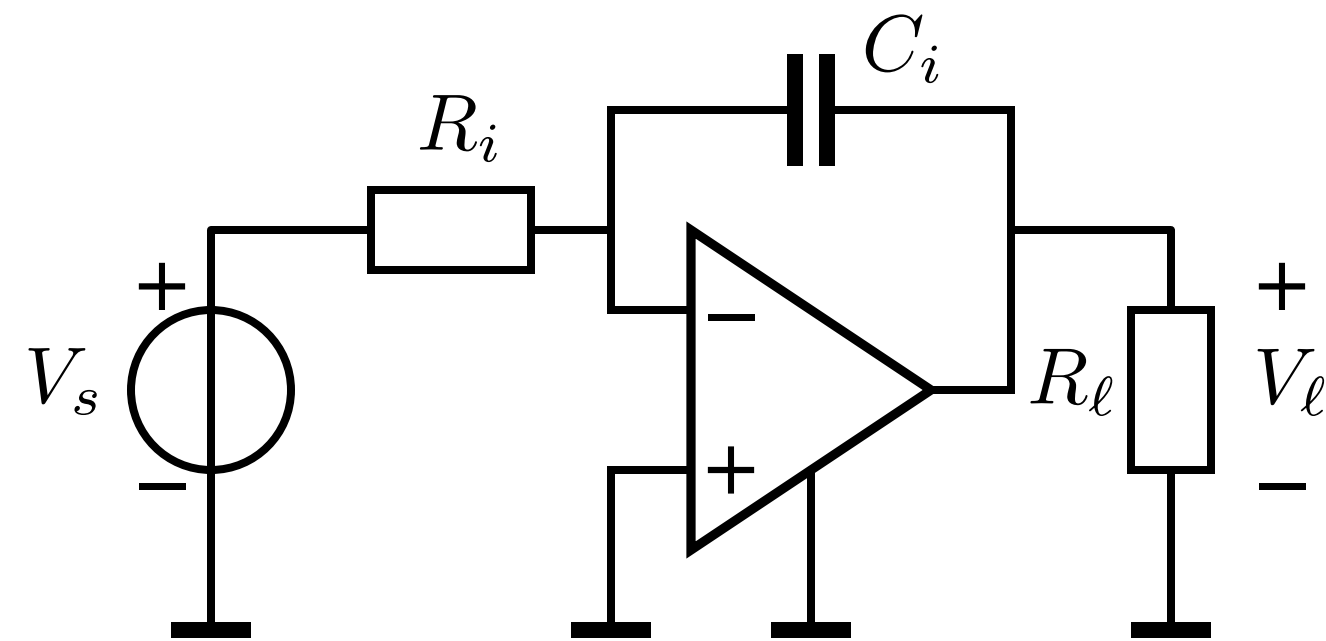


Structured Electronic Design

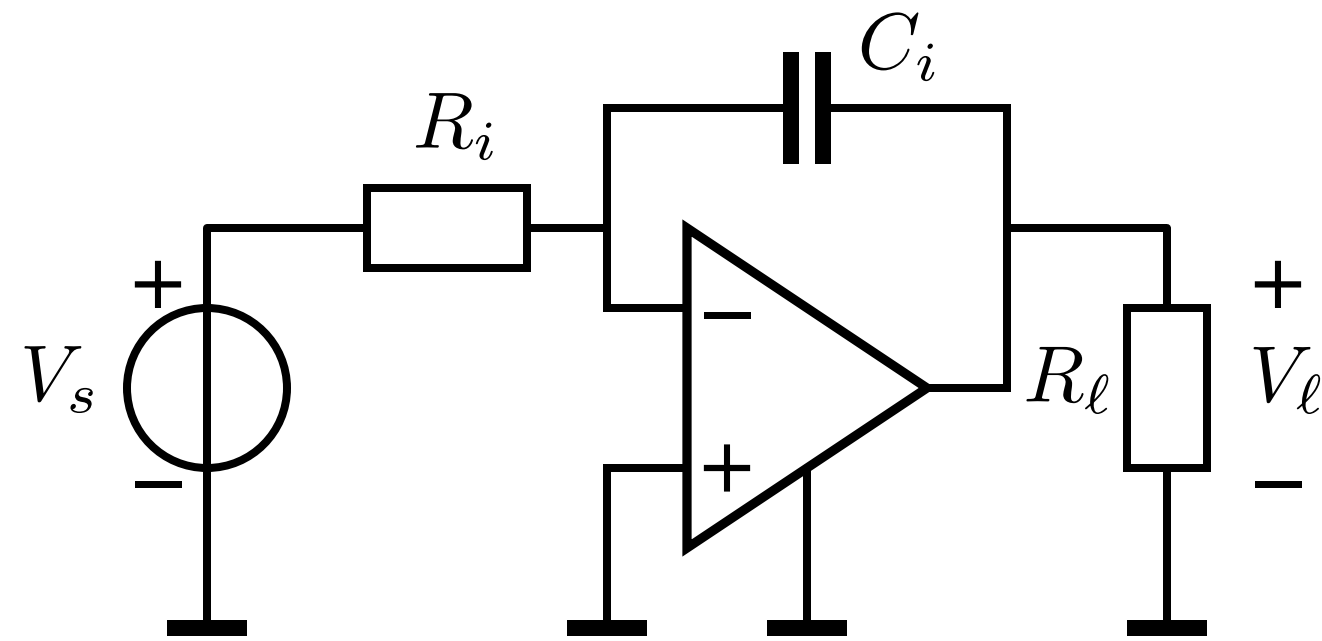
Example: Bandwidth of Negative Feedback Integrator

Example integrator bandwidth

Example integrator bandwidth

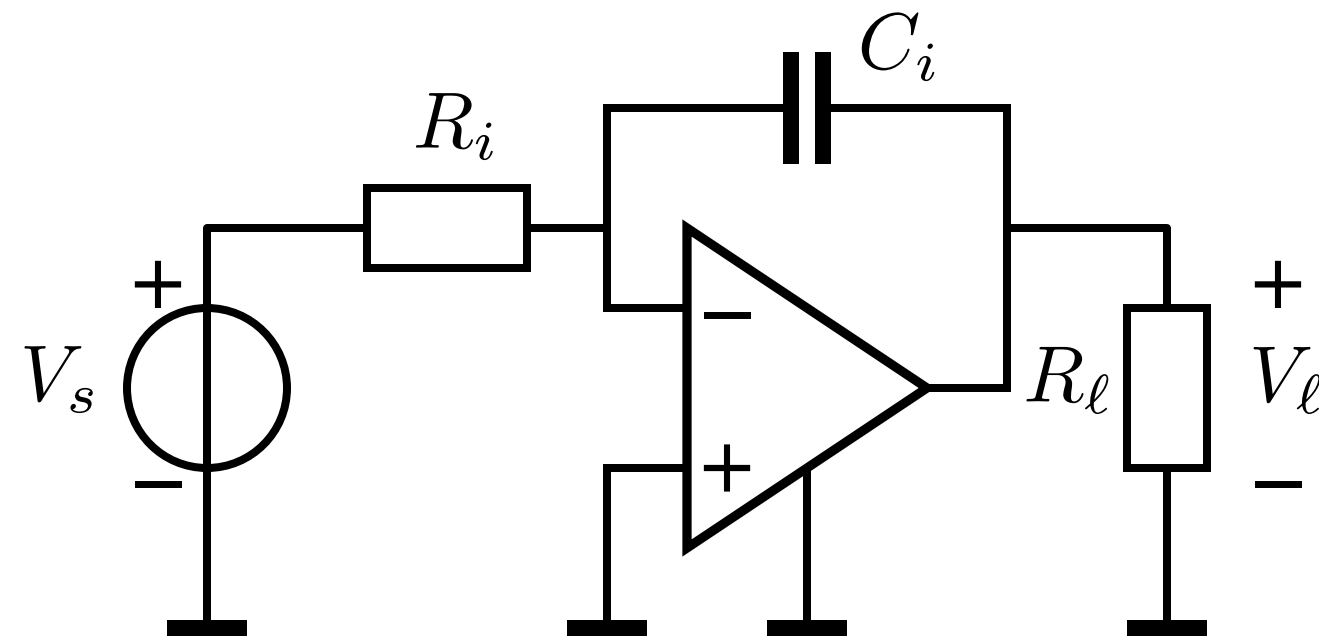


Example integrator bandwidth



OpAmp modeled as VCVS:

Example integrator bandwidth



OpAmp modeled as VCVS:

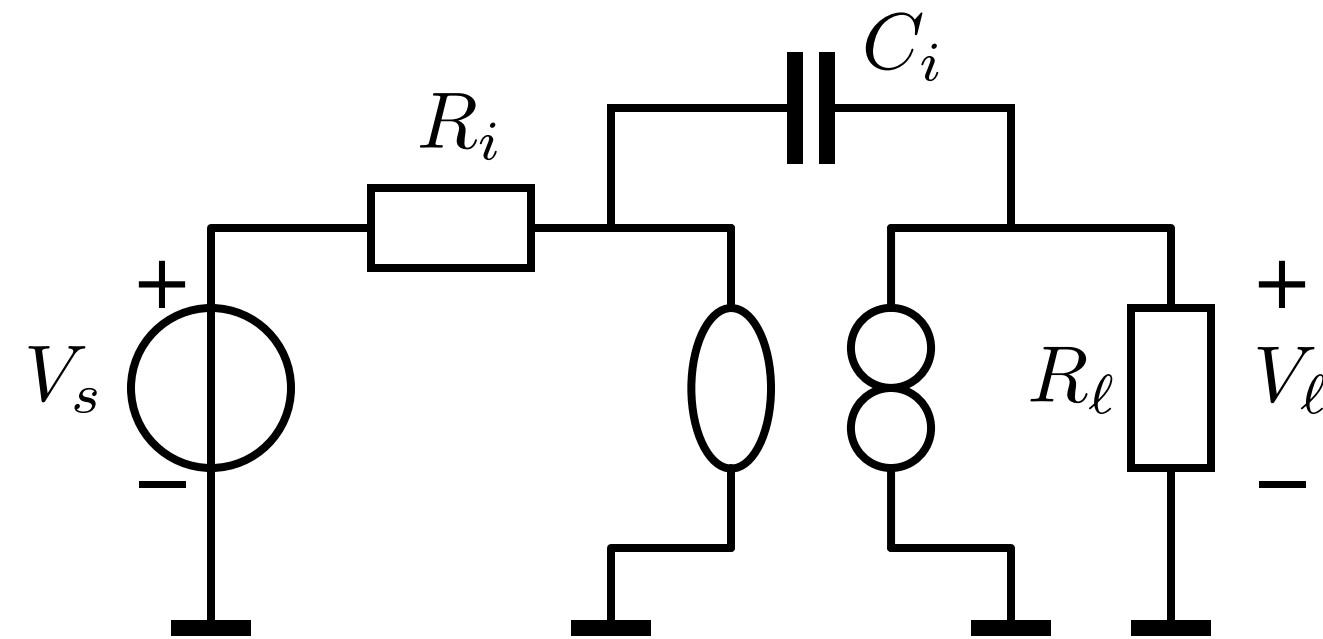
$$A_v = \frac{A_0}{1 + s \frac{A_0}{2\pi GB}}$$

