11014 MS1

MPLAB® Simulator Fundamentals

Class Objective

- **When you finish this class you will be able to:**
  - Use MPLAB® Simulator to **test and debug** firmware
  - Create and apply simple **stimulus**
  - Use **Logic Analyzer** and **Instruction Trace**

Agenda

- **Understanding MPLAB® Simulator**
  - (demo)
- **Stimulus**
  - Asynchronous
  - Simple Synchronous
  - (Lab 1)
- **Tools of Simulator**
  - Stopwatch
  - Trace
  - Logic Analyzer
  - (Lab 2)

MPLAB® IDE and Simulator

What is MPLAB® Simulator?

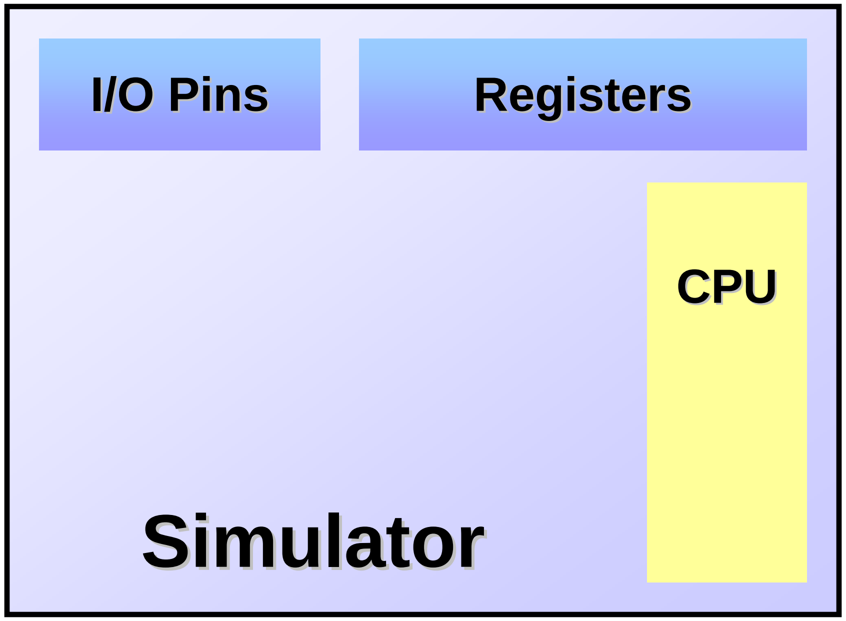
- One of the MPLAB® debuggers
- Supports all PIC® MCU & dsPIC® DSC families
  - Baseline
  - Mid-Range
  - PIC18
  - PIC24
  - dsPIC30
  - dsPIC33
- Speed
- Sophisticated stimulus engine

Why MPLAB® Simulator?

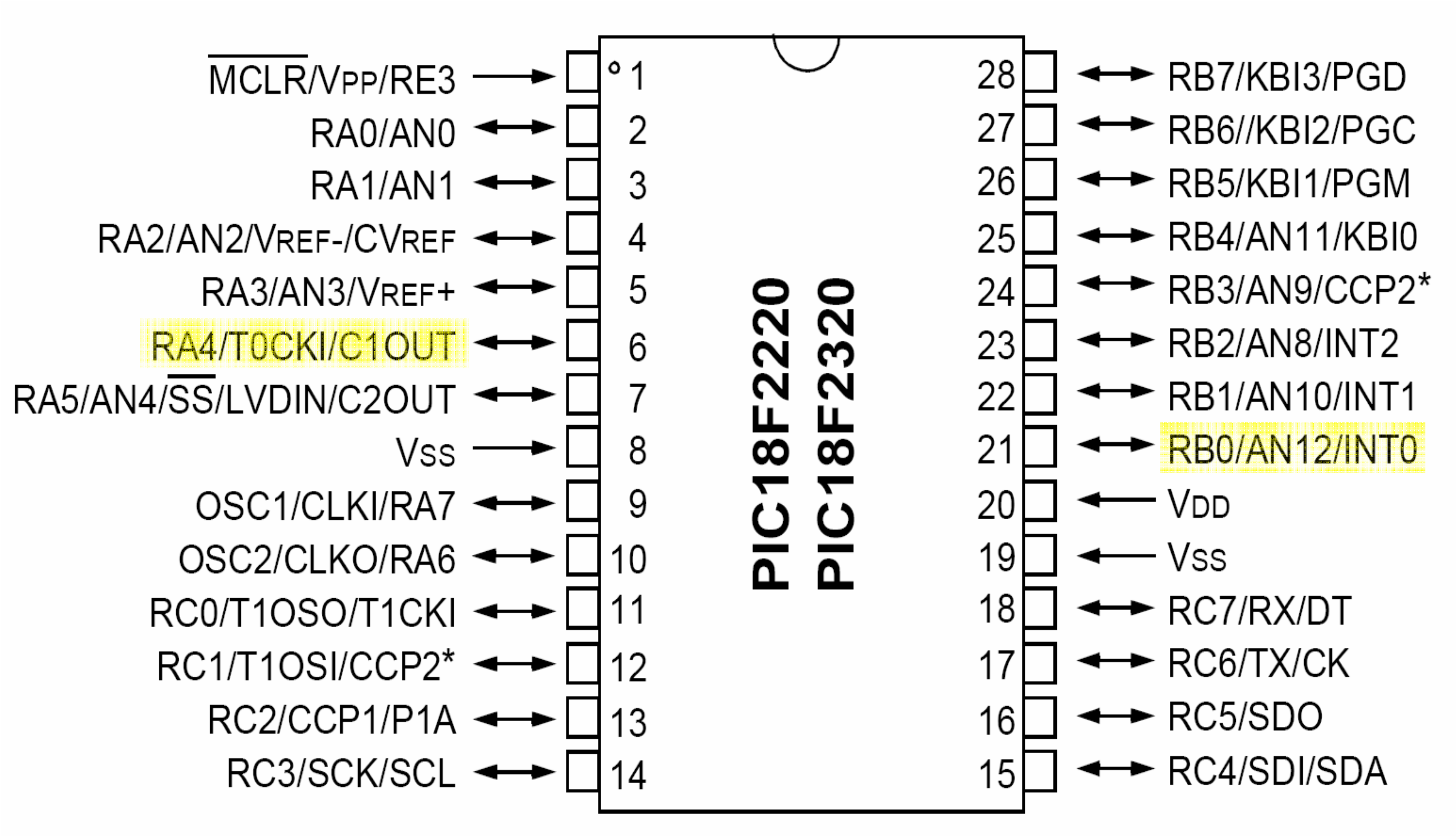
- **Pure software debugger**
  - Develop firmware before silicon arrives
  - Much faster than using ICD, ICE
- **Repeatable testing**
  - With pre-set stimulus
- **Load testing**
- **Free!**

Block Diagram of Simulator

- Cycle-based CPU simulation
- Registers
  - SFR (WREG, RXREG, T1CON)
  - GPR (2F0h)
- I/O Pins
  - RA0 (PORTA)
  - U1RX, T0CKI

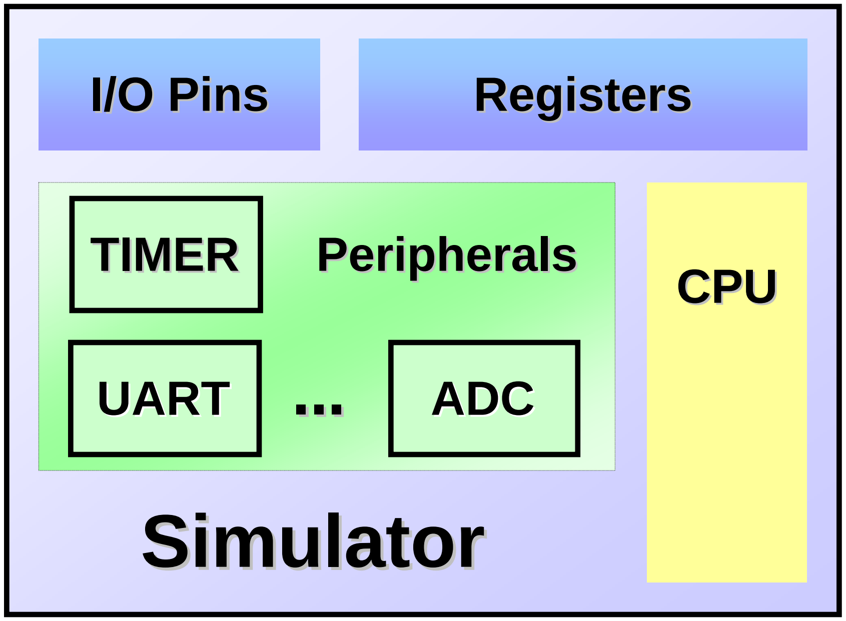


Alias Names of I/O Pins



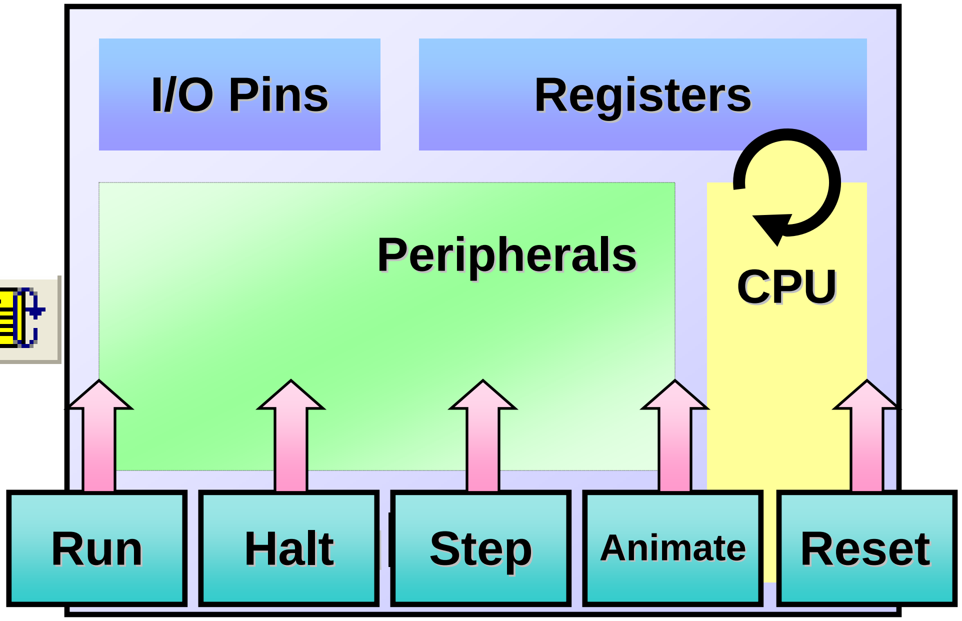
Block Diagram of Simulator

- Simulate behavior of peripherals
  - TIMER
  - UART, CCP, PWM, ADC
  - Input Capture
  - Output Compare
  - Comparator



