Edinburgh Napier University

LABview: Control and Monitoring of Car Park System

Module ELE09104 EE-Engineering Applications

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Abstract

This report details all the steps taken to design a control and monitoring system of a predefined car park system using LABView.

It shows the process behind the realisation and testing of a Drive Control PCB which is connected to the system to drive the barrier.
It also shows the different elements in programmes with examples of the code and logic for: Controlling and powering the barrier motor, dealing with switches and sensors. It offers a simple example of a control and monitoring panel which could be used by an operator.

The conclusion sums the main objectives of the project (Designing the programme for the system), introduces some of the difficulties the engineers had to overcome (Designing the logic behind the barrier operation, dealing with the ports on the data acquisition card…), opens up on potential additional features and finishes with a post client demonstration feedback and recommendations (Review of the operator panel).

Table of content.

Introduction.

The main focus of the ELE09104 Module Engineering Applications - Electrical and Electronics, was to develop a solution to control and monitor a car park system. This report focuses on controlling and monitoring the system using LABview and complementary tools. This only represents a half of the complete application (The other half being the control and monitoring using a microcontroller). The LABview system should allow an operator to monitor the different switches, sensors and the number of empty spaces in the car park. It should also allow the operator to override the microcontroller system, open and close the barrier in case of a system malfunction.

This report will offer an account and description of the tasks undertaken to provide a working system fulfilling the requirements of the car park application. First, a short presentation of the main equipment and tools used to create a solution will be provided. Then, an explanation of the different parts of the programme and control panel realised with LABview will be offered. Finally the report will conclude with a summary of the objectives and tasks achieved as well as comments about the development process with possible improvements and additional features.

I Equipment: Car park, DAQ card, LABview and PCB control.

This section will detail the equipment used to design and control the car park. Each element will be presented and its function described. Finally, a short description of how these elements interact will be given.

1.1 The Car park.

The car park system is composed of these elements (see fig 1.1 below):

A. Push buttons:

- “Ticket” at the entrance to simulate a user obtaining an entry ticket.
- “Paid” at the exit to simulate a user paying and leaving the car park.
- Two “Help” buttons in the event the user would have an issue at the barrier.

B. Sensors:

These detect the position of the car in the car park. They are numbered from 1 to 4 and are placed at the entrance, exit but also pre and post barrier.

C. Traffic Lights:

The main way of the car park being a single way it is necessary to have traffic lights to alternate the passage of cars. There are placed at the entrance and exit of the car park.

D. Motorised barrier:

The stepper motor(4 poles) will allow to raise and lower the barrier electrically. Two sensors will allow to detect if the barrier is up or is it is down.

E. LCD Screen:

The screen will allow to communicate with the car park user at the entrance and exit. This will allow the user to understand the tasks he may have to perform to enter and exit the car park.

