RADIO ENGINEERING
MICROWAVE RADIO
C/I OBJECTIVES
4-GHZ SYSTEMS

CONTENTS PAGE

1. GENERAL

1.01 This section contains the carrier-to-interference (C/I) objectives for 4-GHz microwave radio systems. Also included herein are the baseband interference spectra from which the C/I objectives are derived.

1.02 The C/I objectives are calculated for the TD type of radio systems; however, the objectives can be used for other radio systems which have characteristics similar to those specified in this section.

1.03 Refer to Section 940-330-104 for instructions regarding the interpretation of the data contained in this section and for the relationship between the baseband interference spectra and the C/I objectives as tabulated.

2. 4-GHZ RADIO SYSTEMS

2.01 The characteristics of TD-type radio systems were used in the calculation of 4-GHz C/I objectives. These characteristics are shown in Table A. All parameters except frequency stability are used to calculate the spectral density of the transmitted signal. It can be assumed that systems which have characteristics similar to those shown in Table A will also have C/I objectives and interference spectra similar to those shown in this section.

2.02 The different TD-type systems are identified by their circuit load; ie, TD (600), TD (900), etc. TD (600) is additionally designated as TD (600L) and TD (600U) to differentiate between the two types of multiplex in common use (L600 and

TABLE A

4-GHZ RADIO SYSTEM CHARACTERISTICS

SYSTEM	CHANNEL CAPACITY	TOP BASEBAND FREQUENCY (MHZ)	BOTTOM BASEBAND FREQUENCY (MHZ)	TOTAL RMS FREQUENCY DEVIATION (KHZ)	PER CKT DEVIATION 0 DBMO (KHZ)	FREQUENCY TOLERANCE %	PRE-EMPHASIS TYPE
TD	600L	2.778	0.060	980	252	0.005	CCIR
TD	600U	3.084	0.564	980	252	0.005	CCIR
TD	900	4.532	0.564	953	200	0.005	CCIR
TD	1200	5.772	0.564	779	142	0.005	CCIR
TD	1500	7.284	0.564	535	87	0.005	CCIR
TD	1800	8.524	0.564	339	50	0.005	CCIR

U600, respectively). All other channel loads are assumed to be U600 derived circuits.

2.03 All calculations for the TD type of radio systems were performed with CCIR pre-emphasis. The calculations are not very sensitive to the type of pre-emphasis used. The use of CCIR pre-emphasis permits coordination with other carriers and permits a more universal approach to verification of the calculations outside the Bell System.

2.04 The description of the TV signal is omitted from Table A because the parameters used to describe the message systems are not suitable to describe TV transmission. The modulated spectral density of TV signals does not lend itself to a calculation; consequently, the spectrum of the "Girl in Straw Hat" color pattern with 226L pre-emphasis and low index modulation has been used for interference calculations. A 6.2-MHz unmodulated sine wave was used to simulate a diplexed audio program channel and was added to the TV signal via a split-pad arrangement. The 6.2-MHz subcarrier was adjusted to a level of −12 dBV at the zero dBV transmission level point.

2.05 The use of a different TV signal spectrum would produce a different power density spectrum and, consequently, different C/I objectives depending on the TV picture content. The "Girl in Straw Hat" color pattern was chosen as an average signal on the basis of spectrum shape and peak deviation. This signal should not be considered as a worst case calculation, but it is considered a signal representing typical operating conditions. The peak deviation without diplexer was 2.96 MHz.

3. BASEBAND INTERFERENCE SPECTRA

3.01 Baseband interference spectra for TD (600U), TD (900), TD (1200), TD (1500), and TD (1800) operating with cochannel separation are shown in Fig. 1. through 5, respectively, and with 20-MHz separation in Fig. 6 through 10, respectively. Figures 11 and 12 contain the baseband interference spectra for cases when TD (600L) is involved. The baseband interference spectra for interference into TV is not given because the video channel is not composed of individual voice circuits and therefore the interference at a particular frequency in the video channel is of no value. For convenience, interference noise in dBrnc0 is normalized to zero RF interference suppression (C/I=0). There is no significance to this other than the convenience for conversion to the suppression necessary to meet a chosen interference noise objective.

3.02 All calculations assume a 0.005 percent radio frequency stability tolerance and the worst case frequency orientation for each calculation. For cochannel operation, the worst frequency orientation occurs when the frequency separation is equal to the top baseband frequency. Beyond this point the interference decreases. The TD systems with 0.005 percent frequency stabilities can be separated as much as 0.4 MHz (4 GHz × 0.005% × 2). For 20-MHz separation, the worst frequency orientation occurs when the two signals are as close as the combined frequency stabilities allow (19.6 MHz).

