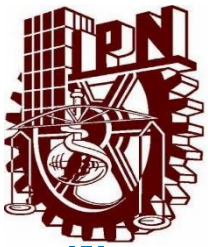


INSTITUTO POLITÉCNICO NACIONAL

ESCUELA SUPERIOR DE CÓMPUTO

ESCOM

Ejercicio 14

“Calculadora”

Alumno: Borís Rodríguez Arce

Grupo:3CM15

6/06/2021

Profesor: José Juan Pérez Pérez

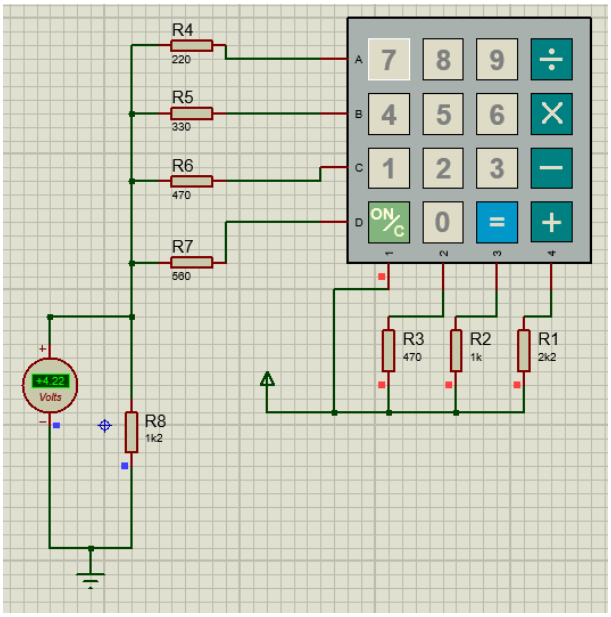
Problema

- **a) Armar el circuito del teclado analógico, comprobar de forma Práctica cada uno de los voltajes al pulsar cada botón y calcular teóricamente cada uno de estos voltajes, comprobar que deben ser muy similares ambos valores.**
- **b) Escribir un programa en ensamblador para poder leer el valor a través del ADC y mostrarlo de forma binaria en 2 puertos, comprobar teóricamente estos valores con la formula indicada en el manual del microcontrolador, tomar nota de estos valores ya que son los que se usaran para el circuito final.**
- **c) El circuito final consiste en conectar el teclado analógico y 6 displays multiplexados, y deberá escribirse un programa que muestre los dígitos hexadecimales (0 – 9) correspondientes a los botones pulsados.**

- **a)**

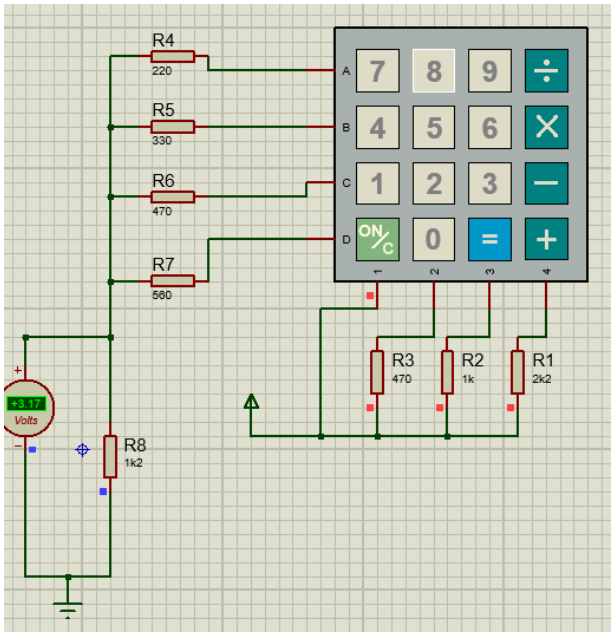
Tecla A1

$$\frac{V1 * R8}{(R4 + R8)} = \frac{5 * 1200}{220 + 1200} = \frac{6000}{1420} \approx 4.2253$$



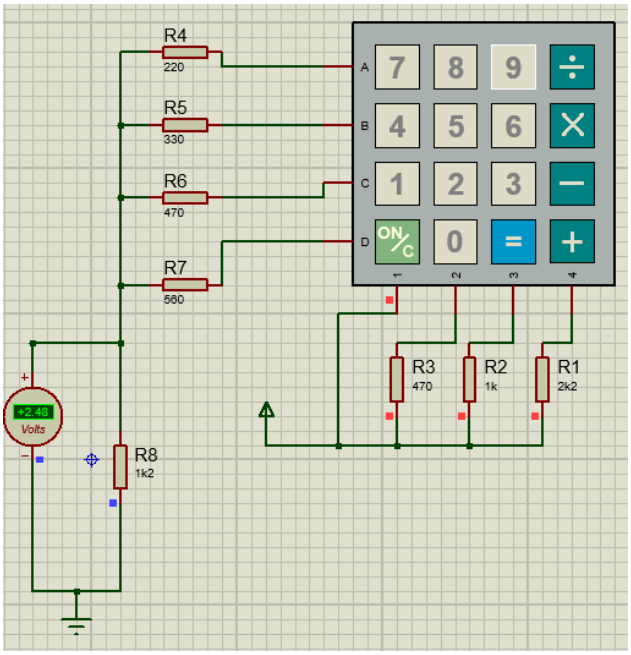
Tecla A2

$$\frac{V1 * R8}{(R4 + R8 + R3)} = \frac{5 * 1200}{220 + 1200 + 470} = \frac{6000}{1890} \approx 3.1746$$



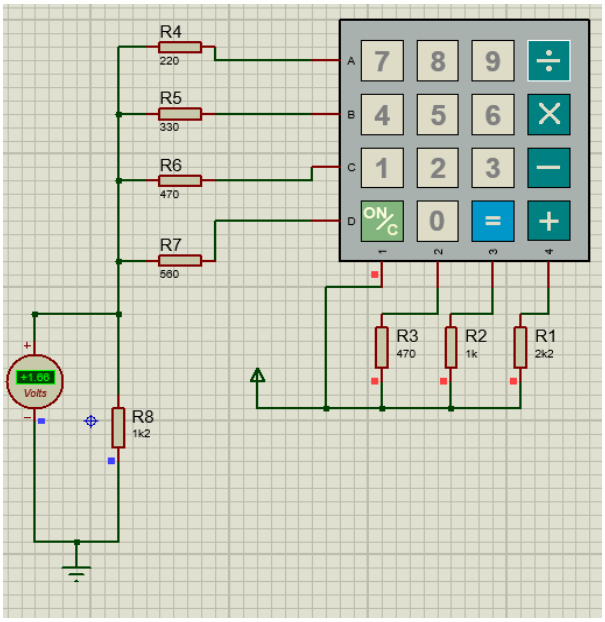
Tecla A3

$$\frac{V1 * R8}{(R4 + R8 + R2)} = \frac{5 * 1200}{220 + 1200 + 1000} = \frac{6000}{2420} \approx 2.4793$$



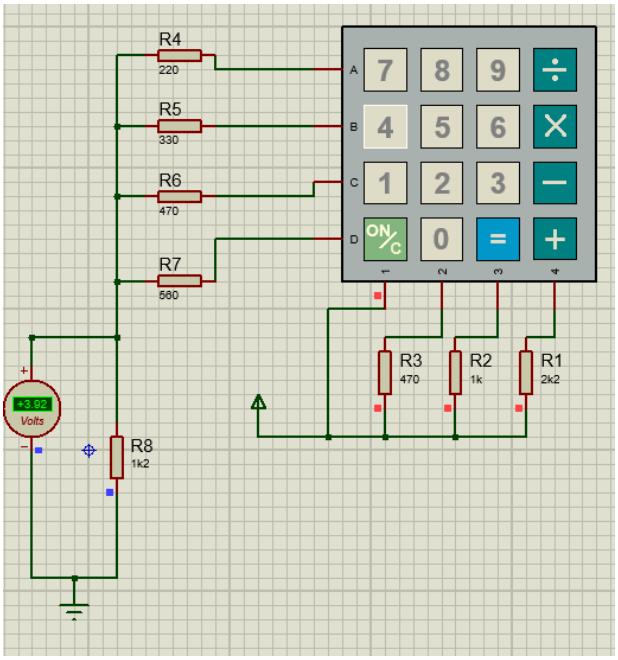
Tecla A4

$$\frac{V1 * R8}{(R4 + R8 + R1)} = \frac{5 * 1200}{220 + 1200 + 2200} = \frac{6000}{3620} \approx 1.6574$$



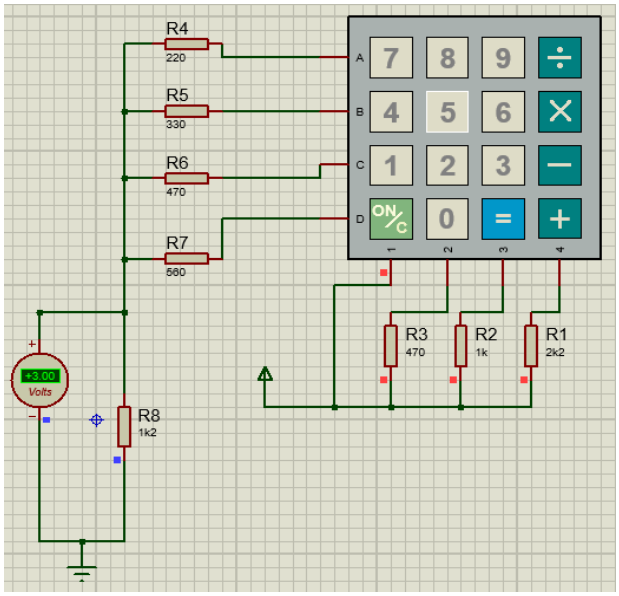
Tecla B1

$$\frac{V1 * R8}{(R5 + R8)} = \frac{5 * 1200}{330 + 1200} = \frac{6000}{1530} \approx 3.9215$$



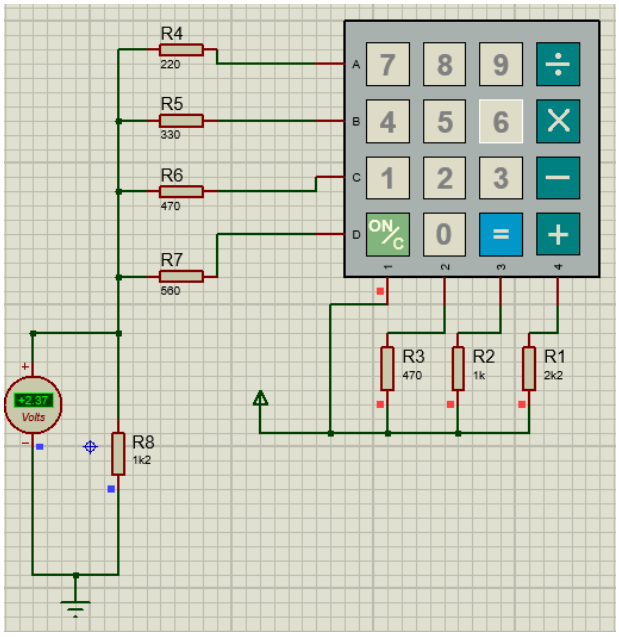
Tecla B2

$$\frac{V1 * R8}{(R5 + R8 + R3)} = \frac{5 * 1200}{330 + 1200 + 470} = \frac{6000}{2000} \approx 3.0000$$



