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 80

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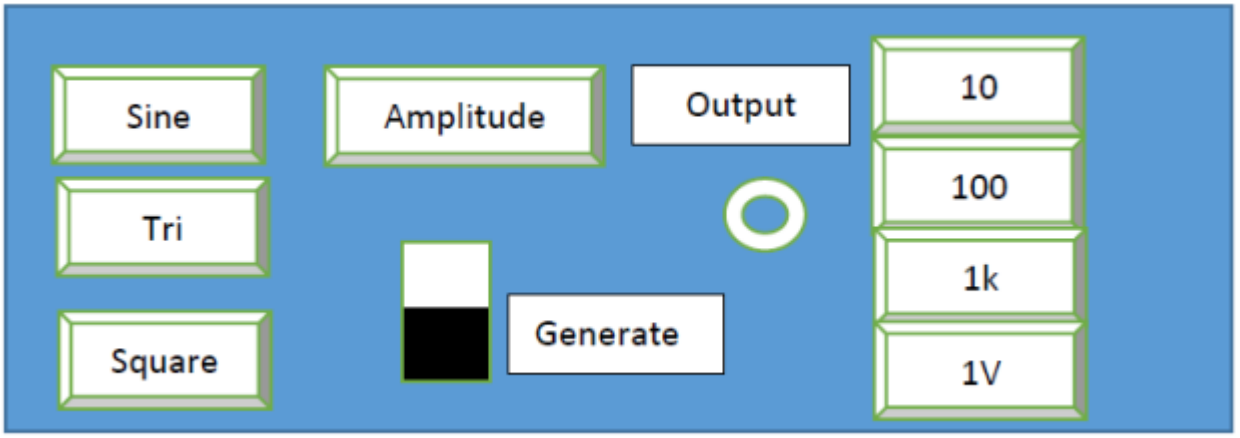
P18: System to be designed: Frequency Generation

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 needs to be generated)

When generate switch should be turned on and then the frequency generation is enabled ie, 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 of
- 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

1. 8086 Microprocessor
2. 8253 Programmable Interval Timer
3. 8284 Clock Generator
4. 8255 Programmable Peripheral Interface
5. 3 X 74LS373 (Octal Latch)
6. 2 X 74LS245 (Octal Buffer)
7. 2 X 2732 (ROM – 4K)
8. 2 X 6116 (RAM – 2K)
9. 74LS138 (3 – 8 Decoder)
10. 74LS04 (Not Gate)
11. 7432 (Or Gate)
12. DAC0830 (DAC)
13. Op Amp (LM741)
14. 3X3 Keypad
15. Digital Oscilloscope

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

  Amplitude needs be set upfront.
- 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 C lower: Input

Hence, the control word is **10001010b**

Which is written to the control register.

