An Efficient Low Cost Wiper System for Autonomous Vehicle

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Abstract—The traditional wiper system requires driver's attention to switch on the wiper system during precipitation. Whereas in traffic condition, driver should not be diverted by manual adjustment of switching the wiper system which may leads to accident. Probably 80% of accidents are mainly due to distraction of driver. In this scenario we need to obtain an automatic wiping on the wind screen during rain so as to avoid distraction of driver. The existing automatic wiper system has false wiping just after the rainfall stops which can be overcome by using proposed wiper system. Always just after the rainfall a few droplets on the existing water sensor will be sustained until it is cleaned or inherently evaporated. These water drops make a connection between two grid lines to occur false wiping. The advantage of proposed automatic wiper system is compared with the water sensor of existing automatic wiper system after rainfall. The proposed system in this paper is more accurate and economically cheap which can be implemented in all low and middle level cars. In order to avoid critical situation this automatic wiper system provides variable wiping speed based on precipitation level. This automatic wiper system has low cost plate based water sensor, ATMEGA8 microcontroller, MOSFET driver and wiper motor.

Keyword-80% of accidents, existing automatic wiper system, false wiping, advantage of proposed automatic wiper system, plate based water sensor, ATMEGA8 microcontroller, MOSFET driver and wiper motor.

I. INTRODUCTION

All automotive industries seek to provide low cost system for all the applications including automatic wiper system in automobile. In recent trends automotive industries focusing on autonomous vehicle which means self-drive system on different applications. For this scenario, this paper offers low cost wiper system with simple and effective concept of electro mechanical concept to wipe the windscreen automatically. Automatic wiping has been done during rainfall without human interrupt. Thus an uninterrupted makes to avoid distraction of the drive and secure from accidents. Nowadays vehicles are more automated whereas the cost of the embedded system used for different critical applications are too high. Basically, increase in technology will enhance the vehicle cost. This criterion makes to develop low cost automatic wiper system. The wiper system has been implemented to forecast in all low cost vehicles.

In previous works, touch sensor is used to drive the wiper system automatically. The principle behind capacitive sensor is change in capacitance when water or object fall on the dielectric or conductive material on the sensor commands the controller to drive the wiper. This type of system [1] has disadvantages that sometime insects may fall on the touch sensor while driving the car on road side which leads to drive the wiper system during sunny. Capacitive rain Sensor system requires good maintenance at all time. This maintenance plays vital factor for the driver to clean windshield on every day. An intelligent rain sensing uses bottle for rain water level measurement, but this system [2] may not provide accurate reading to wipe and also it requires proper maintenance. In some case, vibration on the bottle may cause fault reading which may leads false wiping. Smart Wiper Control System [3] uses infrared sensor which is implemented in the latest cars but it has few disadvantages. The One is space occupied on the screen is small and the second (main) drawback is need of clear wiping on the windscreen, where the sensor is placed. Even a small water line on optical coverage area will lead to go on wipe. Automatic wiper system using Image processing [4] as well as [5] is more cost and requires good maintenance, whereas this cannot be implemented in the low cost vehicles. This system takes more time for data processing. Hence the response time is more compare to any other system as discussed earlier in this paper. Above systems cause inaccurate result after rainfall condition due to water droplets or waterline on the respective sensors.

Above all drawbacks can be fulfilled by placing low cost plate based water sensor on the windscreen. The low cost plate based water sensor consists of two or more copper/aluminium plates placed at precise distance which acts like infinite resistance under no rainfall condition and finite resistance under rainfall condition. This type of sensor could be used in low cost vehicles without IR sensor. To obtain the following criteria some of the objectives are detection of rainfall by using low cost sensors, Implement using low cost components, better

performance, to adapt on all the vehicles, make a system compact, smart response time and optimal system for different environments.

II. DESIGN OF AUTONOMOUS WIPER SYSTEM

An algorithm design generates variable pulse width for different instant value of linear voltage from the plate based water sensor. The flow chart as shown in the figure 1 represents complete design of proposed automatic wiper system without human interrupt.

