

Peninsula Engineering Solutions, inc.

Microwave RF Repeaters

Guidelines for Equipment Selection

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Table of Contents

Introduction	1
General	1
Repeater Selection	2
Sources of Information.....	2
Repeater Selection Form.....	2
Frequency Band	3
Table 1, Microwave RF Repeaters.....	3
Configuration	4
Table 2, System Configurations.....	4
Table 3, Available Configurations, (• = Available)	4
Delay Equalization	5
Table 4, RF-1500E, 16 MHz RF Bandwidth , no equalizers available, always unequalized.....	6
Table 5, RF-2000E, 20 MHz RF Bandwidth	6
Table 6, RF-2000EW, 30 MHz RF Bandwidth , always equalized.	7
Table 7, RF-2500E, 20 MHz RF Bandwidth , no equalizers available, always unequalized.....	7
Table 8, RF-4000, 40 MHz RF Bandwidth	8
Table 9, RF-4000N, 28 MHz RF Bandwidth , no equalizers available, always unequalized.	9
Table 10, RF-4500, 40 MHz RF Bandwidth	9
Table 11, RF-6000E, 30 MHz RF Bandwidth	10
Table 12, RF-6000EL, 28 MHz RF Bandwidth , no equalizers available, always unequalized. ...	10
Table 13, RF-6000EW, 40 MHz RF Bandwidth , always equalized.	11
Table 14, RF-7000EL, RF-8000EL, 28 MHz RF Bandwidth , no equalizers available, always unequalized.....	11
Table 15, RF-7000E, RF-8000E, 30 MHz RF Bandwidth	12
Table 16, RF-6000E-04, -44, RF-8000E-04 , 2 Amplifier 1+1, low cost.	12
Table 17, RF-11000, 40 MHz RF Bandwidth	13
Table 18, RF-11000L, 28 MHz RF Bandwidth , no equalizers available, always unequalized....	13
Frequency Spacing	14
Table 20, MW RF Repeater - Frequency Spacings.....	15

Power Amplifiers 16

Modulation 16

 Table 21a, Repeater Output Power 16

 Table 21b, Repeater Output Power 17

Final Repeater Selection 18

 Examples 18

Repeater Monitor and Alarm Systems 19

 Alarm Equipment for Microwave RF Repeaters 19

 Selecting RMAS Equipment 20

 Repeater Monitor and Alarm System Selection Form 20

 Configuration 20

 Table 22, Remote Monitor and Alarm System Configurations (• = Available) 20

 Configuration, continued 21

 Table 23, RMAS & Repeater Applications, (• = Applies), (Tx VDC) 21

 Final RMAS Selection 22

 Repeater Monitor and Alarm System Selection Form, RMAS-120, RF-6000EW-16 22

 Repeater Monitor and Alarm System Selection Form, RMAS-120, RF-11000-51 22

 Repeater Monitor and Alarm System Selection Form, RMAS-120, RF-1500E-01 22

 Repeater Monitor and Alarm System Selection Form, RMAS-120, RF-2000EW-12 22

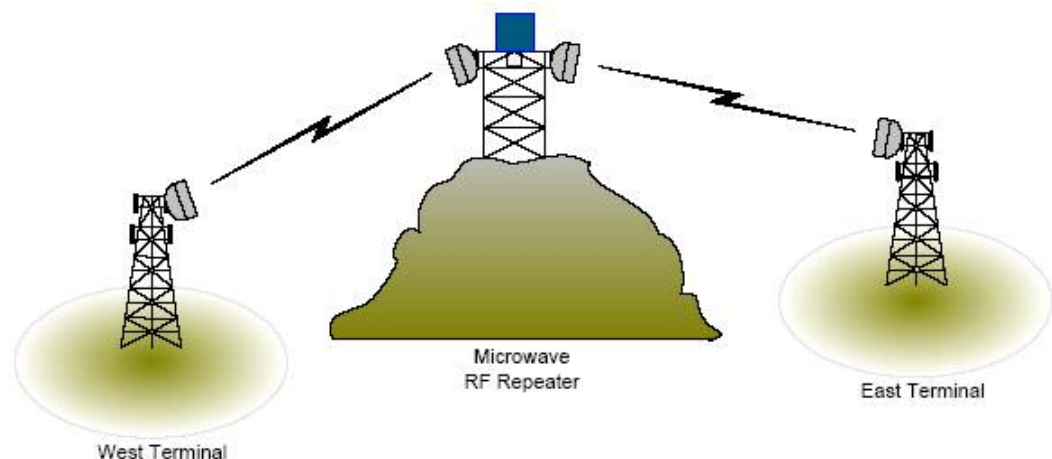
Introduction

General

Microwave RF Repeaters are used as intermediate relay stations in radio relay networks. The families of RF Repeaters produced by Peninsula Engineering Solutions are classified as non-dropping, on-frequency through repeaters. Peninsula Engineering Solutions produces a wide range of RF Repeaters in many different configurations so that they may best fit the applications. These guidelines will assist the system engineer or planner in the choice of repeater and its configuration.

Since new products are regularly introduced, product summaries included here may need to be supplemented by reference to product Operations Manuals.

Repeater Equipment selection should be made in conjunction with Radio Link and Path Design. The process is often interactive. Peninsula Engineering Solutions has Microwave RF Repeater Path Data Sheets in Microsoft Excel[®] format to assist the Radio Planner in this task. A working knowledge of microwave radio path engineering methods is necessary.



Repeater Selection

Sources of Information

To accurately determine the proper choice of microwave RF repeater, several sources of information will be consulted. The primary sources are:

- 1 The End User or Customer
- 2 OEM Microwave Terminal Supplier
- 3 Peninsula Engineering Solutions Applications or Field Projects Engineer
- 4 Peninsula Engineering Solutions Equipment O&M Manuals
- 5 Peninsula Engineering Solutions Price Book
- 6 This Selection Guide

The Repeater Selection Form below is marked in *italics* with likely information sources referencing the list above.

