

48810A & 48810B

User's Manual



RADIO FREQUENCY SYSTEMS
CELWAVE

Cablewave



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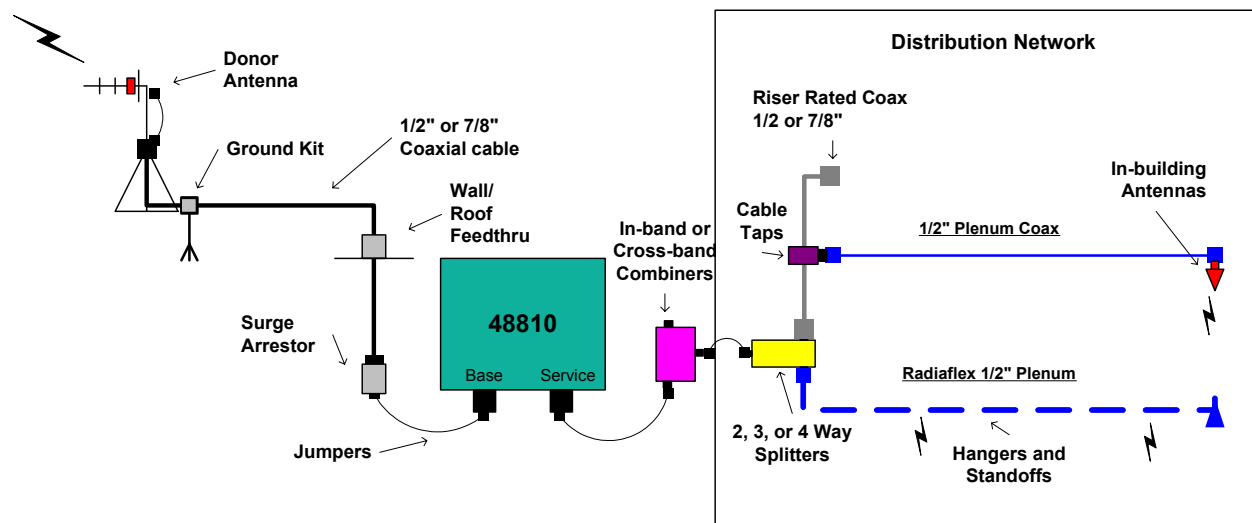
General Statements

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 in the 1900 MHz PCS band. 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.

The 48810 PCS Band Repeater can be used to cover indoor or outdoor areas. It is designed and optimized for low cost, high reliability, and ease of use. This manual provides information on the proper operation and care of the repeater, 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. For assistance with this repeater installation and/or design of the distribution network to get the best coverage possible 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 AND 2.1091.

Repeaters like the 48810 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, 1.1310 and 2.1091. 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.
- Maximum service area antenna gain is 10 dB.

There are two types of antennas attached to this unit. 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 in occupational / controlled exposure areas. The maximum composite power of the uplink path is +15 dBm (32 mW). 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 @ +15 dBm (32 mW) and a maximum antenna gain of 28 dB, the donor antenna installation will not exceed 20 Watts (+43 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.

Service antennas are also fixed mounted and covered by the same MPE considerations as the donor antenna. However, a more stringent method would be to consider these antennas in the worse case as mobile devices mounted in the ceiling of a general population/uncontrolled exposure area with a minimum separation of 20 cm. According to section 2.1091 routine evaluation is not required for frequencies above 1500 MHz if the ERP is less than 3 watts. The maximum power of the 48810 downlink (base to service area) is +15 dBm (32 mW). Assuming an antenna gain of 10 dB, ERP would be 25 dBm or .316 W. As such, the service area antennas are categorically excluded.

Product Overview

Field Tune-up, Alignment or Calibration

Before applying power set the rotary switch (located on the face plate) to the desired band of operation. 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 24 and by the DOC in accordance with RSS 131.

