- The output from a current to voltage converter is given by:—

$$V_{out} = -I \times R_f$$

- A bridge is said to be in balance when:—

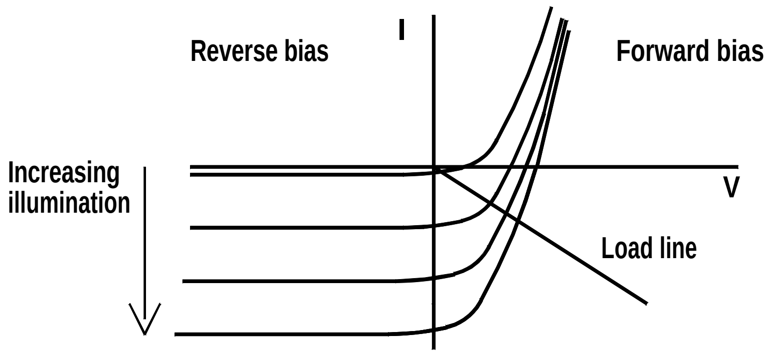
$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

- The output from a differential amplifier is given by:—

$$V_{out} = \frac{R_2}{R_1} \times (V_2 - V_1)$$

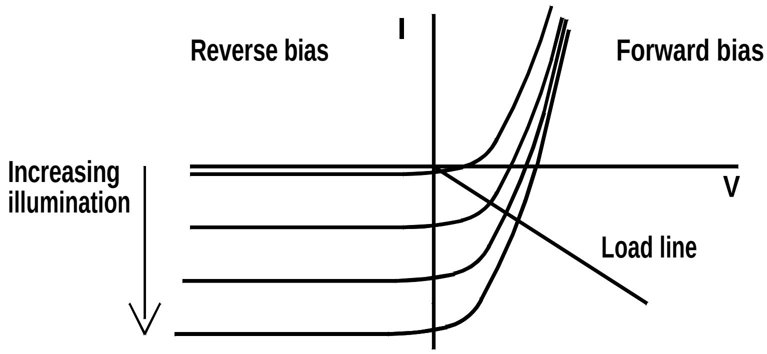
A transducer or sensor responds to an external environment or stimulus and
Gives an output signal which is a function of one parameter of the environment or stimulus.
Pressure sensor gives an output voltage proportional to the pressure
Platinum metal resistor resistance increases in proportion to the temperature.

Many commercial transducers have built in signal conditioning electronics.



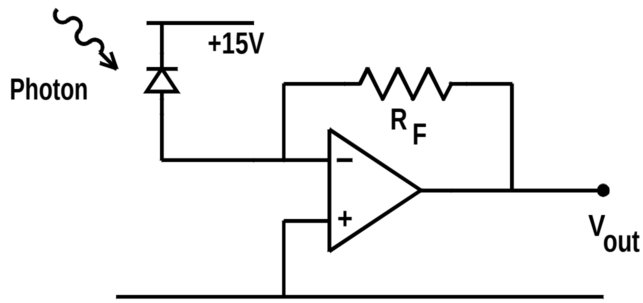
Photodiodes and Current to Voltage conversion.

Large area silicon pn junction diodes,
Light is absorbed in the silicon and generates electron-hole pairs.
Photoconductive and photovoltaic response of photodiode.



In the top right and the bottom left quadrant of operation, an external voltage drives current through the device.
In the bottom right hand quadrant, the signs of the current and the voltage are opposite. and the device can drive current through an external load

Two configurations:—
Reverse biased Current prop to Light
Forward bias Generates a voltage which increases with light. non linear.



Photodiode in photoconductive mode used with a current to voltage converter.

