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 UNDESIRED OPERATION.

IF THIS PRODUCT IS SUSPECTED OF CAUSING HARMFUL INTERFERENCE WITH OTHER EQUIPMENT, DISCONTINUE OPERATION IMMEDIATELY AND CONTACT HARMONIX CORP. AS SHOWN BELOW.

FCCID # O2700000-30-30

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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, FCC license or special authorization is not 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 un-obstructed 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 recommended 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 is dedicated to providing our customers the maximum utility in performance, reliability and speed.

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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 configurations 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
155-0400-MM	OC3 (155Mbps)	400	Patch	Multimode	SC
155-0800-MM	OC3 (155Mbps)	800	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
622-0200-SM	OC12 (622Mbps)	200	Patch	Single-mode	SC
622-0400-SM	OC12 (622Mbps)	400	13" Parabola	Single-mode	SC

* Other fiber termination styles available upon special request

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Harmonix GigaLINK Standard Model
Range Performance Envelopes

Model No.	Maximum RF Path
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	200 meters
622-0400-SM	400 meters
622-0800-SM	800 meters

Reliability Statement

All Harmonix GigaLINK products are designed to provide a minimum statistical reliability of 99.99% (BER < 1 x 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.

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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 reseller for details and pricing.

Fiber Optic Cable Types

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. **Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.**

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

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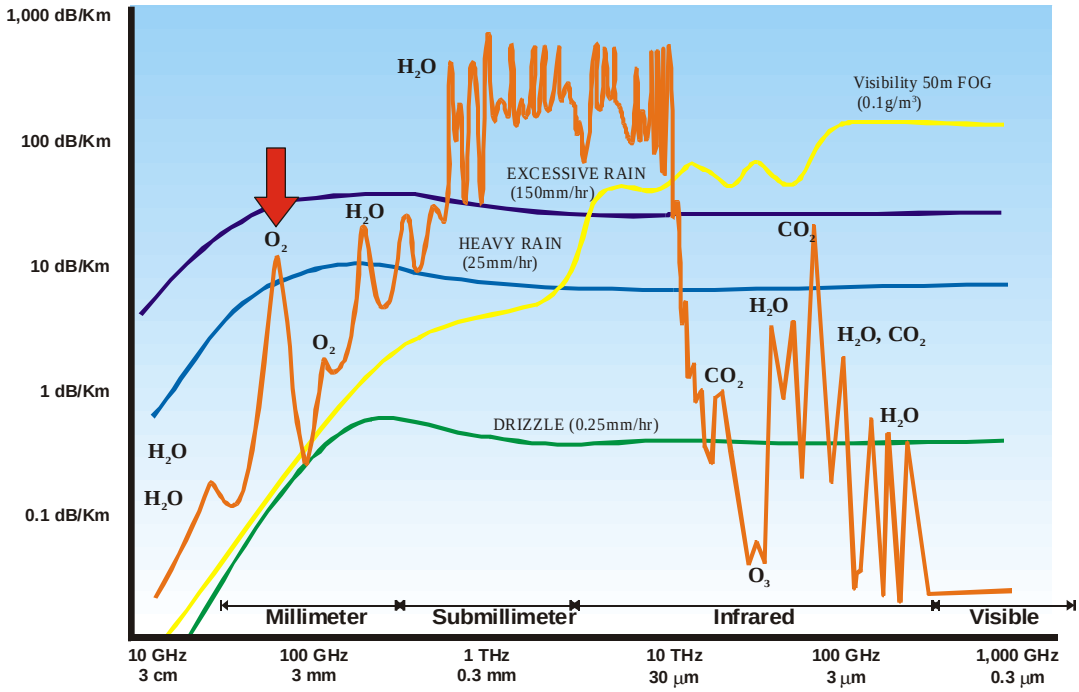
Section 2

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.

