Vehicle Parking Watch for A Sustainable Traffic Management

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Abstract

Traffic congestion, especially in developing countries, has long been recognized as a challenge. In the Philippines, where road networks and paved roads are very limited, the usual response to congestion is to build additional lanes to increase capacity. However, this approach is always limited by the availability of funding. Due to this constraint, local government units, being empowered by the Local Government Code of 1991, use many styles and means of solving traffic congestion problems in their local units. Iligan City, for example, implemented parking pricing as a management strategy through a City Ordinance to reduce traffic congestion problems. This study attempts to establish habits and rituals of discipline in the use of narrow streets in Iligan City. A model of the vehicle parking watch device is developed, installed and tested in the MSU-IIT campus. This device detects illegally parked vehicles in NO PARKING areas and warn the motorist of the NO PARKING regulation.

Key Words: parking, traffic congestion, management, sustainability, discipline

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Introduction

Traffic management is one of the essential elements of social education and control. It is necessary for the creation of habits and rituals of discipline on the road. On the other hand, road discipline will likely have spill-over effects into other behavioral areas like corruption, crime, garbage disposal and other areas essential for a healthy and friendly environment.

The Philippines consists of many ethnic groups spread across an archipelago. Each of these ethnic groups has its unique culture that dictates the people's way of life in and out of their community. Some groups are more disciplined than others.

Iligan City is 37 kms away from Marawi City, home of the Maranaos, and 87 kms. away from Cagayan de Oro City. The volume of road traffic in Cagayan de Oro City is higher compared to that in Iligan City or in Marawi City yet Cagayan de Oro road users are more disciplined as manifested in the orderly discharge of traffic.

The road is one of the places where the norms of civility are being demonstrated. It is where the law enforcers are tested in their ability to enforce traffic rules and regulations to citizens who openly violate them. It is where habits of obedience or of defiance are formed and maintained, where youths learn and unlearn civic responsibility, and where reforms can be immediately implemented and gains demonstrated. Traffic discipline should not be looked upon as a mere reflection of the poor state of discipline in a society; it can be re-engineered so as to influence the state of national discipline.

This study develops a device known as the vehicle parking watch to help traffic police enforce the NO PARKING traffic regulation in particular sections of the roads in Iligan City. The benefits that can be derived from this study include increased capacity and smooth flow of traffic and behavioral transformation among motorists to instantly obey rules and regulations. The device is developed, installed and tested as shown in Figure 1.

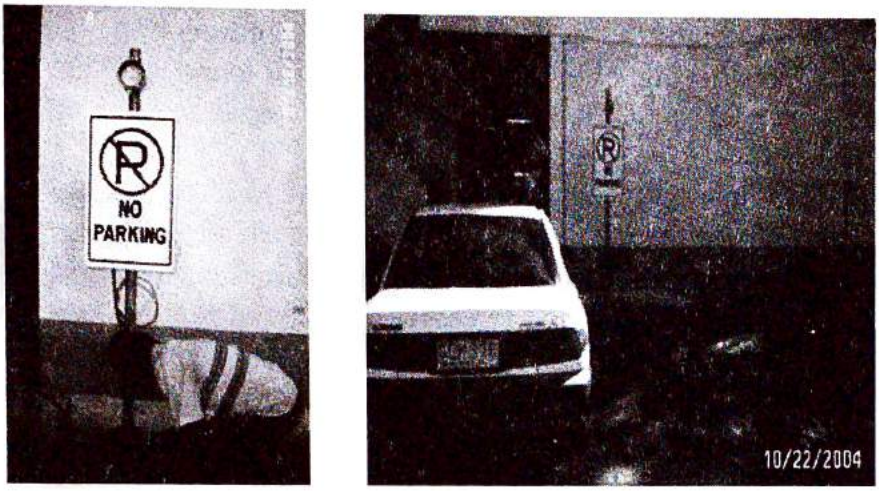

Figure 1. Installation and Testing of the Vehicle Parking Watch Device

Other countries have more advanced researches on the development of traffic sensors with application in parking, traffic jams and vehicle classification. Acquiring technology developed by other countries is costly and technically unsustainable in the long term. This is because, in case of major failure of the device, technical experts need to be hired from the source country. In case of replacement of parts, parts need to be ordered from the source country. This study also hopes to provide solutions to the technical and economic aspects of traffic management.