The photodiode current, I_{pd}, flows in R_f.
The voltage across R_f is 0$V - V_{out}$ and therefore we get:—

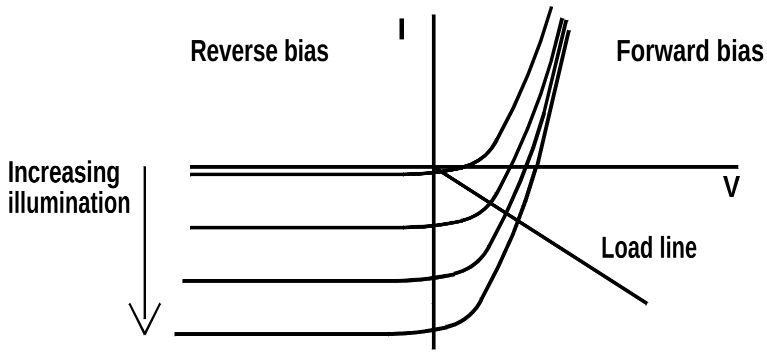
$$V_{out} = -I_{pd} \times R_f$$

we have an output voltage which is proportional to transducer current
with the scaling determined by the feedback resistor, R_f.
This circuit configuration is called a Current to Voltage converter or I–V converter.

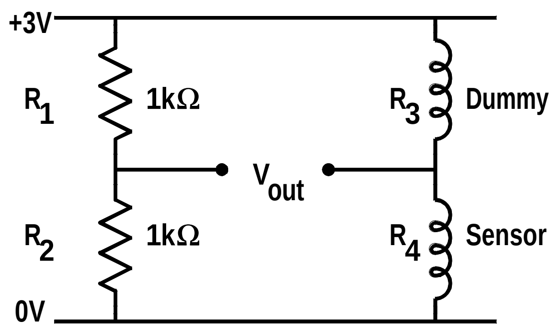
Bridge Circuits.

Many sensors whose response to a stimulus takes the form of a change in resistance.
but show some sensitivity to other ambient stimuli.
Dealing with cross sensitivity with a bridge system of two resistive sensors in series.
One sensor is exposed to the stimulus to be measured, the other dummy sensor is either made insensitive to the stimulus or is shielded from the stimulus.
Both sensors are exposed to the environment.
Any environmental effects balance out but the stimulus to be measured remains.

A flammable gas sensor for detecting hydrogen or methane in the atmosphere is an example.
A current in a palladium coated filament heats the filament.
Catalytic combustion occurs on the filament
Filament temperature rises and causes the resistance of the filament to increase.



Use a dummy filament, which is not coated with palladium
No temperature rise and resistance increase due to catalytic combustion of flammable gas.
Both filaments show similar temperature and resistance changes due to fluctuations in supply voltage, ambient temperature and cooling due to ambient air flow.
Filaments are mounted in metal gauze covered flameproof housing