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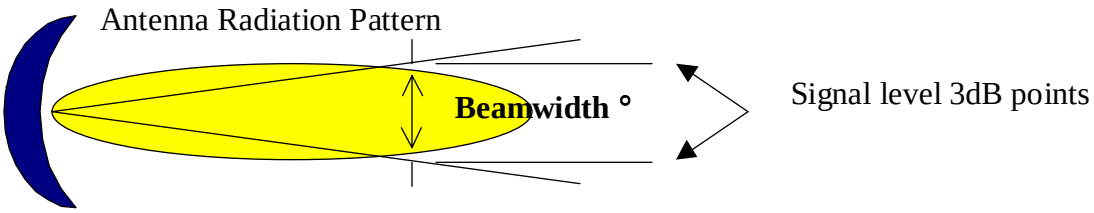
Antenna Gain / Antenna Beamwidth

To increase the level of RF energy available to the radio receiver, Harmonix employs high-performance, high gain (directivity) antennas specifically selected for a given range. Focusing the RF energy into a more confined pattern beamwidth increases the gain of an antenna. The antenna beamwidth is defined in degrees of an arc between 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.

Configuration	Antenna Gain (dBi)	3dB Beamwidth
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 59.05-64GHz 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”.

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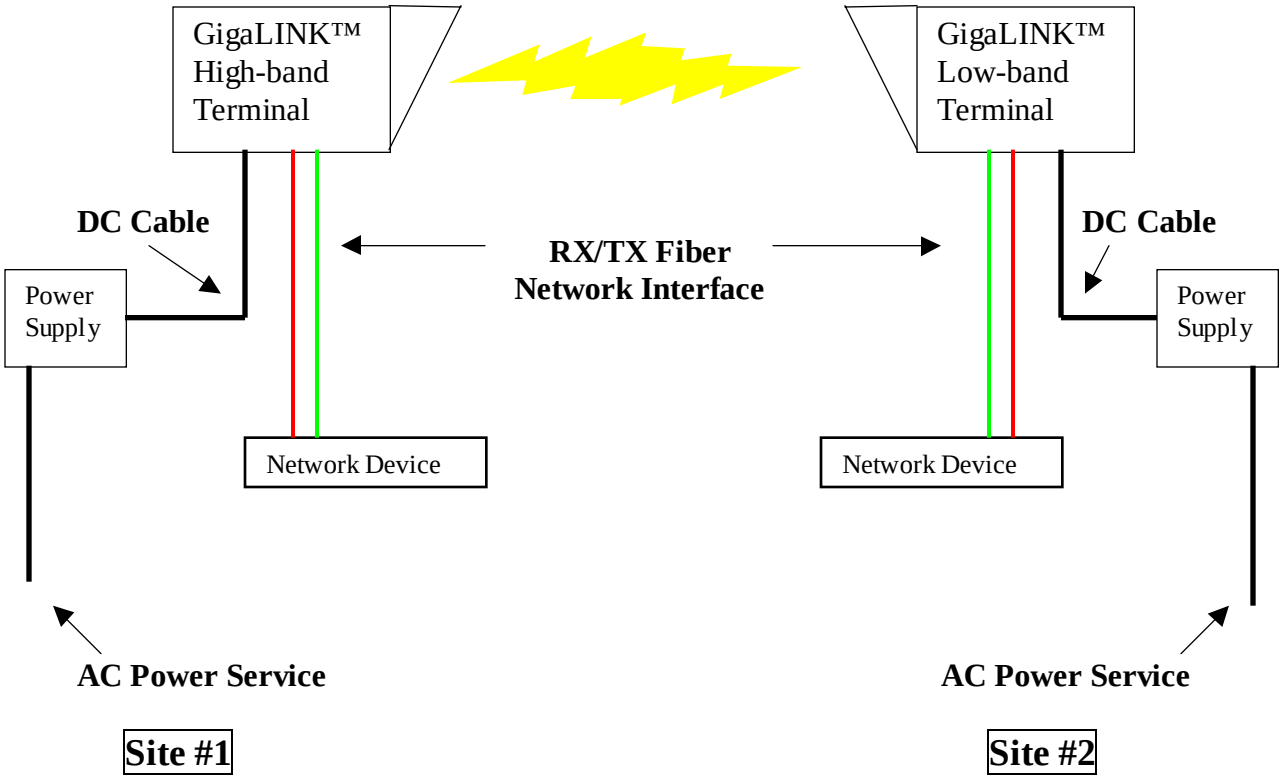
Section 3. GigaLINK™ System Basics