FCC ID
IWD48810

Canada
TBD

Theory of Operation

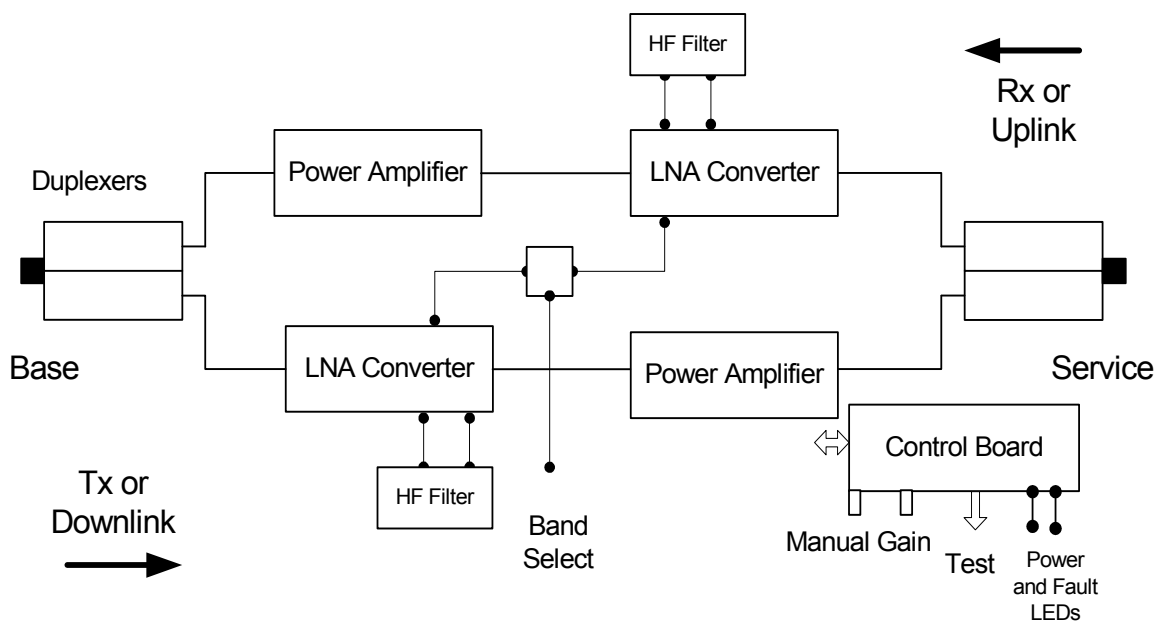
The 48810A and 48810B repeaters are designed to enhance radio communication in buildings, basements, tunnels and other RF shielded environments. The 48810A has a 15 MHz band customer selectable to A,B, or C block, the 48810B has a 5 MHz band selectable to D, E, or F block.

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.

Both links have AGC (automatic gain control) to prevent overdrive. Manual gain adjustment is also provided. The composite output power is set at the factory and limited by the AGC circuitry so that intermodulation signals will not exceed -13 dBm as specified by the FCC.

The control board distributes DC power to the amplifier modules and monitors each module for any fault conditions. LED indicators provide visual diagnostics while the 15 pin Dsub connector has DC and TTL test points for more in-depth trouble shooting.

Block Diagram



Electrical Specifications

| | Downlink | Uplink |
|---|-------------------|-------------------|
| 48810A, Block, selectable | A, B, C | A, B, C |
| 48881B, Block, selectable | D, E, F | D, E, F |
| Gain, no attenuation | 87 dB | 87 dB |
| Gain Flatness, typical | ±1.0 dB | ±1.0 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* | +15 dBm | +15 dBm |
| TDMA, CDMA, GSM | | |
| Impedance | 50 Ohms | 50 Ohms |
| VSWR, input | 1.5 | 1.5 |
| Propagation Delay, worst case at band edge | <3.0 microseconds | <3.0 microseconds |
| Power, 120/220 Auto Ranging, IEC-320 Socket | 120 VAC@1.4A | 120 VAC@1.4A |

