

# General Communications Technician - Level 2 (GCT2) Competency Requirements



The General Communications Technician Level 2 certification is a journeyman level program modeled after wide-ranging private wireless communication systems along with the [U.S. Department of Homeland Security \(DHS\)](#) guidelines covering many of the disciplines in the COMT program. The GCT2 competency comprises more complex areas which a radio communications technician and/or engineer will encounter in the public safety communications or business / commercial radio fields. This GCT2 certification will involve more knowledge of intricate skills and troubleshooting.

The purpose of the GCT2 is to provide a certification program that expands upon the coverage included in the ETA® [GCT1](#) competencies. Before attempting the GCT2 certification a technician must hold the GCT1 or the [Associate CETa](#) pre-requisite certification. Prior RF experience in industry and public safety best practices is highly suggested. Both the GCT1 and GCT2 certifications must be [maintained](#).

The following **Level 2** Competency listing is a more thorough acknowledgement and description of extensive individual subject topics in electronics areas in which industry General Communications Technicians (GCT2) would comprehend and experience. (Some competencies may be similar to items in GCT1, kept for emphasis and may apply in multiple categories).

## 1.0 Safety

- 1.1. List the basic building / workplace safety protocols per industry standards to include:
  - 1.1.1. falling object mitigation
  - 1.1.2. fire prevention and suppression
  - 1.1.3. Occupational Safety and Health Administration (OSHA) rules
- 1.2. Describe general power safety guidelines, including:
  - 1.2.1. battery systems
  - 1.2.2. "Lock Out / Tag Out" rule
    - 1.2.2.1. other power system precautions
- 1.3. Describe general tools and equipment safety
- 1.4. List personal protection equipment (PPE) used in the communication fields
- 1.5. Describe Radio Frequency (RF) safety
- 1.6. Describe communications safety requirements used near machinery
- 1.7. Describe safety measures used with communication sites including:
  - 1.7.1. tower and elevated surfaces
  - 1.7.2. ladder safety (ANSI A14)
- 1.8. Describe grounding and lightning protection safety measures
- 1.9. List fiber optic safety requirements
- 1.10. List laser use safety requirements
- 1.11. Describe hazardous chemicals and materials handling situations

## 2.0 Electronic and Electrical Principles

- 2.1. Review Ohm's law and formulas
- 2.2. Review Watt's Law formula
- 2.3. Explain complex DC circuits to include:
  - 2.3.1. series
  - 2.3.2. parallel
  - 2.3.3. series-parallel
- 2.4. Describe Alternating Current (AC) waveforms to include:
  - 2.4.1. polarity reversal
    - 2.4.1.1. frequency
    - 2.4.1.2. period
  - 2.4.2. Define the relationship between frequency and period
  - 2.4.3. Describe AC calculations
    - 2.4.3.1. reactance
      - 2.4.3.1.1. inductive
      - 2.4.3.1.2. capacitive
    - 2.4.3.2. impedance

## General Communications Technician Level 2 Knowledge Competencies

- 2.4.4. Describe relationship of each of the following to each other:
  - 2.4.4.1. Root Mean Square (RMS)
  - 2.4.4.2. Peak
  - 2.4.4.3. Average (Avg)
  - 2.4.4.4. Peak-to-Peak
- 2.5. Describe decibels (dB) and their use including:
  - 2.5.1. RF
    - 2.5.1.1. effective radiated power (ERP) formula
  - 2.5.2. power
    - 2.5.2.1. compare relative power levels (dB)
    - 2.5.2.2. measure absolute power (dBm)
  - 2.5.3. audio
    - 2.5.3.1. compare gain and loss
- 2.6. Explain how to use the metric system including:
  - 2.6.1. prefixes and their acronyms
- 2.7. Describe harmonics applications and effects in communications
- 2.8. Calculate power conversions for loads

### 3.0 Fundamentals of Radio Systems

- 3.1. Explain that radio systems have four different components including:
  - 3.1.1. transmitters
  - 3.1.2. receivers
  - 3.1.3. power supplies
  - 3.1.4. audio and control
- 3.2. Describe how transmitters are under processor control including:
  - 3.2.1. sending information to a carrier on an assigned frequency
  - 3.2.2. frequency control having stages which includes:
    - 3.2.2.1. oscillators for operating frequency, channel steps and accuracy
    - 3.2.2.2. amplifiers
    - 3.2.2.3. multipliers and mixer stages
    - 3.2.2.4. intermediate power amplifiers
    - 3.2.2.5. power amplifiers
    - 3.2.2.6. power control boards
- 3.3. Explain how modulation is the process of adding intelligence to an RF carrier
- 3.4. Describe the most common modulation modes including:
  - 3.4.1. amplitude (AM) is a heterodyne process
  - 3.4.2. frequency (FM)
  - 3.4.3. phase (PM)
  - 3.4.4. digital
    - 3.4.4.1. digital signal processors (DSP)
  - 3.4.5. frequency-shift keying-non-return-to-zero (FSK-NRZ)
  - 3.4.6. 4-level (C4FM)
    - 3.4.6.1. next generation digital narrowband (NXDN™)
    - 3.4.6.2. digital mobile radio (DMR)
      - 3.4.6.2.1. MOTOTRBO™
  - 3.4.7. time division multiple access (TDMA)
  - 3.4.8. global signaling for mobile communications (GSM)
  - 3.4.9. Project 25 (P25)
    - 3.4.9.1. Phase 1
    - 3.4.9.2. Phase 2
  - 3.4.10. code division multiple access (CDMA)
  - 3.4.11. Terrestrial Trunked Radio (TETRA)
    - 3.4.11.1. TETRAPOL
  - 3.4.12. phase shift keying (PSK)
    - 3.4.12.1. quadrature PSK (QPSK)
    - 3.4.12.2. coherent (CPSK)
  - 3.4.13. quadrature amplitude modulation (QAM)
  - 3.4.14. 4-level pulse amplitude modulation (PAM-4)

