48910, 920, 930

User's Manual

RADIO FREQUENCY SYSTEMS
CELWAVE Cablewave

200 Pondview Drive, Meriden, CT 06450 • (877) 737-9675 • Fax (203) 821-3852
www.rfsworld.com

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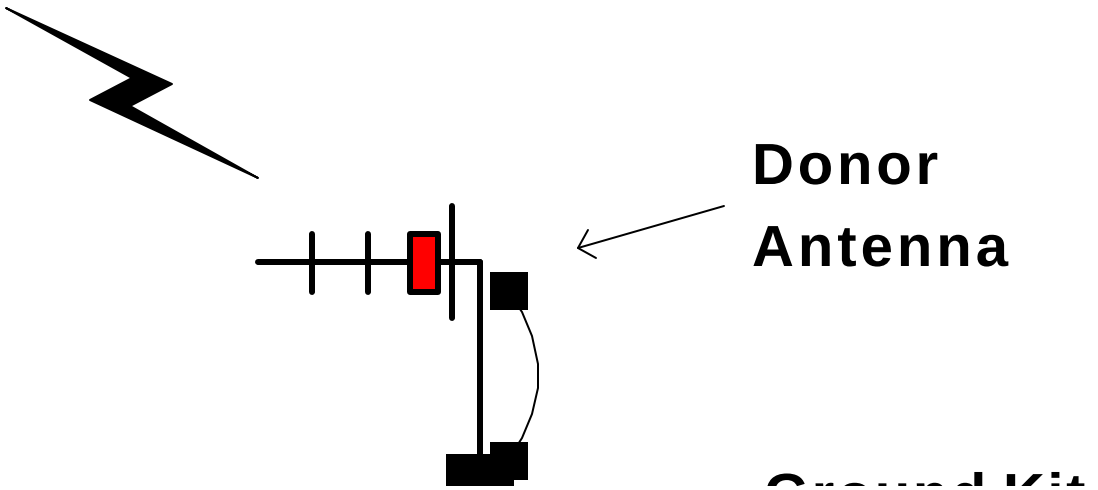
General Statements

Thank you for selecting this RFS product. We are confident that you will find this product in proper working order, meeting all stated specifications. If not, please contact customer service immediately at 1-800-321-4700 and we will resolve the issue without hesitation.

Please read this manual. A full understanding of product operation will support optimal performance and prevent accidental damage not covered by the stated warranty.

- Do not operate this product without proper loads on both antenna ports. You must connect both antenna ports to an antenna or a 50-Ohm load, rated for at least 1 watt.
- These products receive and amplify RF signals. As such, these products are intended for use by the licensee of the respective service and should not be used without the expressed permission of the licensee.
- Do not remove the cover for service. There are no internal adjustments. Path manual gain adjustment access holes are clearly marked on the bottom. Under normal circumstances, you need not make any adjustments. For more information, see installation section.
- The terminology “RX” and “TX” are being replaced by “UL” for uplink and “DL” for downlink respectively.

The 48900 series bi-directional amplifiers/ repeaters/signal boosters are designed and optimized for low cost, high reliability, and ease of use. This manual provides information on the proper operation and care; however, Radio Frequency Systems can provide the total package of components and hardware for any type of repeater installation. See our catalog for the full line of antennas, coaxial cables, and accessories at www.rfsamericas.com. To achieve the best possible coverage, contact RFS Applications Engineering at 1-800-659-1880 for technical assistance and/or design of the distribution network.



For distribution network design assistance, contact RFS Applications Engineering at 1-800-659-1880.

Maximum Permissible Exposure Limits

THIS PRODUCT IS CATEGORICALLY EXCLUDED FROM ROUTINE ENVIRONMENTAL EVALUATION ACCORDING TO CFR 47, SECTION 1.1037.

Repeaters like the 48900 series generate radio signals and thereby give rise to electromagnetic fields. The installer is expected to have a complete understanding of CFR Title 47, Sections 1.1307 and 1.1310. A brief discussion follows but is not intended to be a substitute. Additional information can also be obtained from OET Bulletin 65.

