Phase 4 Design, Inc

RoIP Integration for Remote Sites

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Notes

RoIP Integration for Remote Sites

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What are we going to discuss today

Topic for today / Agenda

Cover the aspects of VoIP vs RoIP

Examine Radio Side Challenges

Cover the aspects of using radio as a Haulback

Examine Potential Solutions

Cover the aspects of the RoIP Network Interface

Discuss Network Requirements for RoIP

About Us

Dave Grant – Instructor / dave@phase4.org

Mike Grant – Producer – Student Coordinator / mike@phase4.org

Phase 4 Design, Inc. has been serving the telecommunications industry since 1990. We are located in the Pacific Northwest and we serve customers all across the US. Dave started working in 2-Way Radio in 1972.

In 2009-2010 we retooled the company to focus on custom Telex RoIP integration, training and support, including SIP Phone Systems.

Since then we have developed online training classes for Telex RoIP and Basic 2-Way Radio. These classes are live and interactive with multiple HD cameras during online labs. Mike joined us in mid-2016 as the online class Producer and Student Coordinator.

In 2016 our work with the Washington State Department of Fish and Wildlife was a feature article in *MissionCritical Communications Magazine*, November/December 2016 issue.

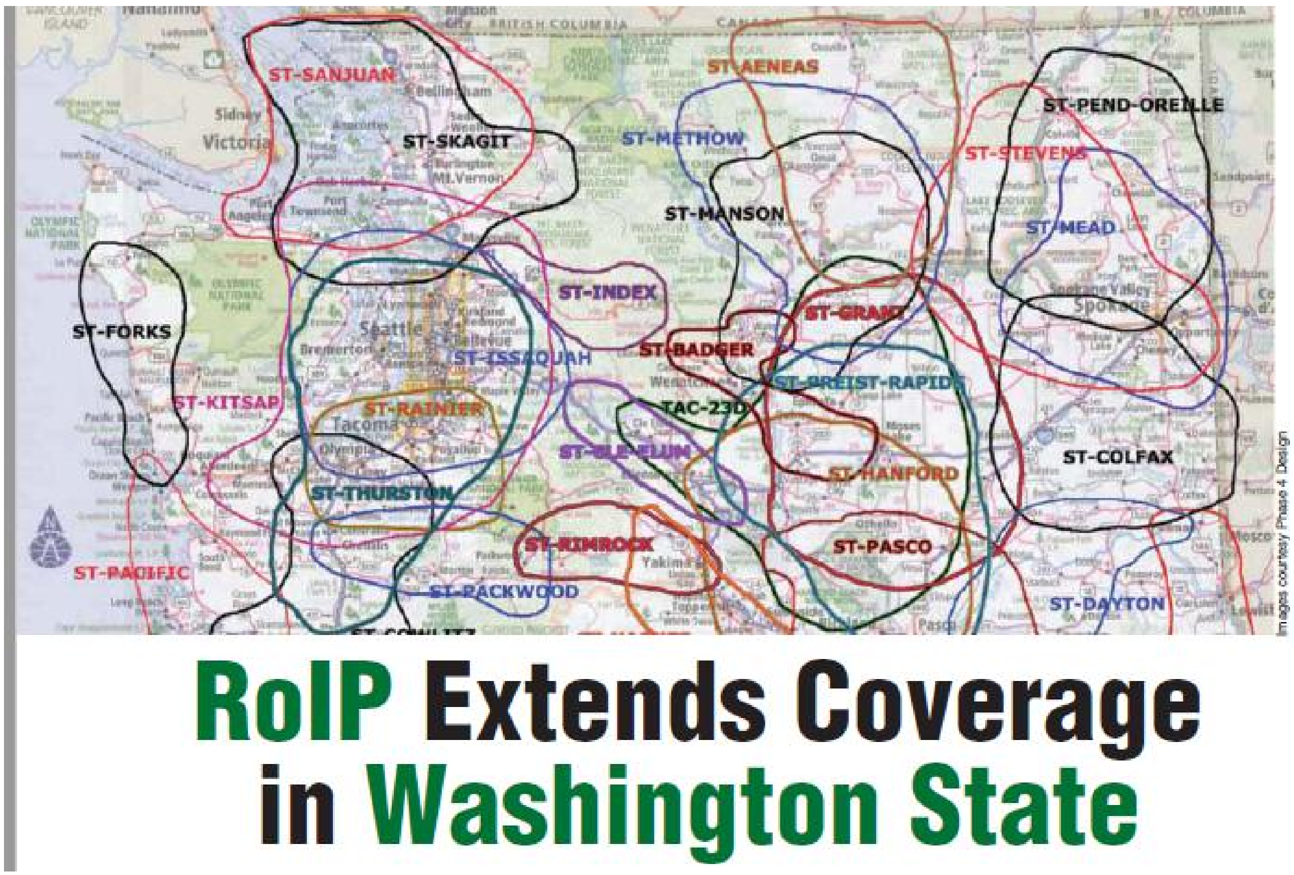


Figure 1 Featured in MissionCritical Communications Magazine

About You

Radio Experience

Anyone have RoIP Experience?

Anyone have IT Experience?

Anyone have an example system to use?

What do you want to get from this session?

Basic Premise

We need to do an upgrade to a RoIP System.

How do we interface our RoIP Cloud to a site that is more than 2 hours away?

VoIP[1] v RoIP[2]

VoIP

- **Mission**
  - Provide for the delivery of Voice Calls via IP Networks
  - Provide support of Advanced PSTN and Mobile Features
  - Provide PTT services to Land Mobile Radio via IP Networks

- **Architecture**
  - Session Based
  - Requires Server or End-Point Negotiation
  - Server exposes a Single Point of Failure

[1] VoIP - Voice over Internet Protocol
[2] RoIP - Radio over Internet Protocol

RoIP Integration for Remote Sites

- **Standards**
  - Vonage, Comcast, IMS, Skype, Cisco, Avtec, Zetron

- **Protocols**
  - Session Initiation Protocol (SIP) RFC 3261

  - H.323v2 (International Telecommunications Union)
  - RTP (Real Time Protocol)
  - Internet Group Management Protocol Version 3
  - Multicast Listener Discovery Protocol Version 2 (MLDv2) for Source-Specific Multicast
  - Multicast VoIP
  - Differentiated Services Code Point (DSCP)
  - Project 25 Console Subsystem Interface (P25 CSSI)
  - Project 25 Inter Subsystem Interface (P-25 ISSI)
  - Vendor Specific Proprietary Protocols

RoIP

- **Mission**
  - Provide PTT services to Land Mobile Radio via IP Networks
  - Provide Enhanced Remote Radio Control via IP Networks
  - Provide IP equivalent to a 2 Wire or 4 Wire Audio Circuit

- **Architecture**
  - Stream Based
  - Static Mapping of End-Points
  - No Single Point of Failure

- **Standards**
  - Bridging System Interface (BSI) Draft
  - APCO P25 DFSI
  - Telex Radio Dispatch Proprietary System
  - Mindshare Radio Dispatch Proprietary System

