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RF-4000 Repeater

Microwave Repeater Systems

Applications

- Low-cost, highly reliable 4-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 1800 FDM, 1920 PCM(140Mb/s) or multiple video.
- Compatible with any manufacturer's 4-GHz radio terminal.
- Solar power compatible -- economical in thin routes and remote locations.

Features

- RF output power up to +25 dBm analog and FSK, lower power for digital.
- Power consumption only 2.5 amperes at 12 Vdc for duplex operation.
- Solar 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.
- Duplex frequency diversity, multi- RE channel and three-way or "Y junction" configurations available.
- Only one active element per channel, the internally redundant linear amplifier.
- AGC/ALC provided to correct input fades and reduce overload.
- Amplifiers can be replaced without disrupting service.
- RMAS-I20 Alarm system (optional) to remotely monitor repeater.
- Provided with directional couplers for in-service RE output power measurements.
- No frequency conversion -- received signal is filtered, amplified, and re-radiated.
- Very reliable, greater than 85,000 hours MTBF for duplex.
- Approved for use with 4-GHz radio systems.
- Available as a self-contained RF repeater for use with customer-furnished antenna and power equipment or as a complete package including repeater, antenna, solar electric panels, battery charger and batteries.
- Steel, weatherproof, lockable cabinet. No environmental shelter required in most installations.

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1. GENERAL

- This Section provides information for the Peninsula Engineering RF-4000 RF Repeater Assembly; hereinafter referred to as the RF-4000. The RF-4000 may be used with any manufacturer's 4-GHz radio operating in the 3.4-4.2 GHz frequency range to provide an intermediate repeaterlinks. Terminal capacity is limited only by the repeater RF bandwidth.
- The RF-4000E assembly is an RF through repeater designed for remote locations. Only alignment of antennas and AGC/ALC is required. The use of highly reliable components and minimum active circuitry eliminates most subsequent maintenance. The repeater assembly consists of an equipment mounting panel and waveguide manifolds contained in a steel, weatherproof cabinet. In most applications the complete assembly is wall-, pole- or tower-mounted. An example of repeater mounting is shown in figure 1; front view of the repeater is shown in figure 2.
- In addition to the RF-4000 repeater assembly, Peninsula Engineering Group offers accessory equipment consisting of antennas and mounting hardware, waveguide, batteries, and an ac power supply with an integral standby battery. The recommended antennas are solid or high performance types chosen per application.

2. FUNCTIONAL DESCRIPTION

Basic Repeater

- The RF-4000 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 Figure 3.1, 3.2).
- The received signal from "A" antenna, identified as frequency "f1," enters the repeater panel via the cabinet mounted CPR-229 W/G connector and is then fed to a branching circulator.

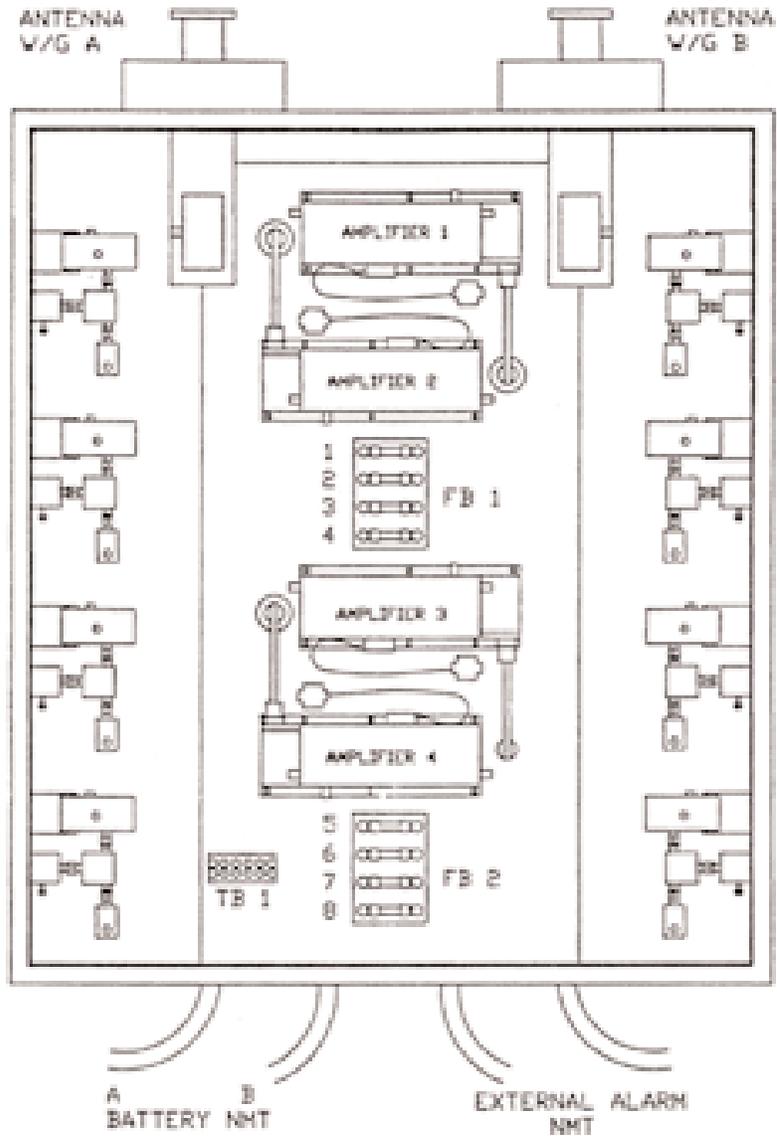
From the circulator, the f1 signal is passed through the f1, f3 receive pad (optional) to the f1 receive bandpass filter. The bandpass filter passes the f1 signal to a terminated coaxial circulator and a coaxial circulator which is terminated with a receiving equalizer. Then f1 signal passes to amplifier 1. The amplified signal passes through a transmit equalizer, a terminated coaxial circulator. Then fi signal passes through a coaxial circulator, which is terminated with a transmitting equalizer, and the f1 transmit bandpass filter to the branching circulator through the (optional) f1, f3 transmit pad and then to the cabinet mounted CPR-229 W/G connector for connection to the "B" antenna.

