RUPRECHT-KARLS-
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Exercise 4b:
Time Domain

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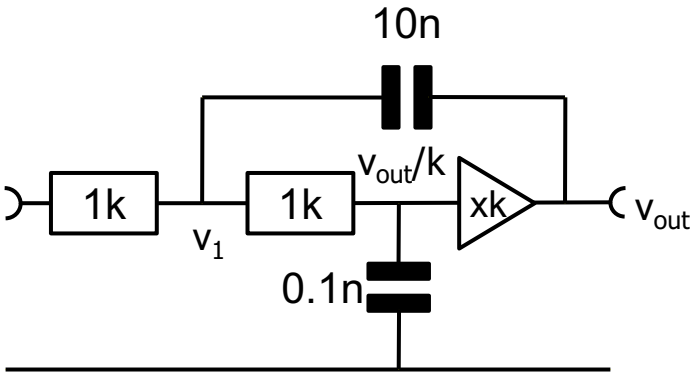
Exercise 4b.1

- Derive H[s] for the following active filter.



- For which k do you get a divergence ?
- For k=1, derive the step response of the circuit

- Simulate the circuit and compare quantitatively.

Solution 4b.1

- H[s]

```
In[221]:= EQ1 = (vin - v1)/1 == (v1 - vout/k)/1 + (v1 - vout) s 10;

          EQ2 = (v1 - vout/k)/1 == vout/k s 1/10;

In[224]:= $Assumptions = k > 0 && s > 0 && ω > 0;

In[225]:= Eliminate[{EQ1, EQ2}, v1] // Simplify

Out[225]= (5 + 51 s + 5 s^2) vout == 5 k (vin + 10 s vout)

In[226]:= Solve[%, vout] // First

Out[226]= {vout → -(5 k vin)/(-5 - 51 s + 50 k s - 5 s^2)}

In[227]:= H_active[s_, k_] = vout/vin /. % // Simplify

Out[227]= (5 k)/(5 + (51 - 50 k) s + 5 s^2)

In[228]:= H_active[s, 1]

Out[228]= 5/(5 + s + 5 s^2)
```

Solution 4b.1

- Divergence:

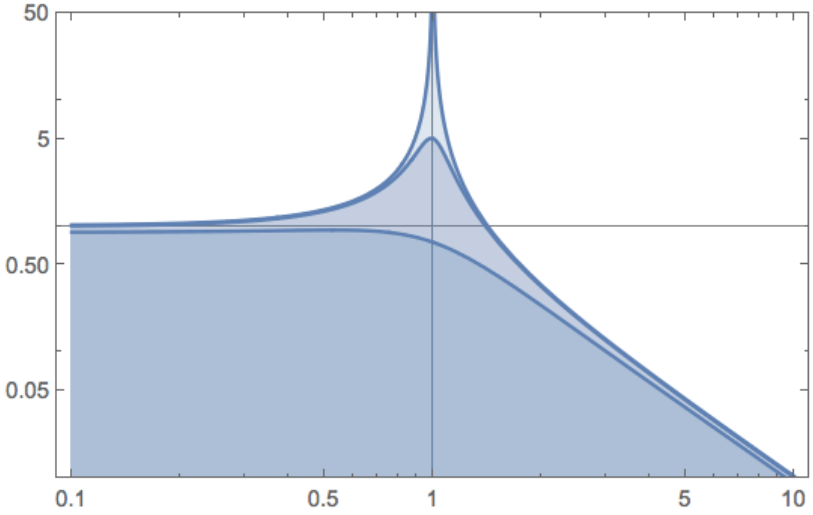
```
In[249]:= gpeak = Abs@H_active[i, k]

Out[249]= 5 Abs[k / (51 - 50 k)]

In[253]:= Solve[51 - 50 k == 0, k] // N

Out[253]= {{k → 1.02}}
```

```
LogLogPlot[{Abs@H_active[i ω, {0.9, 1, 1.02}]}, {ω, 0.1, 10},
 Frame → True, PlotRange → {Full, {0.01, 50}}, Filling → Axis,
 GridLinesStyle → Directive[Gray, Thin], GridLines → {{1}, {1}}]
```