Example integrator bandwidth

Ideal gain: replace controller with a nullor:

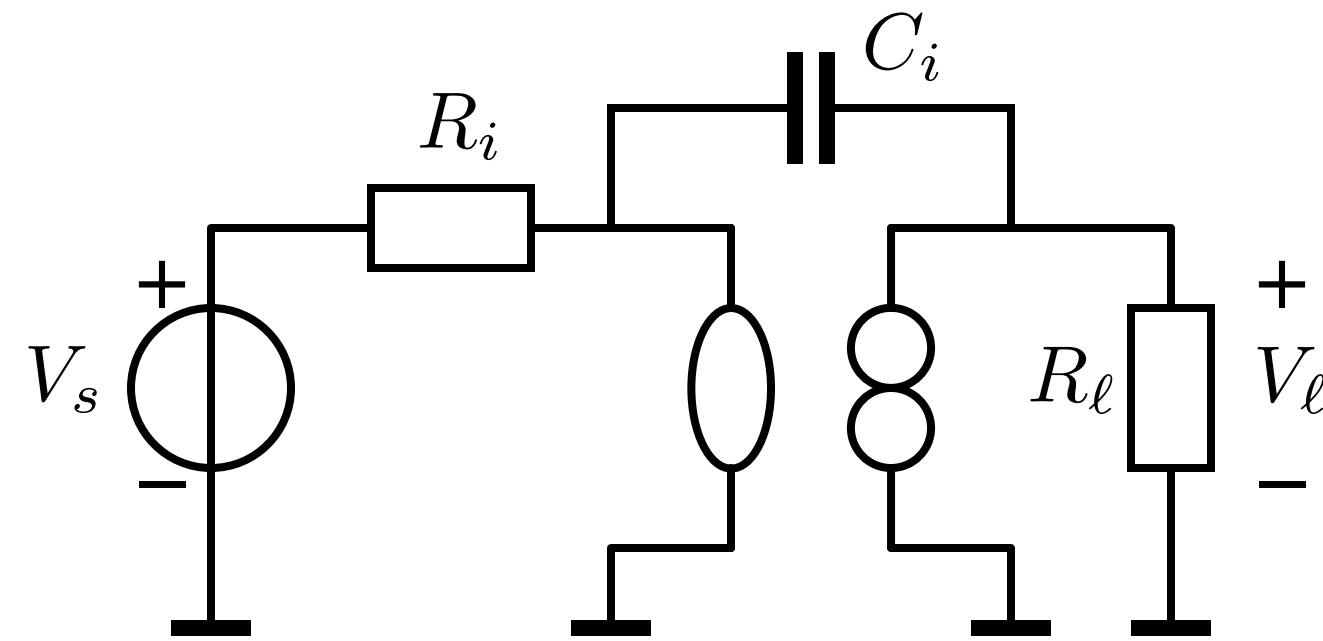
Example integrator bandwidth

Ideal gain: replace controller with a nullor:



Example integrator bandwidth

Ideal gain: replace controller with a nullor:



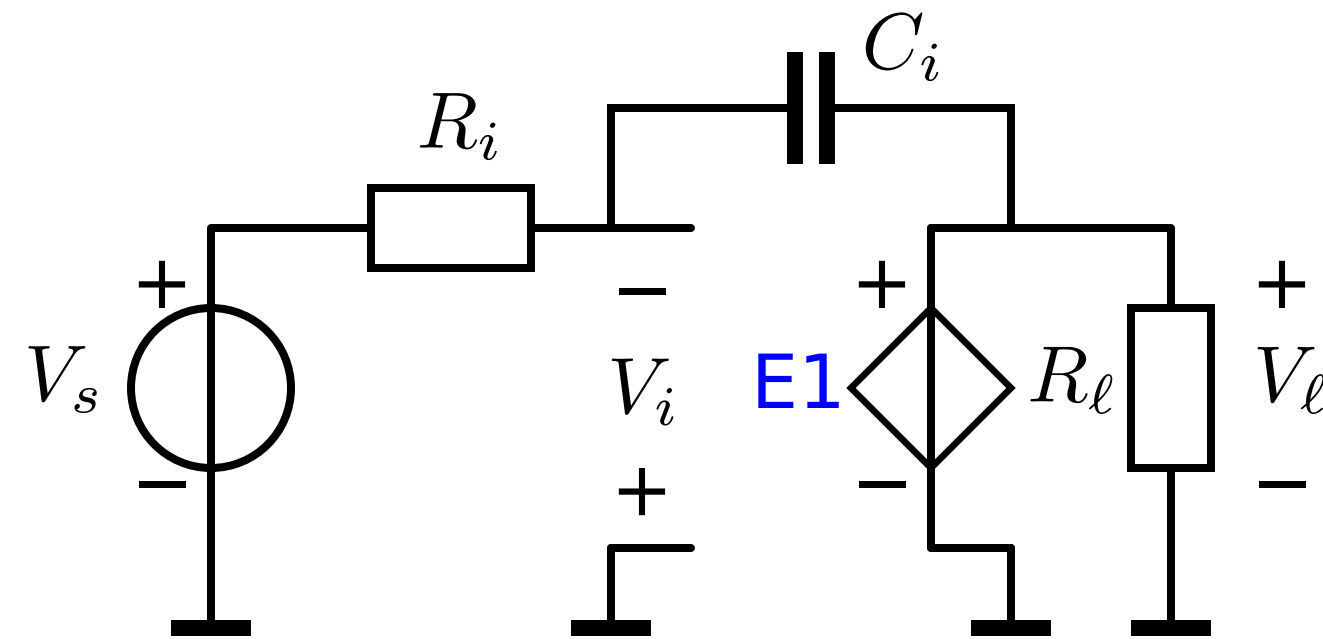
$$\frac{V_\ell}{V_s} = -\frac{1}{sR_iC_i}$$

Example integrator bandwidth

Select loop gain reference such that the asymptotic gain equals the ideal gain

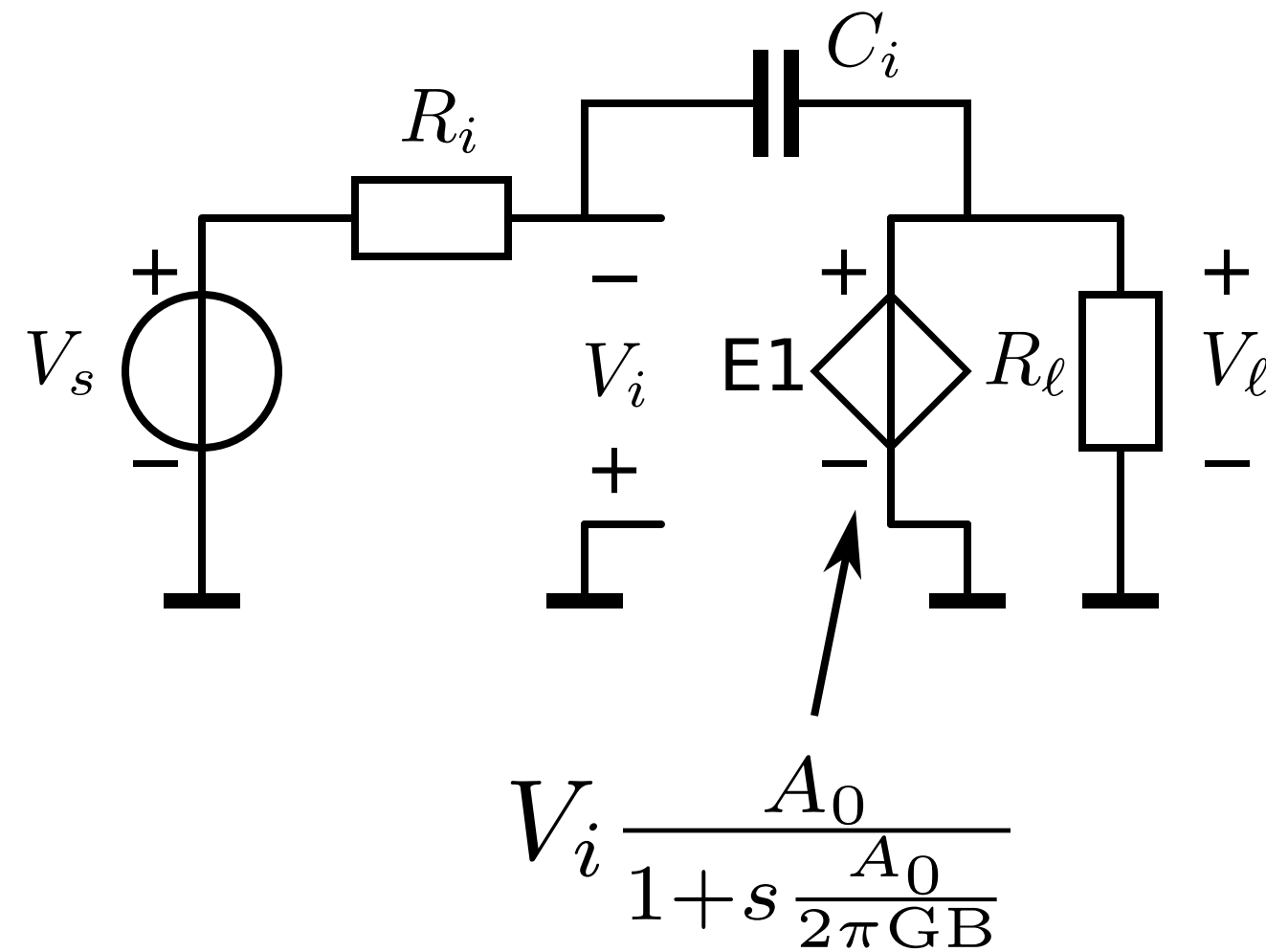
Example integrator bandwidth

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Example integrator bandwidth

