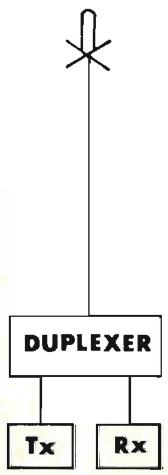

This booklet has been written for the many people engaged in two-way radio communications who are NOT radio engineers. A non-technical presentation of a rather complex subject has been attempted in an effort to bring about a better understanding of duplexers used in two-way radio systems.

You can hardly expect to become and expert on duplexers just by reading this, but if some of the fog is lifted and the picture seems a little clearer . . . we shall feel amply rewarded for our effort.

About Duplexers

Ever consider how difficult ordinary conversation would be if our telephone system were a "simplex" system? With a simplex system you talk to the other party, then listen, then talk again, etc. You cannot talk and listen at the same time. If you miss the first part of the other person's message, you have to wait until he is through talking before asking him to repeat it. This "built-in delay" slows down the thought process and makes an exchange of information more difficult. Fortunately, we aren't confronted with this problem because our telephone system is a "duplex" system and we can carry on a natural conversation.

But what about our radio system? If a duplex system is superior to a simplex system, why are most of our radio systems simplex? Several reasons, the most common being:

(1) A duplex system requires the use of two frequencies (one for transmit, one for receive) and only certain radio users can obtain authorization for use of a second frequency.

(2) A duplex system requires additional equipment items and the system might be more costly than a simplex system.

(3) Certain unique technical problems must be overcome with a duplex system . . . and that's what this booklet is all about.

The Simplex System. The typical simplex system consists of a transmitter and receiver operating on the same frequency (Fig. 1). The antenna changeover relay (located within the radio set) switches the antenna to the transmitter whenever the microphone button is depressed or to the receiver whenever the microphone button is released. You cannot transmit and receive at the same time. If the transmitter and receiver shown in Fig. 1, were both connected directly to the antenna system, by-passing the antenna changeover relay, the receiver would be severely desensitized (performance degraded) and probably physically damaged by the output power of the transmitter. And the transmitter would be less efficient since a portion of its power would go into the receiver.

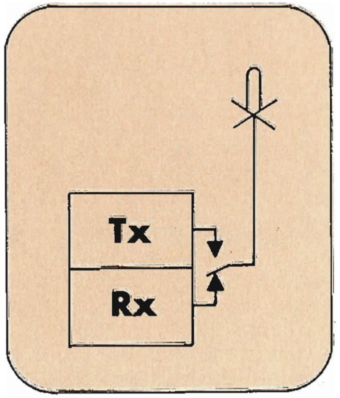

Figure 1

The Duplex System. There are numerous types of duplex systems but they all have one thing in common; the transmitter operates on one frequency and the receiver operates on another. The duplex system generally is installed to accomplish one or more of the following goals:

(1) to replace the wire line control circuit between the base station and remote control point and/or

(2) to extend or relocate the coverage area of a radio system, and/or

(3) to improve the exchange of information between two parties by allowing the parties to transmit and receive at the same time.

The MOBILE REPEATER SYSTEM is probably the best example and least complicated of all duplex systems. It involves little more equipment than that used with the conventional simplex system yet provides considerably greater range between one mobile unit and another. Consider first the typical simplex system (Fig. 2). This system might be expected to provide communications over a distance of 30 miles between the base station and mobile units and possibly 10 miles between mobile units.

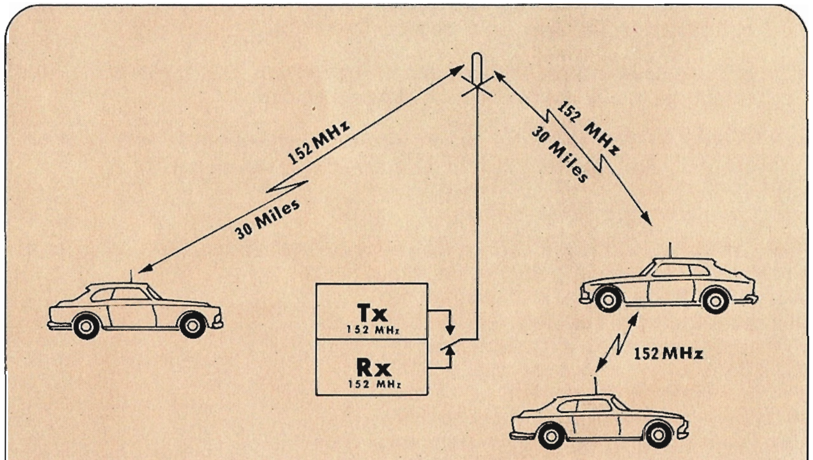

Figure 2

Now consider the same system installed as a mobile repeater system (Fig. 3). The system provides the same 30 miles coverage between the base station and mobile units as before, but coverage up to a distance of 60 miles is now possible between mobile units since the repeater station will automatically re-transmit any signal it receives. For example, as car #1 transmits, the radio frequency signal is received by the station receiving antenna and fed down the transmission line to the receiver. The signal is then routed into a coupling device which turns the transmitter on and, at the same time, the audio (voice) is fed into the transmitter. The transmitter broadcasts the signal out the transmitting

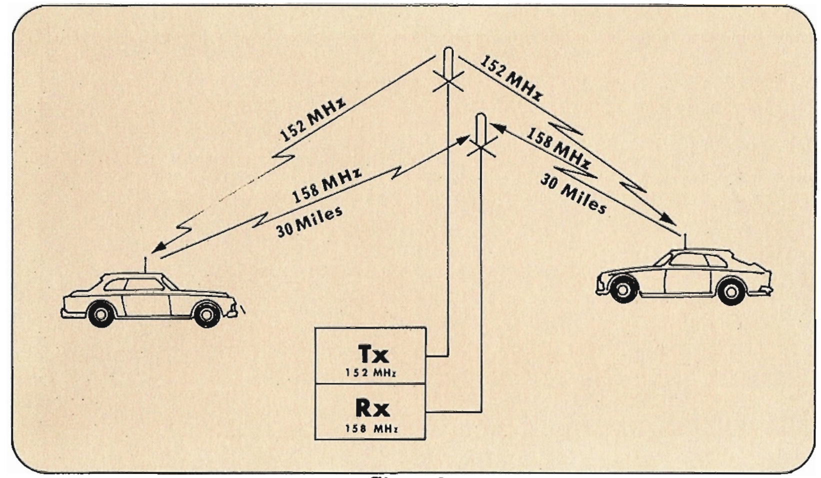

Figure 3

antenna on a new frequency. All of this occurs at a speed approaching the speed of light so reception of a signal is virtually simultaneous with the transmission of the signal.

From an operational standpoint, the use of the mobile repeater system may eliminate the need for an operator at the office. Even so, most systems include a control point at the office so that communication is available between office and mobile units. There are many types of duplex systems, of course, and two more examples are shown in Fig. 4 and 5.