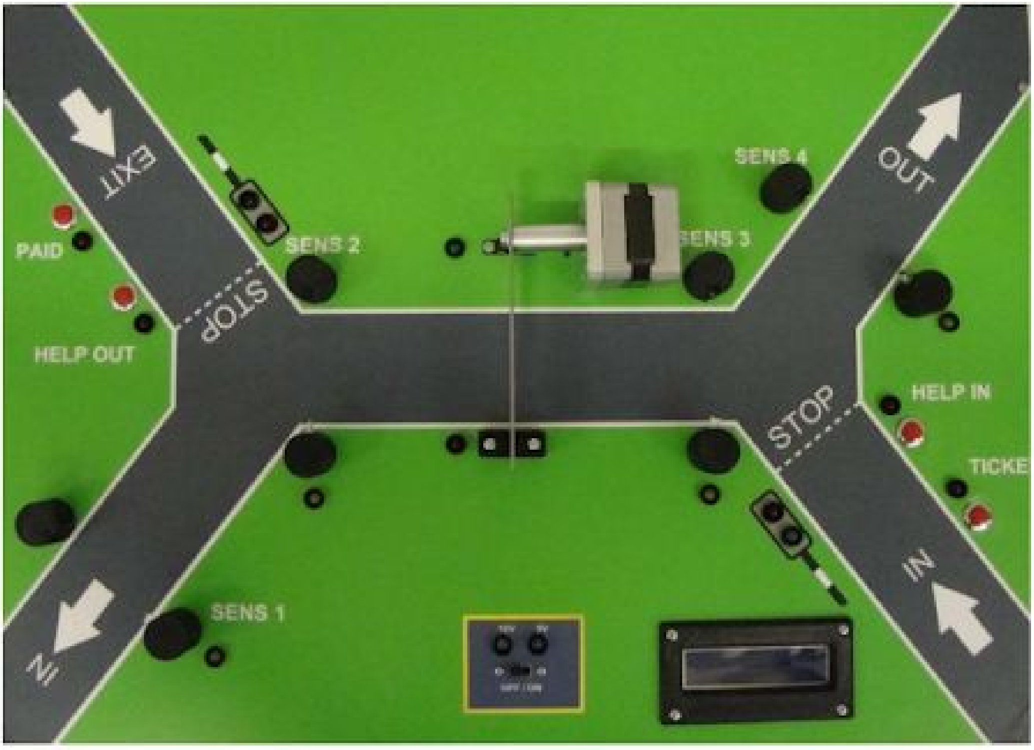

Fig 1.1 Car park system overview.

1.2 The DAQ Card

The data acquisition (DAQ) card is used to connect the PC (internally through a PCI card) to the car park system.

Data acquisition is the process by which and electrical or physical signal is measured (for example: push buttons and sensors) and then processed by the computer. The signal comes from the sensor through the DAQ card, where it processed and digitalised, to be used in the programme (Here LABview).

This card is also used to send out signals to trigger devices. In the car park example, signals are sent out trigger the system override and motor (Up and Down).

1.3 Description of LABview and R language.

LABview is the software used to design, operate and monitor the car park. The strength of LABview lies within the rapidity of putting applications together, testing and debugging them. Using the graphical language R, allows the user to programme intuitively and rapidly put the programme together and observe it running to get instant feedback from the system being monitored and controlled.

1.4 The Drive Control System PCB.

It was necessary to supplement the car park system with a drive system circuit to trigger the step motor. The board will allow through the commands on LABview to trigger the override of the system, the motor and chose between barrier up and barrier down.

The PCB is composed of:

- A supply with and ON/OFF circuit and potential divider circuit (to the logic and to the driver circuits).
- A TTL Clock circuit to control the pulse of the logic gate.
- A logic circuit to set the motor ON/OFF and revert the polarity, changing the way the motor spins
- A driver circuit powering the drive and spinning the stepper motor.
- Connectors to send signals in and out of the card.

The different parts were assembled using the same process until the PCB was complete and working:

1. Breadboard prototype.
2. Testing prototype.
3. Soldering components on pre-manufactured board.
4. Testing soldered circuit.

A final test was realised. The board (Fig 1.4 below) was connected to a drive and controlled through LABview and the DAQ card to verify the motor could be controlled clockwise and anti clockwise. Frequency variation creating a change of speed was also tested. During the test the output of the PCB was measured using an oscilloscope. The reaction wave is square shaped.

