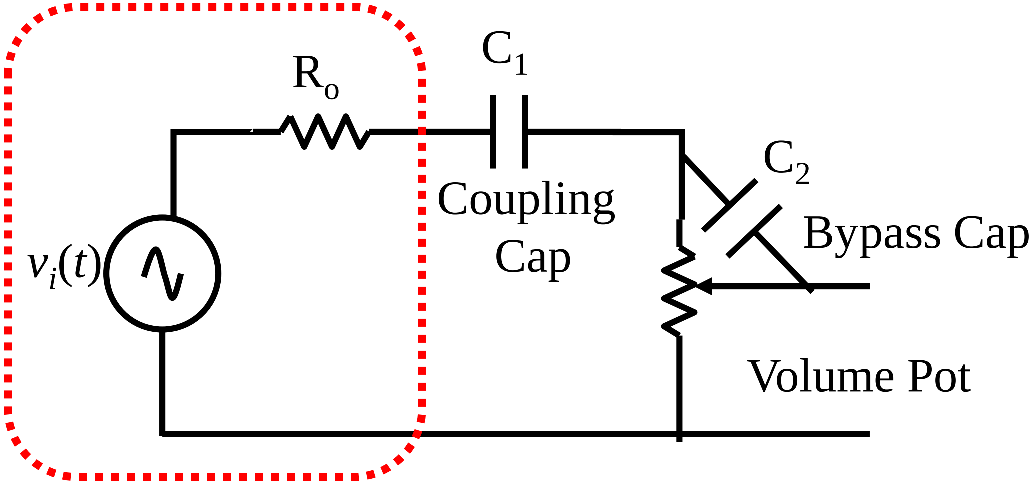
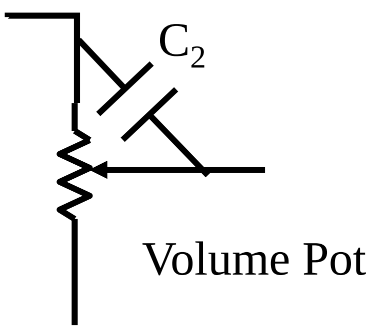
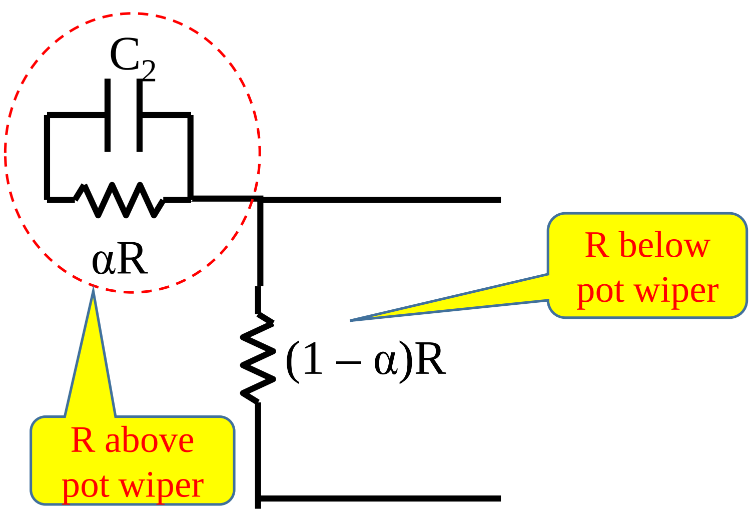


