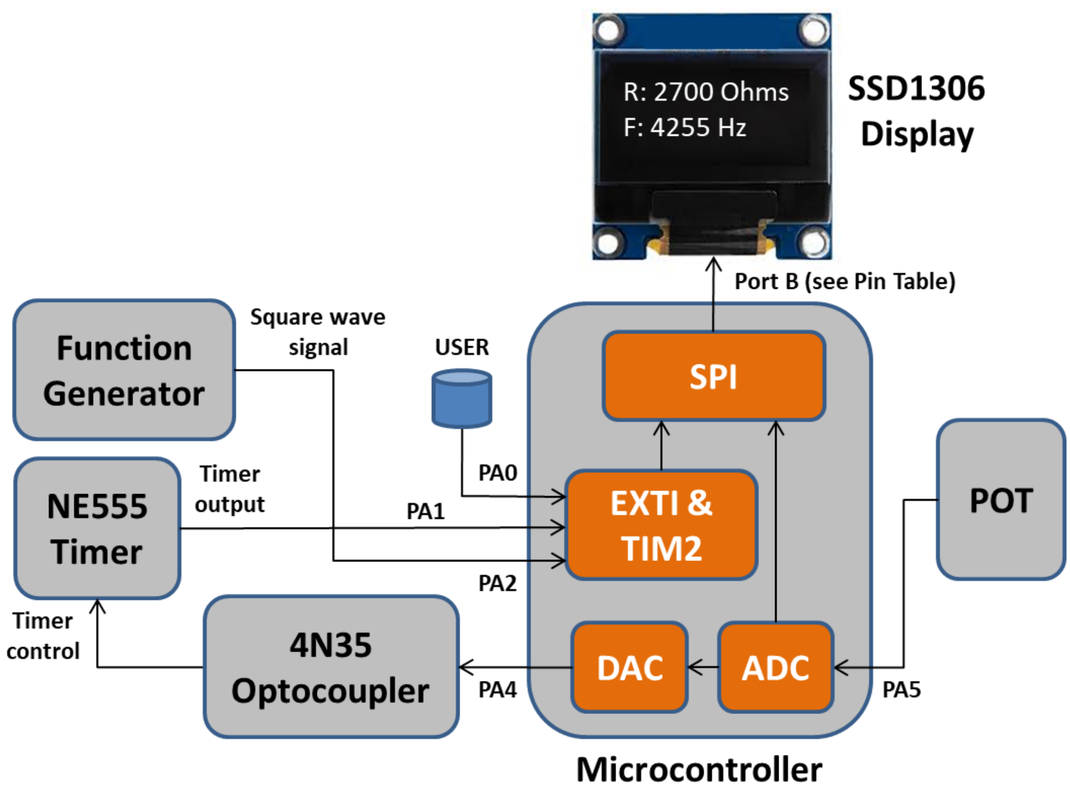
PROJECT: PWM Signal Generation and Monitoring System

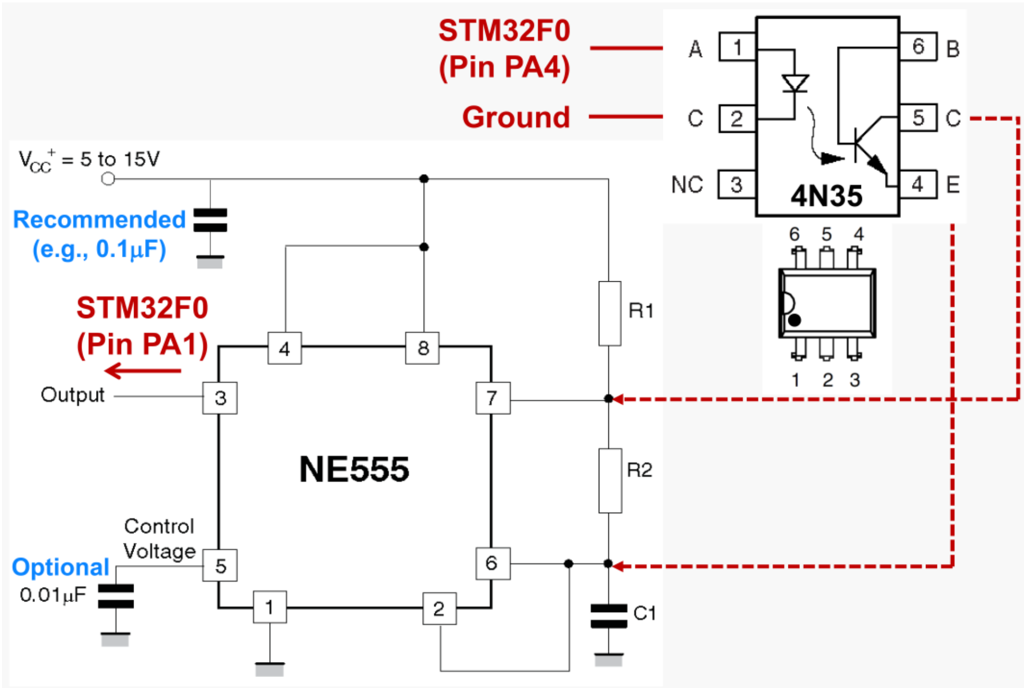
Objective

Your objective is to develop an embedded system for monitoring and controlling a pulse-width-modulated (PWM) signal generated by a 555 timer (**NE555** IC). An optocoupler (**4N35** IC), driven by the microcontroller on the **STMF0 Discovery** board, will be used to control the PWM signal frequency and duty cycle.