Solution 4b.1

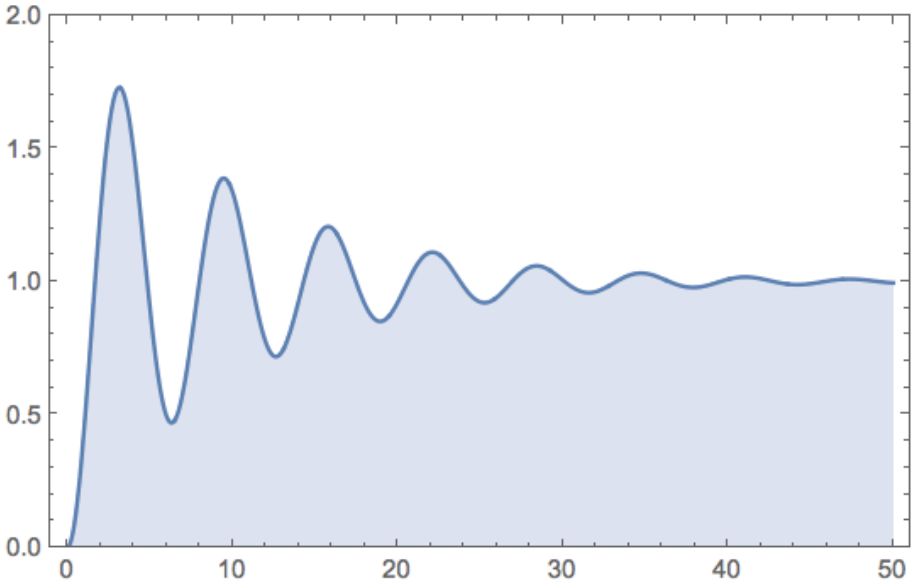
- Step Response

In[322]:=
$$\text{Step1} = \text{InverseLaplaceTransform}\left[\frac{H_{\text{active}}[s, 1]}{s}, s, t\right] // \text{Simplify}$$

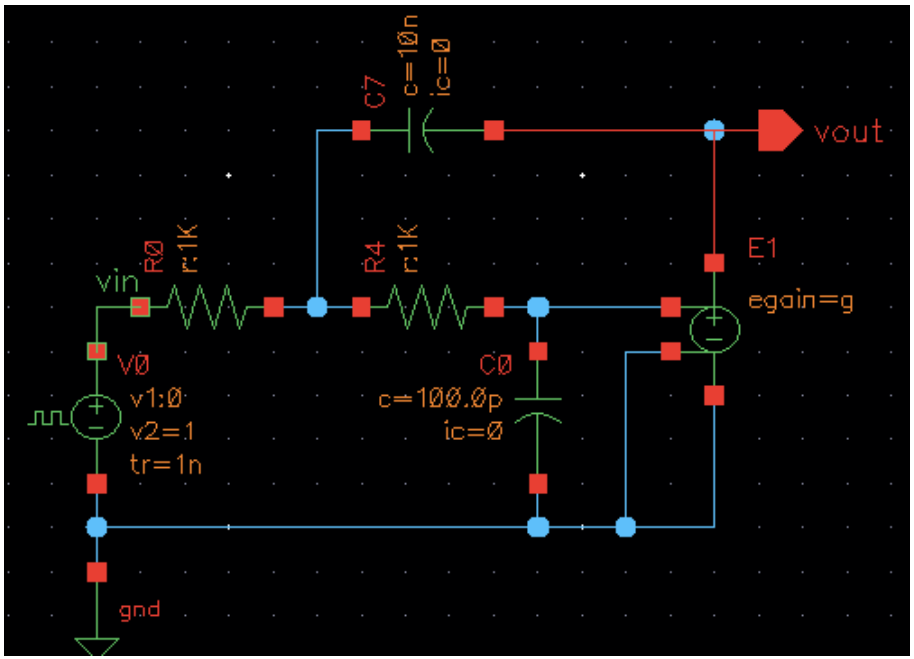
Out[322]=
$$1 - e^{-t/10}\,\text{Cos}\left[\frac{3\sqrt{11}\,t}{10}\right] - \frac{e^{-t/10}\,\text{Sin}\left[\frac{3\sqrt{11}\,t}{10}\right]}{3\sqrt{11}}$$

