

MOTOTRBO™ REPEATER

PROFESSIONAL DIGITAL TWO-WAY RADIO SYSTEM



SLR 1000 Repeater Basic Service & Installation Manual

JUNE 2017

© 2017 Motorola Solutions, Inc. All rights reserved



MN003557A01-AA

Preliminary FCC Filing

Notice

Foreword

This manual covers all versions of the MOTOTRBO SLR 1000 Repeater, unless otherwise specified. It includes all the information necessary to maintain peak product performance and maximum working time, using levels 1 and 2 maintenance procedures. These levels of service go down to software issues or replacement of an accessory, which are commonly performed by local service centers, Motorola Solutions Authorized Dealers, self-maintained customers, and distributors.



CAUTION: These servicing instructions are for use by qualified personnel only. To reduce the risk of electric shock, do not perform any servicing other than that contained in the Operating Instructions unless you are qualified to do so. Refer all servicing to qualified service personnel.

General Safety Precautions

For more information, see [General Safety and Installation Standards and Guidelines](#).

Computer Software Copyrights

The Motorola Solutions products described in this manual may include copyrighted Motorola Solutions computer programs stored in semiconductor memories or other media. Laws in the United States and other countries preserve for Motorola Solutions certain exclusive rights for copyrighted computer programs, including, but not limited to, the exclusive right to copy or reproduce in any form the copyrighted computer program. Accordingly, any copyrighted Motorola Solutions computer programs contained in the Motorola Solutions products described in this manual may not be copied, reproduced, modified, reverse-engineered, or distributed in any manner without the express written permission of Motorola Solutions.

Furthermore, the purchase of Motorola Solutions products shall not be deemed to grant either directly or by implication, estoppel, or otherwise, any license under the copyrights, patents or patent applications of Motorola Solutions, except for the normal non-exclusive license to use that arises by operation of law in the sale of a product.

Document Copyrights

No duplication or distribution of this document or any portion thereof shall take place without the express written permission of Motorola Solutions.

No part of this manual may be reproduced, distributed, or transmitted in any form or by any means, electronic or mechanical, for any purpose without the express written permission of Motorola Solutions.

Disclaimer

The information in this document is carefully examined, and is believed to be entirely reliable.

However, no responsibility is assumed for inaccuracies. Furthermore, Motorola Solutions reserves the right to make changes to any products herein to improve readability, function, or design. Motorola Solutions does not assume any liability arising out of the applications or use of any product or circuit described herein; nor does it cover any license under its patent rights nor the rights of others. Controlled copies of this document is available through Motorola Solutions On-Line (MOL).

Trademarks

MOTOROLA, MOTO, MOTOROLA SOLUTIONS and the Stylized M logo are trademarks or registered trademarks of Motorola Trademark Holdings, LLC and are used under license. All other trademarks are the property of their respective owners.

© 2017 Motorola Solutions, Inc.

All rights reserved.

Preliminary FCC Filing

Notice

General Safety and Installation Standards and Guidelines

ATTENTION!




WARNING: For safe installation, operation, service and repair of this equipment, follow the safety precautions and instructions described below, as well as any additional safety information in Motorola Solutions product service and installation manuals and the Motorola Solutions R56 Standards and Guidelines for Communications Sites manual (which can be obtained by ordering CDROM 9880384V83). To obtain copies of these materials, please contact Motorola Solutions as directed at the end of this section. After installation, these instructions should be retained and readily available for any person operating or servicing this repeater or working near it.

Failure to follow these safety precautions and instructions could result in serious injury or property damage.

The installation process requires preparation and knowledge of the site before installation begins. Review installation procedures and precautions in the Motorola Solutions R56 manual before performing any site or component installation. Personnel must use safe work practices and good judgment, and always follow applicable safety procedures, such as requirements of the Occupational Safety and Health Administration (OSHA), the National Electrical Code (NEC), and local codes.

The following are additional general safety precautions that must be observed:

- To continue compliance with any applicable regulations and maintain the safety of this equipment, do not install substitute parts or perform any unauthorized modifications.
- All equipment must be serviced by Motorola Solutions trained personnel.
- If troubleshooting the equipment while the power is on, be aware of live circuits which could contain hazardous voltage.
- Do not operate the radio transmitters unless all RF connectors are secure and all connectors are properly terminated.
- All equipment must be properly grounded in accordance with the Motorola Solutions R56 and specified installation instructions for safe operation.
- Openings between the fins on the chassis are provided for ventilation. Do not block or cover openings between the fins that protect the devices from overheating.
-  Some equipment components can become extremely hot during operation. Turn off all power to the equipment and wait until sufficiently cool before touching.
- Maintain emergency first aid kits at the site.
- Never store combustible materials in or near equipment. The combination of combustible material, heat and electrical energy increases the risk of a fire hazard.
- Equipment shall be installed in a site that meets the requirements of a "restricted access location," per (UL60950-1 & EN60950-1), which is defined as follows: "Access can only be gained by service persons or by users who have been instructed about the reasons for the restrictions applied to the location and about any precautions that shall be taken; and access is through the use of a tool or lock and key, or other means of security, and is controlled by the authority responsible for the location."

- Ensure that the installation area can safely support the weight of the repeater.



- Burn hazard. The metal housing of the product may become extremely hot. Use caution when working around the equipment.



- RF energy burn hazard. Disconnect power in the cabinet to prevent injury before disconnecting and connecting antennas.
- Shock hazard. The outer shields of all Tx and Rx RF cables outer shields must be grounded per Motorola Solutions R56 manual.
- All Tx and Rx RF cables shall be connected to a surge protection device according to Motorola Solutions R56 manual. Do not connect Tx and Rx RF cables directly to an outside antenna.



- **Attention** Compliance with National and International standards and guidelines for human exposure to Electromagnetic Energy (EME) at Transmitter Antenna sites generally requires that persons having access to a site shall be aware of the potential for exposure to EME and can exercise control of exposure by appropriate means, such as adhering to warning sign instructions. See this installation manual and Appendix A of Motorola Solutions R56.

This product complies with the requirements set forth by the European R&TTE regulations and applicable CENELEC standards concerning human exposure to Electromagnetic Energy (EME) at Transmitter Antenna sites. [Appendix E: MOTOTRBO Repeater EME Assessment on page 99](#) in this manual includes an EME exposure analysis of a typical system configuration for this product.

For a different system configuration than the typical configuration, compliance with applicable EME exposure standards (current versions of the EN50384, EN50385, IEC/IEEE 62704-2, and United States Federal Communication Commission, "Evaluating compliance with FCC guidelines for human exposure to radio frequency electromagnetic fields," OET Bulletin 65 (Ed. 97-01), August 1997. Supplement C (Edition 01-01) to US FCC OET Bulletin 65 (Edition 97-01), "Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radio frequency Emissions," June 2001 standards for occupational and general public exposure, respectively) can be evaluated by either employing the indoor or outdoor methods illustrated in the typical system configuration EME exposure analysis included in [Appendix E: MOTOTRBO Repeater EME Assessment on page 99](#) in this manual, or employing another suitable method among those described in the current version of the EN50383 standard.

Once the occupational and general public compliance boundaries are determined, means to ensure that workers and people are outside the respective boundaries, for instance using appropriate signage or restricted access, should be implemented; if this is not possible or practically achievable for the specific system configuration, the configuration should be modified in order to make it possible. The R56 Standards and Guidelines for Communications Sites manual (which can be obtained by ordering CDROM 9880384V83) provides examples of signage that can be used to identify the occupational or general public compliance boundaries.

Refer to product specific manuals for detailed safety and installation instructions. Manuals can be obtained with product orders, downloaded from <https://businessonline.motorolasolutions.com>, or purchased through the Motorola Solutions Aftermarket & Accessory Department.

This is a class A product. In a domestic environment, this product may cause radio interference in which case the user may be required to take adequate measures.

Notice

MOTOTRBO SLR 1000 Repeater Supplemental Safety and Installation Requirements

ATTENTION!

The MOTOTRBO SLR 1000 Repeater must be installed in a suitable, in-building location, or suitable outdoor location. A restricted access location is required when installing this equipment into the end system.

When installing the equipment, all requirements of relevant standards and local electrical codes must be fulfilled.

The maximum operating ambient temperature of this equipment is 60 °C. The maximum operating altitudes are supported, up to 2000 meters above sea level. Reduced performance above 2000 meters may result.

Preliminary FCC Filing

This page intentionally left blank.

Notice

Environmental Information

Material Content



NOTICE:

- The Motorola Solutions MOTOTRBO SLR 1000 Repeater system and its subsystems have been created in compliance with the environmental goals of the European Union's Restriction of Hazardous Substances (RoHS 2) Directive 2011/65/EU and the Waste Electrical and Electronic Equipment (WEEE) Directive 2012/19/EU as well as Motorola Solutions corporate goals to minimize environmental impact of its products.
- This Motorola Solutions policy is reflected throughout the entire design, procurement, assembly, and packaging process.
- In support of these efforts to provide environmentally-responsible products, please comply with the information in the following sections regarding product disposal for systems being replaced.

Disposal of your Electronic and Electric Equipment

Do not dispose of electronic and electric equipment or electronic and electric accessories with your household waste. In some countries or regions, collection systems have been set up to handle waste of electrical and electronic equipment.

In European Union countries, contact your local equipment supplier representative or service center for information about the waste collection system in your country.

Disposal Guideline



— The European Union's WEEE directive symbol on a Motorola Solutions product indicates that the product should not be disposed of with household waste.

Preliminary FCC Filing

This page intentionally left blank.

Document History

The following major changes have been implemented in this manual since the previous edition:

Edition	Description	Date
MN003557A01-AA	Initial release of the MOTOTRBO SLR 1000 Repeater Basic Service & Installation manual	June 2017

Preliminary FCC Filing

This page intentionally left blank.

Contents

Document History.....	11
List of Figures.....	19
List of Tables.....	21
List of Procedures.....	23
Related Publications.....	25
Summary of Bands Available.....	27
Chapter 1: SLR 1000 Repeater.....	33
1.1 Notations Used in This Manual.....	33
1.2 Description.....	33
1.3 Operating Features.....	35
1.4 Frequency Ranges and Power Levels.....	36
1.5 Specifications.....	36
1.6 Theory of Operation.....	39
1.7 Basic Repeater Level Troubleshooting – RDAC and LEDs.....	40
1.8 SLR 1000 Repeater Model Numbering Scheme.....	42
1.9 UHF High Power Model Chart.....	42
Chapter 2: SLR 1000 Satellite Receiver.....	43
2.1 Description.....	43
2.2 Operating Features.....	43
2.3 Frequency Ranges.....	43
2.4 Specifications.....	43
2.5 Configuration.....	43
2.6 Basic Station Level Troubleshooting – RDAC and LEDs.....	44
2.7 Model Chart.....	44
Chapter 3: SLR 1000 Transceiver Board.....	45
3.1 Description.....	45
3.1.1 General Description.....	45
3.1.2 Input and Output Connections.....	45
3.1.3 Frequency Bands.....	46
3.2 Receiver Subsystem.....	46
3.2.1 Specifications.....	46
3.3 Transmitter Subsystem.....	47
3.3.1 Specifications.....	47
3.4 Station Control Subsystem.....	47
3.4.1 Audio.....	48

3.5 Station Control Interface.....	49
3.5.1 Bottom Panel Connections.....	49
3.5.2 Expansion Board Interface Connector.....	49
Chapter 4: SLR 1000 Front Panel.....	51
4.1 Description.....	51
Chapter 5: SLR 1000 Bottom Panel.....	53
5.1 Description.....	53
5.1.1 General Description.....	53
5.2 Bottom Panel Interfaces.....	53
5.2.1 DC Power Inlet.....	54
5.2.2 USB.....	54
5.2.3 Ethernet.....	54
5.2.4 Auxiliary (Aux)/Accessory.....	55
Chapter 6: SLR 1000 Test Equipment And Service Aids.....	57
6.1 Recommended Test Equipment.....	57
6.2 Service Aids.....	57
Chapter 7: SLR 1000 Performance Check or Testing.....	59
7.1 General.....	59
7.2 Transmitter Testing.....	59
7.2.1 Introduction.....	59
7.2.2 Test Equipment.....	59
7.2.3 Verifying Transmitter Circuitry.....	60
7.3 Receiver Testing.....	61
7.3.1 Introduction.....	61
7.3.2 Required Test Equipment.....	62
7.3.3 Verifying Receiver Circuitry.....	62
Chapter 8: SLR 1000 Programming and Tuning.....	65
8.1 Introduction.....	65
8.2 Radio Management Setup.....	65
8.3 Reference Oscillator Alignment.....	66
8.3.1 Tuning the Reference Oscillator.....	66
8.4 Repeater Tuning Setup.....	66
8.5 Rx Audio Level Set.....	67
8.5.1 Tuning the Rx Audio Level Set.....	67
8.6 Tx Audio Level Set.....	68
8.6.1 Tuning the Tx Audio Level Set.....	68
8.7 Modulation Limit Alignment.....	69
8.7.1 Tuning the Modulation Limit (with no Tx Data and no PL).....	69
8.7.2 Verifying the Modulation Limit (with no Tx Data and no PL).....	69

Chapter 9: SLR 1000 Maintenance and Disassembly/Reassembly.....	71
9.1 Introduction.....	71
9.2 Routine Maintenance.....	71
9.3 Preventive Maintenance.....	72
9.3.1 Inspection.....	72
9.3.2 Cleaning Procedures.....	72
9.4 Safe Handling of CMOS and LDMOS Devices.....	72
9.5 Installing a Duplexer.....	73
9.6 Installing a High-Speed Solid-State Antenna Switch.....	75
Chapter 10: SLR 1000 Installation.....	77
10.1 Pre-Installation Considerations.....	77
10.1.1 Installation Overview.....	77
10.1.2 Site Environmental Conditions.....	77
10.1.3 Equipment Ventilation.....	78
10.1.3.1 Ventilation for a Ceiling Mount.....	78
10.1.3.2 Ventilation for a Wall Mount.....	78
10.1.4 AC and DC Input Power Requirements.....	79
10.1.4.1 DC Input Power Requirements.....	79
10.1.4.2 AC Input Power Requirements.....	79
10.1.4.3 Ground Connection.....	79
10.1.4.4 Battery Connection.....	79
10.1.4.5 RF Antenna Connections.....	80
10.1.4.6 System Cable Connections.....	80
10.1.5 Equipment Mounting Methods.....	80
10.1.6 Site Grounding and Lightning Protection.....	80
10.1.6.1 Electrical Ground.....	81
10.1.6.2 RF Ground.....	81
10.1.6.3 Lightning Ground.....	81
10.1.6.4 Equipment Grounding.....	81
10.1.7 Recommended Tools and Equipment.....	81
10.1.8 Equipment Unpacking and Inspection.....	82
10.1.8.1 Unpack Equipment.....	82
10.1.8.2 Initial Inspection.....	82
10.2 Mechanical Installation.....	82
10.2.1 SLR 1000 Repeater Package Contents.....	82
10.2.2 Mounting the SLR 1000 Repeater to a Wall or Ceiling.....	83
10.2.3 Mounting the SLR 1000 Repeater to a Pole.....	83
10.3 Electrical Connections.....	84
10.3.1 Power Supply Connections.....	85

10.3.1.1 DC Input Power Connection/ DC Power Connection.....	85
10.3.1.2 AC Input Power Connection.....	85
10.3.1.3 Ground Connection.....	86
10.3.1.4 RF Antenna Connections.....	86
10.3.1.5 System Cable Connections.....	86
10.3.2 Installing Cable Grommet Connectors or Plugs.....	86
10.4 Post Installation Checklist.....	87
10.4.1 Apply Power.....	87
10.4.2 Verify Proper Operation.....	87
10.4.3 Front Panel LEDs.....	87
10.4.4 Repeater Codeplug Data Backup.....	88
10.5 General Bonding and Grounding Requirements.....	88
10.6 General Cabling Requirements.....	88
Appendix A: Accessories.....	89
Introduction.....	89
Antennas.....	89
Cables.....	89
Documentation.....	89
Duplexers.....	90
Mounting.....	90
Service Tools.....	90
Appendix B: Replacement Parts Ordering.....	91
Replacement Parts Ordering.....	91
Basic Ordering Information.....	91
Motorola Solutions Online.....	91
Mail Orders.....	91
Telephone Orders.....	91
Fax Orders.....	92
Parts Identification.....	92
Product Customer Service.....	92
Appendix C: Motorola Solutions Service Centers.....	93
Motorola Solutions Service Centers.....	93
Servicing Information.....	93
Motorola Solutions Service Center.....	93
Motorola Solutions Federal Technical Center.....	93
Motorola Canadian Technical Logistics Center.....	93
Appendix D: SLR 1000 Series Third Party Controllers.....	95
Overview.....	95
Tone Remote Adapter.....	95

Compatibility.....	96
Hardware Connections.....	96
Radio Management Configuration (For a 2-Channel Remote Control).....	96
Tone Remote Adapter Settings.....	97
Radio Rx.....	97
Radio Tx.....	98
Channel Steering.....	98
Monitoring.....	98
PTT.....	98
Wildcard 1 (optional).....	98
Appendix E: MOTOTRBO Repeater EME Assessment.....	99
Executive Summary.....	99
Device Power Characteristics.....	99
Outdoor Exposure Prediction Model.....	100
Whole-Body SAR Compliance.....	100
Peak 1-g Average SAR Compliance.....	101
Indoor Exposure Prediction Model.....	102
Exposure in Front of the Antenna.....	102
Exposure at Ground Level.....	103
Typical System Configuration.....	104
Exposure Limits.....	104
EME Exposure Evaluation.....	105
Exposure in Front of the Antenna.....	105
Exposure at Ground Level.....	105
Compliance Boundary Description.....	105
Product Put In Service.....	106
References.....	106
Glossary of Terms and Acronyms.....	109

Preliminary FCC Filing

This page intentionally left blank.

List of Figures

Figure 1: SLR 1000 Repeater Bottom View.....	34
Figure 2: SLR 1000 Repeater Left View.....	34
Figure 3: SLR 1000 Repeater Right View.....	34
Figure 4: SLR 1000 Repeater Bottom View.....	34
Figure 5: SLR 1000 Repeater Front View.....	34
Figure 6: SLR 1000 Repeater Front View (without top cover).....	34
Figure 7: RDAC Diagnostic Screen.....	40
Figure 8: SLR 1000 Repeater Model Numbering Scheme.....	42
Figure 9: Operation Mode Configuration for Satellite Receiver Functionality.....	44
Figure 10: SLR 1000 Repeater Transceiver Board Connector Locations.....	45
Figure 11: SLR 1000 Repeater Audio Block Diagram.....	48
Figure 12: SLR 1000 Repeater Bottom Panel Connector Names and Locations.....	53
Figure 13: DC Power Inlet Connector.....	54
Figure 14: USB Connector.....	54
Figure 15: Ethernet Connector.....	54
Figure 16: Auxiliary/Accessory Connector.....	55
Figure 17: Test Equipment Setup for Verifying Transmitter Circuitry.....	61
Figure 18: Test Equipment Setup for Verifying Receiver Circuitry.....	63
Figure 19: Radio Management Setup.....	65
Figure 20: Bottom View of SLR 1000 Repeater.....	65
Figure 21: Tx Menu Tree (Ref. Oscillator).....	66
Figure 22: SLR 1000 Repeater Tuning Equipment Setup.....	67
Figure 23: RX Menu tree (Rx Rated Volume).....	67
Figure 24: Auxiliary Connector.....	68
Figure 25: Tx Menu Tree (Tx Rated Volume).....	68
Figure 26: TX Menu Tree (Tuning Procedure with No Tx Data).....	69
Figure 27: SLR 1000 Repeater Front View (without top cover).....	74
Figure 28: SLR 1000 Repeater Front View (without top cover) with a Duplexer.....	74
Figure 29: SLR 1000 Repeater Front View (without top cover).....	75
Figure 30: SLR 1000 Repeater Front View (without top cover) with an Antenna Switch.....	76
Figure 31: Bracket Mounting Holes.....	83
Figure 32: Location of Repeater M6 Screw Mounts.....	83
Figure 33: Bracket Receiving Slots.....	83
Figure 34: U-Bolt Bracket Assembly.....	84
Figure 35: Location of Repeater M6 Screw Mounts.....	84
Figure 36: Bracket Receiving Slots.....	84

Figure 37: SLR 1000 Repeater Bottom Panel Connector Names and Locations.....	84
Figure 38: Radio Management Settings to Configure SLR 1000 Repeater for Analog Mode.....	95
Figure 39: Model L3276 Tone Remote Adapter.....	96
Figure 40: Signal Connections Between SLR 1000 Repeater and Motorola L3276 25-Pin Connector for a 2-Channel Remote Control.....	96
Figure 41: Radio Management Configuration for L3276 Tone Remote Adapter (For a 2-Channel Remote Control).....	97
Figure 42: H-Field and SAR Distributions for Exposure from a Dipole Antenna.....	100
Figure 43: Reference Frame for the Point of Interest (POI) Cylindrical Co-Ordinates.....	102
Figure 44: Schematic of the Ground-Level Exposure Model Adopted for the Assessment.....	104
Figure 45: Compliance Boundary for General Public (GP) and Occupational (OCC) Exposure.....	106

List of Tables

Table 1: SLR 1000 Repeater Bottom View Callout Legend.....	34
Table 2: SLR 1000 Repeater Left View Callout Legend.....	34
Table 3: SLR 1000 Repeater Right View Callout Legend.....	34
Table 4: SLR 1000 Repeater Front View Callout Legend.....	34
Table 5: SLR 1000 Repeater Front View (without top Cover) Callout Legend.....	34
Table 6: SLR 1000 Frequency Ranges and Power Levels.....	36
Table 7: SLR 1000 Repeater General Specifications (All Bands).....	36
Table 8: SLR 1000 Repeater Specifications.....	37
Table 9: SLR 1000 Repeater Front Panel LED Indicators.....	40
Table 10: SLR 1000 Front Panel LED Definitions.....	41
Table 11: SLR 1000 Repeater Front View (without top Cover) Callout Legend.....	45
Table 12: Specifications of Receiver Subsystem.....	46
Table 13: Specifications of Transmitter Exciter Subsystem.....	47
Table 14: SLR 1000 Repeater Connector Types and Primary Functions.....	53
Table 15: DC Power Inlet Connector Callout Legend.....	54
Table 16: USB Connector Callout Legend.....	54
Table 17: Ethernet Connector Callout Legend.....	54
Table 18: Auxiliary/Accessory Connector Callout Legend.....	55
Table 19: Recommended Test Equipment.....	57
Table 20: Service Aids.....	57
Table 21: Bottom View of the SLR 1000 Repeater Callout Legend.....	65
Table 22: SLR 1000 Repeater Front View (without top Cover) Callout Legend.....	74
Table 23: SLR 1000 Repeater Front View (without top Cover) with a Duplexer Callout Legend.....	74
Table 24: SLR 1000 Repeater Front View (without top Cover) Callout Legend.....	75
Table 25: SLR 1000 Repeater Front View (without top Cover) with an Antenna Switch Callout Legend.....	76
Table 26: SLR 1000 Repeater Package Contents.....	82
Table 27: SLR 1000 Repeater Connector Types and Primary Functions.....	84
Table 28: Indoor EME Compliance Distances Based on Example UHF Evaluation.....	99
Table 29: Outdoor EME Compliance Distances Based on Example UHF Evaluation.....	99
Table 30: Whole-Body Average SAR Results.....	100

Preliminary FCC Filing

This page intentionally left blank.

