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Design and Implementation of Intelligence Car Parking Systems

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ABSTRACT
The intelligent Car Park System is a system designed to prevent problems usually associated with car parks. This study would cover a wireless transmitter and receiver which is the sensor. The principle of electromagnetic field would be employed in which an inductor would be wound and buried under the entry and exit post of parking garage as a sensor to detect the metal under the vehicle; once the vehicle passes across the searching coil and it automatically opens the parking garage door and closes it after a few minutes. This aimed at solving congestion, indiscriminate parking and the problem of locating empty parking lots. Others significances of the paper are: to eliminate the need for manual operations and make life easier and secure for car owner and eradicates human inconsistencies. It also examines in details how the automatic gate system works and to understand the concepts involved so as being able to incorporate such into an intelligent Car Parking System.

Keywords
Car parking systems, electromagnetic field.

1. INTRODUCTION
For over thirty years, traffic information has been provided to help motorists make en-route decisions. The development of Intelligent Transportation Systems (ITS) and Advanced Traffic Management Systems (ATMS) have begun to improve transportation through the use of technology. Along the same lines, system like Intelligent Vehicle Highway Systems (IVHS), acquire, analyse, communicate, and present information to assist surface transportation. Travellers are moving from a starting location to their desired destination. Data from IVHS can now be utilized as information for en-route assistance as well as collection of traffic data. Information Technology is beginning to recognize the importance of post-trip information dissemination by providing information on the location and

availability of parking. Real-time information can be accurately provided to motorists through Intelligent Parking Systems (IPS) to reduce congestion in or near parking areas, insufficient utilization of the available parking space stock, road congestion caused by space-searching traffic, access problems and safety hazards caused by illegal parking and environmental strains[1], [5], [2]. Recently, people find it easy when using the parking systems because the system is fully automatic [2], [3]. The complexity calls for better management of the parking system which involves technical improvement in the system used. Additionally, users of the parking system commented that bigger parking space means they have to spend more time to find parking area [3].

1.2 Specific Objectives

- To design and implement an intelligent car parking system for both domestic and an official environment.
- To alert the customers when the parking garage is filled and when vehicles are not allowed into the garage until spaces are available.

2 LITERATURE REVIEW OF SIMILAR PROJECTS

2.1 Parking Guidance in Tapiola

Difficulty in finding an unreserved parking space in developing countries is a major challenge. In a research according to [4] opined that insufficiency of Car packs are not only the problems but also, the availability of the location of the available space. The searching traffic, caused by this lack of information, can in some cases be estimated to account for as much as 20 to 30% of the total traffic in cities. The unnecessary traffic generated by searching for vacant parking spaces aggravates congestion on streets and increases the volumes of traffic. The general purpose of parking guidance is to guide the driver to a suitable parking space along a suitable route and thus reduce searching traffic. The paper outlines the research done by [1]in Tapiola, Finland in the year 1992.The system consists of a series of gate-arm counters and induction loop detectors located at the entrance and exits of the car parks count the vehicles going in and out of the car parks. This data is processed in car park counting units and sent to the control center. The central computer assesses the overall situation and decides what to display in each of the 19 changeable message signs on the streets. With this available data, drivers are aware of parking vacancies and locations thereby reducing traffic congestions.

2.2 Vehicle Arrival/Departure Management System Using Remote Bar Code Readers

Research carried out by [2] discusses the development of a remote bar code reader-applied management system for arriving and departing vehicles. The system designed for use at a substation or similar facility, scans a bar code sticker on the windshield of an approaching vehicle and sends signals to open a motor-driven entrance gate, while at the same time automatically recording the type of vehicle, license plate number, vehicle-owner's name, time of arrival/departure and other relevant data.

2.3 Siespace – Car Park Control and Information Systems

Siemens' car park control and information system, SIESPACE, guides the motorist to vacant parking areas, SIESPACE is a modular system designed for use in an urban network where a choice of car parking is available. A computer based in station collates information and determines the appropriate messages to be displayed on guidance signs.

