The Lenkurt® Demodulator

NEWS FROM LENKURT ELECTRIC

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Military Versus Commercial

CARRIER SYSTEM DESIGN

For several years, Lenkurt has been developing two of the most advanced carrier systems available today. Despite the fact that both were developed nearly simultaneously by two teams within the same company, the systems are remarkable for their differences rather than their similarities. Each was designed to satisfy rigorous — but different — needs. This article contrasts the differing equipment requirements of military and commercial communications and shows how in good design, "form follows function."

Science and technology press forward constantly, again and again opening the way for achievements previously not practical, and revealing better ways of doing old jobs. Eventually, even perfectly adequate equipment is gradually replaced by designs which take advantage of newer techniques. In commercial communications, however, new features or techniques are rarely the basis for retiring old equipment for new. Instead, old equipment is usually retired as it passes the point where it can continue to serve reliably and economically. Often, well-proved designs may even be preferred because of the refinement and dependability of the equipment.

This is not generally so in military systems. Yesterday's fighter plane, although still a superb aircraft, may be virtually useless against another which has only a slight performance advantage. In military communications, a similar philosophy applies. Although communications systems are not pitted against each other in combat, commu-

Figure 1. Lenkurt 45BX carrier equipment in telephone toll center. Protruding equipment on right is Lenkurt 33A carrier, a classic older design still in great demand because of its reliability and performance. Relatively controlled environment in such centers reduces an important problem forced on military equipment.

nications dependability and performance could provide the decisive edge which makes the difference between victory and defeat.

Contrast in Economics

The cost of civilian communications equipment may be spread over a long, predictable life span, thus permitting a careful estimate of the performance required. Commercial equipment can be designed to perform a certain function to a certain standard of quality — no more, no less. This careful blending of economics and engineering results in systems of very high efficiency, and provides communications of the lowest cost consistent with reliability and high quality.

The extremely high stakes involved in military action prohibit this philosophy of prudent economy. No matter what the cost of a military communications system, it proves to be a tremendous bargain if it helps prevent a war or win a battle. Equipment which falls short of doing its required job under the strenuous conditions of crisis, might just as well not be built in the first place.

The Military Problem

Unlike civilian communications networks, which evolve in a deliberate, carefully-organized pattern to match the gradually changing needs of our civilization, military needs are most likely to erupt full-grown in an hour, and under the worst possible circumstances.

Military equipment must be designed to be "at home" in whatever situation it finds itself. Temperature extremes, sandstorms, blizzards, unskilled handling — these and more, are typical of some of the adversities which may hamper proper communications.

Because the circumstances under which a military system may be used are largely unpredictable, it must be assumed that the traffic load will be severe. More facsimile, digital data transmission, and other pulse-type communications are used than in civilian systems. These types of signal impose a much heavier load than ordinary voice messages because the randomly-occurring speech sounds average out statistically, when many channels are involved. For this reason, a military system must

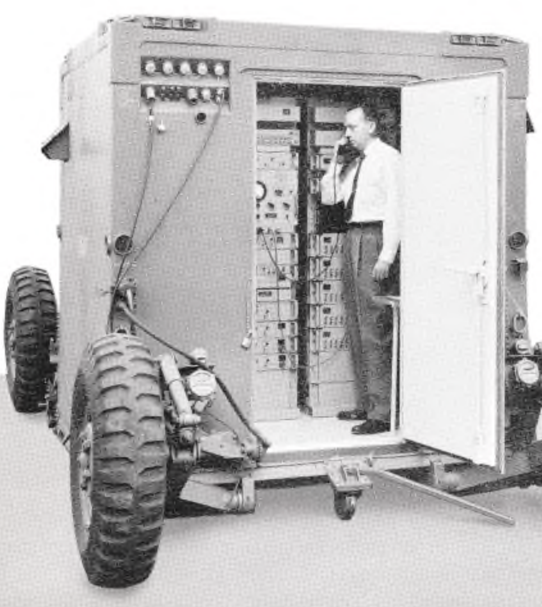

Figure 2. AN/FCC-17 tactical shelter for 60-channel carrier terminal. Wheels are extended for travel, may be retracted as shown during use, so that shelter rests on ground. Wheels may also be completely detached when shelter is used in semi-permanent location.

Figure 3. Roll out shelves in military system allow easy access and maintenance to all circuits. Military system requires greater rack depth than commercial system, but permits shorter racks. Deep racks permit roll-out shelves and provide additional mechanical strength.

be able to accomodate a considerably heavier load than its civilian counterpart, for a given number of channels.