- **Protocols**
  - RTP (Real Time Protocol)
  - Multicast
  - Internet Group Management Protocol Version 2
  - Differentiated Services Code Point (DSCP)
  - Project 25 Console Subsystem Interface (P25 CSSI)
  - Project 25 Inter Subsystem Interface (P-25 ISSI)
  - Project 25 Digital Fixed Station Interface (P-25 DFSI)
  - Vendor Specific Proprietary Protocols

Haulback Link Requirements

- Fade margin > 20db
- Direct Ethernet Access to Remote Radio
- Alarm and Remote Diagnostics
- Separate antennas for link radio

Haulback Link Assumptions

- Penetration is adequate
- No Signal Reflection / Refraction
- No Multipath
- Building lease / Microwave Path Right of Way / LOS Path

Type of Sites

Urban Building Top Site

- Penetration
- Signal Reflection / Refraction
- Multipath
- Building lease / Microwave Path Right of Way
- Radio enclosure – Inside Building / Roof top hut / Outside Cabinet
- Community Antenna System requirements
- Antenna Support – Building Mounted / Tower – Pole Mounted
- Site Interference and Filtering requirements
- Power Requirements

Sub Urban Building / Mobile Site

- Signal Reflection / Refraction
- Multipath
- Building lease / Microwave Path Right of Way
- Radio enclosure – Inside Building / Roof top hut / Outside Cabinet
- Community Antenna System requirements
- Antenna Support – Building Mounted / Tower – Pole Mounted
- Site Interference and Filtering requirements
- Power Requirements

Low Mountain Site

- Signal Reflection / Refraction
- Multipath
- Building lease / Microwave Path Right of Way
- Radio enclosure – Inside Building / Outside Cabinet
- Community Antenna System requirements
- Antenna Support –Tower / Pole Mounted
- Site Interference and Filtering requirements
- Power Requirements

High Mountain Site

- Signal Reflection / Refraction
- Building lease / Microwave Path Right of Way
- Radio enclosure – Inside Building / Outside Cabinet
- Community Antenna System requirements
- Antenna Support –Tower / Pole Mounted
- Down-tilt Phasing on antenna
- Site Interference and Filtering requirements
- Power Requirements / Solar / Thermal / Batteries

Types of Radio Services

Wide Area Coverage

- Base
- Repeater

Control and Haulback

- Control Station
- Drop Link Control Station
- Microwave
- Satellite
- NLOS Data Link

- **Local Base**

A Local Base Radio is typically used for simplex communications from a fixed point with a tower mounted antenna. The base can local or remote to the user and normally have a power output range of 50-500 watts.

Depending on the location and terrain a base radio can have simplex ranges of 20-100 miles. The base will typically communicate with a hand held or mobile radio.

The base radio is normally located at a fixed location. This typically means that it is either AC powered or is connected to a site battery system.

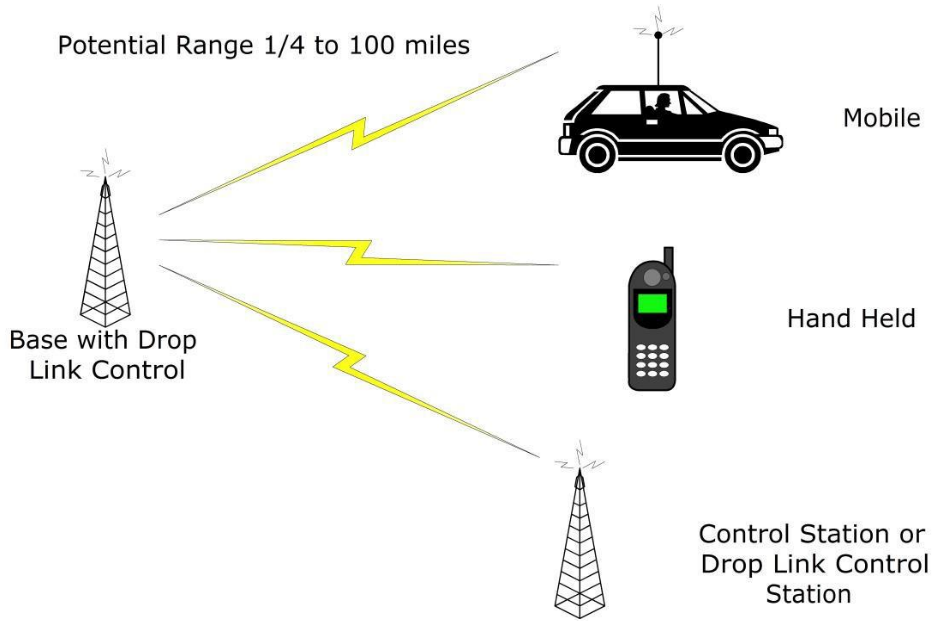


Figure 2 Base Radio Service

- **Remote Base / Repeater**

A Repeater is typically used for duplex communications from a fixed point with a tower mounted antenna. The repeater can be local or remote to the user and normally have a power output range of 50-500 watts. A Remote Base is typically used for simplex communications.

Depending on the location and terrain a repeater can have duplex ranges of 20-100 miles. The Repeater will typically communicate with a hand held, mobile radio or control station.

The repeater radio is normally located at a fixed high site location. This means that it is typically connected to a site battery system.

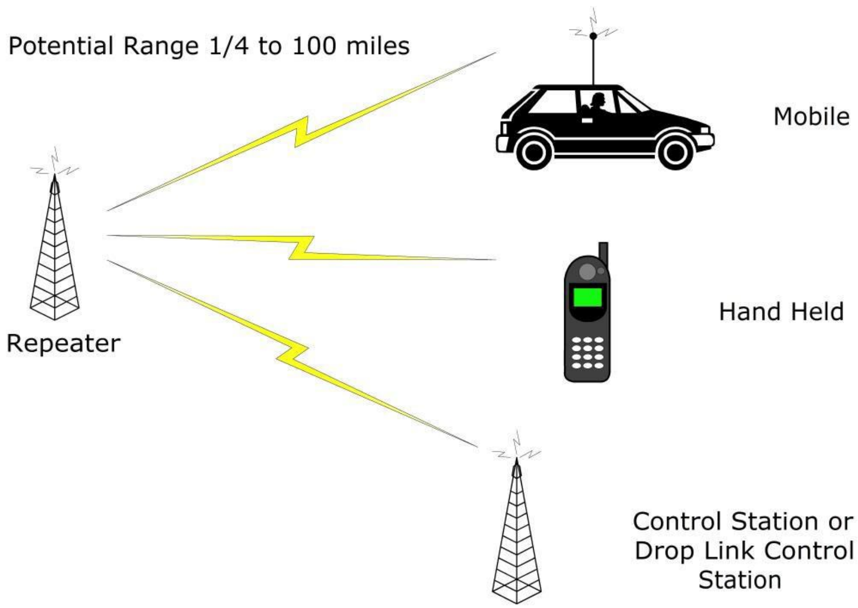


Figure 3 Repeater Radio Service

- ## Control Station

The Control Station is used to allow simplex control of a repeater from a remote location. The control station can be a hand held, a mobile or a base that is under local or remote control. The typical power output is 10-50 watts.