- In the other direction, the receive signal from "B" antenna, identified as frequency "f2," enters the repeater panel via the cabinet mounted CPR-229 W/G connector and is then fed to a branching circulator. From the circulator, the f2 signal is passed through the f2, f4 receive pad (optional) to a receive branching circulator and then to the f2 receive bandpass filter. The bandpass filter passes the f2 signal to a terminated coaxial circulator and coaxial circulator which is terminated with a receive equalizer and then to amplifier 2. The amplified signal passes through a transmit equalizer, terminated coaxial circulator and the f2 transmit bandpass filter to the transmit branching circulator through the (optional) f2, f4 transmit pad and then to the TR branching circulator and the cabinet mounted CPR-229 W/G connector for connection to "A" antenna.
- Receive pads RX f1, f3 and RX f2, f4 reduce the repeater receive signals to approximate the recommended input level (shown in Table 4.1). The transmit pads designated TX f1, f3 and TX f2, f4 reduce the output signal levels of the repeater to prevent overloading of the terminal receiver in a short path. Pads are mounted on the side mounted W/G to coax adapters.

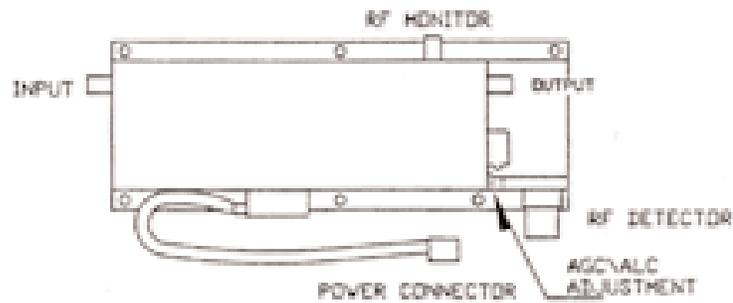
Amplifiers

- In digital radio applications the amplifiers operate at a reduced average power level according to the list below, in order to maintain linearity over the entire signalling envelope. +25 dBm nominal output is available with analog FM or digital FSK radio systems. Each amplifier is mounted on the front of the panel to allow easy replacement in the field. Necessary information for ordering spare or replacement amplifiers is provided in Part 4.

FIGURE 2.0 MECHANICAL LAYOUT



RF-4000-12 RF REPEATER



090-0137-01 AMPLIFIER

RF-4000 Repeater

MODULATION	POWER BACK OFF	MAXIMUM POWER OUTPUT
FM/FSK/MSK	0 dB	+25 dBm
4PSK	-2	+23
16QAM	-6	+19
64QAM	-10	+15
QPR3/9QPRS	-5	+20
QPR7/49QPRS	-6	+19

Directional Couplers

• Directional couplers, built into the amplifiers, provide signal monitor points. These allow in-service measurement of transmit output power. The monitor points are calibrated to indicate actual RF output power at the antenna connector. 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 transmit output power.

For example:

(1)	Power meter indication	=	+6.8dBm
(2)	Loss marked at monitor	=	21.1dB
(3)	W/G Branching Loss	=	-2.9dB

	Output Power	=	+25.0dBm

Power Supply

• The only active elements in the RF-4000 assembly are the amplifiers which operate from a +13.5 Vdc source. Current requirements are 1.25 Amperes per amplifier. The repeater assembly may be powered from solar panels/batteries, primary cells only, or from an ac/dc supply with standby battery (shown in Figures 3.4 and 3.4).

• Storage batteries and solar cell panels are selected on the basis of the average 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. Regulators are included with the solar panels to prevent overcharging the batteries or boiling the electrolyte. Peninsula Engineering Group will provide assistance in determining the appropriate battery capacity. The latitude,

longitude, and altitude of the site should be specified when requesting assistance.

• In areas where commercial power is available, an ac power supply can be provided. The ac power supply will provide ample current to power all amplifiers; therefore, only one supply is generally used. The power supply also contains a standby battery to provide power during ac power failures. The battery is float charged while the power supply is on and will supply 40-60 hours of standby power during a power failure.

• In locations where commercial power is not available and solar panel charging is impractical, primary cell batteries capable of powering an RF-4000 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.

3. ALARMS

• The RF-4000 repeater can be provided with an optional alarm system to remotely monitor the repeater site.