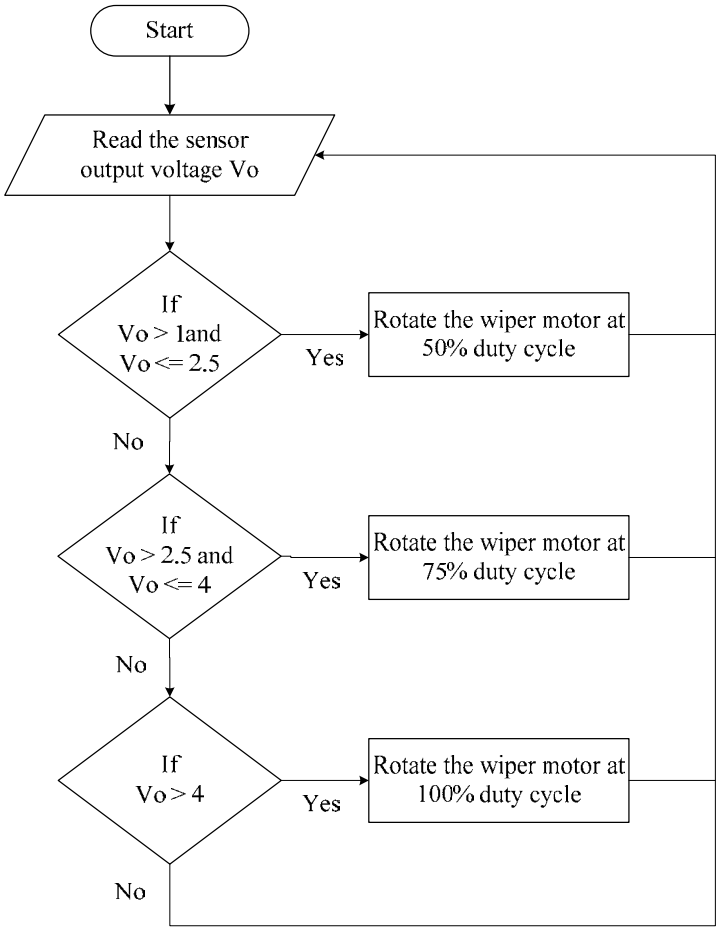

Figure 1: Flowchart of automatic rain sensing

This system performance will be more efficient and cost effective than any other systems. Once the vehicle is in ON condition, the designed algorithm reads the status of sensor. If the linear output voltage of plate based water sensor is greater than threshold voltages then appropriate duty cycle is generated to rotate the wiper motor at different speed. Above algorithm is put into infinite loop to avoid distraction of the driver.

III. IMPLEMENTATION

A. Functional blocks

A function blocks consists of battery, voltage regulator, ATMEGA8, driver circuit and wiper motor. A pictorial representation of function block diagram is shown in the figure 2 represents assemble of blocks in proper sequence. All the vehicles have 12V battery for storage/retrieve of electrical energy. Therefore battery supplies electric energy for all accessories in the vehicle. To make automatic wiper system work inside the vehicle it must be connected to battery. In this wiper system, output of each block is interface with input of another block.

