USERS MANUAL
For
48710 and 48722
Bi-Directional Amplifiers

RADIO FREQUENCY SYSTEMS

CELWAVE Cablewave

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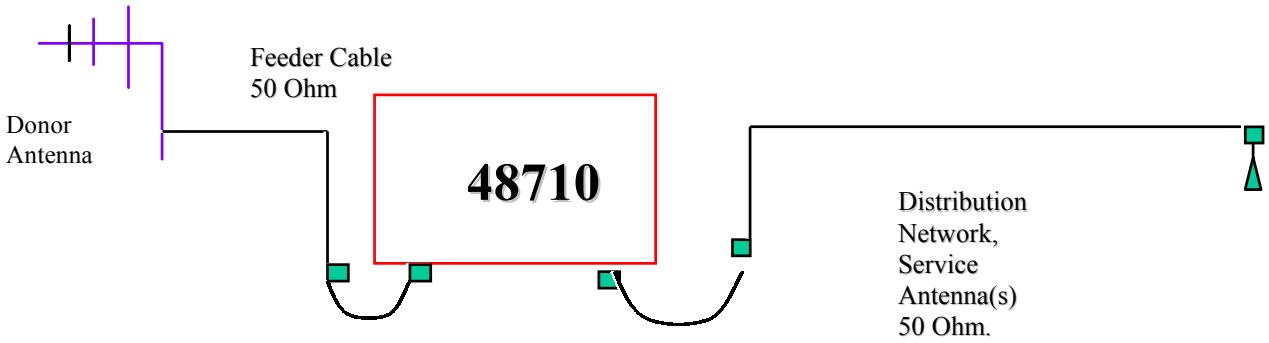
GENERAL STATEMENTS

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 800 321-4700 and we will resolve the situation without hesitation.

Please take the time to read through this consise manual. A full understanding of the way this product operates will support optimal performance and prevent accidental damage not covered by the stated warranty. Ninety percent of installations have no problems at all, it's the ten percent that cause the frustration.

- ***Under no circumstances should these units be operated without proper loads on both antenna ports. Either a antenna or a 50 Ohm load, rated for at least 1 watt, must be connected to both antenna ports before appling power.***
- ***These products receive and amplify RF signals in the 800 MHz Cellular Band. As such, these products are intended for use by the lisencee of the respective service and should not be used without the expressed permission of the lisencee.***
- ***There are no internal adjustments. Do not remove cover except for service. Path manual gain adjustment access holes are clearly marked in the bottom. Under normal circumstances you need not make any adjustments. See installation quikguide for more information.***



For distribution network design assistance, contact our field technical support at 800 659-1800.

MAXIMUM PERMISSIBLE EXPOSURE LIMITS

THIS PRODUCT IS CATAGORICALLY EXCLUDED FROM ROUTINE ENVIRONMENTAL EVALUATION ACCORDING TO CFR 47 SECTION 1.1307.

Repeaters like the 48710 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 bulliten 65.

- ANTENNA INSTALLATION BY QUALIFIED TECHNICAL PERSONNEL ONLY.
- INSTALLATION INSTRUCTIONS ARE FOR THE PURPOSE OF SATISFYING FCC RF EXPOSURE COMPLIANCE AND ARE NOT OPTIONAL.
- ALL ANTENNAS (DONOR AND SERVICE) ARE TO BE FIXED MOUNTED AND PHYSICALLY SECURE TO ONE LOCATION.
- MAXIMUM DONOR ANTENNA GAIN 28 DB
  - NON-BUILDING MOUNTED DONOR ANTENNAS MUST BE GREATER THEN 10 METERS ABOVE GROUND.
- MAXIMUM SERVICE AREA ANTENNA ERP IS 1.0 WATT
  - MINIMUM SEPARATION TO ANY BODY PART OF ANY PERSON IS 25 CM

There are two types of antennas attached to the 48710. The donor antenna is typically roof mounted and service antennas are typically mounted in publically assesable areas. All of the antennas are 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 (806-824 and 896-902 MHz) back to the base site (uplink path). These are typically mounted on roof tops or tower structures. The maximum composite power of the 48710 uplink path is 1.0 W (+30 dBm). Section 1.307 (b) (1) excludes from routine environmental evaluation facilities, operations, and transmitters that, according to table 1 "Cellular Radiotelephone Service", are less then 1000 W ERP for building mounted antennas and less then 1000 W and greater then 10 meters above ground for non-builidng mounted antennas. As such, with a maximum power from the 48710 uplink path of 1.0 W (+30 dBm) and a maximum antenna gain of 28 dB, the donor antenna installation will not exceed 1000 Watts (+60 dBm) and is catagorically exlcuded.

