Basic Systems Technician (BST)
Competency Requirements

The Basic Systems Technician (BST) stand-alone certification is for individuals trained in the basic foundational levels of electronics used in troubleshooting systems and their functions without the need for component circuit analysis. The intent is to introduce a foundation of skills (in a wide variety of electronic industries) needed by technical personnel to advance their competency and efficiency with their work endeavor. If not specifically stated, the most recent technical standard revision is referenced. The BST is the foundational electronics systems certification and the next concentration up in knowledge is the Associate CET or the Systems Level Technician.

The following knowledge competency listing identifies the individual subject topics which Basic Systems Technicians (BST) are expected to learn in preparation for the ETA® International BST certification written examination:

1.0 BASIC SAFETY

- 1.1 Describe the general safety guidelines for the following:
  - 1.1.1 Personal and Personal Protective Equipment (PPE) including:
    - 1.1.1.1 bodily and/or sensory precautions
    - 1.1.1.2 heat precautions
    - 1.1.1.3 stress precautions
    - 1.1.1.4 health emergency training such as First Aid, CPR and AED
      - 1.1.1.4.1 shock
  - 1.1.2 Electrical and Electronics including:
    - 1.1.2.1 equipment and static discharge (ESD)
    - 1.1.2.2 bonding and grounding
    - 1.1.2.3 surge protection
  - 1.1.3 Workplace including:
    - 1.1.3.1 tools – hand, electrical, pneumatic
      - 1.1.3.1.1 “one-hand” rule
    - 1.1.3.2 fire prevention and suppression
      - 1.1.3.2.1 Describe the different classes (A, B, C, D, & K) of fires and the type of extinguishers used to fight them including automatic systems
    - 1.1.3.3 falling object mitigation
    - 1.1.3.4 slips, trips and falls mitigation
    - 1.1.3.5 elevated situation protections including:
      - 1.1.3.5.1 tower
      - 1.1.3.5.2 roof
      - 1.1.3.5.3 ladder
    - 1.1.3.6 machinery precautions
      - 1.1.3.6.1 motors
      - 1.1.3.6.2 generators
    - 1.1.3.7 emergency stop precautions
  - 1.1.4 Describe solder safety as it pertains to burns and potential fires or damage to facilities or personnel including:
    - 1.1.4.1 causes and mitigation of solder fumes
    - 1.1.4.2 effects of lead poisoning
  - 1.1.5 Radio Frequency (RF) use and exposure precautions
  - 1.1.6 Power guidelines:
    - 1.1.6.1 “Lock Out / Tag Out” rule
    - 1.1.6.2 Battery safety and management
    - 1.1.6.3 converters and capacitors
    - 1.1.6.4 alternative power and standby situations
  - 1.1.7 Compliance guidelines:
    - 1.1.7.1 Occupational Safety and Health Administration (OSHA®)
    - 1.1.7.2 National Electrical Code (NEC®) of the National Fire Protection Assoc.(NFPA®)

1.1.7.3 Authority Having Jurisdiction (AHJ)
1.1.7.4 Material Safety Data Sheet (MSDS or SDS)
1.1.8 Special circumstances including:
1.1.8.1 fiber optics
1.1.8.2 laser use
1.1.8.3 hazardous chemicals
1.1.8.4 materials handling

2.0 LOGICAL THINKING - PRINCIPLES FOR PROBLEM SOLVING

2.1 Describe the basic deductive thinking process
2.2 Describe the basic inductive thinking process
2.3 Discuss critical thinking problem solving
2.4 Explain how service/operations manual recommendations/instructions guidelines can:
2.4.1 describe powering up/on procedures
2.4.2 define product/system function(s)
2.4.3 describe diagnostic software
2.4.4 identify visual inspection procedures
2.5 Explain online resources and solutions options including:
2.5.1 manufacturer/factory support
2.5.2 blog forums / chat rooms
2.5.3 videos
2.5.4 search engine
2.6 Discuss product/system design/applications such as test points
2.7 Describe diagram interpretation including:
2.7.1 Block/Flow
2.7.2 Ladder
2.7.3 Schematic
2.7.4 Symbols
2.8 Describe basic troubleshooting processes including:
2.8.1 Half-split method
2.8.2 input/output (I/O) checks
2.8.3 comparison testing
2.8.4 heat/cool and smell testing
2.8.5 board level swapping
2.8.6 intermittent resolution testing