List of Procedures

Verifying Transmitter Circuitry	60
Verifying Receiver Circuitry	62
Tuning the Reference Oscillator	66
Tuning the Rx Audio Level Set	67
Tuning the Tx Audio Level Set	68
Tuning the Modulation Limit (with no Tx Data and no PL)	69
Verifying the Modulation Limit (with no Tx Data and no PL)	69
Installing a Duplexer	73
Installing a High-Speed Solid-State Antenna Switch	75
Mounting the SLR 1000 Repeater to a Wall or Ceiling	83
Mounting the SLR 1000 Repeater to a Pole	83
Installing Cable Grommet Connectors or Plugs	86

Preliminary FCC Filing

This page intentionally left blank.

Related Publications

Related Publications	Part No.
MOTOTRBO SLR 1000 Quick Start Guide	MN003581A01

Preliminary FCC Filing

This page intentionally left blank.

Summary of Bands Available

Table below lists the SLR 1000 Repeater bands available in this manual.

For details, see [UHF High Power Model Chart on page 42](#).

Frequency Band	Bandwidth	Power Level
UHF	400 – 527 MHz	1 – 10 W

Preliminary FCC Filing

This page intentionally left blank.

Notice

Commercial Warranty

Limited Warranty

MOTOROLA COMMUNICATION PRODUCTS

I. What This Warranty Covers And For How Long

MOTOROLA SOLUTIONS INC. ("MOTOROLA") warrants the MOTOROLA manufactured Communication Products listed below ("Product") against defects in material and workmanship under normal use and service for a period of time from the date of purchase as scheduled below:

Repeater	Two (2) Years
Product Accessories	One (1) Year

Motorola, at its option, will at no charge either repair the Product (with new or reconditioned parts), replace it (with a new or reconditioned Product), or refund the purchase price of the Product during the warranty period provided it is returned in accordance with the terms of this warranty. Replaced parts or boards are warranted for the balance of the original applicable warranty period. All replaced parts of Product shall become the property of MOTOROLA.

This express limited warranty is extended by MOTOROLA to the original end user purchaser only and is not assignable or transferable to any other party. This is the complete warranty for the Product manufactured by MOTOROLA. MOTOROLA assumes no obligations or liability for additions or modifications to this warranty unless made in writing and signed by an officer of MOTOROLA. Unless made in a separate agreement between MOTOROLA and the original end user purchaser, MOTOROLA does not warrant the installation, maintenance or service of the Product.

MOTOROLA cannot be responsible in any way for any ancillary equipment not furnished by MOTOROLA which is attached to or used in connection with the Product, or for operation of the Product with any ancillary equipment, and all such equipment is expressly excluded from this warranty. Because each system which may use the Product is unique, MOTOROLA disclaims liability for range, coverage, or operation of the system as a whole under this warranty.

II. General Provisions

This warranty sets forth the full extent of MOTOROLA's responsibilities regarding the Product. Repair, replacement or refund of the purchase price, at MOTOROLA's option, is the exclusive remedy. THIS WARRANTY IS GIVEN IN LIEU OF ALL OTHER EXPRESS WARRANTIES. IMPLIED WARRANTIES, INCLUDING WITHOUT LIMITATION, IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED TO THE DURATION OF THIS LIMITED WARRANTY. IN NO EVENT SHALL MOTOROLA BE LIABLE FOR DAMAGES IN EXCESS OF THE PURCHASE PRICE OF THE PRODUCT, FOR ANY LOSS OF USE, LOSS OF TIME, INCONVENIENCE, COMMERCIAL LOSS, LOST PROFITS OR SAVINGS OR OTHER INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE SUCH PRODUCT, TO THE FULL EXTENT SUCH MAY BE DISCLAIMED BY LAW.

III. State Law Rights

SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES OR LIMITATION ON HOW LONG AN IMPLIED WARRANTY LASTS, SO THE ABOVE LIMITATION OR EXCLUSIONS MAY NOT APPLY.

This warranty gives specific legal rights, and there may be other rights which may vary from state to state

IV. How To Get Warranty Service

You must provide proof of purchase (bearing the date of purchase and Product item serial number) in order to receive warranty service and, also, deliver or send the Product item, transportation and insurance prepaid, to an authorized warranty service location. Warranty service will be provided by Motorola through one of its authorized warranty service locations. If you first contact the company which sold you the Product, it can facilitate your obtaining warranty service. You can also .

V. What This Warranty Does Not Cover

Defects or damage resulting from use of the Product in other than its normal and customary manner.

Defects or damage from misuse, accident, water, or neglect.

Defects or damage from improper testing, operation, maintenance, installation, alteration, modification, or adjustment.

Breakage or damage to antennas unless caused directly by defects in material workmanship.

A Product subjected to unauthorized Product modifications, disassemblies or repairs (including, without limitation, the addition to the Product of non-Motorola supplied equipment) which adversely affect performance of the Product or interfere with Motorola's normal warranty inspection and testing of the Product to verify any warranty claim.

Product which has had the serial number removed or made illegible.

Freight costs to the repair depot.

A Product which, due to illegal or unauthorized alteration of the software/firmware in the Product, does not function in accordance with MOTOROLA's published specifications or the FCC type acceptance labeling in effect for the Product at the time the Product was initially distributed from MOTOROLA.

Scratches or other cosmetic damage to Product surfaces that does not affect the operation of the Product.

Normal and customary wear and tear.

VI. Patent And Software Provisions

MOTOROLA will defend, at its own expense, any suit brought against the end user purchaser to the extent that it is based on a claim that the Product or parts infringe a United States patent, and MOTOROLA will pay those costs and damages finally awarded against the end user purchaser in any such suit which are attributable to any such claim, but such defense and payments are conditioned on the following:

that MOTOROLA will be notified promptly in writing by such purchaser of any notice of such claim;

that MOTOROLA will have sole control of the defense of such suit and all negotiations for its settlement or compromise; and

should the Product or parts become, or in MOTOROLA's opinion be likely to become, the subject of a claim of infringement of a United States patent, that such purchaser will permit MOTOROLA, at its option and expense, either to procure for such purchaser the right to continue using the Product or parts or to replace or modify the same so that it becomes noninfringing or to grant such purchaser a credit for the Product or parts as depreciated and accept its return. The depreciation will be an equal amount per year over the lifetime of the Product or parts as established by MOTOROLA.

MOTOROLA will have no liability with respect to any claim of patent infringement which is based upon the combination of the Product or parts furnished hereunder with software, apparatus or devices not furnished by MOTOROLA, nor will MOTOROLA have any liability for the use of ancillary equipment or software not furnished by MOTOROLA which is attached to or used in connection with the Product. The foregoing states the entire liability of MOTOROLA with respect to infringement of patents by the Product or any parts thereof.

Laws in the United States and other countries preserve for MOTOROLA certain exclusive rights for copyrighted MOTOROLA software such as the exclusive rights to reproduce in copies and distribute copies of such Motorola software. MOTOROLA software may be used in only the Product in which the software was originally embodied and such software in such Product may not be replaced, copied, distributed, modified in any way, or used to produce any derivative thereof. No other use including, without limitation, alteration, modification, reproduction, distribution, or reverse engineering of such MOTOROLA software or exercise of rights in such MOTOROLA software is permitted. No license is granted by implication, estoppel or otherwise under MOTOROLA patent rights or copyrights.

VII. Governing Law

This Warranty is governed by the laws of the State of Illinois, USA.

Preliminary FCC Filing

This page intentionally left blank.

Chapter 1

SLR 1000 Repeater

1.1

Notations Used in This Manual

Throughout the text in this publication, there are WARNING, CAUTION, and Note notations. These notations are used to emphasize that safety hazards exist, and due care must be taken and observed.



NOTICE: An operational procedure, practice, or condition which is essential to emphasize.



CAUTION: CAUTION indicates a potentially hazardous situation which, if not avoided, might result in equipment damage.



WARNING: WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or injury.



Symbol indicates areas of the product that pose potential burn hazards.

1.2

Description

The Motorola SLR 1000 Repeater provides a modular, flexible analog and digital station designed for today's communication systems and for the future.

The station is available for use in these configurations:

- Analog Conventional
- Digital (MOTOTRBO)
- MOTOTRBO DMR Tier 2 Conventional – Single Site
- MOTOTRBO DMR Tier 2 Conventional – IP Site Connect
- MOTOTRBO Capacity Plus Trunking
- MOTOTRBO Connect Plus Trunking
- MOTOTRBO Capacity Max Trunking
- MOTOTRBO Digital Voting



NOTICE: Certain software features enabled through Radio Management can be configured with the Online Help or with a regional representative. See the regional Ordering Guide to determine the features available within the respective regions.

The repeater can either be configured as a stand-alone repeater or as a repeater connected to a network, as in the case of operating in IP Site Connect mode. As a repeater, it listens on one uplink frequency, and then re-transmits on a downlink frequency, thus providing the RF interface to the field subscribers. When configured for analog station operation, the repeater is designed to operate with most existing analog systems, which enables a smooth migration to the MOTOTRBO system.

When configured for digital operation, the repeater offers additional services. The digital repeater operates in TDMA mode, which essentially divides one channel into two virtual channels using time slots; therefore the user capacity is doubled. The repeater utilizes embedded signaling to inform the field radios of the busy/idle status of each channel (time slot), the type of traffic, and even the source and destination information.

See the following figures and tables for connections, ports, LEDs, and their descriptions.

Figure 1: SLR 1000 Repeater Bottom View

Table 1: SLR 1000 Repeater Bottom View Callout Legend

Label	Description
1	USB Port Programming Interface
2	Ethernet Port
3	Aux/Accessory Port
4	DC Power Inlet
5	Bonding Ground Connection

Figure 2: SLR 1000 Repeater Left View

Table 2: SLR 1000 Repeater Left View Callout Legend

Label	Description
1	Receiver RF (Rx) Input
2	Option Dependent 1/GNSS Option Dependent 2/WLAN

Figure 3: SLR 1000 Repeater Right View

Table 3: SLR 1000 Repeater Right View Callout Legend

Label	Description
1	Transmitter RF (Tx) Input
2	Pressure Equalization Vent

Figure 4: SLR 1000 Repeater Bottom View

Figure 5: SLR 1000 Repeater Front View

Table 4: SLR 1000 Repeater Front View Callout Legend

Label	Description
1	Status
2	Ethernet Link/Network Connectivity
3	Reference (for future use)

Figure 6: SLR 1000 Repeater Front View (without top cover)

Table 5: SLR 1000 Repeater Front View (without top Cover) Callout Legend

Label	Description
1	Transmitter RF (Tx) Output
2	Pressure Equalizer Vent

Table continued...

Label	Description
3	Receiver RF (Rx) Output
4	Transmitter RF (Tx) Input
5	Jumper Connection to enable external on/off function
6	Bonding Ground Connection
7	DC Power Inlet
8	Aux/Accessory Port
9	Ethernet Port
10	USB Port Programming Interface
11	Header Connection for optional antenna switch
12	Option Dependent 1 and 2
13	Expansion Board Connection (for future use)
14	Receiver RF (Rx) Input
15	Front Panel Flex Connector

1.3

Operating Features

The following are the standard features of an SLR 1000 Repeater model:

- MOTOTRBO Conventional Operation (2-Slot TDMA, 4FSK Modulation)
- Analog Conventional Operation (FM)
- Continuous Duty Cycle Operation over -30 °C to +60 °C
- Meets or exceeds the following standards:
- TIA603D
- ETSI 086
- ETSI 113
- ETSI TS 102 361-1 Part 1: DMR Air Interface Protocol
- ETSI TS 102 361-2 Part 2: DMR Voice and Generic Services and Facilities
- ETSI TS 102 361-3 Part 3: DMR Packet Data Protocol
- ETSI TS 102 361-4 Part 4: DMR Trunking Protocol
- Synthesized Frequency Generation
- Female N-type Antenna Connector (Tx)
- Female N-type Antenna Connector (Rx)
- Ethernet Port (Network)
- USB Port (Service)
- 4 configurable GPIO ports (Digital)
- 1 configurable GPI ports (Analog)
- 1 configurable GPO ports (Analog)
- 1.5 PPM Frequency Stability (Temperature AND 1-Year Aging) (VHF and UHF)
- Station Diagnostic Tests – Fixed Set of Tests run upon Start-up

- Physical Dimensions: 11" H x 9" W x 4" D (27.94 x 22.86 x 10.16 cm) without brackets or other peripheral equipment
- Weight: 10 pounds (4.56 kg) excluding cabinet or other peripheral equipment

Motorola Solutions Network Interface:

- IP Site Connect
- Repeater Diagnostics and Control (RDAC)
- Capacity Plus
- Connect Plus
- Capacity Max

Third Party Controller Interface:

- Tone Remote Adapter

In addition, the following features are also included. These features are shipped in a preset condition, but may be altered through the use of Radio Management.

- 64 Tx/Rx Frequencies – Factory Programmed with 1 Tx, 1 Rx
- 12.5 kHz or 25 kHz Operation – Factory Programmed to 12.5 kHz
- 1 Tx and 1 Rx (PL or DPL) Squelch Code per channel – Factory Programmed to CSQ
- Base Station Identification (BSI) – Factory Programmed as “BLANK” (“BLANK” disables BSI)
- Push-To-Talk (PTT) Priority – Factory Programmed to Repeat Path

1.4

Frequency Ranges and Power Levels

The SLR 1000 Repeater is available in the following frequency ranges and power levels as specified in [Table 6: SLR 1000 Frequency Ranges and Power Levels on page 36](#).

Table 6: SLR 1000 Frequency Ranges and Power Levels

Frequency Band	Bandwidth	Power Level
UHF	400 – 527 MHz	1 – 10 W

1.5

Specifications

[Table 7: SLR 1000 Repeater General Specifications \(All Bands\) on page 36](#) shows the specifications of the SLR 1000 Repeater.

Table 7: SLR 1000 Repeater General Specifications (All Bands)

Parameter	Specifications
Number of Channels	64
Frequency Generation	Synthesized
Input Voltage DC	10.8 – 15.6 VDC
Station Weight	10 lbs (4.56 kg)

Table continued...

Parameter	Specifications
Temperature Range	-30 °C to +60 °C (-22 °F to +140 °F)
Ingress	IP65
Antenna Connectors	Tx: N-Type Rx: N-type
Modes of Operation	Half-Duplex/ Duplex
Height	11" (27.94 cm)
Width	9" (22.86 cm)
Depth	4" (10.16 cm)

Table 8: SLR 1000 Repeater Specifications

Parameter	Specifications
UHF	
Input Power (All Modulations) *	
Standby (13.6 VDC)	0.73 A
10 W Transmit at Rated Power (13.6 VDC)	3 A
Frequency Reference	
Internal Frequency Stability (PPM)	0.5 PPM (temperature)
Frequency Bands	
Electronic Bandwidth	400 – 527 MHz
Receiver	
Selectivity 25 kHz / 12.5 kHz (TIA603)	75 dB/ 65 dB
Selectivity 25 kHz / 12.5 kHz (ETSI)	70 dB/ 63 dB
Sensitivity (12 dB SINAD)	0.3 uV
Sensitivity (5% BER)	0.3 uV
Intermodulation Rejection (TIA603D)	80 dB
Intermodulation Rejection (ETSI)	70 dB
Spurious Rejection (TIA603D)	85 dB
Spurious Rejection (ETSI)	75 dB
Conducted Spurious Emissions	-57 dBm
Audio Distortion	<3%

Table continued...

Parameter	Specifications
	UHF
Audio Response	Per TIA/ ETSI
FM Hum and Noise 25 kHz / 12.5 kHz	-50 dB/ -45 dB
	Transmitter
Rated Output Power (Continuous Duty)	1 – 10 W
Intermodulation Attenuation	40 dB
Adjacent Channel Power 25 kHz / 12.5 kHz	75 dB / 60 dB
Modulation Fidelity (4FSK)	FSK Error 5% FSK Magnitude 1%
Wideband Noise (1 MHz) @ Rated Pout	-152 dBc/ Hz
Rated System Deviation	±2.5 kHz @ 12.5 kHz ±5.0 kHz @ 25 kHz
Spurious Harmonics and Emissions	-36 dBm < 1 GHz -30 dBm > 1 GHz
Audio Distortion	< 3%
Audio Response	Per TIA/ ETSI
FM Hum and Noise 25 kHz / 12.5 kHz	-50 dB/ -45 dB
FCC Identifier	ABZ99FT4096
FCC Emission Designators	11K0F3E 16K0F3E 7K60FXD 7K60F7D 7K60FXE 7K60F7E 7K60F7W 7K60FXW

All specifications noted above are in accordance to their respective TIA603D, ETSI 300 – 086, and ETSI 300 – 113 standards unless otherwise noted.



NOTICE: (*) Typical performance under the following conditions (when applicable): Nominal VSWR conditions (VSWR <1.5:1)

1.6

Theory of Operation

The SLR 1000 Repeater provides the radio frequency (RF) link between the repeater and the subscriber radios. The repeater acquires inbound signals through its external receive (Rx) antenna and then amplifies, filters and demodulates the signals into data or voice packets. From that point, the data is either forwarded to the repeater's transmitter to subscriber radios, and/or the data is delivered through a wired interface for distribution to networked repeaters, consoles, or other networked infrastructure.

The repeater consists of a single transceiver board.

