Lyd- og vibrasjonsfiltre i måleutstyr

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Veienettverk

- Filtre og veienettverk: Gradere vekten eller viktigheten til et signal basert på signalets frekvensinnhold.
- Frekvens = frekvens av sinusformet signal
- Sinussignal + Lineært system = sant
- A-nettverket historisk basert på likelydkurver.
- A-, B-, C kurve avhengig av nivå

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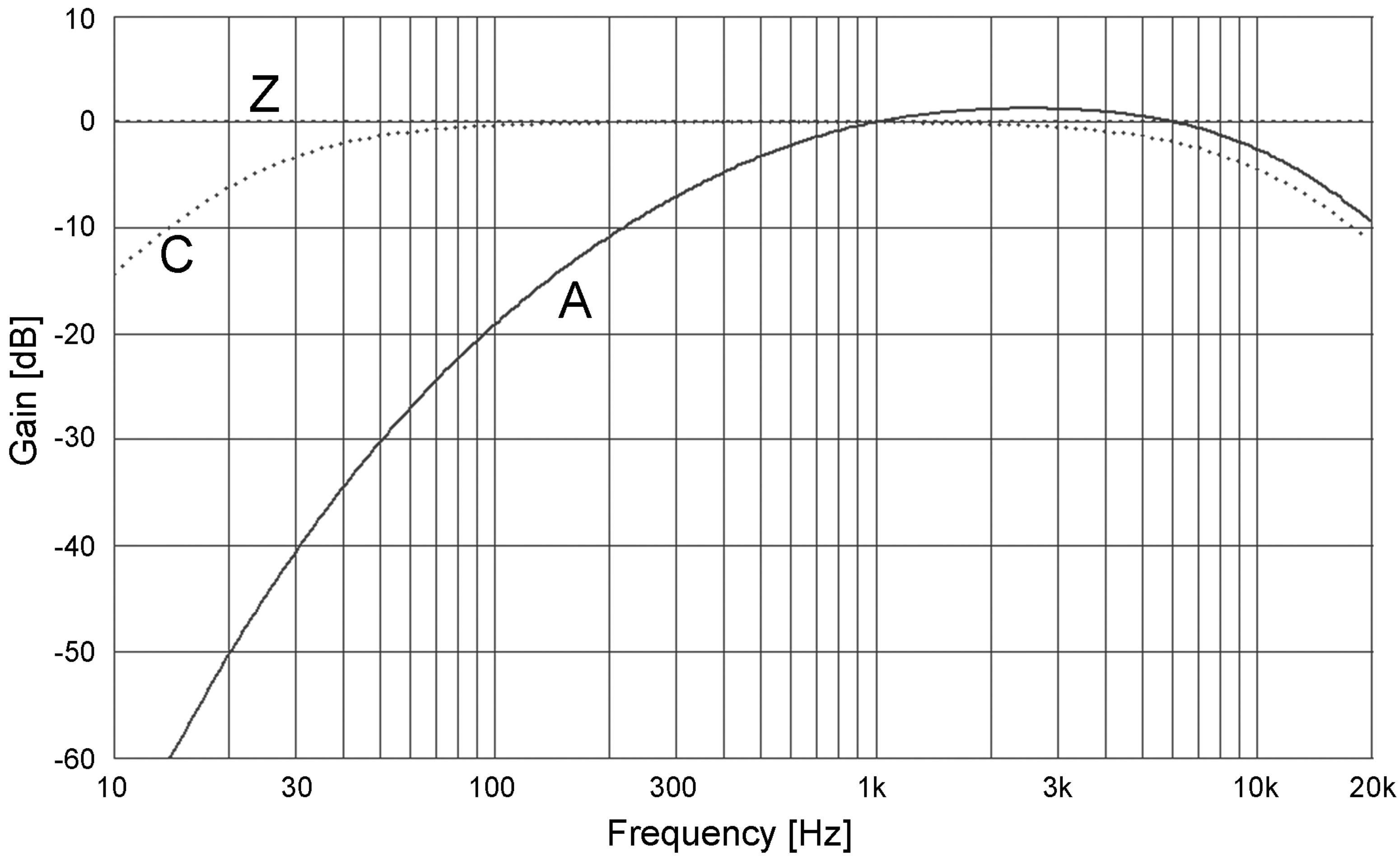
A-vekting