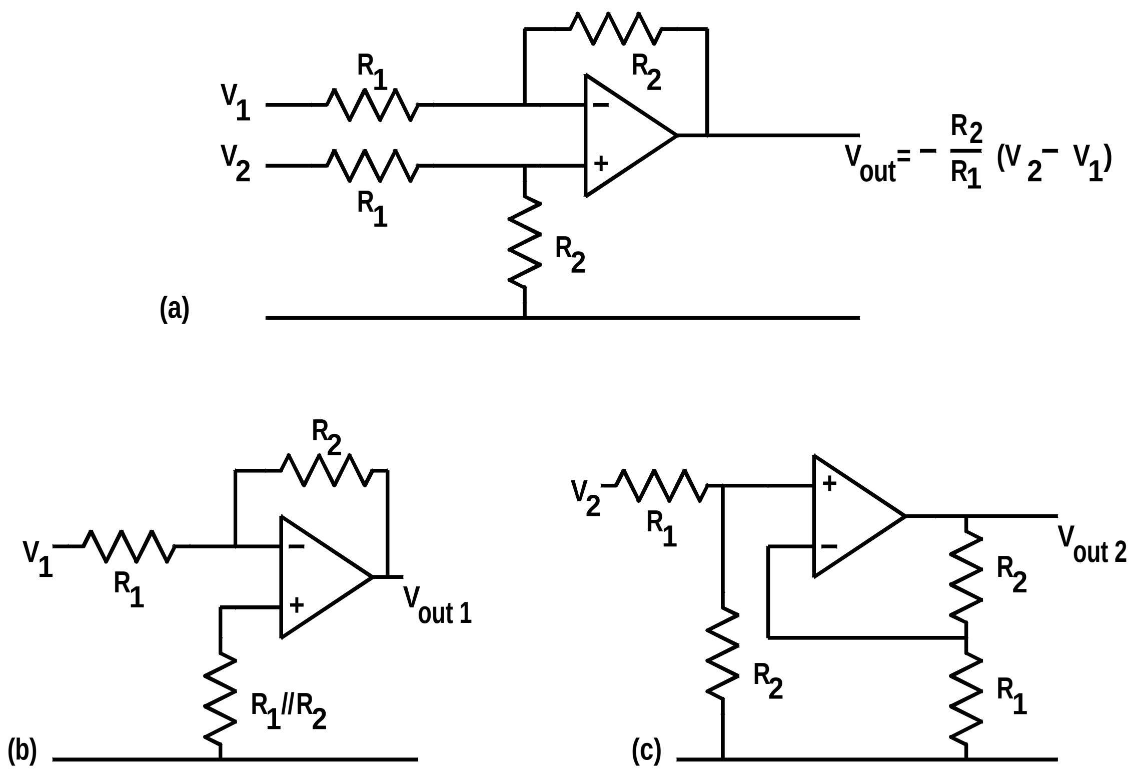


Bridge circuit for flammable gas detector

If there is no flammable gas present then the differential bridge output voltage marked V_{out} is zero.
A small concentration of flammable gas changes the sensing filament but not the dummy filament
Bridge then gives a non zero output.

The Differential Amplifier. A typical application of the differential amplifier is to measure small voltage difference signals which occur in circuits such as the bridge circuit.

In a bridge circuit there is a usually large common mode signal, about $1.5V$ in the case of the flammable gas sensor bridge
A small difference voltage is to be measured in the presence of this large common mode signal.



The differential amplifier.

Apply the principle of superposition

Set $V_2 = 0$. Input V_1 gives

$$V_{out1} = -\frac{R_2}{R_1} \times V_1$$

Set $V_1 = 0$ and Redraw the circuit.
Potential divider of R_1 and R_2 which gives a signal of $\frac{R_2}{R_1+R_2} \times V_2$

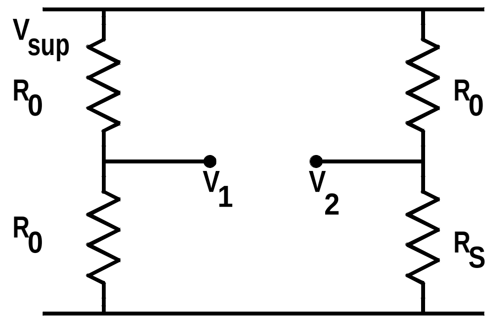
$$A_V = 1 + \frac{R_2}{R_1} = \frac{R_1 + R_2}{R_1}$$

The output signal due to input signal V_2 acting alone is therefore

$$V_{out2} = \frac{R_2}{R_1 + R_2} \times \frac{R_1 + R_2}{R_1} \times V_2 = \frac{R_2}{R_1} \times V_2$$

Superimpose to get

$$V_{out} = \frac{R_2}{R_1} \times (V_2 - V_1)$$



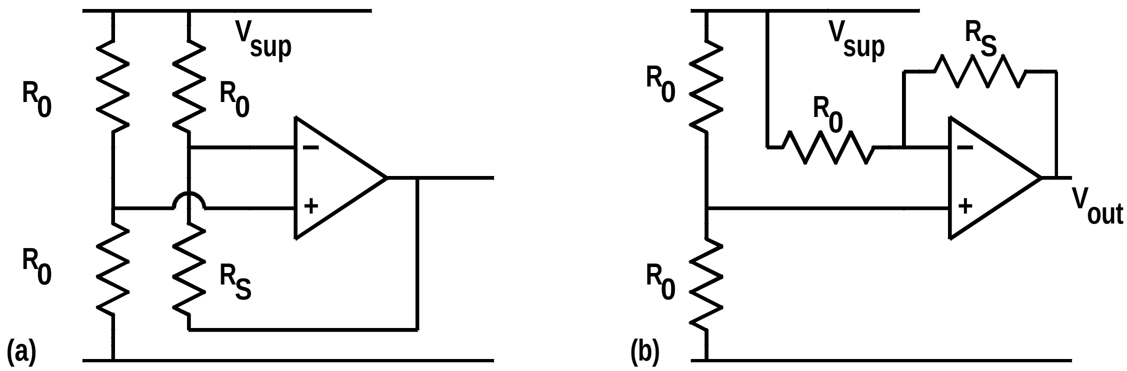
Out of Balance Bridge.