3.03 In the cochannel cases, Fig. 1 through 5, the interference is a result of sideband overlap. The amount of sideband overlap is small for 20-MHz separation and calculations reflect this lower interference potential as shown in Fig. 6 through 10. When TD (600L) is the desired system, Fig. 11, a carrier beat appears in the baseband interference spectrum. Carrier beats are significant when the total instability of both signals exceeds the bottom baseband frequency of the desired system placing the beat signal in a message circuit slot. In TD systems when L600 multiplex is used on the desired system, carrier beats may fall within the working baseband. This does not mean that carrier beats are not possible in systems with U600 multiplex. However, the assumption is made that the probability of having the total frequency instability between any two transmitters of 4000-mile systems exceed the bottom baseband frequency is so small that it can be neglected. Figure 12 contains the baseband interference spectrum when TD (600L) is the interfering system. Carrier beats fall below the working baseband of the desired systems since it is assumed that they use U600 multiplex.

4. C/I OBJECTIVES

4.01 Tables B, C, and D contain the minimum C/I objectives necessary to protect analog radio systems against unacceptable interference from other radio systems. These are C/I ratios as encountered at receiver inputs and therefore are independent of the system RF power, antenna discrimination, path loss differences, and cross-polarization. The entries designate the required isolation between the two interfering systems to meet a stated noise objective. All objectives are calculated for long-haul baseband noise objectives of 4 dBrnc0 per exposure for continuous interference and 17 dBrnc0 per exposure for carrier beat interference. Section 940-330-104 describes more fully the use of these objectives and adjustments which can be made for specific situations.

4.02 Table B contains the C/I objectives for cochannel operation. These values are derived from the maximum value of the baseband interference as shown by the spectrum plots. Fig. 1 through 5 show that the cochannel objectives are controlled by continuous interference mechanisms and not by carrier beats.

4.03 Table C contains the C/I objectives for 20-MHz separation. These values are derived from Fig. 6 through 10. In cases where the values derived from the baseband interference spectra are less than 25 dB for TD systems with interstitial filter or 35 dB for TD systems without interstitial filter, the 25-dB or the 35-dB objective given in Table C should be used. When the calculated interference is unrealistically low, as in Fig. 6 through 10, care must be exercised that the proper C/I objective is used. In this region interference, often nonlinear and equipment dependent, may manifest itself as direct crosstalk and can cause significant threshold degradation. To avoid this type of interference, a minimum objective of 25 dB, for TD systems with interstitial filter or 35 dB, for TD systems without interstitial filter must be used. The 25-dB objective is based on the design of the TD radio system which was engineered to tolerate an adjacent channel 25 dB below the desired channel, due to an expected 25-dB antenna cross-polarization discrimination (XPD). This minimum amount of required discrimination has not proved to be too restrictive. When the calculated objective is above the limiting values, the calculated values in Table C should be used.

4.04 Table D contains the C/I objectives for cochannel separation when TD (600L) is involved. As explained earlier, when TD (600L) is the desired system, carrier beats can appear in the working baseband. Hence, three objectives are given. The top entry represents the required isolation due to carrier beats when both carriers are unmodulated. Although there is no signal transmitted, this value is easy to calculate and represents an upper bound objective. The middle entry represents the required isolation due to carrier beats when both carriers are modulated. Since the difference between the first two entries is significant, as a practical matter it is not reasonable to use the unmodulated objective. However, it is also not reasonable to use the modulated objective since it is common practice to transmit unmodulated carriers at certain times. Therefore, an objective should be selected assuming that the interfering signal is unmodulated and that the desired signal is modulated. When only one of the two carriers is modulated, an objective halfway between the

TABLE B

INTERFERENCE OBJECTIVES (C/I) IN 4-GHZ BAND, COCHANNEL, ANALOG SYSTEMS

		INTERFERING CARRIER					
		TD (1800)	TD (1500)	TD (1200)	TD (900)	TD (600U)	TV
DESIRED CARRIER	TD (1800)	68	71	76	80	83	85
	TD (1500)	67	69	71	75	77	80
	TD (1200)	65	67	68	70	73	75
	TD (900)	65	66	66	67	68	72
	TD (600U)	64	65	64	65	66	69
	TV	62	62	62	62	62	62

Note: Based on a baseband objective of 4 dBrnc0 per exposure.

TABLE C

INTERFERENCE OBJECTIVES (C/I) IN 4-GHZ BAND, 20-MHZ SEPARATION, ANALOG SYSTEMS

		INTERFERING CARRIER						
		TD (1800)	TD (1500)	TD (1200)	TD (900)	TD (600U)	TV	TV WITH DIPLEX
DESIRED SYSTEM	TD (1800)	35	41	46	40	36	26/35	41
	TD (1500)	31/35	36	34/35	32/35	28/35	25/35	36
	TD (1200)	25/35	25/35	25/35	25/35	25/35	25/35	25/35
	TD (900)	25/35	25/35	25/35	25/35	25/35	25/35	25/35
	TD (600U)	25/35	25/35	25/35	25/35	25/35	25/35	25/35
	TV	25/35	25/35	25/35	25/35	25/35	25/35	25/35

Note: Based on a baseband objective of 4 dBrnc0 per exposure.

Key: 25/35 — Use 25 for TD systems with interstitial filter.
Use 35 for TD systems without interstitial filter.

