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SUBJECT: Coordination Requirements for Single Frequency Interferences Between Type P1 and Various Toll Carrier Systems - File 36675-9

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ABSTRACT

It is envisioned that an appreciable field of use for the P1 Carrier System potentially exists on lines that are basically toll lines, but which may also be utilized to provide rural facilities. This memorandum is the first of a series of studies to determine the coordination requirements between P1 and various toll carrier systems. It presents the computed carrier frequency system equal level coupling losses required to limit single frequency interferences to objective values in the various carrier systems.

Coordination of P1 carrier systems with any of the toll carrier systems operating below 36 kc will require that P1 channels in this frequency range be established on a stackable basis, while coordination with any of the toll carrier systems in the 36 to 100 kc range will require that P1 channels be established on a grouped basis.

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Rural Subscriber Carrier System (Type P1) - Coordination
Requirements for Single Frequency Interferences Between
Type P1 and Various Toll Carrier Systems - File 36675-9

MM-55-2433-6

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MEMORANDUM FOR FILE

1. Introduction and Purpose

A proposed study is underway of the coordination problems associated with the use of Type P1 Carrier Systems on lines which are basically toll lines, but which may also be utilized to provide rural facilities. A previous memorandum mentioned that it is possible to experience crosstalk exposures to toll carrier systems on such lines, either in the cable or open wire sections, or both. Since it is envisioned that an appreciable field of use for the P1 Carrier System potentially exists on this type of plant, a study of coordination limitations has been deemed desirable. This memorandum will therefore present the computed required carrier frequency system equal level coupling losses, from a single frequency standpoint, based on two simplifying assumptions;

- (1) That Type P1 and toll carrier systems may be assigned to facilities of similar transmission performance and
- (2) That directions of transmission for P1 and toll carrier systems can be coordinated by the option of transmitting high or low P1 frequency allocations from the central office.

In order to minimize computations, this study further assumes that the P1 and toll carrier systems will be co-terminus.

It is realized that a substantial percentage of the prospective P1 carrier layouts will not embody these idealized conditions. Therefore, subsequent studies should include variations from these assumptions, such as (1) nonco-terminus layouts, (2) P1 and toll carrier systems on dissimilar facilities, (3) limitations on oppositely directed carrier systems, etc.

(1) Memorandum entitled "Rural Subscriber Carrier System - Proposed Study of Coordination of Type XP Carrier Systems with Toll Carrier Systems - File 36675-9", 2-15-54, R. Clark.

The coupling losses computed in this and succeeding studies will be translated into estimated permissible lengths of exposures for the various layouts, and will be reported in a summarizing memorandum for the entire coordination study.

2. Conclusions

The conclusions listed herein pertain only to single frequency interference coupling loss requirements. These conclusions depict general and specific restrictions on coordination within the limiting assumptions mentioned above. Future studies will indicate the extent to which coordination is possible when these restricting assumptions are modified for less ideal layouts.

- (1) The attached Fig. 1 depicts a graphic summary of the expected degree of compatibility of the P1 carrier system with the toll carrier systems listed thereon.
- (2) Coordination of P1 Carrier Systems with any of the toll carrier systems operating below 36 kc will require that P1 channels in this frequency range be established on a stackable basis. Also, as mentioned previously, it will be necessary to be able to transmit P1 high or low frequencies in either direction, since the direction of transmission for toll systems vary with respect to rural routes in different central office areas and with respect to different rural routes in the same central office area.
- (3) Coordination of P1 Carrier Systems with any of the toll carrier systems operating in the 36-100 kc range will require that P1 channels be established on a grouped basis. The requirement for transmitting P1 high or low groups in either direction still applies for this frequency range.
- (4) The use of a staggered stackable P1 channel on lines supporting toll carrier systems below 36 kc probably will be precluded, since either the upper or lower sideband associated with the 18 kc P1 carrier will be oppositely directed to either East to West or West to East toll carrier allocations. Operation of stackable P1 channels (staggered or normal) on lines supporting normal grouped P1 channels will also be precluded regardless of whether toll systems are involved.

- (5) With the exception of CN allocations of Type C systems, the transmitted 12 kc Pl carrier causes disturbances only in channel 2 of the various C allocations and the 24 kc Pl carrier interferes only with channel 1 of the various C allocations.
- (6) The worst interferences in Type C carrier systems caused by Pl signaling tones will be roughly equivalent to the least interfering effects in the same toll system caused by the transmitted Pl carrier, for a given carrier frequency system equal level coupling loss.
- (7) The transmitted carriers of only the staggered Pl allocations cause single frequency interferences in the Types OB, OC, J, N and ON1 systems. The interferences appear as 2 kc tones in these toll systems. Conversely, the transmitted carriers of Types OB, OC, N and ON1 systems cause 2 kc tones in only the staggered Pl allocations. Thus from a transmitted carrier interference standpoint, non-staggered Pl allocations will not cause or experience single frequency interferences when placed on a route supporting these particular toll systems. The only exception to the above is the nonstaggered Pl carrier at 96 kc which interferes with Type J East to West channels. However, this Pl channel will probably be rendered unusable because of opposite direction of transmission with respect to J systems.
- (8) The following Table 1 summarizes the computed carrier frequency system equal level coupling losses necessary to limit the various interfering tones to objective values in the toll and Pl carrier systems.

TABLE 1

Computed Carrier Frequency System Equal Level Coupling Losses
to Limit Worst Single Frequency Interference Cases in Toll
and Pl Carrier Systems to Objective Values

<u>Toll Carrier System</u>	<u>Approximate Coupling Loss Required from Pl to Toll System</u>	<u>Approximate Coupling Loss Required from Toll System to Pl*</u>
C	49 db	54 db
H	29 db	-
Lenkurt 33A	38 db	52 db
N	67 db	38 db
OA, OB, OC	46 db	53 db
ON1	63 db	48 db
J	50 db	44 db

*As discussed in Section 5.2, these coupling losses should be increased about 5 db for Pl circuits employing equalized subsets, such as types 500C and D, on voice frequency extensions beyond remote Pl terminals.

- (9) With two possible exceptions, the losses shown in the above Table 1 in the column "Approximate Coupling Loss Required from Pl to Toll System" are applicable, within the assumptions set forth at the beginning of this memorandum, to the projected short haul Exchange Trunk Carrier System, if this trunk carrier system consists of Pl carrier equipment with modified signaling arrangements. The two exceptions are Types H and Lenkurt 33A carrier systems both of which experience single frequency interferences caused only by the Pl in band signaling tones. The losses in the column "Approximate Coupling Loss Required from Toll System to Pl" should, however, be relaxed (decreased) about 3 db for the Exchange Trunk Carrier System application. This is possible because the average local subscriber voice frequency loop loss plus the local central office loss is expected to be about 3 db higher than the average rural subscriber voice frequency loop loss beyond the outlying Pl carrier terminal.

It will be noted that the computed carrier frequency coupling losses in Table 1 are not the same for the P1 to toll carrier path as for the toll to P1 carrier path. This is because (1) level differences act as a crosstalk advantage in the one path and necessarily as a disadvantage in the reverse path and (2) the C, H, Lenkurt 33A, and J systems are normally not compandored, whereas the P1 carrier system will be compandored. Thus, an expander advantage is applicable only in the computations for the toll to P1 interferences for these particular toll systems.

3. General

MM-49-2400-15¹ presents the results of judgment tests of 25 observers to determine the allowable interference from single frequency tones when observing over a carrier telephone circuit. Pertinent among the details involved in the conditions of the tests are that the maximum allowable single frequency inputs to the subscriber's loop for various frequencies in the audio range were determined by the observers while simultaneously listening to recorded speech volumes of -30 VU at the input to a 3 db subscriber's loop with a thermal noise of 10 dba at this point.² The loop consisted of one mile of 24 gauge cable, a 120 D repeating coil, a 48 volt toll grade battery supply, and a 302 or a 500 type subset. The maximum allowable single frequency disturbances, as obtained from these tests for a 500 type subset, will be used as one "yardstick" in computing the coupling losses in this memorandum.

In considering any noise which is introduced into a system somewhat less than 50% of the time, but more than 1% of the time, and which has not been included in considerations establishing the noise objective for that particular system, it appears reasonable that this extraneous noise should not be permitted to materially increase the RMS noise objective of the system. Thus, another basis of computing allowable single frequency interferences is to consider the noise objective of a particular carrier system for all normal noises such as tube or transistor noise, resistance noise, power line noise,

¹Technical Memorandum 49-2400-15 entitled "Requirements on Unwanted Tones in a Carrier Telephone System - File 36725-1", 11/14/54, J. L. Lindner.

²-30 VU represents about a 3% minimum local talker volume, referred to the input of the local switchboard, on a distribution curve with a 50% point at -19 VU and a sigma of 5.9 VU.

babble, etc. The noise contributed by any one source not originally considered in setting the objective is then limited to a value equal to the objective minus 6 db, when the total of all other noises is at the objective value. The maximum allowable single frequency disturbances between Type P1 and toll carrier systems as determined by this method, with TLU line weighting, will be used as a second "yardstick" in computing the required coupling losses in portions of this memorandum. The results so obtained will be briefly compared to the losses computed using MM-49-2400-15 as a base.

The attached Appendix A shows some of the characteristics of the carrier systems which will be considered in this study, and the attached Fig. 2 and Fig. 3 depict frequency allocations for these carrier systems. It is to be remembered, however, that some of the P1 Carrier System characteristics shown in Appendix A are subject to change since this carrier system is still in the development stage.

4. Format of this Memorandum

This memorandum considers P1 Carrier Systems in combination with the Western Electric carrier systems and one Lenkurt carrier system that may be commonly encountered in routes also utilized to provide rural facilities. The approach for each combination will be to devote the first portion of each numbered section to investigating single frequency interferences in the toll carrier system caused by a P1 system, and then to investigate in the second portion of the section single frequency interferences in the P1 Carrier System caused by the toll system under discussion.

The attached Appendices A through Q, which are referenced in appropriate sections, are used to indicate the numeric assumptions for the various carrier systems and to provide sample computations for each of the cases considered.

5. Type P1 and C Carrier Combinations

5.1 Interferences in C Carrier Channels

Referring to Fig. 2, maximum potential coordination of the P1 Carrier System with toll carrier systems below 36 kc will require that P1 channels in this frequency range be established on a stackable basis (assuming prior establishment of East and West toll carrier terminals) with the 12 kc carrier of the P1 system transmitting East to West and the 24 kc carrier transmitting West to East. The interfering tones

produced in the various Type C allocations by these two P1 carriers are shown in the following Table 2. Staggered P1 carriers at 18 and 30 kc have been omitted because present design arrangements do not permit the use of these two frequencies on a stackable basis.

Table 2

Interfering Tones (in kc) Produced in Various C Allocations
by Transmitted P1 12 kc and 24 kc Carriers

P1 Carriers	C Allocations																	
	CA			CB			CS			CU			CN*			CT*		
	Channels			Channels			Channels			Channels			Channels			Channels		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
12 kc	-	.4	-	-	.4	-	-	2.6	-	-	2.6	-	1.9	-	-	-	2.6	-
24 kc	2.2	-	-	.8	-	-	.4	-	-	2.6	-	-	-	-	.3	.3	-	-

*It is understood that an insignificant percentage of CN and CT allocations are in plant; however, each is shown here for completeness.

