



# **FS31H-4X-USR**

**User Manual**

**UHF Headend Repeater Unit**

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### Version A

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### Revision History

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## 1.0 Company Info

Fiber-Span is a premier provider of advanced RF ON FIBER® technologies and solutions for fiber optic based transmission of high fidelity radio-frequency wireless voice, data and multiservice networking applications. Fiber-Span's proprietary RF/Fiber Optic transceivers, transmitters and receivers are rugged, compact OEM modules and subsystems designed for easy integration into commercial cellular, GSM, PCS/PCN, M/LMDS, WLL, IF, satellite terminal or distinctive antenna system configurations. Fiber-Span is addressing public safety needs by providing fiber optic wireless solutions for police, fire, emergency, first responder and Homeland Security radio systems applications. Fiber-Span's solutions for Defense and Military organizations are also leading the way by providing reliable and secure communications links for ground, airborne, shipboard, radar, telemetry, GPS and intelligence solutions in the HF/UHF/VHF and microwave radio frequencies. Fiber-Span's evolving class of product addresses the growing demand and movement toward the convergence of wire line and wireless networks, and the requirement for high performance, high bandwidth RF ON FIBER® solutions and networks. Fiber-Span's customers are global wireless communication systems original equipment manufacturers (OEM), radio frequency (RF) system integrators, and military system architects. More information about Fiber-Span products is available from the contact info listed below.

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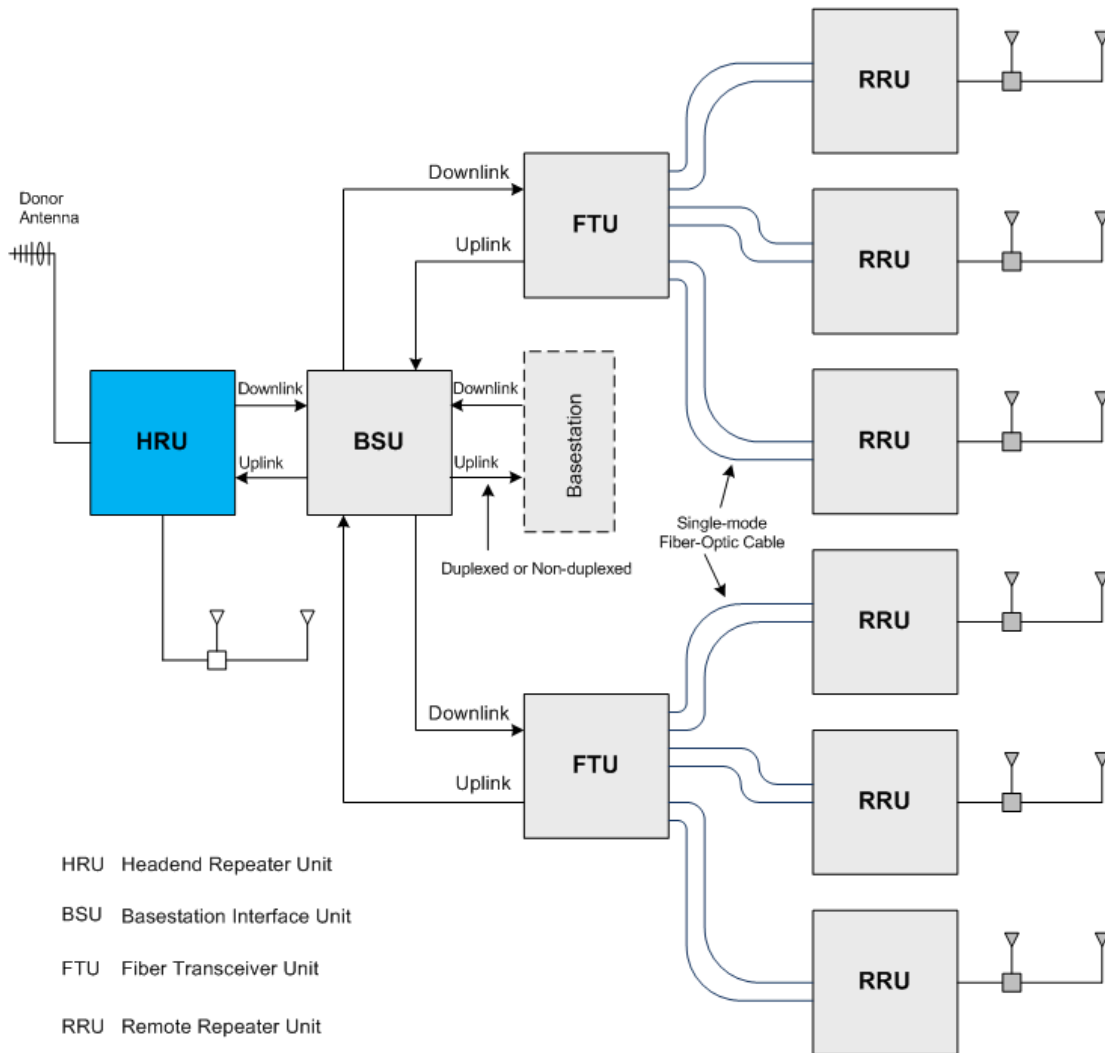
## 2.0 Product Introduction

This manual covers the Headend Repeater Unit (HRU). Most applications for simple coverage enhancement solutions would require a Bi-Directional Amplifier (BDA). The HRU is Fiber-Span's equivalent technology to the BDA. The HRU has additional hardware that allows a direct connection to fiber-optic transceivers.

## 2.1 HRU Description

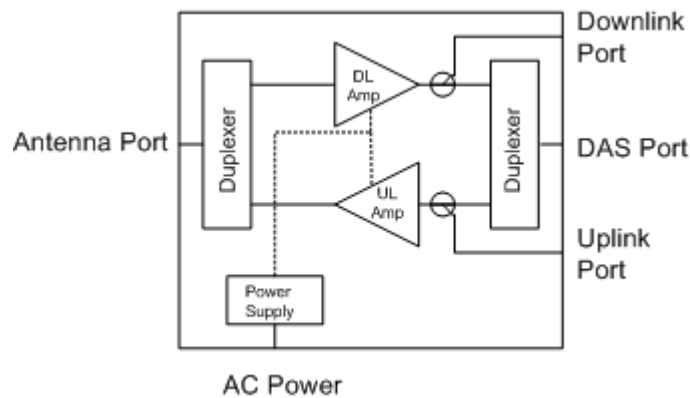
The HRU is the interface to the donor antenna and is located at the Headend of any in-building coverage solution. The following diagram illustrates how the HRU fits into the Fiber-Span system architecture.

Fiber-Span System Architecture and Product Family



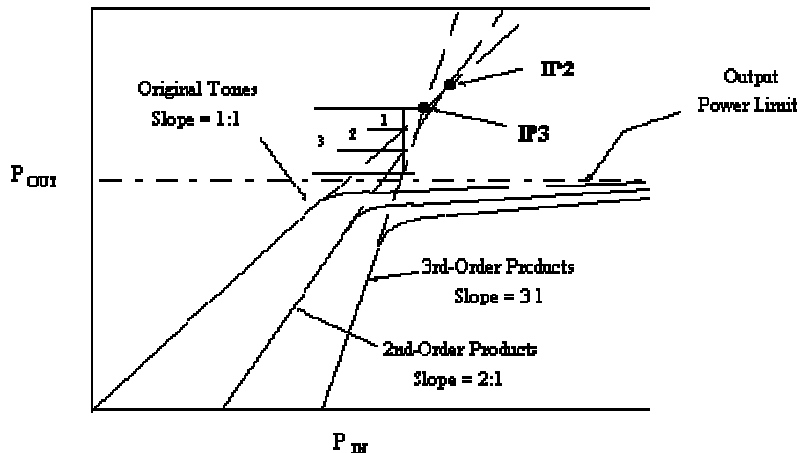
The HRU amplifies RF frequencies in both the downlink and uplink paths with duplexers that provide both downlink and uplink frequency bands on a single distributed antenna system. The HRU is used to provide cost efficient wireless coverage in areas that have poor coverage.

