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EECS Student Magazine

Works from Students at the University of Cincinnati

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Foreword from Tyler Westland

Tyler Westland, *PhD Comp. Sci., EECS Student Magazine Editor*

I am pleased to see so many submissions for our second issue of EECS Student Magazine. The IEEE student club hopes to see this magazine evolve into a competitive and rewarding opportunity, for students to publish in. We still have a lot of work that must be done before those possibilities become realities. It is wonderful that students have stories to tell of their quest for knowledge and experiences in our college.

Therefore, I urge you to take a a chance to get noticed by fellow students and faculty members. One may think this is a simple submission to a student magazine; however, this could be your shot at getting noticed for advanced opportunities, like careers, scholarships, and more. You never know; the opportunities available are endless, and it could be your chance to shine. I hope to see your valuable learning opportunities in our next issue.

Foreword from Zachariah Fuchs

Dr. Zachariah Fuchs, *EECS, Assistant Professor*

THE inaugural issue of the EECS Student Magazine was an overwhelming success, and the positive feedback provided by students, faculty, and industry has inspired our student authors to publish a new edition of the Student Magazine each semester. The 2019 Fall Semester edition contains a wide variety of interesting articles that represent just a sample of the diverse projects and activities taking place within our department. These activities and projects expand our student's learning beyond the classroom and provide valuable real-world experience as well as exposure to the broader engineering community. I would like to thank everyone who helped make this edition possible. As this is a student driven publication, Tyler Westland, our student editor, did an exceptional job in recruiting student authors and shepherding the articles along their revision process. I would also like to give a special thanks to Teresa Hamad for her assistance in collecting and editing papers as they were submitted. Teresa's assistance was a critical component to both this edition as well as the previous edition's success. Lastly, Marc Cahay, our EECS department chair, has been the primary driving force and cheerleader of the publication since its initial creation.

SRAM design - A Comparative Study

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***Abstract*—SRAM is the most required and widely used component in VLSI chips because of its small access time and large storage density. It is a major part of cache memory. It holds the data as long as the power is applied to the memory. Even though they have benefits like speed and low standby leakage, power consumption is always a problem. SRAM's are faster compared to DRAM but they are costly. In this paper, power, delay and Static noise margin (SNM) of 6T, 9T and 12T SRAM were compared.These SRAM cells were simulated in UMC90nm technology using cadence virtuoso tool. Butterfly curve method is used to find the SNM of the SRAM[1].**

I. Introduction

THERE are different types of semiconductor memories that are available out of which DRAM and SRAM are widely used. SRAM is more expensive than DRAM. However, it is faster and consumes less power. SRAM is easier to operate than DRAM, as it does not require periodic refreshment to maintain data. For high speed PC's SRAM memories are critical to enhance operating speed whereas DRAM's are utilized as a part of main memory, where there is more significance for density than speed. In this work we have focused on the comparison of 6T, 9T, and 12T SRAM bit cells based on the parameters like power delay and static noise margin (SNM)[2].

II. Circuit Design and Analysis

A. Six Transistor (6T) SRAM Cell Design

The 6T SRAM cell that we have taken, works on 1V power supply in conventional 90nm technology. If the supply voltage applied to the SRAM operation is low, then power consumption is also scaled down. Data bits those are to be stored in SRAM are applied to the cross coupled inverters. These cross coupled inverters will have '0' and '1' stable states. Apart from the transistors in these cross coupled inverters, additionally two access transistors are connected. These two transistors are used to control the read and write operations of 6T SRAM cell. The cell is generally enabled by word line (WL) controlling the access transistors. Both the access transistors control data transferring in read and write transistors. Generally, SRAM works in 3 nodes of operation namely hold mode, read mode write mode.[3] For write operation in the 6T SRAM cell, initially WL is set high such that the write operation can be performed. Here both the bit lines (BL and BLB) are input lines. Consider memory bits initially consists of bit 0. BLB is connected to the ground so that voltage difference occurs between QB and BLB. Voltage is applied to BL and BLB hence Q will be 1. Initially bit cell consists of 0 and after the operation it consists of 1. Therefore bit 1 is successfully written into the memory.For a read operation in 6T SRAM cell, WL is set high, to read a bit (0 or 1). When the SRAM is in read mode both bit lines are pre-charged to VDD. Let us consider Bit 1 is initially stored in SRAM bit cell. Since Q and BL are high, there will be no discharge. But QB is low and there will be a voltage difference between node voltage at BLB and QB. Hence BLB voltage decreases and there will be a discharge and Current flow. Both the bit lines are connected to the sense amplifier that acts as a comparator.[4] When BLB is low, output will be 1. Hence read operation is verified. Similarly, if we consider 0 is stored initially, there will be a discharge at Q and BL causing voltage difference. As bit voltage decreases output will be 0. Therefore, in both cases read operation is verified. When SRAM is in hold mode, WL is connected to the ground. Till power is applied, data is retained in SRAM cell. To operate SRAM in read mode or write mode word line is to be set high.[5]

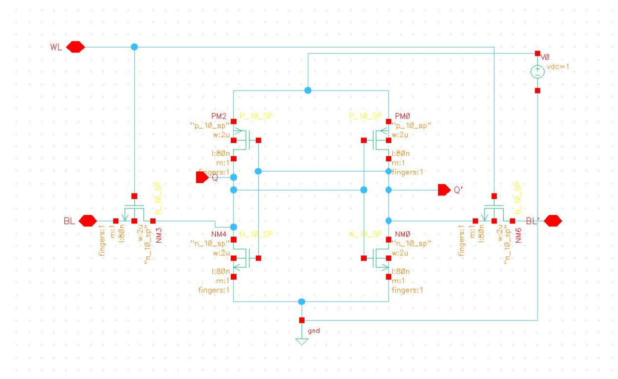

Fig. 1. 6T SRAM design

B. Nine Transistor (9T) SRAM Cell Design

9T SRAM's structure is similar to that of 6T SRAM, but it consists of 3 additional NMOS transistors M5, M6, and M7. In these, M5 and M6 are bit line access transistors controlled by the input data and M7 is controlled by read signal.For 9T SRAM to operate in read mode Write signal enable (WL) is to be set low and Read Signal Enable (RL) is to be set high thus activating M7. If Node 1 stores 1 BL is discharged through M5 to M7. If Node 2 stores 1 BLB is discharged through M6 to M7. Therefore, M3 and M4 are cutoff and the storage nodes 1 and 2 are completely isolated from the bit lines during read operations.[6] The initial conditions to achieve write operation is to set RL low and WL as high (M7 operated in cut off mode). To write '0' at node 1, BL and BLB are discharged and charged at respectively and a '0' is forced into SRAM cell. Similarly, to write '0' at node 2 (this implies writing '1'

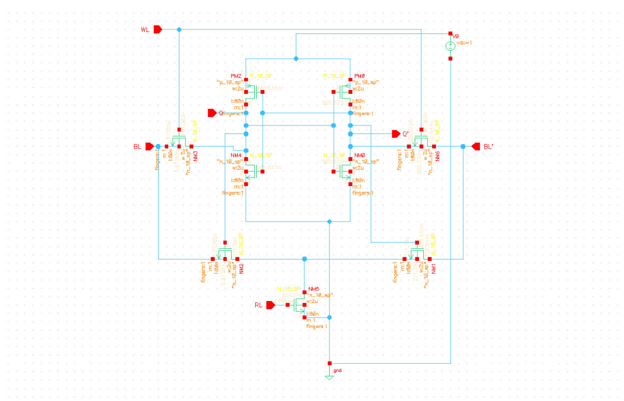

Fig. 2. 9T SRAM design

at node 1) BL and BLB are charged and discharged at node 2 to force ‘0’ onto N2 through N4.

C. Twelve Transistor (12T) SRAM Cell Design

In the 12T SRAM cell structure, transistors M1 to M4 are arranged as a pair of inverters cross coupled with each other.Transistors from M7 to M10 forms 2 pairs of PMOS devices and acts as supply switches such that each pair of PMOS devices having source terminals coupled to the supply voltage.Their drain terminals are coupled to one of the two inverters.The gate terminals of M9 and M10 are coupled to write word line and the gate terminals of M7 and M8 are connected to write BL and BL’ respectively. Both M5 and M6 acts as write access switches similar to the 6T SRAM cell. The 6 devices (M5 to M10) are related to write operation.[7]

For read operation, devices M11 and M12 are used. The storage node QB is decoupled from the read bit lines by M11 (here M11 is turned on).When RWL is forced from 0 to 1, a path from RBL to GND becomes transparent. Through this path charges on RBL begin to discharge. This whole process is the Read operation. After the completion of read operation RWL is again forced from 1 to 0 and RBL is pre-charged back to VDD.[8]

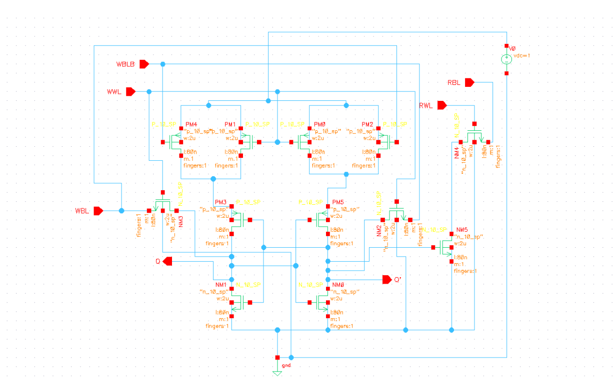

Fig. 3. 12T SRAM design

For write operation, devices M5 to M10 are used. Let us assume that 0 is initially stored at node Q and 1 is initially stored at node Q’ and bit 1 is to be written at node Q. To begin the write operation both WBLB and WBL are asserted to 1 so that device M7 is turned on and M8 is turned off. Now WWL is forced from 0 to 1 which turns on M5, M6 and turns off M9,M10. Here path from supply to the node QB is cut, such that no current can flow into the storage nodes. A path from node QB to GND is formed. Similarly, a path from supply to node Q is formed through M5. Through M6, discharge at node QB is incurred, while Q is charged through M5. Here a charge contention between M1 and M5 is occurred. However, before writing 1 at node Q, writing 0 at node QB would complete because of strong VGS of M6 as well as no charge contention in discharging path. Thus, charge contention between M1 and M5 would be eliminated after the discharging at node QB.This process turns M2 on and M1 off and makes a path from VDD through M7 and M2 to node Q and path to GND is closed.This in turn switches off M4 and helps charging node Q by causing M3 to become transparent. By this process writing 1 at node Q and 0 at node Q’ is completed. The asserted signal on WWL, WBL and WBLB are reset back to 0. With this reset, power is transferred to cross coupled inverters through transistors from M7 to M10, while M5 and M6 are turned off.[1]