This service is normally used in a point to point configuration where the locations of both ends of the communication path are known. Depending on terrain a control station can have simplex range of 20-75 miles.

The control station radio is normally located at a fixed location. This means that it is either AC powered or is connected to a site battery system.

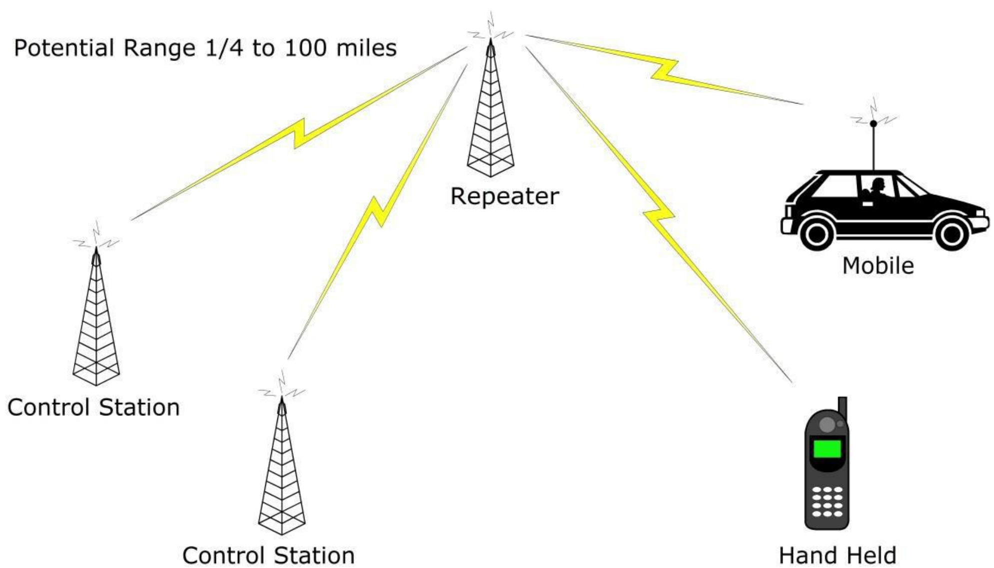


Figure 4 Control Station Service

- **Drop Link Control Station**

The Drop Link Control Station is used to allow simplex control of a repeater from a remote location as well as provide for link radio control of additional repeaters. The control station can be a hand held, a mobile or a base that is under remote control. The typical power output is 10-50 watts.

This service is normally used in a “point to point to point” configuration where the locations of all ends of the communication path are known. Depending on terrain a control station can have simplex range of 20-75 miles.

The drop link control station radio is normally located at a fixed location. This means that it is either AC powered or is connected to a site battery system.

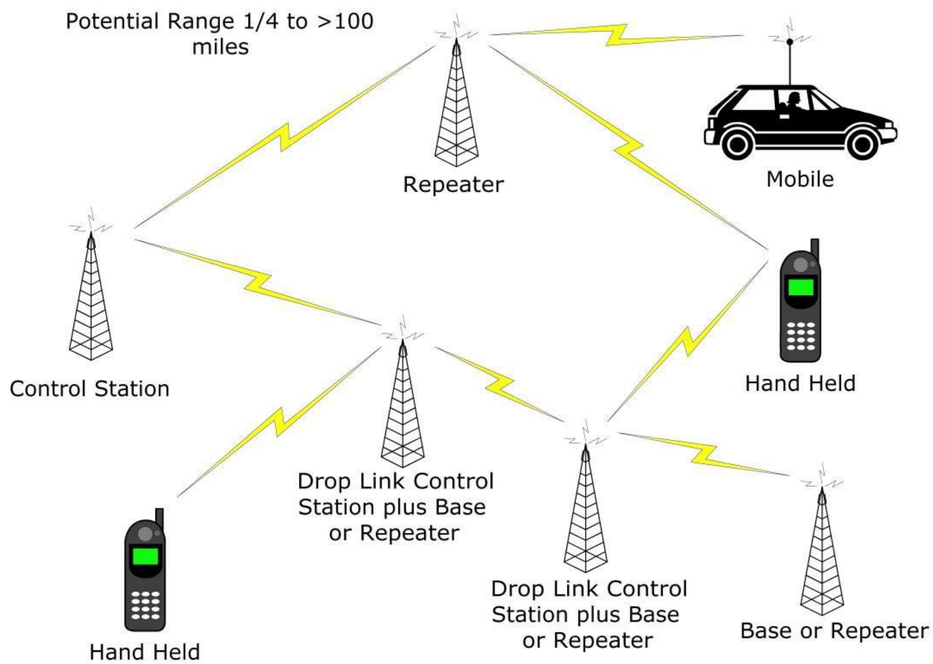


Figure 5 Drop Link Control Service

- **Microwave**

A Microwave radio is typically used for duplex communications from a fixed point with a tower mounted antenna. This service is always point to point and requires a LOS path. Microwave is normally at a frequency of 1GHz and up. This service can carry both analog and digital data and can simulate both the Control Station and Drop Link Control Station by terminating some control information and forwarding control information to additional microwave radio sites.

Depending on the location and terrain a microwave installation can have multi-channel duplex ranges of 20-100 miles. Microwave radios will typically require a dish type antenna on both ends of the path.

The microwave radio is normally located at a fixed location. This means that it is either AC powered or is connected to a site battery system.

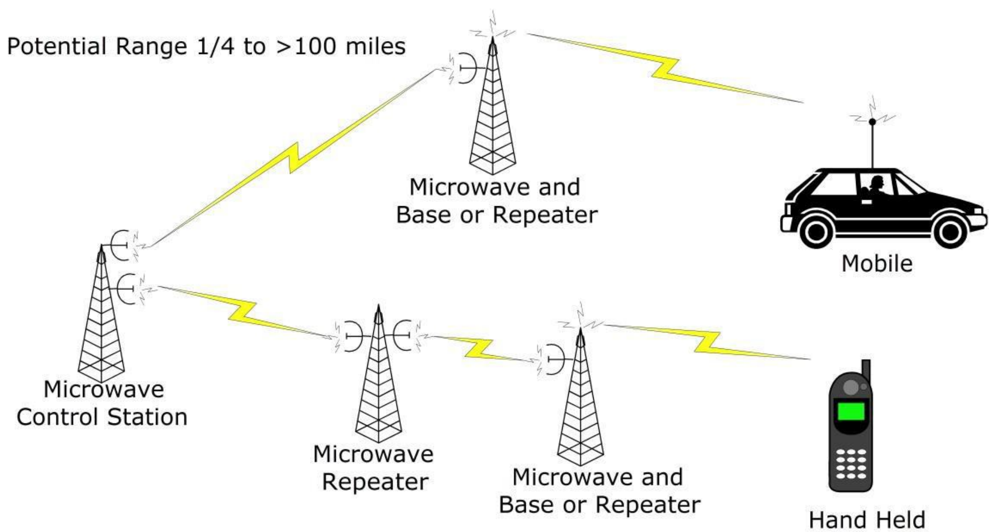


Figure 6 Microwave Radio Service

- **NLOS Microwave**

A NLOS Microwave radio is typically used for duplex communications from a fixed point with a tower mounted antenna. This service is always point to point and can point to multipoint as well. It does not require a LOS path. NLOS Microwave is normally at a frequency of 1GHz and up. This service can carry both analog and digital data and can simulate both the Control Station and Drop Link Control Station by terminating some control information and forwarding control information to additional NLOS microwave radio sites.

