



Manual  
Part #  
7-9603-1

**Installation and Operation Manual for  
the SBIII Digital Signal Booster  
Model 613-8 (with G1A or G2A mounting)**



**WARNING:** This is **NOT** a consumer device. It is designed for installation by **FCC Licensees** and **Qualified Installers**. You must have an **FCC license** or express consent of an FCC Licensee to operate this device. This booster can be configured as either a Class A or Class B signal booster. If configured as a Class B signal booster (as defined in 47 CFR 90.219), you **MUST** register this signal booster online at [www.fcc.gov/signal-booster/registration](http://www.fcc.gov/signal-booster/registration). Unauthorized use may result in significant forfeiture penalties, including penalties in excess of \$100,000 for each continuing violation.



## TERMS AND CONDITIONS OF SALE

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<http://www.birdrf.com/~media/Bird/Files/PDF/Sales/bird-terms-and-conditions-of-sales.ashx>

## DISCLAIMER

Product part numbering in photographs and drawings is accurate at time of printing. Part number labels on Bird products supersede part numbers given within this manual. Information is subject to change without notice.

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Version Number	Version Date
1	08/09/17

### Symbols Commonly Used

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WARNING



High Voltage



CAUTION or ATTENTION



Hot Surface



Important Information



ESD Electrostatic Discharge



Training Video Available



Electrical Shock Hazard

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## *Changes to this Manual*

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We have made every effort to ensure this manual is accurate. If you discover any errors, or if you have suggestions for improving this manual, please send your comments to our Solon, Ohio facility to the attention of the Technical Publications Department. This manual may be periodically updated. When inquiring about updates to this manual refer to the manual part number and revision number on the revision page following the front cover.



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#### **For Class A or Class B Unintentional Radiators**

This equipment has been tested and found to comply with the limits for a Class A or Class B digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which the user will be required to correct the interference at his own expense.

#### **Pour Classe-A ou Classe-B Radiateurs Involontaires**

Cet équipement a été testé et jugé conforme avec les limites de la Classe-A ou Classe-B des appareils numériques, suivants à la Partie 15 des règlements de la FCC. Ces limites sont conçues pour fournir une protection raisonnable contre les interférences dangereuses lorsque l'équipement est utilisé dans un environnement commercial. Cet équipement génère, utilise et peut émettre des fréquences radio et, s'il n'est pas installé et utilisé conformément aux instructions du manuel, ceci peut causer des interférences dangereuses aux communications radio. Le fonctionnement de cet équipement dans une zone résidentielle est susceptible de causer des interférences mauvaises dans lequel l'utilisateur sera tenu pour responsable de corriger l'interférence à sa propre discrétion.

**WARNING:** Changes or modifications which are not expressly approved by Bird could void the user's authority to operate the equipment.

**AVERTISSEMENT:** Les changements ou modifications qui ne sont pas approuvés par Bird pourrait annuler l'autorité de l'utilisateur de faire fonctionner l'équipement.



**ATTENTION:** 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.



**ATTENTION:** Cet appareil est conforme à la Partie 15 des règlements de la FCC. L'opération doit se conformer aux deux conditions suivantes: (1) cet appareil ne peut causer d'interférences nuisibles et (2) cet appareil doit accepter toute interférence reçue, y compris les interférences qui peuvent provoquer un fonctionnement indésirable.





## OVERVIEW

Signal boosters extend radio coverage into areas where abrupt propagation losses prevent reliable communication. The system receives an RF signal, raises its power level, and couples it to an antenna so that it can be re-radiated. The Bird 613-8 family of signal boosters is designed to operate in either the 700 or 800 MHz range. Dual-band models are available that include both 700 and 800 MHz systems in the same enclosure box. The system is based on a module design with each module capable of handling 14 or 30 filters in the uplink and downlink direction. The signal booster is available

in a variety of configurations as shown in **Table 1**. The product model number is used to describe each configuration available. Model number nomenclature is described in table 1.

The size of the system can be tailored to the customers needs by increasing or decreasing the number of filters used. Each module is bi-directional with one downlink and one uplink signal branch. Each of the two branches in a module are independently tunable to their required pass frequencies via software interface. The booster uses digital processing techniques to provide a wide

613-8XX-YYUD-Z-O (nomenclature breakdown)	
<b>613</b>	Designates product as 700 - 800 MHz channelized signal booster
<b>8XX</b>	Designates operating frequency band 3B = 764 - 806 MHz 9A = 806 - 869 MHz 3E = 764 - 869 MHz
<b>YY</b>	Designates how many modules are used and number of filters available A = 1 x 14 (700 MHz) or (800 MHz) filter B = 1 x 30 (700 MHz) or (800 MHz) filter AA = 1 x 14 (700 MHz) filter and 1 x 14 (800 MHz) filter BB = 1 x 30 (700 MHz) filter and 1 x 30 (800 MHz) filter AB = 1 x 14 (700 MHz) filter and 1 x 30 (800 MHz) filter BA = 1 x 30 (700 MHz) filter and 1 x 14 (800 MHz) filter
<b>UD</b>	Designates the type of output for the uplink and downlink HH = High Power Uplink and Downlink HL = High Power Uplink and Low Power Downlink LH = Low Power Uplink and High Power Downlink LL = Low Power Uplink and Downlink FH = High Power Fiber Remote FL = Low Power Fiber Remote HF = High Power Fiber Head-end LF = Low Power Fiber Head-end
<b>Z</b>	Designates mounting style G1A = Painted enclosure G2A = Stainless steel enclosure
<b>Options</b>	Designates the options that have been added Blank = no options added N = NFPA/IFC Configuration H = Head-end booster (Dual Port) R = Remote-end booster (Dual Port) 1 = 3 MHz Preselector, NPSPAC Pre-Rebanding (866 - 869 MHz) 2 = 3 MHz Preselector, NPSPAC Post-Rebanding (851- 854 MHz) 3 = 10 MHz Preselector (851-861 MHz)
<b>Table 1: Model number nomenclature.</b>	

Parameter	Specification
Frequency Range (MHz) 700 Band 800 Band	764 - 776 and 794 - 806 806 - 824 and 851 - 869
Filters	14 - 30 uplink filters per band 14 - 30 downlink filters per band
Maximum Gain *	95 dB
Filter Bandwidth	Programmable standard filters include 12.5 KHz, 12.5 KHz low delay, 25 KHz, 3 MHz, 9 MHz. Other custom filters can be configured by the user or factory to meet specific system requirements.
Output Level High Power Low Power	+34 dBm +22 dBm
Maximum Input Level	-20 dBm
RF In/Out Impedance	50 Ohms Nominal
Alarms	Form-C Contacts (NO or NC)
Power	90 - 250 VAC, 50/60 Hz or +24 VDC
Operating Temperature Range	-30°C to +60°C
* <b>Note:</b> The booster ships from the factory with the gain adjusted to 60 dB. The customer should adjust the gain higher only after verifying there is sufficient antenna isolation. Refer to the section of this manual titled Antenna Isolation.	
<b>Table 2:</b> System specifications.	

range of filter choices to the end user. It is possible to program digital filters as narrow as 6.5 KHz and as wide as 3.0 MHz centered at any frequency within the licensed range.

The SBIII Digital Signal Booster is capable of operating as either a Class A booster (no filters greater than 75 KHz passband width) or as a Class B booster (having filters with a greater than 75 KHz passband width). The boosters operating class (A or B) is user determined via configuration. Class B operation must be enabled by the customer and the customer is responsible for registering a booster operated as Class B with the FCC. System specifications for the 613-8 family of signal boosters are listed in **Table 2**.

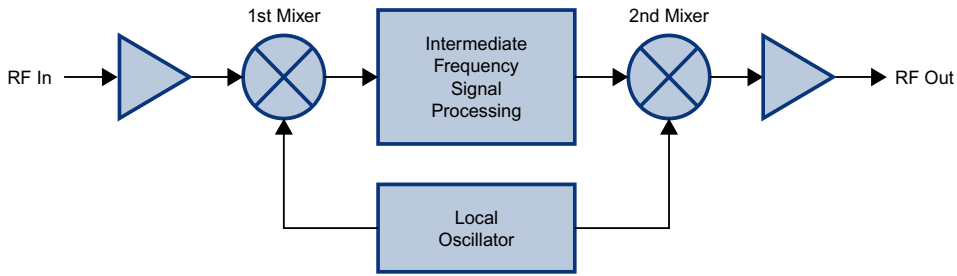
### SBIII Options

There are optional configurations available for the SBIII booster as shown in table 1. Each of these

optional configurations must be installed in the booster at the time of manufacture. A brief discussion of each option is provided below.

**N** = With this option installed the booster is capable of meeting NFPA/IFC compliance requirements. In an NFPA compliant booster the alarm terminal interface is expanded out to five sets of alarm contacts. In addition, A bias-T circuit is installed in the booster and a remote antenna line sensor is provided.

**H** = The antenna connection for the service side of the booster is split into an individual uplink and downlink connector. This allows the booster to operate as the head-end in a multi-booster system. This option is typically used when the booster is connecting to a fiber optic transceiver. Extra filtering is included in the booster as needed.



**Figure 1:** The down converter / up converter process.

**R** = The antenna connection for the donor side of the booster is split into an individual uplink and downlink connector. This allows the booster to operate as a remote booster in a multi-booster system. This option is typically used when the booster is connecting to a fiber optic transceiver. Extra filtering is included in the booster as needed.

**1** = A 3 MHz preselector is included at the donor antenna port. The preselector will be tuned at 866 - 869 MHz.

**2** = A 3 MHz preselector is included at the donor antenna port. The preselector will be tuned at 851 - 854 MHz.

**3** = A 10 MHz preselector is included at the donor antenna port. The preselector is tuned at 851 to 861 MHz.

### Down / Up Conversion

A channelized signal booster has much in common with a superheterodyne (superhet) receiver. The incoming signal is converted to a lower frequency so that single channel selectivity can be obtained. It is then filtered. Unlike the superhet receiver however, the signal is not demodulated. Instead, it is up-converted back to its original frequency where it is further amplified to reach a useful power level.

**Figure 1** shows a simplified block diagram that illustrates the down/up conversion principle. An incoming signal at (Freq IN) is amplified and applied to the first mixer along with a signal from a local oscillator (Freq LO). A third signal at an intermediate frequency (Freq IF) is produced as a result of the mixing. The intermediate frequency is given by the following relationship:

$$(1) \text{ Freq IF} = \text{Freq IN} - \text{Freq LO}$$

The IF signal from the mixer then passes through digital filtering with single channel bandwidth before being amplified and passed on to the second mixer. The second mixer also receives the same local oscillator signal (Freq LO). The result is a mixing product frequency at the output of mixer 2. The output frequency (Freq OUT) is given by the following relationship:

$$(2) \text{ Freq OUT} = \text{Freq IF} + \text{Freq LO}$$

Substituting equation (1) for the “Freq IF” term in equation (2) allows the “Freq LO” terms to be canceled yielding:

$$(3) \text{ Freq Out} = \text{Freq IN}$$

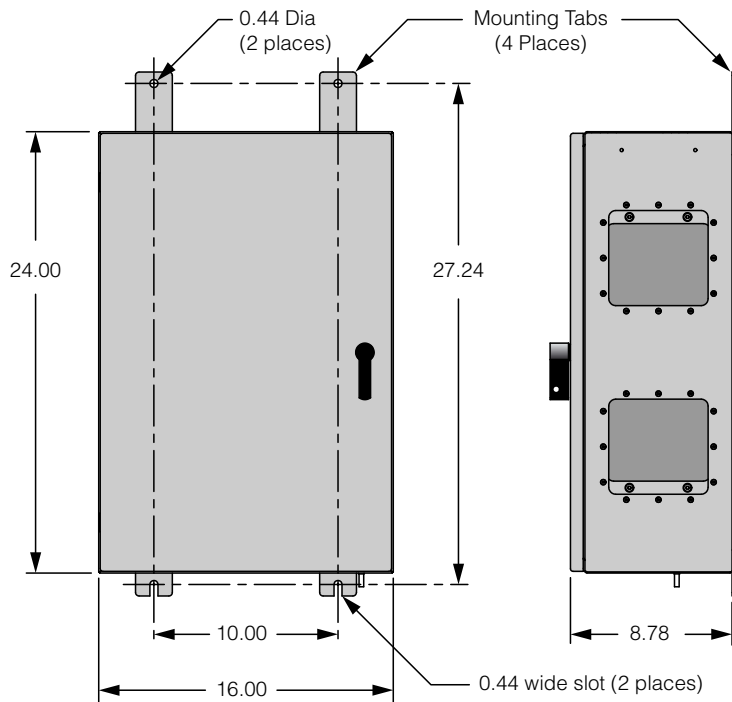
The implication of equation (3) is that the frequency stability of the signal that is processed by this type of signal booster is not affected by the frequency stability of the signal booster itself. Frequency stability depends only on the stability of the signal source producing the signal to be boosted. A shift in the LO frequency will cause the center of the filter bandwidth to move with respect to the signal. For very narrow filter widths, the channel modules LO may be locked to a high stability 10 MHz reference.

### UNPACKING

It is important to report any visible damage to the shipping company immediately. It is the customers responsibility to file damage claims with the shipping company within a short period of time (1 to 5 days). Care should be taken when removing the unit from the packing box to avoid damage to the unit.

### INSTALLATION

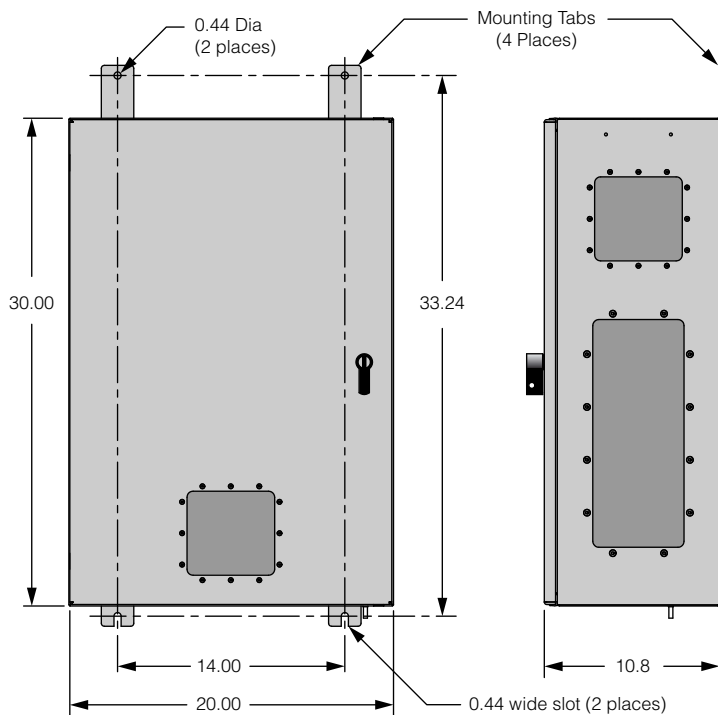
The following sub-sections of the manual discuss general considerations for installing the booster. All



**Lockable Door Latch**  
(user supplied padlock)

**Note:** To open the door handle insert a slotted screw driver into the silver slot and turn to the vertical position. At the same time turn the black handle. This will release the latching mechanism and the door can now be opened. When the door is closed and the black handle is turned down, the silver slot will reset to the horizontal position re-enabling the latching mechanism.

**Figure 2A:** Cabinet mounting hole layout for single-band boosters.



**Lockable Door Latch**  
(user supplied padlock)

**Note:** To open the door handle insert a slotted screw driver into the silver slot and turn to the vertical position. At the same time turn the black handle. This will release the latching mechanism and the door can now be opened. When the door is closed and the black handle is turned down, the silver slot will reset to the horizontal position re-enabling the latching mechanism.

