



Harmonix GigaLINK™

Installation and Operating Manual

Version 1.1; May 22, 2000

THIS DEVICE COMPLIES WITH PART 15 OF THE FCC RULES. OPERATION IS SUBJECT TO THE FOLLOWING TWO CONDITIONS. (1) THIS DEVICE MAY NOT CAUSE HARMFUL INTERFERENCE, AND (2) THIS DEVICE MUST ACCEPT ANY INTERFERENCE RECEIVED, INCLUDING INTERFERENCE THAT MAY CAUSE UNDESIRE OPERATION.

FCCID # XXXXXXXXXXXXXXX

Through the expenditure of substantial time, effort and money, Harmonix Corp. has developed and owns confidential and proprietary information relating to design and development of millimeter wave radio frequency products and signal processing techniques. This manual contains proprietary information granted to our customer only for the specific purposes of installing and operating our millimeter wave radio products. Any use or disclosure of the contained proprietary information for purposes other than that granted is strictly forbidden. All information contained within this document should be considered proprietary and confidential.

Harmonix Corp.
1755 Osgood St.
N. Andover, MA 01845
(978) 974 0931, (978) 974 0969 fax
www.hxi.com

GigaLINK Introduction and Overview:

Thank you for choosing the Harmonix GigaLINK radio system. You have selected the world's fastest commercially available radio system, thereby demonstrating a discerning grasp of the unique utility of our product.

The Harmonix GigaLINK™ millimeter wave radio system represents an entirely new approach to broadband communications. Based on our extensive experience with millimeter wave systems for military and research applications, we now apply these techniques to a commercially priced version with our ultra-broadband family of GigaLink™ radio products.

The Harmonix GigaLINK™ broadband radio systems operate in the newly allocated ISM band covering the frequency range of 59.05 – 64.0 GHz. Due to the unlicensed status of this band, no FCC license or special authorization is required to operate our GigaLINK™ systems. In addition, the high atmospheric absorption of RF energy at this frequency virtually eliminates any chance of interference from competing systems or unauthorized interception of the broadcast signal.

The installation procedures detailed within this guide are similar to those used to install any wireless system. In fact, certain attributes of the 59.05 – 64.0 GHz band actually simplify deployment. The key to any successful installation project is proper planning and design. The Harmonix GigaLINK radio product has been designed for ease of installation and trouble-free operation. We recommend that you read and fully understand this guide prior to initiating the actual installation work.

As stated above, the key to successful installation is proper system planning and execution. As with most wireless systems, the GigaLINK radio system requires unobstructed Line of Sight (LOS) to operate reliably. Because of the extremely high data bandwidth provided by the GigaLINK system (100Mbps, OC3 or OC12) it is likely that our radio systems will be utilized as a critical or primary network connection. This absolute reliance on our systems for connectivity demands a focused attention to detail in order to assure un-interrupted operation.

Each GigaLINK Radio system configuration is designed to provide a statistical availability of 99.99% for a specific path length. Failure to adhere to the recommend path limits will result in greatly reduced reliability and quality of service.

Please follow the installation guidelines contained within and contact Harmonix directly with any questions or problems. The staff at Harmonix Corp. is dedicated to providing our customers the maximum utility in performance, reliability and speed.

Harmonix Corp.
1755 Osgood St.
N. Andover, MA 01845
(978) 974 0931, (978) 974 0969 fax
www.hxi.com

Table of Contents:

<u>Section</u>	<u>Pages</u>
1. The Harmonix GigaLINK™ Product Family	
a.) Standard Model Description/Specifications	
b.) Standard Model Range Performance Envelope	
c.) Available Data protocols/Fiber Types/Termination Styles	
d.) FCC Part 15, unlicensed operation compliance Statement	
2. 60 GHz Millimeter Wave Signal Propagation Basics	
a.) Oxygen Absorption Spectrum	
b.) Standard Antenna Beamwidths	
3. GigaLINK™ System Basics	
4. GigaLINK Installation Procedure	
a.) Confirming un-obstructed Line of Sight	
b.) Path Engineering/Fade Margin Budgeting	
c.) Selecting proper terminal locations	
d.) Selecting terminal mounting technique	
e.) Mechanical installation	
f.) Electrical and Network Services	
5.) RF Terminal Alignment	
6.) Network Connection	
7.) Troubleshooting and Terminal Maintenance	
8.) Harmonix Standard Warranty / Replacement Policy	

Section 1: The Harmonix GigaLINK™ Product family

The Harmonix GigaLINK product is offered in various configurations for optimum performance for each specific application. Models are offered for 3 different data protocols (100Mbps FX, OC3 and OC12) and with different antenna configuration for reliable performance on varying range RF paths.