Assuming a 3 db toll trunk connection to the disturbed subscribers loop, a disturbed C carrier circuit equivalent of 6 db, and a level difference advantage¹ of 13 db, minimum computed carrier frequency system equal level coupling losses are indicated in Table 3 for the various interfering tones shown in Table 2 using limits set forth in MM-49-2400-15 (hereafter referred to as Method A). For comparison purposes, the coupling losses were also computed using the carrier system noise objective as a base (hereafter referred to as Method B). A sample computation for Table 3 is contained in the attached Appendix B.

¹If the level of carrier system A is, say, 13 db lower than the level of carrier system B at the same physical location, then crosstalk energy from system A into system B would be 13 db less than if the two carrier systems were equal level. Consequently, the required system equal level crosstalk coupling loss, from system A to system B, could be reduced 13 db from that which would be required for equivalent performance if both systems were at the same level.

Table 3

Minimum Carrier Frequency System Equal Level Coupling Losses (in db) to Limit Single Frequency Interferences in C Carrier Channels Due to Pl Carriers, to Objective Values for Methods A and B

<u>Pl Carriers</u>	<u>CA Channels</u>		<u>CB Channels</u>		<u>CS Channels</u>		<u>CU Channels</u>		<u>CN Channels</u>		<u>CT Channels</u>	
	<u>1</u>	<u>2</u>										
	Method A		35		35		47		47	49		
12 kc												
Method B		34		34		37		37	40			37
Method A	48		45		35		47			30		30
24 kc												
Method B	38		43		34		37			29		29

It should be mentioned again that the equal level coupling losses depicted in Table 3, and succeeding tabulations, are based on level differences of Pl and C carrier systems which would obtain only when these systems are coterminus and assigned to similar facilities. Further, for a given level difference at the central office transmitting end, the coupling losses would be relaxed by about 3.5 db when considering the transmitted carriers of the remote Pl terminals, since these carriers (and sidebands) experience approximately 3.5 db bridging loss due to the carrier frequency termination at the remote end of the carrier line.

The values in Table 3 indicate that computing system equal level coupling losses by the process of considering system noise objectives (Method B) results in relatively small deviations from the losses computed by Method A for interfering tones below about .8 kc. However, the losses computed by Method B are considerably relaxed for interfering tones of 1 kc or greater, being in the order of 10 db less stringent than those calculated by Method A in the 1.9 to 2.6 kc range.

The P1 Carrier System will utilize "in band" signaling consisting of three tones; namely 1150 cps, 1750 cps and 2500 cps to provide 4 party selective and 8 party semiselective ringing. The 2500~ tone will be used as a ringing frequency to be interrupted at a 20 cycle rate, and therefore will be present any time a rural subscriber is being signaled. The 1750~ tone will be used to select tip or ring conductors by its presence or absence and will therefore be present, as an average, in 50 per cent of the cases when a subscriber is being signaled. Further, the 1150~ tone will be used to select positive or negative bias, by its presence or absence, and will therefore be present 50 per cent of the cases when a subscriber is being signaled. Thus, there is a .50 probability that the 2500~ and 1750~ tones will be on the line at the same time and a .50 probability that the 2500~ and 1150~ tones will be on the line at the same time. A .25 probability exists that the 1150~ and 1750~ tones will be on concurrently and that all three tones will be on the line at the same time.

The interfering tones in the various C allocations caused by the three signaling tones, simultaneously applied, in the P1 channels associated with 12 kc and 24 kc carriers are given in the following Table 4.

Table 4

Single Frequency Tones (in kc) in C Allocations Caused by Signaling Tones of P1 Carrier System

P1 Signaling Tones	C East - West Allocations																	
	CA Channels			CB Channels			CS Channels			CU Channels			CN Channels			CT Channels		
	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>
<u>P1 12 kc Allocation</u>																		
1.15 kc, LSB			1.55			1.55			1.45			1.45			-			1.45
1.75 kc, LSB			2.15			2.15			.85			.85			-			.85
2.5 kc, LSB			-			-			-			-			1.10			-
1.15 kc, USB	2.75					2.75			-			-			.75			-
1.75 kc, USB	2.15					2.15			.85			.85			-			.85
2.5 kc, USB	1.40					1.40			1.60			1.60			-			1.60
<u>C West - East Allocations</u>																		
<u>P1 24 kc Allocation</u>																		
1.15 kc, LSB			-			-			1.55			1.45			-			-
1.75 kc, LSB			-			2.75			2.15			.85			2.45			2.45
2.5 kc, LSB			1.00			2.00			-			-			1.70			1.70
1.15 kc, USB	1.05					1.95			-			-			1.45			1.45
1.75 kc, USB	.45					2.55			2.65			-			2.05			2.05
2.5 kc, USB	-					-			1.90			1.10			2.80			2.80

USB - Upper sideband LSB - Lower sideband

Interferences below .4 kc and above 2.8 kc now shown.

Table 5

Minimum Carrier Frequency System Equal Level Coupling Losses (in db) Required to Limit Single Frequency Interferences in C Carrier Channels, Due to F1 Signaling Tones, to Objective Values

F1 Signaling Tones	C East - West Allocations																	
	CA Channels			CB Channels			CS Channels			CU Channels			CN Channels			CT Channels		
	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>
<u>F1 12 kc Allocation</u>																		
1.5 kc, LSB		27			27			30			30			-				30
2.0 kc, LSB		"			"			"			"			-				"
2.5 kc, LSB		-			-			-			-			29				-
1.5 kc, USB	28			28			-			-			27					-
2.0 kc, USB	"			"			30			30			-					30
2.5 kc, USB	"			"			"			"			-					"
<u>C West - East Allocations</u>																		
<u>F1 24 kc Allocation</u>																		
1.5 kc, LSB		-			-		27			30			-					-
2.0 kc, LSB		-			25		"			"			27					27
2.5 kc, LSB		29			"		-			-			"					"
1.5 kc, USB	30			25			-			-			29					29
2.0 kc, USB	"			"			25			-			"					"
2.5 kc, USB	-			-			"			29			"					"

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As previously mentioned, in some cases only one of the P1 signaling tones (2500~) may be on at a time, or this 2500~ tone may be on with one or both of the other two signaling tones (1150~ and 1750~). Thus, the interfering tones in the C allocations indicated in Table 4, are the maximum possible interferences, and may not be realized in many cases. The above Table 5 summarizes, however, the computed carrier frequency system equal level coupling losses necessary to limit the interferences in the C allocations from the combinations of tones indicated in the above Table 4 to a value equal to the C carrier system noise objective of 32 dba at zero level minus 6 db, with appropriate TLU line weightings as shown in the sample calculation of Appendix C.

A comparison of the system equal level coupling losses required for the P1 signaling tones (above Table 5) with losses required for single frequency interferences due to the P1 transmitted carriers (Table 3) indicates that the losses computed in connection with the carrier interference are more stringent than the losses computed for the P1 signaling tone interferences in all of the commonly used C allocations, i.e. CA, CB, CS, CU. This is, of course, to be expected since the transmitted P1 carrier is +4 dbm at the line terminals, while each signaling tone is about 16 db down on the carrier at this point.

5.2 Interferences in P1 Channels

C carrier systems are carrier suppressed. Therefore, the only potential sources of single frequency interferences in the P1 channels are C pilot frequencies. The C system pilot frequencies will fall into sidebands associated with P1 carriers at 12 and 24 kc causing interfering tones as indicated in the following Table 6.

Table 6

Interfering Tones (in kc) Produced in P1 System by C Carrier Pilots

<u>C Pilot Frequencies</u>	<u>P1 Stackable Channel 1</u>	
	<u>Sidebands of 12 kc Carrier</u>	<u>Sidebands of 24 kc Carrier</u>
CA & CB, E-W, 12.35 kc	.35	-
CA, W-E, 26.15 kc	-	2.15
CB, W-E, 23.25 kc	-	.75
CS, CU & CT, E-W, 9.45 kc	2.55	-
CS, W-E, 24.35 kc	-	.35
CU, W-E, 21.45 kc	-	2.55
CT, W-E, 23.75 kc	-	.25
CN, E-W, 10.55 kc	1.45	-
CN, W-E, 19.85 kc	-	-

As previously indicated, coupling losses derived by Method A are more restrictive than coupling losses derived by Method B. Therefore as a conservative approach, the succeeding coupling losses will be derived on the basis of Method A, with the exception of the coupling losses required to limit interferences in the toll systems by virtue of P1 signaling tones. Method B appears to be a better approximation for two or three simultaneous single frequency interferences in a message channel, and will thus be used for computations involving interferences from P1 signaling tones.

Table 7 shows the computed minimum carrier frequency system equal level coupling losses required to limit single frequency interferences in a P1 channel from +8 dbm C carrier pilots at the +18 db sideband level point to objective values of single frequency noise, in the presence of 18 dba of inherent P1 carrier system noise at zero level in the P1 system after the expander. A sample computation is contained in Appendix D. The values in Table 7 are based on a P1 expander advantage of 26 db to single frequency interference as derived in Appendix E.

Table 7

Minimum Carrier Frequency System Equal Level Coupling Losses (in db) Required to Limit Single Frequency Interference in a P1 Channel, Due to C System Pilots, to Objective Values Based on Method A

<u>C Pilots</u>	<u>P1 Stackable Channel 1</u>	
	<u>Sidebands of 12 kc Carrier</u>	<u>Sidebands of 24 kc Carrier</u>
CA & CB E-W, 12.35 kc	38	-
CA W-E, 26.15 kc	-	54
CB W-E, 23.25 kc	-	49
CS, CU & CT E-W, 9.45 kc	53	-
CS W-E, 24.35 kc	-	38
CU W-E, 21.45 kc	-	53
CT W-E, 23.75 kc	-	32
CN E-W, 10.55 kc	54	-
CN W-E, 19.85 kc	-	-

As previously mentioned, the observer's circuit used in the tests reported in MM-49-2400-15 consisted of a 48 volt toll grade battery supply, one mile of 24 gauge cable, and 500 type subsets (as well as 302 types). Most of the voice frequency extensions beyond remote P1 carrier terminals will

be less than 5 miles in length and will consist mainly of 109 steel wire. Further, a substantial portion of the P1 carrier subscribers will have 500 type subsets. All subscribers served by carrier will utilize the 20 volt battery supply of the remote carrier terminals. Since the supply voltage to these subsets will be 28 volts lower than the toll grade battery supply, and since the 20 volt P1 battery supply dc resistance will be about 230 ohms (as compared to about 67 ohms of the 48 volt toll grade battery supply), it is estimated that the receiver of an equalized 500 or 501 subset (served by P1 carrier systems) will be about 5 db more sensitive than the receivers of the 500 sets used in the MM-49-2400-15 tests. Therefore, the coupling loss figures shown in the above Table 7, as well as in succeeding tables depicting interferences in P1 channels, should be increased about 5 db for circuits employing equalized subsets, such as the 500 C and D, beyond the remote carrier terminals.

Further, as indicated in Appendix E, the P1 expander advantage to single frequency noise will vary slightly depending on the talker volume reaching the expander; therefore, the above computed coupling losses may vary within about ± 2 db.

