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4805/4806/2804 MAJOR DESIGN EXPERIENCE EXPO

April 20, 2022
The Inn at Virginia Tech

COLLEGE OF ENGINEERING
BRADLEY DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
VIRGINIA TECH

AGENDA

Registration	9–10 a.m.
Welcome	10–10:30 a.m.
Presentations	10:30–12:30 p.m.
Posters & Pizza	12:30–2 p.m.
Awards	2–2:30 p.m.

Presentation Tracks 10:30-12:30

Track 1 - Latham DEF 1 - Toby Meadows (MOC)
(Dominion Energy) Open Source Power System Planning and Operations Game
(VPT) Digital & Analog Magnetic Levitation System
(Dominion Energy) Interactive Power System Protection Concepts Demo
(VPT) Magnetic Levitation
(Dominion Power) Power Adaptive Dynamic Compute Nodes
(VT CPES) IPT Transformer Design with Space-Constrained Receiver
(VT CPES) Medium-Voltage Power Electronic Interrupter System
Track 2 - Latham BC - 2 - Dushan Boroyevich (MOC)
(VT CPES) Condition Monitoring and Lifetime Prediction of Power Devices
(VT CPES) EMI Test Hardware Development
(VT CPES) A Silver Sintering Fixture and Control System for Fabricating High-Voltage Power Electronics Modules
(VT CPES) Energy Transfer Protocol for 5G-Operated Nanogrids
(VT CPES) Next-Generation Distributed Communication and Control Network for High-speed Multi-phase Drive Systems
(VT CPES) A Unified Design Tool for High-Performance LLC Resonant Converter
(Wiley Wilson) Emergency Management Center in Blacksburg, VA
Track 3 - Duckpond - Bill Plymale (MOC)
(VT ECE) Fault-Tolerant Power Electronic Systems
(VT ECE) Communication System Design for Ocean Wave Powered Autonomous Robots
(TMEIC) Lithium Ion Battery Modeling
(VT Facilities) Building Ladder Safety System
(ADI) Digital Beamforming Demo with Quad MxFE
(MITRE) UAS High Frequency Surface Wave Radar Array
(Phase II) Automated Frequency Management
Track 4 - Smithfield - Sook Ha (MOC)
(VT ECE) Coin Cherrypicker
(VT ECE) Machine Learning Card Authenticators (MLCA)
(VT ECE) Fitness Watch Open Sound Control Interface
(VT ECE) Intelligent Devices for Future Medical Workspaces
(VT ECE) Electronic Textiles for Sensing Human Motion
(VT ITSO) Cybersecurity Signal Collector/Analyzer
(VT ECE) Interactive ECE Degree Planner
Track 5 - Solitude - Shelley Stover (MOC)
(NASA) Additive Manufacturing of Electronics
(NASA) VSAT Algorithm Aboard Artemis
(Aero) Cislunar PNT Satellite System
(LMCO) Aircraft Wiring Characterization
(Micron) Dynamics of Electron Tunneling Between Vibrating Atoms in a Cu Nanofilament
(Micron) Organic Electrodes for Flexible Electronic Devices
(NAVAIR) Aircraft Data Acquisition Device
Track 6 - Drillfield - Vassilios Kovanis (MOC)
(NAVAIR) IEEE SoutheastCon 2022 Hardware Competition Software Team
(NAVAIR) IEEE SoutheastCon 2022 Hardware Competition Hardware Team
(MMC) MMC Diabetic Monitoring App
(VT TREC) Grounded Force Feedback Arm with Haptic Gloves
(Benten) MiniMi - Interactive Healthy Habit Doll
(VT ME) Bio-sensor to Measure Ventricle Flow-Rate and Pressure for Children with Congenital Heart Disease (CHD)
(NAVAIR) Magnetic Debris Accumulator

The Major Design Experience (MDE) provides our emerging, undergraduate engineers with the opportunity to apply all the skills they have learned throughout their undergraduate education into one final project with a hands-on approach. For most, this is their first real opportunity to work as part of a design team and engineer an effective solution to a real need, for a real customer.

The Spring 2022 Expo is our largest ever. These 172 students organized to solve 42 different team projects will showcase their innovation, creativity, and results which focused on the design, build, test, and delivery of a realistic project for a real customer. Six industry sponsors and three organizations from within Virginia Tech have sponsored these projects. Our sponsors serve as the customer throughout the project lifecycle providing real feedback and mentorship to the students who participate.

For this group of students, most of their undergraduate education was online and remote. While their MDE has returned to an onsite, shared teamwork, physical lab experience, they've still been impacted by illness and disruptions throughout their workflow. They have persevered and demonstrated determination and grit which will serve them well as engineers in the field.

We could not have provided our students these realistic project experiences without our 16 different sponsoring companies, many of whom were dealing with their own COVID challenges. Some of those sponsors supported as many as three concurrent projects in this cohort. I'd also like to thank our Virginia Tech directorates, departments, and research centers who are supporting almost half of our current projects.

Congratulations to each of our 172 students. Their dedication and diligence are evidenced throughout these 42 projects. On behalf of these students, and myself, thank you. It is because of you our industry sponsors, our subject matter experts, and our MDE faculty that we are able to provide tremendous support in developing our next generation of engineers.

Luke Lester
Roanoke Electric Steel Professor and Department Head
Bradley Department of Electrical and Computer Engineering

Welcome to the 2022 Spring Major Design Experience (MDE) Expo where our Electrical and Computer Engineering students will showcase their engineering knowledge, skills, and abilities. We have 172 MDE students representing 42 project teams. We also have an Integrated Design Team showing their sophomore level design project during the poster session. Later today, we will also take a few moments to recognize some students who have excelled in the eight courses that comprise our ECE base curriculum. These students are already learning the knowledge and skills that will ensure their MDE projects succeed. Much of these students' college experience has been within the context of COVID and they have displayed resilience and an ability to adapt and work within conditions of stress. These students have persisted and demonstrated their readiness to rise to meet and address significant world challenges with high quality engineering results.

The main goal of the MDE program is to provide our ECE students a realistic engineering experience and to provide them a safe environment to grow and learn for their first engineering project as part of a design team. These students developed creative strategies to build, test, and deliver their projects. We hope you will take time to discuss the technical, planning, communications, business, and teamwork activities that underpin their results.

The students could not have adapted and delivered without the tireless efforts and support of our SMEs and more than 30 unique sponsor/customers. MDE is made possible with the dedicated support of our sponsors and subject matter experts whom we cannot thank enough. We, and our students, appreciate your commitment to encourage and facilitate our Virginia Tech ECE students as they prepare to make lasting contributions to society by engineering and delivering quality solutions to tackle our most important societal needs.

The MDE program would like to thank Luke Lester for his vision to establish the MDE program and for his continued support in every aspect of the program. Special thanks to the instructors and teaching assistants who make this all possible. Because of each of you, we are all better indeed!

To our ECE students: Your culminating experience wasn't without its challenges, but you committed to the process and most produced exceptional results. You stand at the door to becoming contributing Engineers! And as VT ECE Hokie engineers, be certain that you are ready to invent the future in the spirit of "Ut Prosim" (That I may serve)!!!

J. Scot Ransbottom
Director of Design Projects
Bradley Department of Electrical and Computer Engineering

Sponsors

We greatly appreciate their support.

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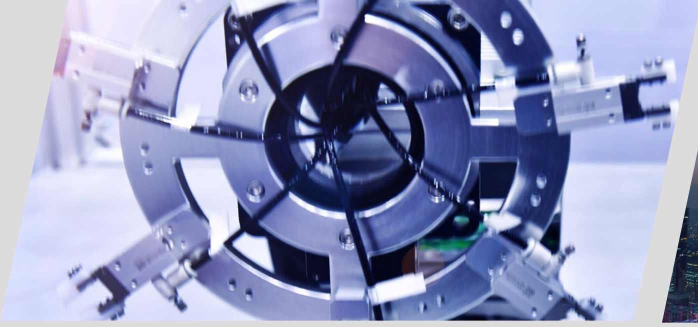
Project Leadership

This class is only possible because of the commitment, dedication, and spirit of the following Customers and Subject Matter Experts. Thank you!

Sponsor	Customers	Project	Subject matter expert (SME)
Aerospace Corp, El Segundo, CA	John Janesksi, Jim Fishenden, Britany Chamberlain	Cislunar PNT Satellite System	Scott Bailey
Analog Devices, Greensboro, NC	Michael Jones	Digital Beamforming Demo with Quad MxFE	Louis Beex
Benten Tech, Chantilly, VA	Tony Ma	MiniMi - Interactive Healthy Habit Doll	Leyla Nazhand-Ali
CPES, Blacksburg, VA	Yuhao Zhang	Condition Monitoring and Lifetime Prediction of Power Devices	Ming Xiao, Qihao Song
CPES, Blacksburg, VA	Qiang Li	EMI Test Hardware Development	Dong Dong, Tyler McGrew
CPES, Blacksburg, VA	Igor Cvetkovic	Energy Transfer Protocol for 5G-Operated Nanogrids	Kenneth Test
CPES, Blacksburg, VA	Khai Ngo	IPT Transformer Design with Space-Constrained Receiver	Minh Ngo, Bo Li
CPES, Blacksburg, VA	Dong Dong	Medium-Voltage Power Electronic Interrupter System	Jian Liu
CPES, Blacksburg, VA	Boran Fan	Next-Generation Distributed Communication and Control Network for High-Speed Multi-Phase Drive Systems	Vladmir Mitrovic, Yu Rong
CPES, Blacksburg, VA	Christina DiMarino	A Silver Sintering Fixture and Control System for Fabricating High-Voltage Power Electronics Modules	Mark Cairnie
CPES, Blacksburg, VA	Eric Hsieh	A Unified Design Tool for High-Performance LLC Resonant Converter	Chunyang Zhao
Dominion Energy, Richmond, VA	Matt Gardner	Interactive Power System Protection Concepts Demo	Virgilio Centeno
Dominion Energy, Richmond, VA	Matt Gardner	Power Adaptive Compute Nodes	Jaime De La Ree Lopez
Dominion Energy, Richmond, VA	Matt Gardner	Open Source Power System Planning and Operations Game	Walid Saad
Lockheed Martin-Aeronautics, Fort Worth, TX	Tony Keith	Aircraft Wiring Characterization	Yizheng Zhu
Marsh & McLennan, Raleigh, NC	Zak Kornblum	MMC Diabetic Monitoring App	Sook Ha



Sponsor	Customers	Project	Subject matter expert (SME)
Micron, Manassas, VA	Zuzana Steen	Dynamics of Electron Tunneling Between Vibrating Atoms in a Cu Nanofilament	Amrita Chakraborty, Marius Orlowski
Micron, Manassas, VA	Marius Orlowski	Organic Electrodes for Flexible Electronic Devices	Amrita Chakraborty, Daniel Herrera
MITRE, Quantico, VA	Dale W. Herdegen, Andy Thompson, Julia B Huynh, Dennis Milam, Dave Maples	UAS High Frequency Surface Wave Radar Array	Mike Ruohoniemi
NAVAIR, Cherry Point, NC	Dario Hashemi, Dylan Gooch, Brittany Cline	Aircraft Data Acquisition Device	Adnan Sarker
NAVAIR, Cherry Point, NC	Brandon Krahn, Patrick Horney, Kevin Conner, Brittany Cline	Magnetic Debris Accumulator	Peter Han
NAVAIR PAX, NAS, Patuxent River, MD	Andrian Jordan, Israel Jordan, Theresa Shafer	IEEE SoutheastCon 2022 Hardware Competition Hardware Team	Arthur Ball, Stephen Moyer (Engineering Education)
NAVAIR PAX, NAS, Patuxent River, MD	Andrian Jordan, Israel Jordan, Theresa Shafer	IEEE SoutheastCon 2022 Hardware Competition Software Team	Arthur Ball, Stephen Moyer (Engineering Education)
Phase II, Quantico, VA	Ross Osborne	Automated Frequency Management	Tim Solie, Phase II
SSAI/NASA Goddard, Greenbelt, MD	Beth Paquette, Christopher Green, Jonathan Kelly	Additive Manufacturing of Electronics	Tim Talty
SSAI/NASA Langley Hampton, VA	Carl Mills, Jeryl Hill	VSAT Algorithm Aboard Artemis	Haibo Zeng
TMIEC, Roanoke, VA	Matt Mandros	Lithium Ion Battery Modeling	Ryan Gerdes
VPT, Blacksburg, VA	Dan Sable	Digital and Analog Magnetic Levitation Systems	Campbell Lowe, VPT, Inc.
VPT, Blacksburg, VA	Dan Sable	Magnetic Levitation	Matthew Strehle, VPT, Inc.
VT ECE, Blacksburg, VA	Luke Lester	Coin Cherrypicker	Creed Jones
VT ECE, Blacksburg, VA	Lei Zuo	Communication System Design for Ocean Wave Powered Autonomous Robots	Yaling Yang


Sponsor	Customers	Project	Subject matter expert (SME)
VT ECE, Blacksburg, VA	Tom Martin	Electronic Textiles for Sensing Human Motion	Tom Martin
VT ECE, Blacksburg, VA	Lei Zuo	Fault Tolerant Power Electronic Systems	Marif Daula
VT ECE, Blacksburg, VA	Ben Knapp	Fitness Watch Open Sound Control Interface	Ben Knapp
VT ECE, Blacksburg, VA	Mary Brewer, Garrett Campbell, Nicole Gholston	Interactive ECE Degree Planner	William Plymale
VT ECE, Blacksburg, VA	Ben Knapp	Intelligent Devices for Future Medical Workspaces	Ben Knapp
VT ECE, Blacksburg, VA	Luke Lester	Machine Learning Card Authenticators (MLCA)	Creed Jones
VT Facilities, Blacksburg, VA	Greg Winters	Building Ladder Safety System	Almuatazbellah Boker
VT ITSO, Blacksburg, VA	Randy Marchany	Cybersecurity Signal Collector/ Analyzer	Brad Tilley (IT Security Office)
VT ME, Blacksburg, VA	Alexandrina Untaroiu	Biosensor to Measure Ventricle Flow-Rate and Pressure for Children with Congenital Heart Disease	Bright Katey (ME)
VT Trec lab, Blacksburg, VA	Alex Leonessa	Grounded Force Feedback Arm with Haptic Gloves	Alex Leonessa (TREC Lab)
Wiley Wilson	Steve Bowman, Mark Adkinson, Dan Morton	Emergency Management Center in Blacksburg, Va.	Minh Ngo

Guest speakers

In addition to our project sponsors and subject matter experts, there were many others who significantly contributed to the success of this class. We want to take this opportunity to express our deep-felt appreciation and thanks for their contributions.

Shelley Stover

Communications

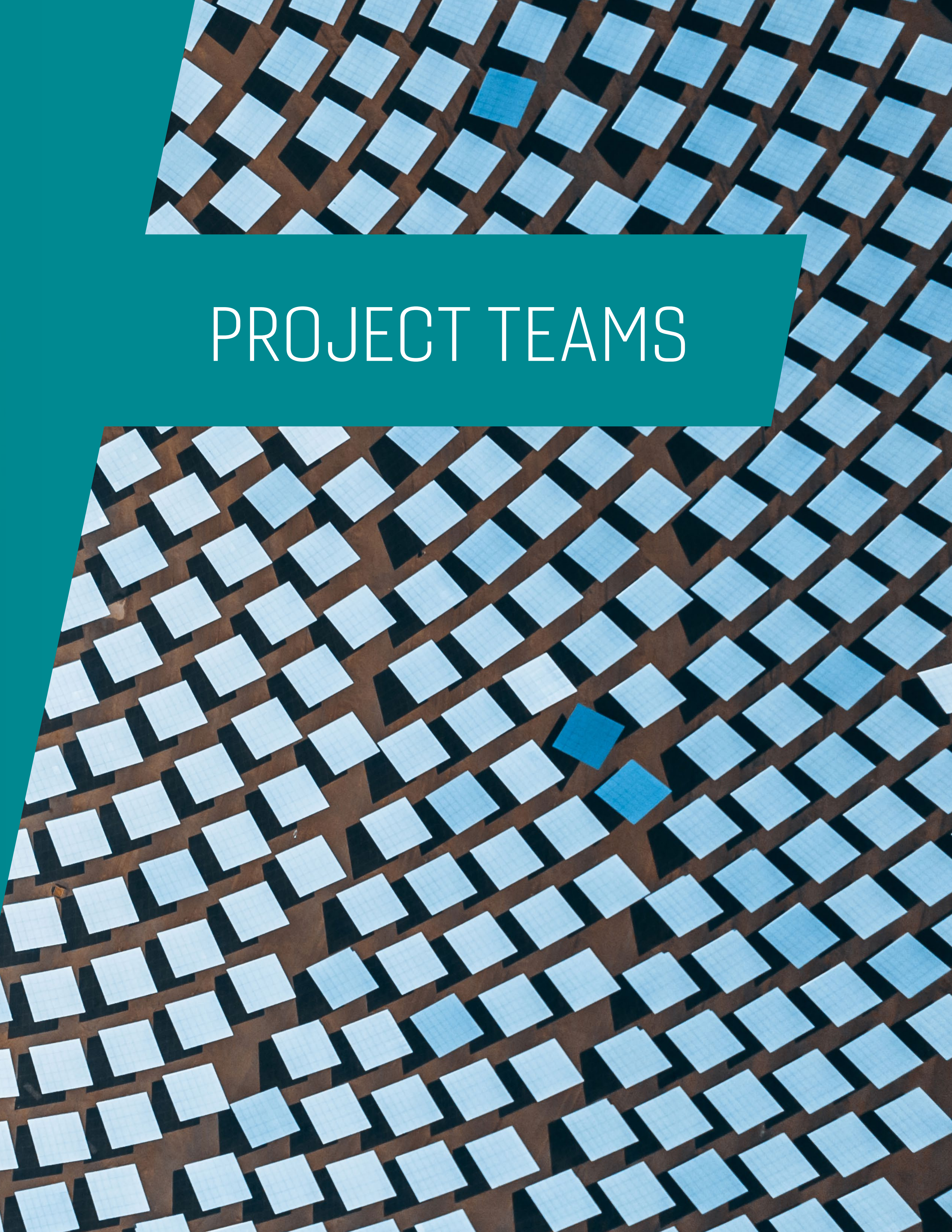
Sal Bezos, Mark Mondry, and Ken Schulz

Innovation and Intellectual Property Management

Alex DeRieux

Progress Reporting

PROJECT TEAMS



Cislunar PNT Satellite System

LEFT TO RIGHT: Jordan Lloyd, Adam Kimbrough, Luke Myers | **SME:** Scott Bailey

CHALLENGE

To design and evaluate a satellite constellation's performance in providing position, navigation, and timing (PNT) services to a user in Cislunar space. This system is needed for more precise missions in cislunar space to allow for further space exploration and lunar development.

Jordan Lloyd Richlands, Va.

Bachelor of Science
Controls, Robotics, and Autonomy

Aspirations: I am very interested in aerospace, transportation, and defense. I hope to get a job with a military contracted aerospace company or an automotive company.

Class Comment: This course gave me real-world experience in satellite constellation design. The knowledge I have gained will help me efficiently transition into my professional career.

Adam Kimbrough Richmond, Va.

Bachelor of Science in Electrical Engineering
RF & Microwave

Aspirations: I would like to work in RF test & measurement, especially in support of defense use-cases or satellite communications.

Class Comment: This course allowed me to gain new and extensive knowledge surrounding the topic of satellite constellation orbit design.

Luke Myers Elkton, Va.

Bachelor of Science in Electrical Engineering
Electrical Engineering (general)

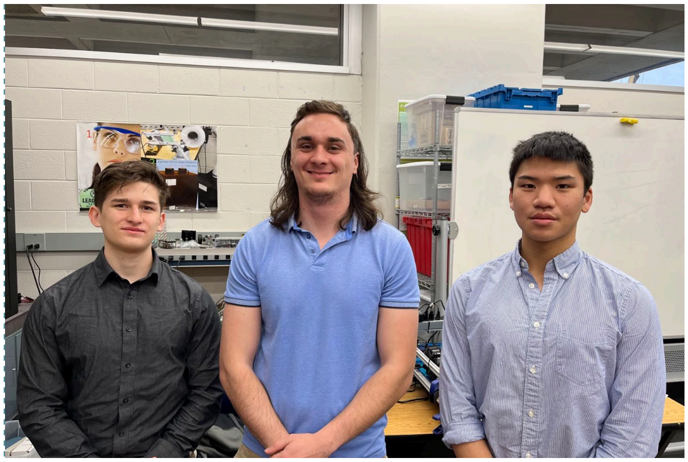
Aspirations: I am looking forward to continuing work in the aerospace, military, and defense industry—designing, developing, and building aircraft electronics.

Class Comment: This course has given me the valuable opportunity to work on a real world project with a real company. Our project challenged us to learn something new and adapt quickly.

PROJECT SPONSORS: JOHN JANESKSI, JIM FISHENDEN, BRITANY CHAMBERLAIN

AEROSPACE

Digital Beamforming Demo with Quad MxFE



LEFT TO RIGHT: Alex Sablan, Tim McDonald, Alec Yip
SME: Louis Beex

CHALLENGE

To perform digital beamforming using Analog Devices' Quad MxFE and create a demonstration kit for trade shows. To perform beamforming, we controlled an electronic turntable to emulate a radial shift, calculated the beamforming weights, and applied the offsets to electronically steer the beam.

Tim McDonald Fairfax, Va.

Bachelor of Science in Electrical Engineering
Electrical Engineering (general)

Aspirations: I would like to work in industry as a RF engineer and travel the world whenever I can.

Class Comment: This is a good course that allows a lot of freedom for the students. It's a great experience and a once-in-a-lifetime opportunity.

Alex Sablan Virginia Beach, Va.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I want to enter the workforce as a data scientist or software engineer that utilizes machine learning to enhance the capabilities of modern technology.

Class Comment: This course allowed me to use my knowledge where the application was necessary.

Alec Yip Vienna, Va.

Bachelor of Science in Electrical Engineering
Radio Frequency and Microwave

Aspirations: I want to pursue higher education in electrical engineering (especially in antennas), work in industry, and write a textbook.

Class Comment: This is a good course that allows students of all disciplines to combine their knowledge to complete a year-long project.

PROJECT SPONSOR: MICHAEL JONES

ANALOG DEVICES
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MiniMi - Interactive Healthy Habit Doll

LEFT TO RIGHT: Darrian Burnett, Robert McHugh, Saakshi Naveen, Sarang Rajeev, Zebo Lu | **SME:** Leyla Nazhand-Ali

CHALLENGE

To design and build a smart doll that interacts and talks with a child via a speech recognition engine and NLP library to encourage healthy behaviors. Incorporates passive data collection using integrated wearables that can log exercises and reports data to a connected mobile app that is accessible to parents.

Darrian Burnett Ashburn, Va.

Bachelor of Science in Computer Engineering
Controls, Robotics, and Autonomy
Minor in Biomedical Engineering

Aspirations: My Career goals are to work towards a further integration of technology and AI into the field of medical research and diagnosis.

Class Comment: This class helped me to get more real world program management experience, along with helping to get more comfortable with communication between engineers and superiors/supervisors.

Zebo Lu Beijing, China

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: My career goal is to start as a software engineer and explore the area of AI.

Class Comment: This class helped me learn the experience of working and communicating as a team and designing a prototype for the real industry.

Robert McHugh St. Michael's, Md.

Bachelor of Science in Computer Engineering
Computer Engineering

Aspirations: My goal for my career is to be able to use the knowledge I've learned and the skills that I've developed to be able to do meaningful work for this country.

Class Comment: This class helped me further understand how a long project works in industry by improving my skills in time management, program management, planning, and communication.

Saakshi Naveen Bristow, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: My career goal is to become a software engineer and make software that makes an impact.

Class Comment: This class has helped me improve my project management skills. It has also helped me learn how to create effective design documentation.

Sarang Rajeev Kerala, India

Bachelor of Science in Computer Engineering
Bachelor of Science in Electrical Engineering
Machine Learning and Controls, Robotics and Autonomy

Aspirations: My goal is to join the field of software engineering and later machine learning, bringing quality and my own creativity to work while pushing my team to success.

Class Comment: This class taught me different parts of managing a team project in terms of planning, documentation, and communication with team and superiors.

PROJECT SPONSOR: TONY MA, KATIE CHANG, ELINA BAJRACHARY

BENTEN TECHNOLOGIES
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Condition Monitoring and Lifetime Prediction of Power Devices

LEFT TO RIGHT: Liam Gaffney, Vincent Pagliaro
SMEs: Ming Xiao, Qihao Song

CHALLENGE

To design a circuit board that allows for the condition monitoring and testing of a GaN semiconductor. Data collected from the testing of the circuit will be used for a comparison to ideal data collected through a physics based simulation. After discrepancies between the two sets of data are fixed, it is possible to determine the degradation that the GaN semiconductor experienced and what may have caused a breakdown of the device.

Liam Gaffney Sayville, N.Y.

Bachelor of Science in Electrical Engineering
Energy and Power Electronics Systems

Aspirations: I want to join a company that will help contribute to a better world by providing power to areas that currently aren't getting the resources they need.

Class Comment: I appreciate that this course provides valuable experience for what working in a real industry may be like. Communicating in a team setting to achieve a goal will greatly help me succeed in future work environments.

Vincent Pagliaro Somers, N.Y.

Bachelor of Science in Electrical Engineering
Electrical Engineering (general)

Aspirations: I wish to find myself a job that is something that I enjoy, that is secure, and that can provide me with the means to experience life to the fullest.

Class Comment: I greatly appreciated this course and project for its focus on providing interaction between the students and industry professionals. This has allowed me to learn many things that will aid in my future success.

PROJECT SPONSOR: YUHAO ZHANG

CPES
Center for Power Electronics Systems

EMI Test Hardware Development

TOP LEFT TO RIGHT: Justin Green, Aman Patel
BOTTOM LEFT TO RIGHT: Alessia Scotto di Luzio, Anaya Acharya
SMEs: Dong Dong, Tyler McGrew

CHALLENGE

Create a low power EMI test kit that can be used in a graduate classroom setting to teach EMI Testing and Filtering concepts. This test kit will generate, measure, and filter EMI through various methods.

Anaya Acharya Dubai, UAE

Bachelor of Science in Electrical Engineering
Controls, Robotics and Machine Learning

Aspirations: Actively contribute to the fast-growing semiconductor industry through my knowledge and skills acquired during my undergraduate degree and from future experiences.

Class Comment: Through this course, I was able to get insight into the industry practices involved for designing products/devices through basic specification given by the customer.

Justin Green Ellicott City, Md.

Bachelor of Science in Electrical Engineering
Electrical Engineering (general)

Aspirations: I want to be challenged at work every day, and work on cutting edge technology to support US military efforts.

Class Comment: This course has given me the chance to learn practical electrical engineering skills like PCB design and EMI filtering techniques, while also reinforcing good communication and teamwork.

Aman Patel South Chesterfield, Va.

Bachelor of Science in Electrical Engineering
Electrical Engineering (general)

Aspirations: I want to work as an electrical engineer within a fast-paced and competitive company that focuses on sustainability. I want to be one of the first engineers that makes key contributions in decentralizing the power grid.

Class Comment: This class has exposed me to the professional engineering environment, helping to strengthen my communication skills and technical skills. In addition, I have improved my teamwork and time management skills, which will help me in my engineering career.

Alessia Scotto Leesburg, Va.

Bachelor of Science in Electrical Engineering
Energy & Power Electronic Systems

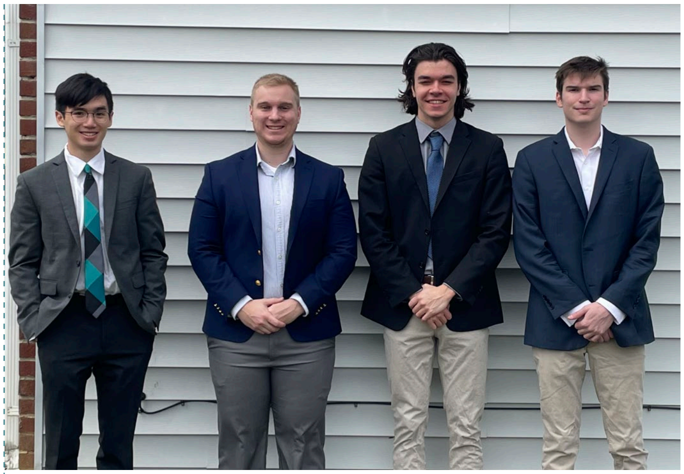
Aspirations: I hope to work on challenging new developments and eventually develop my own ideas and products to make a valuable impact to society.

Class Comment: This course has given me experience with the engineering process and professional world. This experience has taught me the importance of consideration factors in product design as well as customer relationships and professionalism.

PROJECT SPONSOR: QIANG LI

CPES
Center for Power Electronics Systems

Energy Transfer Protocol for 5G-Operated Nanogrids



LEFT TO RIGHT: T.K. Trinh, Connor Mackert, Daniel Mauro, Chris Keating | SME: Kenneth Test

CHALLENGE

To design, simulate, and emulate an energy transfer protocol which synchronizes power in micro-grids and nano-grids using network communication protocols. This protocol and emulation testbed can be used as a base for future electric power and cybersecurity research.

Christopher Keating Fairfax, Va.

Bachelor of Science in Computer Engineering
Control, Robotics, and Automation

Aspirations: I hope to ultimately become a leader/project manager in the software design field.

Class Comment: The design project has gave me a great idea of real-world project development and the timelines associated with undertaking a large project.

Connor Mackert Manassas, Va.

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: I aspire to make a genuine difference in the world through ethical computer engineering practices.

Class Comment: The Major Design Experience has provided me with the necessary project management, communication, and technical/research skills to make a great impact on professional engineering projects.

Daniel Mauro Middletown, N.J.

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: I hope to someday be designing top-notch software programs for some of the world's larger tech companies.

Class Comment: This course has made me realize the importance of a good team and extensive planning in real-world engineering projects.

Tukhang Trinh Burke, Va.

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: I aim to contribute to the public trust in the everyday use of technology by improving its security and/or privacy aspects.

Class Comment: This project has taught me the process and pace of engineering from a research and development prospective while setting realistic deadlines to follow.

PROJECT SPONSOR: IGOR CVETKOVIC

CPES
Center for Power Electronics Systems

IPT Transformer Design with Space-Constrained Receiver

LEFT TO RIGHT: Mathew Szpakowski, Divya Mathews
SMEs: Minh Ngo, Bo Li

CHALLENGE

To design and build a safe, reliable, and efficient wireless inductive power transfer system suitable for an electric vehicle.

Divya Mathews Fairfax Station, Va.

Bachelor of Science in Electrical Engineering
Computer Engineering

Aspirations: My goal is to learn how skills we have developed can be applied in different fields of science.

Class Comment: This course has given me experience with the entire design process from start to end, including redirections when meeting roadblocks and the importance of communication.

Mathew Szpakowski Ridgefield, Conn.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: My goal is to use the skills I've acquired at Virginia Tech to create a better and brighter world.

Class Comment: This course taught me a lot of valuable lessons such as the importance of communication, teamwork, scheduling, and applying theory to real world application.

PROJECT SPONSOR: KHAI NGO

CPES
Center for Power Electronics Systems

Medium-Voltage Power Electronic Interrupter System

LEFT TO RIGHT: Gabe Scott, Garrett Mass, Tyler Robbins
SME: Jian Liu

CHALLENGE

Our team has been tasked with building, testing, and troubleshooting the high-frequency auxiliary power supply and voltage clamping units of a medium voltage DC power electronic interrupter system. New protection systems like this one will help secure future grid infrastructure as the need for DC microgrids and transmission increases with the introduction of alternative power generation sources.

Garrett Mass Chesapeake, Va.

Bachelor of Science in Electrical Engineering
Energy and Power Electronics Systems

Aspirations: My career goal is to be a well respected electrical engineer, to grow within my company, and to be a great asset throughout my career.

Class Comment: I enjoyed being able to work hands-on with an electrical project and learning how to solder. This course was the first time I have gained useful experience working with electronics. This course has also exposed me to dealing with sponsors.

Tyler Robbins Millsboro, Del.

Bachelor of Science in Electrical Engineering
Energy and Power Electronics Systems

Aspirations: My career goal is to work as an electrical engineer at a company that specializes in solar generation and grid-scale battery storage.

Class Comment: I enjoyed applying the various electrical engineering concepts I've learned over the past four years in a hands-on environment. The mistakes I have made along the way in this course have proven to be invaluable lessons.

Gabe Scott Roanoke, Va.

Bachelor of Science in Electrical Engineering
Energy and Power Electronics Systems

Aspirations: I want to start a firm that specializes in AC power and protection analysis, mostly pertaining to medium voltage applications.

Class Comment: I enjoyed being able to learn how to solder and troubleshoot complex electrical circuits in a semi-production environment. The use of professional schematic software and application of power electronics concepts will be invaluable to my future endeavors.

PROJECT SPONSOR: DONG DONG

CPES
Center for Power Electronics Systems

Next-Generation Distributed Communication and Control Network for High-Speed Multi-Phase Drive Systems

LEFT TO RIGHT: Sabrina Lesser, Fairuz Ahmed, Evan Miller
SMEs: Vladmir Mitrovic, Yu Rong

CHALLENGE

To design and build an Human Machine Interface (HMI) for a high speed control network of a multi-phase drive system. The HMI is used to visualize real time data from a Zynq-7000 SoC family controller using a Windows Forms Graphical User Interface (GUI) and send commands to the controller of the multi-phase drive system.

Fairuz Ahmed Falls Church, Va.

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: I want to explore career paths in the cybersecurity and software development fields. I want to work with companies that are on the forefront of the cybersecurity field and I want to have meaningful contributions to keeping people safe online.

Class Comment: This course has given me a lot of experience with GUI programming with C# and has helped me learn how to create and stick to a roadmap for team projects that I might be a part of in the future. I appreciate the skills that this class has prepared me with for joining the workforce.

Sabrina Lesser Herndon, Va.

Bachelor of Science in Computer Engineering
Bachelor of Science in Electrical Engineering
Chip-Scale Integration, and Controls, Robotics, and Autonomy

Aspirations: My aspiration in to work in research and development in the field of controls, robotics, and autonomy, or digital circuit design.

Class Comment: I appreciated the opportunity to apply my theoretical knowledge to a real-world application.

Evan Miller Titusville, N.J.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: I am a DevOps engineer that strives to innovate automated software deployments through GitOps, Continuous Delivery, and Infrastructure as Code for research technology on cloud architectures.

Class Comment: This course provides a more hands-on applied approach to engineering problem solving than previous coursework. This experience stimulates a less theoretical and more practical and agile approach to the design and troubleshooting of computer systems.

PROJECT SPONSOR: BORAN FAN

CPES
Center for Power Electronics Systems

A Silver Sintering Fixture and Control System for Fabricating High-Voltage Power Electronics Modules

LEFT TO RIGHT: Jason Kendrick, Johnathan Ciesla, Aaron Sprung
SME: Mark Cairnie

CHALLENGE

We designed a device to automate the process of silver sintering by using a programmable logic controller to manage a pneumatic and thermal system along with a graphical interface. Silver sintering is used for high temperature power electronics packaging as an alternative solution to soldering.

Jonathan Ciesla Virginia Beach, Va.

Bachelor of Science in Electrical Engineering
Electrical Engineering (general)

Aspirations: My aspiration is to contribute to the current power electronics industry and develop new technologies to improve infrastructure. I want to work in a high-demand environment.

Class Comment: This course helped improve my knowledge of the design process and industry skills to help me transition as a new professional electrical engineer. The software and hardware problem solving skills I have learned have gave me confidence to be a better thinker and developer.

Jason Kendrick Richlands, Va.

Bachelor of Science in Electrical Engineering
Power Systems

Aspirations: My aspiration is to continue my work in the oil and gas industry. I hope the work I do helps play a part in America's desire for energy independence as well as creating ethical and environmentally friendly sources of energy.

Class Comment: I feel that this course helped me with project planning on a much larger scale than what I have done in the past and further my skills with working with a team. From my little time that I have had in industry I know that these skills are important to have and are very valuable to your employer.

Aaron Sprung Williamsburg, Va.

Bachelor of Science in Electrical Engineering
Controls, Robotics & Automation

Aspirations: My aspiration is to work at a company that will further my growth in controls and robotics. Ultimately, I want to solve the industries tough problems concerning controls.

Class Comment: I found this course grew my skills through the design process in a team environment. I pushed my technical ability and developed additional skills to bring future employers, which includes project planning, specific requirements, and technical documentation.

PROJECT SPONSOR: CHRISTINA DIMARINO

CPES
Center for Power Electronics Systems

A Unified Design Tool for High-Performance LLC Resonant Converter

LEFT TO RIGHT: Matthew Gray, Pablo Estrada, Nicholas Ritz
SME: Chunyang Zhao

CHALLENGE

Create and test an LLC resonant converter design tool. This tool will take desired converter specifications from the user and use them to calculate ideal component values with a chosen power device. In addition to fixed converter specifications, the tool will present design tradeoffs to the user, which the user will be able to adjust so the output converter meets their needs.

Pablo Estrada Ashburn, Va.

Bachelor of Science in Electrical Engineering
Energy & Power Electronics Systems

Aspirations: I look forward to joining the work force and contribute to the aid and development of frontline cutting-edge power electronics.

Class Comment: I am very grateful this class has allowed me to experience a full year-long design project. Working closely with teammates, customer, and subject-matter expert will serve as a valuable experience that I will carry on into my professional career.

Matthew Gray Chesapeake, Va.

Bachelor of Science in Electrical Engineering
Energy & Power Electronics Systems

Aspirations: My goal is to work on and help produce a product or technology that improves the quality of life for everyone. Seeing everyone around me enjoying something that I helped create would be amazing.

Class Comment: Within this course, I was able to develop meaningful relationships with my teammates while also working on an exciting project. I am excited to translate the skills I learned into the professional setting.

Nicholas Ritz Virginia Beach, Va.

Bachelor of Science in Electrical Engineering
Energy & Power Electronics Systems

Aspirations: I hope to make use of my power systems and electronics knowledge in the shipping industry to aid in the decarbonization of shipping.

Class Comment: This course has been a great lesson in project management and group work, and a great exploration into modern converter technology. What I have learned both professionally and technically will be invaluable as I begin my career.

PROJECT SPONSOR: ERIC HSIEH

CPES
Center for Power Electronics Systems

Interactive Power System Protection Concepts Demo

LEFT TO RIGHT: Bernard Cieplak, Joseph DiNiso, Tanner Joyce, Nashin Rodriguez, Dillan Murphy | **SME:** Virgilio Centeno

CHALLENGE

Our project is designed as an educational program for young high school students and/or freshman college students to educate them in the importance of power system protection. It consists of providing users with the ability to see a power system design, simulate certain faults on the system, and change system protection settings. The simulation will provide the user with details on what caused the fault, what type of fault it is, and how the system behaves after the protection components respond to the fault.

Bernard Cieplak Culpeper, Va.

Bachelor of Science in Computer Engineering
Networking & Cybersecurity

Aspirations: My career goal is to work as a Cyber Warfare Engineer in the US Navy when I commission in May.

Class Comment: I appreciate the flexibility Dominion has given us in developing the final project. That flexibility allowed our team to get creative with our solution and to experiment with different implementation approaches.

Joseph DiNiso Long Island, N.Y.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: My goals are to grow as a software engineer and eventually take on leadership positions. I aspire to use my skills and talents to help others and change the world positively.

Class Comment: This course gave me the opportunity to learn about all aspects of the tech stack and helped me develop my skills both in project management and in software development.

PROJECT SPONSOR: MATT GARDNER

Tanner Joyce Martinsville, Va.

Bachelor of Science in Electrical Engineering
Electrical Engineering (general)

Aspirations: I will be working for Dominion Energy with System Protection after graduation, and I aspire to help make our power grid more reliable and efficient while learning more about the power utility industry.

Class Comment: I have enjoyed working on a project that is similar to my career path and learning how to properly plan and execute an engineering project will prove valuable for my professional career.

Dillan Murphy Fairfax, Va.

Bachelor of Science in Computer Engineering
Networking & Cybersecurity

Aspirations: My aspirations are to lead and manage teams of software engineers in a small or medium sized company so that I can give more detailed assistance to those on my teams who need it.

Class Comment: This course gives a slower paced explanation of how to integrate with the working industry and how to draft the necessary charts and graphs needed to be successful.

Nashin Rodriguez Brooklyn, N.Y.

Bachelor of Science in Electrical Engineering
Energy & Power Electronics Systems

Aspirations: My career goal as an engineer is to contribute to designing and implementing new devices to make life safer for future generations.

Class Comment: I appreciate the opportunity to experience working in an engineering team and having sponsors provide us with ideas of how to improve our project to best suit the task.

Dominion Energy

Power Adaptive Compute Nodes

LEFT TO RIGHT: Ken Torres, Shannon Woolfolk, Andrew Beauchemin, Boyan Pan, Dave Anderson | **SME:** Jaime De La Ree Lopez

CHALLENGE

Create a distributed computing network of at least 5 nodes in various locations, reliant on isolated solar power. Node coordination of data processing is determined by the power availability at each location.

Dave Anderson Alexandria, Va.

Bachelor of Science in Computer Engineering
Chip-Scale Integration

Aspirations: I want to continue learning about and developing software so that I can give back to the open source community whose efforts and examples have supported me from high school to college.

Class Comment: This course gave me a better understanding of how project management can make or break a final result, as well as how to effectively make tradeoffs in the pursuit of a final product.

Andrew Beauchemin Fairfax Station, Va.

Bachelor of Science in Computer Engineering
Networking & Cyber Security

Aspirations: My career aspiration is to work in the cybersecurity industry or in software development.

Class Comment: This course was interesting because it allowed me to balance my abilities with the requirements of a customer.

