RADIO ENGINEERING
MICROWAVE RADIO
ANTENNAS AND REFLECTORS
TD-RADIO DUPLEX ANTENNA SYSTEMS

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1. GENERAL

1.01 This section is reissued to include information on 1500-circuit loading on parabolic antennas and 1500-circuit duplex antenna operations. Changes to text and illustrations emphasize the use of the standard TD frequency plan to simplify duplex antenna operations. Operating characteristics of parabolic and horn-reflector antennas are updated.

1.02 The term "duplex" describes an arrangement where transmitters and receivers for one direction are connected to the same antenna. "Simplex" describes the usual arrangement for TD-radio systems where all transmitters for a given direction are connected to a single antenna and all receivers for that same direction are connected to a separate antenna.

1.03 The duplex arrangement is applicable in any route where the total number of one-way channels to be operated plus the guard band can be accommodated in the available frequency space. The width of the guard band is dependent, among other considerations, on path length. The longer the path the lower the received signal level and the wider the guard band required. In actual practice, the width of the guard band is set on the basis of average path length with sufficient margin so that the longer paths will not be overexposed. The frequency plan depends on the type of antenna and waveguide used and on whether or not interstitial channels are used.

Note: The duplex mode of operation is intended primarily for routes where the cross section in the next several years is not expected to exceed five channels if parabolic antennas are used, or eight channels if ultrahigh performance or horn-reflector antennas are used. When a system is under consideration for duplex operation, it is essential that the potential for growth along the route be examined. If a full cross section appears likely, it may be advantageous to start out on a standard simplex antenna basis.

1.04 TD-radio routes designed for duplex antenna operations reduce the number of antennas and waveguide runs per repeater station from four to two, and the number per terminal station from two to one, with corresponding economies. Isolation between transmitting and receiving paths is obtained by using a special frequency plan in which all transmitters feeding a given antenna are tuned to one end of the 3700- to 4200-MHz band. Receivers connected to that antenna are tuned to the opposite end of the band with a guard band in between. Additional isolation can be obtained either by cross polarizing the transmitting path with respect to the receiving path, or, by using certain nonstandard waveguide arrangements.

1.05 It is very important to note that the antenna system controls and affects the overall system performance greatly; therefore, extreme care must be taken in using the antenna system properly. Such antenna parameters as gain, cross polarization discrimination, side-to-side coupling loss, and front-to-back transmission ratio dictate the system channel loading. This is why only a few channels are permitted in duplex antenna operation.

1.06 In the following paragraphs the term "standard" frequency plan is used to mean either one of the basic TD-radio frequency plans of Fig. 1, the standard TD-radio frequency plan of Fig. 2, or some combination of channels that are a part of these plans. Nonstandard plans that are combinations of channels that are not directly part of Fig. 1A or Fig. 1B are not recommended. Included in the nonstandard category are:

(a) Plans not using the normal 40-MHz shift between transmitter and receiver frequencies on the same channel.

(b) Plans in which the "A" frequency of one channel connects to the "B" frequency of another.

(c) Plans using a mixture of regular and interstitial frequencies on the same antenna with the same polarization, such as channels 7, 8, 9, 4, 5, and 6.

(d) Plans in which receivers and transmitters operating over the same path both use the "A" or the "B" frequencies. Normally, a station transmits "A" frequencies and receives "B" frequencies, or vice-versa, over a given path.

2. INTERFERENCE CONSIDERATIONS

A. Standard TD Frequency Plan

2.01 Generally, two types of interference are of particular importance to FM signals: co-channel and adjacent channel interferences. Both types of interference can render the interfered receiver useless if they are not suppressed. The interference can be in the form of tones or noise that may fall directly on the desired signal or may first fall on some other frequencies and then be converted in the interfered receiver (A+B−C type tones, for example) to fall in the desired signal band.

Far-End Interference

2.02 In the basic TD-radio frequency plans of Fig. 1, signals reaching a receiving antenna from the transmitters at the far repeater station are separated by 80 MHz. The closest undesired signal, therefore, is 80 MHz removed from the desired signal and it is delivered to the receiver at the same low level as the desired signal level, nominally −26 dBm. With 80-MHz channel spacing and separate transmitting and receiving antennas, there is sufficient rejection of undesired signals in each receiver to permit operation without interference, even under extreme fading conditions.

2.03 With interstitial channels as in Fig. 2, the closest interfering signal is 20 MHz away. The rejection required for this closer frequency spacing is provided by the use of cross polarization and IF filters.

Near-End Interference

2.04 At each repeater station the nearest high-level transmitted signal, +37 dBm, is 20 MHz removed from the desired receiving frequency in the TD frequency plan. The transmitting antennas for this frequency are aimed along the same path

