# *AC coupled instrumentation amplifier circuit*

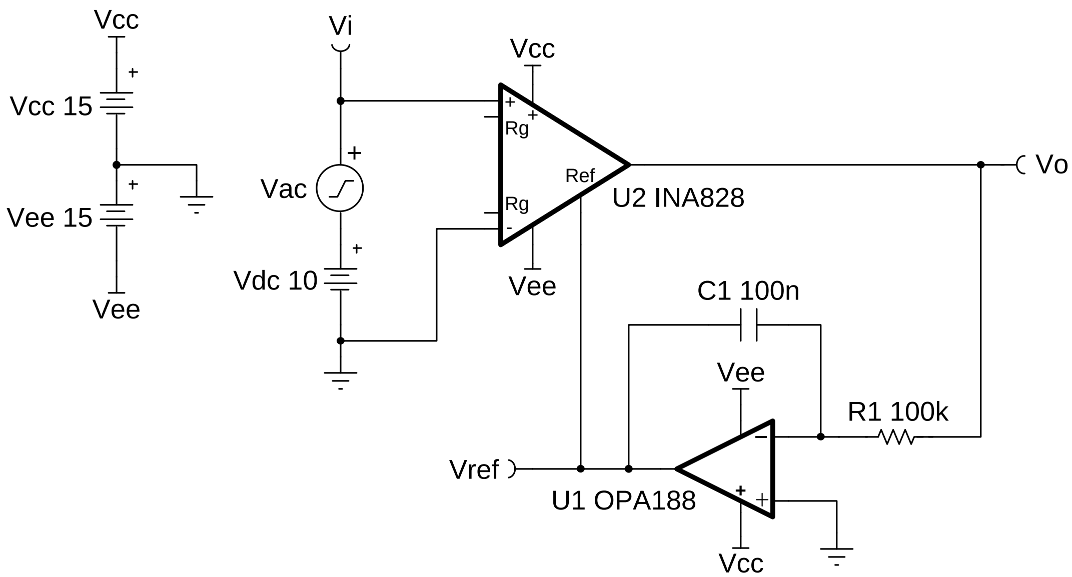
## Design Goals

| Input | | Output | | Supply | |
|---|---|---|---|---|---|
| $V_{iMin}$ | $V_{iMax}$ | $V_{oMin}$ | $V_{oMax}$ | $V_{cc}$ | $V_{ee}$ |
| –13V | 13V | –14.85V | 14.85 | 15 | –15 |

| Lower Cutoff Frequency ($f_L$) | Gain | Input |
|---|---|---|
| 16Hz | 1 | ±2VAC; +10VDC |

## Design Description

This circuit produces an AC-coupled output from a DC-coupled input to an instrumentation amplifier. The output is fed back through an integrator, and the output of the integrator is used to modulate the reference voltage of the amplifier. This creates a high-pass filter and effectively cancels the output offset. This circuit avoids the need for large capacitors and resistors on the input, which can significantly degrade CMRR due to component mismatch.




## Design Notes

1. The DC correction from output to reference is unity-gain. $U_1$ can only correct for a signal within its input/output limitations, thus the magnitude of DC voltage that can be corrected for will degrade with increasing instrumentation amplifier gain. See the table in Design Steps for more information.
2. Large values of $R_1$ and $C_1$ will lower the cutoff frequency, but increase startup transient response time. Startup behavior can be observed in the Transient Simulation Results.
3. When AC-coupling this way, the total input voltage must remain within the common-mode input range of the instrumentation amplifier.

## Design Steps

1. Set the lower cutoff frequency for circuit (integrator cutoff frequency). The upper cutoff frequency will be dictated by the gain and instrumentation amplifier bandwidth.