Select loop gain reference such that the asymptotic gain equals the ideal gain

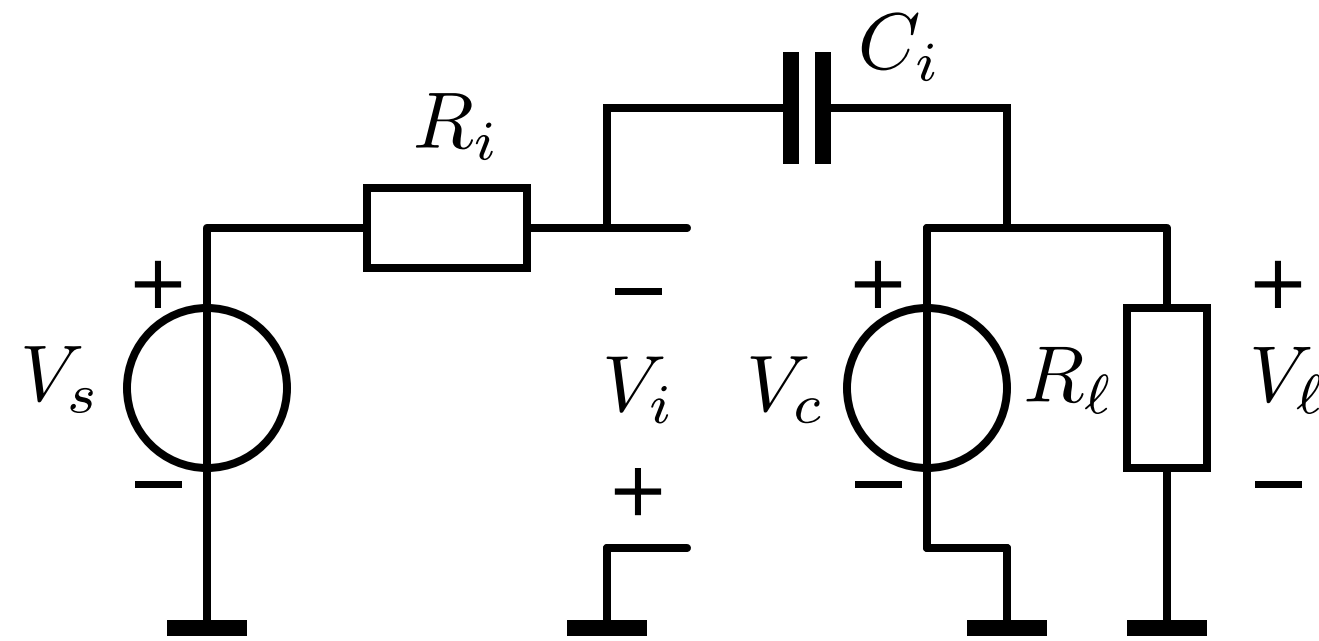


Example integrator bandwidth

Evaluate the loop gain:

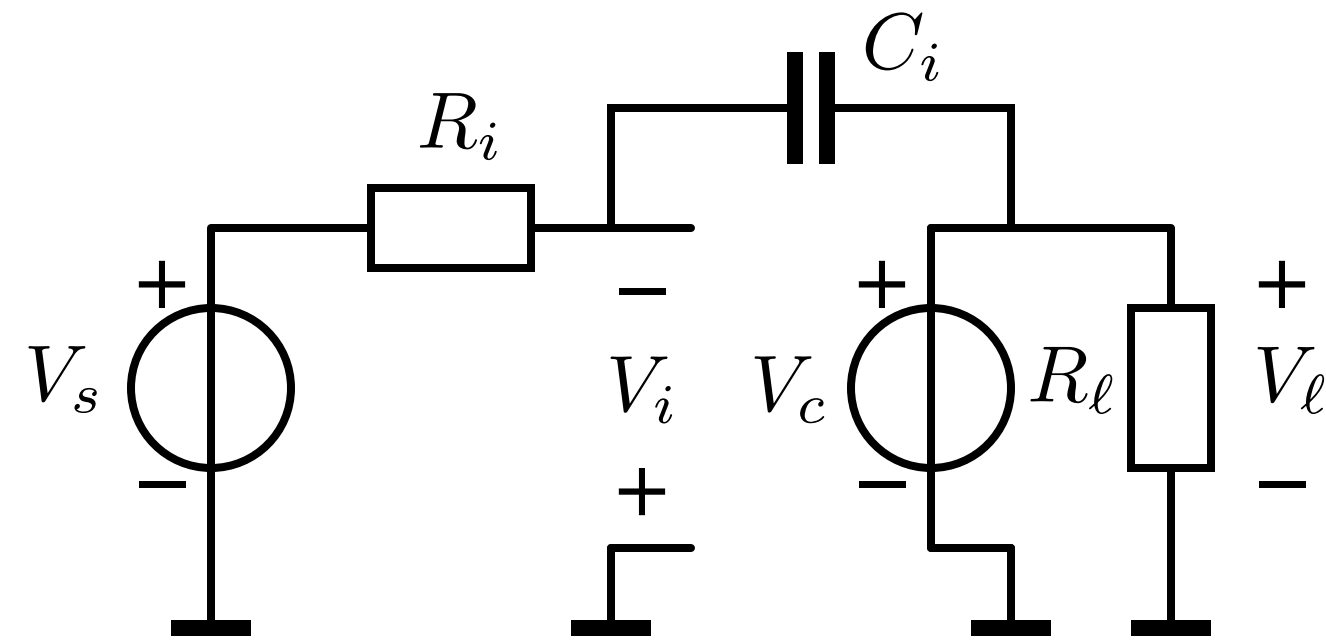
Example integrator bandwidth

Evaluate the loop gain:



Example integrator bandwidth

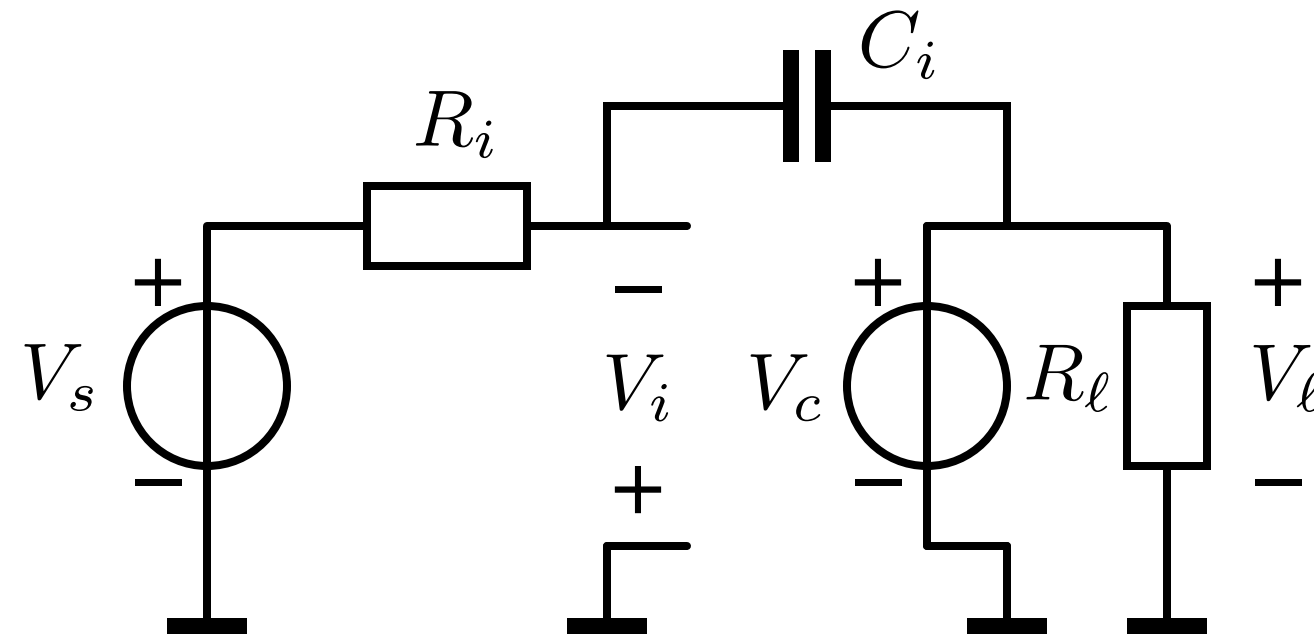
Evaluate the loop gain:



$$A_{\text{ref}} = \frac{A_0}{1 + s \frac{A_0}{2\pi \text{GB}}}$$

Example integrator bandwidth

Evaluate the loop gain:

