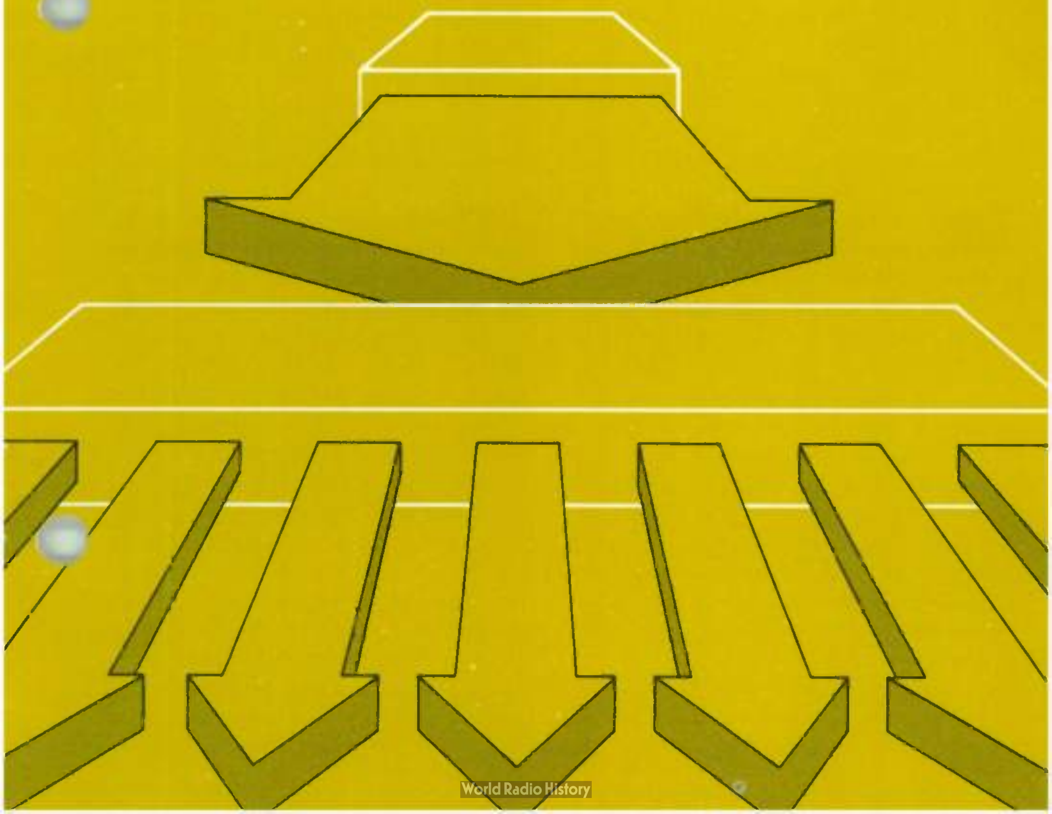
GTE LENKURT

DEMODULATOR

OCTOBER 1972

Carrier In Customer Distribution Networks



Once considered a temporary expedient for expanding the customer distribution network, subscriber carrier now offers permanent, improved service, and economic savings to both customer and telephone company.

Necessity gives impetus to invention, and it was necessity that led to the development of carrier systems specifically designed for the customer distribution network. Today, the result of this development is a potential savings of millions of dollars annually. The customer distribution network includes central office and switching equipment as well as all of the telephone equipment and lines from the central office to the customer's premises. It is also known as the exchange distribution network or the loop plant. Station or subscriber carrier equipment is located between the customer and the central office, in the area known as the customer or subscriber loop.

A carrier system on the customer's end allows two or more independent conversations to take place on one- or two-wire pairs that extend between telephone customers and the central office. Prior to the development of such carrier systems, each telephone line was linked to a central office by a single, physical wire pair, with power being supplied for the customer loop by the central office. (See Figure 1.)

The earliest form of what might be termed subscriber carrier, employed the technique of superimposing voice modulated carrier-frequency signals on electric power lines. This technique, called "power-line carrier," brought telephone service to remote customers (provided they had electricity) without the necessity of stringing telephone lines.

Equipment developed in the early 1950's was designed to assign several customers to each line, thereby providing new-customer service without adding cable pairs. Originally, this type of service, which postponed the high cost of installing new open wire, was primarily used to reach remote customers. These early systems provided service for 2 to 10 parties on one loop. The electronic circuitry of the early carriers made wide use of vacuum tubes and therefore required periodic maintenance by skilled personnel. Much of the maintenance of these systems consisted of replacing aging tubes or allowing for aging by adjustment of power levels on the line. For this reason, carrier has been mainly regarded as a temporary expedient for telephone service until physical lines can be installed. Today, with the era of the vacuum-tube carriers almost passé, solid-state subscriber carrier as a permanent medium, warrants investigation.

The many telephone companies already using permanent subscriber carrier have based their decision to do so on certain relevant facts. First, copper, being an element of the earth, has a finite quantity. As it becomes more scarce, its price will increase. Also, the labor cost of laying or stringing new cable can only go up in the future. Carrier may be used to circumvent some of these expenditures. The solid-state components of modern carrier equipment need little or no maintenance, and their performance and reliability far surpasses that of the early vacuum-tube equipment. Some additional points in favor of modern carrier systems as compared to older

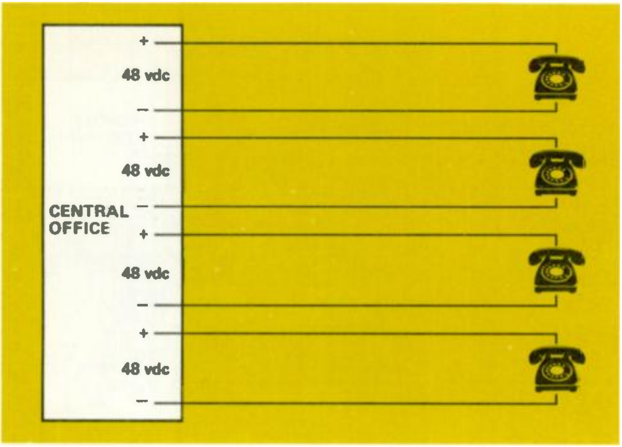


Figure 1. Prior to carrier, each subscriber line was powered by the central office and required one physical cable pair per customer circuit.

types include conservation of floor and rack space, lower terminal-equipment cost, lower power consumption, and lower repeater costs.