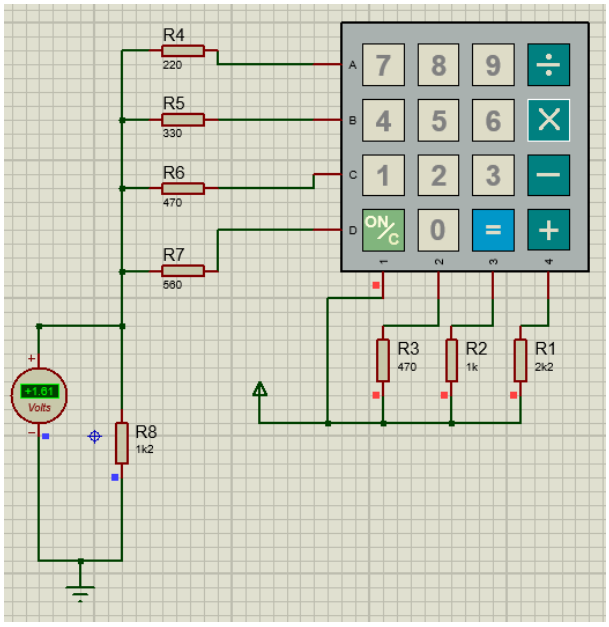
Tecla B3

$$\frac{V1 * R8}{(R5 + R8 + R2)} = \frac{5 * 1200}{330 + 1200 + 1000} = \frac{6000}{2530} \approx 2.3715$$



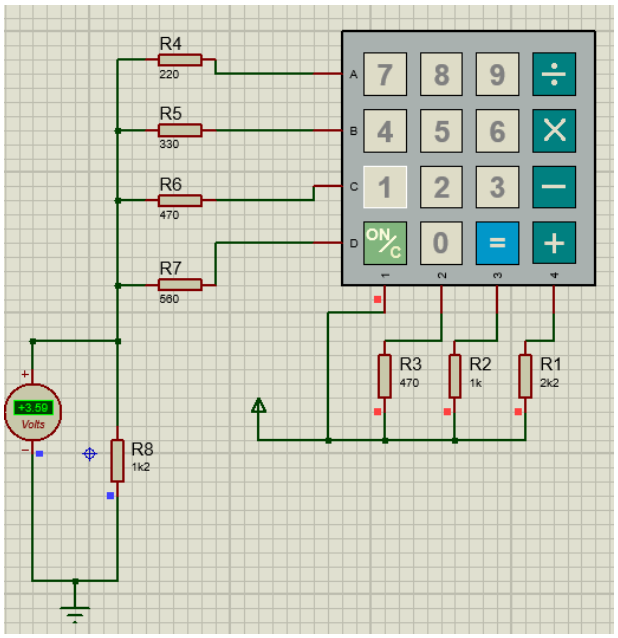
Tecla B4

$$\frac{V1 * R8}{(R5 + R8 + R1)} = \frac{5 * 1200}{330 + 1200 + 2200} = \frac{6000}{3730} \approx 1.6085$$



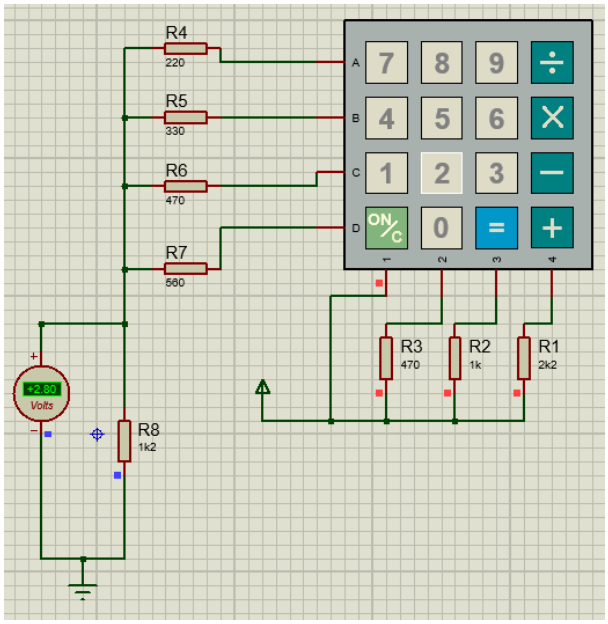
Tecla C1

$$\frac{V1 * R8}{(R6 + R8)} = \frac{5 * 1200}{470 + 1200} = \frac{6000}{1670} \approx 3.5928$$



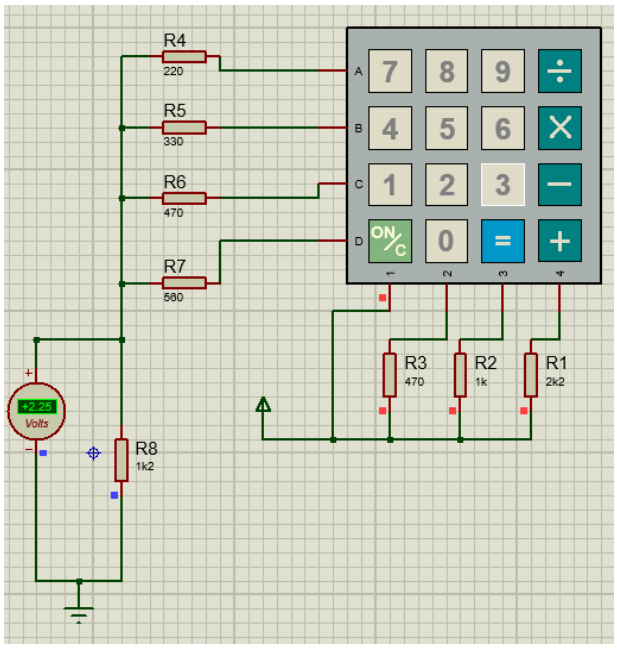
Tecla C2

$$\frac{V1 * R8}{(R6 + R8 + R3)} = \frac{5 * 1200}{470 + 1200 + 470} = \frac{6000}{2140} \approx 2.8037$$



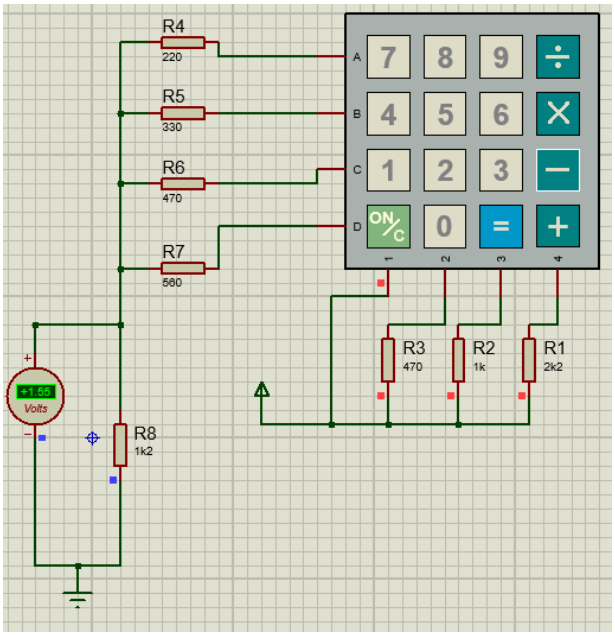
Tecla C3

$$\frac{V1 * R8}{(R6 + R8 + R2)} = \frac{5 * 1200}{470 + 1200 + 1000} = \frac{6000}{2670} \approx 2.2471$$



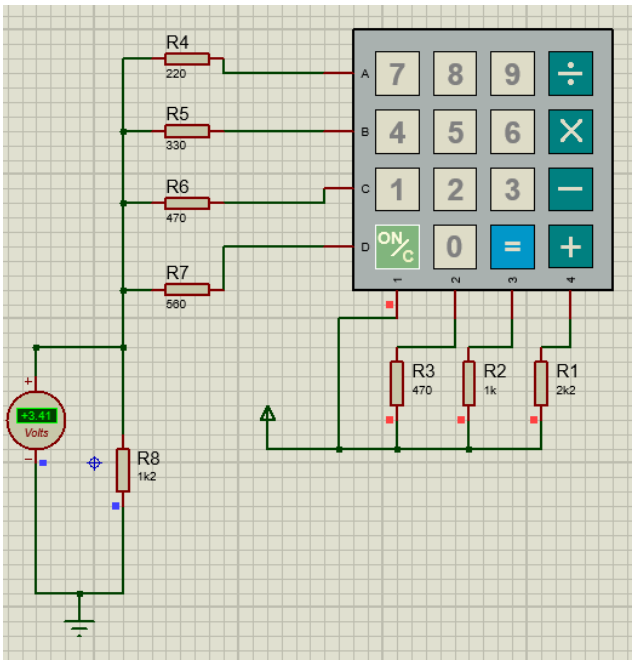
Tecla C4

$$\frac{V1 * R8}{(R6 + R8 + R1)} = \frac{5 * 1200}{470 + 1200 + 2200} = \frac{6000}{3870} \approx 1.5503$$



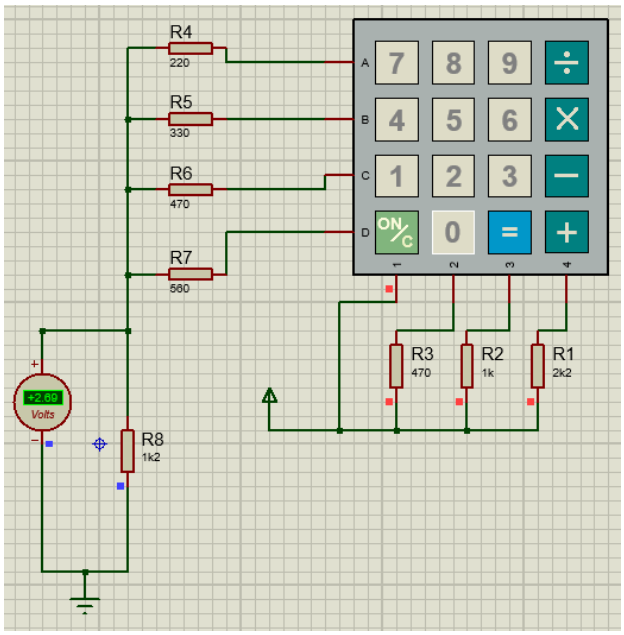
Tecla D1

$$\frac{V1 * R8}{(R7 + R8)} = \frac{5 * 1200}{560 + 1200} = \frac{6000}{1760} \approx 3.4090$$



