Industrial Electronics - (IND)

Competency Requirements: CET Core and Specialties

Industrial electronics technicians are expected to obtain knowledge of industrial electronics core concepts which are then applicable to all the various specialty areas of industry. Once the technician has acquired these skills, abilities and knowledge, they will have a good industrial/automation electronics basis and would be prepared for the additional specialty areas covering a broad range of additional automation technologies.
The IND Core journeyman level covers twelve different categories with five IND Specialty areas covering additional categories. The IND Core certification examination will cover **all 16** category areas, while the pending IND Specialty category examinations will cover those specific areas in depth.
Basic electronics content should have been previously acquired through the Assciate CETa certification. The CETa is the pre-requisite foundation to journeyman level CET certification.

Industrial electronics technicians must be knowledgeable in the following technical areas:
CORE:

1.0 Safety

1.1. List First Aid equipment and describe industrial first aid procedures including:
- 1.1.1. shock mitigation
- 1.1.2. cut and abrasion treatment
- 1.1.3. blunt force treatment

1.2. Identify fire hazards and how to handle different classes of fires in the workplace

1.3. List basic rules associated with workplace safety including:
- 1.3.1. identifying surrounding conditions and possible safety issues
- 1.3.2. explaining the safe procedures while working in confined spaces
- 1.3.3. explaining industrial electrical safety rules described in electrical codes (e.g. NEC®, National Electrical Code; CEC, Canadian Electrical Code {CSA C22.1})
- 1.3.4. explaining safe lifting procedures
- 1.3.5. climbing and safety rules that OSHA (Occupational Safety and Health Administration of the U.S. Dept. of Labor) and ANSI A14 dictates for workers at heights (American National Standards Institute)
- 1.3.6. identifying potential environmental hazards in the workplace including:
  - 1.3.6.1. atmosphere monitoring including low explosive limits (LEL),
  - 1.3.6.2. flammability,
  - 1.3.6.3. HAZMAT reactions (hazardous materials)
- 1.3.7. summarizing the use of material safety data sheets (MSDS)

1.4. Describe what types of Personal Protection Equipment (PPE) should be worn for work environments where there is danger of:
- 1.4.1. Arc Flash and Arc Blast
- 1.4.2. eye injury
- 1.4.3. ear injury
- 1.4.4. head injury
- 1.4.5. lung injury
- 1.4.6. other injuries and the required work apparel

1.5. Describe safety procedures required working with and around industrial equipment including:
- 1.5.1. Lockout / Tag Out
- 1.5.2. tools and machines
- 1.5.3. products
- 1.5.4. test equipment

1.6. Explain safe work procedures for fiber optics including:
  1.6.1. handling and disposal
  1.6.2. installation environment and electrical hazards
  1.6.3. light sources
1.7. List safety precautions for static sensitive electronics components and products
1.8. Describe the Robotic safety concerns including:
  1.8.1. intrinsic fail safe system
  1.8.2. hard guards
  1.8.3. perimeter guards
  1.8.4. safety mats
  1.8.5. E-Stop (emergency stop)

2.0 Industrial Mathematics

2.1. Explain and identify single load electrical power circuits including:
  2.1.1. output
  2.1.2. input
2.2. Explain electrical circuits formulas including:
  2.2.1. series
  2.2.2. parallel
  2.2.3. complex (series-parallel)
2.3. Describe formulas for power, resistance, voltage and current as they apply to equipment and/or systems such as conductors, terminations and loads that have various combinations of capacitance, resistance and inductance
2.4. Explain mechanical advantage including:
  2.4.1. pivot/lever law
  2.4.2. torque
  2.4.3. units of measure including:
    2.4.3.1. Newton-meters
    2.4.3.2. foot pounds
  2.4.4. identifying pulley ratios
    2.4.4.1. single
    2.4.4.2. dual
  2.4.5. explaining belt sizes, and tension specifications
  2.4.6. gear ratios
2.5. Explain fluid power and flow calculations
2.6. Explain how to convert between decimal, binary, octal and hexadecimal numbering systems
2.7. Explain how to express gain and loss using the decibel (dB) and suffixes in power and signal level calculations

3.0 Diagrams and Schematics

3.1. Read and identify flow chart symbols and their use for the following:
  3.1.1. process control
  3.1.2. troubleshooting
  3.1.3. processor programming
3.2. Distinguish schematic diagrams for:
  3.2.1. electrical
    3.2.1.1. component
    3.2.1.2. circuit function
  3.2.2. electronics
  3.2.3. fluid power
3.3. Identify and explain ladder diagrams for the following applications:

3.3.1. PLC (programmable logic controller)
3.3.2. electrical
3.4. Recognize and read block diagrams for:
3.4.1. electronics
3.4.2. digital logic
3.4.3. microprocessors
3.4.4. use in troubleshooting techniques
3.4.5. test points
3.5. Identify pictorial diagrams for:
3.5.1. parts placement
3.5.2. assembly
3.5.3. system placement
3.6. Explain Piping & Instrument diagrams (P&ID) and how they correlate to electrical wiring, relay logic, ladder logic and schematic diagrams

4.0 Electrical Components

4.1. Explain uses of different light producing (emitting) devices
4.2. Identify NEMA® (National Electrical Manufacturers Association) plug and receptacle outlet patterns
4.2.1. Describe physical requirements/best practices in installation of NEMA enclosures
4.3. Describe resistive component device types and their use including:
4.3.1. differences between fixed and variable
4.3.2. differences between traditional carbon versus metal film
4.3.3. potentiometers and rheostats
4.3.4. thermistors
4.3.5. light dependent resistors (photocells)
4.3.6. metal oxide varistor (MOV)
4.4. Explain the correlation of resistive components to actual devices and equipment where they are utilized, especially in regards to industrial electrical/electronic signaling devices and/or instrumentation
4.5. Describe capacitive components/ types and how they are used
4.6. Explain the correlation of capacitive components to actual devices and equipment where they are utilized, especially in regards to industrial electrical/electronic signaling devices and/or instrumentation
4.7. Identify transducer types and how they are used including:
4.7.1. thermal transducers and sensors
4.7.2. pressure sensors
4.7.2.1. load cell transducer
4.7.3. strain gauge
4.7.4. linear variable differential transformer (LVDT)
4.7.5. chemical transducers and sensors
4.7.5.1. turbidity
4.7.5.2. pH
4.7.6. acoustic transducers and sensors including:
4.7.6.1. ultrasonic
4.7.7. magnetic sensors
4.7.8. proximity sensors including:
4.7.8.1. radar and sonar
4.7.9. optical sensors including camera and video and photodiode sensors
4.7.10. infrared sensors

4.7.11. Explain how ohms law correlates to these devices and the components contained within them
4.8. Describe the use of iso-couplers
4.9. Describe the use of optical isolators
4.10. Recognize operational amplifier system level applications and characteristics of:
4.10.1. low noise
4.10.2. high input impedance
4.10.3. low output impedance
4.10.4. very high gain
4.10.5. sensors including difference detection
4.10.6. signal reduction/cancellation
4.10.7. Explain the circuit function application for amplifiers
4.11. Explain requirements for distribution system line amplifiers
4.12. Describe integrated circuit and semiconductor use in systems including:
4.12.1. differences/tolerances of supply voltages for CMOS versus TTL
4.12.2. designs using combinational logic:
4.12.2.1. decoders to activate an output action
4.12.3. Multiplexer/data selector
4.12.4. Demultiplexer/data distributor

5.0 Electro-Mechanical Devices

5.1. Describe switch types and their uses (SPST, SPDT, DPDT, etc.)
5.1.1. Explain the difference between a “pole” and the “throw of a switch”
5.1.2. Explain how switches can be sensors and control devices
5.2. Explain the use of timers for the following purposes:
5.2.1. general purpose
5.2.2. delay
5.2.3. interval
5.2.4. programmable
5.2.5. elapsed
5.2.6. 555 Timer
5.3. Recognize counters used for:
5.3.1. products
5.3.2. cycles
5.4. Explain thermal and magnetic differences among:
5.4.1. circuit breakers
5.4.2. Cut-Outs
5.4.3. overloads
5.5. Identify the structure and use of the following relays:
5.5.1. stepping
5.5.2. latching
5.5.3. motor starter – contactor
5.5.4. solid state
5.6. Define the component features of the following sounding (aural alert) devices:
5.6.1. speaker
5.6.2. buzzer
5.6.3. bell
5.7. Describe the use of solenoids as:
5.7.1. actuators for loading and sizing
5.7.2. control valves
5.7.3. clamps
5.7.4. drivers

