Audio Bass and Treble Filters for SoftWave

February 5, 1994

$fc := 0.2 \cdot \frac{\pi}{2}$ $\sigma := \frac{\sqrt{2}}{2}$

$a := \tan\left[\frac{1}{2} \cdot \left(fc - \frac{\pi}{2}\right)\right]$ $a = -0.727$

$A := 0.25$ $F := \text{if}(A > 1, A \cdot 0.707, A \cdot 1.414)$

$\gamma d := \left(\frac{F^2 - 1}{A^2 - F^2}\right)^{0.25}$ $\gamma d = 1.935$

$\gamma n := \sqrt{A} \cdot \left(\frac{F^2 - 1}{A^2 - F^2}\right)^{0.25}$ $\gamma n = 0.967$

$20 \cdot \log\left(\frac{\gamma n}{\gamma d}\right) = -6.021$ dB

$n1 := 1 + 2 \cdot \sigma \cdot \gamma n + \gamma n^2$ $n3 := 1 - 2 \cdot \sigma \cdot \gamma n + \gamma n^2$

$n2 := -2 \cdot \left(1 - \gamma n^2\right)$

$d1 := 1 + 2 \cdot \sigma \cdot \gamma d + \gamma d^2$ $d3 := 1 - 2 \cdot \sigma \cdot \gamma d + \gamma d^2$

$d2 := -2 \cdot \left(1 - \gamma d^2\right)$

$$T(\rho) := \frac{n1 + n2 \cdot \rho^{-1} + n3 \cdot \rho^{-2}}{d1 + d2 \cdot \rho^{-1} + d3 \cdot \rho^{-2}}$$