Both the transceiver terminals and power supply boxes provided with the GigaLINK™ systems 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:



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GigaLINK™ System Installation Kit Component List

Item	Description	Qty Supplied	Re-Order #
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	

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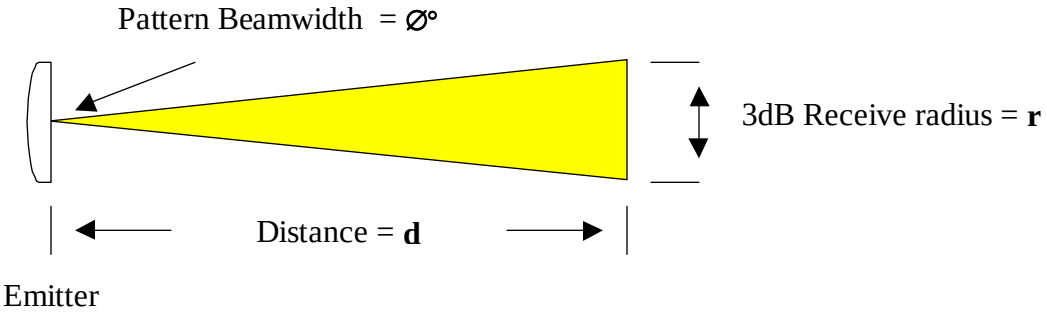
Section 4. GigaLINK™ Installation Procedure

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 ∅°/2 = r/d,**
And **r = d * tan ∅°/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

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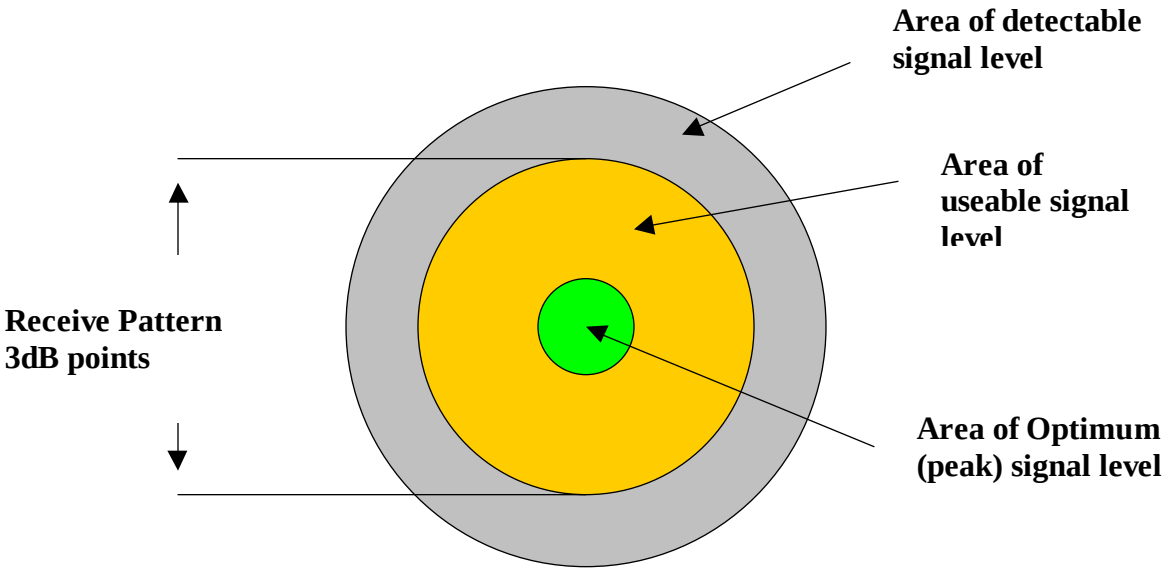
Relative Signal Strength Distribution of Circular Receive Area



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, there is no need for complex calculations to account for free space losses or rain fades. The maximum recommended range limits were calculated for a minimum fade margin of 10 dB under extremely heavy rain conditions (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.

