

WIRELESS COMMUNICATIONS ELECTRONICS TECHNICIAN (WCM)



WCM Competency Requirements:

The following is a listing of each topic considered necessary in the education of workers performing installation, maintenance and repair of mobile and fixed radio communications systems. Also included are topics on additional frequencies used in telecommunications field, wireless industry best practices, and digital communication technologies. There are 22 general categories. This COMPETENCY listing is the identification of each individual subject in which the technician must be knowledgeable and skilled.

Technicians seeking the Wireless Communications Electronics Technician as a Certified Electronics Technician specialty are also required to have a basic education in fundamental electronics. That basic knowledge is assessed in the Associate CET examination (or the GCT1 examination). The Wireless Communications (WCM) serves as a journeyman option for the Associate CET (or the GCT1).

1.0 RADIO THEORY

- 1.1 Describe electromagnetic transmission and reception theory
- 1.2 List common radio frequency bands
- 1.3 Identify the basic block diagram sections of a radio transmitter and a receiver
- 1.4 Define bandwidth in terms of the FCC's requirements for various private, commercial and public safety frequency allocations
- 1.5 List the functions of receiver stages
- 1.6 Describe frequency tuning or channel switching methods
- 1.7 Explain what propagation can be expected in the various bands

2.0 COMPONENTS, TERMINOLOGY AND SYMBOLS

- 2.1 Identify the components below, their symbols and usages:
 - 2.1.1 Microphones and speakers
 - 2.1.2 Rotary encoders
 - 2.1.3 Inductance, Reactance and Capacitance
 - 2.1.4 Transistors
 - 2.1.5 Integrated Circuits
 - 2.1.6 Special IC circuits
 - 2.1.7 Relays and thyristor switches
 - 2.1.8 Motors and generators
 - 2.1.9 Fuses & circuit breakers
 - 2.1.10 Batteries
 - 2.1.11 Power supply components
 - 2.1.12 Softpots
 - 2.1.13 Common types of electronic displays

3.0 SATELLITE – DATA – TELECOMMUNICATIONS

- 3.1 Explain the applications pertaining to two-way radio for the following:
 - 3.1.1 Satellite
 - 3.1.2 GPS (Global Positioning System)
 - 3.1.3 High speed telephone
 - 3.1.4 Telecommunications
- 3.2 List potential interference to or from items listed above in 3.1

4.0 MOBILE SYSTEMS

- 4.1 Describe basic simplex operation
- 4.2 Explain how mobile relay – simplex/duplex works
- 4.3 Compare remote control and manual control systems
- 4.4 Define RF link and explain its purpose
- 4.5 List common RF transmission band assignments or allotments pertinent to commercial and private radio communications
- 4.6 List competing services encountered by radio workers

- 4.7 List common frequencies and bands used for Public Safety services
- 4.8 Explain paging systems communications
- 4.9 Describe trunking (single/multi-site)
- 4.10 Compare conventional single and multi-site communications systems
- 4.11 Define simulcast systems and list their purposes
- 4.12 Define satellite voting systems and show how they are used
- 4.13 Compare wireless data systems with two-way voice communications
- 4.14 Describe CTCSS (Continuous Tone Coded Squelch System) squelch operation
- 4.15 Define and list how DCSS (Digitally Coded Squelch Signaling) is used
- 4.16 Explain the differences between point-to-point and point-to-multipoint transmissions
- 4.17 Describe the function of a repeater

5.0 COMMERCIAL RADIO NETWORKS

- 5.1 Describe the operational characteristics of two-way radio communications systems
- 5.2 List technical characteristics of working communications systems
- 5.3 Explain programming characteristics of system receivers and transmitters
- 5.4 Describe the concepts used in trunking radio systems

6.0 BLOCK DIAGRAMS – SCHEMATICS - FLOW CHARTS

- 6.1 Identify diagram symbols used in communications radio service
- 6.2 Explain how to trace power and signal paths in a radio receiver and transmitter
- 6.3 Describe the purpose of and be able to locate schematic test points
- 6.4 Estimate normal signals and voltages expected at schematic locations
- 6.5 Describe the purpose of flow charts

