RS-232 and RS-422 Interface Circuits

Adapted from a lab by Bob Nicholson.

Introduction

You will design, build and test an RS-232 interface circuit using the MAX/ICL-232 line driver/receiver IC and measure its output slew rate and input and output impedances. Then you will design, build and test an RS-422 interface circuit using the MC3487 and MC3486 line driver and receiver ICs and again measure the slew rate and impedances.

The ICL232, MC3487 and MC3486 datasheets are available on the course web site.

Pre-Lab

Prepare a pre-lab report including the diagrams and answers asked for in the following sections. Submit your report in PDF format to the appropriate dropbox on the course web site *before the start of the lab*.

You can create the sketches and schematics using a drawing or schematic-capture program, or by scanning or taking a photograph of a hand-drawn sketch.

The purpose of drawing *your own* schematic diagrams is to make sure you become familiar with the circuit.

Always identify the source of anything in your report not created by you. Copying material without mentioning the source is called *plagiarism* and can have serious consequences.

Note that specifications may include minimums, maximums, both or neither. For example there may be a minimum input impedance, a maximum or both. When asked for a specification in the questions below, include all that apply and identity the type (minimum or maximum).

RS-232 Interfaces

Use the ICL232 datasheet from the course web site to answer the following questions.

1. Sketch the schematic diagram of an RS-232/V.28 interface circuit using a MAX/ICL232 integrated circuit[1]. Include the four required charge-pump capacitors, noting the polarities of the capacitors. The 1μF bypass capacitor from V_{CC} to ground is optional.

2. Read at least the first section of the "Detailed Description" section of the ICL232 Datasheet. Understanding how the IC works will help you troubleshoot any problems. Answer the following questions:

   (a) How many transmitters does this chip have? How many receivers?

   (b) Assuming a 5V supply voltage, what range of voltages would you expect on the receiver inputs and outputs? On the transmitter inputs and outputs?

   (c) How many charge pumps does the MAX/ICL232 have?

   (d) What are they used for?

   (e) With reference to the charge pump schematic in Figure 5 of the ICL 232 data sheet, approximately what voltages would you expect to see across C3 and C4?

   (f) What is the voltage (relative to ground) at the positive terminal of C1 when S1 and S3 are closed and S2 and S4 are open?

   (g) When the switch positions are reversed?

3. If the driver was being used for a handshaking signal (e.g. RTS), what logic level (H or L) at the input would assert that signal (make it true)?

4. If the driver was being used for a data signal (e.g. TxD) what logic level (H or L) would be used to output a '1'?

[1] The Functional Diagram schematic on page 2 is missing a connector dot. The capacitor connections are correctly shown in Figure 1.

5. What are the ICL232 receiver input and transmitter output impedance (resistance) specifications?

6. What are the ICL232 slew rate specifications?

7. Assuming the minimum slew rate, how long would it take for the signal to switch from −10 to +10 V? If this reprsents 10% of the bit period, what is the maximum bit rate?

RS-422 Interfaces

Use the MC3486 and MC3487 datasheets from the course web site to answer the following questions.

1. Sketch the schematic of an RS-422 interface circuit using one MC3487 and one MC3486 IC. *Ensure that the tri-state controls on both chips are enabled.*

2. Why doesn't the MC3287 require a negative supply or charge pump?

3. Assuming the minimum slew rate, how long would it take for the signal to switch from 0 to +5 V? If this represents 10% of the bit period, what is the maximum bit rate?

