ADC

TELECOMMUNICATIONS

TECHNICAL MANUAL

EXHIBIT III

(PRELIMINARY)

BTS-7010

WIRELESS MODEM
TERMINATION SYSTEM (WMTS)

REV: 0

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SYSTEM DESCRIPTION

The Wireless Modem Termination System is a hub modem system that accepts full duplex 100BaseT Ethernet, arranges the incoming Ethernet data frames, multiplexes in TDM and modulates a downstream 64 QAM carrier. The 64 QAM IF output (44 MHz) signal/s is fed to the RF input/s of the Base Transceiver Station (BTS).

This manual covers both Upstream and Downstream information, however only the downstream components apply to this Type Acceptance submittal. The Downstream components include the following:

- WMTS Chassis
- Host Card
- Universal Cards (x2)
- Downstream Cards (x2)

Each WMTS chassis supports up to two downstream channels; therefore four-channel operation requires two WMTS chassis and corresponding circuit board cards.

vyyo

V3000 Wireless Hub

Vyyo is a leading global provider of broadband wireless access systems for MMDS, LMDS, 3.5 GHz, 10.5 GHz, WCS, UHF and unlicensed bands used by telecommunications operators to deliver wireless, high-speed data connections to business and residential subscribers. Vyyo's flexible point-to-multipoint systems are based on the Internet Protocol (IP) used for data and voice transport over the Internet, providing cost-effective and scalable solutions to support broadband wireless services.

The V3000 Wireless Hub (WMTS) serves as a data communications bridge between Vyyo's V251 Wireless Modems installed at the subscriber's home or office and network backbone connections (routers) located at a central office or base station. The V3000 is a carrier class wireless system that features hot-swap modification or system module replacement by the operator while maintaining continuous operation. When used in combination with the V251 Wireless Modems, the wireless hub enables radio frequency (RF) performance in any of the currently licensed or unlicensed point-to-multipoint frequency bands. This is accomplished, in part, by permitting the system operator to establish upstream sub-channels and downstream channels with various combinations of modulation techniques.

The wireless hub chassis supports multiple RF modules. Each module may be either an Upstream Demodulator (receiver) module or a Downstream Modulator (transmitter) module for the V251 series modems. The downstream modules are available in single channel versions. The upstream modules are available in single or hex (6) channel versions. This gives the system engineer the flexibility to configure a system for each deployment scenario using multiple channels or sub-channels, multiple sectors or a combination.

DOCSIS Standard Adapted for Wireless Systems

Vyyo's systems employ an enhanced version of DOCSIS which was adapted for wireless environments from the cable industry's DOCSIS standard. The specification is excellent in network and data link protocols, QoS, convergence, synchronization, registration, encryption, privacy, etc. However, because DOCSIS was designed for cable TV systems, it is inadequate to address some unique characteristics of the wireless environment, e.g., frequency offset and drift, dynamic range, spurious emissions, multipath and fading immunity. Vyyo's wireless enhancements allow robust operation over the full spectrum, including licensed or unlicensed. A few of the specific wireless enhancements that are incorporated in the V251 Wireless Modem are:

- Three types of downstream modulation (QPSK, 16QAM, and 64QAM)
- Two types of upstream modulation (QPSK and 16QAM)
- Multiple symbol rate options upstream and downstream
- Frequency compensation for offset, drift over temperature and aging
- Low spurious emissions and harmonics
- Extended dynamic range
- Robust power control

These enhancements allow the V251 Wireless Modem to meet the requirements of the FCC and to provide robust performance in the RF path.

ENABLING HIGH-SPEED WIRELESS INTERNET ACCESS

- Carrier class wireless hub
- Redundancy
- Hot swapping
- Point-to-multipoint broadband wireless Internet access
- Virtual Private Network (VPN)
- Upgradeable and expandable — one chassis can support multiple channels
- Powerful, easy-to-configure network management system
- MMDS, LMDS, 3.5 GHz, 10.5 GHz, WCS, UHF & unlicensed bands

WIRELESS HUB RF CHARACTERISTICS

DATA	DOWNSTREAM	UPSTREAM
IF Frequency Range	41 to 47 MHz	5 to 65 MHz
RF Frequency Range	Depends on ancillary equipment - MMDS, LMDS, 3.5 GHZ, 10.5 GHz, WCS, UHF and unlicensed	
RF Channel Bandwidth	3 MHz, 3.5 MHz & 6 MHz	400, 800 & 1,600 kHz
Connector Impedance	75 ohms	75 ohms
Spurious Emissions	Up to -55 dBc at channel edge and up to -60 dBc at 3 MHz from channel edge	
Modulation Format	QPSK, 16 & 64 QAM	QPSK & 16 QAM
Data Rate per channel (raw)	10.6 to 31.8 Mbps	640 Kbps - 2.56 Mbps & 1.28 Mbps - 5.12 Mbps
Data Rate per chassis	Channels x data rate per channel up to 100 Mbps	
RF Signal Level	20 to +40 dBmV	-15 to +35 dBmV
Frequency Compensation	Locked to 10 MHz reference	± 100 kHz

PROTOCOLS	SPECIFICATION
Network Protocols	IP, ICMP & ARP
Transports Protocols	TCP & UDP
Application Protocols	SNMP, TFTP & DHCP

NETWORK FEATURES

Network Management	DOCSIS related Internet drafts, RFCs and MIBs (IETF IPCDN Working Group) with private extensions
Security	Baseline Privacy with key negotiation and transfer
Encryption	DES 56 Bit Encryption and Decryption
Forward Error Correction	Reed Solomon / Trellis Decoder, Reed Solomon Encoder, ITU-T J.83 Annex B / C
Quality of Service	Per DOCSIS 1.1 available through future software upgrades
User Quantity	Consistent with data rates

INTERFACE

Network Connector	RJ-45 100baseT Female
IF Interface	Type F Female Connector
Power	110 - 230 VAC or -48 VDC 350 Watt maximum for P2601, request applicable power plug type with order

PHYSICAL

Dimensions	Rack mounting 19" x 15" x 15"; 44 x 38 x 38 cm
LED Indicators	1 alpha-numeric plus 7 LEDs per module
RF Slots	6
Operating Temperature	32 - 104°F / 0 to 40° C
Storage Temperature	-40 to 257° F / -40 to 125° C
Storage Temperature Humidity	10 to 90% non-condensing

All specifications are subject to change.

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vyyo

SECTION 1: INTRODUCTION

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1 MANUAL CONTENTS

This manual provides instructions for installing, operating and troubleshooting the Axity™ Broadband Wireless Access System. Information in this manual is divided into sections as listed below:

- **Section 1 - Introduction:** Provides an overview of the Axity system.
- **Section 2 - Wireless Modem Termination System Hardware Description:** Provides a hardware overview of the WMTS.
- **Section 3 - Wireless Modem Termination System Functional Description:** Provides a functional overview of the WMTS.
- **Section 4 - WMTS Installation:** Provides procedures for installing the Wireless Modem Termination System.
- **Section 5 - WMTS Turn-up and Configuration:** Provides procedures for optimizing and configuring the Wireless Modem Termination System.
- **Section 6 - Operation:** Provides procedures for testing the system and performing tasks required for proper operation.
- **Section 7 - Troubleshooting:** Provides information for troubleshooting problems with the WMTS.
- **Appendix A –** Glossary of terms

2 SYSTEM OVERVIEW

The high-speed Axity Broadband Wireless Access System is designed to allow business, school, government and residential users to access private and public data networks over wireless channels. The system provides high-speed connectivity over wireless RF networks to and from a computer or LAN using packet-based, point-to-multipoint (PTMP) architecture. Major applications are Internet access, transfer of multimedia, video conferencing, distance learning, and remote control access.

The system configuration contains a number of base stations referred to as “hubs.” The equipment specifications, cellularization approach, availability requirements, and propagation conditions determine the coverage area served by a single hub. The coverage area radius, as measured from the base station, ranges from 5 miles for mini-cell, sectorized deployments to greater than 20 miles for single-hub super-cell systems.

The term “downstream” refers to the broadcast transmission of information from the base station to subscriber(s). The term “upstream” refers to the transmission from subscribers to the base station over a time division multiple access (TDMA) link. In TDMA systems, a single upstream channel is shared by assigning subscribers specific time intervals for transmission. The Wireless Modem Termination System (WMTS), located at the hub, controls the allocation of upstream bandwidth.

Axity provides maximum coverage, capacity and reliability to users within a service area by optimizing CPE and cell site RF configurations and leveraging key features such as selectable modulation order, selectable symbol rates, and advanced wireless algorithms.

The Axity system offers selectable modulation in order to provide sufficient downstream link budget margin above the system carrier-to-noise plus interference level (C/N+I). This allows the Axity platform to address both long and short distances in either super-cell or mini-cell configurations. Selectable modulation also allows Axity systems to operate on the borders between sectors or cells where interference potential is high. The system employs 16 or 64 Quadrature Amplitude Modulation (QAM) or Quaternary Phase Shift Keying (QPSK) modulation for the downstream and QPSK for the upstream.

In addition, selectable symbol rates in both the downstream and upstream enable the Axity network planner to optimize the use of the available spectrum.

Figure 1-1 shows a typical configuration of the Axity system at the base station cell site and the residential or business subscriber location. The system consists of a WMTS, a WMU located at the customer premise, data networking equipment, the configuration, operating and control software, and the interconnecting radio channel equipment.

The Axity system interfaces on the network side to various LAN or WAN connections including Ethernet, DS3, OC3, etc., via a router. The subscriber’s PC interfaces to the WMU’s 10BaseT Ethernet port. The WMTS interfaces to the WMU over the wireless channel. This wireless link allows the end user access to the service provider’s resources.

The base station RF equipment includes the RF transmitter and the downstream antenna assembly, which transmits information from the WMTS to the subscriber WMU. From the subscriber location, the upstream antenna/transverter and WMU receive information from the subscriber location and pass it upstream through the WMTS to the network.

Optional automated backup is provided with the automatic backup system (ABS) selecting either the primary or backup transmitter if one should fail. In the case of multiple primary transmitters, priority backup may be enabled. Receiver backup is currently under development.

The optional Supervisory Control and Data Acquisition System (SCADA) is a Simple Network Management Protocol (SNMP)-based management application that provides operators with local or remote real-time monitoring and control of the transmitters, receivers, and automatic backup system.

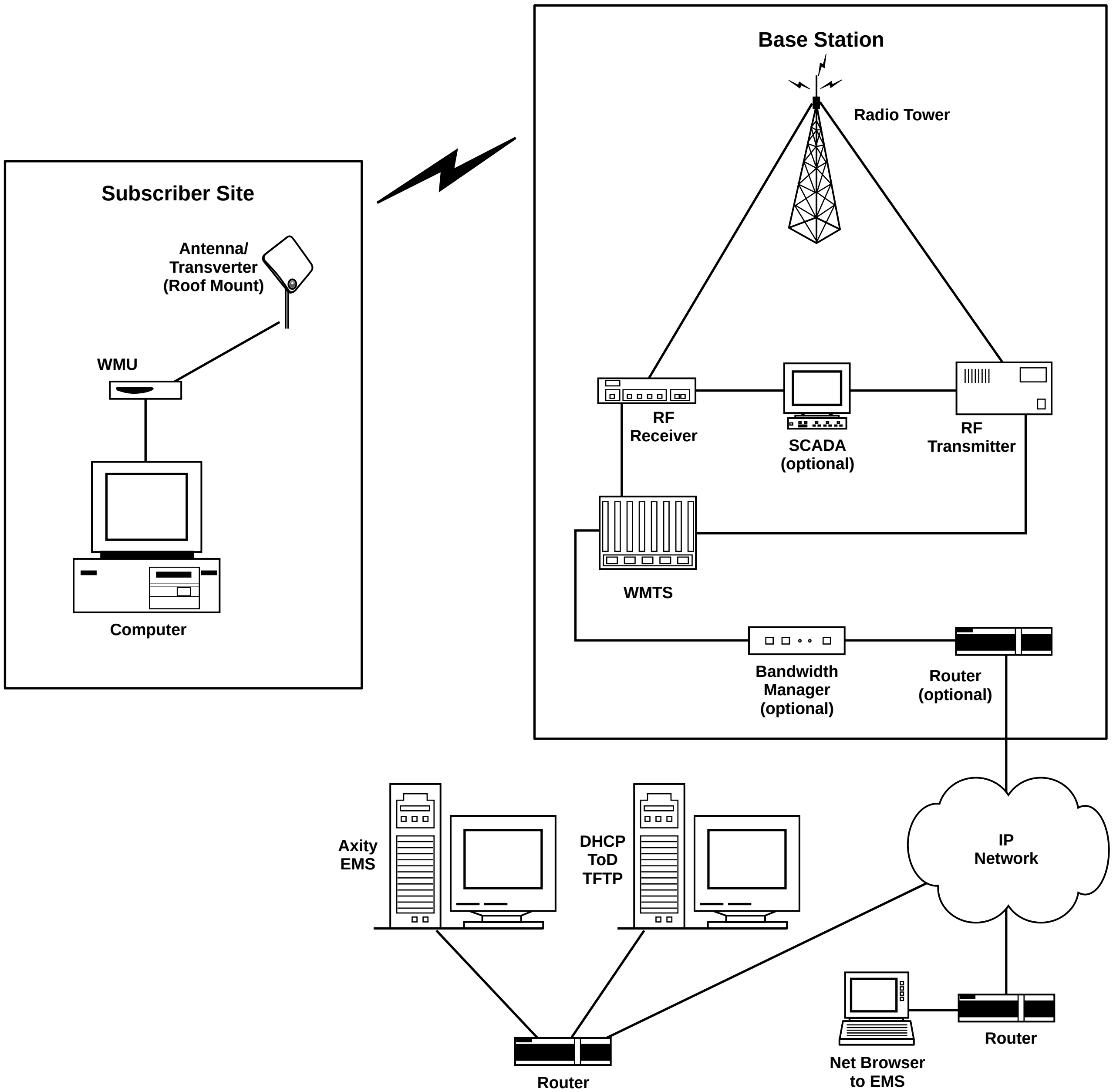

Figure 1-1. Axity System Architecture

3 BASE STATION EQUIPMENT (NON-RF)

3.1 WMTS (Wireless Modem Termination System)

The WMTS is a hub modem system that serves as a bridge between the network interface and the subscriber's modem operating over wireless channels. The WMTS provides the timing, synchronization, and ranging algorithms necessary to keep the WMUs communicating with their WMTS.

The WMTS provides a full duplex 100BaseT Ethernet interface to the network IF. The WMTS arranges the incoming Ethernet data frames, multiplexes (in TDM) and modulate the downstream carrier. The WMTS also receives upstream information from the WMUs. It demodulates the upstream signal, multiplexes TDMA-based data and provides it to the network interface. It consists of the WMTS chassis, redundant power supplies, redundant host cards, control and forward card, one downstream module, and up to five upstream modules.

3.1.1 Minimum System Requirements

- WinNT Workstation or Server that meets the requirements of a Pentium III 400 Mhz, 128 MbRAM, 6 Gb hard drive, network interface controller card, Internet browser such as Netscape 4.06 or later or Internet Explorer 4.01 or later.
- ServicePro software installed on the server, which includes DHCP server, TFTP server, ToD server, and the Alopa SNMP server
- Straight-through serial cable with DB-9 male and DB-9 female connectors

3.2 Router (Delete?)

The router is used for a network edge device, which will provide correct IP forwarding and a WAN interface back to the main network devices.

3.3 Bandwidth Manager (Delete?)

The bandwidth manager is used to control flow to and from each WMU separately. It is capable of setting both minimum guaranteed and maximum throughput for each WMU. This device is capable of controlling flow on both IP address and type.

3.4 Receive Antenna

The US RF signal from the CPE is received with an antenna mounted on the tower at the base station. The antenna is directed toward the desired upstream sector with the chosen frequency of operation.

3.5 Headend Test WMU

The Headend Test WMU resides in the cabinet with the WMTS and is connected to the RF pads through the use of the cg coupler and directional couplers with an appropriate attenuate. It is designed to test the wireless link within a site prior to the RF leaving the building.

