Georgia
NGR-11-002-020
N66-15392

N66-15392 (ACCESSION NUMBER) (THRU)
11 (PAGES) / (CODE)
CR 69341 (NASA CR OR TMX OR AD NUMBER) 09 (CATEGORY)
FACILITY FORM 602

Hc. 1.00
MF .50

THE EFFECT OF LOAD CONDUCTANCE ON THE SELECTIVITY OF NOTCH FILTERS*

SYNOPSIS--It has been found that notch filters using hyperbolically shaped RC lines have less fluctuations in selectivity due to load than those using exponentially shaped lines; the latter, in turn, fluctuate less than those using trigonometric lines. The longer a hyperbolic line is, the less it is affected by the load. Author

In two recent letters,[1,2] nonuniform RC lines of several shapes were discussed and the selectivity of a notch filter was defined. It was also shown that the three nonuniform—the trigonometric, the exponential, and the hyperbolic—RC lines can be used in notch filters to produce a wide range of selectivity at open circuit by properly choosing the parameters of these lines. It is the purpose of this communication to show the effect of a load resistance on the selectivity of notch filters using variously shaped lines.

The circuit and notation used here are given in Fig. 1, in which R_s represents the nulling resistance and G_L is the load conductance. The value of G_L is expressed as a multiple of $1/R_t$, where R_t is the total resistance of the RC line. The RC line may be any one of the three lines mentioned in References 1 and 2. When the filter is used in the feedback circuit of an amplifier,[2] the load conductance represents the input conductance of the forward amplifier.

In making a quantitative comparison of the effect of G_L on various notch filters, the following four typical groups of lines have been selected. These lines are classified according to their open-circuit notch selectivities. Group A has an open-circuit selectivity of 120, group B 80, group C 40.672, and group D 20. It should be noted that the uniform line (or an exponential line with $\alpha = 0$) belongs to group C. The parameters of the trigonometric lines are limited to the ranges $0 < x_1 < \pi/2$ and $\pi/2 < x_2 < \pi$. Trigonometric lines with parameter values outside these ranges have the shape of and are not materially different from exponential lines.

Generally, the selectivity of a notch filter decreases as G_L is increased. Fig. 1 shows this decrease of selectivity of several typical notch filters using different nonuniform RC lines as G_L is varied from 0 to 5. It can be observed from Fig. 1 that the selectivity of a hyperbolic line is less subject to the effect of load than an exponential line, which is in turn less than an trigonometric line.

Fig. 2 shows how the selectivities of notch filters using lines from the same group vary for several fixed loads when the line parameters are varied continuously. Fig. 2a pertains to the trigonometric line and Fig. 2b pertains to the hyperbolic line. The variable x_2 is used as the abscissa since its value is an indication of how far to the right of the point at which both lines assume the shape of the exponential line ($x_2 = \pi/2$ for the trigonometric line and $x_2 = 0$ for the hyperbolic line). The corresponding values of x_1 for any x_2 are found on the appropriate contours in Fig. 2 of Reference 2.

The selectivities of notch filters using exponential lines from the four groups at different loads are given in Table 1.

Table 1

NOTCH SELECTIVITIES OF FILTERS USING EXPONENTIAL LINES AT DIFFERENT LOADS

G_L	Group A	Group B	Group C	Group D
0	120.0	80.0	40.672	20.0
0.5	83.849	61.760	35.664	18.810
1	64.246	49.941	31.572	17.715
2	43.680	35.872	25.456	15.791

In conclusion, it can be said that the shaping of an RC line such that its resistance first increases and then decreases will result in a notch filter whose selectivity is affected to a lesser degree by a load than a filter using a monotonic line. The further the resistance decreases as the line approaches the output, the less effect the load resistance has on the selectivity of the filter. Conversely, the opposite shaping results in an opposite tendency. Hence, when a notch filter is used in connection with a finite or variable load, the RC line should be shaped as much in the form of Fig. 1c of Reference 1 as possible to reduce the effect of load resistance.

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Footnote

*This work was supported by NASA under grant NGR-11-002-020

References

1 SU, K. L.: 'Hyperbolic RC transmission line,' Electronics Letters, 1965, 1, p. 59.

2 SU, K. L.: 'The selectivity of notch filters using nonuniform RC lines,' Electronics Letters, (Accepted for publication, date manuscript received: 19th August 1965).

