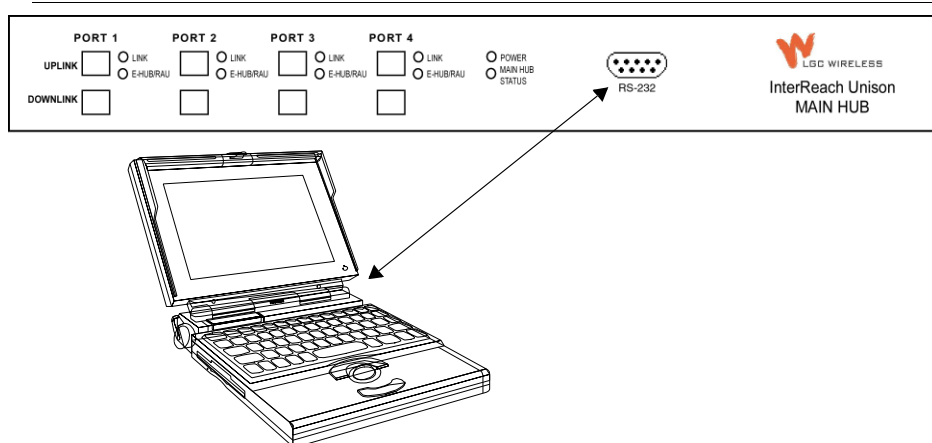


Installing and Using the AdminManager Software

The AdminManager software is used to install, configure, and maintain the Unison system from a PC or laptop that you connect directly to a Main Hub's front panel serial port.

You can use the AdminManager to remotely view system status by connecting a PC or laptop to the Unison system via a dialup modem.

Figure 7-1 PC Connected to Main Hub



7.1 Installing the AdminManager Software

7.1.1 PC/Laptop Requirements

- Operating System:
 - Windows 2000 Professional (recommended)
 - Windows 98 SE with IE 5.0
- 1 Communication Port (COM1–COM4)
- 133 MHz or higher Pentium-compatible CPU
- 64 MB memory (Windows 2000) or 32 MB (Windows 98 SE)
- At least 150 MB free disk space
- VGA or higher resolution
- Standard 9600 Modem
- CD-ROM drive
- DB-9 female-to-DB-9 female NULL modem cable

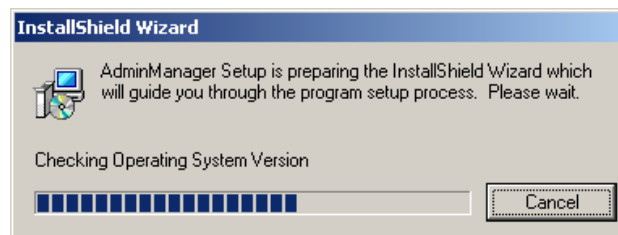
✓ Installing AdminManager

Install the AdminManager software on a PC/laptop that meets the requirements as described in Section 7.1.1.

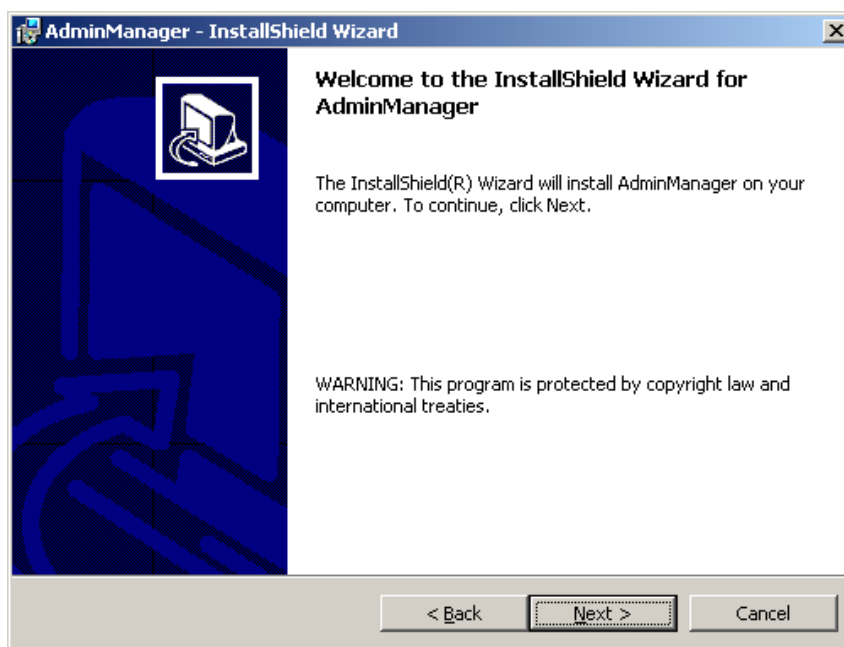
1. Turn on the PC/laptop and insert the AdminManager CD into the PC/laptop's CD drive.

setup.exe should automatically start. If it does not, double-click "setup.exe" on the CD-ROM.

The following pop-up window is displayed while InstallShield checks the PC's system.

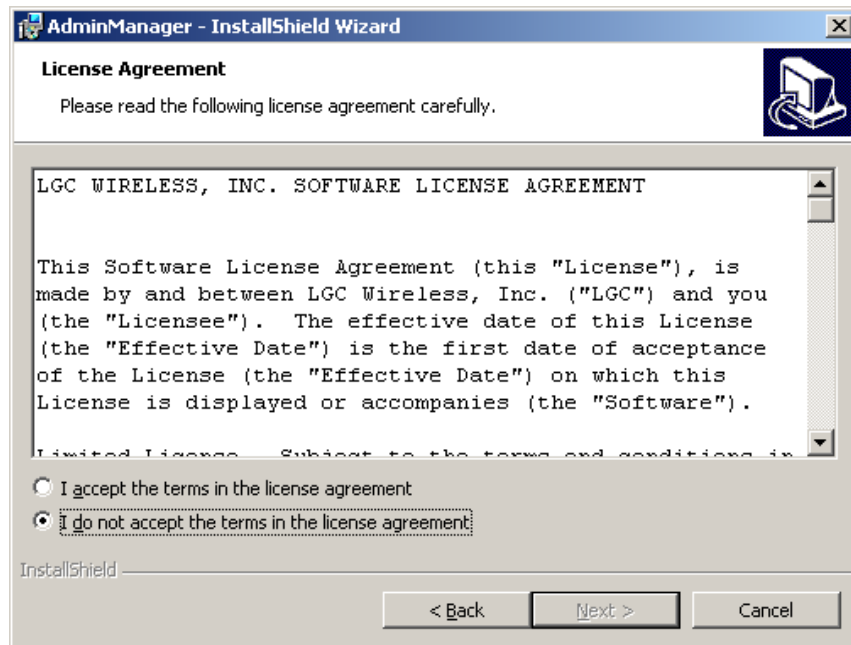


The Welcome to InstallShield Wizard window is displayed.



2. Click the NEXT button to begin the AdminManager installation.

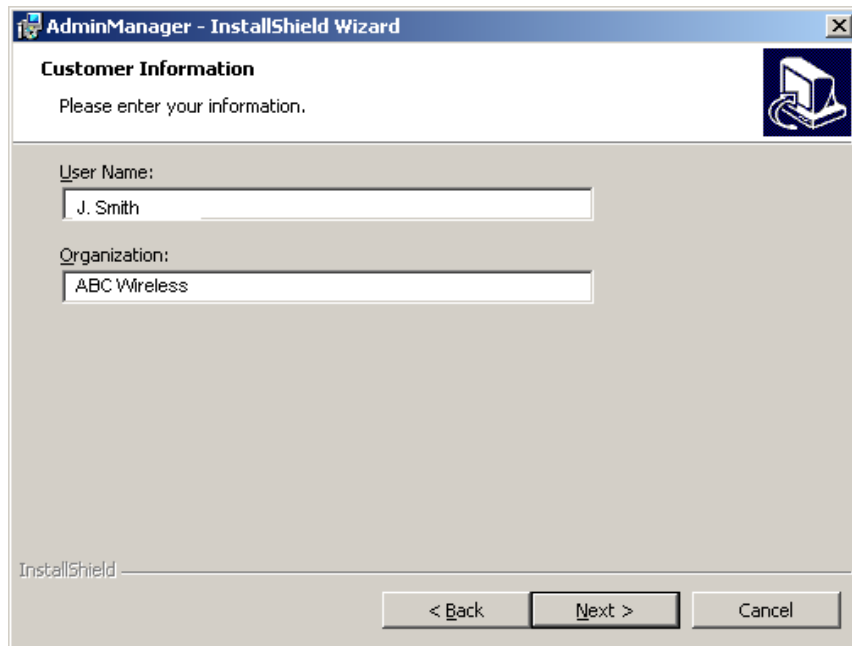
The License Agreement window is displayed.



If you select the "I do not accept" radio button, the InstallShield Wizard stops and the windows close.

3. Read the agreement and select the “I accept” radio button, and then click the NEXT button.

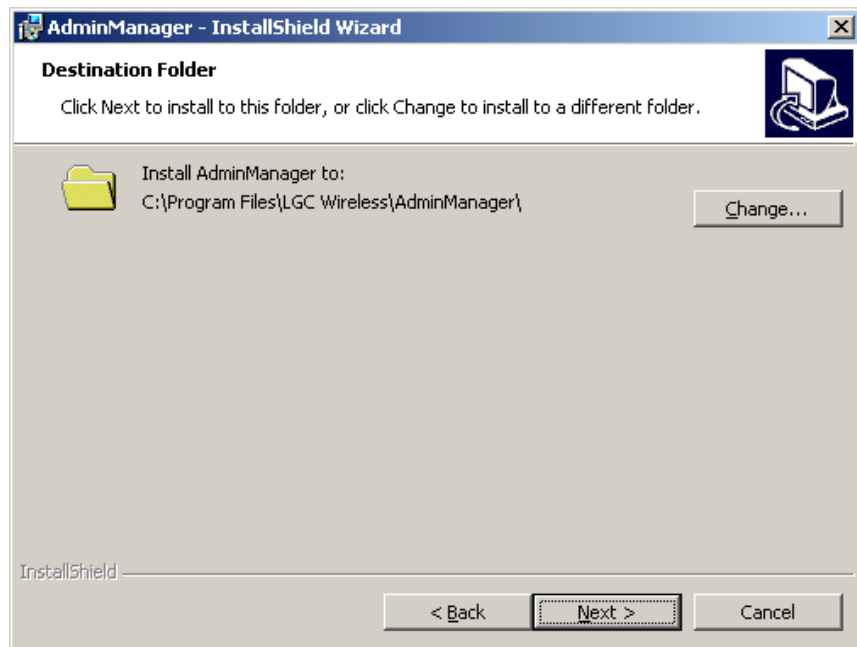
The Customer Information window is displayed.



The screenshot shows a Windows-style dialog box titled "AdminManager - InstallShield Wizard". The main heading is "Customer Information" with a subtext "Please enter your information." and a small icon of a computer with a circular arrow. Below this, there are two text input fields: "User Name:" with the text "J. Smith" and "Organization:" with the text "ABC Wireless". At the bottom left, the text "InstallShield" is visible. At the bottom right, there are three buttons: "< Back", "Next >" (which is highlighted with a black border), and "Cancel".

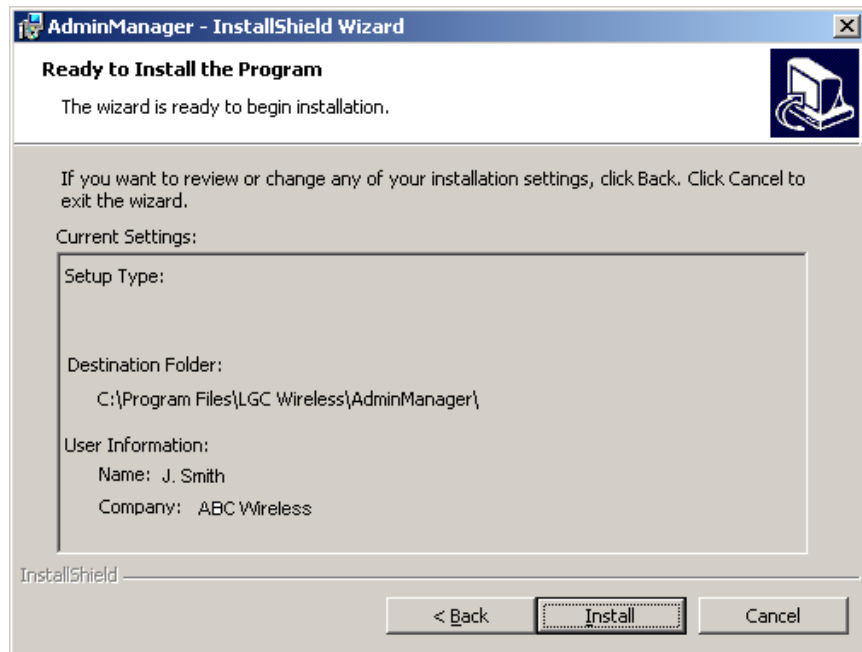
4. Enter a User Name and Organization in the text boxes, and then click the NEXT button.

The Destination Folder window is displayed



5. Click the NEXT button to accept the default destination.

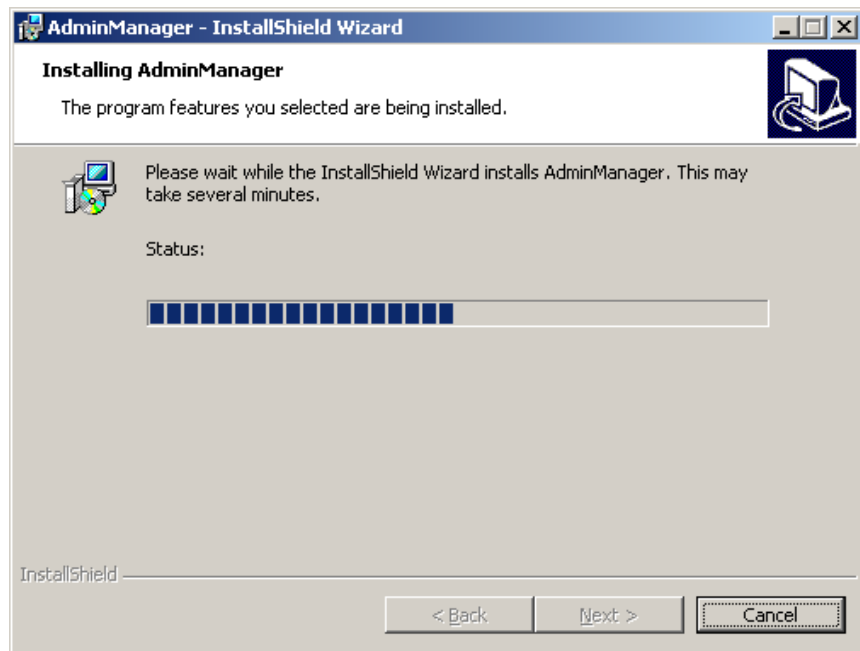
The Ready to Install the Program window is displayed.



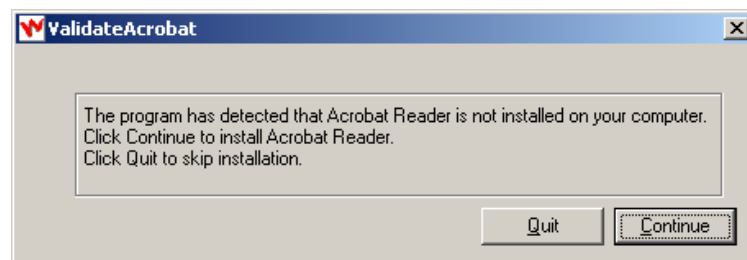
NOTE: To change information that is displayed in the Ready to Install the Program window, click the BACK button and make changes in previous windows.

6. Click the **INSTALL** button if the information that is displayed in the Ready to Install the Program window is correct.

The Installing AdminManager window is displayed.

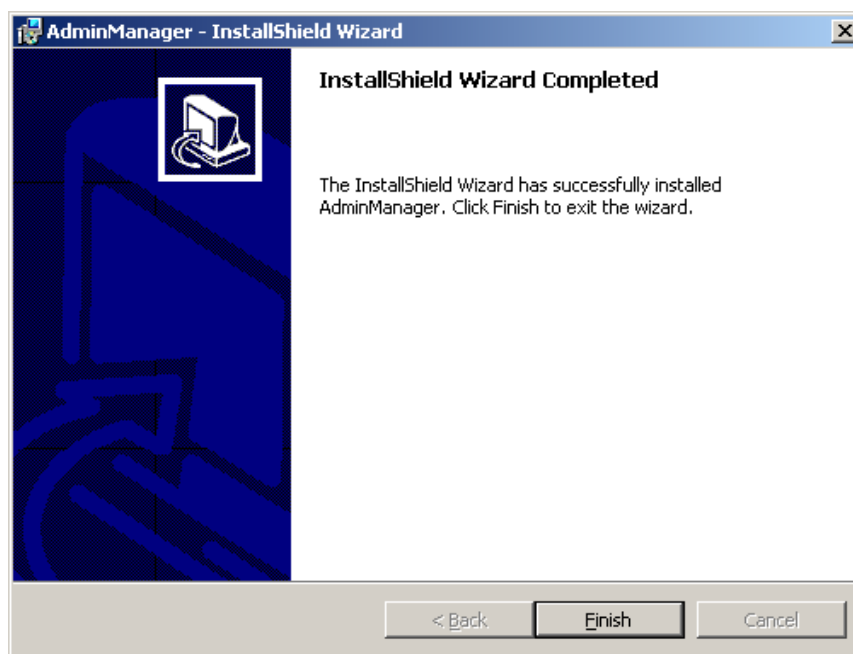


PDF files are used for Help. If the InstallShield Wizard detects that the PC does not have software for viewing PDF files, the following pop-up is displayed.