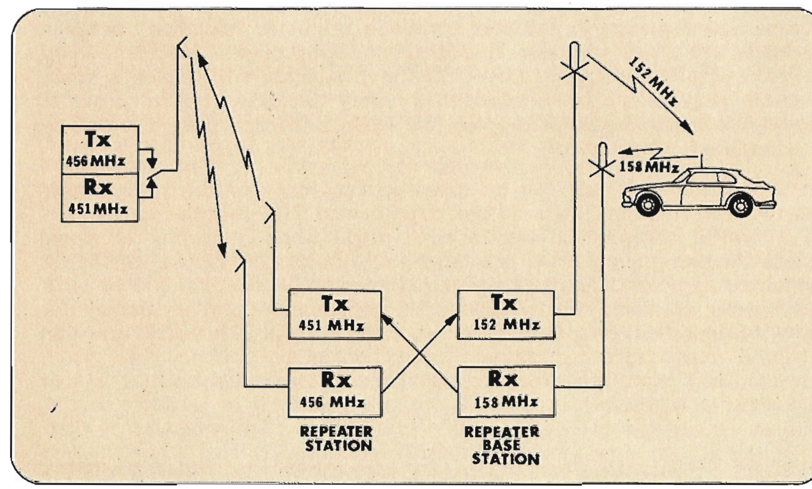

Figure 4

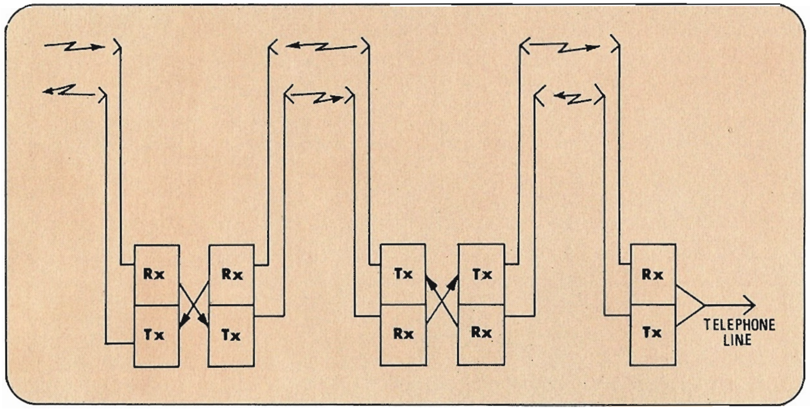

Figure 5

Why No Duplexer? In all of the preceding illustrations, we have not shown the use of a single duplexer. Our reasons are twofold: (1) the theory of operation of a duplex system is easier to understand without the duplexer and (2) the point is shown that a duplex system does not necessarily have to include the use of a duplexer. Two separate antennas (one for transmit, one for receive) can serve the function of a single antenna and duplexer, or vice versa.

Need for Isolation. The reason for using two antennas (or a single antenna and duplexer) in a duplex system is to obtain "isolation" between the transmitter and receiver. This isolation, expressed in dB, is one of the most important considerations in the design of any duplex system. Adequate isolation must be provided in every duplex system in order to prevent the performance of the receiver from being adversely affected by its associated transmitter.

But why should a transmitter on one frequency degrade the performance of a receiver operating on a different frequency? The specifications covering a typical communications receiver might show that any rf signal outside the extremely narrow passband (50 kHz or less) of the receiver is attenuated by up to 100 dB (a power reduction of 10,000,000,000 to 1). If the receiver is that selective, why be concerned about a transmitter operating on a frequency that is, for example, 5 MHz away. Good question . . . and a considerable portion of this booklet will be devoted to the answers. Let's start by taking a close look at the characteristics of our transmitter and receiver.

Receiver Selectivity. The modern day communications receiver receives a relatively high frequency signal (50 MHz, 150 MHz, 450 MHz) and

systematically lowers the frequency, in steps, as the signal passes through various stages of the receiver. As the frequency of the signal becomes lower, the passband of the receiver can be made more narrow, more selective (Fig. 6). Finally, the received signal is lowered to a point where the circuitry in the receiver is able to pass an extremely narrow band of desired frequencies while rejecting all other frequencies by, let's say, 100 dB. This is the OVERALL SELECTIVITY of the receiver and, appropriately, is the performance characteristic described on the receiver specification sheet.

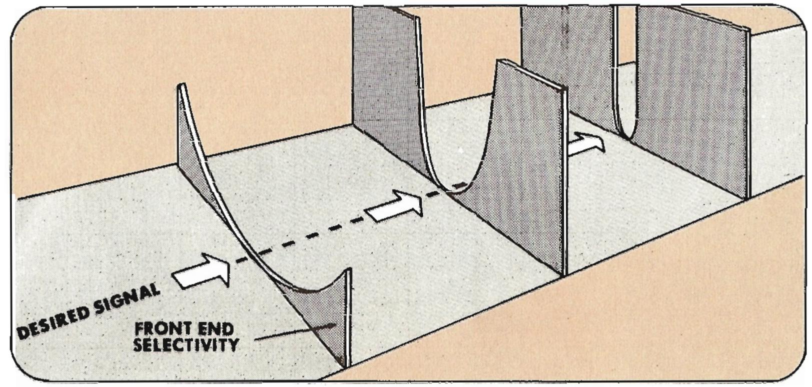

Figure 6

Remember, though, it took virtually all of the receiver's stages to finally narrow the passband to a narrow band of frequencies. The receiver's selectivity wasn't, and can't be this sharp at its input. While the overall selectivity of the receiver is excellent, the front-end stages of the receiver are relatively broad and cannot reject completely the strong signal from our transmitter, even though our transmit frequency might be several megahertz from our receive frequency.

Receiver Desensitization. For optimum performance, critical voltage and current levels exist at certain points throughout the front end stages of a receiver. If these levels are radically changed, the performance of the receiver will become erratic and/or degraded at its operating frequency. This being so, what keeps the receiver from being degraded whenever the signal from a nearby transmitter enters the front end stages of our receiver? . . . Nothing. In fact, the problem is so common we even have a name for it . . . RECEIVER DESENSITIZATION. Receiver desensitization results from a strong, off-frequency carrier from a nearby transmitter (nearby in frequency and nearby in location). And it doesn't have to be as near in frequency and location as we might think. A transmitter can be operating several megahertz from our receiving frequency and/or be located several thousand feet from our receiving antenna and still cause interference to our receiver (Fig. 7).