<u>Frequency, MHz</u>	<u>Traffic</u>	<u>Modulation</u>	<u>Repeater Model</u>	<u>Config.</u>	<u>Delay Equalization</u>	<u>Power Amplifier Level</u>	<u>Output Power</u>	<u>Repeater Part Number</u>
f1 <i>1,2</i>	<i>1,2</i>	<i>1,2</i>	<i>3,4,5,6</i>	<i>3,4,5,6</i>	<i>6,3,2</i>	<i>6,3,2</i>	<i>6,4,3</i>	<i>4,5</i>
" f2	"	"			"	"	"	
f3 "	"	"			"	"	"	
" f4	"	"			"	"	"	
f5 "	"	"			"	"	"	
" f6	"	"			"	"	"	
f7 "	"	"			"	"	"	
" f8	"	"			"	"	"	

Repeater Selection Form

Frequency Band

Microwave RF Repeaters are first selected by the operating frequency range. Determine the terminal transmit and receive frequencies. Normally frequencies are known to the End User, Customer or OEM Microwave Terminal Supplier. In early project stages, only the general frequency range may be known. This is enough for most planning. Final frequencies must be known in order to book the order and to verify frequency spacing rules.

Select the RF Repeater. Refer to table 1.

<u>Frequency Range</u>	<u>RF Repeater</u>
1390-1535 MHz	RF-1500E
1700-2300 MHz	RF-2000E, RF-2000EW
2300-2700 MHz	RF-2500E
2408-2467 MHz	RF-2500E-SS
3400-4200 MHz	RF-4000, RF-4000N
4400-5000 MHz	RF-4500
5925-7125 MHz	RF-6000E, RF-6000EL
6400-7125 MHz	RF-6000EW
7125-7900 MHz	RF-7000E, RF-7000EL
7700-8500 MHz	RF-8000E, RF-8000EL
10,700-11,700 MHz	RF-11000, RF-11000L

Table 1, Microwave RF Repeaters

Configuration

Determine the *Transmitter-Receiver* (TR) configuration planned at the terminals and select the corresponding RF Repeater configuration. Not all configurations are available for each RF Repeater Model. Other configurations may be possible with special design, please consult Peninsula Engineering Solutions. Alternative solutions are possible with antenna arrangements.

Note (1). The N+P convention used indicated the number of Working RF Channels or Carriers/Bearers, N and the number of Protection RF Channels or Carriers/Bearers, P. The terminal radios are normally designated the same way. (e.g. 3 Working and 1 Protection = 3+1)

<u>Terminal, Duplex</u> ⁽¹⁾	<u>RF Repeater</u>	<u>Comments</u>
1+0 Unprotected	1+0	Standard Duplex with protected amplifiers
1+1 Hot Standby	1+0	Standard Duplex with protected amplifiers
1+1 Frequency Diversity	1+1, 2+0	2 Duplex
2+1 Multi-Line	2+1, 3+0	3 Duplex
3+1 Multi-Line	3+1, 4+0	4 Duplex
4+1 Multi-Line	4+0 & 1+0	5 Duplex, 2 repeater enclosures
5+1 Multi-Line	4+0 & 1+1	6 Duplex, 2 repeater enclosures
6+1 Multi-Line	4+0 & 2+1	7 Duplex, 2 repeater enclosures
7+1 Multi-Line	4+0 & 3+1	8 Duplex, 2 repeater enclosures

Table 2, System Configurations

<u>RF Repeater</u>	<u>1+0, 1+1</u>	<u>2+1, 3+1</u>	<u>4+1, 5+1</u>	<u>6+1, 7+1</u>
RF-1500E	•	No	No	No
RF-2000E, RF-2000EW	•	No	No	No
RF-2500E	•	No	No	No
RF-4000, RF-4000N	•	c	c	c
RF-4500	•	c	No	No
RF-6000E	•	•	•	•
RF-6000EL	•	No	No	No
RF-6000EW	•	•	•	•
RF-7000E	•	c	c	c
RF-7000EL	•	No	No	No
RF-8000E	•	c	c	c
RF-8000EL	•	No	No	No
RF-11000	•	•	c	c
RF-11000L	•	No	No	No

Table 3, Available Configurations, (• = Available, Standard), (c=Consult PESi)

Delay Equalization

Most RF Repeaters are available with *Delay Equalization* available as an option. Delay Equalization corrects for the normal parabolic group delay shape in the RF channel that is generated by the *channel* or *branching* filters. The choice to add delay equalization depends on the type of microwave signal that is being repeated and whether there are multiple RF Repeaters in *tandem*. Delay Equalizers also add loss to the repeater, possibly reducing the system fade margin and reliability.

The situation when Delay Equalizers are required is when the normal unequalized delay is great enough to cause unacceptable errors in digital systems or intermodulation distortion in analog FM systems. In digital systems, the peak-to-peak delay over the major modulation lobe should be less than 1/3 of the symbol rate. Adaptive Equalizers in digital radio systems often correct for delay variations introduced by RF repeaters. The following charts are useful in determining the need for equalization.

Determine if Delay Equalizers are required.

The charts below show the differences between an *Unequalized Channel* and an *Equalized Channel*. Note that two equalizer sections are used to create a more uniform, that is, flatter channel *Group Delay* response.