- Click **CONTINUE** to install Acrobat Reader from the CD onto your PC.
- Click **QUIT** to skip the installation of Acrobat Reader.

When the installation is finished, the InstallShield Wizard Completed window is displayed.



7. Click the **FINISH** button to end the InstallShield Wizard session and close the window.

An AdminManager shortcut is added to your PC's Start menu and an icon is added to your desktop.

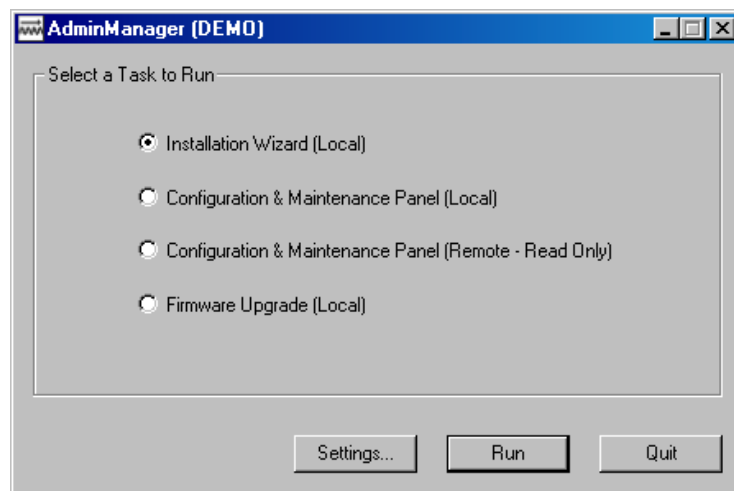
✓ Starting AdminManager

1. Using the NULL modem cable, connect the PC/laptop to the Main Hub's front panel RS-232 connector.
2. Turn on the power to the Main Hub, if it is not already on.
3. Double-click the AdminManager icon to start the software.

Alternately, you can click the Start button that is on the PC's taskbar, click Programs, click AdminManager, and then click the AdminManager application.

The following window is displayed when AdminManager starts.

Figure 7-2 AdminManager Start Window



You can display the AdminManager User Guide at any time while the software is running by pressing the F1 key.

AdminManager Operation Modes

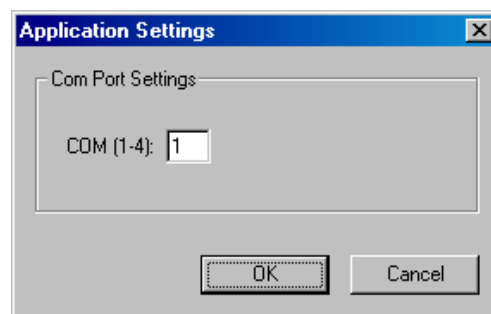
You can choose one of four operation modes from the AdminManager Start window.

- **Section 7.2 Installation Wizard 7-13**
Select this option when you are installing a system or a Main Hub for the first time. Also, when you are replacing a Main Hub select this option to set the frequency band.
- **Section 7.3 Configuration & Maintenance Panel 7-25**
 - **Section 7.3.2 Options when Connected Locally 7-29**
Select this option when you want to perform specific tasks, such as perform the system test and set system parameters, or check the status of an operating system. All options are available when you are connected locally.
 - **Section 7.3.3 Read-Only Options when Connected Remotely 7-34**
The Configuration Panel is displayed in a read-only state. When you are connected remotely there are a limited number of options available. The options let you check the status of the system and determine if a site visit is required. (This is the only operation mode you can choose when you are connected remotely.)
- **Section 7.4 Upgrading Firmware 7-38**
Select this option when you are upgrading a component's firmware.

Buttons

- **Settings**

Clicking the SETTINGS button displays the Application Setting dialog box in which you enter the communications port number that the modem will connect to for remote monitoring and that the PC will use for connecting directly to a Main Hub



- **Run**

Depending on the operation option that you selected, clicking the RUN button displays the Step 1 panel of the Installation Wizard, the Configuration & Maintenance window, or the Firmware Update window.

- **Quit**

Clicking the QUIT button stops the AdminManager and closes the panel.

7.2 Installation Wizard

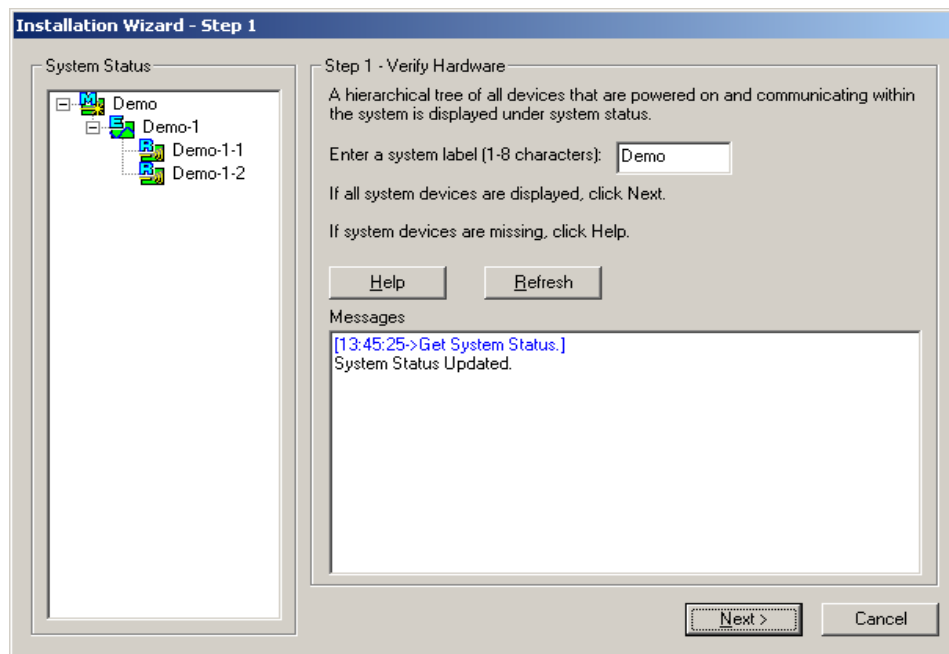
Use the Installation Wizard when you are installing a new system or a new Main Hub to a system. Installation consists of four steps; each one is displayed in a separate panel of the Wizard.

- Section 7.2.1 Step 1: Verify Hardware 7-14
- Section 7.2.2 Step 2: Set Operation Band 7-16
- Section 7.2.3 Step 3: Configure System Parameters 7-20
- Section 7.2.4 Step 4: Final System Test 7-22

7.2.1 Step 1: Verify Hardware

During this step, the AdminManager software is in a listening mode. The Main Hub detects downstream units (Expansion Hubs and RAUs) and automatically reports the system configuration, which AdminManager displays as a configuration tree in the System Status pane of the Step 1 panel.

Figure 7-3 Step 1: Verify Hardware Panel



✓ Verify Hardware Configuration

1. Enter a system label (up to 8 characters) in the System Label text box.
This label is assigned to the Main Hub and appears in the System Status tree.
2. Click the NEXT button when the configuration is displayed correctly in the System Status pane.

The Main Hub automatically reports any change in system status to the AdminManager, which automatically updates the System Status tree.

7.2.1.1 Description of Step 1 Panel

Panes

- **System Status**

A hierarchical tree of detected system components is displayed in the System Status pane. See Section 7.5 on page 7-39 for more information about the System Status tree.

- **Messages**

Status and error messages are displayed in the Messages pane. If the status is okay, the NEXT button is selectable.

Command Buttons

- **Help**

Clicking the HELP button displays the Unison Hardware Troubleshooting Guide.

- **Refresh**

Clicking the REFRESH button issues a query status command to the Main Hub and the System Status tree is updated. Also, any disconnect status is cleared. While the Main Hub does report system status to the AdminManager automatically, you can use this button to force an update if communications fail or if there has been a status change that is not showing in the System Status tree.

- **Next**

Clicking the NEXT button displays the Installation Wizard Step 2 panel.

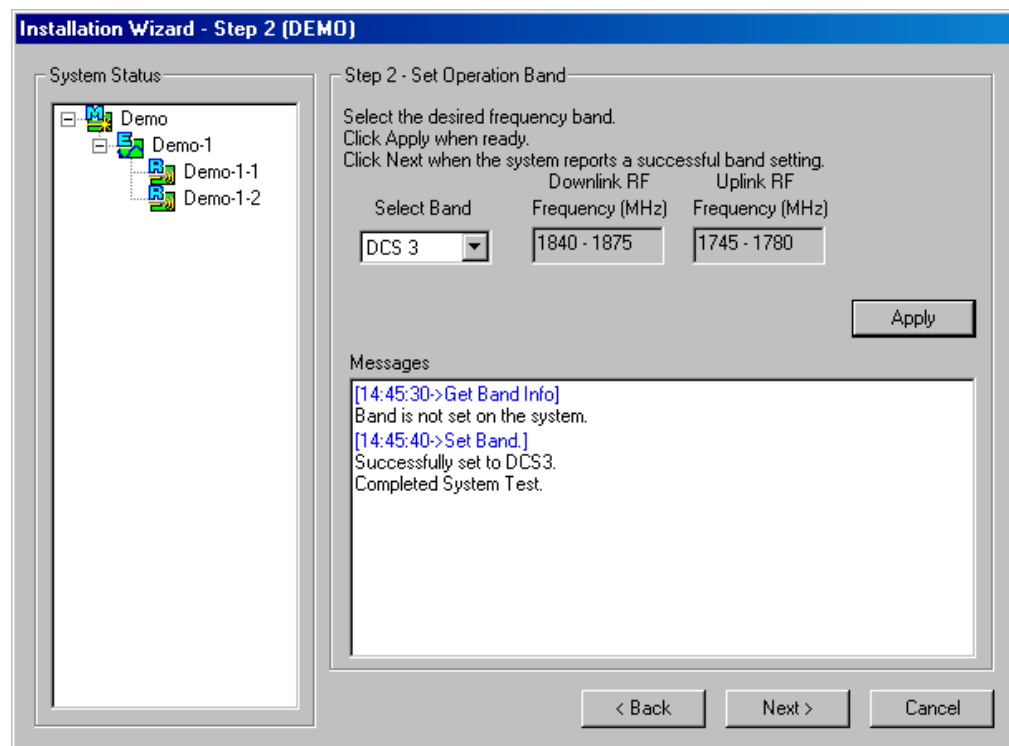
- **Cancel**

Clicking the CANCEL button quits the Installation Wizard and displays the Admin-Manager Start window (Figure 7-2).

7.2.2 Step 2: Set Operation Band

The Main and Expansion Hubs are manufactured and shipped without a band of operation programmed into them. The RAUs, on the other hand, are manufactured to a specific band or set of bands. In order for the system to perform, you must program the Main and Expansion Hubs to the band that the downstream RAUs are intended for.

Figure 7-4 Step 2: Set Operation Band



 Set Operation Band

1. Select a band from the Select Band drop-down list box.
2. Click the APPLY button.
3. Click the NEXT button if:
 - a. The configuration is displayed correctly in the System Status pane.
 - b. There are no error messages in the Messages pane.

If a band setting error message is displayed, you can:

1. Disconnect the unit from the system.
2. Click the BACK button to return to Step 1.
3. Click the REFRESH button to clear the disconnected unit.
4. Click the NEXT button to continue to Step 2.

NOTE: “Band not initialized” faults can only be cleared by performing Step 2. The Configuration & Maintenance panel does not provide a way to clear these faults.

7.2.2.1 Description of Step 2 Panel

Panes

- **System Status**

A hierarchical tree of detected system components is displayed in the System Status pane. See Section 7.5 on page 7-39 for more information about the System Status tree.

- **Messages**

Status and error messages are displayed in the Messages pane. If the status is okay, the NEXT button is selectable.

Drop-Down List Box

- **Select Band**

Choose from:

Unison Band	RF Passband	
	Downlink (MHz)	Uplink (MHz)
Cellular	869–894	824–849
DCS1	1805–1842.5	1710–1747.5
DCS2	1842.5–1880	1747.5–1785
DCS3	1840–1875	1745–1780
EGSM	925–960	880–915
GSM	935–960	890–915
iDEN	851–869	806–824
PCS A&D	1930–1950	1850–1870
PCS B&E	1945–1965	1865–1885
PCS D&B	1950–1970	1870–1890
PCS E&F	1965–1975	1885–1895
PCS F&C	1970–1990	1890–1910
UMTS 1	2110–2145	1920–1955
UMTS 2	2125–2160	1935–1970
UMTS 3	2135–2170	1945–1980

Command Buttons

- **Apply**

Clicking the **APPLY** button issues the set band command to the Main Hub and all downstream components, and initiates a system test.

In order for the system to complete the band configuration, the factory-set band of all the attached RAUs must match the band command issued by the AdminManager software. If the band command matches the RAU's, then the system band is set. If the band command does not match, the command is rejected and a "Set band error" message for that RAU is displayed.

- **Back**

Clicking the **BACK** button returns AdminManager to the Step 1 panel.

- **Next**

Clicking the **NEXT** button displays the Installation Wizard Step 3 panel. This button is selectable only when the **APPLY** function is successful.

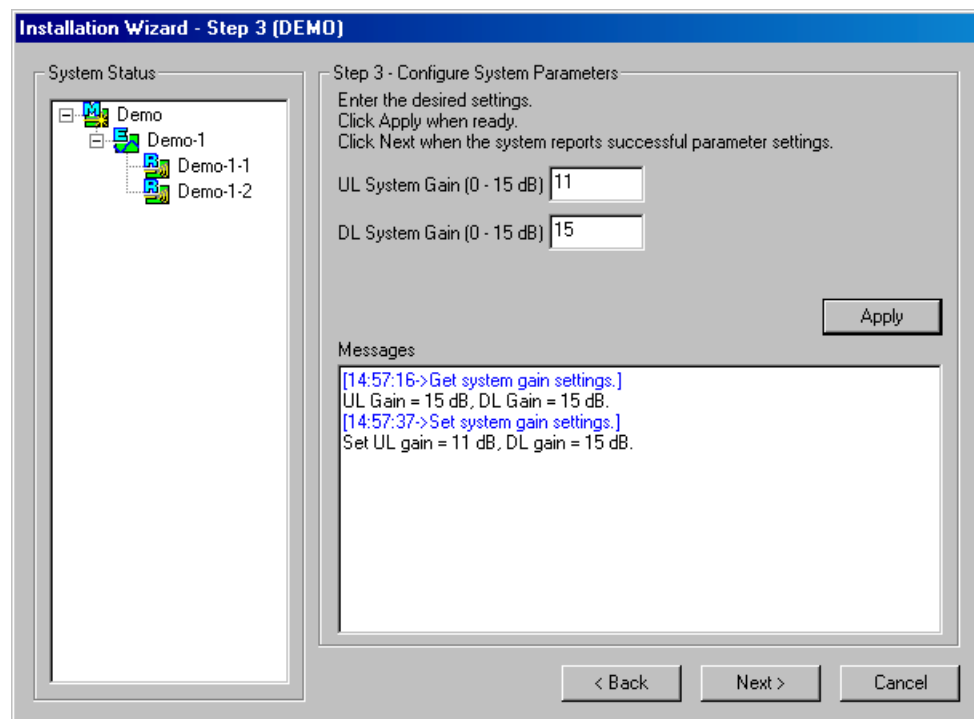
- **Cancel**

Clicking the **CANCEL** button quits the Installation Wizard and displays the AdminManager Start window (Figure 7-2).

7.2.3 Step 3: Configure System Parameters

From this panel, you can set uplink and downlink system gain from 0 dB to 15 dB in 1 dB steps. By default, the UL and DL System Gain is set at 15 dB. Current hardware settings are shown in the text boxes when the panel is first displayed. Figure 7-5 shows the display after the UL System Gain was changed to 11 dB.

Figure 7-5 Step 3: Configure System Parameters



✓ Configure System Parameters

If you want to keep the values as they are initially displayed, click the NEXT button.

If you want to change the values:

1. Enter a value in the UL System Gain text box, if desired.
2. Enter a value in the DL System Gain text box, if desired.
3. Enter the callback number if a callback number text box is displayed.

If a callback number is set in the Main Hub, this panel displays an additional callback number text box, letting you change the number, if desired.

4. Click the APPLY button when you are ready.
5. Click the NEXT button if:
 - a. The configuration is displayed correctly in the System Status pane.
 - b. There are no error messages in the Messages pane.

