Give a detailed description of the design of hardware. The description should include mechanical drawings, location diagrams, electrical circuit schematics, circuit simulation or test results, PCB overlays, wiring diagrams, connector pinout lists, pneumatic/hydraulic circuit diagrams
The project includes a wide array of hardware types, each with specific requirements to be interfaced with in software and with other the other hardware components. This section will seek to outline the requirements of the individual components used, as well as the scheme with which they were interfaced with each other.

0.1 Scope of the Jousting Robot's System Hardware

The jousting robot, being composed of 2 interacting systems, namely the Commander and Mobile Robot, has a hardware requirement that was also split into two. The Commander hardware and Mobile Robot hardware will be here discussed separately to highlight the differences.

0.2 Hardware shared between Commander and Mobile Robot

The Commander and Mobile robot function in a master/slave relatoionship and so required a common denominator of components for communication between them. These common components included the PIC18f4520 MNML microprocessor, and the Xbee communication hardware.

0.2.1 PIC18f4520 Microcontroller

The PIC18f4520 is a RISC microcontroller with harvard architecture and is well suited to embedded projects. The MNML board used provides access to the MPLABx development environment through the RJ45 connector via the ICD (in circuit debugger).

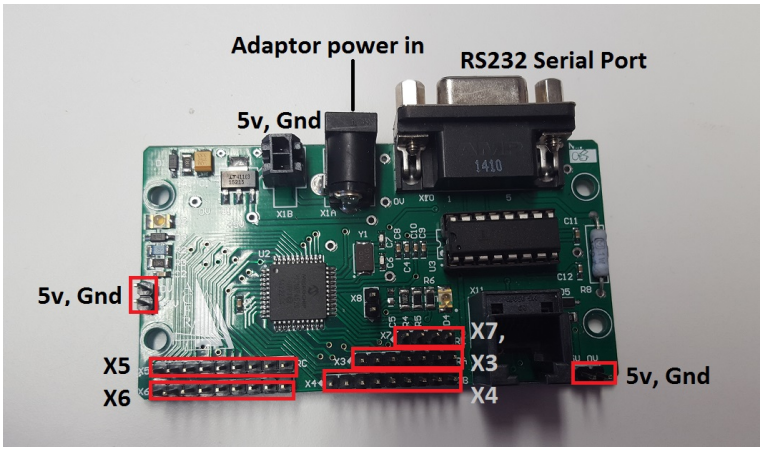

Figure 1: The MNML PIC18f4520 microcontroller

The PIC contains:

- 3 external interrupt sources
- 4 timer modules
- 2 CCP (capture/compare/PWM) modules
-

0.3 Mobile Robot Hardware Design

0.3.1 Power Supply

The Mobile Robot was powered by a Zippy Flightmax 4.2 Ahr Lithium Iron Phosphate (LiFePO4) battery. It consists of 4 series connected cells together producting a typical voltage of 12.8V. The battery is rated for a continuous discharge rate of 126A and a charge rate of 8.4A. The battery is connected to a power supply circuit that has several functions:

1. It provides a connection point for the 12.8V battery.
2. It provides a connection point for external power supplies if the battery is removed.
3. It provides 5V DC power at 1.5A to other hardware on the Mobile Robot.
4. It provides a switch for turning power to the Mobile Robot off or on.
5. It carries the Pololu 707 Dual VNH3SP30 Motor Driver board and provides power to it.
6. It provides connection points for motor driver signals, motor leads and encoder signals.

INSERT SCHEMATIC HERE

0.3.2 Computer Design

Description of computer hardware, including all interface circuitry to sensors, actuators, and I/O hardware.

0.3.3 Sensor Hardware

1. IR sensors: 3 Sharp GP2Y0A41SK0F Infrared Sensors were used to measure distance, with an effective range of 4-40cm, which corresponds to an output voltage of 0.4 to 3.1V. Exceeding 40cm, IR sensor output is saturated. There are 3 connections for the IR sensor,Vcc(nominally 5V), Gnd, and an analog output.

encoder.png

Lead colour	Function
Blue	+5 V Supply
Green	+0 V Supply (GND)
Yellow	A quadrature output signal
White	B quadrature output signal

Figure 2: Encoder mounted on motor shaft, and wire functions

2. encoder: The rear motor shaft is fitted with a hall effect encoder which provides 2 square waves as outputs, one 90 degrees out of phase with the other. By measuring which signal is leading we can identify the direction of the wheel, and the frequency of the pulses tells us the speed. The sensor has 64 counts per revolution resolution.

