# EE230 - Experiment 7

Param Rathour - 190070049
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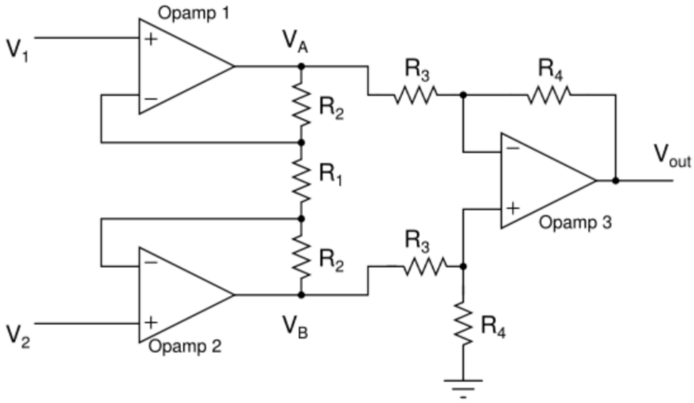


Figure 1: Three-Opamp Instrumentation Amplifier

# 1 Three-Opamp Instrumentation Amplifier using TL084

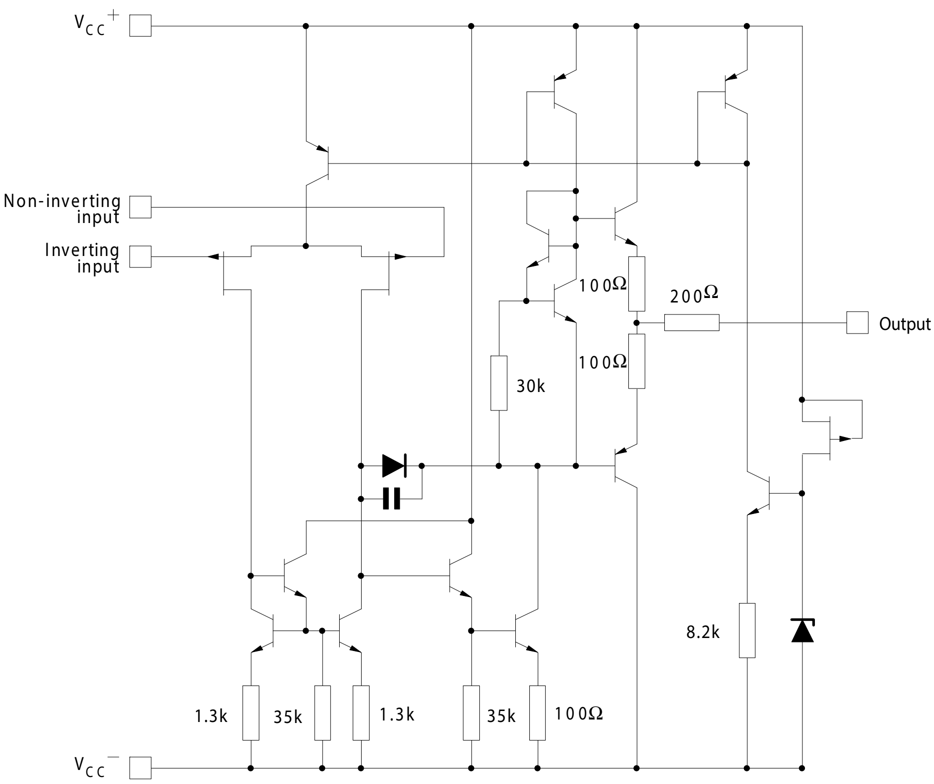


Figure 2: Circuit schematics TL084

$$A_{\mathrm{d}} = \frac{V_{\mathrm{out}}}{V_2 - V_1} = \frac{R_4}{R_3}\left(1 + \frac{2R_2}{R_1}\right)$$

## 1.1 Measurement of the Differential Voltage Gain, $A_{\mathbf{d}}$

$V_1 = 0, V_2 = 10\sin(\omega t)mV, V_{\mathrm{CC}} = 15V, -V_{\mathrm{CC}} = -15V, R_1 = R_2 = 10k\Omega, R_3 = 1k\Omega, R_4 = 100k\Omega$

Here, $A_{\mathrm{d}} = \frac{R_4}{R_3}\left(1 + \frac{2R_2}{R_1}\right) = \frac{100k}{1k}\left(1 + \frac{2\cdot 10k}{10k}\right) = 300$

