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Dr. Andrew Rawicz
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April 20, 1999

Subject: ENSC 370 Process Report – *Automated Windshield Wiper Control System*

Dear Dr. Rawicz,

The enclosed document, *Automated Windshield Wiper Control System Process Report*, outlines the development process our group experienced in creating our system for ENSC 370. Our project goal is to fully automate windshield wiper control through a sensor that will detect the amount of rainfall and control wipers accordingly.

This document details the current state of the device, deviations from our original specifications, and our future plans for the device. In addition, we outline some of the budgetary and time constraints we encountered.

The members of RainWorks Innovations consist of four 3rd year Engineering Science students in the Electronics option. This four-member team includes Vincent Yen, Roger Stock, Dennis Lee and Kevin Kan. Should any questions arise, please contact Roger Stock at 945-5078 or by e-mail at rstock@sfu.ca rstock@sfu.ca.

Sincerely,

Roger Stock, Vincent Yen, Dennis Lee and Kevin Kan

Encl.: *Automated Windshield Wiper Control System Process Report*

Automated Windshield Wiper Control System
Design Specifications

Submitted by: RainWorks Innovations:
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Steve Whitmore

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Date: April 20, 1999

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1 Introduction

Motivated by the existing market demand for an economical, kit form automated wiper system, Rainworks created AWWCS (Automated Windshield Wiper Control System). Consisting of Roger Stock, Kevin Kan, Dennis Lee and Vincent Yen, the Rainworks Innovation team was created for rain related automobile products. The following report concludes the process undertaken by RainWorks Innovations for the realization of an AWWCS prototype.

2 Current State of the Device

At this point, all features outlined in the proposal have been met, if not exceeded. The AWWCS receives both rain and user input. The data is processed and a decision is made to actuate a windshield wipe. Figure 1 gives an overview of the main system units shown by block diagrams.

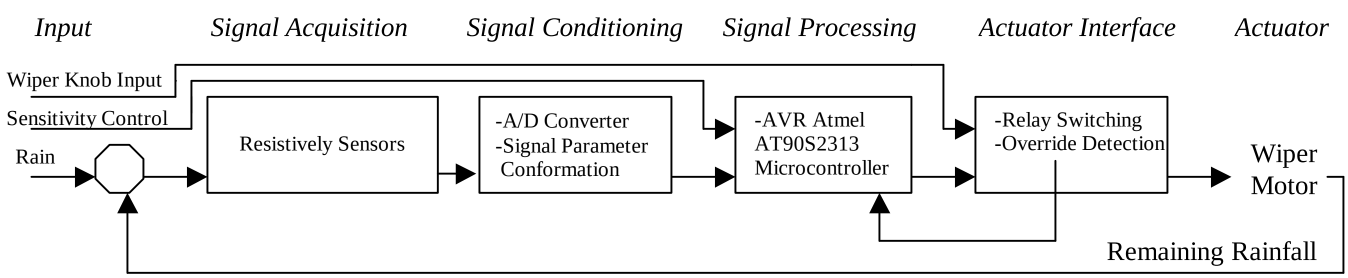

Figure 1: AWWCS system overview

As can be seen from figure 1, the AWWCS consists of 4 stages. The current state of the device will be explained by reviewing each of the stages.

In the first stage, signal acquisition, the amount of rain on the windshield will be measured and processed by the AWWCS. The AWWCS will then decide to actuate the wiper to clean the windshield. The rain amount detected on the windshield will be determined by our resistivity sensors that we designed ourselves.

The sensor, which is located on the lower right of the front windshield, consists of 3 different materials: conductive epoxy, clear epoxy and acrylic enamel. These substances form the most durable, cost-efficient and non-intrusive sensor solution we could conceive.

In the second stage, signal conditioning, the analog signals obtained by the resistivity sensors are converted into the digital domain suitable for processing by the microcontroller. Figure 2 illustrates the block diagram of the variable resistor signal conditioning block.