   $$f_L = \frac{1}{2\pi \times R_1 \times C_1} = 16\ \text{Hz}$$

2. Choose a standard value for $R_1$ and $C_1$.

   $$C_1 = 100\ \text{nF}$$

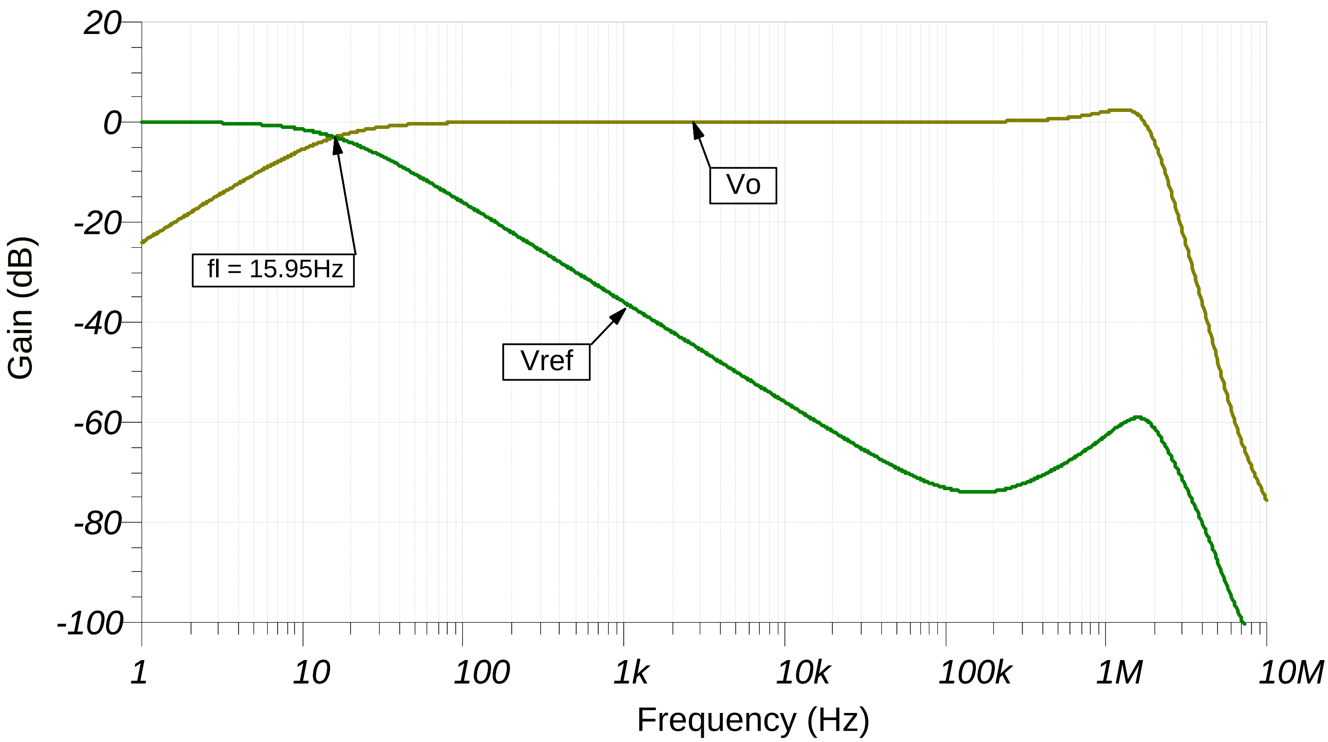
   $$R_1 = \frac{1}{2\pi \times 100\ \text{nF} \times 16\ \text{Hz}} = 99.47\ \text{k}\Omega \approx 100\ \text{k}\Omega\ \text{(standard value)}$$

3. The DC rejection capabilities of the circuit will degrade with gain. The following table provides a good estimate of the DC correction range for higher gains.