Subscriber and Station Carrier

The terms subscriber carrier and station carrier are often used synonymously because both systems perform the same function in much the same way. There is, however, by arbitrary definition, a technical difference between the two. In a subscriber carrier system, channels are usually terminated at one or two remote points, with the remote terminals being locally powered. Service to customers is then distributed from these remote points. On some systems, each channel drop can operate at loop resistances (total resistance of the length of wire between the subscriber's premises and the remote subscriber terminal) of up to 1600 ohms.

GTE Lenkurt recently developed a PCM (pulse code modulation) subscriber carrier system. PCM subscriber carrier systems such as the GTE Lenkurt 910A provide two groups of 24 single-party channels, and may be equipped with four-party channel units to serve 192 subscribers over four cable pairs.

Station carrier systems have been developed by several manufacturers, and although different design techniques have been used, the overall operation of the equipment is similar. The two basic choices of equipment are single-channel and multichannel carrier. Single-channel carrier provides an additional single-party line over one cable pair. Multichannel carrier provides up to 10 voice channels on one cable pair.

Station carrier systems permit individual remote channels to be located randomly anywhere along the carrier transmission path, since they are all powered from the serving central office. Typically, the channel drops (the length of line from the remote terminal to the customer) of these systems are limited to a few hundred feet of wire because of central office power limitations on the carrier equipment. Subscriber carrier systems generally require some initial adjustments by maintenance personnel, while station carrier systems automatically regulate both carrier and voice-frequency signals, and therefore require no additional adjustments. Figure 2 shows a typical example of subscriber and station carrier applications. For simplicity, this article will refer to station

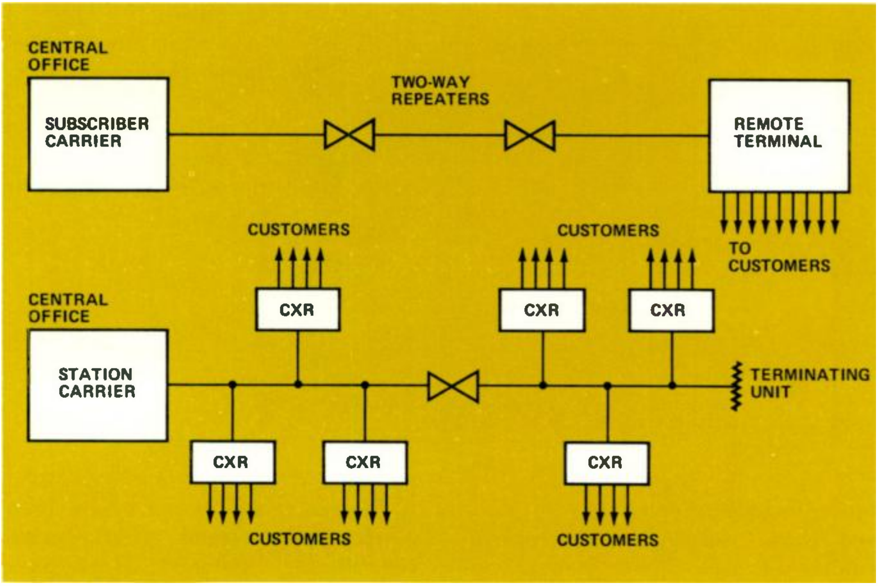


Figure 2. Subscriber carrier systems distribute customer lines from locally powered remote terminals. Station carrier terminals are powered from the central office and are randomly distributed along the line.

carrier and subscriber carrier, simply as *carrier*, unless a point must be made with reference to a particular system.

Uses

The same economic necessity that led to the initial development of subscriber carrier has increased in recent years with the migration of customers to suburban and rural areas. The multiparty line that was once considered adequate in rural areas is no longer acceptable to many new customers and the trend is to provide single or two-party service. This increasing demand for upgraded telephone service has depleted the stock of available cable pairs in many areas. Figure 3 shows a typical customer distribution network extending over a 15 to 20-mile distance with an almost-depleted cable supply at junction D. Should the area beyond junction D experience an influx of new customers, the decision of whether to install additional cable or use subscriber carrier must soon be made. Installation of cable is a costly venture in any case, and may often be forestalled or avoided by installing carrier equipment. Also, an error in estimation of future needs for that area can be costly. Too few cable pairs will necessitate additional cable installation in the future. Too many cable pairs lying idle over a period of years can mean economic waste in material and labor costs. Utilization of permanent carrier may reveal, in many cases, that additional cable will not be required for many years. In addition to eliminating the cost of cable installation, use of carrier avoids the time loss incurred between order and delivery of cable, and the scheduling of construction crews for new cable plant.

Carrier systems can also fill the requirement for short-notice demands for business, residential, or seasonal services. The simplicity of installation and maintenance is a great economic

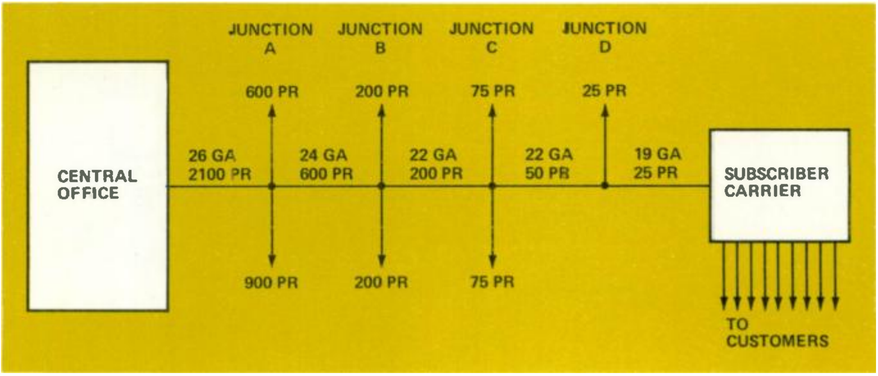


Figure 3. Addition of subscriber carrier to existing cable provides many new customer telephone channels.

benefit in such cases. As in much of today's electronic equipment, troubleshooting of carrier systems consists of isolating a problem to a particular channel unit and replacing the inoperative unit with a spare.