Functions of Simulator

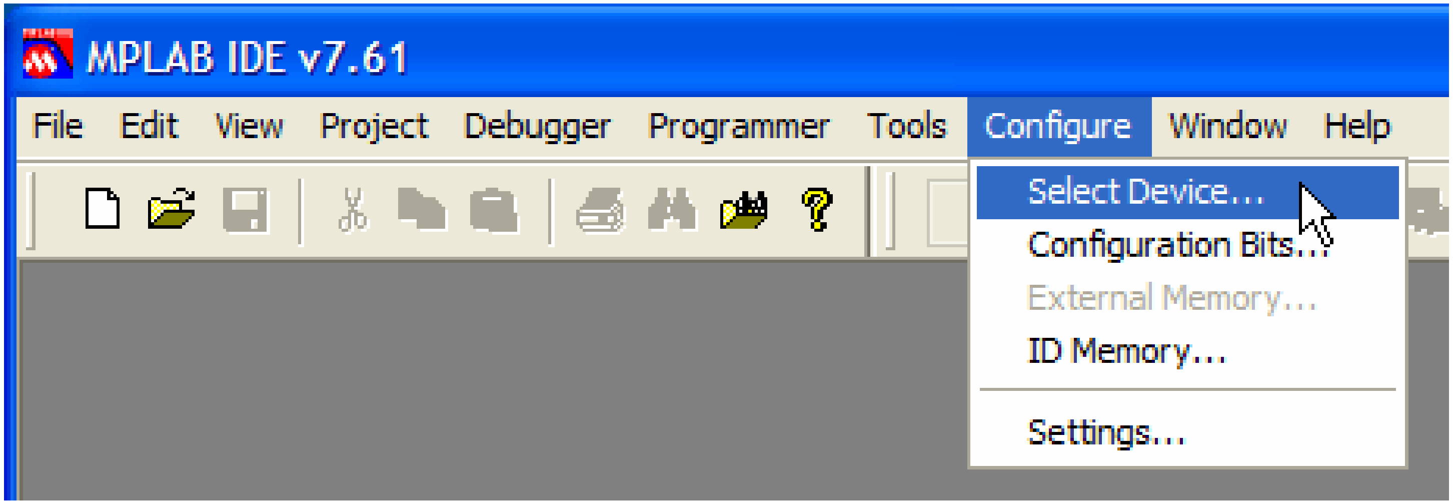
- Run: until breakpoint is reached ▶
- Halt: stop! ⏸
- Step Into {} Out {}
- Step Over {}
- Animate: slow ▶▶
- Reset: start over



Using Simulator

1. **Start MPLAB® IDE**
   Start>Programs>Microchip>MPLAB IDE >MPLAB IDE

2. **Select the right device**
   Configure>Select Device...



