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December 18, 2000

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, BC
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Re: ENSC 340 Project Process Report for a Drying Machine Auto-Stop Upgrade

Dear Dr. Rawicz:

The attached document, *Process Report for Drying Machine Auto-Stop Upgrade,* outlines our project for ENSC 340 (Transducers and Embedded Systems). Our project goal is to design a device that allows drying machine users to conserve energy, to enjoy more convenience, and to prolong fabric lifetime with their use of drying machines.

This document reviews the overview of the project and technical implementation of the solution. Also we will discuss the problems that we have encountered, including technical, financial, scheduling, and group dynamics issues. In addition, we will also discuss some possible improvements and experiences that we gained from this project.

The people that constitute the *EaStar Group* are five brilliant students in SFU Engineering Science: Eric Jen, Jeffrey Chien, Edward Chen, Steven Liao, and Chris Lo. If you have any questions or concerns about our proposal, please contact us by e-mail at ensc340-jesec@sfu.ca.

Sincerely,

EaStar Group

Enclosure: ***Process Report for Drying Machine Auto-Stop Upgrade***

Drying Machine Auto-Stop Upgrade

Process Report

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1. Overview of the Project

1.1 Overall Functionality

The *Drying Machine Auto-Stop Upgrade* module consists of four major subsystems, including Actuators, Sensors, User Interface, and Control Unit. This module is designed to be compatible with any type of dryer, regardless of the dryer operating voltage (110V or 220V), the physical size of the dryer, and the dryer model. However, one required functionality for dryer using the *Drying Machine Auto-Stop Upgrade* module is the capability to stop when dryer door is opened.

When in operation, the Sensors subsystem will constantly monitor the relative humidity inside the dryer drum. When the moisture level inside the dryer has reached the desired level set by the user, actuators will be activated to open the dryer door and this action will cause the dryer to stop.

The Actuators, User Interface, and Control Unit subsystems will be installed on the exterior of the dryer, whereas the Sensors will be placed on the inside of the dryer door. Overall, the installation of the *Drying Machine Auto-Stop Upgrade* module will be simple and easy.

Figure 1 below shows the correlation of the four major subsystems.

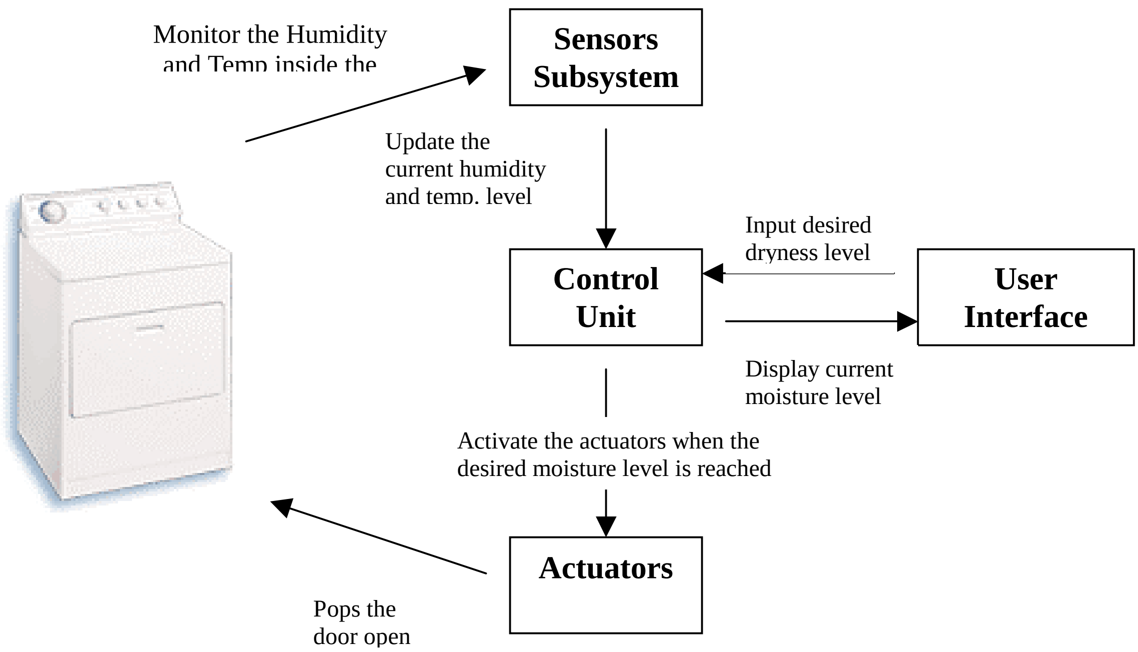


Figure 1: Correlation among Subsystems

The prototype module will demonstrate the following features:

- **Ability to detect the moisture level inside the dryer drum**
- **Ability to process the input from the user along with the current sensor status, and make a decision of whether the dryer should be stopped**
- **Ability to display the current moisture level inside the dryer drum**
- **Ability to stop the dryer when the desired dryness level is reached**
- **Ability to restore the original configuration of the module once the dryer is stopped**

The following figure shows the correlation between the three different modes of the module.

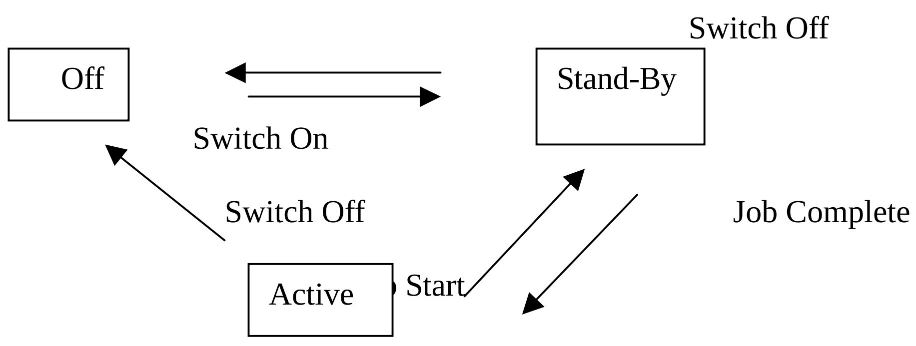


Figure 2: Correlation among basic operation modes

1.2 Actuator Subsystem

The purpose of this subsystem is to open the dryer door automatically when the desired dryness for the clothes has been reached. The actuator is activated according to the commands sent from the Control Unit, and shall remain in the Stand-by State until such commands have arrived. Upon activation, the actuator will open the dryer door and thus cause the dryer to stop. Once the dryer door pops open, the Actuator subsystem will return to its original stand-by mode.

1.3 Sensor Subsystem

The Sensor subsystem consists of a relative humidity (RH) sensor and a signal-processing module. The relative humidity data taken from the RH sensor and is sent to the signal-processing module. The signal-processing module processes this information to a form that's appropriate for the control unit, and sends the processed relative humidity information to the control unit.

1.4 User-Interface Subsystem

The User Interface subsystem allows the user to select the preferred dryness level for clothes. This user input is sent to and processed by the Control Unit. Moreover, the User Interface subsystem provides feedback by displaying the current moisture level, or rather the relative dryness of the clothes. This subsystem will display 2 operations for the *Drying-Machine Auto-Stop Upgrade* module: Active mode and Standby mode.

1.5 Control-Unit Subsystem

The Control Unit activates the Actuator subsystem based on the relative humidity information given by the Sensor subsystem and the desired moisture level information given by the User-Interface subsystem. After the relative humidity information is obtained from the Sensor subsystem, this information is interpreted as a voltage level. This voltage level is then compared with the desired moisture level, which is also represented by a voltage level, to determine whether the Control Unit subsystem activates the Actuator subsystem. If the voltage level representing relative humidity matches with that representing the desired moisture level, the Control Unit subsystem activates the Actuator subsystem.

The flow-chart shown on the next page outlines the overall flow of the Control-Unit subsystem.

