

**DIGITAL CLOCK DISTRIBUTOR
LOCAL PRIMARY REFERENCE
ENGINEERING GUIDELINES**

FOR USE WITH 090-42121-01 LIGHTNING PROTECTOR BOX

CONTENTS	PAGE	Figures (Cont'd)	Page
1. GENERAL	2	5. Wire Inductance	15
2. GLOBAL POSITIONING SYSTEM	3	6. Wire Impedance	15
3. LORAN-C TRANSMISSIONS	4	7. Cable Bend Angles	16
4. SYSTEM CONFIGURATIONS	6	8. Sample Multiple Lightning Protector Setup	16
5. LIGHTNING PROTECTION PHILOSOPHY AND GROUNDING PRINCIPLES	14	9. Lightning Protector and Lightning Protector Box	17
A. Lightning Protection Philosophy	14	10. Shielded Cable Preparation	17
B. Single Lightning Protector Scheme	17	11. Central Office Grounds	21
C. Dual Lightning Protector Scheme	18	12. GTR Single Lightning Protector Grounding Scheme	22
D. Local Grounding Principles and Lightning Protector Placement	18	13. GTR Dual Lightning Protector Grounding Scheme	23
E. Central Office Ground System Overview	20	14. LORAN Antenna Single Lightning Protector Grounding Scheme (Type 2 Lightning Protector)	24
6. GPS ANTENNA INSTALLATION CONSIDERATIONS	26	15. LORAN Antenna Dual Lightning Protector Grounding Scheme (Type 2 Lightning Protector)	25
A. Cabling Considerations	26	16. Fiber Bending Radius	27
B. Cabling Material	27	17. GTR Power Cable Limits (Single Lightning Protector)	27
C. GTR Antenna Location and Mounting	30	18. GTR Power Cable Limits (Dual Lightning Protectors)	28
7. LORAN ANTENNA INSTALLATION CONSIDERATIONS	41	19. Fiber Optic Cable	29
A. Cabling Considerations	41	20. Metal Conduit Considerations	29
B. Cabling Materials	41	21. Example Aerial View of Building Rooftop	31
C. Location and Mounting	42	22. Example Side View of Antenna Obstructions	31
8. DCD-LPR SHELF INSTALLATION CONSIDERATIONS	45	23. Example Side View of Placement with Respect to Reflective Surface	32
9. INDEX	48	24. GTR Location—Distance from Reflective Objects	35
Figures		25. GTR Location—Field of View	35
1. Basic DCD-LPR System GPS Configuration	8	26. Basic GTR Mountings (Single Lightning Protector)	37
2. DCD-LPR GPS System Configuration with SSM	10	27. Basic GTR Mountings (Dual Lightning Protectors)	38
3. Basic DCD-LPR LORAN-C System Configuration	11	28. Prodelin Corp. Rectangular Block Mast Mount	39
4. Stand-alone DCD-LPR GPS Configuration	13	29. Examples of GTR Mast Configurations	40
		30. LORAN Antenna's Cone of Influence	43

Figures (Cont'd)	Page
31. Basic LORAN Antenna Mounting Arrangements	44
32. GPS Time-of-Day Cabling	47

Tables

A. LORAN-C Stations	4
B. DCD-LPR Cards	6
C. GPS Basic Ordering Configuration	9
D. LORAN-C Basic Ordering Configuration	12
E. Recommended Grounding Distances	19

1. GENERAL

1.01 This section provides the following information about the Digital Clock Distributor - Local Primary Reference (DCD-LPR) System:

- A brief explanation of Global Positioning System (GPS) transmissions
- A brief explanation of Long Range Navigation-version C (LORAN-C) transmissions
- Engineering considerations including lightning protection
- Symmetricom philosophy on lightning protection
- Antenna site selection information
- System configuration and mounting information

1.02 This section was reissued for the following reasons. Changes and additions are marked by change bars.

- Made minor changes to Sections 2 and 6.
- Made major changes to Section 5.
- Revised Figures 12 and 13.
- Added new Figures 5, 6, 7, 8, 9 and 10.
- Added Table E.
- Removed previous issue Figure 21.

1.03 All product names, service marks, trademarks, and registered trademarks used in this document are the property of their respective owners.

1.04 The following abbreviations are used in this section:

AIS	Alarm Indication Signal
ANSI	American National Standards Institute
DCD	Digital Clock Distributor
ETSI	European Telecommunications Standards Institute
GPS	Global Positioning System
GTI	GPS Timing Interface
GTR	GPS Timing Antenna/Receiver
ITU	International Telecommunication Union
LORAN-C	Long Range Navigation-Version C
LOU	LPR Oscillator Unit
LPR	local primary reference
LTI	LORAN-C Timing Interface
MIS	Maintenance Interface, System
NTP	Network Time Protocol
OPGP	office principal ground point
pps	pulses per second
PRS	primary reference source
RAIM	Receiver Autonomous Integrity Monitoring
SSM	Synchronization Status Messaging
ST2	Stratum-2 Clock
ST2E	Enhanced Stratum-2 Clock
ST3E	Enhanced Stratum-3 Clock
TI	timing interface card or slot
TNC	Transit Node Clock
TNC-E	Enhanced Transit Node Clock
TOD	Time-of-Day
UTC	Universal Coordinated Time

Notes:

1. Where information is common to the TNC-E, ST2, ST2E, TNC, and ST3E cards, these cards are collectively referred to as clock cards.
2. Where information is common to the TNC-E, ST2, and ST2E cards, these cards are collectively referred to as rubidium clock cards. The TNC-E and ST2E clock cards are identical in specifications, functions, controls and indicators, and acceptance test procedures. The TNC-E name uses ITU standard terminology; the ST2E name uses ANSI standard terminology. The TNC-E and ST2E are inter-

changeable.

3. Where information is common to the TNC and ST3E cards, these cards are collectively referred to as quartz clock cards.
4. When DCD System or DCD Shelf are used, it refers to any of Symmetricom's synchronization timing distribution shelves; e.g., Time-Hub 5500, DCD-519, DCD-523, DCD-521/C, DCD-ST2, DCD-400, DCD-520, and TimeExpander.

1.05 The DCD-LPR System generates Stratum-1 quality synchronization primary reference source (PRS) signals from received signals from GPS satellites and/or LORAN-C terrestrial transmitters. Additionally, the GTI card generates an NTP Type 4 TOD serial signal, based on UTC for driving a TOD server. The two PRS output signals are either DS1 (1.544 Mbps) or E1 (2.048 Mbps) depending on the type of GTI or LTI card installed in the DCD-LPR shelf. The PRS outputs provide primary and/or secondary input signals to the DCD System. The DCD-LPR shelf has two interface card slots (upper slot A and lower slot B). The shelf may be equipped with:

- One or two GPS Timing Interface (GTI) cards
- One or two LORAN Timing Interface (LTI) cards
- One GTI card and one LTI card
- One GTI card and one LPR Oscillator Unit (LOU) card for stand-alone PRS operation
- One or two GTI cards, plus a TOD adapter kit for PRS and NTP TOD outputs

1.06 Generally, the DCD-LPR System is designed for ANSI-standard applications – all connections and cabling on the rear of the shelf. The DCD-LPR/C System, an ETSI-standard shelf with all connectors and cabling on the front of the shelf, is described in the DCD-LPR/C manual (997-44100-13).

2. GLOBAL POSITIONING SYSTEM

2.01 The United States Government has developed a navigation system called the Global Positioning System (GPS). It is a satellite-based, radio navigation aid designed to provide global, all-weather, pre-

cise navigation and timing capability to users 24 hours a day.

2.02 The satellites, circling the earth at approximately 20,200 km (11,000 nmi), are arranged in six orbits with four satellites in each orbit. Each orbit is inclined 55 degrees from the equator and separated by 60 degrees longitude from the adjacent orbit. Each satellite orbits the earth in approximately 12 hours. The position of the constellation repeats its orbital pattern every 24 hours \pm 4 minutes.

2.03 The geometry of the satellite constellation is oriented such that it furnishes direct line-of-sight timing signals from at least four satellites (and usually more) to any monitor station on or near the earth's surface at all times.

2.04 The UTC traceable signal transmitted by the GPS satellites is used in conjunction with the users' local or external oscillators to enable the DCD-LPR, to generate a PRS compliant with ANSI T1.101 and ITU-T G.811.

2.05 The DCD-LPR System mediates the multiple GPS satellites available by using the GPS Timing Reference Interface (GTI) card together with the GPS Timing Antenna/Receiver (GTR). The GTR manages the received signal from all the satellites in view, and qualifies the performance of each, using the Receiver Autonomous Integrity Monitoring (RAIM) algorithm.

2.06 The performance of each tracked satellite is observed and compared to the others. Unacceptable performance data results in suspect satellites being dropped from the timing solution and replaced by the next best satellite, if one exists. A maximum of eight satellites can be tracked at any one time.

2.07 The GTR automatically examines all visible satellites, and a maximum of six satellites (the best satellites in view) are processed simultaneously to derive the timing solution for the GTI.

2.08 The GTI utilizes a 1 pps, 4 kHz clock, and 4 kb/s data channel signal from the GTR, and converts these into two primary rate DS1 (T1) or E1 timing output signals which comply with the MTIE mask for PRS, as defined in ANSI T1.101, Telcordia GR-2830, and ITU Recommendation G.811. These two signals are supplied as inputs to the DCD System, where they are groomed for distribution.

2.09 The DCD-LPR, when coupled with the clocks in the DCD Shelf, or the LOU card in the DCD-LPR Shelf, outputs time and frequency signals synchronized to within 10 nanoseconds of the GPS/UTC time received from the satellite(s). During times satellites are not being tracked, the DCD-LPR enters holdover mode and continues to output framed all-ones signals still compliant with the PRS specifications. These signals are derived from external local (temperature-compensated) oscillators for up to 24 hours, then the outputs are either squelched or output an AIS signal (the number of hours, as well as defining whether the signal is squelched or AIS, is user-selectable). The number of hours the hold-over maintains PRS compliance depends on source and quality of the external oscillator signals (6 hours for quartz source or 24 hours for rubidium source).

3. LORAN-C TRANSMISSIONS

3.01 LORAN-C is a navigation system based on terrestrial transmitters. It also provides precise timing services 24 hours a day. The frequency of each LORAN-C transmitter is controlled by three cesium clocks, whose frequency accuracy is traceable to UTC. A system receiving the signal from a single station can produce an extremely accurate frequency

output, traceable to the international UTC, and accepted as a PRS signal.

3.02 LORAN-C signal transmissions are produced by a series of transmitters, usually segmented into groups of four or five stations with a repetitive signal characteristic. The important characteristic of these signals is the Group Repetition Interval (GRI). The GRI is a unique time pause in microseconds between the master station transmission and each of its slave stations' transmissions in a chain. LORAN transmitters are located all over the Northern Hemisphere of the globe with 100 percent coverage of the continental United States, and most of Canada and Mexico. Refer to Table A for a detailed listing of LORAN-C transmitter locations.

3.03 The LORAN-C Timing Interface (LTI) card produces two highly stable and accurate 1.544 Mb/s DS1 outputs by phase locking an external local frequency standard (e.g., rubidium oscillator) to the received LORAN-C radio transmission. The data acquisition circuitry in the LTI, in conjunction with the local oscillator of the DCD Shelf, allows the DCD-LPR to frequency lock to the third positive zero crossing of the LORAN-C signal, and output a PRS signal compliant with ANSI T1.101 and ITU Recommendation G.811 standards.

Table A. LORAN-C Stations

GRI	CHAIN	LTI GRI CODE	STATION	LOCATION
59300 μ s	Canadian East Coast	2	M X Y Z	Caribou, Maine USA Nantucket, Massachusetts, USA Cape Race, Newfoundland, Canada Fox Harbor, Labrador, Canada
59900 μ s	Canadian West Coast	4	M X Y Z	Williams Lake, British Columbia, Canada Shoal Cove, Alaska, USA George, Washington, USA Port Hardy, British Columbia, Canada
79600 μ s	Gulf of Alaska	7	M X Y Z	Tok, Alaska, USA Narrow Cape, Kodiak Island, Alaska, USA Shoal Cove, Alaska, USA Port Clarence, Alaska, USA
79700 μ s	Norwegian Sea	8	M W X Y Z	Ejde, Faeroe Island, Denmark Bo, Norway Sylt, Germany Sandur, Iceland Jan Mayen, Norway

Table A. LORAN-C Stations (Cont'd)

GRI	CHAIN	LTI GRI CODE	STATION	LOCATION
79800 μ s	Southeast USA	9	M W X Y Z	Malone, Florida, USA Grangeville, Louisiana, USA Raymondville, Texas, USA Jupiter, Florida, USA Carolina Beach, North Carolina, USA
79900 μ s	Mediterranean Sea	10	M X Y Z	Sellia Marina, Italy Lampedusa, Italy Kargabarun, Turkey Estartit, Spain
82900 μ s	North Central USA	12	M W X Y	Havre, Montana, USA Baudette, Minnesota, USA Gillette, Wyoming, USA Williams Lake, British Columbia, Canada
89700 μ s	Great Lakes	13	M W X Y Z	Dana, Indiana, USA Malone, Florida, USA Seneca, New York, USA Baudette, Minnesota, USA Boise City, Oklahoma, USA
96100 μ s	South Central USA	14	M V W X Y Z	Boise City, Oklahoma, USA Gillette, Wyoming, USA Searchlight, Nevada, USA Las Cruces, New Mexico, USA Raymondville, Texas, USA Grangeville, Louisiana, USA
99400 μ s	West Coast USA	15	M W X Y	Fallon, Nevada, USA George, Washington, USA Middletown, California, USA Searchlight, Nevada, USA
99600 μ s	Northeast USA	16	M W X Y Z	Seneca, New York, USA Caribou, Maine, USA Nantucket, Massachusetts, USA Carolina Beach, North Carolina, USA Dana, Indiana, USA
99700 μ s	Northwest Pacific	17	M W X Y Z	Iwo Jima, Japan Marcus Island, Japan Hokkaido, Japan Gesashi, Okinawa, Japan Barrigada, Guam
99800 μ s	Icelandic	18	M W X	Sandur, Iceland Angissoq, Greenland Ejde, Faeroe Island, Denmark
99900 μ s	North Pacific	19	M X Y Z	Saint Paul, Pribilof Island, Alaska, USA Attu, Alaska, USA Point Clarence, Alaska, USA Narrow Cape, Kodiak Island, Alaska, USA

4. SYSTEM CONFIGURATIONS

4.01 The DCD-LPR System provides management of the GPS and/or LORAN-C primary reference sources.

4.02 The type of reference available depends on the type of timing interface card(s) installed in the DCD-

LPR Shelf and its associated antenna and/or receiver. The GTI card provides timing based on GPS; the LTI card provides timing based on LORAN-C.

4.03 Cards which may be included in the DCD-LPR System are listed in Table B.

Table B. DCD-LPR Cards

CARD	NAME USED IN THIS SECTION	PART NUMBER	REVISION	FEATURES
ANSI-STANDARD CARDS				
GTI ^{V5}	GTI-17	090-42140-17	–	Input: 5 MHz or 10 MHz, from quartz, rubidium, or better quality clocks, any combination of two quartz, rubidium, or better quality clocks, or LOU card Output: 1.544 Mb/s (T1) Framing format: ESF or D4 Time-of-Day SSM capable
GTI	GTI-15	090-42140-15	A	Input: 5 MHz or 10 MHz, from quartz, rubidium, or better quality clocks, any combination of two quartz, rubidium, or better quality clocks, or LOU card Output: 1.544 Mb/s (T1) Framing format: ESF or D4 Time-of-Day
GTI ^{V5}	GTI-15	090-42140-15	B or later	
GTI	GTI-13 (Note 4)	090-42140-13	D or earlier	Input: 5 MHz or 10 MHz, from quartz, rubidium, or better quality clocks, any combination of two quartz, rubidium, or better quality clocks, or LOU card Output: 1.544 Mb/s (T1) Framing format: ESF or D4
GTI ^{V5}	GTI-13 (Note 4)	090-42140-13	E or later	
GTI	GTI-11 (Note 4)	090-42140-11	–	Input: 5 MHz or 10 MHz, from rubidium or better quality clocks, ST2E or ST2 cards only Output: 1.544 Mb/s (T1) Framing format: ESF or D4
LTI	LTI	090-41140-01	–	Input: 5 MHz from rubidium or better quality clocks, ST2E or ST2 cards only Output: 1.544 Mb/s (T1) Framing format: ESF or D4
ITU-STANDARD CARDS				
GTI ^{V5}	GTI-18	090-42140-18	–	Input: 5 MHz or 10 MHz, from quartz, rubidium, or better quality clocks, any combination of two quartz, rubidium, or better quality clocks, or LOU card Output: 2.048 Mb/s (E1) Framing format: CCS/CAS with or without CRC4 Time-of-Day SSM capable

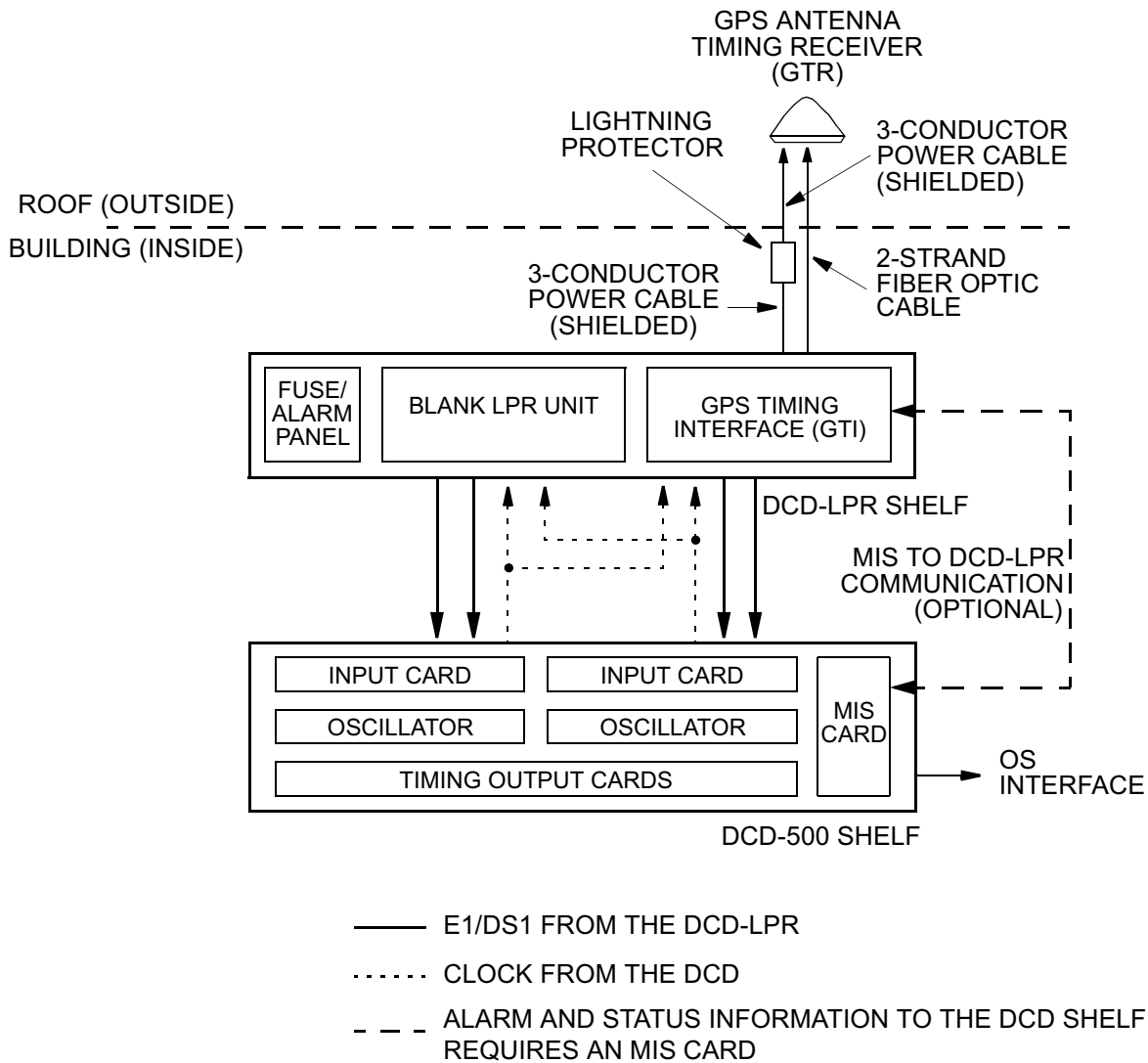
Table B. DCD-LPR Cards (Cont'd)

CARD	NAME USED IN THIS SECTION	PART NUMBER	REVISION	FEATURES
ITU-STANDARD CARDS (Cont'd)				
GTI ^{V5}	GTI-16	090-42140-16	–	Input: 5 MHz or 10 MHz, from quartz, rubidium, or better quality clocks, any combination of two quartz, rubidium, or better quality clocks, or LOU card Output: 2.048 Mb/s (E1) Framing format: CCS/CAS with or without CRC4 Time-of-Day
GTI	GTI-14 (Note 4)	090-42140-14	D or earlier	Input: 5 MHz or 10 MHz, from quartz, rubidium, or better quality clocks, any combination of two quartz, rubidium, or better quality clocks, or LOU card Output: 2.048 Mb/s (E1) Framing format: CCS/CAS with or without CRC4
GTI ^{V5}	GTI-14 (Note 4)	090-42140-14	E or later	
GTI	GTI-12 (Note 4)	090-42140-12	–	Input: 5 MHz or 10 MHz, from rubidium or better quality clocks, TNC-E cards only Output: 2.048 Mb/s (E1) Framing format: CCS/CAS with or without CRC4
ANSI-STANDARD AND ITU-STANDARD CARDS				
LOU	LOU-1	090-42145-01	–	Source: one oven-controlled crystal oscillator with two parallel outputs
LOU	LOU-2	090-42145-02	–	Source: two independent oven-controlled crystal oscillators, each with one output
Notes:				
1. The ^{V5} indicates that this is a Version 5 card.				
2. Where information is common to all GTI cards, these cards are collectively referred to as GTI cards.				
3. Where information is common to both LOU cards, these cards are collectively referred to as LOU cards.				
4. Manufacture discontinued.				