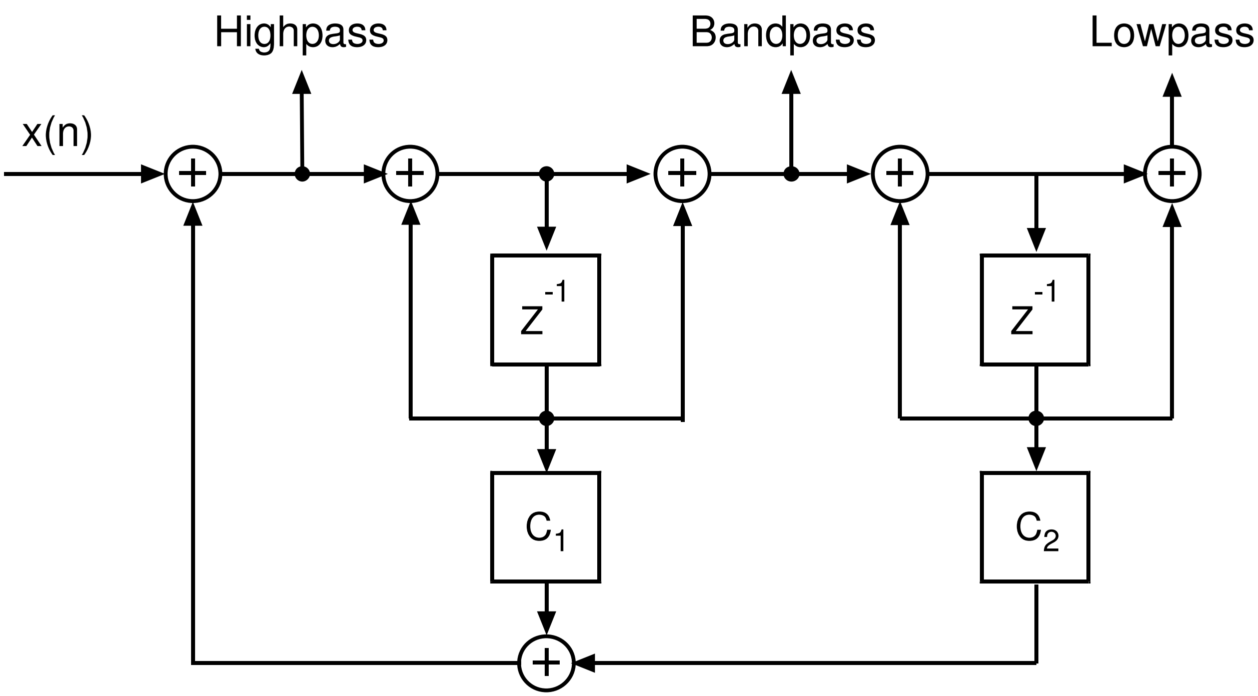
$$w_A(f) = K_A \frac{(f/f_1)^2}{1+(f/f_1)^2} \frac{f/f_2}{\sqrt{1+(f/f_2)^2}} \frac{f/f_3}{\sqrt{1+(f/f_3)^2}} \frac{1}{1+(f/f_4)^2}$$