TABLE D

INTERFERENCE OBJECTIVES (C/I) IN 4-GHZ BAND, COCHANNEL, ANALOG SYSTEMS, LONG-HAUL REQUIREMENTS FOR L600 AND U600 MULTIPLEX

		INTERFERING CARRIER		
		TD (1500)	TD (600U)	TD (600L)
DESIRED CARRIER	TD (1500)	69	77	77
	TD (600U)	65	66	65
	TD (600L)	66 56 68	66 55 66	66 50 66

Note 1: Carrier beat objectives are based on a baseband objective of 17 dBrnc0 per exposure and include a 10-dB burble factor.

Note 2: Continuous interference objectives are based on a baseband objective of 4 dBrnc0 per exposure.

Key:
66 ← Carrier beat objective with both carriers unmodulated
50 ← Carrier beat objective with both carriers modulated
66 ← Continuous interference objective

first two entries may be used when the interference is between like systems. The proper value between unlike systems must be calculated and, in the case of interference into TD (600L) from other TD systems using U600 multiplex, the modulated value should be used since it is the wanted system that is responsible for the reduction of the carrier beats. Both of the carrier beat entries are based on a 17 dBrnc0 baseband noise objective as explained in Section 940-330-104. The carrier beat entries also contain a 10-dB reduction due to an assumed inherent carrier spreading known as "burble." The use of the 10-dB burble factor may not be justified in every case. If both interfering systems have very pure (no jitter) carriers, and if there is no inherent carrier spreading, the use of the burble factor is not justified. In these cases, both carrier beat objectives must be raised 10 dB. The bottom entry represents the required isolation due to continuous interference and is based on a long-haul baseband noise objective of 4 dBrnc0. The largest of the three entries, after adjustments for specific situations as described above, should be used as the actual objective.

4.05 For interference cases in which the separation is greater than 20 MHz, a minimum objective of 20 dB should be used unless otherwise specified. At separations greater than 20 MHz, the interference is caused by different mechanisms than at the smaller separations and tends to be nonlinear and equipment dependent. These interferences vary with equipment types and, in most cases, little information is known about these different mechanisms. An objective of 20 dB has proved to be sufficient isolation and has not been too restrictive.