• Conditions that are typically monitored are listed below:
Alarm Conditions Monitored (Optional)

Standard Telemetry:

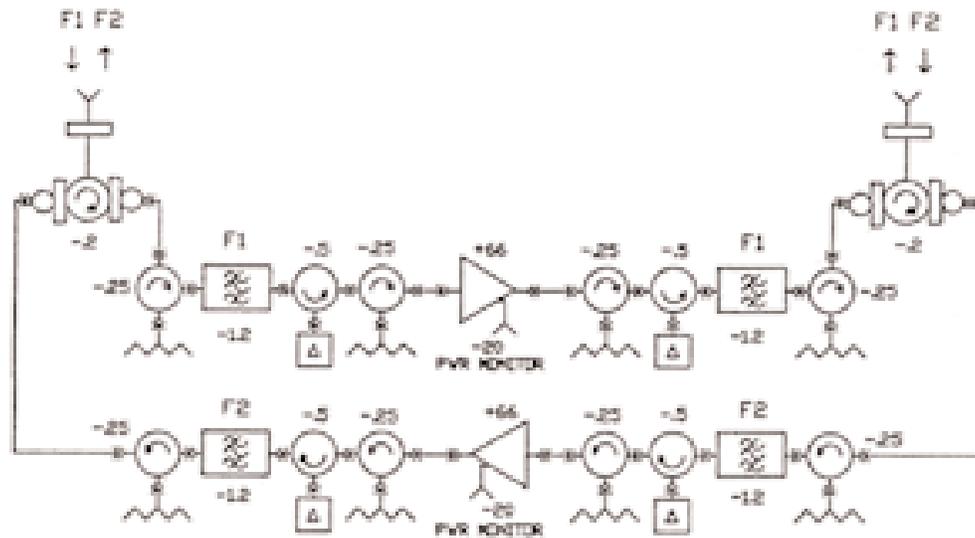
- a) A and B Battery Voltage
- b) Battery Temperature

Standard Trip Points:

- c) A and B Battery Major Alarm (2)
- d) East and West RF Output Low (2)
- e) Amplifier Alarm
- f) Cabinet Door Open
- g) Waveguide pressure low
- h) 6 Each Uncommited Points, Strappable GND or Open=Alarm

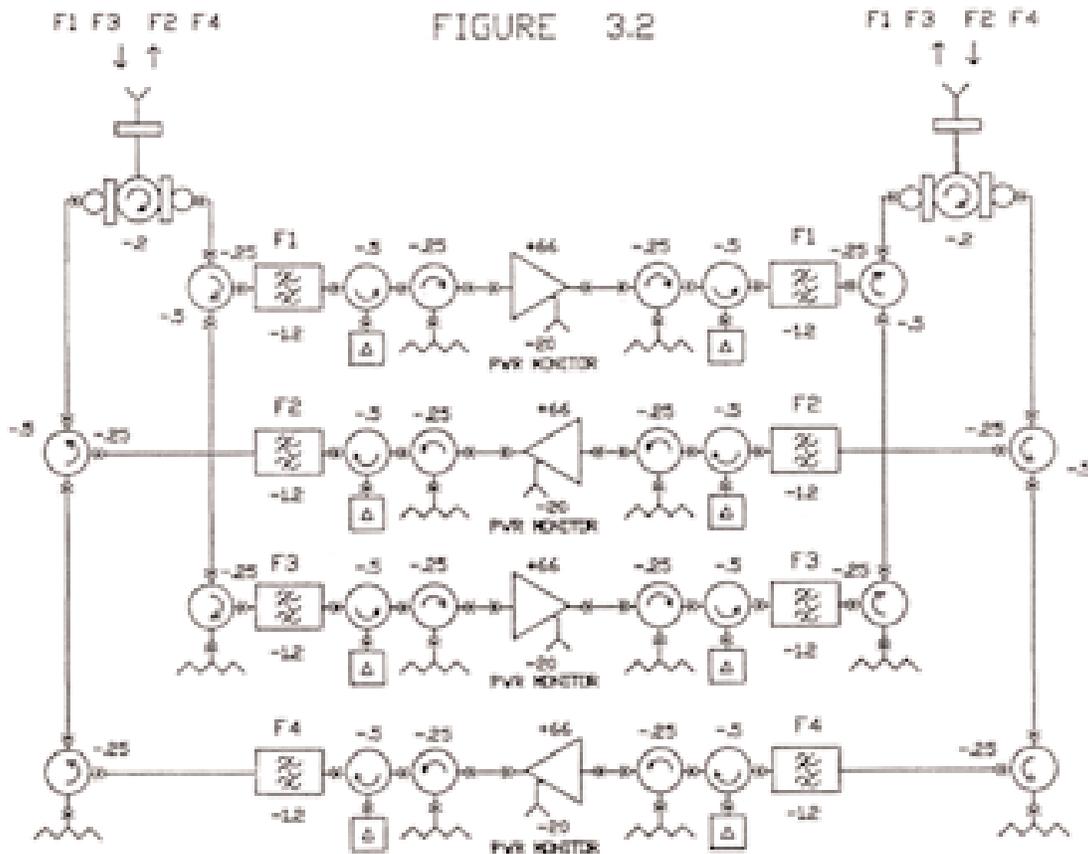
• The alarms are relayed back to the terminal through the use of a low rate telemetry signal directly modulated on the RF in a non-interfering fashion. Alarms are visually displayed on the terminal receiver unit. Alarm contact closure are available for input to standard microwave supervisory systems.