GPS System

4.04 The latest version of GTI cards; i.e., GTI-17 (T1) and GTI-18 (E1) have all the latest features and are completely compatible as replacements for older

version GTI cards; i.e., GTI-15, GTI-13, and GTI-11 (T1); or GTI-16, GTI-14, and GTI-12 (E1). GTI-11 and GTI-12 cards are no longer supported for future firmware/hardware upgrades (see Figure 1).



Note: The single lightning protector scheme is shown in this figure.

Figure 1. Basic DCD-LPR GPS System Configuration

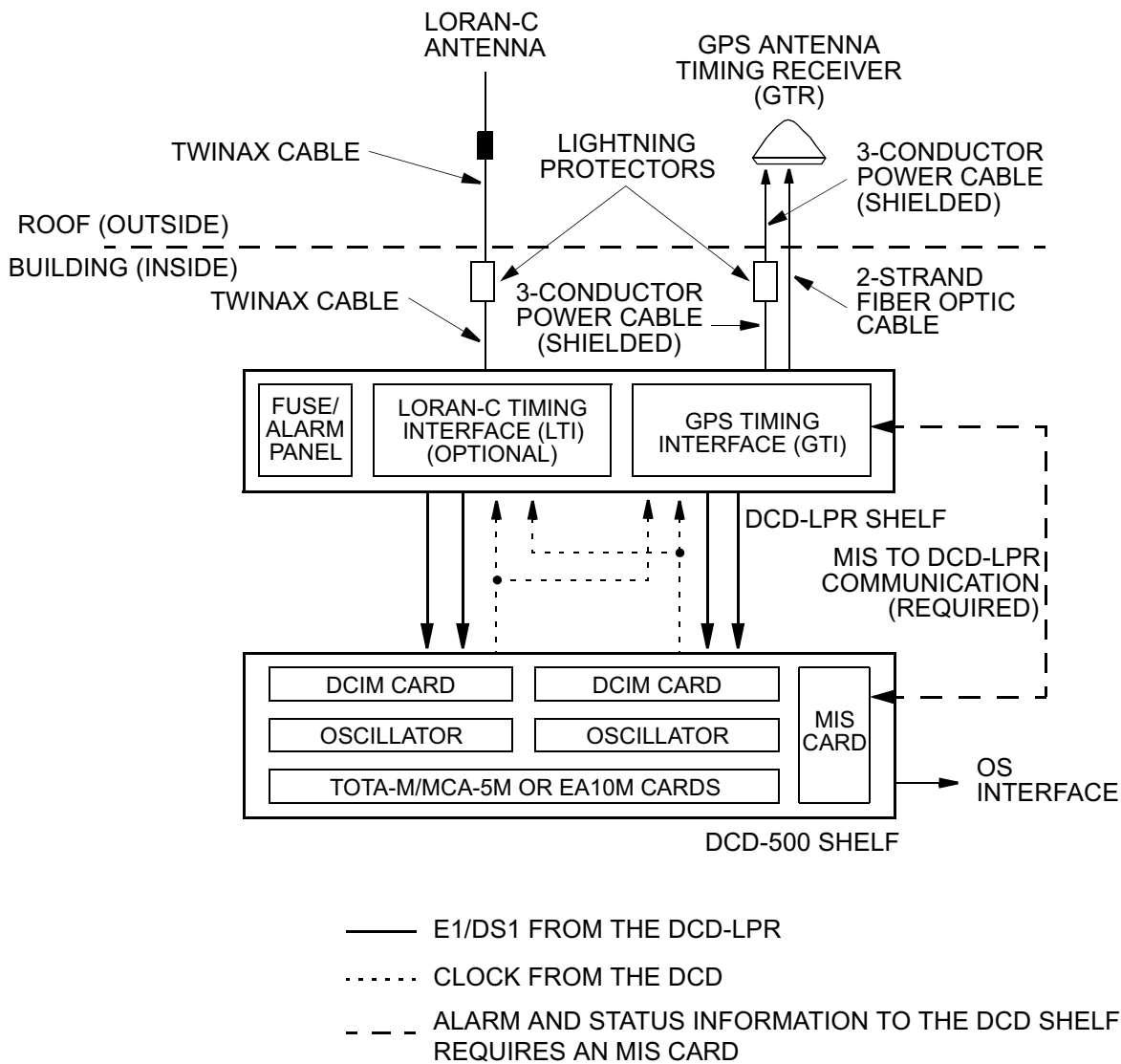
4.05 The current basic ordering configuration for GPS is listed in Table C.

Table C. GPS Basic Ordering Configuration

QTY	PART NUMBER	DESCRIPTION
1	990-45100-11	DCD-LPR Shelf
1	990-42100-17	GPS Timing Kit, T1, SSM, TOD (ANSI) (Note 1)
1	990-42100-18	GPS Timing Kit, E1, SSM, TOD (ITU) (Note 1)
1	090-45198-01	Blank LPR Unit
1	060-45110-xx	Fiber Optic Cable with ST-230 connectors (Note 2)
1	060-45126-xx	GTR Shielded 3-Conductor Power Cable with GTR Power Connector (Note 2)
OPTIONAL NTP TOD		
1	990-42181-01	TOD Adapter/Converter Kit
OPTIONAL STAND-ALONE OPERATION		
1	090-45145-01	LOU-1 Card (Install in one DCD-LPR card slot) (Note 3)
1	090-45145-02	LOU-2 Card (Dual quartz oscillators)
<p>Notes:</p> <ol style="list-style-type: none"> GPS Timing Kits include the following: <ul style="list-style-type: none"> (1) GTR Antenna/Receiver, p/n 090-42110-01 (1) GTI Card, p/n 090-42140-yy (yy = 17 or 18) (1) I/O Wire-wrap Module, p/n 090-42150-01 (1) GTR Mounting Hardware Kit, p/n 093-42100-01 (includes one lightning protector) xx = length of cable in increments of 100 feet; i.e., -01 = 100 feet, -02 = 200 feet, etc. Additionally, the fiber optic cable may be ordered in 50 feet (-50), 150 feet (-21), 250 feet (-22), and 350 feet (-23) lengths. Maximum fiber cable length is 4000 feet. Maximum power cable length is 1200 feet. Contact Symmetricom for an external GTR power supply if cable distance between DCD-LPR, lightning arrester, and GTR is greater than 1200 feet. If LOU card is not used, then two external 5 MHz assist signals must be provided from the DCD System. 		

4.06 If dual (redundant) GPS receivers are desired, then order a second GPS Timing Kit, Fiber Optic Cable and Power Cable, and do not order the Blank LPR Unit. One TOD Adapter will accommodate two TOD signals from the two GTI cards, but a second RS-422 to RS-232 Converter, p/n 090-42182-01, must be ordered.

4.07 If SSM is desired, then the DCD System must be equipped with SSM capable cards such as DCIM-EA (ITU) or DCIM-T (ANSI), EA10M (ITU), or TOTA-M and MCA-5M (ANSI). Both ITU and ANSI systems require an MIS-55 or later communications card. Refer to the appropriate DCD-521/C, DCD-519, or DCD-523 manual for part numbers (see Figure 2).



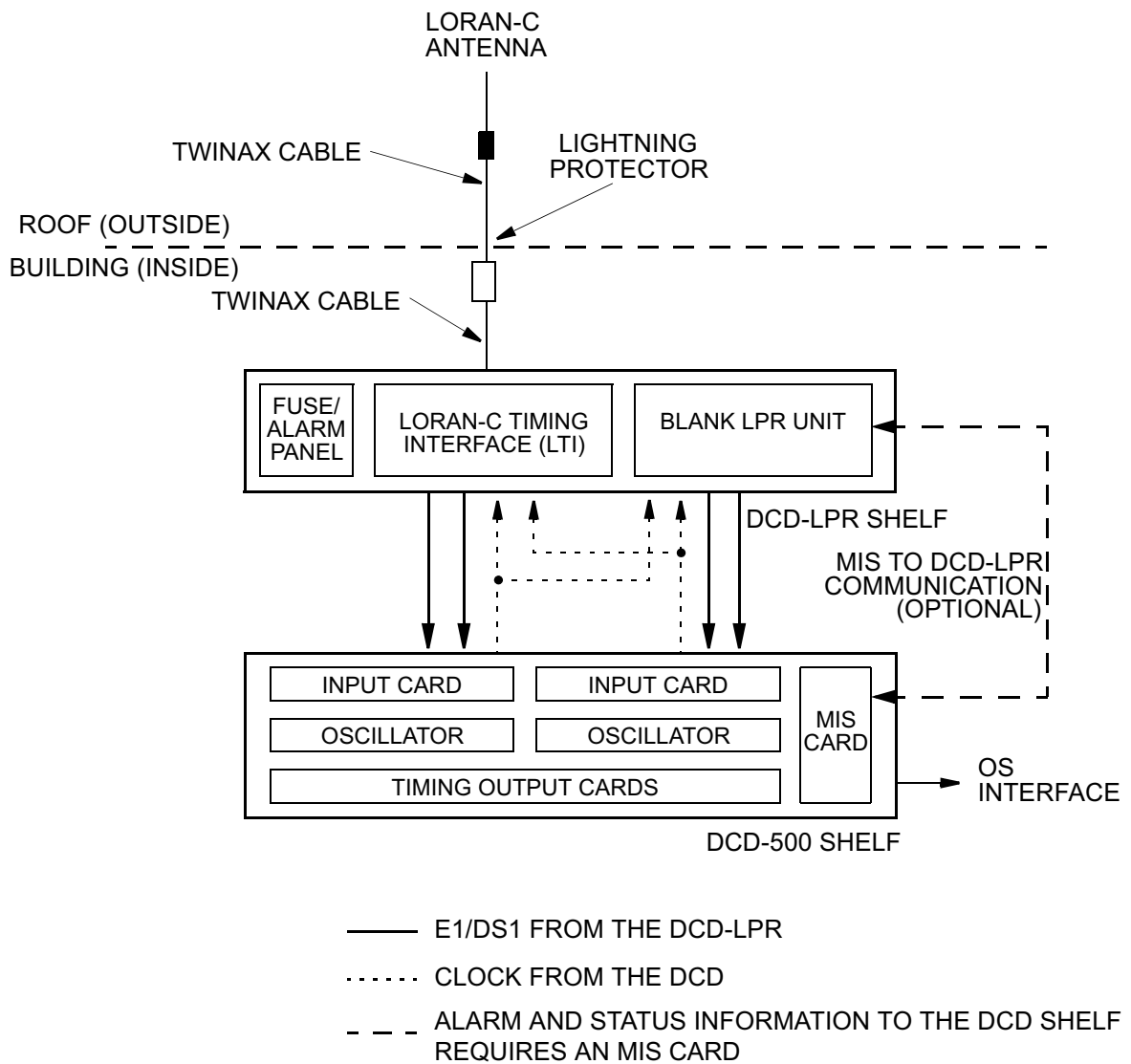
Note: The single lightning protector scheme is shown in this figure.

Figure 2. DCD-LPR GPS System Configuration with SSM

4.08 The GTI card will report alarms and events to an MIS-55 card in a DCD System and will accept TL1 commands from an MIS-55 card.

LORAN-C System

4.09 The LTI card will only work with an external rubidium or better 5 or 10 MHz assist signal. It will not work with a LOU-1 or LOU-2 card (see Figure 3).



Note: The single lightning protector scheme is shown in this figure.

Figure 3. Basic DCD-LPR LORAN-C System Configuration

4.10 The current basic ordering configuration for LORAN-C is listed in Table D.

Table D. LORAN-C Basic Ordering Configuration

QTY	PART NUMBER	DESCRIPTION
1	990-45100-11	DCD-LPR Shelf (Note 1)
1	090-45198-01	Blank LPR Unit (Note 1)
1	990-41100-01	LORAN-C Timing Kit, T1 (ANSI only)
1	060-45130-xx	LORAN Signal Cable (Note 2)
Notes: 1. If equipped in the same DCD-LPR shelf with a GPS Timing Kit or another LORAN Timing Kit, then only one DCD-LPR shelf is required, and the Blank LPR Unit is not required. 2. xx = length of cable in increments of 100 feet; i.e., -01 = 100 feet, -02 = 200 feet, etc. Maximum length is 1000 feet.		

4.11 The LTI does not do NTP TOD or SSM. The LTI will report alarms and events to an MIS-55 card in a DCD System, but does not accept TL1 commands from an MIS-55 card.

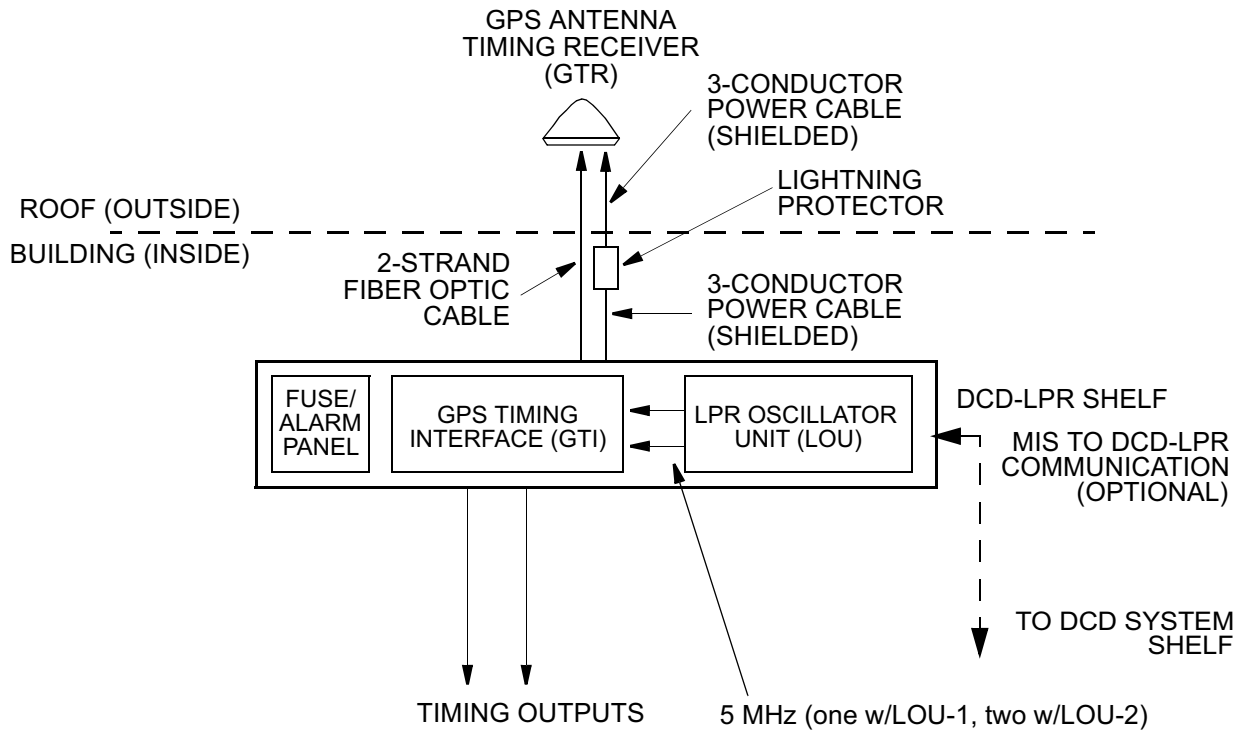
Stand-alone GPS Configuration

4.12 The stand-alone configuration provides the necessary signal conditioning for the GPS derived primary rate signals by using the signal from the oscillator on the LOU card to meet industry standard requirements for PRS under normal conditions.

Note: Revision C or earlier DCD-419, and all revisions of the DCD-400, do not have a connector on the backplane for output of the 5 MHz reference to the DCD-LPR. These shelves can be upgraded to office PRS via use of the LOU card (described later in this section).

4.13 The stand-alone configuration consists of the the DCD-LPR Shelf equipped with one GTI card and one LOU card (see Figure 4).

4.14 For more information on DCD-LPR configurations, refer to the Functional Description section of this manual.



Note: The single lightning protector scheme is shown in this figure.

Figure 4. Stand-alone DCD-LPR GPS Configuration

5. LIGHTNING PROTECTION PHILOSOPHY AND GROUNDING PRINCIPLES

5.01 Thunderstorms and lightning flashes do not occur with uniform frequency throughout the world. They vary with the climate and topography of particular locations. To determine site susceptibility to thunderstorms and lightning flashes, consult relevant isoceraunic data compiled by the World Meteorological Organization.

5.02 A lightning flash may be comprised of multiple return strokes with consequent slow decay, static potentials, producing radio noise analogous to precipitation static in its ability to degrade reliable radio signal reception.

5.03 The information contained in this section describes considerations for lightning protection, the types of grounds available at a central office (CO), and some general principles that may be employed. Follow the approved company practices regarding grounding and lightning protection.

5.04 This practice assumes that the site building's lightning protection system was designed and installed according to national and local standards, and local company practices. At a minimum, the lightning protection system for the building includes:

- An arrangement of air terminals to intercept lightning strikes
- A conductor system to carry lightning current to the ground
- An arrangement of ground terminals in contact with the earth
- Interconnection (bonding) of metal objects to minimize potential differences

A. Lightning Protection Philosophy

5.05 This practice only covers proper lightning protector placement and grounding for the DCD-LPR GPS and LORAN-C receivers.

5.06 Critical to the protection of the DCD-LPR GPS and LORAN-C receivers is a lightning protector, a

device that prevents lightning damage to these systems.

5.07 Both receivers make use of either a single lightning protector or two lightning protectors to provide protection against damage and harm to equipment and personnel. A single lightning protector setup requires that a suitable ground point be located and the lightning protector mounted on that ground point. The ground point can be located either inside or outside the building housing the antenna system.

5.08 As mentioned previously, the most important step of installing any antenna system, such as the DCD-LPR GPS and LORAN-C antennas, is locating a low impedance, low resistance earth ground point for grounding the antenna's lightning protector. This ground point, if outside the building, should be at or near where the antenna cable enters the building. If the ground point is inside the building, such as a Central Office (CO) Ground Plate, then it should be within 50 feet of the cable entry point (the closer to the entry point, the better).

5.9 Once the ground point is located, the lightning protector should be mounted on the ground point, or no more than 15 feet away from the ground point. If possible, the lightning protector should be oriented such that its ground cable is a straight shot to the ground point. The lightning protector ground terminal cable should be, at a minimum, 4.115 mm (6 AWG).