## General Communications Technician Level 2 Knowledge Competencies

- 3.5. Describe how receivers return frequency signals to their original format including:
  - 3.5.1. receiver bandwidth must match the transmitter modulation scheme
  - 3.5.2. superheterodyne receiver stages:
    - 3.5.2.1. RF
    - 3.5.2.2. mixer
    - 3.5.2.3. local oscillator
    - 3.5.2.4. IF (image frequency)
    - 3.5.2.5. limiter
    - 3.5.2.6. detector - demodulator
    - 3.5.2.7. audio or data
  - 3.5.3. additional receiver stages:
    - 3.5.3.1. squelch
    - 3.5.3.2. automatic gain control (AGC)
    - 3.5.3.3. automatic volume control (AVC)
    - 3.5.3.4. automatic frequency control (AFC)
    - 3.5.3.5. ultra-high stability oscillator
    - 3.5.3.6. audio amplifier
- 3.6. Explain how demodulation is the process of separating intelligence from an RF carrier
- 3.7. Describe the most common demodulation schemes including:
  - 3.7.1. diode in AM called "Envelope Detection"
  - 3.7.2. detector in FM as one of the following:
    - 3.7.2.1. discriminator
    - 3.7.2.2. ratio
    - 3.7.2.3. quadrature
    - 3.7.2.4. slope
  - 3.7.3. digital demodulation via DSP
- 3.8. Describe how audio or RF filters allow frequencies to pass through radio systems including:
  - 3.8.1. low-pass (LPF)
  - 3.8.2. high-pass (HPF)
  - 3.8.3. band-pass (preselector)
  - 3.8.4. band-stop
- 3.9. Explain how RF power supplies work including:
  - 3.9.1. analog
  - 3.9.2. switching

### 4.0 Tools, Methods and Test Equipment

- 4.1. Review the common tools used in RF communications
- 4.2. Describe the use and operation of the following meters:
  - 4.2.1. standalone voltmeters to include
    - 4.2.1.1. analog multimeter
    - 4.2.1.2. digital multimeter (DMM)
    - 4.2.1.3. impedance loading
  - 4.2.2. Wattmeters to include:
    - 4.2.2.1. inline
    - 4.2.2.2. analog
    - 4.2.2.3. digital
- 4.3. Describe the use and operation of Communication Service Monitors (CSM) to include:
  - 4.3.1. instrumentation:
    - 4.3.1.1. RF Monitor
    - 4.3.1.2. signal generator
      - 4.3.1.2.1. repeater received signal strength (RSS)
    - 4.3.1.3. spectrum analyzer
    - 4.3.1.4. modulation monitor
    - 4.3.1.5. tone encoder
    - 4.3.1.6. tone decoder
    - 4.3.1.7. antenna analyzer
    - 4.3.1.8. power meter
    - 4.3.1.9. voltmeter
    - 4.3.1.10. transmission levels

## General Communications Technician Level 2 Knowledge Competencies

- 4.3.1.11. oscilloscope
- 4.3.1.12. tracking generator
- 4.3.1.13. distortion analyzer
- 4.3.1.14. SINAD meter
- 4.3.1.15. RF frequency error meter
  - 4.3.1.15.1. transmitter frequency error
  - 4.3.1.15.2. receiver frequency error
- 4.3.1.16. cable fault analyzer
- 4.3.1.17. audio frequency counter (AFC) mode
- 4.3.1.18. bit error rate (BER) meter
- 4.3.2. accuracy:
  - 4.3.2.1. frequency
  - 4.3.2.2. modulation
    - 4.3.2.2.1. Deviation Meter Bessel Null measurement
  - 4.3.2.3. output level
  - 4.3.2.4. automatic testing
  - 4.3.2.5. port power maximums
- 4.4. Describe the use and operation of additional antenna test equipment including:
  - 4.4.1. frequency domain reflectometer (FDR)
  - 4.4.2. time domain reflectometer (TDR)
  - 4.4.3. standing wave ratio (SWR) meter
- 4.5. Describe the use and operation of audio transmission test sets to include:
  - 4.5.1. transmission impairment measurement sets (TIMS)
- 4.6. Describe the use and operation of the following:
  - 4.6.1. lineman's handset (Butt-set)
  - 4.6.2. ground resistance tester
  - 4.6.3. local area network (LAN) tester
- 4.7. Explain the use and operation of a Spectrum Analyzer including:
  - 4.7.1. frequency range
  - 4.7.2. sensitivity
  - 4.7.3. selectivity
  - 4.7.4. span
  - 4.7.5. dynamic range
  - 4.7.6. bandwidth selection
  - 4.7.7. "Time Base Accuracy"
  - 4.7.8. power levels
  - 4.7.9. tracking generator
  - 4.7.10. storage
  - 4.7.11. persistence
  - 4.7.12. markers
  - 4.7.13. sweep speed
- 4.8. Explain the "Noise Floor" of a device or system
- 4.9. Explain the use and operation of an oscilloscope including:
  - 4.9.1. vertical stage(s)
  - 4.9.2. bandwidth
  - 4.9.3. trace(s)
  - 4.9.4. horizontal
    - 4.9.4.1. sweep speed
  - 4.9.5. time base
  - 4.9.6. accuracy
  - 4.9.7. Lissajous pattern
  - 4.9.8. triggering
    - 4.9.8.1. auto
    - 4.9.8.2. normal
    - 4.9.8.3. single
      - 4.9.8.3.1. re-arm switch
  - 4.9.9. delay
  - 4.9.10. storage