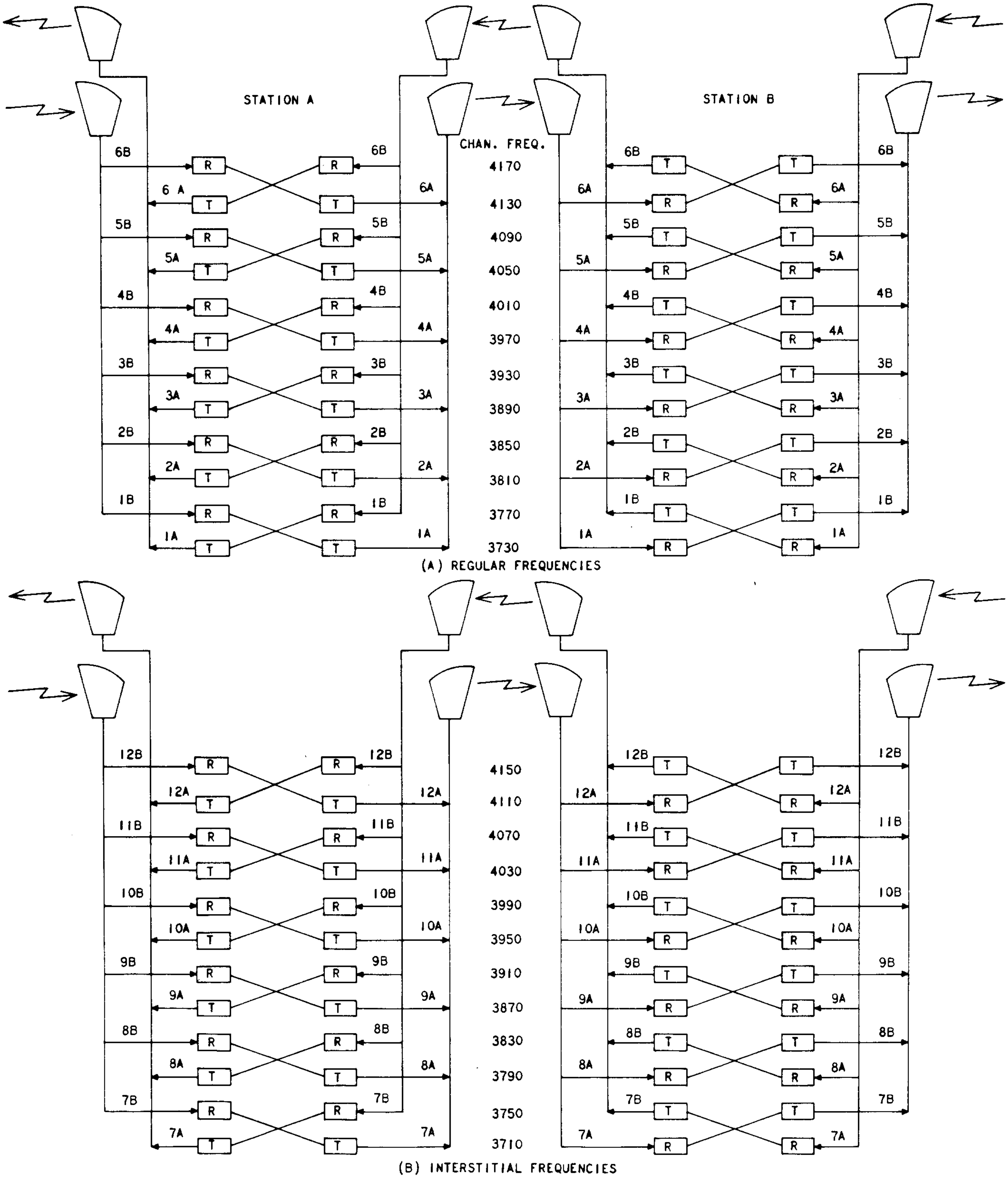


Fig. 1—Basic TD Radio Frequency Plans

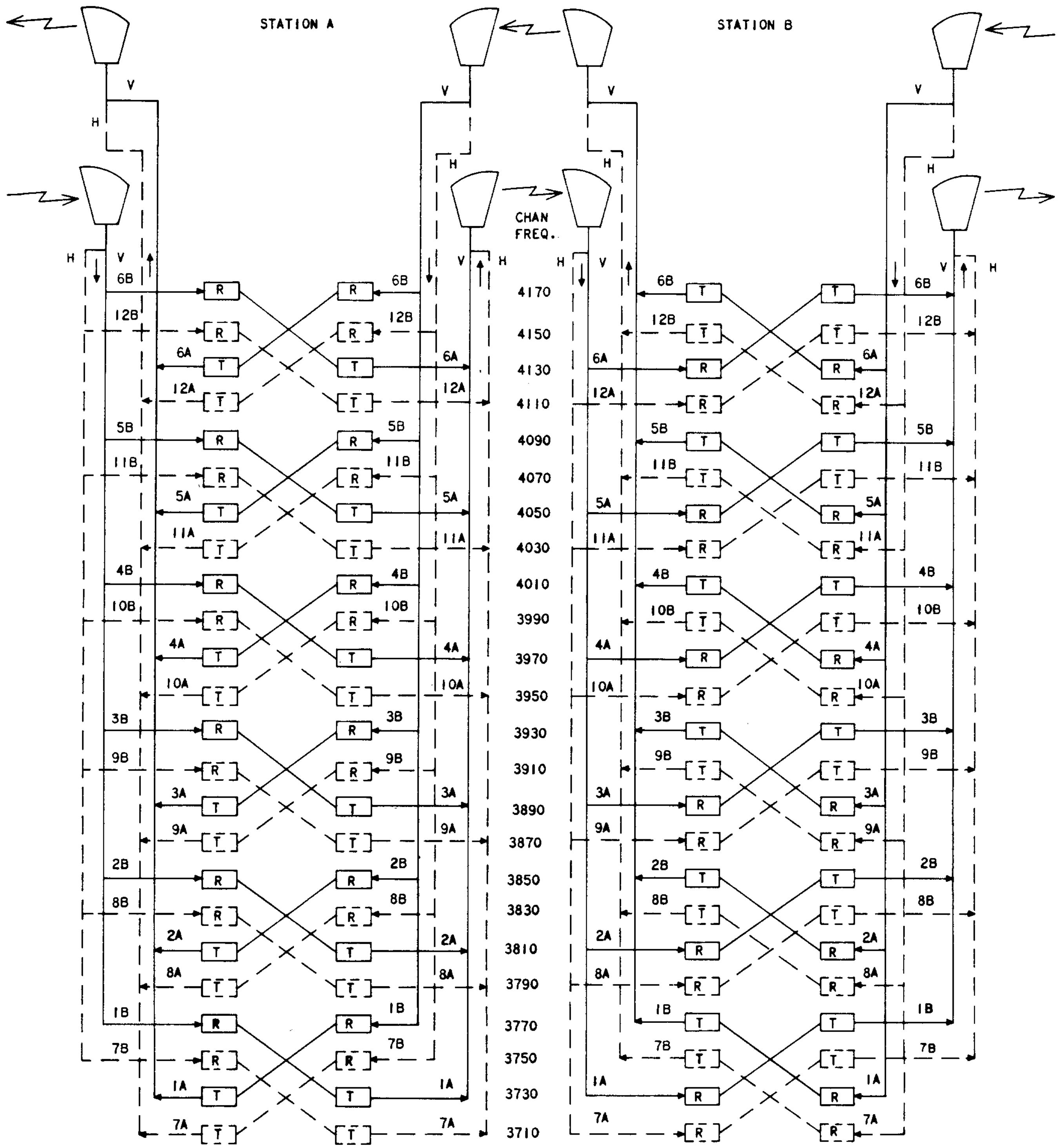


Fig. 2—Standard TD Radio Frequency Plan

as the receiving antennas, also along a path in the opposite direction, with a side-to-side coupling loss (isolation) between them of 85 dB or more where horn-reflector antennas are used.

2.05 Where standard parabolic antennas are used side by side, near-end interference between adjacent channels in the same direction sometimes occurs because coupling loss between antennas is 10 to 20 dB lower (Table A). The use of different antennas or supplementary IF filters may be required in such cases.

B. Duplex Antenna Systems

Single Polarization

2.06 If a single antenna is used for both transmission and reception, means must be found for obtaining the 85 dB or more of isolation which is usually available when separate antennas are used for transmitting and receiving. If parabolic antennas are used, additional isolation may be obtained by providing greater separation between transmitting and receiving frequencies or by modifying the receiver selectivity.

2.07 Normally, TD-radio bays are arranged in order of increasing frequency, with the lowest frequency channel nearest the antenna. When a single antenna is used for both transmitting and receiving on the same polarization, it may be necessary to violate this rule by placing higher frequency transmitting channels ahead of lower frequency receiving channels. The penalty for this violation of the increasing frequency order is generally small and will not cause appreciable degradation of transmission quality in short systems using single antennas.

2.08 In TD-2, TD-3, or TD-3A 1500-circuit loading, at least 45 dB of isolation between the transmitter and the receiver may be obtained at the transmitter carrier frequencies, by placing the transmitting channel branching filter in the waveguide run between the antenna and the receiving channel branching filter. This isolation is obtained because both parallel branches of the channel filters contain stop sections which greatly reduce through transmission at the branching frequency.

> ***Note:*** In TD-3D a different type of channel filter is used—a combination of 2A circulator and a bandpass filter. In this case, placing the transmitter between the antenna and the receivers does not provide any more selectivity at the transmitter carrier frequency.

2.09 Assuming a value of 45-dB isolation and +37 dBm transmitter output, the interfering carrier will be −8 dBm. With a nominal −26 dBm desired signal, the interfering signal is 18 dB stronger than the desired signal. A guard band is used to provide additional suppression to prevent interference.

2.10 For +37 dBm (5 watts) output power, a guard band of 120 MHz should be provided. Some of the frequency plans suggested in this section result in 120-MHz or greater guard band.

TABLE A

SIGNIFICANT ANTENNA PARAMETERS (AVERAGE VALUES IN dB)

ANTENNA	GAIN (3950 MHz)	RETURN LOSS	S-S COUPLING LOSS	XPD	F-B RATIO
Std 10′ Parabolic (KS-15924)	39.5	20.0	70.0	—	50.0 ± 5.0
UHP Parabolic (Andrew UHX10-37C)	39.5	30.0	95.0	32.0	65.0
Horn-Reflector (KS-15676)	39.5	40.0	100.0	35.0	70.0

In those that do not, one of the channels must be omitted to widen the guard band, with a corresponding reduction in the number of available broadband channel assignments.

2.11 Under trouble conditions, such as the loss of the carrier, the transmitter noise may spread out enough to cause interference to adjacent receivers tuned to channels as much as 40 MHz away or to image channels 140 MHz away. IF filters are useful for minimizing the adjacent channel interfering effects of transmitter noise. As for image channels, the protection is provided by the transmitter selectivity and antenna discrimination characteristics.

Dual Polarization

2.12 If a KS15676 horn-reflector antenna and circular waveguide are used for duplex antenna operation, cross polarization may be utilized to attain isolation between transmitting and receiving frequencies. The 1407A network may be used to separate polarizations. Isolation between polarizations with the 1407A network is about 35 dB or better. Assuming 35 dB of isolation, a guard band is still required between the transmitting and receiving frequencies as will be discussed later.

3. FREQUENCY PLANS FOR DUPLEX ANTENNA SYSTEMS

3.01 Frequency plans that can be employed with duplex antenna systems use opposite ends of the frequency band for transmission in opposite directions. To avoid interference, the standard frequency plan should be used on systems that connect with other systems. Where no such connection exists, but one is expected in the future, it is necessary to work out and use a coordinated plan that will avoid changing frequencies at a later date. For isolated systems where such coordination at junction points is not necessary, more channels can sometimes be obtained by a nonstandard frequency plan.

3.02 All of the illustrations and examples suggested in this section show direct-fed antennas. In some rare cases, periscope antenna arrangements, although not recommended, can be used for duplex operations. However, periscope antenna systems cannot be used at stations transmitting in two directions on the same frequency, because of the poor front-to-back transmission ratio of periscope configurations.

> ***Note:*** FCC rules ban the installation and use of periscope antenna systems. Waivers for new periscope antenna systems may be considered in exceptional cases.

A. Standard Frequency Plans

3.03 A duplex plan can be developed from the standard plan (Fig. 1) by using only the channels remaining after allowing for the required guard band between transmitting and receiving channels. Fig. 1A is the basic plan, using regular channel frequencies (channels 1 through 6) to provide six two-way channels. In Fig. 1B, the alternate or interstitial frequencies (channels 7 through 12) are used for six additional two-way channels. These two are combined in Fig. 2 to form the standard TD frequency plan.

3.04 Fig. 3 is an example of a duplex plan that is compatible with the standard plan. Such an arrangement can be used with either the parabolic reflector or horn-reflector antennas since it uses only one polarization. A maximum of five one-way channels are possible with this scheme: three in one direction and two in the other, or four and one. Fig. 3 shows regular frequency assignments, but the corresponding alternate frequencies can be used instead.

> ***Note:*** The frequency plan sketches, Fig. 1 through 9, do not represent the physical order of repeater bays in a station. The actual order of bays is explained in Part 6.