5.10 The size of a wire is for current carrying capabilities, not to reduce the impedance of the wire. Voltage drops in a conductor is a function of resistance and inductance. Skin effect and circuit geometry affect both of these parameters. The graph in Figure 5 will show the inductance of a wire using the formula $L = 0.005081 (\log_{10} 4l/d - 1 + \mu/4)$ where L is the length having the main effect on the inductance of a wire. The graph in Figure 6 will show the impedance of a wire with respect to the length and diameter of the wire. This shows that the resistance of a wire is greatly affected by length and not by the diameter of the wire.

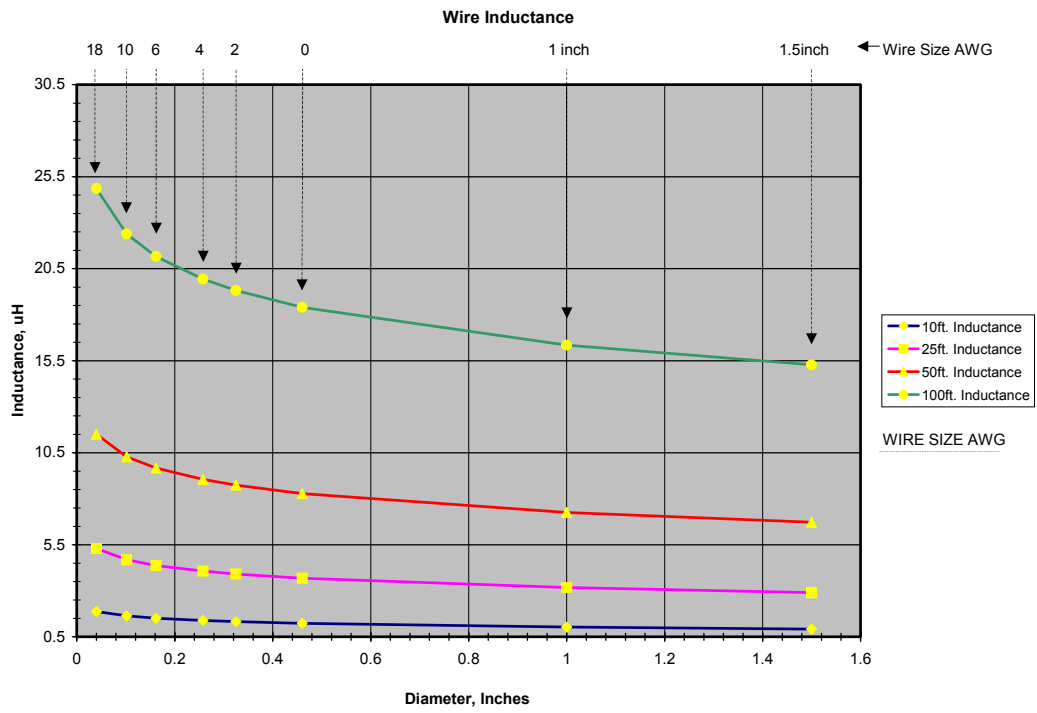


Figure 5. Wire Inductance

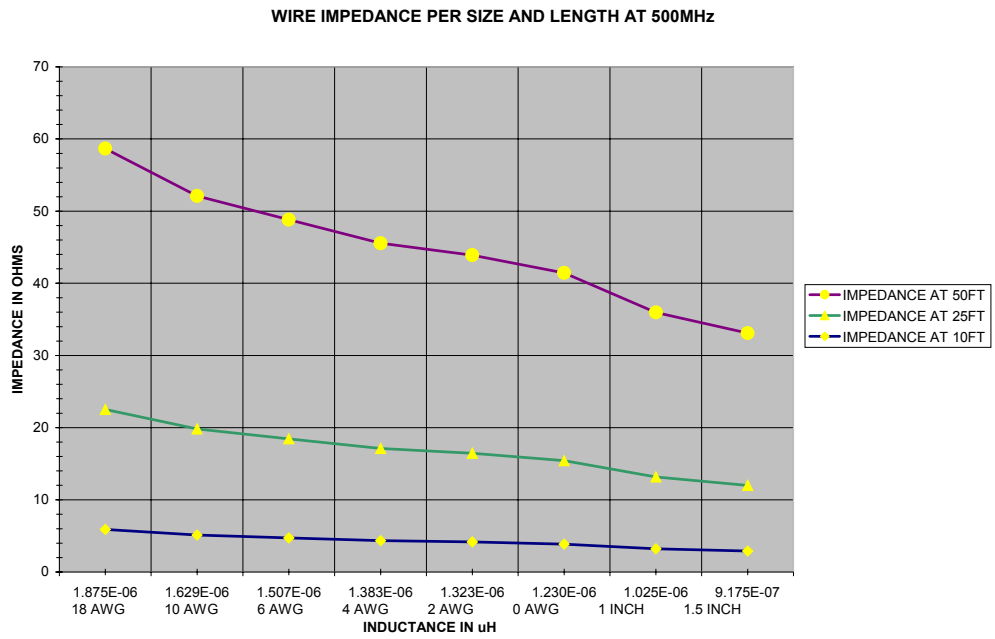


Figure 6. Wire Impedance

5.11 After the lightning protector mounting site is determined, the mounting sites for the antenna and the DCD-LPR Shelf are then determined. Once these three locations are known, the antenna cable is then routed from the antenna to the lightning protector and then to the DCD-LPR Shelf.

5.12 Bends in the antenna and lightning protector ground terminal cables must be kept to a minimum. Any bends must be 90 degrees or greater with a minimum bending radius of 8 inches. See Figure 7.

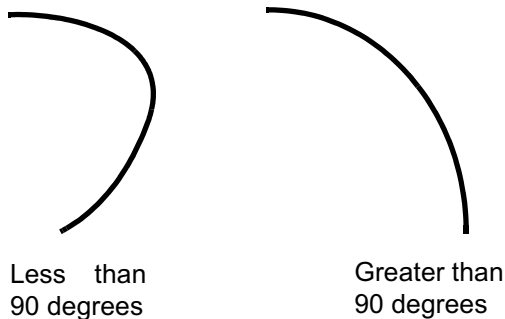


Figure 7. Cable Bend Angles

5.13 The outside lightning protector and its placement is the most important part of lightning protection. Generally, a lightning protector installed, as described earlier, provides sufficient protection against damage and harm to equipment and personnel. However, large lightning currents in conductors generate huge magnetic fields around them, cutting across other conductors and inducing substantial current flows in these other conductors.

5.14 To protect against these induced currents a second lightning protector, called the “inside lightning protector”, may be installed. The same principles that apply to placement and grounding of the outside lightning protector also apply to the inside lightning protector.

5.15 A system of multiple lightning protectors can be used to provide additional protection. Figure 8 shows the deployment of such a system.

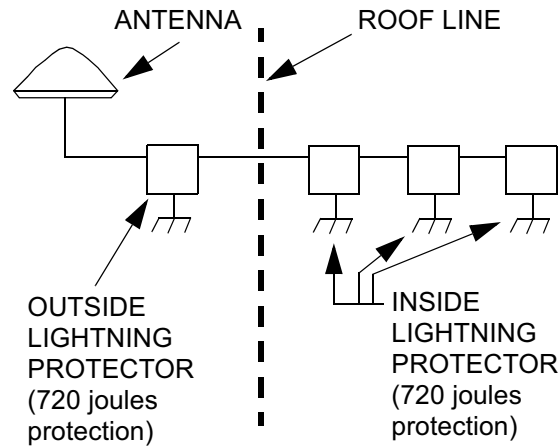


Figure 8. Sample Multiple Lightning Protector Setup

5.16 Additionally, using a three-conductor shielded antenna power cable for the GPS antenna system from the antenna to the outside lightning protector and then on to the DCD-LPR Shelf offers additional protection. The shield drain wire must be grounded on both sides of the lightning protector(s). The shield drain wire must not be grounded at the DCD-LPR Shelf. The shield prevents induced currents in the conductors inside the shield, and keeps them at the same potential during a lightning strike.

5.17 These guidelines shall not supersede or violate national and local code standards, or local company practices and procedures. They are presented as guidelines to offer the most effective protection to equipment and personnel during lightning strikes. Symmetricom’s equipment warranty is voided by lightning damage.

GPS Lightning Protectors

5.18 The lightning protectors for the dual lightning protector scheme consist of one lightning protector designated for installation outside the building, and the other for inside the building. Both protectors are shipped in the GPS Timing Kit.

5.19 The lightning protector in the single lightning protector scheme and the inside lightning protector in the dual lightning protector scheme have a three-terminal spark gap inductance, and are designed with semiconductor devices that limit the voltage to maximum 60 volts.

5.20 The outside lightning protector is a three-terminal spark gap inductance that fires or shorts when

the differential voltage on the power leads exceeds its breakdown threshold. The plus and minus terminals short to ground.

5.21 Figure 9 shows the lightning protector and the lightning protector box.

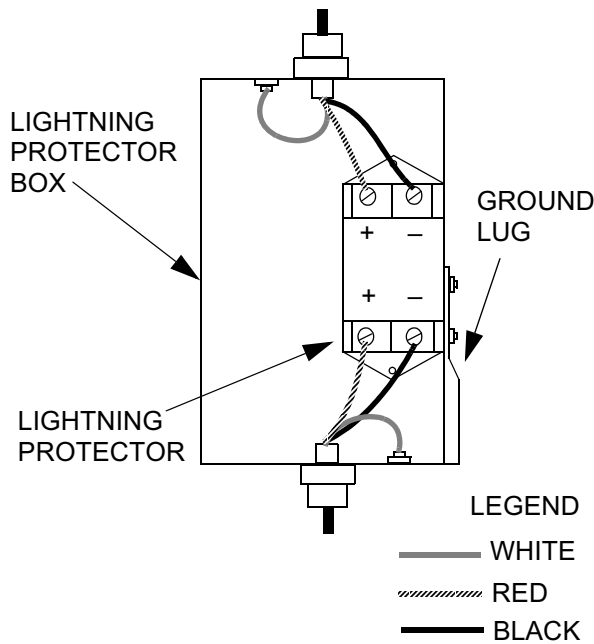


Figure 9. Lightning Protector and Lightning Protector Box

5.22 To assemble the lightning protector, do the following:

1. Remove the lightning protector box lid.
2. Orient the lightning protector box so that the GND lug is facing the desired direction.
3. Mount the lightning protector box to the utility box using #10 screws.
4. Prepare the shielded cable by stripping and folding back the shield (see Figures 9 and 10).
5. Insert the prepared cable through the opening in the lightning protector box. See Figure 9.
6. Ground the CMN lead to the lightning protector box per Figures 9 and 10.

7. Terminate the red (+) and black (-) wires to the lightning protector per Figure 9. Observe polarity.
8. Install the external GND to the lightning protector box.
9. Replace the lightning protector box lid.

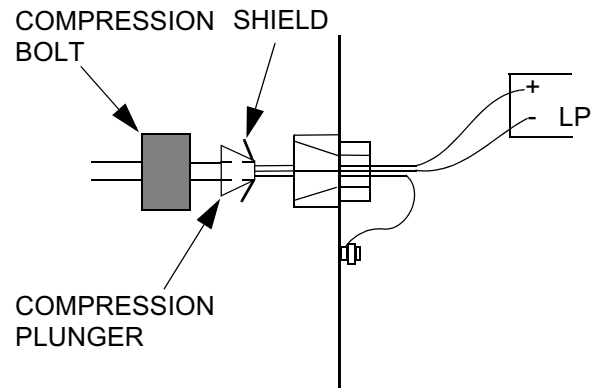


Figure 10. Shielded Cable Preparation

LORAN Lightning Protectors

5.23 There are two types of LORAN lightning protectors available: Type 1 and Type 2. Type 1 has BNC connectors; Type 2 has screw terminals. Both protector types can be installed either inside or outside the building. The LORAN protectors are a three-stage hybrid circuit, composed of gaseous discharge, resistive, and low capacitance silicon components. The plus and minus terminals short to ground. Selection of the type is dependent upon the choice of connector desired.

B. Single Lightning Protector Scheme

5.24 The single lightning protector scheme is recommended for locations which do not have the inside and outside ground points connected to an office principal ground point (OPGP), for both GTR and LORAN applications. In this application, the lightning protector is grounded to a Central Office ground bar that is bonded to the OPGP. The OPGP is a bus bar normally located near the AC entrance switchgear. It functions as:

- The central connection point for all main grounding connectors and earth electrodes

- The point of origin for the vertical equalizer
- The Central Office ground bus bar for the floor where it is located (typically the basement)

C. Dual Lightning Protector Scheme

5.25 The dual lightning protection scheme should only be used in locations that have the inside and outside ground points connected to an OPGP. The outside lightning protector is grounded to either a locally determined alternative (if applicable) or ring ground, and the inside lightning protector is connected to the building ground system. Symmetricom offers separate dual lightning protector schemes for GPS and LORAN antenna systems. The dual lightning protector scheme should be used only at sites that have a valid roof ring ground system. If in doubt about the ring ground system, it is preferred that the single lightning protector scheme be used.

D. Local Grounding Principles and Lightning Protector Placement

5.26 In GTR applications, a shielded 1.47 mm (16 AWG) three-conductor power cable with a built-in 1.47 mm (16 AWG) drain wire is used for the connection between the GTR and the lightning protector(s) and between the lightning protector(s) and the DCD-LPR Shelf. In LORAN applications, shielded two-conductor twinax cables are used for all connections between the LORAN antenna, the lightning protectors, and the DCD-LPR Shelf.

5.27 The shield of the GTR power cable is open at the GTR and grounded at the lightning protector; the built-in drain wire (on the lightning protector end) is connected to the grounding plate on the lightning protector. The drain wire on the DCD-LPR cable section is also connected to the ground plate on the lightning protector.

5.28 The shield allows the three conductors inside the lightning protector to rise to the same potential (with minimal difference of potential between them) during a near-lightning strike. The common (CMN) leads from both the DCD-LPR Shelf and the GTR are also connected to the grounding plate on the lightning protector. The CMN lead between the DCD-LPR Shelf and the GTR is required to ensure proper balance between power supplies.

5.29 The shield of the GTR power cable keeps the three leads at the same potential, and because the

shield is grounded at the lightning protector, they (including the CMN lead) will be kept at the building ground potential. If they rise sufficiently above ground, the lightning protector will fire and bring the power leads (and the CMN lead) back to ground potential.

5.30 The shield of the LORAN twinax cable is open at the antenna and at the LPR shelf, and connected on both sides of the lightning protector(s).

5.31 The following principles highlight general grounding rules for both GTR and/or LORAN antennas to minimize damage from lightning strikes:

Note: Do not substitute other lightning protectors for those supplied with the GTR and/or LORAN antenna.

- The ground wire should be as short (less than 4.5 meters [15 feet] is recommended) and straight as possible, and grounded to a CO ground bar bonded to the OPGP. Solid copper is recommended; 4.115 mm [6 AWG] wire should be used. Larger gauge cable must be used if the ground cable is longer than 15 feet.

Note: Lightning discharge will not travel around right angle bends; it will find the shortest and straightest path possible to earth ground.

- The length of the antenna cable run on the roof should be encased in weather-resistant, non-metallic conduit. Minimize the length of the exposed antenna cable runs on the roof.
- The lightning protector should be located within 15 meters (50 feet) of the point where the cables from the GTR and/or LORAN antenna enter the building (per company practice); Symmetricom recommends that the lightning protector be located within 3 meters (10 feet) of the cable entry point.
- Under no circumstances should the shielded cable run inside the building be more than 15 meters (50 feet) before the shield is grounded to a CO ground bar that is bonded to the OPGP.
- The DCD-LPR should be connected to frame ground per the installation procedure.

- f. The lightning protector should be grounded to a CO ground bar that is bonded to the OPGP. Other acceptable alternatives are to ground it to building steel, metal conduits, air conditioner ducts, or other metallic items known to be well grounded per national or local code.
- g. DIG GND to battery RTN (on the DCD-LPR backplane) is factory-strapped at TB1 only.
- h. Make sure that all connections are tight to avoid arcing, corrosion, and intermittent operation.
- i. All bends must be 90 degrees or greater with a minimum bending radius of 8 inches (see Figure 7). *Do not loop* the ground or power wires. If ground wires cross or are adjacent, they must be bonded at that point.
- j. Have an office grounding specialist verify the quality of ground and grounding protection methods. Deviations or omissions to grounding and protection principles may cause serious damage to equipment and/or personnel.

5.32 Table E shows recommended grounding distances for the ground wire, lightning protector, and shielded cable run.

Table E. Recommended Distances

ITEM	DISTANCE
Ground Wire	< 4.5 m (15 ft) and grounded to CO ground bar
Lightning Protector	Located within 3 m (10 ft) of cable entry point
Shielded Cable Run	Cannot exceed 15 m (50 ft) before the shield is grounded to a CO ground bar

Caution: *Exceeding ground length recommendations may reduce effectiveness of lightning protection system.*

5.33 The following principles highlight general grounding rules for both GTR and/or LORAN antennas to minimize damage from lightning strikes:

Note: Do not substitute other lightning protectors for those supplied with the GTR and/or LORAN antenna.

- a. The length of the antenna cable run on the roof should be encased in non-metallic weather-resistant conduit. Minimize the length of the exposed antenna cable runs on the roof.
 - b. When considering placement of the lightning protectors, use the following guidelines:
 - If installing either a PVC mast and metal conduit for the cable run, or a metal mast and PVC conduit, the outside lightning protector should be installed at the closest point of transition from PVC to metal. The outside lightning protector must be installed inside a junction box, and grounded to the metal conduit or roof ring ground. The inside lightning protector should be installed as close as possible to the point where the cables from the GTR and/or LORAN antenna enter the building.
 - c. The DCD-LPR should be connected to frame ground per the installation procedure.
 - d. The ground wire for the outside lightning protector must be as short (less than 4.5 meters [15 feet] is recommended) and straight as possible, in accordance with local office practice, and grounded to outside building (ring) ground. If using metallic conduit for cable runs, ground the outside protector to the metal conduit, if possible. All joints of metallic conduit must be bonded together, and both ends of the conduit run must be connected to the ring ground.
- Note:** Lightning discharge will not travel around right angle bends; it will find the shortest and straightest path possible to ground. If improperly installed, it may arc to some building frame ground, and result in hazardous consequences.
- e. The inside lightning protector should be grounded to a CO ground bar that is bonded to the OPGP. Keep the ground wire as short (less than 4.5 meters [15 feet] is recommended) and straight as possible in accordance with local company practice. Do not undersize this grounding wire.
 - f. The inside lightning protector should be located close to the DCD-LPR Shelf; Symmetricom

recommends maximum 3 meters (10 feet); not to exceed 15 meters (50 feet).

- g. The outside lightning protector must be contained in a weather-resistant junction box, and the lightning protector connected to outside building (ring) ground. If PVC mast and conduit are used, ground at the point of entry into the building. If metal conduit for cable runs is used, grounding to the conduit is preferred, and the conduit bonded to ring ground. *Keep the ground wire as short and straight as possible in accordance with local company practice. Do not undersize this grounding wire.*
- h. The outside and inside protectors must have separate ground points that are tied to the OPGP by separate paths.
- i. DIG GND to battery RTN (on the DCD-LPR backplane) is factory-strapped at TB1 only.
- j. Make sure that all connections are tight to avoid arcing, corrosion, and intermittent operation.
- k. All bends must be 90 degrees or greater with a minimum bending radius of 8 inches (see Figure 7). *Do not loop* the ground or power wires. If ground wires cross or are adjacent, they must be bonded at that point.
- l. Have an office grounding specialist verify the quality of ground and grounding protection methods. Deviations or omissions to grounding and protection principles may cause serious damage to equipment and/or personnel.

E. Central Office Ground System Overview

5.34 Generally, several types of central office grounds are available. Typical grounding types are:

- a. Ring Bonding Bus: a ring bonding bus (also referred to as “ring ground”) located around the rooftop of a structure with a low-resistance conductor (copper bar) directly connected to

earth at multiple points. The function of this ground is to ensure that all exposed conductive surfaces are at the same potential and to provide a low reactive (inductive) path to earth through which direct lightning strike currents can flow. The ring bonding bus located inside the building serves the same purpose as the ring bonding bus located on the roof.