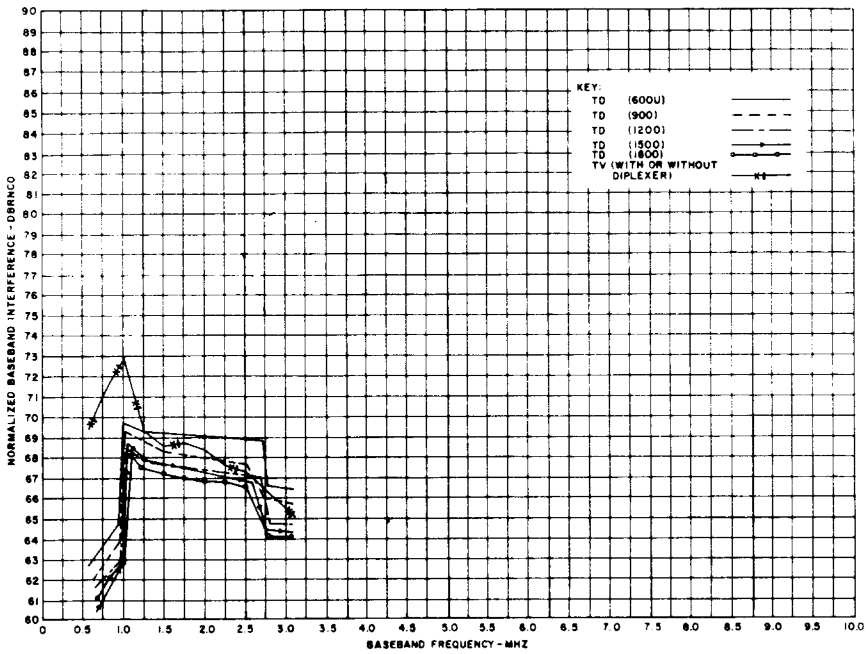

Fig. 1—Baseband Interference Into TD (600U)—Cochannel Separation

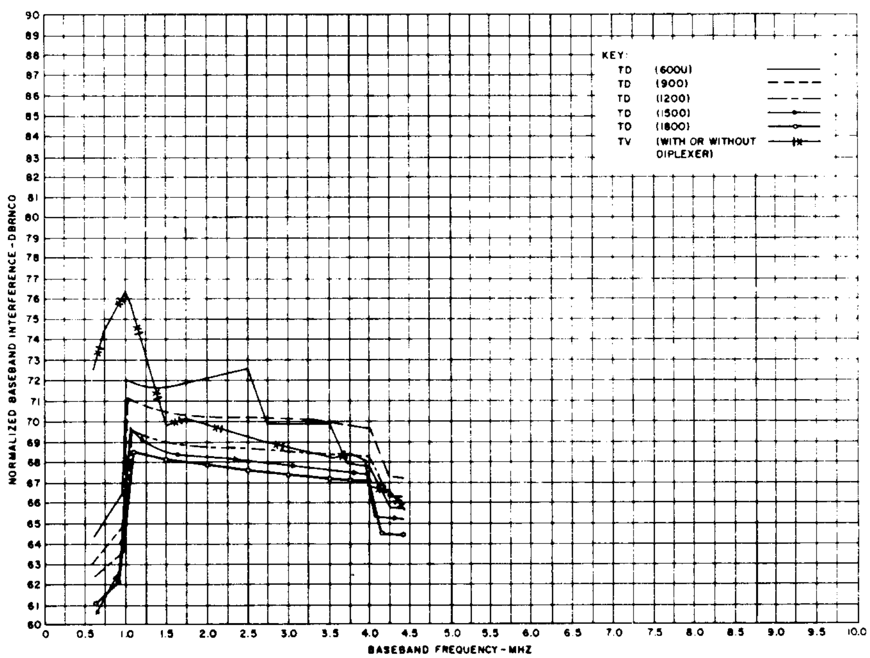

Fig. 2—Baseband Interference Into TD (900)—Cochannel Separation

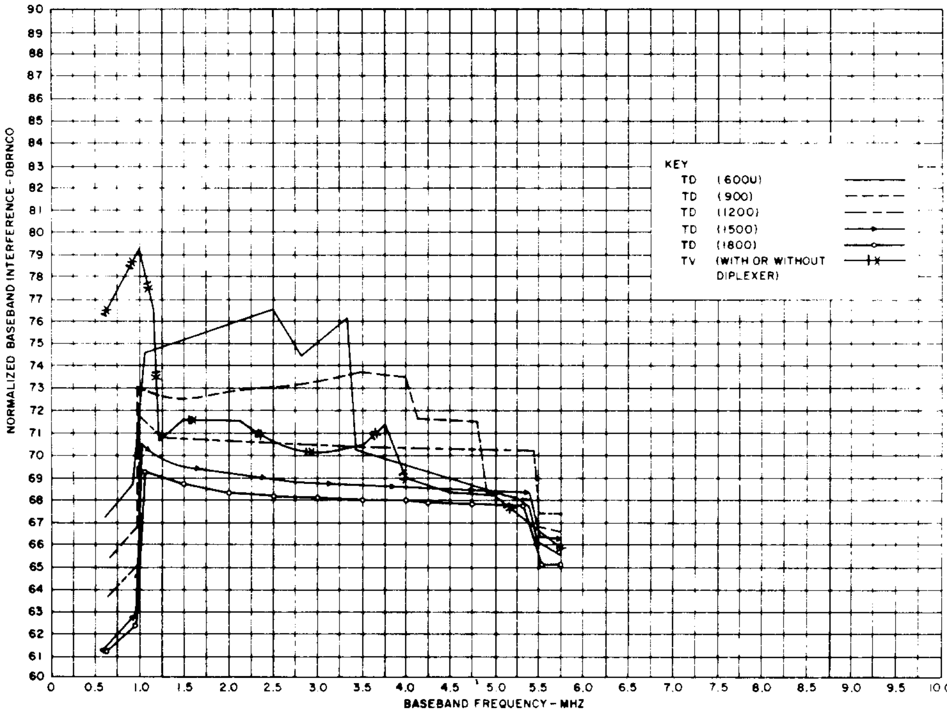