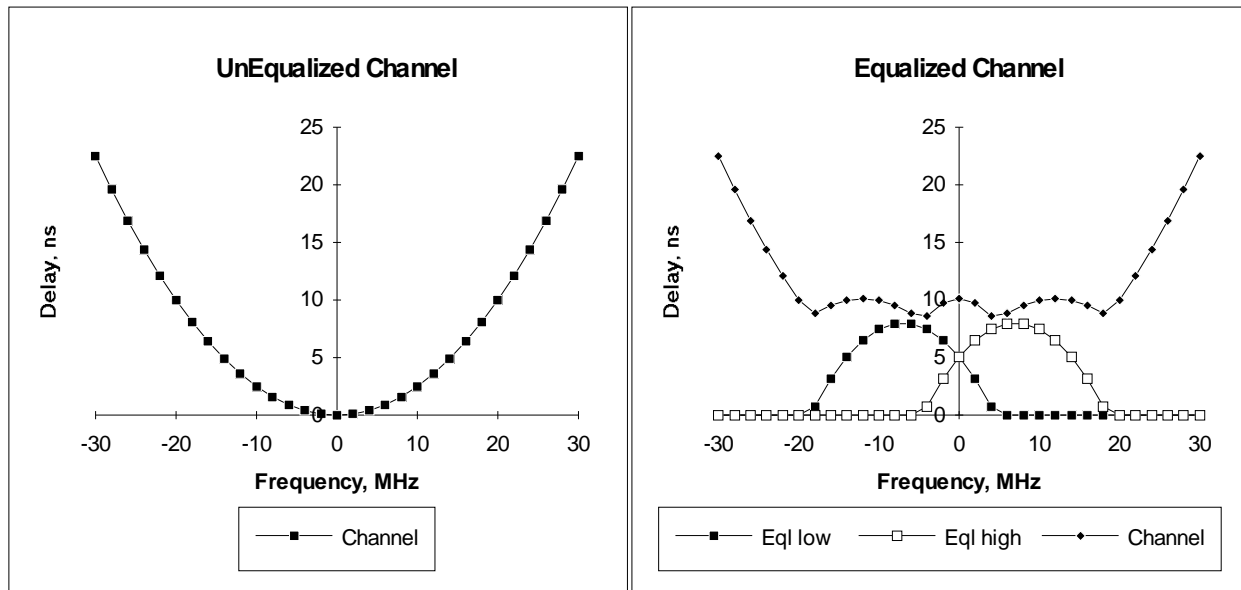


Chart 1, 2, Typica Channel Delay

Table 4, RF-1500E, 16 MHz RF Bandwidth, no equalizers available, always unequalized.

Traffic	Modulation	Equalizers, 1 Repeater	Max Tandem Repeaters
6.5 Mb/s, 4xDS1, 3.5 MHz	4 FSK, 16QAM, QPR3, 9QPRS	No	3
13 Mb/s, 8xDS1, 3.5 MHz	16QAM, 64QAM, QPR7, 49QPRS	No	3
2 Mb/s, 1xE1	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	3
8 Mb/s, 4xE1, 1xE2	QPSK, OQPSK, 4QAM, 4PSK	No	3

Table 5, RF-2000E, 20 MHz RF Bandwidth, no equalizers available, always unequalized.

Traffic	Modulation	Equalizers, 1 Repeater	Max Tandem Repeaters
6.5 Mb/s, 4xDS1, 3.5 MHz	4FSK, 16QAM, QPR3, 9QPRS	No	3
13 Mb/s, 8xDS1, 3.5 MHz	16QAM, 64QAM, QPR7, 49QPRS, 32TCM	No	3
26 Mb/s, 16xDS1, 5 MHz	64QAM, 128TCM	No	2
45 Mb/s, 1xDS3, 10 MHz	QPR9, 81QPRS, 64QAM, 64TCM	No	2
2 Mb/s, 1xE1	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	3
8 Mb/s, 4xE1, 1xE2	QPSK, OQPSK, 4QAM, 4PSK	No	3
8 Mb/s, 4xE1, 1xE2	FSK, MSK	No	2
34 Mb/s, 1xE3, 14 MHz	16QAM, 16TCM, 32TCM	No	2
34 Mb/s, 1xE3, 28 MHz	QPSK, OQPSK, 4QAM, 4QPSK, FSK, MSK	N/A, Use RF-2000EW	N/A, Use RF-2000EW
≤ 300 FDM Channels, ≤ 5 MHz	FM analog	No	2
480 FDM Channels, 10 MHz	FM analog	No Use RF-2000EW	1
600 FDM Channels, 10 MHz	FM analog	No Use RF-2000EW	1
TV, Color	FM analog	Yes	1

Table 6, **RF-2000EW, 30 MHz RF Bandwidth**, always equalized.

Traffic	Modulation	Equalizers, 1 Repeater	Equalize at <i>n</i> Tandem Repeaters
45 Mb/s, 1xDS3, 10 MHz	QPR9, 81QPRS, 64QAM, 64TCM	Yes	1
34 Mb/s, 1xE3, 28 MHz	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	Yes	1
34 Mb/s, 1xE3, 14 MHz	16QAM, 16TCM, 32TCM	Yes	1
480 FDM Channels, 10 MHz	FM analog	Yes	1
600 FDM Channels, 10 MHz	FM analog	Yes	1
960 FDM Channels 14 MHz	FM analog	Yes	1
1200 FDM Channels 28 MHz	FM analog	Yes	1
TV, Color	FM analog	Yes	1

Table 7, **RF-2500E, 20 MHz RF Bandwidth**, no equalizers available, always unequalized.

Traffic	Modulation	Equalizers, 1 Repeater	Max Tandem Repeaters
≤ 13 Mb/s, 8xDS1, 3.5 MHz	16QAM, 64QAM, QPR7, 49QPRS	No	3
≤ 8 Mb/s, 4xE1, 1xE2	QPSK, OQPSK, 4QAM, 4PSK	No	3
34 Mb/s, 1xE3, 14 MHz	16QAM, 16TCM, 32TCM	No	2
≤ 300 FDM Channels, ≤ 5 MHz	FM analog	No	2

Table 8, RF-4000, 40 MHz RF Bandwidth

Traffic	Modulation	Equalizers, 1 Repeater	Equalize at <i>n</i> Tandem Repeaters
≤ 13 Mb/s, 8xDS1, ≤ 3.5 MHz	16QAM, 64QAM, QPR7, 49QPRS	No	4
45 Mb/s, 1xDS3, 10 MHz	QPR9, 81QPRS, 64QAM	No	4
45 Mb/s, 1xDS3, 20 MHz	16QAM, 16TCM, 32TCM	No	3
90 Mb/s, 2xDS3, 20 MHz	64QAM, 32TCM	No	2
135 Mb/s, 3xDS3, 20 MHz	256TCM	No	2
34 Mb/s, 1xE3, 14 MHz	16QAM, 16TCM, 32TCM	No	3
34 Mb/s, 1xE3, 28 MHz	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	2
140 Mb/s, 4xE3, 40 MHz	16QAM, 16TCM, 32TCM	Yes	1
155 Mb/s, OC-3 40 MHz	64QAM, 128TCM	Yes	1
600 FDM Channels, 10 MHz	FM analog	No	2
960 FDM Channels, 20 MHz	FM analog	Yes	1
1260 FDM Channels, 20 MHz	FM analog	Yes	1
1500 FDM Channels, 20 MHz	FM analog	Yes	1
1800 FDM Channels, 40 MHz	FM analog	Yes	1
TV, Color	FM analog	Yes	1

Table 9, RF-4000N, 28 MHz RF Bandwidth, no equalizers available, always unequalized.