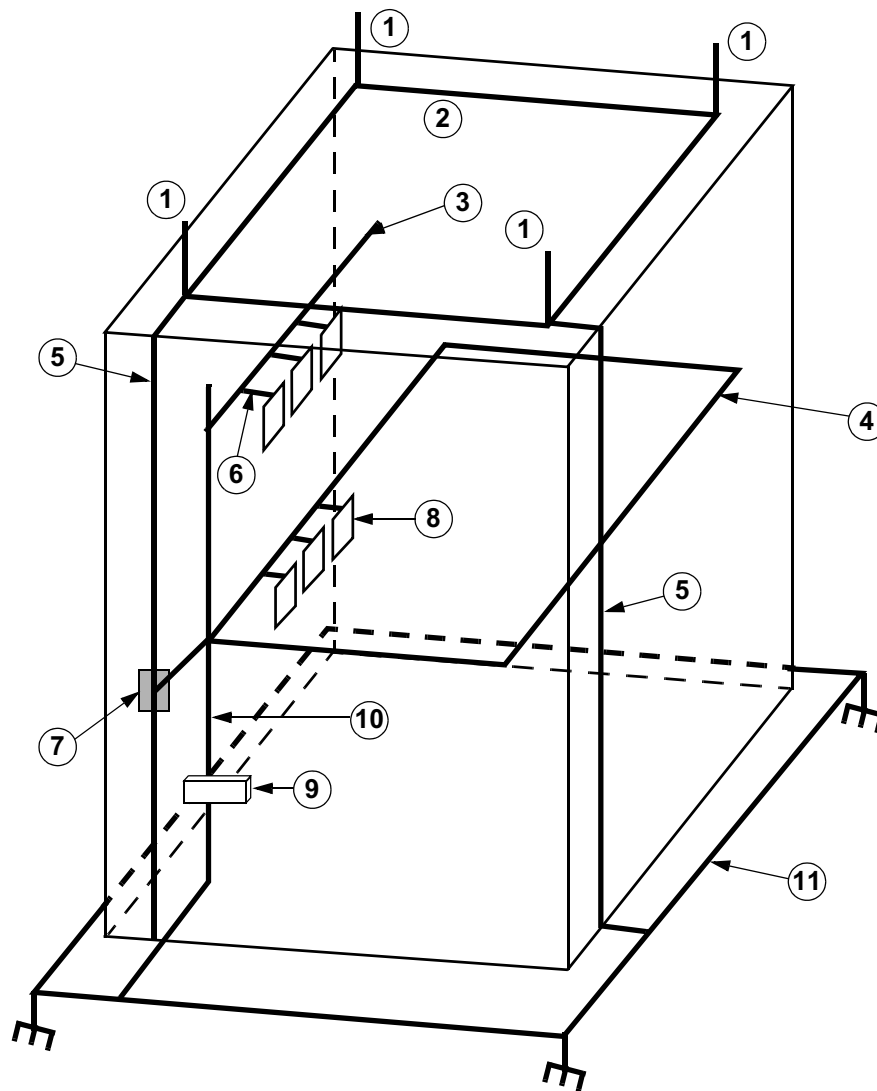
- b. Protection Ground: protection ground is used to ground lightning-protection devices to earth ground by means of a low-resistance conductor to earth.
- c. Frame Ground: frame ground is primarily an electromagnetic interference (EMI) drain at the equipment level and is not designed to dissipate high current from sources such as lightning.
- d. Earth Ground: this is the earth itself. All other grounds are ultimately connected to earth ground.

Note: Battery return is a conductor from the equipment to the office battery and should not be considered a ground.

- e. The OPGP is a bus bar normally located near the AC entrance switchgear. It functions as:
 - The central connection point for all main grounding connectors and earth electrodes
 - The point of origin for the vertical equalizer
 - The CO ground bus bar for the floor where it is located (typically the basement)

5.35 Figure 11 shows the various grounds available at a central office, and Figure 12 and Figure 13 show how the GTR uses these grounds.

5.36 Figure 14 and Figure 15 show how the LO-RAN antenna uses the various grounds available at a central office.

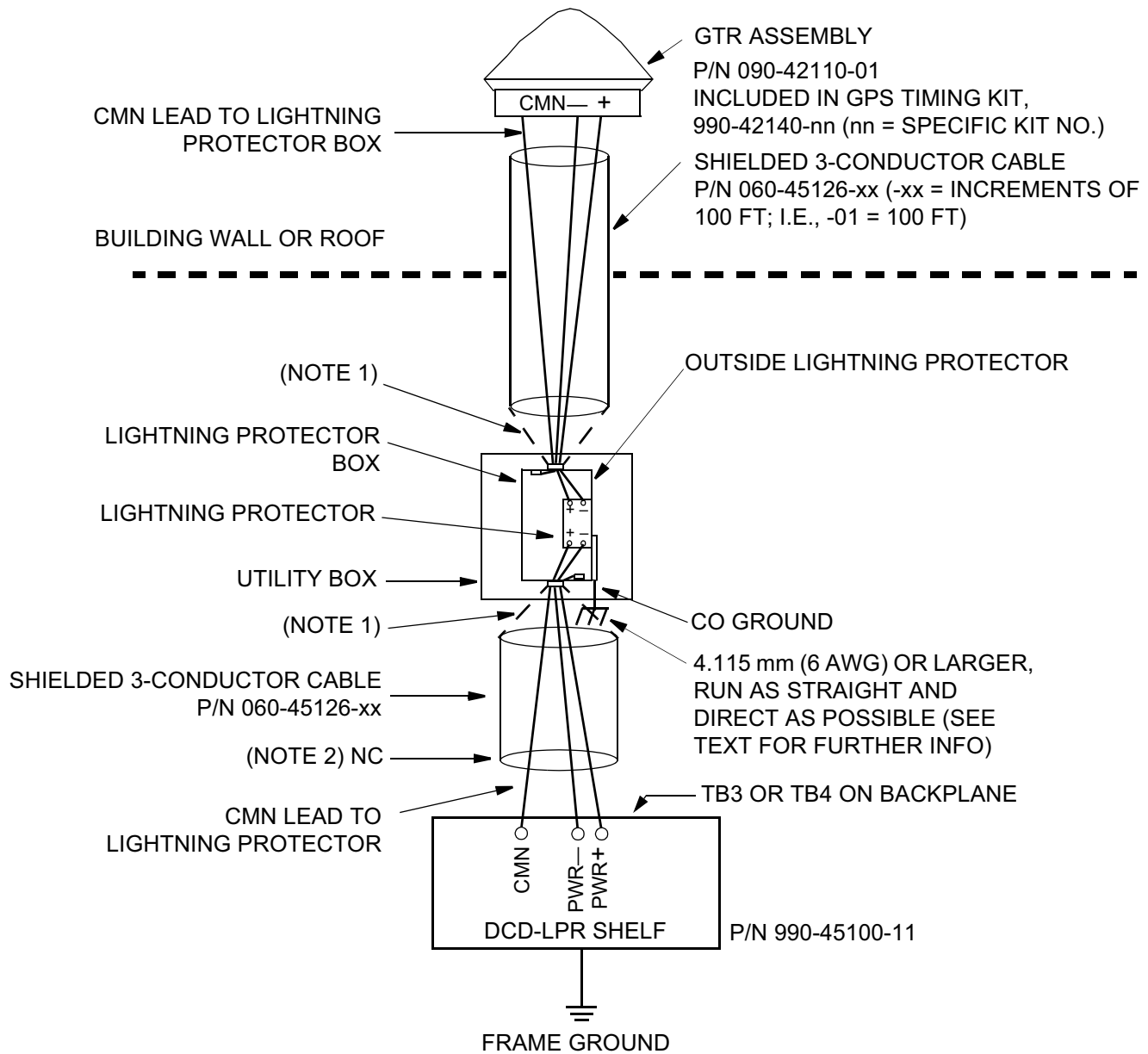


- | | |
|--|---|
| ① Lightning rod (Note 1) | ⑦ Cable entrance facility (ground window) |
| ② Ring bonding bus (on roof) (Note 2) | ⑧ Equipment frame |
| ③ Bonding bus (2nd floor) | ⑨ OPGP (CO ground) |
| ④ Ring bonding bus (inside building - 1st floor) | ⑩ Vertical equalizer |
| ⑤ Down conductor (Note 3) | ⑪ Station ground (Earth) (Note 4) |
| ⑥ Equipment bonding conductor | |

Notes:

1. Lightning rods (air terminals) are connected to the ring bonding bus or to building structural steel.
2. The ring bonding bus is also referred to as ring ground.
3. There are two down conductor paths shown; multiple paths are recommended. At minimum, one connection path to Earth at each corner of the building.
4. Multiple path connections to Earth ground.

Figure 11. Central Office Grounds



- Notes:
1. See Figure 10 for shield and conductor termination at both ends of lightning protection box.
 2. The shield is not connected at the DCD-LPR Shelf.
 3. Use NO-OXide at all mechanical connections.

Figure 12. GTR Single Lightning Protector Grounding Scheme

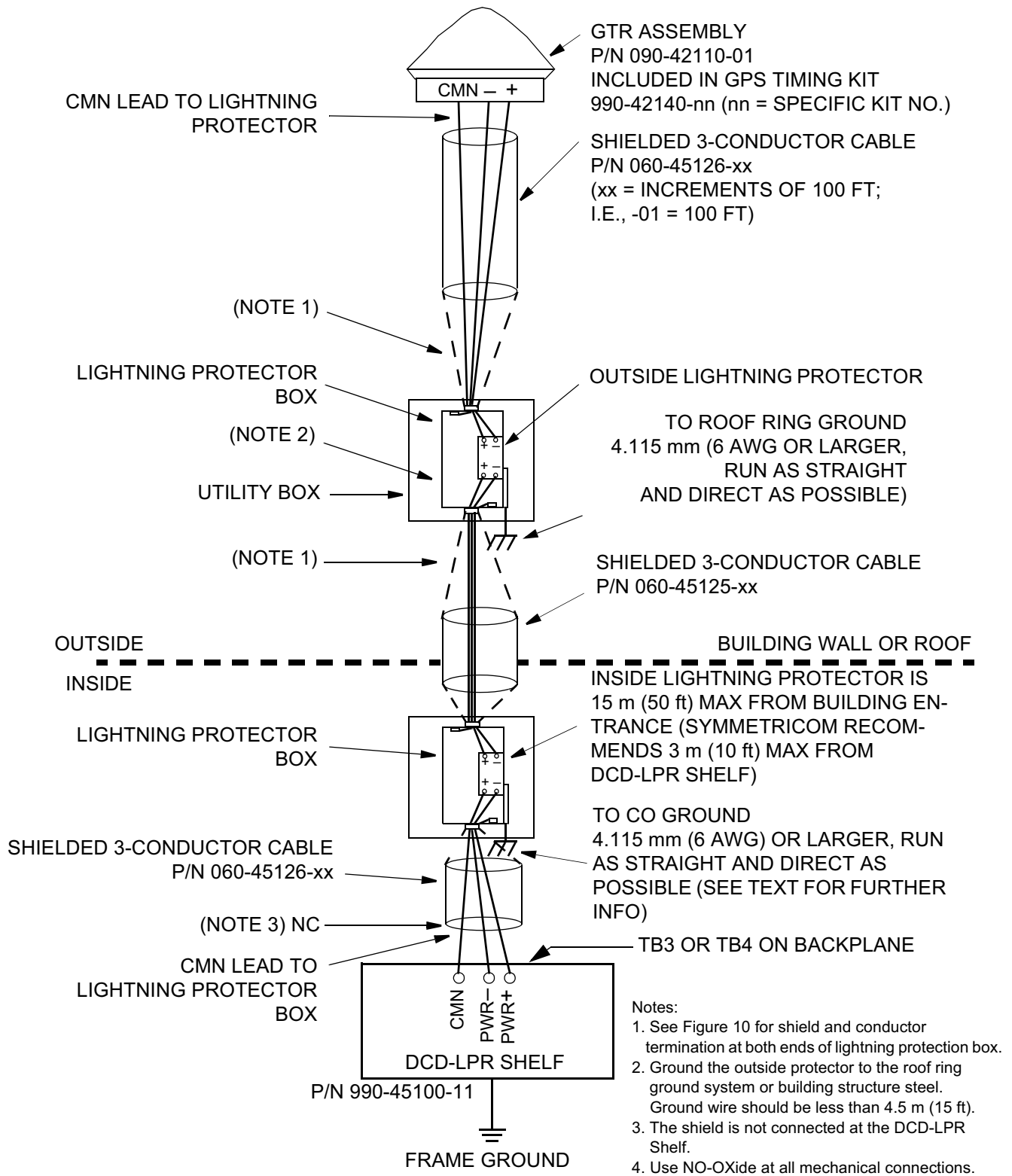
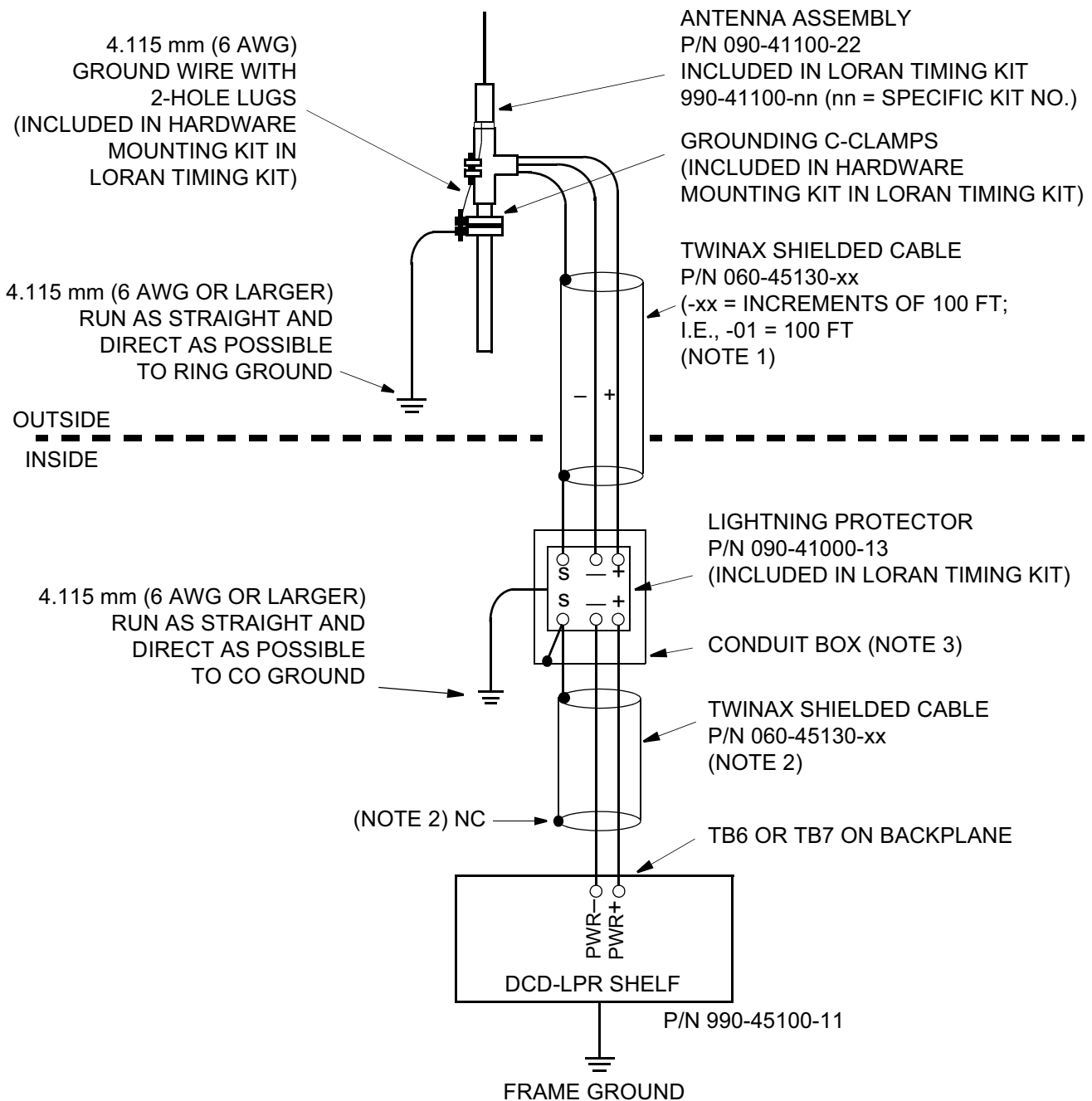


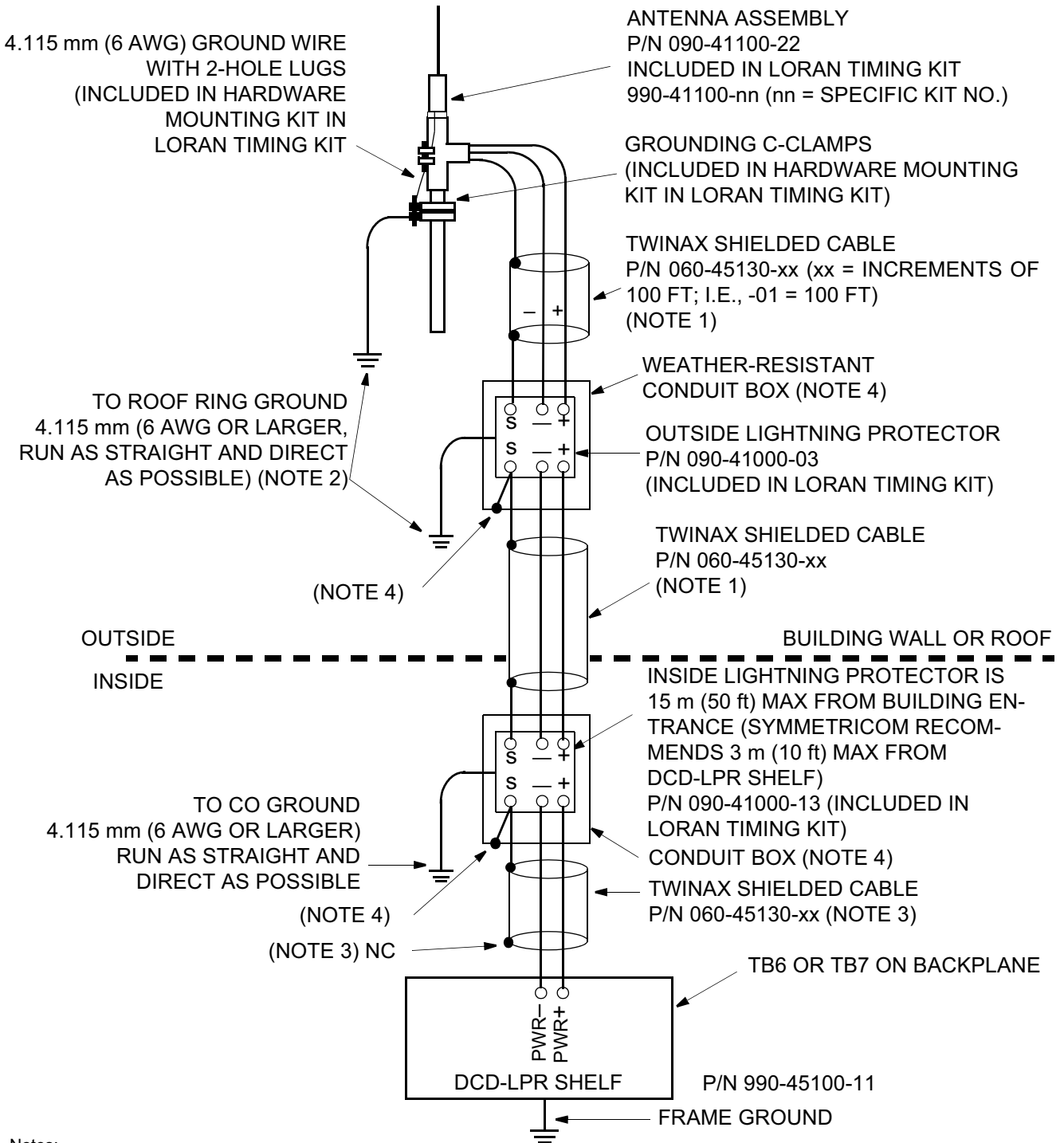
Figure 13. GTR Dual Lightning Protector Grounding Scheme



Notes:

1. The twinax shield is grounded at both sides of the lightning protector.
2. The twinax shield is not connected at the DCD-LPR, instead it is cut off and taped back as per company practice.
3. If the conduit (junction) box is metal, ground the box to the spare #6 stud on the grounding plate. A non-metallic junction box is recommended.

