Automation of Vehicular Parking Using Loop Detector with single lane traffic: A Design Approach

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***Abstract*— With increase in number of vehicle users day by day, traffic and parking of vehicles have become major problems. In this paper, we have designed an automatic vehicular parking system using loop detector which detects the presence of vehicle and displays the corresponding parking slots available in the parking area so that manual risk is reduced. In the past many parking systems were developed using magneto-resistive sensors, IR sensors and image processors. Here we are using low cost loop detector that is also insensitive to any climatic conditions, easy to maintain, long lasting and whose detection range is maximum. Loop detector works on the principle of change in its inductance (due to change in flux density) when a metal surface comes closer to it. A better approach was followed in developing the algorithm for parking.**

***Keywords*— Loop detector, Tank circuit, Vehicle detection, Smart parking, Resonance circuit**

I. INTRODUCTION

In the past vehicle detection is done by using different types of sensors like Pneumatic sensors, magneto sensors, video image processors, IR sensors etc. However, the biggest drawback of these technologies is evident when vehicles either accelerate or decelerate while crossing the sensors, since, in such situations these sensors develop accuracy problems [2]. Pneumatic sensor sends a burst of air pressure along a rubber tube when vehicle passes over the tube. But these sensors are highly temperature sensitive and cause maintenance issues. Magnetic sensors are passive devices that indicate the presence of a metallic object by detecting the perturbation in the Earth’s magnetic field created by the object. These magnetic sensors cannot generally detect stopped vehicles and they have small detection zone. Similarly, surveillance video camera sensors have accuracy problems in recognizing a small vehicle (e.g., a passenger car) behind a big vehicle (e.g., Innova or Xylo) in congested conditions and are affected by illumination problems, bad weather conditions, shadows, vehicle/road contrast, water etc. Further, the installation of a video image processor may require 50 ft. or greater camera mounting height for optimum presence detection which is not possible if we consider a Multi stored car parking area. Similarly, IR sensors are affected by glint from sunlight, atmospheric particles and are sensitive to water concentrations in fog, haze, rain and snow as well as to other obscurants such as smoke and dust. So we have used loop detector whose detection zone is maximum, cheap, and insensitive to any climatic conditions. Loop detectors overcome the problem of mounting the sensor with supportive cross arms [1].

The principle components of an Inductive loop system include one or more turns of insulated loop wire wound in a shallow slot sawed in the pavement of a road at the entrance of car parking and at parking slots. Whenever a vehicle passes over the loop or stops within the loop, the inductance of the loop decreases [3]. We designed a module which gives a fixed voltage without a vehicle and during the presence or passage of a vehicle, this voltage changes because of the decrease in inductance [4]. This voltage shift is observed using a microcontroller, which triggers a pulse whenever a vehicle approaches.

The present work proposes a new and simple inductive loop sensor structure that senses the presence of a vehicle without any errors. The details of the new inductive loop structure, circuit design, and methodology followed, principle of operation, experimental set-up and results of field trails are discussed in the following sections of the paper.

II. NEW INDUCTIVE LOOP SENSOR

The main part of the loop detector is the tank circuit. Designing and operating frequency of the tank circuit plays a key role in vehicle detection. If we use series LC circuit, then the current will be maximum at resonance which cannot be measured with practical ammeters and if we go for parallel LC circuit, we need a current source which is practically not possible. So to rectify above problems, we have used CLC tuned circuit which is shown below in Fig1.

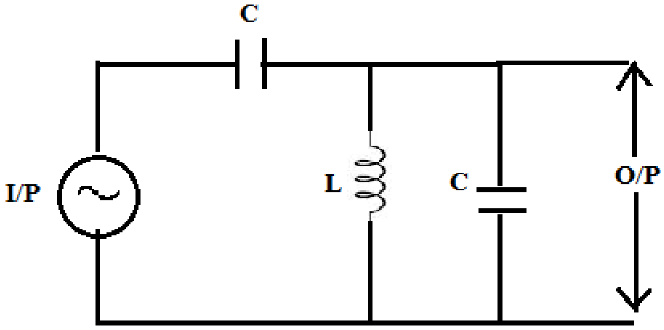


Fig1: CLC Tuned Circuit

Here the inductance (L) is provided by the loop which is made from 18gauge insulated copper wire. Upon trying different shapes of the loop like rectangular, elliptical and circular, it was observed that circular loop gives more inductance and is able to track the changes faster than the rest whenever a metal surface approaches. Theoretically inductance of the loop is given by

$$L = N^2 R\mu \left[\ln\left(\frac{8R}{a} \right) \right] \text{ Henry.}$$

Where N is the number of turns, R is the radius of the loop, μ is the permeability of the medium, a is the thickness of the wire [7].

Once the tuned circuit is properly designed, the frequency of operation is the key factor to be considered. The resonant frequency of the above tuned circuit is given by

$$F_r = \frac{1}{2\pi\sqrt{LC}} \text{ Hz.}$$

Where L is the inductance of the loop and C is the equivalent capacitance of the tuned circuit. Whenever a metal surface (vehicle) approaches the loop, the inductance of the loop decreases and the resonant frequency of the circuit increases.

