

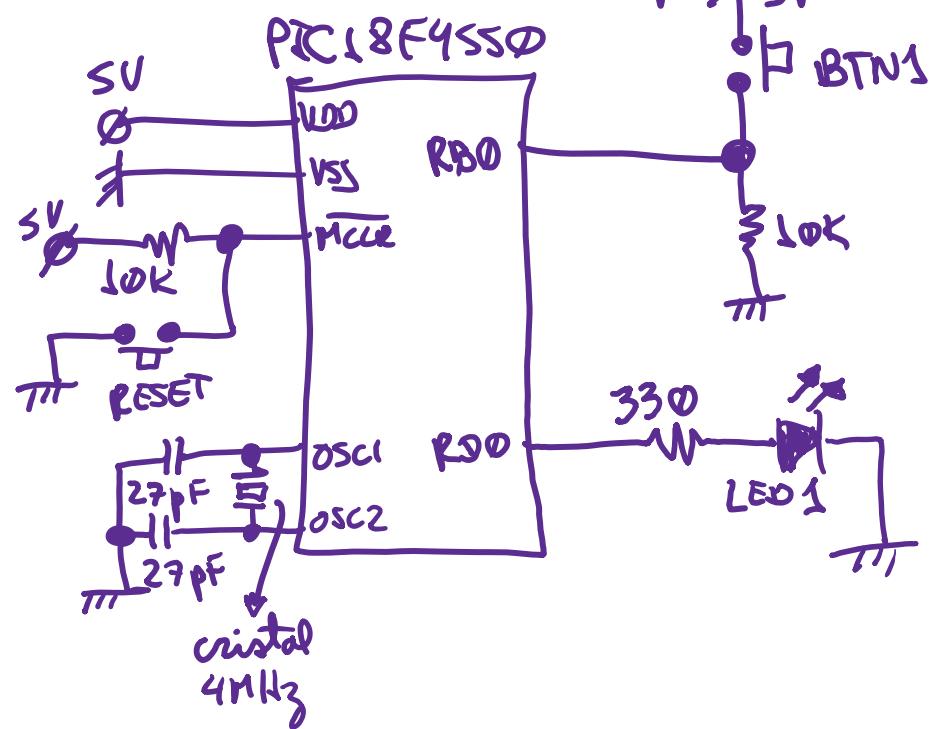
Sistemas Digitales: Introducción a los microcontroladores Parte 2

Ingeniería Electrónica
UPC 2018

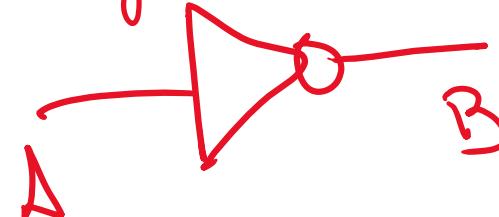
Por Kalun Lau

Ejemplo: Negador lógico

Circuito a implementar:



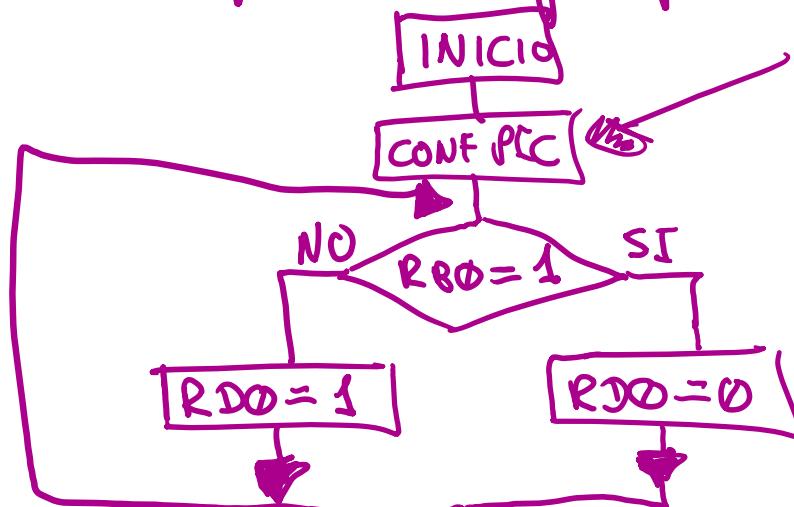
Symbol:



truth table:

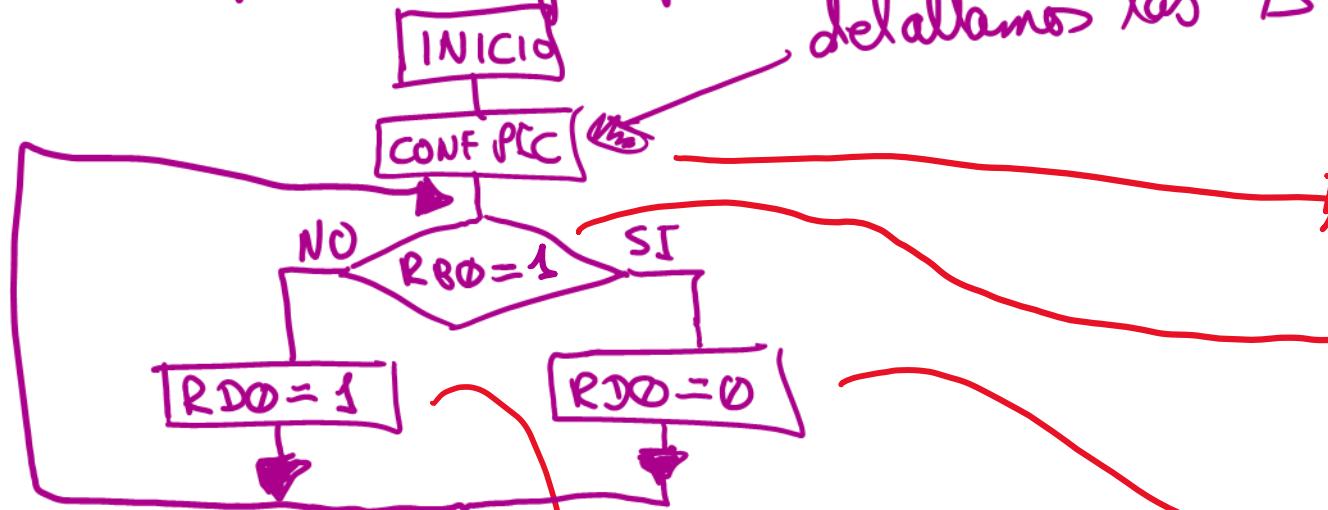
A	B
1	0
0	1

Diagrama de flujo:



Ejemplo: Negador lógico

Diagrama de flujo:



detallamos los E/S

Bóidge en MPASM:

configuro: bcf TRISD, 0
inicio: btfss PORTB, 0
goto False
verdadero: bcf LATD, 0
goto inicio
False: bsf LATD, 0
goto inicio

Creación del proyecto en el MPLAB X

MPLAB X IDE v5.05 - 20182_sisdig_negadeitor : default

File Edit View Navigate Source Refactor Production Debug Team T

New Project... Ctrl+Shift+N
New File... Ctrl+N
Open Project... Ctrl+Shift+O
Open Recent Project
Import >
Close Project (20182_sisdig_negadeitor)

seleccionar

New Project

Steps

1. Choose Project
- 2. Select Device**
3. Select Header
4. Select Tool
5. Select Plugin Board
6. Select Compiler
7. Select Project Name and Folder

Select Device

Fami... All Families Devi... **PIC18F4550**

escoger el modelo del microcontrolador

< Back Next > Finish Cancel Help

New Project

Steps

1. Choose Project
2. Select Device
3. Select Header
4. Select Tool
5. Select Plugin Board
- 6. Select Compiler**
7. Select Project Name and Folder

Select Compiler

Compiler Toolchains
HI-TECH PICC18-PRO
HI-TECH PICC18-STD
mpasm
mpasm (v5.81) [C:\Program Files (x86)\Microchip\MPASM\v5.81]\Compiler
XC8 [Download Latest]
XC8 (v2.00) [C:\Program Files (x86)\Microchip\XC8\v2.00]\Compiler

