Packet Data Networks and Microwave RF Repeaters

Longer, Faster, More Reliable

Introduction

Communications networks are rapidly moving toward all packet based[1] technologies. Microwave radio equipment has developed to not only serve packet networks but to take advantage of characteristics previously unavailable in digital TDM[i] networks.

Peninsula Engineering Solutions' Microwave RF Repeaters have continued to find excellent applications in digital, packet data networks. This note describes how Peninsula's RF Repeaters not only fit but provide advantages to all packet networks.

Packet Capacity

Microwave channel plans conform to national and international standards. The widest channels are normally 30 and 40 MHz, particularly below 18 GHz. The available capacity is limited by the channel bandwidth and modulation complexity. Microwave RF Repeaters support the widest standard channel bandwidths: 28, 30, 40 and 56 MHz. Microwave RF Repeaters support modulations from simple FSK and QPSK through complex 256QAM and 512QAM and more.

Table 1, Typical capacities supported, Mb/s

	Channel Bandwidth, MHz			
Modulation	28 (ETSI[ii])	30 (FCC[iii])	40 (ETSI, FCC)	56 (ETSI)
32QAM	125	125	180 Mb/s	250
64QAM	150	150	225	300
128QAM	180	200	250	350
256QAM	200	225	300	450
512QAM	225	250	350	500

Networks that require greater capacity than can be provided by a single channel will normally operate two or more radio channels in parallel over the same hop. Typically the radio channels are on different frequencies. Certain radio equipment is capable of reusing one channel twice by employing both vertical and horizontal polarizations simultaneous. The microwave antennas provide 30 to 40 dB of discrimination between polarizations. The radio equipment has the capability of cancelling interference due to cross polarization leakage or interference. This capability is termed: Cross Polarization Interference Cancellation or XPIC[iv]. Peninsula's RF Repeaters can support multi-carrier XPIC operation over 2 hops and up to 16 duplex channel pairs[v].

Low Latency

The direct linear amplification scheme of Peninsula's true Microwave RF Repeaters results in very low latency or propagation delay through the repeater equipment. Typical per channel latency in 30 and 40 MHz bandwidth RF Repeaters is 100 to 150[vi] nanoseconds, measured from antenna port to antenna port. 150 nsec is equivalent to approximately 150 feet or 45 meters of microwave signal propagation through air. Typical digital microwave radio equipment in repeater configuration has a latency of 100 to 700 microseconds measured from antenna port to antenna port. Peninsula's true microwave RF Repeaters offer a low latency advantage unmatchable by digital microwave radio repeaters.

Table 2, Comparison of Latency Values

			Microwave Propagation in air	
Latency	Microseconds µsec, µs	Milliseconds msec, ms	Feet	km
100 ns	0.100	0.00010	98	0.030
150 ns	0.150	0.00015	147	0.045
100 µs	100	0.100	98,328	30.0
150 µs	150	0.150	147,491	45.0
300 µs	300	0.300	294,983	89.9
500 µs	500	0.500	491,638	149.9
700 µs	700	0.700	688,293	209.8
1000 µs	1000	1.000	983,276	299.7

VoIP

Voice over IP (VoIP) is an application where low latency and low jitter are important in providing best performance to the end users. Voice (VoIP) is real time traffic as opposed to non-real time data traffic. Round trip delays greater than 10 ms are noticeable to talkers. Round trip delays greater than 300 ms are uncomfortable for talkers and listeners due to the interactive nature of human speech. Jitter can result from packets arriving at different rates or even out of order. Packet routing over a variety of paths, channels and networks is the primary cause of jitter.

[1] Ethernet, Packet Data, Internet Protocol (IP)

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RF Repeaters pass the entire traffic channel spectrum at once without breaking down the traffic to packet levels. As a result, RF Repeaters introduce no packet jitter.

Echoes can occur when there is a reflection from a distant point such as a 2-wire telephone set. Long echoes in the order of 300 to 500 ms and more are often disruptive to human speech patterns. Minimizing the transmission latency will also reduce the echo delay time.

Database Access

Remote database access has become a vital part of today's business information management. Businesses and organizations with multiple physical locations typically need to share common information often residing in computer databases. While it is possible to provide remote access via secure IPsec VPN[vii] over public Internet, the latency and jitter can be worse than that required for good performance. Database applications such as "Fat Client" ERP and MRP often require multiple query/response actions to complete a transaction. If the network round trip latency is more than even 20 ms, the effect is slower performance as the multiple delays accumulate. 100 mile VPNs over public Internet can have latencies of 50 to 100 ms or more.

Organizations may elect to use dedicated, low latency, networks between major centers as a way to improve database performance. Regional medical centers and clinics linked together are a good example. Private microwave radio can reduce round trip latency below VPNs and on par or better than leased fiber optic data service. The cost of a private microwave network can be less than fiber providing capacity demand is met.

Microwave networks spanning multiple hops between data centers can be built with microwave RF Repeaters between radio terminals since data service is limited to the ends. RF Repeaters have very low latency and can result in 100 mile, 4-hop paths with less than 800 µsec or 0.8 ms. An all microwave radio 100 mile design would have 130 µsec or 1.3 ms latency at best.

Microwave RF Repeaters are an advantage when networks must meet stringent SLA[viii] and QoS[ix] objectives.