7.2.3.1 Description of Step 3 Panel

Panes

- **System Status**

A hierarchical tree of detected system components is displayed in the System Status pane. See Section 7.5 on page 7-39 for more information about the System Status tree.

- **Messages**

Status and error messages are displayed in the Messages pane. If the status is okay, the NEXT button is selectable.

Text Boxes

- **UL System Gain and DL System Gain**

Both the uplink and the downlink system gain can be adjusted from 15 dB to 0 dB in 1 dB increments using these text boxes.

Command Buttons

- **Apply**

Clicking the APPLY button sets the selected value.

- **Back**

Clicking the BACK button returns AdminManager to the Step 2 panel.

- **Next**

Clicking the NEXT button displays the Installation Wizard Step 4 panel.

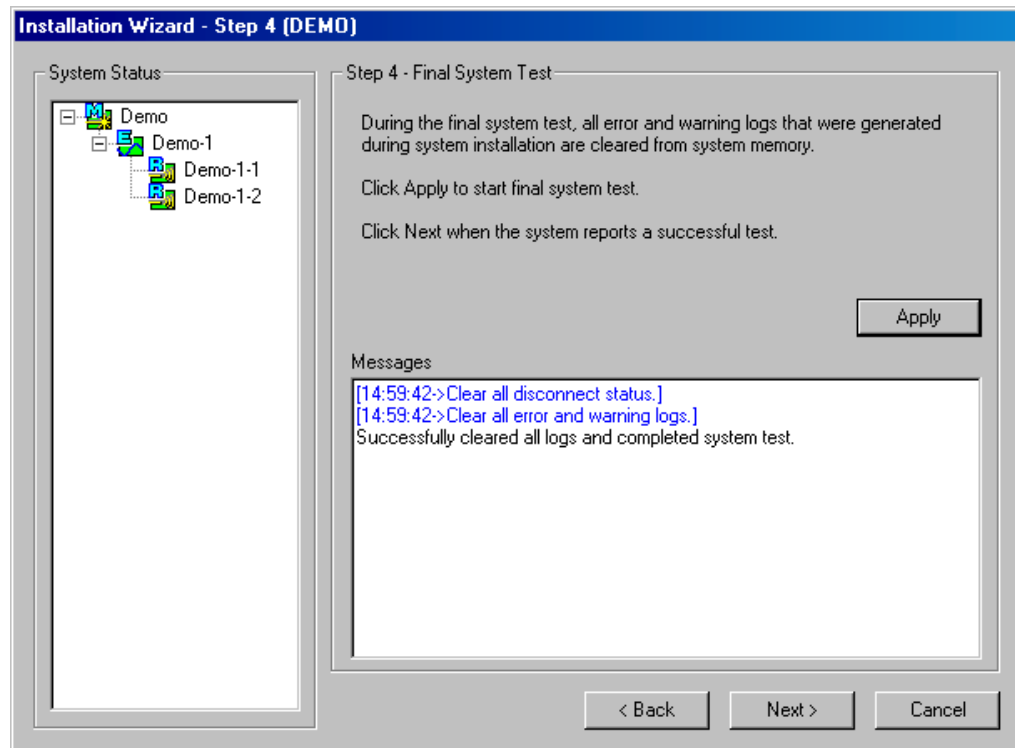
- **Cancel**

Clicking the CANCEL button quits the Installation Wizard and displays the AdminManager Start window (Figure 7-2).

7.2.4 Step 4: Final System Test

This step performs an end-to-end RF path functional test that includes cable length estimation and system gain refinement. Any disconnect status is cleared and all fault logs are cleared.

Figure 7-6 Step 4: Final System Test



✓ Perform Final System Test

1. Click the APPLY button if the configuration is displayed correctly in the System Status pane.
For a fully loaded system (one Main Hub, four Expansion Hubs, and 32 RAUs), it can take 1.5 minutes to complete the test.
2. Click the NEXT button when a successful test message is displayed in the Messages pane.

You can use the BACK button to return to previous steps and make changes if an error is displayed in the Messages pane.

7.2.4.1 Description of Step 4 Panel

Panes

- **System Status**

A hierarchical tree of detected system components is displayed in the System Status pane. See Section 7.5 on page 7-39 for more information about the System Status tree.

- **Messages**

Status and error messages are displayed in the Messages pane. If the status is okay, the NEXT button is selectable.

Command Buttons

- **Apply**

Clicking the APPLY button starts the final system test.

- **Back**

Clicking the BACK button returns AdminManager to the Step 3 panel.

- **Next**

Clicking the NEXT button displays the Installation Wizard Finish panel. This button is selectable only when the APPLY function is successful.

- **Cancel**

Clicking the CANCEL button quits the Installation Wizard and displays the AdminManager Start window (Figure 7-2).

7.2.5 Finish Panel

The Finish panel is displayed when the final system test is successfully completed.

Figure 7-7 Finish Panel



1. Click the **FINISH** button.
A **Save As** dialog box is displayed.
2. Specify a file name and where to save the command file.
All of the commands that were issued during the installation are saved in the command file.

7.2.5.1 Description of Finish Panel

Command Button

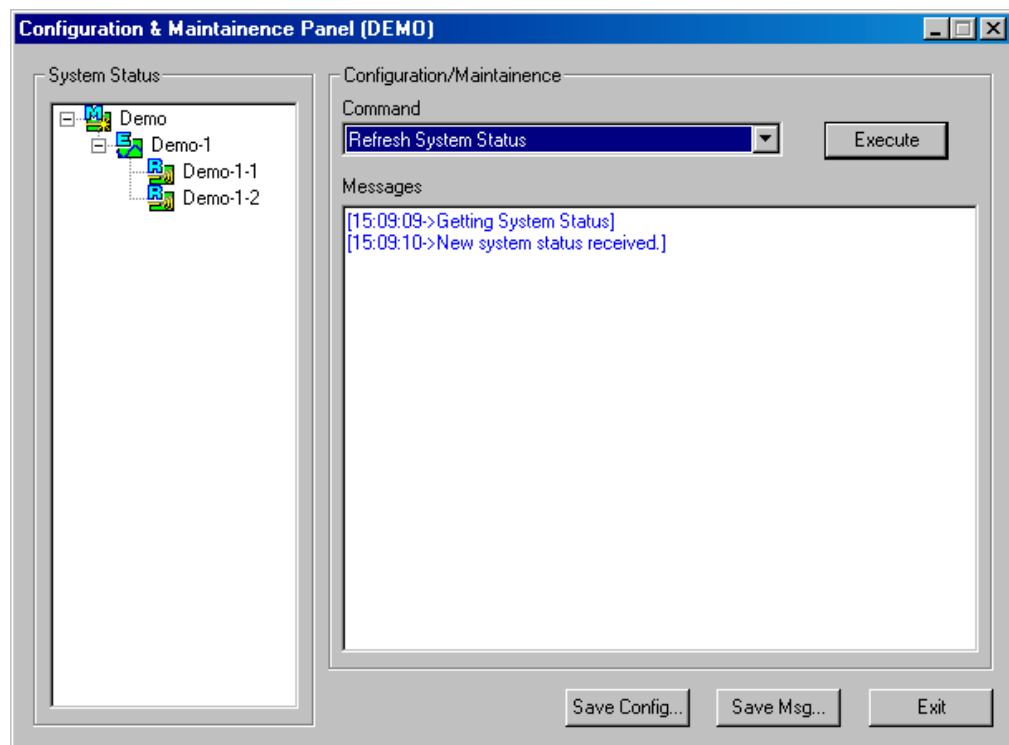
- **Finish**

Clicking the **FINISH** button displays a **Save As** dialog box for saving the configuration file and then quits the session.

7.3 Configuration & Maintenance Panel

The Configuration & Maintenance Panel is used after the initial installation of a system. From this panel you can check status of the system, get current errors and warnings, get information about a particular unit in the system, set system parameters, and perform a system test, for example.

Figure 7-8 Configuration & Maintenance Window



7.3.1 Window Description

Panes

- **System Status**

A hierarchical tree of detected system components is displayed in the System Status pane. See Section 7.5 on page 7-39 for more information about the System Status tree.

- **Messages**

Status and error messages are displayed in the Messages pane.

Drop-Down List Box

Table 7-1 Configuration and Maintenance Window Options

Connection		Option
Local	Remote	
✓		Advanced RAU Settings
✓		Clear All Disconnect Status
✓		Command Unit In-Service
✓		Command Unit Out-of-Service
✓	✓	Get Current Errors
✓	✓	Get Current Warnings
✓	✓	Get System Parameters
✓	✓	Get Unit Info
✓	✓	Refresh System Status
✓		Set Callback Number
✓		Set Contact Sense Properties
✓		Set System Parameters
✓		System Test

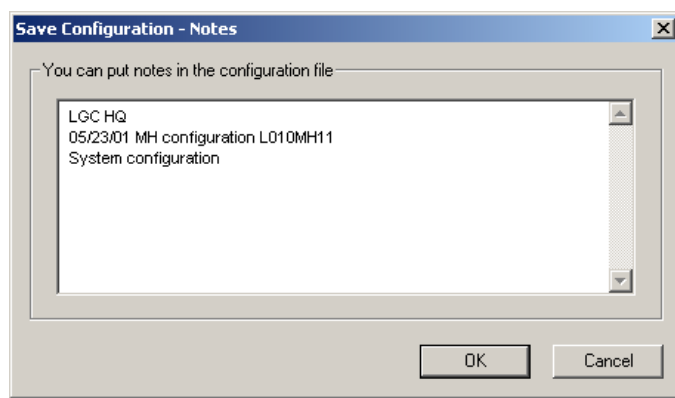
Command Buttons

- **Execute**

Clicking the EXECUTE button starts the command that is selected in the Command list box.

- **Save Config**

Clicking the SAVE CONFIG button displays the Save Configuration Notes dialog box. Any additional information that you type into the text box is saved at the top of the configuration file.



After you click OK in this dialog box, the Save As dialog box is displayed, in which you specify the name of the file and where to save the configuration file. Following is an example configuration file that includes notes:

```

Begin Notes *****
LGC HQ
05/23/01 MH configuration L010MH11
System configuration
End Notes *****

Frequency Band is DCS Low.
System Gain: UL = 12 dB, DL = 4 dB.
Callback Number is 1234567.
System label is LGC.

Main Hub Information:
Serial Number: L010BMH1
Part Number: 7405101
Revision Number: 03
Firmware Revision: 010526

Expansion Hub LGC-1 Information:
Serial Number: L010BEH9
Part Number: 7405101
Revision Number: 03
Firmware Revision: 010513

RAU LGC-1-5 Information:
Serial Number: L010BRU1
Part Number: 7405101
Revision Number: 03
Firmware Revision: 010021

```

- **Save Msg**

Selecting the SAVE MSG button displays the Save As dialog box in which you specify the name of the file and where to save the contents of the Message text box.

- **Exit**

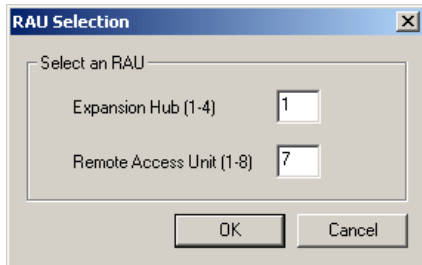
Selecting the EXIT button quits the session and displays the AdminManager Start window (Figure 7-2).

7.3.2 Options when Connected Locally

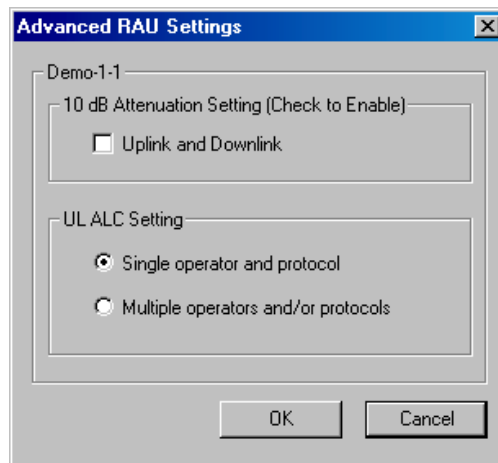
When you are locally connected to the Main Hub, you can choose the following options in addition to those listed in Section 7.3.3, “Read-Only Options when Connected Remotely,” on page 7-34 (also, see Table 7-1 on page 7-26).

Advanced RAU Settings

- Set uplink and downlink 10 dB attenuation for an individual RAU
Refer to “Using the 10 dB Attenuation Setting” on page 7-30 for a description of this setting.
- Select a UL ALC setting for an individual RAU
Refer to “Using the Uplink ALC Setting” on page 7-31 for a description of this setting.



1. Enter the Expansion Hub number and the RAU number in the text boxes on the RAU Selection dialog box and click OK.
The Advanced RAU Settings dialog box is displayed.
In the Advanced RAU Settings example shown below, Demo-1-1 indicates that RAU number 1 that is connected to Expansion Hub number 1 in the “Demo” Main Hub system is selected.
2. Select the Uplink and Downlink check box to enable the 10 dB attenuation setting.
3. Select a radio button from the UL ALC Setting list.



Using the 10 dB Attenuation Setting

By selecting the Uplink and Downlink checkbox in the Advanced RAU Settings dialog box, the uplink and downlink signals in the individual RAU, which you specified in the RAU Selection dialog box, are both reduced by 10 dB. One reason you may want to use this setting is to reduce the RAU's output power when an RAU is located near an exterior wall of a building and its RF signal is going beyond the wall to the outside of the building, where it can negatively affect the outdoor macro system.

The following table shows some examples of how the 10 dB attenuation setting affects coverage distance. These examples assume a 0 dB gain system, a 3 dBi gain antenna, and the difference between a -85 dB and a -75 dB design.

Frequency	Environment	Reduction in Coverage Distance
800 MHz	Open, like a parking garage	24 meters (80 feet)
800 MHz	Heavily walled, like a Hospital	12.5 meters (41 feet)
1900 MHz	Open, like a parking garage	24 meters (80 feet)
1900 MHz	Heavily walled, like a Hospital	9 meters (30 feet)

You can use the following formula to calculate the reduction in distance covered.

- d_{orig} = original distance
- d_{new} = new distance with 10 dB attenuation enabled
- PLS = path loss slope [dB]

$$d_{\text{new}} = (10^{-10/\text{PLS}})d_{\text{orig}}$$

Examples:

$$d_{\text{new}} = 0.31 d_{\text{orig}} \text{ for PLS} = 20 \text{ dB (free space)}$$

$$d_{\text{new}} = 0.46 d_{\text{orig}} \text{ for PLS} = 30 \text{ dB}$$

Using the Uplink ALC Setting

Uplink automatic level control (UL ALC) circuitry within the RAU provides automatic level control on high-power signals in the uplink path. This functionality is required to prevent compression caused by a single or multiple wireless devices that are in very close proximity to an RAU. Compression causes signal degradation and, ultimately, bit errors, and should be prevented. Two settings are available to optimize UL ALC performance:

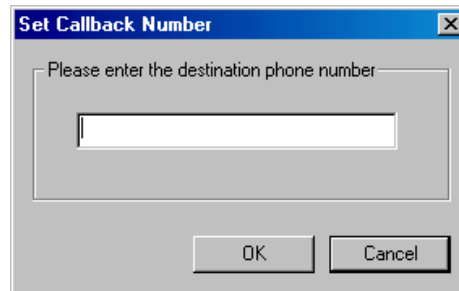
- **Single Operator and Protocol:** Use when only one operator and protocol is on-the-air within the Unison system's configured and adjacent frequency bands.
- **Multiple Operators and/or Protocols:** Use when more than one operator and/or protocol is present in the Unison system's frequency and adjacent frequency bands.

The following table shows the frequency bands that are adjacent to the bands that the system is configured for.

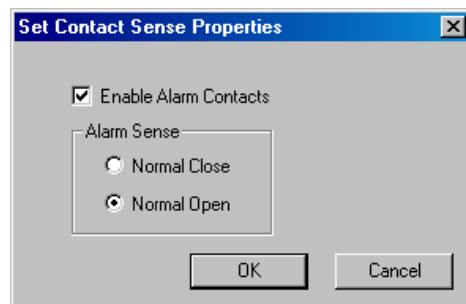
Table 7-2 Frequency Bands Adjacent to System Configured Bands

System Configuration	Adjacent Bands
iDEN	Cellular
Cellular	iDEN
PCS AD	PCS B
PCS DB	PCS A, PCS E
PCS BE	PCS D, PCS F
PCS EF	PCS B, PCS C
PCS FC	PCS E
GSM	–
EGSM	–
DCS 1	DCS 2
DCS 2	DCS 1, DCS 3
DCS 3	–
UMTS 1	UMTS 2, UMTS 3
UMTS 2	UMTS 1, UMTS 3
UMTS 3	UMTS 1, UMTS 2

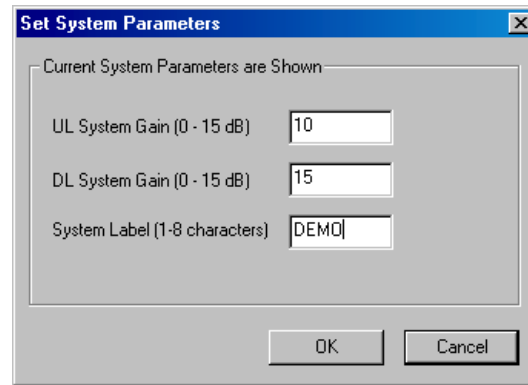
- **Clear All Disconnect Status:** clears a port disconnect fault when an Expansion Hub or an RAU is disconnected and will not be re-connected.
- **Command Unit In-Service:** returns a unit to service that was previously removed from service; restores a component to the system's alarm monitoring; displays the unit lock, unit not system tested, or normal operation icon.
- **Command Unit Out-of-Service:** removes a unit, and all of its downstream units, from service, there is no RF transmission; lets you temporarily remove a component from the system's alarm monitoring; displays unit "lock" icon.
- **Set Callback Number:** displays a dialog box in which you enter the phone number that the system uses to communicate with OpsConsole users. You can use up to 64 characters: 0 through 9, and the comma (,) for a pause. Leave the field blank if you do not want the unit to call out. Refer to your modem documentation for other characters that you can use. To disable callback, leave the text box empty.