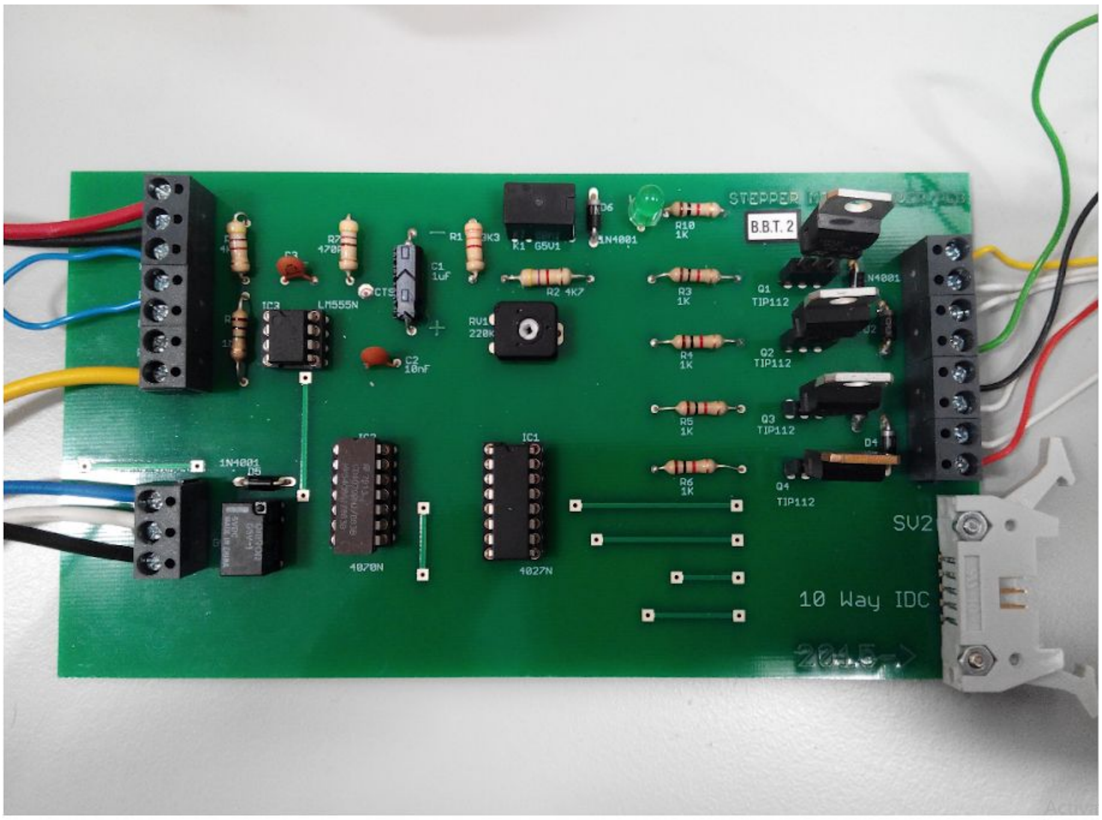

Fig 1.4 Assembled and Functional Drive Control System PCB.

1.5 Connecting and Testing the System.

1.5.1 Connecting the System.

The complete car park control and monitoring system with LABview is composed of three elements:

First, the computer with the integrated DAQ card to interact with the world outside of the PC. This card offers analogue and digital inputs. These ports are configured in LABview to obtain or send the right signal corresponding to the necessary car park port as shown in Table 1.5.1 below.

Table 1.5.1 DAQ Card Analogue/Digital Inputs and Output.

	AIGND	**1**	**2**	**AIGND**	
SENS 2	ACH0	3	4	ACH8	***Help In***
SENS 4	ACH1	5	6	ACH9	***Help Out***
SENS 3	ACH2	7	8	ACH10	***Lights In***
SENS 1	ACH3	9	10	ACH11	***Lights Out***
Barrier Up	ACH4	11	12	ACH12	***Drive In 1***
Barrier Down	ACH5	13	14	ACH13	***Drive In 2***
Ticket	ACH6	15	16	ACH14	***Drive In 3***
Paid	CH7	17	18	ACH15	***Drive In 4***
	AISENSE	19	20	DAC0OUT	
Motor Speed	DAC1OUT	21	22	RESERVED	
	AOGND	**23**	**24**	**DGND**	
	DIO0	25	26	DIO4	***Emergency Control***
Motor On/Off	DIO1	27	28	DIO5	
Motor Direction	DIO2	29	30	DIO6	
	DIO3	31	32	DIO7	
	DGND	**33**	34	+5 V	

Secondly, The DAQ Card on the PC is connected using a PC 50-way ribbon cable onto the LABView DAQ connector on the car park as shown on Fig 1.5.1 below.

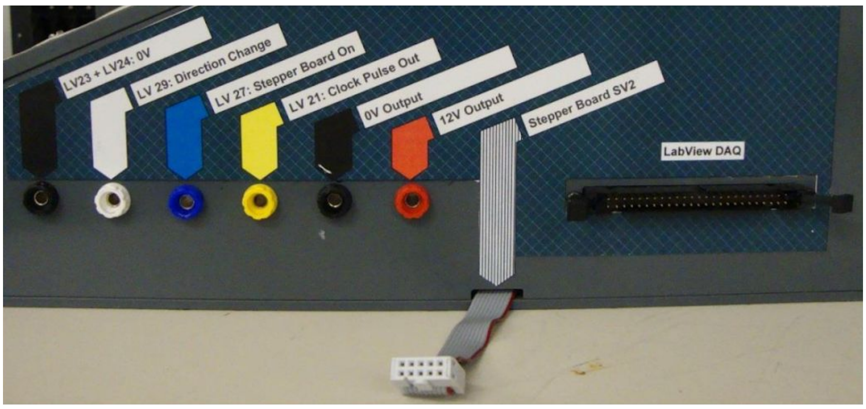

Fig 1.5.1 Car park Connectors - Input/Outputs.

Finally, the PCB controlling the motor is connected to the car park using the colour coded connector (Fig 1.5.1 above) and wires connectected to the PCB wire connectors. A 10-way output connecter is also connected to the car park to control the stepper drive.

Fig 1.5.2 (below) details the connections from the PCB to the car park. P7 are P6 are connected by a jumper wire to disable the on-board clock. LABview will manage the clock for the system.