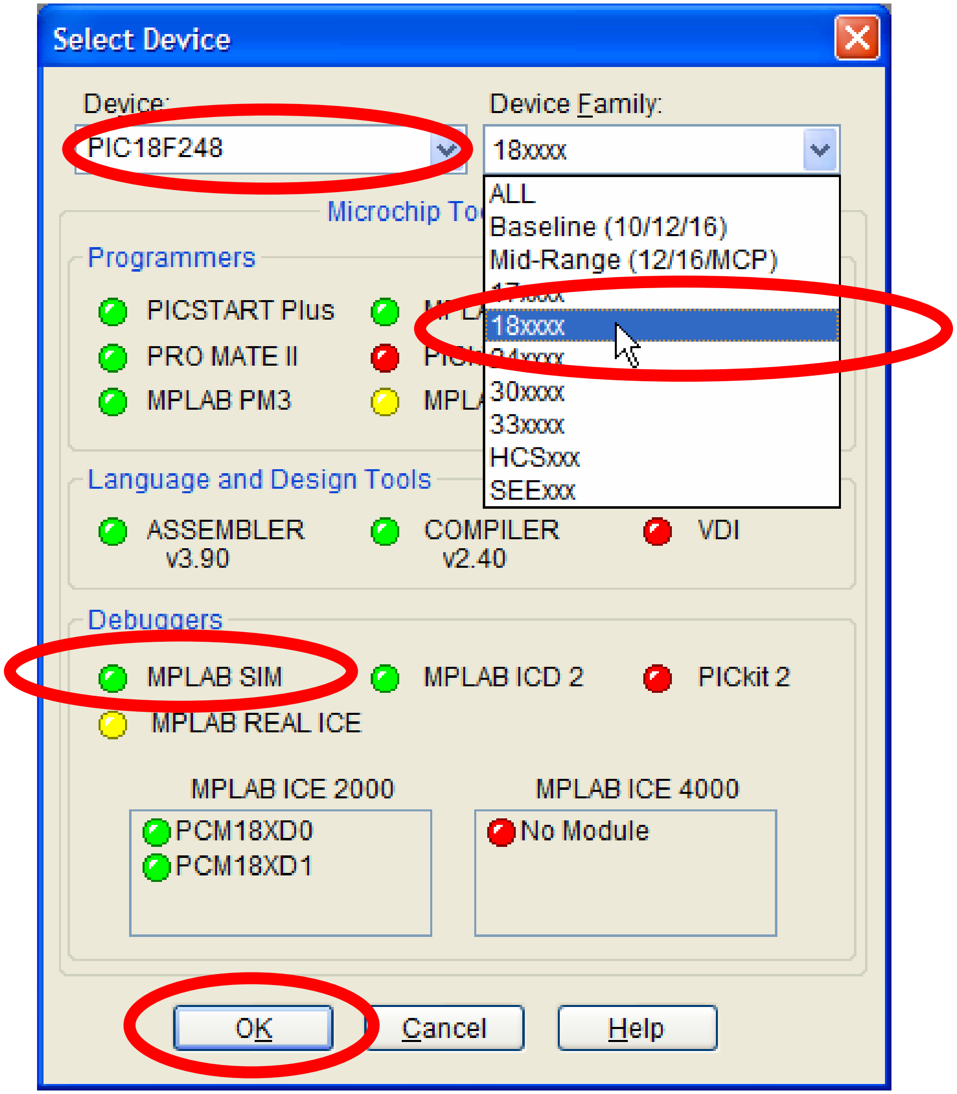
Select the Right Device

3. **Choose the Device Family**
4. **Then choose Device**
5. **Tool Support**

Green: *supported*

Yellow: *beta*

Red: *not ready*



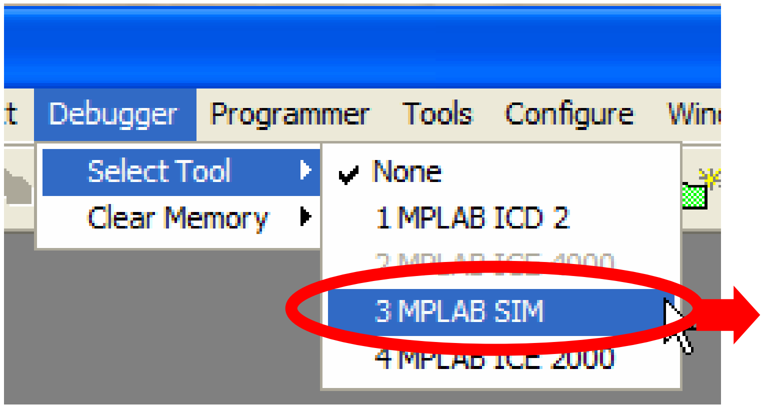
Select Device

Device: PIC18F248

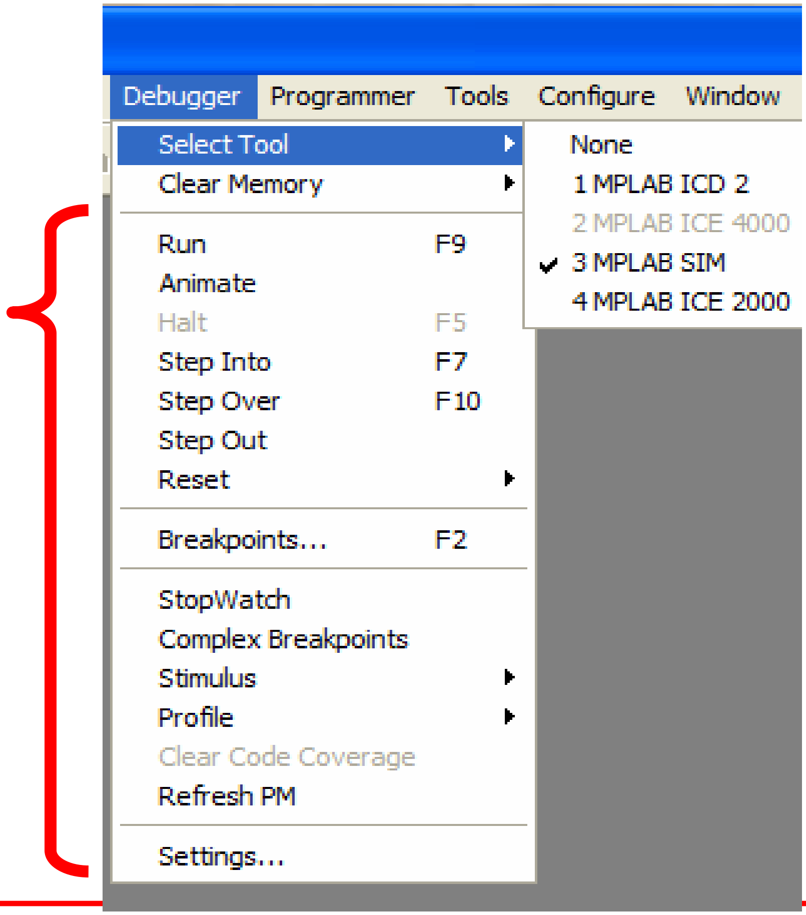
Device Family: 18xxxx

Simulator

6. **Select the Simulator**
   Debugger>Select Tool>MPLAB SIM

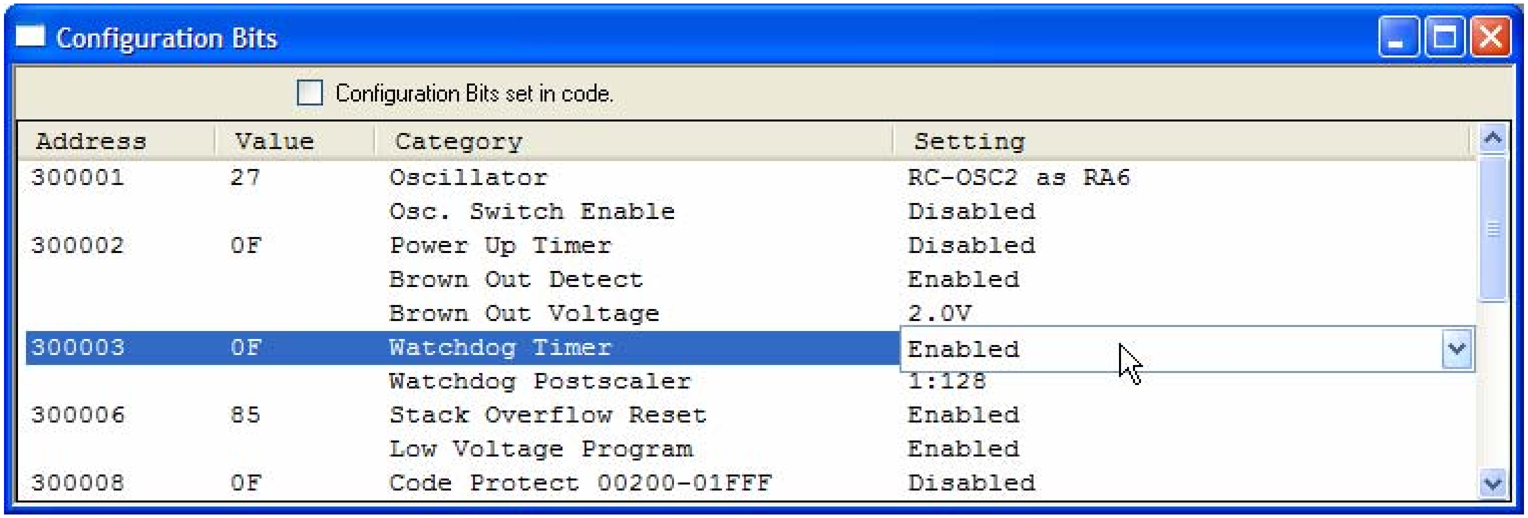


7. **Simulator functions available**



Simulator

8. **(Optional) Configure device**
   Configure>Configuration Bits...



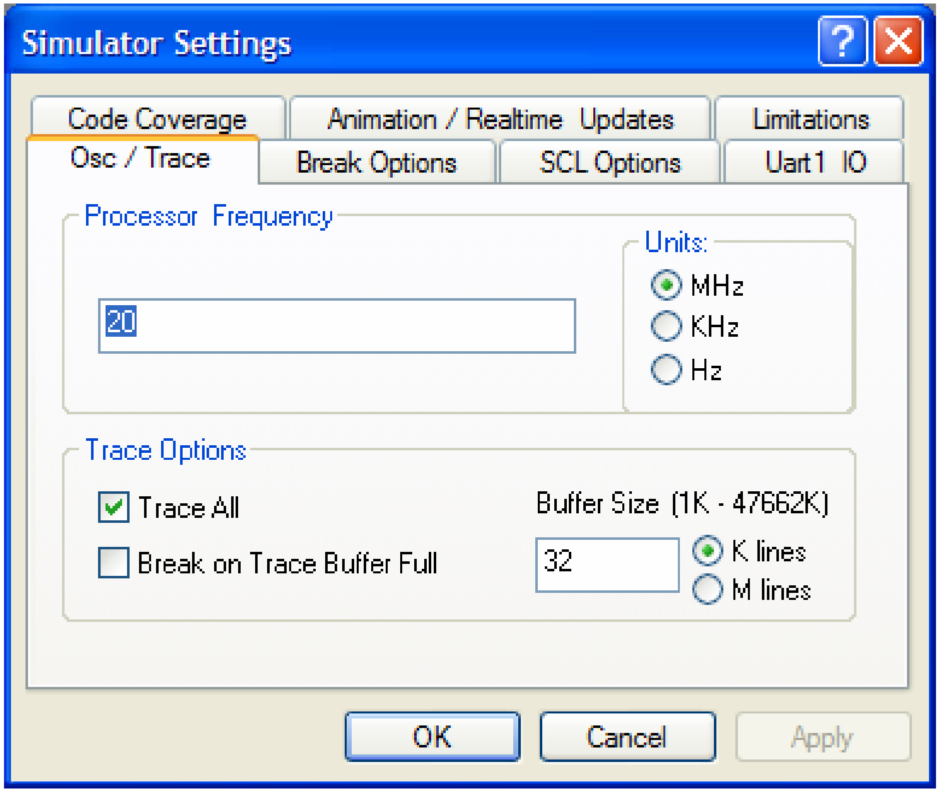
Address	Value	Category	Setting
300001	27	Oscillator	RC-OSC2 as RA6
		Osc. Switch Enable	Disabled
300002	0F	Power Up Timer	Disabled
		Brown Out Detect	Enabled
		Brown Out Voltage	2.0V
300003	0F	Watchdog Timer	Enabled
		Watchdog Postscaler	1:128
300006	85	Stack Overflow Reset	Enabled
		Low Voltage Program	Enabled
300008	0F	Code Protect 00200-01FFF	Disabled

- **Changes to configuration effective after next processor reset**
- **Alternatively, set these in code using __config directive**

Simulator

9. (Optional) Check Simulator Settings *Debugger>Settings...*

- Trace Options
- UART I/O
- Animation Speed
- Real time updates
- Break options
- Code Coverage



Processor Frequency

20

Units:
● MHz
○ KHz
○ Hz

Trace Options

☑ Trace All

□ Break on Trace Buffer Full

Buffer Size (1K - 47662K)

32
● K lines
○ M lines

Demo: Using MPLAB® Simulator

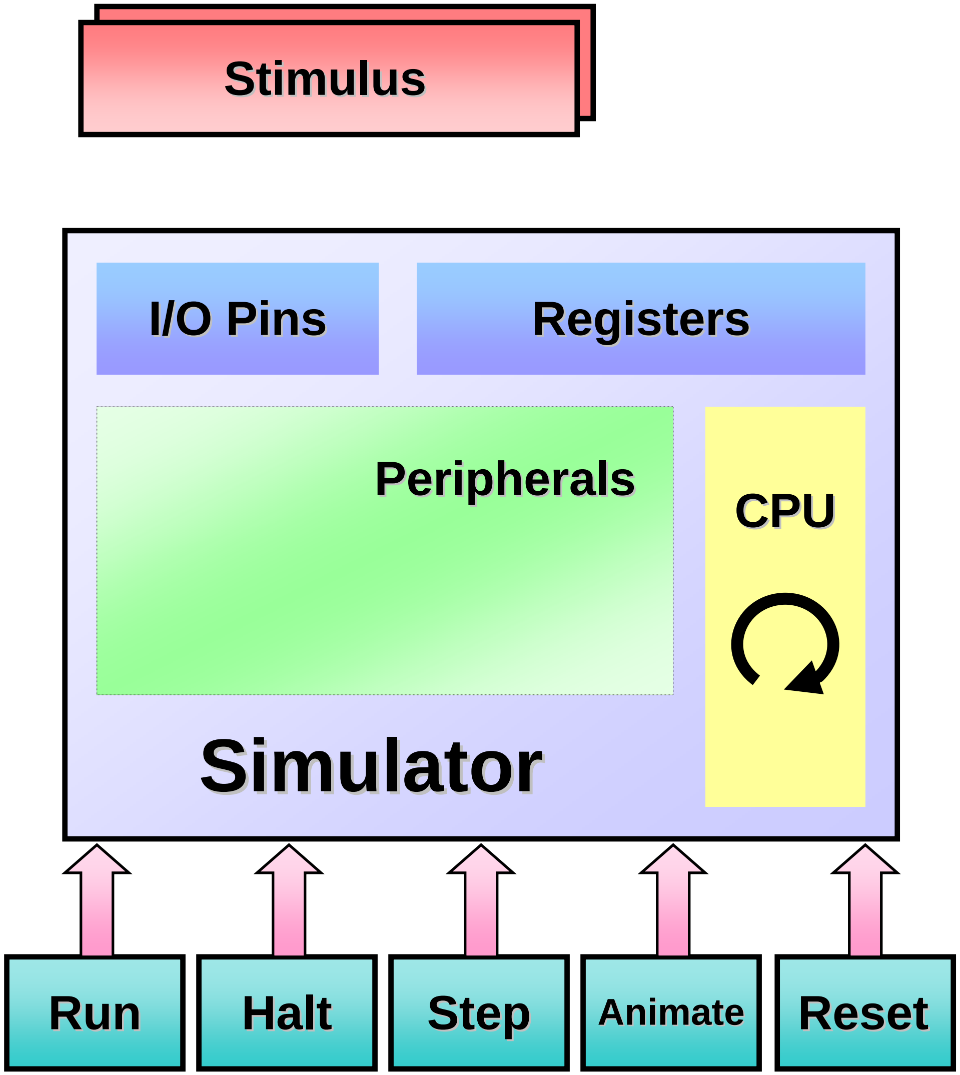
Stimulus

Stimulus

- A signal to stimulate a device through I/O ports / variables
- Signal can be:
  - UART data (communications)
  - ADC data (temperature sensor)
  - Digital I/O (switches)

Two Kinds of Stimulus

- Asynchronous
  - Any time
- Synchronous
  - Preset time



Asynchronous Stimulus

- User-initiated (click a button)
- Any time during simulation
- Apply to:
  - I/O pins
  - UART buffer registers (RCREG)
- Actions:
  - Set low / high
  - Pulse low / Pulse high
  - Toggle

Synchronous Stimulus

- **Pre-programmed when to happen**
- **Applicable to**
  - I/O Pins
  - All registers
- **Tied to events, e.g.**
  - When it is @ cycle 20 or @ 120 ms
  - When PC reaches address 0xC40
  - When ADCBUF is read in program
  - When RA4 is set

