(54) Title: SERIAL DATA EXPANSION UNIT

(57) Abstract

Serial connections which communicate with a central processing unit via a system bus are connected to a parallel to serial multiplexer/demultiplexer unit (210) which receives the relatively low speed serial outputs of the serial connections as a parallel input and outputs input data as a high speed serial data stream (21). A remote peripheral connection unit (22) contains a parallel to serial multiplexer/demultiplexer unit (220) which receives the high speed serial data stream and reconstitutes this data as a plurality of low speed serial outputs to connected peripheral devices. When the parallel to serial multiplexer/demultiplexer is applied to ICDUs (20, 24) of locomotives, the redundancy requirement for the ICDUs is easily accommodated. Each parallel to serial multiplexer/demultiplexer unit installed in each ICDU includes a health monitor which transmits data to the parallel to serial multiplexer/demultiplexer in the remote peripheral connection unit having control logic receiving the data transmitted from each health monitor and performing the switching to transfer connections from a failed or falling ICDU to other ICDU.
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SERIAL DATA EXPANSION UNIT

DESCRIPTION

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention generally relates to a means for multiplexing a large number of serial data connections onto a few connections and, more particularly, to a means to expand the number of serial data connections to an Integrated Computer and Display Unit (ICDU) without dramatically increasing the amount of connections to the unit.

Background Description

A typical example of the need for multiplexing a large number of serial data connections onto a few connections is for an operator’s display in a diesel locomotive. The operator’s display is referred to as an Integrated Computer and Display Unit (ICDU). In this application, two ICDUs are required for redundancy so that the failure of one unit does not disable the locomotive. These ICDUs need to connect to a large number of different peripheral devices, typically by means of a serial data connections. These peripheral devices are usually not located in the console where the ICDUs are mounted and it is not desirable to cable a large number of connectors into the console. Examples are the engine management unit, which controls the diesel engine of the locomotive, and the electronic air brake controller. Such peripheral devices include a local processor which receives data from and transmits data to the ICDU.
Additionally, because of the previously noted redundancy needs, either ICDU must be able to communicate with these peripheral devices so that either may assume control of the peripheral devices in the event of a failure of the other. However, in typical operation, each ICDU displays different information and controls different peripheral devices than the other. In the event of failure of one of the ICDUs, the other ICDU displays information and controls peripheral devices necessary for the operation of the locomotive.

**SUMMARY OF THE INVENTION**

It is therefore an object of the present invention to provide a means to expand the number serial data connections to a computer without dramatically increasing the amount of connections to the computer.

It is another object of the invention to provide for redundancy of control in these serial data connections to the computer.

According to the invention, the serial connections which communicate with a central processing unit (CPU) via a system bus are connected to a high speed parallel to serial multiplexer/demultiplexer unit. This unit receives the relatively low speed serial outputs of the serial connections as a parallel input and outputs the input data as a high speed serial data stream. In this mode, the high speed parallel to serial multiplexer/demultiplexer unit functions as a parallel-to-serial shift register, receiving a plurality of sampled serial inputs as a single parallel input and outputting a high speed serial bit stream containing the sampled serial inputs. A remote peripheral connection unit contains a complementary high speed parallel to serial multiplexer/demultiplexer unit which receives the high speed serial bit stream and reconstitutes this data as a plurality of low speed serial outputs to connected peripheral devices. Thus, in this mode the high speed parallel to serial
multiplexer/demultiplexer unit of the remote peripheral connection unit functions as a serial-to-parallel shift register, receiving the high speed serial data stream and reconstituting the low speed serial outputs. The system is bi-directional; that is, communication paths are supported from the peripheral devices to the CPU, in which case the modes of the respective high speed parallel to serial multiplexer/demultiplexer units are reversed.

