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INTRODUCAO

Este documento apresenta os filtros necessarios para o projeto de um simulador de linha que tenha as mesmas caracteristicas de atenuacao e fase do modelo TLN-1 da Wandel & Goltermann.

A implementacao do simulador de linha e feita atraves de um processador de sinais acoplados a conversores A/D e D/A. Este documento nao descreve o projeto dos circuitos digitais daquele processador. Apresentaremos aqui apenas os filtros analogicos (circuitos e curvas de resposta) e digitais (que devem ser programados no processador) que tem a mesma resposta do TLN-1.

FILTROS ANALOGICOS

Assumimos que os mesmos filtros usados pelo modem RT-29 (veja documento interno Rhede, H.S. Malvar, "Projeto dos filtros de entrada e saida para o modem RT-29", 11/fev/88) sao adequados, por razoes ja explicadas no documento citado.

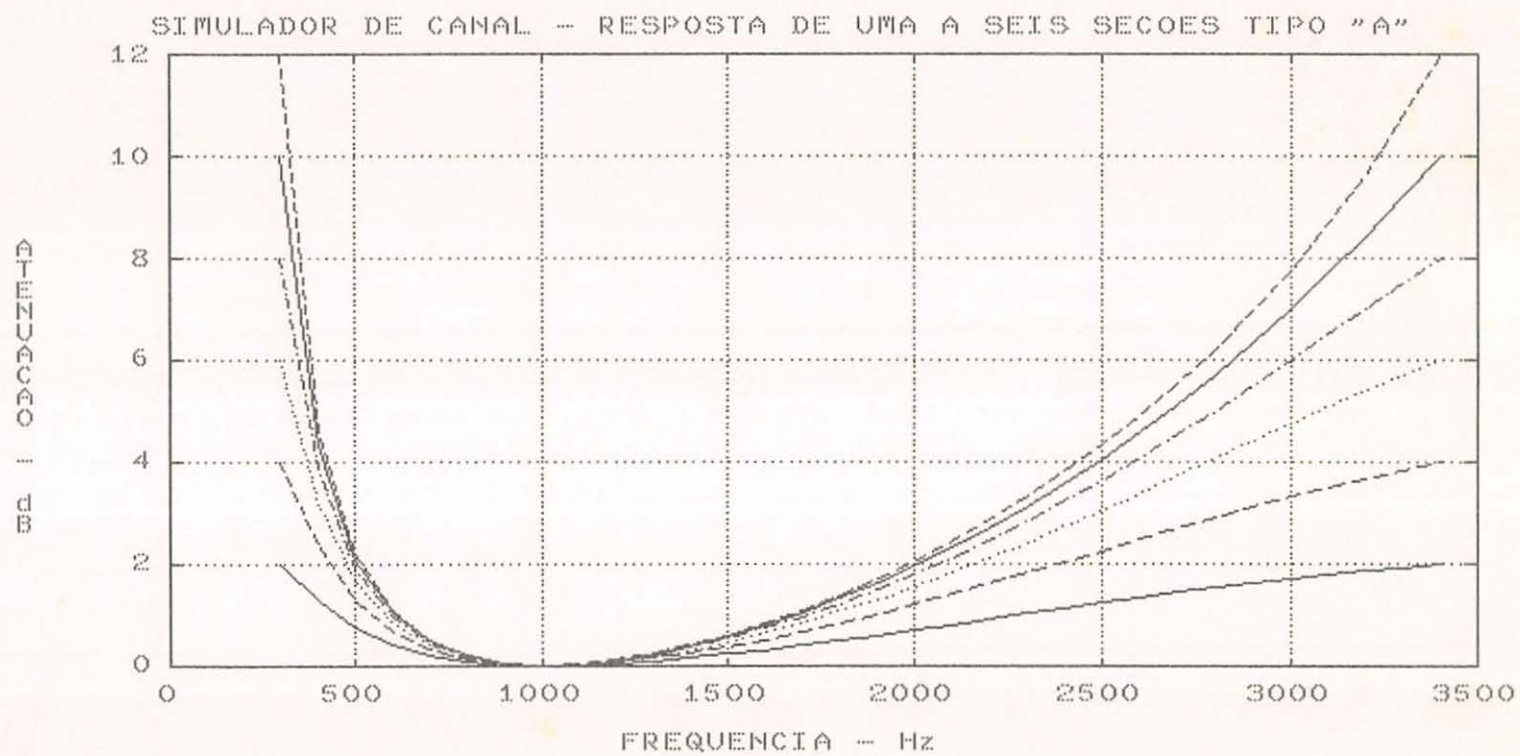
O esquema dos dois filtros analogicos, o que precede o conversor A/D e o que se segue ao conversor D/A, sao mostrados nas paginas a seguir, assim como as suas curvas de resposta em frequencia. De acordo com os conversores A/D e D/A utilizados, alteracoes de ganho podem vir a ser necessarias.

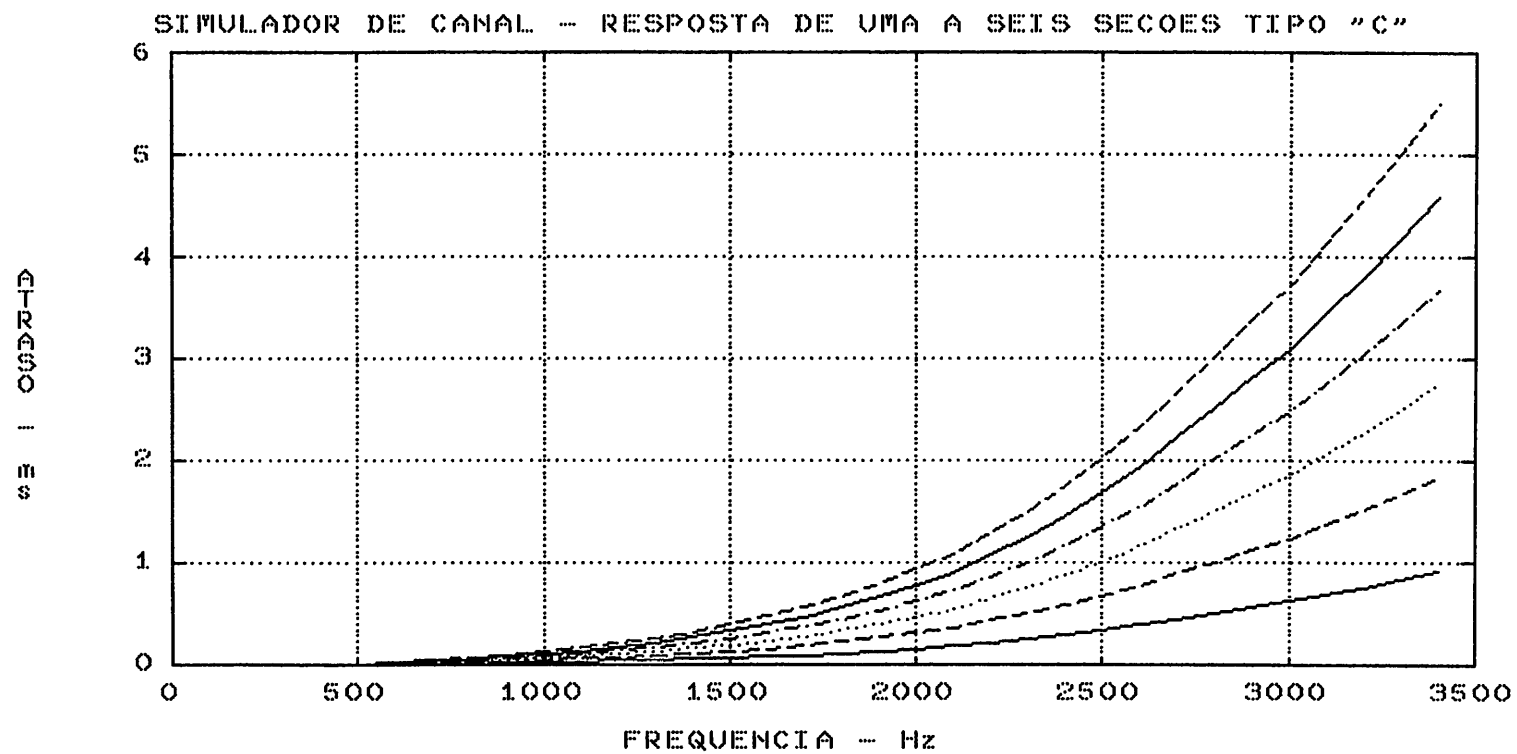
O atraso de grupo de tais filtros deve ser compensado no processador digital. Assim, apresentamos tambem os equalizadores de atraso que compensam esses filtros (esses equalizadores sao os mesmos que foram sugeridos para o RT-29).