3.05 An additional one-way channel can be obtained, for TD-2 only, as shown by the dashed lines of Fig. 4 where channels 7 through 12 are used. This scheme cannot be used with regular channels 1 through 6 because of the 60-MHz spacing that results between channels 6A and 13. The channel 10B-13 combination is nonstandard and is found only in some existing TD-2C bays since channel 13 is no longer available for order. Although this channel uses a nonstandard combination, all the others are standard. If expansion to a simplex standard frequency plan is desired, the frequency-sensitive parts of the channel 13 transmitters and receivers can be replaced by channel 10A components. This makes possible the use of three two-way channels before expansion

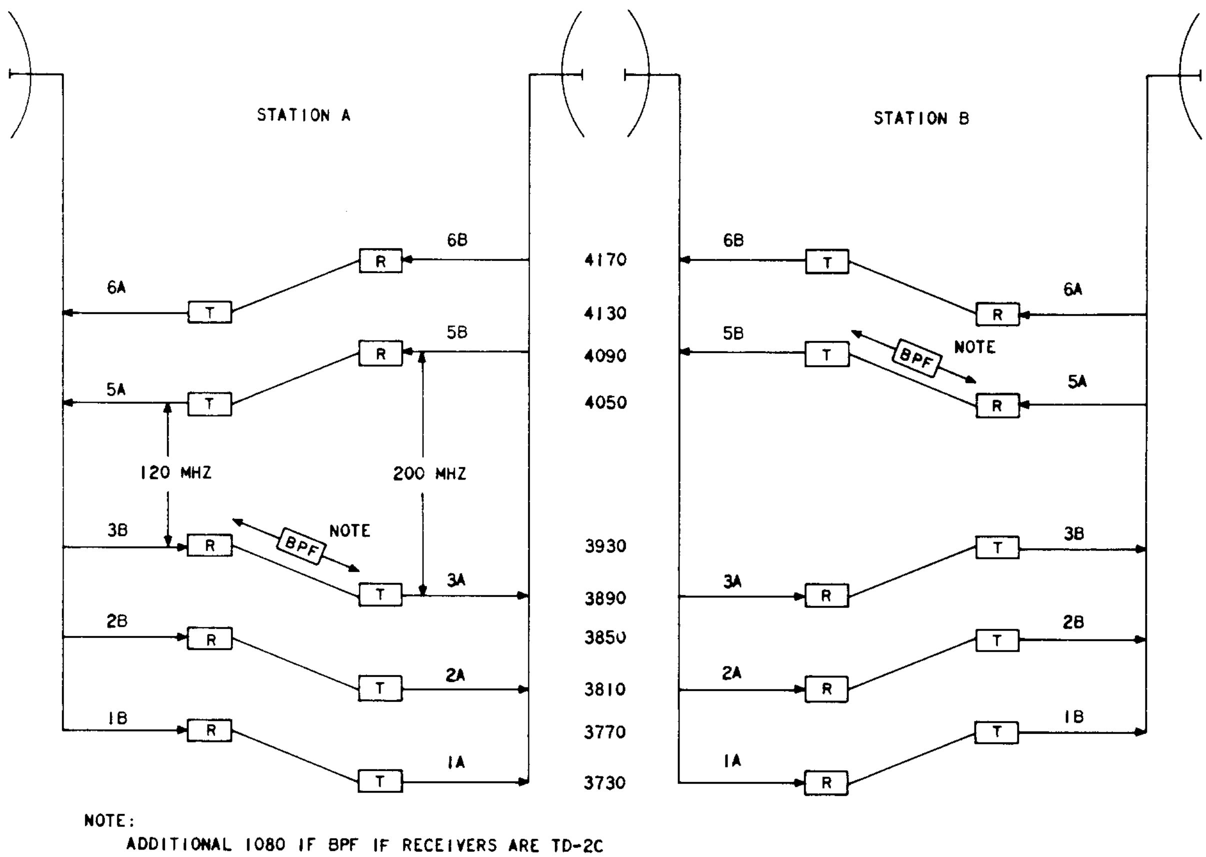


Fig. 3—Five-Channel Regular Frequency Duplex Plan

with a minimum of equipment replacement upon conversion to simplex operation.

3.06 Another way to use the channel frequency assignments of Fig. 3 is shown in Fig. 5. Here, use is made of the dual polarization capability of the antenna by using vertical polarization for one direction of transmission and horizontal polarization for the opposite direction. The 1407A networks provide some isolation between the receivers and transmitters.

3.07 With a KS15676 horn-reflector antenna, somewhat greater route capacity can be obtained by the use of cross polarization. It is important to keep in mind that no transmitter combinations are allowed that would produce third order A+B−C type products which fall on a desired receiver signal.

3.08 Fig. 6 shows an example of a dual-polarized plan. The channels drawn with solid lines are the same as in Fig. 3. Those drawn with dashed lines are the channels added using cross polarization. Channel 3 was eliminated to reduce possible third order products which result in co-channel interference.

3.09 The plans of Fig. 3, 4, 5, and 6 can be expanded to the full standard simplex plan by adding the second set of antennas and making the necessary waveguide rearrangements.

B. Nonstandard Frequency Plans

3.10 Somewhat more efficient use of the band can be made by means of certain frequency plans that are not entirely compatible with the standard plan. However, such nonstandard plans are ***not recommended*** as they inevitably lead to interconnection problems which may result in an expensive interference-prone "bucking" station with some transmitters and receivers having identical frequencies.

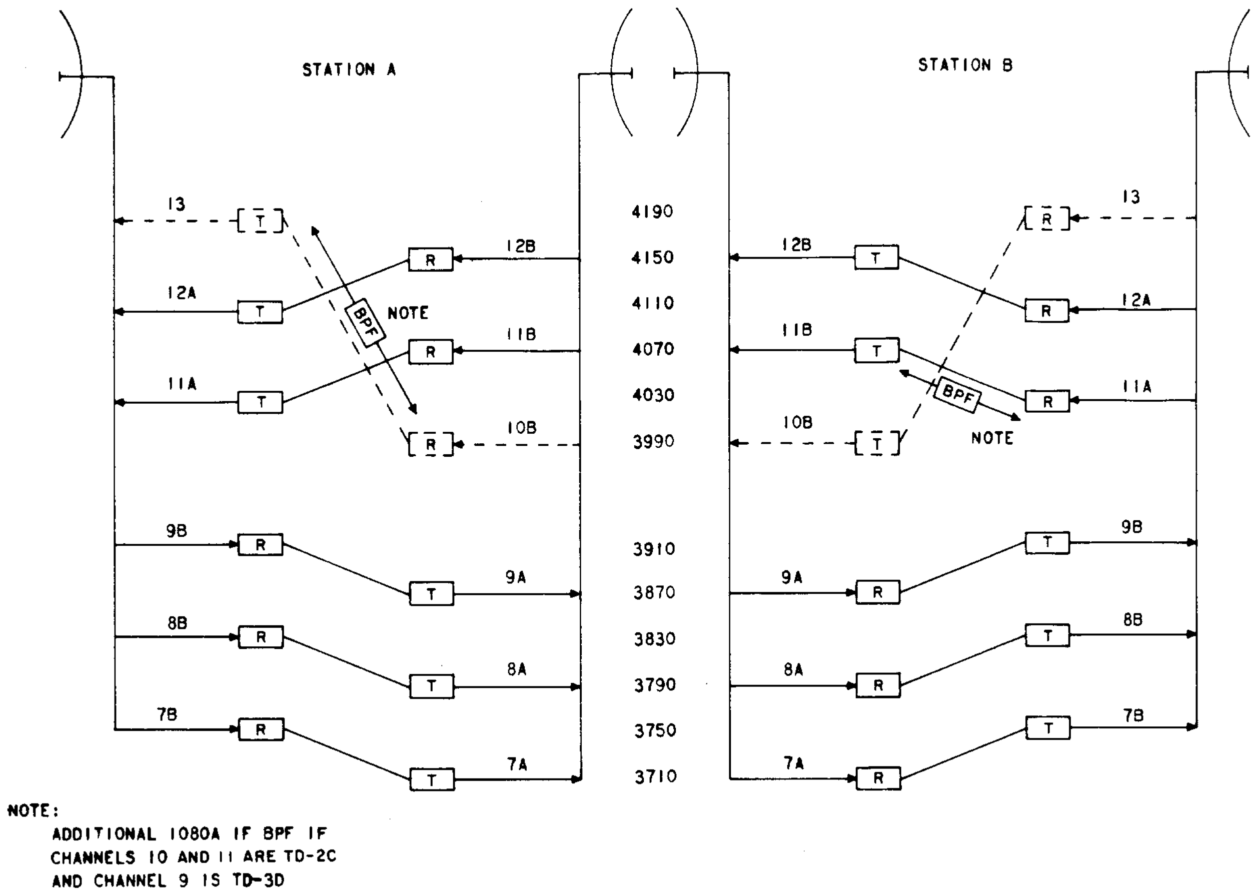


Fig. 4—Five-Channel Duplex Plan with Optional Sixth Channel

3.11 In Fig. 7, a maximum of six one-way channels can be operated on a single antenna. These can be three each way, or four and two, five and one, etc. The difficulty with this plan is that it transmits in one direction on the lower (or A) frequency of each channel and transmits in the other direction on the higher (or B) frequency. If such a plan were used at a station using the standard plan, transmitters at one end of the band would operate on the same frequencies as receivers, with the possibility of interference. However, there are some situations where Fig. 7 can be used, such as isolated routes ***not connecting*** with other routes.

3.12 Cross polarization can be used for isolation between transmitters and receivers as in Fig. 5. Fig. 8 shows the nonstandard arrangement.

3.13 Additional channels can be added by means of cross polarization if a horn-reflector or other dual-polarized antenna is used. Fig. 9 shows such a plan in which four additional one-way channels can be obtained.