As a final difficulty, the *circumstances* of military use make particularly severe demands on the physical structure of the equipment. It must be able to withstand the severe mechanical shock and vibration associated with transportation of all types, as well as shock that might result from hostile action. In addition to being ruggedly built, the equipment must be designed so that maintenance is particularly easy, since there is never assurance that well-trained personnel will always be available to keep the system running properly.

The Problems of Commercial Design

There is quite a difference between good design in a military system and in a system suitable for commercial communications. The military system must achieve certain performance characteristics regardless of cost. A commercial system, on the other hand, must meet very definite performance requirements, but within rigorous cost limitations. This can be done, not by cheapening the design, but by making it much more specialized in its function.

In a military system, quality of performance means ability to overcome adverse conditions; in a commercial system, high quality invites and stimulates more use, thus permitting the system to justify itself economically. A very careful balance is involved. Improved performance certainly invites more patronage, but increases the cost of the system at a very rapid rate. The quality of the system must not be so high that no one can afford to use it. Nor should the quality of communication be so poor that other means prove more satisfactory.

Recent Examples

Two new carrier systems provide an unusual opportunity to show how these problems were met in commercial and military engineering practice. The military system, designated *"Multiplexer Set AN/FCC-17,"* will be the standard carrier system used by the United States

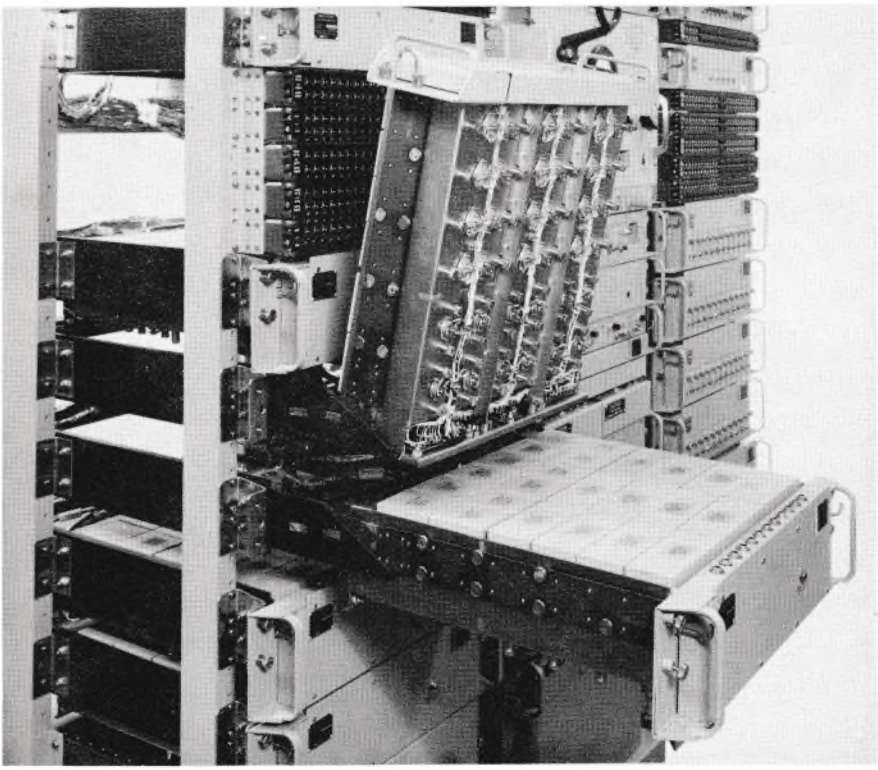

Figure 4. Military system employs deep, rugged racks to support equipment. Roller slides permit inspection and maintenance of all circuits without interrupting service. Extended drawers each contain channel filters and modulators for 12 transmitting channels. Each drawer may be locked fully extended and may be tilted upward for access to bottom interconnections.

Air Force in filling its carrier communications needs all over the globe. The commercial system, known as *Type 46A*, supplements and extends the usefulness of Lenkurt's 45-class carrier systems, used by more organizations around the world than any other carrier equipment.

Both systems are transistorized, both provide up to 600 channels. Both are designed to provide circuits of very high quality over great distances. Beyond this, the similarities end.

Versatility

Both systems are extremely versatile, each in a different way.

The AN/FCC-17 was designed for *universal* use, permitting transmission over radio and, with auxiliary equipment, wire or cable. There is no restriction on the type of information which it can accept for transmission; speech, digital data, facsimile, and related types of signals may be transmitted over any or all channels without requiring special treatment.