- 4.10. Describe passive intermodulation (PIM) testers to include:
  - 4.10.1. PIM Theory
  - 4.10.2. new construction versus legacy systems differentiation
  - 4.10.3. external PIM
- 4.11. Explain “Equipment Testing” best practices to include:
  - 4.11.1. calibration
  - 4.11.2. stabilization
  - 4.11.3. warm-up procedure
  - 4.11.4. test lead loss compensation
- 4.12. Identify pass/fail limits for tolerances

## 5.0 Connectorization

- 5.1. Define the terms connector/connection
- 5.2. Describe common connector types to include:
  - 5.2.1. networking connectors
- 5.3. Describe a connector’s general characteristics
- 5.4. Describe a wire’s physical material makeup
- 5.5. Describe the National Electrical Code (NEC®) specific articles to include:
  - 5.5.1. wire sizing standards also listing American Wire Gauge (AWG) properties
  - 5.5.2. TIA-568A and TIA-568B sequences
  - 5.5.3. color coding to the TIA-598 standards:
    - 5.5.3.1. DC
    - 5.5.3.2. AC
    - 5.5.3.3. telecom
- 5.6. Explain why wire length should always include slack
- 5.7. Describe DC voltage and wiring to include:
  - 5.7.1. source voltage
  - 5.7.2. current
  - 5.7.3. polarity
- 5.8. Describe AC voltage and wiring to include:
  - 5.8.1. adhering to NEC® installation standards especially ground/bonding practices
  - 5.8.2. proper plug and receptacle use per National Electrical Manufacturers Association (NEMA®)
- 5.9. List “Telecom Category” cable designations
- 5.10. Describe RF cables and connection components to include:
  - 5.10.1. coaxial
  - 5.10.2. dielectric
  - 5.10.3. signal loss
  - 5.10.4. connector types
  - 5.10.5. impedance matching

## 6.0 Power Systems

- 6.1. Describe physical installation of infrastructure powered equipment including:
  - 6.1.1. power systems voltage and current requirements:
    - 6.1.1.1. AC power
    - 6.1.1.2. DC power
  - 6.1.2. power connections:
    - 6.1.2.1. fuse and breaker requirements:
      - 6.1.2.1.1. operating environment
      - 6.1.2.1.2. load centers
      - 6.1.2.1.3. disconnection requirements (Cut-off, Alarm, Transfer)
      - 6.1.2.1.4. surge protection
    - 6.1.2.2. battery power:
      - 6.1.2.2.1. sizing and handling
      - 6.1.2.2.2. 13.8 VDC devices
      - 6.1.2.2.3. 24/48 VDC battery operated devices
      - 6.1.2.2.4. uninterruptible power supply (UPS)
      - 6.1.2.2.5. low voltage disconnect(s)

## General Communications Technician Level 2 Knowledge Competencies

- 6.1.2.3. generators
- 6.1.2.4. renewable energy systems to include:
  - 6.1.2.4.1. solar
  - 6.1.2.4.2. fuel cell
  - 6.1.2.4.3. wind
  - 6.1.2.4.4. hydro
- 6.1.2.5. distribution systems
- 6.1.3. installation planning procedures including infrastructure

### 7.0 Antennas, Transmission Lines and Towers

- 7.1. Define the antenna performance of a radio system
- 7.2. Describe the antenna's:
  - 7.2.1. polarization orientation
    - 7.2.1.1. vertical
    - 7.2.1.2. horizontal
    - 7.2.1.3. circular
    - 7.2.1.4. cross
  - 7.2.2. length(s)
    - 7.2.2.1. wavelength
  - 7.2.3. resonance
  - 7.2.4. bandwidth
  - 7.2.5. "Half-Power" or "3dB Points"
  - 7.2.6. beamwidth
  - 7.2.7. gain
    - 7.2.7.1. Isotropic Theory
      - 7.2.7.1.1. Effective Isotropic Radiated Power (EIRP)
      - 7.2.7.1.2. dBi, dBW, dBd
  - 7.2.8. match
  - 7.2.9. return loss versus VSWR (voltage standing wave ratio) (aka: SWR)
    - 7.2.9.1. maximum VSWR
      - 7.2.9.1.1. fixed
      - 7.2.9.1.2. mobile
      - 7.2.9.1.3. portable
  - 7.2.10. Downtilt
    - 7.2.10.1. Formula:  $\text{Angle} = \text{ArcTAN}(\text{Height/Distance})$
  - 7.2.11. devices
    - 7.2.11.1. drain holes
    - 7.2.11.2. Balun
  - 7.2.12. types
    - 7.2.12.1. dipole(s), including variations on and complexities of:
      - 7.2.12.1.1. Ground plane
      - 7.2.12.1.2. Collinear
      - 7.2.12.1.3. Panel
      - 7.2.12.1.4. Loaded coil
      - 7.2.12.1.5. Log periodic
      - 7.2.12.1.6. Cardioid
    - 7.2.12.2. omnidirectional
      - 7.2.12.2.1. discone
    - 7.2.12.3. directional
      - 7.2.12.3.1. Yagi-Uda (a complex parallel dipole)
    - 7.2.12.4. dish
    - 7.2.12.5. disguised / hidden
    - 7.2.12.6. low profile
    - 7.2.12.7. fractal
    - 7.2.12.8. handheld transceivers
  - 7.2.13. separation and its affects

