WIRELESS TECHNOLOGIES

LinkNet UniServ Unit (USU)
RF - FIBER
Interface Modules
User Manual
Installation, Operation
And Maintenance

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PROPRIETARY STATEMENT

TRADE MARK NOTICE

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1. USU MODULES

Overview

Theory Of Operation

The USU RF to Fiber Modules provide a single-band link from a Head-End Distribution center to multiple local antennae. RF Signals are distributed over a pair of Single-Mode Fiber-Optic Distribution Lines to each USU Remote.

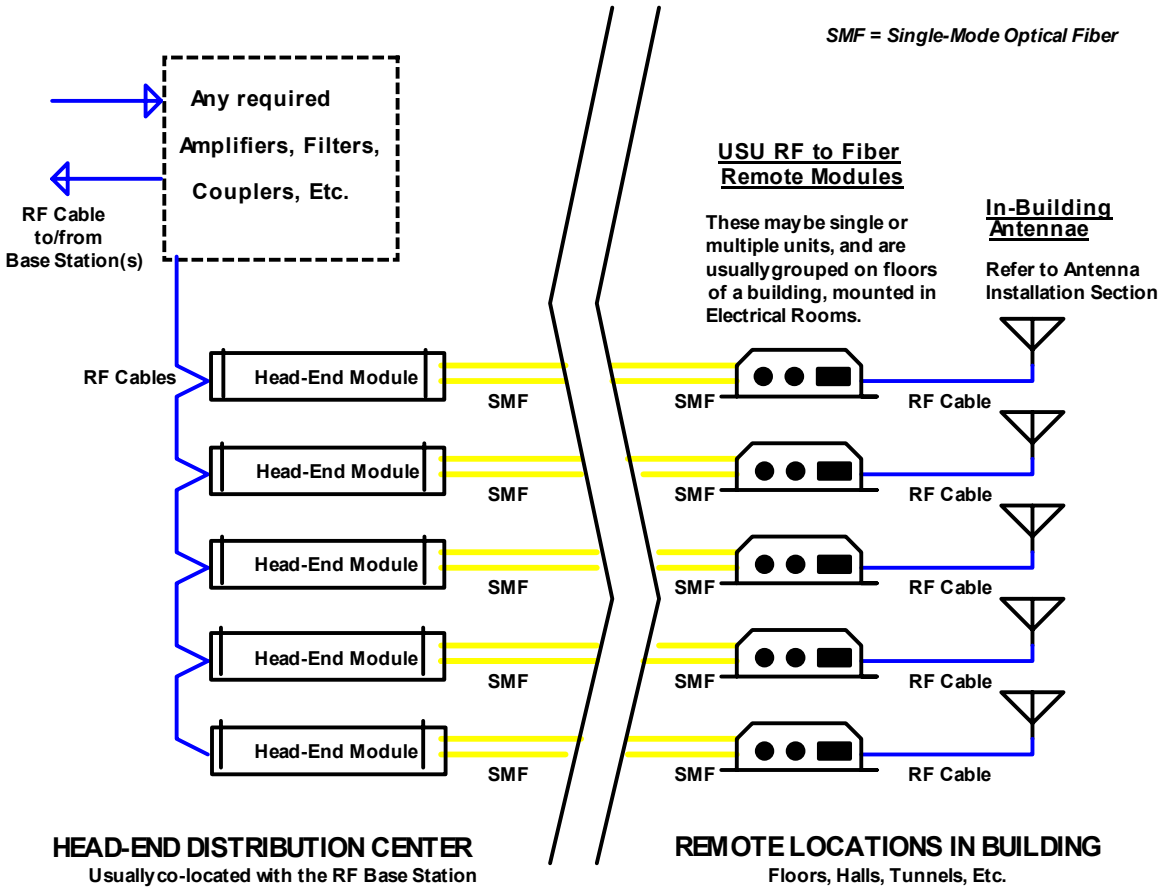
Each Head-End Module can interface to multiple Remote Modules, the number depending upon the Head-End Model.

The Head-End Modules **do not** transmit directly out into the air.

Note that the Remote Module Fiber-Optic I/O's are band specific, but the Head-End Fiber-Optic I/O's are not; the Head-End I/O's may be used for any band.

