



Electronics Technicians Association, International COMPETENCY REQUIREMENTS

WIRELESS COMMUNICATIONS ELECTRONICS TECHNICIAN WCM/MSS VERSION 2008

The following is a listing of each topic considered necessary to be included in a course of study directed towards the education of workers performing installation, maintenance and repair of mobile and fixed radio communications systems. There are 24 general categories of training. This COMPETENCY listing is the syllabus, or identification of each individual subject, in which the technician must be knowledgeable and skilled.

Technicians seeking the USMSS Certified Electronics Technician specialty are required to also have a basic education in fundamental electronics. That basic knowledge is assessed in the Associate CET examination. The Associate CET exam, plus the USMSS wireless communications specialty examination go together to form the complete journeyman CET exam.

WCM MSS COMPETENCIES

1.0 RADIO THEORY

- 1.1 Describe electromagnetic transmission and reception theory
- 1.2 List common radio frequency bands
- 1.3 Draw a basic block diagram of a radio transmitter and a receiver
- 1.4 Define bandwidth and describe common radio and television channel limits
- 1.5 List the functions of receiver stages
- 1.6 Describe frequency tuning or channel switching methods
- 1.7 Name ten major events or personalities in radio history
- 1.8 Explain what propagation can be expected in the various bands

2.0 COMPONENTS, TERMINOLOGY & SYMBOLS

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

3.0 BASIC ANALOG CIRCUITS

- 3.1 Describe basic AC and DC radio power supplies
- 3.2 Explain the function of different types of amplifiers including RF and IF stages
- 3.3 Identify a basic audio amplifier circuit
- 3.4 Compare AM and FM audio detectors
- 3.5 Explain AVC (Automatic Volume Control) and AGC (Automatic Gain Control) circuits and their operation
- 3.6 Name the major segments of a transmitter carrier generation circuit
- 3.7 Explain how various modulators are used in transmitters
- 3.8 Explain what each of the components of a transmitter power output circuit does

- 3.9 Identify the circuit for an operational amplifier and explain its operation
- 3.10 Define gain and explain how it is measured
- 3.11 Define bi-directional amplifier and explain where they are used
- 3.12 Explain the purpose and concept of PLL (phase locked loop) and VCO (voltage controlled oscillator) circuits

4.0 TRANSMISSION LINES, ANTENNAS AND TOWERS

- 4.1 Explain wave propagation and its relative speed in air or cabling
- 4.2 Describe reception theory and mobile antennas
- 4.3 Identify polar patterns for different types of antennas
- 4.4 Describe cross polarization
- 4.5 Define antenna gain and explain why it is important
- 4.6 Describe hand-held transceiver antennas
- 4.7 Explain the circuits for antenna combining networks
- 4.8 Explain how diplexers and duplexers are used
- 4.9 Define cavities, circulators and isolators and show where they are used
- 4.10 Explain the purpose and methods of grounding communications products
- 4.11 Explain lightning protection devices
- 4.12 Explain Beam tilt
- 4.13 Describe base station antennas
- 4.14 Define receiver multi-coupling
- 4.15 List radio tower components and installation practices
- 4.16 Explain tower safety and OSHA (Occupational Safety and Health Agency) contractor regulations
- 4.17 Explain the purpose & theory of transmission line testing
- 4.18 Describe the functions of test equipment used in transmission line testing of head-end sites
- 4.19 Explain proper documentation in transmission sites
- 4.20 Explain tower top amplifiers, their usage, testing for functionality, benefits and disadvantages
- 4.21 Describe when and why attenuators are used

5.0 CABLING & CONNECTORS

- 5.1 Describe coaxial cable characteristics
- 5.2 Explain proper installation of coaxial connectors, jacks, plugs, describing crimping and prepping
- 5.3 Explain cable routing, bend ratios, pulling tension and building cabling regulations
- 5.4 Explain the purpose of NEC® (National Electrical Code®) Article 770
- 5.5 Compare proper and improper impedance matching principles
- 5.6 Define ground loop and name common causes and effects
- 5.7 Define balanced/unbalanced pairs
- 5.8 Explain line loss for different types of cabling
- 5.9 Explain the importance of proper cable termination
- 5.10 Explain the principles used in Frequency Domain Reflectometry
- 5.11 Compare Time Domain Reflectometry with Frequency Domain Reflectometry
- 5.12 Identify type-N, UHF, Mini UHF, BNC, TNC, SMA, and 7/16 DIN connectors
- 5.13 List common color codes for telephone wiring.

