METHOD AND APPARATUS FOR ELECTRICALLY COUPLING DIGITAL DEVICES

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BACKGROUND OF THE INVENTION

The present invention is generally related to communication of digital data. More particularly, the present invention is related to communication of digital data among digital devices having different operating voltages.

Digital devices employ families of integrated circuits to operate on digital data and provide logical functions and operations. However, digital devices that must communicate may operate at different operating voltages. For example, some well-known logic families operate at a nominal voltage of 5.0 volts. Other logic families operate at nominal supply voltages of 3.3 volts or 1.8 volts. Some systems use combinations of more than one of these logic families.

When data is communicated among digital devices operating at different operating voltages, some transformation must be made to ensure reliable communication. The voltages generated by one device and corresponding to digital logic levels may be inappropriate for the input of another device. For example, a 1.8 volt supply device will have an output logic one level of approximately 1.8 volts. This may not be sufficient to be detected as a logic one at the input of a 5 volt supply device, which expects a logic one to have a value closer to 5.0 volts.

One accommodation for this problem is to provide pull-up resistors at the inputs of the 5 volt logic. If the voltage provided to the input is only driven to, for example, 1.8 or 3.3 volts, the pull-up resistor will pull the voltage to a value close to 5.0 volts to ensure accurate input level protection. However, pull-up resistors introduce a risk of latch-up, have poor noise immunity and reduced peak operating speed and increase overall current drain.

Another solution involves designing a cable that connects a 5 volt device and a lower voltage device such as a 3.3 volt device. The cable includes an active voltage conversion circuit for shifting input and output voltages. Such a cable tends to be an expensive alternative, however. The cable must be custom made for the application and must include the components of the active circuit.

Accordingly, there is a need for a method in apparatus for communicating digital data among devices having different operating voltages.

BRIEF SUMMARY OF THE INVENTION

By way of introduction only, in one embodiment, a method for communicating digital data between digital devices provides a voltage tolerant, digital input/output interface. The interface is implemented by varying the supply voltage of a logic family at one end of a connection to match the logic voltage used at the other end of the connection. In the preferred embodiment, the supply voltage is provided by a voltage regulator that tolerates an over-voltage condition on its output.

The foregoing description has been provided only by way of introduction. Nothing in this section should be taken as a limitation on the following claims, which define the scope of the invention.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** is a circuit diagram of a circuit for communicating data among digital devices having different operating voltages;

FIG. **2** is a first circuit in accordance with the present invention for communicating data among digital devices;

FIG. **3** is a second circuit in accordance with the present invention for communicating data among digital devices;

FIG. **4** illustrates a circuit in accordance with the present invention for communicating data among digital devices; and

FIG. **5** is a block diagram illustrating a communication device in accordance with the present invention.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

Referring now to FIG. **1**, it shows a circuit diagram of a circuit **100** for communicating data among digital devices having different operating voltages. The circuit **100** is typically embodied in a cable which connects to digital devices. In the illustrated embodiment, the two digital devices are a cellular telephone **101** and a cellular modem **103**. The cellular telephone **101** provides wireless communication with a remote location. The cellular modem **103** provides data communication between the cellular telephone **101** and another digital device, such as a personal computer. The components of the circuit **100** are typically embodied as one or more integrated circuits contained within a plastic connector at the end or ends of the cable.

The circuit **100** includes a data transmission circuit **102** and a data reception circuit **104**. The data transmission circuit **102** communicates digital data received at a pin **106** at one end of the cable to a pin **108** at the other end of the cable. Similarly, the data reception circuit **104** communicates data received at a pin **110** at one end of the cable to a pin **112** at the other end of the cable.

The circuit **100** is configured for electrically coupling two digital devices which have differing operating voltages. In the illustrated embodiment, the modem operates at 5 volt logic levels and the cellular telephone operates using either 3.3 or 5 volt logic levels. In FIG. **1**, the modem power supply is designated Vcc and is nominally 5 volts. The cellular telephone power supply is designated Vdd and is nominally 3.3 volts. The circuit **100** receives Vcc at a pin **114** and Vdd at a pin **116**. The circuit **100** uses these voltages in the data transmission circuit **102** and the data reception circuit **104**. Not all connections are shown in FIG. **1** so as to not unduly complicate the drawing figure.

The data transmission circuit **102** includes a pull-up resistor **120**, a first transistor **122**, a second transistor **124** and a third transistor **126**. The data transmission circuit **102** also includes a resistor **128**, a resistor **130**, a resistor **132**, a resistor **134** and a resistor **136**. Digital data are received at the pin **106** and provided to the data transmission circuit **102**. The digital data typically has one of two voltage values. A first voltage value is approximately Vcc and corresponds to a logic one. A second voltage value is approximately ground and corresponds to a logic zero. When a logic one