RF-11000 Microwave RF Repeater

Operations Manual

550-0211-01

Revision B

October 2008

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Chapter 1. Overview

General Information

The **Peninsula Engineering Solutions RF-11000 Microwave RF Repeater**, hereafter referred to as the RF-11000 (or *the repeater)*, is a linear, bi-directional, on-frequency RF repeater for microwave point-to-point networks. The RF-11000 may be used with any manufacturer's compatible 11-GHz radio operating in the 10.7-11.7 GHz frequency range to provide an intermediate repeater.

Applications

- Low-cost, highly reliable 11-GHz microwave through repeater for extending range of or clearing obstructed microwave radio paths.
- Excellent performance with analog, digital, or video microwave radios; channel capacity to 2400 FDM, 2688 PCM (4 DS3 or 180 Mb/s), OC-3, STM-1 (155.52Mb/s), Internet Protocol, multiple video or mixed traffic.
- Compatible with any manufacturer's 11-GHz radio terminal.
- Solar and wind power compatible -- economical in light to heavy routes and remote locations.

Features

- Power Amplifier RF output power up to +32 dBm, 1.5 Watts.
- Power consumption only 65 Watts, solar rated, at +24 VDC for duplex operation.
- Solar powered, hybrid solar and wind powered, ac powered, or powered by primary cells.
- Compact and lightweight -- ideally suited for remote sites that do not have access roads or commercial power.
- Environmentally protected aluminum, weathertight, lockable cabinet. No extra environmental shelter required in most installation. Suitable for use at unimproved sites anywhere in the world -- Alaska to Saudi Arabia.
- Internally protected duplex (FDD), frequency diversity, space diversity and three-way or "Y junction" system configurations are available.
- Only one active element per channel, the internally redundant linear amplifier.
- AGC/ALC provided to correct input fades, regulate output power and reduce overload.
- Adaptable to new radio modulations and capacities as technology advances.
- RMAS-120 Alarm system (optional) can remotely monitor repeater.
- Equipped with directional couplers for in-service RF output power measurements.
- No frequency conversion -- received signal is filtered, amplified, and re-radiated.
- Very reliable, greater than 85,000 hours MTBF for 1+0 duplex.
- Available as a self-contained RF repeater for use with customer-furnished antenna and power equipment or as a complete package including repeater, antenna, photovoltaic modules, battery charger and batteries.

Functional Description

1. The RF-11000 assembly is an RF through repeater designed for remote locations. Little alignment is required, and the use of highly reliable components and minimum active circuitry eliminates most subsequent maintenance. The repeater assembly consists of an equipment mounting panel, contained in a aluminum, weatherproof cabinet. If desired, the complete assembly may be wall-mounted. In most applications however, the complete assembly is pole- or tower-mounted. Front views of the repeater are shown in Figures 1 and 2.
2. In addition to the RF-11000 repeater assembly, Peninsula Engineering Solutions offers accessory equipment consisting of antennas and mounting hardware, waveguide, batteries and hardware, and an ac power supply with an integral standby battery. The recommended antennas are solid or high performance types chosen per application.

Basic Repeater

3. The RF-11000 duplex repeater uses internally redundant amplifiers for transmission in each of two directions. Each amplifier is powered by two separate battery supplies for added reliability. Bandpass filters and circulators, which form a duplexer network, direct the received signals to the amplifiers and combine the amplifier outputs with the received signals to a common antenna port for transmission in each direction (see Figures 4 to 7). The repeater supports frequency division duplex, FDD, radio link systems where separate frequencies are used in each direction.
4. The received signal from "A" antenna, identified as frequency "f1", enters the repeater panel via the cabinet mounted WR75, cover flange and is then fed to a RX-TX branching circulator. Then from the channel branching circulator, the f1 signal is passed to the f1 receive bandpass filter. The bandpass filter passes the f1 signal to a terminated coaxial circulator and (optional) f1 receive pad and then to amplifier 1. The amplified signal passes through the (optional) f1 transmit pad. From the transmit pad the f1 signal then passes through a terminated coaxial circulator and the f1 transmit bandpass filter to the channel branching circulator and then to the RX-TX branching circulator. From there to cabinet mounted WR75, cover flange for connection to the "B" antenna.
5. In the other direction, the receive signal from "B" antenna, identified as frequency "f2", enters the repeater panel via the cabinet mounted WR75, cover flange and is then fed to a RX-TX branching circulator. Then from the channel branching circulator, the f2 signal is passed to the f2 receive bandpass filter. The bandpass filter passes the f2 signal to a terminated coaxial circulator and (optional) f2 receive pad and then to amplifier 2. The amplified signal passes to (optional) f2 transmit pad. From the transmit pad the f2 signal then passes through a terminated coaxial circulator and the f2 transmit bandpass filter to the transmit channel branching circulator and then to the RX-TX branching circulator and the cabinet mounted WR75, cover flange for connection to "A" antenna.
6. Receive pads RX f1 and RX f2 reduce the repeater receive signals to approximate the recommended input level. The transmit pads designated TX f1 and TX f2 reduce the output signal levels of the repeater to prevent overloading of the terminal receiver in a short path. Pads are mounted on input and output of amplifiers. Nominal input and output power level for various repeater channel configuration are listed at in Technical Summary following this section.
7. Delay Equalizers are added to correct for the slope and parabolic group delay introduced by the bandpass filters and branching networks. Equalized repeaters are recommended for high capacity systems, tandem repeater applications and multiple carrier 1+1, 2+0 configurations.

Amplifiers

8. In digital radio applications, in order to maintain linearity over the entire signaling envelope, the amplifiers operate at a reduced average power level to meet the output power level requirement as shown in Technical Summary. Each amplifier is mounted on the front of the panel to allow

easy AGC/ALC and linear gain adjustments. It also provides easy amplifier replacement in the field. Necessary information for ordering spare or replacement amplifiers is provided later in Chapter 1, *Ordering Information*.

Directional Couplers

9. Directional couplers, built into the amplifiers, provide signal monitor points, "RF MON". These allow in-service measurement of transmit output power. The monitor points are calibrated for calculating the actual RF output power at the amplifier output and at the antenna port flange. When measuring transmit power, the power meter reading obtained, plus the loss (in dB) marked at the amplifier monitor point, minus the branching loss (in dB) marked on the panel, equals actual antenna port transmit output power.

Example 1 Amplifier Output	
Power Meter indication	+5.0 dBm
Cal Loss at RF MON	+ 19.0 dB
Amplifier Output =	+24.0 dBm

Example 2 Antenna Port Output	
Power Meter indication	+5.0 dBm
Cal Loss at RF MON	+ 19.0 dB
Tx Branch Loss	- 2.8 dB
Antenna Port Output =	+21.2 dBm

AGC/ALC Adjustment

10. There is a field-adjustable potentiometer on the amplifier. The amplifier output power set level is adjusted by AGC/ALC potentiometer. This is a multi-turn potentiometer.

Linear Gain Adjustment

11. On the amplifier, there is a second field-adjustable potentiometer for linear gain adjustment to limit its maximum gain. Gain adjustment is typically only used in cases where antenna isolation is inadequate to support the required C/E at maximum gain. In the majority of cases, the AGC/ALC automatic adjustments are all that is needed.

Power Supply

12. The only active element in each frequency channel of the RF-11000 assembly is the amplifier which operates from a +8.5 VDC source. Two DC supplies of +24 VDC are brought into the repeater enclosure. They are converted to +8.5 VDC by two DC-DC converters and power the amplifiers in redundant-protecting mode. Current requirements, at +24 VDC, are 2.7 Amperes per duplex system and 5.4 Amperes per duplex, frequency diversity system. The repeater assembly may be powered from alternative energy source such as solar panels, wind turbines, primary cells only, or from an AC/DC supply with standby battery (shown in Figures 8 and 9).
13. Storage batteries and photovoltaic modules are selected on the basis of the insolation and temperature range at the site. The batteries are engineered to provide the required reserve capacity across the temperature range and during periods when the output from the solar panels is low or not available. Controllers are used with the solar panels to efficiently charge the batteries without overcharging. Peninsula Engineering Solutions can determine the solar and battery capacity. The location of the site should be specified when requesting assistance.
14. In areas where commercial power is available, an AC power supply can be provided. Although one AC power supply will provide ample current to power all amplifiers, dual AC power supplies are recommended for higher reliability. The dual AC power supply system also contains two rectifier/chargers and two sets of standby battery to provide power during AC power failures. Each battery is float charged while the power supply is on and has 100 Amp-hours as standard capacity. Additional batteries can be purchased if needed.

15. In locations where commercial power is not available and solar panel charging is impractical, then alternative power sources such as thermal-electric generator, TEG, fuel cell or motor generator are available. Power sources may be used in combination to create hybrid power solutions capable of operating in very demanding applications. Primary cell batteries capable of powering an RF-11000 repeater in excess of a year are available. In such applications, the battery installation should be given an environmental shelter according to the manufactures' recommendations. Contact Peninsula Engineering Solutions for assistance in designing the best power supply system.

Alarms

16. The RF-11000 repeater can be provided with an optional alarm system (RMAS) to remotely monitor the repeater site. Conditions that are typically monitored are listed below:

Standard Telemetry:

a) A Battery Voltage
b) B Battery Voltage
c) Battery Temperature
d) Auxiliary Voltage

Standard Trip Points:

c) A and B Battery Major Alarm
d) East and West RF Output Low
e) Amplifier Alarm
f) Cabinet Door Open
g) Feedline pressure low
h) Uncommitted Points

17. The standard alarms are typically relayed back to the terminal site through the use of a low rate telemetry signal directly modulated on the microwave carrier in a non-interfering fashion. Alarms are visually displayed on the standard terminal receiver unit. Alarm contact closure outputs are available for input to standard microwave supervisory systems.
18. Alternative alarm equipment is available that transmits alarm data via UHF radio telemetry links operating in parallel to the microwave hop. This type of alarm equipment is used when access to the terminal radio AGC is not available or compatible.
19. Alarm closures can be converted to SNMP reporting over IP networks using Peninsula's SNMP-SL10 unit.

Licensing

All owners of the RF-11000 should consult with the appropriate local and national agencies for information about licensing.

FCC ID (note 1)	EK2A1101
FCC Emission Designator	Repeater, Amplifier or same as terminal radio
Power Output	0.08 ~ 0.8 Watts
Frequency Range	10.7 ~ 11.7 GHz
Frequency Stability (note 2)	Amplifier
Modulating Frequency	Dependant on terminal radio equipment

Licensing Notes:

1. The RF-11000 series are FCC approved for use with any 11-GHz radio equipment.
2. The repeater does not have any frequency determining components; therefore, for FCC data, frequency stability is shown as amplifier. The actual frequency stability is a function of the associated end terminal radio equipment.

Technical Specification Summary

General	
Frequency Range	10.7 ~ 11.7 GHz
Linear Amplifier Gain	63 dB typical, 61 dB minimum
AGC/ALC	15 dB down fade 5 dB up fade
Transmit Power, Level 2, Amplifier Output	+32 dBm[1] with no backoff, see Table 4
Noise Figure, Amplifier Input	3.5 dB[2] at maximum gain, 4.5 dB at minimum gain
Propagation Delay, Antenna Port to Antenna Port	100 ± 20 nsec at f_0
Branching Losses, Rx and Tx	See Tables 2 and 3 for configurations
Antenna Connections	
Antenna Ports	WR75, Cover Flange
Waveguide Type	WR75
Return Loss, Antenna Port	26 dB across assigned channels
Frequency Plan	
Channel Bandwidth – High Capacity	40 MHz maximum
Channel Bandwidth – Low ~ Medium Capacity	20 MHz maximum
T-R Spacing	130 MHz minimum
T-T Spacing (1+1, 2+0) on common feeders	80 MHz minimum
Channel Response: High Capacity, Equalized	
Amplitude	± 0.5 dB, f_0 ± 20 MHz
Group Delay Ripple	5 nsec P-P, f_0 ± 20 MHz
Group Delay Slope	± 5 nsec, f_0 ± 20 MHz maximum
Channel Response: High Capacity, Un-Equalized	
Amplitude	± 1.0 dB, f_0 ± 20 MHz
Group Delay Ripple	10 nsec P-P, f_0 ± 20 MHz
Group Delay Slope	± 10 nsec, f_0 ± 20 MHz maximum
Channel Response: Low ~ Medium Capacity, Un-Equalized	
Amplitude	± 1.0 dB, f_0 ± 10 MHz
Group Delay Ripple	10 nsec P-P, f_0 ± 10 MHz
Group Delay Slope	± 10 nsec, f_0 ± 10 MHz maximum
Electric Power Requirements	
Power Configuration	A & B Battery Inputs, Auto-Redundant
Nominal Voltage	+24 VDC
Voltage Range	+19 ~ +30 VDC, at TB1, TB2
Polarity	Negative Ground
Current and Power	See Table 1

[1] Guaranteed transmit power is 1 dB less.

[2] Guaranteed noise figure is 1 dB greater.

Environmental Conditions	
Housing Type	Weather Tight Aluminum
Ambient Temperature	-40°C ~ +60°C
Relative Humidity	90% (housing internal) 100% (housing external)
Altitude	15,000 Feet, 4600 meters
Reliability	
MTBF	85,000 hours
MTTR	30 minutes, on-site
Dimensions: 2-Antenna Port, 1 ~ 4 Frequency Channels	
Height, including antenna ports and mounting rails	36.20 inches, 920 mm
Width, door closed	23.25 inches, 591 mm
Depth, including mounting rails	20.50 inches, 521 mm
Weight	See Table 1

Table 1 DC Power Consumption and Weight per Model

MODEL	Current[3] Amps Max	Power[4] Watts Max	Solar Rated Power, W	Weight[5] lb	kg
RF-11000-41	2.7	73	65	108	49
RF-11000-42	5.4	146	130	122	55.5
RF-11000-51	2.7	73	65	110	50
RF-11000-52	5.4	146	130	124	56.5
RF-11000-41L	2.7	73	65	108	49
RF-11000-42L	5.4	146	130	122	55.5

[3] Current is specified at +27.0 VDC at TB1, TB2. Current increases when the battery voltage decreases. Combined A + B Battery currents are shown. Normally, each battery current is half of the total for even numbers of provisioned amplifiers.

[4] Power is quite constant over the operating voltage range due to the switching DC/DC converters.

[5] Weight does not include optional alarm equipment mounted inside the repeater. Add 5.5 lb, 2.5 kg for standard RMAS-120 transmitter, add 8 lb, 3.5 kg for RMAS-120 transmitter with UHF radio telemetry link.

Table 2 Branching Losses – RF-11000 High Capacity Models

MODEL	BW MHz	Delay Eql	Channel	Receive Branch Loss, Typical*, dB	Transmit Branch Loss, Typical*, dB
RF-11000-41	40	No	F1, F2	2.4	2.8
RF-11000-42	40	No	F1, F4	2.4	2.9
			F2, F3	2.7	2.8
RF-11000-51	40	Yes	F1, F2	3.6	2.8
RF-11000-52	40	Yes	F1, F4	3.5	2.9
			F2, F3	3.9	2.8

Table 3 Branching Losses – RF-11000L Low ~ Medium Capacity Models

MODEL	BW MHz	Delay Eql	Channel	Receive Branch Loss, Typical*, dB	Transmit Branch Loss, Typical*, dB
RF-11000L-41	20	No	F1, F2	2.4	2.8
RF-11000L-42	20	No	F1, F4	2.4	2.9
			F2, F3	2.7	2.8

Note: * Guaranteed branching losses are 1 dB greater.