Fiber-span has additional unique hardware in the HRU that allows it to feed fiber-optic transceivers (FTU). This is the main difference between the HRU and a typical BDA. The downlink port is tapped off the output of the downlink amplifier. The uplink frequencies are combined prior to amplification in the uplink amplifier. The separate downlink and uplink ports are present on the bottom of the unit along with the antenna port and a DAS port. The following block diagram better illustrates how the HRU is configured.



## 2.2 Theory of Operation (Gain and Power Output)

The amplifiers used in the BDA provide a set amount of gain. Gain is defined as the ratio in the amount of RF power of the output and input of the amplifier. If +20dBm of RF power is required at the DAS port and -50dBm is measured at the antenna port, the gain must be set to 70dB.



When multiple RF carriers are input to an RF amplifier, the RF output power will be the input power plus the gain.

Power output = Power input + Gain (in decibels)

Power output = Power input x Gain (in Watts)

As seen by the preceding figure, the output power tracks the input power linearly. Eventually as the input power increases, the amplifier output power reaches the output power limit. When this happens, intermodulation products are generated at the amplifier output. The intermodulation products with the most likelihood of generation are 2<sup>nd</sup> and 3<sup>rd</sup> order. For every 1dB increase in input RF power, the 3<sup>rd</sup> order intermodulation products increase 3dB. If one were to plot the 3<sup>rd</sup> order output power on a graph as in the preceding figure, the slope of the 3<sup>rd</sup> order products would intersect the line of the output power plotted vs. the input power. This point is defined as the 3<sup>rd</sup> order intercept and is used by amplifier manufacturers to characterize the maximum output power of an RF amplifier.

The RF output power of the amplifiers is defined as the total RF output power inside the bandwidth of the duplexers. This RF output power is divided into the number of dominant RF carriers at the output of the amplifier.

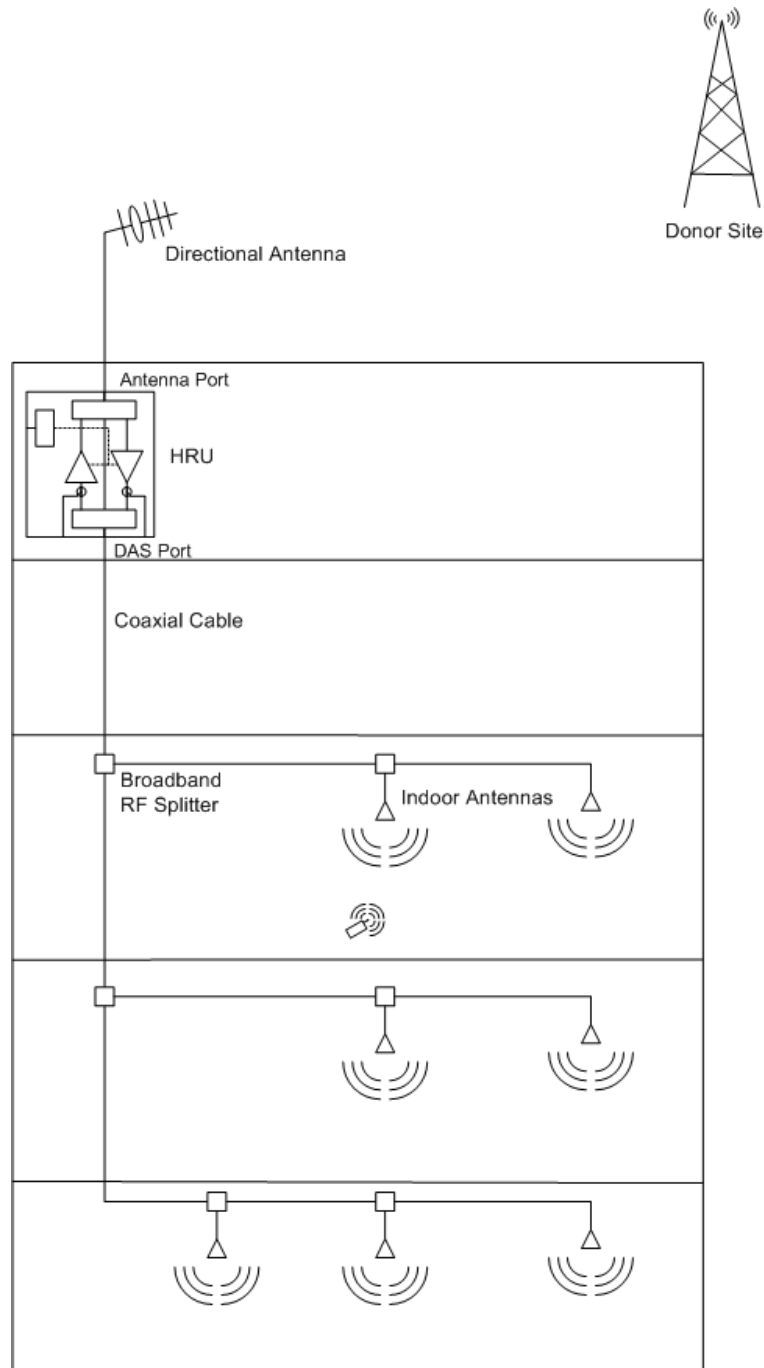
## 2.3 Product Applications

The HRU has several purposes.

- As a single unit to provide coverage for a single band of wireless service;
- As multiple units amplifying coverage for multiple services;
- As an amplifier to feed fiber-optic transceivers and provide RF wireless coverage using coaxial cable fed from the HRU.

The following diagrams help illustrate a typical coverage solution for a single band of wireless service.

