Microwave Radio Technician - (MRT)
Competency Requirements

This competency for Radio Frequency (RF) Microwave Radio Systems Fundamentals identifies the elements required for technicians to install, align, maintain, and operate point-to-point microwave radio systems. To meet the criteria of this competency, the technician is expected to obtain knowledge from written course material and/or training along with successful passing of the microwave radio systems certification examination. Prior experience with radio systems and equipment is suggested. This competency includes core concepts of radio frequency (RF) energy, including how to identify it and safety requirements when working in an RF environment.

Required elements of the competency include:

1.0 Radio Frequency (RF) Safety Fundamentals

- 1.1 Describe how to recognize and assess the presence of RF energy at radio sites including:
  - 1.1.1 the difference between non-ionizing radiation and ionizing radiation
  - 1.1.2 identifying various radio antennas and their potential safety hazard
  - 1.1.3 what mitigation measures can be taken to reduce the RF hazard
  - 1.1.4 identifying and interpreting the meaning of standard signage at radio sites
- 1.2 Describe personal protection equipment (PPE) used while working with microwave
- 1.3 Describe safety measures used with towers and elevated surfaces
- 1.4 Describe testing equipment safety procedures

2.0 Radio Frequency Fundamentals Overview

- 2.1 Define basic radio spectrum concepts and fundamentals
- 2.2 Describe core terms associated with radio services including:
  - 2.2.1 wavelength
  - 2.2.2 bandwidth
  - 2.2.3 narrow band radio signals comparing to LMR (Land Mobile Radio)
  - 2.2.4 signal gain
  - 2.2.5 attenuation
  - 2.2.6 noise
- 2.3 Explain the difference between the use of fiber optic cables versus microwave radio systems in wireless networks
- 2.4 Identify various microwave radio system configurations including:
  - 2.4.1 linear microwave systems
  - 2.4.2 SONET (Synchronous Optical Network) Link
  - 2.4.3 mesh network
- 2.5 Units of measure:
  - 2.5.1 Define the decibel (dB)
  - 2.5.2 Describe the difference between dB and dBm
  - 2.5.3 Define the importance of measuring accuracy when using units of measure

3.0 Microwave Digital Modulation Schemes

- 3.1 Define radio modulation in general terms
- 3.2 Describe the differences between:
  - 3.2.1 Continuous Waves (CW) carriers
  - 3.2.2 Amplitude modulation – AM
  - 3.2.3 Frequency modulation –FM
  - 3.2.4 Phase modulation –PM
  - 3.2.5 Trellis coding modulation (TCM) – (convolutional coding)
- 3.3 Describe the core element of digital modulation and coding
- 3.4 Define Carrier-to-Noise ratio (C/N) and its purpose in digital modulation
- 3.5 Describe how a digital modulator uses a low pass filter to enhance bandwidth efficiency
- 3.6 Explain how digital codes work in an analog wireless environment
- 3.7 Describe the core principle of Quadrature Phase Shift Keying (QPSK)
- 3.8 Define Quadrature Amplitude Modulation (QAM) and how it's used in wireless networks including:

- 3.8.1 how to decode numerically, examples of QAM
- 3.8.2 how to describe the differences in QAM levels from 16 QAM to 128 QAM
- 3.8.3 why noise and data rates used in QAM are inter-related

3.9 Describe the decoding process used in digital modulation
3.10 Define regeneration of digital signals versus demodulation of analog signals
3.11 Identify the transmitter output RF carrier shape using a spectrum analyzer while using a bandpass filter to achieve compliance

4.0 Microwave Radio Equipment

4.1 Identify features of microwave radio equipment
4.2 Describe a digital transmitter block diagram including its key elements
4.3 Describe a digital receiver block diagram including its key elements
4.4 Describe how digital traffic interfaces with microwave equipment including:
- 4.4.1 T1 interface - TCM
- 4.4.2 Ethernet interface
- 4.4.3 optical interface - SONET

4.5 Describe the performance indicator purpose of the “Eye Pattern” when used in digital radios
4.6 Define transmitter (Tx) power requirements at microwave radio frequencies
4.7 Explain the importance of linear power amplifiers and power control in transmitters
4.8 Describe the basic operation of a microwave receiver (Rx) including:
- 4.8.1 Voltage Controlled Oscillator (VCO)
- 4.8.2 frequency control

4.9 Define Receive Signal Level (RSL) in microwave and point-to-point systems
4.10 Describe Bit Error Rate (BER) including:
- 4.10.1 the meaning of 10^{-6} BER
- 4.10.2 why BER is such an important operating parameter

4.11 Describe the role of radio timing and Inter-Symbol Interference (ISI)
4.12 Describe the operation of the Antenna Coupling Unit (ACU) in microwave radio systems
4.13 Describe microwave radio terminal protection configurations including:
- 4.13.1 Monitored Hot-standby
- 4.13.2 Space Diversity use and advantages
- 4.13.3 non-protected redundancy

