LGCell™ Wireless Networking System

Version 4.0

Installation, Operation, and Reference Manual

PN 8100-40
620004-0 Rev. E

Your comments are welcome – they help us improve our products and documentation. Please address your comments to LGC Wireless, Inc. corporate headquarters in San Jose, California:

Address	2540 Junction Avenue San Jose, California 95134-1902 USA
	Attn: Marketing Dept.
Phone	1-408-952-2400
Fax	1-408-952-2410
Help Hot Line	1-800-530-9960 (U.S. only) +1-408-952-2400 (International)
Web Address	http://www.lgcwireless.com
e-mail	info@lgcwireless.com service@lgcwireless.com

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SECTION 1

General Information

This section contains the following:

1.1 Purpose and Scope

This document describes the LGCell™ Distributed Antenna System and its installation. The following sections are included:

- Section 2 LGCell 4.0 System Description
- Section 3 LGCell Main Hub
- Section 4 LGCell Expansion Hub
- Section 5 LGCell Remote Access Unit
- Section 6 Managing and Planning an LGCell Project
- Section 7 Designing an LGCell Solution
- Section 8 Installation Requirements and Safety Precautions
- Section 9 Installing the LGCell
- Section 10 Maintenance, Troubleshooting, and Technical Assistance
- Appendix A Cables and Connectors
- Appendix B Compliance Information
- Appendix C Frequently Asked Questions
- Appendix D Glossary

1.2 Conventions in this Manual

The following table lists the type style conventions used in this manual.

Convention	Description
bold	Used for emphasis
BOLD CAPS	Used to indicate labels on equipment

Measurements are listed first in metric units, followed by U.S. Customary System of units in parentheses. For example:

0° to 45°C (32° to 113°F)

The following symbols are used to highlight certain information as described:

NOTE: This format is used to emphasize text with special significance or importance, and to provide supplemental information.

CAUTION: This format is used when a given action or omitted action can cause or contribute to a hazardous condition. Damage to the equipment can occur.

WARNING: This format is used when a given action or omitted action can result in catastrophic damage to the equipment or cause injury to the user.

Procedure

This format is used to highlight a procedure.

1.3 Acronyms in this Manual

Acronym	Definition
BDA	bidirectional amplifier/repeater
BTS	base transceiver station
Cat-5	Category 5 (twisted pair cable)
CDMA	Code Division Multiple Access
C/I	carrier to interface
CISP	Certified Installation Service Provider
dB	decibel
dBm	decibels relative to 1 milliwatt
DCS	Digital Communications System
DL	downlink
EGSM	Extended Global Standard for Mobile Communications
GHz	gigahertz
GSM	Groupe Speciale Mobile (now translated in English as Global Standard for Mobile Communications)
Hz	hertz
iDEN	Integrated Digital Enhanced Network (Motorola variant of TDMA wireless)
IF	intermediate frequency
LAN	local area network
LED	light emitting diode
mA	milliamps
MBS	microcellular base station
MHz	megahertz
MMF	multimode fiber
MTBF	mean time between failures
NF	noise figure
nm	nanometer
PBX	private branch exchange
PCS	Personal Communications System
PLL	phase-locked loop
PLS	path loss slope
RAU	Remote Access Unit
RF	radio frequency
RSSI	received signal strength indicator

Acronym	Definition
SMA	sub-miniature A connector (coaxial cable connector type)
SNR	signal-to-noise ratio
ST	straight tip (fiber optic cable connector type)
STP	shielded twisted pair
TDMA	Time Division Multiple Access
TP	twisted pair
UL	uplink; Underwriters Laboratories
UMTS	Universal Mobile Telecommunications System
UPS	uninterruptable power supply
UTP	unshielded twisted pair
WOS	wireless office service

1.4 Standards Conformance

- Complies with industry standards for IS-19B/AMPS, J-STD-8, IS-136/TDMA, IS-95B/CDMA.
- Utilizes the TIA/EIA 568-A Ethernet cabling standards for ease of installation.
- Distributes signals over a building's existing industry-standard cable infrastructure of multimode fiber (MMF) and unshielded twisted pair/shielded twisted pair (UTP/STP) cable.
- See Appendix B for compliance information.

1.5 Related Publications

- MetroReach Focus Configuration, Installation, and Reference Manual; LGC Wireless part number 8500-10
- ARM2000 Installation, Operation, and Reference Manual; LGC Wireless part number 8305-10
- LGC Wireless Complementary Products Catalog; LGC Wireless part number 8600-10
- Neutral Host System Planning Guide; LGC Wireless part number 9000-10

SECTION 2

LGCell 4.0 System Description

This section contains the following:

2.1 System Overview

The LGCell acts as an extension of the outdoor, macrocellular network to provide RF signal coverage and capacity to places where the signals are not always available or adequate, such as inside a building, tunnel, subway, or other hard-to-reach locations.

LGCell features:

- Supports all cellular protocols.
- Provides uniform radio coverage.
- Distributes cellular signals through standard multimode fiber (MMF) and standard UTP/STP cables, which are found in most office buildings.
- Uses a double-star topology, which allows for easy, cost-effective growth of coverage and capacity.

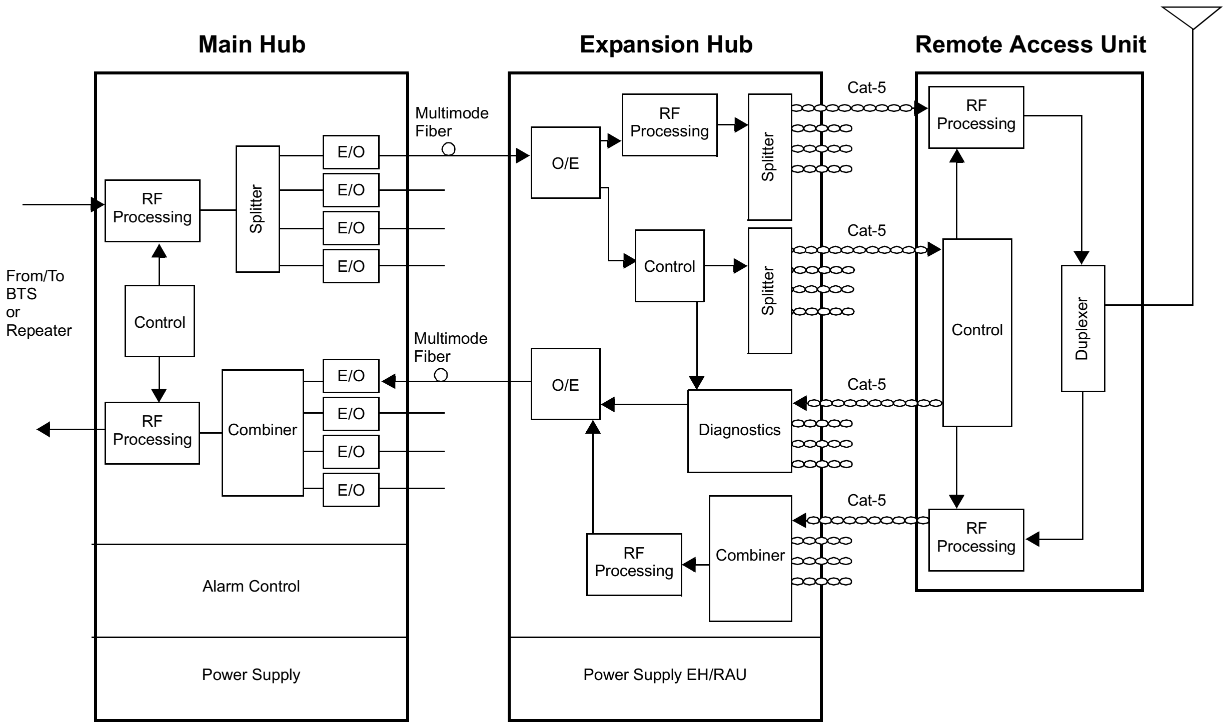
The LGCell system consists of three components, as shown (from top to bottom) in the following figure:

- Remote Access Unit
- Expansion Hub
- Main Hub

Figure 2-1 **LGCell Components**

The following figure shows a block diagram of a single band LGCell system. Note that uplink and downlink RF and control signals for an RAU travel through one Cat-5 cable.

Figure 2-2 **LGCell System Block Diagram (Single Band)**



LGCell components are available in the following frequencies and protocols:

- **Single-Band Frequencies and Protocols**
  - 800 MHz Cellular
  - 800 MHz iDEN
  - 900 MHz GSM[1]
  - 900 MHz EGSM[1]
  - 1900 MHz PCS (4 band options)
- **Dual-Band Frequencies and Protocols**

  The Main Hubs and Expansion Hubs in a dual-band system each consist of two single-band hubs. The Dual Band RAUs contain electronics for two bands and have combined output ports.
  - 800 MHz CDMA & 900 MHz GSM (China only)
  - 800 MHz Cellular & 1900 MHz PCS
  - 900 MHz GSM & 1800 MHz DCS
  - 900 MHz EGSM & 1800 MHz DCS
  - 1800 MHz DCS & 1800 MHz DCS

1. Approved for use with paging and two-way messaging in the U.S. and Canada.

2.2 System Operation

Downlink (Base Station/Repeater to Wireless Handsets)

- The LGCell system's **Main Hub** is usually installed in a 19 in. (483 mm) equipment rack in a wiring closet or equipment room inside the facility where coverage will be provided. Coaxial cable is used to connect the Main Hub to a local base station or to a repeater that is attached to a roof-top antenna. The Main Hub receives the incoming RF signals and splits them to feed four internal fiber optic transceivers that convert the RF signals to optical signals. The Main Hub transmits the optical signals over multimode fiber to up to four Expansion Hubs, which are usually installed in other telecom closets throughout the facility.

WARNING: Exceeding the maximum input power could cause failure of the Main Hub (refer to Section 7.1 on page 7-3 for maximum power ratings). Attenuators may be required to limit the maximum composite power into the Main Hub.

- The **Expansion Hub** converts the optical signals back to electrical signals, which are then transmitted to up to four Remote Access Units (RAUs) over Cat-5 UTP/STP cabling.
- The **Remote Access Unit** receives the electrical signals from the Expansion Hub and transports the signals over a short coaxial cable to an attached passive antenna, which then transmits the RF signals to wireless handsets.

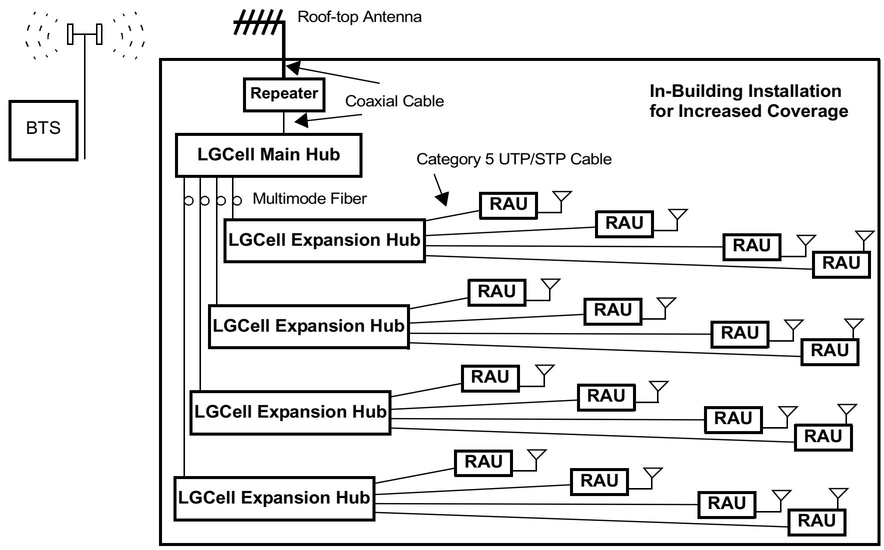
Uplink (Wireless Handsets to Base Station)

- The passive antenna relays the RF signals from wireless handsets to the **Remote Access Unit**, which then transmits the signals to the Expansion Hub over Cat-5 UTP/STP cabling.
- The **Expansion Hub** converts the electrical signals to optical signals and transmits the signals to the Main Hub over MMF.
- The **Main Hub** converts the optical signals to the proper frequency band RF signals and sends them to a local base station or to a repeater that is connected to a roof-top antenna.

2.2.1 Using LGCell to Increase Coverage and Capacity

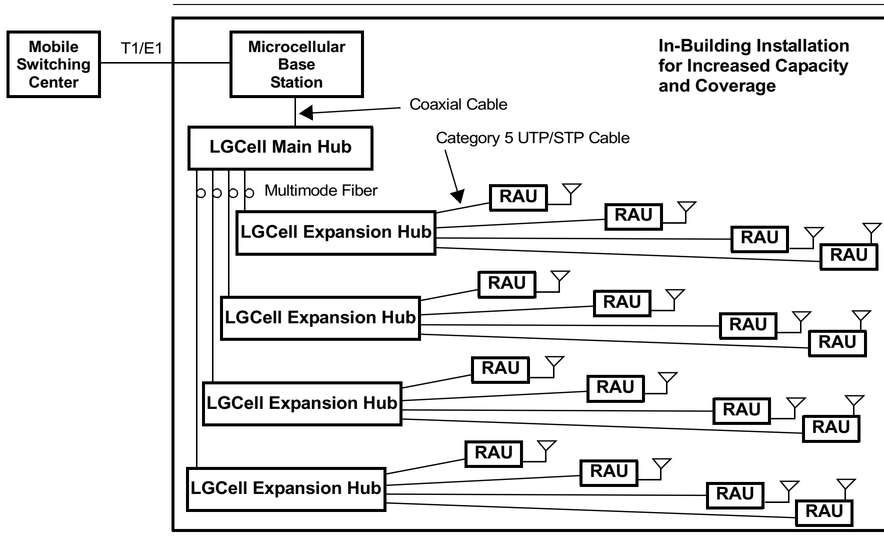
You can extend the outdoor, macrocellular network indoors by connecting the LGCell system to a repeater that is attached to a roof-top antenna. The following figure illustrates how the LGCell can be used to enhance in-building coverage.

Figure 2-3 Increasing Coverage with LGCell



You can increase the number of users who are able to communicate through their wireless handheld devices by connecting an LGCell system to a local, centralized base station. In this configuration, the base station provides voice channel capacity and the LGCell provides coverage.