6.0 BLOCK DIAGRAMS, SCHEMATICS, FLOW CHARTS

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

7.0 HAND TOOLS AND SOLDERING

- 7.1 Explain the proper usage of basic hand tools
- 7.2 Describe the proper usage of soldering irons and aids
- 7.3 Explain how desoldering equipment and aids are used
- 7.4 Describe flux and explain its purposes
- 7.5 Describe cold – defective solder joints and list reasons they occur
- 7.6 Describe methods of replacing surface mount components
- 7.7 Describe wire wrap reconnection precautions
- 7.8 List proper equipment care routines
- 7.9 Explain how hot air bonding equipment is used
- 7.10 Define RoHS (Restriction of Hazardous Substances) and explain its purpose
- 7.11 Describe various solder leads (gull wing, j-leads, ball grid array)

8.0 GROUNDING – LIGHTNING PROTECTION

- 8.1 Describe antenna grounding conventions
- 8.2 Describe grounding standards for a communications facility
- 8.3 Describe the concept of a common grounding electrode system and identify National Electrical Code® requirements as related to a communications facility
- 8.4 Name NEC lightning protection rules articles
- 8.5 List ground fault protection devices
- 8.6 Define grounding blocks and explain how rods and proper wire sizes are used
- 8.7 Explain how equipment protection is enhanced with the use of, Transient Voltage Surge Suppressors, (MOVs [metal oxide varistors] and SADs[Silicon Avalanche Diode]), also known as Surge Protection Devices (SPD)
- 8.8 Identify Cadweld bonding

9.0 RADIO MATHEMATICS AND FORMULAS

- 9.1 Convert dB (decibel) readings to dBmV and microvolt levels
- 9.2 Explain and compare dBi, dBm, dBw, dBd terminology
- 9.3 Describe proper uses for scientific calculators
- 9.4 List numbering systems commonly used in technician work (powers of 10, binary addition & subtraction, octal, hexadecimal)
- 9.5 Convert frequency to wavelength and vice-versa
- 9.6 Calculate the Effective Radiated Power (ERP) of a system given input and component losses or gains
- 9.7 Calculate the free-space path loss of a given RF signal for a given distance

10.0 INTERFACING

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

11.0 COMPUTER AND DIGITAL CIRCUITS

- 11.1 Identify the symbols for digital gates and their truth tables
- 11.2 Compare common memory devices used in radio communications
- 11.3 Explain how tuning is accomplished in radio receivers and transmitters
- 11.4 Describe how microprocessor controls are used in radio
- 11.5 Compare RAM (Random Access Memory) – PROM (Programmable Read Only Memory) – EEPROM (Electrically Erasable Programmable Read Only Memory) – ROM (Read Only Memory)
- 11.6 Describe how DACs (Digital to Analog Converters) and ADCs (Analog to Digital Converter) are used
- 11.7 Define modems and explain their purposes
- 11.8 List the types of drivers used in Wireless Communication applications
- 11.9 Describe TTL (Transistor - Transistor Logic) and CMOS (Complimentary Metal Oxide Semiconductor) outputs

12.0 COMPUTER APPLICATIONS

- 12.1 Describe the use of the following in Wireless Communications applications:
 - 12.1.1 Word processors
 - 12.1.2 Databases
 - 12.1.3 Spreadsheets
 - 12.1.4 Internet
 - 12.1.5 Parts procurement services
 - 12.1.6 Virus eradication systems
 - 12.1.7 Diagnostic programs
 - 12.1.8 Utility programs
 - 12.1.9 Laptop with Com port, null modem, terminal software
 - 12.1.10 RS232 and USB interfacing
- 12.2 Describe Codeplug, Firmware, Flashcode

13.0 INTERNET APPLICATIONS

- 13.1 Describe parts, literature and product information/ordering via Internet
- 13.2 Explain how to access troubleshooting and diagnostics software

14.0 MOBILE SYSTEMS

- 14.1 Describe basic simplex operation
- 14.2 Explain how mobile relay – simplex/duplex works
- 14.3 Compare remote control and manual control systems
- 14.4 Define RF link and explain its purpose
- 14.5 Explain paging systems communications
- 14.6 Describe trunking (single/multi-site)
- 14.7 Compare conventional single and multi-site communications systems
- 14.8 Define simulcast systems and list their purposes
- 14.9 Define satellite voting systems and show how they are used
- 14.10 Compare wireless data systems with two-way voice communications
- 14.11 Describe CTCSS (Continuous Tone Coded Squelch System) squelch operation
- 14.12 Define and list how DCSS (Digitally Coded Squelch Signaling) is used
- 14.13 Explain the differences between point-to-point and point-to-multipoint transmissions
- 14.14 Describe the function of a repeater