When the principles of the invention are applied to ICDUs installed in locomotives, the redundancy requirement for the ICDUs is easily accommodated. The high speed parallel to serial multiplexer/demultiplexer unit installed in each ICDU includes a health monitor which transmits data to the high speed parallel to serial multiplexer/demultiplexer unit in the remote peripheral connection unit. The latter unit includes control logic which receives the data transmitted from each health monitor and performs the necessary switching to transfer connections from a failed or failing ICDU to the other ICDU.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The foregoing and other objects, aspects and advantages will be better understood from the following detailed description of a preferred embodiment of the invention with reference to the drawings, in which:

- Figure 1 is a block diagram showing a typical Personal Computer (PC) serial connection;
- Figure 2 is a block diagram showing a modification of the serial connection shown in Figure 1 according to one aspect of the invention;
- Figure 3 is a block diagram showing a redundant configuration of the serial connection of Figure 2 according to another aspect of the invention;
Figure 4 is a block diagram of the high speed parallel to serial multiplexer/demultiplexer unit; and

Figure 5 is a logic diagram of the selector logic.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Referring now to the drawings, and more particularly to Figure 1, there is shown a typical Personal Computer (PC) with a plurality of serial connections. In the specific example described, the PC is based on an Intel i486 or later microprocessor 12 which communicates with an Industry Standard Adapter (ISA) system bus 14 (Institute of Electrical and Electronic Engineers (IEEE) Standard 996) with a plurality of Universal Asynchronous Receiver Transmitters (UARTs) 16, 16. The UARTs, in turn, are connected with RS232 buffers (driver/receiver) 18, 18 using Transistor Transistor Logic (TTL). Each RS232 buffer provides an interface for a serial port. While ten UARTs, RS232 buffers and serial ports are shown, this is by way of example only, and more or less may be provided depending on the application. In this conventional serial connection, each peripheral device must be connected to a respective serial connection port at the PC.

Although not shown, it will be understood that a personal computer of the type generally shown in Figure 1 typically has a number of adapter cards connected to the ISA bus 14 to support various devices, including a display and a hard drive or other mass storage. The arrangement shown, while typical for PC serial connections, is also illustrative of Integrated Computer and Display Units (ICDUs) installed in locomotive cabs. And while most PCs are configured with only two serial ports, ICDUs quite typically have ten and possibly more serial ports. This presents a problem in making the connections to the ICDU.
In the modification according to the present invention shown in Figure 2, the ICDU 20 includes a microprocessor 202 which communicates with an ISA system bus 204 with a plurality of UARTs 206₁ to 206₁₀, similarly to the PC shown in Figure 1. In addition, the ICDU 20 includes a high speed parallel to serial multiplexer/demultiplexer unit 210 that converts the TTL connections between the RS232 buffers and the UARTs to much higher speed serial data. This high speed parallel data is then transmitted over a single cable 21 from the ICDU 20 to a remote peripheral connection unit 22 which contains a high speed parallel to serial multiplexer/demultiplexer unit 220. In the remote peripheral connection unit 22, the high speed data is demultiplexed, optically isolated and buffered by the RS232 buffers 228₁ to 228₁₀. Connection is then made to the peripheral device via a plurality of serial ports. This arrangement minimizes the connections to the ICDU; that is, a single high speed serial connection versus up to ten serial connections in this example. The serial connections to the peripheral devices are made at the remote peripheral connection unit 22. This hardware modification also has the benefit of being totally software compatible with the serial data connections of the ICDU.

A typical serial interface is composed of eight signals plus return, or nine lines. Of these eight signals, only two, transmit and receive data, might have a maximum bit rate of 19200 bits per second (bps). The remaining signals are for status and have low bandwidth requirements. The aggregate bandwidth for a typical serial connection is about 20 kbps in each direction. Therefore, ten such serial data interfaces would require only 200 kbps in each direction if the bandwidth were efficiently utilized. In reality, more bandwidth is required, but still well within practical limits. The high speed parallel to serial multiplexer/demultiplexer units 210 and 220 can be easily implemented with parallel-to-serial and serial-to-parallel shift registers. The inputs and sampled outputs of the UARTs 206₁ to 206₁₀
are connected in parallel to the shift registers which comprises the high speed parallel to serial multiplexer/demultiplexer unit 210. Likewise, the inputs and sampled outputs of the buffers 208, to 208, are connected in parallel to the shift registers which comprises the high speed parallel to serial multiplexer/demultiplexer unit 220. Thus, the position of the data in the shift register and, hence, the serial data stream between the units 210 and 220 is the multiplexing function of the data.