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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 unobstructed Line of Sight and a stable/secure mechanical attachment point. In order of precedence primary considerations should include;

1. Locations with unobstructed Line of Sight to target terminal
2. Locations affording secure mechanical mounting provisions
3. Locations isolated from vibration
4. Locations away from possible moving obstructions (workers, cranes etc.)
5. Locations accessible to service personnel for maintenance
6. 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 the time of order.

Figure 1. Standard Wall Mount (all hardware included)

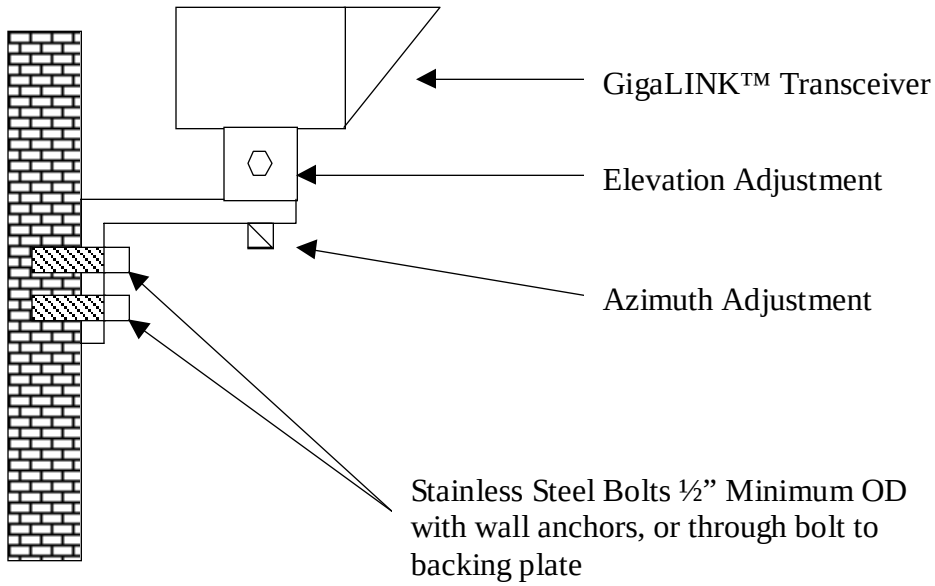

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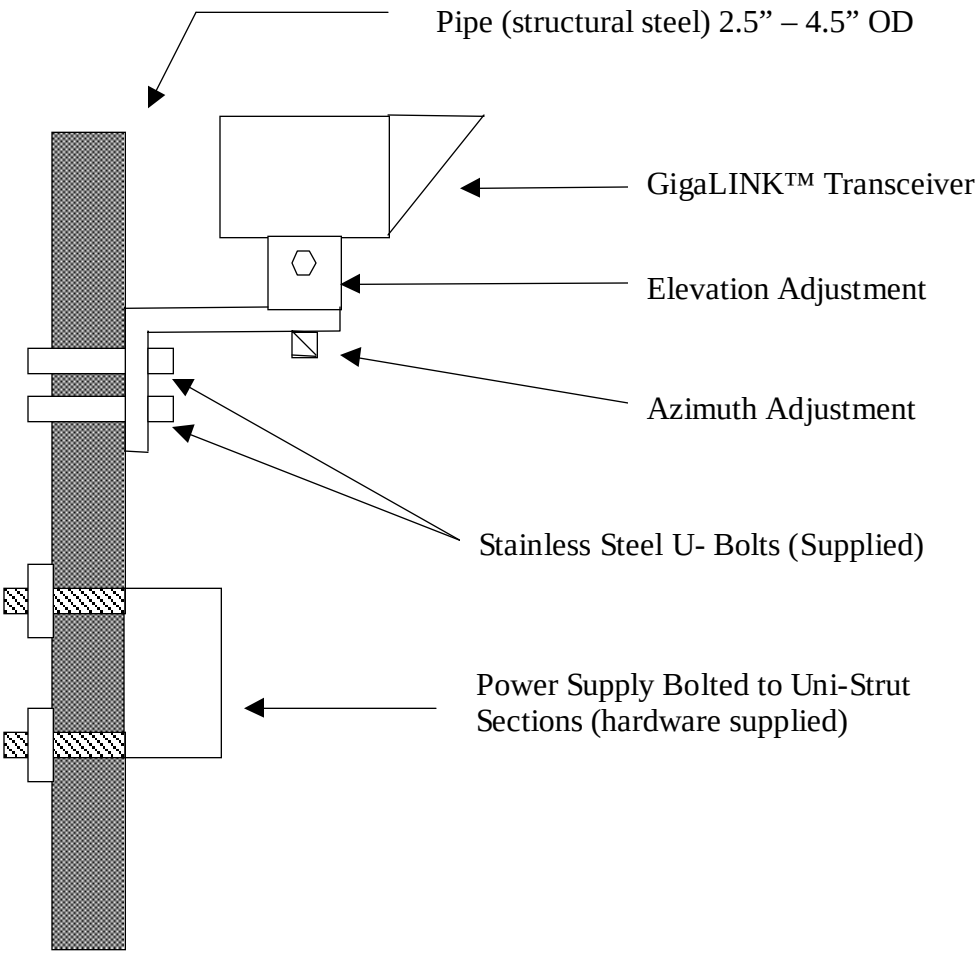
Figure 2. Standard Pipe Mount (all hardware included)



