Advanced Radio Cells
incorporated

ARCi Internet

Broadband Fixed Wireless Internet Delivery System

Physical Planning and Installation Manual

AR1255 Integrated Headend Transceiver

AR3155 Integrated Subscriber Transceiver

March 2002

March 1, 2002

Advanced Radio Cells Inc.

LIMITED WARRANTY. ARCi warrants to Buyer at the time of delivery that the equipment will be free from defects in material and workmanship under normal use and service. ARCi's sole obligation under these warranties is limited to replacing or repairing, at its option, at its factory, any equipment which is returned to ARCi, transportation, duties, and taxes prepaid, within twelve (12) months after delivery. In the case of products not of ARCi's own manufacture, the only warranty available is that provided by the original equipment manufacturer. ARCi shall return the equipment to Buyer freight prepaid. THIS WARRANTY IS EXPRESSED IN LIEU OF ALL OTHER WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, AND OF ALL OTHER OBLIGATIONS OR LIABILITIES ON THE PART OF ARCi, AND IT NEITHER ASSUMES NOR AUTHORIZES ANY OTHER PERSON TO ASSUME FOR ARCIANY OTHER LIABILITIES IN CONNECTION WITH THE SALE OF PRODUCTS. IN NO EVENT WILL ARCi BE LIABLE FOR CONSEQUENTIAL DAMAGES EVEN IF ARCi HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. This Warranty does not apply to any of such products which shall have been repaired or altered, except by ARCi, or which shall have been subjected to misuse, negligence, or accident or operation outside the environmental specifications. Repairs or replacements of Equipment made during the warranty period or thereafter will be warranted, as provided above, for the remainder of the original warranty period or for ninety days from the date of return, as applicable, whichever is longer.

RETURN OF EQUIPEMENT UNDER WARRANTY: If an item of Equipment malfunctions or fails in normal intended usage and maintenance within the applicable Warranty Period:

(a) the Customer shall promptly notify ARCi of the problem and the serial number of the defective item;

(b) ARCi shall, at its sole option, either resolve the problem over the telephone or provide the Customer with a Returned Materials Authorization number (RMA #) and the address of the location to which the Customer may ship the defective item;

(c) if the problem is not resolved over the telephone, the Customer shall attach a label to each returned item describing the fault and the Customer's return address. The Customer shall, at its cost, properly pack the item to be returned, prepay the insurance and shipping charges, and ship the item to the specified location;

(d) if the ARCi product shall prove to be defective in material or workmanship upon examination by ARCi, ARCi shall either repair or replace the returned item at its sole option. The replacement item may be new or refurbished; if refurbished, it shall be equivalent in operation to new Equipment. If a returned item is replaced by ARCi, the Customer agrees that the returned item shall become the property of ARCi.

(e) ARCi shall ship the repaired item or replacement to the Customer's return address by carrier and method of delivery chosen by ARCi at its cost. If Customer has requested some other form of conveyance, such as express shipping, then the Customer shall pay the cost of return shipment.

Advanced Radio Cells Inc.

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ARCi Internet

Broadband Fixed Wireless Internet Delivery System

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Table of Contents

B. Introduction

Introduction

The ***ARCi Internet*** system, deployed in conjunction with the ***Vyyo Broadband Wireless Access System***, provides a complete end-to-end solution for ISPs and other fixed wireless operators seeking to expand their markets by offering wireless delivery of the Internet to their customers at performance levels that normally exceed DSL.

The ARCi Internet Solution

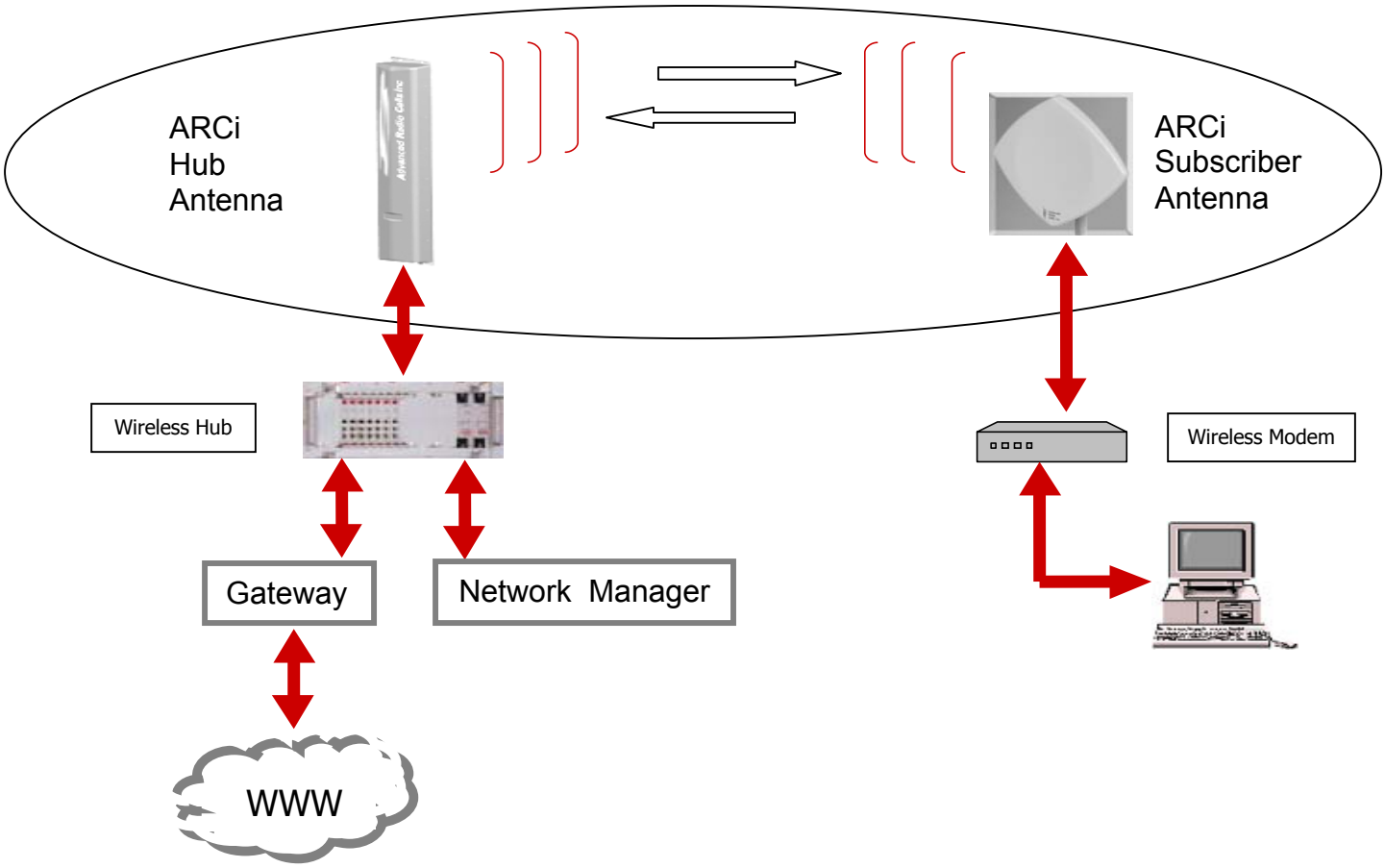

Figure 1

Typically the ***ARCi Hub Antenna*** is mounted on a building roof or tower structure with an unobstructed (as possible) view of the geographic area to be served by the ***ARCI Internet*** system. Each ARCi Hub Antenna "illuminates" a horizontal arc of about sixty degrees and a distance of about five miles. Therefore, an omni directional system would

require six ARCi Hub Antennas arranged pointing outward spaced every 60 degrees. A system only looking up a narrow canyon from one end might require only one ARCi Hub Antenna. Cables are run from the antenna(s) into the building to the hub equipment room.

The ***ARCi Subscriber Antenna*** is mounted outdoors at the subscriber location with line of sight to the hub antenna. A single cable is run to the modem and computer inside the subscriber location.

The electronic equipment associated with the ARCi Hub Antenna and the ARCi Subscriber Antenna is housed in weatherproof enclosures inside each antenna housing.

The ***Wireless Hub*** (also known as the Wireless Modem Termination System, or ***WMTS***), controls the flow of data between the Gateway to the Internet and each subscriber wireless modem. It transmits a continuous downstream of user data interspersed with modem commands to each ***Wireless Modem*** in the system. When a user has data to transmit upstream to the Internet, the modem awaits its time slot (as assigned by the wireless hub), turns on its transmitter, sends its data to the hub, and then turns off its transmitter. The ***WMTS***, working in conjunction with the ***Network Manager***, provides the system with TCP/IP-related services such as DHCP server, TFTP server, time server, etc.

The ***Gateway*** provides certain TCP/IP and ISP functions such as routing, address translation, caching, security, etc.

The Hub Antenna and Subscriber Antenna are ARCi products. The WMTS and Wireless Modem are components of the Vyyo Broadband Wireless Access System.

The Network Manager is an IBM-compatible PC with the Windows 2000 operating system, Network Manager software provided by Vyyo, and a commercial SNMPc package. The Gateway consists of a PC running ISP-provided software (probably a form of Unix) and may also include external hardware such as a router, CSU/DSU. etc.

The protocols that govern the operation of the ***ARCi Internet*** system and the ***Vyyo Broadband Wireless Access System*** generally conform to the cable TV industry DOCSIS standard, as enhanced for wireless operation.

