
USACE / NAVFAC / AFCESA UFGS-16797A (April 2004)

Preparing Activity: USACE

Superseding
UFGS-16797A (July 1994)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 25 June 2004

Revised throughout - changes not indicated by CHG tags

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DIVISION 16 - ELECTRICAL

SECTION 16797A

ONE-WAY FM RADIO DATA CONTROL SYSTEM

04/04

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SECTION 16797A

ONE-WAY FM RADIO DATA CONTROL SYSTEM 04/04

NOTE: This guide specification covers the requirements for one-way FM radio data control systems.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

PART 1 GENERAL

1.1 REFERENCES

NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA ANSI/EIA/TIA-232-F (2002) Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41 (1991) Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits

IEEE Std 142 (1992) Recommended Practice for Grounding of Industrial and Commercial Power Systems - Green Book

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2003) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 780 (2000) Installation of Lightning Protection Systems

UNDERWRITERS LABORATORIES (UL)

UL 1585 (1998; Rev thru Feb 2004) UL Standard for Safety Class 2 and Class 3 Transformers - Fourth Edition

UL 512 (1993; Rev thru Mar 1999) Fuseholders

1.2 SYSTEM DESCRIPTION

1.2.1 General

NOTE: Designer must show location of radio frequency (RF) equipment to be controlled. Designer must also show any Government furnished equipment (GFE).

A complete one-way FM radio control system shall be provided. The system shall consist of the energy management software and computer, command generator, transmitter, communication links, antenna system, radio switches, communication links surge protection, and power line surge protection. [The system shall be compatible with the existing one-way FM radio control equipment shown.] [The system shall be interfaced with the UMCS as shown.]

1.2.2 Environmental Requirements

Equipment to be utilized indoors shall be rated for continuous operation under ambient environmental conditions of 2 to 49 degrees C 35 to 120 degrees F dry bulb and 10 to 95 percent relative humidity, noncondensing. All other equipment shall be rated for continuous operation under the

ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.

1.2.3 Electrical Requirements

NOTE: Designer must show electrical details for power sources and UPS if required.

The equipment shall operate from an AC voltage source as shown, plus or minus 10 percent, at a frequency of 60 Hz, plus or minus 2 percent. The backup system transmission shall be connected to the uninterruptible power supply (UPS) as specified and shown.

1.2.4 Power Line Surge Protection

Equipment connected to AC circuits shall be protected from power line surges. Equipment shall meet the requirements of IEEE C62.41. Fuses shall not be used for surge protection.

1.2.5 Communications Links Surge Protection

Communications equipment shall be protected against surges induced on any communications link. Cables and conductors which serve as communications links shall have surge protection circuits installed at each end. Protection shall be furnished at equipment and additional triple electrode gas surge protectors rated for the application on each circuit shall be installed within 1 meter 3 feet of the building cable entrance. Surge protection shall meet the requirements of NFPA 780 guidelines and specifications.

1.3 RADIO FREQUENCY COMMUNICATION EQUIPMENT (RFCE) SYSTEM REQUIREMENTS

The command transmitter and antenna installations shall be designed to maintain minimum field strength of 30 microvolts/meter at any point in the controlled area during transmission.

1.4 TECHNICAL DATA AND COMPUTER SOFTWARE

NOTE: The acquisition of technical data, data bases and computer software items will be in accordance with the Federal Acquisition Regulation (FAR) and the Department of Defense Acquisition Regulation Supplement (DFARS). Those regulations, as well as the Army and Corps of Engineers implementations thereof, should be consulted to ensure that a delivery of critical items of technical data is not inadvertently lost.

Specifically, the Rights in Technical Data and Computer Software Clause, DFARS 52.227-7013, and the Data Requirements Clause, DFARS 52.227-7031, as well as any requisite software licensing agreements will be made a part of the CONTRACT CLAUSES or SPECIAL CONTRACT REQUIREMENTS of the contract. In addition, the appropriate DD Form 1423 Contract Data Requirements List will be filled out for each

distinct deliverable data item and made a part of the contract. Where necessary, a DD Form 1664, Data Item Description, shall be used to explain and more fully identify the data items listed on the DD Form 1423. It is to be noted that all of these clauses and forms are required to assure the delivery of the data in question and that such data is obtained with the requisite rights to use by the Government.