15.0 SATELLITE – DATA – TELECOMMUNICATIONS

- 15.1 Explain the applications pertaining to two-way radio for the following:
 - 15.1.1 Satellite
 - 15.1.2 GPS (Global Positioning System)
 - 15.1.3 High speed telephone
 - 15.1.4 Telecommunications
- 15.2 List potential interference to or from 15.1 items

16.0 RADIO ENVIRONMENT WORKPLACE SAFETY AND BUSINESS PRACTICES

- 16.1 List the general topics contained in CFR 47 Part 15 (Code of Federal Regulations)
- 16.2 Explain basic FCC (Federal Communications Commission) rules pertaining to two-way communications
- 16.3 List FAA (Federal Aviation Administration) rules pertaining to communications systems
- 16.4 List OSHA safety rules for contractors and workers at heights
- 16.5 List NEC® (National Electrical Code®) provisions applicable to radio, antenna, and cabling workers
- 16.6 List licenses required for radio stations and technicians
- 16.7 Define ESD (Electrostatic Discharge)
- 16.8 Describe safety precautions when handling fiber optics cabling
- 16.9 List hazards potential when using power tools

- 16.10 Define First Aid and explain precautions uncertified people should abide by
- 16.11 List fire potentials in electronics technician work environments
- 16.12 List electrical shock potential peculiar to electronics workers
- 16.13 Describe transmitter RF (Radio Frequency) exposure hazards
- 16.14 Describe ground faults and devices to preclude shock hazards
- 16.15 List Beryllium hazards
- 16.16 Explain ladder precautions and lifts dangers
- 16.17 Explain work area environment concerns for technicians
- 16.18 Explain RF monitoring and its purpose
- 16.19 Explain billing procedures for repairs and important factors of a bill
- 16.20 Explain how to calculate productivity for yourself and the total shop

17.0 FREQUENCY BANDS FOR MOBILE COMMUNICATIONS

- 17.1 List common RF transmission band assignments or allotments pertinent to commercial and private radio communications
- 17.2 List competing services encountered by radio workers
- 17.3 List common frequencies and bands used for Public Safety services

18.0 TEST EQUIPMENT & MEASUREMENTS

- 18.1 Explain the functions of a Communications Service Analyzer
- 18.2 Describe how the TDR (Time Domain Reflectometer), OTDR (Optical Time Domain Reflectometer) and FDR (Frequency Domain Reflectometer) are used
- 18.3 Define SWR (Standing Wave Ratio) and show how SWR and watt meters are used
- 18.4 Define return loss and insertion or cable loss and explain the difference
- 18.5 Compare S/N and C/N
- 18.6 Describe how dummy loads, DMMs (Digital Multimeters), logic probes, pulsers, and signal generators are used
- 18.7 Explain SINAD/AC voltmeter/distortion analyzers and audio generators usage
- 18.8 Describe how spectrum analyzers are used
- 18.9 Identify common RF test cables and converters used in 2-way communications
- 18.10 Describe how variable power supplies are used in service technician work
- 18.11 Explain how to perform power measurements
- 18.12 Describe how to use frequency and modulation measurement equipment

19.0 TROUBLESHOOTING

- 19.1 Describe techniques for localizing circuitry defects in communications equipment
- 19.2 Explain how to use block diagrams and test points
- 19.3 Explain how to use heat or cold to locate intermittent circuitry problems
- 19.4 Compare PC board and surface mount component replacement techniques
- 19.5 Define signal overdrive and explain its causes and effects

20.0 COMMERCIAL RADIO NETWORKS

- 20.1 Describe the operational characteristics of two-way radio communications systems
- 20.2 List technical characteristics of working communications systems
- 20.3 Explain programming characteristics of system receivers and transmitters
- 20.4 Describe the concepts used in trunking radio systems

21.0 MODULATIONS SCHEMES

- 21.1 Describe AM (Amplitude Modulation) methods and limits
- 21.2 Describe FM (Frequency Modulation) methods and deviation limits
- 21.3 Describe companding
- 21.4 Describe pre-emphasis/de-emphasis and what purpose it serves
- 21.5 Explain the principles and advantages of SSB (Single Side Band)
- 21.6 Define TDMA (Time Division Multiple Access) and describe the concept
- 21.7 Compare CDMA (Code Division Multiple Access) with TDMA and FDMA modulation schemes