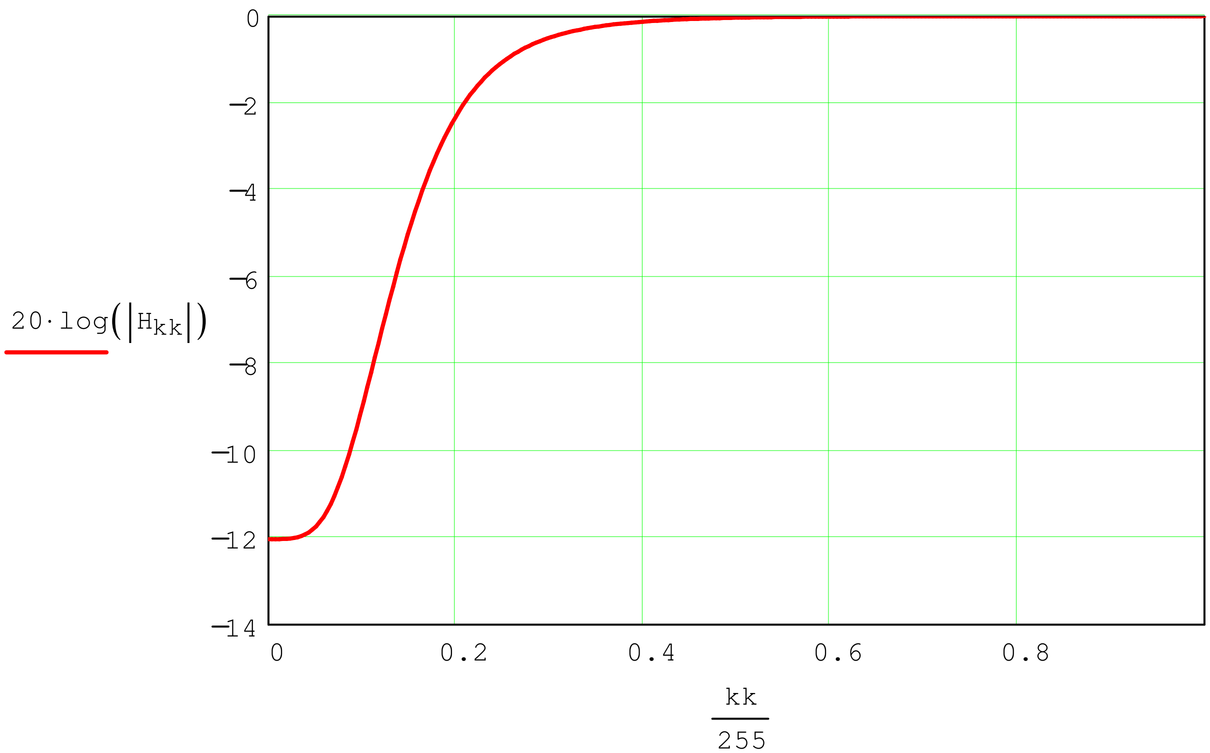
$kk := 0 .. 255$

$f_{kk} := \frac{kk \cdot \pi}{255}$ $jx := \sqrt{-1}$

$zf_{kk} := \cos\left(f_{kk}\right) + jx \cdot \sin\left(f_{kk}\right)$

$$cm_{kk} := \frac{a + (zf_{kk})^{-1}}{1 + a \cdot (zf_{kk})^{-1}}$$

$$H_{kk} := T(cm_{kk})$$



Check substitution results:

Lowpass Shelving Filter

$$nx1 := n1 \cdot a^2 + n2 \cdot a + n3$$

$$nx2 := 2 \cdot a \cdot n1 + n2 \cdot a^2 + 2 \cdot a \cdot n3 + n2$$

$$nx3 := n1 + a \cdot n2 + n3 \cdot a^2$$

$$dx1 := d1 \cdot a^2 + d2 \cdot a + d3$$

$$dx2 := 2 \cdot a \cdot d1 + d2 \cdot a^2 + d2 + 2 \cdot a \cdot d3$$

$$dx3 := d1 + d2 \cdot a + d3 \cdot a^2$$

$nx1 = 2.405$

$nx2 = -5.822$

$nx3 = 3.697$

$dx1 = 1.969$

$dx2 = -5.402$

$dx3 = 4.553$

$$P(z) := \frac{nx1 + nx2\cdot z^{-1} + nx3\cdot z^{-2}}{dx1 + dx2\cdot z^{-1} + dx3\cdot z^{-2}}$$

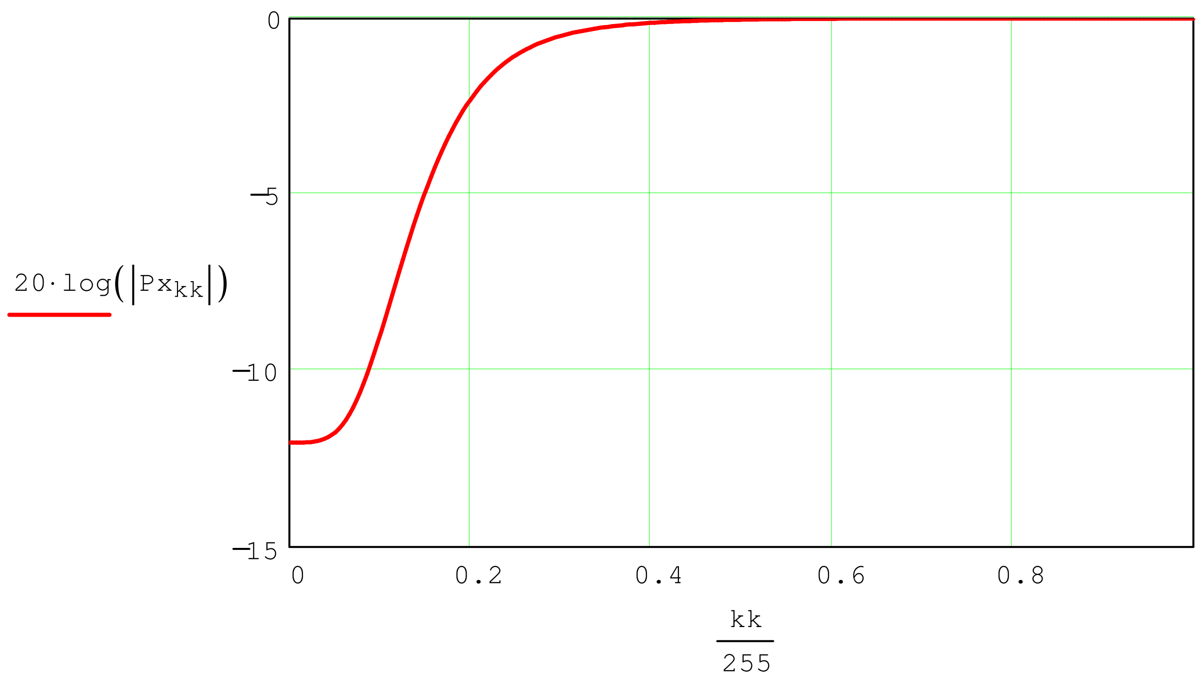
$nx1 = 2.405$
$nx2 = -5.822$
$nx3 = 3.697$