C. System Description

Basic ARCi Internet – System Description

Single Sector Hub Configuration

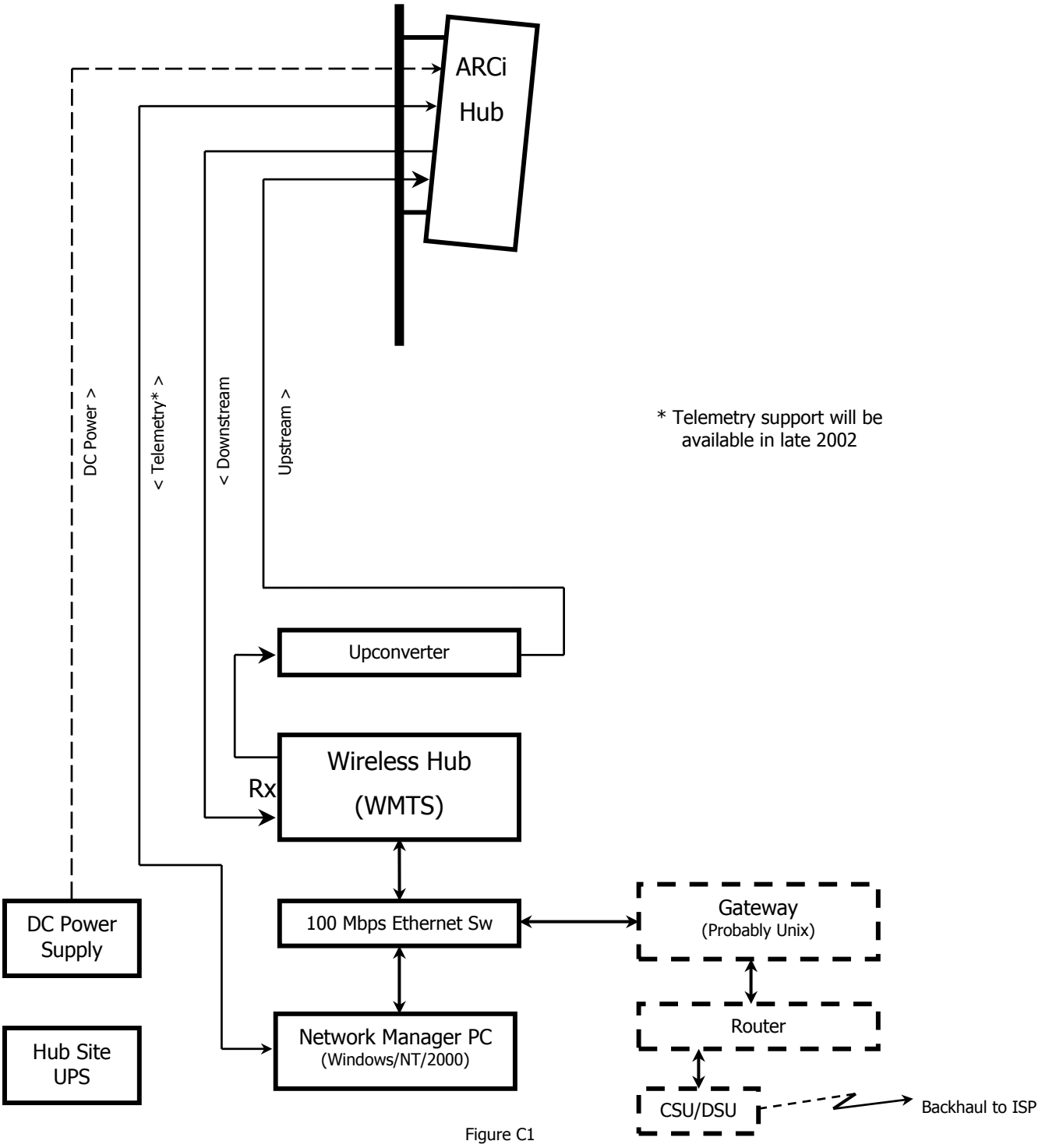

Figure C1

Basic ARCi Internet – System Description

Single Sector Hub Configuration

The **ARCi Internet** hub location consists of one or more ARCi Hub Antennas mounted on the building roof or adjacent tower or monopole structure and its associated equipment located in the interior hub equipment room. Signal and power cables are run from the hub antenna(s) to the hub equipment room. See figure C1 on the preceding page.

The outdoor ARCi Hub Antenna is mounted on a vertical pipe or tower leg, aimed at the geographic area to be served. As each hub antenna covers a sector (arc) about 60 degrees wide, from one to six hub antennas are required depending on the desired coverage. Each hub antenna requires its own upstream, downstream and power connection to the hub equipment room.

Refer to the *Frequency/Coverage Planning* section of this manual for the details of antenna coverage and frequency utilization.

The *Installation Details* section provides mounting information, test access and system grounding recommendations for the antenna and wireless hub.

The *ARCi Specifications* section provides dimension, weight and mounting details.

Located in the equipment room are:

1. Wireless Hub and its network manager system
2. Downstream Upconverter
3. 100 Mbps Ethernet switch
4. Gateway system
5. Router and ISP access equipment
6. Uninterruptible power supply system (UPS) to protect all hub equipment
7. DC power supply for the hub antenna electronics

The Wireless Hub (WMTS), Upconverter and Network Manager components are purchased from ARCi or directly from Vyyo, Inc.

The Gateway and ISP access equipment are selected and configured according to the requirements of the particular ISP and the backhaul facility between the hub site and the ISP facilities.

The customer also must provide a DC power supply with sufficient capacity to operate the radio equipment. The UPS is strongly-recommended to protect system operation throughout short outages, as well as to provide isolation between incoming power line anomalies and the hub electronic equipment. See the *Hub Installation Details* section of this manual.

Multi-Sector Hub Configuration

The Multi-Sector configuration consists of two or more ARCi Hub antennas mounted on a common building roof or tower/monopole structure served by a single Wireless Hub (WMTS) located in an adjacent equipment room.

As each Hub antenna covers a sector sixty degrees wide, six ARCi Hub antennas are required for complete 360-degree coverage. Fewer Hub antennas may be required depending on the relationship of the Hub site to the geography to be covered by the system.

Each hub requires a separate Upstream and Downstream IF cable, so a six sector (six ARCi Hub) installation would require 12 IF coaxial cables. Refer to figure C1. The DC power and telemetry cables are simply paralleled in a multi-sector configuration. This can be accomplished by running separate power/telemetry cables from each ARCi Hub antenna to the equipment room, or by installing an Outdoor Junction Box (OJB) on the mounting structure adjacent to the Hub antennas and paralleling the DC power and telemetry in the OJB.

See the *Hub Installation Details* section of this manual for more information.

Hub Interfaces

Industry standard interfaces are employed between the various elements of the Hub system. Refer to Figure 2. Note that specific manufacturer and part numbers are given in the *Installation Details* section of this manual. See also the ARCi and Vyyo specifications sections of this manual.

ARCi Hub Antenna

Transmit and receive signal interfaces:

75 ohm type F female connectors

Premium quad-shielded RG-6 coax cable recommended (e.g. Belden 1189A)

Upstream signal frequency 6.4 through 32 MHz, nominal signal level -4 dBmV.
Maximum cable loss between ARCi hub and WMTS: 15 dB at 30 MHz.

Downstream signal frequency 477 through 577 MHz, nominal signal level 50 dBmV.
Maximum cable loss between upconverter and ARCi hub: 15 dB at 500 MHz.

Power interface:

Switchcraft type EN3 6 pin male connector on both upstream and downstream radio enclosures (two per hub antenna)

Nominal 8.5 Vdc at 920 +/- 100 mA, combined upstream and downstream

Telemetry:

RS-485, implemented in same connector as power interface on both upstream and downstream radio enclosures. [Telemetry support will be available in late 2002].

Wireless Hub (WMTS)

75 ohm type F female connectors

Upstream input signal frequency 6.4 through 32 MHz, nominal signal level -4 dBmV.

Downstream output signal frequency 44 MHz, nominal signal level 20 dBmV. (input to Upconverter)

Network connection RJ45 female connector, 100 Mbps 100baseT Ethernet LAN

Upconverter

75 ohm type F female connectors

Input signal frequency 44 MHz; level range +38 dBmV to +45 dBmV.

Output signal frequency 477 through 577 MHz; maximum signal level +60 dBmV.

100 Mbps Ethernet Switch

The Ethernet switch is the connection point for all TCP/IP data flow on the **ARCi Internet** side of the gateway (subnet).

Subscriber traffic flows through the Gateway to the Internet via the Switch, as does Network Management traffic to and from the WMTS and the Internet. Other devices such as a laptop computer can be plugged into the switch provided that they are configured with the proper TCP/IP addresses for the system subnet.

Network Manager PC

The network manager PC provides services to the ARCi Internet system such as DHCP, TFTP, SysLog and time servers. It also provides remote operational visibility and control into the **ARCi Internet** via SNMPc. Note that with appropriate address translation in the Gateway, the Network Manager may be installed at a remote location such as the ISP's control center. See the Vyyo V3000 Wireless Hub Users' Manual for more detail.

The network manager PC also monitors certain parameters of the transmitter(s) and receiver(s) located within the associated ARCi hubs. It also enables upstream frequency selection for each hub receiver. [Telemetry support for this function will be available in late 2002]..

Gateway / Router / Backhaul

This equipment provides functions required to interface the **ARCi Internet** system to the backhaul transmission facility to the ISP, which will normally specify and configure this equipment. It interconnects with the **ARCi Internet** system via a standard port on the 100 Mbps Ethernet switch.

Some notes on the gateway

Once it is configured and running, the ARCi wireless network is simply a standalone IP network that requires the presence of a gateway through which packets are routed between the ARCi network and the Internet. The network interface on the ARCi side of the gateway must be 100baseT Ethernet. The gateway itself is typically one of two types depending on the network IP address:

If the network IP address is registered with its country's Network Information Center then the gateway may be nothing more than a conventional router.

If, on the other hand, the network IP address is one of the RFC1597 private addresses the gateway must be a proxy server of some sort. For example, the gateway may provide RFC1631 Network Address Translation services.

Additional security measures such as firewalls may be added at the customer's option.

DC Power Supply

The DC power supply is located in the equipment room and supplies DC power to operate all of the ARCi hubs in the installation. In a single sector hub configuration a single power cable is furnished which has two power connectors on the outside end[1] and is run along with the signal cables from the hub antenna to the equipment room. In a multi-sector hub configuration separate power/telemetry cables can be run to the equipment room from each ARCi Hub, or an Outdoor Junction Box (OJB) can be installed in the vicinity of the hub antennas (rooftop / tower structure) and a single appropriately sized cable run to the equipment room. See the *Hub Installation Details* section of this manual for more information.

The electronics in the hub antenna are designed to function with a DC voltage at the hub nominally 8.5 Vdc +/- 0.5 V.

In a single sector hub the voltage drop on the power cable is calculated and the DC power supply voltage is set in the equipment room. The current drawn by a single hub (both transmitter and receiver) is 950 mA +/- 10%.

In a multi-sector hub where an OJB is employed, the power supply remote sense samples the DC voltage at the distribution terminals within the OJB and returns the sample to the DC power supply via the DC power sense cable.

See the *Hub Installation Details* section of this manual for more information on recommended power supplies

[1] Within a given ARCi hub antenna, the transmit and receive electronics are housed in separate inner enclosures and have separate power connectors.

