



## ClearFill® Space1

### L-RU

(incl. L-RU800-2, L-RUSMR800-2, L-RU700-2, L-RU1900-2, L-RU1721-2)

## User Handbook

**Part. No.:**

L-RU800-2:	16501014
L-RUSMR800-2:	16501015
L-RU700-2:	16501016
L-RU1900-2:	16501017
L-RU1721-2:	16501018



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## Contents

<b>1</b>	<b>GENERAL</b>	<b>4</b>
1.1	IMPRINT	4
1.2	ABBREVIATIONS	5
<b>2</b>	<b>DESCRIPTION OF CLEARFILL® SPACE1 SYSTEM</b>	<b>6</b>
2.1	GENERAL SYSTEM PERFORMANCE	9
<b>3</b>	<b>DESCRIPTION OF REMOTE UNIT</b>	<b>11</b>
3.1	BLOCK SCHEMATICS OF THE REMOTE UNIT	12
3.2	FUNCTIONAL BUILDING BLOCKS OF THE REMOTE UNIT	14
3.2.1	Uplink	14
3.2.2	Downlink	15
3.2.3	Monitoring	15
3.2.4	Function of ALC	15
3.2.5	Duplexer	15
<b>4</b>	<b>SPECIFICATIONS</b>	<b>16</b>
4.1	ELECTRICAL SPECIFICATIONS	16
4.2	MECHANICAL SPECIFICATIONS	18
4.3	OPTICAL LINK	18
4.4	COMPLIANCE	18
<b>5</b>	<b>MODULE DESCRIPTIONS AND SPECIFICATIONS</b>	<b>19</b>
5.1	OPTICAL TRANSCEIVER	19
5.1.1	Optical Transmitter	19
5.1.2	Optical Receiver	19
5.2	POWER SUPPLY	19
<b>6</b>	<b>INSTALLATION AND COMMISSIONING</b>	<b>20</b>
6.1	GENERAL STATEMENTS	20
6.1.1	Safety Considerations / Sicherheitshinweise (English / Deutsch)	20
6.1.2	Packing List	20
6.2	INSTALLATION PROCEDURE	21



6.3	COMMISSIONING PROCEDURE	23
<b>7</b>	<b>MAINTENANCE, REPAIR AND WARRANTY</b>	<b>24</b>
7.1	INTRODUCTION	24
7.2	ROUTINE CHECKS	24
7.3	REPAIR	24
7.4	TROUBLESHOOTING	25
7.5	WARRANTY	28
<b>8</b>	<b>NOTES</b>	<b>29</b>



## 1 General

Thank you for selecting this RFS product. We are confident that you will find this product in proper working order and meeting all stated specifications.

Please read this manual. A full understanding of product operation will support optimal performance and prevent accidental damage not covered by the stated warranty.

### 1.1 Imprint

These operating instructions are published by

**Radio Frequency Systems GmbH**  
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## 1.2 Abbreviations

ALC	Automatic Level Control
BP	Band-pass
BTS	Base Transceiver Station
DAS	Distributed antenna system
DL	Downlink
EIN	Equivalent Input Noise
EMI	Electro Magnetic Interference
EN	A standard established by the European Committee for Standardization
ETSI	European Telecommunications Standards Institute
HP	High-pass
HU	Height Units
IEC	International Electrotechnical Commission - International standards organization dealing with electrical, electronic and related technologies
IP3	Third-order intercept point
MU	Master Unit
ORx	Optical receiver
OTRx	Optical transceiver
OTx	Optical transmitter
PCB	Printed Circuit Board
POI	Point of interception
PSU	Power supply unit
PTFE	Polytetrafluoroethylene
RoHS	Restriction of Hazardous Substances
RU	Remote Unit
TRx	Transceiver (Transmitter-Receiver)
UL	Uplink
WEEE	Waste of Electrical and Electronical Equipment
WiFi	Wireless Fidelity

## 2 Description of ClearFill®Space1 System

When coverage is needed in a large building (typically larger than 200,000 sq ft), RF repeaters driving passive distributed antenna systems (DAS) often become impractical due to their coaxial cable loss. ClearFill®Space1 is offering great value because the signal loss in fiber is extremely low compared to coaxial cable. ClearFill®Space1 can provide excellent coverage over broad areas.

ClearFill®Space1 is a mid power indoor coverage solution that meets any RF distribution needs – from simple entry-level systems to the most complex applications.

ClearFill®Space1 is a modular RF-over-fiber distribution system that provides reliable and highest quality indoor coverage of 2G and 3G wireless services in airports, hospitals, campus, enterprises, convention centers, high-rise buildings and tunnels.

The ClearFill®Space1 system is a plug-and-play fiber-optical repeater system consisting of two main components: a Master Unit (MU) and Remote Units (RU), connected via a fiber-optical link(s).



**Figure 1 – Master unit L-MU of ClearFill®Space1**

Three types of RF broadband MU are feeding one, two or four RU providing high level of flexibility.

