

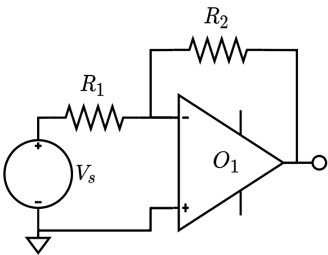
Operational amplifier circuits

1. Simple inverting op-amp

The ideal operational amplifier is supported as a 3-terminal element. Let's see how the program handles circuits with OpAmps included. The analysis is done as with any other circuit.

```
circuit = Circuit('circuits/r_op_amp.txt');  
circuit.list
```

```
ans =  
'Vs 1 0 AC Vs  
R1 1 2 R1  
R2 2 3 R2  
O1 0 2 3  
,
```



```
ELAB.analyze(circuit)
```

Symbolic analysis successful (0.243211 sec).

```
circuit.symbolic_node_voltages
```

```
ans =  

$$\begin{pmatrix} v_1 = V_s \\ v_2 = 0 \\ v_3 = -\frac{R_2 V_s}{R_1} \end{pmatrix}$$

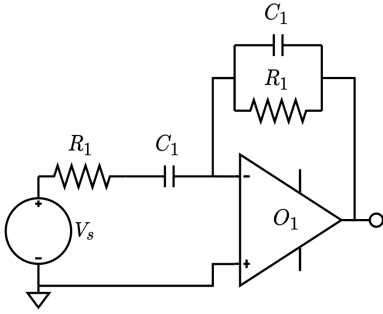
```

2. Inverting op-amp with additional reactive elements.

This is a slightly more complex example. We are still dealing with an inverting amplifier configuration.

```
circuit = Circuit('circuits/rc_op_amp.txt');  
circuit.list
```

```
ans =  
'Vs 1 0 AC Vs  
R1 1 2 20000  
R2 3 4 20000  
C1 2 3 C1  
C2 3 4 C2  
O1 0 3 4  
,
```



Suppose we want to know what values for the capacitors, we need to choose, to achieve poles at $p_1 = -1000 \text{ rad/s}$ and $p_2 = -5000 \text{ rad/s}$.

```
ELAB.ec2sd(circuit,1,4)
```

Symbolic analysis successful (0.396128 sec).

Symbolic transfer function calculated successfully (4.039197e-01 sec).

ans =

$$\frac{v_4}{v_1} = - \frac{C_1 R_2 s}{(C_1 R_1 s + 1) (C_2 R_2 s + 1)}$$

From this transfer function, it is immediately apparent, that if $R_1 = R_2 = 20k\Omega$, then $C_1 = 1/1000R_1 = 0.05\mu F$ and $C_2 = 1/5000 = 0.01\mu F$.