Lab 4 - 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 compare its characteristics with the RS-232/V.28 specifications. Then you will design, build and test an RS-422 interface circuit using the MC3487 and MC3486 line driver and receiver ICs and compare their characteristics with the RS-422/V.11 specifications.

The ICL232, MC3487 and MC3486 datasheets and the ITU-T V.28 (equivalent to RS-232) and V.11 (equivalent to RS-422) specifications are available on the course web site. We will use the ITU standards because they are freely available while the EIA/TIA standards are not.

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 high-quality photograph of a hand-drawn sketch. There is a scanner in SW1-3555 that is available during lab proctor hours.

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 be a minimum value, a maximum, both or neither. When asked for a specification below, include all that apply and identity the type (minimum or maximum).

RS-232 Interfaces

Use the RS-232/V.28 specifications and 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 on the course web site. Understanding how the IC works will help you troubleshoot any problems. Answer the following questions: What does a charge pump do? How many does the MAX/ICL232 have? Why does it need that many?

3. If the driver was being used for a handshaking signal, what logic level (H or L) would assert that signal (make it true)? If the driver was being used for a data signal what logic level (H or L) would be used to output a '1'?

4. In V.28 the term "Generator" is the line driver and "Load" is the receiver. What are the RS-232/V.28 input (load) and output (generator) impedance specifications (Hint: Sections 3 and 4)? What are the corresponding specifications for the ICL232 IC?

5. What is the recommended maximum RS-232/V.28 output slew rate (Hint: Section 6)? What is the maximum load capacitance allowed by the specification (Hint: Section 3)? What are the MAX/ICL232 slew rate specifications? For what load does this specification apply? What

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

do you expect to happen to the slew rate as you increase the load capacitance?

RS-422 Interfaces

Use the RS-422/V.11 specifications and 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. What are the RS-422/V.11 logic level specifications?
3. Why doesn't the MC3287 require a negative supply or charge pump?
4. What is the rise time specification for the MC3487? What is the RS-422/V.11 rise time specification (Hint: Section 5.3)? What is maximum bit rate assuming this rise time is equal to 10% of the maximum bit period.
5. Why would you use a balanced transmission line when testing an RS-422 interface?

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.

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.

Each of the ICs includes two or four drivers and receivers. You can measure any one of them.

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:

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

A waveform consisting of alternating high and low levels form a square wave that has a frequency that is *half* of the bit rate.

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).

Oscilloscope Measurements

Use the Math trace as in Lab 1 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 output impedance of the driver meet the RS-232/V.28 specification (if any)? 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 the input impedance of the receiver meet the RS-232/V.28 specification? Does it meet the ICL232 specification?
4. Apply a 100 kbps (50kHz) 50% duty cycle TTL-level (0 to 5V) signal to the logic-level input of the driver using the function generator and measure the rise time at the output using a 10x probe. Does the rise time meet the MAX/ICL232 specification? Compute the corresponding slew rate

assuming the slew rate is constant. Does it meet the RS-232/V.28 specification?

5. Connect the output of the line driver to the input of the receiver (remember to remove any potentiometers used to measure input or output impedances) and again measure the slew-rate. Does the receiver have any appreciable effect?

6. Monitor the output of the receiver and adjust the frequency until the high:low ratio is about 1:3 (or vice-versa). Record this frequency as the maximum frequency (half of the maximum bit-rate).

RS-422 Interface

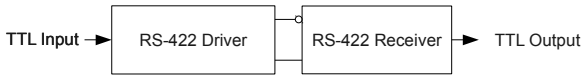
1. Build the interface circuit, connecting the outputs from the MC3487 to the inputs of the MC3486.

2. Using a function generator, apply a 9600 bps TTL 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 and know where your ground references are for both channels.

   Capture the waveforms you observe on both channels for two cycles of V_{in}. Measure and record the MARK and SPACE voltages. Do they fall within RS-422/V.11 specifications?

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

4. Connect the output of the line driver to the receiver as shown in the diagram below. Connect the RS-422 driver and receiver grounds. At the RS-422 receiver, connect a 120 ohm resistor between the differential inputs. Measure and record the maximum bit-rate that you can achieve using the same 1:3 pulse width criteria as above. How does this bit rate compare to the bit rate that can be achieved with the RS-232 interface? What specification limits the RS-232 data rate compared to the RS-422 data rate? Why did the designers of the RS-232 interface choose to set this limit? How could users of RS-422 circuits deal with this issue? (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.