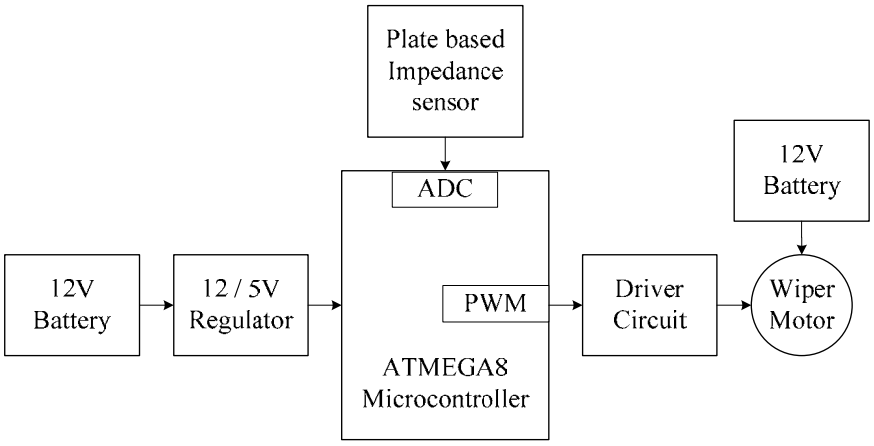

Figure 2: Function block diagram of wiper system

The 12V battery is connected to 12/5V regulator because microcontroller requires 5V dc supply. The plate based water sensor is hooked into input port pin of microcontroller. The Linear voltage at input port pin of microcontroller is depending on the intensity of the rainfall. The intensity of rainfall is high, and then conduction will be more between two plates which leads to generate 100% duty cycle by microcontroller i.e. high speed. Just the same, if the intensity decays then microcontroller generates 75% for medium speed and 50% for low speed based on the intensity of rainfall as shown in table 1.

Table 1: Duty cycles

Duty cycle	Wiper motor speed
25%	Too low
50%	Low
75%	Medium
100%	Fast

A selected output port pin of microcontroller must be hooked into existing wiper motor via MOSFET driver with proper pin configuration. The MOSFET driver is chosen, to obtain variable constant potential for different speed.

B. Plate based water sensor

This system contains low cost plate based water sensor which work under different operation modes. Water sensor operates in an infinite resistance mode during no rainfall condition and finite resistance mode during rainfall condition. Plate based water sensor consists of two or more copper/aluminium plates separated by a small distance as shown in the figure 3.

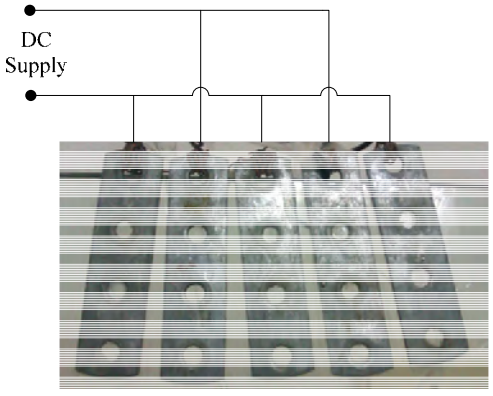

Figure 3: Plate based water sensor

Resistance between two plates is infinite because there is no closed path between them. Hence, a small drop of water in between two plates cause flow of charges from one plate to another. Now the connection forms between adjacent plates and thus a drop of water between the plates interrupt the microcontroller. The plate

based water sensor has two terminals, one terminal of the sensor is connected to 5V power supply and other terminal is connected to input port pin of microcontroller.

C. ATMEGA8 Microcontroller

Atmega8 is an 8-bit microcontroller which performs 8-bit operation. This processing unit plays a vital role to process input and output signals. Basically, atmega8 has some features like USART, SPI, ADC, timer/counters, programmable Watchdog Timer, internal and external interrupts. In this paper, the main function of microcontroller is to monitor linear variable voltage accordingly generate DC pulse at variable duty cycle. As voltage through input pin of microcontroller is linear consequentially variable DC pulse is generated. For instance, microcontroller must be instructed by proper coding using software and flashed into internal EEROM. Choose the suitable software to flash the application program into microcontroller. Some of the software like boot flasher, flash magic etc will help to flash the application program into internal read only memory of the microcontroller. Application program has been designed to provide variable DC pulses based on the linear voltage from plate based impedance sensor. Inbuilt ADC is used to convert linear voltage into digital value. Based on digital value variable duty cycle is obtain using PWM. The PWM based timer is chosen to obtain variable DC pulse on variable voltage of sensor.

D. MOSFET driver and wiper motor

A MOSFET based driver is to obtain voltage controlled voltage source. The driver delivers same potential from microcontroller to wiper motor with same interval of time. Some times without driver circuit lead to inverse the potential across the wiper motor. The existing wiper motor has six terminals in that four terminals are used to wipe the windshield at three different speeds namely low, medium and fast. Each speed takes one terminal with respect to ground. In this proposed automatic wiper system, instead of four terminals, two terminals are taken to obtain three different speeds. The fast terminal of wiper motor is taken to rotate at three different speed using PWM with respect to ground. Depending on the intensity of rainfall microcontroller will generate three different duty cycles to rotate the wiper motor at low, medium and fast condition.