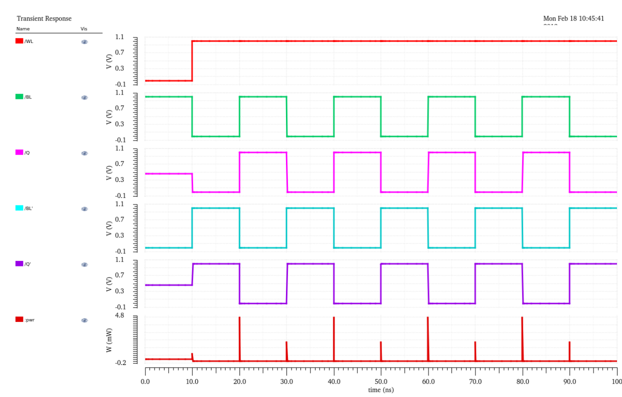

Fig. 4. 6T SRAM simulation output

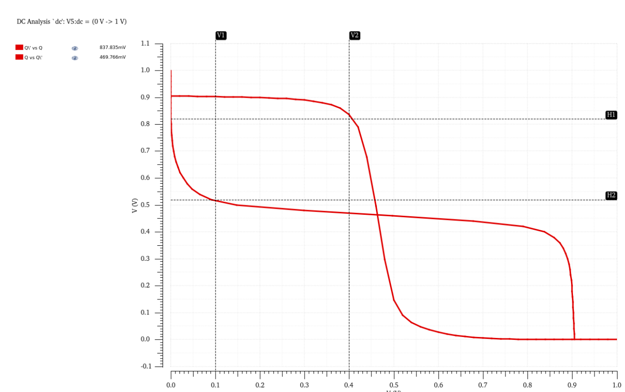

Fig. 5. 6T SRAM SNM

III. Conclusion

Thus 6T, 9T and 12T SRAM’s have been simulated using cadence and parameters like power, delay and SNM have been calculated. It is found that 6T SRAM is better compared to 9T

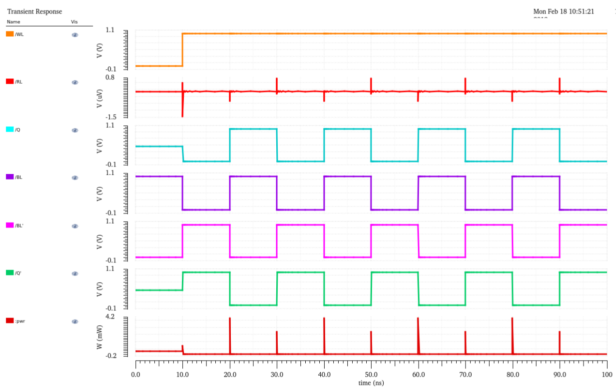

Fig. 6. 9T SRAM simulation output

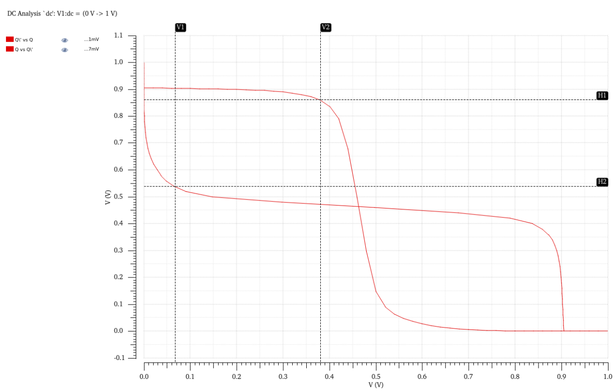

Fig. 7. 9T SRAM SNM

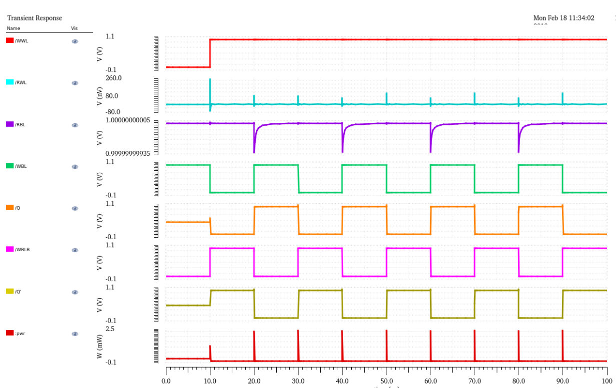

Fig. 8. 12T SRAM simulation design

and 12T as it has higher SNM and lower delay. Though 12T SRAM has less power dissipation, delay is high and SNM is low when compared to 6T. Hence 6T SRAM is preferred.

References

[1] Debasis Mukherjee, Hemanta Kr Mondal, and BVR Reddy. "Static noise margin analysis of SRAM cell for high speed application". In: *International Journal of Computer Science Issues (IJCSI)* 7.5 (2010), p. 175.

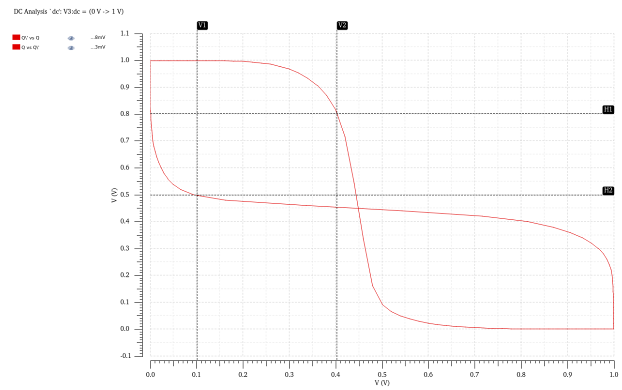

Fig. 9. 12T SRAM SNM

SRAM	Power (μW)	Delay(as) (WL vs BL)	Delay(ps) (BL vs Q)	SNM (mV)
6T	24.5	0.057	6.645	320
9T	34.78	2.186	14.35	315
12T	20.08	1.698	6.354	302

Table 1 Comparison of power, delay and SNM

Fig. 10. Comparison Table

[2] Neil HE Weste and David Harris. *CMOS VLSI design: a circuits and systems perspective*. Pearson Education India, 2015.

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[5] M Rabaey Jan, Chandrakasan Anantha, Nikolic Borivoje, et al. *Digital Integrated Circuits–A Design Perspective*. 2003.

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[8] Jaydeep P Kulkarni and Kaushik Roy. "Ultralow-voltage process-variation-tolerant Schmitt-trigger-based SRAM design". In: *IEEE transactions on very large scale integration (VLSI) systems* 20.2 (2011), pp. 319–332.

Design of a Thermoelectric Generator for a 15000 kg Autoclave used in the Sterilization of Palm Fresh Fruit Bunches

Daniel Suarez, *M.S. Electrical Engineering*

***Abstract*—The following project explains in detail the design of a Thermoelectric Generator (TEG) for a 15000 kg autoclave used in the sterilization of Palm Fresh Fruit Bunches. The main purpose of the project is to harvest energy dissipated as heat through the surface of the autoclave using a TEG and analyze if the waste heat recovery is sufficient to power the target application. The design and optimization of the TEG were done using thermoelectric simulation tools, which determine the principal parameters of the proposed TEG.**

I. Introduction

An autoclave is a pressure vessel commonly used in industrial processes that require elevated pressure and temperature. Its main purpose in Palm Oil Extraction (POE) is to perform sterilization by subjecting Palm Fresh Fruit Bunches (FFB) to pressurized saturated steam (PSS) following a strict duty cycle. This is required before oil extraction to avoid acidification due to its biochemical decomposition. The figure below briefly schemes an autoclave and its control valves.

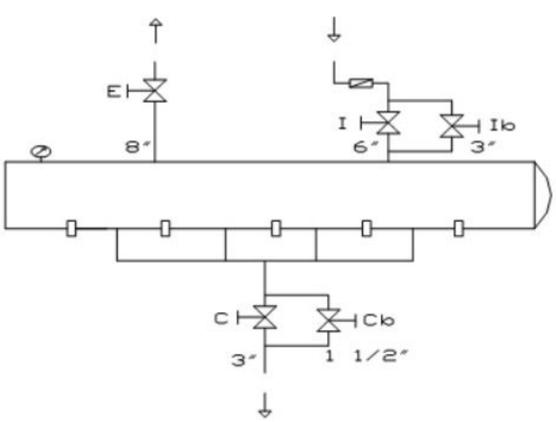

Fig. 1. Schematic of an autoclave (San Daniel, 2016.)

FFB sterilization requires PSS at 40 PSI(g) (275.79 kPa(g)), which sets the steam temperature to be 141.11 °C. This value can be obtained from tables, such as TABLE I and has been proved using infrared thermometers.

TABLE I
SATURATED STEAM FOR DIFFERENT TEMPERATURES (SPIRAX SARCO, 2018)

Saturated Steam Tables

Pressure			Temperature
bar		kPa	°C
0.30		30	69.10
0.50	absolute	50	81.33
0.75		75	91.78
0.95		95	98.20
0	gauge	0	100.00
0.1		10	102.66
0.2		20	105.10
0.3		30	107.39
0.4		40	109.55
0.5		50	111.61
0.7		70	115.40
0.9		90	118.80
1.1		110	121.96
1.3		130	124.90
1.5		150	127.62
1.7		170	130.13
1.9		190	132.54
2.2		220	135.88
2.6		260	140.00
3		300	143.75

Pascal's law states that the pressure applied to an enclosed fluid is equally undiminished to all points in the fluid. This means that temperature is also equally distributed throughout the pressure chamber. Therefore, the entire surface of the autoclave dissipates heat and can be used for thermoelectric generation. Figure 2 shows a CAD model of the autoclave.

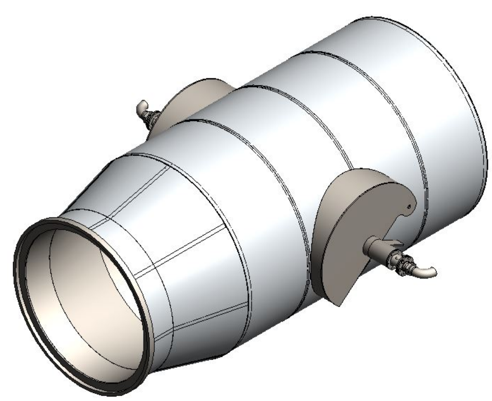

Fig. 2. CAD model of an autoclave (San Daniel, 2016.)

San Daniel Oil Extraction Mill is located in La Concordia, Ecuador, where the average ambient temperature is 30 °C. The mill currently utilizes three 15000 kg (capacity) autoclaves for FFB sterilization. The duty cycle used for sterilization is described below.

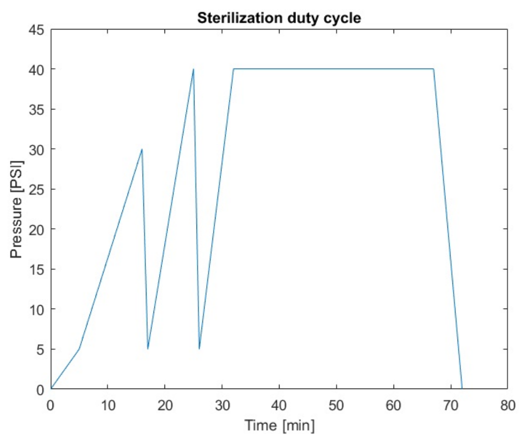

Fig. 3. Sterilization duty cycle (San Daniel, 2016.)

From a first insight, it is possible to say that the duty cycle for sterilization is not ideal for TE generation since the autoclave has cooldown periods (seen as periods where PSS is not applied). However, they are very short and would only matter for the first cycle after the Mill has gone thought maintenance. Moreover, the autoclaves are built of ASTM A36 steel and during load and unload operations; they are kept warm with steam flow.

Each autoclave is related to four proximity sensors that determine its rotational position depending on the operation. Three of them define the position of the autoclave for the load, sterilize and unload operations. The last sensor is for safety redundancy. The target application of this project is to power all four sensors.