Typical Application

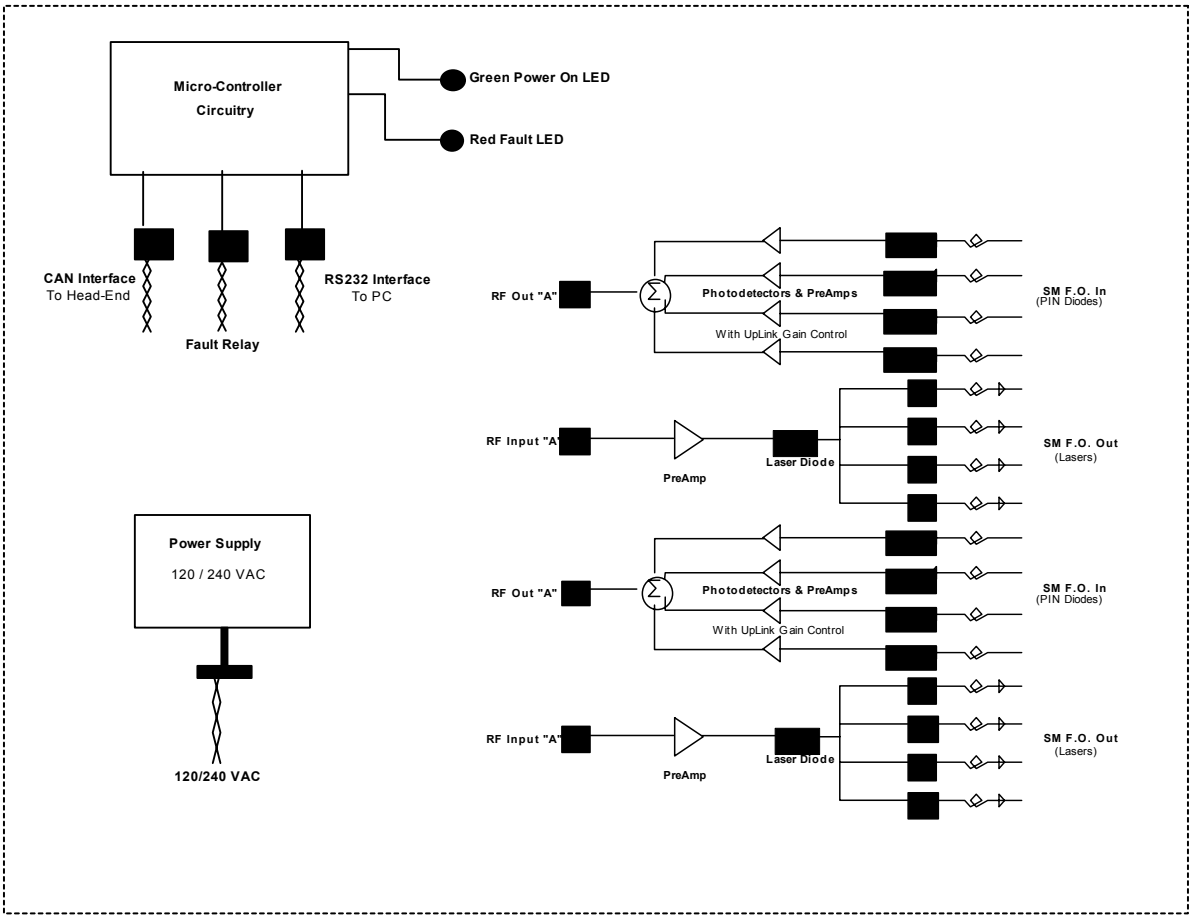
A typical installation would be....



