

YOU'RE HEARD, LOUD AND CLEAR.

**Installation and Operation Manual
for the Two-Way Signal Booster System
Model Number 61-70/71/72-50-XXX-XX**



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| | |
| | |
| | |

Symbols Commonly Used



WARNING



ESD Electrostatic Discharge



CAUTION or ATTENTION



Hot Surface



High Voltage



Electrical Shock Hazard



Training Video Available



Important Information



Changes to this Manual

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 Angola, New York 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.

Contact Information

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For Class A Unintentional Radiators

This equipment has been tested and found to comply with the limits for a Class A 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 case the user will be required to correct the interference at his own expense.



Changes or modifications not expressly approved by TX RX System Inc. could void the user's authority to operate the equipment.

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.



WARNING: To satisfy FCC RF exposure requirements for transmitting devices, a separation distance of 87 Centimeters or more should be maintained between the UPLINK antenna of this device and persons during device operation. To satisfy FCC RF exposure requirements for transmitting devices, a separation distance of 30 Centimeters or more should be maintained between the DOWNLINK antenna of this device and persons during device operation. To ensure compliance, operations at closer than these distances is not recommended.

The antenna used for this transmitter must not be co-located in conjunction with any other antenna or transmitter.

Antenna System Installation

The antenna or signal distribution system consists of two branches. An uplink branch typically uses an outdoor mounted, unidirectional gain antenna such as a yagi and a downlink signal radiating system consisting of a network of zero-gain whip antennas or lengths of radiating cable usually mounted inside of the structure.

Even though the antenna system may not be supplied or installed by TX RX Systems. The following points need to be observed because both the safety of the user and proper system performance depend on them.

- 1) Antenna system installation should only be performed by qualified technical personnel.
- 2) The following instructions for your safety describe antenna installation guidelines based on FCC Maximum RF Exposure Compliance requirements.
- 3) The uplink antenna is usually mounted outside and exchanges signals with the repeater base station or donor site. It is typically mounted permanently-attached to the building wall or roof. The gain of this antenna should NOT exceed 10 dB. Only qualified personnel should have access to the antenna and under normal operating conditions, no one should be able to touch or approach it within 87 Centimeters (35 inches).
- 4) The downlink or in-building signal distribution system is connected to the downlink booster port using coaxial cable. The distribution system may use radiating coaxial cable or a network 1/4 wave whip antennas whose gain does not exceed 0 dB for any radiator. These antennas should be installed so that the user cannot approach any closer than 30 Centimeters (12 inches) from the antenna.

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GENERAL DESCRIPTION

Signal boosters extend radio coverage into areas where abrupt propagation losses prevent reliable communication. No frequency translation (conversion) occurs with this device. The UHF version of Signal Booster II (SB II) is a broadband, bi-directional signal booster available in a variety of configurations as shown in **Table 1**. The product part number is used to describe each configuration available. The UHF version of SB II is available in the 450 to 512 MHz frequency range, using 3 distinct sub-bands. Each of the three UHF sub-band types are identical except for differences in the input/output filtering used in the unit. This manual details the installation and operation of the UHF SB II family of boosters which includes all three sub-bands within the UHF frequency range.

The system can be ordered in one of three gain configurations including High-Gain (+80 dB gain), Medium-Gain (+60 dB gain), and Low-Gain (+45 dB gain). The maximum gain of the system is determined by the exact type of cards plugged into the low and mid level slots as shown in the block diagrams at the back of this manual. The maximum gain of the uplink or downlink branch is adjustable and can be setup independently. In addition, the gain of each branch can be reduced up to 30 dB in 0.5 dB increments via software interface.

The bandwidth of the system is determined by the passband of the input output filtering. The filters passband is determined by its physical construction so must be determined at the time of order. As

shown in table 1 the system may be ordered in any of 4 different bandwidths including 0.15, 0.5, 1.0, and 2.0 MHz.

Three cabinet styles are available. The G1 suffix denotes a NEMA-4 style cabinet which is suitable for indoor or outdoor use. The G2 suffix denotes a stainless steel NEMA-4X style cabinet suitable for corrosive environments such as salt air and the RM suffix a rack mount version which is intended for indoor mounting only.

UNPACKING

It is important to report any visible damage to the carrier immediately. It is the customer's responsibility to file damage claims with the carrier within a short period of time after delivery (1 to 5 days). Care should be taken when removing the unit from the packing box to avoid damage to external heat-sink fins. Use caution because the heatsink fins can have somewhat sharp corners. Signal Booster II (SB II) weighs about 100 lbs. so use enough people when lifting the unit.

INSTALLATION

The following sections discuss general considerations for installing the booster. All work should be performed by qualified personal in accordance with local codes.

Location

The layout of the signal distribution system will be the prime factor in determining the mounting location of Signal Booster II. However, safety and ser-

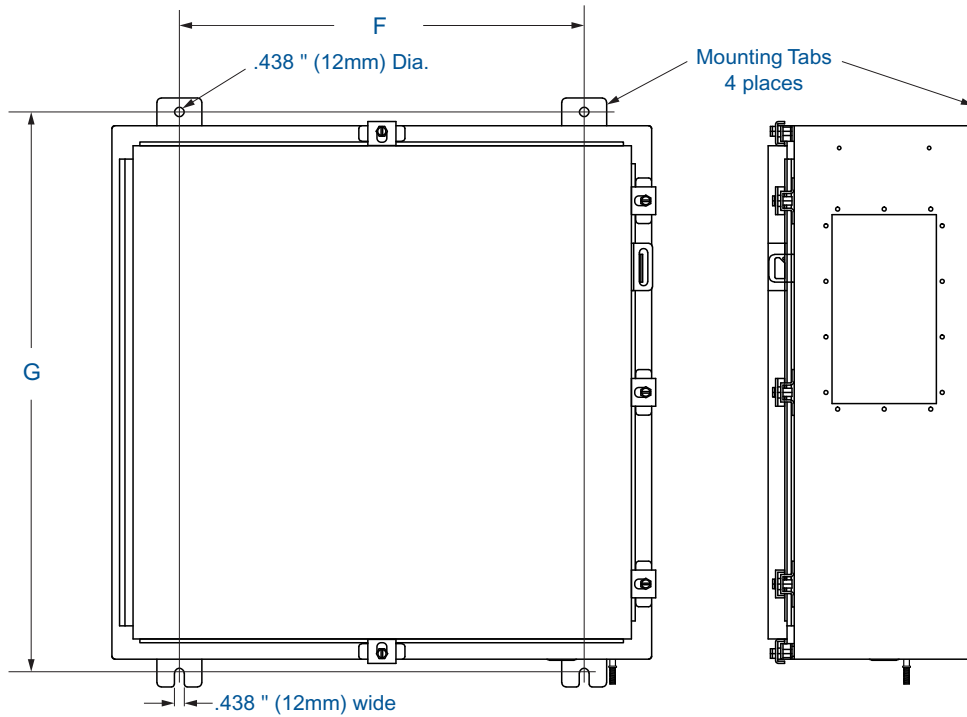
61 - 70 - 50 - A2.0 - G1 (Example)

| FAMILY | FREQUENCY BANDS | MODEL | COARSE GAIN | BANDWIDTH | ENCLOSURE TYPE |
|------------|--|------------------------|---------------------------------------|---|--|
| 61 = 2 Way | 70 = 450 - 470 71 = 470 - 490 72 = 488 - 512 | 50 = Signal Booster II | A = 80 dB * B = 60 dB C = 45 dB | 0.15 = 150 KHz 0.5 = 500 KHz 1.0 = 1.0 MHz 2.0 = 2.0 MHz | G1 = Painted, Nema4 G2 = Stainless, Nema4X RM = Rack Mount |



* Gain of 80 dB model set to 50 dB at factory. Please measure antenna isolation before resetting.

Table 1: Part number designations for UHF SB II.



| Cabinet Dimensions | Dimension F | Dimension G |
|--------------------------------|-------------|--------------|
| 16 x 12 x 6 (406 x 305 x 152) | 9.5 (241) | 17.25 (438) |
| 16 x 16 x 6 (406 x 406 x 152) | 10 (254) | 17.25 (438) |
| 16 x 20 x 6 (206 x 508 x 152) | 14 (356) | 17.25 (438) |
| 20 x 16 x 6 (508 x 406 x 152) | 10 (254) | 21.25 (540) |
| 20 x 20 x 6 (508 x 508 x 152) | 14 (356) | 21.25 (540) |
| 24 x 12 x 6 (610 x 305 x 152) | 9.5 (241) | 25.25 (641) |
| 24 x 16 x 6 (610 x 406 x 152) | 10 (254) | 25.25 (641) |
| 24 x 20 x 6 (610 x 508 x 152) | 14 (356) | 21.25 (540) |
| 24 x 24 x 6 (610 x 610 x 152) | 18 (457) | 25.25 (641) |
| 30 x 20 x 6 (762 x 508 x 152) | 14 (356) | 31.25 (794) |
| 30 x 24 x 6 (762 x 610 x 152) | 18 (457) | 31.25 (794) |
| 36 x 24 x 6 (914 x 610 x 152) | 18 (457) | 37.25 (946) |
| 16 x 12 x 8 (406 x 305 x 203) | 9.5 (241) | 17.25 (438) |
| 20 x 16 x 8 (508 x 406 x 203) | 10 (254) | 21.25 (540) |
| 20 x 20 x 8 (508 x 508 x 203) | 14 (356) | 21.25 (540) |
| 20 x 24 x 8 (508 x 610 x 203) | 18 (457) | 21.25 (540) |
| 24 x 16 x 8 (610 x 406 x 203) | 10 (254) | 25.25 (641) |
| 24 x 20 x 8 (610 x 508 x 203) | 14 (356) | 25.25 (641) |
| 24 x 24 x 8 (610 x 610 x 203) | 18 (457) | 25.25 (641) |
| 24 x 30 x 8 (610 x 762 x 203) | 24 (610) | 25.25 (641) |
| 30 x 20 x 8 (762 x 508 x 203) | 14 (356) | 31.25 (794) |
| 30 x 24 x 8 (762 x 610 x 203) | 18 (457) | 31.25 (794) |
| 30 x 30 x 8 (762 x 762 x 203) | 24 (610) | 31.25 (794) |
| 36 x 24 x 8 (914 x 610 x 203) | 18 (457) | 37.35 (946) |
| 36 x 30 x 8 (914 x 762 x 203) | 24 (610) | 37.25 (946) |
| 42 x 30 x 8 (1067 x 762 x 203) | 24 (610) | 43.25 (1099) |

| Cabinet Dimensions | Dimension F | Dimension G |
|---------------------------------|-------------|--------------|
| 42 x 36 x 8 (1067 x 914 x 203) | 30 (762) | 43.25 (1099) |
| 48 x 36 x 8 (1219 x 914 x 203) | 30 (762) | 49.25 (1251) |
| 60 x 36 x 8 (1524 x 914 x 203) | 30 (762) | 61.25 (1556) |
| 20 x 16 x 10 (508 x 406 x 254) | 10 (254) | 21.25 (540) |
| 24 x 20 x 10 (610 x 508 x 254) | 14 (356) | 25.25 (641) |
| 30 x 24 x 10 (762 x 610 x 254) | 18 (457) | 31.25 (794) |
| 36 x 24 x 10 (914 x 610 x 254) | 18 (457) | 37.25 (946) |
| 36 x 30 x 10 (914 x 762 x 254) | 24 (610) | 37.25 (946) |
| 42 x 30 x 10 (1067 x 762 x 254) | 24 (610) | 43.25 (1099) |
| 48 x 30 x 10 (1219 x 762 x 254) | 24 (610) | 49.25 (1251) |
| 48 x 36 x 10 (1219 x 914 x 254) | 30 (762) | 49.25 (1251) |
| 60 x 36 x 10 (1524 x 914 x 254) | 30 (762) | 61.25 (1556) |
| 24 x 20 x 12 (610 x 508 x 305) | 14 (356) | 25.25 (641) |
| 24 x 24 x 12 (610 x 610 x 305) | 18 (457) | 25.25 (641) |
| 30 x 24 x 12 (762 x 610 x 305) | 18 (457) | 31.25 (794) |
| 36 x 24 x 12 (914 x 610 x 305) | 18 (457) | 37.25 (946) |
| 36 x 30 x 12 (914 x 762 x 305) | 24 (610) | 37.25 (946) |
| 36 x 36 x 12 (914 x 914 x 305) | 30 (762) | 37.25 (946) |
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| 48 x 36 x 12 (1219 x 914 x 305) | 30 (762) | 49.25 (1251) |
| 60 x 36 x 12 (1525 x 914 x 305) | 30 (762) | 61.25 (1556) |
| 30 x 24 x 16 (762 x 610 x 406) | 18 (457) | 31.25 (794) |
| 36 x 30 x 16 (914 x 762 x 406) | 24 (610) | 37.25 (946) |
| 48 x 36 x 16 (1219 x 914 x 406) | 30 (762) | 49.25 (1251) |
| 60 x 36 x 16 (1524 x 914 x 406) | 30 (762) | 61.25 (1556) |

Figure 1: Cabinet mounting hole layouts.

viceability are also key considerations. The unit should be located where it cannot 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 the unit should become detached from its mounting surfaces for any reason.