Standard GigaLINK™ Product Summary

Data Rate (XXX) –Range Meters (XXXX) – Fiber Type (XX)

Model No.	Protocol	Range (M)	Antenna	Fiber	Termination*
100-0400-MM	100Mbps FX	400	Patch	Multimode	SC
100-0800-MM	100Mbps FX	800	13" Parabola	Multimode	SC
100-1200-MM	100Mbps FX	1,200	13" Parabola	Multimode	SC
155-0400-MM	OC3 (155Mbps)	400	Patch	Multimode	SC
155-0800-MM	OC3 (155Mbps)	800	13" Parabola	Multimode	SC
155-1200-MM	OC3 (155Mbps)	1,200	13" Parabola	Multimode	SC
155-0400-SM	OC3 (155Mbps)	400	Patch	Single-mode	SC
155-0800-SM	OC3 (155Mbps)	800	13" Parabola	Single-mode	SC
155-1200-SM	OC3 (155Mbps)	1,200	13" Parabola	Single-mode	SC
622-0200-SM	OC12 (622Mbps)	200	Patch	Single-mode	SC
622-0400-SM	OC12 (622Mbps)	400	13" Parabola	Single-mode	SC
622-0800-SM	OC12 (622Mbps)	800	13" Parabola	Single-mode	SC

* Other fiber termination styles available upon special request

Harmonix Corp.
 1755 Osgood St.
 N. Andover, MA 01845
 (978) 974 0931, (978) 974 0969 fax
 www.hxi.com

Harmonix GigaLINK Standard Model Range Performance Envelopes

<u>Model No.</u>	<u>Maximum RF Path</u>
100-0400-MM	400 meters
100-0800-MM	800 meters
155-0400-MM	400 meters
155-0800-MM	800 meters
155-0400-SM	400 meters
155-0800-SM	800 meters
622-0200-SM	
622-0400-SM	200 meters
622-0800-SM	400 meters
	800 meters

Reliability Statement:

All Harmonix GigaLINK products are designed to provide a minimum statistical reliability of 99.99% ($BER < 1 \times 10^{-9}$) when operated within the recommended range envelope. Exceeding the specific model range restrictions will result in unreliable operation particularly during adverse weather.

Statistical availabilities in excess of 99.99% may be achieved by choosing the next longer range system for a given path or by co-locating two GigaLINK systems. Traditional circuit redundancy methods utilizing collapsible ring architectures or media diversity may also increase statistical availability.

Harmonix Corp.
1755 Osgood St.
N. Andover, MA 01845
(978) 974 0931, (978) 974 0969 fax
www.hxi.com

Available Data Protocols:

Standard Harmonix GigaLINK systems are available in the following popular telecommunication protocols and provide full duplex compliance with each. During operation the GigaLINK wireless segment mimics fiber connectivity for network devices.

100BaseFX - OC3 (155Mbps) - OC12 (622Mbps)

Because the Harmonix GigaLINK RF transmission and modulation technique are essentially protocol independent, other specialized protocols and custom data rates optimized for specific applications are available as special orders. Please contact Harmonix or your authorized Harmonix re-seller for details and pricing.

Fiber Optic Cable Types:

The Harmonix offers a variety of fiber optic interface types as standard products. GigaLINK radio systems designed for Multimode Fiber utilize LED sources to comply with Multimode Fiber provisions. Multimode fiber compatible products are available in OC3 and 100Base FX protocols.

GigaLINK single-mode fiber compatible systems utilize a laser source to provide the required level of optical signal. Single mode fiber is the standard of choice for GigaLINK OC12 due to the extremely high data rates. Harmonix also will provide OC3 GigaLINK terminals (suffix SM) optimized for single mode fiber.

Fiber Termination Styles:

All GigaLINK radio systems are configured for SC fiber interfaces in either single or multimode. Other termination styles are available as special orders. Please consult Harmonix or your authorized Harmonix re-seller for details and pricing.

FCC Compliance Statement:

The Harmonix GigaLINK™ family of products is type certified for unlicensed operation in compliance with FCC Part 15. Harmonix GigaLINK radio products are factory set for frequency, frequency stability and transmitter power levels. No user-authorized adjustments are provided. Tampering with or changing any radio operational parameters will void the factory warranty and is a direct violation of federal law.

For detailed information on GigaLINK Part 15 certification and rules governing Part 15 Unlicensed operation, please visit the Federal Communications Commission home page at;