Models

MODEL	DESCRIPTION
US800TP USU Remote Module	Wall, Shelf, or Rack Mounted Remote Module that connects to the Single-Mode Fiber-Optic Distribution Lines and provides a single duplex Antenna RF Distribution connection. This model covers **800MHz Trunking / iDEN / Public-Safety Services** (806-824 MHz / 851-869 MHz).
US800C USU Remote Module	As above, but this model covers **800MHz Cellular Services** (824-849 MHz / 869-894 MHz)
US900P USU Remote Module	As above, but this model covers **900MHz Paging Services** (896-902 MHz / 928-941 MHz)
US1900P USU Remote Module	As above, but this model covers **1.9GHz PCS Services** (1850-1910 MHz / 1930-1990 MHz).
Note that for each Model above there is a Model with a **"-2"** suffix. These extra models have **separate Rx and Tx RF Ports** instead of a combined Transceiver (Antenna) Port.	
US-PS01	Power Supply for 1 US Remote Module.
LNKFIB-H03 Head-End Module	This is a 1U high, 19" Rack-Mount Module providing low signal level interfacing between Head-End RF Modules and 8 Pairs of Single-Mode Fiber-Optic Distribution Lines. The 8 Fiber-Optic Pairs are in two groups of four, with the RF connections combined inside the Module in those groupings.
LNKFIB-H04 Head-End Module	This is a 1U high, 19" Rack-Mount Module providing low signal level interfacing between Head-End RF Modules and 4 Pairs of Single-Mode Fiber-Optic Distribution Lines. The RF connections for the 4 Fiber-Optic Pairs are combined inside the Module.

Block Diagrams LNKFIB-H03 and LNKFIB-H04 Head-End Modules

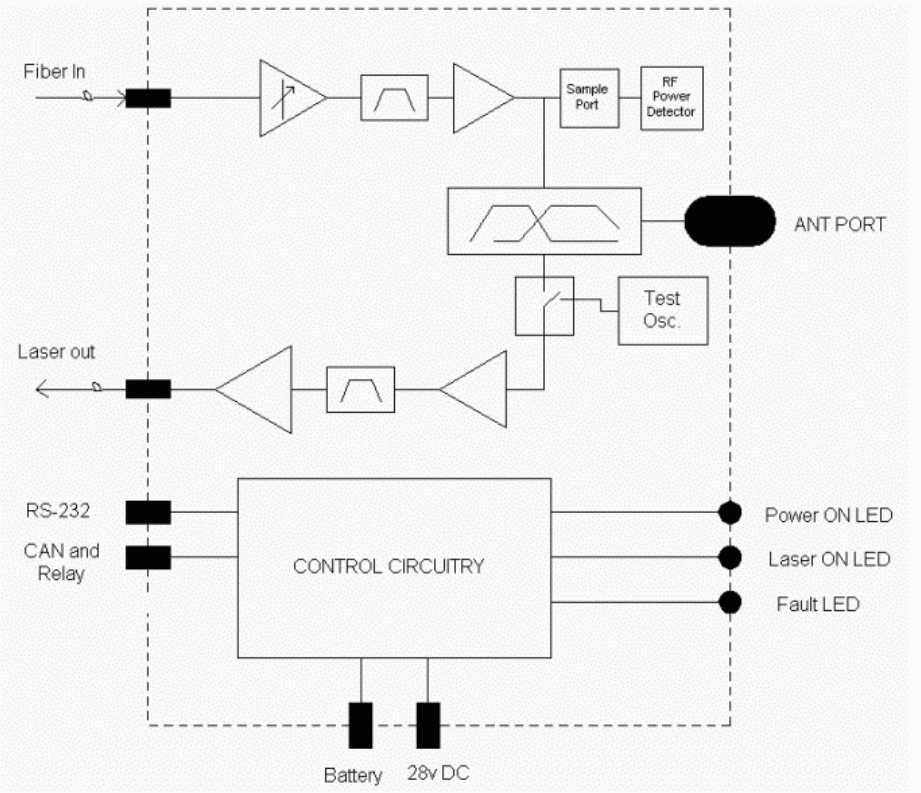


In the LNKFIB-H03 Head-End Module the 8 Fiber-Optic Pairs are in two **Banks (A & B)** of four, with the RF connections combined inside the Module in those groupings. The LNKFIB-H04 is identical, but with one Bank of 4 removed.

Each of the Groups of four consists of a single RF Input feeding a single Laser Transmitter split optically to four Fiber-Optic Outputs. The four matching Fiber-Optic Inputs each go to their own Photodiode Receiver, followed by a 0 to -15dB digitally controlled attenuator providing Uplink Gain Control. The RF signals from the four digital attenuators are combined into a single RF Output.