6.0 Wiring and Codes

- 6.1. Describe copper wire types and their characteristics including:
  - 6.1.1. solid
  - 6.1.2. stranded
  - 6.1.3. braided
- 6.2. Explain cabling attenuation and return loss
- 6.3. Explain the use of circuit protection devices including:
  - 6.3.1. fuses
  - 6.3.2. circuit breakers
  - 6.3.3. UPS (uninterruptible power supplies)
  - 6.3.4. motor overloads
  - 6.3.5. safety relays
- 6.4. Explain Electrical Code (NEC, CEC, TIA-568, -598) wiring/conductor codes sections pertaining to:
  - 6.4.1. conductor/wire size (Articles 110, 210, 310, 600, et al)
    - 6.4.1.1. American Wire Gauge (AWG)
  - 6.4.2. wire color codes (Articles 210, 220, 230, 250, 300)
  - 6.4.3. wiring methods (Article 300)
  - 6.4.4. grounding and bonding (Article 250)
  - 6.4.5. low voltage standards (Article 393)
  - 6.4.6. high voltage standards (Article 490)
  - 6.4.7. standards for class 1, 2 and 3 circuit wiring (Article 725)
  - 6.4.8. cables and raceways (Article 770)
  - 6.4.9. color code identification and premises jacket colors (TIA-598-C)
- 6.5. Explain Industrial fiber optic cables and configurations including:
  - 6.5.1. difference between the uses of plenum and riser rated cabling
  - 6.5.2. cable length markings
  - 6.5.3. connector and endface cleaning
  - 6.5.4. insertion loss testing in accordance with TIA-568
- 6.6. Describe Industrial networks cabling including:
  - 6.6.1. uses and bandwidth of balanced twisted-pair cabling in accordance with TIA-568:
    - 6.6.1.1. unshielded (UTP)
    - 6.6.1.2. shielded (STP)
  - 6.6.2. mechanical performance characteristics of all cabling:
    - 6.6.2.1. bend radius
    - 6.6.2.2. measurements
    - 6.6.2.3. tensile loading
    - 6.6.2.4. splitters and couplers
    - 6.6.2.5. harnesses/hangers applications
    - 6.6.2.6. DAS/small cell terminations
  - 6.6.3. TIA 606B labeling standards

7.0 AC Power Sources and Motors

- 7.1. Describe the structure and operation of AC Motors including:
  - 7.1.1. asynchronous
  - 7.1.2. synchronous
- 7.2. Describe the structure and operation of AC power sources including:
  - 7.2.1. single-phase
  - 7.2.2. three-phase
  - 7.2.3. high-tension service distance distribution
- 7.3. Explain the use of transformers in power transmission systems including:

7.3.1. the operation of a transformer for:
7.3.1.1. isolation
7.3.1.2. voltage step-up
7.3.1.3. current step-down
7.3.1.4. voltage step-down
7.3.1.5. current step-up
7.3.2. calculations, characteristics and properties for:
7.3.2.1. inductance
7.3.2.2. impedance
7.3.2.3. capacity
7.3.2.4. efficiency
7.3.2.5. power ratings
7.3.2.6. winding characteristics
7.3.3. how single phase are used in the plant power grid systems:
7.3.3.1. generation
7.3.3.2. transmission
7.3.3.3. distribution
7.3.3.4. end user
7.3.4. how multi- phase are used in the plant power grid systems:
7.3.4.1. generation
7.3.4.2. transmission
7.3.4.3. distribution
7.3.4.4. end user
7.3.5. the applications of three-phase systems:
7.3.5.1. Delta connection to Wye
7.3.5.2. Wye connection to Delta

7.4. Explain the calculation of sine wave variables
7.5. Identify AC monitoring and troubleshooting devices, power losses and loss calculations
7.6. Explain all elements of power quality including:
7.6.1. impedance
7.6.2. voltage drop
7.6.3. ambient temperature
7.6.4. leading
7.6.5. lagging
7.6.6. voltage spike
7.6.7. peak voltage
7.6.8. RMS (root mean square) voltage
7.6.9. power factor
7.6.10. harmonics
7.6.11. frequency
7.6.12. reactance
7.6.12.1. inductive
7.6.12.2. capacitive
7.6.13. how to circumvent power quality issues
7.6.13.1. eddy currents
7.7. Explain how to load and size a motor actuator
7.8. Explain how AC variable frequency drive (VFD) motors are used and controlled

8.0 DC Power Sources and Motors

8.1. Identify methods of creating DC energy and storage in systems
8.2. Explain calculating variables and feedback in DC circuits