Depending on the location and terrain a NLOS microwave installation can have multi-channel duplex ranges of 20-100 miles. NLOS Microwave radios may not require a dish type antenna on both ends of the path.

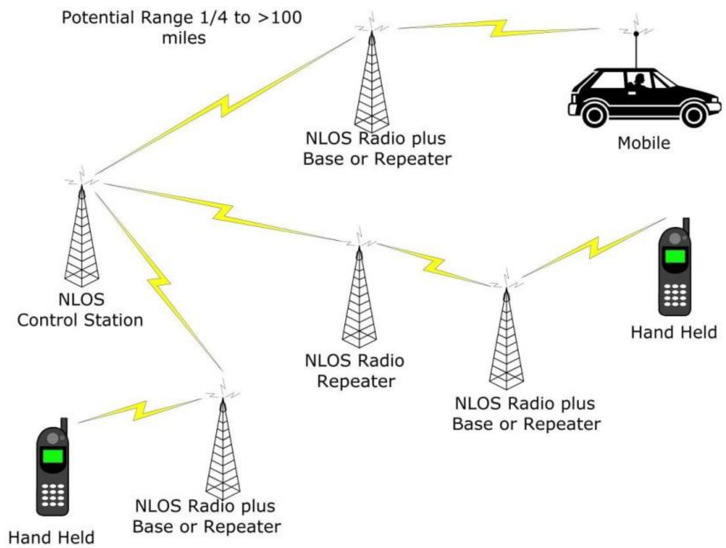


Figure 7 NLOS Microwave Service

- **Satellite**

A Satellite radio is the terrestrial end of a geostationary communications link. It is used for duplex audio and data from a fixed point.

This radio service will typically require a dish antenna and will need to be positioned at the point of use with portable or trailer mounted dish.

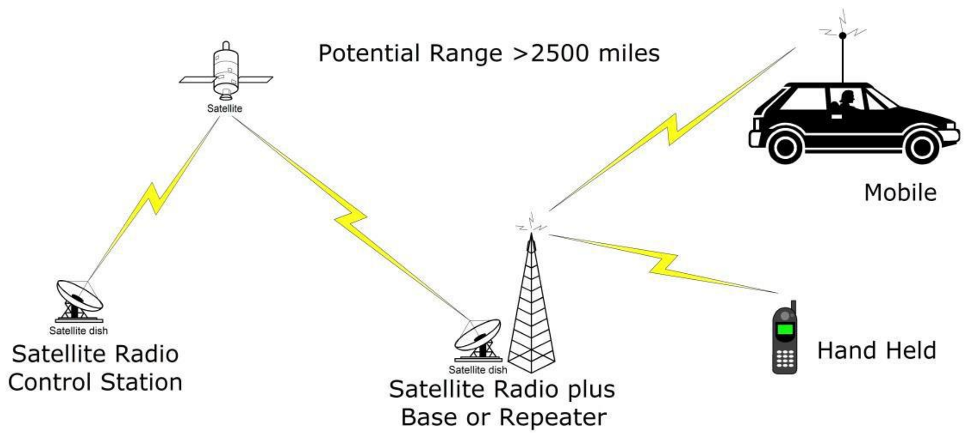


Figure 8 Satellite Service

Mode of Transmission

Mode of Transmission refers to the basic type of RF Carrier that is used to transfer information.

- ## Analog

When we refer to an Analog Mode of transmission, the RF Carrier contains some form of analog modulation that is being used to convey information. At some point a human operator can listen directly to a received transmission and recover information.

- ## Digital

When we refer to a Digital Mode of transmission, the RF Carrier is a true binary code stream that cannot be interrupted by a human operator without decoding the stream.

Modulation

- ## Modulation Type

Some form of Modulation is required to transmit and receive information. Previously we discussed different forms of modulation and saw that different radio services may be required to use a certain type of modulation in order to comply with system standards. Beyond standards compliance the different forms of modulation have varied feature sets and some provide advantages in signal to noise ratio, path loss and signal recovery. Digital types of modulation supply forward error correction and improve readability.

- **Amplitude Modulation (AM)**

Amplitude Modulation describes the method used to attach information, like voice, to a single frequency radio carrier. In the case of AM, the carrier frequency remains stationary and the voice audio is used to vary the transmit carrier and generate side bands containing the information. The downside to AM is that half of the carrier power is wasted in the carrier itself and not modulation. This type of modulation is used extensively on aircraft and in commercial broadcast radio. When noise and interference become an issue on AM transmissions; two alternate methods of AM are Morse Code (CW) and Single Side Band (SSB). In the case of CW the receiver only needs to determine carrier on or off. In the case of SSB, the carrier is filtered out and some of that power is put into the SSB modulation. SSB is the preferred type of modulation on HF radio communications.

- **Frequency Modulation (FM)**

Frequency Modulation improved on AM and uses 100% of RF transmit power to transfer information. By using a carrier that moves in frequency instead of amplitude there is no need for a carrier signal. The transmitted information causes the carrier frequency to change in relationship to an applied audio signal. FM typically refers to some form of voice or tone modulation that can be received directly from a receiver by a human

- ## Digital Modulation

Digital Modulation can be applied to an AM or FM carrier. The thing that makes it different is that any digital modulation requires some form of decoder to be received by a human. Typically Digital Modulation is applied to an FM carrier with a binary one sent as the highest deviation frequency and a binary zero sent as the lowest deviation frequency and nothing is used in between. A proprietary example of Digital Modulation is the Motorola TRBO Radio in TDM mode.

- ## P25 / NXDN Common Air Interface (CAI)

The Common Air Interface (CAI) is a standardized form of Digital Modulation that allows for non-proprietary digital communications between many different brands of radios. P25 and NXDN are two published CAIs that are in common use today.

Transmit / Receive

The purpose of 2-Way radio is to transmit and receive information. Three major factors come into play when we are setting up a communications system. The RF power output, Modulation and Receive Sensitivity factors are critical to having a working system.

• RF Power Level

RF Power is the first factor in how far you can communicate. The loss of power across space can be calculated. To better understand that loss we refer to RF Power in terms of dbm. This is done so that we are referenced against a standard power level that can be used in both transmit and receive signal level calculations. As an example a 100 watt transmitter would be suppling a +50dbm signal. Figure 8 shows RF power in dbm starting at 0dbm.