Traffic	Modulation	Equalizers, 1 Repeater	Max Tandem Repeaters
≤ 13 Mb/s, 8xDS1, ≤ 3.5 MHz	16QAM, 64QAM, QPR7, 49QPRS	No	4
45 Mb/s, 1xDS3, 10 MHz	QPR9, 81QPRS, 64QAM	No	2
45 Mb/s, 1xDS3, 20 MHz	16QAM, 16TCM, 32TCM	No	2
90 Mb/s, 2xDS3, 20 MHz	64QAM, 32TCM	No	1
34 Mb/s, 1xE3, 14 MHz	16QAM, 16TCM, 32TCM	No	2
34 Mb/s, 1xE3, 28 MHz	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	1
600 FDM Channels, 10 MHz	FM analog	No	2
960 FDM Channels, 20 MHz	FM analog	No	1

Table 10, RF-4500, 40 MHz RF Bandwidth

Traffic	Modulation	Equalizers, 1 Repeater	Equalize at <i>n</i> Tandem Repeaters
34 Mb/s, 1xE3, 14 MHz	16QAM, 16TCM, 32TCM	No	3
34 Mb/s, 1xE3, 28 MHz	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	2
140 Mb/s, 4xE3, 40 MHz	16QAM, 16TCM, 32TCM	Yes	1
155 Mb/s, OC-3 40 MHz	64QAM, 128TCM	Yes	1
600 FDM Channels, 10 MHz	FM analog	No	2
960 FDM Channels, 20 MHz	FM analog	Yes	1
1260 FDM Channels, 20 MHz	FM analog	Yes	1
1800 FDM Channels, 40 MHz	FM analog	Yes	1
TV, Color	FM analog	Yes	1

Table 11, RF-6000E, 30 MHz RF Bandwidth

Traffic	Modulation	Equalizers, 1 Repeater	Equalize at <i>n</i> Tandem Repeaters
≤ 13 Mb/s, 8xDS1, 3.5 MHz	16QAM, 64QAM, QPR7, 49QPRS	No	4
26 Mb/s, 16xDS1 5 MHz	225QPRS, QPR15	No	4
45 Mb/s, 1xDS3, 10 MHz	QPR9, 81QPRS, 64QAM, 64TCM	No	3
90 Mb/s, 2xDS3, 29.58 - 30 MHz	16QAM, 16TCM, 32TCM	If required by Radio	2
135 Mb/s, 3xDS3, 29.58 - 30 MHz	64QAM, 128TCM	If required by Radio	2
140 Mb/s, 4xE3 30 MHz	64QAM, 128TCM	If required by Radio	2
155 Mb/s, OC-3 29.58 - 30 MHz	128TCM	If required by Radio	2
180 Mb/s, 4xDS3, 40 MHz	16QAM, 64QAM, 128QAM, 32TCM, 64TCM, 128TCM	If required by Radio	2
≤ 300 FDM Channels, ≤ 5 MHz	FM analog	No	3
≤ 600 FDM Channels, 10 MHz	FM analog	No	2
1800 FDM Channels 29.58 - 30 MHz	FM analog	Yes	1
TV, Color	FM analog	Yes	1

Table 12, RF-6000EL, 28 MHz RF Bandwidth, no equalizers available, always unequalized.

Traffic	Modulation	Equalizers, 1 Repeater	Max Tandem Repeaters
≤ 13 Mb/s, 8xDS1, 3.5 MHz	16QAM, 64QAM, QPR7, 49QPRS	No	1
26 Mb/s, 16xDS1, 5 MHz	64QAM, 128TCM	No	1
26 Mb/s, 16xDS1, 10 MHz	16QAM, 32TCM	No	1
45 Mb/s, 1xDS3, 10 MHz	64QAM, 32TCM, QPR9, 81QPRS	No	1
≤ 300 FDM Channels, ≤ 5 MHz	FM analog	No	1
≤ 600 FDM Channels, 10 MHz	FM analog	No	1

Table 13, **RF-6000EW, 40 MHz RF Bandwidth, always equalized.**

Traffic	Modulation	Equalizers, 1 Repeater	Equalize at <i>n</i> Tandem Repeaters
135 Mb/s, 3xDS3, 40 MHz	16QAM, 32TCM	Yes	1
135 Mb/s, 3xDS3, 40 MHz	64QAM, 128TCM	Yes	1
140 Mb/s, 4xE3 40 MHz	16QAM, 32TCM	Yes	1
140 Mb/s, 4xE3 40 MHz	64QAM, 128TCM	Yes	1
155 Mb/s, OC-3 40 MHz	64QAM, 128TCM	Yes	1
180 Mb/s, 4xDS3, 40 MHz	16QAM, 64QAM, 128QAM, 32TCM, 64TCM, 128TCM	Yes	1
1800 FDM Channels 40 MHz	FM analog	Yes	1
2400 FDM Channels 40 MHz	FM analog	Yes	1
TV, Color	FM analog	Yes	1

Table 14, **RF-7000EL, RF-8000EL, 28 MHz RF Bandwidth, no equalizers available, always unequalized.**

Traffic	Modulation	Equalizers, 1 Repeater	Max Tandem Repeaters
≤ 13 Mb/s, 8xDS1, 3.5 MHz	16QAM, 64QAM, QPR7, 49QPRS	No	1
26 Mb/s, 16xDS1, 5 MHz	64QAM, 128TCM	No	1
26 Mb/s, 16xDS1, 10 MHz	16QAM, 32TCM	No	1
45 Mb/s, 1xDS3, 10 MHz	QPR9, 81QPRS, 64QAM, 64TCM	No	1
2 Mb/s, 1xE1	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	1
8 Mb/s, 4xE1, 1xE2	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	1
34 Mb/s, 1xE3, 28 MHz	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	1
34 Mb/s, 1xE3, 14 MHz	16QAM, 16TCM, 32TCM	No	1
≤ 300 FDM Channels, ≤ 5 MHz	FM analog	No	1
≤ 600 FDM Channels, 10 MHz	FM analog	No	1