UNIVERSITY OF MICROCHIP UOFM MASTERs 2007

Destination of Stimulus

- I/O Pins

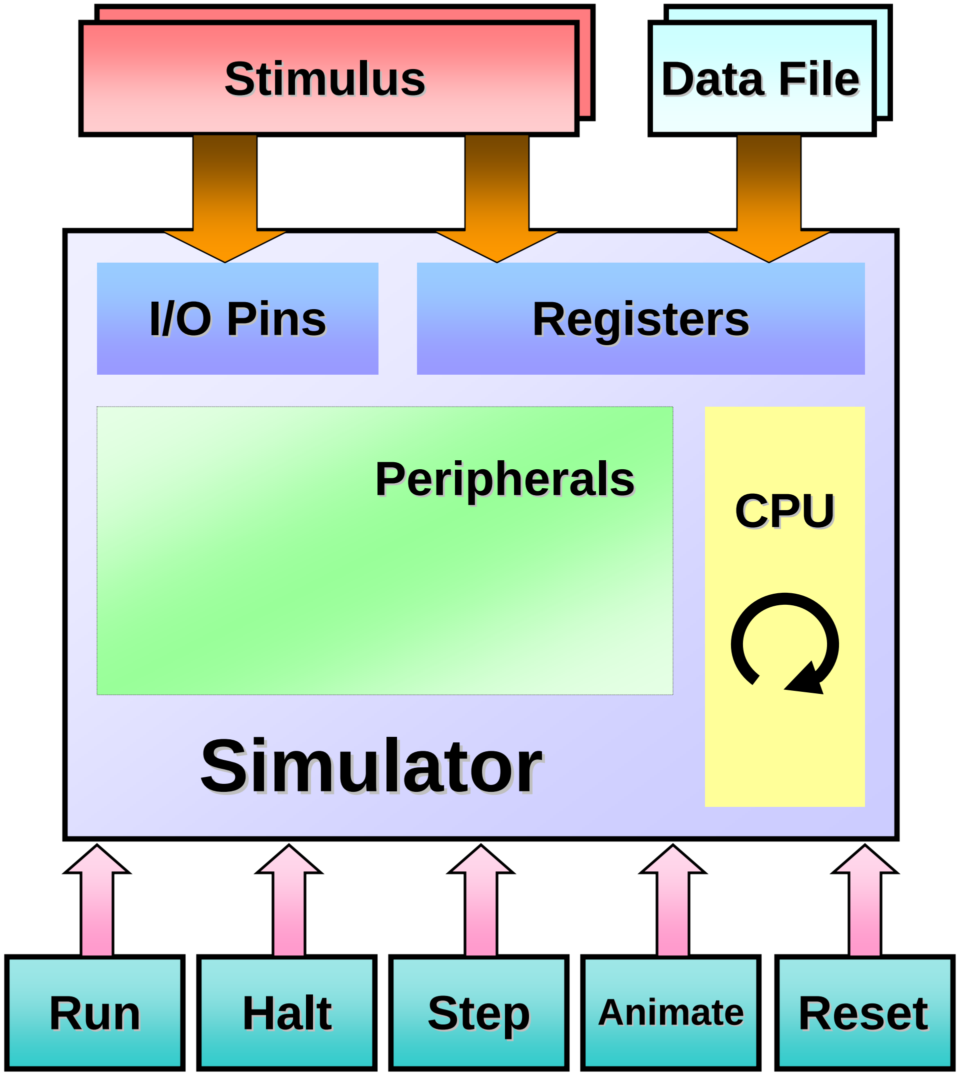
  Toggle pin

  T0CKI
- Registers

  UARTRX ← 123

  foo ← 0x5B
- Data

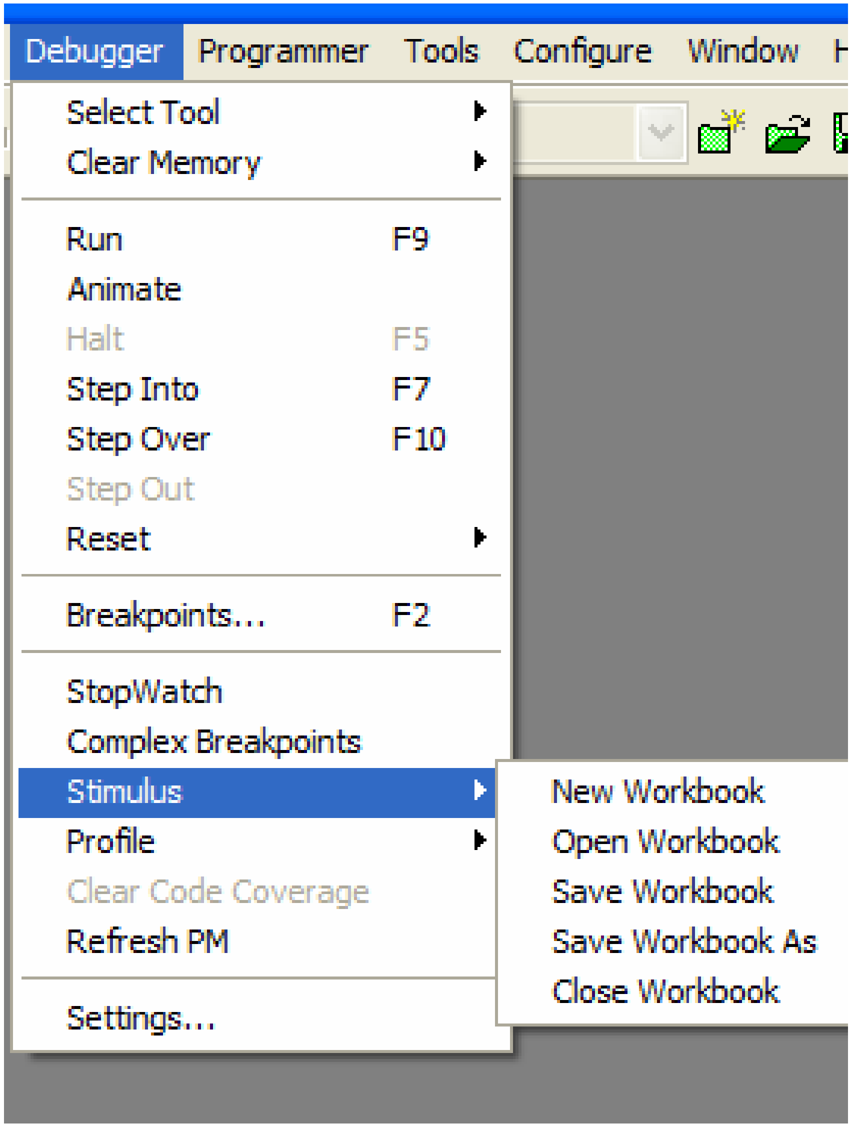
  Can be injected from data file



Using Stimulus GUI

Using Stimulus

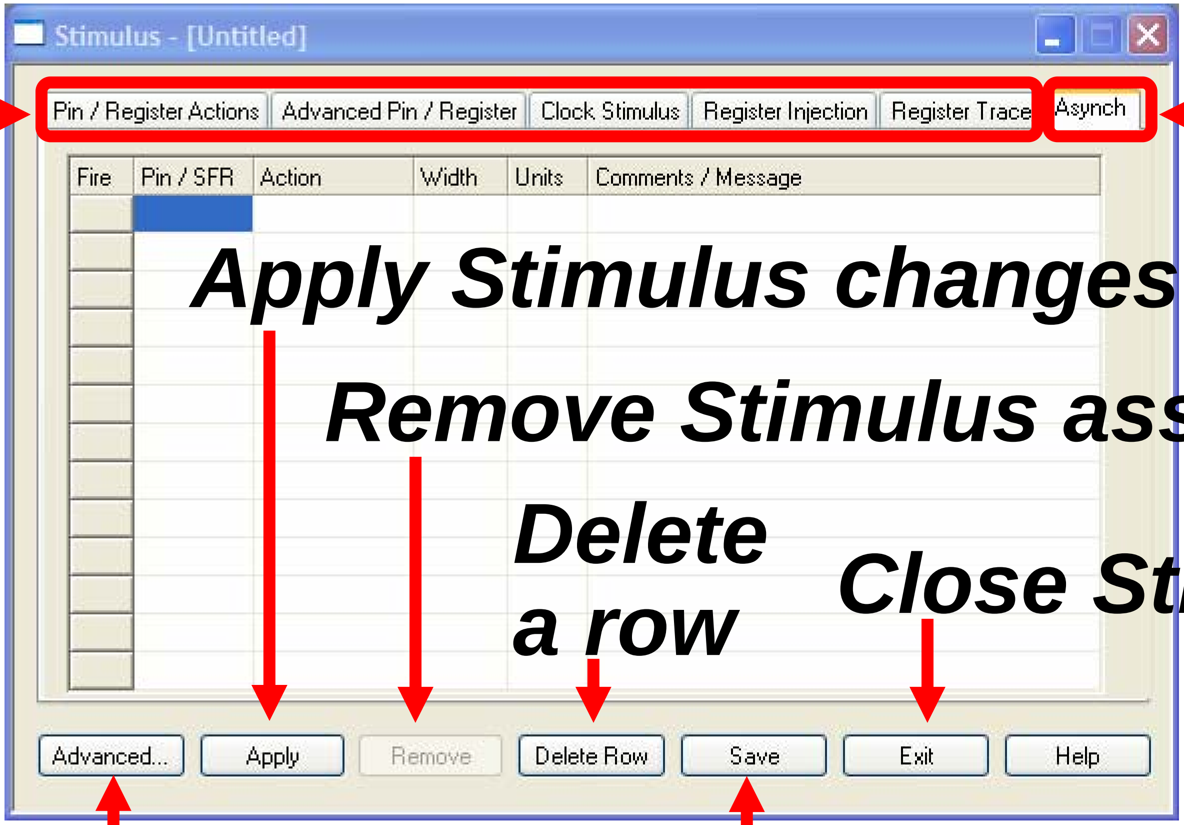
- **Stimuli are defined in workbook:**
  - New Workbook
  - Open Workbook
  - Save Workbook
  - Save Workbook As
  - Close Workbook