<http://www.fcc.gov/oet/fccid/cert#>

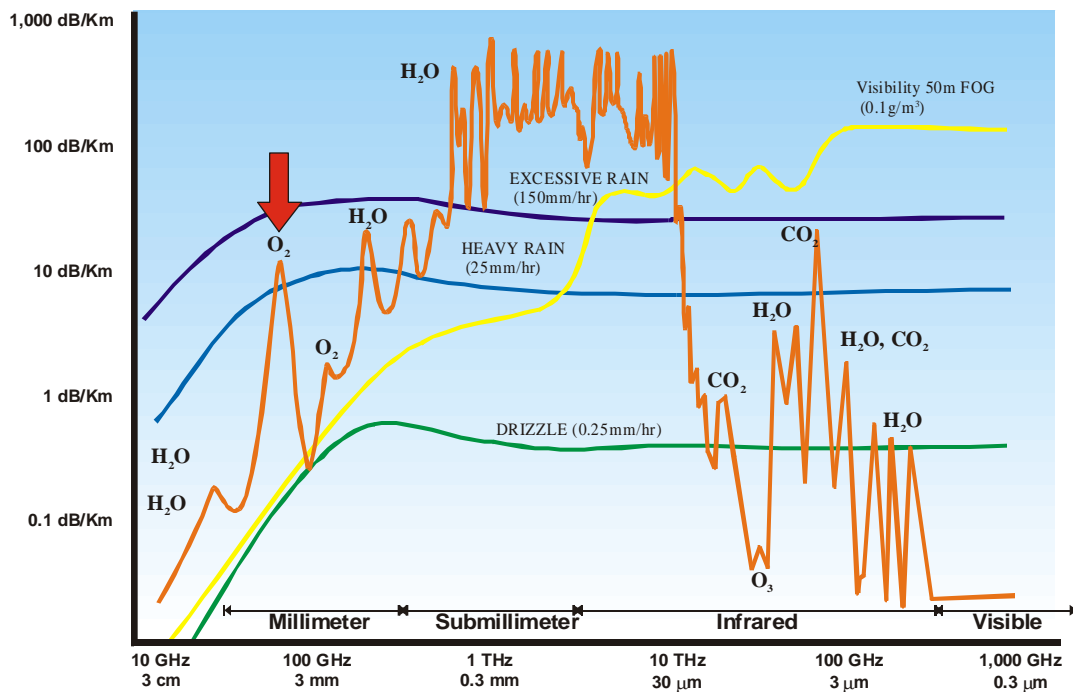
Harmonix Corp.
1755 Osgood St.
N. Andover, MA 01845
(978) 974 0931, (978) 974 0969 fax
www.hxi.com

Section 2

60GHz Millimeter Wave Signal Propagation Basics

Oxygen Absorption Spectrum: By far the most limiting factor for RF transmission in the new 59.05 to 64GHz ISM band is the effect of oxygen absorption on the transmitted signal. Figure 1; below, details the absorptive properties of atmospheric O_2 at a center frequency of 60GHz (indicated by the red arrow).

Fig. 1 Oxygen Absorption Properties



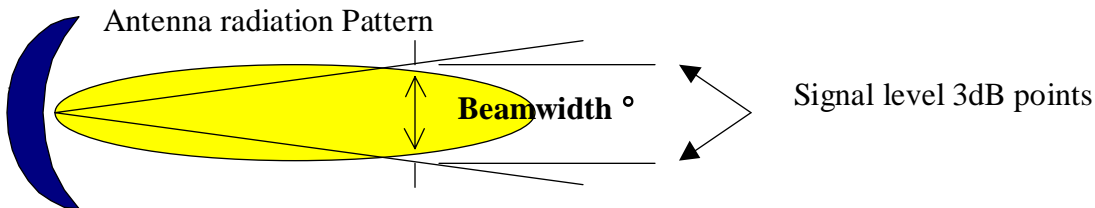
Fortunately, the atmospheric concentration of naturally occurring diatomic oxygen (O_2) is relatively constant and expected absorption can be modeled accurately. In addition, the absorptive properties of oxygen dramatically reduce the likelihood of converging interfering signals.

The effects of oxygen absorption, while a curse for those seeking long-distance transmissions, is a blessing for those seeking interference free wide-band RF connections up to 1 mile in range.

Harmonix Corp.
 1755 Osgood St.
 N. Andover, MA 01845
 (978) 974 0931, (978) 974 0969 fax
 www.hxi.com

Antenna Gain / Antenna Beamwidth:

To increase the level of RF energy available to the radio receiver, Harmonix employs high performance high gain (directivity) antennae specifically selected for a given range. The gain of an antenna is increased by focusing the RF energy into a more confined pattern beamwidth. The antenna beamwidth is defined in degrees of an arc between to end points where the signal level is half that at the center of the beam (-3dB).



The relationship between antenna gain and beamwidth for standard GigaLINK antenna configurations is detailed below.

<u>Configuration</u>	<u>Antenna Gain (dBi)</u>	<u>3dB Beamwidth</u>
Standard Patch	> 30dBi	3.5°
13" Parabola	> 38dBi	1.7°

As shown in the diagram above, as the distance from the transmitter increases the size of the 3dB radiation pattern increases as a factor of the beamwidth. The signal however, is attenuated quickly in free space predominately by the effects of oxygen absorption in the 59-64GHz ISM Band (16dB/KM).

