SENSORS

An electronic system can be considered as being made up of three sections.

Input signal sensors/transducers were used to convert changes in some physical quantity into an electrical signal. Signal **processing units** such as logic gates were used to process the electrical signals and drive **output transducers.** In this workbook we shall be considering input signal sources in some detail and how a transistor switch can be used as a buffer between the processing unit and the output transducer.

INPUT SIGNAL SENSORS

In modern industry, electronic control systems are used to perform tasks that used to be done by human operators. The human body is an example of a very complex control system which is fitted with sophisticated sensors such as eyes, ears, nose, skin and the tongue. If electronic control systems are to be able to compete with human operators, sensitive optical, acoustic, gas, tactile and temperature sensors must be available. Most of the devices that we shall be considering have resistance which changes with some physical quantity and are used in voltage dividing networks.

A. OPTICAL SENSORS

LIGHT DEPENDENT RESISTOR (LDR)

A Light Dependent Resistor is a component whose resistance depends upon the intensity of light falling upon its resistive track. An LDR has a resistance of several megohms in total darkness and a resistance of less than a hundred ohms in very bright light. Its resistive track is made from cadmium sulphide and can be clearly seen through the transparent cover.

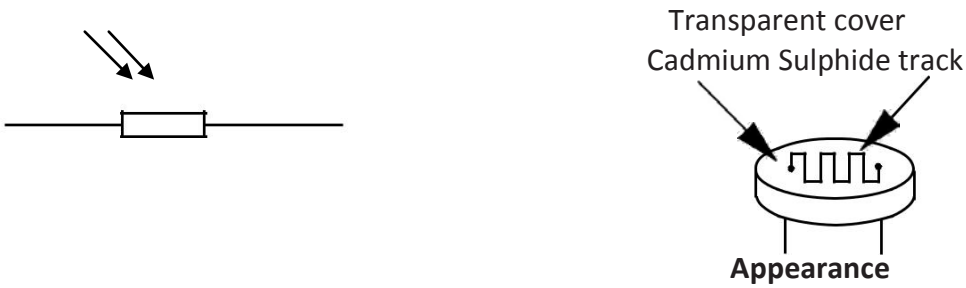


Fig. 1 Light Dependent Resistor

The main disadvantage of an LDR as an optical sensor is its relatively slow response time. The resistance rise time from the illumination provided by a 60W lamp at a distance of 1m to that in total darkness takes about 75ms. The reverse takes up to 350ms.

A light sensing unit can be made up by connecting an LDR in series with a resistor across the supply rails to form a voltage dividing chain.

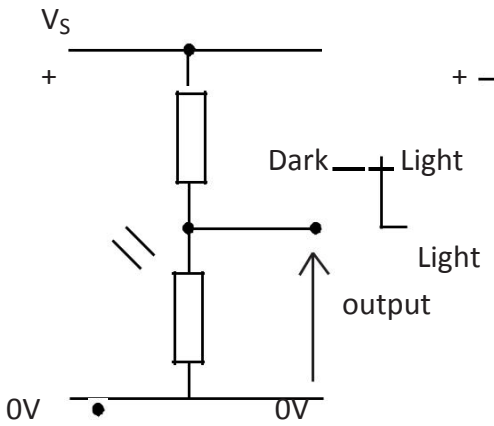


Fig. 2a

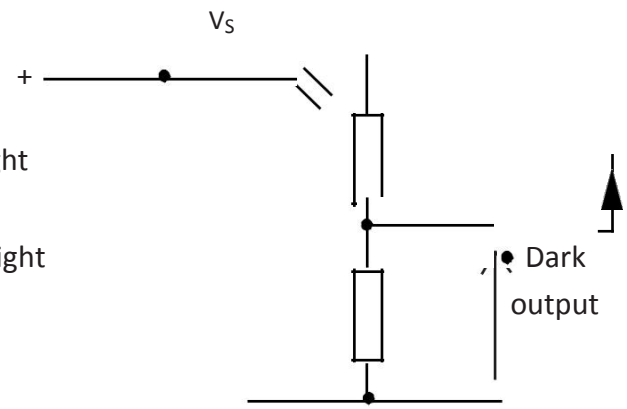


Fig. 2b

Fig.2 Light Sensing Unit

Consider the arrangement shown in Fig. 2a. When the LDR is in **darkness**, it will have a very high resistance and most of the supply voltage is dropped across it. The output signal will be **high**.