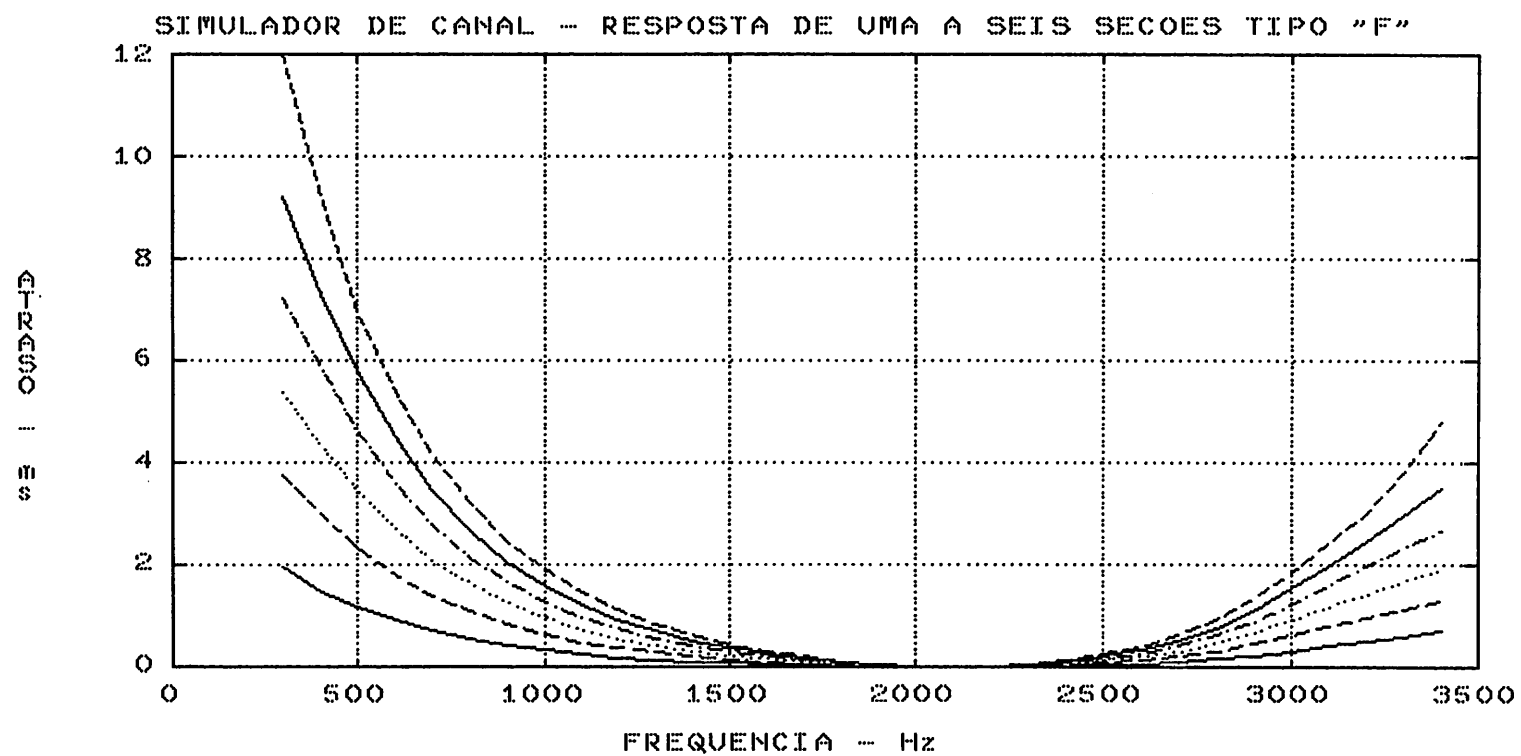
Finalmente a correcao da distorcao $\sin(x)/x$ do conversor D/A tambem pode ser feita no processador digital. Os coeficientes do filtro que fazem tal correcao sao os seguintes:

$$h(0) = h(2) = -0,06268$$

$$h(1) = 1.12536.$$







Note que o equalizador de $\sin(x)/x$ e um filtro FIR de fase linear, com os coeficiente acima, que garantem um ganho unitario em d.c. e um erro de compensacao de ± 0.14 dB.