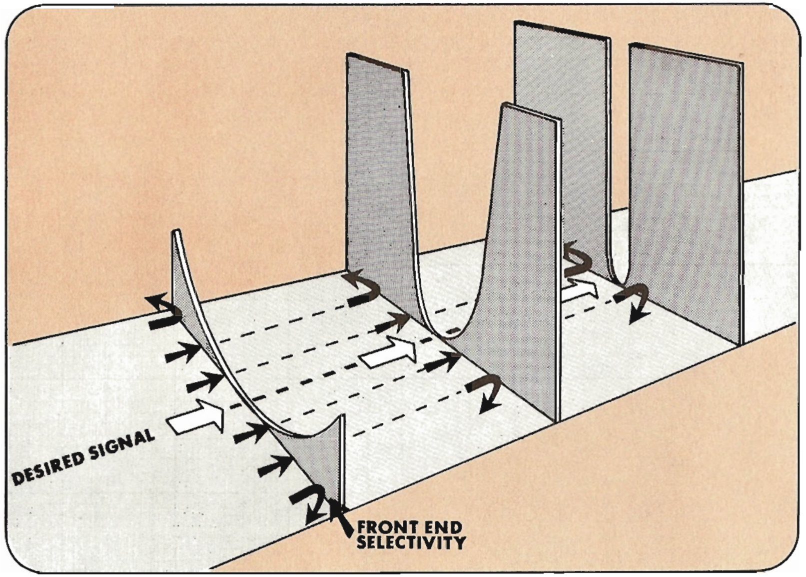

Figure 7

With a duplex system, we know our transmitting frequency will be fairly close to our receive frequency and the transmitting antenna will usually be close to—possibly the same as—our receiving antenna. At this point, it's obvious that we need to somehow isolate the receiver from the degrading effect of another transmitter(s) in the area. More on this later, but let's now consider another problem that exists whenever a transmitter is operated in close proximity to a receiver.

Transmitter Noise. Ideally, we would have our transmitter confine all of its output power within a narrow band of frequencies on the assigned transmit channel. But this isn't possible. Certainly, the bulk of the power is confined within the assigned channel but some of the power is radiated on other frequencies above and below the carrier frequency. This undesired radiation is referred to as "transmitter broad band noise radiation" or simply, "transmitter noise". Filter circuits in the transmitter eliminate a considerable portion of this undesired radiation but, even so, enough noise energy is radiated to degrade the performance of

a receiver operating several megahertz away. The level of noise is greatest at frequencies close to the transmitter's carrier frequency, (Fig. 8).

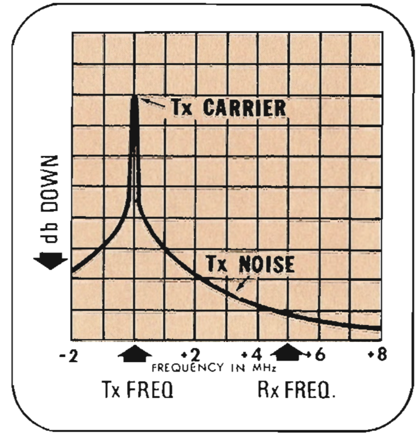

Figure 8

Transmitter noise appears as "on-channel" noise interference to the receiver and CANNOT be filtered out at the receiver. It falls exactly on the receiver's operating frequency and competes with the receiver's desired signal. But don't confuse transmitter noise interference with receiver desensitization discussed previously. These are two entirely different forms of interference. TRANSMITTER NOISE appears as ON-CHANNEL interference to the receiver, masking the receiver's desired signal and reducing effective sensitivity. RECEIVER DESENSITIZATION is the result of a strong OFF-CHANNEL transmitter carrier entering the broad front end of the receiver, upsetting critical voltage and current levels and reducing gain of the receiver. Both forms of interference degrade the performance of the receiver but they are different and must be eliminated by different means. This brings us to the next subject . . .

Isolation Between Transmitter and Receiver. In the preceding paragraphs, we have established the fact that a certain isolation between transmitter and receiver must exist in a duplex system if normal receiver performance is to be expected. The questions that now arise are: (1) how much isolation is required to protect the receiver from being desensitized by the transmitter carrier?, (2) how much isolation is required to reduce transmitter noise at the receive frequency to a level where it will have little or no effect on the performance of the receiver? The answer to both questions is: It depends on a number of things. It depends on how close together the transmitter and receiver frequencies are; it depends on the frequency band; it depends on the output power of the transmitter, and it depends, of course, on the individual characteristics of the transmitter and receiver which vary with manufacturer and model. Unfortunately, specific answers cannot be given to these questions in this booklet. For specific answers, we must contact the manufacturer of the radio equipment.

Usually, the radio equipment manufacturer will have data such as that shown in Fig. 9, covering each radio model that might be used in duplex systems. At a given separation between transmit and receive frequencies, these curves will indicate the amount of isolation (in dB) that must be provided to protect the receiver from its associated transmitter. One curve illustrates the amount of isolation required to protect the receiver from being desensitized by the transmitter; the other shows the amount of isolation required to reduce transmitter noise to a negligible level. The important thing to notice is that things really change as the frequency separation is decreased. The isolation requirement might double, for example, when the frequency separation is reduced from 5 MHz to 1 MHz.

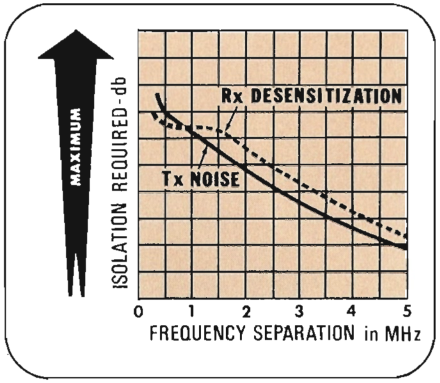

Figure 9

How to Get Isolation. Once the amount of isolation required for a duplex system is determined, we can obtain this isolation by either (1) using an appropriate duplexer or, (2) using two antennas separated by a given distance. Let's take the second option first.

Horizontal Antenna Separation. We know the intensity of a radio signal diminishes rapidly as it travels through space. This is due to the resistance presented by space to the radio signal (propagation loss).

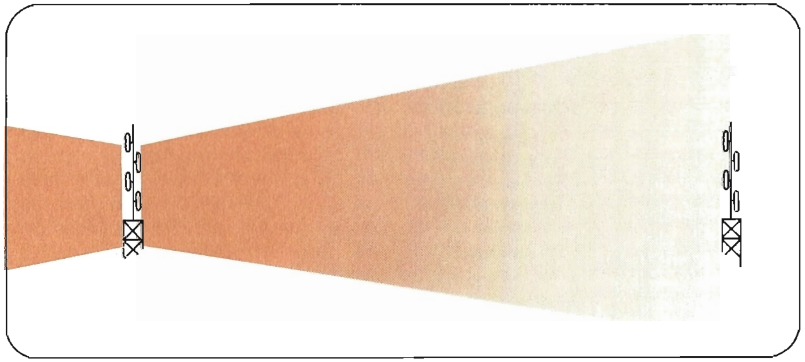

Figure 10

Because of this attenuation, our transmitting and receiving antennas can be horizontally displaced a given distance to obtain a given amount of isolation (Fig. 10). If the distance between the two antennas is great enough, the receiver can be completely protected from its associated transmitter (i.e., protected from desensitization and from transmitter noise interference). Of course, the receiver still might be vulnerable to other transmitters located near the receiving site.