## General Communications Technician Level 2 Knowledge Competencies

- 7.3. Describe distributed antenna systems (DAS) to include:
  - 7.3.1. connectivity
    - 7.3.1.1. coaxial
      - 7.3.1.1.1. splitters
      - 7.3.1.1.2. taps
      - 7.3.1.1.3. leaky cable
    - 7.3.1.2. internet protocol (IP)
      - 7.3.1.2.1. fiber optic
      - 7.3.1.2.2. Ethernet
      - 7.3.1.2.3. existing LAN/Cat5e/Cat6/6A
  - 7.3.2. “Donor Antenna”
    - 7.3.2.1. system gain design
  - 7.3.3. direct fiber connection to carriers
  - 7.3.4. distribution system
    - 7.3.4.1. channelized BDA– Class A
    - 7.3.4.2. Band pass BDA – Class B
  - 7.3.5. isolation between donor and distribution systems per NFPA 1221 - 2019
  - 7.3.6. performance of DAS
- 7.4. Describe transmission lines to include:
  - 7.4.1. characteristic impedance
  - 7.4.2. maximum power
  - 7.4.3. causes of signal dB loss per 100 feet
    - 7.4.3.1. higher frequency
    - 7.4.3.2. longer length
    - 7.4.3.3. connector loss
  - 7.4.4. physical dimensions
    - 7.4.4.1. weight
    - 7.4.4.2. diameter (gauge, shielding, and jacket)
    - 7.4.4.3. jacket rating
      - 7.4.4.3.1. plenum rating
      - 7.4.4.3.2. riser rating
    - 7.4.4.4. shielding percentage
    - 7.4.4.5. bend radius
    - 7.4.4.6. design choices of cable type
    - 7.4.4.7. velocity factor
- 7.5. Describe other antenna system and transmission line measurements to include:
  - 7.5.1. wattmeter
  - 7.5.2. return loss
  - 7.5.3. Distance-To-Fault (DTF)
  - 7.5.4. PIM testing
  - 7.5.5. PIM results
  - 7.5.6. difference between FDR and PIM testing
- 7.6. Describe tower attributes and criteria to include:
  - 7.6.1. types:
    - 7.6.1.1. pole
      - 7.6.1.1.1. guyed
      - 7.6.1.1.2. side mounted
    - 7.6.1.2. standalone
    - 7.6.1.3. self-supporting
    - 7.6.1.4. portable:
      - 7.6.1.4.1. Cell on wheels (C.O.W.)
      - 7.6.1.4.2. S.O.W. (site on wheels)
      - 7.6.1.4.3. C.O.L.T. (cell on light truck)
      - 7.6.1.4.4. C.O.P. (cell on platform)
  - 7.6.2. FAA and FCC regulations to include:
    - 7.6.2.1. height requirements

## General Communications Technician Level 2 Knowledge Competencies

- 7.6.2.2. visual requirements
  - 7.6.2.2.1. tower lamp
  - 7.6.2.2.2. tower painting
  - 7.6.2.2.3. aviation safety
- 7.6.2.3. location and maintenance details
- 7.6.3. shadowing and its affects
- 7.7. Describe proficient engineering practices for grounding and lightning protection