Table 15, RF-7000E, RF-8000E, 30 MHz RF Bandwidth

Traffic	Modulation	Equalizers, 1 Repeater	Equalize at <i>n</i> Tandem Repeaters
≤ 13 Mb/s, 8xDS1, 3.5 MHz	16QAM, 64QAM, QPR7, 49QPRS	No	4
45 Mb/s, 1xDS3, 10 MHz	QPR9, 81QPRS, 64QAM, 64TCM	No	3
90 Mb/s, 2xDS3, 30 MHz	16QAM, 32TCM	If required by Radio	2
135 Mb/s, 3xDS3, 30 MHz	64QAM, 128TCM	If required by Radio	2
2 Mb/s, 1xE1	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	3
8 Mb/s, 4xE1, 1xE2	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	3
34 Mb/s, 1xE3, 28 MHz	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	2
34 Mb/s, 1xE3, 14 MHz	16QAM, 16TCM, 32TCM	No	2
140 Mb/s, 4xE3 30 MHz	64QAM, 128TCM	If required by Radio	2
155 Mb/s, OC-3 30 MHz	128TCM	If required by Radio	2
180 Mb/s, 4xDS3, 40 MHz	16QAM, 64QAM, 128QAM, 32TCM, 64TCM, 128TCM	If required by Radio	2
≤ 300 FDM Channels, ≤ 5 MHz	FM analog	No	3
≤ 600 FDM Channels, 10 MHz	FM analog	No	2
1800 FDM Channels 30 MHz	FM analog	Yes	1
TV, Color	FM analog	Yes	1

Table 16, RF-7000E-04, -44, RF-8000E-04, -44, 2 Amplifier 1+1, low cost.

Traffic	Modulation	Equalizers, 1 Repeater	Max Tandem Repeaters
2 Mb/s, 1xE1	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	4
8 Mb/s, 4xE1, 1xE2	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	4
34 Mb/s, 1xE3, 28 MHz	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	2
34 Mb/s, 1xE3, 14 MHz	16QAM, 16TCM	No	2
68 Mb/s, 2xE3, 28 MHz	8PSK, 16QAM, 16TCM	No	1

Table 17, RF-11000, 40 MHz RF Bandwidth

Traffic	Modulation	Equalizers, 1 Repeater	Equalize at <i>n</i> Tandem Repeaters
45 Mb/s, 1xDS3, 10 MHz	64QAM, 64TCM	No	3
45 Mb/s, 1xDS3, 20 MHz	16QAM, 32TCM	No	3
90 Mb/s, 2xDS3, 40 MHz	16QAM, 32TCM	No	2
135 Mb/s, 3xDS3, 40 MHz	16QAM, 64QAM, 32TCM, 64TCM	If required by Radio	2
180 Mb/s, 4xDS3, 40 MHz	16QAM, 64QAM, 128QAM, 32TCM, 64TCM, 128TCM	If required by Radio	2
34 Mb/s, 1xE3, 28 MHz	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	3
140 Mb/s, 4xE3, 40 MHz	16QAM, 32TCM	No	2
155 Mb/s, OC-3 40 MHz	64QAM, 128TCM	If required by Radio	2
1260 FDM Channels, 40 MHz	FM analog	Yes	1
1800 FDM Channels, 40 MHz	FM analog	Yes	1
TV, Color	FM analog	Yes	1

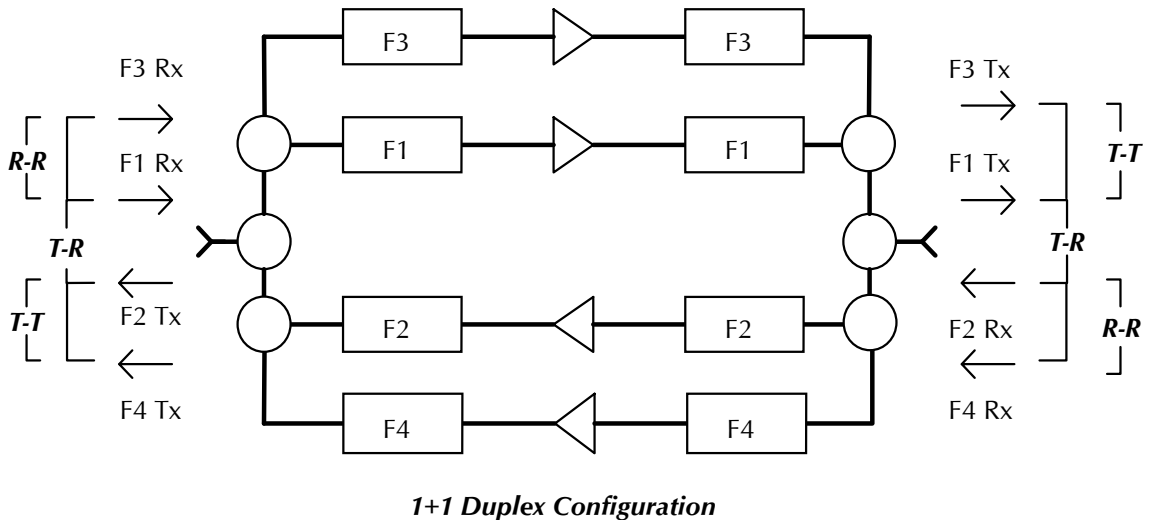
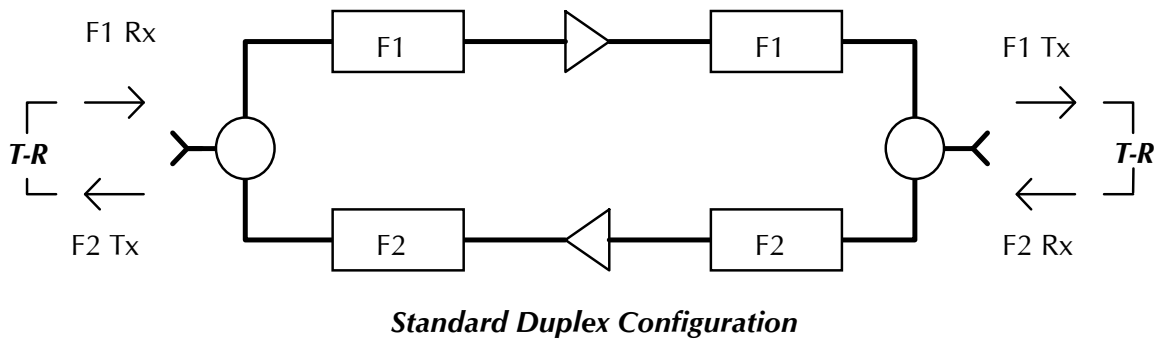
Table 18, RF-11000L, 28 MHz RF Bandwidth, no equalizers available, always unequalized.