6. Type P1 and H Carrier Combinations

Type H carrier is a single channel carrier suppressed system and makes use of upper and lower sidebands of a 7.15 kc carrier for East to West and West to East directions of transmission, respectively. P1 system coordination with only Type H carrier will permit the use of stackable or grouped and staggered allocations, the only requirement being that the sidebands associated with the P1 12 kc carrier be transmitted in the same direction as the East to West upper sideband of Type H.

There are no single frequency interferences in P1 channels from Type H systems. There is, however, a potential interference in Type H arising from the 2.5 kc signaling tone in the lower sideband of the P1 12 kc carrier. This tone causes a 2.35 kc tone in the H East to West allocation. The minimum system equal level coupling loss necessary to limit this tone to an objective value is 29 db as computed in Appendix F.

7. Type P1 and Lenkurt 33A Carrier Combinations

7.1 Interference in Lenkurt 33A Channels

Referring to Fig. 2, it is noted that Lenkurt Type 33AS and 33AX are stackable carrier systems judiciously arranged to coordinate with Western Electric Types C and H carrier systems. As in the case of C carrier, maximum coordination efforts require that the P1 channels associated with 12 and 24 kc carriers be established on a stackable basis.

No single frequency interferences will be encountered in the Lenkurt channels by virtue of transmitted P1 carriers. There are, however, potential interferences in the Lenkurt channels arising from the signaling tones of P1. The signaling tones of the 12 and 24 kc P1 channel may, as a worst condition, cause interfering tones in the various Lenkurt allocations as noted in the following Table 8.

Table 8

Single Frequency Tones (in kc) in Lenkurt 33 AS and 33 AX Allocations Caused by Signaling Tones of P1 Carrier System

<u>P1 Signaling Tones</u>	<u>Lenkurt 33 AS</u>				<u>Lenkurt 33 AX</u>			
	<u>East to West Channels</u>		<u>West to East Channels</u>		<u>East to West Channels</u>		<u>West to East Channels</u>	
	<u>1</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>3</u>
<u>P1 12 kc Channel</u>								
1.15 kc LSB	.65	-	-	-	.65	-	-	-
1.75 kc LSB	1.25	-	-	-	1.25	-	-	-
2.5 kc LSB	2.00	-	-	-	2.00	-	-	-
1.15 kc USB	-	-	-	-	-	-	-	-
1.75 kc USB	-	.75	-	-	-	-	-	-
2.5 kc USB	-	1.50	-	-	-	2.50	-	-
<u>P1 24 kc Channel</u>								
1.15 kc LSB	-	-	-	-	-	-	-	-
1.75 kc LSB	-	-	.75	-	-	-	-	-
2.5 kc LSB	-	-	1.50	-	-	-	2.50	-
1.15 kc USB	-	-	-	-	-	-	-	-
1.75 kc USB	-	-	-	.75	-	-	-	-
2.5 kc USB	-	-	-	1.50	-	-	-	2.50

Interferences below .4 kc and above 2.8 kc not shown.

The following Table 9 summarizes the computed carrier frequency system equal level coupling losses necessary to limit interferences from the combinations of tones indicated in Table 8 to a value equal to an assumed Lenkurt carrier system noise objective of 32 dba¹ at zero level minus 6 db with appropriate line weightings as shown in the sample calculations of Appendix G.

Table 9

Minimum Carrier Frequency System Equal Level Coupling Losses (in db)
Required to Limit Single Frequency Interferences
in Lenkurt 33 Channels, Due to Fl Signaling Tones,
to Objective Values

Fl Signaling Tones	Lenkurt 33 AS				Lenkurt 33 AX			
	East to West Channels		West to East Channels		East to West Channels		West to East Channels	
	1	2	2	3	1	2	2	3
<u>Fl 12 kc Allocation</u>								
1.15 kc LSB	38	-	-	-	38	-	-	-
1.75 kc LSB	"	-	-	-	"	-	-	-
2.5 kc LSB	"	-	-	-	"	-	-	-
1.15 kc USB	-	37	-	-	-	-	-	-
1.75 kc USB	-	"	-	-	-	-	-	-
2.5 kc USB	-	"	-	-	-	33	-	-
<u>Fl 24 kc Allocation</u>								
1.15 kc LSB	-	-	37	-	-	-	-	-
1.75 kc LSB	-	-	"	-	-	-	-	-
2.5 kc LSB	-	-	"	-	-	-	33	-
1.15 kc USB	-	-	-	37	-	-	-	-
1.75 kc USB	-	-	-	"	-	-	-	-
2.5 kc USB	-	-	-	"	-	-	-	33

¹Detailed transmission information for Lenkurt carrier systems is not available. If, however, it is assumed that the battery filter circuits are as good as Western Electric Type C and that modulation is held within acceptable limits, then an assumed noise performance comparable to Type C carrier is appropriate.

7.2 Interference in P1 Channels

It is of interest to note that there are no potential sources of single frequency interference in nonstaggered P1 channels from any of the Lenkurt 33 AS allocations inasmuch as carrier is not transmitted in Lenkurt Type 33 systems and since the signaling tones of the 33 AS channels are out of band with reference to sidebands of P1 12 kc, 24 kc and 36 kc carriers. There are, however, potential single frequency interferences in the P1 nonstaggered channels caused by the 4 kc signaling tones of Lenkurt 33 AX allocations 2 E-W, 2 W-E, 3 W-E and 3 E-W. These signaling tones cause 1 kc interfering tones in each of the three P1 allocations associated with 12, 24 and 36 kc carriers. The minimum carrier frequency system equal level coupling losses necessary to limit this 1 kc tone to an objective value in the P1 channels is 52 db as computed in Appendix H.

8. Type P1 and N Carrier Combinations

8.1 Interferences in N Channels

As shown in Fig. 3, P1 carriers either side of the 54 kc cut-apart frequency transmit in opposite directions. For maximum coordination P1 carriers above 54 kc should be transmitted in the same direction as N low group. In this arrangement, P1 channel 4n would become nonusable due to opposite direction transmission. Also the operation of P1 channel 3n would be precluded if N channel 13 is used. P1 channel 3s would be nonusable if either N channel 13 or 12 were used. In addition, all coordination ceases to be possible when the P1 exposure to N exceeds an N repeater section, since N channels experience frequency frogging at a repeater.

From Fig. 3, it is seen that the transmitted carriers of normal grouped P1 channels (e.g. 12, 24, 36 kc etc.) do not cause any interfering tones in any of the N carrier channels. However staggered grouped P1 carriers at 42 kc, 66 kc, 78 kc and 90 kc potentially disturb N carrier low group channels 13, 10, 8 and 7, respectively, and cause 2 kc tones in each of these channels. Table 10 indicates the minimum carrier frequency system equal level coupling losses required to limit this tone to objective values. The coupling losses shown in Table 10 assume a 3 db toll trunk connection to the subscribers loop, a disturbed N carrier circuit equivalent of 5 db, an N expander advantage of 23 db to noise, and a noise objective of 32 dba at zero level in the N system. A sample computation is depicted in Appendix I.

Table 10

Minimum Carrier Frequency System Equal Level Coupling Losses (in db) Required to Limit 2 kc Interferences in an N Carrier System, Due to P1 Carriers, to Objective Values

<u>P1 Carriers</u>	<u>N Carrier Low Group Allocations</u>			
	<u>7</u>	<u>8</u>	<u>10</u>	<u>13</u>
42 kc				67
66 kc			65	
78 kc		64		
90 kc	63			

The transmitted P1 carriers may also demodulate against the 3700~ N carrier signaling tones and cause a 1700~ interfering tone in the N channel. However, this 1.7 kc tone will not require coupling losses significantly larger than those shown in Table 10 and are, therefore, not computed.

8.2 Interferences in P1 Channels

The transmitted N carriers at 40, 64, 80 and 88 kc will fall into P1 staggered allocations 3s LG, 1s HG, 2s HG, and 3s HG¹ respectively, and cause 2 kc tones in each of these allocations. In addition, the 3700~ signaling tones of the N channels will cause interfering tones in the various P1 staggered allocations. However, inasmuch as the N signaling tones are 15 db below the transmitted N carriers, only the interference caused by the N carriers is considered here.

Table 11 indicates the computed minimum carrier frequency system equal level coupling losses required to limit the 2 kc interfering tone to an objective value of -70.5 dbm at zero level after the P1 expander. These computations assume a 1 db average voice frequency loop beyond the outlying P1 terminal, a 4 db disturbed P1 carrier equivalent, a P1 expander advantage to single frequency noise of 26 db, and appropriate level difference advantages. A sample calculation is contained in Appendix J.

¹LG - Low Group, HG - High Group.

Table 11

Minimum Carrier Frequency System Equal Level Coupling Losses (in db) Required to Limit Single Frequency Interference in a P1 Channel, Due to N Carriers, to Objective Values

<u>N1</u> <u>Carriers</u>	<u>P1 Allocations</u>			
	<u>3s LG</u>	<u>1s HG</u>	<u>2s HG</u>	<u>3s HG</u>
Ch-13, 40 kc	34			
CH-10, 64 kc		36		
Ch- 8, 80 kc			37	
Ch- 7, 88 kc				38

9. Type P1 and OA Carrier Combinations

9.1 Interference in OA Channels

Referring to Fig. 2, it is seen that coordinating P1 carrier systems with Type OA systems is similar to the problem of coordinating with Type C in that P1 channels in the 2 - 36 kc range must be established on a stackable basis (assuming existing OA systems) with the 12 kc carrier of the P1 system transmitting East to West and the 24 kc carrier transmitting West to East. Of these two P1 carriers, only the 12 kc carrier produces a single frequency tone in the OA system, which tone falls into OA channel 2 East to West at 2 kc. The minimum carrier frequency system equal level coupling loss required to limit this 2 kc interference in the OA channel to an objective value of -72.5 dbm at the input to a 3 db subscribers loop (-65.5 dbm at zero level after the OA expander) is 46 db as computed in Appendix K with the assumptions indicated therein.

9.2 Interference in P1 Channels

Conversely, the 14 kc carrier of OA channels 1 and 2, East to West, will fall into the upper sideband associated with the 12 kc P1 carrier and will cause a 2 kc tone in this sideband. The minimum carrier frequency system equal level coupling loss required to limit this 2 kc interference in the P1 channel to an objective value of -74.5 dbm at the input to a 1 db P1 subscribers loop (-70.5 dbm at zero level after the P1 expander) is 53 db as computed in Appendix L.

Further, the 3700~ signaling tones of OA channels 2 and 3 East to West will demodulate against the 12 kc P1 carrier causing 1700 cycle and 2300 cycle tones, respectively, in the lower sideband of this P1 allocation. However, since these OA signaling tones are 6 db down on the OA transmitted carrier, the interference caused by these OA signaling tones will require coupling losses no greater than the 53 db figure quoted above, and are, therefore, not computed. Signaling tones of OA channels 1 and 2 West to East fall out of band in the P1 allocation associated with the 24 kc carrier.

10. Type P1 and OB and OC Carrier Combinations

10.1 Interferences in OB and OC Channels

Types OB and OC carrier systems have no standardly established directions of transmission for high or low groups, such as East to West or vice versa. Thus, a particular office may, for instance, be high group transmitting for OB systems and low group receiving for OC systems. In such cases, maximum coordination effort would, in addition to requiring grouped P1 channels, limit the usable P1 channels to the following: P1 channels 1n, 1s, and 2n (see Fig. 3) assuming attempted coordination with OB; or P1 channel 3n assuming coordination with low group OC. If, however, the central office under consideration is OB high group transmitting and OC low group transmitting, then maximum coordination effort may (depending on further studies) permit the use of all seven P1 channel allocations, i.e., channels 1n, 1s, 2n, 2s, 3n, 3s and 4n.

