Sarah Ferguson
Gavin Darcey

A Controllable Function Generator

Overview

This project will implement a basic function generator capable of creating periodic square, sine, and sawtooth (triangle) waveforms. The output will be very similar to that found on a standard lab function generator, with controllable frequency and amplitude. In addition to the generation and basic control of the wave through pushbuttons on the labkit, we will implement video output for additional control and measurement display. The video component will use a standard ps/2 mouse as input to allow a user extra control over the waveform.

There are two major components to this project – the wave generation and the video output. The wave type is selected by the user, both by buttons on the labkit and by on-screen buttons shown on the monitor display. Wave generation is handled globally by one functional state machine (FSM) that accepts user input – wave type, frequency, and amplitude, and generates 8 bits of data that are fed to an 8-bit digital to analog converter in order to create the proper analog waveform. Due to the mechanical "bounce" seen on the labkit buttons when depressed, all button inputs will be debounced and synchronized before being sent to the FSM. The frequency and amplitude are standardized to start at 1 kHz and 5V peak to peak, respectively, upon power-up and can then be adjusted up and down by the user, via the labkit pushbuttons and on-screen controls. The FSM will keep track of the current frequency and amplitude, as well as the wave type, in order for this information to be properly displayed on the video screen.

Our DAC will be the Analog Devices AD7224, which has a settling time of 7 µs, or a maximum operating frequency of about 142 kHz. Because of this, we will be able to generate waveform frequencies of up to 10 kHz while still allowing for enough samples per second (in this case, about 10) to generate a smooth waveform. We will include enough logic to bring the minimum frequency down to 100 Hz, and the amplitude will range from 5V peak to peak to 1V peak to peak. The DAC is readily available in the lab, and is extremely easy to wire to the user outputs of the labkit for its 8 bits of input. We believe we can use a system clock of 1 MHz.

The video display is not necessarily a real-time view of the waveform; such a measurement will be quickly verified with an oscilloscope. Instead, it is a real-time summary of what is being generated and will present the amplitude, frequency, duty cycle, and wave type measurements as reported by the FSM. We will use xvga to display the video and will reserve various sections of the screen for measurement display.

Specifications:

Debouncer:
Inputs:
Signals from buttons and switches on FPGA labkit
Outputs:
Synchronized and debounced signals corresponding to each input

Waveform FSM:
Inputs:
Synchronized and debounced signals from Debouncer module
Outputs:
8-bit digital waveform sent to DAC
Amplitude, frequency, duty cycle, and type of waveform sent to the Video Module

Digital to Analog Converter (DAC) – *AD7224 8-bit DAC*:
Inputs:
8-bit digital waveform from Waveform FSM
Outputs:
Analog voltage output corresponding to desired wave

Video:
Inputs:
Amplitude, frequency, duty cycle, and type of waveform from the Waveform FSM
Image from Image RAM
Outputs:
Monitor output
Image selector sent to Image RAM

Image RAM:
Inputs:
Image selector from Video Module
Outputs:
Image sent to Video Module

Peripheral inputs and outputs:

Inputs*:*

Labkit button_up, button_down, button_left, button_right: The user can press the up and down buttons to respectively increase and decrease the amplitude of the waveform. Likewise, the left and right buttons are used to decrease and increase the frequency of the waveform. The signals from these buttons are debounced and synchronized in the Debouncer module before they are sent to the Waveform FSM. The FSM analyzes the inputs to determine how to adjust the current amplitude and frequency, which are output to the DAC and Video modules. If time permits, the functionality offered by these 4 inputs will also be offered by mouse control on-screen.

Labkit button [2:0]: These buttons are used to determine which type of waveform is output. Initially, the user will press button 0 to display the square wave, button 1 for the ramp wave, and button 2 for the sine wave. The signals from these buttons are debounced and synchronized in the Debouncer module before they are sent to the Waveform FSM. The FSM analyzes the inputs to determine the appropriate wave type, which is output to the DAC and Video modules. Eventually, this functionality will be extended to on-screen buttons on the monitor, and the wave type will be selectable with a mouse click.

Labkit switch [7:0]: These switches correspond to the duty cycle of the square wave. They are debounced and synchronized in the Debouncer module before they are sent to the Waveform FSM. The FSM analyzes the 8-bit input to determine the appropriate duty cycle, which is output to the DAC and Video modules. If time permits, these switches will be removed and the mouse will instead be given this functionality.

PS/2 mouse: We will use a serial port mouse to control any on-screen actions taken by the user. We plan on using the mouse control Verilog module posted on the Fall 2005 website as reference.

Outputs:

VGA output: We will use the standard VGA output from the labkit to the computer monitors in the lab.

Testing:

Each module will be individually built and tested using Xilinx test benches. Once the Debouncer and Waveform FSM modules have passed their individual tests, they will be connected. The DAC output will be tested with the oscilloscope to ensure that the correct waveform is being generated. The Video and Image RAM modules will also be connected and tested via observation on the computer monitor. After these tests are passed, all of the modules will be connected. The final test will be the demonstration of each waveform (viewed on the oscilloscope) and the correct display of measurements simultaneously.

Division of Labor:

Sarah will be responsible for the video output to the monitor, including the storage and selection of images in the RAM.

Gavin will be responsible for debouncing the user inputs and creating the logic in the Waveform FSM to transform these inputs into signals usable by the DAC and Video modules.

If time permits, mouse control will be added. Gavin will be responsible for the interpreting the movements of the mouse and translating these movements into changes in amplitude, frequency, duty cycle, and wave type. Sarah will be responsible for creating buttons displaying the three different wave types. She will also modify the waveforms so that they reflect the changes in amplitude, frequency, duty cycle, and wave type.