DESIGN ASSIGNMENT ON

FREQUENCY GENERATION

Submitted in partial fulfillment of the requirements of the course:

EEE/INSTR/ECE/CS F241 – Microprocessor Programming & Interfacing

Birla Institute of Technology & Science, Pilani

Submitted By: Group Number 26

2014B4A7587P AKSHAY GOEL.

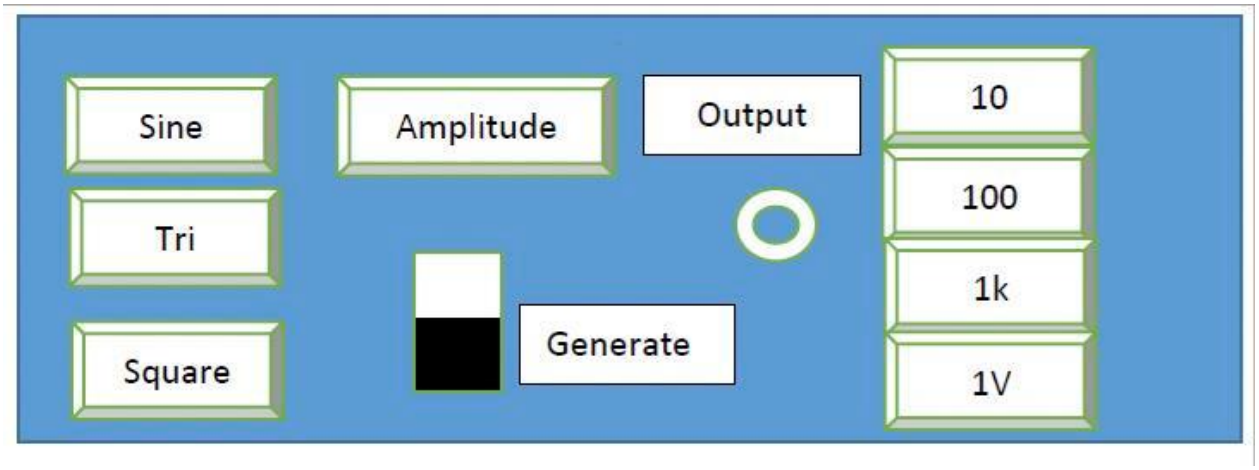
2014B4A7637P V GAUTHAM.

2014B4A7658P APURVA MITTAL.

2014B4A7715P ADITYA SHAH.

System to be designed: Frequency Generation

Description: This system is used to generate a Sine/Triangular/Square waveform of Frequencies ranging from 10 Hz to 99KHz. Voltage is between 0-10V. User Interface:



On system power up the user has to configure the desired type of waveform (square/triangle/square) , frequency and amplitude. To generate a Square Waveform of Frequency 9.35 KHz the user has to press square key, followed by 1K Key- 9 Times, 1K Key – 4 Times, 100 Key –3 Times 10 Key- 5 Times.

To select the Amplitude, the user will have to press Amplitude key and then press the 1V key “n” number of times where “n” is the peak to peak amplitude of the waveform to be generated. (only integer values of output voltages need to be generated) When generate switch should be turned on and then the frequency generation is enabled i.e., the square waveform of that frequency will be generated.

When frequency generation is enabled, if the user wants to change the waveform into another type for e.g. sine he just has to press sine. When a signal of different type/amplitude /frequency has to be generated, the user will have to turn-off the generate switch and then configure the function generator as mentioned above.

Design Specifications

- This system is used to generate a Sine/ Triangular/ Square waveform
- The used can select between these three types of waveforms using the keypad.
- The keypad is also used to select the frequency and the amplitude of the waveform generated.
- Frequencies ranging from 10 Hz to 99KHz and Voltage between 0- 10V can be generated by the system.
- The waveform can be changed at a later stage by pressing the button on the keypad.

For example: To generate a Square Waveform of Frequency 9.35 KHz the user has to press square key, followed by 1K Key (key number 5) - 9 Times, 100 Key (key number 6) - 3 Times and 10 Key (key number 9) - 5 Times.

Components Used

COMPONENTS	**NOS.**
8086 MICRO-PROCESSOR	1
8253 Programmable Timer	1
74138 3x8 Decoder	2
8255 Programmable Peripheral interface	1
74LS373 (Octal Latch)	3
74LS245(Octal Buffer)	2
2732 (ROM – 4k)	2
6116 (RAM- 2K)	2
DAC 08030	1
OP.AMP. MC1741SG	1
3X3 Keypad	1
Digital Oscilloscope	1
RESISTORS AND CAPACITORS OF REQUIRED VALUE.	

