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EXAR UARTS IN RS-485 APPLICATIONS

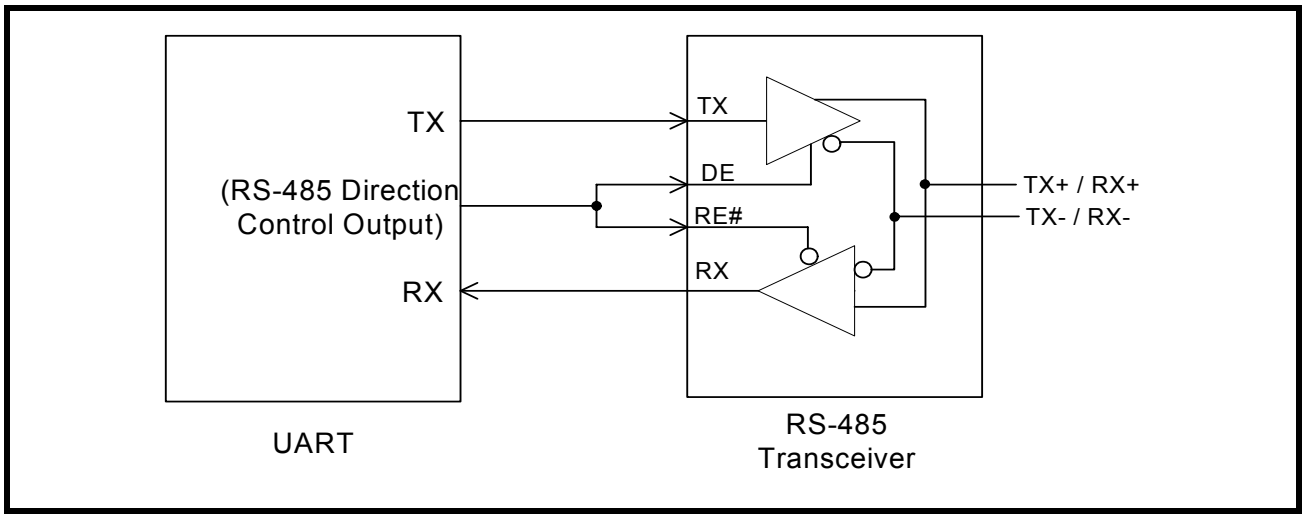
1.0 INTRODUCTION

This application note discusses the benefits of Exar's patented Automatic RS-485 Half-Duplex Direction Control feature (patent #6,765,626) available in Exar's enhanced UARTs and how this feature simplifies the software driver implementation for using UARTs in a half-duplex RS-485 environment.

2.0 HARDWARE CONNECTIONS

Figure 1 below shows the typical connection of a UART to a half-duplex RS-485 transceiver. The same output from the UART will control both the Driver Enable (DE) and Receiver Enable (RE#) inputs to guarantee that the RS-485 transceiver is only either transmitting or receiving.

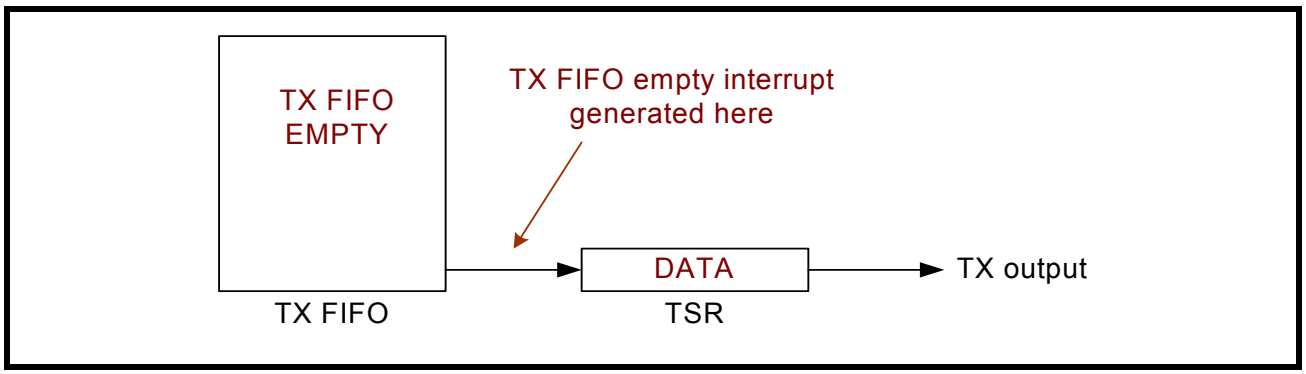
FIGURE 1. TYPICAL CONNECTION BETWEEN UART AND RS-485 TRANSCEIVER



