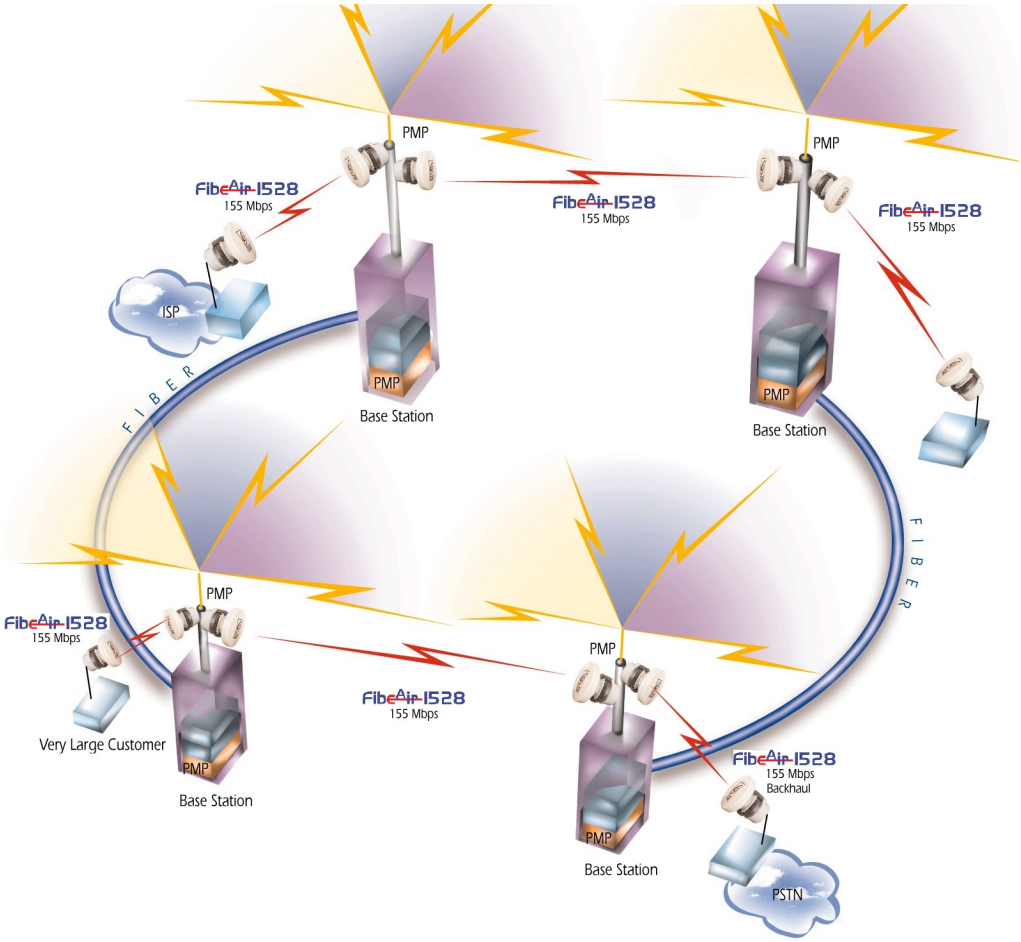
LMDS Backhaul



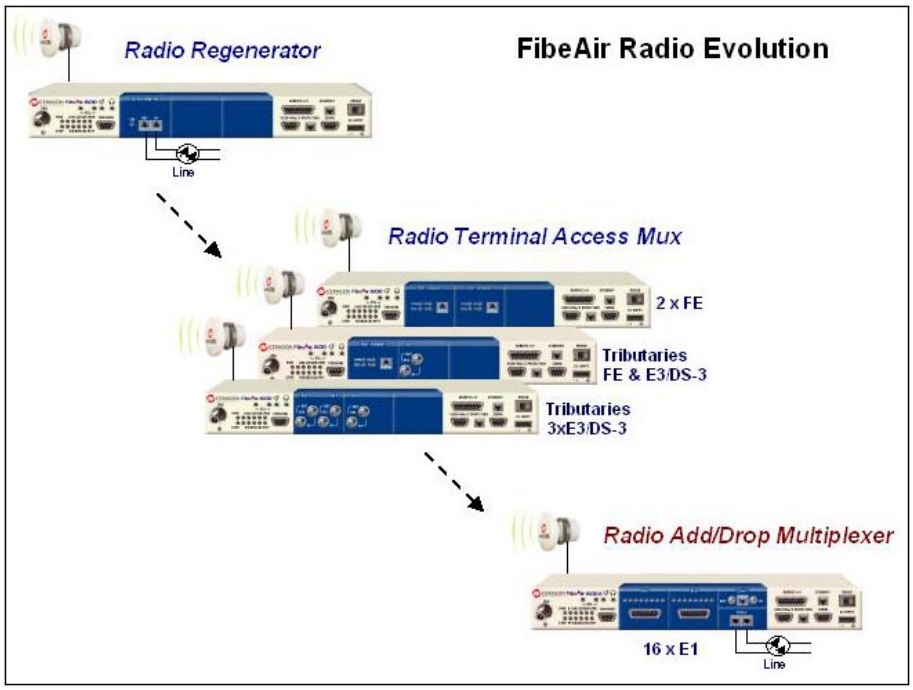
LMDS Backhaul

The high capacity FibeAir 1500/1528 is the ideal wireless building block for the LMDS Backhaul network. Operating in the LMDS frequency bands, the system offers a wireless SONET/SDH ring solution delivering high spectral efficiencies. The system can also provide 155Mbps link from a hub to a large customer, and additional connections can be made to the PSTN and ISP.

FibeAir 1500A/1528A

Ceragon recently added the 1500A (16 QAM modem) and 1528A (128 QAM modem) to its FibeAir family of products. FibeAir 1500A/1528A is Ceragon's SDH IDU with a built-in Add-Drop Multiplexer. The built in ADM increases wireless network reliability and reduces overall network cost. Using FibeAir 1500A/1528A saves the network planner a substantial cost of installing a stand-alone ADM at each site where the add/drop-capability requirement does not exceed 32 E1s, and costs for training and spare parts.

Until FibeAir 1500A/1528A with its fully integrated ADM was introduced by Ceragon, the company provided point-to-point radio links throughout the world. With the introduction of FibeAir 1500A/1528A, Ceragon has broadened its scope to that of a wireless network solution provider, offering both regenerator and integrated network ADM units.



FibeAir 1500A/1528A is a one-box solution for 155 Mbps multiplexed data transmission. The system provides an OC-3/STM-1 wireless ring operating in the 6, 7, 8, 11, 13, 15, 18, 23, 26, 28, 32, and 38 MHz frequency bands. The unit is based on the same field-proven technology as the FibeAir 1500, with the addition and improvement of ADM-specific cards.

FibeAir 1500A/1528A supports chain and ring topologies. It can be used in pure SDH wireless networks or in mixed (wired and wireless) networks. The ability to add/drop traffic in each node of the network provides network flexibility and ease of planning. Ring topologies provide traffic protection without the need for redundant radio equipment as is required for protected (1+1) radio configurations.

The system supports path protection and synchronization mechanisms, and implements In-Band Management for seamless integration in the network.

Ceragon's management concept involves Ceragon management applications integrated with existing network management platforms.

FibeAir network management is controlled by Ceragon's network management software. CeraView™, Ceragon's SNMP-based GUI element manager, and

PolyView™, Ceragon's open interface network management software, run on Windows 95/98/2000/NT and over HP OpenView (Windows or UNIX).

CeraView and PolyView extend HP OpenView functionality for Ceragon elements in the network.

Features

The following are features of the 1500A/1528A systems:

- Optimized carrier class wireless wireline solution for cellular and service providers.
- Provides up to 31 E1/T1 tributary interfaces per site, optical and/or radio aggregate.
- Path protection and network synchronization in accordance with SONET/SDH standards.
- External synchornization inputs/outputs.
- Unique SNMP-based element and network management, supports path protection and in-band management.

Applications

FibeAir 1500A/1528A supports ring and chain topologies, with full add-drop functionality and path protection in the ring. As a standard ADM, it can easily be integrated in the network with other vendor equipment.

FibeAir's standard in-band management capability enables management of external equipment and FibeAir products within the SONET/SDH network. External synchronization outputs are used to synchronize external equipment with the network.