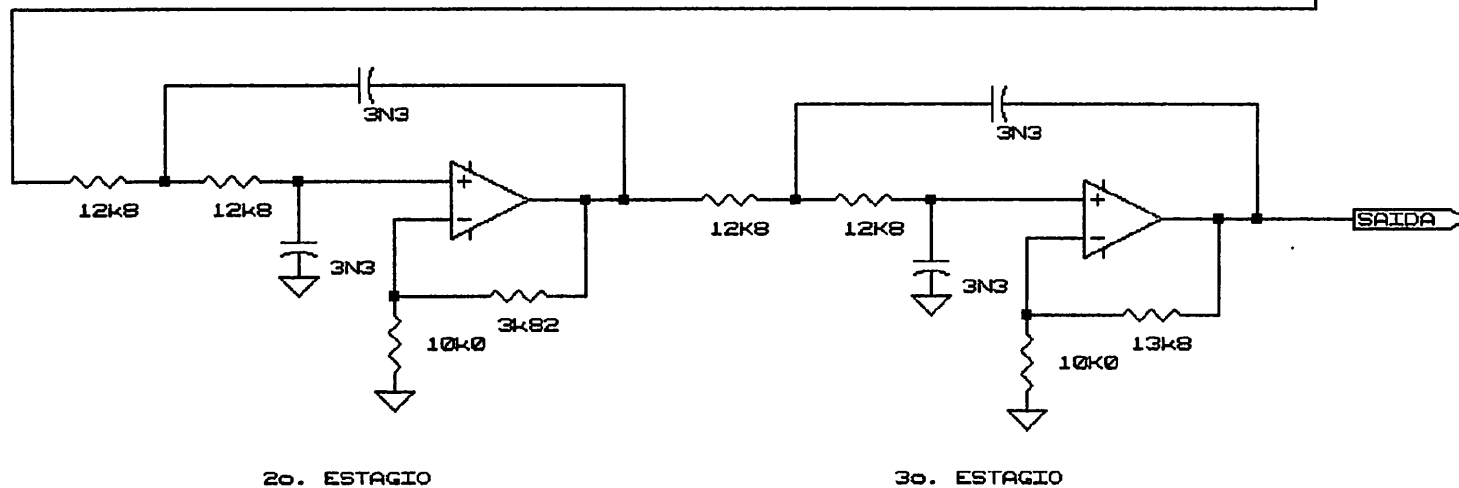
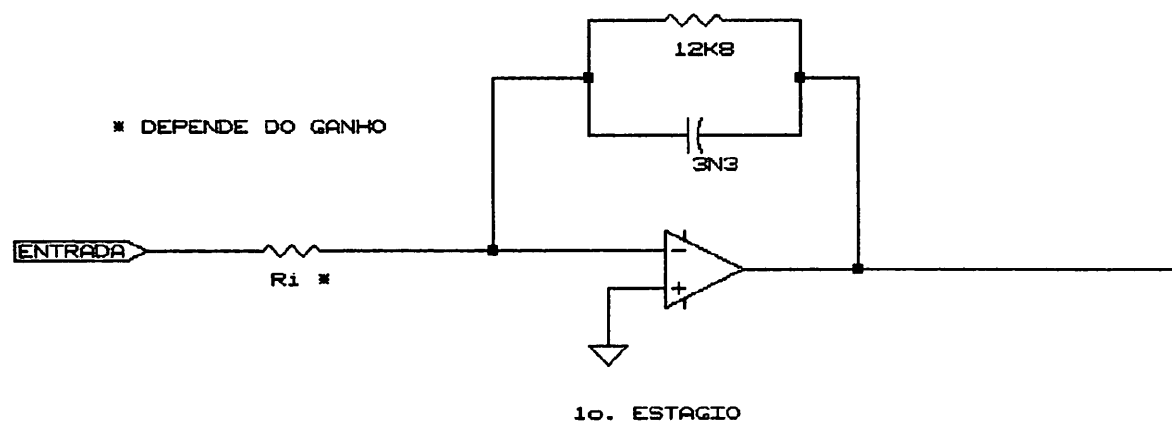
Uma vez que os filtros analogicos tenham sido compensados, basta entao projetar os filtros digitais que tenha curvas de resposta iguais as curvas do TLN-1.

FILTROS DIGITAIS

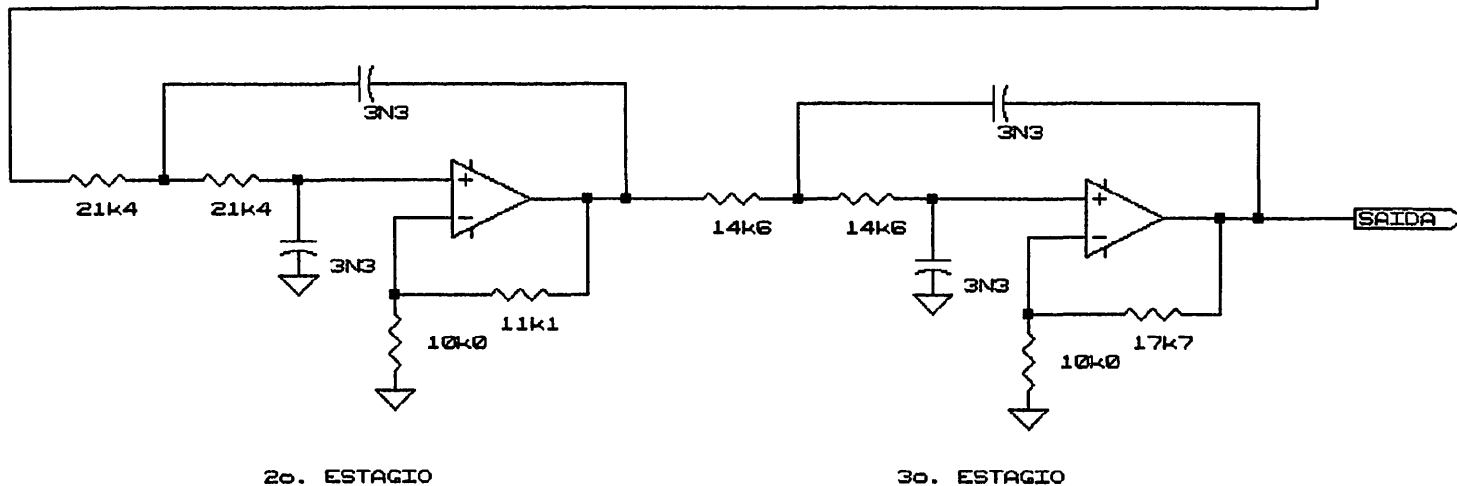
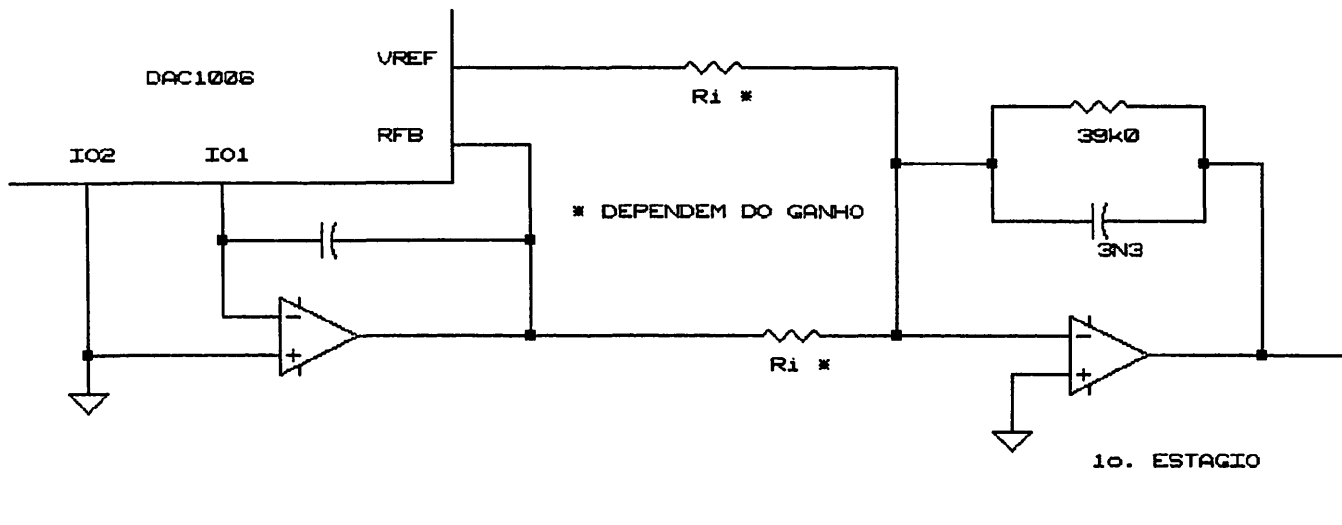
Assumimos que o processador trabalhara com um frequencia de amostragem de 9600 Hz. Uma outra opcao seria o uso de 19200 Hz, para minimizar o aliasing dos filtros analogicos. No entanto, esta ultima opcao dificultaria em muito o projeto de filtros digitais adequados (e tambem geraria modulos biquadraticos com polos proximos demais do circulo unitario, o que levaria a problemas devido a precisao finita do processador). Assim, optamos pela frequencia de 9600 Hz.