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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 the 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 the 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.

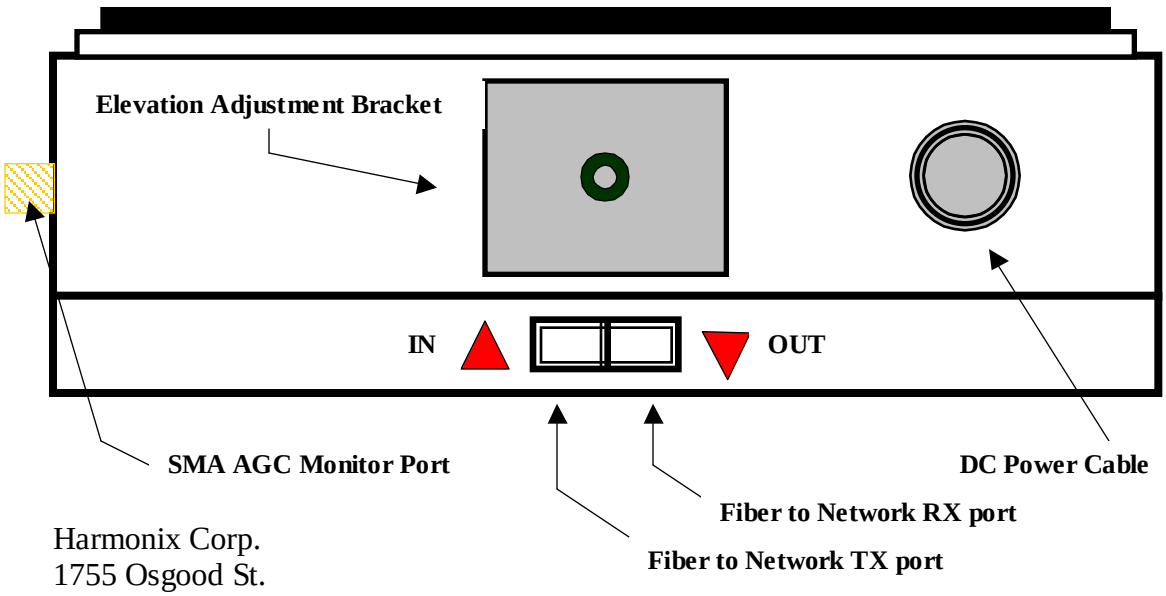
3.) Install GigaLink™ Terminal to "L" Bracket using supplied pivot bolt and washers.

4.) Install Network Service (TX/RX Fiber) to GigaLINK Terminal (Fig. 6.).

5.) With power supply switch in the OFF position, install the DC power cable between the 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)



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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 should 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.