Next stage's
Input Impedance
Effectively Infinite

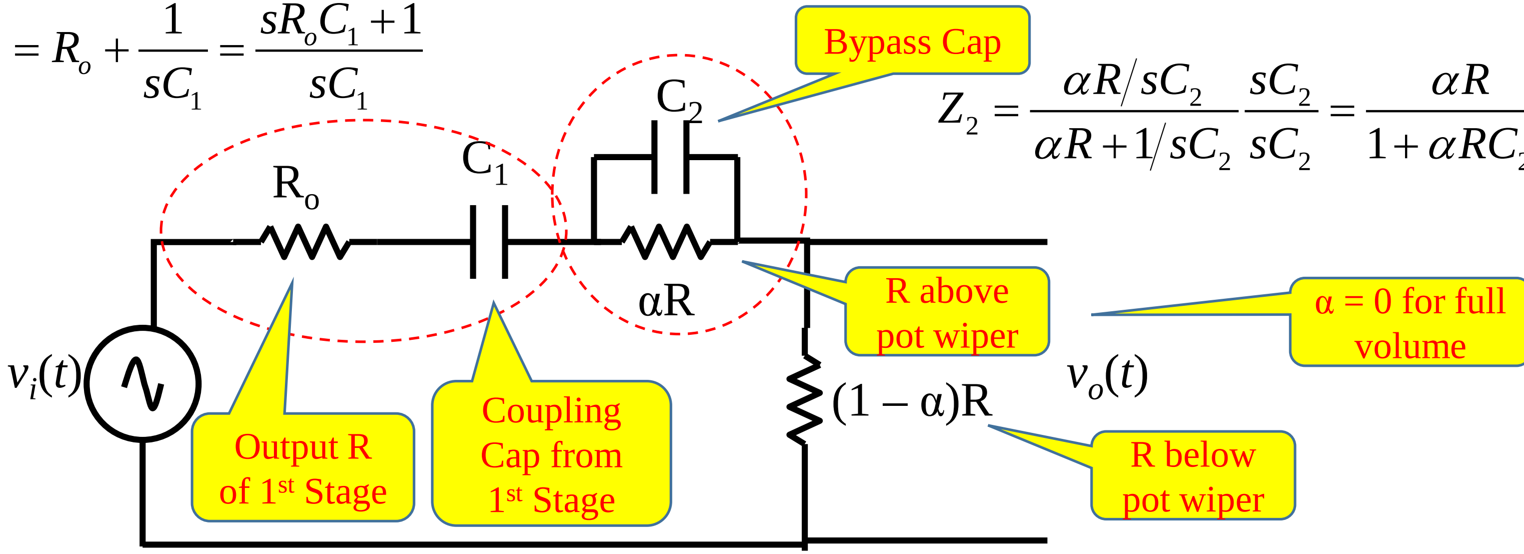
Thevenin Model
of First Stage:
Ro ≈ 38k output
resistance of stage





$$Z_1 = R_o + \frac{1}{sC_1} = \frac{sR_oC_1 + 1}{sC_1}$$

$$Z_2 = \frac{\alpha R / sC_2}{\alpha R + 1/sC_2} \frac{sC_2}{sC_2} = \frac{\alpha R}{1 + \alpha R C_2 s}$$



$$Z_T = Z_1 + Z_2 = \frac{sR_oC_1 + 1}{sC_1} + \frac{\alpha R}{1 + \alpha R C_2 s} = \frac{(sR_oC_1 + 1)(1 + \alpha R C_2 s)}{sC_1(1 + \alpha R C_2 s)} + \frac{\alpha R C_1 s}{sC_1(1 + \alpha R C_2 s)}$$

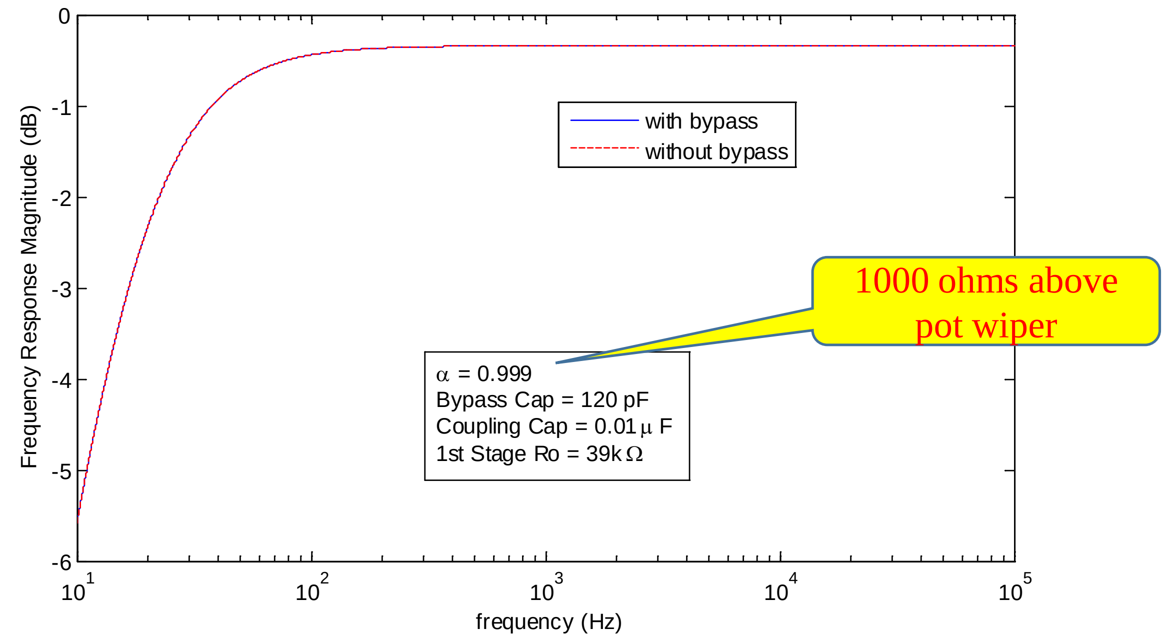
$$= \frac{(1 + sR_oC_1)(1 + \alpha R C_2 s) + \alpha R C_1 s}{sC_1(1 + \alpha R C_2 s)}$$