8.3. Explain AC to DC power supply conversions including:
  8.3.1. Half Wave
  8.3.2. Full Wave
    8.3.2.1. Conventional
    8.3.2.2. Bridge
8.4. Identify DC monitoring and troubleshooting devices
8.5. Describe the structure and operation of DC Motors including:
  8.5.1. Servo
  8.5.2. Stepper
  8.5.3. Wound:
    8.5.3.1. Series
    8.5.3.2. Shunt
    8.5.3.3. Compound

9.0 Networking, Interfacing, and Programming

9.1. Identify the differences in modes of data transmission including:
  9.1.1. Ethernet
  9.1.2. Wireless
  9.1.3. Supervisory Control and Data Acquisition (SCADA)
9.2. Describe addressing modes including:
  9.2.1. internet protocol (IP)
  9.2.2. devices
9.3. Describe Highway Addressable Remote Transducer automation protocol (HART®)
9.4. Describe the 4-20 ma current loop Industrial Analog Communication standard
9.5. Describe how an Input Output (I/O) communication bus works
9.6. Identify the digital communication forms and their structure
  9.6.1. serial (RS-232, -422, -485)
  9.6.2. parallel
9.7. Demonstrate ability to utilize the following types of discrete controller modules:
  9.7.1. DC and AC
  9.7.2. analog
  9.7.3. specialty (such as communications; coprocessors; encoders; motion)
  9.7.4. signal conditioning
9.8. Explain syncing/sourcing of I/O modules
9.9. Describe common connection diagrams used with PLCs
9.10. Define scan time and scan cycle
9.11. Compare memory size and mapping
9.12. Explain how data is input, output, filed and addressed
9.13. Describe the requirements for hardware and software interfacing including optical couplers
  9.13.1. HMI (human machine interface)
9.14. Compare CPU speed requirements
9.15. Calculate the power requirements for a PLC power supply
9.16. Identify the symbols for relays and other common ladder diagram devices and graphics
9.17. Describe a short software program typical of a simple PLC application

10.0 Test Equipment and Troubleshooting

10.1. Identify how to use the following measuring devices including:
  10.1.1. tape and rigid rulers
  10.1.2. calipers
  10.1.3. micrometer
  10.1.4. torque gauge

- 10.1.5. angle and level devices
- 10.2. Explain how to use a hydrometer
- 10.3. Explain how to use the following electrical monitoring instruments:
  - 10.3.1. oscilloscope
  - 10.3.2. Earth Ground Resistance meter
  - 10.3.3. MegaOhm meter
  - 10.3.4. power quality analyzer
  - 10.3.5. wattmeter
  - 10.3.6. DMM (digital multimeter)
    - 10.3.6.1. ammeter
      - 10.3.6.1.1. AC clamp on
      - 10.3.6.1.2. DC inline
    - 10.3.6.2. ohmmeter
    - 10.3.6.3. voltmeter
    - 10.3.6.4. diode check
    - 10.3.6.5. capacitor check
    - 10.3.6.6. frequency measurement
    - 10.3.6.7. temperature reading
  - 10.3.7. logic probe
  - 10.3.8. loop calibrator
- 10.4. Describe the differences in applications of the above monitoring devices to include:
  - 10.4.1. trending/tuning/adjusting of analog or “bars”
  - 10.4.2. accuracy of digital readouts
  - 10.4.3. overemphasizing minor variations and apparent precision
  - 10.4.4. locating hardware and software errors
- 10.5. Identify fluid power measuring instruments and their use:
  - 10.5.1. fluid flow meter
  - 10.5.2. pressure gauge
- 10.6. Describe how to use the following network test instruments:
  - 10.6.1. toner and probe kit
  - 10.6.2. multifunctional cable tester
  - 10.6.3. network auto tester
- 10.7. Describe a visual and continuity inspection of a circuit
- 10.8. Describe an emergency stop test-emergency disconnect test
  - 10.8.1. Explain how to perform a program reload
- 10.9. Explain how to calibrate test equipment

SPECIALTY AREAS:

Industrial Technologies Service Specialist should be knowledgeable in the following additional technical Specialty areas in addition to the prior Core areas:

Specialty 1:

11.0 Industrial Communications

- 11.1. Define industrial communications information transmission methods
- 11.2. Identify the differences in modes of data transmission
- 11.3. Identify the structures of network digital communications
- 11.4. Describe how an Input Output (I/O) communication bus works
- 11.5. Explain Highway Addressable Remote Transducer automation protocol (HART®) communications
- 11.6. Identify the difference between physical and logical network topologies
- 11.7. Explain addressing in a digital network

