



# RF Interference Mitigation - RFIM (Level 1) and Advanced Interference Mitigation – AIM (Level 2) Competency Requirements

This competency listing covers individual subject topics in which Radio Frequency Interference (RFI) is identified and then corrected by technicians. To meet the competency criteria an Interference Mitigation technician is expected to obtain knowledge from the written and practical RF interference hunting and mitigation material to pass either the **RFIM** or **AIM** certification examination(s).

**RFIM** Level 1 includes basic knowledge concepts of and experience with radio frequencies, how they interact in the environment and within equipment, and how to identify and to correct interference problems. RFIM Level 1 is a Stand-Alone certification only.

**AIM** Level 2 includes advanced knowledge concepts of and prior experience with radio frequencies, how they interact in the environment and within equipment, further applications with spectrum analyzer operations including identification, mitigation and documentation of interference situations. **AIM** Level 2 can be a Stand-Alone certification or is the Journeyman portion of the **CET** certification requiring that the basic electronics exam also be passed, either the Associate CETa or General Communications Technician 1 (GCT1).

While neither interference mitigation certification has a required course or class as a pre-requisite, there are training programs available to assist a technician's expanded comprehension of the competencies and techniques. Prior extensive experience with RF interference and analyzing equipment is strongly recommended as a pre-requisite to the **AIM** certification.

Required elements of the competency and expected certification include:

## 1.0 Safety

- 1.1. Describe Radio Frequency (RF) safety protocols per industry standards
  - 1.1.1. Explain the FCC OET65 bulletin
  - 1.1.2. Explain the IEEE/ANSI C-95 standard
- 1.2. Describe general safety guidelines including:
  - 1.2.1. AC power
  - 1.2.2. battery systems
  - 1.2.3. vehicle and driving procedures
  - 1.2.4. lifting and carrying equipment over distance
- 1.3. Describe general tools and equipment safety
- 1.4. List personal protection equipment (PPE) used in the communication work
- 1.5. Describe communications safety requirements used near machinery
- 1.6. Describe safety measures used with tower and elevated surfaces
  - 1.6.1. Explain environmental safety procedures
- 1.7. Describe grounding and antenna safety measures in the National Electrical Code (NEC®)

## 2.0 Radio Interference Principals – Radio Overview

- 2.1. Define Basic RF spectrum and RF propagation including:
  - 2.1.1. radio frequency bands
  - 2.1.2. wavelength
  - 2.1.3. receiver parameters:
    - 2.1.3.1. sensitivity
    - 2.1.3.2. selectivity
  - 2.1.4. RF site parameters:
    - 2.1.4.1. Noise Floor
    - 2.1.4.2. effective sensitivity
    - 2.1.4.3. antenna pattern anomalies
- 2.2. Describe RF 'Core Terms' associated with radio services including:
  - 2.2.1. bandwidth – narrow band and wideband
  - 2.2.2. the difference between signal gain and attenuation
  - 2.2.3. both man-made and atmospheric radio noise

## Radio Frequency and Advanced Interference Mitigation Knowledge Competencies

- 2.3. Explain what Signal-to-Noise ratio (S/N) means
- 2.4. Describe the general principles of Shannon's Law including:
  - 2.4.1. how it impacts the ability to pass digital data
- 2.5. Describe the overall impact of radio interference in the following wireless services:
  - 2.5.1. 4G - cellular
  - 2.5.2. LTE
  - 2.5.3. 5G
  - 2.5.4. Small Cells - DAS
  - 2.5.5. Public Safety
  - 2.5.6. Government
- 2.6. Units of Measure
  - 2.6.1. Define decibel (dB) including:
    - 2.6.1.1. dBm
    - 2.6.1.2. dBc
    - 2.6.1.3. dBd
    - 2.6.1.4. dBi
  - 2.6.2. Describe the difference between dB and dBm
  - 2.6.3. Describe dBm and dBc and how they are related to each other
  - 2.6.4. Explain the importance of accuracy when using units of measure
  - 2.6.5. Describe how units of power in Watts and dBm are related
- 2.7. Explain the formula and factors that are part of Free Space Loss
- 2.8. Describe how an antenna can have gain
  - 2.8.1. Describe the difference between dBd and dBi when referring to antenna gain
- 2.9. Describe what Rayleigh Fading is and how it affects radio signals
- 2.10. Define multipath radio signals and MIMO Technology (Multiple Input Multiple Output)
- 2.11. Describe the large amount of RF energy carried over a very broad spectrum in CATV networks
  - 2.11.1. Describe the CATV network shields protecting the analog and/or digital carriers
  - 2.11.2. Describe RF Interference resulting from disturbed or damaged shields
- 2.12. Describe how an ISO-Tee adapter is built and how it should be used to test for effective sensitivity