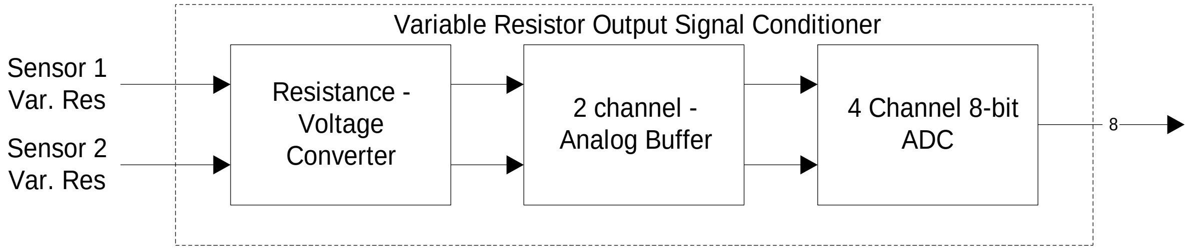

Figure 2: Detailed block diagram of variable resistor output signal conditioner

As shown in figure 2, the output signal from the rain sensor is not directly coupled to the ADC, but rather to a buffer first and then into the ADC. This is done for two reasons:

- to increase the input resistance of the stage immediately after sensor
- to decrease any potential damage to the ADC

The ADC that we are using has a fairly low input resistance and this will provide significant loading on our sensor. In addition, the maximum allowable voltage swing of input signals that is fed into the ADC is 0 to 1V. The ADC digital output range is calibrated to this value.

The user interface will be specified before we move on to the third stage, signal processing. Figure 3 shows the user interface, which is a sensitivity switch available for the user.

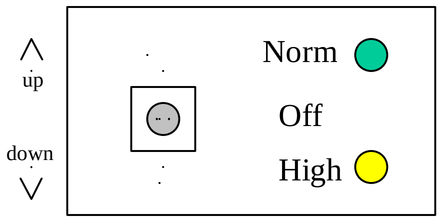

Figure 3: User interface - sensitivity switch

User interface provides sensitivity and off mode control; the UI is composed of a sensitivity switch and two state LEDs. There are two states of sensitivity available to the user, as well as the off state.

1. **Off**: By turning the sensitivity knob to "Off", the user disables the AWWCS. Under this state, no automated wiping action will be taken.

2. **Normal**: This sensitivity level is the default sensitivity level built in the AWWCS.

3. **High**: By turning the sensitivity knob to "High", the user can request the AWWCS to take wiping actions under lighter rain condition than the default sensitivity level built in the AWWCS.

In the third stage, signal processing, the Atmel AVR microcontroller (AT90S8515) is used for signal processing. Signal processing now accounts for intermittent and continuous wipes. In addition, JIT (just in time wiping) is implemented by the microcontroller. In addition, manual override from the native control, as well as sensitivity switch functions are also implemented in the AVR microcontroller.

In the fourth stage, actuator interface, the AWWCS controls the wipers. The system also detects manual override and returns native wiper control to the user. The actuator interface will be implemented with switching relays. The native control inputs are fed into the microcontroller for manual override decisions.

The AWWCS system will operate in two states:

1. AWWCS system enabled: The wiper knob is set to off and the wipers are taking command from the microcontroller.
2. Manual Override: The wiper knob is set to any wiper state (not off) and the AWWCS system is ignored.

The AWWCS has been installed on an 87 Toyota Tercel and is able to work as desired under various test conditions, such as rainfall frequency and raindrops in different areas.

3 Deviation of the Device

With the exception of the motor interface, modifications have been performed on each device functional parts to maximum efficiency, size and cost.

The sensor consists of four conductive strips and is hooked up to a voltage divider network. Raindrops falling in between will change the resistance of the sensor, and thus the voltage observed across the resistance network. The sensor is composed of conductive epoxy, clear epoxy and acrylic enamel. Clear epoxy is added between conductive epoxy strips to prevent the rainwater from being caught in between the conductive strips. After repeated attempts, we perfected the masking process for the conductive epoxy; we were able to make the gap between conductive strip small enough to detect mist. With the improved modification, we were able to eliminate the variable capacitance sensor outlined in the design spec used to detect mist. In addition, the perfection of the custom integration of the sensor onto the actual car windshield has resulted in a sleek, non-intrusive design that may have further development potential. The ADC of signal conditioning has been selected to calibrate to the range of input voltage variations, as opposed to stepping the input voltage up to 5V.

Signal processing has several features that increase the robustness of the device. The featured are, in rough, conflicting control input resolution, motor interface short protection and typical code optimization. In addition, one 40 pin Atmel AVR microcontroller, the ATS8515 is selected, rather than two small 20 pin ATS2313 for ease of coding; inter-device communications are eliminated, as well as complex I/O pin mapping.