Cable Condition

Carrier equipment can only be as good as the cable over which it transmits. The decision to install carrier on existing cable facilities must take into consideration the serviceability of the cable. Besides pair integrity, cable pairs to be used for carrier transmission must be devoid of loading coils, building-out networks, and bridge taps. (See the December, 1971 issue of the Demodulator for one method of detecting these devices.) On multichannel station carrier systems, it is also necessary to install a terminating unit near the distant end of each cable pair to eliminate carrier frequency reflections which can cause signal attenuation. The maximum operating length of any carrier system depends on the gauge of wire that is used. On most multichannel station carrier systems, repeaters are required at approximately 35-dB intervals along the line.

The GTE Lenkurt 910A PCM system, which uses a D2-type format, can feed 15 repeaters from the central office and 15 more from the remote terminals for a total of 30 repeaters. (See the January, 1972 issue of the Demodulator for an explanation of D2-type terminals.) On 19 gauge cable, the typical spacing between these repeaters is about 8000 feet. This means that a fully equipped PCM system can extend to 240,000 feet (30 repeaters X 8000 ft.), or approximately 45 miles. The use of 24 gauge cable decreases repeater spacings to 5,000 feet, which gives a maximum range of approximately 28 miles. Greater distances, as much as 500 miles if necessary, can be achieved by addition of auxiliary power units along the line. As with other types of carrier systems, PCM channels can be added as they are needed, thus minimizing initial expenditures. PCM also provides an improved quality of service on long applications, since signals are regenerated at each repeater and retransmitted without any noise that may have been picked up along the line.

New Installation

The high reliability of modern subscriber and station carrier systems has made them acceptable as permanent installations rather than just tempor-

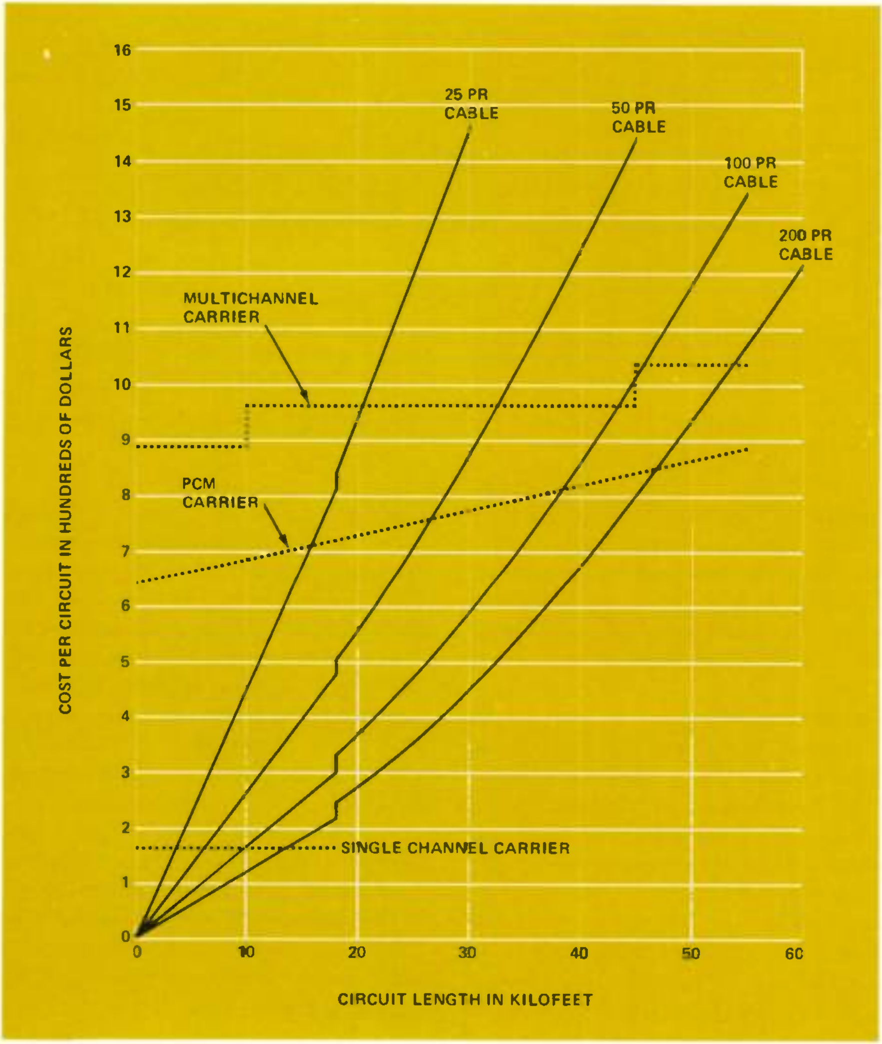


Figure 4. Typical example of comparison of in-place costs for single and multichannel subscriber carrier versus buried cable, with a 1200Ω customer loop-resistance limit. Beyond the crossover point, the in-place cost of carrier is more economical than cable plant.

ary solutions to a problem, to be replaced when additional cable is installed. This same reliability can also make carrier an important component in the design of *new* telephone installations. And, it is no longer limited to providing service to rural areas; carrier is now used in metropolitan areas as well. Planning new cable facilities requires an accurate estimate of the number of cable pairs that will be needed over a period of years. An initial requirement of 50 circuits may increase to 400 circuits in a period of a few years, depending on the population development of an area.

If an accurate estimate of future needs is difficult to make, subscriber carrier can be used to eliminate the risk of providing too many or too few cable pairs. Using a hypothetical situation, an area which requires 50 circuits initially, may require 600 circuits in five years. Rather than install a cable that contains 600 or more circuits, and initially have many idle pairs, a 50-pair cable can be installed. By using PCM subscriber carrier in the initial installation, additional equipment channels may be purchased as needed over an extended period of time. Each PCM group can provide 24 channels on two-cable pairs, and 50 cable pairs can support 25 PCM groups. This means that 600 single-party voice circuits (24 channels X 25 PCM groups) can be derived from 50 cable pairs, if PCM subscriber carrier is used. (This assumes that adequate near-end crosstalk loss exists between pairs to be used for PCM carrier.)