### 8.0 Operating Principles of Radio and Electronic Communications Equipment

- 8.1. Explain basic international, federal, state, tribal and local (authorities having jurisdiction-AHJ) regulations rules and regulations pertaining to two-way communications including:
  - 8.1.1. licensing
  - 8.1.2. spectrum usage
  - 8.1.3. Type Acceptance Number (TAN) of a transmitter
- 8.2. Explain federal government licensing including:
  - 8.2.1. Broadcast Bureau or similar department
  - 8.2.2. Wireless Telecommunications Bureau (WTB) or similar department
    - 8.2.2.1. public safety
    - 8.2.2.2. Homeland Security (DHS)
  - 8.2.3. FCC (other national) rules and regulations
  - 8.2.4. Frequency coordinators
    - 8.2.4.1. National Telecommunications and Information Administration (NTIA)
      - 8.2.4.1.1. federal government
      - 8.2.4.1.2. military
    - 8.2.4.2. public safety agency coordinators, such as APCO, EWA, et.al.
    - 8.2.4.3. commercial and business coordinators
- 8.3. List frequency spectrum band allocations to include:
  - 8.3.1. VLF
  - 8.3.2. LF
  - 8.3.3. MF (300 kHz to 3.0 MHz; AM Broadcast, Maritime Ship to Shore, Maritime Long Range)
  - 8.3.4. VHF (30 MHz to 300 MHz)
    - 8.3.4.1. Lowband
    - 8.3.4.2. Mid-band
    - 8.3.4.3. FM Broadcast
    - 8.3.4.4. Highband
    - 8.3.4.5. 220MHz (Ham, Commercial, Positive Train Control)
  - 8.3.5. UHF
    - 8.3.5.1. 380-470 MHz (Military, Federal, Amateur Ham, Commercial)
    - 8.3.5.2. 470-512 MHz (T-band)
    - 8.3.5.3. 700 MHz (Long Term Evolution {LTE}, Commercial and Public Safety)
    - 8.3.5.4. 800 MHz (Public Safety-Emergency Responders, Cellular, Specialized Mobile Radio {SMR or Trunking})
    - 8.3.5.5. 900 MHz
    - 8.3.5.6. 1.8-1.9 GHz (Broadband Personal Communications Service {PCS})
    - 8.3.5.7. 2.1 GHz (Universal Mobile Telecommunications System {UMTS}, 3G)
    - 8.3.5.8. 2.4 GHz (Industrial, Scientific and Medical) (802.11b, g, and n)
  - 8.3.6. other higher frequencies
- 8.4. Describe additional transmitter technical specifications to include:
  - 8.4.1. frequency stability
  - 8.4.2. number of channels
  - 8.4.3. power levels:
    - 8.4.3.1. power splitters
  - 8.4.4. distortion:
    - 8.4.4.1. bit error rate (BER)
  - 8.4.5. radiation
- 8.5. Describe additional receiver technical specifications to include:
  - 8.5.1. sensitivity
  - 8.5.2. selectivity



## General Communications Technician Level 2 Knowledge Competencies

- 8.6. Define propagation to include:
  - 8.6.1. Line-of-Sight (LoS)
  - 8.6.2. Groundwave
  - 8.6.3. Skywave
    - 8.6.3.1. near vertical incidence skywave (NVIS)
- 8.7. Describe common RF formulas to include:
  - 8.7.1. Free Space Path Loss (FSL) formula for communication systems using LoS propagation:  
 $20 \cdot \text{LOG}_{10}[\text{Frequency(MHz)}] + 20 \cdot \text{LOG}_{10}[\text{Distance(miles)}] + 36.6$ 
    - 8.7.1.1. obstructions adjustment
    - 8.7.1.2. over water adjustment
  - 8.7.2. Line-of-Sight (LoS) Range
    - 8.7.2.1. Formula:  $\text{Distance(miles)} = \text{Square Root of } \{2 \text{ times Height(feet)}\}$
    - 8.7.2.2. when formula conditions hold untrue
  - 8.7.3. Propagation model software programs
  - 8.7.4. Rayleigh Fading
- 8.8. Describe radio system communication types including:
  - 8.8.1. simplex
  - 8.8.2. half duplex
  - 8.8.3. full duplex
  - 8.8.4. "Duty Cycle"
- 8.9. Describe different types of radios including:
  - 8.9.1. mobile
    - 8.9.1.1. "FCC Control Station"
  - 8.9.2. base station
    - 8.9.2.1. repeater
  - 8.9.3. portable
- 8.10. Describe why vehicular repeaters are required
- 8.11. Describe the consoles used in radio control schemes including:
  - 8.11.1. direct control
  - 8.11.2. DC control
  - 8.11.3. tone remote control
  - 8.11.4. internet protocol (IP) control:
    - 8.11.4.1. simple network management protocol (SNMP)
- 8.12. Describe radio paging systems including:
  - 8.12.1. types of pagers and systems
  - 8.12.2. page initiation and capcode
  - 8.12.3. encoding schemes
- 8.13. Explain audio conditioning including:
  - 8.13.1. automatic gain control
  - 8.13.2. pre-emphasis
  - 8.13.3. flat audio
  - 8.13.4. de-emphasis
  - 8.13.5. delivered audio quality (DAQ)
- 8.14. Define Interconnection to include public switched telephone network (PSTN) connection
- 8.15. Describe a software defined radio (SDR)
- 8.16. Define 'Simulcast' operations and systems
- 8.17. Describe coded squelch systems on a given radio channel to include:
  - 8.17.1. Tone Squelch (a.k.a. continuous tone coded squelch system - CTCSS) to describe:
    - 8.17.1.1. wideband allowed modulation
    - 8.17.1.2. narrowband allowed modulation
  - 8.17.2. digital coded squelch (DCS) to describe:
    - 8.17.2.1. allowed codes
- 8.18. Define Automatic Number Identification (ANI) (Fleet) Systems
- 8.19. Describe a mobile data system to include dedicated terminals and keys, laptops and tablets
- 8.20. Describe the receiver voting systems in very large communications systems including:
  - 8.20.1. noise or signal-to-noise(S/N)
  - 8.20.2. received signal system indicator (RSSI)
  - 8.20.3. IP (lowest BER chosen)