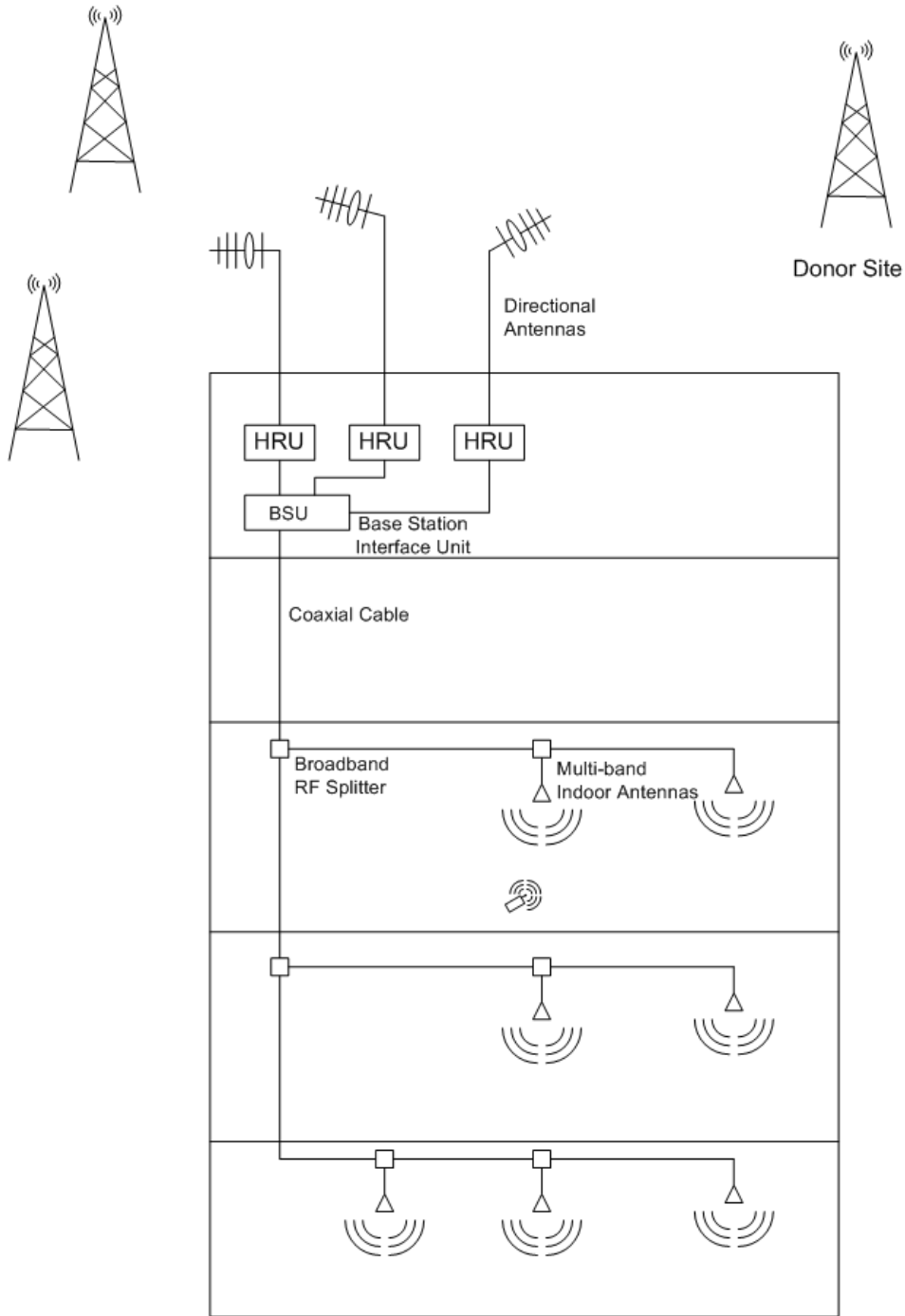




Typical HRU RF Amplification System

A single band of RF channels is amplified in both directions (downlink and uplink). The RF channels are then distributed over a single distributed antenna system on floors where coverage is needed using coaxial cable, RF splitters and indoor ceiling mount antennas.

The HRU can provide coverage for multiple wireless services as shown in the following diagram.

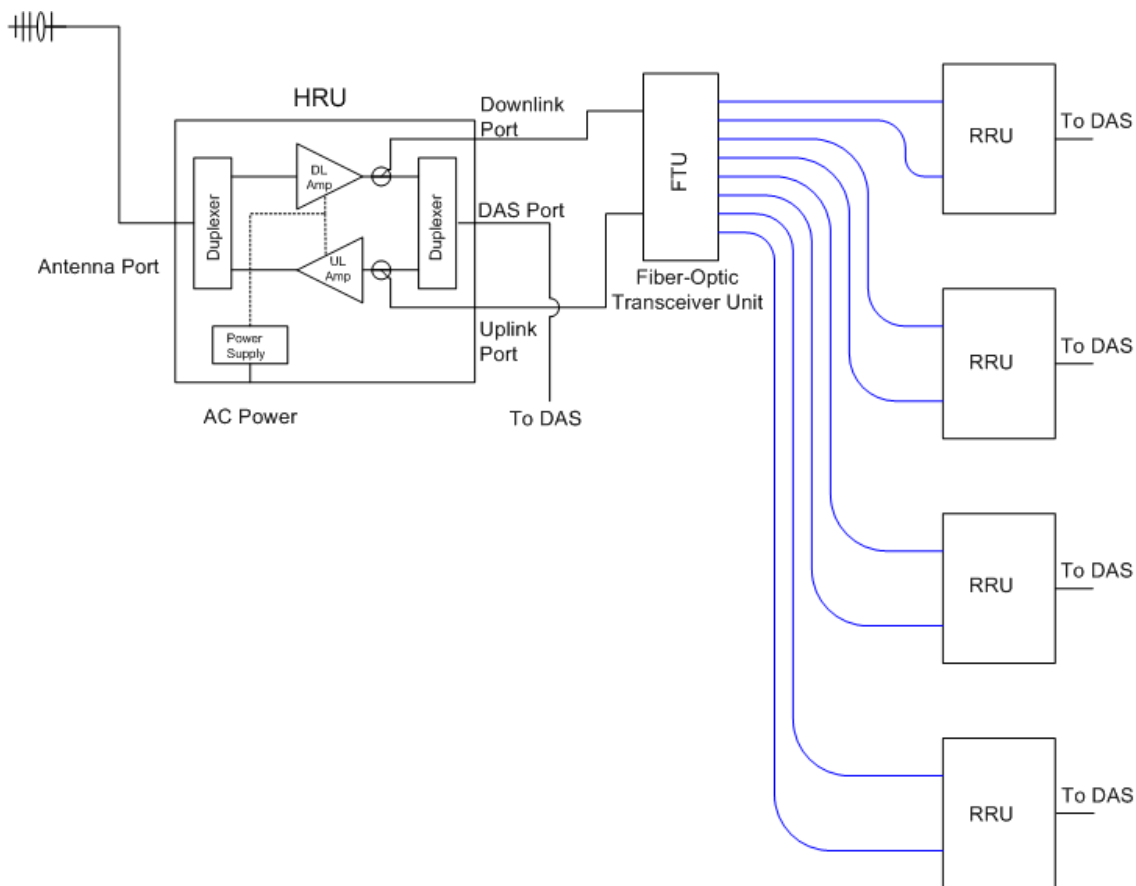


Typical HRU RF Amplification System

The BSU (Base Station Interface Unit) combines the frequency bands of the wireless services onto a single common coaxial output. The BSU also provides adequate isolation between the frequency bands to prevent the possibility of oscillation between two or more HRU's.

A separate HRU is required for each wireless service because each HRU is capable of amplifying a single spectrum of channels. For example, one HRU would be need for a UHF frequency band and a separate HRU would be required for an 800MHz frequency band.

The HRU can also feed fiber-optic transceivers (FTU) which convert the downlink RF signals to optical signals and convert uplink optical signals to RF signals. The FTU can then feed multiple RRU's for coverage over a much wider area. This is illustrated in the following diagram.



In this instance a BSU is not required; however, when multiple HRU's or FTU's are required, a BSU is needed.

For more details on the FTU, BSU and RRU, refer to their respective manuals.

### 3.0 Detailed Description

This section deals with the actual components that are assembled to make up the HRU. The main subassemblies are:

1. RF Amplifiers – These provide RF signal amplification.
2. Duplexers – These units separate and combine downlink and uplink spectrums and reduce interference.
3. Alarm Motherboard – This assembly combines alarms and provides a single contact closure summary alarm.
4. Power Supply – This unit converts the AC power to DC power as required by the active components.

### 3.1 Amps

There are two types of amplifiers that Fiber-Span uses to provide the appropriate amount of gain required to provide coverage solutions:

1. LNA – The LNA (low noise amplifier) is the first amplifier that the RF signal is amplified by when passing through the HRU. It has a low noise figure to provide an overall lower noise figure for the entire amplifier.
2. Power Amp – The output power amplifier provides additional gain and has some additional features like ALC (automatic level control) and pre-distortion.