Basic ARCi Internet – System Description

Subscriber Configuration

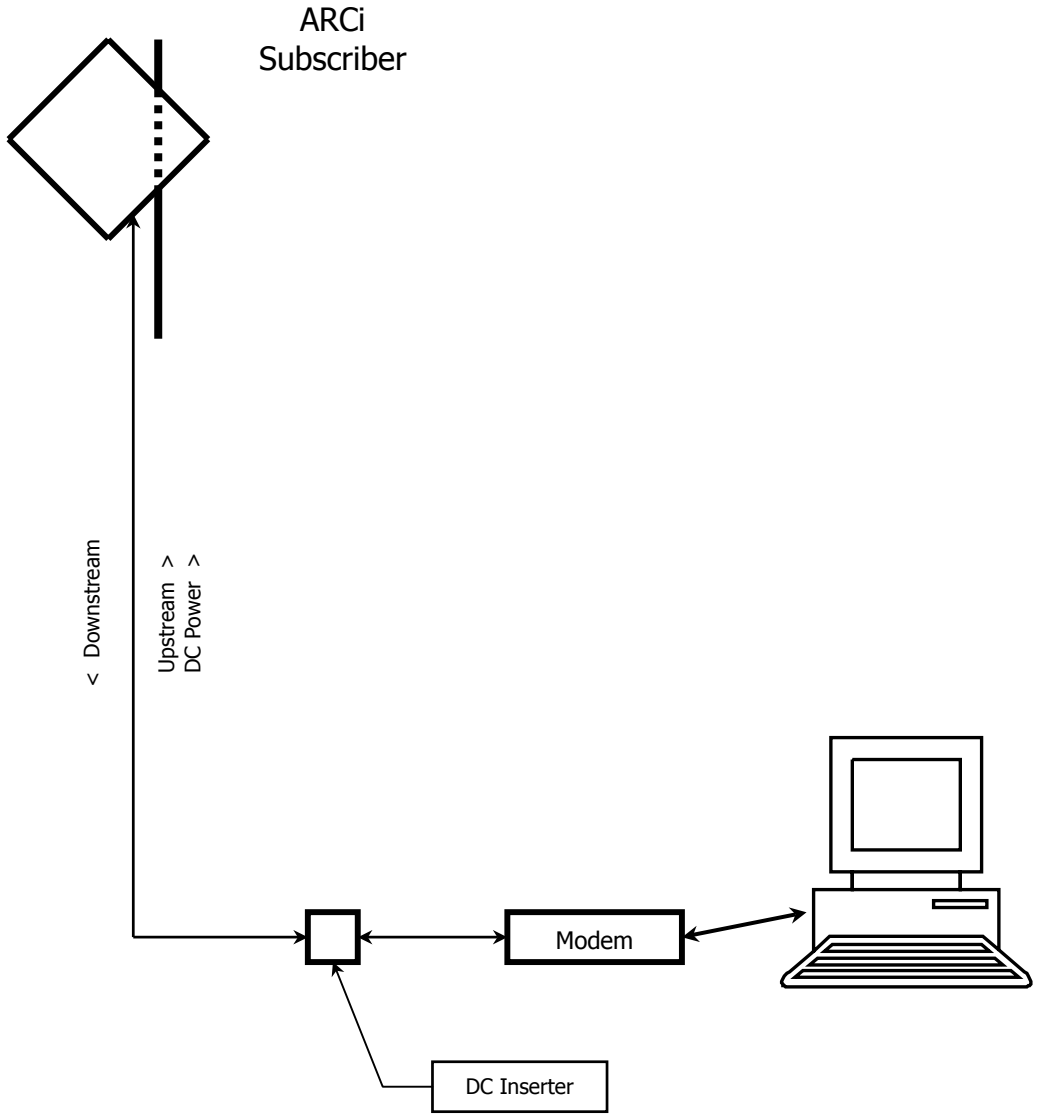

Figure C2

The **ARCi Internet** subscriber installation consists of the ARCi subscriber integrated antenna and radio system mounted on the exterior of the subscriber facility and the wireless modem located inside the structure. A single power and signal cable is run between the integrated antenna and the modem location. See figure C2.

The outdoor ARCi Subscriber Unit is mounted on a chimney or a tripod similar to a TV antenna, or on a pipe mounting arrangement similar to a small satellite TV dish. It must be in a position with

line of sight to the hub location. At the time of installation the antenna is carefully aimed to transmit and receive to/from the hub.

The *Subscriber Installation Details* section provides mounting information and grounding recommendations for the integrated antenna.

The *ARCi Specifications* section provides dimension, weight and mounting details.

Inside the Subscriber Location, the wireless modem is connected to the PC by means of a standard Ethernet LAN cable. Alternatively a LAN hub or switch may be employed between the modem and the PC(s), as the modem has a gateway function that will support up to 15 PCs[2] sharing the modem. A small DC inserter device is connected between the modem and the lead to the outdoor unit. The inserter has a cord mounted power supply (wall wart) as does the modem.

Subscriber Interfaces

See also the ARCi and Vyyo specifications section of this manual.

ARCi Integrated Antenna

The data transmit and receive signals as well as the DC power share a common cable with an ARCi proprietary electrical interface. Connections are:

75 ohm type F female connector

Quality dual-shielded RG-6 coax cable recommended (e.g. Belden 9116)

Wireless Modem

75 ohm type F female connector to DC inserter and integrated antenna

Data connection RJ45 female connector, 10 Mbps standard 10BaseT Ethernet LAN (straight-through cable to PC)

[2] The number of PCs supported by a single modem is 75.

D. Antenna and Frequency Planning

Antenna and Frequency Planning

Antenna Patterns

Horizontal

The ARCi standard hub antenna is moderately directional, transmitting and receiving in a coverage pattern 60 degrees wide[1]. This means that the geographic coverage of the antenna is 30 degrees on each side of a line drawn straight out from the front of the antenna. Geography further to the sides or rear of the antenna receives increasingly less signal.

Therefore, a system where the hub location is roughly in the center of the geography to be served would probably employ six ARCi hub antennas (each with its own integrated electronics) aimed 60 degrees apart to complete the circle of coverage. A hub located at one side of the coverage area might only require 3 hub antennas to provide 180 degrees of geographic coverage.

Vertical

Similarly, the antenna is directional in the vertical plane[2]. This means that elevations above straight out from the front of the antenna (up in the sky) receive less power, as do elevations below straight out. Therefore, the antenna is normally pointed at the furthest subscriber to be served, with the lower elevations providing appropriately less power to closer subscribers.

Antenna Patterns

See the Antenna Patterns section of this manual for measured plots typical of ARCi antennas.

Other Antenna Configurations

Contact ARCi for other antenna configurations. FCC regulations require that the combination of the actual power output of the ARCi transmitter and the gain of the antenna *together* do not exceed specified limits.

Frequency Planning - Downstream

Available Channels

There are 16 available downstream channels in the ARCi standard frequency plan. The downstream frequency is established by the front panel control of the upconverter. The displayed frequency on the upconverter (in MHz) is the center of the 6 MHz wide downstream signal.

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[1] ARCi's standard antenna has a so-called "half power beam width", or "3 dB beam width" of 60 degrees in the horizontal plane. The ARCi 2001, beta units have 3 dB beam widths of 45 degrees.

[2] The 3 dB beam width in the vertical plane is 3 degrees.

The frequencies displayed in Table D1 were chosen such that the resulting signal as received by the modem corresponds to a standard EIA CATV channel. This is because the modem, when not properly initialized or when it has lost track of the downstream signal, will "step" through the standard EIA channel list looking for a downstream signal. Alternatively, the modem may be optioned through its administrator interface to lock onto a specific downstream frequency, removing this requirement.

When the ARCi hub antenna is utilized in an MMDS repeater application its frequency conversion (from upconverter output to carrier output) can be factory modified[3] to meet the requirements of the MMDS transverter frequency plan. Contact the ARCi factory for more information on alternative frequency plans.

Table D1 – ARCi Standard Downstream Frequency Plan

Upconverter center freq. (MHz)	**Carrier** center freq. (MHz)	**Modem** center freq. (MHz)	**Modem** EIA Channel
481	5729	429	58
487	5735	435	59
493	5741	441	60
499	5747	447	61
505	5753	453	62
511	5759	459	63
517	5765	465	64
523	5771	471	65
529	5777	477	66
535	5783	483	67
541	5789	489	68
547	5795	495	69
553	5801	501	70
559	5807	507	71
565	5813	513	72
571	5819	519	73

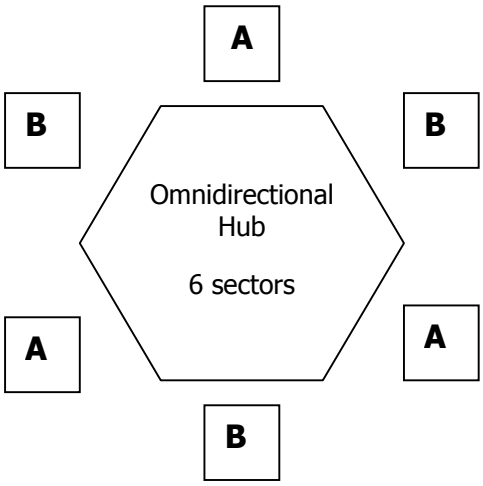
Adjacent Sectors

The ARCi standard hub antenna has been described above as having a half power horizontal beam width of 60 degrees. But, the energy of the antenna does not simply cut off at 30 degrees in horizontal pattern from the centerline of the antenna. Rather, the energy falls off as the angle from the centerline increases. This means that a subscriber in the vicinity of 30 degrees clockwise from antenna A will also be in the vicinity of 30 degrees counterclockwise from adjacent antenna B. Subscribers in the overlap zone – especially if they are relatively close to the hub – will receive downstream signals from both adjacent hub antennas. This will cause unacceptable

[3] The ARCi subscriber unit has a fixed conversion that cannot be modified.

interference if both hub antennas are transmitting on the same frequency, even though the subscriber is receiving nominally the same signal from both hub antennas.

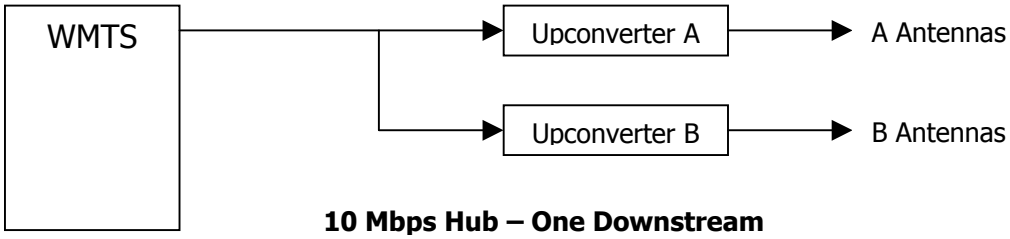
The solution for this is to ensure that adjacent hub antennas are never transmitting on the same frequency. A minimum of two frequencies (and a maximum of six frequencies) is required for an omnidirectional system employing six – 60 degree hub antennas. See Figure D1, following.