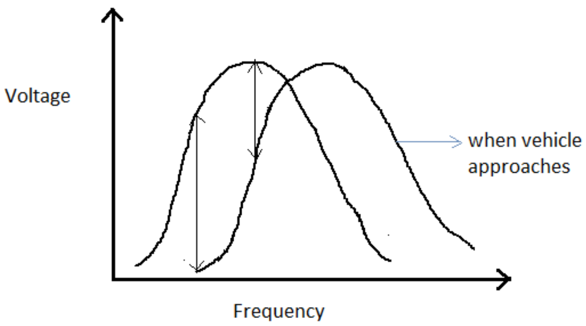


Fig2: Voltage vs. Frequency without and with Vehicle

Now the two possibilities for the frequency of operation are i) at the resonant frequency ii) Below or above the resonant frequency. From the above Fig2, practically we have observed that voltage shift is more if operated at just below or above the resonant frequency than at resonant frequency. As we are using this voltage shift to find the presence of a vehicle, more voltage shift gives fewer errors in detection.

TABLE I
Voltage Shift for Different Frequency of Operation

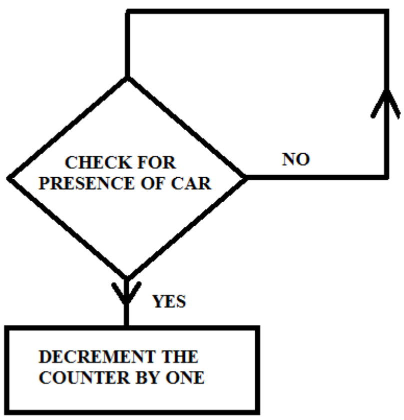
Frequency of Operation	Voltage Shift Observed
114KHz	1V
100KHz	1.25V
95KHz	3V
90KHz	2.4V
85KHz	2V
75KHz	1.3V

TABLE I shows about the voltage shift for different frequencies of operation (supply voltage 12V) assuming vehicle metal parts are 15cm above the ground. The resonant frequency of the tuned circuit we developed is 100 KHz.

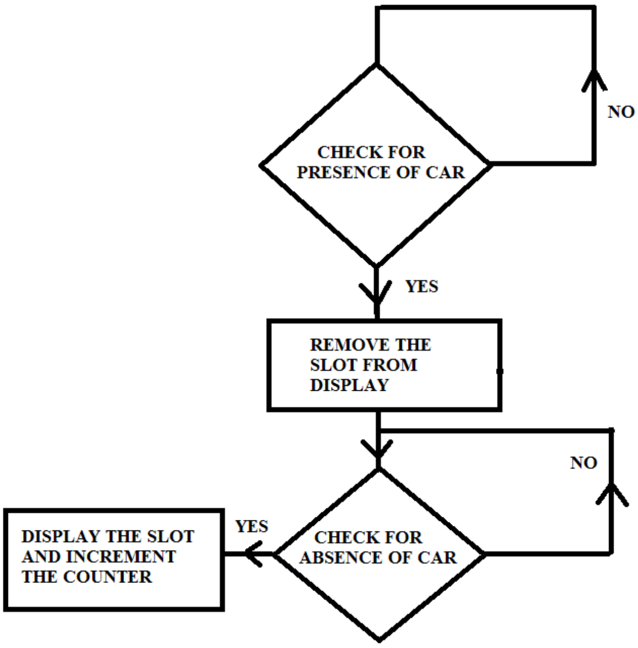
Even if we drive the tank circuit with a square wave signal, the output from the tank circuit is a sinusoidal signal because a square wave is a combination of different frequency sine waves [5] and the tuned circuit acts as a filter allowing only one sinusoidal signal of operating frequency. The voltage of this sinusoidal signal decreases whenever a metal surface approaches. It is difficult to compare the voltages in AC, so the sinusoidal signal is rectified and converted to DC. Now we will have a threshold such that if the output DC voltage is more than threshold, it indicates absence of the vehicle and if the DC voltage is less than the threshold, it indicates the presence of vehicle. This voltage comparison can be done using either a comparator or controller. The problems with analog comparators are, they are not very precise and are slow [6]. So we used controller for voltage comparison. As we are connecting a high output impedance rectifier circuit to low input impedance controller, to avoid loading effect we need a voltage buffer. So we used a unity gain op-Amp voltage follower (voltage buffer) to connect rectifier and controller [6].

III. SMART PARKING

In this paper we are discussing a situation, where a parking region may contain thousands of parking slots which are busy at times. We developed a system where a loop sensor is placed at every parking slot and one more loop sensor at the entrance with single lane traffic. This loop sensor at the entrance is connected to a counter showing the number of parking slots still vacant. When a vehicle passes over this sensor, the counter value decrements by one. We are using a counter to avoid last user problem. This arises when there is only one slot available and before the user reaches the parking slot; there is a chance of a new user getting inside. To avoid this inconvenience to the last user, we are going for a counter. The algorithm for car parking is explained through following flow charts.