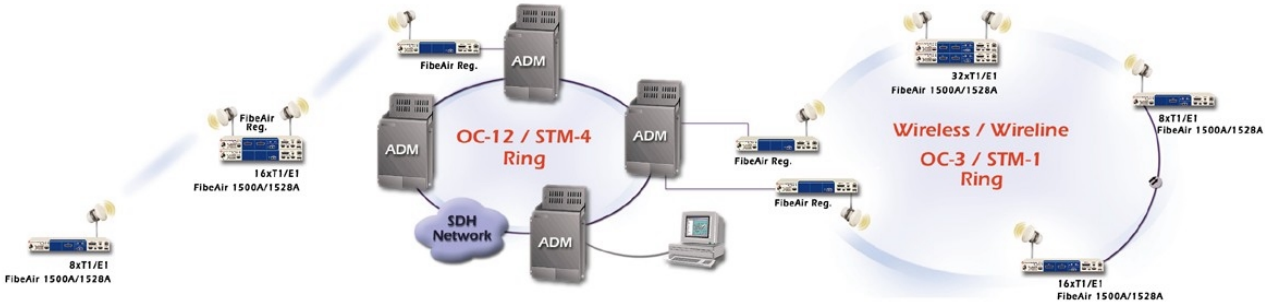
FibeAir 1500A/1528A also supports cascaded topologies, and enables a "highway" type network that drops E1s/T1s at each node.

One possibilty for FibeAir 1500A/1528A deployment is as an access network transmission solution. Instead of Fiber-to-Curb/Building/Office (FTTC/FTTB/FTTO), FibeAir 1500A/1528A can be used for Radio-to-Curb/Building/Office (RTTC, RTTB, RTTO).

At rapidly developing sites using relatively old optical infrastructures, fiber lines may not reach the customer. In such cases, the service provider can use FibeAir 1500A/1528A units for inter-connection and service distribution.

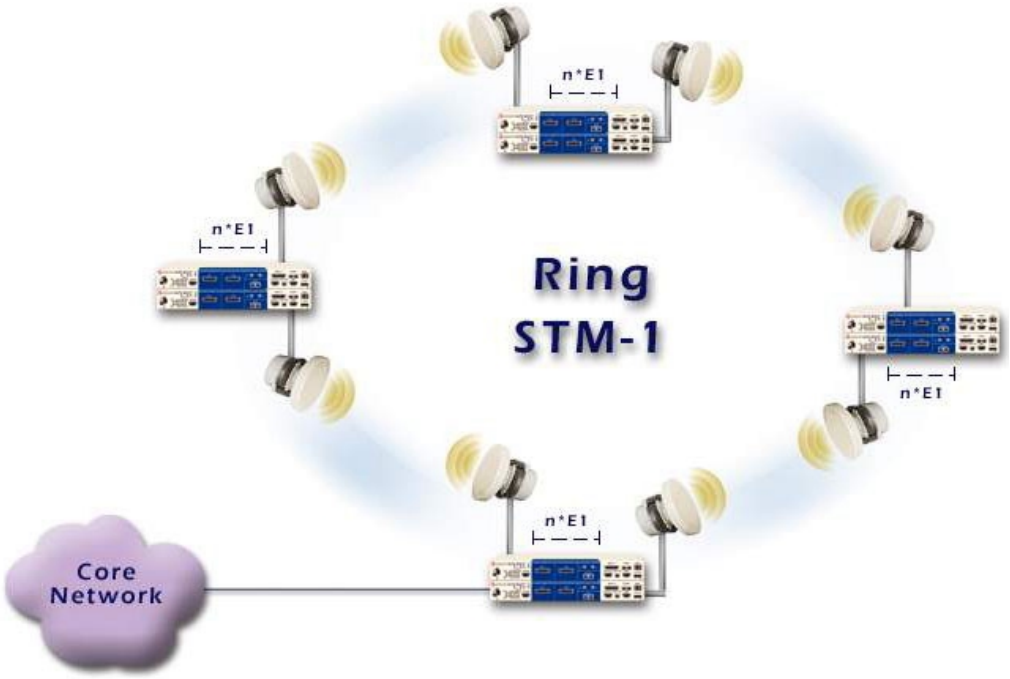
In many cases, customers obtain required capacity via leased lines. FibeAir 1500A/1528A can be used as a cost-effective alternative to leased lines and terminal equipment. In approximately three years, the initial investment in FibeAir 1500A/1528A will be returned, whereas use of leased lines over three years will yield much higher cost.

The following illustration shows FibeAir 1500A/1528A integrated in a typical wireless/wireline network.

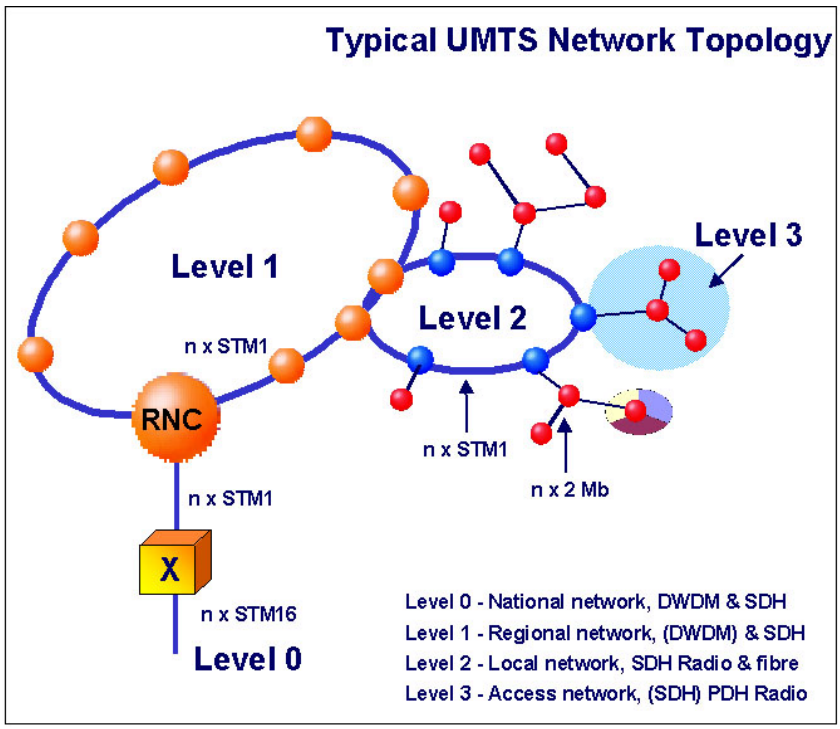


FibeAir 1500A/1528A Integrated in a Wireless/Wireline Network

The following illustrations show FibeAir 1500A/1528A wireless network possibilities:



FibeAir 1500A/1528A Integrated in a Wireless SDH Access Ring



Generic UMTS Network Topology

FibeAir 1500A/1528A, with its integrated ADM, can provide the basis for the Level 1 and Level 2 rings shown in the illustration above.

FibeAir 1500S/1528S

In this modern age, data security is becoming more and more important for many organizations and service providers. Data security is required to protect the customer's privacy and the confidentiality of their businesses. Encryption technologies provide the highest data security level.

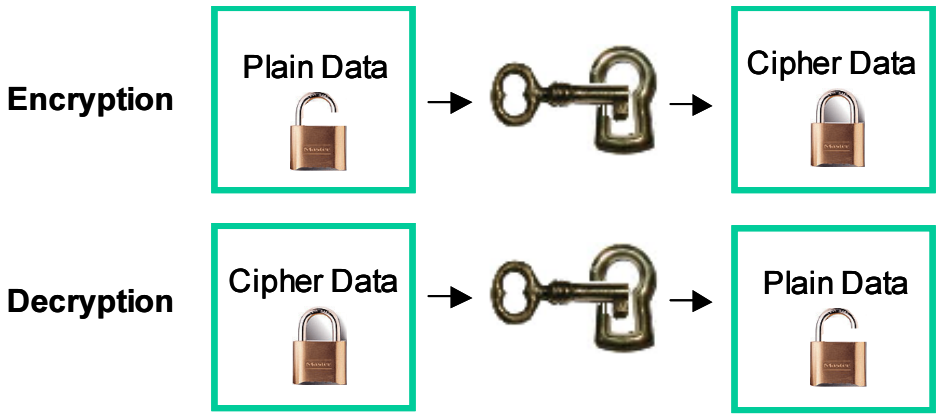
Encryption is a process that inverts the sensitive source information (plain data) to a pseudo-random series (encrypted data) before transmitting it to the target. This pseudo-random series is completely meaningless for all parties that don't share the common secret (encryption keys), while those who do can use it to decrypt the data back to meaningful information.

Due to the growing demand to enhance information security over the PTP wireless link, Ceragon Networks implemented the solution of adding another layer of protection against eavesdropping on the wireless signal and unauthorized access to the rooftop. Our proprietary solution is known as **EncryptAir™**, which is a system that enables the highest level of information security over the wireless medium, without degrading link performance.

The unique EncryptAir™ solution was integrated in our FibeAir family of products, introducing the first carrier class encrypted PTP wireless link.

Encryption Technology

Modern encryption techniques are based on several crucial elements, as shown in the following illustration:



Encryption Algorithm

The encryption algorithm is a uni-directional algorithm that randomizes information so that it cannot be deciphered without having the encryption keys.

An example of an encryption algorithm is DES (Data Encryption Standard), the most popular encryption standard, which is FIPS PUBS 46-3 (Federal Information Processing Standards Publications) compliant.

