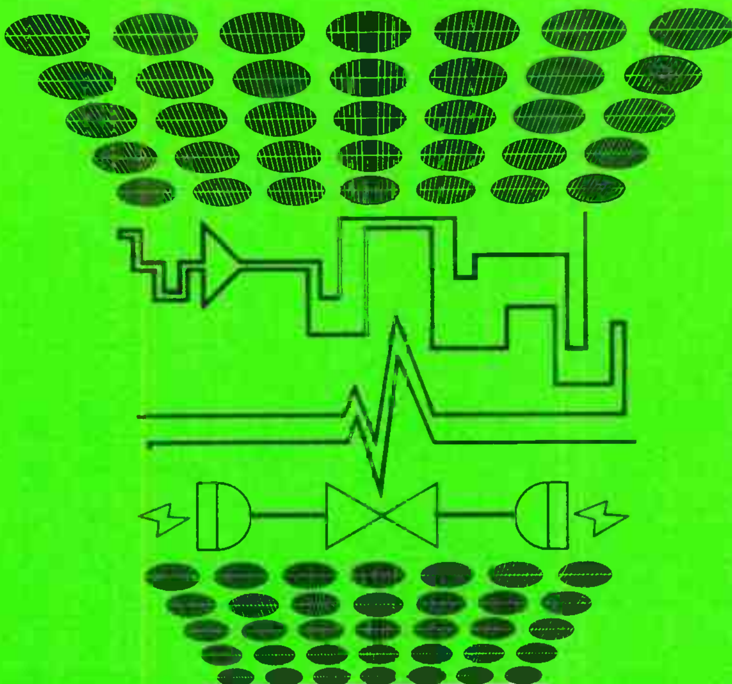
GTE LENKURT

DEMODULATOR

MAY/JUNE 1976



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Editor
GTE Lenkurt Demodulator

1, which is a component diagram of the GTE Lenkurt 700F1 repeater. The amplifiers are linear and operate in Class A mode, so that there is a uniform output for a given input over the band of operation (2.11-to-2.20 GHz, in this case).

The microwave frequency coming from the eastern direction (F1) enters the antenna, passes through circulator A, which directs the signal to bandpass filter FL_1A, which is tuned to F1 and thus eliminates any extraneous signals, and enters circulator B. The first output port of circulator B is to filter FL_2A, but since FL_2A is tuned to pass only F2 (the West frequency), F1 is returned to circulator B and directed to isolator 1. Hybrid 1 splits the energy of the signal, which is then amplified by the two amplifiers, recombined in phase, passed through circulator C and filter FL_1B, and finally directed by circulator D to the West antenna. The same process takes place in the opposite direction for signals going to the East antenna. The total gain achieved in the repeater is approximately 45 dB. The two-amplifier configuration also gives the system redundancy, since failure of one amplifier does not cause loss of signal continuity, but only causes a 6-dB drop in output signal level.

Shrouded Antennas

Because the input and output frequencies of an rf repeater are the same, there is the possibility of interference (side-to-side coupling) between the two frequencies at the repeater location. Also, the possibility of signal overshoot is another problem which must be dealt with when using an rf repeater (see Figure 2). In the GTE Lenkurt rf repeater system, these problems have been largely alleviated by the use of special shrouded antennas. A shrouded antenna is simply a parabolic antenna which has a shroud or circular panel that extends beyond the feedhorn. Since the shroud is made of conductive material and is, in fact, physically connected to the parabolic portion of the antenna, the microwave energy beam is maintained within the confines of the parabola – much more so than with the standard parabolic antenna – thus eliminating most interference from side lobes. Cross-polarization of the transmit and receive antennas also serves to enhance side-to-side