**Figure 2B:** Cabinet mounting hole layout for dual-band boosters.

work should be performed by qualified personnel and in accordance with local codes.

### Location

The layout of the signal distribution system will be the prime factor in determining the mounting location of this unit. However, safety and serviceability are also key considerations. The unit should be located where it can not be tampered with by the general public, yet is easily accessible to service personnel. Also, consider the weight of the unit and the possibility for injury if it should become detached from its mounting for any reason.

The booster needs to be installed such that there can be unobstructed air flow around the equipment. Ensure that the heat sink fins are unobstructed. The various subassemblies within the equipment cabinet will stay warm during normal operation so in the interest of equipment longevity, avoid installation locations that carry hot exhaust air or are continually hot.

### Mounting

**Figures 2A and 2B** show the mounting hole dimensions and layout for the single-band and the dual-band enclosure. Mount the cabinet using 3/8" (10 MM) diameter steel bolts (not supplied). We recommend flat washers on both ends and a lock washer under the nut. Nut and bolt mounting is preferred to the use of lag bolts. Use backer blocks where necessary to spread the force over a larger area. In areas of known seismic activity, additional devices such as tether lines may be necessary.

Because Bird cannot anticipate all of the possible mounting locations and the structure types where these devices will be located, we recommend consulting local building inspectors, engineering consultants or architects for advice on how to properly mount objects of this type, size and weight in your particular situation. It is the customer's responsibility to make sure that these devices are mounted safely and in compliance with building codes.

### Cable Connections

All cabling connections to the booster should be made and checked for correctness prior to powering up the system. RF cables are connected at the top of the booster cabinet while power (both AC and DC) as well as alarm connections are made inside the cabinet via conduit openings located at the bottom or top of the cabinet.

### AC LINE CONNECTION

The signal booster is designed to be hard-wired to a single phase AC line supplying 90 - 250 VAC at 50/60 Hz. The power supply assembly used in the booster is auto ranging so there is no voltage select switch (110/240) on the power supply assembly. Bring the AC line into the cabinet through a conduit opening in the bottom or top of the enclosure as shown in **Figure 3**. Connect the hot and neutral wires to the input of the AC circuit breaker and connect the earth ground wire to the cabinet ground connection as shown in **Figure 4**. Use conduit for running the AC wiring into the enclosure and #14 gauge or larger conductors. The AC feed line should have an independent circuit breaker (a 15 Amp breaker is recommended).

### DC POWER CONNECTION

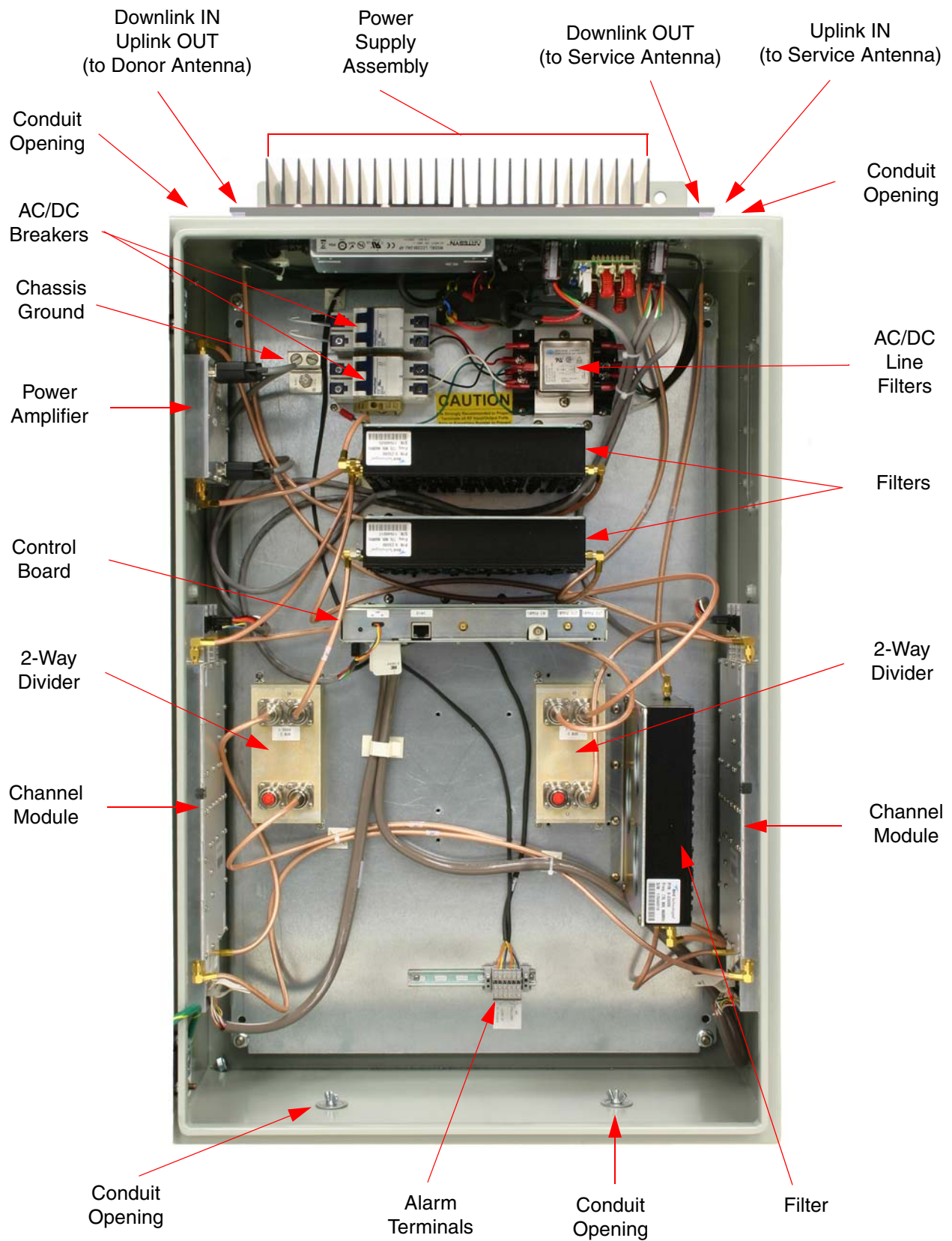
The booster may be run on a 24 VDC backup power source. Bring the DC power line into the cabinet through a conduit opening in the top or bottom of the enclosure and connect the red (+) and black (-) feed lines to the DC circuit breaker. Use a conduit for running the DC wiring into the enclosure. The booster will automatically switch to this backup DC source when the AC supply fails for any reason including a power outage or intentional disconnection. It is not necessary that the DC hookup be made for normal booster operation on the AC line.

### ALARM CONNECTIONS

Alarm Form-C contact terminals are located on the main mounting panel inside the enclosure as shown in figure 4. These terminal contacts are intended for connection to the customer's supervisory data acquisition system or a fire panel in the case of an NFPA compliant signal booster system.

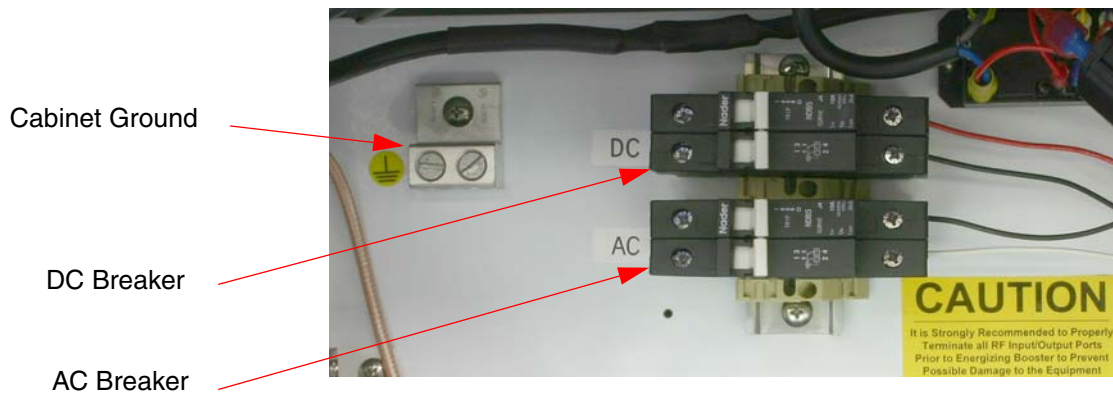
In a non-NFPA compliant signal booster two alarm functions are available including Summed Alarm and Loss of AC. In a fully NFPA compliant signal booster three additional alarm functions are provided including Antenna Malfunction, Charge Fail, and Low Battery.

The normal condition for the booster is power applied, the booster operating as usual, and no alarms occurring in the booster or the battery backup unit. Under these normal conditions there will be continuity between Com and NC alarm terminal contacts and no continuity between the Com and NO contacts. When an alarm condition occurs the alarm terminal contacts will change state. The



**Figure 3:** Front view of the typical booster with the door removed for clarity.





**Figure 4:** AC/DC Circuit Breakers.

alarm terminal strip uses screw terminals for ease of connection. Route the alarm wires through one of the conduit openings at the top or bottom of the enclosure, strip about 3/16" of insulation from the end of each wire and attach to the appropriate terminal screw. Alarm connections should be made with suitable hook-up wire typically between #20 to #22 gauge and in accordance with any local wiring codes.

#### NFPA COMPLIANCE

The signal booster is designed to be compliant with the national public safety in-building codes issued in the International Fire Code and by the National Fire Protection Association. The booster accomplishes compliance when used in conjunction with an appropriate battery backup unit. An optional battery backup unit is available from Bird including the models 6160-110-24-NR and the 6160-220-24-NR battery backups. Detailed installation and operating instructions for the battery backup unit are included with the backup unit when it ships from the factory.

An NFPA compliant signal booster system is designed to easily interface to fire alarm panels. Five alarms are provided including SB Failure (FAIL), Loss of AC Power (AC), Charge Fail (CHG), Antenna Malfunction (ANT), and Low Battery Capacity (BAT). These five alarm functions are available at the terminal contacts shown in figure 4. The terminals provide a common access point to the alarm signal relay contacts. Available alarm functions include;

**SB Failure** - this is a summed alarm that is active when any number of fault conditions arise within the booster unit such as when an over current or high temperature event occurs.

**Loss of AC Power** - indicates that AC power to the booster unit has failed.

**Low Battery Capacity** - the source of this alarm is the battery backup unit and it indicates that the battery backup voltage level has dropped significantly.

**Charge Fail** - the source of this alarm is the battery backup unit and it indicates failure of the battery charger. If the battery charger loses AC power this alarm will be active.

**Antenna Malfunction** - indicates there is a loss of RF cable integrity between the signal booster unit and the remote antenna line sensor. In order to detect an antenna malfunction an antenna line sensor must be installed as close to the Donor antenna as possible. This sensor works with the Bias-T circuit inside the booster cabinet to verify the continuity of the antenna line. Refer to **Figure 5**. The sensor is waterproofed but the connections to both the antenna and the antenna feedline should be sealed to prevent water entry. We recommend that the connections be tightly and completely wrapped with rubber splicing tape. Connect the port that is labeled "antenna" on the sensor to your donor antenna and the port that is labeled "transline" to the antenna feedline cable coming from the signal booster.





**Figure 5:** The remote antenna line sensor. (part# TXR-036)

All five of the alarms use “supervising” alarm circuits. A supervised circuit includes technology that will detect open or shorted circuits regardless of the alarm status. This is accomplished by using EOL (end-of-line) resistors at the alarm terminal strip in the signal booster cabinet. The value of the EOL resistors is a function of the alarm panel so you should consult the manual for the alarm panel when you are determining the resistor value.

#### RF CONNECTIONS

N(f) bulkhead connectors are available at the top of the booster enclosure box for connection to the system antennas as shown in **Figure 6**. Make sure the correct branch of the antenna system is con-

nected to its corresponding uplink/downlink connector or the system will not work properly. Using high quality connectors with gold center pins is advised. Flexible jumper cables made of high quality coax are also acceptable for connecting to rigid cable sections.



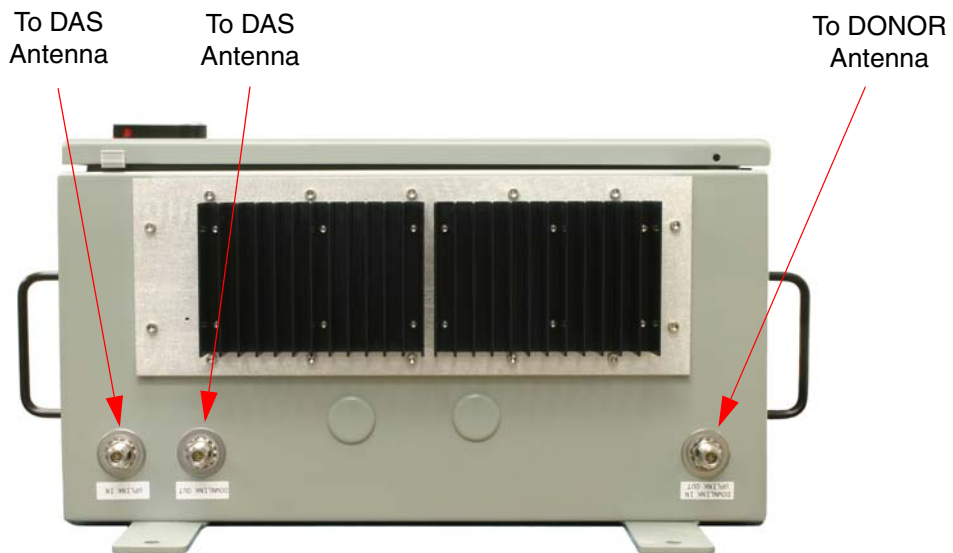
**Caution:** RF ports must be terminated before energizing booster. The ERP (effective radiated power) from the booster system must not exceed +37 dBm (5 Watts) in order to remain compliant with FCC regulations.



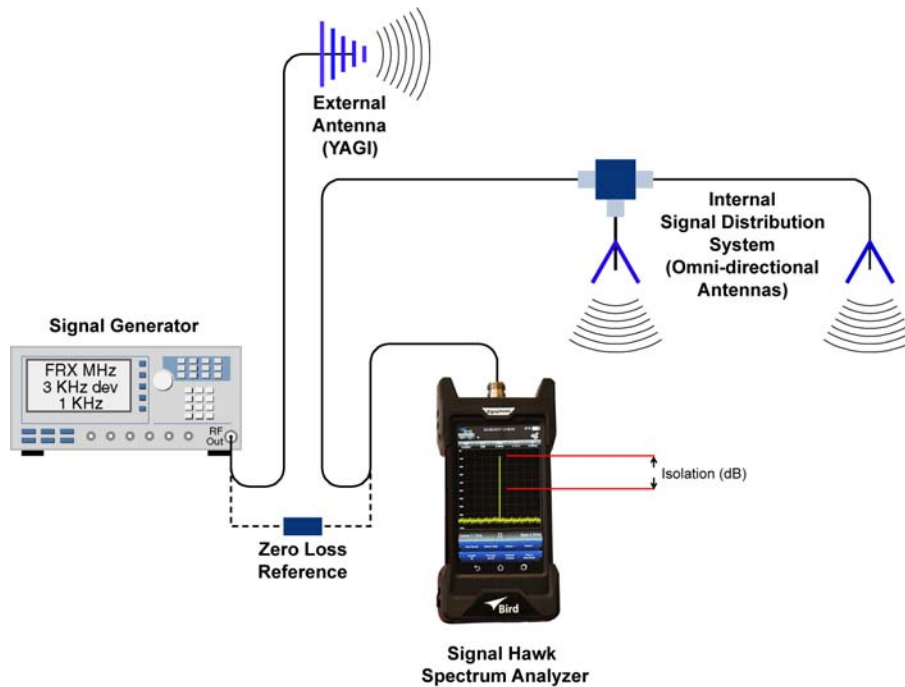
**Caution:** The maximum continuous input power level for this booster is -20 dBm. Stronger input signals will cause the unit to exceed it's IM specifications. Static input signals greater than -10 dBm may damage the unit. **NOTE:** For fiber feed boosters please refer to **Appendix B** for a discussion of the input power levels associated with the fiber fed side of the booster.