Vehicle Parking Watch

A sensor, consisting of 4 turns of 2-mm diameter wire, is embedded in a 2.0-m x 3.0-m concrete pavement. As this sensor detects a vehicle parked on top of the pavement, it activates the warning beacon, used in conjunction with the NO PARKING sign, to produce a flashing light. The sensor also activates the sound signal system to further warn the motorist of his violation, in case he fails to notice the flashing beacon.

The Inductive Loop Sensor. Inductive loop detector technology has been used for the detection of vehicles since early 1960's. The first loop detector designs were based on solid-state analog technology using discrete components including transistors, diodes, etc. These designs were very similar in many respects and provided detection of vehicles occupying the zone defined by the perimeter of the loop. The loop occupies areas that vary from small areas (e.g., 1.8 m. x 1.8m.) to very large areas (e.g., 1.8 m. x 30.5 m.).

The primary component of an inductive loop detector is a wire carrying an alternating current. Any wire with flowing current that is constantly changing exhibits a property called inductance. Inductance is an electrical behavior that tends to resist the flow of alternating current. It is greatly affected by several factors including the geometry of the wire and the environment where it is placed. The inductance becomes noticeable when the wire is shaped as a loop with many turns.

In this study, the sensor consists of four 2-mm diameter wire loops. These loops are embedded in a 2-m. x 3-m. concrete. The inductance of these loops is calculated using the following formula (Bowick, 1982):

$$L_{rect} = N^2 \frac{\mu_o \mu_r}{\pi}\left[-2(w+h)+2\sqrt{h^2+w^2}-h\ln\left(\frac{h+\sqrt{h^2+w^2}}{w}\right)-w\ln\left(\frac{w+\sqrt{h^2+w^2}}{h}\right)+h\ln\left(\frac{2h}{a}\right)+w\ln\left(\frac{2w}{a}\right)\right] \quad (1)$$

where N = number of turns
w = width of concrete pavement
h = height of concrete pavement
a = radius of wire
μ_o = magnetic permeability of free space
μ_r = relative permeability of the medium

The value returned by this calculation is the nominal inductance of the sensor because the value of μ_r used is approximately close to unity. If a vehicle parks on top of the concrete pavement, the value of μ_r will increase, thus also the ground loop's inductance.

Any conductor such as wire has a property called *resistance*. When an alternating current passes through the wire, another kind of resistance develops. This resistance is called *inductive reactance*, also known as an imaginary resistance (Hayt, *et al.*, 1993). Thus, a wire has two kinds of resistance when an alternating current is passing through. The sum of the *resistance*, R and the *inductive reactance*, X_L is properly termed as *impedance, Z*.

$$Z = R + jX_L \qquad (2)$$

where Z = impedance (Ω)
R = resistance (Ω)
X_L = inductive reactance (Ω)

The inductive reactance is a function of the frequency of the alternating current and the inductance of the loop.

$$X_L = 2\pi f L \qquad (3)$$

where f = frequency (Hz)
L = inductance (H)

The resistance of the loop is constant as long as the length of the loop remains the same. The inductive reactance, X_L, of the loop varies with the inductance, L, of the loop assuming that the frequency remains constant. Thus, the total impedance of the loop varies as the inductance varies.

The variation of the loop's impedance can be detected by using a voltage divider circuit as shown in Figure 2.

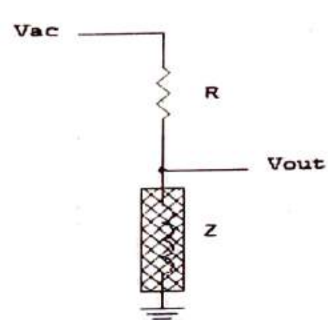

Figure 2. Voltage Divider Circuit

The output voltage, V_{out} of this circuit is a function of the input voltage, V_{ac} and the two resistances R and Z. The equation is given below.

$$V_{out} = \left[\frac{\mathbf{Z}}{\mathbf{R} +} \right] \text{ x } V_{ac} \qquad (4)$$

where: V_{out} = the output ac voltage
V_{ac} = the input ac voltage
Z = impedance of the loop
R = resistance

The complete block diagram of the vehicle sensor is shown in Figure 3.