Traffic	Modulation	Equalizers, 1 Repeater	Max Tandem Repeaters
26 Mb/s, 16xDS1, 5 MHz	64QAM, 128TCM	No	1
45 Mb/s, 1xDS3, 10 MHz	64QAM, 64TCM, 128TCM	No	1
45 Mb/s, 1xDS3, 20 MHz	16QAM, 32TCM	No	1
34 Mb/s, 1xDS3, 28 MHz	QPSK, OQPSK, 4QAM, 4PSK, FSK, MSK	No	1
600 FDM Channels, 10 MHz	FM analog	No	1
960 FDM Channels, 20 MHz	FM analog	No	1

Frequency Spacing

Microwave RF Repeaters use bandpass filters to separate transmit and receive signals from the radio terminals that pass through the repeaters. There are rules on what frequency spacings are permitted. When a repeater is detail designed in a radio relay network, these rules must be understood and followed. In general, the rules conform to those used by terminal radios. There are exceptions from time to time.

The two basic repeater specifications that apply are the Transmit to Receive (T-R) Spacing and the Transmit-to-Transmit (T-T) Spacing (same as Receive-to-Receive Spacing). Simple duplex equipment configurations are easy to understand as only T-R spacing applies. The more complex 1+1, 2+1, 3+1 and other multiline configurations demand more study before being able to reach a rule conclusion. Please see the following diagrams to understand more about the spacing definitions.



<u>RF Repeater</u>	<u>Repeater Bandwidth, MHz</u>	<u>T-R Spacing MHz, min., Common Feeder</u>	<u>T-T Spacing MHz, min., Common Feeder</u>
RF-1500E	16	49	28
RF-2000E	20	50	28
RF-2000EW	30	80	42
RF-2500E	20	50	28
RF-4000	40	80	80 (with digital radio)
RF-4500	40	80	80 (with digital radio)
RF-6000E	30	80	56
RF-6000EL	28	80	56
RF-6000EW	40	100	80
RF-7000E	30	80	56
RF-7000EL	28	80	56
RF-8000E	30	80	56
RF-8000EL	28	80	56
RF-11000	40	130	80
RF-11000L	28	130	80

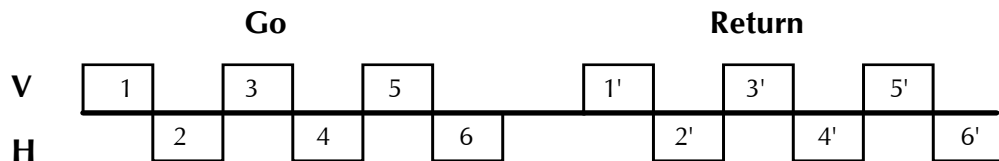
Table 20, MW RF Repeater - Frequency Spacings

The term *Common Feeder* refers to a single coaxial cable or waveguide used to connect all the signals under consideration to the microwave antenna. Configurations where *Separate Feeders* are used may have closer system frequency spacings.

Examples:

- Separate transmit and receive feeders when dual polarized antennas are used.
- Separate transmit and receive antennas, dual polarized T-R, T-R with adjacent channels on opposite polarization.

These Separate Feeder configurations require consulting with engineering for semi-custom work. The work is relatively easy but is not in normal documents.



Typical Microwave Frequency Plan

V = Vertical Polarization. H = Horizontal Polarization

Channel Pairs: 1, 1'; 2, 2';...6, 6'.

Power Amplifiers

In several of the repeaters such as RF-6000E/EW, RF-7000E and RF-8000E there is a selection of power amplifiers available. These amplifiers are shown as Level 1, Level 2 and so on. The selection depends on the results of the radio link planning such as with Peninsula Engineering Solutions Path Data Sheets. Consider that higher power amplifiers are more expensive and consume more power.

Modulation

The modulation of the microwave radio terminal must be considered. The repeater output power setting is determined by the terminal modulation. Normally, repeaters operate with one carrier per amplifier. Some repeater configurations operate with two carriers per amplifier and are so noted (I). Refer to tables 21a and 21b.

RF Repeater	FM FSK 4FSK MSK	16 QAM	64 QAM	256 QAM	512 QAM	16 TCM	32 TCM	64 TCM	128 TCM
RF-1500E	+23	+17	+13	+11	+9	+16	+14	+13	+12
RF-2000E, L1	+24	+18	+14	+12	+10	+17	+15	+14	+13
RF-2000E, L2	+28	+22	+18	+16	+14	+21	+19	+18	+17
RF-2000EW, L1	+24	+18	+14	+12	+10	+17	+15	+14	+13
RF-2000EW, L2	+28	+22	+18	+16	+14	+21	+19	+18	+17
RF-2500E	+23	+17	+13	+11	+9	+16	+14	+13	+12
RF-4000	+25	+19	+14	+13	+11	+18	+16	+15	+14
RF-4500	+25	+19	+14	+13	+11	+18	+16	+15	+14
RF-6000E, EL, L1	+24	+18	+14	+12	+10	+17	+15	+14	+13
RF-6000E, EL, L2	+28	+22	+18	+16	+14	+21	+19	+18	+17
RF-6000E-04 L1 (I)	+20	+14	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RF-6000E-44 L2 (I)	+24	+18	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RF-6000EW, L1	+24	+18	+14	+12	+10	+17	+15	+14	+13
RF-6000EW, L2	+28	+22	+18	+16	+14	+21	+19	+18	+17
RF-7000E, EL, L1	+24	+18	+14	+12	+10	+17	+15	+14	+13
RF-7000E, EL, L2	+28	+22	+18	+16	+14	+21	+19	+18	+17
RF-7000E-04 (I)	+20	+14	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RF-8000E, EL, L1	+24	+18	+14	+12	+10	+17	+15	+14	+13
RF-8000E, EL, L2	+28	+22	+18	+16	+14	+21	+19	+18	+17
RF-8000E-04 (I)	+20	+14	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RF-11000, L	+27	+21	+17	+15	+13	+20	+18	+17	+16