#### PRE-RF CONNECTION TEST

Antenna isolation between uplink and downlink should be measured before connecting the signal booster to the antenna system. This step is necessary to insure that no conditions exist that could



**Figure 6:** Connections at the top of the booster cabinet.



**Figure 7:** Typical test equipment interconnection for measuring antenna isolation.

possibly damage the signal booster and should not be skipped for even the most thoroughly designed system.

### Antenna Isolation

Just like the feedback squeal that can occur when the microphone and speaker get too close together in a public address system, a signal booster can start to self oscillate. This can occur when the isolation between the Uplink and Downlink antennas does not exceed the signal boosters gain by at least 15 dB. Oscillation will reduce the effectiveness of the system and may possibly damage amplifier stages. Isolation values are relatively easy to measure with a spectrum analyzer and signal generator.

### REQUIRED EQUIPMENT

The following equipment is required in order to perform the antenna isolation measurements.

- 1) Signal generator for the frequencies of interest capable of a 0 dBm output level. Modulation is not necessary.
- 2) Bird "Signal Hawk" spectrum analyzer which will cover the frequencies of interest and is capable

of observing signal levels down to -135 dBm or better.

- 3) Double shielded coaxial test cables made from RG142, RG55 or RG223 coaxial cable.

### MEASUREMENT PROCEDURE

To measure the antenna isolation perform the following in a step-by-step fashion.

- 1) Set the signal generator for a 0 dBm output level at the center frequency of the boosters passband.
- 2) Set the spectrum analyzer for the same center frequency and a sweep width equal to or just slightly greater than the passband chosen earlier in step 1.
- 3) Temporarily connect the test leads of the signal generator and spectrum analyzer together using a female barrel connector, see **Figure 7**. Observe the signal on the analyzer and adjust the input attenuator of the spectrum analyzer for a signal level that just reaches the 0 dBm level at the top of the graticule.

- 4) Referring to figure 7, connect the generator test lead to one side of the antenna system and the spectrum analyzer to the other side of the antenna system then observe the signal level. The difference between the observed level and 0 dBm is the isolation between the sections. If the signal is too weak to observe, the spectrum analyzer's bandwidth may have to be narrowed and its input attenuation reduced. The isolation value measured should exceed the signal booster's gain figure by at least 15 dB.
- 5) Repeat step 4 again with the signal generator set at the passband edges in order to see if the isolation is remaining relatively constant over the complete width of the passband.
- 6) Repeat the isolation measurements if necessary at other system passbands to determine the overall minimum isolation value for the system. Physical modification of the antenna system maybe required in order to reach an acceptable minimum value.

### RF EXPOSURE

To comply with FCC RF exposure compliance requirements, a separation distance of at least 100 cm must be maintained between the Donor antenna of this device and all persons. This device must not be co-located or operating in conjunction with any other antenna or transmitter.

### EXPOSITION RF

Pour conformer aux exigences d'exposition de FCC RF, une distance de séparation d'au moins 100 cm doit être maintenue entre les Donor antenne de cet appareil et toutes les personnes. Cet appareil ne doit pas être co-localisé ou exploités en conjonction avec toute autre antenne ou transmetteur.

### SIGNAL FLOW BLOCK DIAGRAMS

The signal booster is available as either a single-band model or a dual-band model. Single-band models are constructed with a single channel module tuned to pass either the 700 or 800 MHz bands. Dual-band models are constructed with two channel modules, one tuned to pass the 700 MHz band signals and one tuned to pass 800 MHz band signals.

The individual channel module is bi-directional containing one downlink branch and one uplink branch. The branches within the module are functionally identical because the same circuit board designs are used in each branch. The uplink and downlink branches may be programmed to pass any frequency in their appropriate passband. **Figure 8** is the signal flow block diagram of the typical single-band booster and **Figure 9** is the signal flow block diagram of the typical dual-band booster.

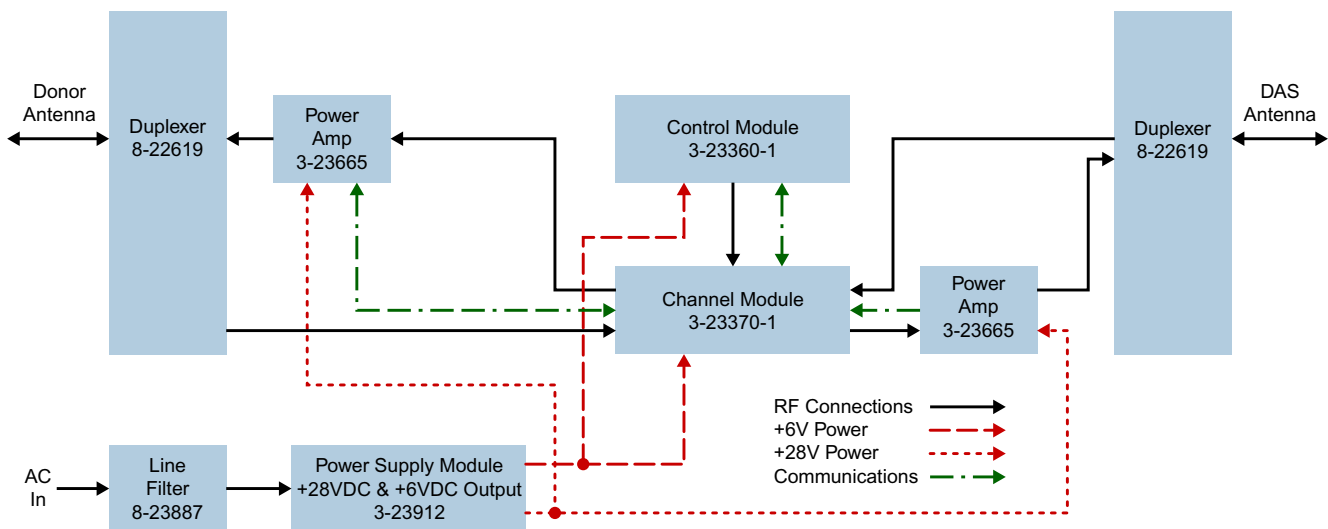
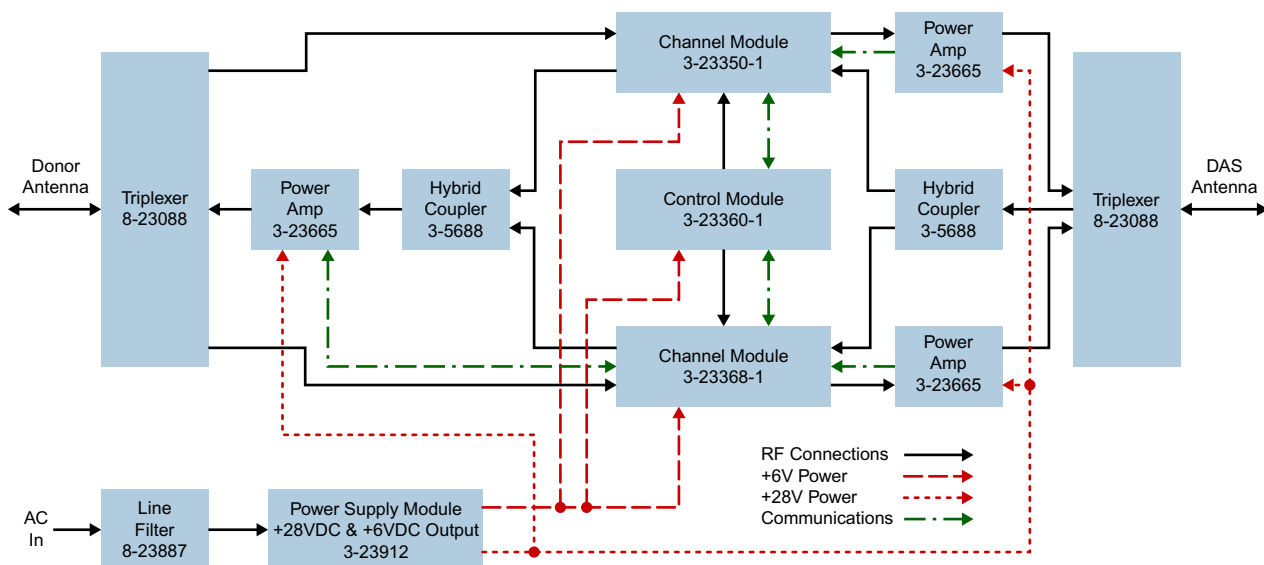


Figure 8: Signal flow block diagram of the single-band booster.



**Figure 9:** Signal flow block diagram of the dual-band booster.

#### UPLINK AND DOWNLINK INPUT SIGNALS (SINGLE-BAND BOOSTER)

Uplink input signals are received by the DAS antenna and applied to the duplexer. The uplink input signals pass through the duplexer and are fed into the uplink input port of the channel module. Downlink input signals are received by the Donor antenna and applied to the duplexer. The downlink input signals pass through the duplexer and are then applied to the downlink input of the channel module.

#### UPLINK AND DOWNLINK INPUT SIGNALS (DUAL-BAND BOOSTER)

Uplink input signals are received by the DAS antenna and applied to the triplexer. The uplink input signals pass through the triplexer and are fed into a directional coupler where they are distributed to the uplink input port of both the 700 and 800 MHz channel modules.

Downlink input signals are received by the Donor antenna and applied to the triplexer. The downlink input signals pass through the triplexer and exit at either the 700 or 800 MHz output port. The 700 and 800 MHz downlink input signals are then applied to the downlink inputs of the respective 700 and 800 MHz channel modules.

#### CHANNEL MODULE

The uplink input signals and the downlink input signals are applied to their respective down-converter boards when they enter the channel module. Within the channel module the input signals are down converted, digitized, and then DSP filtering is performed. There are two styles of channel modules available, a 14 filter version and a 30 filter version. After DSP filtering the analog signal is recreated and up-converted to the original frequency before being transmitted from the channel module at the downlink and uplink output ports.

Channel modules are available in two different output powers, a high-level output and a low-level output. If the signal booster is a high-power model, a low-level channel module is used in conjunction with a power amplifier in the system. If the booster is a low-power model, then a high-level channel module is used without amplification. Signal booster models that have the fiber optic option installed in them have enhanced down-converter boards that are capable of handling the high level signals (0 dBm typ) from the optical conversion.

#### UPLINK AND DOWNLINK OUTPUT SIGNALS (SINGLE-BAND BOOSTER)

Uplink and Downlink output signals leave the channel module at the UL OUT and DL OUT connectors respectively. The downlink and uplink output sig-

nals are then passed on to a power amplifier stage. The output of the power amplifier is passed through a duplexer then radiated from the donor or DAS antenna respectively.

### UPLINK AND DOWNLINK OUTPUT SIGNALS (DUAL-BAND BOOSTER)

Uplink and Downlink output signals leave the channel module at the UL OUT and DL OUT connectors respectively. The 700 and 800 MHz uplink output signals are combined with a directional coupler then passed on to a power amplifier stage. The output of the power amplifier is passed through a triplexer then radiated from the donor antenna. Downlink output signals leave the channel module and are applied to a power amplifier stage. The output of the power amplifier is passed through a triplexer then radiated from the DAS antenna.

### SYSTEM SETUP

The design of the signal booster allows for the first three filters to be programmed to pass either wideband or narrowband signals. Wideband signals are considered to be those with a bandwidth wider than 1 MHz while narrowband signals are those with a bandwidth narrower than 1 MHz. Subsequent filters after the first three must be programmed to pass narrowband signals. Note that for Class A operation the occupied filter bandwidth of all filters is limited to 75 KHz. If there are any filters in the occupied bandwidth above the 75 KHz threshold then the booster is operating in the Class B mode. If configured as a Class B signal booster (as defined in 47 CFR 90.219), you MUST register this signal booster online at [www.fcc.gov/signal-booster/registration](http://www.fcc.gov/signal-booster/registration).

Typically the filter bandwidth is usually kept small, such as one of the predefined bandwidths of 12.5, 25, or 12.5 KHz low delay. In areas where group delay is a concern the filter rejection bandwidths or rejection amount can be modified using the filter design tool.



When programming a filter for wideband it is important to note that the filter cannot be programmed wider than the hardware filter being used in the booster design.

When the booster is shipped from the factory it is programmed in a generic fashion as follows; the first wideband filter will be set to 500 KHz above the lowest frequency in the band, the second wideband filter will be set to the center frequency of the band, and the third wideband filter will be set to 500 KHz below the highest frequency in the band. All of these filters will be set up as 12.5 KHz low delay filters. In addition, the gain of the booster is factory set for 60 dB. The customer should adjust the gain higher only after verifying there is sufficient antenna isolation. Refer to the section of this manual titled Antenna Isolation. Changes to this initial setup are the customer's responsibility. If you need help with programming your frequencies please contact your sales representative at Bird.

### OPERATION

Power is applied to the booster by turning the circuit breakers inside the cabinet to the ON position. Both the AC and DC breakers are ganged so they function as a 2-pole switch. When the unit is powered ON there are LED's located on several of the subassemblies within the cabinet that will become

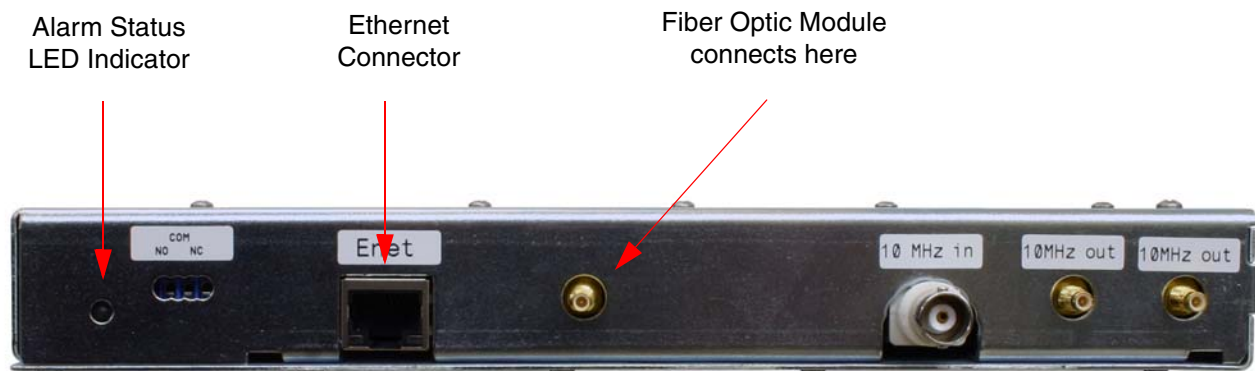


Figure 10: Ethernet connector on the control board.

illuminated to indicate the ON condition. The function of each of these indicator LED's are listed in **Table 3**.