Prove-In Distance

The term *prove-in distance* implies the results of an economic study which compares different mediums; cable and carrier, for example. The point along the length of a facility at which the cost of utilizing one transmission medium or another is equal, is called the crossover point. Before this point or beyond it, one transmission medium is more economical than the other. The distance from the central office at which this point occurs is known as the prove-in distance. Figure 4 is a typical example of how the results of a new-cable installation versus carrier installation comparison might appear. The carriers in this case are of the single-channel and multichannel type, such as the GTE Lenkurt 84A, 82A, and 910A. The prove-in distance for such systems, using a 50-pair cable, is approximately 6 kilofeet for single-channel station carrier, 32 kilofeet for multichannel station carrier, and 26 kilofeet for PCM subscriber carrier. Beyond these distances, carrier would be the more economical choice. Prove-in distances will vary for individual systems, since costs are dictated by such factors as number of cable pairs, gauge size, circuit requirements, and geographical location.

Economics

Approximately one third of a telephone company's investment dollar is spent on the customer distribution network. Recent studies based on new cable installation versus carrier installation costs indicate that enormous annual savings could be incurred by the telephone industry by the proper use of these carrier systems – a significant incentive for the proliferation of new carrier in the customer distribution network. The basic reason for this savings is that about 80% of telephone customers are within 18 kilofeet of the central office. This condition is highly conducive to the extensive use of single-channel station carrier systems, since most can operate within the 18-kilofoot distance. PCM carrier also shows great promise, since it can generally prove in at distances as short as 16 kilofeet.

The story of carrier is mainly one of economics. Yet, it also provides technical improvements in transmission, frequency response, and signaling capability. It also eliminates installation of additional cable, loop extenders, voice frequency amplifiers, and long-line adapters. Electronics has played a major role in toll and exchange-trunk facilities for many years. Now, with increasing consistency, electronics will be appearing on the customer's end of the line.

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UNIV. OF CALIF. RADIATION LAB.
BLDG. 88, ROOM 113
BERKELEY, CAL 94720

GTE Lenkurt Station and Subscriber Carrier Systems

System	Number of channels	Approximate distance	Type of service
82A (DSB-AM)	1-6	20 miles	Rural subscriber applications. Provides up to 4-party service. Drop off channels as required.
82B (DSB-AM)	1-6	25 miles	Subscriber and exchange-grade service. Designed for concentrated use of channels at permanent locations such as hotels, PBX boards, and trailer parks.
821B	1-24	25 miles	Up to four 82B systems in a special cabinet available for apartment houses and office buildings and for temporary facilities at sporting events, etc.
83A (FM)	1*	18 kilofeet	High-quality channel for special applications such as data requiring C4 conditioning. Provides single-party service. Designed for second lines on premises as well as initial service to a new customer — on a permanent or seasonal or emergency basis.
84A (AM)	1*	18 kilofeet	POTS (Plain Old Telephone Service). Provides single-party service. Designed for second lines on premises as well as initial service to a new customer — on a permanent or seasonal or emergency basis.
910A (PCM)	1-24	50 miles	Initially POTS (Plain Old Telephone Service). Designed with D2-type encoding for improved toll-quality channels, standardization of equipment, and ease of maintenance. Weatherproof housing available. Future channel units will provide many other special services — coin service and foreign exchange will be available soon.
XU (PM)	1-20	30 miles	Rural subscriber applications or toll-connecting service. Provides 1-10 party service for areas of concentrated service.
XL (PM)	1-8	55 miles	Same as XU except used on open wire.

*1 carrier-derived voice channel in addition to the physical channel on pair.

For additional information, write GTE Lenkurt, Department C134.

The GTE Lenkurt Demodulator is circulated monthly to technicians, engineers and managers employed by companies or government agencies who use and operate communications systems, and to educational institutions. Permission to reprint granted on request.

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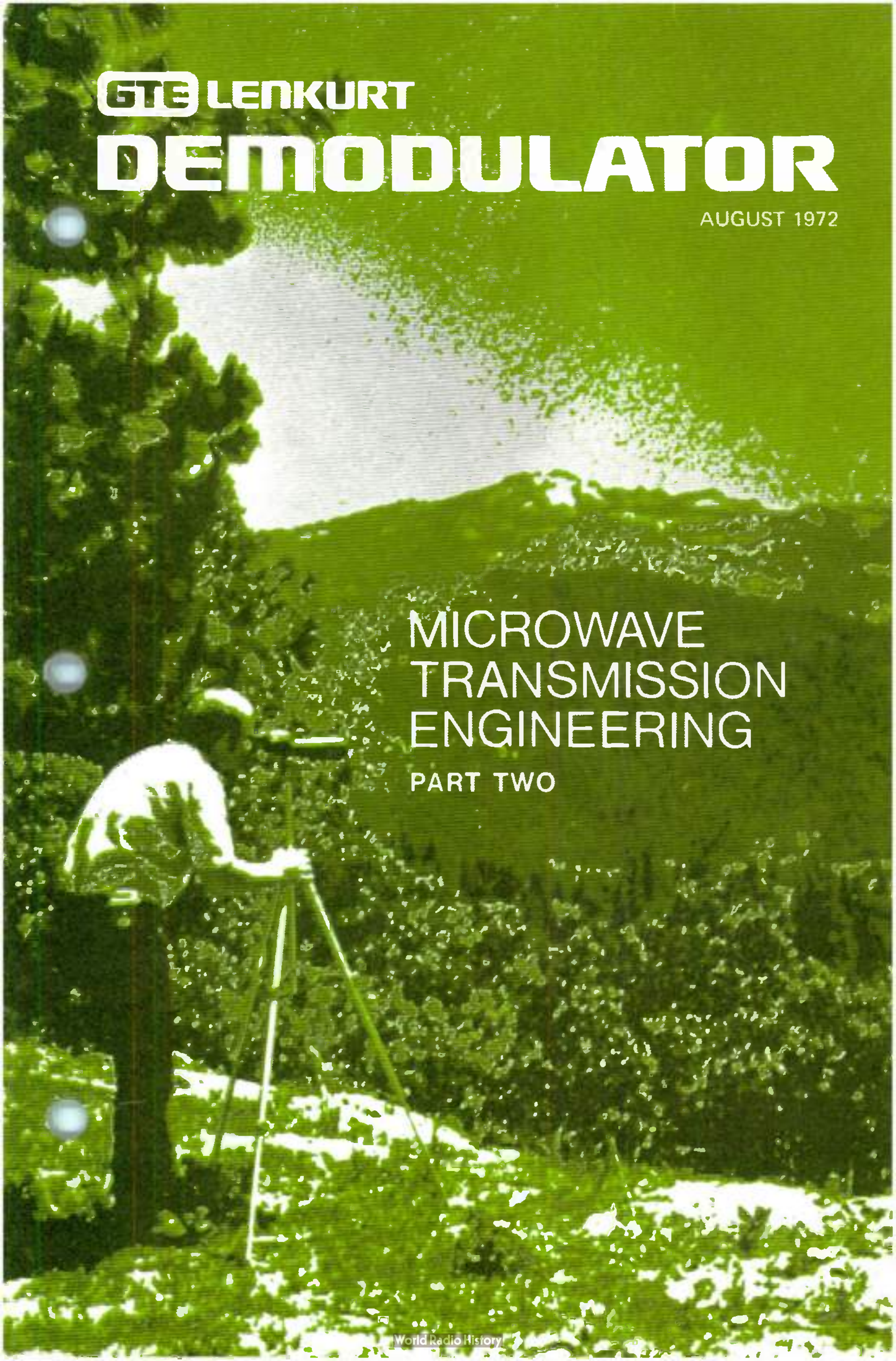
DEMODULATOR