3. Xbee (functions more like a sensor in robot)

0.3.4 Actuator Hardware

The primary actuators on the Mobile Robot were the two motors connected to the wheels. The two motors could be controlled independently allowing for turning functionality. The motor output shafts were connected to multi-stage planetary gearboxes having reduction ratios of 131.25:1. Table 3 lists the acronyms and abbreviations used in this document. The output shaft

Parameter	Value
Part number	Pololu 1447
No-load speed @ 12 V	80 RPM
No-load current @ 12 V	300 mA
Stall current @ 12 V	5 A
Stall torque @ 12 V	1.765 Nm
Positive terminal lead	Red
Negative terminal lead	Black

Figure 3: DC gearmotor and specifications

from the gearbox was connected to the 90mm wheel via 2 M3 screws that bore down on the shaft flat face.

0.3.5 Operator Input Hardware

The input to the Mobile Robot comes from the Commander, and as such there is no operator input hardware other than the power switch which is supplied by the power board circuit.

0.3.6 Operator Output Hardware

The output of the mobile robot are PWM motor and Xbee, PWM motor cause the movement of the robot. Xbee can also see as the output hardware since it transmit the robot status back to the commander. Hence it is both input and output hardware.

0.3.7 Hardware Quality Assurance

The IR sensor is sensitive and it might cause error and unstable value if the system only take 1 IR sensor output value. In order to stablize the IR output data, we store the IR value into an array, and the IR output data is store into the array and it keep overwrite it. In software module, taking the average value in the array and send it to the commander via Xbee will improve the quality of the IR data. The array size is 10 so it have enough buffer to smooth the raw IR data.

Describe any measures that were taken to control (improve) hardware quality and reliability Heartbeats, brownout conditioning/resets, reset conditions, testing and validation, etc.

0.4 Commander Hardware Design

0.4.1 Power Supply

Unlike the Mobile Robot, the power requirements of the Commander could be fulfilled from a single 9v battery plugged into the PIC, and all power for peripheral components supplied by the PIC. Due to the many components connected to the power lines, a power rerouting circuit needed to be constructed. This circuit is shown in the next section as it involved interfacing with the PIC.

0.4.2 Computer Design

Description of computer hardware, including all interface circuitry to sensors, actuators, and I/O hardware.

0.4.3 Sensor Hardware

0.4.4 Actuator Hardware

There was no actuating hardware present on the Commander, however, the Xbee hardware served as a means of communication between Commander and Mobile Robot.

0.4.5 Operator Input Hardware

Input hardware consisted of a 2 axis joystick, which is 2 potentiometers at mounted right angles to each other. This joystick also contains a button that can be used by depressing the joystick. A second, separate button was used on the commander for starting and stopping the mobile robot. The commander also included a master power switch.

0.4.6 Operator Output Hardware

The main output hardware consisted of an LCD screen which displayed the state of the system, as well as basic information about the Mobile Robot to to the operator. 3 LEDs were also in the original design, a power indicator, a radio link integrity indicator, and an LED to indicate the Mobile Robot was in Autonomous mode, however these LED indicators were not implemented in the final product.

0.4.7 Hardware Quality Assurance

The main hardware quality assurance policy was implemented on the PIC, with a brownout detector enabled by default on the microcontroller.

0.5 Hardware Validation

Details of any systematic testing to ensure that the hardware actually functions as intended.

0.5.1 Commander

Testing the commander by using LCD display first to make sure the desired outputs are correct, then send the outputs via xbee to verify if the outputs are still correct.
Joystick should systematic testing with the mobile robot first, then connect it to the commander

0.5.2 Mobile Robot

Before attaching the IR sensor into the minimal board, connect it to the demo board fist and test its output analog voltage whether it match the desire output. Once it was done, combine the IR sensor module and Xbee module, send the IR data via xbee and verify if the IR data are correct after it transmits via xbee.
In order to test the PWM motor if it actually functions as intended, attach the joystick direct to the robot minimal board, it can isolate the serial module and test the PWM motor hardware only.

0.6 Hardware Calibration Procedures

Procedures for calibration required in the factory, or in the field.

0.6.1 Commander

0.6.2 Mobile Robot

0.7 Hardware Maintenance and Adjustment

Routine adjustment and maintenance procedures.

0.7.1 Commander

0.7.2 Mobile Robot