

**FCC Part 22
Transmitter Certification**

Test Report

FCC ID: DNY0C5EKLIT0800

FCC Rule Part: CFR 47 Part 22 Subpart H

ACS Report Number: 05-0459-22H

Manufacturer: EMS Wireless
Equipment Type: Cellular Fiber-optic RF Distribution Remote Unit
Model: EkoLite II 800

Installation and Operators Guide

Operator's Manual

EkoLite II Fiber Optic Distributed Antenna System



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- Increase the separation between the equipment and receiver.
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ESD = ELECTROSTATIC DISCHARGE SENSITIVE DEVICE

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EMS *Wireless* Customer Support
2850 Colonnades Court
Norcross, Georgia 30071 U. S. A.
+1 (770) 582-0555 x5310

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EMS *Wireless* warrants to the original purchaser all standard products sold by EMS Wireless to be free of defects in material and workmanship for two (2) years from the date of shipment. During the warranty period, EMS *Wireless'* obligation, is limited to repair or replacement of any product that EMS Wireless proves to be defective. This warranty does not apply to any product which has been subject to alteration, abuse, improper installation or application, accident, electrical or environmental over-stress, negligence in use, storage, transportation, or handling.

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All EMS Wireless products are manufactured to high quality standards and are warranted against defects in workmanship, materials and construction, and to no further extent. Any claim for repair or replacement of a device found to be defective on incoming inspection by a customer must be made within 30 days of receipt of the shipment, or within 30 days of discovery of a defect within the warranty period.

This warranty is the only warranty made by EMS *Wireless* and is in lieu of all other warranties, expressed or implied, except as to title, and can be amended only by a written instrument signed by an officer of EMS *Wireless*. EMS *Wireless* sales agents or representatives are not authorized to make commitments on warranty returns.

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This fiber optic laser transmitter contains a class IIIb laser product as defined by the US Department of Health and Human Services, Public Health Service, Food and Drug Administration. This laser product complies with 21 CFR, Chapter I, Subchapter J of the DHEW standards under the Radiation Control for Health and Safety Act of 1968. The laser module certification label is located on the equipment enclosure and it also shows the required DANGER warning logotype (as shown below).

The EMS *Wireless* laser products are used in optical fiber communications systems for radio frequency and microwave frequency analog fiber optic links. In normal operation, these systems are fully enclosed and fully shielded by the hermetically sealed laser metal package. Laser bias current is limited by the internal control circuitry. The transmitters are coupled to glass fiber and have 1310 nm optical output wavelength with typically 0.5 to 20 mW output depending on the model. The optical radiation is confined to the fiber core. Under these conditions, there is no accessible laser emission and hence no hazard to safety or health.

Since there is no human access to the laser output during system operation, no special operator precautions are necessary when fiber is connected to the transmitter and receiver. During installation, service, or maintenance, the

service technician is warned, however, to take precautions which include not looking directly into the fiber connector or the fiber which is connected to the fiber connector before it is connected to the fiber optic receiver. The light emitted from the fiber optic connector or any fiber connected to the connector is invisible and may be harmful to the human eye. Use either an optical power meter or an infrared viewer or fluorescent screen for optical output verification. All handling precautions as outlined by the FDA and ANSI Z136.2 and other authorities of class IIIb lasers must be observed.

Do not attempt to modify or to service this Product. Contact the EMS *Wireless* Customer Support Department for a return authorization if service or repair is necessary.

Disclaimer

Every attempt has been made to make this material complete, accurate, and up-to-date. Users are cautioned, however, that EMS Wireless Inc. reserves the right to make changes without notice and shall not be responsible for any damages, including consequential, caused by reliance on the material presented, including, but not limited to, typographical, arithmetical, or listing errors.



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1.0 Introduction

The system overview describes the need for distributed RF antenna systems in general terms and the concept of a fiber optic repeater system. The functional overview describes the EkoLite II system as it is broken down into its major components.

1.1 System Overview

The EkoLite II System is designed to distribute Cellular and PCS radio signals within a building or campus of buildings where coverage/capacity would be otherwise impeded. Using fiber optics to distribute the signals, and a network of local antennas, the coverage area can be greatly enhanced. Correctly installed, the EkoLite II is “transparent” to the service provider while simultaneously greatly enhancing the coverage on the user’s side.

One of the key advantages of a fiber optic RF distribution system is that it separates the issues of coverage and capacity. In an alternative system that covers a building by distributing radio base stations, one must add a base station in that area when faced with the problem of poor coverage in one section. Thus, capacity is added to a section which might not need it. Similarly, when faced with a capacity problem in a portion of the building, one would need an additional base station regardless of whether additional coverage is required.

Coverage and capacity are two separate problems. With a fiber optic RF distribution system, there are separate solutions to the two separate problems. For poor coverage, an additional fiber optic antenna is added; for an area with insufficient capacity, more base station transceivers are added. In this way, equipment and channels are most efficiently used, and the entire system is more economical. Not only can the fiber optic RF distribution system be used to create uniform coverage throughout the entire building, including stairwells, elevator shafts and garages, regardless of the size and construction, but it enables centralization of the equipment. In the fiber optic RF distribution system, the bulky equipment (such as the base station transceivers, filters, and power supplies) are located in an equipment room, while the antennas are strategically placed for coverage. This factor is especially significant in buildings where aesthetics are key, since it is easier to conceal a small fiber optic antenna than several radios.

In addition to the aesthetic advantages of distributed fiber optic antennas, the overall system cost and complexity is greatly reduced. A typical application for the

EkoLite II system would be a multi-floor building such as the one depicted in Figure 1. In buildings of this type it is common to find equipment rooms for Heating, Ventilation and Air-Conditioning (HVAC) and other utilities such as data networking and telephony equipment.

There are numerous advantages to centrally located utilities and services and cellular equipment is no exception. Since the fiber optic antennas cover the entire cellular band and are format independent, they are capable of sending any type of signal throughout the building, whether analog, digital or CDPD, and they can send them all simultaneously.

The fibers typically emanate from a source point (small base station) in the building. These fibers run from that source point, piping the signal to many locations throughout the building as shown in Figure 1.

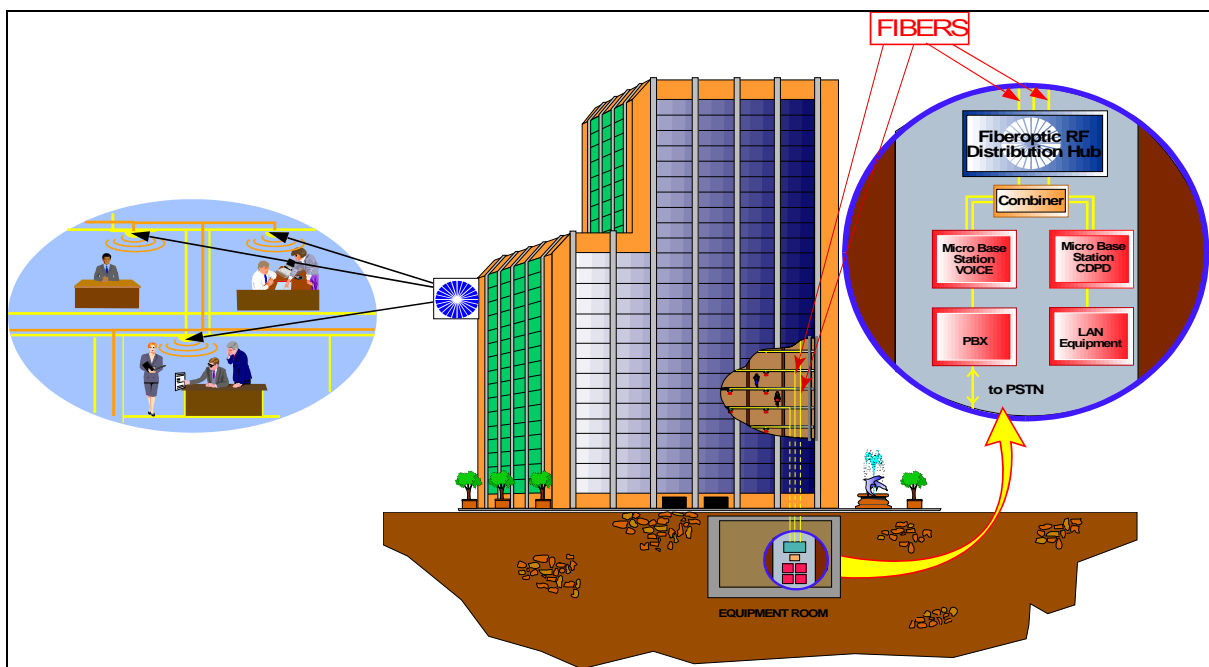


Figure 1. Typical EkoLite II Application.

Because the capacity is determined by the base station equipment, not the antennas, once a building is wired for RF distribution via fiber optics, capacity and new services can be added without any changes visible to the customer.

1.2 Functional Overview

There are four main components comprising the EkoLite II System: The Hub, the Remote, the Fiber, and the Antenna. Figure 2 is a functional diagram of the EkoLite II system.