E. Hardware implementation

A schematic diagram shows an interconnection of each component to perform a specified task as shown in figure 4. A 12V battery is connected to 7805 voltage regulator.

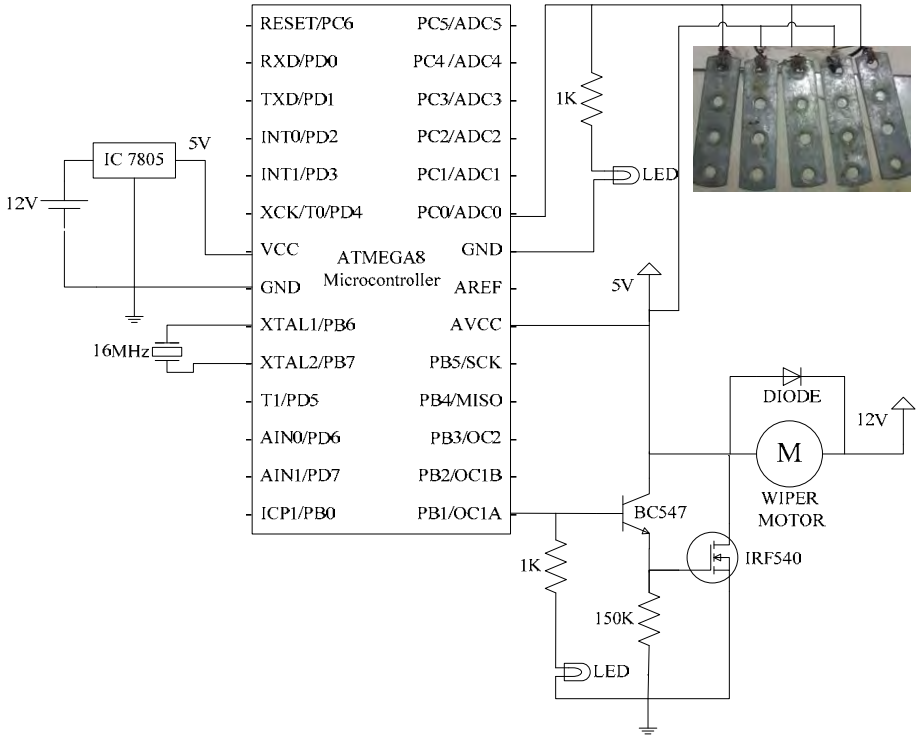

Figure 4: Circuit diagram of automatic wiper system

This voltage regulator converts 12V to 5V to initiate microcontroller and other electronic components. LEDs are used to indicate the response of the sensor and microcontroller. The Plate based water sensor output voltage is zero during no rainfall condition. The sensor output voltage is linearly variable depending on the intensity of rainfall condition. An algorithm designed for three different duty cycles depending on variable output voltage of plate based impedance sensor. The inbuilt ADC is used to convert linear variable voltages into digital outputs

for better performance. ADC is use to enhance an accuracy and resolution of the system. This inbuilt configuration gives cost effective and less complexity on compact system.