3.0 SOFTWARE CHALLENGES

The main challenge for using a UART in a half-duplex RS-485 environment is making sure that the RS-485 transceiver is in the TX mode before transmitting and that the RS-485 transceiver does not return to the RX mode until all of the data has been transmitted. The industry standard 16550 UARTs generate an interrupt when the TX FIFO is empty, however, there may still be data in the Transmit Shift Register (TSR). Therefore, some additional software is required to ensure that the TSR is also empty when using a UART that does not have Exar's Auto RS-485 Half-Duplex Direction Control Feature.

FIGURE 2. UART TRANSMIT INTERRUPT BEHAVIOR



3.1 Possible Software Solutions

3.1.1 Polling Example

The first way to do this is to poll the LSR register. Let's assume that the RTS# signal is used to control the direction of the RS-485 transceiver and RTS# needs to be HIGH for transmit and LOW for receive.

```
//Initialization
IER = 0x00;                          //Interrupts are not enabled
MCR bit-1 = 1;                       //Set RS-485 transceiver in RX mode
...
//Transmit Routine
MCR bit-1 = 0;                       //Set RS-485 transceiver in TX mode
Write data to TX FIFO (THR);
While (LSR bit-6 == 0);              //wait until the TX FIFO + TSR is empty
MCR bit-0 = 1;                       //TX completed, set RS-485 transceiver back to RX mode
```

However, this is not very efficient since the CPU/MCU has to wait for this routine to finish.

3.1.2 Interrupts + Polling Example

The other way is to use the TX empty interrupt. However, even when using the TX empty interrupt, the software still needs to poll the LSR register as described in section 3.0.

```
//Initialization
IER = 0x02;                          //TX empty interrupt enabled
MCR bit-1 = 1;                       //Set RS-485 transceiver in RX mode
...
//Transmit Interrupt Service Routine
if (more data to send)
        MCR bit-1 = 0;               //set or keep RTS# pin HIGH for TX mode
else {
        while (LSR bit-6 == 0);      //poll until TX FIFO + TSR is empty
        MCR bit-1 = 1;               //TX completed, set RS-485 transceiver back to RX mode
}
while (more data to send AND data less than FIFO size)
        write data to THR;
```

This is more efficient than the polling example, but there is still a while loop that keeps the CPU/MCU busy when it can be doing other tasks.

3.1.3 Auto RS-485 Half-Duplex Direction Control Feature

The most efficient way to use a UART in a half-duplex RS-485 environment is to use an Exar UART that has the Automatic RS-485 Half-Duplex Direction control feature. This feature changes the behavior of the UART in two ways.