AUGUST 1972

MICROWAVE TRANSMISSION ENGINEERING

PART TWO



The basic information needed for microwave transmission engineering is essentially the same as it was twenty-five years ago, but the techniques used to gather and refine this data are constantly being improved.

Once path data has been gathered for a proposed microwave path, it is a routine engineering matter to determine antenna sizes and tower heights, to plot profiles, and to calculate system performance. Path surveys are therefore conducted for two purposes: first, to ensure that the system will operate with the necessary performance; and second, to keep the costs down to the lowest possible level and still maintain performance. Consequently, the path survey is used principally to determine minimum tower heights, minimum number of repeaters, and locations which do not result in excessive building, access, power, and maintenance costs.

Path Contouring

There are several methods used to determine elevations at the sites and along the path. Each method has merits, and each if properly used can provide the required information to make an accurate profile. Four methods are discussed, the choice is made on the basis of survey team experience, economics, and other factors.

The first method is the time-proven land survey; using transit, level, rod and chain. This method can provide all the information required for both site and path engineering, however it requires more manpower than a survey team normally used for microwave surveying, thus incurring higher costs.

A second method utilizes a combination of transit and altimeter. Surveying for sites (property lines, towers, etc.,) with transit and precision altimeter, keeps the survey team to a two-man effort.

For determining the elevation variations along a microwave path a sensitive and accurate altimeter is required, one capable of measuring to within five feet. This requires a precision instrument in good working condition. The use of an altimeter requires meticulous and careful work, and good records, plus some cooperation by nature, to get good results. Because of the potential sources of error, it is highly desirable to do a good deal of checking and cross-checking. On some days, unusually large and sudden barometric pressure changes may occur,

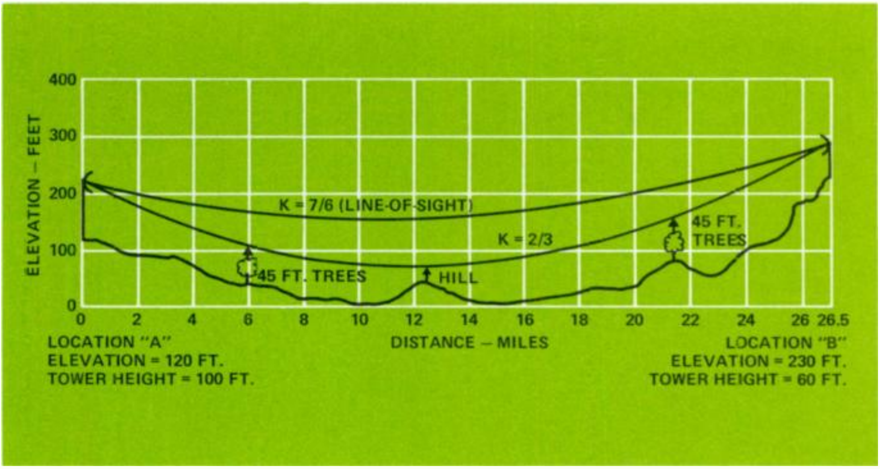


Figure 1. A tentative path profile can indicate the critical points that should be checked in the field.

and in some cases it may be necessary to discard all the results and wait for a more favorable day. Maximum use should be made of bench marks and other points of known elevation which can be obtained from such sources as the Geodetic Survey.

In well-developed areas where networks of roads exists, it is often possible to check all, or almost all of the critical points by criss-crossing back and forth along the route. Tentative path profiles often show that there are only a few points which are really critical insofar as clearance is concerned (see Figure 1). In general it is only the high points which are of interest, since they control tower height requirements.

The most accurate altimeter method for determining elevations is known as the two-altimeter method. The process involves placing both altimeters at the nearest bench mark and calibrating them exactly alike. The altimeter measures changes in atmospheric pressure so both have to be calibrated to measure from the same reference point – in this case, the pressure at a known elevation such as a bench mark.

The work should be done during stable weather conditions, and in the period from at least one hour after sunrise to one hour before sunset. One altimeter remains at the bench mark throughout the measuring period. If the stationary altimeter is manually read, readings of temperature and elevation (which would indicate pressure changes) should be taken every five minutes until the roving altimeter returns. The readings of the two instruments should then be compared. If the readings of the two instruments differ by as much as five feet after temperature stabilization, the instruments should be recalibrated and the survey repeated.

Figure 2. The barograph and the roving altimeter are calibrated to a known elevation at the beginning of the survey and rechecked at the conclusion.

If the fixed altimeter is a recording type rather than a manually read type, manpower is conserved. The principle of operation is the same as with two manually read instruments. Figure 2 shows the calibration of two altimeters.