11.8. Identify addressing modes
11.9. Explain network protocols as they relate to the:
    11.9.1. Open Systems Interconnection (OSI) model
    11.9.2. ISO IS 7498 standard for the OSI model
11.10. Explain the data link layer of the OSI model and the terms including:
    11.10.1. “MAC”, Media Access Control
    11.10.2. “LLC”, Logical Link Control
11.11. Identify the digital communication forms and their structure
    11.11.1. serial (RS-232 both)
    11.11.2. parallel
11.12. List the seven types of communication cabling
11.13. Describe XbaseY communication cable classifications and their use
11.14. Identify the advantages optical fiber cabling has over wire

12.0 Networks

12.1. Describe network bus classifications and the devices with which they connect
12.2. Explain fieldbus protocols associated with a process bus network
12.3. Describe common basic network terminology
12.4. Explain how the TIA 606B standard is used to label cabling systems
12.5. Identify the basis of an industrial wireless communication system
12.6. Explain the difference between single channel radio and spread spectrum wireless communication
12.7. Identify the transmission protocols used for wireless communications
12.8. Identify the wireless protocol standards
12.9. Identify the advantages/disadvantages wireless networks have over wired networks
12.10. Explain network cybersecurity systems
12.11. Identify wireless cybersecurity encryption methods
12.12. Describe how a Supervisory Control and Data Acquisition (SCADA) system manages a network

Specialty 2:

13.0 Fluid Power

13.1. Describe Pascal’s law calculations (principle of transmission of fluid-pressure)
13.2. Identify compressor types and how they work
13.3. Identify the types of prime movers used with pumps
13.4. Describe hydraulic pump types and identify the terms:
    13.4.1. accumulator
    13.4.2. cavitation
13.5. Explain filter dryer methods
13.6. Identify pneumatic system components and their function
13.7. Identify pneumatic valve types
    13.7.1. Describe valve actuation methods
13.8. Describe the function of linear cylinders/actuator types
13.9. Identify pneumatic plumbing methods
    13.9.1. Describe an air distribution systems design

Specialty 3:

14.0 Instrumentation

14.1. Specify items typically regulated by process control
14.2. List types of final elements used in process control

14.3. Explain the application of the 4-20 ma current loop system
14.4. Identify methods used in process control for measurements of:
    14.4.1. position
    14.4.2. temperature
    14.4.3. pressure
    14.4.4. level
    14.4.5. flow
14.5. Identify analyzers used in process control to measure:
    14.5.1. gas
    14.5.2. humidity
    14.5.3. solids moisture
    14.5.4. liquid
        14.5.4.1. density
        14.5.4.2. viscosity
14.6. Identify types of electrochemical instrumentation
14.7. Describe methods of automatic control and calculations for:
    14.7.1. ON-OFF
    14.7.2. proportional
    14.7.3. integral
    14.7.4. derivative
14.8. Describe methods of magnetic control and calculations
14.9. Explain how HMI and 'Touch Technology' monitor contacts use:
    14.9.1. SAW (Surface Acoustic Wave)
    14.9.2. Resistive
    14.9.3. Infrared
    14.9.4. Surface capacitive
    14.9.5. Projected capacitive
14.10. Explain how to calibrate instruments, gauges, sensors, switches, meters and transmitters

Specialty 4:

15.0 PLCs (Programmable Logic Controllers)

15.1. Explain the information derived from a PLC nomenclature tag
15.2. Identify PLC output types
15.3. Describe the process and methods used to input / program a PLC including:
    15.3.1. PLC schematic symbols
    15.3.2. PLC ladder diagrams functions including:
        15.3.2.1. logic
        15.3.2.2. math
        15.3.2.3. compare
    15.3.3. PLC expansion addressing
15.4. Describe methods used for networking PLCs
15.5. Describe the following types of discrete controller modules:
    15.5.1. DC and AC
    15.5.2. analog
    15.5.3. microcontrollers
    15.5.4. specialty (such as communications; coprocessors; encoders; motion)
    15.5.5. signal conditioning
15.6. Describe open source protocols and devices that use them to include:
    15.6.1. Arduinos
    15.6.2. PIC microcontrollers and DSCs
    15.6.3. Raspberry Pi