1.2.1 Hub

The Hub interfaces directly to the service provider's BTS and is typically located in the equipment or utility room in most installations. It is recommended that the distance from the BTS to the Hub be kept as short as possible to make the EkoLite II "transparent" to the service provider. The Hub is the heart of the system and contains a microprocessor based controller which automatically sets the desired power level for each of the remotes during installation. At the user's discretion, the power level may be adjusted at each remote according to individual requirements. In most applications, however, the hub will measure the amount of optical loss in each fiber and set the gain accordingly. This greatly reduces the installation and setup time.

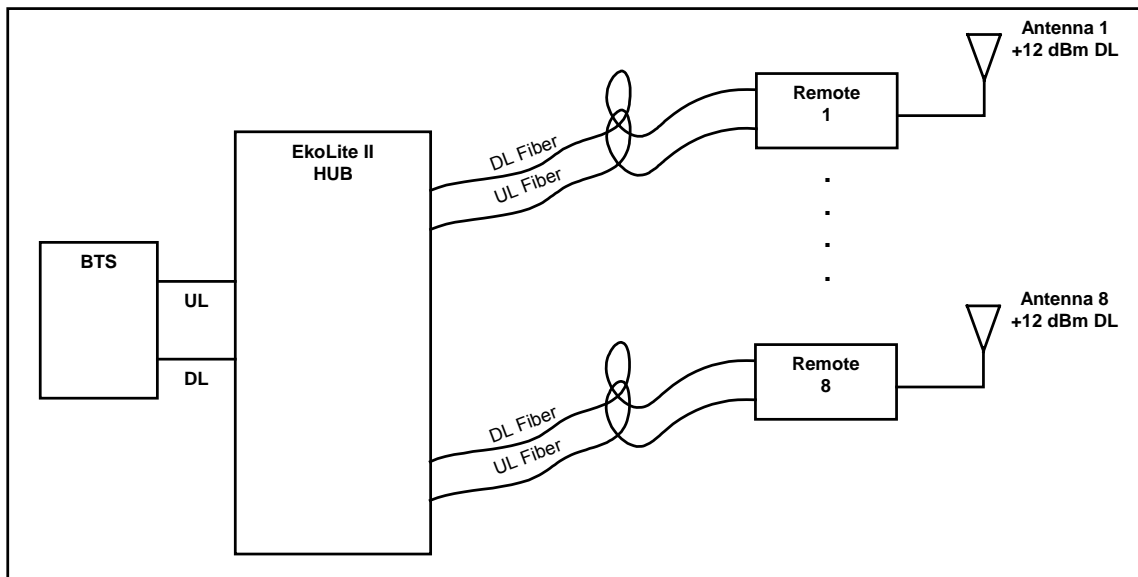


Figure 2. EkoLite II functional diagram.

In addition to automatically adjusting the initial gain settings, the Hub continuously monitors the operational status of each of the Remote units.

If more than one Hub is used, one Hub will be designated the Master Hub and the others will be slaved to that Hub. The Master Hub has a Master controller daughter card which is the chief difference between it and the Slave Hubs.

Each EkoLite II Hub can support up to eight Remotes. If more than eight Remotes are required, up to 3 additional Hubs can be added allowing for a total of 32 Remotes.

1.2.2 Fiber

EMS recommends single mode 9/125 μm optical fiber for use in the EkoLite II system. It is also recommended that a high quality SC/APC connector be used to minimize reflections at the mating ends of the fiber. SC/APC connectors are standard on both the Remote and the Hub. All connectors should be thoroughly cleaned prior to each mating and plastic caps used to cover the connectors when not mated. Dust and other contaminants can scratch and permanently damage fiber connectors rendering them useless.

The maximum length for a fiber run is a function of the loss within the fiber itself plus some margin for aging and other factors.

The maximum fiber loss (including connectors) for EkoLite II is 2.0 dB. This correlates to roughly 2 km for a typical fiber such as Corning's SMF-28.

1.2.3 Remote Unit

The remote is designed to convert the Fiber Optic Signals to/from RF and transmit those signals to/from the Hub. Figure 3 is a functional diagram of the EkoLite II remote. Figure 4 is a pictorial view of the remote.

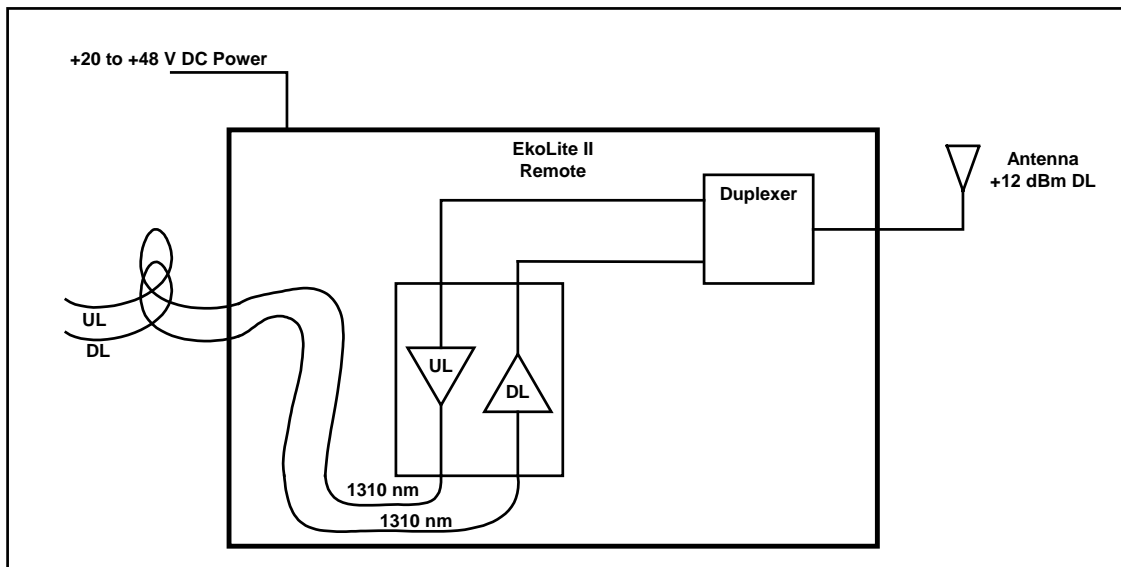


Figure 3. EkoLite II Remote Unit Block Diagram.

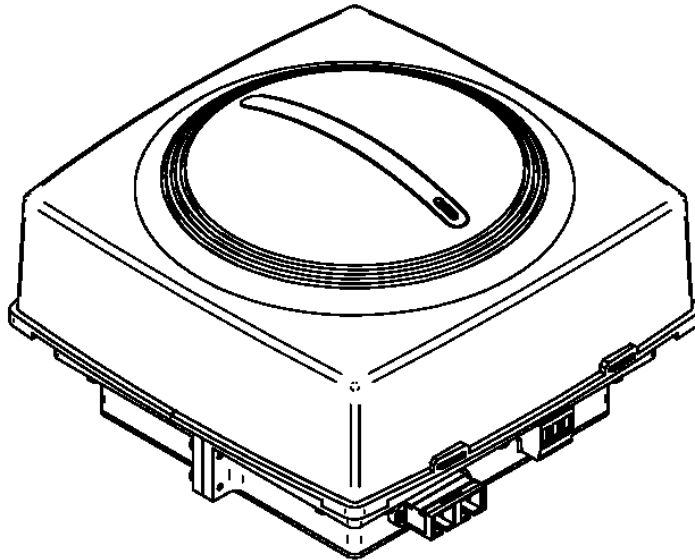


Figure 4. EkoLite II Remote

The standard EkoLite Remote has a self-contained antenna. Optionally, an SMA(f) connector may be specified so an external antenna may be used. In this case, the internal antenna is not installed at the factory. Also, internal 1:2 or 1:4 power splitters may be specified and factory installed inside the remote unit so multiple antennas can be used. The outputs from these splitters are SMA(f) connectors on the back of the remote unit.

1.2.4 Optional Components

The components listed above are mandatory for any EkoLite II system deployment. For added safety, flexibility, and convenience to the installer, several optional components are also offered. The following sections describe some of the more frequently used optional components.

1.2.4.1 AC Power Supply

There are two power supply offerings available from **EMS Wireless** which are specifically designed for deployment in EkoLite II systems. The AC Supply is shown in Figure 4. It has 16 outputs for EkoLite II systems.

