System Design

5 Mbit/s Repeater Carrier-band to Single-mode Fiber Optic

Models
CBR-7AC
CBR-7DC

References:

- Relcom's Carrier-band Network Handbook
- Relcom's Guide to Industrial Fiber Optics
- CBR-7 product specifications, document PS-029
- CBR-7 Installation and Testing, document 501-281

Purpose of a Repeater

A Repeater is used to extend the distance covered by a coaxial cable network or to add more stations to the network. A single network can be expanded, or small networks can be joined by adding Repeaters. When networks are expanded or joined, each of the smaller coaxial cable networks become a Segment of the larger network. Each segment has the same limits on length and number of stations as a single network without a Repeater.

Fiber Optic Repeaters work in pairs. One Repeater picks up a signal from a Carrier-band network segment, processes the signal and sends it out over the Fiber Optic segment. The other Repeater picks up the fiber optic signal, processes it and sends it out over the other Carrier-band network segment.

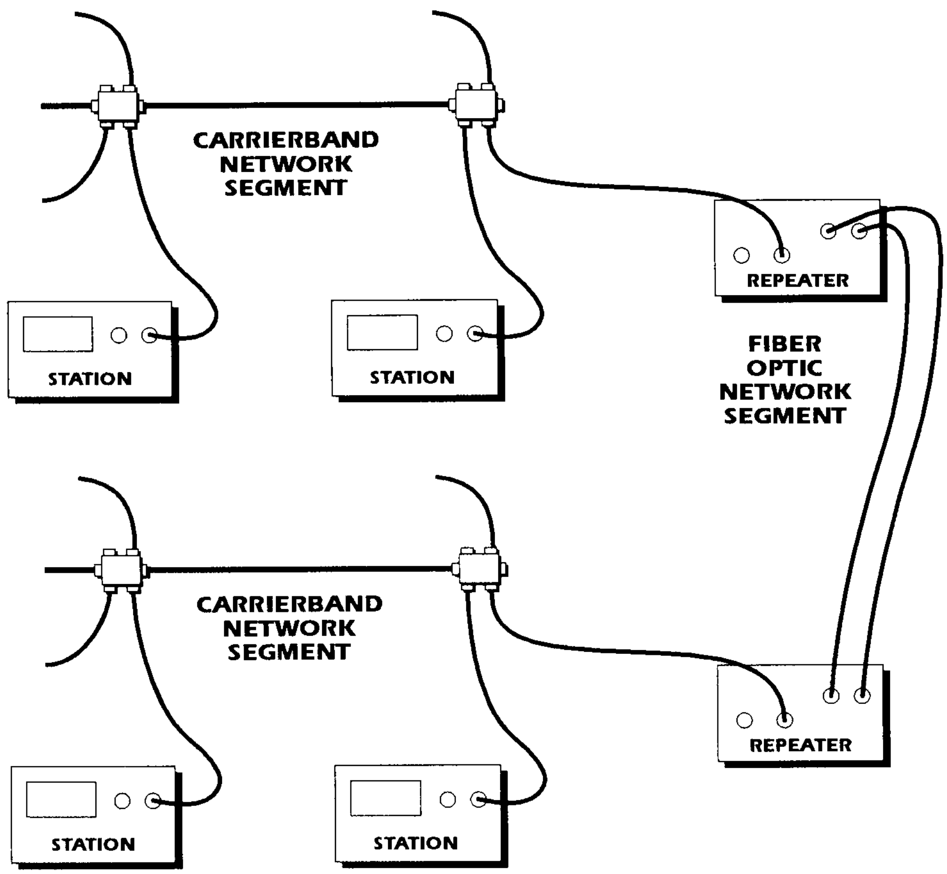

Figure 1. Fiber Optic Repeater and Network Segments

Fiber optic repeaters are useful for several reasons: They can span long distances. Since fiber optics do not conduct electricity, the fiber optic repeaters eliminate ground current problems, are immune to lightning strikes, and do not pick up noise.

The Fiber Optic Repeaters described here are for single mode fiber optic cable that can interconnect carrier-band coaxial cable segments up to about 60 km in length, depending on cable and connector attenuation.

How the Repeater Works

The Fiber Optic Repeaters are intended to work with the Carrier-band network as defined in the IEEE 802.4 and the equivalent ISO 8802/4 standards. The Carrier-band network operation is described in Relcom's Carrier-band Network Handbook

Two Fiber Optic Repeaters are needed to connect Carrier-band network segments. The connection to the Carrier-band network segment is through the F connector labeled A. Each Repeater has an XMIT (Transmit) and a REC (Receive) fiber optic connector. The REC fiber optic connector is an ST type; the XMIT is an FC type. The XMIT of one Repeater is connected to the REC of the other one and vice versa.

