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Design Issues of Microcontroller Interfacing

4.1 Introduction

In this chapter design issues of interfacing microcontrollers to some common electronic circuits have been discussed. These important issues are critical to the success of a project. Open collector configuration, loading problems, microcontroller’s cross-bar configuration, driving output load etc are a few of the issues discussed.

4.2 Open-Collector Configuration

In many situations the output of a circuit is in an open-collector configuration. The term open-collector usually refers to a transistor output. In this configuration the collector of the transistor is kept open i.e., it is not connected to the positive supply, as shown in figure 4.1. Usually the transistor operates in cut-off or saturation regions i.e., as a switch. For proper functioning, the collector of the transistor should be connected to a positive supply through a pull-up resistor to complete the circuit. This provides an advantage to the designer as the pull-up resistor can be connected to a range of different voltages. The voltage level should be above the transistor saturation level.

\[ +\text{V}_{\text{cc}} \]

\[
\begin{array}{c}
\text{Pull-up resistor} \\
\hline
Q1
\end{array}
\]

Fig. 4.1 Open-collector configuration
Another advantage of open-collector configuration is to interface devices with different voltage levels. If instead of a bipolar junction transistor (BJT) a MOSFET is used, the term open-drain is commonly used.

The choice of voltage level depends on the application and it must be within the allowable limit of the transistor. The value of the pull-up resistor is to be properly selected so that the current through the transistor doesn’t exceed the allowable limit of the transistor. Since the transistor operates in saturation, the current through the pull-up resistor, $R$, as well as through the transistor is approximately equal to $V_c/R$ neglecting the collector to emitter voltage drop. Typical value of the collector current is in the range of 10mA to 100mA. If the current exceeds the allowable limit, the transistor may burn out.

In many situations instead of a pull-up resistor, different types of loads, such as power relay, solenoid, motor, coil, or incandescent lamp may be used. Some loads (power relay, solenoids, motors, coils) are inductive in nature. Usually an inductive load generates a very high voltage spike when the switch is turned off. The designer should be very careful while those types of loads are used. If it is unavoidable, the transistors must be protected from transient over-voltages. The use of transient suppression components, RC filter, and free-wheeling diode parallel to the load is useful. Also a snubber or a zener diode across the transistor may be helpful. This is critical, as a single transient pulse may damage the transistor.

In case of capacitive load, though rare in practice, it must be assured that the in-rush current does not exceed the maximum current rating of the transistor.

If the load is an incandescent lamp, care must be taken because it has a very high start-up current. The filament glows and the resistance of the lamp settles to a steady-state value. Usually it is not recommended to use incandescent lamp for open-collector output; rather LED is to be used.

### 4.3 Protection of Microcontroller from Over-Voltage

In this section we will discuss a few tips to protect electronic circuits, especially the microcontroller, while the external signals are interfaced. The damage is caused due to over-overvoltage. With the help of some simple protection devices, it is possible to increase the EMI (Electro Magnetic Interference) and ESD (Electro Static Discharge) immunity level of the complete circuit and system. Usually all semiconductor devices, mainly ICs, contain internal protection circuits but it is not practical to incorporate large protection devices. The external protection devices provide a higher level of surge protection. Though the knowledge of internal surge protection circuit may be helpful in selecting an external protection device with an appropriate power rating and turn-on voltages, the data sheets usually do not disclose the details of internal protection circuits.

The main function of an external protection device is to limit the current through an IC or microcontroller by reducing the magnitude of surge voltage. It is expected that the protection device will turn on before the internal circuit turns on and absorb the entire energy of the surge pulse. The location of the protection device is very important to determine whether the majority of the surge energy is