The user interface has been seamlessly integrated into the dashboard of the test vehicle. A panel from the dashboard has been modified and removed. The user interface was placed on the removed panel and placed back into the dashboard. Further studies on natural mapping reveals that the UI should be placed right behind the native wiper control for intuitive application of the interface.

The sounds from the relays switching were sufficiently distracting for us to implement sound damping to the container. Play-Do was selected for its sound damping properties. The play-do was wrapped in saran-wrap to prevent it from drying out. Clearly, this is a temporary, but effective solution.

4 Future Plans

Our custom designed rain sensors currently operate simply and effectively. Plans are now underway to approach the major car manufactures for a functional demonstration as a proof of concept. In addition, Rainworks are currently seeking additional funding for a further development of the rain sensor, as well as applications outside the automotive industry. As of now, the materials for a complete system will cost $40, making the AWWCS a cost effective product that can be easily shipped in kit form.

5 Budgetary and Time Constraints

5.1 Budget Constraints

The following shows our budget as anticipated at the time our Project Proposal was composed:

Rain Sensor	$60
Wiring	$10
Microprocessor / Debugger	$30
User Interface	$30
Windshield Wiper	$10
Total	$140

The following shows the actual cost of the project up to April 20

Rain Sensor Materials	$25
Wiring, Connectors	$20
Microprocessor / Debugger	$10
Discrete Components	$40
User Interface	$15
Miscellaneous	$30
Total	$140

As surprising as it may seem, we actually met our budget. Although component selections are now different, we have met all our budgetary constraints.

5.2 Time Constraints

We underestimate the complexity involved in custom designing a rain sensor that is durable, cheap and gives consistent results. At least 20 design iterations and 5 different conceptual approaches were performed before we settle on the final configuration at March. 15. We were unable to meet any of our preset deadline and timeline, and our product was four weeks behind schedule. We were fortunate that the device design was drastically simplified and that efficient group dynamics and hiearchial structure was in place for our group to function effectively and finish the project before the deadline. However, one project demonstration postponement was necessary, and valuable timeline lessons are gleaned from that.

6 Inter-Personal and Technical Experiences

Our group functioned as a complete and harmonious unit. Contrary to dire warning of the friendship element to group breakups, we started this 370 project as good friends, and we are leaving the 370 project as even better friends. Our friendship was advantageous to bringing our group dynamics into a more personal level; we can easily communicate our frustrations and dissatisfaction with compassionate support from within the group.

Vincent Yen

I have gained valuable insights to group dynamics, furthered my understanding in software development, as well as expanded my skill with lab equipment. Basically, I was going into the course looking for hardware experience that I was sorely lacking, and I came out with extensive hardware and software experience. I learned to budget my time, allocate the proper engineering resources for tasks and manage a group effectively.

Dennis Lee

Technically, I’ve learned to create a website for this project and got a taste of how to bring a product to realization. In addition, I realized how important the fundamental concepts and theories we learned in class are to excel in engineering field. This realization will definitely change the way I learn and look at things for the years to come. I’ve also learned to work as a team. Each member in our group has talents in different fields, and it is this difference that makes this group a whole. Interpersonally, I’ve learned to be humble and understanding. Our project include a wide range of activities and no matter how advanced or simple a task is, somebody has got to do it. I am very thankful that all members in this group have common understandings and are always dedicated to whatever they are assigned to work on.

Roger Stock

There were many areas where I learned a great deal. Some of them being more technical, some being more interpersonal, I feel what I have gained from this course has met all my expectations entering the challenge of a project course.

I enjoyed the practical experience of applying theory to a real problem. So many of the things taken for granted in the classroom have to be accounted for such as making sure discrete components of correct parameter specifications are available for purchase to complete the implementation to a solution.

Procrastination and missing project deadlines are not an option; it's clear to me that unexpected errors and problems are to be expected. As our project approached the final deadline, unforeseen errors almost cost us a working product for the demo. The value of time management has never been made more obvious to me.

Kevin Kan

Through this project I have been challenged both in technical expertise and interpersonal relations. From a technical perspective, the project allowed me to work with both hardware and software. This being my first project there were many unexpected difficulties in developing the rain sensor.