Table 21a, Repeater Output Power

RF Repeater	FM FSK MSK	QPSK OQPSK 4 PSK 4 QAM	8 PSK 8 QAM	QPR3 9QPRS	QPR5 25QPRS	QPR7 49QPRS	QPR9 81QPRS	QPR15 225QPRS
RF-1500E	+23	+21	+19	+18	+17.5	+17	+16	+14
RF-2000E, L1	+24	+22	+20	+19	+18.5	+18	+17	+15
RF-2000E, L2	+28	+26	+24	+23	+22.5	+22	+21	+19
RF-2000EW, L1	+24	+22	+20	+19	+18.5	+18	+17	+15
RF-2000EW, L2	+28	+26	+24	+23	+22.5	+22	+21	+19
RF-2500E	+23	+21	+19	+18	+17.5	+17	+16	+14
RF-4000	+25	+23	+21	+20	+19.5	+19	+18	+16
RF-4500	+25	+23	+21	+20	+19.5	+19	+18	+16
RF-6000E, EL, L1	+24	+22	+20	+19	+18.5	+18	+17	+15
RF-6000E, EL, L2	+28	+26	+24	+23	+22.5	+22	+21	+19
RF-6000E-04 L1 (1)	+20	+18	+16	N/A	N/A	N/A	N/A	N/A
RF-6000E-44 L2 (1)	+24	+22	+20	N/A	N/A	N/A	N/A	N/A
RF-6000EW, L1	+24	+22	+20	+19	+18.5	+18	+17	+15
RF-6000EW, L2	+28	+26	+24	+23	+22.5	+22	+21	+19
RF-7000E, EL, L1	+24	+22	+20	+19	+18.5	+18	+17	+15
RF-7000E, EL, L2	+28	+26	+24	+23	+22.5	+22	+21	+19
RF-7000E-04 (1)	+20	+18	N/A	N/A	N/A	N/A	N/A	N/A
RF-8000E, EL, L1	+24	+22	+20	+19	+18.5	+18	+17	+15
RF-8000E, EL, L2	+28	+26	+24	+23	+22.5	+22	+21	+19
RF-8000E-04 (1)	+20	+18	N/A	N/A	N/A	N/A	N/A	N/A
RF-11000, L	+27	+25	+23	+22	+21.5	+21	+20	+18

Table 21b, Repeater Output Power

Final Repeater Selection

With all the needed information collected and the various selections made, it is time to refer to the price book or individual repeater manuals for model and part number selection. Refer to the repeater selection form below and the examples on the following page. Fill out the selection form.

<u>Frequency, MHz</u>	<u>Traffic</u>	<u>Modulation</u>	<u>Repeater Model</u>	<u>Config.</u>	<u>Delay Equalization</u>	<u>Power Amplifier Level</u>	<u>Output Power</u>	<u>Repeater Part Number</u>
f1								
f2								
f3								
f4								
f5								
f6								
f7								
f8								

Repeater Selection Form

Examples

Completed Repeater Selection Forms are shown below.

<u>Frequency, MHz</u>	<u>Traffic</u>	<u>Modulation</u>	<u>Repeater Model</u>	<u>Config.</u>	<u>Delay Equalization</u>	<u>Power Amplifier Level</u>	<u>Output Power dBm</u>	<u>Repeater Part Number</u>	
f1 5974.85	135 Mb/s	64 QAM	RF-6000E	1+1	Yes	1	+14	900-0221-32	
6226.89 f2	"	"			"	2	+18		
f3 6034.15	"	"			"	1	+14		
6286.19 f4	"	"			"	2	+18		
f5									
f6									
f7									
f8									

<u>Frequency, MHz</u>	<u>Traffic</u>	<u>Modulation</u>	<u>Repeater Model</u>	<u>Config.</u>	<u>Delay Equalization</u>	<u>Power Amplifier Level</u>	<u>Output Power dBm</u>	<u>Repeater Part Number</u>	
f1 1716.0	34 Mb/s	QPSK	RF-2000EW	1+0	Yes	1	22	900-0212-11	
1835.0 f2	"	"			"	1	22		
f3									
f4									
f5									
f6									
f7									
f8									

Repeater Monitor and Alarm Systems

Alarm Equipment for Microwave RF Repeaters

Peninsula Engineering Solutions manufactures alarm equipment for use with microwave RF repeaters. The alarm equipment is the RMAS-120. The RMAS-120 is the third generation alarm equipment available for all currently manufactured repeaters.

Since Microwave RF Repeaters are on-frequency, through repeaters without circuit drops, traditional alarm systems used by terminal radios cannot be directly used here. The RMAS-120 was specifically developed to provide remote monitoring and alarms for RF repeaters installed in remote locations.

The RMAS-120 Alarm equipment consists of a transmitter unit located at the repeater site inside the RF Repeater enclosure and a receiver unit located at one of the adjacent microwave radio terminals. Optionally, two receiver units may be employed, one at each terminal end.

The alarm transmitter unit gathers inputs from the RF repeater, associated power systems, antenna systems and security; combines these inputs into a serial data stream and transmits the information to the distant receiver unit by low level, amplitude modulating one or more microwave carriers that pass through the RF repeater. The microwave carrier transports the alarm information to the distant radio terminal where the alarm receiver extracts the information from the automatic gain control (AGC) circuit of the microwave radio receiver. The alarm receiver then decodes the information into point-by-point outputs for extension to other supervisory or network management systems used in the radio relay or transmission network.

Alternative alarm data transport is available where a UHF radio telemetry link is provisioned. Typically, 900 MHz unlicensed spectrum allocations are used. The radio telemetry link operates in parallel with one of the microwave paths, thus, benefiting from line-of-sight propagation.

For more details, refer to the Operations Manuals for the specific equipment.

Selecting RMAS Equipment

RMAS equipment can be selected correctly only after first choosing the microwave RF repeater with its specific configuration. Refer to the RMAS Selection Form below for the information needed. There are completed examples of the selection form at the end of this section.