However, according to section 1.1307 (b) (1), the appropriate exposure limits of 1.1310 are applicable to all facilities, operations, and transmitters. As such, the MPE (maximum permissable exposure) of section 1.1310 apply to the donor antenna installation. OET Bulliten 65 provides some methods of calculating the 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 for every installation. As mentioned in the beginning of this section, it is the responsibility of the installer to know and assure that sections 1.1307 and 1.1310 are being met.

The following is a typical installation senario for the donor antenna. Assuming a roof top installation and that the area is uncontrolled/ general population (worse case), the MPE at 824 MHz is .549 mW per cm^2. A higher level is specified for controlled areas in 1.1310 table 1 (A). Using a 10 dB gain yagi antenna (typical in about 80% of installations) and assuming the uplink is being driven to its maximum output power (+30 dBm), the resultant ERP is +40 dBm or 10,000 mW. OET Bulliten 65 provides the formula below for calculating the power density with the EPA reccomended factor for ground reflection:

1.05 ERP / πR^2 Where R is the distance to center (any body part of person)

Solving for 10,000 mW at 3 ft. (91.44 cm) we get a power density of .4 mW per cm^2.

The yagi antenna in this senario must be mounted in such a way that no body part of any person may come closer then 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, it can be assumed that the area is always general population/uncontrolled and that the minimum distance in most installations will be less then 3 feet. According to table 1 (B) of section 1.1310, the MPE for power density at 894 MHz is .596 mW / cm2. The maximum power out of the 48710 on the downlink (base to service area) is +30 dBm (1000 mW). Assuming no feeder able loss and a service area antenna gain of 0 dB, a safe minimum seperation of 25 cm (10 inches) is required to stay within the MPE.

1.05 x 1000 mW / 3.14 x 252 = 1050 / 1962.5 = .535 mW / cm2

Thus, the service area antennas should be mounted such that a no body parts of any person may come closer that 25 cm. The service area antenna gain is 0 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 3 dB to make up for the loss of the spliter 3.6 dB. The maximum service area antenna gain for any specific location can be calculated by: 0 dB + accumulated losses to the antenna.

FIELD TUNE-UP, ALIGNMENT OR CALIBRATION

The 48710 series repeaters are aligned and calibrated at the time of manufacture. These units are designed to retain this calibration for the useful life of the product. There is no field tune-up or alignment necessary.

FCC ID AND CANADA CERTIFICATION NUMBERS

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

The FCC identification number for each particular model appears on a label on the face plate of the units. Applicable FCC Identification and Canadian ISC Numbers are shown.

FCC ID Number	**CANADA**
IWD48710	XXXXXXX

PRODUCT OVERVIEW

THEORY OF OPERATION

The 48710 series signal boosters are designed to enhance radio communications in buildings, basements, tunnels and other RF shielded environments. The 48710 is tuned for the 800 MHz SMR band and the 48722 is tuned for the 900 MHz SMR band.