The staggered transmitted P1 carriers at 42 kc, 66 kc and 90 kc fall into OB low group channel 4, OB high group channel 2, and OC low group channel 2, respectively, causing a 2 kc tone in each of these channels. The minimum carrier frequency system equal level coupling loss required to limit this 2 kc interference to an objective value in the OB and OC channels (assuming P1 directions of transmission coordinated with OB and OC) is 46 db, computed as shown in Appendix K for OA interference.

10.2 Interference in P1 Channels

The transmitted OB 44 kc and 64 kc carriers and the OC 92 kc carrier fall into P1 allocations 3s LG, 1s HG and 3s HG, respectively, causing 2 kc tones in each of these sidebands. The minimum carrier frequency system equal level coupling loss required to limit this 2 kc interference to an objective value in the P1 channels is 53 db, computed in a manner similar to that shown in Appendix L for OA considerations.

11. Type P1 and ON1 Carrier Combinations

11.1 Interferences in ON1 Channels

Type ON1 carrier systems basically utilize type N equipment in the cable section to derive a maximum of 20 single sideband channels in five groups of four channels per group in roughly the same frequency spectrum utilized by N carrier systems. Appendix A depicts some of the more outstanding characteristics of the ON1 carrier system. Referring to Fig. 3, it is noted that maximum coordination of P1 with type ON1 carrier would require grouped P1 channels with the high group of P1 transmitting in the same direction as low group ON1. Further, this coordination may preclude the use of P1 channels 3s and 4n. Type ON1 channels are added in the order of applying Group 1 first, Group 2 second, Group 3, Group 5, and Group 4. Thus, for those cases where Group 5 is not being operated, it may be possible to utilize P1 channels 3s and 4n.

The transmitted P1 staggered grouped carriers at 42 kc, 66 kc, and 90 kc fall into ON1 Group 5 (Channel 4), Group 4 (Channel 3) and Group 3 (Channel 2), respectively, causing 2 kc interfering tones in each of these ON1 allocations. The minimum carrier frequency system equal level coupling loss requirements for this tone in the various ON1 channels are as shown in the following Table 12. A sample computation is contained in Appendix M.

Table 12

Minimum Carrier Frequency System Equal Level Coupling Losses (in db) Necessary to Limit 2 kc Interference in ON1 Channels, Due to P1 Carriers, to Objective Values

<u>P1 Carriers</u>	<u>ON1 Carrier Low Group Allocations</u>		
	<u>Grp. 5 (Channel 4)</u>	<u>Grp. 4 (Channel 3)</u>	<u>Grp. 3 (Channel 2)</u>
42 kc	63		
66 kc		61	
90 kc			59

11.2 Interference in P1 Channels

It follows, from the above, that ON1 carriers at 44 kc, 64 kc and 92 kc fall into P1 allocations 3s LG, 1s HG and 3s HG, respectively, causing 2 kc tones in each of these P1 channels. The minimum carrier frequency system equal level coupling loss requirements for this tone for the three P1 allocations are shown in the following Table 13. A sample computation is contained in the attached Appendix N.

Table 13

Minimum Carrier Frequency System Equal Level Coupling Losses (in db) Required to Limit 2 kc Interferences in P1 Channels Due to ON1 Carriers, to Objective Values

<u>ON1 Carriers</u>	<u>P1 Allocations</u>		
	<u>3s LG</u>	<u>1s HG</u>	<u>3s HG</u>
44 kc	35		
64 kc		36	
92 kc			38

In addition to the above potential single frequency interferences in the P1 channels caused by the ON1 carriers, a 2 kc interference in P1 channel 2s HG potentially exists from a level control oscillator associated with the ON1 system. This oscillator, the frequency of which is 76 kc, is used to maintain a nominally constant repeater load in the ON1 system when it is equipped with four or less of the possible 5 four-channel groups. The following Table 14 depicts the level of this control oscillator relative to nonsloped ON1 carriers at the -28 db carrier level point, for various numbers of "working" groups. Also shown is the energy contained in this 76 kc tone at the line terminals for the conditions of various group "loads".

Table 14

	<u>ON1 Groups Equipped or Working</u>				
	<u>1</u>	<u>1,2</u>	<u>1,2,3</u>	<u>1,2,3,5</u>	<u>1,2,3,4,5</u>
Control oscillator, relative level at -28 db carrier point.	+10.5 db	+8.5 db	+7 db	+4 db	None
Energy in 76 kc cont. osc. tone at line terminals	+1.1 dbm	+ .9 dbm	-2.4 dbm	-5.4 dbm	None

The carrier frequency system equal level coupling losses required to limit the 2 kc interfering tone in P1 channel 2s HG (caused by the ON1 76 kc oscillator) to -74.5 dbm at the input to a 1 db P1 subscriber's loop are shown below in Table 15 for the various 76 kc energies at the line terminals of an ON1 system. A sample computation is contained in Appendix O.

Table 15

Minimum Carrier Frequency System Equal Level Coupling Losses (in db) Required to Limit 2 kc Interference in P1 Channel 2s HG, Due to ON1 Level Control Oscillator, to Objective Value

	<u>ON1 76 kc Level Control Oscillator Energies</u>			
	<u>+1.1 dbm</u>	<u>+ .9 dbm</u>	<u>-2.4 dbm</u>	<u>-5.4 dbm</u>
Required Coupling Losses	48	47	44	41

12. Type P1 and J Carrier Combinations

12.1 Interference in J Channels

From Fig. 3, it can be seen that attempted coordination of P1 with J carrier systems not only necessitates the use of grouped P1 channels, but that P1 channel 3n will probably not be usable since either the high or low group

transmission of this P1 channel will be oppositely directed to J West to East transmission. In addition, P1 channels 3s and 4n will be rendered nonusable, if an attempt is made to coordinate P1 usable high group allocations with J carrier West to East direction. If, on the other hand, P1 usable low group allocations are coordinated with the J carrier West to East direction, P1 allocation 4n HG will be in the same direction as J carrier East to West transmission, and probably would be usable at the expense of not using P1 channels 1n, 1s, 2n, 2s.

Only the staggered allocations of the P1 carrier system cause single frequency interference (by virtue of transmitted carrier) in J carrier West to East transmission, and all such interferences will appear as 2 kc tones in the various J allocations. The 96 kc P1 carrier (nonstaggered channel 4n HG) is the only P1 source of single frequency interference in J East to West transmission and causes 1 kc, 3 kc and 2 kc tones in J East to West JSA channel 1, JNB channel 1, and JSB channel 12, respectively.

The minimum carrier frequency system equal level coupling loss necessary to limit the 2 kc tones in the J channels to a value of -72.5 dbm at the input to a 3 db subscriber's loop is 50 db as computed in Appendix P. Similarly, the coupling loss requirements for the aforementioned 1 kc and 3 kc tones are about 50 and 44 db, respectively.

12.2 Interference in P1 Channels

The only source of single frequency interference in P1 channels from J carrier systems are from J-2 pilots at 40 kc, 80 kc and 92 kc, which pilot frequencies cause 2 kc tones in P1 staggered allocations 3s LG, 2s HG and 3s HG. These pilot frequencies are applied to the line with an energy of -3 dbm. The minimum carrier frequency system equal level coupling loss necessary to limit the 2 kc interferences in P1 channels to -74.5 dbm at the input to a 1 db P1 subscriber's voice frequency loop is 44 db as computed in Appendix Q.

2433-^{RC}-GM

R. CLARK

Attached:

Drawings ES-932139 (Fig. 1)
 ES-931932 (Fig. 2)
 ES-931933 (Fig. 3)

Appendices A through Q

SUMMARY OF COORDINATION POSSIBILITIES BETWEEN PI AND TOLL CARRIER SYSTEMS - CARRIER FREQUENCY SYSTEM EQUAL LEVEL COUPLING LOSSES APPLICABLE TO SINGLE FREQUENCY INTERFERENCES

PI CARRIER ALLOCATIONS ^①

TOLL CARR. SYS.	STACKABLE CHANNELS				NORMAL GROUPED CHANNELS				STAGGERED GROUPED CHANNELS		
	1	2	3	4	1n	2n	3n	4n	1s	2s	3s
	12 & 24 KC	36 & 48 KC	60 & 72 KC	84 & 96 KC	12 & 60 KC	24 & 72 KC	36 & 84 KC	48 & 96 KC	18 & 66 KC	30 & 78 KC	42 & 90 KC
C	54 DB	✓	✓	✓		54 DB	✓	✓		APPROX 48 DB	✓
H	29 DB	✓	✓	✓	29 DB	✓	✓	✓	✓	✓	✓
LENKURT 33A	52 DB		✓	✓	52 DB		52 DB	✓			✓
N	✓	②					②		65 DB	64 DB	63 DB ③
OA	53 DB		✓	✓				✓		53 DB	✓
OB	✓			✓			✓		53 DB	APPROX. 46 DB	53 DB
OC	✓	✓	✓		✓	✓			✓	APPROX. 46 DB	53 DB
OD	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ON	✓								61 DB	MAX 48 DB	
J	✓			50 DB					50 DB	50 DB	

LEGEND AND NOTES



INDICATES COMPATABILITY BY VIRTUE OF NO FREQUENCY OVERLAP



INDICATES THAT OPERATION OF PI CHANNEL WILL BE PRECLUDED BY VIRTUE OF OPPOSITE DIRECTION OF TRANSMISSION WITH RESPECT TO TOLL SYSTEM.



INDICATES THAT OPERATION OF PI CHANNEL WILL BE CONTROLLED BY CROSSTALK. THE REQUIRED COUPLING LOSSES WILL BE COMPUTED IN SUBSEQUENT MEMORANDUM.



COUPLING LOSSES SHOWN ARE THOSE REQUIRED TO LIMIT SINGLE FREQUENCY INTERFERENCES IN THE WORST CASE, EITHER IN THE TOLL TO PI SYSTEM PATH OR VICE VERSA.



WOULD PROBABLY BE NON-USABLE IF N CHANNEL 13 IS USED.