$$H(s) = \frac{(1-\alpha)R}{(1-\alpha)R + Z_T} = \frac{(1-\alpha)R}{(1-\alpha)R + \dfrac{(1 + sR_oC_1)(1 + \alpha R C_2 s) + \alpha R C_1 s}{sC_1(1 + \alpha R C_2 s)}}$$

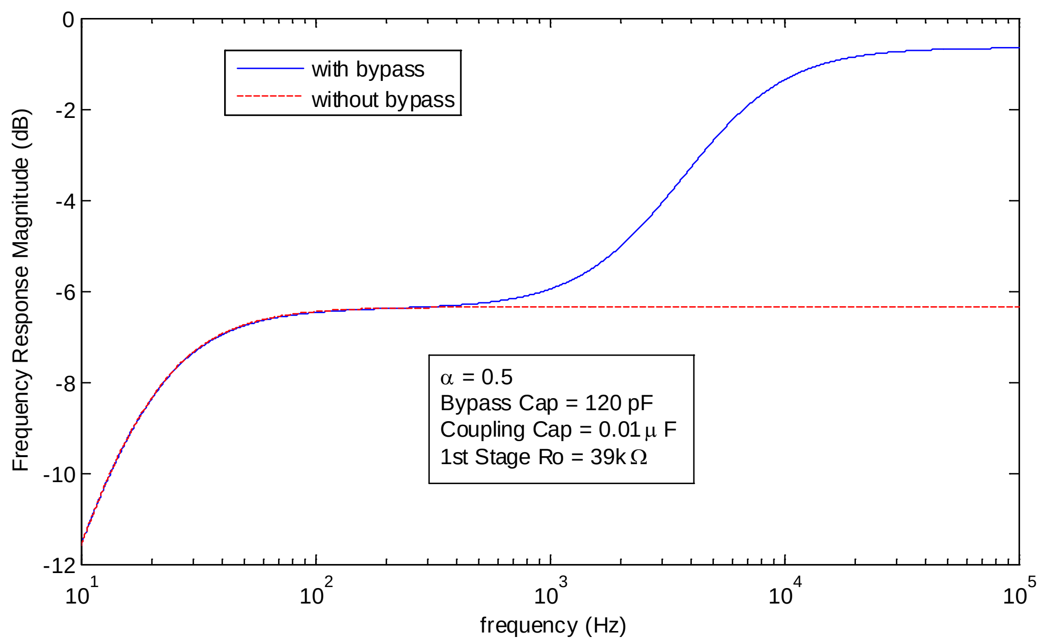
$$= \frac{(1-\alpha)RsC_1(1 + \alpha R C_2 s)}{(1-\alpha)RsC_1(1 + \alpha R C_2 s) + (1 + sR_oC_1)(1 + \alpha R C_2 s) + \alpha R C_1 s}$$

```
function  bypassed_volume_pot(Ro,C1,C2,Rpot,beta)
% bypassed_volume_pot
% Computes and plots frequency response for a bypassed
% volume pot in a tube
amp.
% Assumptions:
%   (i) previous stage modeled as output resistance Ro
%   (ii) next stage is modeled as infinite resistance
%
% Inputs:
%   Ro = output resistance of previous stage (in ohms)
%   C1 = coupling cap from previous stage (in uF)
%   C2 = bypass cap (in pF)
%   Rpot = voluume pot resistance (in ohms)
%   beta = "percent up" on volume pot (beta = 1 is full up)

%
% Output:  Plot of frequency response

C1 = C1*1e-6;
C2 = C2*1e-12;

f=logspace(1,5,10000);
w=2*pi*f;
s=j*w;

alpha = 1 - beta;

%%% Z1 = series combo of Ro and C1 impedance
Z1 = Ro + 1./(s*C1);

%%% Z2w = parallel combo of alpha*Rpot and C2 impedance
%%% ("w" means "with" the bypass)
Z2w  = ( (alpha*Rpot)./(s*C2) )./( alpha*Rpot + 1./(s*C2));
```