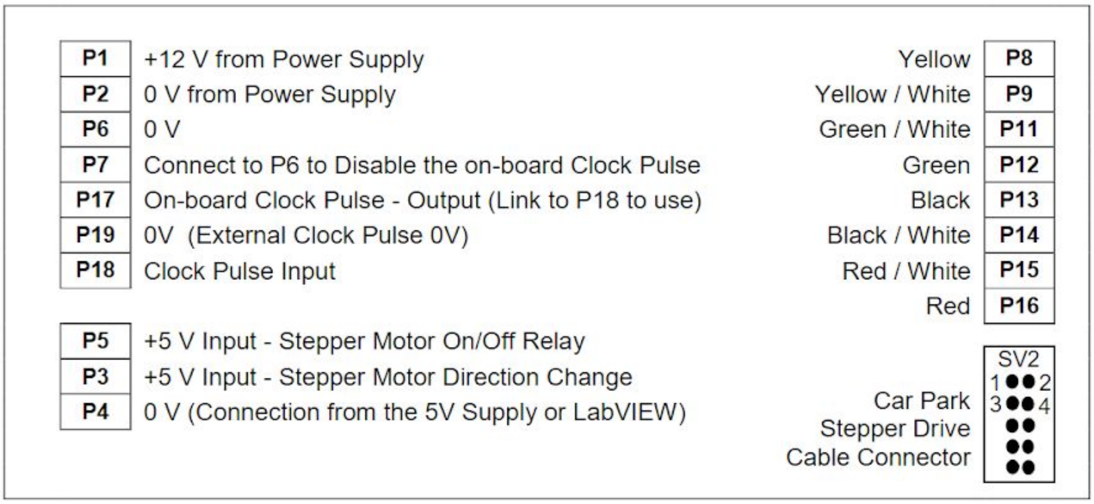

Fig.1.5.2 Motor Control PCB - Connectors Input/Output.

1.5.2 Testing the System.

Once the different subsystems connections are checked and the LABview programme is loaded (More on this in the next section), the car park can be turned on.

Before pressing the system override, sensors and switches can be tested against their display on the front panel (More on this in the next section). This checks if sensor and/or switch issues could stop the programme from running the loop correctly (for example: a sensor being off when supposed to be on). Once these checks have been performed, the loop can be triggered normally. The switches and sensors are then triggered according to a logical sequence a user would go through when going in and out of the car park.

II LABview Control System of the Car park.

This section present the different features and parts of the programme which allows the operator to override the microcontroller, to manually trigger the barrier and monitor the car park.

2.1 LABview Car park programme.

All of the components presented here a contained with a while loop. This allows to run the programme continuously until the emergency switch is pressed.

2.1.1 Barrier Control Programme.

The barrier functions are controlled by three Case Structures as shown in Fig 2.1.1. If the conditions are not met to for a case structure the output default to “false” stopping the motor.

The first case structure is true when the override switch is triggered. The signal from the override is also sent to the DAQ card so the microcontroller stops.

The second case is triggered when the first case is “true” and the sensor “Barrier Up” is not triggered (this signal is inverted so will provide a 1 in this case) or the “Barrier activation” is triggered.

The third case is triggered when the previous cases are “true” and when the inverted signal of “Barrier activation” and “Barrier Down” outputs a 1.

The outputs of case 2 and 3 are sent to an array which send the signal to the car park through the DAQ card.