FIGURE 3.1



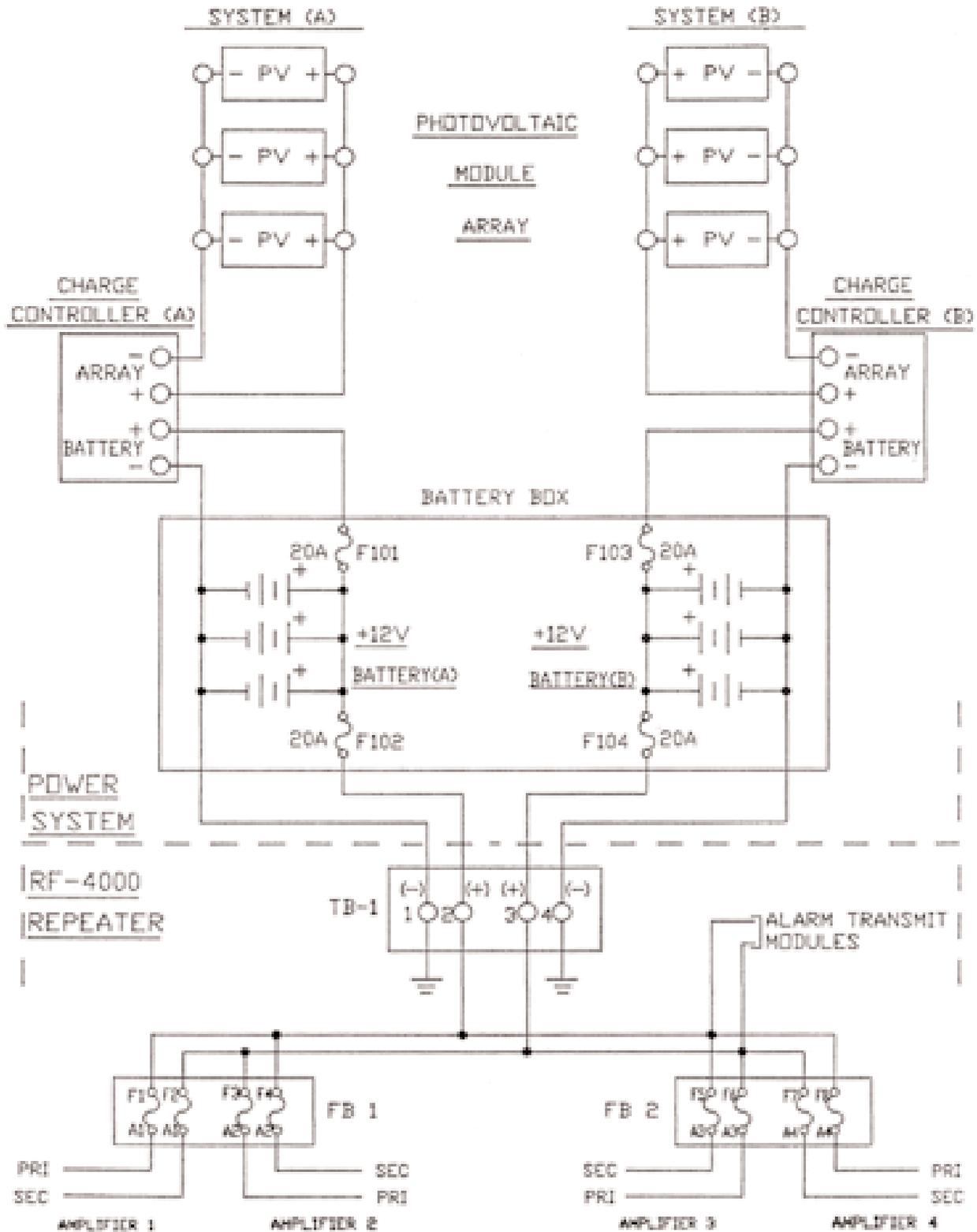
RF-4000-11 RF REPEATER, DUPLEX, EQUALIZED