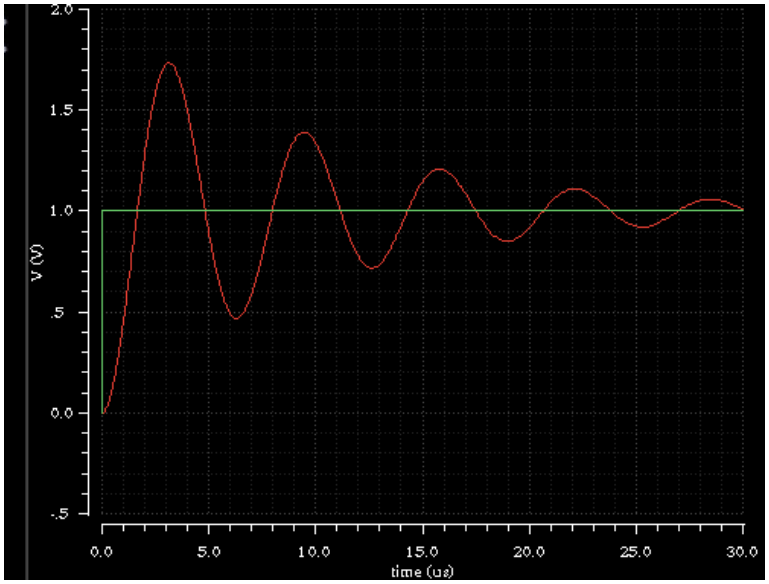
In[287]:=
```
Plot[Step1, {t, 0, 50}, PlotRange → {0, 2}, Frame → True, Filling → Axis]
```

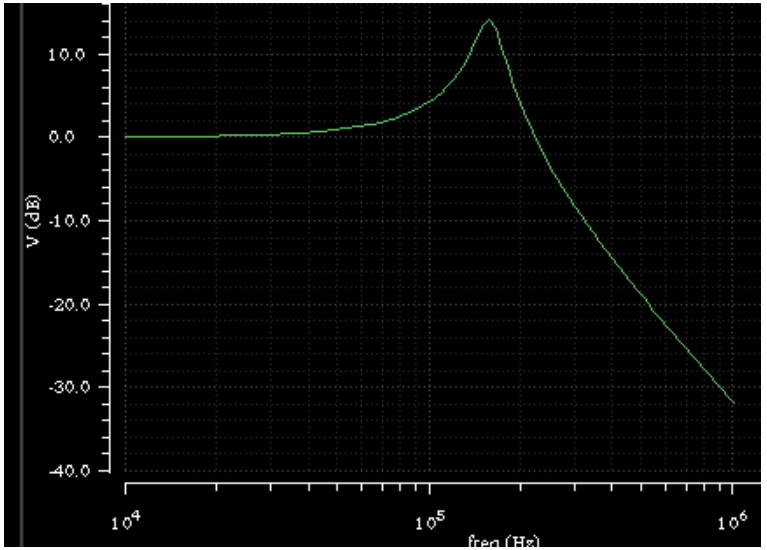
Out[287]=



Simulation:


C7
c=10n
ic=0
vout
R0
r:1K
vin
R4
r:1K
E1
egain=g
V0
v1:0
v2=1
tr=1n
C0
c=100.0p
ic=0
gnd


2.0
1.5
1.0
.5
0.0
-.5
V (V)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
time (us)


10.0
0.0
-10.0
-20.0
-30.0
-40.0
V (dB)
10^4
10^5
10^6
freq (Hz)