Table 4 Transmit Power Backoff[6] per Modulation Type

Modulation Type[7]	Backoff	Level 2 PA Output
FM Analog, 24 ~ 96 FDM	0.0 dB	32.0 dBm
FM Analog, 120 ~ 300 FDM	0.0	32.0
FM Analog, 420 ~ 2400 FDM	0.0	32.0
FM Analog, Color Video	0.0	32.0
FSK, MSK	0.0	32.0
BPSK	1.0	31.0
QPSK, OQPSK, 4PSK, 4QAM	2.0	30.0
8PSK	4.0	28.0
16QAM	6.0	26.0
32QAM	8.0	24.0
64QAM	10.0	22.0
128QAM	12.0	20.0
256QAM	13.0	19.0
512QAM	14.0	18.0
32TCM	9.0	23.0
64TCM	10.0	22.0
128TCM	12.0	20.0
256TCM	14.0	18.0
OFDM QPSK	11.0	21.0
OFDM 16QAM	15.0	17.0
OFDM 64QAM	19.0	13.0
COFDM QPSK	6.0	26.0
COFDM 16QAM	9.0	23.0
COFDM 64QAM	13.0	19.0
9QPRS/QPR3	5.0	27.0
25QPRS/QPR5	5.5	26.5
49QPRS/QPR7	6.0	26.0
81QPRS/QPR9	7.0	25.0
225QPRS/QPR15	9.0	23.0

Note: Peninsula Engineering Solutions may change performance specifications where necessary to meet industry requirements.

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[6] Transmit power set point is reduced as the modulation becomes more complex. This power "backoff" provides adequate linearity as required by the system performance objectives. The ALC adjustment on each amplifier is used to set the output power level. To calculate the repeater's output power at the antenna port flange, take the amplifier power output without backoff, reduce that level by the backoff listed in this table, then subtract the transmit branch loss for the specific configuration from Tables 2 or 3.

For Example: Level 2 Amplifier Power Output = +32 dBm without backoff reduction, Modulation is 256QAM, therefore backoff = 13.0 dB, RF-11000-41 Tx Branch Loss = 2.8 dB,. Output power at antenna port flange = +32.0 – 13.0 – 2.8 = +16.2 dBm.

[7] Modulations listed are the most popular types. List is not exclusive. If a modulation is not listed, contact the company for specific details.

Ordering Information

The RF-11000 RF Repeater Assembly is ordered by specifying the system model number RF-11000-XX (Tables 5 and 6). Attenuators are provisioned by specifying their part numbers. Transmission engineering must be completed before ordering because the necessary attenuator values are determined from the path calculations. Part numbers are listed in Table 7.

When doing the initial system layout of a radio link which includes an RF-11000 Microwave RF Repeater Assembly, several factors must be considered prior to ordering, to ensure correct antenna connections and proper installation. Consider the following topics before ordering the RF-11000 Microwave RF Repeater:

Repeater Transmit and Receive Frequencies

Repeater frequencies are coordinated with the adjacent terminal radios. See the block diagrams for more detail. Orders cannot be accepted without firm frequencies. Frequency assignments within the repeater can optimize the orientation of the repeater antenna ports relative to the site antennas. Peninsula Engineering can assist in determining the frequencies and assignments.

Terminal Radio Modulation, Traffic Capacity and Repeater Transmit Power Level

Repeater transmit power levels are set based on the modulation and traffic capacity of the adjacent terminal radios. Please include the modulation and traffic capacity details with the purchase order. Peninsula Engineering will determine the proper transmit power level. Modulations and traffic capacity beyond those listed in this manual may be possible to support, contact Peninsula Engineering Solutions for more details.

Electric Power System

The repeater site power system should be detailed during the system design phase. Peninsula Engineering Solutions can provide this design service and the power equipment. Power systems may include: Solar, Wind, AC, TEG, Motor Generator, Fuel Cell or other power sources. All power systems include a battery plant and associated charge control equipment. Battery capacity must be adequate for the load, location and power source.

Antennas

The types and sizes of antennas required to meet the system requirements. Transmission engineering can determine the antenna details. Transmission engineering and antennas are available from Peninsula Engineering Solutions.

Feedlines

Type and length required for antenna connections (including jumper assemblies); note that waveguide is available from Peninsula Engineering Solutions.

Mounting

Special requirements for the repeater and antennas specific to the intended tower or supporting structure. The repeater normally mounts outdoors in its all-weather enclosure. Peninsula Engineering Solutions can provide construction engineering support.

Alarm System

The Repeater Monitor and Alarm System equipment is optional. Please refer to Tables 9 and 10 for ordering details or refer to the alarm equipment manuals.

When ordering, specify a shipping destination and a billing address. Peninsula Engineering Solutions returns an order acknowledgment with the scheduled shipping date. Each shipment includes an equipment list showing the equipment ordered and shipped, including details about system and equipment options.

System Options and Assembly Part Number

Table 5 RF-11000 Microwave RF Repeater, High Capacity Models[8]

40 MHz Channel Bandwidth (maximum)[9]			
Standard Assembly	**Part Number**	**Description**	**Frequencies**
RF-11000-41	900-0211-41	1+0/1+1 Hot Standby Equivalent, Duplex, Un-Equalized, PA Level 2, 2	F1, F2
RF-11000-42	900-0211-42	1+1 Frequency Diversity or 2+0, Duplex, Un-Equalized, PA Level 2, 2	F1, F2, F3, F4
RF-11000-51	900-0211-51	1+0/1+1 Hot Standby Equivalent, Duplex, Delay Equalized, PA Level 2, 2	F1, F2
RF-11000-52	900-0211-52	1+1 Frequency Diversity or 2+0, Duplex, Delay Equalized, PA Level 2, 2	F1, F2, F3, F4

Table 6 RF-11000 Microwave RF Repeater, Low ~ Medium Capacity Models[10]

20 MHz Channel Bandwidth (maximum)[11]			
Standard Assembly	**Part Number**	**Description**	**Frequencies**
RF-11000L-41	900-0211-41L	1+0/1+1 Hot Standby Equivalent, Duplex, Un-Equalized, PA Level 2, 2	F1, F2
RF-11000L-42	900-0211-42L	1+1 Frequency Diversity or 2+0, Duplex, Un-Equalized, PA Level 2, 2	F1, F2, F3, F4

[8] High Capacity is > 45 Mb/s per channel carrier.

[9] Repeaters may operate with less than maximum assigned channel bandwidth but not more.

[10] Low to Medium Capacity is ≤ 45 Mb/s per channel carrier.

[11] Repeaters may operate with less than maximum assigned channel bandwidth but not more.

Table 7 Coaxial Attenuator Pads

Part Number	Attenuation	Part Number	Attenuation
149-0128-01	1.0 dB	149-0128-11	11.0 dB
149-0128-02	2.0 dB	149-0128-12	12.0 dB
149-0128-03	3.0 dB	149-0128-13	13.0 dB
149-0128-04	4.0 dB	149-0128-14	14.0 dB
149-0128-05	5.0 dB	149-0128-15	15.0 dB
149-0128-06	6.0 dB	149-0128-16	16.0 dB
149-0128-07	7.0 dB	149-0128-17	17.0 dB
149-0128-08	8.0 dB	149-0128-18	18.0 dB
149-0128-09	9.0 dB	149-0128-19	19.0 dB
149-0128-10	10.0 dB	149-0128-20	20.0 dB

Coaxial Attenuator Pads: equipped with SMA male and female connectors and rated to 18 GHz. May be inserted in receive or transmit lines for RF level coordination. Transmission engineering will determine attenuator requirements.

Table 8 Spare and Accessory Equipment

Part Number	Description
090-0196-01	Amplifier, Higher Power Level 2, for High Capacity Repeater
090-0196-01L	Amplifier, Higher Power Level 2, for Low ~ Medium Capacity Repeater
175-0025-03	Fuse, Blade Type, 5-Ampere, DC
550-0211-01	Manual, Operations, RF-11000 Microwave RF Repeater

Table 9 Alarm System Options, High Capacity Repeaters

Standard Assembly	Part Number	Description
RMAS-120-01	900-0782-01	Standard Telemetry, 1+0, for 1 ~ 2-amplifier repeaters
RMAS-120-02	900-0782-02	Standard Telemetry, 1+1, for 3 ~ 4-amplifier repeaters
RMAS-120-81	900-0782-81	UHF Telemetry, 1+0, for 1 ~ 2-amplifier repeaters
RMAS-120-82	900-0782-82	UHF Telemetry, 1+1, for 3 ~ 4-amplifier repeaters

Table 10 Alarm System Options, Low ~ Medium Capacity Repeaters

Standard Assembly	Part Number	Description
RMAS-120L-01	900-0782-01L	Standard Telemetry, 1+0, for 1 ~ 2-amplifier repeaters
RMAS-120L-02	900-0782-02L	Standard Telemetry, 1+1, for 3 ~ 4-amplifier repeaters
RMAS-120L-81	900-0782-81L	UHF Telemetry, 1+0, for 1 ~ 2-amplifier repeaters

UHF Radio Kits including antennas, feedlines and lightning protection are available from Peninsula Engineering Solutions.

Alarm closures can be adapted to SNMP reporting over IP networks using Peninsula Engineering's SNMP-SL10 equipment.

Contact Peninsula Engineering Solutions for details and assistance.