2.4 Saint Paul Advanced Parking Information System

Developments in Minnesota, (1995) shows that Advanced Parking Information System was deployed in late 1995 and early 1996 as a test case under the Minnesota Guidestar Program. Minnesota Guidestar provides overall direction for the Minnesota Department of Transportation's (MnDOT). It is a program that provides a focus for Strategic planning, project management and evaluation. The APIS itself was utilized in the Downtown Saint Paul area to inform drivers of parking location and availability so that they would have the opportunity to make advance decisions hopefully helping reduce congestion and Pollution. The goal of MnDOT is to use the system continuously however, the APIS was only deployed during events in which the Civic Center attracted greater than 2,000 visitors, the Music Center attracted greater than 1,000 visitors, or a combination of events occurred simultaneously.

The system operates using loop detectors, ticket splitters or cash registers as vehicle counting equipment located at each garage or lot. A controller interface is also required since the equipment is not capable of calculating a "space available" number. This interface counts and calculates space availability as each car enters or exits the lot in real time. This number is then transmitted via modem to a central computer at the city. The central computer then sends the required signal along to the variable message signs with the help of MnDOT's Microsoft-based Ramp Management Software. The operator controls the system from the central computer and, at any time, has the ability to read and modify sign messages, correct parameters, check the state of an entire mounted electronic sign mast or parking facility, and take appropriate action as required [5].

2.5 Security Assured Car Park

Derbyshire based Parksafe Systems Ltd is the first car park operator in the UK to guarantee the safety of vehicles, and their contents. The system was installed in Derby city council's Bold Lane car park, under a partnership agreement. Operations started in January 1998 and the company claims, with justification, to have created the most secure public car system. In two years of operation there has not been a single theft of either a vehicle or its contents. This contrasts with seven vehicles stolen and 71 broken into during the year ended December 1997.

Bold Lane car par is an edge of city center multi-storey car park with 440 spaces. It has automatic entry and exit gates, individual bay sensors, secure pedestrian entry points, sophisticated close circuit television (CCTV) and panic buttons every 15 metres on the parking decks and in the stair wells.The strengths of the Parksafe system are that not only is casual access prevented but also that it does not rely on the vigilance of its attendants to monitor CCTV cameras. In addition to cameras in stairwells and pedestrian walkways there is one covering every four parking spaces. However, the relevant camera is only switched on, and an attendant alerted, if a bay sensor is activated or a panic button is pushed. In that event, attendants are able to observe record and take appropriate action.

3 METHODOLOGY

Circuit design and Analysis

The methodology employed in this project is experimental where all the following mentioned devices and components would be used.

3.1 Principle of Operation

The principle of operation is based on a sensor, which detects the car entering and exiting the building. The garage door automatically opens, once the vehicle is moving towards the building gate and closes after car has passed through the gate. Three displays are used for the monitoring of **ENTRY / EXIT.** The sensor is installed at the doors post of the parking garage. This project employed the use of sensing the metal underneath the car in which the sensor is buried and installed underground. The metal underneath the car is detected using the beat frequency technique whereby an inductor is a search coil, which forms part of a Logic Control (LC) network circuit. The LC network is part of a colpitts oscillator stage, which oscillates at a constant frequency. The field strength of the coil reduces as a metal enters the field, which consequently tends to dampen the oscillations and also drift the frequency. The output is fed to a peak detector (which senses the dc level) and comparators with a variable reference for sensitivity adjust. Once a metal enters the field, the output of the comparator goes LOW and triggers a monostable stage for time (T), during which two operations are achieved.

1. A monostable multivibrator, which clocks the counter to count-up for **ENTRY**. If a car enters into the building, while the **EXIT** counter count – down, an independent counter is configured to count UP/ DOWN to monitor both the Entry and Exit. This counter will display the **NET** count, which is the number of cars still left inside a particular car lot or garage.