4 EMS (ELEMENT MANAGEMENT SYSTEM)

ADC's Axity Element Management System (EMS) manages the WMTS and WMUs. The Axity EMS is an advanced functionality Web-based system. It communicates with managed devices using the Simple Network Management Protocol (SNMP), and can be accessed either locally or remotely over the Internet.

Through the EMS, the network administrator can manage and monitor both the base station/hub devices and the WMUs located at the subscriber premise. The client/server architecture of the EMS provides the facilities to manage the system from various locations over the Internet. Because the Axity EMS provides this user-friendly Web interface, technicians attempting to troubleshoot problems at remote locations can easily access network management data and interfaces necessary to perform their tasks.

5 CUSTOMER PREMISE EQUIPMENT

The hardware configuration for the CPE consists of outdoor transverter/antenna assemblies, an indoor WMU, indoor power supplies, and associated coaxial cabling as shown in Figure 1-2 for the single user CPE configuration and Figure 1-3 for the multiple user CPE configuration. A single coax interconnect provides the DC and IF (intermediate frequency) signal handling between the transverter and indoor equipment. Typically, a 17 dBi integrated planar antenna/transverter will provide sufficient signal gain. Other antennas can also be used with a standalone transverter for locations that require a different gain.

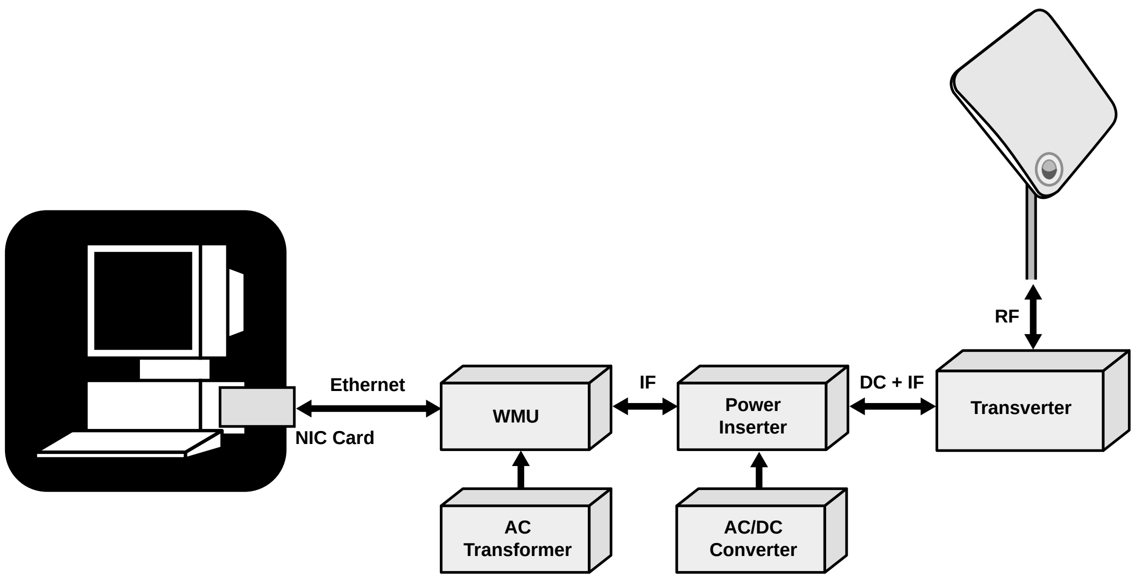

Figure 1-2. CPE Configuration – Single User

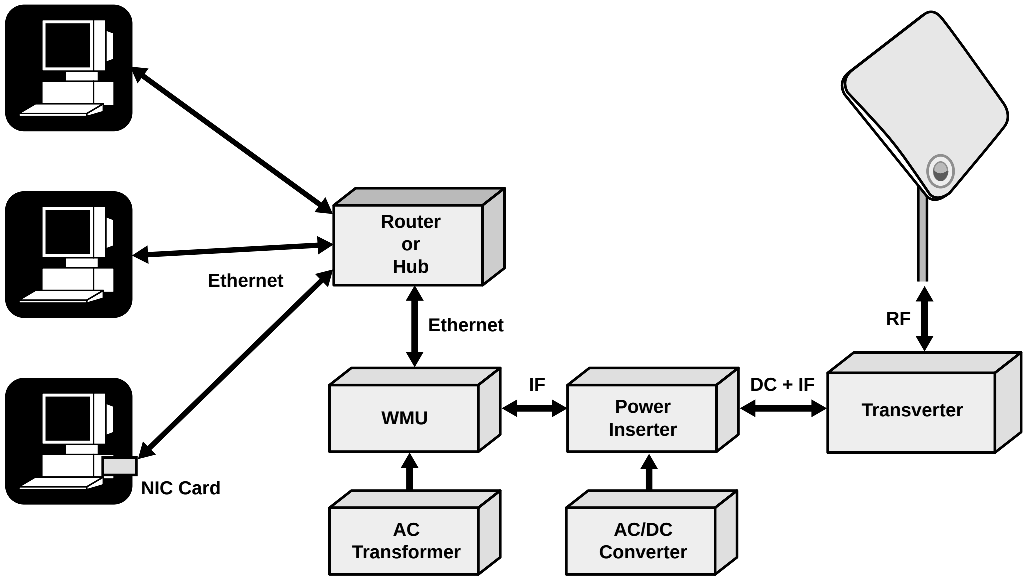

Figure 1-3. CPE Configuration – Multiple User

5.1 WMU (Wireless Modem Unit)

The WMU is a DOCSIS-based wireless modem with specific wireless enhancements for robustness. The system is connected to the subscriber equipment through a standard 10BaseT Ethernet network interface card (NIC) or a hub or other Ethernet device for multiple users.

The WMU, which is installed adjacent to the computer, performs the data to IF signal modulation and demodulation. It is housed in a complete, standalone enclosure.

5.2 Transverters and Antennas (Delete?)

Either a 17 dBi integrated planar antenna/transverter for typical installs or a 21 or 24 dBi grid antenna with standalone transverter for high directivity installs or a 17 dBi planar array antenna with attenuator and standalone transverter for close range installs can be used, depending on the requirements of the site.

5.3 WMU Interaction

5.3.1 Channel Acquisition

After scanning for a downstream channel (frequency), the WMU obtains QAM lock and finds the MPEG packets with the well-known PID associated with DOCSIS. Several downstream channels may need to be searched before the WMU finds the one with DOCSIS data. Channel acquisition is successful when the WMU decodes MPEG-2 frames that bear the DOCSIS well-known PID. The MPEG-2 frames are then stripped away and the resulting MAC frames are passed to the MAC layer for processing.

5.3.2 Obtaining Upstream Parameters

During this phase, the WMU looks for three MAC messages that are repeatedly sent by the WMTS to provide a common time reference to all WMUs. The first message is the Time Synchronization message (SYNC). The second one defines the Upstream Channel Descriptor (UCD). The final message is an Upstream Bandwidth Allocation Map (MAP), which matches the upstream channel described in the UCD.

5.3.3 Ranging

The WMU must be initially ranged into the system. During ranging the WMU must complete the following three processes:

- Timing adjustment
- Transmit frequency tuning
- Transmit power adjustment

To begin the ranging process, the WMU transmits a ranging request to the WMTS. Upon receipt, the WMTS sends a ranging response back to the WMU. Once initial ranging is completed, a similar ranging process occurs periodically to continuously adjust frequency, timing and power level.

5.3.4 IP Layer Establishment

Once timing, frequency, and power are set, the WMU must establish IP connectivity. The IP address is established by use of a Dynamic Host Configuration Protocol (DHCP), which assigns an IP Address to the WMU. DHCP is administered by either the operator or some other service provider.

5.3.5 Registration

The registration process begins with the WMU downloading a configuration file from the server through the use of TFTP (Trivial File Transfer Protocol). This file contains operating information for the WMU, such as downstream and upstream frequencies, etc. These service provisioning items are taken into account when the subscriber initiates wireless modem service.

SECTION 2: WIRELESS MODEM TERMINATION SYSTEM DESCRIPTION

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1 INTRODUCTION

This section provides a detailed physical description of the Wireless Modem Termination System.

2 ARCHITECTURE

The WMTS base station is typically located between the subscriber unit and the service provider (SP) or a WAN to provide high-speed connectivity over wireless networks. Per the DOCSIS specification, the WMTS supports up to 8129 subscriber units over the wireless network. The WMTS accepts IP data from the WAN via an Ethernet bus, which outputs data over the wireless network and vice versa.

The WMTS incorporates integrated architecture for video and data. It carries all traffic in IP format over wireless channels. The WMTS uses a distributed MAC (media access control) scheme, which reduces network access time and simplifies network control. The networking universal cards contain the MAC function responsible for managing network access and control.

2.1 Wireless Hub (Base Station) Overview

The Axity base station comprises the indoor and outdoor RF equipment, the WMTS chassis and the router with the switch. The ISP and the physical network are interfaced to the hub. The EMS may be connected locally via the switched hub or remotely via the Internet. Refer to Figure 2-1.

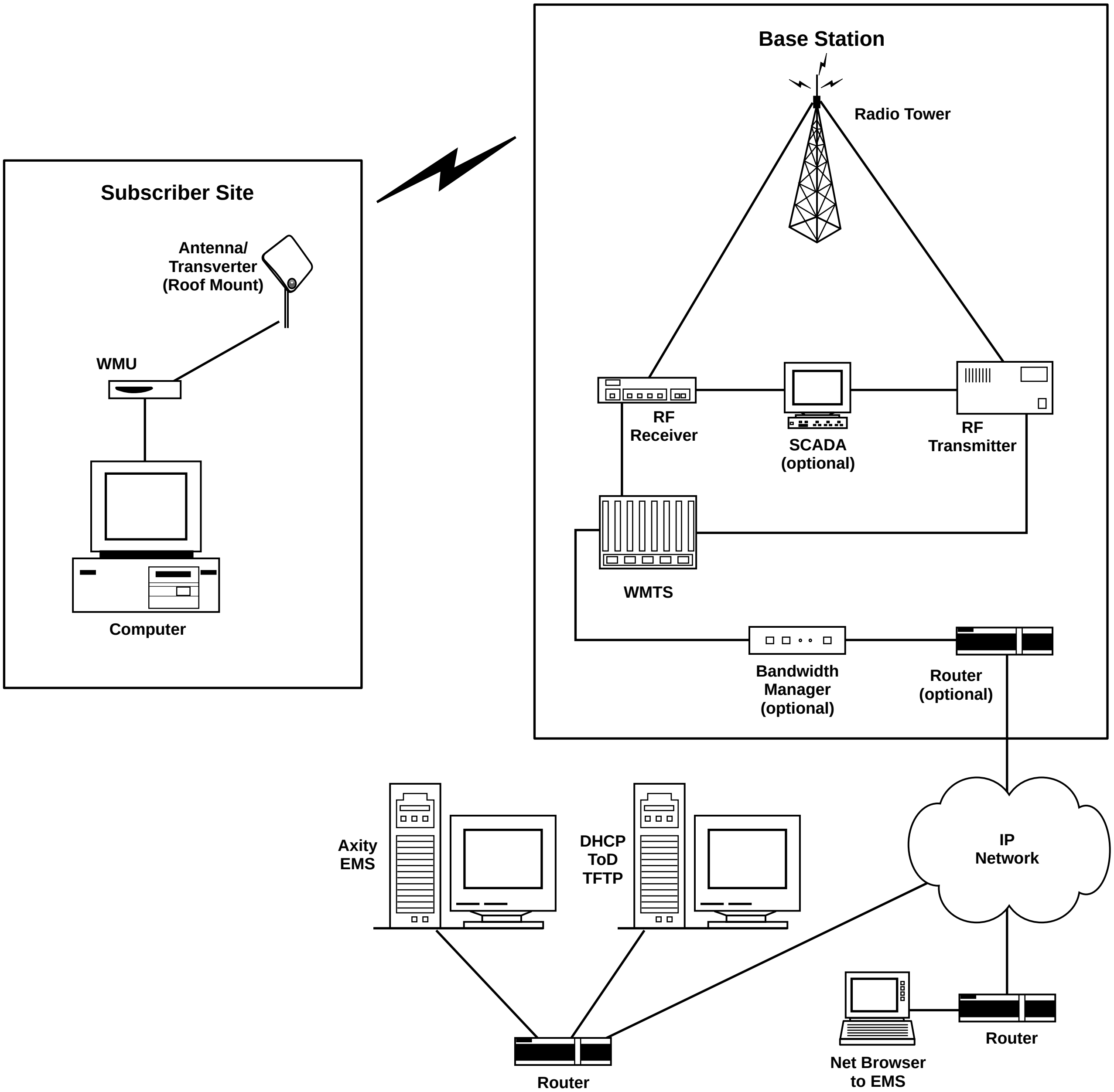

Figure 2-1. Axity System Overview

The Wireless Modem Termination System uses a modular design that includes:

- WMTS chassis with integrated backplane
- Host cards (primary and backup)
- Up to eight universal cards, which are configured for upstream, downstream or control/forwarding functions
- One downstream card
- Up to five upstream cards
- Redundant AC power supplies
- Two fan tray assemblies

The WMTS is responsible for setting the upstream bandwidth to its subtending WMU modems.

2.2 Structure

The WMTS chassis is the core of the Axity system. It contains the host cards, controller and forwarder (C&F) card and the upstream and downstream modules. The upstream module contains the universal card and upstream (demodulator) card. The downstream module contains the universal card and the downstream (modulator) card. The system cards communicate and handle traffic over a standard internal compact PCI bus.

The host card serves as bus arbitrator, providing system clock and timing. When the WMTS boots up, the host card initializes all the other system cards, identifying the C&F card. The C&F card then identifies the downstream and upstream universal cards and downloads the relevant application software and firmware to the flash memory of each card.

The downstream universal card is connected to the downstream card, which generates the downstream IF to send data over the wireless channel via the transmitter. The upstream universal card is connected to the upstream card, which demodulates the incoming IF to obtain data sent over the wireless channel from the upstream downconverter.

The C&F card, which is connected through the network interface via 100BaseT full duplex Ethernet port, communicates with the EMS.

The minimal WMTS configuration, which is illustrated in Figure 2-2, contains the following:

- Host card
  - For bus arbitration and system clock generation
  - System application downloading to the universal cards
- Three universal cards (configured as follows)
  - C&F card connected to the switch or router via an Ethernet bus
  - Downstream card connected to the modulator to transmit data to WMU
  - Upstream Card connected to the demodulator to receive data from the WMU
- Downstream card to modulate data and generate the IF for the RF transmitter

- Upstream card to demodulate the incoming IF from the RF upstream downconverter
- Two power supplies (two active and one backup)

To extend the system, more upstream and downstream modules can be inserted into the system. Each module consists of a universal card and an appropriate wireless application. The system can be extended by any combination of six RF modules in the eight slots. Two slots are reserved – one for the host card and one for the C&F card.

The system can be extended to any combination of one downstream and five upstream modules or two downstream and four upstream modules.

