Pulse Width PGA

```
ClearAll["Global`*"]
```

Non-inverting integrating amplifier

```
ei1 = vo == (vip - vin) GBW / (s + wo)
```

$$vo == \frac{GBW\ (-vin + vip)}{s + wo}$$

```
ei2 = vin → vo s / (s + wc)
```

$$vin \to \frac{s\ vo}{s + wc}$$

```
ei3 = ei1 /. ei2
```

$$\mathbf{vo == \frac{GBW\ \left(vip - \frac{s\ vo}{s+wc}\right)}{s + wo}}$$

$$vo == \frac{GBW\ \left(vip - \frac{s\ vo}{s+wc}\right)}{s + wo}$$

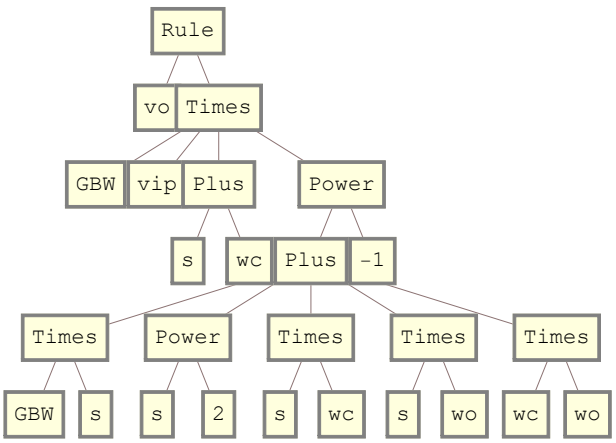
```
ei4 = Solve[ei3, vo][[1, 1]]
```

$$vo \to \frac{GBW\ vip\ (s + wc)}{GBW\ s + s^2 + s\ wc + s\ wo + wc\ wo}$$

```
ei4[[2, 1]]
```

GBW

```
TreeForm[ei4]
```



```
e1 = InverseLaplaceTransform[(s + a) / (s^2 + a s + b), s, t]
```

$$\left(-a\, e^{\left(-\frac{a}{2}-\frac{1}{2}\sqrt{a^2-4b}\right)t} + \sqrt{a^2-4b}\; e^{\left(-\frac{a}{2}-\frac{1}{2}\sqrt{a^2-4b}\right)t} + a\, e^{\left(-\frac{a}{2}+\frac{1}{2}\sqrt{a^2-4b}\right)t} + \sqrt{a^2-4b}\; e^{\left(-\frac{a}{2}+\frac{1}{2}\sqrt{a^2-4b}\right)t}\right) \Big/ \left(2\sqrt{a^2-4b}\right)$$

```
e2 = Roots[s^2 + (wc + bw + w0) s + w0 wc == 0, s]
```

$$s == \frac{1}{2}\left(-bw - w0 - wc - \sqrt{-4\, w0\, wc + (bw + w0 + wc)^2}\right) \;||$$

$$s == \frac{1}{2}\left(-bw - w0 - wc + \sqrt{-4\, w0\, wc + (bw + w0 + wc)^2}\right)$$

```
e2[[1]] /. bw → 2 * Pi * 3 * 10^6 /. wc → 10^6 /. w0 → 18.9 // N
```

$$s == -1.98496 \times 10^7$$

```
e2[[2]] /. bw → 2 * Pi * 3 * 10^6 /. wc → 10^6 /. w0 → 18.9 // N
```

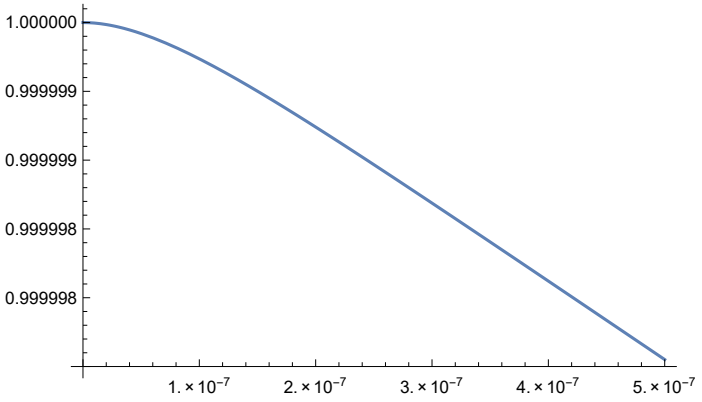
$$s == -0.952161$$

Constant input initial condition: Vo=(s+a)/(s^2 + as + b)*vo(0) - b0)/(s^2 + as + b)*vp(0)

```
ezi1 = InverseLaplaceTransform[
  (s + (wc + bw + w0)) / ((s^2 + (wc + bw + w0) s + w0 wc)) /. bw → 1 * 10^7 /. wc → 4 * 10^6 /.
    w0 → 20 // N, s, t]
```

$$-4.08163 \times 10^{-7}\, e^{-1.4\times10^7\, t} + 1.\, e^{-5.71428\, t}$$

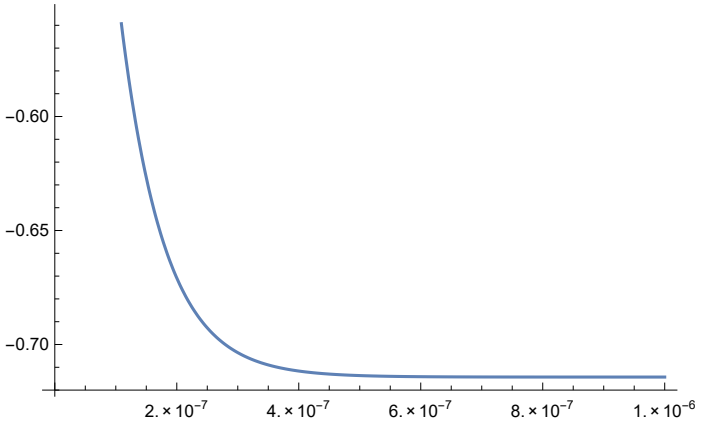
```
Plot[ezi1, {t, 0, 0.5 × 10^-6}]
```




```
ezi2 = InverseLaplaceTransform[
  (-bw) / ((s^2 + (wc + bw + w0) s + w0 wc)) /. bw → 1 * 10^7 /. wc → 4 * 10^6 /. w0 → 20 // N,
  s, t]
```

$$-1. \times 10^7 \left(-7.14285 \times 10^{-8}\, e^{-1.4\times10^7\, t} + 7.14285 \times 10^{-8}\, e^{-5.71428\, t}\right)$$