The roving altimeter is used to measure the elevations along the path. At each measuring point, a record is made of the mileage, the temperature, the time, the trees and other obstructions, and any other terrain features of interest in preparing the profile. The roving altimeter should be used as close to the bench mark as possible. As many bench marks should be used as

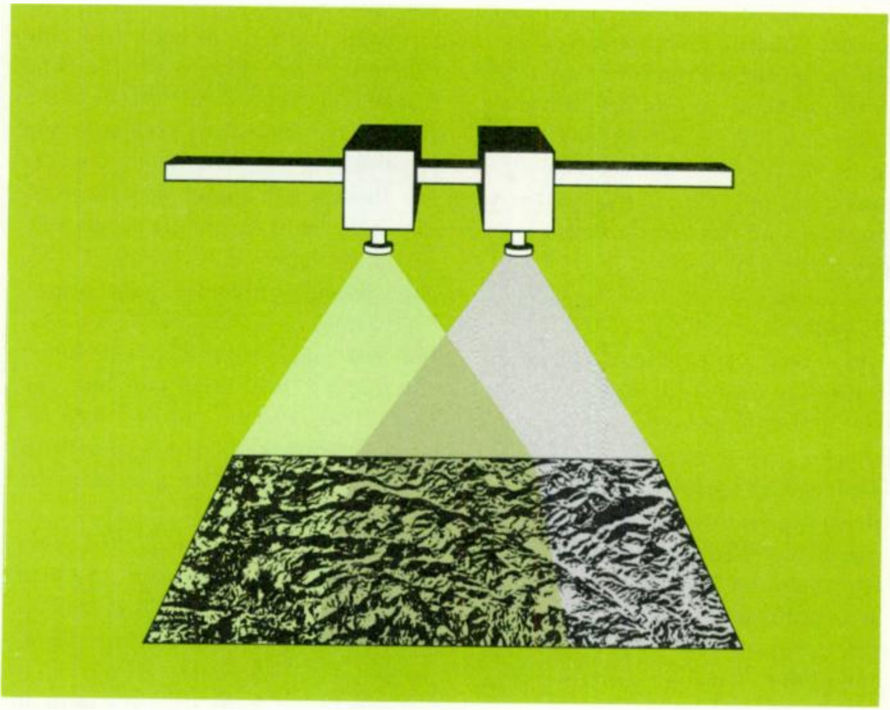


Figure 3. Stereoplotting is used to compile topographical map detail from a pair of aerial photographs that overlap by 60%. The information gathered from the photographs gives only relative elevations and must be compared to known elevations to determine absolute values.

necessary to accurately survey all the path. The final measurement at the bench mark on each measuring trip provides a reasonable check on the data. The team then moves to the next bench mark and proceeds in the same manner. If there is only one bench mark near a path, it is desirable to create secondary bench marks.

The computed elevations for the points measured are determined after corrections have been made for variations in temperature and pressure. There should be enough points measured to fully describe the profile of the path.

If the terrain along the proposed path is not conducive to the altimeter method, aerial photography provides a third method. The relative elevations are then determined by stereoplotting (see Figure 3). The accuracy of this method is good but the cost is substantially higher than the altimeter survey method. In a case involving a fairly large number of profiles, and where added manpower would be required to conduct an altimeter survey, aerial photography should be investigated as an alternative to a field survey. It should be borne in mind however, that the field altimeter team or survey party brings in more than just elevation data, and such additional information is necessary in any event. A fourth method of profiling involves flying over the path with equipment which measures clearance using the radar principle. This is also relatively expensive and has certain limitations, such as site staking.

Obstacles

In mountainous country where all of the intermediate terrain along the path is rough and timbered, a field altimeter survey should not be attempted if adequate clearance can be determined by other means. This can often be determined by "flashing" the path. Flashing involves two parties, one at each site, preferably equipped with two-way VHF radios for communications. Lacking the radio, it is possible to coordinate by time.

The flashing is done either with a mirror reflecting the sun or with a high-power searchlight. Some engineers prefer the searchlight since it is easier to spot than mirror flashing, even in broad daylight, and the searchlight has the advantage of not being dependent upon sunshine (see Figure 4). When flashing with either a mirror or searchlight, extreme care must be taken particularly at night or in the winter to ensure that the beam is not passing through bare trees which will become obstacles when they leaf out in the spring.

For flashing to be effective, it is necessary for the sending party to establish the exact direction to the opposite site, and to concentrate the flashing along that path. One way of doing this is to drive stakes to mark the exact path and then gradually raise the beam until it is level with the distant horizon. This process should be repeated at frequent intervals until the far party is known to have seen and identified the flashes. At the far site the flashes will appear very large. A transit set up at the far site can be very useful, both for observing the flashes and obtaining accurate path sitings. The terrain clearance can be visually, but not precisely, established during the flashing. It is important that any known ridges and obstacles which appear close to the line-of-sight path be checked for elevation, and adequate clearance computed.

Another visual technique that may be utilized to check for adequate clearance in rugged terrain is balloon flying. In this process a helium filled, streamlined balloon is raised on a measured line from one site until it can be seen at the next site. In this way it is possible to determine the necessary tower heights. Since the balloon is quite stable, a reflective shield attached to the line can be used as in the flashing technique to record the sitings between antennas.

Complete profiles for paths and alternate paths should be carefully plotted with obstructions and estimated antenna height requirements, together with all the details relating to possible interference. In addition, all pertinent supporting data, altimeter readings, maps, and bench-mark information should be furnished.

The final profiles provide the basis for microwave system engineering, including the final selection of paths, antenna elevations, antenna sizes and configurations, and computation of

Figure 4. A searchlight provides an efficient method of "flashing" a path in daylight and poor visability at distances up to 30 miles.

expected signal strengths, fade margins, and system noise.

After final selection of the precise locations for the towers and antennas, the latitude and longitude of each location must be carefully determined. For systems under FCC jurisdiction, the rules require that the coordinates of the antenna or final radiating element be determined to within one second of a degree. Path azimuths should be determined to the nearest tenth of a degree of arc and path distances to the nearest tenth of a kilometer. Present GTE Lenkurt procedures involve the use of computers for these calculations.

Interference

Within the past year or two there have been several significant developments affecting the frequency coordination problem within the U.S.A. Since the FCC opened the door to the so-called specialized common carriers, there has been a large increase in the number of companies filing for microwave routes. Furthermore since many of the new systems tend to follow the same routes – often already congested with existing microwave systems – the interference problem is amplified even further. There is also a growing problem of coordination between terrestrial microwave systems and earth-satellite systems sharing the same bands. At present there are only a handful of earth stations within the U.S.A. which provide international service via satellite; these stations are located in isolated and well shielded areas. But with the imminent establishment of domestic satellite operations there will be a large increase in the number of earth stations, and they will probably be located close to large population centers and hence in areas with large concentrations of terrestrial microwave systems.