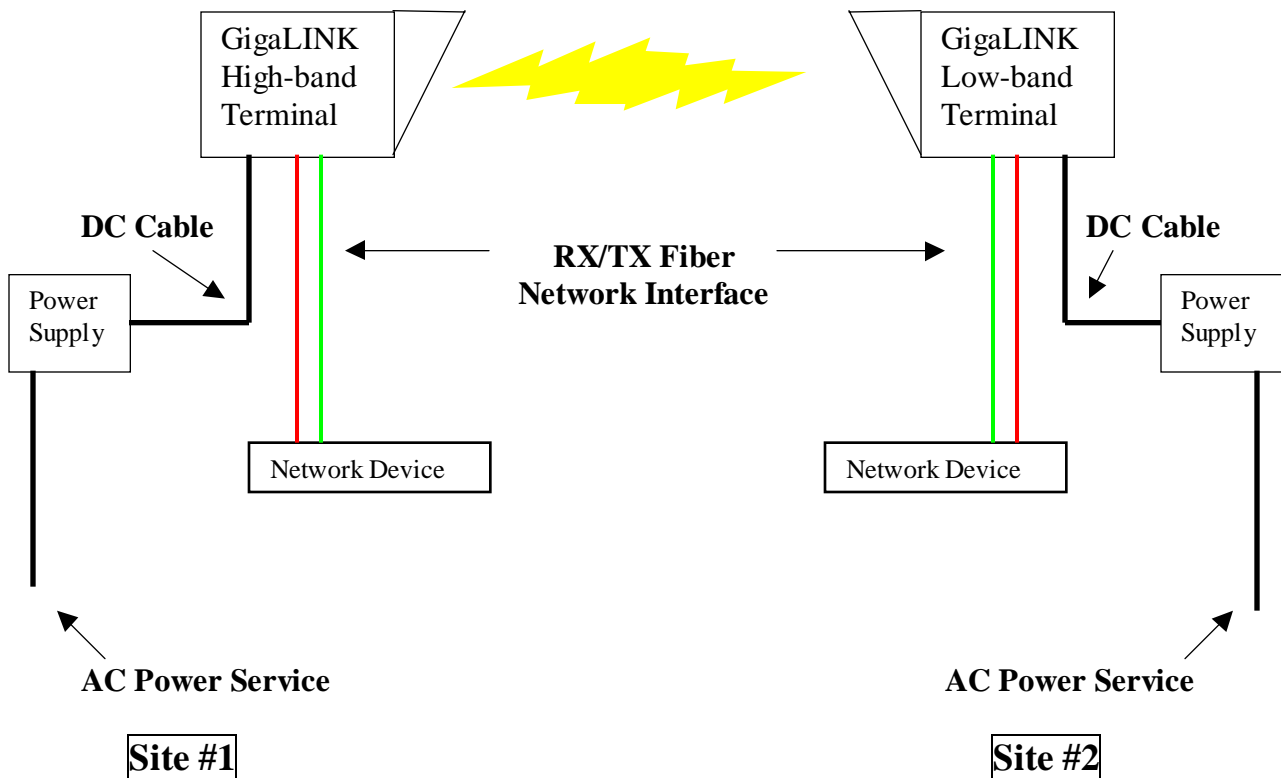
During terminal alignment, the challenge is to focus the transmitter as precisely as possible onto the center of the receiving antenna. The received signal strength drops by half between the center point of focus and the 3dB edges of the receive pattern "spot".

Section 3. GigaLINK System Basics

Both the transceiver terminals and power supply boxes provided with the GigaLINK system are fully self-contained and sealed. There are no field level repairs or adjustments authorized on these devices. Opening the housing of the radio terminal is a violation of non-disclosure policy, will void the equipment warranty and is a direct violation of FCC Part 15 regulations.

The Harmonix GigaLINK system is shipped as a complete kit with everything necessary to complete a successful installation. The certified installer must only obtain AC power and the required network fiber services terminated with the proper termination style. Standard mounting systems are provided based on the antenna configuration chosen for the specific path.

Installed GigaLINK System Block Diagram:



Harmonix Corp.
 1755 Osgood St.
 N. Andover, MA 01845
 (978) 974 0931, (978) 974 0969 fax
 www.hxi.com

GigaLINK System Installation Kit Component List

<u>Item</u>	<u>Description</u>	<u>Qty Supplied</u>	<u>Re-Order #</u>
1.	GigaLINK Radio Transceiver (High-band)	1	
2.	GigaLINK Radio Transceiver (Low-band)	1	
3.	GigaLINK DC Power Supply	2	
4.	Power Supply Cable Assy. (1.8m)	2	
5.	Fiber Loop-back Jumper	2	
6.	SMA AGC Monitor Pigtail	2	
7.	Pan & Tilt Terminal Mount	2	
8.	Pipe Mount Bracket with U-Bolts & hardware	2	
9.	Terminal Mount Hardware Kit (stainless)	2	
10.	GigaLINK Installation/Operation Manual	2	

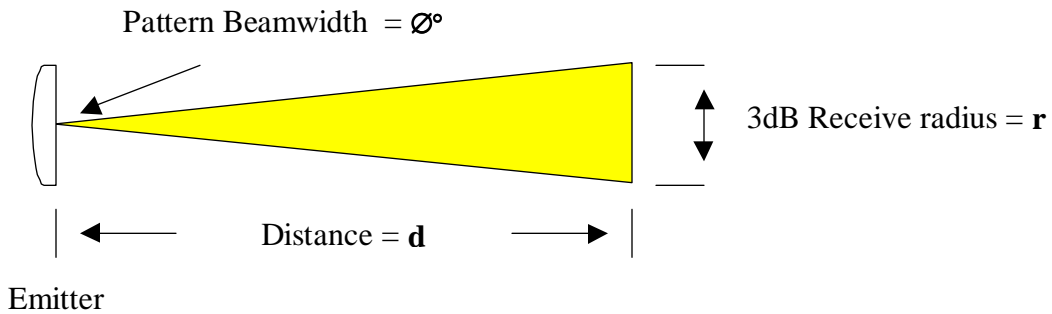
Insert Section for optional Installation Components

Section 4; GigaLINK Installation Procedure

Confirming Line of Sight (LOS)

Without exception all microwave and millimeter wave wireless systems require unobstructed “Line of Sight” to operate reliably. In most cases, LOS can be confirmed visually, particularly in the case of a short-range product like the Harmonix GigaLINK system where both ends of a proposed link should fall within visual range.

