EE 5314 Embedded Microcontroller System Design
Low Frequency Signal Generator and Scalar Network Analyzer
Fall 2016 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 measurement 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.. The pc boards, tools, and any optional items are not included in this collection of parts.

2 Hardware Description

Microcontroller:
An ARM M4F core (TM4C123GH6PMI microcontroller) is required.

Serial interface:
If using the EK-TM4C123GXL evaluation board, then the UART0 tx/rx pair is routed to the ICDI that provides a virtual COM port through a USB endpoint.

Analog interface:
The system is capable of measuring an analog signal with a voltage range of +/- 5V with frequencies up to 450 kHz. An op amp is used to form an ideal rectifier. The rectified signal is then sent to 2 op amps that are configured as leaky integrators with two different time constants.

The system uses an MCP4821 DAC with an integral 2.048V reference to create a number of waveforms with a voltage range of +/-5V at frequencies up to 40 kHz. An op amp is used to level shift this signal to a +/-5V range.

All four op amps are part of a TLV2374 rail-to-rail input/output quad op amp powered from +/-5V supplies.

The circuit will be provided in class. Both the op amp, DAC, and resu and DAC are bypassed with a 0.1uF capacitor.

+/- 5V supply:
The 5V supply is derived from the USB bus. A -5V power rail is created using a ILC7660 charge pump. 22uF capacitors are connected to the input and output of this dc-to-dc converter.

Connections:
A three-position terminal block will be provided to allow a device under test to be connected to the signal output, signal input, and ground.

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
TM4C123G evaluation board (ARM M4F)	1
MCP4821 SPI DAC with internal reference	1
ILC7660 (analog negative rail charge pump)	1
TLV2374 (quad rail-to-rail input/output op amp)	1
22ohm, 1% resistor (DAC reconstruction filter)	1
1k, 1% resistor (DAC signal conditioning)	2
10k, 1% resistor (DAC signal conditioning)	2
12k, 1% resistor (ADC signal conditioning)	2
23.7k, 1% resistor (ADC signal conditioning)	3
47k, 1% resistor (ADC signal conditioning)	6
49.9k, 1% resistor (DAC signal conditioning)	1
52.3k, 1% resistor (DAC signal conditioning)	1
0.1uF capacitor (bypassing, reconsruction filter)	3
1 uF capacitor (short time constant filter)	2
22 uF capacitor (long time constant filter, dc-to-dc converter)	3
1N914 diode (ideal rectifier)	2
2x10 double-row header, unshrouded	2
14pin 300mil socket (for quad op amp)	1
8pin 300mil socket (for charge pump and DAC)	2
Wire (22-24 AWG solid wire, 3+ colors)	1
PC board (approx 4.5x6”)	1
ST-7565R based graphics LCD and parts	Optional
Tools, safety glasses, …	1 each

4 Software Description

A virtual COM power using a 115200 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.

Signal Generation:

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

If “square FREQ, AMP” is received, the hardware shall output a square wave with a frequency of FREQ (Hz), and amplitude of AMP (V).

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

The amplifier is designed to reach amplitudes of +/- 5V with no load connected if the USB bus voltage is sufficient. In practical use, voltages of +/- 4.5V are typically available.

Signal Analysis:

If “voltage” is received, the hardware shall return the average voltage on the input.

Although limited by output impedance, signal bandwidth, and scalar measurements, it is possible to make a number of primitive swept frequency measurements. 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 FREQ1, FREQ2” is received, the system shall sweep a sinusoidal output from FREQ1 to FREQ2 and capture the output on the corresponding input. The results should be presented in a tabular format.

If “display sweep” is received, a table of sample conditions and sample values will be displayed from the most recent sweep..

If “display z” is received, an estimate of the load impedance magnitude shall be displayed from the most recent sweep (optional).

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

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, do so at your own risk 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 Friday, 10/7. After Monday, 10/10, 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 the date and at the time indicated in the syllabus, 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). The project is an individual project.

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!