$dx1 = 1.969$

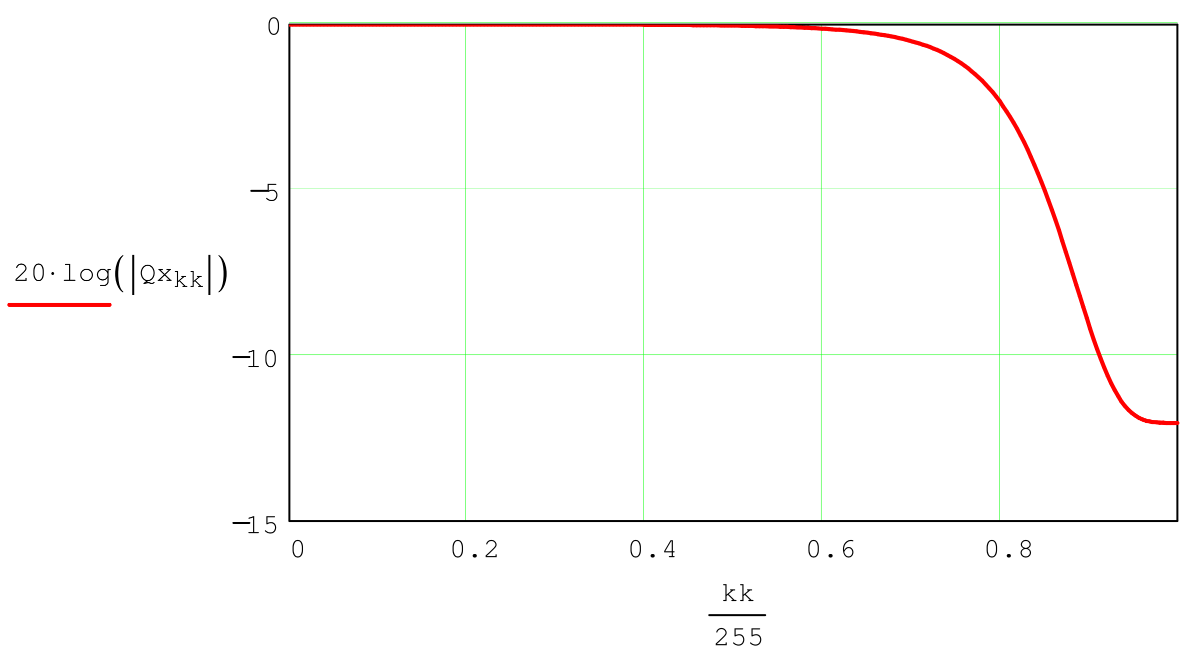
$dx2 = -5.402$

$dx3 = 4.553$

$$Px_{kk} := P\left(zf_{kk}\right)$$



$$Qx_{kk} := P\left(-zf_{kk}\right)$$



Calculate Same for Upper Shelf

$fc2 := 1.0 \cdot \frac{\pi}{2}$ $a := \tan\left[\frac{1}{2}\cdot\left(fc2 - \frac{\pi}{2}\right)\right]$

