Current-to-Voltage converter & Voltage-to-Current converter

I to V converters:

One of the most common use of current-to-voltage converter is in DAC s and in sensing current through photodetectors such as photo cells, photo diodes, and photo voltaic cells. Photo sensitive devices produce a current that is proportional to an incident radiant energy or light and therefore can be used to detect the light.

A current-to-voltage converter (or transimpedance amplifier) is an electrical device that takes an electrical current as in input signal and produces a corresponding voltage as an output signal. Three kinds of devices are used in electronics: generators (having only outputs), converters (having inputs and outputs) and loads (having only inputs). Most frequently, electronic devices use voltage as input/output quantity, as it generally requires less power consumption than using current.

The converter acts as a linear circuit with transfer ratio $k = V_{OUT}/I_{IN}$, called the transimpedance, which has dimensions of [V/A] (also known as resistance). That is why the active version of the circuit is also referred to as a transresistance or transimpedance amplifier.In some cases, there is a need for converters having current as the input and voltage as the output. A typical situation is the measuring of current using instruments having voltage inputs. A current-to-voltage converter is a circuit that performs current to voltage transformation. In electronic circuitry operating at signal voltages, it usually changes the electric attribute carrying information from current to voltage. Typical applications of current-to-voltage converter are measuring currents by using instruments having voltage inputs, creating current-controlled voltage sources, building various passive and active voltage-to-voltage converters, etc. In some cases, the simple *passive current-to-voltage converter* works well; in other cases, there is a need of using *active current-to-voltage converters*. There is a close interrelation between the two versions - the active version has come from the passive one.

Ideal current-to-voltage converters have zero input resistance (impedance), so that they actually short the input source. Therefore, in this case, the input source has to have some resistance; ideally, it has to behave as a constant current source. Otherwise, the input source and the current-to-voltage converter can saturate.

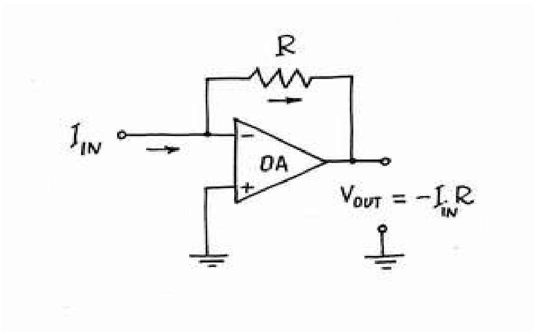

Figure 2.4

The basic idea above is implemented in the op-amp current-to-voltage converter. In this circuit, the output of the operational amplifier is connected in series with the input voltage source; the op-amp's inverting input is connected to point A. As a result, the op-amp's output voltage and the input voltage are summed.

From other viewpoint, the output of the operational amplifier is connected in series with the resistor R in the place of the compensating voltage source B_H from Fig. 12. As a result, the op-amp's output voltage and the voltage drop V_R are subtracted; the potential of the point A represents the result of this subtraction (it behaves as a virtual ground).

Op-amp I-to-V converter = passive I-to-V converter

V to I converters

Voltage-to-current converters feeding to grounded loads often find their way into industrial measurements and control applications. The conventional textbook circuit needs both positive and negative-supply rails. In this circuit:

$$e_{in} - e_1 = I_L R_S$$

Therefore, the load current is:

$$I_L = e_{in}/R_S - e_1/R_S$$

The first term is proportional to the input voltage e_{in}, and the second term is a constant. Here, e_1 is derived from the negative power-supply rail through a potentiometer:

$$I_L = e_{in}/R_S + (-e_1)/R_S$$

R_S is selected so that the first term gives 16 mA for full-scale input voltage, and the potentiometer is adjusted so that the second term provides a constant 4 mA. In effect, the output ranges from 4 to 20 mA, corresponding with zero to full input voltage. But failure of the negative power supply causes erroneous output. Moreover, there may be equipment where the negative power supply is not available, requiring generation just for this application.

In such cases, there's a slightly different circuit that works on a single-supply rail ***(Fig. 2)***. This circuit uses one half of the quad operational amplifier LM324. The first amplifier is configured as a subtractor, while the second amplifier is configured as a current converter.

The output of the first amplifier at A equals e_1 minus e_{in}. Here, e_1 is derived from the positive power supply by potentiometer P_1. The voltage at B equals V minus $I_L R_S$.

Op amp inputs at A and B are the same, so:

$$e1 - e_{in} = V - I_L R_S$$

$$I_L = e_{in}/R_S + (V - e_1)/R_S$$

The first term is proportional to the input voltage, with the second term a constant. R_S is chosen so that the first term gives 16 mA for full-scale input voltage, and the potentiometer is adjusted such that the second term supplies a constant 4 mA. In effect, the output is 4 to 20 mA, corresponding to zero to full input voltage. Thus, this circuit works without using a negative power-supply rail.

The volage to current converters can be used in such applications as low voltage DC and AC voltmeters, diode match finders, LEDs and zener diode testers.