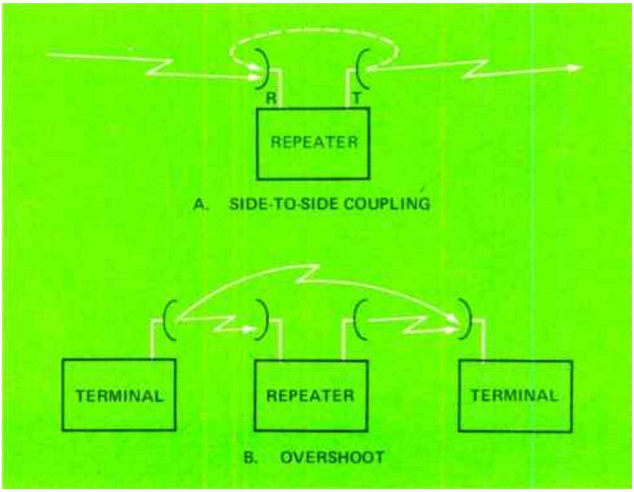

Figure 2. Side-to-side coupling and signal overshoot are two types of interference that may exist at a repeater location.

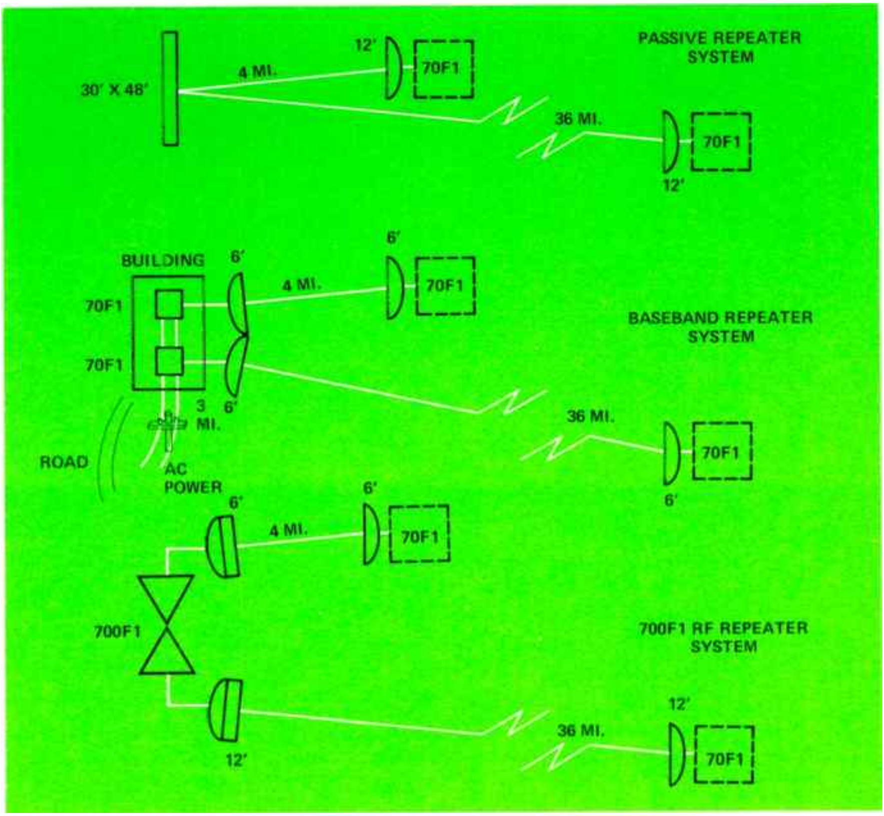

Figure 3. The use of an rf repeater can provide a simple, economical alternative to narrowband repeater applications.

isolation, as well as minimize the signal overshoot interference problem.

Power Requirements

As with any active device, the question of a power source is always a point of economic concern. A passive repeater, while requiring no power source, may be economically prohibitive in locations where accessibility is difficult, because of size and gain limitations at 2 GHz. Active repeaters, on the other hand, are very costly when installation is required at locations with difficult access: aside from the initial radio equipment expense, access roads for routine maintenance must be built and maintained, utility power lines or local power generators provided, and buildings constructed. The rf repeater presents a simple, economical alternative to both the passive and active narrow-band repeater installation (see Figure 3).

While the rf repeater is not limited to remote locations with difficult access, since it has various ac/dc power options, it can play an important role in such areas by virtue of its unusually low power requirements (about 4W). Solar power enables the rf repeater to be used where other types of repeater installation would not be economically feasible.