- **Set Contact Sense Properties:** enables/disables the external sensing of either normally open or normally closed contact closures; displays "contact sense alarm" or "contact sense okay" icon.



- **Set System Parameters:** displays a dialog box from which you select uplink and downlink gain settings, and/or specify a system label. If the system label text box is left empty, the System Status tree displays the default label “1”.

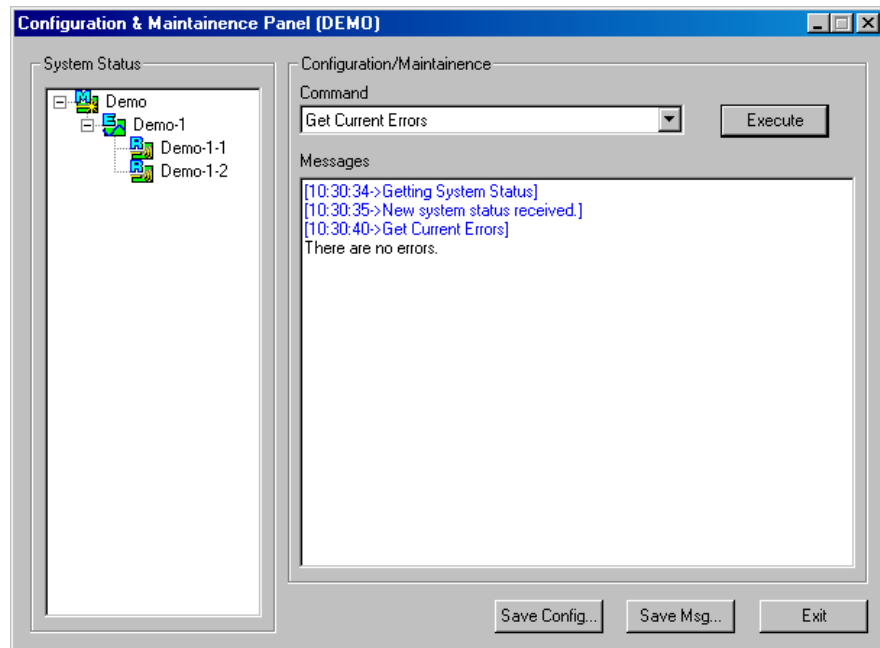


- **System Test:** An end-to-end RF path functional test that includes cable length estimation and system gain refinement is performed during the system test. System operation is suspended while the test is being performed. For a fully loaded system (one Main Hub, four Expansion Hubs, and 32 RAUs), it can take 1.5 minutes to complete the test.

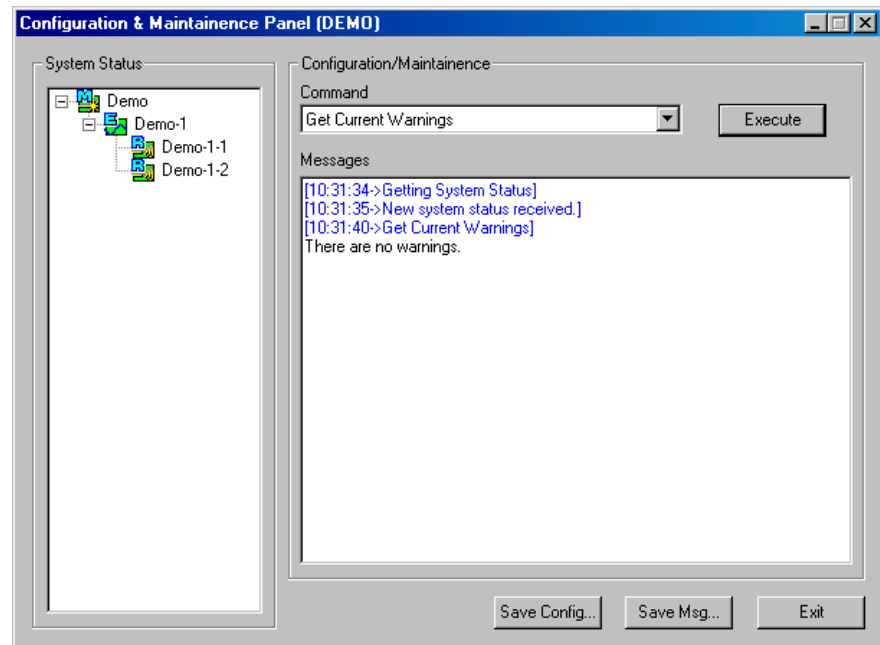
7.3.3 Read-Only Options when Connected Remotely

You can only choose read-only options and view system status when you are remotely connected to the Main Hub. You cannot set parameters or change system configuration remotely. (See Table 7-1 on page 7-26.)

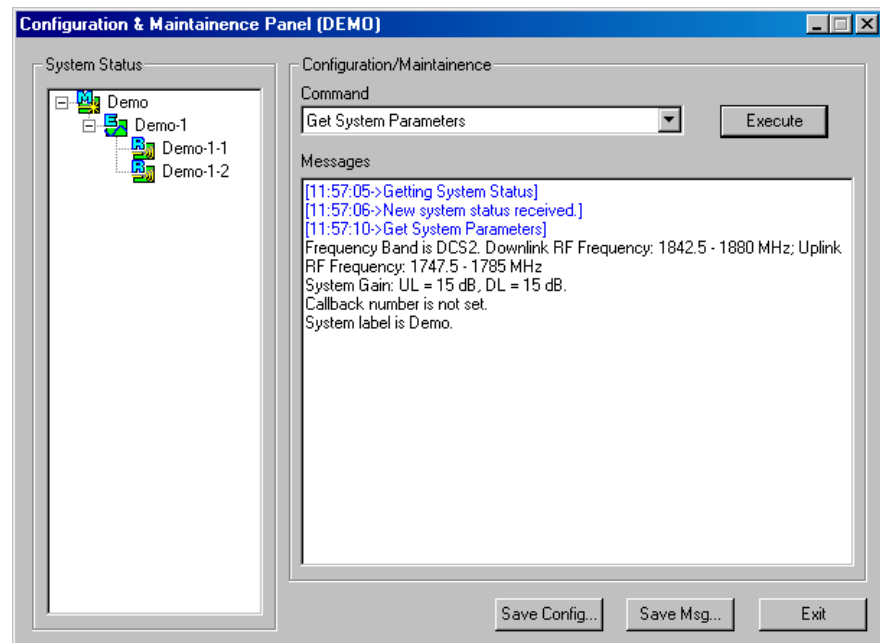
- **Get Current Errors:** displays the highest priority error with a recommendation for resolving it



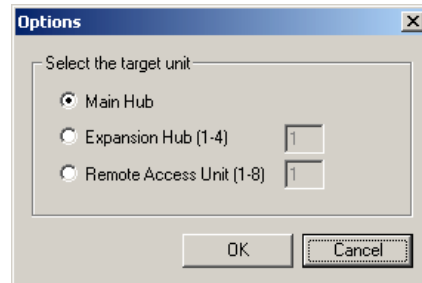
- **Get Current Warnings:** displays the highest priority warning with a recommendation for resolving it



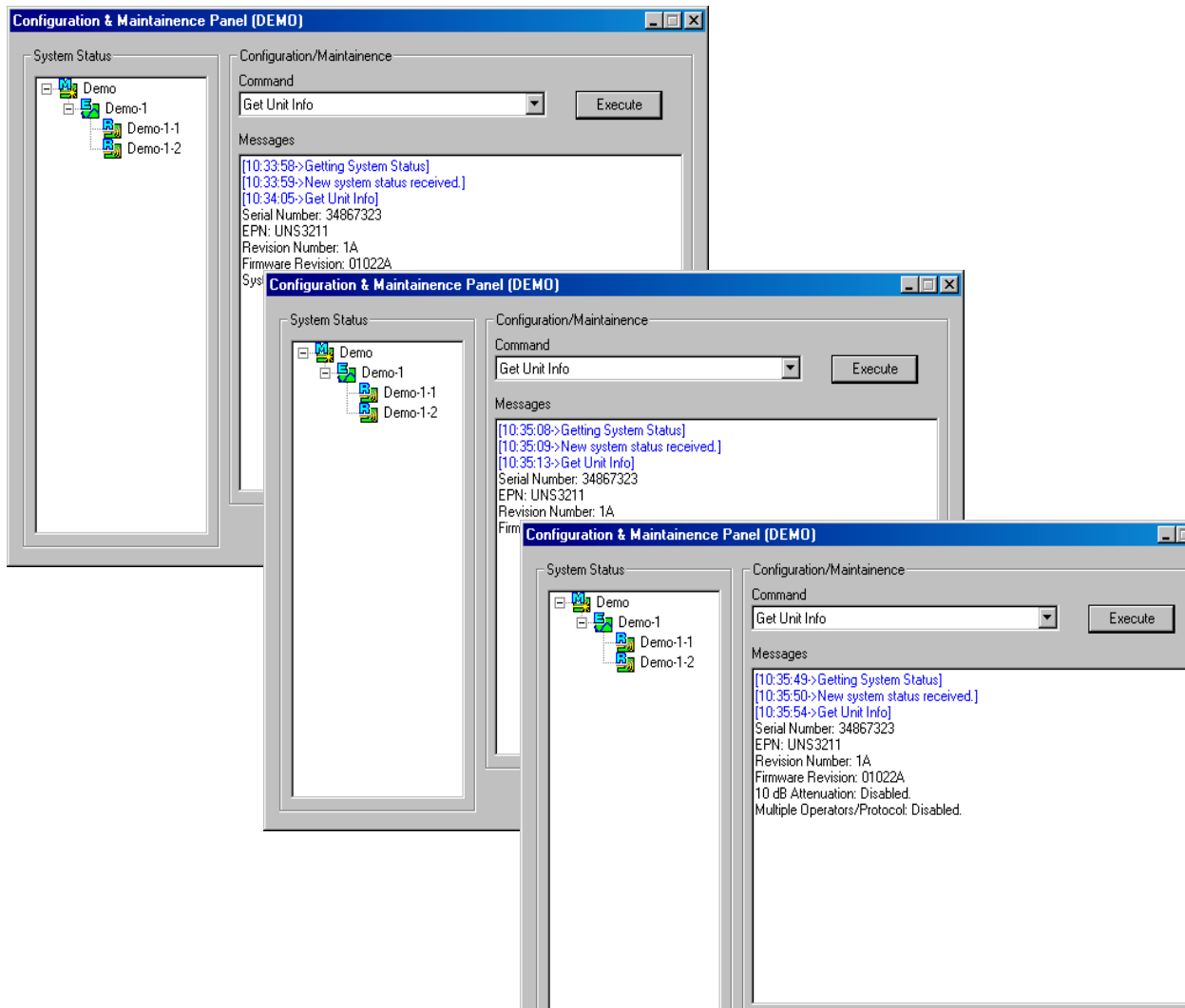
- **Get System Parameters:** displays the frequency band, callback number, uplink and downlink system gain, and system label



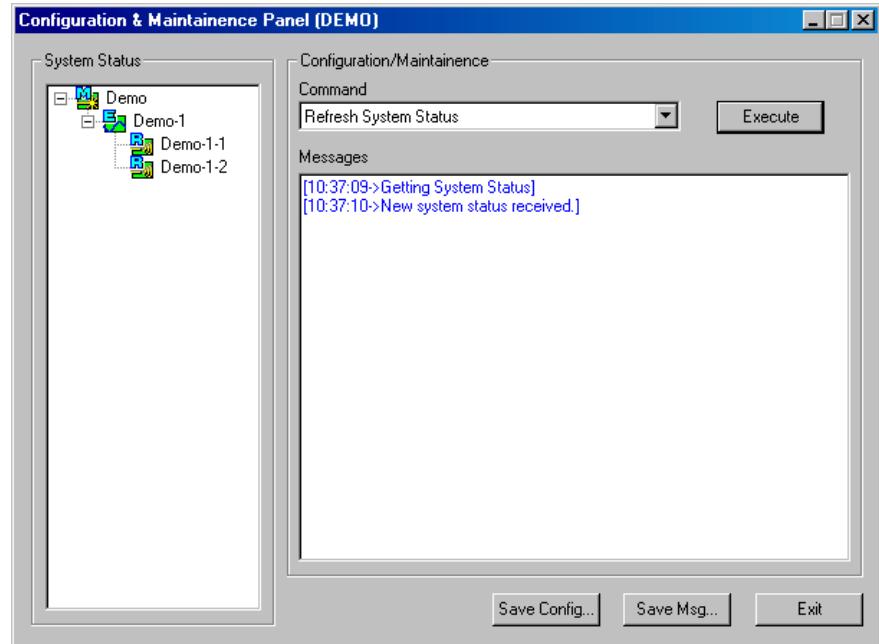
- **Get Unit Info:** displays the Options dialog box in which you select a unit.



Select a unit and click the OK button to display that unit's serial number, part number, revision number and firmware version. Additionally, the advanced settings for the RAU are displayed when RAU information is requested.



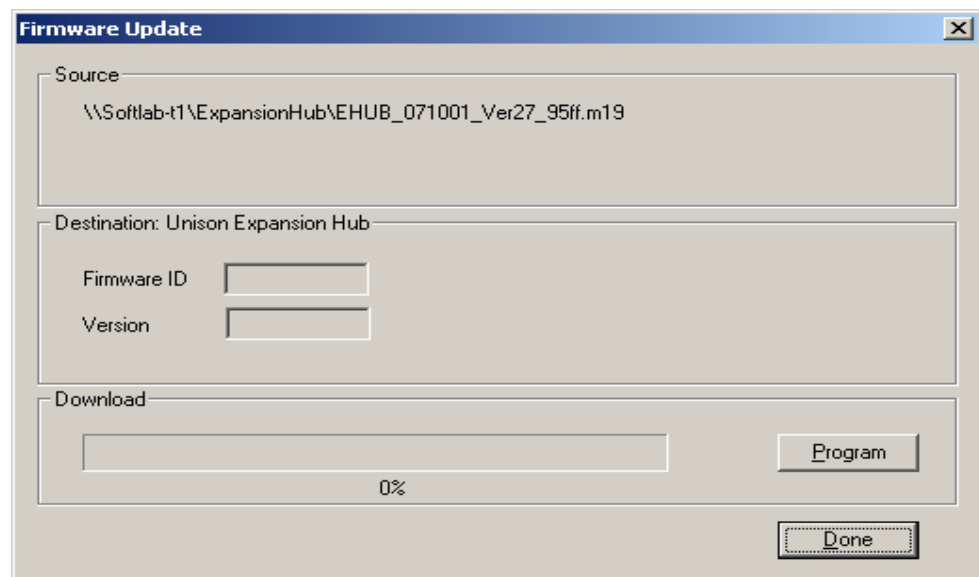
- **Refresh System Status:** requests system status and updates the System Status tree



7.4 Upgrading Firmware

The firmware update program automatically detects which unit the firmware is intended for and displays the firmware ID and version number in the Firmware Update window, as shown in the following figure.

Figure 7-9 Firmware Update Window



✓ Updating Firmware

1. Copy the firmware program to the PC.
2. Start AdminManager and select the Firmware Update radio button on the Start window, and then click run.
An Open File dialog box is displayed.
3. Choose the .m19 file you want to open from the Open File dialog box and click OPEN.
The firmware ID and version number are displayed in the Firmware Update window.
4. Click the PROGRAM button to start the download.
This button changes to CANCEL during the download, click it to stop the firmware update.
5. Click the DONE button.
This button is enabled when the download is completed.

7.5 System Status Tree

A hierarchical tree of the detected system components is displayed in the System Status pane.

7.5.1 System Status Tree Icons

The following table shows the icons that may appear in the System Status tree.