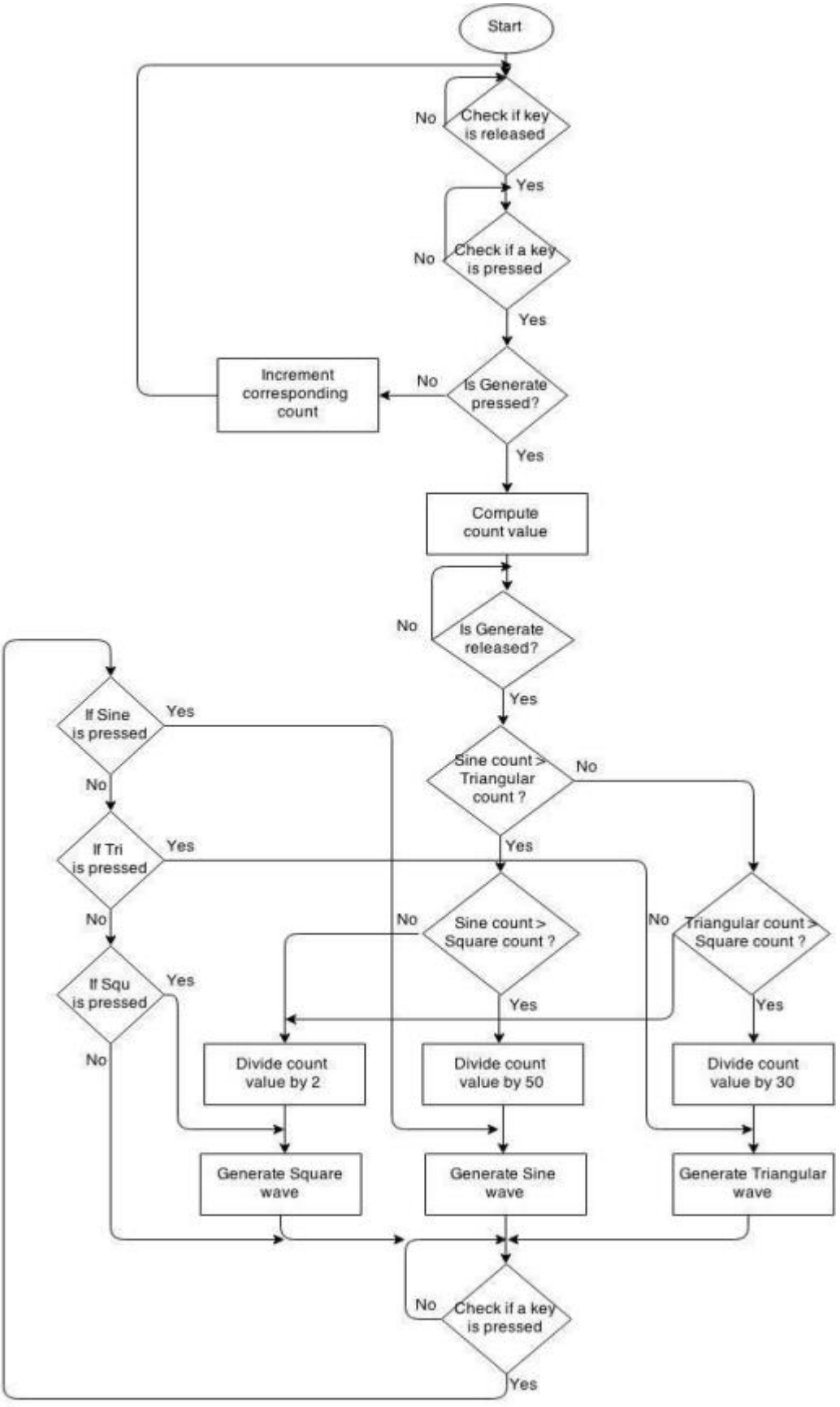
Address Map

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

Memory map:

RAM-1 (6116): 0200h – 03FFh
RAM-2 (6116): 1000h – 17FFh
ROM-1 (2732): 1800h – 27FFh
ROM-2 (2732): 2800h – 37FFh

FLOW CHART


Start
Check if key is released
No
Yes
Check if a key is pressed
No
Yes
Is Generate pressed?
No
Increment corresponding count
Yes
Compute count value
Is Generate released?
No
Yes
If Sine is pressed
Yes
No
Sine count > Triangular count ?
No
Yes
If Tri is pressed
Yes
No
Sine count > Square count ?
No
Triangular count > Square count ?
No
If Squ is pressed
Yes
No
Yes
Yes
Divide count value by 2
Divide count value by 50
Divide count value by 30
Generate Square wave
Generate Sine wave
Generate Triangular wave
Check if a key is pressed
No
Yes

CODE:

```
#make_bin#


#load_segment=FFFFH#
#load_offset=0000H#


#cs=0000H#
#ip=0000H#
#ds=0000H#
#es=0000H#
#ss=0000H#
#sp=FFFEH#
#ax=0000H#
#bx=0000H#
#cx=0000H#
#dx=0000H#
#si=0000H#
#di=0000H#
#bp=0000H#


; starting    of  the   program


jmp   st:
db  2042    dup(0)
st:    cli


one_k                db          0
vfac                 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      13 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

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       vfac,    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       [di],128
mov       [di+1],144
mov       [di+2],160
mov       [di+3],176
mov       [di+4],191
```

```
mov     [di+5],205
mov     [di+6],218
mov     [di+7],228
mov     [di+8],238
mov     [di+9],245
mov     [di+10],251
mov     [di+11],254
mov     [di+12],255
mov     [di+13],254
mov     [di+14],251
mov     [di+15],245
mov     [di+16],238
mov     [di+17],228
mov     [di+18],218
mov     [di+19],205
mov     [di+20],191
mov     [di+21],176
mov       [di+22],160
mov       [di+23],144
mov       [di+24],128
mov       [di+25],127
mov       [di+26],111
mov       [di+27],95
mov       [di+28],79
mov       [di+29],64
mov       [di+30],50
mov       [di+31],37
mov       [di+32],27
mov       [di+33],17
```

```
mov         [di+34],10
mov         [di+35],4
mov         [di+36],1
mov         [di+37],0
mov         [di+38],1
mov         [di+39],4
mov         [di+40],10
mov         [di+41],17
mov         [di+42],27
mov         [di+43],37
mov         [di+44],50
mov         [di+45],64
mov         [di+46],79
mov         [di+47],95
mov       [di+48],111
mov       [di+49],127

; Initializing   8255   (setting    it  to   i/o   mode)

mov             al,  10001010b
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
cmp     al, SINbutton
; If SIN button is pressed, then:
jnz     trib
inc     sine_w

;inc makes sine_w 1 which means it is selected
jmp     key1


trib:
cmp     al, TRIbutton
```

```
; Else if TRI button is pressed, then:
jnz             squb
inc             triangular_w
jmp             key1

squb:
cmp             al, SQUbutton
; Else if SQU button is pressed, then:
jnz     vfb
inc             square_w
jmp             key1

vfb:
cmp             al, vbutton
;else if vbutton is pressed
jnz             okb
inc             vfac
jmp             key1

okb:
cmp             al, OKbutton
; Else, if 1K button is pressed, then:
jnz             hunb
inc             one_k
jmp             key1

hunb:
cmp             al, HUNbutton
; Else, if 100 button is pressed, then:
```

```
jnz             tenb
inc             one_hundred
jmp             key1


tenb:
cmp             al, TENbutton
; Else, if 10 button is pressed, then:
jnz             genb
inc             ten
jmp             key1


genb:
cmp             al, GENbutton
; Else, if GEN button was pressed:
jz      end_k
jmp             key1


end_k:

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

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

; 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  wave  form  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

; Code to generate sine wave

sine_gen:
mov             dx, portA
;mov dx, 00H
mov             ax,count
mov             bl,50
div             bl
mov             ah,00
mov             bl, al

; Initialize timer
call initTimer
lea             si, list
mov             cl, 50
x99:
mov             al, [si]
mul             vfac
mov             bl,10
div             bl
mov             [si],al
inc             si
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

call wait
J1:
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
call    wait
mov     al, bl
add     al, stepsize
cmp     al, vfac
jnz     g1
g2:
out     portA, al
mov     bl, al
call    wait
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     wait
in              al, portC
and             al, 70H
cmp             al, 70H
jne             key


mov             al, vfac
out             portA,  al
mov             al, vfac
out             portA,  al
```

