Competency Requirements

Antenna System Analysis Technician – 2007

The following is a listing of each topic considered necessary to be included in a course of study towards the education of technicians performing Antenna System Analysis using a frequency domain reflectometer (FDR).

There are 11 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 ETA® Antenna System Analysis Technician certification are required to also have a basic education in fundamental electronics and wireless communications. The basic electronics knowledge is assessed in the ETA Associate CET examination. The wireless communications knowledge is assessed in the ETA WCM or USMSS wireless examination. The Antenna System Analysis certification is a Journeyman level certification and counts towards the requirements for Master certification (CETma).

Antenna System Analysis Competencies

1. **Introduction to Antenna System Commissioning**
   - 1.1. Explain the purpose of antenna system commissioning
   - 1.2. Explain the benefits of antenna system commissioning
   - 1.3. Explain the technologies available for antenna system commissioning:
     - 1.3.1. Time Domain Reflectometer (TDR)
     - 1.3.2. Frequency Domain Reflectometer (FDR)
   - 1.4. Describe the differences between the TDR and FDR
   - 1.5. List antenna system diagram requirements
   - 1.6. List antenna system commissioning documentation requirements

2. **RF Fundamentals**
   - 2.1. Explain the maximum power theorem and maximum power transfer
   - 2.2. Explain impedance mismatch and its effect
   - 2.3. Explain signal reflections and its effect
   - 2.4. Explain how to calculate reflection coefficient
   - 2.5. Explain voltage standing wave ratio (VSWR) and its cause
   - 2.6. Explain standing waves
   - 2.7. Explain return loss and its relationship to the primary signal
   - 2.8. Describe impedance mismatch versus VSWR or return loss
   - 2.9. Explain attenuation/insertion loss, its cause, and its effect
   - 2.10. Explain how an antenna transmits and receives an electromagnetic wave
   - 2.11. Explain how electromagnetic waves propagate through the atmosphere

2.12. List and describe antenna system components used in commercial and private radio communications systems

3. Mathematics

3.1. Explain absolute values
3.2. Explain the decibel (dB) unit and why it is important in large signal variations
3.3. Explain how to add and subtract decibel values
3.4. Explain how power and voltage ratios are converted to dB values
3.5. Describe the usage of each of the following decibel values:
  3.5.1. dBc
  3.5.2. dBd
  3.5.3. dBi
  3.5.4. dBm

4. Coaxial Cable Fundamentals

4.1. Describe coaxial cable construction
4.2. Explain what determines coaxial cable impedance
4.3. Explain the *skin effect* in a conductor
4.4. Describe a coaxial cable equivalent circuit using capacitance, inductance, and resistance
4.5. Explain coaxial cable velocity factor
  4.5.1. Explain how velocity factor impacts FDR measurements
  4.5.2. Explain how velocity factor impacts the length of a tuned coaxial stub
4.6. Explain coaxial cable attenuation or cable loss
  4.6.1. Explain how changes in cable size impacts impedance
  4.6.2. Explain how changes in frequency impacts impedance

5. RF Transmission Line (Coaxial Cable) Installation

5.1. Describe coax cable hanger usage and mounting conventions
5.2. Explain the importance of proper hanger spacing
5.3. Describe coax cable grounding kits and what purpose they serve
5.4. Explain coax cable grounding requirements as defined by applicable industry codes and standards
5.5. Describe proper ground kit and connector weatherproofing
5.6. Describe coax cable bending radius and the impact of an improper bending radius
5.7. Describe lightning protection requirements and the devices used for proper lightning protection

6. RF Connectors

6.1. Describe and identify commonly used RF connectors
6.2. Explain connector specifications
6.3. Describe connector installation requirements
  6.3.1. Detail proper coaxial cable preparation procedures and tools
  6.3.2. Explain the purpose of connector torque specifications and the impact of improper torque
6.4. Describe connector installation tools