3.14 There are other possible combinations that can be used; however, when selecting a plan, three rules must be observed:

(1) Leave a guard band at least 100 MHz wide between the closest transmitting and receiving frequencies on the same antenna.

(2) Adjacent channels on the same lineup of channel-branching filters must be at least 80 MHz apart.

(3) Make sure that transmitter combinations do not produce third order A+B−C type products that could fall on a desired signal.

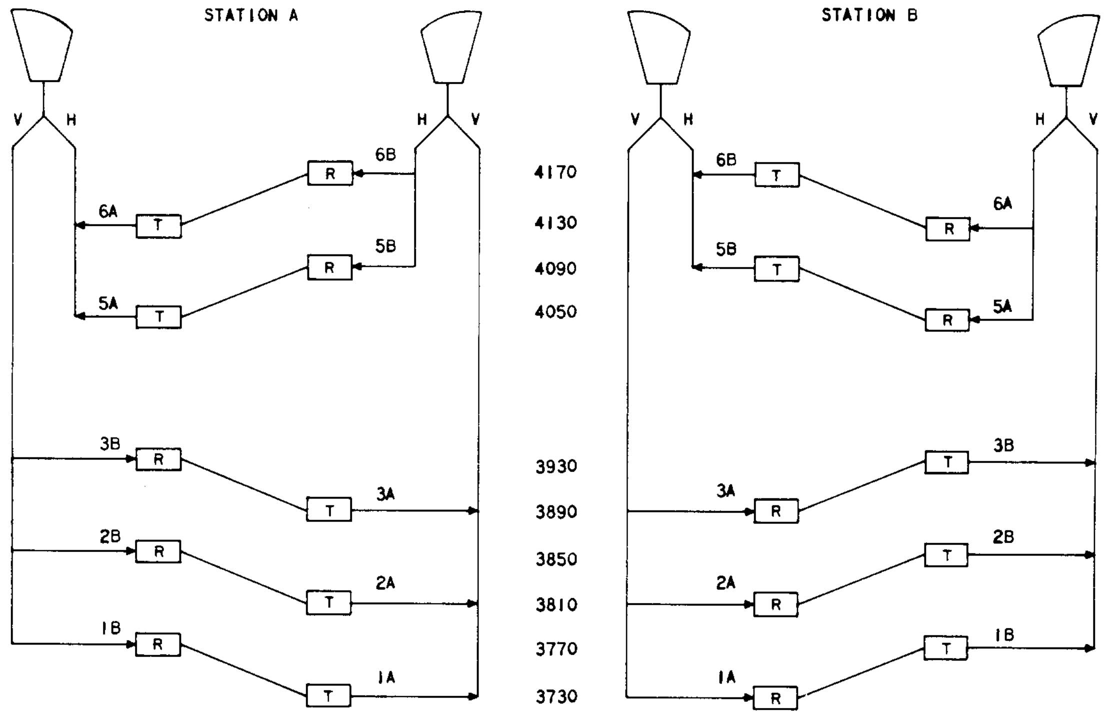


Fig. 5—Five-Channel Dual Polarization Duplex Plan

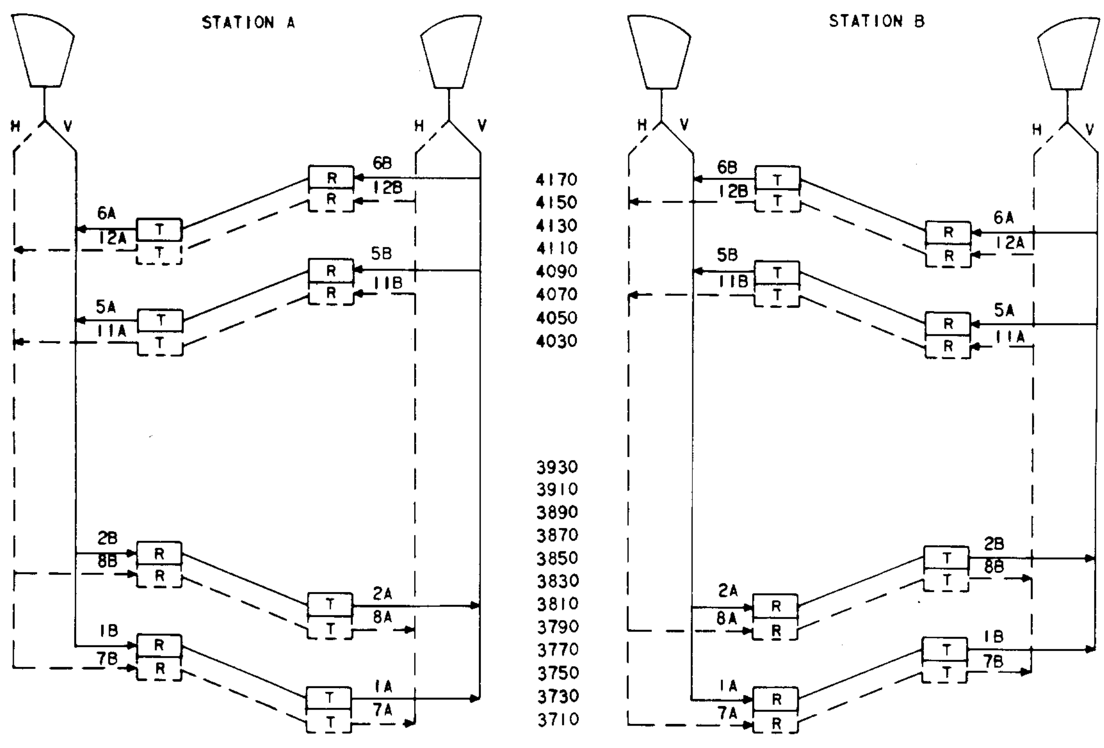
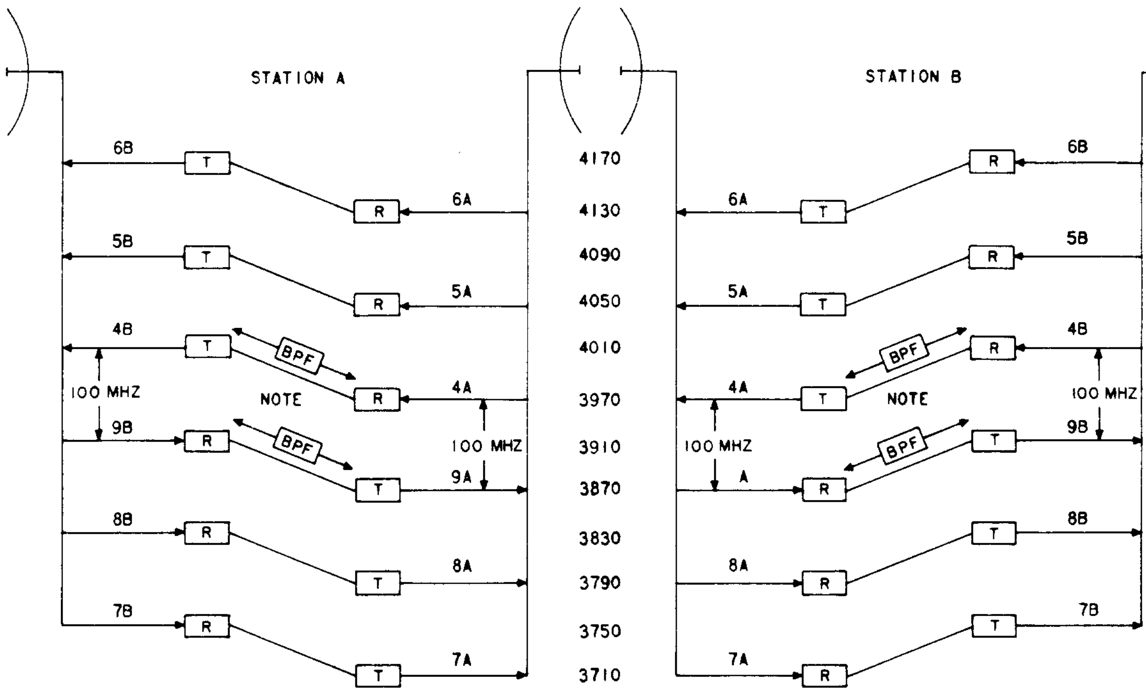


Fig. 6—Eight-Channel Duplex Plan



NOTE:
ADDITIONAL 1080A IF BPF
IF TD-2C RECEIVERS

Fig. 7—Six-Channel Nonstandard Duplex Plan

4. ANTENNA CONSIDERATIONS—1500 CIRCUIT LOADING

A. Parabolic Antennas

4.01 Two types of parabolic antennas can be used in the TD-radio systems: the KS15924 standard parabolic dish and the ultrahigh performance (UHP) type such as the Andrew UHX10-37C. The UHP type is basically the standard parabolic-type dish modified with a shroud around its rim. The front of the antenna has a stretched weather cover forming a drum-like structure. The shroud contains radiation absorbing material to reduce the side lobe energy and, as a result, both the side-to-side coupling loss and the front-to-back transmission ratio are improved by about 20 dB over the standard parabolic dish. This improved performance is very important for 1500-circuit operation, since it reduces the adjacent channel as well as co-channel interferences. Other advantages of the UHP antenna compared to the KS15924 antenna are its return loss which is increased to 30 dB, and its capability to handle dual polarizations. The KS15924 antenna can only be operated on a single polarization. Table A compares the characteristics of parabolic antennas with those of horn-reflector antennas.