3.0 MANUFACTURING PRINCIPLES AND PROCESSES

3.1 Define a product's country of origin, model and serial number
3.2 Discuss design engineering processes
3.3 Explain production project management processes including:
3.3.1 continuous
3.3.2 batch
3.3.3 job
3.3.4 "just-in-time" manufacturing
3.4 Define automation processes
3.5 Describe assembly processes
3.6 Explain production testing
3.7 Define quality control processes
3.8 Describe shipping processes

4.0 TOOLS AND TECHNIQUES

4.1 Define powered and hand tools including:
4.1.1 screwdrivers
4.1.2 cutters and saws
4.1.3 files and sanding
4.1.4 strippers
4.1.5 hammers
4.1.6 wrenches and pliers

- 4.1.7 specialized connector tools including:
  - 4.1.7.1 cable prep
  - 4.1.7.2 crimpers
  - 4.1.7.3 soldering tools
  - 4.1.7.4 drills
- 4.1.8 measuring instruments including:
  - 4.1.8.1 leveling devices
- 4.1.9 lights
- 4.1.10 miscellaneous

4.2 Define quality workmanship and productivity

4.3 Describe soldering / desoldering techniques:
- 4.3.1 List types of solder and reasons for choosing each
- 4.3.2 Explain the reasons for flux usage and describe types
- 4.3.3 List causes and precautions to prevent or reduce solder splatter
- 4.3.4 Identify cold solder joints and explain causes
- 4.3.5 Explain heat shunts, why and how they are used
- 4.3.6 Differentiate between good and bad mechanical and electrical solder connections
- 4.3.7 Describe proper care of solder and de-solder equipment and tools including:
  - 4.3.7.1 de-soldering principles
  - 4.3.7.2 de-soldering equipment and how it is used
  - 4.3.7.3 of braid-wick solder removers

4.4 Compare common skill strength capabilities

4.5 Describe power supply operation including:
- 4.5.1 batteries
- 4.5.2 variable voltage (DC) units

4.6 Describe measuring devices used including:
- 4.6.1 distance
- 4.6.2 flow speed
- 4.6.3 volume
- 4.6.4 temperature
- 4.6.5 level
- 4.6.6 pressure
- 4.6.7 power
- 4.6.8 voltage
- 4.6.9 current
- 4.6.10 resistance

4.7 Define identification and labeling standards, such as TIA 606 and ANSI/AMSE A13

4.8 Define measurement dimension systems including
- 4.8.1 SAE (SAE International) – U.S. Standard units (inches)
- 4.8.2 SI (International System of Units) - Metric
  - 4.8.2.1 Describe the metric prefixes

4.9 Explain numbering systems, such as decimal, binary and hexadecimal

4.10 Explain conversion measurement calculations between systems
- 4.10.1 Describe how to use decibel (dB) measurements

5.0 COPPER WIRING, CABLE AND CONNECTORS

5.1 Describe the basic conductor concepts of wiring and cabling

5.2 Explain the roles of the following:
- 5.2.1 National Electrical Code (NEC®)
- 5.2.2 Canadian Electrical Code (CEC) and other international electrical codes
- 5.2.3 National Electrical Safety Code (NESC®)
- 5.2.4 Telecommunications Industry Association (TIA®)
  - 5.2.4.1 Electronic Industries Alliance (EIA)

5.3 Explain the American Wire Gauge (AWG) or other scale usage

5.4 Explain “Category” of stranded cabling (Cat X)

5.5 Explain why solid versus stranded copper wiring is used
- 5.5.1 Explain why other elemental wiring is used

5.6 Describe the various insulation components used on wire

- 5.7 Explain why wire cabling connections are critical for circuits and equipment:
  - 5.7.1 "Registered Jack" (RJ)
- 5.8 Describe DC voltage and wiring techniques
- 5.9 Describe AC voltage and wiring techniques
- 5.10 Explain why equipment's connector performance is counted as part of a loss budget
- 5.11 Explain why "measured against reference" is zero volts or ground
- 5.12 Describe the telecommunication connection methods in:
  - 5.12.1 Balanced circuits
    - 5.12.1.1 Multi-paired cabling
    - 5.12.1.2 Unshielded twisted pair (UTP)
  - 5.12.2 Shielded circuits
    - 5.12.2.1 Coaxial
    - 5.12.2.2 Shielded twisted pair (STP)
- 5.13 Describe the network connection methods in:
  - 5.13.1 Local Area Networks (LANs)
  - 5.13.2 Wide Area Networks (WANs)
- 5.14 Explain connector impedance
- 5.15 Describe the NEC cable types that might require grounding or isolation
- 5.16 Explain entrance cable bonding and grounding per NEC® Articles 250 and 770