Table 7-3 System Status Tree Icons

Icon	Description
	Main Hub normal operation
	Main Hub fault
	Main Hub lock (unit and all downstream units are out-of-service)
	Main Hub has not been system tested
	Main Hub warning
	Expansion Hub normal operation
	Expansion Hub fault
	Expansion Hub lock (unit and all downstream RAUs are out-of-service)
	Expansion Hub has not been system tested
	Expansion Hub warning
	RAU normal operation
	RAU fault
	RAU lock
	RAU has not been system tested
	RAU warning
	No communication
	Contact sense alarm
	Contact sense okay

Designing a Unison Solution

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

1. Determine the wireless service provider's requirements.

This information is usually supplied by the service provider:

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

The design goal is always a stronger signal than the cell phone needs. It includes inherent factors which will affect performance (see Section 8.4.1 on page 8-33).

- RF source (base station or BDA), type of equipment if possible

2. Determine the power per carrier and input power from the base station or BDA into the Main Hub: Section 8.1, "Maximum Output Power per Carrier at RAU," on page 8-3.

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

3. Determine the in-building environment: Section 8.2, "Estimating RF Coverage," on page 8-19.

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

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

4. Develop an RF link budget: Section 8.4, “Link Budget Analysis,” on page 8-32.

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

5. Determine the appropriate estimated path loss slope that corresponds to the type of building and its layout, and estimate the coverage distance for each RAU: Section 8.2, “Estimating RF Coverage,” on page 8-19.

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

6. Determine the items required to connect to the base station: Section 8.6, “Connecting a Main Hub to a Base Station,” on page 8-46.

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

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

8.1 Maximum Output Power per Carrier at RAU

The following tables show the recommended maximum power per carrier out of the RAU SMA connector for different frequencies, formats, and numbers of carriers. These limits are dictated by RF signal quality and regulatory emissions issues. The maximum input power to the Main Hub is determined by subtracting the system gain from the maximum output power of the RAU. System gain is software selectable from 0 dB to 15 dB in 1 dB steps. Additionally, both the uplink and downlink RAU gain can be reduced by 10 dB.

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

Refer to Section 8.7, "Designing for a Neutral Host System," on page 8-50 when combining frequencies or protocols on a single Main Hub.



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

Table 8-1 800 MHz (AMPS) Power per Carrier

No. of Carriers	Power per Carrier (dBm)
1	10.0
2	10.0
3	10.0
4	10.0
5	10.0
6	10.5
7	9.5
8	8.5
9	8.0
10	7.0
11	7.0
12	6.5
13	6.0
14	5.5
15	5.5
16	5.0
20	4.0
30	2.0



WARNING: For 800 MHz AMPS, do not exceed the maximum composite input power of 1W (+30 dBm) to the Main Hub at any time.

Table 8-2 800 MHz (TDMA) Power per Carrier

No. of Carriers	Power per Carrier (dBm)
1	10.0
2	10.0
3	10.0
4	10.0
5	10.0
6	10.0
7	9.5
8	8.5
9	8.0
10	7.5
11	7.0
12	6.5
13	6.5
14	6.0
15	5.5
16	5.5
20	4.5
30	2.5



WARNING: For 800 MHz TDMA, do not exceed the maximum composite input power of 1W (+30 dBm) to the Main Hub at any time.

Table 8-3 800 MHz (CDMA) Power per Carrier

No. of Carriers	Power per Carrier (dBm)
1	16.0
2	13.5
3	12.0
4	11.0
5	10.0
6	9.5
7	8.5
8	8.0



WARNING: For 800 MHz CDMA, do not exceed the maximum composite input power of 1W (+30 dBm) to the Main Hub at any time.

Table 8-4 800 MHz (iDEN) Power per Carrier

No. of Carriers	Power per Carrier (dBm)
1	10.0
2	10.0
3	10.0
4	10.0
5	9.0
6	8.0
7	7.0
8	6.5
9	6.0
10	5.5
11	5.0
12	4.5
13	4.0
14	4.0
15	3.5
16	3.0
20	2.0
30	0.5



WARNING: For 800 MHz iDEN, do not exceed the maximum composite input power of 1W (+30 dBm) to the Main Hub at any time.

Table 8-5 900 MHz (GSM or EGSM) Power per Carrier

No. of Carriers	Power per Carrier (dBm)
1	10.0
2	10.0
3	10.0
4	10.0
5	9.0
6	8.5
7	8.0
8	7.5
9	7.0
10	6.5
11	6.5
12	6.0
13	5.5
14	5.5
15	5.0
16	5.0



WARNING: For 900 MHz GSM or EGSM, do not exceed the maximum composite input power of 1W (+30 dBm) to the Main Hub at any time.

Table 8-6 900 MHz (EDGE) Power per Carrier

No. of Carriers	Power per Carrier (dBm)
1	10.0
2	10.0
3	10.0
4	10.0
5	9.0
6	8.5
7	8.0
8	7.5
9	7.0
10	6.5
11	6.5
12	6.0
13	5.5
14	5.5
15	5.0
16	5.0



WARNING: For 900 MHz EDGE, do not exceed the maximum composite input power of 1W (+30 dBm) to the Main Hub at any time.

Table 8-7 1800 MHz (DCS) Power per Carrier

No. of Carriers	Power per Carrier (dBm)
1	10.0
2	10.0
3	10.0
4	10.0
5	10.0
6	9.5
7	8.5
8	7.5
9	7.0
10	6.5
11	6.0
12	5.5
13	5.0
14	5.0
15	4.5
16	4.0



WARNING: For 1800 MHz DCS, do not exceed the maximum composite input power of 1W (+30 dBm) to the Main Hub at any time.

Table 8-8 1800 MHz (EDGE) Power per Carrier

No. of Carriers	Power per Carrier (dBm)
1	10.0
2	10.0
3	10.0
4	10.0
5	9.0
6	8.0
7	7.5
8	6.5
9	6.0
10	5.5
11	5.0
12	4.5
13	4.5
14	4.0
15	3.5
16	3.5



WARNING: For 1800 MHz EDGE, do not exceed the maximum composite input power of 1W (+30 dBm) to the Main Hub at any time.

Table 8-9 1800 MHz (CDMA Korea) Power per Carrier

No. of Carriers	Power per Carrier (dBm)
1	14.5
2	12.0
3	10.5
4	9.5
5	8.5
6	8.0
7	7.0
8	6.5



WARNING: For 1800 MHz CDMA (Korea), do not exceed the maximum composite input power of 1W (+30 dBm) to the Main Hub at any time.

Table 8-10 1900 MHz (TDMA) Power per Carrier

No. of Carriers	Power per Carrier (dBm)
1	10.0
2	10.0
3	10.0
4	10.0
5	10.0
6	9.0
7	8.0
8	7.0
9	6.5
10	6.0
11	5.5
12	5.0
13	5.0
14	4.5
15	4.0
16	4.0
20	3.0
30	1.0



WARNING: For 1900 MHz TDMA, do not exceed the maximum composite input power of 1W (+30 dBm) to the Main Hub at any time.

Table 8-11 1900 MHz (GSM) Power per Carrier

No. of Carriers	Power per Carrier (dBm)
1	10.0
2	10.0
3	10.0
4	10.0
5	10.0
6	9.5
7	8.5
8	7.5
9	7.0
10	6.5
11	6.0
12	5.5
13	5.0
14	5.0
15	4.5
16	4.0



WARNING: For 1900 MHz GSM, do not exceed the maximum composite input power of 1W (+30 dBm) to the Main Hub at any time.

Table 8-12 1900 MHz (CDMA) Power per Carrier

No. of Carriers	Power per Carrier (dBm)
1	14.5
2	12.0
3	10.5
4	9.5
5	8.5
6	8.0
7	7.0
8	6.5



WARNING: For 1900 MHz CDMA, do not exceed the maximum composite input power of 1W (+30 dBm) to the Main Hub at any time.

Table 8-13 1900 MHz (EDGE) Power per Carrier

No. of Carriers	Power per Carrier (dBm)
1	10.0
2	10.0
3	10.0
4	10.0
5	9.0
6	8.0
7	7.5
8	6.5
9	6.0
10	5.5
11	5.0
12	4.5
13	4.5
14	4.0
15	3.5
16	3.5



WARNING: For 1900 MHz EDGE, do not exceed the maximum composite input power of 1W (+30 dBm) to the Main Hub at any time.

Table 8-14 2.1 GHz (WCDMA) Power per Carrier

No. of Carriers	Power per Carrier (dBm)
1	14.5
2	11.0
3	8.5
4	7.0
5	6.0
6	5.0
7	4.5
8	3.5



WARNING: For 2.1 GHz WCDMA, do not exceed the maximum composite input power of 1W (+30 dBm) to the Main Hub at any time.

Allowing for Future Capacity Growth

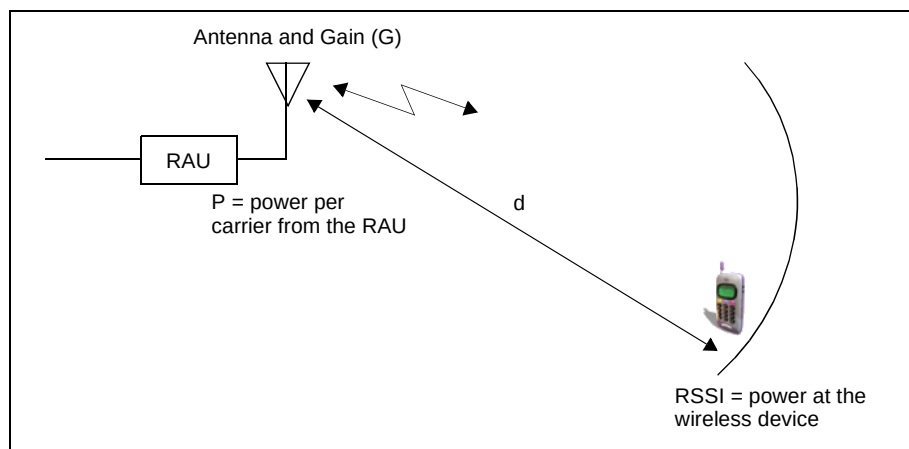
Sometimes a Unison deployment initially is used to enhance coverage. Later that same system may also need to provide increased capacity. Thus, the initial deployment might only transmit two carriers but need to transmit four carriers later. There are two options for dealing with this scenario:

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

8.2 Estimating RF Coverage

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

Figure 8-1 Determining Path Loss between the Antenna and the Wireless Device



$$(P + L_{\text{coax}} + G) - \text{RSSI} = \text{PL} \quad (1)$$

The path loss (PL) is the loss in decibels (dB) between the antenna and the wireless device. The distance, d , from the antenna corresponding to this path loss can be calculated using the path loss equations in Section 8.2.1 and in Section 8.2.2.

The following table lists coaxial cable loss.

Table 8-15 Coaxial Cable Losses

Length of Cable	Loss at 800 MHz (dB)	Loss at 1900 MHz (dB)
0.9 m (3 ft)	0.4	0.6
1.8 m (6 ft)	0.9	1.4
3.0 m (10 ft)	1.5	2.4

8.2.1 Path Loss Equation

Indoor path loss obeys the distance power law¹ in equation (2):

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

where:

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

As a reference, the following table gives estimates of signal loss for some RF barriers.¹

Table 8-16 Average Signal Loss of Common Building Materials

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

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

8.2.2 Coverage Distance

Equations (1) and (2), on pages 8-19 and 8-20, respectively, can be used to estimate the distance from the antenna to where the RF signal decreases to the minimum acceptable level at the wireless device.

Equation (2) can be simplified to:

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

where PLS (path loss slope) is chosen to account for the building's environment. Because different frequencies penetrate partitions with different losses, the value of PLS will vary depending on the frequency.

Table 8-17 shows estimated path loss slope (PLS) for various environments that have different "clutter" (i.e., objects that attenuate the RF signals, such as walls, partitions, stairwells, equipment racks, etc.)

Table 8-17 Estimated Path Loss Slope for Different In-Building Environments

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

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

Table 8-18 gives the value of the first term of Equation (3) (i.e., $(20\log(4\pi f/c))$) for various frequency bands.

Table 8-18 Frequency Bands and the Value of the first Term in Equation (3)

	Band (MHz)		Mid-Band Frequency (MHz)	$20\log(4\pi f/c)$
	Uplink	Downlink		
800 MHz Cellular	824–849	869–894	859	31.1
800 MHz iDEN	806–824	851–869	837.5	30.9
900 MHz GSM	890–915	935–960	925	31.8
900 MHz EGSM	880–915	925–960	920	31.7
1800 MHz DCS	1710–1785	1805–1880	1795	37.5
1800 MHz CDMA (Korea)	1750–1780	1840–1870	1810	37.6
1900 MHz PCS	1850–1910	1930–1990	1920	38.1
2.1 GHz UMTS	1920–1980	2110–2170	2045	38.7

For reference, Tables 8-19 through 8-25 show the distance covered by an antenna for various in-building environments. The following assumptions were made:

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

Table 8-19 Approximate Radiated Distance from Antenna for 800 MHz Cellular Applications

Facility	Distance from Antenna	
	Meters	Feet
Manufacturing	63	205
Hospital	39	129
Airport	63	205
Retail	55	181
Warehouse	63	205
Parking Garage	73	241
Office: 80% cubicle/20% hard wall	55	181
Office: 50% cubicle/50% hard wall	47	154
Office: 20% cubicle/80% hard wall	39	129

Table 8-20 Approximate Radiated Distance from Antenna for 800 MHz iDEN Applications

Facility	Distance from Antenna	
	Meters	Feet
Manufacturing	64	208
Hospital	40	131
Airport	64	208
Retail	56	184
Warehouse	64	208
Parking Garage	75	244
Office: 80% cubicle/20% hard wall	56	184
Office: 50% cubicle/50% hard wall	48	156
Office: 20% cubicle/80% hard wall	40	131

Table 8-21 Approximate Radiated Distance from Antenna for 900 MHz GSM Applications

Facility	Distance from Antenna	
	Meters	Feet
Manufacturing	60	197
Hospital	38	125
Airport	60	197
Retail	53	174
Warehouse	60	197
Parking Garage	70	230
Office: 80% cubicle/20% hard wall	53	174
Office: 50% cubicle/50% hard wall	45	148
Office: 20% cubicle/80% hard wall	38	125

Table 8-22 Approximate Radiated Distance from Antenna for 900 MHz EGSM Applications

Facility	Distance from Antenna	
	Meters	Feet
Manufacturing	60	197
Hospital	38	125
Airport	60	197
Retail	53	174
Warehouse	60	197
Parking Garage	70	231
Office: 80% cubicle/20% hard wall	53	174
Office: 50% cubicle/50% hard wall	45	149
Office: 20% cubicle/80% hard wall	38	125

Table 8-23 Approximate Radiated Distance from Antenna for 1800 MHz DCS Applications

Facility	Distance from Antenna	
	Meters	Feet
Manufacturing	58	191
Hospital	30	100
Airport	58	191
Retail	51	167
Warehouse	58	191
Parking Garage	75	246
Office: 80% cubicle/20% hard wall	50	166
Office: 50% cubicle/50% hard wall	42	137
Office: 20% cubicle/80% hard wall	30	100

Table 8-24 Approximate Radiated Distance from Antenna for 1800 MHz CDMA (Korea) Applications

Facility	Distance from Antenna	
	Meters	Feet
Manufacturing	58	191
Hospital	30	100
Airport	58	191
Retail	51	167
Warehouse	58	191
Parking Garage	75	247
Office: 80% cubicle/20% hard wall	51	167
Office: 50% cubicle/50% hard wall	42	138
Office: 20% cubicle/80% hard wall	30	100

Table 8-25 Approximate Radiated Distance from Antenna for 1900 MHz PCS Applications

Facility	Distance from Antenna	
	Meters	Feet
Manufacturing	56	183
Hospital	29	96
Airport	56	183
Retail	49	160
Warehouse	56	183
Parking Garage	72	236
Office: 80% cubicle/20% hard wall	49	160
Office: 50% cubicle/50% hard wall	40	132
Office: 20% cubicle/80% hard wall	29	96

Table 8-26 Approximate Radiated Distance from Antenna for 2.1 GHz UMTS Applications

Facility	Distance from Antenna	
	Meters	Feet
Manufacturing	54	176
Hospital	28	93
Airport	54	176
Retail	47	154
Warehouse	54	176
Parking Garage	69	226
Office: 80% cubicle/20% hard wall	47	154
Office: 50% cubicle/50% hard wall	39	128
Office: 20% cubicle/80% hard wall	28	93

8.2.3 Examples of Design Estimates

Example Design Estimate for an 800 MHz TDMA Application

1. Design goals:

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

2. Power Per Carrier: The tables in Section 8.1, “Maximum Output Power per Carrier at RAU,” on page 8-3 provide maximum power per carrier information. The 800 MHz TDMA table (on page 8-5) indicates that Unison can support 6 carriers with a recommended maximum power per carrier of 10.5 dBm. The input power should be set to the desired output power minus the system gain.

3. Building information:

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

4. Link Budget: In this example, a design goal of -85 dBm is used. Suppose 3 dBi omni-directional antennas are used in the design. Then, the maximum RF propagation loss should be no more than 98.5 dB (10.5 dBm + 3 dBi + 85 dBm) over 95% of the area being covered. *It is important to note that a design goal such as -85 dBm is usually derived taking into account multipath fading and log-normal shadowing characteristics. Thus, this design goal will only be met “on average” over 95% of the area being covered. At any given point, a fade may bring the signal level underneath the design goal.*

Note that this method of calculating a link budget is only for the downlink path. For information to calculate link budgets for both the downlink and uplink paths, see Section 8.4 on page 8-32.

