INDIAN INSTITUTE OF TECHNOLOGY
KHARAGPUR
DEPARTMENT OF ELECTRONICS AND ELECTRICAL COMMUNICATION

EC49001

MICROCONTROLLERS LABORATORY

ASSIGNMENT NUMBER

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Question:

Write programs to generate the following waveforms through a DAC:

i) Tangential
ii) Saw-tooth
iii) Trapezoidal
iv) Sinusoidal

Calculate the max frequency and amplitude that you could obtain in each case.

Objectives:

Familiarise with the workings of a Digital-to-Analog Converter (DAC). The DAC we interface with in 8051 has 255 steps for 0V to 5V (0.02V least count).

Compute the necessary values of mathematical functions using a general purpose programming language.

Description:

i) Trapezoid:

For this we simply write a loop for the rise time (left slope) and increment a variable, then wait for it to reach max value, where the value stays for a defined interval and then we write a loop for the fall time (right slope).

ii) Sawtooth, Sinusoid and Tangential

For these three categories, we simply create a look-up table. The values (and in fact assembly code) is generated using a Python script to store in the register memory. A pointer then iteratively goes over the memory values where the output is shown in the scope.

Code:

i) Sawtooth

```
START: ; Sawtooth
CLR P0.7
MOV R1, #05H

; Storing values

MOV 5, #0
MOV 6, #39
MOV 7, #72
MOV 8, #100
MOV 9, #124
```

```
MOV 10, #144
MOV 11, #161
MOV 12, #175
MOV 13, #187
MOV 14, #198
MOV 15, #206
MOV 16, #214
MOV 17, #220
MOV 18, #225
MOV 19, #230
MOV 20, #234
MOV 21, #237
MOV 22, #255
MOV 23, #215
MOV 24, #182
MOV 25, #154
MOV 26, #130
MOV 27, #110
MOV 28, #93
MOV 29, #79
MOV 30, #67
MOV 31, #56
MOV 32, #48
MOV 33, #40
MOV 34, #34
MOV 35, #29
MOV 36, #24
LOOP:
MOV A, @R1                  ; Stores value of function from @R1
MOV P1, A
INC R1
CJNE R1,#37,LOOP   ; If not reached the end of memory, keep looping
MOV R1, #05H                ; Start again
SJMP LOOP
DELAY:             ; Delay module
MOV R0,#100
DJNZ R0,$
RET
```

ii) Sine

```
START: ; Sine
CLR P0.7
MOV R1, #05H
; Storing values
MOV 5, #128
MOV 6, #152
MOV 7, #176
```

```
MOV 8, #199
MOV 9, #218
MOV 10, #234
MOV 11, #246
MOV 12, #253
MOV 13, #255
MOV 14, #253
MOV 15, #246
MOV 16, #234
MOV 17, #218
MOV 18, #199
MOV 19, #176
MOV 20, #152
MOV 21, #128
MOV 22, #103
MOV 23, #79
MOV 24, #56
MOV 25, #37
MOV 26, #21
MOV 27, #9
MOV 28, #2
MOV 29, #0
MOV 30, #2
MOV 31, #9
MOV 32, #21
MOV 33, #37
MOV 34, #56
MOV 35, #79
MOV 36, #103
MOV 37, #127

LOOP:
MOV A, @R1                ; Stores value of function from @R1
MOV P1, A
INC R1

CJNE R1,#37,LOOP   ; If not reached the end of memory, keep looping
MOV R1, #05H              ; Start again
SJMP LOOP

DELAY:              ; Delay module
MOV R0,#100
DJNZ R0,$
RET
```

ii) Tangent

```
START: ; Tangent
CLR P0.7
MOV R1, #05H

; Storing values

MOV 5, #128
```

```
MOV 6, #134
MOV 7, #141
MOV 8, #149
MOV 9, #160
MOV 10, #175
MOV 11, #205
MOV 12, #255
MOV 13, #255
MOV 14, #0
MOV 15, #50
MOV 16, #80
MOV 17, #96
MOV 18, #106
MOV 19, #114
MOV 20, #121
MOV 21, #128
MOV 22, #134
MOV 23, #141
MOV 24, #149
MOV 25, #160
MOV 26, #175
MOV 27, #205
MOV 28, #255
MOV 29, #255
MOV 30, #0
MOV 31, #50
MOV 32, #80
MOV 33, #96
MOV 34, #106
MOV 35, #114
MOV 36, #121

LOOP:
MOV A, @R1                ; Stores value of function from @R1
MOV P1, A
INC R1

CJNE R1,#37,LOOP    ; If not reached the end of memory, keep looping
MOV R1, #05H              ; Start again
SJMP LOOP

DELAY:                  ; Delay module
MOV R0,#100
DJNZ R0,$
RET
```