Geometrically speaking, the autoclaves are a composed by three cylinders, one being truncated (see Figure 2). The simplicity of the surfaces allow to easily attach a module of multi-leg TEG covering a wide area, which is pertinent for TE generation. The figure below illustrates a schematic of a multi-element TEG.

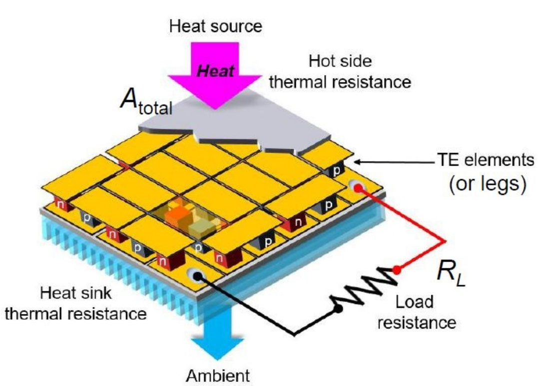

Fig. 4. Multi-element TEG (Bahk, 2018.)

II. Heat transfer analysis

Harvesting electrical energy through thermoelectrics is only feasible when a temperature gradient is present along a specific material, due to heat transfer. Therefore, the boundary temperatures are by far one of the most important parameters that define thermoelectric generation, followed by all other variables that determine heat transfer.

Figure 5 explains the thermal circuit for a multi-leg TEG with substrates.

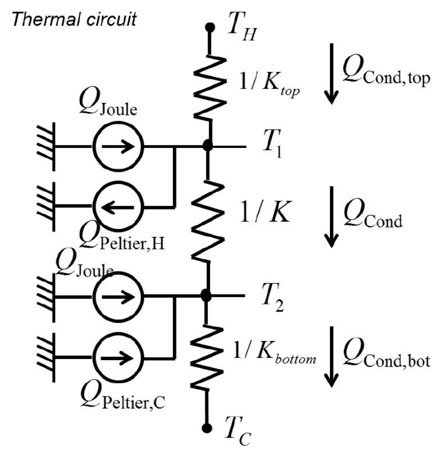

Fig. 5. Thermal circuit for a multi-leg TEG (Bahk, 2018.)

From the model, two heat balance equations and one equation from the electrical model solve for T1, T2 and I (electric current) with unique solutions. However, to optimize the design as well as reduce calculations, a simulation tool was used (ADVTE).

As mentioned before, the boundary temperatures are crucial in the design of a TEG. For this design:

$$T_H = 414.26^\circ K$$
$$T_C = 303.15^\circ K$$
$$\Delta T = T_H - T_C = 111.11^\circ K \tag{1}$$

The next important parameters that must be defined are the heat transfer coefficients for both boundaries of the TEG. One of the sides of the TEG (substrate) is directly attached to the surface of the autoclave, meaning that heat transfer on the hot side is determined by conduction. The heat transfer coefficient (U) for conduction is given by:

$$\frac{1}{UA} = \sum R_{TH} = \sum \frac{l}{\kappa A} \tag{2}$$

Where "l" is the thickness of the element, "A" the area it covers and "κ" the thermal conductivity of the material. For substrates used in thermoelectric generation, a material with low thermal conductivity and high electrical conductivity should be selected, in order to increase heat transfer and avoid short-circuits. For this design, Silicon Dioxide **(κ=1.4 W/mK)** with a thickness of **2 mm** was selected. Since the surface of the substrate is that of the TEG and only one substrate is needed, the heat transfer coefficient is obtained as:

$$U = \frac{\kappa}{l} = 700 \frac{W}{m^2 K} \tag{3}$$

On the cold boundary, heat transfer is determined by free convection (air). A heat transfer coefficient of **12 W/m2K** was selected as a typical value regarding the ambient temperature.

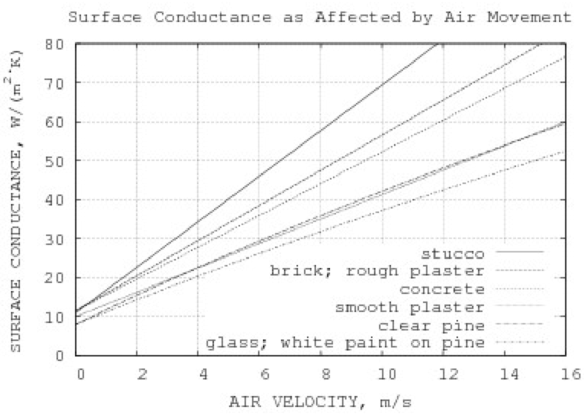

Fig. 6. Surface conductance vs. air movement.

One more important parameter defining heat transfer within the TEG is the thermal conductivity of the gap filler, which is defined by the material that is in direct contact with the TE-legs inside the TEG (see Figure 4). As known, heat transfer is not entirely a 1D transport, which is why heat is going to dissipate transversely to the ambient. For this application, air was selected as the material of the gap filler. Its thermal conductivity is **0.024 W/mK.**

III. Electrical analysis

The electrical model for a multi-leg TEG is briefly described in the figure below.

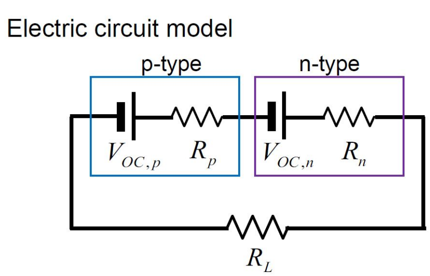

Fig. 7. Electric circuit model for a multi-leg TEG (Bahk, 2018.)

From the figure:

$$P_L = \frac{R_L (S_p - S_n)^2 (\Delta T)^2}{R_L + (R_p + R_n)} \tag{4}$$

If **Load Matching Condition** is applied:

$$S = S_p - S_n \tag{5}$$

$$R_L = R = R_p + R_n \tag{6}$$

Where S is the equivalent Seebeck coefficient of the TEG. Then:

$$P_{out} = \frac{S^2 (\Delta T)^2}{4R} \tag{7}$$

From this analysis, the rest of all design parameters are established. To maximize power, first, we have matched the equivalent electrical resistance of the TEG to that of the load. All four proximity sensors are inductive and rated for **10 V** and 10 mA meaning a total power consumption of **400 mW.** This sets the total resistance to be **250 Ω.**

Additionally, it is clear to see that the voltage and thus the power are proportional to the Seebeck coefficient (defined by the material) and to ΔT. Since our temperature variance is fixed by our system, it is important to select an adequate material. For this project, **Bismuth Telluride** was selected, due to its performance and high Figure of Merit around the temperature range needed. Its absolute Seebeck coefficient at 400 °K is around 210 μV/K for p and n type.

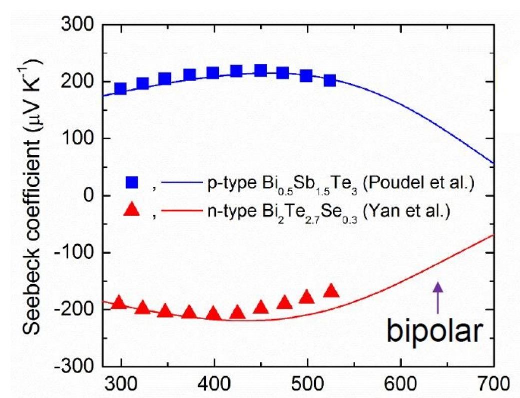

Fig. 8. Seebeck coefficient vs temperature for "BiTe" (Bahk, 2018.)

As shown, all mathematical models are based on a multi-leg TEG (couple p-n). All concepts hold for a multi-element TEG, which is a module composed by multi-leg TEGs (p-n) electrically connected in series and thermally connected in parallel. As a result, a new design parameter is defined as the relationship between the number of multi-leg TEGs and a ratio between the area of the multi-leg TEG and the area of the multi-element TEG. This parameter is called Fill Factor:

$$F = \frac{N(A_p + A_n)}{A} \tag{8}$$

It is clear that by increasing the total surface (increasing N indirectly), it is possible to increase power and voltage due to increased heat input. However, tuning the number of pairs as well as the areas covered by the TEG elements may have other results because of electrical and thermal conductivities.

Since the material is fixed and optimized by the simulator, the only variables left for tuning to achieve the target application specifications are:

- The Total surface area
- The Fill Factor or Fractional Coverage
- The Area of p and n-type elements

IV. TEG DESIGN AND RESULTS

Each autoclave used in San Daniel was built following the dimensions specified in Figure 9. As already mentioned, the simplicity of the surfaces allow to easily implement a multi-element TEG covering a wide area in order to compensate voltage and power needs if necessary due to a not very significant ΔT. The substrates can be easily designed curved thus facilitating the implementation.

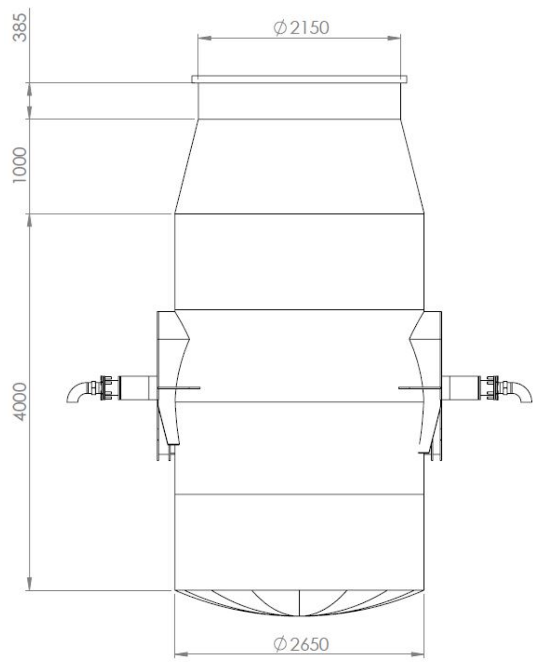

Fig. 9. Mechanical drawing of an autoclave (San Daniel, 2016.)

The following table summarizes all the parameters that manage to provide the best results for this design.

TABLE II
DESIGN PARAMETERS FOR MULTI-ELEMENT TEG

Number	Parameter	Value	Unit
1	T_H	414.26	K
2	T_C	303.15	K
3	U_H	700	W/m^2K
4	U_C	12	W/m^2K
5	Gap filler κ	0.024	W/mK
6	Total surface area	6000000	mm^2
7	Fractional coverage	0.1	-
8	A_n	100	mm^2
9	A_p	100	mm^2

All these parameters were uploaded into the ADVTE simulator. The independent variable for the design is the thickness of the multi-element TEG. The simulations are run from zero to 10 mm thickness, in steps of 0.1 mm. All properties for Bismuth Telluride are embedded into the simulation tool, according to p-n types.