X seleccionar MPASM

< Back Next > Finish Cancel Help

New Project

Steps

1. Choose Project
2. Select Device
3. ...

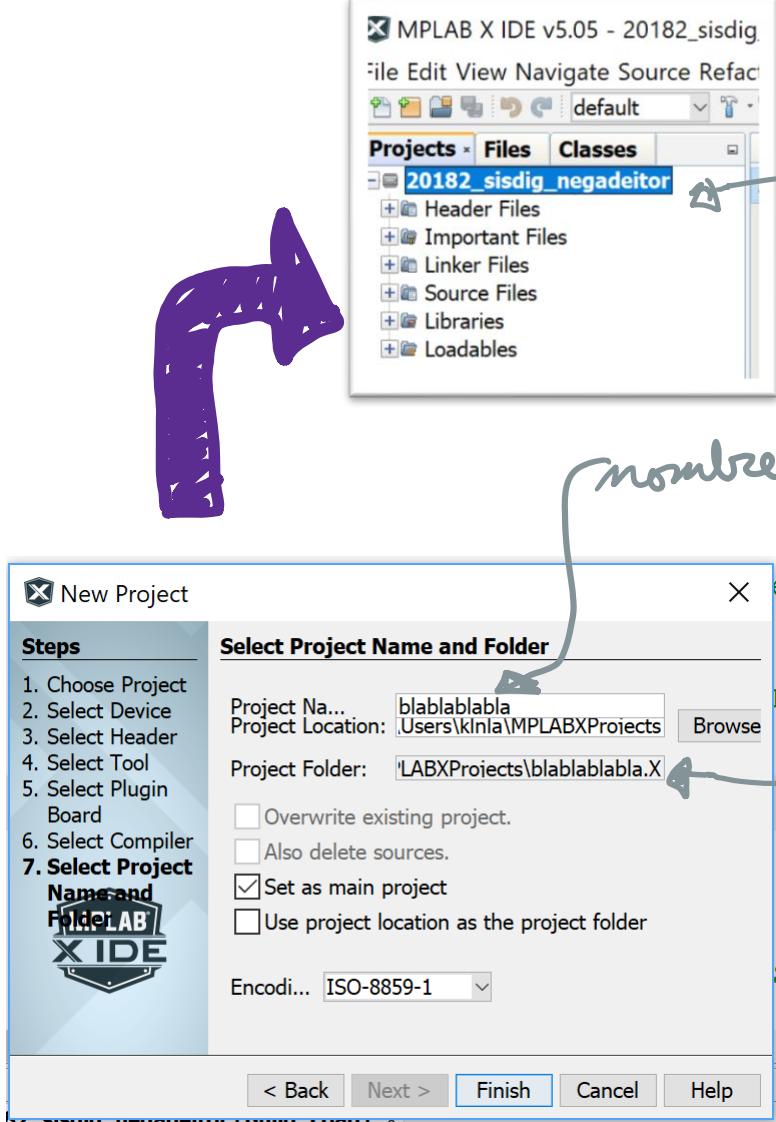
Select Tool

Atmel-ICE
ICD 3
ICD 4
PTK-Kit 4
PTK-Kit3
PM3
Real ICE
Simulator
Snap
Alternate Tools
EDBG
JTAGICE3
MEDBG
NEDBG
PICKIT2
Power Debudder

< Back Next > Finish Cancel Help

seleccionar PICKIT2

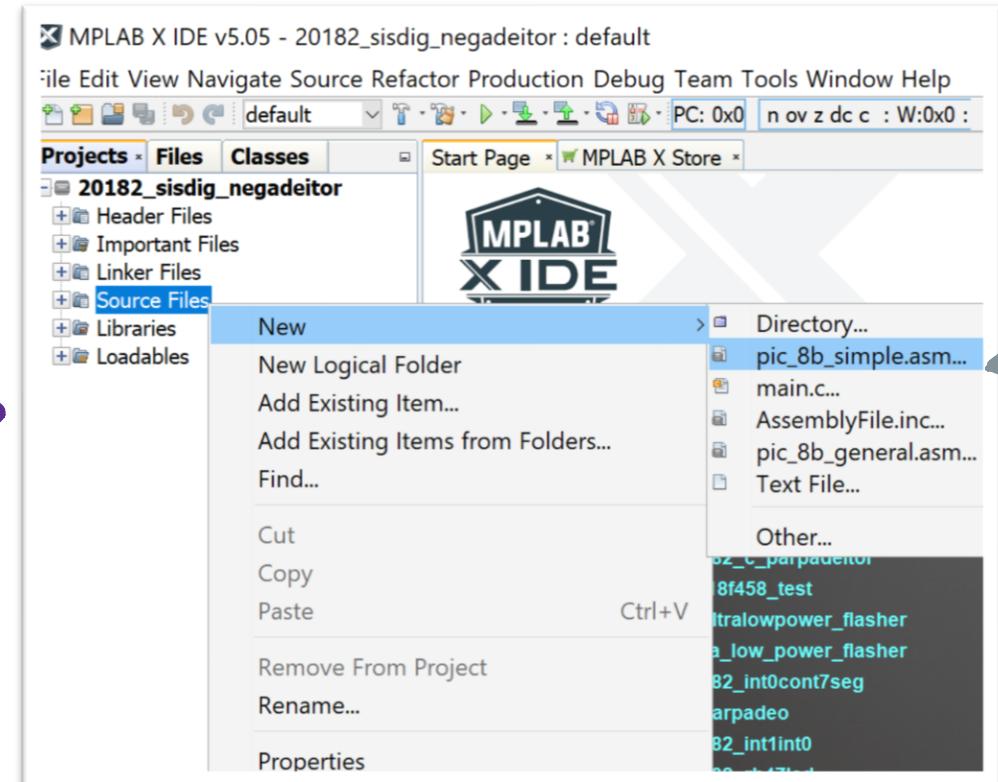
Creación del proyecto en el MPLAB X



proyecto creado

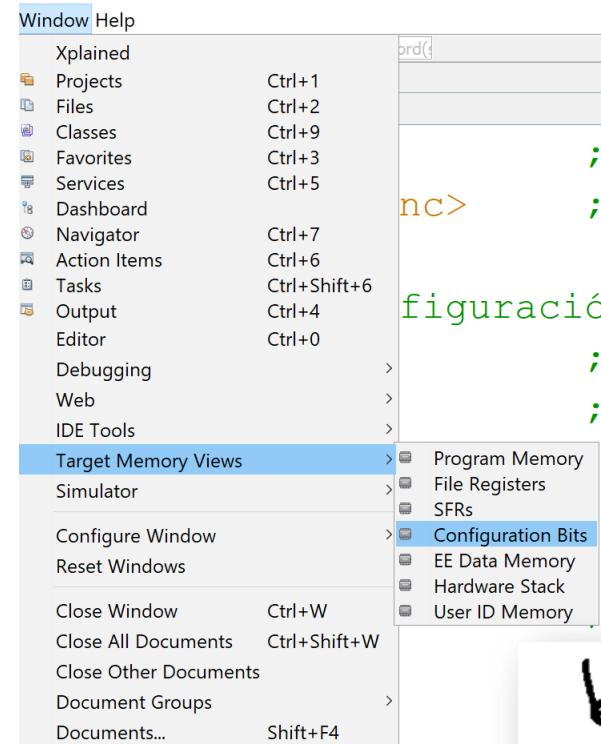
nombre del proyecto

verificar ruta donde
se va a almacenar
el proyecto



creación
de un
nuevo
archivo
fuente

Obtención de los bits de configuración



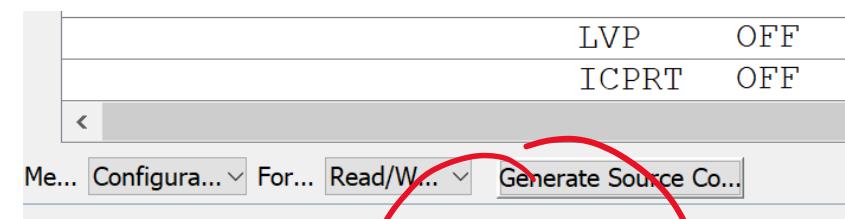
b<u>its de configuraci<u>ón:

CONFIG {

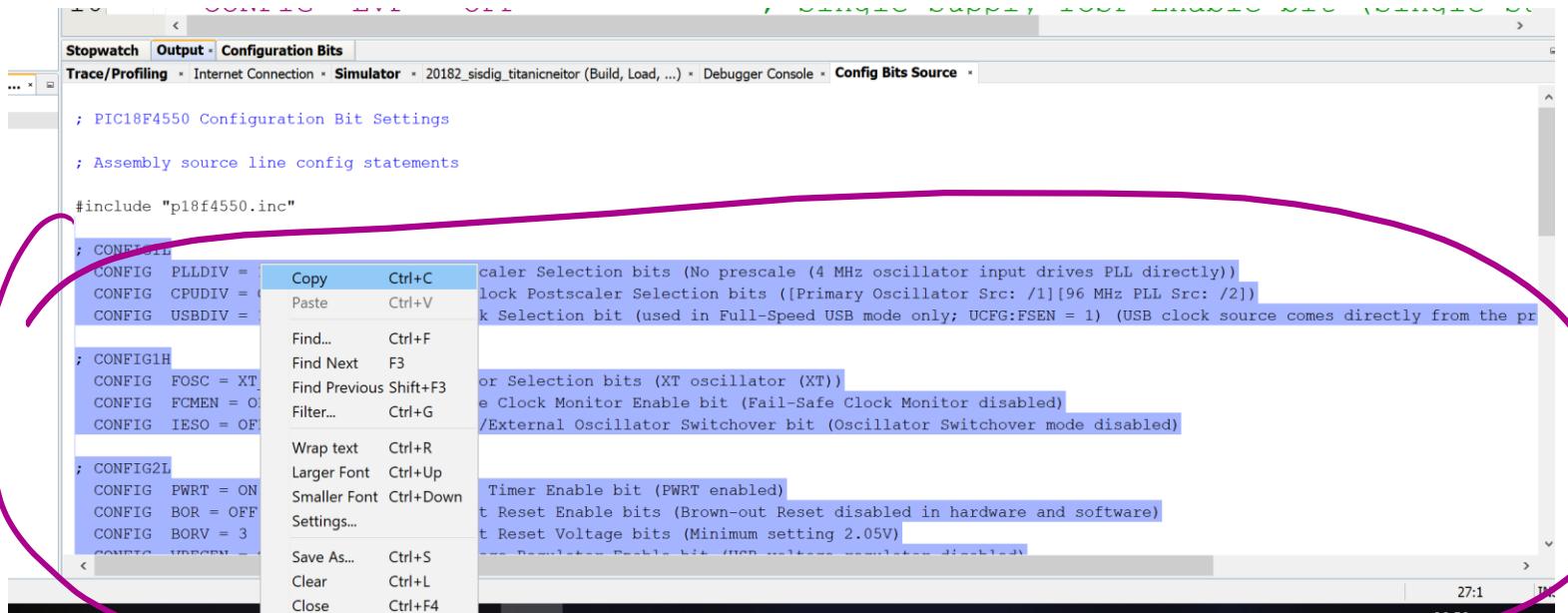
- PWRT = ON
- BOR = OFF
- PBADEN = OFF
- MCLRE = ON
- WDT = OFF
- LVP = OFF
- FOSC = XT-XT