Vertical Antenna Separation, another means of isolating the receiver from the transmitter, is more effective, more convenient and thus used more often than horizontal separation. The same tower is usually used for both antennas, one antenna being mounted a given distance above the other. In addition to the isolation provided by space attenuation, we get the extra isolation caused by the "cone of silence" that exists between most vertically stacked antennas. The cone of silence is a null (lack of gain) in the radiation pattern above and below the typical vertically polarized antenna (Fig. 11).

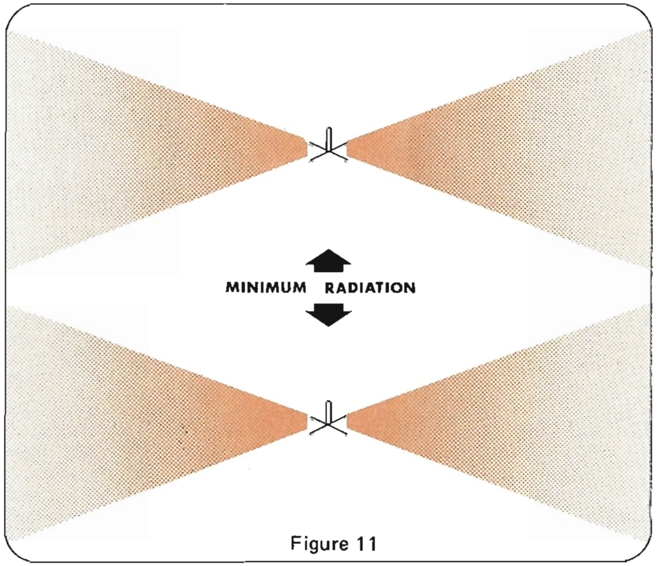

Figure 11

Curves showing the attenuation (in dB) versus antenna separation (in feet) for half wave dipole antennas are illustrated at the back of this booklet. Fig. 25 covers vertical antenna separation; Fig. 26 covers horizontal antenna separation. A glance at these curves reveals the obvious superiority of vertical antenna separation. Note: The isolation values obtained by vertical and horizontal separation of antennas are not directly additive. If the two antennas are mounted in such a manner that both vertical and horizontal antenna separation is involved, the antenna manufacturer should be contacted for advice.

Or we could use a duplexer to achieve the required isolation between the receiver and transmitter. The duplexer can be used to connect the transmitter and receiver to a single antenna in such a manner that both units can be operated at the same time. This means the duplexer replaces one of the two antennas and one of the two lengths of coaxial cable in the typical duplex system (Fig. 12).

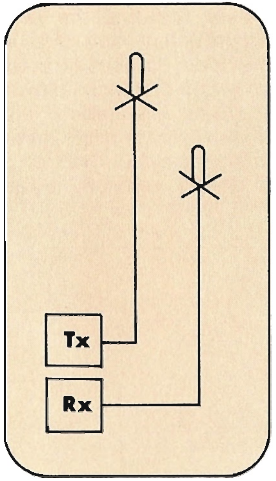

Figure 12a

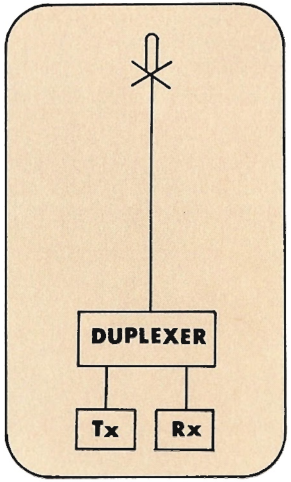

Figure 12b

Advantages of a duplexer. Generally, the savings in cost of the second antenna and cable will more than pay for the duplexer. But economy is seldom the reason for use of a duplexer. There are other, more important reasons:

(1) ISOLATION. The proper duplexer will provide the necessary isolation between the transmitter and receiver even when both units are connected to the same antenna.

(2) ANTENNA PATTERN. Without a duplexer, the duplex system must have two antennas. Both antennas cannot be mounted at the same exact location on the antenna support structure so the radiation patterns of the two antennas will probably be different. This means the coverage area of the transmitter might be somewhat different from the coverage area of the receiver. With a duplexer, the system uses a common antenna which provides the same pattern for both transmitter and receiver.

(3) TOWER SPACE. Good antenna sites are scarce and usually crowded. Obviously, it's easier to find a place to mount one antenna than two. If space on the antenna structure (tower, building) is being rented, the cost might be less for a single antenna.

But you can't get something for nothing. As might be expected, the duplexer has some losses, or inefficiencies, that must be considered. These losses will be discussed in a later section of this booklet.

Things Duplexer Must Do. Duplexers are available in a variety of models and, typically, several of the models appear to meet our requirements. Which one do we choose?

Well, in many instances, several duplexer models WILL meet all of our requirements and the particular model selected becomes a matter of preference. In other instances, however, our system requirements might narrow the number of acceptable duplexer models to only a few. Basically, there are two distinct types of duplexers used in the two-way radio communications industry: the bandpass duplexer, and the band-reject duplexer. Each type has its advantages and disadvantages and both types will be discussed in the following paragraphs. Whatever the type, the duplexer selected MUST provide certain functions if optimum system performance is to be achieved.

A duplexer MUST:

(1) Be designed for operation in the frequency band in which our duplex system operates—obviously.

(2) Be capable of handling the output power of the transmitter.

(3) Be designed for operation at, or less than the frequency separation between our transmit and receive frequencies.

(4) Provide adequate rejection to transmitter noise occurring at our receive frequency. It's all right to have too much rejection but not too little.

(5) Provide sufficient isolation to prevent receiver desensitization. Again, too much isolation is fine; too little results in performance degradation.

And, for greater efficiency, the duplexer SHOULD:

(1) Offer as little loss as possible to our desired transmit and receive signals. All other things being equal, the lower the insertion loss, the better the system will perform.

Losses Through the Duplexer. The output signal from the transmitter and the incoming signal to the receiver are both reduced somewhat by losses in the duplexer. These losses (expressed in dB) are usualy referred to as "insertion loss, Tx to antenna" and "insertion loss, Rx to antenna" on the duplexer specification sheet. Generally, the insertion loss will increase as the separation between transmit and receive frequencies is decreased. For the transmitter, insertion loss values of 0.5 dB, 1.0 dB and 2.0 dB correspond to a reduction of output (watts) of approximately 11%, 20% and 37%, respectively. For the receiver, insertion loss values of 0.5 dB, 1.0 dB and 2.0 dB mean a reduction of 5%, 11% and 20% to the signal strength (microvolts) of the incoming signal.