In **bright light**, the resistance of the LDR is low and most of the supply voltage is dropped across the resistor. In this case, the output voltage signal level will be **low**. A sudden change from darkness to bright light produces a falling edge at the output.

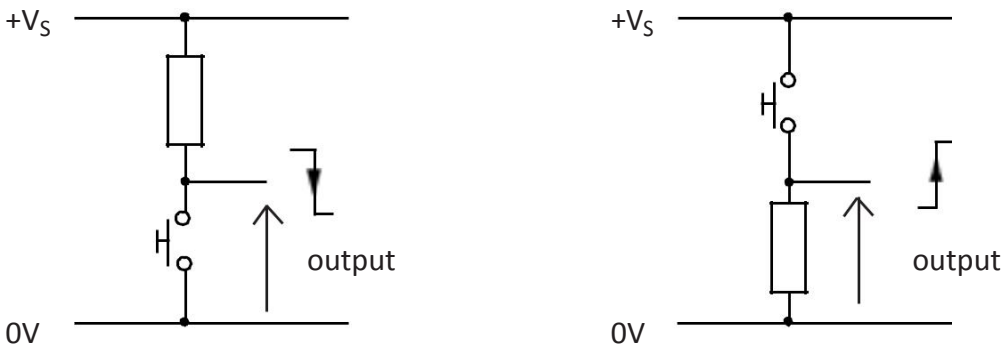
You should be able to explain how a change from darkness to bright light produces a rising edge at the output of the arrangement shown in Fig.2b.

B. TACTILE SENSORS

1. MICROSWITCHES

A micro switch can be used to form a simple tactile sensor. Micro switches are available with various types of actuators.

'Pull-up' or 'pull-down' resistors can be used to provide a falling edge, or a rising edge, when the switch is activated.



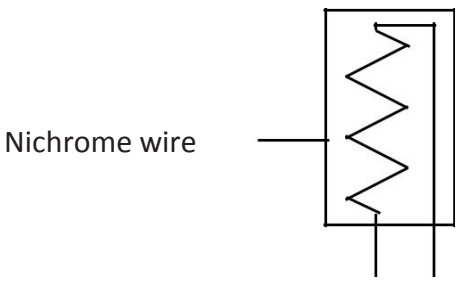
Pull-up resistor **Pull-down resistor**

Tactile sensor

When used in this manner, the micro switch forms a **digital input sensor** i.e. it provides a signal which can only take up one of two values. Problems can arise due to switch 'bounce' but these can easily be overcome using Schmitt trigger devices.

2. STRAIN GAUGES

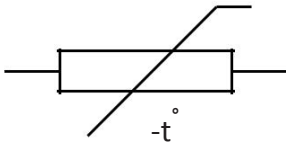
Strain gauges are made up from a thin piece of nichrome wire cemented between two thin pieces of acetate. When the acetate is bent the wire is stretched and its resistance increases. Stain gauges can be used to produce an analogue signal.



Strain gauge

C. TEMPERATURE SENSORS

A **thermistor** is a component whose resistance depends upon its temperature. Variation of resistance with temperature is much greater than for ordinary resistors. Symbols used for the two types available are shown below.

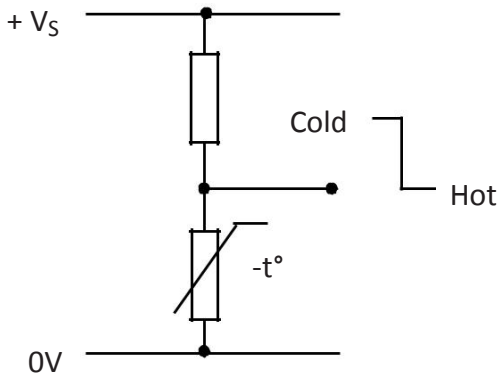


ntc Type

Symbols for thermistor

The resistance of a negative temperature coefficient (ntc), disc type thermistor, decreases when its temperature is increased.