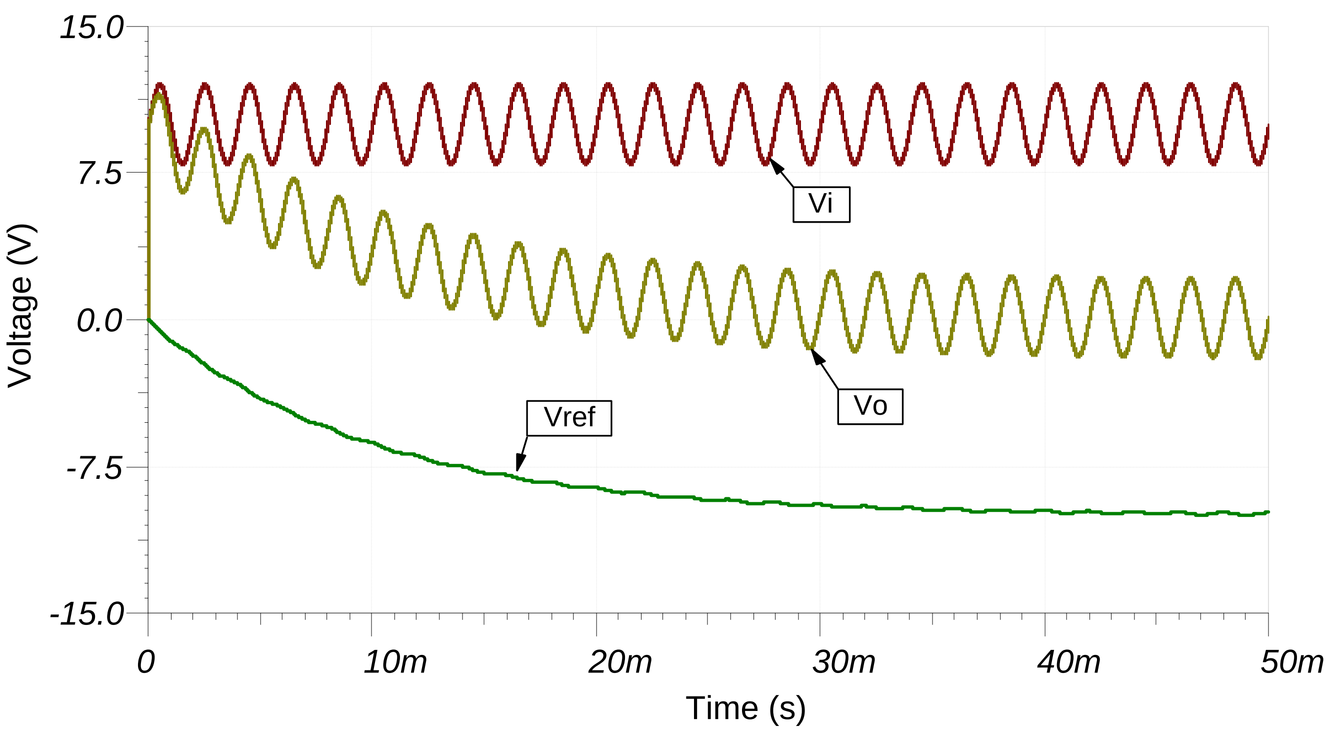
| Gain | DC Correction Range |
|---|---|
| 1V/V | ±10V |
| 10V/V | ±1V |
| 100V/V | ±0.1V |
| 1000V/V | ±0.01V |

**Design Simulations**

**AC Simulation Results**




**Transient Simulation Results**



## Design References

See Analog Engineer's Circuit Cookbooks for TI's comprehensive circuit library.

See TINA-TI™ circuit simulation file, SBOMAU0.

See TIPD191, http://www.ti.com/tool/tipd191.

## Design Featured Instrumentation Amplifier

| INA828 | |
|---|---|
| $V_{ss}$ | 4.5V to 36V |
| $V_{inCM}$ | $V_{ee}$+2V to $V_{cc}$–2V |
| $V_{out}$ | $V_{ee}$+150mV to $V_{cc}$–150mV |
| $V_{os}$ | 20µV |
| $I_q$ | 600µA |
| $I_b$ | 150pA |
| UGBW | 2MHz |
| SR | 1.2V/µs |
| #Channels | 1 |
| www.ti.com/product/INA828 | |

## Design Featured Op Amp

| OPA188 | |
|---|---|
| $V_{ss}$ | 8V to 36V |
| $V_{inCM}$ | $V_{ee}$ to $V_{cc}$–1.5V |
| $V_{out}$ | Rail-to-rail |
| $V_{os}$ | 6µV |
| $I_q$ | 450µA |
| $I_b$ | ±160pA |
| UGBW | 2MHz |
| SR | 0.8V/us |
| #Channels | 1,2,4 |
| www.ti.com/product/OPA188 | |

## Design Alternate Op Amp

| TLV171 | |
|---|---|
| $V_{ss}$ | 2.7V to 36V |
| $V_{inCM}$ | $V_{ee}$–0.1V to $V_{cc}$–2V |
| $V_{out}$ | Rail-to-rail |
| $V_{os}$ | 750µV |
| $I_q$ | 525µA |
| $I_b$ | ±10pA |
| UGBW | 3MHz |
| SR | 1.5V/us |
| #Channels | 1,2,4 |
| www.ti.com/product/OPA188 | |