Implementation of a 1 Mbps Packet Data Link Using 10 GHz RF

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Abstract

Presented is the design and the authors' experiences with implementation of an Amateur Radio Packet Data Link operating at one megabit/sec. The technology used is FSK modulation of Gunnplexors in the 10GHz amateur RF allocation. The digital interface is to an IBM PC bus using the PCLAN (SYTEK 6120) adapter card running the KA9Q implementation of TCP/IP suite of protocols.

Need for faster links

Faster links support the movement of higher traffic volumes. This can also be stated as latent demand for service. If a user knows it will take longer to deliver a mail message electronically, than to put a stamp on it and send it via the USMAIL, then he won't even bother with E-mail.

Higher traffic volumes also come as a result of new applications attracting more users. Examples of new applications include DX spotting network software, on-line call book databases, and distributed applications such as the ARES/Finder program by WN6I and N6KL.

Some applications have real-time response time criteria, such as remote control of repeaters and digitized repeaters. Higher baud rates are needed before these applications can even become usable. Keyboard to Keyboard QSO's could be viewed as a real-time application.

Why use Microwave for Higher Speed Packet?

The best explanation is simply the price to performance ratio. For about the same expense as a complete 2M packet station running at 1200 bps, one end of a 1 Mbps, 10 GHz link can be constructed. Add in the benefit of being able to build it versus buy, and there is no comparison.

The major cost items are the Gunnplexor ($50), the parabolic reflector ($35), and parts for the I/O adapter ($150).

Bandwidth is another major factor in the choice of microwaves. Data rates and bandwidth needed are directly proportional. In fact, the microwave bands are the only ones with sufficient not in-use bandwidth to support higher speeds.

Another major factor in the choice of microwaves is antenna sizes. At microwave frequencies, antennas of reasonable size are better able to focus the transmit power in the direction desired and not waste it in directions where the receiver is not positioned.

Microwave Modem Theory of Operation

The microwave modem is based on Gunnplexor transceiver units used in such items as motion detectors, radar guns, and radar detectors. The model chosen for the initial prototyping is the NEC ND751AAM. Other units, including the MA/COM will work as well.

The units operate in pairs and the transmit frequencies differ by the first i-f frequency of the receivers. Therefore the LO for the first conversion stage is the locally transmitted signal. Data carrier Detect (DCD) will not be present in either unit until both units are transmitting and the antennas aligned.

The Gunnplexors produce 5 to 10 milliwatts of power, which is feed into a parabolic reflector. A pyramidal horn and a short section of waveguide are built to properly illuminate the reflector. With a two foot diameter reflector and a f/D of .46, the system will have a gain of 33 dB.

Modulation is FSK. Frequency shifting of the Gunnplexor is done by varying the bias voltage of the transceiver with a LM317 adjustable three terminal regulator. ECL differential drivers (MC10116) are used to allow long data lines with some noise immunity.

The FSK receiver performs a second conversion with the second LO running between 135 and 165 (nominal 150) producing a second i-f of 45MHz. Detection and conversion is performed by a MC13055 FSK IC. This chip is spec'd to run at 2 Mbps, but we have pushed it to 10 MBps. Data out is in the form of ECL differential drivers.

Because the Gunnplexors are not frequency locked and may wander with temperature and over time, an AFC is implemented on the incoming data and adjusts the second LO to keep the data centered on 45 MHz (the second i-f). A search oscillator is included as well to sweep the second LO should the two units loose carrier lock.

The Gunnplexor, modulator, and a receive preamplifier assembled with MMICs are all mounted in a box at the feed point of the parabolic reflector.

Output from this box, and down from the pole is the first i-f -- 105 MHz. The remaining FSK receiver components are assembled in a box adjacent to the computer. One end of a link consumes 450ma @ 12VDC.

In the initial units, an audio channel was provided to assist in debugging the digital side and help with alignment of the antenna.

Digital Theory of operation

The original intend of the project was to use standard issue PC 802.3 adapter cards. N3EUA had the idea to slow them down to 2 Mbps by changing the crystal from 20 MHz to 4 MHz. However, commercial ethernet adapters just can't be slowed down so easily. The serial interface chip in each commercial adapter quit working if it wasn't within .001% of 10 Mbps. This chip accepts the TTL NRZI frame format the 802.3 controller chips put out, adds clocking, and produces Manchester encoding.

The PCLAN card introduced by IBM some years ago runs 802.3 at 1 Mbps over CATV coaxial systems. This card is also known as the SYTEK 6120. It has on a full length PC adapter card a 80186 microprocessor, RAM, ROM, 82586 802.3 controller, and a custom serial interface chip.' Modulation technique is FSK. The unit is full duplex and operates split. The S/W on this card implements the IBM PC Netbios interface.