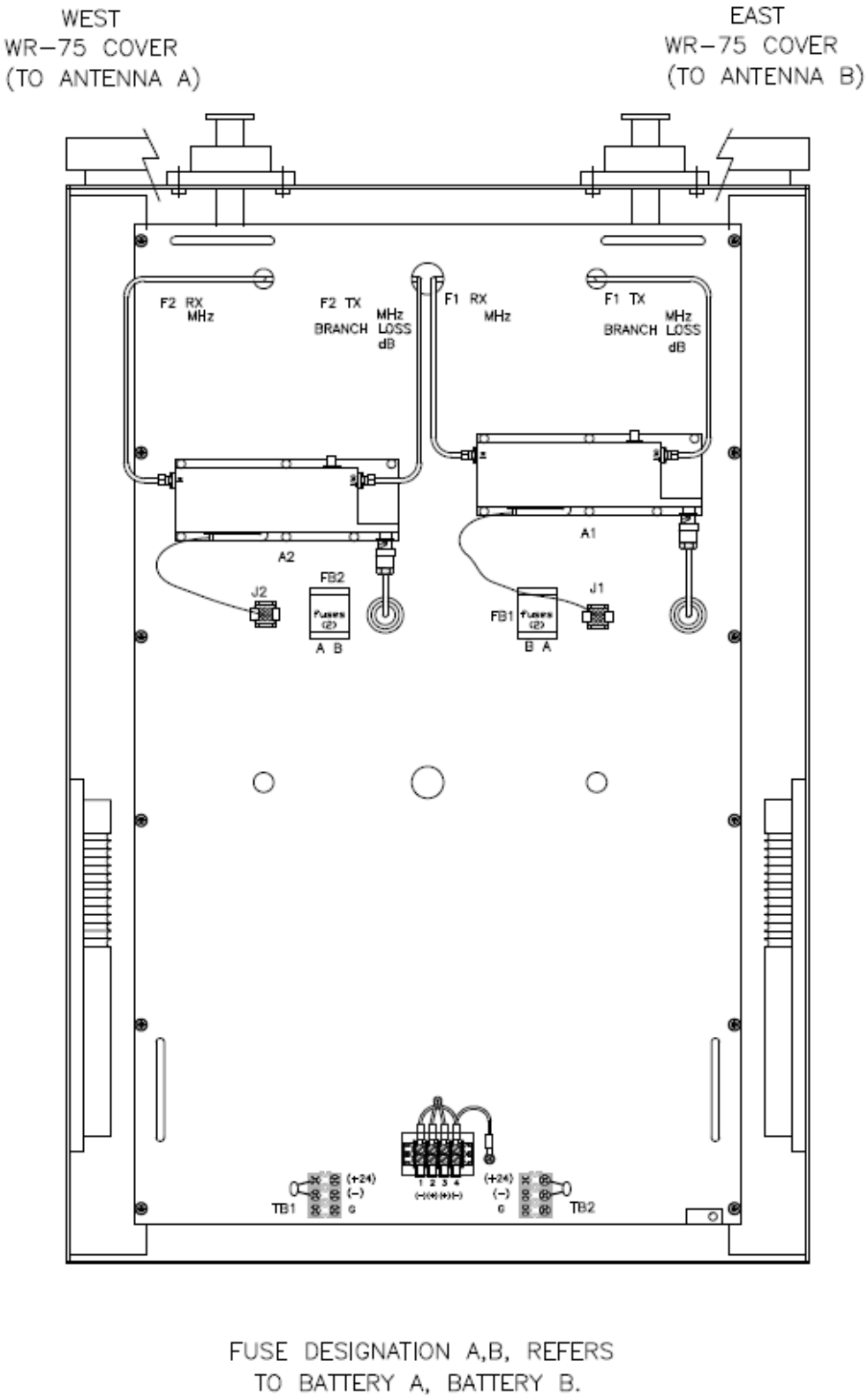


Figure 1 RF-11000-41, 51
Mechanical Layout, 1 – 2 Frequency Channels

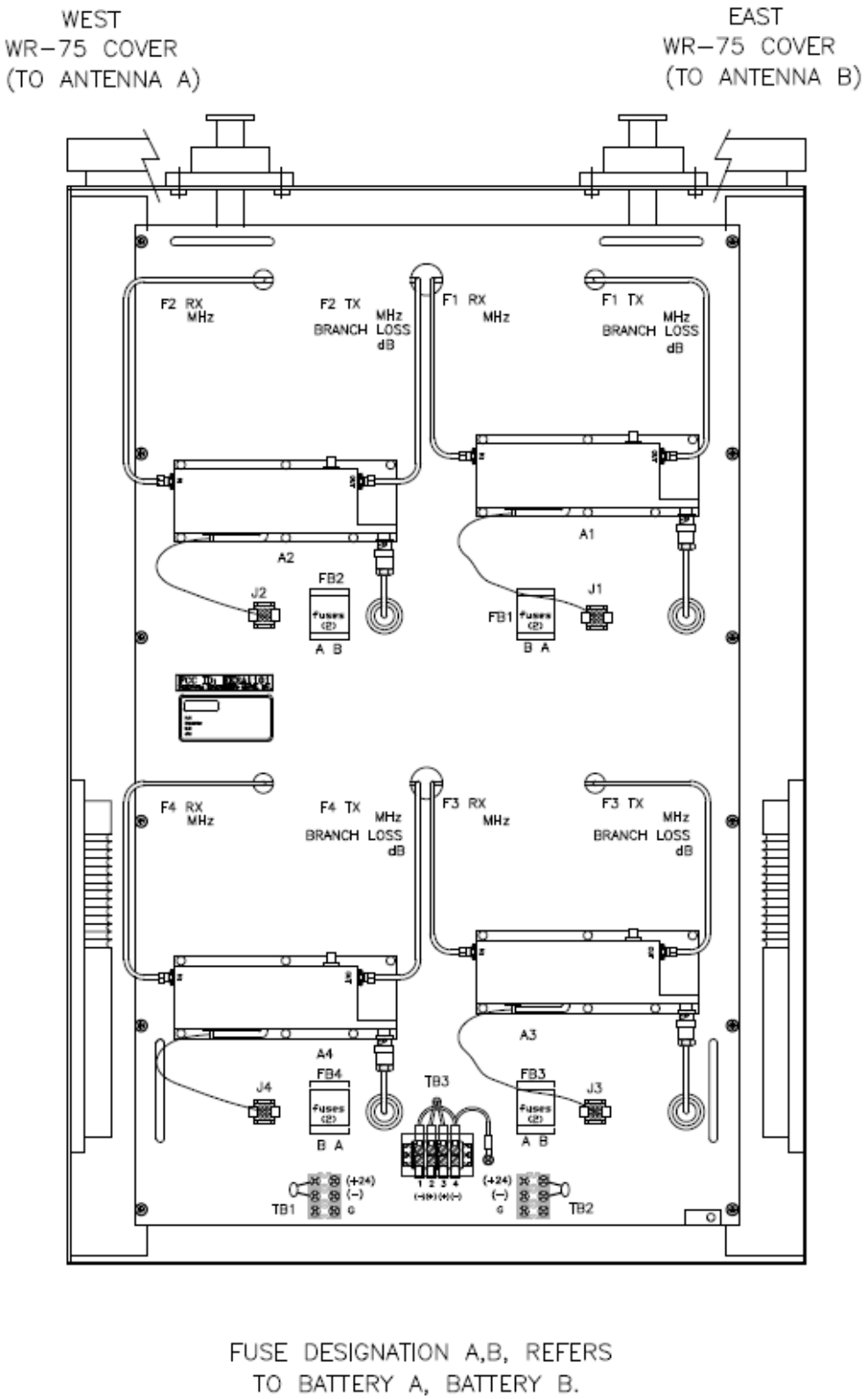
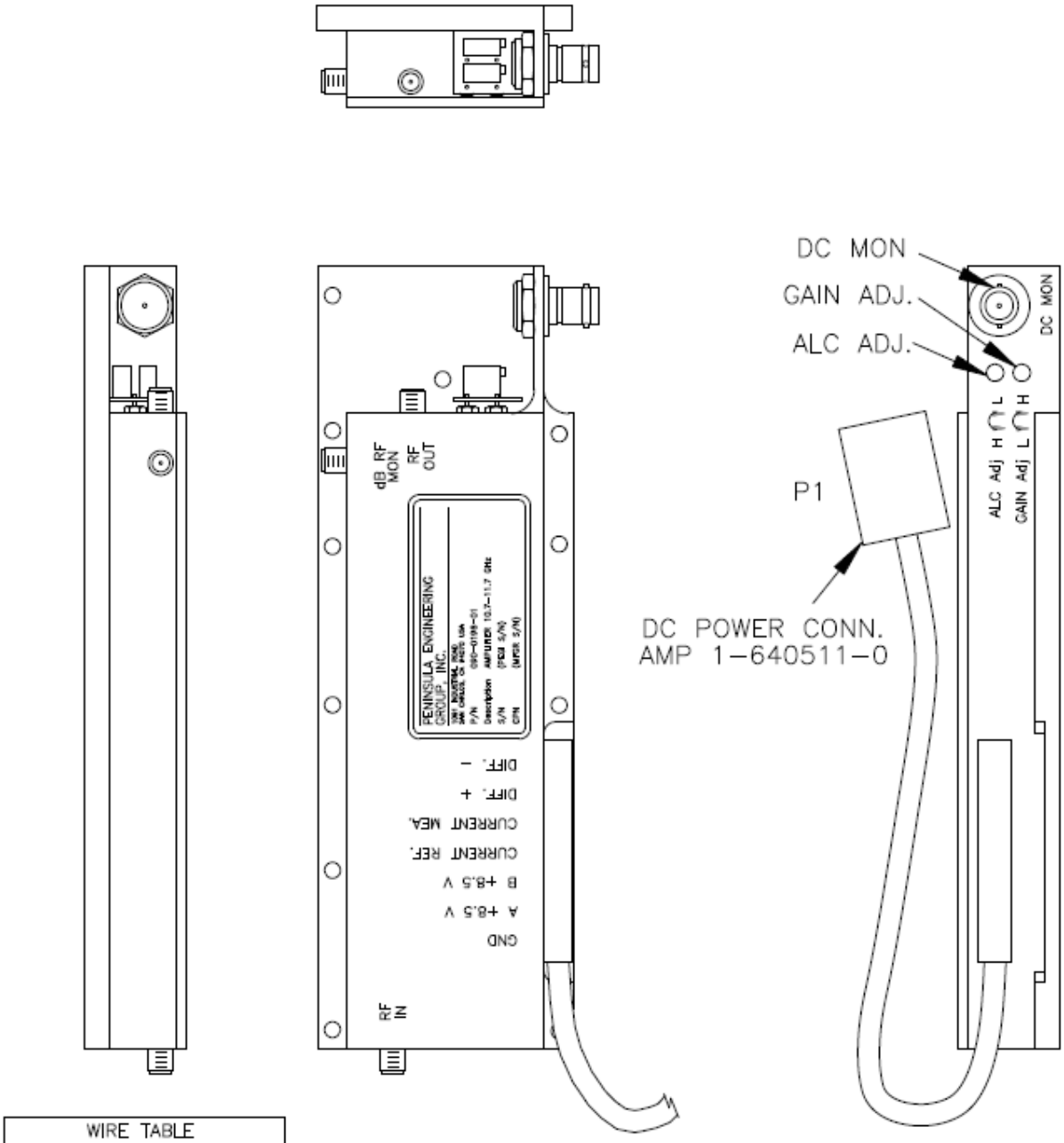


Figure 2 RF-11000-42, 52
Mechanical Layout, 3 - 4 Frequency Channels



WIRE TABLE	
FROM CONNECTOR	TO AMPLIFIER
PIN 1	GND
PIN 2	A +8.5 V
PIN 3	B +8.5 V
PIN 4	CURRENT REF
PIN 5	CURRENT MEA
PIN 6	DIFF +
PIN 7	DIFF –