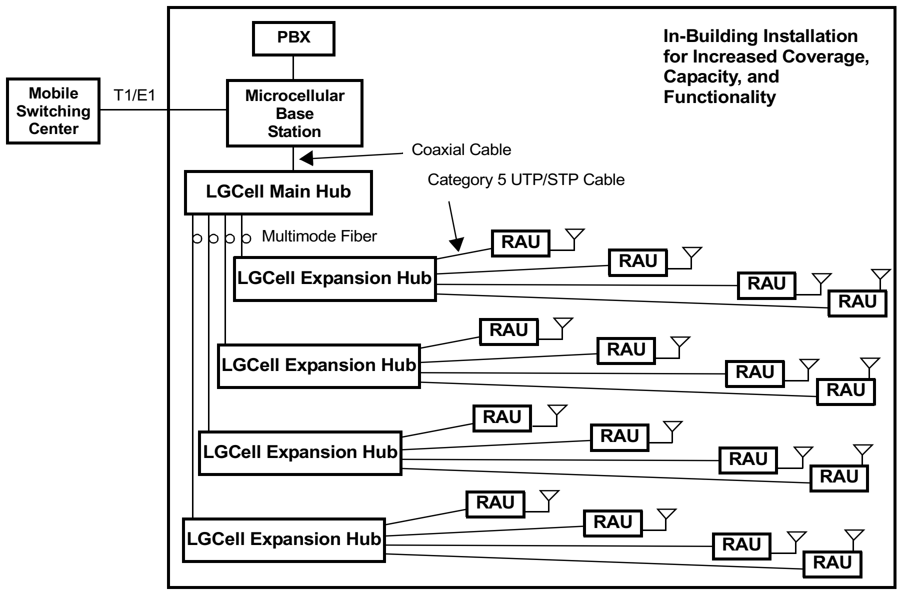
Figure 2-4 Increasing Capacity and Coverage with LGCell



2.2.2 Using LGCell to Increase Coverage, Capacity, and Functionality

Interfacing the LGCell with a base station/PBX network gives wireless phone users PBX functionality through their wireless phones, anytime, anywhere. The following figure shows an example installation for wireless office service (WOS).

Figure 2-5 Increasing Coverage, Capacity, and Functionality with LGCell



With the LGCell/base station/PBX* solution, employees can use a wireless phone in place of a wireline desk phone to access the PBX while inside the building and use the same phone for wireless communications while outside the building. Employees can access PBX features such as four-digit dialing, call delivery, call forwarding, call-waiting, conferencing, and voice mail from their wireless phone.

In this configuration, the base station private wireless network transmits RF signals indoors, and the macrocellular network takes over outdoors.

*Check with your PBX manufacturer/vendor for compatibility, connection, and operation.

2.2.3 Using LGCell to Simultaneously Support Multiple Bands/Protocols

The LGCell can simultaneously support more than one frequency band. Two options include:

- The Dual Band LGCell for an Operator running parallel networks in the same market
- The neutral host configuration, which is described here

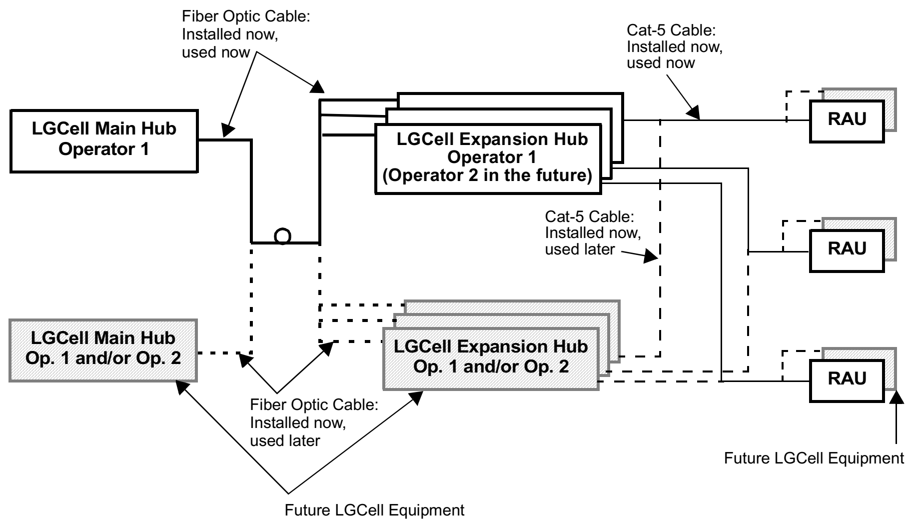
The term “neutral host” refers to the fact that the system supports multiple wireless Operators and that the equipment typically is owned by a third-party company.

Neutral host systems are deployed in situations such as the following:

- Public microcellular applications such as airport terminals, subways/train stations, and similar public buildings usually require that the in-building RF distribution system infrastructure be capable of supporting any current frequency band and protocol, including paging and messaging, and that it be future-proof.
- It is common for the same service provider to be licensed to operate in multiple bands in the same geographical area. For example, some Asian and European service providers have licenses in both 900 MHz and 1800 MHz bands. Some North American service providers operate in both 800 MHz and 1900 MHz bands.
- A building owner will often allow service providers to provide wireless service in their building only if they cooperate and share the infrastructure equipment and distribution system. Delays in service implementation and loss of revenue occur when the competing service providers do not agree on how to share the equipment and installation costs.

Additional distribution cabling infrastructure, beyond initial requirements, often is installed to accommodate adding Operators or services or to enhance capacity by sectorizing the distribution equipment at a later time.

Figure 2-6 **Example Neutral Host Application**



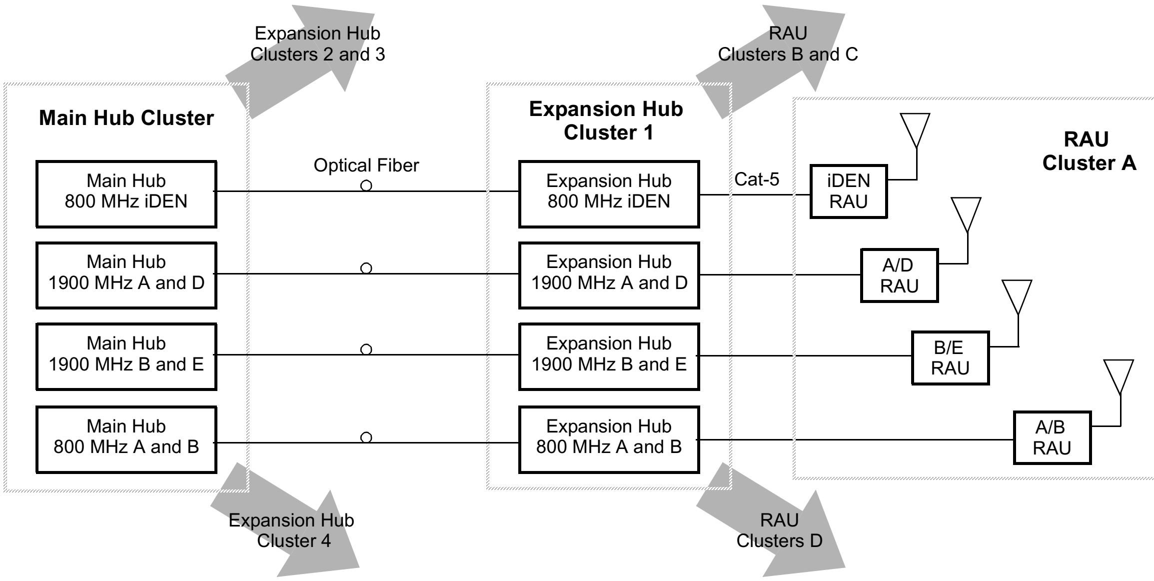
Neutral host systems are deployed as shared or dedicated systems.

- **Shared System**: Multiple wireless Operators use the same set of LGCell hardware to distribute RF signals.
- **Dedicated System**: Each Operator uses an independent LGCell system.

In order to simplify coverage planning and minimize installation costs, the equipment is “clustered” and installed in groups. The number of Hubs and RAUs required for a system is determined by their ability to be shared.

The configuration shown in Figure 2-7 supports up to 7 Operator bands.

Figure 2-7 **LGCell Neutral Host Configuration**



Refer to the *Neutral Host Planning Guide* (PN 9000-10) for more information about this type of configuration.

2.3 System Bandwidths

2.3.1 800 MHz and 900 MHz Systems

The 800 MHz and 900 MHz LGCell systems have fixed bandwidths of operation, as shown in the following table.

Table 2-1 Bandwidths: 800 and 900 MHz

LGCell System	System Bandwidth (MHz)	Uplink Freq. Range (MHz)	Downlink Freq. Range (MHz)
800 MHz Cellular[a]	25	824–849	869–894
800 MHz iDEN	18	806–824	851–869
900 MHz GSM[a]	25	890–915	935–960
900 MHz EGSM	35	880–915	925–960

a. The 800 MHz CDMA/900 MHz GSM dual-band LGCell is composed of two single-band LGCells (one 800 MHz Cellular and one 900 MHz GSM) and supports the following frequency bands:

800 MHz CDMA
Downlink: 870 to 880 MHz
Uplink: 825 to 835 MHz
Bandwidth: 10 MHz

900 MHz GSM:
Downlink: 954 to 960 MHz
Uplink: 909 to 915 MHz
Bandwidth: 6 MHz

2.3.2 1800 MHz and 1900 MHz Systems

The 1800 MHz DCS (GSM) and 1900 MHz PCS systems have a bandpass filter that is positioned within the uplink and downlink bands. This position is specified when the equipment is ordered and it is set during manufacturing.

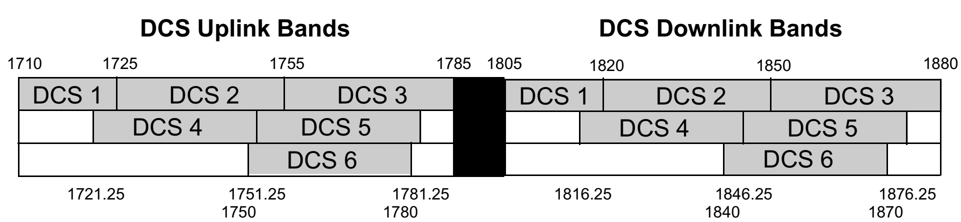
1800 MHz DCS (GSM) System Bandwidth

The 1800 MHz DCS (GSM) bandpass filter is positioned within the 75 MHz band during manufacturing. The bandpass filter is 30 MHz for all bands except DCS1, which is 15 MHz.

When ordering the DCS product, select the appropriate band of operation from the list of available bands as shown in the following table.

Table 2-2 Band Frequency of the DCS 1800 MHz LGCell

Band	System Bandwidth (MHz)	Uplink (MHz)	Downlink (MHz)
DCS 1	15	1710 to 1725	1805 to 1820
DCS 2	30	1725 to 1755	1820 to 1850
DCS 3	30	1755 to 1785	1850 to 1880
DCS 4	30	1721.25 to 1751.25	1816.25 to 1846.25
DCS 5	30	1751.25 to 1781.25	1846.25 to 1876.25



1900 MHz PCS System Bandwidth

The 1900 MHz PCS bandpass filter is positioned within the 60 MHz band during manufacturing. The PCS bandpass filter is 20 MHz.

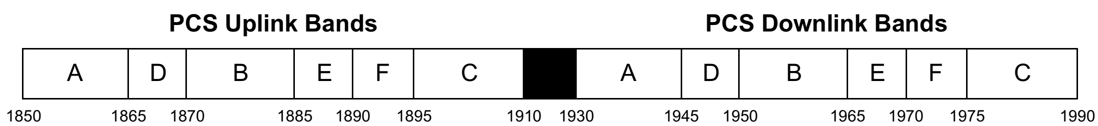
Table 2-3 **Bandwidths: 1900 MHz PCS**

<table>
<tr><th>Band</th><th>PCS Bandwidth in the US (MHz)</th><th colspan="2">LGCell System Bandwidth (MHz)</th><th>Uplink (MHz)</th><th>Downlink (MHz)</th></tr>
<tr><td>A</td><td>15</td><td rowspan="2">20</td><td></td><td>1850 to 1865</td><td>1930 to 1945</td></tr>
<tr><td>D</td><td>5</td><td rowspan="2">20</td><td>1865 to 1870</td><td>1945 to 1950</td></tr>
<tr><td>B</td><td>15</td><td rowspan="2">20</td><td>1870 to 1885</td><td>1950 to 1965</td></tr>
<tr><td>E</td><td>5</td><td rowspan="2">10</td><td>1885 to 1890</td><td>1965 to 1970</td></tr>
<tr><td>F</td><td>5</td><td></td><td>1890 to 1895</td><td>1970 to 1975</td></tr>
<tr><td>C</td><td>15</td><td colspan="2"></td><td>1895 to 1910</td><td>1975 to 1990</td></tr>
</table>

LGCell equipment can be ordered in the following configurations:

- Bands A and D
- Bands D and B
- Bands B and E
- Bands E and F

LGCell equipment does not support band C.



2.4 System Specifications

2.4.1 Physical Specifications

Parameter	Main Hub	Expansion Hub	Remote Access Unit
RF Connectors	3, N-type female	4, RJ-45	Single Band: 1, RJ-45; 1, SMA female Dual Band (900/1800, 800/900, 800/1900): 2, RJ-45; 1, SMA female Dual Band (1800/1800): 2, RJ-45; 2, SMA female
Remote Alarm Connector (contact closure)	1, 9-pin D-sub, female 1, 25-pin D-sub (not used), male	—	—
MMF Connectors	4 Pair, ST female	1 Pair, ST female	—
LED Alarm and Status Indicators	Sync, Power, Port Link Status, Port Sync	Sync, Power, Port Link Status, Port Sync	Power, Sync
AC Power (Universal)			
Typical	117V AC, 0.22 amp @ 60 Hz 230V AC, 0.11 amp @ 50 Hz	117V AC, 0.47 amp @ 60 Hz 230V AC, 0.24 amp @ 50 Hz	—
Maximum	117V AC, 0.30 amp @ 60 Hz 230V AC, 0.15 amp @ 50 Hz	117V AC, 0.64 amp @ 60 Hz 230V AC, 0.32 amp @ 50 Hz	—
Power Consumption Typical Maximum	25 W 35 W	32 W / 55 W with 4 RAUs 45 W / 75 W with 4 RAUs	5.7 W 7.5 W
Enclosure Dimensions (height × width × depth) Excluding angle-brackets for 19" rack mounting of hubs.	44.5 mm × 438 mm × 229 mm (1.75 in. × 17.25 in. × 9 in.) 1U	44.5 mm × 438 mm × 229 mm (1.75 in. × 17.25 in. × 9 in.) 1U	Single Band: 36 mm × 110 mm × 140 mm (1.4 in. × 4.3 in. × 5.5 in.) Dual Band (900/1800, 1800/1800): 68 mm × 157 mm × 203 mm (2.7 in. × 6.2 in. × 8 in.) Dual Band (800/900, 800/1900): 35 mm × 261 mm × 200 mm (1.4 in. × 10.3 in. × 7.9 in.)
Weight	< 3 kg (< 6.5 lb)	< 3 kg (< 6.5 lb)	Single Band: < 0.4 kg (<1 lb) Dual Band: < 0.8 kg (< 1.8 lb)
MTBF (hours)	298,000	461,000	965,000

2.4.2 Environmental Specifications

Parameter	Rating
Operating Temperature	0° to +45°C / 32° to +113°F
Non-operating Temperature	–20° to +85°C / –4° to +185°F
Operating Humidity; non-condensing	5% to 95%

2.4.3 Alarm LEDs

The Main Hub has **LINK STATUS** and **SYNC** LEDs for each fiber port. The Expansion Hub has **LINK STATUS** and **SYNC** LEDs for each Cat-5 (RAU) port.

