7.3.2 System Gain (Loss) Relative to UTP/STP Cable Length

The recommended minimum length of UTP/STP cable is 20 meters (66 ft) and the recommended maximum length is 50 meters (165 ft). If the UTP/STP cable is less than 20 meters (66 ft), system performance may not meet specifications; the absolute minimum cable length is 10 meters (33 ft). If the UTP/STP cable is longer than 50 meters (165 ft), the gain of the system will decrease, as shown in Table 7-23.

Only *shielded* Cat-5 cable (STP) should be used when running parallel Cat-5 cables for an LGCell system.

Table 7-23 System Gain (Loss) Relative to UTP/STP Cable Length

UTP/STP Cable Length	Typical change in system gain (dB)	
	Downlink	Uplink
800 MHz Cellular; 800 MHz iDEN; and 900 MHz GSM and EGSM		
60 m / 198 ft	–0.7	–0.3
70 m / 231 ft	–2.9	–2.1
80 m / 264 ft	–5.1	–3.9
90 m / 297 ft	–7.3	–5.7
100 m / 330 ft	–9.5	–7.5
1800 MHz DCS (GSM)		
60 m / 198 ft	–1.2	–0.3
70 m / 231 ft	–3.9	–2.1
80 m / 264 ft	–6.6	–3.9
90 m / 297 ft	–9.3	–5.7
100 m / 330 ft	–12	–7.5
1900 MHz PCS		
60 m / 198 ft	–1.0	–0.3
70 m / 231 ft	–3.5	–2.1
80 m / 264 ft	–6.0	–3.9
90 m / 297 ft	–8.5	–5.7
100 m / 330 ft	–11	–7.5

7.4 Link Budget Analysis

A link budget is a methodical way to account for the gains and losses in an RF system so that the quality of coverage can be predicted. The end result can often be stated as a “design goal” in which the coverage is determined by the maximum distance from each RAU before the signal strength falls beneath that goal.

One key feature of the link budget is the maximum power per carrier discussed in Section 7.1. While the maximum power per carrier is important as far as emissions and signal quality requirements are concerned, it is critical that the maximum signal into the Main Hub never exceed +21 dBm (126mW) minus system gain. Composite power levels above this limit will cause damage to the Main Hub.

Table 7-24 LGCell Maximum Input Power

LGCell System	Maximum Input Power	
Simplex Ports (all LGCells)	+21 dBm	126mW
Duplex Ports (Cellular)	–9 dBm	126µW
Duplex Ports (iDEN, GSM, EGSM, DCS, CDMA-Korea)	+21 dBm	126mW
Duplex Ports (1900 MHz PCS)	–19 dBm	12.6µW

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

7.4.1 Elements of a Link Budget for Narrowband Standards

The link budget represents a typical calculation that might be used to determine how much path loss can be afforded in an LGCell design. This link budget analyzes both the downlink and uplink paths. For most configurations, the downlink requires lower path loss and is therefore the limiting factor in the system design. It is for this reason that a predetermined "design goal" for the downlink is sufficient to predict coverage distance.

The link budget is organized in a simple manner: the transmitted power is calculated, the airlink losses due to fading and body loss are summed, and the receiver sensitivity (minimum level a signal can be received for acceptable call quality) is calculated. The maximum allowable path loss (in dB) is the difference between the transmitted power, less the airlink losses, and the receiver sensitivity. From the path loss, the maximum coverage distance can be estimated using the path loss formula presented in Section 7.2.1.

Table 7-25 provides link budget considerations for narrowband systems.

Table 7-25 Link Budget Considerations for Narrowband Systems

Consideration	Description
BTS Transmit Power	The power per carrier transmitted from the base station output
Attenuation between BTS and LGCell	This includes all losses: cable, attenuator, splitter/combiner, and so forth. On the downlink, attenuation must be chosen so that the maximum power per carrier going into the Main Hub does not exceed the levels given in Section 7.1. On the uplink, attenuation is chosen to keep the maximum uplink signal and noise level low enough to prevent base station alarms but small enough not to cause degradation in the system sensitivity. If the LGCell noise figure minus the attenuation is at least 10 dB higher than the BTS noise figure, the system noise figure will be approximately that of the LGCell alone. See Section 7.5 for ways to independently set the uplink and downlink attenuations between the base station and the LGCell.
LGCell Gain	This is the system gain (see Table 7-22 on page 7-25)
Antenna Gain	The radiated output power includes antenna gain. For example, if you use a 3 dBi antenna at the RAU that is transmitting 0 dBm per carrier, the effective radiated power (relative to an isotropic radiator) is 3 dBm per carrier.
BTS Noise Figure	This is the effective noise floor of the base station input (usually base station sensitivity is this effective noise floor plus a certain C/I ratio).
LGCell Noise Figure	This is the LGCell's uplink noise figure, which varies depending on the number of Expansion Hubs and RAUs, and the frequency band. The LGCell uplink noise figure is specified for a 1-1-4 configuration. Thus, the noise figure for an LGCell (or multiple LGCells whose uplink ports are power combined) will be *NF(1-1-4) + 10*log(# of Expansion Hubs)*. This represents an upper-bound because the noise figure is lower if any of the Expansion Hub's RAU ports are **not** used.

Table 7-25 **Link Budget Considerations for Narrowband Systems (continued)**

Consideration	Description
Thermal Noise	This is the noise level in the signal bandwidth (BW). Thermal noise power = –174 dBm/Hz + 10*Log*(BW). **Protocol** / **Signal Bandwidth** / **Thermal Noise** TDMA / 30 kHz / –129 dBm CDMA / 1.25 MHz / –113 dBm GSM / 200 kHz / –121 dBm iDEN / 25 kHz / –130 dBm
Required C/I ratio	For each wireless standard a certain C/I (carrier to interference) ratio is needed to obtain acceptable demodulation performance. For narrowband systems, (TDMA, GSM, EDGE, iDEN, AMPS) this level varies from about 9 dB to 20 dB.
Mobile Transmit Power	The maximum power the mobile can transmit (power transmitted at highest power level setting).
Multipath Fade Margin	This margin allows for a certain level of fading due to multipath interference. Inside buildings there is often one or more fairly strong signals and many weaker signals arriving from reflections and diffraction. Signals arriving from multiple paths add constructively or destructively. This margin accounts for the possibility of destructive multipath interference. In RF site surveys this margin will not appear because it will be averaged out over power level samples taken over many locations.
Log-normal Fade Margin	This margin adds an allowance for RF shadowing due to objects obstructing the direct path between the mobile equipment and the RAU. In RF site surveys, this shadowing will not appear because it will be averaged out over power level samples taken over many locations.
Body Loss	This accounts for RF attenuation caused by the user's head and body.
Minimum Received Signal Level	This is also referred to as the "design goal". The link budget says that you can achieve adequate coverage if the signal level is, on average, above this level over 95% of the area covered, for example.

Nested table (Thermal Noise):

Protocol	Signal Bandwidth	Thermal Noise
TDMA	30 kHz	–129 dBm
CDMA	1.25 MHz	–113 dBm
GSM	200 kHz	–121 dBm
iDEN	25 kHz	–130 dBm

7.4.2 Narrowband Link Budget Analysis for a Microcell Application

Narrowband Link Budget Analysis: Downlink

Line	Downlink	
	Transmitter	
a.	BTS transmit power per carrier (dBm)	33
b.	Attenuation between BTS and LGCell (dB)	–30
c.	Power into LGCell (dBm)	3
d.	LGCell gain (dB)	0
e.	Antenna gain (dBi)	3
f.	Radiated power per carrier (dBm)	6
	Airlink	
g.	Multipath fade margin (dB)	6
h.	Log-normal fade margin with 8 dB std. deviation, edge reliability 90% (dB)	10
i.	Body loss (dB)	3
j.	Airlink losses (not including facility path loss)	19
	Receiver	
k.	Thermal noise (dBm/30 kHz)	–129
l.	Mobile noise figure (dB)	7
m.	Required C/I ratio (dB)	12
n.	Minimum received signal (dBm)	–110
p.	**Maximum path loss** (dB)	97

- c = a + b
- f = c + d + e
- j = g + h + i
- n = k + l + m
- k: in this example, k represents the thermal noise for a TDMA signal, which has a bandwidth of 30 kHz
- p = f – j – n

Narrowband Link Budget Analysis: Uplink

Line	Uplink	
	Receiver	
a.	BTS noise figure (dB)	4
b.	Attenuation between BTS and LGCell (dB)	–10
c.	LGCell gain (dB)	0
d.	LGCell noise figure (dB)	27
e.	System noise figure (dB)	27.2
f.	Thermal noise (dBm/30 kHz)	–129
g.	Required C/I ratio (dB)	12
h.	Antenna gain (dBi)	3
i.	Receive sensitivity (dBm)	–92.8
	Airlink	
j.	Multipath fade margin (dB)	6
k.	Log-normal fade margin with 8 dB std. deviation, edge reliability 90% (dB)	10
l.	Body loss (dB)	3
m.	Airlink losses (not including facility path loss)	19
	Transmitter	
n.	Mobile transmit power (dBm)	28
p.	**Maximum path loss** (dB)	101.8

- e: enter the noise figure and gain of each system component (a, b, c, and d) into the standard cascaded noise figure formula

$$F_{sys} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \ldots$$

where

$F = 10^{(\text{Noise Figure}/10)}$

$G = 10^{(\text{Gain}/10)}$

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

- i = f + e + g – h
- m = j + k + l
- p = n – m – i

7.4.3 Elements of a Link Budget for CDMA Standards

A CDMA link budget is slightly more complicated because the spread spectrum nature of CDMA must be considered. Unlike narrowband standards such as TDMA and GSM, CDMA signals are spread over a relatively wide frequency band. Upon reception, the CDMA signal is de-spread. In the de-spreading process the power in the received signal becomes concentrated into a narrow band, whereas the noise level remains unchanged. Hence, the signal-to-noise ratio of the de-spread signal is higher than that of the CDMA signal before de-spreading. This increase is called *processing gain*. For IS-95 and J-STD-008, the processing gain is 21 dB or 19 dB depending on the user data rate (9.6 Kbps for rate set 1 and 14.4 Kbps for rate set 2, respectively). Because of the processing gain, a CDMA signal (comprising one Walsh code channel within the composite CDMA signal) can be received at a lower level than that required for narrowband signals. A reasonable level is –95 dBm, which results in about –85 dBm composite as shown below.

An important issue to keep in mind is that the downlink CDMA signal is composed of many orthogonal channels: pilot, paging, sync, and traffic. The composite power level is the sum of the powers from the individual channels. An example is given in the following table.

Table 7-26 Distribution of Power within a CDMA Signal

Channel	Walsh Code Number	Relative Power Level	
Pilot	0	20%	–7.0 dB
Sync	32	5%	–13.3 dB
Primary Paging	1	19%	–7.3 dB
Traffic	8–31, 33–63	9% (per traffic channel)	–10.3 dB

This table assumes that there are 15 active traffic channels operating with 50% voice activity (so that the total power adds up to 100%). Notice that the pilot and sync channels together contribute about 25% of the power. When measuring the power in a CDMA signal you must be aware that if only the pilot and sync channels are active, the power level will be about 6 to 7 dB lower than the maximum power level you can expect when all voice channels are active. The implication is that if only the pilot and sync channels are active, and the maximum power per carrier table says that you should not exceed 10 dBm for a CDMA signal, for example, then you should set the attenuation between the base station and the LGCell so that the Main Hub receives 3 dBm (assuming 0 dB system gain).

An additional consideration for CDMA systems is that the uplink and downlink paths should be gain and noise balanced. This is required for proper operation of soft-handoff to the outdoor network as well as preventing excess interference that is caused by mobiles on the indoor system transmitting at power levels that are not coordinated with the outdoor mobiles. This balance is achieved if the power level transmitted by the mobiles under close-loop power control is similar to the power level transmitted under open-loop power control. The open-loop power control equation is

$$P_{TX} + P_{RX} = -73 \text{ dBm (for Cellular, IS-95)}$$

$$P_{TX} + P_{RX} = -76 \text{ dBm (for PCS, J-STD-008)}$$

where P_{TX} is the mobile's transmitted power and P_{RX} is the power received by the mobile.

The power level transmitted under closed-loop power control is adjusted by the base station to achieve a certain E_b/N_0 (explained in Table 7-27 on page 7-34). The difference between these power levels, Δ_P, can be estimated by comparing the power radiated from the RAU, $P_{downink}$, to the minimum received signal, P_{uplink}, at the RAU:

$$\Delta_P = P_{downink} + P_{uplink} + 73 \text{ dBm (for Cellular)}$$

$$\Delta_P = P_{downink} + P_{uplink} + 76 \text{ dBm (for PCS)}$$

It's a good idea to keep $-12 \text{ dB} < \Delta_P < 12 \text{ dB}$.

Table 7-27 provides link budget considerations for CDMA systems.

Table 7-27 Additional Link Budget Considerations for CDMA Systems

Consideration	Description
Multipath Fade Margin	The multipath fade margin can be reduced (by at least 3 dB) by using different lengths of optical fiber (this is called "delay diversity"). The delay over fiber is approximately 5µS/km. If the difference in fiber lengths to Expansion Hubs with overlapping coverage areas produces at least 1 chip (0.8µS) delay of one path relative to the other, then the multipaths' signals can be resolved and processed independently by the base station's rake receiver. A CDMA signal traveling through 163 meters of MMF cable will be delayed by approximately one chip.
Power per carrier, downlink	This depends on how many channels are active. For example, the signal will be about 7 dB lower if only the pilot, sync, and paging channels are active compared to a fully-loaded CDMA signal. Furthermore, in the CDMA forward link, voice channels are turned off when the user is not speaking. On average this is assumed to be about 50% of the time. So, in the spreadsheet, both the power per Walsh code channel (representing how much signal a mobile will receive on the Walsh code that it is de-spreading) and the total power are used. The channel power is needed to determine the maximum path loss, and the total power is needed to determine how hard the LGCell is being driven. The total power for a fully-loaded CDMA signal is given by (approximately): total power = voice channel power + 13 dB + $10log_{10}(50\%)$ = voice channel power + 10 dB
Information Rate	This is simply $10log_{10}$(9.6 Kbps) = 40 dB for rate set 1 $10log_{10}$(14.4 Kbps) = 42 dB for rate set 2

Table 7-27 **Additional Link Budget Considerations for CDMA Systems**

Consideration	Description
Process Gain	The process of de-spreading the desired signal boosts that signal relative to the noise and interference. This gain needs to be included in the link budget. In the following formulas, P_G = process gain: $P_G = 10log_{10}(1.25\ MHz / 9.6\ Kbps) = 21$ dB rate set 1 $P_G = 10log_{10}(1.25\ MHz / 14.4\ Kbps) = 19$ dB rate set 2 Note that the process gain can also be expressed as $10log_{10}$ (CDMA bandwidth) minus the information rate.
Eb/No	This is the energy-per-bit divided by the received noise and interference. It's the CDMA equivalent of signal-to-noise ratio (SNR). This figure depends on the mobile's receiver and the multipath environment. For example, the multipath delays inside a building are usually too small for a rake receiver in the mobile (or base station) to resolve and coherently combine multipath components. However, if artificial delay can be introduced by, for instance, using different lengths of cable, then the required E_b/N_o will be lower and the multipath fade margin in the link budget can be reduced in some cases. If the receiver noise figure is NF (dB), then the receive sensitivity (dBm) is given by: $P_{sensitivity} = NF + E_b/N_o$ + thermal noise in a 1.25 MHz band – P_G = NF + E_b/N_o – 113 (*dBm/1.25 MHz*) – P_G
Noise Rise	On the uplink, the noise floor is determined not only by the LGCell, but also by the number of mobiles that are transmitting. This is because when the base station attempts to de-spread a particular mobile's signal, all other mobile signals appear to be noise. Because the noise floor rises as more mobiles try to communicate with a base station, the more mobiles there are, the more power they have to transmit. Hence, the noise floor rises rapidly: *noise rise* = $10log_{10}(1 / (1 – loading))$ where *loading* is the number of users as a percentage of the theoretical maximum number of users. Typically, a base station is set to limit the loading to 75%. This noise ratio must be included in the link budget as a worst-case condition for uplink sensitivity. If there are less users than 75% of the maximum, then the uplink coverage will be better than predicted.
Hand-off Gain	CDMA supports soft hand-off, a process by which the mobile communicates simultaneously with more than one base station or more than one sector of a base station. Soft hand-off provides improved receive sensitivity because there are two or more receivers or transmitters involved. A line for hand-off gain is included in the CDMA link budgets worksheet although the gain is set to 0 dB because the in-building system will probably be designed to limit soft-handoff.

Other CDMA Issues

- Never combine multiple sectors (more than one CDMA signal at the same frequency) into an LGCell. The combined CDMA signals will interfere with each other.
- Try to minimize overlap between in-building coverage areas that utilize different sectors, as well as in-building coverage and outdoor coverage areas. This is important because any area in which more than one dominant pilot signal (at the same frequency) is measured by the mobile will result in soft-handoff. Soft-handoff decreases the overall network capacity by allocating multiple channel resources to a single mobile phone.