- The transceiver board is comprised of three subsystems, which are the Receiver subsystem, Transmitter subsystem, and Station Control subsystem. At a high level, these subsystems are further explained, as follows:
 - The Receiver subsystem is a dual heterodyne Receiver which receives the RF signal from the subscriber's transmitter. It then converts the resulting final intermediate frequency (IF) from an analog signal to that of a digital word in IQ signal format. Finally, the Receiver delivers the IQ signal, through the SSI bus, to the Station Control subsystem for demodulation. Also, the Receiver subsystem provides for its own metering and diagnostics through software, and self-contained calibration (no field tuning is needed for the Receiver subsystem).
 - The Transmitter subsystem converts a two-port base band data signal, sent over the SSI bus from the Station Control subsystem, to an analog signal representation. The analog signal is then modulated with a low-power RF transmitter carrier that is generated by the Exciter subsystem. The power modulated RF carrier is then amplified and delivered to the antenna. The Exciter subsystem constitutes the transmitter of the repeater. Also, the Exciter subsystem provides its own metering and diagnostics through software, and a self-contained calibration (no field tuning is needed for the Exciter subsystem).
 - The heart of the Station Control subsystem is the Texas Instruments DM8148 Host/ DSP processor. In general, the SCM controls the entire coordination of the repeater functions. Specifically, the Station Control subsystem provides for the following functions:
 - + Contains and runs the preloaded repeater software
 - + Manages inbound and outbound RF and Audio traffic
 - + Provides an on-board USB port for local configuring, alignment, and diagnostics through the following applications:
 - Radio Management Configuration Client (RM)
 - Tuner application
 - Repeater Diagnostic and Control (RDAC) software
 - + Provides an Ethernet port for IP site connectivity and remote RDAC
 - + Provides GPIO connectivity for third-party controller interfaces
 - + Provides for analog repeater audio connectivity
 - + Data and Control to the Receiver subsystem through the SPI and SSI respectively
 - + Data and Control to the Exciter subsystem through the SPI and SSI respectively
 - + Control of the Transmitter's set power through the SPI
 - + Configuration and fault management
 - + Generates the internal station reference

- + Provides control of the front panel indicator LEDs.
- The Transmitter subsystem delivers the amplified signal to the transmitter antenna port at a power level within the rated power band of the repeater, for transmission to the subscriber radios. In addition, it provides the following hardware functions for the repeater.
 - + Harmonic attenuation
 - + Inter-modulation attenuation (IMA) suppression
 - + RF power control (primary means)
 - + Meters for diagnostics
 - + Power roll back for temperature
 - + Self-Contained calibration (no field alignment is needed for PA).

1.7

Basic Repeater Level Troubleshooting – RDAC and LEDs

Diagnostic tests are available for the Transceiver. If a problem occurs during station operation, it is logged as an alarm that is read with the Repeater Diagnostic and Control application (RDAC). See [Figure 7: RDAC Diagnostic Screen on page 40](#) for the RDAC diagnostic screen.

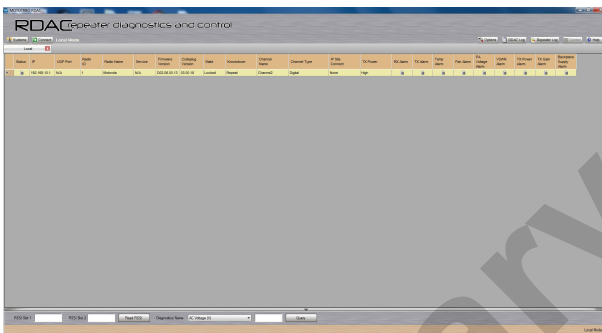


Figure 7: RDAC Diagnostic Screen

The station operator then evaluates the problem locally or remotely, as the station maintains an Alarm Log with the name of the alarm that has failed since the last power up. Through the RDAC application's Alarm Log, the alarm messages aid in identifying the FRU that failed along with the fault condition.

After booting up the repeater, the three LEDs (Power/ Status, Network, and Reference LEDs) flash in unison.

The general status and condition of the SLR 1000 Repeater can be obtained by observing the three LED indicators on the front panel. [Table 9: SLR 1000 Repeater Front Panel LED Indicators on page 40](#) shows the LED symbols and their meaning, while [Table 10: SLR 1000 Front Panel LED Definitions on page 41](#) identifies the information conveyed through the LED indicators.

Table 9: SLR 1000 Repeater Front Panel LED Indicators


LED	Definition
	Status

Table continued...



LED	Definition
	Ethernet Link/ Network Connectivity
	Reference

Table 10: SLR 1000 Front Panel LED Definitions

LED Function Name	LED Color	LED State	Status Indication
Power/Status	Off	Off	Off
	Green	Solid	Operating Normally, with DC power
	Red	Flashing	Repeater is Disabled (by customer)
		Solid	Not Operational – Major Alarm
	Amber	Flashing*	Check Alarm Log – Alarm occurred and cleared but remains latched (configurable)
		Solid	Repeater Operational – Minor Alarm
Ethernet/ Network Connectivity	Off	Off	No Ethernet connection
	Green	Solid	Connectivity/ Linked
		Flashing	Attempting to connect to the system
Reference	Off	Off	For future use



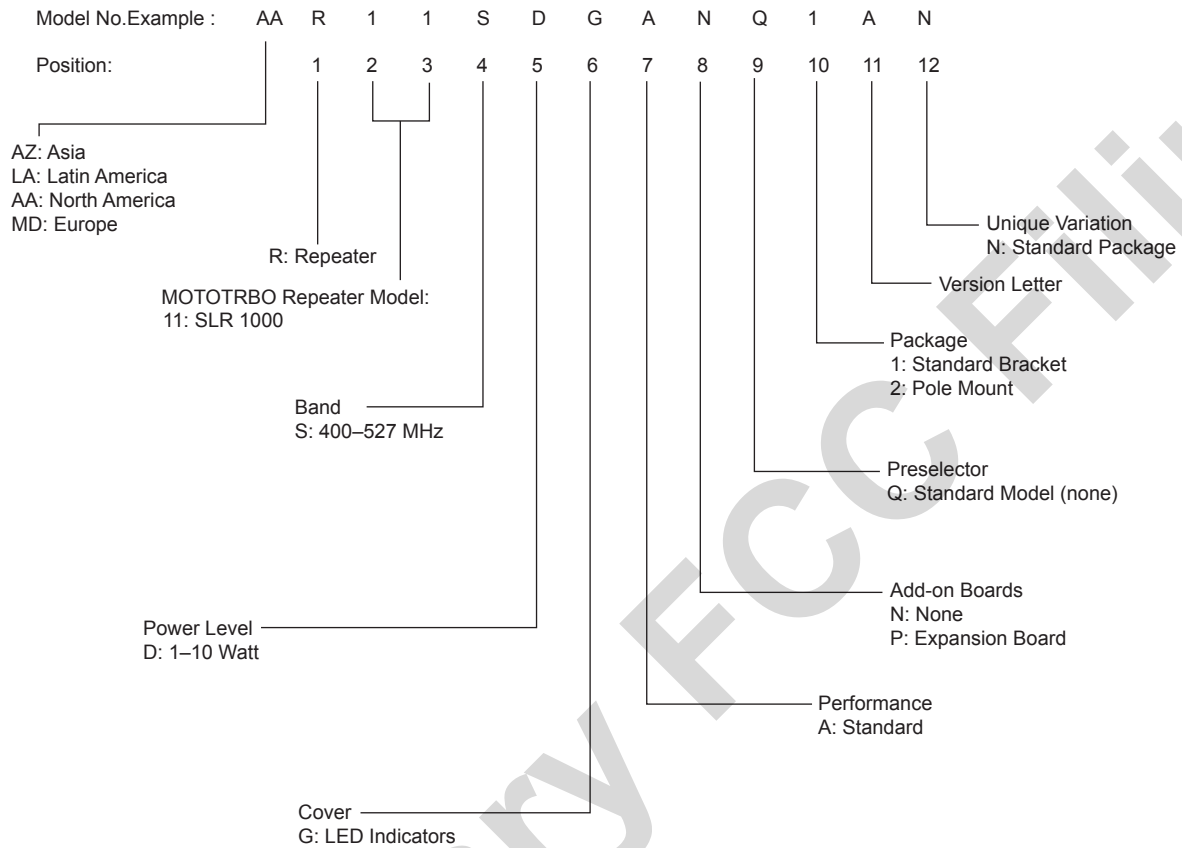
NOTICE: All LEDs flashing in unison indicate the repeater is booting up. The RDAC application will be needed when the Status LED is red (solid or flashing). This status indicates a minor or major alarm. The RDAC application is used to identify the specific alarm and probable diagnosis to aid in identifying the FRU at fault.

(*) Not supported in initial release.

1.8

SLR 1000 Repeater Model Numbering Scheme

Figure 8: SLR 1000 Repeater Model Numbering Scheme



1.9

UHF High Power Model Chart

SLR 1000, UHF, 400 – 527 MHz	
Model	Description
AAR11SDGANQ1AN	400–512 MHz, 1 – 10 W, SLR 1000 Repeater

Chapter 2

SLR 1000 Satellite Receiver

2.1

Description

The main purpose of the Satellite Receiver is to eliminate "dead zones" in a communications system by improving the "talk-in" coverage on a particular receive frequency when used in a receiver voting system.

The Motorola Solutions SLR 1000 Repeater is not offered as an exclusive Satellite Receiver only model, rather the repeater can be configured through Radio Management to operate as a Satellite Receiver in a receive only mode of operation. As such, the context of this chapter assumes that the repeater is configured as a Satellite Receiver.



NOTICE: Configuring the repeater as a Satellite Receiver is only compatible with the MOTOTRBO Digital Voting feature.

2.2

Operating Features

The features are identical to the SLR 1000 Repeater, with the exception that all transmitter related functions are not applicable. See [SLR 1000 Repeater on page 33](#) for more details.

2.3

Frequency Ranges

The supported frequency ranges are identical to the SLR 1000 Repeater's receive frequency ranges. See [SLR 1000 Repeater on page 33](#) for more details.

2.4

Specifications

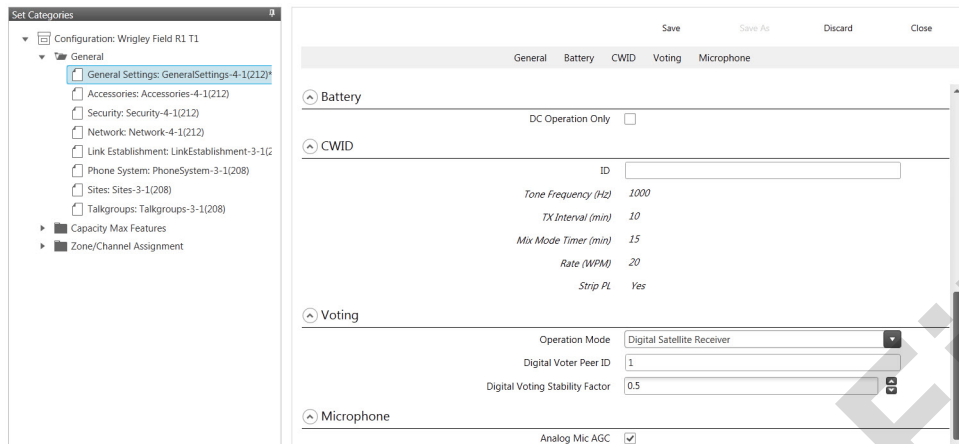
The specifications are identical to the SLR 1000 Repeater, with the exception that all transmitter related specifications are not applicable. See [SLR 1000 Repeater on page 33](#) for more details.

2.5

Configuration

Other than setting the general personality configurations, set the **Operation Mode** parameter under the **General Settings** menu in Radio Management to **Digital Satellite Receiver**. See the following figure.

Figure 9: Operation Mode Configuration for Satellite Receiver Functionality



2.6

Basic Station Level Troubleshooting – RDAC and LEDs

The troubleshooting procedures are similar to the SLR 1000 Repeater with regards to the control, transmitter, and receiver sub-systems. See [SLR 1000 Repeater on page 33](#) for more details.



NOTICE: When configured for receiver only operation, the repeater does not support any transmitter sub-system functions. As such, disregard all references to the transmitter section in [SLR 1000 Repeater on page 33](#). This includes any transmitter related topics in the RDAC and the front panel LEDs.

2.7

Model Chart

The model chart is identical to the SLR 1000 Repeater. See [UHF High Power Model Chart on page 42](#) for more details.

Chapter 3

SLR 1000 Transceiver Board

3.1

Description

The Transceiver board is described in this section. A general description, identification of inputs and outputs, and functional theory of operation are provided. The information provided is sufficient to give service personnel a functional understanding of the module, allowing maintenance and troubleshooting to the module level.

3.1.1

General Description

The Transceiver board provides the receiver, transmitter, and station control functionality for the repeater. Additionally the external connections to the station are connected directly to the transceiver board.

3.1.2

Input and Output Connections

Figure 10: SLR 1000 Repeater Transceiver Board Connector Locations on page 45 shows the Transceiver board input and output external connections.

Figure 10: SLR 1000 Repeater Transceiver Board Connector Locations

Table 11: SLR 1000 Repeater Front View (without top Cover) Callout Legend

Label	Description
1	Transmitter RF (Tx) Output
2	Pressure Equalizer Vent
3	Receiver RF (Rx) Output
4	Transmitter RF (Tx) Input
5	Jumper Connection to enable external on/off function
6	Bonding Ground Connection
7	DC Power Inlet
8	Aux/Accessory Port
9	Ethernet Port
10	USB Port Programming Interface
11	Header Connection for optional antenna switch
12	Option Dependent 1 and 2
13	Expansion Board Connection (for future use)
14	Receiver RF (Rx) Input
15	Front Panel Flex Connector

3.1.3

Frequency Bands

The Transceiver board covers the following bands with unique models:

- 400 – 527 MHz

3.2

Receiver Subsystem

The Transceiver board includes the receiver circuitry for the station. A cable connects the board connector to an N-type connector on the upper left hand side of the repeater.

See [Figure 10: SLR 1000 Repeater Transceiver Board Connector Locations on page 45](#) for the location of this connector. The receiver section performs highly-selective bandpass filtering and dual down-conversion of the desired RF signal. A custom Receiver IC then performs an analog-to-digital conversion of the desired received signal and outputs the digitized signal to the controller section via a serial synchronous interface. Included in the receiver section is:

Frequency Synthesizer Circuitry

Consists of a phase-locked loop and Voltage-Controlled Oscillator (VCO), generates the first LO injection signal.

Varactor-tuned Preselector Filter(s)

Provides bandpass filtering of the station Receiver RF input.

Receiver Front End Circuitry

Performs filtering, amplification, and the first down conversion of the Receiver RF signal.

Receiver-specific piece of transceiver IC Circuitry

Consists of receiver-specific parts of a transceiver IC which performs the second down conversion, filtering, amplification, and analog-to-digital conversion of the receive signal.

Analog to Digital Converter (ADC) Circuitry

Converts analog Receiver status signals to digital format for transfer to the controller circuitry located on the Transceiver board.

3.2.1

Specifications

Table 12: Specifications of Receiver Subsystem

Parameter	Specifications
	UHF
Frequency Bands	400 – 527 MHz
Selectivity 25 kHz/ 12.5 kHz (TIA603D)	75 dB/ 50 dB
Selectivity 25 kHz/ 12.5 kHz (TIA603)	75 dB/ 65 dB
Selectivity 25 kHz/ 12.5 kHz (ETSI)	70 dB/ 63 dB
Sensitivity (12 dB SINAD)	0.3 uV
Sensitivity (5% BER)	0.3 uV
Intermodulation Rejection (TIA603D)	80 dB
Intermodulation Rejection (ETSI)	70 dB
Spurious Rejection (TIA603D)	85 dB

Table continued...

Parameter	Specifications
	UHF
Spurious Rejection (ETSI)	75 dB
Audio Distortion	<3%
FM Hum and Noise 25 kHz/ 12.5 kHz	50 dB/ 45 dB

3.3

Transmitter Subsystem

The Transmitter subsystem on the Transceiver board provides the transmitter functions for the station. The Transmitter subsystem interfaces directly with the controller section, which provides control signals and monitoring, and routes transmit data to the Exciter.

The RF carrier is generated by a frequency synthesizer consisting of synthesizer circuitry and Voltage-Controlled Oscillator (VCO) circuitry. Exciter circuit control signals, monitoring, and audio processing are handled by the controller section of the transceiver board. Included in the transmitter subsystem are:

Frequency Synthesizer Circuitry

Consists of a phase-locked loop and Voltage-Controlled Oscillator (VCO), generates a modulated RF signal at the transmitter carrier frequency.

RF Isolation Switch

Allows the controller section to turn on/off the Exciter RF input signal which greatly reduces signal leakage when the transmitter is de-keyed.

Analog to Digital Converter (ADC) Circuitry

Converts the analog transmitter status signals to the digital format for transfer, upon request, to the controller section of the Transceiver board.

3.3.1

Specifications

Table 13: Specifications of Transmitter Exciter Subsystem

Parameter	Specifications
	UHF
Frequency Range	400 – 527 MHz
Electronic Bandwidth	Full Bandwidth
Output Power	10 W
Harmonics	-76 dBc

3.4

Station Control Subsystem

The Station Control Subsystem is described in this section. A general description, identification of controls, indicators, and inputs/outputs, a functional block diagram, and functional theory of operation are provided.

The Controller circuitry performs the digital signal processing, data formatting and audio routing for the station and provides the external interfaces to the rest of the site.

The Controller section consists of seven main ICs. These are:

- Texas Instrument DM8148 Host/DSP Processor
- EMMC Flash memory
- DDR3 memory
- Texas Instruments Power Management IC
- NOR Flash
- TI AIC3204 Codec

General controller functionality includes:

- Data and Control interface to the transceiver ICs
- Audio interface with CODEC IC
- UART interface to expansion board
- Intermodule communication (SPI, I2C)
- Ethernet port
- USB Device port
- External physical interfaces (connectors, LEDs, external references etc.)
- Station Reference Control

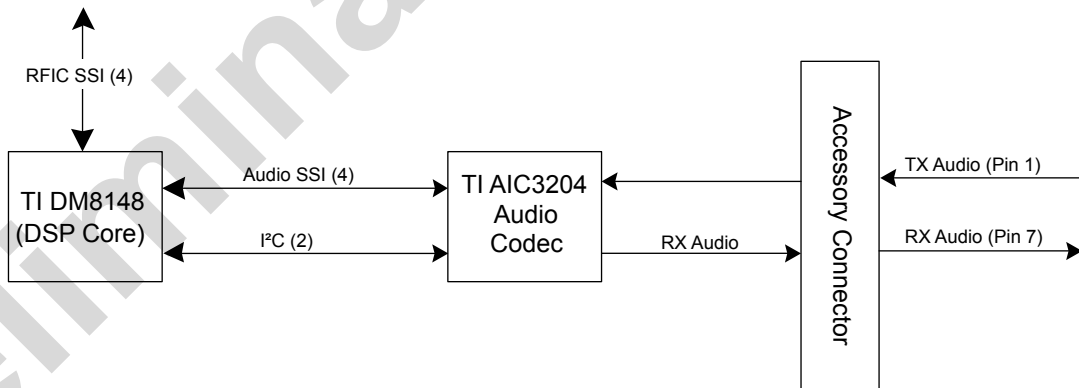
3.4.1

Audio

The analog audio stages are used exclusively for external accessories connected through the bottom RJ-45 accessory connector.

The critical components of the audio circuit are the TI DM8148 processor and a Texas Instruments AIC3204 dual channel audio codecs. [Figure 11: SLR 1000 Repeater Audio Block Diagram on page 48](#) details the specific interconnects between the critical components.

Figure 11: SLR 1000 Repeater Audio Block Diagram



The repeater digital audio is handled primarily by the DM8148 processor. The TX RFIC generates a 24.576 MHz master clock (MCLK) that the DM8148 uses to drive its McASP SSI interface for the audio codecs. The bulk of the audio processing is done in the DaVinci's DSP core. The audio codecs contain DACs and ADCs and handle the conversion of the digital audio to analog audio and vice versa.

There is one TX audio line routed in from the rear accessory connector. This is TX Audio 1 (Pin 1, used for analog and slot 1 digital).

For the RX outputs, there is only 1 which is connected to the accessory connector. RX Audio 1 on pin 7 (to be used for analog and slot 1 digital).

3.5

Station Control Interface

This section describes the different types of connectors and connections to the station control.

3.5.1

Bottom Panel Connections

See [Ethernet on page 54](#) for details.

3.5.2

Expansion Board Interface Connector

The expansion board interface utilizes a 30-pin vertical LIF connector. The location is detailed in [Figure 10: SLR 1000 Repeater Transceiver Board Connector Locations on page 45](#). [Table 11: SLR 1000 Repeater Front View \(without top Cover\) Callout Legend on page 45](#) shows the pin number locations.

Preliminary FCC Filing

This page intentionally left blank.

Chapter 4

SLR 1000 Front Panel

4.1

Description

The Front Panel board user interface includes three LED indicators. The board is connected to the modem interface through a flex cable. The LED indicators inform the user of the state of the repeater. The LED indications are transferred to the front panel through a serial peripheral interface.

Preliminary FCC Filing

This page intentionally left blank.

Chapter 5

SLR 1000 Bottom Panel

5.1

Description

The Bottom Panel interface provides the electrical interconnection interface between the SLR 1000 Repeater and the end user's system. This includes the connectors necessary to program/configure the repeater, as well as interface the repeater to the power system, system controllers, LANs, and other communications and maintenance equipment. This section provides a general description, identification of inputs/ outputs and how the inputs are connected and sealed, and a pin-out listing for all connectors, including information on signal names, functions, and levels.