As curvas do TLN-1 sao divididas em tres grupos, caracterizados pelo tipo de distorcao de canal que e simulada: Distorcoes de fase nos tipos "C" e "F", e distorcoes de amplitude do tipo "A". Para cada tipo, existem sete posicoes, que controlam a intensidade da distorcao. A posicao "0" sempre significa que a distorcao nao esta presente, e as posicoes de "1" a "6" apresentam distorcoes que crescem com a posicao selecionada. Essas curvas, para as posicoes "1" a "6", sao apresentadas nas proximas paginas.

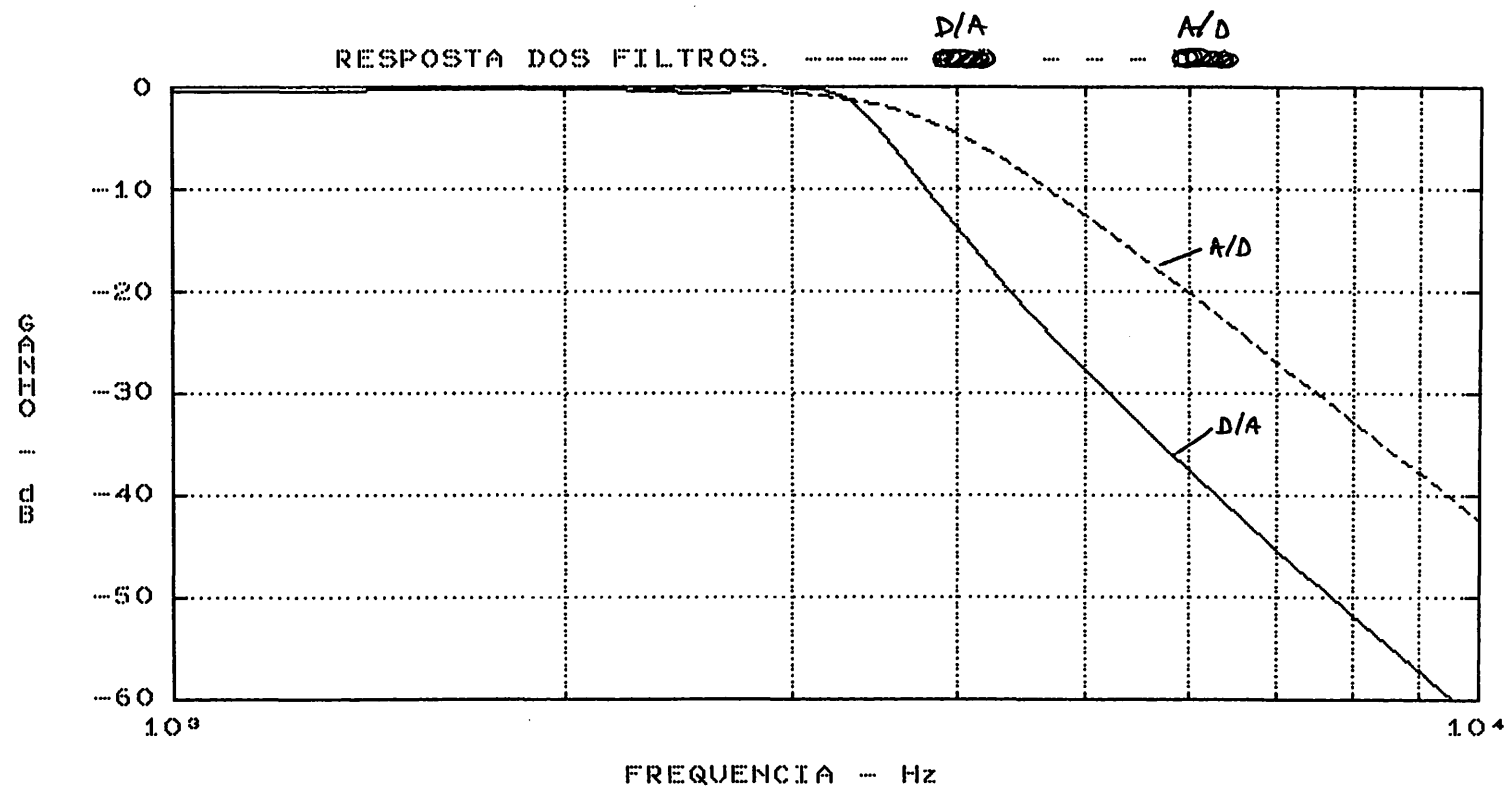
Para a simulacao de linhas, assumimos uma banda passante de 300 Hz a 3400 Hz. Assim, os erros de aproximacao sao validos apenas para essa banda.



RHEDE TECNOLOGIA S.A.		
Title		
FILTRO DO A/D - SIMULADOR DE LINHA		
Size	Document Number	REV
A	H. MALVAR 001	A00
Date:	May 17, 1988	Sheet of



RHEDE TECNOLOGIA S.A.			
Title			
FILTRO DO D/A - SIMULADOR DE LINHA			
Size	Document Number		REV
A	H. MALVAR 001		A00
Date:	May 17, 1988	Sheet	of



EQUALIZADOR DE ATRASO. COMPENSACAO DO FILTRO QUE
PRECEDE O A/D

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.30759470E+00	.45280680E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.30759470E+00	.22084480E+00

CONST= .48772410E-01

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.51467570E+01	.20503400E+02

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.25101970E+00	.48772410E-01

Erro maximo na banda 300 - 3400 Hz : +/- 0.004 ms

EQUALIZADOR DE ATRASO. COMPENSACAO DO FILTRO QUE
SE SEGUE AO CONVERSOR D/A

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.12113880E+00	.18505470E+01
.32185520E+00	.18453640E+01
.55156730E+00	.16302210E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.12113880E+00	.54038080E+00
.32185520E+00	.54189850E+00
.55156730E+00	.61341370E+00

CONST= .32265820E-01

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.34362940E+01	.34245240E+01
.10000000E+01	-.19593960E+01	.34053680E+01
.10000000E+01	.52589520E+00	.26576210E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.10034370E+01	.29201140E+00
.10000000E+01	-.57538440E+00	.29365400E+00
.10000000E+01	.19788190E+00	.37627630E+00

Erro maximo na banda 300 - 3400 Hz : +/- 0.004 ms

Simulacao de distorcao do tipo "A"

Nas paginas seguintes temos as tabelas dos coeficientes dos filtros que simulam a distorcao de atenuacao do tipo "A", para posicoes de "1" a "6". Note que para cada posicao, dois filtros devem ser colocados em cascata: um que tem a curva de atenuacao desejada, e um equalizador de atraso para que a simulacao de secao "A" tenha uma fase o mais linear possivel. Para as tabelas apresentadas, temos o erro de aproximacao de cada curva, em dB ou em milisegundos. Em todos os casos, esses erros sao suficientemente pequenos para que nao precisem ser considerados.