Figure 14. LORAN Antenna Single Lightning Protector Grounding Scheme (Type 2 Lightning Protector)



Notes:

1. The twinax shield is grounded at both sides (ANTENNA and LPR) of the outside lightning protector, and the LPR side of the inside lightning protector. Shield continuity is inside the weather-resistant conduit box. It is recommended to make a shield connection at the ANTENNA side of the inside lightning protector.
2. Ground the outside protector to roof ring ground system or building structure steel. Ground wire should be less than 4.5 m (15 ft).
3. The twinax shield is not connected at the DCD-LPR, instead it is cut off and taped back as per company practice.
4. If the conduit (junction) box is metal, ground the box to the spare #6 stud on the grounding plate. A non-metallic junction box is recommended.

Figure 15. LORAN Antenna Dual Lightning Protector Grounding Scheme (Type 2 Lightning Protector)

6. GPS ANTENNA INSTALLATION CONSIDERATIONS

6.01 This section describes guidelines to consider when installing the GTR, including:

- Cabling considerations and materials required
- Antenna location
- Lightning protection location

6.02 Installation procedures are to follow local company procedures.

Note: Throughout this section, the “xx” noted in a cable part number, is used in place of the number indicating the length. For example, the part number for the fiber optic cable is seen as “060-45100-xx”; the part number for a 121.3 meter (400 foot) section of fiber optic cable is 060-45100-04, a 91 meter (300 foot) section is 060-45100-03, etc.

A. Cabling Considerations

6.03 The GTR antenna assembly uses two-strand fiber optic (for GTI to GTR communication) cables. For power, shielded three-conductor cables are used. The maximum fiber optic cable distance allowable between the GTR and the DCD-LPR, using the Symmetricom external power supply, is 1,213 meters (4,000 feet). If using the GTI power supply, the maximum distance is 304.8 meters (1,000 feet).

6.04 For single lightning protection schemes, the power cables are a shielded, 1.47 mm (16 AWG), stranded, three-conductor cable with a 1.47 mm (16 AWG) drain wire for connection between the GTR and the lightning protector, and between the lightning protector and the DCD-LPR Shelf. For dual schemes, the same cabling materials are required as for the single lightning protector installation, plus an additional shielded cable is required to connect the inside lightning protector to the outside lightning protector.

6.05 It is recommended that one cable (p/n 060-45126-xx) be ordered for the overall cable run from the antenna to the lightning protector(s) and on to the DCD-LPR Shelf. The cable is pulled and cut at the lightning protector(s) for connection through the lightning protector(s).

6.06 Regardless of whether an internal power supply or an external power source is used, the maximum cable distance between the GTR and the power supply that can be supported using 1.47 mm (16 AWG) wire is 243 meters (1,200 feet).

6.07 Specifications for the external power source at the GTR interface are:

- Maximum 1.16 amps in-rush current
- Nominal operation: 6.4 watts continuous (200 mA at 32 volts)

Note: If an external power supply is desired, the Symmetricom Stand-alone Power Supply (p/n 990-40031-01) or an equivalent is recommended. For information regarding the Symmetricom power supply, contact Symmetricom Customer Assistance Center (CTAC) at one of the following numbers:

- +44 (0) 1189 699 799 (U.K.)
- +1 408 428 7907 (U.S.A.)

Note: The following toll-free number is available in some countries to access Symmetricom’s Inside Sales and CTAC in the U.S.A.: +1 888 367 7966 (U.S.A.).

6.08 All cable runs outside the building must have the cables encased in weather-resistant conduit. The conduit should be large enough to accommodate the fiber optic cable and connectors, power cable and connectors, as well as pulling wires. Either metal or PVC conduit may be used; it is recommended that if PVC conduit is used, a minimum 50.8 mm (2 inch) UL listed #651 PVC conduit (minimum Schedule 40) be used. Symmetricom recommends using non-metallic conduit as metallic conduit requires special grounding and bonding techniques.

Warning: Avoid hard (tight) corner small radius turns and any unnecessary turns. The minimum bending radius is eight inches. All bends must be 90 degrees or greater (see Figure 7).

6.09 Cables must be run as straight as possible; the fiber optic cable can have maximum 50.8 mm (2 inches) bending radius; stripped (unsheathed) fiber cable can have maximum 25.4 mm (1 inches)

bending radius (Figure 16). All cables should be run in accordance with local company practices.

Caution: *Less than a 50.8 mm (4 inch) bending radius; 25.4 mm (2 inch) for stripped (unsheathed) fiber cable could cause fiber breakage or excessive fiber loss.*

Warning: *Do not attempt to coil excess GTR power cable into the junction box. Failure to observe this caution may result in increased damage if a lightning strike occurs.*

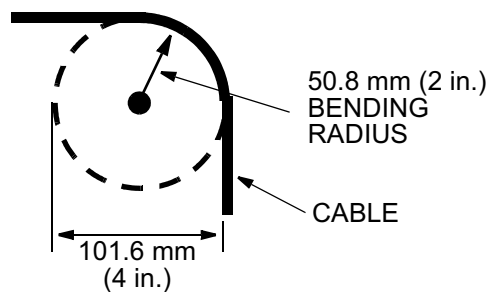


Figure 16. Fiber Bending Radius

B. Cabling Material

6.10 The following cable materials are required for installation:

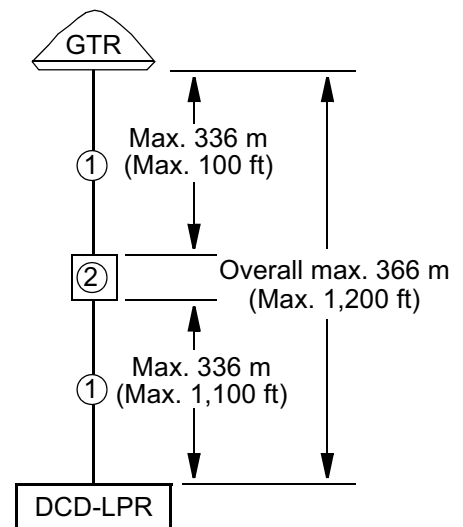
- The GTR shielded power cable, p/n 060-45126-xx, comes with the GTR power connector, p/n 121-00805-01, terminated on one end and unterminated on the other end. It is a shielded three-conductor 1.47 mm (16 AWG) stranded cable with a built-in 1.47 mm (16 AWG) drain wire for GTR power connection from the DCD-LPR Shelf through the lightning protector(s). The cable must be long enough to allow the following connections:

- Single lightning protector (Figure 17)
 - GTR to outside lightning protector
 - outside lightning protector to DCD-LPR Shelf
- Dual lightning protector (Figure 18)
 - GTR to outside lightning protector
 - outside lightning protector to inside lightning protector

- inside lightning protector to DCD-LPR Shelf

Notes:

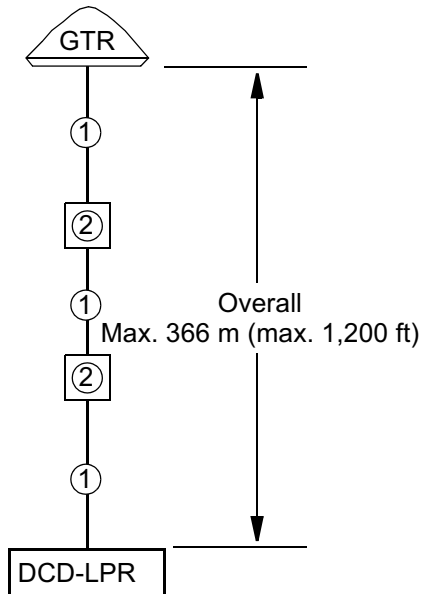
1. The cable is pulled to the lightning protector(s), then cut for terminating through the lightning protector(s).
2. The maximum overall allowable length of power cable between the GTR antenna and the DCD-LPR Shelf is 1200 feet (366 meters). For distances greater than 1200 feet an external power source, p/n 990-40031-01, is required. If an external power source is used, the GTR power supply daughterboard on the GTI card must be removed to prevent standing antenna alarms.
3. The outside and inside protectors must have separate ground points that are tied to the OPGP by separate paths.



- ① Shielded 3-conductor power cable (with power connectors: p/n 060-45126-xx)
- ② Lightning protector

Figure 17. GTR Power Cable Limits (Single Lightning Protector)

4. A GTR Grounding Upgrade Kit, p/n 093-45126-01, is available to upgrade existing LPR sites that were installed with unshielded power cable (p/n 060-45120-xx and p/n 060-45140-xx) and lightning protectors without grounding plates for multiple lead connection.



- ① Shielded 3-conductor power cable (with power connectors: p/n 060-45126-xx)
- ② Lightning protector

Figure 18. GTR Power Cable Limits (Dual Lightning Protectors)

- The fiber optic cable is a 200 micron core, 850 nm wavelength multimode fiber optic Riser-rated cable used to connect the GTR to the DCD-LPR. Fiber optic cables may be purchased from Symmetricom or Lucent Technologies. Symmetricom offers the cable in two configurations:
 - Riser-rated fiber cable with ST-320 connectors and pulling mechanism (p/n 060-45110-xx)
 - Riser-rated fiber cable only (p/n 060-45100-xx)

- Lucent Technologies offers the cable in two configurations:
 - Riser-rated fiber cable with ST-320 connectors and pulling mechanism (p/n BP04344-xx)
 - Riser-rated fiber cable only (p/n BP04343-xx)

Notes:

1. The fiber optic cable from Symmetricom contains two different colored insulated fiber strands, a fiberglass strengthener, and two filler cables (Figure 19); other manufacturers may differentiate each cable by texture (smooth or ribbed).
 2. The fiber optic cables with connectors are stocked by Symmetricom in the following lengths:
 - 15.0 meters (50 feet)
 - 30.3 meters (100 feet)
 - 45.5 meters (150 feet)
 - 60.7 meters (200 feet)
 - 75.8 meters (250 feet)
 - 91.0 meters (300 feet)
 - 106.2 meters (350 feet)
 3. For lengths greater than 106.2 meters (350 feet), cable is only available in 30.3 meter (100 foot) increments up to 455 meters (1000 feet)
 4. For lengths greater than 455 meters (1000 feet), contact the Symmetricom Inside Sales Department for Special Order procedures.
- If field installation of ST-230 connectors is desired, then four fiber optic compound cleave crimp-on ST-style connectors (200 micron core, multimode fiber) are required. A package of six may be ordered from Symmetricom (p/n 093-42100-21). A fiber ST-230 terminator connector tool will be required for crimping on the connectors at the field site. The fiber ST-230 terminator

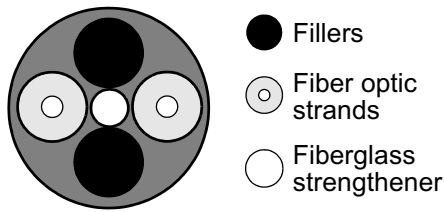


Figure 19. Fiber Optic Cable

connector tool may be ordered from Lucent Technologies (p/n TK7-230-ST).

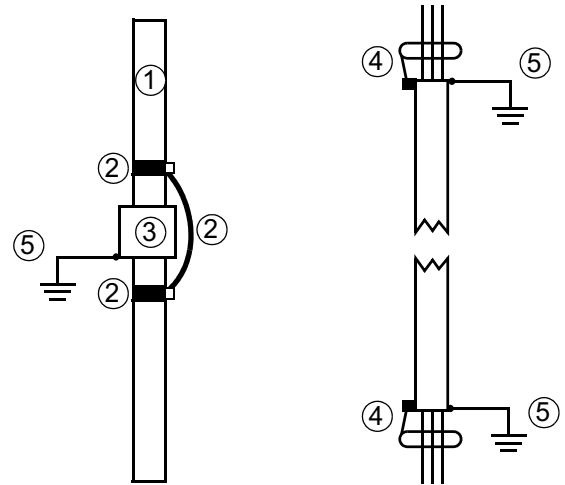
- 4.115 mm (6 AWG) grounding wires (or larger for long runs); this cable is user-provided
- Spade lug connectors to fit a 1.47 mm (16 AWG) wire, 6.4 mm (0.25 inch) wide, and fit a #6 stud (included in GTR hardware kit)
- A two-hole (for #10 stud) crimp lug for 4.115 mm (6 AWG) ground wire is provided in the GTR hardware kit
- Weather-resistant conduit, metal or PVC; it is recommended that a minimum 50.8 mm (2 inch) UL listed #651 PVC conduit (minimum Schedule 40) be used if PVC is chosen for cable runs

Note: Metal conduit should be used if the conduit is to be used for ground.

- Expansion joint sleeves to prevent breaks in the conduit due to expansions and contractions

Note: If metal conduit is used, conduit joints must be bonded (generally, threading of the pipe is not adequate) and, at minimum, both ends of the conduit run must be connected to

building structural ground via the ring ground, metal conduits, air conditioning ducts, etc. It is recommended that an intermediate point along the conduit be also grounded (Figure 20).



A. Conduit Joints

B. Cable shield bonds

- ① Conduit
- ② Strap around joint, and use an antioxidant on all connections
- ③ Joint sleeve
- ④ The shield must be bonded to the metal conduit where it enters and leaves the conduit
- ⑤ Both ends of the conduit must be connected to ring ground. For multiple conduit section runs, some midway joint sleeves should be connected to ring ground

Figure 20. Metal Conduit Considerations

C. GTR Antenna Location and Mounting

Warning: *Do not select an antenna location that could be an electrical or physical hazard to work persons or equipment. Avoid proximity to all high-voltage sources. Mount in an easily maintainable location.*

Location

6.11 It is recommended that a site survey be performed to determine the best rooftop location for the GTR, as well as required materials. While performing the site survey, consider the selection of possible mounting locations in relation to the cable entry point in the building, accessibility, and proximity to suitable ground points.

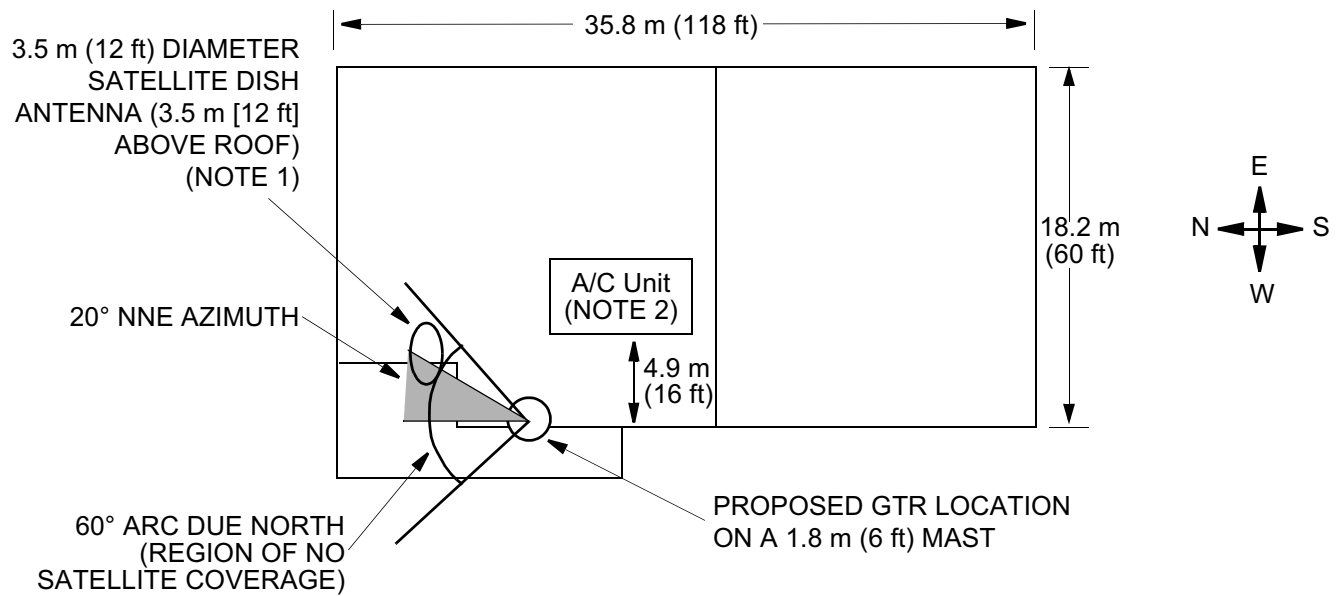
6.12 The ideal mounting location for the GTR provides an unobstructed (360 degrees) view of the sky 10 degrees and higher above the horizon. If this is the case, proceed to instructions for mounting the GTR. The GTR must be able to see a minimum of four satellites at all times in order to have continuous alarm free operation.

6.13 If the ideal location is not available, the following minimum requirements must be met:

- 300 degrees azimuth view of the sky
- No vertical obstructions
- 10 degrees altitude above the horizon line
- Any azimuthal (horizontal) obstruction in the same horizontal plane as the GTR should be, if possible, confined within a 60 degree arc due north of the GTR if in the Northern Hemisphere, and due south in the Southern Hemisphere

Note: For lightning protection reasons, the GTR should not be the highest object on a building or tower, if possible.

6.14 If the minimum requirements cannot be met, a compromise must be made between performance and satellite coverage. The less coverage, the fewer the number of satellites being used in the timing solution for GPS-derived time. The consequence of this is the DCD clocks may experience holdover more often than if the minimum requirements had been met. This fact may influence the network engineer to select rubidium over quartz clocks.



Notes:

1. Receive only—C band (4 GHz) and KU band (12 GHz)—south direction azimuth, 45° altitude.
2. The dimensions of the air conditioning unit shown in this figure are: 7.3 m (24 ft) length x 3.6 m (12 ft) width x 1.5 m (5 ft) height.

Figure 21. Example Aerial View of Building Rooftop

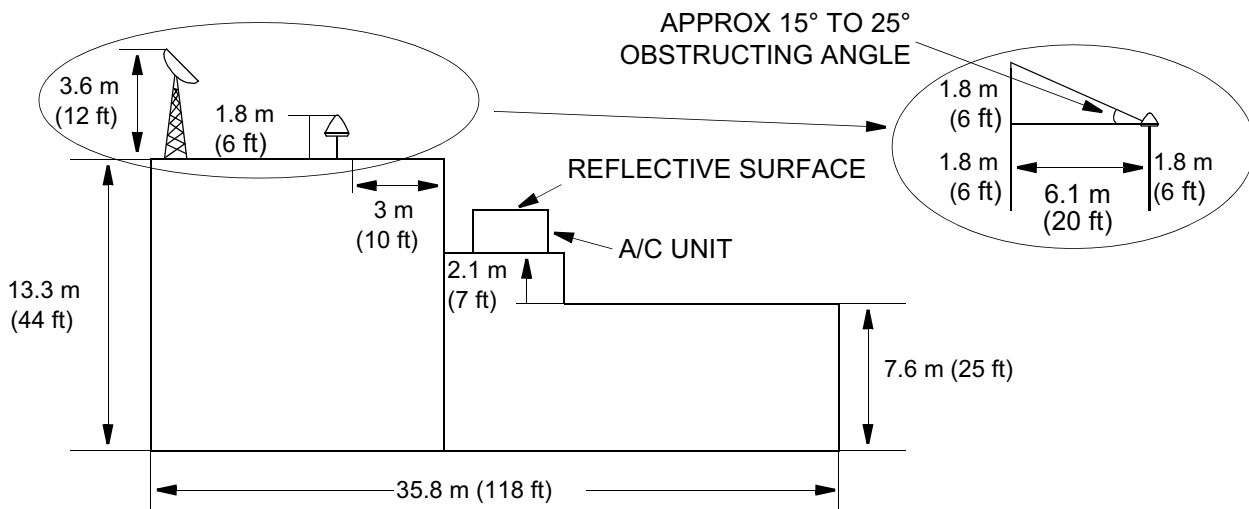
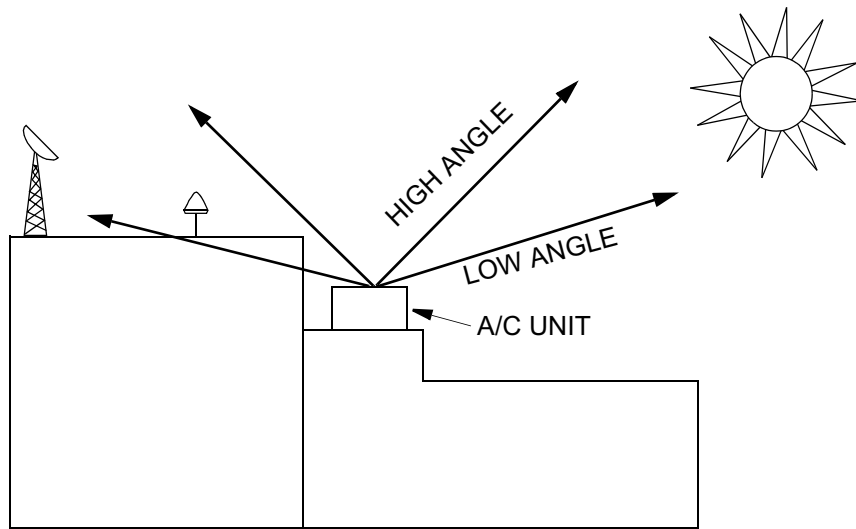


Figure 22. Example Side View of Antenna Obstructions



- Horizontal distance from vertical reflective structure (e.g., heating ducts, equipment housings, etc.) is recommended to be twice the height of the structure, minimum 3.0 m (minimum 10 ft).
- Vertical distance above metallic reflective object minimum 1.4 m (minimum 4 ft).