Power (W/mW)	dBm	Power (W/mW)	dBm
200 W	53	2.5 W	34
100 W	50	2 W	33
80 W	49	1.6 W	32
64 W	48	1.25 W	31
50 W	47	1 W	30
40 W	46	800 mW	29
32W	45	640 mW	28
25 W	44	500 mW	27
20 W	43	400 mW	26
16 W	42	320 mW	25
12.5 W	41	250 mW	24
10 W	40	200 mW	23
8 W	39	160 mW	22
6.4 W	38	125 mW	21
5 W	37	100 mW	20
4 W	36	10 mW	10
3.2 W	35	1 mW	0

Figure 9 Watts to dbm

• Receiver Sensitivity

Receive Sensitivity is the third factor that is involved with a 2-Way transmission. As shown in the previous section, Figure 9 begins with 0dbm and goes up from there. A receiver is measured down from 0dbm with a typical sensitivity of -107dbm or 1 microvolt.

dBm TO MICROVOLTS CONVERSION CHART (For 50 Ω System)

dBm	uV	dBm	uV	dBm	uV
0	224,000	-47	1,000	-94	4.47
-1	200,000	-48	891	-95	3.99
-2	178,000	-49	795	-96	3.55
-3	159,000	-50	709	-97	3.17
-4	141,000	-51	633	-98	2.82
-5	126,000	-52	563	-99	2.52
-6	112,000	-53	501	-100	2.24
-7	100,000	-54	447	-101	2.00
-8	89,100	-55	399	-102	1.78
-9	79,500	-56	355	-103	1.59
-10	70,900	-57	317	-104	1.41
-11	63,300	-58	282	-105	1.26
-12	56,300	-59	252	-106	1.12
-13	50,100	-60	224	-107	1.00
-14	44,700	-61	200	-108	0.891
-15	39,900	-62	178	-109	0.795
-16	35,500	-63	159	-110	0.709
-17	31,700	-64	141	-111	0.633
-18	28,200	-65	126	-112	0.563
-19	25,200	-66	112	-113	0.501
-20	22,400	-67	100	-114	0.447
-21	20,000	-68	89.1	-115	0.399
-22	17,800	-69	79.5	-116	0.355
-23	15,900	-70	70.9	-117	0.317
-24	14,100	-71	63.3	-118	0.282
-25	12,600	-72	56.3	-119	0.252
-26	11,200	-73	50.1	-120	0.224
-27	10,000	-74	44.7	-121	0.200
-28	8,900	-75	39.9	-122	0.178
-29	7,950	-76	35.5	-123	0.159
-30	7,090	-77	31.7	-124	0.141
-31	6,330	-78	28.2	-125	0.126
-32	5,630	-79	25.2	-126	0.112
-33	5,010	-80	22.4	-127	0.100
-34	4,470	-81	20.0	-128	0.0891
-35	3,990	-82	17.8	-129	0.0795
-36	3,550	-83	15.9	-130	0.0709
-37	3,170	-84	14.1	-131	0.0633
-38	2,820	-85	12.6	-132	0.0563
-39	2,520	-86	11.2	-133	0.0501
-40	2,240	-87	10.0	-134	0.0447
-41	2,000	-88	8.91	-135	0.0399
-42	1,780	-89	7.95	-136	0.0355
-43	1,590	-90	7.09	-137	0.0317
-44	1,410	-91	6.33	-138	0.0282
-45	1,260	-92	5.63	-139	0.0252
-46	1,120	-93	5.01	-140	0:0224

Figure 10 Rx Sensitivity in dbm

Antennas

- **Types**
    - Non-Directional
    - Directional
- **Models**
    - Indoor / Outdoor
    - Vertical / Horizontal Polarized
    - Unity Gain / Ground Plane
    - Collinear array / Downtilt
    - Yagi
    - Corner Reflector
    - Parabolic Dish
- **Patterns**
    - Based against a ¼ wave vertical goundplane as 0db gain
    - Uses the physical and electrical environment to modify pattern shape
    - Configurations depend on operating frequency and location
- **Gain**
    - Gain is achieved by redirecting existing RF energy
    - Uses the physical and electrical environment to modify gain
    - Configurations depend on operating frequency and location

- **Loss**
  - Loss is achieved by redirecting existing RF energy
  - Uses the physical and electrical environment to modify loss
  - Configurations depend on operating frequency and location
- **Propagation**
  - Effected by Sun spot and atmospheric conditions
  - Depends on frequency
  - Propagation must be considered when selecting an antenna
- **Fade**
  - A loss of signal strength caused by environment or propagation
  - Always factor in a 20db Fade Margin
  - In a point to point configuration, Fade Margin must be considered
- **Polarization**
  - Vertical, Horizontal or Circular
  - Depends on radio service used

Link Path Profile

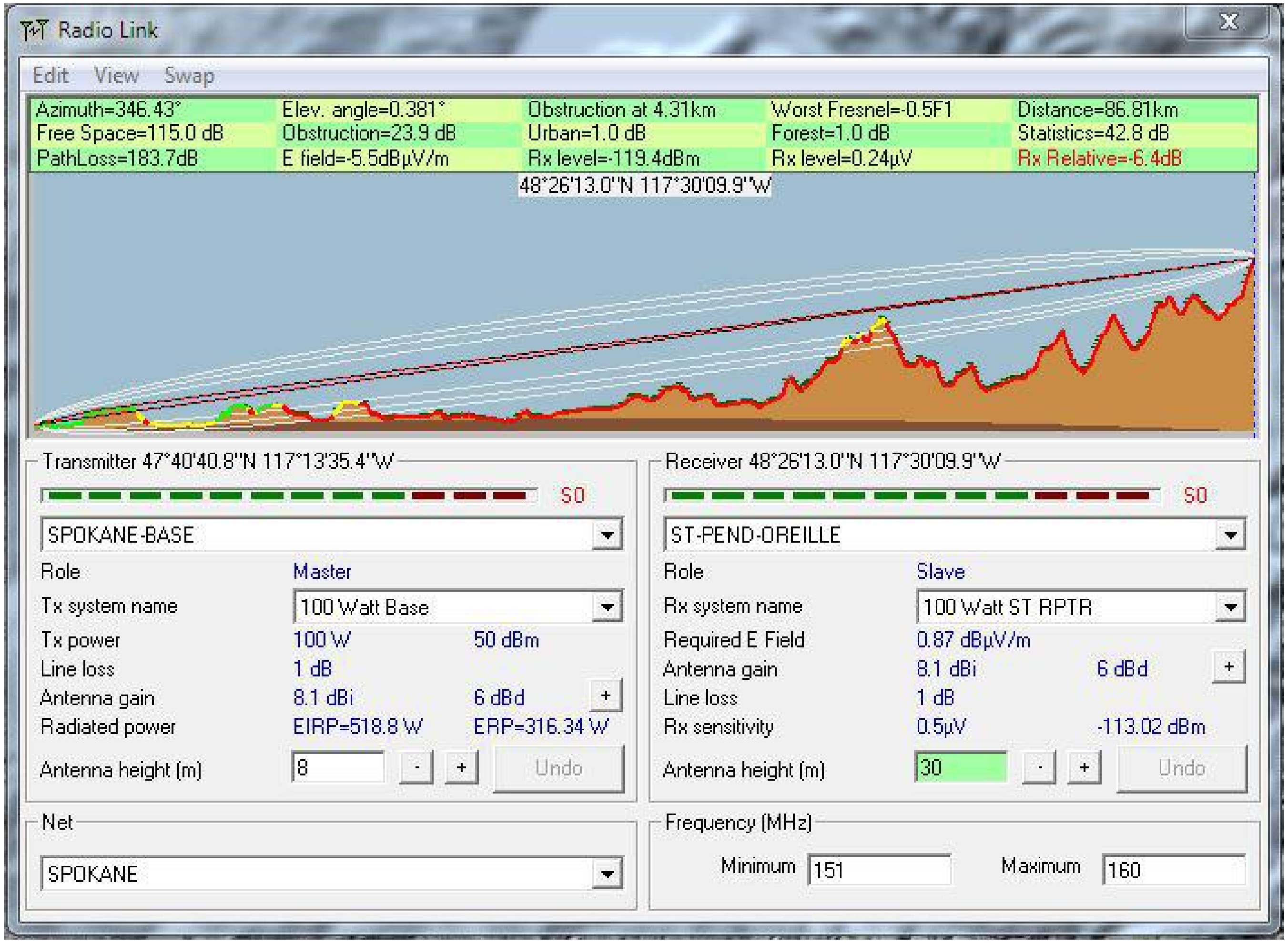
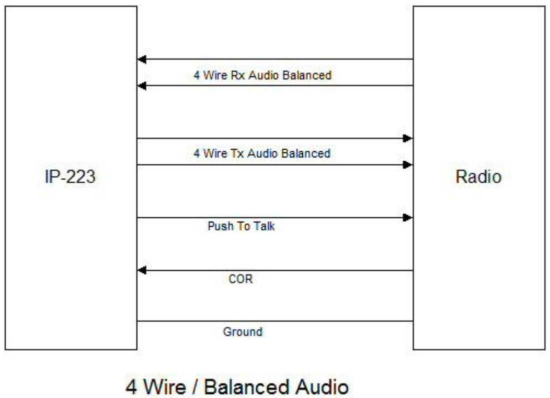


