TYPE N AND ON CARRIER REPEATERS — REPEATERED HIGH-FREQUENCY LINE GENERAL INFORMATION — METHOD OF COMPUTING CARRIER SLOPE

This section is reissued to add slope computation values and to make minor corrections. ←

Slope equalization is accomplished by frequency inversion at each repeater and allows one section to effectively compensate for the slope introduced in the previous section. Slope equalizers are provided in each repeater and group receive unit to correct for the accumulated deviation along the line. These equalizers are under the manual control of the SLOPE switch, mounted on the front of the unit, and are adjustable in three steps designated A, B and C.

This section gives the step-by-step procedure to be followed in determining the slope and in plotting the computed slope line of all N, ON1 and ON2 carrier systems. All values for the most common system arrangements are included. Procedures are included for determining the values for less common system arrangements.

In order to obtain consistent results, the method of least squares will generally be used for slope computation. A plot of the carrier levels should also be made as an aid in detecting equipment or line irregularities.

In cases where the slope plot indicates a relatively smooth line, the graphic method of determining slope may be used. However, this method should not be used when the plotted line indicates bulge or other deviations.

Form E-4558-4 is used for determining and plotting slope on ON1 systems. Form E-4558-6 is used for determining and plotting slope on N and ON2 systems. (Form E-4558-6 replaces Forms E-4558-1, -2, -3 and -5.) Forms E-4558-1, E-4558-2 and E-4558-3, in stock, may still be used for determining and plotting slope on N systems. Use the procedures outlined in this section and the values given on the forms. Form E-4558-5, in stock, may still be used for determining and plotting slope on ON2 systems. Use the procedures and values outlined in this section.

STEP	PROCEDURE
	(A) Preparation (See Fig. 3)
	When Form E-4558-6 is used, the required factors for most situations are printed on the back of the form. The values for columns (a) and (b) are arranged so that the back page can be folded and placed over the front of another page for this portion of the computation.
1	In Block 1 of the form being used, enter the required values in columns (a) and (b). (Or use the method described above.) See Figs. 1 and 5 for ON1 or Figs. 2, 3 and 4 for N & ON2.
2	In Blocks 2, 3 and 4 enter the K, M and N values.
3	In Block 1 of the form, record the channel carrier output readings of each carrier in column (c), if positive, and in column (d), if negative.

STEP	PROCEDURE
4	Determine the scale to use in Block 5. Cross off the unused scales. (If necessary fill in the scale on the left hand side as required.)
5	Plot the measured values of the channel carrier outputs [columns (c) and (d)] in the graph section of Block 5.
6	Determine the slope using Part (B) or (C) as required.
	(B) Computation Using the Method of Least Squares (See samples in Figs. 4, 5 & 6)
1	Multiply the readings of column (c) or (d) by column (a) or (b), as indicated, and record in column (e) or (f).
2	Total the figures of columns (c), (d), (e) and (f).
3	Determine the difference between the totals in columns (c) and (d) and retain the sign of the larger — call this difference (g).
4	Determine the difference between the totals in columns (e) and (f) and retain the sign of the larger — call this difference (h).
5	Enter in Block 2, in the space provided, the value and sign of (h) as determined in Step 4, and divide by the constant (K) shown. This determines the output slope (S) of the individual carriers and should generally be positive for a high group output and negative for a low group output. The design slope requirement is obtained from the circuit layout card.
6	Enter in Block 3, in the space provided, the value and sign of (g) as determined in Step 3 and divide by the constant (M) shown. This determines the value of the Y intercept Y_0.
7	Enter in Block 4, the value and sign of the slope (S) as determined in Block 2, and multiply by the constant (N) shown. The result retains the same sign as the slope (S). To this, add algebraically the value of Y_0 determined in Block 3. This is done as follows: If both the product NS and Y_0 have the same sign, add directly and use the same sign for Y_{12}. If NS and Y_0 have different signs, subtract the smaller from the larger and use the sign of the larger for Y_{12}.
8	Determine the location of the Y_0 line from the back of the form. Draw this line in Block 5.
9	On the Y_0 line plot the value determined in Block 3; and on the Y_{12} line plot the value determined in Block 4. Draw a straight line through these two points extending from the first to last carrier. This line represents the computed slope as determined by the method of least squares.