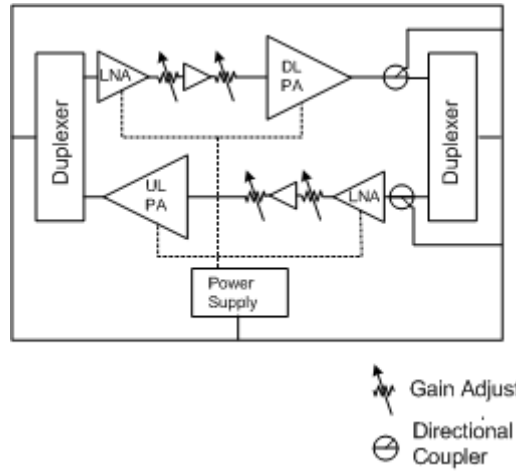
The amplifiers that Fiber-Span utilizes are powered from a DC power supply. The RF amplifiers are type A broadband and draw a constant amount of current to set the bias point of the amplifier.

The power amplifiers employ an Automatic Level Control (ALC) circuit to ensure the RF output power does not destroy the final gain stage of the RF amplifier. When the ALC circuit is active, a red light illuminates on the RF amplifier housing. This means the RF output power of the amplifier has reached the factory set limit and the ALC is reducing the gain to protect the final gain stage of the amplifier.

The amplifier gain can be reduced to prevent the ALC circuit from becoming active.

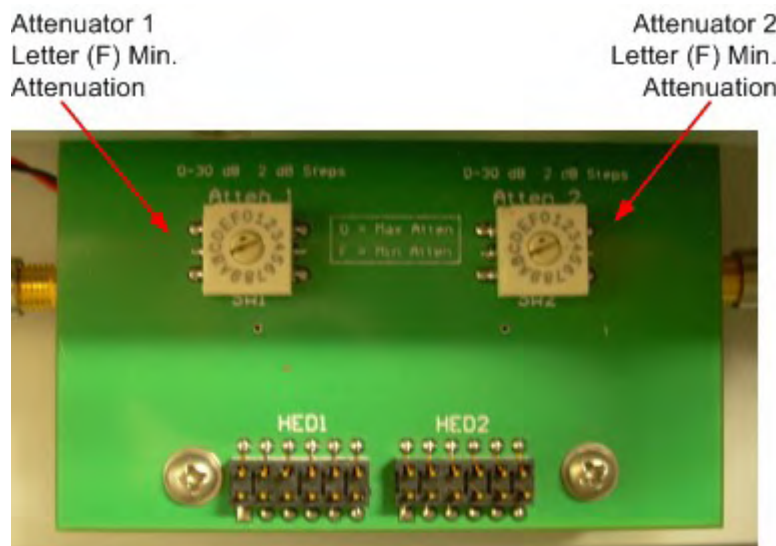
The amplifiers also employ a form of pre-distortion to allow multiple channels to operate at higher levels with reduced intermodulation signal levels. The input RF signal into the amplifier is pre-distorted such that after amplification, the intermodulation products are reduced from what would normally be experienced in an amplifier without pre-distortion.

The gain of the HRU is set by adjusting potentiometers in between the LNA and the power amplifier. Refer to the following block diagram.



The potentiometers are located inside the HRU cabinet are as shown in the picture below.

*Note: Variable Attenuators are not included with Rack-Mount versions of the HRU.*



Digital Attenuator Board  
2dB/ Step. Position 0 Max. Attenuation  
Clockwise increases gain

When the dial indicators on each of the potentiometers are pointed towards the letter “F”, the attenuation is 0dB and the amplifier is at maximum gain. When the potentiometers are rotated counterclockwise, the gain is reduced by 2dB with every click or incremental change in position.

A small screwdriver is required to adjust the gain settings. The following table summarizes the amount of attenuation associated with each dial indicator setting.

Dial Indicator	Attenuation
0	30 dB
1	28 dB
2	26 dB
3	24 dB
4	22 dB
5	20 dB
6	18 dB
7	16 dB
8	14 dB
9	12 dB
A	10 dB
B	8 dB
C	6 dB
D	4 dB
E	2 dB
F	0 dB

For example to provide 20dB of attenuation, one of the potentiometers would be turned towards the '5' position. Alternatively, both potentiometers can be positioned at the 'A' position to provide 10dB of attenuation each for a total of 20dB.

### 3.2 Duplexers

The duplexers used in the HRU perform two specific functions:

1. Provide adequate isolation between the downlink and uplink frequency bands to prevent oscillation; and
2. Provide a suitable bandpass characteristic to prevent unwanted interference from/to other donor sites in the area.

The amount of isolation required depends on the overall gain of both the downlink and uplink amplifiers. As the gain increases, so does the isolation requirement and the size of the duplexers.

Fiber-Span provides duplexers that match the existing frequency bands that are in use. In the 800MHz SMR spectrum, the downlink and uplink frequency bands are 45MHz apart. In the UHF spectrum, the frequency bands can be anywhere within the band, however the downlink

and uplink frequencies are 3 MHz, 5 MHz, 9 MHz, or 10 MHz apart. Fiber-span offers the following UHF frequency arrangements. These frequency bands are listed below.

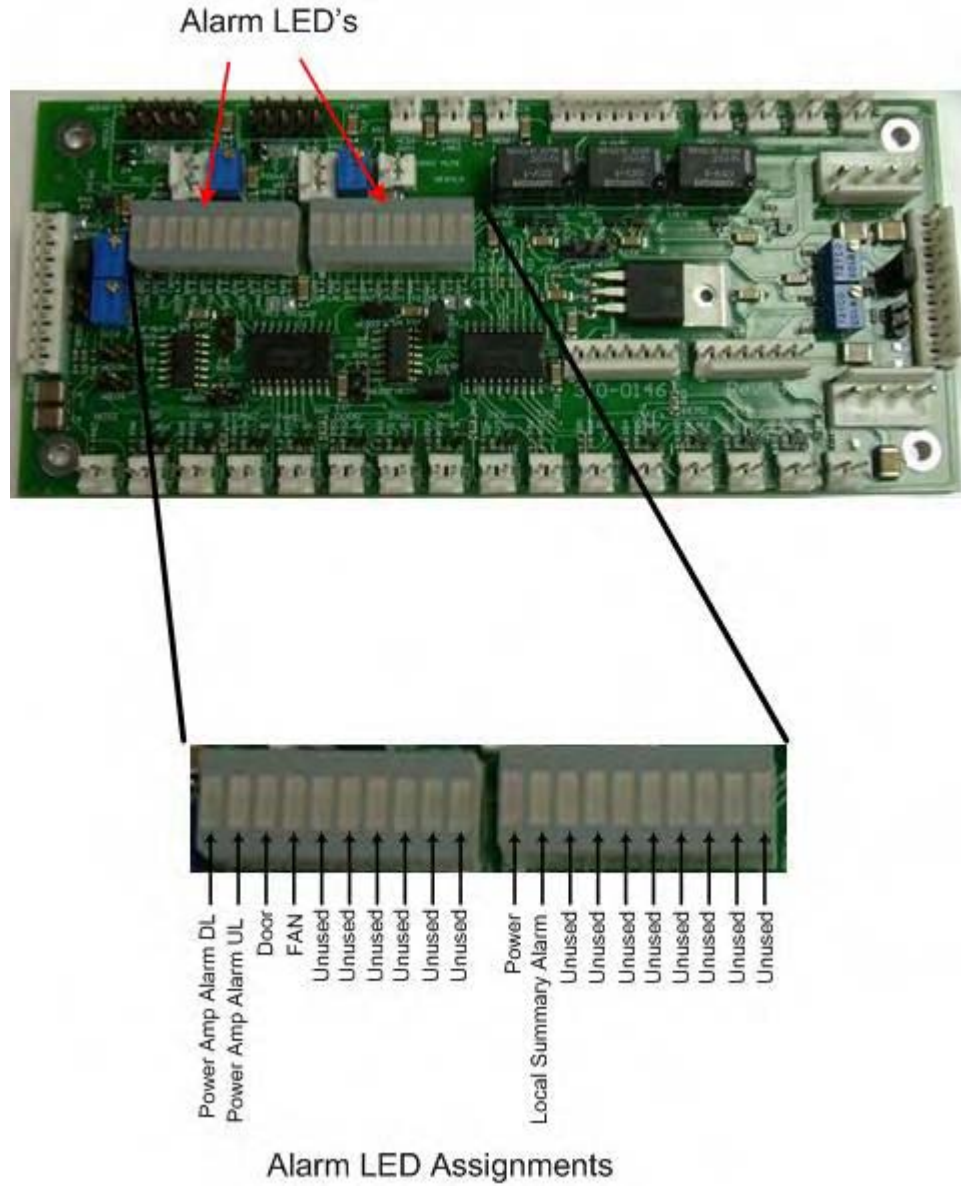
The UHF Downlink frequency is 457 - 462 MHz and the Uplink frequency is 464 - 469 MHz.