6 Tabs of Stimulus Window

Synchronous

Asynchronous



Apply Stimulus changes

Remove Stimulus association

Delete a row

Close Stimulus

Advanced SCL operations

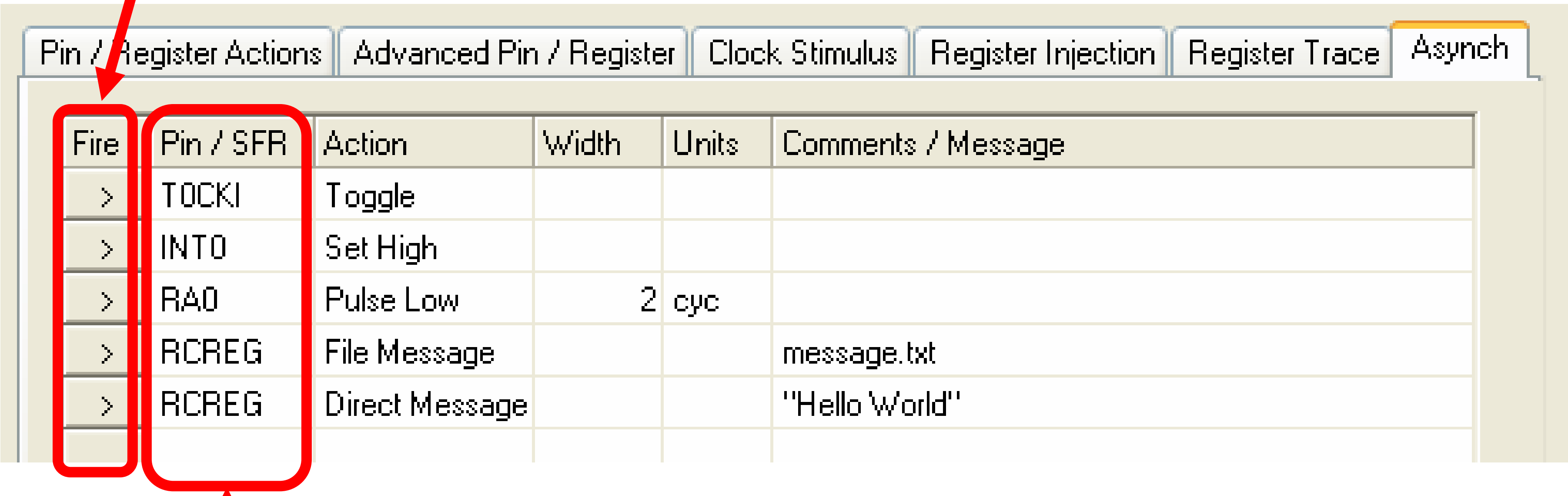
Save all stimulus definitions to workbook

Steps to Define/Use Stimulus

1. **Bring up stimulus window**
   Debugger>Stimulus>New Workbook
2. **Define stimulus**
3. **Save stimulus (optional)**
   Debugger>Stimulus>Save Workbook
4. **Apply stimulus**
5. **Stimulus window remains open**
6. **Start simulation**

Asynchronous Stimulus

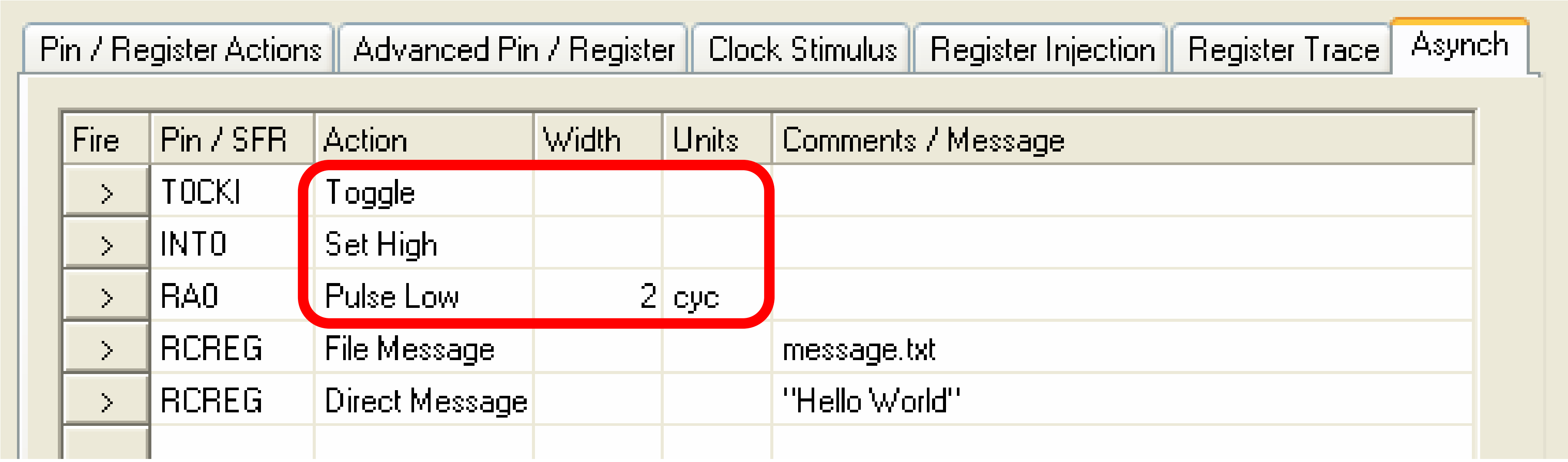
- Last tab in Stimulus Window
- Fire button for each row



Fire	Pin / SFR	Action	Width	Units	Comments / Message
>	T0CKI	Toggle			
>	INT0	Set High			
>	RA0	Pulse Low	2	cyc	
>	RCREG	File Message			message.txt
>	RCREG	Direct Message			"Hello World"

- Destination: I/O Pin or RCREG

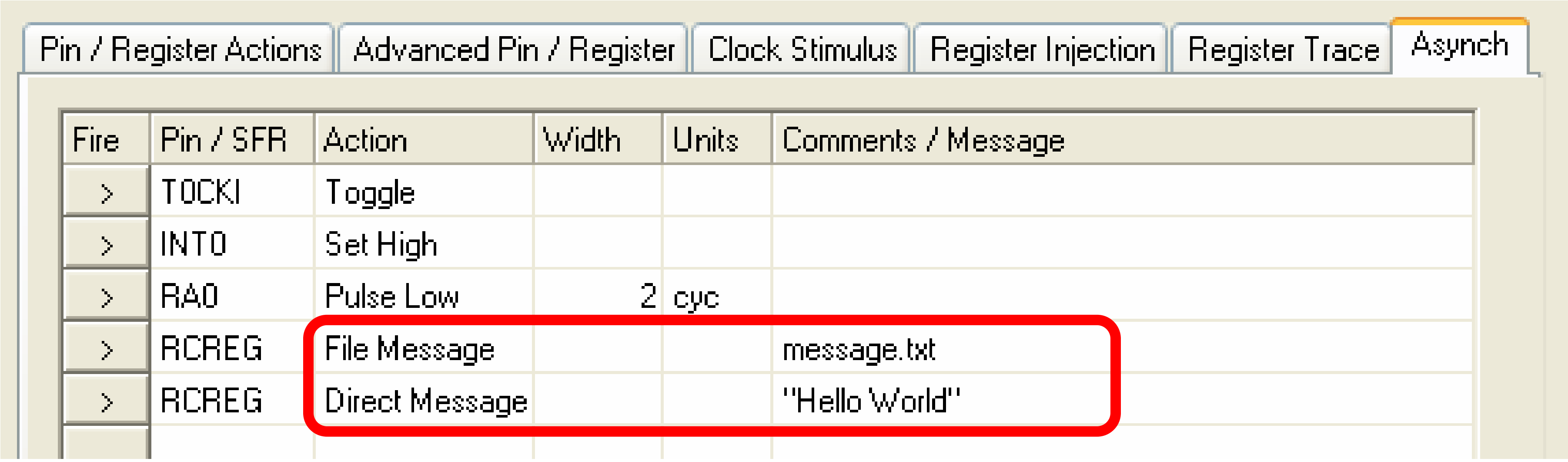
Asynchronous Stimulus



Fire	Pin / SFR	Action	Width	Units	Comments / Message
>	T0CKI	Toggle			
>	INT0	Set High			
>	RA0	Pulse Low	2	cyc	
>	RCREG	File Message			message.txt
>	RCREG	Direct Message			"Hello World"

- **Action for I/O Pin:**
  - Set High/Low
  - Toggle
  - Pulse High/Low for *2 cycles*

Asynchronous Stimulus



Fire	Pin / SFR	Action	Width	Units	Comments / Message
>	T0CKI	Toggle			
>	INT0	Set High			
>	RA0	Pulse Low	2	cyc	
>	RCREG	File Message			message.txt
>	RCREG	Direct Message			"Hello World"

- **Action for RCREG:**
  - **Message-based Stimulus**
    - File Message: **Inject from file**
    - Direct Message: **defined in GUI**
  - **More information in appendix**

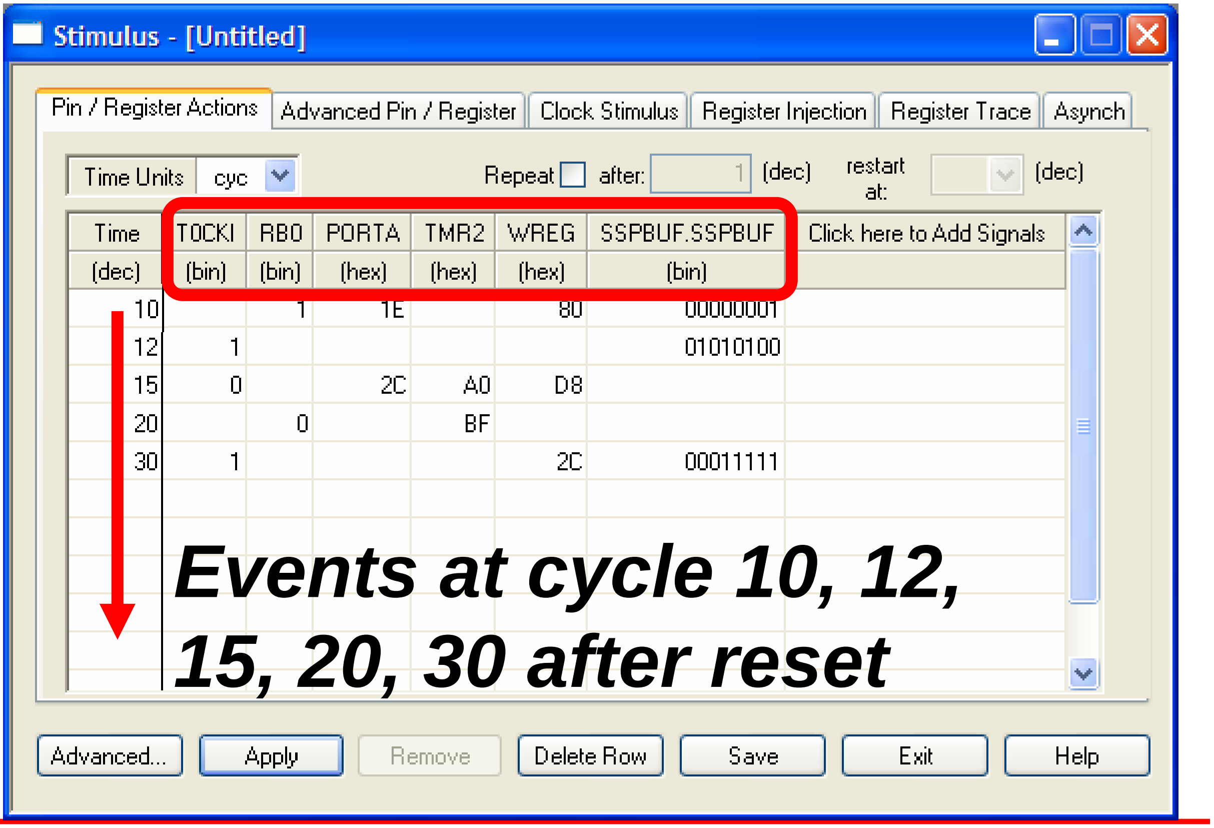
Asynchronous Summary

- **Quick stimulus to test application**
- **Possible uses:**
  - True random event (user key press)
  - Asynchronous UART message