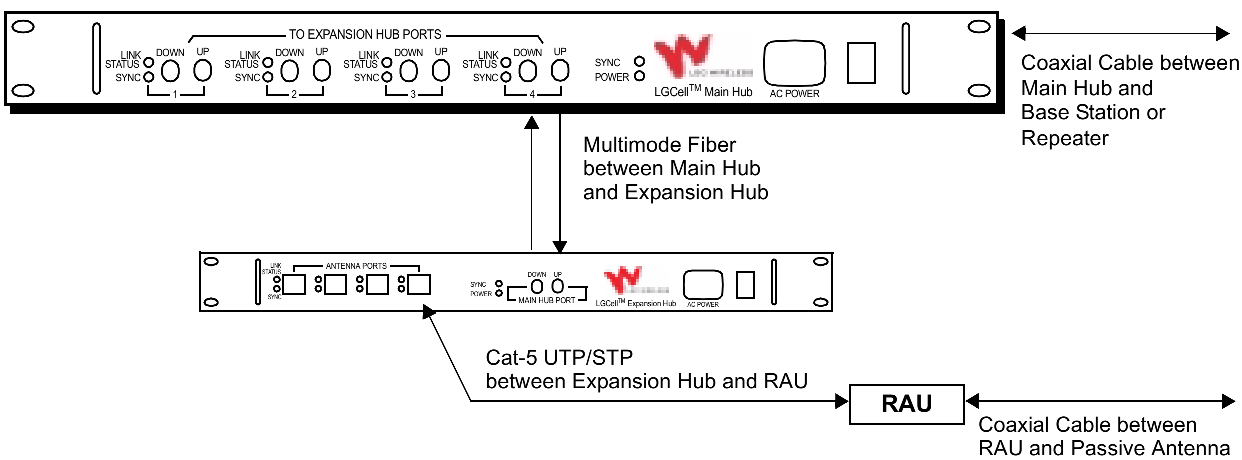
Unit	Alarm Name	LED Color	Condition
Main Hub	Power	Green	AC power is ON
	Sync (above power)	Green	Main Hub's phase lock loop (PLL) is locked
		Off	Main Hub's PLL is not locked
	Port Link Status	Green	The Main Hub is receiving a signal from the Expansion Hub without an alarm signal
		Red	The Main Hub is receiving an alarm signal from the Expansion Hub
	Port Sync	Green	The Expansion Hub and its connected RAUs do not have an alarm
		Red	There is no Expansion Hub connected
Expansion Hub	Power	Green	AC power is ON
	Sync (above power)	Green	The Expansion Hub is receiving the pilot signal
		Off	The Expansion Hub is not receiving the pilot signal
	Port Link Status/Port Sync	Green/Green	The RAU is connected and functioning properly
		Green/Red	The Connected RAU is malfunctioning
		Red/Green	The RAU has been disconnected or the cable is cut
		Red/Red	No RAU is connected
RAU	Power	Green	DC power to RAU
	Sync	Red	PLL is not locked or clock power is low

SECTION 3

LGCell Main Hub

The Main Hub is the LGCell’s central distribution point. On the dowlink, it receives RF signals from a base station or a repeater and converts them to optical signals, which it distributes to Expansion Hubs. On the uplink, the Main Hub receives optical signals from the Expansion Hubs and converts them back to RF signals to be relayed to a base station or a repeater.

Figure 3-1 **The Main Hub in an LGCell 1-1-1 Configuration***



*1-1-1 configuration = 1 Main Hub, 1 Expansion Hub, and 1 Remote Access Unit

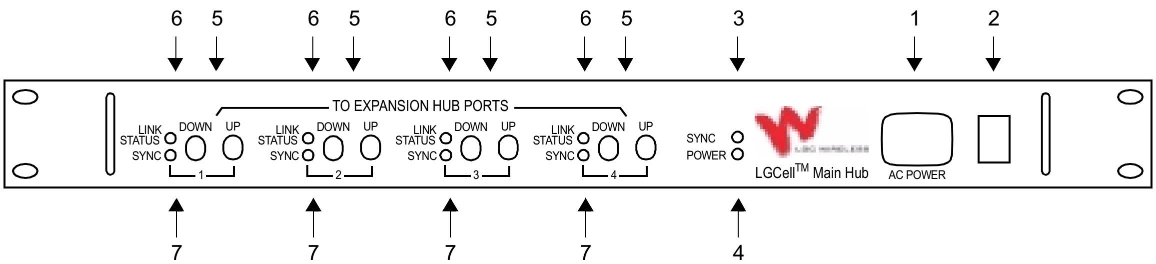
LGCell Main Hub Features

- Mounts in a standard 19 in. (483 mm) equipment rack
- Connects to a base station or repeater using coaxial cable
- Supports up to four Expansion Hubs using standard 62.5µm/125µm multimode fiber (MMF) cable
- Displays system status with front panel LEDs
- Provides contact closures and error latches for major errors through a D-sub 9-pin connector on the rear panel

3.1 LGCell Main Hub Front Panel

The front panel of a Main Hub is shown in the following figure.

Figure 3-2 **Front Panel of a Main Hub**



1. AC power cord connector
2. Power On/Off switch
3. One LED for unit sync status (labeled **SYNC**)
4. One LED for unit power status (labeled **POWER**)
5. Four MMF ports (labeled **1**, **2**, **3**, **4**)
   - One standard female ST optical connector for MMF downlink (labeled **DOWN**)
   - One standard female ST optical connector for MMF uplink (labeled **UP**)
6. One LED per port for port link status (labeled **LINK STATUS**)
7. One LED per port for port sync status (labeled **SYNC**)

3.1.1 MMF Downlink/Uplink Ports

The Main Hub's MMF downlink/uplink ports transmit/receive optical signals to/from Expansion Hub(s) using industry-standard 62.5µm/125µm MMF cable. There are four MMF ports (labeled **1**, **2**, **3**, and **4**) on the Main Hub's front panel. Each MMF port has two female ST optical connectors: one for downlink (output) and one for uplink (input).

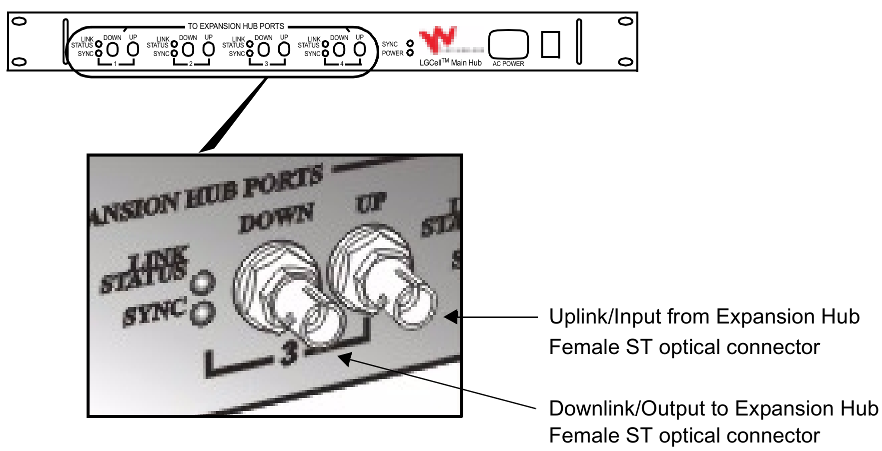
- **MMF Downlink Connector**

  This female ST connector (labeled **DOWN**) is used to transmit the downlink optical signals to an attached Expansion Hub.

- **MMF Uplink Connector**

  This female ST connector (labeled **UP**) is used to receive the uplink optical signals from an attached Expansion Hub.

Figure 3-3 MMF Downlink/Uplink Ports on the Main Hub



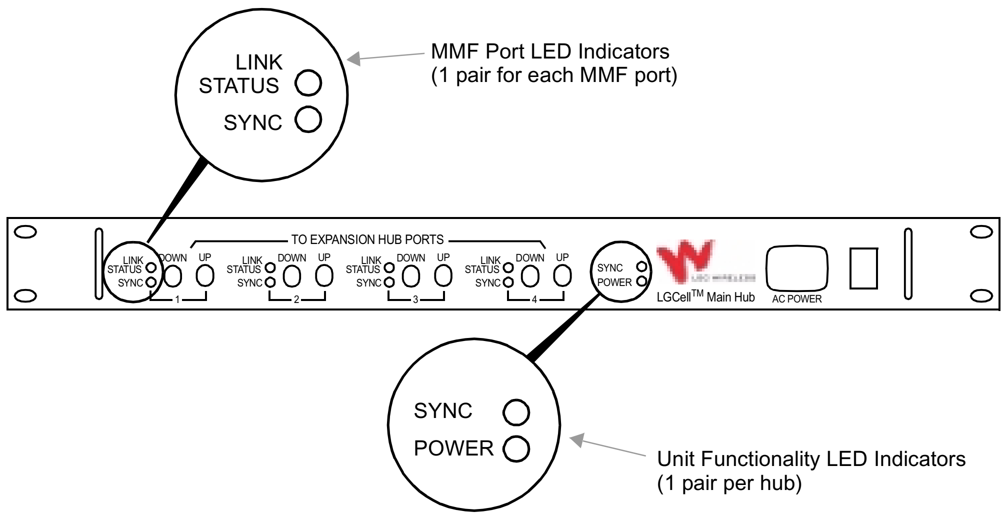
Port Disconnect Memory

The Main Hub detects when active fiber is connected to its MMF ports. An alarm is issued and latched if an active fiber cable from an MMF port on the Main Hub or an attached Expansion Hub is disconnected. The port disconnect memory and major alarm are cleared if you reconnect the fiber into the same functioning port. The error latch remains active until power is cycled. If you do not want to use that port, you should cycle the Main Hub's power to clear the port disconnect memory and the error latch.

3.1.2 Main Hub LED Indicators

The front panel of the Main Hub has LEDs that provide diagnostic information and operational status of the unit.

Figure 3-4 **Main Hub Front Panel LEDs**



The Main Hub's MMF port LEDs can be used to help troubleshoot downstream problems; however, the LEDs do not indicate which downstream component has the problem.

The Main Hub's LED indicators are described in the following table.

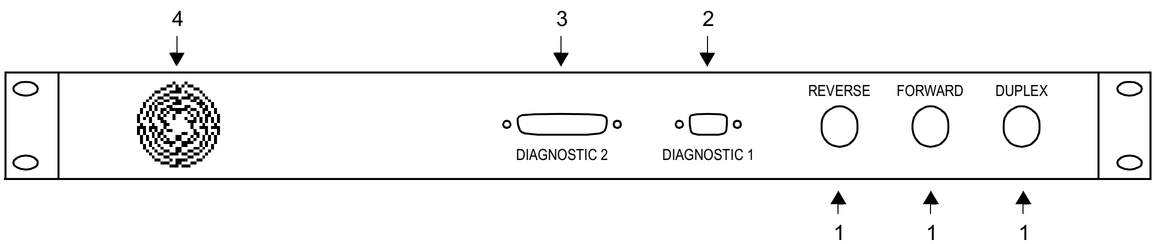
Table 3-1 **Main Hub LED Indicators**

MMF Port Indicators	Color	Indicates
LINK STATUS	Green	Good connection to the Expansion Hub that is connected to the port.
	Red	Connection problem with the Expansion Hub that is connected to the port.
SYNC	Green	Expansion Hub connected to the port is operating properly.
	Red	An alarm with the Expansion Hub that is connected to the port.
Unit Functionality Indicators	**Color**	**Indicates**
SYNC	Green	Main Hub is correctly producing the synchronization signal.
	Off	Main Hub is not correctly producing the synchronization signal.
POWER	Green	Main Hub has power.

3.2 LGCell Main Hub Rear Panel

The rear panel of a Main Hub is shown in the following figure.

Figure 3-5 Rear Panel of a Main Hub



1. Three N-type, female connectors with dust caps:
   - One simplex uplink, unidirectional (labeled **REVERSE**)
   - One simplex downlink, unidirectional (labeled **FORWARD**)
   - One duplexed, bidirectional (labeled **DUPLEX**)
2. One 9-pin D-sub connector (labeled **DIAGNOSTIC 1**)
3. One 25-pin D-sub connector, factory use only (labeled **DIAGNOSTIC 2**)
4. Air exhaust vent

3.2.1 Main Hub Rear Panel Connectors

N-Type Female Connectors

There are three N-type female connectors on the rear panel of the Main Hub: one duplex and two simplex. Generally, the simplex connectors are used together and the duplex connector is used by itself.

- **Simplex Connectors**

  The simplex connectors provide unidirectional connection of a Main Hub to a local base station or to a repeater that is connected to a roof-top antenna.

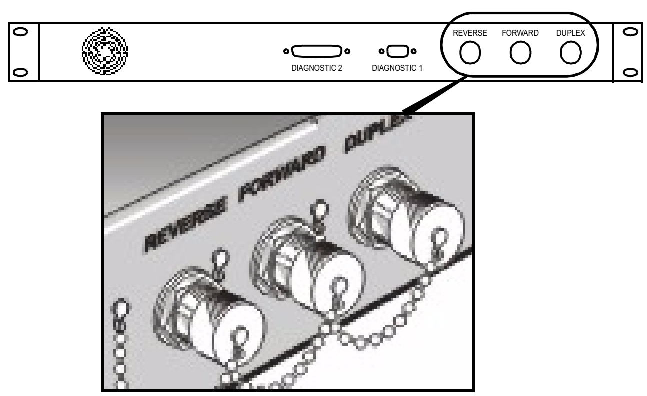
  – The **REVERSE** connector transmits uplink RF signals to a base station or a repeater.