As noted in the previous section, the spot size of the 3dB antenna transmission pattern increases proportionately with range. Therefore, it is important to insure that the RF path is clear of obstructions for the entire 3dB beamwidth at any point along the transmission path. The diagram and formula shown below can be used to determine necessary clearance at any point along the RF path.

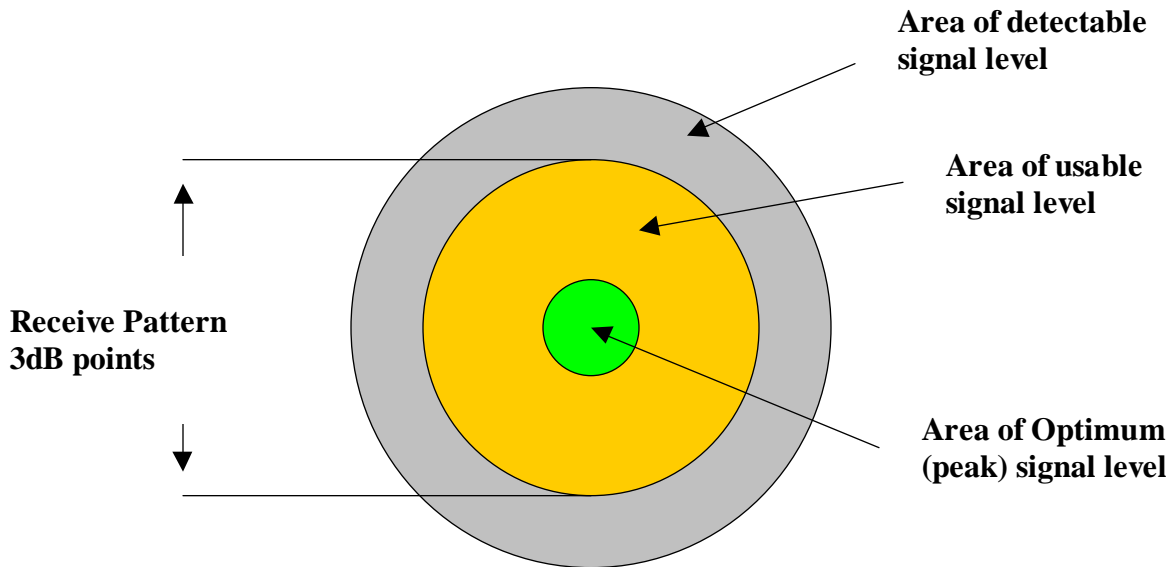


Where; $\tan \frac{\varnothing}{2} = r/d,$
 And $r = d * \tan \frac{\varnothing}{2}$
 And **(2) r = Receive Spot Diameter**

GigaLINK Receive Area at Maximum rated Ranges:

GigaLINK Antenna Style	Antenna Beamwidth	Distance (Meters)	Spot Diameter (Meters)	Spot Diameter (Feet)
Patch 30dBi	3.5°	400	24.44	80.19
13" Parabola 38dBi	1.7°	800	23.74	77.89

Relative Signal Strength Distribution of Circular Receive Area



Path Engineering/Fade Margin Budgeting:

Unlike traditional microwave and wireless systems, the Harmonix GigaLINK system is designed to provide 99.99% statistical availability when used within the maximum recommended range envelope. Therefore, no complex calculations to account for free space losses or rain fades are required. The maximum recommended range limits were calculated for a minimum fade margin of 10 dB under the worst rain conditions possible (25mm/hr.). In practice, except for ranges at the extreme limit of the envelope, actual fade margins will be higher.

The most critical factor in achieving the desired reliability level is precision of the antenna alignment during installation. Failure to align both terminals on the center (optimum) region of the receive area will greatly reduce the level of signal received and in turn the available fade margin. Likewise, if the GigaLINK terminals are not mounted securely enough, misalignment from terminal movement due to wind or vibration can also result in unreliable operation.

Harmonix Corp.
1755 Osgood St.
N. Andover, MA 01845
(978) 974 0931, (978) 974 0969 fax
www.hxi.com

Selecting GigaLINK™ Terminal Locations:

Several factors must be considered when selecting each GigaLINK terminal location. The ideal location for the GigaLINK terminals is one that provides un-obstructed Line of Sight and a stable/secure mechanical attachment point. In order of precedence primary considerations should include.

