The Wireless Internet Connection

By Robert Perelman, Times Microwave Systems

High speed Internet connections are the lifeline of business communication. In larger urban areas, there are typically several competing providers of high speed connections. But in second and third tier markets (population of less than 500,000) this is not the case.

Wireless technology offers important advantages compared to wired systems for providing high speed Internet access in smaller markets. Clearwire Technologies has developed a system using the unlicensed 2.4 GHz ISM (Industrial, Scientific, Medical) band, that is ideally suited for deployment in second and third tier markets. The selection of an antenna feeder cable that is flexible, provides the required RF performance and is suitable for installation in a wide range of environments was a critical element of the system design.

In large urban areas businesses can choose from several alternatives to hook up to the Internet at high data rates. The local exchange carrier will typically offer dedicated T1 or T3 lines. Cable modems may be an option. They offer high data rates, but typically in only one direction and the cable TV plant covers residential areas, so access may not be possible for business users. DSL offers high data rates at low cost, but requires close proximity to the central office. Several types of wireless systems have been deployed in urban areas. Wireless systems can provide high speed connections that can be implemented quickly over large geographical areas without a large investment in physical plant.

There are several types of wireless systems that are being deployed including LMDS, MMDS, CDPD, narrowband PCS and satellite systems. Clearwire’s system uses a portion of the spectrum at 2.4 GHz that has been allocated for spread spectrum data links. Links can be established without an FCC license, as long as the system operates within the power limitations established by the FCC. With the excellent propagation characteristics of these frequencies, and the excellent sensitivity of the receivers, subscribers as far as 25 miles from the base station can be served. This allows the system to be economically deployed in areas with a low concentration of potential business customers.

Clearwire is implementing the system in markets such as Louisville, Rochester and Memphis. This requires setting up a few low power base stations throughout the metropolitan area. Existing building or tower sites are used. Selection of sites is based on accessibility to the high speed Internet backbone, the terrain, and the suitability of existing sites. Co-location is not a problem because of the low power levels of the system. Once the base stations are installed, customers are added by installing a wireless router at the customer’s location, with an antenna pointed at the base site.

The antenna may be located either inside or outside of the customer’s building. In many situations, a suitable antenna location may be 100 feet or more removed from the router. The antenna feeder cable needs to have insertion loss in the range of 8 to 12.5 dB. Combined with the antenna gain and system output power, staying within this loss range for the feeder cables results in a level of radiated power within the allowable FCC maximum limits and high enough for proper system performance. By standardizing on an effective gain for the combined antenna and feeder run, the need to adjust power levels at the site is eliminated and the installation of the system is simplified.

Low loss, flexible LMR cable was chosen for this system instead of the other types of coaxial cable that were considered, including corrugated copper and braided RG cables. Corrugated
copper cables are expensive, too stiff to allow easy routing in buildings, and difficult to attach onto connectors. Braided RG cables do not offer low enough loss or good enough shielding for most of the applications within this system. LMR cable offers several benefits for this system including:

- Loss comparable to corrugated copper cables of similar size
- Shielding better than 90 dB
- Flexibility to allow easy installation in buildings
- Resistance to kinking and damage during installation
- Easy connector attachment
- Availability of plenum and riser listed versions for indoor installations
- High quality, readily-available connectors

LMR cables are constructed using a foam polyethylene dielectric and a bonded aluminum tape outer conductor with a tinned copper braid over it. The DB versions of the cables used for this application include a moisture resistant flooding compound that completely encapsulates the braid, protecting it from potential moisture ingress and corrosion. The outer jacket is a UV resistant, black polyethylene. The inclusion of 3% carbon black gives the jacket a 20-year life expectancy in an outdoor environment.

Times supplied Clearwire with fully tested assemblies, terminated with TNC connectors and tested to verify insertion loss and return loss performance. They were shipped directly to the sites as they were required. By purchasing the cable with the connectors attached and with electrical performance verified, the incidence of cable problems was virtually eliminated, the need to have technicians that could install the cable connectors was eliminated and compliance with FCC maximum ERP requirements was assured.