7.0 BASIC ANALOG CIRCUITS

- 7.1 Describe basic AC and DC radio power supplies
- 7.2 Explain the function of different types of amplifiers including RF and IF stages
- 7.3 Identify a basic audio amplifier circuit
- 7.4 Compare AM and FM audio detectors
- 7.5 Explain AVC (Automatic Volume Control) and AGC (Automatic Gain Control) circuits and their operation
- 7.6 Explain how various modulators are used in transmitters
- 7.7 Explain what each of the components of a transmitter power output circuit does
- 7.8 Identify the circuit for an operational amplifier and explain its operation
- 7.9 Define gain and explain how it is measured
- 7.10 Define bi-directional amplifier and explain where they are used
- 7.11 Explain the purpose and concept of PLL (phase locked loop) and VCO (voltage controlled oscillator) circuits

8.0 HAND TOOLS AND SOLDERING

- 8.1 Identify soldering tools and accessories
- 8.2 List proper equipment care routines
- 8.3 Identify the proper soldering sequence
- 8.4 Visually identify proper and improper soldering techniques
- 8.5 Identify the proper desoldering sequence
- 8.6 Identify the qualities of a good solder joint
- 8.7 Know the differences between available solder alloys
- 8.8 Describe flux and explain its purposes
- 8.9 Describe cold – defective solder joints and list reasons they occur
- 8.10 Describe methods of replacing surface mount components
- 8.11 Describe wire wrap reconnection precautions
- 8.12 Explain how hot air bonding equipment is used
- 8.13 Define RoHS (Restriction of Hazardous Substances) and explain its purpose
- 8.14 Describe various solder leads (gull wing, j-leads, ball grid array)

9.0 COMPUTER AND DIGITAL CIRCUITS

- 9.1 Identify the symbols for digital gates and their truth tables
- 9.2 Compare common memory devices used in radio communications
- 9.3 Explain how tuning is accomplished in radio receivers and transmitters
- 9.4 Describe how microprocessor controls are used in radio
- 9.5 Compare RAM (Random Access Memory), PROM (Programmable Read Only Memory), EEPROM (Electrically Erasable Programmable Read Only Memory), ROM (Read Only Memory)
- 9.6 Describe how DACs (Digital to Analog Converter) and ADCs (Analog to Digital Converter) are used
- 9.7 Define modems and explain their purposes
- 9.8 List the types of drivers used in Wireless Communication applications
- 9.9 Describe TTL (Transistor - Transistor Logic) and CMOS (Complementary Metal Oxide Semiconductor) outputs

10.0 COMPUTER APPLICATIONS

- 10.1 Describe the use of the following in Wireless Communications applications:
 - 10.1.1 Word processing reports, databases, spreadsheets
 - 10.1.2 Internet
 - 10.1.3 Parts, literature, product information/ordering via Internet
 - 10.1.4 Explain how to access troubleshooting and diagnostics software
 - 10.1.5 Virus eradication systems
 - 10.1.6 Diagnostic programs
 - 10.1.7 Utility programs
 - 10.1.8 Laptop/Tablet with Com port, null modem, terminal software
 - 10.1.9 RS232 and USB interfacing
 - 10.1.10 Codeplug, Firmware, Flashcode

11.0 INTERFACING

- 11.1 List expected signal levels into or out of interconnected products used in radio work
- 11.2 Define impedance matching and explain impedance mismatch
- 11.3 Describe the various numbering systems used in two-way radio technology