Encryption Keys

Encryption keys are the common secret between the source and the target, used as an input for the encryption algorithm to encrypt the plain data or decrypt the encrypted data.

Encryption keys can be either symmetric or asymmetric. A symmetric key requires the same secret key for both sides of the link. An asymmetric key requires a different secret key for both sides of the link.

Key Exchange

Since using the same encryption key for a long period of time will degrade encryption reliability, the key is replaced frequently, safely securing the encrypted data.

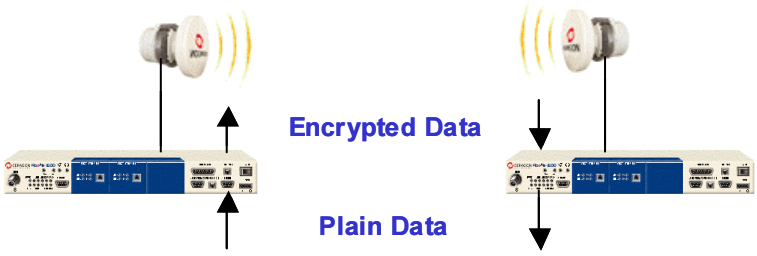
Encryption Synchronization

In order to decrypt the data correctly, the decryptor at the receiver side must be synchronized with the encryptor at the transmitter side. A synchronization protocol is used to keep both sides synchronized using the same key, the same initialization vector, and by starting at the same point.

Wireless Encryption

Wireless connections are more complex to encrypt. The need to overcome BER and fades in the radio channel, while maintaining the radio system performance, requires special handling.

The following figure shows a FibeAir encrypted link.



FibeAir Encrypted Link

The plain data passing through the FibeAir IDU is encrypted and transmitted to the ODU. The encrypted data protects the information flowing to the rooftop against potential eavesdroppers.

EncryptAir, Ceragon Networks' robust encryption mechanism, employs the DES algorithm, which is more suitable for wireless medium, while maintaining the field-proven FibeAir system quality performance.

EncryptAir™ - Ceragon Encryption

EncryptAir is based on proprietary Ceragon Networks technology and provides the first high capacity (155 Mbps+) wireless encryption connection.

EncryptAir implements the DES (Data Encryption Standard) algorithm, which uses symmetric encryption keys, a common secret between source and target, in order to encrypt/decrypt the data.

EncryptAir also implements proprietary algorithms that enable the highest level of information privacy.

Once established, each link has a unique set of encryption keys, allowing many links to operate in the same area, with no link intercepting the data of another link.

The following figure illustrates Ceragon's DES implementation. The standard DES core is empowered with Ceragon proprietary protocols to maintain DES algorithm strength in the wireless connection.

EncryptAir DES I*mplementation*

EncryptAir components include the following:

FPGA - The DES core is implemented in hardware to minimize additional end-to-end delay.

CKEP - Ceragon Key Exchange Protocol

CKEK - Ceragon Key Encryption Key

CESM - Ceragon Encryption Synchronization Mechanism

Automatic Key Management

Integrated in the FibeAir 1U IDU, the EncryptAir algorithm is completely transparent to the operator, functioning automatically without the need for manual key loading or replacement. Encryption can be disabled/enabled via the CeraView® management application.

Keys are the most important part of the encryption algorithm. Knowing the correct key enables the decryption of encrypted information. Not knowing the key makes it impossible to decrypt the data. Since there are more than 70,000,000,000,000,000 (seventy quadrillion) possible keys, the possibility of discovering a particular key is extremely unlikely when typical eavesdropping techniques are used. If the key is changed frequently, the risk of its discovery is diminished even further.

Unique Ceragon protocols were designed to generate secret keys and keep them safe and un-discoverable. The EncryptAir algorithm consists of random key generation, frequent key replacement, and a unique set of keys for each link, for operation in a dense wireless environment. The key consists of 64 binary digits (0s or 1s), whereby 56 bits are used directly by the encryption algorithm, and the remaining 8 bits are used for error detection (parity).

Encryption Performance

The encryption algorithm and protocols were designed to overcome BER and fades, enabling smooth operation over the wireless channel.

EncryptAir maintains the following system parameters:

- Effective bandwidth
- Throughput (payload rate)
- Delay
- BER performance
- System threshold (operation distance)

Supported Products

EncryptAir is available upon request in the following FibeAir Family products:

- FibeAir 1500/1528/3100/6200
- SDH/SONET, IP, and ATM traffic
- All frequencies (ETSI/FCC)

Supported Standards

- Federal Information Processing Standards Publications - FIPS PUB 46-3, Compatible (DES)
- NIST DES compliant, certification #152, as published in http://csrc.nist.gov/cryptval/des/desval.html

FibeAir 1500 Family System Overview

General

The Ceragon FibeAir 1500 Family is available in 6-38 GHz frequency bands to meet user requirements. The FibeAir system consists of an Indoor Unit (IDU), an Outdoor Unit (ODU), and a high-performance antenna.

FibeAir Main Modules

Indoor Unit (IDU)

A compact, 17” wide, 1U-high unit, mount compatible for both ETSI and ANSI standard racks. The IDU includes physical line interfaces, a full-function SONET/SDH regenerator internal multiplexer, an advanced modem, and a main manager card. The IDU can also include optional encryption modules for secure data transfer.

Indoor Unit (IDU)

IDU major functions:

- Modulate/demodulate the 155 Mbps SONET/SDH payloads.
- Local and remote system management and control (IDU + ODU).
- Provide interfaces for 2 Mbps wayside channel, 64 Kbps user channel and 64 Kbps Order Wire channel.
- Provide I/O line alarms.
- Integral multiplexer enables Datacom and Telecom applications convergence.

Outdoor Unit (ODU)

Outdoor Unit (ODU)

The ODU consists of high sensitivity RF circuitry with half band tuning range for most frequencies. An independent controller controls the ODU and its functions, and communicates with the IDU. This controller provides the IDU precise received levels (in dBm) and other indications.

The ODU, which is adjacent to the antenna, is enclosed in a compact, weather-proof enclosure and connects to the IDU via a single coaxial cable of up to 300 m (1000 ft).

ODU major functions:

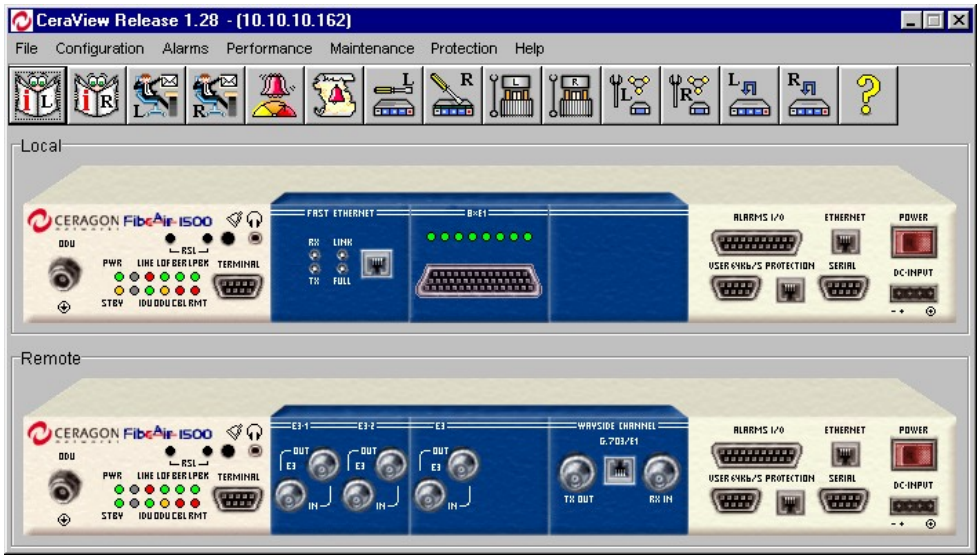
- Interface between antenna and IDU (reception/transmission of microwave signals).
- Power transmission control.

Antenna

The high-performance antenna is available in the following lengths: 1’ (30 cm), 2’ (60 cm), 3’ (90 cm), 4’ (120 cm), or 6’ (180 cm). For low frequencies (6-11 GHz), other antenna sizes (8-15 ft) are available.

