

EXPERIMENT #4 FULL-DUPLEX UART DATA LINK

INTRODUCTION:

This experiment should give you a feel for the "big picture" of data communications, for all of the basic subsystems are now present.

The data link will be a full-duplex one, meaning that data will be able to flow in both directions at the same time. The data will be carried by a pair of fiber optic cables using the digital circuitry from experiment 1. Figure 1 shows the basic setup.

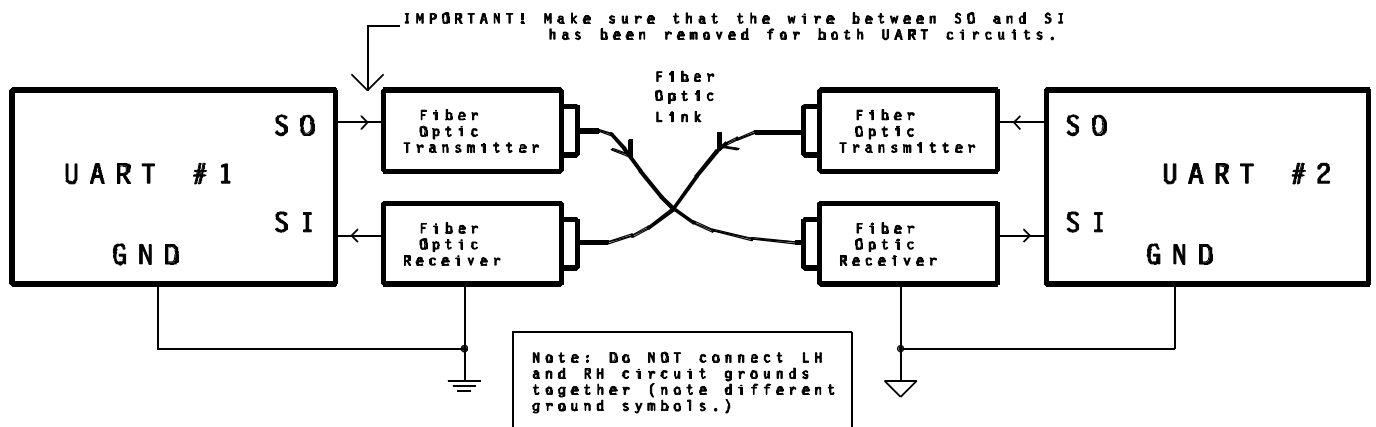


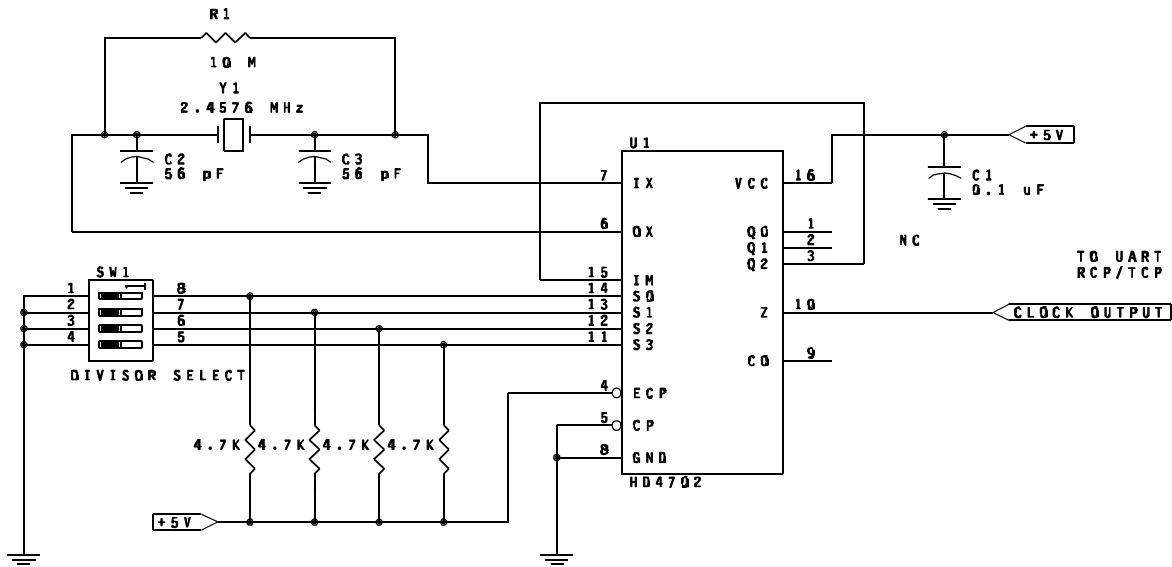
Figure 1: Full-Duplex UART Data Link

Moderately high data rates are possible in this circuit; the primary limiting factor is the fiber optic receiver itself, which is based on a phototransistor. Recall that the receiver's phototransistor gets turned on and off by the incoming light beam. Because of a junction phenomena called carrier storage, a phototransistor can be quite slow in turning off when the light beam is turned off. It almost acts as if there is a "capacitor" inside the base-emitter PN junction of the device! Nonetheless, data rates in excess of 10 Kbps are possible with this circuit.

BAUD RATE GENERATOR

As demonstrated in lab 3, UARTs require stable clock (frequency) sources. The best way of getting a stable frequency is to use a quartz crystal, and the circuit of figure 2 (next page) does just that. This circuit uses a special IC chip called a BAUD RATE GENERATOR, or BRG. The BRG contains a crystal oscillator plus a programmable divider. The oscillator always operates at a constant frequency; in the case of figure 2, it is 2.4576 MHz.

In the case of the HD-4702 of figure 2, the divisor is chosen by the appropriate 4-bit binary input on the S0, S1, S2, and S3 pins. For example, if S0=1, S1=0, S2=1 and S3=1, then the internal divisor will be 512 and the resulting output frequency will be $2.4576 \text{ MHz} / 512 = 4800 \text{ Hz}$. This corresponds to a data rate of $4800 \text{ Hz} / 16 = 300 \text{ BPS}$. (Recall that a UART clock frequency is generally 16 times the desired data rate).



Note: Code "0000" or "0001" gives 19.2 KBPS data rate; see text.

Figure 2: Programmable BAUD Rate Generator (BRG)

The truth table on the first page of the HD-4702 data sheet shows how to program the divisors to get each desired data rate. (The data sheet is located at the rear of this lab manual.)