7.4.4 Spread Spectrum Link Budget Analysis for a Microcell Application

Spread Spectrum Link Budget Analysis: Downlink

Line	Downlink	
	Transmitter	
a.	BTS transmit power per carrier (dBm)	30.0
b.	Voice activity factor	50%
c.	Maximum composite power (dBm)	40.0
d.	Attenuation between BTS and LGCell (dB)	–30
e.	Power per carrier into LGCell (dBm)	3.0
f.	Composite power into LGCell (dBm)	10.0
g.	LGCell gain (dB)	0.0
h.	Antenna gain (dBi)	3.0
i.	Radiated power per carrier (dBm)	3.0
j.	Total radiated power (dBm)	13.0
	Airlink	
k.	Handoff gain (dB)	7.0
l.	Multipath fade margin (dB)	6.0
m.	Log-normal fade margin with 8 dB std. deviation, edge reliability 90% (dB)	10.0
n.	Additional loss (dB)	0.0
o.	Body loss (dB)	3.0
p.	Airlink losses (not including facility path loss)	19.0
	Receiver	
q.	Mobile noise figure (dB)	7.0
r.	Thermal noise (dBm/Hz)	–174.0
s.	Receiver interference density (dBm/Hz)	–167.0
t.	Information ratio (dB/Hz)	41.6
u.	Required Eb/(No+lo)	7.0
v.	Receive Sensitivity (dBm)	–118.4
w.	Minimum received signal (dBm)	–99.4
x.	**Maximum path loss** (dB)	102.4
y.	Difference between open- and closed-loop transmitter power (dB)	–2.0

- b and c: see notes in Table 7-27 regarding power per carrier, downlink
- e = a + d
- f = c + d
- i = e + g + h
- j = f + g + h
- p = –k + l + m + n + o
- s = q + r
- v = s + t + u
- w = p + v
- x = j – w
- y = j (downlink) + m (uplink) + P

  where

  P = Ptx + Prx = –73 dB for Cellular
  –76 dB for PCS

Spread Spectrum Link Budget Analysis: Uplink

Line	Uplink	
	Receiver	
a.	BTS noise figure (dB)	3.0
b.	Attenuation between BTS and LGCell (dB)	–30.0
c.	LGCell gain (dB)	0.0
d.	LGCell noise figure (dB)	23.0
e.	System noise figure (dB)	33.4
f.	Thermal noise (dBm/Hz)	–174.0
g.	Noise rise 75% loading (dB)	6.0
h.	Receiver interference density (dBm/Hz)	–134.6
i.	Information rate (dB/Hz)	41.6
j.	Required Eb/(No+lo)	5.0
k.	Handoff gain (dB)	0.0
l.	Antenna gain (dBi)	3.0
m.	Minimum received signal (dBm)	–91.0
	Airlink	
n.	Multipath fade margin (dB)	6.0
o.	Log-normal fade margin with 8 dB std. deviation, edge reliability 90% (dB)	10.0
p.	Additional loss (dB)	0.0
q.	Body loss (dB)	3.0
r.	Airlink losses (not including facility path loss)	19.0
	Transmitter	
s.	Mobile transmit power (dBm)	28.0
t.	Effective transmitted power (dBm)	9.0
u.	**Maximum path loss** (dB)	100.0

- e: enter the noise figure and gain of each system component (a, b, c, and d) into the standard cascaded noise figure formula

$$F_{sys} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \ldots.$$

where

$F = 10^{(\text{Noise Figure}/10)}$

$G = 10^{(\text{Gain}/10)}$

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

- h = e + f + g
- m = h + i + j –k – l
- r = n + o + p + q
- t = s – r
- u = t – m

7.4.5 Considerations for Re-Radiation (over-the-air) Systems

The LGCell can be used to extend the coverage of the outdoor network by connecting to a roof-top donor antenna that is pointed toward an outdoor base station. Additional considerations for such an application of the LGCell are:

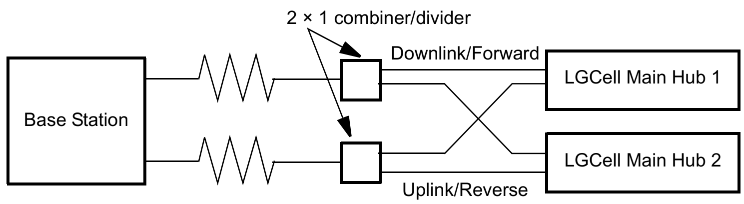
- Sizing the gain and output power requirements for a bi-directional amplifier (repeater).
- Ensuring that noise radiated on the uplink from the in-building system does not cause the outdoor base station to become desensitized to wireless handsets in the outdoor network.
- Filtering out signals that lie in adjacent frequency bands. For instance, if you are providing coverage for Cellular B-band operation it may be necessary to filter out the A, A' and A" bands which may contain strong signals from other outdoor base stations.

Further information on these issues can be found in LGC Wireless' application notes for re-radiation applications.

7.5 Connecting a Main Hub to a Base Station

The first consideration when connecting LGCell Main Hubs to a base station is to ensure there is an equal amount of loss through cables, combiners, etc. from the base station to the Main Hubs. For this example, assume that the base station will have simplex connections, one uplink and one downlink. Each of these connections will need to be divided to equilibrate power for each Main Hub. For example, two Main Hubs will require a 2×1 combiner/divider; four Main Hubs will require a 4×1 combiner/divider; and so on.

Figure 7-2 Connecting LGCell Main Hubs to a Simplex Base Station



When connecting an LGCell to a base station, also consider the following:

1. The downlink power from the base station must be attenuated enough so that the power radiated by the RAU does not exceed the maximum power per carrier listed in Section 7.1, “Maximum Output Power per Carrier at RAU,” on page 7-3.
2. The uplink attenuation should be small enough that the sensitivity of the overall system is limited by the LGCell, not by the attenuator. However, some base stations are adversely affected by received signals that are above –50 dBm, for example. It is therefore helpful to attenuate the uplink in order to retain the maximum number of received signals.

If, in an area covered by an LGCell, a mobile phone indicates good signal strength but consistently has difficulty completing calls, it is possible that the attenuation between the LGCell and base station needs to be adjusted. In other words, it is possible that if the uplink is over-attenuated, the downlink power will provide good coverage, but the uplink coverage distance will be small.

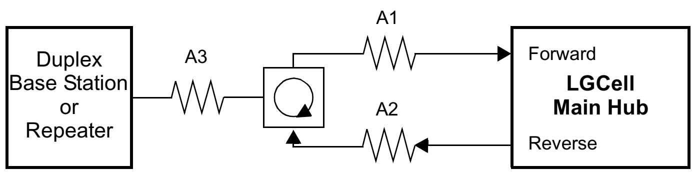
The simplex ports of the Main Hub are usually used for base station connections. However, there is an exception. In cases where several base stations are combined to drive the LGCell(s), the loss from the combiners may be high enough to adversely affect the uplink sensitivity. Since the Cellular and PCS LGCells have gain on the duplex port, this port can be used as the reverse port to overcome the attenuation.

NOTE: When using the duplex port on Cellular or PCS Main Hubs, reduce the power out of the base station to accommodate for the gain of the duplex port. For example, if the power out of the base station is 30 dBm per carrier, and the target RAU output is 0 dBm per carrier, you must attenuate the base station signal by 60 dB before going into the Main Hub because the system gain through the duplex port of the 800 MHz Cellular LGCell is 30 dB. (Refer to Table 7-22 on page 7-25.)

7.5.1 Attenuation

Figure 7-3 shows a typical setup wherein a duplex base station is connected to an LGCell. For a simplex base station, eliminate the circulator and connect the simplex ports of the base station to the simplex ports of the Main Hub. Add attenuators to regulate the power appropriately.

Figure 7-3 LGCell to Duplex Base Station or Repeater Connections



- A typical circulator has an IP3 of +70dBm. If you drive the circulator too hard it will produce intermods that are bigger than the intermods produced by the LGCell. Depending on the LGCell model, the IP3 at the Forward port input of the LGCell can be as high as +30 dBm. The IP3 of the circulator at that same point (i.e., following attenuator A1) is +70dBm – A1. Thus, to keep the system IP3 from being adversely affected by the circulator, attenuator A1 should be no more than 35 dB.
- A filter diplexer can be used in place of the circulator. The IP3 of the diplexer can be assumed to be greater than +100 dBm. If a diplexer is used, A3 can be omitted.
- A1+A3 should be chosen so that the output power per carrier at the RAU's output is correct for the number of carriers being transmitted. Suppose the base station transmits 36 dBm per carrier and it is desired that the RAU output be 6 dBm per carrier and the forward port gain is 0 dB. Then A1+A3=30 dB.
- A2+A3 should, ideally, be at least 10 dB less than the noise figure plus the gain of the LGCell. For example, if the reverse port has a 0 dB gain (it does for all current LGCell models) and if there are eight RAUs, the noise figure (depending on the LGCell model) is approximately 25 dB. So A2+A3 should be about 10 to 15 dB. If A2+A3 is too large, the uplink coverage distance can be severely reduced.
- Given these three equations:
  A1 ≤ 35 dB
  A1+A3 = 30 dB (in this example)
  A2+A3 = 10 dB (in this example)
  we could choose A1=20 dB, A2=0 dB, A3=10 dB for this example.

7.5.2 Uplink Attenuation

The attenuation between the LGCell's **REVERSE** port and the base station does two things:

1. It attenuates the noise coming out of the LGCell.
2. It attenuates the desired signals coming out of the LGCell.

Setting the attenuation on the uplink is a trade-off between keeping the noise and maximum signal levels transmitted from the LGCell to the base station receiver low while not reducing the SNR (signal-to-noise ratio) of the path from the LGCell RAU inputs to the base station inputs. This SNR can not be better than the SNR of the LGCell by itself, although it can be significantly worse.

For example, suppose we have a GSM LGCell system consisting of one Main Hub, four Expansion Hubs, and 16 RAUs (1-4-16) with uplink NF=28 dB. (See Table 7-27 on page 7-34.) If we use 30 dB of attenuation between the LGCell's reverse port and the base station (which has its own noise figure of about 4 dB), the overall noise figure will be 35 dB. (Refer to the formula on page 7-32.) Thus, by using this amount of attenuation, the SNR is reduced by 7 dB. That causes a 7 dB reduction in the uplink coverage distance. Now, if the attenuation instead is 0 dB, the cascaded noise figure is NF=28.01 dB, which implies that the uplink sensitivity is limited by the LGCell, a desirable condition. But now the maximum signal from the LGCell into the base station is as high as –40 dBm. This can cause problems for some base stations. We can reduce the maximum received signal levels by using some attenuation. For instance, if the attenuation is 10 dB, the maximum received signal is –50 dBm and the noise level is reduced by 10 dB but the cascaded noise figure is still only 28.16 dB (for a SNR reduction of only 0.15 dB). Even with a 20 dB attenuator, the cascaded noise figure is 29.45 dB. This is an SNR reduction of 1.44 dB. So, in this situation it would be good to use at least 10 dB of uplink attenuation but not more than 20 dB.

Rule of Thumb

A good rule of thumb is to set the uplink attenuation, A2+A3 in Figure 7-3 on page 7-42, as follows:

A2+A3 < LGCell uplink NF + uplink gain (0 dB for reverse port) – BTS NF – 10dB

and round A2 *down* to the nearest convenient attenuation value.

7.5.2.1 Uplink Attenuation Exception: CDMA

In CDMA systems, the power transmitted by the mobile is determined by the characteristics of both the uplink and downlink paths. The power transmitted by the mobile should be similar in open-loop control (as determined by the downlink path) as during closed-loop control (as determined by the uplink and downlink paths). In addition, the mobile's transmit power when it communicates with a base station through the LGCell should be similar to the power transmitted when it communicates with a base station in the outdoor network (during soft hand-off). Because of these considerations, you should not allow the downlink and uplink gains to vary widely.

Open-loop power control:

$$P_{TX} = -76 \text{ dBm (for PCS)} - P_{RX}$$

where P_{TX} is the power transmitted and P_{RX} is the power received by the mobile. If PL is the path loss (in dB) between the RAU and the mobile, and P_{DN} is the downlink power radiated by the RAU, then

$$P_{TX} = -76 \text{ dBm (for PCS)} - P_{DN} + PL$$

Closed-loop power control:

$$P_{TX} = \text{noise floor} + \text{uplink NF} - \text{process gain} + Eb/No + PL$$

$$= -113 \text{ dBm/1.25 Mhz} + NF - 19 \text{ dB} + 7 \text{ dB} + PL$$

where Eb/No = 7 dB is a rough estimate, and NF is the cascaded noise figure of the LGCell uplink, the uplink attenuation, and the base station noise figure. Equating P_{TX} for the open-loop and closed-loop we see that

$$NF = 49 - P_{DN}$$

where P_{DN} is determined by the downlink attenuation. Since P_{DN} for the LGCell is about 10 dBm, we see that the cascaded noise figure is about 39 dB, which is considerably higher than that of the LGCell itself. This implies that we should use a fairly large attenuation on the uplink. This case suggests using as much attenuation on the downlink as on the uplink. The drawback of doing this is that the uplink coverage sensitivity is reduced. A link budget analysis will clarify these issues. Typically, the uplink attenuation between the LGCell and the base station will be the same as, or maybe 10dB less than, the downlink attenuation.

7.6 Designing for a Neutral Host System

Designing the LGCell for a neutral host system uses the same design rules previously discussed. Since a neutral host system typically uses *multiple systems in parallel,* we find it best to design for the worst case system so that there will not be holes in the covered area and the economies of a single installation can be achieved. For example, as indicated Section 7.1, the 1900 MHz RF signals do not propagate throughout a building as well as the 800 MHz systems, therefore, we design to the 1900 MHz path loss formula.

7.6.1 Capacity of the LGCell Neutral Host System

As indicated in Section 2.3, “System Bandwidths,” on page 2-11, each Main Hub can support more than one sub-band of the Cellular or PCS bands. The exception to this is the iDEN Main Hub, because the SMR band is not split into sub-bands.

The 800 MHz Main Hub can support both the A band and the B band simultaneously. Also, the 1800 MHz and 1900 MHz Main Hubs can support two bands each (as the frequencies currently are allocated).

For example, a neutral host system that consists of one iDEN, one 800 MHz, and two 1900 MHz systems can support up to seven separate service providers:

- 1 on iDEN
- 2 on 800 MHz, A band and B band
- 2 in each 1900 MHz

7.6.2 Example LGCell Neutral Host System

The following example configuration assumes:

- 0 dBm per carrier output
- Each System supports two bands, and therefore, two Operators (Exception: iDEN supports one Operator)

Example Configuration:

- 800 MHz iDEN: System 1
  - l - iDEN system: 8 Channels, 23 voice calls
- 800 MHz Cellular: System 2
  - l - TDMA Band: 8 Channels, 23 voice calls
  - l - CDMA Band: 2 Channels, 30–40 voice calls
- 1900 MHz PCS: Systems 3 & 4 (2 band combinations/system)
  - l - TDMA Band: 8 Channels, 23 voice calls
  - l - CDMA Band: 2 Channels, 30–40 voice calls
  - l - GSM Band: 4 Channels, 31 voice calls

Number of subscribers* that could be served in this example:

- 800 MHz Cellular: System 1
  - l - iDEN Operator: 23 voice calls, 315 subscribers
- 800 MHz Cellular: System 2
  - l - TDMA Operator: 23 voice calls, 315 subscribers
  - l - CDMA Operator: 30–40 voice calls, 438–620 subscribers
- 1900 MHz PCS: Systems 3 & 4 (2 band combinations/system)
  - l - TDMA Operator: 23 voice calls, 315 subscribers
  - l - CDMA Operator: 30–40 voice calls, 438–620 subscribers
  - l - GSM Operator: 31 voice calls, 456 subscribers

This configuration supports growth for up to 7 Operators.

* Based on Standard Erlang B 2% GOS requirement. Each user has a 0.05 wireless Erlang which is higher than the standard 0.035 wireless Erlang.

SECTION 8

Installation Requirements and Safety Precautions

This section contains the following subsections:

8.1 Installation Requirements

8.1.1 Cable and Connector Requirements

The LGCell equipment operates over standard TIA/EIA 568-A specification, Category 5 (Cat-5) unshielded twisted pair (UTP) or shielded twisted pair (STP) and standard 62.5µm/125µm multimode fiber cable (MMF), at a wavelength of 1310 nanometers (nm).

These cables are widely used industry standards for Local Area Networks (LANs). The regulations and guidelines for LGCell cable installation are identical to those specified by the TIA/EIA 568-A standard for LANs.

European standards require that only STP cable be used. Also, to ensure specified performance, STP cable is required in all multi-system installations that use parallel Cat-5 cables in common ducting.

LGC Wireless recommends plenum-rated Cat-5 UTP/STP and MMF cable and connectors for conformity to building codes and standards.

8.1.2 Neutral Host System Requirements

As in any LGCell system, a neutral host system requires one pair of MMF strands between each Main Hub and each Expansion Hub, and one Cat-5 cable between each Expansion Hub and each RAU. To help achieve the cost savings possible in a neutral host system, it is advantageous to install additional cables for future growth.

To alleviate the possibility of interference between LGCell systems, **STP cable is required** for neutral host systems.

8.1.3 Distance Requirements

The following table shows the distances between LGCell components and related equipment.

Table 8-1 LGCell Distance Requirements

Equipment Combination	Cable Type	Distance	Additional Information
Repeater to Main Hub	Coaxial; N male connectors	3–6 m (10–20 ft) typical	Limited by loss and noise. Refer to your link budget calculation.
Base Station to Main Hub	Coaxial; N male connectors	3–6 m (10–20 ft) typical	Limited by loss and noise. Refer to your link budget calculation.
Main Hub to Expansion Hub	62.5µm/125µm Multimode Fiber; ST male optical connectors	1 km (3300 ft)	Up to 2 km (6600 ft) allowed. (See “System Gain (Loss) Relative to MMF Cable Length” on page 7-26.) 3 dB optical loss, port-to-port
Expansion Hub to RAU	Cat-5 STP/UTP; RJ-45 male connectors	10 m (33 ft) absolute minimum 20 m (66 ft) recommended min. 50 m (165 ft) recommended max.	Up to 100 m (330 ft) allowed. (See “System Gain (Loss) Relative to UTP/STP Cable Length” on page 7-27.)
RAU to passive antenna	Coaxial; SMA male connectors	1–3.5 m (3–12 ft) typical	Limited by loss and noise. Refer to your link budget calculation.