The simulation results for voltage, current and power output are presented as follows:

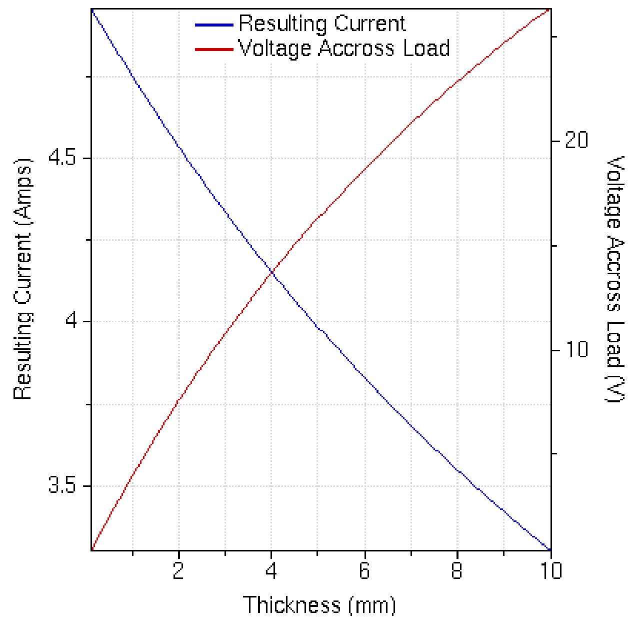

Fig. 10. Voltage and current vs thickness of multi-element TEG.

The optimum design for voltage and power is for a 9 mm multi-element TEG. Although the initial target application was to obtain 400 mW and 10 V, by targeting such small power, the voltage was too low and impossible to attain 10 V. The total surface of the biggest cylinder composing the autoclave is given by:

$$A_T = \pi DL = 33.3m^2 \tag{9}$$

By utilizing only 18% of the entire available surface, it was possible to generate not only 24.6856 V, which is the typical DC voltage for industrial control, but also 84.4483 W as shown in Figure 11.

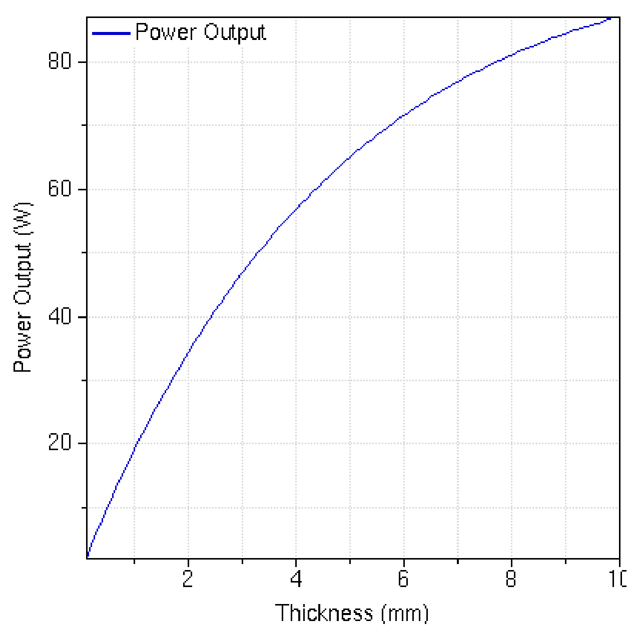

Fig. 11. Power output vs thickness of multi-element TEG.

The following figure describes the Seebeck coefficient for Bismuth Telluride as a function of temperature.

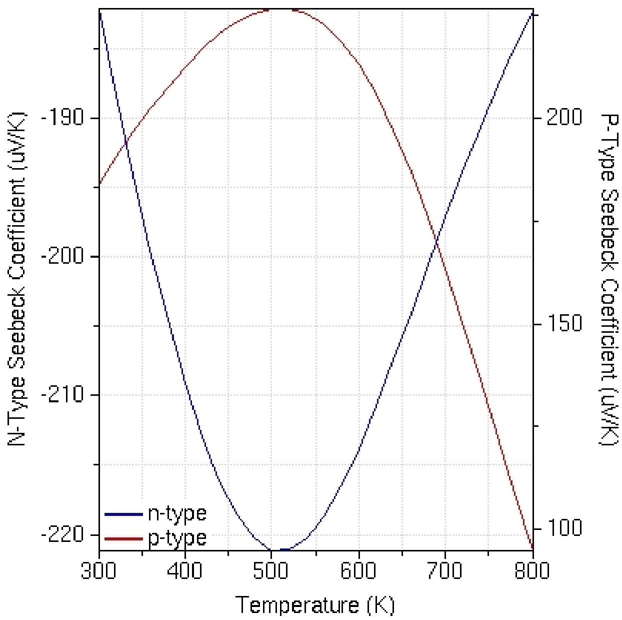

Fig. 12. Seebeck coefficient vs temperature for "BiTe".

Using Equation 5, the equivalent Seebeck coefficient at 400 °K is given by:

$$S = S_p - S_n = 421.59\frac{\mu V}{K}$$

V. Conclusions

Not only the target application voltage and power were attained but also were significantly increased. In spite of having a low temperature variance, the wide area available greatly influences the power output as well as the voltage through the fill factor (number of pairs of multi-leg TEGs).

For a **9 mm multi-element TEG,** the results are shown in the table below.

TABLE III
Summary of Thermoelectric Generation values

Number	Parameter	Value	Unit
1	Voltage	24.6856	V
2	Power	84.4483	W

From Equation 7, it is possible to estimate the number of pairs of multi-leg TEGs required for the design:

$$N = \frac{AF}{A_p + A_n} = 3000$$

From the analysis, if the Fill Factor was further increased, the first conclusion would be to say that power and voltage would increase. This statement holds for voltage. However, as the Fill Factor is increased, the Number of Pairs is increased thus decreasing the electrical conductivity of the module. This actually results in a loss of power for higher Fill Factors. This is shown in Figure 13. Since P = VI, it is clear to see that the current has greatly decreased due to a higher electrical resistance. Hence, power is reduced for higher Fill Factors.

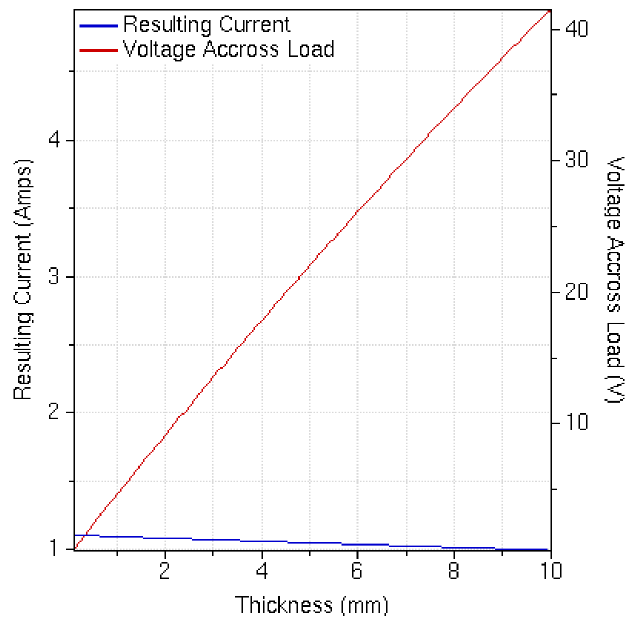

Fig. 13. Voltage and current vs thickness of TEG for F = 0.5.

Another approach to further increase power is by increasing the total surface area of the TEG, while keeping the Fill Factor constant. This results in a significant increase in voltage and power. In order to regulate voltage, surfaces of each individual TEG element (p-n type) must be increased, thus decreasing the voltage but keeping power constant.

Up to 400 W were achieved by only using 60% (20 m2) of the total surface of the biggest cylinder that composes the autoclave. This power is more than enough to feed all the control circuits of the sterilization plant in the mill. This includes control hydraulic valves, pressure sensors, PLCs and HMIs.

Further decreasing the length of the substrate in contact with the hot surface was also simulated. Using a 1 mm substrate (UH=1400 W/m2K), power is slightly increased. However, wide area usage has a greater impact and it is much easier to implement.

Due to the nature of the project and the target application, further material optimization is not required. Using commercial Bismuth Telluride will suffice. However, in further implementation, costs would become a variable needed to be analyzed, thus probably demanding material enhancement using Solid-State Physics.

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Photovoltaic Electric Energy
A New Course for Renewable Energy at UC

Nan Feng, *BS, Elec. Eng.,* Yunja Wu, *BS, Elec. Eng.,* Nathan Oliver, *BS, Elec. Eng.,* Wyatt Ross, *BS, Arch. Eng.,* Alexancer Milleman, *BS, Elec. Eng.*

***Abstract*—Beginning in Fall of 2019 a new course, ELTN 4059C Photovoltaic Electric Energy, is being offered in the Department of Electrical Engineering and Computer Science (EECS) at University of Cincinnati (UC).[1] The goal is to bring the awareness of climate change that impacts the environment we are living in and to promote renewable energy as an alternative energy source to fossil fuels. In taking the course, students have the opportunity to become familiar with the individual components involved with a solar electric system including: charge controllers, solar PV (photovoltaic) modules, inverters, and batteries. This course focuses on instructing students on the proper safety precautions necessary for installation of solar systems. Students get hands-on experience through the weekly lab sessions of the course, in which actual solar systems are constructed and their behaviors are observed. The EECS Department has recently become a registered North American Board of Certified Energy Providers (NABCEP) solar PV training and exam provider. Students complete and pass the course will be eligible to take the NABCEP Photovoltaic Associate exam on campus. Passing the NABCEP Photovoltaic Associate exam qualifies a student to design, sell, install, or maintain solar PV systems in a supervised capacity. Students with this credential will become more competitive in the solar industry job market.**

I. Introduction and Goal

(By Alexander Milleman, Electrical Engineering)

IN the Fall of 2019, EECS began offering a course on solar photovoltaic (PV) electric energy, ELTN4059C. This course instructs students on the importance of renewable energy, particularly solar, and allows them to get hands-on experience assembling and constructing solar systems. This course could not have come at a better time considering the environmental issues facing our world. There is no denying that we need to educate people on the importance of renewable energy, and this course aims to do just that.

Throughout the semester, students have the opportunity to become familiar with the individual components involved with a solar electric system including: charge controllers, solar PV modules, inverters, and batteries. The course focuses on instructing students on proper safety of solar installation and awareness of necessary precautions when installing such systems. In the classroom, students gain insight into the National Electric Code (NEC) standards, proper techniques for system setup, and begin understanding the characteristics of solar PV modules. Students get hands-on time through the weekly lab session of the course, in which actual solar systems are constructed and their behaviors are observed. The ultimate goal of the course is to have students pass the National Board of Certified Energy Practitioners (NABCEP) exam at the end of the semester, and become certified NABCEP Associates in Photovoltaic system setup. Recently, UC has become a verified instructor for the NABCEP exam, and we are now capable of proctoring the exam as well. This course will have a positive impact on the College of Engineering and Applied Science, and the NABCEP associates the course produces will have positive impacts on our environment. The lab sessions are held in the Hermann-Schneider quadrangle on Friday afternoons.