  – The **FORWARD** connector receives downlink RF signals from a base station or a repeater.

- **Duplex Connector**

  The **DUPLEX** connector provides bidirectional (both uplink and downlink) connection between the Main Hub and a base station or a repeater. This connector has a fixed gain of 0, 30, or 40 dB, depending on the system (see Table 7-22 on page 7-25).

Figure 3-6 N-type Female Connectors on the Main Hub



NOTE: Always keep the dust cap on unused N-type connectors.

WARNING: Exceeding the maximum input power could cause failure of the Main Hub (refer to Section 7.1 on page 7-3 for maximum power ratings). Attenuators may be required to limit the maximum composite power into the Main Hub.

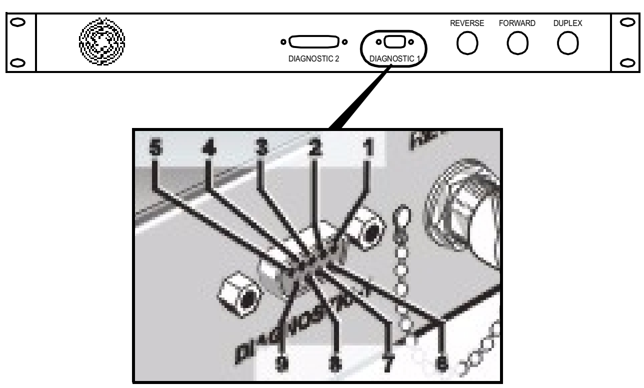
9-pin D-sub Connector

The 9-pin D-sub connector (labeled **DIAGNOSTIC 1**) provides contact closures and error latches for monitoring major errors.

The following table lists the function of each pin on the 9-pin D-sub connector. Pin locations are labeled on Figure 3-7.

Pin	Function
1	+10 V (fused)
2	Not connected
3	Not connected
4	Error Latch (positive connection)
5	Error Latch (negative connection)
6	DC Ground (common)
7	Major Error (positive connection)
8	Error Reset
9	Major Error (negative connection)

Figure 3-7 **9-pin D-sub Connector on the Main Hub**



Use the error pin connections to determine the error status: send a current of no more than 40 mA @ 40V DC maximum (4 mA @ 12V DC typical) through the positive connection. The current will return through the negative connection. An error is indicated if current ceases to flow through the error connection.

25-pin D-sub Connector

Reserved for factory use only.

3.3 LGCell Main Hub Alarm

The two error connections, Major Error and Error Latch, are relay connections. They are either open or short circuit as shown in the following table.

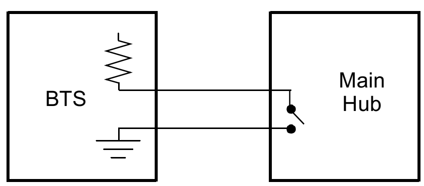
Operation	Major Error	Error Latch
Proper Operation	Short Circuit	Short Circuit
Error	Open Circuit	Open Circuit
Error Latch indicates that there has been a major error which was cleared.	Short Circuit	Open Circuit

- **Major Error**

  The Main Hub senses, then latches, major errors, which can be monitored via the alarm port's contact closures. Red or unlit (off) LEDs on the front panel indicate when an alarm is detected. (Refer to Section 10.2 on page 10-2 for help trouble-shooting using LEDs.)

  The major error contact can be brought back to the BTS for alarm monitoring if the BTS provides +40V DC or less.

Figure 3-8 **Monitoring Main Hub Alarms from the BTS**



- **Error Latch**

  The error latch provides historical information for troubleshooting when you use an external alarm monitor. The recommended method of clearing an error latch is to connect pin 8 (error reset) to pin 1 (+10V) for at least one second. You can power cycle the unit to clear the error latch, but if you are not monitoring alarms externally, there is no need to do this. Normal operation of the system will not be affected by an uncleared error latch.

3.4 LGCell Main Hub Specifications

Note that for dual band systems, the specifications are per band.

Table 3-2 **Main Hub Specifications**

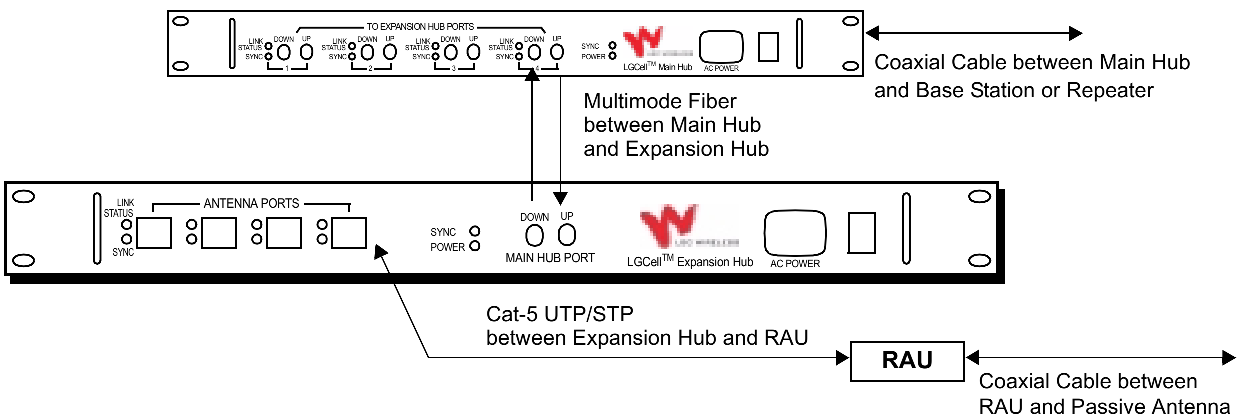
Specification	Description
Dimensions (H × W × D)	44.5 mm × 438 mm × 229 mm (1.75 in. × 17.25 in. × 9 in.); 1U
Weight	< 3 kg (< 6.5 lb)
Operating Temperature	0° to 45°C (32° to 113°F)
Operating Humidity, non-condensing	5% to 95%
Clearance	Front: minimum 50 mm (2 in.) Rear: minimum 76 mm (3 in.)
RF Connectors	3, N-type female
Remote Alarm Connector, contact closure	1, 9-pin D-sub female 1, 25-pin D-sub female (not used)
Multimode Fiber Connectors	4 pair, ST female
LED Alarm and Status Indicators	MMF Port: Link Status, Sync (4 pair) Unit Functionality: Sync, Power (1 pair)
AC Power (Universal)	
Typical	117V AC, 0.22 amp @ 60 Hz 230V AC, 0.11 amp @ 50 Hz
Maximum	117V AC, 0.30 amp @ 60 Hz 230V AC, 0.15 amp @ 50 Hz
Power Consumption	
Typical	25 W
Maximum	35 W
Frequencies	• 800 MHz Cellular • 800 MHz iDEN • 900 MHz GSM • 900 MHz EGSM • 1800 MHz DCS • 1900 MHz PCS • 800 MHz Cellular & 1900 MHz PCS • 900 MHz GSM & 1800 MHz DCS • 900 MHz EGSM & 1800 MHz DCS • 1800 MHz DCS & 1800 MHz DCS
MTBF (hours)	298,000

SECTION 4

LGCell Expansion Hub

The Expansion Hub is LGCell's intermediate distribution point. It converts optical signals that it receives from the Main Hub to intermediate frequency (IF) electrical signals that it transmits over Cat-5 cable to the RAUs.

Figure 4-1 The Expansion Hub in an LGCell 1-1-1 Configuration*



*1-1-1 configuration = 1 Main Hub, 1 Expansion Hub, and 1 Remote Access Unit

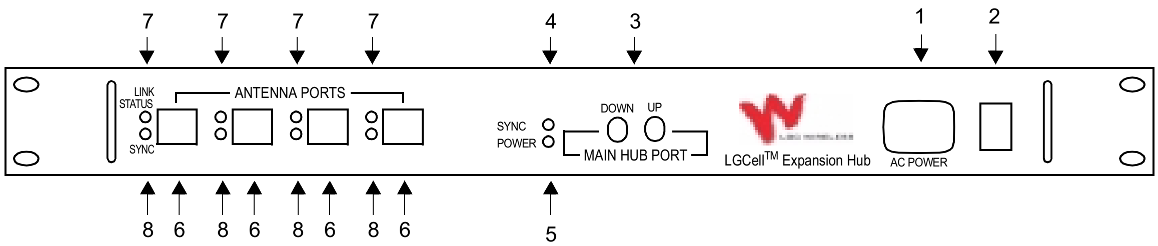
LGCell Expansion Hub Features

- Mounts in a standard 19 in. (483 mm) equipment rack
- Connects to Main Hub using 62.5µm/125µm multimode fiber (MMF) cable
- Supports up to four RAUs per band using Cat-5 UTP/STP cable with RJ-45 connectors
- Provides DC power to RAUs through the UTP/STP cable
- Has easily accessible front panel connectors
- Displays its status and the status of attached RAUs with front panel LEDs
- Communicates with Main Hub for system alarm status

4.1 LGCell Expansion Hub Front Panel

The front panel of an Expansion Hub is shown in the following figure.

Figure 4-2 Front Panel of an Expansion Hub



1. AC power cord connector
2. Power On/Off switch
3. MMF Port (labeled **MAIN HUB**)
   - One standard female ST optical connector for MMF downlink (labeled **DOWN**)
   - One standard female ST optical connector for MMF uplink (labeled **UP**)
4. One LED for unit sync status (labeled **SYNC**)
5. One LED for unit power status (labeled **POWER**)
6. Four standard Cat-5 UTP/STP cable RJ-45 female connectors (labeled **ANTENNA PORTS 1**, **2**, **3**, and **4**)
7. One LED per RJ-45 connector for link status (labeled **LINK STATUS**)
8. One LED per RJ-45 connector for sync status (labeled **SYNC**)

4.1.1 MMF Downlink/Uplink Port

The Expansion Hub's MMF downlink/uplink port transmits and receives optical signals to/from the Main Hub using industry-standard 62.5µm/125µm MMF cable. There is one MMF port (labeled **MAIN HUB**) on the Expansion Hub's front panel. The MMF port has two female ST optical connectors: one for downlink (input) and one for uplink (output).

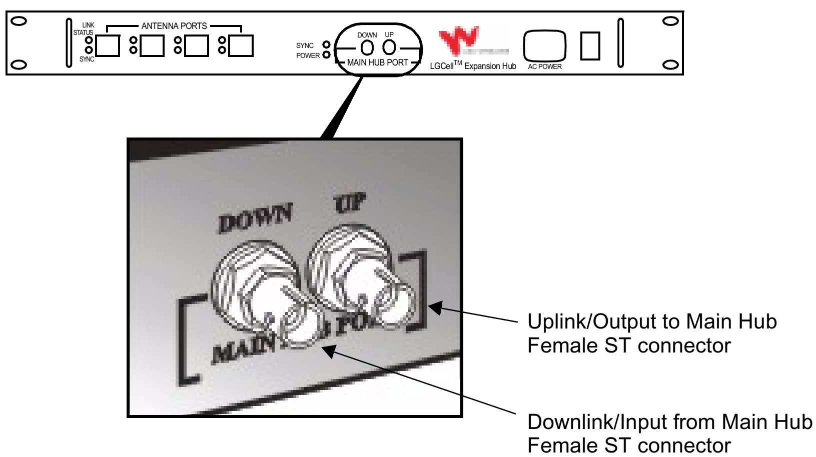
- **MMF Downlink Connector**

  This female ST optical connector (labeled **DOWN**) is used to receive downlink optical signals from the Main Hub.

- **MMF Uplink Connector**

  This female ST optical connector (labeled **UP**) is used to transmit uplink optical signals to the Main Hub.

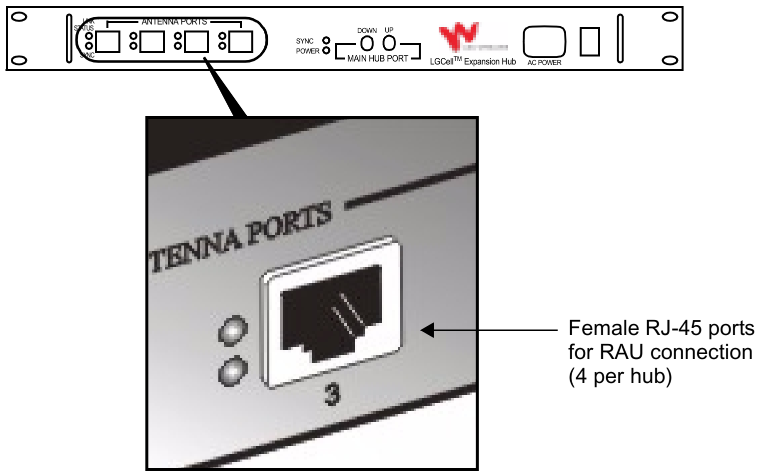
Figure 4-3 **MMF Downlink/Uplink Port on the Expansion Hub**



4.1.2 RJ-45 Ports

The Expansion Hub's RJ-45 ports are for the Cat-5 UTP/STP cables that are used to transmit and receive electrical signals to/from up to four RAUs. There are four ports on the Expansion Hub's front panel.

Figure 4-4 RJ-45 Ports on the Expansion Hub



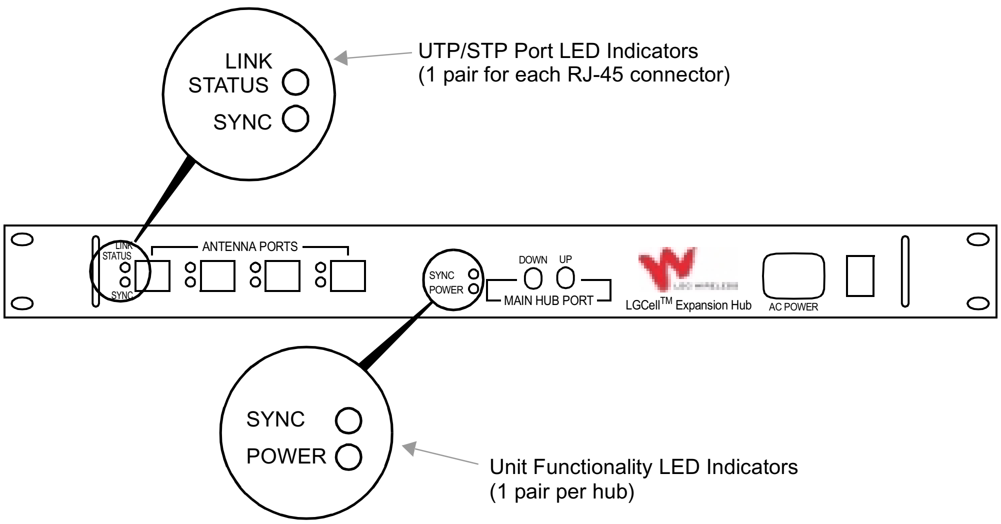
Port Disconnect Memory

The Expansion Hub detects when active UTP/STP cable and RAUs are connected to its RJ-45 ports. An alarm is issued and latched if you disconnect an active UTP/STP cable or an attached RAU. The port disconnect memory and alarm are cleared if you reconnect the cable into the same functioning port. The error latch remains active until power is cycled. If you do not want to use that port, you should cycle the Expansion Hub's power to clear the port disconnect memory and the error latch.