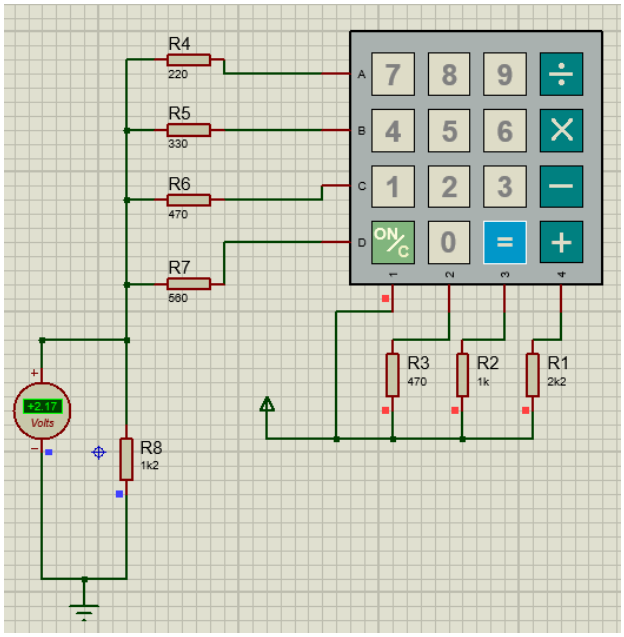
Tecla D2

$$\frac{V1 * R8}{(R7 + R8 + R3)} = \frac{5 * 1200}{560 + 1200 + 470} = \frac{6000}{2230} \approx 2.6905$$



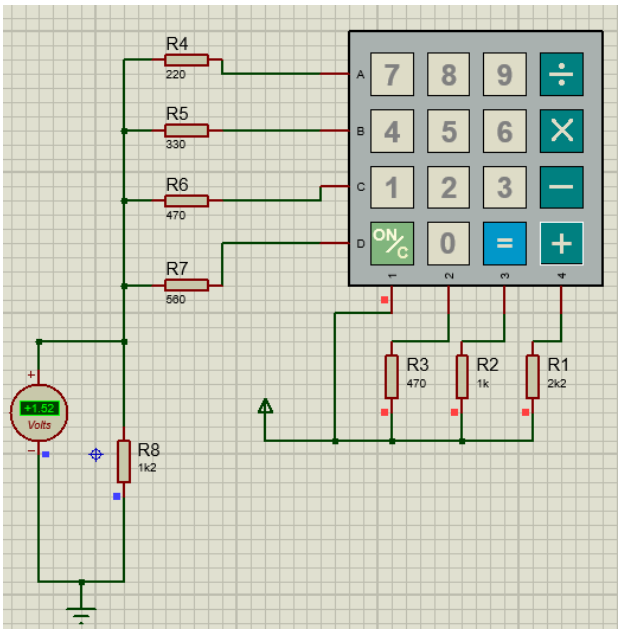
Tecla D3

$$\frac{V1 * R8}{(R7 + R8 + R2)} = \frac{5 * 1200}{560 + 1200 + 1000} = \frac{6000}{2760} \approx 2.1739$$



Tecla D4

$$\frac{V1 * R8}{(R7 + R8 + R1)} = \frac{5 * 1200}{560 + 1200 + 2200} = \frac{6000}{3960} \approx 1.5151$$



- **b)**

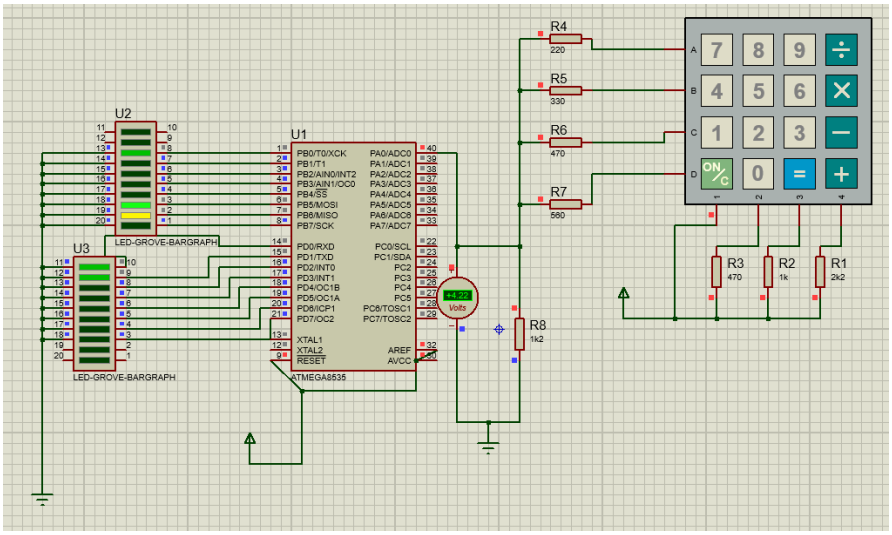
Código.

```
.include"m8535def.inc"
.org 0x000
rjmp start
.org 0x00E
rjmp conv

start:
ldi r16,low(RAMEND)
out spl,r16
ldi r16,high(RAMEND)
out sph,r16
ser r16
out ddrd,r16
out ddrb,r16
ldi r16,$ED
out adcsra,r16
sei

loop:
out portd,r16
out portb,r17
rjmp loop

conv:
in r17,adcl
in r16,adch
reti
```

Simulación

Tecla A1

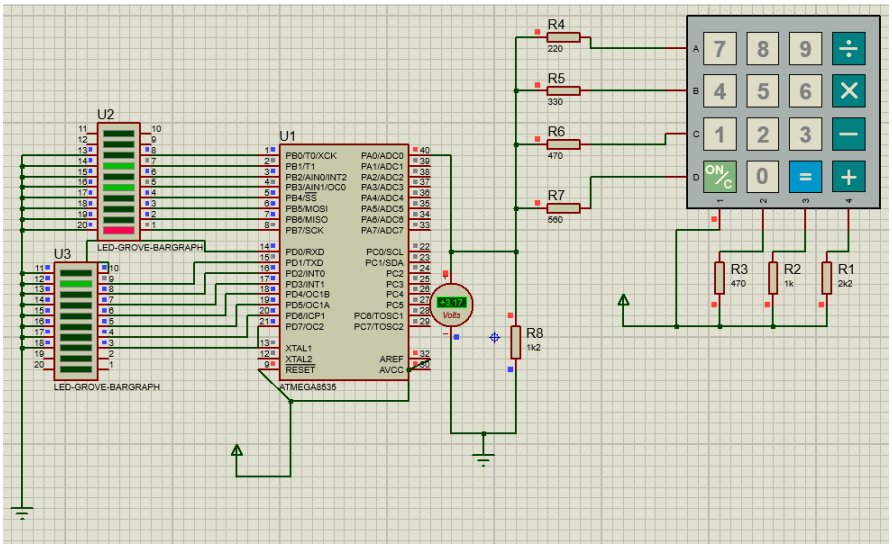
$$ADC = \frac{VIN * 1024}{VREF} = \frac{4.22 * 1024}{5} = 864.256$$



00000011 01100001 = 0x0361 = 865

Tecla A2

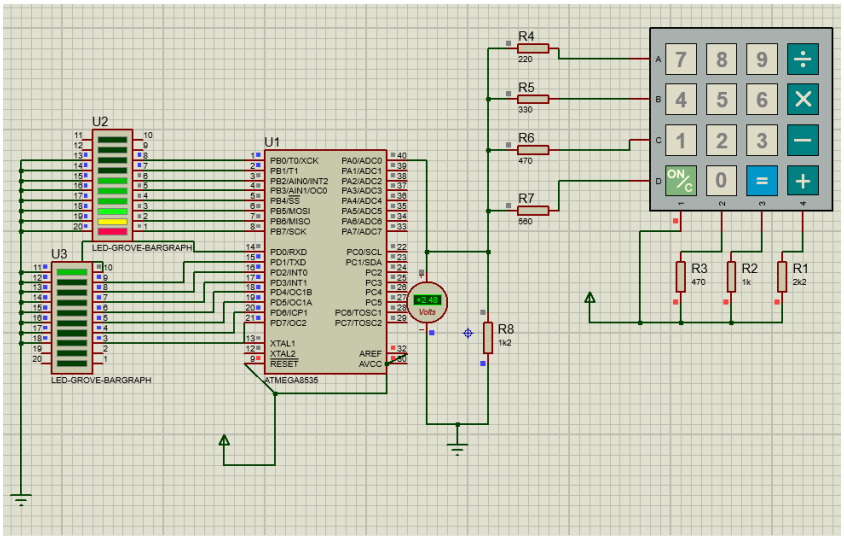
$$ADC = \frac{VIN * 1024}{VREF} = \frac{3.17 * 1024}{5} = 649.216$$



00000010 10001010 = 0x028A = 650

Tecla A3

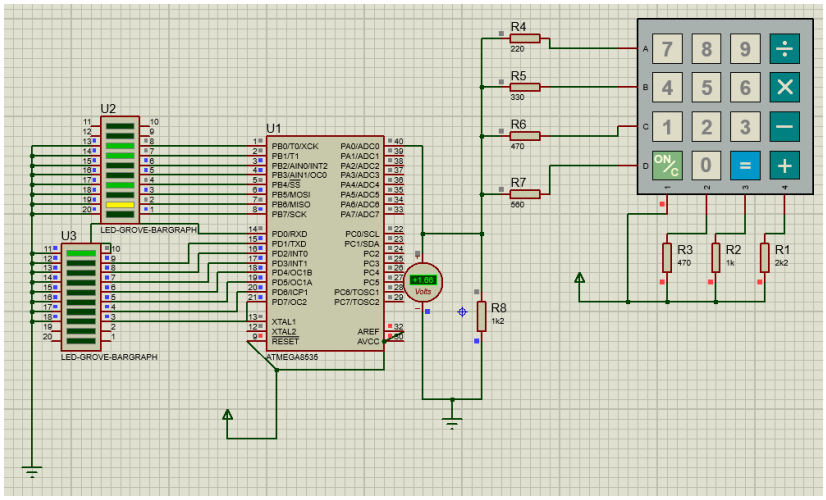
$$ADC = \frac{VIN * 1024}{VREF} = \frac{2.48 * 1024}{5} = 507.904$$