2. The switching of the sliding door was achieved using a logic gate and timer to control the opening and closing of the door. Once the metal under the car is detected two monostable is trigger, one is design to activate the switching circuit which is responsible for the opening of the gate, while the other monostable later activate the switching circuit which is responsible for the closing of the gate. Once the full capacity of the garage is achieved, the garage gate automatically denied entry to others cars coming in, also truck and bike of heavy and lower capacities of range set are disallowed.

This project employed the use of principle of AC to DC converter for the power supply unit in which two different voltages were derived; 5v DC and 12v DC. The 5v works for the entire circuit while the 12v was used to power the relays and the auto reverse DC motor.

3.2 Oscillator Stage – Search Coil

The oscillator stage is designed using a colpitts oscillator where the search coil is the inductor L. Fig 1 shows the oscillator circuit. The oscillator stage generates a varying output when the metal is in the field.

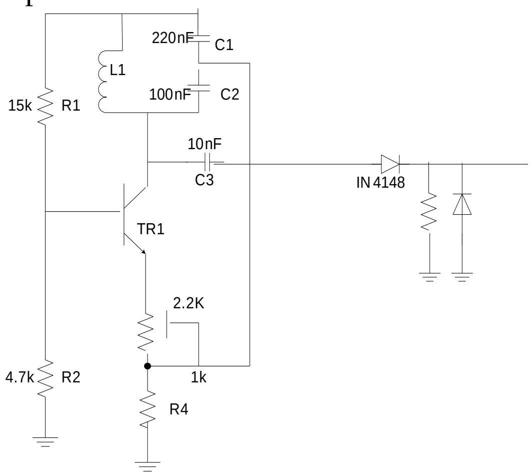

Figure 1. Colpitts oscillator stage. Source: [5]

For the colpitts oscillator stage the frequency of oscillation f_o, is given by,

$f_o = 1 / (2\pi\sqrt{LC})$

Where:

f_o = 10KHz = 10,000Hz
C = [C_1C_2 / (C_1 + C_2)]
C_1 = 100nF = 100 x 10^{-9} F = 1 x 10^{-7} F
C_2 = 220nF = 220 x 10^{-9} F = 2.2 x 10^{-7} F
L = ?
C = [C_1C_2 / (C_1 + C_2)] = [(1 x 10^{-7}) x (2.2 x 10^{-7})] / [(1 x 10^{-7}) + (2.2 x 10^{-7})]
Therefore,
C = 6.875 x 10^{-8} F (or 68.75nF)
Transposing L and substituting for all the values in f_o,
$f_o = 1 / (2\pi\sqrt{LC})$
$L = 1 / (2\pi f_o)^2 x C$
L = 1 / [(2 x 3.14 x 1000)^2 x 6.875 x 10^{-8}]
L = 0.368814519H (or 368.8mH) being inductance(ß).
To get a uniform field, a toroid has to be designed to represent the inductor of inductance = 368.8mH.

Fig 2 shows the search coil (toroid).

