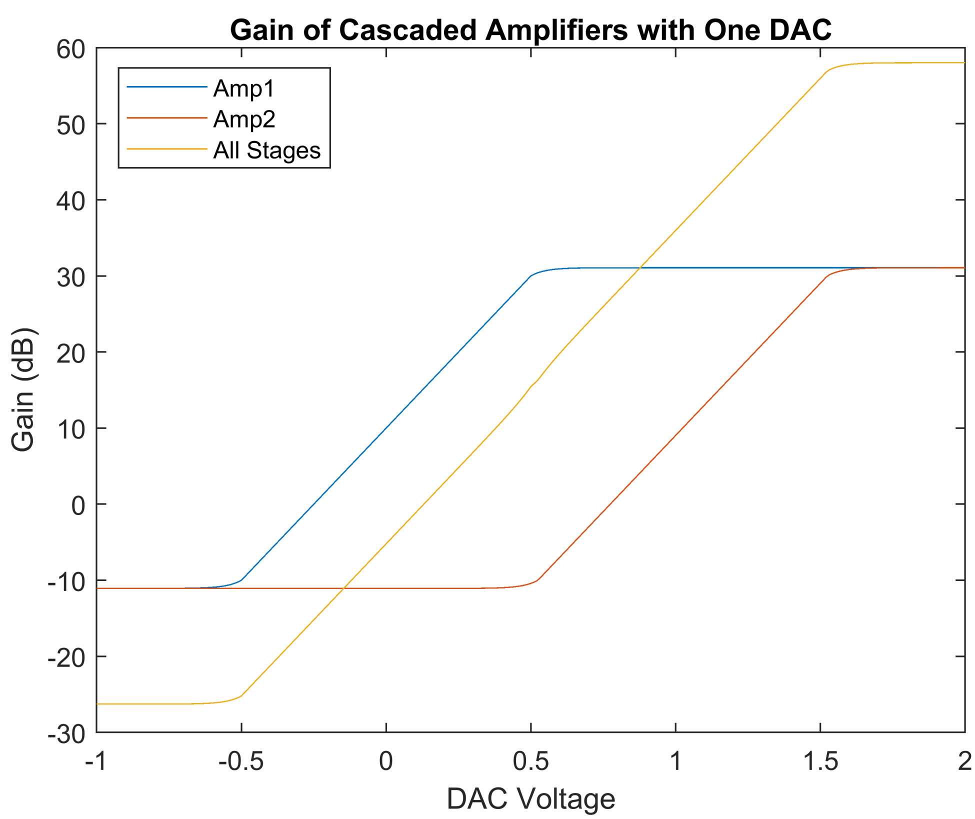
```
% Gain of Amplifer/Attenuator Chassis
% using two cascaded AD603 variable-gain amplifiers
% Alan Fisher, updated 2022-06-07
offset1 = 0;
offset2 = 1.024;
G0 = 10;
Vg = (-1:0.01:2);
G1 = Gain(Vg,offset1,G0);   % Gain in dB vs. control voltage
G2 = Gain(Vg,offset2,G0);
G  = G1+G2;
% Input voltge of AD603 must be <=2, and buffer op amp can deliver 5.
Gin = 20*log10(100/239);    % Attenuation at input to first AD603
% Partially compensate for this loss with gain at output op amp (without
% loss of overall bandwidth)
Gout = 20*log10(1+330/680);
G = G+Gin+Gout;
plot(Vg,G1)
xlabel('DAC Voltage')
ylabel('Gain (dB)')
hold on
plot(Vg,G2)
plot(Vg,G)
hold off
title('Gain of Cascaded Amplifiers with One DAC')
legend({'Amp1';'Amp2';'All Stages'},'Location','NorthWest')
```




```
fprintf('G1 gain from %.2f to %.2f dB',min(G1),max(G1))
```

```
G1 gain from -11.07 to 31.07 dB
```

```
fprintf('G2 gain from %.2f to %.2f dB',min(G2),max(G2))
```

```
G2 gain from -11.07 to 31.07 dB
```

```
fprintf(['G  gain from %.2f to %.2f dB\n',...
         'Includes attenuation of %.2f dB after input buffer\n',...