The 46A has been designed to permit coordination with virtually all other types of carrier system used for long-haul service. A variety of standard options provide pilot frequencies and operating levels recommended by C.C.I.T.T. or used in such systems as the

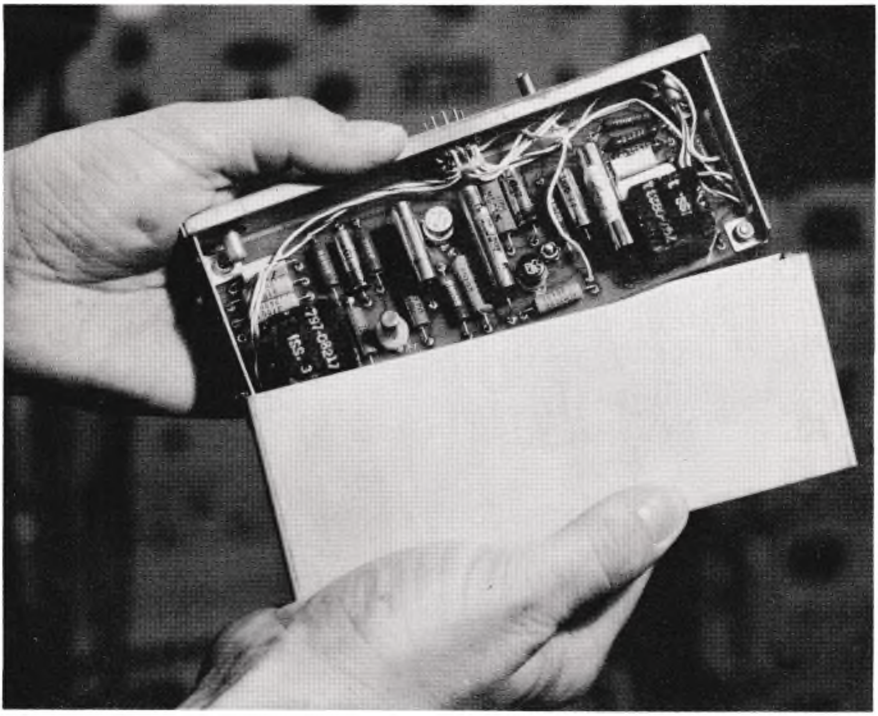

Figure 5. Conventional etched circuit techniques are used within sealed plug-in units of AN/FCC-17 system. Units are sealed to protect them from environment and handling. Internal repairs are performed at maintenance depot.