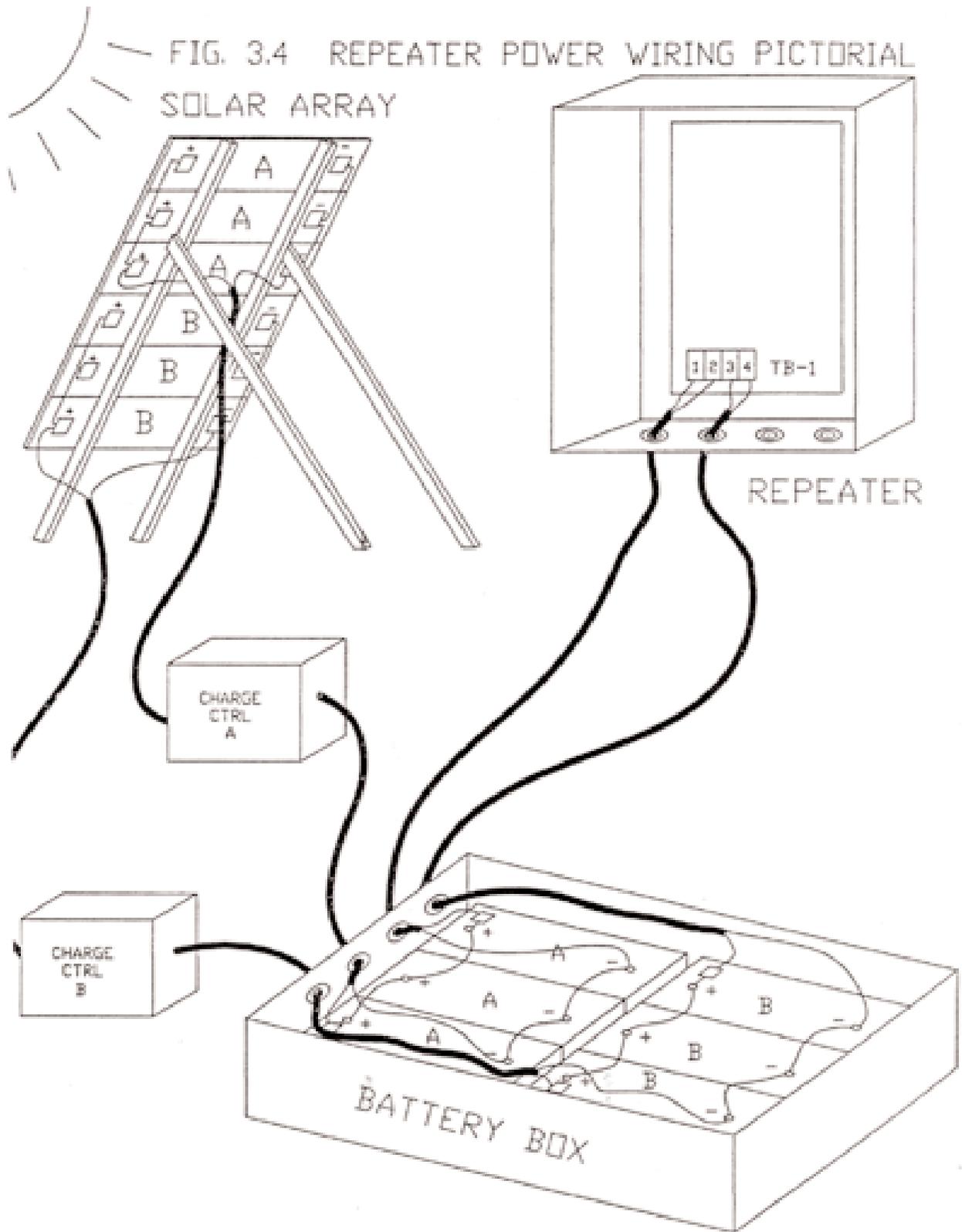
FIGURE 3.2



RF-4000-12 RF REPEATER, 1+1 FREQUENCY DIVERSITY, EQUALIZED

FIGURE 3.3 POWER BLOCK DIAGRAM





RF-4000 Repeater

4. LICENSING

RESERVED

(a) Terminal transmit-Repeater receive frequencies (F1 and F2.

(b) Physical mounting of RF-4000 repeater on tower (or crossarms) in relation to mounting of antennas.

5. ORDERING

• The RF-4000 RF Repeater Assembly is ordered by specifying the system model number RF-4000E-11 through RF-4000-12. Attenuators are provided 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 Figure 4.

• When doing the initial system layout of a radio hop which includes a RF-4000 RF Repeater Assembly, several factors must be considered prior to ordering, to ensure correct antenna connections.

• The RF-4000 repeater may be factory-tuned so that f1 associates with the lower of the two frequencies and f2 with the higher; or vice versa. By comparing the factors listed above, correct antenna/waveguide feeding connections will result. The equipment order must specify the f1 and f2 frequencies. For example:

f1 RCV = 3610.0MHz or f1 RCV = 3830.0MHz

f2 RCV = 3830.0MHz f2 RCV = 3610.0MHz

• Orders should include a shipping destination and a billing address. Upon receipt of your order, Peninsula Engineering returns an acknowledgement with the scheduled shipping date. An equipment list, showing the equipment ordered and shipped, is included with the shipment.

Figure 4
Standard Assemblies
RF 4000E Repeater Ordering Information

Standard Assembly	Description	Frequencies (MHz)	
RF-4000-11 (900-0151-11)	Duplex, Operates in the 3.4 - 4.2 GHz Band Maximum loading 1800 FDM channels, 1920 PCM channels or multiple video channel	F1	F2
RF-4000-12 (900-0151-12)	Duplex, Frequency Diversity (4 amplifiers)	F1 F3	F2 F4

Coaxial Attenuator

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

149-0128-XX Coaxial Attenuator. Equipped with SMA male and female connectors. May be inserted in receive line or transmit line for RF level coordination.

Figure 4.2

Spare/Replacement Amplifier Ordering

Description	Stock Number
Amplifier	149-0150-01
Sparing Kit	091-0005-01

Figure 4.3

Alarms Ordering, RMAS-100-02 Alarm System

Standard Assembly Stock Number	Transmit Module	Freq. Diversity Sensor Card	Receiver Module
900-0040-05	1	0	1
900-0040-06	1	0	2
900-0040-07	1	1	1
900-0040-08	1	1	2

One alarm transmit module can send information to terminals at one or both ends of the Repeater Link. Order receive modules for one or two locations as needed. Frequency diversity or two channel duplex (1+1) systems require an additional frequency diversity sensor card for the transmit module.

6. INSTALLATION

General

- When the RF-4000 equipment is received, inspect it carefully for damage. Claims for damage should be reported directly to the transportation company involved immediately, in accordance with their instructions.
- The RF-4000 assembly can be mounted on crossarms on a wood-pole structure, a steel tower, or on a wall. At extremely hot environment, eg. desert, shading from direct sunshine may be required. 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 housing are shown in Figure 5.
- Prior to cutting to length and connecting the coaxial feedlines, verify which repeater receive frequency associates with each antenna port. The repeater receive frequencies are marked on the repeater waveguide manifold.
- The waveguide feedlines are terminated in CPR-229 W/G connectors. The RE-4000 waveguide manifolds are not designed for pressurization. Use external pressure windows as they will prevent pressure from entering the manifold. The small volume of equipment waveguide does not require pressurization.

Power Wiring

- Remove fuses F1, F2, F3, and F4 (F5, F6, F7, F8 for 2 chan) from the fuse blocks in the RE 4000 assembly. If storage batteries are used, remove the fuses from the holders in the battery boxes. The power leads can be brought into the repeater housing through the 13-mm (1/2) inch-non-metallic conduit (NMT) fittings. Use paired 10-gauge (2.50-mm) wire from the batteries to the repeater terminal block and from the solar panels to the charge controller terminal block. Connect the leads to terminal block TB I as shown in figure 2, 3.3 and 3.4. If a single ac supply is used, jumpers must be installed between terminals 2 and 3 on the lower side of the terminal block as shown in figure 2, 3.3 and 3.4. The power leads are then connected to terminals 1 and 2 as shown. Note that the equipment uses a negative ground. Do not replace the fuses at this time.