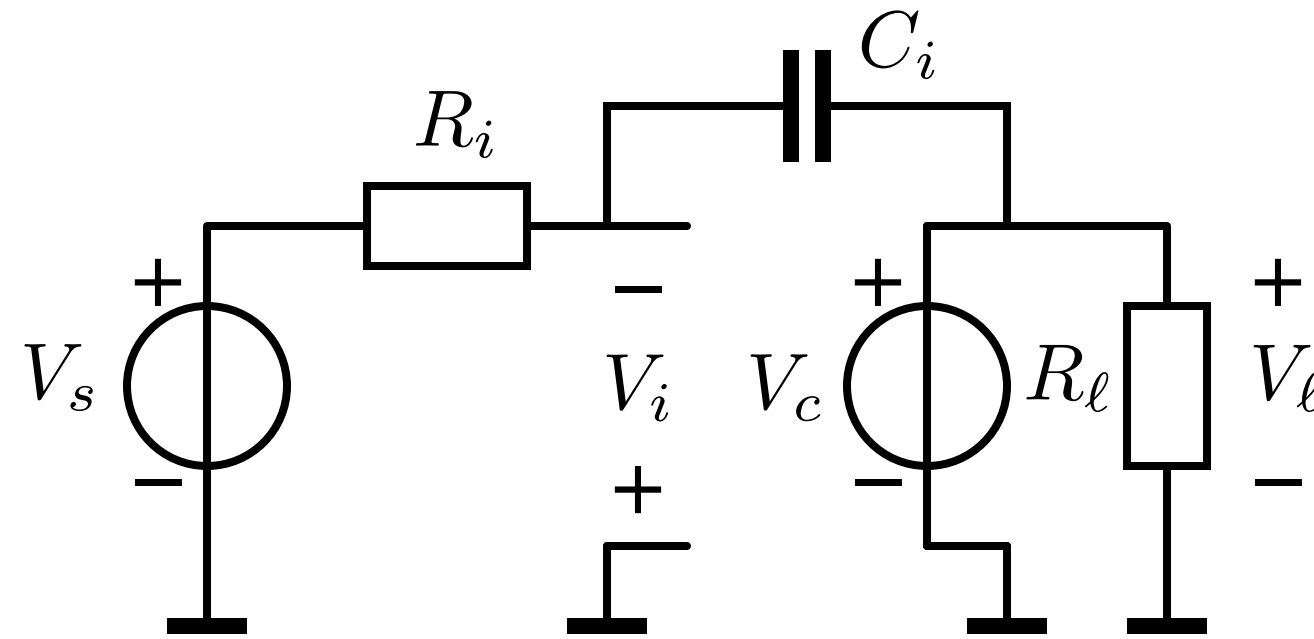


$$A_{\text{ref}} = \frac{A_0}{1 + s \frac{A_0}{2\pi \text{GB}}}$$

$$\lambda\beta\kappa = \left. \frac{V_i}{V_c} \right|_{V_s=0} = -\frac{sR_iC_i}{1+sR_iC_i}$$

Example integrator bandwidth

Evaluate the loop gain:

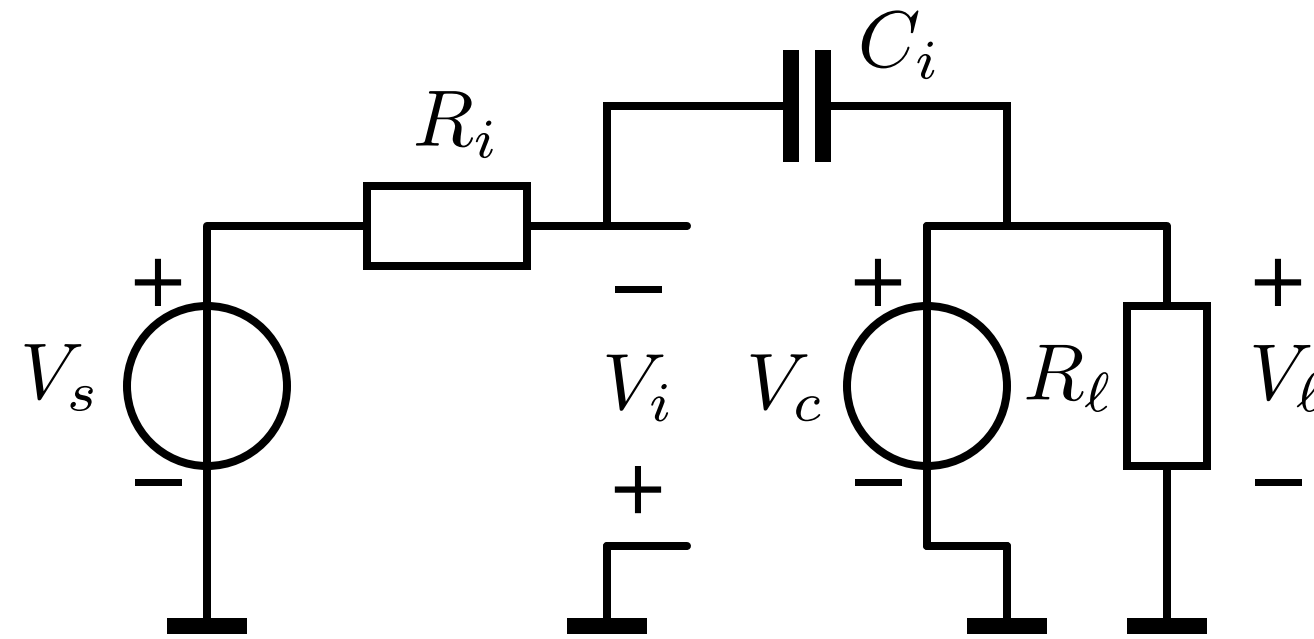


$$A_{\text{ref}} = \frac{A_0}{1 + s \frac{A_0}{2\pi \text{GB}}}$$

$$\lambda\beta\kappa = \left. \frac{V_i}{V_c} \right|_{V_s=0} = -\frac{sR_iC_i}{1+sR_iC_i} \quad L = -\frac{sR_iC_i}{1+sR_iC_i} \frac{A_0}{1+s \frac{A_0}{2\pi \text{GB}}}$$

Example integrator bandwidth

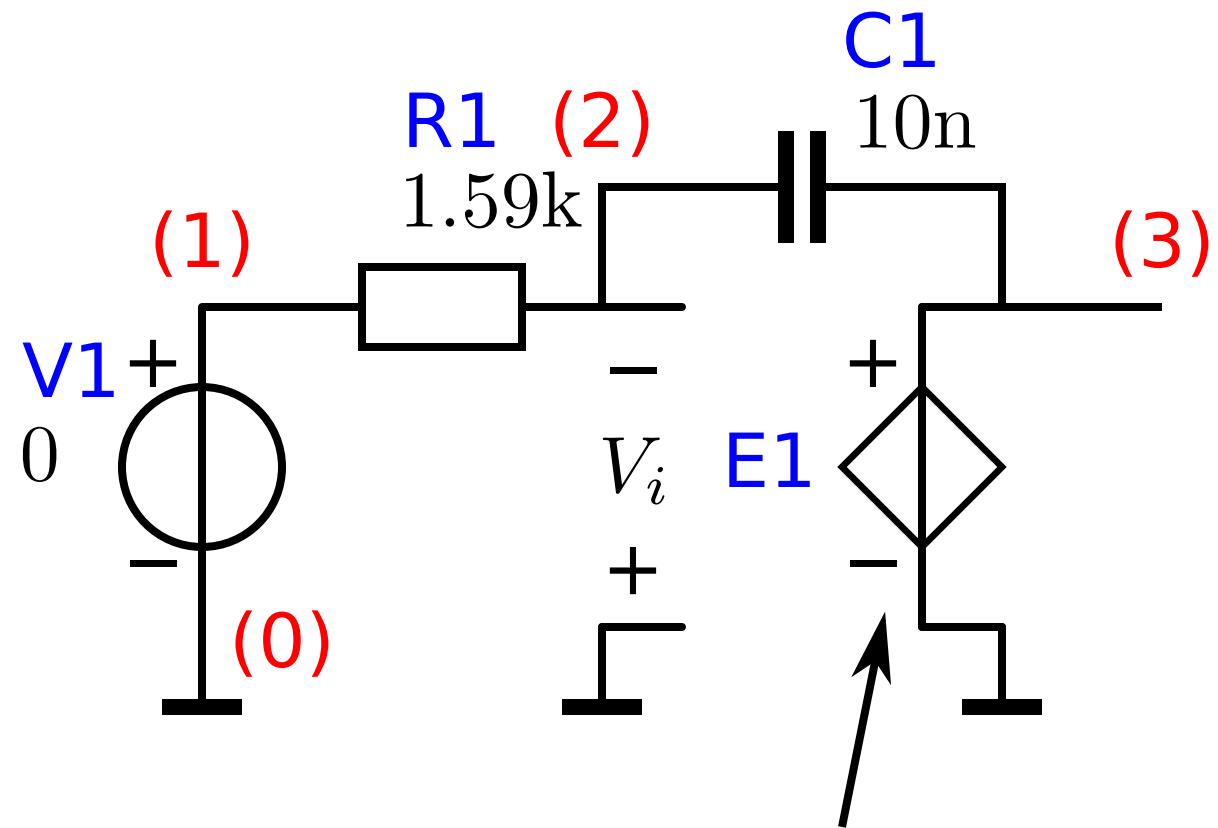
Evaluate the loop gain:



$$A_{\text{ref}} = \frac{A_0}{1 + s \frac{A_0}{2\pi \text{GB}}}$$

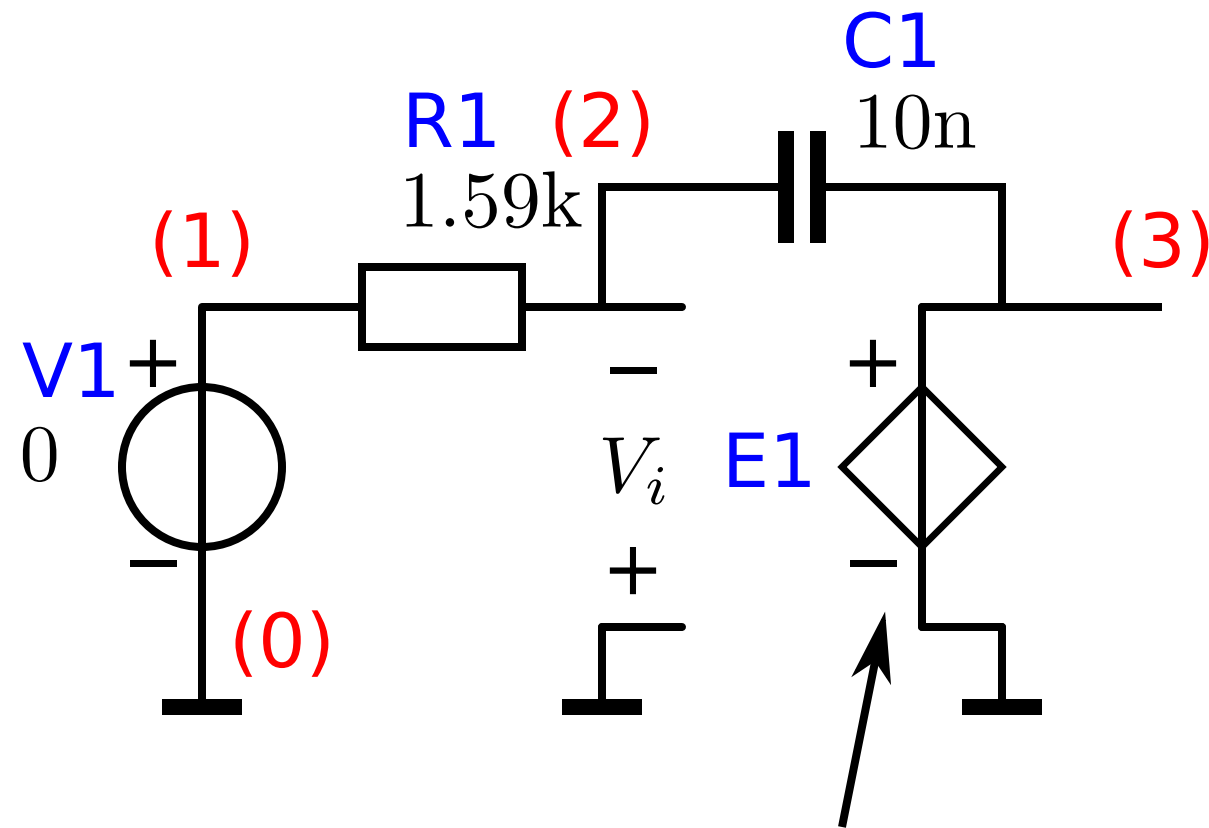
$$\lambda\beta\kappa = \left. \frac{V_i}{V_c} \right|_{V_s=0} = -\frac{sR_iC_i}{1 + sR_iC_i} \quad L = -\frac{sR_iC_i}{1 + sR_iC_i} \frac{A_0}{1 + s \frac{A_0}{2\pi \text{GB}}}$$