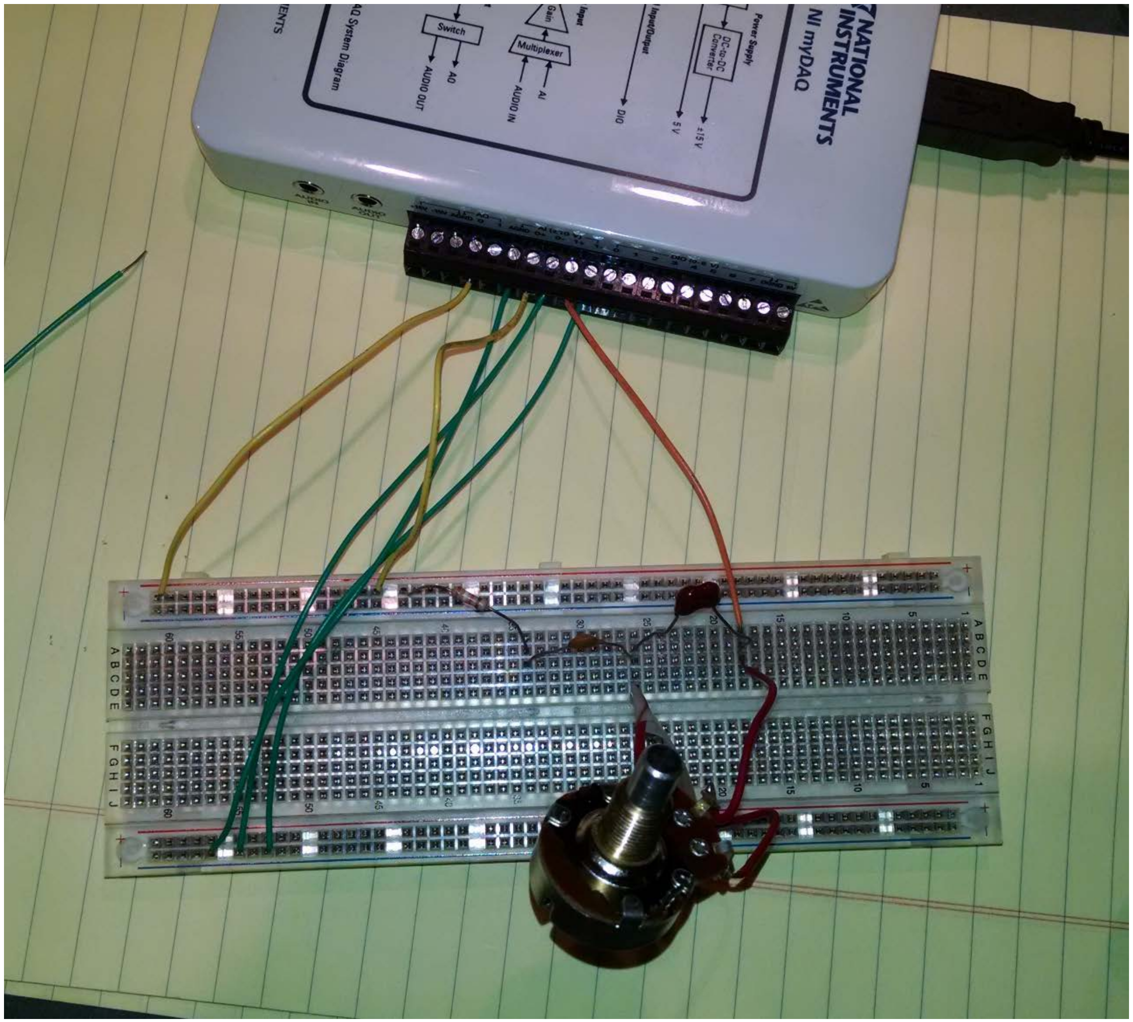
```
%%% Z2wo = alpha*Rpot
%%% ("wo" means "withOUT" the bypass)
Z2wo  = alpha*Rpot;

%%%  Z_T =  series combo of Z1 and Z2
Z_Tw =  Z1 + Z2w;
Z_Two =  Z1 + Z2wo;

%%% Now find freq response via voltage divider:
Hw = (1-alpha)*Rpot./( Z_Tw + (1-alpha)*Rpot );
Hwo = (1-alpha)*Rpot./( Z_Two + (1-alpha)*Rpot );

semilogx(f,20*log10(abs(Hw)),'b',f,20*log10(abs(Hwo)),'r--')
end
```



