CPE3500: Embedded Digital Signal Processing Project

Project: Code Detection with DTMF Tones

Introduction:

The purpose of this project is to acquire audio signals, identify the frequency content and make an action based on the received information.

Required Equipment:

Personal computer with System Workbench for STM32 installed.

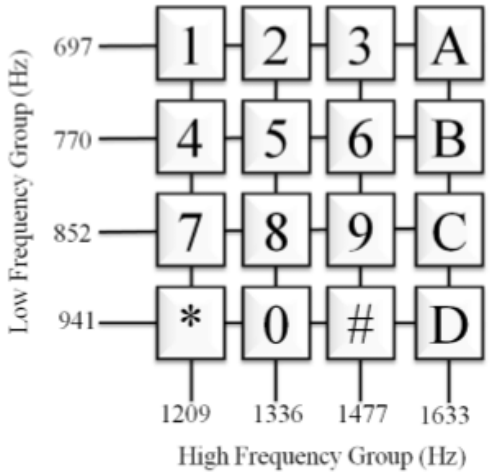
STM32L476RG Nucleo Development Board

Boostxl-Audio Board

DTMF Signaling:

Dual-tone multi-frequency signaling (DTMF) is a telecommunication signaling system using the voice-frequency band over telephone lines between telephone machine and other communication devices. It is used to control automated equipment and signal user intent, such as the number they wish to dial or entering specific pass codes.

DTMF works by assigning eight different audio frequencies to the rows and columns of the keypad. The columns on the keypad are assigned high-frequency signals, while the rows are assigned low-frequency signals. When you press a key—which corresponds to a number or symbol—the phone generates a tone that simultaneously combines the high-frequency signal from the column that key is in with the low-frequency signal of the row it's in.



Project Instructions:

The student is to create a project on STM32 Nucleo board that will receive audio signal generated from a DTMF tone generator and detect which key is pressed to actuate the on-board LED if the key is correct.

The project must meet the minimum requirements:

1) Create a new project on STM32Cube IDE with CMSIS DSP libraries included.
2) Configure ADC and TIM6 to capture audio signal of length 2048 with a sampling frequency of 20 kHz.
3) Configure Push button as an external interrupt which will start the ADC when it is pressed and released.
4) Use online tone generator in https://onlinetonegenerator.com/dtmf.html to generate the desired tones.
5) By pressing and holding the tone generator key, press the pushbutton to start audio recording.
6) After the ADC buffer is filled, take the FFT of the recorded signal.
7) Write an algorithm to detect which key is pressed by analyzing the FFT of the signal.
8) If the pressed key (code) is the same as predefined number, turn on the LED 2 sec.
9) If the pressed key (code) is not correct, blink the LED fast couple of times in one sec.

Challenging Goal:

Create a 4 digit pass code defined at the beginning of the code. Receive 4 consecutive tones after 4 push button pressing and check whether the DTMF code matches with the predefined pass code. Perform step 8 and 9 accordingly.

Stretch Goal:

Record short sound effects for correct and wrong codes. Using the DAC generate those sound effects for the step 8 and 9.

Project Assessment:

The student will present the project by preparing a report and recording a short video demonstration which shows the testing of number the code with both correct and wrong pass code inputted by the user. The student is expected to upload the following files to the D2L dropbox:

1. 1-PDF document:
    a. Page 1: Cover sheet with your name, date, class, etc.
    b. Provide background information about DTMF signaling
    c. Provide connection diagram of Nucleo board and Audio board.
    d. Code sections of definitions, main function, and any other custom or callback function.
    e. Export the FFT of the test DTMF tone recordings and plot them in Matlab.
    f. Conclusion
2. Recorded short video demonstrating the testing.