Example integrator bandwidth



$$V_i \frac{1000}{1 + 628.3s}$$

Example integrator bandwidth



$$V_i \frac{1000}{1 + 628.3s}$$

Integrator

V1 1 0 0

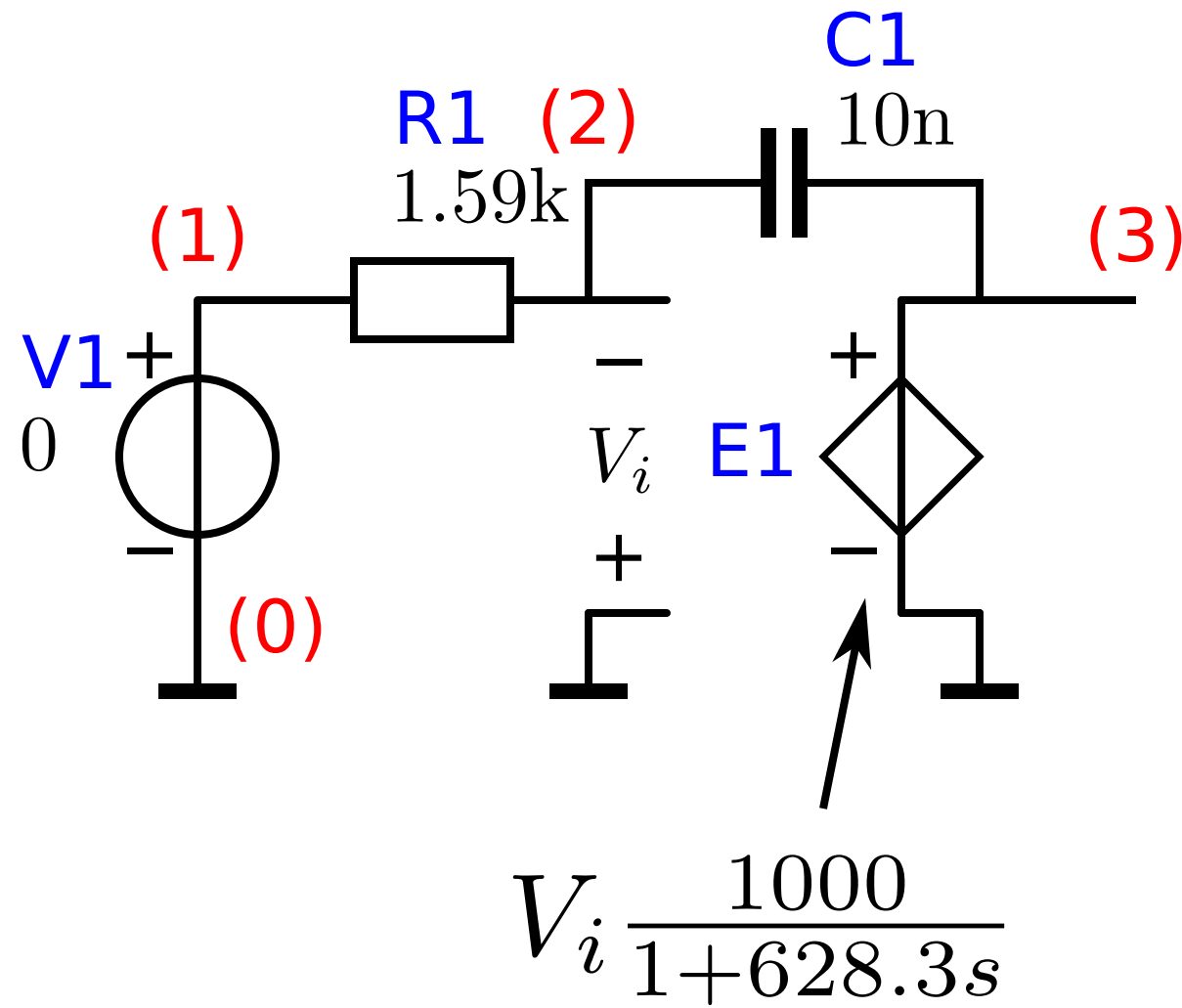
R1 1 2 1.59k

C1 2 3 10n

E1 3 0 0 2 {1k/(1+s/2/pi/100)}

.end

Example integrator bandwidth



Integrator

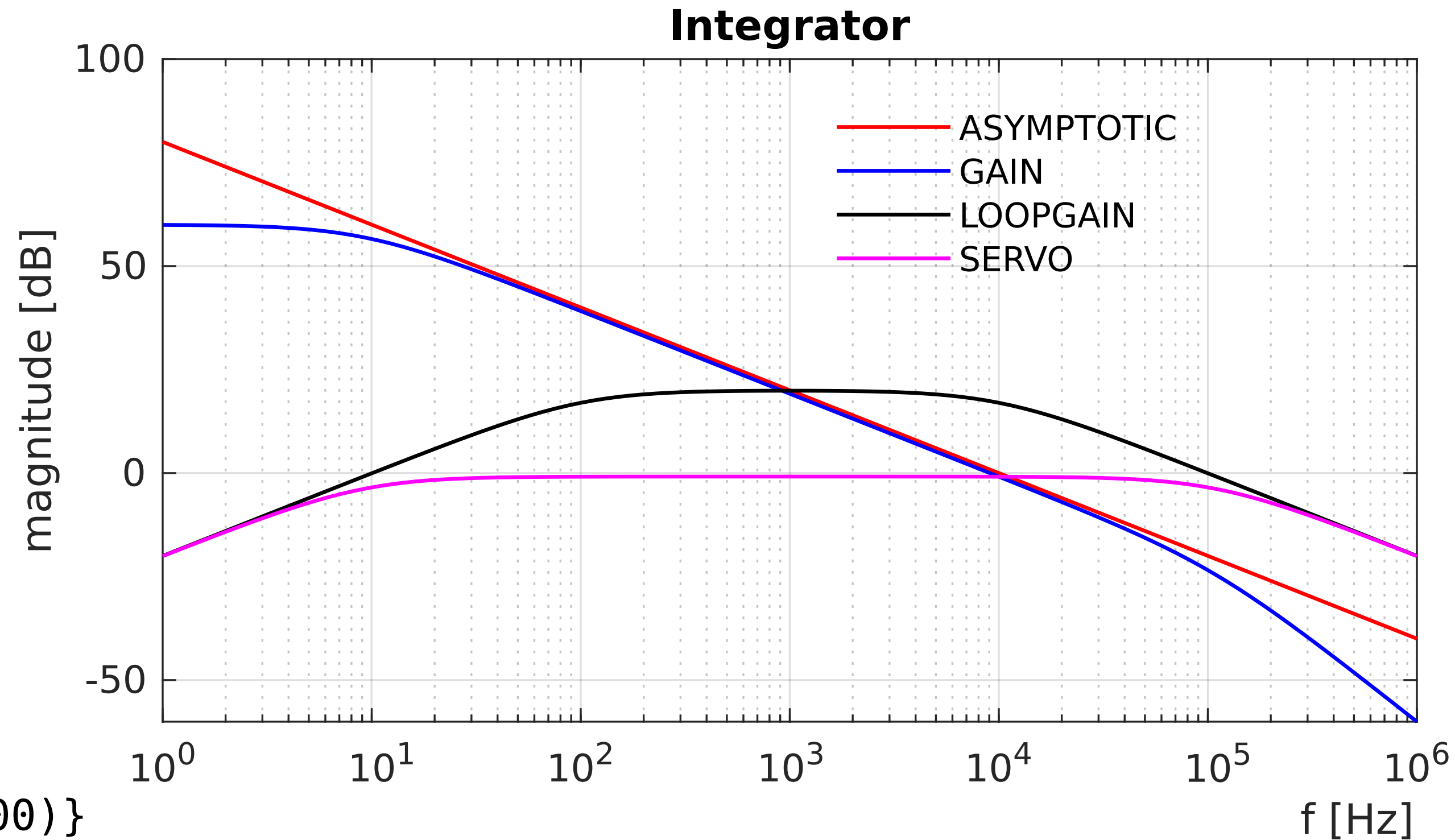