Ultrahigh Performance Parabolic Antenna

4.02 The data in Table A show that except for gain, the UHP parabolic dish antenna is not quite as good electrically at 4 GHz as the horn antenna. However, if the existing tower is designed to support only the parabolic antenna, the UHP antenna can be used for 1500-circuit loads. If the front-to-back ratio is degraded by "environment" to less than 60 dB and side-to-side coupling loss is less than 80 dB, the full 24 channels (12 transmitting, 12 receiving) in one direction should be reduced to 12 channels (6 transmitting and 6 receiving). This is required in simplex operation so that the co-channel and adjacent channel interferences will not be intolerably high. The expected co-channel interference noise for 4-GHz systems, assuming the 65-dB and 70-dB front-to-back ratios for UHP parabolic antenna and the horn-reflector antenna respectively, is shown in Table B.

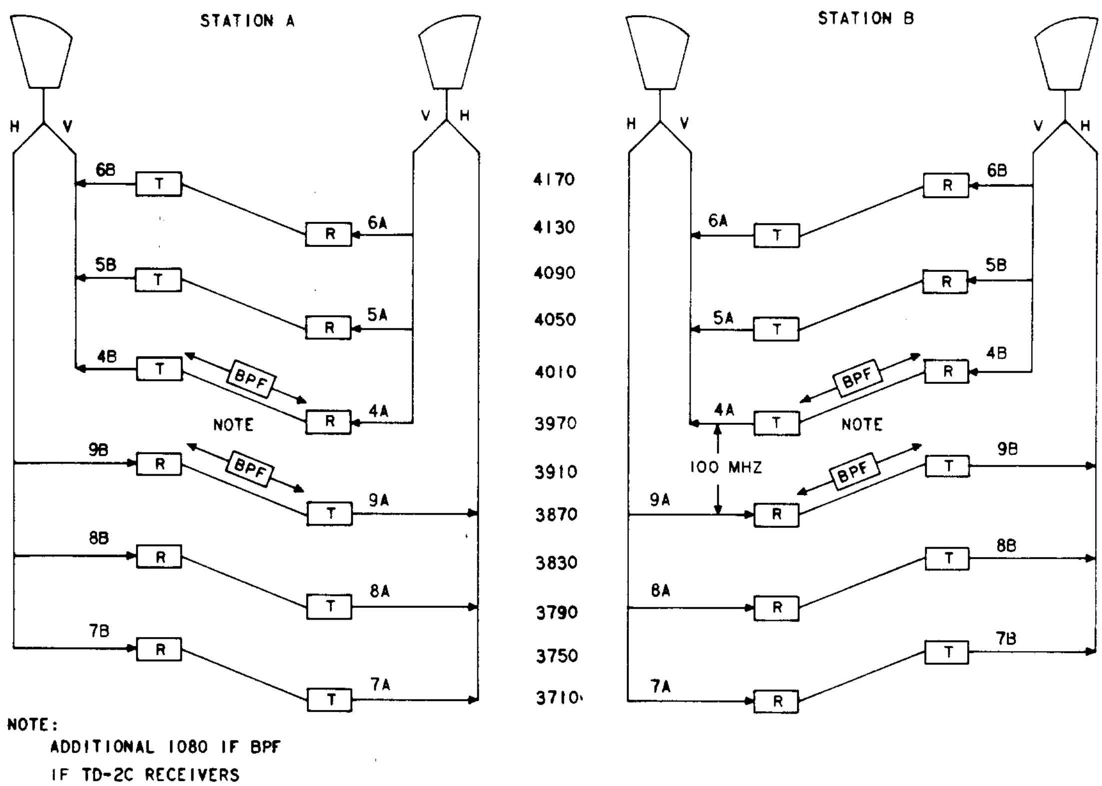


Fig. 8—Six-Channel Dual Polarization Nonstandard Duplex Plan

4.03 The co-channel noise will increase dB-for-dB with reductions of front-to-back ratio if two transmitters in the same station are transmitting in opposite directions at the same frequency. If a video channel is present in one direction, do not use a message channel transmitting in the opposite direction on the same frequency.

4.04 If the side-to-side coupling loss or front-to-back ratios are so poor that only 12 channels (6 two-way channels) should be used in one direction; apply the following rule:

> ***Use polarizations such that if a station receives on regular channels for E-W direction, then it must receive on interstitial channels for W-E, or vice versa.***

This will guarantee that no two channels in the same station will be transmitting at the same frequency in both directions. Furthermore, for any given receiver, there is only one adjacent channel 20 MHz away. The standard TD frequency plan should be followed to eliminate any interconnection problems with existing routes.

KS15924 Standard Parabolic Antenna

4.05 Typically, the standard parabolic antenna has a front-to-back ratio of 50 dB ±5 dB and a side-to-side coupling loss of 70 dB ±5 dB. Since it can only handle one polarization, even under the most favorable conditions a maximum of only 12 channels (6 receiving, 6 transmitting) can be used for two-antenna (simplex) operation.

4.06 The poor front-to-back ratio dictates that to avoid high co-channel interference, only one transmitter may be operated on a particular frequency at a given station. Also ruled out are 20- or 40-MHz channel spacings to avoid unacceptable adjacent channel noise and tones which interfere with CRS (carrier resupply) operation. As a result, it is recommended that no more than 6 channels (3 transmitting, 3 receiving) in one direction be used. In addition, a receiver having a transmitter 80 MHz away must have the transmitter frequency blocked by a band rejection filter or a terminated channel dropping network tuned to the transmitter frequency. This filter must be inserted in the receiving waveguide to eliminate a very strong

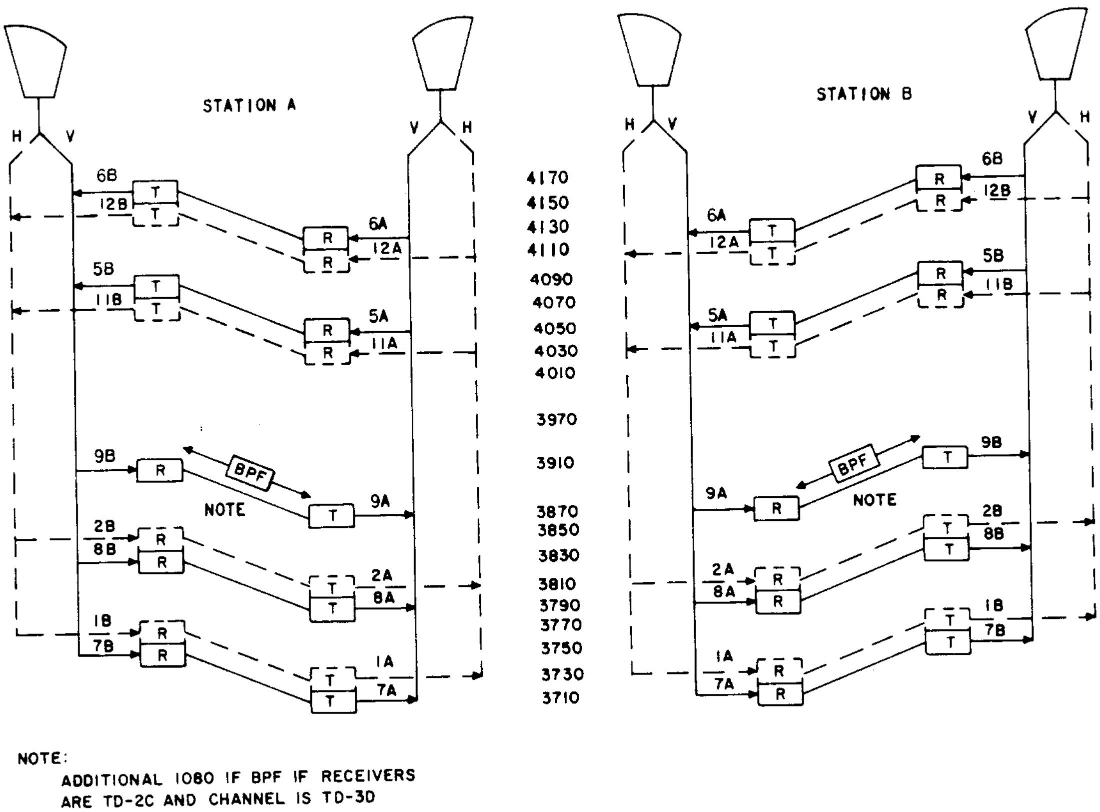


Fig. 9—Nine-Channel Interstitial Nonstandard Plan

TABLE B

EXPECTED CO-CHANNEL INTERFERENCE NOISE DUE TO FRONT-TO-BACK TRANSMISSION RATIOS (4 GHz SYSTEMS)

INTERFERING SYSTEM (CIRCUIT LOAD)	INTERFERED SYSTEM (1500 CIRCUIT)	
	HORN-REFLECTOR KS-15676 (dBrnc0)	UHP PARABOLIC UHC10-37C (dBrnc0)
1500	3	8
1200	5	10
900	7	12
TV	13	18

resultant 10-MHz baseband tone. This tone, generated in the receive modulator, could be 25 dB out of limits.