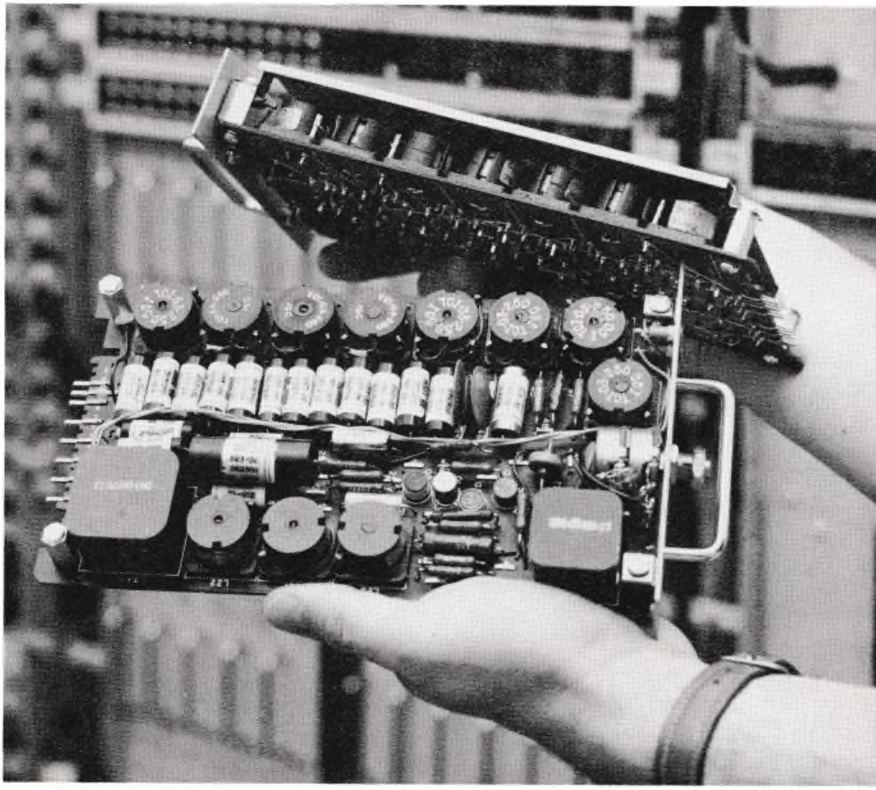

Figure 6. Typical 46A plug-in units. Shield has been removed from lower unit. Round objects shown at edge of both units are ferrite inductors used in filters. Note stitched wiring visible on upper unit. This type of construction permits automatic fabrication, yet provides even better repairability and reliability than expert hand wiring.

Western Electric "L" carrier system. To enhance the versatility of the equipment, 46A channel banks are designed for use with the group and common equipment of such systems.

Mechanical Construction

Radical new construction methods are used by each system to meet its special objectives. One of the prime requirements of the Air Force system is mobility and the ability to function reliably despite physical abuse. All the equipment is suitable for use either in fixed installations or in mobile communication centers. One tactical version is illustrated in Figure 2. This is a 60-channel terminal mounted within a special mobile shelter to permit travel over rough terrain.

Heavy four-post racks support the roll-out shelves in which all equipment is mounted. Each shelf may be extended and tilted up for inspection, and adjustment without interfering with the operation of the system. Virtually all electrical components are contained within sealed units which plug into the sliding shelves. This technique permits defective units to be replaced immediately, and protects the components from dirt, moisture, and improper handling. In addition to speeding field maintenance, plug-in units permit equipment repairs to be handled at efficient central depots.

The 46A system does not require the extreme mechanical ruggedness of the AN/FCC-17, but is designed for conventional mounting on racks of the sort found in all telephone and communication centers. Instead of the sealed circuits found in the military system, all components are mounted on insulating boards which plug into equipment shelves. Figure 7 shows a close view of a typical 46A shelf with several of the plug-in units removed. Typical plug-in units are visible to the right and left in the picture.

As in the military system, plug-in modules permit very rapid maintenance in case of equipment failure. Unlike the AN/FCC-17, all circuit components are exposed. This is permissible because the 46A does not have to cope with the unusually wide range of environmental conditions for which the AN/FCC-17 is designed.

In the military system, printed or etched wiring is used to achieve uniformity and maximum space economy, thus enabling all active circuits to be enclosed in sealed containers to protect them from the environment.

The 46A equipment uses Lenkurt's unique stitched wiring process (de-

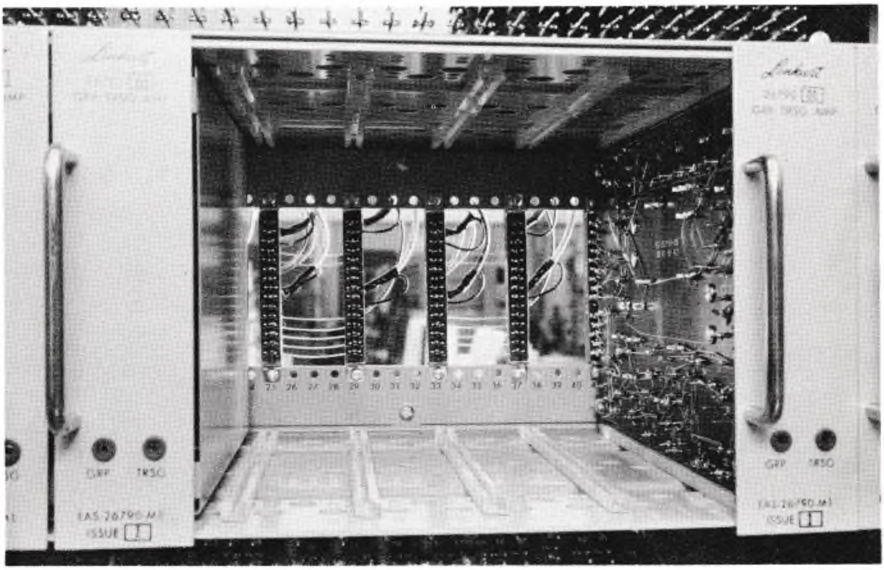

Figure 7. 46A plug-in units are held by nylon slides, and plug into receptacles at rear of shelf. In this view, four plug-in units have been removed. Note stitched wiring on unit at right.