V1 1 0 0

R1 1 2 1.59k

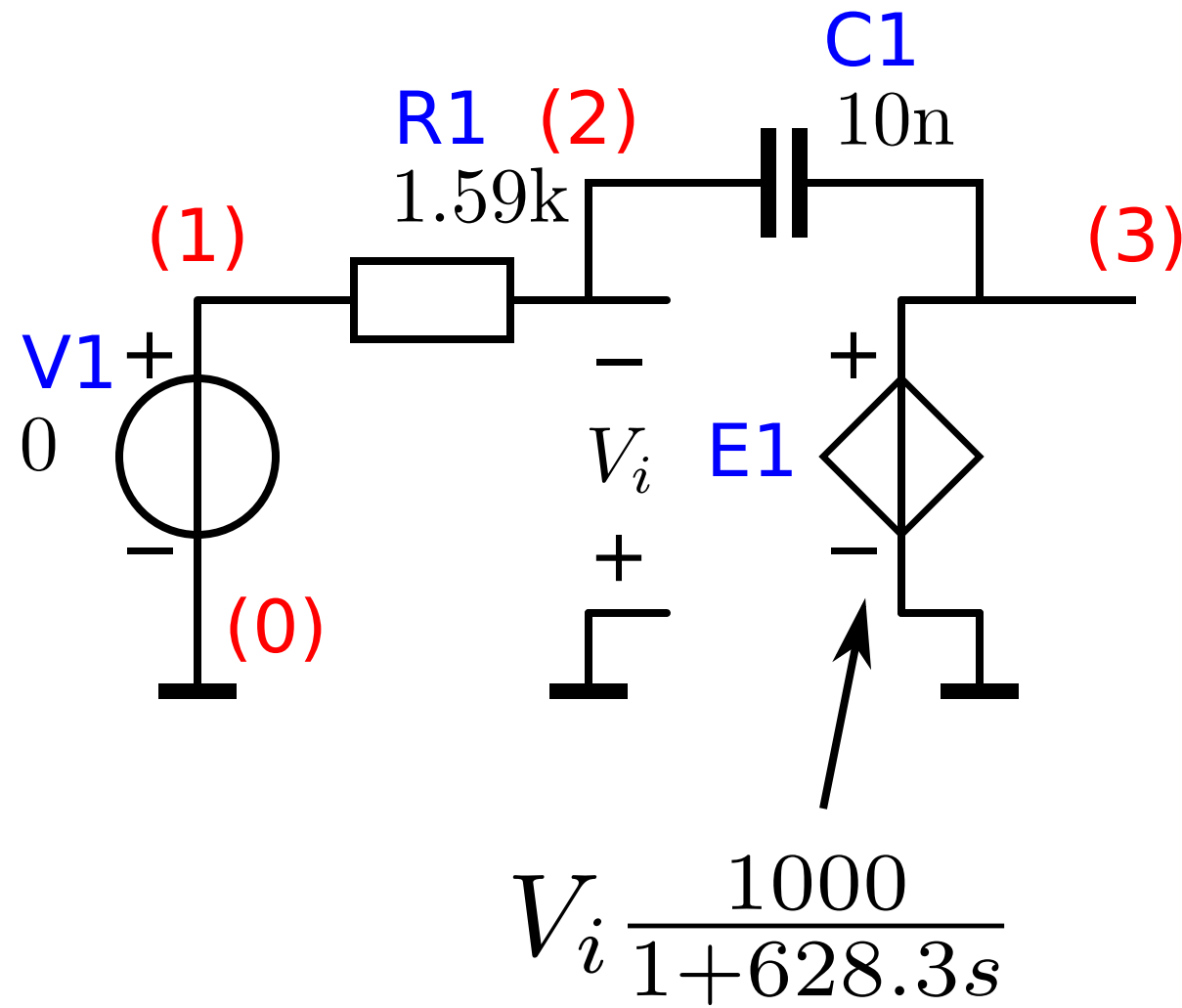
C1 2 3 10n

E1 3 0 0 2 {1k/(1+s/2/pi/100)}

.end



Example integrator bandwidth



Integrator

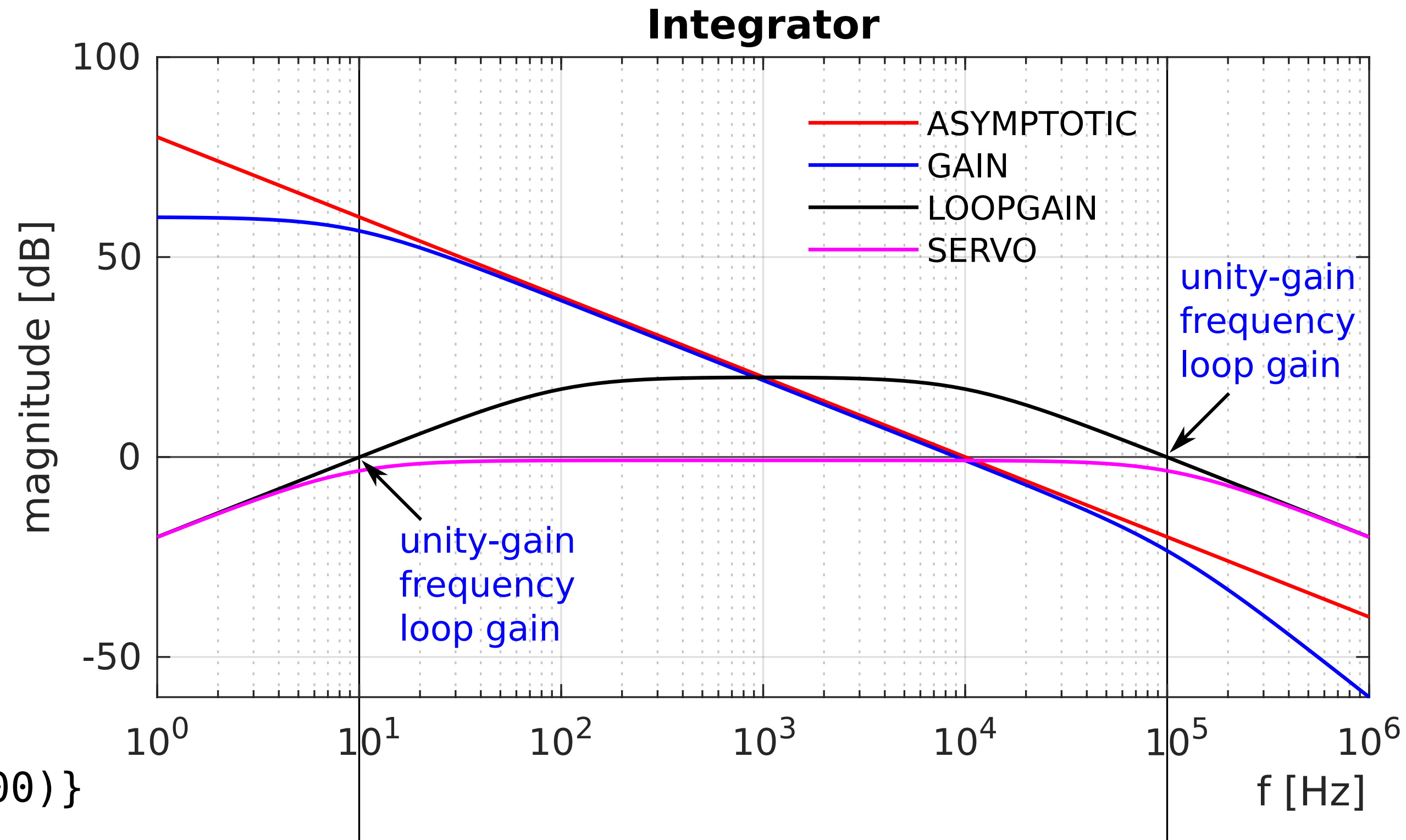
V1 1 0 0

R1 1 2 1.59k

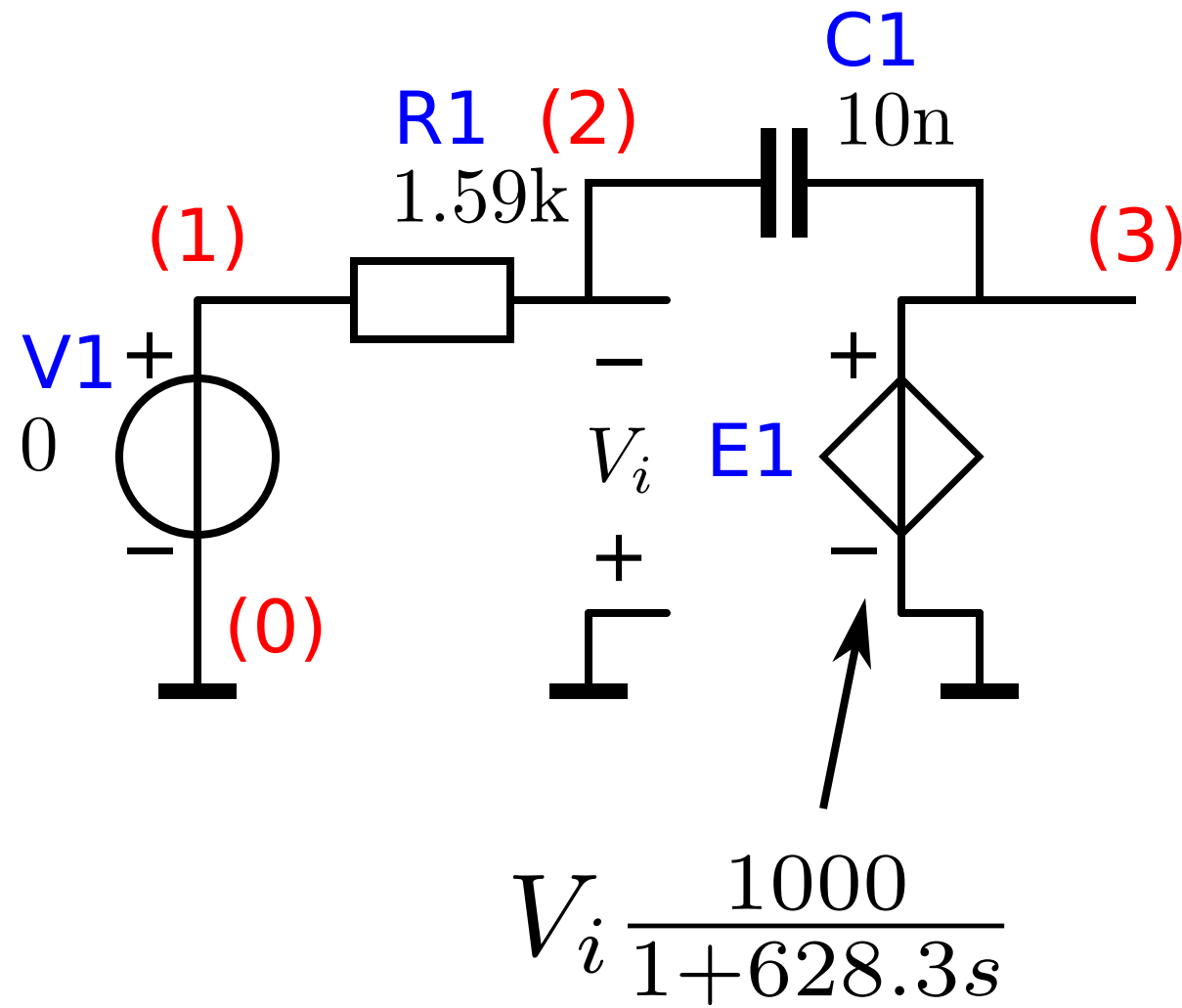
C1 2 3 10n

E1 3 0 0 2 {1k/(1+s/2/pi/100)}