Boyan Pan Csangsha, China

Bachelor of Science in Electrical Engineering
Bachelor of Science in Computer Engineering
Robotics and Machine Learning

Aspirations: I want to combine the software with hardware to integrate programs and algorithms that can only run on powerful devices like a server into all devices including embedded systems that consume milliwatts.

Class Comment: This course gives me a glimpse into working with an engineering team with different people handling different parts and customers with needs. It helps me to step closer to becoming an engineer.

Ken Torres Fairfax, Va.

Bachelor of Science in Electrical Engineering
Energy & Power Electronic Systems

Aspirations: I would like to be a be a valuable contributor to a company focused on renewable energy generation and perhaps start my own company. My main goal is to leave the world a better place.

Class Comment: This course has provided valuable lessons and experience working on a team and seeing a customer's project through from start to finish. Having the course continue over two semesters has allowed us to create a design we are proud of.

Shannon Woolfolk Gainesville, Va.

Bachelor of Science in Electrical Engineering
Energy & Power Electronic Systems

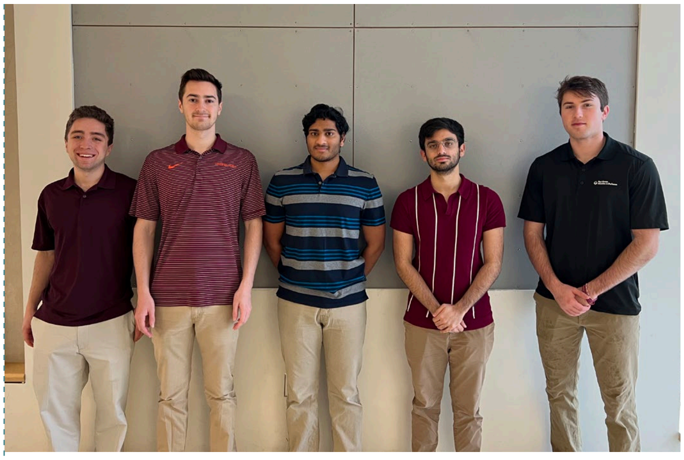
Aspirations: I want to make green energy more accessible, sustainable, and efficient. I would love to see technology completely dependent on clean energy in the next couple decades.

Class Comment: This course gave me a better understanding of how engineering, communication, and business will combine in industry. It helped me learn how to effectively demonstrate my work with stakeholders not directly involved with the project.

PROJECT SPONSOR: MATT GARDNER

Dominion Energy®

Open Source Power System Planning and Operations Game



LEFT TO RIGHT: Jeremy Naka, Tyler Milot, Karthik Kashyap, Aman Mathur, Steven Shumadine | **SME:** Walid Saad

CHALLENGE

We designed and developed a video game to teach the public about power systems planning and operations. The game is played on a local network by four players in a web browser.

Tyler Milot Chesapeake, Va.

Bachelor of Science in Computer Engineering
Networking & Cybersecurity

Aspirations: My career goal is to design user applications for a software company.

Class Comment: This course helped me learn how to work in a team on a realistic engineering project.

Jeremy Naka Fairfax, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: I want to improve or create processes that benefit many people worldwide.

Class Comment: This course gave me an understanding of what engineering will be like in the real world.

Aman Mathur Cary, N.C.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: After graduation, I hope to improve my technical skills as a software developer and further pursue my passion for game development.

Class Comment: This class provided a great opportunity to work on a large-scale project with a team. I was able to learn many professional skills in a hands-on environment.

Steven Shumadine Herndon, Va.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: To become an Aquaculturist.

Class Comment: This was a good class.

Karthik Kashyap Yorktown, Va.

Bachelor of Science in Computer Engineering
Machine Learning

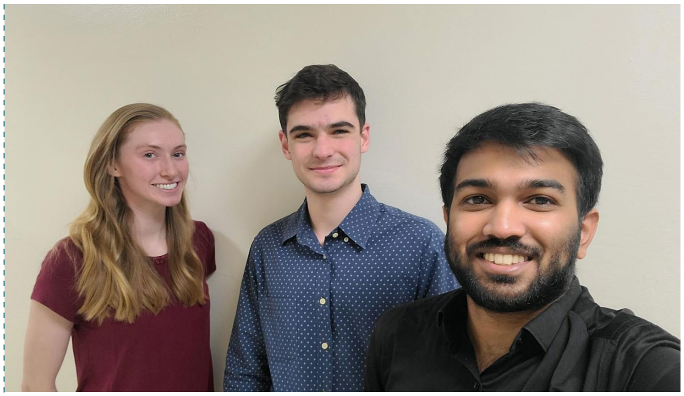
Aspirations: After college, I want to pursue a career in military AI applications.

Class Comment: The course helped teach me about the proper steps when tackling a large scale team project.

PROJECT SPONSOR: MATT GARDNER

Dominion Energy®

Aircraft Wiring Characterization



LEFT TO RIGHT: Alicia Harman, Tilden Fernandez, Sahil Pai
SME: Yizheng Zhu

CHALLENGE

To characterize a classical electrical aircraft wiring harness and compare this to a harness of fiber optic cable. This analysis can be used to demonstrate the viability of fiber optics for signaling in aircraft, and to contrast the benefits of the two methods.

Tilden Fernandez Charlottesville, Va.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: I want to work in the aviation industry, and potentially the space industry in the future. My career goal is to help make commercial flight safer for everyone.

Class Comment: I appreciate that this course provides complex engineering problems and works to create a realistic industry experience. This environment has helped me move away from a student mindset and prepare for post-graduation.

Alicia Harman Damascus, Md.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: I want to work in the defense industry, doing cybersecurity to better protect the United States and its allies from cyberattacks.

Class Comment: This course improved my problem-solving skills when working in a team and allowed me to practice real-world engineering by consulting subject matter experts and contacting organizations for parts and equipment.

Sahil Pai Mangalore, India

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: I aspire to work in a multinational company in this industry, leave a mark, and lead by an example.

Class Comment: This course has given me many insights into what industry will be like and the type of challenges we will have to face. I couldn't have asked for a better experience before moving on to my professional career.

Zhiyuan Zhang Guangdong, China

Bachelor of Science in Electrical Engineering

Aspirations: I want to be an electrical engineer and try to reduce the cost of factory production.

Class Comment: Don't wait, don't hesitate. Otherwise, you will spend your whole life wondering whether or not you could have made a difference.

PROJECT SPONSOR: TONY KEITH

LOCKHEED MARTIN

MMC Diabetic Monitoring App

LEFT TO RIGHT: Rui Wang, Trevor McNeil, Muhannad Al-Aufi, Olivia Foster, Meghana Mudunuri | **SME:** Sook Ha

CHALLENGE

To design and build a user-friendly mobile application that will assist in managing the everyday upkeep of living with diabetes. The application allows the user to create their own account, track their past test history, and add new test results either using a photograph or through manual input.

Muhannad Al-Aufi Muscat, Oman

Bachelor of Science in Computer Engineering
Networking & Cybersecurity

Aspirations: I aspire to learn about the different kinds of software development and how we can connect them all together to create useful systems.

Class Comment: This class showed me the effectiveness of working with a team to solve multiple problems and make connections.

Olivia Foster Leesburg, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: I aspire to gain as much knowledge as I can and put that knowledge towards positively impacting people's lives.

Class Comment: This class helped me realize all the details that make up a team dynamic. It also improved my skills in communicating with a client.

Trevor McNeil San Antonio, Texas

Bachelor of Science in Computer Science, Bachelor of Science in Electrical Engineering
Controls, Robotics, and Autonomy

Aspirations: I want to learn a variety of different aspects of software development and have better understanding on how they interact.

Class Comment: This class helped me see a real-world problem, gain experience working with a diverse team, and how to communicate with a client.

Meghana Mudunuri Los Angeles, Calif.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: My career goal is to go into management within the software engineering field and focus on large scale development.

Class Comment: This class helped me learn more how to communicate with a team and how to manage expectations between a client and a mentor.

Rui Wang Zhuhai, China

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: I would like to use software development knowledge to design impactful software.

Class Comment: This class gave me real world problem solving experience.

PROJECT SPONSOR: ZAK KORNBLUM

MarshMcLennan

Dynamics of Electron Tunneling Between Vibrating Atoms in a Cu Nanofilament

LEFT TO RIGHT: Jim Furches, Nick King, Mihir Savadi
SMEs: Amrita Chakraborty, Marius Orlowski

CHALLENGE

To design and execute an experimental and data acquisition methodology to observe and manipulate memory cells in novel ReRAM arrays, in such a way as to effectively investigate the anomalous quantum behaviors that arise as a result of thermal energy transfer between said memory cells. The methodologies and the resultant data acquired will be used to better characterize this novel technology.

Mihir Savadi Singapore, Singapore

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I hope to contribute to the development of low level architectural trends that drive modern-day computing, via involvement in general industrial semiconductor and VLSI efforts. I am especially interested in novel artificial intelligence accelerators and open-source generatively designed processor architectures.

Class Comment: My MDE project has helped me develop intuition for parts of the semiconductor pipeline that I otherwise would have never been exposed to. This experience will be invaluable in expanding my breadth of subject matter knowledge.

Jim Furches Yorktown, Va.

Bachelor of Science in Computer Engineering,
Bachelor of Science in Physics Controls, Robotics & Autonomy

Aspirations: I aspire to apply novel machine learning techniques to challenging scientific problems to enable new discoveries. I would also like to contribute to the development of quantum computers.

Class Comment: This project has exposed me to the fabrication of semiconductor devices, which is vital to the development of a variety of technologies like quantum devices, and the experience I gained is very valuable.

Nick King Bluefield, Va.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I aspire to research and develop new technologies in the field of Virtual Reality, specifically in the realm of immersion and intuitive interactions for both entertainment and training purposes. I also hope to research ways to shorten the gap between human and computer interactions.

Class Comment: Given my area of interest and career aspirations, it was unlikely I would gain familiarity with semiconductor fabrication and operational theory if not for the MDE course. This project has given me a unique opportunity to research cutting edge hardware technologies and gain valuable teamwork experience.

PROJECT SPONSOR: ZUZANA STEEN

Micron

Organic Electrodes for Flexible Electronic Devices

LEFT TO RIGHT: Thomas Olivero, Daniel Hall, Nick Bampton
SMEs: Amrita Chakraborty, Daniel Herrera

CHALLENGE

To develop a procedure for depositing and patterning PEDOT:PSS, an organic, conductive polymer with applications in flexible electronics like wearables and ReRAM devices. Additionally, raw PEDOT:PSS and graphene and copper nanoparticle doped would be investigated for their effects on conductivity.

Nicholas Bampton Midlothian, Va.

Bachelor of Science in Electrical Engineering
Bachelor of Arts in Mathematics Communications and Networks

Aspirations: I hope to pursue my passion for learning and research to eventually earn a Ph.D.

Class Comment: This course offered a complex, professional project which, while not always straightforward or clearly laid out, offered valuable experience and insight into real-world problems.

Daniel Hall Midlothian, Va.

Bachelor of Science in Computer Engineering
Bachelor of Science in Electrical Engineering
Chip Scale Integration, Controls, Robotics, & Autonomy

Aspirations: I hope to work closely with FPGAs and systems that will go to space as a software engineer.

Class Comment: I appreciate that this course gave me a hard-to-find opportunity to learn something new in the field of chip development.

Thomas Olivero Midlothian, Va.

Bachelor of Science in Computer Engineering
Bachelor of Science in Electrical Engineering
Machine Learning & Controls, Robotics, & Autonomy

Aspirations: I hope to work with memory devices.

Class Comment: Clean room experience is valuable. The front end where architecture got appended to every assignment was weird.

PROJECT SPONSOR: MARIUS ORLOWSKI

Micron

UAS High Frequency Surface Wave Radar Array

LEFT TO RIGHT: Kyle Shea, Zach Schutz, Devin Mong
SME: Mike Ruohoniemi

CHALLENGE

Conduct a study of a notional unmanned aircraft system (UAS) lofted time-staggered MIMO frequency modulated continuous High Frequency Surface Wave Radar (HFSWR) system. Perform modeling, simulation, and analysis to determine the feasibility of the system and identify potential performance envelope, operational and technical limitations, and initial design parameters.

Devin Mong Rochester Hills, Mich.

Bachelor of Science in Electrical Engineering
Electrical Engineering (general)

Aspirations: My career goal is to contribute as an electrical engineer to one of the Big 3 automotive corporations (Ford, Fiat-Chrysler, or General Motors). I would like to be part of the future development of electrical and autonomous vehicles.

Class Comment: I appreciate being personally involved with an industry sponsor and being exposed to the novel engineering problems faced today. The High Frequency (HF) radar engineering skills I have learned throughout both semesters have helped me learn how to problem solve.

Zachary Schutz Hamilton, N.J.

Bachelor of Science in Electrical Engineering
Communications and Networking

Aspirations: My career goals are to obtain a position in the government sector working in signal processing or communications systems, go back to school to obtain a master's in electrical engineering, and eventually start my own company focusing on government contracts.

Class Comment: This course gave me more experience with the research and development side of production and the thought process that goes into it.

Kyle Shea King George, Va.

Bachelor of Science in Electrical Engineering
Radio Frequency & Microwave

Aspirations: My career goal is to work for the department of defense and develop/test equipment for the war fighter.

Class Comment: This course was a nice alternative experience to the classroom.

PROJECT SPONSORS: DALE W. HERDEGEN, ANDY THOMPSON, JULIA B HUYNH, DENNIS MILAM, DAVE MAPLES

MITRE

Aircraft Data Acquisition Device

LEFT TO RIGHT: Mark Stephens, Cole Murphy, Philip Works, Skyler Smith, Abel Thomas | **SME:** Adnan Sarker

CHALLENGE

Design a hand-held data logger to record temperature, humidity, sound, and vibration from the V-22 and other aircraft.

Cole Murphy Mobile, Ala.

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: I hope to pursue a career in the cybersecurity field, while also looking back at my college experience fondly.

Class Comment: This course has helped prepare for what my future job experiences might be like.

Skyler Smith Randolph, N.J.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: Aspiring machine learning engineer/data scientist.

Class Comment: The ability to work hands on with actual clients has proven invaluable.

Mark Stephens Ruther Glen, Va.

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: I hope to work in cyberoperations for the government in support of military operations.

Class Comment: This course has allowed me to work on a project in my field in a different capacity than I have experienced previously.

Abel Thomas Vernon Hills, Ill.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: To work in embedded software and make a difference with the products I develop.

Class Comment: This course gave me the opportunity to gain professional industry experience and work on industry grade projects.

Phil Works Virginia Beach, Va.

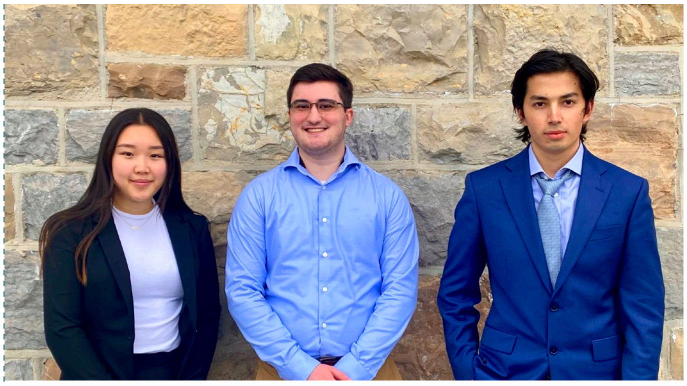
Bachelor of Science in Computer Engineering
Software Systems

Aspirations: Become an embedded software engineer and develop products that make people lives easier.

Class Comment: This course has provided me with the opportunity to connect with professional in industry and work with a tremendous group of team members.

PROJECT SPONSORS: DARIO HASHEMI, DYLAN GOOCH, BRITTANY CLINE

Magnetic Debris Accumulator



LEFT TO RIGHT: Diana Kim, Joe Kenyon, Hasan Nugmanov
SME: Peter Han

CHALLENGE

A debris accumulator utilizes a magnetic field array to capture and hold ferrous particles from lubricating oil flowing downstream from a main rotor gearbox and upstream from a heat exchanger assembly of the H-1 helicopter. The magnetic field arrays are to be designed and simulated to maximize capture efficiency such that the captured ferrous particles can be analyzed to diagnose any failing parts.

Joe Kenyon Mechanicsville, Va.

Bachelor of Science in Electrical Engineering

Aspirations: My career goal is to obtain my PE license and work as a professional engineer in the electrical engineering industry.

Class Comment: This course gave me the opportunity to further develop my teamwork skills as well as my own technical experience and background.

Diana Kim Huntington, W.Va.

Bachelor of Science in Electrical Engineering

Aspirations: I aspire to look back on my career and be proud of the contributions I made to the technological advancements.

Class Comment: This course allowed me to experience the importance of teamwork as well as different backgrounds, knowledge, and specialties.

Hasan Nugmanov Centreville, Va.

Bachelor of Science in Electrical Engineering

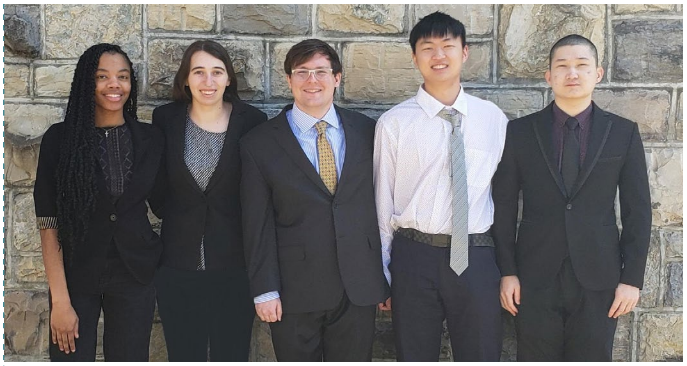
Aspirations: To be one of the generations in the family who graduated from a U.S. university with a degree in engineering and achieved success in this field.

Class Comment: The project gave me the opportunity to work with a company where I can learn how the job works and get skills in the field.

PROJECT SPONSORS: BRANDON KRAHN, PATRICK HORNEY, KEVIN CONNER, BRITTANY CLINE

NAVAIR

IEEE SoutheastCon 2022 Hardware Competition Hardware Team



LEFT TO RIGHT: Tayler Anderson, Kathryn Robertson, Kenneth Janak, Ruizhe Li, Yitao Bai | **SMEs:** Arthur Ball, Stephen Moyer (Engineering Education)

CHALLENGE

Working with the IEEE Robotics Competition Software team, a Mardi-Gras themed robot will be designed, built, and tested to compete in the 2022 IEEE SouthEastCon Hardware Competition. This robot should be capable of starting in a restricted configuration, navigating the course autonomously, collecting bracelets, detecting game pieces, and launching the bracelets into the bins or nets.

Tayler Anderson Stafford, Va.

Bachelor of Science in Electrical Engineering
Controls, Robotics, and Autonomy

Aspirations: I plan to get a job in the electronics industry and become a professional electrical engineer to allow me to create a positive impact on society.

Class Comment: This course has helped me enhance my collaboration skills while working on a large team and helped me use skills from my course work in practice.

Yitao Bai Shanghai, China

Bachelor of Science in Electrical Engineering
Controls, Robotics, and Autonomy

Aspirations: Be a direct PhD graduate student at VT.

Class Comment: The course provided me a good opportunity to work as a professional engineer.

Kenneth Janak Fulshear, Texas

Bachelor of Science in Electrical Engineering
Controls, Robotics, and Autonomy

Aspirations: I hope to get a job at a robotics company to assist engineering teams in creating a better world.

Class Comment: This course has provided the opportunity to gain valuable experience in an engineering team setting and created many openings to enhance my problem-solving capabilities.

Ruizhe Li Hunan, China

Bachelor of Science in Computer Engineering
Controls, Robotics, and Autonomy

Aspirations: I am fascinated by computer engineering, and I hope to have a positive impact on society.

Class Comment: The course has helped me improve the professional skills and learn how to be a good engineer.

Kathryn Robertson Dayton, Md.

Bachelor of Science in Electrical Engineering
Communications and Networking

Aspirations: I plan to work in the space industry as an electronics engineer with the hope of eventually becoming an astronaut.

Class Comment: This course has allowed me to develop my leadership skills and apply knowledge gained from courses, internships, and personal projects.

PROJECT SPONSORS: ANDRIAN JORDAN, ISRAEL JORDAN, THERESA SHAFER

IEEE SoutheastCon 2022 Hardware Competition Software Team

LEFT TO RIGHT: Gauraang Khandekar, Denison Livingston, Joseph Arbolino, Mari Melke, Julie Ruger, William Grimsley, Nathan Moeliono
SMEs: Arthur Ball, Stephen Moyer (Engineering Education)

CHALLENGE

Working with the IEEE Robotics Competition Hardware team to design and create a robot that autonomously navigates an L-shaped track while completing different tasks such as starting in a 1 cubic foot position, pushing marshmallows off the road, traveling under a power pole and picking up beads off of trees and placing them in bins or nets.

PROJECT SPONSORS: ANDRIAN JORDAN, ISRAEL JORDAN, THERESA SHAFER

Joseph Arbolino Netcong, N.J.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: I would like to continue in the field of Software Systems, but also begin to branch into more interesting fields. I also find modern PC hardware interesting, so I'd like to explore opportunities in that field as well.

Class Comment: The course has given me an idea of what a large scale project would be like in industry, and I think I will be better prepared for my future career because of it.

William Grimsley Stafford, Va.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: I really enjoy writing code and debugging. I am looking to make a career out of it by hopefully becoming a software engineer.

Class Comment: This class has allowed me to experience a large scale project for the first time. I am working with a large team of several different backgrounds/disciplines which has given me a lot of insight.

Gauraang Khandekar Mumbai, India

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: I thoroughly enjoy coding and, given my interest in business, I look forward to exploring a career in data analysis.

Class Comment: This course has given me the opportunity to work in a team and experience what working on a real-world project feels like. It has helped me develop skills I can use while working in the corporate world.

Denison Livingston Weddington, N.C.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: I am very interested in the field of virtual reality and brain-machine interfacing, so I would like to provide my skills to forward these fields in whatever way I can.

Class Comment: This class has given me, as well as everyone else in the group, an opportunity to develop teamwork skills and flexibility, while facilitating a professional environment.

Nathan Moeliono Twinsburg, Ohio

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: I would love to have a fun career doing software engineering .

Class Comment: This is the first time most of the team has worked on a robot, so it was really cool to see how all the skills we learned throughout college could be combine to make something so complex.

Mari Melke Alexandria, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: I would really enjoy getting the chance to expand my knowledge in specific areas of computer engineering, such as cybersecurity.

Class Comment: Being in this course has given me the chance to go out of my comfort zone and learn new skills outside of what I have learned from other classes. I am thankful to have this experience because it allows me to be open about learning new skills.

Julie Ruger Mount Laurel, N.J.

Bachelor of Science in Computer Engineering
Controls, Robotics and Autonomy

Aspirations: I want to continue to expand my knowledge about cybersecurity and robotics.

Class Comment: I appreciate the opportunity to learn the thought process for a complex objective, and enjoyed working with people who shared similar passions. All the design steps have made me feel more comfortable starting to work in industry.

Automated Frequency Management

LEFT TO RIGHT: Caleb Brittenbender, Andy Heller-Jones, Logan Lynch | **SME:** Tim Solie, Phase II

CHALLENGE

To design and build a system for taking in frequency management data including known tables of allocations, antenna datasets, locations, and Transmission/Receiving modules in order to properly perform spectrum management tasks for a given area. The system will take in incoming interference reports and attempt to resolve, perform frequency assignments, provide reference data to requesting bodies, and refer to superior authorities for various deconfliction procedures.

Caleb Bittenbender Leesburg, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: To work as a designer and programmer of synthesizer software.

Class Comment: Unique experience in planning and executing a larger-scale project with a client.

Andy Heller-Jones Richmond, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: To work in Embedded Systems, eventually working as system architect.

Class Comment: It was nice to work with my peers within the major and to work directly with a client.

Logan Lynch Alexandria, Va.

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: To pursue a career in Cybersecurity and Penetration Testing.

Class Comment: This design project has introduced many new challenges not found in standard VT courses.

PROJECT SPONSOR: ROSS OSBORNE

PHASE II
THE OTHER SIDE OF SERVICE

Additive Manufacturing of Electronics

LEFT TO RIGHT: Justice Lin, Kavin Chaisawangwong, Mia Blitt, Sam Everett, Enzo Saba | **SME:** Tim Talty

CHALLENGE

To design and build a software package using Python that converts .dxf files of PCB layouts into STEP files that contain the paths that the 3D printer will follow. This package comes with a user-friendly interface that allows the users to interact with the conversion process.

Mia Blitt Yorktown, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: I am pursuing a career in embedded system design.

Class Comment: This course offered me the ability to work on a very interesting problem in the real world and with an interesting customer. That is something not offered in any other course I have come across and provided invaluable experience.

Kavin Chaisawangwong Bangkok, Thailand

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I hope to work in data analytics, combining the knowledge that I've acquired from both my majors.

Class Comment: The course essentially gave me a look into how engineers conduct themselves in the real world. It was definitely a useful experience.

Sam Everett Hampton, Va.

Bachelor of Science in Computer Engineering
Networks and Cybersecurity

Aspirations: I wish to pursue a career in information and operational security in the ever evolving cyberspace.

Class Comment: MDE provided a very different experience compared to most classes. We had to interact with a customer who expected an end product and figure out how to get there and what to do to deliver something that would satisfy our customer.

Justice Lin Yilan, Taiwan

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I aspire to learn more about my focus area by pursuing my master's and applying my machine learning knowledge to solve engineering problems.

Class Comment: The course provided me with the hands-on experience of working with my peers to accomplish a task and interacting with clients in a professional environment. These opportunities are invaluable for any student looking to become a practicing engineer.

Enzo Saba Beirut, Lebanon

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: My goal is to become an excellent software engineer, and to forever be learning

Class Comment: I really enjoyed working on a project in Additive Manufacturing.

PROJECT SPONSOR: BETH PAQUETTE, CHRISTOPHER GREEN, JONATHAN KELLY

SSAI
SCIENCE SYSTEMS AND APPLICATIONS, INC.
Science and Technology with Passion

NASA

VSAT Algorithm Aboard Artemis

LEFT TO RIGHT: Yichen Liu, Colin Wargo, Ian Wildemann, Anna Borgowski, Mithil Adsul | **SME:** Haibo Zeng

CHALLENGE

NASA Langley Research Center (LaRC) and Science Systems and Applications Inc. (SSAI) are developing a vertical solar array technologies (VSAT) unit to be deployed on the lunar surface for the 2024 Artemis mission. Once deployed, this unit will extend its 30-foot mast with deployable booms carrying a solar panel array. The movement of motors to achieve this task must be modeled with a control algorithm that can be tested on commercial off-the-shelf (COTS) and NASA-provided hardware.

Mithil Adsul Manassas, Va.

Bachelor of Science in Electrical Engineering
Space Systems

Aspirations: My goal is to work in the space industry when I graduate! I have pursued a space systems major in hopes of continuing to work on projects like VSAT upon graduation.

Class Comment: This course helped me develop a deeper understanding of engineering in a professional setting, particularly in a NASA/NASA Contractor setting.

Anna Brogowski Ramsey, N.J.

Bachelor of Science in Computer Engineering
Controls Robotics & Autonomy

Aspirations: My goal in life is to work on the next Mars, or other planetary, rovers. I've been drawing things that I've wanted to build since I was little, and I've always been driven to learn more about and build things for space.

Class Comment: This course gave us our first real application of the things we've learned in our undergraduate degrees. It was very cool seeing our ideas come to life with such renowned companies, like as NASA and SSAI.

Yichen Liu Shanghai, China

Bachelor of Science in Computer Engineering
Controls Robotics & Autonomy

Aspirations: I would like to use my knowledge to help people have the equal accessibility to technology and modern lifestyle, no matter what background or level of education they have.

Class Comment: This course provided us with a real-world, industry-like experience, which helps me experience the form of work, just like an internship.

Colin Wargo Falls Church, Va.

Bachelor of Science in Electrical Engineering
Controls Robotics & Autonomy

Aspirations: I would like to be able to share my knowledge that I have gained, and will gain, with others—helping to teach the new generation of engineers.

Class Comment: I have gained some experience in projects through internships and through this class[KB2] .

Ian Wildemann Newport News, Va.

Bachelor of Science in Electrical Engineering
Controls Robotics & Autonomy

Aspirations: My goal is to be an inventor. I want to have the knowledge and experience to be able to invent or help invent nearly any electrical device a customer asks me to.

Class Comment: This class has helped me get real world experience with design and bringing ideas into the real world.

PROJECT SPONSORS: CARL MILLS, JERYL HILL

SSAI Science Systems and Applications, Inc. Science and Technology with Passion

NASA

Lithium Ion Battery Modeling

LEFT TO RIGHT: Caleb Zhang, Calen Farmer, Charlie Snyder, Joao Vitor Tozzi Mafra | **SME:** Ryan Gerdes

CHALLENGE

To test and model electric vehicle battery efficiency, using a scaled down, remote control, electric vehicle, for package delivery and mail service, and to improve fuel efficiency during delivery routes. The models are used when the companies make the switch from gas and diesel powered vehicles to electric vehicles.

Calen Farmer Grand Coulee, Wash.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: As a computer engineer, I hope to lead a team of talented and highly motivated engineers to help develop animatronics and entertainment with Disney and Universal Studios.

Class Comment: I appreciate the opportunity to further my skills in project management, product developing, and product testing during the course of our project. The lessons I have learned will be carried through to future endeavors and make me a better engineer.

Charlie Snyder Annapolis, Md.

Bachelor of Science in Electrical Engineering
Controls Robotics and Autonomy

Aspirations: As an Electrical Engineer, I would like to use my degree to help the less fortunate.

Class Comment: I really have appreciated the opportunity to get a glimpse into a real company client relationship.

Joao Vitor Tozzi Mafra Vitoria, Brazil

Bachelor of Science in Electrical Engineering
Energy and Power Electronics Systems

Aspirations: After I graduate, I want to work in a big renewable energy company, especially in the solar industry, energy, or automotive industry (working with electric vehicles).

Class Comment: It was an incredible opportunity to increase my skills in communication, project management, and electric vehicles. This class helped me to become a better engineer.

Caleb Zhang Jiangxi, China

Bachelor of Science in Electrical Engineering
Controls Robotics and Autonomy

Aspirations: I loved cars and robots when I was a child, so I decided to pursue this major.

Class Comment: I found this course very interesting because electric vehicles will be the major transportation in the next few decades.

PROJECT SPONSOR: MATT MANDROS

TMEIC
We drive industry

Digital and Analog Magnetic Levitation Systems

LEFT TO RIGHT: Chris Payne, Michael Koch, Olivia Moldoveanu, Dan Menten | **SME:** Campbell Lowe, VPT, Inc.

CHALLENGE

To design a magnetic levitation system consisting of a solenoid and sensor working in tandem to attract or repel a magnet, using both analog and digital controls. The system is also responsible for moving a magnet horizontally as well as vertically, which is accomplished through multiple solenoids in phase offsets from each other, essentially passing around the magnet.

Michael Koch

Staunton, Va.

Bachelor of Science in Computer Engineering
Chip-Scale Integration

Aspirations: After graduation, I will be joining Texas Instruments for a Validation Engineering rotation program. Afterward, I hope to attain a master's degree and break into a digital design-oriented role.

Class Comment: This course gave me experience with customer-facing and customer-adjacent operations in an engineering background. This was the first project that did not feel contrived or purely academic in nature.

Daniel Menten Upper Saddle River, New Jersey

Bachelor of Science in Electrical Engineering
Electrical Engineering (general)

Aspirations: I aspire to make a positive impact in people's lives. I also hope to further pursue my musical passions.

Class Comment: I learned a lot about working on a project in a team environment, and it has helped prepare me for being the best engineer I can be.

Olivia Moldoveanu Chantilly, Va.

Bachelor of Science in Electrical Engineering
Micro-Nano Systems

Aspirations: After graduation, I will be working for Texas Instruments as a product engineer, and I wish to then move towards graduate school and finally start my own company.

Class Comment: This course was an excellent example of how much work needs to be done (spreadsheets, Gantt charts, slideshows) to accomplish one engineering task. Communication cannot be understated as a necessary skill for engineers and this course provides the opportunity to learn it.

Christopher Payne Alexandria, Va.

Bachelor of Science in Electrical Engineering
Electrical Engineering (general)

Aspirations: After graduation, I plan to find a job in the Washington, D.C. area, hopefully with my current internship at the Naval Research Laboratory.

Class Comment: This course did a magnificent job laying out what engineering projects might encompass in the professional field, including teamwork, communication, and experimentation.

PROJECT SPONSOR: DAN SABLE

VPT
Power Your Critical Mission Today

Magnetic Levitation

LEFT TO RIGHT: Eric Danson, Tom Coleman, Brett Burcher, Nicholas Yarnall | **SME:** Matthew Strehle, VPT, Inc.

CHALLENGE

To design, build, and demonstrate a unique magnetic levitation system capable of moving an object both vertically and horizontally while rejecting disturbances.

Brett Burcher Fredericksburg, Va.

Bachelor of Science in Electrical Engineering
Controls, Robotics, and Autonomy

Aspirations: My career goal is to have a positive and substantial impact on the communities that my industry serves.

Class Comment: This course provided experience in project management, presentation skills, and technical skills at a high level. I believe it will continue to benefit its participants throughout their careers.

Tom Coleman, Alexandria, Va.

Bachelor of Science in Computer Engineering
Controls, Robotics, and Autonomy

Aspirations: Utilizing my engineering foundation, I want to take part in experience technology-focused consulting to promote business growth in this industry.

Class Comment: This course has improved my technical skills, especially with control theory. This has been valuable for understanding and communicating with team members in a refined manner. I also understand industry expectations and am better equipped to handle them.

Eric Danson Fredericksburg, Va.

Bachelor of Science in Computer Engineering
Chip-Scale Integration

Aspirations: I want to design analog or digital integrated circuits.

Class Comment: I appreciate gaining a better understanding of project organization and the processes involved.

Nicholas Yarnall Burke, Va.

Bachelor of Science in Electrical Engineering (general)
Bachelor of Science in Mathematics

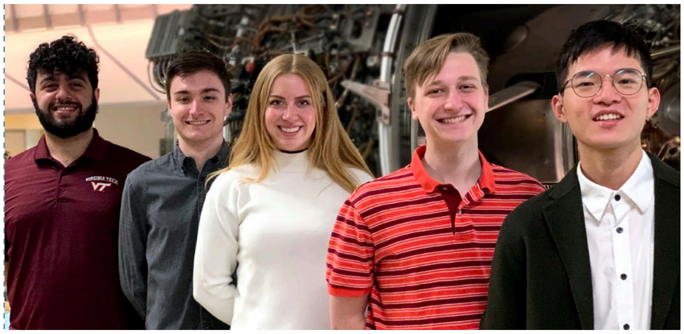
Aspirations: My current career aspirations are to become proficient in my field of work and create a start-up business to bring new and innovative methods to impossible problems.

Class Comment: This course has provided me the opportunity to extensively work on both my hard and soft skills. Sharpening my technical understanding in circuit design, control theory, and programming as well as improving my communication skills and being a team player.

PROJECT SPONSOR: DAN SABLE

VPT
Power Your Critical Mission Today

Coin Cherrypicker



LEFT TO RIGHT: Mohammed Humadi, Michael Trail, Madalyn Killian, Christopher Fritsch, Jianzhu Chen | **SME:** Creed Jones

CHALLENGE

To design an interface that allows the user to upload the obverse and reverse of a coin, display the qualities of the coin in terms of color classification, Sheldon Scale coin grading, outlier-features, etc. This tool is to help increase the throughput and accuracy of checking a high volume of coins for numismatic significant pieces while also negating the factor of human error.

Jianzhu Chen Foshan, China

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: I want to fulfill my parents' expectation of me becoming a first generation Master's Student in our family.

Class Comment: I learned to value hard work and believe in working as a team. I am fascinated by how this senior design project can be applied. I look forward to exploring more incredible challenges in my graduate studies.

Christopher Fritsch Chesapeake, Va.

Bachelor of Science in Computer Engineering
Controls Robotics and Autonomy

Aspirations: I want to increase peoples free time by automating menial labor in people's lives.

Class Comment: The senior design course taught me a lot about project planning and how to set short- and long-term goals for myself. Working with others on a long-term project is much different from working on a short group assignment.

Mohammed Humadi Manassas, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (General)

Aspirations: I want to constantly be learning new technologies and languages in order to keep myself motivated to learn. I would like to use my knowledge to mentor future engineers who don't have access to a software engineering curriculum.

Class Comment: This course has taught me how to productively work as a team. I have discovered different ways to handle team conflict, and different methods of planning for the team's future.

PROJECT SPONSOR: LUKE LESTER

Madalyn Killian Houston, Texas

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: I want to continuously improve my software engineering skill set throughout my professional industry career, expanding my knowledge of computer engineering on a day-to-day basis.

Class Comment: The senior design course has taught me time management skills along with improving my soft skills such as leadership and communication between team members. It has also been a rewarding experience seeing a project from the beginning stages to completion.

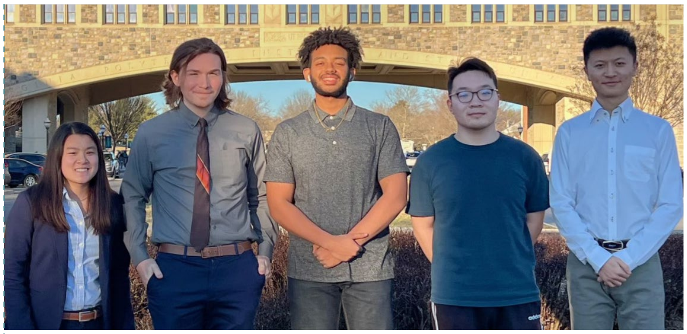
Michael Trail Centreville, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (General)

Aspirations: I want to revolutionize the data analytics and data science world and interweave it into everyday life.

Class Comment: I learned several lessons about teamwork and real-life project design and planning. I look forward to moving into industry with all my newfound knowledge and experience.

Communication System Design for Ocean Wave Powered Autonomous Robots



LEFT TO RIGHT: Ryan Landry, Michael Fuhrer, Kurby Gebremedhin, Qianhui Xie, Ziheng Xu | **SME:** Yaling Yang

CHALLENGE

To design and implement the software and electronics that will enable control of an autonomous ocean wave powered robot. This project scope includes developing a robust communication framework between the robot and land base, an autonomous navigation system, user interface, power monitoring, and motor control. This project is done in parallel with a Virginia Tech Mechanical Engineering senior design team and requires close collaboration to ensure a holistic end-product.

Michael Fuhrer Ashburn, Va.

Bachelor of Science in Computer Engineering
Networking & Cybersecurity

Aspirations: To have a steady and interesting job that will let me pursue my hobbies.

Class Comment: Very insightful into the early stages of engineering design.

Kurubell Gebremedhin Arlington, Va.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I have a passion for software engineering and hope to blend my interests in artificial intelligence and business administration to eventually start my own company where I would be able to make a positive and meaningful impact towards the lives of others.

Class Comment: This course has been a fantastic way for me to get a glimpse of the career path I chose and being able to work independently to our goal has been a great refresher from my other college courses.

Ryan Landry Lexington, Ky.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: I hope to become a software engineer specializing in graphical user interfaces. I want to be able to work on projects that are developed for the greater good.

Class Comment: Participating in this course allowed me to work on a project that brought a lot of different specializations together. Being able to create a working product was very satisfying and rewarding.

Qianhui Xie YiChang, China

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: To get an interesting internship opportunity.

Class Comment: This course has provided great experiences with engineering structure and hands-on work.

Ziheng Xu Yunnan, China

Bachelor of Science in Electrical Engineering
Electrical Engineering (general)

Aspirations: I hope to pursue a Firmware Engineering position and learn more in the Engineering Field.

Class Comment: This course provides a nice environment to me to practice on engineering experiments on practical and professional work. It helps to contribute my engineering design and the process of being engineer.

PROJECT SPONSOR: LEI ZUO

Electronic Textiles for Sensing Human Motion

LEFT TO RIGHT: Eddie Roll, Devansh Chawla, Amanda Gift, Raviraag Rajasekhar, Craig Benson | **SME:** Tom Martin

CHALLENGE

To design a low-power garment containing soft sensors to measure the elbow and shoulder joint angles of a child's movements. This garment can help physical therapists measure angles of children with muscle disease and potentially be used in combination with shape memory alloys to increase these children's range of movement.

Craig Benson Herndon, Va.

Bachelor of Science in Electrical Engineering
Controls Robotics and Autonomy

Aspirations: I want to become a leader of an engineering team producing strongly engineered products for customers. I want my work to primarily deal with the software of embedded systems but also include hardware concepts.

Class Comment: This course has given a look into what real world challenges hold and how problems do not always have one clear answer. It has showed me that documenting and planning a project is just as important as working on it.

Devansh Chawla New Delhi, India

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: My goal is to become a robotics software engineer. Eventually I want to start a robotics software company to solve/automate industrial testing and manufacturing.

Class Comment: This course has given us the tools and exposure to know more about the project development pipeline from start to end. This course has been an experience in real work project development!

PROJECT SPONSOR: TOM MARTIN

Amanda Gift Bristow, Va.

Bachelor of Science in Computer Engineering
Controls Robotics and Autonomy

Aspirations: I want to program and design my own video games and applications, specifically focusing on artificial intelligence and virtual reality. Eventually, using my experiences, I want to create my own video game development company.

Class Comment: This course has given me a chance to take what I've learned about engineering in these past few years and actually apply it in a way that's meaningful.