EQUALIZADOR DE AMPLITUDE. SIMULACAO DE SECAO "A" - POSICAO 1

THE ERROR CRITERION USED IS MINIMUM 4 FOR THE MAGNITUDE AND
MINIMUM 0 FOR THE GROUP DELAY

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.32078240E-01	.79462410E+00
.69913370E+00	.29214820E+00

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.50897140E-01	.76081070E+00
.82526870E+00	.10887640E+00

CONST= .85723350E+00

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.15811850E+01	.63142750E+00
.10000000E+01	.34215310E+00	.85350590E-01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.15022110E+01	.57883290E+00
.10000000E+01	.18576070E+00	.11854060E-01

Erro maximo na banda 300 - 3400 Hz : +/- 0.023 dB

EQUALIZADOR DE ATRASO. SIMULADOR DE SECAO "A" - POSICAO 1

THE ERROR CRITERION USED IS MINIMUM 0 FOR THE MAGNITUDE AND
MINIMUM 4 FOR THE GROUP DELAY

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.15731280E+00	.17601690E+01
.42214660E+00	.18987900E+01
.68614140E+00	.17610980E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.15731280E+00	.56812730E+00
.42214660E+00	.52665130E+00
.68614140E+00	.56782770E+00

CONST= .28864950E-01

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.30991030E+01	.30981940E+01
.10000000E+01	-.91959300E+00	.36054020E+01
.10000000E+01	.19443090E+01	.31014650E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.10002930E+01	.32276870E+00
.10000000E+01	-.25505980E+00	.27736160E+00
.10000000E+01	.62690030E+00	.32242830E+00

 Erro maximo na banda 300 - 3400 Hz : +/- 0.024 ms

EQUALIZADOR DE AMPLITUDE. SIMULACAO DE SECAO "A" - POSICAO 2

THE ERROR CRITERION USED IS MINIMUM 4 FOR THE MAGNITUDE AND
MINIMUM 0 FOR THE GROUP DELAY

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.61267900E-02	.88821980E+00
.69442140E+00	.27196650E+00

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.29372260E-01	.79284150E+00
.35402540E+00	.63758700E-01

CONST= .71334250E+00

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.17761110E+01	.78893450E+00
.10000000E+01	.31195490E+00	.73965790E-01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.15789370E+01	.62859760E+00
.10000000E+01	-.56450270E-01	.40651720E-02

Erro maximo na banda 300 - 3400 Hz : +/- 0.096 dB

EQUALIZADOR DE ATRASO. SIMULADOR DE SECAO "A" - POSICAO 2

THE ERROR CRITERION USED IS MINIMUM 0 FOR THE MAGNITUDE AND
MINIMUM 4 FOR THE GROUP DELAY

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.12357490E+00	.17471290E+01
.39953220E+00	.19513740E+01
.68074970E+00	.18559910E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.12357490E+00	.57236750E+00
.39953220E+00	.51245950E+00
.68074970E+00	.53879580E+00

CONST= .24975690E-01

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.32342280E+01	.30524600E+01
.10000000E+01	-.12114690E+01	.38078600E+01
.10000000E+01	.19963550E+01	.34447010E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.10595480E+01	.32760460E+00
.10000000E+01	-.31814950E+00	.26261470E+00
.10000000E+01	.57954370E+00	.29030090E+00
.10000000E+01	-.65080980E+00	.10588840E+00
.10000000E+01	-.56030650E+00	.27482270E+00
.10000000E+01	.19996800E+00	.31213200E+00
.10000000E+01	.93692830E+00	.40210070E+00

 Erro maximo na banda 300 - 3400 Hz : +/- 0.025 ms

EQUALIZADOR DE AMPLITUDE. SIMULACAO DE SECAO "A" - POSICAO 3

THE ERROR CRITERION USED IS MINIMUM 4 FOR THE MAGNITUDE AND
MINIMUM 0 FOR THE GROUP DELAY

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.14780470E-01	.95353000E+00
.78061410E+00	.32772240E+00

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.37219380E-01	.80647140E+00
.37185390E+00	.77969070E-01

CONST= .58780410E+00

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.19050040E+01	.90921950E+00
.10000000E+01	.50583400E+00	.10740200E+00

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.16019290E+01	.65039610E+00
.10000000E+01	-.61095930E-01	.60791760E-02

Erro maximo na banda 300 - 3400 Hz : +/- 0.202 dB

EQUALIZADOR DE ATRASO. SIMULADOR DE SECAO "A" - POSICAO 3

THE ERROR CRITERION USED IS MINIMUM 0 FOR THE MAGNITUDE AND
MINIMUM 4 FOR THE GROUP DELAY

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.24105080E+00	.16584930E+01
.47671050E+00	.16696760E+01
.68622740E+00	.14993670E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.24105080E+00	.60295700E+00
.47671050E+00	.59891860E+00
.68622740E+00	.66694790E+00

CONST= .58008560E-01

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.24104700E+01	.27505990E+01
.10000000E+01	-.24410910E+00	.27878180E+01
.10000000E+01	.16560270E+01	.22481030E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.87634360E+00	.36355720E+00
.10000000E+01	-.87562770E-01	.35870340E+00
.10000000E+01	.73663290E+00	.44481950E+00

 Erro maximo na banda 300 - 3400 Hz : +/- 0.035 ms

EQUALIZADOR DE AMPLITUDE. SIMULACAO DE SECAO "A" - POSICAO 4

THE ERROR CRITERION USED IS MINIMUM 4 FOR THE MAGNITUDE AND
MINIMUM 0 FOR THE GROUP DELAY

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.33258810E-01	.96960600E+00
.75061990E+00	.47861510E+00

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.47656100E-01	.82600690E+00
.49258010E+00	.19415070E+00

CONST= .53082800E+00

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.19286360E+01	.94013580E+00
.10000000E+01	.67818090E+00	.22907240E+00

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.16335330E+01	.68228740E+00
.10000000E+01	-.90506390E-02	.37694490E-01

Erro maximo na banda 300 - 3400 Hz : +/- 0.255 dB

EQUALIZADOR DE ATRASO. SIMULADOR DE SECAO "A" - POSICAO 4

THE ERROR CRITERION USED IS MINIMUM 0 FOR THE MAGNITUDE AND
MINIMUM 4 FOR THE GROUP DELAY

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.94308440E-01	.14830880E+01
.36509820E+00	.17513550E+01
.63476310E+00	.17925090E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.94308440E-01	.67426870E+00
.36509820E+00	.57098640E+00
.63476310E+00	.55787720E+00

CONST= .46131200E-01

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.28369390E+01	.21995510E+01
.10000000E+01	-.14404310E+01	.30672450E+01
.10000000E+01	.14728550E+01	.32130890E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.12897810E+01	.45463820E+00
.10000000E+01	-.46961710E+00	.32602550E+00
.10000000E+01	.45839220E+00	.31122700E+00