4.1.3 Expansion Hub LED Indicators

The front panel of the Expansion Hub has LEDs that provide diagnostic information and operational status of the unit and attached RAUs.

Figure 4-5 **Expansion Hub Front Panel LEDs**



The Expansion Hub's LED indicators are described in the following table.

Table 4-1 **Expansion Hub LED Indicators**

UTP/STP Port Indicators/Color		
LINK STATUS	**SYNC**	**Indicates**
Green	Green	RAU is connected and functioning properly.
Green	Red	RAU is connected but malfunctioning.
Red	Green	RAU has been disconnected or the cable is cut.
Red	Red	No RAU is connected.
Unit Functionality Indicators	**Color**	**Indicates**
SYNC	Green	Expansion Hub is receiving the synchronization signal from the Main Hub.
	Off	A fault with the MMF downlink or the unit is faulty.
POWER	Green	Expansion Hub has power.

4.2 LGCell Expansion Hub Rear Panel

The Expansion Hub's rear panel has one air exhaust vent and no connectors.

4.3 LGCell Expansion Hub Alarm

The Expansion Hub communicates its status and the status of connected RAUs to the Main Hub over the MMF cable. The Main Hub's MMF port LEDs can be used to help troubleshoot downstream problems; however, the LEDs do not indicate which downstream unit has the alarm.

4.4 LGCell Expansion Hub Specifications

Note that for dual band systems, the specifications are per band.

Table 4-2 Expansion Hub Specifications

Specification	Description
Dimensions (H × W × D)	44.5 mm × 438 mm × 229 mm (1.75 in. × 17.25 in. × 9 in.); 1U
Weight	< 3 kg (< 6.5 lb)
Operating Temperature	0° to 45°C (32° to 113°F)
Operating Humidity, non-condensing	5% to 95%
Clearance	Front: minimum 50 mm (2 in.) Rear: minimum 76 mm (3 in.)
RF Connectors	4 ports, RJ-45
Multimode Fiber Connectors	1 pair, ST female
LED Alarm and Status Indicators	UTP/STP Port: Link Status, Sync (4 pair) Unit Functionality: Sync, Power (1 pair)
AC Power (Universal) Typical Maximum	 117V AC, 0.47 amp @ 60 Hz 230V AC, 0.24 amp @ 50 Hz 117V AC, 0.64 amp @ 60 Hz 230V AC, 0.32 amp @ 50 Hz
Power Consumption Typical Maximum	 32 W / 55 W with 4 RAUs 45 W / 75 W with 4 RAUs
Frequencies	• 800 MHz Cellular • 800 MHz iDEN • 900 MHz GSM • 900 MHz EGSM • 1800 MHz DCS • 1900 MHz PCS • 800 MHz Cellular & 1900 MHz PCS • 900 MHz GSM & 1800 MHz DCS • 900 MHz EGSM & 1800 MHz DCS • 1800 MHz DCS & 1800 MHz DCS
MTBF (hours)	461,000

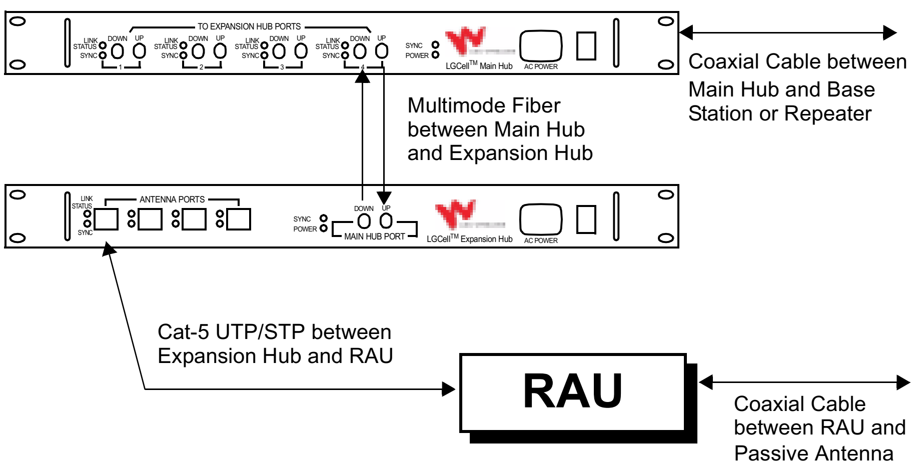
SECTION 5

LGCell Remote Access Unit

The Remote Access Unit (RAU) is an active transceiver that connects to an Expansion Hub using industry-standard Cat-5 UTP/STP cable. The cable delivers radio signals, control signals, and electrical power to the RAU.

An RAU passes electrical signals between an Expansion Hub and an attached passive antenna.

Figure 5-1 The Remote Access Unit in an LGCell 1-1-1 Configuration*



*1-1-1 configuration = 1 Main Hub, 1 Expansion Hub, and 1 Remote Access Unit

LGCell Remote Access Unit Features

- Transmits intermediate frequency (IF) signals to and from Expansion Hub using Cat-5 UTP/STP cable with RJ-45 connectors
- Converts IF to RF (downlink) and RF to IF (uplink)
- Uses a female SMA connector for connecting to standard passive antennas
- Displays its operational status with LEDs
- Plenum-rated unit
- Mounts above a false ceiling or in a plenum-rated location

5.1 LGCell Remote Access Unit Connectors

RJ-45 Port

There is one RJ-45 port on each single band RAU, and two ports on each dual band RAU.

Figure 5-2 RJ-45 Port on a Single Band RAU

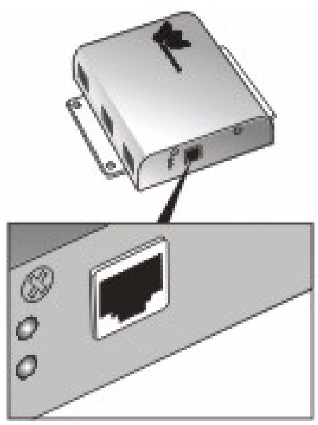
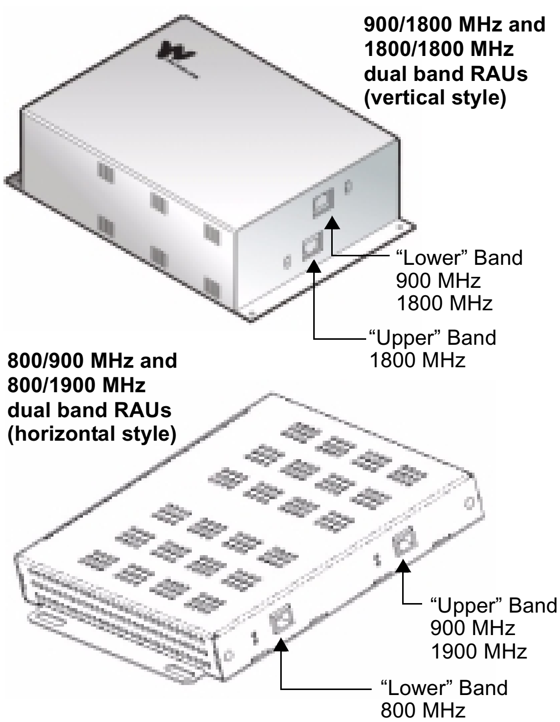


Figure 5-3 RJ-45 Ports on LGCell Dual Band RAUs



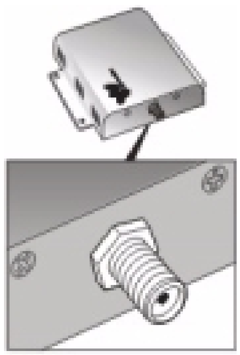
Bands (MHz)	RAU style	RJ-45 Port "Lower" Band	RJ-45 Port "Upper" Band
900/1800	Vertical	Top (900)	Bottom (1800)
1800/1800[a]	Vertical	Top (1800)	Bottom (1800)
800/900	Horizontal	Left (800)	Right (900)
800/1900	Horizontal	Left (800)	Right (1900)

a. On an 1800/1800 MHz dual band RAU, the ports are interchangeable. It does not matter which Cat-5 cable coming from the 1800/1800 dual band Expansion Hub you plug into the top or the bottom RJ-45 port. However, you may want to plug the top 1800 MHz Expansion Hub's Cat-5 cable into the top port and the bottom Expansion Hub's cable into the bottom port for easier troubleshooting later.

SMA Connector

There is one female SMA connector on a single band RAU, one on the 800/900, 800/1900, and 900/1800 dual band RAUs, and two on the 1800/1800 dual band RAU. The connector is a duplexed RF input/output port that connects to standard passive antennas.

Figure 5-4 SMA Connector on the Single Band RAU

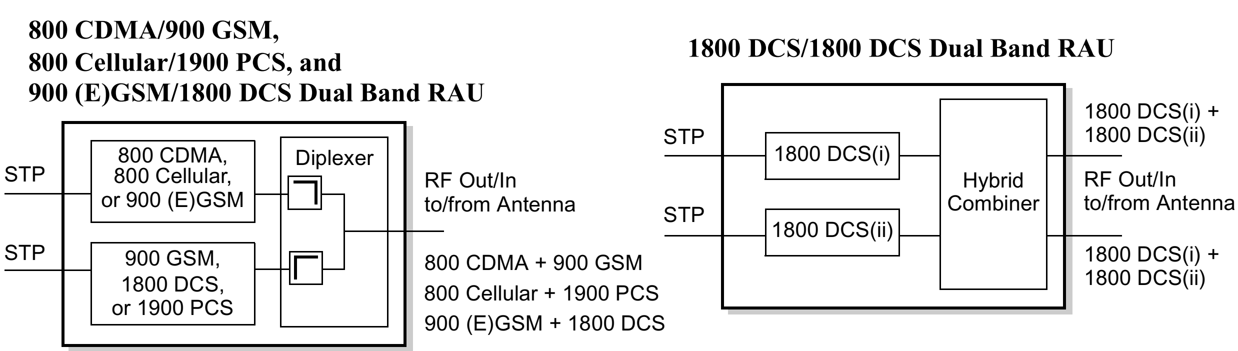


Each 800/900, 800/1900, and 900/1800 dual band RAU has a single female SMA connector. The RAU uses a diplexer to combine the lower and upper band signals from the lower and upper band Expansion Hubs for output to a single passive antenna. Conversely, the uplink signals are separated into lower and upper band signals and sent to the Expansion Hubs.

The 1800/1800 dual band RAU has two female SMA connectors. The RAU combines the signals from each of the 1800 MHz bands on the 1800/1800 dual band Expansion Hub and passes the signals to both SMA connectors. On the uplink, all signals are sent to both 1800 MHz bands on the 1800/1800 dual band Expansion Hub. When attaching one passive antenna, terminate the unused connector with an SMA-type 50 ohm terminator (LGC Wireless part number 4100).

Diagrams of the dual band RAUs are shown in the following figure.

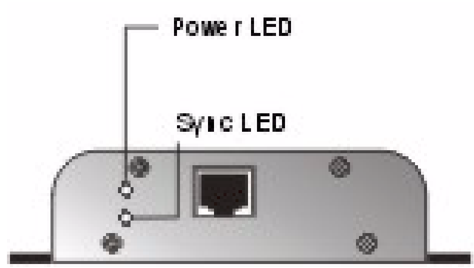
Figure 5-5 Block Diagram of the Dual Band RAUs



5.1.1 Remote Access Unit LED Indicators

The RAU has LEDs that provide diagnostic information and operational status of the unit.

Figure 5-6 RAU LEDs



The RAU's LED indicators are described in the following table.

Table 5-1 RAU LED Indicators

LED	Color	Indicates
POWER	Green	RAU is receiving power from the connected Expansion Hub.
SYNC	Red	PLL is not locked or clock power is low.
	Off	No fault.

When the RAU **SYNC** LED turns red, it indicates that the RF power in the RAU is shut down. When the fault is corrected, the **SYNC** LED turns off.

5.2 LGCell Remote Access Unit Alarm

The RAU communicates its status to the Expansion Hub over the Cat-5 cable. The Expansion Hub, in turn, communicates the status to the Main Hub. The Main Hub's MMF port LEDs can be used to help troubleshoot downstream problems; however, the LEDs do not indicate which downstream unit has the alarm.

5.3 LGCell Remote Access Unit Specifications

Table 5-2 RAU Specifications (Single Band Unless Indicated Otherwise)

Specification	Description
Dimensions (H × W × D)	
Single Band	36 mm × 110 mm × 140 mm (1.4 in. × 4.3 in. × 5.5 in.)
Dual Band (vertical): 900/1800, 1800/1800	68 mm × 157 mm × 203 mm (2.7 in. × 6.2 in. × 8 in.)
Dual Band (horizontal): 800/900, 800/1900	35 mm × 261 mm × 200 mm (1.4 in. × 10.3 in. × 7.9 in)
Weight	
Single Band	< 0.4 kg (< 0.9 lb)
Dual Band: all	< 0.8 kg (< 1.8 lb)
Operating Temperature	0° to 45°C (32° to 113°F)
Operating Humidity, non-condensing	5% to 95%
RF Connectors	
Single Band	1 RJ-45; 1, SMA female
Dual Band: 900/1800, 800/900, 800/1900	2 RJ-45; 1, SMA female
Dual Band: 1800/1800	2 RJ-45; 2 SMA female
LED Alarm and Status Indicators	Power, Sync
Power Consumption	
Typical	5.7 W
Maximum	7.5 W
Frequencies	• 800 MHz Cellular* • 800 MHz iDEN • 900 MHz GSM* • 900 MHz EGSM • 1800 MHz DCS • 1900 MHz PCS
MTBF (hours)	965,000

* The 800 MHz CDMA/900 MHz GSM RAU is designed for use in China. It comprises one 800 MHz Cellular and one 900 MHz GSM single band RAU as well as a diplexer that filters and combines the bands.

The RF passband for the 800 MHz CDMA/900 MHz GSM RAU is shown in Table 5-3.