The Group-of-Four RF Input and Output combining inside the Module alleviates the need for external combining / splitting.

US Remote Modules

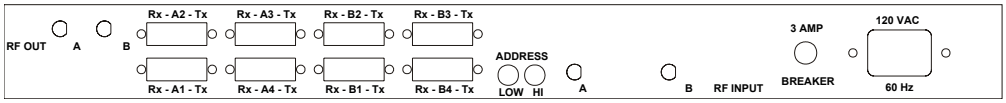


The US series Remote Modules have a Fiber-Optic transceiver pairs downlink and uplink filtering, and an downlink RF Power Amplifier.

Connections

LNKFIB-H03 and LNKFIB-H04 Head-End Module Connections

The LNKFIB-H03 Head-End has two Downlink RF Inputs providing the signal for eight Downlink Optical Outputs arranged as groups of four, "A" and "B". It also has eight Uplink Optical Inputs combined in two groups of four providing RF Outputs "A" and "B". The RF and optical connections are all on the rear panel. The Group-of-Four RF Input and Output combining inside the Module alleviates the need for external combining / splitting.



The CAN, RS232, and Fault Relay Interface connections are all on the front panel. Their connections are...

RS232 Connection:
The RS232 Port is for interfacing to a PC via a Null-Modem DB9 female to female cable, and operates at 9600 baud, 8 bits, no parity, and 1 stop bit. It is a 3-wire connection with...

DB9 Pin #	Signal
2	RS232 Receive
3	RS232 Transmit
5	Ground

User I/O Connection:
This Connection is via a standard 15-pin Female D-Sub Connector on the side of the enclosure...

DB15 Pin #	Signal
1	CAN High
9	CAN Low
8	CAN Common (Ground)
3	Fault Relay Common
2	Fault Relay - Closed for Fault
4	Fault Relay - Open for Fault

The Form-C Relay is rated at 30 VDC or 30 VAC @ 0.5 Amp.
Also, refer to the **DCM000000103 CAN Wiring Guide**.

US Remote Module Connections

The Remote Module has 1 or 2 SMA RF Connections..

RF Xcvr: For the normal (**non -2**) models there is a single RF Transceiver port used to connect to a distributed indoor antenna system.

RF Tx & Rx: For the 2-Port (**-2**) models there are RF Transmit and Receive Ports used to connect to external filtering and combining, then to a distributed indoor antenna system. Consult with Kaval for details.

Fiber-Optic Ports: There are two SC/APC Single-Mode Fiber-Optic Connections for cabling to the Head-End.

RS232 Connections: There are two RS232 Connections via standard 9-pin Female D-Sub Connectors. They are wired as...

DB9 Pin #	Signal	
1	DCD in	(RS232 #2 only)
2	Transmit	
3	Receive	
5	Ground	
6	DSR	(or +5V Power)
7	CTS in	
8	RTS out	
9	RI in	

RS232 #1 is for interfacing to a PC via a straight-through DB9 male to female cable, and operates at 9600 baud, 8 bits, no parity, and 1 stop bit.

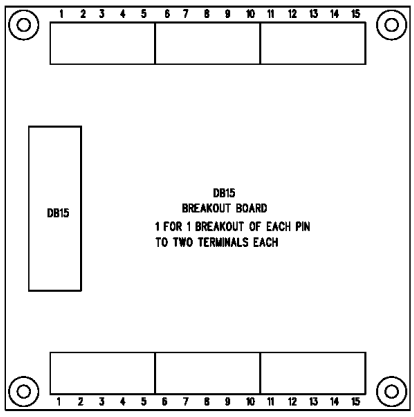
RS232 #2 is for custom software controlled applications.

User I/O Connection: This is a standard 15-pin Female D-Sub Connector...

DB15 Pin #	Signal
1	CAN High
9	CAN Low
8	CAN Common
2	Fault Relay - Closed for Fault
3	Fault Relay - Common
5	Fault Relay - Open for Fault
6	+28 VDC at up to 0.5 Amp
7	Ground
10	Aux. In #1 (contact to ground)
11	Aux. In #2 (contact to ground)
12	Aux. In #3 (contact to ground)
13	Aux. Out #1 (open collector)
14	Aux. Out #2 (open collector)
15	Aux. Out #3 (open collector)

The Form-C Relay is rated at 30 VDC or 30 VAC @ 0.5 Amp. The Aux. lines are under custom software control. Also, refer to the **DCM000000103 CAN Wiring Guide**.