K_A = 1.258905
f1 = 20.60 Hz
f2 = 107.7 Hz
f3 = 737.9 Hz
f4 = 12194 Hz

Veienettverk for lyd



2. ordens generelt nettverk



Del-oktav filtre

$$f_L = f_m \cdot 10^{\frac{-3}{20 \cdot b}}$$

$$f_H = f_m \cdot 10^{\frac{3}{20 \cdot b}}$$

For oktav filter: b=1

$$\frac{f_H}{f_L} = 10^{\frac{3}{10}} = 1.995... \approx 2$$

Midtfrekvens for del-oktav filtre

$$f_m = f_R \cdot 10^{\frac{3x}{10b}} \quad \text{if b is odd}$$

$$f_m = f_R \cdot 10^{\frac{3(2x+1)}{20 \cdot b}} \quad \text{if b is even}$$

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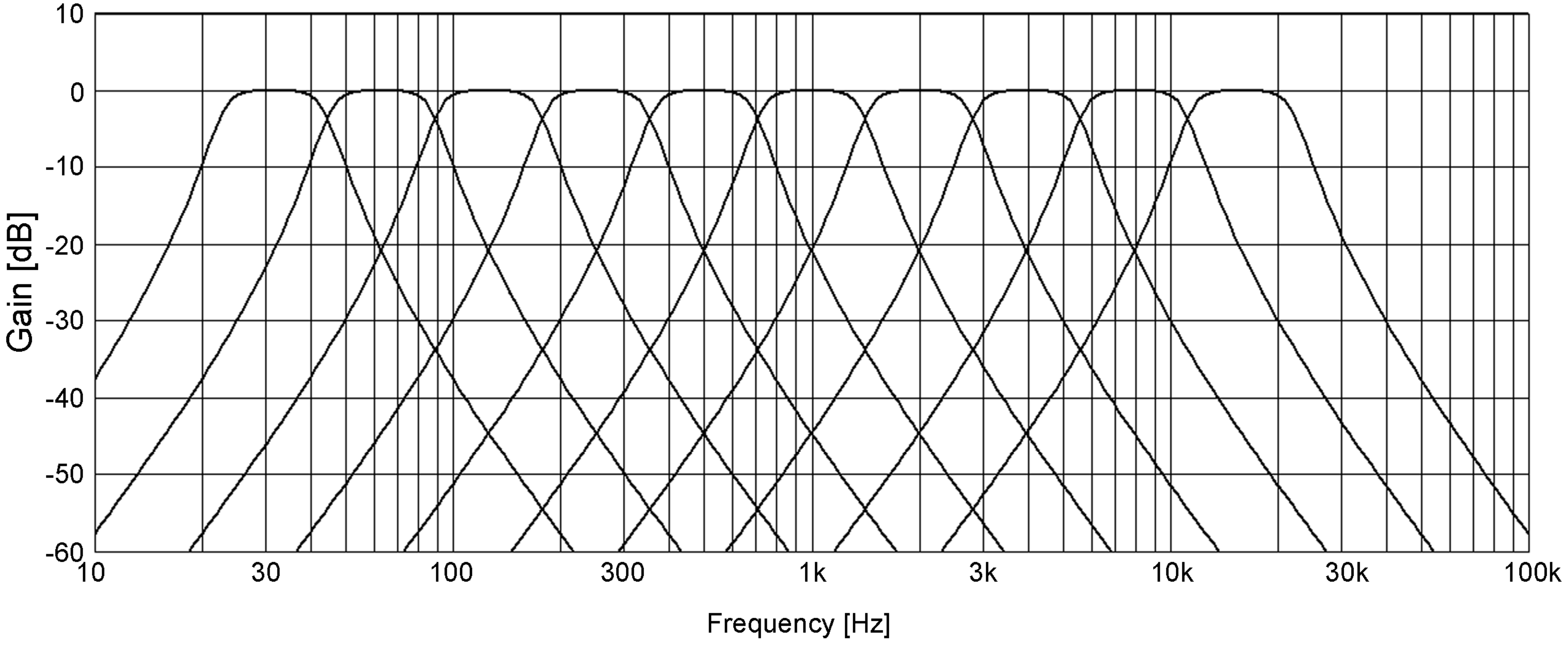
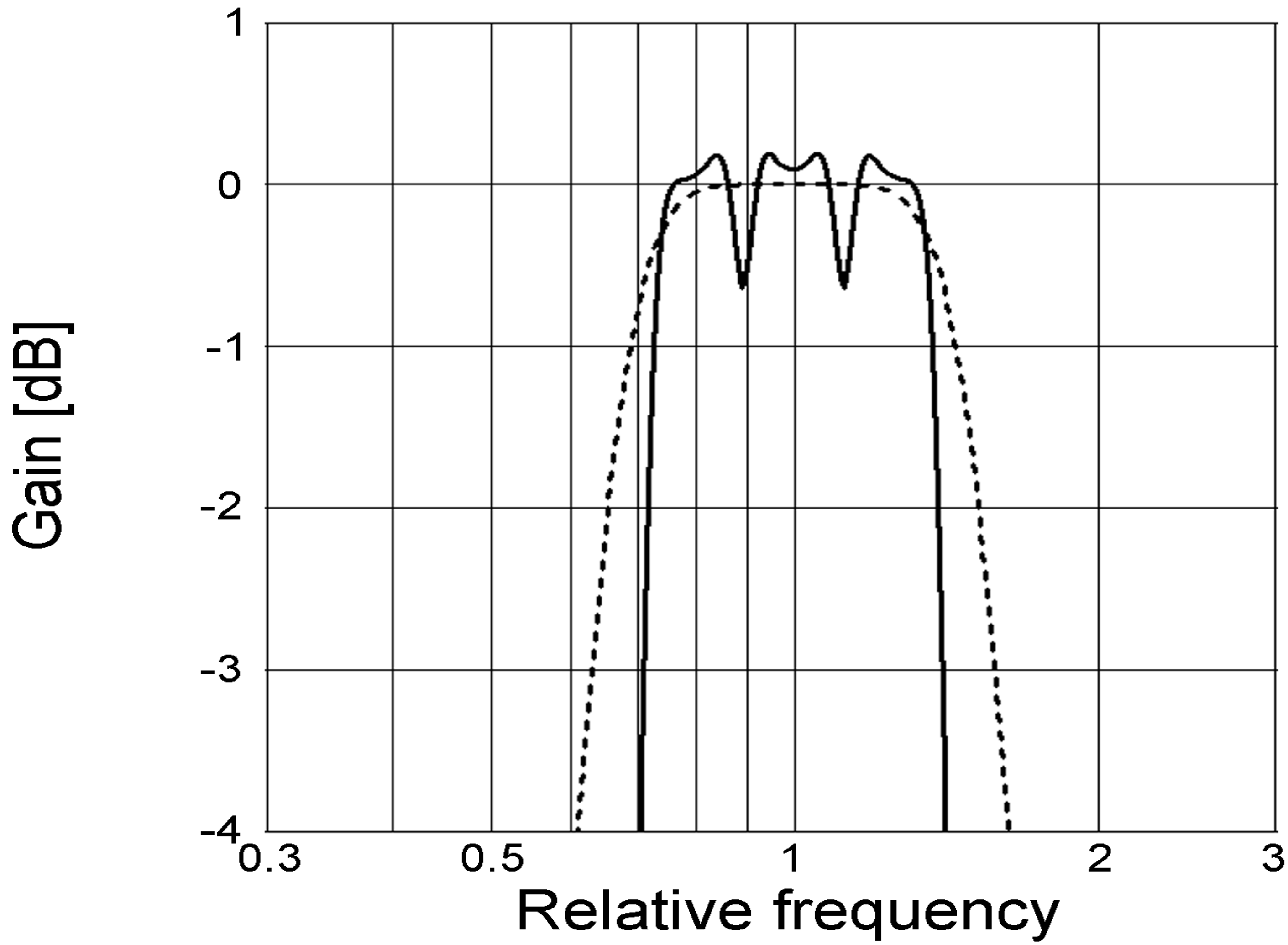
Oktavfiltre



Effektsum av tre 1/3-oktav filtre



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Midtfrekvens for 1/3-oktav filtre

