Electronics Solid State/Semiconductor Systems - AES

Level: 3
Career Cluster: Advanced Manufacturing
Program: Engineering
Pathway(s): Aerospace Engineering Technician

Course Catalog Description

Introduces solid-state electronics and semiconductor devices used in aerospace engineering. Students learn circuit design, testing, and troubleshooting using safe lab practices.

Summary

This course provides students with a comprehensive study of solid-state electronics and semiconductor devices within the context of aerospace engineering technology and avionics systems. Students explore career pathways, professionalism, ethics, and postsecondary opportunities while building a strong foundation in laboratory safety, semiconductor materials, atomic structure, charge carriers, and device behavior. Through the study of pn junction diodes, rectifiers, transistors, field effect transistors, sensors, and other modern semiconductor devices, students learn how electronic components function in aircraft, spacecraft, satellite, navigation, communication, and control systems. Hands-on learning is emphasized as students interpret schematics, construct and test circuits, measure performance, troubleshoot faults, and refine designs using industry-relevant tools and practices. By the end of the course, students apply their understanding of semiconductor theory and electronic circuit design to complete a final project that demonstrates technical knowledge, problem-solving, effective communication, and awareness of aerospace reliability requirements in demanding environments.

Notes

This revised version is more clearly organized and more directly aligned to the Aerospace Engineering Technician pathway. The updated document expands the content into structured instructional sections with objectives and sequenced outcomes, strengthens the emphasis on semiconductor applications in aerospace and avionics systems, and adds new components such as Leadership and Work-Based Learning to better support employability, industry connection, and career readiness. It also places greater emphasis on hands-on circuit construction, testing, troubleshooting, and application of semiconductor concepts in real-world technical settings, giving students more opportunities to connect theory with practice. In addition, the course now reflects a more intentional progression from foundational physics and device theory to circuit performance, diagnostics, and final project-based application. Overall, the new course moves beyond a general solid-state electronics outline to provide a more pathway-specific, student-centered, and standards-aligned framework.

Student Learning Outcomes

1. Career Exploration and Postsecondary Opportunities

Objective: *Students will analyze career pathways in aerospace engineering technician by exploring industry roles, workplace expectations, required education, certifications, professional organizations, and postsecondary opportunities available in Colorado in order to make informed academic and career decisions.*

1) Identify employment opportunities in various fields with a focus in the area of aerospace engineering technician
    a. Recognize the work typically performed, tools and technology used, and nature of work environments
    b. Identify potential certifications within the careers
    c. Find membership organizations associated with the careers
    d. Understand the necessary education associated within the careers
2) Define professionalism within the context of aerospace engineering technician
    a. Criticism and evaluation
    b. Presentation
    c. Assessment
3) Recognize laws, regulations, and ethics significant to the fields of aerospace engineering technician
4) Identify postsecondary opportunities offered in the state of Colorado
    a. Technical college, community college, 4-year institutions
    b. Certificates, associates, bachelor, and advanced degree opportunities

2. Safety Tools and Semiconductor Laboratory Practices

Objective: *Students will apply safe practices and proper procedures when working with electronic components and semiconductor devices used in aerospace and avionics systems to ensure safe operation, reliability, and prevention of component damage.*

5) Interpret electrical and electronics safety standards and procedures
6) Demonstrate safe handling of semiconductor components and lab equipment
7) Identify hazards related to electronic circuits, heat, and electrostatic discharge
8) Apply proper storage and organization techniques for sensitive components
9) Evaluate laboratory workspaces for safety compliance

3. Foundations of Solid State Physics and Materials

Objective: *Students will explain the physical principles of semiconductor materials to analyze their behavior in aerospace electronic and avionics systems.*

10) Describe atomic structure and electron behavior in materials
11) Differentiate conductors, insulators, and semiconductors
12) Explain intrinsic and extrinsic semiconductor materials
13) Analyze how doping affects conductivity and charge carriers
14) Interpret the concepts of valence band, conduction band, and band gap
15) Evaluate how material properties influence electronic device performance