The screenshot shows the 'Configuration Bits' table in the Xplained IDE. The table has columns for Address, Name, Value, Field, Option, Category, and Setting. The table lists various configuration bits with their current values and descriptions. A pink hand icon is drawn over the table, pointing towards the 'Value' column.

Address	Name	Value	Field	Option	Category	Setting
300000	CONFIG1L 00	1	PLL DIV	1	PLL Prescaler Selection bits	No prescale (4 MHz oscillator in
			CPUDIV	OSC1_PLL2	System Clock Postscaler Selectio...	[Primary Oscillator Src: /1][96]
			USBDIV	1	USB Clock Selection bit (used in...	USB clock source comes directly
300001	CONFIG1H 00	XT	FOSC	XT	Oscillator Selection bits	XT oscillator (XT)
			FCMEN	OFF	Fail-Safe Clock Monitor Enable bit	Fail-Safe Clock Monitor disabled
			IESO	OFF	Internal/External Oscillator Swi...	Oscillator Switchover mode disab
300002	CONFIG2L 18	ON	PWRT	ON	Power-up Timer Enable bit	PWRT enabled
			BOR	OFF	Brown-out Reset Enable bits	Brown-out Reset disabled in hard
			BORV	3	Brown-out Reset Voltage bits	Minimum setting 2.05V
			VREGEN	OFF	USB Voltage Regulator Enable bit	USB voltage regulator disabled
300003	CONFIG2H 1E	OFF	WDT	OFF	Watchdog Timer Enable bit	WDT disabled (control is placed
			WDTPS	32768	Watchdog Timer Postscale Select ...	1:32768
300005	CONFIG3H 81	ON	CCP2MX	ON	CCP2 MUX bit	CCP2 input/output is multiplexed
			PBADEN	OFF	PORPB A/D Enable bit	PORPB<4:0> pins are configured a
			LPT1OSC	OFF	Low-Power Timer 1 Oscillator Ena...	Timer1 configured for higher pow
			MCLR	ON	MCLR Pin Enable bit	MCLR pin enabled; RE3 input pin
300006	CONFIG4L 81	ON	STVREN	ON	Stack Full/Underflow Reset Enabl...	Stack full/underflow will cause
			LVP	OFF	Single-Supply ICSP Enable bit	Single-Supply ICSP disabled
			ICPRT	OFF	Dedicated In-Circuit Debug/Progr...	ICPORT disabled



Obtención de los bits de configuración



```
; PIC18F4550 Configuration Bit Settings
; Assembly source line config statements

#include "p18f4550.inc"

; CONFIG1L
CONFIG PLLEDIV = 0           ; Prescaler Selection bits (No prescale (4 MHz oscillator input drives PLL directly))
CONFIG CPUDIV = 0             ; Lock Postscaler Selection bits ([Primary Oscillator Src: /1][96 MHz PLL Src: /2])
CONFIG USBDIV = 0             ; USB Selection bit (used in Full-Speed USB mode only; UCFG:FSEN = 1) (USB clock source comes directly from the primary oscillator)

; CONFIG1H
CONFIG FOSC = XT             ; Oscillator Selection bits (XT oscillator (XT))
CONFIG FCMDEN = OFF           ; Clock Monitor Enable bit (Fail-Safe Clock Monitor disabled)
CONFIG IESO = OFF             ; External Oscillator Switchover bit (Oscillator Switchover mode disabled)

; CONFIG2L
CONFIG PWRT = ON              ; Timer Enable bit (PWRT enabled)
CONFIG BOR = OFF               ; Brown-out Reset Enable bits (Brown-out Reset disabled in hardware and software)
CONFIG BORV = 3                ; Brown-out Reset Voltage bits (Minimum setting 2.05V)

; CONFIG2H
CONFIG MCLRE = ON             ; MCLR Pin Function Selection
CONFIG WDT = OFF               ; Watchdog Timer Enable bit (WDT disabled)
CONFIG LVP = OFF               ; Low-Voltage Programming Enable bit (LVP disabled)
CONFIG FOSC = XT-XT            ; Oscillator Selection bits (XT oscillator (XT))
```

bits de configuración:

CONFIG

- PWRT = ON
- BOR = OFF
- PBDEN = OFF
- MCLRE = ON
- WDT = OFF
- LVP = OFF
- FOSC = XT-XT

Copias y pegas a tu código, luego
borras los bits que no has modificado

Plantilla y código del programa

```
1      list p=18f4550           ;Modelo del microcontrolador
2      #include <p18f4550.inc>    ;librería de nombres
3
4      ;Zona de los bits de configuración del microcontrolador
5      CONFIG FOSC = XT_XT        ; Oscillator Selection bits (XT oscillator (XT))
6      CONFIG PWRT = ON          ; Power-up Timer Enable bit (PWRT enabled)
7      CONFIG BOR = OFF          ; Brown-out Reset Enable bits (Brown-out Reset disabled in hardware and software)
8      CONFIG WDT = OFF          ; Watchdog Timer Enable bit (WDT disabled (control is placed on the SWDTEN bit))
9      CONFIG PBADEN = OFF        ; PORTB A/D Enable bit (PORTB<4:0> pins are configured as digital I/O on Reset)
10     CONFIG LVP = OFF          ; Single-Supply ICSP Enable bit (Single-Supply ICSP disabled)
11
12     org 0x0000                ;Vector de reset
13     goto configura
14
15     org 0x0020                ;Zona de programa de usuario
16 configura:
17     bcf TRISD, 0              ;Puerto D0 como salida
18     bsf TRISB, 0              ;Puerto B0 como entrada
19 inicio:
20     btfss PORTB, 0
21     goto falson
22 verdaderon:
23     bcf LATD, 0
24     goto inicio
25 falson:
26     bsf LATD, 0
27     goto inicio
28
29 end
```