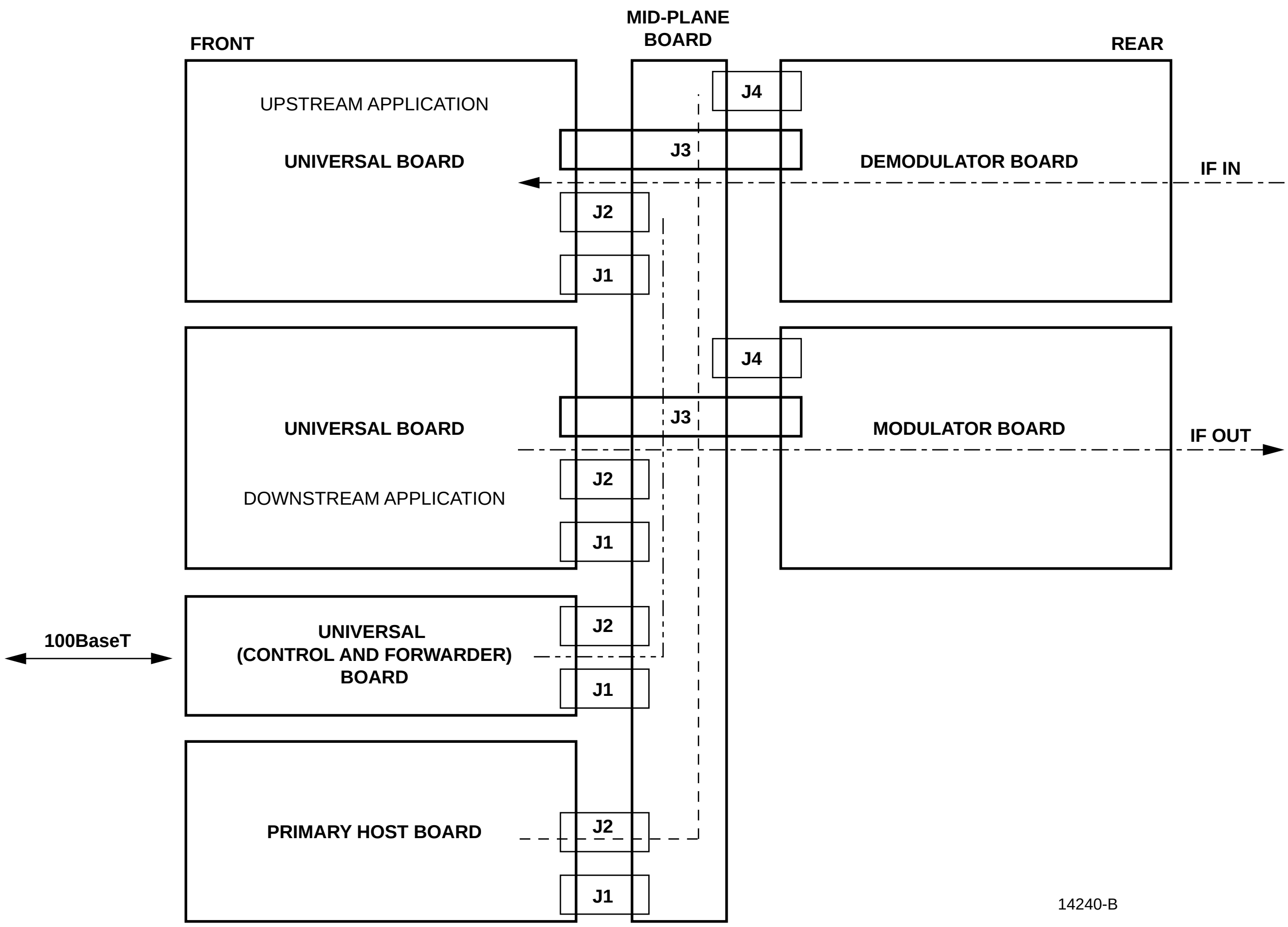

Figure 2-2. Simplified Block Diagram of Minimally Configured WMTS

2.3 Cards, Application Modules and Power Supplies

2.3.1 Universal Card

Each universal card has a single character digital display, seven LED indicator lights, 100-BaseTX Ethernet connector, and two DB-9 serial connectors. It is the basic card in the WMTS system, and supports several independent functions, such as the control and forward application, or downstream and upstream modem applications. The card is configured according to its location in the enclosure. When the downstream card is installed in the associated rear slot, it implements the downstream modem application. When the upstream card is installed in the associated rear slot, it implements the upstream modem application. When the universal card is installed immediately adjacent to the host card, it implements the controller and forwarder (C&F) application, which handles the traffic over the local network connection. The universal card communicates with the other system assemblies via the CPCI bus, which is part of the chassis assembly. An internal system bus is used for front-to-rear slot data transfer communications.

2.3.2 Downstream Card

The downstream (modulator) card, which is labeled **Downstream**, can be located in any of the right six slots on the rear of the chassis. Typically, it resides in the far right slot. This downstream card, when positioned to the rear of a universal card, becomes the downstream module. The downstream module core also provides forward error correction (FEC), signal modulation, and IF front-end.

2.3.3 Upstream Card

The upstream (demodulator) card, which is labeled **Upstream**, can be located in any of the right six slots on the rear of the chassis. The upstream card, when positioned to the rear of a universal card, becomes the upstream module. The upstream module core also provides forward error correction (FEC), demodulation, and IF front-end.

2.3.4 Host Card

The host card is a faceless card whose front panel resembles a blank insert. There are no LED indicators on this card. This card contains logic that arbitrates all WMTS communication on the CompactPCI bus.

When the WMTS powers up, the channel numbers on the universal cards show as dot matrix question marks. As the unit performs a self-test, the system recognizes the cards and the correct channel number will appear in the dot matrix. Channel numbers occur sequentially as 1, 2, 3… starting at the leftmost universal card (when facing the WMTS). If a host card is not functioning properly, this start-up sequence will not complete.

2.3.5 Downstream Application

The downstream application is loaded in the universal card, which is part of the downstream module. The application provides the proper IF signal to be converted for the downstream channel.

2.3.6 Upstream Application

The upstream application is loaded in the universal card, which is part of the upstream module. The application provides the proper RF input signal.

2.3.7 Controller and Forwarder Application

The control application performs all monitor, control, system configuration, provisioning, and connection management tasks. It uses a realtime operating system kernel and is designed to manage various processes such as Simple Network Management Protocol (SNMP), Telnet, and other control tasks. It controls the redundant 100BaseT Ethernet interface for communication to the servers and the two RS-232 console ports for out-of-band management.

The forwarder application provides buffering, packet processing, and forwarding of all normal user data.

The control application uses non-volatile memory to retain configuration, system log, and boot up files, and system images. New images can be downloaded from either the local RS 232 interface or remotely over the Ethernet interface. When a new chassis is powered up, the system is set to the factory default configuration and it may have to be reconfigured for the site requirements.

The controller and forwarder application is loaded in the universal card located adjacent to the host card.

2.3.8 Power Supplies

The WMTS is powered by redundant AC power supplies with an operating range of 90 to 264 VRMS at 47 to 63 Hz. Although the system supports two load-sharing power supplies, one power supply is sufficient for a fully loaded chassis of any configuration. Each power supply is fused separately to allow redundant feeds.

3 WMTS PHYSICAL DESCRIPTION

The WMTS is illustrated in Figure 2-3. The chassis has a fan tray above and below the unit to bring the total height required in the rack to 8U. The eight bay chassis contains eight slots in the front, seven slots in the rear, with a mid-plane card in between to interface the cards. (the 16 bay chassis contains 16 slots in the front, 16 slots in the rear.) The host cards have blank panels. In addition, blank panels cover any unused slots.

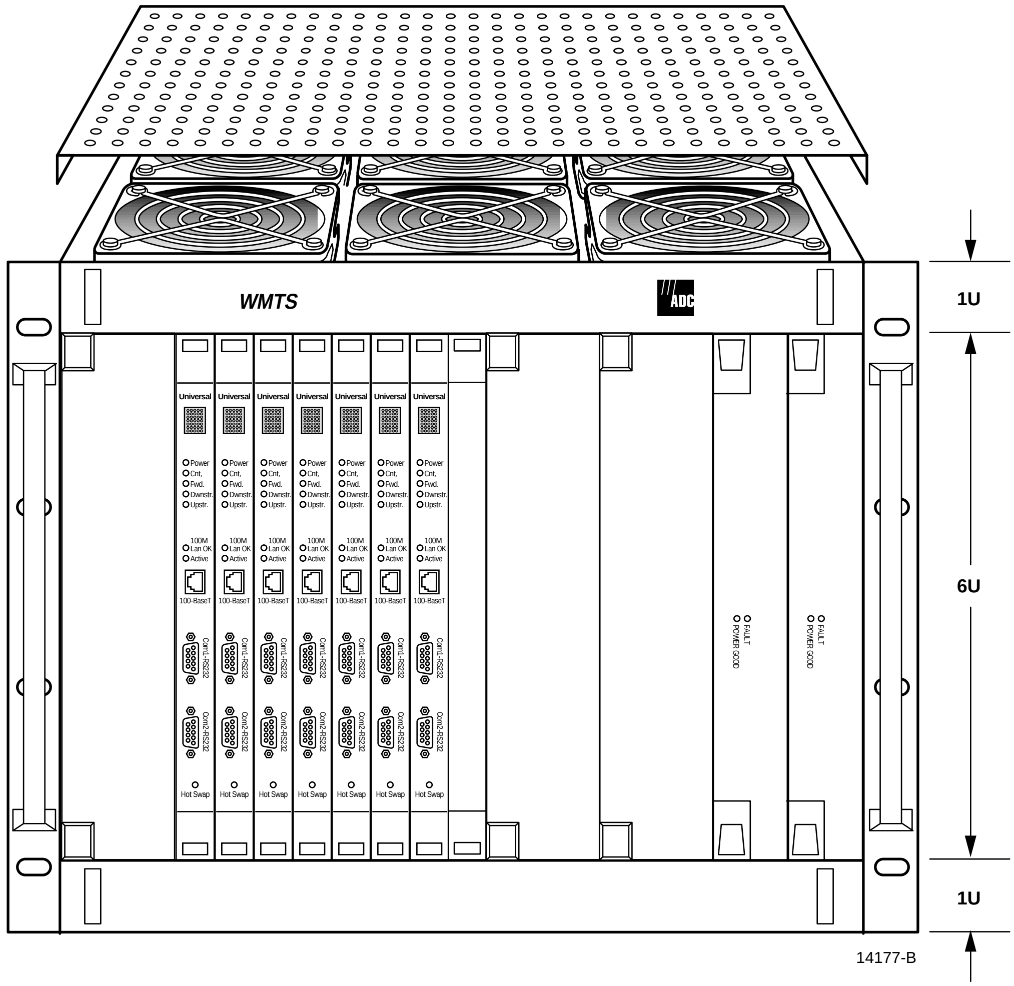

Figure 2-3. WMTS Chassis — Front View

A standard 33 MHz, 32 bit Compaq PCI bus is used to transfer traffic and data between the system cards. The power supplies, primary host card, and the universal cards are inserted in the front of the chassis. The secondary (optional) host card, downstream and upstream cards are inserted in the rear of the chassis. Each card contains three connectors in the front. Connectors J1 and J2 are connected to the mid-plane card. Connector J3 connects the universal card on the front with the downstream and upstream card on the rear of the chassis. Each chassis contains two power supply units, one active and one backup.

The Power ON/OFF switch and the fuse are located on the rear of the power supply.

The front panel of the chassis is illustrated in Figure 2-4, and the rear panel in Figure 2-5.

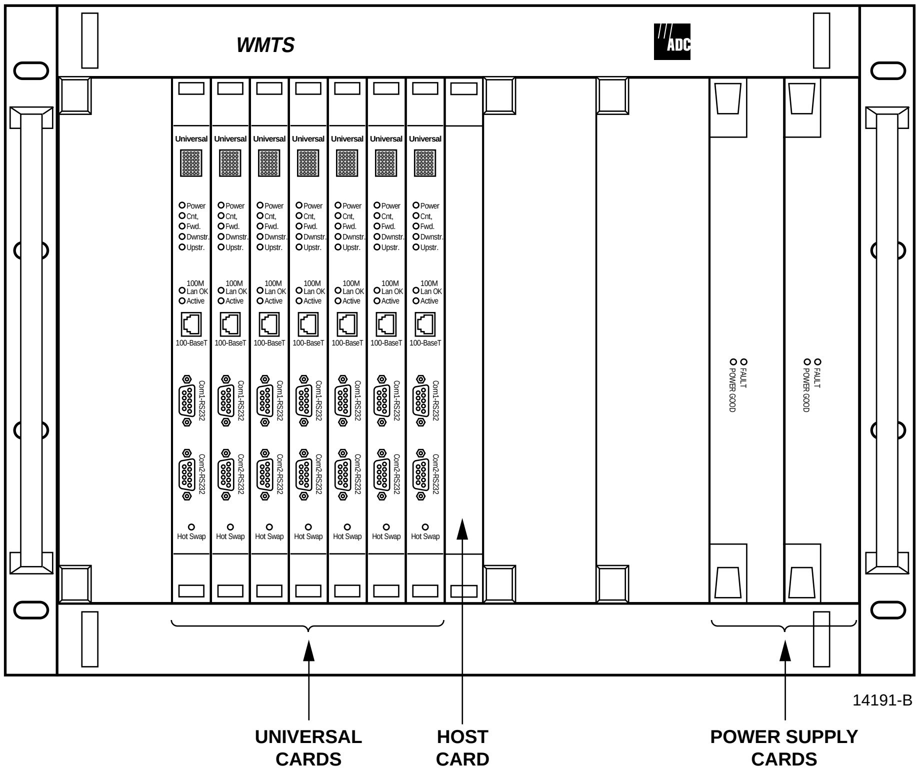

Figure 2-4. WMTS Chassis — Front Panel

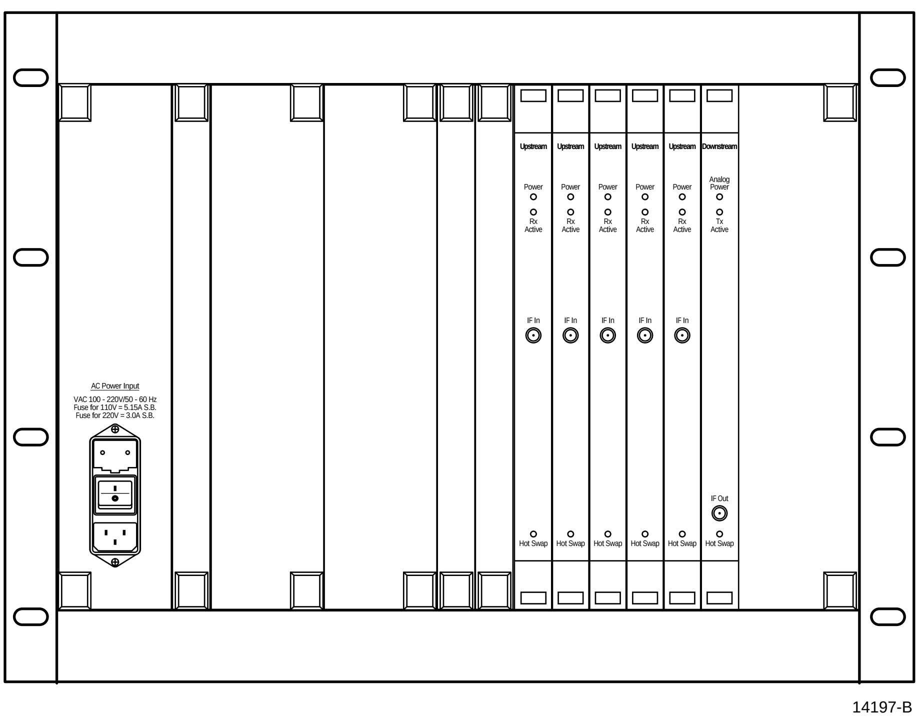

Figure 2-5. WMTS Chassis — Rear Panel

4 ENCLOSURE, PANELS AND INDICATORS

4.1 Enclosure

The WMTS is installed in a standard rack-mounted enclosure. The standard configuration consists of a single enclosure supporting eight slots at the front and seven slots at the rear. Two slots are reserved for the host card and the C&F card. The other six slots may be used for upstream and downstream universal cards. The maximum extension in a single chassis is for 1 modulator (downstream) card and up to 5 demodulator (upstream) cards, or 2 modulators and 4 demodulators. Two fan trays are included, one installed above the chassis and one below.

4.2 Panels and Indicators

Each module except the host card has LED indicators, which assist you in diagnosing possible problems with an interface. For example, on the universal card, a Power LED indicates that the module is seated in the chassis and powered properly. The C&F card front panels serve as the interconnection port.

The card panels house the connectors and the indicators (LEDs) as follows:

- The universal card is detailed in Table 2-1 and illustrated in Figure 2-6.
- The downstream card is detailed in Table 2-2 and illustrated in Figure 2-7.
- The upstream card is detailed in Table 2-3 and illustrated in Figure 2-8.
- The host card are blank.
- The power supply contains two indicators: **Power On** and **Fail**.

4.2.1 Universal Card Panel

When the WMTS system and universal card power up, the channel numbers on the universal cards show as dot matrix question marks. As the unit performs a self-test, the system recognizes the cards and the correct channel number will appear in the dot matrix. The downstream card is typically installed in the far left slot, with a **1** displayed as its channel number. Up to five upstream cards can be installed in the slots to the right of the downstream card. The numbering for these cards will start with a **1** for the far left downstream card, followed by **2** through **4**, depending on the number of cards installed. The far right card is typically the C&F card. Its channel number is **0**.