.end



Example integrator bandwidth



Integrator

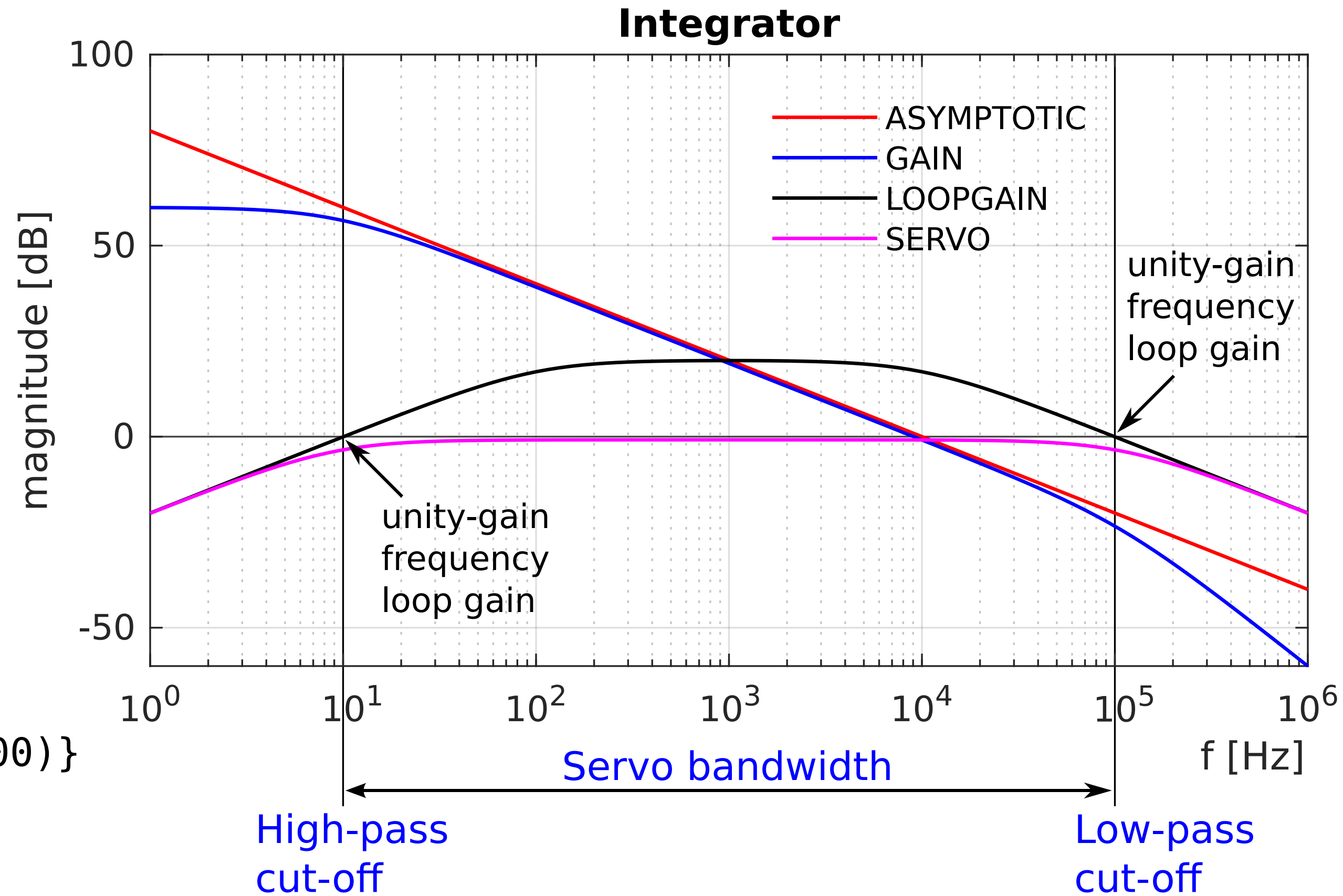
V1 1 0 0

R1 1 2 1.59k

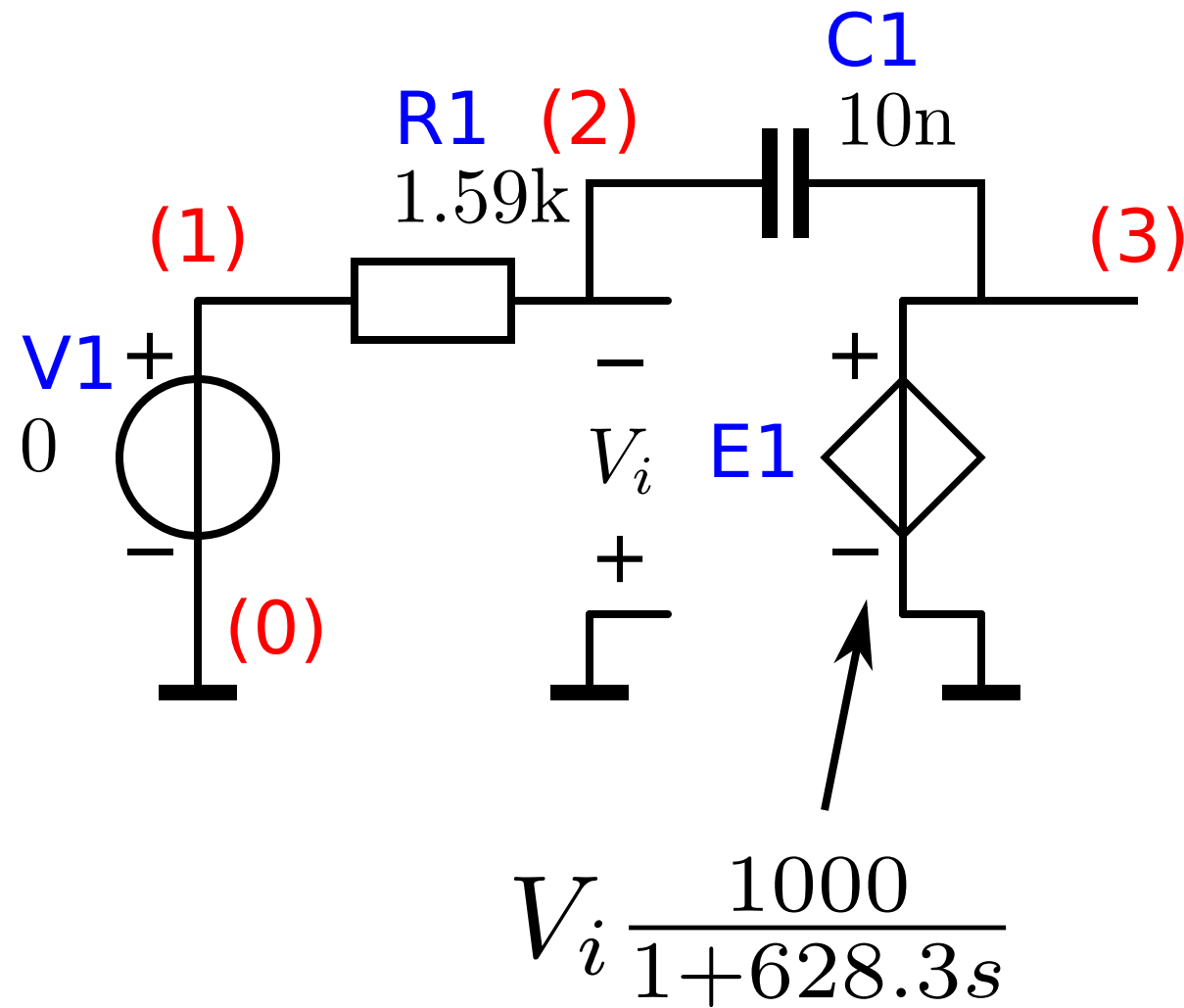
C1 2 3 10n

E1 3 0 0 2 {1k/(1+s/2/pi/100)}

.end



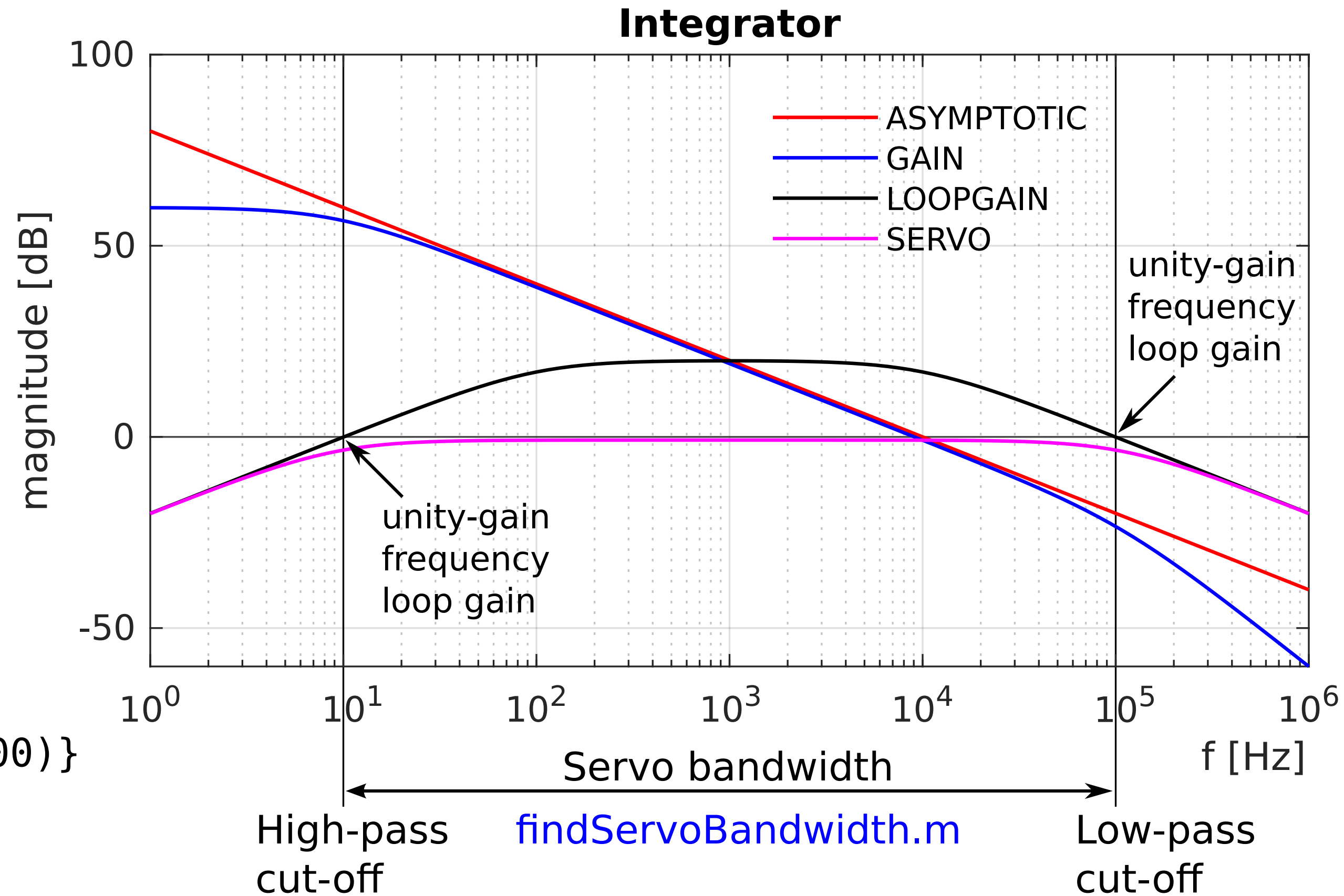
Example integrator bandwidth



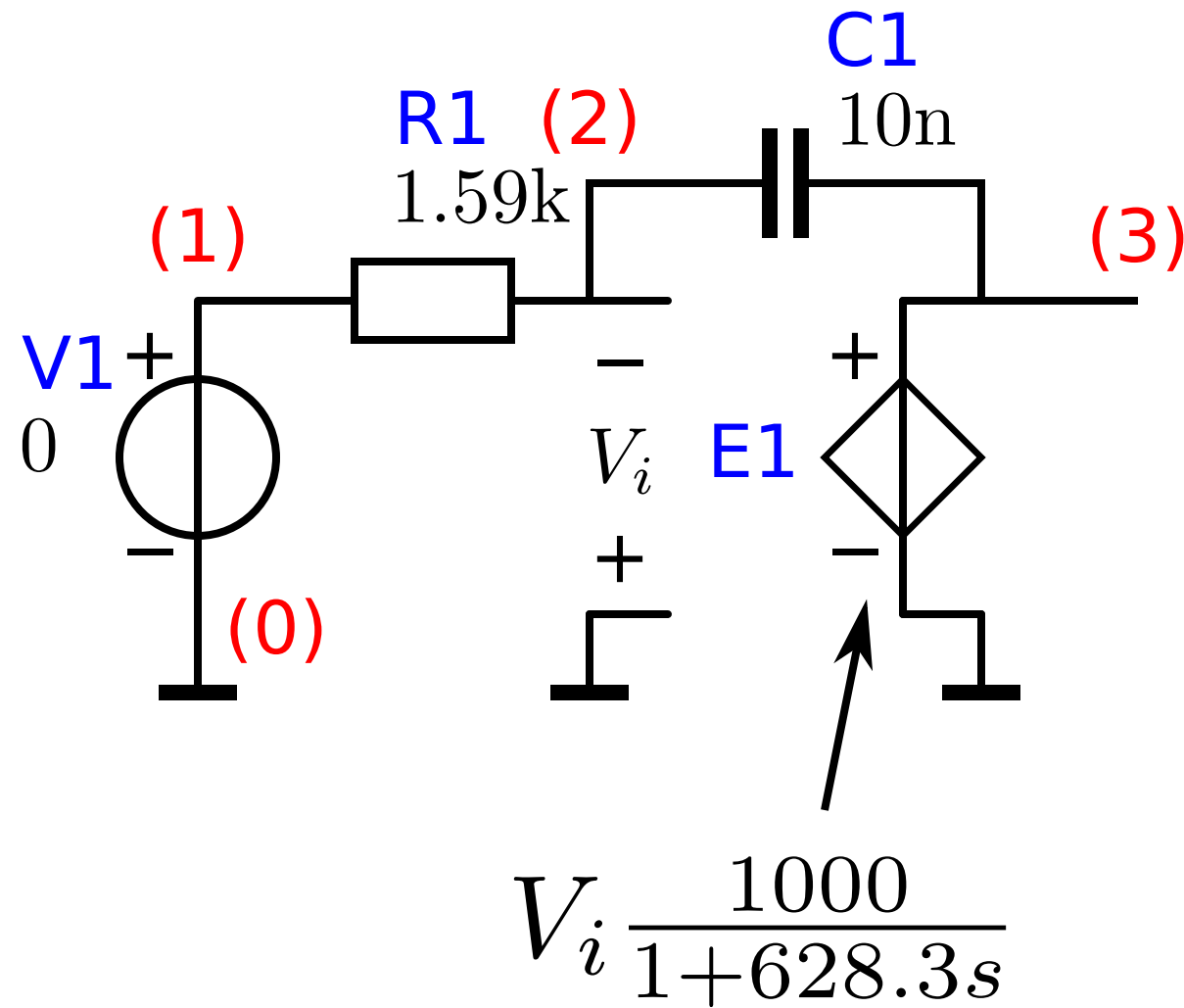