- Antenna installation should be performed by qualified technicians only.
- Installation instructions are not optional and are for the purpose of satisfying FCC RF Exposure Compliance.
- All antennas (donor and service) are to be fixed-mounted and physically secured to one location.
- Maximum donor antenna gain is 28 dB.
- Non building-mounted donor antennas must be greater than 10 meters above ground.
- Maximum service area antenna ERP is 1.0 Watt.
- Minimum separation to any body part of any person is 25cm.

There are two types of antennas attached to this unit. The donor antenna is typically roof mounted and the service antenna is usually mounted in a publicly accessible area. Both antennas should be fixed mounted. Installation considerations for both of these will be discussed separately.

Donor antennas receive the base site TX signals and transmit the mobile TX signals back to the base site (uplink paths). These are typically mounted on rooftops or tower structures. The maximum composite power of the uplink path is 160 mW (+22dBm). Section 1.307(b)(1) excludes from routine environmental evaluation, facilities, operations and transmitters that, according to Table 1 (titled "Cellular Radiotelephone Service"), are less than 1000W ERP for building mounted antennas and less than 1000W and greater than 10 meters above ground for non building-mounted antennas. As such, with maximum power from the uplink path @ 160 mW (+22dBm) and a maximum antenna gain of 28 dB, the donor antenna installation will not exceed 1000 Watts (+60 dBm) and is categorically excluded.

However, according to Section 1.1307 (b)(1), the appropriate exposure limits of 1.1310 are applicable to all facilities, operations, and transmitters. Therefore, the MPE (Maximum Permissible Exposure) of Section 1.1310 applies to the donor antenna installation. OET Bulletin 65 provides methods of calculating power density based upon the ERP and distance. It would be impossible to cover every possible configuration in this manual. Likewise, it would be unreasonable to dictate the exact parameters of every installation; therefore, it is the responsibility of the qualified technician to know and ensure that Sections 1.1307 and 1.1310 of CFR Title 47 are being met.

The following scenario is a typical rooftop installation in an uncontrolled area (worst-case) using a 18 dB gain donor antenna. The MPE @ 824 MHz is 0.549 mW per cm^2. The uplink is being driven to its

maximum output power (+22 dBm); the resultant ERP is +40 dBm or 10,000 mW. OET Bulletin 65 provides the following formula for calculating the power density with the EPA recommended factor for ground reflection:

$1.05\ ERP/\pi R^2$

Where R is the distance to center (of any body part of person).

Solving for 10,000 mW @ 3ft. (91.44 cm) we get a power density of 0.4 mW per cm^2.

The Yagi antenna in this scenario must be mounted in such a way that no body part of any person may come closer than 3 feet in the direction of the main power beam. This will limit exposure to well within the MPE.

Service antennas are also fixed mounted and covered by the same MPE considerations as the donor antenna. However, this assumes that the area is always general population/uncontrolled and that the minimum distance in most installations will be less than 3 feet. According to Table 1(B) of Section 1.1310, the power density @ 894 MHz is 0.596 mW/cm^2. The maximum power of the 48900 downlink (base to service area) is +22 dBm (160 mW). Assuming no feeder cable loss and a service area antenna gain of 8 dB, a safe minimum separation of 10 inches (25 cm) is required to stay within the MPE.

$1.05 \times 1000\ mW/3.14 \times 252 = 1050/1962.5 = 0.535\ mW/cm^2$

Therefore, the service area antenna should be mounted such that no body parts of any person may come closer than 10 inches (or 25 cm). The service area antenna gain is 8 dB in the example above, but may be increased to make up for cable and/or splitter or tap losses. For example, if a 2-way splitter is used to provide for two antennas in different parts of the service area, then the antenna gain may be increased to 11 dB to make up for the loss of the splitter 3.6 dB. The maximum service area antenna gain for any specific location can be calculated as follows:

8dB+ accumulated losses to the antenna.

Product Overview

Field Tune-up, Alignment or Calibration

There is no field tune-up or calibration necessary. These units are aligned and calibrated at the time of manufacture and are designed to retain calibration throughout the life of the product.

FCC ID and Canada Certification Numbers

The listed models have been tested and granted certification by the FCC in accordance with CFR Title 47, Part 90 and by the DOC in accordance with RS 131, Issue 131.