## General Communications Technician Level 2 Knowledge Competencies

- 8.21. Describe a trunking systems operation(s) for communications including:
  - 8.21.1. single site
  - 8.21.2. multi-site
  - 8.21.3. P25 Standard exceptions
  - 8.21.4. TETRA
- 8.22. Define location systems signals to include:
  - 8.22.1. global positioning satellites (GPS)
  - 8.22.2. NMEA interface standard (National Marine Electronics Association)
- 8.23. Define the need and use of gateway systems including:
  - 8.23.1. dedicated gateway switches (Interface leads)
- 8.24. Describe the Amateur Radio Systems and Operators (Ham) importance
- 8.25. Explain radio frequency interference (RFI) inhibiting performance including:
  - 8.25.1. natural interference
  - 8.25.2. man-made interference containing electromagnetic compatibility (EMC) including:
    - 8.25.2.1. co-channel
    - 8.25.2.2. adjacent channel
    - 8.25.2.3. desense (desensitization)
    - 8.25.2.4. image (image frequency)
    - 8.25.2.5. spurious emission
    - 8.25.2.6. spurious response
    - 8.25.2.7. harmonic interference
  - 8.25.3. intermodulation
    - 8.25.3.1. transmitter (an FCC violation)
    - 8.25.3.2. receiver overload
    - 8.25.3.3. external
    - 8.25.3.4. passive (PIM)
  - 8.25.4. power line noise and indicators
  - 8.25.5. time-delay interference (TDI)
  - 8.25.6. fluorescent lamps interference to include:
    - 8.25.6.1. compact FLs (CFLs)
    - 8.25.6.2. energy saving FL ballasts
  - 8.25.7. static electricity interference
- 8.26. Describe interference protective devices including:
  - 8.26.1. band pass (BP) cavities (Filters)
  - 8.26.2. band reject (Notch)
  - 8.26.3. band pass – band reject
  - 8.26.4. low pass
  - 8.26.5. high pass
  - 8.26.6. Crystal filters
  - 8.26.7. duplexers
  - 8.26.8. intermodulation control panels
    - 8.26.8.1. isolators
    - 8.26.8.2. circulators
  - 8.26.9. harmonic filters
- 8.27. Describe how transmitter combiners functions including:
  - 8.27.1. hybrid
  - 8.27.2. star
- 8.28. Describe the function of receiver multi-couplers
- 8.29. Define shielded enclosures benefits to negate interference
- 8.30. Describe bypass capacitors use to negate interference
- 8.31. Describe ferrite beads use to negate interference
- 8.32. Describe effective sensitivity for desensitization testing including:
  - 8.32.1. an ISO-TEE test
- 8.33. Describe interference tracking devices and use to find signals including:
  - 8.33.1. triangulation
  - 8.33.2. Doppler systems
- 8.34. Describe tower top amplifiers (TTA)

## General Communications Technician Level 2 Knowledge Competencies

- 8.35. Explain Keyloading
- 8.36. Define SCADA (supervisory control and data acquisition) and where it is used
- 8.37. Explain the need for portable radios and their accessories to have special physical and operating parameters when used for fire/emergency radio service

### 9.0 Networks - Serial Data, Internet Protocol (IP) to Wireless

- 9.1. Describe numbering systems
  - 9.1.1. decimal
  - 9.1.2. binary
  - 9.1.3. octal
  - 9.1.4. Hexadecimal
  - 9.1.5. binary coded decimal (BCD)
- 9.2. Describe the Open Systems Interconnect (OSI) model
  - 9.2.1. Define model layers
    - 9.2.1.1. Physical
    - 9.2.1.2. Data Link
    - 9.2.1.3. Network
    - 9.2.1.4. Transport
    - 9.2.1.5. Session
    - 9.2.1.6. Presentation
    - 9.2.1.7. Application
- 9.3. Describe the legacy RS232 interface standard including:
  - 9.3.1. data terminal equipment (DTE)
  - 9.3.2. data communications equipment (DCE)
- 9.4. Describe equipment port adapters interface standards including:
  - 9.4.1. serial conversion to RS422 format
  - 9.4.2. serial to USB (universal serial bus):
    - 9.4.2.1. prolific chip set
  - 9.4.3. Ethernet
  - 9.4.4. modem or short-haul modem
- 9.5. Describe data networks including:
  - 9.5.1. hardwired Ethernet
  - 9.5.2. wireless using IEEE 802 standards
- 9.6. Define IP addressing schemes including:
  - 9.6.1. Version 4 (IPv4) ranges
  - 9.6.2. Version 6 (IPv6) ranges
  - 9.6.3. dynamic host control protocol (DHCP)
- 9.7. Define Radio over IP (RoIP) including:
  - 9.7.1. gateway conversions from Analog/Digital (A/D) to D/A
  - 9.7.2. describe latency
  - 9.7.3. multicasting
  - 9.7.4. transmission control protocol (TCP)
  - 9.7.5. user datagram protocol (UDP)
- 9.8. Describe cybersecurity to include:
  - 9.8.1. keeping software and operating systems (O.S., O/S) updated with latest patches
  - 9.8.2. using reputable antivirus programs
  - 9.8.3. recognizing malware
  - 9.8.4. using complex passwords
  - 9.8.5. user names and passwords on multiple sites protocol
  - 9.8.6. keeping personally identifiable information (PII) off social media sites
  - 9.8.7. viewing email in a text format instead of html to avoid malicious links
  - 9.8.8. using search engine protocol (results can lead to malicious sites)
  - 9.8.9. running browsers in "sand box" or virtual machines to isolate files from attacks
  - 9.8.10. using non-administrator accounts whenever possible
  - 9.8.11. disabling Java Script™ in Adobe Acrobat™ readers