Raviraag Rajasekhar Chennai, India

Bachelor of Science in Computer Engineering
Controls Robotics and Autonomy

Aspirations: My career goal is to gain experience in the field of engineering autonomous robots in the health care industry and eventually start my own company.

Class Comment: This course has provided us with a great introduction to how large projects in the real-world are developed. We have gained a lot knowledge regarding the planning and execution of a project and how to tackle the different problems we face during the execution of a large-scale project.

Eddie Roll Fairfax, Va.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: In my career I will work hard to rise to the top of my field. Most importantly, I plan to use the skills learned here at Virginia Tech to help improve the lives of people around the world.

Class Comment: This course has provided me a chance to see a long-term project through from start to finish. The hands-on experience and ability to learn and adapt to new obstacles along the way will be invaluable as I enter the workforce.

Fault Tolerant Power Electronic Systems

LEFT TO RIGHT: Zachary Ruttle, Ben Faunce, Timothy Snow
SME: Marif Daula

CHALLENGE

We designed a converter circuit which takes a varying AC input of low frequency to a consistent but alterable output DC voltage. This is meant to work on high power as it handles input from a wave motion converter, and is built to handle problems inside of both the rectification and the conversion.

Ben Faunce Fairfax Station, Va.

Bachelor of Science in Electrical Engineering
Energy and Power Electronic Systems

Aspirations: My career goal is to work as an electrical engineer in the power industry, with a primary focus on power lines.

Class Comment: I found it very helpful to work with my peers on a project that has given me lots of good experience as I graduate and enter the engineering industry.

Timothy Snow Richmond, Va.

Bachelor of Science in Electrical Engineering
Electrical Engineering (general)

Aspirations: After graduation my goal is to begin a career in control systems, specifically robotics.

Class Comment: This class has been a tough, but insightful experience for me. I believe this course has been good preparation for real work.

Zachary Ruttle Lovettsville, Va.

Bachelor of Science in Electrical Engineering
Energy and Power Electronic Systems

Aspirations: I am going to graduate school next year to get my Master's of Science degree, and will be looking for a job anywhere across America to help in transforming the power grid.

Class Comment: I was happy to work with my peers on a long-term project that gave me a taste of what my major's work is like. It's been a long process with issues that have occurred over the semesters, but we have made it through.

PROJECT SPONSOR: LEI ZUO

Fitness Watch Open Sound Control Interface

LEFT TO RIGHT: Leonardo Apollaro Gama, ..., Darsh Patel, Garret Witt, Daniel Samtani | **SME:** Ben Knapp

CHALLENGE

To create a real-time software interface between a smartwatch and a computer display to enable the control of lighting, sounds, and/or robotic actuators.

Leonardo Apollaro Gama Sao Paulo, Brazil

Bachelor of Science in Computer Engineering
Network & Cybersecurity

Aspirations: I aspire to make a difference on the world with my job always focusing on how I can improve and help people.

Class Comment: This course has been a great experience on how to work with a team on a project with a more professional approach.

Darsh Patel Richmond, Va.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: My career goal is to have a successful software development career ranging across the full stack before moving into Venture Capital within the technology vertical.

Class Comment: This course gave me the opportunity to work with fellow ECE students in enhancing my technical knowledge relating to human computer interaction.

Daniel Samtani Morris Plains, N.J.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: Within my career I hope to make a difference in people's lives by working in consulting to give people the expertise they need on their projects.

Class Comment: The course layout has been able to sharpen my technical skills while working in a real-world situation in consulting a client and providing a solution for the problem they presented to us, which hopefully sets me up to succeed in my career.

Garrett Witt Mannington, W.Va.

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: I hope to pursue a career in cybersecurity focusing on pen-testing.

Class Comment: I liked how this course was much more open ended than other courses I've taken. Being able to decide how I think the project should be done was valuable experience.

PROJECT SPONSOR: BEN KNAPP

Interactive ECE Degree Planner

LEFT TO RIGHT: Luke DiSalvo, Claire Woehr, Antonio Chelala, Thien-Lam Vo, Walid Zeineldin | **SME:** William Plymale

CHALLENGE

ECE students and advisors at Virginia Tech have access to multiple resources for degree planning. These tools include DARS, Hokie GPS, ECE checksheets, timetables for classes, etc. However, currently there is no centralized location for all these tools, and the transfer of information from one tool to the other is often limited. The decentralization of these tools makes it difficult for students to plan their studies at VT as they have to scour through multiple resources with conflicting information. The same issue arises for advisors who have to look through all these resources while advising students. The decentralization wastes time, leads to confusion and misinformation for all parties involved. Our project combines the aforementioned tools into one single tool.

Luke DiSalvo North Andover, Mass.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: To invest in the future, and to be among those who inspire the growth of technology. I would like to be part of something that has a lasting impact on many people.

Class Comment: This project has allowed me to get a glimpse of what it means to be a full stack developer and has given me valuable knowledge about software development tools.

Claire Woehr Charlotte, N.C.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: I want to go into defense contracting to help create new security systems that help protect companies and other organizations from malicious attacks.

Class Comment: This course has given me insight to what I should be expecting when going into the work force as well as a learning experience with the project I assisted on.

Walid Zeineldin Cairo, Egypt

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: To contribute to the advancement in and innovation of the world with the skills and tools that I learn.

Class Comment: This course has given me an idea of how a project is done from start to finish. From planning all the way to production.

Thien-Lam Vo Fairfax, Va.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: To have an impact professionally and socially on others, and to influence others and surround myself with others who want to do good.

Class Comment: The course really taught me what being on a team is like, working on a very large project, defining goals, and the satisfaction of completing a major objective.

Antonio Chelala Beirut, Lebanon

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: As an engineer, I would like to add an entrepreneurial perspective in my career by selling a product which would be part of everyone's daily lives. I am passionate about Software, Cloud, and Security, and want to create a product that will assure a secure network.

Class Comment: This course gave me a real life project simulation and experience that I could encounter in a big company. The skills gained in this class made me a well-rounded engineer.

PROJECT SPONSORS: MARY BREWER, GARRETT CAMPBELL, NICOLE GHOLSTON

Intelligent Devices for Future Medical Workspaces

LEFT TO RIGHT: Khaled Alhmoudi, Keerthana Aluri, Mayank Hirani
SME: Ben Knapp

CHALLENGE

Telemedicine within the ICU has been a popular practice during the start of COVID-19. However, there are limits to how involved a clinician feels when supervising procedures or practices through a screen. MD Hokies will create a fully immersive experience for Tele-ICU clinicians to improve team collaboration within the integration of Tele-ICU practices by implementing a novel free-viewpoint video system.

Khaled Alhmoudi Abu Dhabi, UAE

Bachelor of Science in Computer Engineering
Computer Engineering (General)

Aspirations: I aspire to be a Computer Engineer working on modern-day challenges related to hardware optimization and architecture efficiency.

Class Comment: This course, and specifically this project, have given me real-world experience in identifying problems and prototyping appropriate solutions. I believe our project provided me with a unique experience that has enriched my teamwork abilities in a technical and professional setting.

Keerthana Aluri Richmond, Va.

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: My career goal is to potentially combine my passion for technology and medicine through Virtual Reality to solve problems in the medical workspaces.

Class Comment: This course has allowed me to understand how projects with customers are done in the real world. We lost team members, but we still persevered and outlined our goal.

Mayank Hirani New Delhi, India

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: I want to combine my technical knowledge along with my interpersonal skills to solve complex problems.

Class Comment: This course has given me real-world experience of solving problems as a team. Our team went through various ups and downs. There were times when we questioned whether we would complete our project. But, in the end we pulled through and achieved our goals.

PROJECT SPONSOR: BEN KNAPP

Machine Learning Card Authenticators (MLCA)

LEFT TO RIGHT: Chengpei Wu, Rajan Mann, John Ventura, Vraj Patel, Noah Sanzone | **SME:** Creed Jones

CHALLENGE

To more efficiently grade sports cards using computer vision and machine learning methods compared to traditional grading, which is time intensive and prone to human bias. The objective is to use software to improve upon the most popular, traditional grading methods as offered by companies like Professional Sports Authenticator (PSA).

Rajan Mann Middletown, Del.

Bachelor of Science in Computer Engineering
Controls, Robotics, and Autonomy

Aspirations: I would like to apply the skills from my degree to make strides in machine learning or autonomous systems within the technology industry.

Class Comment: The course provided me with a unique experience where I got to interact with a customer directly and understand his needs for the product. In addition, I developed skills in computer vision and machine learning.

Vraj Patel Richmond, Va.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I would like to apply the machine learning and artificial intelligence skills I acquire through my degree program in the finance industry.

Class Comment: This course has given me a chance to practice engineering in a professional setting before I enter the workforce. I have gained valuable technical and interpersonal skills that I can apply in industry.

Noah Sanzone Richmond, Va.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I aspire to use my knowledge and expertise in computer engineering and artificial intelligence within the space sector to explore the universe.

Class Comment: This course has taught me how an engineer operates within a team in a professional setting. I have learned a multitude of skills through this MDE that I could not be taught in a normal lecture style class.

John Ventura Manassas, Va.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I hope to use my knowledge in ML and software engineering to build cool projects and contribute to society.

Class Comment: This course gave me the experience of working alongside fellow engineers to build a project for a customer. I was able to develop certain skills that will really stick with me throughout my career.

Chengpei Wu Huangshan City, China

Bachelor of Science in Computer Engineering
Networking & Cybersecurity

Aspirations: I would like to use my knowledge and experience in the cybersecurity field to protect people's private information.

Class Comment: This course improved my teamwork skills and let me practice the skills I have learned from the previous courses. It also gave me the insight of how professional engineers work.

PROJECT SPONSOR: LUKE LESTER

Building Ladder Safety System

LEFT TO RIGHT: Mason Kimbrough, Ellen Guo, Jackson Underwood, Rohan Desai, Jared Monseur | **SME:** Almuatazbellah Boker

CHALLENGE

We designed and prototyped a mechanism to control the locking and unlocking of the roof hatches in Virginia Tech's campus buildings. Using several different interfaces, such as a swipe access key card, a keypad and code, or a physical key, a person with access can unlock the hatch from the bottom of the ladder.

Rohan Desai Charlotte, N.C.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: In my career I plan to leverage my knowledge of machine learning to help modernize and improve old technology systems.

Class Comment: This class gave me a great opportunity to interface with multiple clients and work to balance their needs while working towards our goal.

Ellen Guo Washington, D.C.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: To pursue a career that will allow me to apply Machine Learning applications and principles to address Cybersecurity problems.

Class Comment: The MDE experience has provided me valuable insight in how to apply engineering principles to a real-world problem.

Mason Kimbrough Harrisonburg, Va.

Bachelor of Science in Electrical Engineering
Energy and Power Electronic Systems

Aspirations: My career goal is to work as a Surface Warfare Officer in the U.S. Navy, maintaining proper operation of the nuclear reactors on an aircraft carrier. I want to help ensure safety and security for my fellow citizens.

Class Comment: This course has developed my skills in communicating and working in a group environment. These skills will allow me to be a better leader in my future work environment.

Jared Monseur Sterling, Va.

Bachelor of Science in Computer Engineering
Chip Scale Integration

Aspirations: Wherever I go, wherever I work, I want to be a part of building something great. I want to build amazing technology that changes lives.

Class Comment: This course has taught me the fundamental tools to the engineering process. Managing my time, managing a project, and building something that changes lives.

Jackson Underwood Huntsville, Ala.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I am going to begin my career in tech consulting. From this I will learn the business side of large companies. This will allow me to hopefully branch out and start my own business building smart homes.

Class Comment: This class was helpful in giving me the experience of being managed with a more hands off approach. This was very different than the more micromanaged aspect of most classes. It made me a better engineer as I transition into the professional environment

PROJECT SPONSOR: GREG WINTERS

Cybersecurity Signal Collector/Analyzer

LEFT TO RIGHT: Victor Nguyen, Joseph Reilly, Sam Reid, Quincy Brooks, Qasim Wani | **SME:** Brad Tilley (IT Security Office)

CHALLENGE

To design and build a device capable of capturing and storing proximal Wi-Fi and Bluetooth packets for use in security demonstrations. Information gathered by the device will be viewable through a web page containing tables, charts, and other visualizations.

Qunicy Brooks Marriottsville, Md.

Bachelor of Science in Computer Engineering
Networking and Cybersecurity

Aspirations: After graduation, I will be working for the US Government to fulfill my scholarship commitment. I hope to use the knowledge that I've gained from this project to help further my work and protect the nation.

Class Comment: I really liked working with my teammates, SME, and customer. I've learned so much from them and I believe that we have collaborated on a fun, informative, and important cybersecurity project.

Sam Reid Midlothian, Va.

Bachelor of Science in Computer Engineering
Networking and Cyber Security

Aspirations: I hope to continue building knowledge and experience in computer and network security by working in industry to become an expert in my field and make meaningful contributions to current and future security technologies.

Class Comment: Experiencing the process of designing and building a system according to the customer's specification has greatly improved my understanding of the engineering process and helped me feel prepared for working in industry after graduation.

PROJECT SPONSOR: RANDY MARCHANY

Victor Nguyen Richmond, Va.

Bachelor of Science in Computer Engineering
Networking and Cyber Security

Aspirations: I want to obtain real experience working in the industry so that I can continue to learn and apply information on network security. I hope to make a real impact protecting customers and clients from adversaries.

Class Comment: Working with a small team and cooperating with an industry expert to deliver a product has been an enlightening experience. I believe I am more prepared to work in industry immediately after I graduate.

Joseph Reilly Staunton, Va.

Bachelor of Science in Computer Engineering
Networking and Cyber Security

Aspirations: After graduation I will be pursuing a master's degree and hope to work as a system administrator in industry.

Class Comment: I enjoyed working alongside professionals in my chosen field and getting a better understanding of the process engineers go through in industry.

Qasim Wani Doha, Qatar

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I'll be working as a Machine Learning researcher at PathAI where we utilize AI techniques to solve cancer. As far as long-term aspirations go, I aim to exponentially improve the lives of 7 billion people by inventing the next layer of Machine Intelligence.

Class Comment: As the only non-cybersecurity major, it was a really fun experience learning about security in practice. Though being constantly grilled by our mentor wasn't the best of experiences, it does show how much the instructors care about you as an engineer.

Biosensor to Measure Ventricle Flow-Rate and Pressure for Children with Congenital Heart Disease

LEFT TO RIGHT: Varun Modak, Ward McHenry, Sarah Gudelis, Arin Ofir, Anna Taylor | **SME:** Bright Katey (ME)

CHALLENGE

To design a sensor to monitor Blood Pressure and Blood Flow Rate to assess the function of a blood pump for children with congenital heart defects. Research and report on how the sensor can be made to be bio-compatible, low-power, and easy to reproduce. The sensors must be flexible enough to assume the shape of the Total Cavopulmonary Connectors surface, and thin enough to avoid flow restriction.

Sarah Gudelis Holmdel, N.J.

Bachelor of Science in Computer Engineering
Computer Engineering (general)

Aspirations: I hope to work in the biomedical field, working on cutting edge technology that helps impact lives.

Class Comment: This course has allowed me to gain not only technical experience related to computer and biomedical engineering, but also to get experience with working on long term projects.

Ward McHenry Spring City, Pa.

Bachelor of Science in Computer Engineering
Computer Engineering

Aspirations: I hope to pursue a career in software engineering and gain a wide knowledge of many fields.

Class Comment: Throughout this course I was able to gain valuable skills in communicating with not only team members, but customers and supervisorial figures.

Varun Modak Blacksburg, Va.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: My plan is to pursue further studies and work for a company that is making strides in telemedicine, sustainability or edge computing

Class Comment: I appreciate being able to work on a project that could potentially help thousands of children that suffer from congenital heart defects. Moreover, it's been great brainstorming with five other students, each of whom has a unique perspective to offer!

Arin Ofir Blacksburg, Va.

Bachelor of Science in Electrical Engineering
Controls, Robotics, and Autonomy

Aspirations: I hope to continue my education in graduate school for Biomedical Engineering, and to be part of the major advancements in the medical device field.

Class Comment: Through this course I was able to learn about the early stages of the development process of a medical device and work with many Virginia Tech faculty.

Anna Taylor Falls Church, Va.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I hope to find work in a company that uses machine learning in order to improve human quality of life, or better the health of the environment.

Class Comment: This course has pushed me outside of my comfort zone into an area of study that I may have never had experience with. I appreciate how I have gained knowledge of bio-compatible hardware design through self-study and group work.

PROJECT SPONSOR: ALEXANDRINA UNTAROIU

VIRGINIA TECH

Grounded Force Feedback Arm with Haptic Gloves

LEFT TO RIGHT: Max Stelmack, Cameron Dunning, Nicholas Tremaroli, Minh Nguyen, Sam Schoedel
SME: Alex Leonessa (TREC Lab)

CHALLENGE

We developed a system to render forces to a user as they interact with objects in virtual reality. Forces are applied using a robotic arm, which is mounted to the ground and attached to the back of the user's hand.

Cameron Dunning Upton, Mass.

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I want to be a Machine Learning engineer who contributes to artificial intelligence projects

Class Comment: This class has given me the experience and perspective of working on a project from a workforce point of view.

Max Stelmack Centerville, Ohio

Bachelor of Science in Computer Engineering
Controls, Robotics, and Autonomy

Aspirations: I want to design robots for search and rescue operations.

Class Comment: I'm sincerely thankful for the opportunity to overcome a complex design challenge alongside excellent teammates.

Minh Nguyen Ho Chi Minh City, Vietnam

Bachelor of Science in Computer Engineering
Machine Learning

Aspirations: I want to contribute to the machine learning and robotics community as a Machine Learning Researcher.

Class Comment: This course allows me to learn more about robotic deployment and the complexity that comes to software and machine learning integration to robotics.

Nick Tremaroli Briarcliff Manor, N.Y.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: I am pursuing a graduate degree in Software Systems and Robotics.

Class Comment: I am grateful to have been part of such a prestigious class and field of study. The work I have done here will greatly help me as a professional engineer.

Sam Schoedel Fredericksburg, Va.

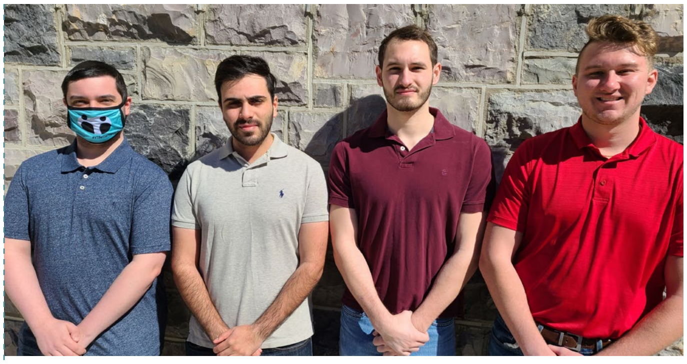
Bachelor of Science in Computer Engineering
Controls, Robotics, and Autonomy

Aspirations: I seek to contribute to the world's knowledge base and capabilities in robotic autonomy through graduate research.

Class Comment: This course has given me crucial experience working with and coordinating the efforts of multiple companies to help us create our customer's desired product.

PROJECT SPONSOR: ALEX LEONESSA

Emergency Management Center in Blacksburg, Va.



LEFT TO RIGHT: Kevin Nolan, Fadi Farid, Colin Farrell, Eric Carr
SME: Minh Ngo

CHALLENGE

To research and design a microgrid emergency management system located in Blacksburg, Virginia. The system utilizes a lithium-ion battery storage bank and solar energy to supply power to a community center, data center, and electric vehicle (EV) charging stations.

Eric Carr Pittsburgh, Pa.

Bachelor of Science in Computer Engineering
Software Systems

Aspirations: My career goal is to work as a software engineer in embedded system design. Ultimately I want to pursue engineering management opportunities once I have gained more experience.

Class Comment: This course supplied a real-world application of the engineering design process and it exposed me to the importance of project management. I appreciate the help from our SME mentor professor and customers throughout the process.

Colin Farrell Bloomsburg, Pa.

Bachelor of Science in Computer Engineering
Bachelor of Science in Electrical Engineering
Micro-Nano Systems, Chip-Scale Integration

Aspirations: My career goal is to work as an entrepreneur in the field of renewable energy or electrical engineering.

Class Comment: This course is a great theory exercise for the viability of a renewable energy microgrid in different scenarios. It has been a great learning experience in terms of the range of considerations one has to make applying a system such as this to the real world.

Fadi Farid McLean, Va.

Bachelor of Science in Electrical Engineering
Micro-Nano Systems

Aspirations: My career goal is to work as electronics engineer. Later in life I would like to develop or design elements of different components.

Class Comment: This course provided important components to surviving in the real world showing us how life would be outside of a classroom.

Kevin Nolan Gloucester, Mass.

Bachelor of Science in Electrical Engineering
Electrical Engineering (general)

Aspirations: My career goal as an electrical engineer is to work in the field of robotics. I would like to work on robots to help people in their everyday lives.

Class Comment: This course has introduced me to how engineering as a job is structured and what we would be expected to do alongside research and design. I feel like this will help me make the transition from school to business.

PROJECT SPONSORS: STEVE BOWMAN, MARK ADKINSON, DAN MORTON

Wiley|Wilson® Constant Progress

ECE2804 Project - SPO2 Meter

LEFT TO RIGHT: Fatima Alkaabi, Hristo Ignatov

CHALLENGE

Using a Red and Infrared LED, a photodiode's output was taken to a series of amplifiers and filters where the signal of the user's heartbeat was cleaned up and amplified. Once that was done, an Arduino interpreted the incoming signal to display the user's heart rate, their bpm and oxygen level.

Fatima Alkaabi Abu Dabi, U.A.E.

CPE

Class Comment: This project was an amazing opportunity to learn the skills I need to be a great engineer including technical and social skills.

Hristo Ignatov Pleven, Bulgaria

CPE

Class Comment: There is nothing wrong with starting from scratch one million times because eventually it will work out.

PROJECT INSTRUCTOR: MD ADNAN SARKER

Bradley Department of Electrical and Computer Engineering

Best in Course Recognition for Base Course performance

Fall 2021

ECE 1004 — Introduction to ECE Concepts

- Amy Appler
- Wesley Flynn

ECE 2024 — Circuits and Devices

- Heesang Han

ECE 2214 — Physical Electronics

- Hayden Craun
- Jack Greer
- Yuanzhi Zhang

ECE 2514 — Computational Engineering

- Amy Appler

ECE 2544 — Fundamentals of Digital Systems

- Freya Archuleta
- Chester Bixler III
- Will Bonner
- Adaline Lee
- Becca Schuette

ECE 2564 — Embedded Systems

- Ben Barber

ECE 2714 — Signals and Systems

- Ian Brown
- Fasil Gebraeb
- Michael Kattwinkel

ECE 2804 — Integrated Design Project

- Fatima Alkaabi
- Hristo Ignatov

PROJECT CONTRIBUTOR ACKNOWLEDGEMENTS

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for his vision and continued unyielding support to prepare our students for the future.

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for being our mentoring team, and making the class and all involved with it better.

Mary Brewer, Nicole Gholston, Kimberly Johnston, Minerva Sanabria-Padilla, Susan Broniak, Alicia Sutherland, Jaime De La Ree, Paul Plassmann, Scott Dunning, and Laura Villada

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Donald Leber

for providing cleanroom access, and training for students.

Chelsey Betts Seeber

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Bianca Norton and Virginia Tech Inn Staff

for helping plan, cater and secure all arrangements to make the Major Design Experience Expo so great.

Special thanks Ms. Amrita Chakraborty

for teaching, coaching, and mentoring our cleanroom teams to produce great semiconductor results.

Special thanks to Alexander DeRieux

for enhancements in course automation and individual progress reporting.

Amrita Chakraborty, Juliet Anderson, Alexander DeRieux, and Bright Katey

for being great teaching assistants in support of more than 250 MDE students currently in progress.

Duane Blackburn, Nam Nguyen, Christine Whiteside, Mike Pochet, Michael Garris, Tom Drayer

for supporting the MDE Expo as judges representing the ECE Industrial Advisory Board.

Dushan Boroyevich, Sook Ha, Vassilios Kovanis, Toby Meadows, Bill Plymale, Shelley Stover

for serving as track masters of ceremonies during the Expo.

Rufus Hinton, Rebecca Rainhart, Bright Katey, Juliet Anderson, Ronaldo Maia, Jean-Luc DeRieux, Kaushiki Valluri

for their all around Expo assistance as Virginia Tech students.

PROJECT POSTERS

AEROSPACE

VIRGINIA TECH

Cislunar PNT Satellite System

Team Members: Adam Kimbrough, Luke Myers, Jordan Lloyd

Problem Statement

The added uncertainty of spacecraft trajectories in cislunar space calls for the development of a precise position, navigation, and timing solution to accommodate smaller and more frequent maneuvers for orbiting missions outside of GPS's main lobe range. This range includes the volume of space from the lunar surface, to the 5 lagrange points, and up to 12-13 GEO (Geostationary Orbit).

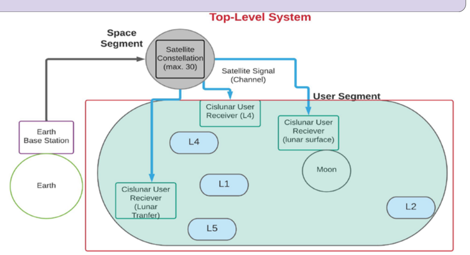
Key Requirements

- < 30 satellites
- Positioning of better than 1 km accuracy
  - Utilizes Kalman or Least Squares filtering
- SWaP: 1U dimensions, < 1.5 kg, < 2 W power

Challenges

- Small (3-person) team w/ only one student specializing in RF
- Modifying software--defined platform meant for GPS to use for Cislunar GNSS
- Learning curve with SOAP (Satellite Orbital Analysis Program)

RF Design



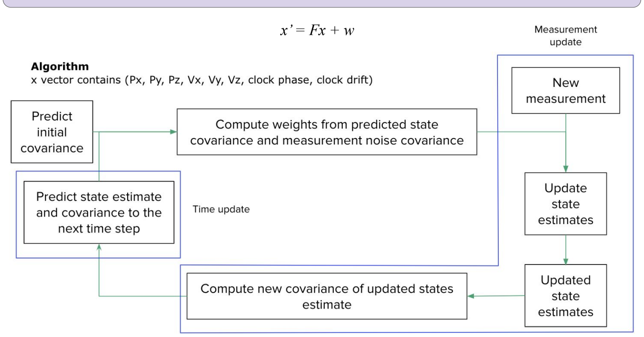
Transmitters
Carrier frequency: 2.4 GHz
Power: 20 dBW
Misc loss: 0 dB
Waveform: BPSK (PRN) - Uplink/Downlink

- Telemetry data rate: 1 Mbps
- Ranging data rate: 50 bps

Kalman Filter

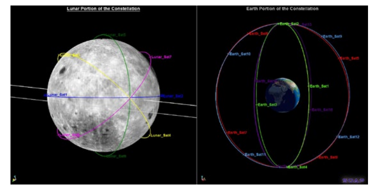
$$x' = Fx + w$$

Algorithm
x vector contains (Px, Py, Pz, Vx, Vy, Vz, clock phase, clock drift)

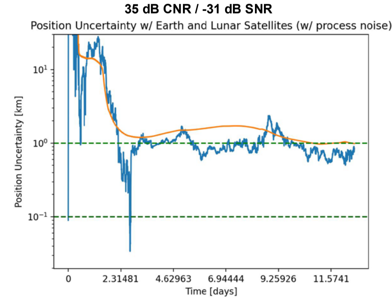


Constellation Design/Results

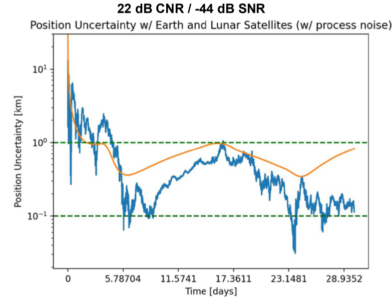
- 24 total satellites
  - 16 Earth-orbiting satellites, 4 planes, Earth-zenith orientation
  - 8 Lunar-orbiting satellites, 4 planes, Lunar-zenith orientation



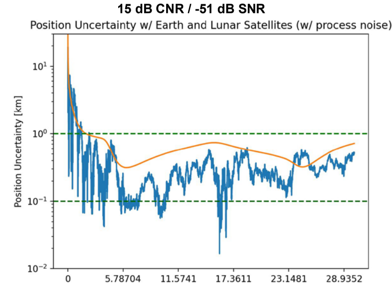
35 dB CNR / -31 dB SNR



22 dB CNR / -44 dB SNR



15 dB CNR / -51 dB SNR



L3,L4,L5 Link Budget

Parameter	Value	Unit	Calculation
Downlink Frequency:	2.4	GHz	Given
Downlink Wavelength	12.5	cm	c/f
Transmit Power	20	dBW	Assume 100 W
Transmit Mismatch Loss	0	dB	Assumption
Transmit Antenna Internal Loss	0	dB	Assumption
Transmit Antenna Directivity	60	dBi	Assumption
Transmit EIRP	80	dBW	TX power + TX antenna gain
Link Distance	300,000	km	Half dist b/w L4 and L5
Frequency Path Loss	40	dB	-20log10(lambda/(4π))
Distance Path Loss	169.5	dB	20log10(r)
Polarization Loss	0	dB	Linear polarization all around
Receive Antenna Internal Loss	0	dB	Given
Receive Antenna Directivity	7	dBi	Given
Atmosphere Losses	0	dB	N/A
System Noise Figure	3.5	dB	Approx. from 2.6 GHz NF graph
Received Power	-126	dBm	Summation of gains + losses
MDS	-106.5	dBm	−174 + NF + 10log10(B), B = 2.5 MHz (2.5 Msps complex)
GPS Processing Gain	43	dB	10*log10(chipping_rate / data_rate)
Carrier-to-Noise Spectral Power Density Ratio	23.5	dBHz	
Minimum C/N	15	dBHz	Best case receiver (lowest signal level)
Link Margin	8.5	dB	

Summary

Satisfactory user position uncertainties of less than 1 km were achieved for the tested DRO and L1NH satellite trajectories using 15 dB and 22 dB C/N, while the tested LLO trajectory experienced a few brief periods (~1-2 days) of outage for 15 dB C/N. A positive link margin for links between two Lagrange points was achieved for 15 dB C/N and 22 dB C/N, but not 35 dB C/N.

Conclusions

A receiver designed to demodulate a C/N of 22 dB or worse will result in better than 1 km of user position uncertainty (excluding LLO orbits) with the designed Earth and Lunar satellite constellation consisting of 16 Earth satellites and 8 Lunar satellites. This also requires the use of GPS-grade atomic clocks.

Acknowledgments

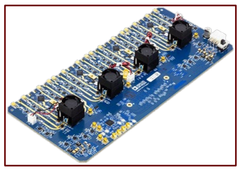
The team thanks Aerospace Corp for the use of their software, SOAP. Special thanks to Daniel Agress for his significant guidance and education in the development of the Kalman Filter as well as satellite orbits and GPS. The team's subject matter expert (SME), Dr. Scott Bailey, and mentor, Toby Meadows were of great help ensuring the success of the team.

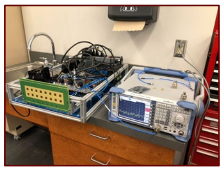
Digital Beamforming Demo with Analog Devices' (ADI) Quad-MxFE

Sponsors: *Michael Jones and Chas Frick* | **SME:** *Louis Beex* | **Mentor:** *Kenneth Schulz*
Names: *Alex Sablan, Tim McDonald, Alec Yip*

Background

5G is emerging as the industry standard by using higher frequency bands. To increase the capabilities of 5G, beamforming is essential; by altering the phases on a receiver to extend the range of 5G signals by receiving more power from a desired direction.





Digital Beamforming: Quad

ADI's response to digital beamforming was the Quad-MxFE board. This board has 16 channels (Tx and Rx), but no one has been able to verify their board. That is our goal: To demonstrate beamforming with the Quad-MxFE and to create the demonstration kit.

Requirements

Our requirements from ADI are listed below:

- Demonstrate digital beamforming using ADI's Quad-MxFE
- Create a user-friendly GUI
- Demonstration kit is durable and portable

We completed all of our requirements from ADI; we performed beamforming, created a GUI, and assembled a demonstration kit for trade shows.

Materials

Our materials list to test digital beamforming are below:

- ADI's Quad-MxFE
- ADI's 8x2 Antenna Patch Board
- VCU-118 FPGA Evaluation Kit
- ComXim's Photography Turntable
- KP-5DPN-1 Parabolic Dish Antenna
- E8257D Analog Signal Generator

How We Demonstrate Beamforming

By multiplying the phases of each receiver by exp(-j$\beta\theta$) (where β is the propagation constant, and θ is the correction angle), we can electronically steer the beam so that the power should be maximum in that direction.

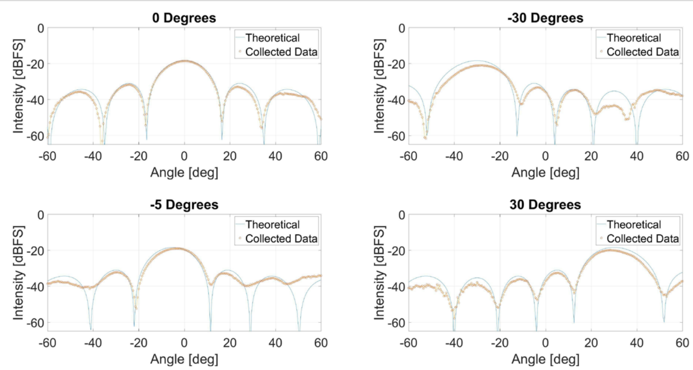
Beamforming Approach & Testing Setup

Our testing setup has two pieces: Transmitter and Receiver.

The Transmitter uses a parabolic dish antenna that connects to the signal generator. We spaced the transmitter and receiver by using the far-field distance equation: r = (D^2)/λ, where 'D' is the length of the radiating element, and λ is the wavelength.

The Receiver comprises of the Quad Mx-FE, antenna board, turntable, and FPGA.

To test the beamformer, we set the beam angle to the desired angle we turn the turntable from -60 to 60 degrees while gathering the 8 different signals from the antenna.



Results

We have to curves in each plot: The theoretical curve (blue) that we should matchi and our actual data (orange). Visually inspecting the curves, we see that the measured values closely match the theoretical values. Thus, we successfully demonstrated digital beamforming.

Summary

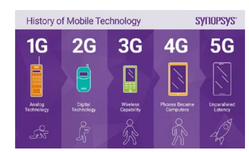
Our project performed in two areas:

- Performed digital beamforming
  - Demonstrated digital beamforming on ADI's new commercial board
  - Produced a testing setup to validate and (possibly) recreate the results
- Created a portable demo kit

Michael Jones (ADI) showcased our results to the University of Oklahoma's Advanced Radar Research Center.

Future Work

This work could be continued by ADI or a future senior design group by recruiting mechanical engineers to design a more robust testing setup that could run by itself for a long period of time to gather a lot of high quality data. This data could then be used to apply beamforming to 5G.



Special Thanks

We would like to thank everyone who has helped us in achieving this momentous goal. In particular, we would like to thank Dr. Steven Ellingson and Robert Yip for their help.

Benten - MiniMi - Interactive Healthy Doll

Team Members: Dare Burnett, Robert McHugh, Saakshi Naveen, Sarang Rajeev, Zebo Lu
SME: Dr. Leyla Nazhand-Ali **Customer:** Benten Technologies Inc.

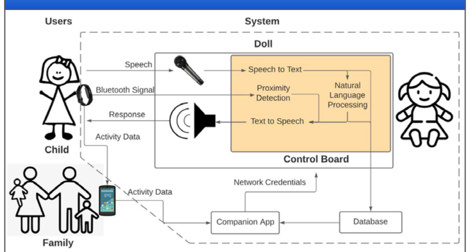
Motivation

- Young African American girls in the United States between the ages of four and eight encounter early obesity problems.
- Studies show that 24% of non-Hispanic black females are considered obese from ages 6-11.
- The evidence suggests that this is because of a lack of healthy eating and active living.
- The age range between four and eight is an imperative time to shape a child's healthy eating and active living habits.

Objectives

- To engage child in dialog regarding healthy habits
- To encourage healthy habits that are focused on quality eating and exercise
- Recognize the girl within close proximity and initiate conversation or begin listening for wake word
- Provide parents information to monitor both conversation and exercise on a mobile app

Overall System Design

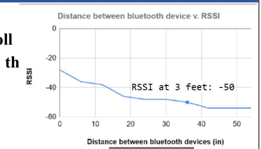


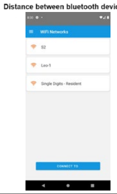
Prototype Videos

- Scan this QR code with the camera of your mobile device to see our product in action!

Initialization & Activation

- The doll is setup by connecting it to the internet, enabling it to record conversations and for speech recognition. This is achieved by the WiFi adapter connected to the doll
  - A hotspot from the device is activated on boot for the phone to communicate with th Jetson Nano on the doll
  - The app allows the the scanned networks to be sent from the doll and credentials for the parent's choice of WiFi to be sent to the doll via SSH
- The doll initiates conversation when the child comes within 3 feet of distance. A bluetooth adapter is used to detect this distance when the doll connects to the wearable device
  - Through testing, we found that the RSSI, Received Signal Strength, is around -50 when the wearable is three feet away with some interference
  - When the RSSI of the wearable is less than -50, the speech to text system is activated





Conversation

- Three ways to trigger a conversation with the doll
  - Wake word, proximity of the child, time of day
- Different functions in the program handle the communication between the voice input, speech-to-text model, and NLP library
  - Speech-to-text is achieved using Mozilla Deep Speech Model
  - NLP library and model is Rasa NLU
  - Text-to-speech is achieved using Google TTS
    - All were chosen in collaboration with the customer
- Process:
  - The speech recognition turns the childs's audio input into segments
  - Segments are sent as input to the NLP
  - The NLP identifies the intent and responds accordingly
  - Response is sent to text-to-speech and is said aloud.

```
[rjmchugh@fedora senior_design]$ python example_cont.py
Receiving SessionBegins ...
Sending messages ...
hi
hi computer
H1, computer.
Output: Hello User
hi
hi computer
hi computer
H1, computer.
Output: Hello User
```

Sample output of speech recognition and NLP

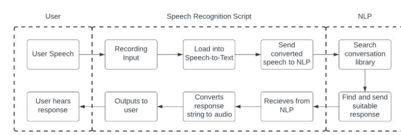
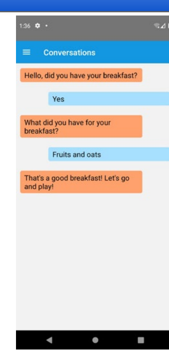
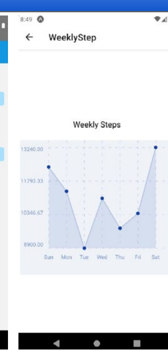


Diagram showing the process of the subsystem

Monitoring Data

- Parents able to monitor the conversations and activity of their children via a companion app
- This data is available to parents so that they can assess the conversations the child is having in order to facilitate healthy living
- Activity Data:
  - Step count information retrieved from the smartwatch
  - A graph showing weekly step counts
- Conversation Monitoring:
  - Conversation data is taken from a server connected to the speech recognition script
  - The server is run on Firebase using Firestore's NoSQL database





Test Result & Analysis

Requirement	Engineering Characteristics	Test Cases	Results	Milestone	Milestone Dates
Detect that the child has entered the room to begin conversation through bluetooth connection with a low cost sensor	Responsiveness	User wearing a compatible smartwatch walks upto 3 feet of the doll and the doll initiates a conversation	100%	Configure Blutooth Adapter onto Jetson Nano	2/14/22
	Cost			Connect Bluetooth Smartwatch with Jetson Nano	3/16/22
	Accuracy			Create Script to call speech to text program when smartwatch is detected within	3/23/22
Monitor child's activities and record the response/interaction with child	Volume	App should show the step count of the person wearing the wearable throughout the day.	80%	Finish the GUI of the mobile app	3/18/22
	Responsiveness			Integrate Xiaomi SDK into the app	4/8/22
Integration with NLP to communicate with the child	Accuracy	User initiates a conversation with the doll by saying "Hey Imani" and asks a question then the doll will respond with an appropriate response	80%	Recording and converting user voice input	2/14/22
	Responsiveness			Sending input to NLP and getting back response	2/28/22
				Outputting NLP response to the user	3/7/22
Wifi integration with the Jetson Nano and the mobile app	Accuracy	User boots the Jetson Nano and connects the network seen on scanned networks on the app. Then, the Jetson Nano connects to the WiFi network.	100%	Scanning and Configuring network via SSH	1/31/22
	Responsiveness			Managing Networks for Jetson Nano from Companion App	3/15/22
Ensure Privacy for parents/guardians and child	Customer Approval	Doll records conversations and stores them so that the parent can monitor the conversations	100%	Storing conversation data in server	3/25/22

Conclusion

- The full product includes a doll, a smartwatch, and a mobile app.
- Learning Experience
  - Created an NLP library
  - Configured the speech recognition program
  - Configured network on a Jetson Nano remotely
  - Added Bluetooth Proximity detection
  - Created ability to pull data from the SDK
  - Learned to use React Native to build the app
- Risks and Tradeoffs:
  - Privacy Concerns
  - Child may be uncomfortable with the doll
- Future Work
  - Expand NLP Library
  - Add more exercises to the app
  - Add more functionality for parents in the app
  - Improve Voice of the doll

Acknowledgements

- The Benten MiniMi team would like to acknowledge the following people for sharing their time, advice, and experience with us :
  - SME: Dr. Leyla Nazhand-Ali
  - Mentor: Dr. Scot Ransbottom
  - Sponsors: Tony Ma, Katie Chang, and Elina Bajracharya from Benten Technologies, Inc.