Integrator

```

V1 1 0 0
R1 1 2 1.59k
C1 2 3 10n
E1 3 0 0 2 {1k/(1+s/2/pi/100)}
.end
    
```



Example integrator bandwidth



Integrator

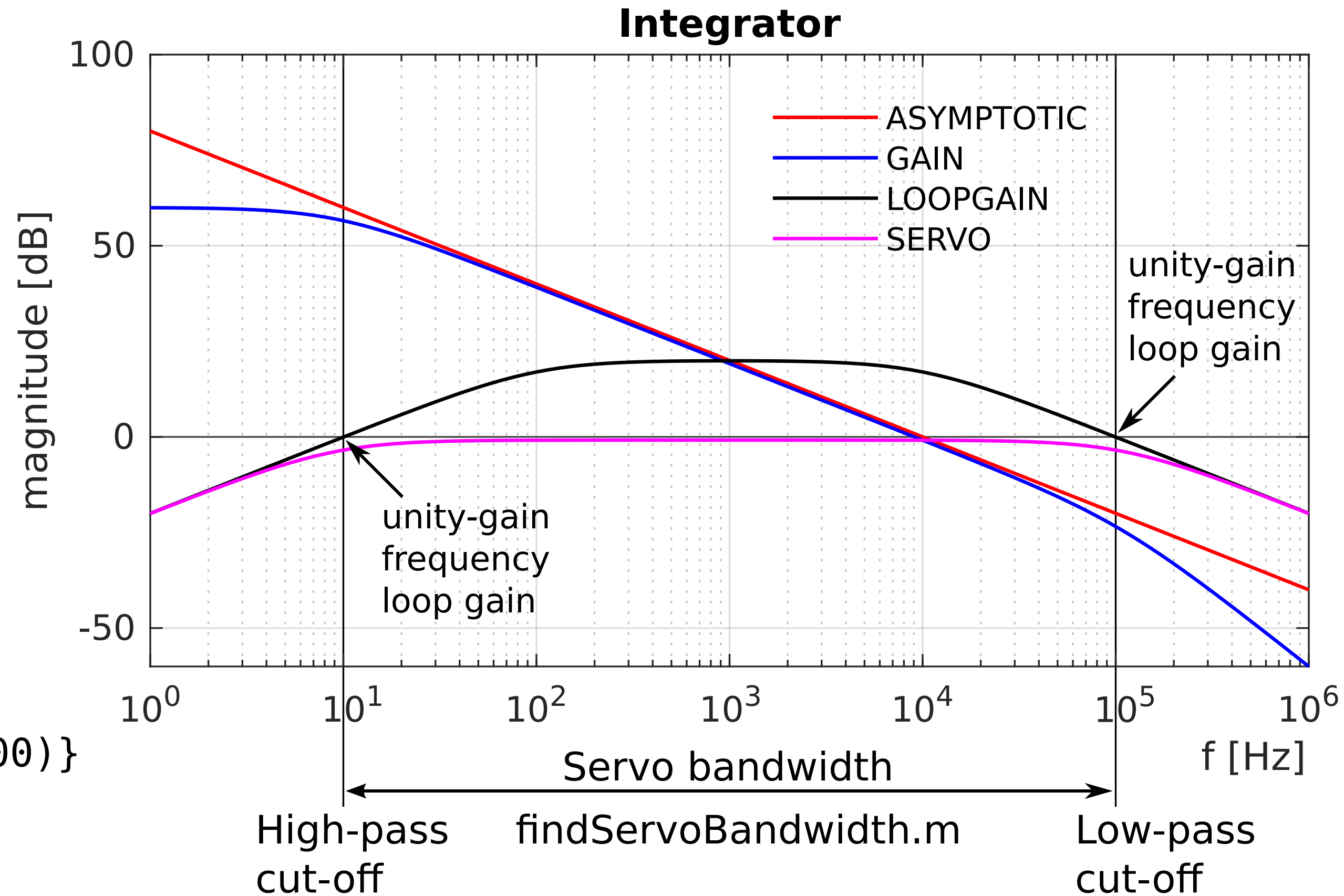
V1 1 0 0

R1 1 2 1.59k

C1 2 3 10n

E1 3 0 0 2 {1k/(1+s/2/pi/100)}

.end



Design questions

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