5. Path Loss Slope: For a rough estimate, Table 8-17, “Estimated Path Loss Slope for Different In-Building Environments” on page 8-21, shows that a building with 50% hard wall offices and 50% cubicles, at 859 MHz, has an approximate path loss slope (PLS) of 37.6. Given the RF link budget of 98.5 dB, the distance of coverage from each RAU will be 62 meters (203 ft). This corresponds to a coverage area of 12,079 sq. meters (129,952 sq. ft.) per RAU (see Section 8.2.1 for details on path loss estimation). For this case we assumed a circular radiation pattern, though the actual area covered will depend upon the pattern of the antenna and the obstructions in the facility.

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

- a. 1 antenna per floor $\times$ 8 floors = 8 RAUs
- b. 8 RAUs $\div$ 8 (max 8 RAUs per Expansion Hub) = 1 Expansion Hub
- c. 1 Expansion Hubs $\div$ 4 (max 4 Expansion Hubs per Main Hub) = 1 Main Hub

Check that the MMF and Cat-5 cable distances are as recommended. If the distances differ, use the tables in Section 8.3, “System Gain,” on page 8-31 to determine system gains or losses. The path loss may need to be recalculated to assure adequate signal levels in the required coverage distance.

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

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

Example Design Estimate for an 1900 MHz CDMA Application

1. Design goals:

- PCS (1920 MHz = average of the lowest uplink and the highest downlink frequency in 1900 MHz PCS band)
- CDMA provider
- 8 CDMA carriers in the system
- -85 dBm design goal (to 95% of the building) — the minimum received power at the wireless device
- Base station with simplex RF connections

2. Power Per Carrier: The tables in Section 8.1, “Maximum Output Power per Carrier at RAU,” on page 8-3 provide maximum power per carrier information. The 1900 MHz CDMA table (on page 8-15) indicates that Unison can support 8 carriers with a recommended maximum power per carrier of 6.5 dBm. The input power should be set to the desired output power minus the system gain.

3. Building information:

- 16 floor building with 9,290 sq. meters (100,000 sq. ft.) per floor; total 148,640 sq. meters (1,600,000 sq. ft.)
- Walls are sheetrock construction; suspended ceiling tiles
- Antennas used will be omni-directional, ceiling mounted
- Standard office environment, 80% hard wall offices and 20% cubicles

4. Link Budget: In this example, a design goal of -85 dBm is used. Suppose 3 dBi omni-directional antennas are used in the design. Then, the maximum RF propagation loss should be no more than 94.5 dB (6.5 dBm + 3 dBi + 85 dBm) over 95% of the area being covered. *It is important to note that a design goal such as -85 dBm is usually derived taking into account multipath fading and log-normal shadowing characteristics. Thus, this design goal will only be met “on average” over 95% of the area being covered. At any given point, a fade may bring the signal level underneath the design goal.*

Note that this method of calculating a link budget is only for the downlink path. For information to calculate link budgets for both the downlink and uplink paths, see Section 8.4 on page 8-32.

5. Path Loss Slope: For a rough estimate, Table 8-17, “Estimated Path Loss Slope for Different In-Building Environments” on page 8-21, shows that a building with 80% hard wall offices and 20% cubicles, at 1920 MHz, has an approximate path loss slope (PLS) of 38.1. Given the RF link budget of 94.5 dB, the distance of coverage from each RAU will be 50 meters (166 ft). This corresponds to a coverage area of 8,031 sq. meters (86,404 sq. ft.) per RAU (see Section 8.2.1 for details on path loss estimation). For this case we assumed a circular radiation pattern, though the actual area covered will depend upon the pattern of the antenna and the obstructions in the facility.

6. **Equipment Required:** Since you know the building size, you can now estimate the Unison equipment quantities that will be needed. Before any RF levels are tested in the building, you can estimate that 2 antennas per level will be needed.
- a. 2 antennas per floor $\times$ 16 floors = 32 RAUs
 - b. $32 \text{ RAUs} \div 8 \text{ (max 8 RAUs per Expansion Hub)} = 4 \text{ Expansion Hubs}$
 - c. $4 \text{ Expansion Hubs} \div 4 \text{ (max 4 Expansion Hubs per Main Hub)} = 1 \text{ Main Hub}$

Check that the MMF and Cat-5 cable distances are as recommended. If the distances differ, use the tables in Section 8.3, "System Gain," on page 8-31 to determine system gains or losses. The path loss may need to be recalculated to assure adequate signal levels in the required coverage distance.

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

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

8.3 System Gain

The system gain can be decreased from 15 dB to 0 dB gain in 1 dB increments and the uplink and downlink gain of any RAU can be decreased by 10 dB in one step using AdminManager or OpsConsole.

8.3.1 System Gain (Loss) Relative to ScTP Cable Length

The recommended minimum length of ScTP cable is 20 meters (66 ft) and the recommended maximum length is 100 meters (328 ft). If the ScTP cable is less than 10 meters (33 ft), system performance may not meet specifications. If the ScTP cable is longer than 100 meters (328 ft), the gain of the system will decrease, as shown in Table 8-27.

Table 8-27 System Gain (Loss) Relative to ScTP Cable Length

ScTP Cable Length	Typical change in system gain (dB)	
	Downlink	Uplink
800 MHz TDMA/AMPS and CDMA; 900 MHz GSM and EGSM; and iDEN		
110 m / 361 ft	-1.0	-0.7
120 m / 394 ft	-3.2	-2.4
130 m / 426 ft	-5.3	-4.1
140 m / 459 ft	-7.5	-5.8
150 m / 492 ft	-9.7	-7.6
1800 MHz GSM (DCS); 1900 MHz TDMA, CDMA, and GSM		
110 m / 361 ft	-1.0	-0.7
120 m / 394 ft	-4.0	-2.4
130 m / 426 ft	-6.4	-4.1
140 m / 459 ft	-8.8	-5.8
150 m / 492 ft	-11.3	-7.6
2.1 GHz UMTS		
110 m / 361 ft	-1.0	-0.7
120 m / 394 ft	-3.2	-2.4
130 m / 426 ft	-5.3	-4.1
140 m / 459 ft	-7.5	-5.8
150 m / 492 ft	-9.7	-7.6

8.4 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 8.1. 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 1W (+30 dBm). Composite power levels above this limit will cause damage to the Main Hub.



WARNING: Exceeding the maximum input power of 1W (+30 dBm) could cause permanent damage to the Main Hub.

8.4.1 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 a Unison 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 8.2.1.

Table 8-28 provides link budget considerations for narrowband systems.

Table 8-28 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 Unison	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 8.1. 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 Unison 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 Unison alone. See Section 8.6 for ways to independently set the uplink and downlink attenuations between the base station and Unison.
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).
Unison Noise Figure	This is Unison’s uplink noise figure, which varies depending on the number of Expansion Hubs and RAUs, and the frequency band. Unison’s uplink noise figure is specified for a 1-1-4 configuration. Thus, the noise figure for a Unison system (or multiple systems whose uplink ports are power combined) will be $NF(1-1-4) + 10 \cdot \log(\# \text{ of Expansion Hubs})$. This represents an upper-bound because the noise figure is lower if any of the Expansion Hub’s RAU ports are not used.

Table 8-28 Link Budget Considerations for Narrowband Systems (continued)

Consideration	Description												
Thermal Noise	This is the noise level in the signal bandwidth (BW). Thermal noise power = $-174 \text{ dBm/Hz} + 10\text{Log}(\text{BW})$. <table><tr><th>Protocol</th><th>Signal Bandwidth</th><th>Thermal Noise</th></tr><tr><td>TDMA</td><td>30 kHz</td><td>-129 dBm</td></tr><tr><td>GSM</td><td>200 kHz</td><td>-121 dBm</td></tr><tr><td>iDEN</td><td>25 kHz</td><td>-130 dBm</td></tr></table>	Protocol	Signal Bandwidth	Thermal Noise	TDMA	30 kHz	-129 dBm	GSM	200 kHz	-121 dBm	iDEN	25 kHz	-130 dBm
Protocol	Signal Bandwidth	Thermal Noise											
TDMA	30 kHz	-129 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.												

8.4.2 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 Unison (dB)	-23
c.	Power into Unison (dBm)	10
d.	Unison gain (dB)	0
e.	Antenna gain (dBi)	3
f.	Radiated power per carrier (dBm)	13
	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)	104

- $c = a + b$
- $f = c + d + e$
- $j = g + h + i$
- $n = k + l + m$
- 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 Unison (dB) -10
c.	Unison gain (dB) 0
d.	Unison noise figure (dB) 1-4-32 22
e.	System noise figure (dB) 22.6
f.	Thermal noise (dBm/30 kHz) -129
g.	Required C/I ratio (dB) 12
h.	Antenna gain (dBi) 3
i.	Receive sensitivity (dBm) -97.4
	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) 106.4

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

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

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

8.4.3 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 8-29 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 Main Hub 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-hand-off 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 8-30 on page 8-38). The difference between these power levels, Δ_P , can be estimated by comparing the power radiated from the RAU, $P_{downlink}$, to the minimum received signal, P_{uplink} , at the RAU:

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

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

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

Table 8-30 provides link budget considerations for CDMA systems.

Table 8-30 Additional Link Budget Considerations for CDMA

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 $5\mu\text{S/km}$. If the difference in fiber lengths to Expansion Hubs with overlapping coverage areas produces at least 1 chip ($0.8\mu\text{S}$) 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 Unison system is being driven. The total power for a fully-loaded CDMA signal is given by (approximately): $\text{total power} = \text{voice channel power} + 13 \text{ dB} + 10\log_{10}(50\%)$ $= \text{voice channel power} + 10 \text{ dB}$
Information Rate	This is simply $10\log_{10}(9.6 \text{ Kbps}) = 40 \text{ dB for rate set 1}$ $10\log_{10}(14.4 \text{ Kbps}) = 42 \text{ dB for rate set 2}$
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: $P_G = 10\log_{10}(1.25 \text{ MHz} / 9.6 \text{ Kbps}) = 21 \text{ dB rate set 1}$ $P_G = 10\log_{10}(1.25 \text{ MHz} / 14.4 \text{ Kbps}) = 19 \text{ dB rate set 2}$ Note that the process gain can also be expressed as $10\log_{10}(\text{CDMA bandwidth})$ minus the information rate.

Table 8-30 Additional Link Budget Considerations for CDMA (continued)

Consideration	Description
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: $P_{\text{sensitivity}} = NF + E_b/N_o + \text{thermal noise in a 1.25 MHz band} - P_G$ $= NF + E_b/N_o - 113 \text{ (dBm/1.25 MHz)} - P_G$
Noise Rise	On the uplink, the noise floor is determined not only by the Unison system, 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: $\text{noise rise} = 10 \log_{10}(1 / (1 - \text{loading}))$ where <i>loading</i> 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 a Unison system. 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.

8.4.4 Spread Spectrum Link Budget Analysis for a Microcell Application

Spread Spectrum Link Budget Analysis: Downlink

Line	Downlink	
	Transmitter	
a.	BTS transmit power per traffic channel (dBm)	30.0
b.	Voice activity factor	50%
c.	Composite power (dBm)	40.0
d.	Attenuation between BTS and Unison (dB)	-24
e.	Power per channel into Unison (dBm)	9.0
f.	Composite power into Unison (dBm)	16.0
g.	Unison gain (dB)	0.0
h.	Antenna gain (dBi)	3.0
i.	Radiated power per channel (dBm)	12.0
j.	Composite radiated power (dBm)	19.0
	Airlink	
k.	Handoff gain (dB)	0.0
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 $E_b/(N_o + I_o)$	7.0
v.	Receive Sensitivity (dBm)	-118.4
w.	Minimum received signal (dBm)	-99.4
x.	Maximum path loss (dB)	-99.4

- b and c: see notes in Table 8-30 regarding power per carrier, downlink
- $e = a + d$
- $f = c + d$
- $i = e + g + h$
- $j = f + g + h$
- $p = -k + l + m + n + o$
- $s = q + r$
- $v = s + t + u$
- $w = p + v$
- $x = j - w$
- $y = j \text{ (downlink)} + m \text{ (uplink)} + P$

where

$$P = P_{tx} + P_{rx} = \begin{array}{l} -73 \text{ dB for Cellular} \\ -76 \text{ dB for PCS} \end{array}$$

Spread Spectrum Link Budget Analysis: Uplink

Line	Uplink	
	Receiver	
a.	BTS noise figure (dB)	3.0
b.	Attenuation between BTS and Unison (dB)	-30.0
c.	Unison gain (dB)	0.0
d.	Unison noise figure (dB)	22.0
e.	System noise figure (dB)	33.3
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 $E_b/(N_0 + I_0)$	5.0
k.	Handoff gain (dB)	0.0
l.	Antenna gain (dBi)	3.0
m.	Minimum received signal (dBm)	-91.1
	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.	Maximum path loss (dB)	100.1

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

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

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.)

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

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

The Unison 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 Unison 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.

8.5 Optical Power Budget

Unison uses SC/APC connectors. The connector losses associated with mating to these connectors is accounted for in the design and *should not* be included as elements of the optical power budget. The reason is that when the optical power budget is defined, measurements are taken with these connectors in place.

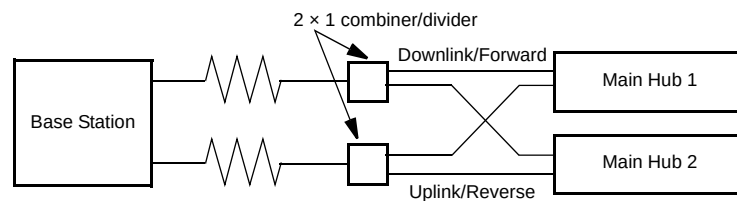
The Unison optical power budget for both multimode and single-mode fiber cable is 3.0 dB (optical).

The maximum loss through the fiber can not exceed 3 dB (optical). The maximum lengths of the fiber cable should not exceed 1.5 km (4,921 ft) for multimode and 6 km (19,685 ft) for single-mode. Both the optical budget and the maximum cable length must be taken into consideration when designing the system.

8.6 Connecting a Main Hub to a Base Station

The first consideration when connecting Unison 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 8-2 Connecting Main Hubs to a Simplex Base Station



When connecting a Unison Main Hub 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 8.1, “Maximum Output Power per Carrier at RAU,” on page 8-3.
2. The uplink attenuation should be small enough that the sensitivity of the overall system is limited by Unison, not by the attenuator. However, some base stations will trigger alarms if the noise or signal levels are too high. In this case the attenuation will have to be large enough to prevent this from happening.

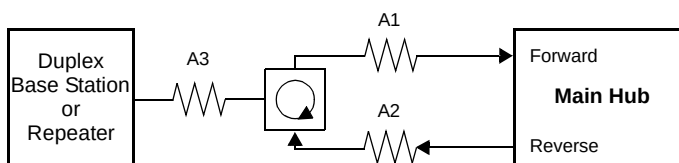
If, in an area covered by Unison, a mobile phone indicates good signal strength but consistently has difficulty completing calls, it is possible that the attenuation between Unison and the base station needs to be adjusted. In other words, it is possible that if the uplink is over-attenuated, the downlink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

When there is an excessive amount of loss between the Main Hub uplink and the base station, the uplink system gain can be increased to as much as 15 dB to prevent a reduction in the overall system sensitivity.

8.6.1 Attenuation

Figure 8-3 shows a typical setup wherein a duplex base station is connected to a Main Hub. 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 8-3 Main Hub 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 Unison. The IP3 at the Forward port input of the Main Hub is approximately +38 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 approximately +30 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 Unison system. For example, if the reverse port has a 0 dB gain and if there are 32 RAUs, the noise figure is approximately 22 dB. So A2+A3 should be about 10 dB. If A2+A3 is too large, the uplink coverage can be severely reduced.
- Given these three equations:
 $A1 < 30 \text{ dB}$
 $A1+A3 = 30 \text{ dB (in this example)}$
 $A2+A3 < 10 \text{ dB (in this example)}$
 we could choose A1=20 dB, A2=0 dB, A3=10 dB

8.6.2 Uplink Attenuation

The attenuation between the Main Hub's reverse port and the base station does two things:

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

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

For example, suppose we have a GSM Unison system consisting of one Main Hub, four Expansion Hubs, and 32 RAUs (1-4-32) with uplink NF=22 dB. (See Table 8-30 on page 8-38.) If we use 30 dB of attenuation between the Main Hub's reverse port and the base station (which has its own noise figure of about 4 dB), the overall noise figure will be 34.3 dB (refer to the formula on page 8-36) which is 12.3 dB worse than Unison by itself. That causes a 12.3 dB reduction in the uplink coverage distance. Now, if the attenuation instead is 10 dB, the cascaded noise figure is NF=22.6 dB, which implies that the uplink sensitivity is limited by Unison, a desirable condition.