Include with the request for proposals a completed DD Form 1423, Contract Data Requirements List. This form is essential to obtain delivery of all documentation. Each deliverable will be clearly specified, both description and quantity required.

Include in the SPECIAL CONTRACT REQUIREMENTS with the request for proposals a payment schedule, obtainable from the UMCS-MCX at Huntsville Division. This payment schedule will define payment milestones and percentages at specified times during the contract period.

The technical data specified herein shall be delivered in accordance with Contract Clauses, Special Contract Requirements, and the Contract Data Requirements List, DD Form 1423 which is attached and made a part of this Contract. Technical data shall be coordinated with the requirements of Section [____]. Data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. Data shall be organized and delivered as follows:

1.4.1 Group I Technical Data Package

1.4.1.1 System Drawings

The data package shall include the following:

- a. FM Radio System block diagram.
- b. FM Radio System component installation and wiring diagrams.
- c. FM Radio System physical layout and schematics.
- d. Details of connections to power sources, including grounding.
- e. Details of surge protection device installation.
- f. Details of cable splicing and connector installations.

1.4.1.2 Equipment Data

A complete data package shall be delivered for all materials, including field and system equipment.

1.4.1.3 FM Transmission System Descriptions and Analyses

The Group I data package shall include complete system descriptions, analyses, and calculations used to configure required equipment. Descriptions and calculations shall show how the equipment will operate as

a system to meet the specified performance requirements. Package shall include calculations and/or test results which indicate adequate signal strength to ensure reliable radio switch operation throughout areas where radio switches are in service.

1.4.1.4 RF Area Coverage Report

The Group I data package shall include an area coverage report incorporating a topographical map with coverage indicated. The following shall be shown on the map:

- a. Location of the transmitter and antenna.
- b. Location of the most distant radio switch in each compass quadrant from the transmitting antenna.
- c. Radials (straight line segments indicating direction, distance and difference in elevation) from the transmitting antenna to the radio switches described in b. above.
- d. Location along each radial of any obstacle to line of sight propagation.
- e. Radiation pattern of the transmitted signal.
- f. Attenuation (dB) between the transmitting antenna and the radio switches described in b. above. The system loss shall take into account the effect of terrain variables such as distance, antenna height, obstructions, and absorption losses.
- g. System gain for each radio switch location described in b. above. The system gain shall take into account the attenuation between the Central Station or repeater and the antennas, the gain of each antenna, and the transmission line losses.
- h. Power output of the transmitter.
- i. Calculated receiver input signal voltages and signal-to-noise (S/N) ratios for radio switches described in b. above.

1.4.1.5 Manufacturer's Certifications

Manufacturer's certifications shall be included with the Group I data package.

1.4.2 Group II Technical Data Package

**NOTE: Remove Group II when there is no Government
furnished equipment.**

The Group II technical data package shall include the results of the testing and calibration of the Government furnished RFCE. Defective or nonrepairable equipment shall be reported. An estimate of the materials and costs required to repair or replace defective equipment shall be provided. Within 10 days after completion of testing and calibration, a certificate shall be provided that the Government furnished RFCE is in calibration and is functioning correctly.

1.4.3 Group III Technical Data Package

NOTE: Insert section number and title for the UMCS specification.

The Group III technical data package shall consist of factory testing data. The Contractor shall prepare and submit test procedures using Section [_____] as a guide for the factory test. The procedures shall explain in detail, step-by-step actions and expected results to demonstrate compliance with the specified requirements, and the methods for simulating the necessary conditions of operation to demonstrate performance of the system. The factory test shall be designed to demonstrate the operation of the stand-alone controller and its associated software and of the UMCS interface and the ability of the proposed system to comply with specified requirements.

1.4.4 Group IV Technical Data Package

1.4.4.1 Performance Verification and Endurance Testing Data

NOTE: Insert section number and title for the UMCS specification.