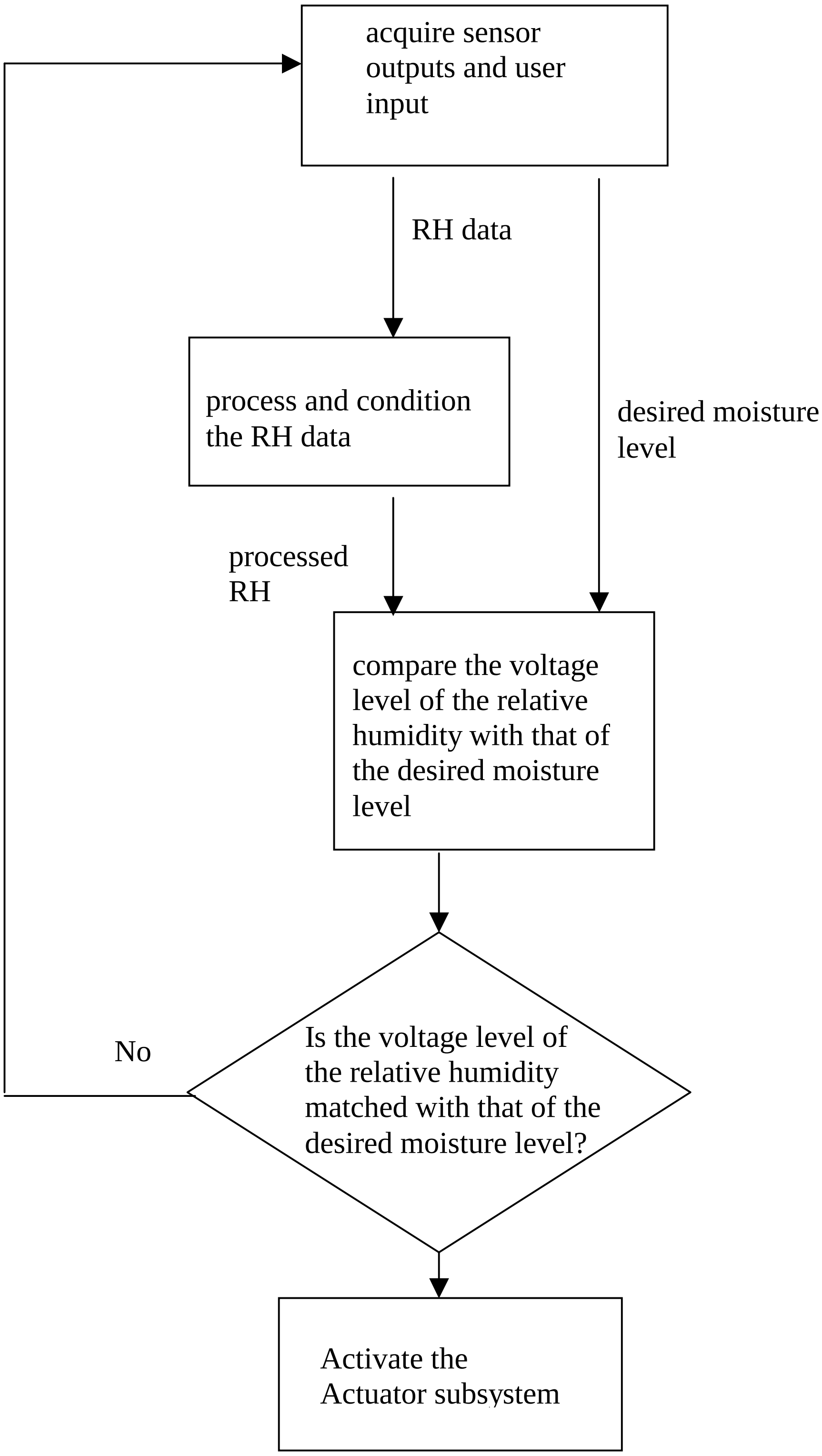


Figure 3: Flow chart representation of Control-Unit Subsystem

2. Technical Implementation of the Solution

In the following paragraphs we briefly discuss the technical implementation of our project.

2.1 Signal Acquisition

The Signal Acquisition stage obtains the input signals from the sensors and the user. Figure 4 shows the context diagram of this stage.