During normal operation, the LED indicators will operate as shown below. If the system locks or malfunctions, some of the lights will remain lit instead of flashing. If this happens, restart the system. If it continues, contact ADC Customer Service.

Table 2-1. Universal Card Indicators

LED	COLOR	INDICATION
Dot Matrix	Red	Channel number corresponding to slot location
		"?" indicates a problem with the downstream or upstream card
Power	Green	On when card is inserted and power is applied
		Off when card is not seated properly or problem exists with the power supply
Cont.	Green	Flashing when controller application is active
		Off when card is set up in conjunction with downstream or upstream IF card or problem exists with C&F universal card
		On when the card is in the correct slot but there is a problem with the universal card
Forwd.	Green	Flashing when forwarder application is active
		Off when card is set up in conjunction with downstream or upstream IF card or problem exists with C&F universal card
		On when the card is in the correct slot but there is a problem with the universal card
Dwnstr.	Green	Flashing when the downstream application is active
		Off if universal card is not coupled with a downstream card or if a problem exists with the downstream card or universal card
Upstr.	Green	Flashing when the upstream application is active
		Off if universal card is not coupled with an upstream card or if a problem exists with the upstream card or universal card
Lan OK	Green	On indicates network integrity of the Ethernet connection (applies to C&F universal card only)
		Off if there is a problem with the connection
Active	Yellow	Flashing when traffic is transferred over the Ethernet connection
		Off when no traffic is flowing
Hot Swap*	Red	Off for normal operation
		On if the card is not seated correctly
CONNECTOR/ SWITCH	**TYPE**	**FUNCTION**
100-BaseT	RJ45	Ethernet connection
Com 1-RS232	D-type	RS-232 link (future use)
Com 2-RS232	D-type	RS-232 link used for local software download
LED	**COLOR**	**INDICATION**
Dot Matrix	Red	Channel Number (*)
Power	Green	ON when the rear card is present
Cnt	Green	Flashing when controller and forwarder application is active
Fwd	Green	Flashing when controller and forwarder application is active
Dwnstr	Green	Flashing when the downstream application is active

Upstr	Green	Flashing when the upstream application is active
100M Lan OK	Green	Indicating network integrity of the Ethernet connection on the C&F universal card only
Active	Yellow	Flashing when traffic is transferred over the Ethernet connection
Hot Swap	Red	If lit, the card can be pulled out and released after pushing the HOT SWAP switch
CONNECTOR/ SWITCH	**TYPE**	**FUNCTION**
100BaseT	RJ45	Ethernet connection
Com 1	D-type	RS-232 link (future use)
Com 2	D-type	RS-232 link used for software download
Hot Swap	Push button	Request for card release while system is ON

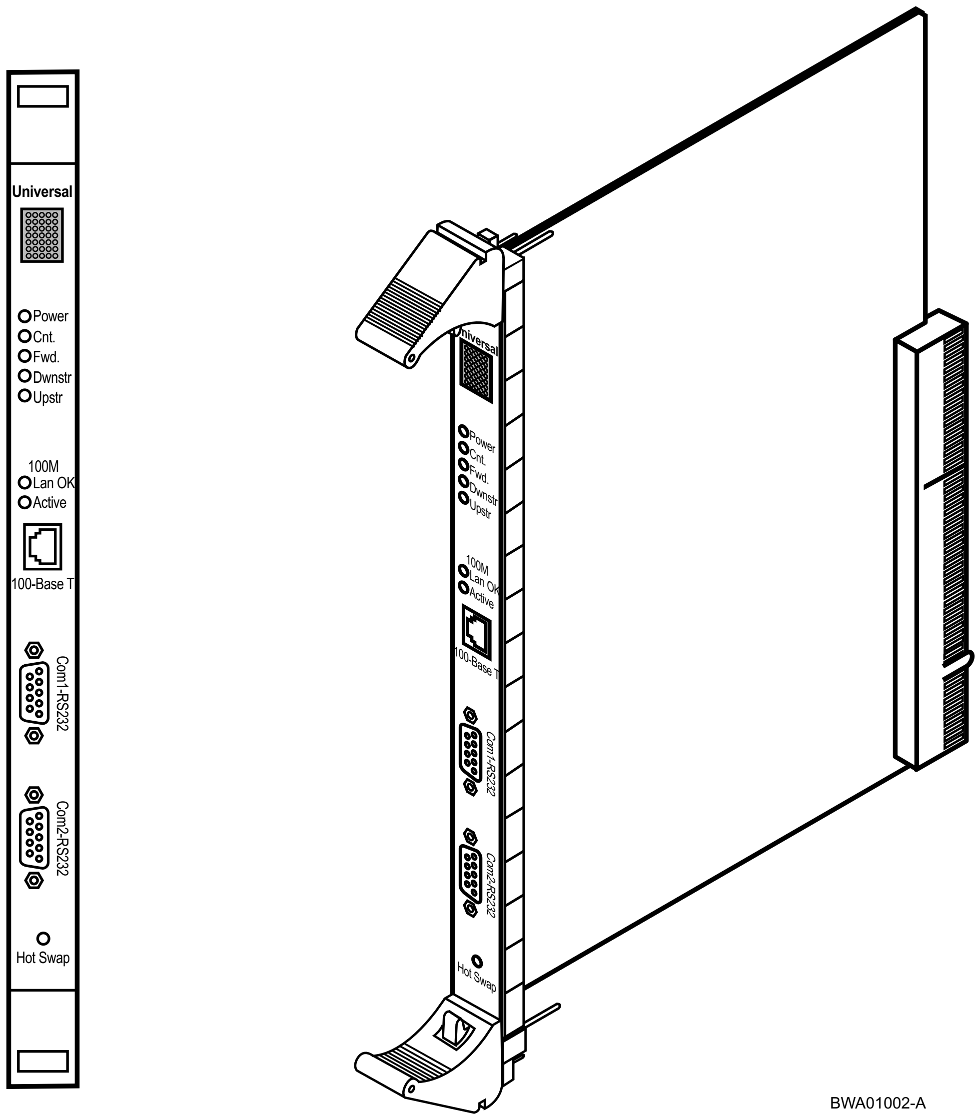

Figure 2-6. Universal Card Panel

4.2.2 Downstream Card Panel

When the WMTS powers up, the channel numbers on the WMTS universal cards show as dot matrix question marks. As the unit performs a self-test, the system recognizes the cards and the correct channel number will appear in the dot matrix.

LED lights on the downstream card will operate as noted below. If the system locks or malfunctions, the **Tx Active** LED may stay lit instead of flashing. If this happens, restart the system. If it continues, contact ADC Customer Service.

Table 2-2. Downstream Card User Panel

LED	COLOR	INDICATION
Analog Power	Green	On when card is powered on
		Off when power to card is disrupted
Tx Active	Yellow	On when downstream traffic is transmitted
		Typically will turn off and on as traffic flows
Hot Swap*	Red	Off in normal operation
		On if the card is not seated correctly or if the Hot Swap switch has been pressed
CONNECTOR/SWITCH	**TYPE**	**FUNCTION**
IF OUT	F-type	IF to Basestation RF Transport Equipment
LED	**COLOR**	**INDICATION**
Analog Power	Green	ON when card is powered on
TX Active	Yellow	Lit when downstream traffic is transmitted
Hot Swap	Red	If lit, the card can be pushed out and released after pushing the HOT SWAP switch
CONNECTOR/SWITCH	**TYPE**	**FUNCTION**
IF OUT	F-type	IF to RF transmitter
Hot Swap	Push button	Request for card release while system is ON

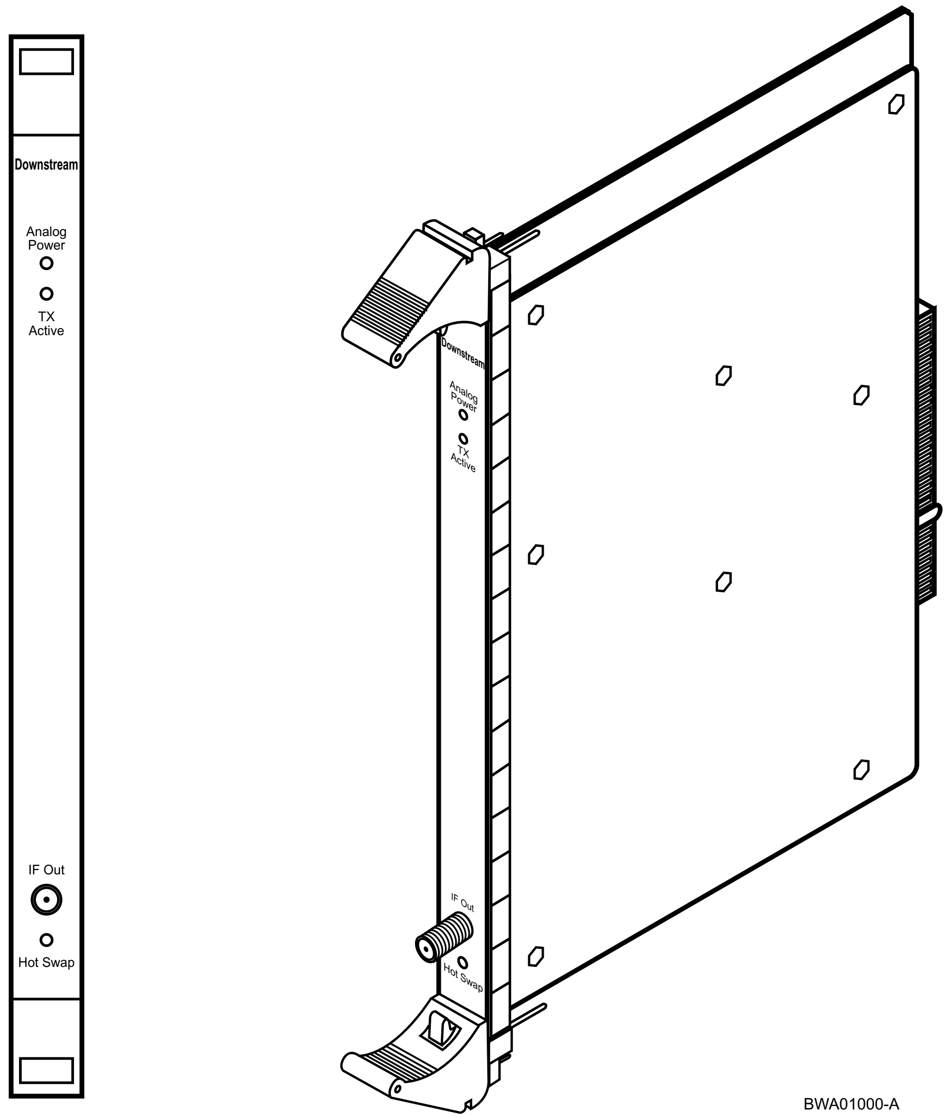

Figure 2-7. Downstream Card Panel

4.2.3 Upstream Card Panel

When the WMTS powers up, the channel numbers on the WMTS universal cards show as dot matrix question marks. As the unit performs a self-test, the system recognizes the cards and the correct channel number will appear in the dot matrix.

LED lights on the upstream card will operate as noted below. If the system locks or malfunctions, the **Rx Active** LED may stay lit, instead of flashing. If this happens, restart the system. If it continues, contact ADC Customer Service.

Table 2-3. Upstream Card User Panel

LED	COLOR	INDICATION
Power	Green	On when card is powered on
		Off when power to card is disrupted
Rx Active	Green	On when upstream traffic is present
		Typically will turn off and on as traffic flows
Hot Swap*	Red	Off in normal operation
		On if the card is not seated correctly of if the Hot Swap switch has been pressed
CONNECTOR/SWITCH	**TYPE**	**FUNCTION**
RF In	F-type	RF from base station RF receiver

* Hot Swap function not available in this release

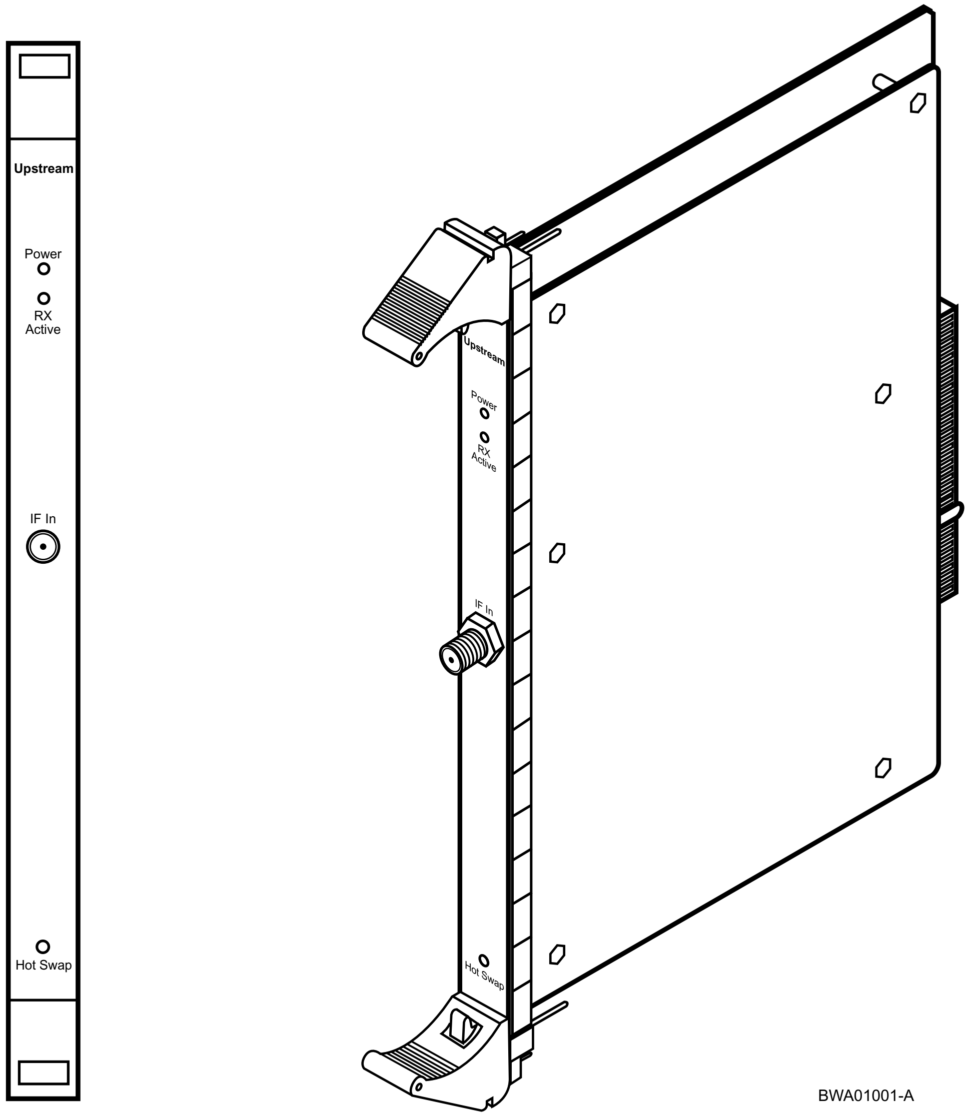

Figure 2-8. Upstream Card Panel

4.3 Cards and Application Modules

4.3.1 Universal Card

The universal card is the basic card in the WMTS. The universal card supports several independent functions, such as the control and forward (C&F) application, or downstream and upstream applications. This means it can function as a C&F card or as an upstream or downstream digital card. The card is automatically configured according to its location in the enclosure. When the downstream card is plugged into the mating rear slot, it implements the downstream application. When the upstream card is plugged into the mating rear slot, it implements the upstream application. When the universal card does not have any mated rear module, it implements the C&F application and handles the traffic over the local network connection. The C&F card is always located next to the host card. The card communicates with the other system assemblies via the internal CPCI bus. An internal system bus is used for on-card intra-board data transfer. This bus structure separates data flow and provides better bus performance and traffic throughput.