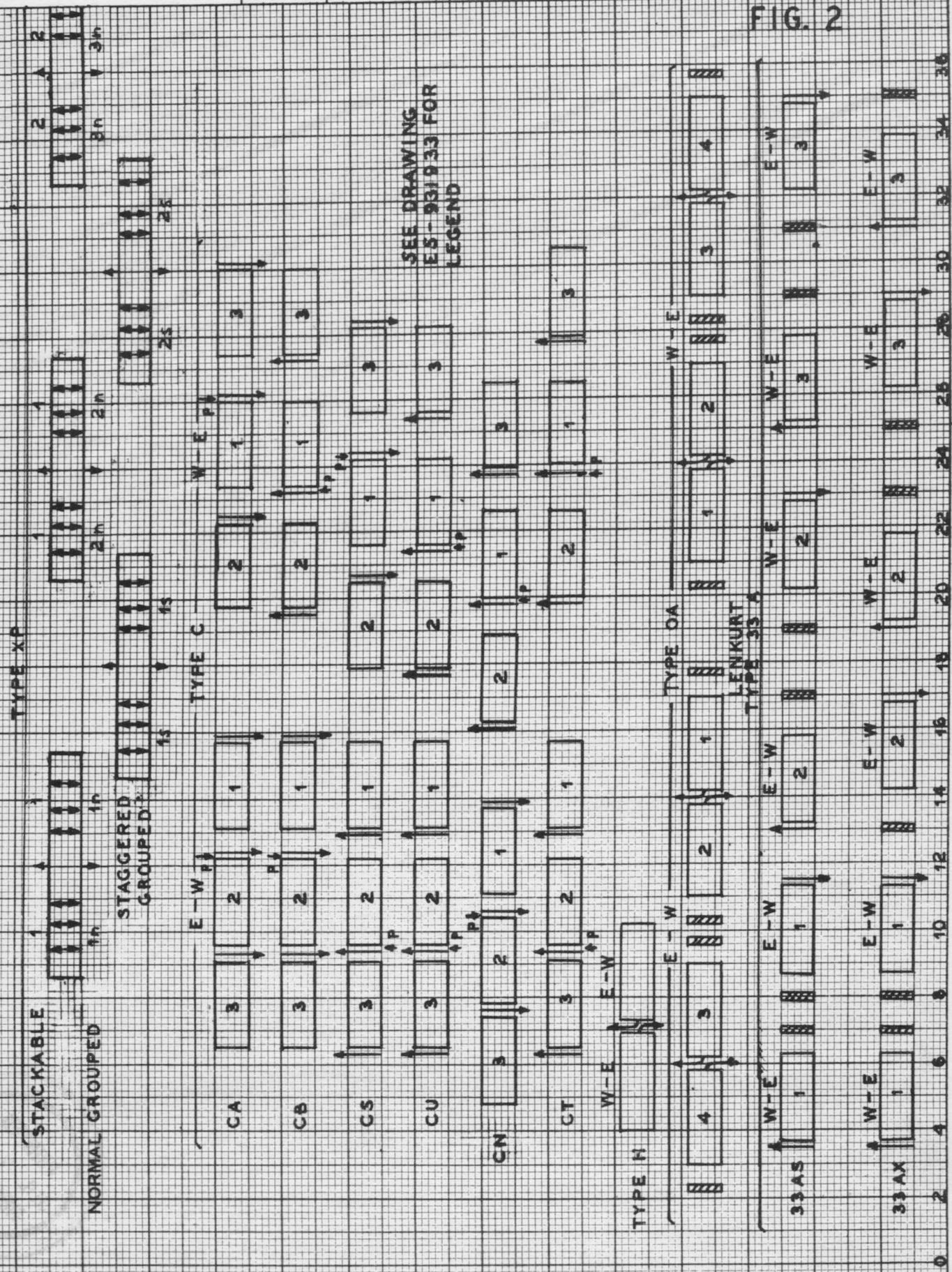


WOULD BE NON-USABLE IF N CHANNEL 13 IS USED OR IF N CHANNEL 12 IS RETAINED.

FIG. 1

FREQUENCY ALLOCATION CHART

FIG. 2



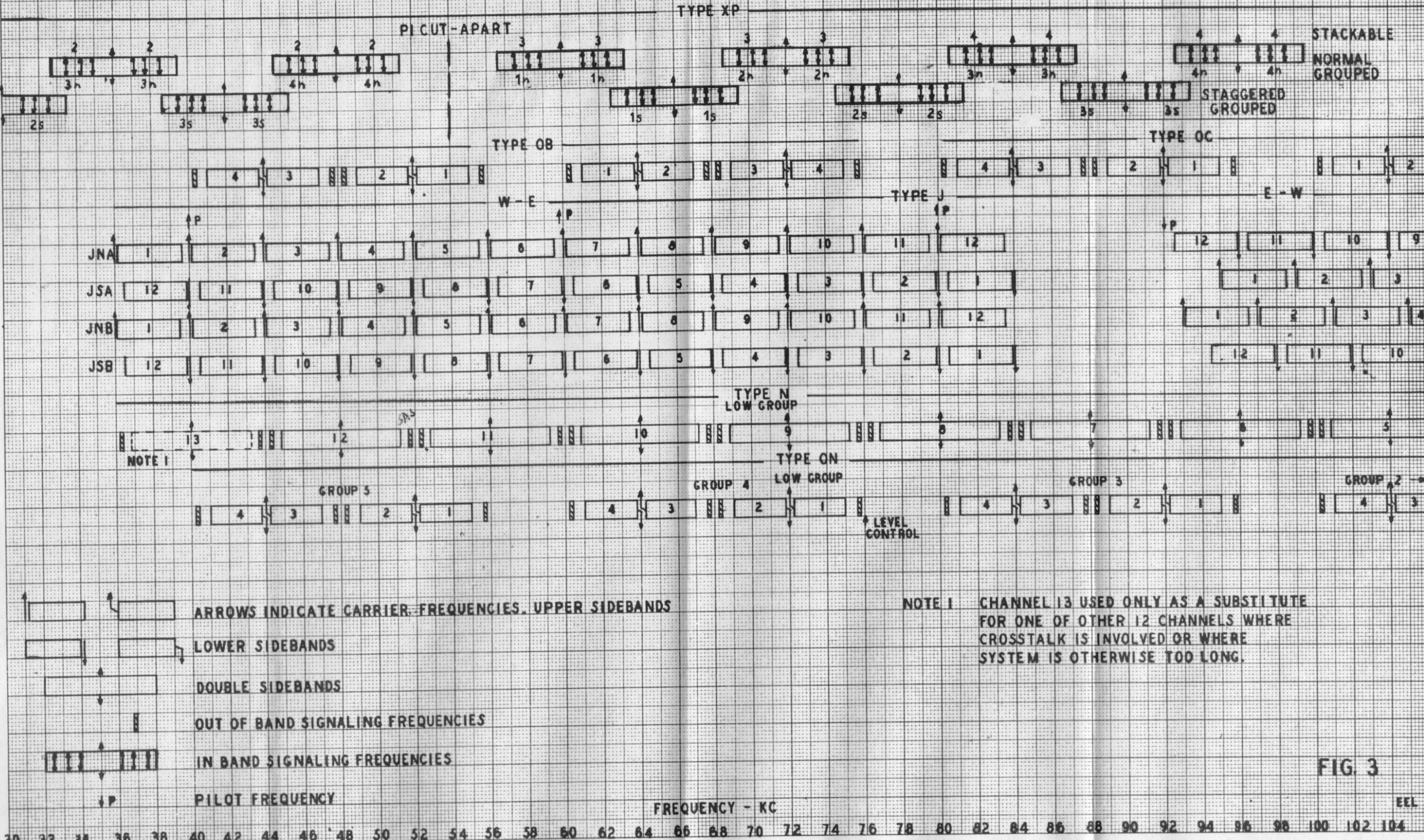
FREQUENCY - KC.

FREQUENCY ALLOCATION CHART

ES-931933

RC 6-4-54
5-24-55

MASSACHUSETTS. CODEX BOOK COMPANY, INC. PRINTED IN U.S.A.



NOTE 1 CHANNEL 13 USED ONLY AS A SUBSTITUTE FOR ONE OF OTHER 12 CHANNELS WHERE CROSSTALK IS INVOLVED OR WHERE SYSTEM IS OTHERWISE TOO LONG.

FIG. 3

EEL

8.02
K400
1.600

NO. 419. MILLIMETERS. 380 BY 250 DIVISIONS.

APPENDIX A

CHARACTERISTICS AND OBJECTIVES OF VARIOUS CARRIER SYSTEMS

Type Carrier	Sidebands (Double or Single)	Signaling Energy Transmitted To Line	Transmitted Carriers	Carrier Energy Transmitted To Line	Single Sideband Transmission Level Point at Line Terminals	Average Maximum Line Loss	Minimum Sideband Receiving Level	Carrier Circuit Equivalent	Assumed Static Noise Objective at Zero Level	Bandwidth (Cycles)	Expander Advantage
F1	Double	Each tone -11 dbm	Yes	Away from C.C. +4 dbm Toward C.C. +1 dbm ⁽⁴⁾	Away from C.C. -8 db Toward C.C. -11 db ⁽⁴⁾	30 db at 96 kc	-38 db on carrier line	4 db	32 dba	3400	26 db to 1 kc Tone
C	Single	Pilots at +8 dbm	No	-	+18 db	45 db at 27 kc	-27 db	6 db	32 dba	2800	Not Compandored ⁽¹⁾
N	Double	Low group -20 dbm to -27 dbm High group -18 dbm to -11 dbm	Yes	Low group -5 dbm to -12 dbm High group -3 dbm to +4 dbm	Low group -20 db to -27 db High group -18 db to -11 db	Low group 45 db High group 64 db	Low group -65 db High group -75 db	5 db	32 dba	3200	23 db
OA	Single	0 dbm	Yes	+6 dbm	0 db	40 db	-40 db	4 db	32 dba	3000	23 db
OB	Single	0 dbm	Yes	+6 dbm	0 db	50 db	-50 db	4 db	32 dba	3000	23 db
OC	Single	0 dbm	Yes	+6 dbm	0 db	50 db	-50 db	4 db	32 dba	3000	23 db
ON	Single	Low group -11 dbm to -18 dbm High group -9 dbm to -2 dbm	Yes	Nominally same as N above	Low group -11 db to -18 db High group -9 db to -2 db	Low group 45 db High group 64 db	Low group -56 db High group -66 db	5 db	32 dba	3000	23 db
J	Single	J-1 pilot at -10 dbm J-2 pilot at -3 dbm	No	-	+17 db	77 db	-60 db	6 db	38 dba ⁽³⁾	3500	Not Compandored ⁽¹⁾
Lenkurt 33AS 33AX	Single	+5 dbm	No	-	+10 db	35 db	-25 db	4 db	32 dba	2800	Not Compandored
H	Single	-	No	-	+16 db	31 db	-15 db	9 db ⁽²⁾	27 dba	2700	Not Compandored

(1) Type C and J systems may be compandored through the use of the 1A compandor. However, the costs of applying a 1A compandor are not generally justified.

(2) For line loss less than 31 db, circuit net loss improvements are realized.

(3) For 4000-mile five-link connection.

(4) Assumes carrier frequency termination at end of carrier line.

Appendix B

Sample Calculation of P1 Single Frequency Interference in "C" Carrier Systems Assuming Co-terminus Systems in Central Office

Consider 0.8 kc tone in CB channel 1 (W-E) caused by P1 carrier at 24 kc demodulating against CB channel 1 carrier at 23.2 kc.

METHOD A

68.5 dbm maximum allowable .8 kc tone at input to 3 db subscriber's loop from MM-49-2400-15

+ .5 db local office loss

-68.0 dbm maximum allowable .8 kc tone at input to local office

+ 2.0 db assumed toll connecting trunk loss

-66.0 dbm maximum allowable .8 kc tone at input to toll connecting trunk

+ 1.0 db assumed toll office loss

-65.0 dbm maximum allowable .8 kc tone at toll board

+ 6.0 db assumed C carrier equivalent

-59.0 dbm maximum allowable .8 kc tone at zero level in C circuit

+14.0 db level advantage of +4 dbm P1 carrier into +18 db level point of C circuit

-45.0 dbm

∴ Carrier frequency system equal level coupling loss required for 800 cycle interfering tone is 45 db by this method of calculation.