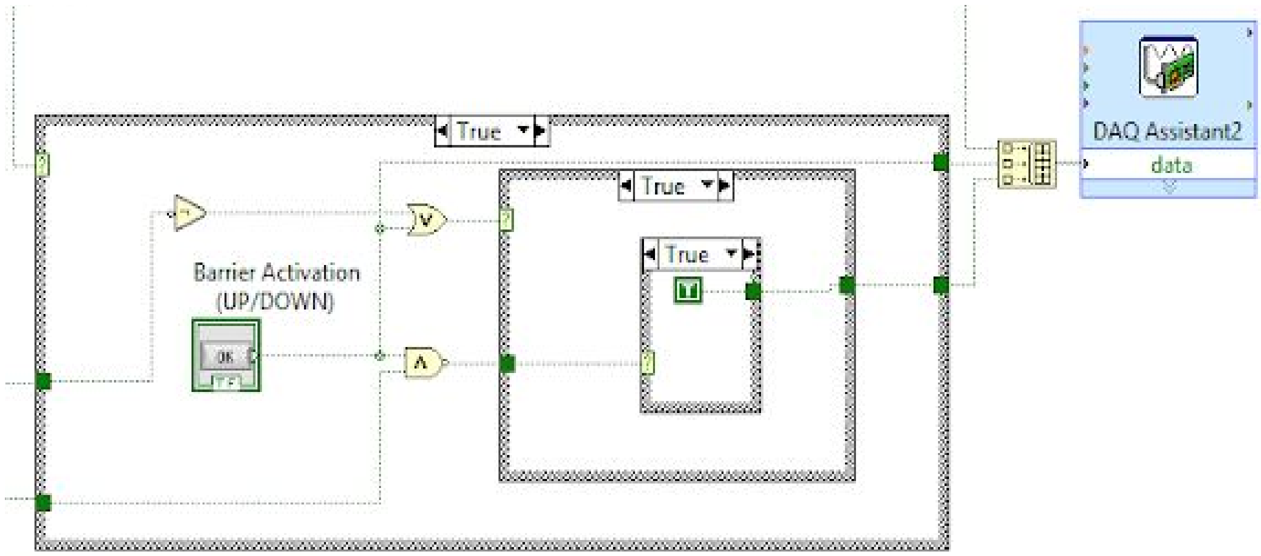

Fig 2.1.1 Barrier Operation - Case structure Control: all conditions "True".

2.1.2 Signal Generator for Motor Power.

Barrier Control Programme offered an explanation for the switching the barrier on and off and change the way it rotates. This part will describe the signal used to put the motor in motion.

As previously mentioned the output wave for the motor is square shaped. The frequency (Hz) and Duty Cycle (%) were set at 30. The amplitude and offset at 2.5. Finally the sampling was set at 1000 Hz. Those values provided the fastest rotation of the barrier for a safe use. This signal is then sent through DAQ 3 to the motor to set its speed.

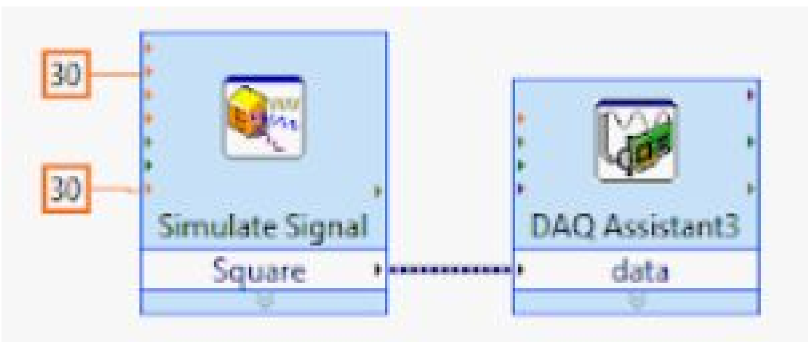

Fig 2.1.2 Signal Generator to control the barrier motor.

2.1.3 Sensors and Switches Monitoring.

This section will describe the different applications for switches and sensors used in this programme.

2.1.3.a Sensors

As shown in Fig 2.1.3.a, the signal from the sensors are acquired through the DAQ card as inputs. They are then converted from analogue to digital and then sent to light displays.

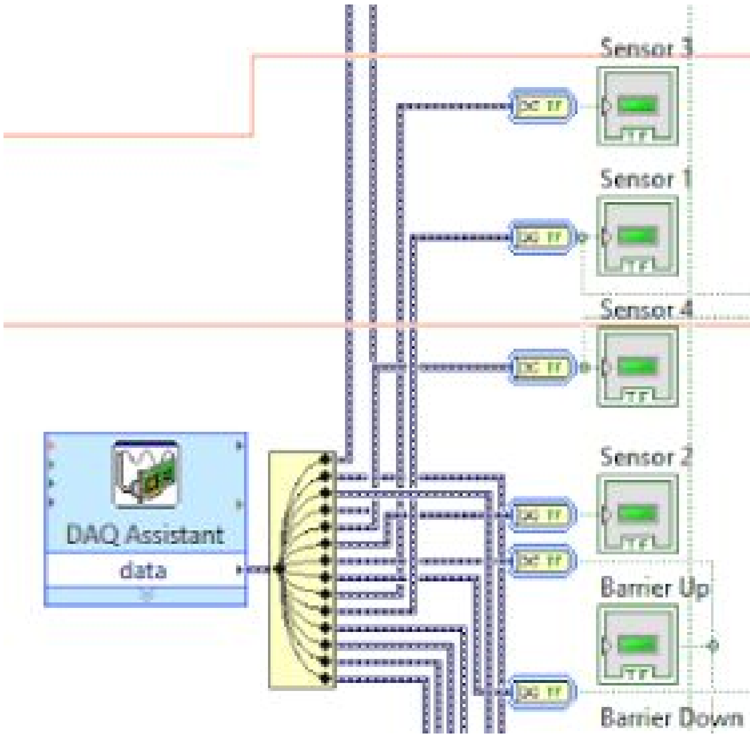

Fig 2.1.3.a Sensor Signal Acquisition through Input DAQ card.