CeraView Management Application

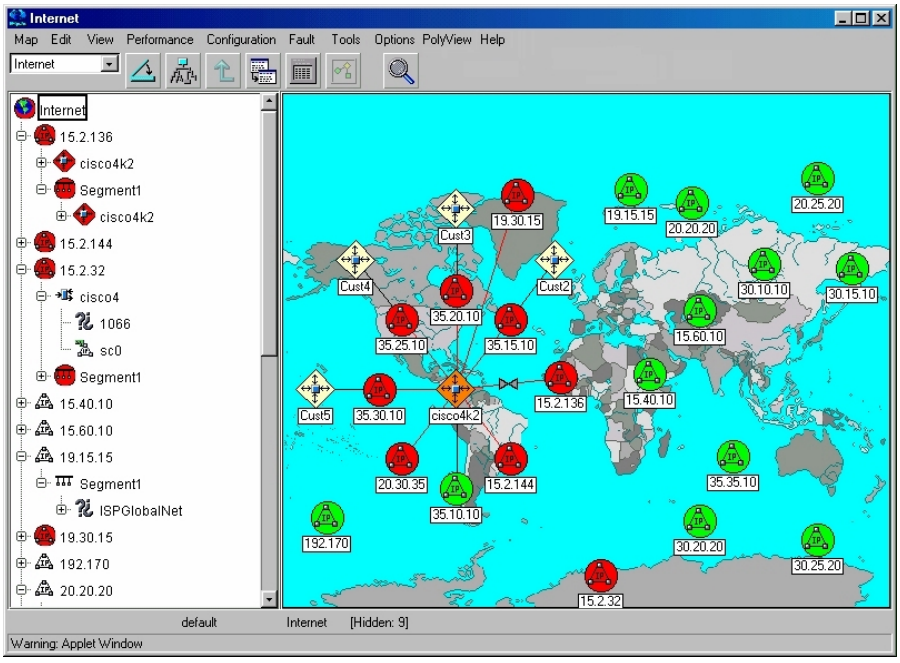
The system is managed either remotely or locally by CeraView, Ceragon’s SNMP-based software, running on either Windows 95/98/2000/NT or UNIX platform, with user-friendly graphical user interface. Ceragon NMS functions are in accordance with ITU-T recommendations for TMN.



CeraView Management Application

PolyView Management Application

PolyView is Ceragon's powerful yet user-friendly NMS (Network Management System) that integrates with other NMS platforms (currently HP OpenView), and systems in which no NMS is used. It provides management functions for Ceragon's FibeAir systems at the network level and individual network element level.



Integrated PolyView Management Application

In-Band Management

In-Band Management refers to a method whereby the network management software sends management packets through the same network it is managing. This differs from out-band management in which the network management software uses a different network (overlay network) in order to communicate with the managed elements.

Ceragon IDUs are capable of forwarding IP packets to Ethernet ports, Serial ports, SDH lines (in the overhead) and Radio interfaces (in the overhead).

The general idea of In-Band Management is that when a packet arrives at an IDU, the software in the IDU checks the IP packet and follows one of two basic scenarios:

- If the destination IP address of the packet is the same as the IP address of the IDU, pass the packet to the IP layer for further processing.
- If the destination IP address of the packet is different than the IP address of the IDU:
  - If the packet arrived from within the ring, send it to the other side. If that side is down, send it back to its origin.
  - If the packet arrived from outside the ring, send it to the radio side. If that side is down, send it to the line side.
  - If the packet belongs to an address outside the ring, send it through the Ethernet port.

Ceragon's FibeAir wireless system provides flexibility in In-Band Management implementation.

The following methods can be used to implement In-Band Management in the FibeAir system:

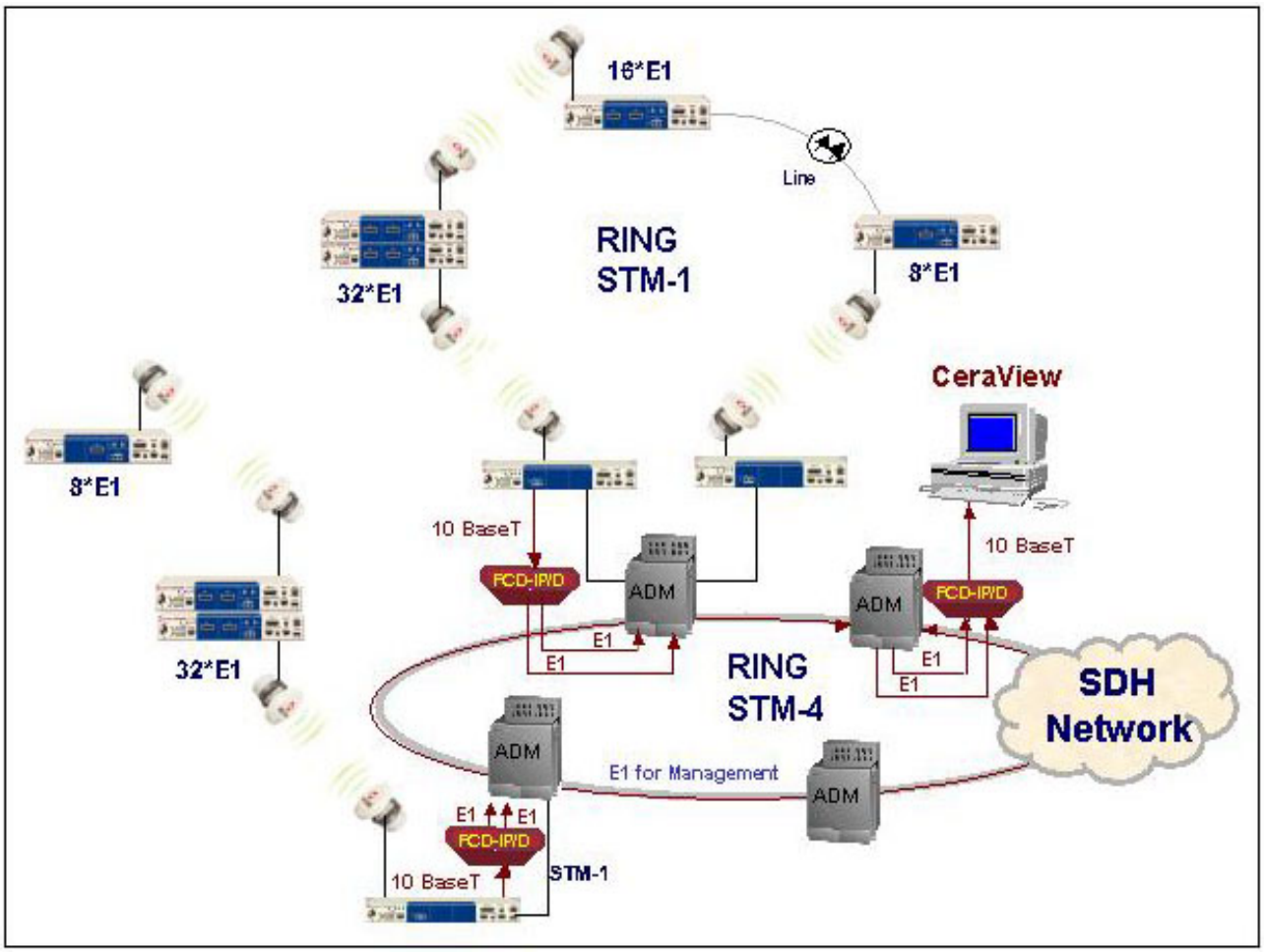
- Transferring DCCr bytes through the radio and the network.
- Transferring DCCr bytes through the radio, but not through the network.
- Transferring DCCr bytes through the 10BaseT wayside channel.

Out-of-Band Management

Out-of-Band Management refers to a method whereby CeraView management signals are transmitted over E1s using FCD-IP/D routers. It is used when several Ceragon sub-networks (ring and chain) are connected to a SONET/SDH network that includes other vendor equipment which do not transparently transmit the DCCR/DCCM data control channels. In such cases, Ceragon sub-networks employ In-Band Management among themselves, and Out-of-Band Management throughout the rest of the network, via FCD-IP/D routers.

Each Ceragon sub-network has a 10BaseT connection to CeraView at the NOC (Network Operation Center). The connection uses one E1 of the transport network, whereby up to 30 sub-networks can be managed using a sinlgle E1 connection.

Management data is protected using the RIP protection method.



Example of Ceragon's Out-of-Band Management Implementation

In the illustration above, the STM-1 ring uses In-Band Management, while the STM-4 ring uses Out-of-Band Management.

FibeAir 1500/1528 Interfaces

OC-3/STM-1 Line Interface

The following most popular OC-3/STM-1 interfaces are supported:

- Multi-mode optical modules, 1300 nm, ST connector.
- Single mode optical modules, 1300 nm or 1500 nm, normal or extended range, ST, FC or SC connectors.
- Electrical (coax) modules, CMI coding, 75 Ω, BNC connector.

Wayside Channel Interface

A plug-in 1.544/2.048 Mbps interface module with standard connectors:

- T1/E1, ITU-T G.703 (supports either balanced or unbalanced interface, BNC connector).
- V.35, X.21, RS-530, V.36 (relevant connectors).
- Ethernet bridge (RJ-45 connector).

User Channel Interface

A 64 kb/s interface module with a RS-232/V.25 (9-pin) interface or Ethernet bridge (RJ-45).

Order Wire Analog Interface

An analog audio interface for use with a supplied headset (microphone and earphone) through a standard mini audio jack. A buzzer and a panel switch (for far-end signaling) are also included.