5.1.1

General Description

Figure 12: SLR 1000 Repeater Bottom Panel Connector Names and Locations on page 53 shows the various interface connector locations. Table 14: SLR 1000 Repeater Connector Types and Primary Functions on page 53 lists the connector types as well as its primary function.

Figure 12: SLR 1000 Repeater Bottom Panel Connector Names and Locations

Table 14: SLR 1000 Repeater Connector Types and Primary Functions

Location	Connector Type	Function(s)
1	N-Type – Female	Transmitter RF (Tx)
2	M6 TORX Screw	Bonding Ground Connection
3	2.1 X 5.5 OD Barrel Connector	DC Power Inlet
4	RJ-45 – Aux/Accessory	Rx Audio, Tx Audio, PTT, 1 PPS, and GPIO
5	RJ-45 – Ethernet	Network
6	Type B USB Socket	Programming Interface
7	Option Dependent	Option Dependent 1 and 2
8	N-Type – Female	Receiver RF (Rx)

5.2

Bottom Panel Interfaces

This section describes the different bottom panel interfaces that are available in the repeater.

5.2.1

DC Power Inlet

The DC power inlet connector is a 2.1 X 5.5 Barrel type coaxial power connector receptacle panel. [Figure 13: DC Power Inlet Connector on page 54](#) shows the location of the pins and [Table 15: DC Power Inlet Connector Callout Legend on page 54](#) lists the functional characteristics of the connector's pins.

Figure 13: DC Power Inlet Connector

[Table 15: DC Power Inlet Connector Callout Legend](#)

Location	Type	Signal Characteristics
Inner	12 V	10.8 – 15.6 VDC
Outer	Ground	4 A (max)

5.2.2

USB

Type B socket (Device Connection) that supports the USB 2.1 protocol standard. [Figure 14: USB Connector on page 54](#) shows the location of the pins and [Table 16: USB Connector Callout Legend on page 54](#) lists the functional characteristics of the connector's pins.

Figure 14: USB Connector

[Table 16: USB Connector Callout Legend](#)

Location	Pin Assignment	Type	Signal Characteristics
1	VBUS	USB Physical Layer	+5 VDC
2	D-		3.6 V differential data
3	D+		
4	GND		Ground

5.2.3

Ethernet

Fully compliant with IEEE and 802.3 and 802.3u standards. Supports 10Base-T, 100Base-Tx rates, full duplex, half duplex mode and flow control. [Figure 15: Ethernet Connector on page 54](#) shows the location of the pins and [Table 17: Ethernet Connector Callout Legend on page 54](#) lists the functional characteristics of the connector's pins.

Figure 15: Ethernet Connector

[Table 17: Ethernet Connector Callout Legend](#)

Location	Pin Assignment	Type	Signal Characteristics
1	Ethernet Tx+	Ethernet Physical Layer	5 V differential data
2	Ethernet Tx-		
3	Ethernet Rx+		
4	Unused		N/A

Table continued...

Location	Pin Assignment	Type	Signal Characteristics
5	Unused		N/A
6	Ethernet Rx-		5 V differential data
7	Unused		N/A
8	Unused		N/A

5.2.4

Auxiliary (Aux)/Accessory

This connection supports the analog interface to the SLR 1000 Repeater, which includes audio, station control, station indicators, and provisions for timing used in various system implementations. [Figure 16: Auxiliary/Accessory Connector on page 55](#) shows the location of the pins and [Table 18: Auxiliary/Accessory Connector Callout Legend on page 55](#) lists the functional characteristics of the connector's pins.

Figure 16: Auxiliary/Accessory Connector

Table 18: Auxiliary/Accessory Connector Callout Legend

Location	Pin Assignment	Type	Signal Characteristics
1	Tx Audio 1	Audio	Transmit Audio – Nominal input level is 80 mVrms for 60% deviation with scaling factor set to 100%. 600 Ω input impedance.
2	GPIO 6	Digital	Output Logic Low: 0.5 VDC max Output Logic High: Open Collector with 10 k pull-up to 5 V Input Logic Low: 0 – 0.8 VDC Input Logic High: 3.0 – 14 VDC
3	Ignition Sense Control		Controls power to the unit if the internal jumper is configured correctly.
4	Ground		
5	GPIO 7 Analog RSSI Out	Digital or Analog	Output Logic Low: 0.5 VDC max Output Logic High: Open Collector with 10 k pull-up to 5 V Input Logic Low: 0 – 0.8 VDC Input Logic High: 3.0 – 14 VDC Analog RSSI: Typically 0.5 VDC for -120 dBm to 2.7 VDC for -60 dBm carrier. Variation with carrier level at approximately 50 mV/dBm.
6	GPIO 9/ *Analog Input 1	Digital	Output Logic Low: 0.5 VDC max Output Logic High: Open Collector with 10 k pull-up to 5 V Input Logic Low: 0 – 0.8 VDC Input Logic High: 3.0 – 14 VDC Analog: 0 – 5 VDC

Table continued...

Location	Pin Assignment	Type	Signal Characteristics
7	Rx Audio 1	Audio	Receiver Audio – Nominal output level is 330 mVrms (into a 50 k Ohm load) with a 60% deviation receive signal. 1000 Ω output impedance.
8	GPIO 4	Digital	Output Logic Low: 0.5 VDC max Output Logic High: Open Collector with 10 k pull-up to 5 V Input Logic Low: 0 – 0.8 VDC Input Logic High: 3.0 – 14 VDC

* = Currently not supported.

Chapter 6

SLR 1000 Test Equipment And Service Aids

6.1

Recommended Test Equipment

The list of equipment includes most of the standard test equipment required for servicing Motorola Solutions SLR 1000 Repeaters.

Table 19: Recommended Test Equipment

Equipment	Example	Application
Service Monitor	Aeroflex 3920 Digital Radio Test Set or equivalent ¹ http://www.aeroflex.com	Frequency/deviation meter, signal generator, oscilloscope, RF power meter for wide-range troubleshooting, and alignment.
Digital RMS Multimeter	Fluke 179 or equivalent http://www.aeroflex.com .	AC/DC voltage measurements.

6.2

Service Aids

Table 20: Service Aids on page 57 lists the service aids recommended for working on the SLR 1000 Repeater. While all of these items are available from Motorola Solutions, most are standard workshop equipment items, and any equivalent item capable of the same performance may be substituted for the item listed.

Table 20: Service Aids

Motorola Solutions Part Number	Description	Application
HSN1006_	Speaker	Listen to audio
PMVN4130_	Customer Programming Software on CD-ROM	Allows servicer to program repeater parameters, tune and troubleshoot repeater.
30009477001	Standard Type "A" to Type "B" USB Programming cable	Connects the repeater front connector to a USB port for radio programming and data applications.
PMKN4166_	Repeater Rear Accessory Test Cable	Connects the repeater's rear connector to microphone and speaker
GMMN4063_	Microphone	To transmit audio

Table continued...

¹ Equivalency can be established with "all-in-one" service monitors and/or the individual functional components of a service monitor (such as RF Signal Generator, RF Spectrum Analyzer, RF Deviation Meter, RF Power Meter, and oscilloscope).

Motorola Solutions Part Number	Description	Application
RLN4460_	Test Box	Used to inject/ measure audio
CB000174A02	DB-25 to RJ-45 Adapter	Used to connect the accessory test cable to the RJ-45 accessory connector

Chapter 7

SLR 1000 Performance Check or Testing

7.1

General

The SLR 1000 Repeater meets published specifications through the manufacturing process by utilizing high-accuracy laboratory-quality test equipment. The recommended field service equipment approaches the accuracy of the manufacturing equipment with few exceptions. This accuracy must be maintained in compliance with the equipment manufacturer's recommended calibration schedule.



NOTICE: Although these repeaters function in digital and analog modes, all testing is done in analog mode. Digital Repeater tests can be performed using an Aeroflex 3900 Series Service Monitor, if the DMR Digital Repeater Test Option is purchased. This auto testing could be performed in lieu of the following Manual testing.

7.2

Transmitter Testing



CAUTION: The SLR 1000 Series Repeater needs to be taken out of service in order to carry out performance testing procedures. Unless the repeater is already out of service, it is recommended to perform the procedures during off-peak hours in order to minimize disruption of service to the system subscribers.

7.2.1

Introduction

While most module faults can be detected by running the repeater diagnostics, the following procedure provides a more traditional method of troubleshooting the transmitter circuitry.

This procedure allows the service technician to make minor adjustments and verify proper operation of the repeater transmit circuitry.

In general, the transmitter circuitry is exercised by injecting and measuring signals using a Service Monitor (or equivalent). Incorrect measurement values indicate a faulty module(s); measurement values within the acceptable range verify proper operation the transceiver board and circuitry.

7.2.2

Test Equipment

The following test equipment are required to perform the procedure:

- Aeroflex 3920 Digital Radio Test Set (or equivalent)
- Microphone (GMMN4063_)
- Power Meter and Sensor
- Station Rear Accessory Test Cable
- Dummy Load (50 Ω , repeater wattage or higher)
- DB25/RJ-45 Adapter

7.2.3

Verifying Transmitter Circuitry

Procedure:

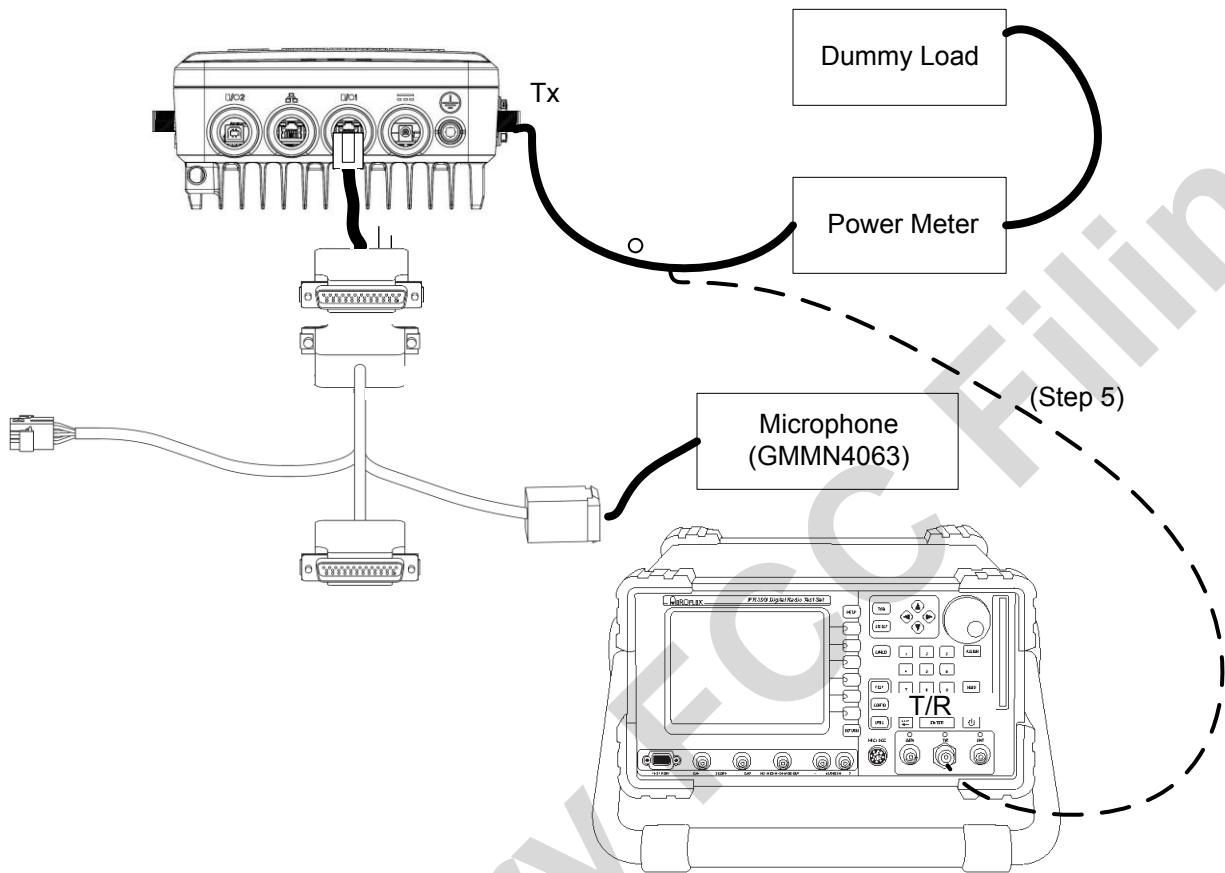
- 1 Connect and set up test equipment as shown in [Figure 17: Test Equipment Setup for Verifying Transmitter Circuitry on page 61](#).
- 2 Apply input power to the repeater.
- 3 Press the PTT switch of the microphone.
- 4 Measure output power by observing reading on an in-line wattmeter.
 - a If the transmitter output is not at proper power (as set for a particular site), adjust the output power as described in the Radio Management online help.
- 5 If the transmitter output power is proper, set up the Service Monitor for spectrum analyzer display.
 - a Press the PTT button and observe the display.

The display should show a single frequency carrier:
 - b If the display shows multiple carriers evenly spaced about the carrier, suspect a faulty Exciter module or PA module.
 - c If the display shows a solid carrier but it is off frequency, suspect the following:
 - Faulty transceiver board
 - Faulty external 5/10 MHz reference source (if used)
 - d If the display shows a single carrier moving erratically, suspect a faulty transceiver board.
- 6 If display is proper, set up Aeroflex 3900 Series Communications System Analyzer to display modulation.
 - a Using the microphone, push the PTT button and speak into the microphone.
 - b Verify that the display shows an audio signal.
 - c If the proper display is not obtained, suspect faulty transceiver board.
- 7 Set the Aeroflex 3900 Series Communications System Analyzer for GEN/ MON MTR.
 - a Press the PTT button and speak loudly into the microphone to cause maximum deviation.

Display should read:

 - 4.60 kHz maximum for a 25 kHz system
 - 3.68 kHz maximum for a 20 kHz system
 - 2.30 kHz maximum for a 12.5 kHz system
 - b If the proper display is not obtained, suspect faulty transceiver board.
- 8 This completes the Verifying Transmitter Circuitry test procedure. If all displays and measurements are correct, the transmitter circuitry may be considered to be operating properly.

Figure 17: Test Equipment Setup for Verifying Transmitter Circuitry



7.3

Receiver Testing



CAUTION:

Performing this procedure requires that the repeater be taken out of service. It is recommended that, unless the SLR 1000 Series Repeater is already out of service, this procedure be performed during off-peak hours so as to minimize the disruption of service to the system subscribers.

If the repeater operates as a repeater, the transmit output from the repeater must be connected to a dummy load to prevent over-the-air broadcast during Receiver testing.

7.3.1

Introduction

While most module faults can be detected by running the SLR 1000 Series Repeater diagnostics, the following procedure provides a more traditional method of troubleshooting the Receiver circuitry.

This procedure allows the service technician to make minor adjustments and verify proper operation of the receiver circuitry on the Transceiver Board.

In general, the Receiver circuitry is exercised by injecting and measuring signals using a Service Monitor (or equivalent). Incorrect measurement values indicate a faulty module(s); measurement values within the acceptable range verify proper operation of the receiver circuitry on the Transceiver Board.

7.3.2

Required Test Equipment

The following test equipment are required to perform the procedure:

- Aeroflex 3920 Digital Radio Test Set (or equivalent)
- Service Speaker (part no. HSN1006_)
- Station Rear Accessory Test Cable
- Dummy Load (50 Ω , repeater wattage or higher) required for repeaters only
- DB25/RJ-45 Adaptor

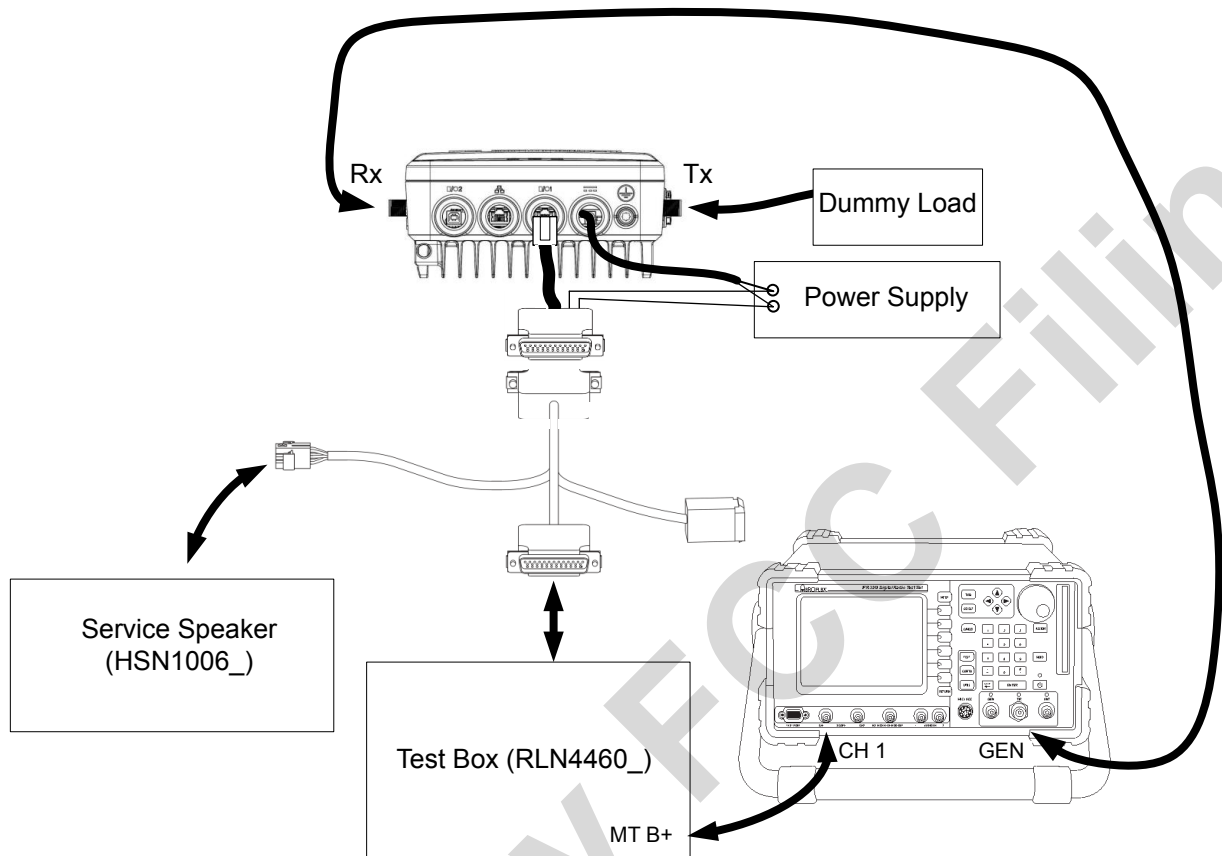
7.3.3

Verifying Receiver Circuitry

Procedure:

- 1 Connect equipment as shown in [Figure 18: Test Equipment Setup for Verifying Receiver Circuitry on page 63](#).
- 2 Set the service monitor to generate a 1.0 μ V (-107 dBm) FM signal at the receiver frequency, modulated by a 1 kHz tone at 3 kHz deviation for 25 /30 kHz channel spacing, or 1.5 kHz deviation for 12.5 kHz channel spacing. The 1 kHz tone should be audible through the external speaker. If no audio is heard, suspect the following:
 - Faulty transceiver board
 - Faulty service monitor-to-station RF cable
 - Left panel to transceiver board cable unplugged
 - Faulty left panel to transceiver board cable
- 3 If audio is heard (the audio volume can be adjusted on the rear of the HSN1006), look at the oscilloscope window on the Aeroflex 3920 (or a separate O-Scope).
 - a Verify that the audio level sine wave measures between 0.75 to 1.5 Vpp.
 - b If not, connect to the tuner and increase the Rx audio level until this is achieved. If the level cannot be obtained, suspect a faulty transceiver board.
- 4 Move the BNC cable from the scope CH 1 input to the Audio 1 input.
- 5 Change System Monitor injection signal level to the noted levels in [Table 8: SLR 1000 Repeater Specifications on page 37](#).
- 6 Measure the receiver 12 dB SINAD sensitivity.
 - a If the SINAD level is less than 12 dB, suspect a faulty transceiver board.
- 7 This completes the Verifying Receiver Circuitry test procedure. If all displays and measurements are correct, the receiver circuitry may be considered to be operating properly.
 - a Remove test equipment, restore the repeater to normal service, and (if applicable) return to the troubleshooting flow chart to resume troubleshooting sequence.

Figure 18: Test Equipment Setup for Verifying Receiver Circuitry



Preliminary FCC Filing

This page intentionally left blank.