The FCC identification number for each particular model appears on a label on the faceplate of the unit. Applicable FCC identification and Canadian ISC numbers are as shown:

FCC ID	**Canada**
IWD48900	TBD

Theory of Operation

The 48900 signal boosters are designed to enhance radio communication in buildings, basements, tunnels and other RF shielded environments. The 48910 is tuned for the 800 MHz Cellular band, the 48920 for the 800 SMR band and the 48930 for the 900 MHz SMR band.

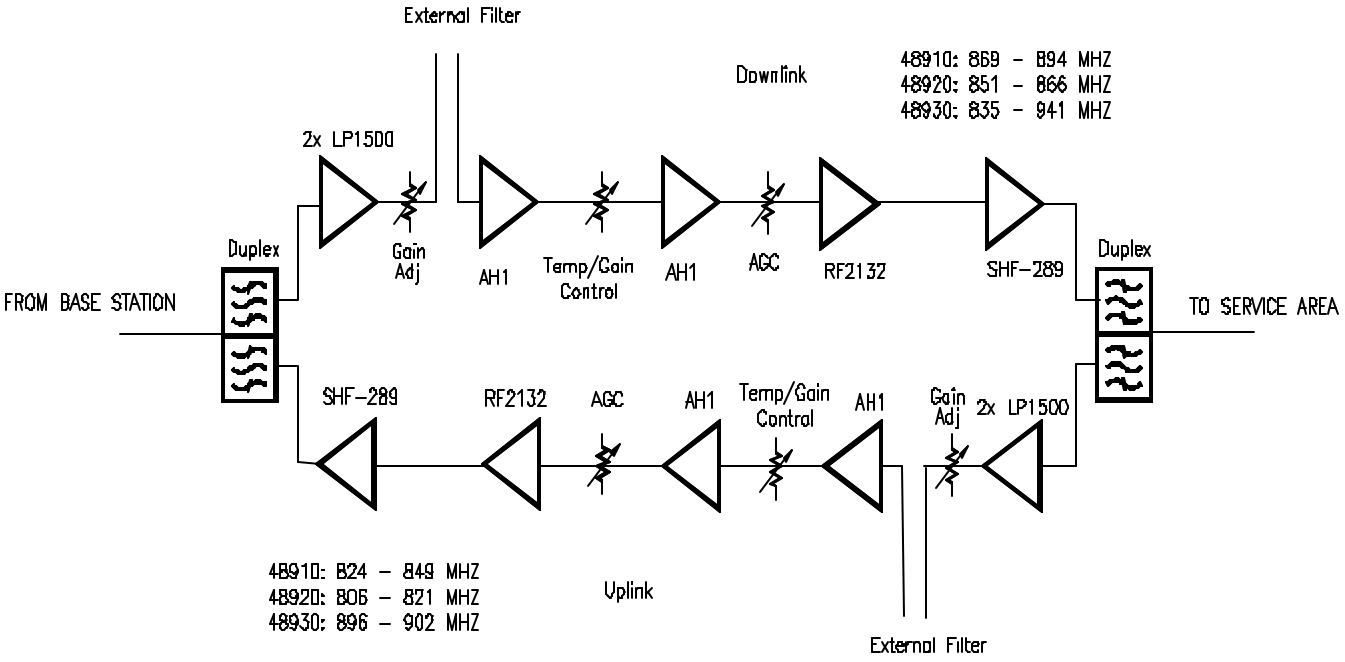
These units work by receiving and amplifying the base TX signals via a donor antenna directed at the desired base site. This RF path is called the downlink. The amplified base TX signal is re-radiated via antenna(s) or radiating cable into the Service Area. Subscriber mobile RF signals are received by the same service area radiating elements and amplified in the uplink RF path to be radiated back to the base via the donor antenna.

The LNAs and Power Amplifiers are broadband. The same amplifiers are used for the uplink and downlin. Likewise, the control board is the same for both models. Differentiation is provided by the duplexing filters on the base and service area connectors that determine the basic passband and direct the RF signals to the proper gain path, uplink and downlink respectively.

Both the downlink and uplink have Automatic Gain Control (AGC) in the power amplifiers to prevent an overdrive condition. Manual gain adjustment is provided in the LNA stage. Overdrive limiting is provided by the AGC circuitry and set at the factory. This ensures that the unit will not exceed FCC limits for spurious emissions.

The control board distributes DC power to the amplifier modules and monitors each module for any fault conditions. LED indicators provide visual diagnostics and a NC / NO relay provides for remote notification for any fault condition.