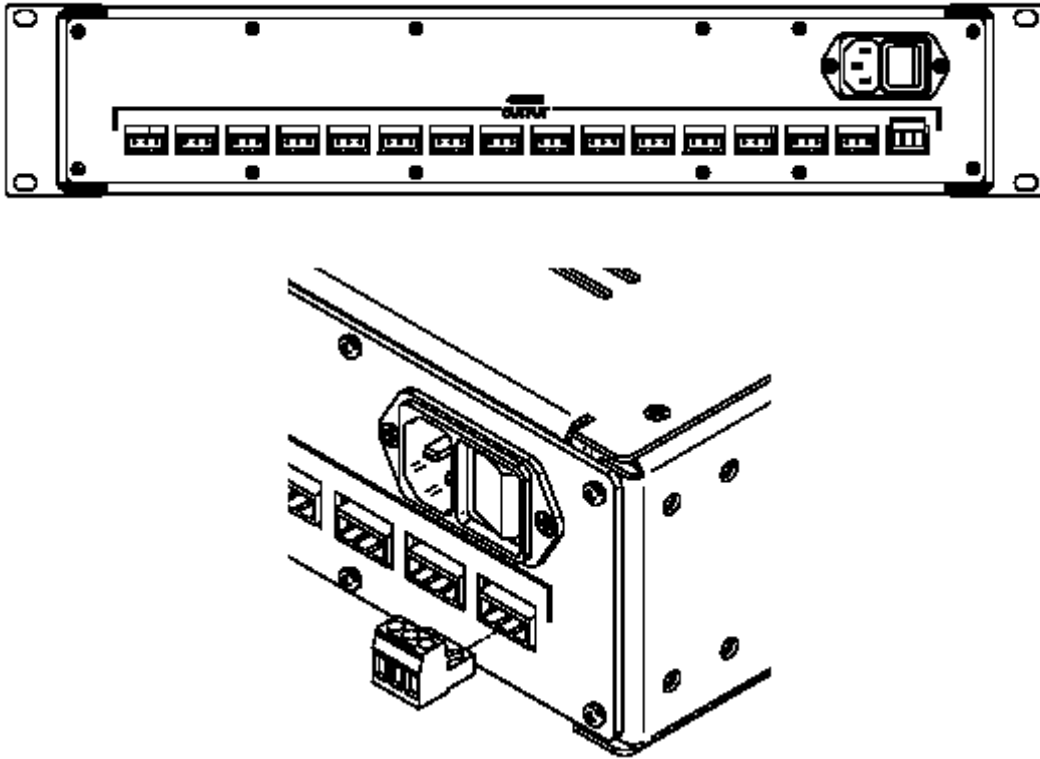
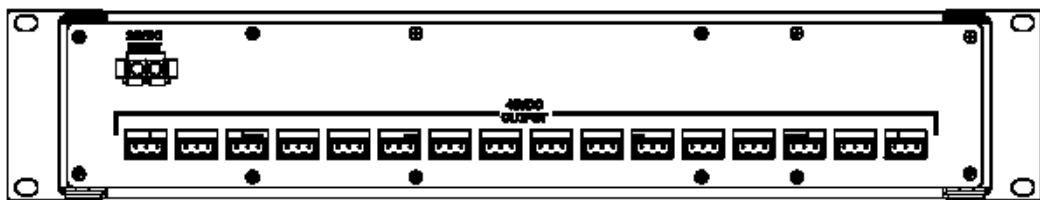


Figure 4. AC Power Supply Rear Panel.

1.2.4.2 DC Power Supply

In many telecommunications applications equipment is powered by 48 Volt DC power. If the user desires, or is required to use 48 volts, EMS offers a DC supply for deployment with the EkoLite II system, as shown in Figure 6.



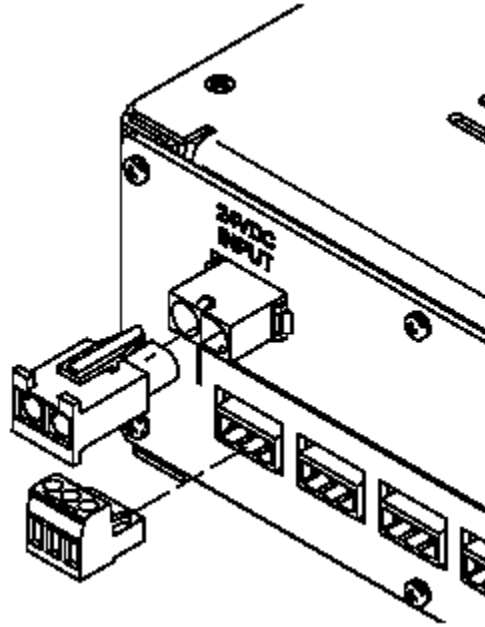


Figure 6. DC Power Supply Rear Panel.

1.2.4.3 RF Combiner

The user desiring to accommodate more than one carrier in an EkoLite II system will require a combiner such as the one depicted in Figure 7.

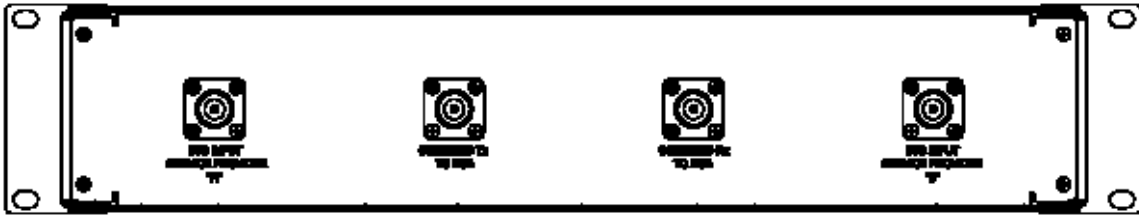


Figure 7. RF Combiner Rear Panel.

The RF Combiner is installed at the Hub and accommodates two BTS inputs.

2.0 Installation Guide

The following guidelines provide a step by step installation procedure which should be followed closely to insure a successful deployment.

2.1 Shipment Contents

The following items should be included with each EkoLite II Shipment:

- Hub(s)
- Remotes(s)
- User manual (this document)
- Software Command Reference Manual
- AC Power supply (optional)

2.2 Site Selection

2.2.1 Hubs

The Hub(s) should be located as close as possible to the donor BTS. Observe all environmental specifications for the hub to avoid damage from moisture, heat, cold, etc.

2.2.2 Remotes

Ensure that each remote location is correct according to the system design drawings. Observe all environmental specifications for the remote to avoid damage from moisture, heat, cold, etc.

2.3 Pre-installation

Prior to installation, a carefully planned system layout should be documented. At a minimum, this document should include the location of the Hub, the location of the Remotes, the Antenna locations, the fiber locations and lengths, and the location of the power supplies for both Hubs and Remotes.

The Hub is located at the Building Base Station or BTS. The Hub interfaces with the user's PCS System. The Remote units are distributed in the building and provide signal coverage. Optical fiber cables connect the Hub to the Remote units. The Hub is typically powered by an AC power supply. The AC power supply will power up to 16 Remotes.

In this section, instructions are provided for organizing the system layout before installation. The installer or operator must make sure that certain requirements have been met before beginning installation. In addition, all cables and fibers must be labeled, and the entire system configuration must be documented. Steps for this pre-installation set-up are given below.

1. Two optical fibers are required for each Antenna unit; each Hub can connect to up to eight Remote units. Angle-polished SC/APC connectorized optical fiber cable must be installed in the building. Any optical connector used between the Hub and the Remote units should be an angle-polished connector specified for return loss >55 dB. Fusion splices to connect fibers are also suitable. Flat polished connectors anywhere along the optical fiber path will degrade the system performance.
2. The customer must provide the following equipment for installation:
 - (a) Optical connector cleaning kit: cotton swabs, alcohol, dust-free compressed air
 - (b) Crimping tool, mating connectors, and pin crimps for the DC electrical connectors and alarm outputs at the Hub.
 - (c) Philips screwdriver
 - (d) Personal computer or laptop with terminal program such as HyperTerminal.
 - (e) Volt Meter
3. Not essential, but useful for diagnostics are the following equipment:
 - (a) RF power meter
 - (b) Optical power meter

- (c) RF Spectrum analyzer
- (d) Signal generator

2.4 Power Supply Installation

If purchased, install the power supply and connect power to the Hub. An on-off switch is located in the rear of the chassis and should remain in the off position until the installation is completed. Before connecting the Hub or Remotes to the power supply, apply AC power to the supply and verify the 48 V output with a Volt meter.

2.5 Single Hub Installation

To Install the Hub, locate it as close as possible to the Service Provider's BTS. Any distance between the BTS and Hub will result in unnecessary cable losses. It is also very important to ensure that the *composite* RF Downlink power does not exceed +20 dBm. Table 1 shows the maximum allowable power setting for each carrier to arrive at a *composite* power of +20 dBm.

Number of Carriers	Power Per Carrier
1	+20 dBm
2	+17 dBm
3	+15.2 dBm
4	+14 dBm
n	+20 - [10log(n)] dBm/ch

Table 1. Power per carrier table

Note that each additional provider requires a reduction in carrier power to maintain the maximum rated input power of +20 dBm.

- Using a Philips screwdriver and the provided screws, secure the Hub in a standard 19" equipment rack near the BTS.
- Connect the Downlink RF Output from the BTS to the RF Input on the Hub.
- Connect the RF Output from the Hub to the BTS Uplink port.
- Connect the power to the Hub.
- If the modem option was purchased and a dedicated phone line is available, connect the RJ-45 phone jack.
- Log onto the Hub as user and follow the system initialization procedures.

2.6 Multiple Hub Installation

For installations requiring more than one Hub, there will be one Hub designated as the Master and the other Hubs will be slaved to the Master. Up to three additional Hubs can be slaved to a single Master Hub. The BTS will only interface to the Master Hub. An optional Master Alarm Controller may be purchased to allow alarms to be reported to an offsite monitoring station. If purchased, the Master Alarm Controller will be factory installed.

- Identify the Master Hub and using a Philips screwdriver and the provided screws, secure the Master Hub in a standard 19" equipment rack near the BTS
- Install the Slave Hub(s) using a Philips screwdriver and the provided screws, secure the Hub(s) in a standard 19" equipment rack near the Master Hub
- Using SMA cables, connect the Slave Downlink Outputs on the rear of the Master Hub to the Slave Downlink Inputs on the Slave Hub(s)
- Using SMA cables, connect the Slave Uplink Inputs on the rear of the Master Hub to the Slave Uplink Inputs
- If purchased, connect a standard RJ-45 phone cable to the Master Alarm Controller located on the rear of the Master Hub.