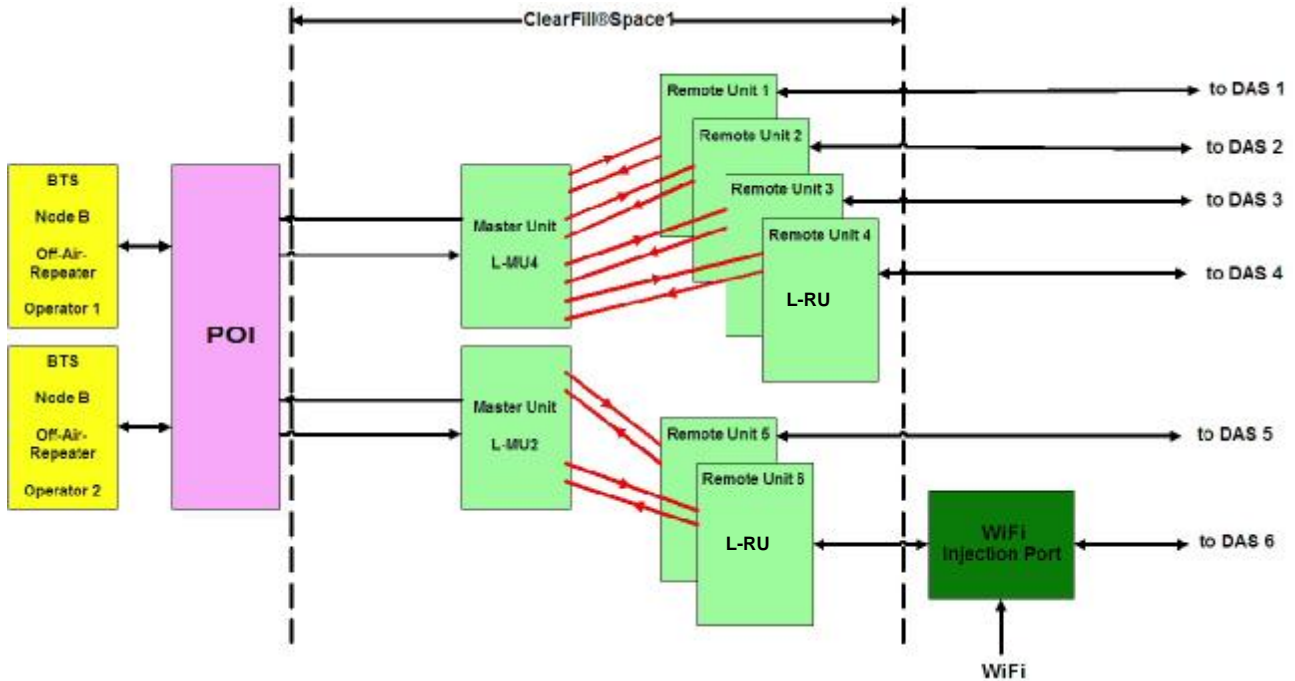
This handbook refers to the RU of a ClearFill®Space1 system. For further information about the L-MU please refer to the User handbook L-MU.

The RU is a fiber-fed, band-selective single-band RF amplifier. The automatically leveled composite output power (22dBm, equivalent to 2x19dBm for two RF carriers) of a single RU guarantees best coverage at low prices and is able to drive an area of typically 50.000 sq ft.



**Figure 2 – Remote unit L-RU of ClearFill®Space1**

An example for a system topology is presented in Figure 3.



**Figure 3 – Example of ClearFill® Space1 System Topology**

Both devices (L-MU and L-RU) include an automatic level control (ALC) in uplink and downlink that eliminates system gain variation, regardless of optical loss guarantying optimised system performance under minimised installation effort.

The interface to the BTS / Node B or an Off-Air Repeater is the master unit. In case of a multi-operator system a combining network (POI) has to be used in order to adapt the input signal to the MU interface.

An opportunity to extend the system to distribute WiFi over the same DAS is foreseen via RFS WiFi injection port.





## 2.1 General System Performance

### Optical link:

- 0 to 6 dB optical attenuation
- Mono-mode fiber

### Plug-and-play function:

- Self-leveling system in UL and DL
- Fixed output power levels of RU in DL
- Fixed output power levels of RU in UL for laser protection
- ALC of MU in DL for auto-leveling of composite input power for varying number of carriers
- ALC of MU in UL for auto-leveling of parallel optical links and compensating for various optical link losses
- Commissioning effort reduced to a minimum
- Operating under ETSI requirements

### Application:

- RU and MU build up an end-to-end RF system connected via a pair of optical fiber. See User Handbook of Master Unit (L-MU series) for additional information about MU.
- The system MU-RU and its plug-and-play functionality is designed to operate for typical DAS applications with nominal UL input signal strengths (into RU RF in/out port) in the range of -55 dBm to -35 dBm.
- As every distributed RF-over-fiber system, ClearFill Space1 introduces signal delays in DL and in UL due to the use of single-mode optical fibers between MU and RU. This delay has to be taken into account by cellular network planning/operation for appropriate setting of BTS/NodeB search windows. This also applies for remote BTS/NodeB's which may be connected to a ClearFill Space1 system over-the-air using an off-air repeater with donor antenna. Establishing a connection between mobile / handheld device and BTS/NodeB may fail due to of improper setting of search window / range.



