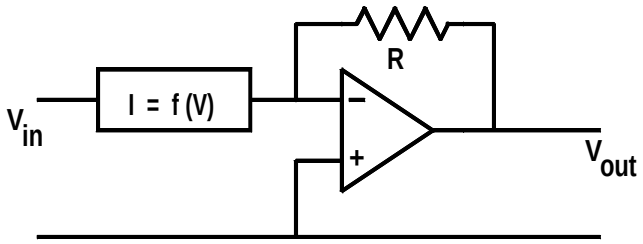
If the I–V characteristic for a device is described by $I = f(V)$ then:—

- putting the device in place of the input resistor of an inverting amplifier gives the forward function.

$$V_{out} = -R \times f\left(V_{in}\right)$$

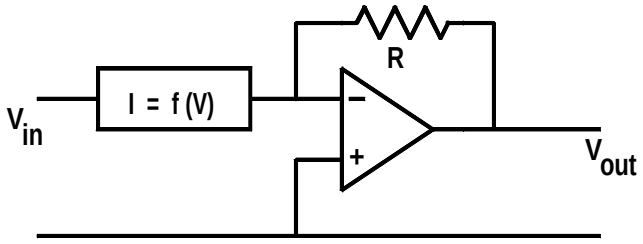
- putting the device in place of the feedback resistor of an inverting amplifier gives the inverse function

$$V_{out} = -f^{-1}\left(\frac{V_{in}}{R}\right)$$



The forward function. Suppose we have a device in which the current through the device is related to the voltage across the device by some arbitrary function such as $I = f(V)$.

The device can be used in place of the input resistor in an inverting amplifier to give the forward function.

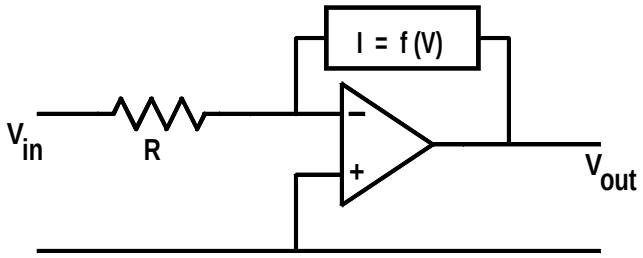


Then, from Unit 39, Rule 1

$$I_{in} = I_f$$

$$V_{out} = -R \times I_f = -R \times I_{in} = -R \times f(V_{in})$$

so that we can now generate an arbitrary function of an input voltage if we have available a device with the appropriate current–voltage characteristic.

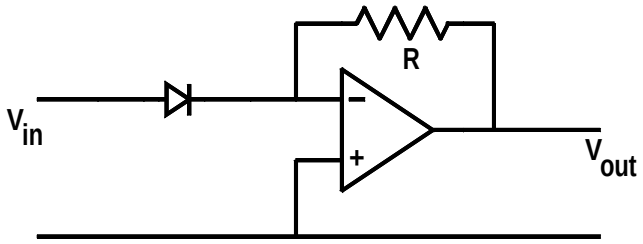


The inverse function.
If the device is used in the feedback path, the inverse function is generated.

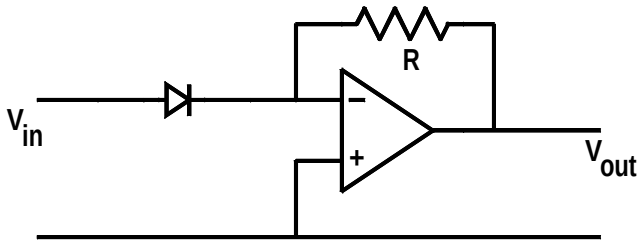
$$\frac{V_{in}}{R} = I_{in} = I_{out} = f\left(-V_{out}\right)$$

which, if f^{-1} represents the inverse function of f, immediately gives

$$V_{out} = -f^{-1}\left(\frac{V_{in}}{R}\right)$$



Derive an expression for the output voltage from this circuit



I–V characteristic in forward bias is

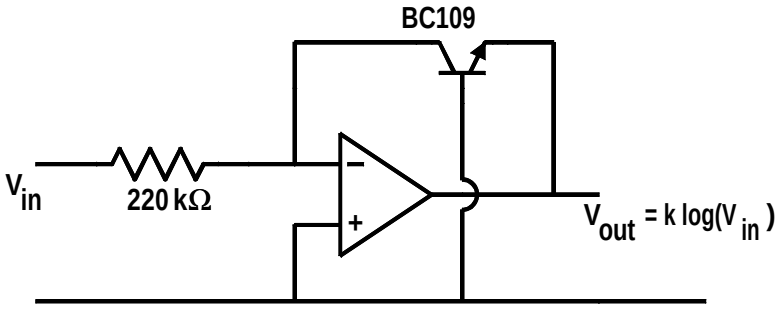
$$I = I_o \exp\left(\frac{V}{25mV}\right)$$

Since the device is in the input path we use

$$V_{out} = -R \times f(V_{in}) = -R \times I_o \exp\left(\frac{V_{in}}{25mV}\right)$$

when the constants are combined

$$V_{out} = -k \log^{-1}(V_{in}) \quad \text{or} \quad -k \,\text{antilog}(V_{in})$$



Problem 46.3

Special diodes, called logging diodes, are available which obey the exponential function over about 7 decades

But a diode connected transistor gives very good log response.

The transistor in this circuit is connected as a transdiode and acts as a high accuracy log response diode