

An Effective Asynchronous Serial Communication Method for Embedded Microcontrollers

Field of the Invention

The present invention relates to a novel method of realising asynchronous serial communication between data terminal equipment and embedded microcontrollers.

Description of the Prior Art

Most of the existing standalone consumer products such as audio and video systems are unable to perform duplex data transfer with other devices. These products only respond to remote controller commands and they are incapable of sending feedback signals back to the remote controller. This is a simplex form of transmission.

To allow the embedded microcontrollers in such products to perform duplex communication with the outside world, some form of interfacing is necessary. In most cases, the UART (Universal Asynchronous Receiver/Transmitter) can be used. However, the use of UART and other supporting components contributes to the increase in product cost.

The embedded microcontroller can also receive data from the outside world using polling method. Polling method will enable the microcontroller to repeatedly check for input signal sent by other equipment. This method eliminates the use of UART but might not be efficient since substantial amount of microcontroller's processing time may be spent on checking for input signal, especially when the microcontroller is required to service other real time activities. The microcontroller may also miss part of or the entire data if the data is sent at the instant when the microcontroller is not polling the input port.

Alternatively, the microcontroller can make use of its special input port with interrupt function to receive data. In this case, the incoming data contain a start bit which trigger a hardware interrupt event. The microcontroller will then poll this input port to read in the data. This method facilitates polling only when data is present. However, most low cost microcontrollers have very few special input ports with interrupt function.

Some microcontrollers have special built-in serial communication port which conforms to established serial communication protocol such as the I²C standard. However, such communication method cannot be used as general solution because majority of the microcontrollers and data terminal equipment are not equipped with such ports.

For the embedded microcontroller to communicate cost effectively with the data terminal equipment, it has to reduce the number of input/output pins used and to eliminate the use of UART and built-in serial communication port. To prevent wastage of the processing time spent on periodically checking for input signal from the data terminal equipment, polling should also be avoided.

Summary of the Invention

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In accordance of one aspect of the present invention, there is disclosed a cost effective asynchronous serial communication system, the said system assembly comprising:

- an infrared remote control receiver;
- a data terminal equipment;
- a transceiver;
- a signal multiplexer;
- an embedded microcontroller; and
- a communication protocol.

The infrared remote control receiver receives infrared signal from the remote controller, demodulates and conditions the signals and sends it to the signal multiplexer.

The data terminal equipment communicates with target devices using existing serial communication means. Three plus one optional signal lines are required. These comprise one data line from data terminal equipment to embedded microcontroller, one strobe signal line from data terminal equipment to embedded microcontroller, one data line from embedded microcontroller to data terminal equipment and one optional strobe signal line from embedded microcontroller to data terminal equipment. The data format used for transmission is derived from existing serial communication protocol standards.

The transceiver receives serial data from the data terminal equipment and converts the logic level of the receiver into a level suitable for both the signal multiplexer and the embedded microcontroller. The transceiver also receives output signal sent by the embedded microcontroller and converts them into logic levels conforming to the requirement of the serial communication channel and the data terminal equipment.

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The signal multiplexer receives two input signals, namely the signal from the infrared remote control receiver and the signal from the transceiver. It selects the appropriate signal to be fed into the embedded microcontroller with the aid of the strobe signal. This strobe signal is also fed into the microcontroller.

With the output signal from the multiplexer and the strobe signal, the embedded microcontroller identifies the signal source by verifying the state of the strobe signal and extracts the data accordingly.

For the embedded microcontroller to send data to the data terminal equipment, it has to format the out going data according to the derived communication protocol. This data is then sent out via the transceiver and the serial communication channel.

The serial communication channel that links the data terminal equipment and the embedded microcontroller comprises of two data lines and a strobe line. One of the data lines carries formatted input data from the data terminal equipment to the embedded microcontroller, while the other carries formatted output data from the embedded microcontroller back to the data terminal equipment. The strobe line is sent by the data terminal equipment to the signal multiplexer for source selection and to the embedded microcontroller for source identification.