Figure 11 Path Profile

Radio Control

Local Control



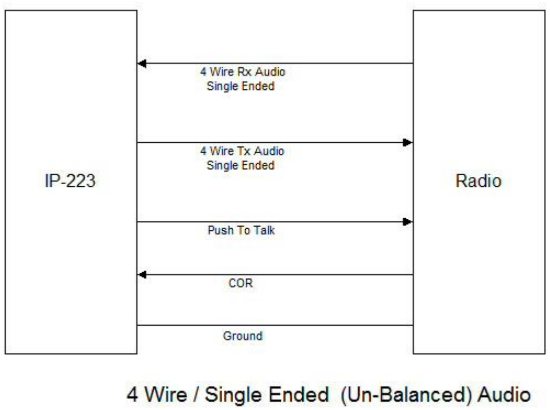
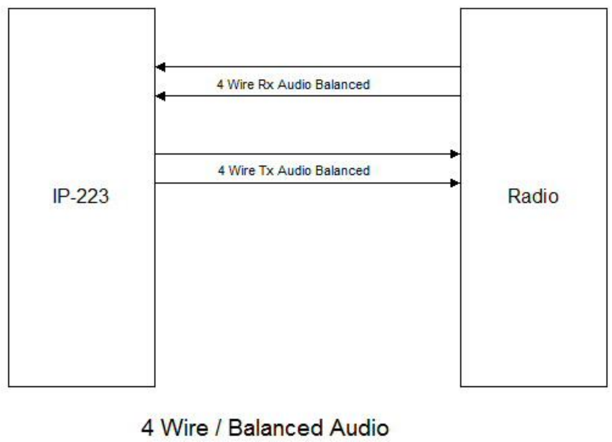


Figure 12 Local Radio Control

Tone Control



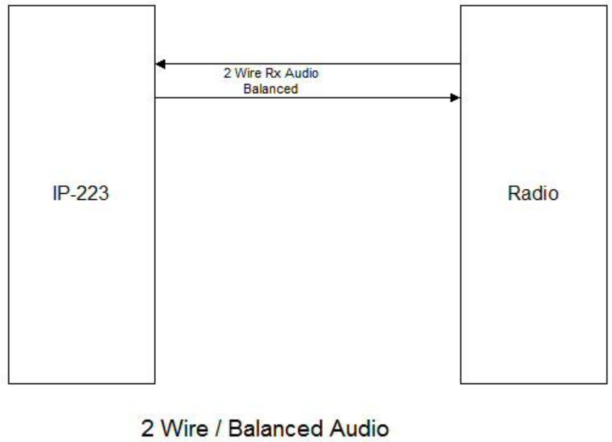
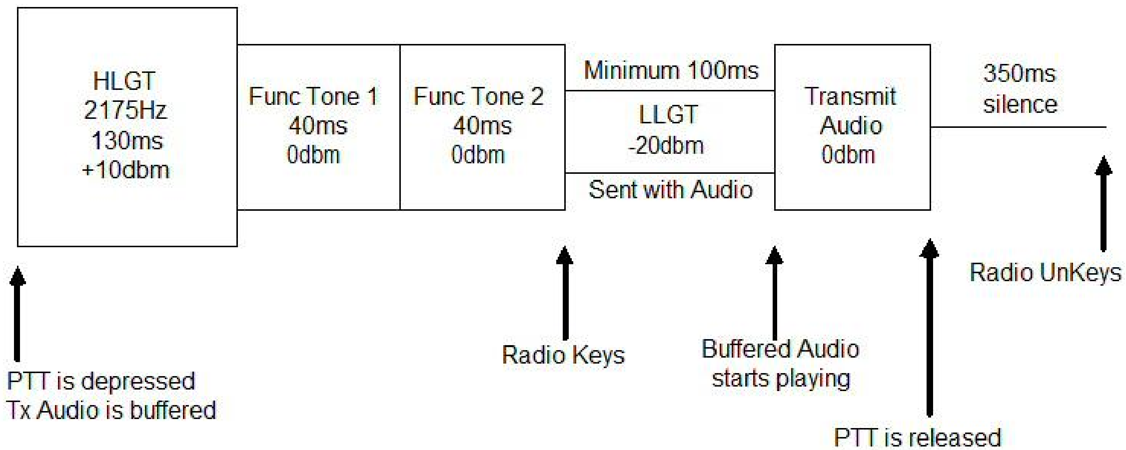


Figure 13 Tone Control

2175Hz Tone Control Format



2175Hz Tone Signaling

PTT sequence begins with HLGT (High Level Guard Tone) that lasts for 130ms and is sent at a level of +10dbm. Following the HLGT are two Function Tone Slots of 40ms each at a level of 0dbm. At the end of the Function Tones the transmitter is keyed up. A LLGT (Low Level Guard Tone) is summed with the dispatch audio and is required to keep the transmitter keyed. LLGT stops when the PTT button is released, radio unkeys after 350ms of silence.