The net savings in interconnections to the ICDU for ten serial interfaces is significant. Instead of requiring 9×10 or 90 interconnections, as few as three higher speed connections are required.

The parallel to serial multiplexer/demultiplexer unit 220 can be modified to allow for redundant connection to two ICDUs, as shown in Figure 3. It is a simple matter to add a second connection via cable 23 to a second ICDU 24. The high speed parallel to serial multiplexer/demultiplexer unit 220′ essentially comprises two sets of parallel-to-serial and serial-to-parallel shift registers, one communicating with the ICDU 20 and the other with the ICDU 24. Each set of shift registers communicates with certain ones of the RS232 buffers 228, to 228, . Control of individual serial interfaces may also be dynamically allocated to either ICDU. Each ICDU 20 and 24 includes data about its health in the serial data sent to the remote peripheral connection unit 22. Control logic is included in the high speed parallel to serial multiplexer/demultiplexer unit 220′ which receives and decodes health status data transmitted from each of the high speed parallel to serial multiplexer/demultiplexer units 210′ and 240. This control logic transfers control of the serial interfaces from one ICDU to the other in the event of the one ICDU failing.

The parallel to serial multiplexer/demultiplexer in each ICDU transmits more information than data from the UARTs. Figure 4 shows in block diagram form a single high speed parallel to serial
multiplexer/demultiplexer unit, there being one set per ICDU and two sets per remote unit. The multiplexer of the parallel to serial
multiplexer/demultiplexer unit comprises a parallel to serial shift and load
register 41 which receives data and status information in parallel and,
under the control of a timing generator 42, loads the parallel input and
shifts serial data out to encoder 43, also controlled by the timing generator
42. The encoder 43 generates the high speed serial output. The
demultiplexer of the parallel to serial multiplexer/demultiplexer unit
comprises a serial to parallel shift and hold register 44. The high speed
serial input is decoded by decoder 45 to provide serial data output and a
clock/load output to the parallel shift and hold register 44. The parallel
output comprises data and status information.

The encoder 43 in Figure 4 combines both the data and the clock
into one high speed serial data stream. This encoder is also chosen to
support reliable data transmission over the chosen media, which could be
coaxial cable, twisted pair, fiber optic, or a wireless connection such as
radio frequency (RF) or infrared (IR). For the initial implementation, the
encoder chosen is a Manchester encoder. This high speed encoded serial
data is then encoded in the remote unit by the corresponding decoder
which recovers the clock and data.

The signals transmitted from the ICDU to the remote unit (220 in
Figure 3) specify both the health of the ICDU and the serial port
connection. This information is decoded in the remote unit for the purpose
of determining which ICDU to connect to a specific serial port. If the
health data transmitted indicates an ICDU failure, then all serial ports are
assigned to the other ICDU to allow the system to continue functioning.
This logic is shown in Figure 5.

The selector logic of Figure 5 comprises an AND gate 51 which
receives as inputs a "Master Health OK" signal and a "Master Select N"
signal. If both of these signals are a logic "1", then AND gates 52 and 54
will be enabled; otherwise, AND gates 53 and 55 will be enabled. AND gate 52 receives a signal "Master Data Out N", and AND gate 53 receives a signal "Slave Data Out N". The output of AND gate 52 or AND gate 53 is passed by OR gate 56 as the data out to the serial port. The data in from the serial port is input to both of AND gates 54 and 55. The output of AND gate 54, when enabled, is a "Master Data In N" signal, and the output of AND gate 55, when enabled, is a "Slave Data In N" signal.