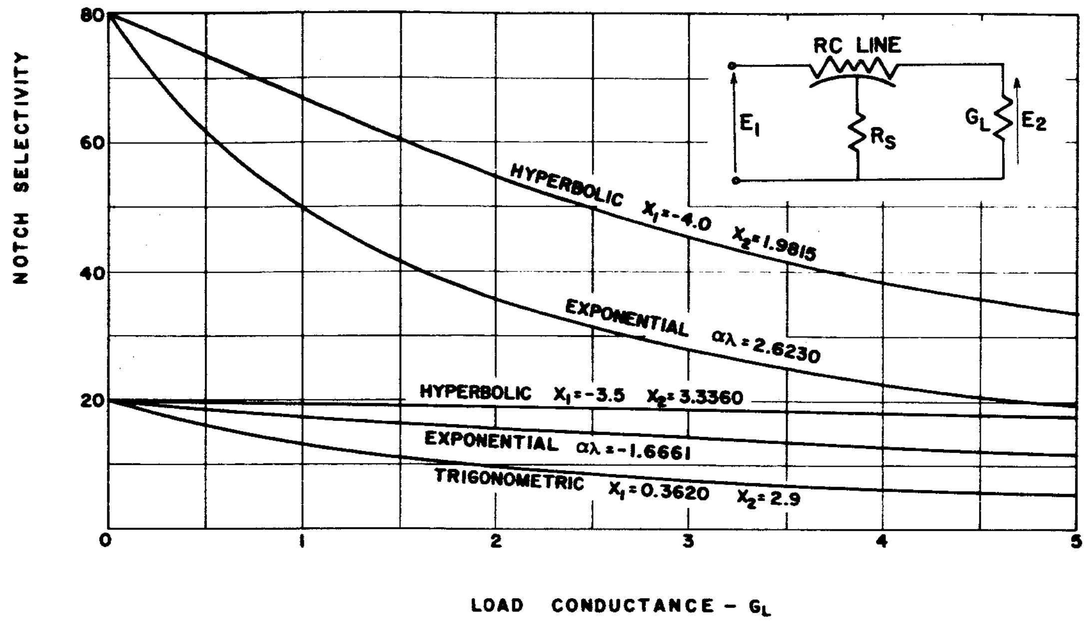
Legends to Illustrations

Fig. 1 Variation of notch selectivity of several notch filters when the load conductance is varied.

Fig. 2 Variation of notch selectivity of four groups of notch filters for variable line parameters and fixed load conductances.

a Notch filters using trigonometric lines.

b Notch filters using hyperbolic lines.