Figure 23. Example Side View of Placement with Respect to Reflective Surface

6.15 The following procedures provide an engineering methodology to perform a physical site survey without test equipment. Different GTR locations and mast heights on the roof may be required during the survey before the best GTR location is found. If the parameters cannot be met, a detailed study using test equipment may be required.

6.16 Figure 21 through Figure 23 are examples of side view and top view drawings of a hypothetical DCD-LPR site. The building has three roof line levels, with a large air conditioning unit, and a transmit and receive dish antenna on the higher roof line.

6.17 To perform a site survey, use the location rules listed at the beginning of this section, and complete the following:

1. Make an aerial view drawing of the building rooftop to approximate scale (Figure 21). A hand sketch will suffice if engineering drawings are not available.
 2. Mark the locations of reflective and obstructing objects on the roof, e.g., air conditioning units, motor/generators, other antennas, towers, metal capped parapets nearby (1/4 mile), tall buildings and trees, etc.
 3. Mark the dimensions (height, width, and length) and distances from walls and other objects on the roof for each obstructing object on the drawing. For antennas, mark the type, e.g., dish, horn, whip, etc., whether it is transmit only, receive only, or transmit and receive on the drawing.
 4. Mark the drawing with other information about the antennas, e.g., azimuth direction and altitude angle above horizon it is pointing, with respect to proposed GTR location, such as N azimuth-10 degrees altitude, NNE azimuth-15 degrees altitude, etc., its operating frequencies (transmit and receive), and its output power in watts or decibels (dBm).
5. Do a visual azimuth survey of objects within 0.2 km (1/8 mile [200 yard]) around the building; check for the following:
 - Height and distance of taller objects, such as extremely high buildings up to 0.4 km (1/4 mile) away.
 - Height, width, and distance to objects, such as towers, buildings, dense tall trees, etc., that may exceed 10 degrees altitude above the horizon with respect to the roof line.
 - Approximate height, width, and distance of these objects from the building.
 - Proximity and height of any high-voltage power lines with respect to the building.
 6. Make a side view drawing of the building, showing the height of the roof line and any obstructing objects (Figure 22 and Figure 23).
 7. Locate the GTR on the rooftop in a position which meets the following requirements:
 - **Is not** within 30 degrees azimuth of the transmission direction of transmitting antennas (to avoid overpowering the front end of the GTR, even though it is at a different frequency)
 - **Is not** underneath high power lines—if it cannot be avoided, ensure that the GTR is placed at least twice as far from the power line as the power line is high (to avoid blockage and multipath effects) (if possible)
 - **Is not** within 3 meters (10 feet) of a corner of the building
 - **Is not** more than 515.7 meters (1200 feet) from the GTR power supply (DCD-LPR Shelf or external source)
 - **Is** at least twice as far from obstructing objects as the obstructing object is high (if possible)

8. Choose the mast height for the GTR, using the following guidelines:

- Placement with respect to a horizontal reflective surface (e.g., air conditioning unit) should be such that only high reflected wave angles strike the GTR (Figure 23 and Figure 24). Typically, this requires the GTR to be elevated on a mast of roughly 1.2 meters (4 feet) (independent of proximity to the horizontal reflective surface).
- Horizontal distance from vertical reflective objects (e.g., tower) is recommended to be twice the height of the metallic reflective object, maximum 3 meters (10 feet) (Figure 25).
- If GTR placement cannot be achieved without violating the 10 degree altitude guideline, or there happens to be another obstruction (either on the building roof or removed from it, e.g., water tower, skyscraper, etc.), choose a GTR location that places the obstruction due north of the GTR (if in the Northern Hemisphere), or due south (if in the Southern Hemisphere). The reason for this is that there are holes in the GPS satellite coverage over the North and South Poles. Thus, by locating the obstruction in the “hole” region, the obstruction is effectively removed because there are no satellites in this region to be blocked.

Note: When the site is near or at the Equator, it does not matter where the obstructing object is with respect to the GTR, it will still obstruct the view of the GTR.

- The GTR is above any local reflective or obstructing object, or high enough that the height of the view obstructing object is not higher than 10 degrees altitude above the

horizon with respect to the height of the GTR.

9. Determine if guy wire requirements for the mast are required.

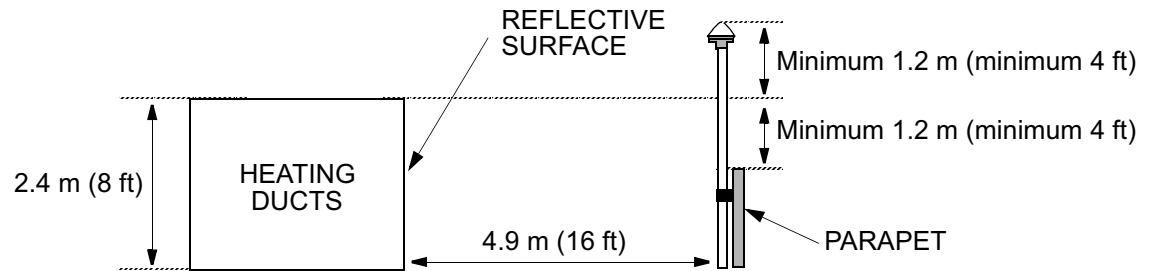
Note: If guy wires are required to support the mast, each wire must be connected to rooftop ring ground.

10. From the information obtained previously, determine the type of mounting hardware needed (e.g., 19.1 mm [0.75 inch] U-bolts or masonry bolts, Romex-type conduit plug, etc.). Determine the location of the following:

- The DCD-LPR Shelf
- The inside and outside lightning protectors
- The grounding points for the lightning protectors and DCD-LPR Shelf (per the guidelines set previously)

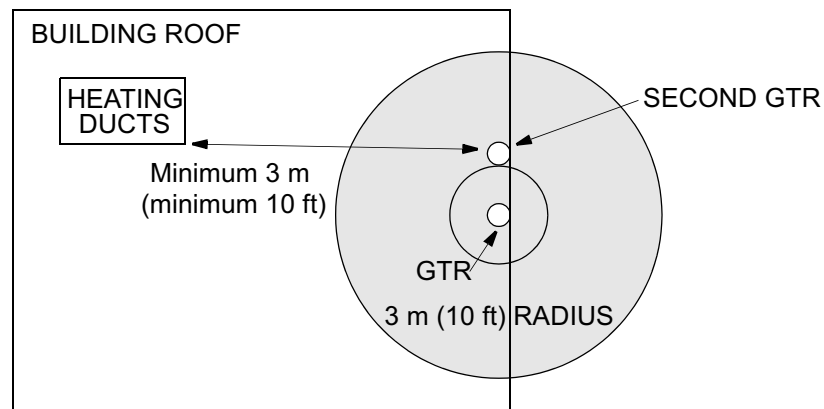
11. To determine the cable lengths required for single lightning protector installations, determine the distance between the following:

- The GTR and the lightning protector (for power cable)
- The lightning protector and the DCD-LPR Shelf (for power cable)
- The GTR and the DCD-LPR (for fiber optic cable)
- The lightning protector and the CO ground bar (grounding wire)
- The DCD-LPR and the DCD master shelf (not necessary if configuring DCD-LPR for stand-alone operation)



- The horizontal distance from the vertical reflective structure (e.g., heating ducts, equipment housings, etc.) is recommended to be twice the height of the structure, minimum 3.0 m (minimum 10 ft).
- Vertical distance above the metallic reflective object minimum 1.2 m (minimum 4 ft).

Figure 24. GTR Location—Distance from Reflective Objects



- Horizontal distance from any other GTR antennas minimum 0.91 m (minimum 3 ft)
- Vertical distance above the parapet, obstructions, horizontal metallic reflective surfaces minimum 1.2 m (minimum 4 ft)

Figure 25. GTR Location—Field of View

12. To determine the cable lengths required for dual lightning protector installations, determine the distance between the following:

- The GTR and the outside lightning protector (for power cable)
- The outside lightning protector and the inside lightning protector (for power cable)
- The inside lightning protector and the DCD-LPR Shelf (for power cable)
- The GTR and the DCD-LPR (for fiber optic cable)
- The lightning protector and the building ground (grounding wire)
- The DCD-LPR and the DCD master shelf (not necessary if configuring DCD-LPR for stand-alone operation)

13. For conduit length (for cable runs), determine the distance between the GTR and the cable entry point.

Mounting

6.18 It is recommended that the GTR be mounted on the rooftop, inside the parapet for connection to outside building (ring) ground. Refer to Figure 26 or Figure 27 for examples of different GTR mountings.

Note: A rooftop mounting platform is available from Prodelin Corp. (Figure 28). Contact Prodelin Corp. (in the U.S.A.) (+1-704-464-4141) for additional information; reference the Rectangular Block Mast Mount, p/n 0800-182.

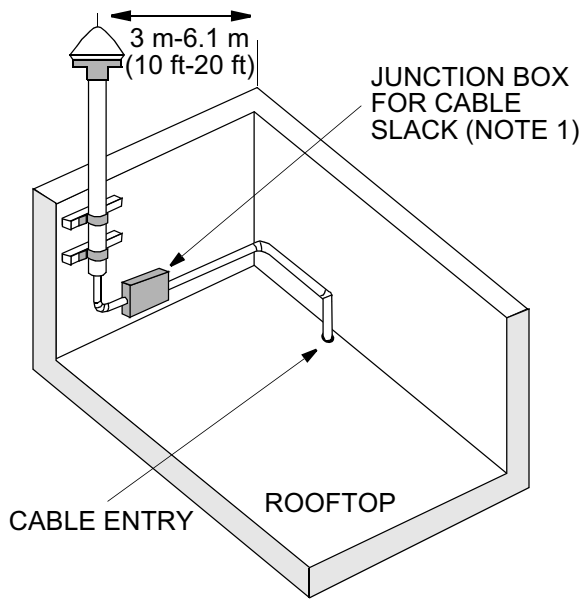
6.19 When mounting the GTR, observe the following guidelines:

- Mount the GTR in such a way that the top of the GTR is at least 1.2 meters (4 feet) above the parapet.
- Mount the GTR in a location with easy access for future maintenance purposes.
- Mount the GTR on either 50.8 mm (4 inch) or 101.6 mm (2 inch) PVC or metal conduit for the mast. If PVC is used, rigid UL listed #651 PVC

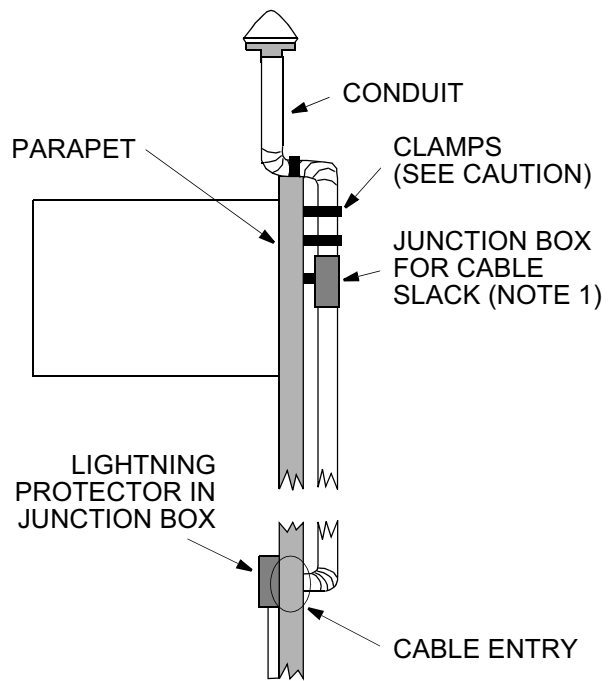
conduit (minimum Schedule 40) is recommended.

Note: If PVC is used, the Schedule type used and the diameter of the mast (50.8 mm or 101.6 mm [4 inches or 2 inches]) depends on the conditions at each installation site. If the installation site is a high-wind location, it may be advantageous to use 101.6 mm (4 inches) of Schedule 80 conduit. If in a low-wind location, the mast is under 1.2 meters (4 feet), and guy wires are used to stabilize the mast, 50.8 mm (2 inch) Schedule 40 may suffice. Contact Symmetricom CTAC for assistance in determining the Schedule type and mast diameter best suited for your location.

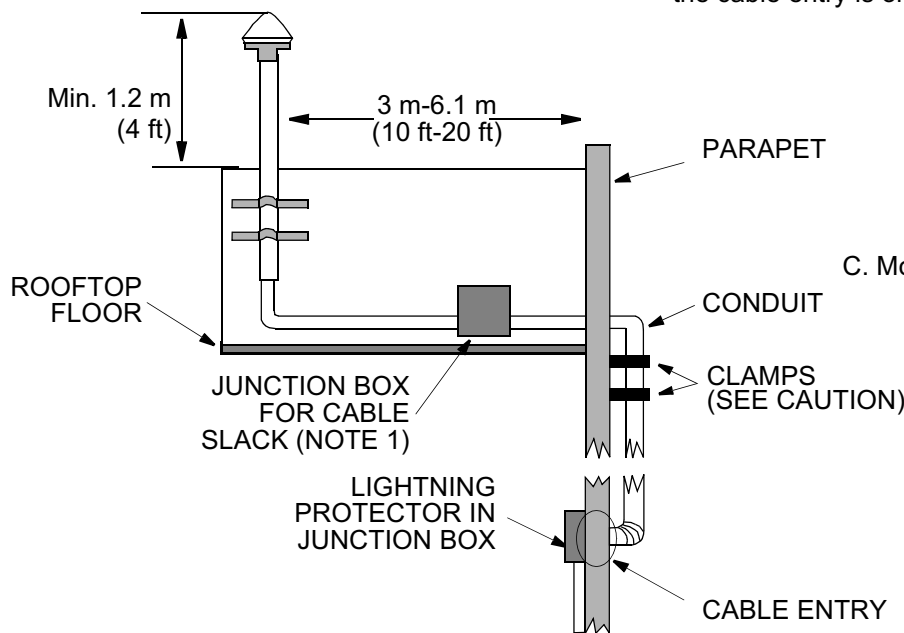
- If using a 50.8 mm (2 inch) mast, a pipe reducer must be user-provided; PVC or metal may be used. If PVC is used, rigid UL listed #651 PVC conduit (minimum Schedule 40) is recommended. Refer to Figure 29 for examples of GTR mast configurations.
- If using the 73.2 mm (2.88 inch) mast from Prodelin Corp., a 101.6 mm to 73.2 mm (4 inch to 2.88 inch) mast adaptor is available from Prodelin (p/n 0800-101).
- All openings around the conduit hub/nonconductive conduit connection, and where the conduit enters the building, must be waterproofed per local company practices.
- It is recommended that all exposed connections be treated with an electrically conductive anti-corrosion compound (Kopr-Shield or equivalent).
- When selecting a cable entry location, and the location to mount the lightning protectors, consideration must be given to the grounding connections for the lightning protectors. The ground connections on the lightning protectors must be as short and straight as possible, in accordance with local company practice, and not near any other equipment. This connection may have to carry large currents in the event of a lightning strike.
- When selecting a cable entry location, keep in mind that Symmetricom recommends the lightning protector be installed within 15 meters (50 feet) of the cable entry location.



A. Mounted to the inside of the parapet and the cable entry is on the rooftop



B. Mounted to the outside of the parapet and the cable entry is on the side of the building



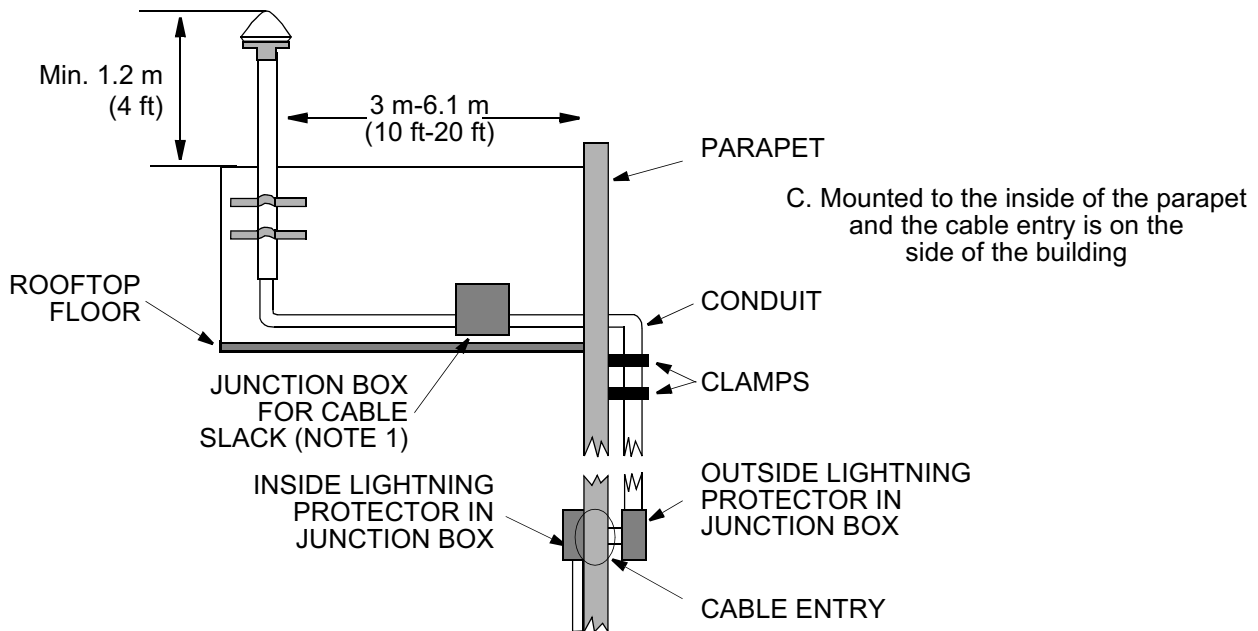
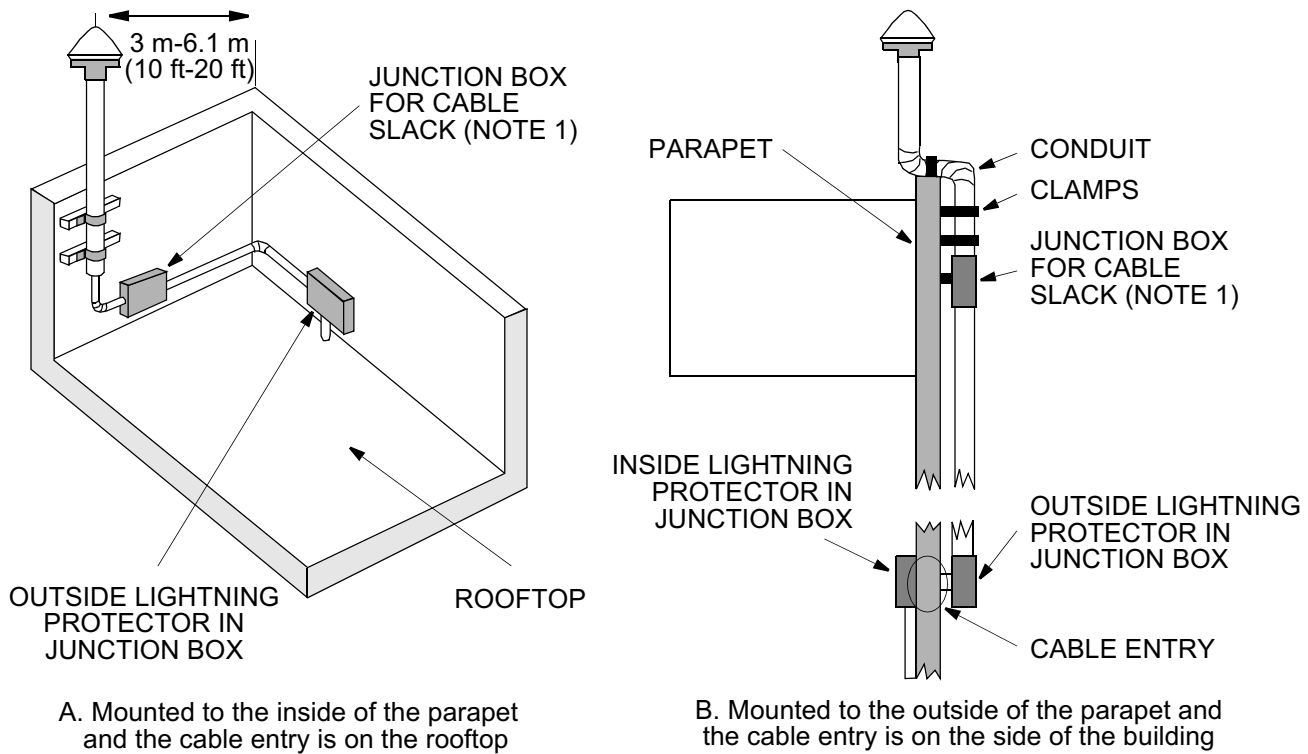
C. Mounted to the inside of the parapet and the cable entry is on the side of the building

Caution: Clamps that form a complete circle around the power cable or the cable conduit are not allowed. The ring clamp acts like a choke coil to induced currents which resists current flow and hampers proper lightning protection. Use nylon screws, bolts, and nuts on the clamps to break the circle.