The Contractor shall prepare and submit test procedures using Section [_____] as a guide, excluding all surge and overvoltage tests, for the performance verification test and endurance test. Surge and overvoltage tests shall not be conducted during the performance verification test. The test procedures shall describe the applicable tests to be performed, and other pertinent information such as specialized test equipment required, and length of performance verification test. The test procedures shall explain in detail, step-by-step actions and expected results to demonstrate compliance with the specified requirements. Receiver input signal voltages and S/N ratios as required by the RF area coverage report shall be verified as adequate for system operation. Performance verification and endurance test procedures shall be submitted by the Contractor and approved by the Government in writing before starting tests.

1.4.4.2 Operation and Maintenance Data

A draft copy of the operation and maintenance data, in manual format, as specified for the Group V technical data package, shall be delivered to the Government prior to beginning the performance verification test, for use during site testing.

1.4.4.3 Training Data

Lesson plans and training data, in manual format, for the training phases, including type of training to be provided, with a list of reference material, shall be delivered for approval.

1.4.5 Group V Technical Data Package

NOTE: Unless the installation has a specific

requirement, specify six copies of the operator's manual and two copies of all other manuals. The number of copies must be coordinated with requirements defined in DD Form 1423.

The Group V technical data package shall consist of the system documentation. The draft copy used during site testing shall be updated with any changes required prior to final delivery of the manuals. Each manual's contents shall be identified on the cover. The manuals shall include the names, addresses, and telephone numbers of each subcontractor installing equipment and systems and of the nearest service representative for each item of equipment and each system. The manuals shall have a table of contents and tab sheets. Tab sheets shall be placed at the beginning of each chapter or section and at the beginning of each appendix. The final copies, bound in hardback loose-leaf binders, shall be delivered within 30 days after completion of the endurance test, and shall include all modifications made during installation, checkout, and acceptance. Manuals delivered shall include:

- a. Functional Design Manual: [two] [_____] copies.
- b. Hardware Manual: [two] [_____] copies.
- c. Operator's Manual: [six] [_____] copies.
- d. Maintenance Manual: [two] [_____] copies.

1.4.5.1 Functional Design Manual

The functional design manual shall identify the operational requirements for the radio control system and explain the theory of operation, design philosophy, and specific functions. A description of hardware functions, interfaces, and requirements shall be included for all system operating modes.

1.4.5.2 Hardware Manual

A manual describing equipment furnished, including:

- a. General description and specifications.
- b. Installation and checkout procedures.
- c. Equipment electrical schematics and layout drawings.
- d. Alignment and calibration procedures.
- e. Manufacturer's repair parts list indicating sources of supply.
- f. Interface definition.

1.4.5.3 Operator's Manual

The operator's manual shall fully explain procedures and instructions for operation of the system.

1.4.5.4 Maintenance Manual

The maintenance manual shall include descriptions of maintenance for all equipment including inspection, calibration, periodic preventative maintenance, fault diagnosis, and repair or replacement of defective components.

PART 2 PRODUCTS

2.1 RADIO FREQUENCY COMMUNICATION EQUIPMENT (RFCE)

NOTE: Show location of repeaters, antennas,
transceivers, etc.

2.1.1 Government Furnished

NOTE: Designer must identify Government furnished
RFCE with model numbers and operating
characteristics. The Government may furnish
existing repeaters, antennas, or antenna space on a
tower or other suitable geographical location. Show
these equipment locations.

The Government will furnish RFCE as indicated. All GFE shall be tested by the Contractor to ensure that the equipment is in calibration and functioning correctly. Modifications to the Contractor's system shall be made to be compatible with the GFE.

2.1.2 Contractor Furnished

RFCE not shown as Government furnished shall be furnished and installed by the Contractor.