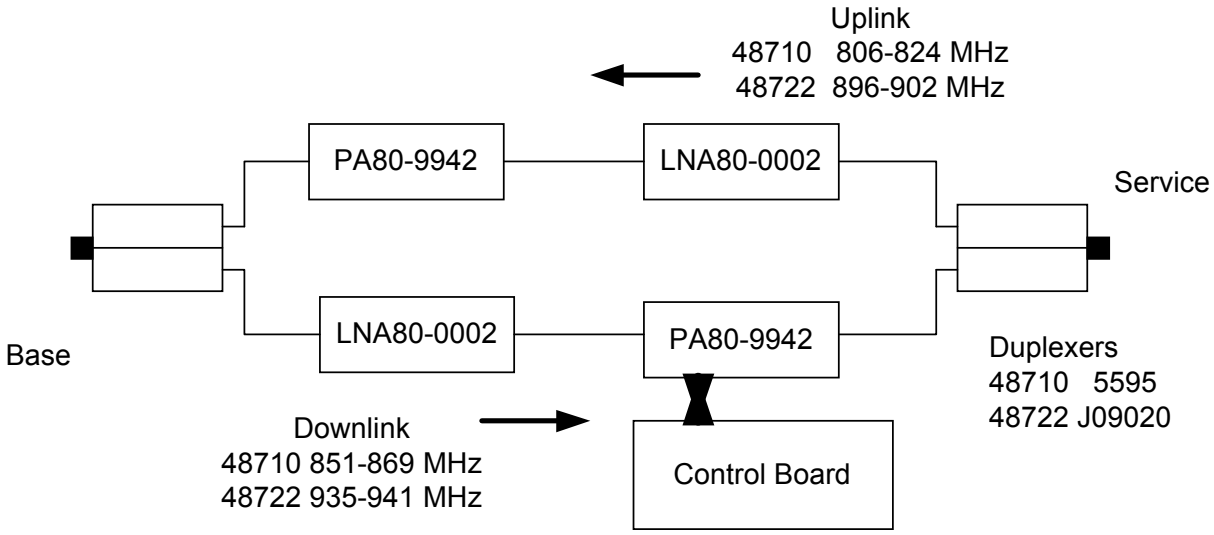
These units work by receiving and amplifying the Base TX signals via a donor antenna directed at the desired base site. This RF path is called the 'downlink". The amplified base TX signal is re-radiated via antenna(s) or radiating cable into the "Service Area". Subscriber mobile RF signals are received by the same service area radiating elements, 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 models are used for the uplink and downlink on both the 48710 and 48722. Likewise, the control board is the same for both models. Differentation is provided by the duplexing filters on the base and service area connectors that determine the basic pass band and direct the RF signals to the proper gain path, uplink and downlink respectively.

Both links have automatic gain control (AGC) in the power amplifiers to prevent overdrive. Manual gain adjustment is provided in the LNA stage. Overdrive limiting is provided by the AGC circuitry and set at the factory and so that the 48710 series will not exceed the FCC limits for spurious emissions

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

Block Diagram



ELECTRICAL SPECIFICATIONS

	Downlink	Uplink
48710 Frequency, MHz	851-869	806-824
48722 Frequency, MHz	935-941	896-901

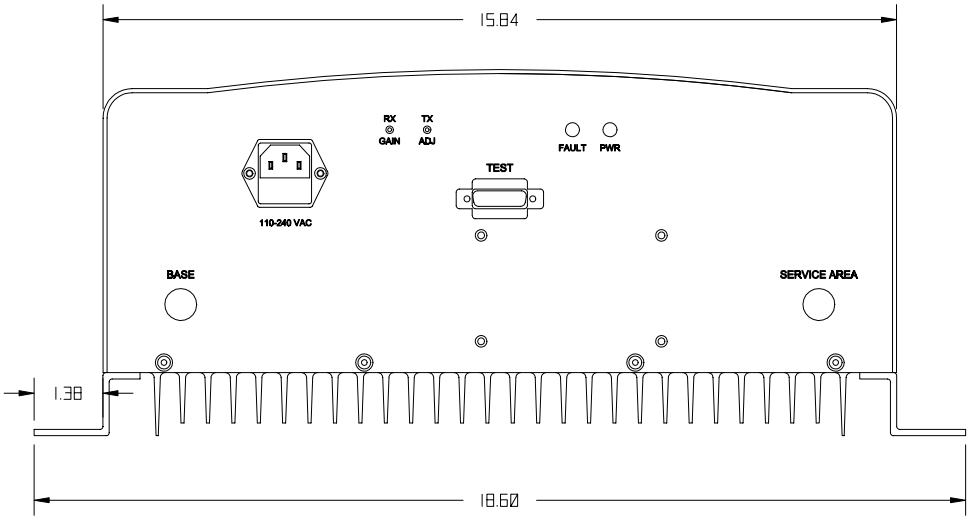
Gain, no Attenuation,	80 dB	80 dB
Gain Flatness, Typ.	±1.0 dB	± 1.0 dB
Manual Attenuator Range	15 dB	15 dB
Output Limiter Range, automatic*	20 dB	20 dB
Noise Figure, Typ.**	2.0 dB	2.0 dB
Composite Power, Typ.*	+30 dBm	+30 dBm
iDEN, CDMA Typ.	+27 dBm	+27 dBm
Impedance, both ports		50 Ohms
VSWR, input, both ports		1.5
Propagation Delay, worst case at band edge		< 3.0 microsecond
Power , 120/220 Auto ranging, IEC-320 Socket		120 VAC @ 1.5 A