4.14 Differentiate between a coaxial relay and “hitless” switching in a microwave radio terminal
4.15 Describe the following in microwave radio systems:
- 4.15.1 microwave circulators
- 4.15.2 microwave isolators
- 4.15.3 microwave duplexers
- 4.15.4 microwave terminators

5.0 Microwave Radio Propagation

5.1 Describe the general characteristics of line-of-sight (LOS) radio propagation
5.2 Define the microwave link budget
5.3 Explain path-related anomalies including:
- 5.3.1 free space loss (FSL)
- 5.3.2 diffraction
- 5.3.3 diffusion
- 5.3.4 rain and moisture impact at high frequencies
- 5.3.5 Fade Margin and the K Factor

5.4 Describe a microwave path fade and the following elements:
- 5.4.1 microwave ducting
- 5.4.2 radio multipath

5.5 Define the Fresnel Zone at microwave frequencies
- 5.5.1 Explain the Fresnel Zone Clearance
  - 5.5.1.1 Explain the importance of “60% of the first Fresnel clearance”
  - 5.5.1.2 Explain what is indicated by multiple even numbered Fresnel Zone clearances
- 5.5.2 Explain how the Fresnel Zone is calculated
- 5.5.3 Describe a path obstruction and its importance
- 5.5.4 Explain the difference between smooth sphere and knife edge reflection

6.0 Microwave Antenna Systems

- 6.1 Describe the difference between a microwave antenna (point-to-point) and other antennas
- 6.2 Explain the following when dealing with microwave antennas:
  - 6.2.1 antenna fundamentals:
    - 6.2.1.1 directivity and gain
    - 6.2.1.2 polarity in E and H planes
      - 6.2.1.2.1 linear, circular, etc
      - 6.2.1.2.2 Co-polarized
      - 6.2.1.2.3 Cross polarization
    - 6.2.1.3 use of radomes on microwave antennas
    - 6.2.1.4 microwave alignment
    - 6.2.1.5 major and minor lobes and their importance
  - 6.2.2 dish size versus frequency of operation
  - 6.2.3 licensing and regulatory requirements
- 6.3 Describe the difference between these two transmission types:
  - 6.3.1 waveguides
  - 6.3.2 coaxial cables
- 6.4 Describe the proper way to install a waveguide connector
- 6.5 Describe the difference between a coaxial di-pole antenna and a feedhorn at microwave frequencies
- 6.6 Explain proper weatherization and grounding for microwave antennas
- 6.7 List microwave antenna mounting hardware, such as mounting kits, harnesses, transitions

7.0 Microwave Radio Testing and Maintenance

- 7.1 Identify common test equipment for microwave system testing
  - 7.1.1 Spectrum Analyzer
- 7.2 Describe how to assemble/calibrate test equipment and safe practices for testing microwave radios
- 7.3 Describe the process for conducting power and frequency measurements on a microwave radio
- 7.4 Describe how to test a waveguide and feedhorn in a microwave radio system using Return Loss (RL) as the performance indicator
- 7.5 Describe how to read and interpret Receive Signal Level (RSL) or Received Signal Strength Indication (RSSI) on a microwave radio and the importance of this measurement
- 7.6 Describe the process for interpreting microwave alarms – use of lights, laptops, keypads
- 7.7 Describe the importance of accurate data documentation

End of RF Microwave Radio System Fundamentals Competencies

Find An ETA Test Site: **http://www.eta-i.org/test_sites.html**

Suggested Study Material and Resources:

Useful white papers and videos can be found at the following web sites: www.mwjournal.com; https://www.electronics-notes.com/; www.pasternack.com, www.complextoreal.com, www.iwatsi.com, https://www.tacticalrf.com/; www.commscope.com/; www.microwaves101.com/; https://www.facebook.com/DoverTraining/ and https://www.linkedin.com/company/dover-telecommunication-services-inc and https://www.globuya.com/US/Cedar-City/615142301945718/Dover-Telecommunication-Services; https://www.linkedin.com/in/dane-brockmiller-566b60 and www.eta-i.org, or by calling ETA® International for other resources at 1-800-288-3824.

Microwave Fundamentals; Thomas Dover; DTS, Inc 2016; pp. 125; see Facebook, LinkedIn, or Amazon

Practical Antenna Handbook, 5E; Joseph Carr & George (Bud) W. Hippisley; ISBN 978-0071639583; McGraw-Hill/Tab Electronics; 2011; pp.784

Electronic Communications: A System Approach; Jeff Beasley, Jonathan Hymer, & Gary M. Miller; ISBN 978- 0132988636; Pearson; 2013; pp.656

Modern Electronic Communication, 9E; Jeff Beasley & Gary M. Miller; ISBN 978-0132251136; Prentice Hall; 2007; pp.992

Handbook of Radio & Wireless Technology; Sam Gibilisco; ISBN 978-0070230248; McGraw-Hill Professional; 1998; pp.640; www.sciencewriter.net

Basic Radio, Principles & Technology; Ian Poole; ISBN 978-0750626323; Newnes; 1994; pp.224

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