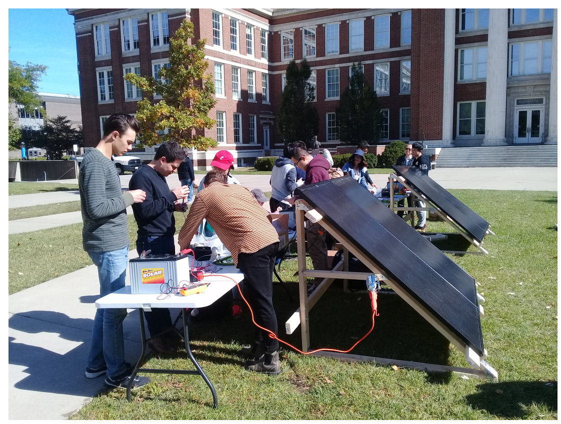

Fig. 1. Alexander Milleman (left) with his team mates during an outdoor lab session

II. Student Experience Sharing – 1

(By Wyatt Ross, Architectural Engineering)

Photovoltaic (PV) Electrical Energy is one of the most beneficial courses I am taking this semester. As a fifth year Architectural Engineering student, I am currently participating in a student design competition held by the US Department of Energy, the Solar District Cup, as part of my senior capstone project. The premise of the competition is to design a district scale solar and battery storage system. With limited exposure to PV energy and solar system design throughout my curriculum, this class serves as an extremely valuable resource for understanding topics pertinent to designing, financing, and operating a solar and battery storage system. Another benefit of taking this course is that it provides an opportunity to acquire a professional certification. Any student who passes the course is eligible to sit for the (NABCEP) PV Associate exam at the end of the semester. I plan to take the exam this December, and with a background in Architectural Engineering, the NABCEP PV Associate certification will be a valuable way to demonstrate my proficiency in PV systems to potential employers. Overall, the class is a great opportunity for anyone interested in PV technology. Students have the chance to work hands-on with real equipment in the labs, and study theory in the classroom. I definitely recommend this course.

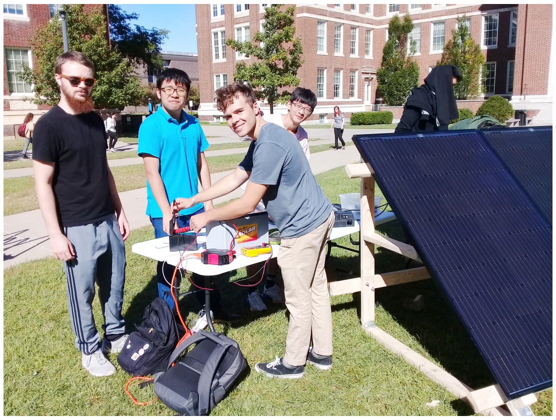

Fig. 2. Wyatt Ross (right) and Nathan Oliver (left) with their team mates during an outdoor lab session

III. Student Experience Sharing – 2

(By Daniel Suarez, Electrical Engineering)

The Photovoltaic Electric Energy course has been very interesting. It has allowed me to obtain a solid foundation in the field of solar energy as well as to understand the importance of alternative energy sources in order to help the environment. Solar energy is the most abundant renewable energy on our planet which can greatly benefit future generations.

Throughout the course, I have had the chance to work directly with commercial PV equipment during our lab sessions, setting up Stand-Alone PV Systems for small applications and measurements. Being able to personally connect, wire and test these circuits has given me valuable hands-on experience and has led me to fully understand the principle and functionality of PV Systems.

Overall, I believe this course provides a great addition of knowledge to my profile. Power generation is very important in the field of Electrical Engineering and I believe having the chance to build suitable concepts not only on Solar Energy but also in Design and Implementation of PV Systems is outstanding. I have enjoyed every minute of the course and I look forward to keep learning about the topic.

IV. Student Experience Sharing – 3

(By Nan Feng and Yunja Wu, Electrical Engineering)

As a result of being interested in solar energy, many students chose to enroll in the ELTN 4059C course called Photovoltaic Electric Energy. The experience from the lectures and labs we have attended so far verifies that our choice was right. The usefulness of this class is beyond what we imaged. In the lecture, Professor Fred Chiou fully considers our needs and educates us to become qualified engineers. Therefore, this class not only teaches us the fundamentals about solar PV markets, electricity and grid-tied systems, but also encourages us to master the necessary skill of the design, installation and application of solar PV systems. Take car battery and the battery used for solar PV systems as an example: through basic knowledge, we mistakenly thought that they can be mutually replaced, because the functions of the two batteries are both to store electricity. But after discussing with each other and listening to Professor Chiou's explanation, we realized that this obviously is not a good idea. In practical applications, the use of a car battery for solar PV systems will result in poor performance because of the different features of the two batteries. Particularly, the discharge current of two kinds of batteries is totally different: the battery used for solar PV systems has the property of long-time drain and small discharge current while a car battery has the property of short-time drain and very big discharge current. All in all, by combining theory and practice, we students can better understand the operations and safety of PV electric energy.

Fig. 3. Yucheng Zhang, Lujing Xion, Daniel Suarez, Alexander Milleman doing lab work

We also practiced many solar PV systems operations in the lab. The labs of this course are well-organized, interesting and useful. We are divided into groups of 3 or 4 people and each group has a complete solar PV system. We all had the opportunity to become familiar with these components. Moreover, we have had many hands-on experiences. For example, we need to use male and female connectors for the system connections. Thus we need to strip wires and fix metal terminals. This process was hard at the beginning but after practicing several times, all of us could do it very well. We also met some difficulties sometimes. For instance, we found our load could not work when the switch was turned on. Professor Chiou suggested us to use voltmeter to check each component's voltage to find the problem. Finally, through the voltage checking, we found that we connected wires on the same side of the switch. That explained why the switch could not work. In the next lab we were able to connect this system fast and well. Through the lab, we have learned that practice makes perfect.

The Photovoltaic Electric Energy course is interesting and beneficial to engineering students. It gives us opportunities to combine our knowledge with hands-on work. We definitely would recommend this course to students who are interested in renewable energy because they could gain very useful knowledge in this enjoyable course.

Fig. 4. Nan Feng (right), Yunjia Wu (left(with teammate Xiang Li

V. Student Experience Sharing – 4

(By Nathan Oliver, Electrical Engineering)

The Photovoltaic course has provided me with an in-depth knowledge of how a Photovoltaic Module works as well as how to design, operate, maintain, and work with potential solar customers. I would highly recommend anyone to take this course, as we are moving into the renewable energy era and employers will give potential employees with a stronger background in renewable energy the edge over those who do not. As a Transmission Planning Co-op for a local utility, I have seen and modeled numerous interconnection projects for solar farms. Ohio is a deregulation state when it comes to generation, meaning that customers in Ohio have the option to choose from whom and where they get their power. This has resulted in Ohio utilities, and other utilities in deregulated states, selling off their generation.

Taking the NABCEP exam after completing this course would help any potential employee of a utility in a regulated state as they would be an expert in solar generation. They would o help their company design a solar farm and connect it to their grid. Any employee working in a deregulated state would be able to help facilitate any interconnection that gets presented, but the utility would not have control over the day to day operation.

References

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VI. Appendix

A. Contact for More Information

Fred Chiou, Associate Professor Educator, EECS Department, chioufd@ucmail.uc.edu, Instructor of the course.

B. More Photos to Share

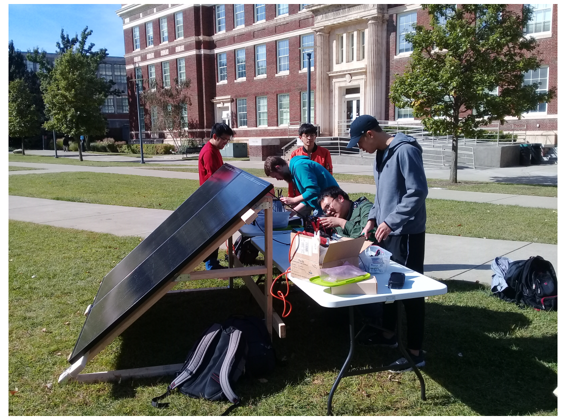

Fig. 5. Nathan Oliver (center in blue)

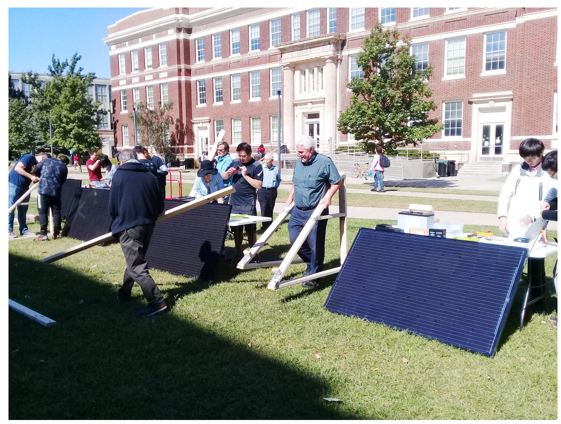

Fig. 6. Professor Max Rabiee (center), Professor Chia Yung Han, Instrumentation Specialist Jason Heyl, and Computer & Info Analyst Robert Montjoy helped set up the ground-mount equipment for solar (PV) system during an outdoor lab session.

Fig. 7. Students learned how to install the ground-mount equipment

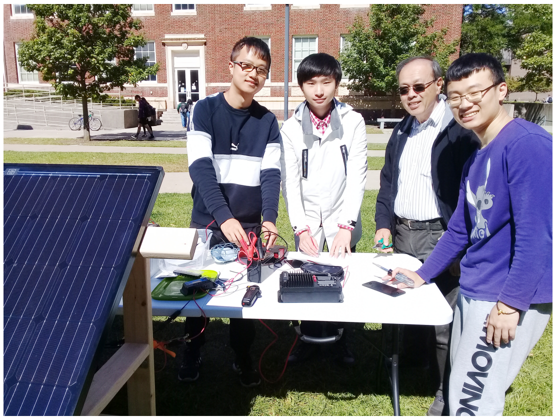

Fig. 8. From left: Students Zhenghong Chen, Xiaoyu Yan, Professor Chia Yung Han, and Zhilu Guo

Fig. 9. Students (from left): Shunran Li, Changwei Li, and Xiaoyu Ou

MakeUC Hackathon

Omar Alsayed, *B.Sc., Computer Engineering*

***Abstract*—MakeUC 2019 was the second edition of a successful computing hackathon led by IEEE and ACM student chapters. MakeUC attracts students from many majors and is inclusive to everyone regardless of their background or graduation year. This paper highlights MakeUC's community, organizing leaders, sponsors, and project submissions from MakeUC 2019.**

I. Introduction

MAKEUC is a 12-hour student-run hackathon organized by IEEE (Institute of Electrical and Electronics Engineers) and ACM (Association for Computing Machinery) student chapters at the University of Cincinnati.

The 12-hour event took place on September 21st in Baldwin Hall at the University of Cincinnati. The event received 180+ sign-ups from 20+ different majors. [1] The MakeUC organizing team is proud of the high student turnout!

II. About MakeUC

MakeUC was founded by IEEE and ACM@UC as a mini-hackathon in the Fall of 2018, the attendance was higher than expected on its first occurrence – 112 students. [1] At MakeUC 2019, the attendance was even higher and the number of people that demonstrated their projects at the end of the hack day went up by 160 percent in comparison to MakeUC 2018. [1] Northrop Grumman, Marathon Petroleum, and Red Bull were our sponsors for this years' edition. Engineers from Northrop Grumman volunteered their time to be mentors side by side with IEEE and ACM@UC organizing leaders.

There were three optional workshops throughout the day, allowing students to learn more about data decryption algorithms, deep neural networks, and technical presentations.

Fig. 1. Hacking in action at MakeUC 2019 [2]

The event took place in three different rooms simultaneously. Fig. 1 shows a picture of the main hacking room, which shows students collaboratively working together to develop amazing hardware and software projects.

III. Projects

A. Cybersecurity

A handful of our attendees decided to participate in Capture The Flag challenge, a cybersecurity hacking challenge hosted by Northrop Grumman. The challenge was introduced by a representative from Northrop Grumman with a workshop to give the participants an idea of where to start. This hack required strong understanding of cryptography, binary exploitation, and reverse engineering. The participants enjoyed the challenge and the winner received a development kit from the company's representative.