STEP	PROCEDURE
	(C) Computation Using the Graphic Method (To be used *only* when the plotted slope line in Block 5 is nearly straight). (See sample in Fig. 7)
1	Draw a straight line connecting the highest peaks of the slope plot and extend the line to the ends of the graph. Call this line A-B.
2	Draw a straight line connecting the lowest valleys of the slope plot and extend the line to the ends of the graph. Call this line C-D. ***Note:*** If these two lines are not nearly parallel, the method of least squares should be used to determine the slope.
3	Draw a straight line connecting a point midway between A and C to a point midway between B and D. Call this line S-S. This line is the optimum slope line.
4	The slope value is the difference in level on line S-S at channels 1 and 12 (or channels 2 and 13).
	(D) Determining Values for Form E-4558-4 and -6 (See examples in Fig. 8) (Required only when values are not given in Fig. 1 or 2)
1	The value of ***M*** to be inserted in Block 3 is the same as the total number of channels (or carrier) used, including the level control oscillator (LCO) if used.
2	Determine the weighting values (W) for columns ***(a)*** and ***(b)*** in Block 1 as follows: (a) Using Table A, determine and list the X value for each carrier used. (b) Add all X values and divide by M (total carriers). This gives the average X value (X_{av}). (c) Take the difference between each X value and the average X value. If the average X value is larger the difference goes in column (a); if the X value is larger, the difference goes in column (b). $X_{av} - X = W$, column (a); $X - X_{av} = W$, column (b).
3	To determine the value of ***K*** for Block 2; square each value obtained in Step 2(c), add these and divide by 22. K = sum of all $W^2 \div 22$. (Use Table B for numbers squared.)
4	To determine the value ***N;*** subtract the X_{av} value from 23 (for the basic N arrangement of channels 1-12), from 24 (for ON1) or from 25 (for ON2 and the basic N arrangement of channels 2-13), and divide the difference by 22. $N = X_{12}$ (or X_{10} or X_{13}) $- X_{av} \div 22$.
5	To determine the position of the Y_0 line, using Table A, determine the carrier number corresponding to the X_{av} value.

TABLE A

X VALUE	N CHANNEL	ON1 CARRIER	ON1 GROUP	ON2 CARRIER	ON2 GROUP	X VALUE
1	1					1
2		1				2
3	2		1	1		3
4		2			1	4
5	3			2		5
6						6
7	4	3		3		7
8			2		2	8
9	5	4		4		9
10						10
11	6			5		11
12		5			3	12
13	7		3	6		13
14		6				14
15	8			7		15
16		LCO		LCO	4	16
17	9	7		8		17
18			4			18
19	10	8		9		19
20					5	20
21	11			10		21
22		9				22
23	12		5	11		23
24		10			6	24
25	13			12		25

TABLE B

Table of Numbers Squared

	.0	.1	.2	.3	.4	.5	.6*	.7	.8	.9	
0	0.0	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.8	0
1	1.0	1.2	1.4	1.7	2.0	2.3	2.6	2.9	3.2	3.6	1
2	4.0	4.4	4.8	5.3	5.8	6.3	6.8	7.3	7.8	8.4	2
3	9.0	9.6	10.2	10.9	11.6	12.3	13.0	13.7	14.4	15.2	3
4	16.0	16.8	17.6	18.5	19.3	20.3	21.2	22.1	23.4	24.0	4
5	25.0	26.0	27.0	28.1	29.2	30.3	31.4	32.5	33.6	34.8	5
6	36.0	37.2	38.4	39.7	41.0	42.3	43.6	44.9	46.2	47.6	6
7	49.0	50.4	51.8	53.3	54.8	56.3	57.8	59.3	60.8	62.4	7
*8	64.0	65.6	67.2	68.9	70.6	72.3	74.0	75.7	77.4	79.2	8
9	81.0	82.8	84.6	86.5	88.4	90.3	92.2	94.1	96.0	98.0	9
10	100.0	102.0	104.0	106.1	108.1	110.3	112.4	114.5	116.6	118.8	10
11	121.0	123.2	125.4	127.7	130.0	132.3	134.6	136.9	139.2	141.6	11
12	144.0	146.4	148.8	151.3	153.8	156.3	158.8	161.3	163.8	166.4	12