External Alarms

FibeAir 1500/1528 supports 13 programmable floating contacts for external alarms, 8 for input and 5 for output.

Protected Configuration

The FibeAir Protected Configuration is connection between two FibeAir terminals to provide system protection (for more information, see *Chapter 7 - Protected Configuration*.

FibeAir 1500A/1528A Interfaces

FibeAir 1500A/1528A provides the following OC-3/STM-1 aggregate interfaces:

- Multi-mode optical modules, 1300 nm, ST connector.
- Single mode optical modules, 1300 nm or 1500 nm, normal or extended range, ST, FC or SC connectors.
- RF - N-type
- E1/T1 Tributary - 120/100 Ohm balanced

Chapter 2

Theory of Operation

This chapter describes the FibeAir 1500 family system and how it operates.

The FibeAir design concept is based on universal radio architecture.

FibeAir 1500/1528

A FibeAir 1500/1528 radio link consists of two FibeAir terminals. Each terminal includes three major components, IDU, ODU, and Antenna. A single cable, carrying communications and DC power, connects the IDU to the ODU.

System Block Diagram

Figure 2-1 shows the FibeAir 1500/1528 main blocks and modules.

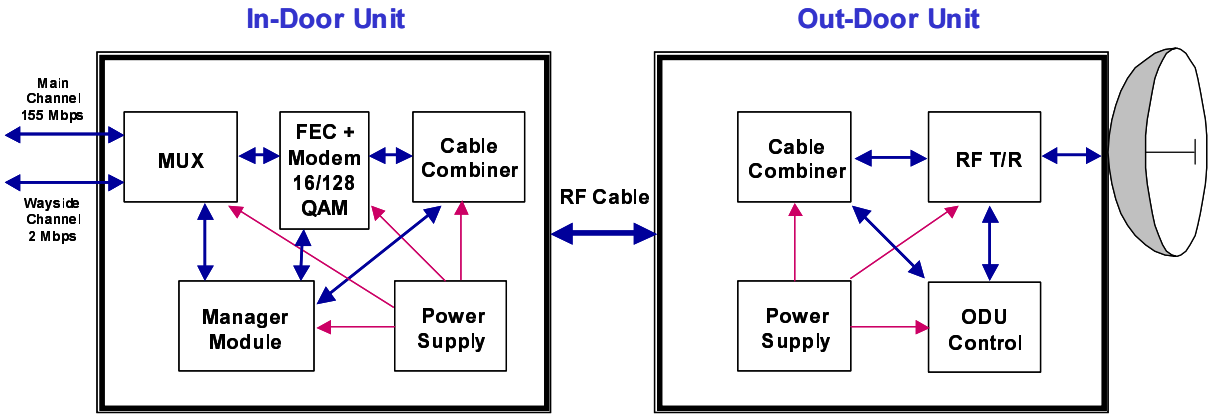


Figure 2-1 FibeAir 1500/1528 System Block Diagram

In Door Unit (IDU)

The IDU is a compact, 17” wide, 1U-high unit, mount compatible for both ETSI and ANSI standard racks. The IDU modulates/demodulates the 155 Mbps Sonet/SDH payloads, manages local and remote units, provides I/O line alarms, and provides interfaces for 1.544/2.048 Mbps Wayside channel, 64 Kbps User channel and 64 Kbps Order Wire channel.

The IDU also interfaces a Local Maintenance Terminal or Network Management System. In addition, status alarms and indicators are provided on the front panel.

The main IDU modules include:

- Network Interfaces
- Multiplexer (MUX)
- Modem
- Manager Card
- Cable Interface
- Power Supply

Multiplexer

The MUX module functions as a Sonet/SDH Regenerator. On the line side it interfaces the OC-3/STM-1 stream, and on the radio side the Modem module.

As a regenerator, the MUX either terminates or regenerates the OC-3/STM-1 RSOH. In one direction, the OC-3/STM-1 stream, interfacing through the MUX Rx line input terminates and the resulting stream is transmitted to the Modulator in the Modem module.

In the opposite direction, the stream coming from the Modem’s Demodulator, undergoes OC-3/STM-1 Regeneration in the MUX, and transmitted through the MUX Tx line output.

In addition, the MUX module uses the OC-3/STM-1 SOH bytes to support other services: 1.544/2.048 Mbps Wayside channel and management, 64 Kbps User Channel and Order Wire channel.

The MUX module may be configured via software for transparency of most of the SOH bytes for maximum system transparency and non-intervention, at the cost of reduced functionality and services.

The multiplexer module enables to integrate different interfaces and services into the SDH payload to converge Datacom and Telecom applications.

Modem

FibeAir 1500 is equipped with a 16-state QAM modem.

FibeAir 1528 is equipped with a 128-state QAM modem.

The modem delivers a 155 Mbps payload in 50/56 MHz channel bandwidth for 16 QAM, and 27.5/28 MHz for 128 QAM, in compliance with FCC/ETSI standards.

The modem is equipped with Digital Signal Processing functions as follows:

- Digital IF - I/Q modulator/demodulator whose functions are:
  - Conversion of the modulated signal to/from the IF frequency.
  - Automatic level equalization on the signal from ODU.
  - Protection against overloads.
- Timing recovery techniques employing digital tracking loop.
- FEC ensures unfaded BER lower than 10^{-13}.

The following figure illustrates a measured 16 QAM constellation.

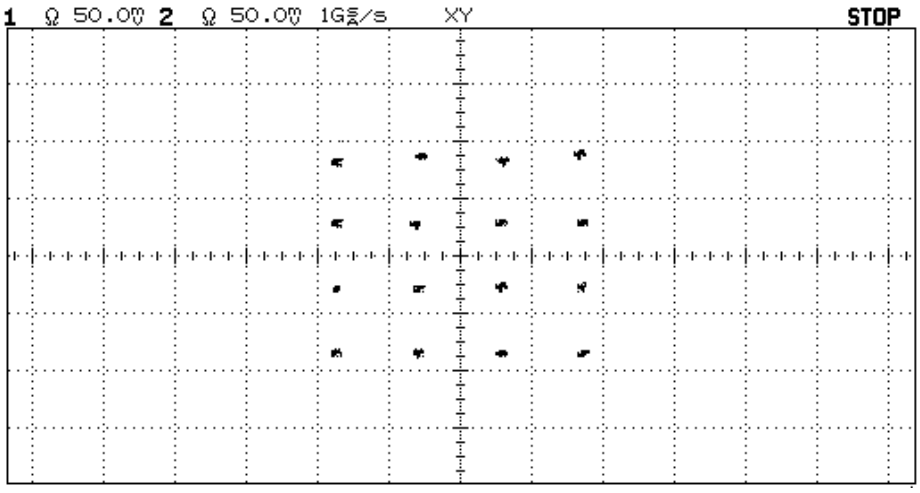


Figure 2-2 16 QAM Constellation

The following figure illustrates a measured 128 QAM constellation.

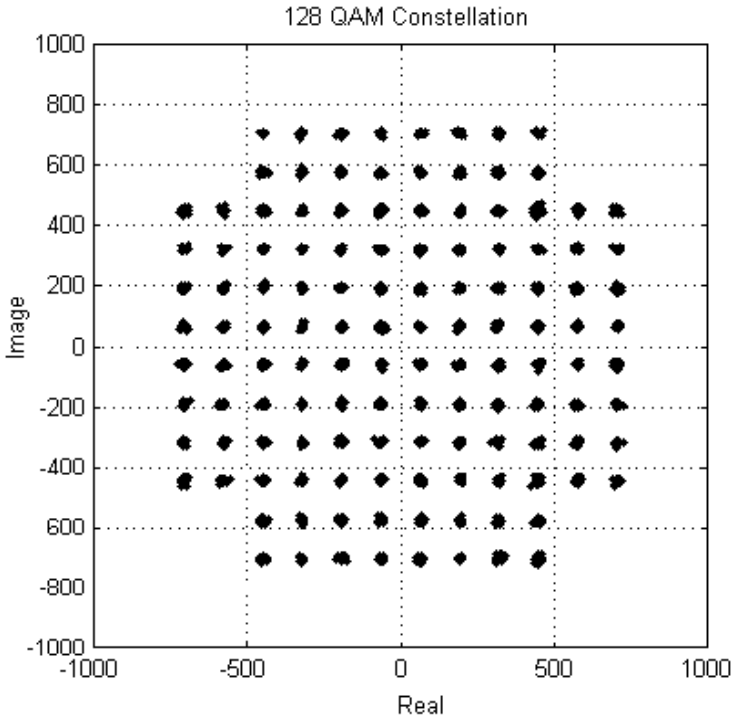


Figure 2-3 128 QAM Constellation

Manager Module

The Manager module controls and manages all system modules of the local and remote units.

The Manager module also supports the user interface through Ethernet or PPP/SLIP to the management station, and an ASCII terminal port. A local or dumb terminal can be used for basic configuration and performance monitoring.