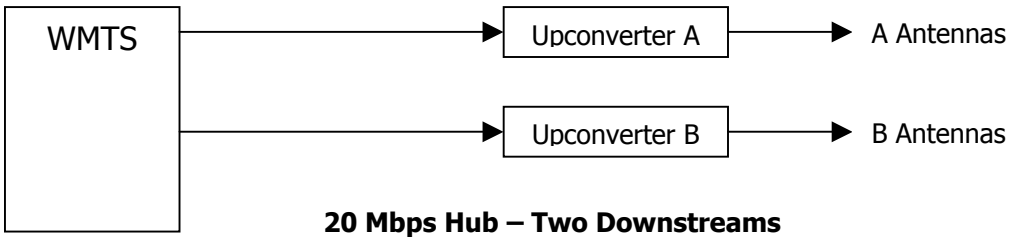
Downstream Channel Example

Figure D1

In a 10 Mbps hub, one WMTS downstream signal is utilized and two upconverters output the same signal on frequency A and frequency B. In a 20 Mbps hub, two WMTS downstream signals are utilized, each driving a separate upconverter A and upconverter B. A 30 Mbps hub can be created by utilizing three upconverters in an ABCABC pattern. See figure D2.



10 Mbps Hub – One Downstream



20 Mbps Hub – Two Downstreams

Figure D2

Frequency Planning - Upstream

Available Channels

There are 3 available upstream channels[4] when channel bandwidth of 3.2 MHz is employed[5]. See Table D2. When configuring the system the user must select the upper or lower carrier as well at the modem transmit frequency. The WMTS commands the modem to its upstream transmit frequency during the modem registration process. [The frequency of each upstream channel in a WMTS is set via a parameter of the *regtree.txt* file in the network management system. See the software installation guide]. All modems utilizing a given upstream channel must transmit on the same frequency, and each modem can operate on only one upstream channel.

Table D2 - ARCi Upstream Frequency Plan

Upstream Data Rate 5.12 Mbps; Channel Bandwidth 3.2 MHz

Modem Tx center (MHz)	**Upper Carrier** center (MHz)	**Up WMTS Rx** center (MHz)	**Lower Carrier** center (MHz)	**Low WMTS Rx** center (MHz)
6.4	5306.4	6.4	5293.6	6.4
9.6	5309.6	9.6	5290.4	9.6
12.8	5312.8	12.8	5287.2	12.8

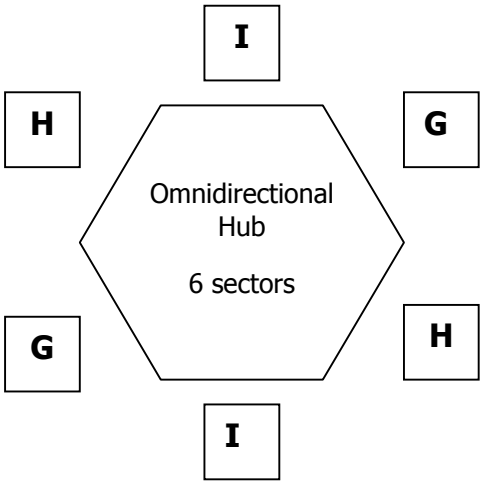
Notes:

1. These frequencies are subject to change.

[4] Additional upstream frequencies will be available in 2002.

[5] Contact the factory when upstream channels bandwidths of 400 KHz, 800 KHz or 1.6 MHz are to be utilized. U.S. FCC-approved systems must employ 3.2 MHz upstream bandwidth.

Generally each upstream channel will terminate in a separate upstream port of the WMTS. WMTS upstream port cards are available in single and six input configurations. Thus, a typical six sector omnidirectional hub would utilize a single six input WMTS upstream card. See Figure D3, following.



Upstream Channel Example

Figure D3

This omnidirectional system might pair downstream channel A (Figure D1) with upstream channel G (Figure 5), etc. See Table D3 for this example.

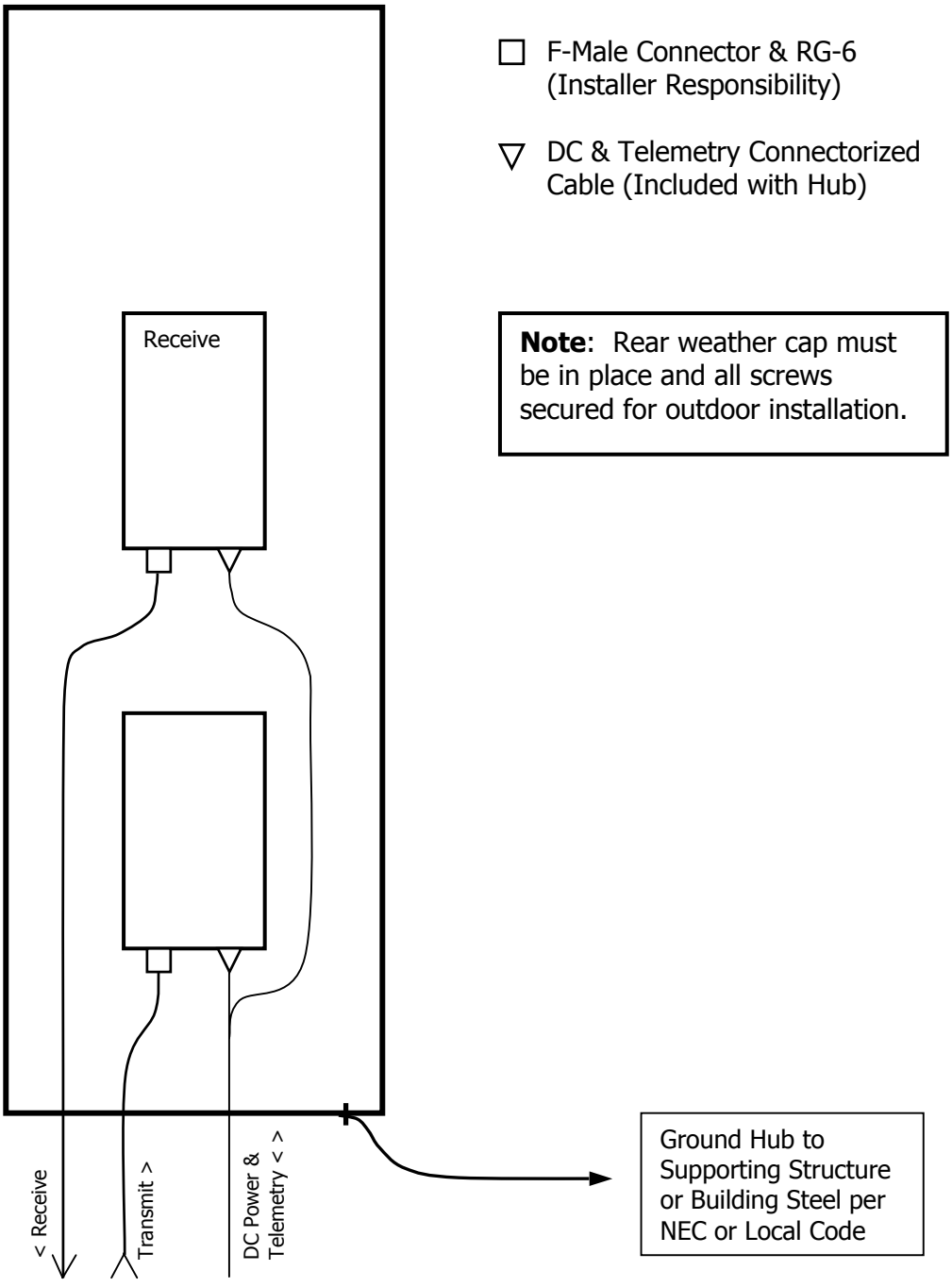
Table D3 – Sector Example

Sector	Downstream Channel	Upstream Channel
North	A	I
NE	B	G
SE	A	H
South	B	I
SW	A	G
NW	B	H

E. Hub Installation Detail

Hub Installation Detail

Schematic Diagram – Outdoor Unit



Hub Installation Detail

Installation Detail – Outdoor Unit (ODU)

Cable connections

It will be more convenient to connect the ODU cables and close the headend rear weather cap prior to attaching the ODU to its mounting pipe. Refer to the Schematic Diagram – Outdoor Unit on the previous page.

Remove the sixteen screws securing the rear weather cap to the anodized aluminum back plate of the antenna, taking care not to damage the gasket around the weather cap. This will reveal two aluminum housings containing the ARCi outdoor electronics[1]. The upper housing contains the receiver and the lower the transmitter. Note the F-female and power/telemetry[2] connectors on the bottom of each.

Attach the receive (upstream) RG-6 to the F connector on the upper electronics housing and the transmit (downstream) RG-6 to the F connector on the lower electronics housing. ARCi recommends the use of premium quad-shielded RG-6 coaxial cable (such as Belden 1189A) for headend installations.

Attach the ARCi-provided power/telemetry "Y" cable to the connectors on both electronics housings (connectors are interchangeable). Note that the power/telemetry connector is keyed and must be rotated into the correct position prior to seating. The locking ring is quite stiff and must be turned approximately ¼ turn clockwise for proper connection. Be sure that the upstream and downstream RG-6 and the power/telemetry cables clear the mounting screw holes for the rear weather cap. Refer to the photograph in Figure E1. Dress the cables as shown in the photograph and secure with a tie-wrap below the lower electronics housing. Although the power/telemetry connectors are interchangeable, the method illustrated in the photograph will produce best results.

It is not necessary to disturb the SMA coaxial connector on the top of each electronics housing. This is the connection to the actual antenna panel.

Replace the headend rear weather cap taking care that the gasket is seated smoothly around the edge of the weather cap and that the three cables pass through the cable access on the bottom end of the weather cap. Replace the sixteen screws securing the weather cap snugly but not tightly enough to distort the gasket. See Figure E2.

[1] Complete replacement of one or both of the aluminum housings containing the electronic assemblies is the only user service possible for the ARCi headend ODU.

[2] The pin connection information is detailed on the last page of this chapter – it is not normally needed as ARCi supplies the power/telemetry cable.

Mounting

Mount the ARCi ODU on a vertical pipe with at least 44 vertical inches clear of unrelated hardware or other impediments. The ODU mounting brackets will accommodate pipe from 1.5 to 2.25 inches in outside diameter. Up-tilt or down-tilt is accomplished by means of adjusting the nuts on the 5/16 inch threaded bolts captive to the mounting assembly. See Figure E3 for details.