12.0 TRANSMISSION LINES, CABLING AND CONNECTORS

- 12.1 Describe coaxial cable characteristics
- 12.2 Explain proper installation of coaxial connectors, jacks, plugs, describing crimping and prepping
- 12.3 Explain cable routing, bend ratios, pulling tension and building cabling regulations
- 12.4 Explain the purpose & theory of transmission line testing
- 12.5 Describe the functions of test equipment used in transmission line testing
- 12.6 Compare proper and improper impedance matching principles
- 12.7 Define ground loop and name common causes and effects
- 12.8 Define balanced/unbalanced pairs
- 12.9 Explain line loss for different types of cabling
- 12.10 Explain the importance of proper cable termination
- 12.11 Explain the principles used in Frequency Domain Reflectometry (FDR)
- 12.12 Compare Time Domain Reflectometry with FDR
- 12.13 Identify type-N, UHF, Mini UHF, BNC, TNC, SMA, and 7/16 DIN connectors

13.0 ANTENNAS AND TOWERS

- 13.1 Explain wave propagation and its relative speed in air or cabling
- 13.2 Describe reception theory and mobile antennas
- 13.3 Identify polar patterns for different types of antennas
- 13.4 Describe cross polarization
- 13.5 Define antenna gain and explain why it is important
- 13.6 Describe hand-held transceiver antennas
- 13.7 Explain the circuits for antenna combining networks
- 13.8 Explain how diplexers and duplexers are used
- 13.9 Define cavities, circulators and isolators and show where they are used
- 13.10 Explain the purpose and methods of grounding communications products
- 13.11 Explain lightning protection devices
- 13.12 Explain Beam tilt

- 13.13 Describe base station antennas
- 13.14 Define receiver multi-coupling
- 13.15 List radio tower components and installation practices
- 13.16 Explain proper documentation in transmission sites
- 13.17 Explain tower top amplifiers, their usage, testing for functionality, benefits and disadvantages
- 13.18 Describe when and why attenuators are used

14.0 GROUNDING – LIGHTNING PROTECTION

- 14.1 Describe antenna grounding conventions
- 14.2 Describe grounding standards for a communications facility
- 14.3 Describe the concept of a common grounding electrode system and identify National Electrical Code (NEC®) requirements as related to a communications facility
- 14.4 Name NEC lightning protection rules articles
- 14.5 List proper bonding and grounding practices
- 14.6 Define grounding blocks and explain how rods and proper wire sizes are used
- 14.7 Explain how equipment protection is enhanced with the use of: Transient Voltage Surge Suppressors, (MOVs [metal oxide varistors] and SADs [Silicon Avalanche Diodes]), also known as Surge Protection Devices (SPD)
- 14.8 Identify exothermic welding methods

15.0 RADIO MATHEMATICS AND FORMULAS

- 15.1 Convert dB (decibel) readings to dBmV and microvolt levels
- 15.2 Explain and compare dBi, dBm, dBW, dBd terminology
- 15.3 Describe proper uses for scientific calculators
- 15.4 List numbering systems commonly used in technician work (powers of 10, binary addition and subtraction, octal, hexadecimal)
- 15.5 Convert frequency to wavelength and vice-versa
- 15.6 Calculate the Effective Radiated Power (ERP) of a system given input and component losses or gains
- 15.7 Calculate Effective Isotropic Radiated Power (EIRP)
- 15.8 Calculate the free-space path loss of a given RF signal for a given distance

16.0 MODULATIONS SCHEMES

- 16.1 Describe AM (Amplitude Modulation) methods and limits
- 16.2 Describe FM (Frequency Modulation) methods and deviation limits
- 16.3 Describe companding
- 16.4 Describe pre-emphasis/de-emphasis and what purpose it serves
- 16.5 Explain the principles and advantages of SSB (Single Side Band)
- 16.6 Define TDMA (Time Division Multiple Access) and describe the concept
- 16.7 Compare CDMA (Code Division Multiple Access) with TDMA and FDMA modulation schemes
- 16.8 Define and describe QPSK (Quadrature Phase Shift Keying) and OQPSK (Offset Quadrature Phase Shift Keying)
- 16.9 Describe Digital Modulation techniques including the APCO (Association of Public Safety and Communications Officials) Project 25 standard
- 16.10 Describe the common types of encryption and algorithms used in two-way communications
- 16.11 Explain keyloading
- 16.12 Define GSM (Global System for Mobile Communications)