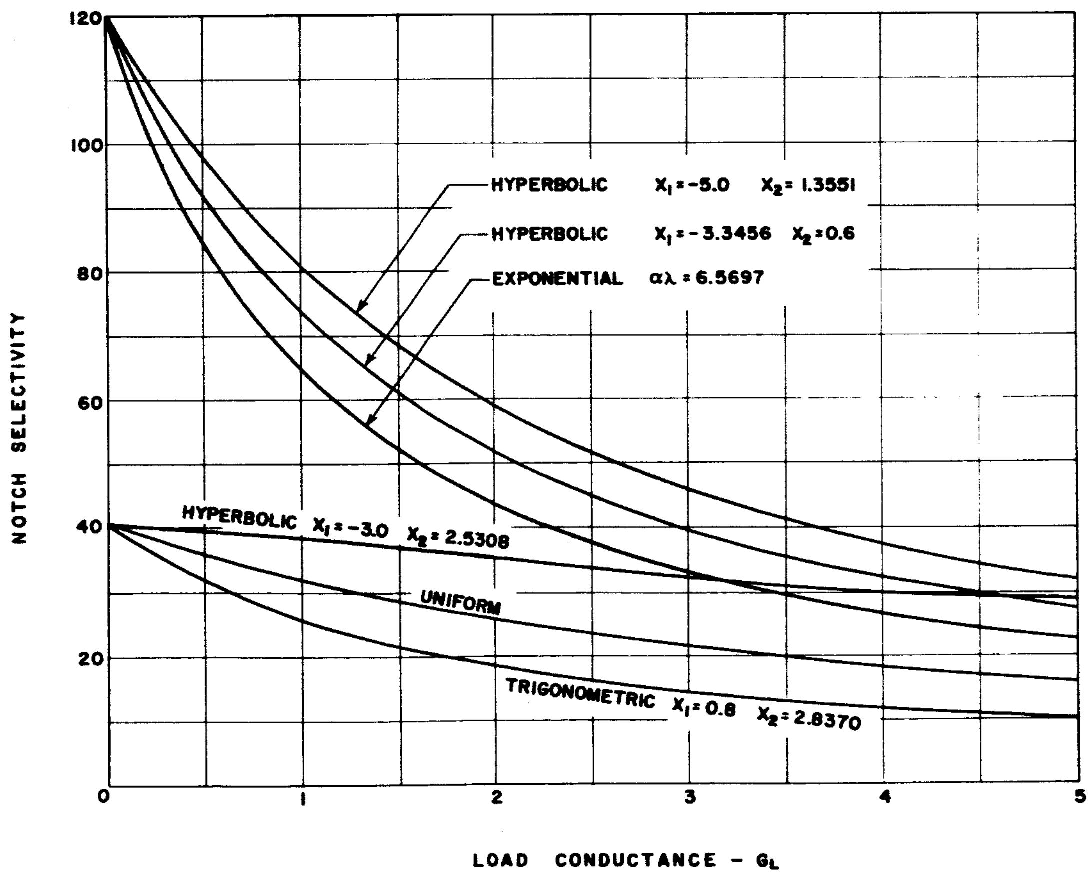
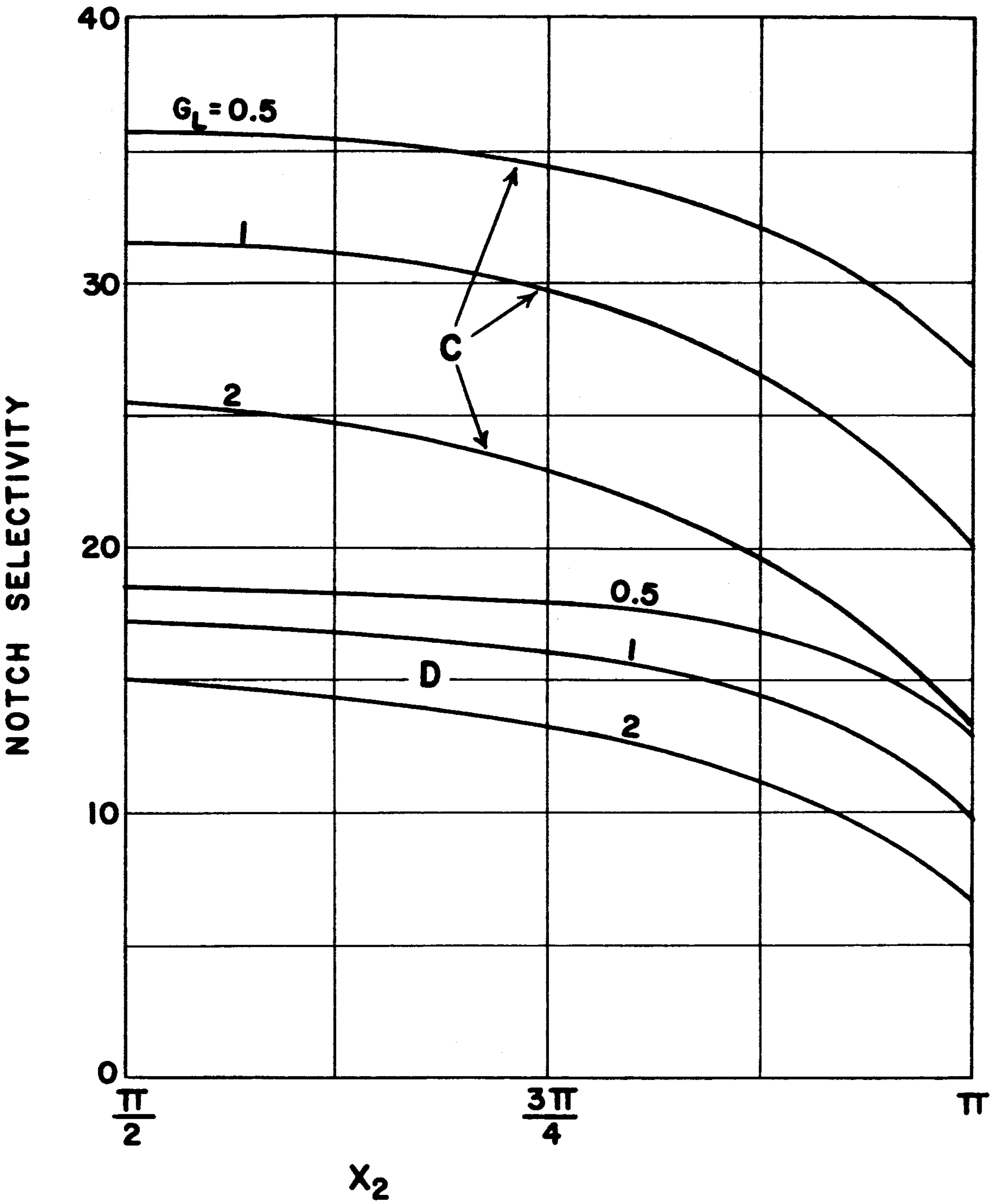