Bandpass Cavities and Bandpass Duplexers

The Bandpass Cavity. Before going into the theory of operation of the bandpass duplexer, we should first review the characteristics of the bandpass cavity. A bandpass cavity is a device that serves as a filter of radio frequencies. It has the ability to let a narrow band of frequencies pass through while frequencies outside of this narrow band are attenuated. Energy is fed into the cavity by means of a coupling loop, which excites the resonant circuit formed by the inner and outer conductors. The second loop couples energy from the resonant circuit to the output. The coupling loops don't affect the resonant frequency; they do help determine the selectivity of the cavity. The narrow band of frequencies that pass through

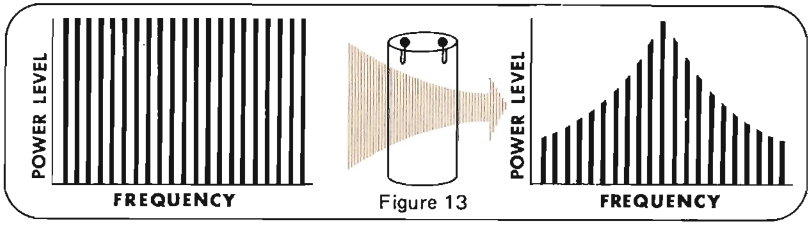

Figure 13

with only slight loss are within a few thousand cycles of the resonant frequency of the cavity. If, for example, the output of a number of signal generators (or transmitters)—all with the same power output but set on different frequencies—were fed into a bandpass cavity, the results would look something like that shown in Fig. 13.

The selectivity of a bandpass cavity is usually illustrated by use of a frequency response curve. The curve indicates the amount of attenuation the cavity provides at discrete frequencies above and below the resonant frequency. It also indicates the amount of insertion loss to the desired (pass)

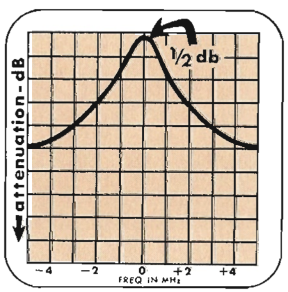

Figure 14

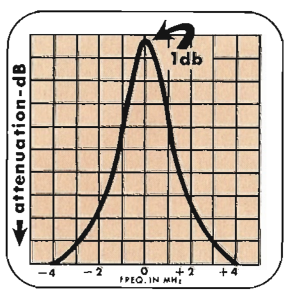

Figure 15

signal at the resonant frequency of the cavity (Fig. 14). If a single cavity will not provide enough rejection to an undesired signal, we can add cavities in series to improve selectivity. The additional cavity will increase the insertion loss at the desired frequency slightly but notice the substantial improvement in overall selectivity (Fig. 15).

The Bandpass Duplexer is so called because it is made up of two or more bandpass cavity filters inter-connected in a duplexer configuration. One or more cavities are placed in the transmitter section of the duplexer and tuned to pass a narrow band of frequencies at the transmit frequency. In a like manner, the bandpass cavities in the receiver section of the duplexer are tuned to pass the narrow band of frequencies at the receiving frequency (Fig. 16).

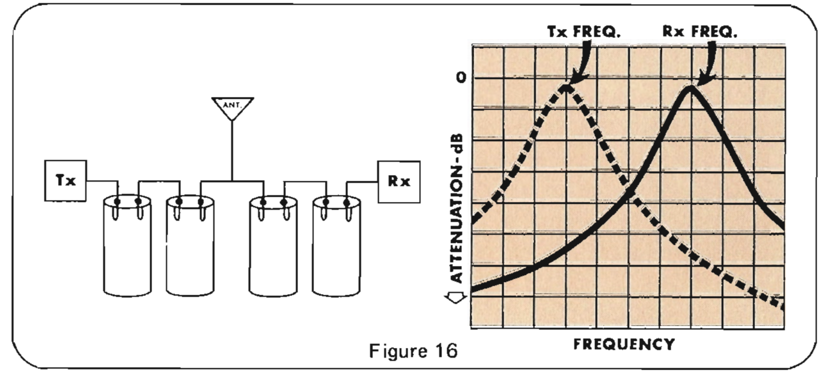

Figure 16

The OUTPUT of the transmitter is fed through the bandpass cavities in the transmitter section of the duplexer, then on to the antenna. Since the cavities are resonant to the transmit frequency, they allow the narrow band of desired frequencies (the transmitter carrier) to pass through with very little loss. But the energy on all other frequencies coming out of the transmitter is attenuated. Transmitter broad band noise energy that would normally be radiated from the transmitter and appear at the receive frequency is reduced to a negligible level. It's rejected by the cavities. By sharpening up the transmitters output, the cavities not only reduce noise at our receive frequency, but—and note this bonus—they reduce transmitter noise on other frequencies as well. This means other receivers in the area might also benefit from the noise reduction feature of the bandpass duplexer. Fig. 17 illustrates how the transmitter

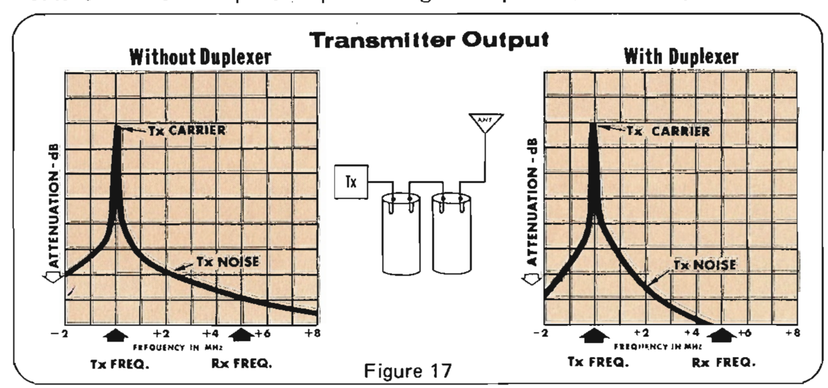

Figure 17

output signal might appear at the input and at the output of the duplexer.