15.6.4. LocNet
15.6.5. DeviceNet
15.6.6. BacNet, etc.
15.7. Explain the advances of hardware and software interfacing including optical couplers
15.8. Describe the application to automation operation of and a production process for:
15.8.1. ladder logic instructions
15.8.2. timer instructions
15.8.3. counter instructions
15.8.4. sequencer instructions
15.8.5. discrete control functions
15.8.6. math comparisons
15.9. Explain how the following functions affect the process control cycle:
15.9.1. loop
15.9.2. data comparison
15.9.3. branch
15.9.4. add/subtract
15.9.5. multiply/divide
15.10. Describe physical requirements/best practices in installation of:
15.10.1. PLC panel layout
15.10.2. enclosure environmental control
15.10.3. maintenance
15.10.4. surge protection

Specialty 5:

16.0 Robotics

16.1. Explain robot design that is created to perform one or more of the “three D’s” (dull, dirty, or dangerous)
16.2. Describe the characteristic robot types to include:
16.2.1. autonomous
16.2.1.1. programmable
16.2.2. guided
16.2.3. remote control
16.2.3.1. ROVs types
16.3. Explain the term “End of Arm Tooling”
16.4. List the six axis of movement in a typical robotic arm
16.5. Define a robotic work-cell to include:
16.5.1. subsystems
16.6. Identify robot power sources
16.7. List robot feedback devices
16.8. Describe the sources of robot hazards as listed in OSHA Instruction PUB 8-1.3 SEP 21, 1987 Office of Science and Technology Assessment
16.9. Describe the purpose of ISO 9283 as it relates to robotics
16.10. Explain how the ANSI/RIA R-15.06-2012 standard will affect the robotics industry

Specialty 6; Additive Manufacturing ?; forthcoming

End of Industrial Technologies Service Specialist Competencies (including all Core and Specialty categories)

Find an ETA® Test Site **http://www.eta-i.org/testing.html**

Associated Suggested Study and Resource Materials:

Modern Industrial Electronics,5E; Maloney; ISBN 978-0130487414; Prentice-Hall, 2003
NFPA 70®: National Electrical Code® (NEC®), (2020) – ISBN 978-1455922970
NFPA 70®: National Electrical Code (NEC®) Handbook (2020) – ISBN 978-1455922901
NFPA 70E®: Standard for Electrical Safety in the Workplace®. (102 pp., 2018, ISBN 978-1455916719**)**
NFPA 780®: Standard for the Installation of Lightning Protection Systems; 978-1455923212
Mike Holt Understanding the National Electrical Code, Volume 1 2017– ISBN 978-098635345-1
Mike Holt's Illustrated Guide to Understanding the National Electrical Code, Vol.2, Based on the 2017 NEC® Handbook– ISBN 978-099039536-2
Mike Holt's Illustrated Guide to Understanding NEC Requirements for Limited Energy and Communications Systems, 2017 - 978-0990395379
Mike Holt's Illustrated Guide to Understanding Low-Voltage and Power –Limited Systems – ISBN 1932685200 (2005)
IEEE Std. 142-2007, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems – ISBN 978-0738156392
IEEE Recommended Practice for Powering and Grounding Electronic Equipment **(IEEE Std 1100-2005)** – ISBN 0738148806
Industrial Electronics: Applications for Programmable Controllers, Instrumentation and Process Control, and Electrical Machines and Motor Controls, 3E*;* Kissell; ISBN 978-0130602411; Prentice Hall, 2002
Electricity & Electronics For Industrial Maintenance*;* Kissell; ASIN**:** B015QNKVM2; Prentice Hall, 2004
Solid State Devices and Systems,4E; Rockis; ISBN 978-0826916372; ATP, 2012; Available through ETA-I at 800-288-3824 or www.eta-i.org
Fundamentals of Industrial Electronics; Wilamowski, Irwin; ISBN 978- 1138074392; Routledge, 2017
Industrial Control Electronics,3E; Bartelt; ISBN 978-1401862923; Delmar Cengage, 2005;
Electrical Motor Controls, 5E; Rockis, Mazur; ISBN 978- 0826912268; ATP, 2013. The FOURTH Ed. ISBN 978- 0826912176; ATP, 2009 is available through ETA-I at 800-288-3824 or www.eta-i.org
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Troubleshooting Electric Motors,4E; Mazur, Proctor; ISBN 978-0826917898; ATP, 2010
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