Fig. 1 Variation of notch selectivity of several notch filters when the load conductance is varied



a

Fig. 2 Variation of notch selectivity of four groups of notch filters for variable line parameters and fixed load conductances

a Notch filters using trigonometric lines

b Notch filters using hyperbolic lines

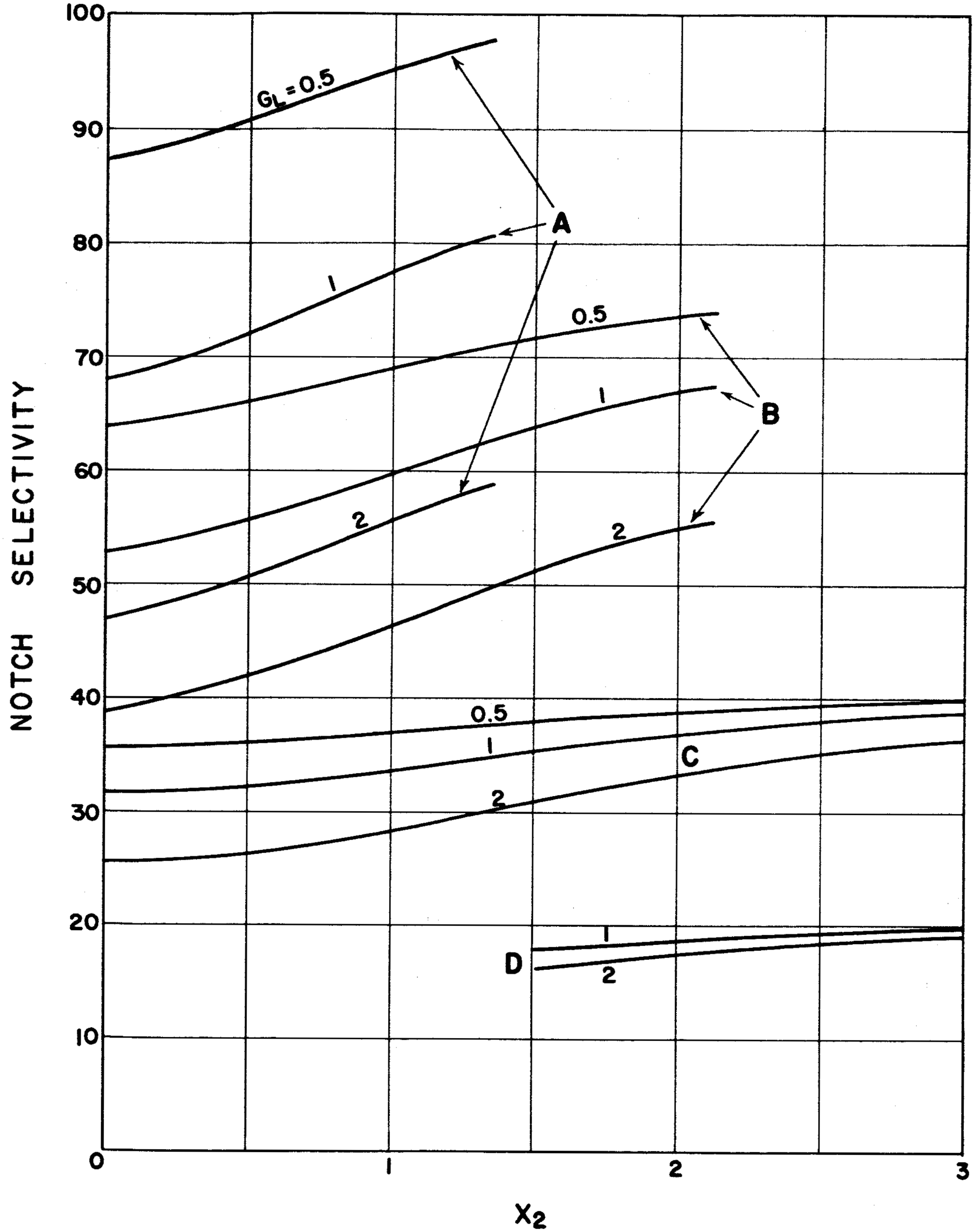

100
90
80
70
60
50
40
30
20
10
0
1
2
3
NOTCH SELECTIVITY
X2
GL = 0.5
1
2
0.5
1
2
0.5
1
2
1
2
A
B
C
D

Fig. 2b