*AGC circuitry monitors the output power and reduces the gain to prevent overdrive or oscillation.

** No attenuation and room temperature

MECHANICAL/ENVIRONMENTAL SPECIFICATIONS

Connectors, RF	N Female
Weight	33 lbs (16.2 kg)
Size L X W X D, wall mount, 36 lbs	13.5 X 18.5 X 7.3 (34.3 x 47 x 18.5 cm) Inches
Mounting Centers	10.75 x 17.40 (27.3 x 44.2 cm) Inches
Diagnostics	15 Pin Din Connector
Operating Temperature, ambient	-30 to +50° C
Humidity	Relative up to 95% (non condensing)
Environmental Rating	Similar to Nema 3R



INTERMOD, POWER , AND AGC

A requirement exists within 47 CFR 90, regarding emissions outside of any particular channel of operation. As a general rule, there shall be no spurious emissions greater than {43 + 10 Log10 (Power Out watts)} dB below the carrier Power Out (dB) level. This is always equivalent to -13 dBm.

The primary contributor to spurious emission is multiple signal intermodulation. As multiple signals are amplified, intermodulation products (IM) are generated. The level of the 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 pass band known as the "composite power". Radio Frequency Systems has designed the 48710 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.

The AGC circuitry is housed in each power amplifier stage. A detector on the output of the amplifer provides a DC voltage proportional to the output power. This voltage is compared to a factory setting. As long as this voltage is less then 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 increase attenuation in proportion to the level of the DC voltage.

The attenuation reduces the output power until the detector voltage is at the safe level again. If the number or power of the signals is reduced the DC offset voltage will reduce level of attenuation. In typical operation, the AGC is only active when needed to prevent overdrive. If the AGC is constantly activating it is suggested that you reduce the gain via the manual attenuator and check to make sure that an oscillation between the base and service area 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 to 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 they are in use in the service area or not. Ideally, the donor antenna is directional. This limits the number of donor base sites the repeater sees and reduces the potential for interference. Observing the signal levels before connecting the repeater is reccomended. Out of band signals can also cause overdrive. The most likely occurance of overdrive is oscilation from inadaquate antenna isolation.

Table 4 lists the typical output power per signal which can be expected from the 48710 for a given number of active signal operating at equal input levels. For a donor site that has 16 signals, the full power per signal would be +14 dBm. Assuming the incoming signal is sufficient such that that level will be achieved.

TABLE 1. TYPICAL OUTPUT POWER PER SIGNAL

Number of Signals	dBm	mW
1	30.0	1000
2	26.0	398
4	22.0	160
8	18.0	63
16	14.0	25
32	10.0	10
64	6.5	5

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 is at the input to the repeater and the gain is 80 dB, the resultant output will be 0 dBm, not +14 as in the above discussion. + 14 dBm in this case is the maximum. So, if the incoming signal is –60 and the gain set for 80 dB, the output would not be +20 dBm with 16 simultaneaous signals, the AGC would reduce the gain to 76 dB and the output to +14 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 only occur if the AGC control limit is exceeeded for about a half second. Power is then cut for 2 seconds. After this time-out, power is brought back on-line. If the overload condition is still present, shutdown will again occur in about 1 second. This cycle will be repeated until the condition causing AGC to reach its limit is removed. Conditions which 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 inadaquate antenna isolation.

