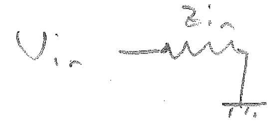
Lecture 4 Block Model

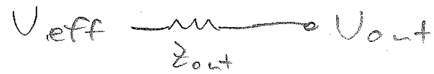
Last time, introduced transfer functions
input impedance
output impedance

transfer functions: $V_{out} = G V_{in}$

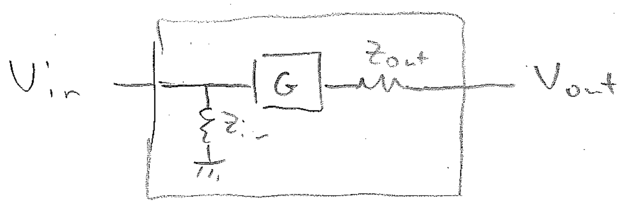
input impedance



output impedance

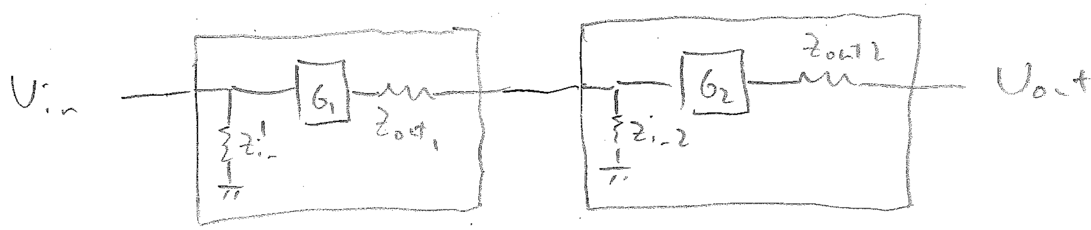


Put together in "block model" for circuit:



Elements in box give effective description of circuit. "Black box" approach: avoid worrying about details of how circuit works.

Mostly useful when combining circuits:



Can see that <u>if</u> $|Z_{out1}| \ll |Z_{in2}|$, have $V_{out} = G_2 G_1 V_{in}$

Transfer functions just multiply.

If $|Z_{out1}| \approx |Z_{in2}|$, form voltage divider, can calculate effect.

Warning: input impedance does, in general, depend on output load

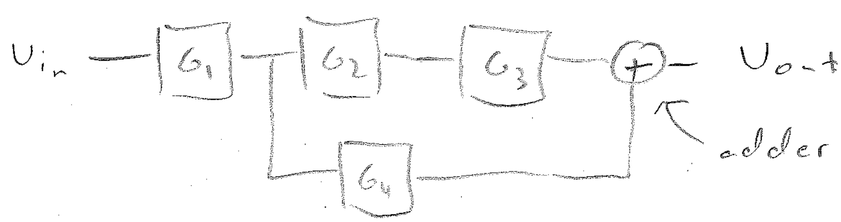
output impedance depends in general on input current

So block model really only works well when $|Z_{out\,1}| \ll |Z_{in\,2}|$

$\Rightarrow$ try to design circuit blocks with low Z_{out}, high Z_{in}

We'll see tools to achieve this.

When we do, just analyze circuit as blocks:



$$V_{out} = G_1(G_2G_3 + G_4)V_{in}$$

Very powerful approach.

Bode plots especially useful here:

$$G = |G|e^{i\phi} \qquad g(dB) = 20 \log |G|$$

So if $G_{TOT} = G_1 G_2$

$$= |G_1||G_2| e^{i(\phi_1 + \phi_2)}$$

$$g_{TOT} = 20 \log(|G_1||G_2|)$$

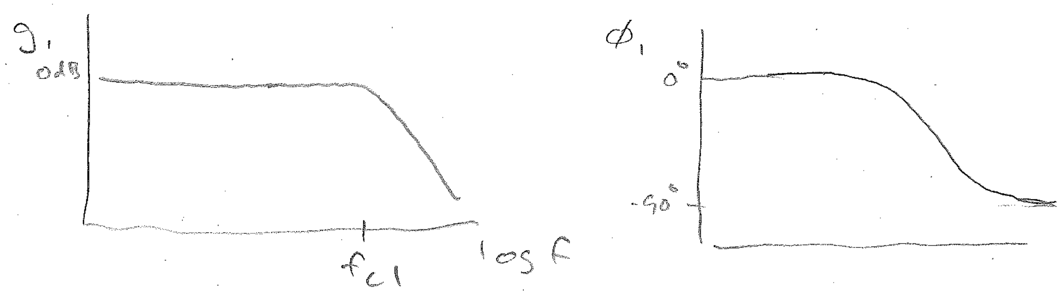
$$= 20 \log |G_1| + 20 \log |G_2|$$

$$= g_1 + g_2$$

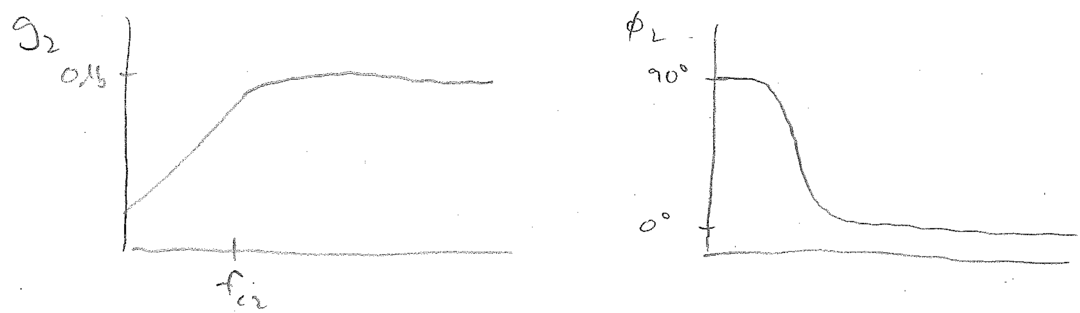
and $\phi_{TOT} = \phi_1 + \phi_2$

So to cascade circuits, just add Bode plot values

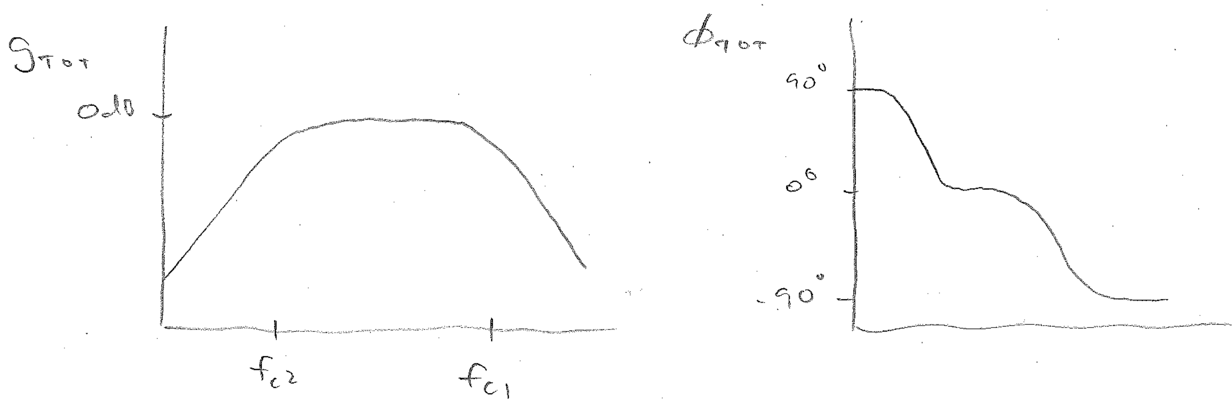
Example: Circuit 1: low pass filter



Circuit 2: high pass filter



Combined:



Can get a good idea what composite circuit does without any analysis.

A few comments about dBs:

I'll give $|G|$ (not in dB) as "x" multiplier

Thus $20\ dB = 10\times$

$40\ dB = 100\times$

Some useful conversions:

$|G| = 2\times \Rightarrow g = 20 \log 2 = 6.02\ dB$

Use $2\times \approx 6\ dB$

$|G| = 3\times \Rightarrow g = 20 \log 3 = 9.5\ dB$

Use $3\times \approx 10\ dB$ (though less accurate)

$|G| = 1.1\times \Rightarrow g = 0.83\ dB$

Use $1.1\times \approx 1\ dB$

Memorizing these lets you do quick conversions in your head:

$30\ dB = 20\ dB + 10\ dB = (10\times)\cdot(3\times) = 30\times$

$0.5\times = (2\times)^{-1} = -6\ dB$

$\frac{1}{\sqrt{2}}\times = (2\times)^{-1/2} = -3\ dB$