The microcontroller will be used to measure the voltage across a potentiometer (**POT**) on the **PBMCUSLK** board and relay it to the external optocoupler for controlling the PWM signal frequency. The microcontroller will also be used to measure: 1) the frequency of the 555 timer signal, or 2) the frequency of the Function Generator signal. Pressing the USER button will toggle which frequency is to be measured by the microcontroller.

The measured frequency and the corresponding **POT** resistance are to be displayed on the LED Display (**SSD1306** IC) on the **PBMCUSLK** board.





Specifications

- In Part 2 of the introductory lab, you have used the Function Generator to generate a square-wave signal. For this project, you will also use the 555 timer to generate an additional square-wave PWM signal. An interrupt request must be raised whenever the USER button is pressed, and the corresponding interrupt handler must "force" **TIM2** to switch between measuring the Function Generator signal frequency and measuring the 555 timer signal frequency.

  IMPORTANT: You must use **PA0** with **EXTI0** for the USER button interrupts, **PA1** with **EXTI1** for measuring the 555 timer signal frequency, and **PA2** with **EXTI2** for measuring the Function Generator signal frequency (as in Part 2 of the introductory lab).

- The STM32F051R8T6 MCU mounted on the **STM32F0 Discovery** board features internal analog-to-digital converter (**ADC**) and digital-to-analog converter (**DAC**). The **DAC** will be used to drive the optocoupler to adjust the signal frequency and duty cycle of the 555 timer output, based on the potentiometer voltage read by the **ADC**.

- The analog voltage signal coming from the potentiometer on the **PBMCUSLK** board will be measured continuously by the **ADC** – this task is to be accomplished using a polling approach. Using those voltage measurements, you will need to calculate the corresponding potentiometer resistance value. You must also determine the lower and the upper limits of the measurable voltage.

- You will use the digital value obtained from the **ADC** to control the frequency of the PWM signal generated by the 555 timer. For that purpose, you will use the **DAC** to convert that digital value to an analog voltage signal driving the optocoupler.

- To display the measured signal frequency and the potentiometer resistance, you will use the **SPI** (to be appropriately configured) to drive the LED Display mounted on the **PBMCUSLK** board. The interface includes 1 serial data signal (**SDIN = SPI MOSI**), 1 clock signal (**SCLK = SPI SCK**), and 3 control signals (**RES#**, **CS#**, **D/C#**). These signals and their associated pin information are shown in the table below.

STM32F0	SIGNAL	DIRECTION
PA0	**USER PUSH BUTTON**	**INPUT**
PC8	**BLUE LED**	**OUTPUT**
PC9	**GREEN LED**	**OUTPUT**
PA1	**555 TIMER**	**INPUT**
PA2	**FUNCTION GENERATOR**	**INPUT**
PA4	**DAC**	**OUTPUT (Analog)**
PA5	**ADC**	**INPUT (Analog)**
PB3	**SCLK (Display D0: “Serial Clock” = SPI SCK)**	**OUTPUT (AF0)**
PB4	**RES# (Display “Reset”)**	**OUTPUT**
PB5	**SDIN (Display D1: “Serial Data” = SPI MOSI)**	**OUTPUT (AF0)**
PB6	**CS# (Display “Chip Select”)**	**OUTPUT**
PB7	**D/C# (Display “Data/Command”)**	**OUTPUT**

Deliverables

- **Demonstration.** You must demonstrate a working project by the end of your ***last lab session***. You must also determine the limitations of your system and be able to explain why your system has such limitations. Your lab TA will inspect your code and ask each group member (individually) a series of technical questions. Your (individual) mark for the project demonstration will be based on your ability to answer your lab TA's questions. This deliverable is worth **30%** of your final lab grade.

- **Project Report.** A substantial project report is required from each student group – it should be written as a standard engineering technical report. It must describe system specifications and outline your design approach (including circuit diagrams and source code), as well as present and analyze experimental results, including a discussion on your system limitations. The report should contain enough information so that another engineer could easily reproduce your system. Each group member will earn the same mark for that group's report. This deliverable is worth **60%** of your final lab grade.

Hints and Advice

- Successful completion of the project requires a thorough knowledge of the available technical documentation. You will need to read Chapters 7, 9, 12, 13, 14, 17 of the **STM32F0xx Reference Manual**, as well as the **NE555** timer datasheet and the **4N35** optocoupler datasheet. Further details on the LED Display interface (3-wire SPI) and commands are provided in the **SSD1306** data sheet.

- **IMPORTANT:** Do <u>NOT</u> use **PA13** and **PA14**. They are reserved for communicating with the ST-LINK chip on the **STMF0 Discovery** board.

- Additional up-to-date information, including “Time Table” and “Project Tips”, can be found on the ECE 355 lab website:

https://www.ece.uvic.ca/~ece355/lab.