## 10.0 Fiber Optic Systems

- 10.1. Describe basic fiber optic characteristics including:
  - 10.1.1. bandwidth
  - 10.1.2. attenuation
  - 10.1.3. optical fiber parts
  - 10.1.4. light source
  - 10.1.5. signal speed
  - 10.1.6. advantages over copper
  - 10.1.7. minimum bend radius
- 10.2. Describe fiber optic modes and bands including:
  - 10.2.1. Single-mode with a core at 9µm and at 1310nm or 1550nm
  - 10.2.2. Multimode cores at 50µm or 62.5µm and usually 850nm
- 10.3. Explain the many fiber optic cable types and uses according to TIA® and NEC® standards
  - 10.3.1. Explain why you never mix and match modes or cores
- 10.4. Describe common fiber optic connectors including:
  - 10.4.1. SC
  - 10.4.2. ST
  - 10.4.3. LC
- 10.5. Describe Fiber to the Antenna (FTTA) including:
  - 10.5.1. baseband unit (BBU)
  - 10.5.2. remote radio unit or head (RRU or RRH)
  - 10.5.3. configurations
    - 10.5.3.1. home run
    - 10.5.3.2. hybrid cabling
    - 10.5.3.3. separate fiber and power distribution
- 10.6. Describe fiber termination equipment including:
  - 10.6.1. cleaning kit
  - 10.6.2. splicing
  - 10.6.3. tools
  - 10.6.4. hardware
- 10.7. Describe fiber optic test equipment including:
  - 10.7.1. optical power meter
  - 10.7.2. video probe microscope
  - 10.7.3. optical time domain reflectometer (OTDR)
  - 10.7.4. optical loss test set (OLTS)
  - 10.7.5. visual fault locator (VFL)
- 10.8. Describe fiber optic training and certification required to work on fiber plants

## 11.0 Telephony

- 11.1. Explain telephony basics including:
  - 11.1.1. voice frequency:
    - 11.1.1.1. signaling
    - 11.1.1.2. digital: DSL, ISDN, T1
    - 11.1.1.3. optical: SONET, FTTx
  - 11.1.2. facsimile (FAX)
  - 11.1.3. data transfer
  - 11.1.4. public switched telephone networks (PSTN)
  - 11.1.5. private networks dedicated direct connections
- 11.2. Describe telephony connectivity to include:
  - 11.2.1. telecom block configurations
- 11.3. Describe telephony circuits type to include:
  - 11.3.1. plain old telephone system (POTS)
  - 11.3.2. two-wire POTS
  - 11.3.3. two-wire / four-wire radio circuits
  - 11.3.4. E & M Signaling interface
  - 11.3.5. apparatus used
  - 11.3.6. demarcation from facility to premise

## General Communications Technician Level 2 Knowledge Competencies

- 11.3.7. wiring types including:
  - 11.3.7.1. single pair
  - 11.3.7.2. two pair
  - 11.3.7.3. twisted pair
- 11.3.8. connections including:
  - 11.3.8.1. standard modular jack – 6P2C or 6P4C
  - 11.3.8.2. standard modular connector – RJ11, RJ14 or RJ45
- 11.4. Explain reporting trouble due to multiple carrier service providers

### 12.0 Satellite Communications Concepts

- 12.1. Explain how satellites are used in communication systems including:
  - 12.1.1. Iridium system creating the low earth orbiting (LEO) multiple satellites
  - 12.1.2. selection of geostationary versus LEO satellite orbits
- 12.2. Describe the equipment types used to interface systems to include:
  - 12.2.1. handheld
  - 12.2.2. portable
    - 12.2.2.1. SMART – federal “satellite mutual aid radio talk” groups
  - 12.2.3. dish
  - 12.2.4. mobile (vehicle)
- 12.3. Describe set-up routines to interface with communications systems including:
  - 12.3.1. azimuth
  - 12.3.2. elevation
  - 12.3.3. block upconverter (BUC) uplink
  - 12.3.4. low noise block (LNB) downlink
- 12.4. Describe satellite communication troubleshooting procedures including:
  - 12.4.1. alignment
    - 12.4.1.1. manually
    - 12.4.1.2. automatically
  - 12.4.2. latency settings

### 13.0 Physical Plant and Site procedures

- 13.1. Define authorization of physical access including:
  - 13.1.1. Sites
    - 13.1.1.1. Private property access
    - 13.1.1.2. Antenna site perimeters
      - 13.1.1.2.1. buildings
      - 13.1.1.2.2. restricted rooms or areas
- 13.2. Describe on-site arrival procedures including:
  - 13.2.1. site entrance
    - 13.2.1.1. evidence of site tampering resolution
  - 13.2.2. other personnel on location
- 13.3. Describe site tasks including:
  - 13.3.1. first visit
  - 13.3.2. safety protocol
  - 13.3.3. inspection
  - 13.3.4. daily work activity
  - 13.3.5. site egress
- 13.4. Describe site owner/lessee responsibility including:
  - 13.4.1. contact information
  - 13.4.2. federal governmental registration (FCC and FAA)
  - 13.4.3. local governmental regulations and procedures
- 13.5. Describe site environmental responsibilities including:
  - 13.5.1. HVAC systems (heating, ventilation, air conditioning)
  - 13.5.2. work lighting
  - 13.5.3. vermin deterrence
  - 13.5.4. weed deterrence