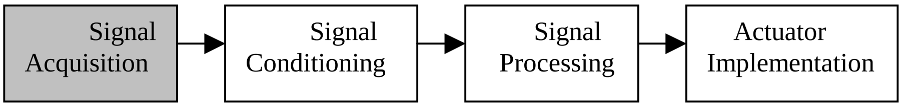


Figure 4: Context Diagram of the Signal Acquisition Stage

RH sensor is mounted inside the dryer to constantly monitor the humidity level. After reviewing various types of humidity sensor, for the prototype module EaStar Group has decided to use the open-capacitor type of humidity sensor found in the Springfield PreciseTemp Indoor/Outdoor Digital Thermometer. Although this type of humidity sensor requires several stages of signal conditioning and processing, it is chosen for its performance, reliability and durability.

2.2 Signal Conditioning

Once the input signals from the sensors have been successfully acquired, they must then be conditioned to the appropriate format required by the Signal Processing stage. However, the user input signals do not require any conditioning since the direct use of user input signal is possible. Figure 5 below shows the context diagram for this stage.

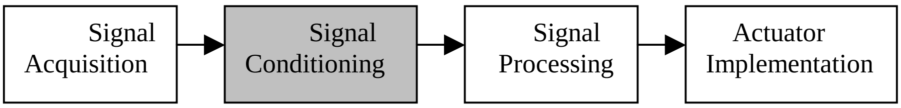


Figure 5: Context Diagram of the Signal Conditioning Stage

Figure 6 below shows the functional block diagram of the Signal Conditioning stage.

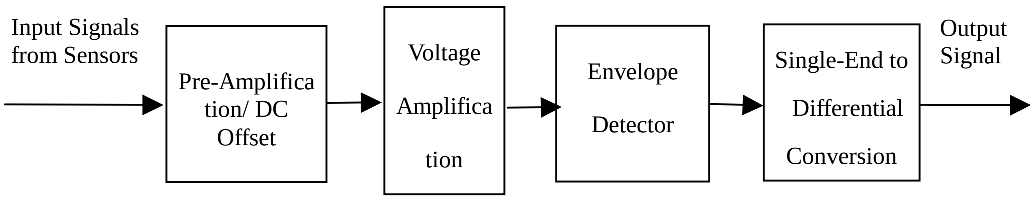


Figure 6: Functional Block Diagram for Signal Conditioning Stage

2.3 Signal Processing

The Signal Processing stage processes and interprets the appropriately formatted sensor information from the Signal Conditioning stage, and then sends the result to the Actuation stage. Figure 7 below shows the context diagram for this stage.

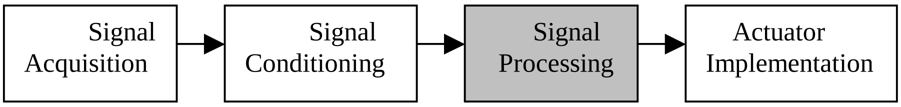


Figure 7: Context Diagram of the Signal Processing Stage

Figure 8 below shows the functional block diagram of the Signal Processing stage.