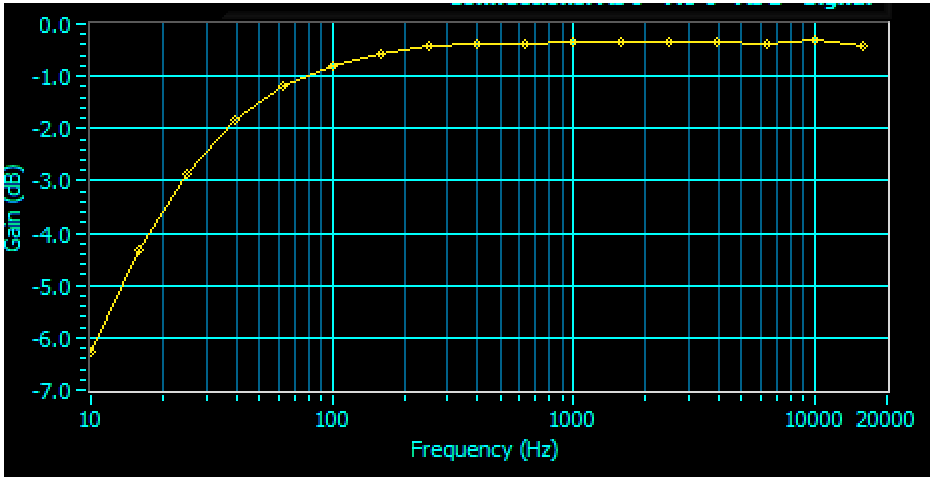
Almost Full Volume



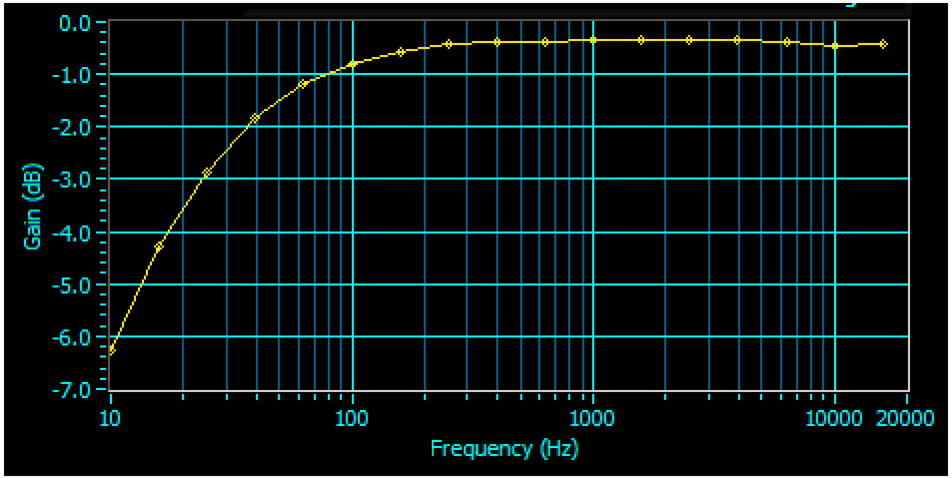
“Half” Volume



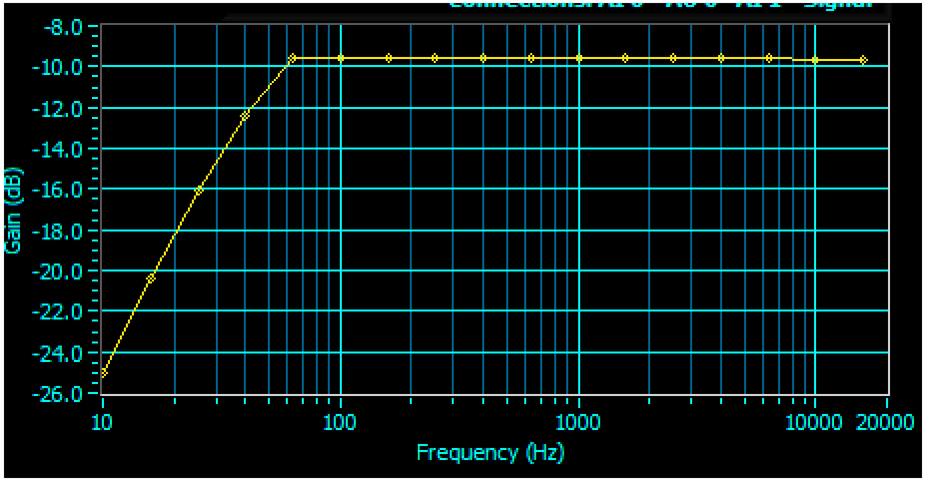
NATIONAL INSTRUMENTS
NI myDAQ
Power Supply
DC-to-DC Converter