Fig. 3—Baseband Interference Into TD (1200)—Cochannel Separation

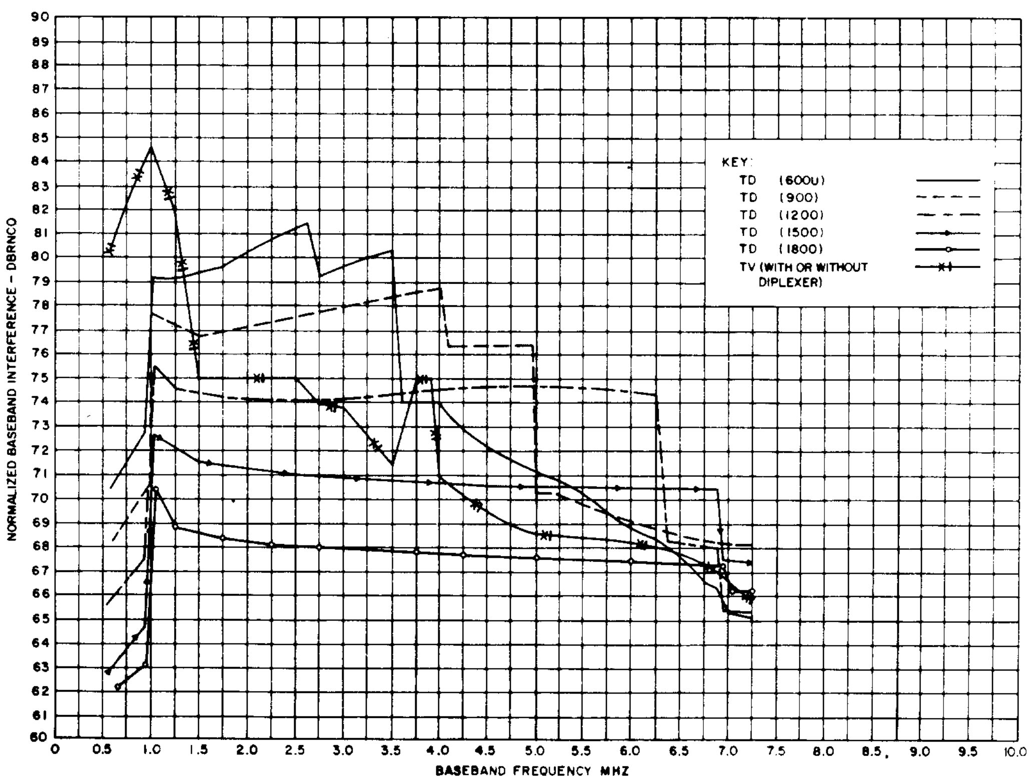

Fig. 4—Baseband Interference Into TD (1500)—Cochannel Separation

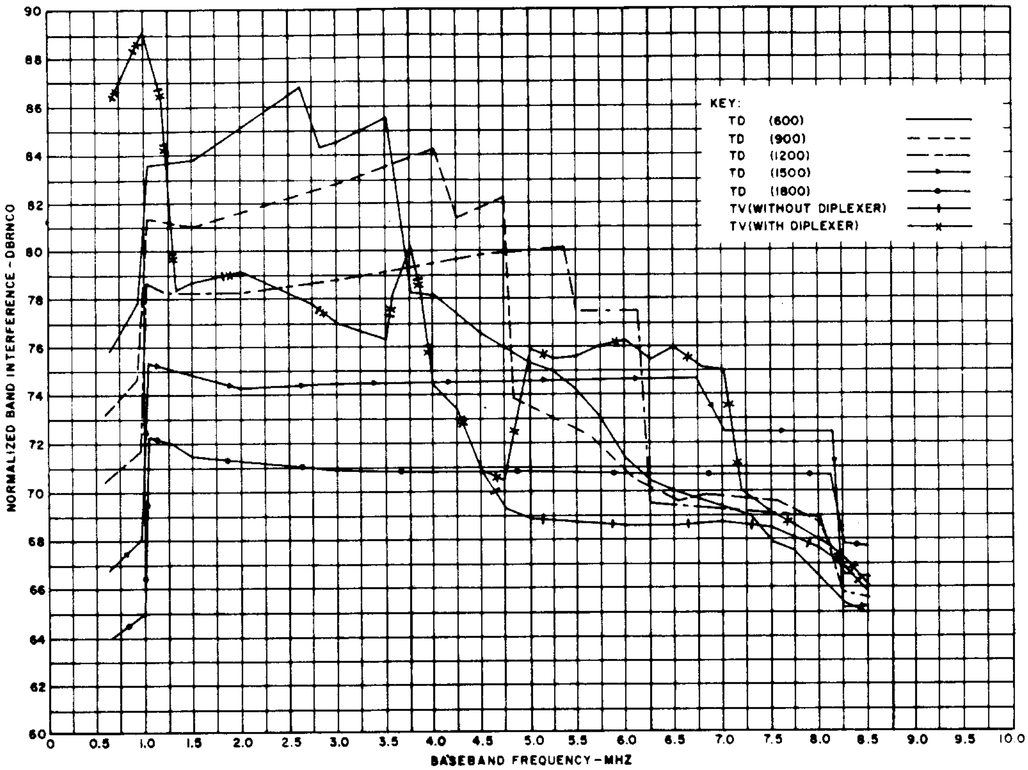

Fig. 5—Baseband Interference Into TD (1800)—Cochannel Separation