The INCOMING SIGNAL from the antenna is fed through the bandpass cavities (usually two or more) in the receiver section of the duplexer, then on to the receiver. These cavities are resonant at the receive frequency so the desired signal passes through the cavities with only slight loss. All other frequencies on either side of the resonant frequency of the cavities are attenuated (Fig. 18). Essentially, the front-end circuitry of the receiver has been sharpened, made more selective. The receiver has been made to "see" a more narrow portion of the fre-

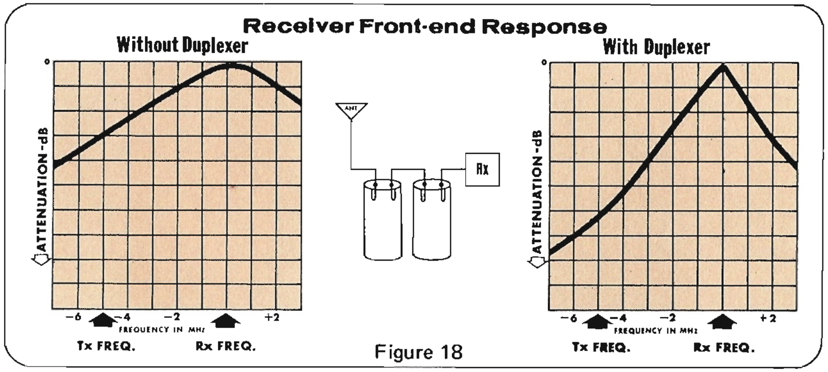

Figure 18

quency spectrum. As a result, the receiver is unaffected by the presence of the nearby "off-frequency" transmitter carrier. As far as the receiver is concerned, the transmitter carrier doesn't exist. Thus, the receiver is protected from desensitization. The bandpass cavities in the receiver section of the duplexer not only protect the receiver from its associated transmitter — and again the bonus — they might also protect the receiver from being affected by other nearby transmitters as well.

The function of the cable harness used on a bandpass duplexer should be mentioned. Certainly, the first function of the cable harness is to interconnect the numerous cavities in the two sections of the duplexer. It also acts as a matching device and makes (1) the outgoing energy from the transmitter 'see" the antenna as the path of least resistance, and likewise, (2) the incoming signal from the antenna to "see" the receiver as the path of least resistance. The "matching" function is accomplished by use of special lengths of cable in the harness.

The bandpass duplexer is a relatively simple device — simple to install, simple to tune — and requires practically no maintenance. If desired, additional cavities can be added to either section to obtain additional isolation. It is not suitable, however, for use in duplex systems with "close" spacing between transmit and receive frequencies. A glance at the bandpass duplexer curve shows that, at reasonable insertion loss levels, it cannot effectively attenuate frequencies near the resonant frequency. Maximum attenuation occurs only at frequencies far removed from the resonant frequency. This, then, limits the use of the bandpass duplexer to systems with "wider" frequency spacing.

Band-Reject Filters and Band-Reject Duplexers

The Band-Reject Filter is a device that functions as a sort of trap of radio frequencies. The band-reject filter has the ability to attenuate a band of frequencies while allowing all other frequencies to pass through with only slight loss. Energy at the resonant frequency (the reject frequency) "sees" the filter as a trap and is coupled to, and consumed in the filter.

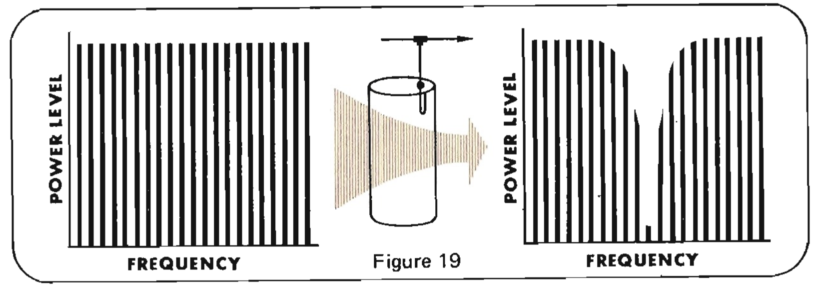

Figure 19

Maximum attenuation occurs at the resonant frequency of the filter while all other frequencies are attenuated to a lesser degree depending on their distance from the resonant frequency (Fig. 19). Unlike the bandpass cavity, the band-reject filter provides a given amount of attenuation at resonance regardless of the separation between the pass and reject frequencies. The filter can be tuned so that the narrow band of rejected frequencies can be several megahertz from the desired pass frequency, or quite close. Minimum frequency separation is limited only by the amount of loss that can be tolerated at the desired frequency. With the use of stubs, the same filter can be made to provide one of several different

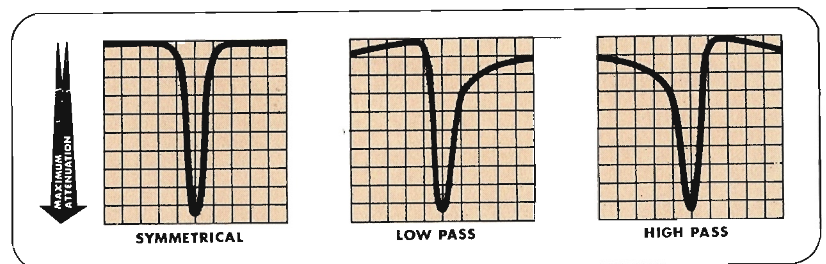

Figure 20

frequency response curves (Fig. 20). Filters can be added in series to obtain additional attenuation to an undesired frequency. Essentially, two filters will provide about twice the attenuation to the undesired frequency as a single filter. The most important feature to notice about the band-reject filter is the steepness of the frequency response curve. This unique feature permits the filter to provide maximum attenuation to an undesired frequency that is extremely close to the desired frequency.

The Band-Reject Duplexer. As would be expected, band-reject duplexers consist of band-reject filters (notch filters) interconnected in a duplexer configuration. One or more filters are placed in the transmitter section of the duplexer and tuned to reject a band of frequencies at the receive frequency. Conversely, the filters in the receiver section of the duplexer are tuned to reject a band of frequencies at the transmit frequency (Fig. 21). This is exactly the opposite of what happens in the bandpass duplexer. But it works. Let's see why.

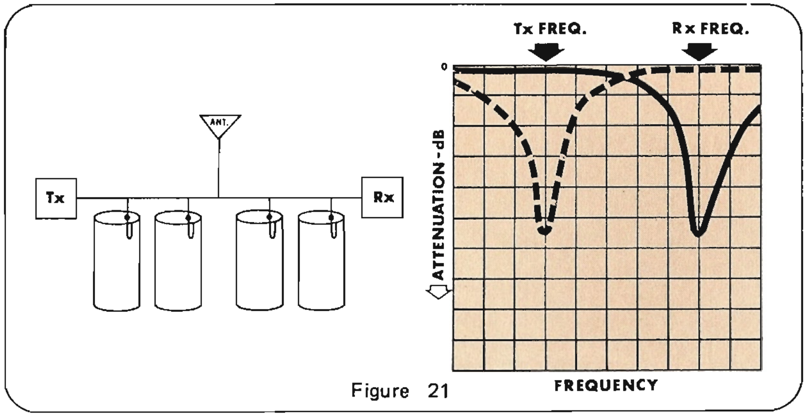

Figure 21

The transmitters OUTPUT is fed through the band-reject filters in the transmitter section of the duplexer, then on to the antenna. Since these filters are tuned to the receive frequency, they accept and absorb the transmitter noise energy being radiated by the transmitter that would normally appear at the receive frequency. The energy on all other frequencies coming out of the transmitter passes by the filters with a lesser degree of attenuation (Fig. 22).