Although signal boosters can operate for years without being attended to, the unit will need to be accessed by service personnel with troubleshooting equipment, such as digital multimeters and spectrum analyzer or a laptop computer from time to time. The location of the power source will also have a bearing on the mounting location. SB II uses external heat sinks and needs to be mounted where there can be an unobstructed air flow over the heat sinks fins. The SB II cabinet will stay warm during normal operation so in the interest of equipment longevity, avoid locations that carry hot exhaust air or are continually hot.

Mounting

Figure 1 shows mounting hole dimensions and layout for the cabinet. 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 surface area. In areas of known seismic activity, additional devices such as tether lines may be necessary.

Because TX RX Systems, Inc. cannot anticipate all the possible mounting locations and 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 these devices are mounted safely and in compliance with local building codes.

CONNECTIONS

All cabling connections to the booster should be made and checked for correctness prior to powering up the system.

AC Line

Signal Booster II is designed to be hard-wired to 110 single phase AC lines at 50 - 60 Hz (see **Figures 2 and 3**). An AC line filter assembly is provided for this purpose. There is a hole provided in the cabinet bottom-wall for bringing in the AC line. Fasten quick connect plugs to the incoming AC line, then connect the ground wire, neutral wire, and hot wire to the respective pins on the top of the AC line filter. Refer to the photo shown in figure 2. The output of the AC line filter is wired into the switch box which also contains a dual convenience outlet for running test equipment. Use conduit for running the wiring into the SB II cabinet and #14 gauge or larger conductors.

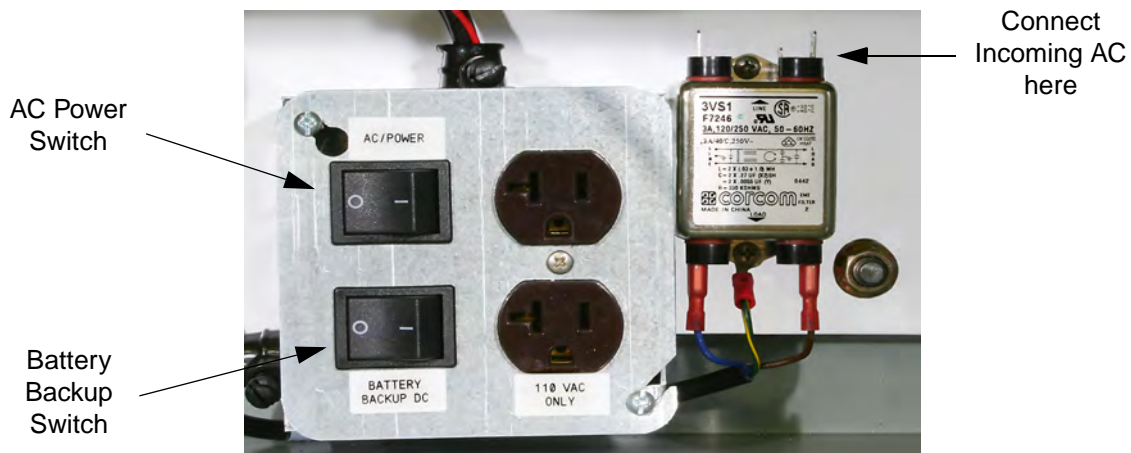


Figure 2: Wiring of AC line entry.

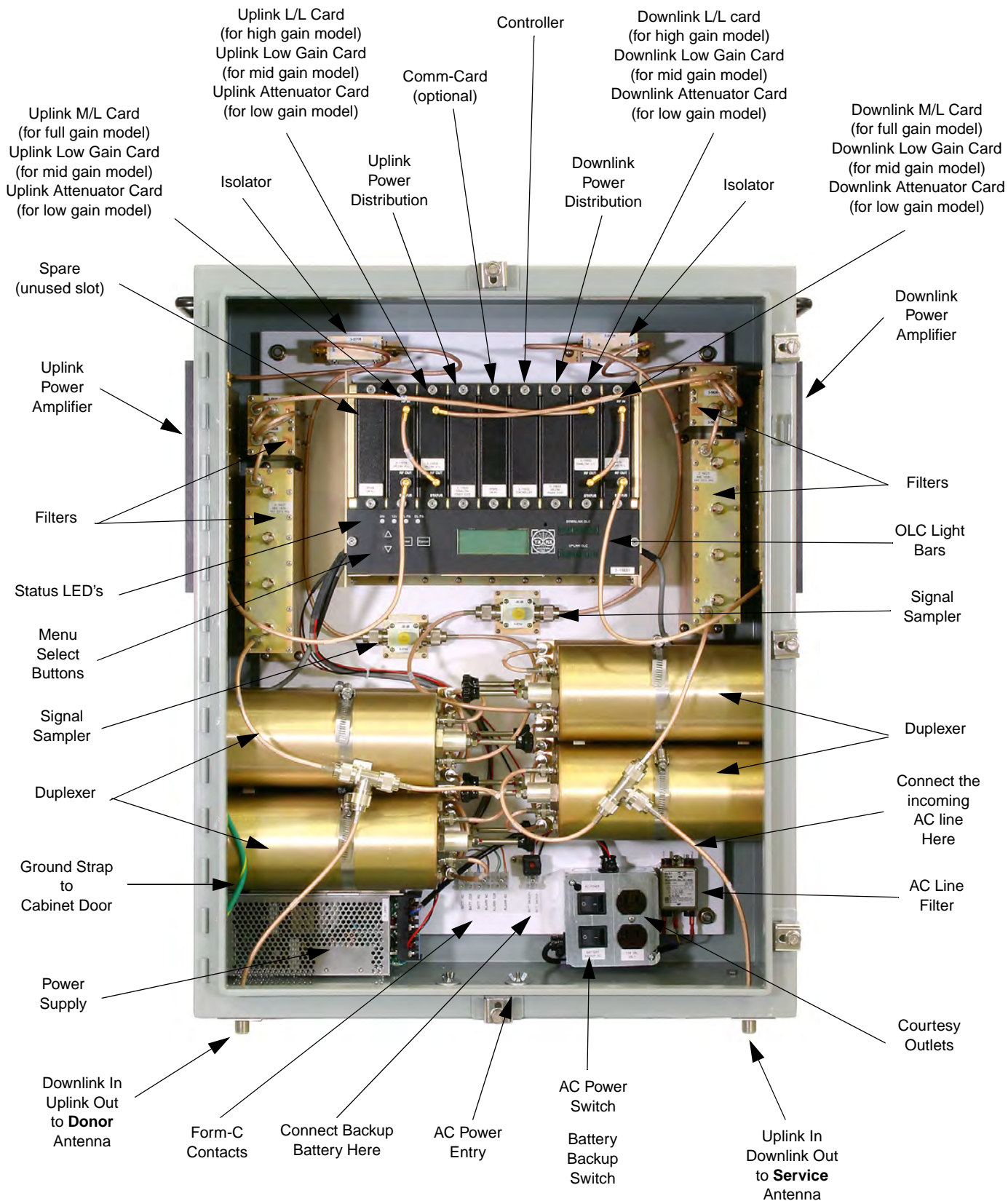


Figure 3: Front view of SB II. Part number 61-71-50-A0.5-G1 two-way signal booster shown as an example.

Backup DC Power

SB II may be run on a DC power source that can supply 24 to 27 volts DC at 2.5 amps. Screw terminals are provided for this purpose (see **Figure 4**). This line should be equipped with a fast-acting 3 Amp fuse. Use #16 or #18 gauge wire for this connection.

The power system in SB II automatically switches to this backup DC input when the AC supply fails for any reason including a power outage or intentional disconnection. It is not necessary that this connection be made for normal operation on the AC line.

Alarm Terminals (Form-C contacts)

Two sets of contacts are provided to monitor the general operating condition of SB II and are intended for connection to a supervisory system. See figure 4.

One set changes state when the AC power supply shuts down for any reason and the unit switches to operation on the backup DC power system.

The other set of contacts changes state when any of a number of fault conditions arises within the electronics such as current drain outside of the expected operating range in some module.

A six-terminal strip is provided for the interface and uses screw terminals for ease of connection. Route the alarm wires through one of the access holes in the bottom of the box, strip about 3/16" of insulation from each end, loosen the screw terminal, insert the wire and retighten. Use #20 or #22 gauge insulated wire.

Use of these terminals is optional. SB II also has a number of status LEDs built-in to individual modules to indicate a fault condition.

RF Connections

N(F) bulkhead connectors are provided on the bottom of the cabinet for connection to the signal distribution system. Be sure that the correct branch of the distribution system is connected 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: The maximum RF input power level for the SBII is -15dBm. Stronger input signals will cause the unit to exceed it's IM specifications. Input signals stronger than 0 dBm will physically damage the unit.

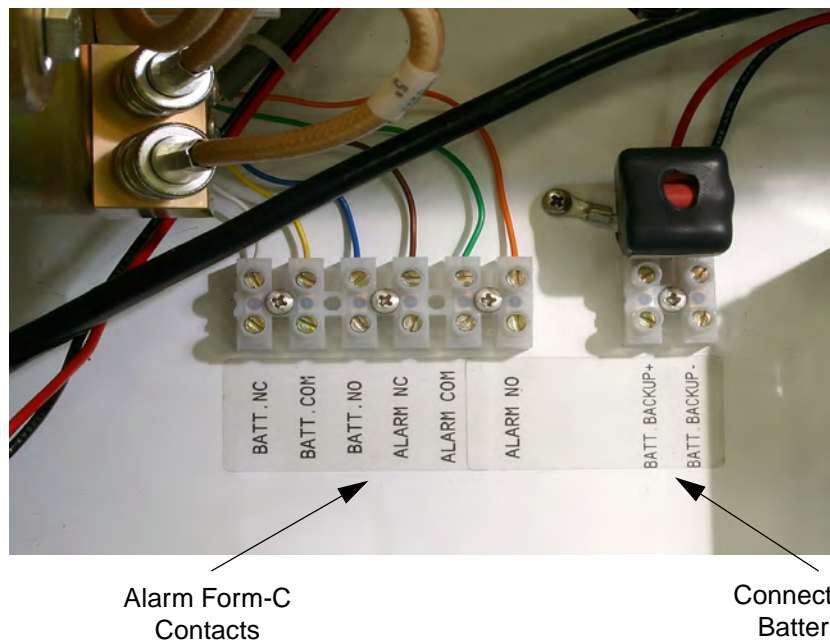


Figure 4: Battery backup and alarm terminals.

PRE-RF CONNECTION TESTS

Antenna isolation between the uplink and downlink branches should be measured before connecting the signal booster to the antenna system. This step is necessary to insure that no conditions exist that could possibly damage the signal booster and should not be skipped for even the most thoroughly designed system.



The 80 dB gain models are factory preset to 50 dB gain and should only be reset to a higher value after determining the safe maximum gain based on antenna isolation.