METHOD B

32 dba maximum allowable noise for C carrier at zero level from all normal noise sources

- 6 db

26 dba maximum allowable noise at zero level from a single unweighted source, i.e. 1 kc

This "rule of thumb" of limiting noise from a single source to a value equal to the objective noise minus 6 db can be shown reasonably valid by the fact that $26 \text{ dba} +_p 32 \text{ dba} = 32.98 \text{ dba}$ ¹ which means that 26 dba of single frequency noise, when added in power addition to a system noise of 32 dba, increases the total noise only by .98 dba.

Continuing with the computations:

Since for 1 kc, 0 dba = -85 dbm

+26 dba maximum allowable 1 kc noise at zero level in C system.

-85 db conversion to dbm

-59 dbm maximum allowable 1 kc noise at zero level in C system

+ 2 db TLU line weighting for .8 kc relative to 1 kc

-57 dbm maximum allowable .8 kc noise at zero level in C system

+14 db level advantage of +4 dbm P1 carrier into +18 db level point of C

-43 dbm

∴ Carrier frequency system equal level coupling loss required for the 800 cycle interfering tone is 43 db by this method of calculation.

¹The symbol $+_p$ is used to denote power addition (RSS).

Appendix C

Sample Calculation of Interference in C Carrier
Allocations Caused by Signaling Tones of
P1 Carrier System

The signaling frequencies to be employed in the P1 carrier system are 1150, 1750 and 2500 cps to select positive or negative bias, select tip or ring conductors, and ring subscriber, respectively. Positive or negative bias is selected by the presence or absence of the 1150~, and tip or ring is selected by the presence or absence of 1750~.

Consider all three signaling tones (1150, 1750 and 2500~) in a P1 upper sideband causing 2.75 kc, 2.15 kc and 1.40 kc tones respectively in a CA East-West channel 1 allocation.

32 dba average maximum allowable noise for C carrier system at zero level from all normal noise sources

- 6 db

26 dba maximum allowable noise at zero level from a single frequency unweighted source.

The TLU line weighting for the interfering tones of 2.75 kc, 2.15 kc and 1.40 kc are -9 db, -7 db, and -3 db, respectively, with reference to a 1 kc tone. For the condition of 100% modulation, the energy of each of three P1 signaling tones will be approximately -4 dbm at zero level, and the weighted power addition of the three tones is $-13 \text{ dbm} + -11 \text{ dbm} + -7 \text{ dbm} = -4.6 \text{ dbm}$.¹

Thus:

+26.0 dba maximum allowable 1 kc noise at zero level in C carrier system

-85.0 db conversion to dbm

-59.0 dbm allowable noise from all tones at zero level in C carrier system.

¹It is assumed the ear combines two or more simultaneous tones approximately on a power addition basis, and that each tone experiences a weighting, with reference to 1000 cycles, prior to this addition due primarily to the subset.

-(-)4.6 db weighting

-54.4 dbm allowable noise at zero level from all three tones.

+26.0 db level advantage of -8 db P1 sideband level and
 +18 db sideband level of C carrier system.

-28.4 dbm

.*. Required carrier frequency system equal level coupling loss is 28.4 db, say 28 db.

It is, however, to be realized that this method of computation is approximate inasmuch as only the fundamental tones have been considered, and the beat frequencies have been neglected. Although no subjective tests have been made to determine the interfering effects of 2 or 3 tones on the ear, it is thought that the magnitude of the beat frequencies in the audio range are appreciably below the magnitudes of the fundamental frequencies causing such beat frequencies.

Appendix D

Sample Calculations of C Carrier Pilot Frequency Interference in P1 Carrier Systems

Consider a 2.15 kc tone in the upper sideband of the P1 allocation associated with a 24 kc carrier, which tone is caused by the 26.15 kc pilot of the C carrier CA allocation.

-72.0 dbm maximum allowable 2.15 kc tone at input to a
3 db subscriber's loop from MM-49-2400-15

- 3.0 db subscriber's loop loss

-75.0 dbm maximum allowable 2.15 kc tone at subset terminals

+ 1.0 db assumed average P1 subscriber voice frequency
loop loss

-74.0 dbm maximum allowable 2.15 kc tone at input to 1 db
loop

+ 4.0 db assumed P1 carrier system equivalent

-70.0 dbm maximum allowable 2.15 kc tone at zero level
after expander in P1 channel

+26.0 db assumed P1 expander advantage

-44.0 dbm maximum allowable 2.15 kc tone at zero level
before expander

-10.0 db level disadvantage of +8 dbm C pilot source into
-8 db level point of a single sideband of P1, plus a
6 db advantage of P1 double sideband demodulation

-54.0 dbm

∴ Carrier frequency system equal level coupling loss
required for the 2.15 kc interfering tone is 54 db.

Appendix E

Derivation of P1 Expander Advantage to Single Frequency Tones

Time has not yet permitted securing sufficient data for the P1 syllabic compandor to establish firm compandor characteristics, but preliminary measurements indicate that the expander will be capable of inserting 1 db of loss for each db of input (below the 0 dbm no-compression point) at least down to inputs of -35 dbm. Although the point at which no further loss is inserted may be somewhat below this input power, -35 dbm is considered to be a safe figure for engineering purposes.

The following conditions are assumed as three different bases for the purpose of computing the P1 expander advantage to single frequency noise;

1. That an observer, utilizing P1 facilities via a remote P1 terminal, is connected to an average local talker within the central office area of the office serving the observer.
2. That an observer, utilizing P1 facilities via a remote P1 terminal, is listening to an average toll talker over a 3 link toll circuit connection of 13 db loss between the toll transmitting switchboard and the toll receiving switchboard, a receiving toll office loss of 1 db, a toll connecting trunk loss of 2 db, and a local office loss of .5 db.
3. That an observer, utilizing P1 facilities via a remote P1 terminal, is listening to a toll talker one sigma down from average volume, and that this toll talker is connected via the same circuits described in 2 above.

The expander advantage to noise and crosstalk of any expander is given by the empirical expression $X - \frac{X-Y}{3}$, in which X is the loss inserted by the expander during the nonspeech interval and Y is the loss inserted during the speech interval.

Simplified Approach

1. Average Local Talker Connection

The average local talker volume has been found to be -19 vu, on a distribution curve with a sigma of 5.9 vu, at the input to the local switchboard. Thus:

- 19.0 vu average local talker volume at input to local board
- 1.4 db conversion to dbm
- 20.4 dbm average local talker speech energy at input to local board
- .5 db local office loss
- 20.9 dbm average local talker speech energy at two-wire input to P1 carrier terminals which has been defined as the zero level point for the P1 carrier system.

Assuming compandor tracking, the average local talker speech energy at zero level after the P1 remote terminal expander is -20.9 dbm, and this energy will have experienced 10.4 db of loss through the expander. Further, the results of judgment tests of 25 observers as reported in MM-49-2400-15 indicate that the maximum single frequency interference which should be allowed at the input to a 3 db subscriber's loop is in the order of -72.5 dbm for frequencies in the 900-2600~ range. This corresponds to -75.5 dbm at the subset terminals, or -74.5 dbm at the input to a 1 db subscriber's loop. Assuming a 4 db P1 carrier equivalent, the permissible single frequency interference at zero level after the expander is -74.5 dbm + 4 db = -70.5 dbm. Thus, assuming that only single frequency noise is holding the expander open during the nonspeech interval;

Expander advantage =

$$35.2 \text{ db} - \frac{35.2 \text{ db} - 10.4 \text{ db}}{3} = \underline{26.9 \text{ db}}$$

and the signal to single frequency noise ratio =

$$-20.9 - (-70.5) = \underline{49.6 \text{ db}}$$

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The figure of 10.4 db used above assumes that only speech holds the expander open during the speech interval, whereas actually both the speech and single frequency noise hold the expander open during the speech interval. However, since the power addition of -10.4 dbm (speech energy at zero level before expander due to average local talker) and -35.2 dbm (single frequency energy at zero level before expander) is practically -10.4 dbm, no adjustment in the computation is necessary.

2. Average Toll Talker on 3 Link Connection

Consider now the case of the average (50%) toll talker whose volume at the toll transmitting board is -15 vu on a distribution curve with a sigma of 5.3 vu.

- 15.0 vu average toll talker volume at toll transmitting board (zero level of toll connection)
- 1.4 db conversion to dbm
- 16.4 dbm average toll talker speech energy at toll transmitting board (zero level of toll connection)
- 13.0 db assumed loss of 3 link toll connection
- 29.4 dbm average toll talker speech energy at receiving toll board
- 3.0 db receiving toll office loss plus toll connecting trunk loss
- 32.4 dbm average toll talker speech energy at input to local office
- .5 db local office loss
- 32.9 dbm average toll talker speech energy at two-wire input to P1 carrier terminals (zero level of P1 carrier system).

As before, the single frequency objective is -70.5 dbm at 1 kc at zero level after the expander, and, in this case, the talker would have experienced 16.4 db of loss through the expander. Thus, the expander advantage for the average toll talker on a 3 link toll connection, and assuming that only single frequency noise holds the expander open during the non-speech interval, is;

Expander advantage =

$$35.2 \text{ db} - \frac{35.2 \text{ db} - 16.4 \text{ db}}{3} = 28.9 \text{ db}$$

and the signal to single frequency noise ratio =
 $-32.9 - (-70.5) = 37.6 \text{ db}$

The figure of 16.4 db does not need correction since the power addition of -16.4 dbm and -35.2 dbm equals -16.3 dbm, which would have negligible effect on a corrected calculation of the above expander advantage.

3. Toll Talker One Sigma Down From Average on 3 Link Toll Connection

In this case, the 16% (one sigma down from average) toll talker volume at the toll transmitting switchboard would be -15 vu - 5.3 vu = -20.3 vu. Thus,

- 20.3 vu 16% toll talker volume at toll transmitting switchboard (zero level of toll connection)
- 1.4 db conversion to dbm
- 21.7 dbm 16% toll talker speech energy at toll transmitting switchboard
- 13.0 db assumed loss of 3 link toll connection
- 34.7 dbm 16% toll talker speech energy at receiving toll board
- 3.0 db receiving toll office loss plus toll connecting trunk loss
- 37.7 dbm 16% toll talker speech energy at input to local office
- .5 db local office loss
- 38.2 dbm 16% toll talker speech energy at two-wire input to P1 carrier terminals (zero level of P1 carrier system)

The expander advantage for this condition is;

$$\text{Expander advantage} = 35.2 \text{ db} - \frac{35.2 \text{ db} - 19.1 \text{ db}}{3} = 29.8 \text{ db}$$

and the signal to single frequency noise ratio is = -38.2 - (-70.5) = 32.3 db. Further, since the power addition of -19.1 dbm and -35.2 dbm = -19.0 dbm, there is no need to recompute the above expander advantage using -19.0 dbm in lieu of -19.1 dbm.

Rigorous Approach

All of the previous computations in this Appendix have assumed that the expander was held open during the non-speech interval only by the objective single frequency noise. In reality, however, the inherent carrier system noise will add to the single frequency noise, and the resultant energy will be applied to the expander, reducing the expander loss during the nonspeech interval. Therefore, if the single frequency noise is to be limited to -70.5 dbm at 1 kc at zero level after the expander, it is of interest to determine the maximum 1 kc tone that can be tolerated at zero level before the expander in the presence of a given amount of circuit noise, and to see how this affects the expander advantages previously computed.