* Sample: 8.6 squared = 74.0

ON 1 CARRIER
ENTRIES FOR FORM E-4558-4

ON 1

GROUPS EQUIPPED																							
1-5			1, 2, 3, 5 LCO			1,2,3,4			1, 2, 3 LCO			1, 2 LCO			1 LCO								
CHAN. OR CARR. NO.	MULTIPLY BY		CHAN. OR CARR. NO.	MULTIPLY BY		CHAN. OR CARR. NO.	MULTIPLY BY		CHAN. OR CARR. NO.	MULTIPLY BY		CHAN. OR CARR. NO.	MULTIPLY BY		CHAN. OR CARR. NO.	MULTIPLY BY							
	– (a)	+ (b)		– (a)	+ (b)		– (a)	+ (b)		– (a)	+ (b)		– (a)	+ (b)		– (a)	+ (b)						
–	–		–	–		–	–		–	–		–	–		–	–							
1	11		1	10.2		–	–		–	–		–	–		–	–							
2	9		2	8.2		1	8.5		1	7.1		–	–		–	–							
3	6		3	5.2		2	6.5		2	5.1		1	5.6		–	–							
4	4		4	3.2		3	3.5		3	2.1		2	3.6		1	5.3							
5	1		5	0.2		4	1.5		4	0.1		3	0.6		2	3.3							
6		1	6		1.8	5		1.5	5		2.9	4		1.4	LCO*		8.7						
7		4	LCO*		3.8	6		3.5	6		4.9	LCO*		8.4	–		-						
8		6	9		9.8	7		6.5	LCO*		6.9	-		–	–		–						
9		9	10		11.8	8		8.5	–		–	-		–	–		–						
10		11	–		–	–		–	–		–	-		–	–		–						
–		–	–		–	–		–	–		–	-		–	–		–						
K	23.2		K	2 1		K	11.7		K	7.3		K	5.3		K	5.2							
M	10		M	9		M	8		M	7		M	5		M	3							
N	.50		N	.54		N	.61		N	.68		N	.75		N	.76							
*	–		*	4.0		*	–		*	7.0		*	8.5		*	10.5							

* REDUCE MEASURED VALUE OF LCO BY AMOUNT SHOWN.

YO POSITION

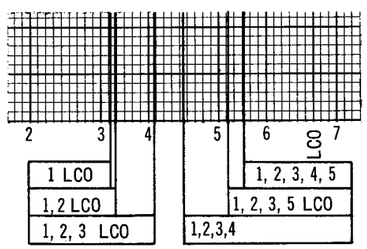


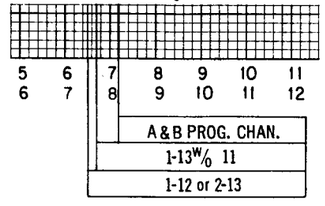
Fig. 1 – Information for Form E-4558-4 (ON1 Carrier) (on back of revised Form E-4558-4 also)

E 4558-6 (11-63)

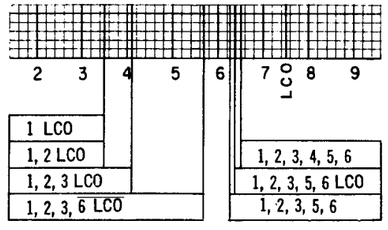
N CARRIER

CHANNEL		CHANNELS EQUIPPED 12 – (a)	12 + (b)	1-13W/o 11 – (a)	1-13W/o 11 + (b)	A&B PROG – (a)	A&B PROG + (b)	CHANNEL	
1	2	-11		-11.3		-12.4		1	2
2	3	- 9		- 9.3		-10.4		2	3
3	4	- 7		- 7.3		- 8.4		3	4
4	5	- 5		- 5.3		- 6.4		4	5
5	6	- 3		- 3.3		-		5	6
6	7	- 1		- 1.3		- 2.4		6	7
7	8		+ 1		+ 0.7		-	7	8
8	9		+ 3		+ 2.7		+ 1.6	8	9
9	10		+ 5		+ 4.7		+ 3.6	9	10
10	11		+ 7		+ 6.7		+ 5.6	10	11
11	12		+ 9		-		+ 7.6	11	12
12	13		+11		+10.7		+ 9.6	12	13
13					+12.7		+11.6	13	
K		26		30		32		K	
M		12		12		11		M	
N		.50		.49		.44		N	

N CARRIER Y_0 POSITION



ON 2 CARRIER Y_0 POSITION



ON 2 CARRIER

CARR	GROUPS EQUIPPED 1, 2, 3, 4, 5, 6 – (a)	1, 2, 3, 4, 5, 6 + (b)	1, 2, 3, 5, 6 – (a)	1, 2, 3, 5, 6 + (b)	1, 2, 3, 5, 6 LCO – (a)	1, 2, 3, 5, 6 LCO + (b)	1, 2, 3, 6 LCO – (a)	1, 2, 3, 6 LCO + (b)	1, 2, 3 LCO – (a)	1, 2, 3 LCO + (b)	1, 2 LCO – (a)	1, 2 LCO + (b)	1 LCO – (a)	1 LCO + (b)	CARR
1	-11		-10.6		-10.8		-9.5		-6.2		-5		-5		1
2	- 9		- 8.6		- 8.8		-7.5		-4.2		-3		-3		2
3	- 7		- 6.6		- 6.8		-5.5		-2.2		-1				3
4	- 5		- 4.6		- 4.8		-3.5		-0.2			+1			4
5	- 3		- 2.6		- 2.8		-1.5			+1.9		-			5
6	- 1		- 0.6		- 0.8			+ 0.6		+3.9		-			6
7		+ 1		-				-		-		-			7
LCO		-		-		+ 2.2		+ 3.6		+6.9		+8		+8	LCO
8		+ 3		-		-		-							8
9		+ 5		+ 5.4		+ 5.2		-							9
10		+ 7		+ 7.4		+ 7.2		-							10
11		+ 9		+ 9.4		+ 9.2		+10.6							11
12		+11		+11.4		+11.2		+12.6							12
K	26		25.5		25.7		21.4		5.7		4.5		4.5		K
M	12		10		11		9		7		5		3		M
N	.50		.52		.51		.57		.73		.77		.77		N