Test Equipment

The following equipment is required in order to perform the pre-installation measurements.

- 1) Signal generator for the frequencies of interest capable of a 0 dBm output level. Modulation is not necessary.
- 2) Spectrum analyzer that covers the frequencies of interest and is capable of observing signal levels down to -100 dBm or better.
- 3) Double shielded coaxial test cables made from RG142, RG55 or RG223 coaxial cable.

Antenna Isolation

Just like the feedback squeal that can occur when the microphone and speaker get too close to each other in a public address system, a signal booster can start to self oscillate. This can occur when the isolation between the input antenna or signal source and the output distribution system does not exceed the signal boosters gain by at least 15 dB. Oscillation will reduce the effectiveness of the system and may possibly damage the power amplifier stages.

In general, if one or both antenna ports are connected to sections of radiating coaxial cable (lossy cable) the isolation will be more than adequate because of the high coupling loss values that are encountered with this type of cable. When a network of antennas are used for the input and output, this problem is much more likely. Isolation values are relatively easy to measure with a spectrum analyzer and signal generator.

Procedure for Measuring Antenna Isolation

- 1) Set the signal generator for a -15 dBm output level at the center frequency of the signal boosters passbands.
- 2) Set the spectrum analyzer for the same center frequency and a sweep width equal to or just slightly greater than the passband chosen in step one.
- 3) Connect the test leads of the signal generator and the spectrum analyzer together using a female barrel connector, see **Figure 5**. 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 5, connect the generator test lead to one side of the signal distribution system (external antenna) and the spectrum analyzer lead to the other (internal distribution system) and observe the signal level. The difference between this 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. Record the isolation value. **The isolation value measured should exceed the signal booster's gain figure by at least 15 dB.**

It is wise to repeat the procedure listed above for measuring antenna isolation with the signal generator set to frequencies at the passbands edges in order to see if the isolation is remaining relatively constant over the complete width of the passband.

Repeat the isolation measurements at the other passband in bi-directional systems and use the lesser of the two values to determine the maximum gain setting.

Increase Isolation or decrease gain?

Modification of the signal distribution system is required to increase isolation between the up and downlink path. This will require significant changes that may or may not be practical from a cost or logistical standpoint. Gain reduction may be the only alternative but this is easy to achieve with Signal Booster II. Gain for both the uplink and downlink path can be set from 50 to 80 dB. Here are the steps to follow.

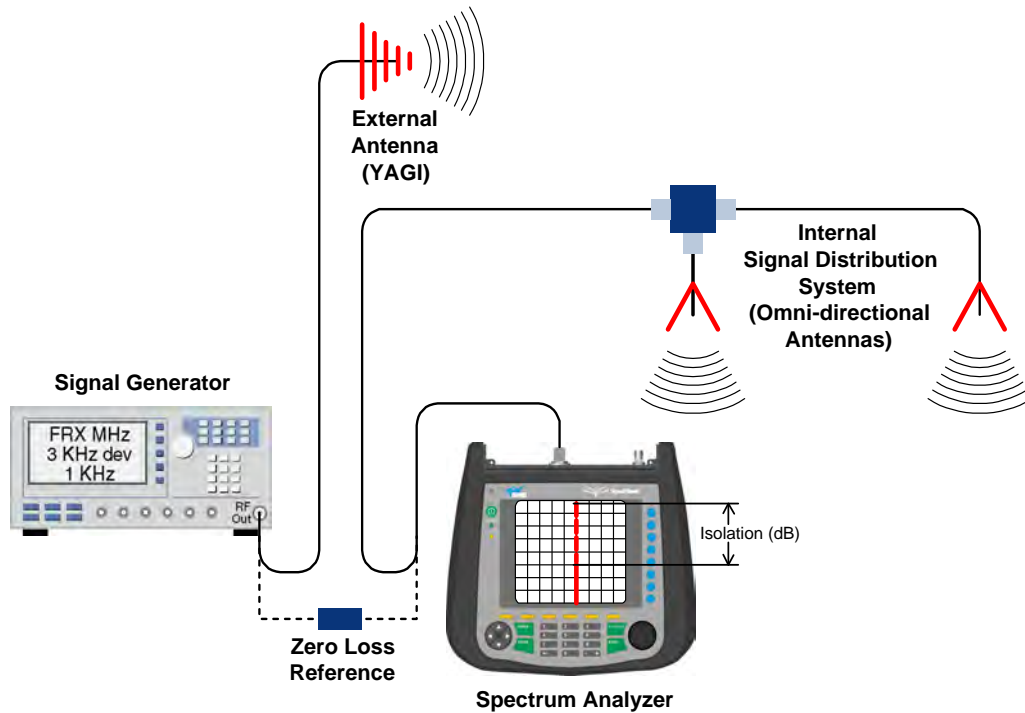


Figure 5: Typical test equipment interconnection for measuring antenna isolation.

- 1) Subtract 15 dB from the measured isolation between uplink and downlink branches of the antenna/signal distribution system. This is the maximum usable gain level for both the uplink and downlink path.
- 2) Accessing the user menu through the front panel, set the gain of the uplink path to the level determined in step 1. A detailed explanation of how to negotiate the menu system is given in the section Normal Operation.
- 3) Repeat step 2 for the downlink path.



Attenuator pads installed by the factory at the time of shipment should not be removed. They insure that system gain meets the customers original specifications.

NORMAL OPERATION

Power is applied to the signal booster by turning on the AC power switch located on the junction box inside the cabinet, refer to figure 2. The following startup sequence occurs.

- 1) At turn-on, the four status LEDs on the front panel glow red for about 5 seconds as the result of entering a self-check mode.
- 2) The two green OLC light bars will be fully lit along their length for approximately 5 seconds.
- 3) The LCD display shows the firmware revision screen for about 5 seconds (see **Figure 6**).

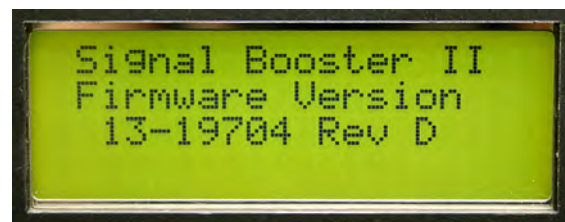


Figure 6: Software version is displayed briefly during the boot-up sequence.

- 4) After the self check is complete, the four status lights should turn green and the light bars should be dark unless a signal is activating OLC action in either the uplink or downlink.



WARNING: If the OLC light-bar segments on both the Uplink and Downlink display light-up and pulse on and off every 1 to 3 seconds simultaneously, **SHUT OFF THE POWER IMMEDIATELY!** The booster may be oscillating. Disconnect the uplink and downlink antenna connections and measure the isolation between the two branches to insure there is sufficient isolation. Reset the booster gain as needed.

- 5) The LCD display should appear similar to **Figure 7** after the self check is complete.

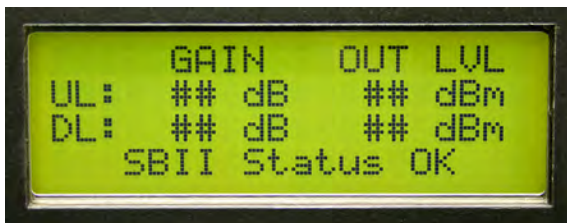


Figure 7: Normal Operational LCD Display.

LED Status indicators

The SB II front panel has 4 status LEDs that glow green or red to indicate the general health of 4 sub-systems from a DC perspective. Additionally, the plug-in 1/2-Gain, Low-Gain, Low-Level, and Mid-Level amplifier cards have tri-color (green-orange-red) status LEDs visible when the cabinet door is open.

FRONT PANEL LEADS:

24V: Green indicates the 24 volt DC Power system is operating properly.

12V: Green indicates the 12 volt DC power system is operating properly.

UL PA: Green indicates that the uplink power amplifier is drawing current within the expected operating range and at a safe temperature.

DL PA: Green indicates that the downlink power amplifier is drawing current within the expected operating range and at a safe temperature.

Module LEADS:

Mid-Level, Low-Level, Low-Gain, Module: Green indicates current or device temperature within the expected operating range. Orange indicates current or temperature slightly out of the expected range but the overall booster operation may still appear normal. Red indicates a large departure from normal current or device temperature and booster operation is likely to be affected. See Alarms section for more details about alarm operation.

Attenuator Module: Green only indicating DC power is applied to the card.

OLC LIGHT BARS

Ideally, there should be little or no light bar activity. Each light bar segment represents an average 3 dB of OLC gain reduction. OLC (output level control) is meant to reduce gain for transient episodes of very strong signals. However, when OLC is active, gain is reduced for all signals being processed by that booster branch and that reduction may compromise communications for weaker signals in the booster's passband.

If more than 2 or 3 light-bar segments are lit up more than occasionally, it is advised that the gain of that branch be reduced. See the SET GAIN paragraph for details.

Front Panel Controls & the LCD Display

SB II is software directed so control of the system is accomplished via user interface with the control panel using the LCD display screen and the menu select buttons, see figure 3. A flow chart showing all of the possible user menu selections is shown in **Figure 8**.

LCD Screen

Once the boot-up sequence is completed (after several seconds) the LCD screen will switch to the main status display as shown in figure 7. This is the normal display for the signal booster. The system will return to this display from any other display if none of the menu interface buttons are pressed within 2 minutes. The exception is the OLC status display which does require a button press to exit. The main status display shows the uplink and downlink gain in dB as well as the uplink and downlink output level in dBm.

If no button is pressed within 2 minutes, system returns to Main Status Display Screen



GAIN OUT LVL
 UL: ## dB ## dBm
 DL: ## dB ## dBm
 SBII Status OK

**SBII USER MENU 1 (8-20460B)
 KEY**

- Press item select UP arrow
- Press item select DOWN arrow
- E** Press ENTER key
- C** **NOTE:** Pressing CANCEL always returns you to the previous menu without saving changes

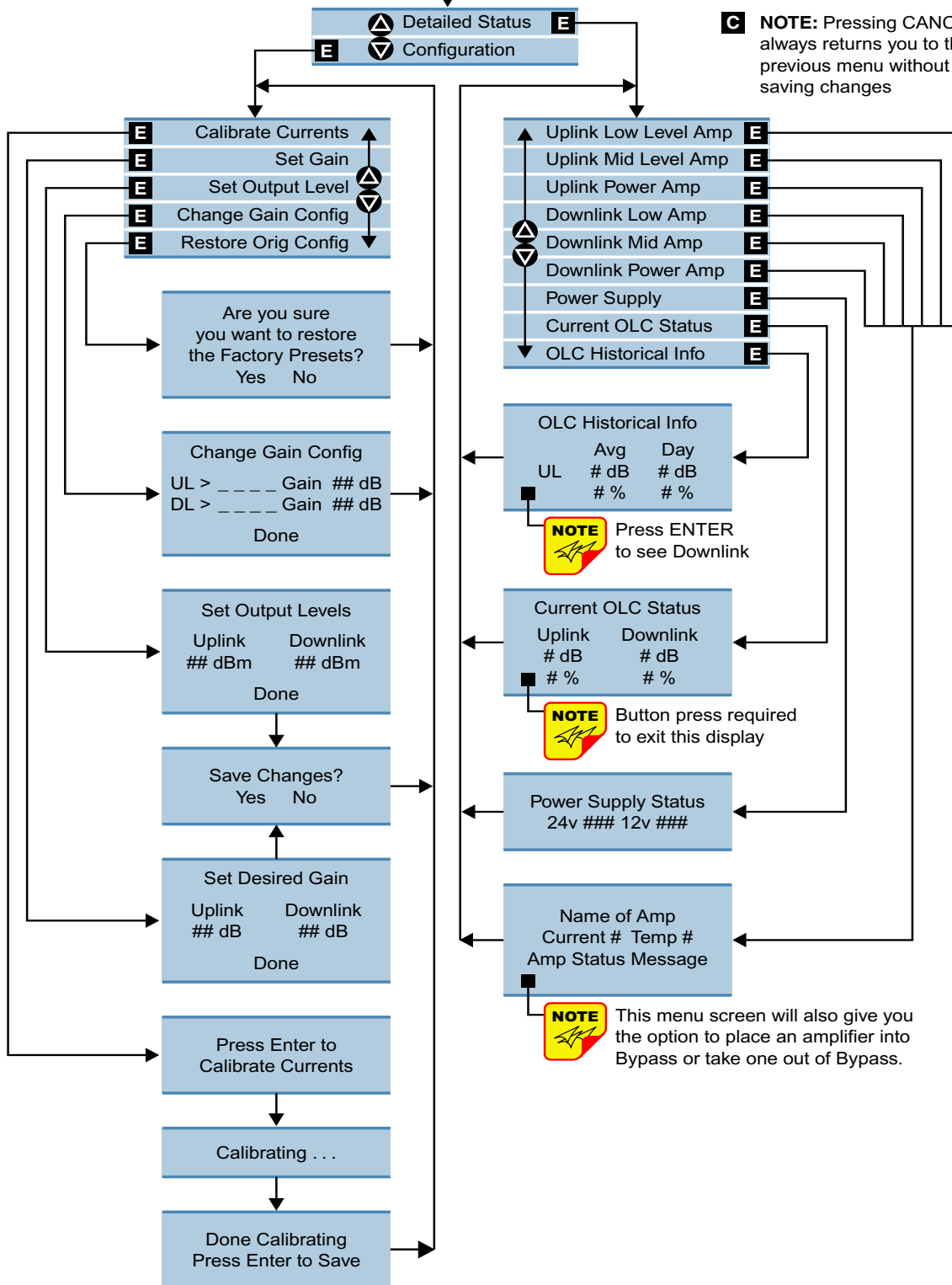


Figure 8: Signal Booster II Menu System.