00000001 11111100 = 0x01FC = 508

Tecla A4

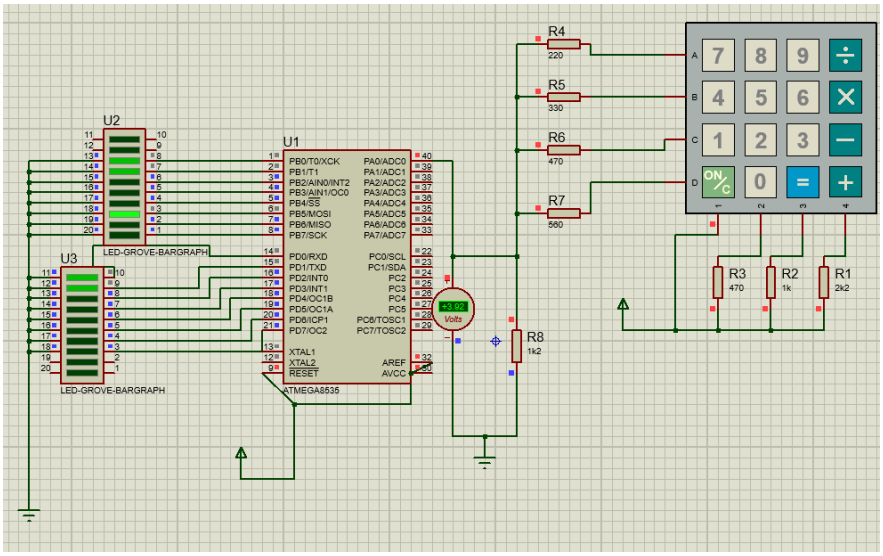
$$ADC = \frac{VIN * 1024}{VREF} = \frac{1.66 * 1024}{5} = 339.968$$



00000001 01010011 = 0x0153 = 339

Tecla B1

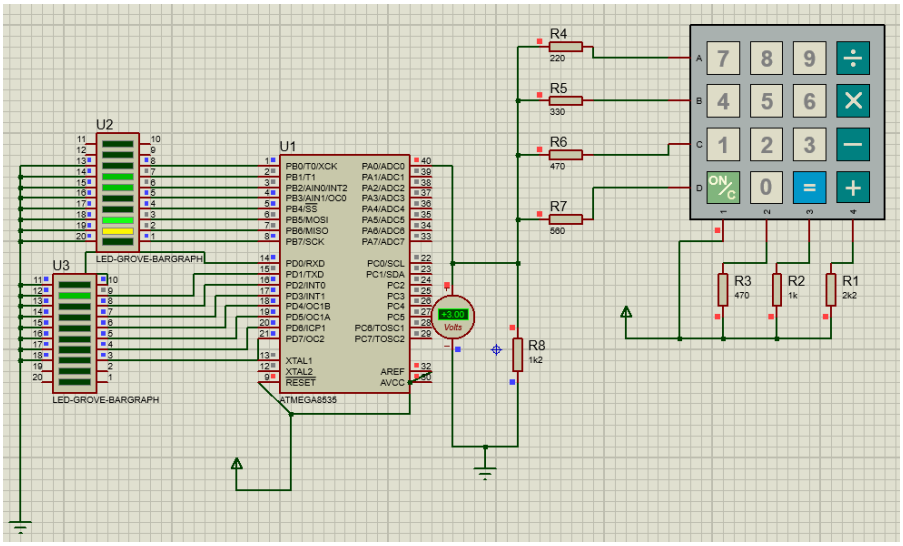
$$ADC = \frac{VIN * 1024}{VREF} = \frac{3.92 * 1024}{5} = 802.816$$



00000011 00100011 = 0x0323 = 803

Tecla B2

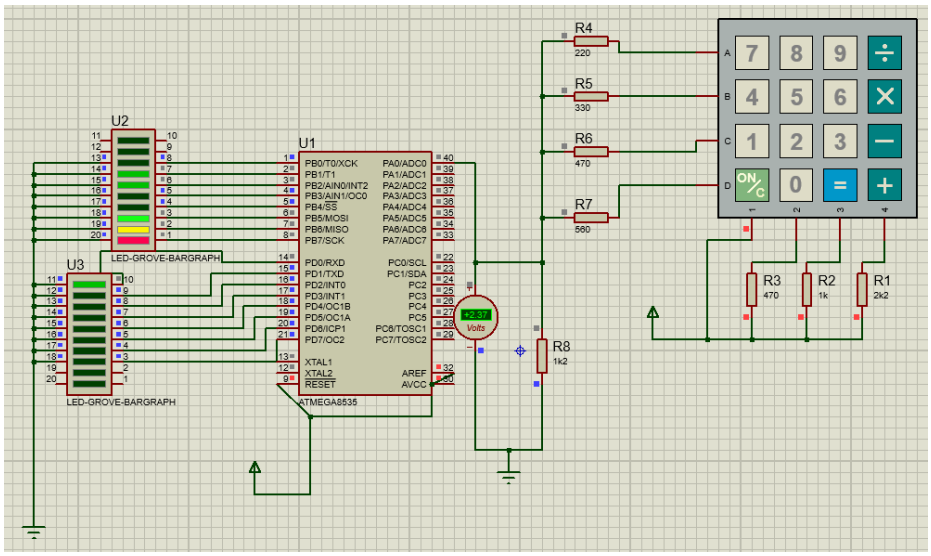
$$ADC = \frac{VIN * 1024}{VREF} = \frac{3 * 1024}{5} = 614.4$$



00000010 01100110 = 0x0266 = 614

Tecla B3

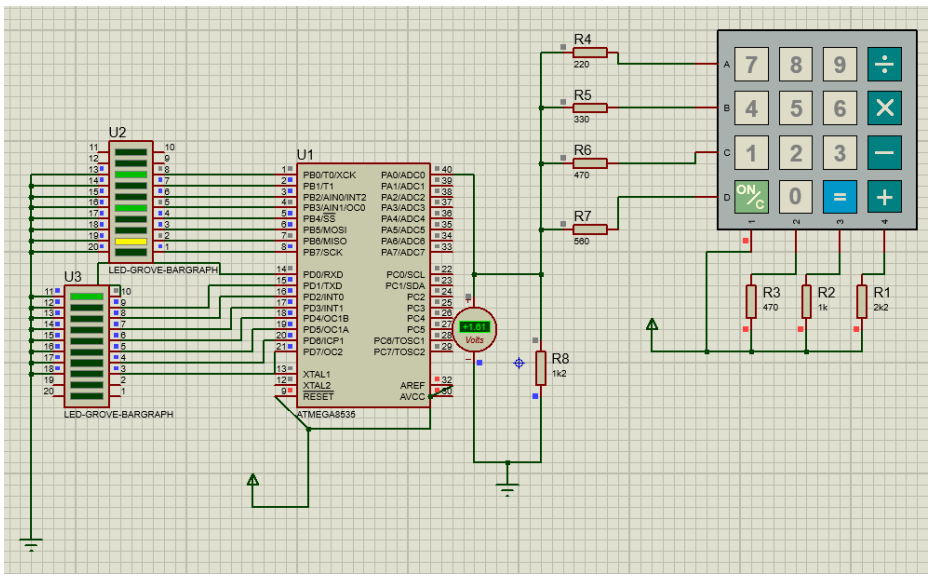
$$ADC = \frac{VIN * 1024}{VREF} = \frac{2.37 * 1024}{5} = 485.376$$



00000001 11100110 = 0x01E6 = 486

Tecla B4

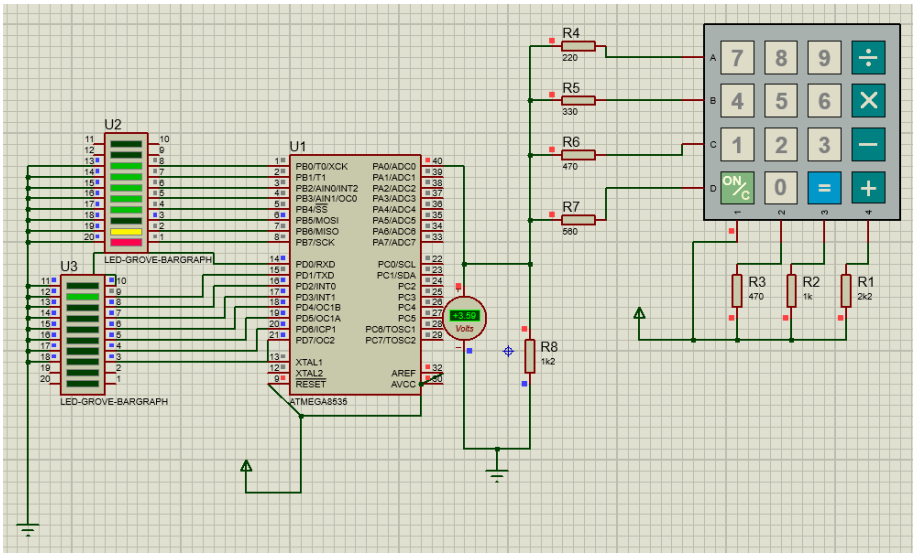
$$ADC = \frac{VIN * 1024}{VREF} = \frac{1.61 * 1024}{5} = 329.728$$



00000001 01001001 = 0x0149 = 329

Tecla C1

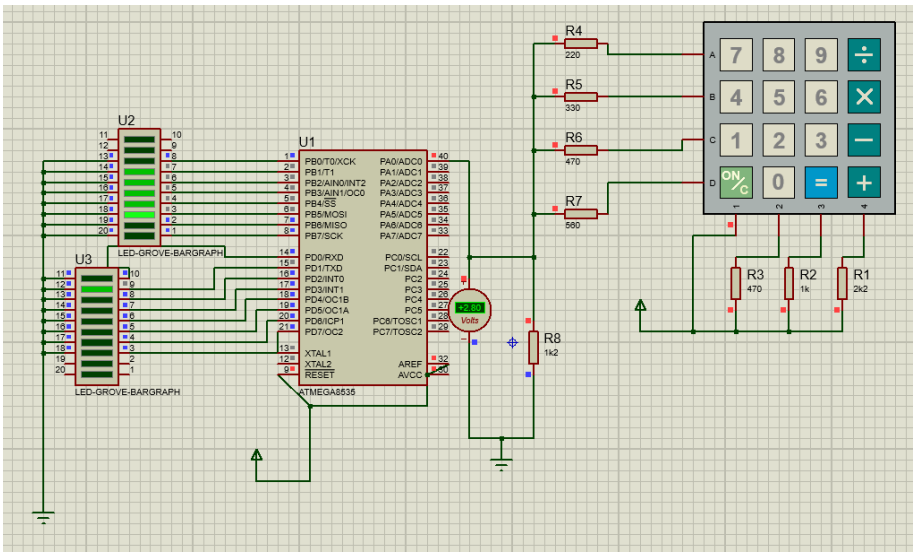
$$ADC = \frac{VIN * 1024}{VREF} = \frac{3.59 * 1024}{5} = 735.232$$