Figure 3 Linear Power Amplifier

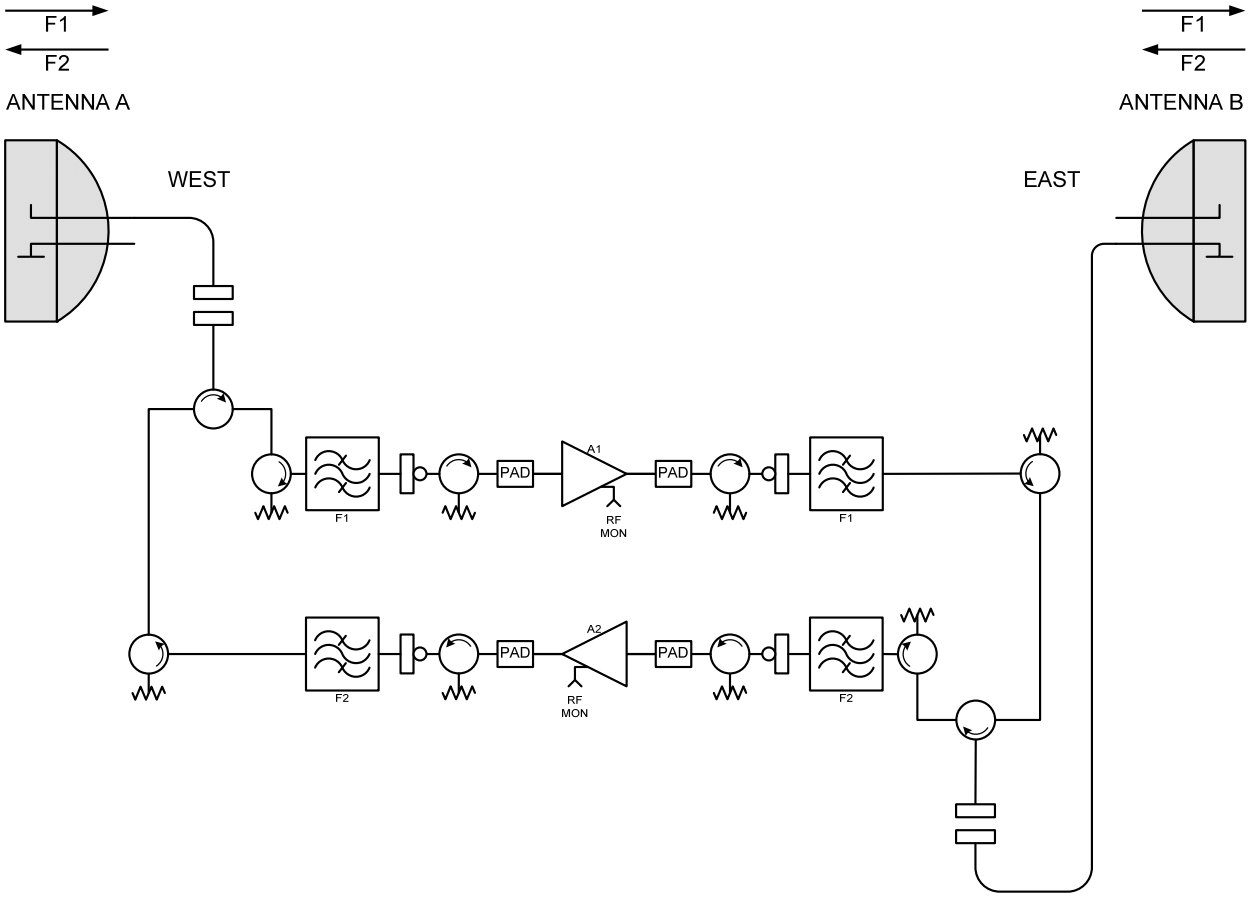


Figure 4 RF-11000-41 1+0 Un-Equalized

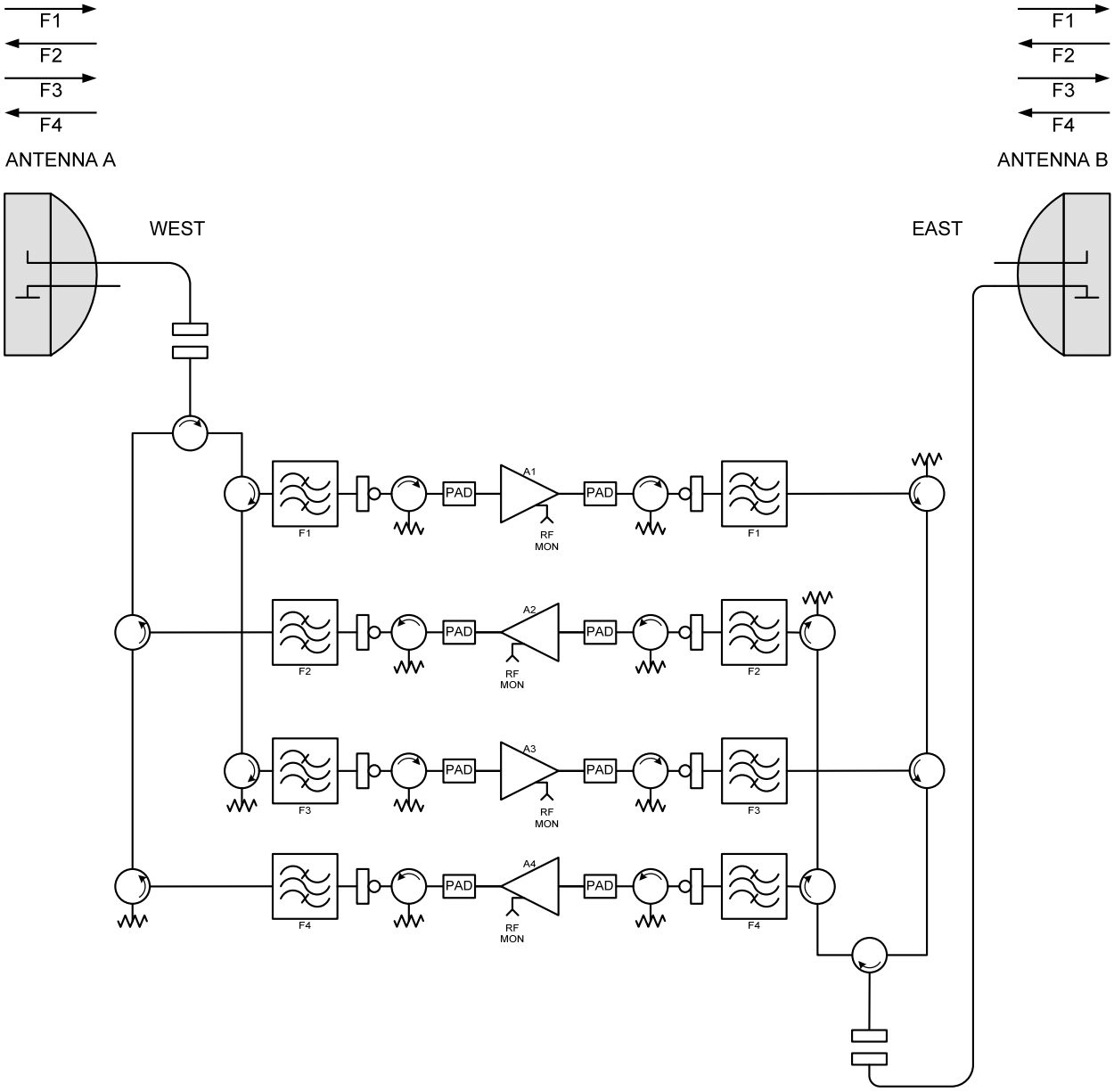


Figure 5 RF-11000-42 1+1 Un-Equalized

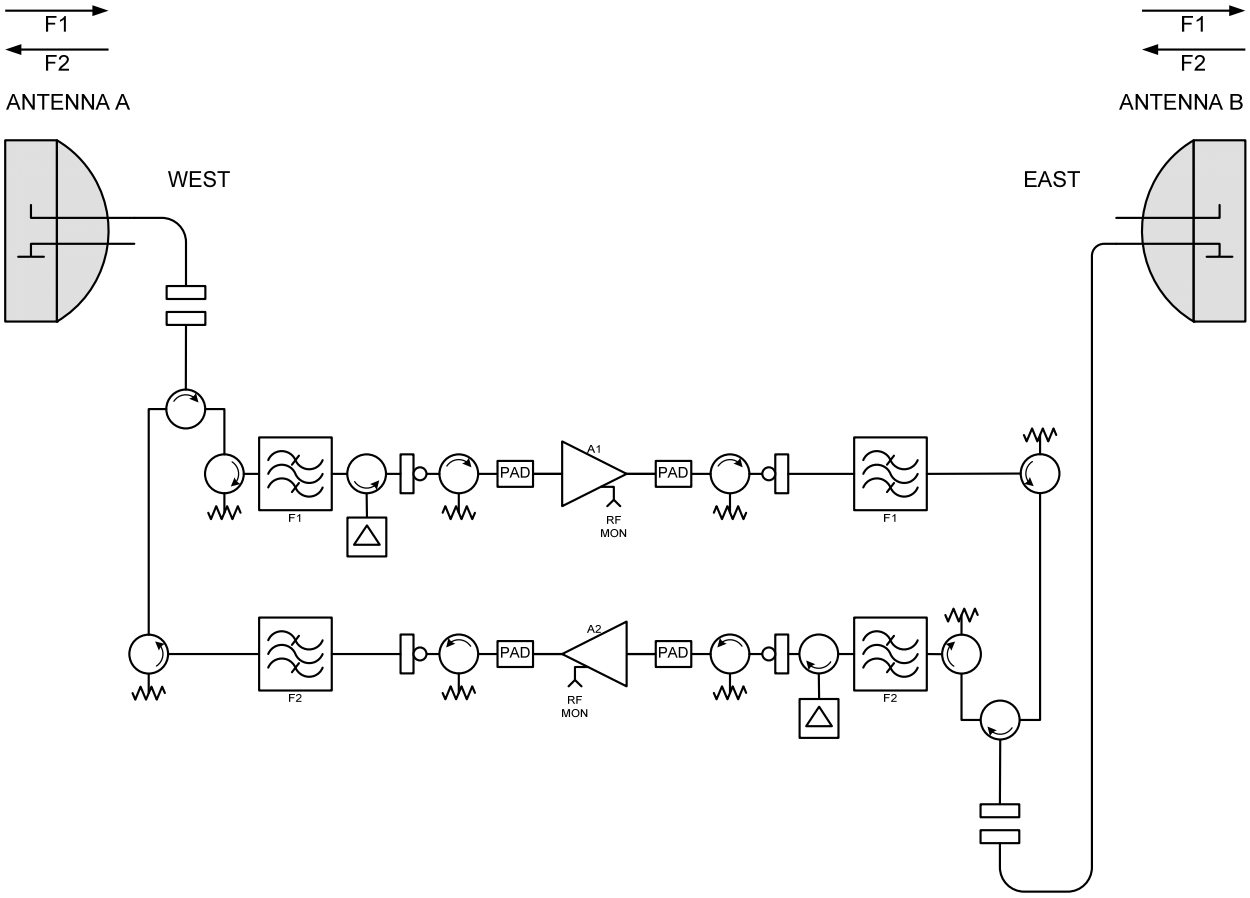


Figure 6 RF-11000-51 1+0 Delay Equalized

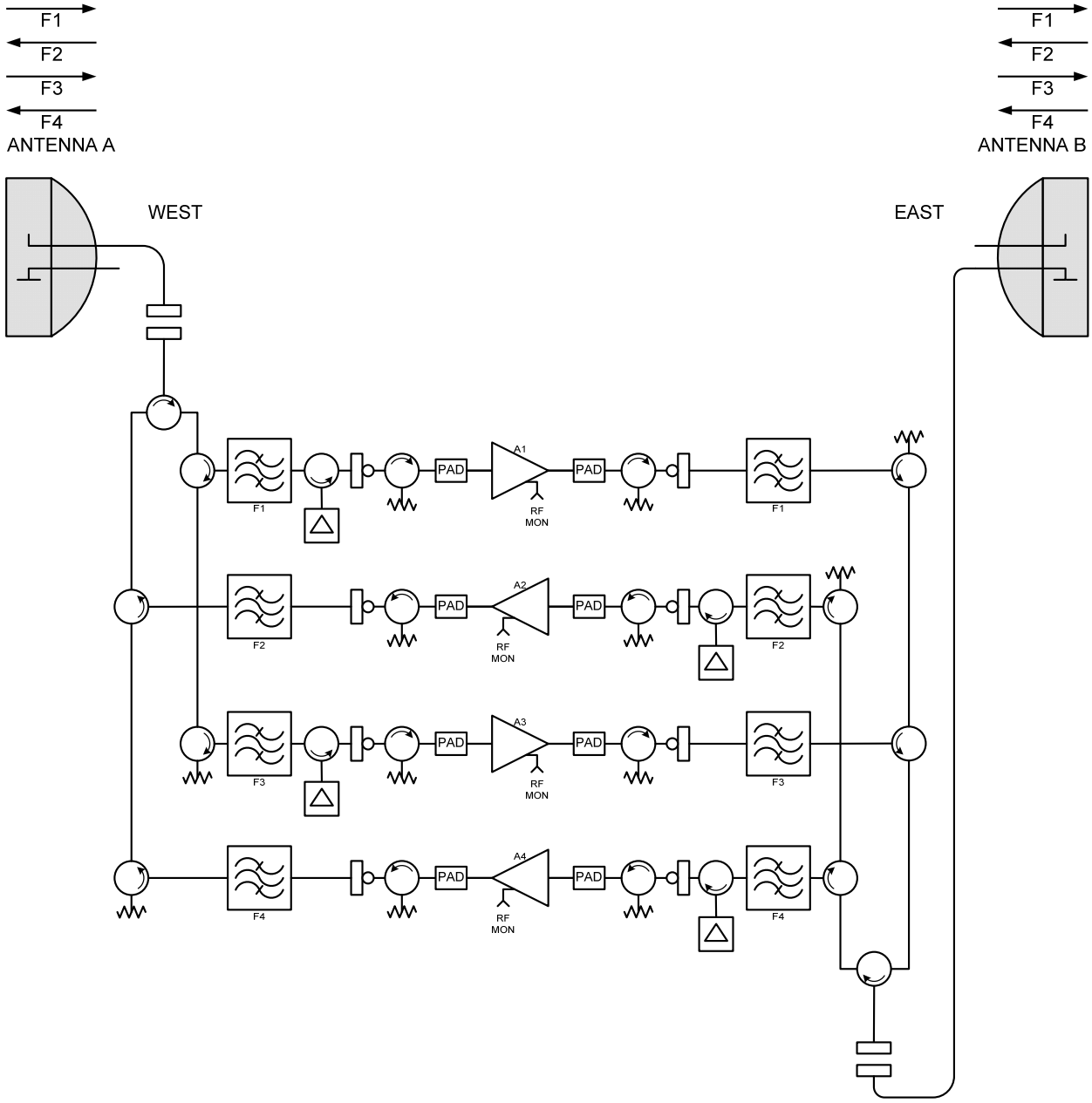


Figure 7 RF-11000-52 1+1 Delay Equalized

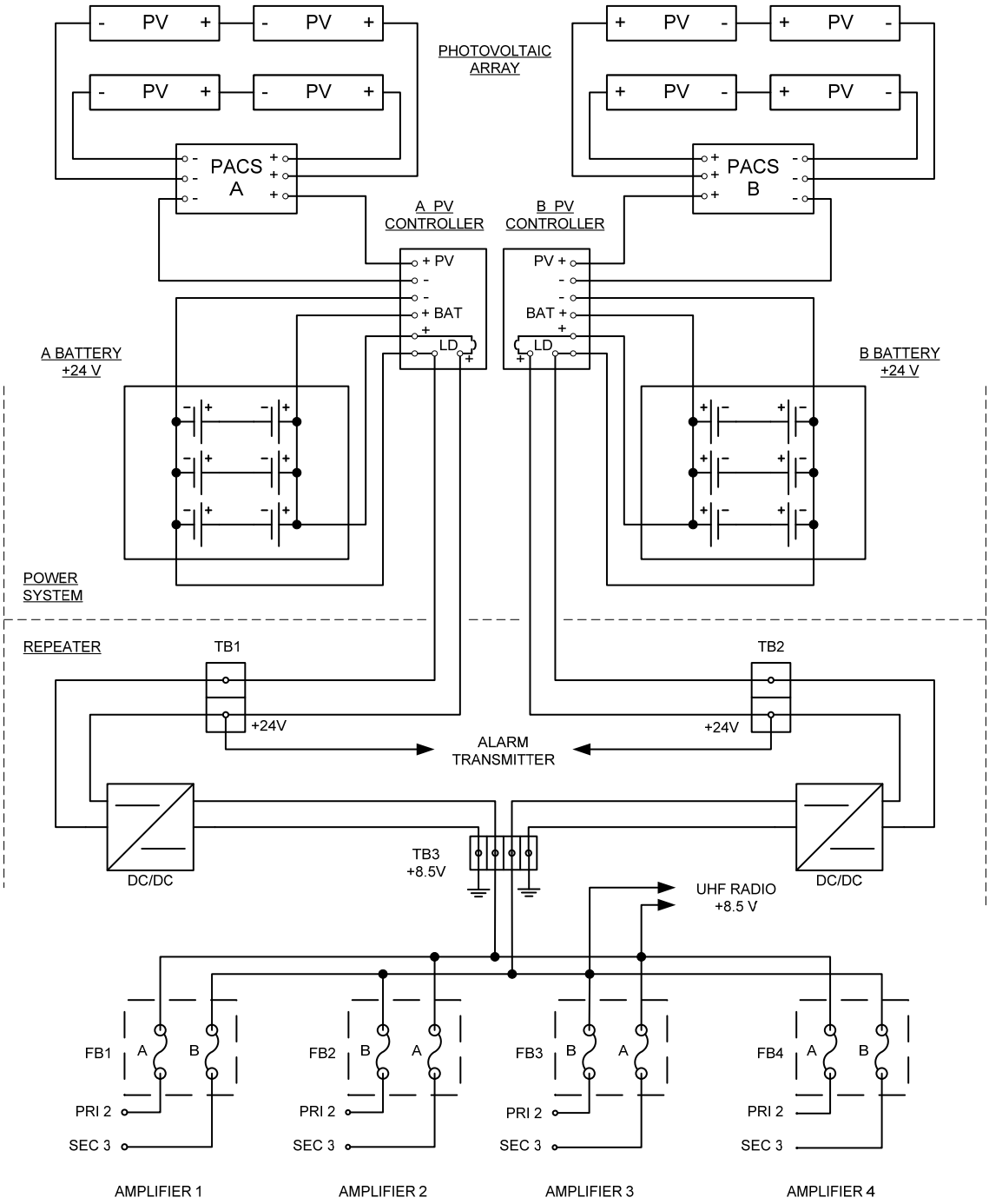


Figure 8 Power Connection Block Diagram

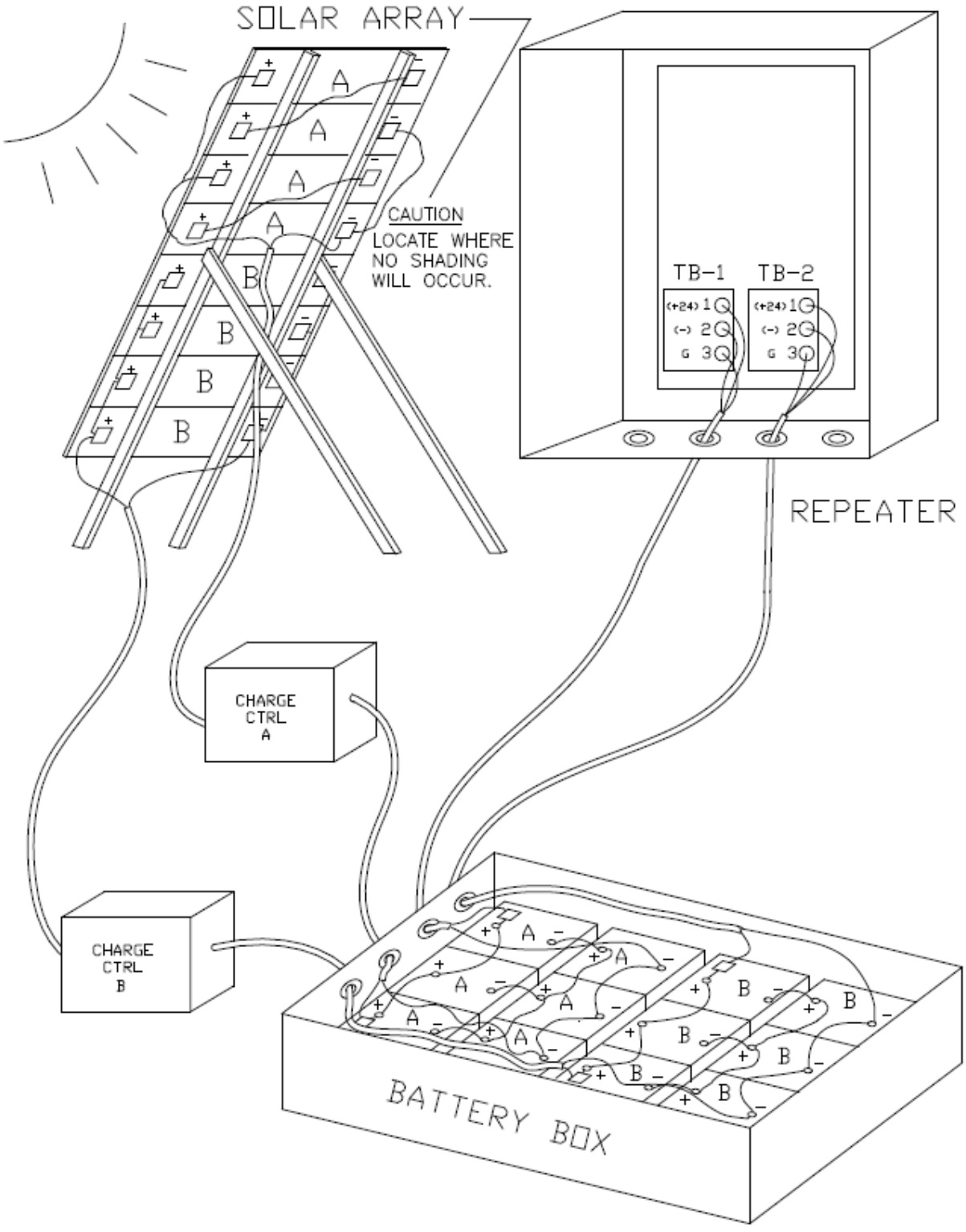


Figure 9 Repeater Power Wiring Pictorial

Technical Services

To supplement the manpower resources of service providers, Peninsula Engineering Solutions offers the following technical services:

- ⇒ Microwave Link design
- ⇒ Power System design
- ⇒ Site and construction surveys
- ⇒ Project management
- ⇒ Installation
- ⇒ Providing accessories (antennas, waveguide, power equipment, and so on)
- ⇒ Training

Quotations for technical services are available upon request.

Contacting Peninsula Engineering Solutions

Contact the Peninsula Engineering Solutions corporate headquarters for sales information or technical assistance for the RF-11000 Microwave RF Repeater, or any other of our communications or related products.

Corporate Headquarters

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Chapter 2. Installation Preparation

Installation Overview

The RF-11000 is designed for indoor or outdoor installation and can be tower, wall or pole mounted. The unit's compact cabinet simplifies installation.

NOTE: *Only qualified service or technical personnel should install and service the RF-11000*.