- **Onto Synchronous Stimulus...**

Pin/Register Actions

- **Define Sequence of stimulus @ pre-set time**
- Pin
  T0CKI, RB0
- Port
  PORTA
- SFR
  TMR2, WREG
- Bit field
  SSPBUF



Time Units: cyc

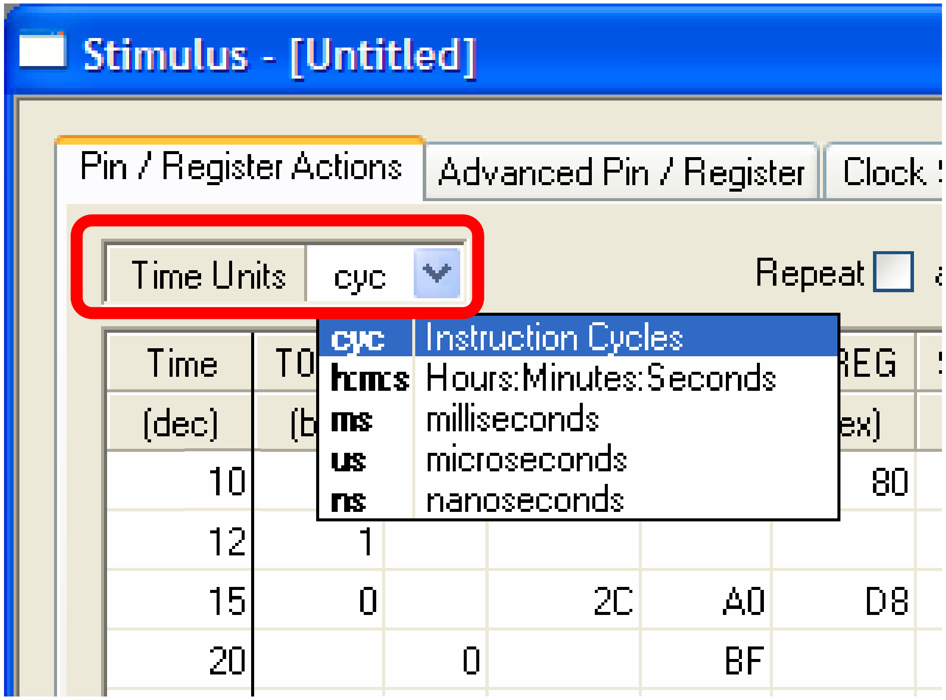
Repeat □ after: 1 (dec) restart at: (dec)

Time	T0CKI	RB0	PORTA	TMR2	WREG	SSPBUF.SSPBUF
(dec)	(bin)	(bin)	(hex)	(hex)	(hex)	(bin)
10		1	1E		80	00000001
12	1					01010100
15	0		2C	A0	D8	
20		0		BF		
30	1				2C	00011111

Events at cycle 10, 12, 15, 20, 30 after reset

Pin/Register Actions

- Time Unit
  - common to all events on this tab
  - Cycle
  - Hour:Min:Sec
  - ms
  - us
  - ns



Time Units cyc

Repeat □

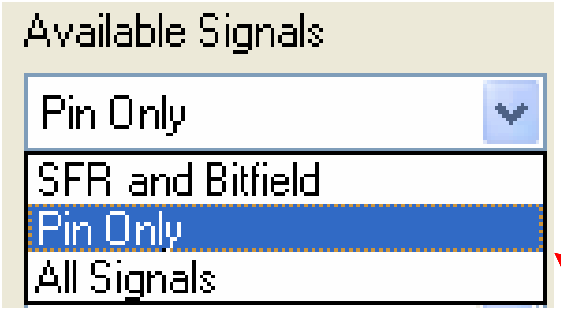
cyc	Instruction Cycles
h:m:s	Hours:Minutes:Seconds
ms	milliseconds
us	microseconds
ns	nanoseconds

Time (dec)	T0 (b				REG ex)
10					80
12	1				
15	0		2C	A0	D8
20		0		BF	

Pin/Register Actions

- **Add/Remove Signals**

Signal Filter:



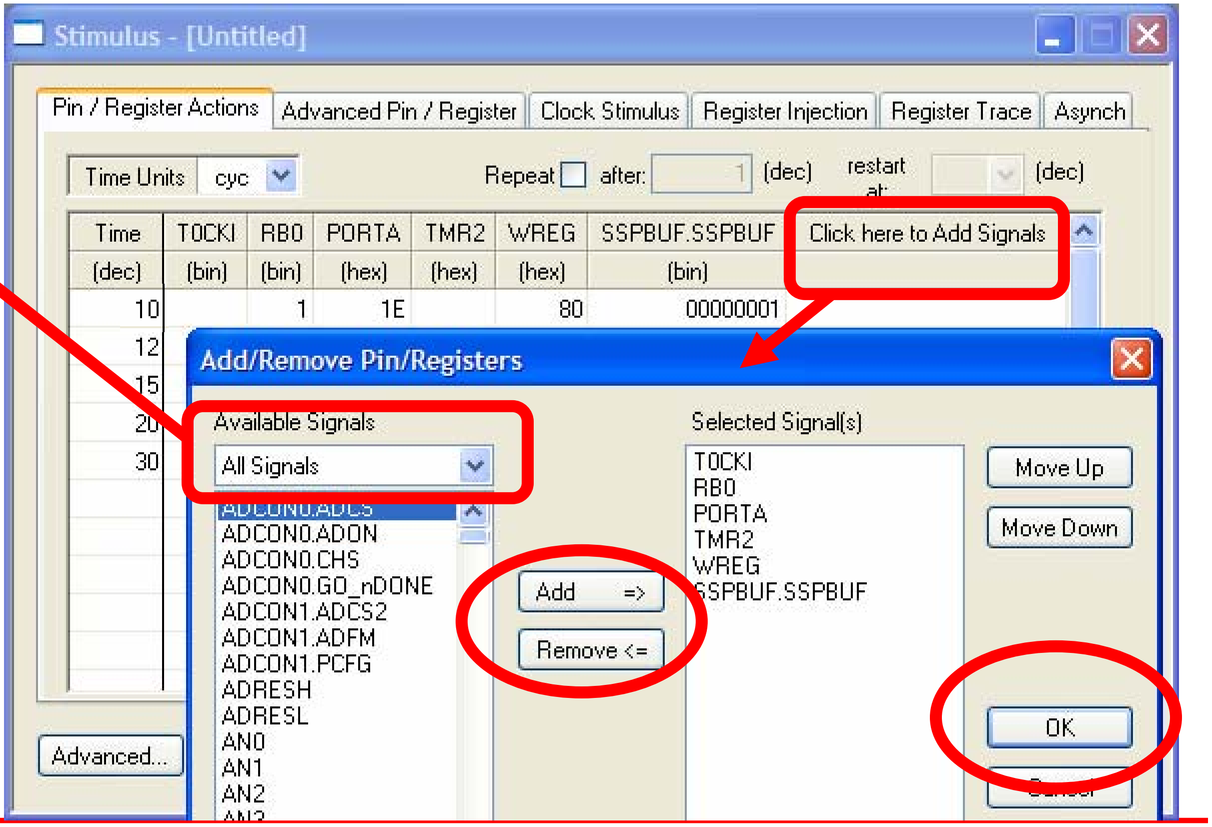
Available Signals

Pin Only

- SFR and Bitfield
- Pin Only
- All Signals

Add/Remove

Click OK



Stimulus - [Untitled]

Time Units: cyc

Repeat □ after: 1 (dec) restart at: (dec)

Time	T0CKI	RB0	PORTA	TMR2	WREG	SSPBUF.SSPBUF	Click here to Add Signals
(dec)	(bin)	(bin)	(hex)	(hex)	(hex)	(bin)	
10		1	1E		80	00000001	
12							
15							
20							
30							

Add/Remove Pin/Registers

Available Signals: All Signals

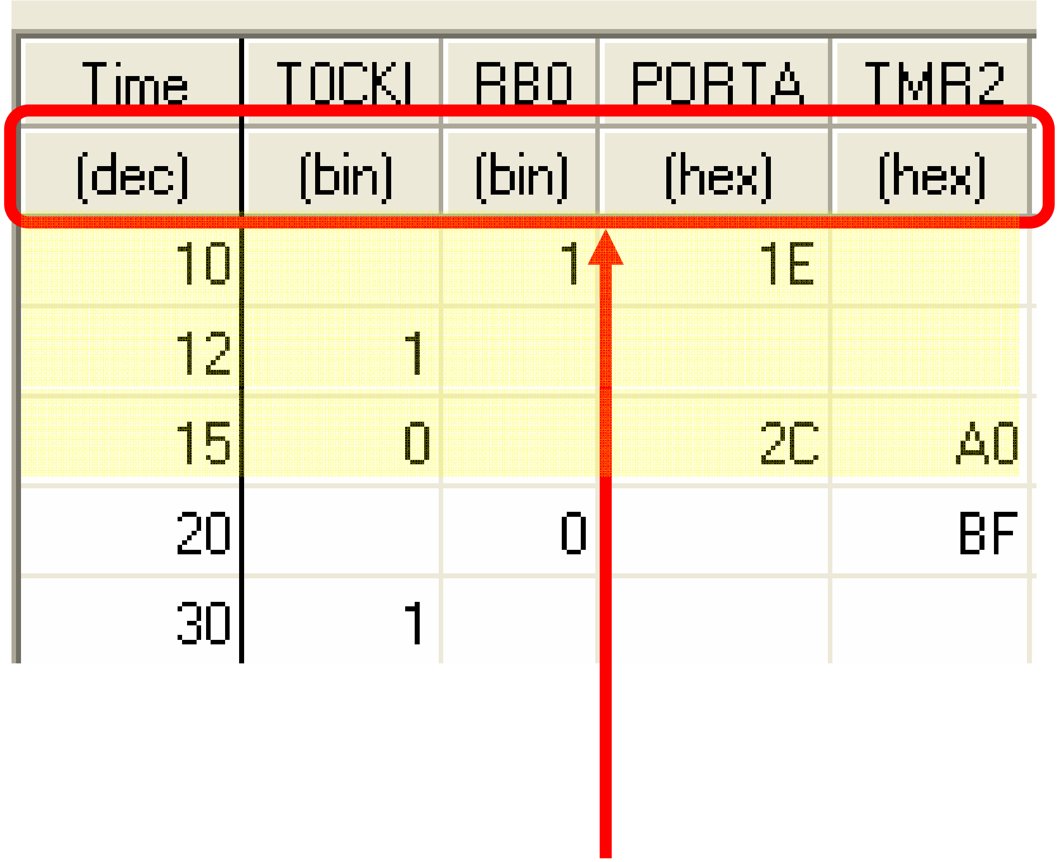
ADCON0.ADCS
ADCON0.ADON
ADCON0.CHS
ADCON0.GO_nDONE
ADCON1.ADCS2
ADCON1.ADFM
ADCON1.PCFG
ADRESH
ADRESL
AN0
AN1
AN2
AN3

Selected Signal(s):

T0CKI
RB0
PORTA
TMR2
WREG
SSPBUF.SSPBUF

What Happens at Run Time?