Assumptions

The following assumptions were made in order to develop the software for the system.

- At the location FFFF0H, where the instruction pointer points on RESET of microprocessor, there exists a JUMP statement leading to the start of the code.

- The user gives sufficient time between two successive key presses, enough to perform all operations associated with a particular key press. The software however is designed to handle de-bounce.

- The user can only increase the frequency or amplitude and never decrease. If he/she requires a lower value of frequency or amplitude, the system needs to shut down and restarted.

- The maximum frequency of signal to be generated s 9.99 kHz and user does not enter anything above this value. There is no such limit on the amplitude as long as it can be stored in one byte of memory.

I/O Map For 8255

Base Address: 00H

Its is I/O mapped I/O System

The addresses of the ports are as follows:

PORT of 8255	Address
PORT A	00H
PORT B	02H
PORT C	04H
Control Register	06H

Data lines: D0-D7 data lines of the microprocessor (as it is connected in even bank)

Port Specification:

Group A: Mode 0

Group B: Mode 0

Port A: Input Port B: Output

Port C upper: Output Port Port C lower: Input Port

Hence, the control word is **10001010b** Which is written to the control register

Address Map

HEX	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
00h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
04h	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
06h	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0

Address Map for 8253

Base Address = 08h
Timer Addresses are as follows:

8253 Timer	Address
Timer 0	08H
Timer 1	0AH
Timer 2	0CH
Control Register	0EH

Data lines: D0-D7 data lines of the microprocessor (as it is connected in even bank)

Address Map:

HEX	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
08h	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
0Ah	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
0Ch	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
0Eh	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0

Control Word is **00110110b**

Memory mapping:

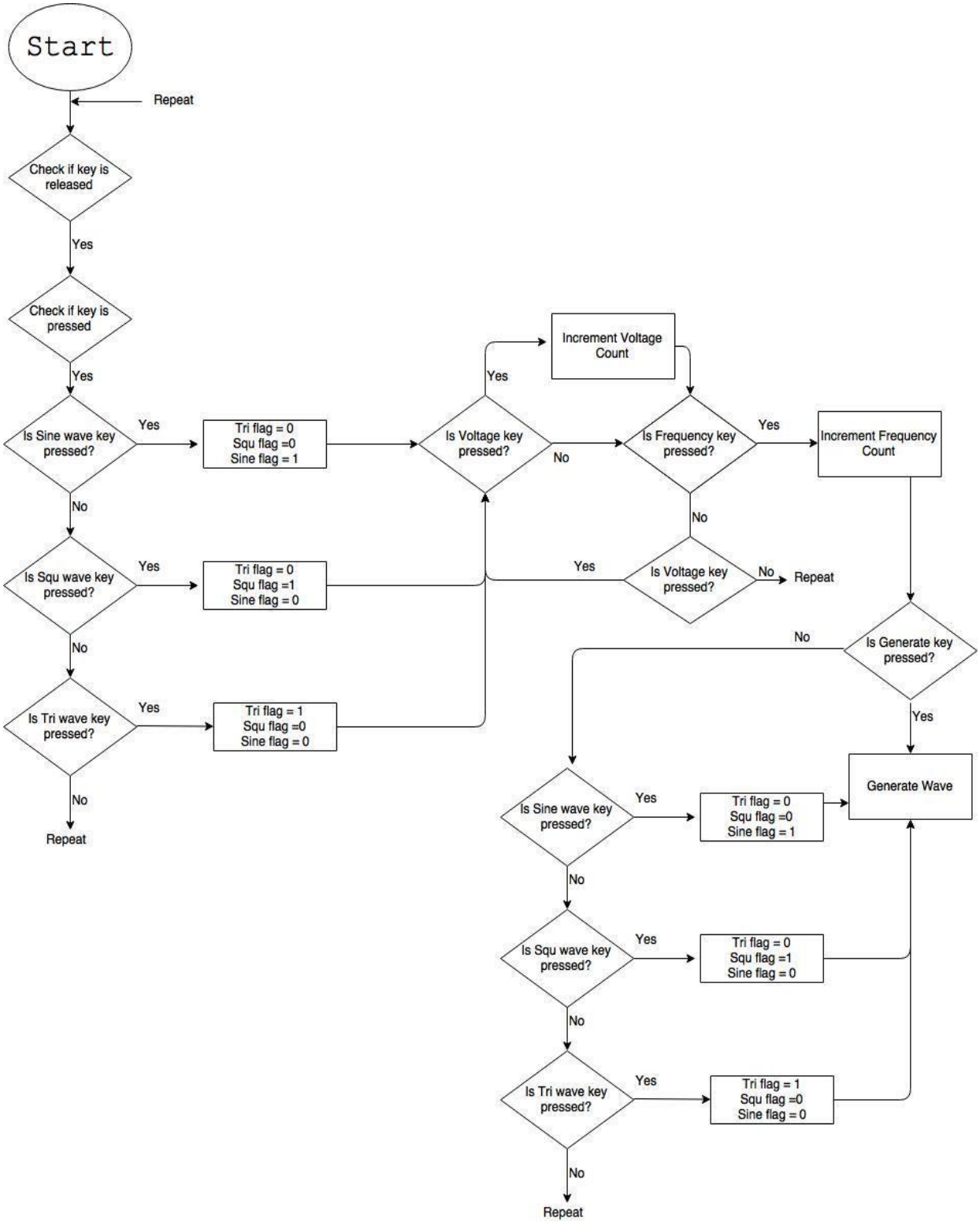
RAM-1 (EVEN) (6116): 02000h – 02FFEh

RAM-1 (ODD) (6116): 02001h – 02FFFh

ROM -1 (EVEN) (2732): 00000h-01FFEh

ROM -1 (ODD) (2732): 00001H- 01FFFh

FLOWCHART


Start
Repeat
Check if key is released
Yes
Check if key is pressed
Yes
Is Sine wave key pressed?
Yes
Tri flag = 0
Squ flag =0
Sine flag = 1
No
Is Squ wave key pressed?
Yes
Tri flag = 0
Squ flag =1
Sine flag = 0
No
Is Tri wave key pressed?
Yes
Tri flag = 1
Squ flag =0
Sine flag = 0
No
Repeat
Is Voltage key pressed?
Yes
Increment Voltage Count
No
Is Frequency key pressed?
Yes
Increment Frequency Count
No
Is Voltage key pressed?
Yes
No
Repeat
Is Generate key pressed?
No
Yes
Generate Wave
Is Sine wave key pressed?
Yes
Tri flag = 0
Squ flag =0
Sine flag = 1
No
Is Squ wave key pressed?
Yes
Tri flag = 0
Squ flag =1
Sine flag = 0
No
Is Tri wave key pressed?
Yes
Tri flag = 1
Squ flag =0
Sine flag = 0
No
Repeat