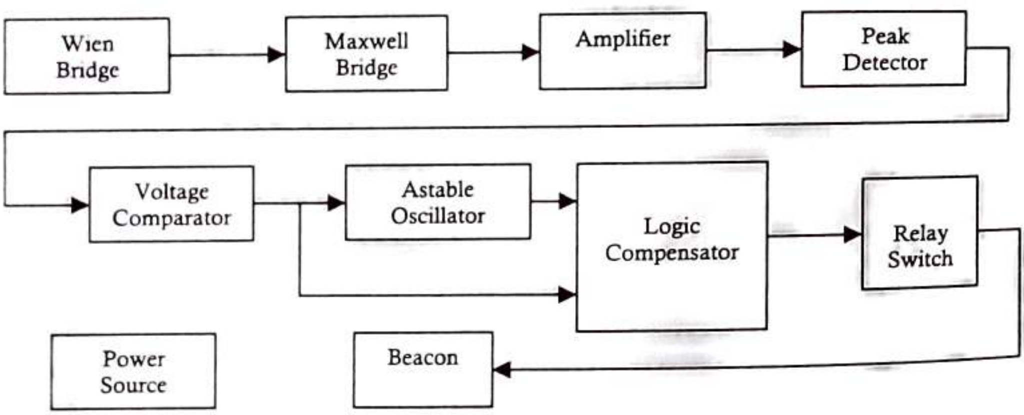

Figure 3. Block Diagram of Vehicle Sensor

The Wien Bridge Oscillator. A Wien Bridge Oscillator is a circuit that provides alternating current to the loop. This type of oscillator is chosen because it produces a satisfactory sinusoidal waveform (Jones, *et al.*, 1991). The actual circuit is shown in Figure 4.

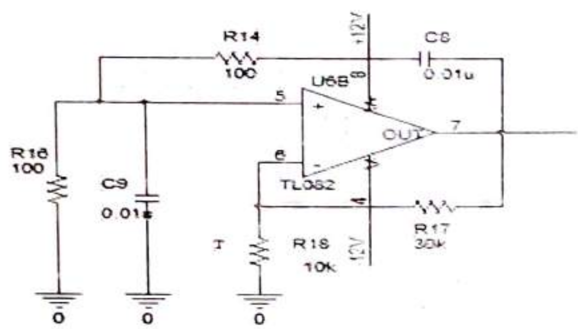

Figure 4. Wien Bridge Oscillator Circuit

The frequency of oscillation is set to 100 kHz, which is the nominal operating frequency. This frequency is commonly used in ground loop detectors. This 100 kHz frequency is low enough to interfere with existing communication equipment but high enough to detect a vehicle over the loop.

Maxwell Bridge. This circuit forms the sensor mechanism of the project. The loop, buried 10-cm. below the surface of the concrete, is part of this circuit. The loop is connected through J3 and J4 in the circuit shown in Figure 5.

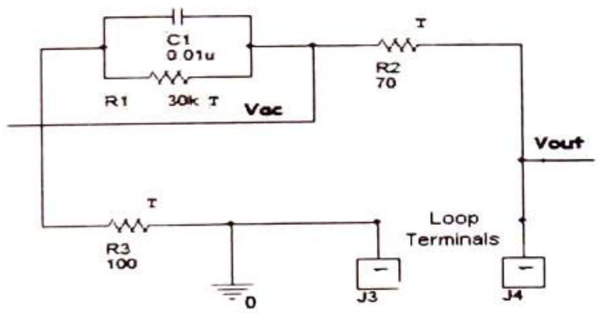

Figure 5. Maxwell Bridge Circuit

R2 and the ground loop form a voltage divider circuit as explained earlier. The ground loop acts as a variable impedance component that will vary the output voltage, V_{out}. The rest of the components are used for stability of the sinusoidal output voltage.

Amplifier. Usually, the output voltage from the bridge circuit is very small. The amplifier is needed to boost this signal to higher amplitude so that it is easy for the succeeding circuits to process it as shown in Figure 6 (Boylestad, *et al.*, 1997).