- At cycle 10:
  - RB0 ← high
  - PORTA ← 1E
- At cycle 12:
  - T0CKI ← high
- At cycle 15:
  - T0CKI ← low
  - PORTA ← 2C
  - TMR2 ← A0



Time	T0CKI	RB0	PORTA	TMR2
(dec)	(bin)	(bin)	(hex)	(hex)
10		1	1E	
12	1			
15	0		2C	A0
20		0		BF
30	1			

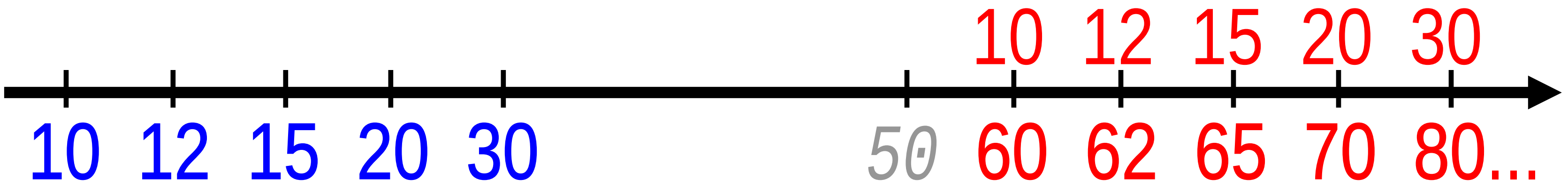
Radix for data entry

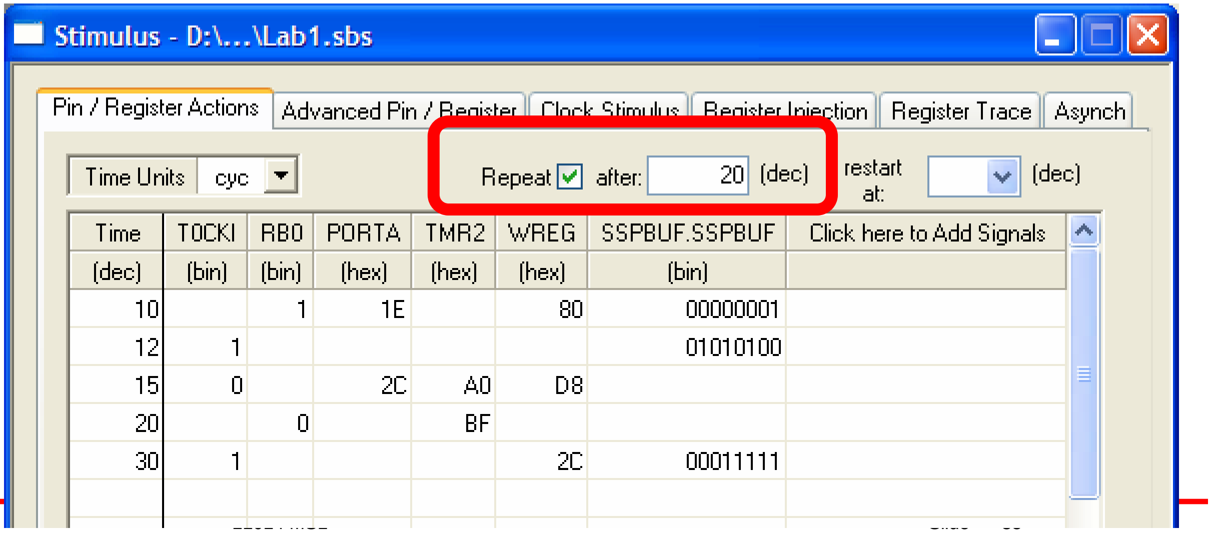
Might need to repeat stimuli

- Check “Repeat” and enter delay

10 12 15 20 30

[wait 20 cycles]





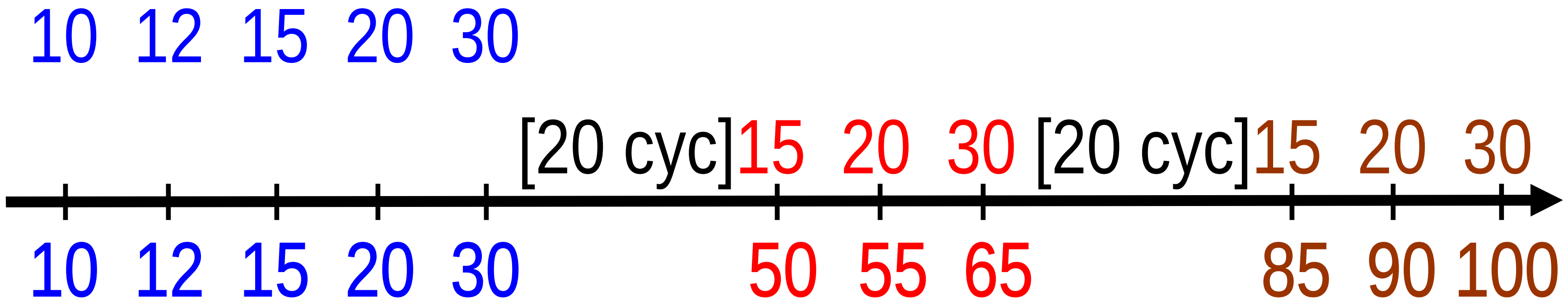
Time Units: cyc

Repeat ☑ after: 20 (dec) restart at: (dec)

Time (dec)	T0CKI (bin)	RB0 (bin)	PORTA (hex)	TMR2 (hex)	WREG (hex)	SSPBUF.SSPBUF (bin)
10		1	1E		80	00000001
12	1					01010100
15	0		2C	A0	D8	
20		0		BF		
30	1				2C	00011111

“Restart at” option

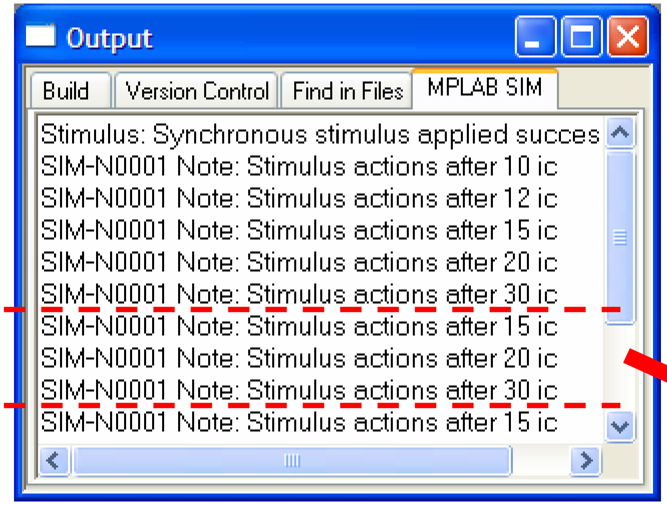
- **Selects which row to begin repeating after delay**



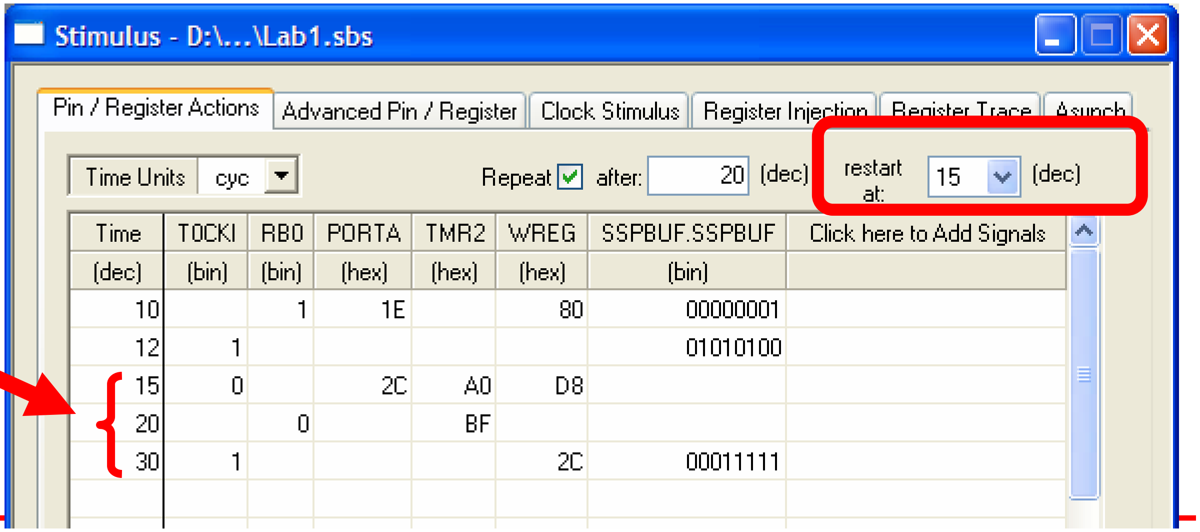
10 12 15 20 30

[20 cyc]15 20 30 [20 cyc]15 20 30

10 12 15 20 30 50 55 65 85 90 100



```
Stimulus: Synchronous stimulus applied succes
SIM-N0001 Note: Stimulus actions after 10 ic
SIM-N0001 Note: Stimulus actions after 12 ic
SIM-N0001 Note: Stimulus actions after 15 ic
SIM-N0001 Note: Stimulus actions after 20 ic
SIM-N0001 Note: Stimulus actions after 30 ic
SIM-N0001 Note: Stimulus actions after 15 ic
SIM-N0001 Note: Stimulus actions after 20 ic
SIM-N0001 Note: Stimulus actions after 30 ic
SIM-N0001 Note: Stimulus actions after 15 ic
```



Time Units cyc

Repeat ☑ after: 20 (dec) restart at: 15 (dec)