Fig. 2 – Form E-4558-6 (back)

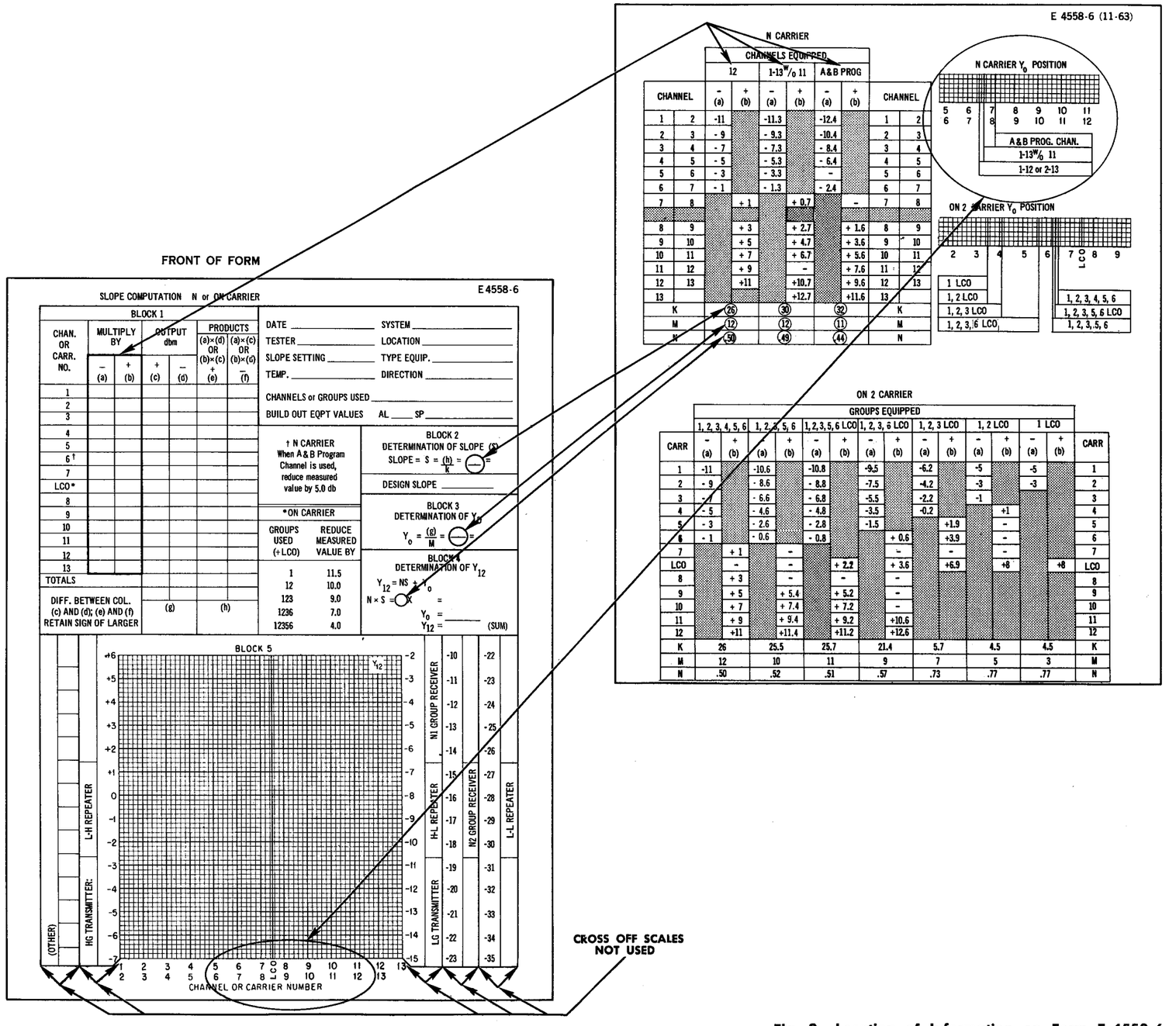


Fig. 3 – Location of Information on Form E-4558-6 (N Carrier)