Assembly Language Program (ALP)

```
.MODEL TINY
.DATA
; starting of the program
one_k db 0
vfac db 0
vfac1 db 0
sine_w db 0
triangular_w db 0
stepsize db 0
square_w db 0
one_hundred db 0
ten db 0
count dw 0
list db 50 dup(0)
list1 db 50 dup(0)

; Giving names for the internal addresses of 8255
portA equ 00H
portB equ 02H
portC equ 04H
cregPPI equ 06H

; Giving names for the internal addresses of 8253
timer0 equ 08H
timer1 equ 0AH
timer2 equ 0CH
cregPIT equ 0EH

; Giving names to the different button hexcodes on keypad
SINbutton equ 66H
TRIbutton equ 56H
SQUbutton equ 36H
vbutton equ 65H
OKbutton equ 55H
HUNbutton equ 35H
TENbutton equ 33H
GENbutton equ 63H

; Initializing the segments to start of ram
.code
.startup
mov     ax, 0200H
mov     ds, ax
mov     es, ax
mov     ss, ax
mov     sp, 0FFFEH
mov     ax, 00H
```

```
mov    vfac, al
mov    one_k, al
mov    vfac1, al
mov    one_hundred, al
mov    ten, al
mov    sine_w, al
mov    triangular_w, al
mov    square_w, al

; Table to generate sine wave
lea    di, list
mov  ax,128
mov    [di],ax
mov  ax, 144
mov    [di+1],ax
mov  ax,160
mov    [di+2],ax
mov  ax,176
mov    [di+3],ax
mov  ax,191
mov    [di+4],ax
mov  ax,205
mov    [di+5],ax
mov  ax,218
mov    [di+6],ax
mov  ax,228
mov    [di+7],ax
mov  ax,238
mov    [di+8],ax
mov  ax,245
mov    [di+9],ax
mov  ax,251
mov    [di+10],ax
mov  ax,254
mov    [di+11],ax
mov  ax,255
mov    [di+12],ax
mov  ax,254
mov    [di+13],ax
mov  ax,251
mov    [di+14],ax
mov  ax,245
mov    [di+15],ax
mov  ax,238
mov  [di+16],ax
mov  ax,228
mov    [di+17],ax
mov  ax,218
mov    [di+18],ax
mov  ax,205
```

```
mov     [di+19],ax
mov   ax,191
mov     [di+20],ax
mov   ax,176
mov     [di+21],ax
mov   ax,160
mov     [di+22],ax
mov   ax,144
mov     [di+23],ax
mov   ax,128
mov     [di+24],ax
mov   ax,127
mov     [di+25],ax
mov   ax,111
mov     [di+26],ax
mov   ax,95
mov     [di+27],ax
mov   ax,79
mov     [di+28],ax
mov   ax,64
mov     [di+29],ax
mov   ax,50
mov     [di+30],ax
mov   ax,37
mov     [di+31],ax
mov   ax,27
mov     [di+32],ax
mov   ax,17
mov     [di+33],ax
mov   ax,10
mov     [di+34],ax
mov   ax,4
mov     [di+35],ax
mov   ax,1
mov     [di+36],ax
mov   ax,0
mov     [di+37],ax
mov   ax,1
mov     [di+38],ax
mov   ax,4
mov     [di+39],ax
mov   ax,10
mov     [di+40],ax
mov   ax,17
mov     [di+41],ax
mov   ax,27
mov     [di+42],ax
mov   ax,37
mov     [di+43],ax
mov   ax,50
```

```
mov    [di+44],ax
mov  ax,64
mov    [di+45],ax
mov  ax,79
mov    [di+46],ax
mov  ax,95
mov    [di+47],ax
mov  ax,111
mov    [di+48],ax
mov  ax,127
mov    [di+49],ax

;creating copy of sine table for reuse
lea  si, list
lea    di, list1
mov cx,50
fill1:  mov al,[si]
     mov [di],al
     inc si
     inc di
     dec cx
     cmp cx,0
   jnz fill1

; Initializing 8255 (setting it to i/o mode)
mov    al, 8AH
out    cregPPI, al

; Keypad interfacing
key1:
   mov    al, 00H
   out    portC, al

; Checking for key release
key2:
   in     al, portC
   and    al, 70H
   cmp    al, 70H
jne    key2

mov     al, 00H
out     portC, al

; Checking for key press
key3:
   in     al, portC
   and    al, 70H
   cmp    al, 70H
je     key3
```

```
; Once key press is detected, then find which row is the pressed key in
mov     al, 06H
mov     bl, al
out     portC, al
in      al, portC
and     al, 70H
cmp     al, 70H
jne     key4

mov     al, 05H
mov     bl, al
out     portC, al
in      al, portC
and     al, 70H
cmp     al, 70H
jne     key4

mov     al, 03H
mov     bl, al
out     portC, al
in      al, portC
and     al, 70H
cmp     al, 70H
je      key3

; Code reaches here once a key has been pressed and its hex code is
    stored in the al and bl registers
; Now we check which button that hexcode corresponds to:
key4: or    al, bl
; If SIN button is pressed, then:
      cmp     al, SINbutton
      jnz     trib
      inc     sine_w       ;makes sine_w 1 which means it is selected
      jmp     key1
; Else if TRI button is pressed, then:
trib: cmp     al, TRIbutton
      jnz      squb
      inc  triangular_w
      jmp     key1
; Else if SQU button is pressed, then:
squb: cmp     al, SQUbutton
      jnz     vfb
      inc     square_w
      jmp     key1
; else if vbutton is pressed
vfb:    cmp al, vbutton
      jnz okb
      inc vfac
      jmp key1
; Else, if 1K button is pressed, then:
```

```
okb:  cmp    al, OKbutton
      jnz     hunb
      inc    one_k
      jmp    key1
; Else, if 100 button is pressed, then:
hunb: cmp    al, HUNbutton
      jnz     tenb
      inc    one_hundred
      jmp    key1