6.0 POWER SOURCING

- 6.1 Describe power supply operations
  - 6.1.1 Explain why AC power must be converted to DC power
    - 6.1.1.1 linear (simple analog)
    - 6.1.1.2 switching
  - 6.1.2 Explain why battery power voltage output changes as it discharges
- 6.2 Describe AC power components including:
  - 6.2.1 connectors and connections
  - 6.2.2 fuses and circuit breakers in load centers
  - 6.2.3 uninterruptible power supplies (UPS) including:
    - 6.2.3.1 sizing considerations
  - 6.2.4 backup generators including:
- 6.3 Describe DC power systems including:
  - 6.3.1 Batteries:
    - 6.3.1.1 Types
    - 6.3.1.2 Capacity
    - 6.3.1.3 Recharging
  - 6.3.2 Distribution options
- 6.4 Describe wire sizing for power systems
- 6.5 Explain how environment affects power systems
- 6.6 Discuss power dissipation applications including:
  - 6.6.1 Capacitors
  - 6.6.2 Disconnect and transfer boxes
  - 6.6.3 Lock out / tag out

7.0 ELECTRONICS SYSTEM CIRCUIT PROCESSES

- 7.1 Describe how a circuit reacts to:
  - 7.1.1 voltage
    - 7.1.1.1 difference of potential
    - 7.1.1.2 drops
  - 7.1.2 current
  - 7.1.3 resistance
- 7.2 Explain Ohm's Law formulas for current, voltage, and resistance
- 7.3 Explain how Power is related to Ohm's law including :
  - 7.3.1 measurement in watts
  - 7.3.2 Watt's law
  - 7.3.3 Joules and kilowatt-hour as an energy unit
- 7.4 Describe why power dissipates in a circuit
- 7.5 Explain the static (electrostatic) sensitivities of circuits

- 7.6 Explain maximum power transfer including:
  - 7.6.1 efficiency
  - 7.6.2 matched impedance
- 7.7 Explain series and parallel circuits including:
  - 7.7.1 series
    - 7.7.1.1 R, L, C are used
  - 7.7.2 parallel
  - 7.7.3 series-parallel
- 7.8 Discuss circuits as inductive, capacitive, reactant and resistive
  - 7.8.1 Summarize the mnemonic “ELI the ICE man”
- 7.9 Explain Kirchhoff’s law and its importance
- 7.10 Identify the following circuit electronics not otherwise described and their use:
  - 7.10.1 resistors
  - 7.10.2 insulators
- 7.11 Describe the operation of common DC circuits
  - 7.11.1 Explain equations relevant to DC circuitry
- 7.12 Describe the operation of common AC circuits
- 7.13 Describe polarity including:
  - 7.13.1 AC voltage
    - 7.13.1.1 Measuring AC voltage
    - 7.13.1.2 Root mean square (RMS)
    - 7.13.1.3 Peak-to-peak
    - 7.13.1.4 Power measured as “average”
  - 7.13.2 AC to DC converters
  - 7.13.3 DC to AC converters
- 7.14 Describe types of transformers and their uses