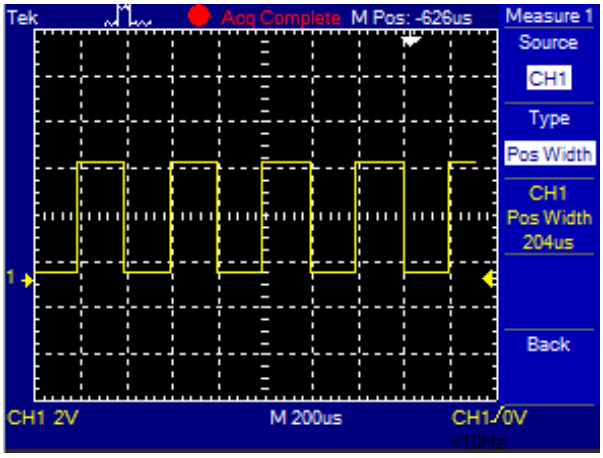

Figure 5: 50% duty cycle for low speed

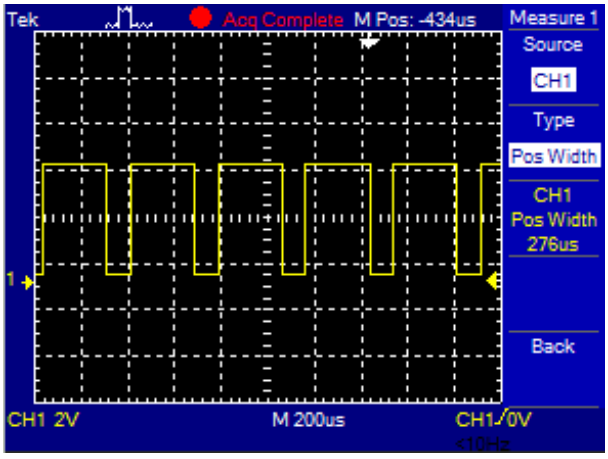

Figure 6: 75% duty cycle for medium speed

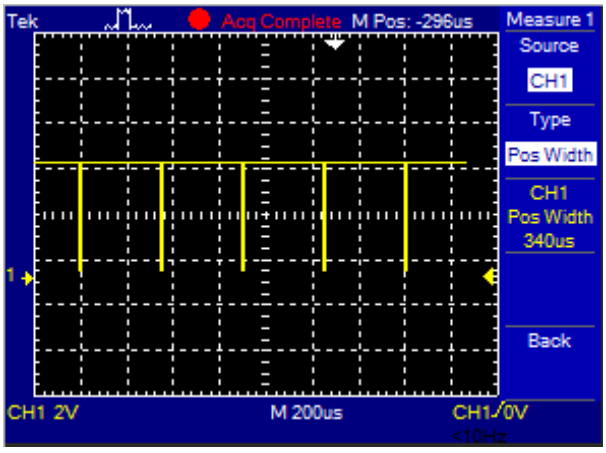

Figure 7: 100% duty cycle for medium speed

Each and every instant of rainfall can be capture using ADC because of its conversion time is one microsecond. Initialize the appropriate control bits to do conversion and generate different pulse width. The duty cycles are generated using PWM by microcontroller based on algorithm designed. The Three different duty cycles to control the wiper motor at low, medium and fast speed as shown figure 5, 6 and 7.

A 25% duty cycle is not considered to wipe at low speed due to jerk. MOSFET driver regulates same potential from microcontroller to wiper motor to avoid false excitation. A complete interconnection of hardware components is shown in figure 8.