Monitoring:

Managing the system in case of malfunction is very simple. Two alarm LED easily refer to specific malfunction for the optical link connection and/or for the power supply. Correction of an identified malfunction is done by exchange of faulty unit. Thus makes Clear-Fill®Space1 a very service-friendly system.

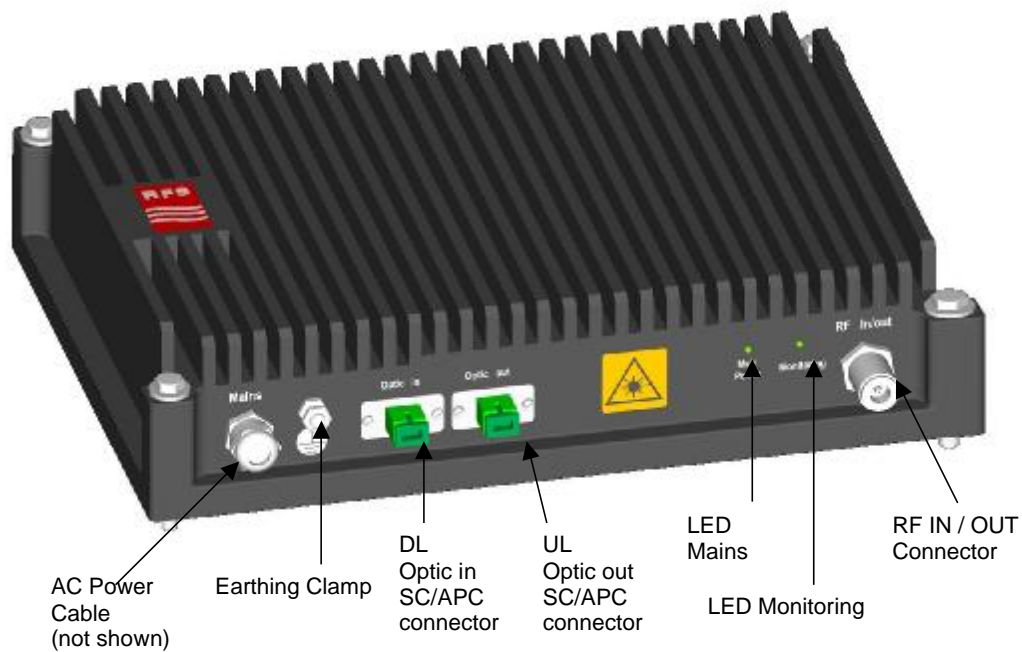
**LED specification and connectivity (Two type of alarm LED at RU):**

- Green illuminated “Main power” LED indicates that the power is ON.
- Green illuminated “Monitoring” LED indicates that the received optical laser signal from MU is functioning within spec.

### 3 Description of Remote Unit

The medium-power RU is designed for applications in buildings and tunnels. Operating in ALC modus in uplink and downlink the RU provides an easy plug-and-play handling without system leveling. The output power level in downlink is fixed according to ETSI requirements. The monitoring of function is locally indicated by LEDs. The summary alarm switches the pilot tone to the optical Master Unit. The optical transceiver operates on mono-mode fibers.

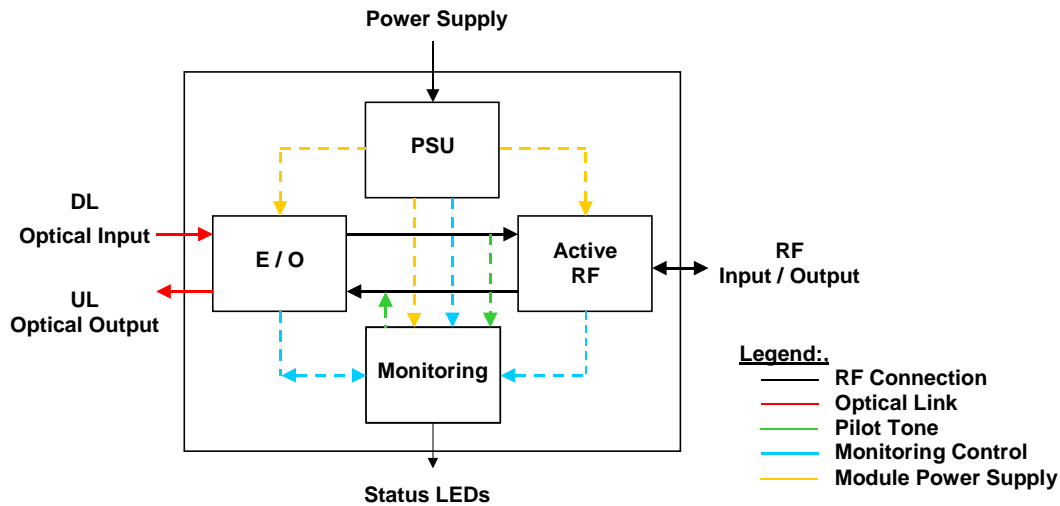
The remote unit comprises an optical transmitter and receiver, active and passive RF components, and a single RF input / output port.