Assume a single frequency input to the expander at zero level of $s/2$ dbm in the presence of $y/2$ dbm of continuous system noise. Then, the expander loss during the nonspeech interval is $-(s/2 +_p y/2)^*$ and the allowable 1 kc tone at zero level after expander is given by;

$$s/2 + s/2 +_p y/2 = -70.5 \text{ (dbm notations will be dropped for convenience)}$$

$$s/2 + s/2 + 0 +_p \frac{y-s}{2} = -70.5$$

$$s + 0 +_p \frac{y-s}{2} = -70.5$$

$$\therefore 0 +_p \frac{y-s}{2} = -s -70.5$$

For the purpose of this study, the P1 inherent steady system noise has been assumed as 18 dba during the nonstatic period** at zero level after the expander which is equivalent to $-82 + 18 = -64$ dbm = y .

 *The symbol $+_p$ is used to denote RSS (power) addition.

**The maximum noise which will occur during the static period (37 hours out of the static season) has been assumed as 32 dba at zero level.

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Remembering that all logs will be to the base 10, the above equation can be solved for s as follows;

$$0 + \frac{y-s}{2} = -s - 70.5$$

$$10 \log \left[10^{0/10} + 10^{(-64-s)/20} \right]$$

$$= -10 \log 10^{s/10} + 10 \log 10^{-70.5/10}$$

$$10 \log 10^{s/10} + 10 \log \left[10^{0/10} + 10^{(-64-s)/20} \right]$$

$$= 10 \log 10^{-70.5/10}$$

$$10 \log \left[(10^{s/10}) (10^{0/10}) + (10^{2s/20}) (10^{(-64-s)/20}) \right]$$

$$= 10 \log 10^{-70.5/10}$$

$$10 \log \left[10^{s/10} + 10^{(s-64)/20} \right]$$

$$= 10 \log 10^{-70.5/10}$$

This becomes:

$10^{2s/20} + (10^{-64/20}) (10^{s/20}) - 10^{-70.5/10} = 0$, and is therefore in the form of the general quadratic equation $AX^2 + BX + C = 0$, from which

$$X = 10^{s/20} = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A} \text{ where } A = 1, B = 10^{-64/20} \text{ and } C = -10^{-70.5/10}.$$

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Therefore, solving for X, or $10^{s/20}$;

$$X = 10^{s/20} = \frac{-10^{-64/20} \pm \sqrt{10^{-64/10} + 4(10^{-70.5/10})}}{2}$$

$$10^{s/20} = \frac{-\frac{1}{10^{3.2}} \pm \sqrt{\frac{1}{10^{6.4}} + \frac{4}{10^{7.05}}}}{2}$$

$$10^{s/20} = \frac{-\frac{.632}{10^3} \pm \sqrt{\frac{3.98}{10^7} + \frac{3.57}{10^7}}}{2}$$

$$10^{s/20} = \frac{-\frac{.632}{10^3} \pm \frac{.868}{10^3}}{2}$$

In the solution of this equation, only the plus sign of the \pm has any meaning, and therefore

$$10^{s/20} = \frac{+\frac{.236}{10^3}}{2} = \frac{1.18}{10^4}$$

or since this is in the form of $b^x = N$, from which $\log_b N = X$ by definition, then

$$\log \frac{1.18}{10^4} = \frac{s}{20}$$

$$\text{or } \frac{s}{20} = -\log \frac{10^4}{1.18} = -3.928$$

Thus $s = -78.5$ dbm
 and $s/2 = -39.2$ dbm, which is the allowable 1 kc noise at zero level ahead of the expander, in the presence of -32 dbm of system noise at the same point, in order to realize 1 kc noise from a single source not greater than -70.5 dbm at zero level after the expander.

As a check on the above solution;

$$s/2 + s/2 + \underset{p}{y/2} = -70.5 \text{ (from start of problem),}$$

$$\text{substituting } s/2 = -39.2 \text{ dbm and } y/2 = -32 \text{ dbm}$$

$$-39.2 \text{ dbm} + (-39.2 \text{ dbm} + \underset{p}{-32.0 \text{ dbm}})$$

$$\text{or } -39.2 \text{ dbm} - 31.2 \text{ dbm} \hat{=} -70.4 \text{ dbm} = -70.5 \text{ dbm.}$$

With an input to the expander at zero level of -39.2 dbm of single frequency noise and -32.0 dbm of continuous system noise, the loss inserted by the expander during the non-speech interval is equal to the power addition of these two input powers, or 31.2 db. This, then, is the loss of the expander which more correctly should be used than the figure of 35.2 db used in the simplified approach.

It should now be of interest to recompute the expander advantage to 1 kc noise for each of the three talker volumes and connections previously described.

1. Average Local Talker

The expander advantage to 1 kc noise for the average local talker now becomes;

$$\text{Expander advantage} = 31.2 \text{ db} - \frac{31.2 \text{ db} - 10.4 \text{ db}}{3} = \underline{24.3} \text{ db.}$$

The total noise at zero level after the expander is now
 $= -64 \text{ dbm} + \underset{p}{-70.5 \text{ dbm}} = -63.1 \text{ dbm.}$ The signal to noise ratio
 for the average local talker $= -20.9 - (-63.1) = \underline{42.2} \text{ db.}$

The total power at zero level actually holding the expander open during the speech interval is $-10.4 \text{ dbm} + \underset{p}{-31.2} \text{ dbm}$, which is practically equal to -10.4 dbm, and therefore there is no need to correct the expander advantage figure of 24.3 db.

2. Average Toll Talker on 3 Link Toll Connection

The expander advantage to 1 kc noise for the average toll talker on the 3 link toll connection, previously described, is;

$$\text{Expander advantage} = 31.2 \text{ db} - \frac{31.2 \text{ db} - 16.4 \text{ db}}{3} = \underline{26.3} \text{ db}$$

and the signal to noise ratio is $-32.9 - (-63.1) = \underline{30.2} \text{ db}$.

The total power at zero level actually holding the expander open is $-16.4 \text{ dbm} + \underset{p}{-31.2 \text{ dbm}}$, which is practically equal to -16.4 dbm , and therefore there is no need to correct the expander advantage figure of 26.3 db.

3. Toll Talker One Sigma Down From Average (16% Talker) on 3 Link Toll Connection

The expander advantage to a 1 kc noise for the toll talker one sigma down from an average volume ($-15 \text{ vu} - 5.3 \text{ vu}$) on the 3 link toll connection is;

$$\text{Expander advantage} = 31.2 \text{ db} - \frac{31.2 \text{ db} - 19.1 \text{ db}}{3} = \underline{27.2} \text{ db}$$

and the signal to noise ratio is $-38.2 - (-63.1) = \underline{24.9} \text{ db}$.

In this case, however, the total power at zero level ahead of the expander, which will hold the expander open during the speech interval is $-19.1 \text{ dbm} + \underset{p}{-31.2 \text{ dbm}} = -18.8 \text{ dbm}$. Thus, the corrected expander advantage is;

$$31.2 \text{ db} - \frac{31.2 \text{ db} - 18.8 \text{ db}}{3} = \underline{27.1} \text{ db}.$$

Table 1 below summarizes the computations made in this Appendix E for comparison purposes.

Table 1

	<u>Talker Energy At Zero Level After Expander</u>	<u>Simplified Method Expander Advantage</u>	<u>Signal to Noise Ratio</u>	<u>Rigorous Expander Advantage</u>	<u>Method Signal to Noise Ratio</u>
1. Average Local Talker	-20.9 dbm	26.9 db	49.6 db	24.3 db	42.2 db
2. Average Toll Talker on 3 Link Toll Conn.	-32.9 dbm	28.9 db	37.6 db	26.3 db	30.2 db
3. 16% Quiet Toll Talker on 3 Link Toll Conn.	-38.2 dbm	29.8 db	32.3 db	27.1 db	24.9 db

It is seen, therefore, that the expander advantage increases with decrease in talker volume (as is to be expected) but at a much reduced rate, and, further, that as the expander advantage increases, the signal to noise ratios decrease, also at different rates. In reality, any of the signal to noise ratios indicated in Table 1 are quite within the realms of providing acceptable circuits. For other computations in this single frequency study, it would greatly simplify matters if one expander advantage figure were used for all conditions. It therefore appears that using an expander advantage of 26 db (for single frequency noise) is reasonable. This has the effect of increasing the signal to noise ratios for the weaker talkers, and is thus not objectionable, as well as the effect of decreasing the signal to noise ratios of the louder talkers who can apparently very easily tolerate a few db reduction.

It is realized that this expander advantage figure of 26 db may not be appropriate for speech crosstalk. The expander advantage will again be derived, therefore, when the problems of sideband interferences between the P1 system and toll carrier systems are studied.

Appendix F

Calculations of P1 Single Frequency Interferences in Type H Systems

The 2.5 kc signaling tone in the lower sideband of the 12 kc P1 channel causes a 2.35 kc tone in Type H East to West transmission. Thus,

27 dba assumed average maximum allowable noise for H carrier at zero level from all normal noise sources

- 6 db

21 dba maximum allowable noise at zero level from a single unweighted source.

The TLU line weighting for the 2.35 kc interfering tone is -7 db. As noted in previous Appendices, the energy in the P1 signaling tones will be about -4 dbm at zero level. Thus the weighted power of the interfering tone is -4 dbm -7 db = -11 dbm.

+21 dba maximum allowable noise at zero level in H carrier system from a single unweighted source.

-85 db conversion to dbm

-64 dbm maximum allowable unweighted noise at zero level in H carrier.

-(-)11 db weighting

-53 dbm maximum allowable weighted noise at zero level in H carrier system from 2.35 kc tone.

+24 db level advantage of -8 db P1 sideband level and +16 db sideband level of H carrier system

-29 dbm

∴ Carrier frequency system equal level coupling loss required is 29 db.

Appendix G

Sample Calculation of Interference in Lenkurt Type 33 Carrier Allocations Caused by Signaling Tones of P1 Carrier System

Consider all three signaling tones (1.15, 1.75 and 2.5 kc) of P1 12 kc channel lower sideband causing .65 kc, 1.25 kc and 2.0 kc interfering tones, respectively, in a Lenkurt 33AS East to West Channel 1.

32 dba assumed average maximum allowable noise for Lenkurt 33A carrier system at zero level from all normal noise sources.

- 6 db

26 dba maximum allowable noise at zero level from a single unweighted source.

The TLU line weightings for the interfering tones of .65 kc, 1.75 kc and 2.0 kc are -4 db, -1 db and -7 db with reference to 1 kc. For the condition of 100% modulation, the energy of each of three P1 signaling tones will be approximately -4 dbm at zero level, and the weighted power addition of the three tones is $-8 \text{ dbm} + -5 \text{ dbm} + -11 \text{ dbm} = -2.6 \text{ dbm}$. Thus,

+26.0 dba maximum allowable noise at zero level in Lenkurt 33A carrier system from a single source.

-85.0 db conversion to dbm

-59.0 dbm maximum allowable unweighted noise due to three tones at zero level in Lenkurt system.

-(-)2.6 db weighting

-56.4 dbm maximum allowable weighted noise at zero level in Lenkurt 33A system from all three tones.

+18.0 db level advantage of -8 db P1 sideband level and +10 db sideband level of Lenkurt 33A systems.