A Repeater listens for signals on both the Carrier-band and the Fiber Optic network segments. The first signal from one of the segments to reach the Repeater "captures" the Repeater. After this, all signals on the other segment are ignored. The Repeater does more than just amplify the received signal. The Repeater recovers digital data from the received signals, eliminating amplitude and phase distortions and noise. The Repeater then transmits a full strength, undistorted signal onto the other network segment. The Repeater is designed to minimize the time required to receive, process and retransmit signals. Transmit delay time through the Repeater is less than 600 nanoseconds and should be added to the cable delay to determine the slot_time of the network.

When the Repeater detects an error condition in the incoming signal, it turns the ERROR light next to the corresponding connector momentarily ON. If the end delimiter is subsequently detected, the E bit is set in the transmitted frame’s end delimiter to indicate that the data in the frame was in error. If no end delimiter is detected before the received signal fades (a “runt” frame), the ERROR light is also turned ON momentarily.

Topologies

Networks with repeaters can be configured in many different ways. The only caveat is that the overall system must not loop back on itself. Although figure 1 shows the Repeater connected at the ends of the trunk cable segments, the Repeater can be connected to any tap on a Carrier-band network segment. More than two segments can be connected using Repeaters. The diagram below shows a linear string of Repeaters connecting several network segments together

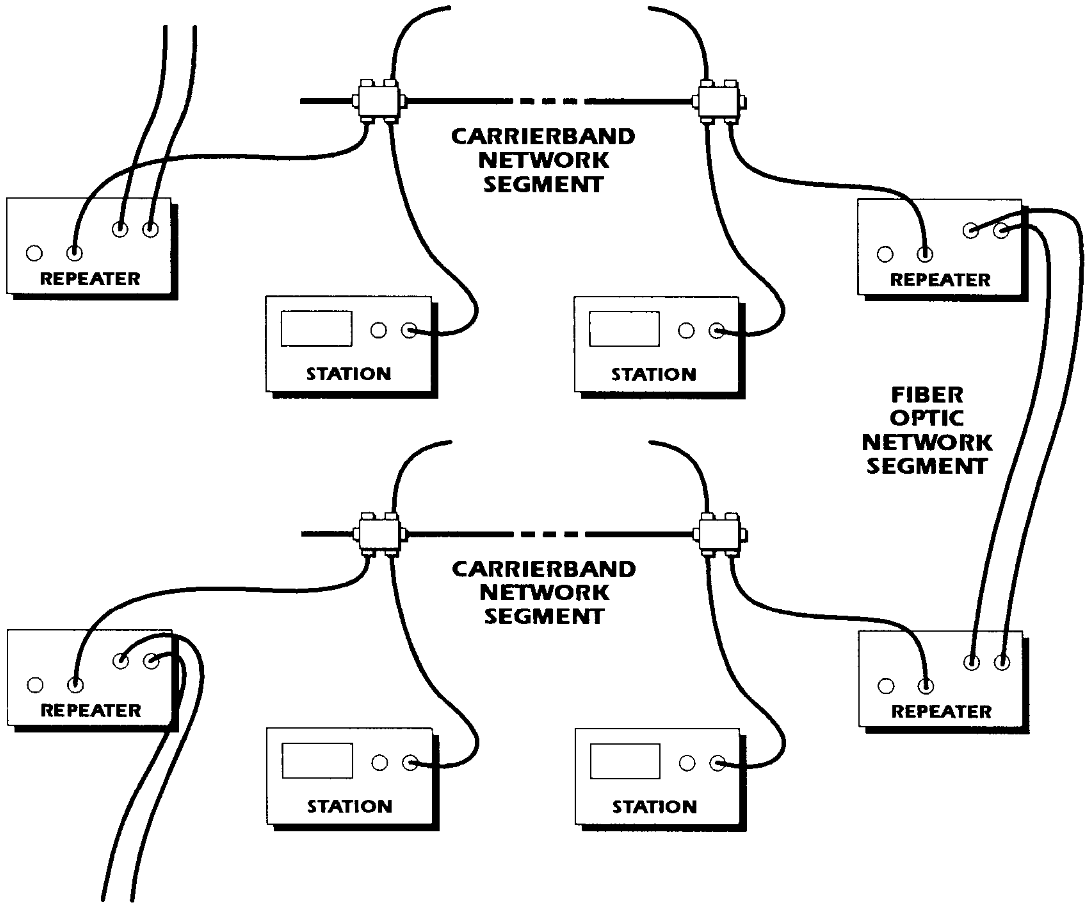

Figure 2. Linear String of Repeaters

When multiple Repeaters are used in a system, ensure that Repeaters and network segments do not get connected in such a way as to create a circular path as shown below. This will cause signal interference and the network will not work.