4.07 The antenna's 20-dB return loss will necessitate a 19A isolator in both the receiver and transmitter waveguide runs to alleviate an RF echo problem. For example, depending on the length of the waveguide run, a 40-dB RF echo will produce an echo noise up to about 16 dBrnc0.

8-Foot Parabolic Antenna

4.08 The 8-foot parabolic antenna has 2 dB less gain than a 10-foot antenna. Therefore, if an 8-foot antenna is used in place of a 10-foot one, the thermal noise in that hop will degrade 2 dB per antenna. For very short hops this may be acceptable. Other characteristics pertaining to the UHP and the standard parabolic dish as described previously, also apply.

B. Duplex Operation

4.09 Duplex operation is primarily used in routes that have few channels and slow growth rate. As noted in 1.02, both the transmitters and receivers in one direction are connected to a single antenna so that a repeater station has only two antennas instead of the usual four as in simplex operations.

4.10 Compared to the usual two horn-reflector antennas used in simplex operations where both antennas are isolated by about 90 dB or more side-to-side coupling loss, single antenna operation has no such isolation. When operating on a single antenna (duplex), the isolation between the transmitters and the receivers depends on the reverse loss of the channel networks, the V-H loss of the polarizer network, and the leakage of the 2A circulator.

4.11 The expected loss between the transmitters and receivers (excluding receiver selectivity) in single-polarization duplex operation, is about 35 dB, i.e., 2A circulator leakage. For dual polarization the loss varies from about 30 dB to 55 dB.

> ***Note:*** In TD-2C, TD-3A, and TD-3C, if the receivers are connected to the end of the transmitter channel networks, the dual polarization loss would be 50 dB or more. In TD-2C and TD-3D when circulators are used to connect the receivers and transmitters together, circulator leakage limits the loss to about 35 dB.

4.12 Normally 85 dB or more isolation is required between transmitters and receivers in duplex operation. This may be made up with additional networks; however, the added networks can be costly and result in high receiver distortions. The alternative to using additional networks is to separate the transmitters and the receivers far enough in frequency (guard band) so that the channel selectivity will be sufficient to protect the receivers. This means the exclusion of some channels; however, it is the preferred solution and should be implemented as described in the following paragraphs.

4.13 If the horn-reflector or ultrahigh performance parabolic antenna is used and dual polarization is employed, a maximum of four transmitters and four receivers can be operated on a single antenna (Fig. 6) without intolerably high interference.

4.14 If the KS15924 standard parabolic antenna is used, its single polarization and poor return loss make it impractical to operate more than two transmitters or receivers at each end of the TD-radio frequency band. An additional channel may be added if the receiver closest to the transmitter, 120 MHz away, is modified by adding an additional 1080A IF bandpass filter as shown in Fig. 3.

5. DUPLEX TO SIMPLEX CONVERSION

5.01 Occasionally, unanticipated growth will occur and make it necessary to add antennas and rearrange stations to increase the channels of the duplex antenna route. Local conditions will dictate the method of rearrangement; however, all changeover plans call for the addition of antennas so that there are two antennas instead of one aimed in each direction at each repeater station. The discussion which follows illustrates basic principles applicable in all cases.

5.02 When it becomes necessary to expand a standard frequency plan system beyond the channel capacity of a duplex system, the conversion process consists of adding a second set of antennas and changing waveguide connections to produce the standard simplex arrangement.

Note: If the standard parabolic antenna had been used, the old antennas in addition to the new antennas may have to be replaced with the horn-reflector, or, if the supporting structure is not adequate, with the UHP parabolic antenna.

6. EQUIPMENT ARRANGEMENTS FOR DUPLEX SYSTEMS

6.01 TD-type microwave transmitters and receivers are usually mounted in 9-foot bays (a 7-foot TD-3D bay is also available). Each bay will accommodate one transmitter and one receiver. The channel branching filters in each bay are connected to those in adjacent bays, so that a transmission path is formed from the incoming waveguide through the string of filters, each channel frequency being dropped or inserted at the appropriate bay. A maximum of six bays are connected together in each line-up.

6.02 At repeater stations, the transmitter and receiver of a given channel are electrically connected at IF frequency in a bay and are associated with a given geographical direction of transmission, e.g., receiving from the east and transmitting toward the west. Ordinarily, there is a 40-MHz shift between receiving and transmitting frequencies.

6.03 In the case of a main or terminal station, usually a different arrangement is used. Here the transmitter and receiver in a bay are associated with opposite directions of transmission, e.g., receiving from the east and transmitting toward the east. In some cases, main station bays may be equipped for transmitting only or for receiving only.

6.04 Where duplex antenna systems are to be employed, several different equipment bay arrangements are possible, depending on expansion plans and available space. Although it is generally desirable to conserve floor space, a bay layout that avoids future rearrangements has a great advantage.

6.05 At TD-type repeater stations using simplex antenna arrangements, channels 1 and 2 or 7 and 8 are usually installed first. Additional channels are then connected in order of increasing frequency. When fully developed, each bay line-up will consist of six transmitters and six receivers, each operating on a frequency 80 MHz from those adjacent to it.

6.06 When interstitial channels (Fig. 6) are installed on either a duplex or simplex basis, separate bay lineups are required for the regular and for the interstitial channel frequencies.

A. Standard Frequency Plans

6.07 At stations using duplex antenna systems and frequency plans that are expected to develop into the standard plan, it will be advantageous to lay out the bay floor plan in such a way that channels can be added without moving existing bays or changing frequency-sensitive components. Fig. 10 illustrates the steps in growth, starting with the bay layout that would be used with the frequency plan of Fig. 3. Each rectangle represents a channel branching filter tuned to the frequency of the inscribed channel number. The blocks drawn with solid lines represent the initial five channels used with the duplex antenna arrangement. Dashed lines show an example of placement of bays when two new channels are added to each direction making it necessary to convert to a simplex antenna plan.

6.08 From Fig. 10 it is evident that some waveguide connections must be made for the duplex antenna method of operation that are not normally needed for simplex schemes. These include the connection from the output side of channel 6A E-W transmitter to the input of channel 1B W-E receiver, and from the output of channel 3A W-E transmitter to the input of channel 5B E-W receiver. Waveguide runs consisting of straight sections, rigid bends, and flexible sections must be used for this purpose. The actual location of these waveguide runs will have to be determined for each installation; there is no standard provision for placing these components. Straight waveguide runs through empty bay spaces can use ED-63543-70, G1, bay-width spacers to facilitate insertion of future bays.

6.09 Fig. 11 shows an equipment layout similar to that of Fig. 10 except that it uses the interstitial frequencies and the nonstandard combination of channels 10B and 13 (Fig. 4) to obtain a sixth channel (3.05). When additional channels are installed, as indicated by the dashed lines of Fig. 11, it will be necessary to change the channel 13 components to channel 10A frequency in order to have a fully standard frequency plan.