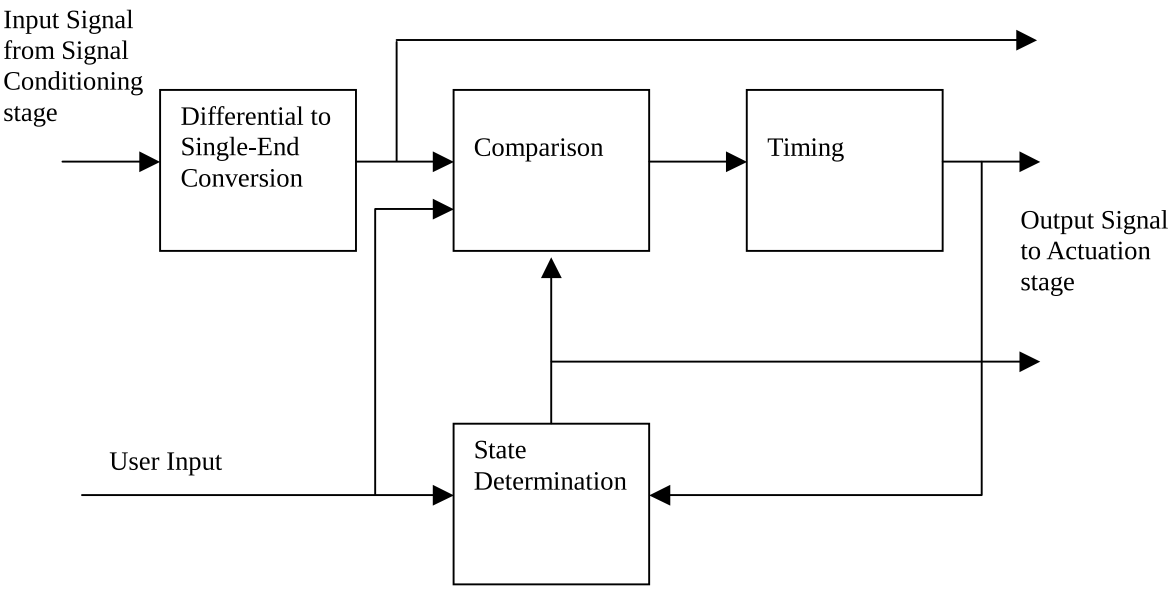


Figure 8: Functional Block Diagram of the Signal Processing Stage

2.4 Actuation

The Actuation stage performs appropriate physical actions according to the signals received from the Signal Processing stage. Figure 9 below shows the context diagram of the Actuation stage.

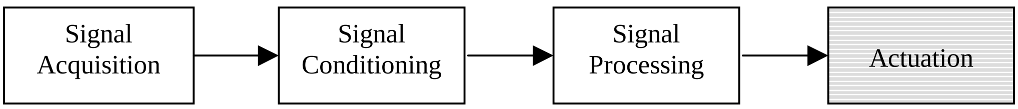


Figure 9: Context Diagram of the Actuation Stage

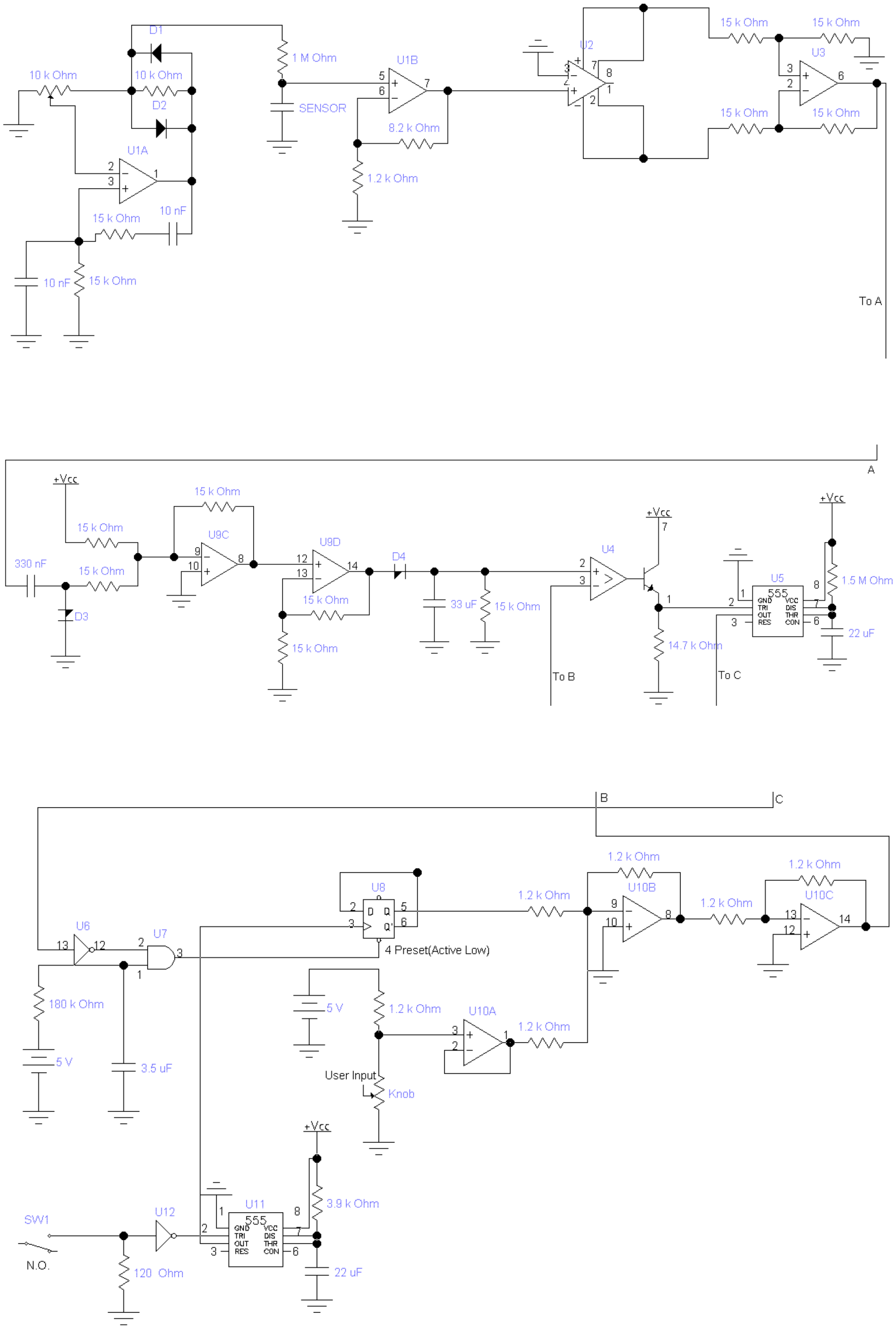
The Actuation stage includes 2 functions that involve 2 subsystems. When the moisture level in the dryer reaches the input desired moisture level, the Control Unit subsystem triggers the Actuator subsystem to stop the dryer. During the operation, moisture level data are continuously delivered to the User Interface subsystem, triggering the LEDs on the display.