Careful study of the truth table gives a clear answer to all the code combinations except for two combinations, 0000 (L L L L) and 0001 (L L L H). The output is given as "MUX Input (IM)" for both of these cases. In these cases, the CLOCK OUTPUT on pin 10 ("Z") isn't derived from the internal divider; it is taken from input pin 15, IM. In the circuit of figure 2, IM is connected back to the chip's Q2 output. The result is: Whenever rate codes 0000 or 0001 are chosen, the data rate will be 19.2 KBPS.

LABORATORY PROCEDURE:

1. Add the BAUD RATE GENERATOR of figure 2 to your UART circuit. Set the transmit/receive parameters as follows: 1200 BPS ; 8,E,1. Data = your choice.
2. Build up the data link as pictured in Figure 1. A laboratory partner is required. The only connection between you and your partner's circuit will be the two fiber optic cables. No grounds nor power supplies may be shared.

IMPORTANT: Be absolutely sure that any existing "loopback" connection between SO and SI (serial out, serial in) on both UART circuits has been removed; the only connections to SO and SI should be to and from the fiber optic transceiver circuits.

3. Does it work? Find out! This is the crucial moment! Apply power...no smoke? Good sign! Try initiating transmission to see if they're "talking."

NOTE: If it doesn't work, try to determine if the problem is in the fiber optic transmitters / receivers, or the UART circuits. Can you figure out a good way to isolate the problem to one or the other? I thought so!

4. Forget about speed limits, we're out to top this baby out! Increase the DATA RATE of both units (using the dip switches on the BAUD RATE GENERATORS) until an error occurs. Don't forget to change both units at the same time so that the parameters will match! REPORT the maximum data rate.

LABORATORY REPORT CONTENTS

- 1) There should be a block diagram of your system, labeling all important signals.
- 2) There are no waveforms to record!
- 3) Circuit description -- describe the major function of each part, and how it fits into the concept of the SYSTEM.
- 4) Circuit Notes -- Make a careful note of any problems you had during this project, and document your solution to them. Also, be sure to indicate what the maximum data rate was that your system supported.