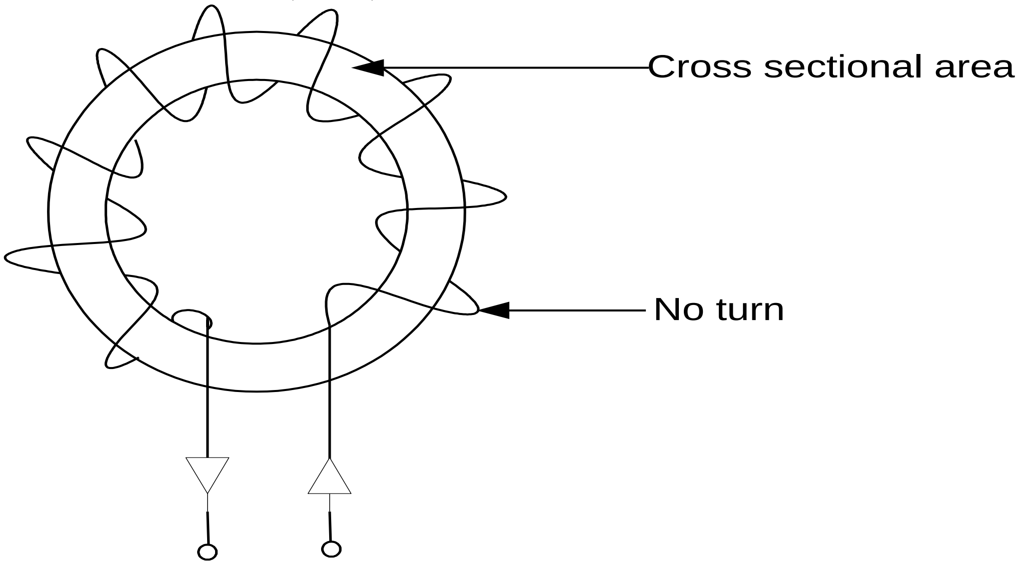

Figure 2. Search coil (toroid). Source: [5]

Where the inductance (ß) = [(μ_oAN^2) / L_o]
Therefore, ß = [(μ_oAN^2)/ L]
The no of turns to give the desired inductance would be calculated.
Where: μ_o is permeability of vacuum (Hm^{-1})
A is cross-sectional area (m^2)
N is number of turns of windings
L_o is length of loop
Since ß = 368.8mH
And μ_o= 4π x 10^{-7} Hm^{-1} = a constant
For L_o = 15cm = 0.15m loop length

and $A = \pi r^2$
where $d = 1cm = 2r$
therefore, $r = 0.5cm$
Thus $r^2 = (0.5)^2$
$A = \pi \times (0.5)^2$
$A = [(22/7) \times 0.25] = 0.79cm^2$
From the equation,
$ß = [(\mu_o A N^2)/ L_o]$
Substituting for all the values,
$0.368814519 = [((4 \pi \times 10^{-7}) \times 0.79 \times N^2) / 0.15]$
Therefore, $N^2 = [(L_o \times ß) / (\mu_o \times A)]$
Therefore, N = 236 turns.
Hence winding 236turns for the inductor will give the required inductance.
Resistors R1, R2 and R4 are dc bias resistors for the transistor T1.

3.3 Comparator - Calibrator

The peak detector output is fed to the inverting input of the comparator, where it is compared with a reference voltage (akin to a reference oscillator in the analog beat frequency type). When metal enters the field, the voltage at the comparator input drops below the reference to give a LOW output that triggers a 555 timer monostable stage. Fig3 shows the comparator stage.

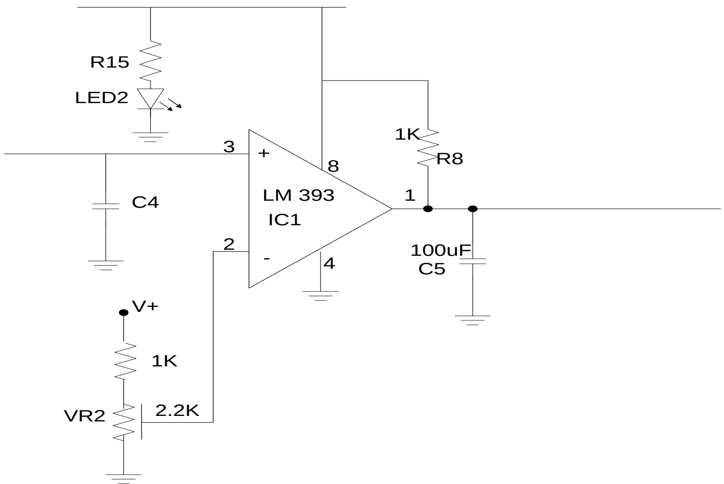

Figure 3. Comparator stage. Source: [5]

VR2 is set at 2.6 V(this is because when metal is detected the voltage drops from approximately 4V to 1.5V), any voltage below 2.6V in the inverting input will make the output of the comparator go low, to trigger the monostable stage since,
$Vout = A_0 \, Vin$
Where A_0 = open loop voltage gain.