Other features include:

- Log file
- Remote software and firmware download (upgrades can be downloaded from local to remote)
- Performance monitoring

Cable Interfaces

A single coaxial cable connects the IDU to the ODU. This cable carries the following signals:

- Transmit and receive modulated signals.
- Transmit and receive control data and communications between the IDU manager and the ODU controller.
- DC power from the IDU to the ODU.

The system automatically issues an alarm if the cable is disconnected and provides protection against shorts. Furthermore, there is no need to measure and define the

length and type of cable used since the system automatically compensates cable parameters.

The following figure illustrates the signal direction through the coaxial cable.

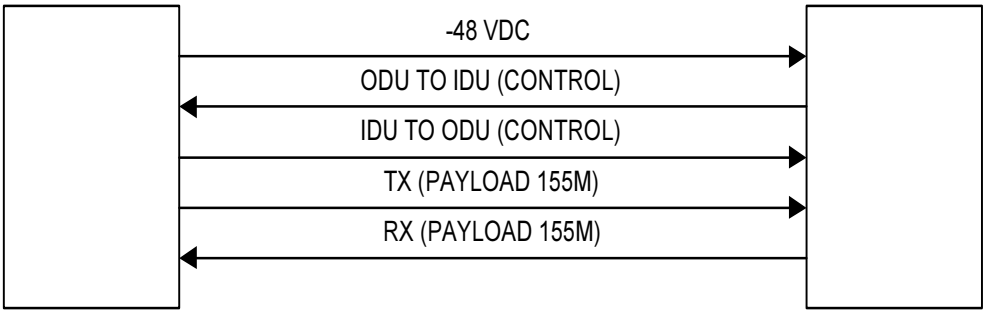


Figure 2-4 Signal Direction Through the Coaxial Cable

Power Supplies

The power supply features:

- Standard Input: -48 VDC
- DC input range: -40.5 VDC to -72 VDC
- DC/DC converter.
- Reverse polarity protection.
- Over-voltage and over-current protection.
- Detection of IDU-ODU cable alarms (i.e. cable open, cable short).

The ODU receives its DC power from the IDU. The PWR LED on the front panel of the IDU continuously lights to indicate the existence of input voltage.

Out Door Unit (ODU)

The ODU is designed to be fastened to the antenna using four latches. The antenna is mounted on a standard mounting pole. The ODU is enclosed in a compact, weather proof enclosure and connects to the IDU via a single coaxial cable that can extend up to 300m (1000 ft).

The ODU major modules include:

- T/R Module - A high sensitivity RF circuitry with full band frequency tuning range.
- Controller - Controls the ODU and provides ODU status signals, and accurate received signal level (RSL) reading (in dBm).
- Cable Combiner.
- Power Supply.

Figure 2-5 ODU Mounted on the Antenna

Note: For FibeAir systems operating at 6, 7, or 8 GHz, the ODU is connected to an external diplexer via an adapter plate. See the end of *Chapter 3 - Installation* for details concerning the dipelxer.

FibeAir 1500A/1528A

FibeAir 1500A/1528A is Ceragon's SDH IDU with a built-in Add-Drop Multiplexer. The built in ADM increases system reliability and reduces overall system cost.

Using FibeAir 1500A/1528A saves the network planner a substantial cost of installing stand-alone ADMs.

If site expansion is necessary at a later time beyond 32 E1s, FibeAir 1500A/1528A IDUs can be replaced by a combination of FibeAir 1500 (Radio SDH Regenerators) and external ADMs. FibeAir 1500A/1528A can then be used elsewhere in the network.

FibeAir 1500A/1528A supports chain and ring topologies. It can be used in pure SDH wireless networks or in mixed (wire and wireless) networks. The ability to add/drop traffic in each node of the network provides network flexibility and ease of planning. Ring topologies are important for protected configurations, and for redundant traffic loads when protection is not configured.

System Block Diagram

Figure 2-6 shows the FibeAir 1500A/1528A main blocks and modules.

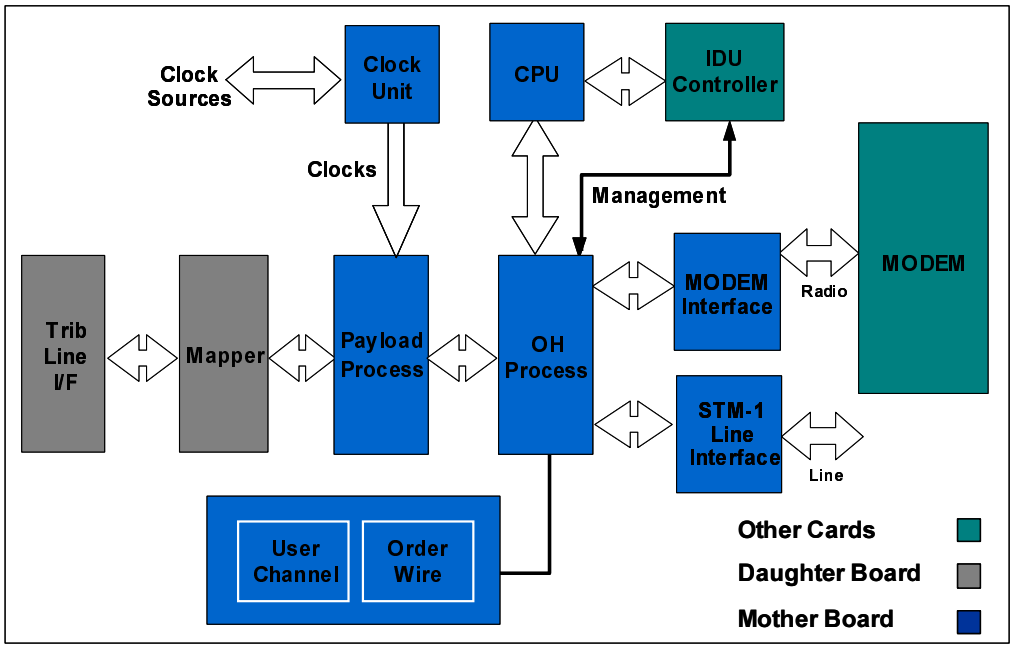


Figure 2-6 FibeAir 1500A/1528A System Block Diagram

The FibeAir 1500A/1528A ADM demultiplexes high-speed traffic streams to lower-speed components, so that an additional low-speed channel can be added.

In networks that cannot identify available low-speed channels within a high-speed bit stream, the ADM is required to demux the high-speed traffic to lower-speed circuits.

As shown in the block diagram, the FibeAir Add-Drop Multiplexer IDU includes the following functions:

Controller Handles configuration and control of all functional units, including trail configurations, protection algorithms, network management tasks, performance monitoring, alarms detection/generation, and diagnostics.

Modem Interface Performs full STM1 termination, including framing and scrambling mechanisms, and LOF detection.

STM1 Line Interface Optical STM1 line interface, includes support for different optical transceiver types, clock recovery, clock synthesis, serial-to-parallel alignment (and vice versa), and LOS/LOF detection.

OH Processing Handles insertion and extraction of Section Overhead and Path Overhead bytes, including PM bytes (B1, B2, B3), management (DCCR, DCCM, Media-Specific), APS channel bytes (K1, K2), trace identifiers (J0, J1), user channel (F1), order-wire (E1), synchronization status message (S1), path signal label (C2), path status (G1), and others. The module also handles AIS and RDI detection and generation.

Payload Processing Handles insertion and extraction of payload envelopes within VC4/VC3 containers, AU pointers (H1, H2, H3) processing (generation and interpretation), accommodation of phase and frequency differences between incoming and outgoing frames via pointer adjustment, multi-frame alignment, TU pointer processing (V1-V4), LOP and LOM detection, and generation of all traffic control signals.

Mapper Maps PDH signals to VC12/VC11/VC3 virtual containers, handles TU pointers (V1-V4) generation and interpretation, and TU Overhead (V5, J2, N2, K4) termination and processing.

Tributary Line Interface Handles PDH line termination, clock and data recovery, decoding/encoding, and line performance monitoring.

Clock Unit ADM synchronization module with very accurate internal source clock. The module receives different clock sources and re-synchronizes network elements. It also performs tasks required by hitless switching, holdover function, jitter and wander attenuation, and others.

Auxiliary Channels User Channel (64 Kbps RS-232 data channel), and Order-Wire (64 Kbps audio channel).