±15 V
5 V
DIO
Multiplexer
Gain
AI
AUDIO IN
Switch
AO
AUDIO OUT



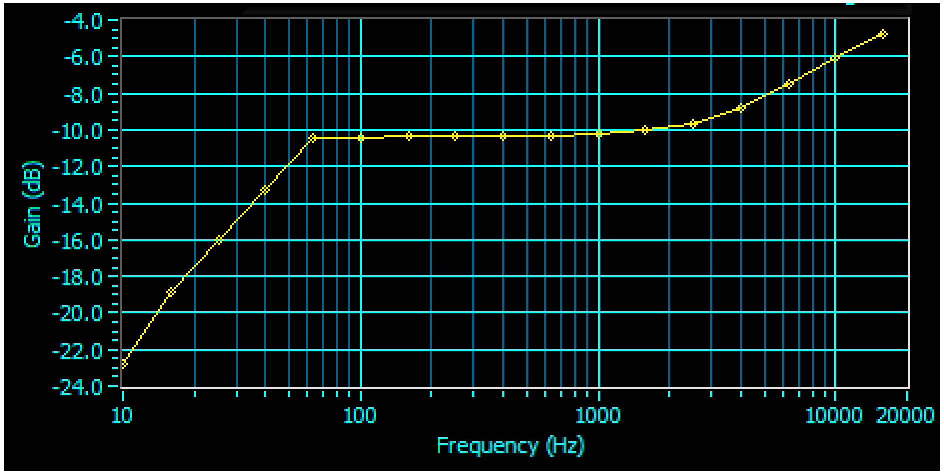
Full Volume
Without Bypass



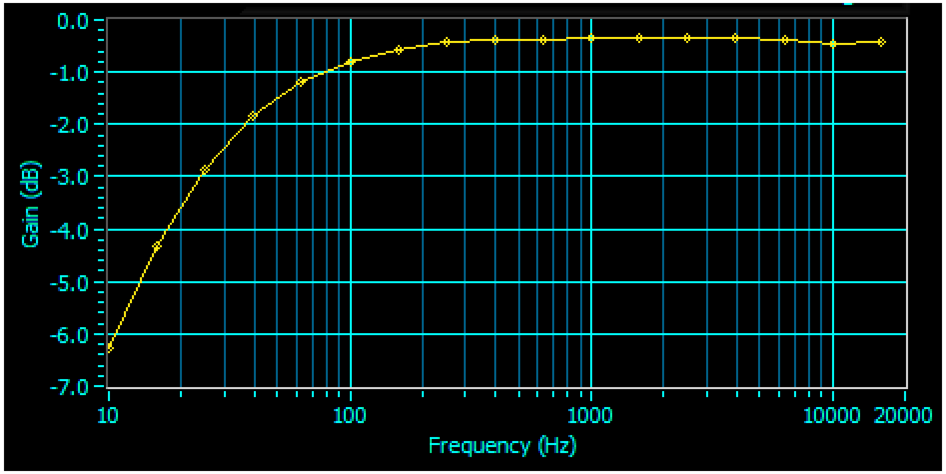
Full Volume
With Bypass
(120 pF)