         'and gain of %.2f dB with output buffer\n'],...
         min(G), max(G), Gin,Gout)
```

```
G  gain from -26.27 to 58.01 dB
Includes attenuation of -7.57 dB after input buffer
and gain of 3.44 dB with output buffer
```

```
fprintf('Gain of bypass path %.2f dB\n\n',20*log10(50/(39+3*2.1+50)))
```

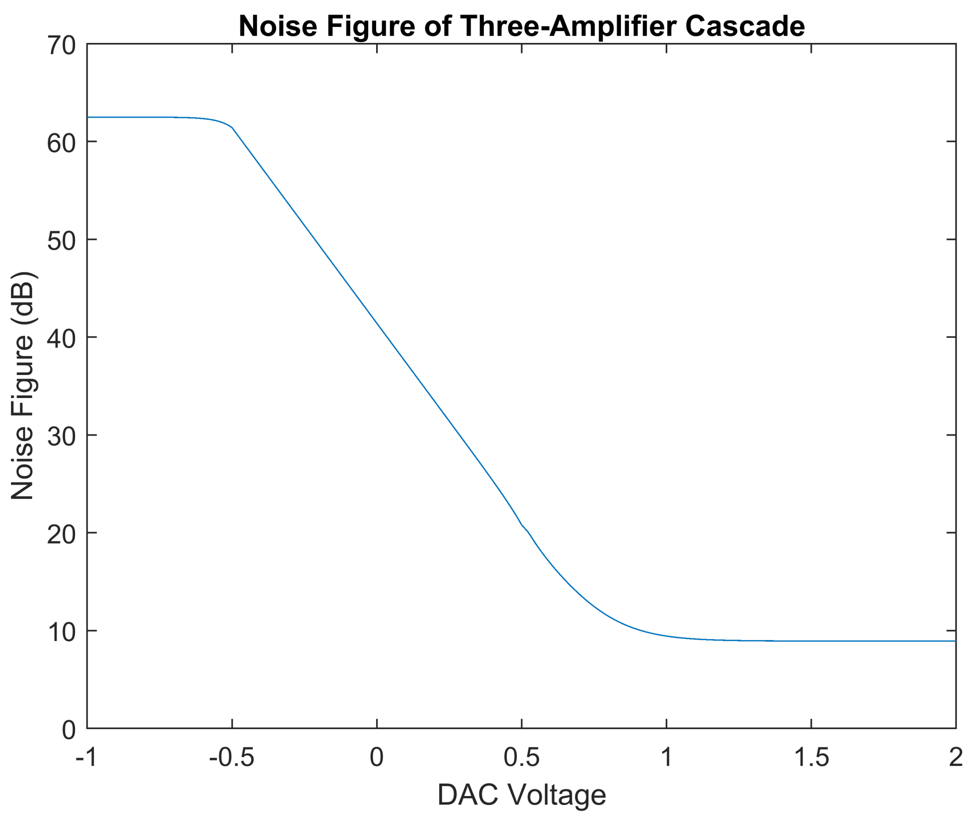
```
Gain of bypass path -5.60 dB
```

```
fprintf([' DAC    Gain\n',...
         ' (V)    (dB)\n']);fprintf('%+0.1f %+8.2f\n',...