B. Software Development

The software hacks covered many computing genres such as video game development, machine learning applications, and app development. Unity was the most common game engine used by game developers; the Unity applications varied from 2D games to VR/AR games. Most machine learning developers decided to use packages, such as TensorFlow, to develop object recognition applications. The hacks were diverse in terms of technology stacks for app development.

C. Hardware Development

Hardware is the main theme of MakeUC. Therefore, most participants leveraged the use of hardware to build their projects. The hardware projects were phenomenal and many of the hardware hackers took the embedded system design route and used the hardware kits provided by the IEEE student chapter-run hardware lab. MakeUC's community witnessed intelligent system design, robotics, hardware-controlled video games, and more.

IV. Conclusion

A lot of people do not know what a hackathon is; the term ”hackathon” is becoming more and more familiar every year. Our goal as organizers is to help every person that has interest in computing and its applications by getting them involved in the coding community through events such as MakeUC.

University of Cincinnati's coding community believes that events such as MakeUC are crucial to effectively develop solutions that can help us leave the world in a better shape compared to how we found it. The community therefore believes that by acting as mentors and passing on our knowledge, we can support collaborative efforts of computing enthusiasts to ultimately empower people and create a positive impact.

References

[1] University of Cincinnati's IEEE Student Group. *MakeUC 2019 Statistics Sheet*. 2019.

[2] University of Cincinnati's IEEE Student Group. *Hacking in action at MakeUC 2019*. 2019.

Cyber@UC and RAPIDS: Teaching the Next Generation of Cybersecurity Professionals

Anthony Cardarelli, *MS, Comp. Sci.,*

***Abstract*—Cyber@UC is UC's official student organization focused on cybersecurity. In May 2017, Cyber@UC was asked to build a SOC (Security Operations Center) to fulfill one of the requirements of the RAPIDS (Regionally Aligned Priorities In Delivering Skills) grant. The goal of the RAPIDS grant was to increase the number of skilled InfoSec professionals to address the increasing shortage of a trained workforce. Cyber@UC accomplished its assigned goal and expanded its operations to make an impact beyond its members and UC students. This paper will cover the lessons learned and the three-year journey outlining Cyber@UC's success.**

I. Foreword

As the founder of Cyber@UC, I would like to express my gratitude for some of the wonderful people who helped me transform Cyber@UC from an unofficial group of students with a passion for cybersecurity into a large organized non-profit that has been able to create a culture of cybersecurity in our Bearcat community, specifically Dr. John Franco, Dr. Marc Cahay, Vicki Baker, Cyber@UC leadership, and all the other organizations and businesses with which we have had the pleasure to work.

II. The Cyber Workforce Problem

Cybersecurity has been an expanding topic of interest in society. This has been driven by data breaches, cyber-attacks, and an increasing reliance on technology. Today, the demand for skilled technology professionals in the fields of cybersecurity, data analytics, and robotics is great and continuously growing. Educational institutions in Southwest Ohio have become hard pressed to adequately supply the technology workforce for these fields which are critical for economic growth and national security. The supply/demand ratio provided by Cyberseek[1] reveals the Cincinnati area to have a very low workforce of cyber security professionals with over 1000 jobs that need to be filled.

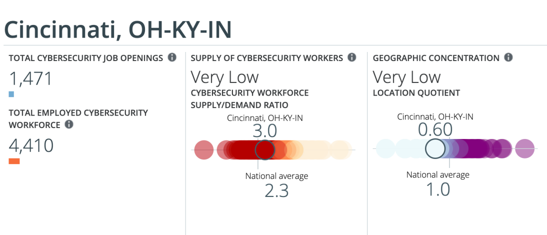

Fig. 1. Cyberseeks Supply/Demand Ratio Statistics for Cincinnati [1]

This undersized workforce combined with the increasing rate of cyber-attacks pose serious problems for the public and private sectors. The US FY2019 budget allocated $15 billion [2] for cybersecurity related activities; this budget is up by over $500 million since only last year. It is because of this trend of increased funding for cybersecurity that projects like RAPIDS are possible.

III. Regionally Aligned Priorities In Delivering Skills

RAPIDS is a collaboration between industry and academia conducting research and development activities tailored towards training a highly skilled workforce of engineers and technicians. This $1 million project is being carried out by the University of Cincinnati, Cincinnati State Technical and Community College, Butler Tech, and Miami University. Each university was assigned a unique task to aid in achieving the goals of RAPIDS.

The University of Cincinnati was given two deliverables: to build a Security Operations Center (SOC) and a Data Analytics Center (DAC). Cincinnati State was requested to build a Software Defined Networking (SDN) lab. Butler Tech's goal was to assemble a cybersecurity training lab to teach students penetration testing and intrusion detection. Miami University was tasked to build a smart factory lab with a focus on Flexible Manufacturing Systems (FMS). These combined projects help increase the number of talented technology professionals in our area to address the workforce deficit and align higher education with the needs of the technology industry.

IV. Cyber@UC Lab Setup

Before we could begin developing the SOC, Cyber@UC needed a lab to work in. Thanks to the wonderful faculty in CEAS, we were given rooms 516 and 513 in the Engineering Research Center as space for our lab and equipment. With the money provided by RAPIDS, Cyber@UC's lab is equipped with 21 rackmount servers, 3 firewalls, two 64-port switches, 8 desktop computers, and plenty of desks and chairs.

Fig. 2. Cyber@UC 516 ERC Lab pre setup

To oversee this new equipment and efficiently prepare the lab for use, Cyber@UC needed an additional committee solely focused on lab planning. Previously, Cyber@UC's organizational structure only consisted of five committees: Public Affairs, Content, Finance, Recruitment/Retention, and Outreach. Each committee represents an area of focus for our organization. Fortunately, the addition of a lab committee allowed for interested Cyber@UC members to get hands-on experience in setting up enterprise level equipment.

Fig. 3. Cyber@UC Treasurer Ryan Baas in the finished lab

The equipment arrived in early June, 2018, and the process of setting up the lab hardware concluded mid-August of that same year. Cyber@UC members involved with this phase of the project were able to gain industry applicable experience in setting up servers just like professionals would in most datacenters today.

Fig. 4. Cyber@UC Head of Content Chris Morrison guarding the servers

Once the lab hardware was all racked in ERC 513 and the workspaces were completed in ERC 516, Cyber@UC began building the Security Operation Center.

V. A Security Operations Center

Security Operations Centers are currently used by industry to keep employees and intellectual property safe. The main function of a SOC is to act as a nucleus to all point security solutions.

Businesses that want to maintain overwatch on their networks and computers deploy a variety of security tools, each accomplishing a specific job. Firewalls, antivirus, endpoint detection systems, intrusion detection/prevention systems, asset management software, open source intelligence databases, and more all are used today to detect malicious threat actors and to keep data secure. The difficulty of having so many tools is being able to effectively manage them and make sense of the information they provide. Many times, network detection systems can be very noisy and generate floods of alerts, with only a miniscule fraction being actionable and useful.

A SOC needs to have the capability to connect with many tools, to filter out unneeded detections, and to correlate actionable data. After data has been correlated and filtered, it must then be enriched with open source intelligence to provide further context for analysts. In the field of cyber defense, context is key to identifying whether activity is malicious. A business that mislabels auditing/developer activity as malicious can result in wasted time and money through useless remediations of legitimate systems.

After filtering, correlating, and enriching data from security point solutions, that data then needs to be intuitively presented to the analyst. This is achieved through ticketing systems which organize and display all relevant detections. Ticketing systems are critical for the operation of a SOC as they provide the ability to track incidents and to identify trends of what is attacking the network. As tickets get worked by analysts, more context is discovered about alerts, and it is with this extra context that the analyst can improve future detections. This feedback loop is important for tuning a SOC to the environment in which they are deployed.

VI. CYBER@UC'S SOC

Cyber@UC was responsible for managing $200,000 of equipment to build a SOC. The Cyber@UC SOC was developed as a senior design project carried out by myself (Anthony Cardarelli) and Evan Pringle. All open source technology was used in the building of the SOC and glued together with a custom written correlation engine and a SOC dashboard.

We used Wazuh as our endpoint detection system. Wazuh works by deploying agents to hosts for monitoring of system events. It can watch for file hash changes, suspicious process chains, network connections, and more. Its capability for live response allows systems to be quarantined in the event of malicious activity. In other words, this tool is a very advanced anti-virus.

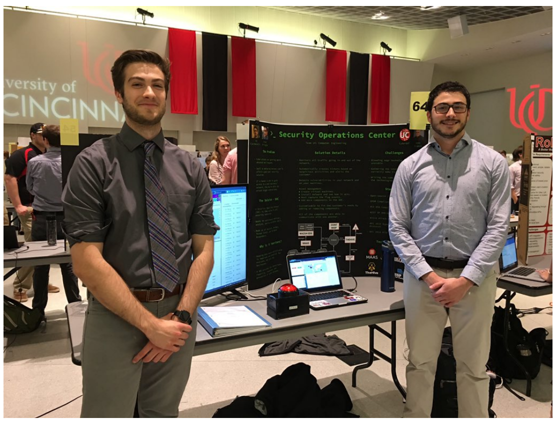

Fig. 5. Evan Pringle and Anthony Cardarelli showcasing the Hack-in-a-box SOC Demo

With host security covered, network security was the next aspect to tackle. For our Full Packet Capture (FPC), we deployed Moloch. A FPC system captures all network traffic and writes the packet captures to disk for safekeeping. These captures can be analyzed in the event of malicious activity to help identify command and control (C2) traffic and to provide more context to the analyst. Moloch also has the abilities to store all captured traffic metadata and to display it in an intuitive Wireshark-like interface, which is useful when hunting for malicious traffic. Moloch works well with another open source network security tool known as Suricata. Suricata was deployed as our labs Intrusion Detection System (IDS). Suricata can be fed rules which look for specific byte patterns, IPs, domains, protocols, and more to detect potentially malicious traffic. Suricata can enrich all the Moloch FPC metadata with its detections, which is useful when analyzing traffic. When a rule fires off, Suricata can log or drop that traffic based on the rule logic.

Now that network and host-based detections are already addressed, the next tool we deployed was for Open Source Intelligence (OSINT). The Malware Intelligence Sharing Platform (MISP) was our tool of choice. MISP is used to store Indicators of Compromise (IOC). An IOC can consist of an IP, filename, hash, domain, or just about anything that could be used to add context to an alert to determine if the activity is malicious. Beyond just storing IOCs, MISP is built to find relations between its IOCs, which helps when trying to perform attribution or determine if an event is part of a larger campaign. The Cyber@UC SOC uses MISP to enrich data collected from the deployed EDS and IDS systems to help guide the correlation engine in what needs to be ticketed.

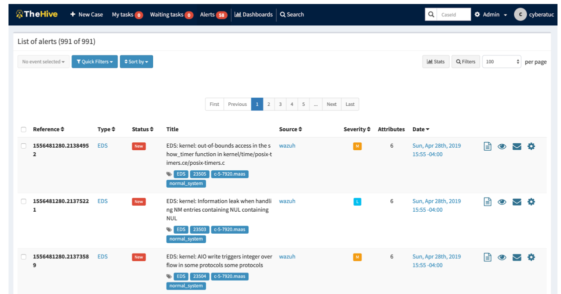

Fig. 6. Screenshot of tickets in The Hive

Ticketing was taken care of by the open source Hive Project. The Hive offers an easy to integrate ticketing platform. Information that was deemed actionable by the correlation engine is sent to The Hive to be displayed for analysts to work.