8.2 Safety Precautions

8.2.1 Underwriters Laboratory Installation Guidelines

Use the following guidelines when installing the LGCell:

1. Do not exceed the maximum ambient air temperature of 45°C during operation. Provide sufficient airflow and cooling within the rack to prevent heat build-up from exceeding this limit.
2. Be careful when servicing these products. If you are removing the system from the rack, turn it off and remove the power cord first. There are no user-serviceable parts inside the hubs or RAUs.
3. Do not compromise the amount of airflow required for safe operation of the equipment when installing it in a rack. Both the Main Hub and the Expansion Hub draw in air on the left side and exhaust heated air at the rear. The hubs pass approximately 6 cu. ft. of air per minute through themselves. The Main Hub dissipates a maximum of 25 watts of heat from its internal circuitry and the Expansion Hub dissipates a maximum of 55 watts (with 4 RAUs attached).
4. The AC input current consumption of the hubs is rated as follows:
   - Main Hub
     - 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
   - Expansion Hub
     - Typical:

       117V AC, 0.50 amp @ 60 Hz
       230V AC, 0.25 amp @ 50 Hz
     - Maximum:

       117V AC, 0.70 amp @ 60 Hz
       230V AC, 0.35 amp @ 50 Hz

   The internal power supply has internal fuses that are not user replaceable. Consider the worst-case power consumption shown on the product labels when provisioning the rack's AC power source and distribution.

8.2.2 General Safety Precautions

The following precautions apply to LGCell products.

- LGCell has no user-serviceable parts. Faulty or failed units are fully replaceable through LGC Wireless. Please contact us at:

  1-800-530-9960 (U.S. only)
  +1-408-952-2400 (International)
  +44(0) 1223 597812 (Europe)

- Never input an RF signal to the Main Hub's duplex or simplex ports that is higher than those defined in Section 7.1 on page 7-3 because the Main Hub could be damaged.
- Although modeled after an Ethernet/LAN architecture and connectivity, LGCell units are not intended to connect to Ethernet data hubs, routers, cards, or other similar data equipment.
- When you connect the multimode fiber (MMF) optical cable, take the same precaution as if installing Ethernet network equipment. All optical fiber ST connectors should be cleaned according to the connector manufacturer's instructions.
- When you connect a radiating antenna to an RAU, **DO NOT** over-tighten the SMA connector. Firmly hand-tightening the connector is adequate.

WARNING: To reduce the risk of fire or electric shock, do not expose this equipment to rain or moisture.

8.2.3 Fiber Port Safety Precautions

The following are suggested safety precautions for working with LGCell fiber ports. For information about LGCell compliance with safety standards, see Appendix B.

WARNING: Observe the following warning about viewing fiber ends in ports. Do not stare with unprotected eyes at the connector ends of the fibers or the ports of the hubs. Invisible infrared radiation is present at the front panel of the Main Hub and the Expansion Hub. Do not remove the fiber port dust caps unless the port is going to be used. Do not stare directly into a fiber port.

- **Test fiber cables:** When you test fiber optical cables, connect the optical power source last and disconnect it first.
- **Fiber ends:** Cover any unconnected fiber ends with an approved cap. Do not use tape.
- **Broken fiber cables:** Do not stare with unprotected eyes at any broken ends of the fibers. Report any broken fiber cables and have them replaced.
- **Cleaning:** Use only approved methods for cleaning optical fiber connectors.
- **Modifications:** Do not make any unauthorized modifications to this fiber optical system or associated equipment.
- **Live work:** Live work is permitted on the LGCell as it is a Class 1 hazard.
- **Signs:** No warning signs are required.
- **Test equipment:** Use Class 1 test equipment.

SECTION 9

Installing the LGCell

This section contains the following:

CAUTION: Although modeled after an Ethernet/LAN architecture, LGCell units are not intended to be connected to Ethernet data hubs, routers, or other similar data equipment.

NOTE: Only LGC Wireless personnel and approved Certified Installation Service Provider (CISP) personnel are authorized to install LGCell systems. Frequency bands are licensed for use by wireless operators.

9.1 Inspecting Shipment

Follow this procedure before installing LGCell equipment:

1. Verify the number of packages received against the packing list.
2. Check all packages for external damage; report any external damage to the shipping carrier. If there is damage, a shipping carrier agent should be present before unpacking and inspecting the contents because damage caused during transit is the responsibility of the shipping agent.
3. Open and check each package against the packing slip. If any items are missing, contact LGC Wireless customer service.
4. Do not remove items from antistatic packing until you are ready to install them. If damage is discovered at the time of installation, contact the shipping agent.

9.2 Installing the Main Hub

9.2.1 Main Hub Installation Checklist

✓	Installation Requirement	Consideration
	Floor Plans	Installation location of equipment clearly marked
	Main Hub	Same frequency and protocol as Expansion Hub(s)
	AC power available	Power cord is 2 m (6.5 ft) long • 117V AC, 0.3 amp @ 60 Hz • 230V AC, 0.15 amp @ 50 Hz
	Rack space available	4.4 cm (1.75 in.) high
	Clearance for air circulation	7.6 cm (3 in.) front and rear
	Suitable operating environment	0° to 45°C (32° to 113°F) 5% to 95% non-condensing humidity
	Donor Antenna-to-LGCell Configuration	
	Donor Antenna	Installed, inspected; N-male to N-male coaxial cable to lightning arrestor/surge suppressor
	Lightning Arrestor or Surge Suppressor	Installed between roof-top antenna and repeater; N-male to N-male coaxial cable
	Repeater	Installed between lightning arrestor/surge suppressor and Main Hub; N-male to N-male coaxial cable
	Base Station-to-LGCell Configuration	
	Microcellular Base Station	Verify RF power (see tables in Section 7.1); N-male to N-male coaxial cable; installed, inspected Attenuation may be required to achieve the desired RF output per carrier at the RAU
	LGCell Alarms to Base Station	
	Alarm cable	If connecting one LGCell system to the base station, make custom cable on site. If connecting multiple LGCell systems to the base station, use the 5-port Daisy-Chain Alarm Cable (PN 4022-5). As necessary, make a custom cable to mate the Daisy-Chain Alarm Cable to the base station's input alarm connector port.
	Cascading multiple Main Hubs	
	Power combiner/divider	N-male to N-male coaxial cables; power combiner/divider to Main Hub and base station or repeater
	Cabling	
	Coax (Simplex)	Coax approved; N-type male unidirectional connectors; repeater or base station to Main Hub
	Coax (Duplex)	Coax approved; N-type male, bidirectional connectors; repeater or base station to Main Hub
	MMF	62.5µm/125µm; ST optical connectors, male; up to 1 km (3300 ft); Main Hub to Expansion Hubs

✓	Installation Requirement	Consideration
	Distances	
	Main Hub is within 3–6m (10–20 ft) of connecting repeater	If longer distance, determine the loss of the cable used for this connection and adjust the RF signal into the Main Hub accordingly. This can be done by readjusting the power from the base station, or by changing the attenuation value between the base station/repeater and the Main Hub.
	Main Hub is within 3–6m (10–20 ft) of connecting base station	
	Main Hub is within 1 km (3300 ft) of Expansion Hub(s); 3 dB optical link budget	
	Miscellaneous	
	Cable manager	Rack space immediately above or below the Main Hub; 8.9 cm (3.5 in.) high

9.2.2 Tools and Materials Required to Install Main Hub

The tools and materials required to install the Main Hub are listed in the following table.

✓	Description
	Philips screwdriver
	Mounting screws and spring nuts
	Fiber cleaning supplies (optical grade alcohol and lint-free wipes)
	Compressed air (optical grade)

9.2.3 Main Hub Installation Procedures

Procedures in this section:

Installing the Main Hub in a Rack

The Main Hub (1U high) mounts in a standard 19 in. (48.3 cm) equipment rack. Allow front and rear clearance of 7.6 cm (3 in.) for air circulation.

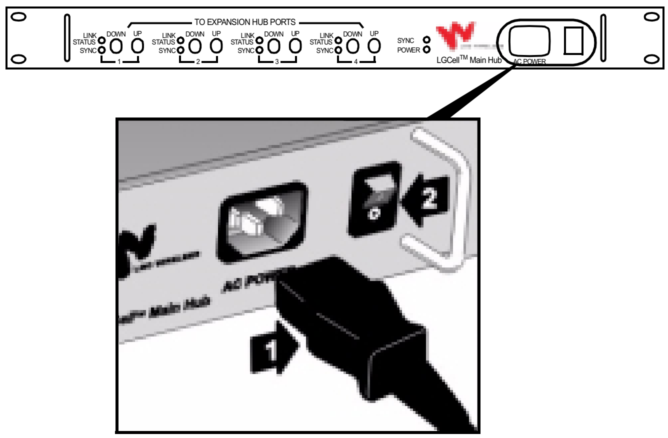
The Main Hub is shipped with #10-32 mounting screws. Another common rack thread is #12-24. Confirm that the mounting screws match the racks threads.

1. Insert spring nuts into rack where needed or use existing threaded holes.
2. Place the Main Hub into the rack from the front.
3. Align the flange holes with the spring nuts installed in Step 1.
4. Insert the mounting screws in the appropriate positions in the rack.
5. Tighten the mounting screws.

Connecting Power and Powering Up

After mounting the Main Hub in the rack, connect AC power. You may use multiple outlet surge protectors for multiple Main Hubs.

1. Connect the AC power cord to the Main Hub (labeled 1 on the following figure).
2. Plug the power cord into an outlet providing AC power.



3. Flip the Main Hub's power switch from position **0** to position **1** (labeled 2 on the figure above.)

   The front panel unit functionality LEDs, **POWER** and **SYNC**, should be green (lit).

Installing an Optional Cable Manager in a Rack

- Fasten the cable manager to the rack, immediately above or below the Main Hub, using screws.

Connecting the MMF cables

Before connecting the MMF cables, confirm that the optical loss does not exceed 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.

Connect all MMF cables (two per port) to the MMF ST female optical connectors (labeled **DOWN** and **UP**) on the Main Hub front panel. Use any available Main Hub port.

To clean the fiber ports:

Use compressed air to blow dust out of each fiber port before you insert the ST optical connector. Note that compressed air should not leave any residue as this will contaminate the fiber port.

To clean the fiber connectors:

Be sure that the MMF cable ST optical connectors are clean and free of dust or oils. If the fiber connector front face is not free of dust or oils, follow the manufacturer's recommendations for cleaning it.

To connect the MMF cables:

The MMF cable is labeled with either **1** or **2**, or is color-coded. This differentiates the connectors for proper connection between the Main Hub and Expansion Hubs.

If the fiber jumper is labeled with **1** or **2**:

1. Connect **1** to **UP** on Main Hub.
2. Connect **2** to **DOWN** on Main Hub.
3. Record which cable number you connected to **UP** and **DOWN**.

   This information is needed when connecting the other end of the MMF cable to the Expansion Hub ports.

If the fiber jumper is color-coded (for example, "blue" or "red"):

1. Connect "blue" to **UP** on Main Hub.
2. Connect "red" to **DOWN** on Main Hub.
3. Record which cable color you connected to **UP** and **DOWN**.

   This information is needed when connecting the other end of the MMF cable to the Expansion Hub ports.

✓ Check the Main Hub Functionality LEDs

The unit functionality LEDs (**POWER** and **SYNC**) should be green. If not, cycle the power to reset the Main Hub.

✓ Check the Main Hub MMF Port LEDs

The MMF port LEDs (**LINK STATUS** and **SYNC**) should be red. This indicates that the other end of the MMF cable is not yet connected to the Expansion Hub ports.

NOTE: Refer to Section 10 for troubleshooting LEDs.

NOTE: You do not have to use all of the MMF ports on the Main Hub. Unused ports do not need to be terminated. Free ports can be used for future growth and to manage changes in the in-building system.

9.2.4 Interfacing LGCell to Base Stations

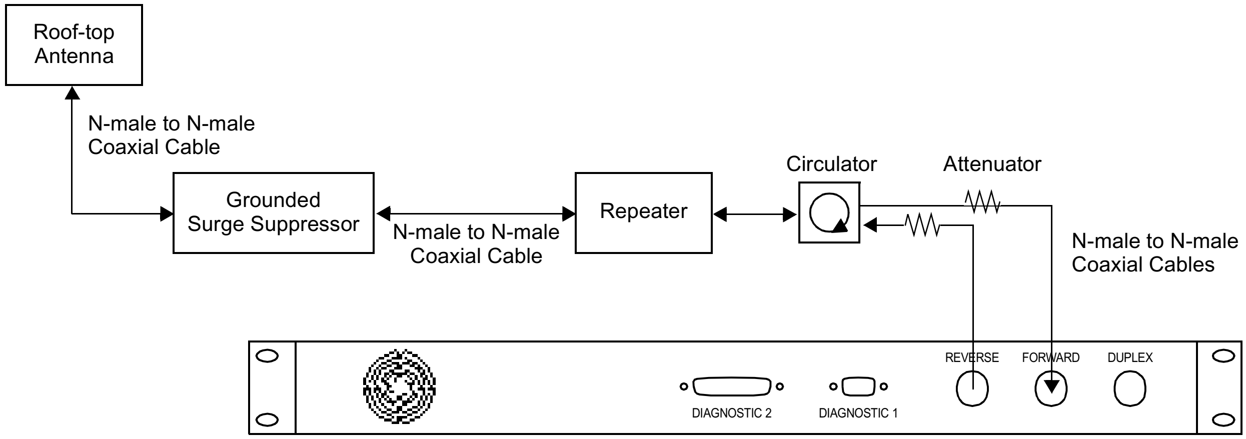
WARNING: Exceeding the maximum input power could cause failure of the Main Hub (refer to Section 7.1 on page 7-3 for maximum power ratings). Attenuators may be required to limit the maximum composite power into the Main Hub.

Connecting a Main Hub to a Roof-top Antenna

LGC Wireless recommends that you use a lightning arrestor or surge protector in a roof-top antenna configuration. Insert the lightning arrestor or surge protector between the roof-top antenna and the repeater that is connected to the Main Hub.

1. Connect an N-male to N-male coaxial cable to the roof-top antenna.
2. Connect the other end of the N-male to N-male coaxial cable to the grounded surge suppressor.
3. Connect an N-male to N-male coaxial cable to the grounded surge suppressor.
4. Connect the other end of the N-male to N-male coaxial cable to the repeater.
5. Connect an N-male to N-male coaxial cable to the repeater.
6. Connect the other end of the N-male to N-male coaxial cable to the circulator **1** connector.
7. Connect an N-male to N-male coaxial cable to the circulator **2** connector.
8. Connect the other end of the N-male to N-male coaxial cable to the **FORWARD** simplex connector on the Main Hub.

   Attenuation may be required to achieve the desired RF output at the RAU.
9. Connect an N-male to N-male coaxial cable to the circulator **3** connector.
10. Connect the other end of the N-male to N-male coaxial cable to the **REVERSE** simplex connector on the Main Hub.

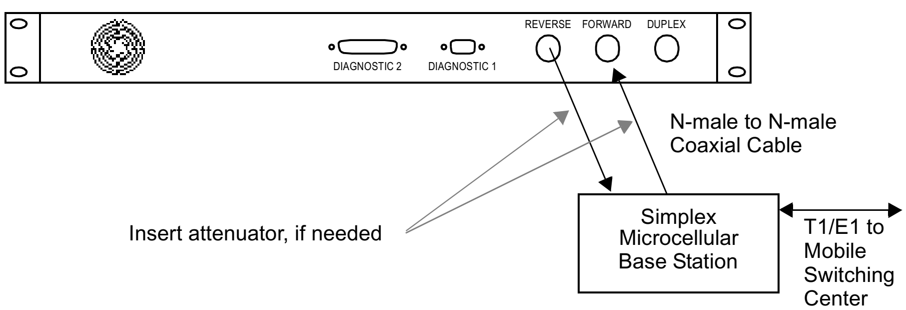


Connecting a Main Hub to an In-Building Base Station

Connecting a Simplex Base Station to a Main Hub:

1. Connect an N-male to N-male coaxial cable to the transmit simplex connector on the base station.
2. Connect the other end of the N-male to N-male coaxial cable to the **FORWARD** simplex connector on the Main Hub.
3. Connect an N-male to N-male coaxial cable to the receive simplex connector on the base station.
4. Connect the other end of the N-male to N-male coaxial cable to the **REVERSE** simplex connector on the Main Hub.