Two relatively new calculation requirements are now being or will soon be imposed on frequency planners as a result of sharing frequencies with satellite systems. Terrestrial microwave stations operating in the 6-GHz common carrier band will in general not be authorized if the antenna beam points within ±2 degrees of any point on the geostationary satellite orbit. (Under certain conditions such a station may be authorized on a waiver basis, but with limitations on the allowable radiated power). A new coordination requirement is now being established to take into account the effects of interference via precipitation scatter, when the beams of a terrestrial station and an earth station intersect with a common volume in the lower atmosphere.

Developments such as these, together with the great number of stations which must be studied and the sheer bulk of the computations which must be made in finding interference-free frequencies for a proposed new route have resulted in a strong trend toward the use of computers to do as much as possible of the searching and calculating processes involved, leaving only the most difficult cases to be resolved by detailed manual calculations.

The requirement to establish and maintain an up-dated base of existing and applied for stations, crucial to an efficient computer operation, has some side benefits. Much information helpful toward the establishment of new routes can be gleaned from a study of existing routes in the area.

There have also been some encouraging recent developments resulting from increased cooperation and interchange of information among users, manufacturers, and the FCC about many of these problems. The common carriers, for example, have been able to reach fairly good agreement among themselves on how to define and calculate an acceptable level of interference into a given microwave system. For the industrial (private user) microwave bands, with comparable but not identical requirements, a joint task force of the E.I.A. (Electronic Industries Association) and the O.F.M.C. (Operational Fixed Microwave Council) has been successful in developing a set of acceptable interference criteria for microwave systems. A recent informal engineering meeting held under FCC sponsorship developed essential agreement on methods to be used in calculating whether or not a microwave beam intersects the geostationary orbit. Thus, though there remain many areas which need further effort, a useful pattern seems to be emerging, looking toward closer co-operation among user groups, manufacturer groups, and the regulatory bodies in finding solutions to the ever increasing interference problems.

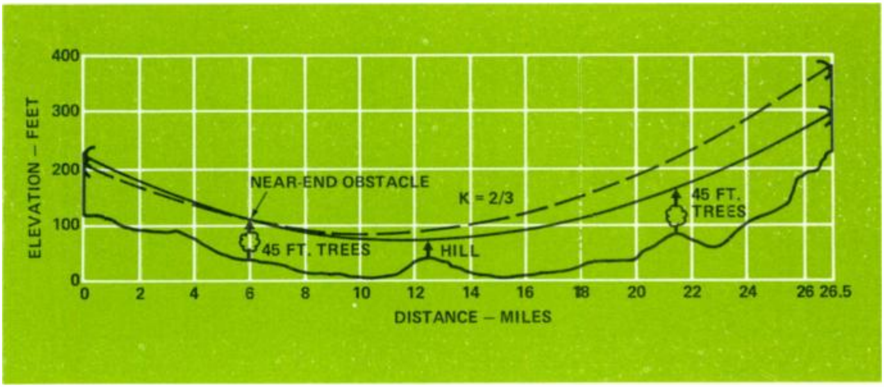


Figure 5. An obstacle near one end of the path will mean that changing the antenna height near the obstacle will result in a larger change at the other end of the path.

An unfortunate but perhaps inevitable consequence of the increasingly complicated calculations required is that it is becoming more difficult for a small user to do his own frequency planning, even if he has a knowledgeable engineering staff. Such users are being forced to turn either to the microwave manufacturers or to companies specializing in providing frequency analysis.

