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Report – Function Generator Serial DAC

Introduction

The purpose of this module is to further explore the PIC microcontroller through another practical application, this time converting digital values to analog waveforms. For this module, an external DAC is interfaced to the microcontroller via a SPI serial communication protocol. The circuit shall consist primarily of, in addition to the microcontroller, two potentiometers, two switches, and the DAC module. The input controls will be used to control various aspects on the output waveform.

Design

This circuit consists of potentiometers controlling amplitude and frequency, switches controlling waveform selection, and a LT1661 DAC converting the digital values to an analog voltage. Power was supplied to the board via an Arduino.

The potentiometers are connected to Port A and read using the ADC module on the port. For the amplitude control, the value is then converted to a factor which can be used to scale the value in the waveform to the appropriate voltage level. The voltage level can vary between 0 and 5 volts. For the frequency control, the number is converted into a factor which will set an appropriate delay. The frequency of the waveform can vary from 10Hz to 100Hz.

The switches are connected to simple digital inputs on Port B. The value of the switches (00-11) will control which waveform is being output to the DAC. The options consist of a sine wave, triangle wave, sawtooth wave, or square wave.

Finally, the LT1661 DAC module is connected to the SPI interface on Port D. The connections consist of a chip select, serial clock, and serial data. Software controlling the module will format the waveform value to the proper 10-bit format, preceded by a four bit value that gives instructions to the module (always 1111). The last two bits are irrelevant and regarded as “don’t cares”.