2.2 FM RADIO CONTROL SYSTEM COMPUTER EQUIPMENT

2.2.1 Computer

The server shall be a standard unmodified digital computer of modular design, with the following minimum requirements:

- a. Microprocessor: minimum 2.2 GHz clock speed
- b. Memory: 1024 MB, expandable to 2 GB
- c. Diskette Drive: 3.5 inches (1.44 MB)
- d. DVD Re-Writeable Drive: minimum speeds (2.4x/8x/12x/10x/32x); 2.4x DVD re-write), 8x DVD (read), 12x CD-R (write), 10x CD-RW (re-write), 32x CD (read) speeds
- e. Hard Drive: minimum 120 GB
- f. Multimedia Drive: 16x speed DVD-ROM
- g. Video Graphics Card, video memory: minimum 64 MB SDRAM
- h. Sound card with stereo speakers
- i. Real -time clock
- j. Front Mounted Ports: 2 USB, 1 serial port and 1 IEEE 1394 port
- k. Total Drive Bays: External (2) 3.5", (3) 5.25"; Internal (2) 3.5"
- l. Total Expansion Slots: 5 PCI; 1 AGP
- m. Total External Ports: 6 USB; 2 serial; 1 parallel; 2 PC/2; 3 IEEE

- 1394 ports
- n. Data/Fax Modem
- o. Network Card: Integrated 10/100Base-T networking interface
- p. Keyboard: QWERTY, 105 keys in ergonomic shape with 2 USB ports
- q. Mouse: USB Optical Scrolling, two-button Mouse

2.2.2 Color Monitor

The monitor shall be sized as shown, but not less than 475 mm 19 inches, viewable area with a minimum resolution of 1280 by 1024 pixels, nonintegrated, and a maximum dot pitch of 0.24 mm. The video output card shall support at least 256 colors at a resolution of 1280 by 1024 at a minimum refresh rate of 70 Hz.

2.2.3 Laser Printer

The laser printer shall meet the following requirements:

- a. Resolution: 1200 by 1200 dots per inch
- b. Printing Time: 16 pages per minute
- c. Data Buffer Size: 32 Megabytes
- d. Media Size: 216 X 279 mm 8.5 X 11 inches
- e. Interfaces: Parallel port or USB port
- f. Paper Cassette: 500 sheet capacity

2.2.4 Uninterruptible Power Supply (UPS)

A self contained UPS suitable for installation and operation at the server shall be provided and sized to provide a minimum of 10 minutes of operation of the server equipment. Equipment connected to the UPS shall not be affected in any manner by a power outage of a duration less than the rated capacity of the UPS. UPS shall be complete with all necessary power supplies, transformers, batteries, and accessories and shall include visual indication of normal power operation, UPS operation, abnormal operation and visual and audible indication of low battery power. Provide USB connection with software for automatic shutdown of data applications.

2.3 FM RADIO CONTROL APPLICATION SOFTWARE

The energy management software shall have the capability to create customizable control strategies to be implemented by the owner. The system shall also include, at a minimum, the following predefined control strategies: direct load control, distributed generation monitoring and control, capacitor bank control, voltage regulator control and thermostat setback control. The system shall have two control modes, manual and automatic. Manual mode shall allow the user to define when specific strategies or groups go into and out of control. Automatic mode shall use the predefined or customized triggers to implement the control strategies. The system shall include, at a minimum, the following predefined control triggers: time of day schedules, digital inputs, kW demand set-points, kVAR setpoints, seasonal and temperature. The system shall provide web interface capability to all energy data and reports.

2.4 COMMAND GENERATOR

NOTE: Edit the following to reflect site conditions. Designer must specify if an energy management software package will be provided or an

interface directly to the UMCS.

The command generator shall accept commands from the [UMCS through an EIA ANSI/EIA/TIA-232-F interface] [energy management software] and shall generate control signals necessary to activate transmitters and to operate radio switches over the FM radio channel. The generator shall contain a digital tone synthesizer and transmitter controller capable of controlling up to 6 transmitters. Command generator shall be fully compatible with existing radio switch control message format to allow for full interchangeability of existing and new switches.

2.5 TRANSMITTER

NOTE: Coordination with the Director of Information Management must be accomplished by the designer and appropriate frequency assignment granted by the installation.

A continuous duty VHF command transmitter shall be provided to transmit at a carrier frequency of [139-173 MHz] [_____]. RF output impedance shall be 50 ohms. Frequency stability shall be within 0.0005 percent over the operating temperature range. Modulation deviation shall be adjustable to plus or minus 5 kHz. FM hum and noise shall be less than minus 60 dB.