Figure 9-1 Simplex Base Station to LGCell Main Hub



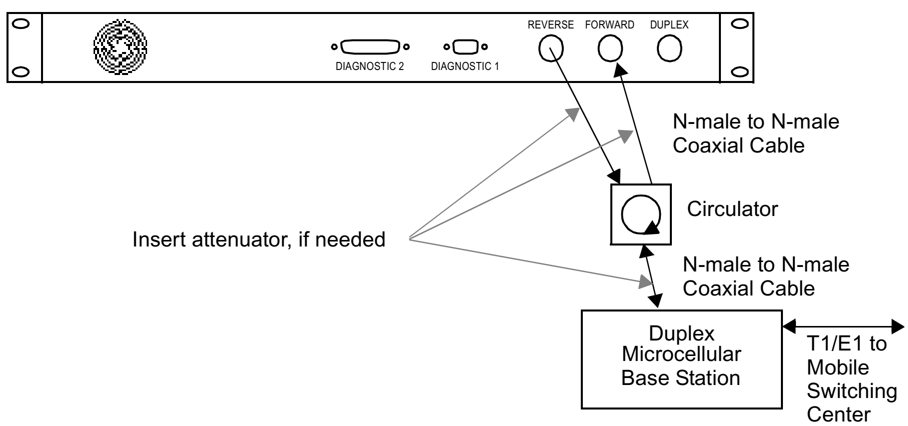
Connecting a Duplex Base Station to a Main Hub:

When connecting to a duplex base station, it is recommended that you use a circulator and connect to the simplex ports on the Main Hub.

You can insert attenuators between the base station and circulator, and between the circulator and Main Hub as needed; refer to Section 7.5.1 on page 7-42 for more information.

1. Connect an N-male to N-male coaxial cable to the duplex connector on the base station.
2. Connect the other N-male connector to a circulator.
3. Connect an N-male to N-male coaxial cable to the **FORWARD** simplex connector on the Main Hub.
4. Connect the other end of the N-male coaxial cable to the transmit connector on the circulator.
5. Connect an N-male to N-male coaxial cable to the **REVERSE** simplex connector on the Main Hub.
6. Connect the other end of the N-male coaxial cable to the receive connector on the circulator.

Figure 9-2 **Duplex Base Station to LGCell Main Hub**



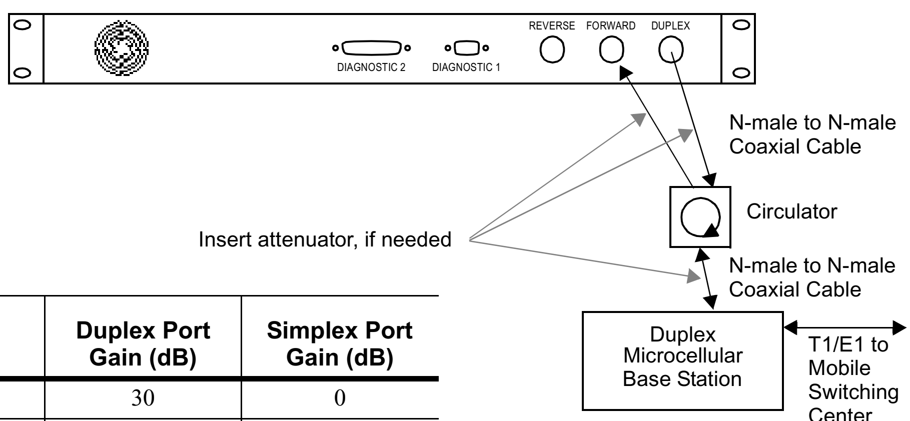
Using the Duplex Port to Increase Gain on the Uplink

Because some types of LGCells have duplex ports with gains of 0, 30, or 40 dB, depending on the frequency and protocol, you can use the simplex forward port for the downlink signals and the duplex port for the uplink signals when gain on the uplink is desired. Duplex port gain is shown in the table in Figure 9-3.

Connecting a Duplex Base Station to the LGCell Duplex/Simplex Ports:

1. Connect an N-male to N-male coaxial cable to the duplex connector on the base station.
2. Connect the other N-male connector to a circulator.
3. Connect an N-male to N-male coaxial cable to the **FORWARD** simplex connector on the Main Hub.
4. Connect the other end of the N-male coaxial cable to the transmit connector on the circulator.
5. Connect an N-male to N-male coaxial cable to the **DUPLEX** connector on the Main Hub.
6. Connect the other end of the N-male coaxial cable to the receive connector on the circulator.

Figure 9-3 Duplex Base Station to LGCell Main Hub

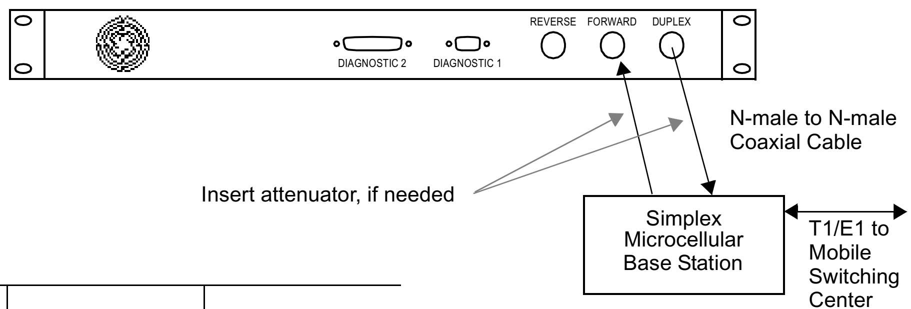


LGCell Frequency/Format	Duplex Port Gain (dB)	Simplex Port Gain (dB)
800 MHz Cellular	30	0
800 MHz iDEN	0	0
900 MHz GSM / EGSM	0	0
1800 MHz DCS (GSM)	0	0
1900 MHz PCS	40	0

Connecting a Simplex Base Station to the LGCell Duplex/Simplex Ports:

1. Connect an N-male to N-male coaxial cable to the transmit connector on the base station.
2. Connect the other end of the N-male coaxial cable to the **FORWARD** simplex connector on the Main Hub.
3. Connect an N-male to N-male coaxial cable to the receive connector on the base station.
4. Connect the other end of the N-male coaxial cable to the **DUPLEX** connector on the Main Hub.

Figure 9-4 **Duplex Base Station to LGCell Main Hub**



LGCell Frequency/Format	Duplex Port Gain (dB)	Simplex Port Gain (dB)
800 MHz Cellular	30	0
800 MHz iDEN	0	0
900 MHz GSM / EGSM	0	0
1800 MHz DCS (GSM)	0	0
1900 MHz PCS	40	0

9.2.4.1 Connecting Multiple LGCell Systems to a Base Station

You can use power combiners/dividers as dividers to connect multiple LGCells in order to increase the total number of RAUs in a system. You can use power combiners/dividers to combine base station channels in order to increase the number of RF carriers the system transports.

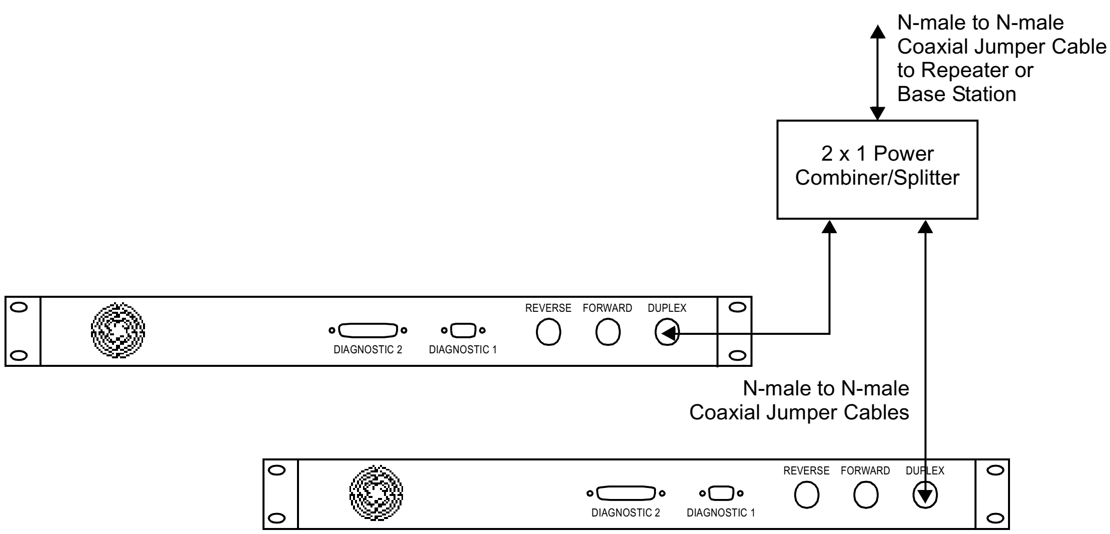
Connecting Two LGCells to a Base Station

Connecting two LGCells increases the total number of supportable RAUs from 16 to 32. Two Main Hubs support up to eight Expansion Hubs which in turn support up to 32 RAUs.

The following equipment is required:

- A 2x1 or 2x2 hybrid power combiner/divider
- 3 N-male to N-male coaxial jumper cables

Figure 9-5 **Connecting Two LGCell Main Hubs using their Duplex Ports**



Connecting Two LGCells to a Base Station

1. Connect the **DUPLEX**, **FORWARD**, or **REVERSE** connector of one of the Main Hubs to an input/output port on the power combiner/divider using an N-male to N-male coaxial cable jumper.
2. Connect the **DUPLEX**, **FORWARD**, or **REVERSE** connector of the second Main Hub to the second input/output port on the power combiner/divider using an N-male to N-male coaxial cable jumper.
3. Connect the combined port of the power combiner/divider to an base station or a repeater using an N-male to N-male coaxial cable jumper.
4. Check the Main Hub LEDs.
   After connecting the LGCells, check all Main Hub LEDs to ensure that the system is operating properly.

Connecting More Than Two LGCells to a Base Station

Repeat this procedure to connect any number of LGCell systems. For three systems, use a 3x1 power combiner/divider, and so on.

NOTE: When you are connecting multiple LGCells to the **FORWARD** and **REVERSE** simplex ports, you will have to use a power combiner/divider for each direction. Terminate each unused power combiner/divider port with a 50 ohm terminator.

9.2.5 Reporting LGCell Alarms to a Base Station

Report LGCell alarms to the base station by connecting the **DIAGNOSTIC 1** port (see "9-pin D-sub Connector" on page 3-7) on the Main Hub's rear panel to the base station's alarm port.

✓ Connecting a Single LGCell System's Alarms to a Base Station

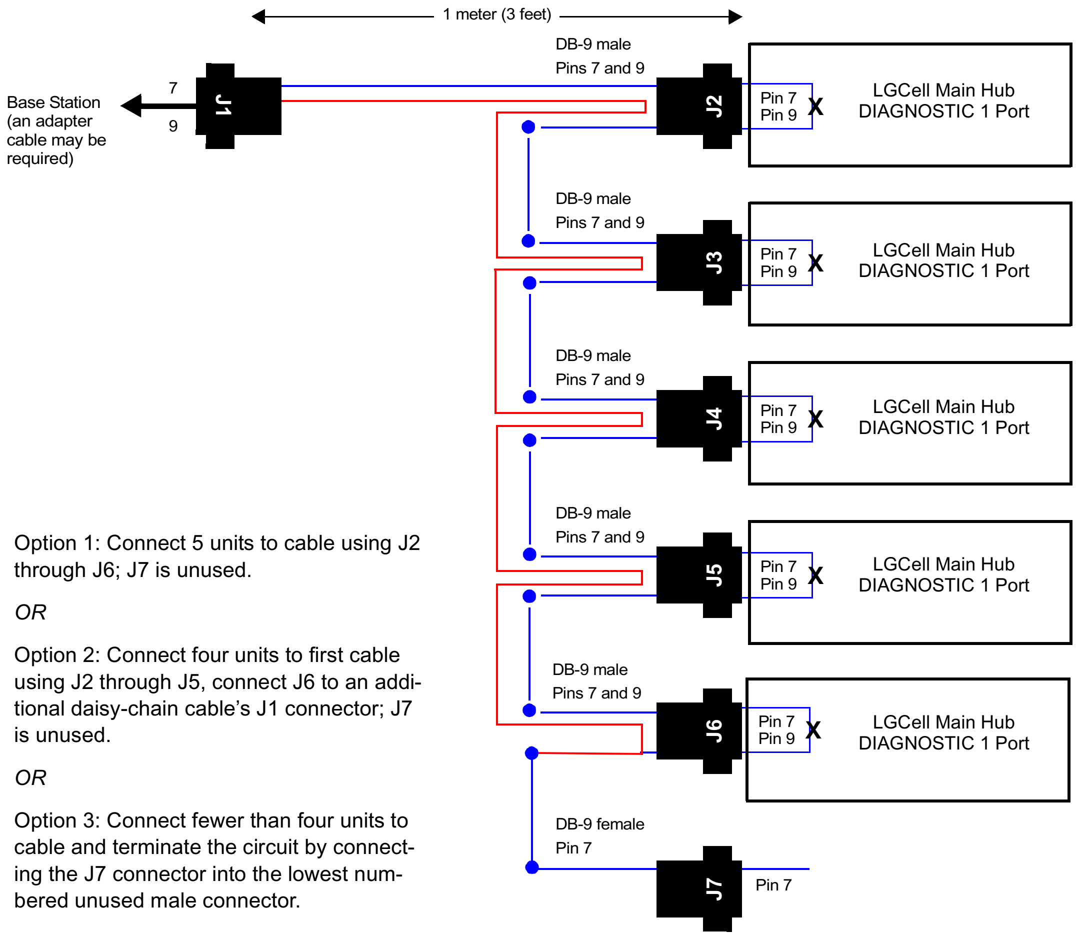
- Make a custom cable for this connection. See "9-pin D-sub Connector" on page 3-7 for the Main Hub's alarm connector pin assignment.

✓ Connecting Multiple LGCell System's Alarms to a Base Station

Use the 5-port Daisy-Chain Alarm Cable (PN 4022-5), shown in Figure 9-6, to route alarms from multiple LGCells to the base station.

Depending on the base station's alarm connector's pin assignment, you may need to make a custom adapter cable in order to connect the LGCell alarms to the base station.

Figure 9-6 **5-port Daisy-Chain Alarm Cable**



To connect 2 to 4 LGCell systems to a base station's alarms:

1. Connect the alarm cable's J2 connector to the **DIAGNOSTIC 1** port on the first Main Hub.
2. Connect the alarm cable's J3 connector to the **DIAGNOSTIC 1** port on the second Main Hub, and so on.
3. Connect the J7 connector to the lowest numbered unused male connector (J2 through J6).

   For example, when connecting 2 LGCell Main Hubs, connect J7 to J4 and leave J5 and J6 unterminated.

To connect 5 LGCell systems to a base station's alarms:

- Connect the alarm cable's J2 through J6 connectors to the **DIAGNOSTIC 1** port on five Main Hubs.

  The J7 connector is unused and is left unterminated.

To connect more than 5 LGCell systems to a base station's alarms:

1. Connect the first alarm cable's J2 through J5 connectors to the **DIAGNOSTIC 1** port on four Main Hubs.
2. Connect the J1 connector of the second daisy-chain cable to the J6 connector on the first cable; J7 is unused.

   You can add daisy-chain cables to accommodate up to 21 Main Hubs in a single chain.
3. Connect the J7 connector to the lowest numbered unused male connector (J2 through J6), if there is one.

9.2.6 Installing Main Hubs in a Neutral Host System

Installing Main Hubs in a neutral host system is the same as described in Section 9.2.3 on page 9-5.

We recommend mounting all neutral host system Main Hubs in the same rack(s), grouped by frequency or carrier. For example, group the Main Hubs for the iDEN carrier(s) together, then the 800 MHz Cellular carrier(s), and so on.

Connecting to base stations and repeaters is the same as described in Section 9.2.4 on page 9-9 and Section 9.2.4.1 on page 9-14.

9.3 Installing the Expansion Hub

9.3.1 Expansion Hub Installation Checklist

✓	Installation Requirement	Consideration
	Floor Plans	Installation location of equipment clearly marked
	Expansion Hub	Same frequency and protocol as Main Hub
	AC power available	Power cord is 2 m (6.5 ft) long • 117V AC, 0.70 amp @ 60 Hz • 230V AC, 0.35 amp @ 50 Hz
	Rack space or wall mount location available	4.4 cm (1.75 in.) high, 1U; Clearance: 3 in. front and rear
	Suitable operating environment	0° to 45°C (32° to 113°F) 5% to 95% non-condensing humidity
	Cabling	
	Cat-5 UTP/STP	TIA/EIA 568-A approved; RJ-45 male connectors; Expansion Hub to RAUs • Absolute Minimum: 10 meters (33 ft) • Recommended Minimum: 20 meters (66 ft) • Maximum: 50 meters (165 ft)
	MMF	62.5μm/125μm; ST optical connectors, male; up to 1 km (3300 ft); Expansion Hub to Main Hub
	Distances	
	Expansion Hub is within 1 km (3300 ft) of Main Hub (see Table 7-22 on page 7-26 if different MMF length)	
	Expansion Hub is within 10 m to 50 m (33 ft to 165 ft) of RAUs (see Table 7-22 on page 7-27 if different length)	

9.3.2 Tools and Materials Required to Install Expansion Hub

The tools and materials required to install the Expansion Hub are listed in the following table.

✓	Description
	Philips screwdriver
	Mounting screws and spring nuts
	Power cord
	Optional L brackets: Used to mount Expansion Hub to wall. (PN 4310 – single, PN 4311 – double)
	6 anchors and 6 screws, or other suitable hardware (not provided): Used to attach L brackets to wall (3 for each bracket).
	Fiber cleaning supplies (optical grade alcohol and lint-free wipes)
	Compressed air (optical grade)

9.3.3 Expansion Hub Installation Procedures

Procedures in this section:

Installing the Expansion Hub

The Expansion Hub (1U high) can mount in a standard 19 in. (48.3 cm) equipment rack or attach to a wall.