Notes:

1. A weather-resistant junction box can be used to hold the excess fiber cable.
2. These are example installations only. Not all parts are available from Symmetricom.

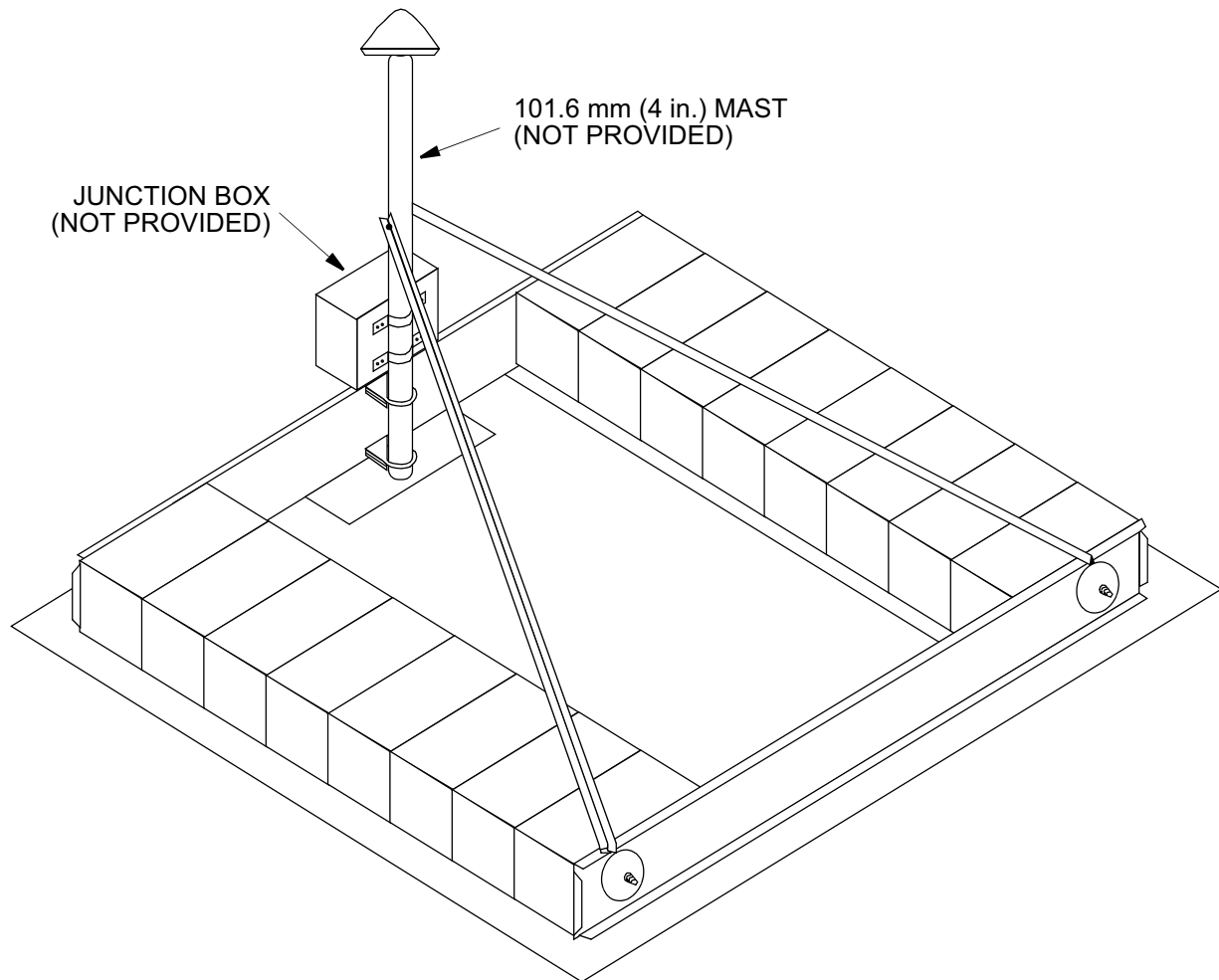
Figure 26. Basic GTR Mountings (Single Lightning Protector)



Notes:

1. A weather-resistant junction box can be used to hold the excess fiber cable.
2. These are example installations only. Not all parts are available from Symmetricom.

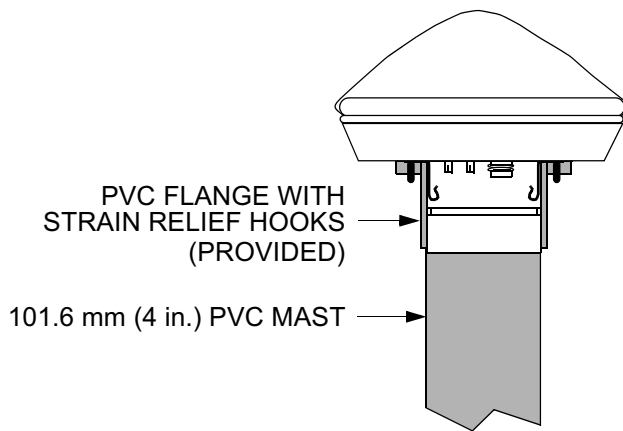
Figure 27. Basic GTR Mountings (Dual Lightning Protectors)



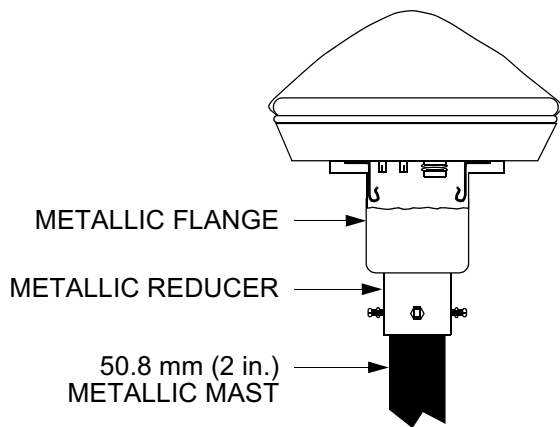
Notes:

1. This is an example configuration only; the Prodelin part number for the platform shown is 0800-182. The actual installation may have to be modified from that shown. Consult Prodelin Corp. for available configurations.
2. A 101.6 mm (4 in.) mast is shown in this figure; a 73.2 mm (2.88 in.) mast is provided by Prodelin Corp. and must be adapted to fit the 101.6 mm (4 in.) flange provided by Symmetricom; a 101.6 mm to 73.2 mm (4 in. to 2.88 in.) mast adaptor is available from Prodelin (p/n 0800-101).

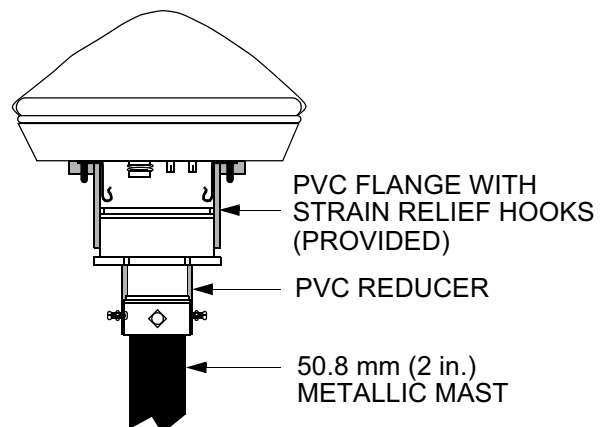
Figure 28. Prodelin Corp. Rectangular Block Mast Mount



A. PVC flange with 101.6 mm (4 in.) PVC mast
(Preferred configuration)



B. Metal flange with
50.8 mm (2 in.) metal mast



C. PVC flange with
50.8 mm (2 in.) metal mast

Note: These are examples only. Not all parts are available from Symmetricom.

Figure 29. Examples of GTR Mast Configurations

- It is recommended that for fiber optic cable slack, a weather-resistant junction box be installed as required. The weather-resistant junction box should be large enough to hold the excess fiber cable. Within the junction box, attempt to provide sufficient cable slack without coiling the fiber cables.

Warning: Do not attempt to coil excess GTR power cable into the junction box. Failure to observe this caution may result in increased damage if a lightning strike occurs.

7. LORAN ANTENNA INSTALLATION CONSIDERATIONS

A. Cabling Considerations

7.01 The LORAN antenna uses twinax cables for all antenna-to-DCD-LPR connections. The maximum allowable cable distance between the antenna and the DCD-LPR is 1,219 meters (4,000 feet).

7.02 The twinax cable between the LORAN antenna and the lightning protector is to be contained in weather-resistant conduit, regardless of whether or not the mast is mounted directly to the rooftop, or when a cable run outside the building exists.

7.03 Cables must be run as straight as possible; avoid 90 degree turns and *do not loop* the wire. All bends must be 90 degrees or greater with a minimum bending radius of eight inches. All cables should be run in accordance with company practices.

B. Cabling Material

7.04 The following cable materials are required for installation:

- Twinax cable, RG-108A (or equivalent) as a plenum-rated or Riser-rated cable (Symmetricom offers the cable [plenum-rated] p/n 060-45130-xx only in 30 meter [100 foot] increments up to 305 meters [1,000 feet]; Belden offers plenum-rated or Riser-rated cables p/n #9272 or #89272). This cable will be separated into sections for installation per the following:

If installing Type 1 lightning protectors:

- One cable must have a TROMPETER TWINAX BNC connector plug #PL30-55 (or equivalent) on one end, and 6.4 mm (0.25 inch) wide spade lug connectors to fit 1.02 mm (18 AWG) wire and connect to a #6 stud on the other end with the shield cut off and taped back per company practice; this cable is used to connect the lightning protector (inside lightning protector if using the dual lightning protector scheme) and the DCD-LPR Shelf.
- For single lightning protector schemes, one cable must have a TROMPETER TWINAX BNC connector plug #PL30-55 (or equivalent) on both ends to connect the lightning protector to the antenna; for dual lightning protec-

tor schemes, two cables must have TROMPETER TWINAX BNC connector plugs #PL30-55 (or equivalent) on both ends to connect the outside lightning protector to the antenna, and to connect the inside and outside lightning protectors.

If installing Type 2 lightning protectors:

- For single lightning protector schemes, one cable must have spade lug connectors on both ends for connection between the inside lightning protector and the DCD-LPR Shelf; for dual lightning protector schemes, two cables must have spade lug connectors on both ends for connection between the inside and outside lightning protector, and between the inside lightning protector and the DCD-LPR Shelf. In either scheme, the end of the cable which connects to the DCD-LPR Shelf must have the shield cut off and taped back per local company practice.
- One cable must have a TROMPETER TWINAX BNC connector plug #PL30-55 (or equivalent) on one end, and 6.4 mm (0.25 inch) wide spade lug connectors to fit 1.02 mm (18 AWG) wire and connect to a #6 stud on the other end; this cable is used to connect the lightning protector (outside lightning protector if using the dual lightning protector scheme) and the antenna.
- Soldering iron, solder, and a 1.1 mm (0.4375 inch [7/16 inch]) open-ended wrench for attaching twinax connectors
- Weather-resistant conduit, metal or PVC; it is recommended that a minimum 5.08 mm (2 inch) rigid UL listed #651 PVC conduit (minimum-Schedule 40) be used if PVC is chosen for cable runs
- 4.115 mm [6 AWG] grounding wires (or larger for longer runs)
- Expansion joint sleeves to prevent breaks in the conduit due to expansions and contractions

Note: If metal conduit is used, conduit joints must be bonded and, at minimum, both ends of the conduit run must be connected to building structural ground via the ring ground, metal conduits, air conditioning ducts, etc. It

is recommended that an intermediate point along the conduit be also grounded.

C. Location and Mounting

Warning: Do not select an antenna location that could be an electrical or physical hazard to workpersons or equipment. Avoid proximity to all high-voltage sources. Mount in an easily maintainable location.

Location

7.05 A major consideration when determining the most appropriate location for the LORAN antenna is interference to the LORAN-C signal. Generally, interference to the LORAN-C signal is in the form of atmospheric noise, such as lightning and severe meteorological conditions. These are generally rare events. As long as the DCD-LPR is receiving a signal from a station within 1,609 km (1,000 miles), these natural conditions will have little effect on signal reception.

7.06 It is recommended that a site survey be performed to determine the best location for the LORAN antenna, and determine what materials are needed. While performing the site survey, keep in mind the selection of possible mounting locations in relation to the cable entry point in the building and accessibility.

7.07 A rooftop where there is access to outside building (ring) ground is recommended for the antenna mounting. The antenna should not be located on the highest point of a building.

7.08 To perform a site survey, complete the following:

1. Determine a location and mounting position for the LORAN antenna which meets the following guidelines to help minimize interference:
 - Ensure that the LORAN antenna is at least 6 meters (20 feet) from any high energy source, such as a two-way transmitter or cellular-radio antenna.

- It is recommended that the antenna not be placed under, or at a distance less than 15 meters (50 feet) from, high-voltage power lines for the following reasons:
 - Corona effects caused by static discharge
 - Anomalous antenna effects (power line acts like an antenna)
 - Ensure that there is a minimum horizontal separation two to three times the height of the high-voltage power line above earth between the antenna and high-voltage power lines.
 - Metallic shielded wires (e.g., fiber optic cable with steel strengthener lines) should be avoided to prevent anomalous antenna effects.
 - The antenna should be separated from any metallic structure, or, if mounting to a building's exterior surface, by at least 1.8 meters (6 feet) of free air space in all directions to minimize interference. Ideally, the antenna should be mounted in a location such that no metallic objects or other antennas are in the antenna's "cone of influence." The cone of influence originates at the base of the antenna, and emanates outward and upward at a 45 degree angle to the antenna (Figure 30).
 - Unlike higher-frequency radio reception, LORAN-C does not require line-of-sight communication, and can be located in valleys or between tall buildings.
 - If mounting to a building's exterior surface, provide a minimum distance from all internal building steel to prevent antenna loading.
 - Do not have "metal" (air conditioning units, air ducts, antenna-tower structures, building steel, etc.) between the antenna and the desired stations.
 - Select an antenna location that will provide free reception to at least two LORAN-C stations.
2. Check and record where and how the antenna is to be mounted (Figure 31 illustrates several mounting positions).

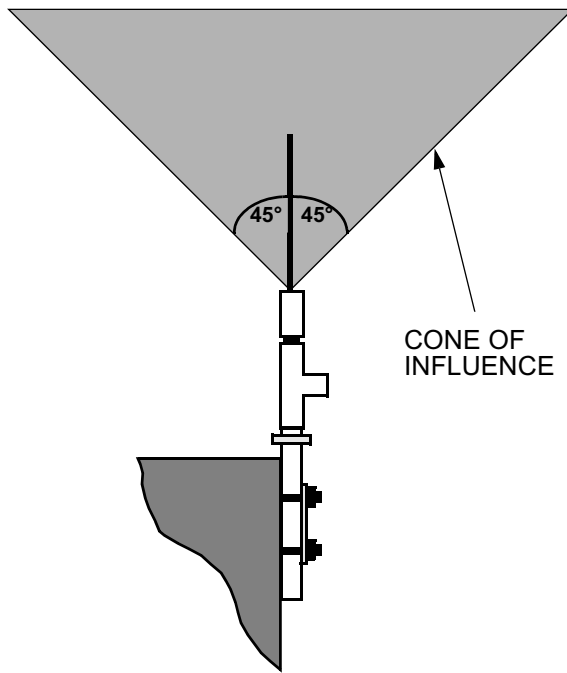


Figure 30. LORAN Antenna's Cone of Influence

3. From the information obtained in Step 2, determine the type of mounting hardware needed (e.g., 1.9 mm (0.75 inch) U-bolts or masonry bolts, Romex-type plug, etc.).
4. Determine the location of the following:
 - DCD-LPR Shelf
 - Lightning protector(s)
 - Grounding points for the lightning protector(s) and DCD-LPR Shelf (per the guidelines set previously)
5. Determine the cable length needed for single lightning protector installations, for the following:
 - Distance between the antenna and lightning protector

- Distance between the lightning protector and DCD-LPR Shelf
 - Distance between the lightning protector and CO protective ground (grounding wire)
6. Determine the cable length needed for dual lightning protector installations, for the following:
 - Distance between the antenna and outside lightning protector
 - Distance between the outside and inside lightning protectors
 - Distance between the lightning protector and building ground (grounding wire)
 - Distance between the inside lightning protector and DCD-LPR Shelf
 7. For conduit length (for cable runs), determine the distance between the LORAN-C antenna and the cable entry point.

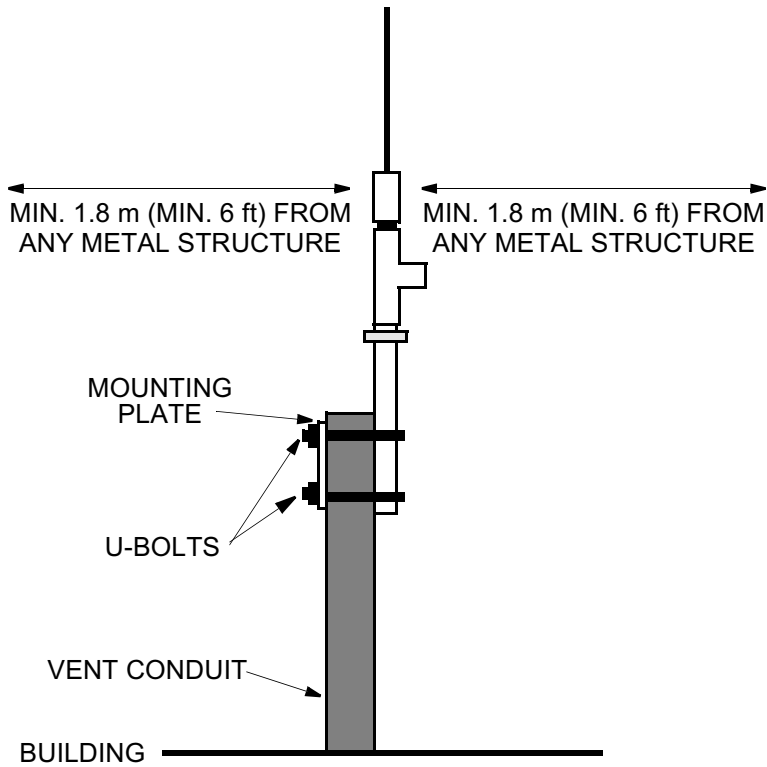
Mounting

7.09 Choices for rooftop mounting depend on the availability of suitable mounting locations, such as: a vent conduit, an existing radio tower, a building parapet, the side of a radio hut, or a similar structure. Figure 31 illustrates some basic mounting arrangements.