2.7 Combiner Installation

To install the combiner, locate it as close as possible to the BTS and Hub installation site. All connections should be made with High quality, low loss RF cables with 50 Ω , type N terminations.

- Connect the Duplexed BTS Input from service Provider A to the Combiner Port A
- Connect the Duplexed BTS Input from service Provider B to the Combiner Port B
- Connect the Combined TX Port on the Combiner to the Hub RF Input Port
- Connect the Combined RX Port on the Combiner to the Hub RF Output Port

2.8 Remote Installation

Follow these steps to install each remote unit.

- For external antenna use, connect the Antenna to the remote using 50 Ω cable with an SMA-type connector.
- Remove the cover on the Remote fiber connector. Using a dust free air source, clean the fiber connector.
- Remove the plastic cover on the fiber and clean the connector tip.
- Connect the fiber(s) to the remote.
- Connect the DC power cable to the remote.
- Ensure that the power switch on the main power supply is in the “off” position and connect the power to the Remote observing the polarity markings.
- Mechanically secure the Remote in its designated location.
- After power-up, the front panel LED should be Amber for 10 seconds and then turn green (assuming the Hub is connected properly)

2.9 System Verification and Initialization

If all the previous steps have been followed carefully, the EkoLite II system is now ready for verification and initialization. Connect to the Hub via serial cable or modem.

Note that if no master controller is present, the user will connect to the “HUB RS232” connector located on the rear of each Hub. If the Master Controller module was purchased, the user can connect to the “Master RS232” port located on the front of the Master Hub.

The standard terminal settings are:

- 9600 Baud
- 8 Data bits
- 1 Stop bit
- No flow control
- No Parity

If you are unfamiliar with serial communications, please refer to Appendix A for a step by step guide to connecting to the Hub.

1. At the Hub, apply power to the system by turning the power to the “on” position. The Hub LEDs should be green if everything is functioning

properly. If any of the LEDs are flashing, there is an alarm condition and you should refer to section 5.0 to troubleshoot the problem.

2. Note that, any unused ports on the Hub will indicate an alarm condition until the user commands the Hub to ignore those ports. Please refer to the System Initialization section for further details. Each Remote has one alarm LED. When power is first applied to the Remote, its LED will be amber for a period of 10 seconds. After the initial period, the LED will indicate either an alarmed condition or normal operation. A solid green LED indication on the Remote is normal and means that everything is functioning properly. If any of the Remote LEDs are *not* green, there is an alarm condition. Refer to section 5.0 to troubleshoot the problem.

2.9.1 User/Guest Login

When the Hub Controller first powers up, there is a start-up message indicating the firmware release and copyright legends:

```
Hub Controller Program V0.99 [Build 04Oct02]
Copyright (c) 2002, EMS-Technologies, Inc.
```

If the user presses the ENTER key, the login prompt is displayed:

```
Hub Controller Program V0.99 [Build 04Oct02]
Copyright (c) 2002, EMS-Technologies, Inc.
```

Username:

There are two basic types of login available to the customer; **guest**, and **user**. The guest login is for simple monitoring of the unit; ability to change settings is limited. The user login is for the customer use and allows basic system changes to be made to the module. Note that the login username and password are **CASE-SENSITIVE!**

```
Hub Controller Program V0.99 [Build 04Oct02]
Copyright (c) 2002, EMS-Technologies, Inc.
```

Username: user

Password: ****

Access granted to user

2>

The last entry “2>” is the prompt indicating the user’s level of privilege. The prompt may be composed of several “reminders”; where a single capital letter indicates a system change. These reminders are as follows:

- <1> Login privilege level of “guest”
- <2> Login privilege level of “user”
- “A” An alarm is active
- “C” Calibration tables are invalid; the default calibration tables are in use.
- “F” Settings do not agree with the stored values in flash memory. This is usually the result of a change due to a user’s command setting. **All settings are read from the user’s settings in flash on power-up. If the check value does not agree, then the default settings are used.**

2.9.2 Command Structure

There is an extensive user help menu available to the user and a separate software command reference manual. The basic format for all the commands is:

<Primary-Command> <Secondary-Command> = <setting>

All commands are made up of this generic format; in some cases, there is no setting or secondary command. The command set is basically a tree diagram, where typing in the primary (and optionally secondary) command with the setting result in a change in the module’s operational parameters. All input is case-insensitive for commands. For example:

set laser 1 = on

This command would turn the laser #1 on at the present potentiometer setting stored in memory.

2.9.3 Remote Alarm Disabling

From the factory, the Hub is programmed to alarm any time a Remote is disconnected from the Hub. This safety feature is designed to indicate such

catastrophic events as the fiber to the Remote being cut. For a Hub that does not use all eight channels, the unused channels will report an alarm by default. These are false alarms and it will be necessary for the user to disable these unused channels to clear the alarms.

The command to disable the unused channels is:

```
2>set fiber <n> = disabled
```

Where n corresponds to the desired channel. In the event that the wrong channel is inadvertently disabled or a remote is added at a later time the disable channel should be enabled using the following command.

```
2>set fiber <n> = on
```

Where n corresponds to the desired channel.

2.9.4 Offsets

Under normal conditions, the factory default power settings are configured to provide +12 dBm output power (1900 MHz models), or +8 dBm (800 MHz models) at each remote. The factory settings will provide optimum performance in most environments; however the user has the option to change the power settings in each remote according to individual requirements.

Set an "offset" to the default value for the desired remote. For example, to set remote 1 to +18 dBm type:

```
2>set remote 1 = -2
```

The range for the offsets is -10 dB to +0 dB and can *only* be set in 1 dB increments. In this way, each remote can be tuned to the user's specific requirements after the system is deployed.

To verify the offsets for each remote the following command may be used:

```
2> get remote n
```

where n is the number of the specific remote offset requested.

3.0 Maintenance

The EkoLite II system is designed to be virtually maintenance free for the user.

CAUTION

*Do Not look directly at the end
of an optical connector which emits laser light!*

The system normally operates without operator intervention. If any unit fails, the line replaceable unit (Remote unit or Hub) should be replaced and the system restored. A failed Remote unit can be removed and replaced with a spare while the rest of the system is operating. A Hub replacement will require temporary loss of signal to its associated Remotes.

One of the most important requirements is to maintain clean, undamaged optical interfaces. Any optical connector which is not used must be covered with a protective cap. There are 16 optical connectors for each Hub and two optical connectors for each Remote unit. These connectors are internal to the units and not field serviceable. To ensure that the internal connectors are not inadvertently damaged, just prior to mating an external optical fiber connector to a Transceiver or Remote unit, the external connector should be cleaned as described below.

3.1 Optical Connector Cleaning

Before each mating of Fiber Connectors, both connectors should be properly cleaned. The following guidelines provide the user with some basic techniques for maintain good fiber connector integrity.

1. It is very important to maintain clean, scratch-free optical connectors. Whenever an optical cable is removed, place a protective cap over the optical connector at both the cable end and at the Hub or Remote unit.
2. The less frequently Fiber Connectors are handled, the better their integrity.
3. To clean an optical connector, gently wipe the tip of the ferrule with a cotton swab moistened with alcohol, then blow the ferrule dry using dust-free compressed air.

4. The optical connectors for the Hubs and the Remote units are internal, and cannot be cleaned in the field.

After the system is installed there should be no need for periodic cleaning of the fiber connectors.

4.0 Specifications

The specifications are divided into several sections including:

- Link Performance Specifications
- User Requirement Specification
- Hub Specifications
- AC Power Supply Specifications
- DC Power Supply Specifications
- RF Combiner Specification
- Remote Specifications
- Alarm Output Specifications

4.1 Link Performance specifications

The performance levels shown in Table 2 are for an optical loss budget of 2 dB, which is the typical optical path loss for 2 km optical fiber and a pair of optical connectors. Optical reflection in both directions must be less than -40 dB. Otherwise, the overall system performance may be degraded.

PARAMETER	DOWNLINK	UPLINK
Passband: PCS	1930 to 1990 MHz	1850 to 1910 MHz
DCS (L)	1805 to 1855 MHz	1710 to 1760 MHz
DCS (H)	1830 to 1880 MHz	1735 to 1785 MHz
Cellular	869 to 894 MHz	824 to 849 MHz
GSM	935 to 960 MHz	890 to 915 MHz
ESMR	851 to 869 MHz	806 to 924 MHz
Optical Budget	2 dB	2 dB
Composite RF Input	+20 dBm	-92 to -40 dBm/ch
RF Loss (at 25°C)	0 dB ± 2 dB	0 dB ± 2 dB
Response Flatness	± 2 dB	± 2 dB
Gain Variation over Temp	± 2 dB	± 2 dB
Downlink 2-Tone Output Carrier to 3rd Order	>48 dB (RF _{out} /tn = 9 dBm)	≥50 dB (RF _{in} /tn = -58 dBm)

PARAMETER	DOWNLINK	UPLINK
Intermodulation		
Output Carrier to Noise: 30kHz BW 200kHz BW $P_{out}=+9dBm$	≥ 64 dB ≥ 56 dB	--- ---
Sensitivity for 200kHz BW for BTS S/N of 9dB	---	-98 dBm
Sensitivity for 1.25MHz BW for E_b/N_o of 7dB and 14.4kHz data rate	---	-111dBm
SFDR in 200kHz BW	53 dB	61 dB
Propagation Delay	$<0.5 \mu s$ (RF) + $5 \mu s/km, typ$ (fiber)	$<0.5 \mu s$ (RF) + $5 \mu s/km, typ$ (fiber)
Impedance	50 Ω	50 Ω
Input/Output VSWR	$<1.5:1$	$<1.5:1$
Hub RF Connector	N-type	N-type
Remote RF Connector	SMA(f)	SMA(f)
Optical Connector	SC/APC	SC/APC
Optical Fiber	9/125 μm (core/clad) 1310 nm, singlemode	9/125 μm (core/clad) 1310 nm, singlemode
Wavelength	1310 nm	1310 nm

Table 2. Link Performance specifications.

