

AGEN/MSYM 436/836: Embedded Controls for Agricultural Applications

Prereqs: AGEN/BSEN 260 or MSYM 416 or Permission

Department of Biological Systems Engineering

Fall 2021

Instructor:

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Virtual Office Hours:

By appointment

Meeting times:

Lecture: MW, 12:00 PM to 12:50 PM

Lab: Wednesday's 1:00 PM to 2:50 PM

Teaching Assistants:

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Catalog Description:

AGEN/MSYM 436/836 Embedded Controls for Agricultural Applications. Prereq: AGEN/BSEN 260 or MSYM 416 or permission. This course introduces students to the basics of embedded controller programming, and the development of Controller Area Network (CAN) bus systems in agricultural applications. Interfacing sensors with analog and digital signals, closed loop control of actuators, transmission and reception of CAN messages, programming of CAN messages in a distributed controller set up for sensor data acquisition, and actuator control will be studied.

▪ **Overarching Learning Goals:**

1. Ability to program micro-controllers (Arduino) using text based programming languages (C/C++)
2. Ability to program micro-controllers (Danfoss) using Graphical User Interface (GUI) programming languages (PLUS+1 GUIDE)
3. Distinguish Analog, Digital, and Frequency output sensor signals, and interface sensors generating these signals with Arduino and Danfoss Controllers
4. Develop Arduino sketches with variables, functions, arrays, if-statements and for-loops.
5. Understand the CAN message structures and CAN bus physical layer.
6. Understand and decode CAN messages obtained from off-road equipment (e.g., tractors, combines, and sprayers).
7. Develop PLUS+1 GUIDE applications with standard function blocks, mathematical components, CAN functions for data acquisition, CAN message transmission and reception, and actuator control
8. Network Plus+1 controllers using CAN message encoding.
9. Develop fully functional programmable CAN bus demonstrators with multiple Plus+1 Controllers.

Class Schedule of Topics (Tentative: Subject to Change)

Week	Topics
1	Voltage, Current, Ohm's Law, Series and Parallel Circuits, Variable Resistors and Potentiometers
2	Analog Signals, Digital Signals, A/D conversion Lab 1 - Voltage, Current Measurement and Introduction to Arduino Interfacing potentiometer with Arduino
3	Variable, Array creation and Pulse Width Modulation (PWM), Lab 2 – Data Acquisition and Sketches development using Arduino , variable and array creation if-else and for loops
4	Lab 3 – PWM using Arduino and Interfacing IR sensors, Motors with Arduino (Arduino Project Assign)
5	Introduction to Controller Area Network Lab 4 – CAN message Data collection from tractors
6	CAN bus Physical Layer and Message Arbitration Lab 5: CAN message decoding from tractor bus
7	CAN bus systems timing, events, and limitations Lab 6: CAN message decoding from implement bus (Arduino Project Due)
8	Introduction to PLUS+1 Controllers Lab 7: PLUS+1 controller pin diagrams, API
9	Introduction to PLUS+1 GUIDE programming Lab 8: Blink LED, Read Analog and Digital signals PLUS+1 controllers
10	PLUS+1 Service tool and log file creation in GUIDE Lab 9: Creating basic and advanced log files for data acquisition and analysis (Course Project Assign)
11	GUIDE Function Blocks and Closed Loop Control Lab 10: PWM using Plus+1 GUIDE
12	GUIDE programming using Pages Lab 11: Creating user defined functions in GUIDE using pages
13	CAN Transmit and Receive blocks in GUIDE Lab 12: Programming for Tx and Rx of CAN messages
14	Message encoding Using GUIDE Lab 13: Analyzing CAN bus traffic and messages using CANKing, Using Danfoss Joystick 600 to perform closed loop control of multiple actuators of a machine system (Course Project Presentations)
15	Finals Week (Project Report Due)

References and Resources:

- <https://www.arduino.cc/en/Main/Software>
- <http://powersolutions.danfoss.com/products/plus-1-software/>
- <https://www.kvaser.com/about-can/higher-layer-protocols/j1939-introduction/>
- https://elearning.vector.com/index.php?seite=v1_can_introduction_en&root=378422&wbt_ls_kapitel_id=489553&wbt_ls_seite_id=489554&d=yes

COVID-19 Face Covering Policy:

An individual in this course has a documented need for face coverings to be required in this course. Without divulging personal or identifying information, such a documented need might be that a member of their household is unable to be vaccinated or has a health condition that makes vaccines less effective for them. As a result, the College of Agricultural Sciences and Natural Resources has determined that face coverings will be required in this course. If you are unwilling to comply with this requirement, please visit with your advisor about different sections or possible alternative courses that you might take in lieu of this one.