Nominal and exact (rounded) frequencies in the range 1 kHz to 10 kHz for one-third octave band filters		
Designation [kHz]	x	Exact [kHz]
1	0	1.000000
1.25	1	1.258925
1.6	2	1.584893
2	3	1.995262
2.5	4	2.511886
3.15	5	3.162278
4	6	3.981072
5	7	5.011872
6.3	8	6.309573
8	9	7.943282
10	10	10.000000

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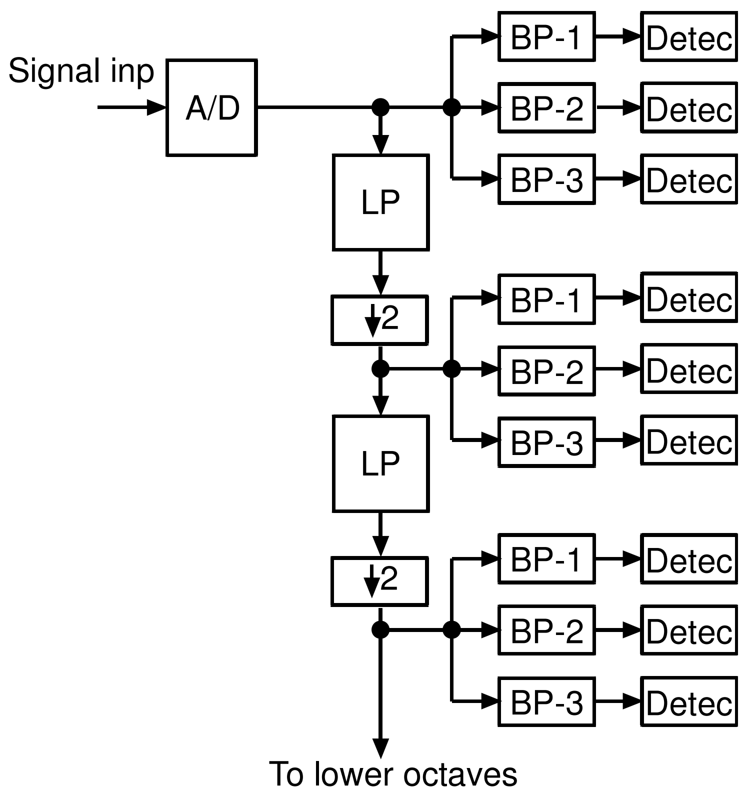
1/3-oktav frekvensanalyse



$$C\left(1+\tfrac{1}{2}+\tfrac{1}{4}+\tfrac{1}{8}+\cdots\right)=2C$$

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Power Spectral density

$$PSD = \frac{p}{\sqrt{f_m \cdot (10^{\frac{3}{20 \cdot b}} - 10^{\frac{-3}{20 \cdot b}})}}$$