Condition Monitoring and Lifetime Prediction of Power Devices

Team Members: Vincent Pagliaro, Liam Gaffney

SME's: Qihao Song, Dr. Ming Xiao Customer and Sponsor: Dr. Yuhao Zhang

Objective:

1) Design: → **2) Modeling:** → **3) Physical Testing:** → **4) Trending:**

1) Design: We designed a circuit board that allowed for the condition monitoring of a GaN Semiconductor.

2) Modeling: We created a 3D design of the circuit board with MATLAB and Altium Designer.

3) Physical Testing: We conducted destructive testing as well as cycle testing on our GaN semiconductor Device

4) Trending: We used data collected during the physical testing phase to establish a trend for our GaN semiconductor

What is GaN:

GaN stands for Gallium Nitride, which is a material that has gained traction as an alternative to silicon in semiconductor devices. The use of Silicon remains widespread throughout the industry, however this new material has drawn comparisons to its Silicon based counterparts to determine which would be more appropriate in real world situations.

GaN advantages compared to Si:

- Higher Breakdown Strength
- Faster Switching Speed
- Less Switching Losses
- Lower On-Resistance
- Less Capacitance and losses when charging or discharging devices
- Less power required to drive circuit
- Smaller devices

GaN disadvantages compared to Si:

- Lack of Condition and Deterioration Testing
- Limited testing applications throughout industry
- Cost of production
- Efficiency of Production due to higher frequency of defects
- Lower Thermal Conductivity
- No Avalanche-effect characteristic

Key Requirements:

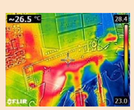
- Design and prototype switching based test circuit for GaN devices
- Design Altium based model for semiconductor test vehicle
- Obtain Lab Access to use proper equipment
- Utilize Curve tracer to establish baseline characteristics of device
- Conduct destructive testing to determine breakdown voltage
- Apply realistic stressors for typical applications
- Apply degradation mechanisms to simulate lifetime of device
- Lifetime Test Must be Accelerated for Repeated Stress
- Apply High Voltage and Low Voltage testing to the device
- Trending of device must be explored

Suggested Additions:

- Predict remaining useful life
- Characterize reliability over temperature
- Comprehensive literature survey of existing lifetime models for Si and GaN devices
- Explore lifetime predictions through analysis of collected real-time waveforms

Before

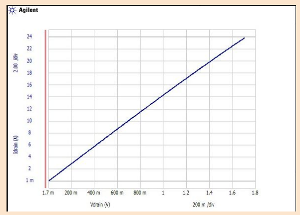
As part of our suggested additions, we conducted some thermal image testing of the device before and after a cycle test



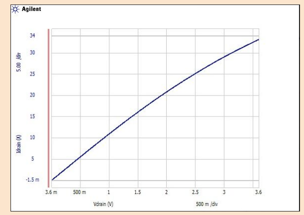
After

Test Results:

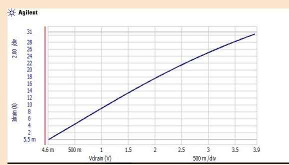
Throughout this experiment we were able to establish a clear degradation trend through lifetime testing of the semiconductor. What we observed was that the device characteristics curve immediately after testing showed higher Resistances when compared to the established benchmark. These higher resistances could reduce the performance of the device or even lead to a premature failure. One interesting point that was observed throughout the testing was that the device experienced a recovery period in which the performance and resistance returned closer to original levels as time went on. They were never observed to recovered fully however.



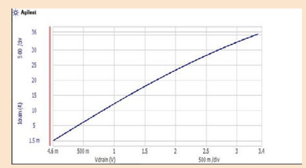
Above Figure: This was the untested characteristics curve for GaN Semiconductor device that was being used. This curve is what we used as a benchmark for our testing.



Above Figure: This was the characteristics curve for GaN Semiconductor device immediately after lifetime testing. The device was tested in the curve tracer for any changes verses the original trace.



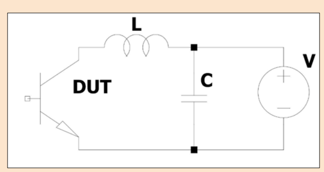
Above Figure: This was the characteristics curve for GaN Semiconductor device 10 minutes after lifetime testing. The device was tested in the curve tracer for any changes verses the original trace.



Above Figure: This was the characteristics curve for GaN Semiconductor device 30 minutes after lifetime testing. The device was tested in the curve tracer for any changes verses the original trace.

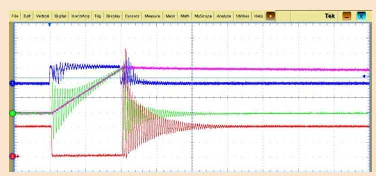
Unclamped Inductive Switching Test Circuit:

The Unclamped Inductive Switching(UIS) Test is a low voltage test that applies stressors to a circuit to simulate overvoltage conditions.

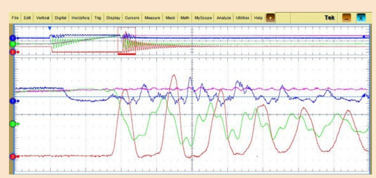


Above Figure: The Above Figure shows the layout of the daughter card for the UIS Test. This piece will attach to the mother board for testing of the GaN device, represented in the figure above as the Device under testing (DUT).

Legend:
- **Drain Voltage Curve**
- **Drain Current Curve**
- **Gate Voltage Curve**
- **Current through Inductor**

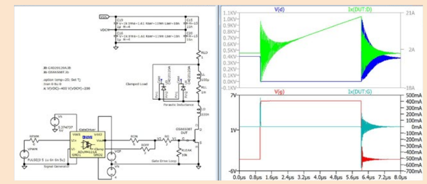


Above Figure: UIS Test Curves for Gate Voltage, Drain voltage, Load Current, and Gate Current

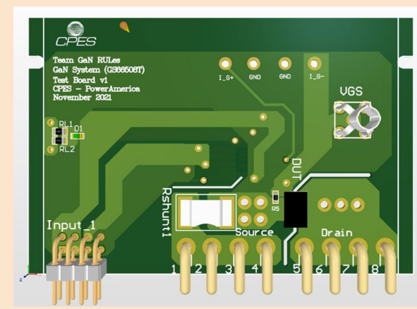


Above Figure: Zoomed in UIS Test Curves for Gate Voltage, Drain voltage, Load Current, and Gate Current

Daughtercard Design and Matlab Testing:



Above Figure: Matlab Circuit design and simulation results



Above Figure: Altium 3D Circuit design

Setbacks and Solutions:

Throughout the course of this project, our group has faced our fair share of hurdles that could have caused our project to fail. These are the setbacks we went through and how we were able to overcome them as a team.

- Losing one of our three team members:
  - We increased the communication and interaction between the remaining members and our customer and SMEs so that we could maintain the appropriate levels of productivity.
- Blowing up one of our semiconductors prematurely:
  - This occurred while we were performing a Clamped Inductive Switching test to determine the breakdown voltage of the device. We chose to modify the test so that it was an Unclamped Inductive Switching test that utilized much lower voltages.
- Having to perform a destructive test on our device:
  - The destructive test that we performed to find the Breakdown voltage of the device was only allowed in the CPES lab after 5pm to ensure the safety of others in the lab. To adhere to this, we focused on scheduling our testing times later in the day.
- Having to change the semiconductor being tested:
  - Late in the design process a semiconductor was identified that would yield much more valuable results when compared to our previous device. We altered our approach and worked with our customer and SME's to ensure that the appropriate test data was collected.

Acknowledgements:

We would like to thank our Customer and SME's for their continued support throughout this design project. We would also like to thank the CPES lab for allowing us to use their equipment and their workspace.

EMI Test Hardware Development

Sponsors: Dr. Qiang Li

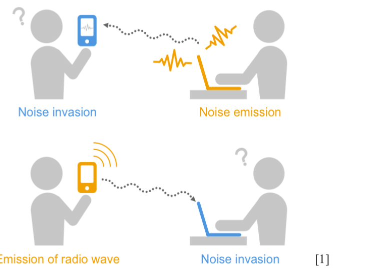
Subject Matter Expert: Dr. Dong Dong and Tyler McGrew

Team: Alessia Scotto, Aman Patel, Anaya Acharya, Justin Green

Background, Purpose, and Introduction

EMI → ElectroMagnetic Interference

- Ever experienced unwanted interruptions during an important call through your phone/landline?



The landline/phone = device, device interruptions = conductive EMI, wireless interruptions = radiative EMI.

Purpose

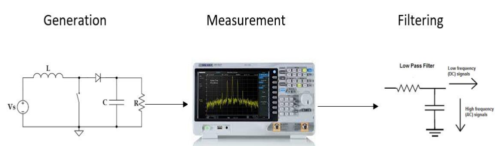
To create a low-power EMI test kit that can be used in a lab setting to teach about EMI generation, EMI measurements, and EMI filtering

Project Specifications

Max. System Power	60W
Max. System Voltage	48V
Max. System Current	1.5A
Industry Standards	EMC, FCC, MIL-STD-461E

3 Phases Demonstrated

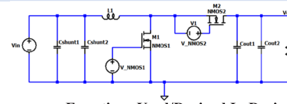
- **EMI Generation** – Designed a boost converter circuit on PCB and used this as the device under test for EMI generation
- **EMI Measurement** – Measured the amount of EMI from the boost converter both in simulation and from the PCB using Line Impedance Stabilization Networks (LISNs) and a spectrum analyzer
- **EMI Filtering –** Designed two different passive EMI filters: a 1st Order filter and a 2nd Order filter.



[2][3][4]

EMI Generation: Boost Converter

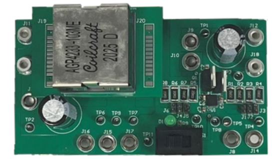
- DC-DC Boost Converter: a power electronics circuit that takes an input DC voltage and outputs an increased DC voltage
- Chosen as EMI Generation Device because it is prone to EMI due to high switching frequencies of a switch-mode power supply.
- Boost Converter Design Parameters: Input 15V, Output 30V, operate at switching frequencies from 100kHz-1MHz
- Two PCB layouts designed in Altium – use of daughter board to switch out inductor values and operating frequency as necessary



Equations Used/Derived In Design:

$$I_L = \frac{V_{out}}{(1-D)*R_{load}},\ V_{out} = \frac{V_{in}}{1-D},\ L = \frac{V_{in}DT_s}{2\Delta i_L},\ C = \frac{V_{out}DT_s}{R_{load}2\Delta v}$$

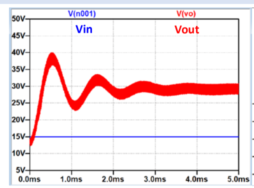
Converter Operations	Fs	Inductor Value
D = 52% V_{in} = 15V V_{out} = 30V	1000kHz	6.8μH
	800kHz	10μH
	500kHz	15μH
	300kHz	33μH
	100kHz	68μH



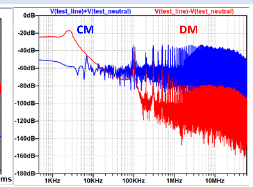
Boost Converter PCB

EMI Measurements: Simulation and PCB Tests

- A LISN was used as an EMI measuring device with the EMI shown on a spectrum analyzer.
- The EMI was simulated as well as measured.
- Common Mode (CM) and Differential Mode (DM) EMI were separated and analyzed individually.



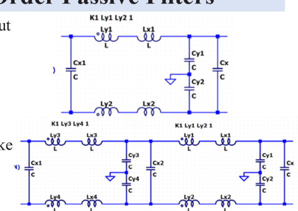
Input/Output Voltage



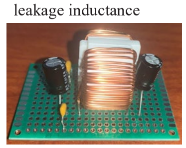
EMI Noise

EMI Filtering: First Order and Second Order Passive Filters

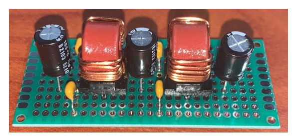
- DM Filter – Low pass Pi Layout: Chosen due to its high input and output impedance
- CM Filter – Low pass L Layout: Chosen due to its low input and high output impedance
- Impedance Mismatching Technique
- Goal: attenuate CM Noise 20dB and DM Noise 30dB
- Component values calculated based on cutoff frequencies and CM Choke leakage inductance



	Ly (uH)	Cy (nF)	Cx (uF)
Filter 1- 1-Stage LF	1400	30	4.7
Filter 2- 2-Stage LF	338	30	3.7
Filter 3- 1-Stage HF	163	30	0.8
Filter 1- 2-Stage HF	11.6	30	1.18

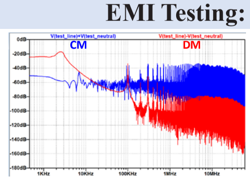


1st Order EMI Filter

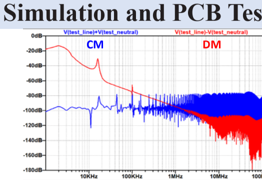


2nd Order EMI Filter

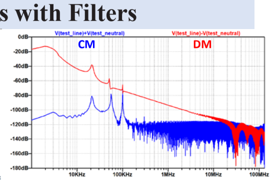
EMI Testing: Simulation and PCB Tests with Filters



No EMI Filters



1st Order EMI Filters



2nd Order EMI Filters

Summary and Analysis

Phases	Sub-Phases	Success	Challenges
EMI Generation	Boost Converter Design	100%	Learning Curve with PCB Design on Altium
EMI Measurement	Simulate CM and DM EMI	100%	Proper modeling of the LISN system on LTSpice
	Measure CM and DM EMI	70%	PCB footprint issues leading to multiple orders
EMI Filtering	1st Order and 2nd Order Passive Filter Design	100%	Finding the best filter models for CM and DM EMI
	Simulate the integrated system to analyze filter design	100%	Required Attenuation vs. High Cutoff Frequency for filters
Integration	Measure the effectiveness of PCB Filters with integrated system	50%	Delays in EMI Measurement from Boost Converter PCB

Conclusion and Future Study

- EMI is the unwanted movement of electromagnetic energy within electrical devices due to changes in current, voltage, and high switching frequency MOSFETS.
- The project focused on creating a tool kit that generated EMI noise with a Boost Converter and suppressed the noise using 1st and 2nd order passive filters.
- For future study, the use of custom PCB filters, the increase in the number of PCB layers, and the analysis of the EMI standards used within the industry will improve the current results.

Acknowledgement

We extend our gratitude to our CPES sponsors, Dr. Dong Dong and Dr. Qiang Li, for their constant help and support throughout the progress of our project. We would also thank our graduate subject matter expert, Tyler McGrew, for sharing his knowledge and expertise during our project.

References

[1] "Noise Suppression Products/EMI Suppression Filters," *Murata Manufacturing Co.* https://www.murata.com/en-sg/products/emc/emifil/library/knowhow/basic/chapter06-p8 (accessed Apr. 08, 2022).

[2] K. Fronczak, "Stability Analysis of Switched DC-DC Boost Converters for Integrated Circuits," Rochester Institute of Technology, 2013. doi: 10.13140/RG.2.1.2646.7606.

[3] "Siglent.eu," *Siglent.eu Store*, 2021. https://www.siglent.eu/product/1137260/siglent-ssa3021x-2-1ghz-spectrum-analyzer-free-tg-license (accessed Apr. 08, 2022).

[4] "Low Pass Filter - Explained," *Learning About Electronics*, 2018. http://www.learningaboutelectronics.com/Articles/Low-pass-filter.php%0A (accessed Apr. 08, 2022).

Energy Transfer Protocol for 5G-Operated Nanogrids

Sponsor: Dr. Igor Cvetkovic - SME: Kenneth Test - Connor Mackert, Tukhang Trinh, Chris Keating, Daniel Mauro

Project Motivation

- 5G Technology introduces new power distribution models.
- Distribution models require a protocol for handling transient events such as load power demand change.
- Low latency and high bandwidth of 5G allow for remote synchronization of nodes to communicate as a "Smart Grid".

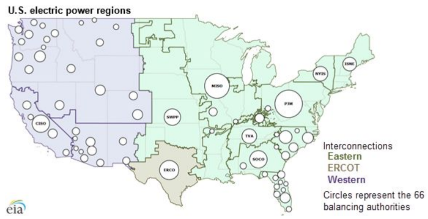


Figure 1: U.S. Power Grid Map

Background

- A microgrid or nanogrid is a self-sufficient energy network attached to the main grid.
- Microgrids/nanogrids contain different types of nodes such as energy sources, storage devices, and loads.
- Events such as changes in power demands, blackouts, and surges require these nodes to adjust and react.

Distributed Energy Resources

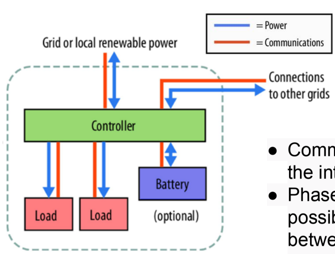


Figure 2: Nanogrid Network

- Distributed Energy Resources (DERs) must be aware of transient events (load power demand, grid frequency droop, etc.).
- Communication of power variables over the internet?
- Phase Locked Loops (PLLs) can possibly be eliminated if the latency between nodes is low enough (saves hardware cost).

Precision Time Protocol

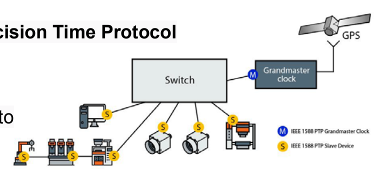


Figure 3: Precision Time Protocol (PTP)

- Precision Time Protocol (PTP) is a clock-based protocol that can be used to better synchronize nodes.
- Nanosecond synchronization.
- Communicates current time as well as delay between nodes
- Base for other protocols such as the White Rabbit Project which can achieve sub-nanosecond sychnoziation with thousands of nodes.

Design Process

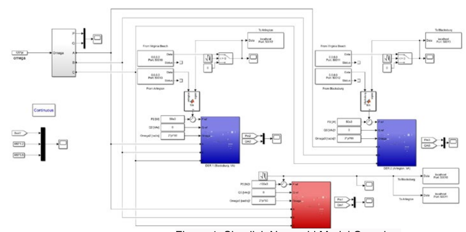


Figure 4: Simulink Nanogrid Model Overview

- Simulate nanogrid system connected to a power grid using MATLAB Simulink. Start with 4G communication.
- **Key requirement**: DERs must react to load change to ensure system voltage stability (within 480 V +- 20%).
- Load demand change is communicated to DERs via User Datagram Protocol (UDP).
- Communication-loss system uses UDP to detect if connection is lost between load and other DER.

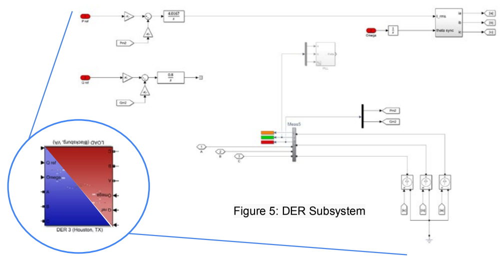


Figure 5: DER Subsystem

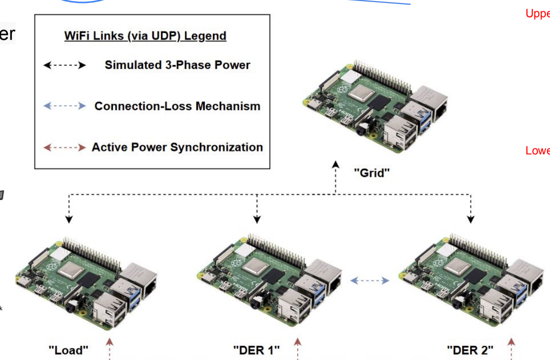


Figure 6: Raspberry Pi System Overview

- Raspberry Pi network representing each microgrid node connected via a WiFi network with inter-node communication via UDP.

Results

Requirement	Simulation	Emulation
Transient data must be handled via network communication	Yes	Yes
Periodic communication failures must not interrupt DER service	Yes	No
Bus voltage must not be greater than 576 V or less than 384 V at any time	Yes	Yes
Emulation system must be composed of 4 Raspberry Pis communicating with each other through network sockets	N/A	Yes
A post-4G protocol must be implemented on the Raspberry Pi System to achieve synchronization of less than 1 ms	N/A	No

Figure 7: Requirements and Results

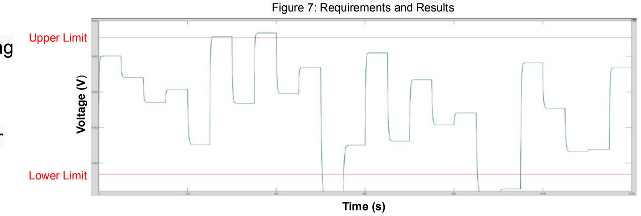


Figure 8: Bus Voltage without Active Power Control

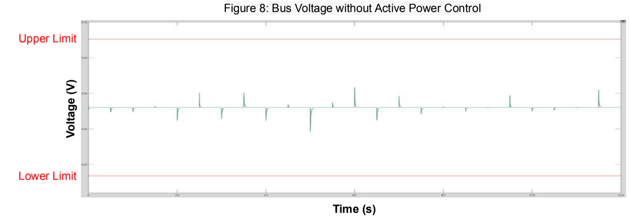


Figure 9: Bus Voltage with Active Power Control

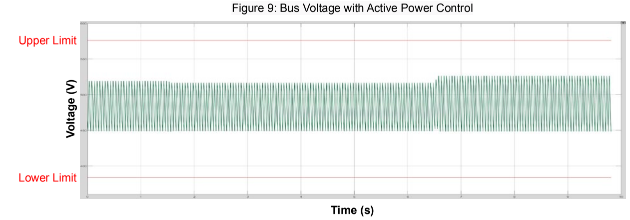


Figure 10: Raspberry Pi System Data

Further Research

- The Raspberry Pi Network provides a real-world hardware model to test the synchronization of nodes.
- Synchronization is a priority. Nodes need to have sub-nanosecond communication latency for overall stability.
- PTP, White Rabbit Protocol, and 5G will provide useful solutions to the problem and will be explored in the future.

IPT Transformer Design with Space-Constrained Receiver

Sponsor: Dr. Khai Ngo **SME:** Minh Ngo, Bo Li **Mentor:** Kenneth Schulz
Team Members: Mathew Szpakowski, Divya Mathews

Motivation & Objectives

Electric vehicles are becoming more popular, and a huge emphasis is placed on using them to combat climate change. A problematic aspect of EVs is how they are charged.

Currently, the standard way to charge electric vehicles is by cord at a plug-in charging station, but wireless charging systems could save cost on cords and expand implementation possibilities.

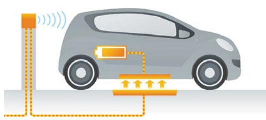
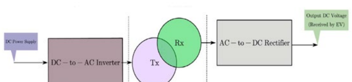


Figure 1. An inductive power transfer (IPT) system requires a transmitter coil located on the ground (powered by the grid), and a receiver coil located on the bottom of the vehicle.

Design Approach

Figure 2. A high-level overview of the functionality of the wireless charging system



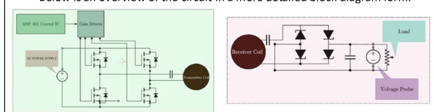
The power grid supplies voltage to the transmitter circuit, consisting of a DC-to-AC inverter. The DC voltage is converted to AC voltage with a microcontroller-supplied pulse signal. AC voltage is required for contactless charge by induction. Each coil emits a magnetic field as a result, which must be attenuated to abide by ICNIRP radiation standards. On the receiver side, the AC current outputted by the receiver coil must be converted back to DC current through the rectifier before it can be used to charge the car's battery. A transformer meeting requirements would have 100% efficiency, with output power equal to input power.

For wireless charging, the principles of magnetic field induction allow for a charged coil to induce a current in another coil at a certain distance without direct contact. The required specifications are as follows:

Parameter	Value
Vin	400 V
Vout	400 V
Gap	100 mm
Pout	330 W
Transformer Efficiency	99%

Simulation

Below is an overview of the circuit in a more detailed block diagram form.



The program PLECS (Piecewise Linear Electrical Circuit Simulation) was used to confirm the functionality of the circuit. Figure 3 below is a screenshot of the current at the receiver.

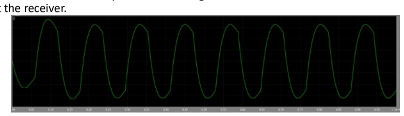
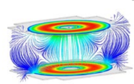


Figure 3. Screenshot of wave



The coil dimensions were initially planned to be determined and optimized by ANSYS simulation, but because of team and time constraints, they were estimated from proportion analysis in relevant research studies. Litz wire was chosen for its power capacity. For our purposes, we used AWG 38.

Circuit

There are two main circuits in this system: A transmitter and receiver circuit. The transmitter circuit is in charge of turning the DC input signal to an AC signal. The receiver circuit is used to turn the current from the receiver coil back into the DC signal suitable for charging the battery of the EV. Both started out as schematics in Autodesk Eagle. Once the design was settled upon, PCBs were printed and soldered.

The parts for the transmitter circuit are: four (4) MOSFETs, two (2) pin headers, two (2) gate drivers, three (3) terminal block five (5) capacitors, four (4) resistors, one (1) TI MSP430 microcontrollers. The microcontroller is in charge of creating an 80 kHz pulse that activates the MOSFETs. This turns the DC signal into AC signal.

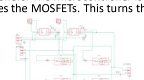


Figure 4. Transmitter Inverter Circuit. The transmitter circuit has two inputs. One is the supply for the microcontroller, and one is the DC power supply that models the electric grid.

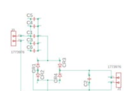


Figure 5. Receiver rectifier circuit. The receiver board is a full bridge rectifier in essence. It uses four (4) diodes, and (2) capacitors. In this circuit, a parallel capacitor configuration was used to help determine correct value.

Coils

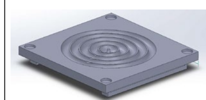


Figure 6. Solidworks 3D design of coil encasing. There are two of these in the integrated design for both Tx and Rx coils. The spacings separated by ridges are there to maintain lumps of coils.

As given by the objectives, the gap between the coils was set at 100mm. For a gap of this size, the diameter of each coil was chosen as 300mm as this is proportional to industry standard. The totals turns was set at 80 turns, grouped into 5 concentric circles of 16 turns each.

Ferrite plates shield the system on either side of the coil. Because of the air gap, stray magnetic field must be attenuated without reducing efficiency.

Integration

The circuits created in Autodesk Eagle were fabricated and the parts were soldered onto it. Casings were 3D printed to protect them. From there, the terminal jacks were used to connect the power supplies and coils.

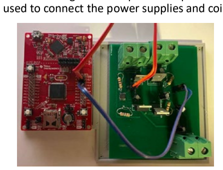


Figure 8. Physical Receiver Board

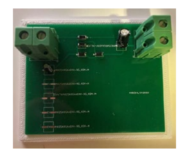


Figure 9. Physical Transmitter Board

Testing and Analysis

Testing was paramount in our design process. It was first necessary to make sure individual parts would work before testing the entirety of the system. The key tools used was a DC power supply, voltmeter, and oscilloscope. The DC power supply would model the input voltage. A load and voltmeter is used to model the battery of the EV. The oscilliscope would make sure the waves are as desired.

Transformer Optimization

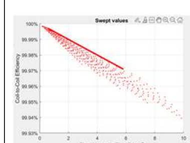


Figure 10. The Cartesian plot, each point representing a different possible design

During the simulation phase, we began a Matlab program to optimize the transformer for 100% efficiency and low values of stray magnetic field.

Stray magnetic field must abide by industry standards (ICNIRP) for radiation.

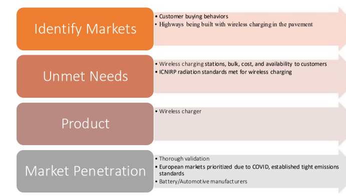
The inputs for this program are inductance and current-to-field matrices for each coil turn, swept in Ansys Maxwell.

The output is a Pareto front, along which the optimal points for coil physical parameters are found, such as Litz wire size, diameter, and coil turns.

Path to Market

Recent global events such as war, inflation, and increased gas prices are leading the way to increased EV usage. The wireless charging standard (SAE J2954), continues to develop through research and implementation. Battery mile ranges have grown drastically, and infrastructure funds have been allotted to increase the availability for charging stations. Electric vehicles are here to stay, forecasted to make up half of car sales by 2030.

Our wireless charger was designed to maintain the current wireless charging standards but must undergo much more testing and validation before heading to the market.



"Overall, as of March 2022, driving an EV is dramatically cheaper per mile than driving a gas-powered vehicle. Nationally, EVs are 3-5 times cheaper to drive per mile than gas-powered vehicles."

- Zero Emission Transportation Association (ZETA)

Challenges and Conclusions

Our team faced challenges and roadblocks throughout the year. Because of a loss of a team member, we lacked sufficient simulation results for the coils of equal size. As a result, we were under time constraints, and could not provide the customer with designs for the desired version, a system in which the transmitter is larger than the receiver. Delays from parts distributers also had a significant negative impact on the project.

As two computer engineers, we learned the importance of risk assessment, especially running into printing and testing delays so close to Expo. We learned simulation techniques required in hardware design planning.

Acknowledgements

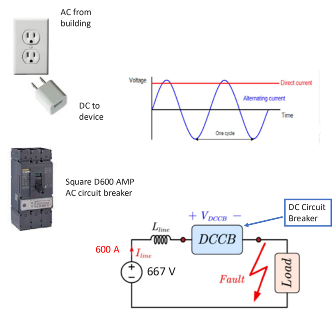
Our team is very grateful to the Major Design Experience (MDE) staff, especially Kenneth Schulz who guided us through the course. Additionally, we are highly appreciative of our Subject Matter Experts. Minh Ngo was highly knowledgeable in the field of power electronics and was able to assist us with any technical problems. Our customer, Dr. Khai Ngo also helped guide us through the project. We would like to thank Lockheed Martin and CPES for financially sponsoring this project.

Medium Voltage Power Electronic Interrupter System

Customer: Dr. Dong Dong SME: Jian Liu Mentor: Kenneth Schulz
Garrett Mass, Tyler Robbins, Gabe Scott

Background/Motivation

- The current standard for power transmission is alternating current (AC)
- There is a growing need for it to be supplemented with direct current (DC)
- The existing AC protection technology is not suitable for DC transmission
- Therefore, this project addresses the need for DC protection technology

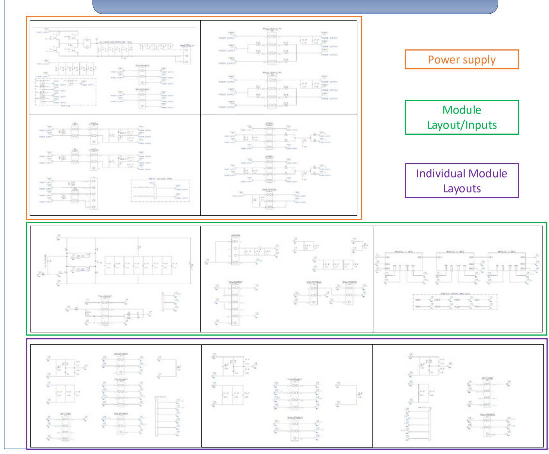


Requirements

Power Supply
- High frequency current loop power supply
- Plotting for insulation
- 48V input
- 24V output

Voltage Clamping Module
- DC voltage 667V
- 1 kA pulse current (less than 500us)
- Clamping voltage 1.3kV
- IGBT requirements in voltage clamping module

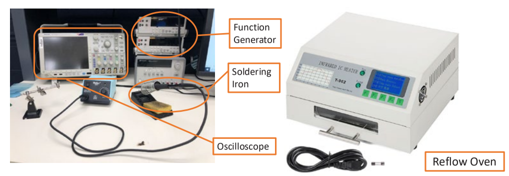
Approach



Fabrication Process

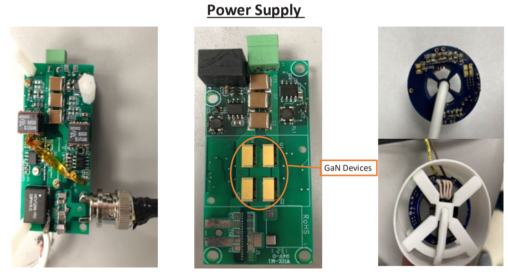
- Used reflow oven for GaN devices on power supply and 48V to 5V buck converter on voltage clamping module in Packaging Lab
- Soldered on all passive components, ICs, IGBTs, and MOVs in CPES Lab

Fabrication Struggles that we overcame
- Soldering surface mounted ICs
- Confirming correct directions of components
- Overheated solder pad of capacitor causing it to become removed



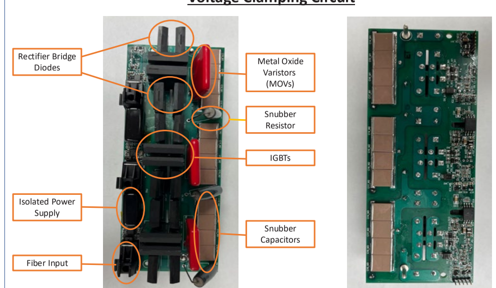
PCBs

Power Supply



Primary Top View | Primary Bottom view | Secondary PCB

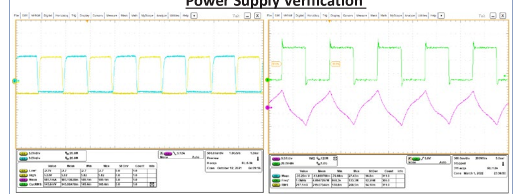
Voltage Clamping Circuit



Top View | Bottom view

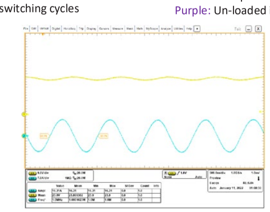
Results

Power Supply Verification



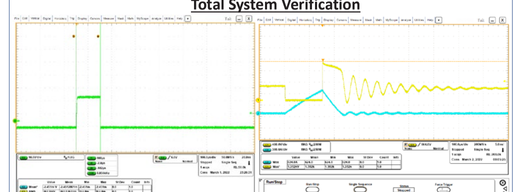
MOSFET gate driver signals for half bridge inverter showing adequate delay between switching cycles

Green: 0 to +48V 1MHz square wave output of primary side
Purple: Un-loaded inductor current



Yellow: 24V voltage of secondary
Blue: 1Mhz current of secondary

Total System Verification



Gate driver 100ms signal pulse used to test modules 1-3 of voltage clamping circuit

Yellow: IGBT voltage
Blue: IGBT current

Summary

- The power supply had an input of 48V, an output of 24V, and operated at high frequency
- The DC bus voltage was around 600V and the IGBTs behaved correctly
- The assembled circuit clamped the voltage at 1.3 kV and was able to withstand 1kA of current
- After the clamping of the voltage, the voltage returned to the bus voltage value and the current returned to zero

Acknowledgements

We want to express our deep gratitude to the following people for their guidance and support throughout the project:
- Dr. Dong – Customer
- Jian Lu – Subject Matter Expert
- Kenneth Schulz - Mentor

Next-Generation Distributed Communication and Control Network for High-Speed Multi-Phase Drive Systems

Sponsor: Dr. Boran Fan, Center for Power Electronic Systems
Subject Matter Experts: Vladimir Mitrovic, Yu Rong
Fairuz Ahmed, Sabrina Lesser, Evan Miller

Background

Virginia Tech's Center for Power Electronic Systems (CPES) is working on a distributed communication and control network for high-speed multi-phase drive systems to drive electric aircraft propellers.

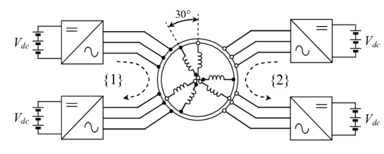
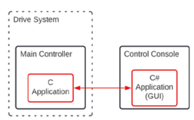


Image of multi-phase drive system courtesy of CPES

Objectives

Create a Human-Machine Interface (HMI) that establishes bi-directional communication between the main controller of the drive system and a control console. The HMI must be compatible with the new high control frequency and should be versatile with a configurable Graphical User Interface (GUI) on the control console.



Deliverables in Red

Requirements

Human Machine Interface Development:
- Develop two software applications that bridge the main controller of a drive system with a control console
- Communication speeds must be at least 100 Mbps
- The control console application is a Windows Forms GUI written in C#
- The main controller application is written in C for a Zynq® 7000 SoC

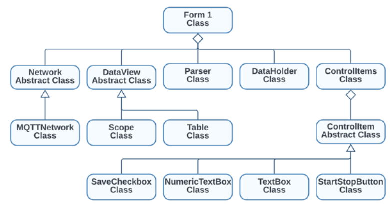
Communication Network Establishment and Verification:
- Testing and verification of the HMI software on a PC control console and a Zynq® 7000 SoC controller

Phase Current Reconstruction (Addon):
- Phase current measurements are necessary for high performance motor control.
- Reconstruct the phase current based on the measured device current.

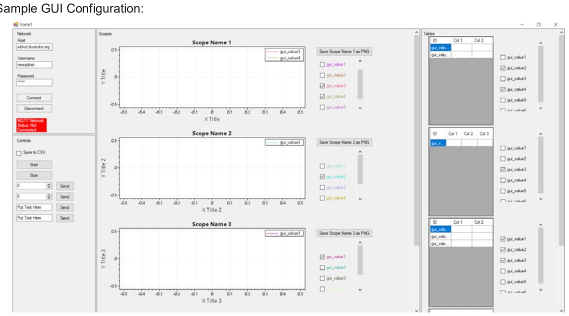
Requirements	Delivered
Human Machine Interface Development	Yes
Communication Network Establishment and Verification	Yes
Phase Current Reconstruction (Optional)	No

Software

- Control Console GUI
  - Windows Forms Application written in C#
  - UML Diagram:



  - The network, controls, scopes, and tables are configurable with a JavaScript Object Notation (JSON) formatted input file
    - Sample GUI Configuration:



- Controller
  - Application written in C
    - freeRTOS (real time operating system)
    - lwIP (lightweight TCP/IP protocol library)
- TCP/IP Communication protocol with MQTT broker used to send messages between the controller and GUI
  - Publisher-subscriber model

Hardware

- The controller and control console were directly connected using an ethernet cable
- For prototyping, a Raspberry Pi with simulated data was used to act as the controller
- The final controller application was implemented on a MYC-C7Z010 Zynq® 7000 board

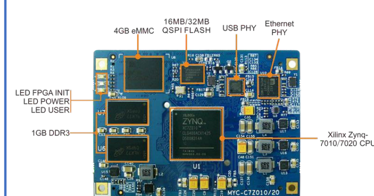


Image of MYC-C7Z010 from MYIR Tech Limited

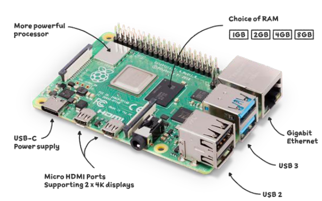
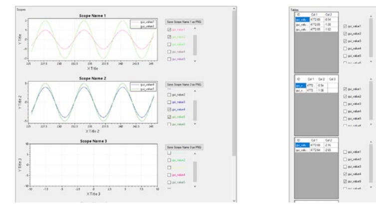


Image of Raspberry Pi from raspberrypi.com

Results & Conclusion

- Bi-directional communication between a controller and control console was established using an MQTT broker
  - Communication speeds over 100 Mbps
  - The application accepts a JSON configuration file to customize the GUI layout
  - User input to the GUI on the console was sent to controller
  - Real-time data visualization of controller variable values shown below



Future

The configurable nature of the HMI makes it easy for CPES to use it for additional applications beyond the original intent to visualize data coming from a controller.

Furthermore, the source code is organized in such a way that facilitates the addition or removal of features without compromising the functionality of the system.

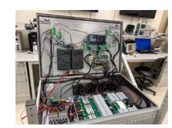


Image of digital controller with gate driver courtesy of CPES

Video

Video Demonstration

Acknowledgements

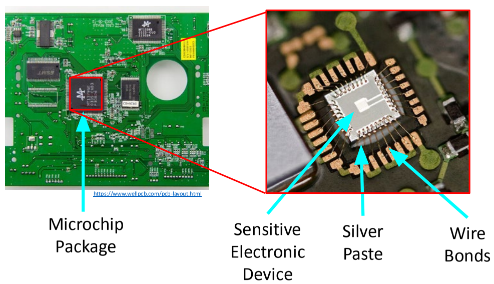
The Power Electronics Systems Team (P.E.S.T.) would like to give a special thanks to Dr. Boran Fan, our customer and advisor throughout the development of this product. Furthermore, P.E.S.T. would like to give many thanks to Vladimir Mitrovic and Yu Rong. These two were our subject matter experts and helped tremendously throughout the testing and development phase of the project. These three individuals gave us their valuable time, insight, and expertise that facilitated the making of this project.

Silver Sintering Fixture and Control System for Fabricating High Voltage Electronics Modules

Sponsor: Christina DiMarino, Virginia Tech CPES—Subject Matter Expert: Mark Cairnie, Virginia Tech CPES
Team Members: Aaron Sprung, Jason Kendrick, & Jonathan Ciesla

Introduction

- Microchip packages protect sensitive electronic devices.
- Silver sintering improves package durability and reliability.
- Manufacturing and processing complexity impedes widespread industry adoption of silver sintering.



Silver Sintering Process

- Demands specific pressure and heat applied at the microchip.
- Drying Stage: Firms silver paste to reduce oozing when pressurized.
- Sintering Stage: Pressure and additional heat applied to create a dense silver bond.