DC Power

- The repeater is normally powered from a dual battery system designated "A" and "B." The "A" battery is wired to power the "A" side of the equipment. Similarly, the "B" battery is wired to power the "B" side of the equipment. Standby power switchover is accomplished within each amplifier. Each amplifier has a primary and secondary battery input. If the primary battery should fail, operation will immediately continue on the secondary battery.

7. TESTS

General

- Few adjustments are required on the RF 4000 repeater. After application of power, AGC/ALC adjustment, and proper antenna orientation, the equipment is ready to be placed in service. Use of portable or mobile radio to establish a talk path between the RF-4000 repeater site and the terminals, will aid in completing the tests and in verification of normal (calculated) system operation.

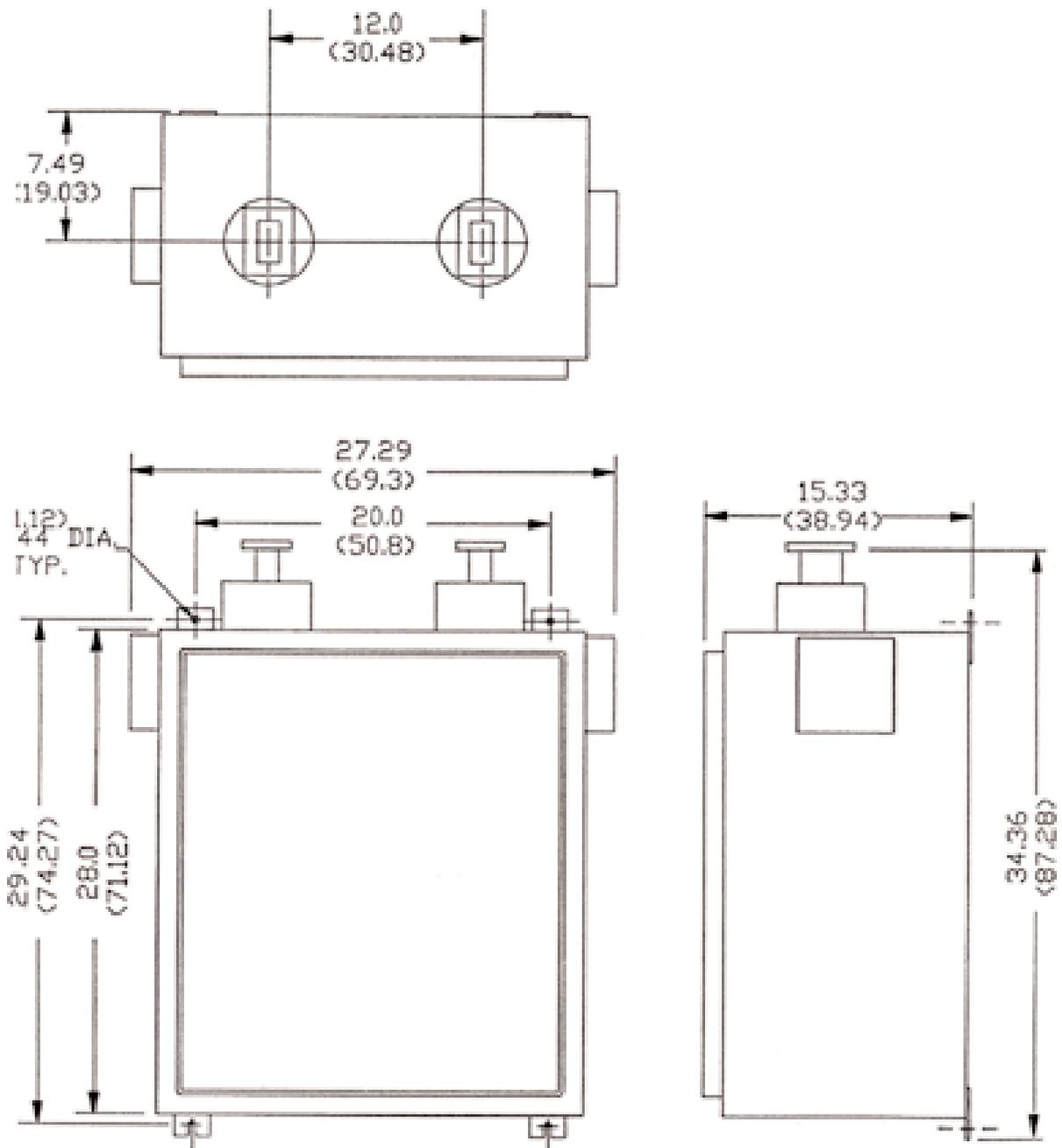
Test Equipment

- The description of test equipment in figure 6 includes the manufacturer's type/model numbers that are available as of the publication date. Since certain models of test equipment may become discontinued or superseded by the manufacturer an any time, it is recommended that a manufacturer's current catalog be used when ordering the equipment. The test equipment manufacturers listed are for reference only and are not intended to show a preference for any one manufacturer. Equivalent test equipment may be used unless otherwise noted. Regardless of the test equipment used, it must be properly maintained, calibrated, and operated according to instructions given by the manufacturer.