The wide range of sizes of LMR cables allows a wide range of feeder lengths to be used with the same attenuation. Table 1 shows the range of lengths and sizes that are supplied, all within the required range of attenuation. The availability of a wide range of lengths with similar insertion loss allows a wide range of system configurations. The same cables can be used for both the subscriber and base station installations.

For indoor installations, versions of the cables that meet the requirements of the National Electrical Code need to be used. If the cable is to be run through an air handling space (such as above a suspended ceiling) a plenum rated cable will need to be used. If it is run between floors or in other areas of the building, a riser rated version of the cable will be required. Table 2 summarizes this information.

In order to meet the National Electrical Code, these cables need to be listed by Underwriters Laboratory. In order to be listed as a plenum cable, the cable needs to pass a test called the Steiner Tunnel Test. This test requires that several runs of cable be placed in a horizontal chamber. Air flows over the cables at a controlled rate. A precisely controlled flame is then introduced. In order to pass the test, there are maximum requirements for both flame spread and smoke generation. This is intended to simulate the situation of a fire in a building. Cables that are installed in air handling spaces, such as the space above a false ceiling are especially dangerous in a fire. If they generate smoke, this can make it impossible for occupants of the building to be able to see well enough to exit the building. In order to pass this test, it is necessary to use special jackets and to use dielectrics which are more fire resistant than polyethylene. Generally fluorocarbons, such as Teflon are the best choice for dielectrics, because in addition to being fire retardant, they have excellent electrical properties and result in cable with low attenuation.

For cables going between floors in a building, there is the somewhat less severe National Electrical Code “riser” category. To get this rating, the cables must pass a vertical tray flame test. This simulates resistance to cables spreading the fire from floor to floor in a building fire. To meet this requirement, special jackets can be applied to cables with polyethylene foam dielectrics. These ratings form a hierarchy, meaning that plenum cables can be installed anywhere in a building, including risers and air handling spaces. Riser cables can be installed anywhere in a building except air handling spaces. For this reason, in large metropolitan areas, such as New York City, the use of plenum cables is mandated for all in-building installations.

In the implementation of the Clearwire system the same basic radio equipment is used for the base and subscriber sites. At the base sites, 3 sector antennas with 120 degree beamwidth were installed to cover the entire surrounding area. At the customer site, the antenna can be installed either inside the building, providing through a window at the cell site or on the outside of the building. The system will operate at distances as great as 25 miles from the cell site. Data rates up to 10 Megabytes per second can be achieved. The cost to the customer depends on the data rates provided, which can be set in the system software. Because there is no license required to establish a microwave link in the 2.5 GHz band, the system can be installed and on the air within days of being ordered by the customer. This is in contrast to the several weeks required to get other types of high speed Internet service, even if it is available. The use of flexible cable in pre-assembled lengths allows for easy installation, without the need for skilled technicians to install the connectors on site.

This same approach can be used for other applications in the ISM bands, which includes frequency allocations at 900 and 5900 MHz, in addition to the 2400 MHz band used in the Clearwire system. The table below shows the attenuation of the different LMR cables at these frequencies.

In order to meet the FCC requirements, for maximum ERP (or the rated power) in ISM band systems, there are two approaches. One approach is to use professional installers to install all of the system equipment. For equipment that is sold to consumers for installation, another approach is required. Special connectors must be used on the antennas, antenna feeders and radio equipment, so that the antennas cannot be replaced by the consumer with higher gain antennas, which would cause the ERP to be exceeded. Times makes available reverse polarity SMA and TNC connectors to satisfy this requirement. A reverse polarity connector is one with the opposite sex pin inside, to prevent it from being able to be mated with a standard component.

The LMR cables are the ideal choice for antenna feeders in the ISM bands. They offer a wide range of sizes, good flexibility for ease of installation, a wide range of connectors in standard and reverse polarity styles, good durability and excellent electrical performance. UL listed versions are available to meet the National Electrical Code requirements for indoor installations. Pre-terminated and tested assemblies can be obtained to assure required electrical performance. This combination of benefits makes them the ideal choice for the implementation of ISM band systems, such as the Clearwire Wireless Internet System.