FibeAir 1500 Family System Specifications

General (For 24 GHz refer to page 2-12)

6-18 GHz

Specification	6 GHz	7/8 GHz	11 GHz	13 GHz	15 GHz	18 GHz
Standards	FCC/ETSI	ETSI/ Canada	FCC/ETSI	ETSI	ETSI/ Canada	FCC/ETSI
Operating Fequency Range	5.925-6.425 GHz, 6.425-7.1 GHz	7.1-8.5 GHz	10.7-11.7 GHz	12.75-13.25 GHz	14.5-15.35 GHz	17.7-19.7 GHz
Tx/Rx Spacing	240, 252.04, 260, 266, 340 MHz	119, 154, 161, 168, 182, 196, 245, 311.32 MHz	500, 520, 530,490 MHz	266 MHz	315, 420, 475, 728 MHz	1010/1560 MHz
RF Channel Spacing	128 QAM: 28/30/40 MHz	128 QAM: 28/29.65 MHz	128 QAM: 28/30/40 MHz	128 QAM: 28 MHz	128 QAM: 28 MHz	16 QAM: 50/55/80 MHz 128 QAM: 40/27.5 MHz

23-38 GHz

Specification	23 GHz	26 GHz	28 GHz	32 GHz	38 GHz
Standards	FCC/ETSI	ETSI	FCC/ETSI/ Canada	ETSI	ETSI/FCC
Operating Fequency Range	21.2-23.6 GHz	24.5-26.5 GHz	LMDS. A1, A2, B, LMCS, ETSI	31.8-33.4 GHz	37-38.4, 38.6-40/37-39.5 GHz
Tx/Rx Spacing *	1008/1200/ 1232 MHz	1008 MHz	350-500/ 1008 MHz	812 MHz	700/1260 MHz
RF Channel Spacing	16 QAM: 50/56 MHz 128 QAM: 30/28 MHz	16 QAM: 56 MHz 128 QAM: 28 MHz	16 QAM: 50/56 MHz 128 QAM: 28 MHz	128 QAM: 28 MHz	16 QAM: 50/56 MHz 128 QAM: 28 MHz

** For additional Tx/Rx schemes, please contact your Ceragon representative.*

All Frequencies

Capacity	OC-3/STM-1 or equivalent
Modulation Type	16 QAM/128 QAM
Frequency Stability	128 QAM: ±0.001%, 16 QAM: ±0.0005%
Frequency Source	Synthesizer
RF Channel Selection	Via NMS
System Configs	Non-Protected (1+0), Protected (1+1), Space Diversity, Frequency Diversity

Supported Standards

Frequency	Standards
6 GHz	EN 300 234
7 GHz	EN 300 234, ITU-R 385
8 GHz	EN 300 234, ITU-R 386
11 GHz	EN 300 234
13 GHz	EN 300 234
15 GHz	EN 300 234
18 GHz	EN 300 430, CEPT T/R12-03, ITU-R F.595-5
23 GHz	EN 300 198, BAPT 211 ZV 02/23, MPT 1409, CEPT T/R13-02, ITU-R REC. F.637-2
26 GHz	EN 300 431, BAPT 211 ZV 11/26, MPT 1420, CEPT T/R13-02, ITU-R REC.748-2
28 GHz	EN 300 431, CEPT T/R13-02, ITU-R REC.748
32 GHz	EN 300 197, ITU-R REC. 746
38 GHz	EN 300 197, BAPT 211 ZV 12/38, MPT 1714, CEPT T/R12-01, ITU-R REC.749

Radio

6-18 GHz

Specification	6 GHz	7/8 GHz	11 GHz	13 GHz	15 GHz	18 GHz
Transmit Power * 16 QAM/128 QAM	-/26 dBm	-/24 dBm	-/20 dBm	-/18 dBm	-/18 dBm	20/17 dBm
Tx Attenuation Range 16 QAM/128 QAM	-/25 dB	-/25 dB	-/25 dB	-/25 dB	-/25 dB	30/25 dB
Receiver Sensitivity (BER=10^{-6}) 16 QAM/128 QAM	-/-68 dBm	-/-68 dBm	-/-68 dBm	-/-68 dBm	-/-68 dBm	-73/-68 dBm

23-38 GHz

Specification	23 GHz	26 GHz	28 GHz	32 GHz	38 GHz
Transmit Power * 16 QAM/128 QAM	20/17 dBm	20/17 dBm	20/17 dBm **	17/15 dBm	15/15 dBm
Tx Attenuation Range 16 QAM/128 QAM	30/25 dB	30/25 dB	30/25 dB	30/25 dB	30/25 dB
Receiver Sensitivity (BER=10^{-6}) 16 QAM/128 QAM	-72/-67 dBm	-72/-67 dBm	-72/-67 dBm **	-70/-67 dBm	-70/-66 dBm

All Frequencies

Receiver Overload (BER=10^{-6})	Better than -15 dBm for 16 QAM and -20 dBm for 128 QAM
Unfaded BER	Less than 10^{-13}

** Transmit power must not be set to any value higher than that specified in the tables.*

*** For LMDS B channel, power is 14 dBm and the receiver sensitivity level is -62 dBm.*

Antenna

6-18 GHz

Specification	6 GHz	7/8 GHz	11 GHz	13 GHz	15 GHz	18 GHz
1 Ft Gain	--	--	--	29.2 dBi	31.9 dBi	33.5 dBi
2 Ft Gain	--	30.1 dBi	--	35.5 dBi	36.6 dBi	38.5 dBi
3 Ft Gain	--	--	--	37.8 dBi	38.9 dBi	42 dBi
4/6 Ft Gain	39.3 dBi	36.4 / 40.2 dBi	40.5/43.6 dBi	41.5/45 dBi	42.6/46 dBi	44.5/48 dBi
8 Ft Gain	41.9 dBi	42.9 dBi	--	--	--	--
10 Ft Gain	43.3 dBi	44.8 dBi	--	--	--	--
12 Ft Gain	45.2 dBi	46.3 dBi	--	--	--	--
15 Ft Gain	46.9 dBi	48.2 dBi	--	--	--	--

23-38 GHz

Specification	23 GHz	26 GHz	28 GHz	32 GHz	38 GHz
1 Ft Gain	35 dBi	36 dBi	36.6 dBi	37 dBi	39 dBi
2 Ft Gain	40 dBi	41 dBi	41.5 dBi	42 dBi	44 dBi
3 Ft Gain	43.5 dBi	44.5 dBi	--	--	--
4/6 Ft Gain	46/49.5 dBi	47/- dBi	--	--	--

All Frequencies

Polarization	Vertical or Horizontal
Standard Mounting OD Pole	48 mm-114 mm/1.9”-4.5” (subject to vendor and antenna size)
High Performance	ETSI class 2, 3

24 Ghz Radio

This type of radio complies with FCC part 15, unlicensed band.

Only the specified antenna shall be used with installation of this radio.

Specification	
Standard	FCC part 15
Operating Frequency	High Band 24.225 GHz
	Low Band 24.075 GHz
Tx-Rx Spacing	150 MHz
RF Channel spacing	50 MHz
Capacity	OC3
Modulation	16 QAM
Frequency Stability	+/- 0.0005%
Transmit Power	0dBm into antenna
Spurious Emissions	FCC Part 15.249
Receiver Sensitivity @10^{-6} BER	-72 dBm
Unfaded BER	> 10^{-13}

Antenna (Typical Performance)

Manufacturer	RadioWaves
Model	HPLP1-26
Diameter	1 ft.
Gain	35.7 dBi
Beam width (3dB)	2.6 Degrees
F/B ratio	55 dB

Payload

155.52 Mbps Main Channel

Payload Types	SONET: OC-3/STS-3, OC-3C/STS-3C SDH: STM-1 ATM: ATM over SONET/SDH IP: IP over SONET/SDH TDM: E3, DS3, E1, T1
Interface Modules	STM-1/OC-3: Electrical - CMI/BNC, Optical - SM/MM Fast Ethernet: 100BaseTx/Fx TDM: E3, 2xE3, DS3, 2xDS3, 8E1, 8T1
Common Interface Combinations	Fast Ethernet + E3/DS3, 2 x Fast Ethernet, Fast Ethernet + 8E1/8T1
Compatible Standards	ITU-T G.703, G.707, G.783, G.823, G.957, G.958, ITU-T I.432, ATM Forum, ETSI ETS 300 147, ETS 300 417, ANSI T1.105, ANSI T1.102-1993, Bellcore GR-253-core, TR-NWT-000499

1544/2048 Kbps Wayside Channel *

Available Interfaces	T1/E1, Ethernet bridge 10Base-T, V.35, X.21, RS-530 or V.36

Note: *The Wayside channel is not available for FibeAir 1500A/1528A.*

ADM (FibeAir 1500A/1528A)

ADM Interfaces	OC-3/STM-1 Aggregate Interfaces: Optical - Single/multi mode: SC type, RF: N type E1/T1 Tributary Interfaces: 120/100 ohm balanced, 75 ohm unbalanced using adapter panel to BT-43/BNC
ADM Configurations	Single: optical and radio aggregates, 1-16 E1/T1 Single with Regenerator: 2 optical or 2 radio aggregates, 1-16 E1/T1 Double: 2 optical or 2 radio aggregates, 1-32 E1/T1
ADM Protection	Topolgies: protected ring, cascaded (chain) Protection Method: path protection, UPSR Synchronization: external inputs/outputs - 1.5/2 Mbps, 2 MHz