4.2 User Requirement Specifications

Table 3 shows requirements that the user must satisfy for proper operation of the EkoLite II system.

PARAMETER	USER REQUIREMENT
Max Composite RF Input (damage level)	+30 dBm (downlink) +10 dBm (uplink)
Max Optical Fiber Length	2 km
Optical Fiber	9/125 μm (core/clad) 1310 nm, singlemode
Optical Connectors	SC/APC
Optical Return Loss	≥ 40 dB
Number of Optical Fibers	Two per remote unit
Chassis AC Power	90 to 135 VAC or 184 to 264 VAC

PARAMETER	USER REQUIREMENT
(factory configured)	50-60 Hz
Backup Power Supply (Optional)	+12 VDC \pm 0.5 V, 8.5 A max load Ripple < 170 mV pp
Remote DC Power	20 - 48 VDC V at 0.4 A Ripple: <170 mV, freq >300 Hz <300 mV, freq <300 Hz
Rack	Chassis: 3U high, 19" (7.5 cm) wide, 12.84" (32.6 cm) deep 1U (1.75" [4.4 cm]) air space above and below each chassis
Temperature Performance to Full Spec Operating Storage Relative Humidity Operating Short Term	5°C to 40°C 0°C to 50°C -20°C to 65°C 20 to 55% 10 to 80% (not exceeding 0.024 lbs water/dry air)
Max Length Wires to Supply DC Power to Antenna Units (Assuming 22 VDC Power)	<2000 ft (<610 meters) with 22 AWG Copper Wire

Table 3. User Requirement Specifications.

4.3 Hub Specifications

Table 4 is a list of specifications for the EkoLite II Hub.

PARAMETER	USER REQUIREMENT
Max Composite RF Input (damage level)	+30 dBm (downlink) +10 dBm (uplink)
Max Optical Link Loss	2 dB
Optical Fiber	Single Mode Fiber
Optical Connectors	SC/APC
Optical Return Loss	\geq 40 dB
Number of Optical Fibers	Two per remote unit
Chassis AC Power (factory configured)	90 to 135 VAC or 184 to 264 VAC 50-60 Hz
Backup Power Supply (Optional)	+24 VDC \pm 0.5 V, 8.5 A max load Ripple < 170 mV pp
Hub DC power	20 - 48 VDC at 7.5W Ripple: <170 mV, freq >300 Hz

PARAMETER	USER REQUIREMENT
	<300 mV, freq <300 Hz
Rack	Chassis: 3U high, 19" (7.5 cm) wide, 12.84" (32.6 cm) deep 1U (1.75" [4.4 cm]) air space above and below each chassis
Temperature Performance to Full Spec Operating Storage	5°C to 40°C 0°C to 50°C -20°C to 65°C
Relative Humidity Operating Short Term	20 to 55% 10 to 80% (not exceeding 0.024 lbs water/dry air)

Table 4. EkoLite II Hub Specifications

4.4 AC Power Supply Specifications

The EkoLite II system is available in AC and DC input power supply options. Shown in Table 5 is a list of specifications for the AC option.

PARAMETER	SPECIFICATION
Input Voltage (factory configured)	90 to 135 VAC or 184 to 264 VAC, 50-60Hz
Output Voltage	+48 VDC ± 0.5 V
Maximum Load	7.8 A
Available Continuous Power	375 W at 50°C
Efficiency	70%
Noise Spikes	<170 mV p-p
AC Power Plug	North America 5-15P
3-pin Remote/Hub power connections	48 VDC ± 0.5 V
Dimensions H x W x D	3.47" x 19" x 12.84" (8.8 cm x 48.3 cm x 32.6 cm)
Temperature Range Performance to Full Spec Operating Storage	5°C to 40°C 0°C to 50°C -20°C to 65°C
Relative Humidity Operating Short Term	20 to 55% 10 to 80% (not exceeding 0.024 lbs

PARAMETER	SPECIFICATION
	water/dry air)

Table 5. EkoLite II AC Power Supply Specifications.

4.5 DC Power Supply Specifications

Table 6 shows a list of specifications for the DC-DC power supply. The supply requires a 24VDC battery input common to wireless service provider base transceiver stations.

PARAMETER	SPECIFICATION
Input Voltage	24VDC Battery
Output Voltage	+48 VDC \pm 0.5 V
Maximum Load	8.5 A
Available Continuous Power	375 W at 50°C
Efficiency	84%
Noise Spikes	<170 mV p-p
AC Power Plug	North America 5-15P
3-pin Remote/Hub power connections	48 VDC \pm 0.5 V
Dimensions H x W x D	3.47" x 19" x 12.84" (8.8 cm x 48.3 cm x 32.6 cm)
Temperature Range	
Performance to Full Spec	5°C to 40°C
Operating	0°C to 50°C
Storage	-20°C to 65°C
Relative Humidity	
Operating	20 to 55%
Short Term	10 to 80% (not exceeding 0.024 lbs water/dry air)

Table 6. EkoLite II DC Power Supply Specifications

4.6 RF Combiner Specifications

The RF Combiner Specifications are listed in Table 7.

PARAMETER	SPECIFICATIONS
BTS TX Input Power, max	+30dBm
BTS TX Input Power No Damage	+40dBm
Combined TX Output Power	+20dBm
Insertion loss per BTS TX	13dB
Isolation - BTS Tx to BTS Tx	45dB
Isolation - Tx to Rx, Min	50dB
Insertion loss - BTS Rx (single band)	< 6dB
Insertion loss - BTS Rx (dual band)	< 10dB
Dimensions	19"L X 12.81"W X 3.47"D (48.3 cm x 32.5 cm x 8.8 cm)
Weight (approximate)	10 lbs. (4.5 kg)
Temperature Range	
Performance to Full Spec	5°C to 40°C
Operating	0°C to 50°C
Storage	-20°C to 65°C
Relative Humidity	
Operating	20 to 55%
Short Term	10 to 80% (not exceeding 0.024 lbs water/dry air)

Table 7. RF Combiner Specifications

4.7 Remote specifications

Table 8 is a list of specifications for the Remote Unit.

PARAMETER	SPECIFICATIONS
Passband:	
PCS	1930 to 1990 MHz
DCS (L)	1805 to 1855 MHz
DCS (H)	1830 to 1880 MHz
Cellular	869 to 894 MHz
GSM	935 to 960 MHz
ESMR	851 to 869 MHz
Optical Connectors	SC/APC
Wavelength	
Uplink	1310 nm ± 30 nm
Downlink	1310 nm ± 30 nm
Optical Output Power (at I-I _{th} = 40 mA)	0 dBm ± 2 dB typical
Optical Return Loss	> 40 dB
LED Indicators	Green: Normal Operation Other than Green: Alarm

PARAMETER	SPECIFICATIONS
External DC Power Supply Requirement	20 - 48 V \pm 1 V at 0.4 A (Max Ripple: <170 mV pp
Dimensions	6.78" x 6.78" x 4.35" (17.2 cm x 17.2 cm x 11.0 cm)
Weight (approximate)	2 lbs (0.9 kg)
Max Uplink RF Input Power	-10 dBm Max (no damage)
Downlink RF Output Power	+12 dBm (normal operation)
Temperature Range Performance to Full Spec Operating Storage Relative Humidity Operating Short Term	5°C to 40°C 0°C to 50°C -20°C to 65°C 20 to 55% 10 to 80% (not exceeding 0.024 lbs water/dry air)

Table 8. EkoLite II Remote Specifications

4.8 Alarm Output Specifications

The Hub has both Internal and External Alarming capability. The following paragraphs describe these alarms in detail.

4.8.1 Internal Alarms

The Internal Hub Alarms are described in Table 9.

Alarm Description	LED Indication
CPU Temperature Alarm	All Flashing Red
Optical Receiver <n>: Low Power Detected when ON	Solid Red
Optical Receiver <n>: Power Detected when OFF	Solid Red
Remote <n> Failure Detected	Flashing Amber
Hub Laser <m> Failure Detected	Flashing Amber (4)
InterHUB Alarm is ACTIVE	(None)
External-1 Alarm is ACTIVE	(None)
External-2 Alarm is ACTIVE	(None)
No Alarm	Solid Green

Table 9. Hub Alarm Conditions.

The user may also log into the Hub and, using the Alarm command, diagnose the alarm conditions.

4.8.2 External Alarms

Frequently the user may desire to interface alarms in the EkoLite II system with a BTS or other systems. For this purpose, user configurable alarm outputs are accessed using J26 and J27 found on the rear panel of the EkoLite II Hub.