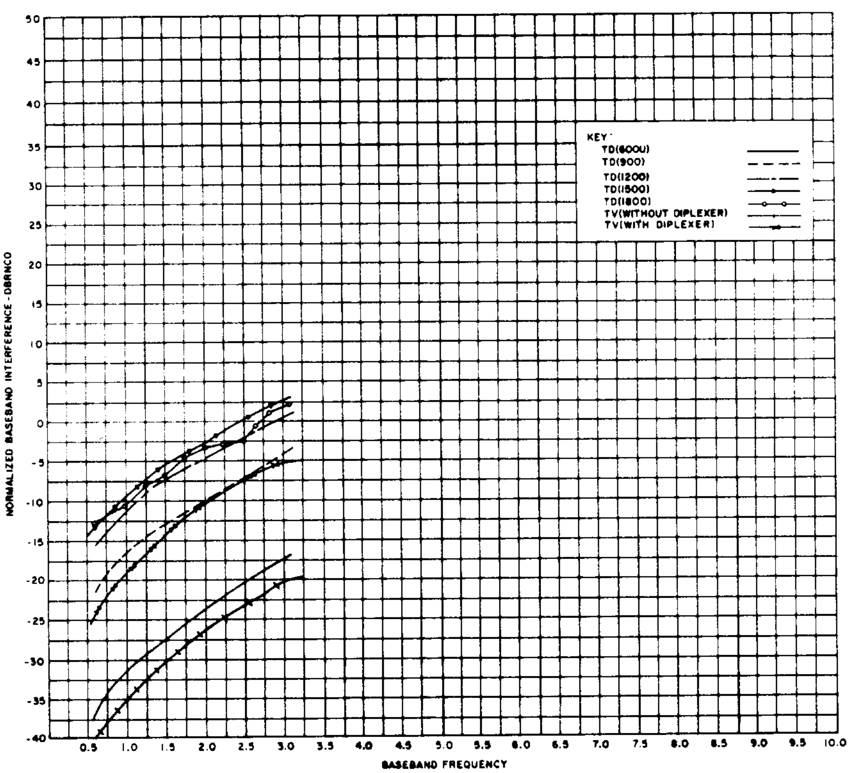

Fig. 6—Baseband Interference Into TD (600U)—20-MHz Separation

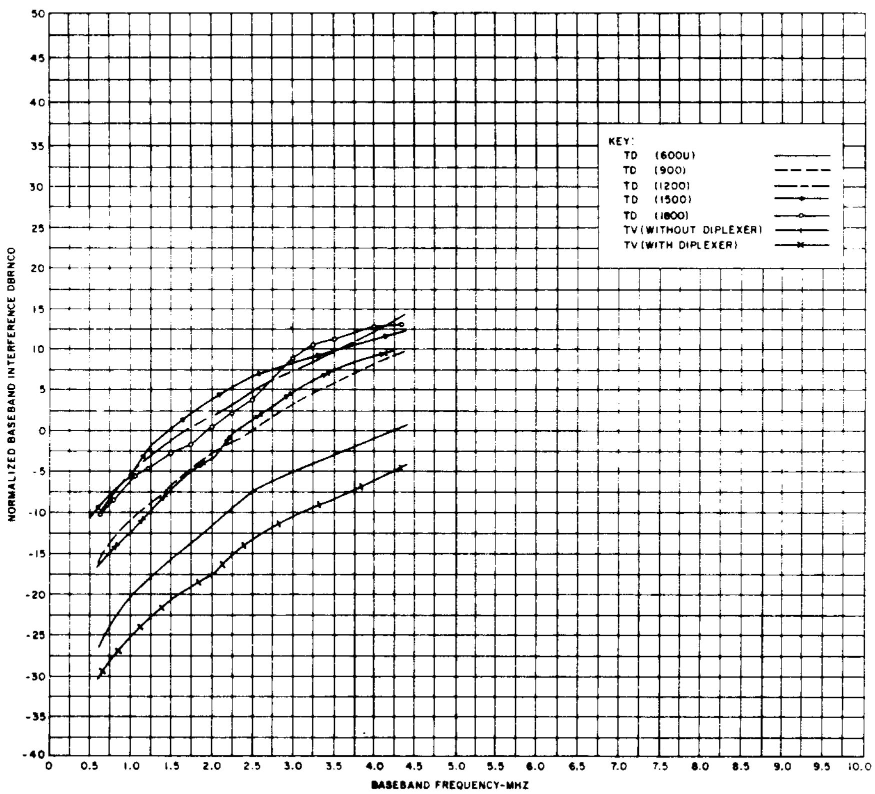

Fig. 7—Baseband Interference Into TD (900)—20-MHz Separation

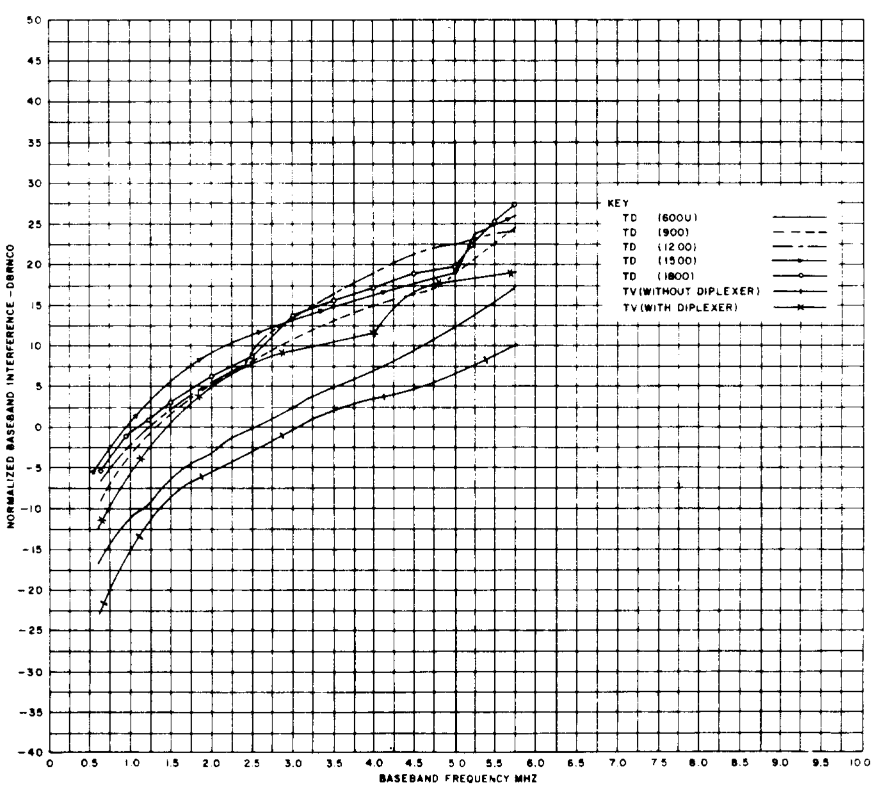