8.0 INDUSTRIAL DEVICES AND AUTOMATION CONTROLS

- 8.1 Define input devices including:
  - 8.1.1 Mechanically operated controls and their symbols:
    - 8.1.1.1 Switches including rotary
    - 8.1.1.2 Pushbutton including membrane
    - 8.1.1.3 Potentiometers including:
      - 8.1.1.3.1 Rheostats
      - 8.1.1.3.2 Rotary encoders
      - 8.1.1.3.3 Up-down counters
  - 8.1.2 Sensors and their symbols:
    - 8.1.2.1 Snap switches
    - 8.1.2.2 Mercury switches
    - 8.1.2.3 Optoelectronic devices
    - 8.1.2.4 Magnetic
    - 8.1.2.5 Temperature
    - 8.1.2.6 Capacitive
    - 8.1.2.7 Vibration
    - 8.1.2.8 Flow
- 8.2 Define output devices including:
  - 8.2.1 Power boosters:
    - 8.2.1.1 Relays
    - 8.2.1.2 Transistors including:
      - 8.2.1.2.1 Bipolar junction (BJT)
      - 8.2.1.2.2 Field Effect (FET)
      - 8.2.1.2.3 Junction (JFET)
      - 8.2.1.2.4 MOSFETs (insulated)
      - 8.2.1.2.5 Insulated gate (IGBT)
    - 8.2.1.3 Silicon Controlled Rectifiers (SCR)
    - 8.2.1.4 Bidirectional Silicon Controlled Rectifiers (TRIAC)
    - 8.2.1.5 Solid state
  - 8.2.2 Visual indicators:
    - 8.2.2.1 Lamps

8.2.2.2 Light emitting diode (LED)
8.2.2.3 Liquid crystal display (LCD)
8.2.2.4 Photo diodes
8.2.2.5 neon
8.2.2.6 Solar cells
8.2.3 Aural indicators:
8.2.3.1 Bells/buzzers
8.2.3.2 electronic annunciators:
8.2.3.2.1 Self-contained
8.2.3.2.2 Speaker
8.2.3.2.3 paging
8.2.4 Explain electromagnets and solenoids
8.2.5 Motors and horsepower including:
8.2.5.1 DC and universal motors:
8.2.5.1.1 Rotor
8.2.5.1.2 Stator
8.2.5.1.3 Commutator
8.2.5.1.4 Series-wound
8.2.5.1.5 Parallel-wound
8.2.5.1.6 Brushless
8.2.5.2 AC 3-phase motors:
8.2.5.2.1 Wye
8.2.5.2.2 Delta
8.2.5.3 AC Induction motors
8.2.5.3.1 slip
8.2.5.4 AC single-phase motors
8.2.5.5 Servomotors
8.2.5.6 Stepper motors
8.3 Describe various analog integrated circuit controllers
8.4 Describe various digital integrated circuit controllers and their symbols including:
8.4.1 Transistor-transistor logic (TTL)
8.4.2 Complementary metal oxide semiconductor (CMOS)
8.4.3 Logic levels
8.4.4 Logic gates (combinational)
8.4.4.1 Explain Boolean equations from truth table for combinational logic circuits
8.4.4.2 Simplify combinational logic circuits to the fewest number of chips using NAND or NOR gates
8.4.5 Sequential (counters, timers)
8.4.6 Field-programmable gate array (FPGA)
8.4.7 Field-replaceable units (FRU)
8.4.8 Digital signal processors (DSP)
8.4.9 Dedicated controllers including:
8.4.9.1 Programmable (PLCs)
8.4.9.1.1 nomenclature tag information
8.4.9.1.2 types of
8.4.9.1.3 processes of input/programming
8.4.9.1.3.1 delays/timers
8.4.9.2 Servo loop systems
8.4.9.3 Variable frequency drives (VFD)
8.4.9.3.1 Interference mitigation
8.5 Describe the laser types and wavelengths associated with serial and parallel laser transmitters
8.6 Describe the basics of robotics use in an automated system
8.7 Explain the basics of additive manufacturing use in an automated system

9.0 MECHANICAL FASTENING PROCESSES

9.1 Define basic mechanical processes including:
9.1.1 planning a work flow
9.1.2 tool preparation and organization
9.1.3 manufacturer recommended procedures

9.2 Describe mechanically connecting/mounting equipment
9.3 Compare the ways and means for fastening or pass through including:
  9.3.1 Hole sizing
  9.3.2 Pilot holes
  9.3.3 Hole reaming
9.4 Explain the various tools to make holes including:
  9.4.1 Punches and awls
  9.4.2 Hole saws
  9.4.3 Drills and drill bits
9.5 Describe mechanical connection hardware including:
  9.5.1 screws
  9.5.2 nuts, washers and bolts
  9.5.3 rivets
  9.5.4 plastic cable ties
9.6 Describe the materials to combine including:
  9.6.1 Plating and coatings
  9.6.2 Strength
  9.6.3 Temperature
  9.6.4 Corrosion factors
9.7 Define torque and torqueing
9.8 Describe additive materials for connections including:
  9.8.1 thread locking adhesives
  9.8.2 thread loosening materials
  9.8.3 cleaning chemicals