All of these solutions send data to a central backend database, which we chose to be Elasticsearch combined with Logstash and Kibana (ELK). Elasticsearch is a non-relational database designed for flexible storage of differently formatted data and lightning-fast search times. Kibana integrates with Elasticsearch and provides a web GUI for exploring stored data and for creating dashboards. Logstash helps feed logs into Elasticsearch. Together, they create a scalable storage system that is fed data from all Cyber@UC SOC tools.

The correlation engine is custom written python code that queries Elasticsearch for data from each security tool. The engine works by grouping data together based on common field values. For example, alerts from the same host will be grouped and ticketed as one. Having one central data lake for the correlation engine to query simplifies the correlation process and makes it easier to modify and tune.

All of these technologies come together nicely to form a low cost, flexible, community supported SOC. Thanks to the RAPIDS grant, the University of Cincinnati faculty, and the hard-working, passionate Cyber@UC members, students now have the ability to come to the lab and gain direct experience working tickets exactly like a cyber analyst would in the industry. Furthermore, this SOC can be used in attack and defend exercises to teach other aspects of cyber security that are important for future professionals to know.

Fig. 7. Cyber@UC Head of Lab Aaron Boyd (Left), Head of Outreach Michael Sengelmann (Center), and President Clifton Wolfe (Right) speaking at the Cybersecurity Education Symposium

In June of this year, the University of Cincinnati hosted the inaugural Cybersecurity Education Symposium to commemorate the second phase of the Ohio Cyber Range (OCR) as well as to announce the start of the third phase. University of Cincinnati faculty and high ranking United States government officials were present as members of Cyber@UC, Clifton Wolfe (Chapter President), Michael Sengelmann (Head of Outreach), and Aaron Boyd (Head of Lab) spoke about the milestones that our organization accomplished in the past few years, including the development of our SOC. Along with many other functions from Phase II, this event served as a means for Cyber@UC to share the impact it has had on the local community through outreach and technological development.

VII. Cyber@UC Outreach

The impact of the Cyber@UC lab reaches beyond just its members. Through funding from RAPIDS, Cyber@UC has been able to expand its outreach operations to collaborate with local high schools, businesses, and other clubs interested in developing cyber talent. Every week, Cyber@UC organizes

Our head of Outreach acts as the intermediary between Cyber@UC and other educational institutions, businesses, and government agencies. Every semester, we attempt to host a number of outreach events involving students at the University and the local community. In the past, we have hosted guest speakers including NSA professionals, who gave a presentation on the history of cryptography and brought an original Enigma machine from the World War II era. We have also coordinated and led CTF events, one of which coincided with several meetings and events to keep local students at the University of Cincinnati involved. These include CTF (Capture the Flag) training sessions every Saturday at 11:00am, organization planning meetings every Sunday at 6:30pm, lab meetings every Monday at 6:30pm, and regular chapter meetings every Wednesdays at 6:30pm that are live-streamed. All of these meetings/events are essential for maintaining the organization's cybersecurity presence at the University of Cincinnati and the state of Ohio.
RevolutionUC's 2018 Hack-a-thon in which we had over 30 participating teams and gave out sponsored awards to the highest-scoring teams.

As important as all of these university centered events are, they are not as impactful as our outreach events with local high schools such as Fairfield, Loveland, and Lakota East. Presentations on bash scripting, Linux basics, python development, reverse engineering, network analysis, cross site scripting, and video game hacking are just some of the topics we have covered to help prepare the future generation of the cybersecurity field. Outreach is only one of the many reasons why Cyber@UC is at the forefront of cybersecurity education in the state of Ohio. Looking to the future, we plan on continuing to grow and increase our impact on the next generation of cybersecurity professionals.

Fig. 8. Anthony Cardarelli Founder of Cyber@UC presenting an example of reverse engineering to students at Loveland High School

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Joint Co-op Institute- Living and Teaching Abroad -EECS Student Experiences

Josiah Smith, *BS, Mech. Eng.,* Madison Waite, *BS, Chem. Eng.,* Gee-Wei Wang, *BS, Comp. Eng.,* Luke Weisenbach, *BS, Chem. Eng.*

***Abstract*—The Joint Co-op Institute program at UC provides the ability for students at Chongqing University in China to take UC curriculum classes and earn degrees from both Chongqing University and the University of Cincinnati. In the Fall 2019 semester, the JCI program hired four students to travel to China to work as teaching assistants for engineering courses. The experience provided the students with the opportunity to grow their professional development skills, expand the understanding of world culture and politics, and explore the country first hand. Below are accounts from each University of Cincinnati student who embarked on the journey.**

I. Josiah Smith

TO To travel the world, diversify myself, and to help others- that is my dream. In seeking these experiences, I found the Joint Co-op Institute at UC. Through a collaboration effort, UC provides curriculum and faculty for students at Chongqing University to pursue engineering degrees from both universities.

In the program, I am one of four teaching assistants aiding with courses for Mechanical Engineering and Electrical Engineering. We help the professors with lecturing and grading, as well as help the students with the class content and improving their English proficiency skills. With this opportunity, I have done my best to take full advantage of experiencing and engaging in an unfamiliar culture. To do this, on the weekends during our free time, the other TAs and I travel to see as much of the country as we can, which sometimes includes very late nights and very early mornings. Given our limited time here abroad, I think each sleep deprived day is well worth it. From mountains to temples to big cities, I am ecstatic to see the world from others' perspective. In a part of the world I may not be able to see again, each trip our group has taken holds a special place in my heart.

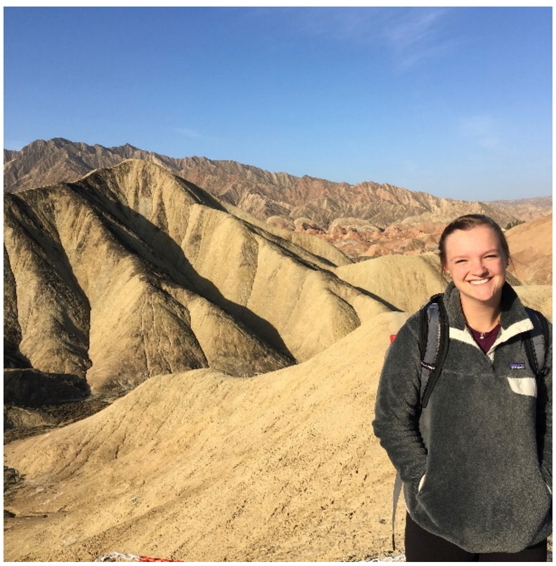
I am extremely grateful I have this opportunity. It has helped me grow professionally, educationally, and personally. Professionally, I have a better understanding of company culture. Since the university is a sort of educational company, I have learned about and gained an appreciation for the educational structure from working closely with the professors and faculty to facilitate learning for the students. Additionally, my communication skills are practiced daily, from students with homework questions, to communicating with the Dean of the college. This has given me insights into the JCI program and how each university maintains their respective educational culture. My leadership is also tested, as I am asked to fill in to lecture or proctor exams, allowing me to practice my management and communication skills. In terms of my education, my understanding of the class topics has been strengthened by helping others with the content I struggled with in the same way. When the information clicks with a student, their eyes light up, and it is rewarding to see their motivation and determination with the content I struggled to learn. Personally, since living and teaching abroad for some time now, I have learned to adapt and be more flexible to other ways of life. With an open mind and flexible attitude, the cultural barriers become almost non-existent. Additionally, I have learned many lessons through the difficulty in the language barrier. The difficulty in communication with students encourages me to continue helping them with their English skills, and strive to help students in any way I can.

As a third-year student, this co-op opportunity allowed me to diversify my work experience to showcase a global perspective and my interest in management and teaching. I hope that through this experience I can motivate others to travel and seek every opportunity to see the world from a different perspective. This is the second opportunity I have had to travel the world this year, the other being a trip with UC Engineers Without Borders in January. Both trips have sent me far outside of my comfort zone, which has been the best way to grow personally. As I continue my engineering degree, I hope I can utilize the lessons I have learned since living and teaching in China. I hope I can also begin a conversation with others about the many opportunities that the UC International

Program has to offer. The connections I have made with the people I have met has brought me great insight into the differences I once overlooked and did not understand. It has been a transformative year, and I'm sure that the lessons I have learned from this experience will be beneficial to me moving forward. Life moves pretty fast, and I am glad I could stop to look around for while so I don't miss it.

II. Madison Waite

So far, this semester has been a great co-op experience for me. I am completing a rotation at Chongqing University in Chongqing, China as a teaching assistant for their Joint Co-op Institute. While this is not a typical co-op, I have enjoyed every second of it.



I am currently a TA for three classes: Probability and Statistics, Engineering Models I, and Engineering Foundations. My daily duties include going to lectures and labs, taking attendance, administering quizzes, collecting assignments, grading these assignments, and updating the gradebook. This TA position is unique because it allows us to form strong relationships with the students with whom we interact.

When I am not working, I travel around China with the other TAs. Some of my favorite memories from our trips so far have been seeing the pandas at the Chengdu Research Base of Giant Panda Breeding, viewing the skyline of Shanghai from the Bund, and visiting the rainbow mountains in Zhangye Danxia Geopark. Being able to explore and experience so many new things is something that I will always value.

I have not had much previous experience traveling, so this co-op has allowed me to see parts of the world that I never imagined seeing, which I've loved. In the future, I plan to continue traveling and experiencing different countries' cultures. This co-op has helped me realize how much there is for me to see, and I hope to be able to incorporate traveling into my future career.

This experience has helped me to grow in many ways. I have gained more confidence in my leadership skills by completing daily tasks, such as leading the lab for a whole class or

working through a problem with a student 1-on-1. I also have become more comfortable with the unknown, coming to China for a whole semester was a big change for me. Since I have been here, I have gotten more used to the idea of expecting the unexpected.

I believe that this co-op will help me immensely in the future as I prepare to enter the full-time work force. I am so grateful for this university and all of the unique opportunities that they are able to offer to students.

III. Luke Weisenbach

Working for the Joint Co-Op Institute at Chongqing University has been an unbelievable experience this semester. While this is not a conventional co-op, it has been the semester I have enjoyed the most and the one in which I have gained the most. I am a teaching assistant in three classes, Heat Transfer, Engineering Foundations, and Engineering Models 1. The responsibilities are different from that of a TA in America. The other TAs and I have a wide range of tasks, from testing lab equipment and running the labs to helping students improve their English; the most rewarding part of this job is seeing the students become more comfortable and confident in themselves and their speaking abilities throughout the semester.

When I am not working, I spend my time traveling throughout China with the other TAs. Part of what makes this co-op so incredible is the opportunity to travel almost every weekend. Being able to experience the geography, architecture, and cultures of the different regions in China is a dream come true. Walking through temples and other religious areas, such as the Dazu Rock Carvings, gave me a deeper appreciation for this part of the culture I could not have gotten without experiencing it firsthand. Other highlights include seeing the Rainbow Mountains at Zhangye Danxia National Geopark, watching the Shanghai skyline light up at The Bund, and eating hot pot in Chongqing. I never thought I would be able to spend an entire semester abroad, so being here is truly a blessing.