A temperature sensing unit can be made up by connecting a thermistor in series with a resistor to form a voltage dividing chain here:



Temperature Sensing Unit

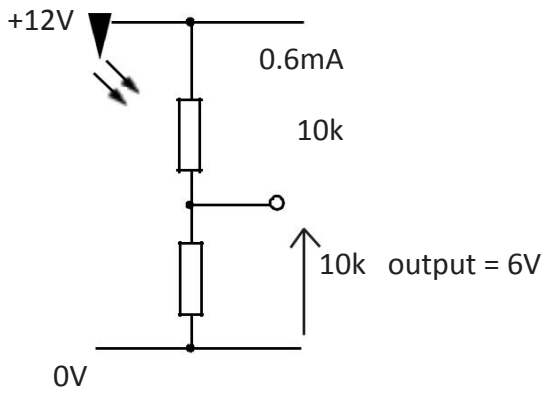
When the temperature is low, the resistance of the thermistor is high and most of the supply voltage will be dropped across it. The output signal level will be high.

When the temperature increases, the resistance of the ntc thermistor decreases and the voltage across it falls. At a high temperature the output signal level will be low.

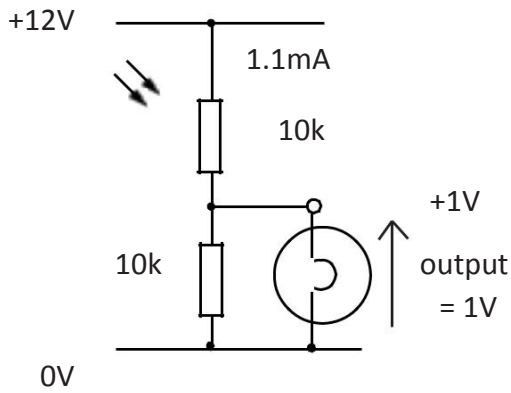
For the arrangement shown, output signal level falls as the temperature rises.

EFFECT OF LOADING

The sensing systems considered are often used as part of a larger system to control an output device e.g. the light sensing unit could be used to switch on a lamp when it becomes dark. They cannot be used to directly control the output device because they can only supply a very limited current. To illustrate this point let us consider a simple example where the light sensing unit is controlling a 6V, 0.06A lamp. The output signal level is just right when the intensity is such that the resistance of the LDR has fallen to 10kΩ.



2a



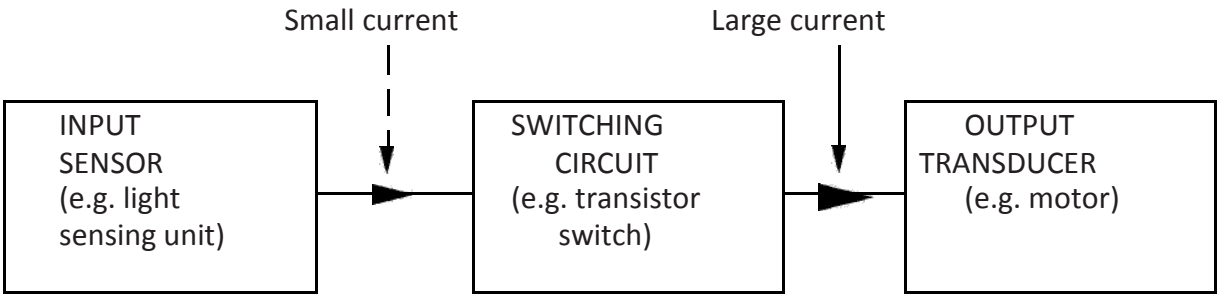
2b

When the lamp is connected across the output, voltage levels change to those shown in Fig 9b. Current through the lamp is limited by the 10kΩ resistance of the LDR. There is a total mismatch between the signal source and the load it is driving. If light intensity increases, current through the lamp would also increase but this would probably destroy the LDR. Practical requirements would also demand that the lamp switches on sharply when light intensity falls to a certain level.

The problem could be overcome by using a transistor switch between the signal source and the load. We shall now consider the use of bipolar transistors as a switching device.

SWITCHING CIRCUITS

Input Signal Sensors cannot provide the large currents required to drive output transducers such as motors and lamps. Switching circuits are fitted between the sensor and the output transducer.



Using a switching circuit

The switching circuit draws a small current from the input sensor and provides the large current required to drive the output transducer.

Transistors are often used to make up the switching circuits in electronic systems. They are cheap, fast in their action and contain no moving parts to wear out.