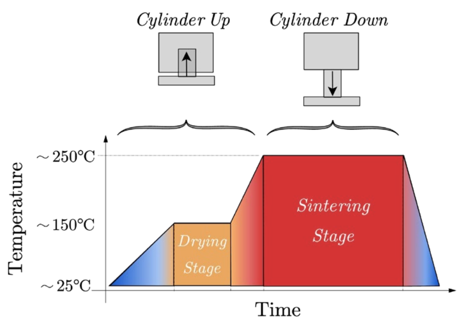
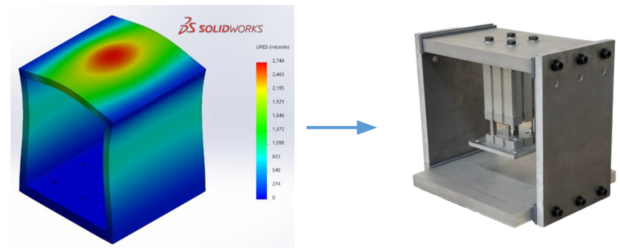


Fig. 1 Optimal Silver Sintering Pressure and Heat Profile

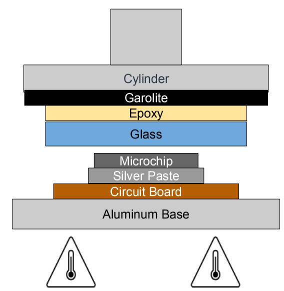
- Pressure must be applied evenly onto microchip to ensure less than 90 microinches of error.
- Our system regulates applied pressure and heat output to deliver an automated, consistent, and repeatable process.

Hardware

- 3D analysis prevented structural failures at maximum stress conditions.
- Displacement studies indicated device's ability to uniformly apply pressure.
- Factor of safety of 4.1 ensures operator safety.



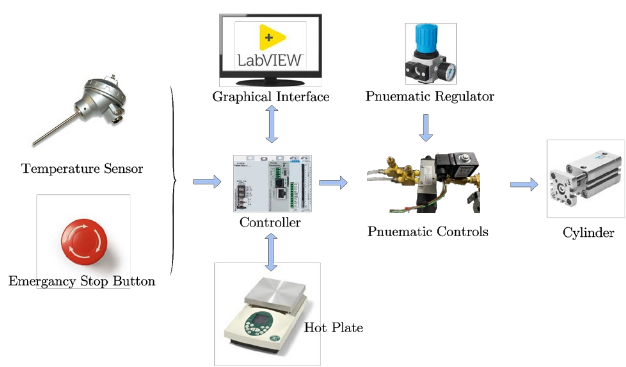
- Glass and epoxy improves uniform pressure by removing deviations from cylinder's vertical axis.
- Cylinder overheating is inhibited by glass and garolite material.
- Hot plate heats silver paste



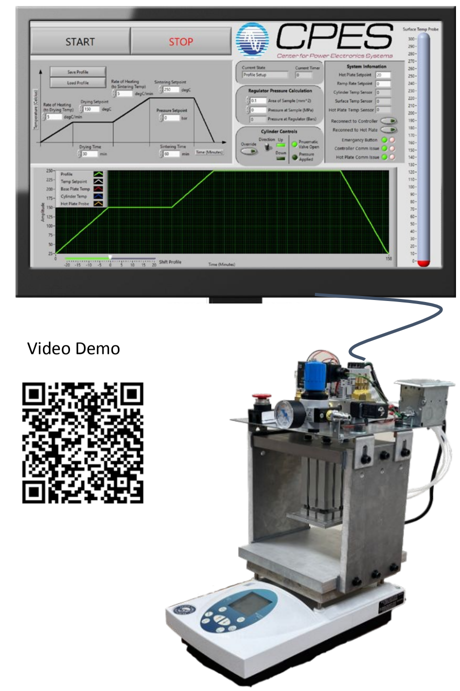
Regulator Pressure Calculated in LabView and Given to User for Adjustment:

$$\text{Pressure}_{\text{cylinder}} = \frac{\text{Pressure}_{\text{microchip}} \times \text{Area}_{\text{microchip}}}{\text{Area}_{\text{cylinder}}}$$

System Overview



Final Product



Project Requirements

CPES Requirements	Our Progress
Budget: $2500	Spent: $2,414
Min. Pressure: 600 lb.	Min. Pressure: 600 lb.
System Pressure: 1-10 bar	System Pressure: 2-10 bar
Temperature Regulation ±5°C	Testing–In Progress

Acknowledgments

The team would like to thank Christina DiMarino of the Virginia Tech CPES, Mark Cairnie of Virginia Tech CPES, and Professor Kenneth Schulz of the Virginia Tech ECE department for their guidance, mentorship, and contribution to the success of this project.

A Unified Design Tool for High Performance LLC Resonant Converter

Sponsor: Eric Hsieh, CPES Lab
Subject Matter Expert: Chunyang Zhao, CPES Lab
Pablo Estrada, Matt Gray, Nick Ritz

Background

LLC resonant converters are a commonly used DC-DC converter in a wide variety of applications. They can be adjusted to fit different specifications as needed, so they are a very versatile converter technology. LLC resonant converters have a complex and time consuming design process due to the many engineering tradeoff decisions that must be made when designing them. The purpose of this project is develop an app that aids the user in making these design decisions by providing necessary plots and calculations, speeding up the design process.

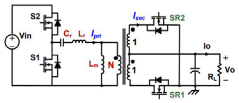


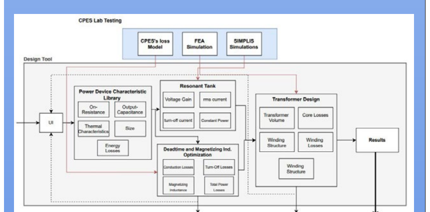
Diagram of LLC Resonant Converter

Objectives

The primary objective of our project was to create a Matlab application that enables the user to easily design an LLC resonant converter. This app speeds up the design process by automatically recalculating component and performance values as well as plotting loss curves.

Some key objectives we started the year with included:

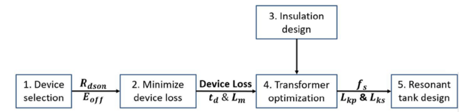
• Versatility	Completed
• User-friendliness	Completed
• Design Tradeoffs	Completed
• Expandable Power Device Library	Completed
• Expandable Magnetic Component Library	Not Completed
• Hardware Design (if time allowed)	Not Completed



Design Process

Before we could begin the implementation of the tool, we first had to understand how these high-performance LLC resonant converters are designed and function. Understanding fundamentally how these converters perform would aid in the later stages of the implementation. Laying out the standardized procedure provided by our sponsors, we were then able to break down each individual process addressing each characteristics that will be a key component in the final tool.

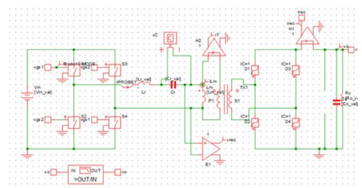
Using this standard design procedure, we can identify the key components needed to design the converter and their characteristics. This is important because this will allow to set input and output parameters in the design tool that will affect only certain steps as well as show the overall effect of the decisions.



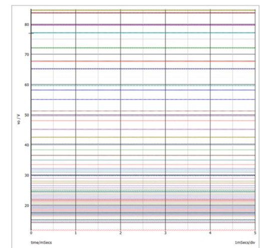
Simulation:

In order for the app to calculate component and performance values, we needed a collection of known data points. This was accomplished in Simplis through simulating a schematic of the LLC resonant converter that used normalized component values. The goal was to obtain voltage gain, primary RMS current, and turn-off current for different ratios of the component values.

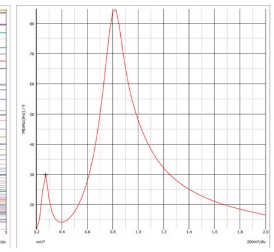
The result was 456 text files containing data points for all 73 frequencies. Over 33,000 data points that the app can use to calculate component and performance values.



Schematic of LLC Resonant Converter in Simplis

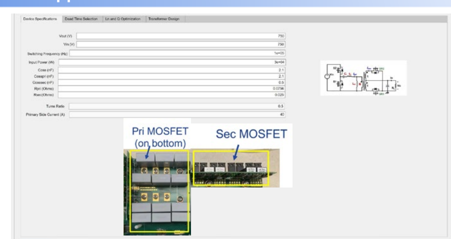


Plot of Vout for all frequencies with Ln=1 and Q=1

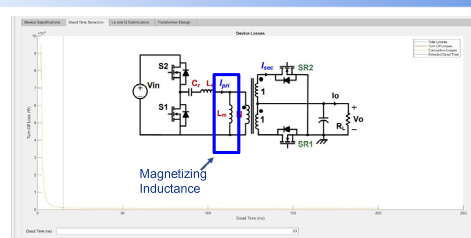


Plot of Vout against frequency with a line of best fit (Ln=1, Q=1)

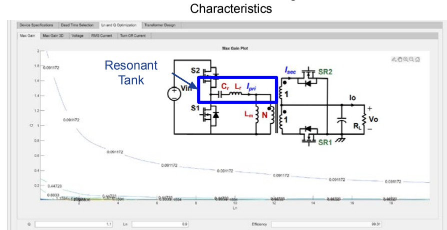
MATLAB Application



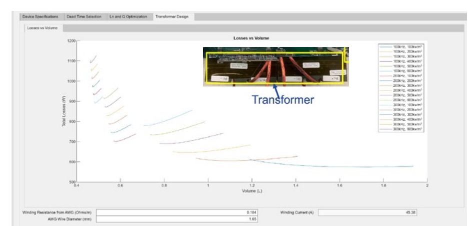
Tab 1: Converter and Switching Device Characteristics



Tab 2: Device Losses vs Dead Time



Tab 3: Ln and Q Selection

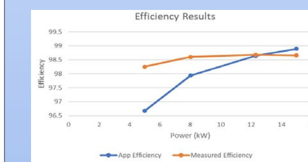


Tab 4: Transformer Optimization

Conclusions

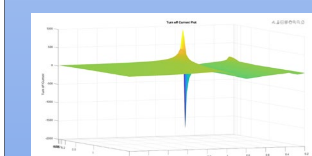
Our final app design incorporates all the necessary design procedures for a user to create an LLC resonant converter to their specifications. While there is never a "perfect" design, the plots and numerical outputs allow the user to see how their design choices affect converter performance so they can optimize it to fit their specific needs.

There were some discussed features that were not implemented due to time constraints, such as comparing multiple devices at once, or having other transformer topologies. We were also unable to verify the app's accuracy by designing and building a converter to the app's specifications, then testing the converter to see if it worked as expected.



Challenges

- Lack of knowledge of LLC resonant converters and their design process
- Lack of experience in developing apps using MATLAB Apps
- Complex design process that requires balancing multiple design parameters:
  - Voltage Gain
  - Conduction Loss
  - Device Loss
  - Frequency/Size



Lessons Learned

- Work items nearly always take longer than initially expected
- Setting clear expectations and project requirements from the start helps a lot in keeping the project on track
- Setting deadlines for smaller goals is much more effective than just having one final deadline

Acknowledgements

- We would like to thank Eric Hsieh and Chunyang Zhao for their continued support and feedback on this project. Without them, this would not have been possible.
- We would also like to thank Kenneth Schultz for his support as a mentor throughout the year.

Interactive Power System Protection Concepts Demonstration Tool

Dominion Energy — Actions Speak Louder

VIRGINIA TECH

Bernard Cieplak, Joseph DiNiso, Tanner Joyce, Dillan Murphy, Nashin Rodriguez
Sponsor: Matthew Gardner, Dominion Energy, **Subject Matter Expert:** Dr. Virgilio Centeno
Mentor: Prof. Shelley Stover

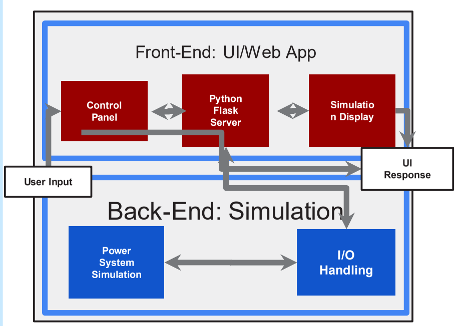
Background

Dominion Energy desires an educational tool in the field of power systems to demonstrate power protection concepts to high school and early college students.

Objective

Create a web application that can properly simulate complex power systems and teach new concepts to high school and college students.

This required the following:
- Design of an educational curriculum for students with different scenarios
- Web application to display the scenarios to the user
- Power system simulation software to calculate updated power system parameters after an event such as a fault has occurred.
- API between the web application and the power simulation software

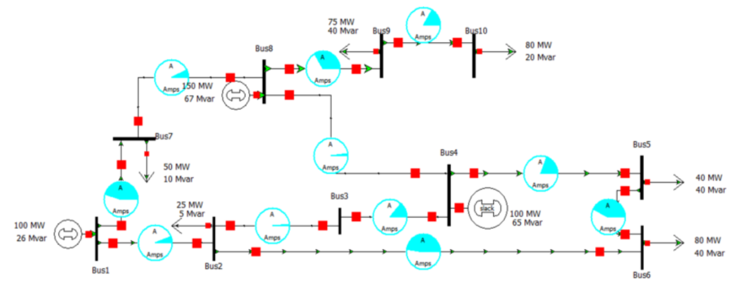


Design Process

We wrote a curriculum that provided information to the user, presented a power system (with clickable components to display system parameters), asked questions related to the system, and provided feedback based on the answers given by the user.

Back-end:
- Calculates bus parameters (i.e. voltage, current, power) from **load-flow analysis** using an algorithm called **Gauss-Seidel**.
- After implementing load-flow analysis we began to add features such as faults.

Front-end:
- Full web application to teach users about power protection concepts.



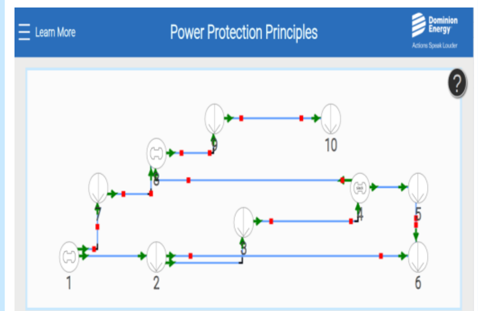
Our goal was to teach systems such as these

-For the web application we used **ReactJS** paired with standard web development tools.
- For the back-end we made a **Python API** to calculate system parameters and return them to the web application.
- To connect the two components we built a **Flask** server for the front-end to query the API.

One of our earliest prototypes. Using an agile approach we built off of this by adding new features as we progressed.

Finished Product

- Standalone web application used to teach system terminology, faults, and power protection schemes to users.
- By having students apply concepts they've learned to real scenarios, they can get a hands-on approach to learning.



The complex system from before, implemented in our program.

Final Remarks

This project was developed with the goal of making the code easy to understand and extend. If we had more time to work on it, we would likely add custom systems designed by the user and more scenarios.

Throughout this project we learned many valuable lessons, some of the most important were:
- Create and stick to a thorough schedule
- Write code to be understood months from now
- Ensure you have a plan before you develop

Power Adaptive Dynamic Compute Nodes

Dave Anderson, Andrew Beauchemin, Boyan Pan, Ken Torres, Shannon Woolfolk
Customer: Matt Gardner and Dr. Jaime De La Ree Lopez, Dominion Energy
SME: Dr. Jaime De La Ree Lopez, Dominion Energy
Mentor: Dr. Scot Ransbottom

Dominion Energy
Actions Speak Louder

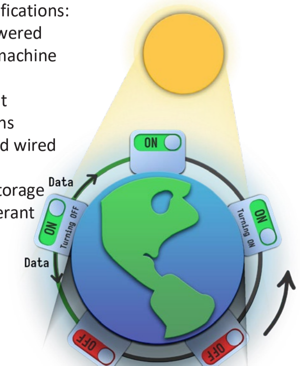
VIRGINIA TECH

Problem

In the last 20 years, large data centers have sprouted across Northern Virginia, and globally, requiring significantly more power than what was intended for the region and drawing a constant load from the grid. Utilities, such as Dominion Energy, must build high voltage power lines, requiring large amounts of copper, which are expensive to construct and maintain, in order to provide sufficient power to these centers.

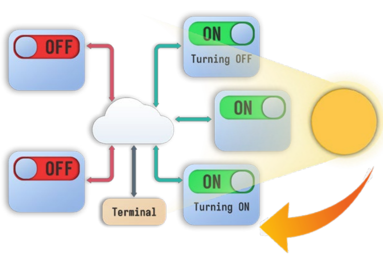
Objective

Target Specifications:
- Solar powered
- Human machine interface
- Persistent operations
- Dedicated wired network
- Energy storage
- Fault tolerant



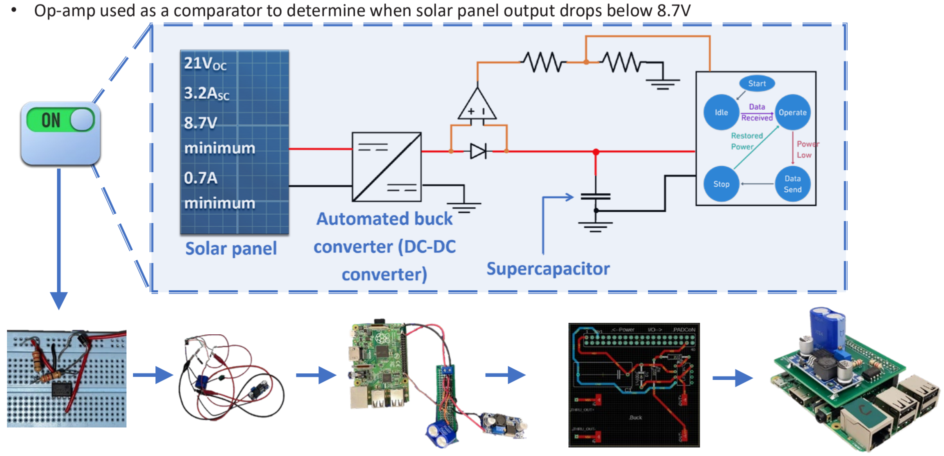
Model Approach

Limiting to 5 nodes simulated by:
- Data center = Raspberry Pi
- Solar farm = power supply circuit
- Fiber optics = ethernet connection
- Energy storage = supercapacitor
- HMI = terminal



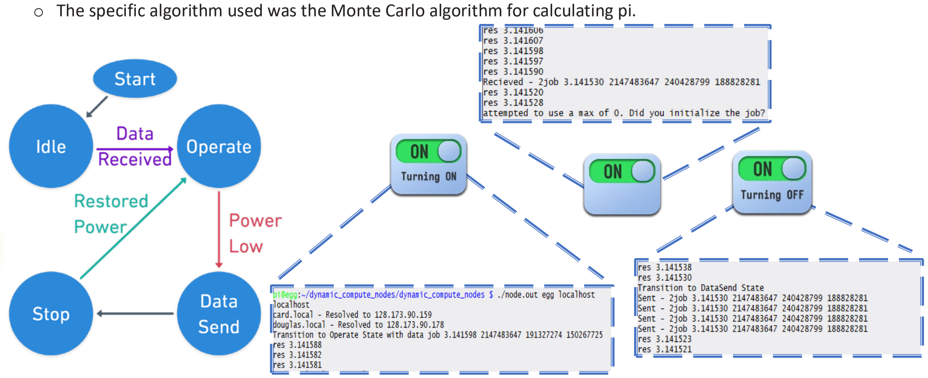
Implementation - Hardware

- Buck converter needed to step down solar panel voltage
- Supercapacitor supplies power to Raspberry Pi during shutdown to mitigate packet loss
- Op-amp used as a comparator to determine when solar panel output drops below 8.7V



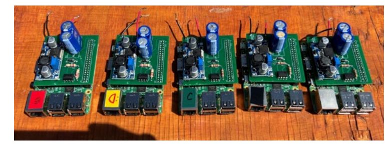
Implementation - Software

- Overarching node software is controlled by a state machine that changes state based on status of surrounding nodes or available power.
- Each node connects to directly connects to adjacent nodes via TCP
- The job class defines an interface that can be used to instance other job types. This interface allows the state machine to easily collect, transmit, receive, and update a running predefined job.
  - The initial job was designed to run algorithms that had many repeated tasks accumulated at the end.
  - The specific algorithm used was the Monte Carlo algorithm for calculating pi.



Results & Conclusion

- Nodes successfully operate on solar power
- Node can transmit relevant job data to adjacent nodes
  - ~30 seconds of shutdown time
- Nodes can accumulate work done on a job and fold that into their own work
- Program can successfully operate on one node, and up to 5 nodes, at any given time



Demo Videos

Future Work

- Handle creation and transmission of generic process state.
- Incorporate higher capacity energy storage
- Scale model to utilize a standard server computer

Acknowledgements

Thank you to:
- Dr. Jaime De La Ree Lopez for his guidance
- Dr. Virgilio Centeno his assistance
- Dr. Matt Gardner for his financial support
- Dr. Scot Ransbottom

Open Source Power System Planning and Operations Game

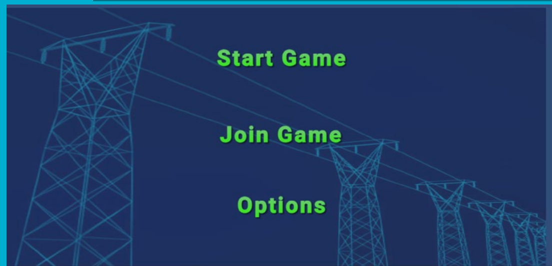
Dominion Energy — Actions Speak Louder

VIRGINIA TECH.

Power Planners

SME: Dr. Walid Saad   Project Mentor: Shelley Stover   Sponsor: Dominion Energy, Richmond, VA

Team Members: Tyler Milot, Jeremy Naka, Aman Mathur, Steven Shumadine, Karthik Kashyap



Start Screen

Game Screen

Upgrade/Build Menu

Town Hover Menu

Power Plant Hover Menu

Game Rules

Game Objective:

- Four players start out with a single coal power plant and two transmission lines going in any direction.
- There are 6 towns randomly generated and the player must supply power to these places via the power sources and transmission lines.
- The player wants to supply power to cities and towns to generate currency.
- On each turn, weather events randomly occur that may damage transmission lines on the corresponding tiles.
- The currency can be used to buy more transmission lines and power sources to build out the grid.
- Each city supplied with power equals 2 victory points and each town is 1.
- The first player to reach 8 victory points wins.

Power Sources:

Power Plant	Cost	Non-Attached Cost	Production	Renewable?
Coal Plant	$50	$100	100MW	non-renewable
Solar	$100	$200	200MW	renewable
Natural Gas	$150	$300	150MW	non-renewable
Nuclear	$200	$400	300MW	non-renewable

Weather Events:

- Three six-sided die are rolled by each player at the beginning of every turn.
- The two numbered die are summed and all tiles with numbers matching the sum are exposed to a weather event designated by the weather dice.
- Moderate weather events have a 25% chance of destroying surrounding power lines.
- Severe weather events have a 75% chance of destroying the surrounding power lines.
- Any weather event besides sunny, prevents solar power plants from producing electricity if touching the affected tile.

Building/Upgrading:

- Power plants can be built using the Build Menu, either attached to an existing network at a reduced cost, or built by themselves at full cost.
- Power plants can be upgraded or downgraded using the Upgrade Menu.
- Transmission lines can be built appended to existing power plants using the build button.
- Transmission lines can be upgraded using the transmission hover menu.

Objective:
Local customers use power on a daily basis that is supplied by Dominion Energy, but most are unaware of the challenges Dominion Energy faces daily to maintain the power grid. During both normal operation and crisis events, customers expect the grid to be 100% reliable. Very few customers understand the work that Dominion Energy does behind the scenes in planning and maintaining a fully operational power grid.

Game Rules

Land Tiles:

- There are four different hexagonal land tiles each representing the different terrains where a power grid could be built.
- The increased difficulty to build in different terrains results in more costly power grids over certain regions of land.
- The four different types are:

Flatlands   Hills   Lakes   Mountains

- The flatlands require 1 power line to supply power, the hills 2, water 3, and the mountains require 4.

Hover Boxes:

- Depicted to the left of this bullet, these hover boxes show up when the user hovers their mouse over a game object.
- The hover boxes provide information about the game objects.
- For a town/city:
  - the power demand in MW
  - the power delivered in MW
  - the happiness level represents the satisfaction of the citizens in a town/city
- For a power plant:
  - the type of power plant
  - the amount of power it produces in MW
  - the amount of power it delivers in MW
- For a transmission line:
  - the ownership of the transmission line
  - the upgrade tier of the transmission line
  - the amount of power that can transfer through the line
  - up to eight slots for transmission lines per hexagon edge

Transmission Line Hover Menu

Tile Number Distribution:

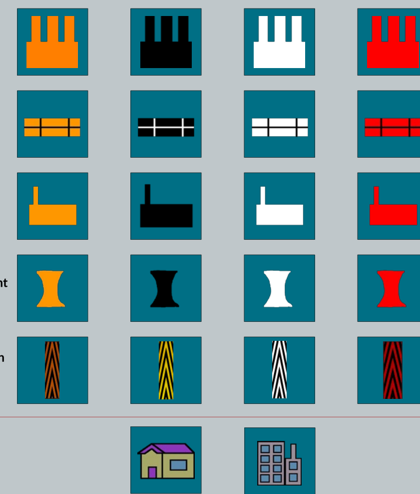
- To promote strategic transmission line placement, the number distribution for tile numbers is predetermined favoring a large quantity of numbers with a higher probability of weather events.
- The following is the distribution of number tiles:

2 and 12 tiles: 4 appearances   4 and 10 tiles: 6 appearances   6 and 8 tiles: 8 appearances
3 and 11 tiles: 5 appearances   5 and 9 tiles: 7 appearances   7 tiles: 10 appearances

Dice Sides

	Side 1	Side 2	Side 3	Side 4	Side 5	Side 6
Dice 1 and Dice 2						
Event Dice						
Weather	Sunny	Sunny	Cloudy	Cloudy	Moderate	Severe

Buildable Game Objects



Programming Software

Game Engine:

- The game is programmed using C#.
- The game engine is Unity WebGL, which is lightweight and perfect for the application of the game.
- Unity is open source.
- Building the game with Unity allows the game to be exported as an executable that can be launched on any PC.
- Using a game engine allowed for easier debugging.
- Because Unity is a popular game engine, there is a lot of available documentation online.
- Unity is a user-friendly video game editor.

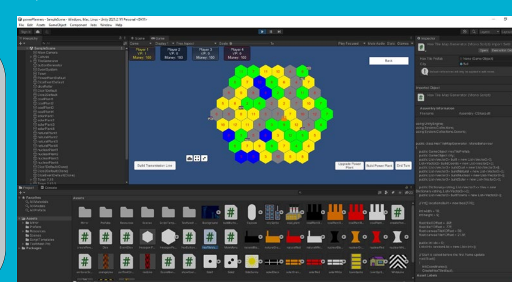
Version Control:

- GitHub was used to combine every group member's code efficiently and reliably.
- GitHub provided an easy way to observe the progress of each group member.
- Github also provided a mechanism to merge different branches of code.
- Each group member had their own individual code branch.

unity

GitHub

Unity Editor Window:



Aircraft Wiring Characterization

Virginia Polytechnic Institute and State University

Tilden Fernandez, Alicia Harman, Zhiyuan Zhang, and Sahil Pai

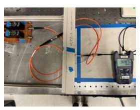
Mr. Tony Keith, Professor Toby Meadows, and Dr. Yizheng Zhu

Problem Statement

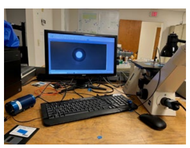
To characterize copper wire and fiber optic cable in terms of flexibility, error rate, weight, power requirements, and reliability, then analyze the viability of replacing copper aircraft wiring harnesses with fiber optics.

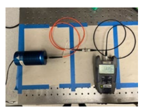
Power Requirements

- Optical power output of a 1m military-grade multimode fiber cable was measured using an LED light source at 850nm wavelength and a hydrogen lamp light source at 1300nm
- Power loss due to coupling was 25% at 850nm and 53% at 1300nm
- Power loss in fiber cable typically measured in dB/km



LED





Hydrogen Lamp

Applying Machine Learning

- The Cold Bend Test was identified as an area where ML could improve efficiency, as the current standard is a simple visual inspect
- Canny Edge detection was used on subsampled images for preprocessing

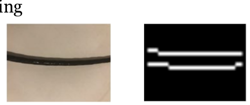


Image data from the cold bend test before and after processing

- The results were limited due to the amount of data we were able to collect, especially for data showing damaged cables

Flexibility Testing

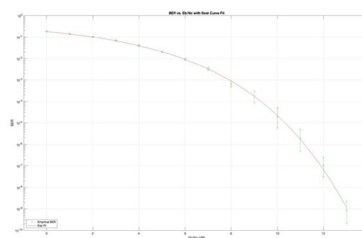
- Standard industry practice is a Cold Bend Test followed by at visual inspection, guided by SAE AS50881b
- A chassis was constructed using readily available products, with a changeable mandrel. A commercial freezers and dry ice were used for temperatures

Left: Cables secured around a ¼ inch mandrel. Right: cabless after 24 hours exposed to dry ice

- Aircraft wiring is manufactured to withstand high tension around minute diameters in extreme cold; conditions which require professional equipment to obtain in an experiment

Bit Error Rate

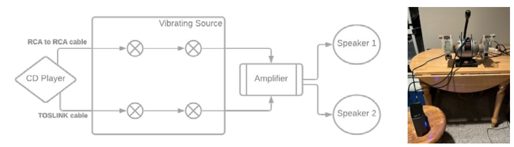
- Error Rate is extremely important due to wiring harnesses controlling flight critical infrastructure



- Both copper wire and fiber optic cable have extremely low error rates, in the order of 10^{-9}
- Kilometers of cable is required for an efficient test

Vibration Testing

- Standard cabling installation is to have cables mounted to aircraft at 6-8in intervals
- The effect of vibrations from a metal grinder were measured by a variation in noise quality from the speakers connected to a DAC with either a TOSLINK fiber cable or RCA to RCA copper cable. No degradation in sound quality was detected.
- Shaker table was inaccessible to perform proper test



A diagram of the vibration testing and the testing implementation

Acknowledgements

Dr. Yizheng Zhu was a significant help advising on fiber optic cables and as a guide for the project as a whole.

Conclusion

Through all the testing, all the wiring and cables met or exceeded the industrial standards we tested against.

Based on the standards for aircraft wiring, no evidence was found to indicate that fiber optics would not be a good alternative to copper, although more testing is necessary.

During this project, limited resources had a significant impact on the quality of tests performed. This was exacerbated by the highly technical nature of many tests, as well as the technical requirements of fiber optic cable in general.

MMC Diabetic Monitoring App

Trevor McNeil, Rui Wang, Meghana Mudunuri, Muhannad Al-Aufi, Olivia Foster
Customer: Zachary Kornblum
SME/Mentor: Dr. Sook Shin Ha

Background

Problem:

The difficulty of managing the everyday upkeep of living with diabetes such as

- routine blood medication
- refilling medication
- tracking past test results

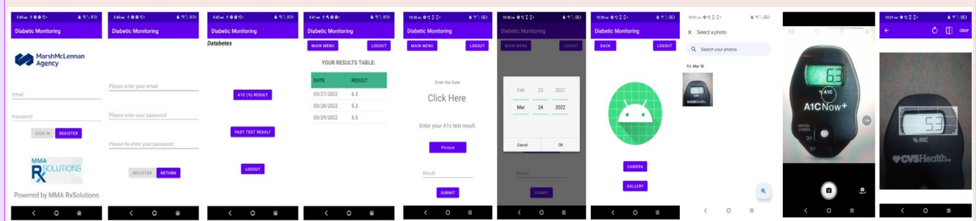
Objective:

To develop a mobile application that provides easier and more accessible care to people with diabetes.

Design Components:

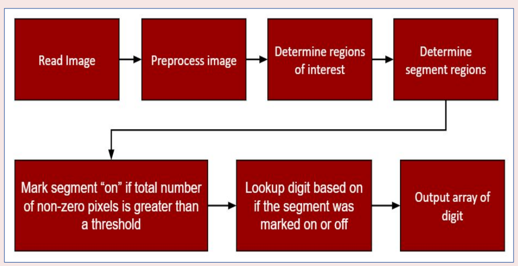
- **Server and SQL Database**:
  - Stores the medication history, user information, the image processing script, and past test results
  - Flagging diaebetic/possible diabetic clients
- **Android Application:**
  - Register new user
  - Display past test results
  - Capture & record A1C test results
- **Image processing:**
  - Seven Segment Optical Character Recognition (SSOCR)
  - Produce an accurate number from an image

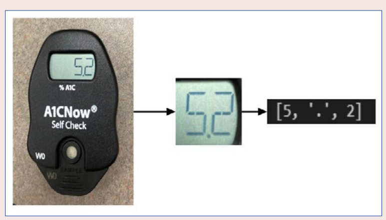
Android Application



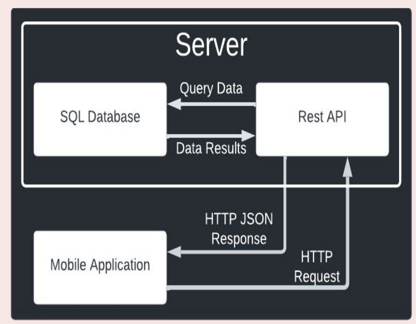
This is the login screen of the android application. From here a user can either register or sign in.	The registration screen asks for name, an email and password.	The main menu screen which appears after a successful login, will have the username displayed along with buttons to different activities.	The past test result screen displays a table with each test result having a correspondin g date to it.	User enters date information and then chooses to manually input A1C result or use a picture.	The date picker uses a scrolling mechanis m.	The input picture screen which gives the option of taking an image or retrieving one from the gallery.	The photo gallery of the user's phone.	Camera access of the user's phone.	Cropping mechanism used after photo is chosen.

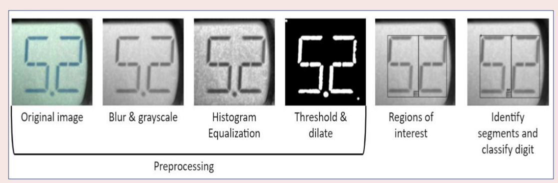
Image Processing





Server and SQL Database





Conclusions

Final Thoughts/Results:

Overall, we have successfully achieved our objective. However, there are many ways to improve our project further, such as creating an IOS version of the mobile application and/or adding other features to the current android application.

Challenges:

- The complexity of each of the individual components.
- Integrating three different components into one system.
- Creating an image detection program with a dynamic input.
- Accounting for different screen sizes when designing the layout of the android application.

Lessons Learned:

- Each part individually needed thorough testing prior to integration in order to efficiently debug.
- SSOCR involves taking time to research and test different methods to find the most optimal solution.
- Teamwork, communication and taking responsibility are the keys to success.

Dynamics of Electron Tunneling Between Vibrating Atoms in a Cu Nanofilament

Team Members: Jim Furches, Nick King, Mihir Savadi
Customer, Sponsor: Zuzana Steen (Micron)
SME: Dr. Marius Orlowski, Amrita Chakraborty
Mentor: Kenneth Schultz

Motivation

Contributing to the research of ReRAM (Resistive Random Access Memory) and its commercial benefits over contemporary mass-market memory technologies such as flash memory, specifically by exploring the thermal, quantum, and electron-tunneling effects that arise between memory cells as they are manipulated.

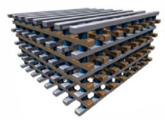


Fig. 1 A typical stacked ReRAM crossbar array. Each crossbar level alternates between copper and platinum, and the space in between each of the intersections (tantalum oxide dielectric not viewable in the figure) is where a filament is formed.

Objectives

- Measure the random cell-state changes that occur in a cell when it is subjected to thermal energy produced from the manipulation of a neighboring cell.

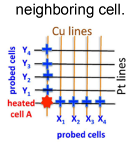


Fig. 2 Diagram of a heated ReRAM cell and the potentially affected cells on shared lines in a crossbar architecture [1]

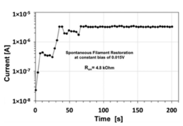


Fig. 3 Graph of a cell's filament restoration after destruction due to heating of a neighboring cell [1]

[1] M. Al-Mamun and M. Orlowski, J. Appl. Phys. 129, 055107 (2021).

- Build the experimental infrastructure needed to collect enough data and allow for scalable data analysis to enable core researchers to effectively study the aforementioned thermo-quantum phenomena.

ReRAM Wafer

- ReRAM devices fabricated by SME for use in this project **(Fig. 4)**.
- Device consists of an assembly of arrays, each array consisting of 5 copper lines and 5 platinum lines in a crossbar pattern separated by a TaOx layer **(Fig. 5)**.
- The intersection of copper and platinum lines forms a cell **(Fig. 6)**.

Fig. 4 Fabricated ReRAM device

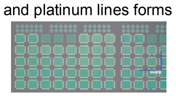


Fig. 5 Microscope image of array assembly

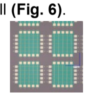


Fig. 6 Image of array cells

Set/Reset in ReRAM

ReRAM stores binary information through 2 operations:

- **Set:** A positive voltage bias between copper and platinum causes the formation of a copper nanofilament through the TaOx, allowing current to flow. This is a low resistance state (LRS)
- **Reset:** Changing the bias polarity and allowing a large current to flow through the filament generates heat, resulting in the rupturing of the filament and halting the flow of electrons. This is a high resistance state (HRS)

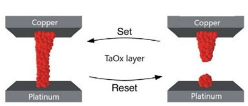


Fig. 7 Visualization of the set/reset operations in ReRAM

Experiment Setup

A Keithley 4200A-SCS Parameter Analyzer was used to stimulate ReRAM cells and measure their response. The Clarius software was used to interface with Keithley.

Experimenting with various Voltage and Current inputs gave us an intuition in the behavior of our ReRAM device, guiding us towards replicating the quantum phenomenon.

Fig. 8 Keithley 4200a-SCS Parameter Analyzer with Clarius software package.

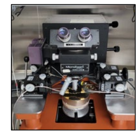


Fig. 9 Microscope setup used to facilitate contact between Keithley inputs and desired ReRAM cell.

Measurement Process

2-Probe measurements to characterize ReRAM cells.

Set operation to form a microfilament in cell. Increasing compliance current (Icc) generates thicker and more resilient filaments.

Reset operation to rupture nanofilament. Resulting data used to determine R_{on} (ON state resistance) value of filament at a given compliance current.

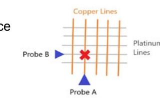


Fig. 10 Diagram of a 2-probe measurement setup on target cell (X)

3-Probe measurement introduces a ground probe to allow simultaneous heating of a target cell and the measuring of a neighboring cell:

- Application of a voltage bias to 2 cells for 30-60s
- 1 V bias to target cell at **~5 mA Icc**
- 0.1 V bias to neighboring cell at **1 mA Icc**

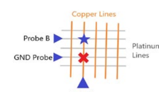


Fig. 11 Diagram of a 3-probe measurement setup on target cell (X) and neighboring cell (★)

Automated Data Collection

Creation of Python scripts to automate data collection and synthesis:

- Naming of collected data files
- Analysis of measurement data, creation of graphs and calculating R_{on}
- Report generation and output

Creation of a centralized database through GitHub which allowed members to collect and process data independently without oversight.

Development of a thorough cell naming schema to document measured cells and associate them with reports generated from Python scripts.

GitHub Logo

Python Logo

Results

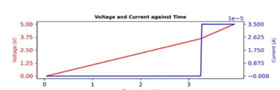


Fig. 12 Setting a cell with a voltage sweep. The sudden jump in the current is the moment the filament was formed.

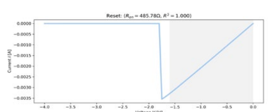


Fig. 14 Determining R_{on} from a Reset plot automatically. The gray region is where the algorithm analyzed the data by performing a linear fit.

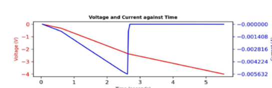


Fig. 13 Resetting a cell with a voltage sweep. The sudden jump in the current is the moment the filament was destroyed.

700+ data files have been collected so far, demonstrating our process is **scalable**

We observed an inconsistent ramp rate during operation (slope of the voltage in **Figs. 12, 13**)

Algorithm accurately determines R_{on}, and R^2 value allows us to ensure quality of results **(Fig. 14)**

Conclusions & Observations

- Discovered that compliance current in the range of **~35-40 µA** resulted in much more stable switching behavior when compared to our initial use of **20 µA**.
- Performing **~4 Set/Reset cycles** on a target cell will result in the rupturing of a neighboring cell's nanofilament that was left in the set state.
- Simultaneous and continuous monitoring of a neighboring cell while a target cell is heated and cooled was not captured.
- Evidence from 2-probe measurement shows occurrence of electron-tunneling phenomena which changes the resistance of the filament during remote heating.
- The effects of the phenomenon were measured and the steps needed to achieve this state have been documented and are replicable.

Challenges

- Finding an strategy for quickly changing which cell is being measured within the confines of the Clarius software.
- Initial use of a **20 µA** compliance current created unstable filaments unsuitable for testing.
- Filament generated during 3 probe experiments were weak and were prone to self-destruction.

Future Work

- Further research in the optimal parameters for robust filament creation during 3 probe measurements.
- Broader scope in measurement of neighboring cells:
    - Diagonal Neighbors
    - Neighbors on Platinum line
    - Neighbors further from target cell

Acknowledgements

We would like to thank the following people for their support throughout this project:

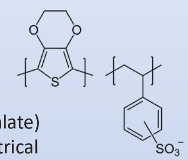
- Donald Leber (Clean Room Manager)
- Kim Medley (Accountant)

Organic Electrodes for Flexible Electronic Devices

Nicholas Bampton, Daniel Hall, and Thomas Olivero
Customer: Marius Orlowski, Sponsor: Zuzana Steen, Micron
Subject Matter Experts: Amrita Chakraborty, Daniel Herrera
Mentor: Kenneth Schulz

Motivation

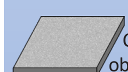
Research into conductive organic compounds has demonstrated them to be promising and cost-effective alternatives to metallic electrodes in flexible electronics, such as wearables, biosensors, and memory. One such material is **PEDOT:PSS** (poly(3,4-ethylenedioxythiophene) polystyrene sulfonate), which can be spun-coated on flexible substrates like Mylar (biaxially-oriented polyethylene terephthalate) while retaining comparable electrical properties to traditional metals.