E 4558-6 (11-63)

SLOPE COMPUTATION N ~~or ON~~ CARRIER

N CARRIER — BLOCK 1

CHANNELS EQUIPPED: 1-13 W/O 11		A&B PROG		OUTPUT dbm		PRODUCTS	
– (a)	+ (b)	– (a)	+ (b)	+ (c)	– (d)	(a)×(d) OR (b)×(c) + (e)	(a)×(c) OR (b)×(d) – (f)
-11.3		-12.4			4.6	57.0	
- 9.3		-10.4			3.4	35.4	
- 7.3		- 8.4			2.8	23.5	
- 5.3		- 6.4			1.9	12.2	
- 3.3		-					
- 1.3		- 2.4			0.9	2.2	
	+ 0.7		-				
	+ 2.7		+ 1.6		6.1		0.2
	+ 4.7		+ 3.6	0.8		2.9	
	+ 6.7		+ 5.6	1.2		6.7	
	-		+ 7.6	2.6		19.8	
	+10.7		+ 9.6	3.3		31.7	
	+12.7		+11.6	3.6		41.8	
30		32		11.5	13.7	233.2	0.2
12		11			11.5	0.2	
Di		.44		(g)		(h)	
(c) AND RETAIN SIGN OF LARGER				-2.2		+233.0	

DATE 3-18-60 SYSTEM 1N C/a -F&I
TESTER M.M.M. LOCATION G/e Reg. Sta.
SLOPE SETTING A TYPE EQUIP. L H Reptr
TEMP. 60° DIRECTION E-W
CHANNELS ~~or GROUPS~~ USED A&B Prog. Chan
BUILD OUT EQPT VALUES AL — SP 6 d 6

† N CARRIER When A & B Program Channel is used, reduce measured value by 5.0 db

*ON CARRIER

GROUPS USED (+LCO)	REDUCE MEASURED VALUE BY
1	11.5
12	10.0
123	9.0
1236	7.0
12356	4.0

BLOCK 2
DETERMINATION OF SLOPE (S)
SLOPE = S = $\frac{(h)}{k} = \frac{233}{32} = +7.3$

DESIGN SLOPE +7.0

BLOCK 3
DETERMINATION OF Y_0
$Y_0 = \frac{(g)}{M} = \frac{-2.2}{11} = -0.2$

BLOCK 4
DETERMINATION OF Y_{12}
$Y_{12} = NS + Y_0$
$N \times S = 44 \times 7.3 = +321.2$
$Y_0 = -0.2$
$Y_{12} = +321.0$ (SUM)

BLOCK 5

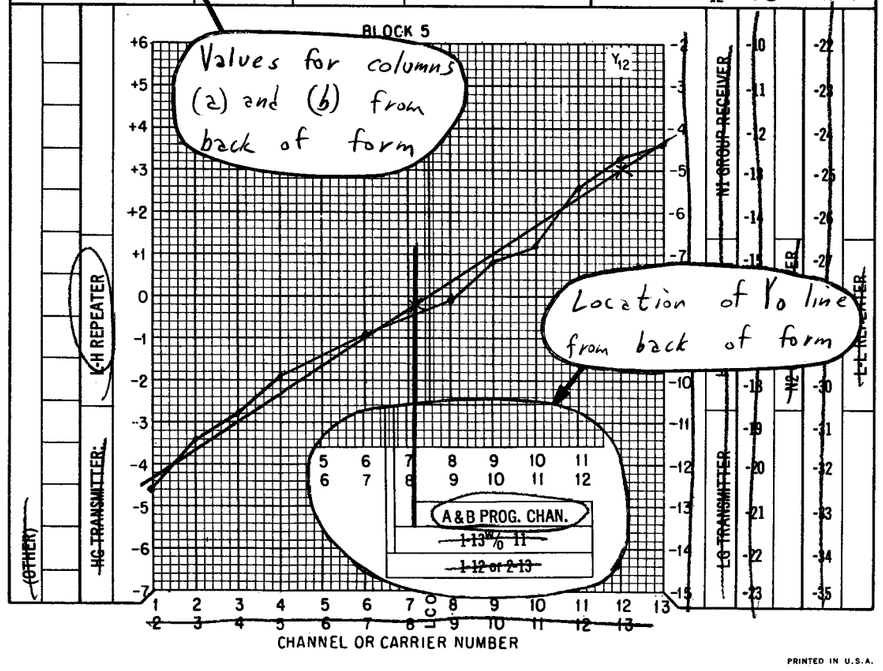


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Fig. 4 – Sample Calculations Showing Location of Information