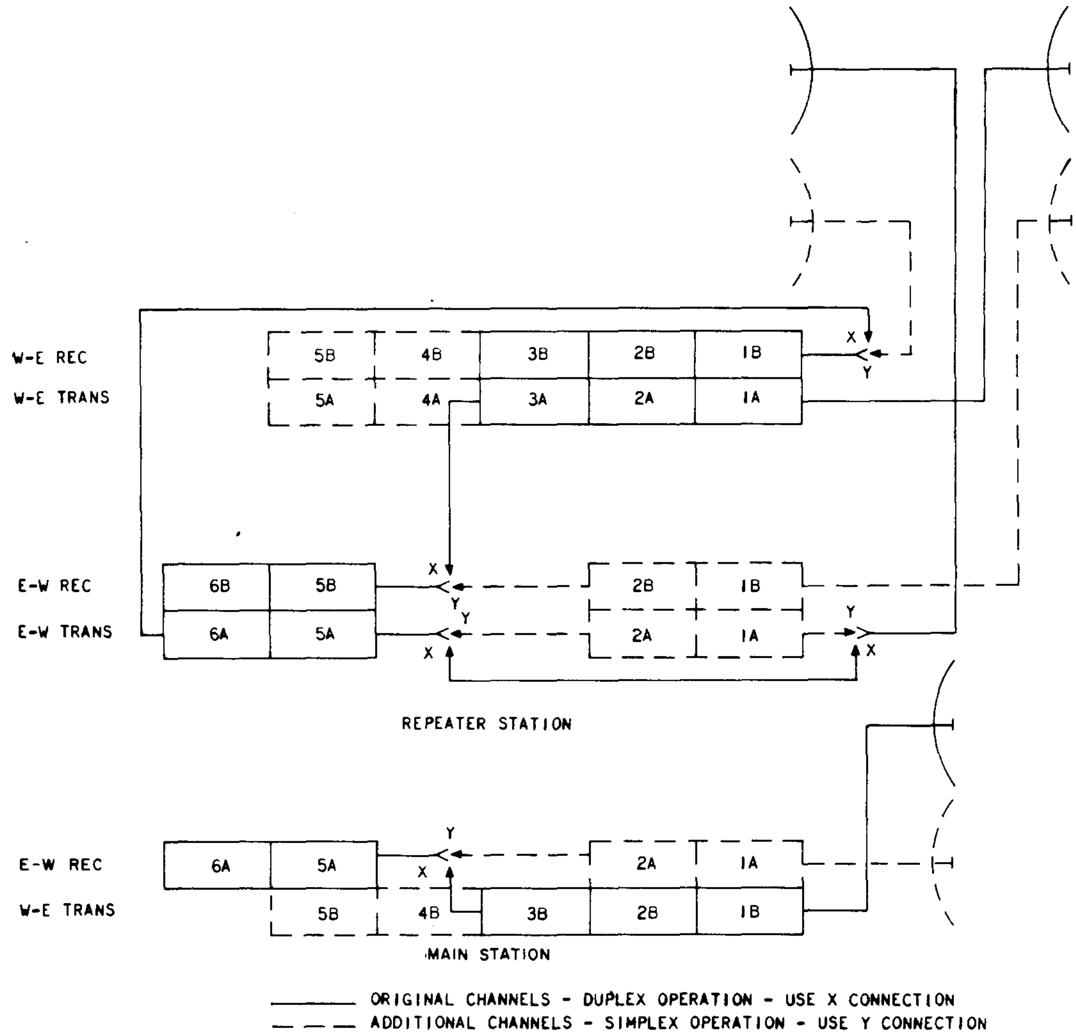


Fig. 10—Equipment Layout—Standard Duplex and Simplex Plan

6.10 The use of channel 13 (4190 MHz) results in a frequency spacing between highest and lowest channels of 440 MHz. Although the normal maximum spacing is only 400 MHz, the effect of the greater separation (slightly poorer return loss) is not serious. However, the use of this scheme should be restricted to the shorter systems. Also, at repeater stations, the bay containing the channel 10B-13 combination requires a receiver microwave generator instead of a 40-MHz shifter.

6.11 Where dual polarization is used as in Fig. 5, the bay layout will be the same as in Fig. 10 except that separate waveguide runs are used between the transmitter-receiver bays and the polarization separation networks at the base of the antenna.

6.12 Fig. 12 and 13 show bay and waveguide arrangements utilizing polarization networks and 2A circulators. Fig. 12 is recommended for TD-3, TD-3A, and TD-3C arrangements. Fig. 13 is recommended for TD-2C and TD-3D arrangements.

B. Nonstandard Frequency Plans

6.13 There are a number of different ways to arrange the bay layout for the nonstandard frequency plans such as in Fig. 7, 8, or 9. If expansion from duplex to simplex antenna operation is expected, a layout such as in Fig. 14 can be used to keep changes in existing bays to a minimum.

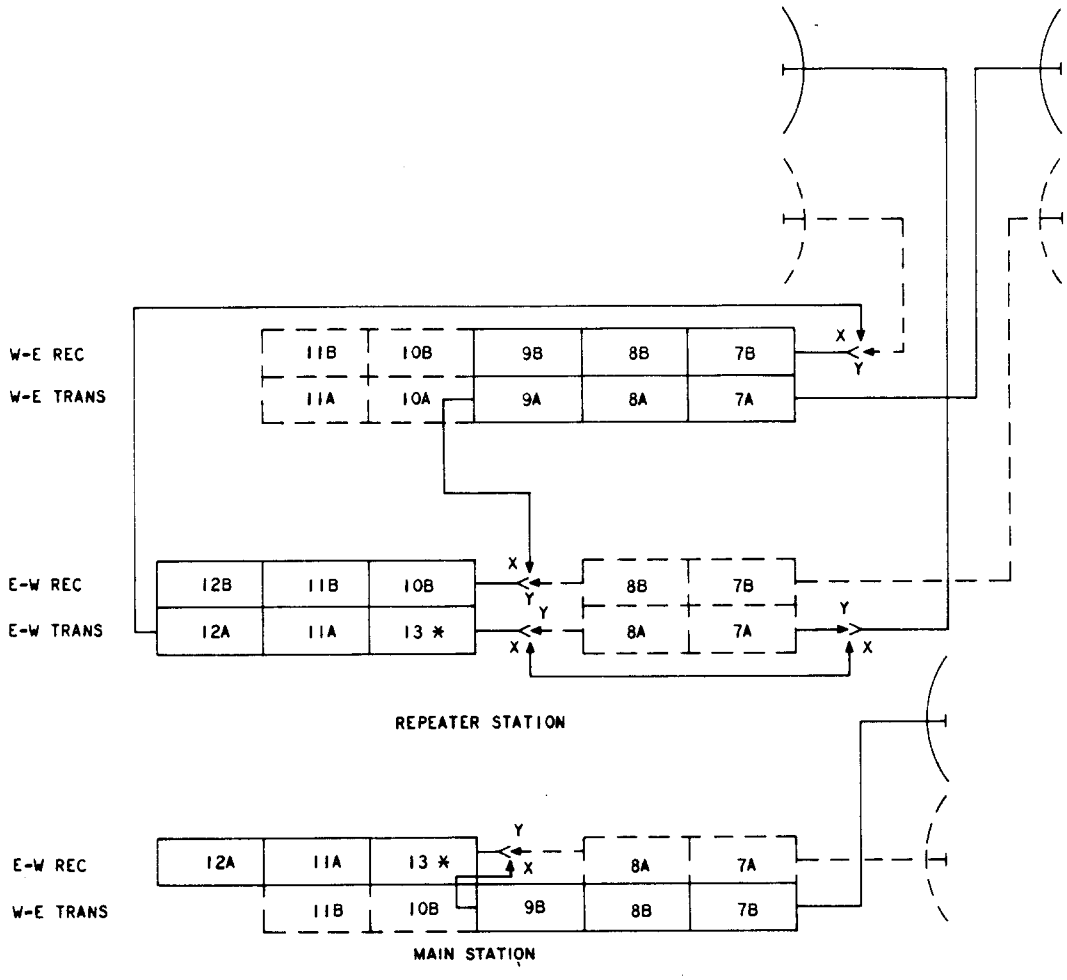


Fig. 11—Equipment Layout—Interstitial Frequency Duplex and Simplex Plans

6.14 If no expansion is anticipated for several years, floor space can be saved by using a layout such as in Fig. 15. Growth beyond three two-way channels would necessitate moving some bays, or changing frequencies. However, this may be the most economical option in the long run especially if building additions are necessary to accommodate the ultimate arrangement and if they can be postponed for several years.