2.5.1 Backup Transmission System

NOTE: The designer must select the applicable bracketed text below, depending upon whether redundant command generators are desired. The designer must review applicability of switching between primary and backup transmission systems.

[A backup transmitter and antenna shall be utilized to assume the functions of the primary transmission system in the event of primary transmission failure. Circuitry shall be provided to detect primary transmission failure and automatically switch the command generator signal and all required controls over to the backup transmitter and antenna.] [A backup command generator, transmitter and antenna shall be utilized to assume the functions of the primary transmission system in the event of primary transmission failure. Circuitry shall be provided to detect primary transmission failure and automatically switch the load shedding signal and all required controls over to the backup transmission system.]

2.5.2 Failure Indication

Visible and audible indication of [primary] [and] [secondary] transmission failure shall be provided at the command generator location.

2.5.3 Manual Remote Control

NOTE: Remove this paragraph when manual remote control is not required.

Manual remote control at the command generator location shall be provided to switch between primary and secondary transmission equipment and to designate either system as primary or secondary.

2.6 RADIO CONTROL SWITCH (RCS) REQUIREMENTS

**NOTE: The designer must show power wiring details
and voltage for each type of radio switch
installation. Standard radio switch voltages are
24, 120, and 208-240 volts.**

2.6.1 General

A Radio Control Switch (RCS) shall consist of a microprocessor based printed circuit board, internal power supply and a control relay. These components are factory assembled into a single weatherproof enclosure of not more than 1500-cubic-inch exterior volume. It shall be cataloged by the manufacturer for continuous duty under the following conditions. Ambient dry bulb temperatures from -22 to 41 degrees C 0 to 105 degrees F and relative humidity ranges from 0 to 100 percent. The RCS shall be of a design which permits installation on exterior walls or air-conditioning disconnects switches. They shall be rated to perform under conditions of constant vibration and severe weather conditions and to perform without degradation of service in any manner. The maximum energy demand for a RCS with transformer shall not exceed 10 volt-amperes.

2.6.2 Addresses

**NOTE: Coordination with the Director of Information
Management must be accomplished by the designer and
appropriate protocol must be used.**

Each RCS shall have a fixed address, which is specifically assigned by the manufacturer. Total possible number of fixed addresses shall be 4,000,000. The RCS shall utilize the [SA-Digital, Golay23.12d, Single tone, Multi-tone, REMS 100, REMS102, Comverge CV-307 POCSAG format, Post Office Code Standardization Advisory Group POCSAG 512 AND 1024 Auto Switch, Comverge SA-205, Comverge SA-206 or the Comverge SA-305/306 code transmission format.] Radio switches shall be fully compatible with existing radio switch control message format to allow for full interchangeability of existing and new switches

2.6.3 Frequency Modulation (FM) Receiver

The Frequency Modulation (FM) Receiver shall be the narrow band, dual conversion, crystal controlled type with an integral antenna and shall operate carrier frequency of [139-173 MHz] [_____]. The minimum allowable frequency deviation shall be +/- 1.0 kHz. Selectivity shall be at least 50 dB down from carrier reference at plus or minus 30 kHz. The frequency stability shall be +/- 0.002 percent for ambient temperatures of -30 to +60 degrees C -22 to +140 degrees F. Image rejection shall be at least 40 dB. The receiver shall have a sensitivity of 20 microvolts per meter or less. Frequency stability shall be within 0.002 percent over the range specified above.

2.6.4 Radio Control Switch

The Radio Control Switch shall decode the baseband signal from the received of [139-173 MHz] [_____] FM carrier. The RCS shall utilize "distributed intelligence" and shall be capable of providing control for a minimum of 8 hours upon the receipt of a single radio command. The RCS shall also utilize a linear control algorithm, which will provide randomly selected start and stop times to ensure smooth transition into as well as out of control. The RCS shall be a two-function controller with the capability of remote programmable cold load pickup. RCSs shall have sufficient memory to record programmed parameters and operation. The unit shall have the capability of dumping this recorded data to a portable retrieval device. The RCS shall incorporate a 7.5-minute plus or minus 1.5-minute timer and restore the controlled service when the time out period has elapsed and another signal is not received. The RCS should also incorporate into an Adaptive Algorithm for air conditioning control. An Adaptive Algorithm (AA) allows the run switch to monitor the run time of the air conditioner it is connected to in blocks of one hour. When the control unit receives an Adaptive Algorithm control message, it takes the previous run time of the air conditioner and controls it for that percentage of time.