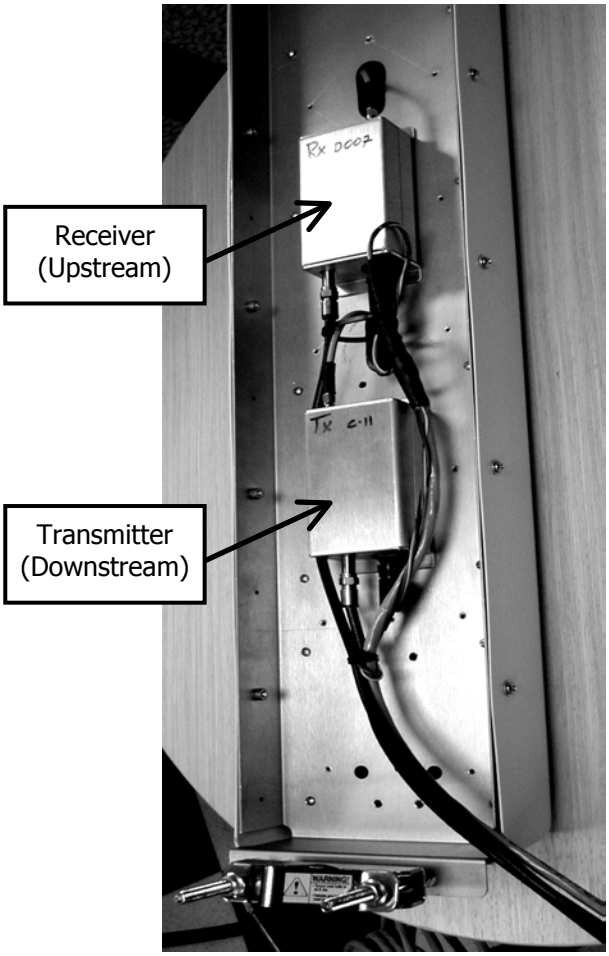


Figure E1 Cable Installation and Dressing

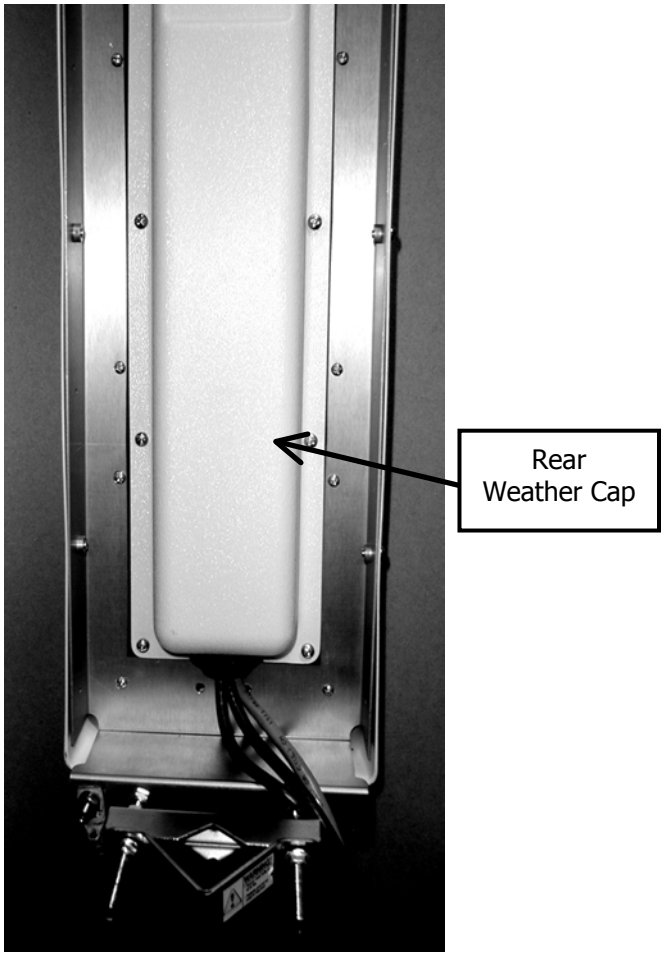


Figure E2 Weather Cap Installed

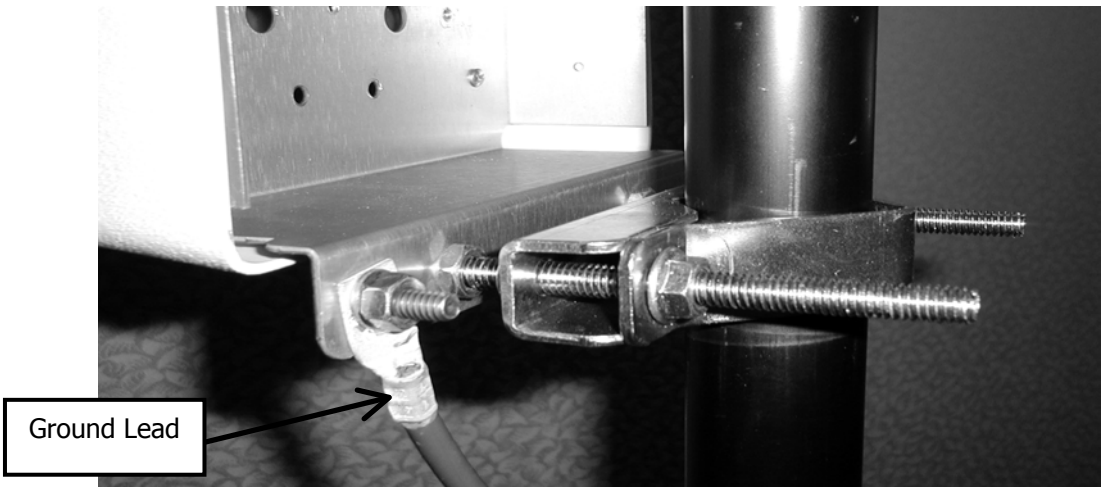


Figure E3 ODU Bracket Detail

Ground the antenna to the metallic mounting structure (tower or monopole) or suitable rooftop ground point per local codes and installation practices. Normally #6 AWG or larger wire is utilized for this purpose. A ¼-20 ground bolt is provided on the bottom flange of the ODU assembly to attach the ground wire[3]. This is illustrated in Figure E3.

Bundle the three cables (2 x RG-6, power/telemetry) with suitable (UV rated) tie wraps and secure to the mounting structure in a manner to prevent rainwater from flowing down the cable and into the cable access opening in the rear weather cap. Figure E4 illustrates a typical installation. Be certain to provide a drip loop of cable bundle is routed upward.

In the case of a single sector, single ARCi headend installation, route the bundle of three cables to the hub indoor equipment room. Take care to leave suitable drip loops and bond the shields of the RG-6 and power/telemetry cables to ground per local codes and installation practices.

If the hub site is multi-sector (two or more collocated ARCi hub ODUs), route the bundle of three cables to the ARCi outdoor junction box (OJB). Refer to the *OJB Schematic Diagram and Installation Details*.

[3] In the very early beta versions of the ARCi ODU the ground bolt is not present. In that case, the ground lead can be attached to the 5/16 inch mounting bolt.

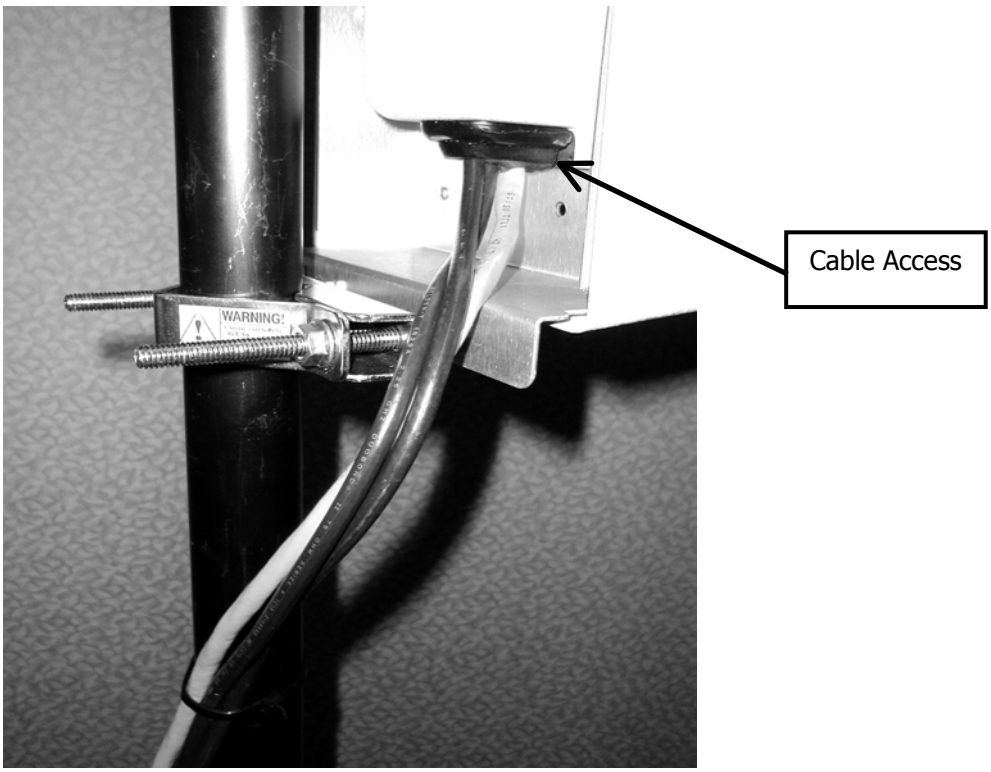


Figure E4 Hub Antenna and Cable Installation

Hub Installation Detail

Installation Detail – Outdoor Junction Box (OJB)

The Multi-Sector configuration consists of two or more ARCi Hub antennas mounted on a common building roof or tower/monopole structure served by a single Wireless Hub (WMTS) located in an adjacent equipment room.

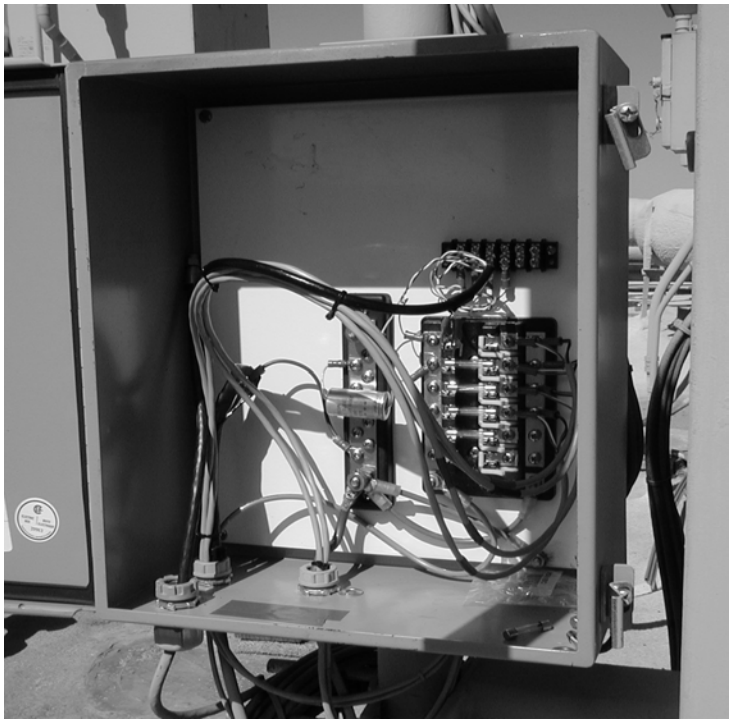
Each hub requires a separate Upstream and Downstream IF cable, so a six sector (six ARCi Hub) installation would require 12 IF coaxial cables. The DC power and telemetry cables are simply paralleled in a multi-sector configuration. This can be accomplished by running separate power/telemetry cables from each ARCi Hub antenna to the equipment room, or by installing an Outdoor Junction Box (OJB) on the mounting structure adjacent to the Hub antennas and paralleling the DC power and telemetry in the OJB.