### COMMUNICATING WITH THE BOOSTER

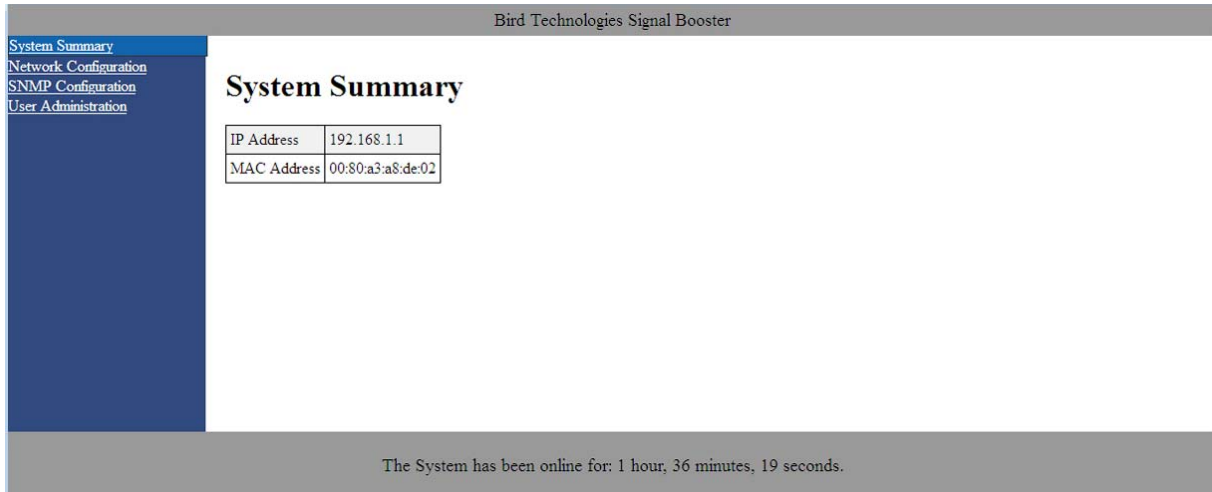
The booster provides Ethernet connectivity that allows access to a web-based user interface for communicating with the control board, programming the individual filters, checking system status,

etc. Communications will require connecting your laptop computer to the Ethernet connector on the control board. **Figure 10** shows the connector. A standard Ethernet (cross-over or straight-through) cable is used to make the connection between your laptop computer and the booster cabinet. Refer to **Appendix A** at the back of this manual for detailed instructions on how to properly connect your laptop computer to the Ethernet port of the booster.

Location	Label	Possible States	Causes	Action to take
Bottom of channel module	DL/UL PWR	Green solid	FPGA successfully loaded	None
Bottom of channel module	DL/UL PWR	Off	Issue with board	Return to factory
Bottom of channel module	DL/UL COM	Red flashes	Exchanging data with control board	None
Bottom of channel module	DL/UL COM	Red solid	Exchanging data with control board	None
Bottom of channel module	DL/UL COM	Off	No data exchanging	None
Bottom of channel module	DL/UL COM	Always Off and it is expected to flash	No data exchanging	Check cabling; return control board to factory
Bottom of channel module	DL/UL DAC	Red solid	DAC overflow	Lower output power setting
Bottom of channel module	DL/UL DAC	Off	DAC normal operation	None
Bottom of channel module	DL/UL ADC	Red solid	ADC overflow	Increase down converter attenuation
Bottom of channel module	DL/UL ADC	Off	ADC normal operation	None
Control board	Alm Status LED	Off	no power, no bootloader, no program	Return to factory
Control board	Alm Status LED	Orange	bootloader installed, no program	return to factory or perform field update
Control board	Alm Status LED	Red	Control board detected a fault	Address fault condition. Contact factory
Control board	Alm Status LED	Green solid	Control board normal operation	None
Power Amplifier	+6 V	Green solid	6 VDC supply to Amplifier is OK	None
Power Amplifier	+6 V	Off	No supply voltage	check power supply and cabling
Power Amplifier	+28 VDC	Off	Power Amp normal operation	None
Power Amplifier	+28 VDC	Red solid	Over current, over temp	Amp shut down, contact factory

**Table 3:** Subassembly LED descriptions.





**Figure 11:** System Summary submenu.

### System Summary Submenu

Once your laptop computer is properly connected to the signal booster the web-based user interface screen will appear as shown in **Figure 11**. This is the System Summary page which shows the IP and MAC address of the control module. On the left-hand side of the screen are a list of the major submenus available to the user including System Summary, Control Panel, Network Configuration, SNMP Configuration, and User Administration.



When the webpage first comes up, the Control Panel menu choice will not be displayed. The user needs to go to the User Administration Page and type in the default user name (**admin**) and default user password (**admin**). After this login function is performed the Control Page menu choice will appear.

Place your cursor over a particular menu heading and left click to make a selection. Each submenu page contains a group of related functions. Without entering your user password the user will only be able to view the pages however and will not be able to make changes without entering a password. After entering a valid password via the Admin submenu the pages will switch from read-only to fully interactive and the user can begin making selections and changes if desired.

### Control Panel Submenu

The Control Panel submenu gives the user the ability to interface with and adjust the RF parameters of the booster. Four tabs are available on the Control Panel Page including FILTERS, FILTER DETAIL, LINK, and SYSTEM. When selected each tab presents a new screen and each screen contains a group of related functions. Selection is made by placing your cursor over the tab and performing a left click.

#### FILTERS TAB

The Filters page gives an overview of all the filters associated with each branch in the booster system. Refer to **Figure 12**. The link drop-down box allows you to select which branch you want to overview. Press the down arrow button and highlight the desired branch. Each filter is accorded one row in the display. The first row of displayed data is used to provide a summation of the input and output power for the branch. The parameters displayed for each filter include; Center frequency, Bandwidth, Channel enabled, Test signal, Squelch, Input signal level as both a numeric value and a bar graph, Maximum allowed output level, and Output signal level as both a numeric value and a bar graph. Changes to the filters are made from the Filter Detail page.

The enable, test signal, and squelch boxes are interactive on this display. Place a check mark in the box when you want the function selected. Place your mouse cursor over the box and left click. A check mark placed in the box for enable, test sig-

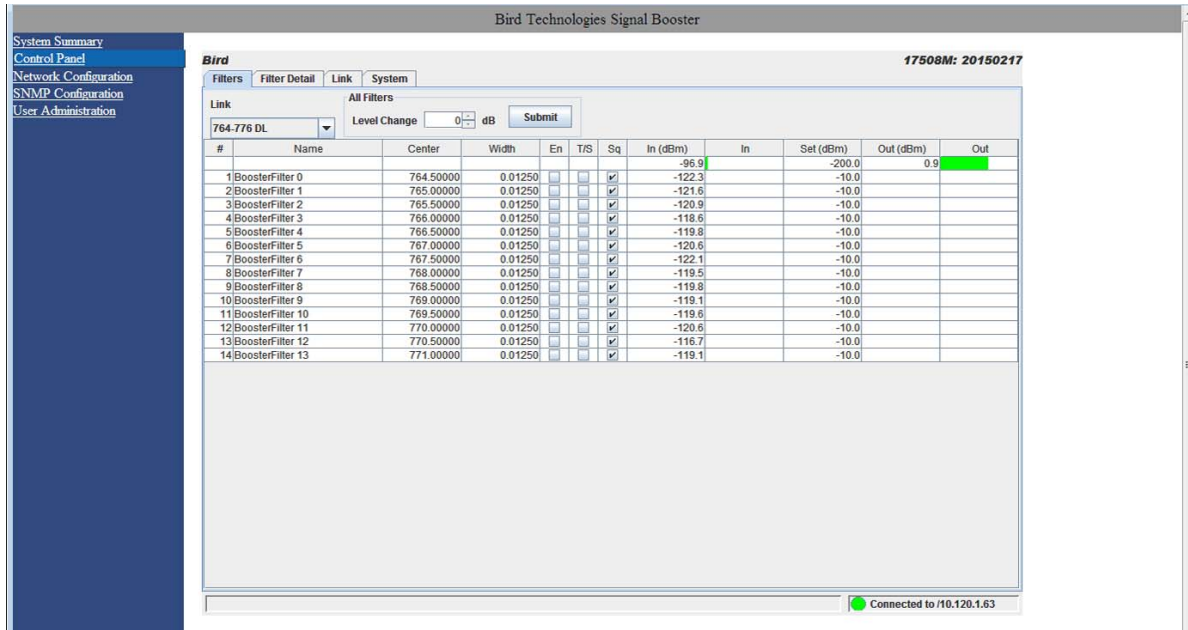


Figure 12: The Filter Summary tab.

nal, or squelch indicates that function is turned on while no check mark indicates the function is turned off. The All Filters area at the top of the page allows the user to adjust the Maximum Output Level of all the filters in a branch simultaneously. Use the up or down arrow to set the level change amount then press the submit button.



On start-up, the booster validates the widths of programmed filters. If any are configured wider than 75 KHz and the booster is set to Class A mode an error message as shown in **Figure 13**

will appear. The offending filter or filters must be corrected or the booster must be switched to Class B mode. Refer to the System Page discussion later in this manual for instructions on switching from Class A to Class B mode of operation.

#### FILTER DETAIL TAB

The Filter Detail page is divided into three functional areas. The first area includes a pair of drop down boxes along with a row of command buttons running down the left side of the screen. The second area is a filter details area in the middle of the screen. The third is a status area on the right side of the screen as shown in **Figure 14**. Once you have interactive access to the Filter Detail page

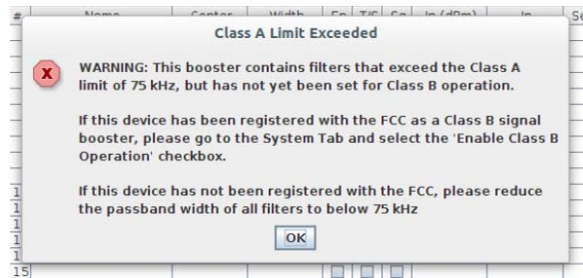


Figure 13: Class A limit exceeded warning message.

you can begin programming the individual filters that you want the booster to pass in the uplink and downlink directions.

The Filter Detail page is designed to interact with one filter at a time. To program individual filters you must select the branch and the filter of interest using the Link and Filter boxes on the left side of the screen. Once the filter has been selected for interaction a label can be assigned to the filter by typing into the name box. Three groups of characteristics need to be defined including frequency band, OLC, and filter specifics. Frequency band is selected from a drop down list. Center Frequency and Desired Output Power level must be entered



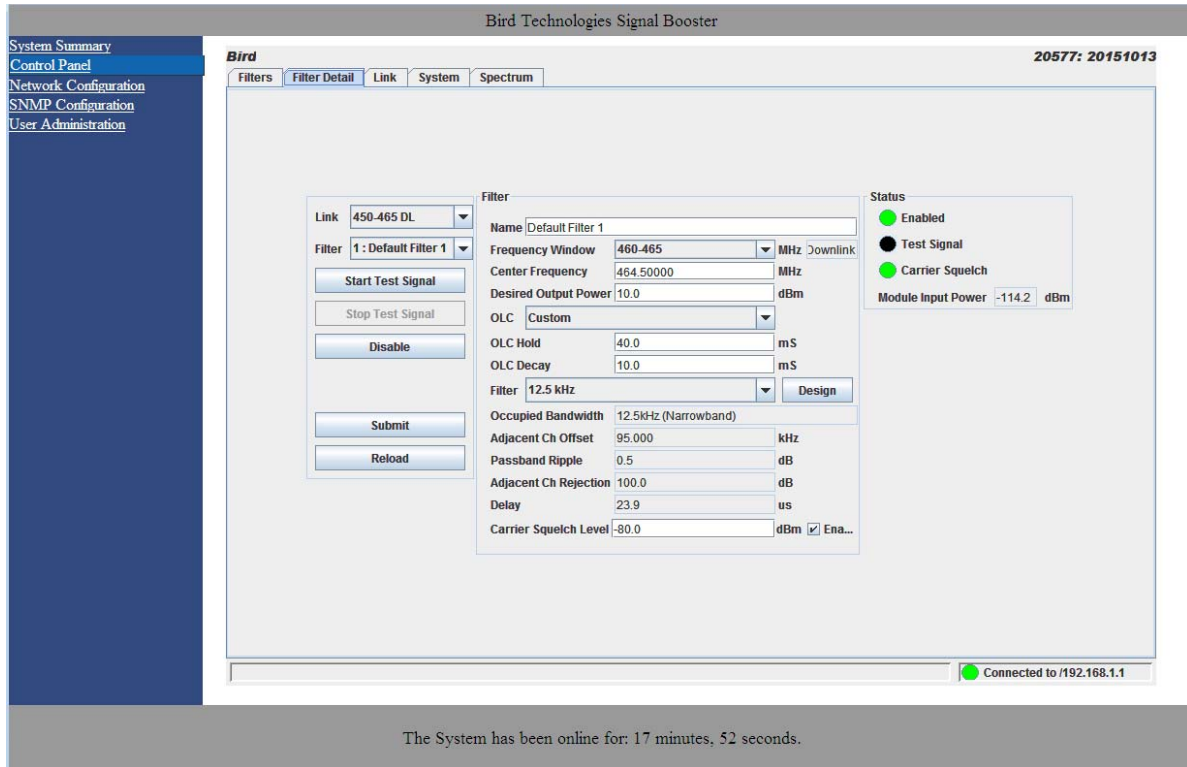


Figure 14: Filter Detail tab.

by the user by clicking in the box and typing in the desired value. Likewise OLC style is determined with a drop down box. The two choices are Custom and APCO 25 Phase 2. OLC Hold time and OLC Decay time must be entered by the user.

Filter specifics are selected from a drop down list that includes Custom, 12.5 KHz, 25 KHz, 12.5 KHz Low Delay, and XML File. Four parameters are customer adjustable including Occupied Bandwidth, Adjacent Channel Offset, Passband Ripple, and Adjacent Channel Rejection. Delay time is calculated by the software. The four adjustable parameters are setup using the Design tool, see the following section of this manual for details.



If a filter passband is selected that exceeds the Class A limit of 75 KHz and Class B operation is not selected (see discussion in System Page section of this manual) then a warning message will appear as shown in **Figure 15**. You MUST set the booster to the Class B mode of oper-

ation if you have any filter with a passband greater than 75 KHz.

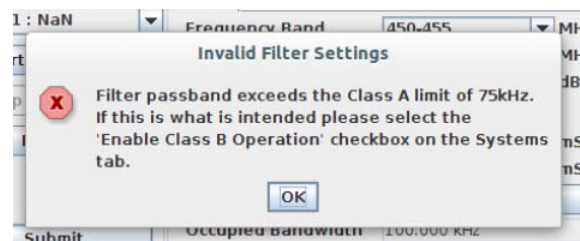
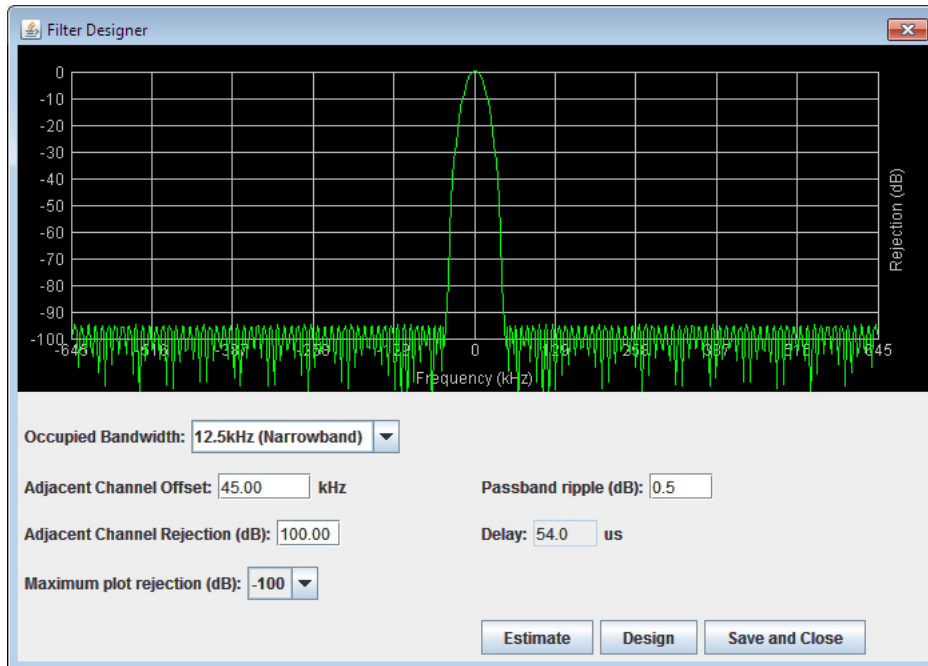


Figure 15: Invalid filter settings warning message.