Grading System:

<u>Component of Work</u>	<u>Contribution to Semester Average</u>
*Class Participation	5%
Labs	20%
Assignments	25%
Projects	50%

The semester average will be determined as a composite of your class participation, assignments and projects. The portion each contributes to the semester average is shown in the table above. The instructor reserves the right to adjust the scale. Borderline grades will be decided based on the completion of assignments and projects. Tentatively three projects will be assigned during the course of the semester.

Grading System for Graduate Student Credit:

Students taking this course for graduate credit (836) are expected to work on a semester long course project. A potential outcome of the project is a technical article that could be submitted to conference proceedings of an international engineering conference or for journal publication.

<u>Component of Work</u>	<u>Contribution to Semester Average</u>
Course Project and Technical Article	Course Project (80%), Technical Article (20%)

The grade assigned will be based on the semester average as shown in the table below.

Semester Average	Grade	Semester Average	Grade	Semester Average	Grade
96.7-100%	A+	83.3-86.7%	B	70.0-73.3%	C-
93.3-96.7%	A	80.0-83.3%	B-	66.7-70.0%	D+
90.0-93.3%	A-	76.7-80.0%	C+	63.3-66.7%	D
86.7-90.0%	B+	73.3-76.7%	C	60.0-63.3%	D-
				0-60.0%	F

Pass/No Pass Option – Students enrolled under this option must achieve at least the percentage required for a C letter grade to receive a passing grade (P). See SCHEDULE OF CLASSES. University policy regarding marks of I (incomplete) and W (withdraw) will be followed in this course. See SCHEDULE OF CLASSES.

Attendance Policy:

Changes to the class schedule or assignments will be announced during the work session. Each student is responsible for everything discussed during the work session. Attendance will not normally be taken; however, excessive absences will adversely affect the class participation portion of your grade.

Academic Dishonesty:

Students are expected to adhere to guidelines concerning academic dishonesty outlined in Section 4.2 of the University's Student Code of Conduct (<http://stuafs.unl.edu/ja/code/>). The BSE Department process for grade and academic dishonesty appeals can be found at <http://bse.unl.edu/academicadvising-index> Students are encouraged to contact the instructor for clarification of these guidelines if they have questions or concerns.

- **Fire Alarm (or other evacuation):** In the event of a fire alarm: Gather belongings (Purse, keys, cellphone, N-Card, etc.) and use the nearest exit to leave the building. Do not use the elevators. After

exiting notify emergency personnel of the location of persons unable to exit the building. Do not return to building unless told to do so by emergency personnel.

- **Tornado Warning:** When sirens sound, move to the lowest interior area of building or designated shelter. Stay away from windows and stay near an inside wall when possible.
- **Active Shooter**
 - **Evacuate:** if there is a safe escape path, leave belongings behind, keep hands visible and follow police officer instructions.
 - **Hide out:** If evacuation is impossible secure yourself in your space by turning out lights, closing blinds and barricading doors if possible.
 - **Take action:** As a last resort, and only when your life is in imminent danger, attempt to disrupt and/or incapacitate the active shooter.
- **UNL Alert:** Notifications about serious incidents on campus are sent via text message, email, unl.edu website, and social media. For more information go to: <http://unlalert.unl.edu>.
- Additional Emergency Procedures can be found here: http://emergency.unl.edu/doc/Emergency_Procedures_Quicklist.pdf

Students with Special Needs

- Students with disabilities are encouraged to contact the instructor for a confidential discussion of their individual needs for academic accommodation. It is the policy of the University of Nebraska-Lincoln to provide flexible and individualized accommodation to students with documented disabilities that may affect their ability to fully participate in course activities or to meet course requirements. To receive accommodation services, students must be registered with the Services for Students with Disabilities (SSD) office, 132 Canfield Administration, 472-3787 voice or TTY.