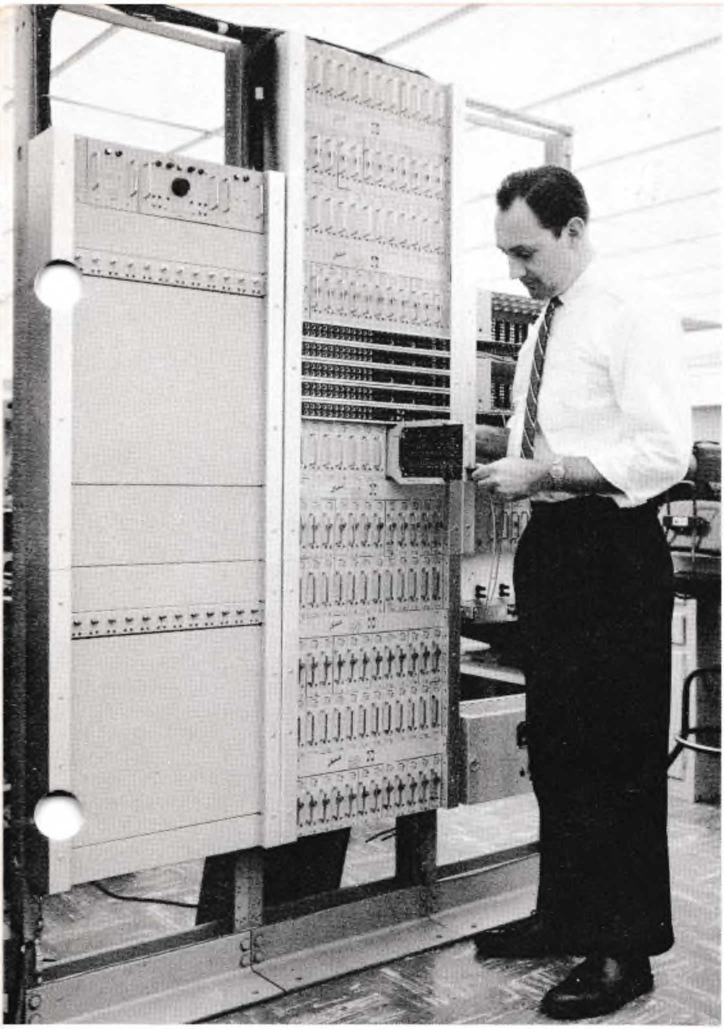

Figure 8. A typical 60-channel 46A terminal with additional common equipment. Left rack includes carrier supply for 288 channels (240 plus 20%). Group equipment for 60 channels is contained in two of the shelves in the rack on right. Engineer is shown using shelf extender which permits access to both sides of plug-in unit while it is connected into system, permitting easy testing and maintenance.

scribed in DEMODULATOR, June, 1960). This construction method is similar to etched wiring in that insulating boards are used to support the components and interconnections. The stitched wiring process combines the uniformity and ease of manufacture of printed circuits with the easier maintenance and repairability of hand wiring. Automatically-inserted staples serve as connection points for components and wire interconnections, thus permitting components to be replaced by less skilled personnel. The penalty for this is the slightly greater space required by the projecting staples (Note the unit to the right in Figure 7).

Load Capacity

The load-handling capacity of a carrier system is one of its most critical design features, since this has an important bearing on the cost, size, and noise performance of the equipment. It is difficult to predict exactly how much load will be imposed by a single voice channel because of the wide range in individual speech characteristics. As the