Note that the **ASY00420 DB15 Breakout Kit** may be ordered to bring the User I/O connections out to screw terminals for easy wiring...



This 4" x 4" Board mounts onto four 3.5" x 3.5" #6 locations, and includes a 6' DB15 to DB15 Cable.

At the rear of the remote unit are the Power and Battery connections...

Head-End to Remote Interconnects

The Single-Mode Fiber-Optic interconnections between the Head-End and Remote Modules are to be made in whatever manner suits the system configuration. For the CAN Network connections please refer to **DCM000000103**.

Fiber-Optic Connections

- All **Fiber-Optic Cabling** must use 9/125 or similar Single-Mode (yellow jacketed) high-quality cable. This cable should typically have less than 0.5 dBo (optical dB) insertion loss per kilometer.
- From the cable manufacturer's specification, ***minimum bend radius*** must be observed.
- Most Kaval products use **SC/APC** connectors. Note that the "APC" is critical. These are ***angle-polished connectors*** and are required to reduce reflections.
- Fiber-Optic Patchcords should be avoided; ***Fusion-Splices*** are preferred to reduce reflections.
- **Fiber-Optic Connectors**, both on cables and equipment, should always have their dust caps in place when not in use. The connector tips must be kept clean and scratch free, and should always be cleaned properly before being connected.
- **Optical Reflections** back into laser diodes cause a disturbance in the lasers gain cavity creating noise and distortion. An OTDR or other Fiber-Optic Instruments should be used to check optical reflections. Fiber-Optic Return Loss should be less than -50 dBo.
- There is a **2 to 1 Relationship** between optical loss and RF loss. One dBo (optical dB) of optical loss corresponds to 2 dB of RF loss.

Power for the Remote Module

The US Remote Module may be powered by any source of negative ground +28VDC power capable of delivering 1 Ampere. This includes the optional single US Remote Module **US-PS01 Power Supply**...

Battery Backup of Remote Module

If the USU Remote Module is being used without a Battery it must be configured to NOT use a battery. Without a battery the USU will shut down or reset with any disruption to the AC power. When power is re-established the system will restart automatically. External batteries may be connected using the **CAB000000055 Battery Cable**. The USU has a built-in battery charger that will automatically recharge the attached battery.

Refer to **DCM000000102 "Battery Backup Manual"**.

For Battery Backup purposes...