### Design Button

When the Design Filter button is pressed a custom design template will be displayed as shown in **Figure 16**. Boxes for the four required filter parameters mentioned earlier are shown along with a graphical representation of the filter's response curve. Enter into the four boxes the parameters you want. Click on the Estimate button at the bottom of the screen and the software will calculate the Delay time for you. Press the Design button to design the filter.



**Figure 16:** The design filter interactive display screen.

The rejection scale of the display can be changed by making a selection from the “maximum plot rejection” drop down list. Choices include -10, -50, and -100 dB scale. When the display is to your satisfaction and does not violate any parameter ranges press the Save and Close button to exit back to the filter detail screen then load the design into the selected filter by pressing the Submit button on the filter detail page.

#### Status Area

The status area of the Filter Detail page uses status indicators to let the user know whether the channel is enabled, if the test signal is on, and if the carrier squelch is on. When the status indicator is illuminated the feature is on and when it is dark the feature is off. The Carrier Squelch status indicator will be green if the channel is squelched. The Carrier Squelch status indicator will stay dark if there is no squelching even if the Carrier Squelch radio button is set to enabled. A test signal can be generated for any channel within the system or every channel simultaneously.

The output power box displays the output power for the channel module. This value should be close but not necessarily exactly the same as the “Desired

Output Level” discussed earlier. The box showing output power is only displayed if the filter is giving an output power. If the filter is not enabled or there is no signal present then there would be no value to display.

#### LINK TAB

The link page is divided into four functional areas including a row of command buttons running down the left side of the screen, a link and settings area in the middle of the screen, and a status area on the right side of the screen as shown in **Figure 17**. The link page is designed to interact with one branch of a module at a time. The branch that is selected for interaction is determined by the Link box on the upper left of the screen. To change the branch that you are going to interact with click on the arrow to display the full drop down box. Scroll down the list until the desired branch is highlighted and click on it. The data displayed in the link area of the display screen will now be for the selected branch.

#### Command Buttons

Clicking on a command button (located on the extreme left-hand side of the page) performs the associated task immediately. The Submit and

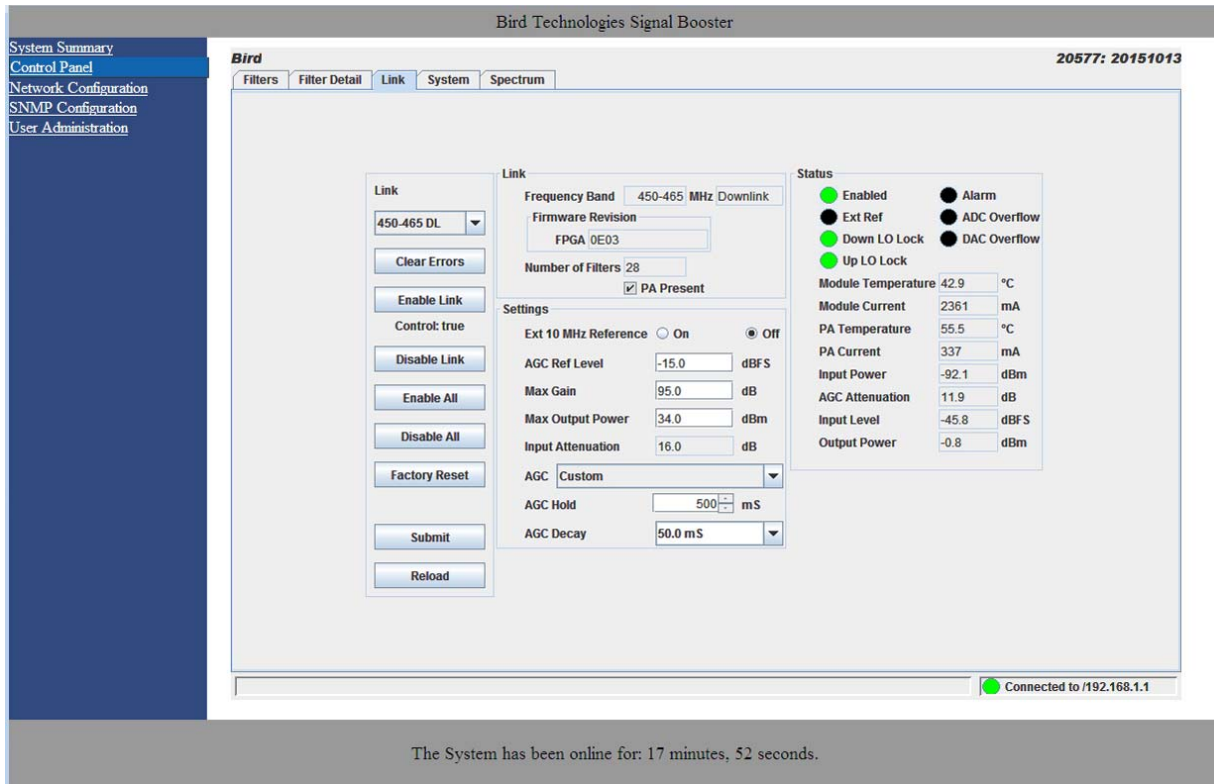


Figure 17: The Link tab.

Reload buttons in the bottom left corner allow any changes you make to the display/interface boxes to be downloaded to the booster. The Submit and Reload buttons act like a trigger sending any changes you made in the interface boxes to the channel module as well as updating any displayed data from the module, but only after the button is pressed. Individual branches or all branches can be enabled or disabled using the enable/disable buttons. After an alarm condition is corrected the alarm can be cleared by selecting the clear errors button. Selecting the factory reset button will return the system to the factory default settings.

#### Link and Settings Area

The link portion of the area displays status information for the branch. The Settings area is a user interactive area where the field engineer can program the operating characteristics of the selected branch. Each parameter in the settings area can be changed by clicking in the box and typing in the new values or by pointing at an arrow to display a drop down box. Most of the adjustable parameters have adjustment limitations as applicable.

The parameters include turning on/off the use of an external 10 MHz reference signal when an external reference is available. If an external reference is not available then leave this feature off and the system will operate from the internal 10 MHz signal. The AGC Reference Level should be set to the calibration value which is -15 dBFS. The ADC reference level can be adjusted when excessively strong input signals are present. The Maximum Output Power is the desired output power level from the booster for the selected branch. The Max Gain allows the user to determine the maximum operating gain of the booster. This can be adjusted based on your antenna isolation.

The changes you make in the Settings area are only applicable to the selected branch. After you have made changes to the various parameters press the Submit command interface button (lower left corner of the screen) in order to copy the changes into the channel module itself.

## Status Area

The status area of the link page lets the user know the status of the channel module and power amplifier if a power amplifier is used in the system design. The status for seven parameters are conveyed by the status indicator next to the parameter name. When the status indicator is green it indicates that the parameter is on and when it is black it indicates the parameter is off. In the case of the Alarm (Summed Alarm), ADC Overflow, and DAC Overflow, the status indicator will turn red during a fault condition.



When the Summed Alarm indicator is red, if the cursor is placed over the indicator, a message tab will appear briefly describing the reason for the alarm condition.

Seven additional parameters are displayed with numerical values. The first group of parameters using a status indicator include; Enabled which indicates whether the branch is on or off, Ext Ref which indicates whether the system is running on an external or internal 10 MHz clock signal, and Down and Up LO Lock which indicate if the down

converter and up converter local oscillators are synchronized to their respective RF signals. The second group of parameters using a status indicator will be black under normal conditions and will turn red to indicate a fault. The Alarm indicator is a summed alarm and will activate when either the module or power amplifier temperature/current exceeds their normal range. Also, the Form-C contacts inside the cabinet will change states. ADC or DAC Overflow indicator shows that the input power to the branch is too high.



If a fault occurs, press the clear errors button on the left side of the page. If the error reappears right away then trouble shooting will need to take place.

The first four numerical parameters are real-time indications of the module and power amplifier temperature/current values. AGC Attenuation updates in real-time and provides an indication of what the AGC is doing. Input Power is a summation of all the input signals to the branch. Output power also updates in real-time and indicates the composite power output for the branch.

The screenshot displays the 'System' tab of the Bird Technologies Signal Booster web interface. The page title is 'Bird Technologies Signal Booster' and the device ID is '20577: 20151013'. The left sidebar contains navigation links: System Summary, Control Panel (selected), Network Configuration, SNMP Configuration, and User Administration. The main content area is divided into sections: 'System Info' with fields for Control Panel Revision (20577 (20577: 20151013)), System Controller Revision (Jun 24 2015 15:41:36), Java Version (1.7.0\_67), Java Vendor (Oracle Corporation), and Location Name (Test Site). Below this are radio buttons for 700 MHz, 800 MHz, and UHF (checked). The 'Oscillation Action' section includes a dropdown menu set to 'ALARM', 'Retry Interval' and 'Retry Limit' fields both set to '-1' sec, and a checkbox for 'Class B Operation Enabled'. At the bottom of this section are 'Submit' and 'Reload' buttons. A 'System Log' section is visible at the bottom. A status bar at the bottom right indicates 'Connected to /192.168.1.1'. A footer message states 'The System has been online for: 17 minutes, 52 seconds.'

Figure 18: The System tab.

## SYSTEM TAB

The system tab lists the control board software versions. A customer-designated location name can be recorded and is useful in situations where multiple boosters are used in the overall system design. There is also a system logbook available on the bottom of this page for use by field engineers when working on the system. Refer to **Figure 18**.

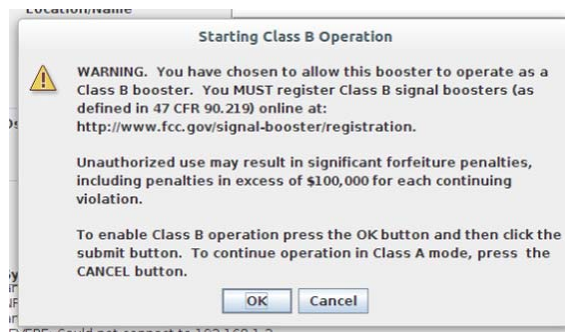
## Oscillation Detection

This feature shuts off the output signals from the booster for both the uplink and downlink whenever an oscillation condition is detected. Oscillation detection occurs whenever port to port isolation falls down to 25 dB or less. For normal operation the port to port isolation needs to be at least 10 dB greater than the gain of the booster. There are four modes of operation for the Oscillation Detection feature including Ignore, Alarm, Shutdown, and Shutdown/Retry.

In the Ignore mode the booster will ignore oscillation events. In the Alarm mode the booster will generate a alarm notification by illuminating (turn RED) the alarm button on the Link Tab and illuminating (turn RED) an LED indicator on the control module. The Shutdown mode is the same as Alarm mode except the booster shuts off the output signals in both the uplink and downlink direction. The shutdown continues until the filters are re-enabled and the alarm is reset. The Shutdown/Retry mode is the same as the Shutdown mode except the booster will retry operation the number of times specified by the user. This is called the retry limit which is entered into the associated box on the System Page. How long the booster waits between each retry attempt is determined by the retry interval. After the retry limit is reached, if the booster is still experiencing an oscillation condition, the booster will enter the regular shutdown mode. The Shutdown/Retry mode is useful in situations where brief transient overdrive signals are occurring.

## Class B Enable

In order to operate the booster with a filter pass-band greater than 75 KHz the booster MUST be configured as a Class B booster and the customer must register the booster online with the FCC. Class B operation is enabled by checking the box labeled "Enable Class B Operation". When the box is checked a warning message will be displayed as shown in **Figure 19** reminding the user to register the booster with the FCC.



**Figure 19:** Starting Class B operation message.

## Network Configuration Submenu

Values for IP Address, Netmask, the Gateway and MAC Address are displayed on the network configuration page. Refer to **Figure 20**.

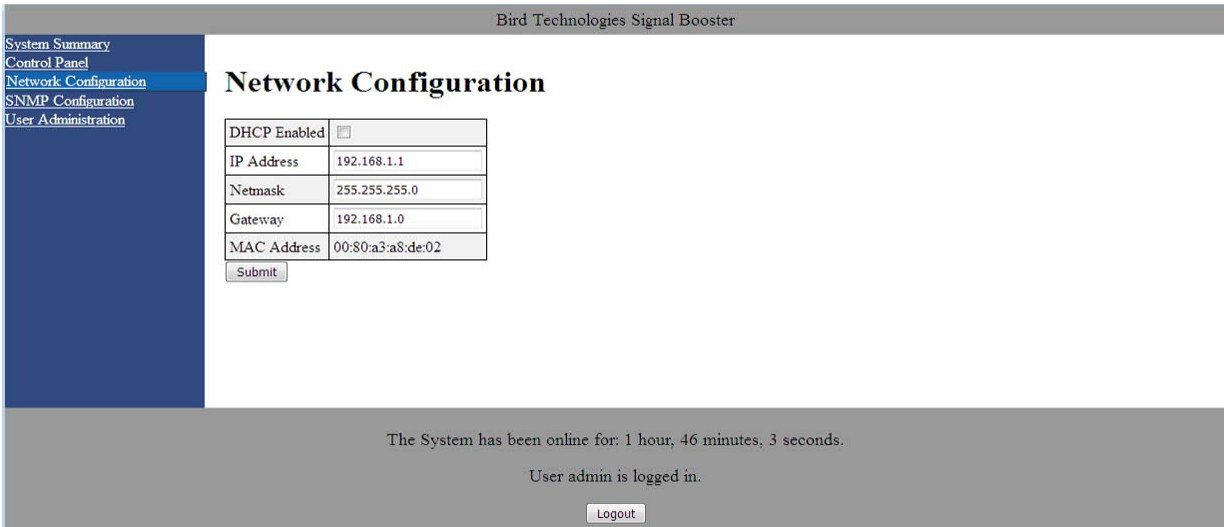
The network configuration page allows the user to enable or disable DHCP. The Dynamic Host Control Protocol (DHCP) is a standardized networking protocol used on IP networks for dynamically distributing network configuration parameters, such as IP addresses for interfaces and services. With DHCP, computers request IP addresses and networking parameters automatically from a DHCP server, reducing the need for a network administrator or a user to configure these settings manually.

The DHCP (Dynamic Host Configuration Protocol) is either active or inactive. When DHCP is active the values for IP address, netmask, and gateway are set to zero. When the DHCP is inactive (default setting from the factory) the IP address, netmask, and gateway values can be modified by the user by typing the desired values into the associated box and pressing the submit button. The customer should consult with their IT department to determine whether DHCP should be active or inactive.

## User Administration Submenu

The User Administration submenu allows password protected access to the booster. The boxes on this page are interactive. To make changes click inside the box and a cursor will appear. Refer to **Figure 21**. The user is queried for a User Name and Password. The default user name is "admin" and the default password is "admin". It is recommended that once the booster system is installed approved users with unique passwords are loaded into the system and the default admin user/password is deleted.