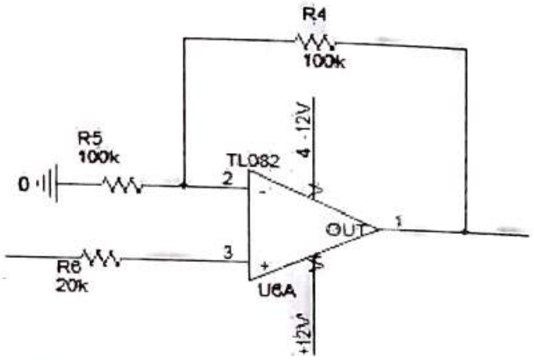

Figure 6. Voltage Amplifier

Peak Detector. The peak detector monitors the peak amplitude of the sinusoidal signal. The output of this circuit is a pure DC voltage (0 *Hz* signal) whose magnitude is equal to the peak value of the AC voltage.

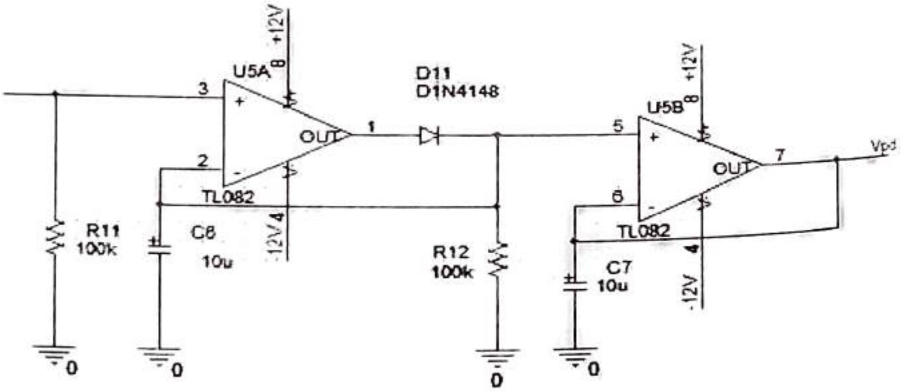

Figure 7. Peak Detector that Monitors Peak Amplitude of the Signal

Voltage Comparator. The output of the peak detector circuit is compared with a reference voltage. This reference voltage is the threshold level. Once a vehicle is over the loop sensor the loop impedance increases thus increasing the output voltage of the bridge circuit and also the amplifier's output. When the peak detector's output increases and exceeds the threshold voltage, the voltage comparator activates the next stage as shown in Figure 8.

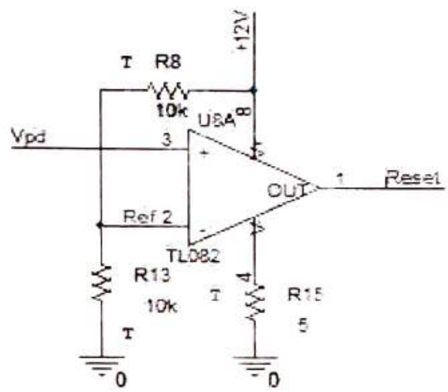

Figure 8. Voltage Comparator Activation to Next Stage

When the peak detector's output voltage is less than the threshold level, the voltage comparator resets the astable oscillator.

Astable Oscillator. This circuit sets the "on" and "off" times of the beacon when the sensor detects a parking vehicle. It will also serve as an anti-false alarm circuitry in case a vehicle passes over the detection zone but has no parking intention. When this circuit is activated by the voltage comparator, it waits for about 30 seconds before the beacon flashes and the alarm rings. Figure 8 below shows the actual circuit of the astable oscillator.

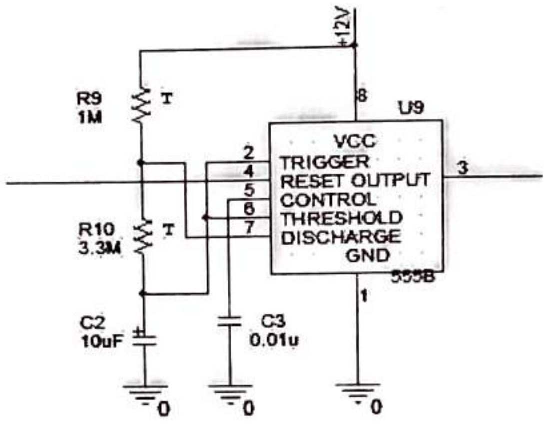

Figure 9. Astable Oscillator Circuit

The beacon flashes for about 20 seconds only and it is activated again after another 30 seconds as long as the vehicle remains parked. This is done to reduce the annoyance caused by the sound of the alarm and noise pollution.