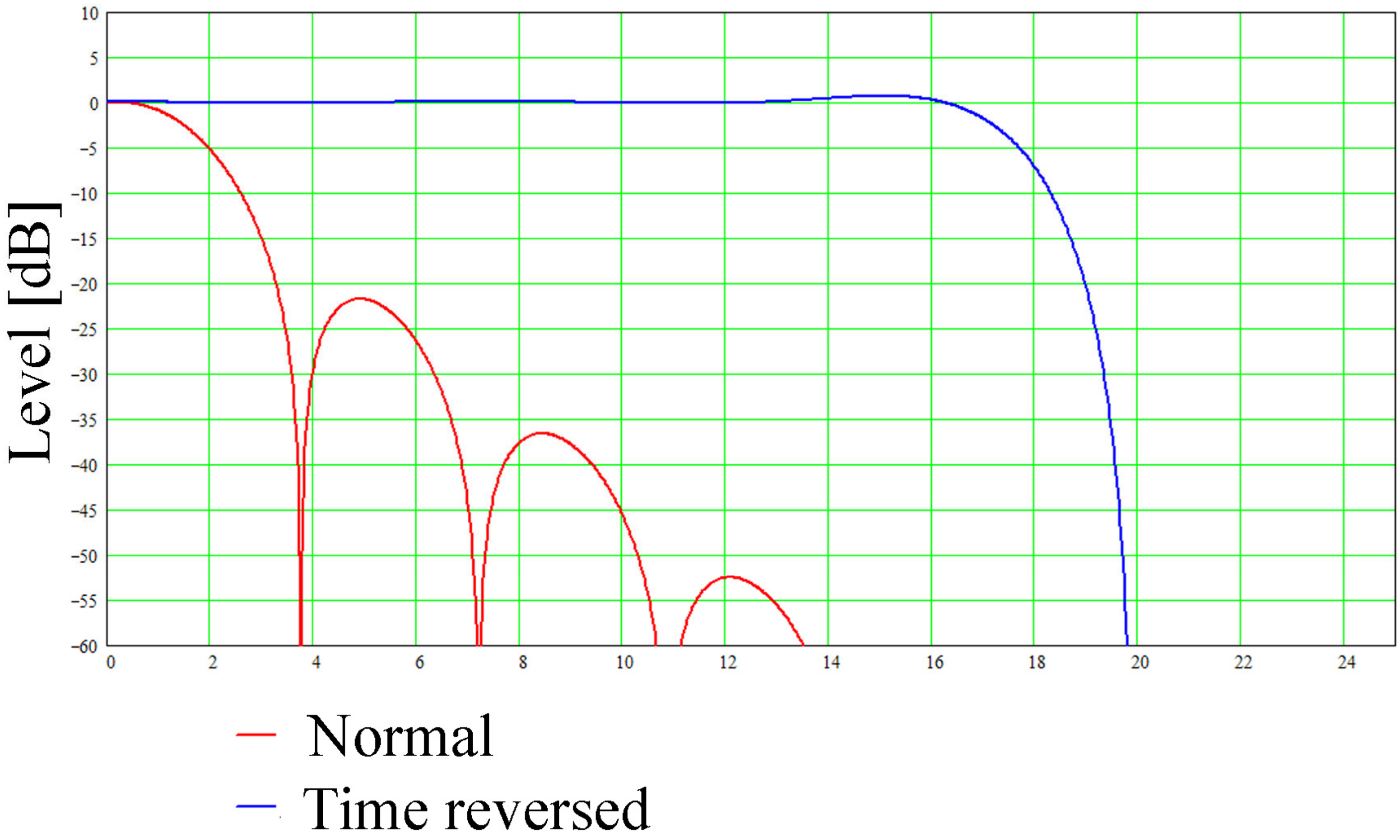
Tidsoppløsning

$$\Delta f \cdot \Delta t \geq 2\pi$$

Etterklang:

T60 ≥ 16/B.

Tidsreversert IIR filter



Parcevals teorem

$$\int_{-\infty}^{\infty} x^2(t)dt = \tfrac{1}{2\pi}\int_{-\infty}^{\infty} \left|X(\omega)\right|^2 d\omega$$

$$\int_{-\infty}^{\infty} x^2(t)dt = \tfrac{1}{2\pi}\sum_n \left\{ \int_{-\omega_{n+1}}^{-\omega_n} \left|X(\omega)\right|^2 d\omega + \int_{\omega_n}^{\omega_{n+1}} \left|X(\omega)\right|^2 d\omega \right\} = \sum_n \int_{-\infty}^{\infty} x_{w_n}{}^2(t)dt$$

Veiet response fra frekvensanalyse

$$L_w = 10\log\left\{\sum_n w^2[f_m(n)] \cdot 10^{\frac{L_n}{10}}\right\} = 10\log\left\{\sum_n 10^{\frac{L_n + L_{weight}(f_m(n))}{10}}\right\}$$

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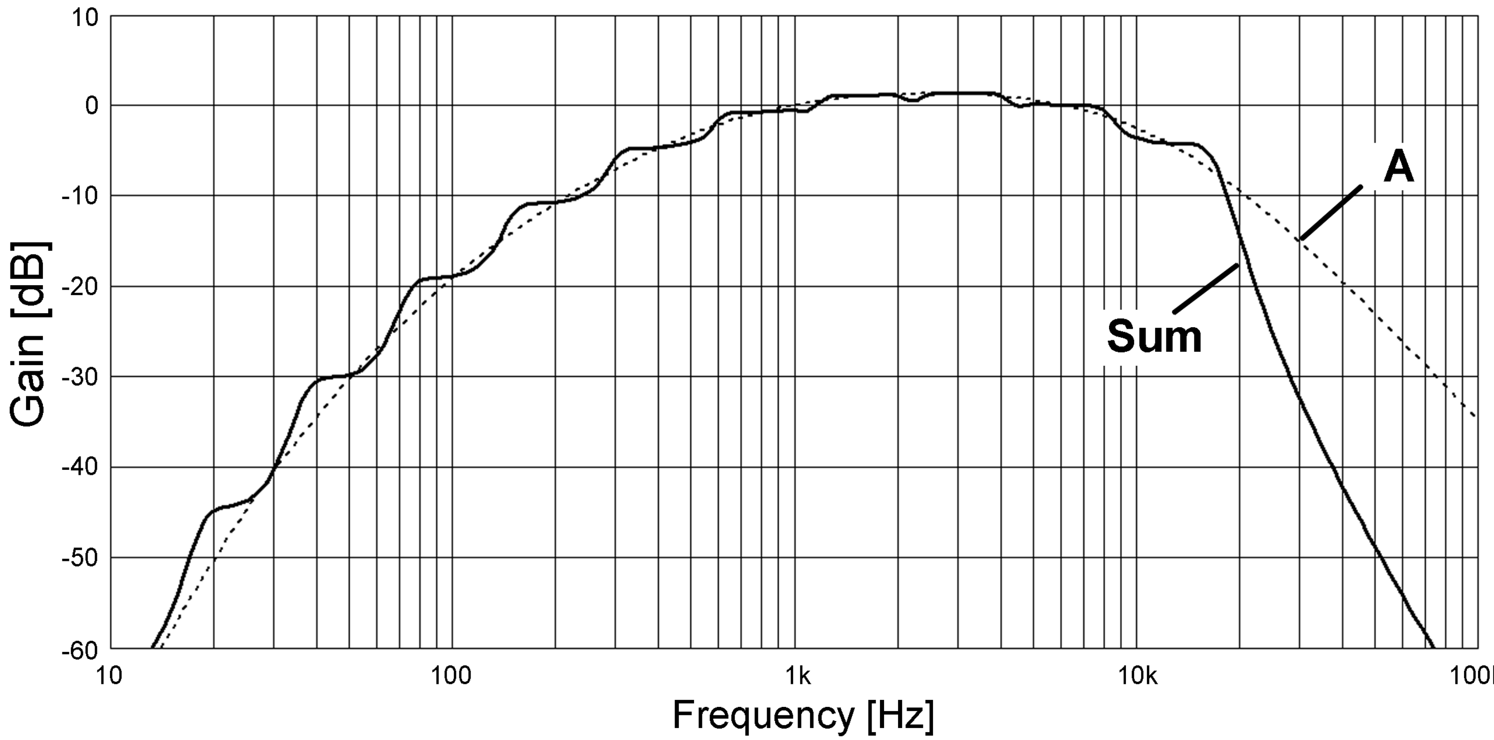
A-veiet oktavbasert