- 21.8 Define and describe QPSK (Quadrature Phase Shift Keying) and OQPSK (Offset Quadrature Phase Shift Keying)
 - 21.9 Describe Digital Modulation techniques including the APCO (Association of Public Safety and Communications Officials) Project 25 standard
 - 21.10 Describe the common types of encryption and algorithms used in two-way communications
 - 21.11 Explain keyloading
 - 21.12 Define GSM (Global System for Mobile Communications)
- 22.0 CONTROL SYSTEMS**
- 22.1 Describe how DC remote control systems operate
 - 22.2 Explain the functions of a remote, and a remote adapter
 - 22.3 List typical frequencies, currents and voltages used in a DC system to key a transmitter, change frequencies, and engage the monitor functions
 - 22.4 Describe how tone remote control systems operate
 - 22.5 Explain the differences between High Level Guard Tone and Low Level Guard Tone
 - 22.5 Explain the advantages of a tone control system over a DC control system
 - 22.6 Define DTMF (Dual Tone Multi Frequency). Name an application where it is used
 - 22.7 Define SCADA(Supervisory Control and Data Acquisition). Explain where it is used
 - 22.8 Describe the use of IP remote control
- 23.0 RF INTERFERENCE**
- 23.1 Define receiver de-sensitization (de-sense) and explain the causes
 - 23.2 List reasons for spurious emissions and receiver response
 - 23.3 Explain site compatibility and reasons for site incompatibility
 - 23.4 Describe co and adjacent-channel interference
 - 23.5 Explain Image Frequency
 - 23.6 Explain transmitter noise
 - 23.7 Define Noise Floor
 - 23.8 Explain Harmonics and Sub-Harmonics
 - 23.9 Define BPL (Broadband over Power Line) interference
 - 23.10 Describe natural noises that can affect radio communication
 - 23.11 Explain wind generated static electricity
 - 23.12 List interference detection methods
 - 23.13 Define inter-modulation and list causes
 - 23.14 Describe minimum filtering and techniques that should be applied at a communications site to help minimize interference
 - 23.15 Describe Passive Intermodulation (PIM)
- 24.0 RF COVERAGE ANALYSIS, TESTING AND DIAGNOSIS**
- 24.1 Describe RF coverage modeling as defined in the Telecommunications Industry Association (TIA) technical service bulletin 88 (TSB 88)
 - 24.1.1 Describe service area
 - 24.1.2 Describe Reliability
 - 24.1.3 Describe how different portable configurations impact system coverage (i.e. type of antenna, use of speaker-microphone)
 - 24.1.4 Describe a balanced coverage design
 - 24.2 Describe RF coverage modeling verification as defined in the TIA TSB 88

Study Material Suggestions:

* *Electronic Communications*, Tom Wheeler, 680 ppg., ISBN 0-13-013139-3, Prentice-Hall, 2001

* The ARRL Handbook, published and revised each year by the American Radio Relay League. Available from the ARRL bookstore at: www.arrl.org or 1 888 277 5289.

* *Electronic Communication* by Robert L. Shrader. Available from the Society of Broadcast Engineers at www.sbe.org or 1 317 253 0418

* *Standard Radio Communications Manual* by R. Harold Kinley. Available from the author at: HKinley@home.com or call 1 864 587 2007 from 6 to 9 PM Eastern Time.

- * FCC Commercial General Radiotelephone Operator License Manual plus Ship Radar by Fred Maia and Gordon West. Available from NRE at PO Box 565206, Dallas, TX 75356 or 1 800 669 9594
- * Comprehensive Electronic Communication, Roy Blake, 1997, West Pub. Co. St Paul, MN, ISBN 0-314-20140-8

The following books may be found in some bookstores:

- * Radio Handbook by William I. Orr
- * Modern Electronic Communication Techniques by Harold B. Killen
- * Electronic Communications by Thomas A. Adamson
- * Amateur Radio Theory course by Martin Schwartz
- * General Radiotelephone Operator's License Study Guide by Thomas LeBlanc
- * CET Communications Exam Book by Ron Crow and Dick Glass (found in some libraries - no longer in print)
- * Wiring for Wireless Sites by P.E., Ira Wiesenfeld, 2002, Thomson, ISBN-10: 1401810373

Many other good texts, as well as earlier and out of print editions may be found at many good libraries and second hand bookstores.

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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. 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 with the material they need to construct a course outline for any course of instruction in wireless communications. Also to provide an outline for those studying to sit for the USMSS exams a guide to the knowledge and skills they will need.