File Edit View Navigate Source Refactor Production Debug Tools



Projects Files Classes

Start Page MPLAB X Sto

botón para compilar el proyecto

Ventana de salida (output)

```
IPLINK 5.09, LINKER
Device Database Version 1.44
Copyright (c) 1998-2011 Microchip Technology Inc.
Errors : 0

IP2HEX 5.09, COFF to HEX File Converter
Copyright (c) 1998-2011 Microchip Technology Inc.
Errors : 0

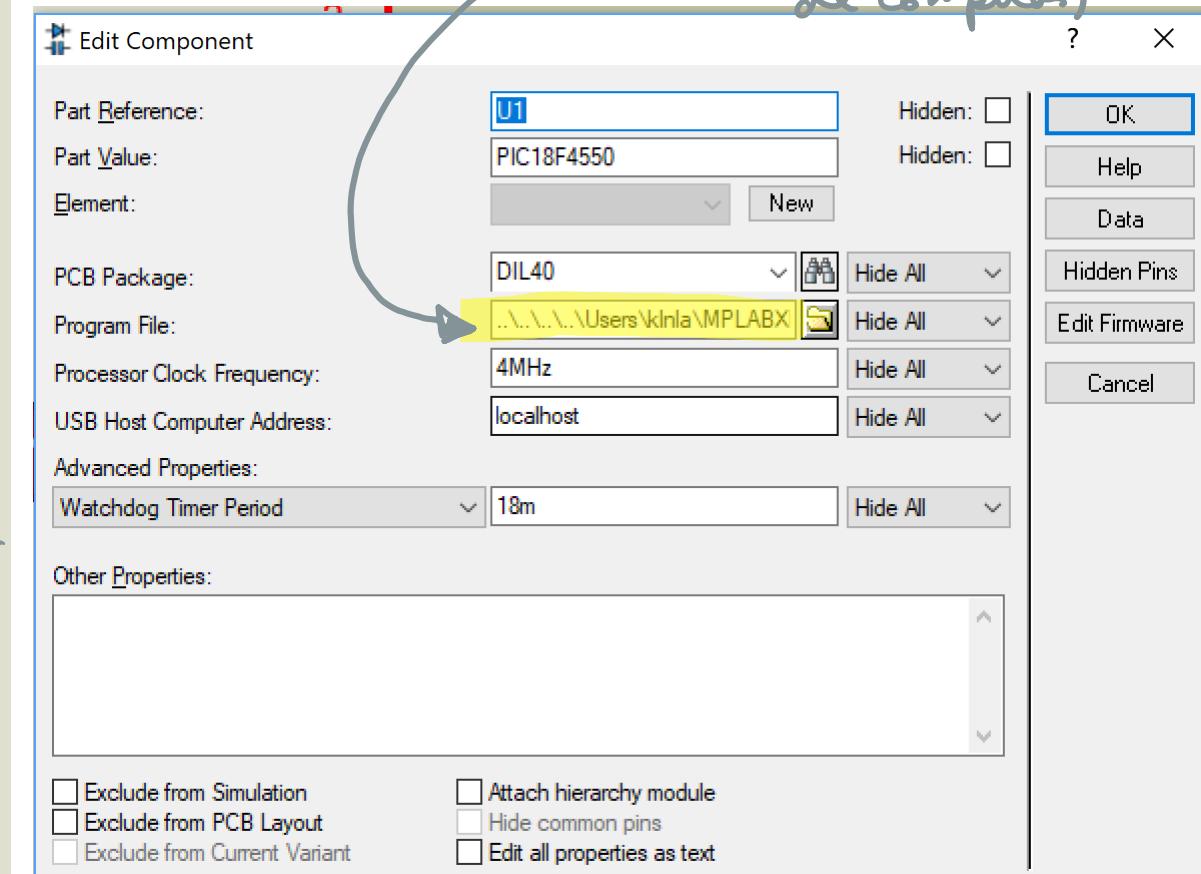
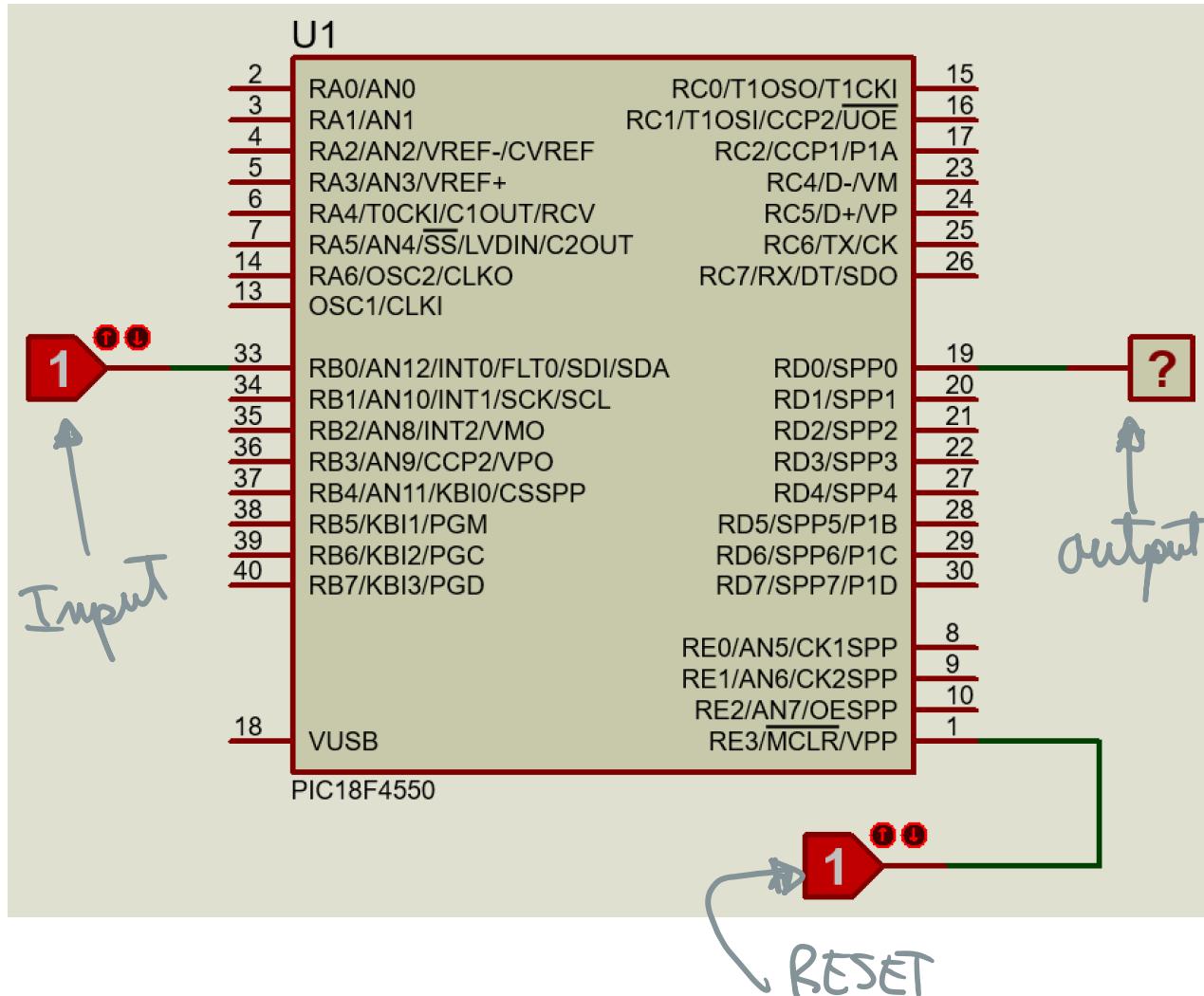
make[2]: Leaving directory 'C:/Users/klnla/MPLABXProjects/20182_sisdig_negadeitor.X'
make[1]: Leaving directory 'C:/Users/klnla/MPLABXProjects/20182_sisdig_negadeitor.X'

BUILD SUCCESSFUL (total time: 1s)
Loading code from C:/Users/klnla/MPLABXProjects/20182_sisdig_negadeitor.X/dist/default/production/20182_sisdig_negadeitor.X.production.
Loading completed
```

MPASM → *.asm
bin → *.hex
↑
lo que se usa
para grabar al PIC18F4550

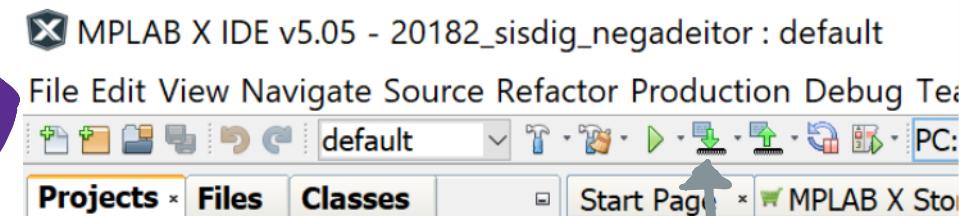
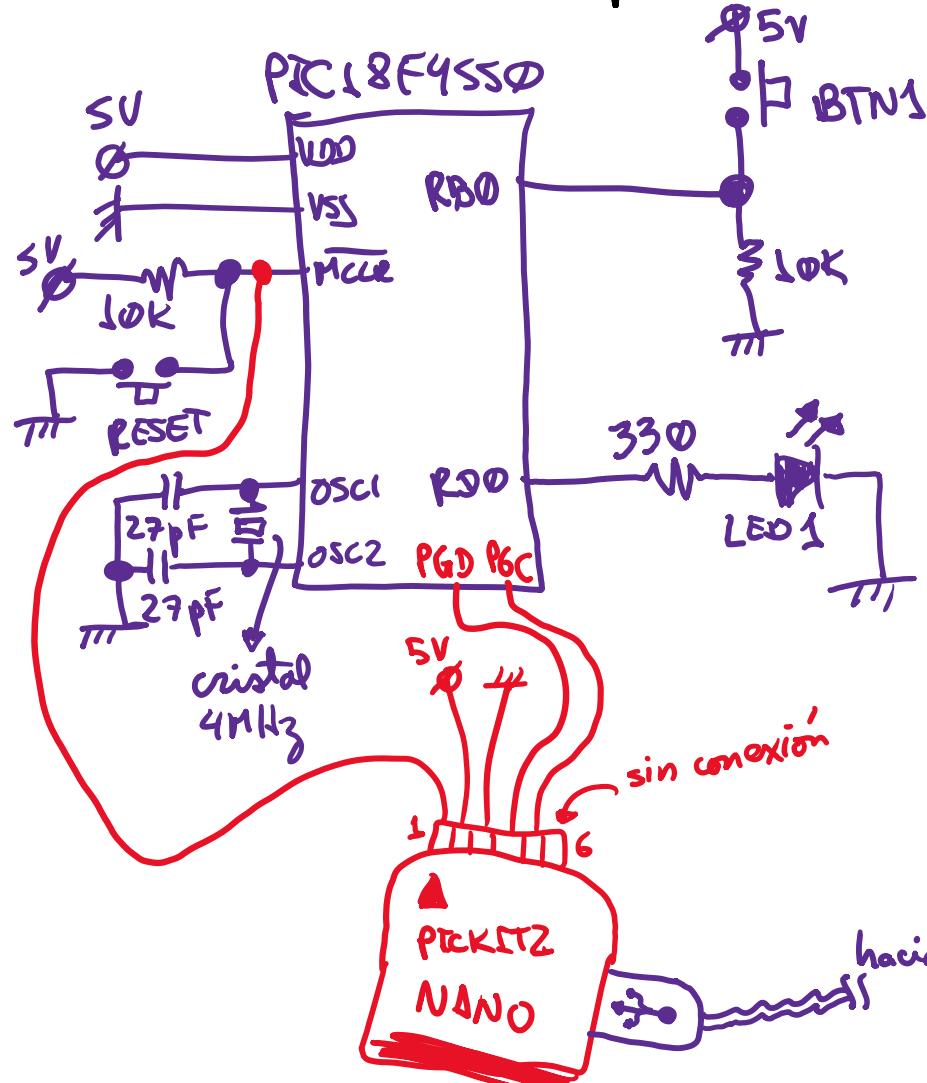
si "build successful" →
se creará el archivo
*.hex