The last line of the main status display gives a summary status message for the entire signal booster. In this example “Status OK” is being displayed. Pressing the “ENTER” button will move you from the main status display into the menu selections and will permit interaction with the system. There are two main functions available within the software menus including configuration settings and detailed status displays.

Configuration Settings

In most cases, the factory default settings are the optimum values for adjustable parameters. The most common setting to be changed by the system’s technician is the gain setting. This is normally done to compensate for varying values of antenna isolation as outlined earlier in this manual or to reduce excessive OLC action resulting from excessive gain.

Please thoroughly study this section before making any adjustments to the configuration values. Each configured item is discussed in detail.



Changes to configuration settings do not take affect until the Main Status screen is re-enabled. This occurs automatically after 2 minutes without button input or manually by pressing the Enter/Done/Cancel buttons to return to the status screen.

RESTORE ORIG CONFIG

This command will restore all configured settings to their original factory default values. SB II ships from the factory preset to the lowest gain possible.

CALIBRATE CURRENTS

Use this command when replacing an RF amplifier. This function automatically calibrates the current alarm “trip” point of each amplifier in the system. Due to manufacturing tolerances there are small differences in current draw between amplifier assemblies. This software function matches the alarm sensing circuit to the respective amplifier assembly and should be repeated whenever an amplifier assembly is replaced.

SET GAIN

This function allows the user to electronically set the gain of the booster in 0.5 dB increments over a range of 30 dB. Gain can be adjusted indepen-

dently for both the uplink and downlink channels but in most cases both uplink and downlink should be set to the same gain value.

Know your antenna isolation before making this adjustment. We recommend that you temporarily disconnect both the uplink and downlink antennas when setting the gain to avoid the possibility of causing the unit to oscillate. After changing the setting, power the unit down, reconnect the antennas and power-up the booster.



A reduction in system gain will also result in an equal reduction in the OLC dynamic range, refer to the section titled “OLC”.

SET OUTPUT LEVEL

Allows the output power for the uplink and downlink channels to be independently adjusted in 0.5 dB increments up to +32 dBm. Note that the OLC circuitry will maintain the systems output level at the values you have selected in this menu.

Use this function ONLY if your system is causing some form of interference to another radio system. You can only reduce the booster’s output power with this command.

CHANGE GAIN CONFIGURATION

Insures proper gain readings when changing basic booster gain by changing the type of plug-in card assemblies.

Use of this menu is ONLY needed when converting your stock SB II to a different gain level by changing the low level, mid-level plug-in amplifier card or the addition of an attenuator card. The addition of these cards will change the unit to another model within the UHF SB II family. Don’t confuse this with simple amplifier bypassing to reduce gain. Uplink and down link can be set independently. Choices for gain are Full, Mid or Low and the ENTER key toggles the gain setting. The corresponding gain level is displayed. Select DONE using the arrow keys and press ENTER to return to the menu. Use the CANCEL button to return to the Status Display.

Detailed Status Screens

These items allow a detailed examination of system components including; all amplifiers (current draw and temperature), the power supply (voltage

level), and the OLC function (present status and historical archive). Each item is discussed below in detail.

AMPLIFIERS

A separate status screen is available for each amplifier in the system. When an amplifier is selected this function will display the present current draw of that amp as well as its present operating temperature in degrees Celsius. In addition, a status message will indicate if the amplifier is connected and whether the amplifier is bypassed or not bypassed. This menu selection also provides the option of placing an amplifier in bypass or taking an amplifier out of bypass.

The current draw will be blank if an amplifier is not connected, will display BYP if the amplifier is bypassed, and will display ATTEN if an attenuator card is being used in place of the amplifier card.



The power amplifier currents will normally fluctuate up to 850 ma when signals are present.

POWER SUPPLY

This function displays the real time power supply voltages for both 24 volt and 12 volt supplies.

OLC

This screen shows the amount of attenuation presently being used by the OLC for both the uplink and downlink channels. In addition, the percentage of OLC presently being used is also shown.



The amount of OLC currently being used in either the uplink or downlink channels is also indicated by LED bar graph displays located on the display panel. Each segment represents 2 to 4 dB of attenuation depending on the gain setting of the booster. The OLC bars should only be active occasionally and no more than 3 or 4 segments briefly lit. Constant light bar activity means the booster gain needs to be reduced for optimum performance.



The system has 60 dB of OLC dynamic range. However, the dynamic range of the OLC is reduced when the user selectable gain is reduced. The reduction will be an equal amount. For instance, if the user selectable gain is reduced by 20 dB then the OLC dynamic range will also be reduced by 20 dB.

OLC DATALOG

This screen displays an OLC Datalog which is the OLC data over the past 100 days for both uplink and downlink branches of the system. This is a rolling 100 day log with day 101 overlapping day 1 and so forth. Day zero represents the current day while day one represents yesterday and so on. The logged data is stored in non-volatile memory and will not be erased when the unit is powered down.

The average OLC attenuation used when the OLC was active is given both for individual days and over the entire past 100 days. The percentage of time the OLC was active is also given for both individual days and over the past 100 days. This archived information will permit the creation of a user signal profile to facilitate optimum system configuration and performance.

This archive feature will allow you to see if the gain of the unit is set too high or if there are transient episodes of strong signals perhaps desensitizing other channels being amplified by the booster.

Alarms

The system continuously monitors the current draw and operating temperature of each amplifier as well as the voltage level of the +12 and +24 VDC supplies. If any of these parameters exceed normal operating levels by a factory preset percentage the system enters an alarm condition. Notification of an alarm condition is provided by LED indicators and Form-C contacts available via the alarm terminal screws.

LED INDICATORS

There are LED indicators for each amplifier in the system as well as the +12 and +24 VDC power supply voltages. The LED indicators for the low, mid, low-gain, and 1/2-gain amplifiers are located on the individual plug-in module. These are tri-color LED's with green representing NORMAL operation, orange representing a WARNING condi-

tion, and red indicating a FAULT. A warning condition occurs when the current draw of the amplifier exceeds nominal by +/- 20%. Fault conditions occur when the current draw exceeds +/- 30% or the amplifiers operating temperature exceeds 80° Celsius. The LED for the attenuator card is green only and indicates DC power applied to the card.

The LED indicators for the power amplifiers are located on the display panel next to the menu select buttons and are dual color LED's. Green represents NORMAL operation while red indicates a FAULT condition. Fault conditions occur when the current draw exceeds 900 ma or falls below 200 ma. Also, whenever the amplifiers operating temperature exceeds 95° Celsius. The power amplifiers do not have a warning state.

The power supply LED indicators are located on display panel next to the menu selection buttons and are also dual color. Green representing normal operation and red a fault condition. A fault condition for the +24 VDC supply occurs whenever the voltage potential drops below +16 VDC (30% below nominal). Likewise, a fault for the +12 VDC supply occurs when the potential is below +8 VDC (30% below nominal).

FORM-C CONTACTS

Form-C contacts are available inside the cabinet next to the power supply assembly, see figure 4. These screw terminals are intended for connection to the customers supervisory alarm or data acquisition system. One set of terminals supplies notification of any alarm condition occurring and the second set of contacts indicate the system is operating on battery backup power.

PERFORMANCE SURVEY

It is a good idea to document the performance of the system after installation so that a reference exists for future comparisons. This information can make troubleshooting an interference problem or investigation of a complaint about system performance much easier. If there are coverage problems with a system, this survey will usually reveal them allowing corrective measures to be taken before the system is put into routine use. The following is an outline of how to do such a survey. Because the nature of each installation can be quite different, only a broad outline is given.

- 1) Measure the gain of the signal booster being careful not to exceed the maximum input level. The recommended maximum RF Input power for the SBII is -15 dBm. Stronger input signals will cause the unit to exceed its maximum IM specifications. Input signals which are stronger

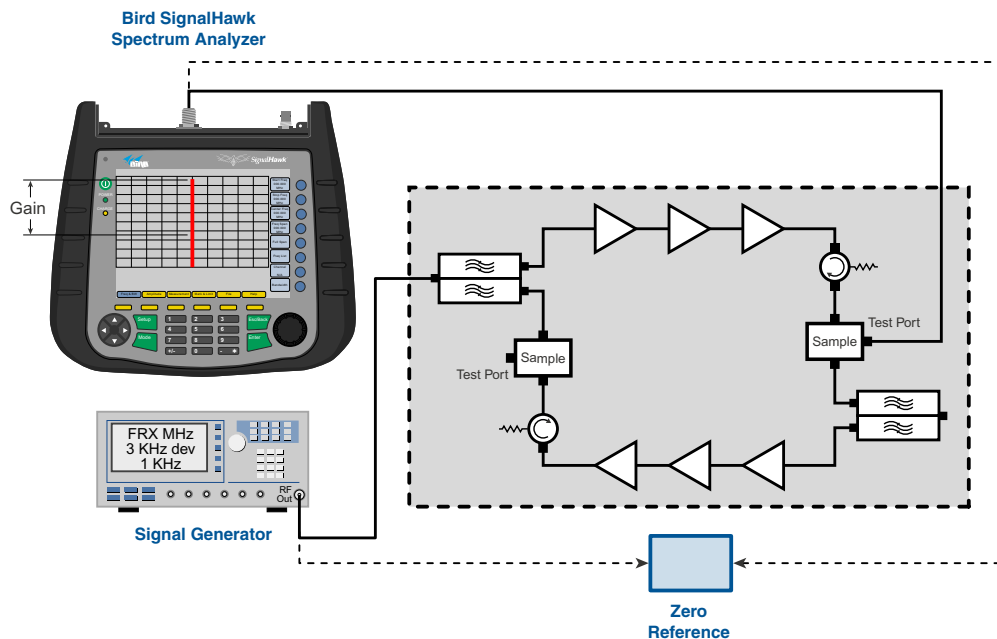


Figure 9: Measuring signal booster gain.

than 0 dBm will physically damage the unit. **Figure 9** shows this being done using a signal generator and spectrum analyzer. Record the measured values for each passband. We recommend that a 50 ohm load be connected to the unused RF port on the bottom of the cabinet during the gain test.

- 2) The spectrum analyzer is connected to the -30 dB signal sampler port following the final output amp. This port will allow the observation of the amplifier output at a considerably reduced output level. This decoupling value (-30 dB) needs to be added to any measured signal value in order to arrive at the actual signal level.
- 3) With a spectrum analyzer connected to the signal sampler port (see **Figure 10**), have personnel with handheld radios move to several predetermined points and key their radios. Record the level of these signals as observed on the analyzer and also record the location of the person transmitting. In this way, a map of the systems performance can be generated.