2.6.5 Control Relay

Control Relay shall be rated for the load that it is shown to control on plans. Relay life shall be at least 300,000 operations at the rated load. When the RCS's address or the SCRAM code is broadcast, the control relay shall be energized to open its contacts and thus interrupt the continuity of a device's control circuit. If there is no power to the board (e.g., utility outage), the control relay shall return to its normally closed position. The RCS shall include two light-emitting diodes (LEDs) which will emit light through a transparent lens of the RCS's weatherproof housing whenever the control relay is open (i.e., activated) or a test signal is received.

2.6.6 Power Supply Transformer

Power Supply Transformer shall be securely mounted inside of the RCS's housing and shall provide the secondary voltage required by the microprocessor based printed circuit board. The Contractor shall not use the thermostatic control voltage to power the RCS's circuit board. The Maximum VA rating of the transformer must meet the requirements of the FM radio circuit board. Unless otherwise noted on plans or in specifications, the primary voltage to be used is 120/240 VAC, 60 Hz. Power supply transformer shall be Class 2, UL approved. It shall be the split bobbin wound coil type utilizing approved materials to meet UL 1585. Power supply transformer shall operate without interference to RCS operation under conditions specified in paragraph FM RADIO CONTROL SYSTEM COMPUTER EQUIPMENT, subparagraph Computer. The power supply transformer shall include fuse protection. The accompanying fuse shall be rated to blow when transformer's current draw exceeds 10 percent of maximum VA rating. It shall be installed on the Hot primary conductor of the transformer in a suitable in-line fuseholder UL 512.

2.6.7 Enclosures

The weatherproof enclosure constructed of a polycarbonate material with door gasket and mounting hardware shall conform to NEMA 250 and shall meet NEMA III and NEMA IV raintight criteria. Finish color shall be the

manufacturer's standard, unless otherwise indicated. Damaged surfaces shall be repaired and refinished using original type finish. A sealed viewing window on each enclosure's door shall correspond with the Contact Position and Test LEDs location. An integral 19 mm 3/4-inch threaded nipple shall provide a weatherproof interface with associated exterior conduit or enclosure. The hinged door with latch shall have a provision for a utility meter seal.

2.6.8 Nameplates

Nameplates shall have unique identifiers engraved or stamped. Permanently attach nameplates to enclosure panel doors and back plates. For each field mounted piece of equipment attach a plastic or metal tag with equipment name and point identifier.

2.7 FIELD TEST UNITS

NOTE: Design must specify what field test unit is needed.

Field test units may be separate or combined as one unit. These units shall be provided to accomplish the following requirements:

- a. Portable Test Unit (PTU) shall be used to exercise and test the proper operation of a load control receiver by using any of the RCS's operational address function commands. The PTU shall transmit a 7.5 minute time-out and 7.5 minute cycle time message to the unit. The PTU also provides cancel commands for all function commands.
- b. The Portable Counter Display (PCD) shall read the RCS's internal memory register by placing it over the RCS's viewing window. The PCD verifies internal addressing, operations counts, and the RCS's serial number.
- c. The Remote Transmission Monitor (RTM) is used to receive FM-radio control messages from the broadcast frequency that the Load Management system is using. The RTM deciphers the message and feeds it back to the Load Management system for a closed loop verification of messages transmitted. Normally one per system is all that is needed on bases.
- d. The Field Strength Unit (FSU) shall determine the location that will give the best signal strength for the load control receivers to be installed.

2.8 ANTENNA SYSTEM

NOTE: The designer must show the topography on the drawings.