2.1.3.b Switches.

- Simple Switch Operation Display:

As in the previous section, the signal is acquired and converted through a transfer functions and displayed on to the relevant display. In the case of Fig 2.1.3.b.1, the signal needed to be inverted to display when the switch was triggered. The signal was at 1 when the mechanical switch was not triggered.

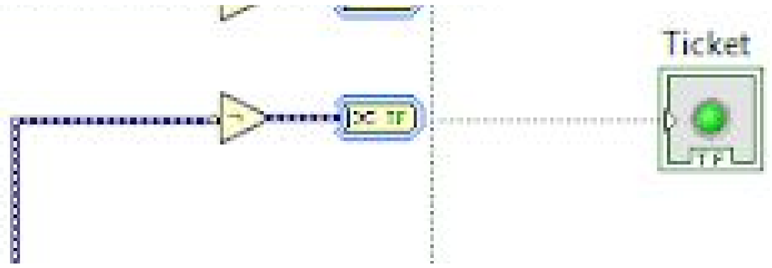

Fig 2.1.3.b.1 Simple Switch with display.

- Switch With a Latching System (Fig 2.1.3.b.2)

This part of the programme is used for the “Help in” and “Help out” buttons. When pressed they will trigger the relevant light on the control panel. Once the light is trigger it will remain on until the “help off” button is triggered by the operator.

For the first case structure if the Help button is triggered the signal goes through to the light displayed. At release of the button the state of the light stays fixed. This is signal then triggers a display on the operator’s control panel that help is needed.

For the second case, if the help button is not pressed and “Help off” or the system override are triggered the “Help” light will unlatch.

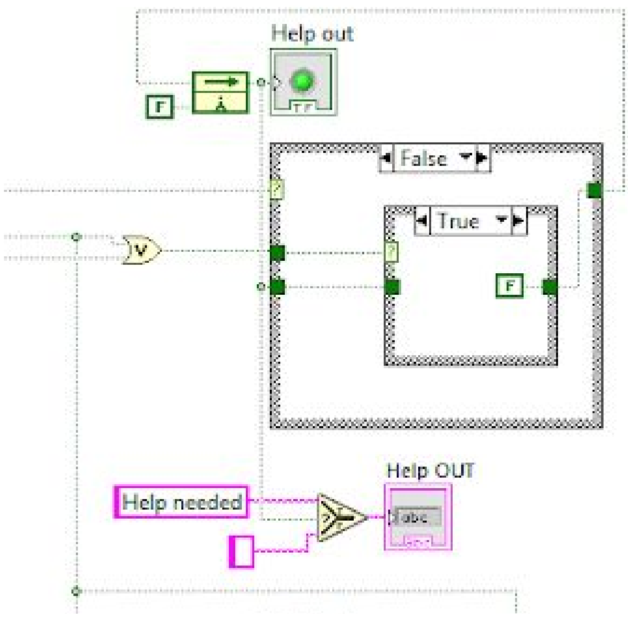

Fig 2.1.3.b.2 Switch with Latching System.

2.1.4 Car Count.

This part will present how the up and down counter with a base of 23 was programmed using a shift register.

2.1.4.a Inputs of the Up and Down Counter.

As shown in Fig 2.1.4.a, “23” is set as a base number sitting outside of the main loop. Sensor 1 will trigger the count down as cars come in and sensor 2 as they go out. The programme also uses barrier down to authorise the count.

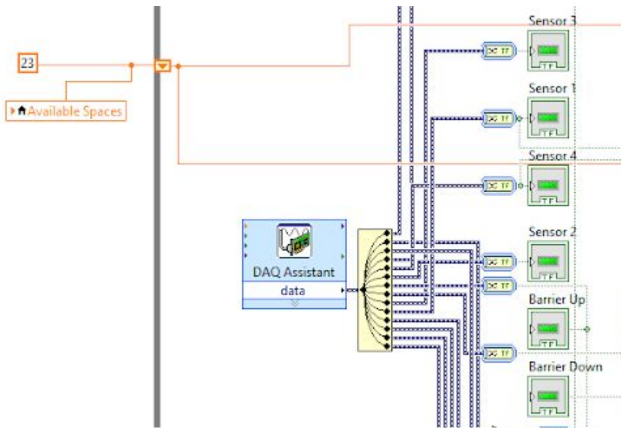

Fig 2.1.4.a Counter Input Section.

2.1.4.b Logic and Output.