And Vin = $V^+ - V^-$
Vout will drop to 0V for the slightest negative difference in voltage since A_0 is often very large (in order of 20000).

3.4 One Shot Monostable Stage

The monostable stage generates a one shot pulse once triggered from the sensor stage. When the comparator gives a low the one shot monostable generates a one shot pulse for one second (1s) to update the counter. Fig 4 shows one shot monostable.

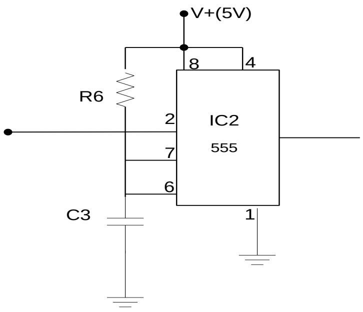

Figure 4. One Shot Monostable Source:[5]

Since T = 1.1RC, and the required time duration of the monostable is 1s; (To allow for fast clocking of the counter).
Letting C=10uF,
Gives R = 1/ 1.1x10uf
= 90.9K = 10uF.

The one-shot monostable stage generates one shot of clock pulse each time the search coil detects a metal. The one-shot monostable is triggered from the output of a comparator, which senses the break beam. The one shot monostable is built around IC2 in Fig 4.

Since T = 1.1RC, and the time duration of the monostable is 5s; (To allow for continuous beeping for time T, after metal has been detected).
Letting C=100uF,
Gives R = 5/ 1.1x100uf
= 9.09K
= 45.5KΩ.
= 47 KΩ.

3.5 Switching Transistor for Relay

The switching transistor switches the power to the auto reverse DC motor as shown in fig 5.

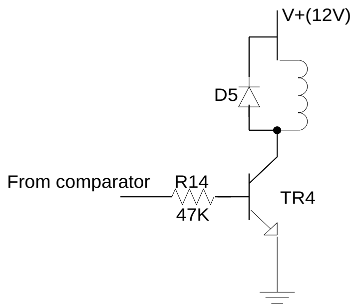

Figure 5. Switching transistor stage. Source:[5]

The transistor as a switch operates in class A mode. A base resistor is required to ensure perfect switching of the transistor in saturation. Diode D5 protects the transistor from back emf that might be generated since the relay coil presents an inductive load.

In this case RC, which is the collector resistance, is the resistance of the relay coil, which is 400Ω for the relay type used in this project.

Hence, given that RC = 400Ω (Relay coil resistance)

V^{+} = 12V (regulated voltage from the power supply stage)

Vbe = 0.6V (silicon)

Vce = 0V (when transistor is switched)

Vin = 3.5(from the comparator output)

Hfe = 300 (from data sheet for BC337)

Since,

$V_{+} = I_c R_c + V_{CE}$ -- equation (1.0)

$V_{in} = I_B R_B + V_{BE}$ -- equation (2.0)

$I_C = \frac{h_{fe}}{I_B}$ -- equation (3.0)

$R_b = \frac{V_{in} - V_{BE}}{I_B}$ -- equation (4.0)

Where,

I_C = collector current

I_B = base current

V_{in} = input voltage

V_t = supply voltage

V_{CE} = collector-emitter voltage

H_{fe}= current gain.

From 1.0, 12 = IcRc +Vce

$$12 = Ic\,(400) + 0$$

and, $Ic = 30mA$

From 3.0, $I_B = 30mA/300$

$= 100uA$

From 2.0, $3.5 = 100uA\ R_B + 0.6$

$R_B = 11.4/200uA$

$= 29K\Omega$

$=30$ K (preferred value).

Hence R11 – R14 = 29K.