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Monitor Measurement in Radio "Listening Mode"

Prior to applying modulation to the Harmonix GigaLINK system it is necessary to measure AGC Monitor voltage output with no modulation applied. By this method it is possible to identify potential sources of in-band interference and avoid interfering with other installed systems.

If an AGC Monitor Voltage in excess of 3VDCis detected, this indicates the presence of a competing system and make unintended interference possible. In the event that potential interference is detected measures must be taken to avoid transmission of potentially interfering signals and these measures include relocating the terminal at least 6 meters away and/or changing the terminal polarization by rotating both terminals 90° on- axis. The standard GigaLINK™ mounting hardware enables quick polarization changes. For details on accomplishing these changes, please contact the factory.

If after changing the polarization an AGC voltage in excess of 3 VDC is detected, the radio system must be exchanged for a system of an alternative frequency.

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 three popular data protocols 100Mbps FX, OC3 and OC12. An OC3 modulation source is suitable for modulating all three protocols for the purposes of alignment. 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's premises equipment, a suitable test signal may be available from the network hub, switch or ATM switch.

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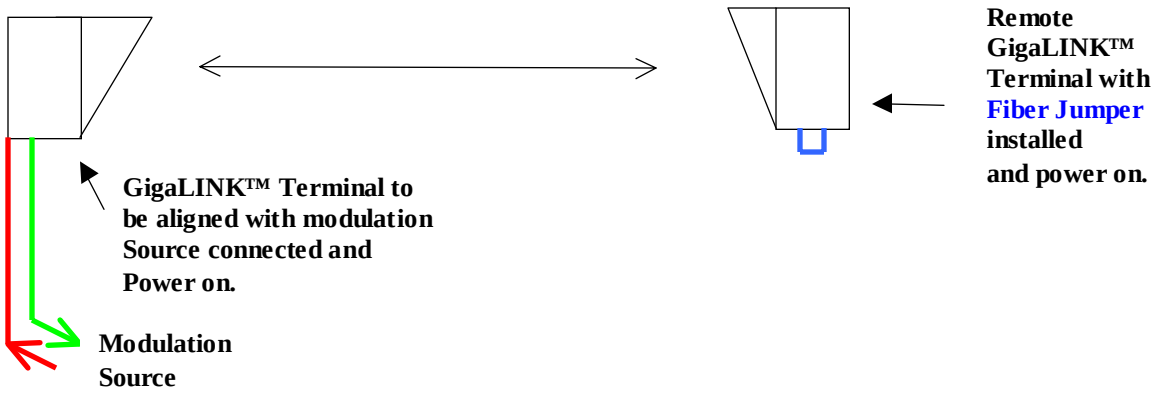
Block Diagram of Test Set-up for Final Alignment



Once a suitable modulation source has been obtained and the GigaLINK™ Terminals have been configured in accordance with figure 6 (page 9), 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 adjustments with the local radio terminal translate into 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 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 the top (2) elevation adjuster bolts to maintain position.

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Azimuth Alignment

After completing the initial elevation adjustment, the 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 the radio left or right until an increasing AGC voltage is observed. Continue minute adjustments until the 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 the 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 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.

Peak Monitor Voltages for Model# vs. Range

Model #	200M	400M	800M
100-0400-MM	3 – 4 VDC	3 – 4 VDC	N/A
100-0800-MM	3 – 4 VDC	3 – 4 VDC	3 – 4 VDC
155-0400-MM	3 – 4 VDC	3 – 4 VDC	N/A
155-0800-MM	3 – 4 VDC	3 – 4 VDC	3 – 4 VDC
155-0400-SM	3 – 4 VDC	3 – 4 VDC	N/A
155-0800-SM	N/A	3 – 4 VDC	3 – 4 VDC
622-0200-MM	3 – 4 VDC	N/A	N/A
622-0400-MM	3 – 4 VDC	3 – 4 VDC	N/A
622-0800-MM	N/A	3 – 4 VDC	3 – 4 VDC
622-0200-SM	3 – 4 VDC	N/A	N/A
622-0400-SM	3 – 4 VDC	3 – 4 VDC	N/A
622-0800-SM	N/A	3 – 4 VDC	3 – 4 VDC

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