MANUAL GAIN ADJUSTMENT

The independent manual attenuators, RX for uplink and TX for downlink, are accessable from the bottom of the unit. They are set fully counter clock wise, at min attenuation – max gain. Manual attenuation is separate from the AGC so these attenuators can be used to reduce overdrive while maintaining the AGC range. At fully clockwise, 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 5 x 20 mm, 3.15 amp fast blow fuse is used to cut power in the event of a severe AC fault. A 5 amp mini ATO fuse is used between the 28 VDC from the power supply and the control board which distributes the power to all components. This is located on the control board.

WARNING: ALWAYS REMOVE POWER BEFORE CHECKING OR CHANGING FUSES. 120 VAC can be lethal. **Always unplug** the amplifier before servicing the interior. **Never insert** conductive objects into any opening. **Do not remove or probe** under the plastic safety cover over the AC terminals of the 28 VDC power supply. **Always use** a standard 3-wire electrical outlet with safety ground for AC power.

INSTALLATION

Do not apply power until antennas have been connected to both the base and service area ports

- Choosing a location for the 48710 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 48710 and 48722 are not intended for outdoor operation without protection. A outdoor version suffix "A" is designed for that purpose. A central location is desired to provide sementry in the distribution network. Further, stacking room near a riser for easy access to the roof and other floors is desired. However, access to clean 110 VAC power is the only requirement.
- Install directional donor antenna and aligned with desired base site.
  Yagis, corner reflectors, and panel antennas work the best. Usually, the more directive the better. The 48710 has sufficiniet filtering to prevent undesired signals from causing interference, however, it is best to reduce the chance for interfernece by directing the mobile signals only towards the desired donor base site.
  Check the incoming signal before connecting. The 48710 will work with a wide range of RF input signal levels. Ideal levels on the down link are in the range of –70 dBm. These levels will provide the maximum output power while not causing significant ovedrive. Also check for extremely strong out of band signals. These may overdrive the filtering and cause gain reduction.
- Connect the donor antenna to the 48710 via 50 ohm coaxial cable.
  Size and type of cable are a matter of choice. Typically ½" Flexwell foam coax is used, plenum rated for inside buildings and work areas. However, 7/8" cable may be used to reduce the longitudinal loss. Superflex cables are easier to install but have higher longitudinal loss.

- Install service area antenna(s).
  Determine 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 neccesary to install several service area antennas For assistance with antenna placement contact RFS Applications Engineering. ***Observe MPE cautions*** when determining the type and location of all antennas!
- Connect service antenna(s) via 50 ohm coaxial cable
  Multiple service area antenna(s)/radiating cable runs may be connected the 48710. Splitters and taps may be used to accommodate unique distribution systems. RFS has all the components needed to complete even the largest installations. See our Web Catalog at www.rfsworld.com or call us.

- Mount the 48710 Repeater upright, make sure there is sufficient space above and below the unit to allow air to flow through the heat sink. Check to make sure the AC power cord can reach the power source. Also provide adaquate bending room for the coxial cable.
- Connect 50 ohm cables – donor antenna to "Base", service antenna(s) to "Service"
- Connect AC power to the 48710 and observe power and fault leds. The PM700-10 comes with each unit. This connects to the 15 pin diagnotics din on the bottom of the unit either directly or via the 10 foot extension cable. The PM700-10 provides LED readouts of the PINs as explained in the diagnostics/troubleshooting section. PIN outputs are TTL and DCV so a DVM can be used to troubleshoot if needed.
- Nintey percent of installations are trouble free. The typical problem with the other ten percent is the signal is too weak or too strong on the downlink. See troubleshooting section for more information
- A test of the installation should include multiple subscribers in various locations in the service area with one subscriber always in the closest proximity to the repeater that will normally be allowed. This will check to make sure that a close-in user does not overdrive the uplink and reduce coverage for other users.
- If there is an overdrive in either the up or down link, reduce path gain via the manual attenuator. Rotate clockwise until the AGC overdrive indicator goes out.

ANTENNA ISOLATION

ISOLATION BETWEEEN 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 lighting up and then quickly off every 2 seconds.

