Circuit Simulation Project

Howland Current Pump Circuit

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under the guidance of

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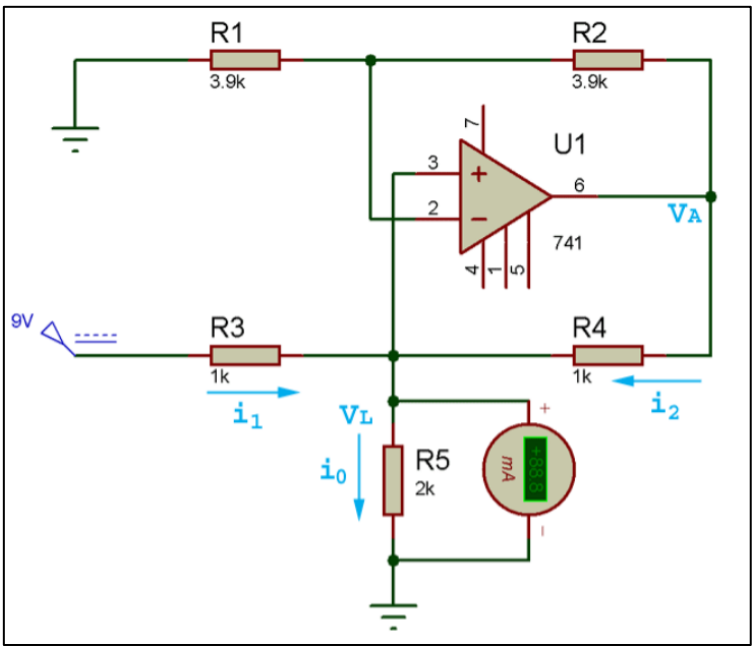
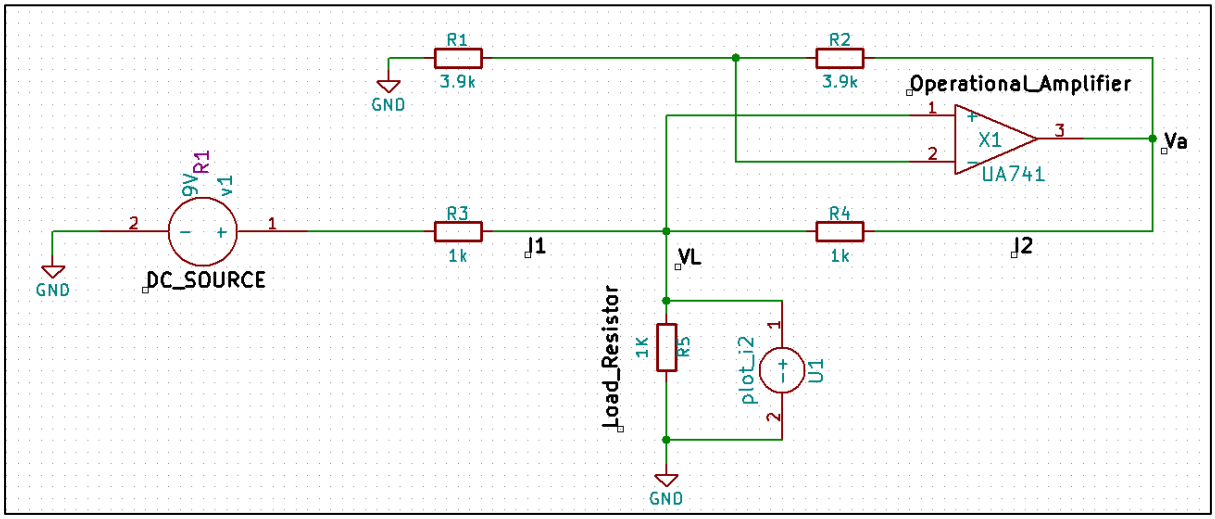
Theory: The Howland Current pump invented in 1962 by Professor Bradford from MIT is designed using an operational amplifier IC and a balanced resistor bridge. There are many instruments specially for medical applications that require a configurable amount of current to the load. For these applications, a circuit like Howland Current Pump is used to maintain constant current value through the load even if the value of load resistance changes. Howland Circuit is extensively used to design Current pumps due to its bidirectional output, ultra-high output impedance and stable output response.

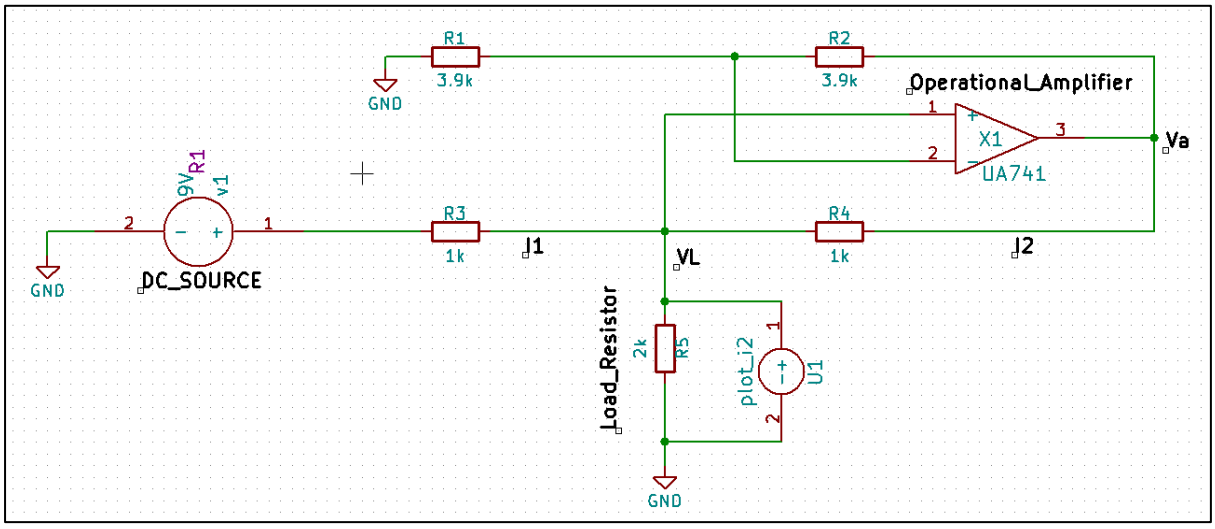
Circuit Diagram:



Schematic diagram in eSim:



Circuit Diagram for 1kΩ Load Resistor



Circuit Diagram for 2kΩ Load Resistor

Working: Using Kirchhoff's Current law and Ohm's law, the output current through the load (resistor R3) is equal to the sum of input current and current through the resistor R4.

$i_{output} = i_1 + i_2$

$i_{output} = (\frac{V1-VL}{R3}) + (\frac{VA-VL}{R4})$

The op-Amp with resistors R1 and R2 is forming a non-inverting amplifier with respect to VL –

$VA = (1 + \frac{R2}{R1})VL$

Using this equation in i_{output} ,

$i_{output} = (\frac{V1-VL}{R3}) + ((1 + \frac{R2}{R1})VL - \frac{VL}{R4})$

On solving we get $i_{output} = AV1 - \frac{VL}{Routput}$ where $A = \frac{1}{R3}$

Evaluating R_{output} from the equation we get –

$R_{output} = R4 / ((R4/R3) - (R2/R1))$

To make i_{output} independent of VL, R_{output} should be infinity. Therefore,

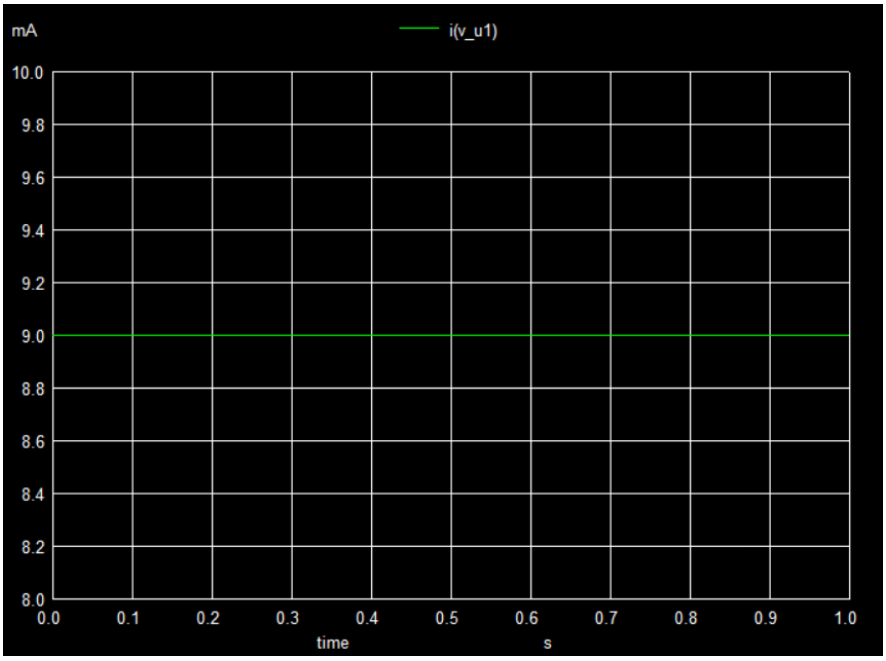
Balanced condition of the bridge –

$$\frac{R4}{R3} = \frac{R2}{R1}$$

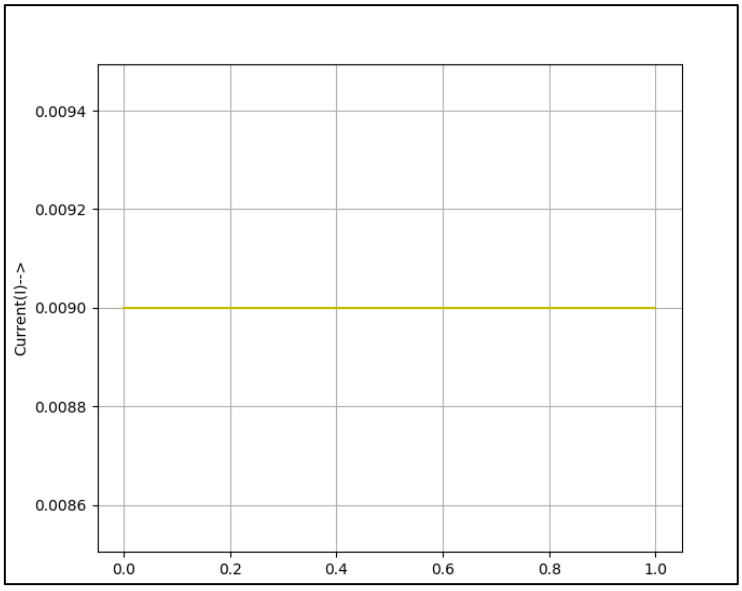
eSim Required Components:

Component Name
Op-amp IC LM741
Resistor – (3.9k – 2 nos, 1K – 3 nos)
9v DC supply

Output:



Python Plot Graph:



Here the simulation is run for two times with two different values of load resistor i.e. 1k and 2k but the current across the resistor remains the same irrespective of the resistor value. Each time, we get a constant current of 9mA across the load resistor.

Reference:

https://circuitdigest.com/electronic-circuits/howland-current-pump-circuit