The parallel to serial multiplexer/demultiplexer in each remote unit transmits more information than data to the UARTs. It also transmits the health status of the other ICDU and data indicating which ICDU that each serial port is assigned to. This allows the software in each ICDU to properly handle the received information. The circuit of Figure 4 is similar in both the ICDU and the remote unit, although the remote unit has two circuits to allow communication with both ICDUs.

The invention may be applied to many different types of serial interfaces and interface levels such as, for example, Enhanced Serial Communication Controller (ESCC) circuits. Applications of this method can include both synchronous and asynchronous interfaces as well as RS232, RS422 and RS485 interfaces. This method may also include a mix of various types of interfaces.

The remote parallel to serial multiplexer/demultiplexer unit 220 preferably contains redundant features so that a single point failure within the unit will not disable all serial ports. This is especially important because the remote parallel to serial multiplexer/demultiplexer unit 220 is a single point connection to all serial devices and hence must have a very high reliability.

Power for the remote parallel to serial multiplexer/demultiplexer unit 220 is preferably provided from both ICDUs 20 and 24. These two power sources are isolated and then shared by a diode circuit. The remote parallel to serial multiplexer/demultiplexer unit 220 thus has power
available as long as either ICDU has power. The control logic of the remote parallel to serial multiplexer/demultiplexer unit 220' may also contains logic to monitor each ICDU and make that status available to the ICDU.

The preferred implementation of the remote parallel to serial multiplexer/demultiplexer unit 220' uses optocouplers and isolated power sources to provide galvanic isolation of each serial interface. This eliminates ground loops and also minimizes the possibility of disturbances on one serial interface affecting another.

While the invention has been described in terms of a single preferred embodiment, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the appended claims.
CLAIMS

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is as follows:

1. A serial data expansion unit for a computer comprising:
   a parallel to serial multiplexer/demultiplexer unit within the computer having a plurality of internal serial input/output connections and a single external input/output serial connection; and
   an external peripheral connection unit including a remote parallel to serial multiplexer/demultiplexer unit having a single external input/output serial connection communicating with the external input/output serial connection of the parallel to serial multiplexer/demultiplexer unit within the computer and a plurality of serial input/output connections communicating with serial ports to which peripheral devices are connected.

2. The serial data expansion unit recited in claim 1 wherein the computer is part of an integrated computer and display unit mounted in a locomotive cab.

3. A serial data expansion unit for first and second redundant computers comprising:
   a first parallel to serial multiplexer/demultiplexer unit within the first computer having a plurality of internal serial input/output connections and a single external input/output serial connection;
   a second parallel to serial multiplexer/demultiplexer unit within the second computer having a plurality of internal serial input/output connections and a single external input/output serial connection; and
   an external peripheral connection unit including a remote parallel
to serial multiplexer/demultiplexer unit having first and second external
input/output serial connections respectively communicating with the
external input/output serial connections of the first and second parallel to
serial multiplexer/demultiplexer units within the first and second
computers and a plurality of serial input/output connections
communicating with serial ports to which peripheral devices are
connected.

4. The serial data expansion unit as recited in claim 3 wherein each of said
first and second parallel to serial multiplexer/demultiplexer units include
monitoring circuits which monitor a condition of the first and second
computers and transmit data related to the monitored condition to the
remote parallel to serial multiplexer/demultiplexer unit, the remote parallel
to serial multiplexer/demultiplexer unit including control logic responsive
to the transmitted data related to the monitored condition of the first and
second computers for controlling connections between the serial ports and
the first and second computers.

5. The serial data expansion unit recited in claim 4 wherein each of said
first and second computers are part of respective first and second
integrated computer and display units mounted in a locomotive cab.
FIG. 1
PRIOR ART

FIG. 2

SUBSTITUTE SHEET (RULE 26)
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) H04J 3/00
US Cl. 370/535

According to International Patent Classification (IPC) or to both national classification and IPC.

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S.: 370/535, 536, 537, 538, 542

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C. See patent family annex.

Date of the actual completion of the international search: 20 JULY 1999

Date of mailing of the international search report: 13 SEP 1999

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