Receipt and Inspection of the RF-11000 Microwave RF Repeater

Immediately upon receipt of the RF-11000 repeater, unpack and inventory the contents against the packing lists, including the contents of the accessory kit and any optional equipment ordered with the unit—see Tables 8, 9 and 10 on page 11. Contact Peninsula Engineering Solutions if any items are missing.

Inspect the unit and accessories thoroughly for shipping damage, especially for damage that may be hidden by the packaging. Pay particular attention to the following:

- ⇒ Bent or dented sheet metal
- ⇒ Loose or broken components
- ⇒ Damaged connectors and waveguide flanges
- ⇒ Damaged or broken wiring or coaxial cables
- ⇒ Missing or damaged contents of the accessory kit
- ⇒ Missing or damaged optional equipment

Note any damage on the waybill and request that the delivery agent sign it for verification. Also, notify the transfer company as soon as possible, submit a damage report to the carrier, and inform the Customer Service Department of Peninsula Engineering Solutions in writing.

NOTE: *Save original shipping crate and packing materials for any future transport of the unit.*

If the RF-11000 repeater is to be stored for later installation or shipment, reseal the packaging of the accessory kit and the repeater.

If power system batteries are to be stored for later installation, the batteries must be recharged monthly and especially, prior to installation. Lead acid batteries stored without charging can degrade to an un-usable condition and will not be covered under warranty.

The following illustrates a typical installation with external equipment.

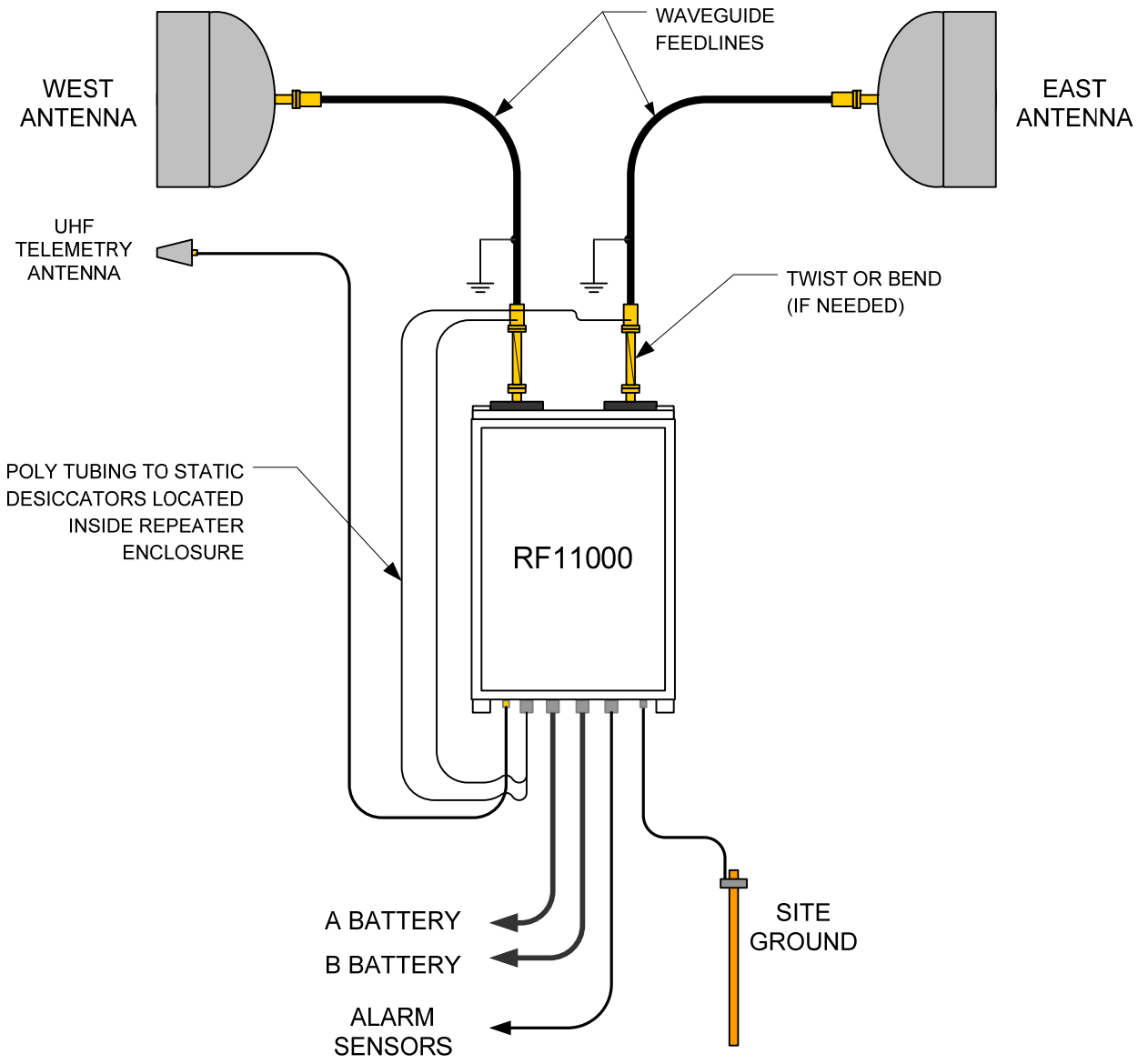

Figure 10 Typical RF Repeater Installation

Installation Equipment

See the following table for a list of required installation equipment. Additional equipment may be needed, depending on specific installation site requirements and optional accessories ordered.

Table 11 Recommended Installation Equipment

Equipment or Item	Function
Site Plan and Path Calculation documentation	To correctly configure the repeater to operate in the microwave network.
1/8-inch small flat blade screwdriver	Used for wiring DC input power terminal blocks.
3/8-inch or ½-inch Ratchet	To drive sockets
7/16-inch socket or wrench	For repeater door clamp bolts.
Digital Voltmeter, 0 ~ 200 V	To test power connections and analog test points.
Spectrum Analyzer, 12 GHz†	For signal identification and alignment
Power Meter, Agilent (HP) 435B with 8481A Sensor*	To test RF power output.
Sweep test equipment, Anritsu SiteMaster™ S820D	To test feedlines and antennas.
Antenna-Path Alignment Test Set, Pendulum Instruments, XL Microwave Path Align-R™ 2241	To align the antennas on path per hop.
Coax Adapters, SMA M-F RT Angle, SMA(m) to N(f)	For power measurements at SMA ports.
RF Test Jumper Cables, SMA(m), 2 ea.	For test equipment, length depends on application.
Mounting Hardware	To mount repeater and antennas.
Electrical Wiring Equipment (as needed)	To connect external systems to inputs and outputs.
Wrist Grounding Strap	To protect against static discharge.
**Equivalent substitutes may be used.* *†If necessary.*	

Note that the site plan and network engineering documentation is used during installation to refer to the intended parameters of the project including gain settings, and antenna location. If necessary, consult a network administrator for more information.

Accessory Kit

Table 12 Accessory Kit

Part Number	Description	Quantity
175-0025-03	Fuse, Blade Type, 5-Ampere, DC	2
550-0211-01	Repeater Operations and Maintenance Manual, CD-ROM	1
090-0196-01	Amplifier, Higher Power Level 2, for High Capacity Repeater	Per Order
090-0196-01L	Amplifier, Higher Power Level 2, for Low ~ Medium Capacity Repeater	Per Order
091-0782-01 or 81*	RMAS-120 Accessory Kit, contents listed below	Per Order
137-0782-04	Cable Clamp Kit	2 or 1*
137-0782-05	Connector, D-Sub 37 Pin	2 or 1*
087-0444-01	Transducer Assy (Battery Temperature Sensor)	1
034-0004-01	Pressure Switch Assy (Feedline Pressure Sensor)	1
125-0001-11	Screw, PHP 12-24 x .750, S/S (Rack mounting)	4

Note: * UHF Accessory Kit, 091-0782-81 quantity.

Pre-Installation Site Review

Each site should be thoroughly reviewed before any equipment is mounted. Site review should include, but not necessarily be limited to, the following factors:

Weather

Determine whether environmental conditions necessitate special shielding of the repeater or other equipment.

Security

Determine whether some type of barrier is needed to protect equipment and if a security light is required.

Aviation

Review tower heights and obstruction lighting requirements as specified by the national aviation authority, e.g. US-FAA, US Federal Aviation Authority or Transport Canada. Normally towers 200 Ft AGL and taller require obstruction lighting. Towers closer to airports have additional lighting and marking requirements. File NOTAMS as required during construction.

Optional Site Equipment

Determine whether additional site equipment, such as a convenience power outlet, pump, generator, or light is required, and, if so, where equipment is to be located and whether special enclosures for any equipment is required.

Wiring and Wiring Access

Determine any special wiring requirements.

Cabinet Access

Determine whether there is enough room for the repeater door to open, once mounted.

The RF-11000 assembly can be mounted on a steel tower, on a steel pipe or square-rail frame, or on a wall. The length of all power leads should be limited and the wire size adequate to minimize the voltage drop. The repeater assembly, battery boxes, solar panels, and antennas should all be mounted before any wiring is done. Mounting-hole dimensions for the repeater enclosure are shown in Figure 11.

Prior to cutting to length and connecting the waveguide feedlines, verify which repeater's receive frequency associates with each antenna port and associated terminal radio site. The repeater receiving frequencies and transmitting frequencies are marked on the top of repeater, near waveguide antenna ports. Coordinate site names are marked in the same location if known.

The waveguide feedlines are terminated in WR75, Cover Flange. The repeater is not designed for pressurization. Use external pressure windows at the WR75, Cover Flanges if the feedlines are to be pressured.

CAUTION: *In an extremely hot and sunny environment, such as a desert, shading from direct sunlight may be necessary to prevent the repeater and associated equipment from overheating. Locating battery enclosures in the shade of the solar array is recommended.*

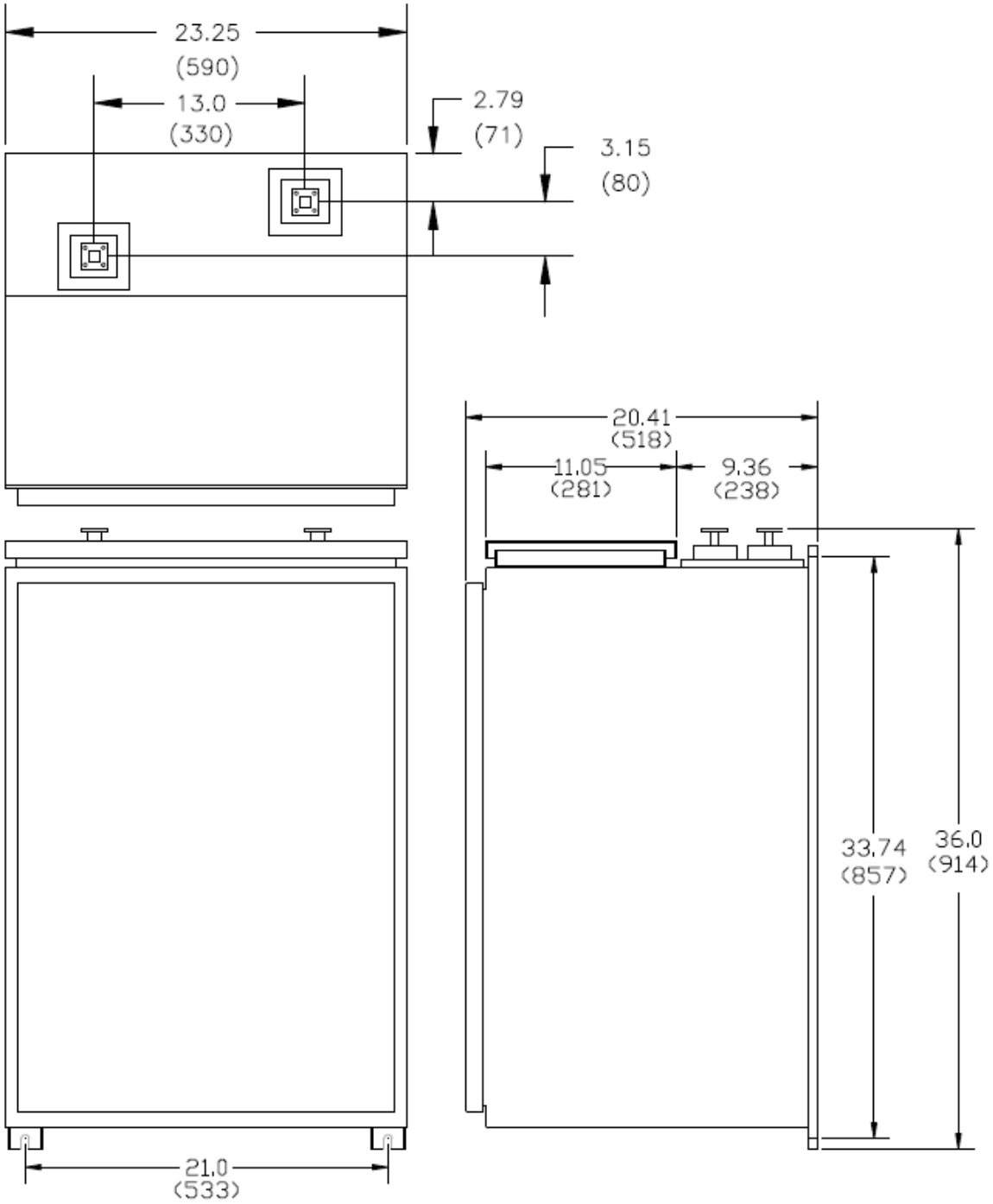

Figure 11 Enclosure Mounting Dimensions
RF-11000, 2-Antenna Port, 1 ~ 4 Frequency Channels

Dimensions are in Inches (mm)

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Chapter 3. Mounting the Antennas

Mount Antennas

Mount all antennas, antenna feedlines, grounding, dehydration and lightning protection. Test the completed antenna system installation prior to repeater equipment installation. Follow details of the site plan if available.

Antenna Types

Microwave RF repeaters can use any one of four typical parabolic antenna types:

- Standard performance, single or dual polarized.
- Improved performance, FCC Category A, single or dual polarized *(Deep Dish, PAR, PAD)*.
- High Performance, single or dual polarized.
- Ultra-High Performance, single or dual polarized.

NOTE: *Antenna type is normally determined by the system requirements, especially the repeater site antenna isolation objective for the radio system modulation. More complex modulations require greater Carrier to Echo, C/E and hence, greater isolation. Repeater system path calculations, path data sheet, are used to determine the antenna size and type.*

Mount the antennas securely on adequate mounting structures. Mounting structures must meet strength, twist and sway requirements for 11 GHz antenna systems. Provide means for alignment adjustments.

Antenna Alignment

Coarse Alignment

To initially orient the antennas:

1. Align the “bore-sight” of the antenna to the calculated azimuth as shown in the site layout or path calculations. Be sure to account for geomagnetic declination when using a magnetic compass. Azimuths are normally shown as True North. Geomagnetic declination varies by site location and typically drifts every year as the location of the earth’s magnetic pole moves.
2. Adjust the elevation to match the calculated elevation angle.