3.6 Counter / Decoder Driver Stage

The counter stage is a cascaded 3-digit counter using 7490 decade counters. To inhibit counting or reset the counter, the reset inputs most go LOW. The D output (MSB) of the first counter is used to clock the second counter while resetting of the counters can be done from the cascaded reset inputs via switchS1.The counter stage counts from units 0-9 before being reset. The output of the counter is fed to the decoder/ driver stage to allow for decimal display that enables the user to know the number of objects that have passed the sensor. The 7447 is 7 – segment decoder which accepts a 4 – bit BCD and produces the appropriate outputs for selection of segments in a 7 – segment displaying arrangement used for representing the decimal numbers 0 to 9. The outputs (a, b, c, d, e, f, and g) of the decoder select the corresponding segments as shown in fig. 6

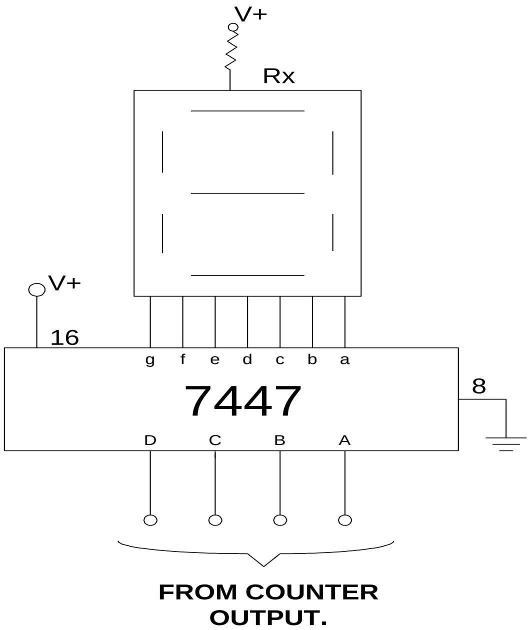

Figure 6. Seven Segment Digital Display. Source: [7]

The value of the limiting resistor R_x is calculated is shown below. The display has the following specifications,

Max. Forward current (If) = 16mA

Voltage drop across each LED V_{LED} = 1.7V

And V^+ = 5V

$$V^+ = IF\,R_x + VLED$$

$$R_8 = \frac{V^+ - VLED}{I_F}$$

$$= \frac{5 - 1.7}{16mA}$$

$$= \frac{3.3}{16mA}$$

$$= 206.25\Omega$$

$$= 220\Omega \text{ preferred value.}$$

Hence R8-R10 = 220Ω

Fig. 7 below shows the counter and decoder driver stage.

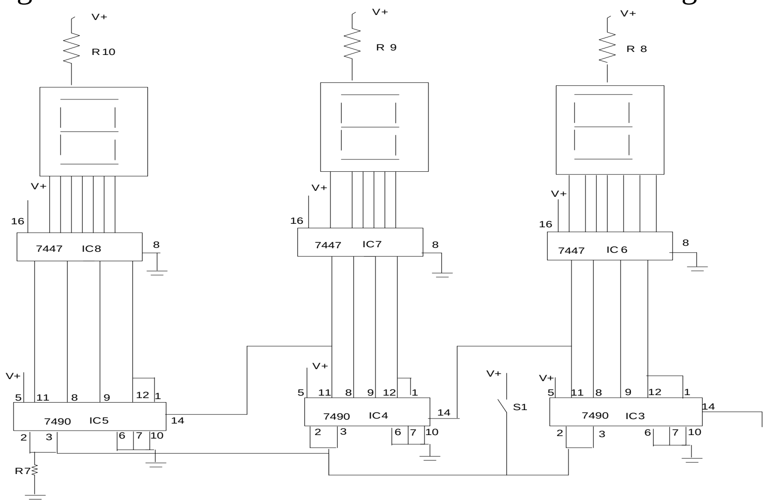

Figure 7. Counter / Decoder Driver Stage.Source :[6]

3.7 Power Supply Stage

All stages in the project use +5v excepts the relay circuit that uses +12V. The power supply stage is a linear power supply type and involves in step down transformer, filter capacitor, and voltage regulators, to give the various voltage levels. The power supply circuit diagram is shown in fig.8.