<u>Repeater Model</u>	<u>Configuration</u>	<u>Operating Voltage</u>	<u>RMAS Model</u>	<u>RMAS Part Number</u>

Repeater Monitor and Alarm System Selection Form

Configuration

Tables 22a, 22b and 23 describe the variety of RMAS-120 configurations available and how they normally match the microwave RF repeaters.

- The Coax, W/G (waveguide) Pressure Switch is used to sense air pressure levels inside pressurized feeders. When the pressure is low, an alarm occurs.
- The Alarm Transmitter and Receiver units automatically operate over a wide range of input voltages. Transmitter nominal battery voltages are listed. Receiver voltage range is listed.
- The Local Transmitter Output consists of point-by-point opto-isolator floating outputs. These are located at the repeater site. This output may be used when other Alarm Supervision equipment is co-located at the repeater site, perhaps a back-to-back radio repeater is already there and may be used to aggregate and transport the alarm data to the maintenance or operations center.

<u>Configuration</u>	<u>RMAS-120-YY</u>	<u>Part Number 900-0782-YY</u>
1+0, One-Way, 1-Amplifier	• RMAS-120-01	900-0782-01
1+0, 2-Amplifiers	• RMAS-120-01	900-0782-01
1+1, 2+0, 2-Amplifiers	• RMAS-120-01	900-0782-01
1+1, 2+0, 4-Amplifiers	• RMAS-120-02	900-0782-02
2+1, 3+0, 6-Amplifiers	• RMAS-120-03	900-0782-03
3+1, 4+0, 8-Amplifiers	• RMAS-120-04	900-0782-04
Coax, W/G Pressure Switch	• <i>Optional</i>	034-0004-01
+12 or +24 VDC Transmitter	• -01, -02, -03, -04	-01, -02, -03, -04
21 to 72 VDC Receiver, + or - polarity	• -01, -02, -03, -04	-01, -02, -03, -04
Local Transmitter Output	• -01, -02, -03, -04	-01, -02, -03, -04

*Table 22a, Remote Monitor and Alarm System Standard Configurations
(• = Available)*

Configuration, continued.

<u>Configuration</u>	<u>RMAS-120-YY</u>	<u>Part Number 900-0782-YY</u>
1+0, One-Way, 1-Amplifier	• RMAS-120-81	900-0782-81
1+0, 2-Amplifiers	• RMAS-120-81	900-0782-81
1+1, 2+0, 2-Amplifiers	• RMAS-120-81	900-0782-81
1+1, 2+0, 4-Amplifiers	• RMAS-120-82	900-0782-82
2+1, 3+0, 6-Amplifiers to 3+1, 4+0, 8-Amplifiers	• RMAS-120-84	900-0782-84
Coax, W/G Pressure Switch	• <i>Optional</i>	034-0004-01
+12 or +24 VDC Transmitter	• -81, -82, -84	-81, -82, -84
21 to 72 VDC Receiver, + or - polarity	• -81, -82, -84	-81, -82, -84
Local Transmitter Output	• -81, -82, -84	-81, -82, -84

*Table 22b, Remote Monitor and Alarm System UHF Telemetry Configurations
(• = Available)*

<u>RF Repeater</u>	<u>RMAS-120</u>
RF-1500E	• -01, -02, -81, -82; +12 VDC
RF-2000E	• -01, -02, -81, -82; +12 VDC
RF-2000EW	• -01, -02, -81, -82; +12 VDC
RF-2500E	• -01, -02, -81, -82; +12 VDC
RF-4000	• -01, -02, -03, -04, -81, -82, -84; +12 VDC
RF-4000N	• -01, -02, -03, -04, -81, -82, -84; +12 VDC
RF-4500	• -01, -02, -03, -04, -81, -82, -84; +12 VDC
RF-6000E	• -01, -02, -03, -04, -81, -82, -84; +12 VDC
RF-6000E-04	• -01,-81; +12 VDC
RF-6000EL	• -01, -02, -81, -82; +12 VDC
RF-6000EW	• -01, -02, -03, -04, -81, -82, -84; +12 VDC
RF-7000E	• -01, -02; -03, -04, -81, -82, -84 +12 VDC
RF-7000E-04	• -01,-81; +12 VDC
RF-7000EL	• -01, -02, -81, -82; +12 VDC
RF-8000E	• -01, -02; -03, -04, -81, -82, -84 +12 VDC
RF-8000E-04	• -01,-81; +12 VDC
RF-8000EL	• -01, -02, -81, -82; +12 VDC
RF-11000	• -01, -02, -03, -04, -81, -82, -84; +24 VDC
RF-11000L	• -01, -02, -81, -82; +24 VDC

*Table 23, RMAS & Repeater Applications,
(• = Applies), (Tx VDC)*

Final RMAS Selection

With all the needed information collected and the various selections made, it is time to refer to the price book or individual RMAS manuals for model and part number selection. Refer to the RMAS selection form examples below. Fill out the selection form.

<u>Repeater Model</u>	<u>Configuration</u>	<u>Operating Voltage</u>	<u>RMAS Model</u>	<u>RMAS Part Number</u>
RF-6000EW-16	3+1	+12 VDC	RMAS-120-04	900-0782-04

Repeater Monitor and Alarm System Selection Form, RMAS-120, RF-6000EW-16

<u>Repeater Model</u>	<u>Configuration</u>	<u>Operating Voltage</u>	<u>RMAS Model</u>	<u>RMAS Part Number</u>
RF-11000-51	1+0	+24 VDC	RMAS-120-01	900-0782-01

Repeater Monitor and Alarm System Selection Form, RMAS-120, RF-11000-51

<u>Repeater Model</u>	<u>Configuration</u>	<u>Operating Voltage</u>	<u>RMAS Model</u>	<u>RMAS Part Number</u>
RF-1500E-01	1+0	+12 VDC	RMAS-120-01	900-0782-01

Repeater Monitor and Alarm System Selection Form, RMAS-120, RF-1500E-01

<u>Repeater Model</u>	<u>Configuration</u>	<u>Operating Voltage</u>	<u>RMAS Model</u>	<u>RMAS Part Number</u>
RF-2000EW-12	1+1	+12 VDC	RMAS-120-02	900-0782-02

Repeater Monitor and Alarm System Selection Form, RMAS-120, RF-2000EW-12