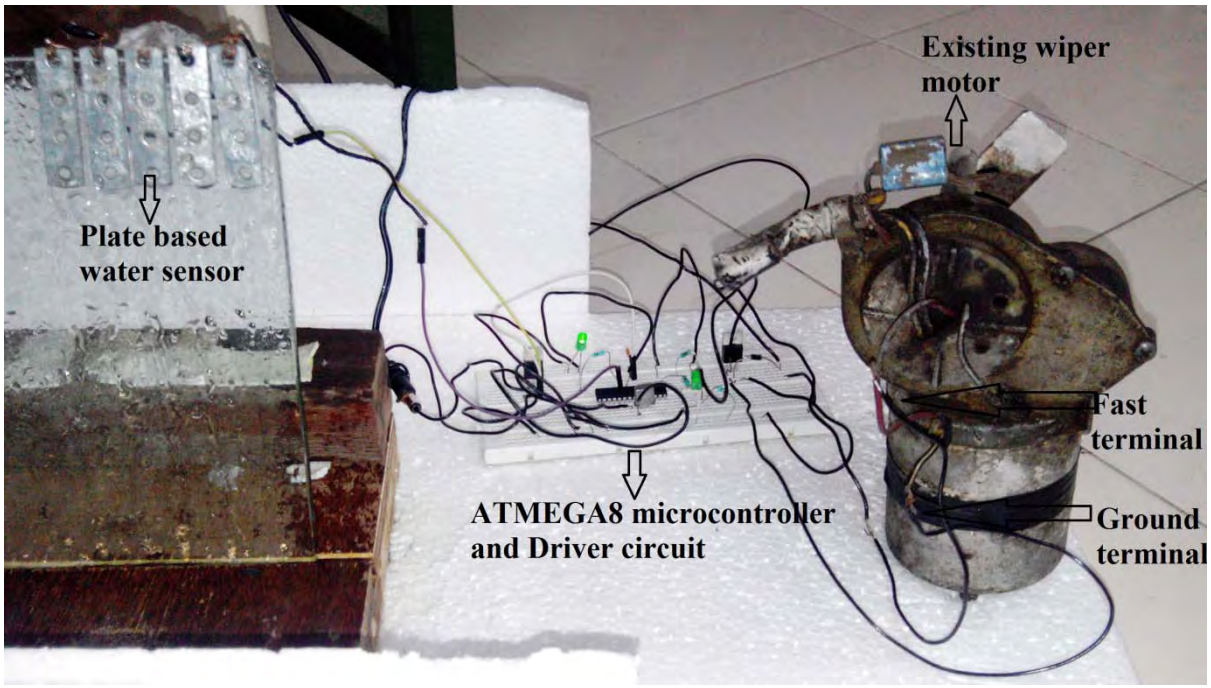

Figure 8: A Pictorial representation of wiper system

F. Software implementation

Software implementation requires two types of software. One of them is AVR studio 4 and another is boot loader. Microcontroller is instructed by using 'C' coding in AVR studio 4. While programming add some of library file in the header. For example, delay function is used then delay library file must be added into the header. This software provides 'build and run' function which generates hex file of application program. Always application program must be hex file. This hex file must be loaded into internal EROM of microcontroller using boot loader software. Once successfully application program is loaded into microcontroller. The microcontroller fetches, decodes and executes the series of bytes from the memory location.

G. Analysis on water sensor

In previous work [7] and [8], PCB based water sensor was used for automatic wiper system which has a drawback which can be fulfilled by using copper/ aluminium plates instead of lead grid lines on the printed circuit board. Basically, water sensor operates in an infinite resistance mode under no rainfall condition and finite resistance mode during rainfall condition. The resistance between two adjacent gridlines is infinity under no rainfall condition because there is no connectivity. Under rainfall condition, if the water drops on these two grid lines make a connection between two grid lines and there will be flow of current from one line to another line which forms finite resistance between two adjacent grid lines. For illustration ohm's law states that if resistance is infinite the current through the grid lines is zero and vice versa.

$$I = \frac{V}{R}$$

The main drawback of water sensor is conduction takes place between two grid lines even after the rain has been stopped. For illustration, from the figure 9 the water drops on the existing water sensor leads to flow of current from one line to adjacent line. Logically, wiper motor rotates on condition between two grid lines. This type of water sensor creates false wiping on windscreen after rainfall due to few drops on the adjacent grid lines.

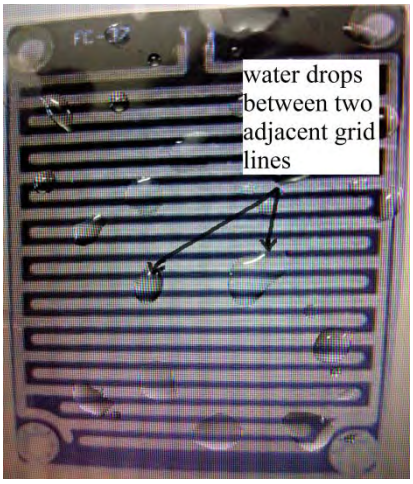

Figure 9: PCB based water sensor

To overcome this drawback place a copper /aluminium plates in vertical/horizontal with precise gap so as to avoid false wiping after wiping. For same figure 3 represents the connection and precise gap between the two plates. The Principle of existing water sensor and proposed water sensor is same, where as plate based water sensor has more accuracy, when compare to PCB based water sensor. A graph shown in Figure 10 represents rise in potential across the two terminals of water sensor while rain condition. The signals of both sensors are almost same and linear, as intensity of rain increases the potential across two terminals also increases with the same.