### **3.3 Alarm Motherboard**

The alarms inside the HRU utilize dry contact relays that are normally open when there are no alarms. These are found on the alarm motherboard. The following alarm conditions will cause the summary dry contact relay to close:

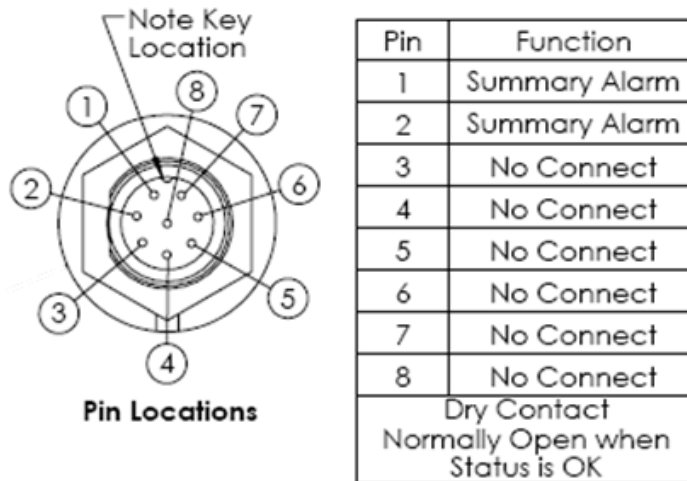
- 1) Power Amp Alarm Threshold – This output power threshold is set on the power amplifier. When the RF output power reaches this threshold, the LED on the alarm motherboard will turn on. This is factory set to be 3dB higher than the ALC threshold. The alarm motherboard receives a voltage from the power amplifier which is scaled according to the RF power supplied at the output of the amplifier.
- 2) Door Open – When the door is opened, a switch is activated that closes a relay contact.
- 3) Fan – Not all models utilize fans, however, if the particular unit has fans installed, alarms will trigger. When the fan seizes, it will draw more current than is necessary for normal operation. This will cause a relay contact to close.
- 4) Power Supply – When there is voltage at the power supply, one of the LED lights on the alarm motherboard will turn on.

The alarms can be distinguished from each other by observing the LED lights on the control board. The location of the LED's on the control board is shown in the following figure.



A summary of these alarms is connected to an 8-pin male Switchcraft connect on the bottom of the HRU. The pin out of the male Switchcraft connector is shown in the following diagram.





When there is an alarm condition, there is a short circuit between pins 1 and 2. This is a summary alarm for any alarm in the HRU.

### 3.4 Power Supply

The power utilized in the HRU is capable of supplying 150W at 28V DC. The power amplifier draws approx. 90W at 28V DC. This is to ensure that there is additional headroom for other minor active components like LNA's and the Alarm Motherboard.

### 3.5 Specifications

Frequency Range	Downlink 457 - 462 MHz, Uplink 464 - 469 MH
Gain	40 dB to 70 dB in 2dB steps
OIP3	54dBm
Noise Figure	7dB
Power per Channel	Refer to Derating Table
Pass Bandwidth	See Frequency Arrangements
Input/Output VSWR	< 2.0:1
Connectors	N- Female
Dimensions (WxHxD in.)	20x20x9 (Refer to following table)
Weight (lbs)	100lbs (20"x20"x9")
Mounting Method	Wall-mount Enclosure
Alarms (dry contact)	1. Downlink Amp RF Power Output 2. Uplink Amp RF Power Output 3. Door Alarm 4. Fan Alarm
MTBF	5 Years

The following table provides the power per RF channel. At these carrier levels, the RF amplifier is operating in the linear range.

**UHF HRU Derating Table**

<b># of RF Channels</b>	<b>Power per Channel (FM)</b>
1	36 dBm
2	33 dBm
4	30 dBm
8	27 dBm

## 4.0 Setup Procedure

### 4.1 Cautionary Notes



Before the unit can be connected to the DAS and powered on, the following cautionary notes must be observed.

Before powering the unit on, it is imperative to measure the downlink composite power level at the antenna port. If the downlink signal level is excessive ( $>-24\text{dBm}$ ), additional external attenuation will be required at the antenna port.

All output ports must be terminated with a 50Ohm load capable of handling 20W of power before the HRU is powered on. Alternatively, the HRU can be connected to the in-building system assuming the connections are 50Ohm with acceptable VSWR ( $<2.0:1$ ). This will prevent damage to the unit.

For HRU's with fans, the fans must not be blocked to allow heat energy to escape the enclosure. An HRU with a blocked fan will have a much lower MTBF.