Financial Trading

Financial trading has become dependent on fast access to stock or commodity exchange databases. While co-location of trading computers provides the fastest connections, not every trader can be or afford to be close. Remote access is the next best solution. The fastest, lowest latency solutions include dedicated fiber optic channels and private microwave radio networks. As described in the database section, Microwave RF Repeaters can be used to advantage in building fast, low latency networks over longer distances. Multi-hop microwave links using tandem RF repeaters can offer lower latency than is possible with dedicated single mode fiber optic links.

Adaptive Coding and Modulation

Packet data based networks are built to tolerate temporary delays due to congestion or path interruption. Non-real time message data is well suited to deal with variable transmission delays and routings. Real time voice (VoIP) over packet networks does not tolerate such variations as discussed in the VoIP section.

Adaptive Coding and Modulation, ACM, is a technique where the microwave radio equipment can change its carrier modulation as propagation conditions dictate. For example; when conditions are good, the link can support 200 Mb/s at 128QAM, then, when a fade occurs, the modulation is reduced to 16QAM and supports 100 Mb/s traffic. The reduction in modulation can increase the system gain by 8 to 10 dB, thus improving reliability at the expense of temporary increase in latency.

To effectively use ACM[x] in mixed real time and non-real time traffic, it is important to assign the real time traffic to higher priority QoS in order to reserve core capacity when modulation complexity is reduced.

ACM enables longer hops or smaller antennas to be used and still meet reliability objectives. When ACM capable radios are combined with RF Repeaters that support ACM, then highly reliable microwave networks can be built in difficult situations more easily than with TDM and fixed modulation radio equipment.

Peninsula Engineering's microwave RF repeaters support ACM by setting linear output power for the most complex modulation employed on the link. As modulations are reduced, the

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RF repeater maintains linear operation and gains the benefit of the improved radio receiver threshold and system gain.

Tandem Repeaters

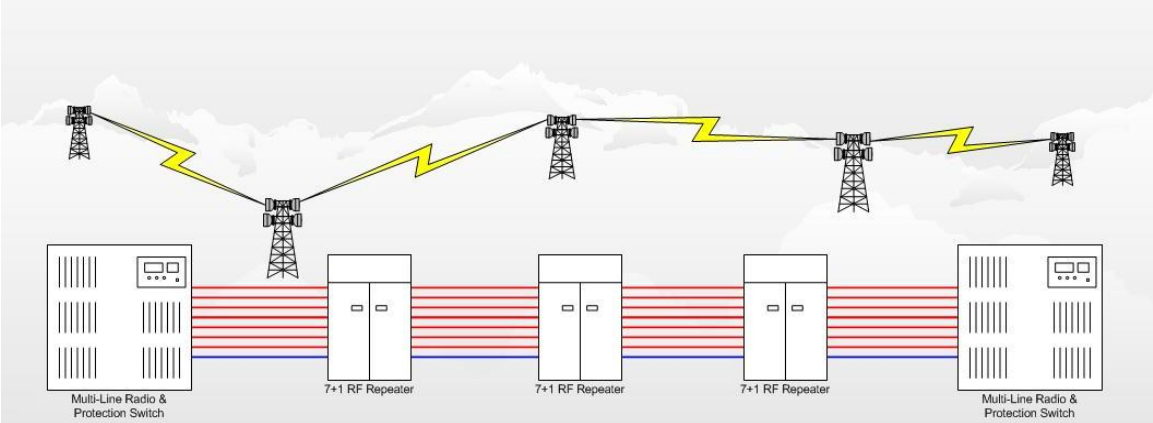
Microwave RF Repeaters are well suited for longer packet data networks. RF Repeaters can be connected in tandem[xi] between a pair of terminal radios. The number of tandem repeaters depends on channel bandwidths, modulation, amplitude and delay distortions and propagation dispersion. Channel static delay equalization and adaptive equalization provide strong countermeasures to channel distortions.

The typical upper limit in the number of tandem RF repeaters is 3 to 5. This results in 4 to 5 radio hops comprising a modulation section. Modulation sections can span 100 to 150 miles[xii].

Conclusion

Peninsula Engineering Solutions' Microwave RF Repeaters are compatible with the best features and capabilities of modern digital packet data microwave radios. The use of Peninsula's RF Repeaters in packet data networks results in longer, faster and more reliable microwave networks than ever before!

Figure 1, Multi-hop modulation section



[i] TDM: Time Domain Multiplex technology, e.g. T1, DS1, E1, ATM, SDH, PDH.

[ii] ETSI: European Telecommunications Standards Institute, European Union and worldwide.

[iii] FCC: Federal Communications Commission, United States of America.

[iv] XPIC: Cross Polarization Interference Cancellation.

[v] Capacity example: 16 x 200 Mb/s = 3200 Mb/s or 3.2 Gb/s route cross section capacity.

[vi] 150 nanoseconds latency or propagation delay is typical of group delay equalized RF repeaters.

[vii] IPsec VPN: Internet Protocol security, Virtual Private Network; a standard that defines secure point-to-point packet connections.

[viii] SLA: Service Level Agreement: Statement or Contract covering measured performance objectives.

[ix] QoS: Quality of Service. Objective may be included in an SLA.

[x] ACM: Adaptive Coding and Modulation; a technique to improve link propagation reliability in packet based networks.

[xi] Peninsula Application Note 650-1006-01 Multi-line Capability in Microwave RF Repeaters

[xii] Modulation Section distance is equivalent to: 165 to 250 km.

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