10.0 INTRODUCTION TO TEST EQUIPMENT

10.1 Differentiate between analog and digital test meters
10.2 Describe how to use the multimeter including:
  10.2.1 analog - volt, ohm, ammeter
  10.2.2 digital (DMM) operation
10.3 Explain device (unit) under test (DUT/UUT) conditions
  10.3.1 Explain impedance loading
10.4 Describe various audio test sets including:
  10.4.1 Transmission impairment measurement set (TIMS)
  10.4.2 Lineman's handset (Butt set)
10.5 Describe a ground resistance test set and its use
10.6 Describe the basic operation of signal/function generator
10.7 Explain how oscilloscope measurements can be used
  10.7.1 Describe how a power analyzer can work in conjunction with an oscilloscope
10.8 Describe spectrum analyzer utilizations
10.9 Describe the connection verifications that a LAN Tester provides
10.10 Compare optical and contact thermometers
10.11 Describe various other measurement meters
10.12 Describe the Time Domain Reflectometer (TDR) applications
  10.12.1 Explain the warnings of proper TDR purposes
10.13 Describe the Frequency Domain Reflectometer (FDR) applications
  10.13.1 Explain the warnings of proper FDR purposes
10.14 Describe the Optical Time Domain Reflectometer (OTDR) applications
10.15 Explain the use of a visual fault locator (VFL) when troubleshooting a fiber span
10.16 Describe the basic operation of an optical loss test set (OLTS)
10.17 Explain why test equipment calibration should be traceable to the National Institute of Standards and Technology (NIST®) calibration standard
10.18 Identify test equipment and accessories protection, safety and usage care

End of BST Knowledge Categories and Competencies

Find an ETA approved school and approved test site: http://www.eta-i.org/test_sites.html

Additional Study Materials and Resources for ETA Systems Technicians Certifications:

Systems Level Technician; I. Wiesenfeld, J. Baldwin, R. Walker, J. Thompson, A. Wiesenfeld, K. Eilers; 2018; Self Publ.; spiralbound; 770ppg.; $??, Available: www.iwatsi.com; Available through ETA 800-288-3824, www.eta-i.org

Cabling: The Complete Guide to Copper and Fiber-Optic Networking, 5E; Andrew Oliviero, Bill Woodward; ISBN 978-1-118-80732-3; Sybex, Inc.; March 2014; softcover; 1284 ppg**.** Available through ETA 800-288-3824, www.eta-i.org

National Electrical Code, 2017; National Fire Protection Assn., Sept.,2016; www.nfpa.org

EM Study Guide series; Karl Eilers; download through ETA at 800-288-3824 or www.eta-i.org

The Associate CET Study Guide, 6E; ISBN 1-891749-07-2; ETA International; 2012; —Available through ETA at 800-288-3824, $60

Electronic Communications: A System Approach, 1E; J.S. Beasley, J.D. Hymer, G.M. Miller; ISBN 978-0132988636; Pearson; Mar 2013; 656 ppg; 0132251136

Modern Electronic Communications, 9E; J.S. Beasley, G.M. Miller; ISBN 978-0132988636; Prentice Hall; May 2007; 992 ppg;

Technicians Guide to Fiber Optics, 4E; Donald J. Sterling; ISBN 1-4018-1270-8; Delmar Learning; Dec 2003; hardcover; 384 ppg; Available through ETA 800-288-3824, www.eta-i.org

Understanding Fiber Optics, 5E; Jeff Hecht; ISBN: 978-0131174290; Prentice-Hall; April 2005; hardcover; 800 ppg

Wiring for Wireless Sites; Ira Wiesenfeld, P.E., CETsr, ISBN 978-1-40181037-5; Prompt; 2002; softcover. Contact ETA® International at 800-288-3824 or eta@eta-i.org

ARRL Handbook, 2017 edition; American Radio Relay League, ISBN 978- 1-62595-063-5, available online from www.ARRL.org

Modern Industrial Electronics,5E; Maloney; ISBN 978-0130487414; Prentice-Hall, 2003