Along with the IBM PC network program, this represented IBM's first PC LAN product. This setup is ideal for Amateur Radio as well. Build a pair of microwave links between your QTH and a good friend's QTH. Now you can access each others hard disk.

To use the PCLANA with the microwave modems, connection is made to the TTL serial interface chip directly. The RF modem on the card is not used whatsoever and is disconnected for this application.

Connection to the serial interface chip requires a TTL to ECL converter and a DCD generator. The microwave modems supply continuous DCD, since they are always transmitting/receiving. The microwave DCD really indicates DSR.

The serial interface chip doesn't use DCD to delimit data, but to determine if the Ethernet has been jammed by a hot transmitter. If DCD is active beyond a fixed time amount, it will declare the cable jammed, and enter a state where it refuses to do anything.

While DCD is used to detect jammed cable, the adapter will not sample for 802.3 preamble until DCD is true. The interface adapter would bring DCD true on the first low to high data bit transition, and also start a re-triggerable one shot. Each low to high transition would restart the one-shot. When the one-shot expires, DCD is brought false.

Initial testing of the interface was with the IBM PC network program. This software package allows PC's to share disk drives. Initial testing was easy. Start the network program, separate the PCs by some reasonable distance, and copy the entire hard disk from one machine to the other.

This could have been a place to stop, but not for us! A packet driver was implemented using the datagram mode of the PCLANA. FTP, inc placed in the public domain a specification for a standard way to interface PC based TCP/IP software packages to ethernet cards. The intent was to have one way to access all the different cards commercially available. When a new card came along, someone could write the driver to support it.

The ever popular KA9Q package has a provision to 'attach' interfaces as packet drivers. Using this interface made the most sense, and has worked well.

Our Experiences

Aligning the parabolic reflectors turned out to be the most challenging part. The path must truly be line of sight (LOS). Microwave propagation is not like VHF or even UHF. The dishes must be pointed at each other within two degrees and have stable mounts before any signal is heard, unlike VHF, where the beam can be rotated around looking for the best signal level.

Data flowed with low BER down to about 12 dB C/N. Over the 13.50 mile test path, C/N was 20 dB, with two-foot reflectors.

Usage in Norcal

An interesting group of advanced packeteers reside in the San Francisco Bay Area. This group has been attempting to form a general use network based on the TCP/IP suite of protocols. This network architecture is two level hierarchical. Each group of Amateurs that have good RF paths to each other form a cell. Each cell has an IP router in it with paths to other cells.

Since the microwave modem is by nature point to point, not broadcast, it usage is to link the IP routers together. The initial usage in Norcal was to link the Cupertino cell IP router to the San Jose router.

Futures

Better DX with this design could be achieved with optimization of the receiver detector bandwidth. Larger diameter dishes will help the DX as well.

Increasing the reflector diameter from two feet to four feet will provide 6 dB of gain, for an increase in four square feet of wind load.

Work is in progress to implement inexpensive 250-500K baud FSK units in the 900 MHz and 1200 MHz Amateur allocations. These bands still have acceptable broadcast qualities for individual user access.

The choice of the PCLANA was a quick way to get on the air and test. What the (near) future holds, is implementation of K3MC's Awesome I/O PC adapter card, described in previous conference papers. The author's presently are experimenting with K3MC's prototype of the awesome I/O, and hope to have replaced the PCLANA cards with awesome I/O, by the time this paper is presented at the conference.

Summary

With the introduction of reliable megabit links, applications providing a variety of services can begin to take shape.

The author's hope to provide a reliable Amateur Radio Packet network with data throughput greater than that available to the user of TELCO dial modems (2.4 to 19.2). This kind of data and networking would provide an environment and inducement for development of applications, rather than just keyboard to keyboard QSO's.

To gain the maximum benefit from higher speed links, Amateur Radio Data Networks will require formation of architecture and planning. No longer will it make sense for a user to buy a radio, antenna, TNC, plug them into a PC, and dial in a frequency to go BBS hopping, or NET/ROM hopping Otherwise the network will never be able to provide reliable services to the intended users.

The view that "I've a Ham license, just like you, and I've got as much right to a frequency as the next Ham", will have to give way to cooperation, organization, and planning.

Creating the level of organization and cooperation needed is perhaps a greater challenge than the technical accomplishments needed to implement an Amateur Radio Packet Network. It's time for the ARRL to re-examine (review ?) it's charter.