Table 5-3 RF Frequency

	800 MHz CDMA		900 MHz GSM	
Parameter	**Downlink**	**Uplink**	**Downlink**	**Uplink**
RF Frequency (full band)	870 to 880 MHz	825 to 835 MHz	954 to 909 MHz	909 to 915 MHz
Bandwidth	10 MHz	10 MHz	6 MHz	6 MHz

5.4 Choosing Passive Antennas

Typically, omni-directional and directional passive antennas are used. Typical antenna gain is approximately 3 dBi for omni-directional antennas and 7 dBi for directional antennas. Antenna manufacturer specifications should be considered when selecting antennas.

Antenna selection considerations include:

- Antenna gain
- Antenna type (omni or directional, etc.)
- Performance
- Appearance (important to the building owner)
- Mounting type (ceiling mount, wall mount)

Refer to the LGC Wireless Complementary Products Catalog or contact your LGC account manager for a complete list of passive antennas that are available from LGC Wireless.

SECTION 6

Managing and Planning an LGCell Project

This section provides information to assist in managing and planning an LGCell system installation.

6.1 Managing an LGCell Project

Proper project management is instrumental in providing timely and accurate deployment of the LGCell system. It is beneficial to have one person manage and coordinate all aspects of the project: planning, designing, and installing the equipment. The project manager is the person responsible for assigning tasks and ensuring scheduled work is performed on time. The project manager also acts as the coordinator between all the people involved in the project.

The following table shows an estimated timeline for project management.

Table 6-1 Project Management Estimated Timeline

Description	Details	Time Interval
Detailed site walk-through/RF survey	Prepare installation information, including RF plan, floor plan, equipment order form, and final design documents.	1 to 2 weeks
Order LGCell equipment	Get all parts and accessories required.	8 weeks*
Select cabling contractor	Complete installation statement of work and provide floor plan with equipment locations, cabling runs, and other materials and connections. Get cabling quotation after walk-through.	2 weeks
Install cable	Monitor installation.	1 to 5 days
Install LGCell	Review installation checklist and prepare all materials. *Refer to Section 6.3 on page 6-8.*	1 to 3 days
Test installation and RF coverage	Be sure there are no uncovered areas. *Refer to Section 6.4 on page 6-9.*	1 hour per RAU
Generate as-built document	Prepare site plan diagram and coverage performance.	1 to 5 days

*Standard delivery after receipt of order.

6.1.1 Project Management Responsibilities

Project management functions are performed throughout the duration of the project, from Site Survey through Commissioning, and include the following:

Lead Project Team

- Identify all project participants and document contact information
- Initiate project kick-off meeting
- Provide coordination of all participants
- Provide regular status reports to all participants including the end-user

Define Scope of Project

- Obtain system approval from all participants
- Define site coverage requirements
- Identify critical path items
- Identify all special requirements or potential “roadblocks”
- Plan installation time requirements

Conduct RF Site Survey

- Review/confirm the preliminary signal readings and results of the RF Site Survey, whether conducted by LGC Wireless or others
- Identify RF project changes and/or restrictions

Prepare Site for Installation

- Conduct site walk-through with all appropriate participants
- Coordinate required permits
- Determine material receiving/storage/disbursement location
- Engage and contract with the cabling sub-contractor
- Schedule material delivery
- Coordinate and manage the installation, termination, and testing of required cables (MMF, UTP/STP, coaxial)
- Coordinate with the base station vendor for the integration of the LGCell system
- Coordinate with the service provider for frequency allocation
- Coordinate the installation of any required AC power, power systems, or power equipment

Manage Installation of System

- Establish and distribute Installation Schedule
- Confirm cable installation if provided by third-party company
- Confirm antenna locations and selection
- Obtain approval of the Installation Plan from primary participants and the end-user
- Conduct pre-installation inspection
- Coordinate installation of the LGCell equipment
- Coordinate installation of antennas

Manage System Commissioning

- Coordinate system test
- Coordinate RF signal and coverage tests
- Coordinate complete RF system test with required participants

Manage System Acceptance

- Coordinate final inspection with required participants
- Prepare System Acceptance Document
- Issue System Acceptance Document
- Prepare As-Built Documents

6.2 Planning an LGCell Installation

Preliminary Planning

- **Complete a preliminary system design for current requirements**

  Compile all of the pertinent information to determine a preliminary system design.

- **Determine design requirements**

  Consult with the end user, the service provider, and the equipment vendors to determine system requirements.

- **Analyze floor plans**

  Review the building floor plans to determine approximate antenna locations and possible locations of equipment rooms. Also, where possible on the floor plans, check for various types of construction materials and installation restrictions.

Preliminary System Design

- **Compute equipment requirements for current traffic rates**

  Base this on the voice channels required and equipment parameters of the base station specified for the system (requires input from service provider RF Engineer).

- **Compute equipment requirements for expansion to future traffic rates**

  Base this on customer requirements and equipment parameters of the base station specified for the system.

- **Make recommendations for a system design for future traffic requirements**

  Provide a possible migration plan to achieve future capacity and coverage requirements, perhaps including provisions for additional equipment and/or sectorization of the existing cells.

Site Survey

- **Conduct on-site RF site evaluation**

  Conduct in-building signal level tests after the preliminary design is completed. Using a test transmitter, introduce an RF signal at the approximate antenna locations and record the signal levels on a copy of the floor plan.

  Conduct a physical review of the building to determine types of construction materials in the floors and walls, and amount of “clutter” in the building. (Clutter is anything that can block or reduce the RF signal coverage.) These will help determine the expected coverage area; the in-building signal loss due to walls, furniture, equipment, people, etc.; and the proposed equipment locations and cabling requirements.

  Identify AC power requirements and extra equipment (cabinets, cable trays, cable racks, etc.)

Frequency Planning

- **Coordinate frequency planning with local carriers**

  Discuss with the local carrier the channel requirements for the system.

Final System Design

- **Complete final design**

  Generate a final design based on preliminary design, results of RF tests, discussions with all appropriate parties involved in the project, and the site evaluation.

- **Create final equipment list**

  Generate a final equipment requirement list based on the final system design.

- **Design review**

  Discuss the final system design with all appropriate parties involved in the project.

- **RF Survey Report**

  Generate an RF Survey Report documenting all design information that you gathered.

- **Traffic analysis of current requirements**

  Determine capabilities in terms of current and future capacity, coverage, and quality of service.

6.2.1 Site Survey Questionnaire

LGC WIRELESS

Site Survey Questionnaire

2540 Junction Avenue | San Jose, CA 95134 | TEL 408-952-2400 | FAX 408-952-2410

Project Information		**End-User Information**	
Project Name:		End-User:	
Purchaser Address:		Site Address:	
Company Name:		Contact:	
Contact:		Phone:	
Phone:		E-mail:	
E-mail:		**BTS Information**	

Type of System Enhancement			
☐ Coverage ☐ Capacity (BTS) ☐ Wireless Office		Manufacturer:	
Building Information		Model No:	
		No. of Carriers:	
Are floor plans available (including map scale)?	☐ Yes ☐ No	No. of Subscribers:	
Is outdoor coverage required?	☐ Yes ☐ No	BHCR?	☐ Yes ☐ No
		Erlangs/Sub:	

Select the Downlink Power, Frequency, Protocol, and Band to Operate Under							
Downlink Power at Mobile (dBm): *Select One*	☐ –65	☐ –70	☐ –75	☐ –80	☐ –85 (default)	☐ –90	☐ –95
Frequencies (MHz): *Select all that apply*	☐ 800	☐ 900 GSM	☐ 900 EGSM	☐ 1800	☐ 1900		
Protocol:	☐ GSM	☐ TDMA	☐ CDMA	☐ SMR/iDEN	☐ AMPS		

Additional Questions	**Select One**		
Are exposed antennas tolerated inside?	☐ Yes	☐ No	☐ Unsure
Are exposed antennas tolerated outside?	☐ Yes	☐ No	☐ Unsure
Are locations above ceiling/closets available for mounting equipment?	☐ Yes	☐ No	☐ Unsure
Have available mounting locations been identified? (please identify on floor plans)	☐ Yes	☐ No	☐ Unsure
Are 19" equipment racks available?	☐ Yes	☐ No	☐ Unsure
Is AC power available at the Main and Expansion Hubs?	☐ Yes	☐ No	☐ Unsure
Are multimode fiber optic cables available?	☐ Yes	☐ No	☐ Unsure
If on a campus, are single-mode fiber optic cables available?	☐ Yes	☐ No	☐ Unsure
Are Cat-5 UTP/STP runs available?	☐ Yes	☐ No	☐ Unsure
If cabling is not available, will customer mandate a subcontractor? If yes, provide details in “Comments” section below.	☐ Yes	☐ No	☐ Unsure
Is a bi-directional amplifier (repeater) needed?	☐ Yes	☐ No	☐ Unsure

Comments: (special installation requirements, subcontractors, coverage areas, contacts, etc.)

6.3 Installation Checklist

Following is an installation checklist.

Table 6-2 Installation Checklist

✓	Item	Comments
	Floor Plans	Detailed floor plans of the project site, suitable for the installation of LGCell equipment and cable. Equipment locations clearly marked on the plans
	RF Site Survey	RF signal readings and antenna orientation details from the RF Site Survey, unless provided by LGC Wireless
	Equipment Enclosures/Structures	Any enclosures or structures required for the LGCell equipment, i.e., roof-top structure, unless provided by LGC Wireless
	Equipment Racks	Procurement and installation of equipment racks, unless provided by LGC Wireless
	Microcellular Base Station	Base station installed prior to LGCell equipment installation
	Roof-top Antenna/Repeater	Roof-top antenna and repeater installed prior to LGCell equipment installation
	Cat-5 cabling	TIA/EIA 568-A approved; RJ-45 connectors; Absolute Minimum: 10 meters (33 ft), Recommended Minimum: 20 meters (66 ft), Maximum: 50 meters (165 ft); Expansion Hubs to RAUs; installed, inspected, tested Shielded Cat-5 cable (STP) should be used for neutral host systems
	MMF	62.5µm/125µm; ST male connectors; up to 1 km (3300 ft); Main Hub to Expansion Hubs; maximum 3 dB optical loss, including connectors, splices, etc.; installed, inspected, tested
	Coaxial cabling	Coax approved; N-type male connectors; repeater or base station to Main Hub; installed, inspected, tested
	Coaxial cabling	Coax approved; N-type male connector; RAU to passive antenna; installed, inspected, tested
	Power	110/220V AC power available at hub locations
	Equipment on-hand and ready for installation:	
	LGCell Main Hub(s)	
	LGCell Expansion Hub(s)	4 per Main Hub
	Remote Access Unit(s)	4 per Expansion Hub
	Passive Antenna(s)	Omni or directional; based on RF design
	UPS/Battery	If required by customer
	Power combiner/divider	Required if cascading multiple Main Hubs. N-male to N-male coaxial cables used to connect power combiner/repeater to Main Hub and base station or repeater.

6.4 System Optimization and Commissioning

After the RF Site Survey is completed and the system is installed, perform the following tasks.

Check Installation

- Check installation of the Main Hubs, Expansion Hubs, Remote Access Units, splitters/combiners, antennas, etc.
- Confirm all cable connections
- Confirm working condition of LGCell equipment
- Confirm that equipment quantities and equipment locations are documented
- Confirm that all equipment and cables are identified and marked with ID number

Check Cabling

- Review test results of Cat-5 cable (UTP/STP) (conduct cable test if testing has not already been completed; the results are needed for the As-Built Document)
- Review test results of coaxial cables; at base station to Main Hub and RAU to antenna
- Confirm and document actual link budget in coaxial cables

Check Optical Loss and Power Levels

- Confirm and document downlink power level out of base station
- Confirm and document downlink power level into Main Hub
- Confirm and document uplink power level out of Main Hub
- Check and document optical loss from Main Hub to Expansion Hub

Verify Coverage

- Conduct floor-by-floor system walk-through, confirming RSSI in all locations of the coverage area. Document RF signal level readings from all locations onto floor plan drawings.
- Confirm outside signal levels where required
- Measure RF signal out of equipment, if required

Check Signal Quality

- Check for neighbor channels/frequencies
- Confirm adjacent channel/frequency signal strength
- Check all call quality requirements of the carrier

Prepare As-Built Document

Prepare the final As-Built Document to include the following:

- Title Page
    - Site Address
    - Contact List
- Table of Contents
    - Introduction
        - Description of system installation including equipment used, unusual applications or obstacles, etc.
    - Equipment Locations
        - Descriptions or diagrams of equipment locations within the facility
    - Wiring Configuration and Specifications
        - Descriptions and tables of MMF and Cat-5 measurements; including Expansion Hub ID numbers, RF signal level readings throughout coverage area, number of RAUs attached, results of the Cat-5 compliance tests, unusual or marginal applications, etc.
    - Base Station Settings
        - Number of channels and sectors, transceiver setting, etc.
        - RF power into Main Hub
        - Amount of attenuation used
    - Coverage Performance
        - Description of test method and outcome
    - Summary
        - Include outstanding issues, future plans, and future considerations
    - As-Built Floor Plans

SECTION 7

Designing an LGCell Solution

Designing an LGCell solution is ultimately a matter of determining coverage and capacity needs. This requires the following steps:

1. **Determine the wireless service provider's requirements.**

   This information is usually supplied by the service provider:

   - Frequency (i.e., 850 MHz)
   - Band (i.e., "A" band in the Cellular spectrum)
   - Protocol (i.e., TDMA, CDMA, GSM, iDEN)
   - Peak capacity requirement (this, and whether or not the building will be split into sectors, determines the number of carriers that the LGCell will have to transmit)
   - Design goal (RSSI, received signal strength at the wireless handset, i.e., –85 dBm)

     The design goal is always a stronger signal than the cell phone needs. It includes inherent factors which will affect performance (see Section 7.4.1 on page 7-29).
   - RF source (base station or BDA), type of equipment if possible

2. **Determine the power per carrier and input power from the base station or BDA into the Main Hub: Section 7.1, "Maximum Output Power per Carrier at RAU," on page 7-3.**

   The maximum power per carrier is a function of the number of RF carriers, the carrier headroom requirement, signal quality issues, regulatory emissions requirements, and the LGCell's RF performance. The power per carrier decreases as the number of carriers increases.

3. **Determine the in-building environment: Section 7.2, "Estimating RF Coverage," on page 7-15.**

   - Determine which areas of the building require coverage (entire building, public areas, parking levels, etc.)