2.5 Enclosure

For our prototype, several plastic enclosures will be employed. The enclosure will not possess sharp corners or edges that would pose a danger to the user. Moreover, the enclosure will not contain protrusions or odd extensions of any form. The plastic enclosure is chosen since plastic is light-weighted and resistive to most chemicals that the module may be exposed. The plastic enclosure will also ensure electrical isolation from the internal circuitry. All electronic components of the module will be shielded and protected from external static voltage sources.

2.6 Schematic Diagrams

Figure 10 on the next page shows the schematic diagrams of our project. All stages mentioned above are shown except for the Actuation stage. The design of the Actuation stage is not included because the approach of implementation is not yet finalized.


D1
10 k Ohm
10 k Ohm
D2
U1A
1 M Ohm
SENSOR
U1B
8.2 k Ohm
1.2 k Ohm
15 k Ohm
10 nF
15 k Ohm
10 nF
15 k Ohm
U2
15 k Ohm
15 k Ohm
U3
15 k Ohm
15 k Ohm
To A
A
+Vcc
15 k Ohm
15 k Ohm
330 nF
15 k Ohm
D3
U9C
U9D
15 k Ohm
15 k Ohm
D4
33 uF
15 k Ohm
U4
+Vcc
To B
14.7 k Ohm
To C
U5
555
+Vcc
1.5 M Ohm
22 uF
B
C
1.2 k Ohm
U10B
1.2 k Ohm
U10C
U8
1.2 k Ohm
1.2 k Ohm
U6
U7
4 Preset(Active Low)
180 k Ohm
5 V
3.5 uF
5 V
1.2 k Ohm
U10A
1.2 k Ohm
User Input
Knob
+Vcc
3.9 k Ohm
SW1
N.O.
U12
120 Ohm
U11
555
22 uF

U1: TL084 Quad LM741 Op-Amp. +Vcc pin4, -Vcc pin11
U2: SSM2142 Differential Line Driver. +Vcc pin6, -Vcc pin5
U3: OP05 Instrumentation Amplifier. +Vcc pin7, -Vcc pin4
U4: LM311 Comparator. +Vcc pin8, -Vcc pin4
U5: LM555 Timer.
U6: SN7404 Hex Inverters. +Vcc pin14, Ground pin7
U7: SN7408 Quadruple 2-Input Positive-AND Gates. +Vcc pin14, Ground pin7
U8: SN7474 Dual D-Type Positive-Edge-Triggered Flip-Flops with Preset and Clear. +Vcc pin14, Ground pin7
U9: TL084 Quad LM741 Op-Amp. +Vcc pin4, -Vcc pin11
U10: TL084 Quad LM741 Op-Amp. +Vcc pin4, -Vcc pin11
U11: LM555 Timer.
U12: SN7404 Hex Inverters. +Vcc pin14, Ground pin7