Application of Power

- If solar panels and storage batteries are used, measure the voltage across the Charge Controller input terminals (+) and (-). Confirm the proper polarity. The voltage reading should be between 12 and 15 Vdc. If the polarity is incorrect or there is no voltage, check and correct the wiring to the solar cell

FIGURE 5.0 CABINET MOUNTING HOLE DIMENSIONS



DIM. IN INCHES (CM)

**Figure 6
Recommended Test Equipment**

Item	Manufacturer and Type Number	Use	Quantity
DVM	Fluke 8022B with 80J-10 current shunt (10 A) or equivalent	Measure 12 to 15 Vdc and current from 150mA to 10 A...	1
RF Power Meter	Hewlett-Packard 435B equipped with 8481A or equivalent	Antenna orientation and output power measurements (-10 to +25 dBm)	1
Spectrum Analyzer	Hewlett-Packard 853A or equivalent with 8559A Plugin or equivalent	Antenna orientation	1
Attenuator	Microlab/FXR AJ-500F, 30 dB or equivalent	Antenna orientation and power alarm set (RMAS-100)	1

panels. If the voltage is low, check to be sure the surfaces of the solar panels are not obscured from sunlight. Next, remove battery input fuses F101 and F103. Battery output fuses should now be in place. Measure the voltage across terminals 1 (-) and 2 (+) and across terminals 3(+) and 4 (-) of repeater terminal block TB 1. Confirm the proper polarity. The voltage reading should be 12.0 to 13.5 Vdc for storage batteries or 13.0 to 14.5 Vdc for an AC power supply. If the polarity is incorrect or there is no voltage, check and correct the wiring of the batteries or AC power supply. Replace battery fuses F101 and F103. Set the digital volt meter (dvm) to read in a range of 2 A or greater and bridge the test leads across the fuse holder for F1; read the current. The current should be 0.8 to 1.4 A. Repeat the current reading across the F2, F3, and F4 fuse holders. Log all voltage and current readings for reference during routine maintenance or trouble location procedures. Replace fuses F1, F2, F3, and F4. If any additional amplifiers are equipped, measure the current at fuses F5, F6, F7, and F8 for amplifiers 3 and 4.

Antenna Orientation, AGC/ALC set and Output Measurement

- Before antenna orientation begins, the amplifiers must be operating in their full gain mode. The setting of the AGC/ALC along with a high input level (greater than desired output power-60 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. To use the amplifier power monitor point as a signal strength indicator, the input level to the amplifier must be less than the level that initiates AGC/ALC action. 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 20 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.

- Connect the power meter or spectrum analyzer to the f1 XMT directional coupler. With a signal transmitted from the A terminal, position the A antenna for a maximum power reading on the meter or analyzer. Remove any temporarily installed input attenuators. 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 Fig 2. Adjust the potentiometer CW to reduce the power setting or CCW to increase the AGC/ALC set point. Log the power reading to fulfill FCC or local administration requirements. Remove the meter from the f1 XMT directional coupler and move it to the f2 XMT coupler. With a signal transmitted from the B terminal, position the B antenna for a maximum power reading on the meter or analyzer. Remove any temporarily installed input attenuators. Set the power level with the AGC/ALC adjustment if needed. Log the power reading to fulfill administration requirements. Measure and log the power at any additional amplifier directional couplers so equipped (f3, f4...). Remove the meter.
- After the antenna orientation has been completed at both terminals and the repeater, AGC readings should be taken at the end terminals and logged for reference. A maintenance test record is shown in figure 7.

8. MAINTENANCE

Routine Maintenance

- Unless unique conditions require more frequent maintenance, routine maintenance should be performed annually. Clean the surfaces of the solar cell panels with isopropyl alcohol or a mild detergent solution. Do not use alcohol compounds containing acetone. Check and clean the wiring connections to the solar regulators and the battery connectors as necessary. Using the dvm set to read current, bridge the test leads across fuse F1 holder. Remove the fuse and read the current. While still bridging the meter across the holder, replace the fuse. Repeat the test across fuse F2, F3 and F4 (F5, F6, F7, and F8) holders. Log the current readings.

Administration Requirements

- Administrations may require measurement of the output power of a repeater at installation and when any changes are made which may cause the output power to change. Using the power meter, measure and log the output power.

Trouble Location

- Soft failure of one amplifier may be indicated by a drop of approximately 6 dB in the received signal level at the terminal in the direction of transmission. This power drop will be indicated on the agc 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 connections. If there is no voltage, check and replace fuses as necessary and check all power lead connections. If voltage is present at both amplifiers, bridge fuse F1 with the dvm set to read current. Remove the fuse and read the current. The reading should be within the same limits. If the current reading is Out of tolerance, amplifier 1 has failed. If the current reading is within the required limits, replace the fuse while keeping the meter connected across the fuse holder Repeat the test for amplifiers 2, 3, and 4.
- 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 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.

Amplifier Replacement, Out of Service

- When an amplifier must be replaced in an Out of Service condition, do the following:

- a) Unplug amplifier's power connector.
 - b) Disconnect input and output SMA cables.
 - c) Disconnect BNC cable from DC monitor point.
 - d) Remove mounting hardware (6 screws).
 - e) Remove amplifier.
- To install the replacement amplifier:
 - a) Mount the amplifier on the panel securing with mounting hardware.
 - b) Connect the BNC cable to DC monitor point.
 - c) Connect input and output SMA cables.
 - d) Check all coax connections for tightness (8in/lbs)
 - e) Plug-in the amplifier's power connector.
 - f) Verify operation by measuring power at SMA power monitor.
 - g) Set output power by adjusting AGC/ALC.