4.8.2.1 Master Hub External Alarm Relays, J26

Connector J26 supplies the user with relay contacts for custom alarm configurations defined by the customer requirements. The dry contact relay outputs are only available in the Master Hub with a Master Hub Controller option installed. J26 pin descriptions are shown in Table 10. Contact current should be limited to 2 Amps or less.

Pin	Signal	Description
1	ALARM-1-NO	Alarm Relay #1 Normally-Open
2	ALARM-1-C	Alarm Relay #1 Contact
3	ALARM-1-NC	Alarm Relay #1 Normally-Closed
4	ALARM-2-NO	Alarm Relay #2 Normally-Open
5	ALARM-2-C	Alarm Relay #2 Contact
6	ALARM-2-NC	Alarm Relay #2 Normally-Closed

Table 10. J26 Connector

A typical application circuit can be seen in Figure 8.

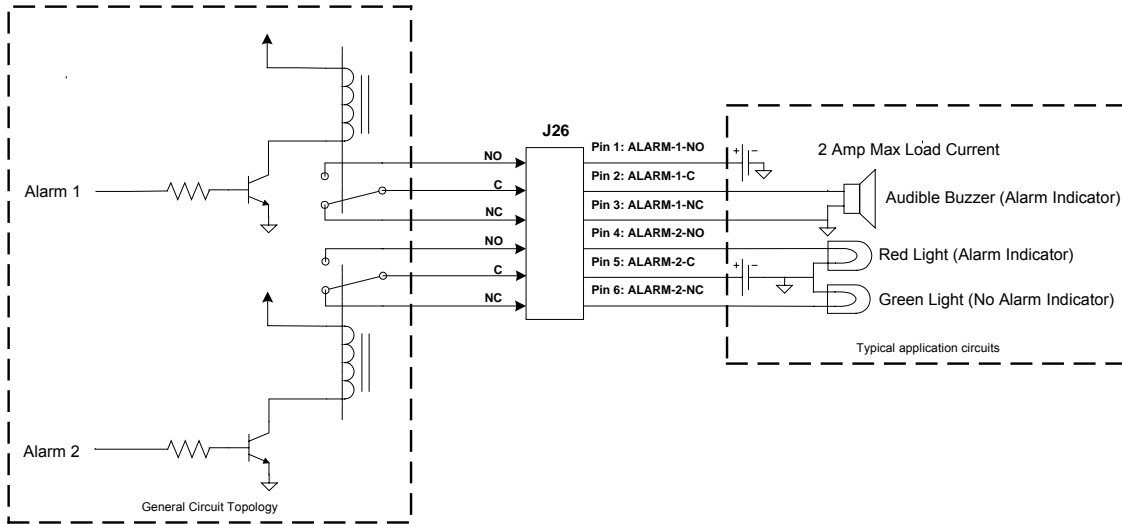


Figure 8: Application of Alarm Relay Contacts

4.8.2.2 Master Hub External Alarm Relays, J27

Connector J27 provides user configurable external alarm connections. J27 alarm outputs are available on all EkoLite II Hubs with or without a master control module. Pin definitions for connector J27 can be seen in Table 9.

Pin	Signal	Description
1	V-ALARM	+5 Volts Output for alarm
2	ALARM-OC	Open-Collector Alarm Output
3	GND	Signal Ground
4	Not Connected	<No connection>
5	EXT-ALARM-1-IN	TTL Alarm Input #1
6	EXT-ALARM-2-IN	TTL Alarm Input #2

Table 11. J27 Connector

The alarm output can be driven using the internal voltage supplied by pin 1. This can be seen in Figure 11.

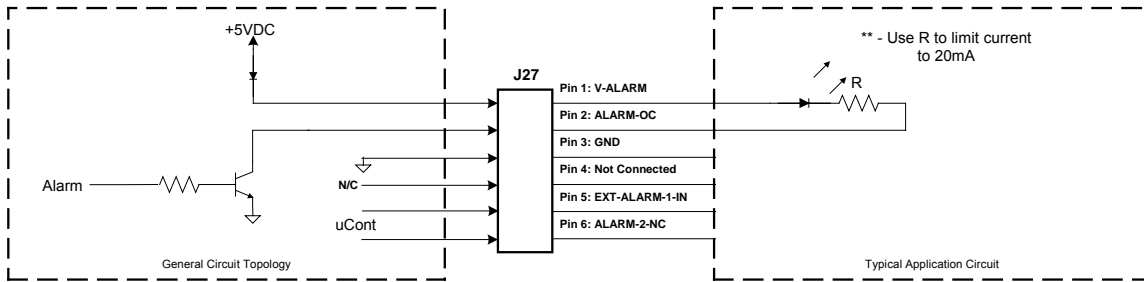


Figure 9. J27 Application, Single Hub using internal supply voltage.

The Hubs may also be configured in an OR configuration as seen in Figure 10. External alarm circuitry must be current limited to 20mA.

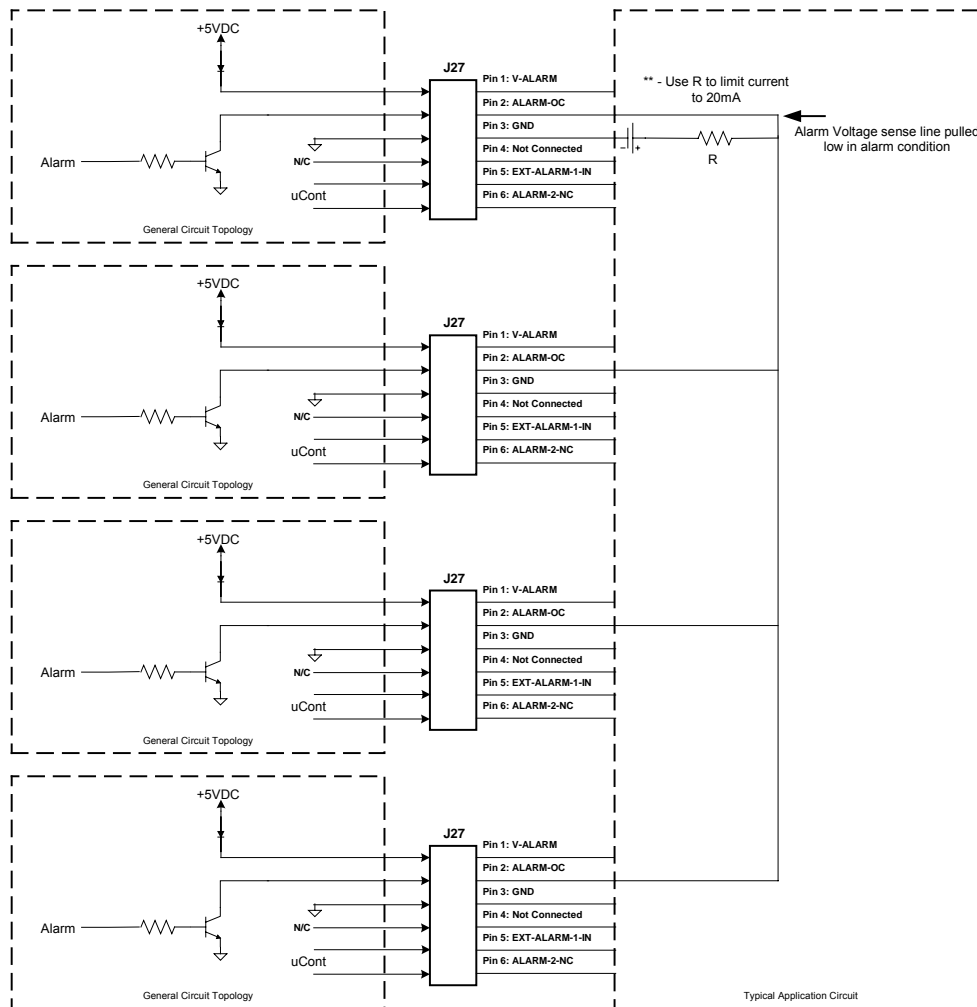


Figure 10. J27 Application, OR Configured Hubs using external supply voltage.

5.0 Troubleshooting Guide

The chief indicator of a failure is the Status LED located on each of the Remotes and the Hub. The user can ascertain the nature of the failure by either logging into the Hub and invoking the Alarm command or by using Tables 12 and 13 below.

Under normal operating conditions, these LEDs will be solid green. If an alarm condition occurs, the LEDs will indicate the nature of the failure and assist the user in deciding on a course of action. It is recommended that, before taking any corrective measures, or disconnecting either the Remote or Hub units, the user ascertain the exact nature of the alarm by referring to the tables below.

5.1 Remote Alarms

The Hub LEDs will indicate when an alarmed condition exists at one of the remotes. To ascertain the nature of a failure, observe both the Remote LED and the Hub LEDs and compare them to Table 12 below.

Alarm Description	Remote LED Indication	Hub LED Indication
RF Uplink Pre-Amp Failure Alarm	Flashing Red	Flashing Red
RF Uplink AGC-Amp Failure Alarm	Flashing Red	Flashing Red
RF Uplink Post-Amp Failure Alarm	Flashing Red	Flashing Red
CPU Temperature Alarm	Flashing Amber	Flashing Red
Remote Laser Failure Alarm	Solid Amber	Solid Red
Remote Laser Feedback Alarm	Solid Amber	Flashing Red
Optical Receive Power Alarm	Solid Red	Flashing Red
RF Overdrive Alarm	Flashing Red	Flashing Red
RF Downlink Power Alarm	Flashing Red	Flashing Red
No Alarm	Solid Green	Solid Green

Table 12. Remote Alarm Conditions

After noting the type of alarm, the failed unit should be replaced.