4. Charge Carriers and Semiconductor Behavior

Objective: *Students will analyze the movement of charge carriers within semiconductor materials to predict electrical behavior in aerospace circuits, sensors, and control systems.*

16) Identify electrons and holes as charge carriers
17) Explain carrier movement under applied voltage
18) Describe drift and diffusion processes
19) Analyze carrier behavior under different temperature and voltage conditions
20) Evaluate how charge flow enables electronic device operation

5. PN Junction Diodes and Device Operation

Objective: *Students will analyze the operation of PN junction diodes to explain their role in controlling current flow in aerospace electronic and avionics applications.*

21) Describe the formation of a pn junction and depletion region
22) Explain forward bias and reverse bias conditions
23) Interpret diode current-voltage characteristics
24) Compare ideal and real diode behavior
25) Analyze barrier voltage and breakdown
26) Evaluate diode performance in circuit applications

6. Diode Applications and Power Conversion

Objective: *Students will apply diode principles to design and evaluate circuits used for power conversion, voltage regulation, and signal processing in aerospace systems.*

27) Construct half-wave and full-wave rectifier circuits
28) Explain rectification and AC to DC conversion
29) Analyze power supply performance and ripple
30) Apply Zener diodes for voltage regulation
31) Evaluate circuit efficiency and output stability
32) Design circuits that meet basic power requirements

7. Transistor Fundamentals and Switching Behavior

Objective: *Students will analyze transistor operation to explain their role as switches and amplifiers in aerospace electronic control and communication systems.*

33) Identify types of transistors including BJT and basic configurations
34) Explain transistor structure and current flow
35) Analyze cutoff, active, and saturation regions
36) Demonstrate transistor operation as a switch
37) Evaluate the role of transistors in electronic control systems

8. Transistor Biasing and Amplification

Objective: *Students will apply biasing techniques to operate transistors effectively as amplifiers in analog aerospace electronics and instrumentation circuits.*

38) Explain the need for biasing in transistor circuits
39) Construct basic biasing circuits
40) Analyze amplifier behavior using transistor configurations
41) Compare different amplifier types and outputs
42) Evaluate signal amplification and circuit stability

9. Field Effect Transistors and Advanced Devices

Objective: *Students will analyze field effect transistor devices to compare their operation and applications in aerospace control, sensing, and power management systems.*

43) Identify JFET and MOSFET devices
44) Explain voltage-controlled operation of FETs
45) Compare FETs and BJTs in function and design
46) Analyze basic FET circuit performance
47) Evaluate appropriate applications of FET technology

10. Semiconductor Devices in Modern Applications

Objective: *Students will evaluate real-world semiconductor devices to explain their role in modern aerospace technology systems, including avionics, navigation, sensing, and communications.*

48) Identify devices such as LEDs, photodiodes, and sensors
49) Explain how semiconductor devices operate in electronic systems
50) Analyze the role of semiconductors in everyday technology
51) Compare device performance across applications
52) Evaluate device selection based on design needs

11. Circuit Construction Prototyping and Testing

Objective: *Students will construct and test semiconductor-based circuits to verify theoretical concepts, performance, and reliability expectations for aerospace applications.*

53) Construct circuits using semiconductor components
54) Interpret electronic schematics accurately
55) Measure voltage and current using testing tools
56) Analyze differences between expected and measured results
57) Modify circuits to improve performance
58) Evaluate reliability and accuracy of constructed circuits

12. Troubleshooting and Diagnostic Analysis

Objective: *Students will diagnose and resolve faults in semiconductor circuits through systematic troubleshooting methods used in aerospace electronic and avionics systems.*

59) Identify common semiconductor circuit failures
60) Apply structured troubleshooting strategies
61) Analyze circuit behavior to locate faults
62) Test components to verify functionality

63) Implement repairs or modifications
64) Evaluate effectiveness of corrective actions

13. Semiconductor Design Application Final Project

Objective: *Students will design, construct, and present a semiconductor-based circuit or subsystem that demonstrates mastery of solid-state concepts in an aerospace application.*