Figure 14 TRC Format

RoIP Integration for Remote Sites

Transmit / Receive Audio and Signaling

- Line Levels - dbm
  - dbm = 1 mW across 600 ohms
  - 0dbm and -10dbm are commonly used
  - Measured with a Line Test Set

- Transmit Modulation and Receive Audio
  - 0dbm Tx Level should yield ~2.2kHz modulation
  - 2.2kHz modulation should yield 0dbm Rx Level
  - .4kHz modulation should yield ~ -20dbm Rx Level

- Receive Audio Gating - CTCSS / DCS
  - CTCSS (Continuous Tone Coded Squelch System)
  - DCS (Digital Coded Squelch)
  - COR (Carrier Operated Relay) Signal
  - TOR (Tone Operated Relay) Signal
  - Not used in 2175Hz Tone Signaling

- ANI and Signaling
  - Analog - DTMF, Fleetsync, MDC 1200
  - Digital - TRBO, NXDN, DFSI
  - Serial Control

Ethernet Network Essentials

Open Systems Interconnection Model

Line Standards on the Wire
- Bitrate / Timing
- Voltage levels
- Cable loss
- Pinouts

Ethernet Speeds, data types
- Protocol overhead
- Broadcast
- Multicast
- MAC Address
- Hexadecimal numbers

Basis for LAN, WAN, Internet definitions

OSI v TCP/IP Model
- The function is identical
- The TCP/IP model combines OSI layers 1 and 2 into the Network Layer
- The TCP/IP model combines OSI layers 3 and 4 into the IP Layer

Open System Interconnection Model[3]

OSI Model			
	Data unit	**Layer**	**Function**
Host layers	Data	7. Application	Network process to application
		6. Presentation	Data representation and encryption
		5. Session	Interhost communication
	Segment	4. Transport	End-to-end connections and reliability
Media layers	Packet	3. Network	Path determination and logical addressing
	Frame	2. Data Link	Physical addressing (MAC & LLC)
	Bit	1. Physical	Media, signal and binary transmission

TCP/IP Model shown with colors. Light Green is *Network Layer*, Light Blue is the *Internet (IP) Layer*, Dark Blue is the Application Layer.

[3] Courtesy of Wiki. The TCP/IP Protocol Stack combines Layers 1 & 2 as well as 3 & 4.

Protocols

Protocol Standards for Levels 1 – 7
- ARP, IGMP, NAT, DNAT, NTP, SIP, QoS, VPN, DNS, FTP, SSH, DHCP, POP, SMTP, HTTP are examples of protocols using the OSI Model

What do you need to know?

Subnet - LAN, WAN, VLAN, etc
- Logical group of Network Hosts
- As small as 2 hosts
- Can be over 16,000,000 hosts

End to End - Connection vs. Connectionless
- Setup Time
- Round-Trips
- Header size
- Error tolerance

Package - TCP[4], UDP[5], Multicast, Packets
- TCP is guaranteed delivery
- UDP is catch this if you can
- Multicast is a special type of UDP
- Bandwidth is bytes/packet * packets/sec
- Maximum ~15,000pps on 10Mb Ethernet

[4] UDP - User Datagram Protocol
[5] TCP - Transmission Control Protocol

Host Location

Location - MAC[6] Addressing, IP[7] Addressing

- Every NIC has a unique MAC Address (48 bits)
- Every NIC can have multiple IP Addresses (32 bits)
- Every IP Address has 65,535 ports each for TCP and UDP
- There are special ranges of IP Addresses

- Multicast Addresses
  - 224.0.0.0 – 239.255.255.255
  - (IP Address begins with 1110)
  - Can be Routed

- Non-Routable Intranet Address
  - 192.168.0.0- 192.168.255.255
  - 10.0.0.0-10.255.255.255
  - 169.254.x.x APIPA (Automatic Private IP Addressing)
  - Still Routable on the Intranet

- Everything else is a Routable Internet Address

[6] 281,474,976,710,656 possible MAC Addresses
[7] 4,294,967,296 possible IP Addresses

Subnet Mask

- Subnet Mask defines the size of the subnet
- Used to break up a larger Subnet
- 255.255.255.0 or /24 allows 254 hosts
- 255.255.255.248 or /29 allows 4 hosts

<u>Example</u>
11111111111111111111111100000000 = 255.255.255.0 or /24
11111111111111111111111111111000 = 255.255.255.248 or /29

Host Identification

Unicast Host Name Resolution (Layer 3) - DNS
- Maps a URL (Uniform Resource Locator) to an IP Address
    - www.phase4.org = 50.194.58.225
- IP Address is 32bits
- One IP Address can have many URL’s
    - www.hostnw.net = 50.194.58.225
- Depends on a Registrar of Record for Internet Addressing
- Uses Port 53, for both UDP and TCP transactions

Unicast Subnet Address Resolution (layer 2) - ARP
- Hard coded into the Ethernet device
- Unique across the universe
- Maps an IP Address to a physical Ethernet Card
    - 10.0.1.239 = 60:6b:9e:a6:ea:17
- MAC Address – 48bits
- One MAC Address can have many IP Addresses
- Depends on the ARP Protocol to locate a host

Packet Routing

Classful v Classless Network Addressing (layer 3)
- Class A, Class B, Class C, Class D
- Class E 240.x.x.x/4
- CIDR (Classless Inter Domain Routing)
- Divides Classful space into smaller address ranges
- Uses the Netmask to filter packets into subgroups
    - 50.194.58.225/29 = netmask 255.255.255.248
    - A /29 network yields a subnet of 8 host addresses
    - The subnet must be on Network Boundary
    - The subnet will always have a DG and BRDCST Address
    - In effect a /29 network has 6 usable host addresses

VLAN (Virtual Local Area Network)
- Generally implemented at Layer 2
- Provides a logical grouping of Ethernet MAC Addresses into a separate subnet
- Requires a managed Layer 2 device to configure VLAN

Unicast Routing
- Requires a single Source and Destination IP Address
- Respects netmask settings
- Supports routing protocols like RIP, OSPF, etc.
- Allows for filtering on IP Address, MAC Address, port and packet type
- Forms the basis for NAT, DNAT, DMZ, Firewall, etc.
- Allows for packet encapsulation protocols
- Provides support for QoS protocols like DSCP, port or address marking
- Does not typically pass Multicast Packets

Multicast Routing

- Not generally supported in Unicast Routers
- Introduces the Listener Host
- MC Branch Addresses maintained by Switch or Router
- MBone (Multicast Internet Backbone)
- Internet Gateway Management Protocol (IGMP)
    - Version 2
    - Version 3
- Direct Address Mapping

A Multicast MAC Address is a combination of an IANA OUI and the Multicast IP Address. (Magic Number)

Multicast Subnet Address Resolution (layer 2)
- Soft coded into the Ethernet Network device
- Ignores netmask, MC is only on subnets with MC Listners
- Unique across the subnet (?)
- Maps an IP Address to a physical Ethernet Card
    - 239.0.0.5 = 01:00:5e:00:00:05
    - 224.0.0.5 = 01:00:5e:00:00:05
- MAC Address – 48bits
- Each MC IP Address has a single MC MAC Address