Simulación en Proteus VSM



ventana de propiedades
del microcontrolador dentro
del diseño en Proteus (doble clic)

Conexión del PICKIT2 con el circuito de la aplicación:



boton para grabar el .hex en el microcontrolador usando el PICKIT2

The Output window displays the following log messages:

```

make[1]: Leaving directory 'C:/Users/ed/Desktop/Template.X'

BUILD SUCCESSFUL (total time: 303ms)
Loading code from C:/Users/ed/Desktop/Template.X/dist/default/production/Template.X.hex
Loading completed
Connecting to programmer...
Programming target...
Programming completed
Running target...

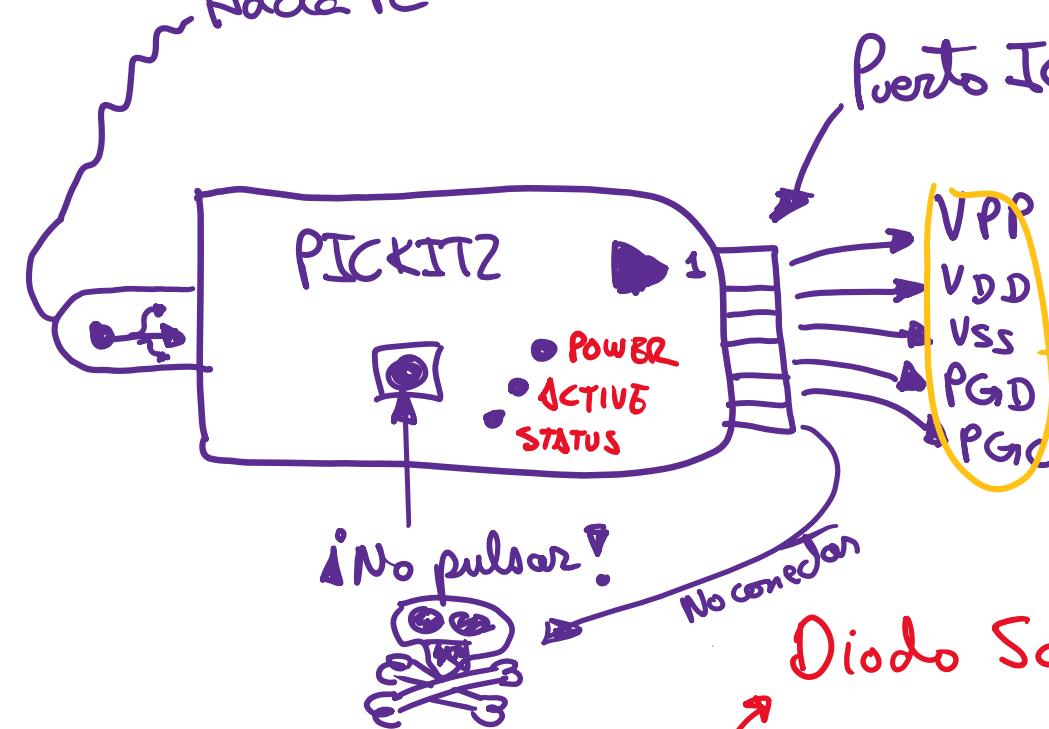
```

A callout points to the "Programming completed" message with the handwritten note: "aplicación corriendo en el circuito".

(verificar que el PICKIT2 se encuentre reconocido por el S.O. Windows)

A tener en cuenta

Hacia PC



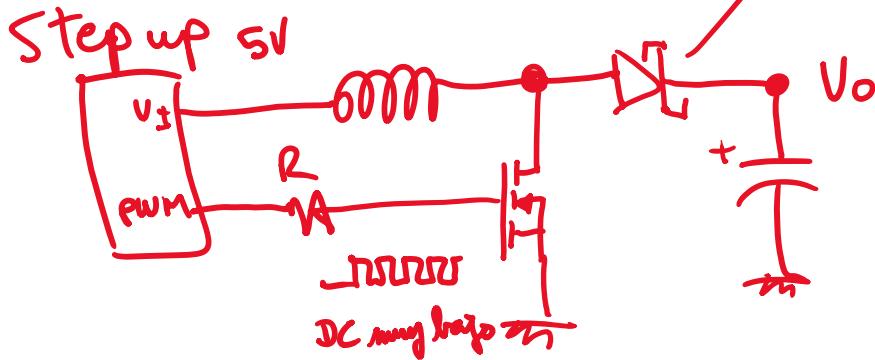
Puerto ICSP (5 pines)

Modo programación

PIC18F4550

5V ó 12V

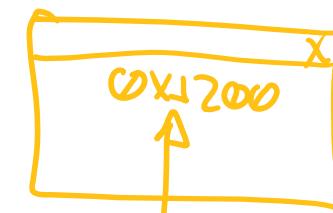
Conexiones bien hechas.



Diodo Schottky

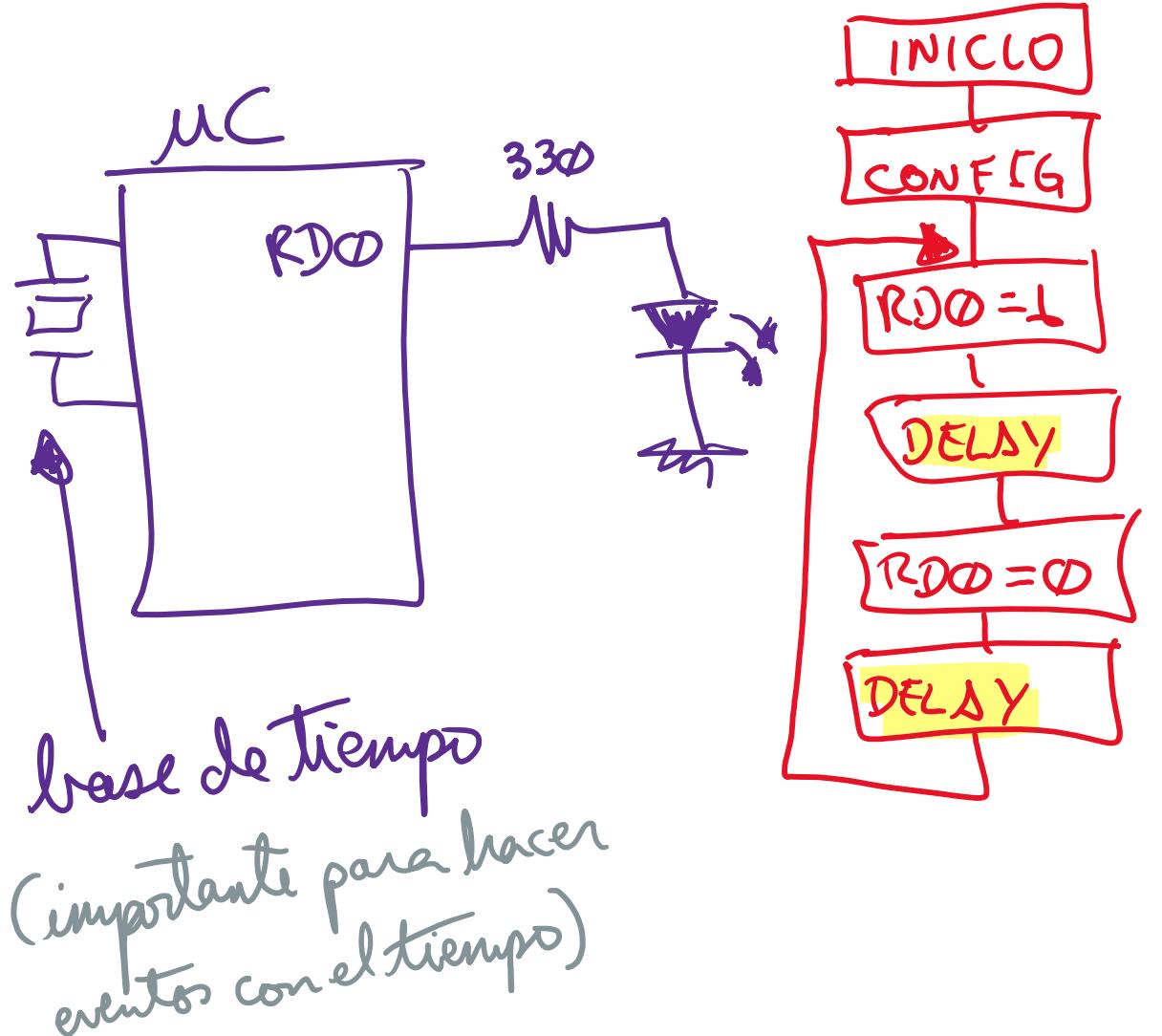
Cuidado!:
cuando parpadea

LED STATUS \Rightarrow Corto circuito en la app



Problemas
de conexión

Titanicneitor: Titilar un LED



¿Cuánto de instrucción?