5.2 Hub Alarms

The Hub has both Internal and External Alarming capability. The following paragraphs describe these alarms in detail.

5.2.1 Internal Alarms

The Internal Hub Alarms are described in Table 13.

Alarm Description	LED Indication
CPU Temperature Alarm	All Flashing Red
Optical Receiver <n>: Low Power Detected when ON	Solid Red
Optical Receiver <n>: Power Detected when OFF	Solid Red
Remote <n> Failure Detected	Flashing Amber
Hub Laser <m> Failure Detected	Flashing Amber (4)
InterHUB Alarm is ACTIVE	(None)
External-1 Alarm is ACTIVE	(None)
External-2 Alarm is ACTIVE	(None)
RF Downlink Power Alarm	Flashing Red
No Alarm	Solid Green

Table 13. Hub Alarm Conditions.

The user may also log into the Hub and, using the Alarm command, diagnose the alarm conditions.

APPENDIX A

Terminal Communications

The EkoLite II can be configured and monitored via direct serial RS-232 connection. The following paragraphs describe in detail how to connect to the Hub.

Direct Terminal Connection

The EkoLite II Hub can be controlled via standard RS232 Communications port located on the front of the Hub chassis. A laptop computer is recommended for system setup and verification. If a laptop is unavailable, a standard Personal Computer may be used but the serial cable connection must be kept less than 10 feet.

Connect a serial cable form the laptop to the Hub and run your favorite terminal program. The standard terminal settings are:

- 9600 Baud
- No Parity
- 1 Stop bit

HyperTerminal Configuration

HyperTerminal is a common communications program included with Microsoft Windows operating systems. Windows 95 and all newer versions of Windows has this software which can be used to initialize the EkoLite II. Following is a step-by-step guide to configuring the software to communicate with your Hub controller.

1. In the Start menu, open the Programs folder. Navigate to the Accessories folder and then the Communications folder.
2. Select the HyperTerminal icon.

3. A dialog box will ask you to name the session. Use any name you choose. For this example, the name EkoLite II was used. Select the icon showing the two telephones as shown in Figure A-1.

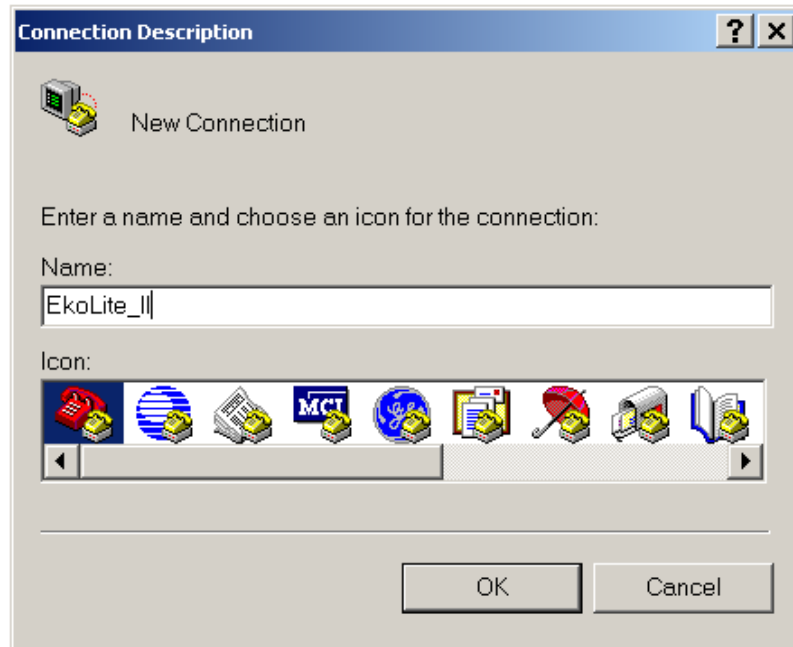


Figure A-1. Connection Description in HyperTerminal

4. For a direct connection to the repeater, choose "Direct to Com X" in the drop down box in Figure A-2.

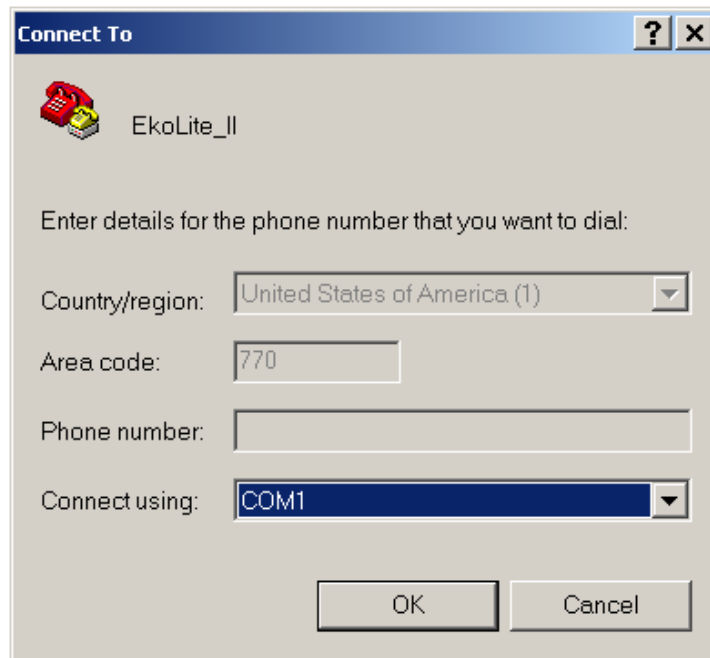


Figure A-2. HyperTerminal Screen for Direct Connection.

5. After clicking OK, you will need to choose "Port Settings." Select:
 - Bits per Second: 9600
 - Data bits: 8
 - Parity: None
 - Stop bits: 1
 - Flow control: None

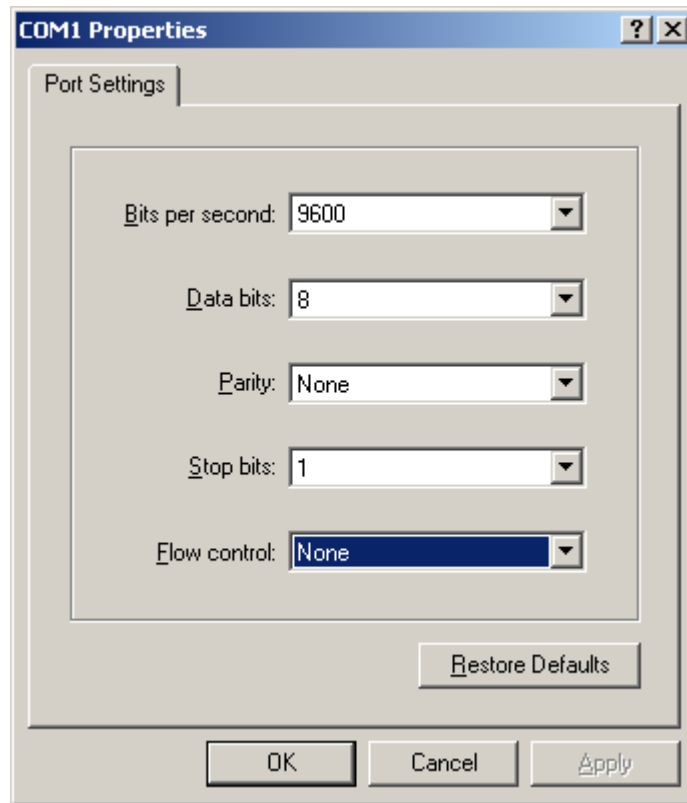


Figure A-3. Port Settings for Direct Connection and Remote Connection

The port settings will be the same for direct connection and remote connection, except for the flow control. For a direct connection to the repeater, make sure flow control is set to “None.”

Installation Guide

EkoLite II Fiber Optic Distributed Antenna System



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1.0 Unpacking:

Carefully remove the EkoLite II hub(s), remote(s), and all supplied accessories from the box. The following items should be included as a minimum with each EkoLite II shipment.

- Hub(s)
- Remotes(s)
- User manual (this document)
- Software Command Reference Manual
- AC Power supply (optional)
- Other accessories, such as fiber optic cable, coaxial jumper cables, server (remote) antennas, etc., as determined by the particular system design.

2.0 Additional Parts Needed for Installation:

The customer must provide the following equipment for installation:

- Optical connector cleaning kit: cotton swabs, alcohol, dust-free compressed air
- Crimping tool, mating connectors, and pin crimps for the DC electrical connectors and alarm outputs at the Hub.
- Philips screwdriver
- Personal computer or laptop with terminal program such as HyperTerminal.
- Volt Meter

Not essential, but useful for diagnostics are the following equipment:

- RF power meter
- Optical power meter
- RF Spectrum analyzer
- Signal generator

3.0 Installation Procedure

3.1 Hubs

The Hub(s) should be located as close as possible to the donor BTS. Observe all environmental specifications for the hub to avoid damage from moisture, heat, cold, etc.

3.2 Remotes

Ensure that each remote location is correct according to the system design drawings. Observe all environmental specifications for the remote to avoid damage from moisture, heat, cold, etc.