Vbat = 24 VDC **Ic = 0.1 Ampere** **Id = 0.75 Ampere**

Module Specifications

Frequency Bands	Refer to Model Chart
Maximum Downlink Power	+38 dBm IP3 Minimum for iDEN, Cell, Page +36 dBm IP3 Minimum for PCS **(see Remote Module Carrier De-Rating Chart)**
Maximum Uplink Power Combined at any Head-End RF Output. *Includes the 4-way combiner loss.*	+4 dBm IP3 Minimum, iDEN/Cell/Page 0 dBm IP3 Minimum, PCS *(7 to 12dB higher for LNKFIB-H01)*
Downlink Gain from Head-End to the Remote Module Antenna Port, assuming 0dB Fiber-Optic Link	**+20 dB after Gain Adjustment** Typical range before Gain Adjust is +20 to +35 dB for 800-900 MHz Bands +20 to +31dB for 1.9 GHz Bands **(See Gain Adjustments)**
Downlink Gain Ripple	+/- 2.5 dB, iDEN, Cell, Page +/- 3 dB, PCS
Uplink Gain from Remote Module Antenna Port to Head-End, assuming 0dB Fiber-Optic Link	**+20 dB after Gain Adjustment** Typical range before Gain Adjust is +20 to +32 dB for 800-900 MHz Bands +20 to +32dB for 1.9 GHz Bands **(See Gain Adjustments)**
Uplink Gain Ripple	+/- 2.5 dB, iDEN, Cell, Page +/- 3 dB, PCS
Max RF Input without Damage To Head-End Units	**+10 dBm**
Uplink Noise at Head-End Unit from any Remote Module Antenna Port assuming 0dB Fiber-Optic Link	< -130 dBm/Hz *(with Uplink Gains Balanced)*
Isolation	**Consult Kaval Engineering Services** (depends upon Head-End Filtering)
Duty Cycle	Continuous
Spurious Outputs	-20 dBm max per Remote Module Antenna Port when operated as per De-rating Chart
Optical Power Level	**Laser Warning:** Invisible Laser Radiation emitting from optical connector. Avoid direct exposure to beam. 150 mW max. @1300nm. Class IIIb. Product complies with 21 CFR 1040.10 and 1040.11.
Optical Path Loss	2 dBO Maximum
Group Delay	<2uS, **NOT** including Fiber-Optic Link
Connectors	SC/APC Fiber-Optic, SMA (50ς) RF D-Sub Data & Control
Head-End Module Power Supply Requirements	120 VAC, 50/60 Hz, 120 VA Typical, 200 VA Max.
Remote Module Power Supply Requirements	28 VDC from external Power Supply 0.75 Ampere Maximum and 24VDC "Gell-Cell" Battery Backup Option
Configuration Options	Either via the USU network and a Gateway Module, or via a PC and an RS-232 Connection.
Operating Temperature Range	-20 to +50°C
Operating Humidity Range	5 to 90% RH, Non-Condensing
Head-End Module Size & Weight	1U High 19” Rack Unit, 14" Deep, 16 lbs Max
Remote Module Size & Weight	2.75” High, 9.25” Wide, 11” Deep, 7 lbs Max
FCC Identifiers	FCC: H6M-US800TP FCC: H6M-US800C FCC: H6M-US900P FCC: H6M-US1900P
Industry Canada Certifications	IC: 1541A-US800TP IC: 1541A-US800C IC: 1541A-US900P IC: 1541A-US1900P

Remote Module Per-Carrier De-Rating

All signals that fall within a given Pass-Band range will "share" power amongst them. A multiple channel effect is Intermodulation - signals produced from non-linear effects between the intended channel signals. This intermodulation may cause interference to receiving equipment. In order to minimize Intermodulation signals, Power de-rating must be applied. In the USA there are FCC Intermodulation Specifications published in the EIA Standard PN2009. Further de-rating is also required to maintain the integrity of complex digital communications signals. The Tables below gives the maximum per channel Output Levels allowed as a function of the number of channels. Note that depending on the actual input levels, the gain may need to be reduced to comply with the above regulations.

The figures shown are to the nearest dB.

iDEN / Cellular / Paging (effective IP3 = +38dBm)					1.9 GHz PCS (effective IP3 = +36dBm)		
Number of Carriers	Power per Carrier per Antenna Port (dBm)		Total Power per Antenna Port (dBm)		Number of Carriers	Power per Carrier per Antenna Port (dBm)	Total Power per Antenna Port (dBm)
	FM	Dig	FM	Dig	Digital	Digital	Digital
1	+24	+17	+24	+17	1	+15	+15
2	+18	+15	+21	+18	2	+13	+16
3	+15	+13	+20	+18	3	+11	+16
4	+13	+11	+19	+17	4	+9	+15
5	+12	+9	+19	+16	5	+8	+15
6	+11	+8	+19	+16	6	+7	+15
7	+10	+7	+18	+15	7	+6	+14
8	+9	+6	+18	+15	8	+5	+14
9	+8	+5	+18	+15	9	+4	+14
10	+7	+4	+17	+14	10	+3	+13
15	+5	+2	+17	+14	15	+1	+13
20	+3	0	+16	+13	20	-1	+12
25	+2	-1	+16	+13	25	-2	+12
30	+1	-2	+15	+13	30	-3	+12

Note: **The above levels are shown for both FM and Digital (CDMA, TDMA, GSM, & iDEN) Signals for 800-900 MHz, and for Digital only for 1.9GHz.** Some combinations may require additional De-Rating. Consult Kaval Wireless Technologies for further information.

Operation

Normal Operation

For both **USU Head-End and Remote Modules** ...