- 4) For signals coming from a fixed antenna or station, record the level of all the desired incoming signals for future reference.

MAINTENANCE AND REPAIR

Signal boosters manufactured by TX RX Systems, Inc. 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 malfunctioning unit or as part of a periodic maintenance program.

- 1) The heatsink area should be cleared of dust and debris.
- 2) Inspect the unit to see that the two power supply LED DC indicators are lit (remove any dust or debris that may obscure the LEDs). This will verify that DC power is flowing properly. Check all hardware for tightness.
- 3) Compare system performance to initial performance levels measured when the system was first installed. The lack of signal can be traced

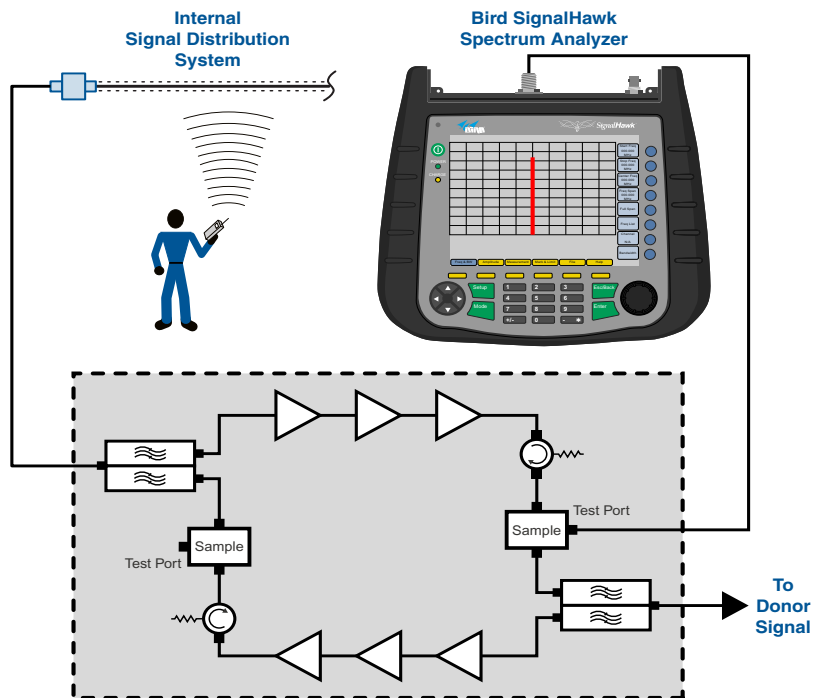


Figure 10: Methodology for doing a performance survey of the signal distribution system.

to a malfunctioning amplifier by progressive signal monitoring from the output (far end) to the input end of the system noting the area where the signal returns to normal level. The next amplifier toward the output end of the system will probably be the one that failed.

or

Measure the gain at any convenient frequency in the working frequency band to verify that the performance is still within specifications.

Power Amplifier Replacement

The SB II power amplifiers are field replaceable. Follow the steps listed below in sequential order. The required tools are a #1 Phillips screwdriver and a 5/16" open-ended wrench.

- 1) Using the Set Gain menu selection reduce the gain of your booster by 20 dB. This will add some additional attenuation to the system in order to help protect the replacement amplifier when you first power the system back-up.
- 2) Turn the booster off.
- 3) Disconnect the booster from both antennas.
- 4) Remove the Phillips screws which hold the amplifier into place, refer to **Figure 11**. The nuts holding the screws are pressed into the cabinet and will remain in place when the screws are removed.
- 5) Slide the amplifier towards the bottom of the cabinet as far as it will go. This will allow the top RF connector to clear the opening. Tilt the top of the amplifier outwards and remove the top RF cable at the SMA connector using the 5/16" wrench. See **Figure 12**.
- 6) Slide the amplifier assembly towards the top of the cabinet as far as it will go. This will allow the bottom RF connector and grey control cable to clear the opening. Tilt the bottom of the amplifier outwards and remove the bottom RF cable

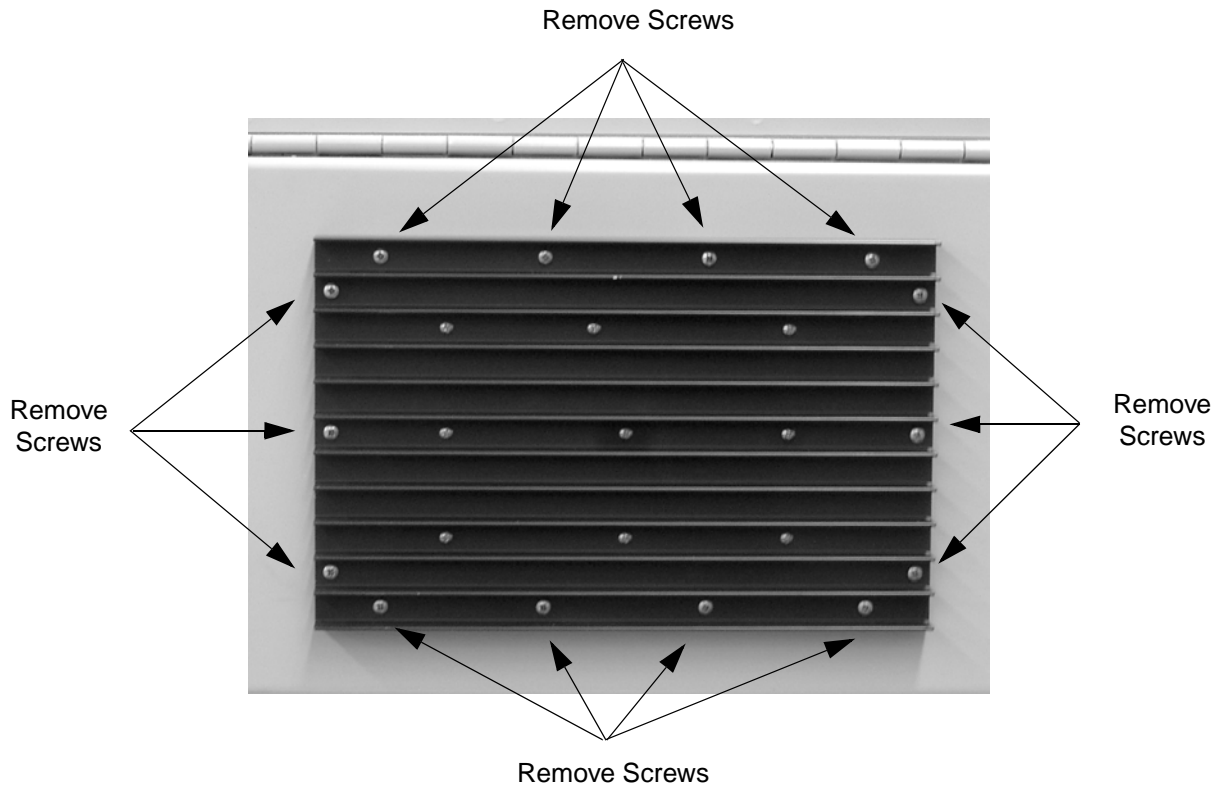


Figure 11: Remove 14 mounting screws to detach amplifier assembly from cabinet.



Figure 12: Slide amplifier towards bottom of cabinet to remove upper cable.

at the SMA connector and the grey control cable. To remove the grey cable from the socket on the amplifier it is necessary to squeeze the top and bottom of the connector together to release a hold down tab. When properly squeezed the grey cable will disconnect easily from the amplifier. Refer to **Figure 13**.

- 7) To replace the amplifier assembly repeat steps 4 through 6 in reverse order. 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 replacement amplifier comes with an attached gasket which must press up against the outside of the cabinet firmly and squarely in order to provide a correct moisture seal.
- 8) Turn on the booster.
- 9) Use a signal generator to inject a -60 dBm test signal into the RF input connector on the bottom of the cabinet associated with the replacement amplifier.
- 10) Use the remaining RF connector on the bottom of the cabinet to measure the output signal level which should be about; 0 dBm on the



Figure 13: Slide amplifier towards top of cabinet to remove lower cables.

high-gain system, -20 dBm on the mid-gain system, and -35 dBm on the low-gain system.

- 11) Increase the gain slowly until the front panel display shows 80 dB (for high-gain systems), 60 dB (for mid-gain systems), or 45 dB (for low-gain systems). Correspondingly the measured output power should be about 20 dBm (for high-gain systems), 0 dBm (for mid-gain systems), and -15 dBm (for low-gain systems).
- 12) Increase the input signal strength to a level such that the output signal is about 30 dBm. For the high-gain system this would require an input signal strength of about -50 dBm. For the mid-gain about -30 dBm and for the low-gain about -15 dBm.
- 13) Increase the input signal in 1 dBm increments and within 2 to 3 increments the OLC circuit in the booster should start working and the output level should hold constant.
- 14) Increase the input signal level to -35 dBm (for high-gain systems), -15 dBm (for mid-gain systems), and 0 dBm (for low-gain systems) and 2 or 3 bars of the OLC bar-graph display should light up green. The measured output levels should hold constant at 30 dBm.



If your booster is not behaving as expected after the replacement amplifier is installed and tested then please contact the field service department before returning the booster to service.

- 15) Reconnect the antennas to the cabinet and adjust your system gain as appropriate.

Module Replacement

The SB II modules are field replaceable. Follow the steps listed below in sequential order. The required tools are a #1 Phillips screwdriver. Two thumb screws hold each module into place.



Power to the SB II cabinet must be turned OFF during the module replacement process except for the amplifier modules which are "HOT" switchable.

- 1) Loosen the two thumb screws which hold the module into place. Phillips screws are incorporated into the thumbscrews and they may need to be loosened first.
- 2) Grasping the two loosened thumb screws pull the module straight out of the card cage.
- 3) To install the replacement module place the module into the guide-rails of the slot and press down firmly into place. Each type of module is keyed uniquely to fit in only one slot within the card cage. Once the card is seated into place properly tighten the thumb screws.

The SB II low level and mid level amplifier stages are field replaceable by simply removing the module and plugging in a replacement. These modules are HOT switchable meaning they can be swapped without powering down the system. RF cables attached to the modules must be removed (5/16" wrench) prior to swapping the modules and must be re-attached after the new module is in place. 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.

Modules can be swapped between the uplink and downlink branches for troubleshooting purposes. If a problem exists in one branch and the problem moves to the other branch when modules are swapped around this indicates a defective module.



After an amplifier module is replaced use the Calibrate Currents software function to properly set the amplifiers alarm trip point. Due to slight differences in component tolerances the trip point must be reset for any new amplifier assemblies introduced into the system.

Display/User Interface Assembly Replacement

The SB II Display/User Interface assembly is field replaceable. Follow the steps listed below in sequential order. No tools are required.



Power to the SB II cabinet must be turned OFF during the display/user interface replacement process.

- 1) Loosen the two thumb-nuts which hold the display/user interface assembly to the card cage.
- 2) Gently tilt only the top of the assembly up from the card cage. Keep the bottom of the assembly in place. The bottom mounting plate (part of the card cage) has an overhang on it to support the display/user interface board. If the assembly is lifted straight out the overhang could possibly damage the interface circuit board.
- 3) With the display/user interface board standing up straight gently move it upwards while lifting it out about an inch or two. This should allow the overhang to clear the interface circuit board without damage.
- 4) Remove the ribbon cable that connects the display/user interface assembly to the card cage, see **Figure 14**.
- 5) To replace the display/user interface assembly repeat steps 1 through 4 in reverse order.

Power Supply Replacement

The SB II power supply assembly is field replaceable. Follow the steps listed below in sequential order. The required tools are a #1 Phillips screwdriver.