3.3 Pre-installation

Prior to installation, a carefully planned system layout should be documented. At a minimum, this document should include the location of the Hub, the location of the Remotes, the Antenna locations, the fiber locations and lengths, and the location of the power supplies for both Hubs and Remotes.

The Hub is located at the Building Base Station or BTS. The Hub interfaces with the user's PCS System. The Remote units are distributed in the building and provide signal coverage. Optical fiber cables connect the Hub to the Remote units. The Hub can be powered with +24 VDC from the BTS, or with an optional power supply providing +48 VDC, 90-130 VAC, or 190-270 VAC. The remote AC power supply will power up to 16 Remotes.

Two optical fibers are required for each remote unit; each Hub can connect to up to eight Remote units. Angle-polished SC/APC connectorized optical fiber cable must be installed in the building. Any optical connector used between the Hub and the Remote units should be an angle-polished connector specified for return loss >55 dB. Fusion splices to connect fibers are also suitable. Flat polished connectors anywhere along the optical fiber path will degrade the system performance.

3.4 Power Supply Installation

If purchased, install the power supply and connect power to the Hub. An on-off switch is located in the rear of the chassis and should remain in the off position until the installation is completed. Before connecting the Hub or Remotes to the power supply, apply AC power to the supply and verify the output voltage with a voltmeter.

3.5 Single Hub Installation

To install the Hub, locate it as close as possible to the Service Provider's BTS. Excessive distance between the BTS and Hub will result in unnecessary cable losses. It is also very important to ensure that the composite RF Downlink power does not exceed +20 dBm. Table 1 shows the maximum allowable power setting for each carrier to arrive at a composite power of +20 dBm.

Table 1. Power per carrier table

Number of Carriers	Power Per Carrier
1	+20 dBm
2	+17 dBm
3	+15.2 dBm
4	+14 dBm
N	+20 – [10log(n)] dBm/channel

Note that each additional provider requires a reduction in carrier power to maintain the maximum rated input power of +20 dBm.

- Using a Philips screwdriver and the provided screws, secure the Hub in a standard 19" equipment rack near the BTS.
- Connect the Downlink RF Output from the BTS to the RF Input on the Hub.
- Connect the RF Output from the Hub to the BTS Uplink port.
- Connect the power to the hub.
- If the modem option was purchased and a dedicated phone line is available, connect the RJ-45 phone jack.
- Log onto the Hub as user and follow the system initialization procedures.

3.6 Multiple Hub Installation

For installations requiring more than one Hub, there will be one Hub designated as the Master and the other Hubs will be slaved to the Master. Up to three additional Hubs can be slaved to a single Master Hub. The BTS will only interface to the Master Hub. An optional Master Alarm Controller may be purchased to allow alarms to be reported to an offsite monitoring station. If purchased, the Master Alarm Controller will be factory installed.

- Identify the Master Hub, and using a Philips screwdriver and the provided screws, secure the Master Hub in a standard 19" equipment rack near the BTS.
- Install the Slave Hub(s), and using a Philips screwdriver and the provided screws, secure the Hub(s) in a standard 19" equipment rack near the Master Hub.
- Using SMA jumper cables, connect the Slave Downlink Outputs on the rear of the Master Hub to the Slave Downlink Inputs on the Slave Hub(s).
- Using SMA jumper cables, connect the Slave Uplink Inputs on the rear of the Master Hub to the Slave Uplink Inputs.
- If purchased, connect a standard RJ-45 phone cable to the Master Alarm Controller located on the rear of the Master Hub.

3.7 Combiner Installation

To install the combiner, locate it as close as possible to the BTS and Hub installation site. All connections should be made with High quality, low loss RF cables with 50 Ω , type N terminations.

- Connect the Duplexed BTS Input from Service Provider A to the Combiner Port A.
- Connect the Duplexed BTS Input from Service Provider B to the Combiner Port B.
- Connect the Combined TX Port on the Combiner to the Hub RF Input Port.
- Connect the Combined RX Port on the Combiner to the Hub RF Output Port.

3.8 Remote Installation

Follow these steps to install each remote unit.

- For external antenna use, connect the Antenna to the remote using 50 Ω cable with an SMA-type connector.
- Remove the cover on the Remote fiber connector. Using a dust free air source, clean the fiber connector.
- Remove the plastic cover on the fiber and clean the connector tip.
- Connect the fiber(s) to the remote.
- Connect the DC power cable to the remote.
- Ensure that the power switch on the main power supply is in the “off” position and connect the power to the Remote observing the polarity markings.
- Mechanically secure the Remote in its designated location.
- After power-up, the front panel LED should be Amber for ten seconds and then turn green (assuming the Hub is connected properly).

3.9 System Verification and Initialization

If all the previous steps have been followed carefully, the EkoLite II system is now ready for verification and initialization. Connect to the Hub via serial cable or modem.

Note that if no master controller is present, the user will connect to the “HUB RS232” connector located on the rear of each Hub. If the Master Controller module was purchased, the user can connect to the “Master RS232” port located on the front of the Master Hub.

The standard terminal settings are:

- 9600 Baud
- 8 Data bits
- 1 Stop bit
- No flow control
- No Parity

If you are unfamiliar with serial communications, please refer to the Operator’s Manual for a step by step guide to connecting to the Hub.

At the Hub, apply power to the system by turning the power to the “on” position. The Hub LEDs should be green if everything is functioning properly. If any of the

LEDs are flashing, there is an alarm condition and you should refer to the Operator's Manual to troubleshoot the problem.

Note that any unused ports on the Hub will indicate an alarm condition until the user commands the Hub to ignore those ports. Please refer to the Operator's Manual for further details.

Each Remote has one alarm LED. When power is first applied to the Remote, its LED will be amber for a period of 10 seconds. After the initial period, the LED will indicate either an alarmed condition or normal operation. A solid green LED indication on the Remote is normal and means that everything is functioning properly. If any of the Remote LEDs are not green, there is an alarm condition. Refer to the Operator's Manual to resolve the problem.

3.10 User/Guest Login

When the Hub Controller first powers up, there is a start-up message indicating the firmware release and copyright legends:

```
Hub Controller Program V0.99 [Build 04Oct02]
Copyright (c) 2002, EMS-Technologies, Inc.
```

If the user presses the ENTER key, the login prompt is displayed:

```
Hub Controller Program V0.99 [Build 04Oct02]
Copyright (c) 2002, EMS-Technologies, Inc.
```

Username:

There are two basic types of login available to the customer: Guest, and User. The guest login is for simple monitoring of the unit, but the ability to change settings is quite limited. The user login is for the customer use and allows basic system changes to be made to the module. Note that the login username and password are CASE-SENSITIVE.

```
Hub Controller Program V0.99 [Build 04Oct02]
Copyright (c) 2002, EMS-Technologies, Inc.
```

Username: user

Password: ****

Access granted to user

2>

The last entry “2>” is the prompt indicating the user’s level of privilege. The prompt may be composed of several “reminders”, where a single capital letter indicates a system change. These reminders are as follows:

<1>: Login privilege level of “guest”

<2>: Login privilege level of “user”

“A”: An alarm is active

“C”: Calibration tables are invalid; the default calibration tables are in use.

“F”: Settings do not agree with the stored values in flash memory. This is usually the result of a change due to a user’s command setting. **All settings are read from the user’s settings in flash on power-up. If the check value does not agree, then the default settings are used.**

3.11 Command Structure

There is an extensive user help menu available to the user which is explained in a separate software command reference manual. The basic format for all the commands is:

<Primary-Command> <Secondary-Command> = <setting>

All commands are made up of this generic format. In some cases, there is no setting or secondary command. The command set is basically a tree diagram, where typing in the primary (and optionally secondary) command with the setting result in a change in the module’s operational parameters. All input is case-insensitive for commands.

For example:

set laser 1 = on

This command would turn the laser #1 on at the present potentiometer setting stored in memory.

3.12 Remote Alarm Disabling

From the factory, the Hub is programmed to alarm any time a Remote is disconnected from the Hub. This safety feature is designed to indicate such catastrophic events as the fiber to the Remote being cut. For a Hub that does not use all eight channels, the unused channels will report an alarm by default. These are false alarms and it will be necessary for the user to disable these unused channels to clear the alarms.

The command to disable the unused channels is:

```
2>set fiber <n> = disabled
```

Where n corresponds to the desired channel. In the event that the wrong channel is inadvertently disabled, or a remote is added at a later time, the disabled channel should be enabled using the following command.

```
2>set fiber <n> = on
```

Where n corresponds to the desired channel.

3.13 Offsets

Under normal conditions, the factory default power settings are configured to provide +12 dBm output power (1900 MHz models), or +8 dBm (800 MHz models) at each remote. The factory settings will provide optimal performance in most environments. However, the user has the option to change the power settings in each remote according to individual requirements.

Set an “offset” to the default value for the desired remote. For example, to set remote 1 to +10 dBm type:

```
2>set remote 1 = -2
```

The range for the offsets is –10 dB to +8 dB and can be set in 1 dB increments. In this way, each remote can be tuned to the user’s specific requirements after the system is deployed.

To verify the offsets for each remote the following command may be used:

2> get remote n

where n is the number of the specific remote offset requested.

These commands allow for most basic set-ups to be configured properly. The Operator's Manual and the companion Software Command Reference Manual contain much more detail for manual configurations.