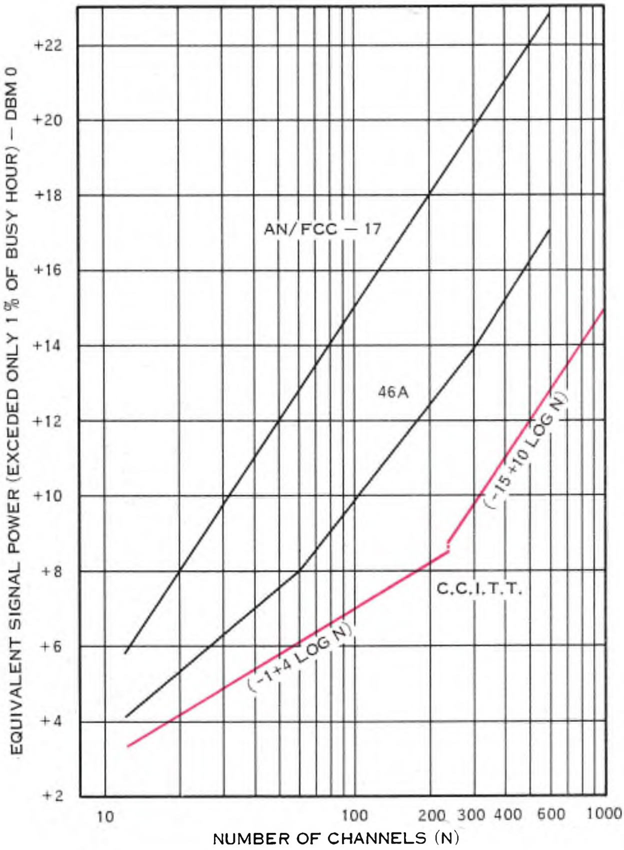

Figure 9. Comparison of load-handling characteristics of AN/FCC-17 system, 46A system, and the load characteristic recommended by CITT. The 46A system will handle more data transmission than provided for in CITT recommendations. Military system will handle 100% data load with no loss of performance.

number of channels increases, however, individual characteristics average out so that the total load becomes easier to estimate.

Careful measurements of the load presented by various numbers of voice channels have led to the C.C.I.T.T. load estimates shown in Figure 9 (red curves). The values shown represent the approximate load presented by speech plus a normal amount of signal power due to signaling tones, carrier leak, and pilot tones.

Because of the steadily increasing amount of data transmission, the load handling ability of the 46A system has been made substantially greater than the "normal" capacity indicated by the C.C.I.T.T. recommendations. The 46A load capability shown in Figure 9 was determined by assuming that ¾ of the channels would use out-of-band signaling tones (an option), $1/6$ of the channels would propably carry telegraph or similar data traffic, and $1/12$ of the channels would be used for SAGE data. Under these conditions of loading, the 46A system meets all noise and distortion standards for long-haul, toll-quality carrier.

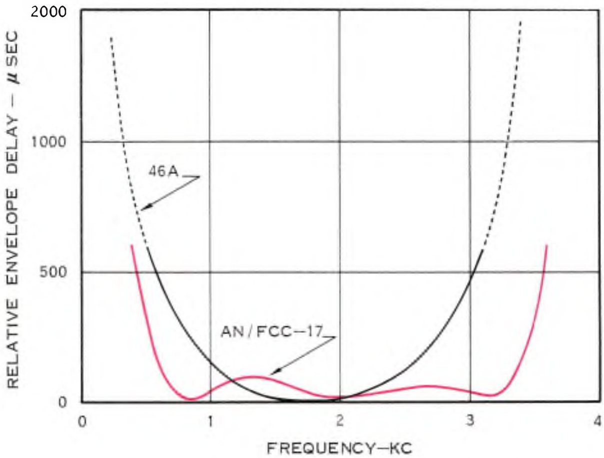

Figure 10. Comparison of relative envelope delay of 46A and AN/FCC-17 channels. Delay equalization is provided for all channels in the military system. 46A-channel filters are designed so that no channel varies more than 25 microseconds from characteristic shown.

It cannot be assumed that the military carrier system will be permitted to enjoy such an equitable and well-rounded load distribution. Being a military system, it must be designed to accommodate the worst possible load that might be applied to it. Accordingly, the AN/FCC-17 was designed to carry 100% data or facsimile.

Delay Distortion

Envelope delay has a much greater apparent effect on the quality of data and facsimile transmissions than on voice circuits. Since both systems place special emphasis on the ability to accommodate pulse transmission, special pains were taken to restrict envelope delay as much as possible.

In any carrier system, almost all the envelope delay experienced is contributed by the channel filters rather than the filters associated with groups of channels. In the 46A system, channel filters were designed to have *uniform* delay characteristics, regardless of their frequency. A "nominal" delay characteristic was determined and all channels must not deviate from this characteristic by more than 25 microseconds. This uniformity permits a standard delay equalizer which can be used with any channel, regardless of frequency.

Since the AN/FCC-17 was designed specifically to handle data, special care was taken to minimize envelope delay over a large portion of the channel passband. Figure 10 compares typical channel envelope delay characteristics of the two systems.

Conclusions

Although both systems are notable for their particular electrical and mechanical features, more outstanding is the way in which each design has been carefully tailored to meet the special needs of its particular application. Although the military system includes many "extras" to obtain its extraordinary performance, it is remarkably compact. Similarly, the 46A improves upon performance standards available in previous equipment, and manages to improve size, cost and reliability at the same time. ●

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