4.3.2 Downstream Card

The downstream card, together with the universal card, is part of the downstream module. The transmission module core includes the forward error correction (FEC) modulation circuit. The modulator card is based on a transmitter/processor and an IF generator. The downstream IF output is nominally centered at 44 MHz, and it supports QPSK, 16QAM, and 64QAM modulation schemes.

4.3.3 Upstream Card

The demodulator card, together with the universal card, is part of the upstream module. The demodulator card is based on a burst receiver and an IF demodulator for QPSK only. The upstream IF input is 5 MHz to 68 MHz.

4.3.4 Host Card

The host cards provide bus arbitration, system clock and timing. A secondary host card can be installed for backup of these functions.

4.3.5 Downstream Application

The downstream application is loaded by the host card into the universal card, which is part of the downstream module. The application provides the composite IF signal to be converted by the modulator for the downstream channel.

4.3.6 Upstream Application

The upstream application is loaded by the host card into the universal card, which is part of the upstream module. The application provides the demodulated input signal.

4.3.7 C&F Application

This application is the overall WMTS controller. The controller manages the entire WMTS and runs the SNMP, which is the administrator management interface program. It provides the 100BaseT interface, which connects the WMTS to the Internet backbone via a switch and the ISP router. The C&F card is always the closest one to the host card.

5 BASE STATION RF COMPONENTS

Every headend or hub requires a transmitter or set of transmitters with the associated filters, power combiner, waveguide or cabling and antenna to send the WMTS modulated signals to the subscriber sites. Similarly, the headend requires an antenna, cabling, filtering, and a receiver/downconverter to process the RF upstream signal from the client sites for the WMTS demodulators. This is illustrated in Figure 2-9.

Figure 2-9. Typical Wireless Internet Access

The RF front end contains the downstream assembly, which transmits information from the WMTS to the subscriber unit and the upstream assembly, which receives information from the subscriber unit.

5.1 Downstream

The downstream path starts with data from the Internet or servers at the service provider or base station through the C&F 100BaseT connector (or control signals generated by the WMTS). These are passed to the appropriate downstream universal card, which sends the signal (still in a digital format) to the downstream card. The data is then passed to the appropriate downstream universal card, which sends the signal (still in a digital format) to the downstream card. The downstream card converts it to the appropriate modulated IF format and frequency (nominally 44 MHz). The IF signal leaves the WMTS chassis and is provided to the RF transmitter, which converts it to the specified RF channel (or sub-channel) and amplifies it to the transmit power level. Typically, multiple transmitters drive a common antenna and these signals are frequency multiplexed in a power combiner. The output of the power combiner is connected to the transmit antenna via a waveguide or coaxial cable or a combination of the two.

There are many aspects to consider when specifying the RF components. One of the primary concerns is that the transmitter be linear, have a flat response, low group delay, and low phase noise suitable for the type of modulation that is being implemented.

The Axity system supports a single downstream channel per chassis, which may drive an omni-directional (omni) antenna, or multiple downstreams. When multiple downstreams are used, they may be allocated to different frequency channels or different antenna sectors or a combination of the two. The optimal approach depends on what spectrum is available, and what the distribution of the customer base is, taking such things as traffic loading, density, and type of service being delivered into consideration.

There are three downstream modulations available: QPSK, which provides 8 Mbps total throughput; 16QAM which supports 17 Mbps; and 64QAM, which supports 28 Mbps. Downstream uses a packet broadcast-multiplexing scheme.

5.2 Upstream

The upstream path starts with the signal being picked up by the antenna which is then passed to the low noise amplifier (LNA) via a coaxial cable or a waveguide and filtering system (which might include the power combiner). The signal is converted from the RF band to an IF signal in the upstream receiver/downconverter. The IF is then presented to the upstream card in the WMTS chassis.

Upstream traffic from the subscriber unit is burst mode.

The upstream downconverter, used to convert the RF to an IF suitable for the demodulator, along with the LNA and filtering, must have good linearity, low distortion, low phase noise, and have a low noise figure. The WMTS IF frequency from the demodulator is 5 to 65 MHz. The RF frequency and the upstream downconverter determine the specific frequency used by a given channel. This frequency should be selected with attention given to interference and filtering considerations.

Upstream throughput is dependent on the sub-channel bandwidth (400 kHz, 800 kHz, and 1.6 MHz) and the modulation type (QPSK). Multiple channels and sub-channels from the same antenna sector, if they are close enough in frequency to allow common filtering, may be processed in the same LNA and upstream downconverter. Channels, which are offset in frequency (for example, an MDS channel and a WCS channel), would require separate upstream filters and downconverter. Different antenna sectors also require separate upstream paths because combining multiple sectors reduces the sensitivity of the receiver.

5.3 Modulation

The modulation and symbol rates used are the primary determinant of the data transfer rate. Wireless systems typically use QPSK upstream and 64 QAM downstream. The signal-to-noise ratio at the receiver determines which modulation formats can be successfully used for a given level of phase noise. The more sophisticated the modulation format, the better the signal-to-noise ratio must be to accurately demodulate the signal.

QPSK is the most tolerant with a required S/N ratio of about 14 dB. 64 QAM passes about three times as many bits per hertz of bandwidth, but requires 27 dB S/N for the same bit error rate. The best modulation type for a system also depends on how much multipath and fading immunity is required for the physical environment. The lower the modulation complexity, the higher the immunity. But the lower the complexity, the lower the data rates that are possible if the channel were perfect.

Immunity from fading and multipath are also determined by symbol rate. The lower the symbol rate, the better the immunity. But again, the lower the theoretical data rate. Also, the lower the symbol rate, the narrower the receiver's bandwidth. This effects the sensitivity and therefore the range from the base station that is possible.

The downstream in the Axity system may be QPSK, 16 QAM, or 64 QAM and can be set by the operator. The upstream bandwidth is also established by the operator. This allows the system operator to configure for optimal format.

The modulation scheme and symbol rate, along with the bandwidth determine data throughput on a wireless channel as listed in Tables 2-4 (upstream) and 2-5 (downstream).

Table 2-4. Data Throughput - Upstream

UPSTREAM		
NOMINAL THROUGHPUT PER SUB-CHANNEL		
		BITRATE (NOMINAL)
CHANNEL WIDTH	SYMBOL RATE	QPSK (2 BITS PER SYMBOL)
400 KHz	320 Ksym/sec	640 Kb/s
800 KHz	640 Ksym/sec	1280 Kb/s
1600 KHz	1280 Ksym/sec	2560 Kb/s

Table 2-5. Data Throughput - Downstream

DOWNSTREAM			
NOMINAL THROUGHPUT PER CHANNEL[1]			
CHANNEL WIDTH	MODULATION TYPE	SYMBOL RATE	BIT RATE
6 MHz	QPSK	5.304 Msym/sec.	10.608 Mb/s
6 MHz	16 QAM	5.304 Msym/sec.	21.216 Mb/s
6 MHz	64 QAM	5.0565 Msym/sec.	30.3414 Mb/s

5.4 Provisioning

Parameters such as modem serial number, frequencies of operation, and power levels are directly associated with the WMU. It is important to keep databases with this WMU information current for both technical and administrative purposes. A parameter like the serial number is not field-changeable and needs to be entered only once. Parameters, such as frequencies of operation and power levels, are manually set at the time of installation. The DOCSIS-based WMTS system automatically negotiates these parameters based on certain conditions. There are parameters associated with the user, such as name, street address, phone number, account number and type of CPE hardware. All these parameters are accounted for during provisioning.

SECTION 3: WMTS FUNCTIONAL DESCRIPTION

Content	Page

1 INTRODUCTION

1.1 Overview

The WMTS is an IP centric bridge for data over radio communication system. It is designed to allow IP access over wireless channels to business, government, schools, hospitals and residential users. The major applications are: Internet access, multi-media, video conferencing, distant learning and more.

Wireless modems interconnect computers and LANs with the Internet world and any other external services using radio waves. Radio signals have several advantages over hardwire systems that include quick deployment, higher data rates than conventional telephone lines, and the ability to service customers independent of the traditional infrastructure. Wireless modems convert data to RF and back to data in a similar manner to ow telephony modems convert data to frequencies that pass through telephone systems. Broadband modems, as referred to in this discussion, perform these functions using frequency bands with at least 6 Megahertz of bandwidth. This allows very high data rates compared to telephony modems. The frequency bands used as examples are the MDS and MDS/ITFS channels.

1.2 Internet Access

Users across the wireless network are provided access to central communication facilities located at the base station. The base station is logically situated between the WAN and ISP on one side, and the wireless network and the Wireless Modem Unit (WMU) on the other side.

1.3 DOCSIS Compliance

The WMU is a DOCSIS compliant device, with enhancement for wireless applications. The system should be regarded as a DOCSIS system, because it implements networks with DOCSIS features over wireless channels.

2 IMPLEMENTATION

2.1 Overview

The downstream channel utilizes a 6MHz bandwidth, which is transmitted by an antenna through the power combiner and waveguide. The upstream channel can be split into several independent sub-channels of different channel widths. The upstream channel may use directional antennas to reallocate sub-channels in different areas.

2.2 Data Throughput

The data throughput is a factor of the symbol rate and modulation scheme.

Table 2-1. Data Throughput - Upstream

UPSTREAM		
NOMINAL THROUGHPUT PER SUB-CHANNEL		
		BITRATE (NOMINAL)
CHANNEL WIDTH	SYMBOL RATE	QPSK (2 BITS PER SYMBOL)
400 KHz	320 Ksym/sec	640 Kb/s
800 KHz	640 Ksym/sec	1280 Kb/s
1600 KHz	1280 Ksym/sec	2560 Kb/s

Table 2-2. Data Throughput - Downstream

DOWNSTREAM			
NOMINAL THROUGHPUT PER CHANNEL			
CHANNEL WIDTH	MODULATION TYPE	SYMBOL RATE	BIT RATE
6 MHz	QPSK	5.304 Msym/sec.	10.6 Mb/s
6 MHz	16 QAM	5.304 Msym/sec.	21.2 Mb/s
6 MHz	64 QAM	5.0565 Msym/sec.	30.3 Mb/s

3 TRAFFIC STRUCTURE

3.1 Overview

The traffic from the base station toward the WMU at the subscriber site is over a downstream channel and back over an upstream channel. This arrangement provides full duplex wireless communication.

3.2 Frame Conversion

On the downstream, the WMTS encapsulates the IP frames into MPEG frames. Each MPEG frame holds 188 bytes and the header holds the Packet Identifier (PID) to identify the original frame (packet). The modem identifies the frames in order to decapsulate the original IP frames. On the upstream the modem inserts IP data into the minislots allocated to it according to the options enlisted in the MAP messages. A typical minislot contains 16 bytes, which is further broken up into ticks. The burst consists of the header, data (payload), and FEC/CRC which is the error control information. The header also contains the Service ID (SID) to implement versatile types of services to each modem. The downstream channel is TDM multiplexed, and the upstream channel is TDMA multiplexed.

4 DOWNSTREAM

4.1 Overview

The forward path data is broadcast toward all the WMUs in a given sector, tuned to a particular channel. Each WMU listens to the downstream and selects its relevant data and converts it to digital data. The downstream PMD (Physical Media Dependent) protocol confirms to ITU--T J-83 Anex B.

4.2 Forward Error Correction (FEC)

The upstream channel is configurable to include user-specified FEC overhead, including none. The flexible FEC coding enables the system operator to set the size of the error protected data blocks and to set the number of correctable errors within each FEC. These changes can be made while the system is operating normally. This flexible FEC coding option enables the system operator to choose for a group of modems to stay on the same frequency by simply increasing the error protection on that channel. Although, the additional few bytes of error protection reduces the channel information rate, it makes the overall system capable of a much higher upstream spectrum utilization.

4.3 Downstream Transmission

The downstream signal from the ISP is converted by the WMTS to an IF signal which drives the transmitter. It consists of the data, encapsulated with Forward Error Correction (FEC) plus control and timing data. It is centered at the IF frequency of 44 MHz and directly drives a MMDS transmitter over a 6MHZ band. There are three downstream modulations available; QPSK which provides 8 Mbps total throughput, 16QAM which supports 17 Mbps, and 64QAM which supports 28 Mbps. The advantage of the slower rates is that the required signal-to-noise ratio is lower and intersignal interference may be reduced. Therefore, customers who have difficult locations in terms of distance, fading, or multipath may be supported, albeit at a slower data rate. The MMDS/ITFS channels cover the RF range of 2500 to 2686 MHz. Each channel is 6 MHz wide (except G4). The downstream antenna is typically contoured toward customers physical residence location to support the customer base. If the customers surround the transmission site, the antenna would typically be an omni type. If the transmission site is near a mountain range or a lake or ocean, then the antenna chosen should have a pattern directing the energy towards the customer base. This allows more of the transmitter power to be directed at the customer base. If the customer base requires more data throughput than can be supported with a single downstream channel, there are a couple of options. One is to assign more MMDS/ITFS channels. The second approach requires multiple transmitters on the same channel and directive antennas. The net data throughput could be quadrupled by using four 90 degree antennas and four transmitters. The polarization of the antennas would be alternated between sectors to reduce sector to sector interference. A third approach to increasing the total downstream bandwidth in a territory is to use a cellularization approach. This would involve a number of lower powered transmission sites, each covering a fraction of the territory serviced by the operator. Cellularization, with sectorization, may be used to increase the system wide data capacity to any level required. The practical trade-off, of physically establishing multiple transmission sites and supporting them is the main limitation. At some point, alternative access methods become more practical. As with MMDS/ITFS TV transmission, the RF signal requires a line of sight path.

4.4 Forward Path Modulation Format

The downstream physical layer is based on the International Telecommunication Union, ITU-T Recommendation J.83 (04/97), Digital Transmission of television signals, Annex B (ITU-T J.83B). This revision of ITU-TJ.83B includes not only the original 16 QAM modulation and a fixed depth interleave used to deliver digital data, but also a 16 QAM for higher downstream channel data rates as well as a variable depth interleaver. DOCSIS PLUS TM downstream channels may occupy a 6 MHz band between 2500 MHz and 2680 MHz. The reliability of the QAM-modulated downstream channels is improved by powerful concatenated FEC provided by the ITU-T J83.B specification. Multiple layers of error detection and error correction, coupled with variable depth interleaving to provide variable-length burst error resilience, delivers error rates ensuring customer satisfaction. The high data rates together with the low error rates, provide a bandwidth efficient delivery mechanism for digital data delivery. The WMU accepts a RF modulated signal with characteristics. The output signal level of the WMTS is variable over the range of 50 - 61 dBmV.

4.5 Variable Depth Interleave

The forward path modulation supports a variable-depth interleave format with characteristics defined according to DOCSIS. Variable depth interleave is a form of error protection. Based on the level of the interleave, the data on the forward path is protected from noise burst lengths. Even with reduced noise margins, the downstream channels are designed to deliver 16QAM signals with signal to noise ratio of 23.5 dB. Interleaving improves protection from noise burst. It also adds latency in the downstream channels. The process of interleaving the outgoing symbols and shuffling the position of the symbols so that normally adjacent related symbols are now separated by unrelated symbols that would otherwise be transmitted later, delays the delivery time of the related symbols. The benefit is that a burst of noise damages only the unrelated symbols. The FEC then corrects the damaged symbols once they are reshuffled back to their original order, as long as the burst damage did not span too many related symbols. There is an intrinsic relationship between the depth of the interleaving and the latency incurred by interleaving. Typical interleaving depth provides 95 microsecond burst protection at the cost of 4 milliseconds of latency. Four milliseconds of latency is insignificant when using standard Internet data services such as web browsing, e-mail and file transfer. However, in near real-time Constant Bit Rate (CBR) services, like IP telephony that have tight end-to-end latency, performance may be impacted. The variable depth interleave, enables the system engineer to trade between how much error protection is required and how much latency is tolerated by the services, to be delivered. The depth of the interleave is also dynamically controlled by the WMTS, based on the RF channel conditions.

4.6 Downstream RF Channels

The RF channel transmission characteristics of the wireless network in the downstream direction, assumed for the purposes of minimal operating capability, are described in the table below. This assumes a nominal analog carrier level of 6 MHz channel bandwidth. All conditions are concurrently presented.