Chapter 8

SLR 1000 Programming and Tuning

8.1

Introduction

This chapter provides an overview of the MOTOTRBO Radio Management (RM) and the MOTOTRBO Tuner application for use on Windows 7™, Windows 8™, or Windows 8.1™. These two MOTOTRBO applications are used for the configuration and alignment of the SLR 1000 Repeater.

8.2

Radio Management Setup

The Radio Management setup, shown in [Figure 19: Radio Management Setup on page 65](#) is used to program the repeater. See [Figure 20: Bottom View of SLR 1000 Repeater on page 65](#) for the actual connectors on the front of the repeater.



NOTICE: See appropriate program on-line help files for the programming procedures.



CAUTION: Computer USB ports can be sensitive to Electronic Discharge. Employ proper ESD practices (wrist strap, grounding, etc.) and do not touch exposed contacts on cables when connected to a computer.

Figure 19: Radio Management Setup

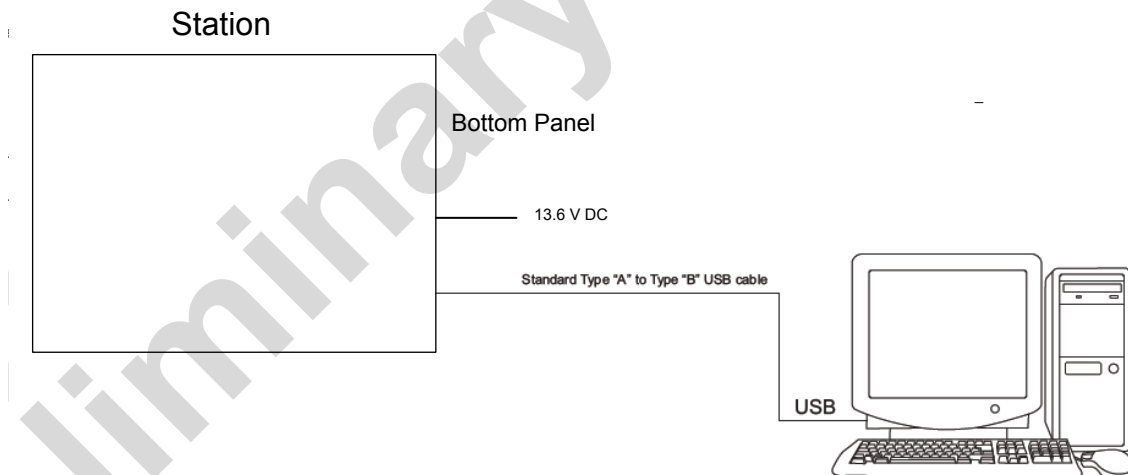


Figure 20: Bottom View of SLR 1000 Repeater

Table 21: Bottom View of the SLR 1000 Repeater Callout Legend

Label	Description
1	USB Port Programming Interface
2	Ethernet Port
3	Aux/Accessory Port

Table continued...

Label	Description
4	DC Power Inlet
5	Bonding Ground Connection

8.3

Reference Oscillator Alignment

This feature is used to adjust the reference oscillator of the repeater. This alignment process should be done as maintenance schedules and regulations require or if the Transceiver board FRU has been replaced in the repeater.

8.3.1

Tuning the Reference Oscillator

Procedure:

- 1 Connect the SLR 1000 Repeater's transmitter antenna port to the Communication Analyzer.
- 2 Power the repeater from either an AC or DC source.
- 3 Launch the Tuner application, and click **Read** to begin reading the repeaters tuning software values.
- 4 Under the **TX** menu in the tree view, select **Ref Oscillator**. See [Figure 21: Tx Menu Tree \(Ref. Oscillator\) on page 66](#)

Figure 21: Tx Menu Tree (Ref. Oscillator)

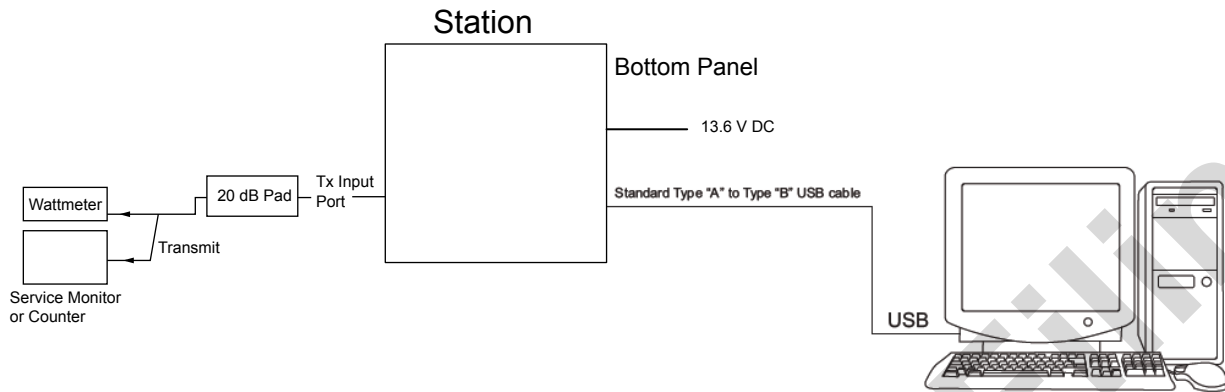
- 5 Configure the currently operating frequency into the Communications Analyzer.
- 6 Click **PTT Toggle** to key up the repeater.
- 7 Adjust the working softpot value until the frequency is within the performance specifications (+/- 40 Hz for UHF) from the frequency point.
- 8 Click PTT Toggle to de-key the repeater.
- 9 To save the tuned softpot value into the repeater codeplug, click **Write**.

8.4

Repeater Tuning Setup

A personal computer (PC), Windows™ operating system, and the MOTOTRBO Tuner application are required to align the repeater. To perform the tuning procedures, the repeater must be connected to the PC and test equipment setup as shown in [Figure 22: SLR 1000 Repeater Tuning Equipment Setup on page 67](#).

Figure 22: SLR 1000 Repeater Tuning Equipment Setup



8.5

Rx Audio Level Set

The procedure outlined in this section is used to set the receive output audio level from the repeater for a given RF deviation of the received RF signal. Perform this procedure any time the Rx audio level needs adjustment.

8.5.1

Tuning the Rx Audio Level Set

Procedure:

- 1 Connect the repeater's receiver antenna port to the Communication Analyzer.
- 2 Power the repeater from either an AC or DC source.
- 3 Launch the Tuner application and click **Read** to read the softpot values.
- 4 Under the **RX** menu in the tree view, select **Rx Rated Volume**. (See [Figure 23: RX Menu tree \(Rx Rated Volume\)](#) on page 67).

Figure 23: RX Menu tree (Rx Rated Volume)

- 5 Set the Communication Analyzer to output a -47 dBm RF signal modulated with a 1 kHz tone at 60% of full deviation on the tuning frequency. The tuning frequency is the value displayed on the Tuner GUI under the heading of "Frequency Points".

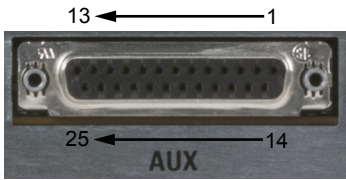



NOTICE: The Tuner aligns this parameter in a 12.5 kHz channel spacing, so 60% is 1.5 kHz of deviation. If Radio Management (RM) is set for 25 kHz operation, the repeater automatically scales the deviation by a factor of two when it is outside the Tuner environment.

Programmed TPL and DPL squelch requirements are automatically disabled for the tuning frequency while in the Tuner environment.

- 6 Adjust the softpot value until the desired receive audio level is achieved at pin #7 (in reference to ground) on the Aux connector. The ground connection provided by the Aux connector is pin 4.

Figure 24: Auxiliary Connector



 **NOTICE:** Optimally, it is recommended to load pin #7 with application loading used during normal operation of the repeater.

- 7 To save the new tuned softpot value into the repeater's codeplug, click **Write**.

8.6

Tx Audio Level Set


The procedure outlined in this section is used to allow adjustment of the transmitter audio level the repeater is expecting at its Aux connector. Adjusting this level set has the effect of increasing or decreasing RF signal deviation for a given transmit audio level. Perform this procedure any time the transmitter audio level needs adjustment.

8.6.1

Tuning the Tx Audio Level Set

Procedure:


- 1 Connect the repeater's transmitter antenna port to the Communication Analyzer.
- 2 Power the repeater from a DC source.
- 3 Apply a 1 kHz signal at the desired input level to pin #1 (in reference to ground) on the Aux connector. The group connection provided by the Aux connector is pin-4. See [Figure 24: Auxiliary Connector on page 68](#)

 **NOTICE:** Optimally, it is recommended to load pin #1 with the application source impedance used during normal operation of the repeater.

- 4 Launch the Tuner application and click **Read** to read the softpot values.
- 5 Under the **TX** menu in the tree view, select **Tx Audio Level**. (See [Figure 25: Tx Menu Tree \(Tx Rated Volume\) on page 68](#)).

Figure 25: Tx Menu Tree (Tx Rated Volume)

- 6 Enter the tuning frequency into the Communication Analyzer (the value displayed on the Tuner GUI under the heading of **Frequency Points**).
- 7 Click **PTT Toggle** to key up the repeater.
- 8 Adjust the softpot value until the desired receive audio level is achieved at pin #7 (in reference to ground) on the Aux connector. The ground connection provided by the Aux connector is pin 4.

 **NOTICE:** The Tuner aligns this parameter in a 12.5 kHz channel spacing, so 60% is 1.5 kHz of deviation. If Radio Management (RM) is set for 25 kHz operation, the repeater automatically scales the deviation by a factor of two when it is outside the Tuner application.

- 9 Click **PTT Toggle** to de-key the repeater.
- 10 To save the new tuned softpot value into the repeater's codeplug, click **Write**.

8.7

Modulation Limit Alignment

This feature is to set the modulation limit of the SLR 1000 Repeater.



NOTICE: A modulation limit alignment is not needed if the repeater is used in repeat mode. This is always the case when the repeater is in digital mode.

8.7.1

Tuning the Modulation Limit (with no Tx Data and no PL)

Procedure:

- 1 Connect the repeater's antenna port to the attenuation pad, if necessary, before connecting to the Communication Analyzer.
- 2 Power the repeater from a DC source.
- 3 Apply a 1 kHz signal at 1.2 Vrms to Pin 1 of the Aux connector.
 - Signal ground is Pin 9 of the Aux connector.
- 4 Launch the Tuner application.
- 5 To read the softpot values, click **Read**.
- 6 Under the **TX** menu in the tree view, select **Modulation Limit**.

Figure 26: TX Menu Tree (Tuning Procedure with No Tx Data)

- 7 Enter the tuning frequency into the Communication Analyzer (the value displayed on the Tuner application).
- 8 To key up the repeater, click **PTT Toggle**.
- 9 Adjust the softpot value until the maximum deviation is 92% of the rated system deviation (RSD). This is tested in a 12.5 kHz channel spacing, so 92% of 2.5 kHz is 2.3 kHz.
- 10 Set the modulation limit to 92% so that any additional deviation incurred by the transmitter VCOs over temperature is compensated for.

Channel Spacing (kHz)	RSD (kHz)	92% of RSD (kHz)	Tolerance (Hz)
12.5	2.5	2.3	+0/ -50

- 11 To de-key the repeater, click **PTT Toggle**
- 12 To save the new tuned softpot value into the repeater's codeplug, click **Write**.

8.7.2

Verifying the Modulation Limit (with no Tx Data and no PL)

Procedure:

- 1 Connect the repeater's antenna port to the attenuation pad, if necessary, before connecting to the Communication Analyzer.
- 2 Power the repeater from a DC source.
- 3 In Radio Management (RM), program the repeater with any frequency within the specified range of the repeater under test, and set the repeater for low power and disable the repeat path.
- 4 Apply a 1 kHz signal at 1.2 Vrms to Pin 1 of the Aux connector.

- Signal ground is Pin 4 of the Aux connector.
- 5 Key up the repeater and measure the deviation
- Key the repeater by grounding Pin 2 of the Aux connector.



NOTICE: RM must have Pin 2 configured as an active low with the PTT function.

- 6 De-key the repeater.

The deviation shall meet the limits shown in the following table.

Channel Spacing (kHz)	Relative Standard Deviation (RSD) (kHz)	92% of RS (kHz)	Tolerance (Hz)
12.5	2.5	2.3	+0/-50
20.0	4.0	3.68	+0/-80
25.0	5.0	4.6	+0/-100



NOTICE:

- The repeater is factory-tuned in accordance to this procedure and specification.
- Verification is performed outside of the Tuner application, such as in normal mode.

Chapter 9

SLR 1000 Maintenance and Disassembly/Reassembly

9.1

Introduction

This chapter provides details about the following:

- Routine maintenance
- Preventive maintenance (inspection and cleaning)
- Safe handling of CMOS and LDMOS devices
- Disassembly and reassembly of the repeater
- Repair procedures and techniques.

9.2

Routine Maintenance



NOTICE: Clean the repeater with a soft dry cloth while in service.

The SLR 1000 Repeater and ancillary equipment have been designed with state-of-the-art technology and operate under software control, thus requiring minimal routine maintenance. Virtually all repeater operating parameters are monitored and self-corrected by the Transceiver and the firmware it runs, which makes adjustments and tuning virtually unnecessary.

Provided that the equipment is installed in an area which meets the specified environmental requirements, the only routine maintenance task required is the calibration of the repeater reference oscillator circuit.

9.3

Preventive Maintenance

Periodic visual inspection and cleaning is recommended.

9.3.1

Inspection

Check that the external surfaces of the SLR 1000 Series Repeater are clean, and that all external controls and connections are in order. It is not recommended to inspect the interior electronic circuitry.

9.3.2

Cleaning Procedures

The following procedures describe the recommended cleaning agents and the methods to be used when cleaning the external and internal surfaces of the SLR 1000 Repeater. External surfaces include the top cover and repeater enclosure.

Periodically clean smudges and grime from exterior enclosure. Use a soft, non-abrasive cloth moistened in a 0.5% solution of mild dishwashing detergent and water solution. Rinse the surface using a second cloth moistened in clean water, and clean any dirt or debris from the heatsink fins.

The only factory recommended liquid for cleaning the printed circuit boards and their components is isopropyl alcohol (100% by volume).

9.4

Safe Handling of CMOS and LDMOS Devices

Complementary metal-oxide semiconductor (CMOS) and laterally diffused metal-oxide semiconductor (LDMOS) devices are used in this family of stations, and are susceptible to damage by electrostatic or high voltage charges. Damage can be latent, resulting in failures occurring weeks or months later. Therefore, special precautions must be taken to prevent device damage during disassembly, troubleshooting, and repair.

Handling precautions are mandatory for CMOS/LDMOS circuits and are especially important in low humidity conditions.

DO NOT attempt to disassemble the repeater without first referring to the following CAUTION statement.



CAUTION: This repeater contains static-sensitive devices. Do not open the repeater unless you are properly grounded. Take the following precautions when working on this unit:

- Store and transport all CMOS/LDMOS devices in conductive material so that all exposed leads are shorted together. Do not insert CMOS/LDMOS devices into conventional plastic "snow" trays used for storage and transportation of other semiconductor devices.
- Ground the working surface of the service bench to protect the CMOS/LDMOS device. We recommend using the Motorola Solutions Static Protection Assembly (part number 0180386A82), which includes a wrist strap, two ground cords, a table mat, and a floor mat, ESD shoes and an ESD chair.
- Wear a conductive wrist strap in series with a 100k resistor to ground. (Replacement wrist straps that connect to the bench top covering are Motorola Solutions part number 4280385A59).
- Do not wear nylon clothing while handling CMOS/LDMOS devices.
- Do not insert or remove CMOS/LDMOS devices with power applied. Check all power supplies used for testing CMOS/LDMOS devices to be certain that there are no voltage transients present.
- When straightening CMOS/LDMOS pins, provide ground straps for the apparatus used.
- When soldering, use a grounded soldering iron.
- If at all possible, handle CMOS/LDMOS devices by the package and not by the leads. Prior to touching the unit, touch an electrical ground to remove any static charge that you may have accumulated. The package and substrate may be electrically common. If so, the reaction of a discharge to the case would cause the same damage as touching the leads.

9.5

Installing a Duplexer

Perform this procedure to install a duplexer into the SLR 1000 Repeater.

Prerequisites: Obtain the following:

- Duplexer kit
- Four M3 screws (obtained from the repeater package)
- T10 bit screwdriver

When and where to use:

Install a duplexer when transmitting and receiving using one antenna.

Procedure:

- 1 Turn off power to the repeater.
- 2 Disassemble the repeater, as follows:
 - a Turn the repeater over and remove the four M4 screws using a T10 bit.
 - b Hold the cover onto the chassis and carefully turn the repeater over.
 - c Slowly remove the top cover, making sure not to damage the front panel flex cable.
- 3 Disconnect the following cables. See [Figure 27: SLR 1000 Repeater Front View \(without top cover\) on page 74](#).
 - a Disconnect the front panel flex cable from the front panel display board.
 - b Cut the tie wrap that secures the Tx and Rx cables.
 - c Disconnect the Rx cable from the Rx output port by gently pulling up.
 - d Disconnect the Tx cable from the Tx output port by gently pulling up.

- e Remove the Tx cable by either cutting the cable from the Tx input port or tie wrapping the cable.



CAUTION: The Tx cable must not touch any components on the board.

Figure 27: SLR 1000 Repeater Front View (without top cover)

Table 22: SLR 1000 Repeater Front View (without top Cover) Callout Legend

Label	Description
1	Transmitter RF (Tx) Output
2	Receiver RF (Rx) Output
3	Transmitter RF (Tx) Input
4	Receiver RF (Rx) Input
5	Front Panel Flex Connector

- 4 Install the duplexer into the repeater, as follows:
 - a Lay the front panel flex cable down across the board.
 - b Place the duplexer into the chassis and align the screw openings, as shown in [Figure 28: SLR 1000 Repeater Front View \(without top cover\) with a Duplexer on page 74](#)
 - c Insert the duplexer antenna port through the Rx input opening in the chassis.
 - d Reinstall the lockwasher and nut onto the antenna port. Torque to 20 in./lbs.
 - e Insert the low passport cable into the Tx output port.
 - f Place the high passport cable underneath the duplexer and insert into the Rx output port.
 - g Secure the duplexer to the chassis with the four M3 screws using a T10 bit. Torque to 10 in./lbs.
 - h Reattach the front panel flex cable to the front panel display board, making sure not to bend the cable.
The cable stops at the black line.
 - i Place the top cover back onto the chassis, making sure not to pinch any cables.
 - j Hold the cover onto the chassis and carefully turn the repeater over.
 - k Reinstall the four M4 screws using a T10 bit. Torque to 20 in./lbs.
- 5 Restore power to the repeater.

Figure 28: SLR 1000 Repeater Front View (without top cover) with a Duplexer

Table 23: SLR 1000 Repeater Front View (without top Cover) with a Duplexer Callout Legend

Label	Description
1	Transmitter RF (Tx) Output
2	Duplexer
3	Receiver RF (Rx) Output
4	Transmitter RF (Tx) Input
5	Receiver RF (Rx) Input

Table continued...

Label	Description
6	Front Panel Flex Connector

9.6

Installing a High-Speed Solid-State Antenna Switch

Perform this procedure to install a high-speed, solid-state antenna switch into the SLR 1000 Repeater.

Prerequisites: Obtain the following:

- Contents of the antenna switch package. Consists of:
 - One antenna switch
 - Two M3 screws
 - Two MCX cables
 - One power cable
- T10 bit screwdriver

When and where to use:

This switch is required for a single antenna, single frequency operation. With the use of the antenna switch, you can configure the repeater as a Direct Mode Range Extender for use with the Extended Range Direct Mode feature. Two separate antennas may be used when enough isolation is maintained between them. The switch can also be used in traditional simplex operation.

Procedure:

- 1 Turn off power to the repeater.
- 2 Disassemble the repeater, as follows:
 - a Turn the repeater over and remove the four M4 screws using a T10 bit.
 - b Hold the cover onto the chassis and carefully turn the repeater over.
 - c Slowly remove the top cover, making sure not to damage the front panel flex cable.
- 3 Disconnect the following cables. See [Figure 29: SLR 1000 Repeater Front View \(without top cover\) on page 75](#).
 - a Disconnect the front panel flex cable from the front panel display board.
 - b Cut the tie wrap that secures the Tx and Rx cables.
 - c Disconnect the Rx cable from the Rx output port by gently pulling up.
 - d Disconnect the Tx cable from the Tx output port by gently pulling up.
 - e Remove the Tx cable by either cutting the cable from the Tx input port or tie wrapping the cable.



CAUTION: The Tx cable must not touch any components on the board.