65) Define a problem requiring a semiconductor solution
66) Design a circuit using appropriate semiconductor components
67) Construct and test a functional prototype
68) Analyze performance using measured data
69) Refine the design based on testing results
70) Present the final solution using technical communication
71) Evaluate system effectiveness and design decisions
72) Reflect on engineering process and learning outcomes

14. Leadership

Objective: *Students will demonstrate leadership skills by applying communication, collaboration, responsibility, and ethical decision-making in classroom, laboratory, and project-based aerospace engineering environments.*

73) Demonstrate effective communication and teamwork in technical settings
74) Apply problem-solving and decision-making skills during projects and lab activities
75) Exhibit responsibility, initiative, and accountability in individual and group work
76) Practice ethical behavior and professionalism in aerospace engineering contexts
77) Evaluate personal leadership growth through reflection and feedback

15. Work-Based Learning

Objective: *Students will connect classroom learning to real-world aerospace engineering and electronics applications through career awareness, industry engagement, and authentic work-based learning experiences.*

78) Identify work-based learning opportunities related to aerospace engineering and electronics
79) Engage with industry professionals through guest speakers, site visits, mentoring, or career-connected activities
80) Apply technical and employability skills in authentic workplace workplace tasks
81) Document and reflect on work-based learning experiences to evaluate career readiness and future goals

16. Career and Technical Student Organizations

Objective: *Using the CTSO Resource Document, chapter activities will provide some of the best opportunities CTSO members will have to learn by doing. A successful program of work creates a positive learning atmosphere in the classroom. CTSO members learn how to accept responsibility, work as a team, manage a budget, and handle success and failure. Per the CTE Admin Handbook, CTSOs are embedded into curriculum.*

Professional Development

Prepare each member for entry into the workforce and provide a foundation for success in a career. Becoming a professional does not stop with acquiring a skill, but involves an increased awareness of the meaning of good citizenship and the importance of labor and management in the world of work.

Community Service

Promote and improve goodwill and understanding among all segments of the community through services donated by CTSO chapters, and to instill in its members a lifetime commitment to community service.

Business and Industry Connections

Increase awareness of quality job practices and attitudes, and increase the opportunities for employer engagement and eventual employment.

Financial Leadership

Plan and participate in activities to allow all members to carry out the chapter's projects. Educate members on their own personal finance for current and future success.

Public Relations

Make the general public aware of the good work that students in career and technical education are doing to better themselves and their community, state, nation, and world.

Social Activities

To increase cooperation in the school and community through activities that allow CTSO members to get to know each other in something other than a business or classroom setting.

Academic Standards Alignment

Colorado CTE courses are required to integrate academic and essential skills into course content. The following academic standards have been identified as aligned to this course and should be integrated throughout instruction.

CO CTE Academic Standards Resources (Rubrics, integration strategies, etc)
CDE Colorado Academic Standards Online (Online standards lookup tool)

Note: Mathematics and Science standards will be added in the future. Visit the Colorado Academic Standards page for the most current version.

Reading, Writing and Communicating Crosswalk

Course: Electronics Solid State/Semi Conductor
Colorado Academic Standards – Reading, Writing, and Communicating

Standard	Prepared Graduate Competency	Description	Course Evidence / Alignment
Standard 1: Oral Expression and Listening	Prepared Graduate 1 – Collaboration	Collaborate effectively as group members or leaders.	Students work collaboratively in laboratory settings to build, test, and compare solid-state devices for aerospace and avionics applications; discuss procedures, safety practices, and device behavior; and apply feedback while troubleshooting and refining circuits.
Standard 1: Oral Expression and Listening	Prepared Graduate 2 – Oral Presentations	Deliver effective oral presentations for varied audiences and varied purposes.	Students verbally explain semiconductor concepts and device operation, communicate testing results and design choices, and present lab findings connected to aerospace electronics,