         [Vg(1:10:length(Vg));G(1:10:length(Vg))]);disp(' ')
```

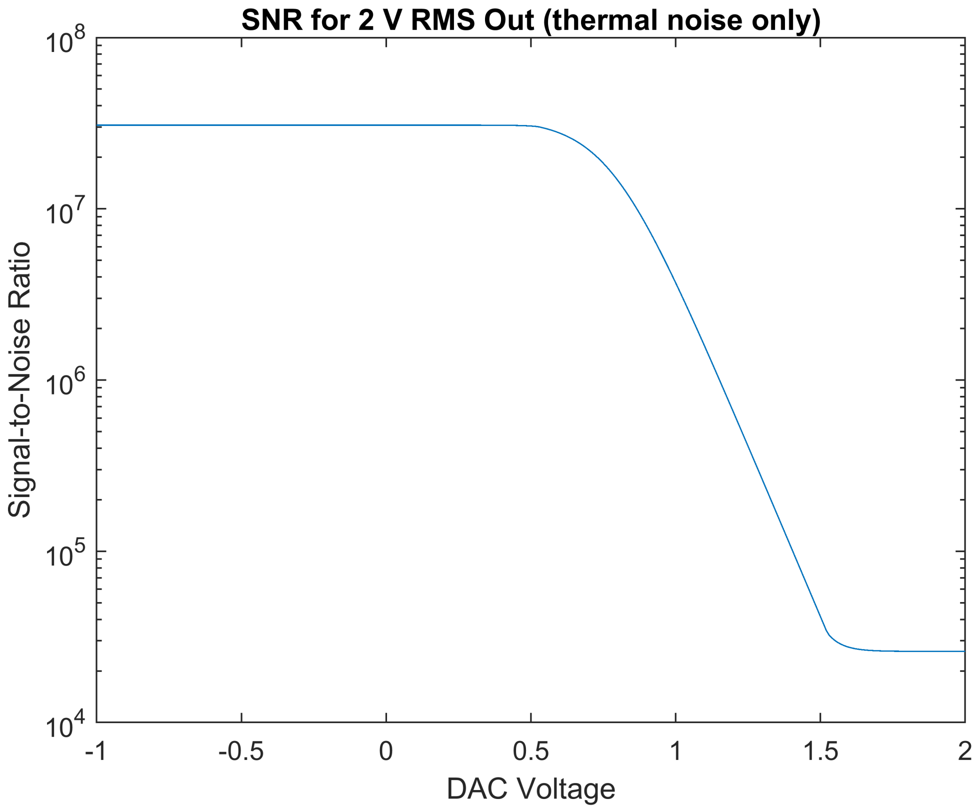
```
 DAC    Gain
 (V)    (dB)
-1.0   -26.27
-0.9   -26.27
-0.8   -26.27
-0.7   -26.25
-0.6   -26.13
-0.5   -25.20
-0.4   -21.20
-0.3   -17.20
-0.2   -13.20
-0.1    -9.20
+0.0    -5.20
+0.1    -1.20
+0.2    +2.80
+0.3    +6.81
+0.4   +10.89
+0.5   +15.46
+0.6   +19.83
+0.7   +23.96
+0.8   +27.98
+0.9   +31.98
+1.0   +35.98
+1.1   +39.98
+1.2   +43.98
+1.3   +47.98
+1.4   +51.98
+1.5   +55.98
+1.6   +57.77
+1.7   +57.98
+1.8   +58.00
+1.9   +58.01
+2.0   +58.01
```

```
% Cascaded noise
g1 = 10.^(G1/10);       % Power gain in linear units
g2 = 10.^(G2/10);
```

```
g  = g1.*g2;
% Noise figure (dB) of the variable-gain amp
NF1 = 40-G1;
NF2 = 40-G2;
F1 = 10.^(0.1*NF1);
F2 = 10.^(0.1*NF2);
F3 = 31.6;
F = F1+(F2-1)./g1+(F3-1)./(g1.*g2);
NF = 10*log10(F);
kB = 1.38065e-23;   % Boltzmann's constant
T0 = 290;           % Reference temperature (K) for noise
BW = 60e6;          % System bandwidth (Hz), limited by ADC input
% Signal-to-noise ratio for a 2-V RMS output into 50 ohms = 0.08 W
SNR = 0.08./(kB*T0*BW*g.*F);
plot(Vg,NF)
xlabel('DAC Voltage')
ylabel('Noise Figure (dB)')
title('Noise Figure of Three-Amplifier Cascade')
```




```
semilogy(Vg,SNR)
xlabel('DAC Voltage')
ylabel('Signal-to-Noise Ratio')
title('SNR for 2 V RMS Out (thermal noise only)')
```




```
function G = Gain(VG,offset,G0)
v = VG-offset;
G = zeros(size(v));
for n=1:length(v)
    if abs(v(n))<0.5
        G(n) = 40*v(n)+G0;
    else
        G(n) = G0+sign(v(n)).*(20+1.07*(1-exp(-(abs(v(n))-0.5)/0.05)));
    end
end
end
```