POWER / OPERATING - This LED will be GREEN when the Module is operating.

LASER - This LED will light GREEN when any one of the Lasers are operating.

F.O. Input - (Remote only) This LED will light GREEN when an Optical Signal is received.

FAULT - If the internal diagnostics detect a problem, then this LED will light Red.

Fault Indications

Each Module continuously performs internal diagnostics. If a problem is detected it will activate its Red Fault LED and Fault Relay. Faults detected include...

- Over Temperature
- Misc. Internal Faults

Detailed Faults are detected by the optional Gateway Module. Details may also be determined via an RS232 connected Terminal Emulator using the **LIST** command.

Configuration and PC Commands

It is possible to re-configure **Modules** in the field, either with a **Personal Computer (PC)** or via the optional **LinkNet Gateway Module**. To use a **PC** it is necessary to connect the DB9 RS-232 connector on the Module to a standard DB9 RS232 Connector on the PC. On the PC a terminal emulation program such as ***HyperTerminal*** is used to communicate to the LinkNet Module. The settings are 9600 baud, 8 bits, no parity, and 1 stop bit. Commands are one or two words followed by pressing *Return*. Commands may be given in upper or lower-case. Available commands are...

Head-End Modules:

ACCESS USER:	Required as a simple password to gain access to customer settable parameters and diagnostics; This will time-out after 10 minutes, and may have to be re-typed.
HELP or ?:	Displays a list of Available Commands.
LIST:	Displays Current Settings and Status Faults, Etc.
VER:	Display the current Version of Software.
ENABLE 1 or 0:	Enables or Disables the Module.
DIGATTN x yyy:	Displays or Sets the Uplink Gain Reduction **yyy**, which is in tenths of a dB. The Optical to RF Path being set is **x**, which is...

x = 0 is for Uplink Optical to RF Path **A1**
x = 1 is for Uplink Optical to RF Path **A2**
x = 2 is for Uplink Optical to RF Path **A3**
x = 3 is for Uplink Optical to RF Path **A4**
x = 4 is for Uplink Optical to RF Path **B1**
x = 5 is for Uplink Optical to RF Path **B2**
x = 6 is for Uplink Optical to RF Path **B3**
x = 7 is for Uplink Optical to RF Path **B4**

Remote Modules:

ACCESS USER:	Required as a simple password to gain access to customer settable parameters and diagnostics; This will time-out after 10 minutes, and may have to be re-typed.
HELP or ?:	Displays a list of Available Commands.
LIST:	Displays Current Settings and Status Faults, Etc.
VER:	Display the current Version of Software.
ENABLE 1 or 0:	Enables or Disables the Module.
DIGATTN ###:	Displays or Sets the Downlink Gain Reduction, which is in tenths of a dB

Please consult Kaval Wireless Technologies for further support.

Gain Adjustments

Gain Adjustment is necessary to compensate for the variations in the Fiber-Optic components of the Head-End and Remote Modules. This must be done after Modules are deployed in a System, and anytime a Module is replaced. The adjustments are on an individual RF Path basis, and each path is adjustable downwards in 1dB steps up to -15dB.

It is recommended that these adjustments be performed with the aid of a Signal Generator and Spectrum Analyzer.

Uplink Gain:

The Uplink Gain is adjusted at the Head-End Module on an individual RF path basis. Please refer to the Head-End **DIGATTN** Commands in the **Configuration and PC Commands** section. All DIGATTN Values are set to 0 (Maximum RF Gain). While monitoring the RF gain via measurements, the individual gain paths are adjusted downwards with the DIGATTN command to meet the Specified Gain. This will optimize / balance both gain and noise.

Downlink Gain:

The Downlink Gain is adjusted at the Remote Module an individual RF path basis. Please refer to the Remote **DIGATTN** Commands in the **Configuration and PC Commands** section. All DIGATTN Values are set to 0 (Maximum RF Gain). While monitoring the RF gain via measurements, the individual gain paths are adjusted downwards with the DIGATTN command to meet the Specified Gain. This will optimize / balance both gain and noise.