### 3.0 Interference Types – Overview and Corrective Actions

- 3.1. Define the meaning of radio interference
- 3.2. Describe the difference between radio noise and radio interference
- 3.3. Describe each of the following interference types:
  - 3.3.1. Co-channel Interference
  - 3.3.2. Adjacent Channel Interference
  - 3.3.3. External spurious noise
  - 3.3.4. Sideband noise
  - 3.3.5. Spurious Response
  - 3.3.6. Harmonics, sub-harmonics and multiples of harmonics
  - 3.3.7. Electrical and power line noise
  - 3.3.8. Image interference
  - 3.3.9. Lamp interference
    - 3.3.9.1. Fluorescent and CFL (Compact FL) lamps
    - 3.3.9.2. Tower lamps
  - 3.3.10. Antenna separation and spacing
  - 3.3.11. RF attenuation by non-electrical objects
  - 3.3.12. RF interference upon non-radio apparatus
- 3.4. Describe each of the prior interference types impact on radio or communications performance
- 3.5. Describe the steps to mitigate each of the prior interference types including:
  - 3.5.1. correcting the source
  - 3.5.2. capacitor use
  - 3.5.3. use of chokes
  - 3.5.4. ferrite beads use
- 3.6. Describe how to mitigate multipath RF interference
  - 3.6.1. Explain the differences between narrowband noise-interference and wideband noise-interference
- 3.7. Describe radio components thought to cause radio interference including:
  - 3.7.1. lightning protectors

- 3.7.2. components hit by lightning
- 3.8. Define radio receiver desense; also known as blocking
  - 3.8.1. Describe the role this kind of radio interference plays in receiver performance
- 3.9. Explain the role radio interference plays in receiver performance
- 3.10. Describe the following radio interference indicators:
  - 3.10.1. receiver threshold
  - 3.10.2. transmitter spurious carriers
  - 3.10.3. transmitter isolation – power

#### **4.0 Intermodulation**

- 4.1. Define Intermodulation when involving radio signals
- 4.2. Describe how Intermodulation is created including:
  - 4.2.1. internal intermodulation
  - 4.2.2. external intermodulation
- 4.3. Describe Passive Intermodulation (PIM) including:
  - 4.3.1. the causes of PIM
  - 4.3.2. which piece(s) of radio equipment a high PIM level most affects and define its impact
  - 4.3.3. the IEC-62037 standard
- 4.4. Describe how PIM testing in general is conducted and sources of PIM including:
  - 4.4.1. the term “2 X 20 Watts” when referring to PIM testing
  - 4.4.2. the function of a PIM tester
  - 4.4.3. the components required of all PIM testers
  - 4.4.4. what is measured on the receive side of a PIM test
  - 4.4.5. how to convert dBm to dBc during a PIM test
  - 4.4.6. the effects of high PIM levels on radio receiver quality and performance

#### **5.0 Filters – Filter Systems Usage to Mitigate RFI**

- 5.1. Define what the term filter (cavity) means when used in radio systems
- 5.2. Describe how a filter is constructed and tuned for various frequencies
  - 5.2.1. Describe how environmental factors affect tuned filters
- 5.3. Explain why filter physical size is connected to the frequency of operation
- 5.4. Describe the following types of radio filters:
  - 5.4.1. Bandpass filter
  - 5.4.2. Band Reject or Notch filter
  - 5.4.3. Low pass filter
  - 5.4.4. High pass filter
  - 5.4.5. Crystal filters
- 5.5. Define the purpose of and common uses of a harmonic filter
- 5.6. Describe the purpose of a pre-select filter
- 5.7. Describe what a circulator and isolator are in a radio antenna system
- 5.8. Describe the following concerning radio duplexers including:
  - 5.8.1. components of most radio duplexers
  - 5.8.2. purpose of a radio duplexer
  - 5.8.3. “insertion loss” meaning when dealing with a duplexer
  - 5.8.4. “critical cable lengths” meaning when dealing with radio duplexers
- 5.9. Define what transmitter combiners are
  - 5.9.1. Explain the use of a transmitter combiner
  - 5.9.2. Describe the benefit to the radio location or site when using a transmitter combiner
  - 5.9.3. Describe how isolators are used in transmitter combiners
- 5.10. Describe receiver pre-amplifiers and multi-couplers including:
  - 5.10.1. pre-amplifiers and multi-couplers used in radio systems
  - 5.10.2. the multi-coupled receiver system antenna typically located on the tower
  - 5.10.3. the gain of the receiver pre-amplifier
  - 5.10.4. how noise and interference play a role in receiver systems
- 5.11. Describe a tower mounted amplifier (TMA) {tower top amplifier-TTA} including:
  - 5.11.1. why TMAs {TTAs} are used in radio networks
  - 5.11.2. how TMAs {TTAs} are powered
  - 5.11.3. how a TMA {TTA} can contribute to site noise, interference and intermodulation
- 5.12. Describe how to tune and verify RF filters using a tracking generator

