RS-232 Interface Circuit

Adapted from a lab by Bob Nicholson.

Introduction

You will build and test an RS-232 interface circuit using the MAX-232[1] line driver/receiver IC and measure its input and output impedances and output slew rate.

The ICL-232 datasheet is 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.

Do not just copy-and-paste the schematic in the datasheet. The purpose of drawing *your own* schematic diagrams is to 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 in the datasheet may be 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 identify the type (minimum or maximum).

Use the ICL-232 datasheet from the course web site to answer the following questions.

1. Sketch the schematic diagram of an RS-232 interface circuit using the ICL-232 integrated circuit[2]. Include the four required charge-pump capacitors, noting the polarities of the capacitors. The $1\mu F$ bypass capacitor from V_{CC} to ground is optional.

2. Read at least the first section of the "Detailed Description" section of the ICL-232 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 voltages should appear on the receiver inputs and outputs? What voltages should appear on the transmitter inputs and outputs?[3]

   (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'?

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[1] The manufacturer prefix for this IC varies but it is commonly referred to as a MAX-232 because it was popularized by Maxim. You will probably be using an ICL-232 in the lab and that's the data sheet that's being supplied.

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

[3] *If you can't answer this question you don't understand the purpose of the MAX-232 and have missed the point of the lab – re-read the datasheet.*

5. What are the ICL-232 *receiver input* and *transmitter output* impedance (resistance) specifications?

6. What are the ICL-232 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 represents 10% of the bit period, what is the maximum bit rate?

Procedure

Where to Measure

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. Your instructor will be very annoyed if you measure the input impedance of the transmitter or the output impedance of a receiver (you should understand why before coming to the lab).

The line drivers expect their inputs to be at 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:
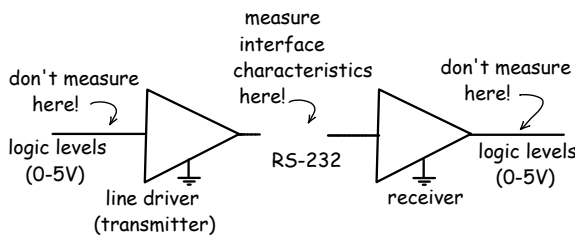
The ICL-232 includes two line drivers (transmitters) and two receivers. You can test either one of the two transmitters and either one of the two receivers.

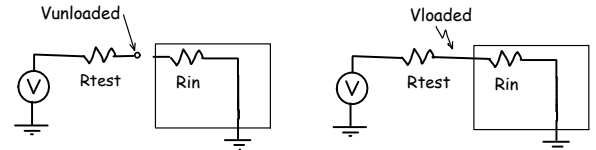### Measuring Input and Output Impedances

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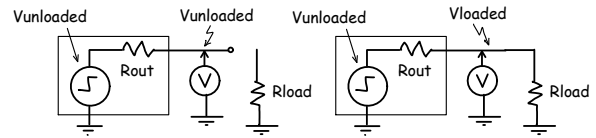
The ratio of the two voltages is:

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

The same procedure can be used to measure the input impedance except the voltage divider consists of a test resistor and the input resistance of the receiver:

However, note that the output voltage versus current characteristic may not be linear and so the apparent input and output impedances may depend on the current. You should make the measurements at the test conditions specified in the datasheet.

Slew Rate Measurement

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.

The slew rate is the slope of the steepest portion of the trace (voltage difference divided by time difference).

Cautions

Note that the $1\,\mu$F capacitors are electrolytic and must be connected with the correct polarity (the striped side is negative).

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).

Measurement Procedure

1. Build the ICL-232 interface circuit. Use a power supply or to force the (logic-level) input to either line driver alternately H (+5V) and L (0V)

and measure the mark and space voltages at the corresponding output. Do these voltages meet the ICL-232 specification(s)?

2. Use a variable resistor (potentiometer or resistor substitution box) to load the line driver output to approximately the test conditions listed in the Electrical Specifications Table entry for Output Resistance. Calculate the output impedance of the line driver. Does it meet the ICL-232 specification(s)?

3. Use a variable resistor and +5V from the power supply to measure the input impedance of the *receiver* at the listed test conditions (V_{in}=3V). Does the input impedance meet the ICL-232 specification(s)?

4. Apply a 100 kbps (50kHz) 50% duty cycle TTL-level (0 to 5V) square-wave signal to the logic-level input of the *line driver* using the AWG and measure the slew rate at the output. Does the slew rate meet the ICL-232 specification(s)?

Lab Report

Submit a lab report with the usual identification information, your measurements (voltages, resistances, times, ...), your calculations and results (impedances, slew rates), the relevant ICL-232 specification(s), and the answers to the questions in the procedure section above.

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