

Cerebot Bluetooth Robot Reference Design

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1300 NE Henley Court, Suite 3
Pullman, WA 99163
(509) 334 6306 Voice | (509) 334 6300 Fax

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 (the remote) 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 sent to the robot are received through the PmodBT2 Bluetooth module, robot status (wheel RPM, VU bus battery voltage, FWD/REV direction) are then transmitted to the remote.

Once power is applied to the remote, Bluetooth module initialization begins, during this process the Bluetooth name of the robot is set to "CEREBOTROBOT" (configurable). Upon initialization completion, 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%, and leave 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 and pmodlib libraries.

Message Processing/Motion

Forward/Reverse speed values received are a percentage of the duty cycle that will be applied to the pulse width modulation driving the enable pin on both the left and right PmodHB5s, which in turn drive the motors. 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 new duty will then be 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 turn is called differential steering .

In an attempt to compensate for differences in motor construction when traveling in a straight line, RPM values for both wheels are monitored and adjusted $\pm 5\%$ 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

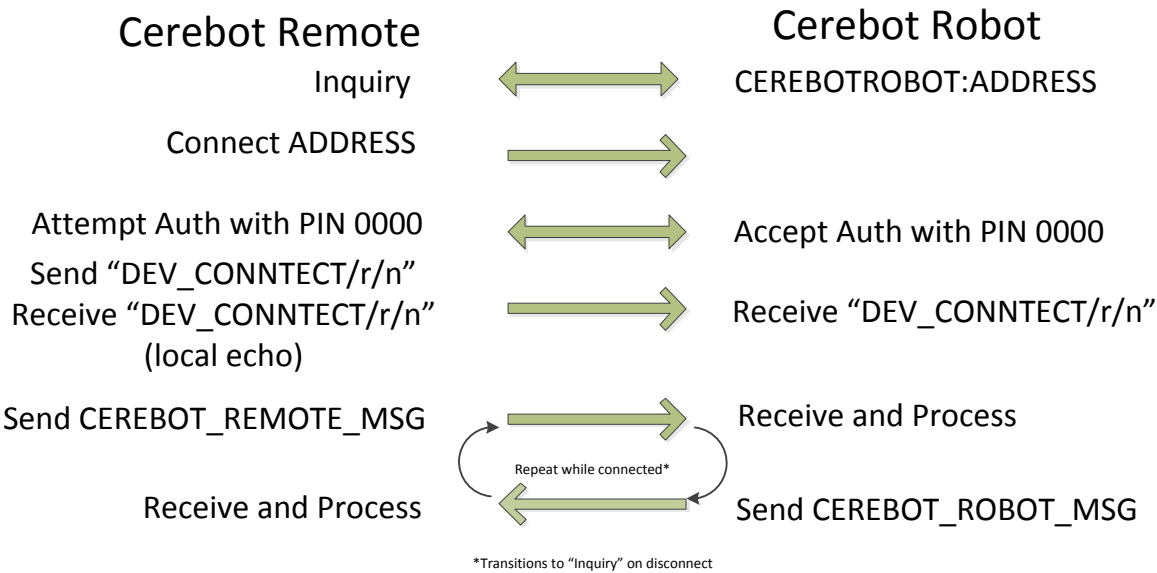
Peripheral Bus: 40Mhz

Port Bitrates:

UART2 - PmodBT2: 115200

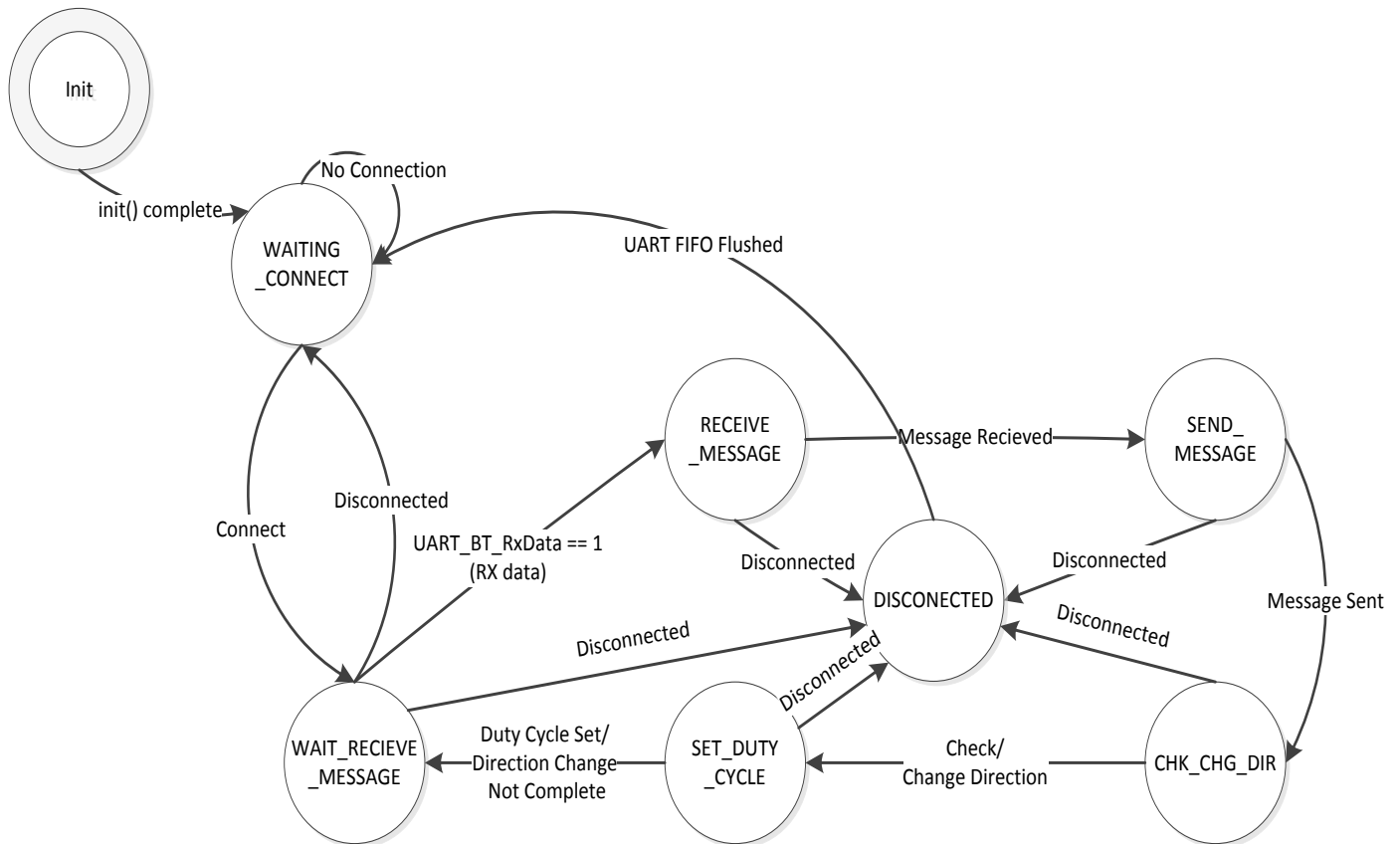
Communication Protocol :

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" .