Implementation

Pictured below (Figure E5) is ARCi's implementation of an OJB as its test site.

Figure E5

The upper barrier strip terminates the shielded/outdoor CAT 5 cable (black jacket) which is the least expensive multi pair cable we could find. One pair is connected between the ground block and the DC+ bus on the fuse block for power supply remote sensing, a second pair is reserved for the future telemetry application and the other two pairs are spares.

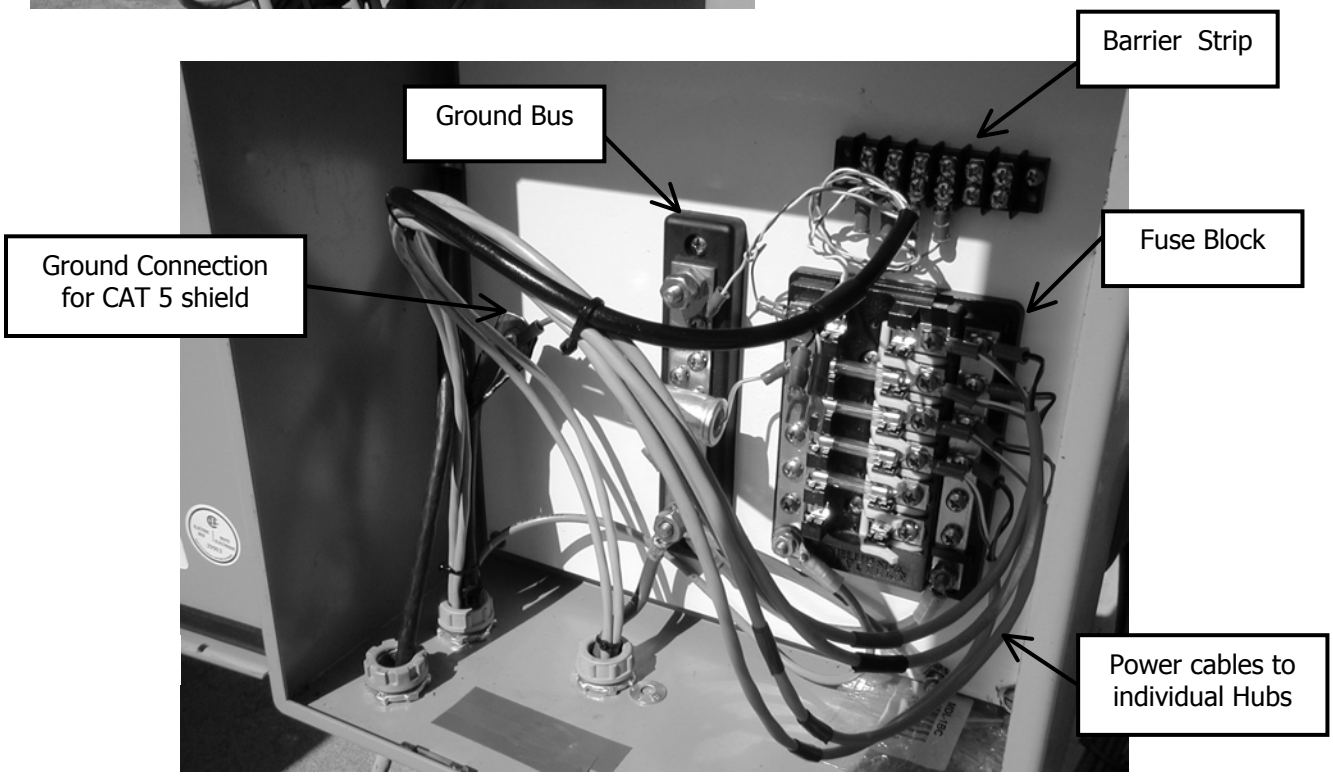


The incoming ground & DC- cable is attached to the bottom of the ground block along with ground leads to the negative bus on the fuse block and the enclosure's ground lug.

The incoming DC+ cable is attached to the bottom of the DC+ bus on the fuse block. Cables to the individual ARCi Hub antennas (light gray) terminate on the right side of the fuse block. The electrolytic capacitor (2200 uFd) across the power supply busses reduces transients when individual Hub power connectors are inserted or removed with power on.

Space is provided at the top of the box for lightning protectors which have not proven to be necessary at our test site in San Jose, CA.

Figure E7



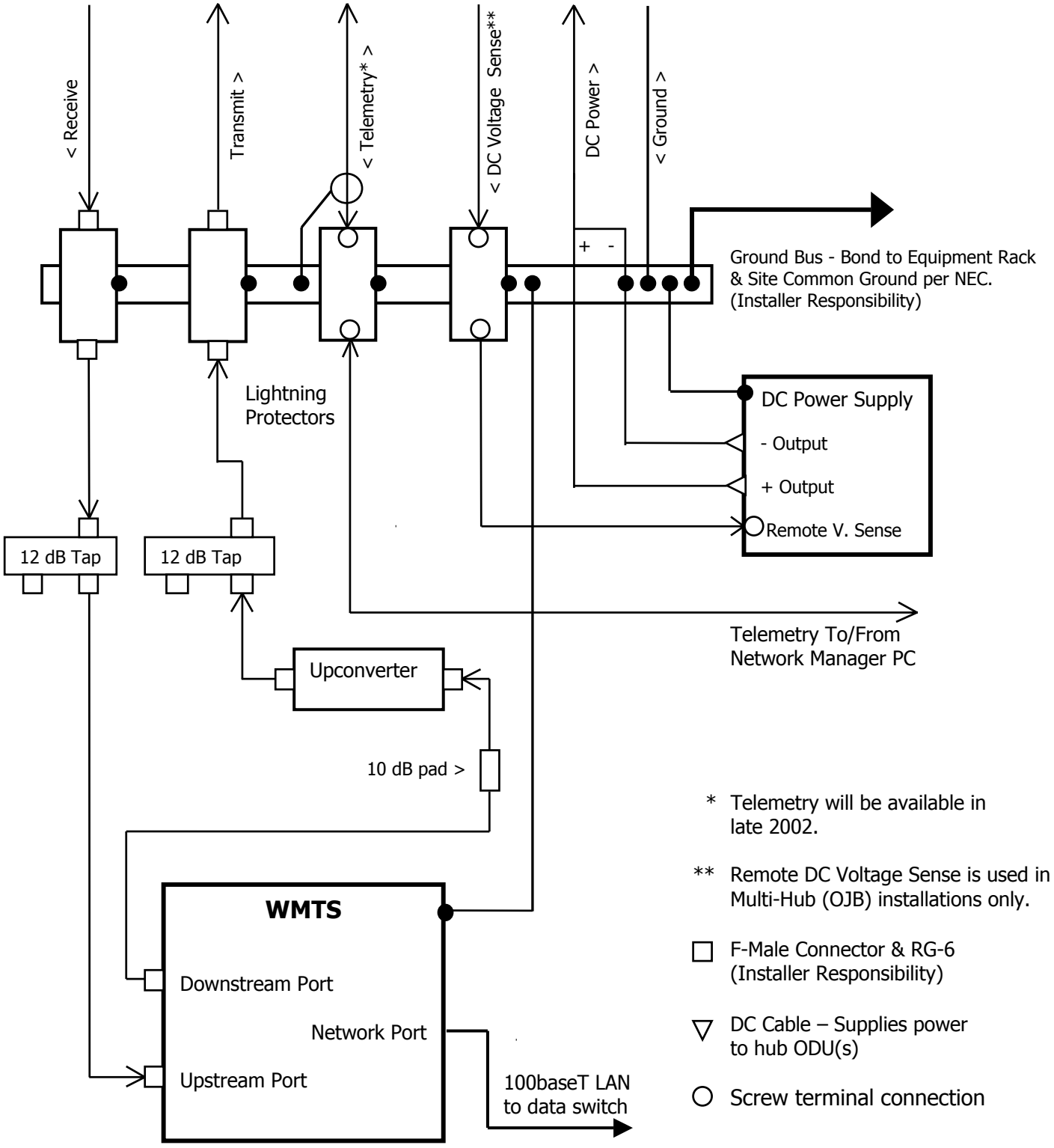
OJB Components

The OJB pictured here is assembled from the following components:

Device	Vendor & Part Number	Source
Enclosure	Hoffman A-1412CH	Electric Supply Trade www.hoffmanonline.com
Inner Panel	Hoffman A14P12	
Fuse Block	Blue Sea Systems 5015	West Marine Retail www.bluesea.com
Ground Bus	Blue Sea Systems 2301	
Dual Bus (use in lieu of fuse block or for telemetry paralleling)	Blue Sea Systems 2702	
Rubber Insert ¾" couplings, locknuts, bushings		Electric Supply Trade
Shielded Cat 5 Cable	Superior Essex BBDN Part #04-001-34	Graybar Electric
Cat 5 Shield Bond Connectors	Hubbell BC285SB	Graybar Electric

Hub Installation Detail

Schematic Diagram – Indoor Equipment



Hub Installation Detail

Installation Detail – Indoor Equipment

Grounding

Proper grounding is critical to the safety, performance and the life of the equipment installed at the hub. Refer to the *Schematic Diagram – Indoor Equipment* on the preceding page. ARCi recommends that the installer follow the general grounding practices employed in cellular and PCS hub sites.

ARCi recommends the following Lightning Protectors from PolyPhaser Corp. (www.polyphaser.com). These PolyPhaser devices are designed to be bolted directly to the ground bus.

75 ohm RG-6 transmit and receive cable	IS-75F-C1
Remote DC voltage sense	IS-SPDDL
RS-485 telemetry	IS-SPHSD

The ground bus, in turn, should be connected with an appropriate conductor (minimum #6 AWG) to the hub site ground that includes the power service and building common ground, per the NEC and local codes.

ARCi recommends the installer run a minimum #6 AWG conductor between the equipment room ground bus and a common ground point adjacent to the hub antenna(s) unless the antenna mounting system consists of a known low impedance ground (as a steel tower or monopole). In the case of a single sector ARCi installation, this point can be the antenna ground bolt or mounting bracket. In a multi sector ARCi installation including an ARCi outdoor junction box (OJB) this conductor can be connected to the ground bus in the OJB, which in turn, is connected to each hub antenna and any nearby building or support structure ground.