Erro maximo na banda 300 - 3400 Hz : +/- 0.053 ms

EQUALIZADOR DE AMPLITUDE. SIMULACAO DE SECAO "A" - POSICAO 5

THE ERROR CRITERION USED IS MINIMUM 4 FOR THE MAGNITUDE AND
MINIMUM 0 FOR THE GROUP DELAY

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.41097160E-01	.98682400E+00
.80235030E+00	.55102550E+00

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.47077880E-01	.83684470E+00
.47372860E+00	.20788870E+00

CONST= .45286280E+00

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.19572210E+01	.97382160E+00
.10000000E+01	.89633650E+00	.30362900E+00

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.16554170E+01	.70030910E+00
.10000000E+01	-.34276790E-01	.43217700E-01

Erro maximo na banda 300 - 3400 Hz : +/- 0.428 dB

EQUALIZADOR DE ATRASO. SIMULADOR DE SECAO "A" - POSICAO 5

THE ERROR CRITERION USED IS MINIMUM 0 FOR THE MAGNITUDE AND
MINIMUM 4 FOR THE GROUP DELAY

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.82848840E-01	.14429740E+01
.35552980E+00	.17386750E+01
.62032780E+00	.17632260E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.82848840E-01	.69301340E+00
.35552980E+00	.57515080E+00
.62032780E+00	.56714220E+00

CONST= .51101140E-01

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.27887440E+01	.20821730E+01
.10000000E+01	-.15246220E+01	.30229890E+01
.10000000E+01	.13015500E+01	.31089670E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.13393430E+01	.48026750E+00
.10000000E+01	-.50434270E+00	.33079840E+00
.10000000E+01	.41864370E+00	.32165030E+00

Erro maximo na banda 300 - 3400 Hz : +/- 0.055 ms

EQUALIZADOR DE AMPLITUDE. SIMULACAO DE SECAO "A" - POSICAO 6

THE ERROR CRITERION USED IS MINIMUM 4 FOR THE MAGNITUDE AND
MINIMUM 0 FOR THE GROUP DELAY

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.48296700E-01	.99456190E+00
.84222100E+00	.73244310E+00

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.42986150E-01	.85462900E+00
.50336310E+00	.18660520E+00

CONST = .37264180E+00

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.19662710E+01	.98915340E+00
.10000000E+01	.12885820E+01	.53647290E+00

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.16936960E+01	.73039070E+00
.10000000E+01	.39431320E-02	.34821500E-01

Erro maximo na banda 300 - 3400 Hz : +/- 0.692 dB

EQUALIZADOR DE ATRASO. SIMULADOR DE SECAO "A" - POSICAO 6

THE ERROR CRITERION USED IS MINIMUM 0 FOR THE MAGNITUDE AND
MINIMUM 4 FOR THE GROUP DELAY

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.77607500E-01	.14283290E+01
.35765520E+00	.17131440E+01
.62164460E+00	.16878580E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.77607500E-01	.70011870E+00
.35765520E+00	.58372220E+00
.62164460E+00	.59246690E+00

CONST= .58625160E-01

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.27721730E+01	.20401240E+01
.10000000E+01	-.14816400E+01	.29348610E+01
.10000000E+01	.12588830E+01	.28488650E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.13588250E+01	.49016620E+00
.10000000E+01	-.50484150E+00	.34073170E+00
.10000000E+01	.44188950E+00	.35101700E+00

 Erro maximo na banda 300 - 3400 Hz : +/- 0.071 ms

Simulacao de distorcao do tipo "F"

Essa distorcao, alem de forte, ocorre tanto em baixas como em altas frequencias, o que exige equalizadores de ordem mais elevada. Para as posicoes "1" a "6", as tabelas de coeficientes estao em anexo. Note que os desvios em relacao as curvas ideais sao da ordem de 0.030 a 0.106 ms, o que nao prejudica o desempenho do equalizador.

EQUALIZADOR DE ATRASO. SIMULACAO DE SECAO "F" - POSICAO 1

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.23479420E-01	.11228590E+01
.78561240E-01	.13331680E+01
.69745580E+00	.13039930E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.23479420E-01	.89058390E+00
.78561240E-01	.75009290E+00
.69745580E+00	.76687540E+00

CONST= .26243960E+00

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.22396110E+01	.12608120E+01
.10000000E+01	-.25855390E+01	.17773380E+01
.10000000E+01	.15160230E+01	.17003970E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.18036820E+01	.83888940E+00
.10000000E+01	-.12626030E+01	.49650390E+00
.10000000E+01	.18576070E+00	.11854060E-01

 Erro maximo na banda 300 - 3400 Hz : +/- 0.031 ms

EQUALIZADOR DE ATRASO. SIMULACAO DE SECAO "F" - POSICAO 2

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.55861640E-01	.10918110E+01
.91407250E-01	.11812540E+01
.14650850E+00	.14191840E+01
.66064110E+00	.13168370E+01
.72732060E+00	.12103910E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.55861640E-01	.91590910E+00
.91407250E-01	.84655770E+00
.14650850E+00	.70463030E+00
.66064110E+00	.75939520E+00
.72732060E+00	.82617960E+00

CONST= .11749660E+00

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.21500830E+01	.11920520E+01
.10000000E+01	-.22657660E+01	.13953620E+01
.10000000E+01	-.25429860E+01	.20140830E+01
.10000000E+01	.12734280E+01	.17340610E+01
.10000000E+01	.15855490E+01	.14650450E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.18036820E+01	.83888940E+00
.10000000E+01	-.16237840E+01	.71665990E+00
.10000000E+01	-.12626030E+01	.49650390E+00
.10000000E+01	.73436220E+00	.57668110E+00
.10000000E+01	.10822530E+01	.68257270E+00
.10000000E+01	.18576070E+00	.11854060E-01

 Erro maximo na banda 300 - 3400 Hz : +/- 0.040 ms

EQUALIZADOR DE ATRASO. SIMULACAO DE SECAO "F" - POSICAO 3

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.53163190E-01	.10714480E+01
.76693900E-01	.11249340E+01
.10865320E+00	.11808050E+01
.16376570E+00	.13444980E+01
.63835410E+00	.12365460E+01
.70076200E+00	.11379900E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.53163190E-01	.93331660E+00
.76693900E-01	.88894070E+00
.10865320E+00	.84688000E+00
.16376570E+00	.74377220E+00
.63835410E+00	.80870440E+00
.70076200E+00	.87874280E+00

CONST= .13792100E+00

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.21130770E+01	.11480000E+01
.10000000E+01	-.21848790E+01	.12654780E+01
.10000000E+01	-.22253580E+01	.13943000E+01
.10000000E+01	-.23408950E+01	.18076740E+01
.10000000E+01	.10414060E+01	.15290450E+01
.10000000E+01	.13421910E+01	.12950200E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.18406590E+01	.87107990E+00
.10000000E+01	-.17265250E+01	.79021560E+00
.10000000E+01	-.15960400E+01	.71720580E+00
.10000000E+01	-.12949760E+01	.55319710E+00
.10000000E+01	.68108270E+00	.65400280E+00
.10000000E+01	.10364250E+01	.77218880E+00
.10000000E+01	.18576070E+00	.11854060E-01

 Erro maximo na banda 300 - 3400 Hz : +/- 0.057 ms

EQUALIZADOR DE ATRASO. SIMULACAO DE SECAO "F" - POSICAO 4

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.57368170E-01	.10510220E+01
.77803320E-01	.10819750E+01
.10401540E+00	.11213490E+01
.14116760E+00	.11941270E+01
.20266970E+00	.13898110E+01
.63205250E+00	.12653770E+01
.67815480E+00	.12133140E+01
.70886310E+00	.11343360E+01