Figure 29: SLR 1000 Repeater Front View (without top cover)

Table 24: SLR 1000 Repeater Front View (without top Cover) Callout Legend

Label	Description
1	Transmitter RF (Tx) Output
2	Receiver RF (Rx) Output

Table continued...

Label	Description
3	Transmitter RF (Tx) Input
4	Receiver RF (Rx) Input
5	Front Panel Flex Connector

- 4 Install the antenna switch into the repeater, as follows:
 - a Place the antenna switch into the chassis and align the screw openings, as shown in [Figure 30: SLR 1000 Repeater Front View \(without top cover\) with an Antenna Switch on page 76](#).
 - b Secure the antenna switch to the chassis with the two M3 screws using a T10 bit. Torque to 10 in./lbs.
 - c Connect one end of the power cable into the P1000 connector on the antenna switch and the other end to the header connector on the repeater board.
 - d Connect one end of an MCX cable into the J1000 connector on the antenna switch and the other end to the Tx output port.
 - e Connect one end of the other MCX cable into the J1001 connector on the antenna switch and the other end to the Rx output port.
 - f Connect the Rx cable to the J1002 connector on the antenna switch.
 - g Reattach the front panel flex cable to the front panel display board, making sure not to bend the cable.
The cable stops at the black line.
 - h Place the top cover back onto the chassis, making sure not to pinch any cables.
 - i Hold the cover onto the chassis and carefully turn the repeater over.
 - j Reinstall the four M4 screws using a T10 bit. Torque to 20 in./lbs.
- 5 Restore power to the repeater.

Figure 30: SLR 1000 Repeater Front View (without top cover) with an Antenna Switch

Table 25: SLR 1000 Repeater Front View (without top Cover) with an Antenna Switch Callout Legend

Label	Description
1	Transmitter RF (Tx) Output
2	J1000 Connector
3	P1000 Connector
4	J1002 Connector
5	J1001 Connector
6	Receiver RF (Rx) Output
7	Transmitter RF (Tx) Input
8	Header Connector
9	Receiver RF (Rx) Input
10	Front Panel Flex Connector

Chapter 10

SLR 1000 Installation

10.1

Pre-Installation Considerations

Proper installation ensures the best possible performance and reliability of the repeater. Pre-installation planning is required. This includes considering the mounting location of the equipment in relation to input power, antennas, and system interfaces. Also to be considered are site environment conditions, the particular mounting method (several available), and required tools and equipment.

It is highly recommended to read the following before installing this type of equipment for the first time:

- this entire installation section before beginning the actual installation, and
- the Motorola Solutions Quality Standard Fixed Network Equipment Installation manual, R56 (which can be obtained by ordering CDROM 9880384V83), specifically refer to the information on ground connection for lightning protection.

10.1.1

Installation Overview

The following information is an overview for installing the repeater and ancillary equipment. Step-by-step procedures for each of the major installation tasks are then provided beginning in [Mechanical Installation on page 82](#).

- Plan the installation, paying particular attention to environmental conditions at the site, ventilation requirements, and grounding and lightning protection.
- Unpack and inspect the equipment.
- Mechanically install the equipment at the site.
- Make necessary electrical and cabling connections, including the following:
 - DC input cabling
 - Coaxial cables to transmit and receive antennas
 - System cables
- Perform a post-installation function checkout test of the equipment to verify proper installation. Proceed to the Optimization procedures to customize the repeater parameters per customer specifications (such as operating frequency, PL, codes, and so on.)

10.1.2

Site Environmental Conditions

The installation location of the SLR 1000 Repeater must follow precautions and be conducted in such a way so that access is limited to technicians with adequate training and skills.



CAUTION: The repeater is a natural-convection cooled device and may get hot when installed in hot and/or high solar load environments. Use of on-board antennas also creates a potential exposure to RF energy that must be considered.

The repeater may be installed in a suitable, restricted access, indoor or outdoor location suitable for electronic communications equipment that do not exceed the equipment specifications for temperature or ingress. Unit orientation, solar loading, antenna, and cable load quality may all affect the temperature and performance of the unit.

The environmental conditions are:

- Operating Temperature Range – Vertical orientation
-30 °C (-22 °F) to +60 °C (+140 °F)

The operating temperature range is the temperature measured close to the repeater, near the fin inlets (bottom). Other factors, such as orientation, solar loading, duty cycle, and VSWR can affect transmit power and/or maximum operating temperature range.

- Ingress
The repeater has been designed to IP65 ingress protection. It provides protection against blowing water and dust and can be deployed in harsh industrial indoor environments and/or outdoor applications where rain, snow, and dust are prevalent.
- Vibration and Loads
The repeater hardware has been designed to survive high vibration and wind loads (up to 150 mph) encountered in outdoor environments and may be installed in vehicular environments when equipped with ruggedized mounting brackets or trunnions.

10.1.3

Equipment Ventilation

The SLR 1000 Repeater is a natural-convection or passively cooled device with no fans. Care must be taken in mounting the unit to ensure that fresh air can flow into the fin entrances and heated air can adequately escape.

10.1.3.1

Ventilation for a Ceiling Mount

Ceiling mounting of the SLR 1000 Repeater requires that the bracket is mounted against the ceiling surface and that the unit is positioned with the fins facing up towards the ceiling.

Fresh air flows into both ends of the fins and the heated air exhausts out the top of the fin channels. The mounting bracket (same as used for the wall mount) provides an adequate gap between the unit fin tips and the ceiling surface. The fin cooling effectiveness in this orientation is slightly lower than vertical wall mount orientations and that some power shutback at high ambients may occur. It is not recommended to mount any optional AC power supplies onto the mounting bracket when in a ceiling orientation, as the exhaust air is restricted from rising and could overheat the power supply unit as well.

10.1.3.2

Ventilation for a Wall Mount

Wall mounting of the SLR 1000 Repeater requires that the bracket is mounted against the wall surface and that the unit is positioned with the fins running vertically.

Fresh air flows into the bottom of the fins and the heated air exhausts out the top of the fin channels. Mounting of the unit with the fins running horizontally or other orientations other than vertical reduces the airflow through the fins and that some power shutback at high ambients may occur. The wall mount bracket provides adequate gap and mounting provisions for integration of an optional AC power supply between the fins and the bracket. As airflow occurs bottom to top, this does not impact thermal performance in the vertical orientation.

10.1.4

AC and DC Input Power Requirements

This section describes the power requirements for the AC and DC inputs, as well as ground, battery, RF antenna, and system cable connections.

10.1.4.1

DC Input Power Requirements

The DC source operates from 10.8 VDC to 15.6 VDC (4A max). This DC source must be located in the same building as the repeater, and it must meet the requirements of a SELV circuit. The appropriate DC disconnects and current limiting devices must be chosen and implemented per R56.

10.1.4.2

AC Input Power Requirements

For indoor applications, a standard indoor power supply with an IEC C13 appliance connector is available. The adapter may be combined with bracket BR000276A01 so that it can be integrated onto the wall mount bracket with the SLR 1000 Repeater or attached directly to the wall or ceiling.

Use a standard 3-wire grounded electrical outlet as the AC source.



CAUTION: The AC socket outlet must be installed near the equipment and must be easily accessible.

For outdoor applications, a sealed IP67 rated AC power converter is available. This unit may be attached directly to the wall mount bracket with the repeater. It includes a water tight cable junction connector and requires extra wiring, conduit, and/or similar provisions to connect to the AC source.

The outlet must be connected to an AC source capable of supplying a maximum of 500 VA. For a nominal 110/120 VAC input, the AC source must supply 1.3A for indoor and 1.2A for outdoor (minimum). Per R56, the minimum ampacity of the circuit (and protective breaker) feeding the repeater should be no less than 15A. For a nominal 220/240 VAC input, the ampacity requirements can be halved.

10.1.4.3

Ground Connection

The repeater is equipped with a ground screw on the bottom panel of the repeater. [Figure 12: SLR 1000 Repeater Bottom Panel Connector Names and Locations on page 53](#) shows the location of the grounding screw. Connect the ground screw to the site ground point. The size of the wire used for this connection must be 8 AWG minimum.



CAUTION: See the Motorola Solutions Quality Standards Fixed Network Equipment Installation Manual R56 (which can be obtained by ordering CDROM 9880384V83), for complete information regarding lightning protection.

The repeater should only be connected to a battery supply that is in accordance with the applicable electrical codes for the end use country; for example, the National Electrical Code ANSI/ NFPA No. 70 in the U.S.

10.1.4.4

Battery Connection

The battery system is connected to the repeater through the DC inlet connector on the bottom panel of the repeater. See [Figure 12: SLR 1000 Repeater Bottom Panel Connector Names and Locations on page 53](#) for the location of the DC inlet connector.



CAUTION: The repeater should only be connected to a battery supply that is in accordance with the applicable electrical codes for the end use country; for example, the National Electrical Code ANSI/NFPA No. 70 in the U.S.

10.1.4.5

RF Antenna Connections

The transmit and receive antenna RF connections are made using two separate connectors in the standard unit. Duplexer and antenna switch accessories are also available to allow duplexed, half duplexed, or simplex single antenna operation. Coax cables from the receive and transmit antennas must be connected to their respective connectors. The position of these connectors are shown in [Figure 2: SLR 1000 Repeater Left View on page 34](#) and [Figure 3: SLR 1000 Repeater Right View on page 34](#), and their respective connector types are noted in [Table 2: SLR 1000 Repeater Left View Callout Legend on page 34](#) and [Table 3: SLR 1000 Repeater Right View Callout Legend on page 34](#).

In addition, an integrated compact antenna accessory is available to facilitate mounting the antenna directly on the unit. If the duplexer or antenna switch accessories are not used, external antennas are required. Additionally, because the antenna is mounted directly to the repeater, it is not recommended to use the integrated antenna in applications where a direct lightning strike to the unit could occur as significant damage to the repeater and/or connected equipment could occur. Consult R56 manual for details and necessary provisions for surge protection on RF cable and antennas.

10.1.4.6

System Cable Connections

System connections are made through the Aux and/or Ethernet connectors on the bottom panel of the repeater. The positions of the Aux and Ethernet connectors are shown in [Figure 12: SLR 1000 Repeater Bottom Panel Connector Names and Locations on page 53](#).

See [Auxiliary \(Aux\)/Accessory on page 55](#) for a description of the signaling that is supported by the Aux connector.

10.1.5

Equipment Mounting Methods

The SLR 1000 Repeater may be mounted on a wall, ceiling, or pole.

10.1.6

Site Grounding and Lightning Protection



CAUTION: Proper site grounding and lightning protection are vitally important considerations. Failure to provide proper lightning protection may result in permanent damage to the radio equipment.

One of the most important considerations when designing a communications site is the ground and lightning protection system. While proper grounding techniques and lightning protection are closely related, the general category of site grounding may be divided into the following sections.

10.1.6.1

Electrical Ground

Ground wires carrying electrical current from circuitry or equipment at the site is included in the category of electrical ground. Examples include the AC or DC electrical power used to source equipment located at the site, and wires or cables connected to alarms or sensors located at the site.

10.1.6.2

RF Ground

This type of ground is related to the bypassing of unwanted radio frequency energy to earth ground. An example of RF grounding is the use of shielding to prevent or at least minimize the leakage of unwanted RF energy from communications equipment and cables.

10.1.6.3

Lightning Ground

Providing adequate lightning protection is critical to a safe reliable communications site. RF transmission cables, and AC and DC power lines must all be protected to prevent lightning energy from entering the site.

Comprehensive coverage of site grounding techniques and lightning protection is not within the scope of this instruction manual, but there are several excellent industry sources for rules and guidelines on grounding and lightning protection at communications sites.



NOTICE: Motorola Solutions recommends the following reference source:
Motorola Solutions Quality Standards Fixed Network Equipment Installation Manual R56: (which can be obtained by ordering CDROM 9880384V83).

10.1.6.4

Equipment Grounding

The SLR 1000 Repeater is equipped with a ground screw on the bottom right of the repeater.

This screw is used to connect the repeater to the site grounding. All antenna cables, and AC and DC power cabling, should be properly grounded and lightning protected by following the rules and guidelines provided in the previous sections. Failure to provide proper lightning protection may result in permanent damage to the repeater.

10.1.7

Recommended Tools and Equipment

In addition to the typical complement of hand tools, the following tools and equipment are recommended for proper installation of the repeater equipment.

- Tarpaulin or plastic drop cloth or cover surrounding equipment while drilling concrete anchor holes.
- Vacuum cleaner for removing concrete dust caused by drilling.

10.1.8

Equipment Unpacking and Inspection

This section describes ways to unpack and inspect the repeater equipment.

10.1.8.1

Unpack Equipment

Remove the repeater from the cardboard box. Remove the foam inserts and remove the repeater from the antistatic bag. Keep all packing components for future shipping of the repeater.

10.1.8.2

Initial Inspection

- After removing the repeater from the packaging, set on the surface for inspection. The front cover and main housing should be free of damage and should have no obvious scuffs or marks.
- The RF connectors should be free of damage. Connectors should not be bent with regard to the back panel. Threads on RF connectors should be free of debris and undamaged.
- Thoroughly inspect the equipment as soon as possible after delivery. If any part of the equipment has been damaged in transit, immediately report the extent of the damage to the transportation company and to Motorola Solutions.
- When a repeater is delivered from Motorola Solutions, it arrives in suitable packing materials. If the unpacked equipment is damaged, return it to Motorola Solutions in its original packaging.



CAUTION: Equipment should be handled in its original packaging until it is delivered to its final destination. If the equipment is damaged while being moved without the original packaging, the warranty claim is not valid.

Improper handling of the repeater may cause personal injury or damage to the repeater.

10.2

Mechanical Installation

This section describes the equipment unpacking and inspection, as well as the mounting procedure for the repeater.

10.2.1

SLR 1000 Repeater Package Contents

Inspect the various parts and fittings within the SLR 1000 Repeater packing box. Verify that all contents are included.

Table 26: SLR 1000 Repeater Package Contents

Description	Quantity
Safety Supplement Leaflet	1
DC Power Cable Assembly	1
Threaded M20 Seal Plugs (IP67/68)	4 (1 spare)
Cable Gland/Cord M20 Seal Cap (IP67/68)	4 (1 spare)
Wall-Mount Bracket	1
Serrated Hex Flange M6 Screws	4

Table continued...

Description	Quantity
SLR 1000 Repeater	1
Serrated Hex Flange M3 Screws	4

10.2.2

Mounting the SLR 1000 Repeater to a Wall or Ceiling

Perform this procedure to mount the SLR 1000 Repeater to either a wall or to a ceiling.



NOTICE: A wall mount provides a vertical fin orientation. This orientation is required for high temperatures and maximum performance.

Prerequisites: Obtain the following:

- Contents of the repeater package. See [SLR 1000 Repeater Package Contents on page 82](#).
- Four #10/32 lag bolts (not included in the repeater package).
- Torque wrench, adjustable wrench, or a ratchet with a 10mm socket

Procedure:

- 1 Attached the bracket to either the wall or ceiling using four #10/32 lag bolts. See [Figure 31: Bracket Mounting Holes on page 83](#).

Figure 31: Bracket Mounting Holes

- 2 Insert the four M6 screws into the repeater chassis side fins and partially tighten. See [Figure 32: Location of Repeater M6 Screw Mounts on page 83](#).

Figure 32: Location of Repeater M6 Screw Mounts

- 3 Place the repeater chassis into the bracket by sliding the M6 screws into the receiving slots on the bracket. Torque to 60 in-lb. See [Figure 33: Bracket Receiving Slots on page 83](#).

Figure 33: Bracket Receiving Slots

10.2.3

Mounting the SLR 1000 Repeater to a Pole

Perform this procedure to mount the SLR 1000 Repeater to a pole.

Prerequisites: Obtain the following:

- Pole Mount Kit. Consists of:
 - One pole mount bracket
 - One ½ in. U-bolt
 - Two ½ in. bolts
 - Four ½ in. nuts
- Torque wrench, adjustable wrench, or a ratchet with a 10mm socket

When and where to use:

There are two possible options for the pole mount installation:

- 1 Using a U-bolt with four ½ in. nuts for poles with a diameter between 2 – 3.5 in.

- 2 Using band clamps for poles of any diameter. The band clamps are not included in the pole mount kit.

Procedure:

- 1 If using the U-bolt for installation, perform the following actions:
 - a Place the two inner ½ in. nuts onto the U-bolt, one on each thread. Adjust each nut approximately 2 in. on each thread allowing enough clearance between the bracket and the repeater.
 - b Attach the pole mount bracket to the U-bolt.
 - c Slide the wall mount bracket onto the U-bolt, with the receiving slots facing upwards, and place the two outer ½ in. nuts onto the U-bolt, one on each thread. Torque all four nuts to 300 in/lb. See [Figure 34: U-Bolt Bracket Assembly on page 84](#).

Figure 34: U-Bolt Bracket Assembly

- 2 If using the band clamps for installation, perform the following actions:
 - a Slide the band clamps through the slots on the pole mount bracket and attach the bracket to the pole.
 - b Attach the wall mount bracket to the pole mount bracket, with the receiving slots facing upwards, using two ½ in. bolts and two ½ in. nuts. Torque to 300 in/lb.
- 3 Insert the four M6 screws, supplied in the repeater package, into the repeater chassis side fins and partially tighten. See [Figure 35: Location of Repeater M6 Screw Mounts on page 84](#).

Figure 35: Location of Repeater M6 Screw Mounts

- 4 Place the repeater chassis into the bracket by sliding the M6 screws into the receiving slots on the bracket. Torque to 60 in-lb. See [Figure 36: Bracket Receiving Slots on page 84](#).

Figure 36: Bracket Receiving Slots

10.3

Electrical Connections

After the repeater equipment has been mechanically installed, electrical connections must be made.

This involves making the following connections to:

- power supply,
- antenna coax cables
- system cables, and
- grounding

[Figure 37: SLR 1000 Repeater Bottom Panel Connector Names and Locations on page 84](#) shows the position of the repeaters external connectors on the bottom panel of the repeater. [Table 27: SLR 1000 Repeater Connector Types and Primary Functions on page 84](#) identifies the connector types as well as a given connector's primary function.

Figure 37: SLR 1000 Repeater Bottom Panel Connector Names and Locations

[Table 27: SLR 1000 Repeater Connector Types and Primary Functions](#)

Location	Connector Type	Function(s)
1	M6 TORX Screw	Bonding Ground Connection

Table continued...

Location	Connector Type	Function(s)
2	N-Type – Female	Receiver RF (Rx)
3	2.1 X 5.5 OD Barrel Connector	DC Power Inlet
4	RJ-45 – Aux/Accessory	Rx Audio, Tx Audio, PTT, 1 PPS, and GPIO
5	RJ-45 – Ethernet	Network
6	Type B USB Socket	Programming Interface
7	Option Dependent	Option Dependent 1 and 2
8	N-Type – Female	Transmitter RF (Tx)

10.3.1

Power Supply Connections

This section describes power, antenna, and cable connections.

10.3.1.1

DC Input Power Connection/ DC Power Connection

Each repeater comes with a 3-meter DC input cable with a barrel type connector output that connects to the repeater.

For DC operation, the DC source power is connected to the repeater through the DC power inlet connector shown in [Figure 37: SLR 1000 Repeater Bottom Panel Connector Names and Locations on page 84](#).

For sealing the cable, first thread the gland nut, then the cable gland over the barrel connector. The connector is inserted into the repeater and then you thread in and torque the cable gland. Last, thread on the nut and torque to compress the gland and seal to the cable jacket. Ensure that the barrel connector is full seated before final tightening of the gland nut.

Longer runs of DC power require a junction box or splice connection of some type near the repeater so that larger gage cable can be used and then connected to the DC barrel cable (cut to length as needed). Cable gage and length should be carefully selected to ensure nominal voltage at the supply does not fall below minimum specified.

The DC source must be located in the same building as the repeater, and it must meet the requirements of an SELV circuit.



CAUTION: Ensure that the appropriate voltage is connected with a nominal 13.6 VDC (10.8 – 15.6 VDC).

10.3.1.2

AC Input Power Connection

AC/DC power supplies are available and operate from 100–240 VAC at 47–63 Hz AC input power. A standard 3-prong line cord is required to connect the power supply to the AC source.



CAUTION: Do not apply AC power to the SLR 1000 Repeater at this time. Make sure that the circuit breaker associated with the AC outlet is turned OFF.

The DC socket-outlet must be installed near the equipment and must be easily accessible.

[Figure 37: SLR 1000 Repeater Bottom Panel Connector Names and Locations on page 84](#) shows the DC power inlet connector. Insert the plug into an appropriate grounded outlet.

The AC converters come with a barrel connector output that connects to the repeater. For sealing, first thread the cable gland nut, then the cable gland over the barrel connector. The connector is inserted into the repeater and then threaded in and the cable gland torqued. Last, thread on the nut and torque to compress the gland and seal to the cable jacket. Ensure that the barrel connector is fully seated before final tightening of the gland nut.