In the second part of the counter system, feedback nodes are used to ensure the transition of the state of the sensors is the trigger for count up or down with the inverse signal of the “barrier down” (or similar to the barrier being up). The count is then displayed on “Available Spaces” and return to the edge of the main while loop.

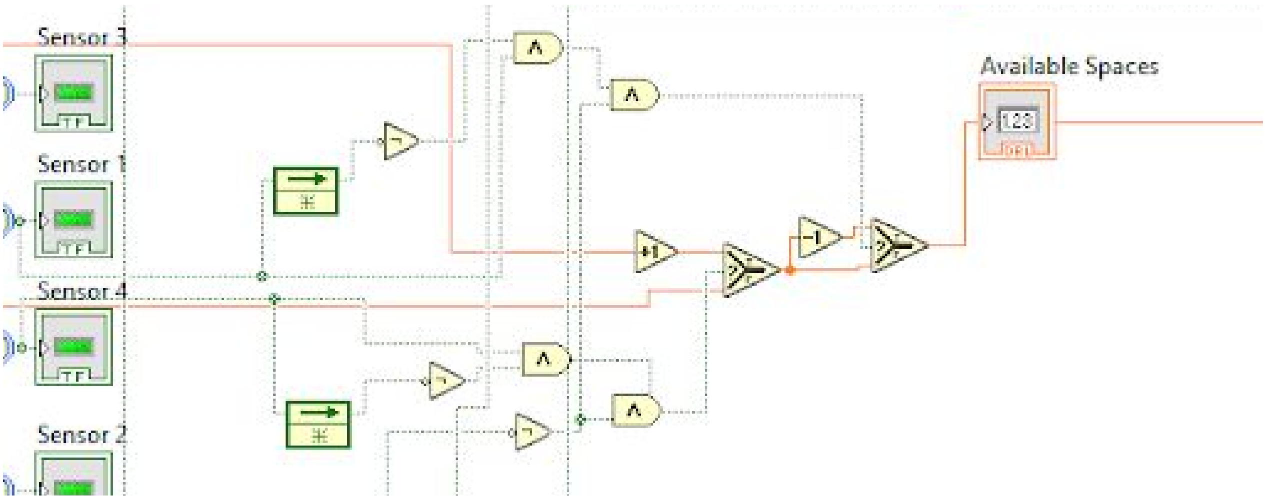

Fig 2.1.4.b Logic section and Output of the Car Counter.

2.2 Car park Operator Control Interface.

This section will present succinctly the main features present on the control panel (Fig 2.2). This is the interface the car park operator will have in front of him at his station.

Fig 2.2 Operator Control Panel.

2.2.1 Operator Controls

As shown in Fig 2.2.1, the controls for the operator are very simple. When prompted the operator can turn off the Help Out or Help In queries with “Help off” or the “Emergency Override Switch” . This switch will also launch the barrier sequence. He can then bring the barrier down using “Barrier Activation”. If the override process was already triggered pressing “Barrier Activation” will cause it to go up again.

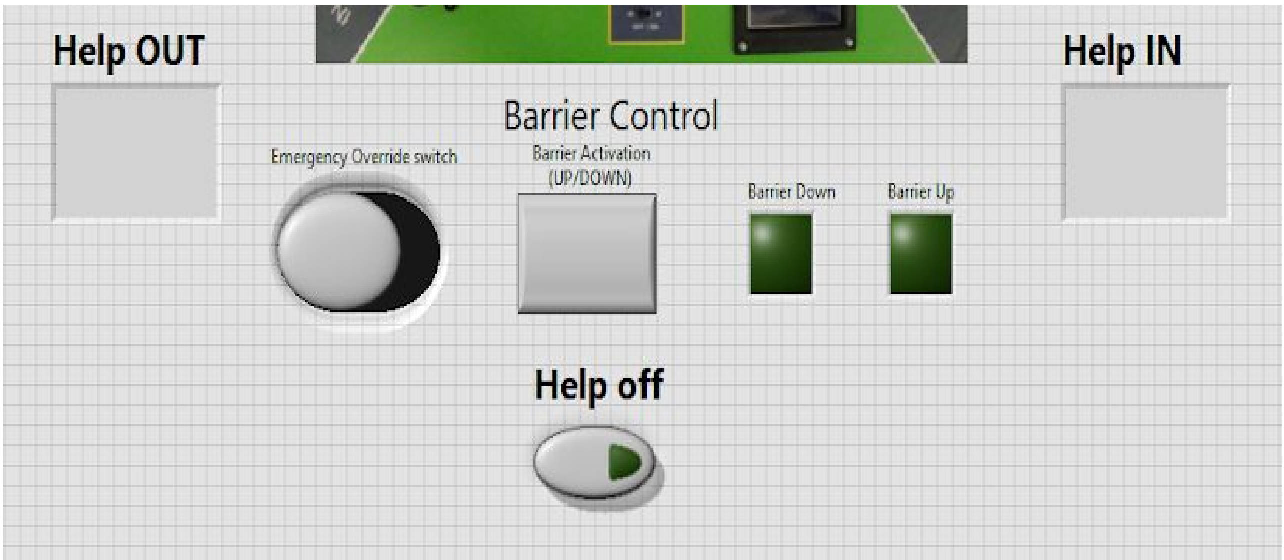

Fig 2.2.1 Operator Controls.