17.0 CONTROL SYSTEMS

- 17.1 Describe how DC remote control systems operate
- 17.2 Explain the functions of a remote and a remote adapter
- 17.3 List typical frequencies, currents and voltages used in a DC system to key a transmitter, change frequencies, and engage the monitor functions
- 17.4 Describe how tone remote control systems operate
- 17.5 Explain the differences between High Level Guard Tone and Low Level Guard Tone
- 17.6 Explain the advantages of a tone control system over a DC control system
- 17.7 Define DTMF (Dual Tone Multi Frequency) and name an application where it is used
- 17.8 Define SCADA (Supervisory Control and Data Acquisition) and explain where it is used
- 17.9 Describe the use of IP remote control

18.0 RF INTERFERENCE

- 18.1 Define receiver de-sensitization (de-sense) and explain the causes
- 18.2 List reasons for spurious emissions and receiver response
- 18.3 Explain site compatibility and reasons for site incompatibility
- 18.4 Describe co and adjacent-channel interference
- 18.5 Explain Image Frequency
- 18.6 Explain transmitter noise
- 18.7 Define Noise Floor
- 18.8 Explain Harmonics and Sub-Harmonics
- 18.9 Define BPL (Broadband over Power Line) interference
- 18.10 Describe natural noises that can affect radio communication
- 18.11 Explain wind generated static electricity
- 18.12 List interference detection methods
- 18.13 Define inter-modulation and list causes
- 18.14 Describe minimum filtering and techniques that should be applied at a communications site to help minimize interference
- 18.15 Describe Passive Intermodulation (PIM)

19.0 RF COVERAGE ANALYSIS, TESTING AND DIAGNOSIS

- 19.1 Describe RF coverage modeling as defined in the Telecommunications Industry Association (TIA) technical service bulletin 88 (TSB 88)
- 19.2 Describe service area
- 19.3 Describe Reliability
- 19.4 Describe how different portable configurations impact system coverage (i.e., type of antenna, use of speaker-microphone)
- 19.5 Describe a balanced coverage design
- 19.6 Describe RF coverage modeling verification as defined in the TIA TSB 88
- 19.7 Describe the distortion pattern of a radio signal caused in a side mounted antenna
- 19.8 Identify common obstructions

20.0 TEST EQUIPMENT AND MEASUREMENTS

- 20.1 Explain the functions of a Communications Service Analyzer
- 20.2 Describe how the TDR (Time Domain Reflectometer), OTDR (Optical Time Domain Reflectometer) and FDR (Frequency Domain Reflectometer) are used
- 20.3 Define SWR (Standing Wave Ratio) and show how SWR and watt meters are used
- 20.4 Define return loss and insertion or cable loss and explain the difference
- 20.5 Compare S/N and C/N
- 20.6 Describe how dummy loads, DMMs (Digital Multimeters), logic probes, pulsers, and signal generators are used
- 20.7 Explain SINAD/AC voltmeter/distortion analyzers and audio generators usage
- 20.8 Describe how spectrum analyzers are used
- 20.9 Identify common RF test cables and converters used in 2-way communications
- 20.10 Describe how variable power supplies are used in service technician work
- 20.11 Explain how to perform power measurements
- 20.12 Describe how to use frequency and modulation measurement equipment

21.0 TROUBLESHOOTING

- 21.1 Describe techniques for localizing circuitry defects in communications equipment
- 21.2 Explain how to use block diagrams and test points
- 21.3 Explain how to use heat or cold to locate intermittent circuitry problems
- 21.4 Compare PC board and surface mount component replacement techniques
- 21.5 Define signal overdrive and explain its causes and effects

22.0 WORKPLACE SAFETY FOR RADIO ENVIRONMENT

- 22.1 List the general topics contained in CFR 47 Part 15 (Code of Federal Regulations) pertaining to two-way communications
- 22.2 Explain basic FCC (Federal Communications Commission) rules pertaining to two-way communications