The antenna system shall utilize vertically polarized antennas, coaxial cable between transmitters and antennas, and matching networks required for the proper coverage. The antenna system shall be either omni-directional or shaped coverage as determined by the Contractor from the topography. The antennas shall be capable of withstanding the environmental conditions of [200] [_____] km/h [125] [_____] mph wind and [13 mm 1/2 inch radial]

[_____] ice without failure. The antenna system shall be selected by the Contractor to meet the requirements as determined from the topography. Lightning protection shall comply with NFPA 780.

2.8.1 Grounding Conductors

Antenna grounding conductors shall be minimum 32-strand, No. 8 AWG copper.

2.8.2 Ground Rods

Ground rods shall be as specified in Section 16370A ELECTRICAL DISTRIBUTION SYSTEM, AERIAL.

2.8.3 Transmission Line

The transmission line between transmitter and antenna shall be 50 ohm impedance, foam dielectric coaxial cable rated for the transmitter output power. Minimum requirement shall be RG-8/U foam dielectric. For lengths in excess of 17 meters 50 feet, transmission line shall be of the corrugated copper outer sheath type with either foam or air dielectric.

PART 3 EXECUTION

3.1 INSTALLATION

NOTE: Coordinate with appropriate electrical sections required by the design.

System components and appurtenances shall be installed in accordance with the manufacturer's instructions and as shown. Necessary interconnections, services, and adjustments required for a complete and operable radio control system shall be provided and shall be fully integrated with the UMCS. Grounding shall be in accordance with IEEE Std 142.

3.1.1 Software

The Contractor shall load all software required for a completely operational one-way FM radio control. The Contractor shall adjust, tune, debug, and commission all software and parameters for controlled systems to assure proper operation in accordance with the specification.

3.1.2 Antenna

Tubular radiator elements shall be plugged to prevent wind vibration fatigue. Vertical tubular elements shall have drain holes near the bottom. Outside connectors shall be snug, filled with silicone grease, and properly sealed with heat-shrink wrap suitable for ambient temperatures of minus 30 to 60 degrees C minus 22 to 140 degrees F.

3.1.3 Interior Work

Interior electrical work shall be installed as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEM and as shown.

3.1.4 Exterior Work

3.1.4.1 Underground

Except as otherwise specified, underground electrical work shall be installed as specified in Section 16375A ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND and as shown.

- a. Where direct burial cable will pass under sidewalks, roads, or other paved areas, the cable shall be placed in minimum 25 mm 1 inch rigid galvanized steel conduit. Conduit may be installed by jacking or trenching, as approved. When direct burial cable is to be placed in heavy use areas other than paved areas and where the cable may be subject to damage from heavy equipment, the cable shall be placed in minimum 25 mm 1 inch rigid PVC conduit schedule 80, buried a minimum of 1067 mm 42 inches below the surface.
- b. Direct burial cable shall be placed below a minimum 75 mm 3 inch wide plastic warning tape buried in the same trench or slot. The tape shall be 305 mm 12 inches above the cable. The warning tape shall be continuously imprinted with the words "WARNING--COMMUNICATION CABLE BELOW" at not more than 1.2 meter 4 foot intervals.
- c. Transitions from underground cable to aerial cable shall be as specified for CONNECTIONS BETWEEN AERIAL AND UNDERGROUND SYSTEMS in Section 16375A ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.
- d. Splices shall be installed in cable boxes. Sufficient cable shall be provided in each splicing location to properly rack and splice the cables, and to provide extra cable for additional splices. Proper strain relief shall be provided. Cable ends shall be protected at all times with end caps except during actual splicing. During the splicing operations, means shall be provided to protect the unspliced portions of the cable from the intrusion of moisture and other foreign matter.
- e. For cable installed in ducts and conduit, a cable feeder guide shall be used between the cable reel and the face of the duct and conduit to protect the cable and guide it into the duct and conduit as it is played off the reel. As the cable is played off the reel, it shall be inspected for jacket defects. Cable shall not be kinked or crushed during installation. A pulling eye shall be attached to the cable and used to pull the cable through the duct and conduit system. Cable shall be hand fed and guided through each manhole. As the cable is played off the reel into the cable feeder guide, it shall be sufficiently lubricated with a type of lubricant recommended by the cable manufacturer. Where the cable is pulled through a manhole, additional lubricant shall be applied at intermediate manholes. Dynamometers or load-cell instruments shall be used to ensure that the pulling line tension does not exceed the installation tension value specified by the cable manufacturer. The mechanical stress placed upon a cable during installation shall not be such that the cable is twisted or stretched.