**Figure 4: Picture of Optical Remote Unit**

### 3.1 Block Schematics of the Remote Unit

Figure 5 shows the functional block schematic of the remote unit, which basically identifies the main building blocks and their interactions. All external interfaces are clearly identified as arrows crossing the boundary of the remote unit.

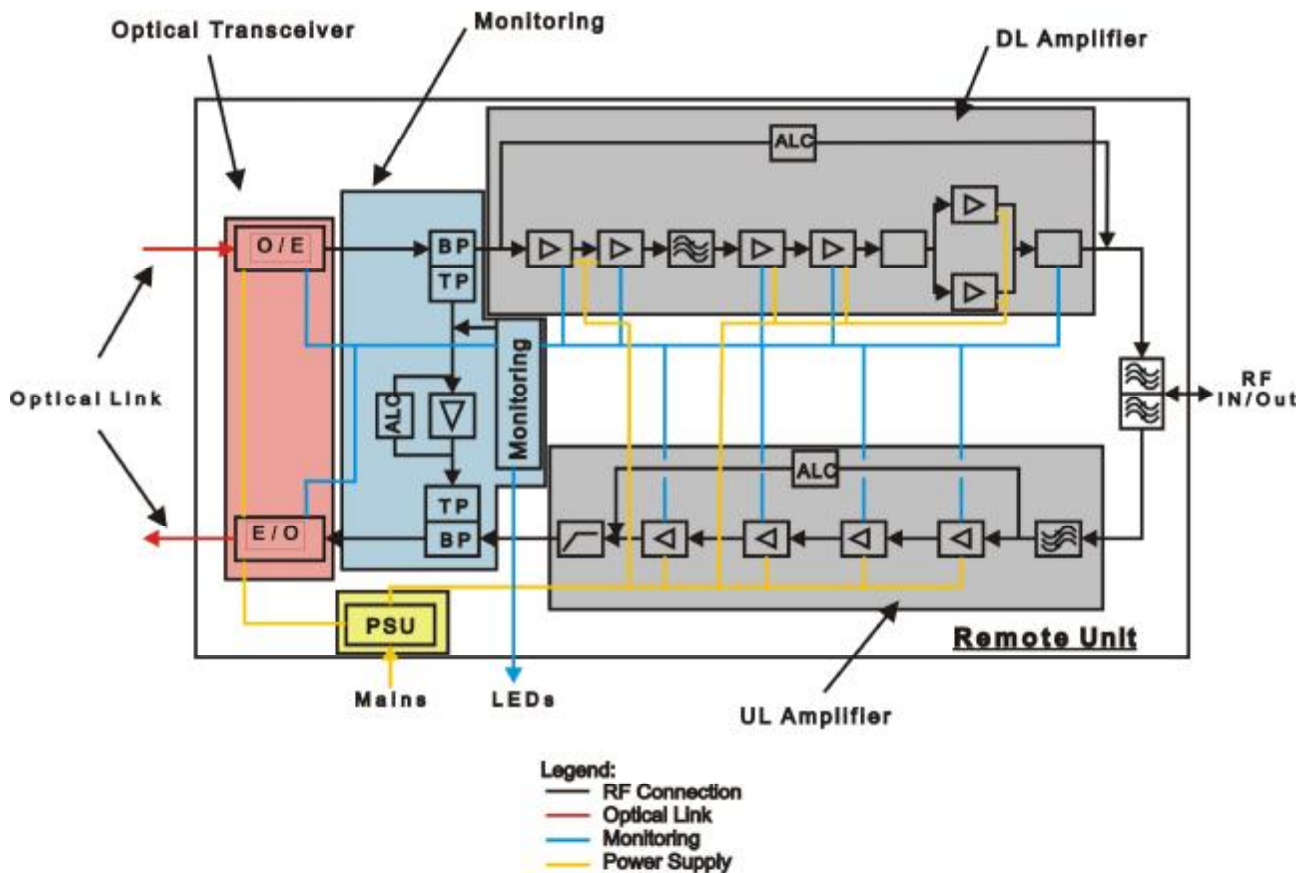


**Figure 5: Functional Block Schematic of the Remote Unit**

- PSU: internal power supply for RU
- E/O: Optical transmitter and receiver integrated into one transceiver module
- Active RF: The combination of all passive and active modules for uplink and downlink including supporting electronics
- Monitoring: All electronics for alarming.