iv) Trapezoid

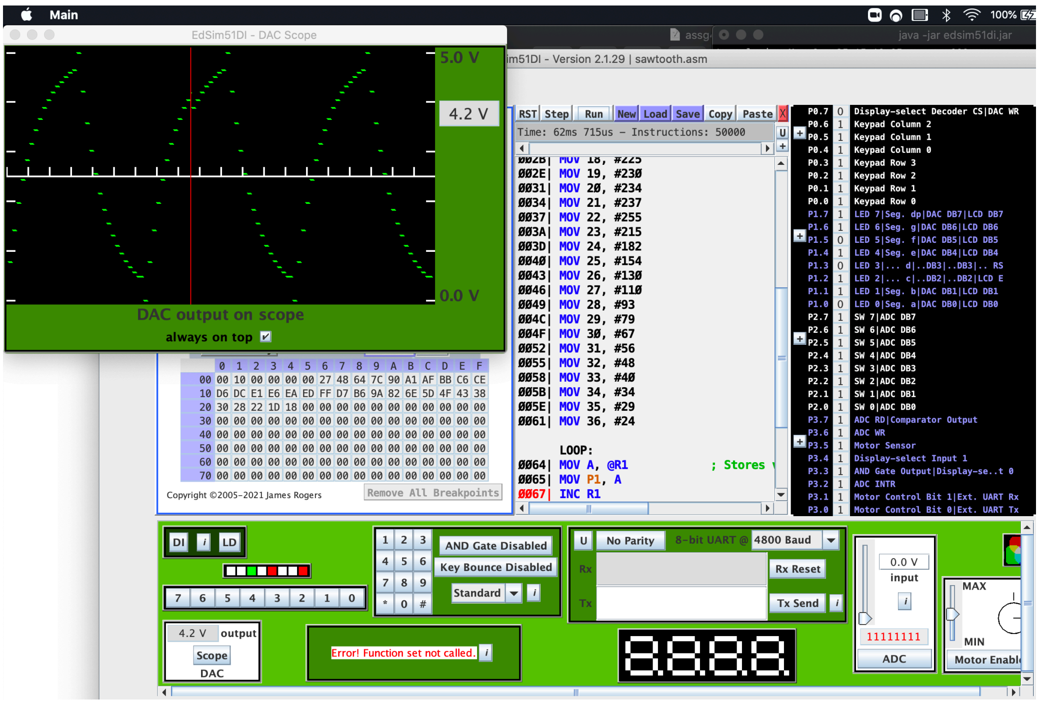
```
START: ;Trapezoid
CLR P0.7;
STEP EQU 04H
W EQU 31H

ORIGIN:
```

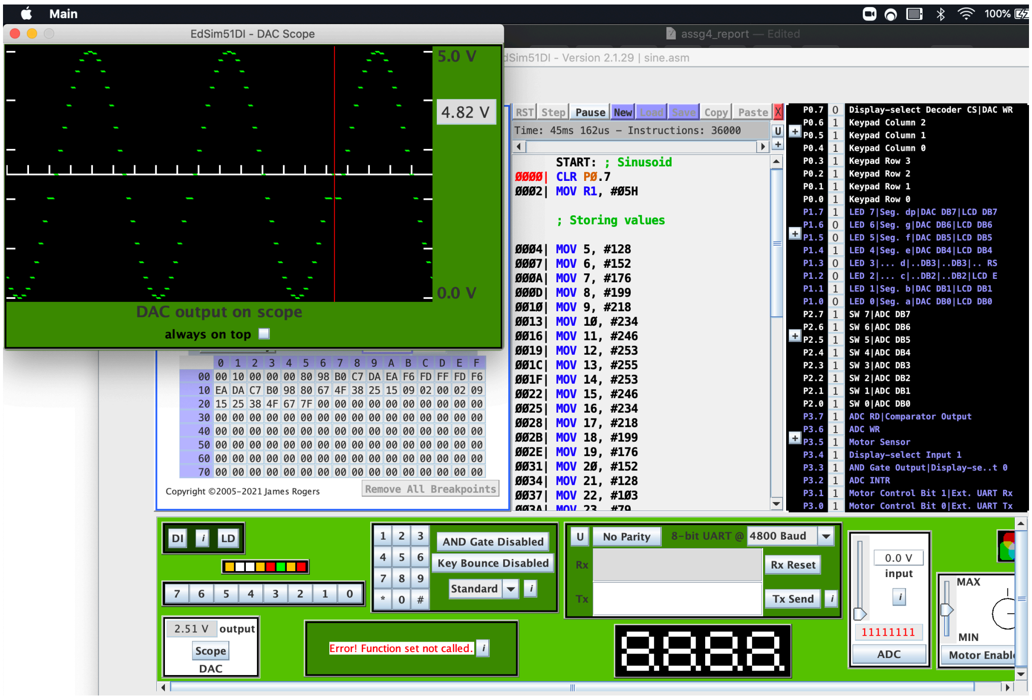
```
7. MOV A,#00H;
8.
9. LEFT:
10.MOV P1,A;
11.ADD A,#STEP;
12.CJNE A,#200,LEFT;
13.MOV A,P1;
14.MOV R7,#W;
15.
16.UP: DJNZ R7,UP;
17.
18.RIGHT:
19.MOV P1,A;
20.SUBB A,#STEP;
21.JNZ RIGHT;
22.MOV P1,#00H;
23.MOV R7,#W;
24.
25.DOWN: DJNZ R7,DOWN;
26.SJMP ORIGIN
```