Block Diagram



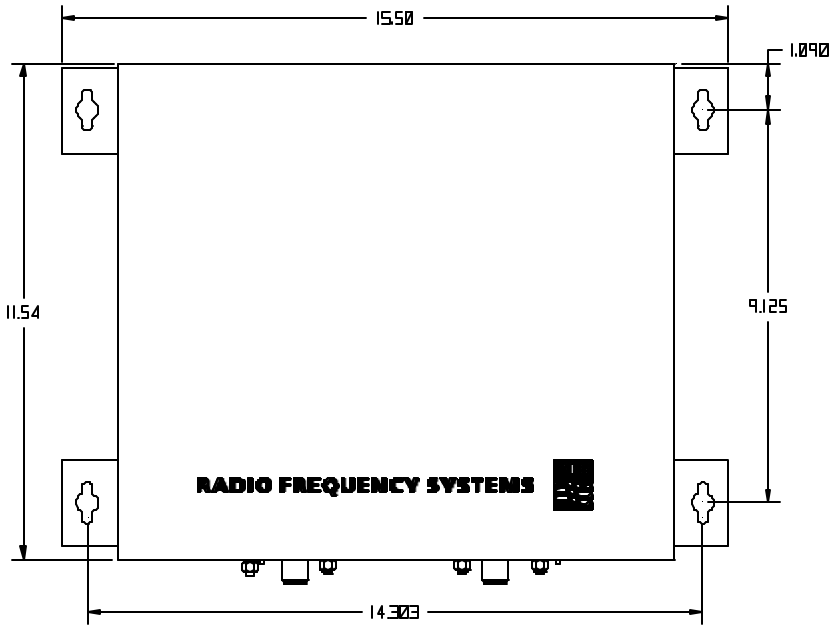
Electrical Specifications

	Downlink	**Uplink**
48910 Freq, MHz	869-894	824-849
48920 Freq, MHz	851-869	806-824
48930 Freq, MHz	935-941	896-901
Gain, no attenuation	65 dB	65 dB
Gain Flatness, typical	±2.0 dB	±2.0 dB
Manual Attenuator Range	20 dB	20 dB
Output Limiter Range, Automatic*	20 dB	20 dB
Noise Figure, typical**	4.0 dB	4.0 dB
Composite Power, typical*	+22 dBm	+22 dBm
iDEN, CDMA, typical	+19 dBm	+19 dBm
Impedance	50 Ohms	50 Ohms
VSWR, input	1.5	1.5
Propagation Delay, worst case at band edge	<0.5 microsecond	<0.5 microsecond
Power, 120/220 Auto Ranging, IEC-320 Socket	110 VAC@ .3 A	

*AGC circuitry monitors the output power and reduces the gain to prevent overdrive and oscillation.
No attenuation and at room temperature.**

Mechanical Specifications	
Connectors, RF	N Female
Weight	17 lbs (7.65 kg)
Size, L x W x D	15.5 x 11.54 x 5.7 Inches (39.4 x 29.3 x 14.5 cm)
Diagnostics	Power, AGC Overdrive, and Fault LEDs

Environmental Specifications	
Operating Temperature, ambient	-10 to +45 °C
Maximum humidity	95% RH (non condensing)
Environmental Rating	Similar to NEMA 3R



Intermodulation, Power, and AGC

Per CFR Title 47, Part 90, there shall be no spurious emissions greater than {43+ 10 Log 10 (Power Out Watts)} dB below the carrier Power Out (dB) level. This is always equivalent to -13 dBm.

The primary contributor to spurious emissions is multiple signal intermodulation. As multiple signals are amplified, they generate intermodulation products (IM). The level of IM is a factor of the amplifiers linearity or 3rd Order Intercept Point (IP3), and the number and power of signals being amplified (Pout).

IM = 3xPout - 2xIP3

'Pout' is the combined power of all the signals in the passband known as the composite power. Radio Frequency Systems, Inc. has designed the 48900 signal boosters using a combination of low distortion amplifiers and automatic gain control (AGC) to achieve maximum output while automatically limiting spurious intermodulation levels to -13 dBm or less for any number/power combination of signals.