## General Communications Technician Level 2 Knowledge Competencies

- 13.6. Describe access to systems including:
  - 13.6.1. locks
    - 13.6.1.1. padlocks
    - 13.6.1.2. RFID (radio freq. identification)
    - 13.6.1.3. card
    - 13.6.1.4. biometric
    - 13.6.1.5. keypad
    - 13.6.1.6. remote
    - 13.6.1.7. smartphone
  - 13.6.2. video surveillance
- 13.7. Describe plant operational power systems including:
  - 13.7.1. AC Power
    - 13.7.1.1. sourcing load
    - 13.7.1.2. rectifying to DC conversion
  - 13.7.2. DC Power
  - 13.7.3. Battery backup systems and regulations including:
    - 13.7.3.1. primary
    - 13.7.3.2. secondary
    - 13.7.3.3. recharging

### End of General Communications Technician – Level 2 Competencies

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 GCT1 or Associate CET level training and certification skills standards and examinations. These are included more than once for the assurance that their application and importance in each category is addressed.

This competencies listing is compiled to serve two purposes:

1. To provide industry and educational institutions with the material they need to construct an outline for any course of instruction in wireless communications for employees or students.
2. To provide an outline for those studying to sit for the General Communications Technician – Level 2 examination (including the former USMSS, MSS or TRNI exams) as a guide to the knowledge and skills they will need. Wireless Communications (WCM) or FCC GROL exams have a more conventional radio communications approach.

Find an ETA approved test site:

[http://www.etai.org/test\\_sites.html](http://www.etai.org/test_sites.html)

**Additional Suggested Study Materials and Resources:**

- General Communications Technician, Level 2, 4<sup>th</sup> printing;** Ira Wiesenfeld, P.E., CETms, Rob Walker, CET, Jay Thompson, CETsr, A.J. Wiesenfeld, BSEE, CETsr; ISBN 978-0-9915913-3-6; Self Published; 2017; softcover. Contact ETA® International at 800-288-3824 or [eta@etai.org](mailto:eta@etai.org)
- Modern Electronic Communication, 9E;** Jeff Beasley, Gary Miller, ISBN 978-0-13225113-6; Prentice Hall; 2007; hardcover.
- Standards and Guidelines for Communication Sites;** Motorola Solutions, Inc; Item# 68P81089E50-C; 2017; e-book. Contact Motorola Solutions, Inc Parts Dept. at 800-422-4210 or [https://www.motorolasolutions.com/en\\_us/products/training.html](https://www.motorolasolutions.com/en_us/products/training.html)
- ARRL Handbook, 2021 (Annual);** Numerous Authors; ISBN 978-1-62595-139-7; The American Radio Relay League, Inc.; 2021
- Practical Antenna Handbook, 5E;** Carr, Hippisley; ISBN 978-0071639583; McGraw-Hill; 2011
- New HAM Radio License? Now What?;** James Sanders, AG6IF; Kindle Edition; Amazon; 2014
- Cabling: The Complete Guide to Copper and Fiber-Optic Networking, 5E;** Andrew Oliviero, Bill Woodward; ISBN 978-1-118-80732-3; Sybex, Inc.; March 2014; softcover; 1284 ppg. Available through ETA 800-288-3824, [www.etai.org](http://www.etai.org)
- 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
- Wiring for Wireless Sites;** Ira Wiesenfeld, P.E., CETsr, ISBN 978-1-40181037-5; Prompt; 2002; softcover. Contact ETA® International at 800-288-3824 or [eta@etai.org](mailto:eta@etai.org)

<https://www.dhs.gov/keywords/communications> & [Emergency Communications](#) & [Office of Emergency Communications](#) & [SAFECOM](#) & [Project 25 Resources and Information](#) | [Homeland Security](#)

<https://www.iwatsi.com/> & <https://www.iwa-radio.com/>; <https://www.electronics-notes.com/articles/radio/>;

<https://www.fcc.gov/>; <http://wireless.fcc.gov/commoperators/index.htm?job=examinations>

<https://www.tacticalrf.com/>; [APCO Project 25](#); & [APCO Interoperability Standards](#);

<https://www.iwceexpo.com/> & <http://urgentcomm.com/>; [RadioReference.com Wiki Reference](#);

<http://www.rcwireless.com/>; <http://www.radioresourcemag.com/>; <https://www.dovertrainingsolutions.com/>;

[https://www.p25bestpractice.com/?utm\\_source=radio\\_academy&utm\\_medium=sidebar&utm\\_campaign=p25bp](https://www.p25bestpractice.com/?utm_source=radio_academy&utm_medium=sidebar&utm_campaign=p25bp)

Refer to [ANSI/TIA TSB-88](#) information;

ETA certification programs are accredited through ICAC, complying with the ISO/IEC 17024 standard.



Accredited to the ISO 17024:2012 standard for certification programs

## General Communications Technician Level 2 Knowledge Competencies

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