00000010 11011111 = 0x02DF = 735

Tecla C2

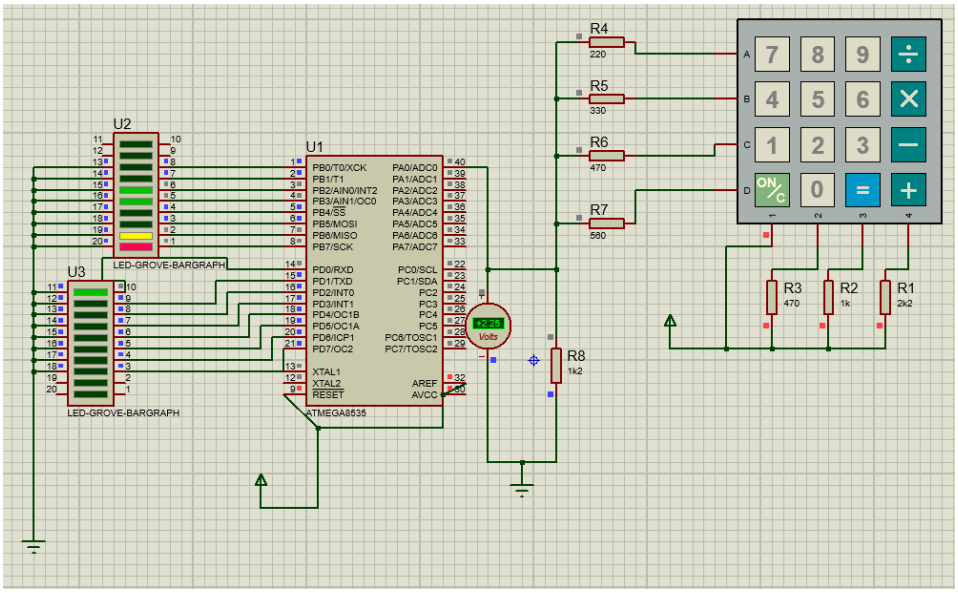
$$ADC = \frac{VIN * 1024}{VREF} = \frac{2.8 * 1024}{5} = 573.440$$



00000010 00111110 = 0x023E = 574

Tecla C3

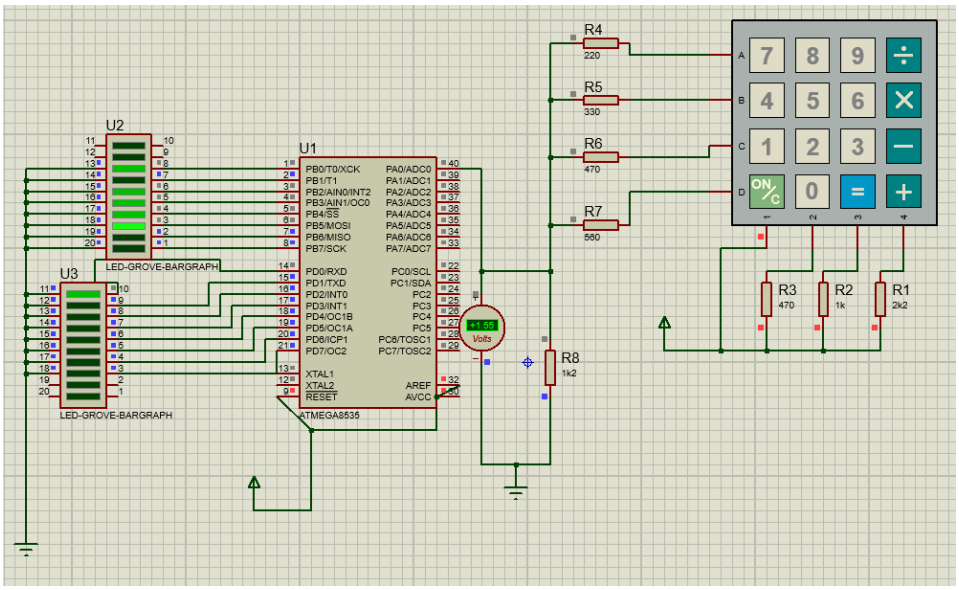
$$ADC = \frac{VIN * 1024}{VREF} = \frac{2.25 * 1024}{5} = 460.800$$



00000001 11001100 = 0x01CC = 460

Tecla C4

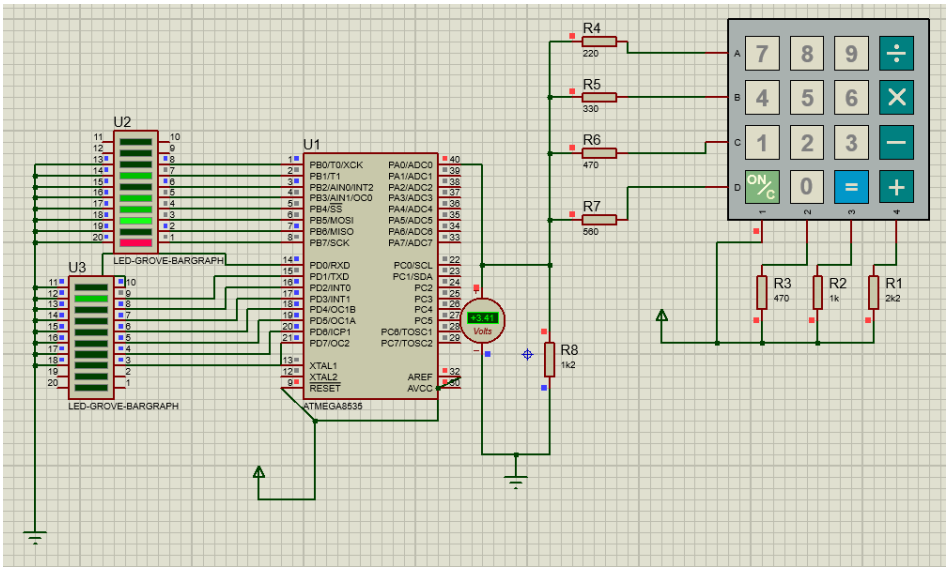
$$ADC = \frac{VIN * 1024}{VREF} = \frac{1.55 * 1024}{5} = 317.440$$



00000001 00111101 = 0x013D = 317

Tecla D1

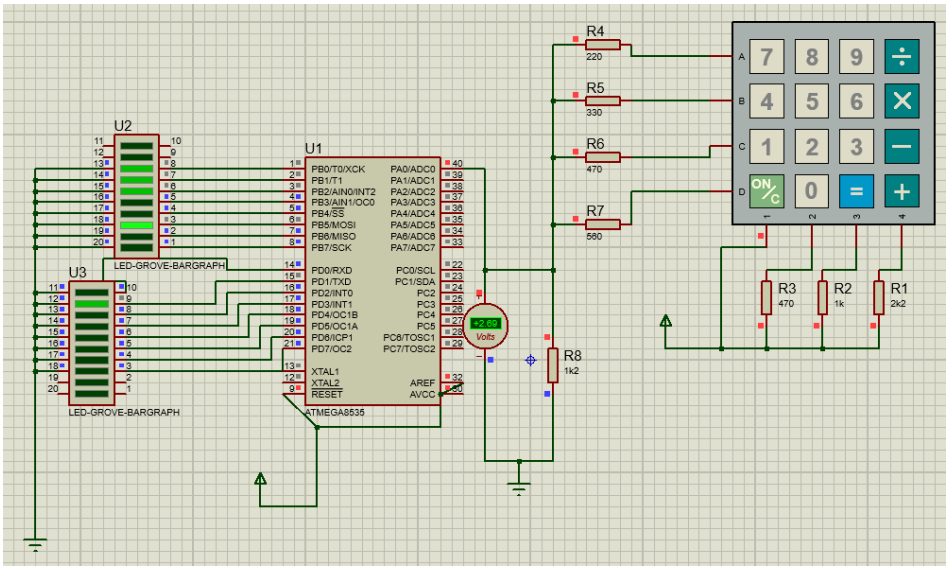
$$ADC = \frac{VIN * 1024}{VREF} = \frac{3.41 * 1024}{5} = 698.368$$



00000010 10111010 = 0x02BA = 698

Tecla D2

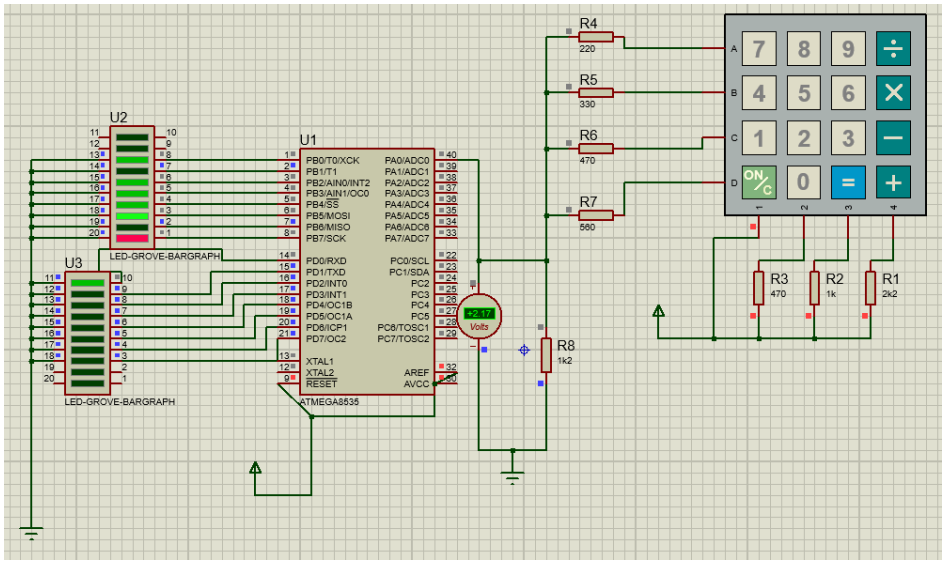
$$ADC = \frac{VIN * 1024}{VREF} = \frac{2.69 * 1024}{5} = 550.912$$