## 6.0 Test Equipment For Interference Hunting

- 6.1. Describe how the following are used to find and define radio interference:
  - 6.1.1. Spectrum Analyzers (SA)
  - 6.1.2. Field Strength meters
  - 6.1.3. Doppler antennas
  - 6.1.4. Directional antennas
  - 6.1.5. Omnidirectional antennas
  - 6.1.6. Signal-sniffers
- 6.2. Describe how each of the above are used to identify good signals versus bad including:
  - 6.2.1. the basic operation of a spectrum analyzer
  - 6.2.2. the added value provided by a direction-finding or directional antenna
  - 6.2.3. when a simple signal-sniffer would be used to find interference
  - 6.2.4. dynamic range limitations
- 6.3. Explain why a monitor receiver or spectrum analyzer is considered the most important tool for finding RFI
- 6.4. Describe how to document interference
  - 6.4.1. Describe what is a screen or trace
  - 6.4.2. Describe how mapping capability helps to identify interference sources and locations
  - 6.4.3. Explain important measurement considerations when documenting radio interference

## 7.0 Finding Interference

- 7.1. Describe the process for finding broadband spurious radio signals
- 7.2. Describe how to assemble test equipment and begin the process for locating frequency specific interference
  - 7.2.1. Define Center frequency
  - 7.2.2. Define Span and the Span key
  - 7.2.3. Explain how to set and identify:
    - 7.2.3.1. RBW (Resolution Bandwidth) filter
    - 7.2.3.2. VBW (Video Bandwidth) filter
- 7.3. Describe how a Yagi antenna and good test cable can be used for finding radio interference directions using triangulation
- 7.4. Describe how a Doppler based antenna system creates accuracy when looking for radio interference

## 8.0 Interpreting Test Results – Corrective Actions

- 8.1. Describe how to best interpret a spectrum analyzer result as follows:
  - 8.1.1. Measurement of the noise floor
  - 8.1.2. Define Occupied Channel Bandwidth (OBW) measurement
    - 8.1.2.1. Using OBW, describe how much bandwidth the interference is creating
  - 8.1.3. Define the “Using the Reference Level” to identify the magnitude of the interfering signal
  - 8.1.4. Describe the use of markers to identify specific frequencies and levels
  - 8.1.5. Identify the following:
    - 8.1.5.1. a legitimate signal versus an unwanted signal
    - 8.1.5.2. an unwanted – interfering radio signal
  - 8.1.6. Describe how to pinpoint the undesired signal in magnitude and direction
- 8.2. Describe how to contact the FCC concerning interference
  - 8.2.1. Describe how to document and keep an FCC/NTIA log(s)
  - 8.2.2. Describe what must be prepared for an FCC inspection
  - 8.2.3. Describe the procedures for NTIA Interfacing

## End of RF Interference Mitigation Competencies

Find An ETA Approved School and/or Test Site:

[http://www.eta-i.org/test\\_sites.html](http://www.eta-i.org/test_sites.html)

**Suggested Additional Study Material and Resources:**

Useful articles, white papers and videos can be found at the following web sites:

[www.doverts.com](http://www.doverts.com), and [www.birdrf.com](http://www.birdrf.com), and <http://iwiesenfel.wix.com/iwa#!>, and [www.radio-electronics.com](http://www.radio-electronics.com), and <http://www.agfranz.com/narda-appnotes.html> or by contacting ETA<sup>®</sup> International for other additional resources

**Radio Frequency Interference from A to Z;** Ira Wiesenfeld, P.E., Thomas K. Dover, Jay Thompson; ISBN: 978-0-9915913-4-3; Self-published; 2015; pp. 218; \$80; Available through ETA 800-288-3824, [www.eta-i.org](http://www.eta-i.org) or through <http://iwiesenfel.wix.com/iwa#!>

**Radio Frequency Interference & Mitigation;** Thomas K. Dover; ISBN: 978-1-9400429-89-2; DTS,inc.; 2015; pp. 150; Available through [www.doverts.com](http://www.doverts.com). Or at Amazon.com

**Wiring for Wireless Sites;** Ira Wiesenfeld, P.E.; ISBN 978-1401810375; Thompson Delmar Learning; 2002; pp. 260; Available through <http://iwiesenfel.wix.com/iwa#!>

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

**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; 2008; pp.640

**Basic Radio, Principles & Technology;** Ian Poole; ISBN 978-0750626323; Newnes; 1998; pp.224

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