			avionics, and system reliability.
Standard 2: Reading for All Purposes	Prepared Graduate 4 – Informational Texts	Read a wide range of informational texts to build knowledge.	Students read and interpret technical manuals, datasheets, schematics, informational texts on solid-state physics, and safety guidelines relevant to aerospace electronics and avionics labs.
Standard 2: Reading for All Purposes	Prepared Graduate 5 – Language in Context	Understand how language functions in different contexts.	Students use accurate electronics and aerospace terminology, interpret symbols and notation, and adjust communication for explanatory, safety, maintenance, and technical reporting contexts.
Standard 3: Writing and Composition	Prepared Graduate 6 – Craft arguments	Craft arguments using techniques specific to the genre.	Students justify circuit design and component selection, defend conclusions from testing and comparison of device characteristics, and support claims with observed data and technical evidence related to aerospace performance needs.
Standard 3: Writing and Composition	Prepared Graduate 7 – Informational Writing	Craft informational/explanatory texts using techniques specific to the genre.	Students produce written explanations of solid-state device operation, lab reports describing procedures and results, and

			explanatory documentation connecting semiconductor theory to aerospace and avionics circuit applications.
Standard 3: Writing and Composition	Prepared Graduate 9 – Writing Process	Demonstrate mastery of their own writing process.	Students draft, revise, and finalize technical lab reports and documentation using correct terminology, symbols, and formatting to produce polished written products aligned to industry expectations.
Standard 4: Research Inquiry and Design	Prepared Graduate 10 – Research and Ethics	Gather information from a variety of sources; analyze and evaluate its quality and relevance.	Students research semiconductor devices and aerospace applications, analyze datasheets and technical references to inform circuit design, and use information ethically to support safe and effective avionics and electronics practices.

Free Resource Links

1. Career Exploration and Postsecondary Opportunities

- O NET Online (careers electronics semiconductor engineering technician pathways) https://www.onetonline.org/
- My Next Move (career exploration electronics engineering technology) https://www.mynextmove.org/
- CareerOneStop (training credentials STEM careers workforce development) https://www.careeronestop.org/
- CCCS Career Advising (Colorado postsecondary pathways engineering programs) https://cccs.edu/career-advising/

2. Safety Tools and Semiconductor Laboratory Practices

- OSHA (electronics lab safety electrical hazards compliance standards) https://www.osha.gov/
- CDC NIOSH (engineering safety hazard prevention workplace labs) https://www.cdc.gov/niosh/
- Electronics Club Safety (electronics lab procedures safe component handling) https://electronicsclub.info/
- Tool Box Talks (technical lab shop safety training procedures) https://www.toolbox-talks.com/

3. Foundations of Solid State Physics and Materials

- Khan Academy Physics (atomic structure electrons materials conductivity basics) https://www.khanacademy.org/science/physics
- MIT OpenCourseWare Materials (solid state materials semiconductor theory basics) https://ocw.mit.edu/
- CK 12 Physics (semiconductor materials band gap conductivity concepts) https://www.ck12.org/physics/
- HyperPhysics Electricity (atomic theory semiconductor principles explanation) http://hyperphysics.phy-astr.gsu.edu/

4. Charge Carriers and Semiconductor Behavior

- Electronics Tutorials Semiconductors (charge carriers electrons holes behavior) https://www.electronics-tutorials.ws/
- All About Circuits Semiconductors (charge flow semiconductor physics basics) https://www.allaboutcircuits.com/
- MIT OCW Semiconductors (carrier transport semiconductor behavior theory) https://ocw.mit.edu/
- Learn About Electronics (charge movement semiconductor operation concepts) https://www.learnabout-electronics.org/

5. PN Junction Diodes and Device Operation

- Electronics Tutorials Diodes (pn junction diode operation characteristics) https://www.electronics-tutorials.ws/diode/

- Learn About Electronics Diodes (diode operation forward reverse bias concepts) https://www.learnabout-electronics.org/
- All About Circuits Diodes (pn junction behavior applications circuits) https://www.allaboutcircuits.com/
- Khan Academy Semiconductors (diode basics semiconductor current flow) https://www.khanacademy.org/science/electrical-engineering