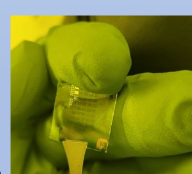
Objectives

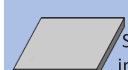
- Develop a process to spin-coat and pattern PEDOT:PSS films on a substrate of SiO_2/Si and Mylar.
- Characterize the effects of spin speed on PEDOT:PSS film properties (conductivity, thickness, density).
- Electrically dope PEDOT:PSS with GNP (graphene nanoplatelets) and copper nanoparticles to determine their effects on conductivity of the film.
- Identify the combination of processes that optimize conductivity.
- Optimize the procedure to maximize conductivity.

Film Process Flow

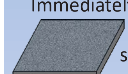


Cleave silicon to obtain a dirty sample. Don't forget to remove the dust!



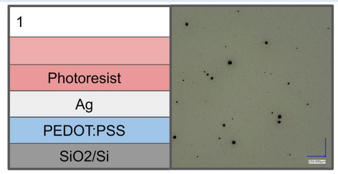


Sonicate the sample in a series of acetone and IPA baths. Dry with nitrogen then place on a hotplate to remove excess moisture. Finish with plasma exposure.

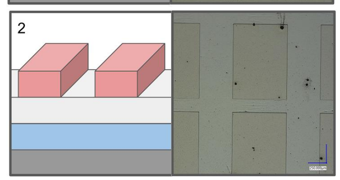


Immediately transfer to spin machine and drop enough PEDOT:PSS to cover the surface of the sample. Spin with the current experimental parameters then transfer to a hotplate at 110° C for ten minutes.

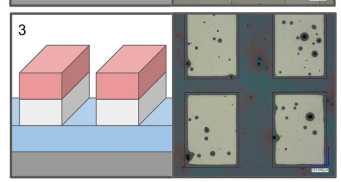
Patterning Process



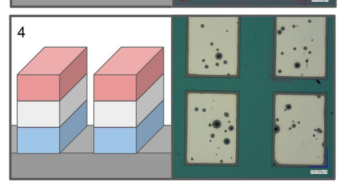
A 100nm layer of silver is deposited using PVD over the PEDOT:PSS for protection during the photolithography process. Photoresist is spun on top of this and exposed to UV light.



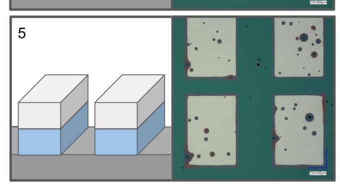
The photoresist is developed in AZ 300 MIF developer solution, leaving some of the silver exposed.



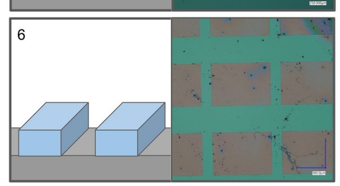
Using a 5:8 HNO_3:H_20 (nitric acid) solution, the exposed silver is etched away, leaving pillars of silver and photoresist, revealing portions of the PEDOT:PSS.



The exposed PEDOT:PSS is etched using O_2 Reactive Ion Etching (RIE).



The sample is dipped in acetone, removing the photoresist off the top of the pillars.



The remaining silver is etched using nitric acid, leaving patterned PEDOT:PSS on the substrate.

Measurements

Sample	Spreading Resistance (Ω/□)
PEDOT:PSS	850k
PEDOT:PSS with GNP	2.3M
PEDOT:PSS + Cu	1.15k
PEDOT:PSS with GNP + Cu	1.13k
PEDOT:PSS twice coated @ 1500 rpm	80k
PEDOT:PSS twice coated + Cu	456
PEDOT:PSS with GNP twice coated	453k
PEDOT:PSS @ 1500 rpm	229k
Cu between PEDOT:PSS	25k

Analysis & Conclusion

- Multiple spin-coating cycles significantly increases conductivity while maintaining the same thickness.
- The increase in conductivity in multi-layered samples is attributed to increased density of the PEDOT:PSS particles.
- The increase in conductivity for copper-doped samples is attributed to copper filling in the spaces between PEDOT:PSS particles.
- Combining these results, a double spin-coated sample with copper was created that achieved 456 Ω/□, an improvement of 3 orders of magnitude.

Future Plans

This demonstrated how conductive organic compounds can be. In the future, a direct comparison should be made against pure metal connections in devices. Additionally, resistance to acids should be tested.

Acknowledgements

Donald Leber, Clean Room Manager
Kim Medley, ECE Department Accountant

UAS High Frequency Surface Wave Radar Array

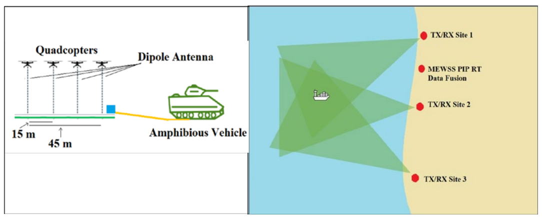
Team Members: Devin Mong, Zachary Schutz, Kyle Shea   Customer: MITRE
SME: Dr. J. Michael Ruohoniemi   Mentor: Prof. Shelley Stover

VIRGINIA TECH™

MITRE

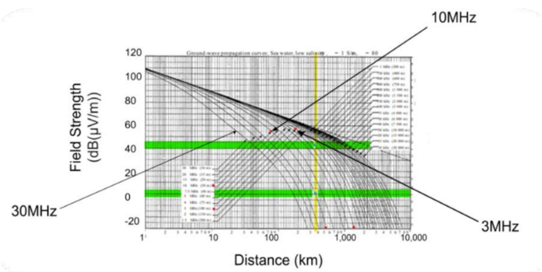
Problem Statement

The goal of this project is to analyze the feasibility of an High Frequency Surface Wave Radar (HFSWR) system that is moveable and operable by a Marine unit along coastlines for over-the-horizon target detection.



Groundwave

A common groundwave application on land is long range communication. When the surface changes from land to salt water, the groundwave can propagate in the lower HF band (1-10 MHz) at a modest transmit power.

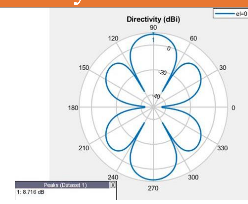


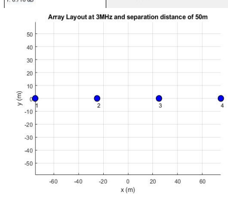
Approach

- To break down this project into manageable parts, we chose to analyze the antenna arrays, the power requirements, and the waveform characteristics of the HFSWR system.
- There are several other components that will need to be explored before the system can progress to a prototype construction.

Antenna Analysis

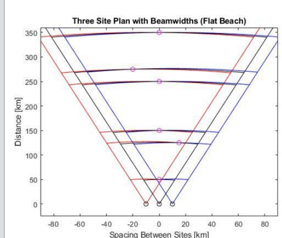
- Linear array of antenna elements was used to construct a beam to detect targets.
- Frequencies were simulated from 3-10 MHz with antenna element spacings of λ, 3/4λ, 1/2λ, and 1/4λ.
- Aim was to eliminate grating lobes and minimize sidelobes.

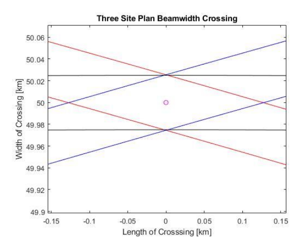




Multi-site Analysis

A multi-site geolocation style approach was used for target detection for precision in range and azimuth.



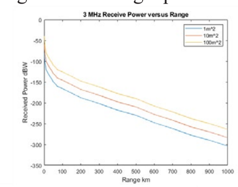


Technical Challenges

- This project presented several challenges including target precision, antenna beamwidth, and power availability.
- To overcome issues with target precision and antenna beamwidth, we explored the geolocation style approach allowing for range accuracy to increase precision.
- Power availability could be solved with COTS generators provided that it would not hinder the tactical abilities of the Marines.

Power Analysis

Using experimental data collected from a 1 KW transmitter electric field density versus range, the return power was calculated using the following equations:



$$P = \frac{|E|^2}{\eta}$$

$$dBW = \frac{dBW}{m^2} + dBm^2$$

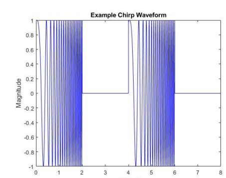
$$Loss\ [dB] = 30 - 2(dBW)$$

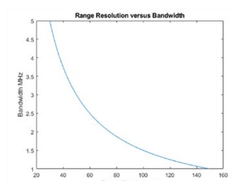
$$Received\ [dBW] = Transmit\ [dBW] - Loss\ [dB]$$

Waveform Analysis

- Linear frequency modulation employs sinusoidal waveforms where the instantaneous frequency increases or decreases linearly over time.
- To reach the desired 50 m range resolution, the transmitted pulse bandwidth needs to be greater than or equal to 3 MHz.

$$S_r \geq c/2BW_{tx}$$





Conclusions

- If the design characteristics provided are followed, we believe that the proposed system would be a practical addition to the tool kit of the Marines.
- As targets move closer to the system, the frequency range of operation could be increased and allow for more flexibility in noise aversion through the use of different channels.

Aircraft Data Acquisition Device

Team: Cole Murphy, Skyler Smith, Mark Stephens, Abel Thomas, and Philip K. Works III
Mentors: Shelley Stover and Toby Meadows | **SME:** Md. Adnan Sarker
Customers: Dario Hashemi and Dylan Gooch | **GTAs:** Amrita Chakraborty, Katey Bright, and Jenni Gallagher

Motivation

Data acquisition, is the process of sampling signals from the physical environment and representing them digitally. For maintenance personnel and engineers at NAVAIR, data acquisition plays a fundamental role in maintaining their aircraft.

Currently, NAVAIR uses data acquisition equipment that is cumbersome and difficult to operate without proper training. The lack of a portable and user-friendly data acquisition system, inhibits maintainers and engineers from quickly diagnosing potential problems with their aircraft.

To provide a solution to this problem, our team developed a handheld data acquisition device capable of recording sound, linear acceleration (vibration), temperature, and humidity from four detachable sensors.

System Architecture

Our design uses a microcontroller unit (MCU) and microprocessor unit (MPU) to drive its functionality.

The MCU gathers data from four sensors then transmits the data using USB 3.0 to the MPU.

The MPU decodes, validates, and displays decoded data on the touch-screen display. The MPU is also responsible for storing data as a .csv to a micro SD card.

Figure 1.0 shows the top level functionality of our system.

Figure 1.0 (Below): High level diagram of system architecture

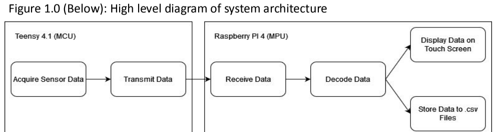


Figure 1.1 to the right, shows a more detailed architecture of our system.

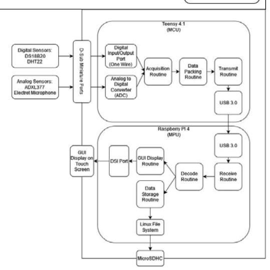


Figure 1.1(Above): Detailed system architecture

Processing Units

The Teensy is responsible for interfacing with the sensors and collecting the raw sensor data by managing multiple timers. This data is packed then transmitted over USB to the Raspberry Pi for decoding, storage, and feedback on the screen.

The Teensy interfaces with the sensors through both analog and digital modes, using the onboard analog to digital converter (ADC) and the OneWire digital communication interface.

The Raspberry Pi 4 is responsible for concurrently receiving data from the Teensy, unpacking it, displaying the data on the touchscreen using Qt, and storing the data on an external SD card utilizing multithreading techniques.

Figure 2.0 (Left): Raspberry Pi 4 used to drive our touchscreen and perform data processing.

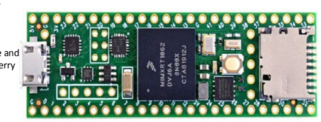


Figure 2.1 (Right): Teensy 4.1 used to acquire and transmit data from the sensors to the Raspberry Pi 4.

https://www.pjrc.com/store/teensy41.html

Engineering and Prototyping Process

The key steps taken during our engineering design process to develop and test our prototype include:

- Acquire data from sensors individually on prototype breadboard circuits.
- Facilitate USB 3.0 Connection between MCU and MPU.
- Facilitate decoding and storage of acquired sensor data on the MPU.
- Integrate the touch screen with the MPU to display live data from select sensors.
- Acquire data from multiple sensors on prototype breadboard circuits.
- Integrate the MPU and MCU and test data transmission.
- Package electronics into the 3D printed housing.
- Integrated testing

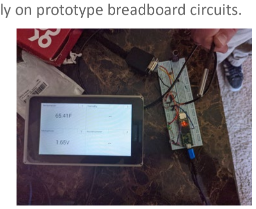


Figure 3.0 (Above): Initial Integration of Device

Prototype Results

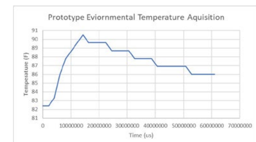


Figure 4.0 (Above): Temperature data acquired from device

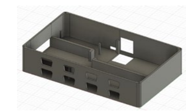
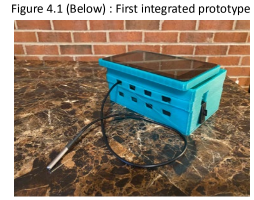


Figure 4.2 (Above): Next Housing Reprint

Figure 4.1 (Below) : First integrated prototype



SCAN ME TO SEE A VIDEO OF THE PROTOTYPE

Challenges

- Sending data between two devices reliably is difficult
- Initial Battery solution was too big to comfortably fit in the device housing
- Each reprint of the housing took about a week
- Lack of detailed mechanical drawings for touch screen, sd card reader, and battery
- Learning to use the 3D design software to design the housing
- Blocking nature of the temperature and humidity sensors

Acknowledgements

The team would like thank: our subject matter expert, MD. Adnan Sarker for his technical support and guidance throughout the semester; our senior design mentors, Toby Meadows and Shelley Stover, for their continuous support and guidance throughout our systems design process; and our customers, Dario Hashemi and Dylan Gooch, for their clear communication of requirements and willingness to offer practical guidance throughout the semester.

Magnetic Debris Accumulator

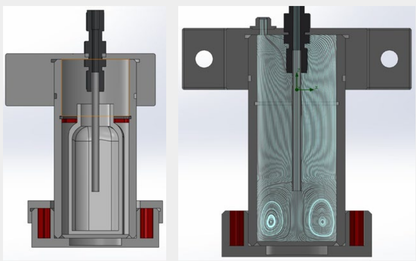
Diana Kim, Joe Kenyon, Hasan Nugmanov

Customers: **Brandon Krahn, Patrick Horney, Kevin Conner**, NAVAIR
Subject Matter Expert: **Peter Han**, Assistant Professor of Practice
Mentor: **Toby Meadows**, Adjunct Professor of Practice

OBJECTIVE

Research the background of electromagnetic and permanent magnetic fields and design 3 to 5 different types of magnetic field arrays for the most efficient way to catch ferrous debris as small as 40 microns. Explore both electromagnetic and permanent magnetic field arrays to determine which one is more viable.

BACKGROUND



Customer's Current Accumulator Design and Its Flow

A debris accumulator utilizes magnetic field arrays to capture and hold ferrous particles from lubricating oil flowing downstream from a main rotor gearbox and upstream from a heat exchanger assembly of the H-1 helicopter. The magnetic field arrays are to be designed and simulated to maximize capture efficiency.

- Ferrous debris inside the gearbox system can degrade the lifespan of components due to microabrasions
- Parts in the gearbox system have different ferrous alloys and these alloys can be detected in the collected debris to determine which parts are failing
- Early detection of such failing parts can prevent critical failures and increase the longevity of the helicopter

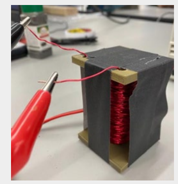
ACKNOWLEDGEMENT

We thank Susan Knight from EMWorks for sponsoring our team and for their assistance with modeling 3D magnetic field arrays.

DESIGN PROCESS

Electromagnet Design

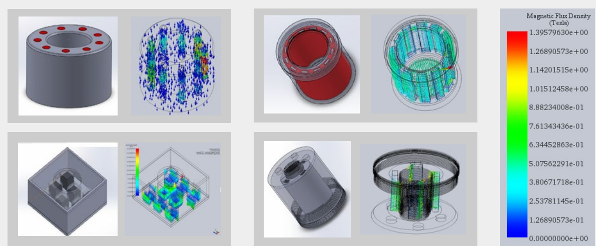
1. **Boost Converter**
   - Variable boost converter designed to create varying magnetic field strength
2. **Solenoid/Stator**
   - Solenoid was designed to test electromagnetic field theory on one direction of a polar field by providing 2-5 tesla along the Z-axis.
   - The stator was designed to test variable x and y axis magnetic field polarities as they change over time, and observe their effects on the debris



Solenoid Attached to Power Supply

Permanent Magnet Design

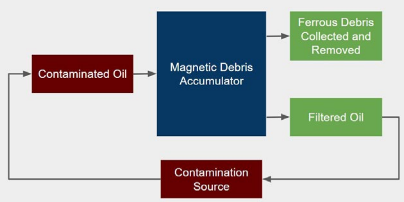
Different arrangements of permanent magnets were tested by creating CAD models of the magnets and their containers. The magnetic fields produced by the permanent magnets were simulated in EMWorks. Figures shows the magnetic fields corresponding to the CAD models. N52 magnet properties were used for the simulations.



Magnet Arrangements and Their Respective EMWorks Simulations

Testing Rig

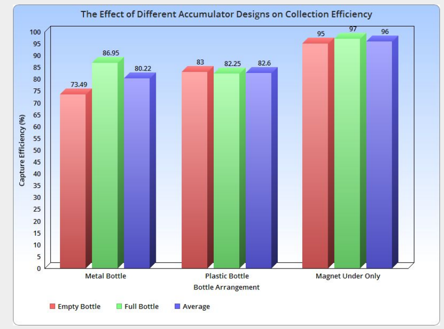
- Our testing rig is an approximate replica of the customer's testing rig. Notably, in place of the aluminum used on the customers design, a stainless steel mug was used to simulate the metal barrier between the debris and the magnets.



Overview of the System

Debris Accumulator

TESTING RESULTS



Different Bottle Arrangements And Their Collection Efficiencies

Observations

1. Greater surface area of the magnets on the bottle increases capture efficiency
2. Pull force at poles significantly larger
3. Magnetic field strength decreases rapidly with distance
4. Relationships among wire gauge, current, and magnetic field critically constrain the design of the solenoid
5. The installation and maintenance of an electromagnet is inconvenient relative to permanent magnets

CHALLENGES

- Supplying high current to the electromagnets was dangerous and difficult compared to the permanent magnets
- Cylindrical magnets orient themselves in the container
- Fluid was restricted to water for testing, which has a different viscosity from oil
- Magnets must be isolated from the gearbox fluid as it gets hot enough to demagnetize the neodymium magnets

CONCLUSION

While de-magnetizability of an electromagnet could be advantageous, it requires more parts and connections to operate, which is not feasible when being added to an existing system. It is recommended that permanent magnets be used for this application. The arrangement and fluid routing should be adjusted such that there is maximum surface area covering fluid path.

IEEE SoutheastCon 2022 Hardware Competition

Hardware Team

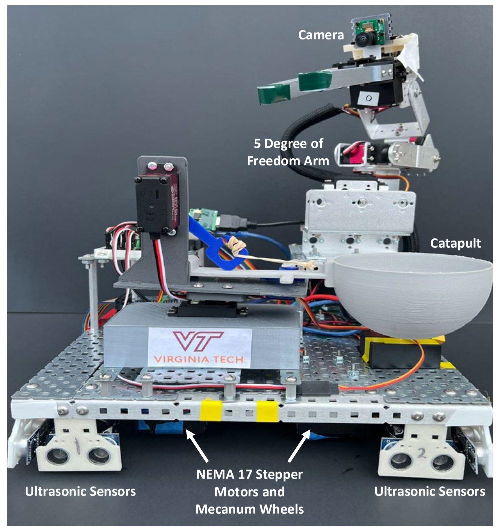
Tayler Anderson, Yitao Bai, Kenneth Janak, Ruizhe Li, and Kathryn Robertson
Sponsor: Andrian Jordan, Israel Jordan, and Theresa Shafer, NAVAIR NAWC
Subject Matter Expert: Dr. Arthur Ball, Virginia Tech
Mentor: Professor Toby Meadows, Virginia Tech

Problem Statement

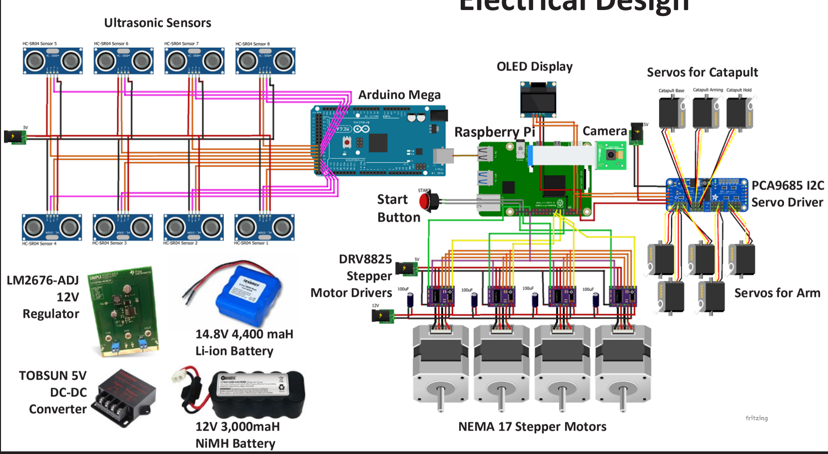
Design, build, and test an autonomous robot to compete in the Hardware Competition at the IEEE SoutheastCon 2022 in Mobile Alabama.

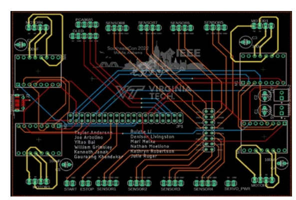
Key Requirements

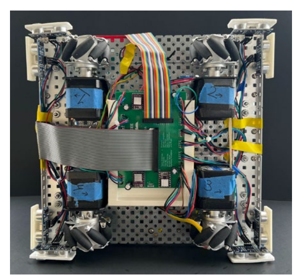
- Fully autonomous
- Navigates L-shaped track without touching barrier walls
  - 3-minute time limit
- Starts in a 1'x1'x1' configuration
- Retrieves bracelets from a tree 21" from the ground
  - 10, 15, and 20 bracelets
- Throws bracelets at least 4" horizontally into nets
- Drops bracelets into cups
- Pushes marshmallow off of the road



Electrical Design







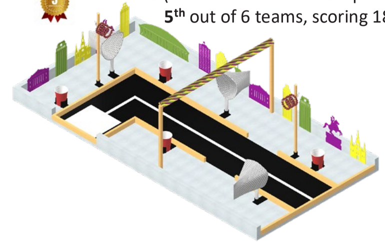
Competition Results

On April 2, 2022, the team traveled to SoutheastCon 2022 in Mobile, Alabama and competed against 27 other universities.

Qualifiers (2 runs with 10 bracelets per tree)
1st out of 28 teams, scoring 139 points

Semifinals (1 run with 15 bracelets per tree)
1st out of 22 teams, scoring 68 points

Finals (1 run with 20 bracelets per tree)
5th out of 6 teams, scoring 18 points



Scan this QR Code to view our videos and pictures from the competition!

Acknowledgements

The Hardware team would like to express their gratitude to the following individuals for the continuous support received throughout this project: Dr. Arthur Ball, Professor Toby Meadows, Dr. Scot Ransbottom, Andiran Jordan, Israel Jordan, Theresa Shafer, Kim Medley, Melanie Gilmore, and Stephen Moyer.

IEEE SoutheastCon 2022 Hardware Competition

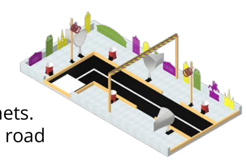
Software Team

Joseph Arbolino, William Grimsley, Gauraang Khandekar, Denison Livingston,
Nathan Moeliono, Mariamawit Melke, Julie Ruger
Sponsor: Israel Jordan, Andrian Jordan, and Theresa Shafer, NAVAIR NAWC
Subject Matter Expert: Dr. Arthur Ball, Virginia Tech
Mentor: Prof Toby Meadows, Virginia Tech

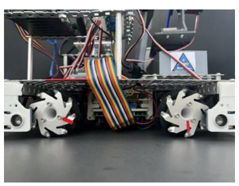
~ Problem Statement ~

Work with the IEEE Robotics Competition Hardware Team to design and create a robot that *autonomously*:

- navigates an L-shaped track
- ducks under a power pole
- fits in a 1 cubic foot position
- picks up bracelets off trees
- tosses bracelets into bins or nets.
- pushes marshmallows off the road



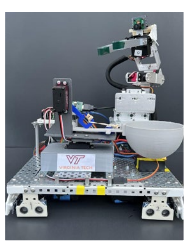
~ Navigation~



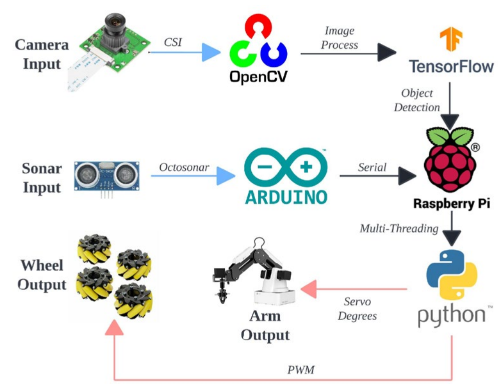
Navigation code was programmed using the NewPing library and used a complex FSM to account for all possible navigation scenarios. Robot movements are refined using real-time sensor data.

~ Arm~

With the feedback that it gets from the camera, the arm is able to perform a series of functions that would allow it to grab the bracelets and place them into the catapult. The catapult then throws them into the nets. Servo angles for these functions were refined through testing and using input from the camera.

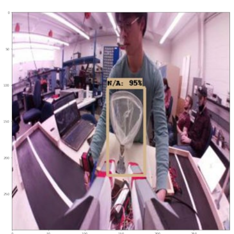


~ Software Layout ~



~ Camera ~

The camera is able to detect the position of objects such as nets or bracelets in real-time using TensorFlow Lite neural networks that have been quantized to fit on our low-memory Raspberry Pi. Computer vision techniques implemented using OpenCV were used to pre-process frames before passing them to the object detection models.



Camera detecting net in real time

Camera on the arm of the robot

~ Competition Results ~

On April 2, 2022, the team traveled to the IEEE SoutheastCon 2022 in Mobile, Alabama and competed against 27 other universities. We had the following results:

- **Qualifiers:** 1st out of 27 teams (10 beads per tree)
- **Semifinals:** 1st out of 22 teams (15 beads per tree)
- **Finals:** 5th out of 6 teams (20 beads per tree)

Scan here to check out some of our competition runs and pictures!

Scan here to check out our GitHub repository!

~ Acknowledgements ~

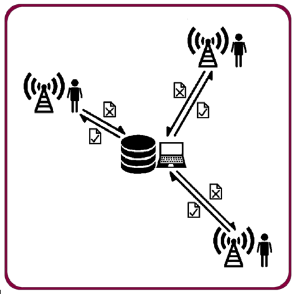
The Software team would like to express their gratitude to the following individuals for the continuous support received throughout this project: Dr. Arthur Ball, Professor Toby Meadows, Dr. Scot Ransbottom, Andiran Jordan, Israel Jordan, Theresa Shafer, Kim Medley, Melanie Gilmore, and Stephen Moyer.

Automated Spectrum Management

Andrew Heller-Jones, Caleb Bittenbender, & Logan Lynch
Customer: Ross T. Osborne, Phase II Staffing and Contracting
Subject Matter Expert: Tim Solie, Phase II Staffing and Contracting

Background

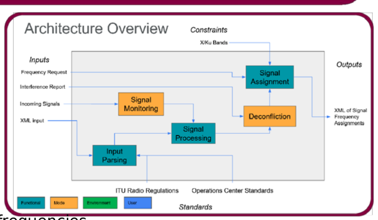
Frequency Management:
- Modern frequency management coordinates multiple radio devices within specific frequency bands.
- The primary goal is to avoid congestion, interference, and hostile jamming on a managed spectrum.
- Traditionally done manually, it faces challenges in response time, adapting to changing frequency bands, and communicating the status of the network to interested parties.
- Our project looks to augment the human operator at the core of spectrum management with a program that can mitigate the above limitations.



Automated Frequency Management:
- Our design focuses on a decentralized service that automatically records incoming frequency requests within a zone of influence.
- From each request, the service evaluates the incoming information and the existing database, and attempts to create a frequency assignment.
- To combat existing deployment issues, the service is designed to be remotely-accessible and scalable, permitting an off-site database.
- Each deployed service manages its own user-configurable location.

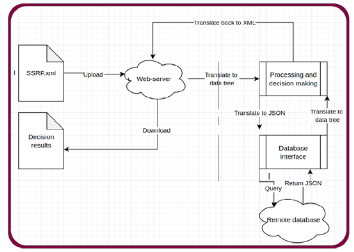
Objectives

- Receive and process frequency requests remotely in SSRF format
- Maintain an accessible database tracking the status of all allocated frequencies
- Deconflict new requests based on existing entries and specific local criteria such as operational bandwidth.
- Compensate for reported interference in the frequency landscape.



Design Process

This system was designed around a remotely-accessible database that receives and stores frequency allotments and assignments as well as spectrum specific data such as locations, tables of allocations, transmission / receiver stations, etc. A purely-software configuration was chosen to increase the flexibility for deployment on-site and in the field as it can be deployed on any available system.



In order to perform proper frequency management for primarily military operations, we chose to utilize the Military Communication-Electronics Board's Standard Spectrum Resource Format (SSRF). The system utilizes SSRF XML files to receive and return data.

Datasets are taken into the system by the SSRF and placed into data graphs which contain the reference key of a dataset, the attributes of a dataset, and the sub datasets of a dataset. Each sub dataset is placed into the database so that they can be individually referenced, while sub datasets remain referenced internally using their reference keys.

Upon request for an assignment of a specific frequency, the following criteria are checked in order to generate approval for a request:
- Prior usage by another entity.
- Shared usage authorization
- Location radius or specific boundaries

These parameters are a starting point for deconfliction and can be expanded in future use.

Data stored in the tree format can easily be translated into JSON format, as it is of hierarchical fashion, for database storage. This format was chosen as it's a straight-forward approach used by our database type and is simpler for easier client-specific modification. This database type can be hosted entirely locally, or configured for remote access and moved to the cloud.

A Flask web framework is used to upload and transmit SSRF documents to the main service for processing.

Use Case Examples

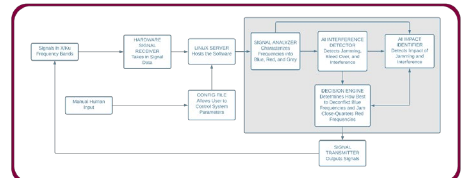
While operating in the Northwest Territories of Canada, the Northern Lights began unexpectedly moving south causing meteorological interferences on UHF, VHF and HF communications. Without proper scanning equipment the teams would be left unable to find appropriate frequencies to operate on, leading to tedious guess and check work and interference with surrounding entities. Furthermore, surrounding entities would be unaware of the reallocation by the team.

The Automatic Frequency Manager looks to resolve these issues by taking in a report of bad bands, and allocating the entity to the new proper bands. While the band may still be under interference, the reallocation is now documented in a centralized database for all relevant entities. This makes reallocation simple and conforming to the needs of the spectrum, and keeps information centralized.

Final Product

The final design features a service that receives SSRF documentation, processes the information, evaluates and utilizes the existing database, and generates an assignment for each request.

- The service identifies incoming frequency assignment requests and reacts automatically. Assignment generation via software is faster than manual methods.
- The database tracks all approved frequency assignments, keeping a record of managed devices and simplifying any necessary adjustments caused by frequency shift or interference.



Challenges

- Background research was a large part of this project. As none of our team members had a background in frequency management, everything was learned specifically for this assignment, from finding the right data formatting to understanding the problems that plague the industry.
- Conflicting API designs hindered efforts to smoothly integrate each individual part.
- Formal testing documentation was not prepared early enough to help guide design.
- Nested data structures in MongoDB required additional search methods.
- Software that worked on its own ran into issues when integrated with additional programs.

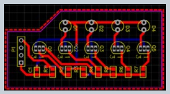
Next Steps

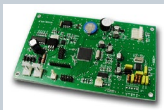
- Integrate an antenna within the database to monitor frequency status of its surroundings without requiring SSRF reports.
- Adapt to ongoing effects that alter the available frequency range. Add ability to reallocate assignments if the available spectrum shifts.
- Increase the number of tracked parameters for each device to improve assignment decision-making.

Additive Manufacturing of Electronics

Mia Blitt, Kavin Chaisawangwong, Sam Everett, Justice Lin, and Enzo Saba
Sponsors: Beth Paquette, and Christopher Green, NASA, Goddard, Maryland
Subject Matter Expert: Dr. Tim Talty, Virginia Polytechnic Institute and State University
Mentor: Dr. Scot Ransbottom, Virginia Polytechnic Institute and State University

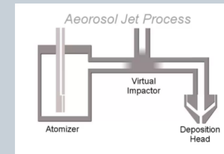
Problem Statment





The National Aeronautics and Space Administration (NASA) is currently perusing the ability to create Printed Circuit Boards (PCBs) through additive manufacturing. This is due to the fact that the traditional process of fabricating PCBs is time consuming and inaccessible in many remote environments. Additive manufacturing offers the ability to create PCBs faster and at the location they are needed.

A key component of this process is the translation of the PCB designs from a 2-dimensional layout design into one that is 3-dimensional and can be read by the printer. The problem space this team worked within was auomating this currently manual process.

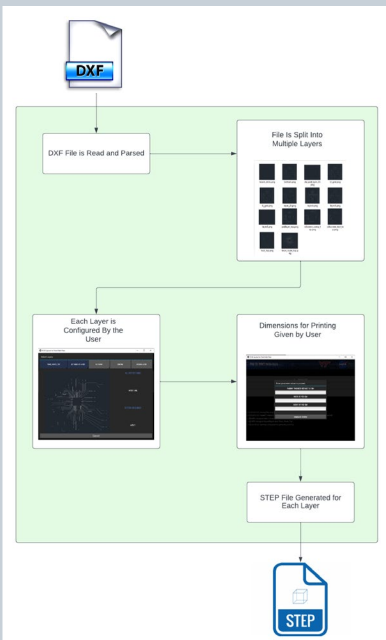


Problem Scope

As agreed upon by the team and the customer, the team will deliver a python software tool capable of:

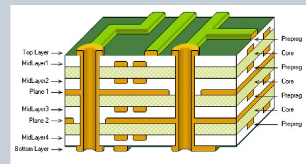
- Taking in DXF files
- Identifying features on the board
- Determine features compatible with additive manufacturing
- Translate board layout to STEP file
- Being operated by any user with a user guide

Design

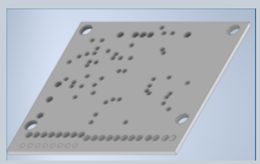


DXF Parsing

This module takes in a layout of a PCB in a DXF file and parses out the data that makes up this design. This layout is broken up into several layers as can be seen to the right. Each of these layers are read individually by this module and linked with their DXF entities. The data that makes up the DXF file is stored in python objects, which are passed between the different modules.



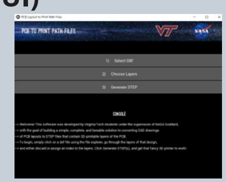
STEP Generation



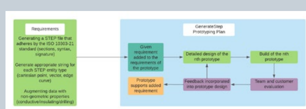
This module takes each layer that is selected by the user for printing and creates a STEP file for that layer. This is done by leveraging the CADQuery library to create 3-dimensional objects that can be printed by the user. An example of a layer created by this module can be seen to the left. These models take into account the dimensions that the user desires them to be at, as well as any padding the user desires on this layer.

Graphic User Interface (GUI)

This module controls the way in which the user interacts with the software tool. It is designed to break up the steps that the user takes into their own page and creates a flow for operating the tool. The GUI is also responsible for prompting the user for the input required at each step of the process. The GUI was created through the use of the kivy library. The page that the user would see when first opening the tool can be seen to the right.



Implementation



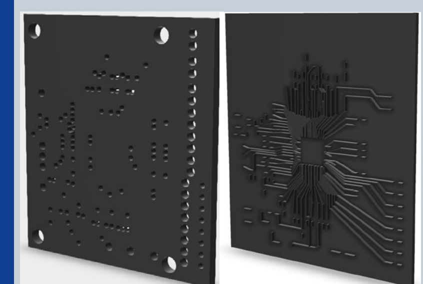
Following this the team began the iterative process of executing the design plan created by the team. It involved taking each requirement for a module, implementing it and then testing it thoroughly. A diagram represting this approach for the STEP Generation module can be seen to the left.

Video Demonstration

A video demonstration of the software created by the team can be seen by scanning the QR code to the right.

Testing and Results

In order to ensure the functionality of the software tool and validate its behavior, unit tests were created. These tests would focus on the behavior and outcomes of each module individually, The results of these tests can be seen below.



Conclusions

Following the execution of the design plan and the testing process, a software tool that generates STEP files from a DXF file of a PCB layout was created. This was tested using a schematic provided by the customer, to ensure the software was functioning.

Potential Extensions

This software tool as it stands has the opportunity to be built on and expanded in the future. Some examples of ways that this project can be extended is by being able to take in more file types and work for multiple printers. As the software currently stands it can only work on dxf files and the printer specified by the customer. The potential uses of this software can be expanded by implementing these features. As the field of additive manufacturing continues to expand and develop the software tool can continue to be built on and improved.

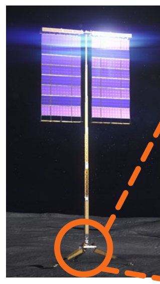
VSAT Algorithm Aboard Artemis

Team Acronym

Colin Wargo, Anna Brogowski, Ian Wildemann, Yichen Liu, Mithil Adsul
Bradley Department of Electrical and Computer Engineering - Virginia Tech
Professor Toby Meadows (Mentor - VT), Professor Haibo Zeng (SME - VT), NASA & SSAI (Customer)

What is VSAT?

- NASA and Science Systems and Applications Inc. require a solar power system on the Moon (VSAT).
- The VSAT will be used to power lunar habitats, rovers, etc. for the Artemis mission.
- Team Acronym has been tasked with designing the VSAT control algorithm and hardware.



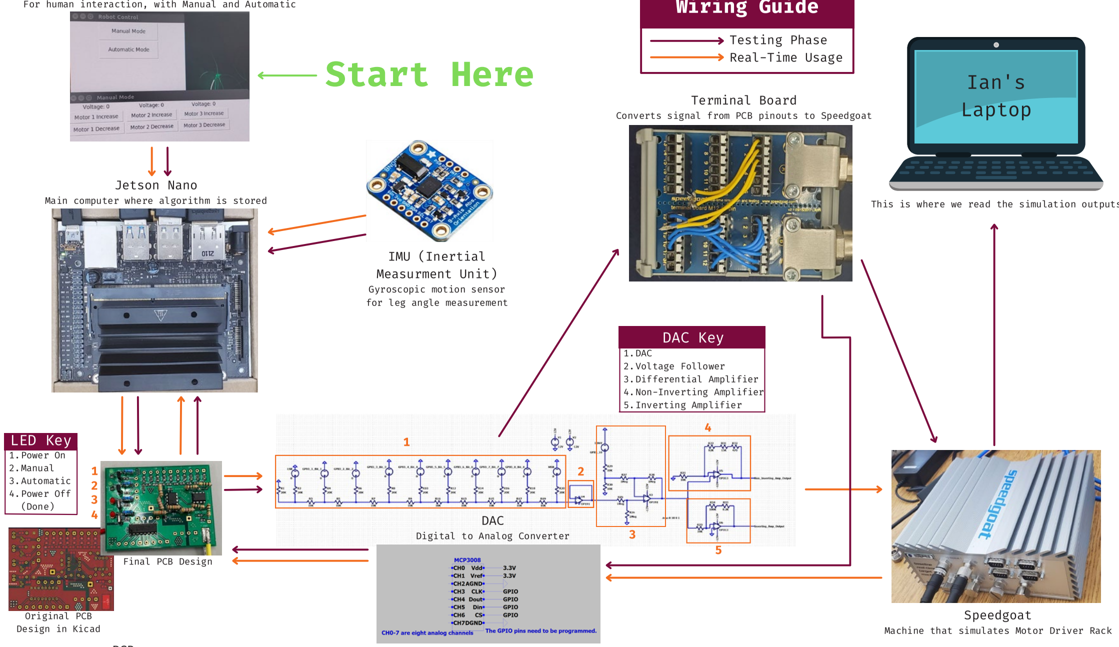
Want to see our algorithm in action?

Scan the QR codes below to see the manual and automatic functions!

Manual

Automatic

Connections Diagram



Difficulties

- The team was unable to get autogenerated code from Stateflow/Simulink to function, so we resorted to writing the code ourselves.
- The team's microcontroller (MCU) board was unable to drive the switch that we were using to switch between motors on the VSAT, as well as the PCB.
- The team was unable to obtain AMP Surface-Mount Soldering Lab (SMSL) access in time, so surface-mount components were soldered by hand.
- In practice, our hardware does not produce the signal we expected, but it does produce a working signal per project requirements.