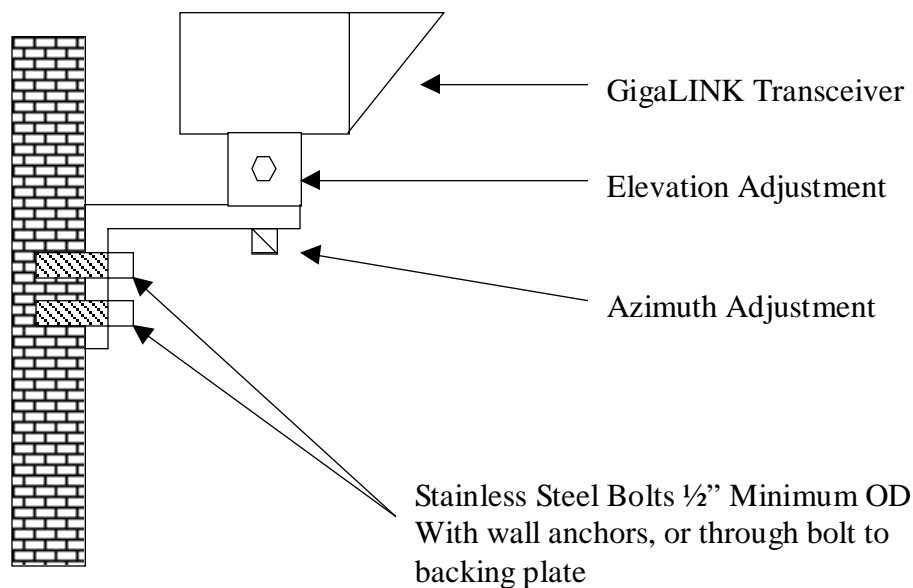
- Locations with unobstructed Line of Sight to target terminal
- Locations affording secure mechanical mounting provisions
- Locations isolated from sources of vibration
- Locations away from possible moving obstructions (workers, cranes etc.)
- Locations accessible to service personnel for maintenance
- Locations convenient to necessary power and network services.

Harmonix supplies several installation kits for a variety of mounting techniques. The best mounting location and attachment method should be determined prior to equipment order during a detailed site survey.

Selecting the Optimum Terminal Mounting Method:

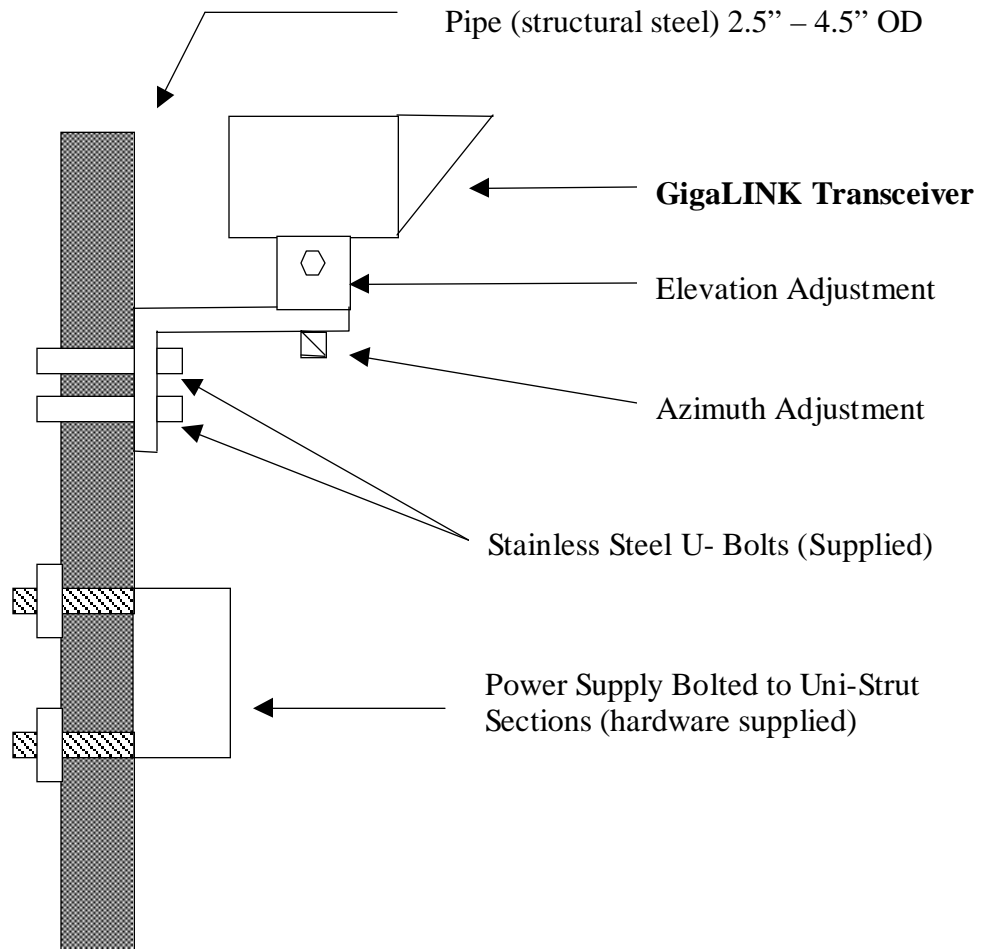
The following sections detail available mounting methods and hardware for the GigaLINK product. Mounting hardware to be specified at time of order.