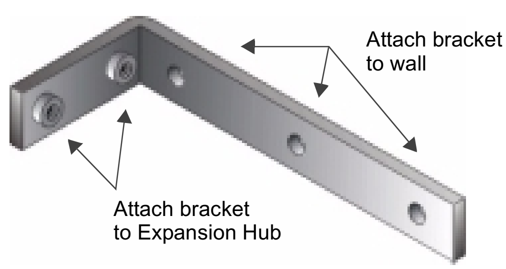
The Expansion Hub is shipped with #10-32 mounting screws. Another common rack thread is #12-24. Confirm that the mounting screws match the rack's threads.

Installing the Expansion Hub in a rack:

1. Insert spring nuts into the rack where needed or use existing threaded holes.
2. Place the Expansion Hub into the rack from the front.
3. Align the flange holes with the spring nuts installed in Step 1.
4. Insert the mounting screws in the appropriate positions in the rack.
5. Tighten the mounting screws.

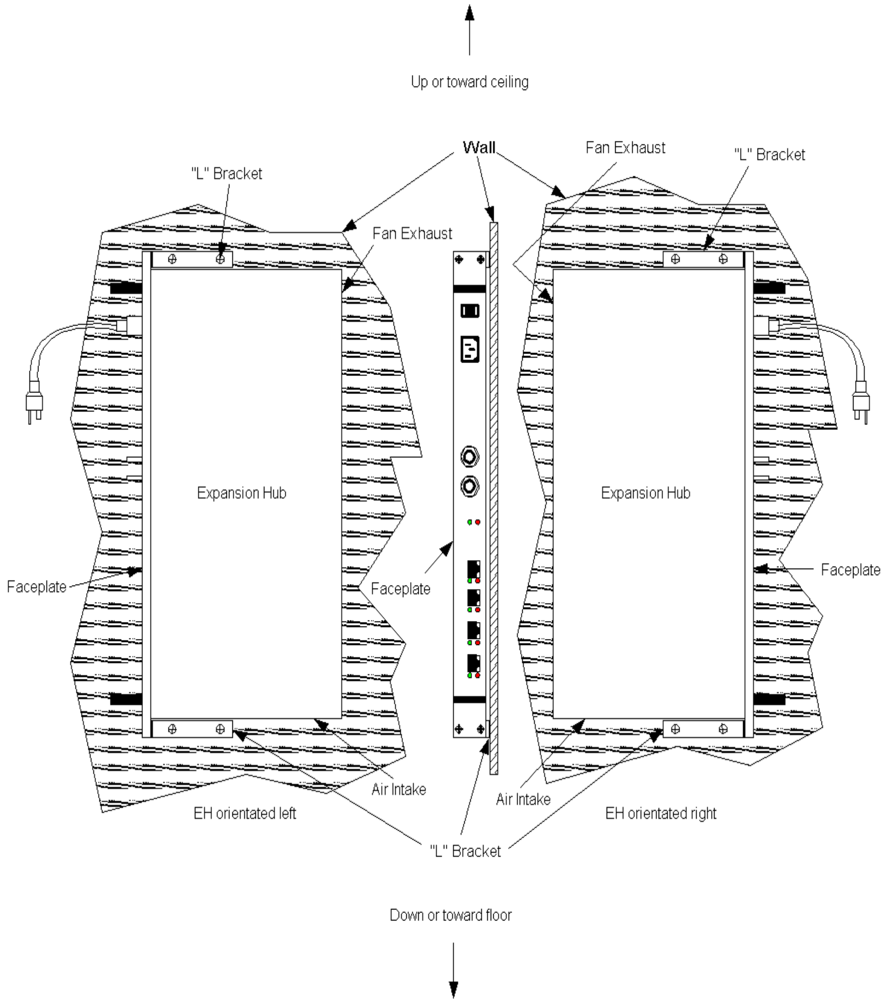
Mounting the Expansion Hub to a wall:

1. Attach the L brackets to the Expansion Hub.
   Using the screws that came with the Expansion Hub, attach the L brackets to the Expansion Hub's rack-mounting holes.



2. Hold the Expansion Hub to the wall in the position where it will be mounted and mark the pre-punched L bracket holes onto the wall for drilling.

Refer to the following figure for wall mounting options.



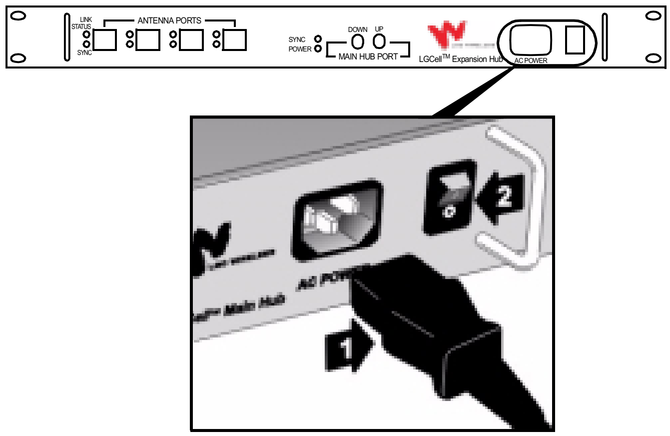
3. Drill the screw holes in the wall and insert the anchors.
4. Attach the Expansion Hub to the wall with the screws.

CAUTION: Mounting the Expansion Hub facing up exposes the connectors to falling dust and debris. Mounting it facing down exposes the fan to falling dust and debris.

Connecting Power and Powering Up

After mounting the Expansion Hub, connect the AC power.

1. Connect the AC power cord to the Expansion Hub (labeled 1 on the following figure).
2. Plug the power cord into an outlet providing AC power.



3. Flip the Expansion Hub's power switch from position **0** to position **1** (labeled 2 on the figure.)

   The front panel **POWER** LED should be green (lit) and the unit **SYNC** LED should be off.

Connect the MMF cables

Before connecting the MMF cables, confirm that the optical loss does not exceed 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.

Connect all MMF cables from the Main Hub to the Expansion Hub(s).

To clean the fiber ports:

Use compressed air to blow dust out of each fiber port before you insert the ST optical connector. Note that compressed air should not leave any residue as this will contaminate the fiber port.

To clean the fiber connectors:

Be sure that the MMF cable ST optical connectors are clean and free of dust or oils. If the fiber connector front face is not free of dust or oils, follow the manufacturer's recommendations for cleaning it.

To connect the MMF cables:

The MMF cable is labeled with either **1** or **2**, or is color-coded. This differentiates the connectors for proper connection between the Main Hub and Expansion Hubs. For proper connection between the Main Hub ports and the Expansion Hub ports, refer to the numbered or color-coded connections that were recorded when the Main Hub ws installed.

If the fiber jumper is labeled with **1** or **2**:

1. Connect **1** to **UP** on Expansion Hub.
2. Connect **2** to **DOWN** on Expansion Hub.

If the fiber jumper is color-coded (for example, “blue” or “red”):

1. Connect “blue” to **UP** on Expansion Hub.
2. Connect “red” to **DOWN** on Expansion Hub.

✓ Check the Expansion Hub Unit Functionality LEDs

The unit functionality LEDs (**POWER** and **SYNC**) should be green if the Main Hub is on.

✓ Check the Expansion Hub MMF Port LEDs

The MMF port LEDs (**LINK STATUS** and **SYNC**) should be red. This indicates that the UTP/STP cable is not yet connected to the Remote Access Unit(s).

✓ Check the Main Hub MMF Port LEDs

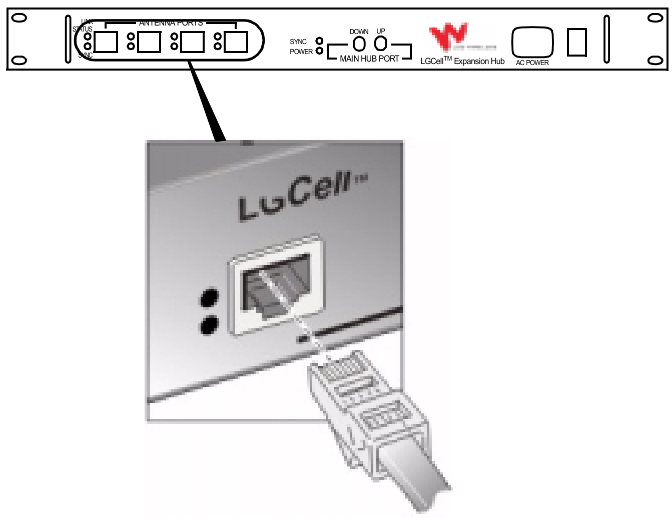
The MMF port LEDs (**LINK STATUS** and **SYNC**) should be green.

NOTE: Refer to Section 10 for troubleshooting LEDs.

Connect UTP/STP cables from the RAUs

Before connecting the UTP/STP cables, confirm that they meet TIA/EIA 568-A specifications.

Connect all UTP/STP cables coming from the RAUs to any available RJ-45 connector on the Expansion Hub, as shown in the following figure. Make sure you connect RAUs that are of the correct frequency and protocol.



Check the Expansion Hub Cat-5 Port LEDs

The Expansion Hub Cat-5 port **LINK STATUS** and **SYNC** LEDs should be green if the RAUs are connected on the other end of the UTP/STP cable.

The Cat-5 port LEDs should be red if the RAUs are not yet connected.

NOTE: Refer to Section 10 for troubleshooting LEDs.

NOTE: You do not have to use all of the Cat-5 ports on the Expansion Hub. Unused ports do not need to be terminated. Free ports can be used for future growth and to manage changes in the in-building system.

9.3.4 Installing Expansion Hubs in a Neutral Host System

Installing neutral host system Expansion Hubs is the same as described in Section 9.3.3 on page 9-21.

If rack-mounting the Expansion Hubs, we recommend mounting all neutral host system hubs in the same rack(s) or location, grouped by frequency or carrier. For example, group the Expansion Hubs for the iDEN carrier(s) together, then the 800 MHz Cellular carrier(s), and so on.

9.4 Installing the Remote Access Unit

9.4.1 Remote Access Unit Installation Checklist

✓	Installation Requirement	Consideration
	Floor Plans	Installation location of equipment clearly marked
	Remote Access Unit(s)	4 per Expansion Hub
	Passive antennas	Coaxial cable terminated correctly
	Suitable operating environment	
	Cabling	
	Cat-5 UTP/STP	TIA/EIA 568-A approved; RJ-45 male connectors; RAU to Expansion Hub • Absolute Minimum: 10 meters (33 ft) • Recommended Minimum: 20 meters (66 ft) • Maximum: 50 meters (165 ft)
	Coaxial	Use low-loss cable; RAU (SMA male connector) to passive antennas; typical 1 m (3.3 ft) using RG142 coaxial cable
	Distance	
	RAU is within 10 m to 50 m (33 ft to 165 ft) of Expansion Hub (see Table 7-22 on page 7-27 if different UTP/STP length)	
	RAU is within RF-design distance of passive antenna, typically 1 m (3.3 ft); coverage will be affected if coaxial cable length differs from what was used to calculate the design plan	

9.4.2 Tools and Materials Required to Install Remote Access Unit

The tools and supplies required to install the RAU depends on the installation method selected; the following table lists suggestions.

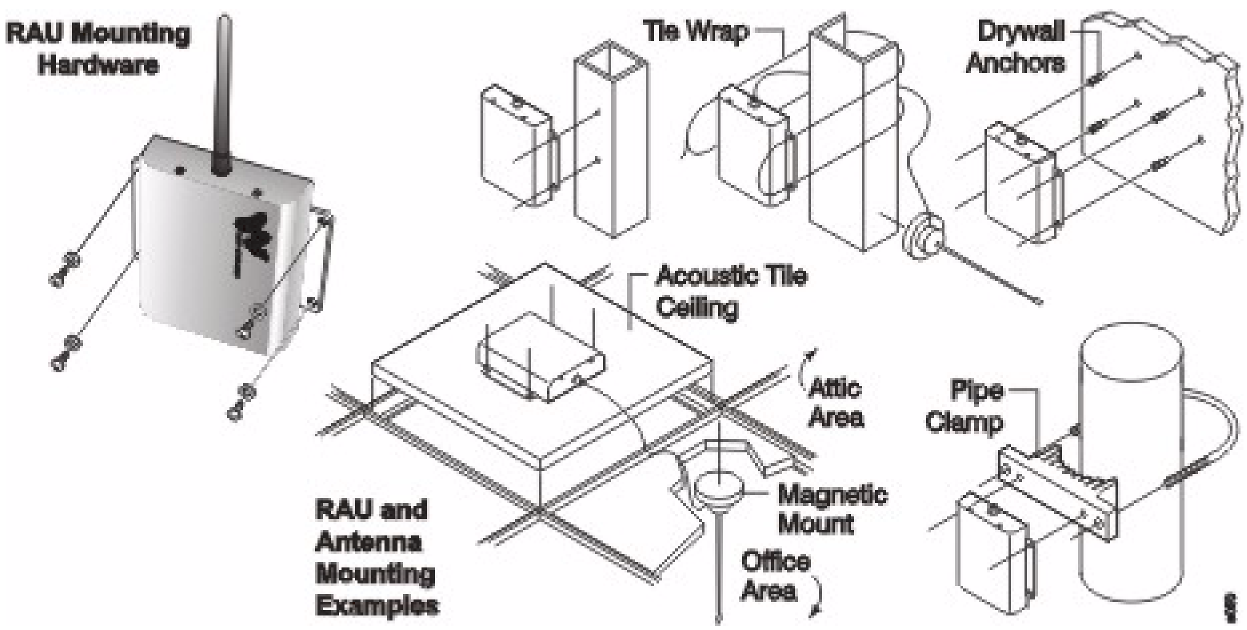
✓	Description
	Philips screwdriver
	Tie Wraps
	Screws
	Drywall Anchors
	Pipe Clamp
	RAU Mounting Plate
	Drill

9.4.3 RAU Installation Procedures

Procedures in this section:

Mounting RAUs

Mount all RAUs in their assigned locations. Refer to the following figure for mounting options.



CAUTION: Install iDEN and 800 MHz Cellular RAUs so that their antennas will be 6 to 8 meters (20 to 26 feet) apart. See Section 9.4.4 on page 9-33 for more information.

Installing Passive Antennas

Refer to the manufacturer's installation instructions to install passive antennas.

Passive antennas are usually installed below the ceiling. If they are installed above the ceiling, the additional loss due to the ceiling material must be considered when estimating the antenna coverage area.

Considerations:

- Use coaxial cable with the least amount of loss possible.
- **Keep iDEN and 800 MHz cellular antennas 6 to 8 meters (20 to 26 ft) apart.**

Connecting the Antenna

Connect a passive antenna to the SMA female connector on the RAU. The following figure shows connecting an optional antenna to a single band RAU.

CAUTION: When connecting to the SMA female connector on the RAU and passive antenna, **DO NOT** over-tighten the connector. Firmly hand-tightening the connector is adequate.

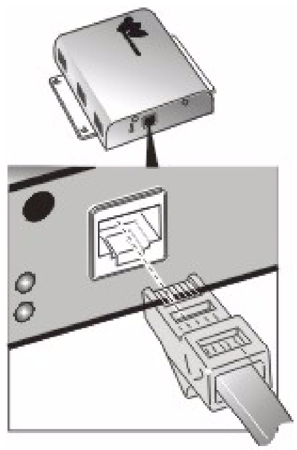
NOTE: If an RAU is installed but an antenna is not connected, the SMA port must be terminated with a 50 ohm terminator (LGC part number 4100).

Connecting the UTP/STP Cable

Connecting UTP/STP to single band RAU:

Before connecting the UTP/STP cables, confirm that they meet TIA/EIA 568-A specifications.

Connect the UTP/STP cable coming from the Expansion Hub to the RJ-45 female jack on the RAU, as shown in the following figure.



Connecting UTP/STP cable to dual band RAU:

- For the 900/1800 dual band RAU:

  Connect the 900 MHz Expansion Hub cable to the top RJ-45 jack and the 1800 MHz cable to the bottom RJ-45 jack.

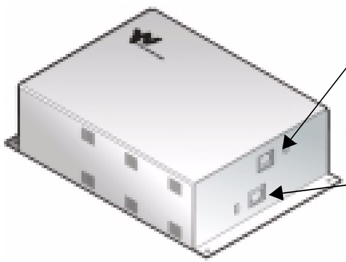
- For the 800/900 or 800/1900 dual band RAU:

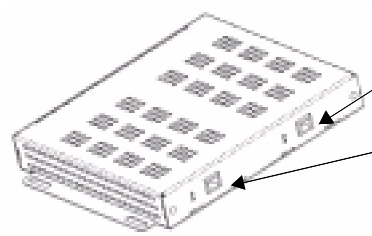
  Connect the 800 MHz Expansion Hub cable to the left RJ-45 jack and the 900 MHz or 1900 MHz cable to the right RJ-45 jack.

- For the 1800/1800 dual band RAU:

  Connect the top (upper) 1800 MHz Expansion Hub cable to the RAU's top RJ-45 jack, and connect the bottom (lower) 1800 MHz Expansion Hub cable to the RAU's bottom RJ-45 jack.

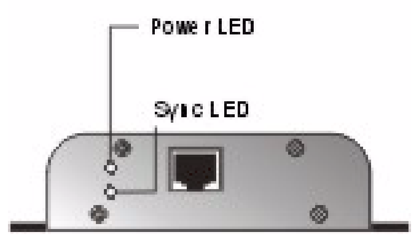
The RJ-45 jacks on both the vertical and horizontal style dual band RAUs are shown in the following figure.





✓ Check the RAU LEDs

The green **POWER** LED should be on and the red **SYNC** LED should be off.



The green **POWER** LED should be lit to indicate that the RAU is receiving power from the Expansion Hub.

The green **POWER** LED should be off if the Expansion Hub is not yet connected.