Solar Power

While the rf repeater can be powered by any conventional power source, its solar-power option provides the transmission engineer with a tool which can be used to design microwave systems for use in situations where it was previously cost-prohibitive to do so.

The heart of the solar power source is the solar cell, which collects the sun's energy and transforms it into electrical power (photovoltaic conversion). Several types of materials may be used to construct a solar cell, including gallium arsenide, cadmium sulfide, cadmium telluride and silicon. To date, most laboratory work and practical applications of the solar cell have used the silicon cell, since its great reliability in power systems for space vehicles and satellites has been proven over the past decade. The type of solar cell used in outer space, however, has been far too expensive for practical terrestrial applications, and not until recently have silicon solar cells been designed for specific use in the earth's environment. It is this latter type of solar cell that can be used to power GTE Lenkurt's rf repeater.

A solar cell consists of a thin wafer of n- or p-type silicon base with a layer of an oppositely charged material diffused onto the base. For example, Figure 4 shows an n-type (arsenic-doped) silicon base joined with a p-type (boron-doped) silicon layer. At the pn junction, free electrons from the n layer combine with positive holes, thus establishing a neutralized boundary along the junction, but leaving a difference of potential across the junction due to the loss of the free electrons and holes when these combined at the junction.

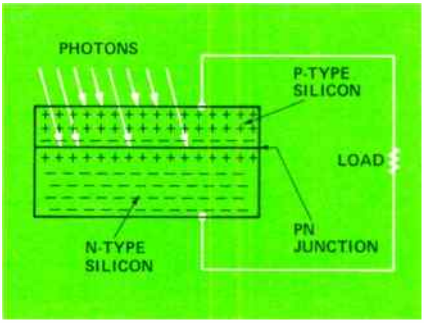

Figure 4. Solar cells provide power for rf repeaters in remote locations.

Because the p layer is extremely thin, sunlight in the form of photons can penetrate it and progress beyond the pn junction. Each photon produces an electron and a positive hole. Because of the electrical field present at the pn junction, the electrons produced are forced to the n, or negative, side—and the holes to the positive side—of the junction. If electrodes or wires are connected to the p and n regions, and a load is connected between them, electric current can be made to flow. Generally, each solar cell develops about .5 volts in direct sunlight, and it is this type of power that is used to operate the 700F1 rf repeater.

Applications

A narrowband rf repeater installed at a remote site, powered by an array of solar cells during the day and rechargeable storage batteries at night, can operate almost indefinitely with a minimum of maintenance. A typical pole arrangement of an rf repeater location appears as shown in Figure 5, although variations of the arrangement are possible. For example, the compactness of the units allows them to be positioned on towers, buildings, or even attached to the tops of grain elevators in country where this type of structure is plentiful.

The 700F1 rf repeater can be interleaved between baseband repeaters on

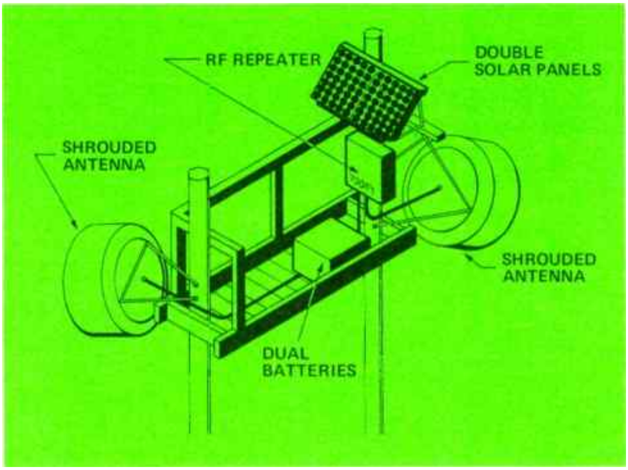

Figure 5. An rf repeater pole installation.

long hops as an economy measure. In flat terrain, for example, where a path between baseband repeaters may be 30 to 40 miles, 300-to-400 foot towers are usually required. By placing an rf repeater at approximately 20 miles, the tower height requirements for the baseband repeaters would then be only 100 to 200 feet, thus saving the high cost of erecting tall towers. The cost savings in this application is substantial due to the low price of the rf repeater.