$A := 0.5$ $F := \text{if}(A > 1, 0.707 \cdot A, 1.414 \cdot A)$

$\gamma d := \left(\frac{F^2 - 1}{A^2 - F^2}\right)^{0.25}$ $\gamma d = 1.189$

$\gamma n := \sqrt{A}\cdot\left(\frac{F^2 - 1}{A^2 - F^2}\right)^{0.25}$ $\gamma n = 0.841$

$n1 := 1 + 2\cdot\sigma\cdot\gamma n + \gamma n^2$ $n3 := 1 - 2\cdot\sigma\cdot\gamma n + \gamma n^2$

$n2 := -2\cdot\left(1 - \gamma n^2\right)$ dB

$d1 := 1 + 2\cdot\sigma\cdot\gamma d + \gamma d^2$ $d3 := 1 - 2\cdot\sigma\cdot\gamma d + \gamma d^2$

$d2 := -2\cdot\left(1 - \gamma d^2\right)$

Check substitution results:

Highpass Shelving Filter

$Nx1 := n1\cdot a^2 + n2\cdot a + n3$

$Nx2 := \left(2\cdot a\cdot n1 + n2\cdot a^2 + 2\cdot a\cdot n3 + n2\right)$

$Nx3 := \left(n1 + a\cdot n2 + n3\cdot a^2\right)$

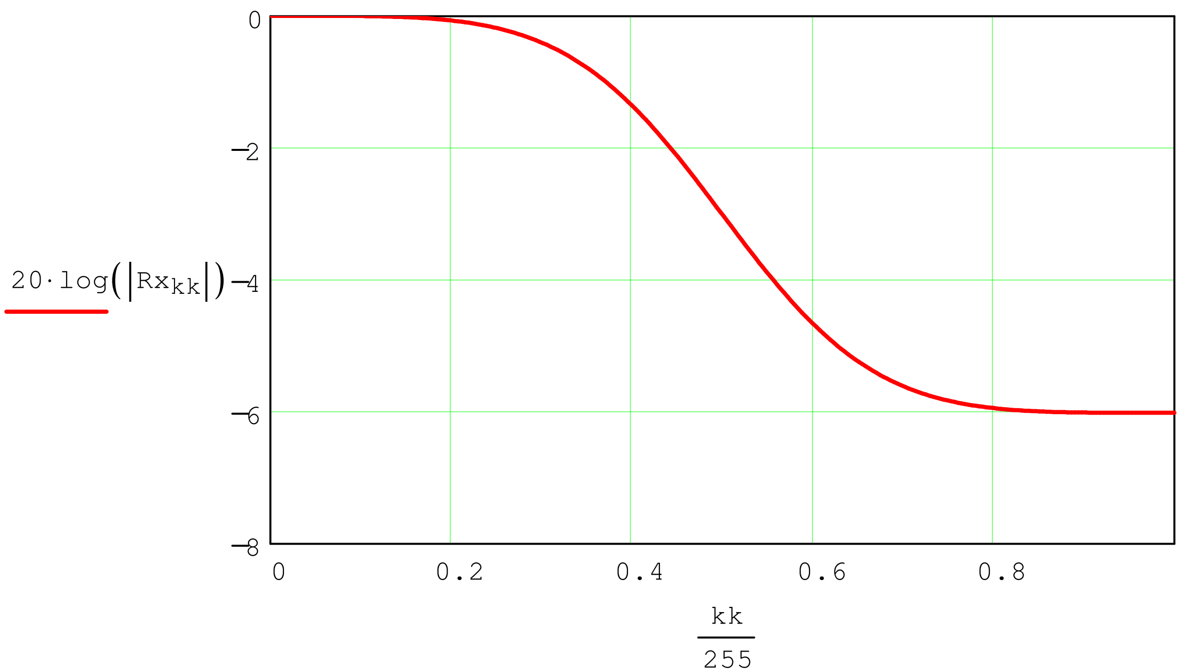
$Dx1 := d1\cdot a^2 + d2\cdot a + d3$

$Dx2 := \left(2\cdot a\cdot d1 + d2\cdot a^2 + d2 + 2\cdot a\cdot d3\right)$