- Obtain floor plans to determine floor space of building and the wall layout of the proposed areas to be covered. Floor plans will also be useful when you are selecting antenna locations.
- If possible, determine the building's construction materials (sheetrock, metal, concrete, etc.)
- Determine type of environment
  - Open layout (e.g., a convention center)
  - Dense, close walls (e.g., a hospital)
  - Mixed use (e.g., an office building with hard wall offices and cubicles)

4. **Develop an RF link budget: Section 7.4, "Link Budget Analysis," on page 7-28.**

   Knowing the power per carrier, you can calculate an RF link budget which is used to predict how much propagation loss can be allowed in the system, while still providing satisfactory performance throughout the area being covered. The link budget is a methodical way to derive a "design goal". If the design goal is provided in advance, the link budget is simply: *allowable RF loss = max. power per carrier – design goal.*

5. **Determine the appropriate estimated path loss slope that corresponds to the type of building and its layout, and estimate the coverage distance for each RAU: Section 7.2, "Estimating RF Coverage," on page 7-15.**

   The path loss slope (PLS), which gives a value to the RF propagation characteristics within the building, is used to convert the RF link budget into an estimate of the coverage distance per antenna. This will help establish the LGCell equipment quantities you will need. The actual path loss slope that corresponds to the specific RF environment inside the building can also be determined empirically by performing an RF site-survey of the building. This involves transmitting a calibrated tone for a fixed antenna and making measurements with a mobile antenna throughout the area surrounding the transmitter.

6. **Determine the items required to connect to the base station: Section 7.5, "Connecting a Main Hub to a Base Station," on page 7-41.**

   Once you know the quantities of LGCell equipment you will use, you can determine the accessories (combiners/dividers, surge suppressors, repeaters, attenuators, circulators, etc.) that are required to connect the system to the base station.

The individual elements that must be considered in designing an LGCell solution are discussed in the following sections.

7.1 Maximum Output Power per Carrier at RAU

The following tables show the recommended maximum power per carrier out of the RAU SMA connector for different frequencies, formats, and numbers of carriers. These limits are dictated by RF signal quality and regulatory emissions issues. The maximum input power to the Main Hub is determined by subtracting the system gain from the maximum output power of the RAU. For most systems the gain is 0 dB. Exceptions are the duplex port for the Cellular LGCell (30 dB gain) and the duplex port of the PCS LGCell (40 dB gain).

Therefore, when you connect a Main Hub to a base station or repeater, the RF power per carrier usually needs to be attenuated in order to avoid exceeding the LGCell's maximum composite output power.

Refer to Section 7.6, "Designing for a Neutral Host System," on page 7-45 when combining frequencies or protocols on a single Main Hub.

WARNING: Exceeding the maximum input power could cause permanent damage to the Main Hub.

Table 7-1 800 MHz Cellular Power per Carrier

TDMA

No. of Carriers	Recommended Maximum Output PPC at RAU (dBm)
1	17.0
2	12.0
3	9.0
4	7.0
5	5.5
6	4.5
7	3.5
8	2.5
9	2.0
10	1.5
11	1.0
12	0.5
13	0.5
14	0.0
15	–0.5
16	–0.5
20	–1.5
30	–3.5

AMPS

No. of Carriers	Recommended Maximum Output PPC at RAU (dBm)
1	20.0
2	14.0
3	10.5
4	7.5
5	6.0
6	4.5
7	3.5
8	2.5
9	2.0
10	1.0
11	1.0
12	0.5
13	0.0
14	–0.5
15	–0.5
16	–1.0
20	–2.0
30	–4.0

CDMA

No. of Carriers	Recommended Maximum Output PPC at RAU (dBm)
1	10.0
2	7.5
3	6.0
4	5.0
5	4.0
6	3.5
7	2.5
8	2.0

Note: These specifications are for downlink power at the RAU output (excluding antenna) for single-protocol applications.

WARNING: For 800 MHz Cellular, do not exceed the maximum composite input power of 126mW (+21 dBm) to the Main Hub's simplex ports, or 126µW (–9 dBm) to its duplex port at any time.

Table 7-2 800 MHz iDEN/CDMA Power per Carrier

iDEN

No. of Carriers	Recommended Maximum Output PPC at RAU (dBm)
1	10.0
2	7.0
3	4.5
4	3.0
5	2.0
6	1.0
7	0.0
8	–0.5
9	–1.0
10	–1.5
11	–2.0
12	–2.5
13	–3.0
14	–3.0
15	–3.5
16	–4.0
20	–5.0
30	–6.5

CDMA

No. of Carriers	Recommended Maximum Output PPC at RAU (dBm)
1	9.0
2	6.5
3	5.0
4	4.0
5	3.0
6	2.5
7	1.5
8	1.0

Note: These specifications are for downlink power at the RAU output (excluding antenna) for single-protocol applications.

WARNING: For 800 MHz iDEN/CDMA, do not exceed the maximum composite input power of 126mW (+21 dBm) to the Main Hub's duplex and/or simplex ports at any time.

Table 7-3 **900 MHz GSM or EGSM Power per Carrier**

The 900 MHz LGCell systems also are approved for use with paging and two-way messaging in the U.S. and Canada.

No. of Carriers	Maximum Output PPC at RAU (dBm)
1	8.0
2	4.0
3	2.0
4	1.0
5	0.0
6	–1.0
7	–1.5
8	–2.0
9	–2.5
10	–2.5
11	–3.0
12	–3.5
13	–3.5
14	–4.0
15	–4.0
16	–4.5

Note: These specifications are for downlink power at the RAU output (excluding antenna).

WARNING: For 900 MHz GSM or EGSM, do not exceed the maximum composite input power of 126mW (+21 dBm) to the Main Hub's duplex and/or simplex ports at any time.

Table 7-4 1800 MHz DCS (GSM) Power per Carrier

No. of Carriers	Maximum Output PPC at RAU (dBm)
1	8.0
2	5.5
3	3.5
4	2.0
5	1.0
6	0.5
7	0.0
8	–0.5
9	–1.0
10	–1.5
11	–1.5
12	–2.0
13	–2.5
14	–2.5
15	–3.0
16	–3.0

Note: These specifications are for downlink power at the RAU output (excluding antenna).

WARNING: For 1800 MHz DCS (GSM), do not exceed the maximum composite input power of 126mW (+21 dBm) to the Main Hub's duplex and/or simplex ports at any time.

Table 7-5 **1800 MHz CDMA (Korea) Power per Carrier**

No. of Carriers	Recommended Maximum Output PPC at RAU (dBm)
1	8.0
2	5.5
3	4.0
4	3.0
5	2.0
6	1.5
7	0.5
8	0.0

WARNING: For 1800 MHz CDMA (Korea), do not exceed the maximum composite input power of 126mW (+21 dBm) to the Main Hub's duplex and/or simplex ports at any time.

Table 7-6 1900 MHz PCS Power per Carrier

TDMA

No. of Carriers	Recommended Maximum Output PPC at RAU (dBm)
1	17.0
2	12.0
3	9.0
4	7.0
5	5.5
6	4.5
7	3.5
8	2.5
9	2.0
10	1.5
11	1.0
12	0.5
13	0.5
14	0.0
15	–0.5
16	–0.5
20	–1.5
30	–3.5

GSM

No. of Carriers	Recommended Maximum Output PPC at RAU (dBm)
1	20.0
2	8.0
3	6.0
4	5.0
5	4.0
6	3.0
7	2.5
8	2.0
9	1.5
10	1.5
11	1.0
12	0.5
13	0.5
14	0.0
15	0.0
16	–0.5

EDGE

No. of Carriers	Recommended Maximum Output PPC at RAU (dBm)
1	17.0
2	8.0
3	6.0
4	5.0
5	4.0
6	3.0
7	2.5
8	2.0
9	1.5
10	1.0
11	0.5
12	0.0
13	0.0
14	–0.5
15	–1.0
16	–1.0

CDMA

No. of Carriers	Recommended Maximum Output PPC at RAU (dBm)
1	10.0
2	7.5
3	6.0
4	5.0
5	4.0
6	3.5
7	2.5
8	2.0

Note: These specifications are for downlink power at the RAU output (excluding antenna) for single-protocol applications.

WARNING: For 1900 MHz PCS, do not exceed the maximum composite input power of 126mW (+21 dBm) to the Main Hub's simplex ports, or 12.6μW (–19 dBm) to its duplex port at any time.

Table 7-7 800 MHz CDMA and 900 MHz GSM Power per Carrier

No. of Carriers	Recommended Maximum Output Power per Carrier at RAU (dBm)	
	800 MHz CDMA (Lower Band)	900 MHz GSM (Upper Band)
1	8.5	6.5
2	6.0	2.5
3	4.5	0.5
4	3.5	–0.5
5	2.5	–1.5
6	2.0	–2.5
7	1.0	–3.0
8	0.5	–3.5
9		–4.0
10		–4.0
11		–4.5
12		–5.0
13		–5.0
14		–5.5
15		–5.5
16		–5.5

Note: These specifications are for downlink power at the RAU output (excluding antenna) for single-protocol applications.

WARNING: For 800 MHz CDMA or 900 MHz GSM, do not exceed the maximum composite input power of 126mW (+21 dBm) to the Main Hub's simplex ports, or 126µW (–9 dBm) to its duplex port at any time.

Table 7-8 **800 MHz Cellular and 1900 MHz PCS Power per Carrier**

No. of Carriers	Recommended Maximum Output Power per Carrier at RAU (dBm)						
	800 MHz (Lower Band)			1900 MHz (Upper Band)			
	TDMA	AMPS	CDMA	TDMA	GSM	EDGE	CDMA
1	16.0	19.0	9.0	15.5	18.5	15.5	8.5
2	11.0	13.0	6.5	10.5	7.0	7.0	6.0
3	8.0	9.5	5.0	7.5	5.0	5.0	4.5
4	6.0	6.5	4.0	5.5	4.0	4.0	3.5
5	4.5	5.0	3.0	4.0	3.0	3.0	2.5
6	3.5	3.5	2.5	3.0	2.0	2.0	2.0
7	2.5	2.5	1.5	2.0	1.5	1.5	1.0
8	1.5	1.5	1.0	1.0	1.0	0.5	0.5
9	1.0	1.0		0.5	0.5	0.0	
10	0.5	0.0		0.0	0.5	–0.5	
11	0.0	0.0		–0.5	0.0	–1.0	
12	–0.5	–0.5		–1.0	–0.5	–1.5	
13	–0.5	–1.0		–1.0	–1.0	–1.5	
14	–1.0	–1.5		–1.5	–1.0	–2.0	
15	–1.5	–1.5		–2.0	–1.5	–2.5	
16	–1.5	–2.0		–2.0	–2.0	–2.5	
20	–2.5	–3.0		–3.0			
30	–4.5	–5.0		–5.0			

Note: These specifications are for downlink power at the RAU output (excluding antenna).

WARNING: For 800 MHz Cellular or 1900 MHz PCS, do not exceed the maximum composite input power of 126mW (+21 dBm) to the Main Hub's simplex ports, or 126µW (–9 dBm) to its duplex port at any time.

Table 7-9 900 MHz GSM or EGSM and 1800 MHz GSM Power per Carrier

	Maximum Output Power per Carrier at RAU (dBm)	
No. of Carriers	900 MHz (Lower Band)	1800 MHz (Upper Band)
1	8.0	8.0
2	3.5	4.5
3	1.5	2.5
4	0.5	1.0
5	–0.5	0.0
6	–1.5	–0.5
7	–2.0	–1.0
8	–2.5	–1.5
9	–3.0	–2.0
10	–3.0	–2.5
11	–3.5	–2.5
12	–4.0	–3.0
13	–4.0	–3.5
14	–4.5	–3.5
15	–4.5	–4.0
16	–5.0	–4.0

WARNING: For 900 MHz GSM or EGSM and 1800 MHz GSM, do not exceed the maximum composite input power of 126mW (+21 dBm) to the Main Hub's duplex and/or simplex ports at any time.

Table 7-10 **1800/1800 MHz GSM Power per Carrier**

No. of Carriers	Maximum Output PPC at RAU (dBm)
1	8.0
2	2.5
3	0.5
4	–0.5
5	–1.5
6	–2.5
7	–3.0
8	–3.5
9	–3.5
10	–4.0
11	–4.5
12	–5.0
13	–5.5
14	–5.5
15	–6.0
16	–6.5

WARNING: For 1800 MHz GSM, do not exceed the maximum composite input power of 126mW (+21 dBm) to the Main Hub's duplex and/or simplex ports at any time.

Allowing for Future Capacity Growth

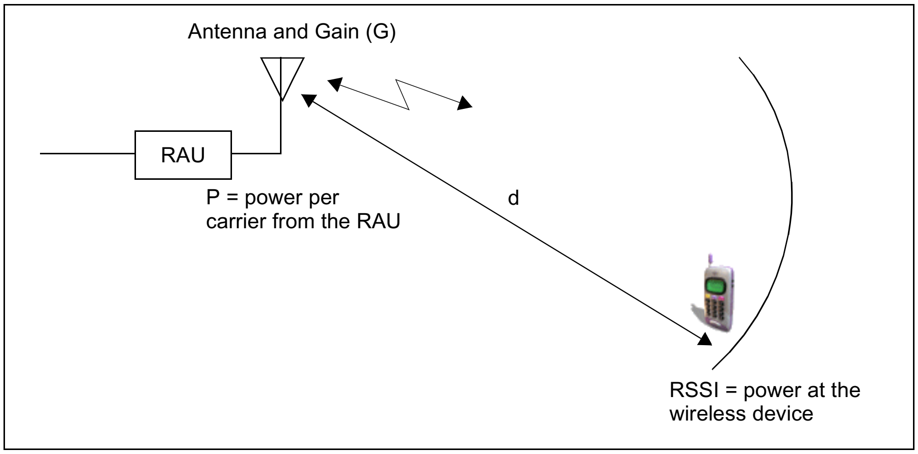
Sometimes an LGCell deployment initially is used to enhance coverage. Later that same system may also need to provide increased capacity. Thus, the initial deployment might only transmit two carriers but need to transmit four carriers later. There are two options for dealing with this scenario:

1. Design the initial coverage with a maximum power per carrier for four carriers.
2. Design the initial coverage for two carriers but leave Expansion Hub ports unused. These ports can be used later if coverage holes are discovered once the power per carrier is lowered to accommodate the two additional carriers.

7.2 Estimating RF Coverage

The maximum power per carrier (based on the number and type of RF carriers that are being transmitted) and the minimum acceptable received power at the wireless device (i.e., RSSI, the design goal) establish the RF link budget, and consequently the path loss between the antenna and the wireless device.