Sensor resistance is given by $R_S = R_o(1+\alpha)$,
Differential bridge voltage is given by

$$V_{Bridge} = V_1 - V_2 = \frac{V_{sup}}{2} - \frac{R_S}{R_o + R_S} \times V_{sup}$$

$$= V_{sup}\left(\frac{1}{2} - \frac{R_o(1+\alpha)}{2R_o + \alpha R_o}\right)$$

which is a nonlinear function of α.



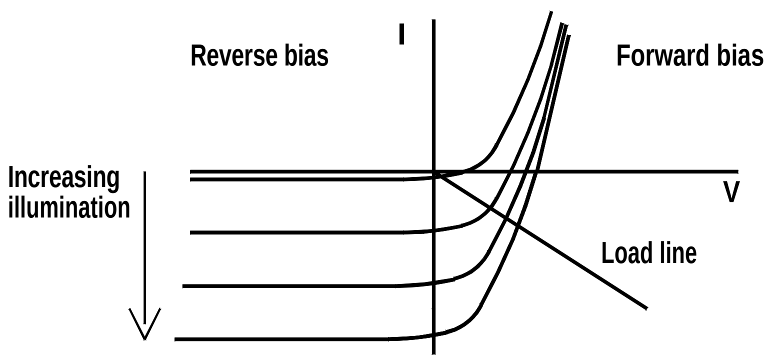
Self Balancing Bridge.

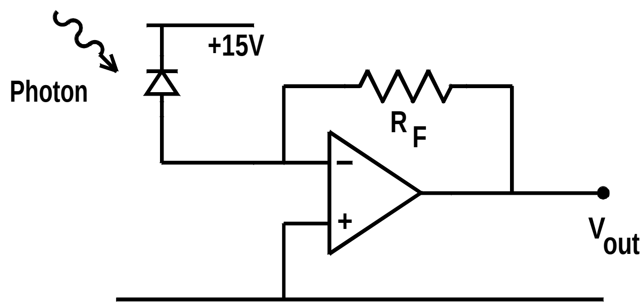
Use op-amp to restore the bridge to balance. Output from the op-amp, $V_{out} = 0$ when $\alpha = 0$ in $R_S = R_o(1+\alpha)$. Offset of $\frac{V_{sup}}{2}$. Input to the inverting amplifier is

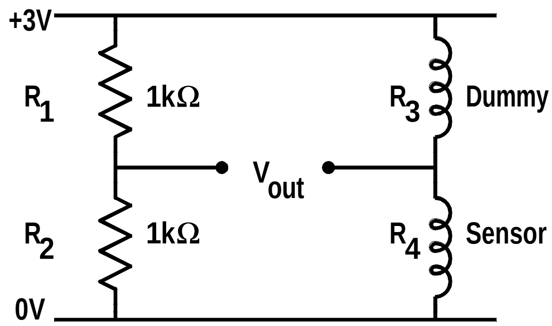
$$V_{sup} - V_{off} = V_{sup} - \frac{V_{sup}}{2} = \frac{V_{sup}}{2}$$

$$V_{out} = -\frac{R_S}{R_o}\left(\frac{V_{sup}}{2}\right) = -(1+\alpha) \times \frac{V_{sup}}{2}$$

which is a linear function of α.


I
Reverse bias
Forward bias
Increasing
illumination
V
Load line


Photon
+15V
R F
−
+
V out


+3V
R1
1kΩ
R3
Dummy
Vout
R2
1kΩ
R4
Sensor
0V