Fine Alignment using test radios

3. Peninsula Engineering recommends using test radios to do the alignment over the hop. This is much easier than attempting to use the limited repeater level indications or measurements. The test radios also provide a talk channel to allow the alignment teams to rapidly communicate with each other.
4. Identify the polarization determined for the hop. Consult the antenna manufacturer’s documentation on identifying the vertical or horizontal antenna port on dual polarized antennas or how the feed assembly is installed and oriented in single (plane) polarized antennas. Failure to properly identify polarizations will result in antenna misalignment and violate the station license.
5. Attach the test radios to the proper antenna waveguide port at each end of the hop.
6. Consult the path calculations, PDS, for the net path loss calculated between the antennas. Correct for feedline losses when connected directly to the antenna waveguide ports.
7. Begin aligning the antennas. It should be possible to meet the calculated net path loss ± 1 dB.
8. Record the alignment and loss details. Provide the records to the end customer or controlling authority.

Alternative Fine Alignment using repeater power measurements

9. This method requires the RF-11000 repeater to be installed, connected to the antenna feedlines and powered up. See Chapter 4 for repeater installation details.

10. Before antenna orientation begins, the amplifiers must be operating in their full gain mode (out of AGC/ALC range). The setting of the AGC/ALC along with a high input level (greater than [desired output power level in dBm - max. linear gain in dB]) may cause the normal action of the AGC/ALC circuit to mask changes in power due to azimuth and elevation sweeping of the antennas. The output power of an amplifier will increase in level as the input level is increased to the point where the AGC/ALC has been set (eg. +18 dBm). Further increases in input level will be absorbed in the AGC/ALC circuit. Use the amplifier power monitor point as a signal strength indicator. The input level can be reduced temporarily by inserting a fixed or variable attenuator pad ahead of the amplifier. The attenuation required will range from 0 to 30 dB depending on desired power and input signal level. Remove the input semi-rigid coax cable and place the attenuator in series with the coax or use flexible coax as required for fit. Reduce the input level until the output power drops below the desired power level. If during antenna orientation, the power rises to the desired power level, reduce the input level again and then continue with antenna orientation.

11. Alternatively, the amplifier's maximum gain can be reduced such that the system is out of AGC/ALC for antenna alignment. Gain adjustment is provided by a potentiometer just below the AGC/ALC adjustment. Be sure to return the potentiometers to their normal positions after antennas are aligned. (Usually at the maximum linear position.)

12. Connect the power meter or spectrum analyzer to the f1 amplifier, A1, RF MON port. With a signal transmitted from the A terminal, position the antenna A for a maximum power reading on the meter or analyzer. After antenna A is aligned, remove any temporarily installed input attenuators. Re-set the power level with the AGC/ALC adjustment if needed. The AGC/ALC adjustment is located near the output end of each amplifier, see Figure 3. Use a screw driver or tuning tool to adjust the AGC/ALC potentiometer CW to reduce the power setting or CCW to increase the AGC/ALC set point. Log the power reading to fulfill FCC requirements. Remove the meter from the f1 Amplifier RF MON to the f2 Amplifier RF MON.

13. With a signal transmitted from the B terminal, position the antenna B for a maximum power reading on the meter or analyzer. After antenna B is aligned, remove any temporarily installed input attenuators. Set the power level with the AGC/ALC adjustment if needed. Log the power reading to fulfill FCC requirements. Measure and log the power at any additional amplifier directional couplers so equipped (f3, f4...). Remove the meter.

14. After the antenna orientation has been completed at both terminals and the repeater, AGC/RSL readings should be taken at the end terminals and logged for reference. Provide the records to the end customer or controlling authority.

Antenna Feedlines

The RF-11000 repeater uses waveguide feedlines. For the 10.7 ~ 11.7 GHz band, typical feedlines are elliptical waveguide such as EWP90 and EP105. The RF-11000 has WR75 Cover Flanges at the top antenna ports. The equipment end of the waveguide feedline must have a matching WR75 Choke/Cover flange installed. The antenna end of the waveguide feedline must have a connector flange that matches the installed antenna's flange. Typical antenna flanges in this band are CPR90G and PDR100.

Waveguide feedlines require dehydration equipment to maintain a dry atmosphere within the waveguide to prevent moisture accumulation which leads to corrosion and higher transmission losses. RF repeater applications typically have shorter waveguide runs and thus, a smaller volume of air within the waveguide. Static desiccators are ideal in this situation. A static desiccator will passively dry air passed through its silica gel as daily temperature and pressure changes gently move the air. These units do not require any power to operate and provide 1 to 2 years field lifetime before requiring replacement or service. Peninsula Engineering recommends mounting static desiccators inside the repeater enclosure to protect against aging from direct sunlight. See manufacturer's specifications and recommendations when considering static desiccators.

Dry Nitrogen is another method to keep waveguides dry without using power. Nitrogen supplied in high pressure bottles is reduced in pressure with a regulator and then passed to a gas pressurization manifold with distribution to the feedlines. Nitrogen replaces the air within the waveguide (purged at installation) and the positive pressure helps force moisture away from entering the waveguide. To warn of an empty gas bottle, the optional RMAS alarm equipment includes a low pressure switch that can be added to the pressurization manifold. When gas pressure drops below 1 psi, a warning alarm is issued.

RF-11000 repeater configurations require one feedline per equipment antenna port, typically:

- ⇒ One for the primary West antenna
- ⇒ One for the primary East antenna
- ⇒ One for the diversity West antenna, if applicable
- ⇒ One for the diversity East antenna, if applicable
- ⇒ One per direction and polarization in Y-Junction applications

The allowable transmission loss for antenna feedlines is specified in the site plan or path calculation, path data sheet documentation for the project. Do *not* install feedlines different than as specified.

Feedline Installation

To install waveguide feedlines:

1. Install the top connector (goes to the antenna). Use a flaring tool for best attachment and match.
2. Raise the cable up the tower to the antenna. Use a hoisting grip.
3. Position the waveguide and secure the top section. Carefully bend the elliptical waveguide to align with the antenna flange. Be mindful of the bend and twist specified limits of the waveguide. If necessary, use rigid twist and bend sections to aid in alignment.
4. Connect the waveguide to the antenna.
5. Securely install the feedline so that it reaches to the installation site of the RF-11000, with enough room to connect to the repeater.
6. Secure the cable to the tower or structure about every 3 feet or 0.9 meters.
7. Carefully measure and cut to length the waveguide.
8. Terminate the waveguide with a WR75 Choke/Cover flange connector.

9. Position the waveguide and secure the bottom section. Carefully bend the elliptical waveguide to align with the repeater equipment top flange. Be mindful of the bend and twist limits of the waveguide. If necessary, use rigid twist and bend sections to aid in alignment.
10. Flexible twist-flex waveguide jumper may be used at either end if needed. These jumpers have higher loss and shorter life than rigid twist and bend sections.
11. Trial fit the bottom connector to the repeater equipment top antenna port flange or intended flange location. Do not permanently install until the feedlines are sweep tested.
12. Install waveguide grounding kits. Normally the waveguide is grounded at the top and bottom and at the shelter entrance. Follow grounding practices prescribed by the controlling authority.
13. Pressure windows are recommended at the repeater equipment top antenna ports.
14. Install dehydration equipment.

Lightning Protection

Peninsula Engineering Solutions strongly recommends installing protection on the tower, structure and on all feedlines to the repeater. A direct lightning strike can damage any electronic equipment. Damage resulting from a lightning strike is not covered under the equipment warranty, whether or not lightning protection is used. However, using lightning protection can minimize the risk of damaging a repeater, and of losing equipment operation during thunderstorms.

Elliptical waveguides are protected by installing grounding kits, typically at the top, bottom and at shelter entrance.

Lightning rods mounted adequately above the highest antenna or power equipment provide a diversion path for lightning strikes. Multiple lightning rods may be required.

Towers, shelters and all equipment must be bonded and grounded to minimize any potential differences that can occur due to a lightning strike.

Follow grounding practices prescribed by the controlling authority.

Sweeping the Antenna Feedlines

Sweep testing of the installed feedlines and antennas is recommended. Sweep testing is the same as performed at a terminal radio site. Measurement of impedance match and insertion loss over the operating frequencies insures that the antenna system is installed properly and is ready to perform.

Most microwave operating companies have developed their own performance standards for antenna systems. Use such standards if available. If company standards are not available, consider the following:

- Sweep frequency range: 10,700 ~ 11,700 dB or across assigned channel bandwidth.
- Impedance Match: 26 dB Return Loss or 1.11:1 VSWR across the channel bandwidth. If tunable connectors are provisioned, adjust the tuning screws to optimize the match.
- Insertion Loss: Per calculated. Typical waveguide loss[12] is 3.0 dB/100 Ft or 10.0 dB/100 m.
- Distance to Fault, DTF: Measure Return Loss of the antenna system components and isolate troubles. Use DTF function of Anritsu Site Master™ test equipment.

If the impedance match or insertion loss is not met, troubleshoot the feedlines and antennas for the source of the problem. Use the “Distance to Fault” function to assist in localizing the trouble. Correct as required before proceeding.

[12] EWP90, EP105. Consult manufacturer’s specifications for loss at the intended frequencies.

Measuring Antenna Isolation – Decoupling

System path calculations by Peninsula Engineering will determine the recommended antenna size and type plus the feed-horn to feed-horn separation and polarization loss. Our experience has been that if the recommendations are followed, antenna isolation will be met with some margin and direct measurement of antenna isolation is not required.

Should there be reason to determine the antenna isolation, proceed with this section.

Measure the actual isolation between the antennas, to ensure that the antennas are sufficiently isolated from each other and that the system C/E objective is met.

CAUTION: *This is an important consideration in all on-frequency repeater installations.*

If the isolation is not sufficient, the repeater might oscillate in the extreme, or the repeater system might have inadequate carrier-to-echo, C/E, margin, which can lead to bit errors in digital radio systems or intermodulation noise in analog radio systems.

In some cases, it may be necessary to reduce the maximum repeater gain by adjusting the amplifier's GAIN setting potentiometer and thus obtaining the required C/E. Normally isolation is met and amplifier GAIN setting allows for maximum ALC managed gain.

C/E = [Isolation, dB] – [Repeater Operating or Maximum Gain, dB]

Example 1: Isolation = 110 dB, Operating Gain (ALC reduced) = 45 dB

C/E = 110 – 45 = 65 dB

Example 2: Isolation = 110 dB, Maximum Gain (full gain) = 60 dB

C/E = 110 – 60 = 50 dB

Table 13 lists the C/E and isolation objectives for various radio modulation types.

Isolation is controlled by the antenna Front-to-Back, F/B, ratio, sidelobe suppression, separation distance between feed-horns, angle between the antenna centerlines, polarization and feedline losses.

Measuring antenna isolation requires a signal generator and a spectrum analyzer. The generator transmits a signal from one antenna, and the spectrum analyzer measures the same signal as the second antenna receives it. Figure 12 shows the equipment set-up. Losses between 80 and 120 dB are measured. Be sure the test equipment is capable of adequately measuring such high loss values.

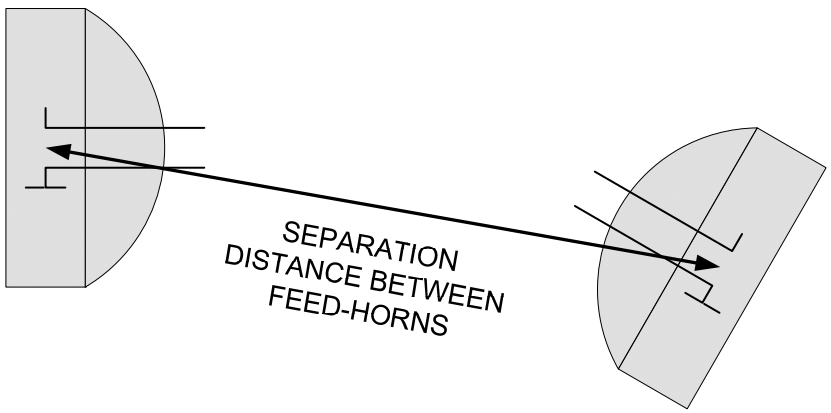

Table 13 C/E Requirements per modulation[13]

Modulation Type	Minimum C/E	Isolation[14]
FM Analog, 24 ~ 96 FDM	30 dB	90 dB
FM Analog, 120 ~ 300 FDM	45	105
FM Analog, 420 ~ 2400 FDM	55	115
FM Analog, Color Video	55	115
FSK, MSK	30	90
BPSK	22	92
QPSK, OQPSK, 4PSK, 4QAM	24	84
8PSK	28	88
16QAM	32	92
32QAM	36	96
64QAM	40	100
128QAM	44	104
256QAM	46	106
512QAM	48	108
32TCM	35	95
64TCM	39	99
128TCM	43	103
256TCM	46	106
OFDM QPSK	24	84
OFDM 16QAM	32	92
OFDM 64QAM	40	100
COFDM QPSK	24	84
COFDM 16QAM	32	92
COFDM 64QAM	40	100
9QPRS/QPR3	30	90
25QPRS/QPR5	31	91
49QPRS/QPR7	32	92
81QPRS/QPR9	34	94
225QPRS/QPR15	38	98

The leakage signal between antennas acts as a co-channel, like interferer. The time offset or echo delay is typically close to 200 nanoseconds with 50 feet, 15 meters, of combined feedlines. In medium to high capacity digital radio systems, this time offset results in intersymbol interference. Adaptive equalizers can reduce the effects of the echo signal. The objective C/E values listed assume minimal correction from adaptive equalizers or forward error correction. As a result, performance may be better than predicted depending on the microwave radio equipment capabilities.

[13] For 10dBrnC$_0$ IM noise, < -1 dB system gain at 10^{-6} BER or BER < 10^{-12} at normal RSL.

[14] Isolation objective assumes a maximum repeater net gain of 60 dB. Isolation required for a specific C/E decreases dB-for-dB as the maximum gain decreases.

