EE 5314 Embedded Microcontroller System Design
Low Frequency Signal Generator and Analyzer
Fall 2011 Project

1 Overview

The goal of this project is to design a system capable of capturing analog signals and generating various waveforms. This project has a command line interface capable of controlling the system and providing captured data back to the user.

Additional capabilities allow output impedance correction, scalar network analysis, and simple voltmeter operations.

A collection of most major parts will be provided to each team. The pc boards, extra connectors, batteries, tools, and any optional items are not included in this collection of parts.

2 Hardware Description

Microcontroller:
A 33FJ128GP802 is used for the system. Bypassing should be provided on both power pin pairs (0.01uF leaded cap). A 10 uF capacitor is required for the core voltage regulator. A 10k resistor from +3.3V to the ~MCLR pin is needed for proper device reset. An ICD interface should also be provided for each node. This part requires 3.3V.

Serial interface:
Your hardware shall provide a serial interface to the PC to accept commands. A SP3232E transceiver is used to translate CMOS logic level signals on the PIC to/from the bipolar signaling used for the RS-232 interface.   Only the RXD (pin 2),TXD (pin 3), and GND (pin 5) signals are used on the RS-232 interface. The SP3232E connects to one of the UART engines of the PIC via two remappable pins. This part requires 3.3V and requires bypassing and 4 capacitors for the switching power supplies (all 0.1 uF).

Analog interface:
The system is capable of capturing two analog signals with a range of +/- 10V with frequencies up to 550 kHz. Two op amps are used for shift the signal inputs from +/- 10V to a 0 to Vdd range for the ADC inputs.

The system can also generate two analog output signals with a range of +/-5V at frequencies up to 45 kHz. Two op amps are used to shift the approximately +/- 1V DAC outputs to a +/- 5V range for the signal output.

All four op amps are part of a TLV2374 quad op amp powered from +/- 6V supplies. The circuit will be provided in class.

+/- 6V supply:
The +6V (approximate) supply is provided by 4xAA batteries. A -6V (approximate) power rail is created using a TC1044S charge pump. 10uF capacitors are connected to the input and output of this dc-to-dc converter.

Vdd Regulator:
A MCP1702 regulator with a 1uF capacitor across the 6V input and a 1uF capacitor across the output can be used to generate the 3.3V supply.

LEDs:
Connect a yellow LED to indicate power on the board. Connect red and greens LEDs to output pins on the PIC. 470ohm current limiting resistors should be used for all LEDs.

Push buttons:
A push button should be connected to an input pin on the PIC.

Connections:
Provide a 10-pin double-row header for the RS-232 interface so that a ribbon cable and DB-9F connector can be connected to communicate with a PC.

BNC connectors or small wires loops shall be provided for Vss, Vdd, and all 4 analog input and output signals.

Graphics LCD display and local control (optional extra credit):
Adding a graphics LCD and corresponding user interface buttons shall yield the potential for additional credit.

3 Suggested Parts List

Part	Quantity
dsPIC33FJ128GP802 (3.3V microcontroller)	1
SP3232E (3.3V RS-232 receiver/driver)	1
MCP1702 (3.3V, 250mA regulator) [low-drop out regulation is not needed]	1
TC1044S (analog negative rail charge pump)	1
TLV2374 (quad rail-to-rail input/output op amp)	1
Red LED (arm/status)	1
Green LED (rs-232 command received)	1
Yellow LED (power)	1
Tactile switch (input switch)	1
470ohm resistor (led current limiters)	3
1k resistor (current limiter before clipper)	2
10k resistor (reset circuit pull-up, DAC signal conditioning)	5
56k resistor (DAC signal conditioning)	4
6.65k, 0.1% resistor (ADC signal conditioning)	2
10k, 0.1% resistor (ADC signal conditioning)	2
12k, 0.1% resistor (ADC signal conditioning)	2
20k, 0.1% resistor (ADC signal conditioning)	2
60.4k, 0.1% resistor (ADC signal conditioning)	2
0.01uF capacitor (bypassing PIC)	2
0.1uF capacitor (bypassing op amp, rs-232 switcher)	7
1 uF capacitor (3.3V regulator input/output cap)	2
10 uF capacitor (core voltage regulator cap, dc-to-dc converter)	3
28pin 300mil socket (for controller)	1
16pin 300mil socket (for SP3232e)	1
14pin 300mil socket (for TLV2374)	1

8pin 300mil socket (for TC1044S)	1
DB9F IDC connector (for rs-232)	1
10pin IDC double-row F connector (for rs-232)	1
3' 9 or 10pin ribbon cable (for rs-232)	1
10pin double-row header (for rs-232 and can)	1
8 MHz ceramic resonator w/ integral caps	2
Wire (22-24 AWG solid wire, 3+ colors)	1
RJ-31 jack (for ICD3 connection)	2
4xAA battery holder	1
1N914 diode (ADC clipper)	4
4xAA batteries	1
PC board (approx 4.5x6")	1
ST-7565R based graphics LCD	Optional
BNC connectors for i/o	Optional
Tools, safety glasses, …	1 each

4 Software Description

An RS-232 interface using a 38400 baud, 8N1 protocol with no hardware handshaking shall be provided with support to the following commands.

General:

If "reset" is received, the hardware shall reset.