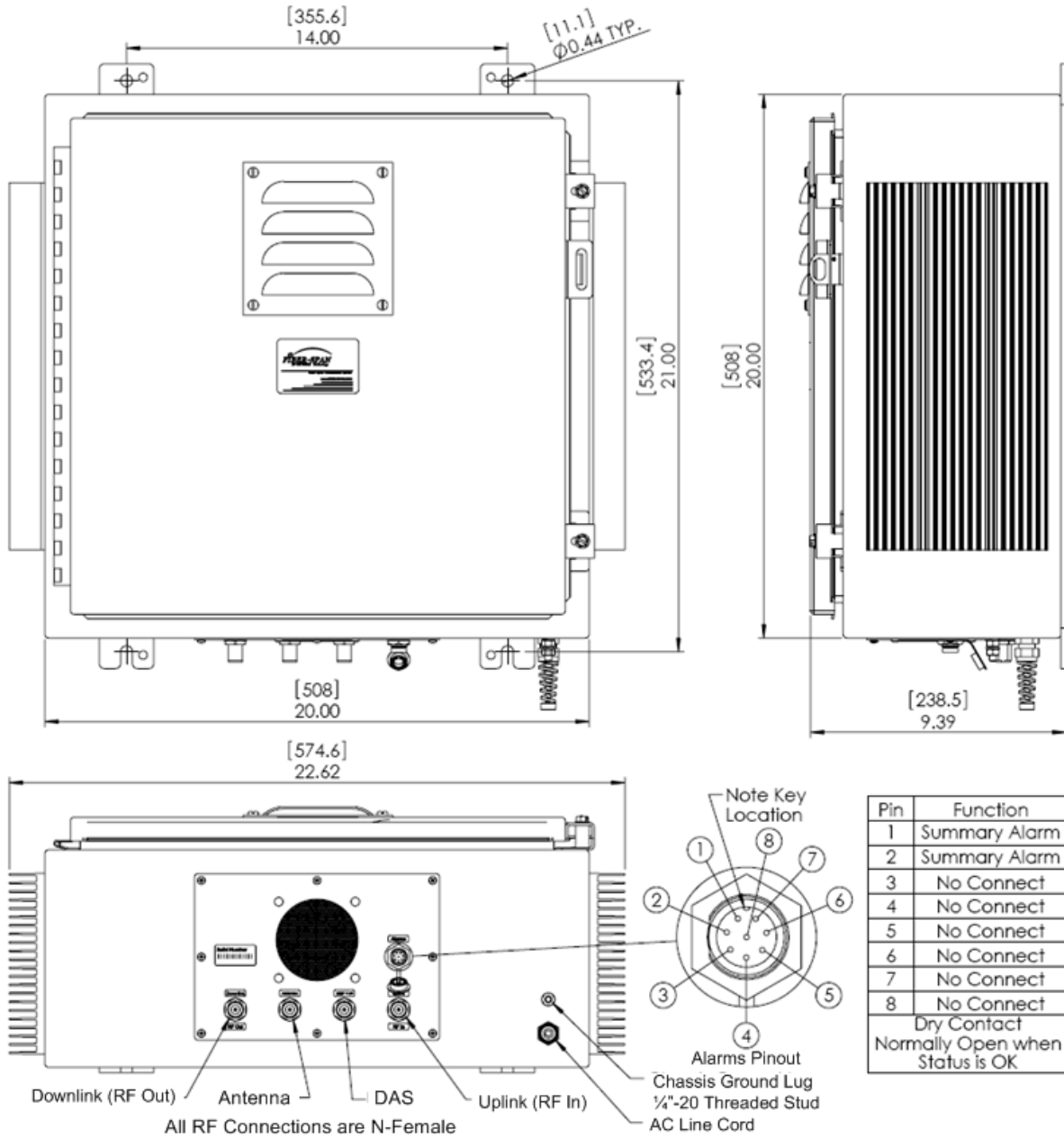
### 4.2 Contents

With the purchase of any HRU the following are included when shipped:

- HRU Product
- HRU User Manual
- Test Data Sheet showing factory set levels
- Outline Drawing

The dimensions for a standard configuration is 20"x20"x9" as shown below. The exception to this configuration is the HRU with a 3 MHz passband and a 5 MHz Tx/Rx separation which is 24"x24"x9".

**UHF HRU Dimensions and Mounting Hole Details  
(Standard Configuration)**



Outline Drawing #1 – Wall-mount version

The factory set output power is 36dBm. The gain of the amplifier is defined as follows:

$$\text{Gain} = 36\text{dBm} - \text{Input Level}$$

Gain is also defined as follows:

$$\text{Gain} = 80\text{dB} - \text{Att1} - \text{Att2}$$

Putting the two equations together:

$$36\text{dBm} - \text{Input Level} = 80\text{dB} - \text{Att1} - \text{Att2}$$

$$\mathbf{\text{Att1} + \text{Att2} = 44 + \text{Input Level}}$$

The attenuators can be set simply knowing what the input power level is into the HRU downlink port. For e.g. if the input power level is -20dBm,

$$\text{Att1} + \text{Att2} = 44 + (-20\text{dBm}) = 24\text{dB}$$

Consult the following table regarding the dial indicator setting.

Dial Indicator	Attenuation
0	30 dB
1	28 dB
2	26 dB
3	24 dB
4	22 dB
5	20 dB
6	18 dB
7	16 dB
8	14 dB
9	12 dB
A	10 dB
B	8 dB
C	6 dB
D	4 dB
E	2 dB
F	0 dB

In this case, Att1 would be set to “3” and Att2 would be set to “F”.

This gain setting excludes the losses from the filters and is handled in the next step.

- 3) Set the final output level of the HRU while connected to the antenna port. To obtain a higher output level, the attenuators can be carefully adjusted one click at a time carefully taking note of the composite output power.

#### 4.4 Uplink Setup

Generally in most applications, the uplink gain is set equal to the downlink gain. In most non-commercial UHF applications, the coverage enhancement system is downlink limited. This is due to the fact that the portable handset transmits at a much higher signal level than a commercial unit (1W to 5W). A portable handset does not have the capability to reduce transmit power like a commercial cell phone, so care must be taken when setting the uplink gain. The uplink gain is set based on what the worst case highest and lowest uplink signal into the HRU from the DAS. The uplink amplifier has 10dB of uplink ALC range.

#### 4.5 De-rating Table

After the downlink gain and the output composite power is set, the power per channel must be measured to ensure that the downlink signal level high enough at the DAS port is sufficient to provide coverage.

The following table summarizes the power per channel for FM type modulation schemes. At these carrier levels, the RF amplifier is operating in the linear mode.

**UHF HRU Derating Table**

Number of RF Channels	Power per Channel (FM)
1	36 dBm
2	33 dBm
4	30 dBm
8	27 dBm

#### 4.6 Power Amp ALC Threshold Setup

The following procedure illustrates how the ALC is set for the downlink. The same can be done for the uplink:

- 1) Set the downlink gain to maximum on the HRU by setting the step attenuators to 0dB (position F).
- 2) Inject a -60dBm carrier into the antenna port with an RF signal generator.
- 3) Measure the output signal level with a spectrum analyzer and a 20dB pad capable of 20W.

- 4) Continue to increase the input signal level with the signal generator until the output signal level does not increase. This is the current setting of the ALC.
- 5) To change the ALC setting, turn the potentiometer on the control board as shown below for the appropriate power amplifier.
- 6) The ALC setting is 31-41dBm at the DAS port or antenna port.



#### **4.7 Power Amp Forward Power Output Alarm Threshold Setting**

The Forward Power Output threshold setting is used to set an alarm when the output power level reaches 3dB above the ALC level. This is normally set at the factory. To adjust this to a different level, follow the following steps;

- 1) Set the downlink gain to maximum on the HRU by setting the step attenuators to 0dB (position F).
- 2) Inject a -60dBm carrier into the antenna port with an RF signal generator.
- 3) Measure the output signal level with a spectrum analyzer and a 20dB pad capable of 20W.
- 4) Continue to increase the input signal level with the signal generator until the required output level is reached.
- 5) Adjust the potentiometer on the alarm motherboard as shown below until the alarm LED comes on.



- 6) The alarm threshold has a range of 11-41dBm at the DAS or Antenna port.



## 5.0 Installation Procedures

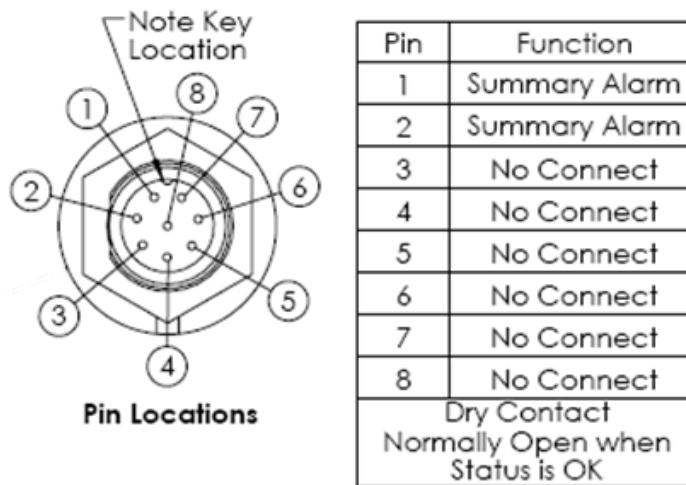
Fiber-Span's HRU is made to operate in a controlled environment such as a telecom room. It is recommended that the temperature inside the room does not exceed +50°C and be above -5°C. The humidity must be 10% to 95%.