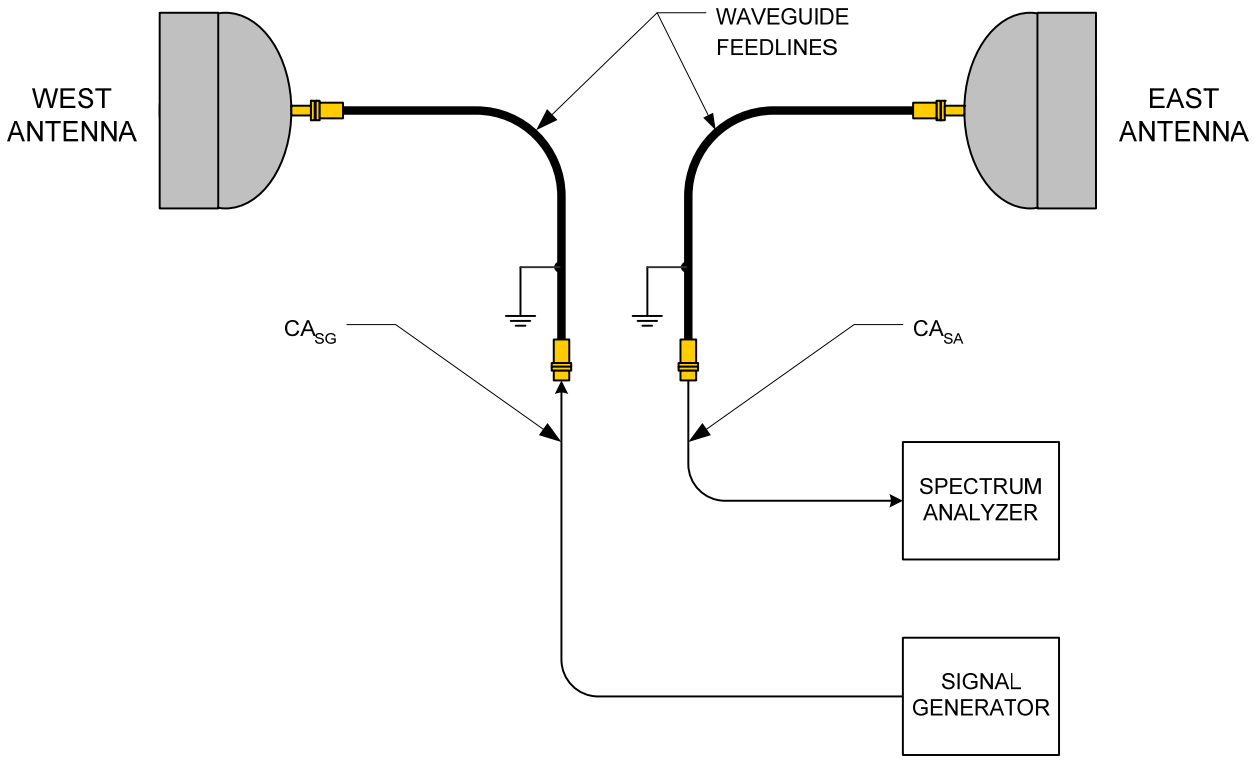

Figure 12 Antenna Isolation Measurement - Equipment Configuration

NOTE: *In all cases, measure antenna isolation with all feedlines, jumpers, cables, and connectors in place. Record all measurements for future reference.*

The equation for antenna isolation measurement is:

$$ISO = P_{GEN} – (L_{C\text{-}GEN} + L_{C\text{-}SA}) - P_{SA}$$

Where:

ISO = Isolation in dB between the antennas.

P_{GEN} = Output level of the signal generator (dBm).

$L_{C\text{-}GEN}$ = Loss of the signal generator cable, CA_{SG} (dB).

$L_{C\text{-}SA}$ = Loss of the spectrum analyzer cable, CA_{SA} (dB).

P_{SA} = Power indicated on the spectrum analyzer (dBm).

For example:

P_{GEN} = 10 dBm

$L_{C\text{-}GEN}$ = 1.0 dB

$L_{C\text{-}SA}$ = 1.0 dB

P_{SA} = -92 dBm

ISO = 10 dBm – (1 dB + 1 dB) – (-92 dBm) = 100 dB

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Chapter 4. Mounting the RF-11000 Repeater

Installation Overview

The RF-11000 assembly can be mounted on a steel tower, on a steel pipe or square-rail frame, or on a wall. The length of all power leads should be limited and the wire size adequate to minimize the voltage drop. The repeater assembly, battery boxes, solar panels, and antennas should all be mounted before any wiring is done.

NOTE: *Only qualified service or technical personnel should install the repeater.*

Figure 13 RF-11000 Installation near Grand Canyon National Park, Arizona, USA

Figure 14 Example of Wall Mounting RF-11000 Repeaters. Note the use of rigid W/G bends and twists.

Mounting Associated Equipment and Space Planning

Mount the site power system and any other associated equipment before mounting and wiring the repeater. Plan the site equipment layout prior to beginning installation.

Recommended power system installation sequence:

1. Ground Ring or grounding provision
2. Battery Enclosures and Batteries
3. Photovoltaic Array, mounting frame and modules
4. Wind Turbine Generator, pipe mount and generator
5. PV Array Combiners
6. PV Controller

Figure 15 Example of Solar and Wind Power Installation

Mounting the Repeater

The RF-11000 has mounting rails on the rear of the enclosure. The mounting holes and slots fit 3/8-inch hardware. Mounting-hole dimensions for the repeater enclosure are shown in Figure 11.

Fabricate a mounting frame using 3/8-inch square rail or Unistrut™ fastened to the tower members, wall or monopole. The square rail sections directly mounting the repeater are normally best horizontal. See Figure 16 for a suggested mounting frame.

Attach the repeater to the square rail using 3/8-inch spring nuts and bolt, washer hardware.

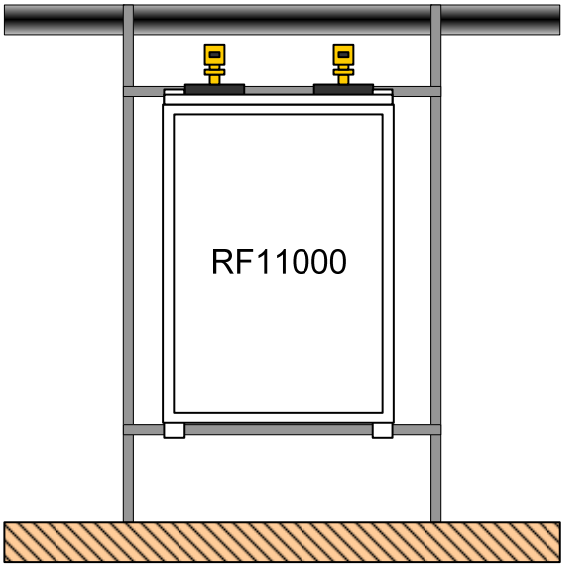

Figure 16 Suggested Mounting Frame

Earth, Ground, and Lightning Protection

When grounding the RF-11000 and associated equipment, follow the general guidelines in the Peninsula Engineering Solutions application note, *Installation Standards for Grounding Requirements*.

Installing the input power to the repeater includes installing the standard electrical service grounds. However, you must also make sure that the repeater enclosure is properly grounded to an earth ground.

The repeater enclosure includes an external grounding lug on the bottom surface as shown in the following figure.

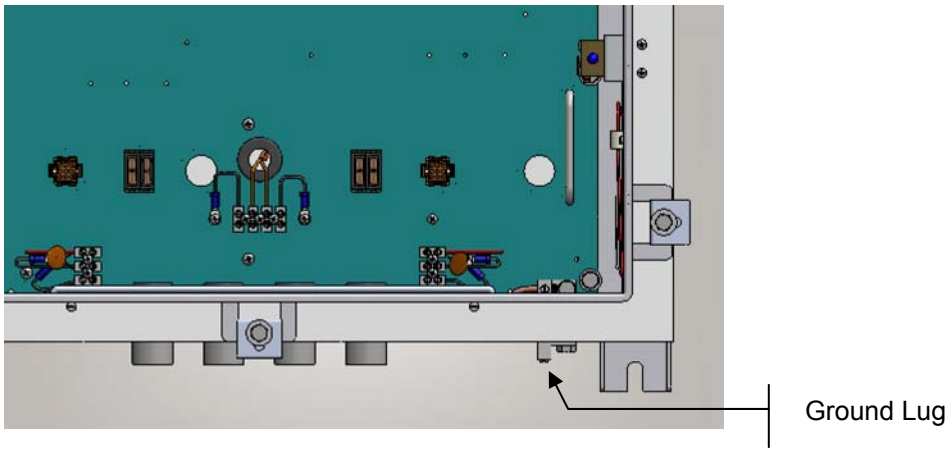

Figure 17 Location of Ground Lug on Repeater Enclosure

1. Connect the screw-compression ground lug to a suitable earth ground—copper ground rod, copper pipe, grounded steel building frame or similar ground point—using 2 to 4 mm, No. 12 to 6 AWG copper wire.
2. Carefully dress the wire along cabinet, and the mounting surface, to the Repeater Grounding System or the Ground Rod. Recommend using CADWELD® to attach the ground wire to the rod or ground point.

NOTE: *When dressing the grounding wire, and forming it around corners; avoid making sharp bends in the wire. Use a generous radius for each wire bend. Sharp bends will cause arc points for lightning surges and strikes.*

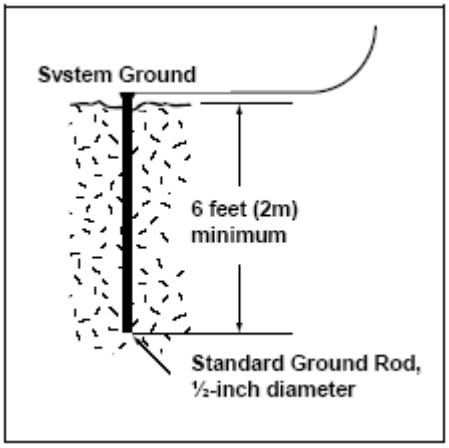

Figure 18 Typical System Ground Rod

CAUTION: *Ground all other cabinets, enclosures, antennas, and coaxial cables used for installation to reduce any damage from a lightning strike or power surge.*

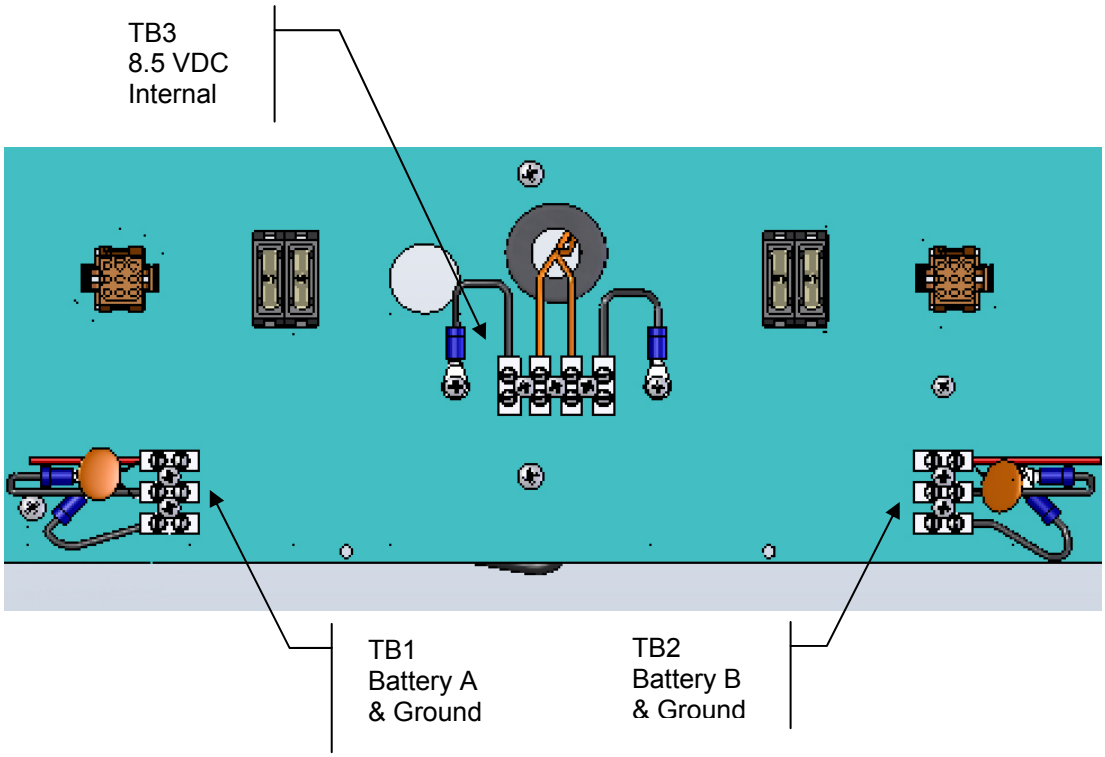

Figure 19 Wiring and Ground Connections, Main Repeater Panel

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Chapter 5. Repeater Tests

Overview

This chapter describes how to test the RF-11000 repeater, to set levels and to verify that it is operating properly.

Test Equipment Required

Table 11 lists test equipment and tools required for testing the RF-11000 repeater. Equivalent equipment may be substituted.

Applying Power to the Repeater

1. Confirm the repeater is connected to the antenna feedlines, is grounded and that the power system has been installed and tested. Confirm that all fuses are removed, amplifiers are unplugged, and RMAS-120 is switched off.
2. Apply primary DC power to Battery A and B terminal blocks TB1 and TB2 on the repeater main panel.
3. Measure the DC voltage at TB1 and TB2.

   Make sure that the voltage is within the operating parameters of the repeater:

   - +24 Volts DC: +19 ~ +30 VDC. Nominal lead acid battery voltage is +25.2 VDC when fully charged and +27.0 VDC when being charged. Correct as necessary

4. If the RMAS-120 alarm equipment is provisioned and installed, switch ON the alarm transmitter. Press the yellow LED switch on the lower left to observe all LEDs illuminate and then report current alarm conditions. To make testing easier, set the LED Switch jumper to DIS. This will allow the LEDs to report without pressing the LED switch.

   - When finished testing, the LED Switch jumper is returned to the ENB position to conserve power by only displaying alarm LEDs when the button is pressed.

5. If the DC power is correct, all the LEDs will light briefly, then these alarm conditions should be present:

Alarm	Condition
Battery A Low	**Clear**
Battery B Low	**Clear**
Door	Alarm when door is open
WG	Either
PWR F1 ~ F8	Clear (amplifiers unplugged)
AMP 1 ~ 8	Clear (amplifiers unplugged)
UC1 ~ 7	Either, clear if not used

6. Insert all fuses. Plug in all amplifier power plugs. Alarm conditions may change.

Alarm	Condition
Battery A Low	**Clear**
Battery B Low	**Clear**
Door	Alarm when door is open
WG	Either
PWR F1	Either
PWR F2	Either
PWR F3	Either if equipped, otherwise Clear
PWR F4	Either if equipped, otherwise Clear
PWR F5 ~ F8	Clear
AMP 1 ~ 8	Clear. Any AMP alarm is a concern and potential amplifier failure.
UC1 ~ 7	Either, Clear if not used.

7. Once the Battery A and B alarms clear or TB1 and TB2 are between +19 and +30 VDC and when measured voltage at TB3 shows +8.5 ~ +9 VDC, then the repeater is powered and ready for testing.
8. Current Test: Measure the Battery A and B current flowing into TB1 and TB2. Repeaters with equal numbers of amplifiers will have the two battery inputs close to equal and approximately half of the total current listed in Table 1. If either battery input has a low or zero current, check the battery source and distribution system. Record currents for reference.
9. The repeater can operate on a single A or B battery input when needed. Each amplifier can draw power from both DC/DC converters and thus either battery input. When one battery source is removed or failed, all the current per Table 1 will flow into the remaining working battery feed.

Transmit Power Adjustment

At this point, the antennas should be mounted, feeders swept, antennas aligned and isolation confirmed. The repeater's power amplifiers have been factory set to the system modulation if known. Fine adjustments are recommended for best performance. Greater than recommended power levels can result in amplitude distortion, radio and line errors (BER). Less than recommended power levels may have been selected by transmission engineering (e.g. short hops). Refer to system path calculations and path data sheets for details.