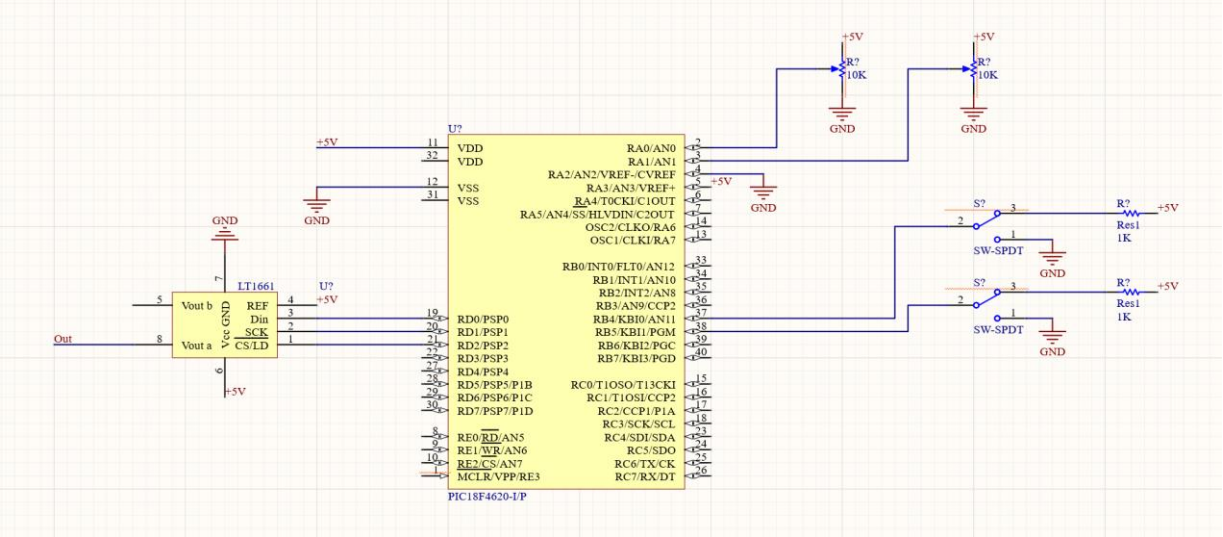


Figure 1. Altium schematic

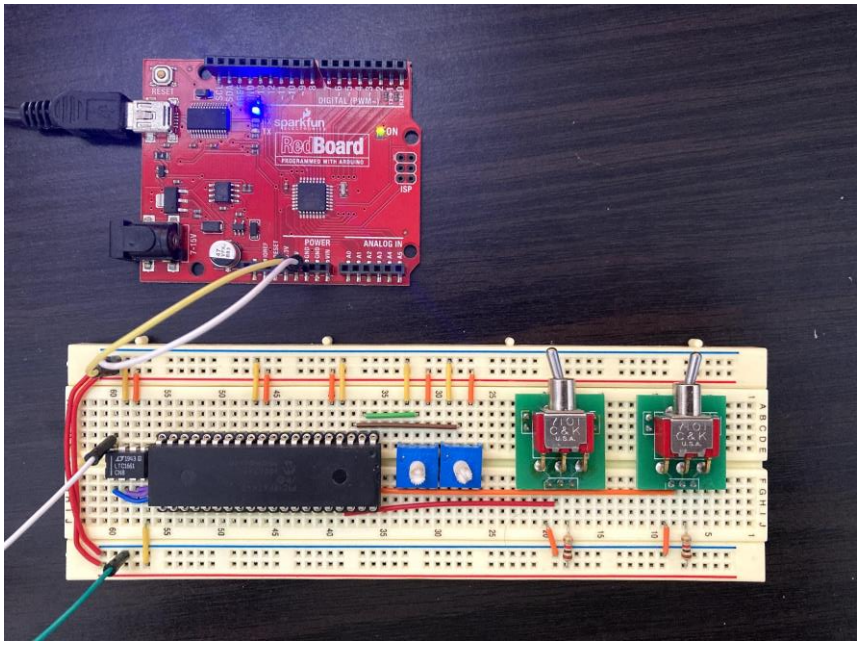
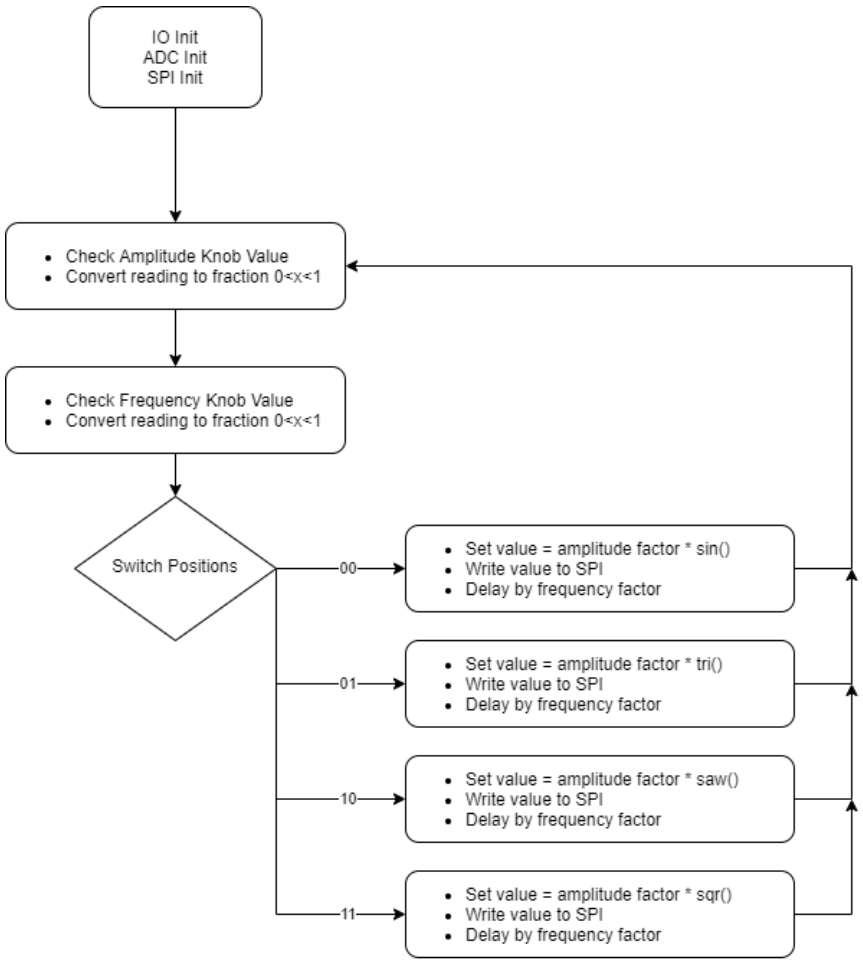


Figure 2. Physical circuit implementation

The software controlling the circuit is the most advanced out of the previous microcontroller modules. The program first goes through an initialization process to properly configure the ADC modules, switch inputs, and SPI module settings. Then, a continuous loop will run to update the values of the input controls and send the corresponding output values to the DAC. The PIC was programmed using the SNAP programmer included with the lab kit. A flowchart for the code utilized is shown below.



Below are a selected number of output waveforms showing the experimental results of the function generator. The signals below demonstrate the 4 distinct waveform options, as well as the ability to adjust frequency and amplitude within the required specifications.

