GenBlocks

Version: 1/10/18

Notes:

- For the purposes of this document, we consider “code” or “software” to refer to programs which runs on a PC and/or on an embedded system.
- While we try our best to allow students to have the freedom to make their own design choices, it is not possible for the teaching staff to support every possible development system.
- **This specification is a *living* document!** Changes will occur and will be released throughout the semester.
- You are permitted to bundle outside orders with other teams in order to reduce the overall cost of shipping, as long as you take into account the UQ Academic Integrity and Student Conduct policy.
- If you see text highlighted in green, it corresponds to ENGG2800-specific requirements
- If you see text highlighted in blue, it corresponds to ENGG3800-specific requirements
- **You must follow all other requirements outlined in the *TP-STD* standards.**

Introduction

Genblocks is a modular electronic function generator system. It consists of three blocks (modular PCBs) which operate independently of each other. These three blocks are:

- A function generator
- A switchable filter
- A power amplifier

The parameters of the generated tones are to be controlled by a simple GUI application, and communication between the device and the PC must happen only over USB. For ENGG2800, this communication must occur using only one UMFT234XF (Digikey part number: 768-1174-ND). All communication must happen over a single USB cable. For ENGG3800, this USB connection must also supply all of the power for the device, or you must source all power from a 5V source.

Please note that all of the following configurations may be tested:

- Function generator alone
- Function generator -> filter
- Function generator -> filter -> amplifier
- Function generator -> amplifier

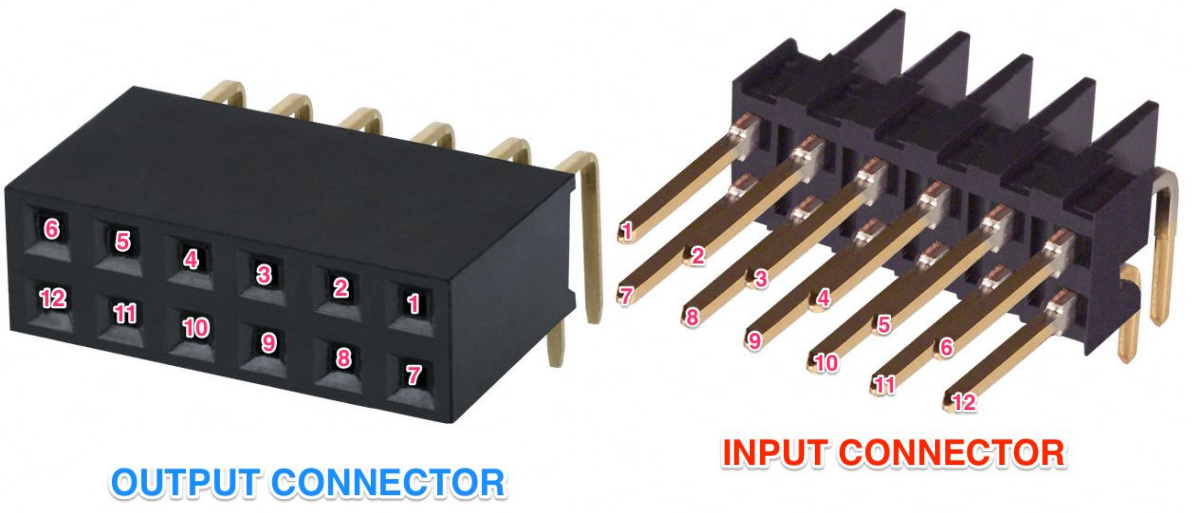
We may also introduce a special splitter block that allows us to introduce our own signals from a benchtop function generator; for example:

- Function generator -> splitter -> amplifier

All of these blocks are connected together using a standard connector, hereafter known as the GenBlocks connector. You may not use any other connections between the blocks. There is one connector specific to the input side, and one specific to the output side. The input connector must plug directly into the output connector without any cables or adapters. **You MUST follow this pinout EXACTLY:**

+5V (pin 1)	GND (pin 7)
+5V	GND
-5V	GND
-5V	GND
I2C_SDA	I2C_SCL
AUDIO (pin 6)	GND (pin 12)

Labelled images of the connectors can be seen below. **Please note that while the physical footprint dimensions are the same for both the input and output connector, the numbering order is reversed between them.** The output connector has the Digikey code S5559-ND and the input connector has the part code 609-3355-ND.