Rule of Thumb

A good rule of thumb is to set the uplink attenuation, A2+A3 in Figure 8-3 on page 8-47, as follows:

$$A2+A3 \approx \text{Unison uplink NF} + \text{uplink gain (0 dB for reverse port)} - \text{BTS NF} - 10\text{dB}$$

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

8.6.2.1 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 Unison 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:

$$\begin{aligned} P_{TX} &= \text{noise floor} + \text{uplink NF} - \text{process gain} + E_b/N_o + PL \\ &= -113 \text{ dBm/1.25 Mhz} + \text{NF} - 19 \text{ dB} + 7 \text{ dB} + PL \end{aligned}$$

where $E_b/N_o = 7 \text{ dB}$ is a rough estimate, and NF is the cascaded noise figure of the Unison uplink, the uplink attenuation, and the base station noise figure. Equating P_{TX} for the open-loop and closed-loop we see that

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

where P_{DN} is determined by the downlink attenuation. Since P_{DN} for Unison is about 10 dBm, we see that the cascaded noise figure is about 39 dB, which is considerably higher than that of Unison 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 Main Hub and the base station will be the same as, or maybe 10 dB less than, the downlink attenuation.

8.7 Designing for a Neutral Host System

Designing 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.

8.7.1 Capacity of the Unison Neutral Host System

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

8.7.2 Example Unison Neutral Host System

The following example configuration assumes:

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

Example Configuration:

- 800 MHz iDEN: 16 channels
- 800 MHz Cellular
TDMA Band: 16 channels
CDMA Band: 3 channels
- 1900 MHz PCS
TDMA Band: 16 channels
CDMA Band: 3 channels
GSM Band: 6 channels

Replacing Unison Components in an Operating System

9.1 Replacing an RAU

Be aware that the new RAU must be the same band as the one you are replacing. If you replace an RAU with one that is of the wrong band, it will not work.

The Main Hub automatically checks the band of a replaced RAU. There is no need to issue commands directly from the Main Hub. Therefore, as long as the RAU is of the correct band, the system will operate properly.

Replacing an RAU

1. Use AdminManager or refer to the As-Built Document to review the current RAU's configuration.
2. Disconnect the Cat-5/6 cable and antenna from the unit to be replaced.
3. Install the new RAU.
4. Connect the antenna and then the Cat-5/6 cable to the new RAU

AdminManager Tasks

- Use the Advanced RAU Settings option on the Configuration & Maintenance panel to set the RAU's 10 dB attenuation and UL ALC settings.
- When convenient, perform System Test to optimize performance.

During System Test, the entire system is temporarily off-line and no RF is being transmitted. For a fully loaded system (one Main Hub, four Expansion Hubs, and 32 RAUs), it can take 1.5 minutes to complete the test.

 Checking the RAU's LEDs

1. The RAU's **LINK** and **ALARM** LEDs should blink (green/red) on power up.
 - If the LEDs do not blink on power up, replace the RAU.
2. After several seconds both LEDs should change to green, which indicates that the unit has been successfully replaced, there is communication with the Expansion Hub, and the RAU band is correct.
 - a. If the **LINK** LED remains green and the **ALARM** LED remains red, verify that the RAU model is correct for the intended frequency band.
 - Disconnect the cable and then reconnect it once; doing this more than once will not change the result.
 - b. If both LEDs still don't change to green, use the AdminManager to determine the exact nature of the fault and see a recommendation of how to correct it.
 - c. If both LEDs turn red (after 45 seconds), the Expansion Hub has terminated communications.

9.2 Replacing an Expansion Hub

✓ Replacing an Expansion Hub

1. Turn off the power to the Expansion Hub.
2. Disconnect all Cat-5/6 cables, both fiber cables, and the AC power cord.
3. Replace the Expansion Hub with a new one.
4. Connect the AC power cord, all Cat-5/6 cables, and both fiber cables – remembering to clean and correctly connect the uplink and downlink fiber.
5. Turn on the power to the Expansion Hub.

✓ AdminManager Tasks

- The Main Hub automatically issues the band setting.
- When convenient, perform System Test to optimize performance.

During System Test, the entire system is temporarily off-line and no RF is being transmitted. For a fully loaded system (one Main Hub, four Expansion Hubs, and 32 RAUs), it can take 1.5 minutes to complete the test.

✓ Checking the Expansion Hub's LEDs

- The LEDs should blink through all states on power up.
 - If the LEDs do not blink on power up, replace the Expansion Hub.
 - If the LEDs do not illuminate at all, make sure the AC power cable is connected.
- The **UL STATUS** and **DL STATUS** LEDs should be green.
- The **E-HUB STATUS** and **POWER** LEDs should be green.
- For each RJ-45 port that has an RAU connected:
 - The **E-HUB/RAU** LEDs should be green.
 - The **LINK** LEDs should be green.

It can take several seconds for each Cat-5/6 connection for the LEDs to display properly.

NOTE: Refer to Section 10 for troubleshooting using the LEDs.

9.3 Replacing a Main Hub

You must record the system configuration settings from the old Main Hub's memory before replacing the unit. You will program the new Main Hub with this information. If the Main Hub is programmed incorrectly, the system will not work. If the Main Hub is not functioning, get the configuration settings from the As-Built Document that was created as part of the original installation.

Get System Configuration Settings

1. Connect the null modem cable to the PC and the Main Hub.
2. Start the AdminManager software.
3. Select the Configuration & Maintenance Panel option from the introductory window.
4. Click the SAVE CONFIG button.

The Save Configuration Notes dialog box is displayed.

5. Type any notes you want to save with the configuration settings into the dialog box and click OK.

The configuration settings are saved in a text file, for example:

```
Begin Notes *****
LGC HQ
05/23/01 MH configuration L010MH11
System configuration
End Notes *****

Frequency Band is DCS Low.
System Gain: UL = 12 dB, DL = 4 dB.
Callback Number is 1234567.
System label is LGC.

Main Hub Information:
Serial Number: L010BMH1
Part Number: 7405101
Revision Number: 03
Firmware Revision: 010526

Expansion Hub LGC-1 Information:
Serial Number: L010BEH9
Part Number: 7405101
Revision Number: 03
Firmware Revision: 010513

RAU LGC-1-5 Information:
Serial Number: L010BRU1
Part Number: 7405101
Revision Number: 03

Firmware Revision: 010021
```

 Replacing a Main Hub

1. Turn off the power to the Main Hub.
2. Disconnect all fiber cables and the AC power cord.
3. Replace the Main Hub with a new one.
4. Connect the AC power cord and all fiber cables – remembering to clean and correctly connect the uplink and downlink fiber cables.
5. Connect the null modem cable to the PC and then to the Main Hub's front panel DB-9 serial connector.
6. Start the AdminManager software.
7. Select the Installation Wizard option from the introductory window.
8. Turn on the power to the Main Hub.

 AdminManager Tasks

- Use the Installation Wizard to:
 - Set the Operation Band
- Use the Configuration & Maintenance panel to:
 - Set Callback Number
 - Set Contact Sense Properties
 - Set System Parameters
 - Perform System Test

During System Test, the entire system is temporarily off-line and no RF is being transmitted. For a fully loaded system (one Main Hub, four Expansion Hubs, and 32 RAUs), it can take 1.5 minutes to complete the test.

Checking the Main Hub's LEDs

- The LEDs should blink through all states on power up.
 - If the LEDs do not blink on power up, replace the Main Hub.
 - If the LEDs do not illuminate at all, make sure the AC power cable is connected.
- For each fiber optic port that has a Main Hub connected:
 - The **LINK** LED should be green.
 - The **E-HUB/RAU** LED should be:
 - Green if the **MAIN HUB STATUS** is green.
 - Red if the **MAIN HUB STATUS** is red.
- The **MAIN HUB STATUS** LED should be:
 - Red if the Main Hub is new from the factory and a band has not been programmed, or if the wrong band is programmed.
 - Green if the Main Hub was previously programmed with a correct band (matches the RAUs in the system).

NOTE: If there is communication between the Main Hub and the Expansion Hubs, use the AdminManager software's Configuration & Maintenance panel to isolate system problems.

SECTION 10

Maintenance, Troubleshooting, and Technical Assistance

There are no user-serviceable parts in any of the Unison components. Faulty or failed components are fully 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 Unison equipment is required.

10.2 Troubleshooting

NOTE: Unison 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 Unison 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-5/6 cable should be tested to TIA/EIA 568-A specifications.

It is recommended that you use the AdminManager for troubleshooting the system, and use the LEDs as backup or for confirmation. However, if there are communication problems within the system, the LEDs may provide additional information that is not available using AdminManager.

To begin troubleshooting, use the AdminManager software to determine the current faults and warnings for all of the units in the system. To troubleshoot, start with the Main Hub's faults and warnings, then proceed to each of the Expansion Hubs, finishing with each of the RAUs.

If you do not have a PC with AdminManager available, the LEDs provide a minimal set of diagnostic information.

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 Fault Indications

Once all of the units are powered on and the cable connections are made, the faults from each unit can be requested using the AdminManager. Start with the Main Hub and work downstream.

Resolve all faults first and then check the warnings. Take appropriate action to resolve the faults, as indicated in the following tables. In cases where there is more than one possible cause, they are listed from the “most likely” to the “least likely” cause. Actions are listed in the order that they should be performed; not all actions may need to be done.

Main Hub Faults

Table 10-1 Main Hub Faults

Fault Message	LED	State	Possible Causes	Action	Impact
Hardware failure	STATUS	Red	Internal hardware failure.	Replace the Main Hub.	System off-line.
Frequency band not programmed	STATUS	Red	Factory default.	Program the frequency band using the AdminManager’s Installation Wizard.	System off-line.
Main Hub is over temperature	STATUS	Red	Fan failure.	If fan is not operating, replace the Main Hub.	Possible unit failure.
			Ambient temperature is above maximum.	If fan is operating, check room environmental controls.	
Failed to perform system test	STATUS	Red	Internal failure.	Replace the Main Hub when possible.	Degraded performance.

Table 10-1 Main Hub Faults (continued)

Fault Message	LED	State	Possible Causes	Action	Impact
EHn uplink AGC failure	STATUS	Red	Uplink fiber has high optical loss.	Measure UL optical fiber loss. Clean the Main and Expansion Hub's uplink fiber ports.	The Main Hub's EHn port is off-line; downlink is okay.
			Main Hub uplink port failure.	Move fiber pair to another port. If fault is not reported, fiber is okay and Main Hub port is dirty or bad. Use the AdminManager to 'Clear All Disconnect Status' to clear the disconnect fault on the original port.	
			Main Hub internal failure.	If common point of failure for more than one Expansion Hub, replace the Main Hub.	
			Expansion Hub internal failure.	Swap suspect Expansion Hub with working Expansion Hub. If fault persists, replace Main Hub; otherwise, replace the Expansion Hub.	

Table 10-1 Main Hub Faults (continued)

Fault Message	LED	State	Possible Causes	Action	Impact
No communication with EHN	LINK	Red	Downlink fiber has high optical loss.	Measure downlink optical fiber loss.	EHN and connected RAUs are off-line.
	E-HUB/RAU	Off		Clean the Expansion Hub's downlink fiber port. Clean the Main Hub's downlink fiber port.	
			Uplink fiber has high optical loss	Measure uplink optical fiber loss. Clean uplink fiber connectors. Clean uplink fiber ports.	
			Main Hub downlink port failure.	Move the Main Hub fiber pair to another port. If fault is not reported, fiber is okay and the Main Hub port is bad. Use the AdminManager's "Clear All Disconnect Status" command to clear the disconnect fault on the original port.	
			Main Hub internal failure.	If common point of failure for more than one Expansion Hub, replace the Main Hub.	
			Expansion Hub downlink port failure.	Swap suspect Expansion Hub with working Expansion Hub. If fault persists, replace the Main Hub; otherwise, replace the Expansion Hub.	
EHN disconnected	LINK	Red	The Expansion Hub was connected and is now disconnected.	If EHN is disconnected, reconnect it or clear the disconnect fault using the AdminManager's "Clear All Disconnect Status" command.	EHN and connected RAUs are off-line.
	E-HUB/RAU	Off			
			The uplink fiber optical loss exceeds minimum threshold.	Check the uplink fiber cable's optical loss. Clean the uplink fiber connectors. Clean the Main and Expansion Hubs' uplink ports.	
			Expansion Hub uplink laser failure.	Check that EHN's uplink laser is operational. (UL STATUS LED is green.)	

Table 10-1 Main Hub Faults (continued)

Fault Message	LED	State	Possible Causes	Action	Impact
EHn/RAU reports fault condition	LINK	Green	Any Expansion Hub or RAU fault	Use the AdminManager to check for Expansion Hub and RAU faults. Proceed to Expansion Hub or RAU troubleshooting section.	EHn and/or RAU off-line
	E-HUB/RAU	Red			

Expansion Hub Faults

Table 10-2 Expansion Hub Faults

Fault Message	LED	State	Possible Causes	Action	Impact
Hardware failure	STATUS	Red	Downlink fiber has high optical loss.	Measure downlink optical fiber loss. Clean the downlink fiber connectors. Clean the Main and Expansion Hubs' downlink fiber ports.	Expansion Hub and connected RAUs are off-line
			Main Hub internal hardware failure.	If common point of failure for more than one Expansion Hub, replace the Main Hub.	
			Expansion Hub internal hardware failure.	Replace the Expansion Hub.	
PLL unlock	STATUS	Red	Downlink fiber has high optical loss.	Measure downlink optical fiber loss. Clean the downlink fiber connectors. Clean the Main and Expansion Hubs' downlink fiber ports.	Expansion Hub and connected RAUs are off-line
			Main Hub internal hardware failure.	If common point of failure for more than one Expansion Hub, replace the Main Hub.	
			Expansion Hub internal hardware failure.	Replace the Expansion Hub.	

Table 10-2 Expansion Hub Faults (continued)

Fault Message	LED	State	Possible Causes	Action	Impact
Frequency band not programmed	STATUS	Red	Downlink fiber has high optical loss.	Measure downlink optical fiber loss. Clean the downlink fiber connectors. Clean the Main and Expansion Hubs' downlink fiber ports.	Expansion Hub and connected RAUs are off-line
			Expansion Hub internal hardware failure.	Replace the Expansion Hub.	
Expansion Hub is over temperature	STATUS	Red	Fan failure(s).	If fans are not operating, replace the Expansion Hub.	Expansion Hub and connected RAUs are off-line. RAUs are commanded off-line which disables their power amplifiers. If the Expansion Hub temperature does not start to drop, the Expansion Hub will disable DC power to all RAUs.
			Ambient temperature above maximum	If fans are operating, check room environmental controls.	
Downlink pilot failure	STATUS	Red	Downlink fiber has high optical loss.	Measure downlink optical fiber loss. Clean downlink fiber connectors. Clean the Main and Expansion Hubs' downlink fiber ports.	Expansion Hub and connected RAUs are off-line.
			Main Hub internal hardware failure.	If common point of failure for more than one Expansion Hub, replace Main Hub.	
			Main Hub downlink port failure.	Move Main Hub fiber pair to another port. If fault is not reported, Main Hub port is bad, replace when possible.	
			Expansion Hub downlink port failure.	Swap suspect Expansion Hub with working Expansion Hub. If fault persists, replace the Main Hub; otherwise, replace the Expansion Hub.	

Table 10-2 Expansion Hub Faults (continued)

Fault Message	LED	State	Possible Causes	Action	Impact
Failed to perform system test	STATUS	Red	Main Hub internal failure.	If common point of failure for more than one Expansion Hub, replace the Main Hub.	Degraded performance.
			Internal failure.	Perform System Test, if failure persists, replace the Expansion Hub.	
RAUn uplink AGC failure	LINK	Red	Cat-5/6 cable length.	Check Cat-5/6 cable length.	RAU is off-line.
	RAU	Off	Expansion Hub uplink port failure or RAU failure.	Move RAU to another port. If no fault reported, replace the Expansion Hub. If fault reported, replace RAU.	
			Expansion Hub internal failure.	If common point of failure for more than one RAU, replace the Expansion Hub.	
No communication with RAUn	LINK	Red	Cat-5/6 cable failure.	Verify that the Cat-5/6 cable has no shorts or opens.	RAUn is off-line.
	RAU	Off	RAU internal failure. or Expansion Hub port failure.	Move the RAU to another port. If fault persists, replace the RAU; otherwise, replace the Expansion Hub.	
RAUn over current	LINK	Green	Cat-5/6 cable failure.	Verify Cat-5/6 cable has no shorts or opens.	RAUn is off-line.
	RAU	Red	RAU internal failure.	Move RAU to another port. If fault persists, replace the RAU. If no fault reported, remove the RAU, power cycle the Expansion Hub, connect known good RAU to port. If fault reported, replace the Expansion Hub.	
RAUn downlink port failure	LINK	Green	Expansion Hub internal failure.	Move the RAU to another port. If fault persists, replace the Expansion Hub. If no fault, flag previous port as unusable and replace the Expansion Hub when possible.	RAUn is off-line.
	RAU	Red			

Remote Access Unit Faults

Table 10-3 Remote Access Unit Faults

Fault Message	LED	State	Possible Causes	Action	Impact
Hardware failure	ALARM	Red	Internal hardware failure.	Replace the RAU.	RAU is off-line.
Frequency band not programmed	ALARM	Red	Wrong version of RAU for frequency band desired.	Replace the RAU if not valid for desired frequency band.	RAU is off-line.
RAU is over temperature	ALARM	Red	Ambient temperature above maximum.	Check environmental controls; move the RAU to cooler environment.	RAU is off-line.
Power supplied by Expansion Hub is too low	ALARM	Red	Cat-5/6 cable failure.	Verify Cat-5/6 cable has no shorts or opens.	RAU is off-line.
			RAU internal failure. <i>or</i> Expansion Hub port failure.	Move the RAU cable to another Expansion Hub port. If fault persists, replace the RAU; otherwise, replace the Expansion Hub.	
			Expansion Hub internal failure.	If common point of failure for more than one RAU, replace the Expansion Hub.	
Power supplied by Expansion Hub is too high	ALARM	Red	Cat-5/6 cable failure.	Verify Cat-5/6 cable has no shorts or opens.	RAU is off-line.
			Expansion Hub internal failure. <i>or</i> RAU internal failure.	Move RAU cable to another Expansion Hub port. If fault persists, replace the RAU, otherwise replace the Expansion Hub.	
Cat-5/6 cable too long	ALARM	Red	Cat-5/6 cable is too long.	Verify that the Cat-5/6 cable has no shorts or opens. Verify maximum Cat-5/6 cable length of 150 meters.	RAU is off-line.