The Remote Unit consists of the following functional building blocks

- The optical transceiver
- The pilot tone monitoring
- The downlink path
- The uplink path
- Duplexer
- Power supply



**Figure 6: Block schematic of the Remote Unit**

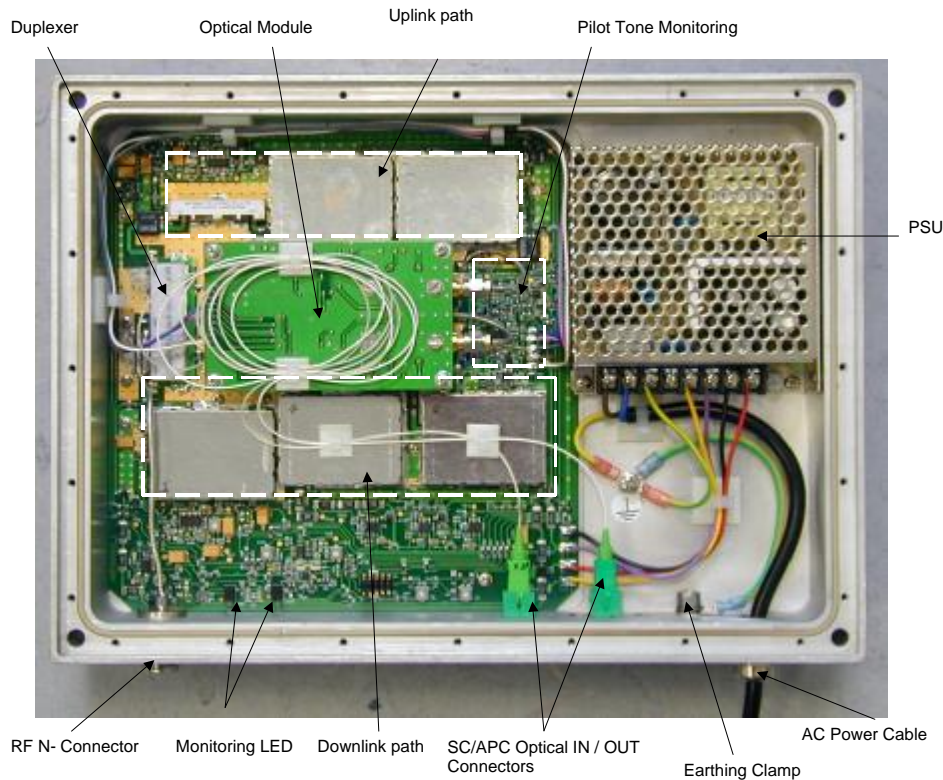
A detailed block schematic of the RU is shown in Figure 4 indicating the optical transceiver part in red, the monitoring electronic in blue, the PSU in yellow and the RF amplifier block in grey.

In downlink, an optical receiver ORx converts the optical input signals from the Optical Master Unit to RF signals. The BP/LP separates RF communications signals from the monitoring pilot tone. A cascade of amplifiers provides sufficient RF gain imbedded in an ALC which keeps the output power level constant compensating optical losses of the optical link. The duplexer separates downlink output signals from uplink input signals.

In uplink, the RF amplifier is embedded in an ALC, which compensates varying input power levels. The output power into the laser OTx is limited protecting the laser against damages. The BP/LP module combines the RF signals with the pilot tone in UL.

### 3.2 Functional Building Blocks of the Remote Unit

A picture of the inner arrangement of the remote unit is shown in Figure 7.



**Figure 7: Inner arrangement of the Remote Unit**

The optical transceiver and the power supply are separate modules. The pilot tone monitoring, downlink, uplink and the duplexer are integrated on one PCB. All modules of the RU are integrated in a cast housing with integrated heat sink designed for wall mounting. The housing has a protection against splash water, dust and dirt. All connections are arranged on the bottom side. The attractive design and the protection class IP 54 allows installing the RU in various environments.

#### 3.2.1 Uplink

The uplink path mainly consists of a four-stage amplifier with two integrated filters, an ALC and a limiter to protect the laser in UL against high power levels and to avoid non-linear operation.

The ALC compensates for different uplink input levels per carrier providing optimised UL performance with regard to spurious free dynamic range.

### 3.2.2 Downlink

The downlink path includes a five-stage amplifier with balanced power amplifier, filters and an ALC, which automatically operates the RU according to ETSI requirements. The downlink path is equipped with a monitoring to control the RF-amplifiers. Each amplifier stage can generate an alarm by controlling the DC-current.

### 3.2.3 Monitoring

All amplifier stages in downlink and uplink as well as the optical transceiver are monitored. Failures are logically combined to a resulting summary alarm that results in a switch-off of the pilot tone.

The alarm matrix of the RU is shown in Table 1 below.

Alarm	LED	OK	Failure
Power supply	Main Power	green	Off
Summary alarm (RF amplifiers, optical modules)	Monitoring	green	red

**Table 1 – Alarm matrix of the RU**

### 3.2.4 Function of ALC

The main part of this ALC system is a detector circuitry. It converts an RF signal to an equivalent DC voltage at its output. The detected voltage is compared with a reference value adjusting an electrical controlled attenuator. Thus, the RF power level at the antenna port is kept constant to maximum and no manual leveling is required.

### 3.2.5 Duplexer

The duplexer at the antenna port is a high performance ceramic duplexer separating uplink and downlink RF-bands.