The AGC circuitry is housed in each power amplifier stage. A detector on the output of the amplifier provides a DC voltage proportional to the output power. This voltage is compared to a factory setting. As long as this voltage is less than the setting, no action is required. However, when the combination of signal level and or number of signals causes the composite power to exceed the safe level, the AGC's comparator generates a DC voltage to a pin diode attenuator that increases attenuation in proportion to the level of the DC voltage.

The attenuation reduces the output power until the detector voltage is at a safe level again. If the number or power of the signals is reduced, the DC offset voltage will reduce the level of attenuation. In typical operation, the AGC is only active when needed to prevent overdrive. If the AGC is constantly activating, RFS suggests that you reduce the gain via the manual attenuator and verify that an oscillation between the base and service antenna systems does not exist.

AGC in the uplink is rarely needed in modern radio installations. As a portable comes closer to the internal antenna network, its signal becomes stronger at the base site. Typically, the dynamic power control at the base will turn the portable's power down to reduce interference and conserve power.

Overdrive is more likely to occur on the downlink path. All active signals at the donor base site will be amplified by the repeater regardless of whether or not they are in use in the service area. Ideally, the donor antenna is directional. This limits the number of donor base sites the repeater recognizes and reduces the potential for interference. RFS recommends that you observe the signal levels before connecting the repeater. Out of band signals can also cause overdrive. The most likely cause of an overdrive condition is oscillation from inadequate antenna isolation.

Table 1 lists the typical output power per signal, which can be expected from the 48900 for a given number of active signals operating at equal input levels. For a donor site that has 16 signals, the power per signal would be +9 dBm, assuming the incoming signal is sufficient so that that level will be achieved.

Number of signals	dBm
1	22.0
2	19.0
4	15.0
8	12.0
16	9.0
32	6.0
64	2.0

TABLE 1: TYPICAL OUTPUT POWER PER SIGNAL

In all cases, the actual signal output power is equal to the input signal power plus the gain of the repeater. If a signal level of -80 dBm exists at the input to the repeater and the gain is 65 dB, the resulting output will be –15 dBm dBm, not +9 as noted in the previous paragraph. +9 dBm in this case is the maximum output for 16 channels.

AGC Automatic Shutdown

When the automatic gain control circuit reaches its limit (25 dB typ), the power amplifier stage is shut down to prevent harmful distortion and potential damage to the booster. Shutdown will occur if the AGC control limit is exceeded for about 1/2 second. Power is then cut for two seconds. After this timeout, power is brought back on-line. If the overload condition is still present, shutdown will again occur in approximately one second. This cycle will be repeated until the condition causing AGC to reach its limit is removed. Conditions that can cause AGC to reach its limit include the presence of one or more very strong channels, a strong in-band noise source, or amplifier oscillation due to inadequate antenna isolation.

Manual Gain Adjustment

The independent manual attenuators, RX for uplink and TX for downlink, are accessible from the bottom of the unit. These are pre-set in the fully counterclockwise position, at minimum attenuation, maximum gain. Manual attenuation is separate from the AGC so these attenuators can be used to reduce overdrive while maintaining AGC range. At the full clockwise position, 20 dB of attenuation will be introduced in the respective gain path.

AC/DC Power

AC power is supplied through a standard 3-wire male plug connected through a standard IEC-320 plug. Connect this plug to any standard 3-wire 120-240 VAC outlet. A 5x20 mm, .315 amp 250VAC slow-blow fuse is used. A 2 amp, 32 VDC, fast-acting fuse is located on the side of each amplifier to protect the DC voltage path. (See "Component Location")

DANGER
Always remove power before checking or changing fuses. 120VAC can be lethal.

- ⌦ Always unplug the amplifier before servicing the interior.
- ⌦ Never insert conductive objects into any opening.
- ⌦ Never remove or probe under the plastic safety shield covering the AC terminals of the 24 VDC power supply.
- ⌦ Always use a standard 3-wire electrical outlet, with safety ground, for connection to AC power.

Grounding and Surge Protection

The unit is case grounded through the three-prong plug. The donor antenna feeder cable should have a cable ground attached to it, along with an inline surge arrestor between the donor antenna and the 48900. The distribution network need not be grounded in building installations. However, the distribution network in tunnels, subways or outdoor installations should also include a cable ground and inline surge arrestor at or near the "service" port.