3.1.4.2 Aerial

NOTE: Aerial cable should be installed on existing poles. Where this is not possible, requirements must be shown on drawings.

Designer must coordinate with facility personnel for ground clearance and establish clearances to be shown on drawings.

Except as otherwise specified, aerial electrical work shall be installed as specified in Section 16370A ELECTRICAL DISTRIBUTION SYSTEM, AERIAL and as shown.

- a. A messenger cable system to support aerial cable shall be furnished. The messenger system, including appurtenances, guys and hardware, shall be capable of withstanding a minimum of 20 kN 4500 pounds of tension.
- b. Transitions from aerial cable to underground cable shall be as specified for CONNECTIONS BETWEEN AERIAL AND UNDERGROUND SYSTEMS in Section 16370A ELECTRICAL DISTRIBUTION SYSTEM, AERIAL.
- c. Splices in aerial cable shall be within 1 meter 3 feet of a pole and placed inside a watertight enclosure. Drip loops shall be formed at the cable entrance to the enclosure. Lashing clamps shall be placed within 305 mm 12 inches of the enclosure.
- d. Lashing wire shall be wound tightly around both the communication cable and the messenger cable by machine methods. The lashing wire shall have a minimum of 3 turns per 305 mm linear foot. Lashing clamps shall be placed at all poles and splices.
- e. Loops shall be formed in the aerial cable at points of connection and at poles to prevent damage from thermal stress and wind loading. The communication cable shall be protected from chafing and physical damage with the use of spiral cut tubing and PVC tape, or plastic sleeves. The ground clearance of installed cabling shall be as shown.

3.1.5 Radio Control Switch (RCS)

Install RCS per manufacturer's guide and seal penetrations with rubber silicone sealant to preclude the entry of water.

3.1.6 Impulse Suppression Surge Arrester Grounding

Impulse suppression surge arresters shall be grounded. Ground resistance shall be not more than 10 ohms. Connections to earth shall be made in the same manner as for secondary neutral ground rod. The aerial portions of surge arrester and secondary neutral ground conductors shall be separate from and independent of each other but both grounds shall be bonded together below grade at the ground rods, or to the ground counterpoise, as applicable and the ground rods shall be spaced a minimum of 6.1 meters 20 feet apart.

3.2 RADIO CONTROL SYSTEM TESTING

3.2.1 General

Demonstrate compliance of the one-way FM Radio Data Control System with the contract documents. Furnish personnel, equipment, instrumentation, and supplies necessary to perform site testing. Ensure that test personnel are regularly employed in the testing and calibration of radio control systems.

Testing shall include the field tests and the performance verification tests. Field tests shall be conducted by the Contractor to determine the system is completely operational. Performance verification test shall be a demonstration to the Government to ensure proper operation of all the components and proper execution of the sequence of operation.

3.2.2 Test Plan

Submit and obtain approval of the field test plan and performance verification test plan for each phase of testing before beginning that phase of testing. Give to the Contracting Officer written notification of planned testing at least 30 days prior to test. Notification shall be accompanied by the proposed test procedures. In no case will the Contractor be allowed to start testing without written Government approval of field test plan and performance verification test plan.

3.2.3 Test Oversight

Tests are subject to oversight and approval by the Contracting Officer.

3.2.4 Test Reporting

Before scheduling the performance verification test, furnish field test documentation and written Certified Statement of Field Test Completion to the Contracting Officer for approval. The statement, certified by the radio control system provider, states that the installed system has been tested and is ready for the performance verification test. Do not start the performance verification test prior to receiving written permission from the Government. During and after completion of the Field Tests, and again after the Performance Verification Tests, identify, determine causes, replace, or repair equipment that fails to meet the specification, and submit a written report to the Government. Document all tests with detailed test results. Explain in detail the nature of each failure and corrective action taken. Provide a written report containing test documentation after the Field Tests and again after the Performance Verification Tests.

-- End of Section --