Figure 7-1 Determining Path Loss between the Antenna and the Wireless Device



$$(P + G) - RSSI = PL \qquad (1)$$

The path loss (PL) is the loss in decibels (dB) between the antenna and the wireless device. The distance, d, from the antenna corresponding to this path loss can be calculated using the path loss equation in Section 7.2.1 or in Section 7.2.3.

The losses due to the coaxial cable that connects the RAU to the antenna are not included in this equation because, typically, the cable is short and the losses are modest. However, if further precision is desired, you can use the coaxial cable losses listed in the following table.

Table 7-11 Coaxial Cable Losses

Length of Cable	Loss at 800 MHz (dB)	Loss at 1900 MHz (dB)
0.9 m (3 ft)	0.6	0.8
1.8 m (6 ft)	1.0	1.5
3.0 m (10 ft)	1.5	2.3

7.2.1 Path Loss Equation

Indoor path loss obeys the distance power law* in equation (2):

$$PL = 20\log(4\pi d_0 f/c) + 10n\log(d/d_0) + X_s \qquad (2)$$

where:

- PL is the path loss at a distance, d, from the antenna (the distance between the antenna that is connected to the RAU and the point where the RF signal decreases to the minimum acceptable level at the wireless device).
- d_0 is taken as 1 meter of free-space.
- f is the operating frequency in hertz.
- c is the speed of light in a vacuum (3.0×10^8 m/sec).
- n is the path loss exponent and depends on the building "clutter".
- X_s is a normal random variable that depends on partition losses inside the building, and therefore, depends on the frequency of operation.

As a reference, the following table gives estimates of signal loss for some RF barriers.*

Table 7-12 Average Signal Loss of Common Building Materials

Partition Type	Loss (dB) @ <2 GHz	Frequency (MHz)
Metal wall	26	815
Aluminum siding	20	815
Foil insulation	4	815
Cubicle walls	1.4	900
Concrete block wall	13	1300
Concrete floor	10	1300
Sheetrock	1 to 2	1300
Light machinery	3	1300
General machinery	7	1300
Heavy machinery	11	1300
Equipment racks	7	1300
Assembly line	6	1300
Ceiling duct	5	1300
Metal stairs	5	1300

*Rappaport, Theodore S. *Wireless Communications, Principles, and Practice*. Prentice Hall PTR, 1996.

7.2.2 Path Loss Slope

Table 7-13 shows estimated path loss slope (PLS) for various environments that have different “clutter” (i.e., objects that attenuate the RF signals, such as walls, partitions, stairwells, equipment racks, etc.)

Table 7-13 Estimated Path Loss Slope for Different In-Building Environments

Facility	PLS for 800/900 MHz	PLS for 1800/1900 MHz
Manufacturing	35	32
Hospital	39.4	38.1
Airport	35	32
Retail	36.1	33.1
Warehouse	35	32
Parking Garage	33.7	30.1
Office: 80% cubicle/20% hard wall	36.1	33.1
Office: 50% cubicle/50% hard wall	37.6	34.8
Office: 20% cubicle/80% hard wall	39.4	38.1

7.2.3 Coverage Distance

Equations (1) and (2), on pages 7-15 and 7-16, respectively, can be used to estimate the distance from the antenna to where the RF signal decreases to the minimum acceptable level at the wireless device.

Equation (2) can be simplified to:

$$PL = 20\log(4\pi f/c) + PLS\log D \qquad (3)$$

where PLS is chosen to account for partition losses. Because different frequencies penetrate partitions with different losses, the value of PLS will vary depending on the frequency.

For simplicity, Equation (3) can be used to estimate the coverage distance of an antenna that is connected to an RAU, for a given path loss, frequency, and type of in-building environment.

Table 7-14 gives the value of the first term of Equation (3) (i.e., (20log(4πf/c)) for various frequency bands.

Table 7-14 Frequency Bands and the Value of the first Term in Equation (3)

	Band (MHz)		Mid-Band Frequency (MHz)	20log(4πf/c)
	Uplink	Downlink		
800 Cellular[a]	824–849	869–894	859	31.1
800 iDEN	806–824	851–869	837.5	30.9
900 GSM[a]	890–915	935–960	925	31.8
900 E-GSM	880–915	925–960	920	31.7
1800 DCS	1710–1785	1805–1880	1795	37.5
1800 CDMA (Korea)	1750–1780	1840–1870	1810	37.6
1900 PCS	1850–1910	1930–1990	1920	38.1

a. The 800 MHz CDMA/900 MHz GSM dual-band LGCell supports the following bands:

800 MHz CDMA
- Downlink: 870 to 880 MHz
- Uplink: 825 to 835 MHz
- Bandwidth: 10 MHz

900 MHz GSM:
- Downlink: 954 to 960 MHz
- Uplink: 909 to 915 MHz
- Bandwidth: 6 MHz

These bands are narrower than those for the 800 MHz Cellular and 900 MHz GSM single-band LGCells. However, because the mid-band frequencies of the 800/900 dual-band LGCell bands are almost identical to those for the single-band LGCells, the 20log(4πf/c) terms also are almost identical. To simplify this table and those that follow, it is assumed that the first term in the equation (3) is the same for the 800 MHz Cellular and the 800 MHz CDMA systems; likewise for the 900 MHz GSM systems.

For reference, Tables 7-15 through 7-21 show the distance covered by an antenna for various in-building environments. The following assumptions were made:

- Path loss Equation (3)
- 0 dBm output per carrier at the RAU output
- 3 dBi antenna gain
- RSSI = –85 dBm (typical for narrowband protocols, but not for spread-spectrum protocols)

Table 7-15 Approximate Radiated Distance from Antenna for 800 MHz Cellular Applications

Facility	Distance from Antenna	
	Meters	Feet
Manufacturing	42	138
Hospital	28	91
Airport	42	138
Retail	38	123
Warehouse	42	138
Parking Garage	49	160
Office: 80% cubicle/20% hard wall	38	123
Office: 50% cubicle/50% hard wall	33	107
Office: 20% cubicle/80% hard wall	28	91

Table 7-16 Approximate Radiated Distance from Antenna for 800 MHz iDEN Applications

Facility	Distance from Antenna	
	Meters	Feet
Manufacturing	43	140
Hospital	28	92
Airport	43	140
Retail	38	125
Warehouse	43	140
Parking Garage	49	162
Office: 80% cubicle/20% hard wall	38	125
Office: 50% cubicle/50% hard wall	33	108
Office: 20% cubicle/80% hard wall	28	92

Table 7-17 Approximate Radiated Distance from Antenna for 900 MHz GSM Applications

Facility	Distance from Antenna	
	Meters	Feet
Manufacturing	40	133
Hospital	27	88
Airport	40	133
Retail	36	118
Warehouse	40	133
Parking Garage	47	153
Office: 80% cubicle/20% hard wall	36	118
Office: 50% cubicle/50% hard wall	31	103
Office: 20% cubicle/80% hard wall	27	88

Table 7-18 Approximate Radiated Distance from Antenna for 900 MHz EGSM Applications

Facility	Distance from Antenna	
	Meters	Feet
Manufacturing	41	133
Hospital	27	88
Airport	41	133
Retail	36	119
Warehouse	41	133
Parking Garage	47	153
Office: 80% cubicle/20% hard wall	36	119
Office: 50% cubicle/50% hard wall	31	103
Office: 20% cubicle/80% hard wall	27	88

Table 7-19 Approximate Radiated Distance from Antenna for 1800 MHz DCS Applications

Facility	Distance from Antenna	
	Meters	Feet
Manufacturing	38	124
Hospital	21	69
Airport	38	124
Retail	33	110
Warehouse	38	124
Parking Garage	48	156
Office: 80% cubicle/20% hard wall	33	110
Office: 50% cubicle/50% hard wall	28	93
Office: 20% cubicle/80% hard wall	21	69

Table 7-20 Approximate Radiated Distance from Antenna for 1800 MHz CDMA (Korea) Applications

Facility	Distance from Antenna	
	Meters	Feet
Manufacturing	38	123
Hospital	21	69
Airport	38	123
Retail	33	109
Warehouse	38	123
Parking Garage	47	155
Office: 80% cubicle/20% hard wall	33	109
Office: 50% cubicle/50% hard wall	28	92
Office: 20% cubicle/80% hard wall	21	69

Table 7-21 Approximate Radiated Distance from Antenna for 1900 MHz PCS Applications

Facility	Distance from Antenna	
	Meters	Feet
Manufacturing	36	119
Hospital	20	67
Airport	36	119
Retail	32	105
Warehouse	36	119
Parking Garage	45	149
Office: 80% cubicle/20% hard wall	32	105
Office: 50% cubicle/50% hard wall	27	89
Office: 20% cubicle/80% hard wall	20	67

7.2.4 Example Design Estimate

1. **Design goals**:
   - Cellular (859 MHz = average of the lowest uplink and the highest downlink frequency in 800 MHz Cellular band)
   - TDMA provider
   - 6 TDMA carriers in the system
   - –85 dBm design goal (to 95% of the building) — the minimum received power at the wireless device
   - Base station with simplex RF connections

2. **Power Per Carrier**: The tables in Section 7.1, "Maximum Output Power per Carrier at RAU," on page 7-3 provide maximum power per carrier information. The 800 MHz Cellular table (on page 7-4) indicates that the LGCell can support 6 carriers with a typical power per carrier of 4.5 dBm.

   4.5 dBm per carrier would be the typical RF signal into the Main Hub's **FORWARD** (downlink) port. If the duplex port is used, you must take into account the gain of the port (Table 7-22 on page 7-25) and adjust the input power accordingly. For example, the duplex port on the 800 MHz LGCell provides 30 dB gain. Therefore, the input power must be no greater than –25.5 dBm per carrier (4.5 dBm – 30 dBm). Similarly, the PCS LGCell has a duplex port gain of 40 dB. All other systems have 0 dB gain through all ports.

3. **Building information**:
   - 8 floor building with 9,290 sq. meters (100,000 sq. ft.) per floor; total 74,322 sq. meters (800,000 sq. ft.)
   - Walls are sheetrock construction; suspended ceiling tiles
   - Antennas used will be omni-directional, ceiling mounted
   - Standard office environment, 50% hard wall offices and 50% cubicles

4. **Link Budget**: In this example, a design goal of –85 dBm is used. Suppose 3 dBi omni-directional antennas are used in the design. Then, the maximum RF propagation loss should be no more than 92.5 dB (4.5 dBm + 3 dBi + 85 dBm) over 95% of the area being covered. *It is important to note that a design goal such as –85 dBm is usually derived taking into account multipath fading and log-normal shadowing characteristics. Thus, this design goal will only be met "on average" over 95% of the area being covered. At any given point, a fade may bring the signal level underneath the design goal.*

   Note that this method of calculating a link budget is only for the downlink path. For information to calculate link budgets for both the downlink and uplink paths, see Section 7.4 on page 7-28.

5. **Path Loss Slope**: For a rough estimate, Table 7-13, "Estimated Path Loss Slope for Different In-Building Environments" on page 7-17, shows that a building with 50% hard wall offices and 50% cubicles, at 859 MHz, has an approximate path loss slope (PLS) of 37.6. Given the RF link budget of 92.3 dB, the distance of coverage from each RAU will be 42 meters (138 ft). This corresponds to a coverage area of 5,641

sq. meters (60,719 sq. ft.) per RAU (see Section 7.2.1 for details on path loss estimation). For this case we assumed a circular radiation pattern, though the actual area covered will depend upon the pattern of the antenna and the obstructions in the facility.

If the area to be covered is essentially an unobstructed hallway with some coverage for the offices on either side of the hallway, a more aggressive design using a lower PLS should be used.

6. **Equipment Required**: Since you know the building size, you can now estimate the LGCell equipment quantities that will be needed. Before any RF levels are tested in the building, you can estimate that 2 antennas per level will be needed.

   a. 2 antennas per floor × 8 floors = 16 RAUs

   b. 16 RAUs ÷ 4 (max 4 RAUs per Expansion Hub) = 4 Expansion Hubs

   c. 4 Expansion Hubs ÷ 4 (max 4 Expansion Hubs per Main Hub) = 1 Main Hub

   Check that the MMF and Cat-5 cable distances are as recommended. If the distances differ, use the tables in Section 7.3, "System Gain," on page 7-25 to determine system gains or losses. The path loss may need to be recalculated to assure adequate signal levels in the required coverage distance.

The above estimates assume that all cable length requirements are met. If Expansion Hubs cannot be placed so that the RAUs are within the distance requirement, additional Expansion Hubs may need to be placed closer to the required RAUs locations.

An RF Site Survey and Building Evaluation is required to accurately establish the LGCell equipment quantities required for the building. The site survey measures the RF losses within the building to determine the actual PLS, which will be used in the final path loss formula to determine the actual requirements of the LGCell.

7.3 System Gain

The following table shows a summary of the system gain when 1 km (3300 ft) of 62.5µm/125µm multimode fiber is used. The optical loss of 1 km (3300 ft) of MMF cable ranges from about 0.6 to 1.0 dB optical, depending on the type of cable (i.e., riser zip-cord, loose tube, slotted core, etc.).

Table 7-22 **System Gain when using Duplex/Simplex Ports**

LGCell Frequency and Format	System Gain (dB)	
	Duplex Port	Simplex Ports
800 MHz Cellular	30	0
800 MHz iDEN	0	0
900 MHz GSM, EGSM	0	0
1800 MHz GSM	0	0
1900 MHz PCS	40	0

NOTE: The maximum input power to the Main Hub is equal to the maximum output power of the RAU minus the system gain. For example, for a Cellular system with 6 TDMA carriers, the maximum output power is 4.5 dBm per carrier. If the duplex port is used, the maximum input power to the Main Hub should be no greater than –25.5 dBm per carrier.

7.3.1 System Gain (Loss) Relative to MMF Cable Length

If the length of MMF cable is less than 1 km (3300 ft), the system gain will increase. If the cable length is between 1 km (3300 ft) and 2 km (6600 ft), the system gain will decrease as the cable length increases. Use the following formula for determining the nominal gain (or loss) of the LGCell. The length of the MMF cable is denoted by *L*:

$$\text{gain (dB)} = 3*(1 - \frac{L}{1000})$$

MMF Cable Length	System Gain (dB)
1 m / 3.3 ft	+3
500 m / 1650 ft	+1.5
1000 m / 3300 ft	0
1500 m / 4950 ft	–1.5
2000 m / 6600 ft	–3

MMF cable length greater than 2 km (6600 ft) is not recommended.

The optical power budget between the Main Hub and Expansion Hub, both downlink and uplink, is 3 dB optical. If fiber distribution panels are used, confirm that the total optical loss of fiber cable, from the Main Hub through distribution panels and patch cords to the Expansion Hub, does not exceed 3 dB optical.