User Channel

User Channel	64 Kbps, RS-232

Service Channel

Engineering Order Wire	ADM CVSD audio channel (64 Kbps)

Note: *All interfaces are available as modular plug-in interface units.*

Network Management, Diagnostics, Status, and Alarms

Type	SNMP, in compliance with RFC 1213, RFC 1595 (SONET MIB)
Local or Remote NMS Station	PolyView, CeraView with advanced GUI for Windows 95/98/2000/NT or UNIX, integrated with HP OpenView
NMS Interface	Ethernet bridge 10Base-T, RS-232 (PPP, SLIP)
Local Configuration and Monitoring	Standard ASCII terminal, serial RS-232
In-Band Management	Uses standard embedded communications channel
TMN	Ceragon NMS functions are in accordance with ITU-T recommendations for TMN
External Alarms	8 Inputs, TTL-level or contact closure to ground, 5 Outputs, Form C contacts, software configurable
RSL Indication *	Accurate power reading (dBm) available at IDU, ODU, and NMS
Performance Monitoring	Integral with onboard memory per ITU-TG.826

***** *The voltage at the BNC port is not accurate and should be used only as an aid.*

Environment

Operating Temperature (Guaranteed Performance)	ODU: -35°C to 55°C IDU: -5°C to 45°C
Relative Humidity	ODU: up to 100% (all weather operation) IDU: up to 95% (non-condensing)
Altitude	Up to 4,500 m (15,000 ft)

Power Input

Standard Input	-48 VDC
DC Input range	-40.5 to -72 VDC
Optional Input	110-220 VAC

Power Consumption

Maximum ODU Power Consumption	For 1+0: 40W For 1+1: 63W
Maximum IDU Power Consumption	For 1+0: 66W For 1+1: 130W

Mechanical

ODU	25 cm diameter x 23 cm depth (10” diameter x 8” depth) Weight: 8 kg
IDU	4.3 cm height x 43.2 cm width x 24 cm depth (1.7” x 17” x 9.4”) Weight: 3 kg
IDU-ODU Coaxial Cable	RG-223 (100 m/300 ft), Belden 9914/RG-8 (300 m/1000 ft) or equivalent, N-type connectors (male)

Chapter 3
Installation

General

This chapter explains how to install and set up the FibeAir 1500 Family system.

For best results, perform all operations in the sequence in which they are presented in this chapter.

Note: Instructions regarding ODU installation for a 6, 7, or 8 GHz FibeAir system are provided in the section *ODU Installation for FibeAir 6/7/8 GHz*, at the end of this chapter.

Unpacking Equipment

FibeAir is shipped in 5 crates. Upon delivery, make sure that the following items are included:

- Two indoor units and accessories
- Two outdoor units
- Two antennas and pole mounts
- One user manual
- One management software (CD).

Unpack the contents and check for damaged or missing parts. Should there be any parts that are damaged or missing, contact your local distributor.

Site Requirements

The first and most important consideration when choosing a prospective site for the ODU is that the point can provide an acceptable “line of sight” with the opposing ODU. A site with a clear, unobstructed view is required.

When considering a site, it is important to check for current and future obstacles. Possible future obstacles are: trees, new buildings, window cleaners on the roof, snow that may accumulate in front of the antenna, etc. The site should be accessible to certified personnel only.

As with any type of construction, a local permit may be required before installing an antenna. It is the owner’s responsibility to obtain any and all permits.

Additional Requirements for North America

Restricted Access Area: DC powered equipment should only be installed in a Restricted Access Area.

Installation Codes: The equipment must be installed according to country national electrical codes. For North America, equipment must be installed in accordance to the US National Electrical Code, Articles 110-16, 110-17 and 110-18, and the Canadian Electrical Code, Section 12.

Overcurrent Protection: A readily accessible Listed branch circuit overcurrent protective device, rated 15 A, must be incorporated in the building wiring.

CAUTION: This equipment is designed to permit connection between the earthed conductor of the DC supply circuit and the earthing conductor at the equipment.

Grounded Supply System: The equipment shall be connected to a properly grounded supply system. All equipment in the immediate vicinity shall be grounded the same way, and shall not be grounded elsewhere.

Local Supply System: The DC supply system is to be local, i.e. within the same premises as the equipment.

Disconnect Device: A disconnect device is not allowed in the grounded circuit between the DC supply source and the frame/grounded circuit connection.

Before Installing the ODU

WATCH FOR WIRES! Installation of this product near power lines is dangerous. For your own safety, follow these important safety rules.

- Perform as many assembly functions as possible on the ground.
- Watch out for overhead power lines. Check the distance to the power lines before starting installation.
- Do not use metal ladders.
- If you start to drop the antenna or mast assembly, move away from it and let it fall.
- If any part of the antenna or mast assembly comes in contact with a power line, call your local power company. DO NOT TRY TO REMOVE IT YOURSELF! They will remove it safely.
- Make sure that the mast assembly is properly grounded.

Assembling antennas on windy days can be dangerous. Because of the antenna surface, even slight winds create strong forces. Be prepared to safely handle these forces at unexpected moments.

Required Components and Equipment

Required System Components

The following FibeAir components are needed to install one radio link:

- Antenna mount and accessories
- Antenna
- ODU
- Cable
- Headset
- BNC headset adaptor
- BNC DVM adaptor.

Required Tools and Equipment

The following tools and equipment are needed to install an ODU:

- 4 x N-type connectors (according to cable type)
- Coaxial cable
- Insulation tape
- Ratchet wrench (3/8” Drive)
- 10mm nut driver
- 13mm socket (3/8” Drive)
- 13mm open/box end wrench
- Phillips screwdriver
- Sharp cutting knife
- Compass (optional)
- Torque wrench
- Digital voltmeter
- Optical view finder (optional)

CeraView PC Requirements

Before you install the CeraView software, verify that your PC has the minimum requirements as follows:

Processor:	Pentium (200 MHz minimum)
Memory (RAM):	32 MB minimum
Operating System:	Windows 95/98/2000/NT
Display Monitor:	800 x 600 minimum, 16,384 colors maximum
Serial Port:	RS-232

Keyboard

Mouse

Suggested Pole Installation

The antenna can be installed on a ground tube, roof, or wall mount. The ground tube or roof/wall mount should be assembled and in place before installing the antenna mount.

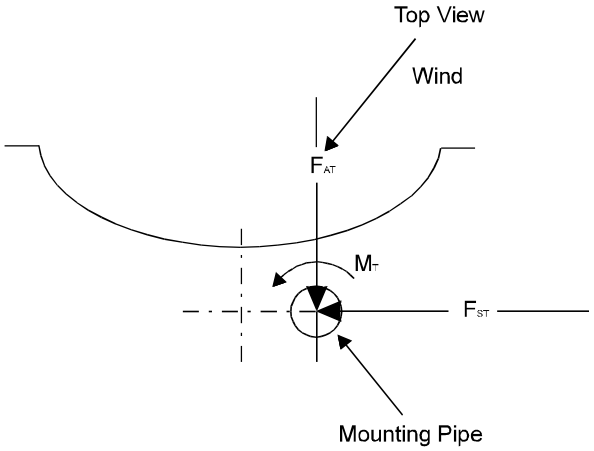


Figure 3-1 Calculating Required Pipe Diameters

Use the following table to determine the pipe diameters:

Antenna Size	1 ft (30 cm)	2-2 1/2 ft (60-75 cm)	4 ft (120 cm)
Minimum Pipe Diameter	50 mm	65 mm	115 mm
Wind Velocity	200 km/h	200 km/h	200 km/h
$F_{AT, max.}$ [N]	303	929	2821
$F_{ST, max.}$ [N]	150	460	1398
$M_{T, max.}$ [Nm]	47	283	894

After determining the pole size, verify that you have the required bolt for the antenna mount, as shown in the following table.

Pipe Diameter (mm)	Bolt size (mm)
48-51	51
52-89	89
90-115	115

Flow of Operations

The installation and setup procedure for FibeAir consists of the following operations (to be performed in the order listed below):

CeraView Management Software:

- Installing the Management Software
- Installing a PPP/SLIP Driver
- Setting the Baud Rate

IDU:

- Installing the IDU
- Turning the IDU on
- Connecting to a PPP/SLIP or Ethernet Port
- Setting the IP addresses
- Setting Local Tx Frequency Channel
- Activating Engineering Order Wire (EOW)
- Setting Antenna Diameter and Distance
- Determining the Expected Signal Level

ODU:

- Installing the antenna assembly
  - Azimuth adjustment
  - Elevation adjustment
- Initial antenna alignment using a compass, optical view finder, and headset
- Alignment - checking actual receive level
- Performing an Initial Check
- Verifying Installation

Installing the IDU in a 19" Rack

The IDU can be installed in a 19" rack (1U) using the rack mount kit. The mount braces are attached to each side of the IDU using the three holes on each side.