E-4558-4 (4-58)

SLOPE COMPUTATION ON1

GROUPS 1, 2, 3, LCO

BLOCK 1

CHAN. OR CARR. NO.	MULTIPLY BY − (a)	MULTIPLY BY + (b)	OUTPUT dbm + (c)	OUTPUT dbm − (d)	PRODUCTS (a)x(d) OR (b)x(c) ± (e)	PRODUCTS (a)x(c) OR (b)x(d) (f)
1	7.1			4.7	33.4	
2	5.1			4.4	22.4	
3	2.1			6.4	13.4	
4	0.1			7.0	0.7	
5		2.9		8.2		23.8
6		4.9		9.0		44.1
LCO*		6.9		8.3		57.3
TOTALS				48.0	69.9	125.2
DIFF. BETWEEN COL. (c) AND (d); (e) AND (f) RETAIN SIGN OF LARGER			(g) −48.0		(h) −55.3	69.9

DATE 9-29-62 SYSTEM SD2 ON LA-SMRA

TESTER HPH LOCATION SBAR NIN

SLOPE SETTING A TYPE EQUIP. HL Rptr

TEMP. 85 DIRECTION E-W

BLOCK 2
DETERMINATION OF SLOPE (S)

$$\text{SLOPE} = S = \frac{(h)}{K} = \frac{-55.3}{7.3} = -7.6$$

BLOCK 3
DETERMINATION OF Y_0

$$Y_0 = \frac{(g)}{M} = \frac{-48.0}{7} = -6.9$$

BLOCK 4
DETERMINATION OF Y_{12}

$Y_{12} = NS + Y_0$

$N \times S = 6.8 \times -7.6 = -51.2$

$Y_0 = -6.9$

$Y_{12} = -12.1$ (SUM)

* MEASURED VALUE LCO REDUCED BY 7.0 db.

BLOCK 5

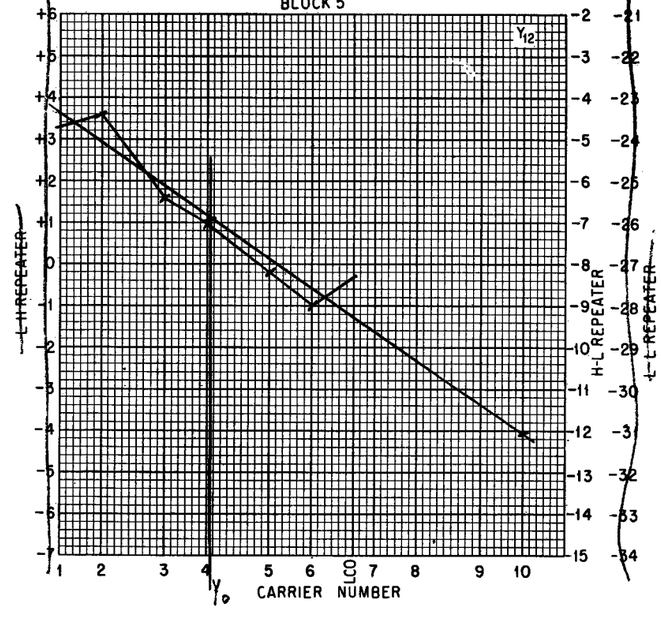

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Fig. 5 – Sample Calculation (ON1) Using Method of Least Squares

E 4558-6 (11-63)

SLOPE COMPUTATION N ~~or ON~~ CARRIER

CHAN. OR CARR. NO.	MULTIPLY BY (a)	MULTIPLY BY (b)	OUTPUT dbm (c)	OUTPUT dbm (d)	PRODUCTS (a)×(d) OR (b)×(c) (e)	PRODUCTS (a)×(c) OR (b)×(d) (f)
~~1~~						
2	11			6.5	71.5	
3	9			5.5	49.5	
4	7			6.2	43.4	
5	5			7.1	35.5	
6†	3			8.8	26.4	
7	1			9.6	9.6	
~~LCO*~~						
8		1		10.0		10.0
9		3		11.0		33.0
10		5		12.0		60.0
11		7		11.9		83.3
12		9		11.5		103.5
13		11		10.6		116.6
TOTALS				110.7	235.9	406.4
				-		235.9
DIFF. BETWEEN COL. (c) AND (d); (e) AND (f) RETAIN SIGN OF LARGER			(g)		(h)	
			-110.7		-170.5	