Future Work

- Redo project with better MCU board.
  - Board must be compatible with autogenerated code.
- Implement switch for better motor control
  - Or triple the hardware.
- Redesign PCB with connectors and all surface-mount components.
- Conduct rigorous testing of control quality.
- Test onsite at NASA.

Testing

Conclusions

- Proof of concept of rapid prototyping was achieved.
- Gained insight into professional engineering design process.
  - Strengthened communication, presentation, and project management skills.
  - Learned to mitigate and overcome setbacks.
  - Communicated and networked with NASA professionals.
- The datasheets of each component should be carefully analyzed before purchasing/design.
- Time management should be improved.
- Simulations can not emulate the real world.
- Shorter wires produce better signals.
- The Jetson Nano is an expensive, and not an ideal MCU board.
- Writing code for DACs is difficult.

Lithium Ion Battery Modeling

Calen Farmer, Charlie Snyder, Caleb Zhang, Joao Vitor Tozzi Mafra
Sponsor: TMEIC | SME: Professor Ryan Gerdes | Mentor: Professor Toby Meadows

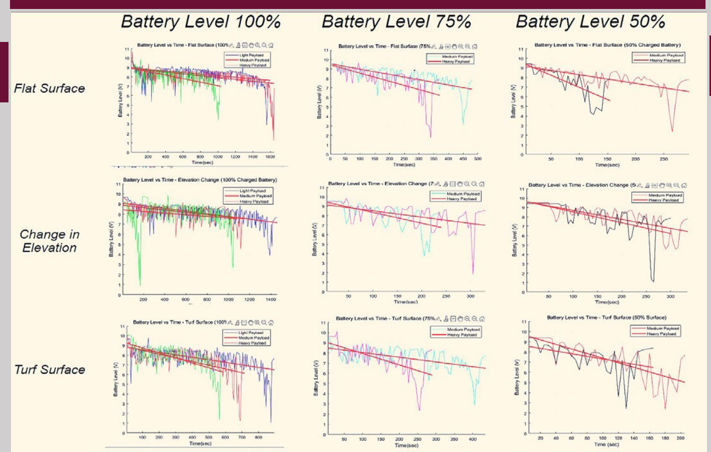
Background

Modeling an electric vehicle's battery as it decreases over the duration of a trip will help delivery companies make the switch to electric delivery vehicles. Little research has been done on electric delivery trucks in practical use and long durations with payloads. Our team has tested various payloads in a vehicle while driving them on various routes to determine the vehicle's distance, speeds, and battery efficiency.

Objectives

- Determine the characteristics of a battery as it discharges over a period of time while driving in a specific environment with varying payloads over different surfaces and battery levels.
- The battery model is a representation of how a full size lithium ion electric vehicle battery would perform under similar conditions.
- The battery model also allows an insight into how EV delivery vehicle batteries would behave during their routes.

Battery Modeling



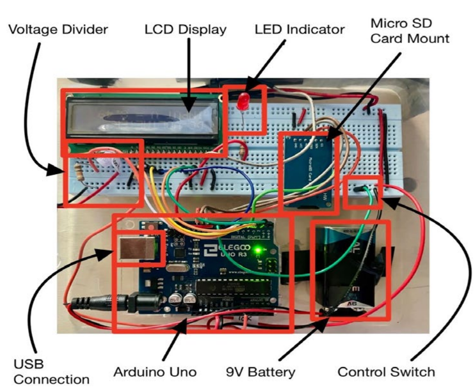
Challenges

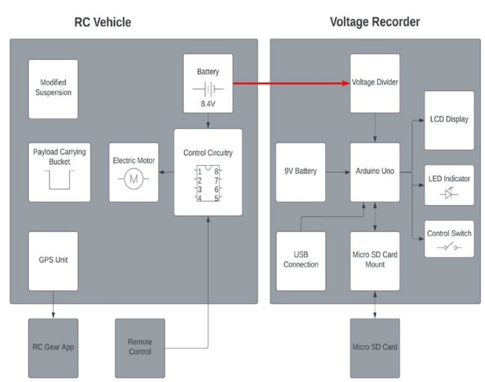
- Changing project scope multiple times over the course of several months.
- Obtaining an electric vehicle or scaled down electric vehicle for testing purposes.
- Measuring voltage on a moving object over a selected period of time.
- Modifying the test vehicle to carry a payload and testing equipment.

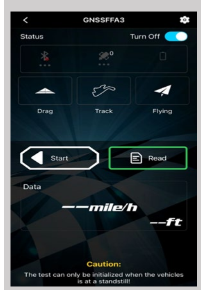
Test Results

Test #	Starting Charge (%)	Route	Payload	Time to Empty (min:sec)	Distance (ft)	Max Speed (mph)	Avg Speed (mph)
1	100	Flat	Light	25:04	19009	22	8
2	100	Flat	Medium	24:38	13028	19	6
3	100	Flat	Heavy	16:20	12549	20	8
4	75	Flat	Medium	7:23	6670	20	10
5	75	Flat	Heavy	5:28	4803	19	9
6	50	Flat	Medium	4:06	3360	20	9
7	50	Flat	Heavy	1:59	1663	15	9
8	100	Elevation Change	Light	21:46	20171	21	10
9	100	Elevation Change	Medium	17:18	15653	19	10
10	100	Elevation Change	Heavy	14:01	11959	19	9
11	75	Elevation Change	Medium	3:16	2710	16	9
12	75	Elevation Change	Heavy	4:36	3760	19	9
13	50	Elevation Change	Medium	4:26	4462	20	11
14	50	Elevation Change	Heavy	3:11	2520	16	9
15	100	Turf	Light	13:35	11306	19	9
16	100	Turf	Medium	11:05	9813	19	9
17	100	Turf	Heavy	8:55	8143	19	10
18	75	Turf	Medium	8:47	5761	17	9
19	75	Turf	Heavy	3:54	3510	17	9
20	50	Turf	Medium	2:43	1867	14	7
21	50	Turf	Heavy	2:08	1352	12	7

Block Diagram and Battery Testing Circuitry







Conclusions

- The data collected was similar to our hypothesis.
- Each type of terrain caused the battery life to shorten during the duration of a single trip, along with the starting battery level.
- The payload had a significant impact on the distance the car was able to travel on a single charge.
- The starting battery percentage had the largest impact on battery life, while lower percentages had a significant impact on distance travelled.
- The variable that had the least impact on the battery life was type of surface the vehicle was driving on. However, the surface did impact the car's ability to accelerate up to speed, which greatly reduced the longevity of the battery life.

Digital and Analog Magnetic Levitation Systems

Chris Payne, Dan Menten, Michael Koch, Olivia Moldoveanu

Customer: Dr. Dan Sable, VPT Inc. **SME:** Campbell Lowe

Background

Magnetic Levitation is an **inherently unstable system** in which an object is suspended in the air by magnetic fields. Commercial applications such as maglev trains and magnetic bearings, require various **stabilization electronic controls**. Our project concerns both **digital** and **analog** implementations of said systems that are used to float a light mass, reject moderate disturbances, and allow a user to have 3-D control of motion for the levitating object.

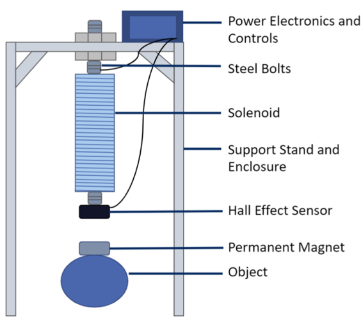


Fig: System Model

Objective

Create the following solutions to levitate a mass:

- Single-Magnet Analog System
- Multiple-Magnet Analog System
- Single-Magnet Digital System
- Multiple-Magnet Digital System

Design a creative display element showcasing one of the above implementations.

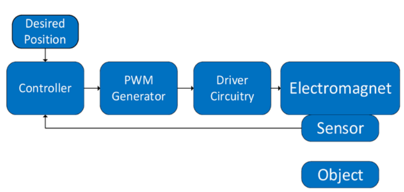


Fig: High-Level System Diagram

System Breakdown

Analog Control Systems

Essential components include:

- Hall effect sensors in close proximity to solenoids receiving magnet position data, and PWM IC that uses the data to generate square waves to feed to the solenoid
- Compensator feedback network built around LF356N Op-Amp
- ICs: PWM Generator, Hex Inverter, Quad Op Amp, LDO, NPN BJT

Fig: Analog Multi-Magnet Test Rig

Digital Control Systems

- Driven by MSP432 microcontroller.
- Eliminates the need for an IC PWM generator and op amp feedback circuit.
- Main driving factors include:
  - GPIO bias voltage inputs
  - PD control algorithm
  - External ICs to raise the PWM signal amplitude to 15V

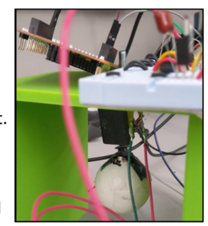


Fig: Digital Single-Magnet Test Rig

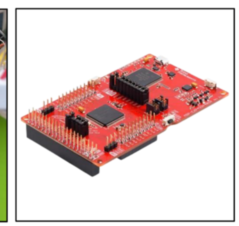


Fig: MSP432P401R, used for digital control

PCB Design

A printed circuit board for the single magnet analog and multi magnet digital systems serves to:

- House electronics permanently
- Mitigate power supply noise
- Reduce complexity for interfacing with the controls

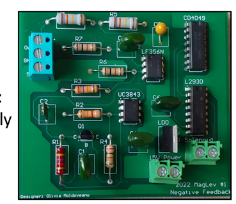


Fig: Analog Single-Magnet PCB

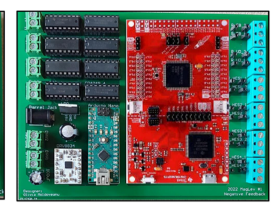


Fig: Digital Multi-Magnet PCB

Creative Element

A self-contained enclosure showcases all of the system functions.

- Theme: Space & Lunar Lander
- Interactive user controls move the levitated object in the XYZ plane.

Fig: Creative Element Housing (Rear View)

Fig: Creative Element Housing (Front View)

Results

Measurement	Analog	Digital
Max Time Floating	30+ mins	20-30 seconds*
Sine Wave Amplitude	8 mm (120 mV) @ 1 Hz	< 1 mm (10 mV)*
Square Wave Amplitude	6 mm (80 mV) @ 1 Hz	< 1 mm (10 mV)*
Sine Wave Frequency	4 Hz @ 80 mV	1 Hz*
Square Wave Frequency	4 Hz @ 80 mV	1 Hz*

*At time of publication

Future Work

Given our current status, our team would like to:

- Levitate heavier objects with larger solenoids and more robust Hall Effect sensors to increase their range of motion.
- Integrate more user interactive controls such as being able to drop and pick up the magnet.
- Create a stand-alone single PCB for an analog multi-magnet solution.

Conclusions

Over the course of this project, we found that:

- The selection of poles and zeros in the controller yields multiple 'working' solutions, but they require tuning in order to find an optimized solution.
- The mechanical and thermal constraints of the project played a larger role than anticipated, primarily in the heating of the solenoids.
- The integration of multiple magnets becomes more difficult as stability decreases drastically.

Acknowledgements

Our team would like to thank the following people for their support and assistance throughout the project:

- Dr. Dan Sable, our customer
- Campbell Lowe, our subject matter expert
- Dr. Scot Ransbottom, our mentor
- The AMP Lab Management, for the use of their space

Magnetic Levitation

Brett Burcher, Tom Coleman, Eric Danson, and Nicholas Yarnall
Sponsor: Dr. Dan Sable, VPT, Inc.
Subject Matter Expert: Matt Strehle, VPT, Inc.

Introduction

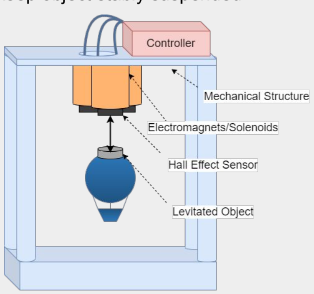
Magnetic levitation is **inherently unstable** since its natural response is unbounded, indicated by a right-half plane pole in the plant transfer function. A **control system** comprising **feedback** and **compensation** can change the frequency response and provide stability.

Objective

- **Stable system optimized for disturbance rejection and reference tracking**
- **Vertical and horizontal object movement capability**
- **Digital control with multiple electromagnets**
- **Printed circuit board design and construction**
- **Creative design**

System Overview

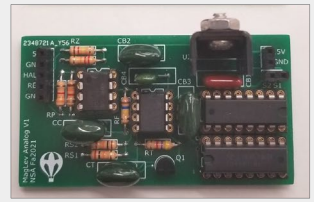
- Mechanical structure provides structural integrity
- Permanent magnet is attached to an object, and the electromagnets generates a magnetic field to counteract the force of gravity
- Controller interfaces with sensor and solenoid to keep object stably suspended



Controller; Analog Compensation

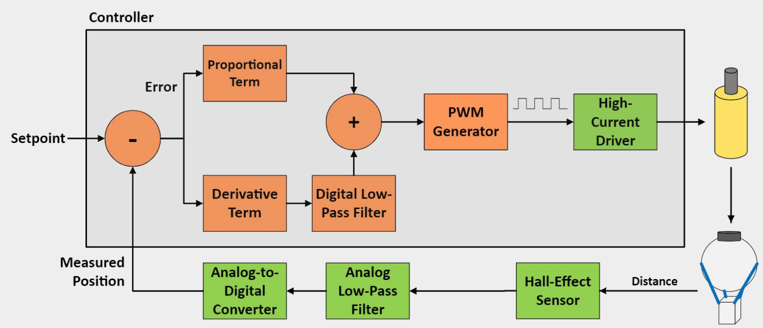
The analog controller utilizes **negative feedback**, which attempts to minimize the error between the setpoint and the measured object position.

- Lead (type II) compensator
- Setpoint via reference voltage
- Demonstrates proof of concept



Single-Solenoid Analog Implementation

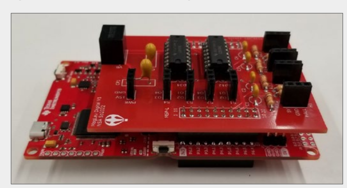
Controller; Digital Compensation



Challenges	- Continuous-time to discrete-time system conversion - Microcontroller interfacing
Feedback	**Filtered Hall-effect** to avoid aliasing and reduce noise
Compensation	**Proportional-derivative compensation** with PWM output implemented on the TI MSP432 microcontroller

The control loop is duplicated for each solenoid and run in parallel to achieve multi-solenoid control. Horizontal movement is achieved with out-of-phase sinusoidal setpoints.

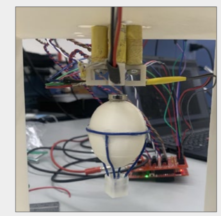
- **Direct interface with MSP432** via two sets of 2x10 pin headers
- Pin headers for Hall-effect sensors, solenoids, and power connections
- Current drivers to power solenoids
- Passive elements to scale and filter Hall-effect output
- Ground plane for noise reduction



Multi-Solenoid Digital Implementation

Results

- **Digitally controlled up to four solenoids**
- **Levitated an object > 3 grams**
- **Horizontal and vertical movement > 2cm**
- **Rejected physical disturbances**
- **Performed reference tracking**
- **Could run indefinitely**
- **Has a safe mode to limit power consumption when object is removed**



Conclusions

The design process of this system focused on the production of functional prototypes to ensure forward progression. Analog and digital prototypes alike we designed, tested, and used to improve the functionality of the next iteration. This process resulted in a robust and effective system that met all the project requirements. The analog compensation taught us the basics of control theory and allowed us to more easily transition to digital compensation.

Acknowledgements

- Dr. Sable, for the opportunity and experience
- Matt Strehle, for his guidance and expertise
- Dr. Ransbottom and the Major Design Experience leadership
- Richard Gibbons and the Integrated Design Studio staff

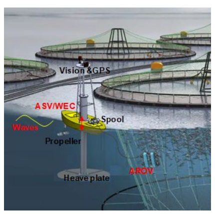
Communication System Design for Ocean Wave Powered Autonomous Robots

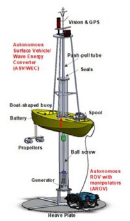
Michael Fuhrer, Kurubell Gebremedhin, Ryan Landry, Qianhui Xie, and Ziheng Xu
Sponsor / Advisor: Dr. Lei Zuo, Virginia Tech
Subject Matter Expert: Dr. Yaling Yang, Virginia Tech

Background Information

- US Department of Energy projects 64% of coastline energy generation is generated from ocean waves
- Viable source of renewable, clean energy for autonomous remote operations

Team Triton is part of an interdisciplinary project with it's focus being on creating a system in which a autonomous robot can communicate with a landbase through wave energy.





[Right] Original design for the ocean wave powered robot. [Left] Example application of robot, autonomous cleaning of aquaculture fish nets.

Objectives

Create a **communication system** for the autonomous robot that can:

- Transmit data with low latency (RTT <3 seconds) and sufficient throughput (625 Bps) , over long distances (> 1 km)
- Provide a communication channel with global range.

Design and implement **onboard electronics** that can:

- Locomote robot through autonomous navigation or live user commands
- Minimize power consumption at low battery

Build a **user interface** for the Landbase that:

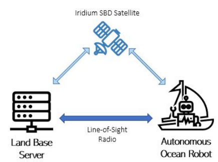
- Capable of displaying GPS coordinates, compass direction, and a live video feed from the robot.
- Allows user to control robot through live control or GPS coordinates

Design Process

Hybrid Comm. Approach

SBD Satellite

- Reliable channel
- Low throughput, high latency
- Ideal for periodic heartbeats and mission updates
- Global range



Line of Sight Radio

- Unreliable channel made reliable by comm. sys.
- High throughput, low latency
- Ideal for live control for busy, coastline navigation
- Ideal range of ~5 km

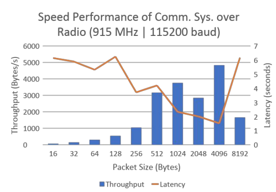
Onboard Electronics

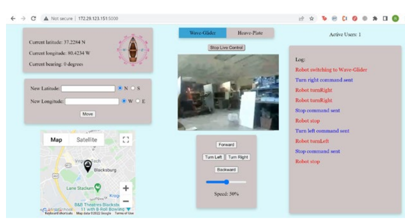
Web Graphical User Interface (WebGUI)

- Has separate back-end that utilizes Python web framework, Flask
- Uses websockets to forward messages from back-end to user interface
- Calls Google Maps API to get real time map of where the robot is located

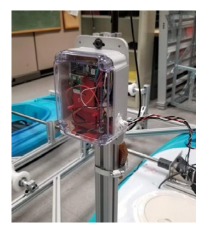
Results

- Maximum throughput of ~5KB/s a
- Average RTT latency of 4.35 seconds.
- 320x240 px color video at 5 fps.





[Above] Screenshot of our WebGUI. Includes compass, Google map, and live video displays. User can enter direct movement or GPS commands to control robot.



[Left] Photograph of our onboard electronics installed within its waterproof enclosure on the robot.

- Idle: 3.82 W
- Low-Power: 1.08 W
- Radio-Active: 6.32 W
- Motors-Active: 59.64 W

Robot expected to generate avg. of 10 W, but capable of generating ~100 W in ideal conditions

We tested our robot in Claytor Lake in Pulaski County, VA. Operators were able to navigate the robot using the provided live video feed and controls.

Conclusion

- Communication system reliably transfers data between a landbase and robot
- Control the robot with live video/controls or autonomously with GPS commands.
- Latency was close to, but failed to meet specifications. However, the comm. sys. has been proven sufficient for live control.

Our proposed communication system and onboard electronics is the first step towards providing ample control, data reliability, and application flexibility for autonomous marine missions.

Future Improvements

- Increase communication system's throughput and decrease latency while maintaining reliability
- Provide a more clearly defined interface with which AROV's may transmit data over Comm. Sys.
- Allow users to input more advanced control routines, e.g. GPS command scheduling
- Allow landbase to manage multiple robots simultaneously

Acknowledgements

- We would like to thank our faculty advisors: Dr. Zuo for overseeing the project and his insight into the marine industry, Dr. Yang for her insight into telecommunications, and Dr. Ransbottom for advising our MDE experience.
- Our interdisciplinary team was funded in part by the USDA and US DoE through the MECC competition

VIRGINIA TECH

Electronic Textiles for Sensing Human Motion

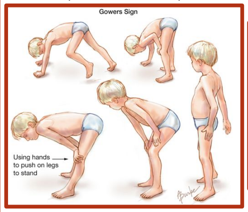
Team Members: Craig Benson, Devansh Chawla, Amanda Gift, Raviraag Rajasekhar, Eddie Roll

COLLEGE OF ENGINEERING
BRADLEY DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
VIRGINIA TECH

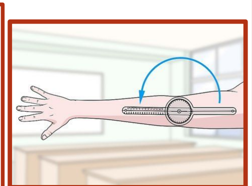
Problem Statement

Children with muscle disease often struggle to move their limbs during tasks that other children take for granted. They frequent trips to the physical therapist's office where their movement is measured, typically with a tool called a goniometer.

Designing a soft garment to measure the elbow and shoulder joint angles of a child throughout the day will limit children's trips to their therapist's office and provide the therapist's with an abundance of data.

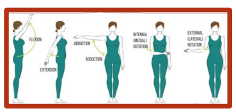


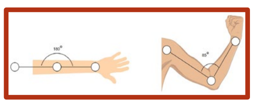
The early signs of muscle diseases in children.


A goniometer used to measure the elbow joint.

Requirements

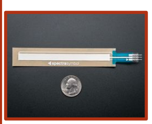
- Completely soft garment - no hard chips or boards larger than a button
- Angle accuracy of ±5 degrees
- Measures angles in real-time


Possible movements of a shoulder joint.


The bend in an elbow joint.

Analysis of Alternatives

Linear SoftPot Ribbon sensor



Pros:
- Measured in resistance.
- Linear behavior.
- Sensitive to low pressures.

Cons:
- **Measures applied pressure location**

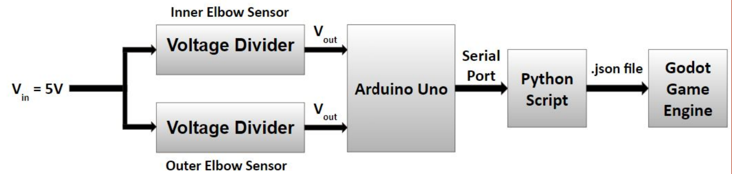
Round Force-Sensitive Resistor

Pros:
- Measured in resistance.
- Measures pressure magnitude.

Cons:
- Non-linear behavior.
- **Not sensitive to low pressures.**

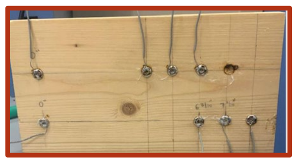
Decision: neither pressure sensor was used.

System Overview



Testing Process

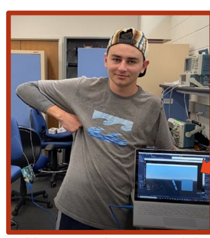
- Tested previous nylon sensors on a stretch testing jig.
- Attempted to sew sensors on nylon.
  - Failed because nylon was too flimsy.
- Successfully sewn sensors on elastic.
- Sewed and glued sensors to the outside of an elbow sleeve.
- Measured the resistance of the sensor at 180° (straight arm), 135°, 90°, 45°, and 25° (fully bent) bends.
- Sewed a sensor to the inside of the elbow.
- Measured the resistance of both sensors at the same bend angles.


The stretch testing jig with snaps 1 inch apart.

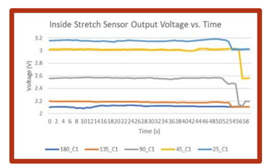

Sensor sewn on a sleeve (right) and a sensor glued on a sleeve with fabric glue (left). The glued sleeve was not soft enough and tests were proceeded with the sewn on sensors.

Test Results

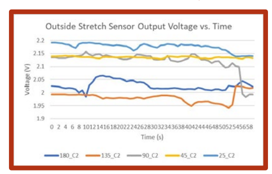
- No two sensors behave the same.
- Regardless of inconsistency, all sensors behave similarly.
- Orientation of sleeve is different every wear.
  - Sensor is not in the same position on the elbow.
- Output Voltage of the outside elbow sensor varied from ~2V-2.2V.
- Output Voltage of the inside elbow sensor varied from ~2V-3.3V


Eddie testing the system while wearing the sleeve on his bent right arm.


A close up view of the computer screen which is displaying a model of the elbow bend in the Godot game engine.



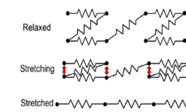
The output voltage results of the sensor on the inside (above) and outside (below) of the elbow over a 1-minute period.



Thread Sensor Theory

- Sewn on elastic using the 3-thread cover stitch.
  - Resistive thread used for the "looper" thread.

- Stretch length and sensor resistance are inversely related.
- After a stretch, the resistance slowly increases as elastic relaxes.

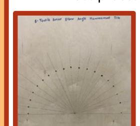


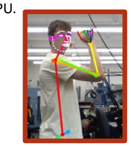
The resistor circuit that models a thread sensor's behavior.

- Applied pressure and sensor resistance are inversely related.
- If the sensor touches itself in any location, the sensor is shorted and does not behave like the resistor circuit.
  - This occurs when a sensor is on the inside of the elbow joint with no insulation.
- Multiple factors of resistance change make it difficult to map resistance to joint angle.

Accuracy Analysis

- Accuracy was measured by a large protractor made by our group.
- An alternative method is the software OpenPose.
  - Post-processing if no GPU.


The large protractor made in the lab.


The OpenPose software analyzing Craig bending his elbow.

Conclusion

- Project was not successful because a consistent angle calculation within ±5 degrees was not accomplished within the elbow.
- The was no sensor for the shoulder developed.
- The inconsistencies in the sensors made it difficult to create a model to accurately map a single resistance value to an angle.

In future research, design teams should aim to incorporate multiple sensors in their design.

- Pressure sensor - account for resistance change due to pressure.
- Rate of change sensor - determine if change in pressure is due to pressure or the relaxation of the material.
- Use multiple sensors and pick relevant readings.

Acknowledgements

Subject Matter Expert and Sponsor: Dr. Tom Martin
Mentor: Professor Toby Meadows
Graduate Student: Sai Reddy
Previous Studies: Amanda Redhouse & Guido Gioberto

Fault Tolerant Power Electronic Systems

Zachary Ruttle, Ben Faunce, Timothy Snow
Sponsor: Lei Zuo, Virginia Tech
Subject Matter Expert: Marif Daula, Virginia Tech

Introduction

Wave energy converters use the kinetic and potential energy of the ocean to generate mechanical energy and turn it into electrical energy. Using waves from the ocean as an energy source can be unreliable as wave force and frequency are difficult to predict. This unreliable source can cause damage to components inside power converters over time.

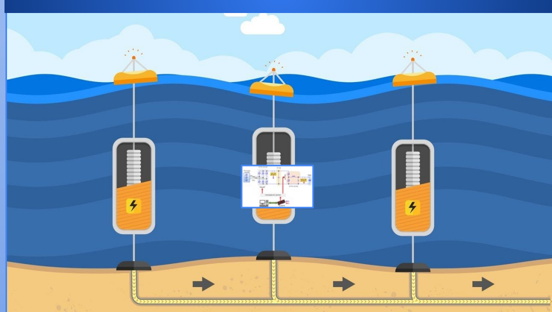
Creating a power system that can take the unsteady wave energy from a wave energy converter and produce a steady output was the overall project mission.

Key Requirements

Create a subsystem for the buoy that can take the energy, generated by a wave energy converter, and transform it into a consistent DC source of power. The system needed:

- Fault Tolerance, able to continue working in case of part failure, 95% reliability
- The ability to operate up to 500 watts
- The ability to control the output voltage between 48 and 500 volts
- Sinusoidal current input through filtration
- Efficiency of rectification and conversion

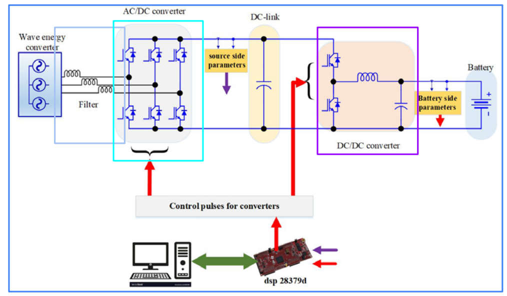
CONOPS



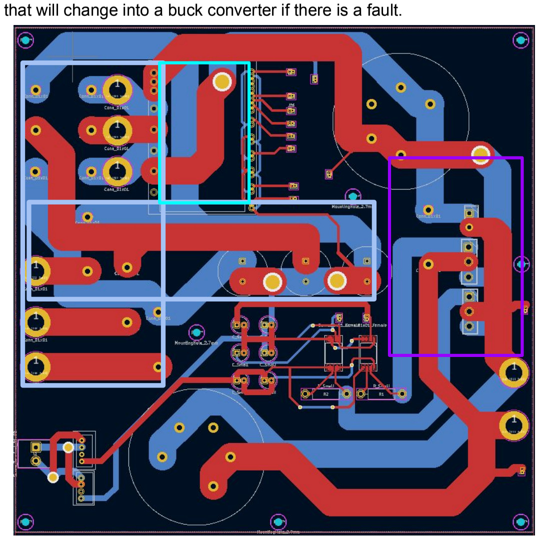
Acknowledgments

- Dr. Marif Daula - Subject Matter Expert
- Dr. Lei Zuo - Customer, Sponsor, and Advisor

Design



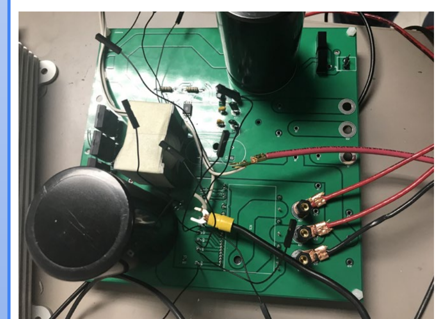
Above is the overall design of our circuit, which is made up of three main subsystems. The first box (blue) is our LCL filter. Its purpose is to ensure that the input signal adheres to IEEE standards, meaning that it is a sinusoidal three phase AC signal. The next subsystem is a three phase rectifier (turquoise), which will take the AC signal and transform it into a DC signal. The last subsystem (purple), is the DC-DC converter. This part is a Buck-Boost converter that will change into a buck converter if there is a fault.



Testing and Results

Simulation proved the concept to be within parameters:

- Able to reach target voltage with 2% ripple, 4% after a fault occurred
- Operates an output of 500 watts or higher with this ripple.
- Voltage can vary based on customer needs, as easily as altering a line of code in controller.
- Total cost under $300 for a unit.



Conclusion

Our simulation and testing helped us to prove that all the requirements listed were met. First the system being fault tolerant was proven in testing where we simulated a fault and the system continued to run and give us the proper output. Our system also is shown to give a controllable output voltage and be able to operate at 500 watts.

Challenges

- Production of the PCB was a new topic for many of us
- Acquiring parts for high power was expensive and specific for inductors
- Having initial design meet expectations

Fitness Watch Open Sound Control Interface

COLLEGE OF ENGINEERING
BRADLEY DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
VIRGINIA TECH.

Presented by the VT Fitness Watch MDE Team

Leo Gama, Darsh Patel, Daniel Samtani, Garrett Witt

Virginia Polytechnic Institute and State University, 302 Whittemore Hall, Blacksburg VA 24061, USA

Motivation

What the VT ECE department wanted out of this project was a comprehensive system that used a smartwatch's sensors to implement a control system for external interactions. The desired communication protocol was Open Sound Control so that the interactions could eventually be between a user and some form of multimedia like music and video. This an external media could receive an action from a sensor whether it be a gesture using the accelerometer or a jump in heart rate to take an action like turning on a light or making music louder. The goal of these interactions is to now allow a user to wear the watch and control certain things from using bodily controlled actions instead of interfacing with a screen.

Objectives

To create a real-time software interface between a smart watch and a computer to enable control of light, sound, and/or robotic actuators by using watch sensors such as accelerometer, gyroscope and temperature. The goal of these interactions is to now allow a user to wear the watch and control certain things from using bodily controlled actions instead of interfacing with a screen.

Approach

Step 1: Obtain data from watch and store the data in a CSV file so that it can be read for signal processing. The data is sent from the watch to a CSV file using Python and JavaScript using Open Sound Control as a way of communication between watch and computer.

Step 2: Signal processes the data from the watch using a specified filter in order to get rid of unwanted signals in the data from the watch.

Step 3: Take the processed data and use Open Sound Control to send the data to a React app dashboard that displays all of the sensor data so the user can visualize the data.

Step 4: Take final data from the dashboard and take a user controlled action based on the data. This includes turning on a light on or having the watch vibrate because a user's heart rate spiked or dropped too low.

Dashboard

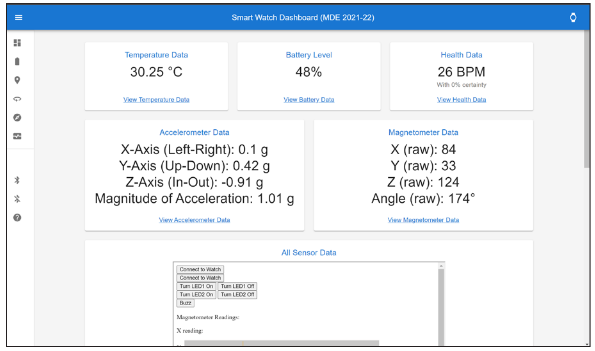


Figure 1: Image showing the functioning web interface dashboard communicating with the Bangle.js smart watch.

System Diagram

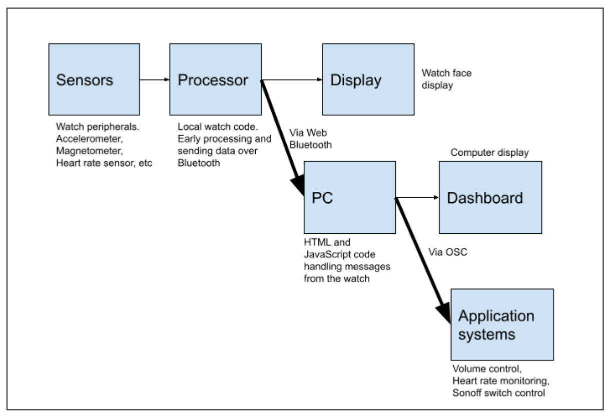


Figure 2: Breakdown showing the system diagram of the architecture used for the connection between the web interface, watch, and application

Conclusions

- A web interface was developed to communicate fitness watch data to a web application communicating smart watch data to an application from which user controlled actions can take place.
- One specific user controlled action is the control of a PC's volume based on rotation of ones wrist while wearing the fitness watch
- A database of live streamed data, heart rate, temperature, accelerometer, and magnetometer was also cached in a manner where the user can see their own sensor data's progression over a period of time when connected to the interface.
- Control of external devices via Wi-Fi connected Sonoff switches was also implemented to demonstrate functionality of a user to control any powered device via control of their fitness watch

Future Work

- Expand the interface to integrate other more popular smartwatches onto our dashboard (ex. Apple Watch, Samsung Gear, Fitbit)
- Group interaction via Open Sound Control to control volume via watch sensors and data.

Acknowledgements

The Smart Watch Team would like to personally thank the following people for their contributions and help towards this project:
- Dr. Ben Knapp (Customer/Sponsor & Subject Matter Expert)
- Dr. William Plymale (Team Mentor)
- Dr. Scott Ransbottom (MDE 4805/4806 Mentor)

Figure 3: The device on the left is the Sonoff control switch used to control externally connected smart devices all over Wi-Fi. The device is used to toggle control of a light based on events triggered by sensor data from the watch. The device on the right is the Bangle.js smart watch which is the physical fitness watch used in this project to demonstrate the full functionality of an interface based on Open Sound Control and which is controlled by sensory inputs from a human user.

ECE INTERACTIVE PLANNER

Team Members: Antonio Chelala, Claire Woehr, Luke DiSalvo, Thien-Lam Vo, Walid Zeineldin
Customer: Mary Brewer, Nicole Gholston **SME:** Dr. William Plymale **Mentor:** Dr. William Plymale

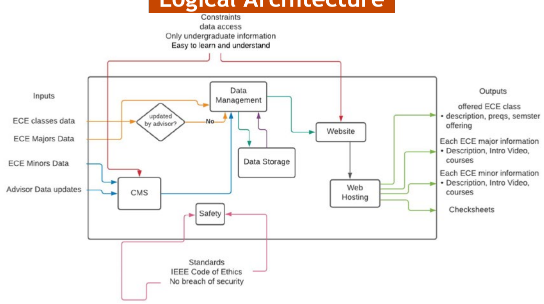
Purpose

ECE students and advisors at Virginia Tech have access to multiple resources for degree planning. These tools include DARS, Hokie GPS, ECE checksheets, timetables for classes, etc. However, currently there is no centralized location for all these tools, and the transfer of information from one tool to the other is often limited. The decentralization of these tools wastes time, leads to confusion, and makes it difficult for students to plan their studies at VT as they have to scour through multiple resources with conflicting information. Our project combines the aforementioned resources into one easy to use tool.

Key Requirements

1. Create a Graphical User Interface (website)
   a. Homepage: Announcements, Updates, Notes
   b. Degrees: Interactive checksheets
   c. ECE Courses: Descriptions, pre/co-requisites, minimum grade, semester offered
   d. Contacts: Advisors
   e. FAQ: Common Questions and Answers about the department
2. Easy use for students, potential students, and advisors
3. Well documented for future teams
4. Link the front-end and back-end together
5. Test application with students and get feedback

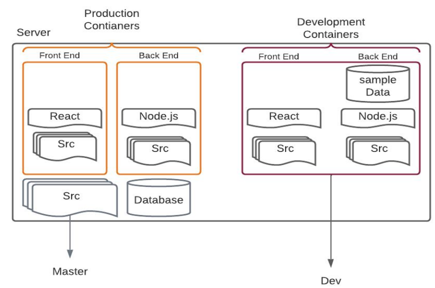
Logical Architecture



Inputs, outputs, constraints, and standards rely on components such as Data management, CMS, data storage, website, web hosting and safety.

Input
The data of each ECE course and majors/minors containing description, pre/corequisites, and semesters offered is inputted along with any updates by advisors.
Output
The output of the website contains ECE courses with description, pre/corequisites, and semesters offered, and each major and minor with description, courses needed, and current checksheet.
Constraints
Data access when wanting linking DARS to the back-end was constricted. A constraint for the website is that it only contains information about undergraduates currently.
Standards
Standards to keep for this project were to abide by the IEEE Code of Ethics. The most important standard, especially for future teams, is high security.

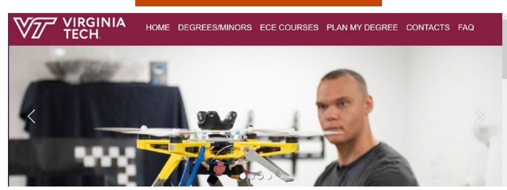
Technical Design



The system was divided into 2 parts: production and development. This split allows for real time development and testing of new features without affecting the production website.

Development
The development side is structured to run in a single container with front-end and back-end data. The development container includes a sample database that changes based on development needs. All the data in the development container are pulled from the projects dev branch
Production
The production side is structured into 3 components: front-end, back-end, and database. This allows for updates to occur on a component level rather than on a system level. The production source code is pulled from the project's master branch

Front-End Design



Our Website consists of 6 major tabs that a user can navigate through.

Home Page: This pages consists of major announcements in the ECE department like, any news of company visits, requests for students, nominations, tutors and more. It also contains information about classes which include add/drop dates, course request availability, C- Petition and more.

Degrees/Minors: Lists all of the majors offered under the Electrical and Computer Engineering department. There are also links to each of the majors checksheets to see what a four-year degree could look like.

ECE Courses: Contains all the offered ECE courses at Virginia Tech. There are also links to descriptions of each class, as well as important information about them.

Plan My Degree: Currently blank as other teams will introduce this. Will eventually allow a student to interactively plan a four-year degree.

Contacts: Lists all of the ECE advisors with relevant information about them.

FAQ: Presents many Frequently Asked Question about an assortment of topics.

Analysis & Conclusion

A Survey was been given out to students along with a prototype of the website to get feedback from the actual users of the product. This feedback will be given to the next team to help them improve the website. Overall, we received positive feedback from the students. Styling and appearance of the GUI need improvement, but the purpose of the project seemed to be impactful for the students.

Top 5 things students like about the website
1. The idea of the interactive planner tool.
2. Easy to navigate and concise information.
3. Checksheets are easier to find.
4. Easy to reach information about different classes.
5. Information is all in one place.

Top 5 improvements student would like to see in the website.
1. Modernize the appearance of the website.
2. Add more graphics.
3. Include majors descriptions and possibly professors for each course.
4. Include more information of secondary focuses and minors.
5. Change the font and colors.

Future Plans

This project will take multiple years to complete, which is why our team's scope was to lay a solid the foundation. Each team will pass down documentation that will guide future teams and provide them with current resources. During some semesters, teams will have the opportunity to work concurrently.

The overall scope of the project is to have an option for students to plan their degree, graphical user interface for back-end so advisors can edit it, and linkage to DARS. The next teams first step is to establish a way for the back-end to communicate with DARS. Currently, the back-end is not linked to the DARS database so the data is hard coded. This will allow the website to receive live updates from changes that are made to the DARS database.

A graphical user interface was a must for the customer. This will allow advisors to sign in and be shown an easy to use editing page. This page will allow advisors to add any announcements, updates, or notes to the home page, make edits to any courses or requirements for majors.