To measure and adjust output power:

1. Calibrate the RF Power Meter for 11 GHz operating frequencies.
2. The far end transmitter operating on repeater frequency F1 must be transmitting at this time.
3. Connect the power meter to the RF MON test port on the side of Amplifier A1 (F1 PA). This is an SMA-female connector. A right-angle adapter with a between series (e.g. SMA to N) adapter (if needed) to fit the power meter sensor are needed to access the test port.
4. Measure and record the power meter reading. Typically, this reading will be between -15 and +15 dBm at RF MON.
5. Add the Cal Loss marked near the RF MON (see Figure 20) to the power meter reading, the result is the Power Amplifier Output Power.

6. Compare the Power Amplifier Output Power reading to Table 4, using the listing for the radio modulation type used.
7. Adjust the AGC/ALC potentiometer as required to set the power amplifier output level equal to the listing in Table 4.
   - Note: Lower levels may have been selected by transmission engineering, please refer to system path calculations and path data sheets for details.
8. Once the power levels have been set, confirm the RMAS Alarm Transmitter PWR alarm is clear for each frequency equipped. If the PWR alarm remains active and the transmit power is correct, then the RMAS Alarm Transmitter alarm point must be adjusted. Please refer to the alarm equipment documentation for adjustment details. The alarm point is normally 5 dB below normal operating power level.

Alarm	Condition	Alarm Point
Battery A Low	**Clear**	< 23 VDC
Battery B Low	**Clear**	< 23 VDC
Door	Alarm	Door Open
WG	Either	Pressurization Low, < 1 PSI
PWR F1	**Clear**	5 dB below normal operating power
PWR F2	**Clear**	“ ”
PWR F3	**Clear**	“ ”
PWR F4	**Clear**	“ ”
PWR F5 ~ F8	Clear	“ ” not available for RF-11000
AMP 1 ~ 8	Clear	Current out of range, high or low
UC1 ~ 7	Either, Clear if not used.	Closure on UC# position

9. To determine the Antenna Port Output Power Level, subtract the TX Branch Loss from the Power Amplifier Output Level. The TX Branch Loss is marked on the repeater panel near the PA. Include any transmit attenuator pad loss if equipped.

Figure 20 Power Amplifier RF MON and TX Branch Loss

Receive and Transmit Attenuator Pads

Receive, RX, pads attenuate input signals that are greater than can be compensated by the repeater amplifier's AGC/ALC circuits. Receive pads are installed on the amplifier input (RF IN) jack.

Transmit, TX, pads attenuate output signals. Transmit signals can also be reduced by adjusting the AGC/ALC potentiometer. In cases of very short hops, more power reduction may be needed. In these cases a TX Pad is normally installed. Transmit pads are installed on the amplifier output (RF OUT) jack.

Pad Installation:

1. If required in the field, the RX/TX attenuator pads should be installed at the RF input or output of the amplifiers.
2. To install the pad, turn OFF the DC power supply first.
3. Disconnect the input or output semi-rigid coax cable from the amplifier.
4. Connect the SMA male end of the pad to the amplifier's SMA female input or output; and then connect input or output cable to the female end of the pad.
5. Check all coaxial connections for tightness (8 in-lbs).
6. Turn ON the DC power supply.
7. Set output power level by adjusting AGC/ALC.

Radio Link Tests

Once the repeater levels have been set and confirmed and antenna alignment is accepted, then confirm microwave signals are received at each terminal radio. Observe and record the receiver AGC or RSL indications for reference.

End to end link tests can now be run. These tests may typically include un-faded BER, radio errors, system thermal and intermodulation noise. Refer to the radio terminal equipment documentation and system engineering requirements for the link test plan.

Completion

When setup and tests are complete, set the RMAS Transmit Alarm LED SWITCH jumper to the ENB position to conserve power by only displaying alarm LEDs when the yellow test button is pressed.

Refer to the RMAS-120 manual for alarm system tests.

Chapter 6. Maintenance and Troubleshooting

The RF-11000 active components are the linear power amplifiers, the DC/DC converters and the optional RMAS alarm equipment if equipped. RF repeaters provide long field operating life, often 15 to 20 years. Technologies and traffic needs often drive the need for upgrade or replacement rather than old age.

Routine maintenance checks of the repeater and its supporting equipment will ensure reliable operation and early detection of problems.

Routine Maintenance

Peninsula Engineering Solutions recommends an annual maintenance schedule for the repeater. The following is a procedure for routine maintenance:

1. Observe the general condition of the installation site and correct any problems.
2. Verify that the repeater and all associated hardware, including antennas, is securely mounted and properly in place.
3. Check input electrical wiring and power system for damage and ensure that connections are tight. Replace any wiring that is suspect.
4. Check any battery terminals for corrosion; clean terminals, if necessary.
5. Check the battery storage capacity condition. Battery impedance testers are recommended. Battery life expectancy is typically 5 to 10 years in an outdoor environment. Replace any weak batteries.
6. Clean solar panels and remove obstructions, if applicable. A mild detergent and water are recommended. Dirt, thick dust and bird droppings can reduce the output by 30%. Shadows from antennas, lightning rods or trees reduce PV output. Life expectancy of PV arrays is 25 years or more.

CAUTION: *Follow manufacturer's instructions when cleaning solar panels. Abrasive or acetone-based solutions can cause damage.*

7. Look for lightning strike damage. Solar panels with "holes" punched in the backing material indicate a lightning strike. Damaged solar panels or equipment should be replaced.
8. Check antennas and feedlines for damage and ensure that connections are tight.

9. If the feedlines are pressurized, check that pressure is holding correctly.
10. If static desiccators are used to dry the feedlines, check the desiccant color. Blue is normal, Pink indicates the desiccant is full of water and needs changing.
11. If feedline pressure is zero or desiccants are very pink, it's best to check the feedlines for water. Drain and dry as required. Inspect for corrosion, correct or replace as required.
12. Check the RMAS alarm transmitter for indications of alarms or trouble.
13. Measure the RF power output level at the RF MON ports. Compare to records.
14. Measure the DC battery load current. Compare to records.

Administrative Requirements

The US-FCC or other local Tele-communications Administrations may require measurement of the output power of the repeater at installation or when any changes are made which cause the output

power to change. Using the power meter, measure and log the output power as directed in Chapter 5.

Troubleshooting

Soft failure of one amplifier will be indicated by a drop of approximately 6 dB in the received signal level at the terminal in the direction of transmission, which will be indicated on the AGC, RSL meter on the terminal equipment. Amplifier AGC/ALC may correct for this drop. The failure of one amplifier will most likely be caused by a failure of DC power to the amplifier. Using the DVM, check for presence of DC voltage at the amplifier power feed through connections. Another way to check is insert DVM probes to pins #1 and #2 (Primary DC), then #1 and #3 (Secondary DC) from the back side of amplifier wire harness as shown in Figure 3. Pin #1 is Ground. Amplifier DC voltage should be +8.4 ~ +9.0 V.

If the received signal at the terminals is low but does not indicate a complete failure on one amplifier, the most likely cause is low voltage from the batteries. Low voltage is an indication of a possible DC-DC converter failure, battery failure, or a failure of the charging system. In the case of the primary cell batteries, the batteries are probably reaching the limit of their life. Check the batteries and all power lead connections. If solar panels are used, be sure they are not obstructed from sunlight and that the surfaces are clean. If an AC power supply is used, low voltage is probably the result of a power failure, the duration of which exceeded the reserve power limits of the standby battery. Check the standby battery in accordance with the instructions given by the manufacturer of the power supply.

NOTE: *Contact the Customer Service Department of Peninsula Engineering Solutions whenever problems with the unit cannot be resolved.*

Table 14 System Troubleshooting

Problem	*Cause*	*Solution*
Overheating	Inefficient Cooling⇒	• Clear any airflow obstructions. • Shade the unit if it is in an extremely hot environment.
Low Voltage or No Voltage *(Low Battery Alarm)*	Improper Solar Charging⇒	• Clean solar panels or remove obstructions. • Do not use an acetone-based solution for cleaning.
	Power Supply Failure⇒	• Check the condition of the power source. • Check all wiring and power leads to the power source. • Check any fuses or circuit breakers in power supply equipment. • Check condition of battery plant. • Check AC power service for outages or other service problems.
	Overload, blown fuse⇒	• Determine the cause of failure. • Correct the failure. • Replace the 5A fuse with a spare.
	Internal DC/DC Converter Failure⇒	• Contact Peninsula Engineering Solutions to replace unit.

Problem	*Cause*	*Solution*
Repeater fails overnight and then restarts the next day *(Solar Powered)*	Improper PV Charging⇒	• Check the PV array for damage, obstructions or dirt.
	PV Array wired to wrong voltage⇒	• Check the PV open circuit voltage, V_{oc}. • Typically the V_{oc} will be 1.5 to 2 x the battery nominal voltage. If V_{oc} is more than 3 x the battery nominal voltage and PWM[15] type PV controllers are used, the array is mis-wired. • V_{oc} may be greater only if MPPT[16] type PV controllers are used.
	Alarm Conditions⇒	• Check for alarm conditions and resolve, if necessary.
	Battery capacity low⇒	• Batteries may be worn out or undersized, replace and correct as necessary.
	Prolonged storms⇒	• Storms or series of storms can reduce battery recharging for days. Batteries may be fully discharged causing the system to fail. Re-evaluate the power source capacity, increase the PV array or add wind turbine generators, increase the battery plant Ah capacity.
Low RF Output or No RF Output	Amplifier power not set⇒	• Set the amplifier output power level.
	Antennas Oriented or Polarized Incorrectly⇒	• Check antenna orientation and re-align, if necessary. • Confirm the correct polarizations are used.
	Alarm Conditions⇒	• Check for alarm conditions and resolve, if necessary.
	Amplifier Failure⇒	• Replace the linear amplifier.
	Terminal radio OFF⇒	• Confirm the terminal radio is transmitting.
	Improper gain setting⇒	• Check gains and re-set, if necessary.
Oscillation or Radio Errors and Distortion	Active Alarm⇒	• Resolve alarm.
	Foreground reflections⇒	• Remove object causing reflection. • Adjust antenna orientation. • Move antenna mounting.
	Improper Antenna Isolation⇒	• Clear area around antennas of excessive plant vegetation growth.
	Improper Gain Settings⇒	• Correctly adjust ALC or GAIN.
	Repeater Amplifier Power too high⇒	• Adjust the amplifier output power to recommended levels. • If errors persist, try reducing the power by 1 dB more.
	MW Radio terminal power too high⇒	• Check radio transmit power level, adjust to recommended levels. • If errors persist, try reducing the power by 1 dB more.

[15] PWM: Pulse Width Modulator. PV Controller type that uses a rapid switch to reduce the average charging current when batteries are fully charged. PV Array V_{oc} should be 1.25 to 2.0 x the nominal battery voltage. Higher Voc can indicate the array is mis-wired (series instead of parallel) resulting in less charging current and power.

[16] MPPT: Maximum Power Point Tracking. PV controller type includes a DC/DC converter to "step down" higher voltage PV arrays. Maximum V_{oc} is limited to the maximum rating of the MPPT controller, typically 150 to 200 VDC.

Amplifier Replacement

When an amplifier must be replaced, do the following:

a) Unplug amplifier's power connector.

b) Disconnect input and output SMA cables.

c) Disconnect the BNC cable from DC monitor point.

d) Remove mounting hardware (11 screws). Hardware may be Pan Head Philips screws or Socket Head Cap screws. The socket head cap screw hardware takes a 3/32 or 7/64-inch Hex Allen Wrench.

e) Remove amplifier.

To install the replacement amplifier:

a) Apply heat sink compound to the mounting surface of the amplifier. Use a very thin layer.

b) Mount the amplifier on the panel securing with mounting hardware.

c) Connect the BNC cable to DC monitor point.

d) Connect input and output SMA cables. Use care to align the SMA connector. Misaligned connectors can destroy the center pins.

e) Check all coax connections for tightness (8-inch/lbs)

f) Plug-in the amplifier's power connector.

g) Verify operation by measuring power at SMA power monitor, PWR MON.

h) Set output power by adjusting AGC/ALC per Chapter 5.

i) Confirm the RMAS alarm transmitter PWR alarm clears. Adjust the alarm as required.

Keeping Spares

Because repeaters are often used to provide critical coverage, customers are advised to follow a sparing policy. While most telecommunications carriers or system operators have internal policies relative to equipment sparing, in the event that one does not exist, Peninsula Engineering Solutions recommends maintaining a minimum of one (1) spare unit for every increment of 10 units or fraction thereof. This assumes that all spares are immediately available to the technician in need for installation.

When travel time to a site is long or access is difficult (helicopter or horse), then, more spares located close to or at the repeater site are recommended. Frequently, organizations will store an amplifier inside an RF repeater, thus, placing the spare exactly where needed. Amplifiers stored in sealed, anti-static packaging is recommended for on-site spare inventory.

Each organization should develop a company-specific, equipment-specific policy that meets their needs, taking into account geographic considerations and the quantity of repeaters used in the network.

Returning the Repeater Equipment for Repair

If a repair or return of the RF-11000, or its components, is necessary, contact the Peninsula Engineering Solutions Customer Service Department for instructions. When calling, include the following information:

- ⇒ Nature of the problem
- ⇒ Model name
- ⇒ Unit serial number

For equipment returns, a representative issues an RMA (Return Material Authorization) and shipping and packaging instructions. When returning the repeater to Peninsula Engineering Solutions, always use the original shipping carton and packaging materials. If the original shipping materials are unavailable, Peninsula Engineering Solutions can send replacement materials at your cost.

CAUTION: *If equipment is not returned to Peninsula Engineering Solutions in the original packaging materials, possible damage could result. Peninsula Engineering Solutions is not liable for any damage resulting from improper shipment.*

The telephone number and email for the Customer Service Department follows:

- ⇒ +1 925 901-0103
- ⇒ Email: rma_admin@peninsulaengineering.com
- ⇒ Web: http://www.peninsulaengineering.com/sup_rma.html

Product Warranty

A one-year, limited warranty is provided with the repeater. A copy of the product warranty is included with the Standard Terms and Conditions. Extended warranties are available for continued protection. For more information, contact the Peninsula Engineering Solutions Customer Service Department.

Peninsula Engineering Solutions, inc.
39 Grand Canyon Lane
San Ramon, California 94582
United States of America

http://www.peninsulaengineering.com/

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Table 15 RF-11000 Maintenance Record

Date				
PV-A Voltage, V_{oc}				
PV-A Voltage, V_{charge}				
PV-B Voltage, V_{oc}				
PV-B Voltage, V_{charge}				
Battery-A Voltage				
Battery-A Temperature				
Battery-B Voltage				
Battery-B Temperature				
Battery-A Load Current				
Battery-B Load Current				
Battery-A ONLY Load Current				
Battery-B ONLY Load Current				
Amplifier A1, F1 PWR MON				
Amplifier A2, F2 PWR MON				
Amplifier A3, F3 PWR MON				
Amplifier A4, F4 PWR MON				
RMAS - PWR F1 DC				
RMAS - PWR F2 DC				
RMAS - PWR F3 DC				
RMAS - PWR F4 DC				