DATE 9-27-63 SYSTEM 104 N Alpha-Delta

TESTER RN LOCATION Delta 5

SLOPE SETTING C TYPE EQUIP. HL Repeater

TEMP. 62° DIRECTION E.W

CHANNELS ~~or GROUPS~~ USED 2-13

BUILD OUT EQPT VALUES AL 0 SP 4

† N CARRIER When A & B Program Channel is used, reduce measured value by 5.0 db

*ON CARRIER

GROUPS USED (+LCO)	REDUCE MEASURED VALUE BY
1	11.5
12	10.0
123	9.0
1236	7.0
12356	4.0

BLOCK 2
DETERMINATION OF SLOPE (S)

SLOPE = $S = \frac{(h)}{k} = \frac{-170.5}{26} = -6.6$

DESIGN SLOPE -7.0

BLOCK 3
DETERMINATION OF Y_0

$Y_0 = \frac{(g)}{M} = \frac{-110.7}{12} = -9.2$

BLOCK 4
DETERMINATION OF Y_{12}

$Y_{12} = NS + Y_0$

$N \times S = 5 \times -6.6 = -33$

$Y_0 = -9.2$

$Y_{12} = -12.5$ (SUM)

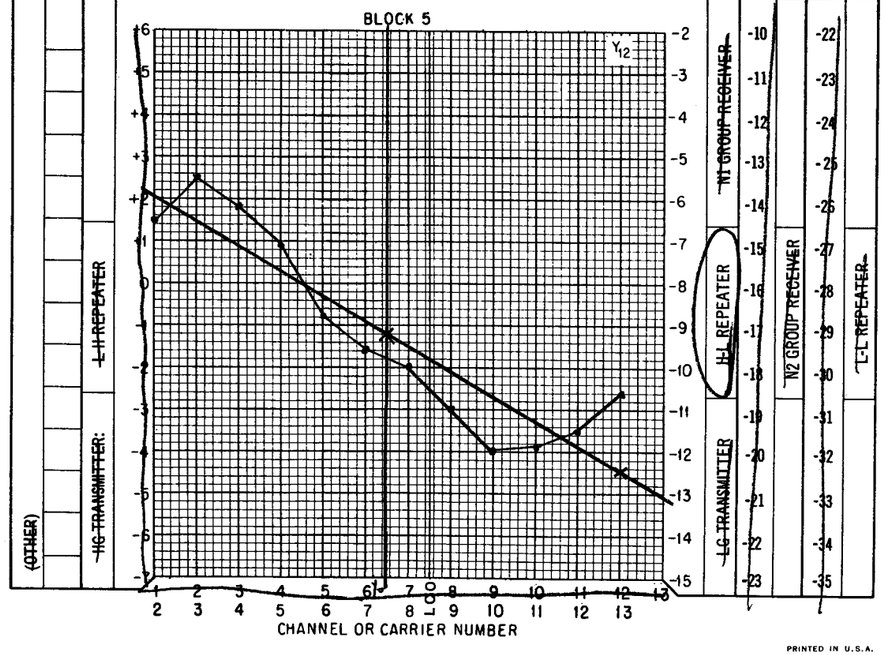

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Fig. 6 – Sample Calculation (N) Using Method of Least Squares

E 4558-6 (11-63)

SLOPE COMPUTATION N or (ON) CARRIER

BLOCK 1

CHAN. OR CARR. NO.	MULTIPLY BY – (a)	MULTIPLY BY + (b)	OUTPUT dbm + (c)	OUTPUT dbm – (d)	PRODUCTS (a)×(d) OR (b)×(c) + (e)	PRODUCTS (a)×(c) OR (b)×(d) – (f)
1				3.4		
2				2.6		
3				1.5		
4				0.6		
5				0.1		
6†			0.0			
7			0.7			
~~LCO*~~						
8			1.8			
9			2.7			
10			3.0			
11			3.2			
12			3.7			
~~13~~						
TOTALS						
DIFF. BETWEEN COL. (c) AND (d); (e) AND (f) RETAIN SIGN OF LARGER			(g)		(h)	

DATE 11/15/63 SYSTEM 503 ON Mul-Smt

TESTER RLW LOCATION Mul NI N

SLOPE SETTING B TYPE EQUIP. L4 Repeat

TEMP. 42° DIRECTION WE

~~CHANNELS or~~ GROUPS USED 1-6

BUILD OUT EQPT VALUES AL 2 SP 4

† N CARRIER When A & B Program Channel is used, reduce measured value by 5.0 db

*ON CARRIER

GROUPS USED (+LCO)	REDUCE MEASURED VALUE BY
1	11.5
12	10.0
123	9.0
1236	7.0
12356	4.0

BLOCK 2
DETERMINATION OF SLOPE (S)
SLOPE = S = $\frac{(h)}{k}$ = — = +7.2

DESIGN SLOPE ±7.0

BLOCK 3
DETERMINATION OF Y_0
$Y_0 = \frac{(g)}{M}$ = — =

BLOCK 4
DETERMINATION OF Y_{12}
$Y_{12} = NS + Y_0$
N × S = X =
Y_0 =
Y_{12} = (SUM)