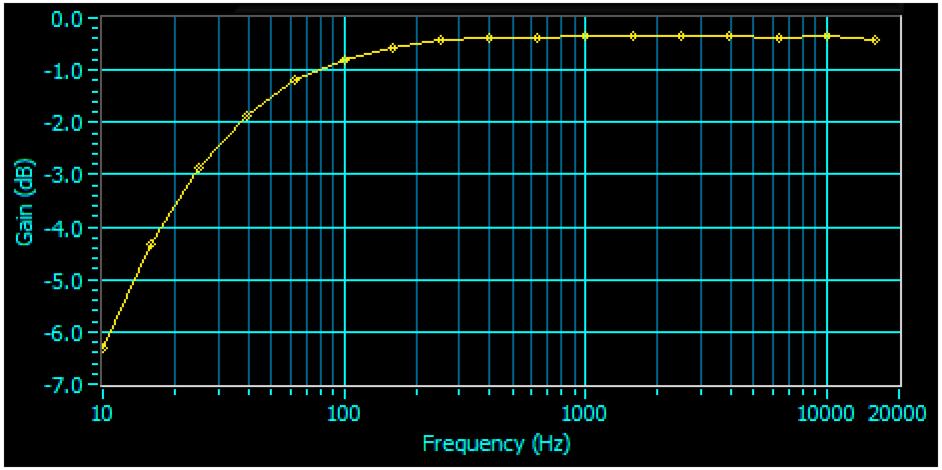
Low Volume
With<u>out</u> Bypass



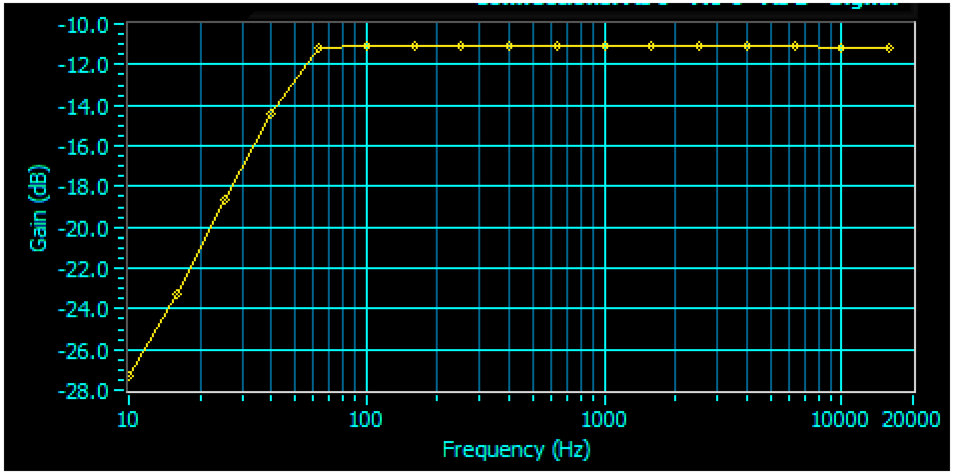
Low Volume
<u>With</u> Bypass
(120 pF)



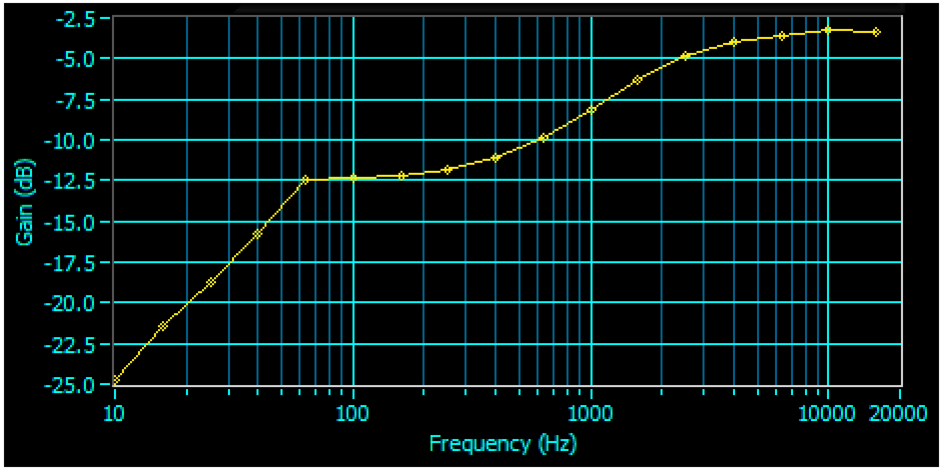
Full Volume
With<u>out</u> Bypass



Full Volume
<u>With</u> Bypass
(1000 pF)



Low Volume
Without Bypass



Low Volume
With Bypass
(1000 pF)