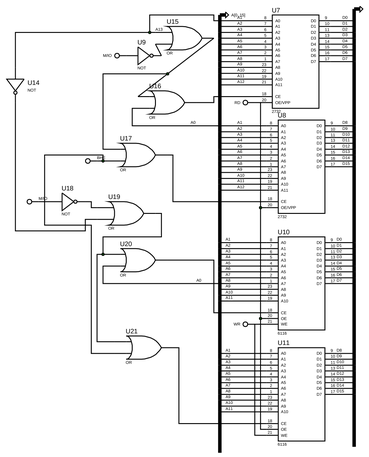
```
in      al, portC
and     al, 70H
cmp     al, 70H
jne     key
call    wait
in      al, portC
and     al, 70H
cmp     al, 70H
jne     key
mov     al, vfac
out     portA, al
jmp     s

; Checking if a key is pressed

key:
mov     al, 06H
mov     bl, al
out     portC, al
in      al, portC
and     al, 70H
cmp     al, 70H
jnz     k3

mov     al, 05H
mov     bl, al
out     portC, al
in      al, portC
and     al, 70H
```

```
cmp             al, 70H
jnz             k3

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

; If a key is pressed, find out which one:

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

; Procedure to compute the value of count
```

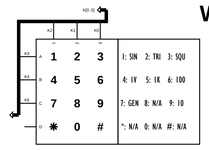
```
computeCount      proc
mov               bx,  00H
mov               al,  100

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

wait  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
```

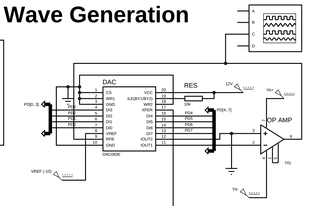
RAM & ROM



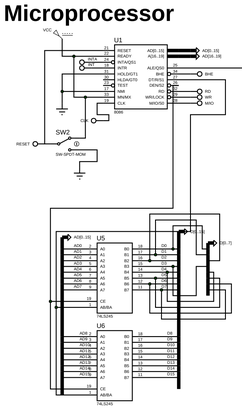
Keypad



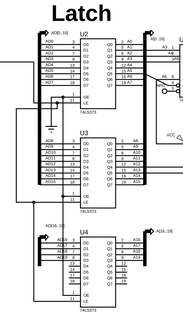
Wave Generation



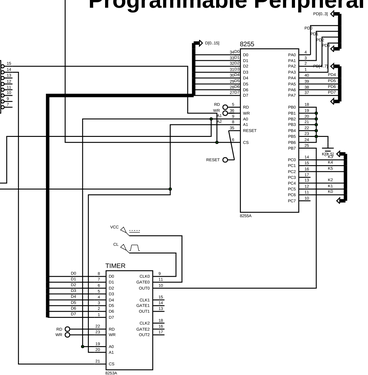
Microprocessor



Latch



Programmable Peripheral Interface



Timer

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BY: @AUTHOR	REV: @REV
DATE:	24-04-2019
PAGE:	1 of 1
TIME:	21:53:44