A platform for research of flocking behaviour in swarms of robots was developed throughout the bachelor's thesis , "Investigating Bio-inspired Object Avoidance in a Swarm of Mobile Robots". Throughout that project an analysis was carried out in order to determine the requirements of the system. This project aims to replace the Raspberry Pi with an FPGA platform, namely a Zynq platform. Using an FPGA/ARM combination is believed to better enable the use of swarm algorithms. Additionally, since the completion of the bachelor's thesis, a new type of microphone has been procured. This type is digital, as opposed to the previous analogue microphones. Much of the electronics developed for that project is developed so as to work around the shortcomings of the Raspberry Pi, as well as the amplifier circuits required for the microphones. This project will redesign the electronics where necessary in order to accommodate the changes on the platform.

1 Analysis

This analysis will seek to expand on the analysis carried out in the aforementioned thesis. Some of the conclusions reached are no longer valid due to the new platform. It is necessary to determine which parts will need redesign and possibly, what new features will need to be added altogether.

1.1 Mechanical Platform

The chassis, battery and motors, including their encoders remain unchanged and as such will not be discussed further in this context. Thoughts about battery.

1.2 Microphones

As mentioned, a new set of digital microphones has been procured for use with this robot. The previous electronic circuits developed include an amplifier section for the analogue microphones. This is no longer necessary. The analysis did find, however, that the multilateration algorithm is more robust when the microphones are further apart therefore, the new microphones will be placed similarly to the previous set.

1.3 Click Generator

Previously, it was attempted to generate a click using a piezo transducer. The attempt did not manage to produce a sufficiently loud click. A piezo transducer deforms when a voltage is applied to it. A higher voltage increases the deformation. By repeatedly pulsing the transducer with a sufficiently high voltage, it should be possible to generate a clicking noise. Some type of circuit will have to be developed to generate the necessary voltage spike.

1.4 PWM Generation

The Raspberry Pi previously used has support only for one PWM channel. In order to fully control the robot, four channels are required. For this reason it was chosen to use an external PWM generator which can be communicated with through I2C. Moving to an FPGA based platform, this is no longer necessary, as it is possible to add as many PWM channels as required in VHDL.

1.5 Motor Driver

The BD6222HFP was chosen as the motor driver in the previous project. This is a full-bridge capable of continuously supplying sufficient power to drive the motors on the robot. While the driver is maintained, a new board will have to be devised to house this driver.

1.6 Power and Current limitations

It was chosen to use linear regulators to supply the 5 and 3.3V rails. This project will analyse whether the added cost of using switch-mode converters is worth the additional cost. A number of fuses were added to limit the current to the motors as well as the current draw from the battery. The battery however, includes a "safety board" which limits the maximum possible current draw, making this fuse irrelevant. The fuses on the motors can be excluded by instead running a check in software such that when a voltage is applied, the encoder signal must represent movement, or the voltage will be cut. Allowing overcurrent for a short period will not damage the motors and therefore this approach is acceptable.

1.7 Embedded Platform

Previously a Raspberry Pi was used to power the platform. As mentioned, it has been requested that the system is ported to a Zynq platform. Currently available to the authors are the Zybo and the Zynqberry platforms. Both are based around the Zynq-7010 chip. A number of GPIO ports are required; four pins for PWM for the motors, four pins for encoders, four pins for microphones, one for a piezo transducer. This amounts to a minimum of 13 pins required. Potentially, an additional number of pins may be used to niterface to debugging LED's. Below is an overview of the pros and cons of the two platforms.

- **Zynqberry:** As the name implies, this platform is made to conform with the physical layout of the Raspberry Pi. Using this platform would allow the reuse of the mounting solution developed for the Raspberry Pi. At 26 total GPIO pins, the Zynqberry can supply the required GPIO.

- **Zybo:** This platform is significantly larger than the Zynqberry. The different form factor requires that a new mounting solution is devised. Additionally, the increased size means that the board will have to be mounted above the tracks to avoid interference. While this is an inconvenience, it should not pose an issue in collisions as the edges of the board are still within the bounds of the robot. At 48 total GPIO pins, the Zybo can supply the required GPIO.

Both platforms are based around the same chip and should therefore be similar in functionality. The authors, however, do have prior knowledge with the Zybo platform. An up-to-date Linux system has been made to function with the Zybo.

1.8 Electronics Board

In order to accommodate the new electronics a new board will have to be designed. The board must support a number of components and circuits, listed below.

- **Motor controller:** The BD6222HFP, a full-bridge motor controller, is used to generate the drive signals for the motors.

- **Piezo:** Generating a click is done using a piezo transducer. A transducer with an internal drive circuit will be used.

Table 1: My caption

Description	Voltage, [V]	Current, [mA]
Barely driving	1	220
Medium driving speed	5	305
Fast driving	8	350

- **5V DC/DC Converter:** The PTH08080W will be used to generate the 5V rail necessary to drive the embedded platform.
- **Connections:** A number of connections has to be present on the board. Passthrough for the microphone add-in board. Passthrough for the motor encoders. Connection for battery.
- **Debug LEDs:** Support for four LEDs for debugging is required. The necessary drive circuitry must be added.
- **Microphone board** ....

1.9 Power Calculations

1.9.1 5 [V] rail

Running at 5[V]:

- Microphones including circuitry, 11[mA]
- SBC, 500[mA]
- Two microcontrollers, 5[mA]
- Six LED channels, 120[mA]

Resulting in a total of 636 [mA] being drawn from the 5[V] rail.

1.9.2 Battery rail

Only the motor will be running directly off the battery rail. To measure the current drawn by the motors a small test was conducted. Three different voltages were applied to the motors by a power supply:

1.9.3 Power Dissipation

When using a linear voltage regulator the power dissipation is as follows:

$$P_d = (V_{in} - V_{out}) \cdot I_{load}$$

In the average case the battery voltage is thought to be the the nominal voltage, using the found drawn current at 5[V] the power dissipation is found.

$$P_{lr} = (7.4[V] - 5.0[V]) \cdot 0.636[A] = 1.5[W]$$

If a switching regulator is used the voltage conversion will happen at a significantly higher efficiency. The pth08080w has a typical efficiency of 93.5% at 5 [V]. The power dissipated in that would be:

$$7.4[V] \cdot 0.636[A] \cdot 0.065 = 0.3[W]$$

The power dissipated at the 5 [V] rail is:

$$P_{5V} = 0.636[A] \cdot 5[V] = 3.18[W]$$

The power dissipated in the motor and motor controller is as in table 2.

Table 2: My caption

Description	Power, [W]
Barely driving	0.2
Medium driving speed	1.5
Fast driving	2.8

The batteries have a capacity of 2600 [mAH], giving the following driving times.

Table 3: My caption

Description	P_{tot} w. LR, [W]	P_{tot} w. sw, [W]	Drive time w. LR	Drive time w. switch	% more drive time
Barely driving	4.9	3.7	3.9	5.2	33
Medium driving speed	6.2	5	3.1	3.8	23
Fast driving	7.5	6.3	2.6	3.1	19