Signal Level Adjustments

Signal Level Adjustment is necessary to ensure that the Downlink RF Carriers transmitted via the Remote Modules are not generating undesired intermodulation products, nor are they being distorted beyond use. Refer to the earlier section on **Remote Module Per-Carrier De-Rating**.

It is recommended that these adjustments be performed with the aid of a Signal Generator and Spectrum Analyzer, and that they be done AFTER the Gain Adjustments.

Adjust the Downlink Interface Amplifiers and/or attenuators between the Base Station (see the **Typical Application** drawing) to achieve the specified de-rated per-carrier level.

Uplink Signals should be monitored as they feed into the Base Station - this is usually a site specific requirement.

Product Warranty

Please contact Kaval Wireless Technologies for a copy of the Standard Product Warranty.

RMA Procedure

All returns, including warranty returns, must have a valid Return Material Authorization (RMA) number.

Customers must contact *KAVAL WIRELESS TECHNOLOGIES* before shipping any product for warranty service and obtain a Returned Materials Authorization and detailed shipping instructions. Shipping charges, for shipment of product to *KAVAL WIRELESS TECHNOLOGIES* for warranty service, will be borne by *KAVAL WIRELESS TECHNOLOGIES* if a defect covered by warranty is found and warranty service is required. At *KAVAL WIRELESS TECHNOLOGIES*'s sole discretion, a service fee will be charged if a returned unit is found by *KAVAL WIRELESS TECHNOLOGIES* not to be defective, or defective for a reason that voids this warranty. Return shipping charges shall, in such case, be the responsibility of the customer.

Laser Safety

- **CAUTION – use of controls or adjustments, or performance of procedures other than those specified herein may result in hazardous radiation exposure.**
- **This laser product is certified as a CLASS I laser product to the requirements of the US Federal Product Performance Standard for Laser Products contained in the regulations in 21 CFR Subchapter J. Class I laser products are not considered to be hazardous.**
- **This laser product incorporates a Class IIIb laser module, which generates levels of invisible laser radiation that may be hazardous. However, this machine incorporates protective housing and optical fibers in the machine design such that there is no exposure or human access to laser radiation when the product is properly installed.**
- **All optical output connections to the LinkNet UniServ Unit (USU) must either have an optical fiber connected or be capped.**
- **UNDER NO CIRCUMSTANCE shall attempts be made to operate this system without the optical fibers connected or with caps removed from the optical output connectors.**
- **All service to the LinkNet UniServ Unit (USU) shall be performed by Kaval Wireless Technologies service personnel, their authorized agents, or personnel trained by Kaval Wireless Technologies.**

CAUTION
INVISIBLE LASER RADIATION WHEN OPEN.
AVOID EXPOSURE TO THE BEAM

Antenna Installation

- All Antenna Installation to be performed by Qualified Technical Personnel only.
- Antenna Installation Instructions and locations below are for the purpose of satisfying FCC RF Exposure Compliance requirements.
- The *In-Building Antenna* connection is via a coaxial cable distribution system with Signal Taps at various points connected to the fixed-mounted *Indoor Antennae*. This is shown in the figure in the Introduction. The *Indoor Antennae* are simple 1/4 Wavelength (0 dB Gain) types. Please consult Kaval Wireless for assistance as required. These Antennae are to be installed such that no person can touch the Antenna, or approach within 0.2 Meters.

ANTENNA INSTALLATION WARNING

ALL ANTENNA INSTALLATION IS TO BE PERFORMED BY QUALIFIED TECHNICAL PERSONNEL ONLY.

ANTENNA INSTALLATION INSTRUCTIONS AND LOCATIONS ARE FOR THE PURPOSE OF SATISFYING FCC RF EXPOSURE COMPLIANCE REQUIREMENTS, AND ARE NOT OPTIONAL.

ALL IN-BUILDING ANTENNAE INSTALLATIONS MUST BE SUCH THAT NO PERSON CAN TOUCH THE ANTENNAE, OR APPROACH CLOSER THAN 0.2 METERS.

FCC Information to Users

- This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provided reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

WARNING

CHANGES OR MODIFICATIONS NOT EXPRESSLY APPROVED BY KAVAL COULD VOID THE USER'S AUTHORITY TO OPERATE THE EQUIPMENT.