External Filter Ports

SMA female connectors on the faceplate of the 48900 allow for connection of externally mounted passive 50 Ohm filtering. The external filter then modifies the related passband. Should the conditions change in the field, the external filter can be removed or replaced with minimal interruption in service. RFS has a variety of filter options, see the application notes on our website of contact RFS Applications Engineering for assistance. Separate ports are provided for both the uplink and downlink.

Two jumpers are required to connect an external filter. One connector on the jumper must be an SMA male to connect to the 48900; the other connector type will depend on the connector on the filter. Ensure that the external filter is mounted close enough so that the jumpers will reach the repeater without undue stress or crimping. Disconnect power from the repeater, then disconnect the jumper from the uplink or downlink as needed. Connect the external filter and reconnect power to the unit. The passband filter will modify the passband of the link.

Installation

WARNING
Do not connect AC power until antennas have been connected to both the base and service area ports.

- Choose an optimal location.

The choice of a location for the 48900 to reside is often dictated by circumstance. These units can withstand a wide range of environmental conditions, but a cooler environment will increase the life of the product. The 48900s are not intended for outdoor operation without protection. Furthermore, a stacking room near a riser for easy access to the roof and other floors is desired. However, access to clean 110/220 VAC power is the only requirement.

- Install directional donor antenna and align with desired base site.

Yagis, corner reflectors and panel antennas work best. The 48900s have sufficient filtering to prevent undesired signals from causing interference; however, it is best to reduce the chance for interference by directing the mobile signals only towards the desired base site.

- Check the incoming signal before connecting.

The product will work with a wide range of RF input signal levels. Ideal levels on the downlink are in the range of -60 dBm. These levels will provide a maximum output power while not causing significant overdrive. Also, check for extremely strong out-of-band signals. These may overdrive the filtering and cause gain reduction.

- Connect the donor antenna to the 48900 via a 50-ohm coaxial cable.

Size and type of cable are a matter of choice. Typically, 1/2" Flexwell foam coax is used, plenum rated for inside buildings and work areas. However, 7/8" cable may be used to reduce longitudinal loss. Superflex cables are easier to install but have higher longitudinal loss.

- Install service area antenna(s).

Determining the location and type of service area antennas is part of the distribution system design. Generally, it is desired to minimize the amount of coax that has to be installed. However, in buildings with extensive obstructions, it may be necessary to install several service area antennas. For assistance with antenna placement, contact RFS Applications Engineering.

IMPORTANT
Observe Maximum Permissible Exposure cautions when determining the type and location of all antennas.

- Mount repeater upright, with the connections toward the floor.

Ensure there is sufficient space above and below the unit to allow airflow through the heat sink. Check to make sure the AC power cord can reach the power source. Also, provide adequate bending radii for the coaxial cables.

- Connect service antenna(s) to "Service" via a 50-ohm coaxial cable.

Multiple service area antennas/radiating cable runs may be connected to the 48900. Splitters and taps may be used to accommodate unique distribution systems. RFS has all the components needed to complete even the largest installations. Visit our website at: www.rfsworld.com, or call us.

- Connect the donor antenna cable to "Base".

- Connect AC power to the unit and observe power and fault LEDs

- Adjust manual gain .

If the yellow DL AGC LED is lit then it is suggested that you reduce the gain in the DL via the manual attenuator. Turn the adjustment clockwise to reduce gain until the AGC LED goes out. Then adjust the UL gain to the same setting to minimize noise generated in the uplink.

If both LEDs are lit then there is likely a oscillation between the antennas – see “Antenna Isolation”. Also read the section on “Intermodulation, Power, and AGC”

- Test the installation.

This test should include multiple subscribers in various locations of the service area. It should also include one subscriber in fairly close proximity to the repeater. This test will check to ensure that a nearby user does not overdrive the uplink and reduce coverage for the other users.

If the UL AGC LED lits during the system test it most likely indicates that there is a hot spot in the service area where the subscriber signal is overdriving the uplink. It is best to minimize this effect by relocating the nearest service antenna or adding a attenuator pad to reduce the UL signal strength.

Antenna Isolation

Isolation between the donor (base) antenna and service area antenna should be 20 dB greater than the gain of the repeater amplifier.