### 5.1 Connectorization

The HRU is supplied with N-female connectors on all RF ports. It is highly recommended that 3 ft jumper cables be used to connect the HRU to coaxial cable, otherwise the RF ports will strip.

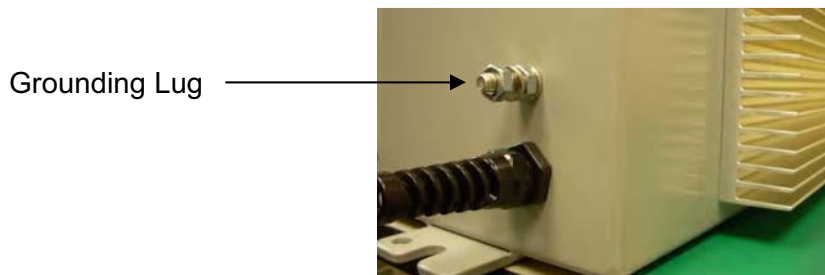
If the HRU is being used as a simple BDA and the downlink port and uplink port are unused, it is recommended that these ports be terminated with a 50Ω load.

The alarm port has an 8-pin male switch-craft connector and is shown below.



### 5.2 Grounding

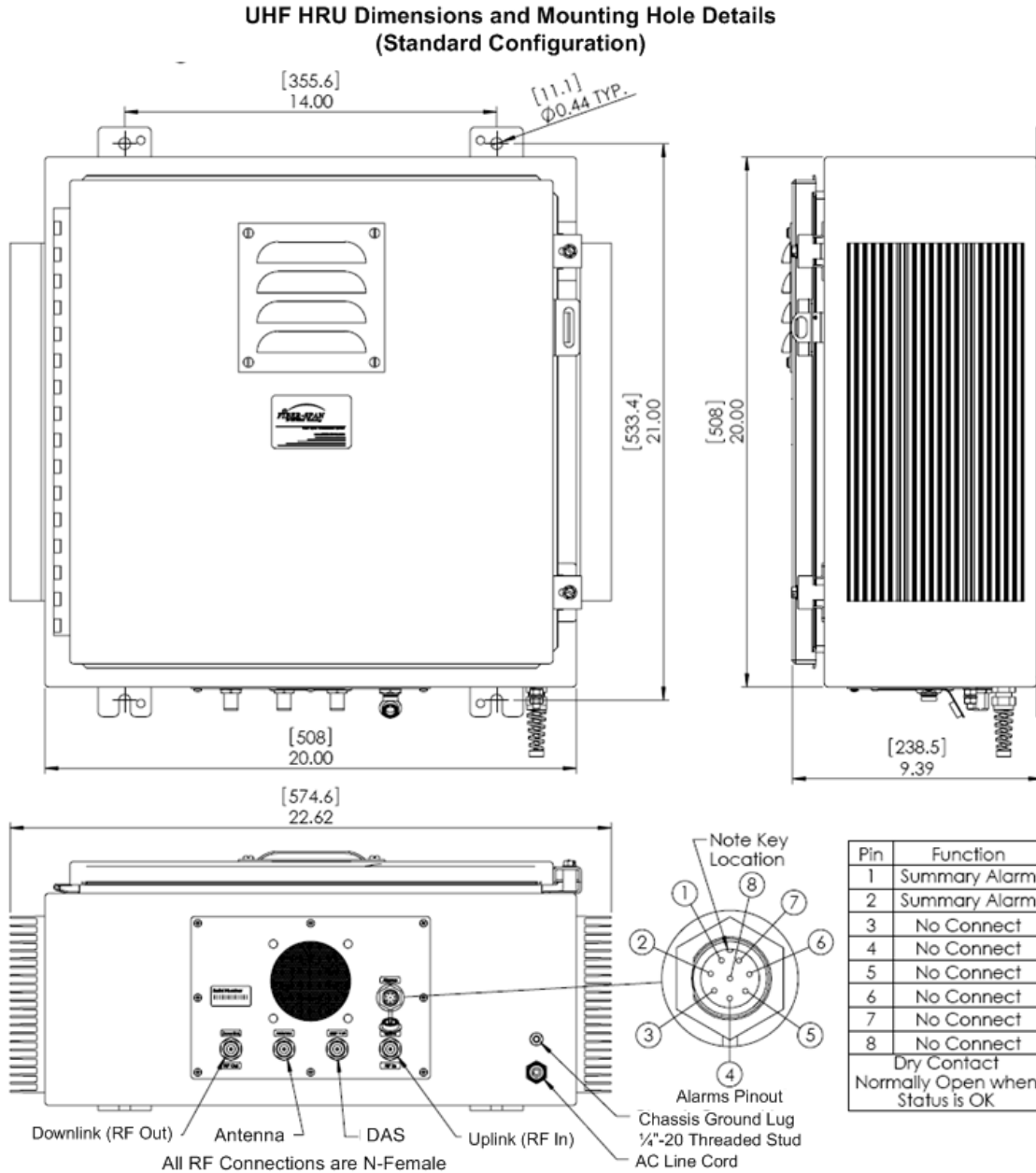
The HRU comes with a grounding lug. Unscrew the nut, remove the lock washer from the ground bolt of the RF BDA located on the bottom of the unit. Insert a 1 hole lug 6 gauge ground awg green THHN wire to the bolt. Slide the lock washer and nut to the bolt, tighten nut until lock washer is compressed. Situate the RF BDA 10 feet away or less from room ground bar. Connect the other end of the ground wire to the building room ground bar.



Surge protection is highly recommended for the coaxial feed to the external donor antenna to prevent damage to the unit during a direct lightning strike.