*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 | 33 lbs (14.9 kg) |
| Size, L x W x D | 13 x 18.76 x 7.5 Inches (33.02 x 47.7 x 19.1 cm) |
| Mounting Centers | 10.75 x 17.56 Inches (27.3 x 44.6 cm) |
| Diagnostics | 15 Pin Dsub Connector |

Environmental Specifications

| | |
|--------------------------------|-------------------------|
| Operating Temperature, ambient | -30 to +50 °C |
| Maximum humidity | 95% RH (non condensing) |
| Environmental Rating | Similar to NEMA 3R |

Intermodulation, Power, and AGC

Per CFR Title 47, Part 24, 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 48810 repeaters 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.

A detector on the output of the power 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. While the extensive filtering in the 48810 will reject out-of-band signals by 80 dB, exceptionally strong out-of-band signals can 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 48810 for a given number of active signals operating at equal input levels. For a donor site that has 3 signals, the full power per signal would be +10 dBm, assuming the incoming signal is sufficient so that that level will be achieved.

| Number of signals | <u>dBm</u> |
|--------------------------|-------------------|
| 1 | 15.0 |
| 2 | 12.0 |
| 3 | 10.0 |
| 6 | 7.0 |
| 12 | 4.0 |

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 87 dB, the resulting output will be +7 dBm, not +10 as noted in the previous paragraph. +14 dBm in this case is the maximum output allowed under any condition. So, if the incoming signal is -70 and the gain is set for 87 dB, the output would not be +17 dBm with 3 simultaneous signals, the AGC would reduce the gain to 80 dB and the output to +10 dBm per signal.

AGC Automatic Shutdown

When the automatic gain control circuit reaches its limit (20 dB), the power amplifier stage is shut down to prevent harmful distortion and potential damage to the repeater. 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 VAC outlet. A 5x20 mm, .315 amp fast-blow fuse is used to disconnect power in the event of a severe AC fault. A 5 amp mini ATO fuse is used between the 5.5 VDC from the power supply and the control board, which distributes the power to all components. This fuse is located on the control board.

| |
|--|
| 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 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 48810 “Base” port. 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.

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.

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 48810 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 48810 is not intended for outdoor operation without protection. A central location is desired to provide symmetry in the distribution network. 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 48810 has 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.

The product will work with a wide range of RF input signal levels. Ideal levels on the downlink are in the range of -75 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 48810 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 MPE 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 Area" port via a 50-ohm coaxial cable.

Multiple service area antennas/radiating cable runs may be connected to the 48810. Splitters and taps may be used to accommodate unique distribution systems.

- Connect the donor antenna cable to "Base".
- Connect the PM800-10 to the test port.

The PM800-10 performance monitor is provided with each unit. This monitor connects to the 15-pin diagnostics Dsub connector on the bottom of the unit either directly or via the 10-foot extension cable. The PM800-10 provides LED readouts of the pins as explained in the diagnostics/troubleshooting section.

- Select the desired band via the rotary switch on the faceplate.
- Connect AC power to the unit and observe. See troubleshooting section.
- 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 service antenna. This test will check to ensure that a nearby user does not overdrive the uplink and reduce coverage for the other users.

See the troubleshooting guide if there is an overdrive condition in either the uplink or downlink.

Diagnostics/Troubleshooting

| LED's located in 487XX faceplate | |
|--|---|
| Problem: | Solution: |
| Green power LED not lit. | Check power source and the AC fuse located in the EIC plug. Check for DC voltage (see below). |
| Green power LED lit and no red Fault LED, unit does not appear to be working. | Check for a break in the donor or distribution networks. First, check both RF output via the DC voltages on Pins 12 and 13 or UL DET.V and DL DET.V from the PM800-10. 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. |
| Red LED is lit. | The red LED indicates a summary fault from any of the fault conditions identified in the Test Points section. Specific action is described in that section. |

| | |
|-------------------------------|---|
| 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 and should be attenuated with a 10 dB in-line attenuation pad on the Base or Service port. |
| Flashing Red Fault LED | This occurs when there is an extreme overdrive condition and the AGC range has been exceeded. Reduce gain via the Gain Adjust and check for strong drive signals on the link. Also see the section on Antenna Isolation. |
| Checking DC Voltage | DC Voltage can be checked via the 15-pin test port. Pins 10 and 11 are the DC voltage associated with the AGC circuitry. There should be at least 1.7 volts to ground-pin 14. Alternatively, you can plug in the PM800-10 monitor into the test port and measure the UL AGCV to ground. |