Fig. 8—Baseband Interference Into TD (1200)—20-MHz Separation

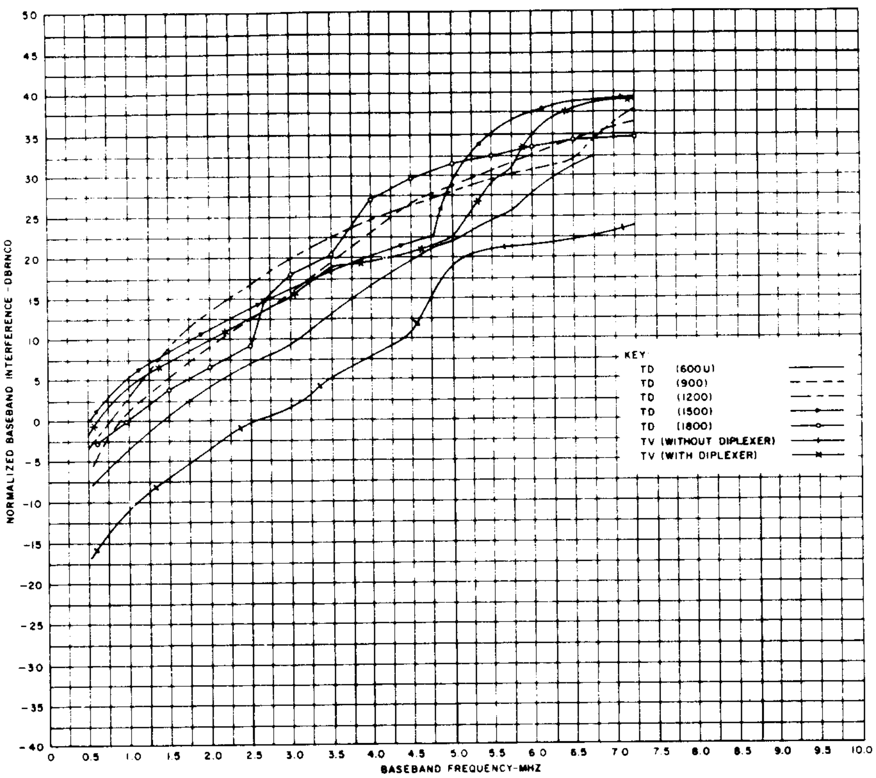

Fig. 9—Baseband Interference Into TD (1500)—20-MHz Separation

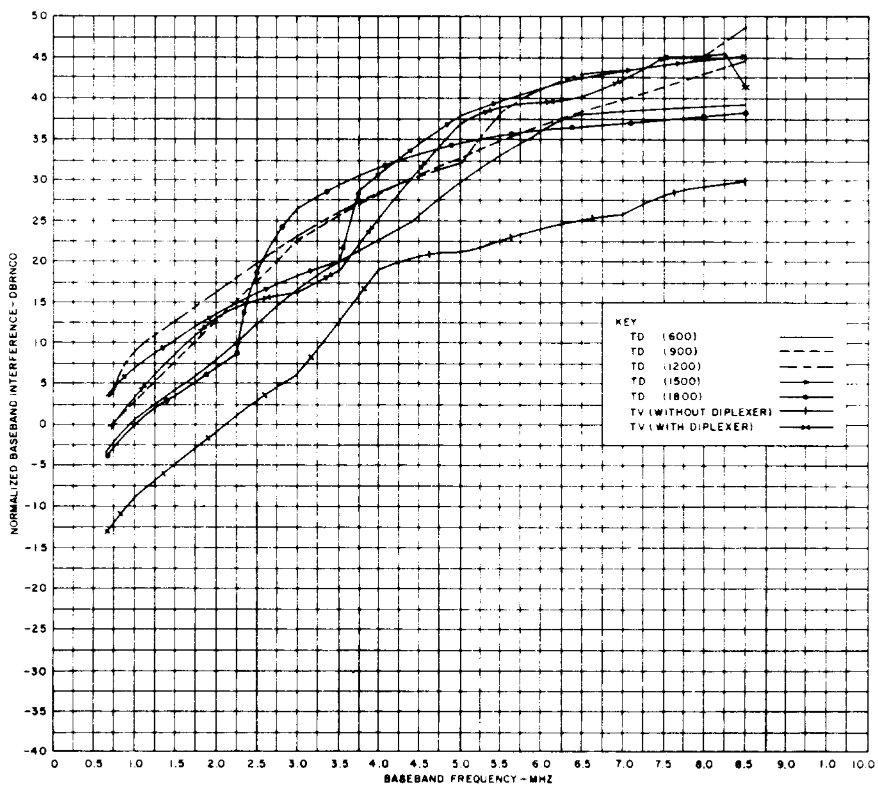

Fig. 10—Baseband Interference Into TD (1800)—20-MHz Separation