Z PLANE POLES

.57368170E-01	.95145510E+00
.77803320E-01	.92423590E+00
.10401540E+00	.89178340E+00
.14116760E+00	.83743210E+00
.20266970E+00	.71952250E+00
.63205250E+00	.79027860E+00
.67815480E+00	.82418870E+00
.70886310E+00	.88157290E+00

CONST= .73617180E-01

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.20679970E+01	.11046470E+01
.10000000E+01	-.20996290E+01	.11706700E+01
.10000000E+01	-.21240200E+01	.12574230E+01
.10000000E+01	-.21572120E+01	.14259380E+01
.10000000E+01	-.22349790E+01	.19315730E+01
.10000000E+01	.10200390E+01	.16011780E+01
.10000000E+01	.12883540E+01	.14721320E+01
.10000000E+01	.13840740E+01	.12867180E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.18720890E+01	.90526680E+00
.10000000E+01	-.17935280E+01	.85421200E+00
.10000000E+01	-.16891850E+01	.79527750E+00
.10000000E+01	-.15128360E+01	.70129260E+00
.10000000E+01	-.11570770E+01	.51771270E+00
.10000000E+01	.63705550E+00	.62454020E+00
.10000000E+01	.87516200E+00	.67928700E+00
.10000000E+01	.10756620E+01	.77717080E+00
.10000000E+01	.18576070E+00	.11854060E-01

 Erro maximo na banda 300 - 3400 Hz : +/- 0.036 ms

EQUALIZADOR DE ATRASO. SIMULACAO DE SECAO "F" - POSICAO 5

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.58173410E-01	.10401790E+01
.73906160E-01	.10648390E+01
.94931490E-01	.10881310E+01
.12166370E+00	.11250050E+01
.16082110E+00	.11939070E+01
.22643140E+00	.13870270E+01
.62862180E+00	.12607650E+01
.67120650E+00	.12465310E+01
.71192690E+00	.11818110E+01
.70461270E+00	.11460120E+01

Z PLANE POLES

.58173410E-01	.96137330E+00
.73906160E-01	.93910870E+00
.94931490E-01	.91900690E+00
.12166370E+00	.88888500E+00
.16082110E+00	.83758630E+00
.22643140E+00	.72096660E+00
.62862180E+00	.79316900E+00
.67120650E+00	.80222630E+00
.71192690E+00	.84615900E+00
.70461270E+00	.87259140E+00

CONST= .43780940E-01

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.20457120E+01	.10819720E+01
.10000000E+01	-.20725320E+01	.11338830E+01
.10000000E+01	-.20801940E+01	.11840290E+01
.10000000E+01	-.20876480E+01	.12656360E+01
.10000000E+01	-.20894830E+01	.14254140E+01
.10000000E+01	-.21012840E+01	.19238430E+01
.10000000E+01	.99139180E+00	.15895290E+01
.10000000E+01	.12771960E+01	.15538400E+01
.10000000E+01	.14599600E+01	.13966770E+01
.10000000E+01	.13739460E+01	.13133430E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.18907260E+01	.92423870E+00
.10000000E+01	-.18278180E+01	.88192510E+00
.10000000E+01	-.17568770E+01	.84457370E+00
.10000000E+01	-.16494850E+01	.79011650E+00
.10000000E+01	-.14658780E+01	.70155080E+00
.10000000E+01	-.10922320E+01	.51979290E+00
.10000000E+01	.62370150E+00	.62911710E+00
.10000000E+01	.82196150E+00	.64356700E+00
.10000000E+01	.10453090E+01	.71598500E+00
.10000000E+01	.10461440E+01	.76141580E+00

 Erro maximo na banda 300 - 3400 Hz : +/- 0.058 ms

EQUALIZADOR DE ATRASO. SIMULACAO DE SECAO "F" - POSICAO 6

Z PLANE ZEROS

Z PLANE POLES

ANGLE/2PI*FS

RADIUS

RADIUS

.57736240E-01	.10431230E+01	.95865970E+00
.61244570E-01	.10551930E+01	.94769380E+00
.78806180E-01	.10597990E+01	.94357480E+00
.98655420E-01	.10783570E+01	.92733680E+00
.12562140E+00	.11028770E+01	.90671940E+00
.16378440E+00	.11549930E+01	.86580630E+00
.22755600E+00	.12884020E+01	.77615540E+00
.66581570E+00	.11667280E+01	.85709790E+00
.62018730E+00	.12258350E+01	.81577050E+00
.73659820E+00	.13141840E+01	.76092860E+00
.69778280E+00	.10943510E+01	.91378350E+00
.73386320E+00	.11208070E+01	.89221440E+00

CONST= .44145540E-01

NUMERATOR COEFFICIENTS

A0

A1

A2

.10000000E+01	-.20520210E+01	.10881060E+01
.10000000E+01	-.20714440E+01	.11134330E+01
.10000000E+01	-.20549700E+01	.11231750E+01
.10000000E+01	-.20539540E+01	.11628540E+01
.10000000E+01	-.20361990E+01	.12163380E+01
.10000000E+01	-.20108820E+01	.13340080E+01
.10000000E+01	-.19459160E+01	.16599790E+01
.10000000E+01	.11613210E+01	.13612540E+01
.10000000E+01	.90386150E+00	.15026710E+01
.10000000E+01	.17786630E+01	.17270790E+01
.10000000E+01	.12741220E+01	.11976040E+01
.10000000E+01	.15027040E+01	.12562080E+01

DENOMINATOR COEFFICIENTS

B0

B1

B2

.10000000E+01	-.18858660E+01	.91902850E+00
.10000000E+01	-.18604120E+01	.89812340E+00
.10000000E+01	-.18296090E+01	.89033350E+00
.10000000E+01	-.17663040E+01	.85995350E+00
.10000000E+01	-.16740410E+01	.82214000E+00
.10000000E+01	-.15073990E+01	.74962050E+00
.10000000E+01	-.11722530E+01	.60241710E+00
.10000000E+01	.85312620E+00	.73461690E+00
.10000000E+01	.60150310E+00	.66548150E+00
.10000000E+01	.10298680E+01	.57901230E+00
.10000000E+01	.10638920E+01	.83500030E+00
.10000000E+01	.11962220E+01	.79604640E+00

 Erro maximo na banda 300 - 3400 Hz : +/- 0.105 ms

Simulacao de distorcao do tipo "C"

As curvas do tipo "C" tem a vantagem de serem exatamente proporcionais. Assim, o atraso na posicao "6" e o dobro do atraso da posicao "3", etc. Portanto, apenas os equalizadores de ordem 1 a 3 foram projetados. Os outros podem ser obtidos por combinacoes: por exemplo, a tabela apresentada para a posicao "C-5" foi obtida pelo uso dos polos e dos zeros dos simuladores das secoes "2" e "3".

Note que os erros de aproximacao sao muito pequenos, ficando entre ± 0.013 ms e ± 0.082 ms.