Test Point Descriptions

The PM800-10 performance monitor is included and is designed to provide convenient visual readout. A DC VOM can be used to quickly assess the health of the unit. The repeater provides the output voltages and the power to operate the PM800-10. The -10 denotes that a 10 foot extension cable is included with the PM800. A 30-foot extension cable (part #: 103300014900) is also available for remote mounting or the PM800 can be directly plugged into the 15-pin test port located on the front plate of the repeater. Should the performance monitor become damaged, contact RFS customer service at 1-800-321-4700 to order a replacement.

In the following description, the term “pin number” refers to the connector pins in 15 pin Dsub Test Port on the 48810. Pin numbering starts upper right and proceeds from right to left, top to bottom when viewed externally. The functions are explained below with details on how the unit is used in practical applications.

➤ **Pins 1-8: Max sink/source = 15mA, output only. Accidental input max = 6.0 VDC**

1. UL LNA Alarm, logic, low=fault
2. DL LNA Alarm, logic, low=fault
3. UL Converter Alarm, logic, low=fault
4. DL Converter Alarm, logic, low=fault
5. UL PA Alarm, logic, low=fault
6. DL PA Alarm, logic, low=fault
7. Temperature Alarm > +85 C, logic, low=fault
8. AGC Alarm, logic, low=fault

Pins 1-6 each refer to a specific module inside the repeater. A low TTL voltage will light the associated LED, indicating a fault condition with that component. See the Component Location section to find the associated component's part number. The faulty component may be removed and sent in for repair, or a replacement may be ordered.

Pin 7 is a temperature alarm indication that the internal temperature has risen above +85°C. The 48810 series use convection cooling, not fans. It is rated for +55°C ambient. In the event of the temperature alarm, check to make sure the unit is mounted upright and vertical. There must be sufficient room below and above the unit to allow airflow to the heat sink.

Pin 8 indicates that the unit is in automatic shutdown mode due to an overdrive that is exceeding the AGC's range. The AGC is non-latching and will clear itself when the overdrive is removed. The alarm light will remain lit even though the shut down feature is powering on and off to check for the overdrive condition.

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. Disconnect the power and the Base and Service cables. Use a spectrum analyzer to look for strong input signals coming from the base donor antenna or the service area distribution network. If there are no strong input signals, check the antenna isolation as described in this manual. Reducing the gain may also help to clear the condition. See AGC section for more information.

Strong uplink signals may be intermittent. These may be present when a mobile in the coverage area is close in to the service area antenna. In this case, the service area antenna must be moved to prevent overdrive under normal operating circumstances.

➤ **Pin 9: Max sink = 8 mA. Max input = 6.0 VDC**

Pin 9 is a remote disable feature. Connecting pin 15 to pin 9 via a relay will cause the repeater to shut down. This can be accomplished with a remote control unit like the RFS RPM700 (remote performance monitor).

9. Disable (input), logic, high=disable

➤ **Pins 10-13: Max sink = 8mA. Max source = 15mA.**

10. UL AGC Voltage, analog, no AGC approximately 5.3 VDC, Full AGC approximately 1.7 VDC

11. DL AGC Voltage, analog, no AGC approximately 26.5 VDC, Full AGC approximately 7.65 VDC

12. UL Det. Voltage, analog, approximately 0 to 3VDC @ approximately 0.3VDC per dB

13. DL Det. Voltage, analog, approximately 0 to 3VDC @ approximately 0.3VDC per dB

Pins 10 and 11 are the indicators for Automatic Gain Control. The circuitry is housed in the PA amplifier stage. It monitors the output power and controls a pin attenuator to reduce gain and thus, the output power if needed to prevent overdrive. The DC voltages on pins 10 and 11 represent the amount of attenuation:

No AGC approx. 5.3VDC, full AGC approx. 1.7VDC. The yellow LEDs on the PM800 will light up when the AGC is active (adding attenuation).