Table 4-1. Assumed MMDS Downstream RF Channel Transmission Characteristics

PARAMETER	VALUES
Frequency range	2.5 GHz to 2.686 GHz
RF channel spacing (design bandwidth)	6 MHz
Transit delay from the headend to the most distant customer	Less than 0.8 msec (typically much less)
Carrier-to-noise ratio in a 6-MHz band	23.5 dB @ 64QAM 18 dB @ 16QAM 15 dB @ QPSK
Amplitude ripple	0.5 dB within the design bandwidth
Group delay ripple in the spectrum	75 ns within the design bandwidth
Burst noise	Not longer than 25 µsec at 10 Hz average rate
Seasonal and diurnal signal level variation	+8 dB

4.7 Transmission Convergence Protocol

A transmission convergence protocol (MPEG-2) allows multiple types of services to share the same RF carrier. For DOCSIS, the TC layer is MPEG-2, a protocol used with increasing frequency in networks. Using MPEG-2 means that other types of information, also encapsulated within MPEG-2 (e.g., voice and video), can all be sent on the same RF carrier as WMU data. MPEG-2 provides a mechanism to identify individual packets within the MPEG-2 stream, in the same way that WMU or a set top box identifies which packets to decode. This mechanism called the PID (Packet Identifier) is present in all MPEG-2 frames. DOCSIS has declared the value Ox1FFE to be the well known PID for all the traffic on the channel. WMUs only operates with MPEG packets with this PID. In addition, MPEG-2 provides a frame structure that facilitates channel lock. MPEG-2 frames start every 188 bytes with a synchronization byte. Searching for this MPEG-2 sync byte, which repeats at both a fairly quick and regular interval, makes it easier to synchronize with the overall bit stream on the channel. Since the newly installed WMU searches several forward path channels for data, this feature helps the WMU to find the proper channel sooner.

4.8 Forward Channels

The WMU accepts a RF modulated signal with characteristics as described in Table 4.2. The output signal level of the WMTS is variable over the range of 50 - 61 dbmv.

Table 4-2. Electrical Input to WMU

PARAMETER	
Center frequency	91 to 857 MHz ±100 kHz
Level range (one channel)	-15 dBmV to +15 dBmV
Modulation type	QPSK, 16QAM, 64QAM
Symbol rate (nominal)	5,057 Msym/sec (64QAM) and 5.304 Msym/sec 16QAM, QPSK
Bandwidth	6 MHz
Total input power (40-900 MHz)	<30 dBmV
Input (load) impedance	75 ohms
Input return loss	> 6 dB
Connector	F connector per [IPS-SP-406] common with the output

5 UPSTREAM

5.1 Overview

The return path information is transmitted from the WMU, in the network over the upstream channel toward the base station. An allocated time slot is assigned to each WMU to send the information. The WMTS converts the received information to digital data.

5.2 Return Channel

The WMU modulator provides QPSK modulation at symbol rates and channel widths, as described in table 5.1.

Table 5-1. WMTS Upstream Performance Requirements

REQUIREMENT	SPECIFICATION
MODULATION	QPSK
SYMBOL RATES	0.320, 0.640, 1.28 Ms/s
RECEIVE LEVEL	-13 to +17, -10 to +20, -7 to +23 dBmV (respective to symbol rates)
CHANNEL BANDWIDTHS	400 KHz, 800 KHz, and 1.6 MHz
FREQUENCY RANGE	5 to 65 MHz
CNR THRESHOLD FOR $1X10^{-6}$ BE	12.5 dB @ QPSK
THROUGHPUT[1]	400 KHz: 520 Kb/s 800 KHz: 1.0 Mb/s 1.6 MHz: 2.0 Mb/s
INPUT IMPEDANCE	75 ohms
FORWARD ERROR CORRECTION	Reed-Solomon codes over GF(256) with T= 1 to 10, Codeword size K = 16 to 253
DESCAMBLER	Pseudo Random Binary Sequence based on the polynomial $x^{15}+x^{14}+$ the seed is variable
TRACKING RANGE	+/- 32 KHz
CHANNELS SUPPORTED	Up to 5

As can be seen from the above table, each upstream channel has an assigned bandwidth associated with it. The occupied bandwidth is directly related to the channel's data rate. The DOCSIS compliant upstream channels, occupies bandwidths of 400, 800 or 1600 KHz. This corresponds to channel data rates of 320, 640 or 1280 kilosymbols per second (ksym/sec).

5.3 Upstream Transmission

The upstream return is directed to the receive antenna on the base station tower. This signal is picked up by the antenna and transferred down the tower via a low loss cable or waveguide. The lower the loss, the better the sensitivity and the further the client sites may be from the base station. The signal may pass down the same waveguide as the MMDS transmission downstream signals if sufficient filtering is used. The upstream RF signal must be filtered to remove interfering neighboring signals and harmonics of lower frequency transmitters and the intermodulation products of the MMDS/ITFS and other transmitters which may be collected on the tower or on nearby towers. This filter should have low loss and low group delay variation. The low receive signal must amplified in a Low Noise Amplifier (LNA). This establishes the noise figure of the receive path and the sensitivity level of the system. A down converter is then used to convert the RF to an IF suitable for the demodulator in the WMTS wireless router. This is typically 2.15 to 2.162 GHz for the MDS channels. Other frequencies may be used but care should be taken to avoid interference with other systems and other sections of this system. The phase noise of the down conversion is important to allow the demodulator to accurately receive marginal signals. Typically -90dBc/Hz at 10kHz offset is required for 64QAM operation.

5.4 Return Path Modulation Format

The upstream channels utilizes a combination of Frequency Domain Multiple Access (FDMA) and Time Division Multiple Access (TDMA). FDMA is provided by the ability to have multiple upstream channels simultaneously supporting multiple modems. TDMA is provided by using "slotting" on the upstream channels. Each upstream channel is divided into equal-time segments called "mini-slots". The use of each mini-slot is controlled by the WMTS at the head end. The WMTS assigns contiguous intervals of mini-slots to individual WMUs, or makes them available for contention by groups of WMUs, or opens them for contention by all modems. The type of contention within the assigned interval is dictated by the WMTS. All DOCSIS compliant WMUs, time-coordinate all their upstream transmissions so that they transmit within the appropriately allocated interval. This provides the mechanism for multiple access in time domain.

Table 5-2. TDMA Upstream Transmission Processing

Filter	Packet Stream Input ⇓
Block the Data	Separate Packet into Information Blocks (=data bytes in one codeword) ⇓
FEC Encode	FEC Encode (Reed-Solomon) each Information Block, using shortened codeword for last block if needed. FEC can be turned off. ⇓
Scramble	Scramble ⇓
Preamble Prepend	Preamble Prepend Symbols ⇓
Symbol Map	Symbol Map the Data Stream Into Modulator Symbols ⇓
Filter	Filter Symbol Stream for Spectral Shaping ⇓
Modulate	Modulate at Precise Times (QPSK) ⇓
	Output RF Waveform Bursts

5.5 MAC Layer Protocol

The MAC layer protocol controls access to the return path. Since several modems may have data to transmit at a given time, the MAC protocol provides a means for the WMTS to indicate which modem can transmit when and for how long. If data is transmitted individually, data "collisions" do not occur on the return path and the system operates efficiently. Collisions cause WMUs to re-transmit data, which is not a very efficient form of operation. The DOCSIS MAC protocol provides a request/grant mechanism. Using this type of protocol, a WMU requests from the WMTS an opportunity to transmit a certain amount of data. As the WMTS receives requests from all the modems with data to transmit, it reserves mini-slots (essentially transmit opportunities) on the return path accordingly. Periodically (every few milliseconds), the WMTS sends a message to the WMUs (over the downstream path) indicating the specific mini-slots granted to each modem. As a result of reserving bandwidth, modems are guaranteed a collision-free interval in which to transmit. The WMTS is responsible for allocating bandwidth to modems based on the type of service to which the user is subscribed. In order for a modem to request bandwidth without first having been allocated a time to send the message, the WMTS periodically allocates a portion of the return channel for any modem to send a request. These requests may collide with a request from another modem. However, the WMTS varies both the length and the frequency of the contention request intervals to keep the number of collisions to a minimum. If collision is detected, the WMUs that sent the messages, back-off random intervals and then retransmit their requests.

5.6 Bandwidth Allocation Map Parameters

The WMTS informs WMU of the allocation of its upstream channel using a MAP (Upstream allocation map). This is a MAC Management message, sent from the WMTS to the WMU, via a downstream channel. The map contains an Allocation Start Time that indicates the time when this MAP takes effect. It also contains a list of Information Elements describing consecutive allocations. The unit of time used in a MAP is called a minislot. Parameters used to configure the MAP affect its effectiveness. These parameters can be updated from the SNMP MIB. A suggested configuration will be offered along with an explanation of each parameter. For each parameter, there is an explanation, location in SNMP MIB table and description of its effect on a MAP.

6 MODEM CONFIGURATION

6.1 Overview

This section describes the procedures required to operate a modem, after being connected to the network and before the green receive lock LED is lit. The modem performs many functions, and each one is briefly described in the following sections.

6.2 Obtain Upstream Parameters

During this phase, the WMU looks for three MAC messages that are repeatedly sent downstream by the WMTS to provide a common time reference to all the modems. The first message is the Time Synchronization message (SYNC). The SYNC message is sent by the WMTS to provide a common time reference to all modems. The second message defines the Upstream Channel Descriptor (UCD). The WMU must find a UCD that describes an upstream channel that matches its own capabilities. For instance, if the WMU could only transmit at certain symbol rates or is limited in its frequency range and modulation types, the WMU may not be able to transmit in a particular upstream channel. The final message can be to find an Upstream Bandwidth Allocation Map (MAP) that matches the upstream channel described in the UCD. The MAP message contains the mini-slot information that indicates when a modem transmits and for how long. The SYNC message provides the time reference for these transmissions. For its transmission the WMU looks in the MAP for the transmit opportunity reserved for modems just connected to the network, At the conclusion of obtaining upstream parameters, the modem has:

* A rough time reference

* The details of an upstream transmit channel

* The details of the initial maintenance transmit opportunities for newly connected wireless modems on that upstream channel

These three points are all used for the "'Ranging" process.

6.3 Provisioning

The wireless modem provisioning and initialization follows the following sequences of events and is managed by the EMS. The WMU:

* Scans for a downstream channel and establishes synchronization with the WMTS

* Obtains transmit parameters

* Performs ranging to acquire upstream frequency and to optimize transmit power.

* Establishes IP connectivity (DHCP) for request and grant

* Transfers operational parameters (downloads parameter files via TFTP)

* Obtains Time of Day

* WMU registration

* Establishes Baseline Privacy

The wireless modem's Plug & Play scheme, minimizes the installation time. The WMU, with a predetermined MAC address, automatically scans a list of factory preset downstream frequencies compatible with standard frequency plans and locks onto the first data downstream channel that is detected. This allows initial automatic acquisition of a downstream frequency during installation, as well as automatic acquisition in the case of a downstream channel frequency change performed by the operator. Every subscriber for high-speed data service has two addresses: a MAC address, and an IP address. To receive and send data in the network, every user must have a MAC (Media Access Control) address. It corresponds to the physical piece of hardware, the Wireless Modem Unit (WMU). When the user is connected to the Internet, a table in the database in the base station relates the MAC address to the Internet (or IP) address. The system uses the Dynamic Host Control Protocol, where the system assigns the IP address to the user, for the duration of the connection or session. This is accomplished by using the pool of IP addresses, which have been supplied to the system for this purpose. When the WMU is connected to the user's computer, part of the installation procedure is to add a Software driver. The driver reads the MAC address and incorporates the MAC address in the

Ethernet protocol data units. This is then transmitted or received in each interaction prior to requiring its IP address in the network. During the first connection of the WMU to the network and the CPE, an entry is made in the address resolution table at the base station. This provides the relationship to the MAC address and the IP address. The IP address is assigned to the user by the network administrator when the user is added to the system. In addition to the addresses associated with the system, as explained above, there are parameters directly associated with the WMU. Some examples are modem serial number, frequencies of operation and power levels. It is important to keep databases with this information current for both technical and administrative purposes. Parameters which are not field-changeable, need to be entered only once. An example of this is the serial number which is set at the time of manufacture. Other parameters are manually set at the time of installation. Examples of these parameters are frequencies of operation and power levels. The system automatically negotiates these parameters based on certain conditions. Finally, there are parameters associated with the user himself. Examples are name, street; address, phone number, account number and type of transverter, WMU and computer hardware. All these parameters are accounted during provisioning.

6.4 Channel Acquisition

The modem first scans for the downstream channel (frequency), then obtains QAM lock, and finds the UCD (Upstream Channel Description) message with the channel characteristics to start upstream transmission. A WMU may have to search several downstream channels before finding the one with correct data. Channel acquisition is successful when the WMU decodes MPEG-2 frames in order to decode the MAC frames (that bear the well known PID). The MAC frames are then passed to the MAC layer, in the WMU, for processing.

6.5 Ranging

Ranging describes the following three processes that the WMU must accomplish. These include:

* Time reference fine adjustment

* Transmit frequency fine tuning

* Transmit power fine adjustment

Since each WMU in the network, is at a unique distance from the WMTS it contains unique settings for these parameters. To begin the ranging process, the WMU transmits a ranging request message to the WMTS during an Initial Maintenance opportunity (as described by the MAP messages), on the upstream channel. The WMU begins to transmit this message at the starting boundary of the initial maintenance opportunity, based on its rough time SYNC and its interpretation of the MAP. This message is sent typically every 10 seconds, until answered. Upon receipt of this message, the WMTS sends a ranging response message addressed to that WMU. If the WMU does not receive a ranging response message from the WMTS within a time out period, one of two things may have happened. First, as the initial maintenance opportunity is available to any WMU just attached to the network, ranging request messages may collide. Second, the WMU transmit power level may be too low to be detected by the WMTS. Consequently, if the WMU does not receive a ranging response message, it increases the transmit power, and waits a random number of initial maintenance opportunities before sending another ranging request. Initial ranging request is interrupted every 200msec, by a system time-out. The WMU repeats the ranging request 16 times, each time changing the transmit power and shifting the upstream frequency by 5kHz. In preparing the ranging response message, the WMTS notes:

The time offset of when it receives the ranging request from the actual beginning of the initial maintenance transmit opportunity.

The exact frequency of the transmission.

The incoming transmission power level.

Based on this data, the WMTS determines the corrections and send them back to the WMU in the ranging response message. The WMU adjusts its parameters based on these corrections and transmits a second ranging request to the WMTS. The WMTS once again returns the ranging response with time, frequency, and power corrections, as needed. This process continues until the WMTS is satisfied with the timing, frequency, and the power settings being used by the WMU. When finished, the timing is synchronized to within less than 1 microsecond, frequency is transmitted to within 10 Hz, and the transmit power level is adjusted to within 1/4dB. The ranging process is first performed during an Initial maintenance transmit opportunity, when a WMU is first connected to the network. Once booted, the ranging process is repeated for each WMU at regular intervals during periodic maintenance opportunities that the WMTS schedules. Periodic tuning of timing, transmit frequency, and transmit power, ensures continued reliable communications between the WMUs and the WMTS. The time synchronization is critical to the function of the MAC protocol. Time synchronization requires that the two-way round trip transmission delay be compensated, since all upstream transmissions are aligned with the mini-slot timing as viewed at the WMTS. Communication is delayed on the downstream direction by the latency, downstream propagation delay and the processing overhead. When the wireless modem sends a transmission upstream, it is delayed by upstream propagation and processing overhead. The sum of these delays is effectively removed by the ranging process. The timing offset causes the wireless modem to transmit at an earlier time than the assigned mini-slot time (as measured by the WMTS). This is in order to compensate for the delays caused by interleaving latency in the downstream propagation in the system, in addition to fixed processing overload in both the WMTS and the WMU. All further transmissions on the return path which take place, are based on the requests from the WMU to the WMTS, and grants from the WMTS to the WMU. Whenever the modem has data to send, it requests a time slot from the on return path, during a request period (as defined on a MAP message). The WMTS grants this request and schedules the WMU, to transmit the data. Initial ranging can be considered analogous to the AutoDiscovery feature. AutoDiscovery is essentially the modem being given an opportunity to transmit without first being given a grant to transmit. The MAC allows this to occur, by offering periodic initial maintenance (paragraph 7.3.3) transmit opportunities on the return channel that can be used by any modem just connected to the network.