Normally the WMTS, upconverter(s), DC power supply, 100baseT data switch, etc. are mounted in a 19-inch equipment rack in the hub equipment room. This rack should also be connected to the ground bus, preferably by a conductor #6 AWG or greater.

When shielded cable is utilized to connect DC power, voltage sense, and/or telemetry between the hub equipment room and the hub antenna, ground the shield to the ground bus in the equipment room.

DC Power

The ARCi hub antenna requires 8.5 Vdc +/- 0.5 volts at the hub antenna and draws approximately 950 mA.

In a single sector installation a small variable voltage linear DC power supply capable of supplying at least 1000 mA is employed. ARCi has successfully tested the following power supply in the single sector configuration:

Agilent E3610A

The voltage (IR) drop of the power cable is calculated and the output of the DC supply is set appropriately.

> *For Example*: If a single ARCi hub is connected with a 100 ft. 18 AWG power cable (and the ground (DC-) connection is sufficiently good so as to present negligible resistance - as it should be), the voltage drop equals (0.95 A x 0.69 ohms/100 ft. x 100 ft.) = 0.66 volts. Set the power supply for (8.5 + 0.66 =) 9.2 Volts.

In a multi-sector installation the DC power supply is chosen with sufficient capacity to deliver at least 1000 mA for each ARCi hub antenna. The DC+ lead is sized to provide reasonable voltage drop between the DC supply and the Outdoor Junction Box (OJB) installed near the hub antennas. A DC voltage sense pair is installed to sample the DC voltage at the distribution bus in the OJB and provide the sample to the DC supply. The DC power supply is then adjusted to provide 8.5 Vdc at the OJB. [The OJB will be available in mid-2002].

ARCi has successfully tested the following power supply in the multi-sector configuration:

[To be determined].

Telemetry

Telemetry is a low speed RS-485 signal implemented on a twisted pair between the hub antenna and the network manager computer in the equipment room. In a multi-hub installation, the telemetry connections are simply paralleled at the telemetry terminal strip in the OJB. [Telemetry will be available in late 2002].

DC Sense and Telemetry Cabling

ARCi has found that shielded outdoor service rated Category 5 data cable is inexpensive, and two of its four pairs can be utilized for telemetry and DC voltage sense. A cable of this type is Superior Essex BBDN part #04-001-34, which utilizes Hubbell Shield Bond Connectors BC285SB (box 100) + tool BCTK.

Transmit (Downstream) Signal Path

The downstream signal from the WMTS is connected to the upconverter that is normally mounted in the rack with the WMTS. A 10 dB pad[4] is inserted at the input to the upconverter to set the proper level.

[4] ARCi will supply one 10 dB pad and two 12 dB taps with each hub. RG6 coaxial cable and connectors are to be supplied by the installer.

The upconverter is adjusted to provide the downstream signal at the center frequency appropriate for the ARCi hub transmitter to create the desired RF carrier frequency. See Table D1 in the *Antenna and Frequency Planning* section of this manual for more information. The output of the upconverter is connected with RG-6 cables through a 12 dB tap, and thence through the lightning protector to the cable to the ARCi hub antenna.

The 12 dB taps provide negligible attenuation to the signal passing through and "copy" of the signal 12 dB lower in level to the tap port. These are utilized for inserting a spectrum analyzer for system set-up and maintenance without disturbing the normal connections.

Receive (Upstream) Signal Path

The upstream signal from the ARCi hub antenna is connected through the lightning protector and through the 12 dB tap to the upstream port of the WMTS.

System Level Setting Notes

General

The head end and subscriber transmitters are designed for linear operation at the maximum output power allowed for compliant operation under the FCC part 15 regulations. In both the head end and the subscriber units the input power level to the ARCi radios determines that of the output. There is no gain adjustment available to the user.

Downstream Power

The head end transmitter power is set by adding fixed attenuators to the downstream IF path, adjusting the output level of the upconverter, or some combination thereof. The ARCi headend ODU is factory calibrated to produce a +30 dBm maximum EIRP when this level is applied to the headend ODU IF input. **This is the level required for FCC compliance**.

Downstream Power Adjustment Procedure

1. Disconnect the IF cable at the input to the head end ODU transmitter and connect the cable to the input of a suitably calibrated spectrum analyzer.

2. Set up the spectrum analyzer as follows:

Center Frequency	IF frequency in use (481 – 571 MHz)
Span	100 MHz
RBW	1 MHz
VBW	30 KHz
Vertical Scale	linear, 10 dB / division
Reference Level	+40 dBmV
Attenuation	20 dB
Detection Mode	Averaging

3. Adjust the IF level at the upconverter or by inserting fixed attenuators as needed to ensure that the observed modulation peaks do not exceed +23 dBmV.

4. As an alternative to performing this adjustment at the rear of the headend ODU, it can be made at the indoor equipment end of the IF cable, as above, if the loss of the cable at the IF frequency is calculated. The observed modulation peaks can then be adjusted so as not to exceed (+30 dBmV + loss dB). For example, the loss of typical good quality RG6 cable is 4.57 dB/100 ft. at 550 MHz.

The most accurate method of setting the actual output power level is to attach an RF power meter capable of measuring up to 6 GHz to the output of the hub transmitter through a 15 inch long RG142B/U SMA-SMA cable and then adjusting the IF level until the power indicated on the meter is +15 dBm. However, ARCi does not recommend that this adjustment be made in the field unless under the direct instruction of the ARCi factory.

Warning! The transmitter must never be operated without a 50 Ω load attached to its RF output connector. Be sure to remove the DC power from the transmitter prior to removing the load from the output.

IMPORTANT NOTE: To comply with FCC RF exposure compliance requirements, antenna installation and device operating configuration described in this user manual must be satisfied. The antenna(s) used for this device must be fixed-mounted on outdoor permanent structures with a separation of at least 1.5 meters from all persons during normal operation.

Upstream Power

The output level of the Cable Modem establishes the subscriber transmitter's output power. An automatic feedback loop, controlled by the WMTS, commands each CM to adjust its output level such that the level of the signal received at the head end is suitable for demodulation by the WMTS. The user may tune this power control loop by modifying the *UpstreamRxGain* parameter in the RegTree file. (See Vyyo V3000 Wireless Hub User's Manual section 7.2). Setting this parameter to 0 will generally yield satisfactory performance.

The ARCi subscriber ODU is factory calibrated to maximum FCC permissible EIRP when the DOCSIS cable modem is at its maximum power output level.

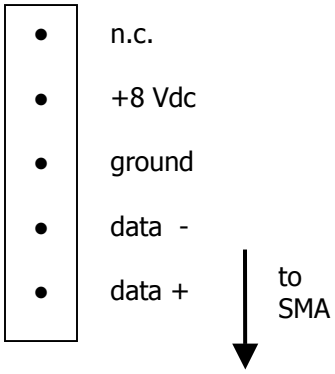
ARCi Hub
Power / Telemetry Cable Convention

Switchcraft EN3			Belden 3124A Downlead	EN3/Internal Headers **Twisted**	**9744**
Pin	1	DC Ground*	Black	Black	[Black
	2	DC + 8.5 VDC*	Red	Red	[Red
	3	Telemetry +	White	Yellow	[White
	6	Telemetry –	Green	Green	[Black
	4 & 5	(reserved)			

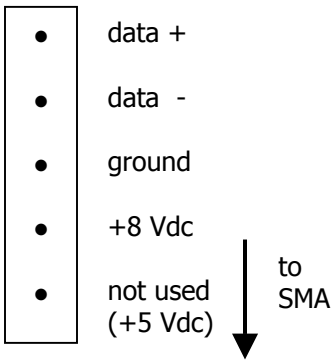
* ARCi lab standard

Internal Headers

AR105 Rx



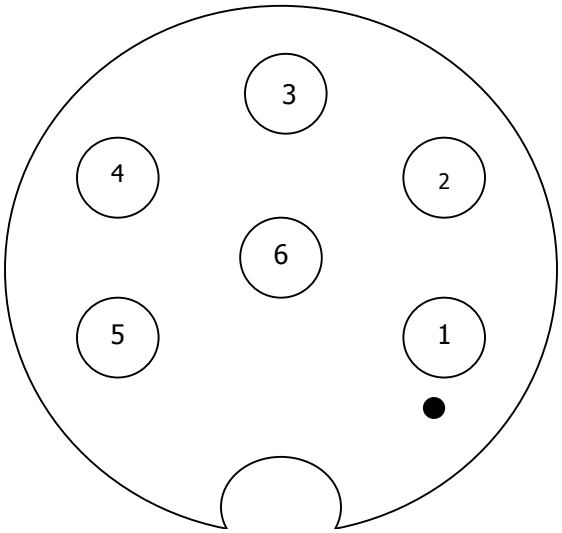
AR150 Tx



Cord Connector Rear View

(equals)