↳ Cuanto se demora en ejecutar una instrucción

$$F_{osc}/4$$

$$4\text{MHz}/4 = 1\text{MHz}$$

$$T = \frac{1}{f} = 1\mu\text{s}$$

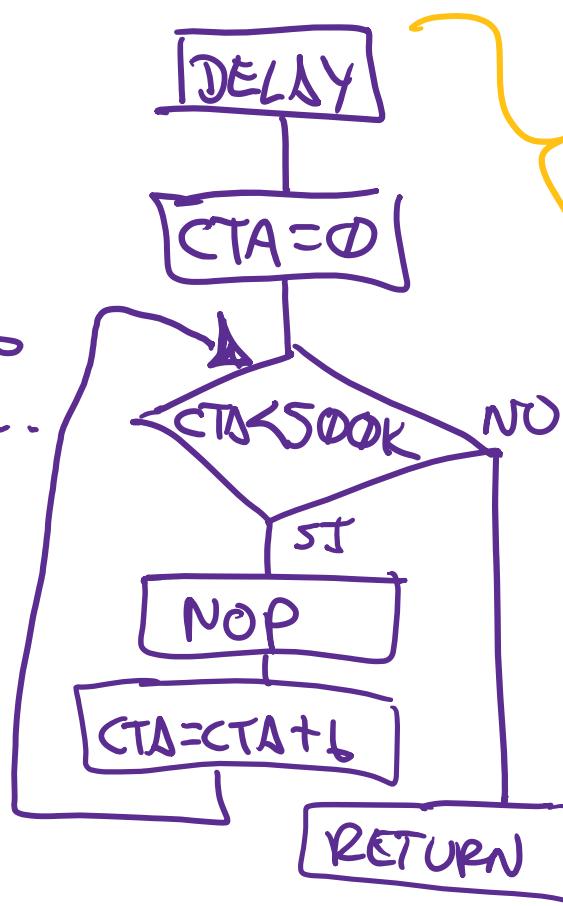
⇒ "Mop" demora 1μs cuando cristal = 4MHz

Titanicneitor: Titilar un LED

Requerimos generar un DELAY ...

~~mop
mop
:~~} Requeriremos
500000 mops
para un retraso
de 500ms ..

No alcanza en la
memoria de programa!



Restricción: el MC
PIC 18F4550 no puedes
colocar 500000, solo
tiene registros de 8 bits
(max 255 de)

En alto nivel:

```
For (int i=0; i<250; i++){  
    For (int j=0; j<250; j++){  
        {mop} → 62500 mops  
    }  
}
```

Instrucciones de decremento e incremento de un registro

decremento [reg] y pregunta si llegó a cero ($Z=1$)

✓ $\text{decfsz } [\text{reg}], d$

incfsz

instrucción complemento a decfsz
(incremento y pregunta si llegó a cero)

✓ $\text{decf } [\text{reg}], f$

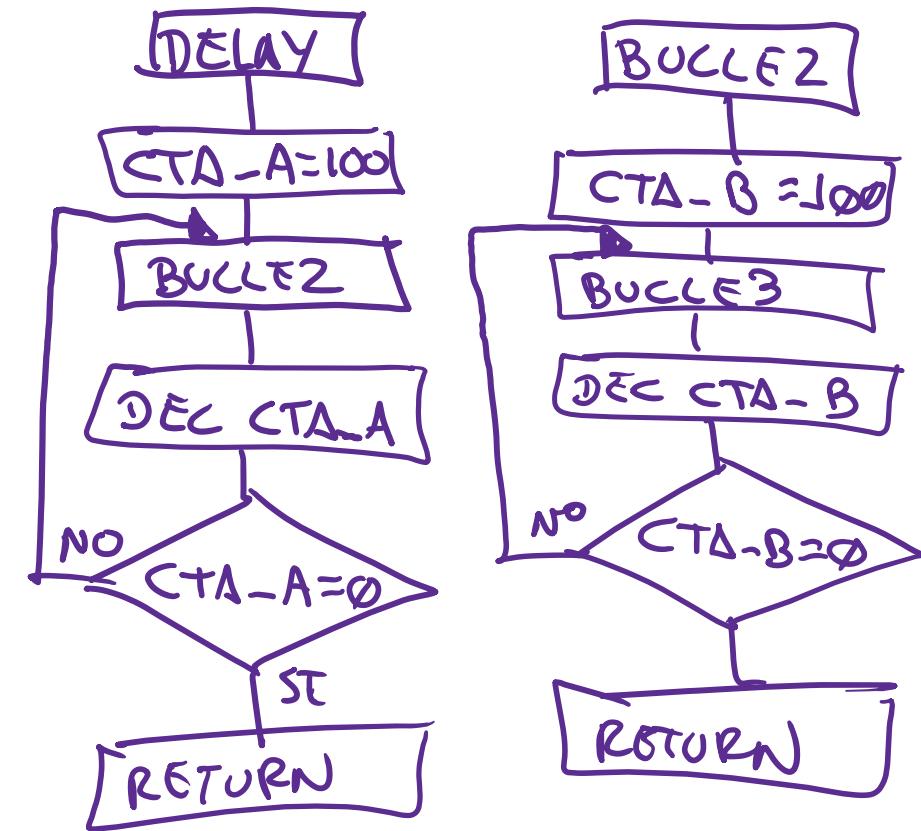
$\text{btts STATUS}, Z$

incf

instrucción complemento a decf
(decremento)

Titanicneitor: Titilar un LED

→ Necesitarán 3 anillos de repetición para alcanzar $\text{DELAY} \sim 500\text{ms}$.