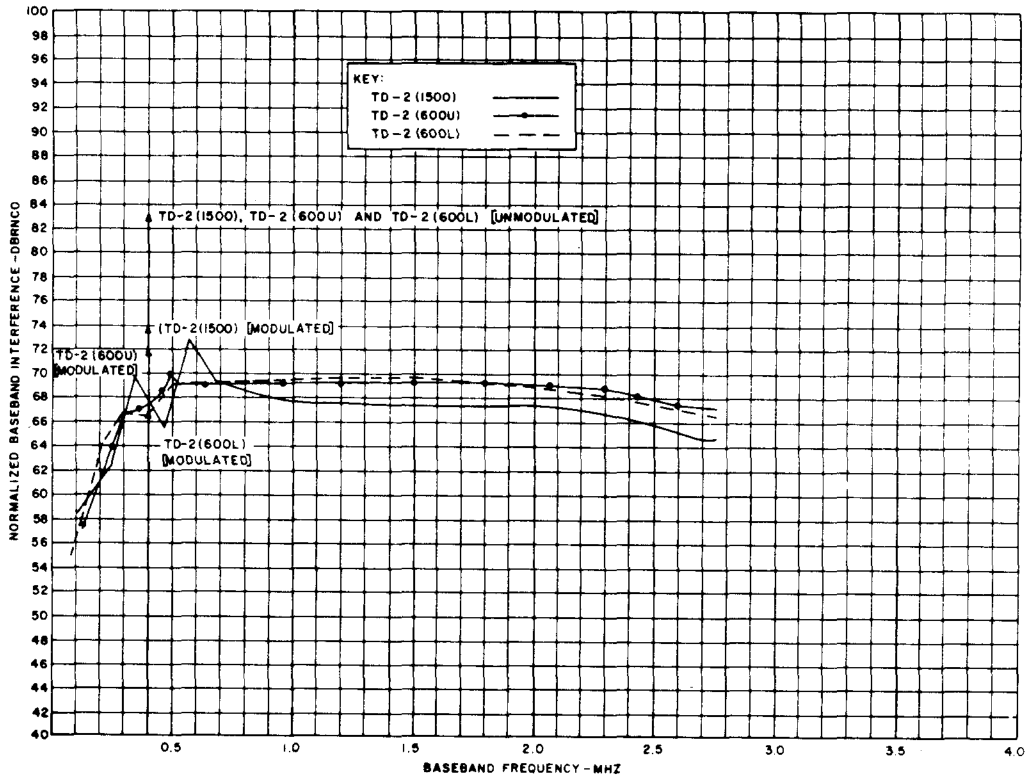

Fig. 11—Baseband Interference Into TD (600L)—Cochannel Separation

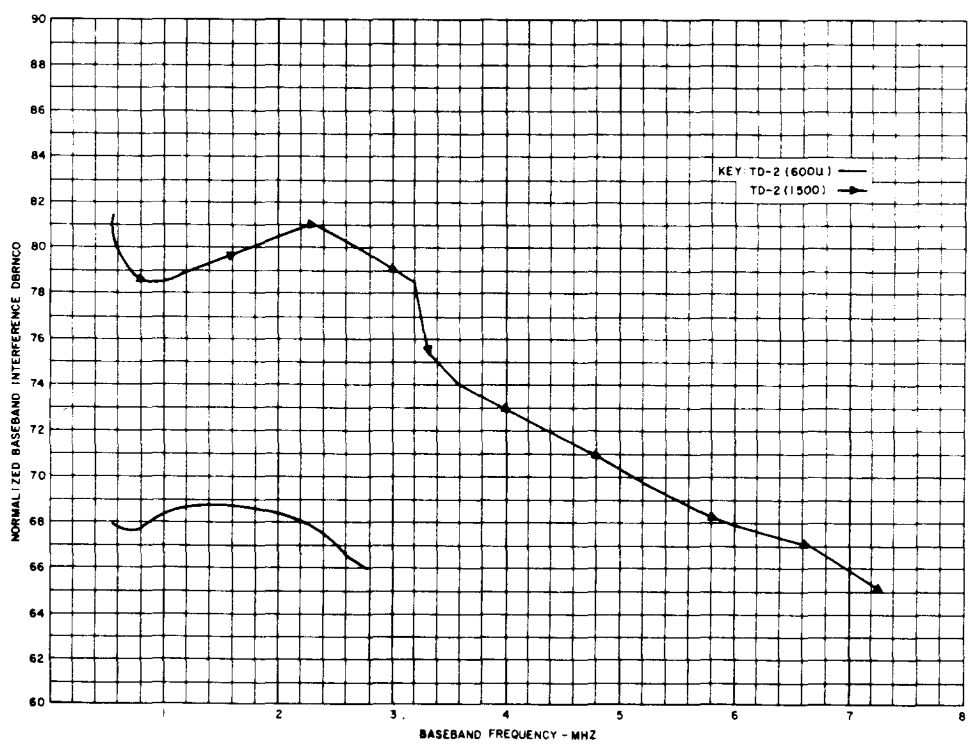

Fig. 12—Baseband Interference from TD (600L) Into TD (600U) and TD (1500)—Cochannel Separation