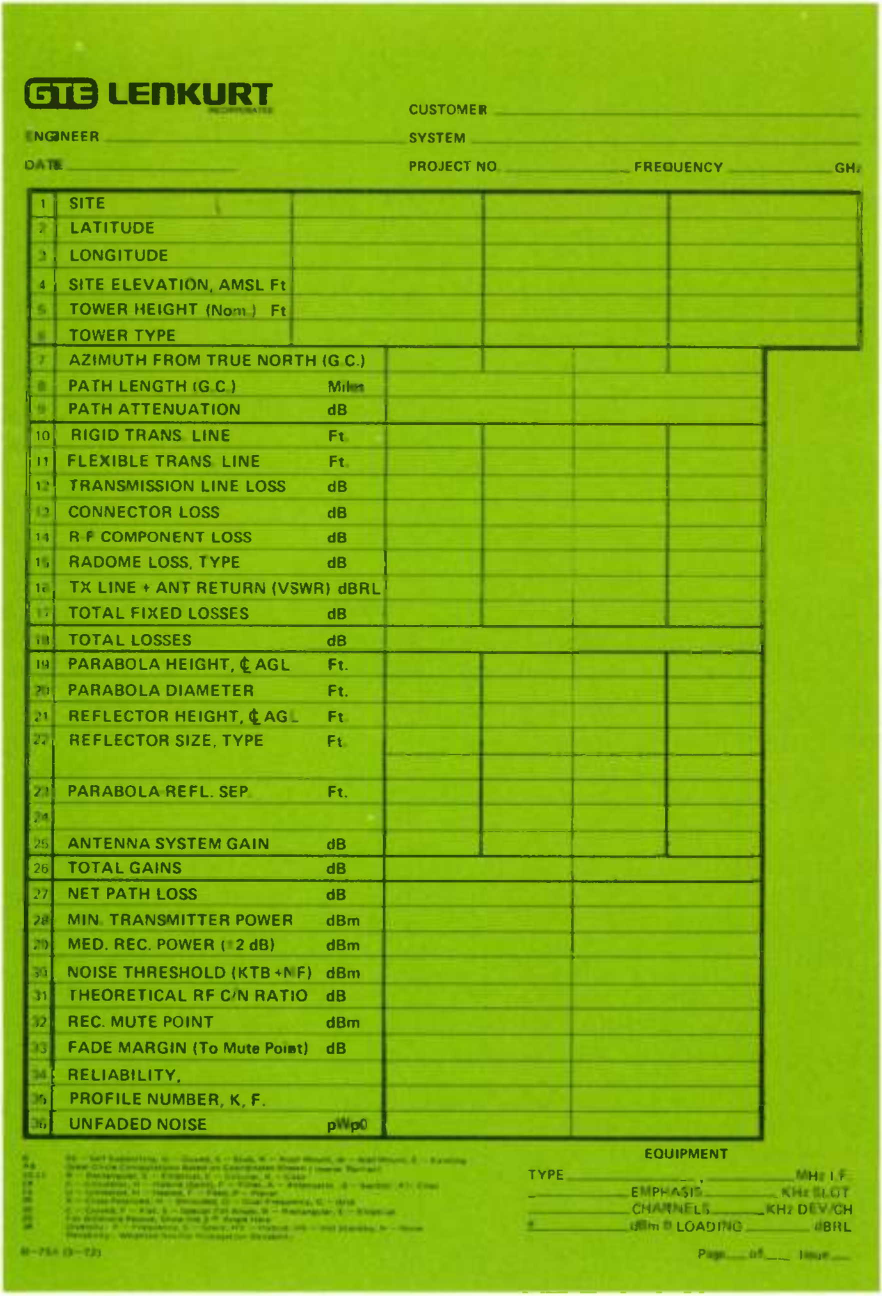
Profiles

After a path has been selected and surveyed, and all the path data collected, the next step is to plot the path profile and determine the required tower heights. The elevations of the end points, and of any high points or controlling obstructions should be carefully plotted. Lower intermediate points can be simply sketched in, if they will not effect clearance problems. Trees, buildings, or other obstacles which have been identified along the path should be accurately plotted.

It is always possible in theory to reduce the required height at one end by raising the height at the other, but whether it will be advisable to do so will depend on where the critical points are located. Often there will be only a single critical point near the center of the path. In such a case the trade-off, at least over a certain range, will be on a one-for-one basis. In other words, raising one tower by X feet allows the other to be lowered by X feet.

If the controlling obstruction is near one end of the path, the trade-off is no longer one-for-one. The path can be thought of as a lever, or an unbalanced seesaw, pivoting around the obstruction point (see Figure 5). Thus a change in height at the end nearer the obstruction can only be counterbalanced by a larger change at the other end, the relation between the two depending on the relative distances.

If there are several controlling obstacles scattered more or less along the path, there would be almost no trade-



GTE LENKURT

ENGINEER ____ CUSTOMER ____
DATE ____ SYSTEM ____
PROJECT NO ____ FREQUENCY ____ GHz

1	SITE	
2	LATITUDE	
3	LONGITUDE	
4	SITE ELEVATION, AMSL	Ft
5	TOWER HEIGHT (Nom.)	Ft
6	TOWER TYPE	
7	AZIMUTH FROM TRUE NORTH (G.C.)	
8	PATH LENGTH (G.C.)	Miles
9	PATH ATTENUATION	dB
10	RIGID TRANS. LINE	Ft
11	FLEXIBLE TRANS. LINE	Ft
12	TRANSMISSION LINE LOSS	dB
13	CONNECTOR LOSS	dB
14	R.F. COMPONENT LOSS	dB
15	RADOME LOSS, TYPE	dB
16	TX LINE + ANT RETURN (VSWR)	dBRL
17	TOTAL FIXED LOSSES	dB
18	TOTAL LOSSES	dB
19	PARABOLA HEIGHT, ℄ AGL	Ft.
20	PARABOLA DIAMETER	Ft.
21	REFLECTOR HEIGHT, ℄ AGL	Ft
22	REFLECTOR SIZE, TYPE	Ft
23	PARABOLA REFL. SEP.	Ft.
24		
25	ANTENNA SYSTEM GAIN	dB
26	TOTAL GAINS	dB
27	NET PATH LOSS	dB
28	MIN. TRANSMITTER POWER	dBm
29	MED. REC. POWER (±2 dB)	dBm
30	NOISE THRESHOLD (KTB+NF)	dBm
31	THEORETICAL RF C/N RATIO	dB
32	REC. MUTE POINT	dBm
33	FADE MARGIN (To Mute Point)	dB
34	RELIABILITY,	
35	PROFILE NUMBER, K, F.	
36	UNFADED NOISE	pWp0

EQUIPMENT

TYPE ____, ____ MHz I.F.
____ EMPHASIS ____ KHz SLOT
____ CHANNELS ____ KHz DEV/CH
____ dBm LOADING ____ dBRL

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Figure 6. Microwave path data calculation sheets are used to determine both qualitative and quantitative design objectives and once completed they become the system documentation for equipment specification and installation.

offs available, since the heights shown at each end would be required to clear the near-end obstructions, even if those at midpath did not exist.

Finding the best combination of antenna heights and assuming that the clearance is adequate, essentially completes the path solution in cases where there is no likelihood of reflections. When surfaces of high reflectivity such as bodies of water, salt flats, or very smooth terrain exist along the path, some additional work may be needed.

Reflections

The "elegant" way to check for reflections is to run height-gain tests to determine the extent of the reflection problem, and the best antenna heights. This is, however, a very expensive process, particularly if the necessary portable towers and test equipment are not readily available and must be purchased or leased.

There are other things short of path testing, which may be done to protect against reflection problems. The first thing to be done, after choosing tentative antenna heights purely on a clearance basis, is to check whether this set of heights has a clear, unblocked reflected path from the potential reflective surface, under expected operating conditions. There may be some terrain feature which blocks one of the reflected paths, but allows adequate clearance for the direct path. This would be a desirable situation which would effectively remove the reflection problem.

If it is found that the initial antenna choices do allow unblocked reflections to exist, it may be possible to change antenna heights, or in some cases even the station locations.

In some cases, it may not be possible to avoid having a potentially reflecting path. In such cases it may be necessary to resort to space diversity to alleviate the problem.

One of the last things to be done is to enter the appropriate data on a microwave path data calculation sheet (see Figure 6), together with the pertinent equipment and performance parameters, and calculations made to determine the amount of antenna gain needed to meet the desired unfaded signal level.

After determining the antenna configuration, the appropriate gains can be entered in the sheet, and the remaining calculations made to determine normal signal level and fade margin. On a single channel or frequency diversity path, the process is quite straight forward and self-explanatory. Some complications arise with space diversity or crossband diversity, in that there are separate waveguide runs and in some cases even separate antenna systems requiring separate calculations.

Coordinated Effort

After all the engineering calculations have been completed, the appropriate equipment to meet the desired and necessary engineering specifications must be furnished and installed. The whole operation from initial request to operating system requires a coordinated effort to result in the best possible microwave system.

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