NOTE: Refer to Section 10 for troubleshooting LEDs.

✓ Check the Expansion Hub MMF Port LEDs

Re-check the Expansion Hub LEDs to verify that the RAUs are operating properly.

The Expansion Hub fiber port **LINK STATUS** and **SYNC** LEDs should be green if the RAUs are connected on the other end of the UTP/STP cable.

9.4.4 Installing Remote Access Units in a Neutral Host System

When installing both iDEN and Cellular systems in parallel, either as dual-band or neutral host systems, special provision must be taken to assure that the individual RAUs do not interfere with each other.

It is recommended that the 800 MHz Cellular and the 800 MHz iDEN RAU's antennas be separated by 6 to 8 meters (20 to 26 feet), to assure that the iDEN downlink signals do not interfere with the Cellular uplink signals.

SECTION 10

Maintenance, Troubleshooting, and Technical Assistance

There are no user-serviceable parts in any of the LGCell components. Faulty or failed components are fullly replaceable through LGC Wireless.

Address	2540 Junction Avenue San Jose, California 95134-1902 USA
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) +44(0) 1223 597812 (Europe)
Web Address	http://www.lgcwireless.com
e-mail	service@lgcwireless.com

10.1 Maintenance

No periodic maintenance of the LGCell equipment is required.

10.2 Troubleshooting

NOTE: LGCell has no user-serviceable parts. Faulty or failed units are fully replaceable through LGC Wireless.

Sources of potential problems include:

- Malfunction of one or more LGCell components
- Faulty cabling/connector
- Antenna, base station, or repeater problem
- External RF interface

NOTE: Faulty cabling is the cause of a vast majority of problems. All Cat-5 cable should be tested to TIA/EIA 568-A specifications.

The diagnostic procedures are based on diagnostic information in Table 10-2 on page 10-5. The table lists all LEDs and indicates what to do under certain circumstances. There is a blank table at the end of this section that you can copy and use to record the LEDs while you troubleshoot an LGCell system.

If you cannot determine the cause of a problem after following the recommended procedures, call LGC Wireless customer help hot line:

1-800-530-9960 (U.S. only)
+1-408-952-2400 (International)
+44(0) 1223 597812 (Europe)

10.2.1 Troubleshooting Guidelines

The following table contains troubleshooting information that the diagnostic LEDs do not cover. Please check the table for a possible cause of a problem. Simple checks or minor adjustments might eliminate the problem and restore proper operation.

Problem/Symptom	Check
No downlink signal output when all diagnostic LEDs are green	Make sure that there is a reasonable amount of power at the input of the Main Hub. Use a power meter to measure the output power from the coaxial cable that feeds the Main Hub. The LGCell is intended for a different frequency band. Verify that your system corresponds to the desired frequency (for example, 800 MHz, 1800 MHz, or 1900 MHz). Check the part number of each unit to be sure you have the proper band (e.g., DAS19M-4A-AD is the part number for a Main Hub set up for 1900 MHz A and D bands).
The system gain is lower than specification	The optical fiber connector may be dirty. Clean the ST optical connector, using the manufacturer's recommended cleaning procedure. There are two types of multimode fiber (MMF), 62.5µm/125µm and 50µm/125µm. Make sure the vertical run of MMF is the 62.5µm/125µm type of fiber. Check the length of MMF and UTP/STP cabling.
Remote Access Unit (RAU) power LED (green LED) stays off after you plug in the twisted pair cable	The Expansion Hub provides power to the RAU. Make sure the Expansion Hub is on. Make sure that the twisted-pair (TP) cable wiring conforms to the TIA/EIA 568-A standard. Use a standard local area network (LAN) cable tester to perform this test. Make sure the Cat-5 is not plugged into the Expansion Hub when doing this test. Possible errors are incorrect wiring and/or cable length.
The LGCell performance is intermittent when you use it for the CDMA application	The uplink and downlink gains are not balanced. A CDMA system performs active power control between the base station and the mobile unit. It is important to maintain a balanced link from the base station ports to the RAU ports (equal uplink and downlink gain) to optimize the performance of the LGCell.
Possible MMF port problem on a Main Hub	To isolate possible port problems on a Main Hub try moving the faulty fiber pair to another port on the hub or to another Main Hub. When you move an active fiber pair, the Main Hub remembers that there was fiber on that port and issues an alarm. You must clear the latched alarm (port disconnect memory feature) by cycling Main Hub power.
Possible RJ-45 port problem on an Expansion Hub	Move the Cat-5 to a spare port or swap the Cat-5 to try and isolate the problem. The Expansion Hub also has port disconnect memory to track which ports have been connected. So when a Cat-5 is disconnected and moved to a new port, an alarm will be issued. You must cycle power to the Expansion Hub to clear the memory and the latched alarm. If the Expansion Hub is suspect, try and remove all RAUs to eliminate any possible RAU failure and then begin to put RAUs back in. Remember to cycle power whenever a RAU is removed.
Possible RAU problem	When working RAU problems, an RAU whose functionality has been confirmed can be used with about 15 m (50 ft) of Cat-5 to quickly verify ports on an Expansion Hub. Simply connect the RAU to one end of the cable and plug the other end into the Expansion Hub ports to verify proper operation.
Troubleshoot downlink problem on an active system	Downlink problems can be troubleshot on an active system by injecting a low-level signal at the Main Hub using the unused port (either the duplex bidirectional port or the simplex downlink port). Then you can go out to the RAU and perform some measurements without disrupting normal service.

10.2.2 Troubleshooting Using the LED Indicators

10.2.2.1 LED Indicator Description

The LGCell Main Hub, Expansion Hubs, and RAUs have front panel LEDs which provide diagnostic information and operational status of each unit. Together they provide an efficient diagnostic display system, which help technicians find the fault if there is a malfunction. The LED indicators for each unit are described in the following table.

Table 10-1 **LGCell Equipment LED Indicators**

	MMF Port Indicators	Color	Indicates
MAIN HUB	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.

	UTP/STP Port Indicators/Color		
	LINK STATUS	**SYNC**	**Indicates**
EXPANSION HUB	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.

	Unit Functionality Indicators	Color	Indicates
RAU	POWER	Green	RAU is receiving power from the Expansion Hub.
	SYNC	Red	RAU lost sync and has shut down RF power.
		Off	No fault.

10.2.2.2 Diagnostic Procedures

Use the following table when diagnosing system problems. For troubleshooting, you can copy the blank table on page 10-8 and use it to record the LED colors on the Main Hub, the particular Expansion Hub indicating a fault, and the RAUs connected to it. This is necessary because the Main Hub, Expansion Hubs, and RAUs typically are geographically distributed.

To determine where the fault might be:

1. Go to the Main Hub and record the LEDs. The Main Hub indicates which Expansion Hub may be faulty by lighting one of its port LEDs red.
2. Go to the Expansion Hub attached to the port that has a red LED.
3. Record that Expansion Hub's LEDs. The Expansion Hub indicates which RAU(s) may be faulty by lighting its antenna LED red.
4. Go to the RAU(s) connected to the Expansion Hub port that is indicating a fault. Record the error.
5. Compare your filled in table to the Diagnostic Table below and begin troubleshooting according to the notes indicated for your situation.

Table 10-2 LED Diagnostics

Visual Alarm LEDs										Remote Alarm Contacts		
Main Hub				Expansion Hub				RAU		DB-9 Connector		
Port		Functionality		Port		Functionality						
Link Status	Sync	Sync	Power	Link Status	Sync	Sync	Power	Power	Sync	Major Alarm Contact	Error Latch Contact	See Note
Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Short	Short	1
Red	Red	Green	Green	Off	Off	Off	Off	Off	Off	Open	Open	2
Green	Red	Green	Green	Green	Red	Green	Green	Off	Off	Open	Open	3
Green	Red	Green	Green	Red	Red	Green	Green	Off	Off	Open	Open	4
Green	Red	Green	Green	Green	Red	Green	Green	Green	Red	Open	Open	5
Green	Red	Green	Green	Green	Red	Off	Green	Green	Red	Open	Open	6
Red	Red	Green	Green	Green	Red	Red	Green	Green	Red	Open	Open	7
Off	Off	Off	Off	Green	Red	Off	Green	Green	Red	Open	Open	8
Green	Red	Red	Green	Green	Red	Red	Green	Green	Red	Open	Open	9
Red	Red	Green	Green	Green	Green	Green	Green	Green	Off	Open	Open	10
Green	Red	Green	Green	Red	Red	Green	Green	Off	Off	Open	Open	11
Green	Red	Green	Green	Green	Green	Green	Green	Green	Off	Open	Open	12
Green	Red	Green	Green	Red	Green	Green	Green	Off	Off	Open	Open	13
Major and Error Latch contacts indicate an alarm when the contacts go from a short to open state.												

Notes:

1. System is functioning properly.
2. The Expansion Hub is off.
   Make sure the power cord is connected to a live AC power jack and that the Expansion Hub power switch is in the on (**1**) position.
3. Power is being delivered to the RAU but it is not turning on.
   a. Check that the UTP/STP cable has been properly crimped and passes a standard TIA/EIA 568-A Cat-5 compliance test.
   b. If the cable is not the problem, replace the RAU.
4. Power is not being delivered to the RAU.
   - Move the UTP cable to a different RJ-45 connector on the Expansion Hub to see if the same problem occurs.
     – If the LEDs on the new port are both green, there is a problem with the Expansion Hub.
     – If the problem persists, there is a problem with either the RAU or the UTP/STP cable.
   - Check that the UTP/STP cable has been properly crimped and passes a standard TIA/EIA 568-A Cat-5 compliance test.
     – If the cable passes the Cat-5 test, replace the RAU.
5. RAU has lost synchronization.
   - Make sure that the UTP/STP passes a standard TIA/EIA 568-A Cat-5 test.
     – If the cable passes the Cat-5 test, replace the RAU.
6. The Expansion Hub is not properly receiving the synchronization signal from the Main Hub.
   a. The MMF cable connection might not be good or if the system was working, the MMF downlink cable is pulled out or cut. Switch MMF cables.
   b. If the problem persists, move the MMF cable to a different Main Hub port on a different Expansion Hub. If this solves the problem, the Main Hub port on the first Expansion Hub is malfunctioning.
   c. If the problem persists, there is an Expansion Hub problem.
   - If moving MMF cables to a different Expansion Hub is not practical, switch the uplink and downlink pairs. (A connection error may have been made when connecting the Main Hub **UP** port to the Expansion Hub **UP** port, and similarly for the **DOWN** ports.)
     – If the Expansion Hub unit **SYNC** LED turns green, one of the MMF cables was bad or the connection between the Main Hub and Expansion Hub was done incorrectly. If both are bad, this test will not help. Switch to a different Main Hub port.

7. The Expansion Hub is not properly receiving the synchronization signal from the Main Hub.
   Too much loss on downlink MMF. Might be due to MMF pairs not attached to the proper connector.
   a. Check that the "**down**" cable end is in the **DOWN** port connector on both the Main Hub and on the Expansion Hub. Same for the "**up**" cable end and connectors for the **UP** port.
   b. If the problem persists, check the integrity of the MMF cable using an Optical Time Domain Reflectometer. If the fiber is faulty, replace it.
   c. If the MMF cable is OK, try using a different Main Hub port.
   d. If the problem persists, replace the Main Hub.
   e. If the problem persists, replace the Expansion Hub.
8. The Main Hub is off.
   - Make sure the power cord is connected to a live AC power jack and that the Main Hub power switch is in the on (**1**)position.
9. Main Hub is not properly generating the synchronization signal.
   - Turn off the Main Hub and then turn it back on. If the unit functionality **SYNC** LED stays off, the Main Hub requires replacement.
10. The Expansion Hub is not properly sending the synchronization signal to the Main Hub.
    - The MMF cable connection might not be good, or if the system was working, the MMF uplink cable is pulled out or cut.
11. The RAU is off.
    - Check that the UTP/STP cable is operating properly.
      – Check that the UTP/STP cable has been properly crimped and passes a standard TIA/EIA 568-A Cat-5 compliance test.
    - If the system was working, the UTP/STP cable is pulled out or cut.
12. There is excessive optical loss in the uplink direction between the Expansion Hub and the Main Hub.
    - Verify that the optical loss in the uplink fiber does not exceed 3 dB optical.
    - Check the fiber ports for debris and clean if necessary.
    - The Main Hub MMF port may be faulty.
      – Move the fiber to another port.
    - The Expansion Hub may be faulty.
13. A Cat-5 cable has been disconnected and moved to a new port. The Expansion Hub's port disconnect memory has issued an alarm.
    - You must cycle power to the Expansion Hub to clear the memory and the latched alarm.

Use the following blank table to record LEDs as you troubleshoot.

Visual Alarm LEDs										Remote Alarm Contacts	
Main Hub				Expansion Hub				RAU		DB-9 Connector	
Port		Functionality		Port		Functionality					
Link Status	Sync	Sync	Power	Link Status	Sync	Sync	Power	Power	Sync	Major Alarm Contact	Error Latch Contact

10.3 Technical Assistance

Call our help hot line for technical assistance:

1-800-530-9960 (U.S. only)
+1-408-952-2400 (International)
+44(0) 1223 597812 (Europe)

Leave your name and phone number and an LGC Wireless customer service representative will return your call within an hour. Be prepared to provide the following information when you receive the return call:

- Company name
- End user name
- Type of system, serial number, frequency
- Approximate time in service (warranty), sales order number
- Description of problem
- LED status

APPENDIX A

Cables and Connectors

This section provides information about cables, connectors, and accessories that an LGCell application might require.

These cables are not provided with the LGCell equipment and must be on site or installed at the site prior to the LGCell installation. LGC Wireless can provide these components, or you can order them through a cable vendor or installer.

A.1 Coaxial Cable

For Duplex RF Connections

- Connects a Main Hub to a repeater or duplex base station
- Provides bidirectional downlink and uplink transmission with one cable for duplex RF connections

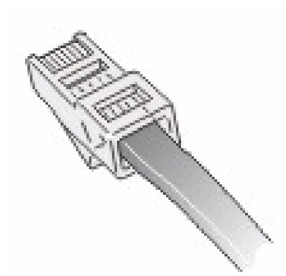
For Simplex RF Connections

- Connects a Main Hub to a repeater or simplex base station
- Provides unidirectional downlink and uplink signals on separate cables for simplex RF connections

A.2 Multimode Fiber Cable

- Connects Main Hub to Expansion Hub(s)
- Transmits (downlink) and receives (uplink) cellular and PCS signals
- Accommodates distances up to 1 km (3300 ft)
- Use industry-standard 62.5µm/125µm fiber

A.3 Category 5 UTP/STP Cable



- Connects the Expansion Hub to the RAU(s)
- Transmits (downlink) and receives (uplink) cellular and PCS signals
- Delivers electrical power to RAU(s)
- Accommodates distances up to 50 meters (165 ft)
- Cat-5 STP is recommended when configuring multiple systems

LGC Wireless recommends plenum-rated Cat-5 UTP/STP cable and connectors

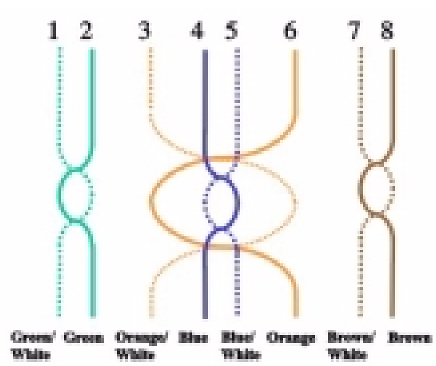
NOTE: Only Cat-5 shielded twisted pair (STP) cable should be used for neutral host systems.

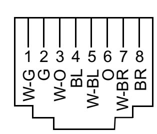
NOTE: UTP/STP cable length is 10 meters (33 ft) absolute minimum, 20 meters (66 ft) recommended minimum, and 50 meters (165 ft) maximum. For cables longer than 50 meters (165 ft), system specifications are slightly degraded. See Section 7.3.2, “System Gain (Loss) Relative to UTP/STP Cable Length,” on page 7-27.

UTP Termination

All UTP cable shall be terminated according to the TIA/EIA 568-A standard. The following diagram shows the top view of the wiring map for Category 5 UTP cable and how the four pairs should be terminated.