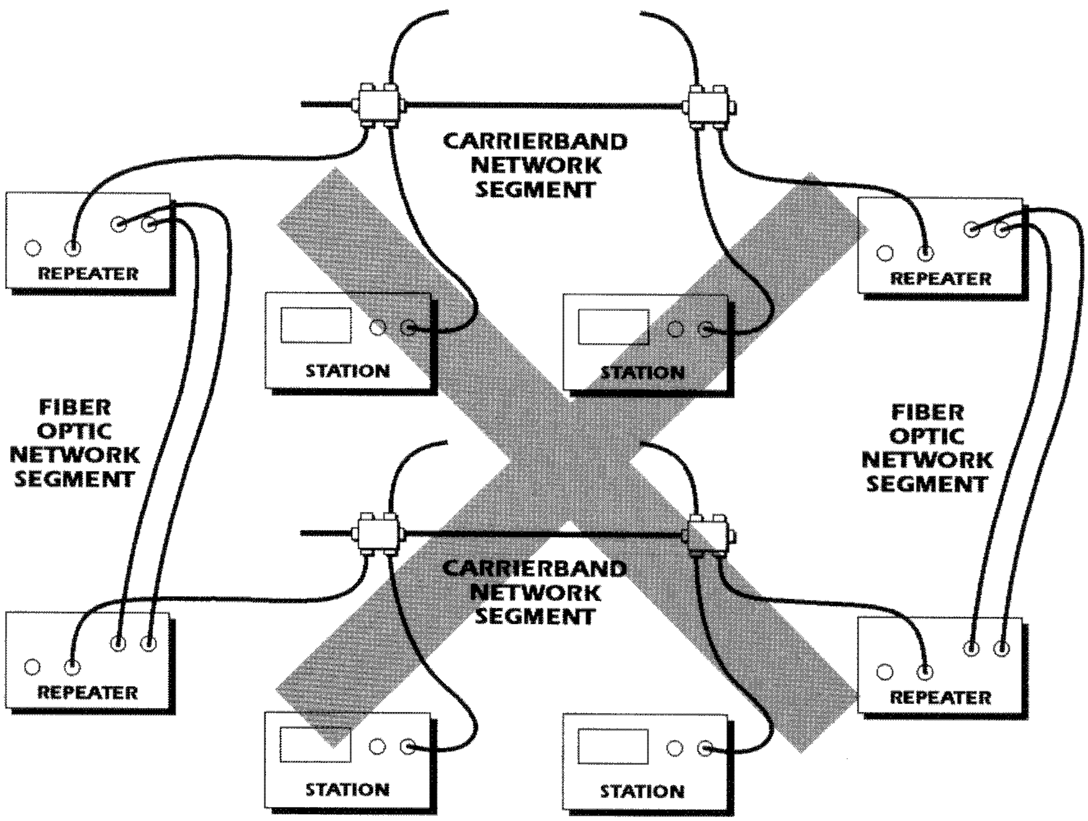

Figure 3. Cross Connected Configuration - DO NOT USE!!

Network System Considerations

The following discussion assumes some familiarity with the operation of the Carrier-band network. If not, please refer to Relcom's Carrier-band Network Handbook, Section 4.

The Repeater is "transparent" to stations on the network segments. No protocol modification to the stations is necessary. All the stations work as if they were on one long trunk cable. There is, however a network parameter, slot_time, that may have to be increased in each network station.

Slot Time

Slot_time is the maximum time any station needs to wait for a response from any other station on the network. Slot_time is defined as:

Slot_time = {(2 x Path_delay + Station_delay + Safety_margin)/0.2 +7}/8

The delays are in microseconds. The delay is divided by 0.2 to make the delay in terms of bit times. (At 5 Mbits/sec. the period of one bit is 0.2 microseconds). The "+7}/8" makes the slot_time in terms of bytes (or octets as they are known in LAN terminology).

Here is a sample calculation of slot_time:

Assume that the station delay, the time between when a station receives a frame and when it responds, is 5 microseconds.

Assume that the trunk cable length of each Carrier-band network segment is 400 meters. If the cable delay for RG-11 cable is 4 nanoseconds/meter then the path_delay is 4 x 400 or 1.6 microseconds on each carrier-band segment.