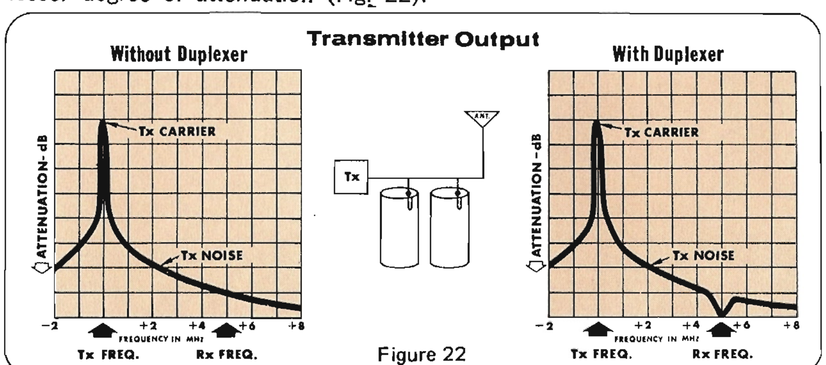

Figure 22

The band-reject duplexer takes a more direct approach in protecting the receiver from noise being radiated by its associated transmitter. In contrast to the bandpass duplexer, the band-reject type does not

alter the overall transmitter noise output. Instead, it selectively rejects transmitter noise at the critical band of frequencies at and near the receive frequency.

The INCOMING SIGNAL from the antenna is fed through the band-reject filters in the receiver section of the duplexer, then on to the receiver. These filters are tuned to the transmit frequency so they trap out and absorb all transmitter energy at and near the transmit frequency that might normally enter the receiver. The desired incoming signal and energy on all other frequencies, pass by the filters with only slight

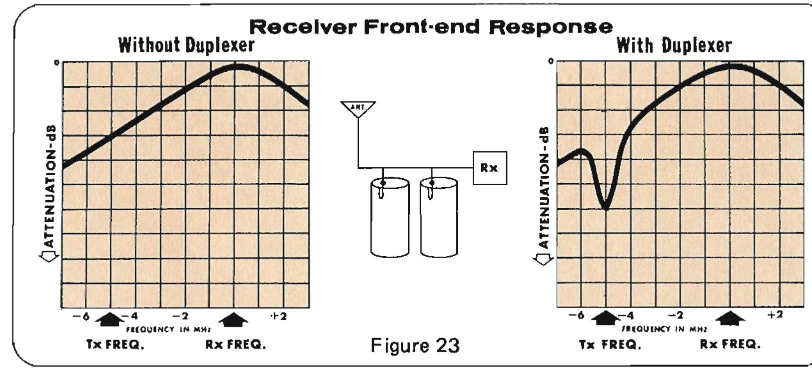

Figure 23

attenuation. The effect of the filters can be envisioned as a barrier placed in the receivers frequency response curve that blocks the passage of any signal within a band of frequencies at the transmit frequency (Fig. 23). Actually, the undesired energy is rejected and reduced to a level where it can no longer affect receiver performance. Since the receiver no longer "sees" the transmitter signal, it is protected from desensitization from the transmitter. Unlike the bandpass duplexer, the band-reject type does not change the overall front-end selectivity of the receiver. Instead, it changes only a portion of the selectivity and makes the receiver unresponsive to the critical band of frequencies at and near the transmit frequency.

The CABLE HARNESS in a band-reject duplexer interconnects the filters in the two sections and makes: (1) the transmitter carrier "see" the low impedance antenna in parallel with the very high impedance filters in the receiver section of the duplexer and, (2) the incoming signal from the antenna "see" the low impedance path to the receiver in parallel with the very high impedance filters in the transmitter section. And that is, of course, the way we want it.

The band-reject duplexer is probably used more often than any other type because of its compact size, low insertion loss and excellent isolation features. It is used often at wide frequency spacing and used almost exclusively at closer frequency spacing. Many of the band-reject models include the shorter helical cavity filters and these models can usually be mounted inside the radio equipment cabinet.

Other Facts About Duplexers

Other Types of Duplexers exist, but they all operate on the principle of the bandpass duplexer or the band-reject duplexer, or a combination of the two. Some (special purpose types) use coils and capacitors in an electronic circuit. These are quite small and generally limited for use in mobile units. Others include a unique cable harness (ring hybrid) with a band-reject duplexer to obtain additional isolation and add a slight bandpass characteristic to the basic band-reject curves. Still others include the use of bandpass cavities in one section of the duplexer and band-reject filters in the other, or a combination of both in each section, in order to achieve a specific isolation characteristic.

Use of Duplexers As Combiners. Duplexers can also be used to couple two transmitters, two receivers, or two single frequency simplex stations into a common antenna. The duplexer might then be called a diplexer or combiner (Fig. 24).

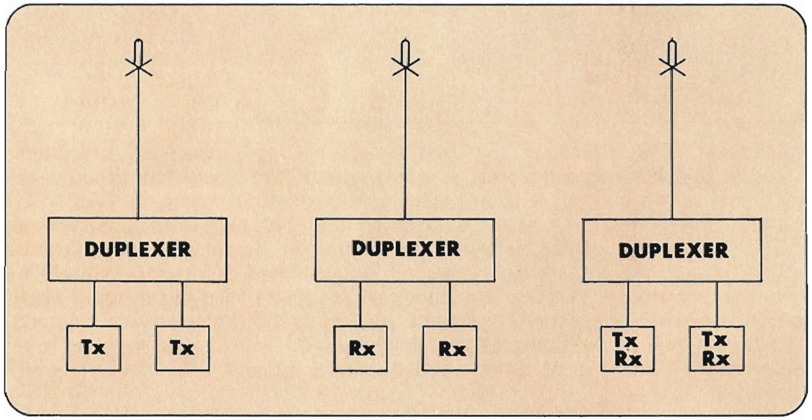

Figure 24

This use of a duplexer is often overlooked. Either the bandpass or band-reject type duplexer is suitable for this purpose and the choice of duplexer should be based on essentially the same system factors considered when combining a transmitter and receiver. A duplexer provides a given isolation between the two units connected to its two inputs and shouldn't really care what these units might be. Of course, the duplexer is designed to handle a given amount of power so the combined output of two transmitters connected to a duplexer must be considered. (Check with the manufacturer of the duplexer.)

Power. Obviously, a duplexer must be rated to handle a given amount of transmitter power. The power rating shown on the duplexer specification sheet probably includes some degree of safety margin but the specified power level should not be exceeded if normal performance is to be achieved. Excess power can cause a voltage breakdown and seriously damage the unit. Excessive power might also cause excessive temperatures, detuning and/or physical damage to the duplexer.