Table 10-3 Remote Access Unit Faults (continued)

Fault Message	LED	State	Possible Causes	Action	Impact
Downlink pilot failure	ALARM	Red	Cat-5/6 cable failure.	Verify that the Cat-5/6 cable has no shorts or opens. Verify maximum Cat-5/6 cable length of 150 meters. Verify minimum Cat-5/6 cable length of 10 meters.	RAU is off-line.
			RAU internal failure. <i>or</i> Expansion Hub port failure.	Move the RAU cable to another Expansion Hub port. If fault persists, replace the RAU; otherwise, replace the Expansion Hub. Or, mark the Expansion Hub's port as unusable.	
			Expansion Hub internal failure.	If common point of failure for more than one RAU, replace the Expansion Hub.	

10.2.2 Warning Indications

Warnings alert you to conditions that may impact system performance and conditions that indicate potential system failure.

Before addressing warnings, ensure that all faults are resolved. Take appropriate action to resolve the warnings, as indicated in the following tables.

Main Hub Warnings

Table 10-4 Main Hub Warnings

Warning Message	Action	Impact
Downlink laser is failing	Replace the Main Hub when possible.	The downlink laser will eventually fail and the system will be off-line.
Temperature is high	Check room environmental controls.	Potential Main Hub failure.
Fan failure	Check the Main Hub fan for rotation, air flow blockage, dust; replace the Main Hub if temperature rises.	Temperature may rise to fault level resulting in Main Hub and connected Expansion Hub(s) and RAU(s) being off-line.
EHn uplink fiber optical loss greater than recommended maximum	Check the uplink fiber cable for optical loss. Clean the cable connector. Clean the fiber ports.	Degraded system performance.

Expansion Hub Warnings

Table 10-5 Expansion Hub Warnings

Warning Message	Action	Impact
Downlink fiber optical loss greater than recommended maximum	Check the downlink fiber cable for excessive optical loss. Clean the cable connector. Clean the fiber ports.	Degraded system performance.
Uplink laser is failing	Replace the Expansion Hub when possible.	The uplink laser will eventually fail resulting in the Expansion Hub and connected RAUs being off-line.
Temperature is high	Check room environmental controls.	Potential Expansion Hub failure.
Fann failure	Check the Expansion Hub fans for rotation, air flow blockage, dust; replace the Expansion Hub if temperature rises.	Temperature may rise to fault level resulting in the Expansion Hub and connected RAUs being off-line.
Cat-5/6 cable between RAUn and Expansion Hub is longer than recommended maximum	Check that the Cat-5/6 cable does not exceed the recommended maximum length.	Degraded system performance.

Remote Access Unit Warnings

Table 10-6 Remote Access Unit Warnings

Warning Message	Action	Impact
Temperature is high	Move the RAU to cooler environment.	Potential RAU failure.
DC voltage is low	Check the Cat-5/6 cable for shorts and opens. Replace the RAU when possible.	Unreliable operation.
Power amplifier is failing	Replace the RAU when possible.	Potential RAU failure.
Cat-5/6 cable between Expansion Hub and RAU is longer than recommended maximum	Check that the Cat-5/6 cable does not exceed the recommended maximum length.	Degraded system performance.
Antenna disconnected	Check the RAU SMA antenna connection.	Poor RAU coverage.

10.3 LED Troubleshooting Guide

The following troubleshooting guide is from the perspective that all Unison equipment is installed, their cables are connected, and they are powered on; it is assumed that the system was operating normally before the current problem. (Refer to Section 6 for information on troubleshooting during initial installation of the system.)

Always use AdminManager, if possible, to troubleshoot the system. The LEDs are for backup troubleshooting; although, an Expansion Hub uplink laser failure can only be resolved using the **EH UL STATUS** LED.

Begin with troubleshooting the Main Hub's LEDs and then the Expansion Hub's LEDs. The RAU LEDs probably will not provide additional information for troubleshooting.

10.3.1 Troubleshooting Main Hub LEDs During Normal Operation

- All of the Main Hub's LEDs should be green during normal operation. If any LEDs are red, get status using the AdminManager software for the exact cause and recommendations.

Table 10-7 Troubleshooting Main Hub Port LEDs During Normal Operation

During Normal Operation	LED	State	Action	Impact
Expansion Hub Not Connected	LINK	Red	If the Expansion Hub was disconnected accidentally, re-connect the cables. The LEDs should change to Green/Red (then Green/Green, after 20 seconds, if the Main Hub band has been programmed). If the Expansion Hub is to be removed from service permanently, then use the AdminManager's 'Clear All Disconnect States' command to clear all disconnect states to no connect states. The Main Hub's port LEDs should change to Off/Off.	Expansion Hub was previously connected, but it is not currently connected; Expansion Hub cable disconnect. The AdminManager software will clear all disconnects caused by installation as part of the clean-up process. After installation, power cycle the Main Hub or use the AdminManager's 'Clear All Disconnect States' command.
	E-HUB/RAU	Off		
Expansion Hub Connected	LINK	Red	Use the AdminManager to determine the exact cause of the Main Hub's faults.	Lost communication with Expansion Hub; could be Expansion Hub problem or fiber cable problem.
	E-HUB/RAU	Off		
	LINK	Green	Expansion Hub or connected RAU reports a fault condition; use the AdminManager to determine the exact cause of the Expansion Hub and RAU's faults.	
	E-HUB/RAU	Red		

Table 10-8 Troubleshooting Main Hub Status LEDs During Normal Operation

During Normal Operation	LED	State	Action	Impact
At Any Time	MAIN HUB STATUS	Red	Use the AdminManager to determine the exact cause of the fault. Power cycle one time. If fault remains, replace the Main Hub.	Internal Main Hub fault.
	MAIN HUB STATUS	Alternating Red/Green	Reduce input signal power; reduce system gain.	Signal compression.

10.3.2 Troubleshooting Expansion Hub LEDs During Normal Operation

- All of the Expansion Hub **LINK** and **E-HUB/RAU** LEDs that have RAUs connected should be Green/Green, indicating that the RAU is powered on, communication is established, and operation is normal.
- The **POWER** and **MAIN HUB STATUS** LEDs should both be Green.

Table 10-9 Troubleshooting Expansion Hub Port LEDs During Normal Operation

During Normal Operation	Port LEDs	State	Action	Impact
RAU is not connected	LINK	Red	If the RAU was disconnected accidentally, re-connect the Cat-5/6 cable. The Expansion Hub's port LEDs should change to Green/Red (then Green/Green, after 20 seconds, if the Main Hub is connected, powered on, and has band programmed). If you are removing the RAU from service permanently, then command 'Clear All Disconnect States' using the AdminManager software. The Expansion Hub's port LEDs should change to Off/Off.	RAU was previously connected, but it is not currently connected; RAU cable is disconnected.
	RAU	Off		
RAU is connected	LINK	Red	Disconnect/reconnect the Cat-5/6 cable to force power-on reset to the RAU. If the port LEDs remain Red/Off, check the Expansion Hub faults using the AdminManager for the exact cause.	Lost communications with the RAU. The RAU could have powered down due to over current; cable could have been damaged.
	RAU	Off		
	LINK	Green	RAU reports a fault condition; check the Expansion Hub faults using the AdminManager for the exact cause.	Depends on the fault condition.
	RAU	Red		

Table 10-10 Troubleshooting Expansion Hub Status LEDs During Normal Operation

During Normal Operation	EH Status LEDs	State	Action	Impact
At Any Time	UL STATUS	Red	Replace the Expansion Hub	Uplink laser failure; no communications between the Main Hub and the Expansion Hub
	DL STATUS	Red	Check the downlink fiber for optical loss	No communications with the Main Hub
	E-HUB STATUS	Red	If either the UL STATUS or the DL STATUS are also red, see above. Cycle power on the Expansion Hub. If fault remains, replace the Expansion Hub.	Internal Expansion Hub fault (including either of the above UL STATUS or DL STATUS states)

10.4 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, model number, frequency
- Approximate time in service (warranty), sales order number
- Description of problem
- LED status
- AdminManager fault and warning status

Cables and Connectors

A.1 Cat-5/6 Cable (ScTP)

- Connects the Expansion Hub to the RAU(s)
- Transmits (downlink) and receives (uplink) cellular and PCS signals
- Delivers DC electrical power to the RAUs. The Expansion Hub's DC voltage output is 36V DC nominal. A current limiting circuit is used to protect the Expansion Hub if it reaches its current limit
- Use shielded RJ-45 connectors
- Distances:
 - Absolute Minimum: 10 meters (33 ft)
 - Recommended Minimum: 25 meters (82 ft)
 - Recommended Maximum: 100 meters (328 ft)
 - Absolute Maximum: 150 meters (492 ft)

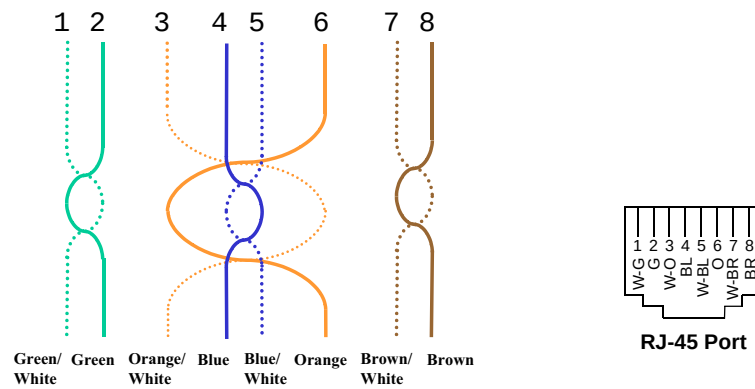
There are four separate twisted pairs in one Cat-5/6 screened twisted pair (ScTP) cable. The ScTP cable loss described in this document is for Cat-5 Mohawk/CDT 55986 or Belden 1624P DataTwist Five cable, or equivalent. The following table lists the functional assignment of the pairs:

Table A-1 Cat-5/6 Twisted Pair Assignment

Pair (wire number)	Function
1 & 2	Clock and Input Voltage
3 & 6	RS485
4 & 5	Uplink IF, UL Pilot and Ground
7 & 8	Downlink IF, DL Pilot and Ground

All Cat-5/6 cable must be terminated according to the TIA/EIA 568-A standard. The following diagram shows the top view of the wiring map for the cable and how the four pairs should be terminated.

Figure A-1 Wiring Map for Cat-5/6 Cable



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

The nominal DC impedance of the Cat-5/6 cable is 0.08 ohm/meter and the nominal RF impedance is 100 ohm.

A.2 Fiber Optical Cables

- Connects Main Hub to Expansion Hub(s)
- Transmits (downlink) and receives (uplink) cellular and PCS signals
- Use industry-standard 62.5µm/125µm MMF or Corning SMF-28 fiber, or equivalent (SC/APC [angle-polished] connectors only)
- Distances:
 - Multimode Fiber: up to 1.5 km (4,921 ft) – 3 dB optical loss maximum
 - Single-Mode Fiber: up to 6 km (19,685 ft) – 3 dB optical loss maximum

A.3 Coaxial Cable

- Connects a Main Hub to a repeater or base station (N-type connectors)
- Connects an RAU to a passive antenna (SMA connectors)

InterReach Unison Property Sheet

Use the “InterReach Unison Property Sheet” form, which is provided on the following page, to document a system configuration. The completed form can be used for future reference when the system is being maintained or components are added or exchanged. An example of a completed form is shown below.

Unit		RAU Attenuation?	Unit	Unit Installation Location
MH - EH - RAU	(EH 1)	Yes/No	Serial No.	
AB-1-n	(EH 1)	---	L010BEH9	2nd floor Telecom closet
AB-1-1	(RAU 1)	no	L010BRU1	Hallway, outside Boardroom
AB-1-2	(RAU 2)	no	L120BRU1	Hallway, outside #230
AB-1-3	(RAU 3)	yes	L007BRU1	Hallway, atrium north side
AB-1-4	(RAU 4)	no	L111BRU6	Hallway, outside #207
1-1-5	(RAU 5)			
1-1-6	(RAU 6)			
1-1-7	(RAU 7)			
1-1-8	(RAU 8)			
1-2-n	(EH 2)	---		
1-2-1	(RAU 1)			
1-2-2	(RAU 2)			
1-2-3	(RAU 3)			
1-2-4	(RAU 4)			
1-2-5	(RAU 5)			
1-2-6	(RAU 6)			
1-2-7	(RAU 7)			
1-2-8	(RAU 8)			
1-3-n	(EH 3)	---		
1-3-1	(RAU 1)			
1-3-2	(RAU 2)			
1-3-3	(RAU 3)			
1-3-4	(RAU 4)			
1-3-5	(RAU 5)			
1-3-6	(RAU 6)			
1-3-7	(RAU 7)			
1-3-8	(RAU 8)			
1-4-n	(EH 4)	---		
1-4-1	(RAU 1)			
1-4-2	(RAU 2)			
1-4-3	(RAU 3)			
1-4-4	(RAU 4)			
1-4-5	(RAU 5)			
1-4-6	(RAU 6)			
1-4-7	(RAU 7)			
1-4-8	(RAU 8)			



InterReach™ Unison Property Sheet

Installer:			Date:		Main Hub Serial Number:
System Label:		System Gain:		Alarm Sense:	
		UL:	DL:	☐ Yes ☐ No	☐ Normally-Closed ☐ Normally-Open
System Band:					
Unit MH - EH - RAU		RAU Attenuation? Yes/No	Unit Serial No.		Unit Installation Location
1-1-n	(EH 1)				
1-1-1	(RAU 1)				
1-1-2	(RAU 2)				
1-1-3	(RAU 3)				
1-1-4	(RAU 4)				
1-1-5	(RAU 5)				
1-1-6	(RAU 6)				
1-1-7	(RAU 7)				
1-1-8	(RAU 8)				
1-2-n	(EH 2)				
1-2-1	(RAU 1)				
1-2-2	(RAU 2)				
1-2-3	(RAU 3)				
1-2-4	(RAU 4)				
1-2-5	(RAU 5)				
1-2-6	(RAU 6)				
1-2-7	(RAU 7)				
1-2-8	(RAU 8)				
1-3-n	(EH 3)				
1-3-1	(RAU 1)				
1-3-2	(RAU 2)				
1-3-3	(RAU 3)				
1-3-4	(RAU 4)				
1-3-5	(RAU 5)				
1-3-6	(RAU 6)				
1-3-7	(RAU 7)				
1-3-8	(RAU 8)				
1-4-n	(EH 4)				
1-4-1	(RAU 1)				
1-4-2	(RAU 2)				
1-4-3	(RAU 3)				
1-4-4	(RAU 4)				
1-4-5	(RAU 5)				
1-4-6	(RAU 6)				
1-4-7	(RAU 7)				
1-4-8	(RAU 8)				

Compliance

C.1 Safety Approvals

- UL/cUL 1950 3rd edition
- CB scheme evaluation with all national deviations
- EN 60950:1992 including amendments A1, A2, A3, A4, and A11

C.2 Radio/EMC Approvals

GSM/EGSM/DCS Products

EMC: ETSI EN 301 489-8 V.1.1.1 (2000-09)

Radio: EN 301502 v.7.0.1 (8-2000)
ETS 300 609-4 V.8.0.2 (2000-10)

Cellular Products

EMC: FCC part 15 class A

Radio: FCC part 22

PCS Products

EMC: FCC part 15 class A

Radio: FCC part 24

iDEN Products

EMC: FCC part 15 class A

Radio: FCC part 90

GSM Products

EMC: FCC part 15 class A

Radio: FCC part 90

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 wire-less 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 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 chartered 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.