## 4 Specifications

### 4.1 Electrical Specifications

#### Frequency range **CDMA800**

Model no.	L-RU800-2
Uplink	824 – 849 MHz
Downlink	869– 894 MHz
Bandwidth	25 MHz

#### Frequency range **SMR800**

Model no.	L-RUSMR800-2
Uplink	806 – 824 MHz
Downlink	851 – 869 MHz
Bandwidth	18 MHz

#### Frequency range **Home Land Security**

Model no.	L-RU700-2
Uplink	764 – 776 MHz
Downlink	794 – 806 MHz
Bandwidth	12 MHz

#### Frequency range **PCS1900**

Model no.	L-RU1900-2
Uplink	1850 – 1910 MHz
Downlink	1930 – 1990 MHz
Bandwidth	60 MHz

#### Frequency range **AWS**

Model no.	L-RU1721-2
Uplink	1710 – 1755 MHz
Downlink	2110 – 2155 MHz
Bandwidth	45 MHz





Composite Output Power in DL	22 dBm typical
RF impedance	50 $\Omega$
Return loss	> 10 dB typical
Input voltage	AC 115/230 V $\pm$ 10%, 50/60 Hz $\pm$ 5%, autoranging Gland with 1.5m cables
Power consumption	< 30 W
ALC operation (UL window at RF in/out port)	ALC active: - 55dBm to -35 dBm *) *) target window for plug-and-play mode Linear mode: < -55 dBm
Master Unit	see User Handbook L-MU series



#### 4.2 Mechanical Specifications

Size	height: 240 mm width: 320 mm depth: 70 mm
Colour	black (RAL 9005) scratch resistant
Cooling:	convection cooling, without fans
Weight:	approx. 5,8 kg
Operating Temperature Range	-10°C to + 50°C
Storage Temperature Range	-20°C to + 75°C
Relative humidity	0% to 90% (non-condensing)
RF Connectors:	N type female
Earthing:	M8 bolt
Location of the interfaces and control element	on bottom when wall mounted
Environmental Protection:	IP 54

#### 4.3 Optical Link

Fiber optic type	mono-mode, 9 / 125
Number of fibers	2 (one for UL, one for DL)
Optical connectors	SC / APC
Wavelength	1310 nm
Optical attenuation	max. 5 km (3miles) distance or 6 dB optical attenuation

#### 4.4 Compliance

EMC	ETSI EN 301 489-1
FCC	FCC part 15/ 22/ 24/ 27/ 90
Safety	IEC / EN60950
Optic	Laser Diode according to IEC / EN 60 825 – 1, class 1 Fiber Optic Link according to IEC / EN 60 825 – 2



## 5 Module Descriptions and Specifications

### 5.1 Optical Transceiver

#### 5.1.1 Optical Transmitter

Wavelength	1310 nm, single mode
Optical Output Power	3 dBm typical
Modulation gain	0,08 mW/mA

#### 5.1.2 Optical Receiver

Wavelength	1310 nm, single mode
Maximum input power	3 dBm optical

### 5.2 Power Supply

The in-built PSU is a high reliability, wide input range, and high efficient AC-DC converter with four outputs at 5 V, 12 V, -12 V and 24 V. To reduce the outgoing disturbance an EMI-filter is built in. To reduce the inrush current at start-up, a soft start circuit is implemented. The output is short circuit, overload and over voltage protected.



## 6 Installation and Commissioning

### 6.1 General Statements

#### 6.1.1 Safety Considerations / Sicherheitshinweise (English / Deutsch)

##### **Safety Considerations**

PTFE and PTFE Composite Materials

Materials should never be heated to the point where smoke or fumes are evolved. Any person feeling drowsy after coming into contact with PTFE especially dust or fumes should seek medical attention.

##### **Sicherheitshinweise**

PTFE und PTFE Verbundwerkstoffe

PTFE und PTFE Verbundwerkstoffe dürfen nicht derart erhitzt werden, dass es zu Rauchentwicklung kommt. Personen die mit solchem Rauch in Berührung kommen und sich unwohl fühlen (z.B. Schläfrigkeit), sollten dringend medizinische Beratung in Anspruch nehmen.

#### 6.1.2 Packing List

Additionally to the remote unit following parts are enclosed to the delivery set:

- § User Handbook L-RU
- § Test report L-RU
- § Packing list
- § 4 screws, 4 washers, 4 dowels

## 6.2 Installation Procedure

The installation may only be carried out by qualified personnel that is familiar with the hazards involved and the relevant statutory regulations.

Before begin of the installation of the RU, all RF cable and optical cable should be installed first.

The procedure for installing the L-RU is generally as follows:

1. Transport the RU to the chosen site in its packaging.
2. Remove the RU from its packaging and check that there are no obvious signs of physical damage. If the unit is physically damaged do **not** proceed with the installation.
3. Drill or fit four wall fixings to which the RU is to be fitted. For the physical dimensions of the wall fixings refer to Figure 8. The type of fixings will depend on the construction of the wall. It has to be ensured that the wall fixings are adequate for a total weight of more than 6 kg.



Note: The provided dowels in the accessories are suitable for installation in indoor areas (closed spaces) only and for following wall constructions.

- Concrete
- Pre-stressed hollow-core concrete slabs
- Natural stone with dense structure
- Solid brick
- Sand-lime solid brick
- Solid block made from lightweight concrete
- Aircrete
- Solid panel made from gypsum
- Hollow block made from lightweight concrete
- Slabs made of perforated bricks
- Hollow concrete blocks etc.