6.5. Explain *passive intermodulation* and its effect

7. Antennas and Antenna Theory

7.1. Explain the electromagnetic field
  7.1.1. Electric field
  7.1.2. Magnetic field
7.2. List common antenna specifications and how they effect system design
  7.2.1. Frequency bandwidth
  7.2.2. Return loss / VSWR
  7.2.3. Gain
  7.2.4. Beam width
  7.2.5. Beam tilt
7.3. Explain how to calculate antenna wavelength
7.4. Explain velocity factor and how it effects antenna length
7.5. Explain antenna radiation pattern
7.6. Describe the radiation pattern for common antennas
7.7. Describe common antenna types
  7.7.1. Dipole
  7.7.2. Directional
  7.7.3. Isotropic
  7.7.4. Omni-directional
  7.7.5. Quarter wave
7.8. Explain antenna gain and how it is measured
7.9. Explain common antenna gain references
  7.9.1. Dipole
  7.9.2. Isotropic
  7.9.3. Quarter wave
7.10. Explain antenna beam width and how it is defined
7.11. Explain antenna frequency bandwidth and how it is measured
7.12. Explain antenna beam tilt
  7.12.1. Mechanical
  7.12.2. Electrical
7.13. Explain vertical, horizontal, and other antenna polarization
7.14. Antenna mounting
  7.14.1. Describe proper antenna mounting and the detrimental effects caused by improper mounting

8. Frequency Domain Reflectometer Testing

8.1. Describe adapter usage requirements
8.2. Describe calibration combo usage and care
8.3. Explain calibration importance and requirements
8.4. Explain phase-stable cable requirements and usage
8.5. Describe proper FDR configuration for a distance-to-fault test
  8.5.1. Cable type
  8.5.2. Data points
  8.5.3. Maximum distance versus frequency
  8.5.4. Resolution

8.6. Antenna testing
  8.6.1. Describe how to test antenna return loss
  8.6.2. Describe how to determine antenna frequency bandwidth
8.7. Attenuation or insertion loss testing
  8.7.1. Describe how to measure the insertion loss of specific components
  8.7.2. Describe how to measure the insertion loss of the antenna system
8.8. Explain the difference between an insertion loss test and return loss test
8.9. Coax cable testing
  8.9.1. Describe how to measure attenuation or cable loss
  8.9.2. Describe how to measure return loss or match
  8.9.3. Describe how to measure the distance-to-fault return loss
8.10. Antenna system testing
  8.10.1. Describe how to measure the return loss or match
  8.10.2. Describe how to measure distance-to-fault
  8.10.3. Describe antenna system sweep "signatures" and their usage

9. Frequency Domain Reflectometer Test Interpretation

9.1. Compare measured component(s) return loss values with manufacturer specifications for the following:
  9.1.1. Antenna response specifications
  9.1.2. Connector specifications
  9.1.3. Feed line specifications
  9.1.4. Lightning suppressor specifications
  9.1.5. Other components
9.2. Explain how to calculate expected system return loss value and compare to measured value
9.3. Explain how to compare location of component(s) on the system diagram to the measured locations
  9.3.1. Identify system components at appropriate return loss levels
  9.3.2. Identify location of faults (if any)
  9.3.3. Identify possible fault causes
9.4. Antenna system sweep signature characteristics
  9.4.1. Explain how to verify antenna meets specifications
  9.4.2. Describe antenna system sweep "signatures" and their usage

10. **FDR Troubleshooting**

10.1. List and describe common antenna problems
10.2. List and describe common cable problems
10.3. List and describe common connector problems
10.4. Explain the process of comparing baseline sweep traces with current traces

Practical Competencies Requirements

1. **FDR Operation**
   - 1.1. Demonstrate proper FDR calibration
   - 1.2. Demonstrate setting markers and limit lines on the FDR
   - 1.3. Demonstrate how to select the test type or mode on the FDR
   - 1.4. Demonstrate how to select display amplitude and/or auto scale on the FDR
   - 1.5. Demonstrate how to select test frequency range on the FDR
   - 1.6. Demonstrate how to select test distance range on the FDR
   - 1.7. Demonstrate how to select cable type on the FDR for a DTF test
   - 1.8. Demonstrate how to set windowing or smoothing option on the FDR
   - 1.9. Demonstrate how to store and recall a trace on the FDR
   - 1.10. Demonstrate how to name a trace on the FDR
   - 1.11. Demonstrate how to set FDR time and date
   - 1.12. Demonstrate use of the FDR PC software tools

Recommended Study Material

- Training materials can be found at the following Motorola internal web site (accessible to Motorola employees only): FDR Information
- Useful white papers can be found at the following web sites: www.anritsu.com and www.bird-electronic.com
- *Practical Antenna Handbook* – ISBN 0071374353
- *Practical Radio Frequency Test & Measurement* – ISBN 0750671610
- *Modern Electronic Communication* – ISBN 0131130374