- 22.3 List licenses required for radio stations and technicians
- 22.4 List FAA (Federal Aviation Administration) rules pertaining to communications systems
- 22.5 List OSHA rules for contractors working on antennas/towers, heights, ladders, including fall safety and portable Ladder Safety according to ANSI 14
- 22.6 List NEC® provisions applicable to radio, antenna, and cabling workers
- 22.7 Explain work environment concerns for technicians
- 22.8 List fire potentials for electronics technicians in the work environment
- 22.9 Describe ground faults and devices used to preclude shock hazards
- 22.10 Define ESD (Electrostatic Discharge)
- 22.11 Describe safety precautions when handling fiber optic cabling
- 22.12 List electrical shock potential to electronics workers
- 22.13 Describe transmitter RF (Radio Frequency) exposure hazards
- 22.14 Explain RF monitoring and its purpose
- 22.15 List Beryllium hazards
- 22.16 Define First Aid and explain precautions uncertified workers should observe

End of Wireless Communications Competencies Listing (with 22 major Categories)

Notes: Certain of the above items will appear redundant, having been addressed in more than one CATEGORY. Also, some of the Competencies above may well have been included in the BASIC or Associate level training and certification skills standards and examination. In most cases these redundant items may need only slight revisiting of the topic, a different view of the topic. However, they are included more than once so that there is assurance that their application in each category is addressed.

This competencies listing is compiled to serve two purposes:

1. To provide educational institutions and Industry with the material they need to construct an outline for any course of instruction in wireless communications for students or employees.
2. To provide an outline for those studying to sit for the Wireless Communications or FCC GROL exams as a guide to the knowledge and skills they will need.

Suggested Additional Resource and Study Material:

WEBSITES: eta-i.org; edmssa.org; glmss.com; fcc.gov; nfpa.org; motorolasolutions.com; c-csc.org; enterprisewireless.org; urgentcomm.com; iwceexpo.com; missioncriticalmagazine.com; rcrwireless.com; and many others...

GROL + Radar; West, WB6NOA, et al; ISBN 978-0945053606; The W5YI Group, 2009;

-Available through ETA at 800-288-3824 or online at <http://www.eta-i.org/>

ARRL Handbook, 2019 (Annual); Numerous Authors; ISBN 978-1-62595-089-5; The American Radio Relay League, Inc.; 2019

General Communications Technician, Level 1, 2Ed.; Ira Wiesenfeld, P.E., CETsr, Rob Walker, LAS, PIM, Jay Thompson, CETsr, A.J. Wiesenfeld, BSEE, LAS; ISBN 978-0-9915913-5-0; Self Published; 2015; softcover. Contact ETA® International at 800-288-3824 or eta@eta-i.org

General Communications Technician, Level 2; Ira Wiesenfeld, P.E., CETsr, Rob Walker, LAS, PIM, Jay Thompson, CETsr, A.J. Wiesenfeld, BSEE, LAS; ISBN 978-0-9915913-3-6; Self Published; 2015; softcover. Contact ETA® International at 800-288-3824 or eta@eta-i.org

Practical Antenna Handbook, 5E; Carr, Hippisley; ISBN 978- 0071639583; McGraw-Hill; 2011

Principles of Electronic Communication Systems, 4E; Frenzel; ISBN 978- 0073373850; McGraw-Hill; 2015

Electronic Communication: A Systems Approach; Beasley, Hymer, Miller; ISBN 978-0132988636; Prentice Hall; 2013

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

Wiring For Wireless Sites; Wiesenfeld; ISBN 978-1401810375; Prompt, 2002;

-Available through ETA at 800-288-3824 or online at <http://www.eta-i.org/>

Antenna Engineering Handbook, 4E; Volakis; ISBN 978-0071475747; McGraw-Hill Prof., 2007

Electronic Communications for Technicians, 2E; Wheeler; ISBN 978- 0131130494; Prentice Hall, 2005

New HAM Radio License? Now What?; James Sanders, AG6IF; Kindle Edition; Amazon; 2014

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http://www.eta-i.org/test_sites.html

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