Screenshot:

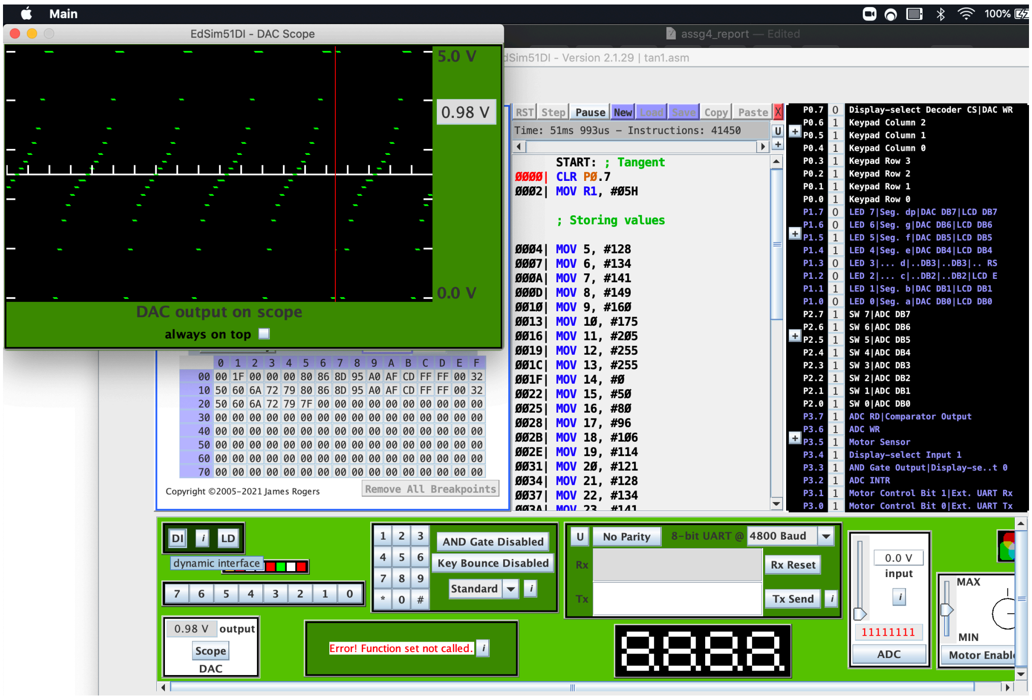
1. Sawtooth



2. Sinusoid



3. Tangential



4. Trapezoid

Results:

For all the figures drawn, the time period is 8 intervals, which corresponds to 4.6KHz. The amplitudes for the same are 2.5 V for all except trapezoid, which has an amplitude of 1.2V.

Discussion:

1. The way to generate multiple lines of assembly code to create the lookup tables was found to be using a python script.
2. The frequency is also guided by a delay module at the end of each code.
3. The theoretical maximum frequency is Fs/2, from the sampling theorem, which turns out to be 6KHz for our simulations.

Summary:

We see that the graphs are clearly visible, maximum amplitude and frequency has been calculated and DAC has been utilised for all of the above. The above has been done for 4 waveforms, for 3 of which we used lookup tables and for 1 we output the waveform algorithmically.