AGC may be intermittent due to temporary overdrive conditions. If the LED is constantly lit then reducing the manual gain via adjustment on the faceplate should cause the LED to go out. The manual attenuator is separate from the AGC attenuator. Reducing the gain via the manual attenuator will optimize the installation and preserve the full AGC attenuation for overdrive conditions.

Pins 12 and 13 are detector output voltages for the associated path. The DC voltage represents the output power. These voltages can be used to roughly estimate the amount of output power. For example, the donor antenna can be rotated to look for maximum output power if a spectrum analyzer is not available.

➤ **Pin 14: Max sink = 1A.**

14. Ground for Pins 10-13.

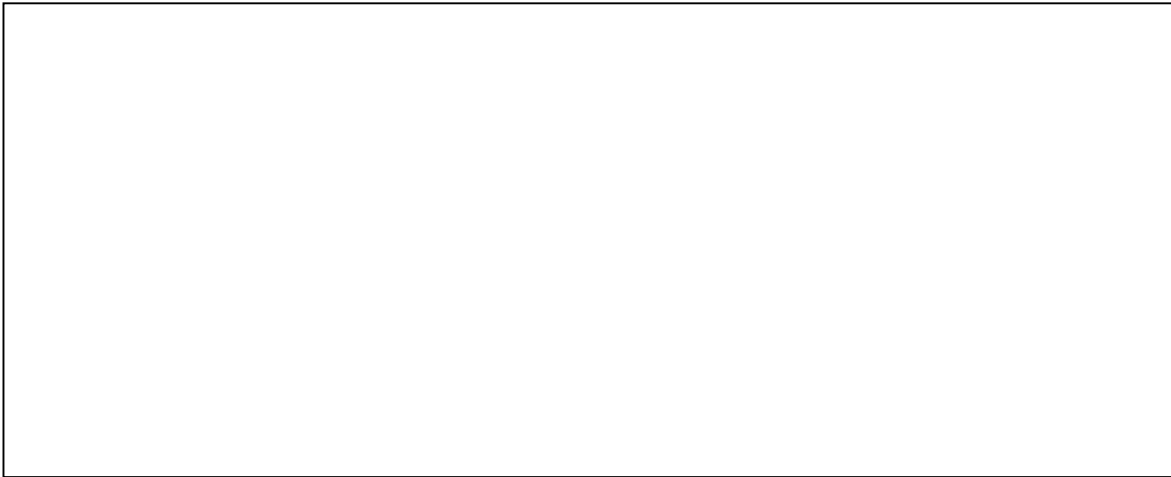
➤ **Pin 15: Max source = 80mA.**

Pin 15: +5VDC, thermally fused (self resetting), 50mA max.

Pin 15 can be used as the drive voltage to disable the unit using Pin 9. It is also used to power the PM800-10 performance monitor, when attached.

Component Location

48810



Field repair for the 48810 is recommended only for the following parts:

| | 48810A | | 48810B | |
|-----------------|--------------|--------------|--------------|--------------|
| | Downlink | Uplink | Downlink | Uplink |
| LNA Converter | | | | |
| Power Amplifier | 101300064002 | 101300064001 | 101300064002 | 101300064001 |
| Control Board | | | | |
| Power Supply | | | | |

Maintenance, Repair and Warranty

Periodic Maintenance

There is no periodic maintenance required for the 48710 or 48722. As long as the repeaters are kept away from extreme temperatures and moisture, they should provide long-term, carefree operation.

However, as a system, 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 Warrant

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 two years 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