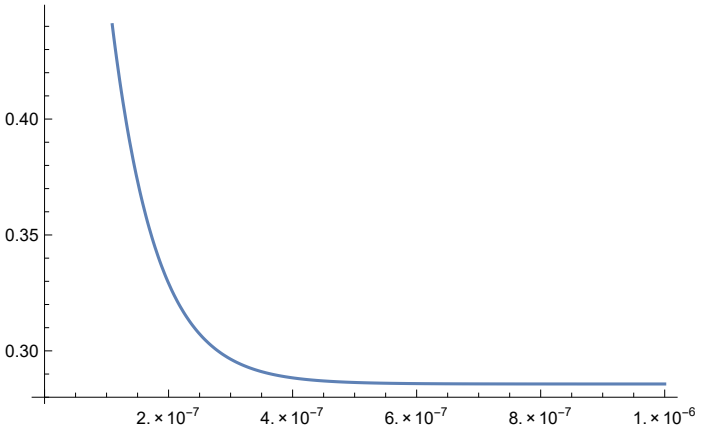
```
Plot[ezi2, {t, 0, 1 × 10^-6}]
```




```
ezi3 = InverseLaplaceTransform[
  (s + (wc + bw + w0 )) / ((s^2 + (wc + bw + w0) s + w0 wc)) - bw /
      ((s^2 + (wc + bw + w0) s + w0 wc)) /.
    bw → 1 * 10^7 /. wc → 4 * 10^6 /. w0 → 20 // N, s, t]
```

$$0.714285\, e^{-1.4\times10^{7}\, t} + 0.285715\, e^{-5.71428\, t}$$

```
Plot[ezi3, {t, 0, 1 × 10^-6}]
```

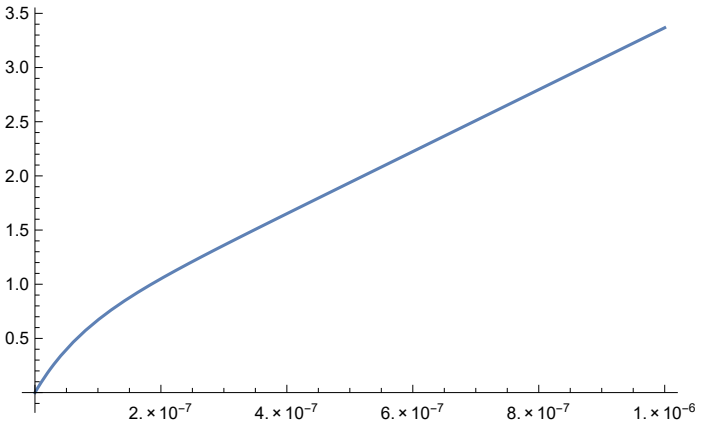


Zero state condition:

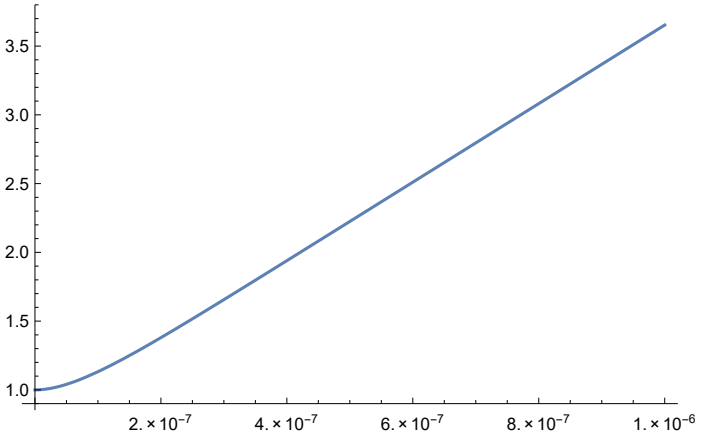
```
ezs1 = InverseLaplaceTransform[
  (bw s + bw wc) / (s (s^2 + (wc + bw + w0) s + w0 wc)) /. bw → 1 * 10^7 /. wc → 4 * 10^6 /.
    w0 → 20 // N, s, t]
```

$$500\,000. - 0.510204\, e^{-1.4\times10^{7}\, t} - 499\,999.\, e^{-5.71428\, t}$$

```
Plot[ezs1, {t, 0, 1 × 10^-6}]
```




```
Plot[ezi3 + ezi4 + ezs1, {t, 0, 1 × 10^-6}]
```




```
InverseLaplaceTransform[(s + b1) / (s^2 + a1 s + a2), t, s]
```

$$\frac{(b1 + s)\ \text{DiracDelta}[s]}{a2 + a1\ s + s^2}$$

```
LaplaceTransform[y[t]'' - y[t] == v[t], t, s] /. {y[0] → 0, y'[0] → 0}
```

```
-LaplaceTransform[y[t], t, s] + LaplaceTransform[y[t]″, t, s] ==
 LaplaceTransform[v[t], t, s]
```