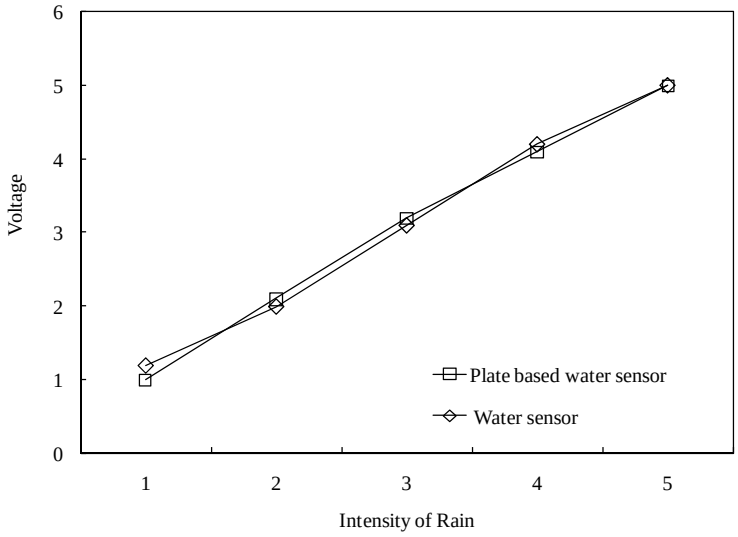

Figure 10: Rainfall condition

Based on intensity of rainfall, algorithm behind for the wiper system is to wipe the windshield at variable speed. The linear variation of potential can be made into variable frequency pulse using timer circuit and PWM of microcontroller. The PWM of microcontroller generates different duty cycle to obtain variable wiping speed on wind shield. Here comes an important note after the rainfall, what could be the potential across the two terminals of water sensors. At instant after rainfall, there will be Water drops on entire vehicle until it is cleaned or inherent evaporated. A Figure 11 shows the potential across both sensors just after the rainfall. It represents there will be potential across the two terminals of existing PCB based water sensor due to presents of water drop on the board which make the connection between the two adjacent grid lines. In proposed plate based water sensor, there will be zero potential across the two terminals. There is no possibility to sustain water drop between two adjacent plates until it is maintained with precise gap. A copper material has better conductivity than aluminum material but the cost of copper material is four times the aluminum material.

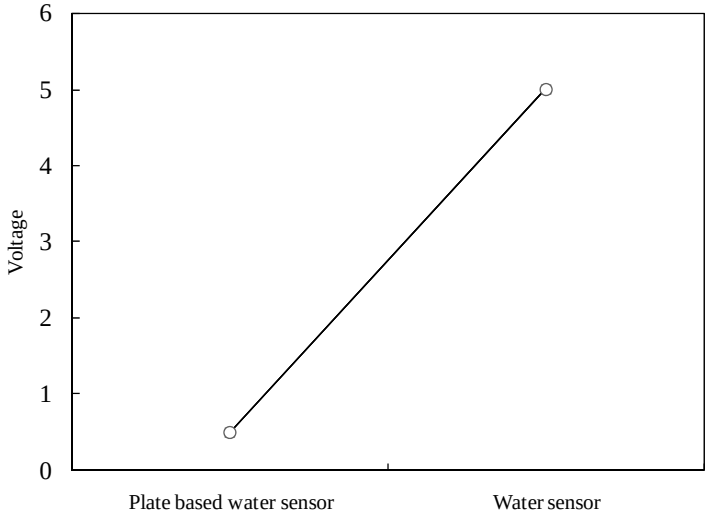

Figure 11: Just after rainfall condition

To obtain variable speed of wiping it is better to use aluminium plates because it has high resistance and low thermal conductivity compare to copper plates.

IV. CONCLUSION

In the paper, plated based water sensor is evaluated on both rainfall and after rainfall condition to obtain accurate result without false wiping under different scenarios. This system is developed with low cost high performance electronic components to fit in all low cost vehicles. The cost to implement is approximately 7$, which is less the any other wiping system in the vehicles. A vertical/horizontal placement of plates give better result compare to any another arrange of plates. The copper/aluminum plates can be fixed on to plastic board and affix on the vehicles instead of placing directly on the windshield.

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