Temperature. Duplexers are expected to remain tuned and provide specified performance over an extremely wide temperature range, generally from —30°C to +60°C, sometimes even greater. This presents a problem since conventional metals will contract when exposed to the lower temperatures (causing detuning) and will expand when exposed to the higher temperatures (causing detuning). To solve this problem, most duplexers are "temperature compensated" to insure that the resonant frequency of the cavity filters remains stable despite a change in temperature. Several methods of temperature compensation may be employed; the most common being the use of INVAR metal at critical points within the filters. The temperature coefficient of INVAR is practically zero and the metal is virtually unaffected by changes in temperature. The specifications on a duplexer usually cover the performance characteristics of the unit operating at the temperature extremes.

Frequency Separation. Duplexers are generally rated as being suitable for use at a certain minimum frequency separation such as "3MHz or more". If operated at closer frequency spacing than recommended, the duplexer will probably have inadequate isolation, excessive insertion loss at the desired frequencies, or both. Duplexers necessarily must be specified as being suitable for use at a given frequency separation when used with a "typical" duplex station. As pointed out previously, the isolation required between a transmitter and receiver at a given frequency separation will vary with manufacturer and model. If a particular duplex station is not "typical" and requires greater isolation than normally expected, the standard duplexer might have to be replaced with one offering greater isolation. If in doubt as to the amount of isolation required at a certain frequency separation, contact the manufacturer of the radio equipment. The duplexer manufacturer might be of help but the radio manufacturer is the ultimate source for this information.

One Final Fact About Duplexers. Decibel Products, Inc. doesn't just write booklets about duplexers, we build them too — in virtually all sizes and types and for any frequency in the 30 to 2000 MHz band. Standard and special models. So when you're thinking about duplexers, think of us. Or better yet, call or write. . . . .

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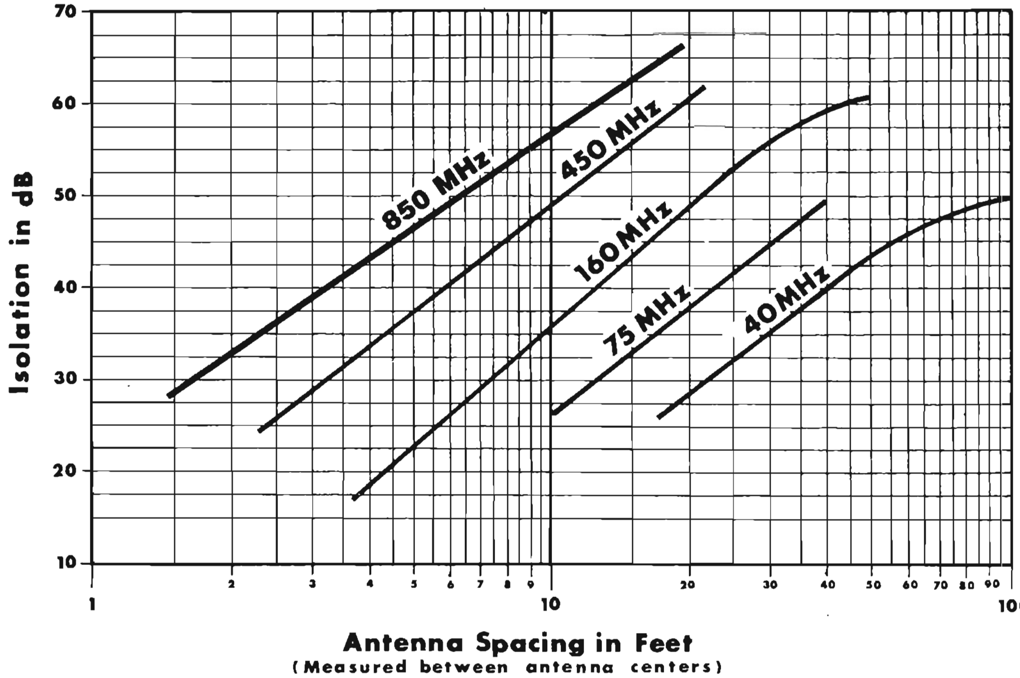
ATTENUATION PROVIDED BY VERTICAL SEPARATION OF DIPOLE ANTENNAS

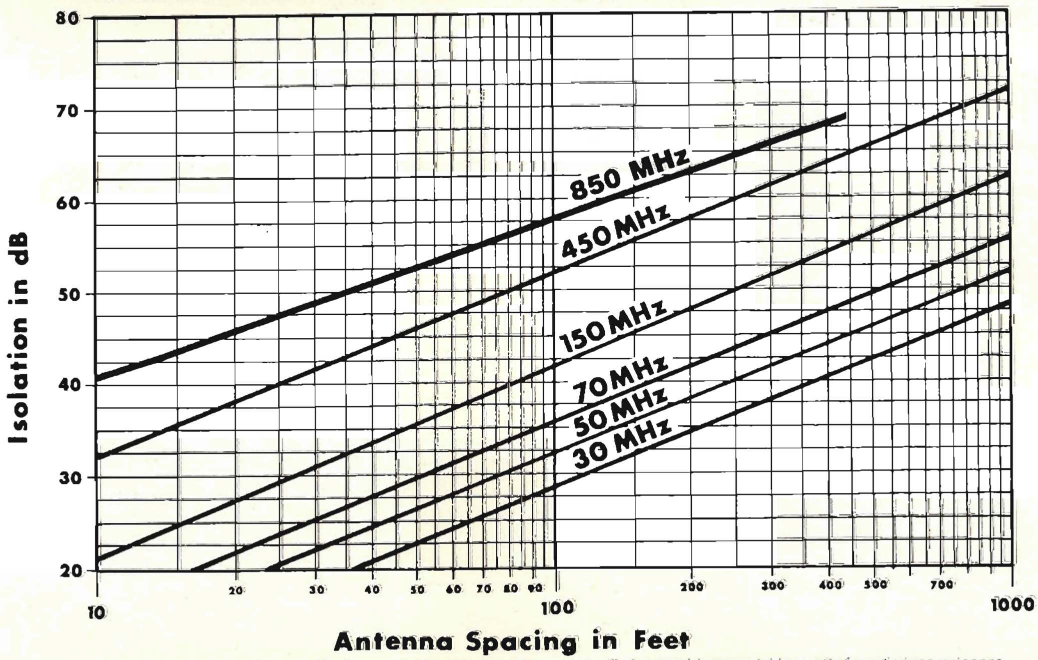


The values indicated by these curves are approximate values because of coupling which exists between the antenna and tower transmission line.

Curves are based on the use of half-wave dipole antennas. The curves will also provide acceptable results for gain type antennas if (1) the spacing is measured between the physical ends of the antennas and if (2) one antenna is mounted directly above the other, with no horizontal offset (exactly collinear). No correction factor is required for the antenna gains.

Figure 25

ATTENUATION PROVIDED BY HORIZONTAL SEPARATION OF DIPOLE ANTENNAS



Curves are based on the use of half-wave dipole antennas. The curves will also provide acceptable results for gain type antennas if (1) the indicated isolation is reduced by the sum of the antenna gains and if (2) the spacing between the gain antannas is at least 50 feet (approximately the far field).

Figure 26