6. Diode Applications and Power Conversion

- Electronics Tutorials Rectifiers (half wave full wave power conversion) https://www.electronics-tutorials.ws/diode/
- Electrical4U Rectifiers (power conversion ac to dc circuits efficiency) https://www.electrical4u.com/
- Learn About Electronics Power Supplies (rectification voltage regulation circuits) https://www.learnabout-electronics.org/
- All About Circuits Power (power supply design rectifier applications) https://www.allaboutcircuits.com/

7. Transistor Fundamentals and Switching Behavior

- Electronics Tutorials Transistors (bjt operation switching amplification basics) https://www.electronics-tutorials.ws/
- All About Circuits Transistors (transistor modes switching circuits) https://www.allaboutcircuits.com/
- Learn About Electronics BJTs (transistor structure switching functions) https://www.learnabout-electronics.org/
- Khan Academy Transistors (transistor basics switching amplification concepts) https://www.khanacademy.org/science/electrical-engineering

8. Transistor Biasing and Amplification

- Electronics Tutorials Amplifiers (biasing transistor amplification circuits) https://www.electronics-tutorials.ws/
- All About Circuits Amplifiers (transistor amplifier design performance) https://www.allaboutcircuits.com/
- Learn About Electronics Amplifiers (signal amplification transistor circuits) https://www.learnabout-electronics.org/
- MIT OpenCourseWare Electronics (amplifier circuits signal gain analysis) https://ocw.mit.edu/

9. Field Effect Transistors and Advanced Devices

- Electronics Tutorials FET (mosfet jfet operation characteristics basics) https://www.electronics-tutorials.ws/
- All About Circuits FET (field effect transistor design applications) https://www.allaboutcircuits.com/
- Learn About Electronics MOSFET (mosfet operation circuits applications) https://www.learnabout-electronics.org/

- MIT OpenCourseWare Devices (advanced semiconductor devices fet applications) https://ocw.mit.edu/

10. Semiconductor Devices in Modern Applications

- SparkFun Electronics (devices led photodiode sensors applications) https://learn.sparkfun.com/
- All About Circuits Applications (semiconductor devices real world systems) https://www.allaboutcircuits.com/
- Electronics Tutorials Devices (semiconductor applications electronic systems) https://www.electronics-tutorials.ws/
- IEEE Global (technology applications semiconductor electronics systems) https://www.ieee.org/

11. Circuit Construction Prototyping and Testing

- SparkFun Breadboard Guide (prototyping circuits electronics breadboarding) https://learn.sparkfun.com/tutorials/how-to-use-a-breadboard
- Adafruit Learning System (electronics prototyping circuits projects testing) https://learn.adafruit.com/
- Digi Key Tutorials (circuit building prototyping electronics design) https://www.digikey.com/en/resources
- Tinkercad Circuits (circuit simulation prototyping testing virtual) https://www.tinkercad.com/circuits

12. Troubleshooting and Diagnostic Analysis

- iFixit (troubleshooting electronics diagnostics repair methodology) https://www.ifixit.com/
- Fluke Learn (electrical troubleshooting measurement diagnostics tools) https://www.fluke.com/en-us/learn
- All About Circuits Troubleshooting (circuit diagnostics fault analysis) https://www.allaboutcircuits.com/
- Engineering Toolbox (problem solving engineering systems troubleshooting) https://www.engineeringtoolbox.com/

13. Semiconductor Design Application Final Project

- Instructables Projects (electronics design build circuit projects ideas) https://www.instructables.com/
- Maker Ed (project based learning electronics engineering design) https://makered.org/
- MIT OpenCourseWare Projects (engineering design semiconductor applications) https://ocw.mit.edu/
- Arduino Education (electronics projects embedded systems design applications) https://www.arduino.cc/education

14. Leadership

- Overcoming Obstacles (communication decision making goal setting leadership skills) https://www.overcomingobstacles.org/
- Leading Teams Open Textbook (teamwork collaboration leadership group dynamics) https://pressbooks.usnh.edu/leadingleadingteams/
- CU Boulder Career Services Teamwork (teamwork collaboration conflict resolution professional skills) https://www.colorado.edu/career/myskills/teamwork
- Stanford Online Free Content (leadership communication professional development learning) https://online.stanford.edu/free-content