Amplifier Replacement, In Service

- When an amplifier must be replaced while the repeater is in service (eg. soft failure), do the following:
 - a) Mount a temporary spare amplifier in and oriented in the same input/output direction as the amplifier to be replaced.
 - b) Remove the SMA terminations from the coaxial circulators in series with the amplifier to be replaced.
 - c) Connect the flexible coaxial cables or semi-rigid coaxial cables (part of the sparing kit) from the input coax circulator open port to the temporary spare amplifier's input SMA. Likewise connect the output coax circulator open port to the temporary spare amplifier's output SMA connector.
 - d) Connect the DC leads from the temporary spare amplifier using the power adapter in the sparing kit to the "A" battery if replacing amplifier A1, or "B" if replacing amplifier A2.
 - e) Disconnect the input coax (both ends) from the amplifier to be replaced. Do not terminate the input

circulator. The signal is now carried in the temporary spare amplifier, but may be 20 dB down. Set the power in the temporary spare amplifier by adjusting the AGC/ALC

- f) Unplug the power connector of the amplifier to be replaced.
 - g) Disconnect the output coax (both ends) from the amplifier to be replaced. The signal level should now be close to normal. Do not terminate the output circulator!
 - h) Disconnect BNC cable from power monitor point.
 - i) Unscrew mounting hardware (6ea) and remove amplifier.
- To install a replacement amplifier in service:
 - a) Mount the amplifier on the panel securing with mounting screws.
 - b) Connect BNC cable to power monitor point.
 - c) Connect the output coaxial cable to the replacement amplifier and its output coaxial circulator. Signal level will drop 20 dB.
 - d) Plug in the amplifier's power connector.
 - e) Connect the input coaxial cable to the replacement amplifier's input. Signal level should be close to normal. Set power by adjusting AGC/ALC.
 - f) Remove the power connections from the temporary spare amplifier.
 - g) Disconnect the flexible or semi-rigid coax cables from the coax circulators and from the temporary spare amplifier.
 - h) Replace the SMA terminations on the coax circulators.
 - i) Remove the temporary spare amplifier.

CAUTION

Due to unpredictable reflections within the RF-4000, operation with a temporary spare amplifier, it may be degraded somewhat from normal, particularly in high capacity digital and analog systems. Be sure the AGC/ALC is set for the correct power level in your system.

**FIGURE 7
PENINSULA ENGINEERING
RF-4000 MAINTENANCE RECORD**

Date				
Solar Panel, System A Voltage :				
Solar Panel, System B Voltage :				
Battery, System A Voltage : Temperature :				
Battery, System B Voltage : Temperature :				
Current Drawn From Battery A Only				
Current Drawn From Battery B Only				
Current Drawn From Battery A While Battery B is Connected				
Amplifier, A1 F1 Power Monitor :				
Amplifier, A2 F2 Power Monitor :				
Amplifier, A3 F3 Power Monitor :				
Amplifier, A4 F4 Power Monitor :				

APPENDIX A

Antenna System

The antenna system is vital to the success of any RF repeater. It was only when high performance microwave antennas became available that high capacity RF repeater became practical. The antennas must have high gain (25-50 dB), clean pattern, low sidelobes and good Front-to-Back ratio. It is the sidelobes and Front-to-Back ratio that control much of the echo that results from antenna to antenna coupling. Foreground obstructions also produce an echo component which is site specific.

The objective for permissible echo varies with the type of transmission and its bandwidth. High capacity analog radios require 50-55 dB C/I while low capacity analog and digital radios require 24-30 dB C/I. The actual amount of echo permitted must be calculated based on the radio manufacturer's specifications and end system design requirements. Table A-1 shows the required RF repeater C/I with different types of radios.

For example, a 16 QAM digital system requires 33 dB

C/I at the repeater. The 2.5 GHz RF repeater gain is 50 dB. antenna-to-antenna decoupling required is $33+50=83$ dB. This can be obtained from two 41 dB gain standard antennas with 48 dB Front-to-Back ratio (F/B). Cross polarization of the antenna is recommended. An antenna Cross Polarization (XPD) of 20 dB is easily obtained. Antenna separation loss of 49 dB is assumed by taking 75% of free space loss between the feeds of the two antennas. The decoupling is now:

+48	dB	F/B of Antenna #1 (standard)
-41	dB	Gain of Antenna #1 (8 foot)
+48	dB	F/B of Antenna #2 (standard)
-41	dB	Gain of Antenna #2 (8 foot)
+20	dB	Antenna XPD
+49	dB	Antenna separation loss (25 feet)
<hr/>		
83	dB	Total decoupling loss
-50	dB	Repeater Gain
<hr/>		
33	dB	C/I

In this situation, two standard antennas are adequate. If the repeater antennas could not be cross polarized, one or even two of the high performance antennas should be used.

Table A-1
C/I Requirements For Digital Radios

For -1 dB system gain at 10^{-6} BER or $BER < 10^{-12}$ at normal RSL, use following table:

MODULATION TYPE	MINIMUM C/I
4 PSK	24
8 PSK	28
16 QAM	33
64 QAM	40
MSK/FSK	30
9 QPRS/QPR 3	31
25 QPRS/QPR 5	32
49 QPRS/QPR 7	33
81 QPRS/QPR 9	35

Table A-2
C/I REQUIREMENTS FOR ANALOG RADIOS

The following table assumes full power available, with emphasis, 175 nsec of delay:

CAPACITY (CHAN)	DEVIATION	C/I for 10 dBmco IM	C/I fo 20 dBmco IM	C/I for 30 dBmco IM
24-48	50	28	18*	8*
72	50	30	20	10*
96	47/50	32	22	12*
120	200	44	34	24
132	30	40	30	20
252	65	42	32	22
300	200	45	35	25
420/480	200	53	43	33
600	200/141	54	44	34

NOTE*: Operation with C/I less than these required values can cause other problems such as increasing the potential for oscillation and is therefore not recommended.