EQUALIZADOR DE ATRASO. SIMULACAO DE SECAO "C" - POSICAO 1

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.61320480E+00	.17214640E+01
.72282560E+00	.13480590E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.61320480E+00	.58090080E+00
.72282560E+00	.74180700E+00

CONST= .18568890E+00

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	.11988050E+01	.29634390E+01
.10000000E+01	.17369440E+01	.18172640E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	.40453180E+00	.33744570E+00
.10000000E+01	.95580160E+00	.55027770E+00

 Erro maximo na banda 300 - 3400 Hz : +/- 0.013 ms

EQUALIZADOR DE ATRASO. SIMULACAO DE SECAO "C" - POSICAO 2

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.54193190E+00	.16066160E+01
.63429790E+00	.13466380E+01
.70577700E+00	.11841400E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.54193190E+00	.62242650E+00
.63429790E+00	.74259020E+00
.70577700E+00	.84449470E+00

CONST= .15235910E+00

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	.42206500E+00	.25812130E+01
.10000000E+01	.11029050E+01	.18134330E+01
.10000000E+01	.14265820E+01	.14021880E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	.16351420E+00	.38741470E+00
.10000000E+01	.60818610E+00	.55144030E+00
.10000000E+01	.10173980E+01	.71317130E+00

 Erro maximo na banda 300 - 3400 Hz : +/- 0.022 ms

EQUALIZADOR DE ATRASO. SIMULACAO DE SECAO "C" - POSICAO 3

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.48998850E+00	.15943870E+01
.58312330E+00	.12972170E+01
.65537270E+00	.12043600E+01
.70509210E+00	.11258510E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.48998850E+00	.62720030E+00
.58312330E+00	.77088120E+00
.65537270E+00	.83031660E+00
.70509210E+00	.88821710E+00

CONST= .12714900E+00

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.10027680E+00	.25420700E+01
.10000000E+01	.66983540E+00	.16827710E+01
.10000000E+01	.11296040E+01	.14504830E+01
.10000000E+01	.13524890E+01	.12675400E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.39446890E-01	.39338020E+00
.10000000E+01	.39805490E+00	.59425780E+00
.10000000E+01	.77877760E+00	.68942560E+00
.10000000E+01	.10670180E+01	.78892960E+00

 Erro maximo na banda 300 - 3400 Hz : +/- 0.041 ms

EQUALIZADOR DE ATRASO. SIMULACAO DE SECAO "C" - POSICAO 4

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.54193190E+00	.16066160E+01
.63429790E+00	.13466380E+01
.70577700E+00	.11841400E+01
.54193190E+00	.16066160E+01
.63429790E+00	.13466380E+01
.70577700E+00	.11841400E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.54193190E+00	.62242650E+00
.63429790E+00	.74259020E+00
.70577700E+00	.84449470E+00
.54193190E+00	.62242650E+00
.63429790E+00	.74259020E+00
.70577700E+00	.84449470E+00

CONST= .23213295E-01

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	.42206500E+00	.25812130E+01
.10000000E+01	.11029050E+01	.18134330E+01
.10000000E+01	.14265820E+01	.14021880E+01
.10000000E+01	.42206500E+00	.25812130E+01
.10000000E+01	.11029050E+01	.18134330E+01
.10000000E+01	.14265820E+01	.14021880E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	.16351420E+00	.38741470E+00
.10000000E+01	.60818610E+00	.55144030E+00
.10000000E+01	.10173980E+01	.71317130E+00
.10000000E+01	.16351420E+00	.38741470E+00
.10000000E+01	.60818610E+00	.55144030E+00
.10000000E+01	.10173980E+01	.71317130E+00

 Erro maximo na banda 300 - 3400 Hz : +/- 0.044 ms

EQUALIZADOR DE ATRASO. SIMULACAO DE SECAO "C" - POSICAO 5

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.48998850E+00	.15943870E+01
.58312330E+00	.12972170E+01
.65537270E+00	.12043600E+01
.70509210E+00	.11258510E+01
.54193190E+00	.16066160E+01
.63429790E+00	.13466380E+01
.70577700E+00	.11841400E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.48998850E+00	.62720030E+00
.58312330E+00	.77088120E+00
.65537270E+00	.83031660E+00
.70509210E+00	.88821710E+00
.54193190E+00	.62242650E+00
.63429790E+00	.74259020E+00
.70577700E+00	.84449470E+00

CONST= .19372307E-01

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.10027680E+00	.25420700E+01
.10000000E+01	.66983540E+00	.16827710E+01
.10000000E+01	.11296040E+01	.14504830E+01
.10000000E+01	.13524890E+01	.12675400E+01
.10000000E+01	.42206500E+00	.25812130E+01
.10000000E+01	.11029050E+01	.18134330E+01
.10000000E+01	.14265820E+01	.14021880E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.39446890E-01	.39338020E+00
.10000000E+01	.39805490E+00	.59425780E+00
.10000000E+01	.77877760E+00	.68942560E+00
.10000000E+01	.10670180E+01	.78892960E+00
.10000000E+01	.16351420E+00	.38741470E+00
.10000000E+01	.60818610E+00	.55144030E+00
.10000000E+01	.10173980E+01	.71317130E+00

 Erro maximo na banda 300 - 3400 Hz : +/- 0.063 ms

EQUALIZADOR DE ATRASO. SIMULACAO DE SECAO "C" - POSICAO 6

Z PLANE ZEROS

ANGLE/2PI*FS	RADIUS
.48998850E+00	.15943870E+01
.58312330E+00	.12972170E+01
.65537270E+00	.12043600E+01
.70509210E+00	.11258510E+01
.48998850E+00	.15943870E+01
.58312330E+00	.12972170E+01
.65537270E+00	.12043600E+01
.70509210E+00	.11258510E+01

Z PLANE POLES

ANGLE/2PI*FS	RADIUS
.48998850E+00	.62720030E+00
.58312330E+00	.77088120E+00
.65537270E+00	.83031660E+00
.70509210E+00	.88821710E+00
.48998850E+00	.62720030E+00
.58312330E+00	.77088120E+00
.65537270E+00	.83031660E+00
.70509210E+00	.88821710E+00

CONST= .16166870E-01

NUMERATOR COEFFICIENTS

A0	A1	A2
.10000000E+01	-.10027680E+00	.25420700E+01
.10000000E+01	.66983540E+00	.16827710E+01
.10000000E+01	.11296040E+01	.14504830E+01
.10000000E+01	.13524890E+01	.12675400E+01
.10000000E+01	-.10027680E+00	.25420700E+01
.10000000E+01	.66983540E+00	.16827710E+01
.10000000E+01	.11296040E+01	.14504830E+01
.10000000E+01	.13524890E+01	.12675400E+01

DENOMINATOR COEFFICIENTS

B0	B1	B2
.10000000E+01	-.39446890E-01	.39338020E+00
.10000000E+01	.39805490E+00	.59425780E+00
.10000000E+01	.77877760E+00	.68942560E+00
.10000000E+01	.10670180E+01	.78892960E+00
.10000000E+01	-.39446890E-01	.39338020E+00
.10000000E+01	.39805490E+00	.59425780E+00
.10000000E+01	.77877760E+00	.68942560E+00
.10000000E+01	.10670180E+01	.78892960E+00

 Erro maximo na banda 300 - 3400 Hz : +/- 0.082 ms