Industrial Electronics: Applications for Programmable Controllers, Instrumentation and Process Control, and Electrical Machines and Motor Controls, 3E*;* Kissell; ISBN 978-0130602411; Prentice Hall, 2002

Solid State Devices and Systems,4E; Rockis; ISBN 978-0826916372; ATP, 2012

Industrial Control Electronics,3E; Bartelt; ISBN 978-1401862923; Delmar Cengage, 2005

Electrical Systems for Facilities Maintenance Personnel; Mazur; ISBN 978- 0826915948; ATP, 2011

Troubleshooting Electric Motors,4E; Mazur, Proctor; ISBN 978-0826917898; ATP, 2010

Electrical Principles and Practices,3E; Mazur, Zurlis; ISBN 978-0826918031; ATP, 2007

Industrial Motor Control,6E; Herman; ISBN 978-1435442399; Delmar Cengage, 2009

Printreading for Installing and Troubleshooting Electrical Systems; Mazur, Weindorf; ISBN 978-0826920508; ATP, 2009

Programmable Logic Controllers,4E; Petruzella; ISBN 978- 0073510880; McGraw-Hill, 2010

Microprocessor and Microcontroller Fundamentals: The 8085 and 8051 Hardware and Software; Kleitz; ISBN 978-0132628259; Prentice-Hall, 1997

Industrial Electrical Troubleshooting; Lundquist; ISBN 978-0766806030; Delmar Cengage 1999; Available through ETA-I at 800-288-3824 or www.eta-i.org

Check online for www.Radio-Electronics.com website; electronics material; Ian Poole; author/editor
Check online for www.Electronicdesign.com website; electronics material**;** Lou Frenzel; Tech.editor
Check online for **NEETS** module content: www.tpub.com/neets/index.htm
Check online for Industrial related content: www.rockwellautomation.com/resources/, www.plc.us, http://www.automationfederation.org/, http://www.redlion.net/resources, www.open-electronics.org, http://www.bb-elec.com/Learning-Center.aspx, www.automationworld.com, www.belden.com, and of course, Wikipedia®.

Also see the list of electronics information websites: http://www.eta-i.org/industry_links_and_resources.html

ETA Basic Systems and Systems Level Technician Committee

Joanna Alford,	East MS CC, (MS)	
Rich Agard, FOI, RESIma	Phil. Fiber Optic Training, SEPTA, (PA)	ragard@aol.com
John Baldwin, CETsr	ETA International, (MN)	jbaldwin@hickorytech.net
Dr. Cedric Bradley	MS Gulf Coast CC, (MS)	
Richard Booth, FOI, FOT	Empire H.S., (AZ)	richard.w.booth@gmail.com
Aaron Cleveland,	MS Gulf Coast CC, (MS)	Aaron.cleveland@mgccc.edu
Joe Cook	East MS CC, (MS)	
Karl Eilers, CAT	ETA International, (MN)	karleilers@hotmail.com
Charlie Hardt	MS Gulf Coast CC, (MS)	charles.hardt@mgccc.edu
Ben Harris		
Dr. Kimberly Jones	MCCB, State BoE, (MS)	
Dwayne LaFontaine	MS Gulf Coast CC, (MS)	
Bob Lovelace, M.Ed.	East MS CC, (MS)	
Jeff Mori,	Eastern Westmoreland CTE, (PA)	jmori33@gmail.com
John Poelma, II	MS Gulf Coast CC, (MS)	john.poelma@mgccc.edu
John Shows,	MS Gulf Coast CC, (MS)	john.shows1@mgccc.edu
Jay Thompson, CETsr	TacticalRF, (AZ, IN)	jay@tacticalrf.com
Jason Throop	East MS CC, (MS)	jthroop@eastms.edu
Rob Walker, CETsr	Walker & Assoc., (TX)	
A.J. Wiesenfeld, P.E., CETsr	AJWiesenfeld & Assoc., (TX)	ajwandassociates@aol.com
Ira Wiesenfeld, P.E., CETms-RF	IWATSI, (TX)	ira@iwatsi.com
Bill Woodward, P.E., FOD	U.S. Federal Contractor	

ETA certification programs are accredited through the ICAC, complying with the ISO/IEC 17024 standard.