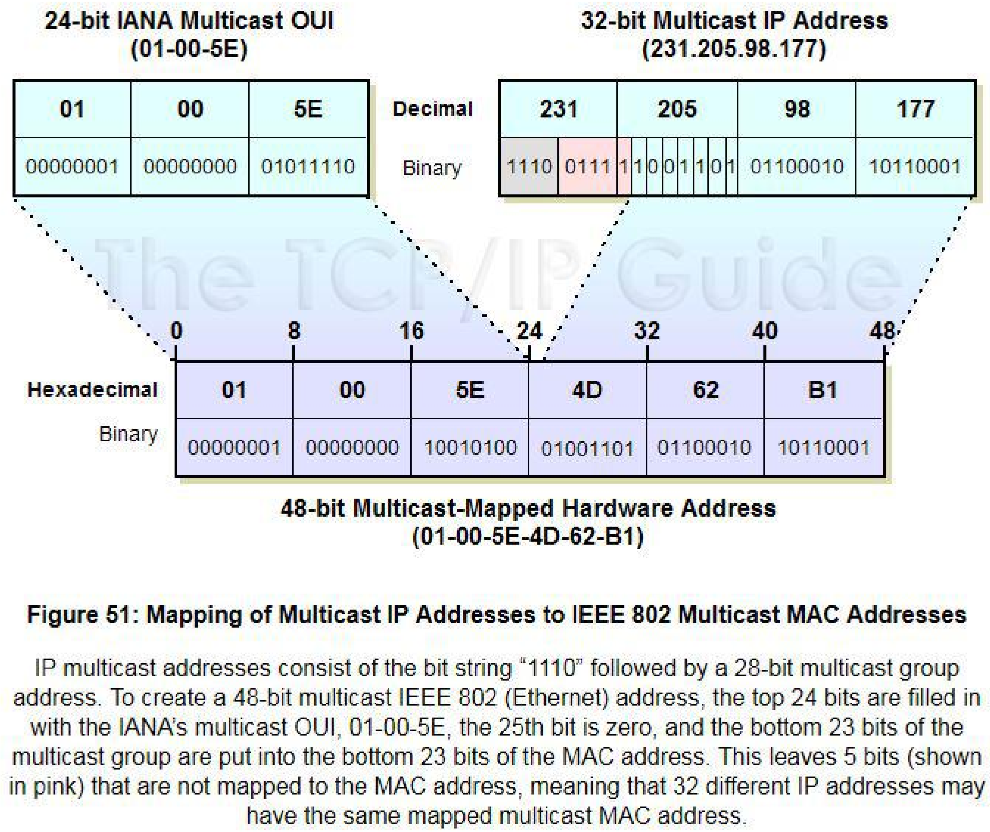


Figure 15 Multicast MAC Creation

Sourced from "The TCP/IP Guide" TCP/IP Address Resolution For IP Multicast Addresses
http://www.tcpipguide.com/free/t_TCPIPAddressResolutionForIPMulticastAddresses.htm
September 20, 2005, Charles M. Kozierok.
Because of the way a Multicast MAC Address is created there is the possibility of different MC Addresses creating the same MC MAC Address.

RoIP Integration for Remote Sites

VPN (Virtual Private Network)

- Typically implemented at Layer 3
- Normally uses encryption
- PPTP, IPSEC, Proprietary (DCB)
- Creates a virtual flat network for Multicast packets

The network shown below illustrates how a VPN can be created within an existing unicast network. This subnet can have completely different IP Addressing schemes as the host network.

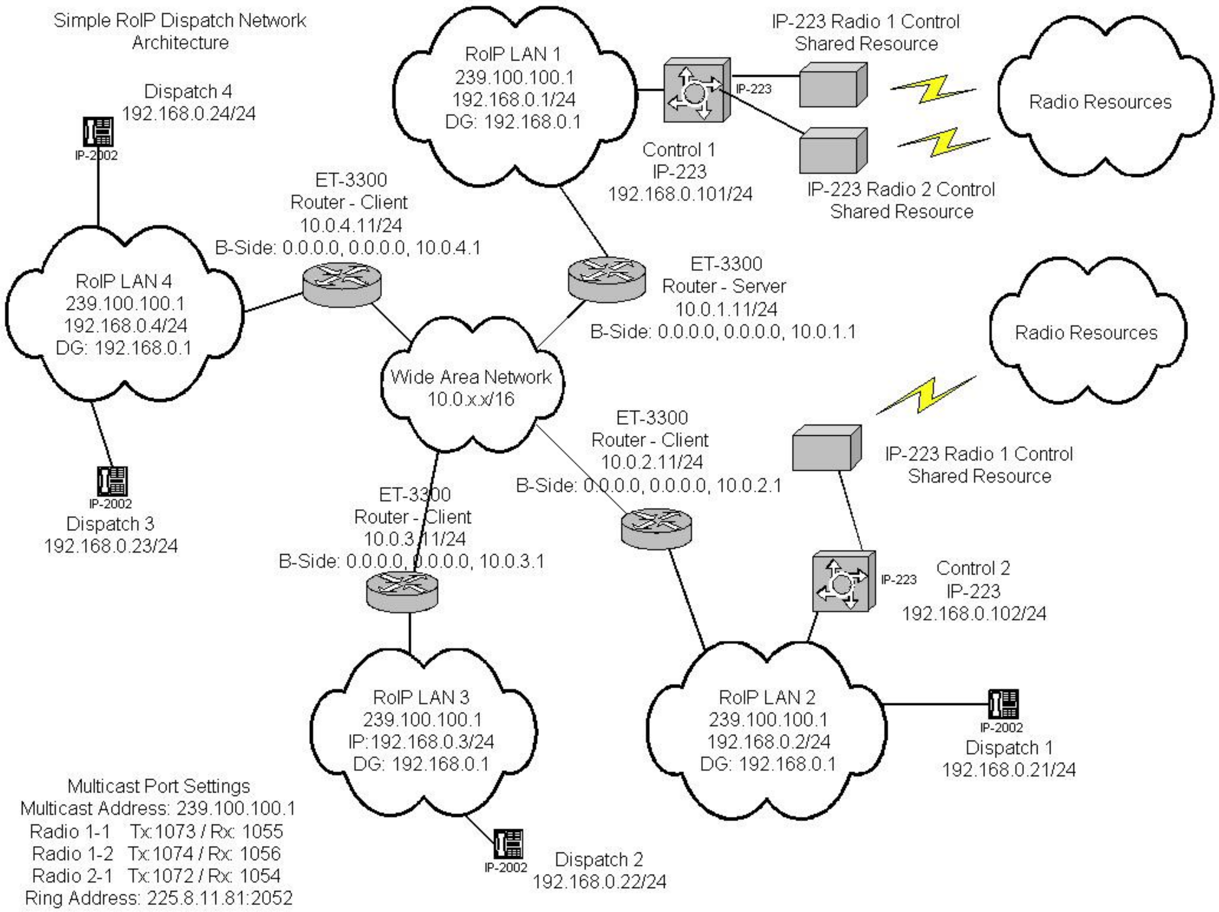


Figure 16 RoIP System using VPN