D3: Shockley Diode
D4: Shockley Diode

SW1: Normally Open Push Button

Note: +Vcc = +12V, -Vcc = -12V

Title EaStar Sensor Unit And Control Unit Schematic Diagram	
Document Number	Rev R0.1
Drawn By Jeffrey Chien	Date Dec. 17, 2000

Figure 10: Schematic Diagrams for Drying Machine Auto-Stop Upgrade

3. Problems Encountered

In the making of this project, we of course encountered problems. We will discuss four major aspects of the problems – technical, financial, scheduling, and group dynamics issues.

3.1 Technical Issues

Throughout the process of designing and implementing our project, our group has been experiencing several technical difficulties. In most occasions, our first resources of solutions are the Engineering Professors at SFU and the two TA's of ENSC 340. Thanks to these generous people[1] who are willing to sacrifice their time to help us, most of the technical problems we encountered are solved within reasonable time periods. Nevertheless, our group still encounters a major technical problem that costs us enormous amount of time before we can reach the solutions.

Our major technical problem in the project is associated with finding the appropriate sensors. Because of the nature of our project, we are required to use a Relative Humidity (RH) sensor. The choice of a suitable RH sensor that fits our functional specifications and budget is more difficult than we thought. This problem stems in the fact that RH sensors are very expensive by nature (from $20 for a small standalone type to $1000+ for a complete RH sensor module). Furthermore, some RH sensors are very vulnerable to static, which makes them very difficult to handle and implement. After four attempts of using a small standalone type RH sensor we purchased in a local company ($27 each), we have finally given up because of its high sensitivity to static. We then turn our attention towards any other RH sensor we can find both on the Internet and company catalogs. However, after massive research, we have not much of a success. Luckily, the suggestions of the ENSC 340 TA's bring us the last bit of hope. The TA's have suggested us to look for any electronic devices that might have a humidity sensitive component in it. In one of the humidity sensors used for monitoring greenhouse conditions, we found an open-capacitor type of humidity sensor. Although this open-capacitor type of sensor requires several stages of signal conditioning before the output signal could be useful to us, it is relatively stable and insensitive to static.

3.2 Financial Issues

Throughout the course of this project, financial discipline is stressed. One group member, Edward Chen, is assigned the duty of Chief Financial Officer. He is in charge of all financial matters regarding this project and keeps other group members up-to-date on the current financial status. Moreover, he is also responsible for

[1] Special thanks to Dr. Andrew Rawicz, Professors: Lucky One, Ash Parameswaran, Patrick Leung, Lab technicians: Fred Heep, Gary Houghton, and TA's: James, Jason

applications to various scholarships and grants that would aid the project.

One of the main financial obstacles in this project is the lack of time to apply for various scholarships and grants. Many require months of preparation before a scholarship is granted. The EUSSEF Fund grants us $100 for our project and this money is spent on purchasing a second-hand dryer. The rest of the budget is to be shared equally among group members.

After comparing different companies for various discrete components, we estimate that each member will need to contribute roughly $50 to the project. This is a very reasonable price to pay considering the magnitude of this project.

3.3 Scheduling Issues

As the project proceeds, we have learned valuable experiences about how to layout a suitable project schedule. Moreover, we have identified a few problems toward the schedule we have set at the beginning of September for our project. For instance, our project schedule is too idealized. We did not put enough considerations to individual group member's ability and course load when composing the schedule. As a result, whenever more than one of the members is having an assignment, lab or exam, our project milestone are often delayed.

Secondly, we have underestimated the amount of time needed for preparing project documentations, conducting researches, and debugging. The period before the due date of the documentations is often when the progress of our project slows. And due to the scope of our project, we should have set a longer period of time for conducting researches as well as debugging.

In the future, when setting up a project schedule, we should closely evaluate the course loads of each group member, plus all issues that could possibly drag our schedule behind. Though advance identification of all problem-causing factors is not realistic, the more prepared we are in advance the less likely that we will face the same delaying problems regarding project schedule.