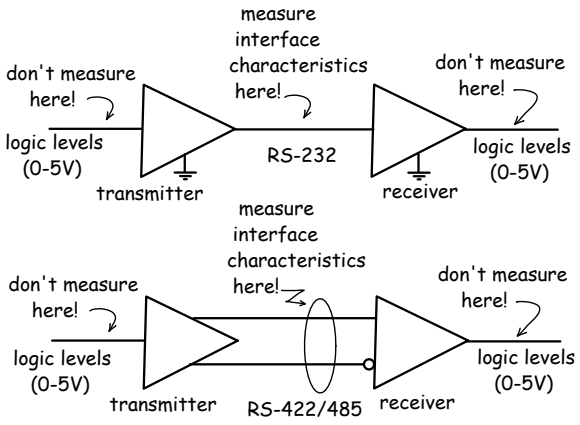
Procedure

Hints

The function of a line driver and receiver is to interface logic levels to line levels. Thus one side of each driver or receiver is a logic-level interface (e.g. TTL) and the other is a line-level interface (e.g. RS-232). Make sure you don't confuse the two interfaces.

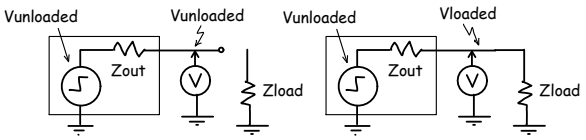
The line drivers expect TTL logic level voltages (0-5V). Set the AWG high and low levels to the correct values. Set the AWG for square-wave output.

We want to measure specifications (impedance, slew rate, etc.) on the *line* side of the interfaces, not on the logic level side. Make sure you are measuring the right interface:



The ICL-232 includes two line drivers (transmitters) and two receivers. You can test any pair. The MC3487 and MC3486 include four drivers or receivers. You can measure any one of the four.

An output impedance can be calculated from the voltage ratio of the loaded and unloaded (open-circuit) output voltages:



The ratio of the two voltages is:

$$\frac{V_{loaded}}{V_{unloaded}} = \frac{Z_{out}}{Z_{out} + Z_{load}}$$

Marks will be deducted for carelessness resulting in the destruction of components. Devices can be damaged by exceeding any of their "absolute maximum ratings" (e.g. reversed power supply polarity).

Note that the 1μF capacitors are electrolytic and must be connected with the correct polarity (the striped side is negative).

Oscilloscope Measurements

Use the Math trace to measure differential voltages since you cannot connect either signal to ground.

Press the Horizontal Scale knob to switch to the delayed timebase mode. In this mode you can "zoom in" on a portion of the waveform to allow more accurate measurements of, for example, the rising or falling edge of a waveform.

Use the Measurement menu to add the (10% to 90%) rise and fall time measurements to the display.

RS-232 Interface

1. Build the MAX-232 interface circuit leaving the output of the line driver and input to the receiver disconnected. Force the logic input to the line driver alternately H (+5V) and L (0V) and measure the MARK and SPACE voltages at the output of the driver. Do they fall within RS-232 specifications?

2. Use a resistor (or a 10k or 20k pot) to measure the output impedance of the line driver. Does it meet the ICL232 specification?

3. Measure the input impedance of the receiver using +5V from the power supply and a 10k resistor or potentiometer. Does it meet the ICL232 specification?

RS-422 Interface

1. Build the interface circuit, connecting the differential outputs of the MC3487 to the differential inputs of the MC3486.

2. Using the AWG, apply a 9600 bps TTL (0-5V) signal to the input of the MC3487. Connect channel two of your scope to the non-inverted output of the MC3487 and channel one to the inverted output. Ensure that both channel inputs are DC coupled.

   Capture the waveforms you observe on both channels for two cycles of V_{in}. Measure the MARK and SPACE voltages. Do they fall within the device specifications?

3. Set up the scope to measure the differential voltage across the two outputs (see instructions above). Capture the waveform.

4. At the RS-422 receiver, connect a 120 ohm resistor between the differential inputs. Measure the slew rate. How does this compare to the RS-232 value?

5. If the RS-232 interface limits the slew rate to reduce interference with other devices why might RS-422 interfaces not do the same? (Hint: what kind of transmission lines are typically used with differential signalling?)

Lab Report

Submit a lab report showing the measurements (voltages, currents, impedances, slew rates, waveforms, etc), and any calculations and answers to the questions asked in the procedure sections above.

Submit your report, in PDF format, to the appropriate dropbox on the course web site.