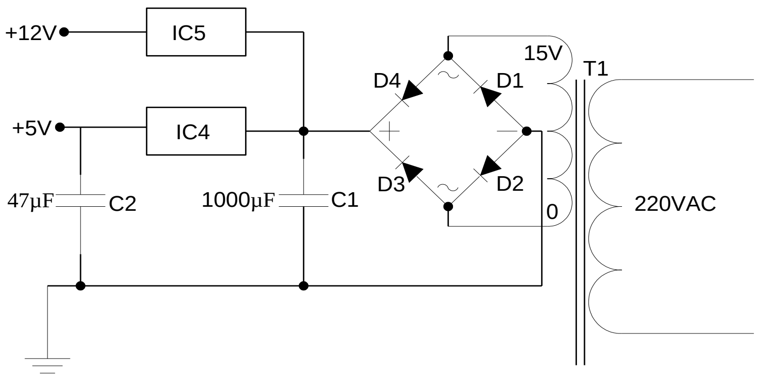

Figure 8. Power Supply Stage. Source [6]

The choice of the filter capacitor is dependent on the output current. Given that:

V_r ($_{rms}$) = 2.4 I_l/C_{FI} ………….. (1)

Were V_r ($_{rms}$) = Rectified D.C ripple voltage

I_l= Load current (mA)

C_{FI} = Filter capacitor (µF)

For a load current of a (500mA), and a ripple factor of 5 %

V_{rms}= Vpeakx√2

= 15v x √2

= 21.2V

For a ripple factor of 5%

$V_{r(rms)}$ = 5/100 x 21.2

= 1.06V

∴From (1)

2.12V = 2.4 x 500mA/C_{FI}

G_{FI} =2.4 x 500mA / 1.06V

=1,132µF

= 1000µF preferred value.

Hence, C1= 1000uF, C2 = 47uF.

3.8 Logic Gate (Xor Gate)

The logic control circuit in this project controls the switching of the relay that is responsible for opening and closing of the gate. The XOR gate only gives a HIGH output when either of the inputs is HIGH and the other is LOW (AB + AB); hence term unequal comparator as shown in fig. 9.

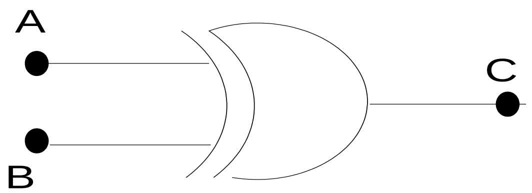

Figure 9. Shows the exclusive OR gate symbol Source: [5]

Table 1. Truth Table

INPUT	INPUT	OUTPUT
A	**B**	**C**
LOW	LOW	LOW
LOW	HIGH	HIGH
HIGH	LOW	HIGH
HIGH	HIGH	LOW

3.9 Comprehensive Circuit Diagram

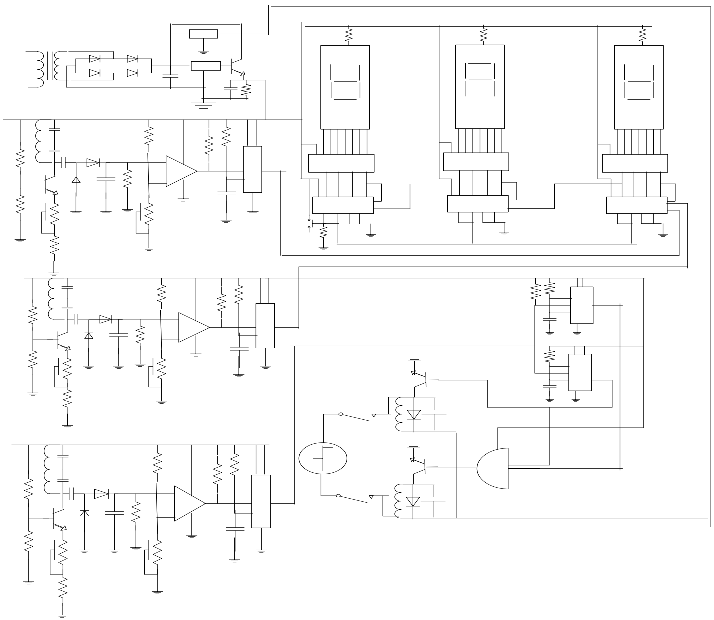

Figure 10. Comprehensive circuit diagram. Source :[7]