; Else, if 10 button is pressed, then:
tenb: cmp    al, TENbutton
      jnz     genb
      inc    ten
      jmp    key1
; Else, if GEN button was pressed:
genb: cmp    al, GENbutton
      jz  end_k
      jmp key1

; Code reaches this point if GEN button is pressed.
; In that case, compute the count required to load in 8253 (PIT)
end_k:
call computeCount

; BX register now stores the frequency in decaHertz
mov    dx, 00H
mov    ax, 10000
div    bx ; dividing 10000 by bx. Quotient stored in ax
i:  mov count, ax

; Calculated count present in count
; Storing count
mov    al, 00H
out    portC, al

; Wait for GEN key release
call waitForGEN

; storing Vfac value to change waveform later
mov dl,vfac
mov vfac1,dl

; BX now stores the value of (actual count * sampling rate)
; Here we have used the sampling rate of ((13*2)-1)*2 = 50
; Selecting the waveform whose button has been pressed the maximum
    number of times:
; If all have been pressed the same number of times, then sine wave will
    be selected
mov    al, sine_w
cmp    al, triangular_w
```

```
jl      slt
cmp     al, square_w
jg      sine_gen
jmp     sq_gen
slt:mov    al, triangular_w
   cmp     al, square_w
   jg      tri_gen
   jmp     sq_gen

; Wave Generation
; Code to generate sine wave
sine_gen:
   mov dx, portA
   mov ax,count
   mov bl,50
   div bl
   mov ah,00
   mov bl, al

; Initialize timer
call initTimer
lea si,list1
lea di, list
mov cl, 50

x99:mov al, [si]
   mul vfac
   mov bl,10
   div bl
   mov [di],al
   inc si
   inc di
loop x99      ;loop to change values of sine table according to given
    input

l5:
   lea     si, list
   mov     cl, 50
   l1:
      mov     al, [si]
      out     portA, al
      in      al, portC
      and     al, 70H
      cmp     al, 70H
      jne     key
      call    wait2
      in      al, portC
      and     al, 70H
      cmp     al, 70H
      jne     key
```

```
      add    si, 01H
   loop   l1
jmp    l5

; Code to generate triangular wave
tri_gen:
   mov    dx, 00H
   mov    ax, count
   mov    bx, 30
   div    bx
qr1:
   mov    ah, 00
   mov    bx, ax

; Initialize timer
call initTimer
mov al,25
mul vfac
mov vfac,al
mov ah,00h
mov bl,15
div bl
mov stepsize,al    ;stepsize such that it takes 15 steps to reach max
    amplitude
mov bl,15
mul bl
mov vfac,al     ;vfac now has max amplitude
mov al, 00H

g1:
   out    portA, al
   mov    bl, al
   in     al, portC
   and    al, 70H
   cmp    al, 70H
   jne    key
   call   wait2
   in     al, portC
   and    al, 70H
   cmp    al, 70H
   jne    key
   mov    al, bl
   add    al, stepsize
   cmp    al, vfac
jnz    g1
   g2:
      out    portA, al
      mov    bl, al
      in     al, portC
      and    al, 70H
```

```
      cmp    al, 70H
      jne    key
      call   wait2
      in     al, portC
      and    al, 70H
      cmp    al, 70H
      jne    key
      mov    al, bl
      sub    al, stepsize
      cmp    al, 00H
   jnz    g2
jmp    g1

; Code to generate square wave:
sq_gen:
   mov dx, portA
   mov ax, count
   mov bx, 02H
   div bx
   mov bx, ax
   mov al,25
   mul vfac
   mov vfac,al
   mov ax,bx

; Initialize timer
call initTimer
mov    al, 80H
out    portA, al
s:  mov    al, 00H
   out    portA, al
   in     al, portC
   and    al, 70H
   cmp    al, 70H
   jne    key
   call   wait2
   in     al, portC
   and    al, 70H
   cmp    al, 70H
   jne    key
   mov    al, vfac
   out    portA, al
   mov    al, vfac
   out    portA, al
   in     al, portC
   and    al, 70H
   cmp    al, 70H
   jne    key
   call   wait2
   in     al, portC
```

```
   and    al, 70H
   cmp    al, 70H
   jne    key
   mov    al, vfac
   out    portA, al
jmp    s

; Checking if a key is pressed
key:mov    al, 06H
   mov    bl, al
   in     al, portC
   and    al, 70H
   cmp    al, 70H
   jnz    k3

   mov    al, 05H
   mov    bl, al
   in     al, portC
   and    al, 70H
   cmp    al, 70H
   jnz    k3

   mov    al, 03H
   mov    bl, al
   in     al, portC
   and    al, 70H
   cmp    al, 70H
   je     key

; If a key is pressed, find out which one:
k3: mov dl,vfac1
   mov vfac,dl
   or  al, bl
; If SIN button is pressed, then:
   cmp    al, SINbutton
   jz     sine_gen
; Else, if TRI button is pressed, then:
   cmp    al, TRIbutton
   jz     tri_gen
; Else, if SQU button is pressed, then:
   cmp    al, SQUbutton
   jz     sq_gen
; Else (i.e. if none of the waveform buttons were pressed), then:
   jmp key



; Procedure to compute the value of count
computeCount proc
   mov    bx, 00H
```