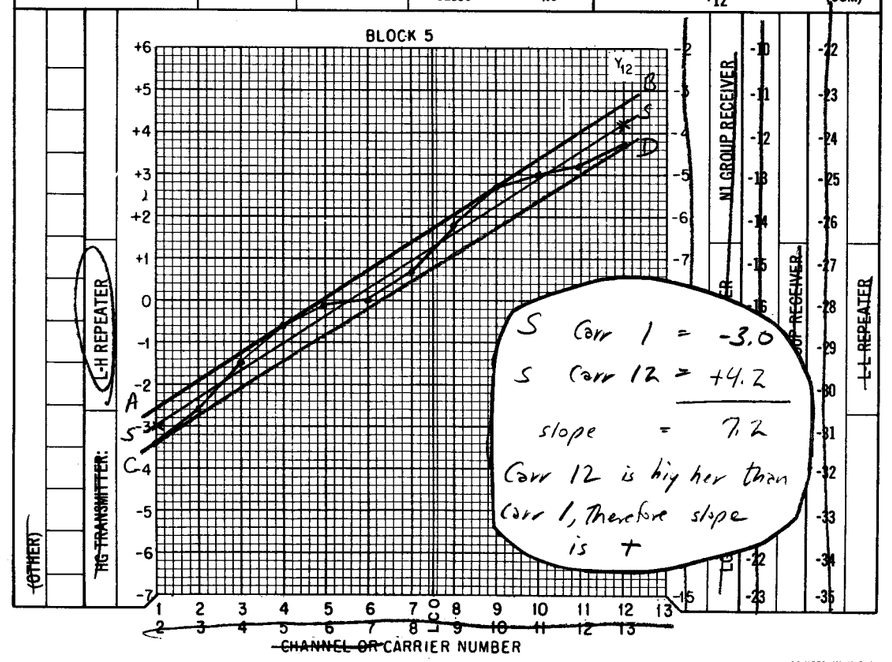

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Fig. 7 – Sample Calculation Using Graphic Method

Sample 1: N Carrier Channels 1-13 Without Channel 3

M = number of channels = 12

CHANNEL	X VALUE		X_{av}		W = X − X_{av} COL (a)	COL (b)	W^2
1	1	−	13.7	=	−12.7		161.3
2	3	−	13.7	=	−10.7		114.5
4	7	−	13.7	=	− 6.7		44.9
5	9	−	13.7	=	− 4.7		22.1
6	11	−	13.7	=	− 2.7		7.3
7	13	−	13.7	=	− 0.7		0.5
8	15	−	13.7	=		+ 1.3	1.7
9	17	−	13.7	=		+ 3.3	10.9
10	19	−	13.7	=		+ 5.3	28.1
11	21	−	13.7	=		+ 7.3	53.3
12	23	−	13.7	=		+ 9.3	86.5
13	25	−	13.7	=		+11.3	127.7
	164						658.8

X_{av} = X total ÷ M
= 164 ÷ 12
= 13.7

K = W^2 total ÷ 22
= 658.8 ÷ 22
= 29.9

N = $(X_{12} - X_{av}) \div 22$
= (23 − 13.7) ÷ 22
= .42

Y_0 = channel corresponding to X value of X_{av}
= channel corresponding to X value of 13.7
= (channel 7 = X value of 13, channel 8 = X value of 15)
= one third the distance between channels 7 and 8

Sample 2: ON2 Carrier, Groups 1-4, no LCO

M = number of carriers = 8

CHANNEL	X VALUE		X_{av}		W = X − X_{av} COL (a)	COL (b)	W^2
1	3	−	10	=	−7		49
2	5	−	10	=	−5		25
3	7	−	10	=	−3		9
4	9	−	10	=	−1		1
5	11	−	10	=		+1	1
6	13	−	10	=		+3	9
7	15	−	10	=		+5	25
8	17	−	10	=		+7	49
	80						168.0

X_{av} = X total ÷ M
= 80 ÷ 8
= 10

K = W^2 total ÷ 22
= 168 ÷ 22
= 7.5

N = $(X_{13} - X_{av}) \div 22$
= (25 − 10) ÷ 22
= .68

Y_0 = channel corresponding to X value of X_{av}
= channel corresponding to X value of 10
= 4.5
= half way between channels 4 and 5 on upper channel scale

Fig. 8 – Sample Calculations Determining Values for Form E-4558-4 or -6