Brief Description of Drawings

Figure 1 is a schematic block diagram of the cost effective asynchronous serial communication system model showing the interaction between the various modules.

Figure 2 is a serial data format used in the serial communication protocol.

Figure 3 is a timing diagram illustrating the signal multiplexer servicing different signal source depending on the state of the strobe signal.

Figure 4 is a timing diagram illustrating an incomplete serial data unit of the infrared remote control signal with missing tail end.

Figure 5 is a timing diagram illustrating an incomplete serial data unit of the infrared remote control signal with missing front end.

Figure 6 is an example of the application of the cost effective asynchronous serial communication system model.

Detailed Description of the Best Mode of Performing the Invention

Figure 1 shows the schematic block diagram of the cost effective asynchronous serial communication model. The system comprises of:

- an infrared remote control receiver 10;
- a data terminal equipment 20;
- a transceiver 30;
- a signal multiplexer 40; and
- an embedded microcontroller 50;

The infrared remote control receiver 10 receives infrared signal from a remote controller. Generally, the infrared signal is modulated before transmission. Therefore, the infrared remote control receiver 10 has to demodulate the infrared signal to retrieve the original information. The demodulated signal is further conditioned into appropriate logic level suitable for inputting into the signal multiplexer 40.

The data terminal equipment 20 refers to devices capable of transmitting and receiving asynchronous serial data, such as a desktop computer, a notebook computer or other equipment that supports the derived asynchronous serial communication protocol. The derived protocol includes three signal lines. They are DATA.in S2, strobe S3 and DATA.out S4.

Before the data terminal equipment 20 sends out data, it will set the strobe signal S3 to high. The strobe signal S3 shall remain high while data is being transmitted. To transmit the data DATA.in S2, the data terminal equipment 20 first prepares the outgoing data by converting them into a predefined data format. This data format is derived from RS-232 serial communication protocol standard. Figure 2 shows an example of the data format. The data is made up of serial data units 110. Each serial data unit 110 comprises of a start bit 111, a predefined number of data bits 112, a stop bit 114 and an

optional parity bit 113. The number of data bits 112 used and the inclusion of the parity bit 113 have to be defined before establishing the communication channel.

The transceiver 30 interfaces between the data terminal equipment 20, the signal multiplexer 40 and the embedded microcontroller 50. The voltage level of the data sent by the data terminal equipment 20 normally does not fit what the microcontroller 50 and signal multiplexer 40 can take. Hence the transceiver 30 is used to convert the voltage level such that it matches the logic level required by the signal multiplexer 40 and the embedded microcontroller 50. Likewise when sending data back to the data terminal equipment 20, the data from the embedded microcontroller 50 has to be converted such that it complies with the logic level of the serial communication channel.

The signal multiplexer 40 receives input signal from both the infrared remote control receiver 10 and the transceiver 30. Only one of these signals is allowed into the embedded microcontroller 50. The strobe signal S3 supplied by the data terminal equipment 20 is used for arbitration. This strobe signal S3 is fed into the source select input of the signal multiplexer 40.

As mentioned, before the data terminal equipment 20 sends out data, it will set the strobe signal S3 to high. With a high strobe signal S6, the signal multiplexer 40 will switch to service the data coming in from the transceiver 30, therefore channelling all the incoming signal from the data terminal equipment 20 to the embedded microcontroller 50. Conversely, when the strobe signal S6 is low, the signal multiplexer 40 will be default to service the signal DATA.in1 S1 from the infrared remote control receiver 10. Figure 3 shows the timing diagram of the data DATA.in1 S1, DATA.in2 S5 and strobe signal S6.

Since the source of the data can be either from the infrared remote control receiver 10 or the data terminal equipment 20, the embedded microcontroller 50 must be able to identify the correct source. To achieve this, the state of the strobe signal S6 is examined. A high strobe signal means data is being sent by the data terminal equipment 20, whereas a low strobe signal denotes data is from infrared remote control receiver 10.