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Vibrasjonsmåling

$$a(t) = A_0 \sin(2\pi f t)$$

$$v(t) = \int_{-\infty}^{t} a(\tau)\,d\tau = -\frac{A_0}{2\pi f}\cos(2\pi f t) = V_0 \cos(2\pi f t)$$

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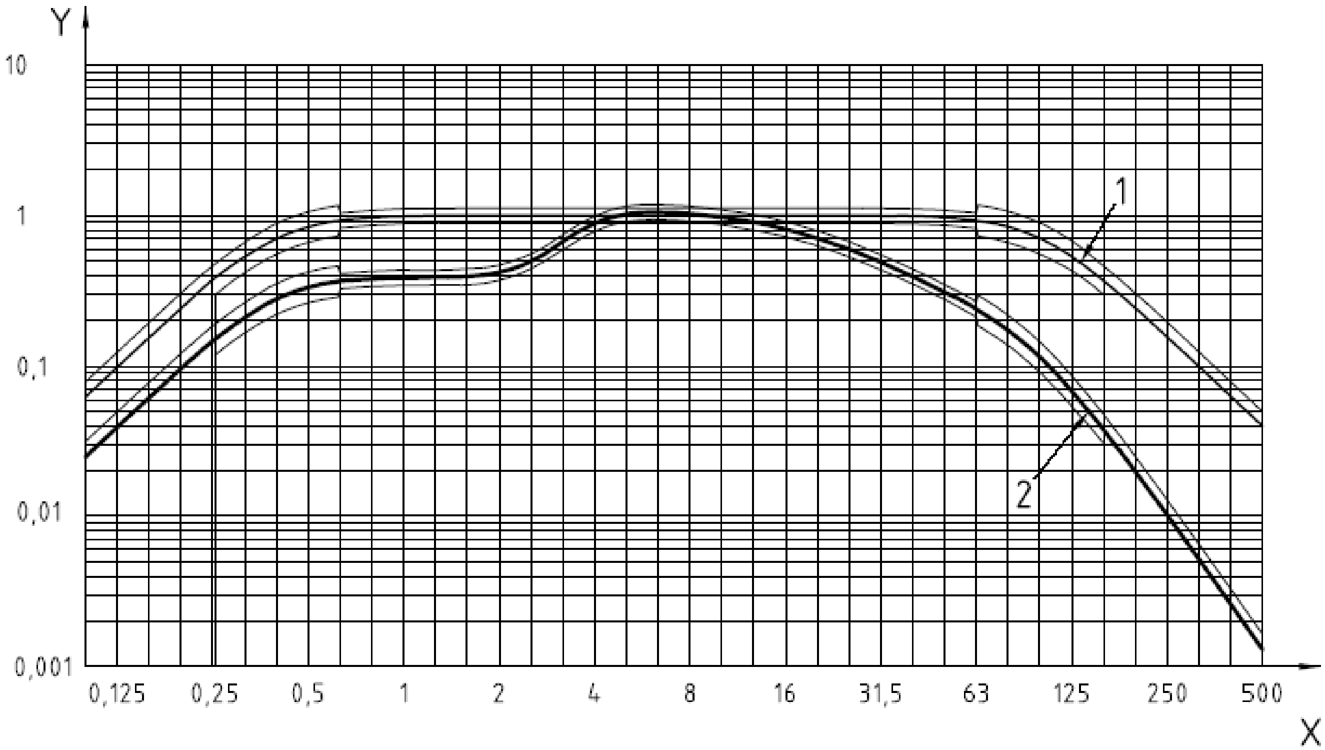
ISO 8041