For the installation in other environment (e. g. tunnel) or other wall construction another dowel must be used, which is suitable for this environment and wall construction.

4. Fit and secure the RU on to the fixings. It is strongly recommended that all four fixing points be used.
5. Earth the RU in accordance with international and local recommendations and requirements.
6. Connect the RU to RF distributing DAS or radiating cable. Connect the two optical link cables from and to the assigned MU and plug in the power cable.

7. Ensure that all the cables leaving the RU first travel downward to ensure that any moisture is directed away from the RU. This is important for installation in tunnel environment.

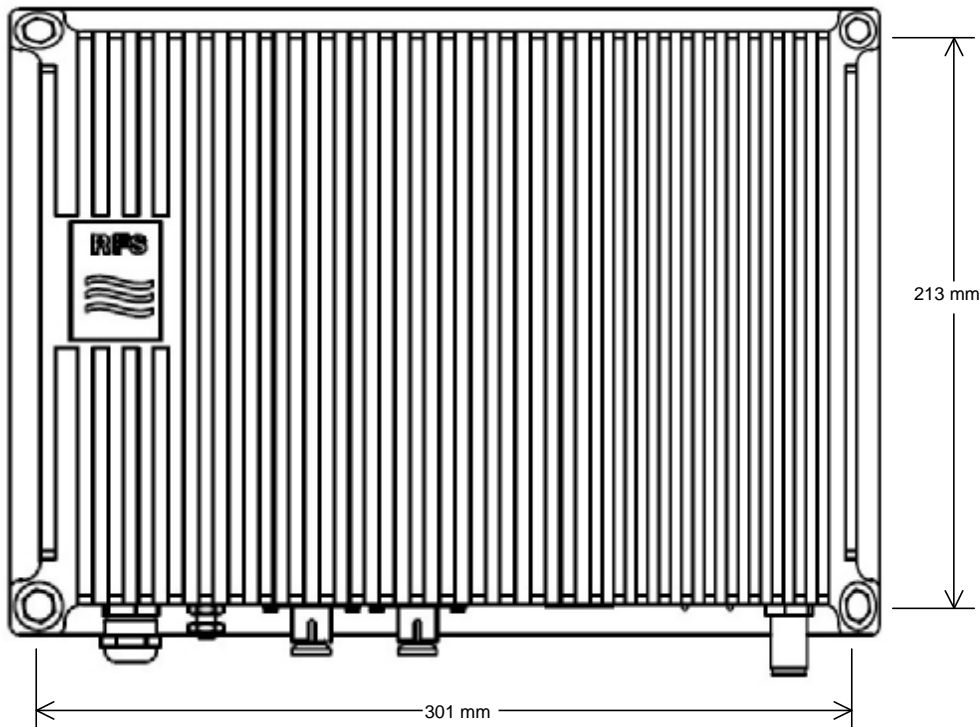


**Note:** It is important that the above installation instructions are followed in the sequence presented to ensure a correct and save installation.

Ensure a suitable mains power supply is available adjacent to the RU. Connect the RU main cables to the mains supply in accordance with local wiring.



**Note:** Avoid looking directly into the optical connectors of the RU if no optical cables or protective sleeve are installed and the RU is switched on.



**Figure 9: Drill Template for wall installation**



### 6.3 Commissioning Procedure

The ClearFill<sup>®</sup>Space1 system (consisting of MU and RU) is equipped with a combination of ALCs, minimum one at the input and one at the output. The dynamic range of the individual ALCs and their reaction time is adjusted to each other. At least the whole system operates in a balanced way providing defined power levels at the output of the system within the specified power levels at the system inputs.

Due to the self-levelling functionality no commissioning and testing of the ClearFill<sup>®</sup>Space1 system is necessary. The system can be set into operation as plug & play compensating automatically for fiber optical losses, for changes of number of operating RF carriers and for all types of temperature and aging effects.



## 7 Maintenance, Repair and Warranty

### 7.1 Introduction

The RU is designed and built to require no periodic maintenance. As long as the unit is kept away from extreme temperatures and moisture, it should provide long-term, carefree operation.

It is strongly recommended that no invasive procedures are performed on the unit in an attempt to verify performance. See section 7.2 for recommended routine performance variation checks.

### 7.2 Routine Checks

Although the RU is a low-maintenance unit, it is recommended to routinely verify the performance of the RU by making test calls or detailed system checks on the actual radio coverage. Several test calls should be made at different positions within each area to get an overall picture of the system performance. This is by far the best way to check the system as it tests the whole system from an operational viewpoint as seen by the users.

It is strongly recommended that no invasive procedures be performed on the unit in an attempt to verify performance unless a serious problem with performance has been identified as described above. Any such invasive procedures are more likely to do damage to the system and create intermittent performance than to be of any practical value.

### 7.3 Repair

Repairs may only be carried out by qualified personnel that are familiar with both the hazards involved and the relevant statutory regulations. Unauthorized modifications or repairs invalidate the warranty claim.

Before contact RFS customer service for repair request please prove the checklist in section 7.4 (Troubleshooting).