3.4 Group Dynamics Issues

The five group members of us worked well overall throughout the project. We hold weekly meetings to discuss and present any obstacles that we encountered or will be encountering in the near future. We work as a whole to solve problems and are open to suggestions from any members. Each of us is given an equal opportunity to contribute and excel in the field of our interests. The workload is divided equally on a voluntary basis.

Due of our busy schedule for this particular semester, it is sometimes difficult to find a time that is suitable for all five of us. We plan our meetings well ahead as we understand that this is a vital aspect of the project. Occasionally, only several of us are able to meet. We compensate this by informing each member of the current status of the project during “non-formal” meetings hours such as after class or during lunch.

There are rarely arguments among us. At most there are disagreements between us regarding component parts and methods of implementation. These are settled through a vote among us after the two sides are given an opportunity to present their views.

Overall, our group work exceptionally well throughout this semester. We are able to solve most of our problems through hard work and cooperation.

4. Possible Improvements

From the mistakes that we made and experiences that we gained, we have more insights into what we should have done. Here we will discuss what we would do differently for our project.

4.1 Time Management

All group members have been exhausted by the amount of work required to meet the schedule of this project combined with other courses. As semester end approaches, assignments, lab reports, and final examination for other courses create a time period in which no progress could be achieved on the project. During this period, we could not keep up the project schedule, implying an inevitable rush at the end. The only possible adjustment to minimize the impact of this period on the timeline of the project is to begin the work earlier. With the schedule of the entire project shifted to one week earlier, the stress could be relieved in the final week.

4.2 Group Dynamics

Overall, our group demonstrates excellent dynamics although certain aspects can be improved. Efficiency of meeting can be improved by better preparation and punctuality of individuals. Also, we should ensure the realization of meeting results as to prevent the unnecessary meetings on decided subjects.

4.3 Part Selection

The major difficulty in part selection is the uncertainty of the availability of products. We usually are able to easily locate companies selling the desired components from the Internet. However, contacting those companies with e-mail proves to be very inefficient and unreliable. A better solution is to search components from local companies. With our inflexible schedule, local companies are a wiser and more reliable choice.

5. Experiences Gained from the Project

At the end of a finished project, the things that we learned are equally important to the result of the project. In the following paragraphs, we discuss the experiences that we gained from this project.

5.1 Technical Skills

During the implementation of individual modules, we experience various problems with the circuit. Through solving these problems, we learn design techniques on TTL. When designing the signal conditioning circuit, we learn some important aspects concerning op-amp circuit design. We also gain experiences on circuit layout skills as the circuit complexity grows. We frequently expose ourselves to circuit simulation tools for circuit design verification. We as well learn how to design protective circuits to avoid IC burnouts when implementing inductor circuits.

5.2 Group Dynamics

Group dynamics plays a very important role in our project. We have experienced the importance of communication between group members. In addition, we practice interpersonal skills and listening skills, which are essential to the successful operation as a team. We learn that we should try to adapt to our different working habit as well as resolve the differences in opinion among ourselves.

6. Conclusion

To say ENSC340 and ENSC305 are challenging courses is a great understatement. Countless hours of hard work are spent by all members in order to meet strict deadlines. Time management is an essential skill to have.

This course offers us a great deal of flexibility. Not only are we able to choose a topic that interests us, but also we are given a chance to find our own solutions to problems. The professor and the TAs play a valuable role in this course and provide us with consultations whenever necessary. The design and implementation approaches toward this project are completely up to us and this offers us a great opportunity to be independent.

In this course, we are able to contribute to all parts of the product cycle. From the developmental stages to the finalized products, we are closely associated with the project at all times. Various types of issues are dealt with, including technical, financial, and group-dynamics. This closely mimics a real-world environment in which financial and group-dynamics issues have equal importance as the technical issues throughout the development of an actual marketable product.

Overall, this is an excellent course in which students apply all of their knowledge and skills to a specific project that interests them. This offers students a chance to excel in their particular field of interest. Although the workload may seem unbearable at times, the real-life knowledge of all aspects of a product development cycle is all worth the hard work.