Figure 1. Standard Wall Mount (all hardware included)



Harmonix Corp.
 1755 Osgood St.
 N. Andover, MA 01845
 (978) 974 0931, (978) 974 0969 fax
 www.hxi.com

Figure 2. Standard Pipe Mount (all hardware included)

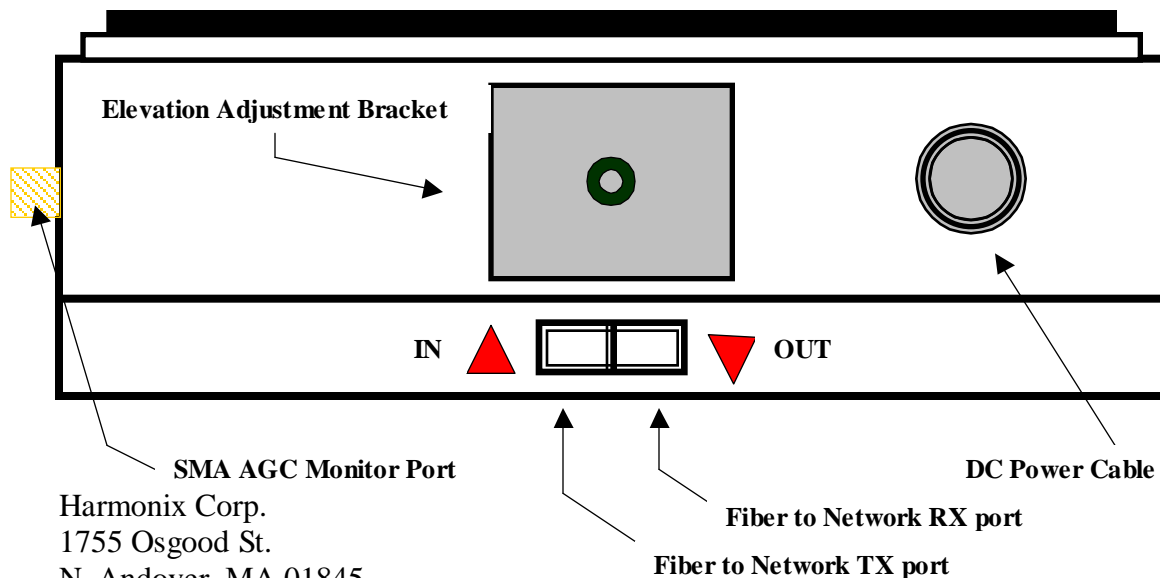


Mechanical Installation:

Once the optimum terminal locations have been selected, it is recommended that both terminals be mechanically installed. The hardware kits(s) specified at the time of order will contain all the necessary piece parts to accomplish a stable installation. The mechanical installation should progress as follows and be completed prior to radio “power-up”.

- 1.) Attach “L” Bracket to Pipe or Wall using recommended attachment method (U-Bolts, Through Bolts with Backing Plate or Wall Anchors)
- 2.) Attach Power Supply Box within 1M of radio terminal using Uni-Strut kit for Pipe mount or Wall Anchor kit for power supply wall mount. Once the power supply boxes have been installed electrical services can be connected by facility electricians.
- 3.) Install GigaLink Terminal to “L” Bracket using supplied pivot bolt and washers.
- 4.) Install Network Service (TX/RX Fiber) to GigaLINK Terminal (Fig. 6.)
- 5.) With power supply switch in the “OFF” position, install DC Power Cable between Power Supply and Radio Terminal.
- 6.) Visually align radio terminals to each other as accurately as possible and temporarily tighten adjustment bolts.

Fig. 6. DC Power and Network Connections (Bottom of GigaLINK Terminal);



Harmonix Corp.
1755 Osgood St.
N. Andover, MA 01845
(978) 974 0931, (978) 974 0969 fax
www.hxi.com

Required Installer Equipment

The Harmonix GigaLINK system was designed to require a minimum of specialized equipment for installation, precision alignment and maintenance. A comprehensive, step-by-step troubleshooting guide with detailed test procedures and additional equipment recommendations is included in a later section of this manual.

RF Terminal Alignment:

After completing the initial mechanical installation and visual alignment steps the GigaLINK radio system is ready for final precision alignment. In order to complete precision alignment, Electrical service must be available at the power supply box and the DC power cable installed. Final alignment is performed on each terminal separately, by making very small alignment adjustments to optimize (peak) the received signal level.

Each terminal alignment will be made in two steps.

Step #1 Elevation (Vertical) Alignment

Step #2 Azimuth (Horizontal) Alignment

AGC Monitor Port

To facilitate terminal alignment and to provide a quantitative measurement of alignment quality, the Harmonix GigaLINK terminal is provided with an AGC output monitor port. The AGC monitor port provides a positive voltage range of 3 – 4 volts DC to indicate the power level of the received signal. A simple self-ranging digital multimeter is all that is necessary to monitor the AGC level. Harmonix provides a SMA Male to pigtail jumper for attachment to the digital multimeter. The AGC monitor port is the primary tool for precision alignment and provides a tangible measurement to verify alignment during future maintenance visits.