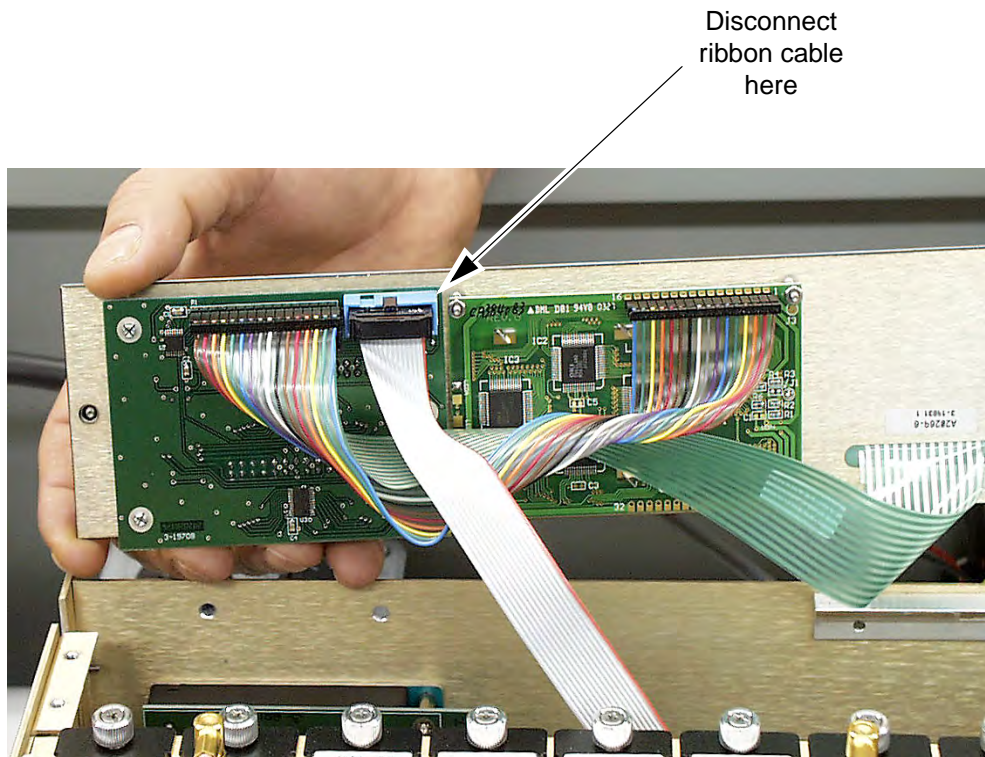


Figure 14: Disconnecting the display/user interface assembly from the card cage.

- 1) Turn off AC power at the junction box.
- 2) Disconnect the 3 conductor cable that brings AC power to the supply from the junction box.
- 3) Disconnect the red and black leads from the power supply that connect to the card cage.
- 4) Remove the Phillips screws that hold the power supply mount bracket to the back plate and remove the assembly from the cabinet.
- 5) Reverse steps 4 through 2 to install the replacement power supply.

Duplexer / Filter Replacement

The component assemblies of the duplexer are field replaceable. Follow the steps listed below in sequential order. The required tools are a #1 Phil-

lips screwdriver with an extended shaft to reach down far enough into the unit to loosen mounting screws.



Power to the SB II cabinet must be turned OFF during the assembly replacement process.

- 1) All RF cables attached to the assembly must be removed.
- 2) Remove the Phillips screws that hold the assembly mount brackets to the back plate and remove the assembly from the cabinet.
- 3) Reverse steps 2 and 1 to install the replacement assembly. 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.

Card Cage Replacement

To replace the card cage follow the steps listed below in sequential order. The required tools are a #1 Phillips screwdriver with an extended shaft to reach down far enough into the unit to loosen the mounting screws.



Power to the SB II cabinet must be turned OFF during the card cage replacement process.

- 1) Disconnect the display/user interface assembly.
- 2) Disconnect 4 cables at the backplane of the card cage which are accessible with the display/user interface board out of the way.
- 3) Remove the row of Phillips screws which hold the card cage to the back plate. There is a row of screws at the top and bottom of the cage.
- 4) To install a replacement cage perform steps 3 through 1 in reverse order.

OPTIONAL EQUIPMENT

Optional equipment can be purchased from TX RX Systems Inc. in order to increase the performance of the signal booster system. These include a plug-in communications card and an automatic voice/pager dialer. The communications card allows both Ethernet and RS-232 communications with the signal booster. The auto voice/pager dialer provides reliable emergency notification of an alarm condition in the signal booster.

Communications Card

The communications card (part# 6150-COM) allows remote monitoring of essential signal booster operating parameters, access to historical OLC data, and the ability to change the boosters configuration. The card is supplied with built-in internet software accessible with any web browser. RS232 communications requires a user supplied terminal program such as Hyper Terminal.

Automatic Voice/Pager Dialer

The automatic voice/pager dialer (part# 6150-PAGE) is installed inside of the SBII cabinet and monitors the signal boosters alarm contacts. When the booster indicates an alarm the voice/pager dialer detects the condition and will initiate notification calls to as many as 8 standard telephones, cellular phones, voice and/or numeric pagers. When

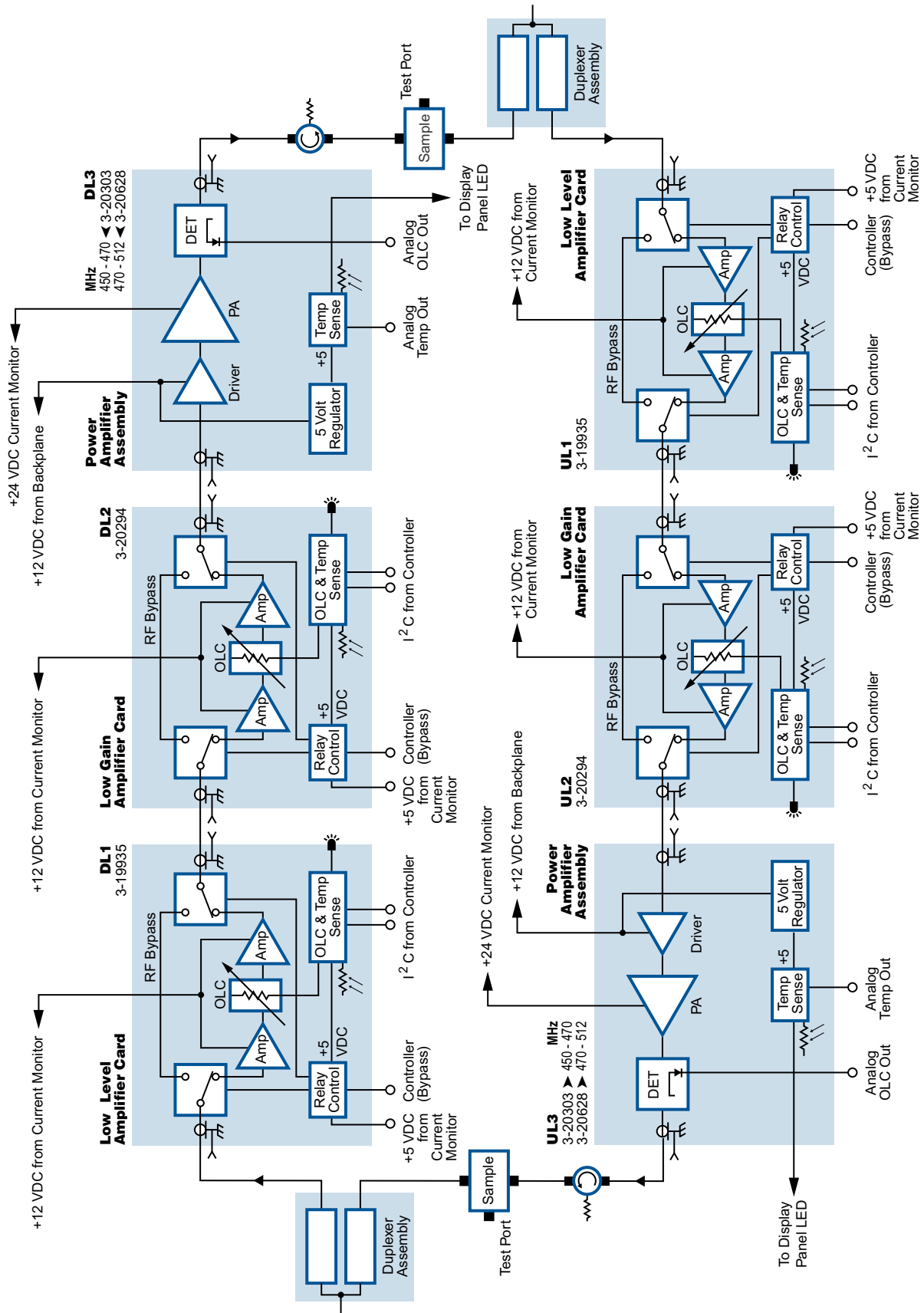
activated, the dialer instantly begins calling the notification numbers in sequence. The notification messages are delivered 1 to 3 times in a row in accordance with a pre-selected number of dialing attempts.

RECOMMENDED SPARES

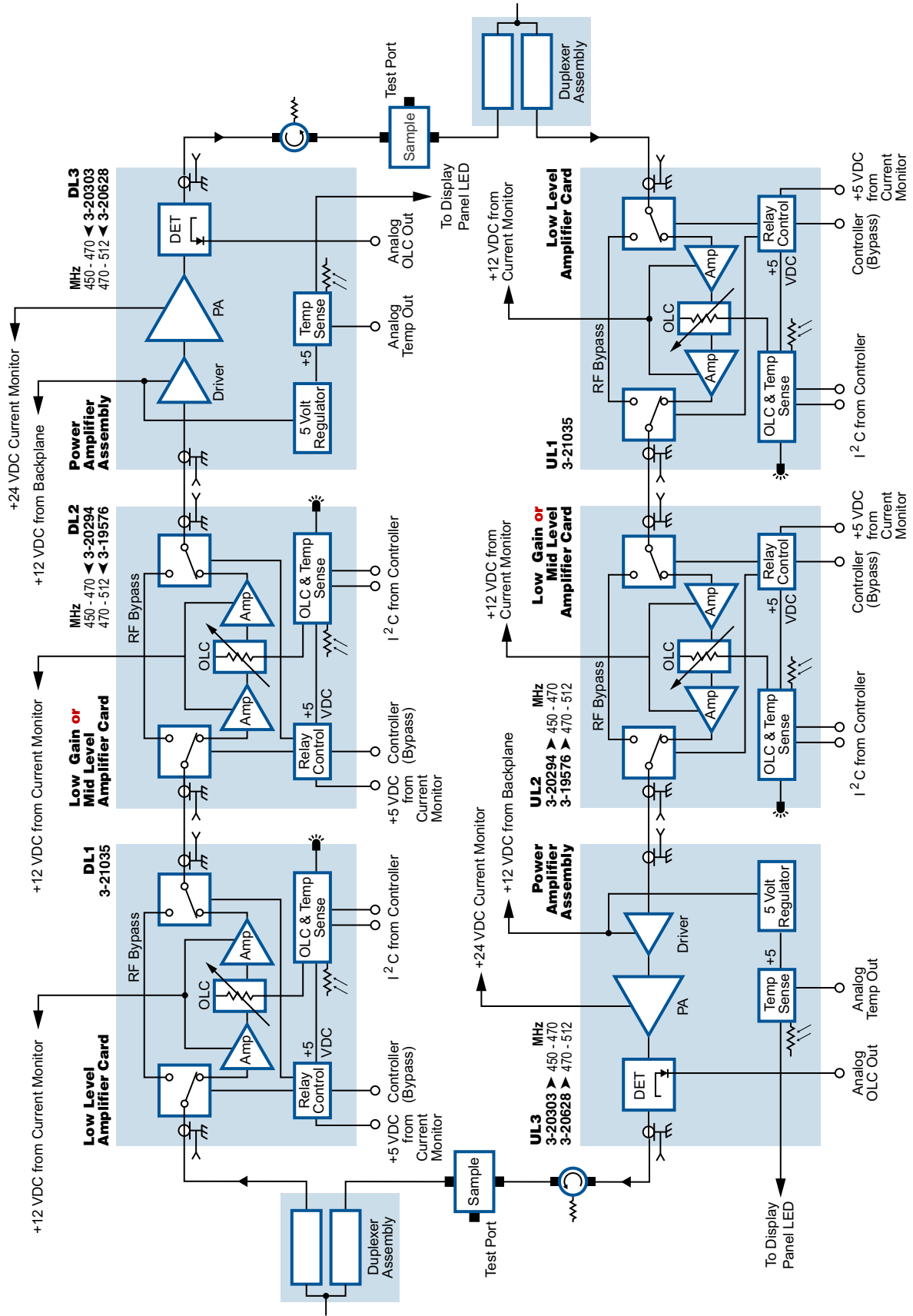
It is recommended that one spare of each of the following assemblies be kept on hand for emergency repair purposes; Power Supply 8-20667, Uplink/Downlink Power Amplifier either 3-20806, 3-20807, 3-20303, or 3-20628 (depending on the specific model of UHF SB II), Mid Level Amplifier Card 3-19576, Low Level Amplifier Card 3-19935, Low Gain Amplifier Card 3-20294, Attenuator Card 3-20208, Power Distribution Card 3-19833, Controller Card 3-19832, and the Display/User Interface Assembly 3-19831.