Function Generator Block

The function generator block is designed to generate various waveforms at user-specified frequencies. These waveforms must be generated with a sample rate of at least 44.1kHz. The following waveform types are required to be supported:

- Sine
- Sawtooth
- Reverse sawtooth
- Triangle
- Square

For ENGG2800, these waveforms must be generated with an 8 bit resolution. For ENGG3800, these waveforms must be generated with a 12 bit resolution.

The block must be able to generate tones with an integer fundamental frequency from 1Hz to 10kHz with better than 10% frequency accuracy. It is acceptable that these waveforms will be distorted toward 10kHz. You are not expected to implement any anti-aliasing filter.

It must be possible with your device to generate two waveforms simultaneously. These waveforms must be generated using separate Digital to Analog converters (DAC) and mixed in the analog domain using a summing amplifier. You may use separate DACs contained in a single IC. You must have test points available to allow the measurement of the individual waveforms on an oscilloscope. The test points can present the waveform over an arbitrary range (they do not need to be -3V to +3V).

All waves must have a user controllable voltage offset and peak-to-peak voltage with the same resolution as the waveform (it is expected that this will be implemented digitally). The maximum Vpeak-peak must be 6V (from -3V to 3V). The tolerance requirement for the voltage output is ±10% or ±100mV, whichever is larger. The waveforms must clip at +/- 3V if the offset and peak-to-peak combination pushes them outside of the valid range. This clipping requirement applies only after the summing amplifier. If you can show that your system will never output anything beyond this range by design, we will consider that as acceptable in lieu of an actual clipping circuit.

The function generator block must be the only block connected to the PC. The function generator must also be the only block that is connected to a power supply.

The function generator block must have a single GenBlocks output connector. For ENGG3800, this connector can be on a separate PCB to any microcontroller development board; however, it must be connected to the development board through a connector that cannot be reversed.

For ENGG2800, you may only power your device from a dual rail, +/- 12V feed from a benchtop lab power supply. For ENGG3800, you may only power your device from a single rail, 5V power supply (either via USB, or via a benchtop lab power supply). You may connect the power to the block using any connector you feel appropriate, but it must be keyed and/or unable to be connected backwards. The tolerance for the -5V/5V rails is ±1V. For ENGG2800, you may use the same test point headers as the initial PCB task, as long as they are far enough apart such that when clips are attached they will not accidentally touch.

Function Generator Block: ENGG3800 Extension

Your function generator block must have an additional two mono, 3.5mm audio sockets. The first of these is an auxiliary output of the audio signal (the same as the GenBlocks connector), and the second is an audio input (of +3V to -3V). You are required to sample this audio input at a sample rate of at least 44.1kHz, and you must compute and show the Fast Fourier Transform (FFT) magnitude of this input signal as a line plot on a T6963C-compatible 128x64 pixel graphic LCD display (provided in your toolbox). 0dB magnitude is defined as a 6V pk-pk sine wave, and everything should be normalised with respect to this. The parameters of the FFT must be selectable on the hardware interface using buttons or switches. The configurable parameters are:

- FFT length (128, 256, 512, 1024, 2048)
- Display start frequency (1Hz - 10kHz in 100Hz steps)
- Display stop frequency (1Hz - 10kHz in 100Hz steps)

The display must be updated at least once per second. The display must also show the current FFT length and display range (start/stop frequency). Finally, the user must have two buttons which can be used to move a cursor left and right along the plot between each frequency bin. The current frequency bin and magnitude of the FFT being pointed to must be printed on the display.

The cursor is not limited to the display range, but rather the full range of the FFT. For a frequency which is displayed on the screen, the cursor must always be visible on the screen. For an off screen cursor, there should be an icon or marker which indicates that the cursor is offscreen. When changing the start or stop frequency, the cursor must remain pointing to the same frequency bin.

When drawing the plot, the magnitude of the FFT must be displayed on the Y axis, and the frequency on the X axis. The line plot must be drawn using linear interpolation using a technique such as Bresenham's algorithm.