00000010 00100111 = 0x0227 = 551

Tecla D3

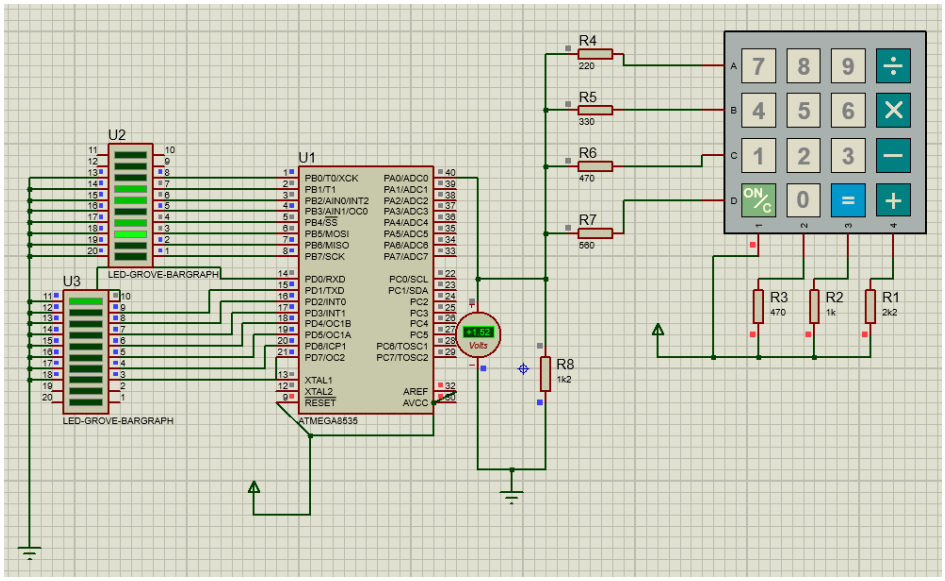
$$ADC = \frac{VIN * 1024}{VREF} = \frac{2.17 * 1024}{5} = 444.416$$



00000001 10111101 = 0x01BD = 445

Tecla D4

$$ADC = \frac{VIN * 1024}{VREF} = \frac{1.52 * 1024}{5} = 311.296$$



00000001 00110110 = 0x0136 = 310

- **c)**

  Código.

```
.include"m8535def.inc"
.def aux = r16 ;Se declaran etiquetas a usar
.def conh = r17
.def conl = r18
.def col = r19
.def sal = r20
.org 0x000 ;Vector a Reset
rjmp start
.org 0x00E ;Vector a Convertidor Analógico - Digital
rjmp conv
start:
ldi aux,low(RAMEND) ;Inicia declaración de Pila
out spl,aux
ldi aux,high(RAMEND)
out sph,aux ;Termina declaración de Pila
ser aux
out ddrd,aux ;Se prepara salida a DDRD
out ddrb,aux ;Se prepara salida a DDRB
ldi aux,$ED
out adcsra,aux ;Se carga $ED en ADCSRA
sei ;Se activa la bandera de interrupción global
```

```
ldi col,$3E ;Se carga $3E en “col”
clr aux ;Se limpia “aux”
clr sal ;Limpia “sal”
loop:
out portb,col ; Sale “col” por PORTB
out portd,sal ;Sale “sal” por PORTD
rjmp loop ;Salto a “loop”
conv: ;Convertidor Analógico Digital
in conl,adcl ;Se guarda ADCL en “conl”
in conh,adch ;Se guarda ADCH en “conh”
cpi conh,$03 ;Se compara si “conh” es $03
brne sigu ;Si no salta a “sigu”
cpi conl,$61
brne un ;Si no es $0361 salta a “un”
ldi sal,$3F ;Si es $0361 carga 0 ($3F)
rjmp ter ;Salta a “ter”
un:
cpi conl,$23
brne do ;Si no es $0323 salta a “do”
ldi sal,$66 ;Si es $0323 carga 4 ($66)
rjmp ter ;Salta a “ter”
do:
clr sal ;Limpia “sal”
rjmp ter ;Salta a “ter”
```

```
sigu:
cpi conh,$02 ;Se compara si “conh” es $02
brne sigd ;Si no salta a “sigd”
cpi conl,$8A
brne uno ;Si no es $028A salta a “uno”
ldi sal,$06 ;Si es $028A carga 1 ($06)
rjmp ter ;Salta a “ter”
uno:
cpi conl,$66
brne dos ;Si no es $0266 salta a “dos”
ldi sal,$6D ;Si es $0266 carga 5 ($6D)
rjmp ter ;Salta a “ter”
dos:
cpi conl,$DF
brne tre ;Si no es $02DF salta a “tre”
ldi sal,$7F ;Si es $02DF carga 8 ($7F)
rjmp ter ;Salta a “ter”
tre:
cpi conl,$3E
brne cua ;Si no es $023E salta a “cua”
ldi sal,$6F ;Si es $026E carga 9 ($6F)
rjmp ter ;Salta a “ter”
cua:
cpi conl,$BA
```

```
brne cin ;Si no es $02BA salta a “cin”
ldi sal,$39 ;Si es $02BA carga C ($39)
rjmp ter ;Salta a “ter”
cin:
cpi conl,$27
brne seis ;Si no es $0227 salta a “seis”
ldi sal,$5E ;Si es $0227 carga D ($5E)
rjmp ter ;Salta a “ter”
seis:
clr sal ;Limpia “sal”
rjmp ter ;Salta a “ter”
sigd:
cpi conh,$01 ;Se compara si “conh” es $01
brne sigt ;Si no salta a “sigt”
cpi conl,$FC
brne unos ;Si no es $01FC salta a “unos”
ldi sal,$5B ;Si es $01FC carga 2 ($5B)
rjmp ter ;Salta a “ter”
unos:
cpi conl,$53
brne dose ;Si no es $0153 salta a “dose”
ldi sal,$4F ;Si es $0153 carga 3 ($4F)
rjmp ter ;Salta a “ter”
dose:
```

```
cpi conl,$E6
brne tres ;Si no es $01E6 salta a “tres”
ldi sal,$7D ;Si es $01E6 carga 6 ($7D)
rjmp ter ;Salta a “ter”
tres:
cpi conl,$49
brne cuat ;Si no es $0149 salta a “cuat”
ldi sal,$27 ;Si es $0149 carga 7 ($27)
rjmp ter ;Salta a “ter”
cuat:
cpi conl,$CC
brne cinc ;Si no es $01CC salta a “cinc”
ldi sal,$77 ;Si es $01CC carga A ($77)
rjmp ter ;Salta a “ter”
cinc:
cpi conl,$3D
brne ire ;Si no es $013D salta a “ire”
ldi sal,$7C ;Si es $013D carga B ($7C)
rjmp ter ;Salta a “ter”
ire:
cpi conl,$BD
brne siet ;Si no es $01BD salta a “siet”
ldi sal,$79 ;Si es $01BD carga E ($79)
rjmp ter ;Salta a “ter”
```

siet:

cpi conl,$36

brne ocho ;Si no es $0136 salta a “ocho”

ldi sal,$71 ; Si es $0136 carga F ($71)

rjmp ter ;Salta a “ter”

ocho:

clr sal ;Limpia “sal”

rjmp ter ;Salta a “ter”

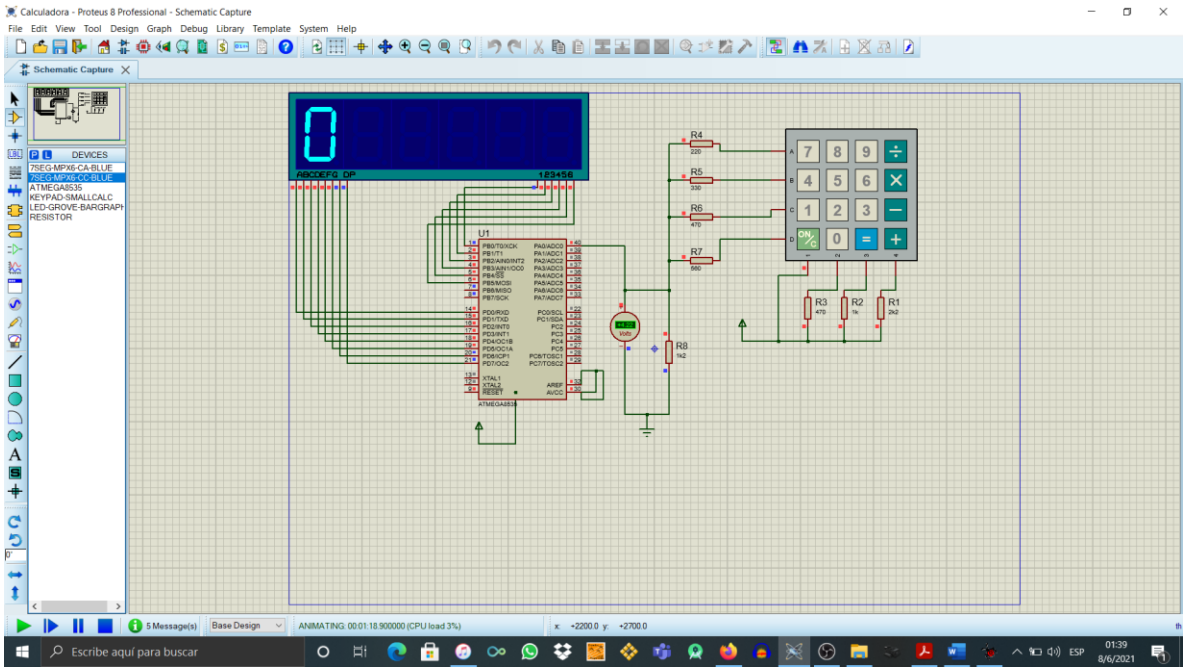
sigt:

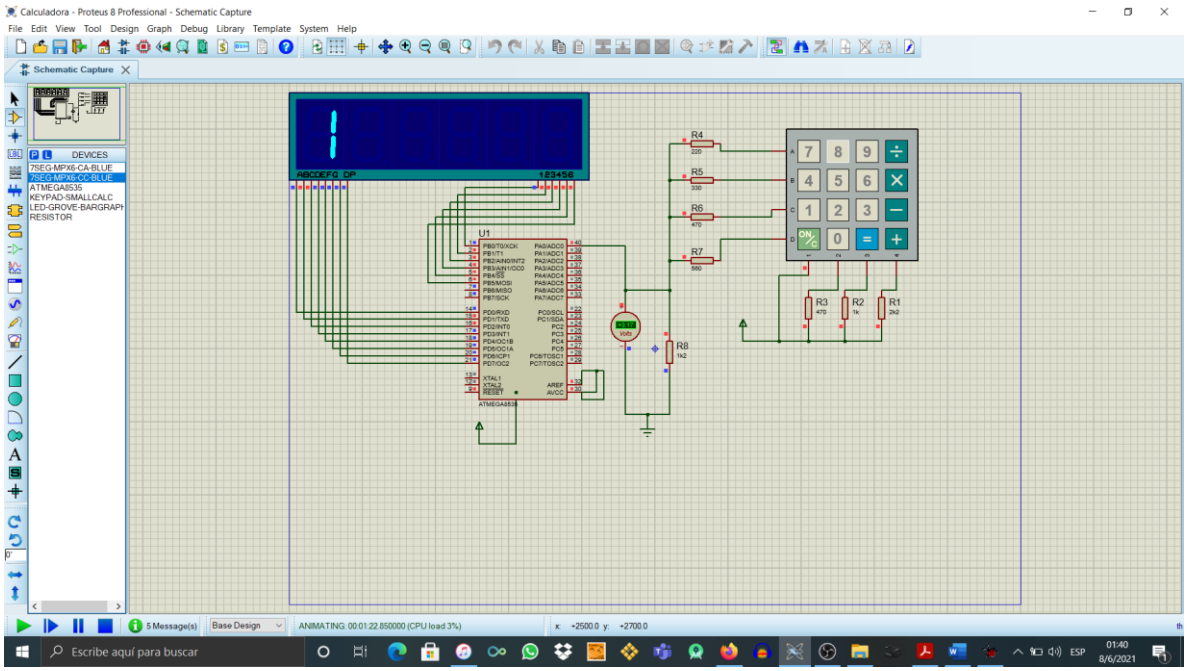
clr sal ;Limpia “sal”

ter:

reti ;Retorno de interrupción

Simulación

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LED-GROVE-BARGRAPH
RESISTOR
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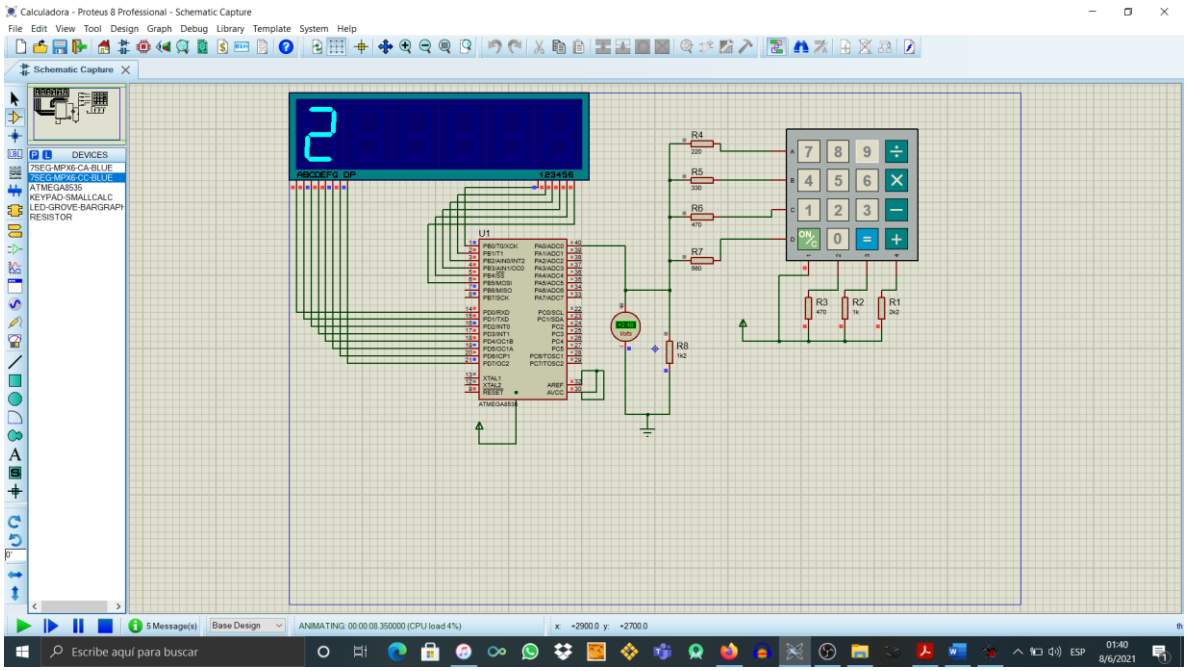
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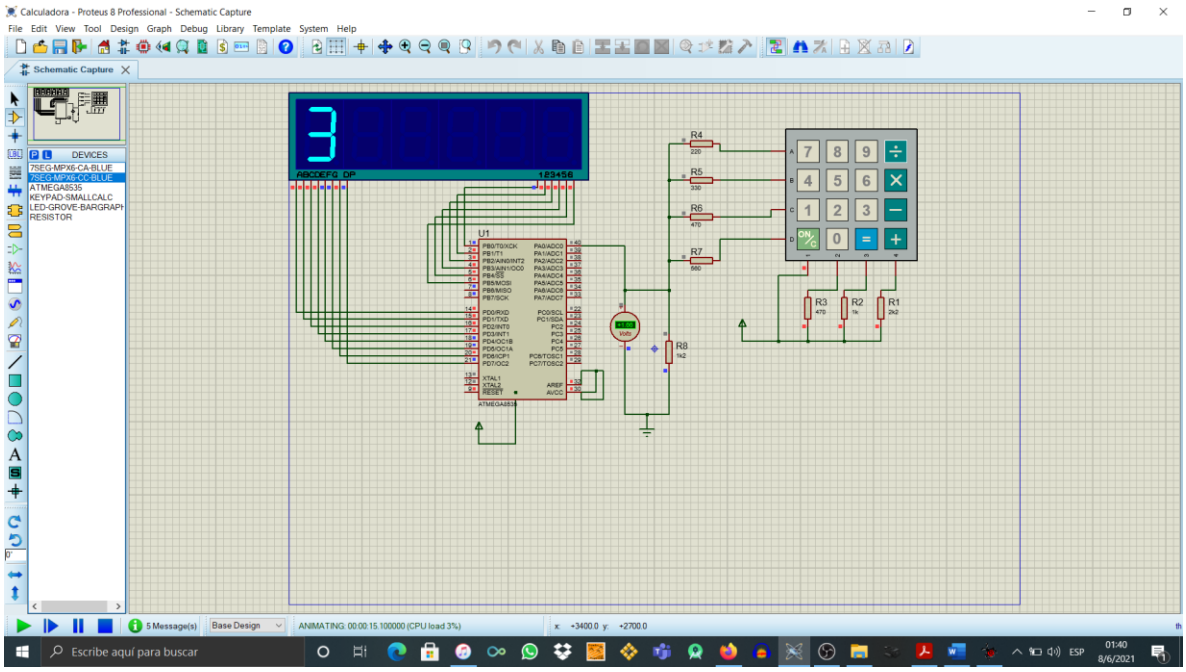
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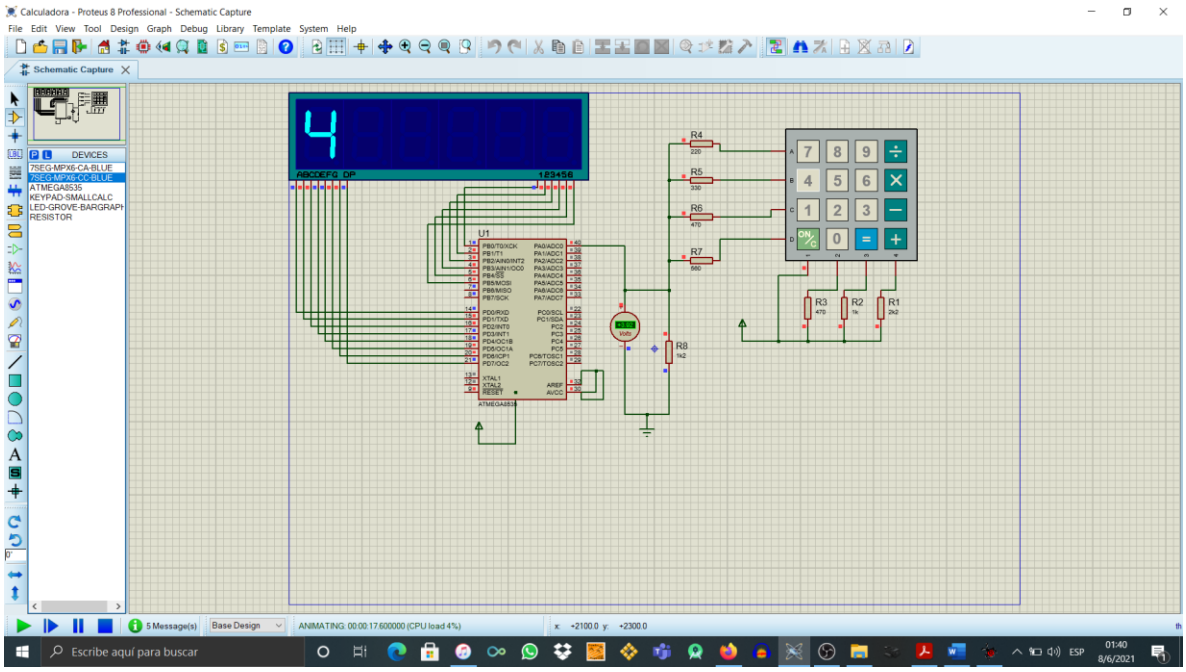
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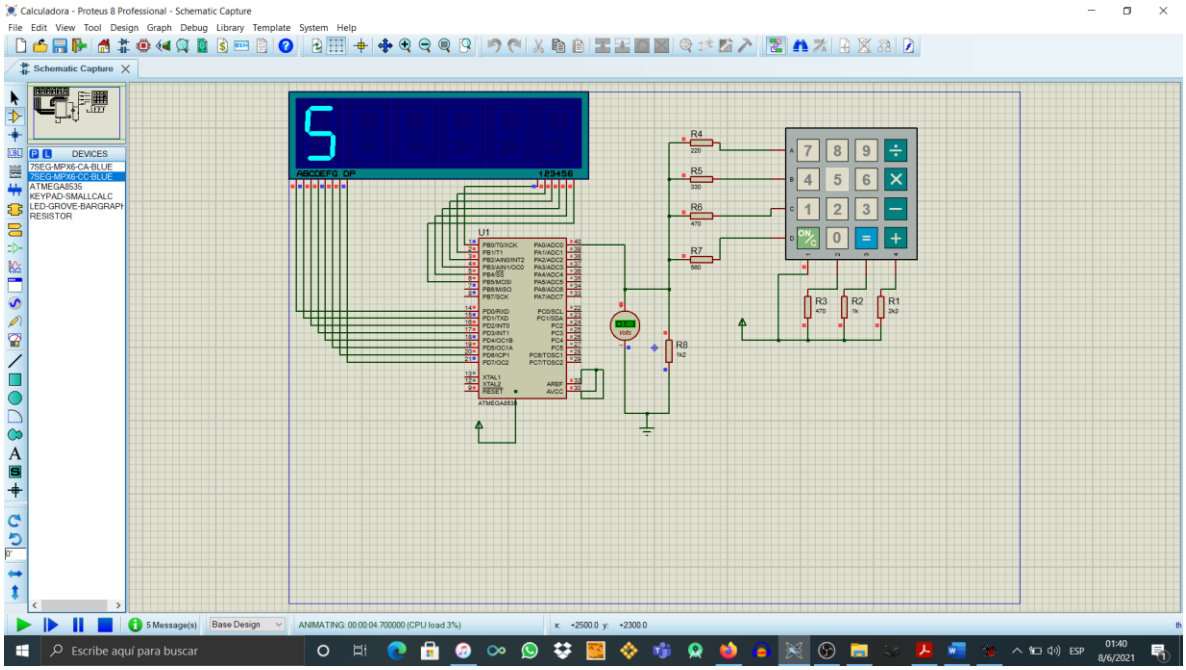
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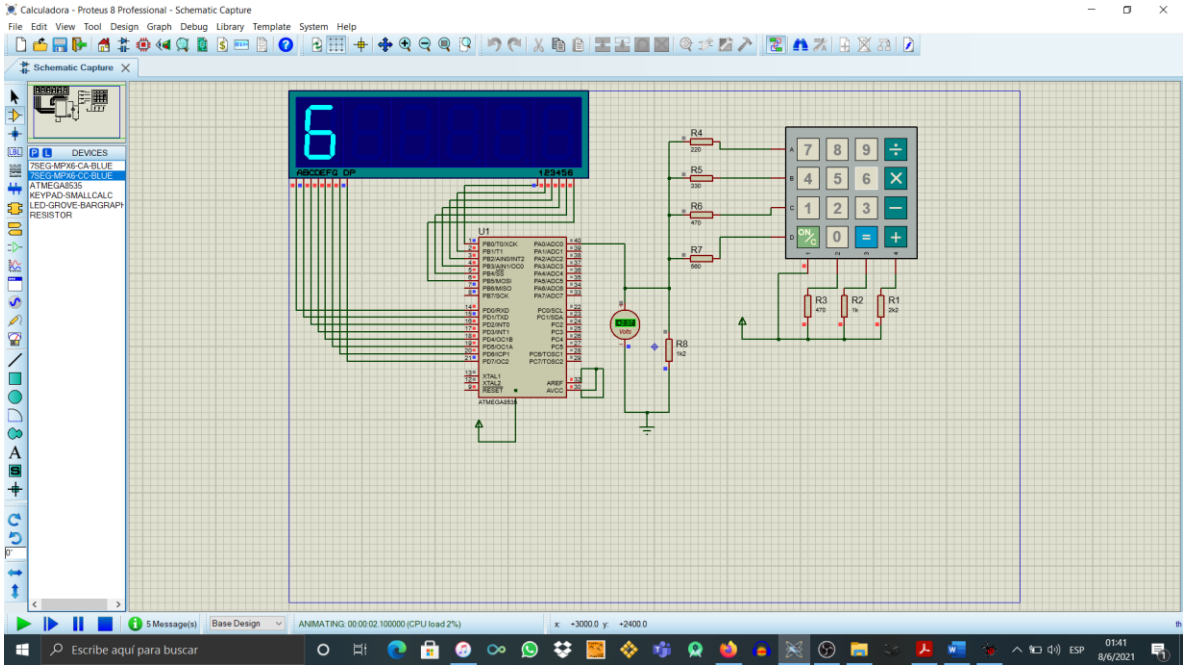
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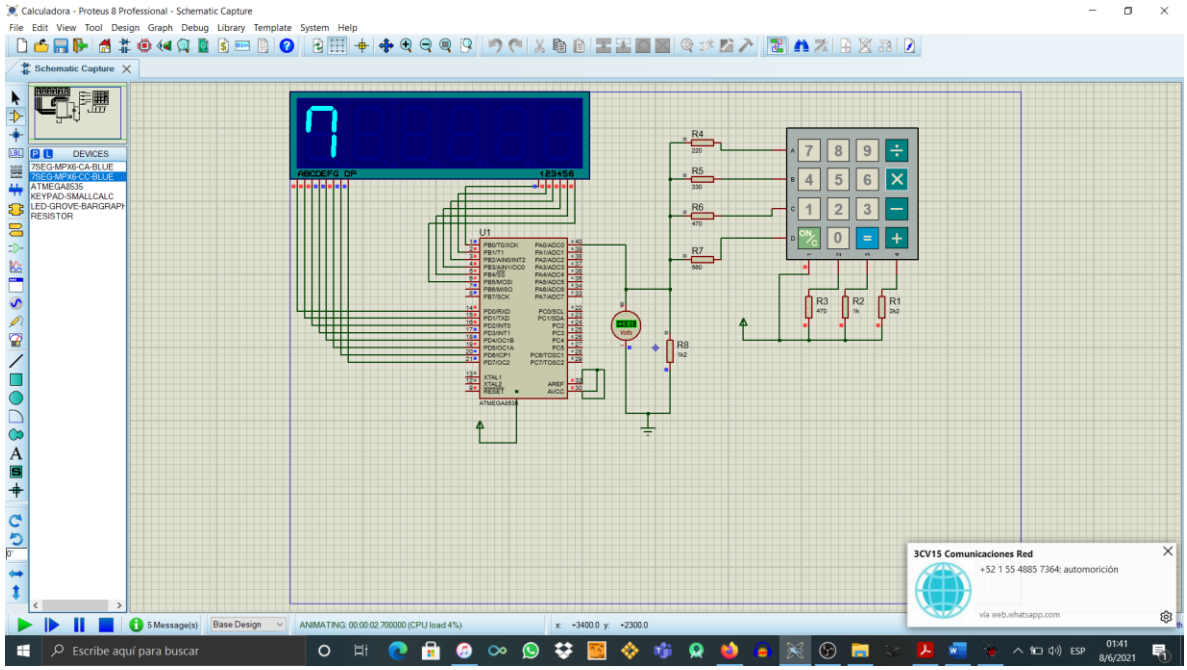
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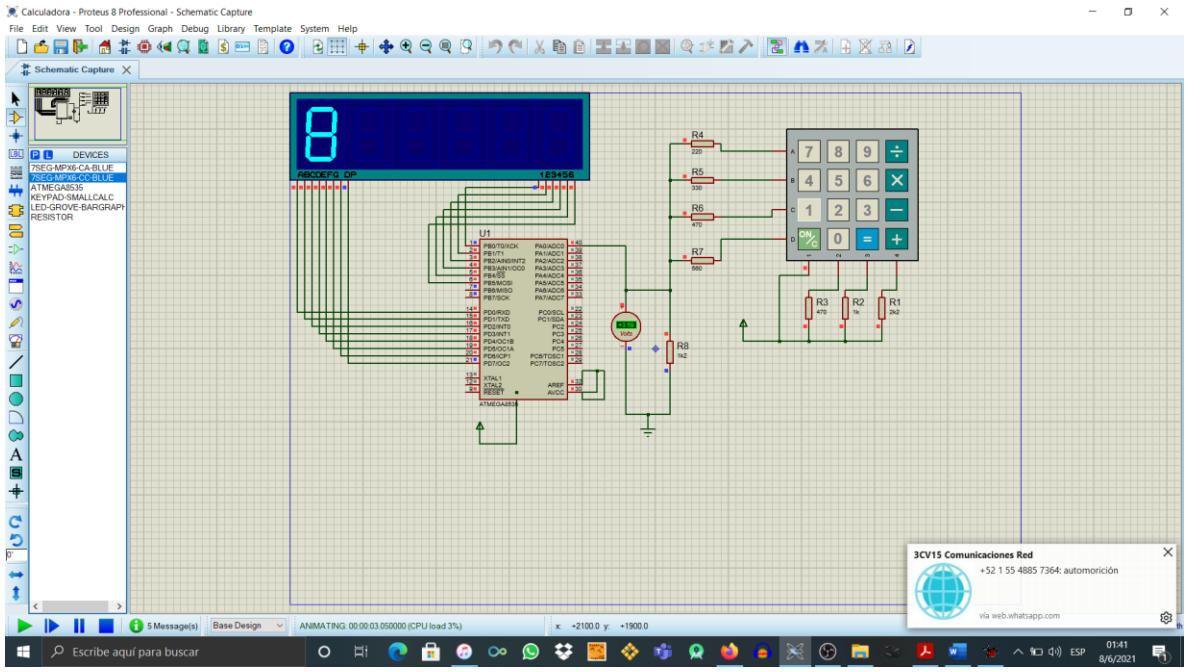
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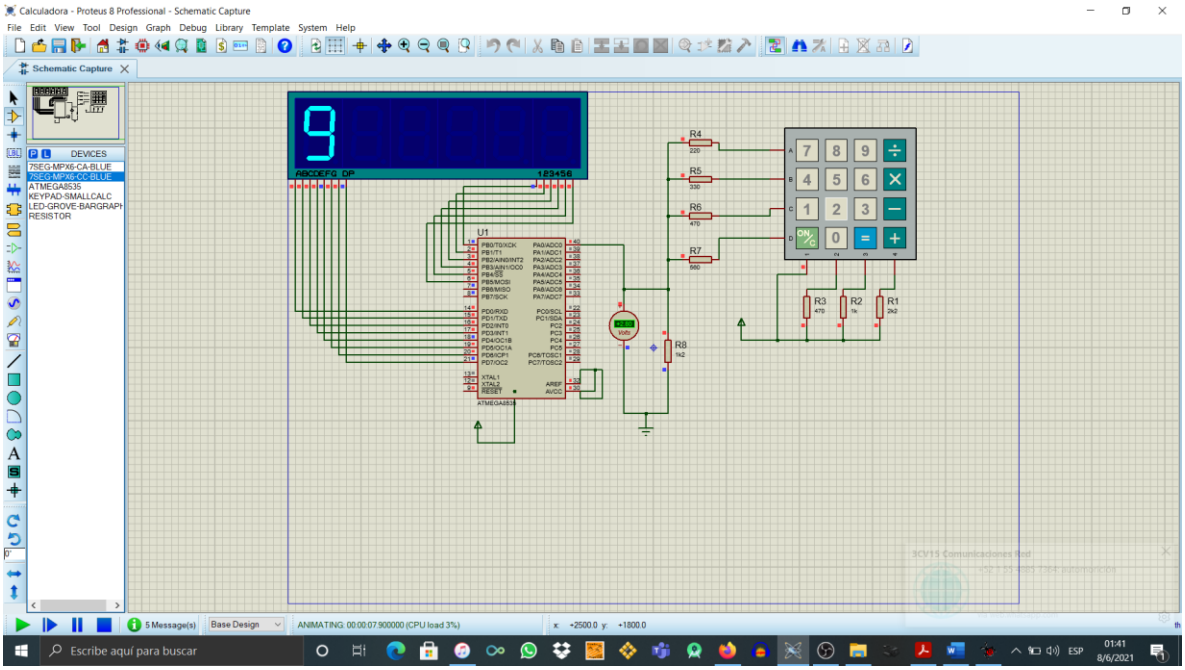
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