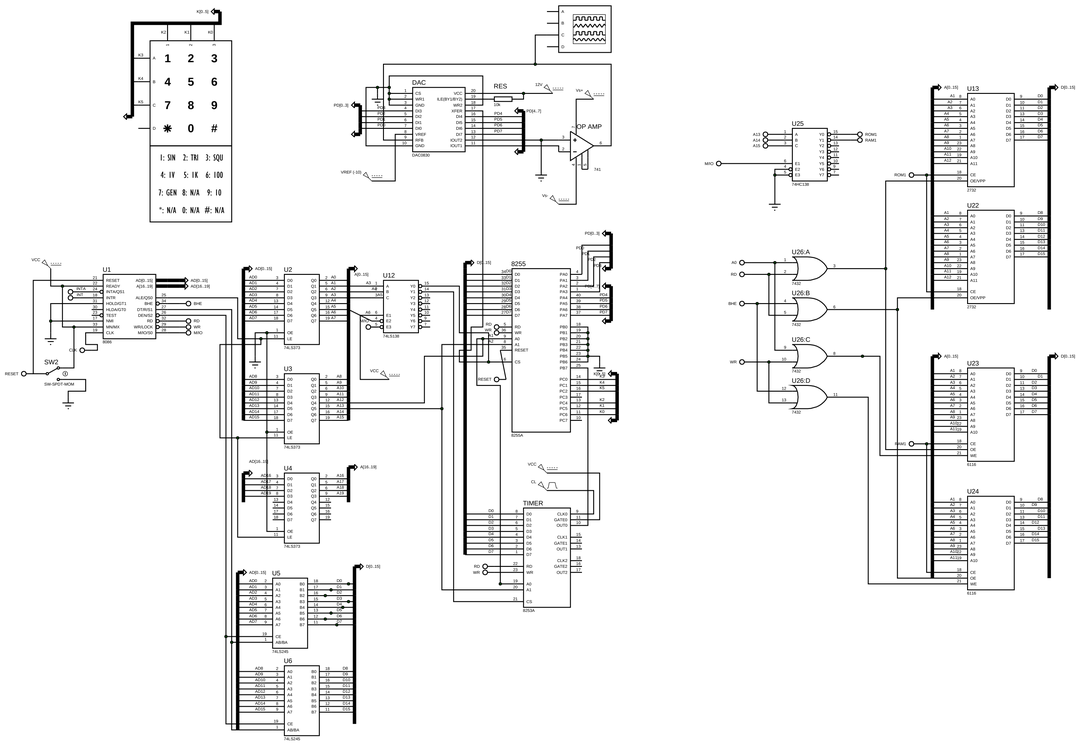
```
   mov    al, 100
   mul    one_k
   add    bx, ax
   mov    al, 0AH
   mul    one_hundred
   add    bx, ax
   mov    al, ten
   mov    ah, 00H
   add    bx, ax
ret
endp

; Wait procedure
wait2 proc
   v1: in     al, portB
      cmp    al, 00H
      jne    v1
   v2: in     al, portB
      cmp    al, 80H
      jne    v2
ret
endp

; Procedure to initialize the 8253 (PIT)
initTimer proc
; Initializing the timer with control word
   mov dx, 0019H
   mov    al, 00110110b
   out    cregPIT, al
; Loading LSB of count value
   mov    al, bl
   out    timer0, al
; Loading MSB of count value
   mov    al, bh
   out    timer0, al
ret
endp

; Procedure to wait for GEN key release
waitForGEN proc
   k1: in     al, portC
      and    al, 70H
      cmp    al, 70H
      jnz    k1
ret
endp

.EXIT
END
```



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