If "baud RATE" is received, the hardware shall enable operation at the indicated baud rate (RATE).

Signal Generation:

If "sine CHAN, FREQ, AMP" is received, the hardware shall output a sinusoidal signal on channel CHAN with a frequency of FREQ (Hz) and amplitude of AMP (V).

If "square CHAN, FREQ, AMP" is received, the hardware shall output a square wave on channel CHAN with a frequency of FREQ (Hz), and amplitude of AMP (V).

If "sawtooth CHAN, FREQ, AMP" is received, the hardware shall output a square wave on channel CHAN with a frequency of FREQ (Hz), and amplitude of AMP (V).

The AMP is guaranteed to reach amplitudes of +/- 5V with no load connected. After calibration, the amplitude will be limited by the load impedance. Points will be awarded based on the best resolution possible for the frequency and amplitude of signals.

Signal Analysis:

If "voltage CHAN" is received, the hardware shall return the current voltage on channel(s) CHAN. CHAN can be 1, 2, or 1|2.

If "capture CHAN, SAMPLE_RATE, SAMPLE_COUNT" is received, the hardware shall acquire SAMPLE_COUNT samples at the SAMPLE_RATE (Hz) selected on channel(s) CHAN when the trigger condition is met. CHAN can be 1, 2, or 1|2.

If "trigger off" is received, the hardware shall remove any trigger conditions for acquisition (captures will start immediately after receipt of a capture command).

If "trigger EDGE VOLTAGE" is received, the hardware shall add a trigger condition for subsequent acquisition using a threshold voltage of VOLTAGE (V) and an edge polarity of EDGE, where EDGE is POS or NEG"

If "display math CHAN" is received, the average, rms, max, and min values will be displayed from the most recent trace. CHAN can be 1, 2, or 1|2. Efforts to compute the time and frequency of the signal will be awarded extra credit.

If "display capture CHAN" is received, a table of sample conditions and sample values will be displayed from the most recent trace. CHAN can be 1, 2, or 1|2.

Calibration:

If "zero input CHAN" is received, the hardware shall compensate for any offset error in signal input CHAN.

If "calibrate input CHAN" is received with an external input is connected to Vdd, the hardware shall compensate for any gain error in signal input CHAN. This should be performed after zeroing the input.

If "zero output CHAN" is received when the output is connected to input channel 2, the hardware shall compensate for any offset errors in signal output CHAN.   This should be performed after input 2 is calibrated.

If "calibrate output OUT_CHAN using input IN_CHAN" is received when the output OUT_CHAN is connected to input channel IN_CHAN, the hardware shall compensate for any gain errors in signal output CHAN. This should be performed after zeroing the output. This allows for compensation of varying load impedances.

Scalar Network Anaysis (optional extra credit):

By sweeping the frequency over a range of frequencies, the transfer function of the hardware can be calculated. The following commands may be supported:

If "sweep CHAN, FREQ1, FREQ2" is received, the system shall sweep a sinusoidal output on output CHAN from FREQ1 to FREQ2 and capture the output on the corresponding input CHAN. CHAN can be 1, 2, or 1|2.

If "display sweep CHAN" is received, a table of sample conditions and sample values will be displayed from the most recent sweep. CHAN can be 1, 2, or 1|2.

If "display z CHAN" is received, an estimate of the load impedance shall be displayed from the most recent sweep.

If "display lcr CHAN" is received, an estimate of the equivalent circuit(s) shall be displayed from the most recent sweep.

5 Testing

Your hardware will be tested in the 148NH lab.

Computers and lab equipment will be provided on campus in Rm 148 NH for you to work on this project. If you do plan on plugging your project into your own machine, <u>do so at your own risk</u> and only after having the hardware tested. Again, you are responsible for anything that happens to your personal machine. Do not connect your project to any machines in the UTA computing labs or in other EE labs.

6 Deadlines

You should complete construction of the hardware by Wednesday, 10/12. After 10/12, a 25% deduction to the hardware portion of the project will be assessed for each class period that the hardware is late. The project hardware may be inspected by the GTAs at any date prior to and including this date.

The project is due on Wednesday, 12/7 @ 4pm, with an oral defense, electronic copy of your code and report, hard copy of your code, and demonstration of hardware and software (including compilation on site). You may work in teams of one, two, or three members. All members of the team shall participate equally and be prepared to answer any question about the project to avoid a deduction in points. Each member of the team will be graded independently, although only one report, hardware, and software submission is needed.

7 Safety Issues

While far beyond the scope of this document, it is important to use tools safely. Safety goggles are a good idea, since you can cause yourself injury if a wire that is being cut flies into your eye. Similarly, if wires being unsoldered are placed under some strain, the solder can be fling toward you. Soldering entails some care to prevent burning yourself or a burning down a building if you forget to turn it off. If you choose to use solder containing lead, then care shall be taken to dispose of lead properly (don't cool off the iron in a drinking fountain, etc.). Always wash your hands after using solder to prevent the build-up of heavy metals in your body. These are a few helpful suggestions and are a very incomplete listing. Please read and understand all safety labels and exercise caution.

Please utilize the supervised lab resources in Rm 148 NH when working on the project for your safety. You may only use the resources in Rm 148 NH when the GTA or other E.E. staff is present.

Have fun!