$V_{\mathrm{out}} = V_2 \cdot A_{\mathrm{d}} = 10m \cdot 300 = 3V$

# 2 INA 128 Instrumentation Amplifier

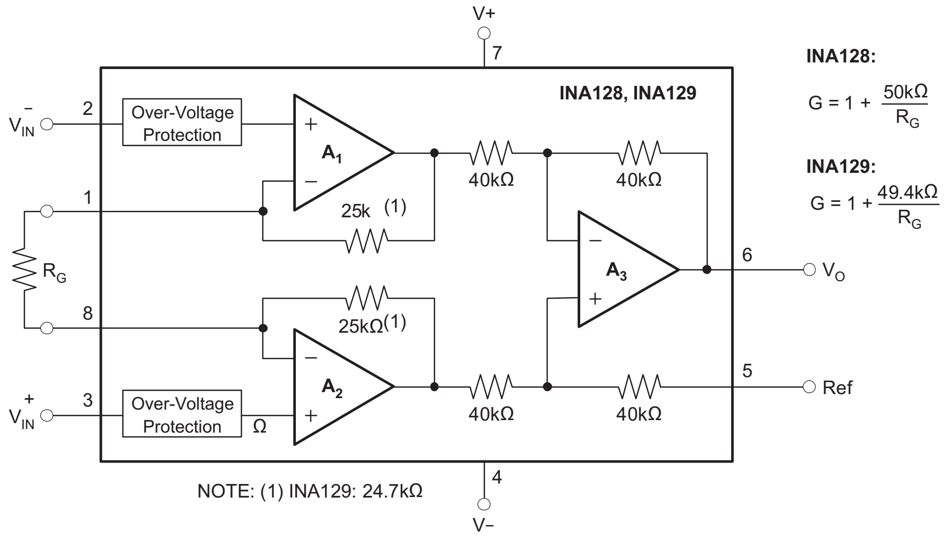


Figure 3: INA 128 Instrumentation Amplifier

$$A_{\mathrm{d}} = \frac{V_{\mathrm{out}}}{V_2 - V_1} = \frac{R_4}{R_3}\left(1 + \frac{2R_2}{R_1}\right) = \left(1 + \frac{50k}{R_G}\right)$$

## 2.1 Measurement of the Differential Voltage Gain, $A_{\mathrm{d}}$

$V_{\mathrm{in}-} = 0, V_{\mathrm{in}+} = 10\sin(\omega t)mV, V_{\mathrm{CC}} = 15V, -V_{\mathrm{CC}} = -15V, R_G = 180\Omega$

Here, $A_{\mathrm{d}} = \left(1 + \frac{50k}{R_G}\right) = \left(1 + \frac{50k}{180}\right) = 277.\dot{7}$

$V_{\mathrm{out}} = V_{\mathrm{in}+} \cdot A_{\mathrm{d}} = 10m \cdot 277.\dot{7} = 2.\dot{7}V$

# 3 Questions

i) In Sec 3.2 and 3.3, even under no-load conditions $V_{\mathrm{out}}$ was found to be non-zero. Give one or two reasons for this.
$\rightarrow$ Under no-load conditions, the four gauges are at rest and so ideally $R_g = R_1 = R_2 = R_3 = R_4$, but due to tolerances of resistors this is not achieved and a small voltage difference is present which gets amplified by the op-amp.
$\rightarrow$ Op-amp non idealities like input bias current, offset voltage also contribute to non-zero $V_{\mathrm{out}}$.

ii) Give two or three major advantages of the three-Opamp instrumentation amplifier as compared to the single-Opamp difference amplifier of Experiment 6.
$\rightarrow$ $A_{\mathrm{d}}$ is easily changeable and can be set to higher values.
$\rightarrow$ Higher differential input resistance.
$\rightarrow$ High CMRR (due to high $A_{\mathrm{d}}$ and low $A_{\mathrm{cm}}$).

iii) Look at the data sheets of TL084 and INA128. Identify the major differences between these two ICs – i.e. Opamp parameters crucial for difference amplifier applications, such as the Loadcell application discussed in this experiment
$\rightarrow$ INA128 has a higher CMRR (120dB) than TL084 (86dB)
$\rightarrow$ TL084 has a lower input bias current ($20pA$) than INA128 ($5nA$)
$\rightarrow$ INA128 has a lower offset voltage ($50\mu V$) than TL084 ($3mV$)
$\rightarrow$ TL084 has a higher slew rate ($16V/\mu s$) than INA128 ($4V/\mu s$)
$\rightarrow$ INA128 has a lower drift ($0.5\mu V/C^\circ$) than TL084 ($10\mu V/C^\circ$)

iv) Identify one or two parameters of the INA128 that makes it superior to the TL084 based instrumentation amplifier.
$\rightarrow$ INA128 is superior to TL084 in CMRR, offset voltage and drift
$\rightarrow$ Additionally, INA128 has higher input voltage protection ($40V$) and lower noise (7 vs $15nV/\sqrt{\mathrm{Hz}}$)

## 3.1 Learnings

Learnt the applications of instrumentation amplifiers, strain gages.