The port of the embedded microcontroller 50 that receives data DATA.in S8 from the signal multiplexer 40 serves as both hardware interrupt port and data input

port. While waiting for data DATA.in S8, this port is configured as interrupt port. When the signal multiplexer 40 sends data to this port, the transition edge of the start bit 111 triggers the embedded microcontroller 50 to execute an interrupt service routine to read in the input data. As the serial data bit clock is not transmitted, the microcontroller has to sample the data according to certain pre-defined data rate. Upon completion of interrupt service routine, this port is to set as interrupt port again to detect for next data input. Using this method, the microcontroller 50 does not need to poll for the input signal DATA.in S8 periodically. Such input ports with interrupt function are already widely used in the design of the infrared remote control signal in modern audio and video systems.

In the event that remote control signal S1 reception is interrupted by strobe signal S6 from data terminal equipment 20 as shown in Figure 4, the embedded microcontroller 50 shall ignore the partially received remote control signal S1 and proceed to capture the data S5 from data terminal equipment 20. This requires the microcontroller 50 to check the strobe signal S6 status while reading the remote control signal S1. Once the strobe signal S6 is detected high, the microcontroller 50 shall set the input port to interrupt port so as to detect the falling edge of the start bit 111 in data sent by data terminal equipment 20.

In the event that only the tail end of the remote control signal S1 appears at DATA.in S8 line as shown in Figure 5, the embedded microcontroller 50 shall capture, verify and discard the remote control signal S1 since the header of signal is missing or incomplete.

When the embedded microcontroller 50 sends data DATA.out S7 to the data terminal equipment 20, the out going data has to be formatted according to a pre-defined format conforming to that used by the data terminal equipment 20. This data is formatted internally by the microcontroller 50. The output data is sent to the data terminal equipment 20 via the transceiver 30 and the serial communication channel. The microcontroller 50 may be required to spare an output port to send strobe signal S9 to mark the frame of the output data. The strobe signal S9 is optional and is not required in many cases.

Figure 6 shows an example of an application of the effective asynchronous serial communication system. It comprises of a remote controller 101, a personal computer 102 and an audio system 103. The audio system 103 is equipped with the said communication system. The personal computer 102 acts as the data terminal equipment 20. The remote controller 101 sends infrared signal to the audio system 103. The infrared remote control receiver 10 in the audio system 103 picks up this signal and performs necessary demodulation and condition functions.

The personal computer 102 is connected to the audio system 103 using its conventional serial communication port that adopts RS-232 protocol. The personal computer 102 uses the transmit data (TxD) and request-to-send (RTS) lines in the RS-232 cable to send data and strobe signal respectively to the audio system 103. It uses the receive data (RxD) line to receive data from the audio system 103. While sending data, the audio system 103 does not need to send strobe signal since the personal computer is already equipped with a UART device.



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Claims

1. A cost effective asynchronous serial communication system, comprising:
 - an infrared remote control receiver;
 - a data terminal equipment;
 - a transceiver;
 - a signal multiplexer; and
 - an embedded microcontroller.
2. Apparatus according to claim 1, wherein the cost effective asynchronous serial communication system comprises of new methods to communicate between data terminal equipment and embedded microcontrollers making use of existing serial interfacing techniques.
3. Apparatus according to claim 1, wherein the said signal multiplexer comprises a switching module that switches between the signal from the infrared remote control receiver and the transceiver in order to efficiently reduce the amount of input ports with interrupt function required by the embedded microcontroller.
4. Apparatus according to claim 1, wherein the said embedded microcontroller is capable of identifying the source of the data signal by detecting the state of the strobe signal and sending formatted serial data to the data terminal equipment system via the transceiver.
5. Apparatus according to claim 4, wherein the said embedded microcontroller comprises methods to discard incomplete remote control receiver data in the event that remote control signal reception is interrupted by transmission of data by the said data terminal equipment.

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