3.10 Component List

1. IN4007 ….RECTIFIER DIODE
2. 7806…….. 5V DC LINEAR REGULATOR
3. 7812……..12V DC LINEAR REGULATOR
4. 7 SEGMENT COMMON ANODE DISPLAY
5. 7447…… DECODER
6. 7490….. DECADE COUNTER…
7. LM393…..VOLTAGE COMPARATOR
8. TIP 41…..BUFFER TRANSISTOR
9. BC 337….. SWITCHING TRANSISTOR
10. 7411…. LOGIC AND GATE
11. NE555…. TIMER

12. 3300UF (25v)…. Filtering capacitor
13. 47uf (25v)
14. 10uf (25v)
15. 4.7k…. RESISTOR
16. 15K
17. 10K
18. AUTO REVERSE DC MOTOR
19. LIGHT EMITEN DIODE
20. COIL
21. IC SOCKET
22. ELECTROMAGNETIC SWITCH. (RELAY)

4 IMPLEMENTATION (CONSTRUCTION AND TESTING)

This session seeks to look at the workability and practicability of the intelligent car parking system when the system is fully constructed and operational. The implementation of this paper was done on the breadboard. The power supply was first derived from a bench power supply in the school electronics lab. (To confirm the workability of the circuits before the power supply stage was soldered).Stage by stage testing was done according to the block representation on the breadboard, before soldering of circuit commenced on Vero board. The various circuits and stages were soldered in tandem to meet desired workability of the project.

4.1 Construction

The construction of the project was done in two different stages.
1. The soldering of the circuits to the boards
2. The coupling of the entire project to the casing.
The first stage was first constructed before the other stages were done. The soldering of the project was soldered on four Vero boards because of the complexity of the circuit.

The first Vero board contains the power supply, oscillator and comparators and the second contains the XOR gate and the monostable stages, the third contains the counter, decoder and display stages; and the fourth contains the switching circuits which could not be displayed because of size of file.

4.2 Casing and Boxing

The second phase of the project construction is the casing of the project. This project was coupled in a metal (PLASTIC) casing. The casing material being wrought metal (STAINLESS STEEL OR FIBER GLASS PLASTIC), designed with special perforation and vents and also sprayed to ensure insulation and give ecstatic value which we couldn't show because of its large size.

TABLE 2. Bill of Quantity

ITEM	QUANTITY
in4007 rectifier diode	9
7806 5v dc linear regulator	1
7812 12v dc linear regulator	1
7 segment common anode display	3
7447 decoder	3
7490 decade counter	3
lm393 voltage comparator	4
tip 41 buffer transistor	1
BC 337 switching transistor	4
7411 logic XOR gate	1
ne555 timer	6
3300uf(25v) filtering capacitor	1
47uf(25v)	6
10uf(25v)	1
4.7k resistor	5
15k	5
10k	5
auto reverse dc motor	2
light emitting diode	1
Coil	4
IC socket	(8 pin) 8, (14 pin) 2, (16 pin) 6
electromagnetic switch relay	4

5. CONCLUSION

The project which is the design and construction of an intelligent car parking system was designed considering some factors such as economic application, design economy, availability of components and research materials, efficiency, compatibility, portability and durability. The performance of the project after testing met design specifications. However, the general operation of the project and performance is dependent on the user who is prone to human error such as failure to perform or omitting a task, slips of action, performing the task incorrectly, lapses of memory, knowledge- based mistakes, etc. The operation is dependent on how well the soldering is done, and the positioning of the components on the Vero-board. If poor soldering lead is used the circuit might form dry joint early and in that case the project might fail. Also if logic elements are soldered near components that radiate heat, overheating might occur and affect the performance of the entire system. Other factors that might affect performance include transportation, packaging, ventilation, quality of components, handling and usage.

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