Logic Compensator. The true output of the astable circuitry is inverted. Once the circuit is activated by the voltage comparator, its output turns on the beacon. False alarms would result. The logic compensator circuit solves this problem by reversing the output of the astable circuit as shown in Figure 10.

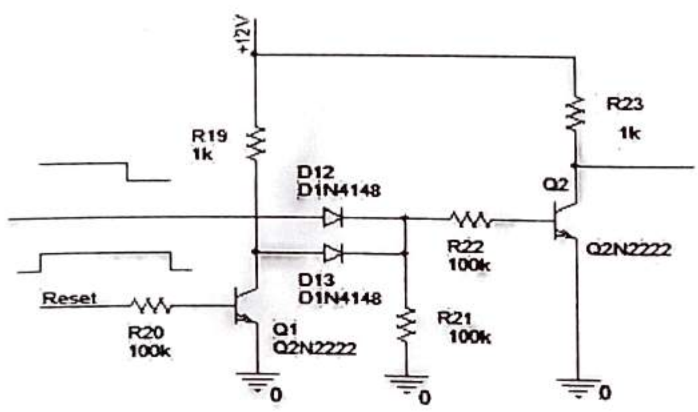

Figure 10. Logic Compensator Circuitry

The output of this circuit drives the relay switch to turn on the beacon.

Relay Switch. In this design, there are several voltage requirements. The beacon needs a minimum of 24 volts in order to produce a flash and a sound. The rest of the electronic circuitry uses 12 volts as the power source. The relay switch is incorporated so that the beacon can be directly connected to the 24-volt supply. The logic compensator then triggers the relay to switch the beacon on or off as shown in Figure 11.

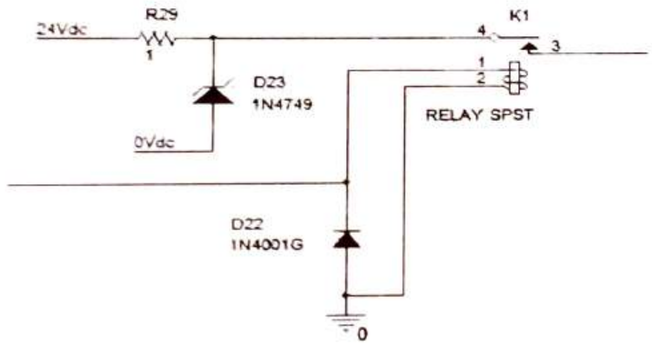

Figure 11. Relay Switch Activation of the Beacon

Power Supply. The power supply module provides the necessary voltage supply to every electronic part in the project. This circuit provides ±12 volts to the oscillator, amplifier and peak detector circuits and +12 volts to the voltage comparator, astable oscillator and logic compensator. It also supplies +24 volts to the beacon.

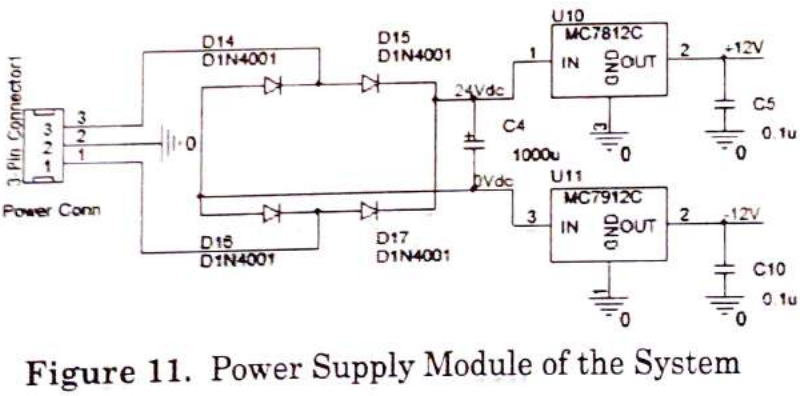

Figure 11. Power Supply Module of the System

Conclusion and Recommendation

The vehicle parking watch device was installed in the MSU-IIT campus. The device responds to illegally parked vehicles without human intervention. The next phase of the study is to install the vehicle parking watch device in NO PARKING areas in Iligan City and to evaluate the public response to its operation. In this phase, another feature will be added to the device, i.e., to inform a remote authority about the status of the NO PARKING area to alert traffic enforcers.

Acknowledgment

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