This subsystem must work without the PC software running.

You may mount the graphic LCD off-board using a cable, but you must use an IDC-style boxed header and ribbon cable.

You must have a momentary pushbutton switch which allows the user to cycle through 5 levels of backlight brightness.

Documentation on the LCD display can be found here.

Switchable Filter Block

This block contains four signal conditioning filters that are user selectable:

- THRU
- 2LP100
- 2LP3K
- 2HP1K

For ENGG2800, the user must be able to select which filter they would like to use using a single, 4-way mechanical switch. It must not be possible to select more than one filter at once. The PCB must be labelled on the correct silkscreen layer near the switch with the filter type. For ENGG3800, the filter type must be controllable using the PC GUI interface.

The filter block must have an input and an output GenBlocks connector.

A description of the filter behaviour is below:
THRU: a through connection (output = input)
2LP100: An active, second order, low pass filter with a cutoff frequency of 100Hz
2LP3K: An active, second order, low pass filter with a cutoff frequency of 3kHz
2HP1K: An active, second order, high pass filter with a cutoff frequency of 1kHz

For a signal within the pass band, all filters must have the same output voltage swing as the function generator block (between -3V and 3V). For all but the 2HP1K filter, the output must be DC coupled. The cutoff frequency of the filter must be accurate within ±10%.

Power Amplifier Block

The power amplifier block is intended to take the +3V to -3V signal and amplify it so that it can be driven into a single-ended, 32 ohm load (typical resistance for headphones) with the same voltage swing . The input to this block is the standard GenBlocks connector, and the output is a mono, 3.5mm audio socket. The signal on this connector must be AC coupled, and must be referenced to the same GND as the input power supply. Please note that if you use a stereo 3.5mm audio socket instead of a mono socket, it must be configured **exactly** the same way as a mono socket would be (tip: signal, ring: GND or floating, sleeve: GND), otherwise you will risk damage to your amplifier when a mono connector is inserted.

The amplifier must have an on-board temperature sensor with a resolution of at least 1C in order to monitor the amplifier for thermal overload. This temperature value must be displayed in the PC software with an update rate of at least 1Hz.

For ENGG2800, this block must have a potentiometer which can be used to adjust the output volume from essentially zero voltage to the maximum voltage swing.
For ENGG3800, this block must have a digitally adjustable gain control from the PC GUI with at least 128 levels (where 0 is no amplitude, and 128 is maximum

amplitude). This gain adjustment must be implemented on this block, and not using the adjustable amplitude functionality of the waveform generation.

Taking into account the AC coupling of the amplifier, for ENGG2800, we expect a gain of 1 for frequencies above 100Hz. For ENGG3800, we expect a gain of 1 for frequencies above 50Hz. In both cases, the gain below these thresholds should be less than or equal to one. The output voltage must be within ±10% of the expected output voltage.

All Blocks

All blocks must have two LEDs which indicate that power has been applied to the block. They must be powered from each of the +5V and -5V rails.

All blocks must be raised/mounted using four M3 x 10mm nylon standoffs and corresponding hex nuts. You may use standoffs up to 40mm long if that is more appropriate for your project. These standoffs must be placed roughly in the four corners of the board. When connecting all blocks together on a level, flat surface such as a table, the unit must be free-standing, with all standoffs touching the table.

For ENGG2800, you may only use AVR 8-bit microcontrollers.

PC Software

You must create PC software with a GUI that allows the control of various parameters of the aforementioned blocks. These include:

- Waveform 1 type
- Waveform 1 frequency
- Waveform 1 peak-to-peak
- Waveform 1 offset
- Waveform 2 type

- Waveform 2 frequency
- Waveform 2 peak-to-peak
- Waveform 2 offset
- Amplifier temperature (display only)
- Filter type
- Output volume

You must also create a single file installer for your software, or you must package it into a run-in-place executable.

Budget

The maximum Bill Of Materials used in the construction of this project is AU$100. You have a development budget of AU$150 available to your team. For ENGG3800, and for the purposes of budgeting, you do not need to include the LCD display.