-38.4 dbm

∴ Carrier frequency system equal level coupling loss required is 38.4 db, say 38 db.

Appendix H

Calculation of Lenkurt Type 33AX Single Frequency Interferences in P1 Carrier Systems

The 4 kc signaling tones of Lenkurt 33AX channels 1-W, channel 2W-E, channel 3W-E, and channel 3E-W cause 1 kc tones in the P1 channels associated with 12 kc, 24 kc, and 36 kc carriers.

-72.5 dbm maximum allowable 1 kc tone at input to 3 db subscriber's loop from MM-49-2400-15

- 3.0 db subscriber's loop loss

-75.5 dbm maximum allowable 1 kc tone at subset terminals

+ 1.0 db assumed average P1 subscriber voice frequency loop loss.

-74.5 dbm maximum allowable 1 kc input to 1 db loop

+ 4.0 db assumed P1 carrier equivalent

-70.5 dbm maximum allowable 1 kc tone at zero level after P1 expander

+26.0 db assumed P1 expander advantage to single frequency noise

-44.5 dbm maximum allowable 1 kc tone at zero level before expander

- 7.0 db level disadvantage of +5 dbm Lenkurt 33A signaling source into -8 db level point of P1, plus 6 db advantage of P1 double-sideband demodulation

-51.5 dbm

∴ Carrier frequency system equal level coupling loss required is 51.5 db, say 52 db.

Appendix I

Sample Calculation of P1 Single Frequency Interference in N Carrier Systems

Consider 2 kc tone in N channel 10 upper-sideband caused by P1 carrier at 66 kc demodulating against the N carrier at 64 kc.

-72.5 dbm maximum allowable 2 kc tone at input to 3 db subscriber's loop from MM-49-2400-15

+ .5 db local office loss

-72.0 dbm maximum allowable 2 kc tone at input to local board

+ 2.0 db assumed toll connecting trunk loss

-70.0 dbm maximum allowable 2 kc tone at input to toll connecting trunk.

+ 1.0 db assumed toll office loss

-69.0 dbm maximum allowable 2 kc tone at input to toll board

+ 5.0 db assumed N carrier system equivalent

-64.0 dbm maximum allowable 2 kc tone at zero level after N expander

+23.0 db assumed N carrier expander advantage

-41.0 dbm maximum allowable 2 kc tone at zero level before N expander

-23.7 db level disadvantage of +4 dbm P1 carrier into N channel at -25.7 db level point, plus a 6 db advantage of N double-sideband demodulation.

-64.7 dbm

∴ Carrier frequency system equal level coupling loss required for the 2 kc tone is 64.7 db, say 65 db.

Appendix J

Sample Calculation of N Carrier Single Frequency Interference in P1 Carrier Systems

Consider 2 kc tone which is in the lower sideband of the P1 channel associated with a 66 kc carrier and which is caused by an N carrier at 64 kc.

-72.5 dbm maximum allowable 2 kc tone at input to a 3 db subscriber's loop from MM-49-2400-15

- 3.0 db subscriber's loop loss

-75.5 dbm maximum allowable 2 kc tone at subset terminals

+ 1.0 db assumed average P1 subscriber voice frequency loop loss.

-74.5 dbm maximum allowable 2 kc tone at input to 1 db loop

+ 4.0 db assumed P1 carrier system equivalent

-70.5 dbm maximum allowable 2 kc tone at zero level after P1 expander

+26.0 db assumed P1 expander advantage

-44.5 dbm maximum allowable 2 kc tone at zero level before expander

+ 8.7 db level advantage of -10.7 dbm 64 kc N carrier into P1 channel at -8 db level point, plus a 6 db advantage of P1 double-sideband demodulation

-35.8 dbm

∴ Carrier frequency system equal level coupling loss required for the 2 kc interfering tone is 35.8 db, say 36 db.

Appendix K

Calculation of P1 Carrier Single Frequency Interference in OA Carrier System

Consider 2 kc tone in OA carrier channel 2, East to West, which is caused by P1 carrier at 12 kc.

-72.5 dbm maximum allowable 2 kc tone at input to a 3 db subscriber's loop from MM-49-2400-15

+ .5 db local office loss

-72.0 dbm maximum allowable 2 kc tone at input to local board

+ 2.0 db assumed toll connecting trunk loss

-70.0 dbm maximum allowable 2 kc tone at input to toll connecting trunk

+ 1.0 db assumed toll office loss.

-69.0 dbm maximum allowable 2 kc tone at input to toll board

+ 4.0 db assumed 0 carrier equivalent

-65.0 dbm maximum allowable 2 kc tone at zero level after OA expander

+23.0 db assumed OA carrier expander advantage

-42.0 dbm maximum allowable 2 kc tone at zero level before OA expander

- 4.0 db level disadvantage of +4 dbm P1 carrier into zero level point of OA carrier system

-46.0 dbm

∴ Carrier frequency system equal level coupling loss required for 2 kc tone is 46 db.

Appendix L

Calculation of OA Carrier Single Frequency Interference in P1 Carrier System

Consider 2 kc tone in upper-sideband of channel associated with P1 12 kc carrier caused by OA carrier at 14 kc.

-72.5 dbm maximum allowable 2 kc tone at input to 3 db subscriber's loop from MM-49-2400-15

- 3.0 db subscriber's loop loss

-75.5 dbm maximum allowable 2 kc tone at subset terminals

+ 1.0 db assumed average P1 subscriber voice frequency loop loss

-74.5 dbm maximum allowable 2 kc input to 1 db loop.

+ 4.0 db assumed P1 carrier equivalent

-70.5 dbm maximum allowable 2 kc tone at zero level after P1 expander

+26.0 db assumed P1 expander advantage to single frequency noise

-44.5 dbm maximum allowable 2 kc tone at zero level before P1 expander

- 8.0 db level disadvantage of +6 dbm OA carrier into -8 db level point of P1, plus 6 db advantage of P1 double-sideband demodulation

-52.5 dbm

∴ Carrier frequency system equal level coupling loss required for the 2 kc tone is 52.5 db, say 53 db.

Appendix M

Sample Calculation of P1 Single Frequency Interference in ON1 Carrier Systems

Consider 2 kc tone in ON1 Group 5 (Channel 4) caused by P1 carrier at 42 kc.

-72.5 dbm maximum allowable 2 kc tone at input to 3 db subscriber's loop from MM-49-2400-15

+ .5 db local office loss

-72.0 dbm maximum allowable 2 kc tone at input to local board.

+ 2.0 db assumed toll connecting trunk loss

-70.0 dbm maximum allowable 2 kc tone at input to toll connecting trunk

+ 1.0 db assumed toll office loss

-69.0 dbm maximum allowable 2 kc tone at input to toll board

+ 5.0 db assumed over-all carrier equivalent

-64.0 dbm maximum allowable 2 kc tone at zero level after 0 carrier expander

+23.0 db assumed 0 carrier expander advantage

-41.0 dbm maximum allowable 2 kc tone at zero level before 0 carrier expander

-22.0 db level disadvantage of +4 dbm P1 carrier into ON1 channel at -18 db point.

-63.0 dbm

∴ Carrier frequency system equal level coupling loss required is 63 db.

Appendix N

Sample Calculation of ON1 Carrier Single-Frequency Interference in P1 Channel Allocations

Consider 2 kc tone in P1 channel 3s LG caused by ON1 carrier at 44 kc.

-72.5 dbm maximum allowable 2 kc tone at input to
3 db subscriber's loop from MM-49-2400-15

- 3.0 db subscriber's loop loss

-75.5 dbm maximum allowable 2 kc tone at subset terminals

+ 1.0 db assumed average P1 subscriber voice frequency
loop loss

-74.5 dbm maximum allowable 2 kc input to 1 db voice
frequency loop

+ 4.0 db assumed P1 carrier equivalent

-70.5 dbm maximum allowable 2 kc tone at zero level
after P1 expander

+26.0 db assumed P1 expander advantage

-44.5 dbm maximum allowable 2 kc tone at zero level
before P1 expander

+10.0 db level advantage of -12 dbm ON1 carrier into
P1 channel at -8 db point, plus a 6 db
advantage of P1 double-sideband demodulation.

-34.5 dbm

∴ Carrier frequency system equal level coupling loss
required for the 2 kc tone is 34.5 db, say 35 db.

Appendix 0

Sample Calculation of ONI 76 kc Level
Control Oscillator Interference in P1 Channel 2s HG

-72.5 dbm maximum allowable 2 kc tone input to 3 db
subscriber's loop from MM-49-2400-15

- 3.0 db subscriber's loop loss

-75.5 dbm maximum allowable 2 kc tone at subset
terminals

+ 1.0 db assumed average P1 subscriber voice frequency
loop loss

-74.5 dbm maximum allowable 2 kc tone at input to 1 db
loop

+ 4.0 db assumed P1 carrier equivalent

-70.5 dbm maximum allowable 2 kc tone at zero level
after P1 expander

+26.0 db assumed P1 expander advantage

-44.5 dbm maximum allowable 2 kc tone at zero level
before P1 expander

- 3.1 db level disadvantage of +1.1 dbm 76 kc source
into P1 channel at -8 db point, plus a 6 db
advantage of P1 double-sideband demodulation

-47.6 dbm

∴ Carrier frequency system equal level coupling loss
required is 47.6 db, say 48 db.

Appendix P

Sample Calculation of P1 Single frequency Interferences in J Carrier Systems

Consider 2 kc tone in J channels caused by transmitted carriers of P1 system.

-72.5 dbm maximum allowable 2 kc tone at input to 3 db subscriber's loop from MM-49-2400-15

+ .5 db assumed local office loss

-72.0 dbm maximum allowable 2 kc tone at input to local board

+ 2.0 db assumed toll connecting trunk loss

-70.0 dbm maximum allowable 2 kc tone at input to toll connecting trunk

+ 1.0 db assumed toll office loss

-69.0 dbm maximum allowable 2 kc tone at input to toll board

+ 6.0 db assumed J carrier circuit equivalent

-63.0 dbm maximum allowable 2 kc tone at zero level in J system

+13.0 db level advantage of +4 dbm P1 carrier into J channel at +17 db point

-50.0 dbm

∴ Carrier frequency system equal level coupling loss required is 50 db.

Appendix Q

Calculation of J Carrier Single Frequency Interferences in Pl Carrier System

Consider 2 kc tone in Pl channels 3s LG, 2s HG and 3s HG caused by J-2 pilots at 40 kc, 80 kc and 92 kc, respectively.

-72.5 dbm maximum allowable 2 kc tone input to 3 db subscriber's loop from MM-49-2400-15

- 3.0 db subscriber's loop loss

-75.5 dbm maximum allowable 2 kc tone at subset terminals

+ 1.0 db assumed average Pl subscriber voice frequency loop loss

-74.5 dbm maximum allowable 2 kc tone at input to 1 db loop

+ 4.0 db assumed Pl carrier equivalent

-70.5 dbm maximum allowable 2 kc tone at zero level after Pl expander

+26.0 db assumed Pl expander advantage

-44.5 dbm maximum allowable 2 kc tone at zero level before Pl expander

+ 1.0 db level disadvantage of -3 dbm J-2 pilot into Pl channel at -8 db point, plus a 6 db advantage of Pl double-sideband demodulation

-43.5 dbm

∴ Carrier frequency system equal level coupling loss required is 43.5 db, say 44 db.