A narrowband rf repeater has an advantage over passive repeaters in situations where it is necessary to place a repeater in the middle of a path. For example, if a requirement exists for extending a 36-channel link between two terminals separated by an intervening mountain range, a comparison can be made between the use of rf and passive repeaters. In this case, the repeater site is determined by the midpath obstruction, since only this location has common line-of-sight visibility to each terminal. Figure 6 shows two possible path applications using passive repeaters at 2 GHz. Path ABC shows the conventional method of passive repeater placement, since a single reflector must be relatively close to the transmitter to achieve the required amount of gain. The path loss in path ABC would be a total of 229.3 dB. The direct path AC would require two reflectors, and therefore show a loss of 246.6 dB, which in this case would be unacceptable. An rf repeater substituted in place of the two passive

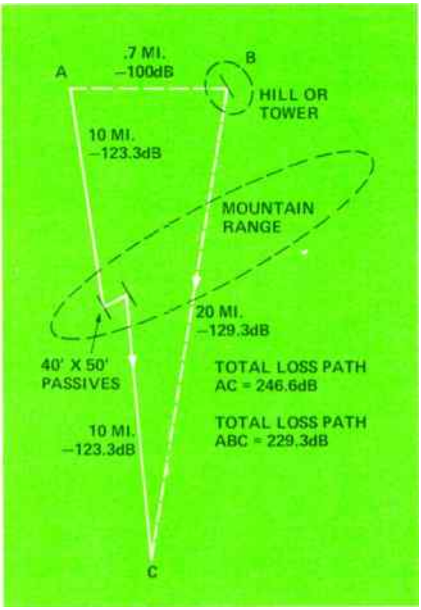

Figure 6. An rf repeater offers improved gain and economy in straight-line path narrowband applications.

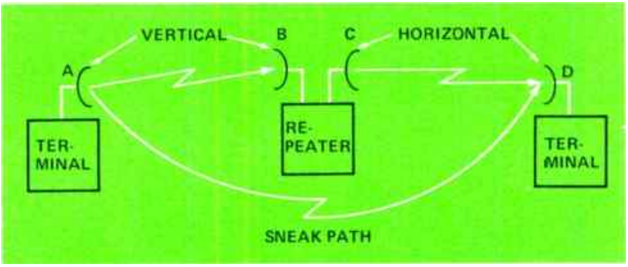

Figure 7. Cross-polarization of antennas can reduce the effects of delay distortion caused by "sneak" paths.

repeaters on path AC would provide improved gain characteristics at approximately one quarter of the cost.

Another application advantage of the rf repeater over the passive repeater is in the reduction of delay distortion. "Sneak" paths, such as that shown in Figure 7, can cause severe distortion of the received microwave signal, since more than one signal will appear at the repeater out of phase with the main signal. Using passive repeaters, very little can be done to eliminate the distortion caused by the sneak path. The rf repeater, like other types of active repeaters, has the option of antenna cross-polarization, so that in the event that delay distortion caused by sneak paths is present, the antenna feedhorns of C and D can be rotated until horizontally polarized with relation to those of antennas A and B, thus greatly reducing delay interference. The sneak path, which is vertically polarized, will have a much smaller interfering effect on horizontally-polarized antenna D. Also, the location of the rf repeater in the microwave path is much less critical than for a reflector, thus it is often possible to make use of terrain features (hills, etc.) to block the sneak paths.

Once a 700F1 repeater installation is completed, maintenance is simple and effective. All that is needed to maintain the system for maximum signal is a common multimeter and a simple power meter. Also, the solar panel may periodically need to be wiped clean, since an accumulation of dirt on the solar cell blocks the sunlight and makes the cell less effective.

The use of the rf microwave repeater is an innovation in the telecommunications industry. As such, it is only beginning its useful existence in the field. And, while the particular device discussed in this article is for a 36-channel system operating at 2 GHz, similar repeaters, but for higher-capacity fm, am, and digital systems, may also become a reality in the near future.

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