6.6 IP Layer Establishment

Once timing, frequency, and power are set, the modem must establish the IP protocol. This is achieved in conjunction with the MAC address of the WMU. An entry of the MAC address in the address translation table at the WMTS, provides the relationship of the MAC address to the IP address. The IP address is established by invoking the Dynamic Host Configuration Protocol (DHCP) which assigns the WMU an IP Address. DHCP runs between the WMU and DHCP server, administered by either the operator or some other service provider. As long as the WMU is active it is leased an IP address to use. After a period of inactivity this IP address is reclaimed and given to another active modem, thereby conserving IP address space.

6.7 Registration

The registration process begins with the WMU downloading a configuration file. The IP address of the configuration file server and the name of the configuration file that the modem is required to download, is included in the DHCP response to the modem. The WMU uses the Trivial File Transfer Protocol (TFTP) to download the configuration file from the server. The configuration file contains the information that the WMU uses to operate, such as how much bandwidth it allows to use as well as the type of services it is allowed to provide. These service provisioning items are taken into account when the subscriber first subscribes to wireless modem service. During the final phase of the registration process, the WMU sends a registration message to the WMTS confirming the configuration file that was received. The WMTS retrieves the copy of the configuration file from the configuration file server. The WMTS compares the file from the server with the data from the WMU to ensure the modem will only use services for which it was authorized. The WMU is finally allowed to transmit real user data into the network only after the configuration file data is cross checked by the WMTS.

6.8 Encryption

Once the modem is registered and begins to send customer data, data link encryption (encryption between the WMU and WMTS only) is implemented, through a BLI (Baseline Privacy Interface). The goal of BPI is to provide wireless modem users with data privacy across the RF network by encrypting traffic flows between a WMU and the WMTS. Since data privacy is the principal service goal of BPI, and given that neither WMU nor WMTS authentication are prerequisite for providing user data privacy, the BPI encryption key distribution protocol does not authenticate either the WMU or WMTS. In the absence of an authentication, BPI provides basic protection service by ensuring that a modem, uniquely identified by its 48-bit IEEE MAC address, can only obtain keying material for the services it is authorized to access. Configuration within the WMU configuration file specifies if a particular WMU operates in the privacy mode. BPI uses Cipher Block Chaining (CBC) mode of the Data Encryption Standard (DES) algorithm [FIPS-46, FIPS-46- 1, FIPS-74, FIPS-81] to encrypt data in both upstream and downstream frames. WMUs use the BPMK protocol to obtain authorization and traffic keying materials, pertaining to a particular Service ID (SID) from the WMTS, and to support periodic reauthorization and key refresh. The key management protocol uses RSA, a public-key encryption algorithm, and the Electronic Codebook (ECB) mode of DES to secure key exchanges between WMU and WMTS. WMUs have factory-installed RSA 1 private/public key pairs, or provide internal algorithms to generate such key pairs dynamically. The frequency of change of the shared secret keys, is an operator determined parameter. These keys can be established for very long period of time (e.g. many weeks to months) or changed as often as every 30 minutes.

In order to run BPI over the RF network the following must be matched:

The WMU is configured to run BPI on its services.

Upon completing WMTS registration, the WMTS will have assigned Service IDs (SIDs) to the registering WMU that match the provisioning. If a WMU is configured to run Baseline Privacy, WMTS registration is immediately followed by initialization of the Privacy security functions. Baseline Privacy initialization begins with the WMU sending the WMTS an authorization request, containing data identifying the WMU (e.g., MAC address), the unicast SIDs that have been configured to run Baseline Privacy. (The list would be empty if a cable modem was configured to only run Baseline Privacy on multicast SIDs.) If the WMTS determines the requesting WMU is authorized for these services, the WMTS responds with an authorization reply containing a list of SIDs (both unicast and multicast) that the WMU is permitted to run Baseline Privacy on. After successfully completing authorization with the WMTS, the cable modem sends key requests to the WMTS, requesting traffic encryption keys to use with each of its Baseline Privacy SIDs (or SAID - Security Associated ID. A algorithm [RFC2104]); the message authentication key is derived from the authorization key obtained during the earlier authorization exchange. The WMTS responds with key replies, containing the traffic encryption keys; the keys are DES encrypted with a key encryption key derived from the authorization key. Like the Key Requests, Key Replies are authenticated with a keyed hash, where the message authentication key is derived from the authorization key.

6.9 Key Update Mechanism

The traffic encryption keys which the WMTS provides to client WMUs have a limited lifetime key value, in the key replies it sends to its client WMUs. The WMTS controls which keys are current by flushing expired keys and generating new keys. It is the responsibility of individual cable modems to insure the keys they are using match those the WMTS is using. Cable modems do this by tracking when a particular key request for the latest key prior to that expiration time. In addition, cable modems are required to periodically reauthorize with the WMTS; as is the case with traffic encryption keys, an authorization key has a finite lifetime which the WMTS provides the WMU along with the key value. It is the responsibility of individual cable modems to reauthorize and obtain (1) a new authorization key and (2) a current list of supported SIDs before the WMTS expires their current authorization key.

6.10Baseline Privacy Key Management (BPKM) Protocol

The BPKM protocol is specified by two separate, but interdependent, state models: an authorization state model (the Authorization state machine) and an operational service key state model (the Traffic Encryption Key, or *TEK* state machine).

6.11Authorization State Machine

The Authorization state machine consists of five states and seven distinct events (including receipt of messages) that can trigger state transitions. The Authorization finite state machine (FSM) is presented below in a graphical format, as a state flow model. The state flow diagram depicts the protocol messages transmitted and internal The typographic conventions in the following flowcharts are:

- Ovals are states

- Events are in italics

- Messages are in normal font

- State transitions (i. e. the lines between states) are labeled with < what causes the transition >/< messages and events triggered by the transition>.

If there are multiple events or messages before the slash "/" separated by a comma, any of them can cause a transition. If there are multiple events or messages listed after the slash, all of the specified actions must accompany the transition.

ADD DIAGRAM (5-4)

6.12TEK State Machine

The TEK state machine consists of six states and nine events (including receipt of messages) that can trigger state transitions. Like the Authorization state machine, the TEK state machine is presented in both a state flow diagram and a state transition matrix.. Shaded states in Figure 5-5 (Operational, Rekey Wait, and Rekey Reauthorize Wait) have valid keying material and encrypted traffic can be passed. The Authorization state machine starts an independent TEK state machine for each of its authorized SIDs (SAIDs).

SECTION 4: WMTS INSTALLATION

Content **Page**

⚠ **Warning**: *Carefully connect units to the supply circuit so that wiring is not overloaded*

⚠ **Warning**: *Read the installation instructions before you connect the system to its power source.*

⚠ **Warning**: *Do not touch the power supply when the power cord is connected. For systems with a power switch, line voltages are present within the power supply even when the power switch is off and the power cord is connected.*

⚠ **Warning**: *For systems without a power switch, line voltages are present within the power supply when the power cord is connected*

⚠ **Warning**: *Before working on equipment that is connected to power lines, remove jewelry (including rings, necklaces, and watches). Metal objects will heat up when connected to the power and ground. This can cause serious burns or weld the metal object to the terminals*

1 INTRODUCTION

The purpose of this document is to describe the specific procedures to install ADC's Wireless Modem Termination System (WMTS). The WMTS utilizes the MDS/MMDS frequency spectrum to obtain two-way communication. The WMTS manages predefined frequencies through its upstream and downstream cards on the back of the unit. On the front, a universal controller card manages its associated upstream and downstream backplane cards, plus a standalone card manages the data to the network. In addition, a microprocessor card manages the operation of the unit and two redundant power supplies provide the power to the chassis.

2 INSTALLATION

2.1 Installing the WMTS

1. Prepare a 19 in. by 8U (one U equals 1.75 in.) rack (at the minimum) to leave 2U at the top and 2U at the bottom for ventilation to avoid overheating, as illustrated in Figure 4-1. If placing one rack on top of the other, leave 2U between the two racks for ventilation and thermal protection. Note that the air intake is from the bottom with exhaust at the top. Included with each WMTS are two air baffles of 2U each. These are to be installed above and below each WMTS.
2. Mount the airflow shelf bracket on top of the rack to direct the heat to the edge at the right side of the chassis, using four screws to fasten the shelf bracket to the rack.
3. Move the WMTS into the rack by using the handles at both sides. Fasten the WMTS front panel to the rack with four screws inserted through the mounting holes (Figure 4-1). Be sure to leave at least 2U at the top and bottom to allow airflow.
4. Verify that the rear upstream and downstream cards and the front universal and power cards are completely inserted and the latches are screwed in.

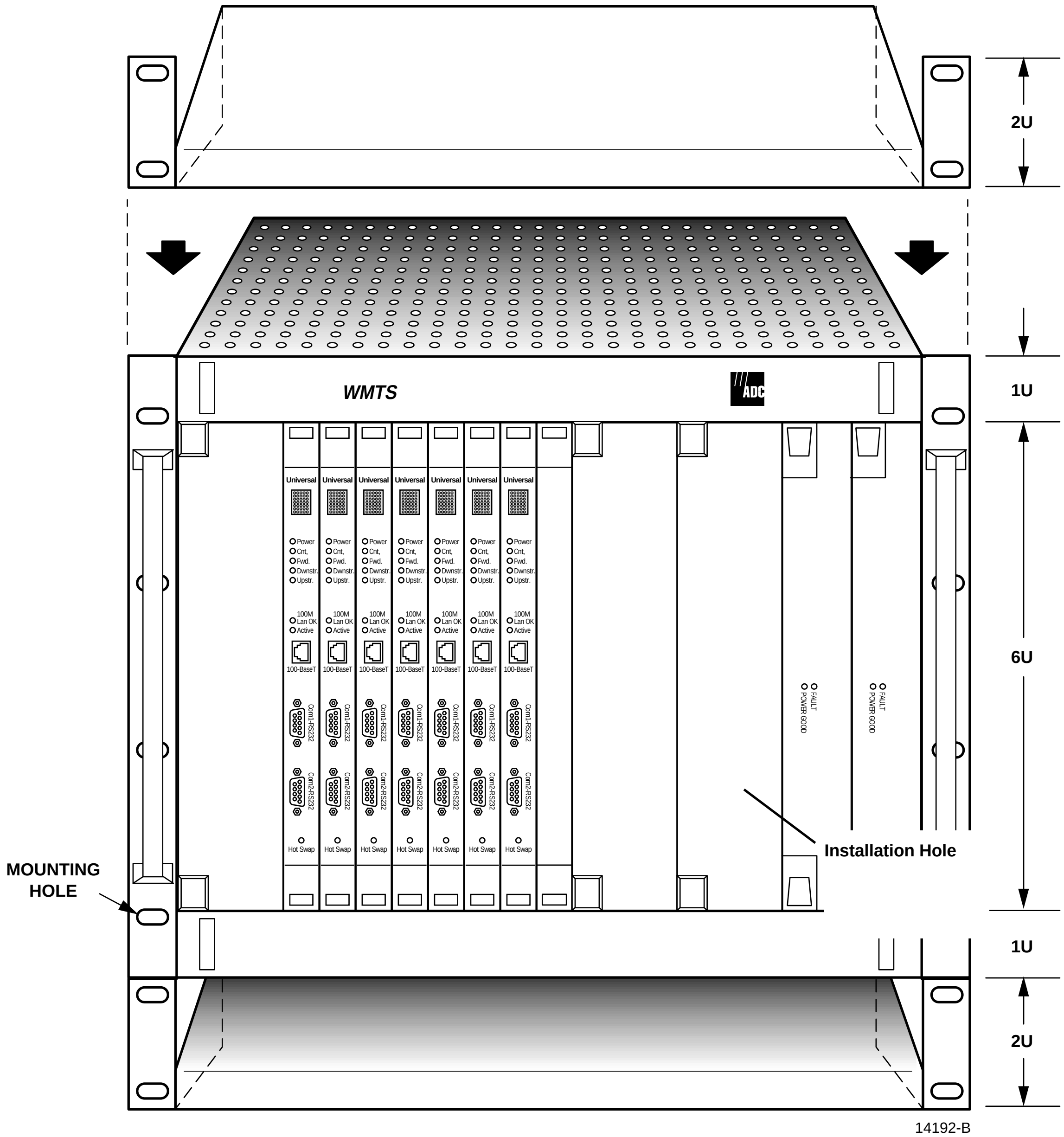

Figure 4-1. WMTS Chassis - Front View

2.2 Connecting the Rear Panel

1. Connect the downstream RF cable to the F-type connector on the rear panel of the downstream card (modulator panel) as illustrated in Figure 4-2.
2. Connect the upstream RF cable to the F-type connector on the rear panel of the upstream card (demodulator panel) as illustrated in Figure 4-3.

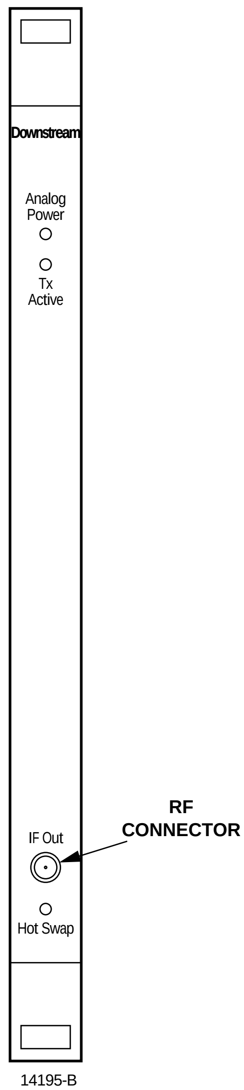

Figure 4- 2. Upstream card

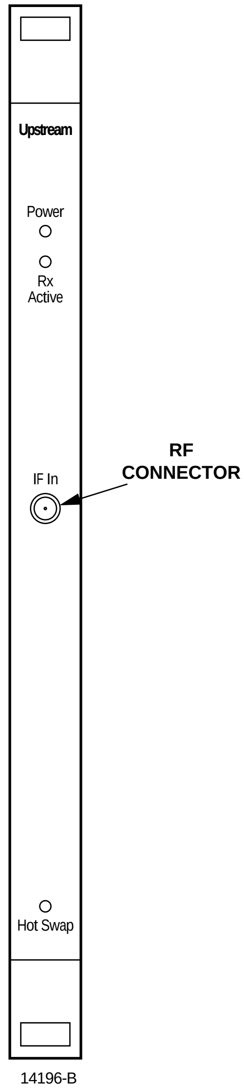

Figure 4-3. Upstream Card

2.3 Connecting the Front Panel

Connect the switched hub Port 1 via 100BaseT cable to the RJ-45 connector on the front of the control and forwarder (C&F) card (see Figure 4-4). The card closest to the host card is the C&F card.

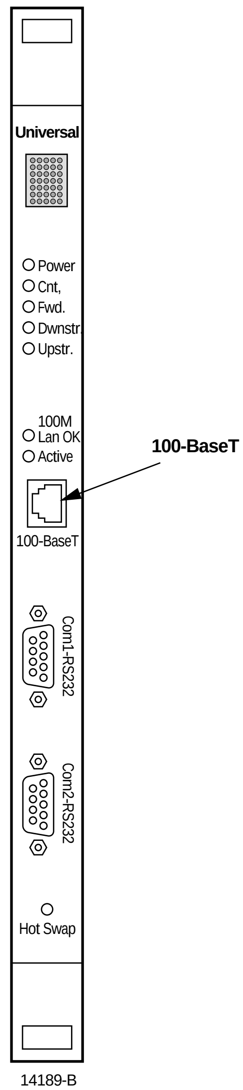

Figure 4-4. WMTS Control and Forwarder Front Panel Connector

2.4 Extracting and Inserting Cards

1. Push the power switch off.
2. Disconnect any cable connected to the cards on the front and the rear.
3. Unscrew the two screws (at the top and button) and extract the card with care from the slot.

4. To insert a new card, push the card into the slot and verify that the card runs in the guides of the slides. Carefully push the card until it plugs into the mid-plane board connector.
5. Check that the newly inserted card aligns with the other cards already installed on the chassis.
6. To extract the fan tray, use the handles on the front of the tray.
7. Lock the card switch and fasten two screws (top and bottom).