15. Work-Based Learning

- Colorado CTE (work based learning toolkit career readiness employer engagement) https://cteincolorado.org/
- CCCS Work-Based Learning (apprenticeships earn and learn workforce development) https://cccs.edu/academic-student-affairs/workforce-development/work-based-learning/
- CareerOneStop GetMyFuture (career readiness job search work experience internships) https://www.careeronestop.org/GetMyFuture/default.aspx
- Chicago Public Schools Work-Based Learning Toolkit (guest speakers site visits job shadowing internships) https://www.cps.edu/academics/work-based-learning/toolkit/

Technology Student Association – National Competitive Events

System Control Technology

Objective: *Students will design, construct, program, troubleshoot, document, and demonstrate a working control-system solution that responds to a TSA-provided problem.*

- Interpret the TSA-provided control-system problem and identify the required functions, constraints, and performance goals.
- Design a system that uses inputs, outputs, circuits, sensors, motors, controls, feedback, or programmable components.
- Create a program or control sequence that allows the system to operate as intended.
- Construct and test the system using approved materials, tools, electronics, and safety procedures.
- Troubleshoot electrical, sensor, programming, mechanical, or reliability issues to improve system performance.
- Maintain an inventor's log documenting design decisions, testing, revisions, and final system operation.
- Demonstrate the completed system and explain how the design meets the problem criteria during judge evaluation.

Resources

- Technology Student Association – System Control Technology competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- Arduino Education – Electronics and control systems https://www.arduino.cc/education
- Tinkercad Circuits – Circuit simulation and prototyping https://www.tinkercad.com/circuits
- All About Circuits – Semiconductor and electronics learning resources https://www.allaboutcircuits.com/

Technology Student Association – National Competitive Events

Technology Problem Solving

Objective: *Students will work as a team to solve an on-site TSA technology challenge by designing, constructing, testing, and evaluating a solution using limited materials, tools, and time.*

- Analyze an on-site TSA problem and identify the required task, constraints, materials, and scoring criteria.
- Collaborate with a partner to plan and construct a working solution within the competition time limit.
- Use approved materials, tools, adhesives, measuring devices, and safety procedures during construction.
- Apply engineering, electronics, and technology concepts to improve the performance of the solution.
- Test the solution using the required objective measure, such as strength, distance, time, accuracy, or task completion.
- Revise the solution based on observed performance and available time.
- Evaluate the final product using TSA criteria for problem solving, construction quality, teamwork, and measurable performance.

Resources

- Technology Student Association – Technology Problem Solving competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- TeachEngineering – Hands-on engineering design challenges https://www.teachengineering.org/
- Science Buddies – Engineering Design Process https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-process-steps
- OSHA – Young Worker Safety and Health https://www.osha.gov/young-workers

Technology Student Association – National Competitive Events

Manufacturing Prototype

Objective: *Students will design, document, fabricate, evaluate, and present a manufactured prototype that meets TSA Manufacturing Prototype requirements for production quality, technical documentation, materials, and product communication.*

- Research the annual TSA Manufacturing Prototype challenge and identify the product requirements, constraints, and intended audience.
- Develop a prototype concept using sketches, technical drawings, CAD models, schematics, or other design-planning tools.
- Create working drawings, detail drawings, a parts list, and documentation needed to communicate the design.
- Fabricate a prototype using appropriate materials, tools, components, and manufacturing processes.
- Document construction, testing, revisions, strengths, weaknesses, materials, and production decisions in a portfolio.
- Prepare a bill of materials and work log that communicate the manufacturing process.
- Present a sales pitch explaining the product, design decisions, production process, cost considerations, and final prototype.

Resources

- Technology Student Association – Manufacturing Prototype competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- Autodesk Fusion – CAD/CAM design and manufacturing tools https://www.autodesk.com/products/fusion-360/education
- Onshape Education – Browser-based CAD and product design tools https://www.onshape.com/en/education/
- DigiKey – Electronics components and circuit learning resources https://www.digikey.com/