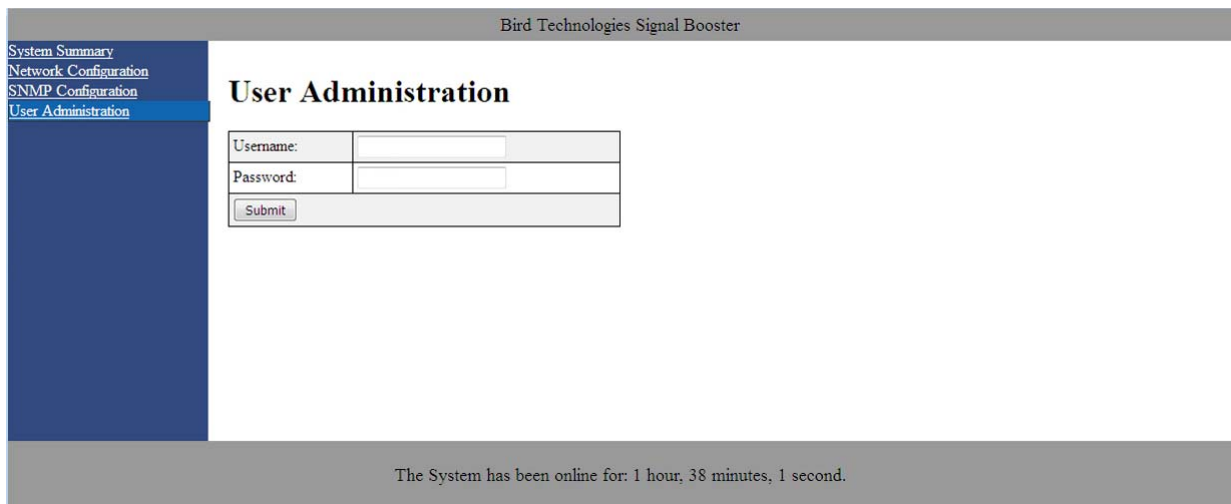


**Figure 20:** The Network Configuration Submenu.

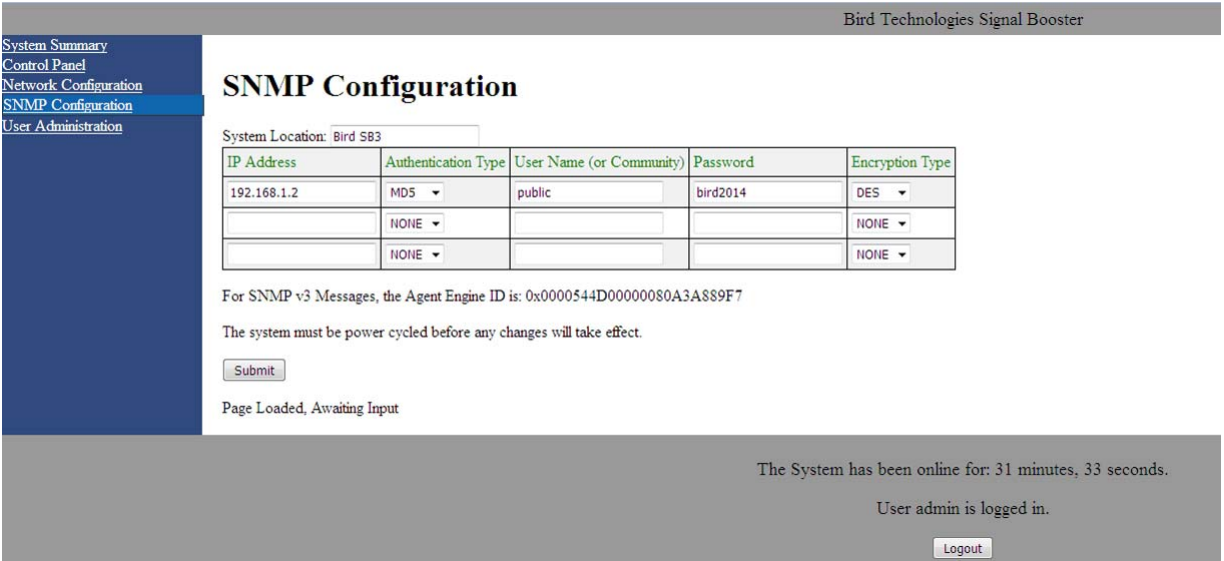
Once the correct user name and password are entered then a menu box for creating a new user will be presented. To create a new user enter the new user name and associated password. Confirm the new password by entering it again and then press the Create User button. Make sure you write down the new user name and password for safe keeping. A menu box for deleting a user is also presented. To delete a user enter their user name in the box and click on the Delete User button.

### SNMP Configuration Submenu

Simple Network Management Protocol (SNMP) is an Internet-standard protocol for managing devices on IP networks. The SNMP feature is designed to provide reliable internet notification of an alarm occurrence or a change in operational status in the booster. In order to configure the booster to send SNMP messages (called traps) to a destination device, such as your computer, the following values need to be entered into the booster; System location, the IP address of the destination computer, Authentication type, User name, Password, and



**Figure 21:** The User Admin Submenu.



**Figure 22:** SNMP Configuration Submenu.

Encryption type, and the Encryption passphrase. **Figure 22** shows the SNMP Configuration display.

The System location is a user defined string which will be returned with every trap that is generated and can assist the user in identifying which unit is sending the trap message. The three destination IP addresses that are entered into the table should be the IP addresses of the computers that you want the traps to be sent to. These destination computers must have SNMP manager software installed and running in order to receive the messages. SNMP manager software installation into the destination computers is the customers responsibility. Consult with your IT specialist for assistance.

Authentication type is used to verify that the person receiving the trap is the person the trap is intended for. Authentication type choices are NONE, MD5, or SHA, with SHA being the strongest encryption type. When using authentication and/or encryption the User Name is the name of the person to receive the trap. If not, this is the community name of the trap receiver. The Password is a string used to encrypt and authenticate the user. It is only used when authentication and/or encryption types are enabled. The Encryption type is used to protect the contents of the message from unauthorized receivers. Encryption type choices are NONE, DES, or AES, with AES being the strongest supported encryption type.

The Agent ID is a value that uniquely identifies the agent sending the traps. The agent is software which runs on the device being monitored and in this case is the signal booster. The SNMP manager software receives the traps and can be run on your computer or another server on your network. For traps that use encryption and/or authentication the manager needs to be configured to receive traps from the specified agent ID. This number is shown on the SNMP submenu page underneath the table, refer to figure 22. Whenever values in the SNMP Configuration screen are changed you must click on the submit button to save the changes.

#### INITIAL SNMP SETUP

When the booster is installed the SNMP feature should be setup for proper communications. There are several steps required for proper setup of the SNMP feature as discussed below.

- 1) Connect a laptop directly to the booster. Refer to **Appendix A** for detailed instructions on how to make a direct connection. The booster is shipped from the factory setup for static IP addressing and with a default IP address of "192.168.1.1". The factory default subnet mask is "255.255.255.0". Change the factory default IP address of the booster to one provided by your IT department.

- 2) Use the Network Configuration to setup the DHCP as either active or inactive. When DHCP is inactive the deck will be using a static IP and the user must enter values for IP address, net-mask, and gateway. Make sure you consult with your IT department regarding setting DCHP active or inactive.
- 3) Use the SNMP Configuration submenu page to enter up to three destination device addresses. These are addresses where the SNMP feature will send trap messages whenever a qualifying event takes place. Qualifying events include the following;
  - A) Down Converter LO Lock Fail
  - B) UP Converter LO Lock Fail
  - C) ADC Overflow
  - D) DAC Overflow
  - E) General Alarm - over current, over temp, and oscillation.
- 4) Setup the SNMP format using the SNMP Configuration submenu page. Items that need to be configured include Authentication Type, User Name, Password, and Encryption Type. Consult with your IT specialist for assistance.
- 5) Load the SNMP manager software into the destination computer and configure the manager so that it will be able to receive the SNMP traps.
- 6) Download MIB files from the Bird Technologies website ([www.birdrf.com](http://www.birdrf.com)) and load the MIB files into your SNMP manager software. The MIB files allow the SNMP manager software to sort out the trap messages into an understandable message format.

The signal booster supports several SNMP Configuration validation checks which help ensure the configuration is setup in a logical format. The validation checks include;

- A) If encryption is enabled but authentication is not enabled a popup window will appear stating that you must enable authentication when encryption is enabled.

- B) If Authentication and/or Encryption is enabled and a password is entered which is < 8 characters long an error message will be displayed.
- C) If an IP address is entered but a User Name is not entered a popup warning will appear but the changes will be submitted.
- D) If a User name is entered but an IP address is not entered a popup warning will appear but the changes will be submitted.

#### SNMP MANAGER EXAMPLE

SNMP manager software is designed to provide a GUI style interface for the user so that traps sent from the booster can be received and displayed for viewing. The SNMP manager software chosen and used by the customer is up to the customers discretion and as such may not exactly match the example shown in this discussion. SNMP manager software packages will need to be properly configured in order to successfully receive messages from the booster. Refer to the SNMP configuration setup discussed earlier in this manual and ask your IT specialists for assistance.

When a qualifying event occurs in the booster a trap is formulated and sent to the destination computer. A typical trap is shown in **Figure 23**. In the example shown the trap messages are shown at the top of the screen display. Three trap messages have been received by this manager from a signal booster. In this particular SNMP manager software package if a trap message is selected the details of that message are displayed in the lower portion of the screen. The details show the raw message as it was received by the manager while the upper box shows the message after it has been interpreted by the MIB files.

#### Creating an Alarm for Testing Purposes

In the example shown in figure 23 an alarm condition was generated in the booster in order to create the trap messages shown. The booster was told to generate its oscillator clock signals using an external reference source but no external source was connected to the booster. This is a quick and easy way to create a temporary alarm for testing purposes. This is accomplished via the Link Page discussed earlier in the manual (refer to figure 17). Select the ON radio button labeled EXT 10 MHz Reference then click the Submit button. Do not connect a signal source to the external osc port on the control module (refer to figure 10). This will



Description	Source	Time	Severity
trapOID: iso.org.dod.internet.private.enterprises.birdtech.products.sbiu.alarms.generalAlarm	192.168.1.1	2016-01-13 14:40:08	
trapOID: iso.org.dod.internet.private.enterprises.birdtech.products.sbiu.alarms.upd.ClockedAlarm	192.168.1.1	2016-01-13 14:40:08	
trapOID: iso.org.dod.internet.private.enterprises.birdtech.products.sbiu.alarms.downt.ClockedAlarm	192.168.1.1	2016-01-13 14:40:08	

Source:	192.168.1.1	Timestamp:	48 minutes 3 seconds	SNMP Version:	3
Trap OID:	iso.org.dod.internet.private.enterprises.birdtech.products.sbiu.alarms.generalAlarm				
Variable Bindings:					
Name:	iso.org.dod.internet.mgmt.mib-2.system.sysUpTime.0				
Value:	[TimeTicks] 48 minutes 3 seconds (288362)				
Name:	snmpTrapOID				
Value:	[OID] generalAlarm				
Name:	iso.org.dod.internet.private.enterprises.birdtech.products.sbiu.system.linkTable.linkEntry.linkId.2				
Value:	[OctetString] Uplink.1				
Name:	iso.org.dod.internet.private.enterprises.birdtech.products.sbiu.system.systemCondition.0				
Value:	[Integer] 22				
Name:	iso.org.dod.internet.private.enterprises.birdtech.products.sbiu.system.systemConditionString.0				
Value:	[OctetString] LO Not Locked. If using external reference, please make sure it is connected				
Description:					

Figure 23: SNMP Manager example.

cause the downlink and uplink oscillators in the channel to shutdown and the booster will enter an alarm condition. Please note that on-air signals will be interrupted during this time. To clear the alarm select the OFF radio button then click the Submit button and finally the Clear Errors button. This will take the booster out of the alarm condition and return it to normal operation.



**IMPORTANT:** The SNMP feature may not send traps when the web page is operational. It may hold the trap messages until the web page interface is closed at which point it will then send the traps to the destination computers.

### MAINTENANCE

Signals boosters manufactured by Bird can perform for years with little maintenance and repair. However, if the amplifiers are subjected to excessively high signal levels, power surges or lightning strikes, failures may occur. The following procedures may be followed for detecting a malfunction-

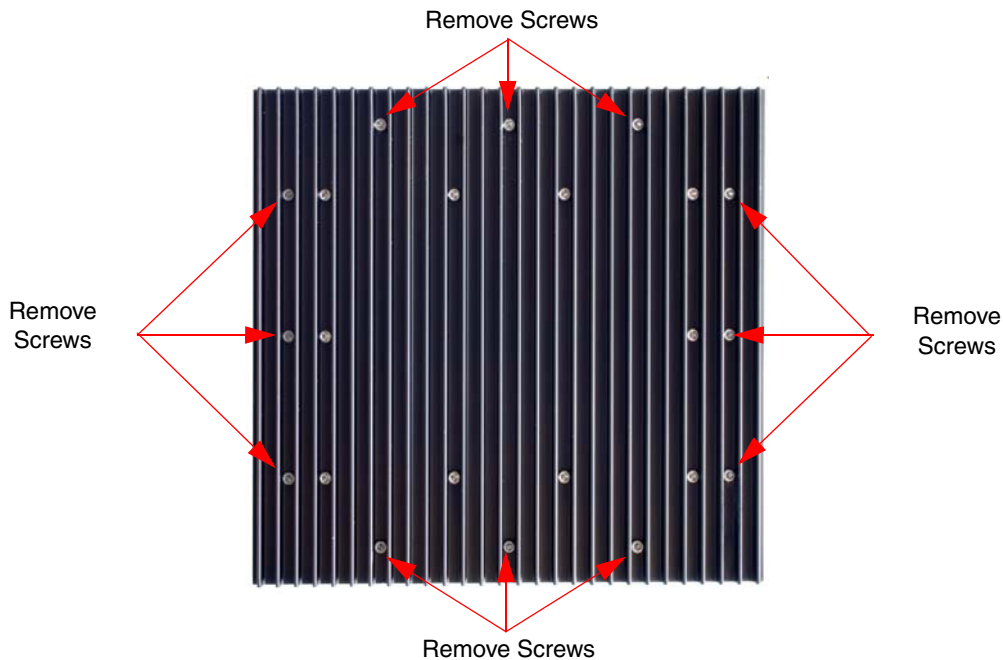
ing subassembly or as part of a periodic maintenance program.

- 1) Heatsink areas should be clear of dust and debris.
- 2) Inspect the unit to see that all LED indicators are illuminated correctly. Check all hardware and cable connections for tightness.
- 3) Compare system performance to initial performance levels measured when the system was installed.

### Power Amplifier Replacement

The SBIII power amplifiers are field replaceable. Follow the steps listed below in sequential order. The required tools are a 3/32" hex head driver.

- 1) Turn off power to the signal booster.
- 2) Disconnect the 28 VDC power cable.
- 3) Disconnect the COM cable.