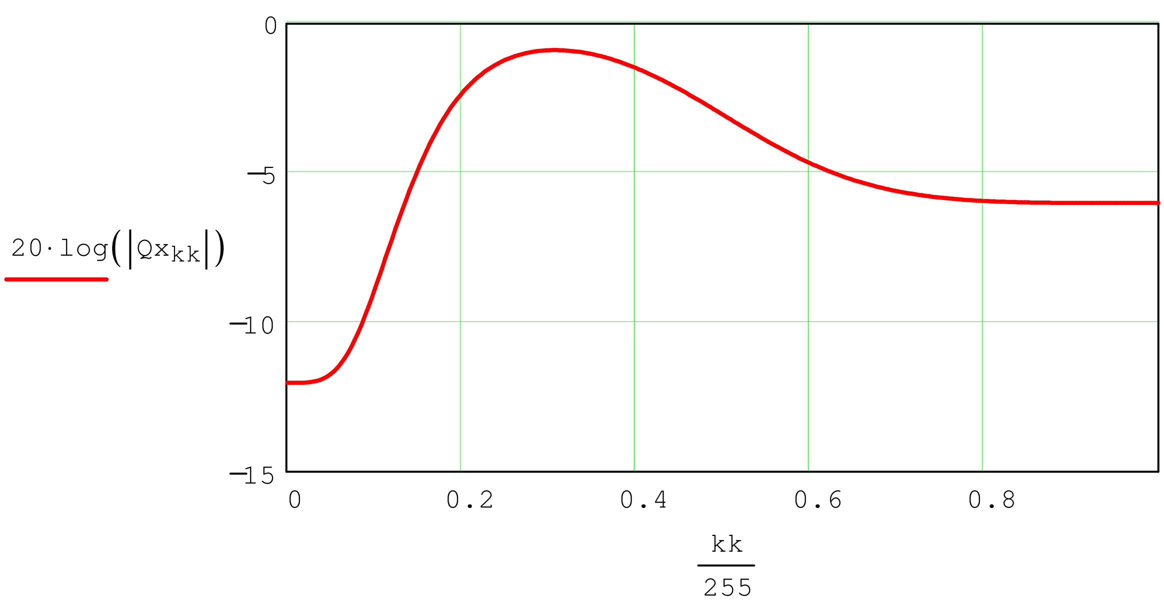
$Dx3 := \left(d1 + d2\cdot a + d3\cdot a^2\right)$

$R(z) := \frac{Nx1 + Nx2\cdot z^{-1} + Nx3\cdot z^{-2}}{Dx1 + Dx2\cdot z^{-1} + Dx3\cdot z^{-2}}$

$Rx_{kk} := R\left(-zf_{kk}\right)$



$Qx_{kk} := Px_{kk} \cdot Rx_{kk}$



$\alpha 0 := nx1 \cdot Nx1$

$\alpha 1 := nx2 \cdot Nx1 - nx1 \cdot Nx2$

$\alpha 2 := nx3 \cdot Nx1 - nx2 \cdot Nx2 + nx1 \cdot Nx3$

$\alpha 3 := nx2 \cdot Nx3 - nx3 \cdot Nx2$

$\alpha 4 := nx3 \cdot Nx3$

$\beta 0 := dx1 \cdot Dx1$

$\beta 1 := dx2 \cdot Dx1 - dx1 \cdot Dx2$

$\beta 2 := dx3 \cdot Dx1 - dx2 \cdot Dx2 + dx1 \cdot Dx3$

$\beta 3 := dx2 \cdot Dx3 - dx3 \cdot Dx2$

$\beta 4 := dx3 \cdot Dx3$

$$F(z) := \frac{\alpha 0 + \alpha 1 \cdot z^{-1} + \alpha 2 \cdot z^{-2} + \alpha 3 \cdot z^{-3} + \alpha 4 \cdot z^{-4}}{\beta 0 + \beta 1 \cdot z^{-1} + \beta 2 \cdot z^{-2} + \beta 3 \cdot z^{-3} + \beta 4 \cdot z^{-4}}$$

$X_{kk} := F\left(zf_{kk}\right)$