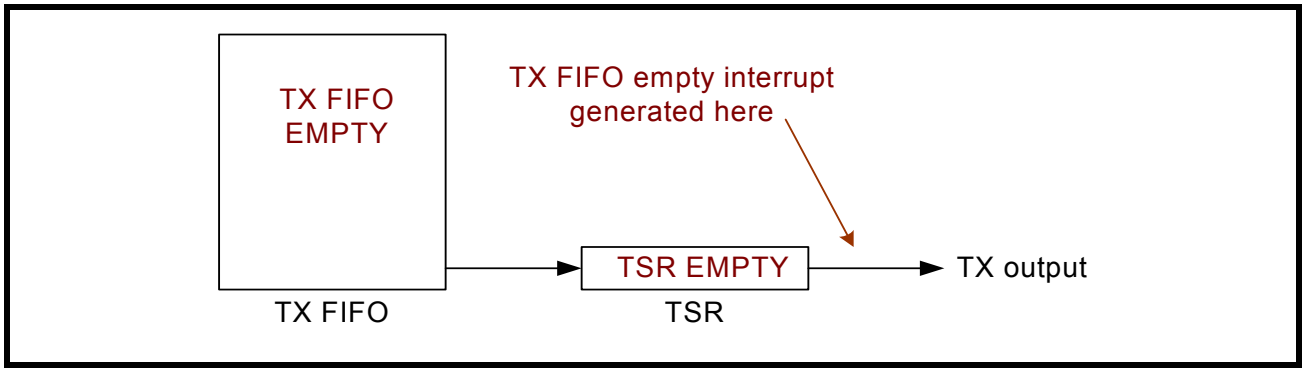
- The behavior of one of the UART outputs becomes a control signal to control the direction of the RS-485 transceiver. While the UART is idle, the control output will enable the receive mode of the RS-485 transceiver. When any data is loaded into the TX FIFO, the control output will automatically enable the transmit mode of the RS-485 transceiver. Once the UART has sent all of the data in the TX FIFO and TSR, the control output will automatically change RS-485 transceiver back to the receive mode.
- The behavior of the transmit empty interrupt changes. Instead of generating an interrupt when the TX FIFO is empty, the interrupt is generated when the TX FIFO and TSR register are both empty and the transmitter is completely idle.

The only thing that needs to be done is:

```
//Initialization
Enable Auto RS-485 Half-Duplex Direction control;
```

The direction of the transceiver will be taken care of automatically by the UART so that the CPU/MCU can perform other tasks.

FIGURE 3. UART TRANSMIT INTERRUPT BEHAVIOR WITH AUTO RS-485 FEATURE



4.0 OTHER FEATURES

4.1 RS-485 Direction Control Outputs

Not all UARTs with the Auto RS-485 Half-Duplex Direction Control Feature use the same output to control the direction of the RS-485 transceiver. Most UARTs use the RTS# output. But some UARTs can use the DTR# output or OP1# output. The table on the next page lists the different outputs that can be used for the Auto RS-485 Half-Duplex Direction control output.

4.2 RS-485 Direction Control Polarity

The polarity of the control output also varies depending on the UART. For some UARTs, the control output is HIGH for transmit mode and LOW for receive mode. However, there are some UARTs where it is the opposite polarity. If the RS-485 control output is in the wrong state, then an external inverter may be required. To eliminate this external inverter, some newer UARTs have a register bit that can invert the default polarity of the Auto RS-485 Half-Duplex Direction Control output.

4.3 UARTs with Enable RS-485 pins

Upon power-up, the control output of the UART may be in the incorrect state until it has been initialized. During this time, the UART may be unintentionally driving the RS-485 network preventing the other nodes from communicating. For the systems that require the RS-485 control output to be in the correct state upon power-up, some UARTs have the Auto RS-485 enable pin. The UARTs that have this pin are also noted in the table on the next page.

4.4 UARTs with Programmable Turn-Around Delay

Most UARTs with the Automatic RS-485 Half-Duplex Direction control feature change from the TX mode to the RX mode almost immediately. However, this may be an issue for applications with long cables. Therefore, some UARTs also have a programmable turn-around delay of 0-15 bits before the control output changes from the TX mode to the RX mode to allow the signal to propagate to the furthest nodes. The table on the next page shows the UARTs that have this feature.