10.3.1.3

Ground Connection

The repeater is equipped with a ground screw on the bottom panel. [Figure 37: SLR 1000 Repeater Bottom Panel Connector Names and Locations on page 84](#) shows the location of the grounding screw. Connect the ground screw to the site ground point. The size of the wire used for this connection must be 8 AWG minimum.



CAUTION: Refer to Motorola Quality Standards Fixed Network Equipment Installation Manual R56 (which can be obtained by ordering CDRom 9880384V83), for complete information regarding lightning protection.

The repeater should only be connected to a battery supply that is in accordance with the applicable electrical codes for the end use country; for example, the National Electrical Code ANSI/ NFPA No. 70 in the U.S.

10.3.1.4

RF Antenna Connections

The transmit and receive antenna RF connections are made using two separate connectors. Coax cables from the receive and transmit antennas must be connected to their respective connectors. The position of these connectors are shown in [Figure 2: SLR 1000 Repeater Left View on page 34](#) and [Figure 3: SLR 1000 Repeater Right View on page 34](#), and their respective connector types are noted in [Table 2: SLR 1000 Repeater Left View Callout Legend on page 34](#) and [Table 3: SLR 1000 Repeater Right View Callout Legend on page 34](#).

10.3.1.5

System Cable Connections

System connections are made through the Aux and/or Ethernet connectors located on the bottom panel of the repeater. The positions of the Aux and Ethernet connectors are shown in [Figure 37: SLR 1000 Repeater Bottom Panel Connector Names and Locations on page 84](#).

See [Auxiliary \(Aux\)/Accessory on page 55](#) for a description of the signaling that is supported by the Aux connector.

10.3.2

Installing Cable Grommet Connectors or Plugs

Cable sealing glands or cordgrips are used to seal the openings in the bottom of the SLR 1000 Repeater when a cable is used with the repeater. It is expected that the RJ-45 cables for LAN and GPIO are field terminated as the RJ-45 connectors cannot fit through the cable gland, and cables are typically made to length on site in a typical installation. Solid plugs are provided to seal the USB Programming connector and any unused cable ports.

Prerequisites: Obtain a 1 in. torque wrench.



NOTICE: Cables must be field terminated on at least one end to allow the cable to be inserted through the cable gland.

Procedure:

- 1 Insert unterminated data cable through the cable gland cap.
- 2 Insert unterminated data cable through the cable gland body.
- 3 Terminate the RJ-45 connector onto the cable and plug into the desired repeater connector.
- 4 Screw the cable gland body into the repeater opening. Torque to 55 in/lb.
- 5 Screw the cap to the cable gland. Torque to 55 in/lb.
- 6 If a cable gland is not used, seal the opening with a M20 threaded plug. Torque to 55 in/lb.

10.4

Post Installation Checklist

After the repeater has been mechanically installed and all electrical connections have been made, power may now be applied and the repeater checked for proper operation.

10.4.1

Apply Power

Turn ON the circuit breaker controlling the AC source to the power converter that is supplying power to the repeater.

10.4.2

Verify Proper Operation

Operation of the repeater can be verified by:

- Observing the state of the three LEDs located on the front panel, and
- Exercising radio operation.



CAUTION: Some repeater components can become extremely hot during operation. Turn OFF all power to the repeater and wait until sufficiently cool before touching the repeater.



Symbol indicates areas of the product that pose potential burn hazards.

10.4.3

Front Panel LEDs

After turning on the repeater power (or after a repeater reset), the three LEDs on the repeater front panel:

- Light for approximately one second to indicate that they are functional, then
- Go off for one second, then
- Indicate the operational status of the repeater.

10.4.4

Repeater Codeplug Data Backup

Backup the repeater codeplug data by using the Radio Management (RM) on a computer.

10.5

General Bonding and Grounding Requirements

Equipment should be attached to a grounding bar using solid or stranded 6 AWG copper wires. See the Motorola Solutions R56 manual Standards and Guidelines for Communication Sites (which can be obtained by ordering CDROM 9880384V83) for more information on proper bonding and grounding at a site.

10.6

General Cabling Requirements

Diagrams for cabling are typically included in the system-specific configuration documentation provided by Motorola Solutions. Also see the Motorola Solutions R56 manual Standards and Guidelines for Communication Sites (which can be obtained by ordering CDROM 9880384V83) for cabling standards.

Appendix A: Accessories

Introduction

Motorola Solutions provides the following approved accessories to improve the productivity of the SLR 1000 Repeater.

For a list of Motorola Solutions-approved accessories, visit the following web site:
<http://www.motorolasolutions.com>.

Antennas

Part No.	Description
HKAE4003_	External Repeater Mounted Antenna (400–460 MHz)
HKAE4004_	External Repeater Mounted Antenna (440–495 MHz)
HKAE4005_	External Repeater Mounted Antenna (490–530 MHz)

Cables

Part No.	Description
CB000303A01	Power Cable, US
0112004B04	N-Type Male to N-Type Male Connector
0112004U04	N-Type Male to BNC Male Connector

Documentation

Part No.	Description
6880309T12	MOTOTRBO System Planner
9880384V83	CDROM for R56 manual
RVN5115_	MOTOTRBO CPS-RM and Tools DVD
PMVN4131_	Asia Tuner CD
GMLN4575_	MOTOTRBO Publication CD
GMVN5141_	MOTOTRBO Software DVD
GMVN5520_	MOTOTRBO RDAC Software CD
PMVN4130_	MOTOTRBO CPS/AirTacer CD
PMVN4171_	MOTOTRBO RDAC APP

Duplexers

Part No.	Description
HFE8400_	UHF Duplexer, 406 – 450 MHz
HFE8401_	UHF Duplexer, 470 – 495 MHz
HFE8454_	UHF Duplexer, 490 – 527 MHz
TDE7780_	UHF Duplexer (Tuned) 450 – 470 MHz w/N Conn

Mounting

Part No.	Description
PMLN7213_	Pole Mount Kit
includes:	BR000144A01 (1) Pole Mount Bracket
	FN000163A01 (1) U-Bolt
	FN000164A01 (2) ½ in. Bolt
	FN000165A01 (2) ½ in. Nut
BR000143A01 (1)	Wall Mount Bracket
FN0001642A01 (4)	M6 Screws
BR000276A01	Indoor Power Supply Mounting Bracket

Service Tools

Part No.	Description
PMKN4166_	Test Cable (for test box and external speaker)
30009477001	USB A to USB B Cable (for programming)
RLN4460_	Test Box
CB000174A02	DB25 to RJ-45 Adapter

Appendix B: Replacement Parts Ordering

Replacement Parts Ordering

This section describes ways you can place your orders for the replacement parts.

Basic Ordering Information

Some replacement parts, spare parts, and/or product information can be ordered directly. While parts may be assigned with a Motorola Solutions part number, this does not guarantee that they are available from Motorola Solutions Radio Products and Solutions Organization (RPSO). Some parts may have become obsolete and no longer available in the market due to cancellations by the supplier. If no Motorola Solutions part number is assigned, the part is normally not available from Motorola Solutions, or is not a user-serviceable part. Part numbers appended with an asterisk are serviceable by Motorola Solutions Depot only.

Motorola Solutions Online

This section describes ways you can place your orders for the replacement parts.

Motorola Solutions Online users can access our online catalog at <https://businessonline.motorolasolutions.com>.

To register for online access:

- Have your Motorola Solutions Customer number available.
- Go to <https://businessonline.motorolasolutions.com> and click on **Sign Up Now**.
- Complete the form and submit it.
- Or, call 1-800-422-4210 (for U.S. and Canada Service Centers only).

Contact your BDM to complete the set-up. Registration is completed within 24 to 48 hours.

Mail Orders

Mail orders are only accepted by the US Federal Government Markets Division (USFGMD).

Motorola
7031 Columbia Gateway Drive
3rd Floor – Order Processing
Columbia, MD 21046
U.S.A.

Telephone Orders

Radio Products and Solutions Organization (see note)
(United States and Canada)
7:00 AM to 7:00 PM (Central Standard Time)
Monday through Friday (Chicago, U.S.A.)
1-800-422-4210
1-847-538-8023 (United States and Canada)

U.S. Federal Government Markets Division (USFGMD)
1-877-873-4668
8:30 AM to 5:00 PM (Eastern Standard Time)

Fax Orders

Radio Products and Solutions Organization (see note)
(United States and Canada)
1-800-622-6210
1-847-576-3023 (United States and Canada)
USFGMD
(Federal Government Orders)
1-800-526-8641 (For Parts and Equipment Purchase Orders)

Parts Identification

Radio Products and Solutions Organization (see note)
(United States and Canada)
1-800-422-4210



NOTICE: The Radio Products and Solutions Organization (RPSO) was formerly known as the Radio Products Services Division (RPSD) and/or the Accessories and Aftermarket Division (AAD).

Product Customer Service

Radio Products and Solutions Organization (United States and Canada)
1-800-927-2744

Appendix C: Motorola Solutions Service Centers

Motorola Solutions Service Centers

This section lists the Motorola Solutions service centers for testing, troubleshooting, and service.

Servicing Information

If a unit requires further complete testing, knowledge and/or details of component level troubleshooting or service than is customarily performed at the basic level, please send the radio to a Motorola Solutions Service Center as listed below or your nearest Authorized Service Center.

Motorola Solutions Service Center

1220 Don Haskins Drive
Suite A
El Paso, TX 79936
Tel: 915-872-8200

Motorola Solutions Federal Technical Center

10105 Senate Drive
Lanham, MD 20706
Tel: 1-800-969-6680
Fax: 1-800-784-4133

Motorola Canadian Technical Logistics Center

181 Whitehall Drive
Markham, Ontario
L3R 9T1
Toll Free: 800-543-3222

Preliminary FCC Filing

This page intentionally left blank.

Appendix D: SLR 1000 Series Third Party Controllers

Overview

The SLR 1000 Repeater is capable of interfacing to a number of third party controllers through the four-wire and GPIO/ GPI interface afforded by the back panel AUX connector. This section covers the connections and signal levels between the third party controllers and the repeater, as well as the audio path configuration needed through Radio Management (RM). Note that this section is not a substitute for a more comprehensive instruction detailed in the vendor's manuals of their respective third party controllers.

The third party controllers supported by the repeater are as follows:

- Tone Remote Adapter (Motorola Model L3276)
- External Supply
- 2-Channel Steering Maximum



CAUTION: Do not hot swap any of the third party controllers as this could (at a minimum) cause a malfunction with the repeater.



NOTICE: The repeater only support the third party controllers noted above when it is configured in analog mode. The screen capture below shows the RM location to configure the repeater for analog mode.

If the third party controllers are supplied power by the repeater, then the repeater needs to be in a powered off state when establishing (or removing) the connection to the repeater back panel connector.

Figure 38: Radio Management Settings to Configure SLR 1000 Repeater for Analog Mode

Tone Remote Adapter

When a dispatch console or deskset sends out signals to a remote repeater, it does so over a Wireline. Two types of signals are sent:

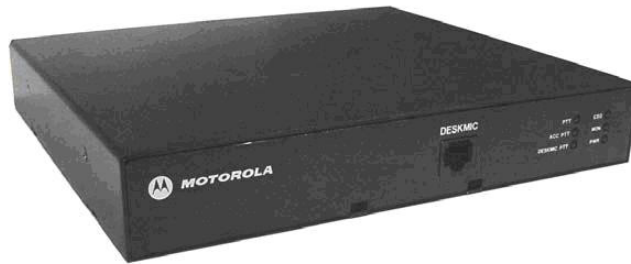
- Audio signal
- Command signals (function tones) that are used to perform the remote control functions.

The SLR 1000 Repeater is capable of decoding function tones, sent over a Wireline from a remote analog deskset or console, through the Motorola Solutions Tone Remote Adapter (Model L3276). When properly configured, the Tone Remote Adapter performs the following functions in conjunction with the repeater:

- Transmit and Receive Audio
- PTT
- Monitor
- Channel Select (up to four frequencies)
- Wildcard (such as, Repeater Knockdown)

See Motorola Solutions Tone Remote Adapter Manual (supplied with the Tone Remote Adapter) for specifications, operation, installation, alignment, programming, alternate configurations, and repair information.

Figure 39: Model L3276 Tone Remote Adapter



Compatibility

Model L3276 Tone Remote Adapter is compatible for all versions of SLR 1000 Repeater software and hardware.

Hardware Connections

The connections between the SLR 1000 Repeater and the Tone Remote Adapter are facilitated with a multi-conductor cable connected between the J7 the repeater back panel AUX 25-Pin connector and that of the Tone Remote Adapter. The connection provides for the following signals:

- Transmit Audio
- Receiver Audio
- PTT
- COR
- Monitor
- Channel Steering
- Wild Card (such as Repeater Knockdown)
- Ground

Signal connections are noted in [Figure 40: Signal Connections Between SLR 1000 Repeater and Motorola L3276 25-Pin Connector for a 2-Channel Remote Control](#) on page 96. The repeater connector and physical Pin locations are noted in the backplane interface board section of this manual. See Motorola L3276 25-Pin manual for its connector and physical Pin locations. The part number for a pre-fabricated cable is noted in the repeater ordering guide.

Figure 40: Signal Connections Between SLR 1000 Repeater and Motorola L3276 25-Pin Connector for a 2-Channel Remote Control

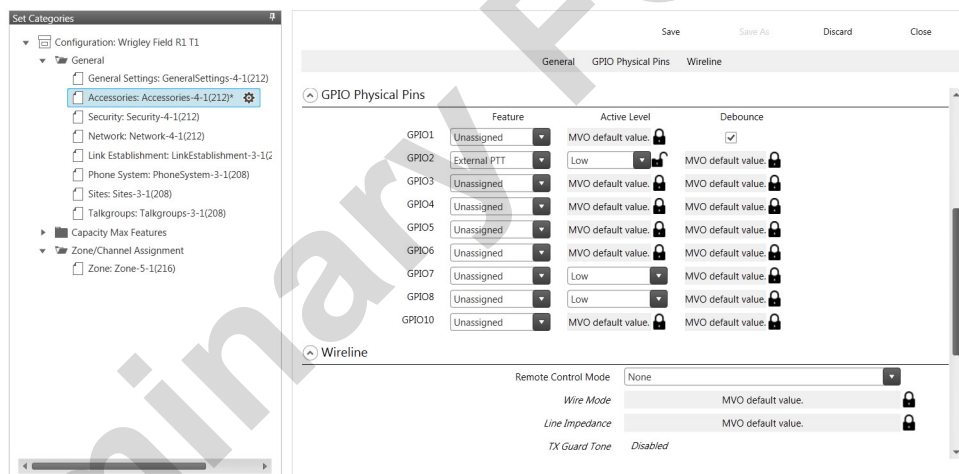
Radio Management Configuration (For a 2-Channel Remote Control)

The SLR 1000 Repeater is configured through the Radio Management (RM) application as shown in [Figure 41: Radio Management Configuration for L3276 Tone Remote Adapter \(For a 2-Channel Remote Control\)](#) on page 97. More specifically, the affected parameters are as follows:

- Audio Type
 - Filtered Squelch
- Analog Accessory Emphasis
 - De & Pre
- Disable Repeat Path

- Un-Checked or Checked
- Tx Audio Priority
 - Set to 0 for console priority
- GPIO Pin number 2
 - Ext PTT
 - Active Low
- GPIO Pin number 5
 - CSQ Detect or PL/ Talk group Detect
 - Active Low
- GPIO Pin number 6
 - Monitor
 - Active Low
- GPIO Pin number 8
 - Channel Select 1
 - Active Low

Figure 41: Radio Management Configuration for L3276 Tone Remote Adapter (For a 2-Channel Remote Control)



NOTICE: This configuration is considered typical. The L3276 Remote Tone Adapter provides alternate configurations that are supported by the repeater as well. See the *L3276 Remote Tone Adapter* manual for additional details.

Tone Remote Adapter Settings

The input and output levels should be adjusted per the Tone Remote Adapter's instructions. The summary below gives a brief overview of the high level characteristics and typical Tone Remote Adapter settings for configuration with the SLR 1000 Repeater.

Radio Rx

The Receiver audio yields 330 mV rms into 50 kΩ with an RF input signal deviating at 60% RSD. With the Remote Tone Adapter's own loading impedance, the "Radio Rx" signal delivered to the phone

patch is at a high enough drive level to leave jumper S10 in the factory default position (position is "out").

Radio Tx

The transmitter yields 60% RSD with 80mV rms into the Tx Audio port. The "Radio Tx" signal delivered by the Remote Tone Adapter is at a high enough drive level to leave jumper S9 in the factory default position (position A).

Channel Steering

Leave Jumper S7 in position B (factory default) to match the SLR 1000 Series Repeater's active low setting for the Channel Steering 1 signaling.

Monitoring

Leave jumper S8 in the "IN" position (factory default) to match the active low setting for the Monitor GPIO signaling.

PTT

Leave jumper S5 in the "IN" position (factory default) to match the active low setting for the PTT GPIO signaling.

Wildcard 1 (optional)

Leave jumper S6 in position A (factory default) to match the active low setting for the Repeater Disabled GPIO signaling.

Appendix E: MOTOTRBO Repeater EME Assessment



NOTICE: The example in this Appendix applies for a UHF band system. For different frequency bands, applicable band-specific parameters should be employed to carry out the computations yielding band-specific compliance boundaries.

Executive Summary

Compliance is established with respect to the U.S. FCC regulations [11] in a typical system configuration of the MOTOTRBO SLR 1000 Repeater described in the following as derived.

A computational assessment was carried out to provide an estimation of the EME exposure and compliance distances relative to the FCC ID ABZ99FT4100, Model AAR11SDGANQ1AN with HKAE4003_, HKAE4004_, and HKAE4005_ antennas.

The following table provides the compliance distances for *general public* and *occupational-type* exposure, for the UHF frequency band, antenna, and parameters considered in this analysis, based on a typical system configuration:

Table 28: Indoor EME Compliance Distances Based on Example UHF Evaluation

Compliance distances	Peak 1-g Average SAR	Whole-Body SAR
General public exposure	40 cm	40 cm
Occupational-type exposure	40 cm (*)	40 cm (*)

Table 29: Outdoor EME Compliance Distances Based on Example UHF Evaluation

Compliance distances	Peak 1-g Average SAR	Whole-Body SAR
General public exposure	67 cm	67 cm
Occupational-type exposure	14 cm (*)	14 cm (*)

(*) This distance is very conservative and may be reduced significantly by carrying out a specific occupational exposure analysis. The present analysis comprises a single distance suitable for both exposure conditions.

Device Power Characteristics

The technical characteristics of the FCC ID ABZ99FT4100 Model AAR11SDGANQ1AN are as follows:

- Transmit Frequency Range: 400–527 MHz
- Maximum Power: 10 W
- Maximum Duty Cycle: 100%
- Antenna Information:
 - Frequency Range: 400–530 MHz
 - Monopole (17 cm)
 - Peak Gain: 4.1 dBi

Outdoor Exposure Prediction Model

This section describes how to determine the outdoor exposure model prediction of an antenna.

Whole-Body SAR Compliance

Full-wave and half-wave simulations are represented to show the exposure conditions.

The full-wave simulations based on the FDTD method were performed at 400 MHz and 470 MHz which includes the operating band of the evaluated antenna. The simulation code employed was XFDTD, version 7.3 by Remcom Inc., State College, PA. The exposed subject was modeled by a heterogeneous full body model standardized for SAR evaluation according to the IEC/IEEE 62704-2 draft standard [12].

The half-wave dipole antenna and maximum radiated power were used to represent the exposure condition. At each frequency, two individual simulations representing the exposure from the front and back at 40 cm distance from the dipole were conducted. No losses other than dissipation of RF energy inside the human body were assumed in the FDTD modeling, which provides an extra degree of overestimation.

Figure 42: H-Field and SAR Distributions for Exposure from a Dipole Antenna

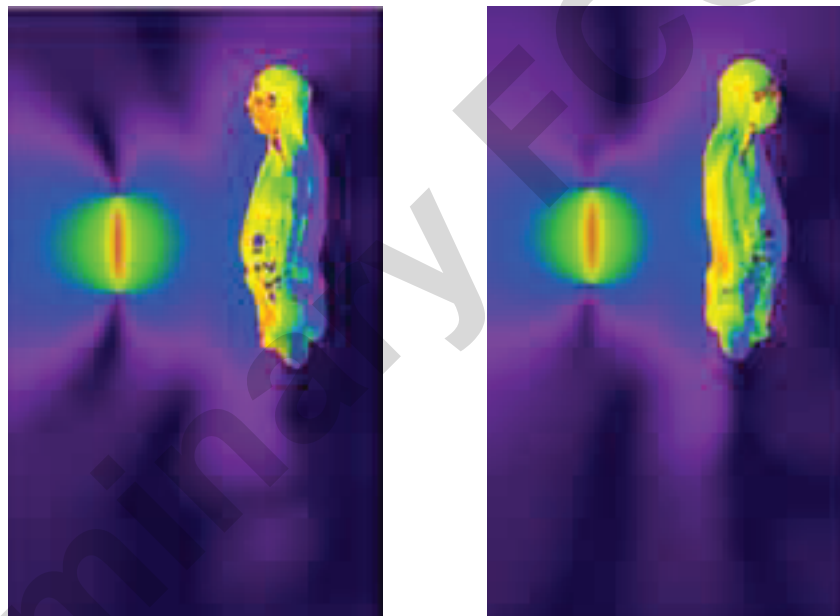


Table 30: Whole-Body Average SAR Results on page 100 presents the whole-body average SAR results for the simulated conditions at. To account for the actual measured antenna gain of 4.1 dBi which is higher than the half -wave dipole gain by factor of 1.57 the whole-body average results were scaled by that factor and are present in a separate column as adjusted whole-body SAR values alongside.