2.2.2 Operator Monitoring

Fig 2.2.2.a demonstrate the visual indicators the operator has available. Here only the entrance side is displayed. The exit side will also be displayed on the control panel as seen on Fig 2.2.

The displays show when the buttons are pushed but also the stage at which the car is going through the car park with sensor 3 and 4. Traffic lights operations are also displayed.

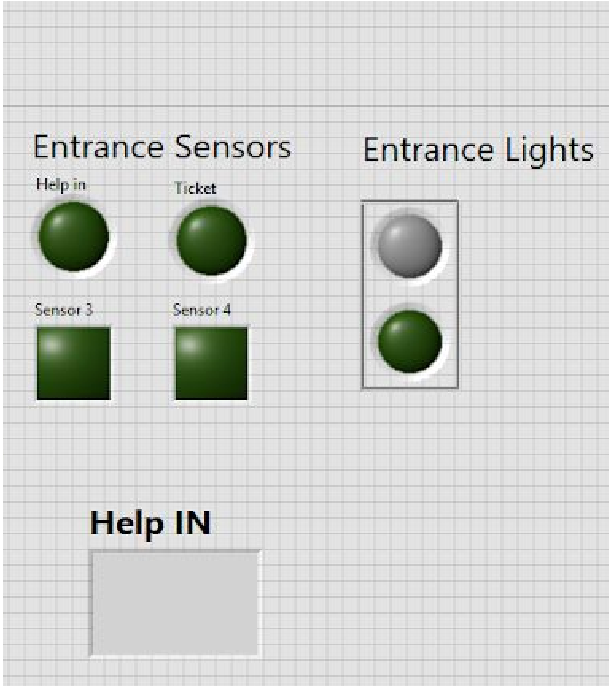

Fig 2.2.2.a Operator Controls.

The operator will also be able to monitor the number of spaces available in the car park thanks to the "Available Spaces" display as shown in Fig 2.2.2.b.

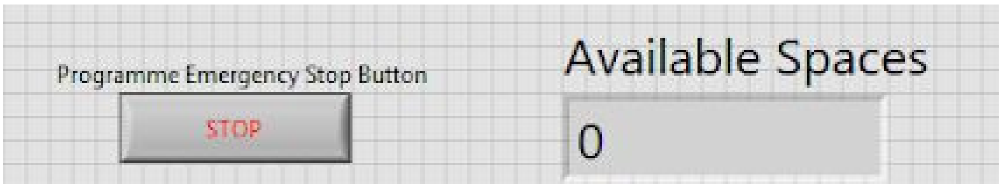

Fig 2.2.2.b Operator Controls.

Conclusion.

In summary, the aim was to develop a LABView Control and Monitoring programme for a predefined system. The car park system being provided without a power control for the drive, a compatible PCB device had to be prototyped, tested and connected to manage to power the drive. This with the LABView programme enabled the control the barrier through the use of a DAQ card to get signals in and out of the computer. The input signals read from the switches and sensors within the system allowed to design a monitoring panel. This panel gives information to the operator about the status of the car park through the sensors but also displays the amount of free spaces available.

Several issues came up during the design process of the programme for the car park. One of the main issues, was configuring the input and output DAQ to be sure the port/line was reading from the right sensor/ switch but also that the right signal was outputted. For the outputs at time it was hard to know if the issue was the programme or the configuration.

The second issue was the logic behind setting the system to override then triggering the barrier and finally reversing the way the barrier was going.

Some additional features were added such as a display for the help queries on the operator panel. An additional feature which was proposed was to add an operator control for the traffic lights. Currently when the system is overridden and the barrier is up but the users do not know if they can proceed or if another will be coming the other way.

After meeting the clients, it was advised that the emergency stop on the operator control would create an issue since it only shuts the LABView programme part therefore the microcontroller would takeover and not stop the system. It was also advised the control panel need a more user friendly aesthetics with more colours rather than an industrial design. This proposition have been taken into account and implemented.