2.5 System Power-on

The WMTS power supplies are factory wired for 115 or 220 VAC (350 W). A power cord and plug are provided to connect the unit to the power source. Turn on the power switch at the rear panel to operate the WMTS.

⚠ **Warning**: *Before turning on the WMTS or plugging in the power cord, set the fuse selector on the rear panel to the proper position (110V or 220V).*

3 INSTALLING AND CONNECTING THE OUTDOOR UNIT

The wireless frequency band determines the type of the combiner and antenna. The WMTS operates in the 2750 band.

3.1 RF Connection

3.1.1 Downstream

Connect the WMTS upstream card connector (F-type) to the upconverter IF In connector, through 10 dB attenuator.

➧ **Note:** The nominal output level of the downstream IF OUT signal is 43 dB, and the typical IF output level to the upconverter is 33 dMmV. If higher input level is required, adjust the input level by changing the attenuator or by adding an amplifier between the WMTS IF output and the IF input of the transceiver.

3.1.2 Upstream

Connect the IF output of the downconverter to the IF IN (F-type) connector of the upconverter/card. Use a splitter if one down converter drives more than one upconverter/card.

SECTION 5: OPERATION

Content	Page

1 INTRODUCTION

This section provides the procedures for testing the system and performing the tasks required for proper operation.

2 PRE-OPERATIONAL CHECKS

2.1 Procedures

The WMTS system is tested and checked at the installation site at two levels:

- Basic level without the wireless components of the system

- Extended level when the test also includes the wireless path of the system.

The purpose of the first test is to check the integrity of the system, isolated from the wireless components. When the basic test is successful, the wireless components of the system are added to the test setup to test communication over the wireless channel.

2.1.1 Test Equipment

The following test equipment and tools are required for testing:

- WMTS connected to a power source
- Power Source Unit
- Spectrum Analyzer
- Connection to network via 100BaseT channel
- Installed NMS station and servers
- WMUs
- PCs as CPE at customer site
- Frequency upconverters and down converters

2.2 Basic Test

2.2.1 Test Setup

The basic setup includes the WMTS, WMU, NMS station installed with DHCP/TFTP/Time servers, VHF upconverter, attenuators and the switched hub.

The test is performed without the wireless components of the system to isolate the system from possible noises interpolated over the radio channel.

During the test, the system components are interconnected by cables and passive RF components, as illustrated in Figure 5-1.

Prior to the test, use appropriate **MIC*. Files** to register the WMUs.

Start the system.

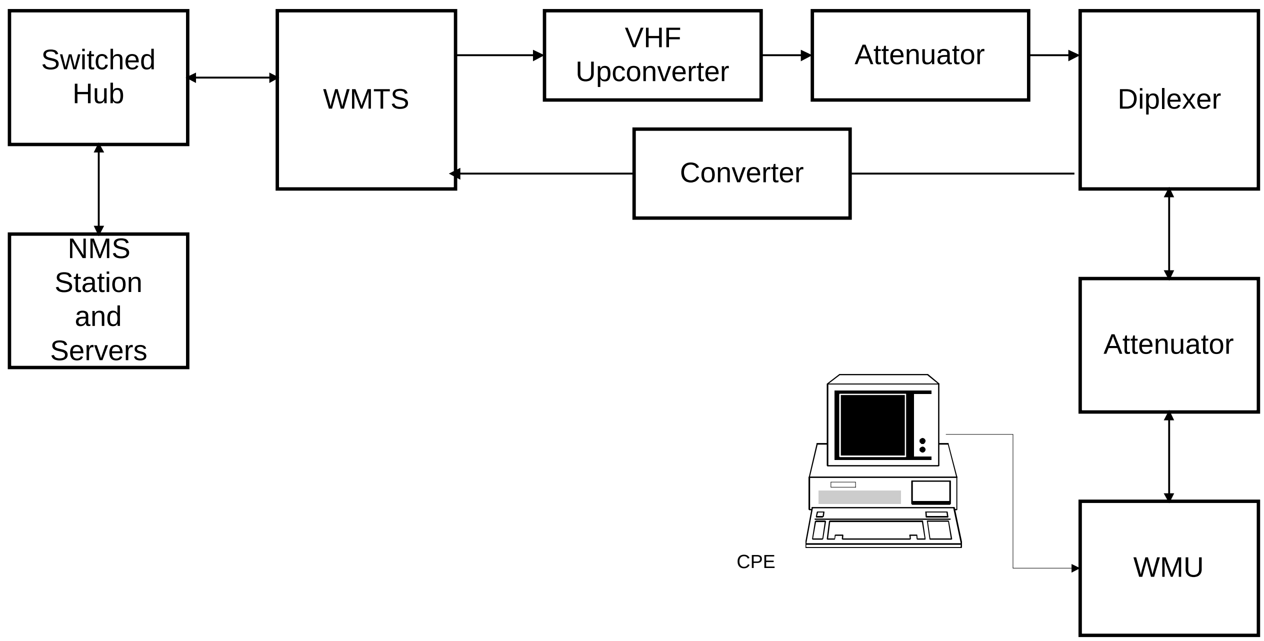

Figure 5-1. Basic Test Setup

2.2.2 Test Procedure

Following the installation of the NMS and IP Servers, the test setup has to be completed and the WMTS and WMU configured. The switched hub has to be configured to 100BaseT. During configuration, all the system components have to be operational.

Observe the LED indicators to verify that all system components are operating properly.

Following the configuration of the various devices and invoking the servers, initiate a Ping test from the NMS station toward the CPE connected to the WMU and vice versa. During the Ping test, messages are exchanged between the CPE and the NMS station. While the Ping test is being performed, the system must be operational. If the Ping test is passed successfully, the system can be extended to integrate the wireless devices and proceed to the extended test.

2.3 Extended Test

2.3.1 Test Setup

The extended test is executed only after the basic test is successfully completed.

The extended test is an end-to-end test and includes the wireless components of the system as illustrated in Figure 5-2. The wireless components may change according to the final setup of the RF front-end of the system.

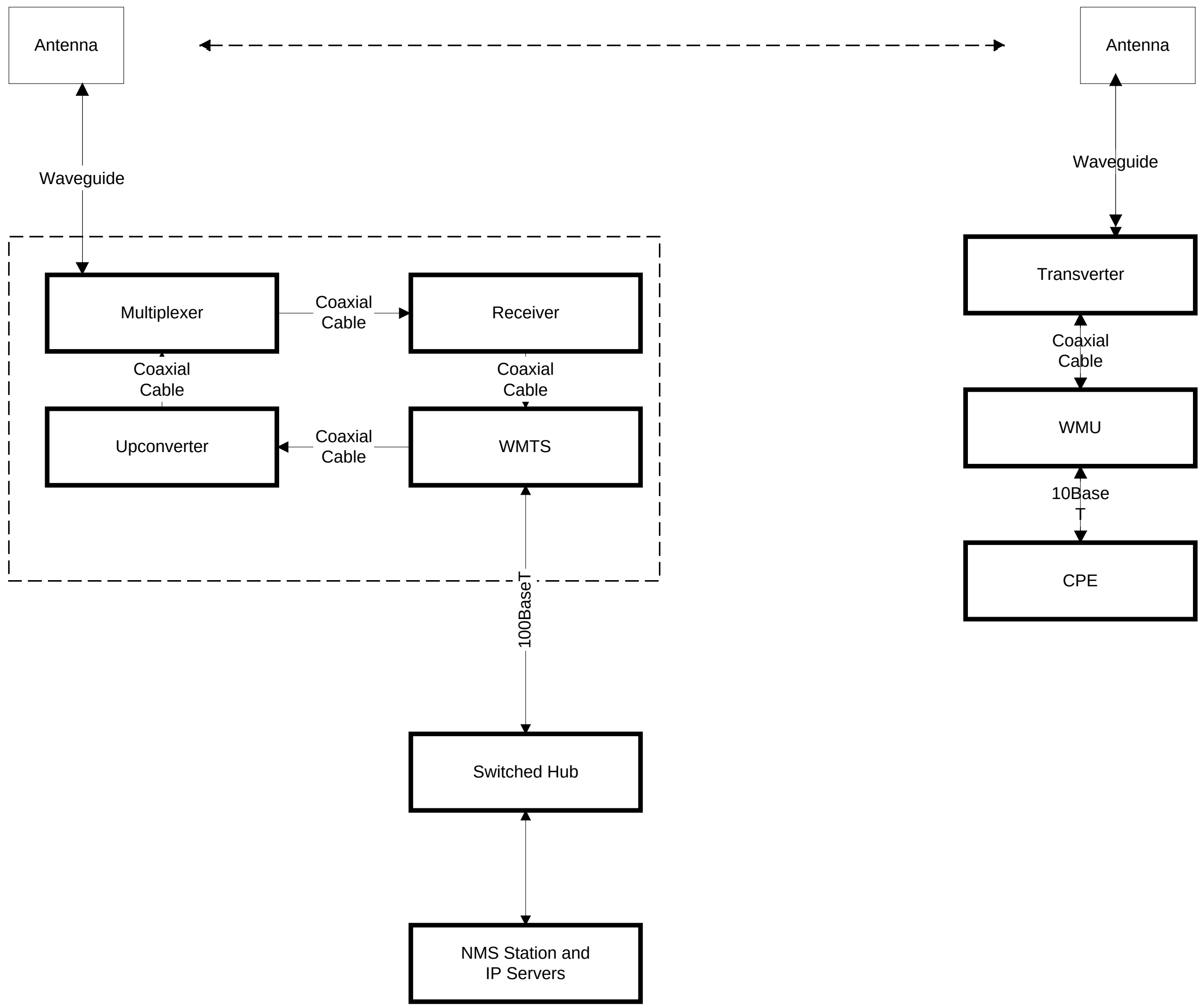

Figure 5-2. Extended Test Setup

2.3.2 Test Procedure

Observe the LED indicators to verify that all system components are operating properly.

Initiate a Ping test from the NMS station toward the CPE connected to the WMU and vice versa, to verify that the system operates properly.

During the Ping test, messages are exchanged between the CPE and the NMS station. During the course of the Ping test, the system must be fully operational.

If the Ping test is successful, the system can be opened to traffic over wireless channels.

3 OPERATION

3.1 Operators Tasks

The operator performs the following tasks:

- Connecting WMTS to a power source
- Handling and modifying the parameters of the WMTS and WMU devices
- Managing subscribers (WMU users)
- Monitoring system performance
- Handling events and alarms
- Downloading software updates
- Troubleshooting the system at operators' level

The system administrator (supervisor) also manages the operators and modifies operators' attributes.

3.2 Handling and Modifying Parameters

Different parameter tables are used for the WMTS and the WMU. The parameters tables are accessed via the synoptic displays of the WMTS and the WMU.

The parameters selection trees for the WMTS and WMU are shown in Table 5-1 and 5-2, respectively.

➧ **Note:** These are sample parameters and will be displayed on the EMS. For full details, go to the Axity Element Management System Software Reference Manual.

Table 5-1.The WMTS Parameters Selection Tree

PARAMETER S	1ST SELECTION	DESCRIPTION
MIB	System	Enter generic information of the WMTS
	Interface Table	Table on supported interfaces. Each downstream channel, upstream channel, MAC layer interface and Ethernet layer have entries at this table.
DOCSIS	MAC Entry	Describes the attributes of each WMU MAC interface, extending the information available from the Interface table
	Status Entry	Status entry for a single MAC layer. An entry in this table exists for each entry of the Interface table that represents a MAC layer (as opposed to other interface types such as upstream and downstream)
	CM Status Table	Maintains a number of status objects and counters for WMUs
	Service Table	Describes the attributes for a single class of service
	Modulation Table	Describes a modulation profile associated with one or more upstream channels
Proprietary	Slot Table	Describes functionality of the WMTS chassis slots. Each entry in the table lists parameters that characterize the functionality of a single slot.

Table 5-2. The WMU Parameters Selection Tree

PARAMETERS	1ST LEVEL	2ND LEVEL	3RD LEVEL	MIB TABLE HEADER	DESCRIPTION
MIB-2	System			System Info	Generic information about the WMU
	Interface			IfEntry	An entry of this table exists for an interface
DOCSIS	RF	Basic		Upstream	Upstream entry
		CM	MAC Table	MACEntry	An entry containing objects describing attributes of each MAC entry, extending the information in ifEntry. An entry in this table exists for each ifEntry with an ifType of docsCableMaclayer.
			Status Table	StatusEntry	Maintains a number of status objects and counters for WMUs
			Service Table	Sevice Entry	Lists details related to the service level
	Device	Identity		BaseInfo	Basic information about the WMU
		Access Table		NmAccess	Lists details related to the network access, such as address and interfaces
		Software		Software Info	Lists the WMU software options
		Server		ServerInfo	Lists the IP server addresses and configuration files
		Event	Event Control	Event Control	Sets the priority of event reports
			Event Table	EventEntry	Describes a network or device event that may be of interest in fault isolation
			Event Info	EventInfo	Lists the information related to an event
		Filter	LLC Filter	LLCEntry	Describes a network or device event that may be of interest in fault isolation
			IP Filter	IPFilter	Lists the filters related to the IP address of the device
			Filter Info	FilterInfo	Lists the information related to a filter

3.3 Managing Subscribers (Users)

The operator has to:

- Assign a WMU to a subscriber
- Add subnet or device
- Remove subnet or device
- Download software to WMUs

3.3.1 Assign a WMU to a Subscriber

Use **User Profiles** option in the **Config** menu to add, configure or delete a user.

3.3.2 Add Subnet or Device

Use **Map Object** option in the **Insert** menu to insert subnet or device.

To change properties of an object or device, use **Properties** option in the **Edit** menu.

3.3.3 Remove Subnet or Device

Use the **Delete** option in the **Edit** menu to delete a subnet or remove a device.

3.3.4 Download Software to WMUs

Use the **Software Info MIB** table to download or updated software to the WMUs.

3.4 Monitoring System Performance

The operator can use the **Log Tool** and the **Trend Reports** to monitor system performance.

3.4.1 Log Tool

To view filtered instances of the **Event Log Database**, use the Event Log Tool option of the **View** menu.

3.5 Handling Events and Alarms

Events enable the operator to audit system behavior. Alarms represent a malfunction or problem in the system that needs attention. Severity of events can activate alarms.

To view filtered instances of the **Event Log Database**, use the **Event Log Tool** option of the **View** menu.

3.5.1 Events

The events are displayed in the **Event Log Tool**. Each event is related to an object or a device. The event log is colored according to the severity of the event.

Six event priorities are defined:

1. Critical - Red
2. Major - Yellow
3. Minor - Magenta
4. Warning - Blue
5. Normal - Green
6. Info - White

Apply the **Event Action Filter** selection tab to determine what happens when an event is received.

Use the **Event Options** option in the **Config** menu to export events to a database.

3.5.2 Alarms

The system can produce various types of alarms, like:

- Audible alarms
- Dialing a pager
- Sending e-mail

Use the **Console Options** and **Event Options** in the **Config** menu to apply one or more of these options.

3.6 Downloading Software Updates

The software can be updated during the life cycle of the system. The WMTS software can be downloaded using the options detailed in Section ?.

The WMU software can be downloaded using the NMS option by selecting the **Software Info MIB** table.

3.7 Managing Operators

The system administrator (supervisor) can add, remove or configure operators according to the access limits described below.

3.7.1 Access Limits

Each operator can have different access permission, as listed in Table 5-3.

Table 5-3. Access Limits

ACCESS LEVEL	CAPABILITIES
Supervisor	Full access to all SNMPc NT capabilities. The administrator always has this access level. You must have supervisor permission to modify any operators attributes.
Operator	Read-only access to database files. No access to privileged information (e.g., set community names, user information). Read/write access to devices using SNMP operations.
Service	Ability to add objects to the map and change polling attributes. Permission to send private RPC messages. Only the remote poller user can have this access level.
Observer	Read-only access to database files. No access to privileged information. Read-only (Get) access to devices using SNMP operations.

3.7.2 Defining Operators

Use the **User Profiles** option in the **Config** menu to add, configure or delete an operator.