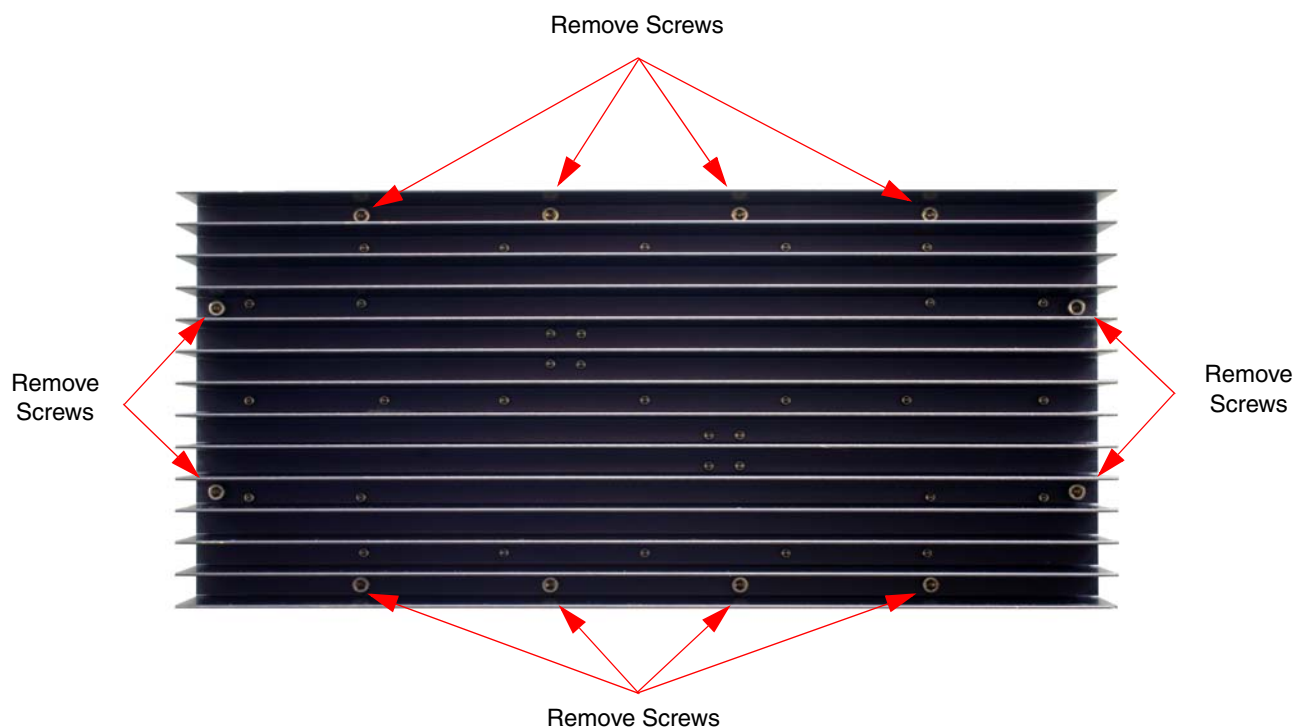
**Figure 24:** Remove mounting screws to detach power amp from cabinet.

- 4) Disconnect the RF In cable.
- 5) Disconnect the RF Out cable.
- 6) Remove the 12 hold down screws (3/32" hex head) that hold the power amplifier assembly to the cabinet. The screw heads are accessible from the heatsink side of the assembly. Refer to **Figure 24**.
- 7) Remove the assembly by pulling it away from the cabinet.
- 8) To install the replacement amplifier reverse steps 7 thru 2. When replacing the RF cables do not overtighten the SMA connectors. They should be tightened just slightly more than hand tight or to the specification of 7 in/lbs. The amplifier assembly comes with an O-ring gasket which must press up against the outside of the cabinet firmly and squarely in order to provide a correct moisture seal.

#### **Channel Module Replacement**

The SBIII channel module is field replaceable. Follow the steps listed below in sequential order. The required tools are a 5/32" hex head driver.

- 1) Turn off power to the signal booster.
- 2) Disconnect the 6 VDC power cable. The power input cable is located at the top of the module next to the LED indicators.
- 3) Disconnect the COM cable. The COM cable is located at the top of the module next to the LED indicators. There may be one or two COM cables depending on the boosters configuration. It is important to re-attach the correct COM cable to the correct plug so it is a good idea to mark the cables as you remove them from the module so as to avoid confusion later during re-installation.
- 4) Remove the control cable. The control cable is located at the bottom of the module and has a white plastic pull tab on it.



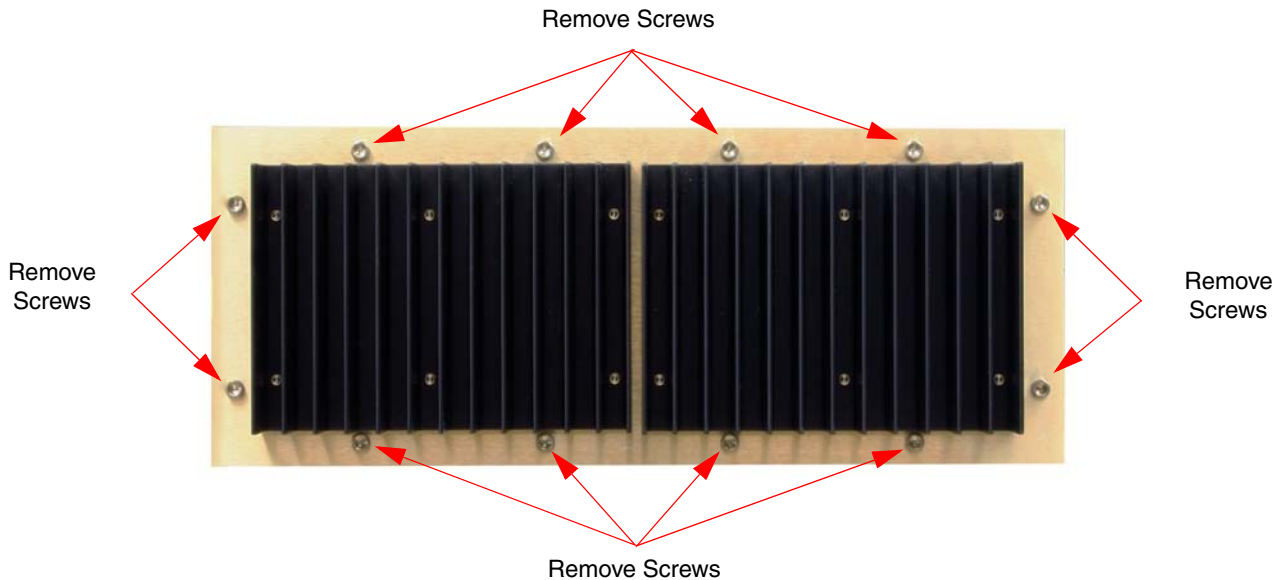
**Figure 25:** Remove mounting screws to detach channel module from cabinet.

- 5) Disconnect the downlink and uplink RF cables.
- 6) Remove the 12 hold down screws (5/32" hex head) that hold the channel module assembly to the cabinet. The screw heads are accessible from the heatsink side of the assembly. Refer to **Figure 25**.
- 7) Remove the assembly by pulling it away from the cabinet.
- 8) To install the replacement channel module reverse steps 7 through 2. When replacing the RF cables do not overtighten the SMA connectors. They should be tightened just slightly more than hand tight or to the specification of 7 in/lbs. The channel module assembly comes with an O-ring gasket which must press up against the outside of the cabinet firmly and squarely in order to provide a correct moisture seal.

#### **Control Module Replacement**

The SBIII Control Module is field replaceable. Follow the steps listed below in sequential order. The required tools are a 5/16" nut driver, a #2 Phillips screwdriver, and a small flat blade screwdriver (jewelers screwdriver).

- 1) Turn off power to the signal booster.
- 2) Disconnect the 6 VDC power connector on the lower left side of the module.
- 3) Disconnect the control cable (one for each channel module). The control cable is located at the lower left side of the control module and has a white plastic pull tab on it.
- 4) Disconnect (3) Form-C control lines from the top of the module. The lines are connected to a terminal strip on the control module. The terminal screws can be accessed through a slot on the front of the control module. Use a small flat blade screw driver (jewelers screwdriver).



**Figure 26:** Remove mounting screws to detach power supply from cabinet.

- 5) The control module is held in place with either mounting bolts or Phillips screws. Use a 5/16" nut driver to remove mounting bolts or a #2 Phillips screwdriver to remove mounting screws. Lift the module up and out of the cabinet.
- 6) Reverse steps 5 through 2 to install the new control module assembly.

#### **Power Supply Replacement**

The SBIII Control Module is field replaceable. Follow the steps listed below in sequential order. The required tools are a 5/32" hex head driver.

- 1) Turn off power to the signal booster.
- 2) Disconnect the AC plug on the right side of the supply.
- 3) Disconnect the three (6 Volt) DC Output plugs on the left side of the supply.
- 4) Disconnect the three (28 Volt) DC Output plugs on the left side of the supply.
- 5) Remove the 12 hold down screws (5/32" hex head) that hold the power supply assembly to

the cabinet. The screw heads are accessible from the heatsink side of the assembly. Refer to **Figure 26**.

- 6) Remove the assembly by pulling it away from the cabinet.
- 7) To install the replacement power supply reverse steps 6 through 2. The power supply assembly comes with an O-ring gasket which must press up against the outside of the cabinet firmly and squarely in order to provide a correct moisture seal.

# APPENDIX A

## ETHERNET CONNECTIVITY

### GENERAL DESCRIPTION

The control module Ethernet connector on the booster provides for 10/100 BASE-T Ethernet connection using the TCP-IP protocol. This product feature allows access to a web-based interface for interacting with the booster. The web based interface requires a JAVA runtime environment (version 1.6.0 or later) to be installed on your laptop. The JAVA software can be downloaded free of charge from the Sun Microsystems website found at “http://java.com/en/download/index.jsp”. The booster is shipped from the factory with a default IP address of “192.168.1.1”.

Two connection schemes are discussed including a direct connection from your laptop computer to the booster as well as connecting the booster to a networked environment. A direct connection (at the installation site) should be established the first time you interface to the booster using the fixed IP mentioned above. Once the initial communications are established the IP address in the booster can be changed to permit a networked connection (from a remote site such as your office).

### Direct Connection

Your initial connection to the booster system should be a direct connection to the booster using an Ethernet cable as shown in **Figure A1**. The signal booster supports Auto-MDIX so a cross-over or straight-through Ethernet cable can be used to make the connection.

### REQUIRED EQUIPMENT

Cat-5 (cross-over or straight-through)  
Laptop Computer with a network interface card installed. In addition, the JAVA run-time environ-

ment version 1.6.0 or later, and a web browser such as Internet Explorer must also be installed on the laptop.

### PROCEDURE

To connect your laptop computer to the front panel LAN port and access the web page interface, perform the following steps;

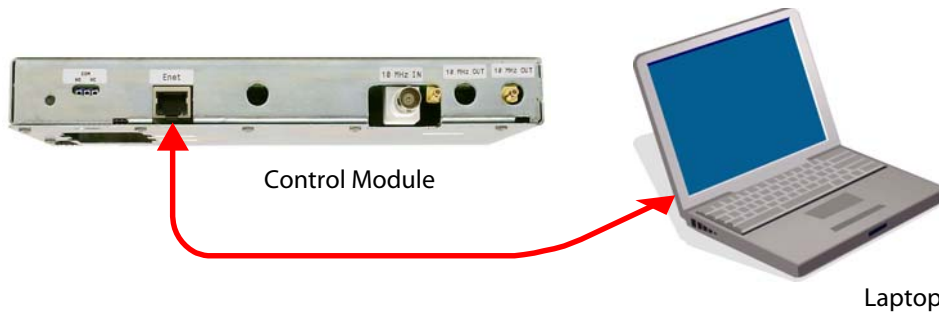
- 1) Insure the JAVA runtime environment software is installed on your laptop.
- 2) Connect your laptop network port to the LAN connector on the booster front panel using a CAT-5 Ethernet cable.



The front panel LAN connector has two built-in bi-color status LED's which will aid you in establishing communications. The meaning of each LED is shown in **Table A1**.

LINK LED (left side)		ACTIVITY LED (right side)	
Color	Meaning	Color	Meaning
Off	No Link	Off	No Activity
Amber	10 Mbps	Amber	Half-Duplex
Green	100 Mbps	Green	Full-Duplex

**Table A1:** LAN port status LED's



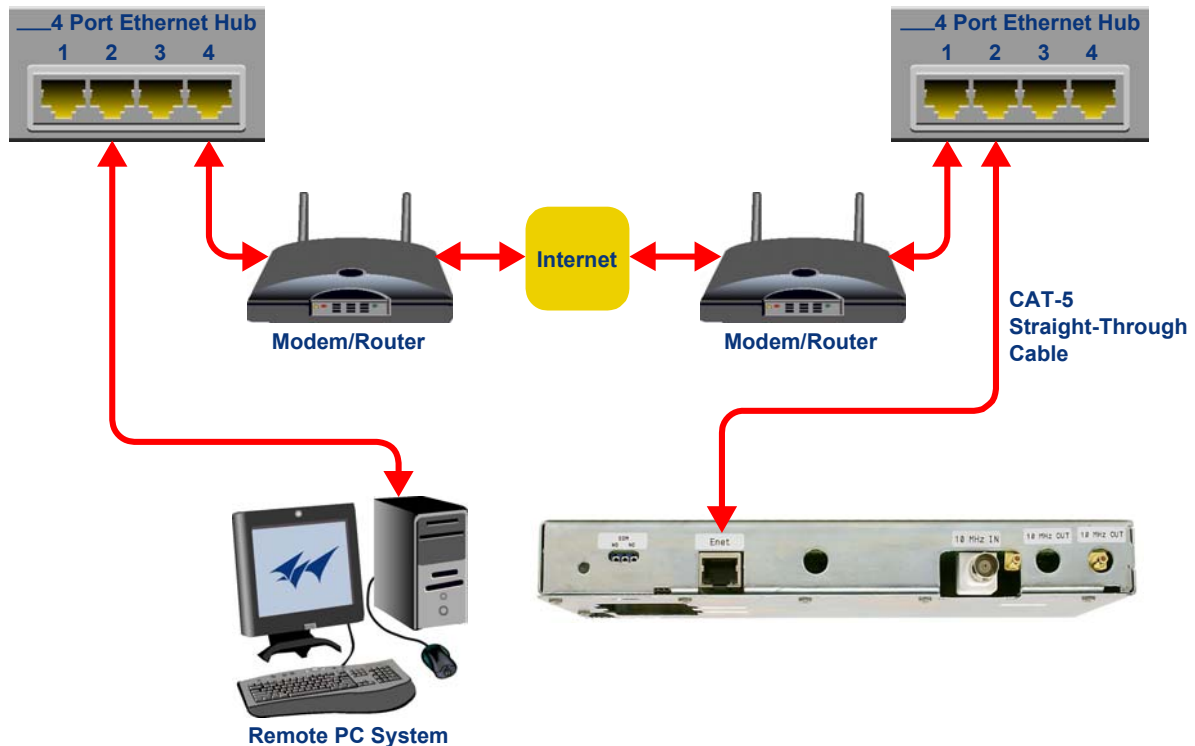
**Figure A1:** Direct connection to the booster.

- 3) The left-most (LINK) status LED built-in to the LAN port connector should illuminate amber or green indicating that a good physical connection is established between your computer and the booster.
- 4) Insure that your laptop's IP address is compatible with the default address of the signal booster system. This may require changes be made to the Ethernet adaptor address on your laptop. Your laptop's IP address will need to be set to "192.168.1.2" along with a subnet mask of "255.255.255.0".
- 5) Launch your web browser software on the laptop.
- 6) In your web browsers address box type-in the address of the booster "http://192.168.1.1" (factory default) and press the ENTER key. The web page interface to the booster should appear in your laptop's browser window. When you launch the web page you may notice that the JAVA applet will load first.

### Networked Connection

Before attempting a networked connection to the signal booster system consult with your IT support personnel for information concerning the correct IP address to use and any additional connectivity issues such as firewall settings. The signal booster uses the Lantronix X-Port as an embedded Ethernet device server for the LAN connection. The Lantronix X-Port uses port 10001 to communicate with the Java applet running on the remote host computer. For off-site communications, the 10001 port will need to be passed through the customers fire-wall in order to make the LAN connection.