While I have been able to travel around the United States, this is my first real experience in another country and it has inspired me to see more of the world and experience as many cultures as I can. Living in Chongqing for the semester has been an experience for which I will be forever grateful. The Joint Co-Op Institute is a great program, and I consider myself extremely lucky to be part of it.

IV. Gee-Wei Wang

Being able to come to Chongqing to be a part of the Joint Co-op Institute program that the University of Cincinnati and Chongqing University hold has been an amazing experience and is something I am extremely grateful to experience. In the JCI program, the students of CQU take their first four years of engineering courses in English at CQU and are given the opportunity to come to UC to study for their 5th year and graduate with Bachelor's degrees from both UC and Chongqing University. At the same time, students at UC are given the opportunity to go to CQU and spend a Co-op semester working as a TA.

Life in China is great: on the weekends we were able to travel all around China to see the beauty in places of Shanghai, Hangzhou, Zhangye, and Chengdu. The cultural differences

I was given the opportunity to work as a TA for Engineering courses here at CQU and it has been an impactful experience to see the students taking classes - the same classes I took at UC that I struggled with, except in a second language! It is amazing, and drives me to work harder in my courses when I get back to UC. I also help students with any questions they have about American Culture and with their English. I hope to be able to aid more and more students and prepare them for any educational and cultural differences when they come to America as many students have done for me.
here were not too hard for me to adjust to luckily due to my Chinese background. There were still some differences in social cues that I am still not able to catch onto due to my lack of fluency in Mandarin, but that drives me to practice my Mandarin so I can connect with my ethnic roots.

This experience will hold a special place in my heart, and I will never forget the memories made here at Chongqing University. If anyone has the opportunity to, I would recommend this experience.

U.C. Experience

Nathan Huber, *BS, Elec. Eng.*

***Abstract*—During my undergraduate studies I was involved in co-founding FlyUC as well as being a part of Hyperloop UC and assisting in starting up an intelligent robotics lab. These activities greatly strengthened my knowledge and leadership skills while being a part of the UC community. I have now started my career as an Electrical Engineer at Coldwater Machine Company, LLC, a Lincoln Electric Automation™ company ("Coldwater").**

I. Introduction

MY time at the University of Cincinnati has allowed me to make a career out of what I love to do and helped me build and grow as a person. I was able to work closely with people who each wanted to change the world in different ways. From working to create the next type of transportation, to reinventing aspects of the health care industry, I was able to gain many valuable skills and life lessons along the way.

II. FlyUC

During my senior year, several friends and I founded the group FlyUC. The primary goal of the group was for students to learn about vertical takeoff and landing (VTOL) aircrafts and compete in the Boeing GoFly competition. The VTOL aircraft design was based around a single person flying a compact aircraft. After a series of phases in the competition, the remaining teams were able to fully assemble their designs and compete against other teams around the globe. As the Electrical Lead, I was responsible for managing members within the electrical group and overseeing that the work completed stayed on schedule and budget. My primary goals were to train others on how to apply the engineering method to problems and getting the project to competition.

III. Hyperloop UC

The few years I worked within the Hyperloop UC electrical group were spent developing high powered battery systems. I also spent time mentoring students and developing hoverboard technology.

The system utilizes a custom manufactured printed circuit board to control four Electronic Speed Controllers (ESC), four servos, four distance sensors, and allows for expandable applications over I2C. The system is controlled by an Android App I developed during my time on the project. The Hyperloop Hoverboard Electrical System is broken down into three categories: Android App, printed circuit board (PCB), and control software

Each category plays a role in allowing the system to operate properly. The Android App communicates over Bluetooth to the circuit board for control and monitoring over the system. The circuit board controls the ESCs and servos; monitors the distance sensors, a safety circuit, and battery health; displays to an LCD screen; and communicates to the Android App. The circuit board also has two microcontrollers: an ATmega328P and an ATtiny85. Overall, the system allows for levitation on metals that are super conductors, such as aluminum, and steering of the levitated unit using servos to control the pitch of the motors.

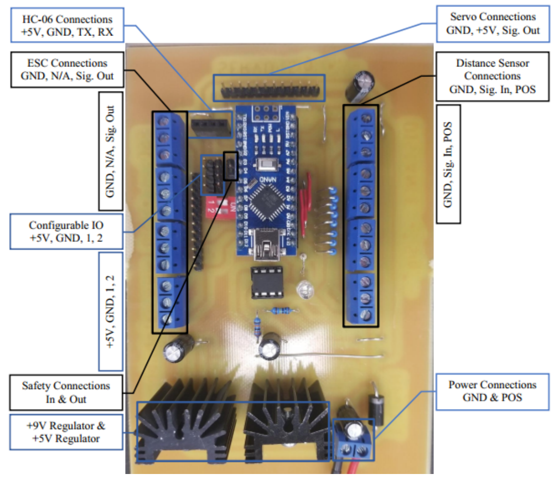


Fig. 1. Hoverboard Circuit Board

IV. Intelligent Robotics and Autonomous Systems

Our work is driven by the idea of being able to help others with the rapidly advancing technology we have today. The biggest inspiration I had for this project was my late grandmother. She developed dementia five years ago and struggled greatly at the nursing home in the last year we had with her. I found it troubling that she and many other residents were having troubles carrying out activities of daily living, such as reaching for a cup and drinking. Having the understanding that something needs to change to help these people is great but being able to design and build something that can help change their lives is even greater.

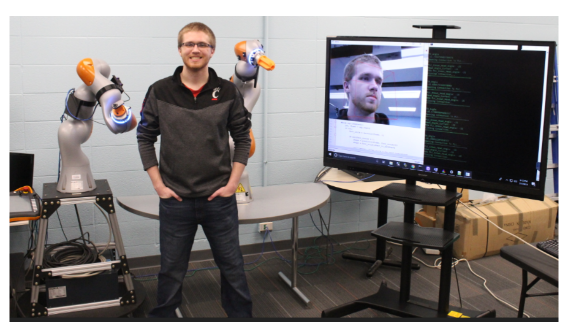


Fig. 2. Robot Setup

With this in mind, my goal was to have a robot work collaboratively with another person in a patient care setting without electrical communication. To accomplish the task of a robot working with another person, we broke the project up into several different tasks. These tasks include, Face Tracking, Impedance Control, and Angular Response.

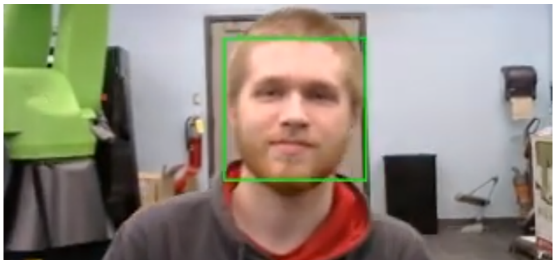


Fig. 3. Face Detection with Robotic Arm

What I was building here was not a final project, but a step toward something else. Something that in the future could change healthcare or industry. The Face Tracking system has the robotic arm follow the user's face within a 2D plane (up, down, left, right). This task is done to better understand and create the algorithms for the robot to respond to user feedback via vision. The current system is not equipped for object detection but would follow a similar premise.

The Impedance Control system has the robotic arm change its position based on the forces applied to the end effector. To maintain personal independence and human responsiveness, the robot's motion needs to have fluidity in its motion and react if it bumps into someone. Human's aren't always predictable and can be clumsy.

The Angular Response is to better understand and create the algorithms for the robot to respond to user feedback based on head angles. Since people and objects will not always be parallel or perpendicular with the robot, the system will need to accommodate for that.

The increased exposure to robotics and the wealth of knowledge I was able to gain while working at Coldwater during Co-Op, gave me the advantage of being able to further manipulate the education I was receiving at UC to develop this idea and project.

V. Conclusion

Over time, I found you do not always need to know the solution to the problem you face, but you do need to know the first steps to take to work toward the ultimate solution. With this mindset, I was able to use knowledge I gained as a Co-Op at Coldwater when working on these projects at UC and the knowledge I gained while at UC when working as a Co-Op at Coldwater.

I always try to remind myself that no thought is too small, no dream is too big. The world will only continue to improve and grow if we continue to push ourselves for new ideas and aspire to be the difference needed for change.

Shared Experiences from EECS Students

Thomas Mantei, *EECS, Professor - Emeritus*

***Abstract*—Recently, the Department facilitated the visit of five EECS students to companies in California. The trip was sponsored by funds provided through the Mantei/Mae Scholar program. The same funds and EECS funds were used to sponsor a group of 14 EECS students to attend the recent Grace Hopper Celebration of Women in Computing conference. Below are brief accounts of both events.**

I. Introduction

FIVE EECS Mantei/Mae Scholars participated in a visit to Silicon Valley in California during the Fall Semester Reading Days. Students visited several major companies in Silicon Valley: Jeff Nainaparampil (EECS 2016) hosted students at Google, where he is a Senior Engineer, and Joseph Senay (EECS 2015) shared his story and career at Infinera. Students also met with the Head of Portal at Facebook, where they participated in a round-table and viewed new product rollouts. One of the highlights of the visit was face-to-face meetings with alums who shared their career paths and provided advice for our students. The students attended a reception in Menlo Park where they networked with successful EECS alumni working in the Valley, and met our new dean, John Weidner.

Fig. 1. Mantei/Mae Scholars in the Valley, from L to R: Benjamin Logsdon, Nicholas Maltbie, Joshua May, Saylee Dharne, and Anna DeBrunner

Student comments on this experience were extremely positive, and we want to make this student experience an annual event. Josh May said '[the trip] broadened my perspective on what I think I am capable of and what I can do in the future.'

Saylee Dharne wrote, 'I met people who were so amazing at starting new things and keeping them going and this is not an opportunity I would have gotten otherwise. Being able to spend time with them and learn from their experiences (as well as get their advice and opinions) was invaluable.'

Benjamin Logsdon wrote, 'Overall, this trip was one of the most helpful experiences I've had at UC in trying to figure out my career after college and my development as a young professional.'

II. EECS Students at Grace Hopper Celebration of Women in Computing Conference

The Grace Hopper Conference is one of the largest and most important gathering of women in technology in the world. In October, 2019, 14 EECS students attended the Grace Hopper Conference held in Orlando, joining 28,000 women in technology for the three-day event. Students met and spoke with representatives from Apple, Google, Facebook, Microsoft, and and Disney, as well as smaller companies and start-ups. Several students found opportunities to interview and received co-op and job offers.

The students' reactions were incredibly positive. 'I believe the Grace Hopper Conference has been one of most motivating experiences I have had in my entire college experience (Mariam Bahassi)'....'The Grace Hopper Celebration of Women in Computing was one of the most impressive and inspiring events I've ever had the pleasure of attending(J.T. Salisbury)'...'My time at the Grace Hopper Celebration was the most empowering event I've ever attended (Meagan Turner)...'I am incredibly grateful for my experience at Grace Hopper this year...just being in the presence of so many women in computing is enough to inspire me and give me the confidence to continue in my field (Sydney O'Connor)'...and 'Grace Hopper has helped me thrive professionally, find amazing job opportunities and placed me in a position to do well post-graduation (Saylee Dharne)'.

Fig. 2.

Students were extremely grateful for the opportunity to attend this life-changing Conference and they feel that it has made them better Bearcats. They will bring their experiences back to UC and motivate more students to pursue technology and to attend events such as the Grace Hopper Conference. There are also plans to support diversity in technology at UC with the help of the student chapters of ACM-W, SWE, and Women in Technology.