| | Low Gain (In-Line) Booster | Medium Gain Booster | High Gain (Head-End) Booster |
|---|---|---|---|
| Minimum Gain | +45 dB | +60 dB | +80 dB |
| Gain Adjustment | Programmable attenuation, 0 - 30 dB, 0.5 dB steps | Programmable attenuation, 0 - 30 dB, 0.5 dB steps | Programmable attenuation, 0 - 30 dB, 0.5 dB steps |
| 3rd Order Output Intercept Point | +54 dBm minimum, with no attenuation | +54 dBm minimum, with no attenuation | +54 dBm minimum, with no attenuation |
| Maximum Input Level | 0 dBm | 0 dBm | 0 dBm |
| Maximum Output Power | +32 dBm (single carrier) | +32 dBm (single carrier) | +32 dBm (single carrier) |
| RF Sampler | PA Output sampler (-30 dB) | PA Output sampler (-30 dB) | PA Output sampler (-30 dB) |
| Noise Figure (without attenuation) | 12 dB maximum | 8 dB maximum | 8 dB maximum |
| Propagation Delay | < 3 μ s (2 μ s for 2 MHz passband) | < 3 μ s (2 μ s for 2 MHz passband) | < 3 μ s (2 μ s for 2 MHz passband) |
| Operating Temperature Range | -30°C to +50°C | -30°C to +50°C | -30°C to +50°C |
| Nominal Impedance | 50 Ohms, < 1.5:1 VSWR | 50 Ohms, < 1.5:1 VSWR | 50 Ohms, < 1.5:1 VSWR |
| Input/Output Connectors | N Female | N Female | N Female |
| RF Sampler Connectors | BNC Female | BNC Female | BNC Female |
| AC Power Input | 100 - 240 VAC; 50 - 60 Hz | 100 - 240 VAC; 50 - 60 Hz | 100 - 240 VAC; 50 - 60 Hz |
| DC Input Voltage | +24 to +27 VDC -48 VDC optional | +24 to +27 VDC -48 VDC optional | +24 to +27 VDC -48 VDC optional |
| Unit Power Consumption (AC/DC) | < 150 VA | < 150 VA | < 150 VA |
| Alarm Terminals | Form-C Contacts Nominal 2A @ 30 VDC or 0.5A @ 125 VAC | Form-C Contacts Nominal 2A @ 30 VDC or 0.5A @ 125 VAC | Form-C Contacts Nominal 2A @ 30 VDC or 0.5A @ 125 VAC |
| FCC Certification** | EZZ5PI616850 | EZZ5PI616850 | EZZ5PI616850 |
| Industry Canada Certification** | 1940A-PI616850 | 1940A-PI616850 | 1940A-PI616850 |
| ** Class B Type Booster Equipment Authorization under FCC Rules Part 90. Canada Certification Part RSS-131. | | | |

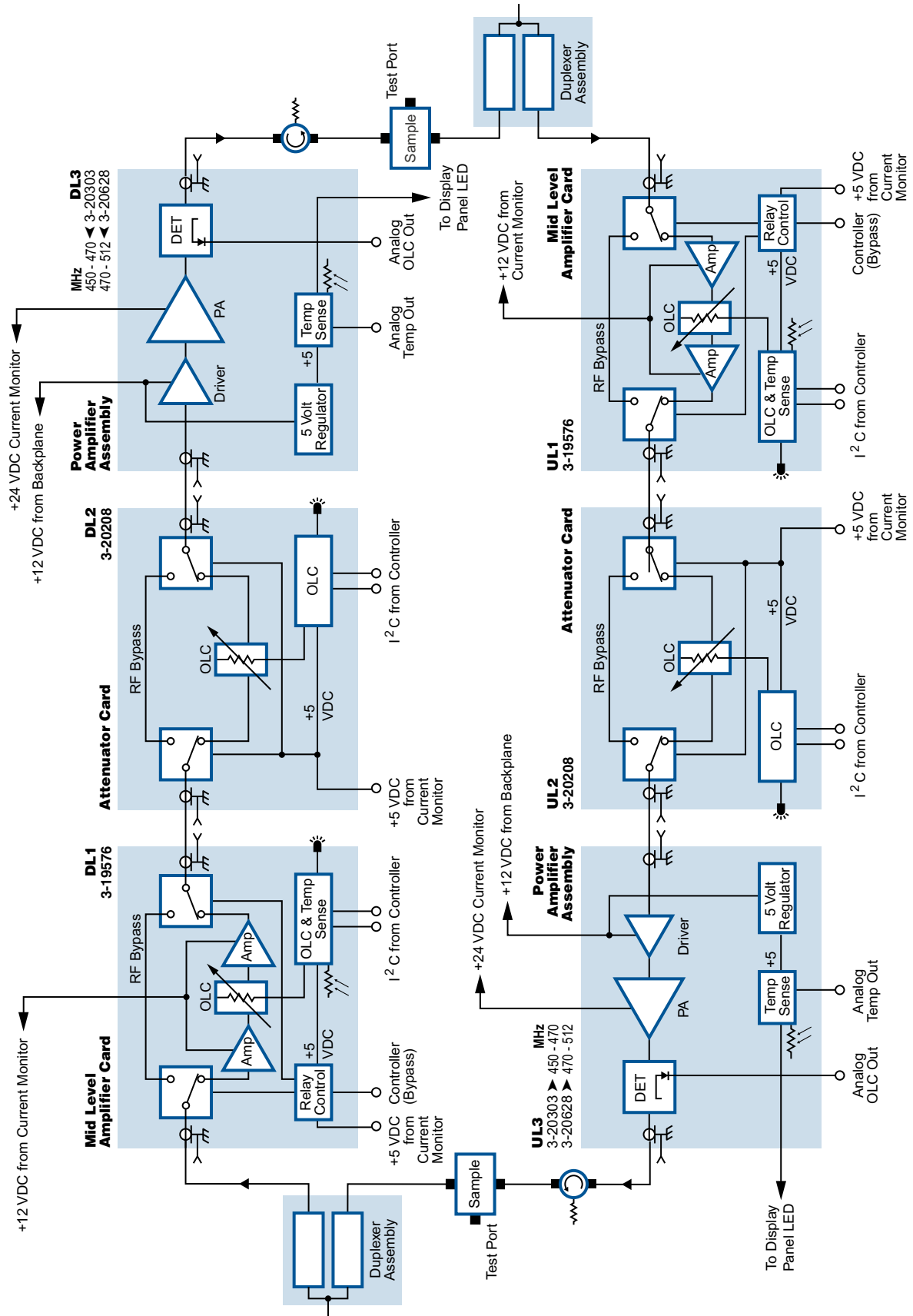
System Specifications



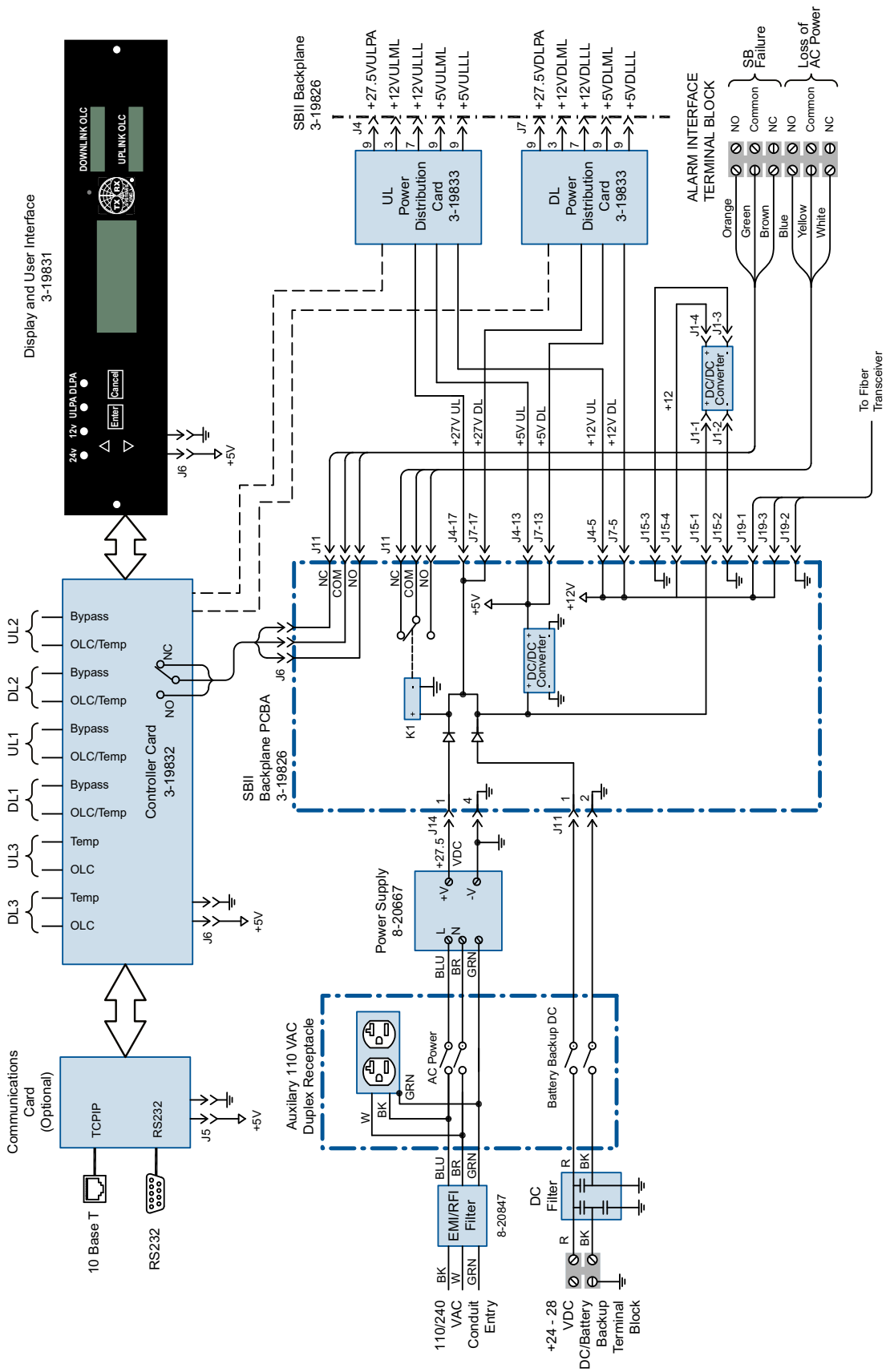
High Gain Model Block Diagram (Part 1 of 2)