Figure A-1 **Wiring Map for Cat-5 UTP Cable**





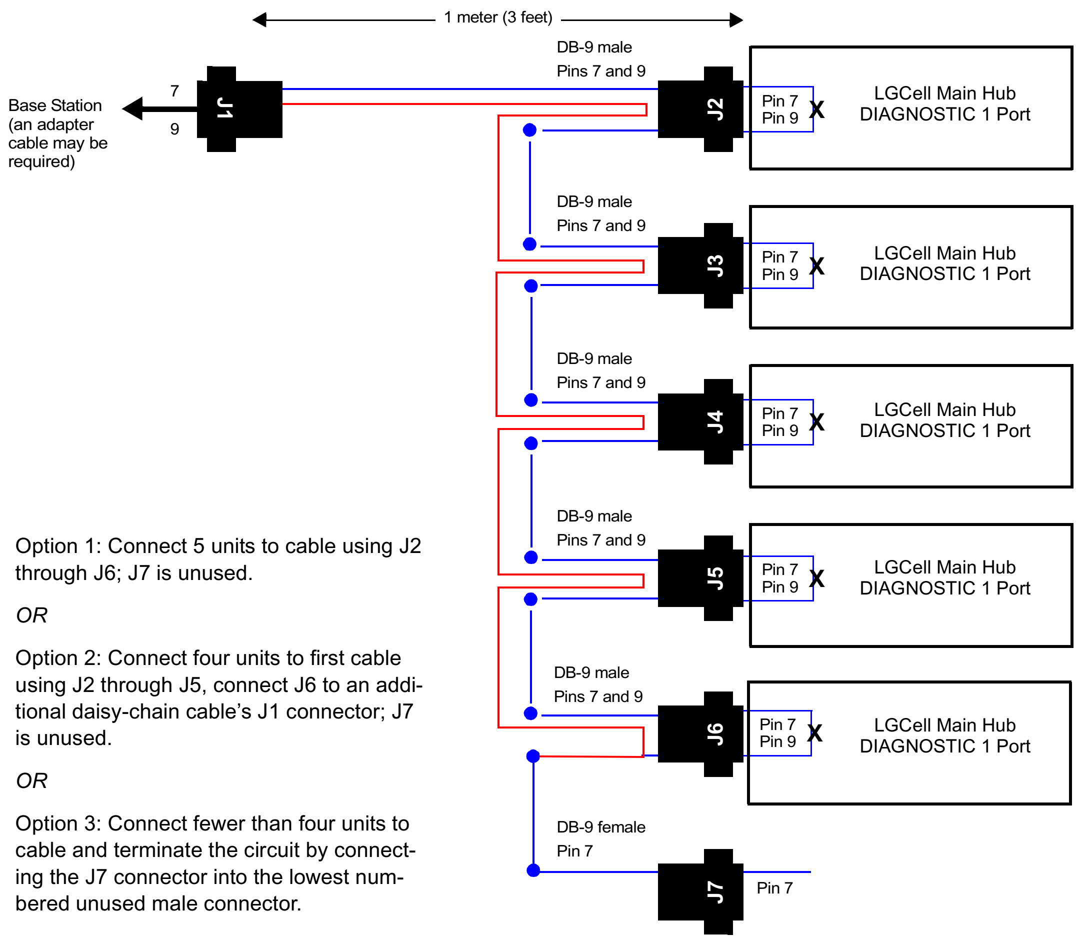
RJ-45 Port

NOTE: Be sure to test cable termination before installing the cable.

A.4 5-port Daisy-Chain Alarm Cable

Use the 5-port Daisy-Chain Alarm Cable (PN 4022-5), shown in Figure , to increase the number of LGCells that are reporting their alarms to the base station.

Figure A-2 **5-port Daisy-Chain Alarm Cable**



APPENDIX B

Compliance Information

All LGCell systems comply with Optical Fiber Safety Standard IEC/EN60825-2. The LGCell distributed antenna system uses light emitting diodes (LEDs) and is rated as a Class 1 optical hazard system. It has an absolute maximum output power of –11.5 dBm at 1310 nanometers (nm). There are no restrictions on the location or use of an LGCell system. No special precautions are required if standard work practices are followed. Additional information on the safe use of optical fiber communications systems is at the end of this appendix.

B.1 LGCell System Approval Status

Appendix B.1.1 through B.1.7 provide LGC Wireless' LGCell system approval status for various countries around the world. Some European countries require National Type Approval to their national standards (such as Germany).

B.1.1 800 MHz Cellular

Telecom: FCC ID: NOO-DAS8-4-W

Hong Kong: Approval number: RF200110, based on the above FCC approval

EMC: FCC Class A, Part 15, Subpart B

Safety: UL 1950 3rd edition and the cUL mark for Canada

NEBS: This is a customer driven conformance certification and typically desired of equipment that is intended to be installed in a Central Office environment. LGC products are intended as Customer Premise Equipment and it is not anticipated that they will be installed in a Central Office environment, therefore NEBS conformance certification has not been pursued at this time.

B.1.2 800 MHz iDEN

Telecom: FCC ID: NOO-DAS8M-4IDEN-W

EMC: FCC Class A, Part 15, Subpart B

Safety: UL 1950 3rd edition and the cUL mark for Canada

NEBS: This is a customer driven conformance certification and typically desired of equipment that is intended to be installed in a Central Office environment. LGC products are intended as Customer Premise Equipment and it is not anticipated that they will be installed in a Central Office environment, therefore NEBS conformance certification has not been pursued at this time.

B.1.3 900 MHz EGSM/GSM

Telecom: FCC ID: LGCell 900 EGSM: NOODAS9M-4E-W
FCC ID: LGCell 900 GSM: NOODAS9M-2-W

Germany: Approval Number A200394M (BAPT 222 ZV 15/ETS 300 609-4)

UK: Approval Number BPS091 ETS 300 609-4 March 1999

Hong Kong: Approval Number RF 200066; approval based on the above UK approval

China: Approval Number (CMIIID): 2000CJ0457

Singapore: Approval Number PRNEQ-0417-2000, Issued to "Roots Communications Pte. Ltd."

EMC: ETS 300 342-3, October 1999

Safety: UL 1950 3rd edition and power supplies, Astec International Ltd., Model LPS43, Universal Micro Electronics Co. Ltd., Model UPO651S-02, and International Power Sources, Inc., Model UPO651S-02 all have CB scheme certifications

B.1.4 1800 MHz GSM

Telecom: ETS 300 609-4, October 1998

Hong Kong: Approval Number RF 200111, approval based on European Approval ETS 300 609-4

China: Approval Number 2000CJ0525

Singapore: Approval Number PRNEQ-0418-2000, Issued to "Roots Communications Pte. Ltd."

EMC: EN 300 339, June 1998

Safety: Power Supplies, Astec International Ltd., Model LPS 43, Universal Micro Electronics Co. Ltd., Model UPO651S-02, and International Power Sources, Inc., Model UPO651S-02 all have CB scheme certifications.

Markings: The UK approval number and the CE mark are required.

B.1.5 1900 MHz PCS

Telecom: FCC: NOO-DAS19-4-X (FCC Part 24E) Distributed Antenna System (Repeater)

Canada: 3077331163A for the “PCS 1900” (RSS-133, Issue 1)

EMC: FCC: Class A, Part 15, Subpart B
Industry Canada: Same as FCC

Safety: UL 1950, 3rd Edition and the cUL mark for the Canadian equivalent.

NEBS: This is a customer driven conformance certification and typically desired of equipment that is intended to be installed in a Central Office environment. LGC products are intended as Customer Premise Equipment and it is not anticipated that they will be installed in a Central Office environment, therefore NEBS conformance certification has not been pursued at this time.

Markings: The FCC approval number and the FCC logo are required. The word Canada followed by the Canadian approval number is required. The UL mark is required.

B.1.6 FCC Regulatory Notice

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation.

B.1.7 Industry Canada Regulatory Notice

This Class B (or Class A, if so indicated on the registration label) digital apparatus meets the requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numerique de la Classe B (ou Classe A, si ainsi indique sur l’etiquette d’enregistration) respecte toutes les exigences du Reglement sur le Materiel Brouilleur du Canada.

B.2 Declaration of Conformity to Type

DECLARATION OF CONFORMITY

We, LGC Wireless, of 2540 Junction Ave., San Jose, California, 95134-1902, declare under our sole responsibility that the product:

LGCell, EGSM/GSM 900 Repeater, Model DAS9M-4E-W, to which this declaration relates, is in conformity with the following standards and/or other normative documents.

ETS 300 342-3, October 1999

ETS 300 609-4, March 1999

BAPT 222 ZV 15

We hereby declare that all essential radio test suites have been carried out and that the above named product is in conformity to all the essential requirements of Directive 1999/5/EC.

The conformity assessment procedure referred to in Article 10 and detailed in Annex IV of Directive 1999/5/EC has been followed with the involvement of the following Notified Body:

BABT, Claremont House, 34 Molesey Road, Walton-on-Thames, KT12 4RQ, UK

Identification Mark: **168**

The technical documentation relevant to the above equipment will be held at:

LGC Wireless, UK
G10 Regus House, Cambourne Business
Park, Cambourne, Cambridge
United Kingdom, CB3 6DP

John Dorsey
RF Approvals Engineer

John Dorsey — March 14, 2001

Signature — Date

Declaration of Conformity to Type

I hereby declare that the product:

LGCell GSM 900 Repeater, Type DAS9M-2-W

is in conformity with the type as described in EC Type-examination certificate:

Certificate of EC type Examination of Electromagnetic Compatibility No. 14082

and satisfies all the technical regulations applicable to the product within the scope of Council Directives 91/263/EEC and 93/97/EEC:

EN 300 339 June 98 (Certificate of EC Type Examination No. 14082 issued by Radiocommunications Agency, UK)
ETS 300 609-4 October 98 (Certificate of Type Approval No. 14028 issued by Radiocommunications Agency, UK)
BAPT 222 ZV 15 (Issued German type approval mark No. TPS A2000296L)

MANUFACTURER:

LGC Wireless Inc.
2540 Junction Avenue
San Jose
California, 95134-1902
USA

Point of contact:

Mr. Paul Allan

Tel: +1 408 952 2486
Fax: +1 408 952 2686

Paul Allan

PAUL ALLAN

California, USA 8/26/99

DECLARATION OF CONFORMITY

We, LGC Wireless, of 2540 Junction Ave., San Jose, California, 95134-1902, declare under our sole responsibility that the product:

LGCell, DCS 1800 Repeater, Model DAS18M-2, to which this declaration relates, is in conformity with the following standards and/or other normative documents.

EN 300 339, June 1998

ETS 300 609-4, October 1998

BAPT 222 ZV 15

We hereby declare that all essential radio test suites have been carried out and that the above named product is in conformity to all the essential requirements of Directive 1999/5/EC.

The conformity assessment procedure referred to in Article 10 and detailed in Annex IV of Directive 1999/5/EC has been followed with the involvement of the following Notified Body:

BABT, Claremont House, 34 Molesey Road, Walton-on-Thames, KT12 4RQ, UK

Identification Mark: **168**

The technical documentation relevant to the above equipment will be held at:

LGC Wireless, UK
G10 Regus House, Cambourne Business
Park, Cambourne, Cambridge
United Kingdom, CB3 6DP

John Dorsey
RF Approvals Engineer

John Dorsey — March 14, 2001

Signature — Date

B.3 IEC/EN 60825-2: Safe Use of Optical Fiber Communication Systems

Part 2 of IEC 60825 provides requirements and specific guidance for the safe use of optical fiber communications where optical power may be accessible at some distance from the optical source. In this part of IEC 825, light emitting diodes (LEDs) are included whenever the word “laser” is used.

B.3.1 Description of LGCell System

The LGCell is a distributed antenna system. It consists of three main components. A Main Hub, which is connected by multimode fiber optic cables to one or more Expansion Hubs. Each Expansion Hub is connected by UTP Cat-5 cable to up to four Remote Access Units. Because LEDs are used to send a signal over the fiber optic cable, the LGCell is covered under the IEC 60825 specification.

B.3.2 Requirements under IEC 60825

Under IEC 60825, LGC Wireless is required to determine the Class of operation of the LGCell system, the hazard level of the LGCell system and any special instructions that must be included in an operators manual as well as any warning labels that may be required on the LGCell system.

The LGCell is covered only under these definitions of section 3 of 60825:

- **3.2 Enclosed System:** A system in which, during normal operation, the optical radiation is totally enclosed, by light-proof cabinets, components, total internal reflection or optical fiber cables and connectors.
- **3.3 End User:** The person or organization using the optical fiber communication in the manner the system was designed to be used. The user cannot necessarily control the power generated and transmitted within the system.
- **3.4 Hazard Level 1:** A hazard level 1 is allocated to any part within an optical fiber communication system at which, under reasonably foreseeable circumstances, human access to laser radiation in excess of the accessible emission limits (AEL) of class 1 for the applicable wavelengths and emission duration will not occur.
- **3.10 Light Emitting Diode (LED):** Any semiconductor device which can be made to produce electromagnetic optical radiation in the wavelength range from 180nm to 1mm. (The optical radiation is produced by the process of spontaneous emission, although some stimulated emission may be present.)
- **3.13 Location with Controlled Access:** A location where access to the protective housing (enclosure) is controlled and is accessible only to authorized persons who

have received adequate training in laser safety and servicing of the system involved. Examples include optical cable ducts and switching centers.

- **3.14 Location with Restricted Access:** A location where access to the protective housing is restricted and not open to the public. Examples include industrial and commercial premises, PBX rooms, computer system rooms, and optical test sets. Distributed fiber networks may pass through unrestricted public areas, restricted areas within premises, as well as controlled areas or they may be deployed entirely within restricted business premises.
- **3.18 Optical Fiber Communication System:** An engineered assembly for the generation, transference, and reception of optical radiation arising from lasers in which the transference is by means of optical fiber for communication purposes.
- **3.19 Reasonable Foreseeable Event:** An event, the occurrence of which under given circumstances can be predicted fairly accurately, and the occurrence of which is a possibility. Examples of reasonably foreseeable events might include the following: fiber cable break, optical connector disconnection, operator error or inattention to safe working practices. Reckless use or use for completely inappropriate purposes is not to be considered as a reasonably foreseeable event.

B.3.3 Installation Notes

The LGCell is covered under these parts of section 5 of 60825:

- **5.2.1.3 Test Equipment:** During installation or testing of an optical fiber cable or system, only test equipment of laser Class 1 should be used.
- **5.2.1.5 Installation Rules:** Each person engaged in the installation or service of an optical fiber cable communication system should observe all rules, procedures, and practices established for the safe operation of optical fiber communication systems.

B.3.4 Evaluation of LGC System

The LGCell is covered under Annex A of 60825.

The LGCell system is a self-contained product that contains an optical fiber communication system that would be safe under normal operating conditions because the optical radiation is totally enclosed and contained under intended operation. However, because of the extended nature of the system, the optical power may be accessible a kilometer from the optical source. The LGCell system contains LEDs, which are the source of radiation covered under IEC 825. Usually a whole fiber optical communication system would not be classified under IEC 825-2 in the same way required under IEC 825-1. This is because, under intended operation, the optical power is totally enclosed, and it could be argued that an interpretation of IEC 825-1 would give a class 1 to all systems, which may not accurately reflect the hazard potential of some systems. If the emitter can be operated separately, it should be classified according to IEC 825-1. However, the power output level of the LGCell system is so low that it always falls into the class 1 hazard level even under 100% modulation conditions. The absolute maximum allowed at 1300nm is +9.5 dBm. The absolute maximum accessible output of the LGCell fiber optic system is –11.5 dBm. Therefore there is no restriction as to location of use of the LGCell system and there is no labeling requirement.

B.3.5 Suggested Work Practices

The LGCell is covered under these parts of section D7 of 60825

The following working practices are suggested for working on the LGCell system:

- **Viewing Fiber:** Do not stare with unprotected eyes at the connector ends of the fibers or the ports of the hub.
- **Test Fibers Cables:** When using test fiber optical cables, the optical power source shall be the last to be connected and the first to be disconnected.
- **Fiber ends:** Any unconnected fiber ends should be covered with an approved cap. Do not use tape.
- **Broken Fiber Cables:** Do not stare with unprotected eyes at any broken ends of the fibers. Report and have any broken fiber cables replaced.
- **Cleaning:** Use only approved methods for cleaning optical fiber connectors.
- **Modification:** Do not make any unauthorized modifications to this fiber optical system of associated equipment.
- **Live work:** Live work is permitted on the LGCell as it is a class 1 hazard.
- **Signs:** No warning signs are required.
- **Test Equipment:** Use class 1 test equipment.

B.4 Human Exposure to RF

The following precautions apply to LGC*ell* products.

- LGC*ell* has no user-serviceable parts. Faulty or failed units are fully replaceable through LGC Wireless. Please contact us at 1-800-530-9960. For international customers, please contact us at +1-408-952-2400.
- Never input an RF signal to the Main Hub Duplex port that is higher than those defined on page 17 in *Section 2, LGCell Equipment*.
- Although modeled after an Ethernet/LAN-like architecture and connectivity, LGC*ell* units (Main Hub, Expansion Hub, and the Remote Antenna Unit) are not intended to connect to Ethernet data hubs, routers, cards or other similar data equipment.
- For improved air circulation, be sure to leave at least one inch (25 mm) of space between all hubs and between any other equipment in the rack. If mounting a hub on the rack's bottom shelf, also leave at least a one inch of clearance from the bottom.
- When you connect the Multi-Mode Fiber (MMF) Optical Cable, take the same precaution as if installing Ethernet network equipment. All optical fiber ST connectors should be cleaned according to the cable manufacturer's instructions.
- When you connect a radiating antenna to an RAU, DO NOT over-tighten the SMA connector. Firmly hand-tightening the connector is adequate.

Antenna gain is restricted to 1.5 W ERP (2.49 W EIRP) in order to satisfy RF exposure compliance requirements. If higher than 1.5 W ERP, routine MPE evaluation is needed. The antennas should be installed to provide at least 20 cm from all persons to satisfy MPE requirements of FCC Part 2, 2.1091.

To reduce the risk of fire or electric shock, do not expose this equipment to rain or moisture.

Fiber Port Safety Precautions

Suggested safety precautions for working with LG*Cell* Fiber Ports follow. For information about LG*Cell* compliance with safety standards, see *Appendix C – Compliance Information*.

- **Viewing fiber:** Observe the following warning about viewing fiber ends in ports.

Do not stare with unprotected eyes at the connector ends of the fibers or the ports of the hubs.Invisible infrared radiation is present at the front panel of the Main Hub and Expansion Hub. Do not remove the Fiber Port dust cover unless the port is in use. Do not stare directly into a Fiber Port.