Key

X frequency, Hz

Y weighting factor

1 band-limiting

2 weighting

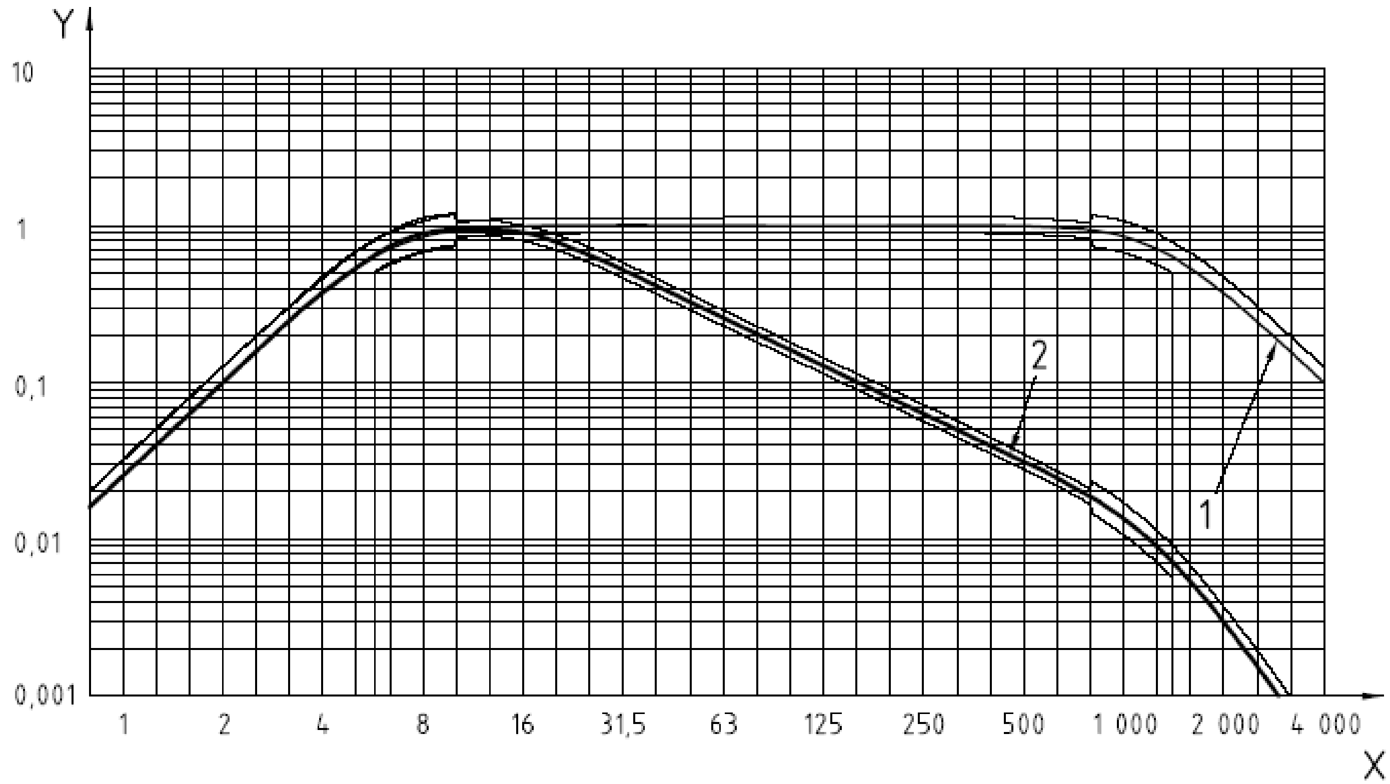
Figure B.1 — Magnitude of frequency weighting W_b for vertical whole-body vibration, z-axis, seated, standing or recumbent person, based on ISO 2631-4

ISO 8041

Table B.1 — Frequency weighting W_b for vertical whole-body vibration, z-axis, seated, standing or recumbent person, based on ISO 2631-4

n	Frequency Hz		Band-limiting			Weighting W_b			Tolerance		
	Nominal	True	Factor	dB	Phase degrees	Factor	dB	Phase degrees	%	dB	$\Delta\varphi_0$ degrees
−10	0,1	0,1	0,062 38	−24,10	159,3	0,024 94	−32,06	160	+26/−100	+2/−∞	+∞/−∞
−9	0,125	0,125 9	0,098 57	−20,12	153,6	0,039 41	−28,09	154,5	+26/−100	+2/−∞	+∞/−∞
−8	0,16	0,158 5	0,155 1	−16,19	146,3	0,061 98	−24,15	147,4	+26/−100	+2/−∞	+∞/−∞
−7	0,2	0,199 5	0,241 5	−12,34	136,6	0,096 45	−20,31	138,1	+26/−100	+2/−∞	+∞/−∞
−6	0,25	0,251 2	0,366 9	−8,71	124,1	0,146 4	−16,69	126	+26/−100	+2/−∞	+∞/−∞
−5	0,315	0,316 2	0,53	−5,51	108,3	0,211 3	−13,50	110,7	+26/−21	+2/−2	+12/−12
−4	0,4	0,398 1	0,703 7	−3,05	90,06	0,28	−11,06	93,14	+26/−21	+2/−2	+12/−12
−3	0,5	0,501 2	0,843 4	−1,48	71,76	0,334 7	−9,51	75,73	+26/−21	+2/−2	+12/−12
−2	0,63	0,631	0,927 9	−0,65	55,78	0,366 6	−8,72	60,94	+12/−11	+1/−1	+6/−6
−1	0,8	0,794 3	0,969 3	−0,27	43,01	0,380 8	−8,39	49,84	+12/−11	+1/−1	+6/−6
0	1	1	0,987 4	−0,11	33,15	0,385 3	−8,29	42,42	+12/−11	+1/−1	+6/−6
1	1,25	1,259	0,994 9	−0,04	25,54	0,386 4	−8,26	38,51	+12/−11	+1/−1	+6/−6
2	1,6	1,585	0,998	−0,02	19,58	0,391 6	−8,14	38,27	+12/−11	+1/−1	+6/−6
3	2	1,995	0,999 2	−0,01	14,84	0,416 8	−7,60	41,76	+12/−11	+1/−1	+6/−6
4	2,5	2,512	0,999 7	0,00	10,97	0,496	−6,09	46,57	+12/−11	+1/−1	+6/−6