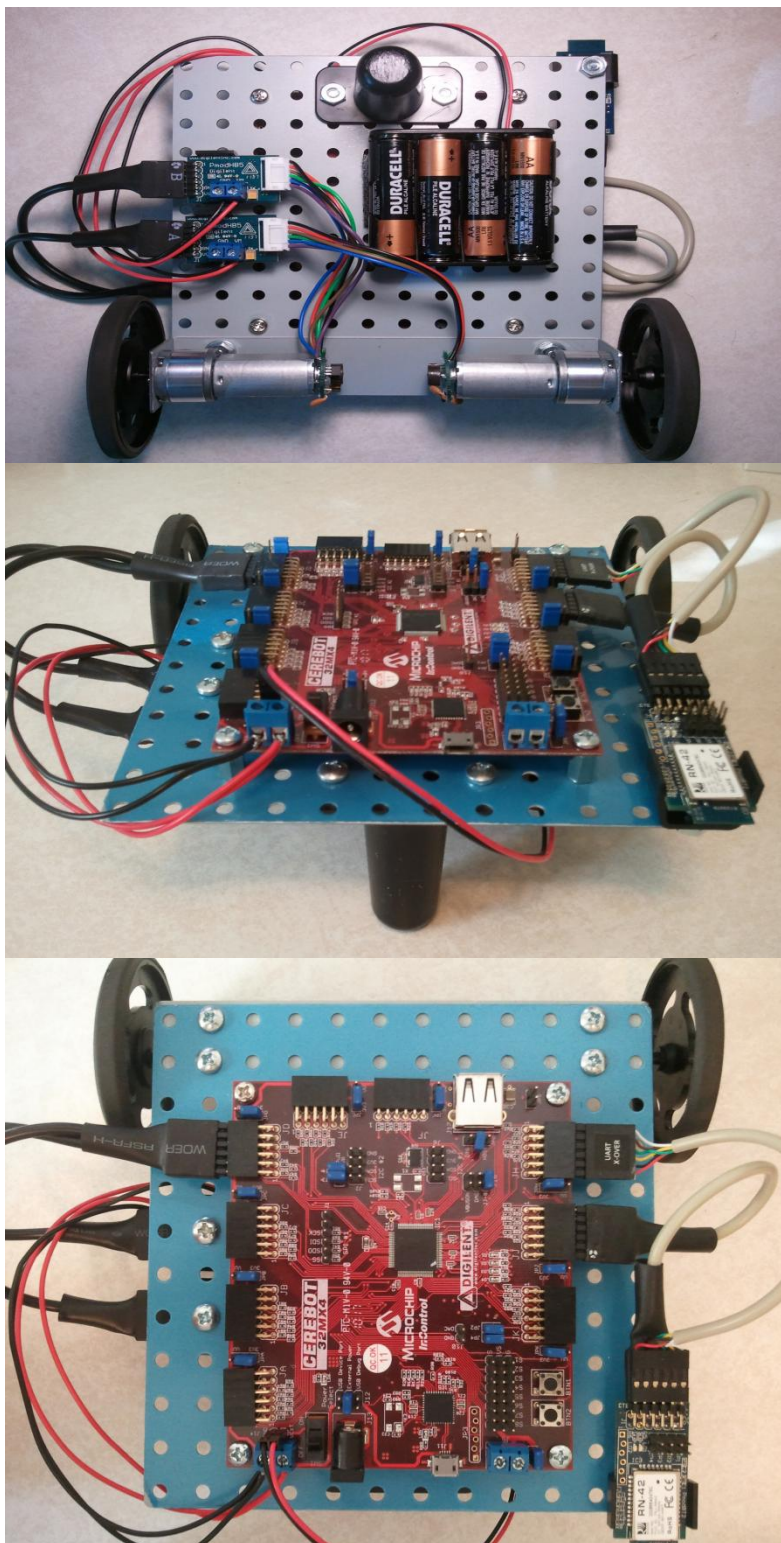
Robot State Diagram:

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 remote 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 remote. 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 | 4 |
| | | 3 | PmodHB5 - J1 | 3 |
| | | 4 | PmodHB5 - J1 | 2 |
| | | 5 | PmodHB5 - J1 | 5 |
| | | 6 | PmodHB5 - J1 | 6 |
| JD | Right Motor | Pin | Peripheral Header | Peripheral Pin |
| | | 7 | PmodHB5 - J1 | 1 |
| | | 8 | PmodHB5 - J1 | 4 |
| | | 9 | PmodHB5 - J1 | 3 |
| | | 10 | PmodHB5 - J1 | 2 |
| | | 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 RM | 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