Table 30: Whole-Body Average SAR Results

Table Number	Frequency MHz	Antenna Position	Whole-Body SAR W/kg	Adjusted Whole-Body SAR, W/kg
1	400	Front	0.010	0.016

Table continued...

Table Number	Frequency MHz	Antenna Position	Whole-Body SAR W/kg	Adjusted Whole-Body SAR, W/kg
2	400	Back	0.012	0.019
5	470	Front	0.010	0.016
6	470	Back	0.012	0.019

The highest adjusted whole-body average SAR value from these simulations is 0.019 W/kg. This value is below the US FCC whole-body SAR limits for both controlled (occupational) and general public exposure environments, 0.4 W/kg and 0.08 W/kg, respectively.

Peak 1-g Average SAR Compliance

The maximum measured gain of the antenna is used in this assessment to produce the conservative evaluation of exposure in the operating condition of the radio.

The compliance relative to the US FCC limits for the peak 1-g average SAR [11] is evaluated at $p=40$ cm from the antenna by estimating an upper bound for said quantity. Evaluation of the peak power density at 40 cm distance is performed based on maxim radiated power $P=10$ W and maximum antenna gain $G_{ant} = 4.1$ dBi:

$$S_{40cm} \leq \frac{P \cdot G_{ant}}{4\pi \cdot r^2} \bigg|_{\substack{P=10.7W \\ G_{ant}=10^{(4.1/10)} \\ r=0.4m}} = \frac{10 \cdot 10^{\frac{4.1}{10}}}{4\pi(0.4)^2} \frac{W}{m^2} < 12.8 \frac{W}{m^2} = 1.28 \frac{mW}{cm^2} \quad (4)$$

Making the further conservative assumption that, at the point of maximum exposure, the whole impinging power over a cross-section equal to one face of a 1-g cube of tissue (an area equal to $1cm^2$ assuming that the tissue density is $1g/cm^3$) is absorbed by the body inside that cube, the following upper bound for the peak 1-g average SAR is derived.

$$SAR_{1-g} < \frac{S_{40cm} \cdot A_{cube}}{M_{cube}} = \frac{1.28 \frac{mW}{cm^2} \cdot 1cm^2}{1g} = 1.28 \frac{mW}{g} \quad (5)$$

This value is below the US FCC peak 1-g average SAR limits [11] for both controlled (occupational) and uncontrolled (general public) environments, 8 W/kg and 1.6 W/kg, respectively.

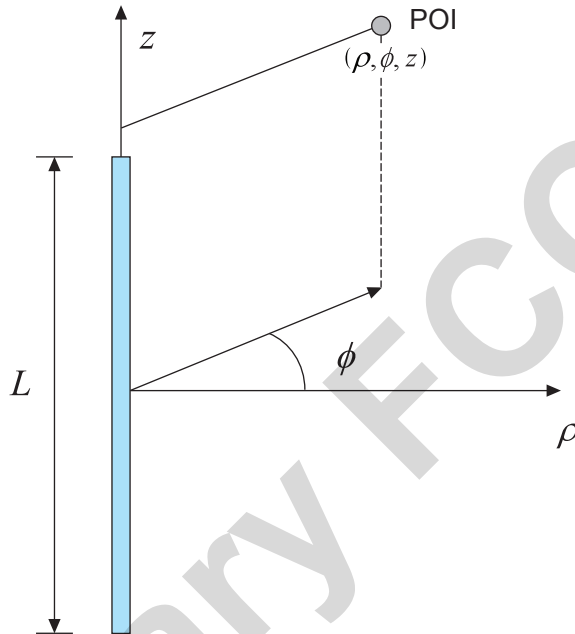
Indoor Exposure Prediction Model

This section describes how to determine the indoor exposure model prediction of an antenna or at ground level.

Exposure in Front of the Antenna

The cylindrical-wave model defined in Clause 8.3.4 of the EN50383:2010 standard is applied to determine the compliance boundaries for workers and general public for a typical system configuration of the SLR 1000 Repeater.

Figure 43: Reference Frame for the Point of Interest (POI) Cylindrical Co-Ordinates



Per the reference frame in [Figure 43: Reference Frame for the Point of Interest \(POI\) Cylindrical Co-Ordinates on page 102](#), the cylindrical-wave model is applicable in the volume described in cylindrical

co-ordinates (ρ, ϕ, z) for omni-directional array antennas as follows:

$$\hat{S}(r, \phi) = \frac{P}{\pi r L \cos^2 \gamma \sqrt{1 + \left(2 \frac{r}{r_0}\right)^2}}, \quad r_0 = \frac{1}{2} D_A L \cos^2 \gamma \quad (1)$$

where

- P
available power at the antenna port (W);
- L
physical antenna length (metres);
- D_A
peak antenna directivity (unit-less), assumed equal to the peak gain G_A ;
- γ
electrical down-tilt angle of the antenna main beam (radians), and

$$r = \frac{\rho}{\cos \gamma}$$

is the distance from the antenna center (metres). Spatial power density averaging may be required by some regulations. As the formula (1) predicts the peak power density, it represents a conservative estimate of the average power density. Thus there is no need to compute the latter.

Exposure at Ground Level

Several methods can be employed to determine the EME exposure at ground level.

Such an assessment is not necessary if the mounting height of the antenna is larger than the compliance distance in front of the antenna, computed using the EN50383:2010 methodology outlined in

[Exposure in Front of the Antenna on page 102](#). If this is not feasible, then the following approach can be employed.

At ground level exposure occurs in the antenna far-field. The antenna phase center is assumed to be the mounting height. The resulting predictive equation for the power density is:

$$S(d) = (2.56) \frac{P \cdot G(\theta)}{4 \pi (H^2 + d^2)}$$

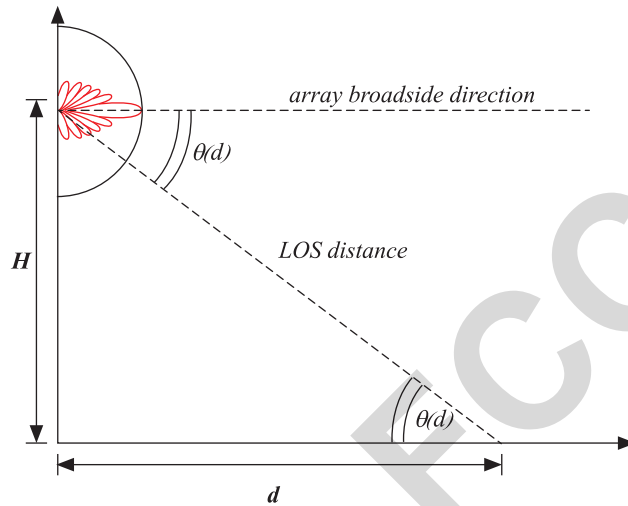
where $G(\theta)$ is the elevation gain pattern, which is approximated by the following expression:

$$G(\theta) = G_A \left| \frac{\sin\left(\frac{k_0 L}{2} \sin \theta\right)}{\frac{k_0 L}{2} \sin \theta} \right|^2$$

$$k_0 = 2\pi/\lambda$$

where k_0 is the free-space wavenumber and L is the effective antenna length yielding the appropriate vertical beamwidth, while H is the antenna height above ground and d is the point of interest (POI) distance from the vertical antenna projection to ground (see the following figure). The multiplicative factor 2.56 is introduced to enforce near-perfect, in-phase ground reflection as recommended in [2]. In this case, spatial averaging is not carried out to make the EME exposure assessment more conservative.

Figure 44: Schematic of the Ground-Level Exposure Model Adopted for the Assessment



Typical System Configuration

The SLR 1000 Repeater operates in different frequency ranges with different channels transmitting 10 W radio frequency (RF) power.

The typical system configuration comprises an omnidirectional array antenna featuring 6–10 dBd gain, installed at or above 20 m from ground level, and fed by the repeater through a combiner characterized by a typical 3 dB transmission loss, and a 30 m 7/8" coaxial cable characterized by a typical 2.7 dB/100m loss, resulting in a total 3.9 dB transmission loss. Based on these characteristics, the RF power at the antenna input is about 20 W.

Since shorter antennas provide a conservative EME exposure assessment from equation (1), when

$$r < r_0$$

, the parameters of a typical 6.6 dBd antennas are employed (it has to be verified that the

resulting compliance distances are indeed smaller than r_0). Such an antenna (such as, Andrew DB408) would exhibit a typical elevation beamwidth of about 14 degrees.

Exposure Limits

Guidelines are used for the EME exposure assessment.

Based on the operating frequency range, the most conservative power density limits are those defined in the ICNIRP guidelines [1]. The guidelines are 10.1 W/m² for occupational exposure, and 2.02 W/m² for general public exposure.

EME Exposure Evaluation

This section describes how to evaluate the EME exposure of an antenna or at ground level.

Exposure in Front of the Antenna

The assessment is based on the following characteristics of the Andrew DB408 antenna:

$$G_A = 10^{\frac{6.6+2.15}{10}} = 7.5 \quad P = 22.9 \text{ W} \quad \gamma = 0 \quad L = 2.7 \text{ m}$$

The parameter r_0 is thus $r_0 = 10.1 \text{ m}$. Upon inserting the power density limits established in [Exposure Limits on page 104](#) into formula (1), the following distances for occupational and general public exposure compliance are respectively determined:

$$r_{\text{occupational}} = 14 \text{ cm}$$

and

$$r_{\text{general public}} = 67 \text{ cm}$$

As both these distances are less than r_0 , the aforementioned choice ([Typical System Configuration on page 104](#)) of considering the shorter, lower gain antenna to perform the assessment is deemed valid. Longer, higher gain antennas would yield shorter compliance distances, for the same input antenna power and operating frequency range.

Exposure at Ground Level

Since the antenna installation height above ground level in the typical system configuration (20 m) is larger than either of the compliance distances determined in [Exposure in Front of the Antenna](#), the EME exposure at ground level is always compliant with the exposure limits defined in the ICNIRP guidelines.

Compliance Boundary Description

Based on the analysis in [EME Exposure Evaluation on page 105](#), the compliance boundaries for occupational and general public exposure are defined as cylinders enclosing the antenna (see [Figure 45: Compliance Boundary for General Public \(GP\) and Occupational \(OCC\) Exposure on page 106](#)), extending 75 cm (one wavelength) above and below the physical antenna, with radii:

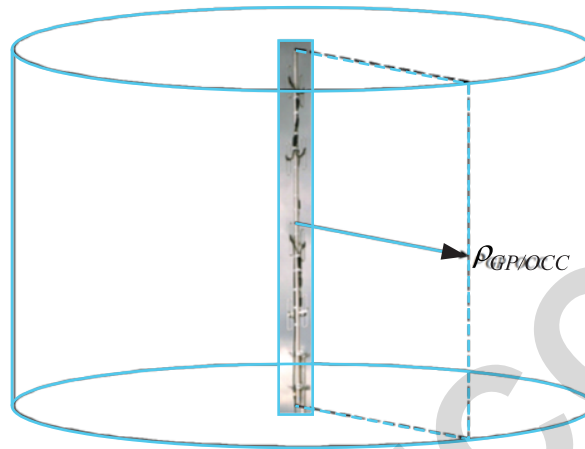
Occupational exposure:

$$\rho_{\text{OCC}} = 2.15 \text{ m}$$

General Public exposure:

$$\rho_{GP} = 6.9 \text{ m}$$

Figure 45: Compliance Boundary for General Public (GP) and Occupational (OCC) Exposure



Product Put In Service

Some regulations require that additional exposure assessments be performed when putting the product in service, to account for antenna site-specific circumstances such as the environment (such as, electromagnetic scatterers) and other antennas. In such cases, certain standards [7]–[10] may need to be considered to determine the most suitable compliance assessment methodology.

References

- 1 International Commission on Non-Ionizing Radiation Protection (ICNIRP), "Guideline for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields", Health Physics, vol. 74, no. 4, pp. 494-522, April 1998.
- 2 United States Federal Communication Commission, "Evaluating compliance with FCC guidelines for human exposure to radio frequency electromagnetic fields", OET Bulletin 65, Ed. 97-01, Section 2 (Prediction Methods), August 1997.
- 3 US Code of Federal Regulations, Title 47, Volume 1, Sec. 1.1310 Radio frequency radiation exposure limits (Revised as of October 1, 2003). http://edocket.access.gpo.gov/cfr_2003/octqtr/47cfr1.1310.htm.
- 4 EN 50383:2010. Basic standard for the calculation and measurement of electromagnetic field strength and SAR related to human exposure from radio base stations and fixed terminal stations for wireless telecommunication systems (110 MHz–40 GHz). CENELEC (European Committee for Electrotechnical Standardization).
- 5 EN 50384:2002. Product standard to demonstrate the compliance of radio base stations and fixed terminal stations for wireless telecommunication systems with the basic restrictions or the reference levels related to human exposure to radio frequency electromagnetic fields

(110 MHz–40 GHz). Occupational. CENELEC (European Committee for Electrotechnical Standardization).

- 6 EN 50385:2002. Product standard to demonstrate the compliance of radio base stations and fixed terminal stations for wireless telecommunication systems with the basic restrictions or the reference levels related to human exposure to radio frequency electromagnetic fields (110 MHz–40 GHz). General public. CENELEC (European Committee for Electrotechnical Standardization).
- 7 EN 50401:2006. Product standard to demonstrate the compliance of fixed equipment for radio transmission (110 MHz–40 GHz) intended for use in wireless telecommunication networks with the basic restrictions or the reference levels related to general public exposure to radio frequency electromagnetic fields, when put into service. CENELEC (European Committee for Electrotechnical Standardization).
- 8 EN 50400:2006. Basic standard to demonstrate the compliance of fixed equipment for radio transmission (110 MHz–40 GHz) intended for use in wireless telecommunication networks with the basic restrictions or the reference levels related to general public exposure to radio frequency electromagnetic fields, when put into service. CENELEC (European Committee for Electrotechnical Standardization).
- 9 EN 50492:2008. Basic standard for the in-situ measurement of electromagnetic field strength related to human exposure in the vicinity of base stations. CENELEC (European Committee for Electrotechnical Standardization).
- 10 IEC 62232:2011. Determination of RF field strength and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure. IEC (International Electrotechnical Commission).
- 11 United States Federal Communication Commission, “Evaluating compliance with FCC guidelines for human exposure to radio frequency electromagnetic fields,” OET Bulletin 65 (Ed. 97-01), August 1997. Supplement C (Edition 01-01) to US FCC OET Bulletin 65 (Edition 97-01), “Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radio frequency Emissions,” June 2001.
- 12 IEC/IEEE 62704-2, Determining the peak spatial-average specific absorption rate (SAR) in the human body from wireless communications devices, 30 MHz to 6 GHz – Part 2: Specific requirements for finite difference time domain (FDTD) modeling of exposure from vehicle mounted antennas. Draft, Dec 11, 2015.

Preliminary FCC Filing

This page intentionally left blank.

Glossary of Terms and Acronyms

This glossary contains an alphabetical listing of terms and their definitions that are applicable to repeater products. All terms do not necessarily apply to all radios, and some terms are merely generic in nature.

Alert tone

Audio signal produced by the station, providing feedback to the user.

Analog

Refers to a continuously variable signal or a circuit or device designed to handle such signals.

ASIC

Application Specific Integrated Circuit.

AUX

Auxiliary.

Band

Frequencies allowed for a specific purpose.

CTCSS

Continuous Tone-Controlled Squelch Systems (PL).

Clear

Channel modulation type in which voice information is transmitted over the channel using analog modulation.

Conventional

Term used for standard non-trunked radio system (usually using TRC/DC console).

CPS

Customer Programming Software: Software with a graphical user interface containing the feature set of a radio.

Default

A pre-defined set of parameters.

Digital

Refers to data that is stored or transmitted as a sequence of discrete symbols from a finite set; most commonly this means binary data represented using electronic or electromagnetic signals.

DPL

Digital Private-Line: A type of digital communications that utilizes privacy call, as well as memory channel and busy channel lock out to enhance communication efficiency.

DSP

Digital Signal Processor, microprocessor specifically designed to perform digital signal processing algorithms.

EIA

Electronic Industries Association.

ESD

Electro Static Discharge.

EU

European Union.

FCC

Federal Communications Commission.

FM

Frequency Modulation.

Frequency

Number of times a complete electromagnetic-wave cycle occurs in a fixed unit of time (usually one second).

FRU

Field Replaceable Unit.

FSK

Frequency Shift Keying.

GNSS

Global Navigation Satellite System.

GPIO

General Purpose Input/Output.

IC

Integrated Circuit: An assembly of interconnected components on a small semiconductor chip, usually made of silicon. One chip can contain millions of microscopic components and perform many functions.

IF

intermediate frequency.

I/O

Input or Output.

kHz

kilohertz: One thousand cycles per second. Used especially as a radio-frequency unit.

LCD

Liquid-Crystal Display: An LCD uses two sheets of polarizing material with a liquid-crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through them.

LED

Light Emitting Diode: An electronic device that lights up when electricity is passed through it.

MDC

Motorola Data Communications. 1200 or 4800 baud data signalling scheme.

MHz

Megahertz: One million cycles per second. Used especially as a radio-frequency unit.

MISO

Master In, Slave Out.

MOSI

Master Out, Slave In.

PA

Power Amplifier that transmits final RF signal to transmit antenna.

PC Board

Printed Circuit Board. Also referred to as a PCB.

PFC

Power Factor Correction.

PL

Private-Line Tone Squelch: A continuous sub-audible tone that is transmitted along with the carrier.

Programming Cable

A cable that allows the Radio Management to communicate directly with the radio using RS232.

PTT

Push-to-talk; the switch located on the left side of the radio which, when pressed causes the radio to transmit.

Radio Management

Software with a graphical user interface containing the feature set of a device.

Receiver

Electronic device that amplifies RF signals. A Receiver separates the audio signal from the RF carrier, amplifies it, and converts it back to the original sound waves.

Repeater

Remote transmit/receive facility that retransmits received signals in order to improve communications range and coverage.

RF

Radio Frequency: The portion of the electromagnetic spectrum between audio sound and infrared light (approximately 10 kHz to 10 GHz).

RSSI

Received Signal Strength Indicator; a dc voltage proportional to the received RF signal strength.

Rx

Receive.

SCM

Station Control Module; station controller.

SELV

Separated Extra Low Voltage.

Signal

An electrically transmitted electromagnetic wave.

SINAD

Acronym for the ratio of signal plus noise plus distortion and noise plus distortion.

SLR

Refers to Digital Professional Repeater model names in the MOTOTRBO Professional Digital Two-Way Radio System.

Spectrum

Frequency range within which radiation has specific characteristics.

SPI

Serial Peripheral Interface (clock and data lines); simple synchronous serial interface for data transfer between processors and peripheral ICs.

Squelch

Muting of audio circuits when received signal levels fall below a pre-determined value. With carrier squelch, all channel activity that exceeds the radio's preset squelch level can be heard.

TOT

Time-out Timer: A timer that limits the length of a transmission.

TPL

Tone Private Line.

Transceiver

Transmitter-Receiver. A device that both transmits and receives analog or digital signals. Also abbreviated as XCVR.

Transmitter

Electronic equipment that generates and amplifies an RF carrier signal, modulates the signal, and then radiates it into space.

Trunking

Radio control system which permits efficient frequency utilization and enhanced control features.

Tx

Transmit.

UHF

Ultra High Frequency.

USB

Universal Serial Bus: An external bus standard that supports data transfer rates of 12 Mbps.

VCO

Voltage-Controlled Oscillator; an oscillator whereby the frequency of oscillation can be varied by changing a control voltage.

VCTCXO

Voltage Controlled Temperature Compensated Crystal Oscillator.

VHF

Very High Frequency.

VIP

Vehicle Interface Port.

VSWR

Voltage Standing Wave Ratio.

WLAN

Wireless Local Area Network.

Preliminary FCC Filing

This page intentionally left blank.