For returns, repairs and ordering contact your RFS customer service or [technical.consulting@rfsworld.com](mailto:technical.consulting@rfsworld.com).



## 7.4 Troubleshooting

You have obtained a state-of-the-art product, which is reliable and operationally safe. Nevertheless, problems or malfunctions may occur. Following we will present strategies how to eliminate possible problems.

The safety instructions must be observed (see notes below the table)!

Please follow the procedures for the troubleshooting in the prescribed order.

### Checklist RU

Symptoms	Reason	Procedure
<ul style="list-style-type: none"> <li>All RU LED are off.</li> </ul>	The power supply is inactive.	<ol style="list-style-type: none"> <li>1. Check the AC voltage</li> <li>2. Check the connectors of AC cable</li> <li>3. Check the AC power cable for damages</li> </ol>
<ul style="list-style-type: none"> <li>RU PSU LED is red.</li> </ul>	The outputs of the PSU have over or under voltage	Reset the RU by switching Off and after a few seconds On of the AC power
	PSU is defect	Please contact RFS customer service for repair or replacement of RU
<ul style="list-style-type: none"> <li>RU Monitoring LED is red.</li> </ul>	Problem with optical signal	Please check the system troubleshooting list (see next page).



**Note:** Always remove AC power cable before checking or changing fuses. 115 / 230 VAC can be lethal.



**Note:** To avoid shock, injury or damage to the RU: use only fuses with the amperage, interrupt, voltage and speed ratings specified.



**Note:** Don't open housing of RU. Warranty exclusion in case housing has been opened!



### System Checklist

The safety instructions must be observed (see notes below the table)!

The following troubleshooting refers to specific alarm LED indications on MU and RU in a ClearFill®Space1 system environment. Please follow the procedures for the troubleshooting in the prescribed order. For guidance the column “Symptoms” gives specific LED status information combinations at MU and RU.

Symptoms	Reason	Procedure
<ul style="list-style-type: none"><li>MU Summary OTx LED is red</li></ul>	One or more optical transmitter is inactive	Please contact RFS customer service for repair or replacement of RU
<ul style="list-style-type: none"><li>MU Link LED to RU is red</li></ul>	No optical signal	<ol style="list-style-type: none"><li>1. Check the optical connectors of the inactive link for fastening or damage</li><li>2. Check the optical cable between MU and RU for damage</li><li>3. Clean with special equipment the ferrules at the optical connectors</li><li>4. Check the following variety of troubleshooting, described below</li></ol>
<ul style="list-style-type: none"><li>MU Link LED is red / RU Monitoring LED is green</li></ul>	No optical signal in UL	<ol style="list-style-type: none"><li>1. Check the optical connectors of the UL (on the MU and RU site) for fastening or damage</li><li>2. Check the optical cable in UL for damage</li></ol>
	OTx of MU is inactive (in this case summary OTx LED is red as well)	<ol style="list-style-type: none"><li>3. Please contact RFS customer service for repair or replacement of MU</li></ol>



Symptoms	Reason	Procedure
<ul style="list-style-type: none"><li>MU Link LED is red / RU Monitoring LED is red</li></ul>	No optical signal	<ol style="list-style-type: none"><li>1. Check the optical connectors of the UL and DL (on the MU and RU site) for fastening or damage</li><li>2. Check the optical cable in UL and DL for damage</li><li>3. Clean with special equipment the ferrules at the optical connectors</li></ol>
	OTRx of MU is inactive	<ol style="list-style-type: none"><li>4. Connect the optical cables of the failure link to the other optical link connectors (in case of L-MU2 and L-MU4) or to the spare device if available (for L-MU1). If the link status OK, then contact RFS customer service for repair or replacement of MU.</li></ol>
	Optical cable is inactive	<ol style="list-style-type: none"><li>5. If the link status is on failure (see point 4) retry the communication with spare devices (MU and RU) if available.</li><li>6. In case of failure status the optical cable is out of order.</li></ol>
	MU or RU is inactive	<ol style="list-style-type: none"><li>7. In case of OK status (see point 5) is MU or RU is inactive. The failure unit can be detected by sequential change of the only one unit (MU or RU). Please contact RFS customer service for repair or replacement of this unit.</li></ol>
<ul style="list-style-type: none"><li>No signal on data / monitoring interface</li></ul>	No data available	<ol style="list-style-type: none"><li>1. Check the data connectors for fastening or damage</li><li>2. Check the data cable for damage</li></ol>



## 7.5 Warranty

The Warranty time is 1 year beginning with the delivery of the equipment. Warranty services do not extend the warranty time. The warranty is not valid for the following:

- Damage caused by improper use
- Damage caused by non-adherence to user handbook
  - Devices which have been opened provided this is not described in the user handbook for maintenance purposes.
  - Devices whose serial number labels have been changed, damaged, removed or exchanged.
  - Devices whose warranty seals are changed, damaged, removed or broken.

We will correct any fault **free of charge** or exchange item (excluding shipment), if

- It can be proved that they are manufacturing faults.
- The faults are reported immediately.
- The faults are reported within the warranty time



## 8 Notes