If the isolation is less than the amplifier gain, then positive feedback sufficient for oscillation is present in the system. Such oscillations will overdrive one or both amplifier chains and continuously activate the AGC auto-shutdown circuitry. This situation will be apparent by the red fault LED being lit.

Antenna isolation is usually not a problem for in-building installations. Isolation is improved by using a directive donor antenna and facing it away from the distribution or service antenna(s). Decoupling is achieved by spatially separating the antennas vertically and/or horizontally. Other factors influencing isolation include multi-path reflections, structures, other antennas, passing vehicles, personnel proximity, etc. Contact RFS Applications Engineering for further assistance.

It is always best to measure the isolation before connecting the repeater. The most direct way to measure the isolation is to inject a known signal into one antenna, and measure the coupled signal at the other antenna. This should be done across the applicable bandwidth to account for the frequency dependency of standing waves.

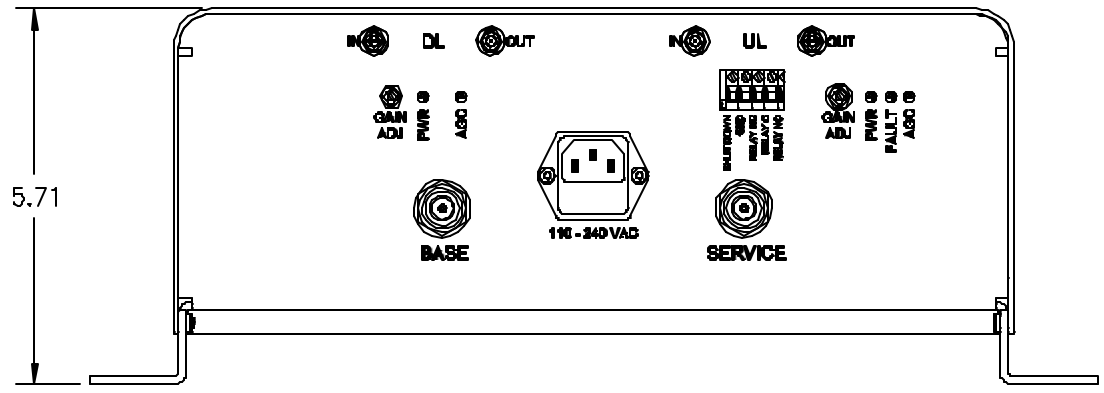
Diagnostics/Troubleshooting

IMPORTANT
The 48900 is not designed for field repair. The outer cover may be removed for some troubleshooting but under no circumstances should the covers be removed from the internal amplifier modules, this will void the warranty.

Test Point Descriptions

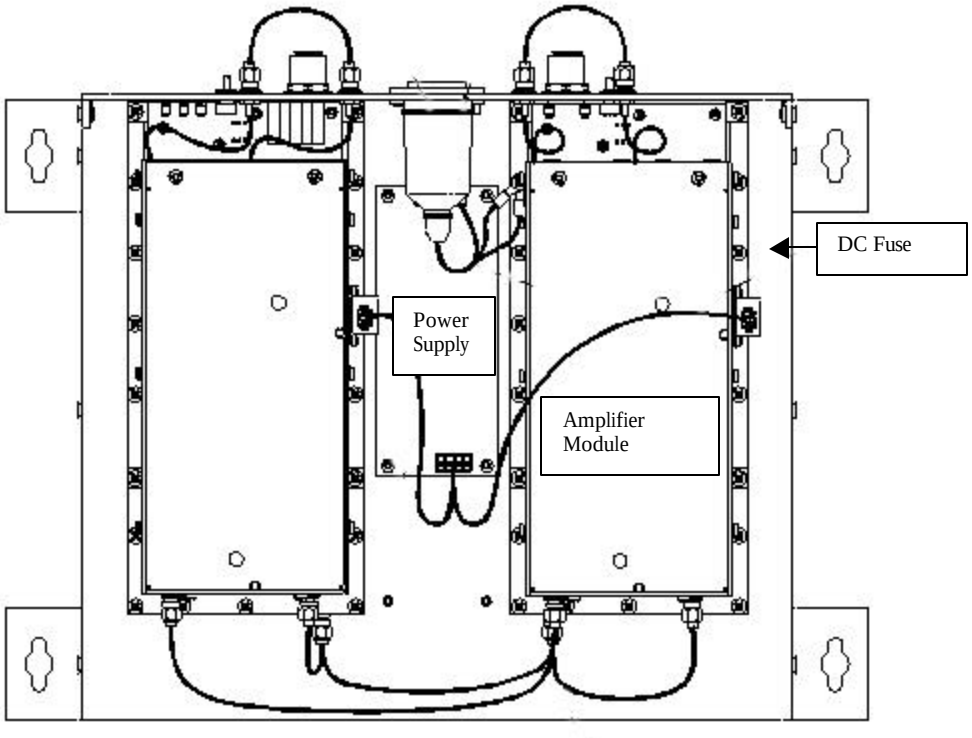
- Green power LEDs indicate DC voltage is applied to the respective link.
- Yellow AGC LEDs indicate AGC is active in the respective link
- Red Fault LED indicates that a under or over current condition exists or that the AGC Shut Down circuitry has been activated.
- Relay NC (normally closed), C (common), NO (normally open) is a summary fault relay that changes state whenever the fault LED is lit or when the power fails. This relay is rated for up to 48 VDC at 2 Amps.
- Shut Down pin will cause the 48900 to shut down when it is connected to GND (ground). Current draw is insignificant.