Once you have the correct IP address you will need to direct connect to the booster system as discussed in the earlier section of this appendix and reconfigure the booster LAN port with this new address. You can then connect the signal booster system using a CAT-5 (cross-over or straight-through) cable to the networked environment and interface to it from a remote computer. **Figure A2** shows the proper way to interconnect the equipment for a networked connection.



**Figure A2:** Network connection to the booster.

## REQUIRED EQUIPMENT

To perform the direct connection to the booster the following items are required.

Cat-5 (cross-over or straight-through) cable.  
Temporary use of a laptop computer with a network interface card installed. In addition, the JAVA runtime environment version 1.6.0 or later, and a web browser such as Internet Explorer must also be installed on the laptop. These items are used to adjust the boosters network settings.

## PROCEDURE

Before a networked connection can be established, the boosters Ethernet Port must be changed to an IP address that's compatible with your network. If you are unsure how to determine this address check with your IT support personnel. To connect the booster Ethernet port to a networked environment and access the web page interface, perform the following steps;

- 1) Change the boosters LAN port IP address. To do this, direct connect your laptop to the booster as discussed in the earlier section of this appendix titled "Direct Connection" and follow steps 1 through 6.
- 2) Launch the configuration Applet in your web browser.
- 3) Click the "Admin" tab at the top of the interface display screen.
- 4) To be safe, take note of the settings currently displayed.
- 5) Select the "User Static IP" radio button.
- 6) Enter the following settings provided by your network administrator;
  - A) IP Address
  - B) Subnet Mask
  - C) Gateway Address
- 7) Click the "Submit" button to apply the changes.
- 8) Once the changes have been successfully applied close your web browser.
- 9) Launch the configuration Applet in your web browser using the newly entered IP address.



## APPENDIX B

### OPTIONAL FIBER OPTIC INTERFACE

The optional fiber optic interface can be added to the SBIII Digital Booster to allow the booster to interface with a head-end or remote-end booster via an optical link. The fiber optic interface consists of a broadband RF over fiber optic transceiver with a very wide dynamic range. Within the fiber optic transceiver assembly a pair of transceivers creates a bidirectional RF to Optical and Optical to RF link. The fiber optic transceiver is shown in **Figure B1** and the specifications for the unit are included as part of this appendix.

The fiber optic transceiver replaces the downlink power amplifier found in a normal (non fiber optic) **head-end** booster system. The fiber optic cable would replace the Downlink In / Uplink Out connector on the normal booster system. This connector would normally be connected to the Donor antenna. In a **remote-end** booster system the fiber optic transceiver replaces the uplink power amplifier. The fiber optic cable would replace the Uplink In / Downlink Out connector on the normal booster system. This connector would normally be connected to the DAS antenna. Refer to the signal flow block diagram for the normal non fiber optic booster.

Status of the TX and RX data flowing to/from the fiber optic transceiver is indicated by the status LEDs on the front panel of the unit as shown in figure B1. When TX or RX data flow is normal the associated status LED will glow a steady green.

Lack of data flow is indicated by the LED indicator turning red.

The fiber optic transceiver has an alarm status output which is routed to the control board of the booster. The alarm status output will become active for two conditions including; laser bias which is a failure of the laser diode or an inadequate received signal power level. These two conditions (pins 7 and 9) are listed in the DB9 Configuration Table on page two of the attached OEM data sheets.

When the control board sees the fiber optic alarm status output go active it will respond in two ways. First it will turn the Summed Alarm status LED located on the control board itself from green to red. Refer to figure 10 which shows a close up view of the control board. Secondly, it will turn the alarm status indicator on the webpage LINK screen to red indicating that a summed alarm has occurred. Refer to figure 17. When the Summed Alarm indicator on the LINK page is red, if the cursor is placed over the indicator a message tab will appear briefly describing the reason for the alarm condition. In the case of a fiber optic transceiver alarm the message displayed will be "alarm\_auxilliary".



For fiber feed systems the input level for the fiber side of the booster is -2.5 dBm.



**Figure B1:** Fiber Optic Transceiver.





# RF over Fiber Optic Transceiver

## OZ810 Series



### FEATURES

- 30 MHz to 3 GHz Bandwidth
- Rugged Dust-Tight Housing
- 3 x 5 x 1.25 in. Weight ¾ lb.
- -20°C to +75°C Operating Temperature
- LD/PD Monitoring and Alarm
- High Spurious Free Dynamic Range
- Automatic Optical Power Control
- 1.3 or 1.5 µm Low Noise Isolated DFB Lasers
- Laser Conforms to Class 1 Emission Level per CDRH and IEC-825 (EN 60825) Standards

### OPTIONS

- Extended Bandwidth of 10 KHz to 3.3 GHz
- CWDM Lasers
- Internal WDM
- RS232 Data Modem
- AGC; Wide Dynamic Range
- Internal transmitter LNA
- Manual Gain Adjust
- Multimode Fiber Compatibility
- Wide DC Input Range from +18V to +30V Supply
- Low Power Dissipation

### APPLICATIONS

- WiMax/4G LTE
- GPS Distribution
- Timing Delay
- Cellular Backhaul
- MMDS
- Remote Antenna Location
- Satcom
- In-Building Solutions DAS
- Outdoor DAS

### DESCRIPTION

The OZ810 is a high performance broadband optical transceiver with very Wide Dynamic Range designed for RF over Fiber applications. A pair of OZ810 transceivers will create a bidirectional RF to Optical and Optical to RF link. OZ810 may also be configured as individual Transmitter (Tx) or Receiver (Rx) units. It is designed in a rugged, compact Dust-tight Cast Metal Housing with optional WDM integrated internally for bidirectional transmission on a single strand of Single Mode Fiber. These linear RFoF links are an excellent alternative to using coaxial cable systems. The OZ810 delivers significant improvement in the transport of RF signals in their native format reliably in many optical networks across broad range of frequencies. The OZ810 offers high Spurious Free Dynamic Range (SFDR) with operational frequencies from 30 MHz to 3.0 GHz. An optional extended bandwidth of 10 KHz to 3.3 GHz is also available.

The *Manual Gain Control* and AGC enable installers an easy way to adjust receiver output RF level to facilitate simple field installations. The Standard optical connector is SC/APC (FC/APC available) for low back reflection applications. The transceiver features a high performance InGaAs photodiode and a linear Isolated DFB Laser operating at 1.3 µm (A) and 1.5µm (B) over 9/125 µm Single Mode Fiber. Average Automatic Power Control (AAPC) is incorporated for optimal optical power stability over the full operating temperature range. The RF interface is via a 50 ohm SMA connector and the RS232 and alarm and monitoring functions are available through DB9. Manual Gain control is also available.

### ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Min	Max	Units
Storage Temperature (Case)	T <sub>s</sub>	-40	+85	°C
Operating Temperature (Case)	T <sub>o</sub>	-20	+75	°C
DC Supply Voltage	V <sub>PD</sub>	+11.5	+12.5	Volts
Maximum RF input into Tx (no LNA)			+15	dBm
Maximum Optical Input into Rx			4	mW

### CHARACTERISTICS OF OZ810

Parameter	Symbol	Min	Typical	Max	Units	Notes
Power Supply Voltage	VCC		+12		Volts	
Power Supply Current	ICC		250	400*	mA	*Imax for RF+Rs232 Data
Laser Optical Output Power			2	4	mW	
Transmitter Operating Wavelength A/B		1310	1310/1550	1590	nm	1
Receiver Operating Wavelength B/A		1310	1310/1550	1590	nm	2
High Frequency Cutoff	HFC		3000	3300	MHz	3
Low Frequency Cutoff	LFC	.01	30		MHz	4
Frequency Response (30 – 3000 MHz)			-/+1.5		dB	
Input/Output Impedance	Z		50		Ohms	
Input/Output VSWR (30-3000 MHz)			1.7:1	2:1		
Spur Free Dynamic Range	SFDR		110		(dB/Hz) <sup>2/3</sup>	5
RF Link Gain		-1	0	+1	dB	5
Input Noise Floor @ 1Ghz	EIN	-130	-134		dBm-Hz	5
Input Third Order Intercept @ 1Ghz	IIP3	27	30		dBm	5, 6
Gain change over optical loss (dB)			+/-1		dB	7
AGC Optical Dynamic Range (dBo)			6		dB	7
Isolation		50	60		dB	8
RS232 Data Rate		1	19.2	19.2	Kbps	9
Group Delay Over 4MHz (30-3000 MHz)				1	nS	

### CHARACTERISTICS OF OZ810 with LNA

Parameter	Symbol	Min	Typical	Max	Units	Notes
Power Supply Voltage	VCC		+12		Volts	
Power Supply Current	ICC		320	460*	mA	*Imax for RF+RS232 Data
Laser Optical Output Power			2	4	mW	
Transmitter Operating Wavelength A/B		1310	1310/1550	1590	nm	1
Receiver Operating Wavelength B/A		1310	1310/1550	1590	nm	2
High Frequency Cutoff	HFC		3000	3300	MHz	3
Low Frequency Cutoff	LFC	.01	30		MHz	4
Frequency Response (30 – 3000 MHz)			-/+1.5		dB	
Input/Output Impedance	Z		50		Ohms	
Input/Output VSWR (30-3000 MHz)			1.7:1	2:1		
Spur Free Dynamic Range	SFDR		110		(dB/Hz) <sup>2/3</sup>	5
RF Link Gain		-1	20	+1	dB	5
Input Noise Floor @ 1Ghz	EIN	-150	-154		dBm-Hz	5
Input Third Order Intercept @ 1Ghz	IIP3		12		dBm	5, 6
Gain change over optical loss (dB)			+/-1		dB	7
AGC Optical Dynamic Range (dBo)			6		dB	7
Isolation		50	55		dB	8
RS232 Data Rate		1	19.2	19.2	Kbps	9
Group Delay Over 4MHz (30-3000 MHz)				1	nS	

1. 1310/1550 nm WDM integration.
  2. 1310/1550 nm WDM integration.
  3. Typical High Frequency Cutoff (HFC) is 3000 MHz. For higher HFC contact Factory.
  4. Typical Low Frequency Cutoff (LFC) is 30 MHz, for lower LFC contact Factory.
  5. Measured and Specified with Optical loss budget of 0 dB, and 1 meter of Single Mode Fiber.
  6. Equivalent to IMD 60dB@0 dBm Total Output Power (2 tone measurement).
  7. With AGC On (AGC optional).
  8. Measured at 1GHz.
  9. RS232 optional. Contact Factory for higher data rates.
- For lower power dissipation version contact factory**

DB-9 CONFIGURATION	
PIN	FUNCTION
1	Laser Enable (+12 V = Laser ON)
2	Data INPUT (Tx RS232)/ OR NC
3	Data OUTPUT (Rx RS232)/ OR NC
4	+12 Volts (400 mA max)
5	Ground
6	Laser Bias Monitor (0.1 V = 10 mA)
7	Laser Bias Alarm (open collector, 25 mA)
8	Received Power Monitor (1 V = 1 mW)
9	Received Power Alarm (open collector, 25 mA)

RF Connector = SMA Female  
 Optical Connector = SC/APC or FC/APC  
 DATA + ALARM = DB9

**Note:** RS232 remote resets via Transmitter pin 1 Laser Enable. To reset temporarily set the +12 V on pin 1 to Zero (0) Volts.

# Celsius to Fahrenheit Conversion Table

CELCIUS	FAHRENHEIT
105	221.0
104	219.2
103	217.4
102	215.6
101	213.8
100	212.0
99	210.2
98	208.4
97	206.6
96	204.8
95	203.0
94	201.2
93	199.4
92	197.6
91	195.8
90	194.0
89	192.2
88	190.4
87	188.6
86	186.8
85	185.0
84	183.2
83	181.4
82	179.6
81	177.8
80	176.0
79	174.2
78	172.4
77	170.6
76	168.8
75	167.0
74	165.2
73	163.4
72	161.6
71	159.8
70	158.0
69	156.2
68	154.4
67	152.6

CELCIUS	FAHRENHEIT
66	150.8
65	149.0
64	147.2
63	145.4
62	143.6
61	141.8
60	140.0
59	138.2
58	136.4
57	134.6
56	132.8
55	131.0
54	129.2
53	127.4
52	125.6
51	123.8
50	122.0
49	120.2
48	118.4
47	116.6
46	114.8
45	113.0
44	111.2
43	109.4
42	107.6
41	105.8
40	104.0
39	102.2
38	100.4
37	98.6
36	96.8
35	95.0
34	93.2
33	91.4
32	89.6
31	87.8
30	86.0
29	84.2
28	82.4

CELCIUS	FAHRENHEIT
27	80.6
26	78.8
25	77.0
24	75.2
23	73.4
22	71.6
21	69.8
20	68.0
19	66.2
18	64.4
17	62.6
16	60.8
15	59.0
14	57.2
13	55.4
12	53.6
11	51.8
10	50.0
9	48.2
8	46.4
7	44.6
6	42.8
5	41.0
4	39.2
3	37.4
2	35.6
1	33.8
<b>0</b>	<b>32.0</b>
-1	30.2
-2	28.4
-3	26.6
-4	24.8
-5	23.0
-6	21.2
-7	19.4
-8	17.6
-9	15.8
-10	14.0
-11	12.2

CELCIUS	FAHRENHEIT
-12	10.4
-13	8.6
-14	6.8
-15	5.0
-16	3.2
-17	1.4
-18	-0.4
-19	-2.2
-20	-4.0
-21	-5.8
-22	-7.6
-23	-9.4
-24	-11.2
-25	-13.0
-26	-14.8
-27	-16.6
-28	-18.4
-29	-20.2
-30	-22.0
-31	-23.8
-32	-25.6
-33	-27.4
-34	-29.2
-35	-31.0
-36	-32.8
-37	-34.6
-38	-36.4
-39	-38.2
-40	-40.0
-41	-41.8
-42	-43.6
-43	-45.4
-44	-47.2
-45	-49.0
-46	-50.8
-47	-52.6
-48	-54.4
-49	-56.2
-50	-58.0

### Return Loss vs. VSWR

Return Loss	VSWR
30	1.06
25	1.11
20	1.20
19	1.25
18	1.28
17	1.33
16	1.37
15	1.43
14	1.50
13	1.57
12	1.67
11	1.78
10	1.92
9	2.10

### Watts to dBm

Watts	dBm
300	54.8
250	54.0
200	53.0
150	51.8
100	50.0
75	48.8
50	47.0
25	44.0
20	43.0
15	41.8
10	40.0
5	37.0
4	36.0
3	34.8
2	33.0
1	30.0

dBm = 10log P/1mW  
Where P = power (Watt)

### Insertion Loss

Input Power (Watts)

	50	75	100	125	150	200	250	300	
Insertion Loss	3	25	38	50	63	75	100	125	150
	2.5	28	42	56	70	84	112	141	169
	2	32	47	63	79	95	126	158	189
	1.5	35	53	71	88	106	142	177	212
	1	40	60	79	99	119	159	199	238
	.5	45	67	89	111	134	178	223	267

Output Power (Watts)

### Free Space Loss

Distance (miles)

	.25	.50	.75	1	2	5	10	15	
Frequency (MHz)	150	68	74	78	80	86	94	100	104
	220	71	77	81	83	89	97	103	107
	460	78	84	87	90	96	104	110	113
	860	83	89	93	95	101	109	115	119
	940	84	90	94	96	102	110	116	120
	1920	90	96	100	102	108	116	122	126

Free Space Loss (dB)

Free space loss = 36.6 + 20log D + 20log F  
Where D = distance in miles and F = frequency in MHz











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