The total layout of the parking region is displayed at the entrance, which shows the total available slots to the users and the information of the particular slot available. When the parking slot is empty, its corresponding number is displayed at the entrance specifying the user about the parking slot. When there is car parked in a particular slot, its number won't be displayed at the entrance. When the car leaves the parking slot, its corresponding slot is displayed at the entrance and the counter is incremented by one. Thus, the free slot is made available to the user.



In a multi-storeyed parking region where there is chance of having thousands of parking slots available, we come across the problem of wiring from each slot to the entrance display unit and it becomes complex at times during installation. So to overcome this problem we used an RF transmitter at each slot which is connected to the detector circuit and an RF receiver at the entrance. This RF receiver receives the information from the RF transmitter of each parking slot and displays this information to the user through an LCD.

IV. TEST RESULTS

The loop detector we developed is tested outdoors with a car and the results are tabulated as follows in Table II:

TABLE II
Voltage Shift for Different Frequency of Operation

Test Case	Voltage(V)
Without any car	3.89V
Heavy vehicle	3.75V
Mini vehicle	3.68V

Fig3: Experimetal seup

The design of the car parking is explained with the following three scenarios and shown in Fig4:

I. *CAR ENTERING AT THE ENTRANCE*

When the voltage of the detector falls below the threshold, the loop at the entrance decrements the counter and displays the corresponding total available slots that are free.

II. *CAR PARKED AT THE PARKING SLOT*

When the voltage falls below the threshold at the parking slot then the corresponding slot is removed from the display at the entrance specifying to the new user that it was filled.

III. *CAR LEAVING THE PARKING SLOT*

The microcontroller when founds that the car left the place from the slot, it increments the counter and at the same time the corresponding slot is displayed at the entrance specifying the user that the particular slot is free for parking.

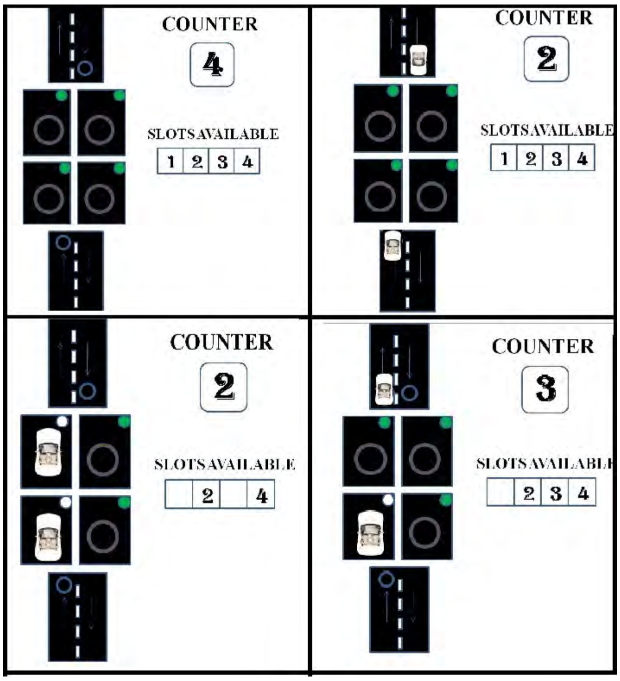


Fig4: Different scenarios in parking

CONCLUSION

The designed loop detector was installed in the ground with a PVC enclosure. As it was not disturbed, errors were minimised. To avoid unnecessary glitches in our circuit a proper coding technique is used. Still a proper design of oscillator with minimum noise helps to reduce glitches in the detector. This loop detector can be used in many other applications like speed detection, Vehicle type detection since it is easy to maintain when once installed and its property of not responding to environmental changes.

REFERENCES

[1] Sheik Mohammed Ali S, Boby George, Lelitha Vanajakshi, Jayashankar V, Jagadeesh Kumar V, "*Multiple Loop Vehicle Detection System for Heterogeneous and Lane-less Traffic*", IEEE,2008

[2] Janusz Gajda, Piotr Piwowar, Ryszard Sroka, Marek Stencel, Tadeusz Zeglen "*Application of inductive loops as wheel detectors"*, Science Direct,2012.

[3] Preeti Bajaj, Prashant Sharma, Amol Deshmukh, V. S. Reinhardt, and S. A. Vaughn, "*Vehicle Classification for Single Loop Detector with Neural Genetic Controller: A Design Approach*" , IEEE 2007

[4] Sonar Meta, Muhammed. G Cinsidikici, "*Vehicle- Classification Algorithm Based on Component Analysis for Single Loop Inductive Detector"*,IEEE transactions on Vehicular technology, vol-59, July 2010.

[5] Signals and Systems, Pearson Edition-4, B.P.Lathi, 2004

[6] Linear integrated circuits, edition 3,Roy Chaudary, 2009

[7] Handbook of Inductive loop Calculations, Mark T. Thompson