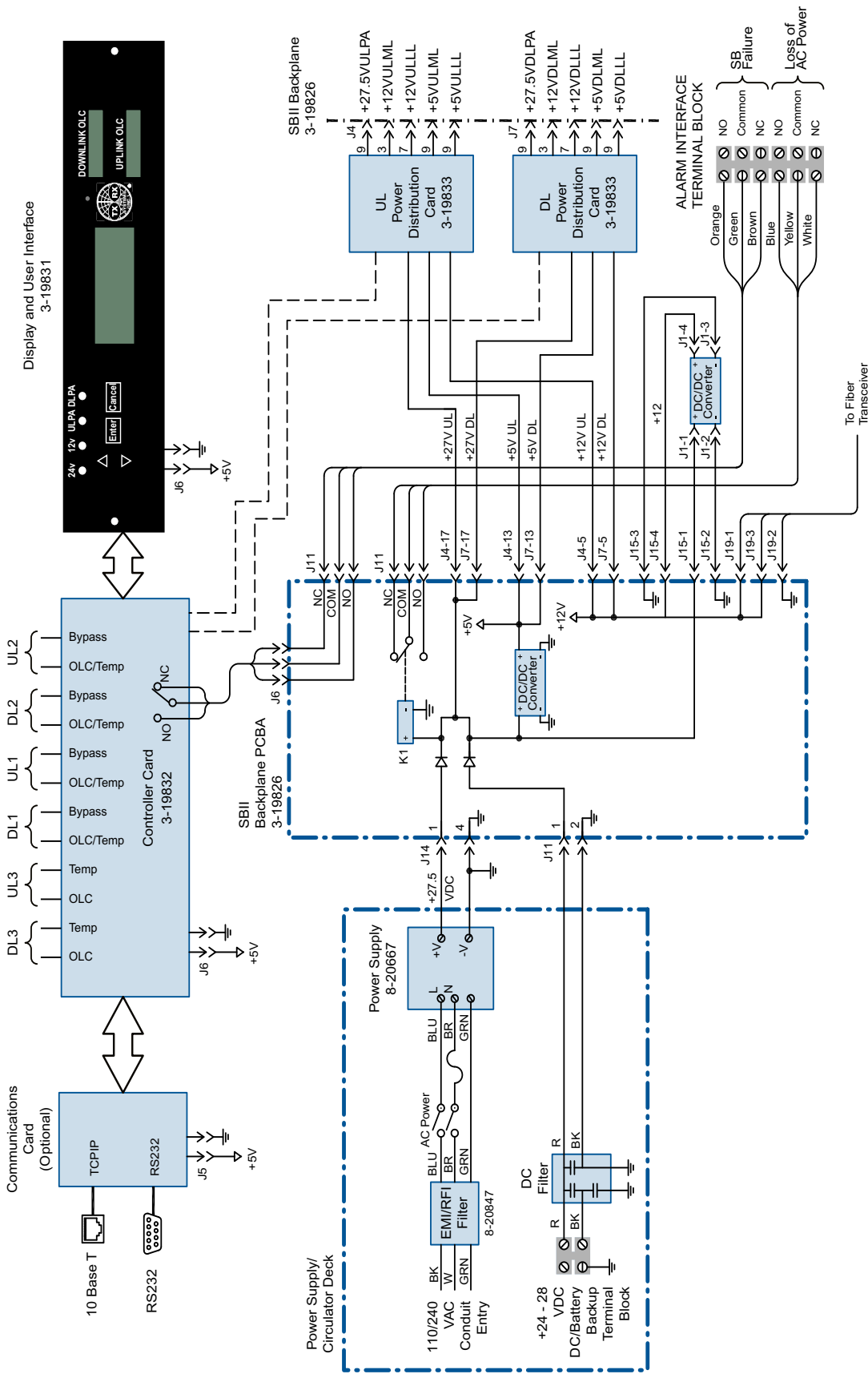
Mid Gain Model Block Diagram (Part 1 of 2)



Low Gain Model Block Diagram (Part 1 of 2)



High, Mid and Low Gain Model Block Diagram - NEMA Enclosure



High, Mid and Low Gain Model Block Diagram - Rack Mount

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 |
| 0 | 32.0 |
| -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 |

Power Ratio and Voltage Ratio to Decibel Conversion Chart

| Loss or Gain | Power Ratio | Voltage Ratio |
|--------------|-------------|---------------|
| +9.1 dB | 8.128 | 2.851 |
| -9.1 dB | 0.123 | 0.351 |

← - dB + →

← - dB + →

| Voltage Ratio | Power Ratio | dB | Voltage Ratio | Power Ratio |
|---------------|-------------|-----|---------------|-------------|
| 1 | 1 | 0 | 1 | 1 |
| 0.989 | 0.977 | 0.1 | 1.012 | 1.023 |
| 0.977 | 0.955 | 0.2 | 1.023 | 1.047 |
| 0.966 | 0.933 | 0.3 | 1.035 | 1.072 |
| 0.955 | 0.912 | 0.4 | 1.047 | 1.096 |
| 0.944 | 0.891 | 0.5 | 1.059 | 1.122 |
| 0.933 | 0.871 | 0.6 | 1.072 | 1.148 |
| 0.923 | 0.851 | 0.7 | 1.084 | 1.175 |
| 0.912 | 0.832 | 0.8 | 1.096 | 1.202 |
| 0.902 | 0.813 | 0.9 | 1.109 | 1.23 |
| 0.891 | 0.794 | 1 | 1.122 | 1.259 |
| 0.881 | 0.776 | 1.1 | 1.135 | 1.288 |
| 0.871 | 0.759 | 1.2 | 1.148 | 1.318 |
| 0.861 | 0.741 | 1.3 | 1.161 | 1.349 |
| 0.851 | 0.724 | 1.4 | 1.175 | 1.38 |
| 0.841 | 0.708 | 1.5 | 1.189 | 1.413 |
| 0.832 | 0.692 | 1.6 | 1.202 | 1.445 |
| 0.822 | 0.676 | 1.7 | 1.216 | 1.479 |
| 0.813 | 0.661 | 1.8 | 1.23 | 1.514 |
| 0.804 | 0.646 | 1.9 | 1.245 | 1.549 |
| 0.794 | 0.631 | 2 | 1.259 | 1.585 |
| 0.785 | 0.617 | 2.1 | 1.274 | 1.622 |
| 0.776 | 0.603 | 2.2 | 1.288 | 1.66 |
| 0.767 | 0.589 | 2.3 | 1.303 | 1.698 |
| 0.759 | 0.575 | 2.4 | 1.318 | 1.738 |
| 0.75 | 0.562 | 2.5 | 1.334 | 1.778 |
| 0.741 | 0.55 | 2.6 | 1.349 | 1.82 |
| 0.733 | 0.537 | 2.7 | 1.365 | 1.862 |
| 0.724 | 0.525 | 2.8 | 1.38 | 1.905 |
| 0.716 | 0.513 | 2.9 | 1.396 | 1.95 |
| 0.708 | 0.501 | 3 | 1.413 | 1.995 |
| 0.7 | 0.49 | 3.1 | 1.429 | 2.042 |
| 0.692 | 0.479 | 3.2 | 1.445 | 2.089 |
| 0.684 | 0.468 | 3.3 | 1.462 | 2.138 |
| 0.676 | 0.457 | 3.4 | 1.479 | 2.188 |
| 0.668 | 0.447 | 3.5 | 1.496 | 2.239 |
| 0.661 | 0.437 | 3.6 | 1.514 | 2.291 |
| 0.653 | 0.427 | 3.7 | 1.531 | 2.344 |
| 0.646 | 0.417 | 3.8 | 1.549 | 2.399 |
| 0.638 | 0.407 | 3.9 | 1.567 | 2.455 |
| 0.631 | 0.398 | 4 | 1.585 | 2.512 |
| 0.624 | 0.389 | 4.1 | 1.603 | 2.57 |
| 0.617 | 0.38 | 4.2 | 1.622 | 2.63 |
| 0.61 | 0.372 | 4.3 | 1.641 | 2.692 |
| 0.603 | 0.363 | 4.4 | 1.66 | 2.754 |
| 0.596 | 0.355 | 4.5 | 1.679 | 2.818 |
| 0.589 | 0.347 | 4.6 | 1.698 | 2.884 |
| 0.582 | 0.339 | 4.7 | 1.718 | 2.951 |
| 0.575 | 0.331 | 4.8 | 1.738 | 3.02 |
| 0.569 | 0.324 | 4.9 | 1.758 | 3.09 |

| Voltage Ratio | Power Ratio | dB | Voltage Ratio | Power Ratio |
|---------------|-------------|-----|---------------|-------------|
| 0.562 | 0.316 | 5 | 1.778 | 3.162 |
| 0.556 | 0.309 | 5.1 | 1.799 | 3.236 |
| 0.55 | 0.302 | 5.2 | 1.82 | 3.311 |
| 0.543 | 0.295 | 5.3 | 1.841 | 3.388 |
| 0.537 | 0.288 | 5.4 | 1.862 | 3.467 |
| 0.531 | 0.282 | 5.5 | 1.884 | 3.548 |
| 0.525 | 0.275 | 5.6 | 1.905 | 3.631 |
| 0.519 | 0.269 | 5.7 | 1.928 | 3.715 |
| 0.513 | 0.263 | 5.8 | 1.95 | 3.802 |
| 0.507 | 0.257 | 5.9 | 1.972 | 3.89 |
| 0.501 | 0.251 | 6 | 1.995 | 3.981 |
| 0.496 | 0.246 | 6.1 | 2.018 | 4.074 |
| 0.49 | 0.24 | 6.2 | 2.042 | 4.169 |
| 0.484 | 0.234 | 6.3 | 2.065 | 4.266 |
| 0.479 | 0.229 | 6.4 | 2.089 | 4.365 |
| 0.473 | 0.224 | 6.5 | 2.113 | 4.467 |
| 0.468 | 0.219 | 6.6 | 2.138 | 4.571 |
| 0.462 | 0.214 | 6.7 | 2.163 | 4.677 |
| 0.457 | 0.209 | 6.8 | 2.188 | 4.786 |
| 0.452 | 0.204 | 6.9 | 2.213 | 4.898 |
| 0.447 | 0.2 | 7 | 2.239 | 5.012 |
| 0.442 | 0.195 | 7.1 | 2.265 | 5.129 |
| 0.437 | 0.191 | 7.2 | 2.291 | 5.248 |
| 0.432 | 0.186 | 7.3 | 2.317 | 5.37 |
| 0.427 | 0.182 | 7.4 | 2.344 | 5.495 |
| 0.422 | 0.178 | 7.5 | 2.371 | 5.623 |
| 0.417 | 0.174 | 7.6 | 2.399 | 5.754 |
| 0.412 | 0.17 | 7.7 | 2.427 | 5.888 |
| 0.407 | 0.166 | 7.8 | 2.455 | 6.026 |
| 0.403 | 0.162 | 7.9 | 2.483 | 6.166 |
| 0.398 | 0.159 | 8 | 2.512 | 6.31 |
| 0.394 | 0.155 | 8.1 | 2.541 | 6.457 |
| 0.389 | 0.151 | 8.2 | 2.57 | 6.607 |
| 0.385 | 0.148 | 8.3 | 2.6 | 6.761 |
| 0.38 | 0.145 | 8.4 | 2.63 | 6.918 |
| 0.376 | 0.141 | 8.5 | 2.661 | 7.079 |
| 0.372 | 0.138 | 8.6 | 2.692 | 7.244 |
| 0.367 | 0.135 | 8.7 | 2.723 | 7.413 |
| 0.363 | 0.132 | 8.8 | 2.754 | 7.586 |
| 0.359 | 0.129 | 8.9 | 2.786 | 7.762 |
| 0.355 | 0.126 | 9 | 2.818 | 7.943 |
| 0.351 | 0.123 | 9.1 | 2.851 | 8.128 |
| 0.347 | 0.12 | 9.2 | 2.884 | 8.318 |
| 0.343 | 0.118 | 9.3 | 2.917 | 8.511 |
| 0.339 | 0.115 | 9.4 | 2.951 | 8.71 |
| 0.335 | 0.112 | 9.5 | 2.985 | 8.913 |
| 0.331 | 0.11 | 9.6 | 3.02 | 9.12 |
| 0.327 | 0.107 | 9.7 | 3.055 | 9.333 |
| 0.324 | 0.105 | 9.8 | 3.09 | 9.55 |
| 0.32 | 0.102 | 9.9 | 3.126 | 9.772 |

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