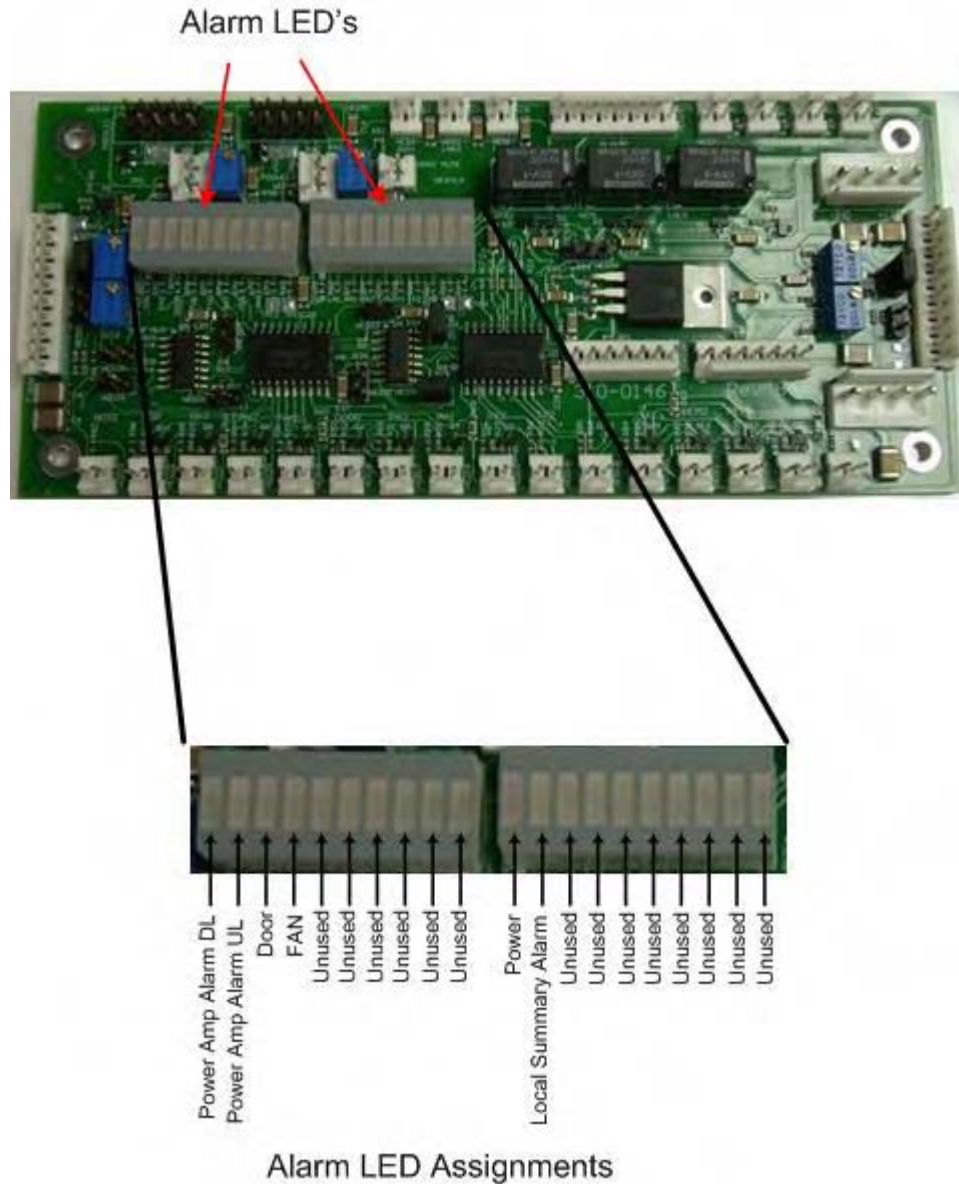
### 5.3 Adequate Anchors required

Bolts of adequate strength are required to mount the HRU which weights approx. 100lbs for the standard 20"x20"x9" configuration and 150lbs for the 24"x24"x9". A total of four (4) bolts are needed to mount the HRU. The bolt patterns for the HRU's are shown in the following diagrams.

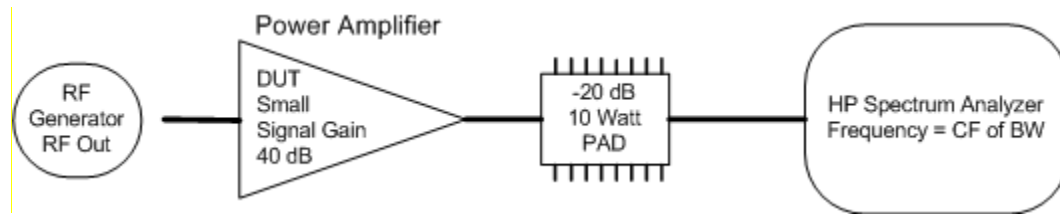


## 6.0 Troubleshooting

In order to trouble shoot the HRU, the alarm lights must be observed as shown in the alarms section.



Based on the LED's, if corrective action does not bring the unit into normal operation by reducing gain or reducing the input signal level, the unit is most like faulty. It is recommended that the gain of the power amplifier be verified by connecting it with a signal generator and spectrum analyzer as shown below after powering the unit off:



A 20dB (10W) attenuator is needed to ensure the RF output does not damage the spectrum analyzer. Most analyzers can accept a 20dBm composite RF input signal level. However, Fiber-Span recommends verifying the specifications of your analyzer prior to connecting to the Power Amplifier.

Set the signal generator and spectrum analyzer to the center frequency of the downlink/uplink frequency spectrum.

Set the RF output level of the signal generator to -40dBm. Verify that the gain of the amplifier is approx. 46dB typical by measuring +6dBm at the RF output taking into account the 20dB RF pad. If the gain is much different than 46dB, then the power amplifier must be faulty and needs replacement.

The ALC setting of the power amplifier is verified by increasing the input signal level of the signal generator. When the output signal level does not increase as the input signal level increases, the ALC level has reached the threshold. If the threshold needs adjustment, refer to the procedure in section 4.

## 6.1 Power LED Light

When the power supply has the correct DC output voltage, the LED will stay lit on the motherboard. Otherwise the LED will be off.

## 6.2 Door Lights

When the door is opened, one of the LED's on the alarm motherboard will be lit.

## 6.3 Amplifier Alarms

An amplifier alarm will trigger under the following condition: The RF power amplifier output power has exceeded the ALC and the PA alarm threshold LED is on. At the same time, the ALC LED on the amplifier will also be lit. It is recommended that the gain be reduced.

## 6.4 Fan Blockage

It is highly recommended that the fan screens be cleaned where the HRU is installed in very dusty or newly constructed environments. Clearing the fan screen will improve air circulation which will allow the unit to operate at a lower temperature increasing the MTBF of the unit.

## **7.0 Warranty Information**

The HRU carries a standard warranty period of one (1) year unless otherwise indicated on the shipping package as noted in the purchase order agreement.

### **7.1 Warranty Limitations**

The warranty is limited to the repair or replacement of the defective product. Fiber-Span will decide which remedy to provide for defective components at its own discretion. Fiber-Span shall have a reasonable time after determining that a defective product exists to repair or replace the problem unit. The warranty applies to repaired or replaced products for the balance of the applicable period of the original warranty or ninety (90) days from the date of shipment of a repaired or replaced component, whichever is longer.

The Fiber-Span standard warranty does not cover products which have been received improperly packaged, altered, or physically damaged. For example, broken warranty seal, labels exhibiting tampering, physically abused enclosure, broken pins on connectors, any modifications made without Fiber-Span authorization, will void all warranty.

### **7.2 Limitations of Damages**

The liability for any defective product shall in no event exceed the purchase price for the defective product. Fiber-Span has no liability for general, consequential, incidental or special damages.

### **7.3 Return Material Authorization (RMA)**

No product may be returned directly to Fiber-Span without first getting an approval from Fiber-Span. If it is determined that the product may be defective, you will be given an RMA number and instructions in how to return the product. An unauthorized return, i.e., one for which an RMA number has not been issued, will be returned to you at your expense. Authorized returns are to be shipped to the address on the RMA in an approved shipping container. It is suggested that the original box and packaging materials should be kept if a defective product needs to be shipped back to Fiber-Span. To request an RMA, please call 908-754-0646.

## Appendix A

### FCC requirements

To comply with FCC RF exposure compliance requirements, the following antenna installation and device operating configurations must be satisfied: A separation distance of at least 1 meter distance must be maintained between the antenna of this device and all persons. RF exposure compliance may need to be addressed at the time of licensing, as required by the responsible FCC Bureau(s), including antenna co-location requirements of 1.1307(b)(3). Maximum permissible antenna gain is 9 dBi for a 1 meter distance. Maximum permissible antenna gain is 15 dBi for a 2 meter distance. (Equipment manufacturers shall provide proper values for antenna gain).