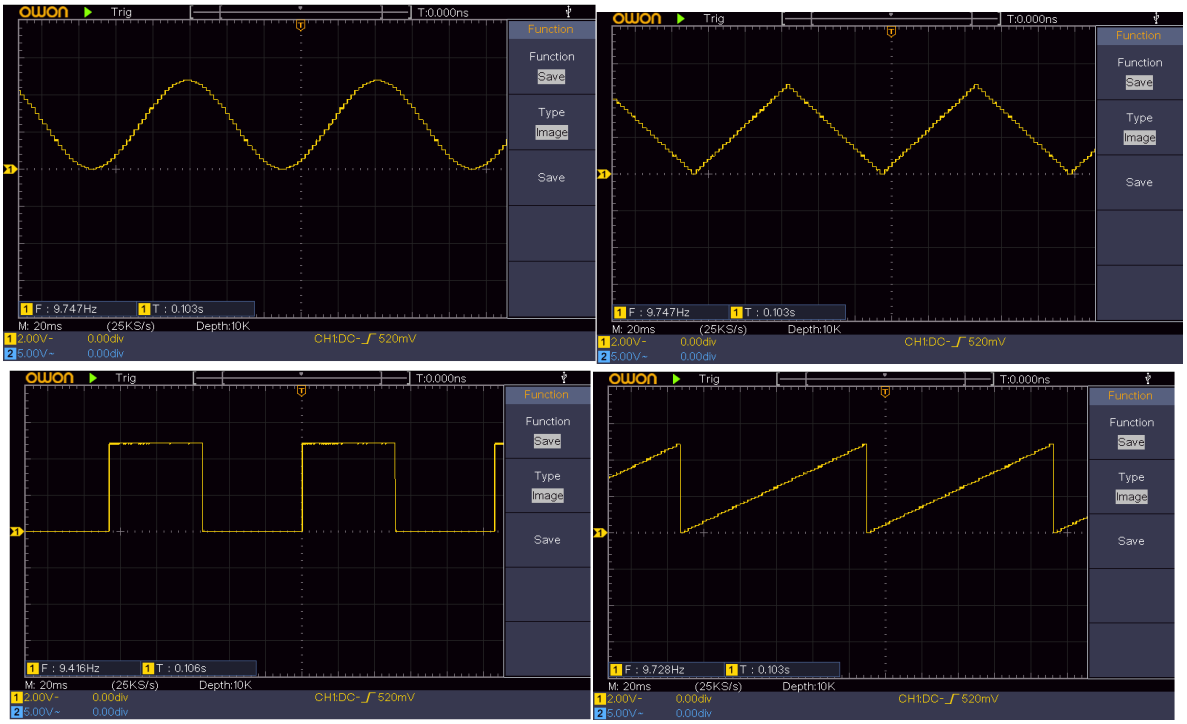


Figure 3. Output waveform options

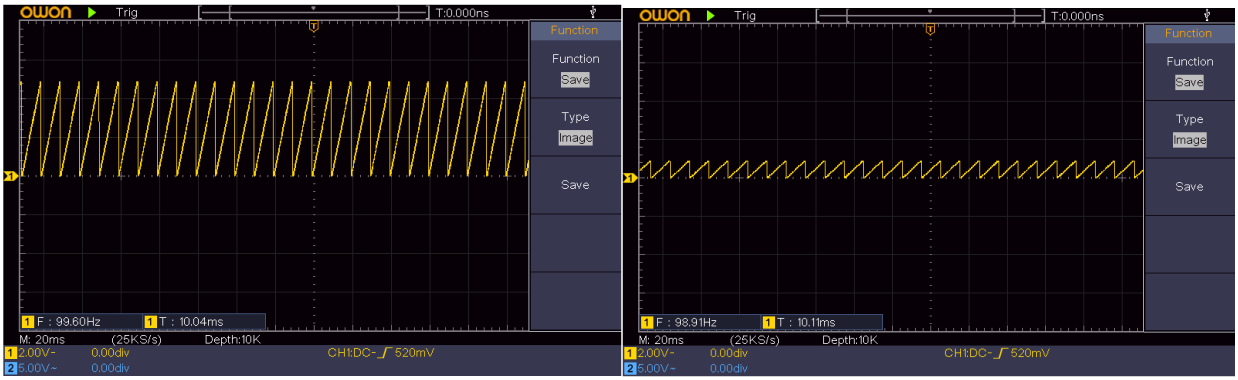


Figure 4. Frequency/amplitude variation

Description	Quantity	Price/Part	Part Number	Source
Potentiometer - 10k Ohms - Through-Hole	2	$ 2.90	3310C-125-103L	https://www.digikey.com/en/products/detail/bourns-inc/3310C-125-103L/2534044
Microcontroller	1	$ 2.75	PIC18F47K40-I/P	https://www.digikey.com/en/products/detail/microchip-technology/PIC18F47K40-I-P/6208289
DAC	1	$ 5.53	LTC1661IN8#PBF	https://www.digikey.com/en/products/detail/analog-devices-inc/LTC1661IN8-PBF/961738
Switch	2	$ 1.34	ANT14SEBQE	https://www.digikey.com/en/products/detail/cit-relay-and-switch/ANT14SEBQE/12502502
Resistor - 1k Ohms - Radial/Through-Hole	2	$ 0.01	CFR-25JR-52-1K	https://www.digikey.com/en/products/detail/yageo/CFR-25JR-52-1K/11974
	Total:	$ 16.78		

Conclusion

The design and implementation of this module was overall a success. It has combined concepts developed in previous modules to produce a truly useful function generator that uses analog to digital conversion, digital to analog conversion, and serial communication with an

external peripheral. Some aspects of this module could be improved. Most specifically, the use of interrupts rather than sequential instruction with delays would increase overall system efficiency and reliability. Ultimately, though, the final design produced accurate readings and the system fully meets all design requirements.