Faceplate



Problem:	Solution:
Green power LEDs on faceplate not lit.	Check power source and the AC fuse located in the EIC plug. Check the DC fuse located inside the 48900 on the side of the individual amplifier modules. Check connections to the internal power supply.
Red LED on faceplate is lit.	First try to cycle the power then watch the AGC LEDS to make sure the unit is not in AGC shut down. If the Fault LED is cycling then an overdrive condition exists. See AGC Automatic Shutdown section.
Green power LED lit and no red Fault LED on faceplate; unit does not appear to be working.	Check for a break in the donor or distribution networks. Also, check to ensure the donor signal is still available to the repeater. An obstruction could be blocking the donor base site or the donor antenna could have become misaligned. Then, check the integrity of the distribution network. Coaxial cable has a minimum bending radius, if that is exceeded the inner conductor may crack or break causing excessive reflections to the signals.
Yellow AGC LED is lit.	AGC LEDs indicate an overdrive condition in the respective link. Reduce the respective link gain via the Gain Adjust until the LED goes out. Generally, the opposing link gain should be adjusted to approximately the same setting. If the LED does not go out, then the input signal is too strong. Sweep the input to the respective link to identify the source of overdrive. If the signal is not a desired signal then external filtering should be considered to attenuate. If the signal(s) are all desired then attenuate the base port with a 10 dB in-line attenuation pad.

Component Location



Only the power supply is field replaceable part number 31500012900

Maintenance, Repair and Warranty

Periodic Maintenance

There is no periodic maintenance required for the 48900. As long as the units are kept away from extreme temperatures and moisture, they should provide long-term, carefree operation.

However, periodically check all RF connections for corrosion, strain damage, and proper tightness. Also, periodically check the AC power connections for integrity.

Ordering and Returning Components

For technical assistance, call Radio Frequency Systems Applications Engineering at 1-800-659-1880.

For returns, repairs, and ordering, contact Radio Frequency Systems Customer Service at 1-800-321-4700 for a Return Authorization Number. Be prepared to provide the model number, serial number of the unit, as well as a description of the symptoms of the problem. Send components or units freight pre-paid with the Return Authorization Number on the outside of the package to:

Radio Frequency Systems

4100 SW Research Way

Corvallis, OR 97333

Limited Warranty

The Seller warrants that, at the time of shipment, the products manufactured by the Seller are free from defects in material and workmanship. The Seller's obligation under this warranty is limited to replacement or repair of such products within one year from the date of shipment. No material is accepted for replacement or repair without written authority of the Seller. Replacement or repair is made only after an examination at the Seller's facility shows defective material or workmanship at the time of manufacture. All shipping charges on the returned material must be prepaid by the Buyer.

The seller is in no event liable for consequential damages, installation costs or other costs of any nature as a result of the use of the products manufactured by the Seller, whether used in accordance with instructions or not. The Seller is not liable for replacement of any product damaged by lightning.

This warranty is in lieu of all others, either expressed or implied. No representative is authorized to assume for the Seller any other liability in connection with the Seller's products.