ISO 8041



Key

X frequency, Hz

Y weighting factor

1 band-limiting

2 weighting

Figure B.11 — Magnitude of frequency weighting W_h for hand-arm vibration, all directions, based on ISO 5349-1

Persepsjonskoding

- Filtre for persepsjonskoding har ofte båndbredde som tisvarer kritisk båndbredde for vårt hørselsystem (100 Hz; 15%)
- Frekvens- og tids-maskering
- Koding reduserer kopasitetsbehovet til 5 – 10%
- Vanlige formater: MP3, WMA, ATRAC ....(>100)

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Fraksjonelle oktavfiltre

- Ingen store endringer i ”design goal”
- Inkludere måleusikkerhet i spesifisering og verifisering
- Beskrive typetesting og periodisk verifisering
- Åpne mulighet for overensstemmelseserklæring

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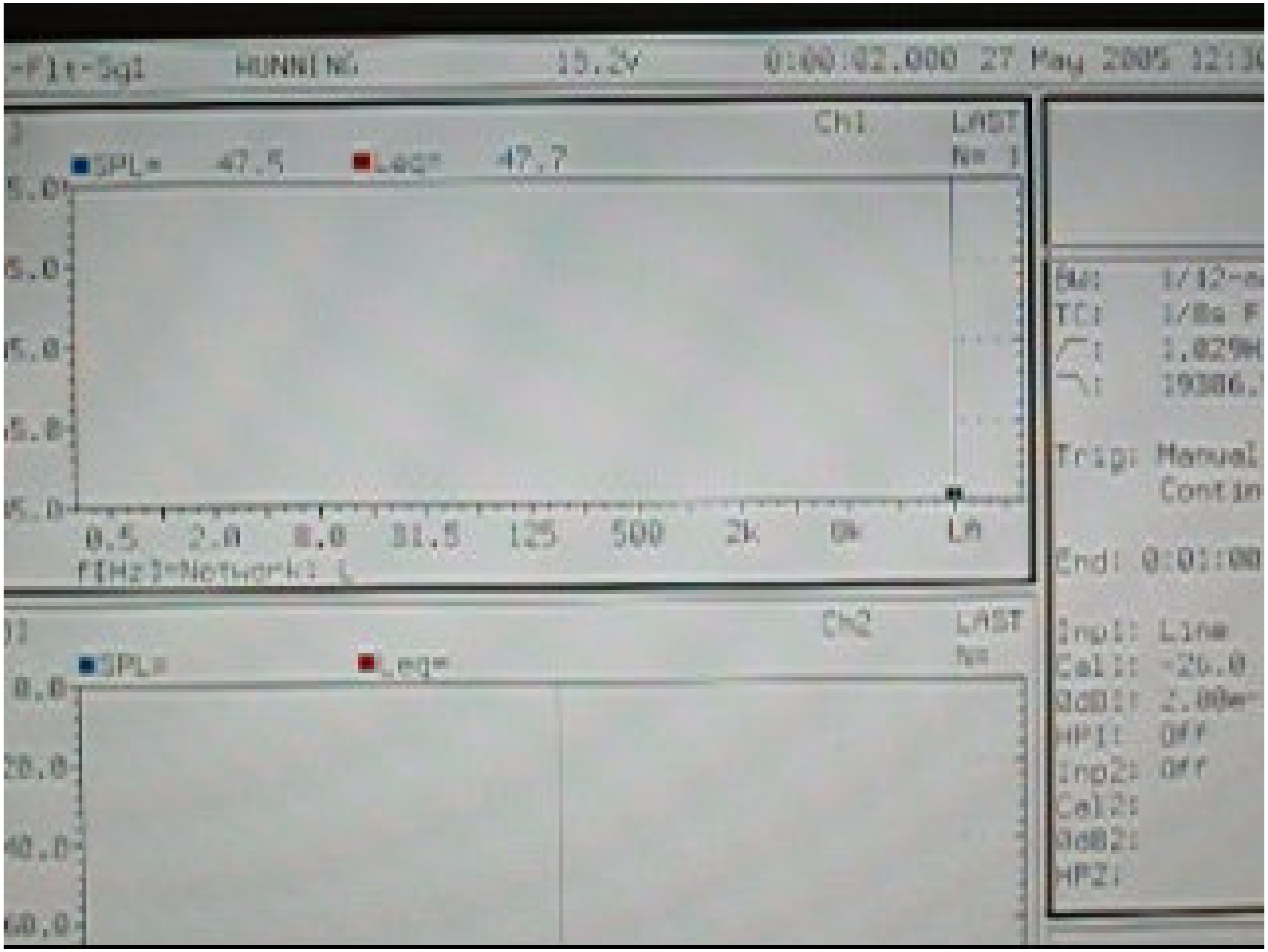
Swept-sine test



Swept-sine test

$$L_{out} := L_{in} - A_{ref} + 10 \cdot \log\left(\frac{T_{sweep}}{Tavg} \cdot \frac{\log\left(\frac{f_2}{f_1}\right)}{\log\left(\frac{f_{end}}{f_{start}}\right)}\right)$$

Bandwidth: 1/12 octave
Measurement time: 60 sec.
Frequency range:

Time-invariant operation: 1,029Hz – 4869,7 Hz (146 bands)
Level measured: 86,6 dB (+0,2/-0,1 dB)
Level calculated: 86,66 dB

SLUTT

Takk for oppmerksomheten!

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