One of the last parts of the customers original scope is to have an option for a student to plan their degree. This was imagined as a checksheet for the major they are interested in, and the courses can be moved around or added, but errors will appear if the schedule is invalid. There might even be a way for a student to sign in so their schedule is saved in the website and advisors can access it if needed.

Since the project is a multiyear project, the scope will change or be added on to. The project will eventually expand to graduate students, contain minors, and incorporate secondary focuses.

Acknowledgements

The team would like to thank the Virginia Tech ECE department for sponsoring this project. We would also like to thank Mary Brewer, Nicole Gholston, and William Plymale, all of the ECE Department for their guidance, mentorship and contribution to the success of this project.

Intelligent Devices For Medical Workspaces: Free-Viewpoint Video System for Tele-ICU Clinicians

Team Members: Khaled Alhmoudi, Mayank Hirani, and Keerthana Aluri
Customer/SME: Dr. Tom Martin Team Mentor: Dr. Scot Ransbottom

VIRGINIA TECH
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VIRGINIA TECH

Project Description

M.D. Hokies created a fully immersive experience for Tele-ICU clinicians by improving team collaboration within the virtual medical workspace. Our product aims to reduce the inconvenience a clinician feels when supervising procedures/practices through a virtual screen.

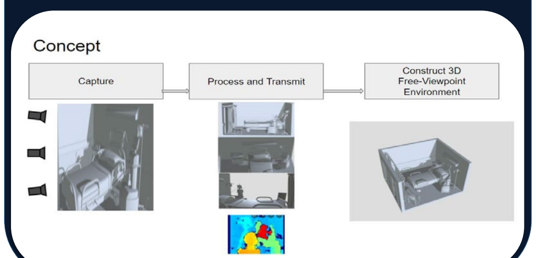
Objective

- Scope problems within medical workspaces that can be solved ~1 year
- Created story boards to finalize on a problem and then create a "proof of concept"

Approach

The high-level system design consists of 3 stages:

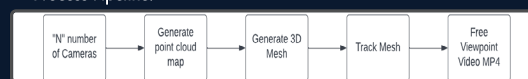
- Capture:
  - This stage involves calculating the number of required ZED cameras for an arbitrary floorplan using visual-cone bounds
- Process:
  - This stages involves using the depth-sensor point clouds to create 3D meshes for each camera view
- Construct:
  - This stage involves using the transmitted 3D meshes to construct 3D virtualized assets for the viewer application



Concept Motivation Diagram

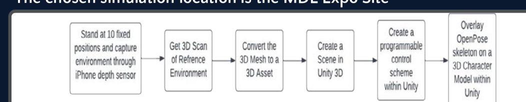
Technical Design

- Process Pipeline:



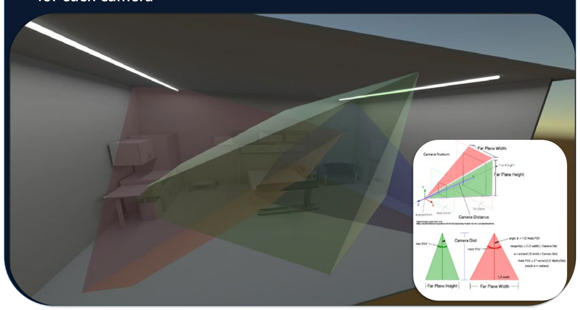
- Simulation Pipeline:

The chosen simulation location is the MDE Expo Site



- Camera Placement Guide:

Ensure proper scene coverage by calculating the visual-cone bounds for each camera



Challenges

- Defining the problem's large scope and identifying the client's needs
- Real-time tracking through Unity Simulation
- Limited experience in the fields of Computer Vision and photogrammetry

Simulation Results

Metric	Simulation Value	Marginal Value	Reference System
Average Frame Rate	59.1 fps	30 fps	• CPU: Intel Core i7-8550U CPU @ 1.80 GHz (8 CPUs) • DirectX Version: 12 • GPU: Intel UHD 620, 4gb video memory @ 1.15 GHz • Ram: 8192MB
Processing Delay	16.9ms	20ms	
Resolution	1024x768p	640x480p	
Vertices (~Point Clouds)	13.7 Million		

Volume (Approx)	20m x 10m x 3m =600m^3
Total Scene Vertices	13.7 Million
Vertices per m^3	22833 Vertices

Future Study

- 3D real time video display of doctor and patient interactions for precise Tele-ICU consultation diagnoses
- Apply product to not only acute procedures, but rigorous ones as well

Acknowledgements

We would like to thank Dr. Tom Martin for working with us to help facilitate the idea generation process, as well as providing great wisdom of his past experiences and expertise. We would like to thank Dr. Scot Ransbottom for helping us apply our lessons learned to real life industry practices, and the Virginia Tech ECE department for giving us the opportunity to work on this exciting project.

Machine Learning Card Authenticators (MLCA)

Team Members: Rajan Mann, Vraj Patel, John Ventura, Noah Sanzone, Chengpei Wu
SME: Creed Jones Customer: Luke Lester

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VIRGINIA TECH.

Background

Over the past 20 years, people have paid card grading companies to have a human assess the value of their sports cards. This process has drawbacks:

- Human grading takes weeks for consumers to get their cards back
- Inconsistent and prone to human error
- Expensive process

Objectives

- Assess the quality of baseball cards with respect to…
  - PSA grinding standards (Grades 1-10)
  - Determine horizontal and vertical margin ratios
  - Detect quality (fraying) of all 4 card corners
  - Determine inner rotation with respect to outer margins
- Create a machine learning model using an online dataset to predict PSA grade
  - This model aims to be at least 85% accurate

Dataset

- Images obtained from collectors.com using ParseHub
- Acceptable vs Unacceptable images

Acceptable

All images have clear margins, no distortion & simple background

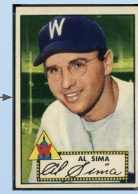
Unacceptable

Unclear Margins | Distracting Background | Distortion/Glare

Card Specifications

The purpose of this module is to detect margins, corners, and rotation to calculate various metrics to quantify the quality of these characteristics of the sports card. The original image is cropped, converted to grayscale, and the canny edge detection is applied.

Original Image

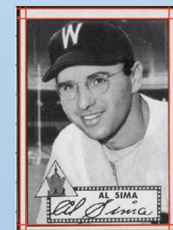


Cropped Image

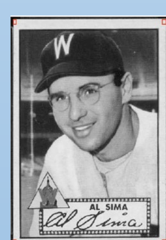
Canny Edge Detector

Margins

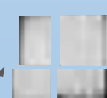
1. Apply Hough transform to detect strong straight lines
2. Calculate pixel ratio between top and bottom horizontal margins and left and right vertical margins



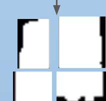
Margin Detection



Corner Detection



Original Corners



Otsu Thresholded Corners

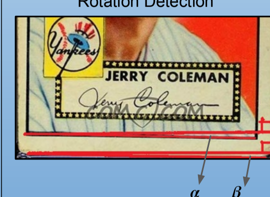
Corners

1. Apply hough transform to detect squares
2. Take a fourth of the square region
3. Apply Otsu thresholding
4. Calculate standard deviation of pixel intensity for each corner

Rotation

1. The points on the Hough lines are chosen to perform the rotation calculation.
2. The rotations of outer borders and inner borders are calculated using arctan.
3. The difference between these two rotations is the relative rotation of inner border to outer border

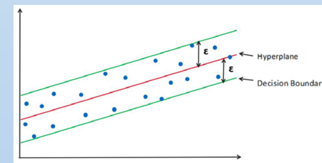
Rotation Detection



We want α - β

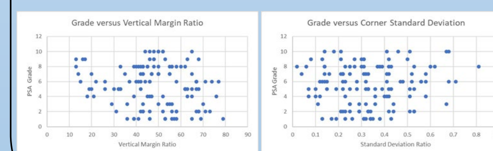
Machine Learning

- The dataset is a csv file containing the PSA grade, card margin sizes, card corner qualities, and inner rotation of each card.
- The dataset is first split between training and testing.
- A support vector regression model was implemented.
  - A decision boundary is used to choose the best hyperplane that fits the training data.



Hyperplane placement based on decision boundary with distance epsilon from the hyperplane

- After training the model, it is used to predict the PSA grade for each card in the testing data.
  - The accuracy of the model is determined by comparing the predicted grade to the assigned PSA grade for a particular card.



Scatter Plots showing feature values versus their assigned PSA grade

Conclusion

In conclusion, the overall accuracy of the machine learning model is 36% given a margin of error for each prediction. This accuracy is not very high, and the reason is there is a lack of cards in the dataset and some of some of the features do not help the model. To improve on this accuracy, more cards need to be added to the dataset, and more research needs to be done into what features best determine a PSA grade.

Acknowledgements

The team would like to thank the following people for their contribution and guidance to this project:

- Luke Lester for the enthusiasm and continued support
- Creed Jones for assistance with technical support
- Scot Ransbottom for assistance with engineering professionalism

Building Ladder Safety System

DIVISION OF CAMPUS PLANNING, INFRASTRUCTURE, AND FACILITIES

Rohan Desai, Ellen Guo, Mason Kimbrough, Jared Monseur, Jackson Underwood

Mentor: Prof. Toby Meadows   SME: Dr. Almuatazbellah Boker

VIRGINIA TECH

Background

Maintenance workers ascending utility ladders at VT, in compliance with OSHA guidelines, must maintain three points of contact with the ladder at all times. Roof access hatches installed in VT facilities utilize mechanical locks to restrict access. To unlock the hatch employees commonly use two hands to secure the lock and key. This violates the three points of contact guideline.

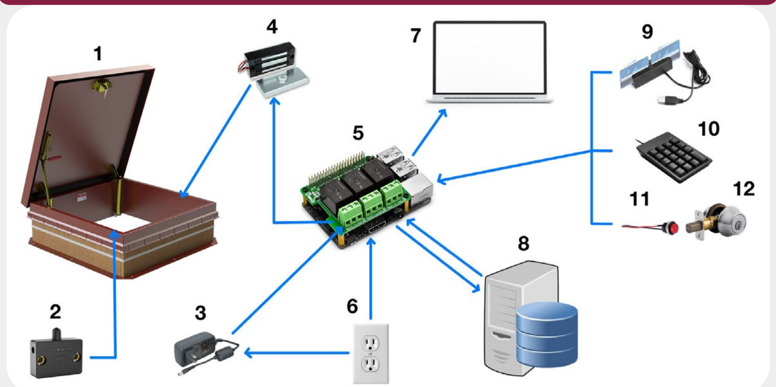
Key Requirements

- Multi-Access Automated Hatch Unlocking Mechanism
- MySQL ID Database
- Environmental, Health, and Safety Graphical User Interface (EHS GUI)
- Access log for determining lock and unlock times

Challenges

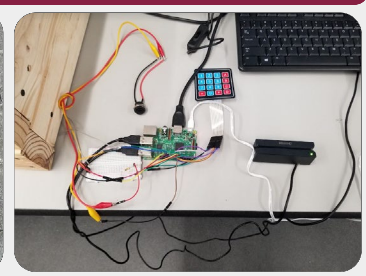
- Initial Relay implementation could not be powered by the raspberry pi
- Two number pad designs did not function as advertised
- Lack of GUI and MySQL database design experience
- Hard to connect between the Raspberry Pi and the Web Server

Raspberry Pi Integration



1. Hatch
2. Open/Closed Sensor
3. AC to DC Power Supply
4. EM Lock
5. Raspberry Pi
6. Wall Outlet
7. Display
8. Server
9. Card Swipe
10. Number Pad
11. Button
12. Deadbolt

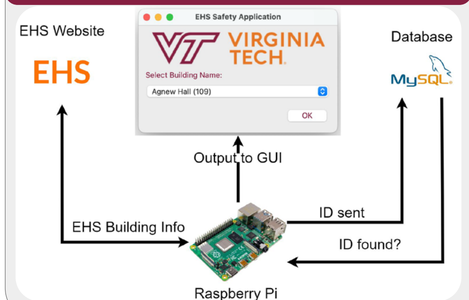
Prototype/Test



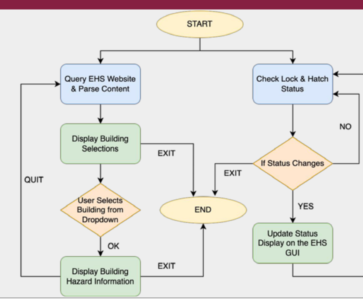
Raspberry Pi reads user input from a number pad, swipe device, and deadbolt used to depress a button, then if valid switches the relays to block or pass current between the power supply and electromagnetic locks, controlling the locked or unlocked status.

View our prototype video

Software Architecture



EHS GUI



Acknowledgement

We would like to thank:

- Professor Toby Meadows
- Dr. Almuatazbellah Boker
- Robin McCall Miller
- Bruce Lytton
- Greg Winters

Cybersecurity Signal Collector And Analyzer

Team Members: Joseph Reilly, Qasim Wani, Victor Nguyen, Quincy Brooks, Sam Reid
Customer: Randy Marchany **SME**: Brad Tilley **Mentor**: Dr. Scot Ransbottom

Purpose

This device will be used by the Virginia Tech IT Security Office in presentations to show some of the reconnaissance abilities of a malicious actor. The Signal Collector and Analyzer should collect Bluetooth and Wi-Fi packets without connecting to a wireless network or Bluetooth device.

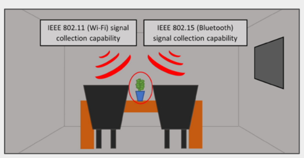
Objectives

- Promiscuously sniff 2.4 GHz and 5.0 GHz Wi-Fi packets
- Promiscuously sniff Bluetooth Low Energy (BTLE) packets
- Sniffing ranges ≥ 100 ft
- Organized data storage
- Interface to display data
- Surprising and inconspicuous form factor

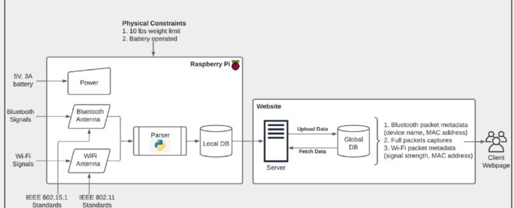
Approach

Our goal was to create a device that collects Wi-Fi and Bluetooth packet data, pushes the data to a remote database, and displays the data on a webpage for a presenter to use in demonstrations. This device was housed in a fake potted plant to demonstrate the inconspicuous nature that such attacks tend to have.

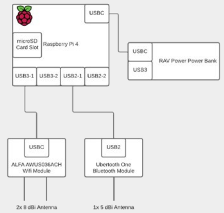
This device pushes Wi-Fi and Bluetooth packet data to a remote MongoDB instance (AWS) and displays the data on a website hosted on Heroku.



Block Diagram



Hardware Design



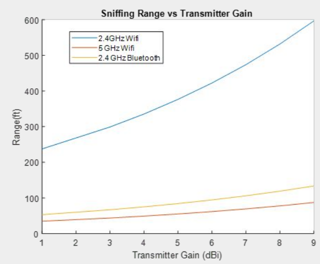
Hardware design diagram

Ubertooth One Bluetooth Module

ALFA AWUS036ACH Wi-Fi Module

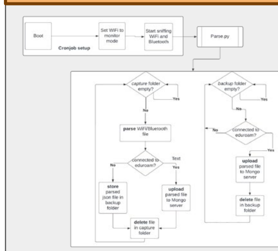
Final prototype outside of housing

Final product in housing

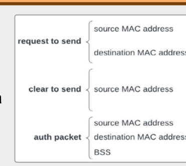


Component	Observed Range
2.4 GHz Wi-Fi	600 ft
Bluetooth	85 ft

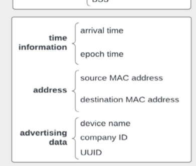
Software Pipeline



Local (Raspberry Pi) SW architecture

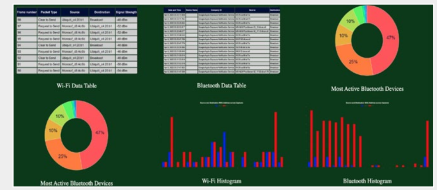


Wi-Fi Mongo Database Schema

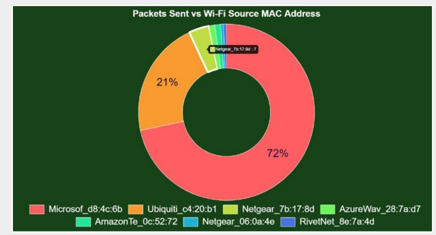


Bluetooth Mongo Database Schema

Client Website



Home page, redirects to different data visualizations



Pie charts showing traffic distribution of most active devices

- Other representations:
  - Line charts for traffic volume over time
  - Histograms for most active devices over time

Conclusion

- Promiscuously sniffed 2.4 GHz and 5.0 GHz Wi-Fi packets
  - Range of 100 feet could not be reached for 5.0 GHz
- Promiscuously sniffed BLTE packets
  - Range of 100 feet could not be reached
- Created a database to organize and store all of the data
- Developed a website to visualize the data to viewers in a meaningful way
- Created an inconspicuous sniffing device with a surprising form factor

Acknowledgement

- **Brad Tilley**, Subject Matter Expert
  - Technical guidance and support throughout the project
- **Randy Marchany**, Customer
  - Providing this project opportunity
- **Dr. Scot Ransbottom**, Mentor
  - Motivating the team and giving feedback

Biosensor to Measure Ventricle Flowrate and Pressure for Children with Congenital Heart Defects

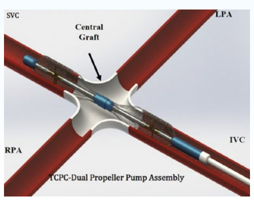
Team Members: Sarah Gudelis, Ward McHenry, Varun Modak, Arin Ofir, Anna Taylor
SME: Bright Katey **Mentor:** Kenneth Schulz **Customer:** Alexandrina Untaroiu

Motivation

- **40,000 children** are born each year in the U.S. with congenital heart defects which require constant surgery
- Around **2000 children were on a waitlist** for heart transplants in 2015, but only **968 were able to receive them**
- Existing procedures reduce cardiac output, necessitate heart transplant every few years and have a **survival rate of 50-70%**, causing hepatic dysfunction and liver cirrhosis

Background

- Dual Propeller Pump was designed and built by the VT Mechanical Engineering Department (Figure 1).
- This device pictured in Figure 1 helps circulate blood through the children's body via an implantable motor with dual propellers and a graft
- Customer requests a device to measure propelled blood flow rate and blood pressure.



SVC - Superior Vena Cava
IVC - Inferior Vena Cava
LPA - Left Pulmonary Artery
RPA - Right Pulmonary Artery

Figure 1. VT ME Figure for Pump Assembly

Objectives

- Design, build, and test a biocompatible sensor to measure blood flow rate and blood pressure in children with congenital heart defects, to constantly monitor the blood flow rate and blood pressure of the patient. The sensors must avoid any possible flow restriction during operation and conform to the connector surface.

System Design and Testing Setup

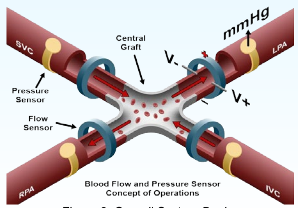


Figure 2. Overall System Design

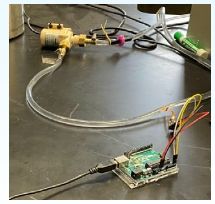


Figure 3. Pressure Sensor Testing Setup

Figure 4. Blood Flow Sensor Testing Setup

Pressure Sensor Design

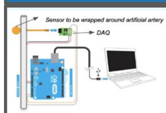


Figure 5. Testing Setup

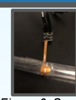


Figure 6. Sensor Around Artificial Artery

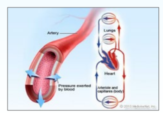


Figure 7. Vessel's Blood Pressure (CPR Life Support Network)

- The pressure sensor is based on the principle of the relationship between applied force and the subsequent change in capacitance.
- Thus, a range of 1 N/m^2 pressure exerted onto the inner walls of the artificial artery is measured by a highly sensitive capacitive force sensor
- The capacitive readings are collected by a DAQ and Arduino for further analysis
- The sensor is wrapped around an artificial artery as opposed to the blood vessel itself, so as to not interfere with natural vessel growth over time.

Flow Sensor Design

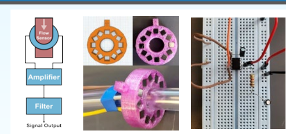


Figure 8. Flow Sensor System Concept and Build.

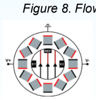


Figure 9. Halbach Array

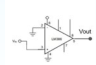


Figure 10. Amp Diagram

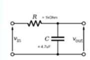


Figure 11. Filter Diagram

- The flow sensor is based on Faraday's law of induction
  - A conductor moving through a magnetic field will experience an EMF proportional to the velocity.
    - "Conductor" is a saline solution.
  - A halbach array to creates the magnetic field.
- Amplification boosts the small signal output from the flow sensor (~5 mv amplitude → ~100 mv amplitude)
- Filter design extracts only a signal's low frequencies of constant flow and heartbeat pulses (< 50 Hz)

Results and Analysis

- The pressure sensor shows increases and decreases in force applied to the artery when flow is started and stopped
- A difference of 0.07 N/m
- The flow sensor shows an ability to distinguish **No Flow** vs **Flow** states
- The flow sensor shows a difference of 0.022 V from no flow baseline under 23.5 ml/s (1.41 L/min)

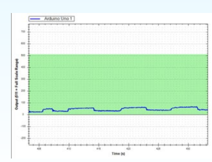


Figure 12. Pressure Sensor Output

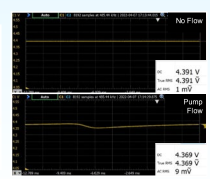


Figure 13. Flow Sensor Output

Future Improvements

Future improvements would commercialize our prototype by following biomedical device standards.

- All internal components must be coated in biocompatible material (ex. Silicon)
- **Artificial Arteries**
  - Polyglycolic acid polymer scaffold: PGA-CL/LA
  - Scaffolding seeded with cells, creating an autologous graft
- **Pressure Sensor**
  - Biocompatible coating: polyurethanes, silicone polymer
- **Blood Flow Sensor**
  - Switch to low power Op-Amp (INA321)
  - 3D-print with biocompatible material (ex: Ti6Al4V)
- **Remote Monitoring**
  - To allow remote data access outside of the patient's body

Conclusion

- The sensors will be attached to the outside of the Dual Propeller Pump to verify the function of the pump device.
- Through research and development, we were able to satisfy all critical requirements given by the customer.

Requirement	Satisfied Through
Mountability	Design
Non-Obstructive	Design
Accuracy	Design
Low Power	Design and Research
3D-Printable	Design and Research
Bio-Compatible	Research

Figure 14: Critical Requirements

Acknowledgements

The Biosensor team would like to thank our SME, Bright Katey, our customer, Alexandrina Untaroiu, and our mentor, Kenneth Schulz for their guidance and expertise throughout the design process.

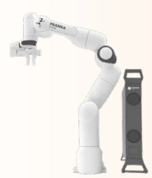
Grounded Force Feedback Arm with Haptic Glove

Cameron Dunning, Max Stelmack, Minh B. T. Nguyen, Nick Tremaroli, Sam Schoedel

Customer: VT TREC Lab, Subject Matter Expert: Dr. Alexander Leonessa

Problem Statement

- Grounded force feedback has been done in the past with the user's hand represented as a simple sphere, but rarely—if at all—with the user's entire hand.
- TREC Lab owns a robotic arm and set of HaptX gloves, the primary physical components required to enable force rendering on a user's entire hand.
- Goal is to develop physical interfaces for mounting the glove to the arm and communication interfaces between a virtual environment and a controller to accurately render forces on the user's hand based on their virtual interactions.



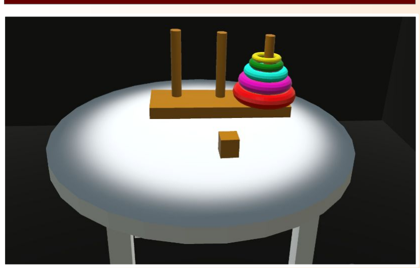
Panda arm

HaptX glove

Key Requirements

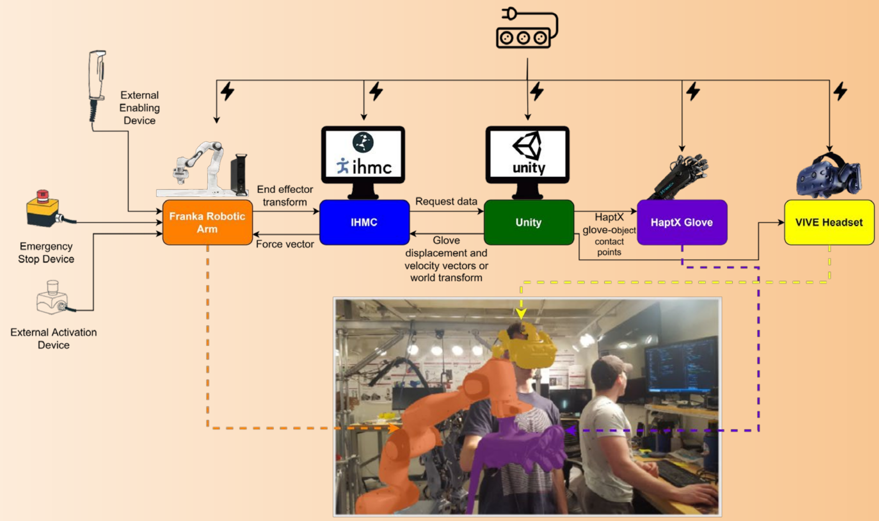
- Simulate interactions in virtual reality.
- Render forces to within an accuracy of 15% of the desired force value, a difference imperceptible to most humans.
- Keep communication pipeline traversal time below that which is perceptible by humans. Any delay in force under 20ms is generally considered imperceptible.

Virtual Environment



"Tower of Hanoi" virtual environment

End-to-end Communication Pipeline



Full communication pipeline diagram

- IHMC Open Robotics Software mediates communication between Unity and the Panda Arm.
- ROS-Bridge websocket connects Unity to IHMC.
- A custom-made TCP local host connects IHMC to the Panda Arm.
- Initialization process is streamlined into a single button press for the user.

Force Control

- Tested various applied forces at the end effector using generic kitchen scale.
- Rendered forces within 1 N (0.25 lbs) of target.
- Force rendering accuracy within the common threshold of human noticeability for forces above 5 N (1.1 lbs).

Simulating 0.5 kg mass on scale

Simulating 2.0 kg mass on scale

Arm Integration

HaptX glove back of hand iterations

- Worked with HaptX to design a new Back of Hand (BoH) to mount glove to arm.
- Iterated numerous times to perfect design.
- Design 3 gives the largest range of motion given the Panda arm joint constraints and common user interactions.

Results

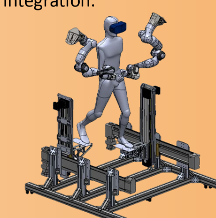
- The arm applies forces on the user's hand to recreate their experiences in virtual reality.
- RosBridge communication between Unity and IHMC works reliably with delay under **7 ms**.
- Socket communication between IHMC and the Franka Emika Panda arm works reliably with delay under **8 ms**.
- User is capable of experiencing interactions with generalized virtual environments.

Implementations	Cube (1-10)	Table (1-10)	Tower (1-10)
Use Object Mass Only	5	1	1
Distinguish Between Static and Dynamic Objects	5	4	5
Generalize Forces Using Glove Displacement	8	6	8

Average user feedback for various interactions across different implementations

Future Work

- This project is intended to integrate into the TREC lab's ForceBot, where users will have force feedback on all limbs.
- Arm system designed around same technologies as ForceBot, but more documentation and testing is required for smooth integration.



Future ForceBot Design

Acknowledgments

- Dr. Alexander Leonessa for the use of the TREC Lab and his dedication to the team's success.
- Jesper Smith for his contribution of ROS Bridge functionality to IHMC Open Robotics Software.
- Dr. Du and his students Qi Zhu and Tianyu Zhou for sharing research on Unity force extraction.
- NSF grant #2024772: A Robotic Platform for Body-Scale Human Physical Interaction in Embodied Virtual Reality.

Emergency Management Center in Blacksburg, VA

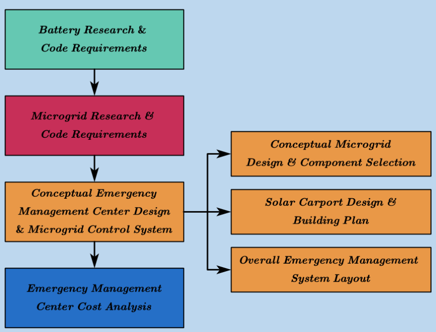
Team: Eric Carr, Fadi Farid, Colin Farrell, Kevin Nolan

SME: Minh Ngo | **Mentor:** Prof. Toby Meadows | **Customers:** Dan Morton & Chuck Niedermayer

Introduction

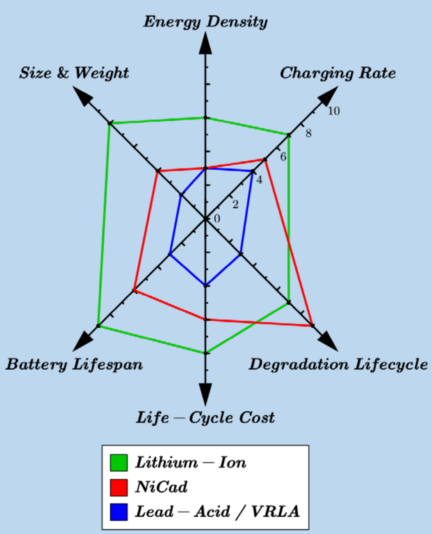
Create an **emergency management center** and **microgrid** utilizing **renewable energy** and **battery storage** to achieve greater energy independence, reduce environmental impacts, and reduce overall electricity costs.

Project Objectives



Battery Research & Code Requirements

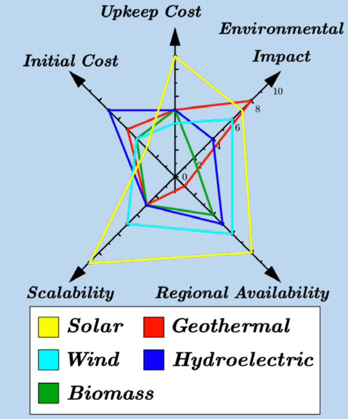
Battery Criteria Comparison



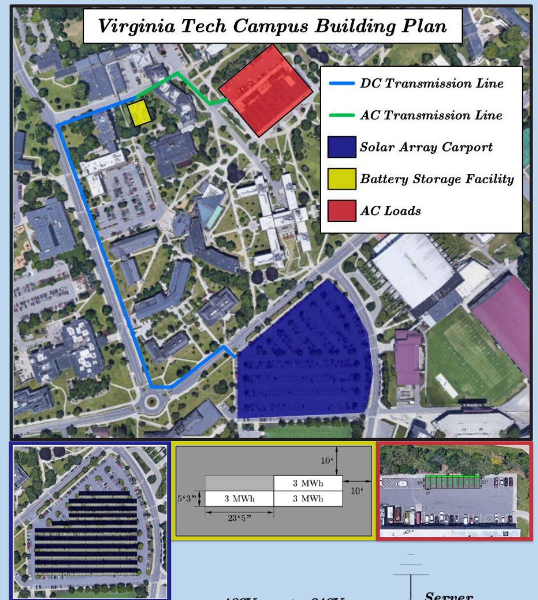
Our selection of the **lithium-ion** battery must abide by the following code requirements: NFPA 1 Ch. 52, UFC 3-600-01, International Building Code, 2021, NFPA 855, and International Fire Code, 2018.

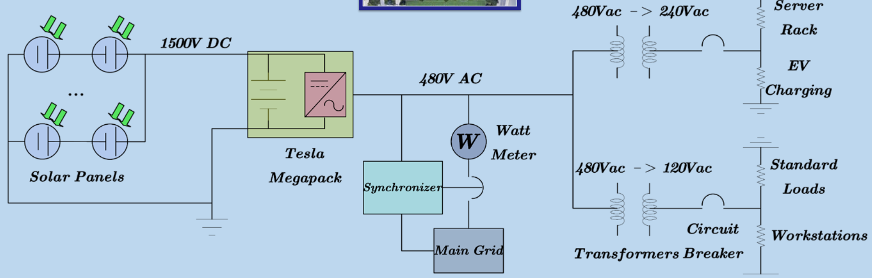
Microgrid Research & Conceptual Design

Renewable Energy Comparison



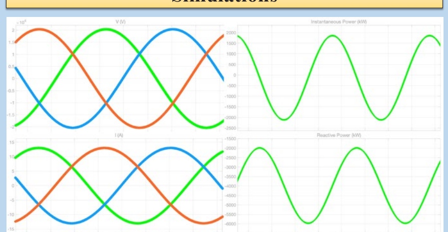
Solar was chosen as our energy source despite its high initial cost due to its long-term cost savings, as well as its superiority in other metrics.





Schematic Diagram of Microgrid

Simulations



Transformer Outputs

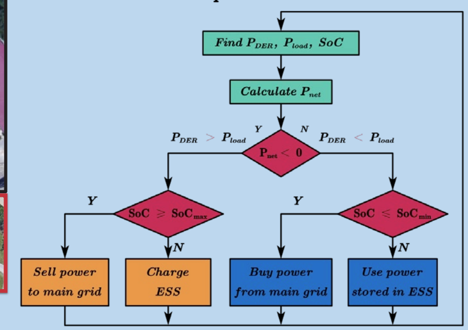
Microgrid System Cost Analysis

Part	Cost	Maintenance
Solar Panels	$2,091,500	Annual
DC Wire	$140,613	Annual
Battery	$4,389,200	Annual
AC Wire	$63,259	Annual
Transformer 1	$31,050	3-6 Months
Transformer 2	$19,763	3-6 Months
Watt Meter	$940	Annual
Synchronizer	$1,771	Annual
Lifetime System Value Generated:		$9,949,681

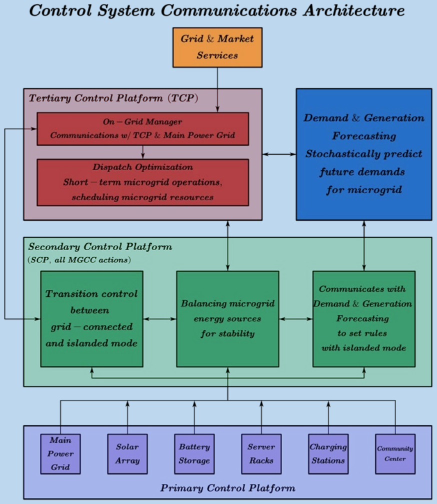
Microgrid Control System

- Microgrids have two main modes of operation:
  - **Grid-connected mode** – supplies or draws power to and from the main grid
  - **Islanded mode** – operates independently from the main grid
- Microgrid sources use **PQ control** and **Droop control** to adjust active power, reactive power, and output power
- Decision Tree Equations:
  - $SoC_{min} \leq SoC \leq SoC_{max}$
  - $P_{net} = P_{load} - P_{DER}$

Economic Dispatch Decision Tree



Control System Communications Architecture



Acknowledgements

Our team would like to thank our SME, **Minh Ngo**, our Mentor, **Prof. Toby Meadows**, and our customers, **Dan Morton** and **Chuck Niedermayer** for their insightful advice and undeniable passion and support throughout this project.

SpO_2 Measurment Instrument Project

Hristro Ignatov and Fatima Alkaabi
Professor Md Adnan Sarker
Department of Electrical and Computer Engineering , Virginia Tech

Introduction

An SpO2 measurement device is an affordable and efficient measurement device that uses multiple LEDs to measure the percentage of oxygen saturation in the blood of a person [2,3]. Using a Red and Infrared LED, the design team was able to construct a system that switches between the two LEDs in order to display the user's heart rate and oxygen level on a display screen. The team worked on this project as part of the Integrated Design Project Course [ECE 2804] under the Department of Electrical and Computer Engineering.

Project Subsystems

Review Of Systems

- **LEDs:**
  Two LEDs, Red and Infrared are used.
- **Transimpedance Amplifier:**
  Converts the current from the sensor into a voltage we can use.[1]
- **Filters and Amplifiers:**
  The main circuit which cleans up the signal and amplifies it for the microcontroller.
- **Arduino:**
  The microcontroller which takes in the input waveforms of the LEDs and calculates the heart rate and oxygen saturation.
- **Display:**
  Shows the user their heart rate and oxygen level.

Design Approach

- **Circuit:**
  For the circuit, the team aimed to make something small and simple while providing the microcontroller with waveforms it could accurately read. Two filters were utilized, a low pass and a high pass, alongside an amplifier and a voltage shifter.
- **Software:**
  The software was designed to measure the Heart Rate and Oxygen level. The Heart Rate was measured by finding two peaks of the incoming signal and finding the difference between them. The Oxygen level was measured by turning on the Red LED, finding its smallest and peak to peak voltage, then turning on the Infrared LED and doing the same. Once both were found they were divided and an R value was calculated:
  R = (red AC/ red DC) / (infrared AC/ infrared DC)

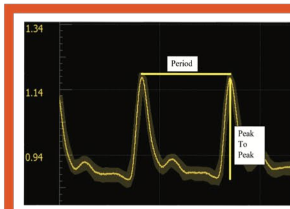


Figure 1: Image of the sensor reading showing the Period and Peak used to measure the heart rate & oxygen level.

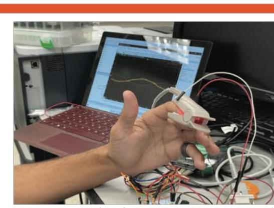


Figure 2: Image of the finger sensor placed on the user's finger that holds the Red and Infrared LED.

Changes From Original

- **Original:**
  Traditional SPO2 devices have added measures to increase speed but result in a lot more noise and complexity. The LEDs are switched quickly which results in large voltage spikes and a waveform that must be further cleaned up using extra filters and software. The software must also incorporate "Interrupt Service Routines" to switch the LEDs quickly enough without blocking the rest of the software.
- **This Version:**
  Our team realized that instead of quickly switching the LEDs, instead the LEDs could be switched only after the data that was needed was extracted. This resulted in a slower reading being done, but cut the complexity and price to a third.

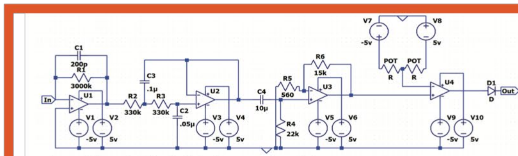


Figure 3: Schematic of the final circuit generated on LTSpice.

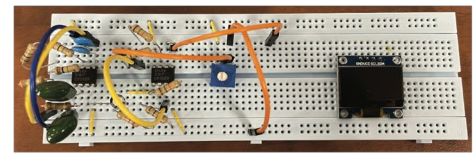


Figure 4: Image of the final circuit implemented on a breadboard.

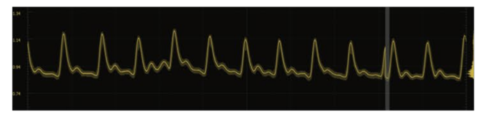


Figure 5: Image of heartbeat waveform generated by the final circuit.

Conclusion

The team was successful in building a fully functioning and accurate SpO2 measurement device using concepts and tools provided by the course instructor. We hope this poster gives the readers an insight of our process and hopefully guidance on future attempts of recreating it.

References

[1] Pulse Oximeter - Fundamentals and Design - NXP. https://www.nxp.com/docs/en/application-note/AN4327.pdf.
[2] "Pulse Oximetry." Yale Medicine, Yale Medicine, https://www.yalemedicine.org/conditions/pulse-oximetry.
[3] How to Design Peripheral Oxygen Saturation (spo2 ... - Ti.com. https://www.ti.com/lit/an/slaa655/slaa655.pdf.

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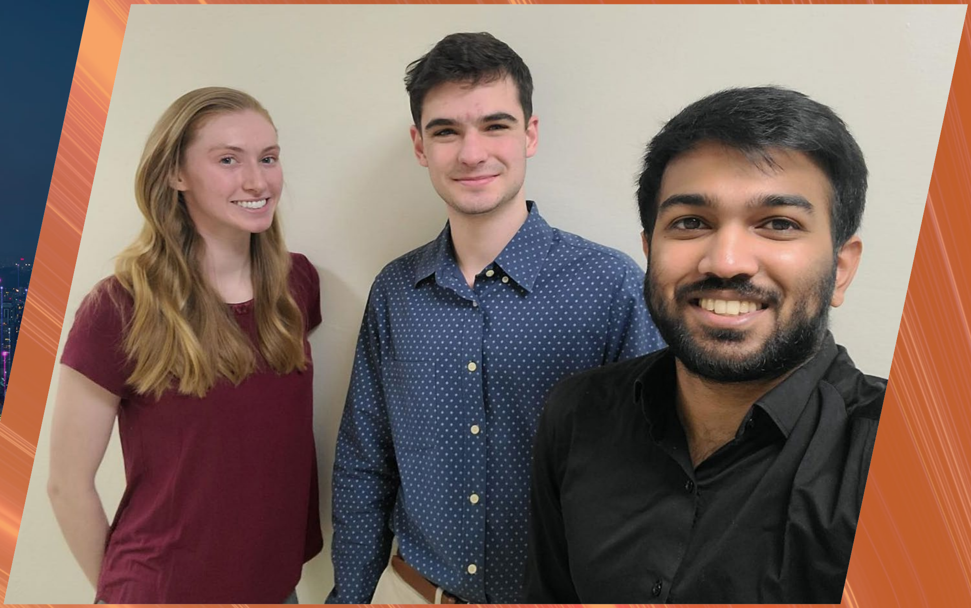
Faculty Advisor:
- Md Adnan Sarker : Sarker@vt.edu



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