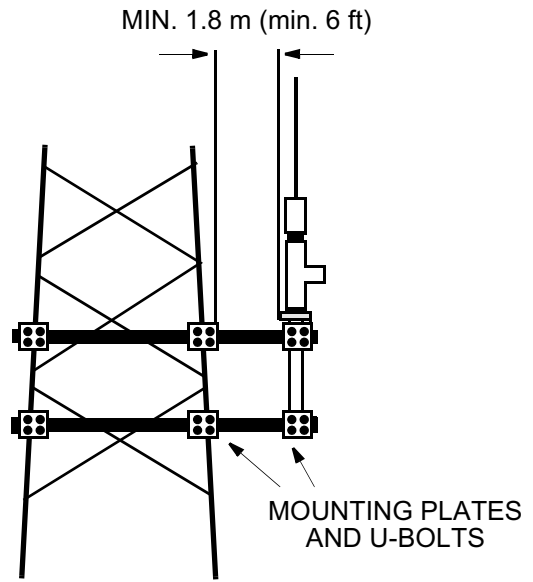
Note: A rooftop mounting platform is available from Prodelin Corp. (Figure 28). Contact Prodelin Corp. (1-704-464-4141) for additional information; reference the Rectangular Block Mast Mount, p/n 0800-182.

7.10 When mounting the LORAN antenna, also observe the following guidelines:

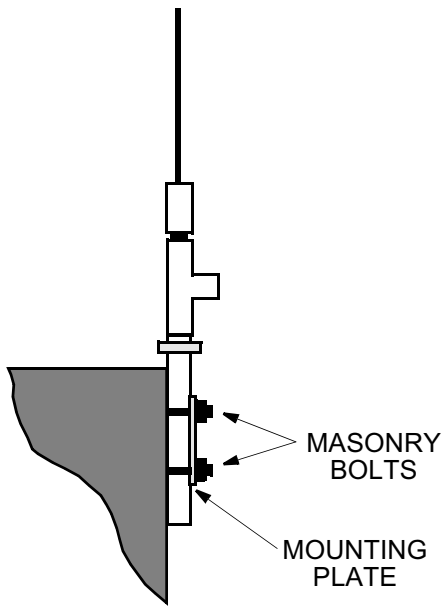
- For mounting the antenna, a 5.1 mm (2 inch) PVC or metal conduit can be used for the mast. If PVC is used, rigid UL listed #651 PVC conduit (minimum Schedule 40) is recommended.



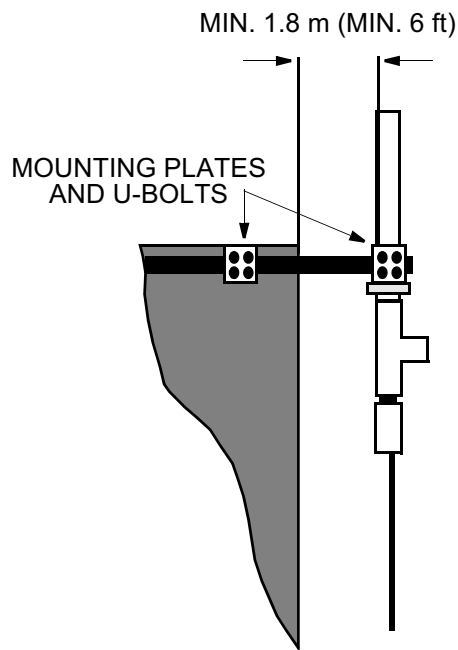
A. Mounting to a Vent Conduit



B. Mounting to a Tower



C. Mounting to a Side of a Building or Parapet (Antenna Above the Building)



D. Mounting to a Side of a Building or Parapet (Antenna Below the Building Roof)

Note: These are example installations only. Not all parts are available from Symmetricom.

Figure 31. Basic LORAN Antenna Mounting Arrangements

Note: If PVC is used, the Schedule type used and the diameter of the mast (10 mm or 5.1 mm [4 inches or 2 inches]) depends on the conditions at each installation site. If the installation site is a high-wind location, it may be advantageous to use 10 mm (4 inch) Schedule 80 conduit. If in a low-wind location, the mast is under 1.2 meters (4 feet), and guy wires are used to stabilize the mast, 5.1 mm (2 inches) Schedule 40 may suffice. Contact Symmetricom CTAC for assistance in determining the Schedule type and mast diameter best suited for your location.

Note: If metal is used, do not connect it to outside building (ring) ground or building steel unless metal conduit is also used.

- Mount the antenna in a location with easy access for future maintenance purposes.
- All openings around the conduit hub/nonconductive conduit connection and where the conduit enters the building must be waterproofed per local company practices.
- It is recommended that all exposed connections be treated with an electrically conductive anti-corrosion compound (Kopr-Shield or equivalent).
- When selecting a cable entry location, as well as a location to mount the lightning protectors, consider the grounding connections for the lightning protectors. The grounding connections on the lightning protectors must be as short and straight as possible in accordance with local company practice, and not near any other equipment. This connection may have to carry large currents in the event of a lightning strike.
- It is recommended that for cable slack, a weather-resistant junction box be installed as required. The weather-resistant junction box should be large enough to hold excess cable. Within the junction box, attempt to provide sufficient cable slack without coiling the power/antenna cables.

8. DCD-LPR SHELF INSTALLATION CONSIDERATIONS

ST2E/ST3E Card Installation

8.01 If using a rubidium/quartz clock combination (i.e., TNC-E and TNC, TNC-E and ST3E, ST2E and ST3E) in the DCD Shelf, ensure that the rubidium clock card is installed and its ACTIVE lamp lit prior to installing the quartz clock card. Failure to allow the rubidium clock card to become active before installing the quartz clock card may prevent the GTI from attaining GTI LOCK.

Isolation Module Cabling

8.02 Depending on the version of DCD-LPR Shelf and the revision of DCD Shelf used, an isolation module must be used. The isolation module is used to reduce potential noise coupling, and match impedances in the cables between the DCD master shelf and DCD-LPR. It also converts the 5 MHz output from a square wave to a sine wave. One module is required for each input required.

8.03 If connecting the DCD-LPR to one of the following DCD master shelves, an isolation module must be used:

- DCD-523 Rev. D or earlier
- All DCD-519s and DCD-ST2
- DCD-419 Rev. D or later

Note: The Revision letter of the DCD Shelf is located on the right rear outside sheet metal shelf with the part number and serial number. This information may be stamped directly on the sheet metal or on a large white label.

Note: DCD-400, DCD-CIM, and DCD-419 Rev. C and earlier do not have 5 MHz output connectors.

8.04 If connecting the DCD-LPR to the DCD-523, Rev. E or later shelf, an isolation module is not required. The isolators are built into the shelf, and the uncorrected raw rubidium from the ST A and ST B sources is fed directly to the DCD-LPR via the OSC A (J11) and OSC B (J12) connectors on the DCD-LPR Shelf backplane.

8.05 When required, the external isolation module is installed between the DCD-LPR Shelf and the DCD master shelf. To connect between the module and the DCD Shelf, two 0.6 meter (2 foot) long RG-59, 75 ohm coax cables are provided.

Note: Depending on the isolation module type, the 0.6 meter (2 foot) 75 ohm coax cable(s) may or may not be shipped already attached to the DCD side of the module.

8.06 For the connection between the DCD-LPR Shelf and the module, use the two 1.8 meter (6 foot) lengths of RG-59, 75 ohm coax cables (provided with the DCD-LPR Shelf). If the DCD-LPR Shelf is not collocated with the DCD Shelf, and longer cables are required, these must not exceed 15 meters (50 feet), and must be user-supplied.

Note: The isolation module(s) must be mounted on the rack next to the DCD Shelf, regardless of whether the DCD-LPR is installed in a collocated or non-collocated location from the DCD Shelf. Attaching the isolation module (to the rack) grounds the module to rack frame ground.

Ground and Power Cabling

8.07 For grounding and power, the following must be user-provided:

- 1.47 mm (16 AWG) stranded wire (red) to run from a battery source to the DCD-LPR Shelf
- 1.47 mm (16 AWG) stranded wire (black) to run from a battery return source to the DCD-LPR Shelf
- 1.47 mm (16 AWG) stranded wire (green) to run from the frame ground to frame ground on the DCD-LPR

Output Cabling

8.08 Twisted pair cable (100 Ω characteristic impedance), 0.644 mm (22 AWG) solid tinned copper conductors, solid shielded, for output connections from the DCD-LPR Shelf to the DCD Shelf, are user-provided.

Alarm and Status Cabling

8.09 Alarm and status information to the DCD Shelf through the MIS card is carried via the factory-provided 20-lead flat ribbon cable, p/n 060-40004-04; the distance between the DCD-LPR Shelf and the DCD Shelf should not exceed 1.5 meters (5 feet).

Note: Alarm and status information to the DCD Shelf requires an MIS^{V5} or MIS^{V4} card be installed in the master shelf.

5 MHz Cabling

8.10 Use 90 degree elbows to make the connections between DCD-LPR and the output connectors on the DCD Shelf (DCD-ST2, 5 MHZ OUTPUT A and B; DCD-419, J35 and J36 [SMB connectors]; DCD-523, OSC A and B OUT; DCD-519, OSC A and B OUT). Without the elbows, regular cabling exceeds the maximum allowable depth for the shelf, and the clear plastic backplane cover cannot be installed. Four 90 degree BNC elbows are factory-provided.

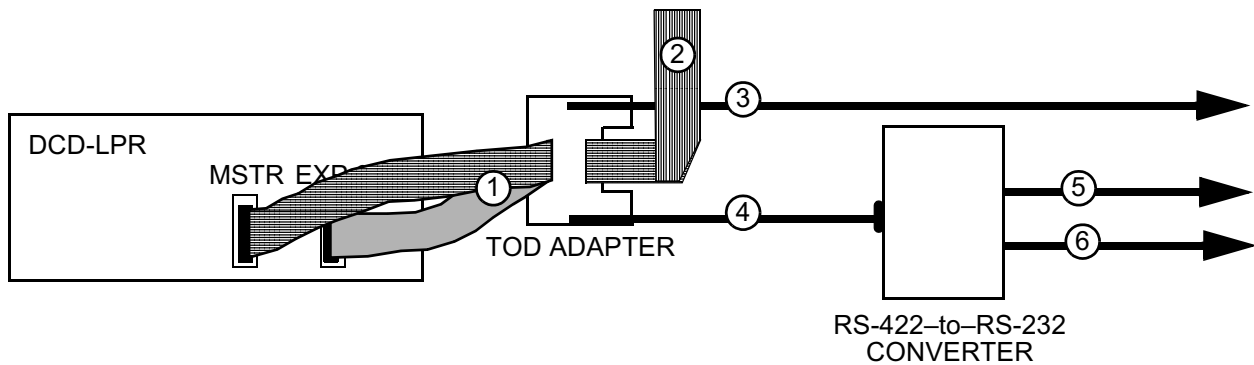
Time-of-Day Cabling

8.11 If configuring the DCD-LPR Shelf for Time-of-Day applications a TOD Adapter Kit, p/n 990-42181-01 (includes RS-422/RS-232 converter, p/n 090-42182-01) must be ordered as a separate line item (see Figure 32 for cabling). Any of the following combinations are possible:

- One GTI card with or without an RS-422-to-RS-232 converter
- Two GTI cards with or without RS-422-to-RS-232 converters
- One GTI card with an RS-422-to-RS-232 converter and one GTI card without an RS-422-to-RS-232 converter

Thermal Insulator

8.12 In DCD Systems equipped with ST3E or TNC cards (and a GTI-13, -14, -15, -16, -17, or -18 card in the DCD-LPR), a thermal insulator must be installed on the oscillator of the ST3E or TNC card, to better regulate the oscillator temperature. The thermal insulator is included in the GTR hardware kit. For information on the insulator, refer to the instructions in the Thermal Insulator Installation kit.



- ① Factory-provided 3-conductor ribbon cable (p/n 060-42181-01).
- ② Factory-provided (with MIS card) flat 20-pin ribbon cable for connection to the LPRS connector on the DCD Shelf (p/n 060-40004-04). *To be used with the MIS^{V5} or MIS^{V4} card.*
- ③ User-provided 0.511 mm (24 AWG) 3 twisted-pair shielded cable (Belden 9680 or equivalent) with a DB9 male connector to provide one RS-422 signal; one cable per GTI card.
- ④ User-provided 0.511 mm (24 AWG) 3 twisted-pair shielded cable (Belden 9680 or equivalent) with DB9 (male) to DB9 (female) connectors (maximum 15 m [maximum 50 ft] if using 1 pps, if not, maximum 305 m [maximum 1,000 ft]); one cable per GTI card.
- ⑤ User-provided standard data cable with a DB25 male connector for to provide one RS-232 signal; one cable required for each GTI card installed.
- ⑥ User-provided coaxial cable with a BNC connector to provide 1 pps TTL output.

Figure 32. GPS Time-of-Day Cabling

9. INDEX**A**

AIS signal 3
 Antenna assembly, GTR 24
 Antenna ground terminal cables 14
 Antenna system, GPS 14
 Antenna, GTR 25
 Antenna, LORAN 39, 40, 41
 Antenna, LORAN-C 41
 Applications, Time-of-Day 44

B

Backplane, DCD-LPR 17
 Backplane, DCD-LPR Shelf 43
 Bonding Bus, Ring 17
 Bonding bus, ring 17

C

Card, DCIM-EA 9
 Card, DCIM-T 9
 Card, EA10M 9
 Card, GTI 3, 6, 12, 25, 44
 Card, GTI-11 6, 7
 Card, GTI-12 7
 Card, GTI-13 6, 7, 44
 Card, GTI-14 7, 44
 Card, GTI-15 6, 7, 44
 Card, GTI-16 7, 44
 Card, GTI-17 6, 7, 44
 Card, GTI-18 6, 7, 44
 Card, LOU 3, 12
 Card, LOU-1 7, 9
 Card, LOU-2 7, 9
 Card, LTI 3, 4, 6
 Card, MCA-5M 9
 Card, MIS 44
 Card, ST2E 2, 43
 Card, ST3E 43, 44
 Card, TNC 43, 44
 Card, TNC-E 2, 43
 Card, TOTA-M 9
 Cards, clock 2
 Cards, GTI 3, 7, 44
 Cards, LTI 3
 Cards, ST2 2
 Cards, ST2E 2
 Cards, ST3E 2, 44
 Cards, TNC 2
 Cards, TNC-E 2
 Cesium clocks 4
 Clock card, quartz 43
 Clock card, rubidium 43
 Clock cards 2

Clock cards, quartz 2
 Clock cards, rubidium 2
 Clock cards, ST2E 2
 Clock cards, TNC-E 2
 Clocks, cesium 4
 Clocks, DCD 29
 CO ground bar 32
 Commands, TL1 12
 Configurations, DCD-LPR 12

D

Data, isoceraunic 14
 Daughterboard, GTR power supply 25
 DCD clocks 29
 DCD master shelf 43, 44
 DCD Shelf 2, 3, 4, 43, 44
 DCD System 2, 3, 9, 12
 DCD Systems 44
 DCD-LPR backplane 17
 DCD-LPR configurations 12
 DCD-LPR Shelf 3, 6, 12, 14, 15, 17, 24, 25, 32, 34, 39, 41, 43, 44
 DCD-LPR shelf 3
 DCD-LPR Shelf backplane 43
 DCD-LPR System 3, 6
 DCD-LPR/C System 3
 DCIM-EA card 9
 DCIM-T card 9
 Direct line-of-sight timing signals 3
 Discharge, lightning 16, 17
 Dual lightning protection scheme 16
 Dual lightning protector 25
 Dual lightning protector installations 34, 41
 Dual lightning protector scheme 15, 16, 39
 Dual lightning protector schemes 39

E

EA10M card 9
 Earth ground 18

F

Flash, lightning 14
 Flashes, lightning 14
 Frame ground 17

G

GPS antenna system 14
 Ground bar, CO 32
 Ground point, lightning protector 14
 Ground system, roof ring 16
 Ground terminal cable, lightning protector 14
 Ground, Earth 18
 Ground, Frame 17
 Ground, Protection 17

Ground, ring 39
 Grounding 15, 16
 grounding 17
 Central Office 17
 principles of 15, 16
 Grounding points 32
 GTI card 3, 6, 12, 25, 44
 GTI cards 3, 7, 44
 GTI-11 card 6, 7
 GTI-12 card 7
 GTI-13 card 6, 7, 44
 GTI-14 card 7, 44
 GTI-15 card 6, 7, 44
 GTI-16 card 7, 44
 GTI-17 card 6, 7, 44
 GTI-18 card 6, 7, 44
 GTR antenna 25
 GTR antenna assembly 24
 GTR hardware kit 44
 GTR power supply daughterboard 25

H

Hardware kit, GTR 44

I

Inside and outside lightning protectors 32
 Inside lightning protector 14, 15, 16, 17, 24, 25, 34, 39, 41
 installation 24
 antenna 24
 Installation kit, Thermal Insulator 44
 Installations, dual lightning protector 34
 Installations, single lightning protector 32
 Isoceraunic data 14

L

Lightning discharge 16, 17
 Lightning flash 14
 Lightning flashes 14
 Lightning protection 14
 Lightning protection scheme 24
 Lightning protection scheme, dual 16
 Lightning protection schemes, single 24
 Lightning protection system 14
 Lightning protector 14, 15, 16, 24, 32, 34, 39, 41
 lightning protector 17
 Lightning protector ground point 14
 Lightning protector ground terminal cable 14
 Lightning protector ground terminal cables 14
 Lightning protector installations, dual 41
 Lightning protector mounting site 14
 Lightning protector placement and grounding 14
 Lightning protector scheme, dual 15, 16, 39
 Lightning protector scheme, single 15, 16

Lightning protector schemes, dual 39
 Lightning protector schemes, single 39
 Lightning protector(s) 24, 25, 41
 Lightning protector, dual 25
 Lightning protector, inside 14, 15, 16, 17, 24, 25, 34, 39, 41
 Lightning protector, outside 14, 15, 16, 17, 24, 25, 34, 39, 41
 Lightning protector, single 25
 Lightning protectors 16, 26, 32, 34, 43
 Lightning protectors, inside and outside 32
 Lightning protectors, Type 1 39
 Lightning protectors, Type 2 39
 Lightning strike 15, 34, 43
 Lightning strikes 15, 16
 LORAN antenna 39, 40, 41
 LORAN-C antenna 41
 LOU card 3, 12
 LOU-1 Card 9
 LOU-1 card 7
 LOU-2 Card 9
 LOU-2 card 7
 LTI card 3, 4, 6
 LTI cards 3

M

Master shelf, DCD 43, 44
 MCA-5M card 9
 MIS card 44
 Mounting site, lightning protector 14

O

Office 19
 Oscillator, rubidium 4
 Outside lightning protector 14, 15, 16, 17, 24, 25, 34, 39, 41

P

Placement and grounding, lightning protector placement 14
 Points, grounding 32
 Protection Ground 17
 Protection ground 17
 Protection scheme, lightning 24
 Protection system, lightning 14
 Protection, lightning 14
 Protector(s), lightning 24, 25, 41
 Protector, lightning 14, 15, 16, 24, 32, 34, 39, 41
 Protectors, lightning 16, 26, 32, 34, 43
 PRS signal 4

Q

Quartz clock card 43
 Quartz clock cards 2

Quartz source 4

R

Ring Bonding Bus 17
Ring bonding bus 17
Ring ground 39
Roof ring ground system 16
Rubidium clock card 43
Rubidium clock cards 2
Rubidium oscillator 4
Rubidium source 4

S

Shelf, DCD 2, 3, 4, 43, 44
Shelf, DCD-LPR 3, 6, 12, 14, 15, 17, 24, 25, 32, 34, 39,
41, 43, 44
Shelf,DCD-LPR 15
Signal, AIS 3
Signal, PRS 4
Single lightning protection schemes 24
Single lightning protector 25
Single lightning protector installations 32
Single lightning protector scheme 15, 16
Single lightning protector schemes 39
Source, quartz 4
Source, rubidium 4
ST2 cards 2
ST2E card 2, 43

ST2E cards 2
ST2E clock cards 2
ST3E card 43, 44
ST3E cards 2, 44
Strike, lightning 15, 34, 43
Strikes, lightning 15, 16
System, DCD 2, 3, 9, 12
System, DCD-LPR 3, 6
System, DCD-LPR/C 3
Systems, DCD 44

T

Terminal cables, antenna ground 14
Terminal cables, lightning protector ground 14
Thermal Insulator Installation kit 44
Time-of-Day applications 44
Timing signals, direct line-of-sight 3
TL1 commands 12
TNC card 43, 44
TNC cards 2
TNC-E card 2, 43
TNC-E cards 2
TNC-E clock cards 2
TOTA-M card 9
Type 1 lightning protectors 39
Type 2 lightning protectors 39