Ejemplo de codificación en base al diagrama de flujo

bucle3:

```
movlw .10  
movwf cta_c
```

otro3:

```
nop
```

decfsz cta_c, f
goto otro3
return

Codificación en Assembler del Titanicneitor

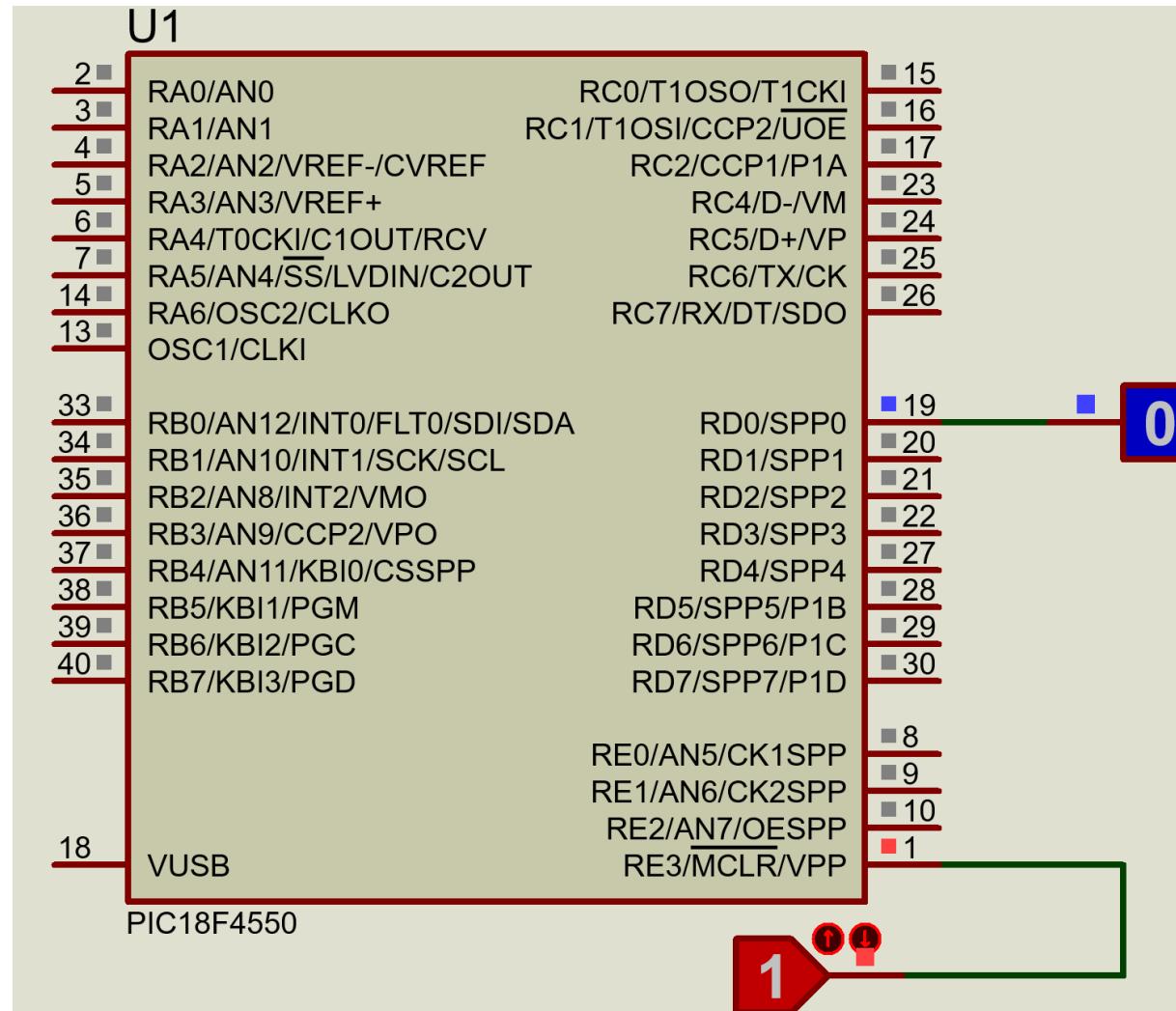
```
1      list p=18f4550          ;Modelo del microcontrolador
2      #include <p18f4550.inc>    ;librería de nombres
3
4      ;Zona de los bits de configuración del microcontrolador
5      CONFIG FOSC = XT_XT        ; Oscillator Selection bits (XT oscillator (XT))
6      CONFIG PWRT = ON          ; Power-up Timer Enable bit (PWRT enabled)
7      CONFIG BOR = OFF          ; Brown-out Reset Enable bits (Brown-out Reset disabled (BOR))
8      CONFIG WDT = OFF          ; Watchdog Timer Enable bit (WDT disabled (controlled by SWDTEN))
9      CONFIG PBADEN = OFF        ; PORTB A/D Enable bit (PORTB<4:0> pins are configured as digital inputs)
10     CONFIG LVP = OFF          ; Single-Supply ICSP Enable bit (Single-Supply ICSP disabled)
11
12     cblock 0x0020
13         cta_a
14         cta_b
15         cta_c
16     endc
17
18     org 0x0000                ;Vector de reset
19     goto configura
20
21     org 0x0020                ;Zona de programa de usuario
22 configura:
23     bcf TRISD, 0              ;Para hacer que el puerto D0 sea salida
24 inicio:
25     bsf LATD, 0
26     call delaymon
27     bcf LATD, 0
28     call delaymon
29     goto inicio
```

} rutina principal

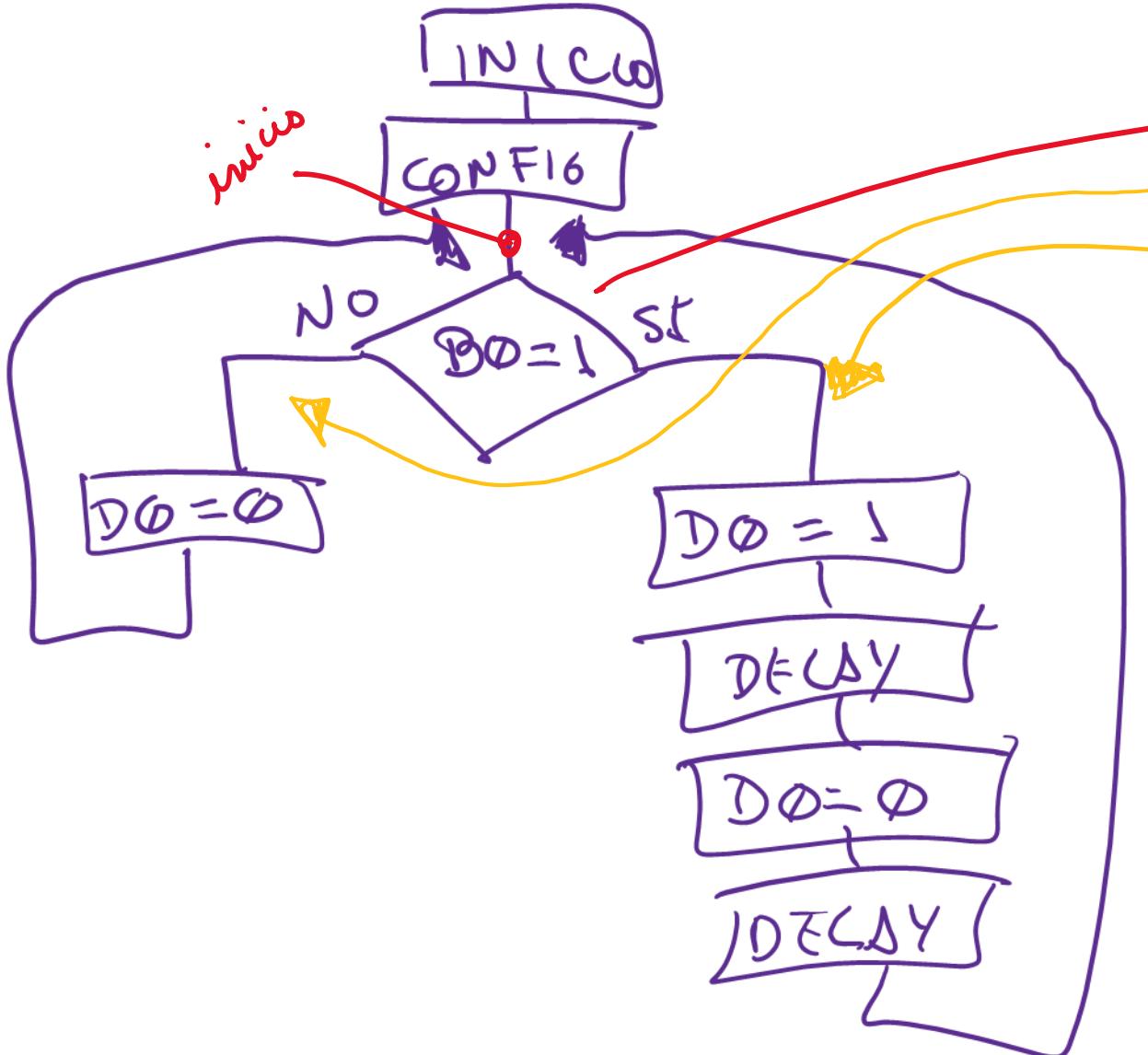
```
30
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58
delaymon:
    movlw .100
    movwf cta_a
otro1:
    call bucle2
    decfsz cta_a, f
    goto otro1
    return
bucle2:
    movlw .100
    movwf cta_b
otro2:
    call bucle3
    decfsz cta_b, f
    goto otro2
    return
bucle3:
    movlw .10
    movwf cta_c
otro3:
    nop
    decfsz cta_c, f
    goto otro3
    return
end
```

Subroutine
de retardo

Simulación en Proteus



Modificando rutina inicial del titilador: Añadiendo entrada de control



inicio:

btfss PORTB, 0
gote falso

bsf LATD, 0

call retardor

bcf LATD, 0

call retardor

gote inicio

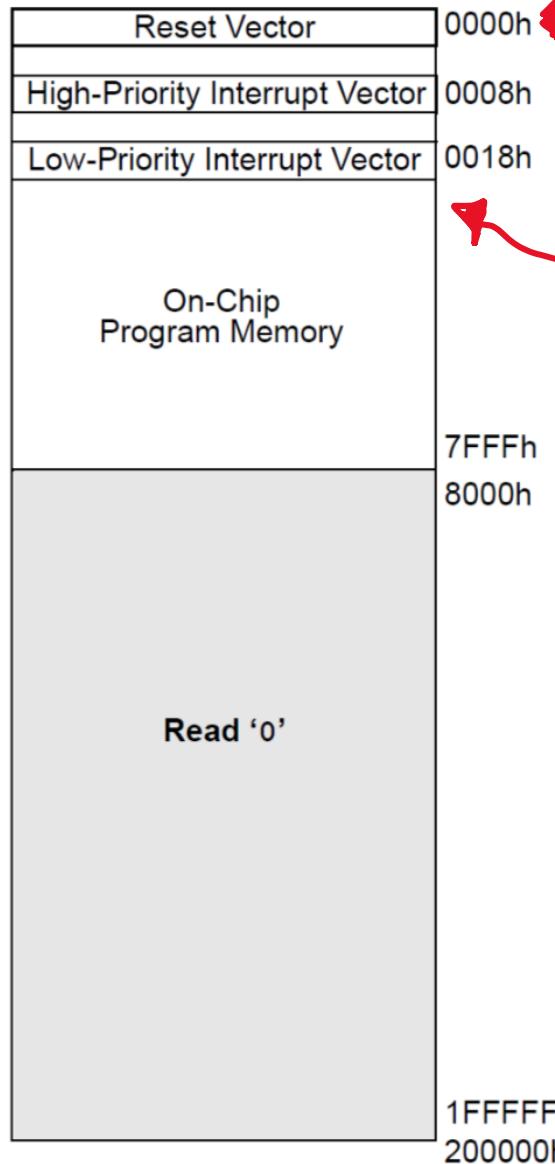
falso:

bcf LATD, 0

gote inicio

Recordando la memoria de programa:

Reservado



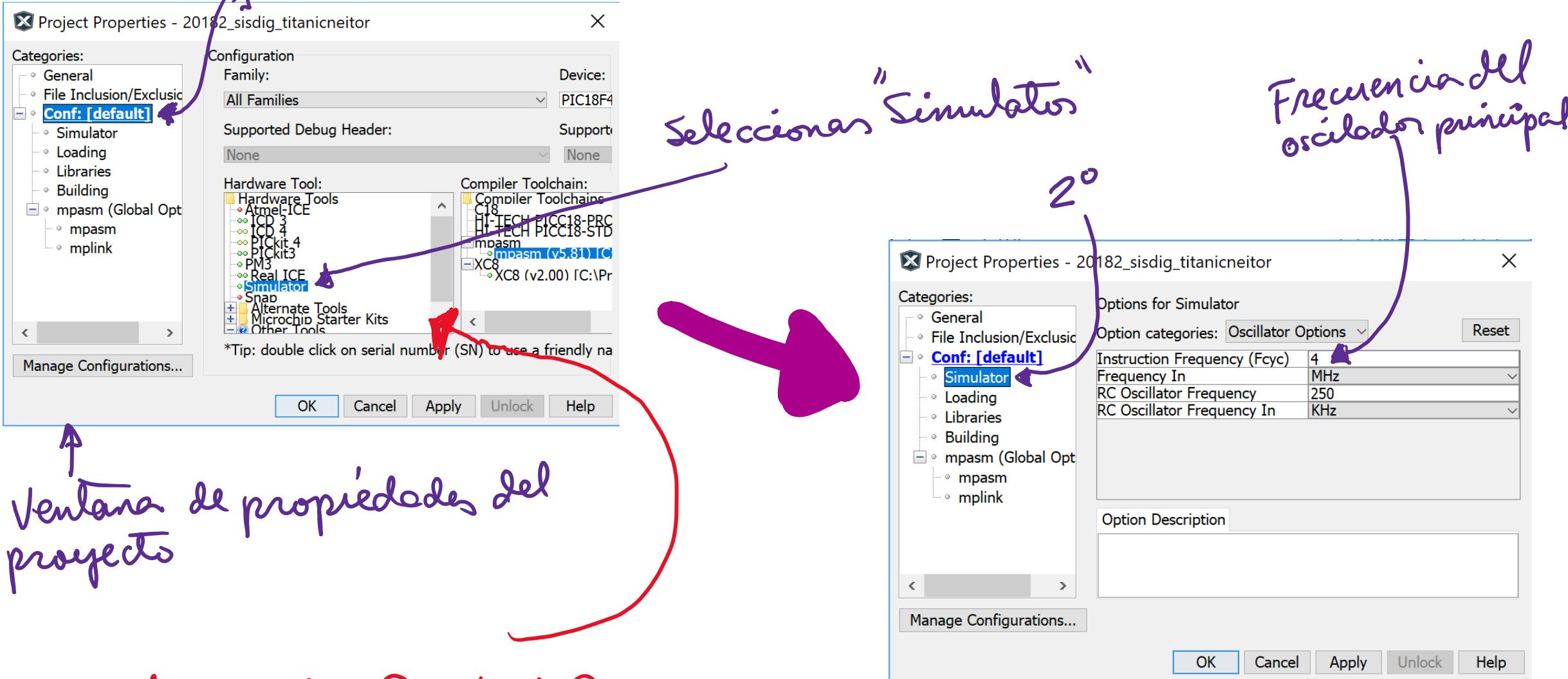
Aquí se dirige cuando hay un PoR,
energizado del UC ó desborde
de WDT (Watchdog Timer)

D partir de aquí se escribe el
programa de usuario

Power on
Reset

no implementado en el PIC18F4550

Usando el “stopwatch” del modo simulador del MPLAB X para obtener la duración de la subrutina de retardo

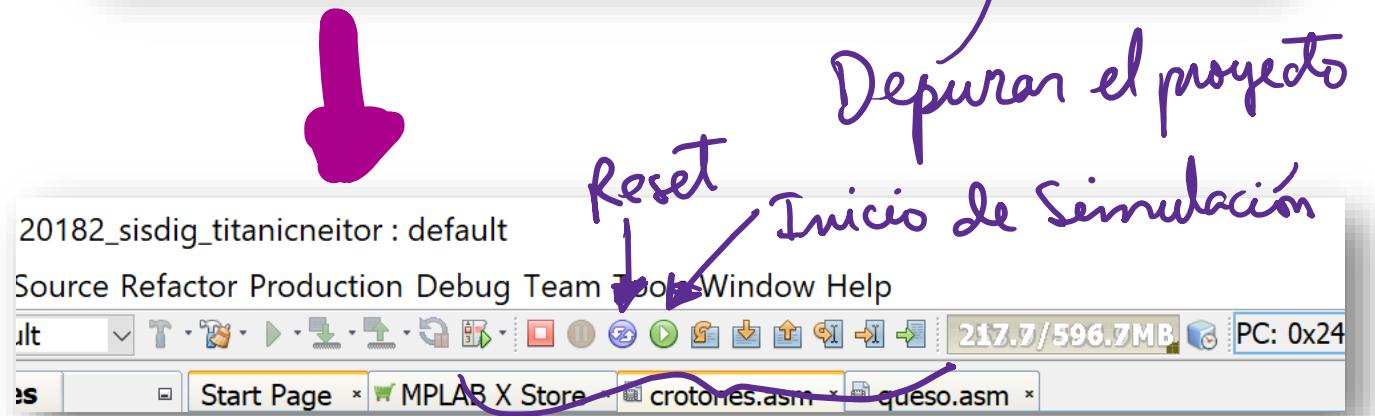
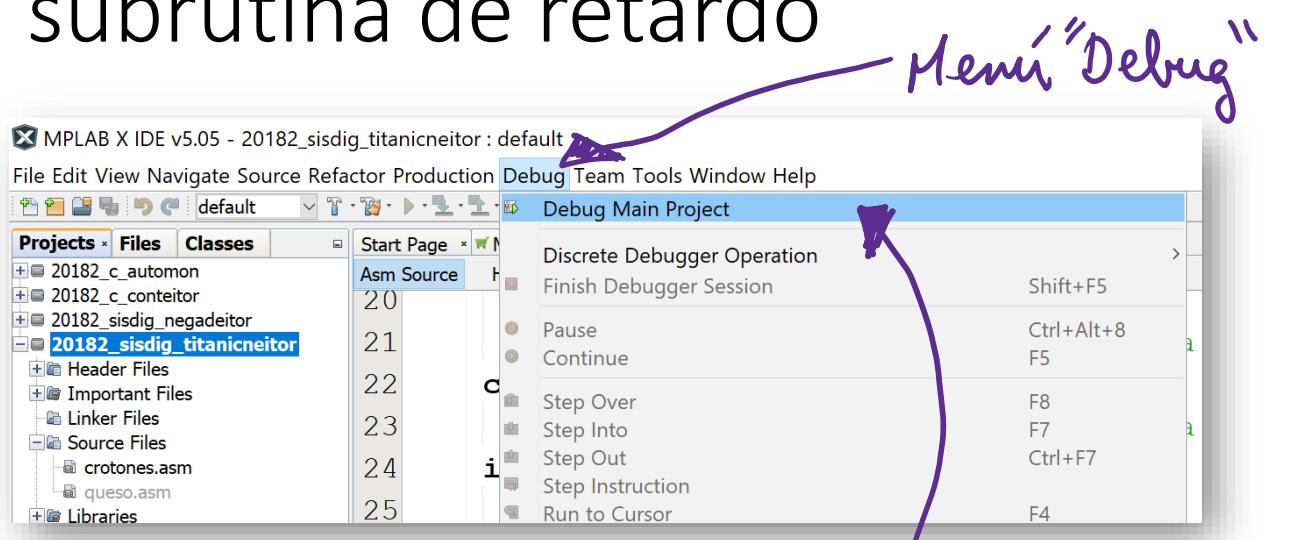
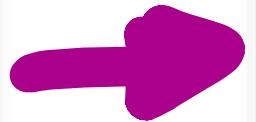


Cambiar de PICKit2 hacia Simulator !

Usando el “stopwatch” del modo simulador del MPLAB X para obtener la duración de la subrutina de retardo

```
24
25 inicio:
26     bsf LATD, 0
27     call delaymon
28     bcf LATD, 0
29     call delaymon
30     goto inicio
31
32 delaymon:
33     movlw .100
```

Establecer los breakpoints
(lugares donde se detendrá
la simulación) haciendo
 clic en el número



Se habilitarán estos
botones

Menú "Debug"

Usando el “stopwatch” del modo simulador del MPLAB X para obtener la duración de la subrutina de retardo