TABLE 1: UARTS WITH AUTO RS-485 DIRECTION CONTROL

UART PRODUCT NUMBER	RS-485 CONTROL OUTPUT	DEFAULT TX POLARITY	INVERT POLARITY FEATURE	ENABLE RS-485 PIN	PROGRAMMABLE TURN-AROUND DELAY
ST16C650A	RTS#	HIGH	YES	NO	NO
XR16L651	RTS#	HIGH	YES	NO	NO
XR16C850	OP1#	LOW	NO	NO	NO
XR16C2850	RTS#	LOW	NO	NO	NO
XR16C2852	RTS#	LOW	NO	NO	NO
XR16C864	OP1#	LOW	NO	NO	NO
XR16L2750	RTS#	LOW	YES	NO	NO
XR16L2751	RTS#	LOW	YES	YES	NO
XR16L2752	RTS#	LOW	YES	NO	NO
XR16V2750	RTS#	LOW	YES	NO	NO
XR16V2751	RTS#	LOW	YES	YES	NO
XR16V2752	RTS#	LOW	YES	NO	NO
XR16M2750	RTS#	LOW	YES	NO	NO
XR16M2751	RTS#	LOW	YES	YES	NO
XR16M2752	RTS#	LOW	YES	NO	NO
XR16M752	RTS#	HIGH	NO	NO	NO
XR68M752	RTS#	HIGH	NO	NO	NO
XR16L784	RTS# or DTR#	HIGH	NO	NO	YES
XR16L788	RTS# or DTR#	HIGH	NO	NO	YES
XR16V598	RTS# or DTR#	HIGH	NO	NO	YES
XR16V698	RTS# or DTR#	HIGH	NO	NO	YES
XR16V794	RTS# or DTR#	HIGH	NO	NO	YES
XR16V798	RTS# or DTR#	HIGH	NO	NO	YES
XR17C152	RTS# or DTR#	HIGH	NO	YES	YES
XR17C154	RTS# or DTR#	HIGH	NO	NO	YES
XR17C158	RTS# or DTR#	HIGH	NO	NO	YES
XR17D152	RTS# or DTR#	HIGH	NO	YES	YES
XR17D154	RTS# or DTR#	HIGH	NO	NO	YES
XR17D158	RTS# or DTR#	HIGH	NO	NO	YES
XR17V252	RTS# or DTR#	HIGH	NO	YES	YES
XR17V254	RTS# or DTR#	HIGH	NO	NO	YES
XR17V258	RTS# or DTR#	HIGH	NO	NO	YES
XR20M1170	RTS#	HIGH	YES	YES	NO
XR20M1172	RTS#	HIGH	YES	YES	NO

5.0 EXAR'S UART AND HALF-DUPLEX RS-485 TRANSCEIVERS SOLUTION

The UARTs in the table on the previous page can be used with Exar's half-duplex RS-485 transceivers for a complete half-duplex RS-485 solution. The table below lists Exar's half-duplex RS-485 transceivers.

TABLE 2: HALF-DUPLEX RS-485 TRANSCEIVERS

RS-485 TRANSCEIVER PRODUCT NUMBER
SP3072E
SP3075E
SP3078E
SP3494
SP1481E
SP1485E
SP3082E
SP3085E
SP3088E
SP3481
SP3483
SP3485
SP4082E
SP481E
SP483
SP485
SP485E
SP485R
SP495

5.1 Exar's UART and Full-duplex RS-485 Transceivers

Any Exar UART can be used with any full-duplex RS-485 (or RS-422 or RS-232) transceiver because the UART transmitter and receiver are independent of each other. In other words, the UART can simultaneously transmit and receive at the same time.

6.0 CONCLUSION

Exar's enhanced UARTS with the patented Automatic RS-485 Half-Duplex Direction control feature can simplify both the hardware design and software development of half-duplex RS-485 applications. Exar offers many enhanced UARTs with different CPU interfaces, FIFO sizes, channels and operating voltages. In addition, Exar offers a complete portfolio of robust half-duplex RS-485 transceivers. Combining Exar's enhanced UARTs with Exar's RS-485 transceivers forms a complete RS-485 application solution.

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Send your UART technical inquiry with technical details to hotline: uarttechsupport@exar.com.