Assume the two Carrier-band segments are separated by 2 km of fiber optic cable. Assume that the delay of fiber optic cable is 5 nanoseconds/meter; then, the path delay of the fiber cable is 5 x 2000 or 10 microseconds.

The transit delay time through each Repeater is 600 nanoseconds or 0.6 microseconds.

Let the safety margin be 0.5 microseconds.

Slot_time = {(2 x [1.6 + 0.6 + 10 + 0.6 + 1.6] + 5 + 0.5)/0.2 +7}/8

= 22 (rounded)

Logical Ring Considerations

Before a Repeater is connected, the stations on each segment operate on their own logical ring network. When a Repeater is connected to the segments, the logical ring is temporarily disturbed while the stations rearrange themselves to form a new, larger logical ring. All the needed actions are performed by the token bus protocol chip in each station.

Similarly, if two segments connected by Repeaters are disconnected, the logical ring is again temporarily disturbed until the stations on each segment reconfigure themselves into two separate logical rings.

Since the distances between stations on networks using Fiber Optic Repeaters can be considerable, the time to pass a token around the logical ring can become significant. The token is passed in order from a higher value address to a lower value address and then back from the lowest to the highest. If the sequential addresses are on separate Carrier-band segments of the network, then the tokens have to traverse the potentially long fiber optic segment many times. If, however, all the stations on one segment can have addresses assigned in one sequential block and stations on another segment have addresses assigned in another sequential block, then the token is passed among all the stations on one segment before it is sent to a station on another segment. This may be beneficial in networks with many stations or networks with large separations of segments.

Fiber-Optic Design

The fiber optic components between two CBR-7 repeaters must be able to carry light signals from the transmitter of one repeater to the receiver of the other. The components include the main cable between the two repeaters, and may also include a patch panel at each end, the patch cables, and an attenuator. Some installations may also have more optical interconnection components.

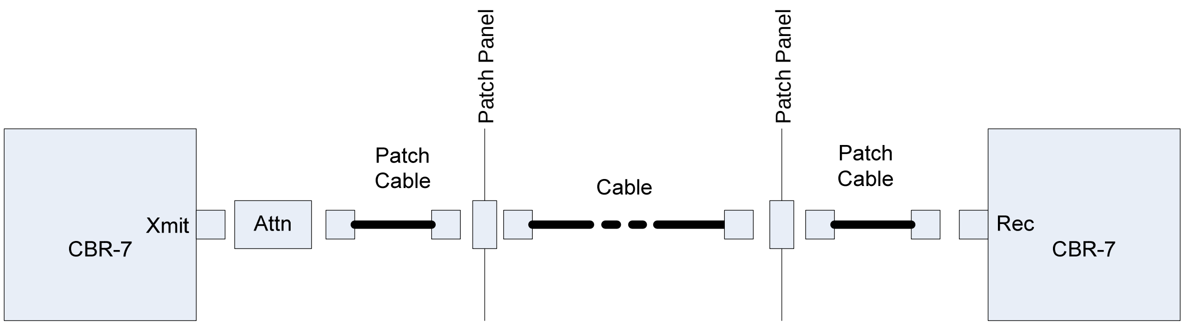

Figure 4. Fiber Optic Components

Attenuation

The total attenuation (insertion loss) of optical components must be at least 15 dB but not more than 24 dB. If necessary, an attenuator must be used on the <u>transmit</u> side of the main fiber-optic cable.

For example: Assume that each optical connection has an attenuation of 0.5 dB and there are two connections at the transmitter side and two at the receiver side. The main cable is 8 km long and has an attenuation of 0.4 dB/km for a total attenuation of 3.2 dB. The total fiber-optic attenuation is

$$2 \times 0.5 + 3.2 + 2 \times 0.5 = 5.2 \text{ dB}$$

To get into the needed attenuation range, a 10 dB attenuator needs to be put at the transmitter output. The **calculated** attenuation of all the fiber optic components is:

$$10 + 5.2 = 15.2 \text{ dB}$$

Return Loss

CBR-7 performance depends on low return losses (reflections) of the optical components. This must be measured from both the transmitter side and the receiver side of the fiber-optic cable.

The value of the Attenuator (if any) + Transmitter Return Loss + Receiver Return Loss must be at least 48 dB.

In the example above, the attenuator's value is 10 dB. Assume the measured Transmitter Return Loss is 20.2 dB and the Receiver Return Loss was measured to be 32.2 dB. Then

10	Attenuator value
20.2	Transmit Return Loss
32.2	Receive Return Loss
62.4	Total

In this example, the total of 62.4 is over the required 48.

The procedures for testing CBR-7 attenuation and return loss are covered in Relcom's document 501-281 CBR-7 Installation and Testing.