- **Test fiber cables:** When you use test fiber optical cables, connect the optical power source last and disconnect it first.
- **Fiber ends:** Cover any unconnected fiber ends with an approved cap. Do not use tape.
- **Broken fiber cables:** Do not stare with unprotected eyes at any broken ends of the fibers. Report any broken fiber cables and have them replaced.
- **Cleaning:** Use only approved methods for cleaning optical fiber connectors.
- **Modifications:** Do not make any unauthorized modifications to this fiber optical system or associated equipment.
- **Live work:** Live work is permitted on the LG*Cell* as it is a Class 1 hazard.
- **Signs:** No warning signs are required.
- **Test equipment:** Use Class 1 test equipment.

APPENDIX C

Frequently Asked Questions

- ***What is the LGCell Distributed Antenna System?***

  The LGCell Distributed Antenna System (DAS) contains multiple low-power radiating elements that are deployed around indoor facilities to improve coverage and capacity. The unique, patented architecture of the LGCell DAS provides an inexpensive solution to the wireless operator or wirless network manager for coverage/capacity upgrades and private microcell applications.

- ***What is twisted pair cable? Will it pick up spurious emissions?***

  Twisted pair (TP) cable is the standard cable that you find at the back of your computer for the network hookup. TP cable is the most ubiquitous cable in any office building. Furthermore, TP cable is inexpensive and easy to install. The twisting nature of the cable creates a transmission line for efficient signal transfer and rejection of spurious emissions The LGCell uses a state-of-the-art common-mode rejection device that reduces pickup of spurious emissions on a TP cable by a factor of 10,000.

- ***Can a single LGCell simultaneously support multiple access standards (such as 1900 TDMA/CDMA/GSM)?***

  Yes. The LGCell is a frequency selective product. The LGCell system is transparent to the protocol that the base station and mobile unit use. You can view the entire system with all the cables together as a frequency selective repeater with a specified gain.

- ***What is the bandwidth of the LGCell?***

  LGCell passes selected frequencies to minimize amplification of unwanted signals. Refer to the data specifications for the RF bandwidth of the system.

  Another interpretation of bandwidth is the amount of data that the LGCell system can transmit. The microcellular or macrocellular base station to which the LGCell is connected limits the bandwidth or capacity of the LGCell, which is independent of the wireless protocol and service. Total, composite output power and spurious emissions are the only constraints that limit the number of channels that an RAU can radiate. Furthermore, the LGCell system will not limit the data rate of the modulation transmitted through the system.

- ***Can the LGCell support multiband operation?***

  The LGCell provides a wide variety of single-band products, including the U.S. 800 MHz, European GSM 900, DCS 1800, Korean PCS 1800, U.S. PCS 1900 systems, and iDEN. You can use these systems together to provide multiband services. In addition, LGC has dual band 800/1900, 900/1800, and 1800/1800 LGCell systems available.

  Additionally, an LGCell neutral host configuration can simultaneously support multiple bands and protocols.

- ***Does the LGCell support paging applications?***

  Yes. The 900 MHz GSM and EGSM LGCells have been approved for paging and two-way messaging in the U.S. and Canada. The products may be used over thier entire operating frequency ranges for such applications.

- ***Can the LGCell system share the same UTP Category 5 cable with the Ethernet network?***

  No. The LGCell system can use the existing unused cabling inside the building; however, you cannot use the same cable to connect an RAU and a computer.

- ***What is the minimum power input to the Main Hub?***

  Refer to link budget calculation for the minimum acceptable power required to provide the desired levels of RF coverage..

- ***What is the minimum detectable power of an RAU?***

  The minimum detectable power of system with 1 RAU is –114 dBm in a 30 kHz bandwidth, –106 dBm in a 200 kHz bandwidth, and –98 dBm in a 1.25 MHz bandwidth. These figures do not take into account the processing gain of different access standards, which could decrease the minimum levels.

- ***What is the difference between connecting the LGCell to a roof-mounted antenna and to a microcellular base station?***

  Connecting the LGCell to a roof-mounted antenna increases the coverage of the indoor environment. Connecting the LGCell to a microcellular base station improves both the coverage and the capacity in the building and might also provide a private wireless office application for the customer.

- ***Does each Main Hub require a separate coaxial feed to the base station?***

  A typical RF input power per channel to the Main Hub is 0 dBm. This provides a lot of margin (link budget margin) for interfacing with antennas through a base station that typically has an output power of 20 dBm. Therefore, a power combiner/splitter might be installed between the Main Hub and the base station. This enables one base station to connect to multiple Main Hubs.

- ***Can I exceed the 3 dB optical loss in the fiber?***

  No. Exceeding the 3 dB optical loss in the fiber will result in an unreliable link indicated by sync alarms.

- ***Is the multimode fiber step or graded index fiber?***

  Graded index.

- ***Can the LGCell use 50µm/125µm multimode optical fiber?***

  The LGCell is designed for use with 62.5µm/125µm fiber. Use of 50µm/125µm fiber results in higher optical losses and degraded performance.

- ***How much space does the Main Hub and Expansion Hub use in a 19 in. rack?***

  Both units use 1U of rack space.

- ***Can I connect the LGCell alarms to a base station?***

  Yes. Use the major alarm contacts only. The base station supplies the return ground and voltage.

APPENDIX D

Glossary

Air Interface A method for formatting data and voice onto radio waves. Common air interfaces include AMPS, TDMA, CDMA, and GSM.

AIN Advanced Intelligent Network. AINs allow a wireless user to make and receive phone calls while roaming outside the user's "home" network. These networks, which rely on computers and sophisticated switching techniques, also provide many Personal Communications Service (PCS) features.

Amplitude The distance between high and low points of a waveform or signal.

AMPS Advanced Mobile Phone Service. AMPS is an analog cellular FDMA system. It was the basis of the first commercial wireless communication system in the U.S and has been used in more than 35 other countries worldwide.

Analog The original method of modulating radio signals so they can carry information which involves transmitting a continuously variable signal. Amplitude Modification (AM) and Frequency Modulation (FM) are the most common methods of analog modulation.

ANSI The American National Standards Institute. A nonprofit, privately funded membership organization founded in 1918 that reviews and approves standards developed by other organizations.

Antenna A device for transmitting and/or receiving signals.

Attenuation The decrease in power that occurs when any signal is transmitted. Attenuation is measured in decibels (dB).

Backhaul A term applied to the process of carrying wireless traffic between the MSC and the base station.

Base Station The radio transmitter/receiver that maintains communications with mobile devices within a specific area.

BSC Base Station Controller. A GSM term referring to the device in charge of managing the radio interface in a GSM system, including the allocation and release of radio channels and hand-off of active calls within the system.

BTA Basic Trading Area. The U.S. and its territories are divided into 493 areas, called BTAs. These BTAs are composed of a specific list of counties, based on a system originally developed by Rand McNally. The FCC grants licenses to wireless operators to provide service within these BTAs and/or MTAs. (See MTA.)

BTS Base Transceiver Station. A GSM term referring to the group of network devices that provide radio transmission and reception, including antennas.

C/I Carrier to interference ratio. The ratio of the desired signal strength to the combined interference of all mobile phones using the system. Usually, the interference of most concern is that provided by mobile phones using the same channel in the system. These are referred to as “co-channel interferers.”

CCITT Consultative Committee on International Telephone and Telegraph. This organization sets international communications standards. The CCITT is now known as ITU (the parent organization).

CDMA Code Division Multiple Access. A digital wireless access technology that uses spread-spectrum techniques. Unlike alternative systems, such as GSM, that use time-division multiplexing (TDM), CDMA does not assign a specific frequency to each user. Instead, every channel uses the full available spectrum. Individual conversations are assigned a unique code which allows the conversation to be spread out over multiple channels; transmitted to the far end; and re-assembled for the recipient using a specific code.

CDPD Cellular Digital Packet Data. CDPD allows data transmission over the analog wireless network. CDPD breaks data into packets and transmits these packets on idle portions of the network.

Cell A cell defines a specific, physical area of coverage of a portion of a wireless system. It is the basic “building block” of all modern wireless communications systems.

Cell Site A term which refers to the location of the transmission equipment (e.g., basestation) within the cell.

CEPT Conference of European Postal and Telecommunications Administrations. This organization’s mandate is to define pan-European wireless communications standards. In 1982, CEPT mandated GSM as the access protocol for public wireless communications systems across Europe.

Channel The path along which a communications signal is transmitted. Channels may be simplex (communication occurs in only one direction), duplex (communication occurs in both directions) or full duplex (communication occurs in both directions simultaneously).

Circuit A communication connection between two or more points. A circuit can transmit either voice or data.

CO Central Office. The main switching facility for a telecommunications system.

CTIA Cellular Telecommunications Industry Association. The CTIA is an industry association made up of most of the wireless carriers and other industry players. It was formed in 1984 to promote the cellular industry and cellular technology.

D-AMPS Digital Advanced Mobile Phone Service. See IS-54.

dB Decibel. A unit for expressing the ratio of two amounts of power. It is often used in wireless to describe the amount of power loss in a system (i.e., the ratio of transmitted power to received power).

DCS Digital Communications System. DCS is often called “upbanded GSM” since it is the GSM access scheme adopted to operate in the 1700–1800 MHz portion of the spectrum.

Digital A method of storing, processing, and transmitting information by representing information as “0s” and “1s” via electrical pulses. Digital systems have largely replaced analog systems because they can carry more data at higher speed than analog transmission systems.

Electromagnetic Spectrum Electrical wave forms in frequency ranges as low as 535 kHz (AM radio) and as high as 29 GHz (cable TV).

ESMR Enhanced Specialized Mobile Radio. Digital mobile telephone services offered to the public over channels previously used for two-way analog dispatch services. ESMR provides digital mobile radio and telephone service as well as messaging and dispatch features.

ETSI European Telecommunications Standards Institute. ETSI was established in 1988 to set standards for Europe in telecommunications, broadcasting and office information technology.

FCC Federal Communications Commission. In the United States, the FCC is responsible for the management and regulation of communication policy for all public communications services, including wireless.

FDMA Frequency Division Multiple Access. A wireless access protocol that assigns each user a specific radio channel for use. Since FDMA only supports one user (or conversation) on each channel, it does not maximize use of the spectrum and is therefore largely been superseded by other access protocols (such as CDMA, TDMA, GSM, iDEN) that support multiple users on a single channel.

Frequency Hopping A wireless signal transmission technique whereby the frequency used to carry a signal is periodically changed, according to a predetermined code, to another frequency.

Fixed An ITU definition for radio communications between specified fixed points. Point-to-point high-frequency circuits and microwave links are two examples of fixed applications.

FM Frequency Modulation. A method of transmitting information in which the frequency of the carrier is modified according to a plan agreed to by the transmitter and the receiver. FM can be either analog or digital.

Forward Channel Refers to the radio channel that sends information from the base station to the mobile station. (See Reverse Channel.)

Frequency The number of times an electrical signal repeats an identical cycle in a unit of time, normally one second. One Hertz (Hz) is one cycle per second.

Frequency re-use The ability to use the same frequencies repeatedly across a cellular system. Because each cell is designed to use radio frequencies only within its boundaries, the same frequencies can be reused in other cells not far away with little potential for interference. The reuse of frequencies is what enables a cellular system to handle a huge number of calls with a limited number of channels.

Gain The increase in power that occurs when any signal is amplified, usually through an amplifier or antenna.

GHz Gigahertz. A measure of frequency equal to one billion hertz.

GSM Groupe Speciale Mobile (now translated in English as Global Standard for Mobile Communications). GSM is the digital wireless standard used throughout Europe, in much of Asia, as well as by some operators in the U.S. and South America.

Handoff The process by which the wireless system passes a wireless phone conversation from one radio frequency in one cell to another radio frequency in another as the caller moves between two cells. In most systems today, this handoff is performed so quickly that callers don't notice.

Hertz A measurement of electromagnetic energy, equivalent to one "wave" per second. Hertz is abbreviated as "Hz".

iDEN Integrated Digital Enhanced Network. A TDMA-based wireless access technology that combines two-way radio, telephone, text message, and data transmission into one network. This system was developed by Motorola. In the U.S., iDEN is used by Nextel in its network.

IEEE The Institute of Electrical and Electronics Engineers. The world's largest technical professional society with members from more than 130 countries. The IEEE works to advance the theory and practice of electrical, electronics, computer engineering and computer science.

Infrastructure A term used to encompass all of the equipment, including both hardware and software, used in a communications network.

IS-54 Interim Standard-54. A U.S. TDMA cellular standard that operates in the 800 MHz or 1900 MHz band. IS-54 was the first U.S. digital cellular standard. It was adopted by the CTIA in 1990.

IS-95 Interim Standard-95. A U.S. CDMA cellular standard that operates in the 800 MHz or 1900 MHz band. This standard was developed by Qualcomm and adopted by the CTIA in 1993.

IS-136 Interim Standard-136. A U.S. TDMA cellular standard based on IS-54 that operates in the 800 MHz or 1900 MHz band.

IS-553 Interim Standard-533. The U.S. analog cellular (AMPS) air interface standard.

ITU International Telecommunications Union. The ITU is the principal international standards organization. It is charted by the United Nations and it establishes international regulations governing global telecommunications networks and services. Its headquarters are in Geneva, Switzerland.

LMDS Local Multipoint Distribution Services. LMDS provides line-of-sight coverage over distances up to 3–5 kilometers and operates in the 28 GHz portion of the spectrum. It can deliver high speed, high bandwidth services such as data and video applications.

Local Loop A communication channel (usually a physical phone line) between a subscriber's location and the network's Central Office.

MHz Megahertz. One million Hertz. One MHz equals one million cycles per second.

Microcell A network cell designed to serve a smaller area than larger macrocells. Microcells are smaller and lower powered than macrocells. As the subscriber base increases, operators must continue to increase the number of cells in their network to maximize channel re-use. This has led to an increasing number of microcells being deployed in wireless networks.

Microwave Electromagnetic waves with frequencies above 1 GHz. Microwave communications are used for line-of-sight, point-to-point, or point-to-multipoint communications.

MSA Metropolitan Statistical Area. The FCC has established 306 MSAs in the U.S. The MSAs represent the largest population centers in the U.S. At least two wireless operators are licensed in each MSA.

MSC Mobile Services Switching Center. A generic term for the main cellular switching center in the wireless communications network.

MSS Mobile Satellite Service. Communications transmission service provided by satellites. A single satellite can provide coverage to the entire United States.

MTA Major Trading Area. The U.S. and its territories are divided into 51 MTAs. Each MTA is composed of a specific number of BTAs. The FCC grants licenses to wireless operators to provide service within these MTAs and/or BTAs. (See BTA.)

Multiplexing The simultaneous transmission of two or more signals on the same radio (or other) transmission facility.

N-AMPS Narrowband Advanced Mobile Phone Service.

PCMCIA Personal Computer Memory Card International Association. This acronym is used to refer to credit card sized packages containing memory, I/O devices and other capabilities for use in Personal Computers, handheld computers and other devices.

PCS Personal Communications Service. A vague label applied to new-generation mobile communication technology that uses the narrow band and broadband spectrum recently allocated in the 1.9 GHz band.

PDA Personal Digital Assistant. Portable computing devices that are extremely portable and that offer a variety of wireless communication capabilities, including paging, electronic mail, stock quotations, handwriting recognition, facsimile, calendar, and other information handling capabilities.

PDC Personal Digital Cellular (formerly Japanese Digital Cellular). A TDMA-based digital cellular standard that operates in the 1500 MHz band.

Phase The particular angle of inflection of a wave at a precise moment in time. It is normally measured in terms of degrees.

PHS Personal Handyphone System. A wireless telephone standard, developed and first deployed in Japan. It is a low mobility, small-cell system.

POP Short for “population”. One person equals one POP.

POTS Plain Old Telephone Service.

PSTN Public Switched Telephone Network. Refers to the international telephone system and includes both local and long distance networks.

Reverse Channel Refers to the radio channel that sends information from a mobile station to a base station. (See Forward Channel.)

RF Radio Frequency. Those frequencies in the electromagnetic spectrum that are associated with radio wave propagation.

Roaming The ability to use a wireless phone to make and receive calls in places outside one's home calling area.

RSA Rural Service Area. One of the 428 FCC-designated rural markets across the United States used as license areas for cellular licenses. (See MTAs and BTAs.)

Sector A portion of a cell. Often, different sectors within the same cell will each use a different set of frequencies to maximize spectrum utilization.

Signal to Noise Ratio The ratio of signal power to noise power at a given point in a given system.

Smart Antenna Refers to an antenna whose signal handling characteristics change as signal conditions change.

Soft Handoff Virtually undetectable by the user, soft handoff allows both the original cell and a new cell to serve a call temporarily during the handoff transition.

Spectrum The range of electromagnetic frequencies.

Spread Spectrum A method of transmitting a signal over a broad range of frequencies and then re-assembling the transmission at the far end. This technique reduces interference and increases the number of simultaneous conversations within a given radio frequency band.

T-1 A North American commercial digital transmission standard. A T-1 connection uses time division multiplexing to carry 24 digital voice or data channels over copper wire.

TDMA Time Division Multiple Access. A method of digital wireless communications that allows multiple users to access (in sequence) a single radio frequency channel without interference by allocating unique time slots to each user within each channel.

TIA Telecommunications Industry Association.

TR-45 One of six committees of the Telecommunications Industry Association. TR-45 oversees the standard making process for wireless telecommunications.

Upbanded A service or technology that has been re-engineered to operate at a higher frequency than originally designed.

Wireless Describes any radio-based system that allows transmission of voice and/or data signals through the air without a physical connection, such as a metal wire or fiber optic cable.

Wireline Wire paths that use metallic conductors to provide electrical connections between components of a system, such as a communication system.

WLANs Wireless Local Area Networks. Technology that provides wireless communications to Portable Computer users over short distances.