Antenna isolation is usally 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. See applications engineering for 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

Green power LED not lit.
Check power source and the the AC fuse located in the EIC plug. Check for DC voltage. Is is rare that the DC fuse will blow and most likely indicates a short of some kind in the repeater. The DC fuse is accesable inside the unit. The Mini ATO 5 amp is a readily available fuse. It can be replaced, however, if the fuse blows again, the unit should be return for service.

Green power LED lit and no Red Fault LED
If the green LED is on but the unit does not appear to be working, the mostly likely senario is a break in the donor or distribution networks. First check both RF paths output via the DC voltages on Pins 12 and 13 or the RX DET.V and Tx DET. V from the PM700.
Also check to make sure that the donor signal is still available to the repeater, obstruction is blocking the donor base site or the donor antenna has 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.

Checking for DC Voltage
DC Voltage can be check via the 15 pin test port. Pins 10 and 11 are the DC voltage associated with the AGC circuitry, there should be at least 7 volts to ground - pin 14. Or plug the PM700 monitor into the test port and measure the RXAGCV to ground.

The Red LED indicates a summary fault from any of the fault conditions identified in the Test Points section. Specific action is describe in that section.

TEST POINTS

The D-sub connector is located on the bottom of the unit. The PM700 performance monitor will provide visual readout or a DC VOM can be used to quickly assess the health of the 48710. The following is the D-sub pin-out with troubleshooting suggestions: Looking at the Din connector from the bottom of the unit, pin numbering starts upper right and proceeds right to left top to bottom.

1. RX LNA Alarm, logic, low = fault
2. TX LNA Alarm, logic, low = fault
3. –not used
4. –not used
5. RX PA Alarm, logic, low = fault
6. TX PA Alarm, logic, low = fault
   Conditions 1 – 6. Remove and replace the faulty component or send the repeater back for repair.
7. Temperature Alarm >+85° C, logic, low = fault
   Check for proper airflow past heat sink. If this fails, send unit in for repair.
8. AGC Alarm, logic, low = fault
   Indicates overdrive. See AGC section
9. Disable (input), logic, high = disable
   Remote disable feature. Connecting pin 15 to this pin will disable the 48710.
10 Rx AGC Voltage, analog, no AGC approx. 26.5VDC, Full AGC approx. 7.65VDC
11 TX AGC Voltage, analog, no AGC approx. 26.5VDC, Full AGC approx. 7.65VDC
   Pins 10 and 11 provide indication of the amount of AGC attenuation. Full AGC indicates strong drive signal or possible oscillation and should be avoided. Check drive levels and antenna isolation. Reduce manual gain to relax AGC level if needed.
12 RX Drive Voltage, analog, approx. 0 to 3VDC @ approx. 0.3VDC per dB
13 TX Drive Voltage, analog, approx. 0 to 3VDC @ approx. 0.3VDC per dB
   Pins 12 and 13 provide a DC voltage that represents the output power of the respective path. These levels can be used to determine if there is signal present when a signal meter is not available.
14 Ground for Pins 10,11,12,13.
15 +5VDC, thermally fused (self-resetting), 50mA max.
   Pin 15 can be used as the drive voltage to disable the unit on Pin 9. It is also used to power the PM700-10 performance monitor.

MAINTENANCE, REPAIR, AND WARRANTY

PERIODIC MAINTENANCE

There is no maintenance for the 48710. As long as the amplifiers are kept away from extreme temperatures and moisture, the amplifier should provide long-term, care-free operation.

However, as a system periodically check all RF connections for corrosion, strain damage, and tightness and periodically check the AC power connections for integrity.

ORDERING & RETURNING COMPONENTS

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

For returns, repairs and ordering, contact Radio Frequency Systems Customer Service at 1-800-321-4700 (602 252-8058 for Latin America) for a Return Authorization Number. Be prepared to

provide the model number and serial number of the unit as well as a description of the symptoms of the problem.

Send components or units freight-paid with the Return Authorization Number on the outside of the package to:

Radio Frequency Systems
4100 S.W. Research Way
Corvallis, Oregon 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 two years from 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 plant 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.

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