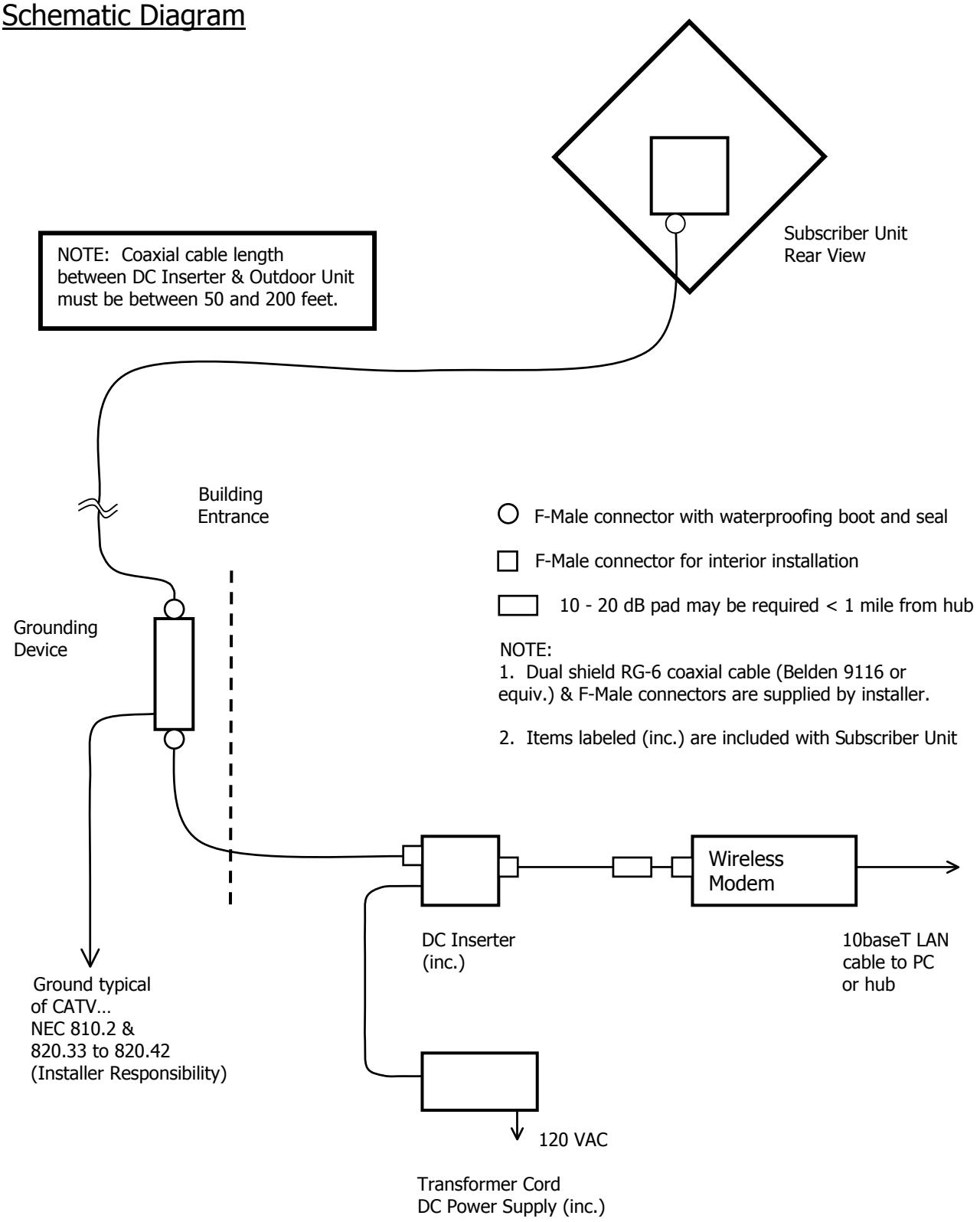
Panel Connector front View



F. Subscriber Inst'l Details

Subscriber Installation Detail

Schematic Diagram

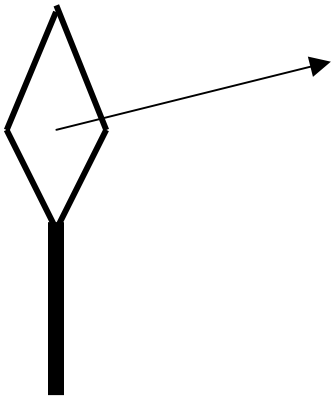


Subscriber Installation Detail

Installation Detail – Subscriber Outdoor Unit

Mounting

Mount the ARCi subscriber outdoor unit (ODU) on a vertical pipe with at least 12 inches clear of any hardware or other impediments. The mounting brackets will accommodate pipe diameter from 1.25 to 2 inches. Up-tilt or down-tilt is accomplished by loosening the cap screws on the sides of the mounting assembly. See Figures F1 and F2. The front face of the antenna must point in the direction of the system hub and have a clear view of the hub antenna[1].



Point center of ODU towards System Hub

Figure F1 Subscriber ODU Orientation

Figure F2
Subscriber ODU Mounting

[1] Subscriber installations located close to the hub installation may work successfully through nearby tree foliage, but this must be verified in the field.

Cable Connection and Grounding

Attach the single RG-6 coaxial cable to the F connector on the rear of the subscriber ODU. Waterproof the connection using a suitable method such as taping with Scotch #88. Be sure to leave sufficient slack to allow the antenna to be oriented and that the cable runs directly downward from the connector to avoid water running down the cable and into the F connection. Route the coaxial cable to the building entry point utilizing UV-resistant tie-wraps and staples or cable clamps as required.

Mount the grounding device (e.g. Radio Shack 15-909C) as near as practicable to the point of cable entry to the structure. See Figure F3. Connect the grounding device to a suitable "grounding electrode".[2] Connect the RG-6 coaxial cable from the subscriber ODU and the RG-6 that enters the structure to the grounding device and waterproof all exterior F connectors as described above.

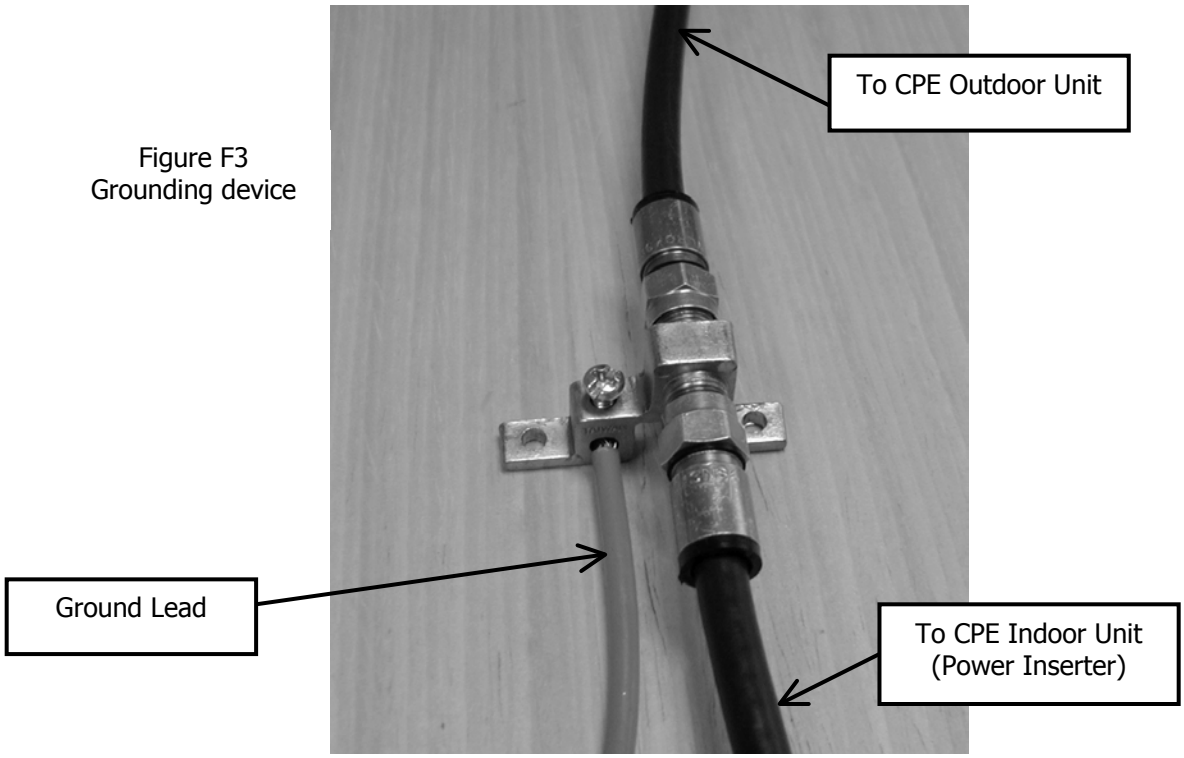


Figure F3
Grounding device

[2] The National Electric Code, sections 820-33 and 820-40, describes this requirement in detail.

DC Power Supply and Inserter

Inside the building, route the RG-6 from the building entrance point to the modem location. Attach an F connector and connect it to the "TO AMPLIFIER" or "TO ANTENNA" F female connector on the power inserter. Depending on the version, the wall mounted DC power supply may:

- be permanently connected to the inserter as shown in Figure F4, left, or

- connect to the inserter with a small DC plug and jack, or

- be an F connector lead to the "12 VDC IN" connector on the power inserter. [In the F-connector case, ARCi will supply a 12-inch F-male-to-F-male cable to connect to the power supply. The installer may choose to furnish a longer cable based on the installation specifics].

Figure F4
Power Inserter and
DC Power Supply

Modem (WMU)

Place the modem where it will be used and attach the short cable on the power inserter (labeled "TO TV" or "TO MODEM" – see Figure F6) to the F connector on the rear of the modem. Connect (the separate) modem wall mounted power supply (included with the modem) to the power connector on the rear of the modem. Plug both wall mounted power supplies into suitable AC power sources – preferably a UPS or surge protected power strip. Connect a straight-through 10BaseT LAN cable between the RJ-45 jack on the modem and the user hub, router or personal computer.

Figure F5
Power Inserter Detail

Note for Close-in Installations

The Subscriber Installation Schematic Diagram (Page F2) shows a 10 or 20 dB pad (attenuator) installed between the power inserter and the modem. Small pads of many values are available with F connectors to screw in line with the coaxial cable connection, and they may be cascaded to sum their attenuation. At the time of system set-up it may be determined that such pads are required in installations less than a mile from the base station site to reduce excess signal.

G. Link Budget Parameters

ARCi Link Budget Parameters

Upstream	minimum	typical	maximum	
Vyyo WMU output spec (dBmV)	+8		+58	
IFL coax loss - Belden 9116	(calculate; length limited by downstream)			1.42 dB/100 ft @ 55 MHz
ARCi CPE IF input (dBmV)	+18		+58	
ARCi CPE RF output (dBm)	-27		+13	
ARCi CPE Tx antenna gain (dBi)		11		
Path		(calculate)		
ARCi Hub Rx antenna gain (dBi)		16		
ARCi Hub RF input level (dBm)	-95	-85		
ARCi Hub RF output level (dBm)	-48	-38		47 dB gain
ARCi Hub RF output level (dBmV)	0	+10		
IFL coax loss – Belden 1189A	(calculate; length limited by downstream)			1.42 dB/100 ft @ 55 MHz
Vyyo WMTS input spec (dBmV)	-15	+10	+35	

Downstream				
Vyyo WMTS output spec (dBmV)	+20		+40	
Cadco upconverter input (dBmV)	+38		+45	
Cadco upconverter output (dBmV)	+50	+60	+65	
IFL coax loss – Belden 1189A	(calculate; 15 dB max loss)			4.57 dB/100 ft @ 550 MHz
ARCi Hub IF input (dBmV)		+50		
ARCi Hub RF output (dBm)		+16		
ARCi Hub Tx antenna gain (dBi)		13		EIRP = +30 dBm
Path		(calculate)		
ARCi CPE Rx antenna gain (dBi)		22		
ARCi CPE RF input level (dBm)	-92		-52	
ARCi CPE IF output level (dBm)	-52		-12	40 dB gain
ARCi CPE IF output level (dBmV)	-4		+36	
IFL Coax Loss - Belden 9116	(calculate; 15 dB max loss)			4.57 dB/100 ft @ 550 MHz
Vyyo WMU input spec (dBmV) (QPSK)	-20		+35	

Readers of this Manual are Encouraged
To Forward Their Corrections and Comments

H. Reader Feedback

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