Loop-Back Fiber Jumper

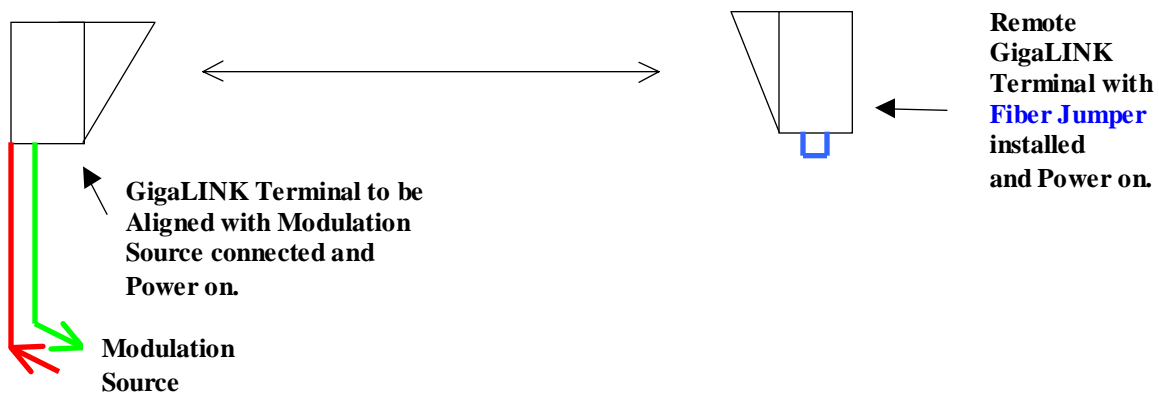
Also included in all Harmonix Installation kits is a fiber jumper of the correct mode and termination type. This fiber jumper is used to “Loop-back” GigaLINK terminals during alignment.

Generating Modulation for the Purposes of Terminal Alignment:

In the absence of actual network traffic, a modulation must be applied at the terminal "IN" port to excite the radio fiber modem and modulate a transmitted signal. This modulation can be created by artificial means to drive the radio transmitter to a high enough RF level to facilitate alignment.

Harmonix offers GigaLINK models in (3) popular data protocols 100Mbps FX, OC3 and OC12. An OC3 modulation source is suitable for modulating all three protocols for the purposes of alignment only. Harmonix recommends the FLUKE OC3Port Plus® OC3/ATM Handheld Test set for this application. In addition, depending on the intelligence and built in test capability of the customer premises equipment, a suitable test signal may be available from the network hub, switch or ATM switch.

Block Diagram of Test set-up for Final Alignment



Once a suitable modulation source has been obtained and the GigaLINK Terminals have been configured in accordance with figure 6, final alignment can begin. Follow the specific steps as detailed on the following page to achieve final (precision) alignment.

Elevation Alignment

Assuming that a rough mechanical alignment for both azimuth and elevation were performed as outlined in the previous section, elevation alignment can now be performed. The following steps detail the elevation alignment procedure. Best results will be achieved when care is taken to make small incremental adjustments. Small adjustment at the radio terminal translate to much larger changes at the remote terminal.

- 1.) Slightly loosen the (4) 13mm bolts that lock the elevation adjustment bracket.
- 2.) Measure the voltage present at the AGC monitor port via pigtail and multimeter.
- 3.) Slowly tilt radio up or down until increasing AGC voltage is observed. Continue minute adjustment until voltage begins to fall, then return to the position where the highest voltage was observed.
- 4.) When satisfied that peak voltage has been achieved tighten top (2) elevation adjuster bolts to maintain position.

Azimuth Alignment

After completing the initial elevation adjustment, azimuth alignment can proceed.

- 1.) Slightly loosen the single 13mm bolt that locks the azimuth adjustment to the “L” Bracket.
- 2.) Measure the voltage present at the AGC monitor port via pigtail and multimeter.
- 3.) Slowly rotate radio left or right until increasing AGC voltage is observed. Continue minute adjustment until voltage begins to fall, then return to the position where the highest voltage was observed.
- 5.) When satisfied that peak voltage has been achieved tighten azimuth adjuster bolt to maintain position.

When the initial azimuth alignment has been completed repeat the elevation alignment again followed by the azimuth alignment until confident that the AGC voltage is peaked.

Repeat the procedure outlined above for the remote terminal following the same methodology. In most cases several incremental alignments in both planes at both terminals will be necessary to achieve optimum alignment for the link.

Harmonix Corp.
1755 Osgood St.
N. Andover, MA 01845
(978) 974 0931, (978) 974 0969 fax
www.hxi.com

Peak AGC Voltages for Model# vs. Range

Model No.	200M	400M	800M	1,000M	1,200M	1,400M
100-0400-MM			N/A	N/A	N/A	N/A
100-0800-MM				N/A	N/A	N/A
155-0400-MM			N/A	N/A	N/A	N/A
155-0800-MM				N/A	N/A	N/A
155-0400-SM			N/A	N/A	N/A	N/A
155-0800-SM						
622-0200-MM		N/A	N/A	N/A	N/A	N/A
622-0400-MM			N/A	N/A	N/A	N/A
622-0800-MM	N/A			N/A	N/A	N/A
622-0200-SM		N/A	N/A	N/A	N/A	N/A
622-0400-SM			N/A	N/A	N/A	N/A
622-0800-SM	N/A			N/A	N/A	N/A