Peripheral Header	Peripheral Pin
		GND	Cerebot 32MX4 - J18	GND
		VM	Cerebot 32MX4 - J18	VEXT

Parts List

Digilent

- (1) Cerebot 32MX4
- (1) PmodBT2
- (1) UART Crossover Cable
- (2) 6 Pin Cable Connector
- (2) 6 Pin Header & Gender Changer
- (1) 2x6 Pin Cable
- (1) 2x6 Pin Header
- (1) Standoffs (Contains 4ea)
- (1) Battery Holder (4 x AA)
- (1) Pmod Clip
- (1) Robotic Starter Kit