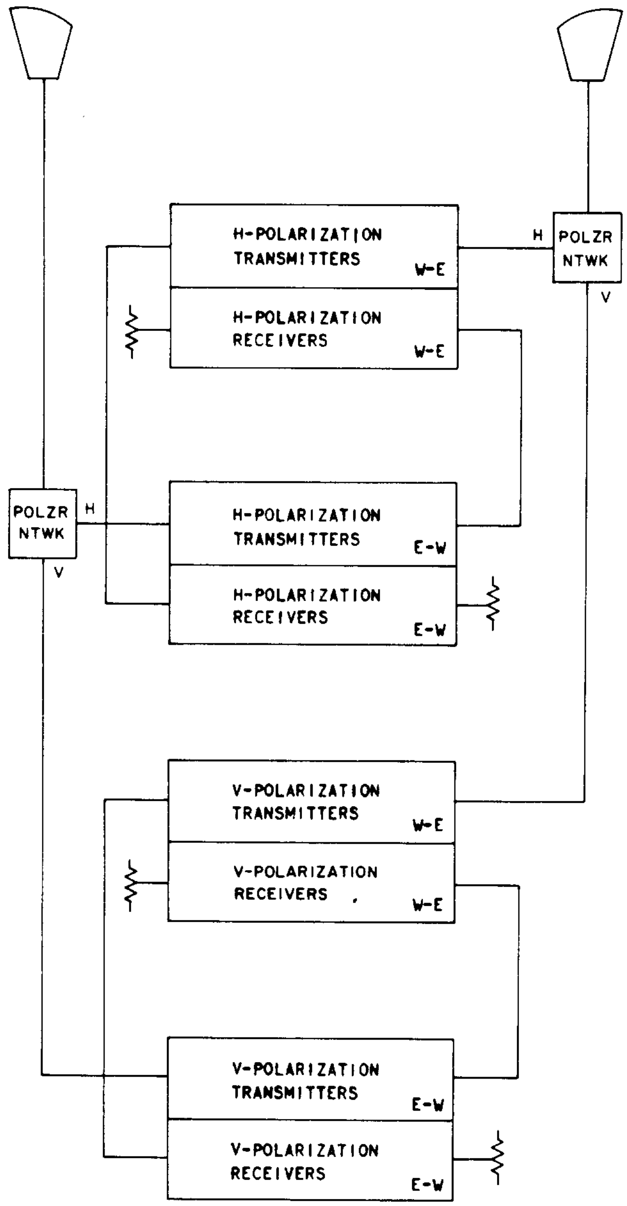


Fig. 12—Duplex Arrangement for TD-3, TD-3A, and TD-3C

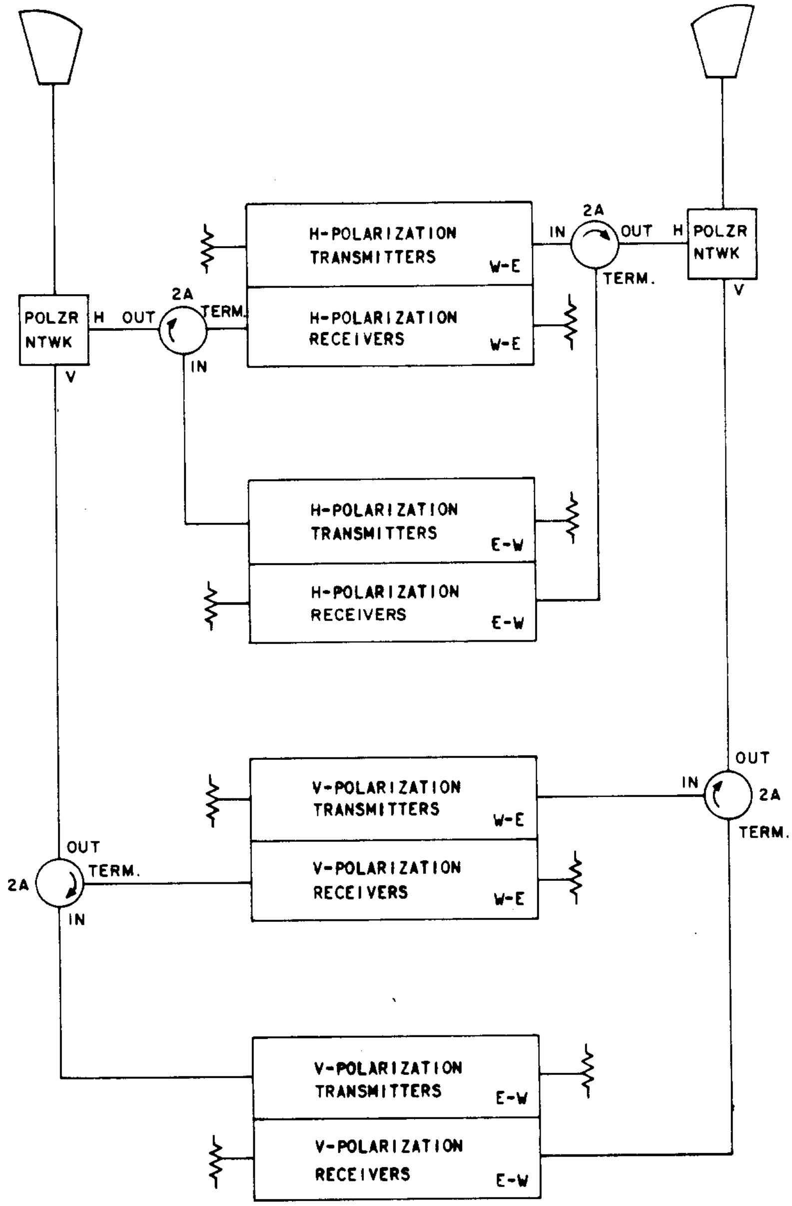


Fig. 13—Duplex Arrangement for TD-2C and TD-3D

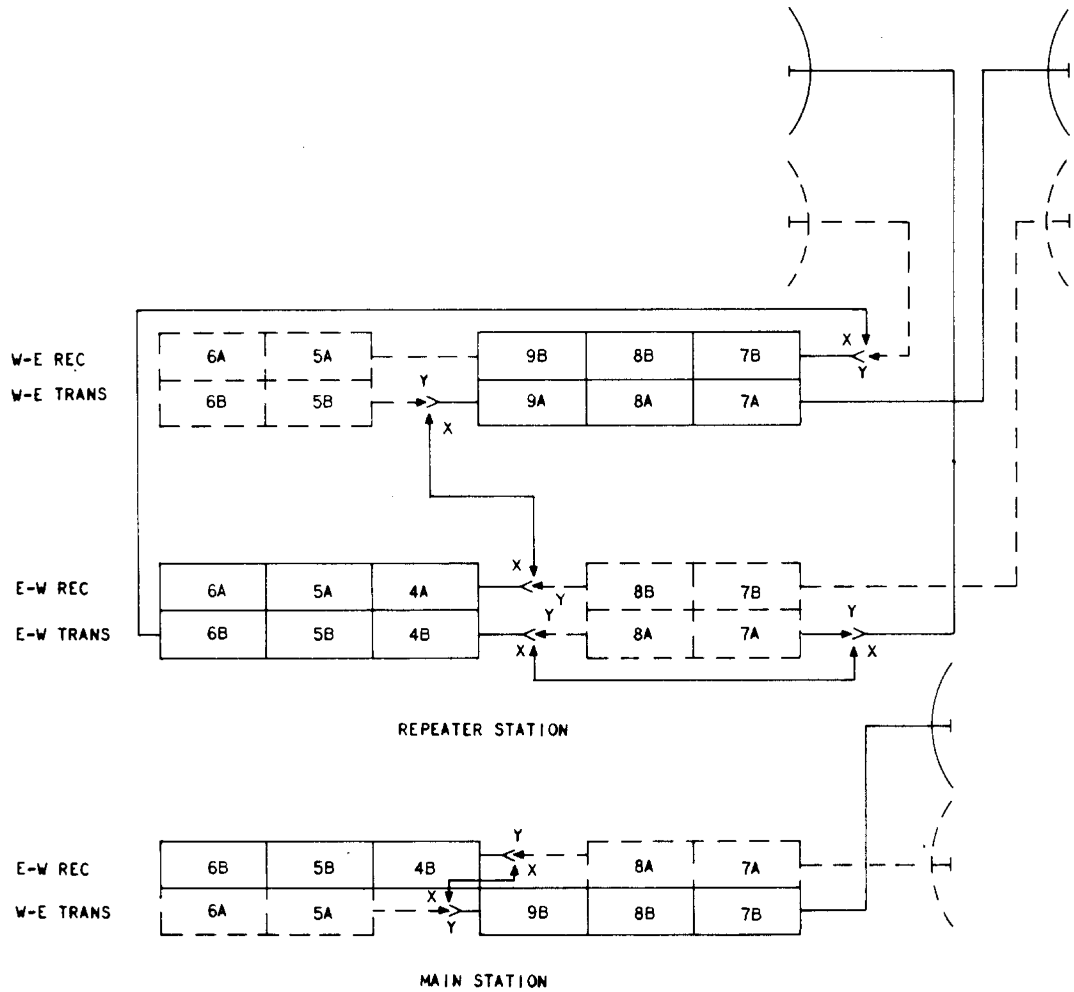


Fig. 14—Equipment Layout—Nonstandard Duplex and Simplex Plans

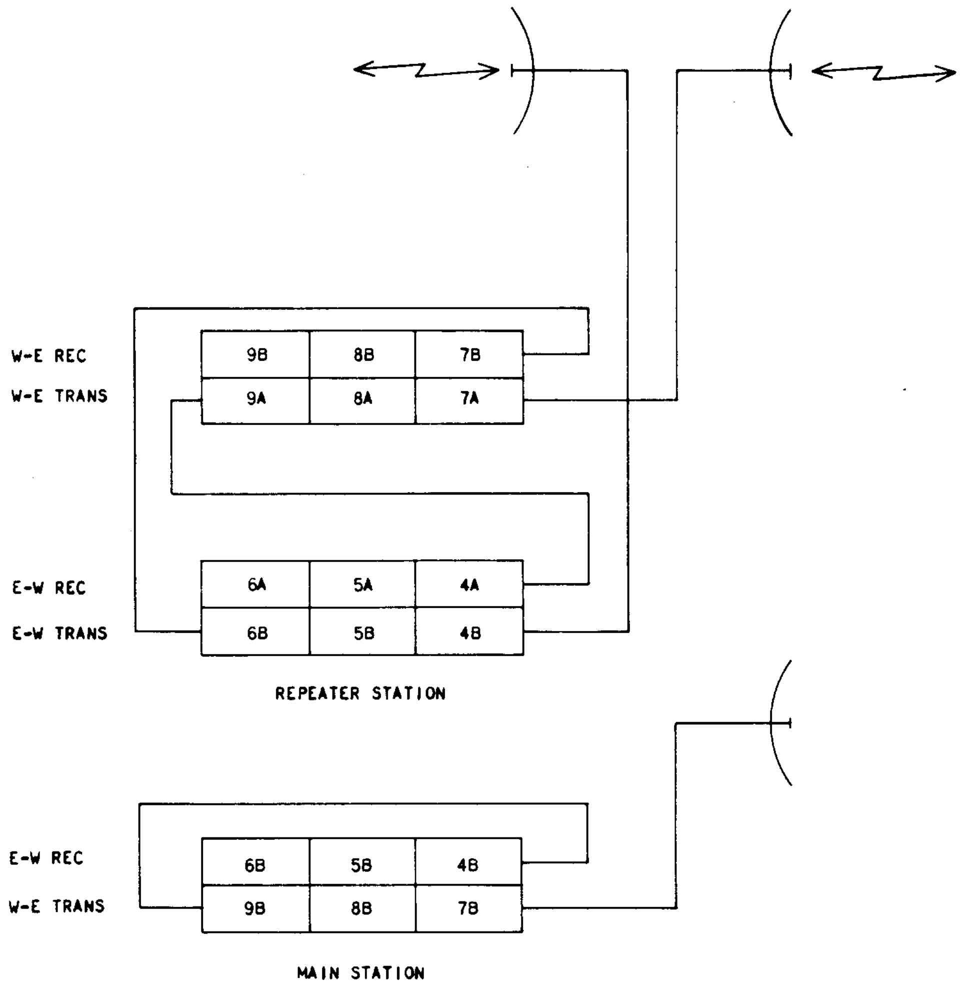


Fig. 15—Minimum Floor Space Layout for Duplex Plan