Time	TOCKI	RB0	PORTA	TMR2	WREG	SSPBUF.SSPBUF	Click here to Add Signals
(dec)	(bin)	(bin)	(hex)	(hex)	(hex)	(bin)	
10		1	1E		80	00000001	
12	1					01010100	
15	0		2C	A0	D8		
20		0		BF			
30	1				2C	00011111	

Pin/Register Summary

- Set / Clear pin, SFR, SFR bit field
- At specific time during simulation
- All data contained in the workbook
- Possible uses:
  - Setting two IRQ flags simultaneously
  - Simulating A/D buffer (ADRES)
  - Setting pulse to ext clock input T0CKI
  - Duration test (using “repeat”)

Lab 1: Simple Stimulus

C:>Masters>11014>Lab1>Lab1.mcw

Other Stimulus Tabs

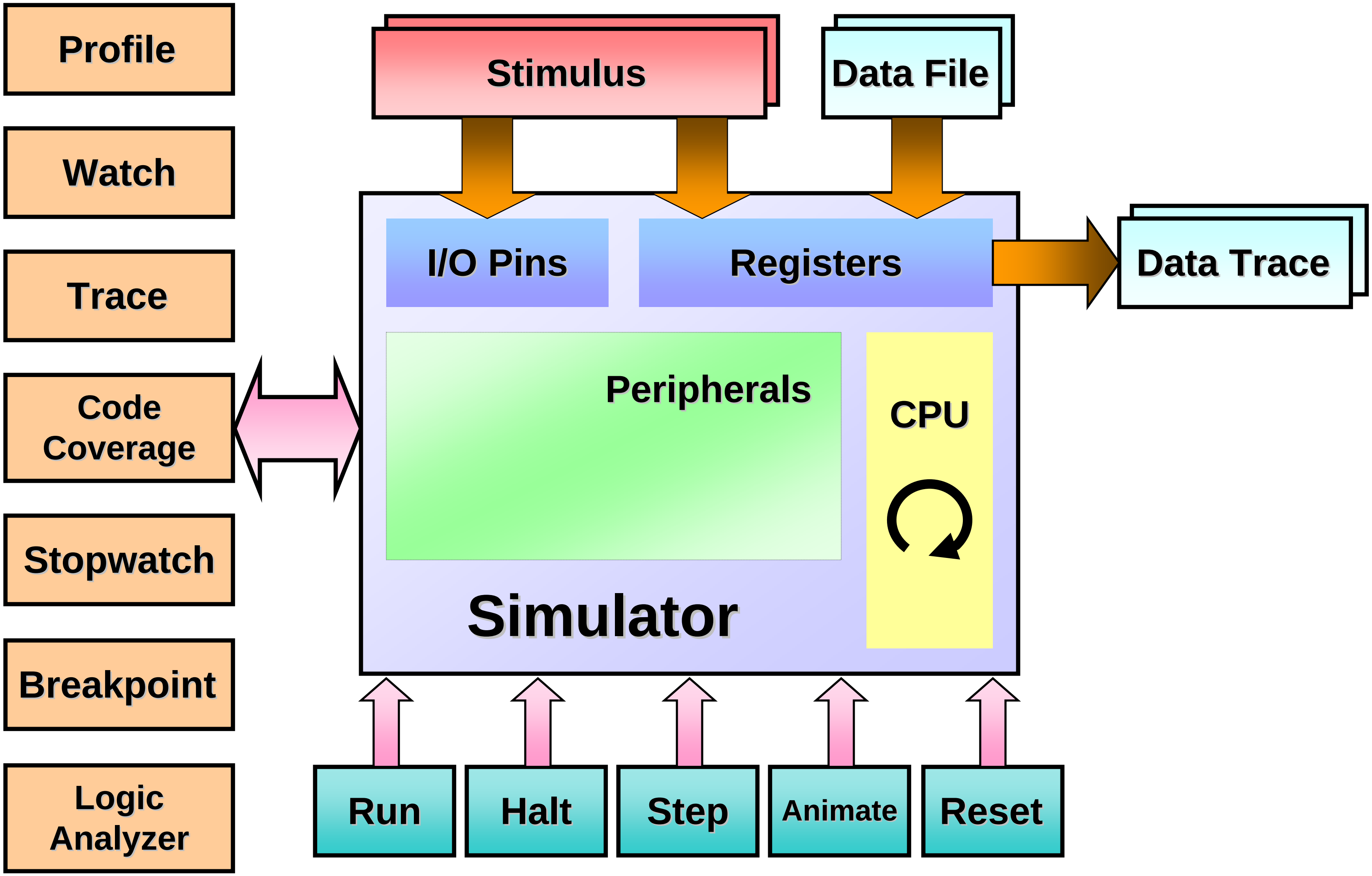
- **Register Injection**
  - Attach input data file to Register or GPR
- **Register Trace**
  - Attach output file to Register or GPR
- **Clock Stimulus**
  - Generates waveform to I/O pin

Other Stimulus Tabs (Cont’d)

- **Advanced Pin/Register**
  - Conditional Pin/Register stimulus
- **Other MASTERS classes**
  - Advanced Stimulus (11015 MS2)
  - Debugging Techniques (11016 MS3) *NEW!*

Tools in Simulator

Tools in Simulator



Tools in Simulator

- Profile
- Watch
- Trace
- Code Coverage
- Stopwatch
- Breakpoint
- Logic Analyzer

- **Profile**
  - Count # of times used by each instruction
- **Real-time Watch Window**
  - See contents of memory / variables during simulation
  - Drag and drop variables from editor

Execution Trace

Profile

Watch

Trace

Code Coverage

Stopwatch

Breakpoint

Logic Analyzer

- Record execution history of program
- Instruction tagged with time stamp (execution cycle)
- Disassembled Opcodes
- Source and Destination Data values
- Source and Destination Address

Execution Trace (cont'd)

Profile

Watch

Trace

Code Coverage

Stopwatch

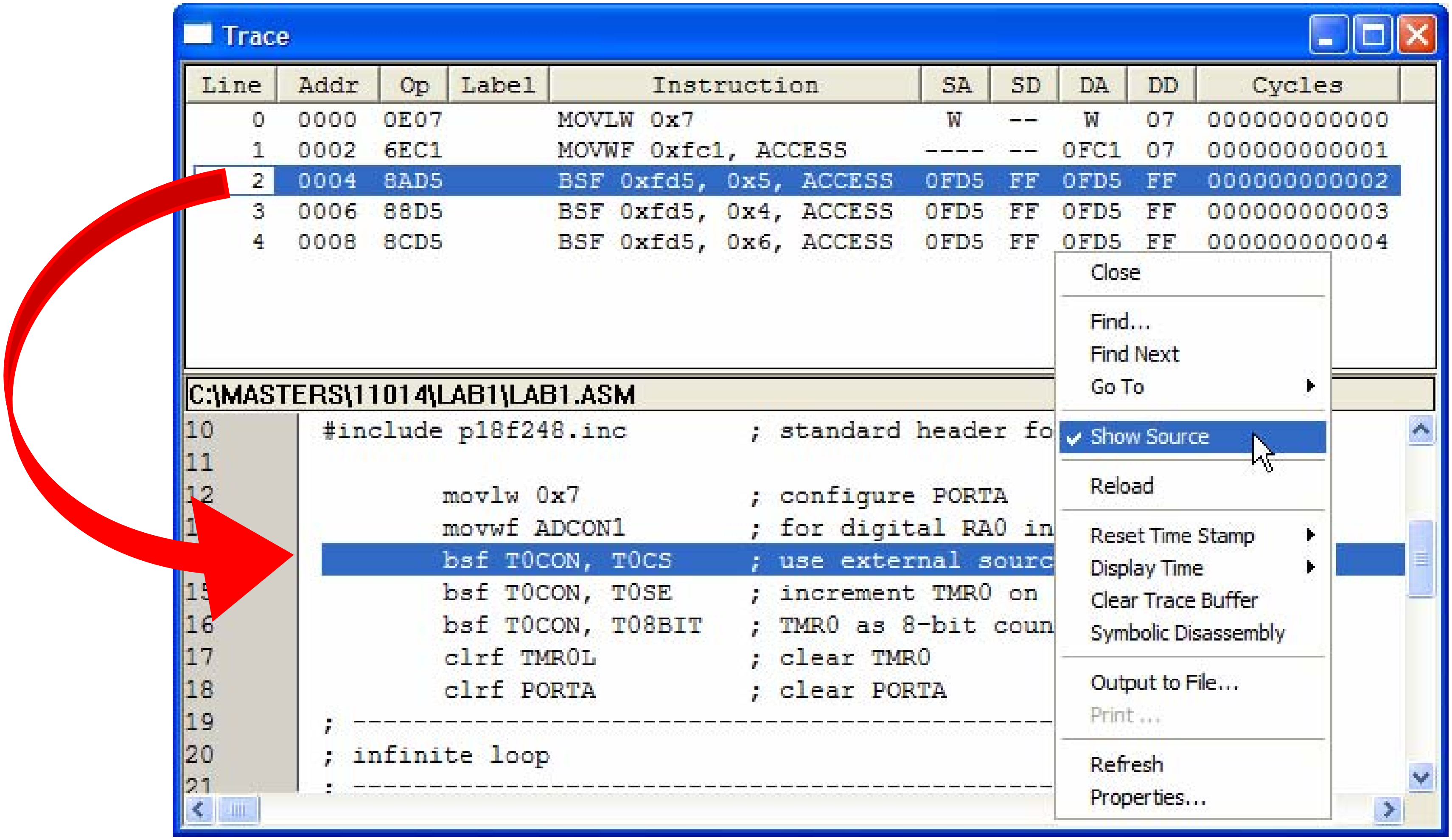
Breakpoint

Logic Analyzer

- Filter In/Out from source
- Trace to Source Correlation
- Select Menu *View>Simulator Trace*
- **Trace All** must be selected in debugger settings
- Trace buffer up to 2GB (one trace record ~40 bytes)

Trace to Source Correlation

- Right click → select *Show Source*



```
Line  Addr  Op    Label  Instruction                SA    SD  DA    DD  Cycles
   0  0000  0E07         MOVLW 0x7                  W     --  W     07  000000000000
   1  0002  6EC1         MOVWF 0xfc1, ACCESS        ----  --  0FC1  07  000000000001
   2  0004  8AD5         BSF 0xfd5, 0x5, ACCESS     0FD5  FF  0FD5  FF  000000000002
   3  0006  88D5         BSF 0xfd5, 0x4, ACCESS     0FD5  FF  0FD5  FF  000000000003
   4  0008  8CD5         BSF 0xfd5, 0x6, ACCESS     0FD5  FF  0FD5  FF  000000000004
```

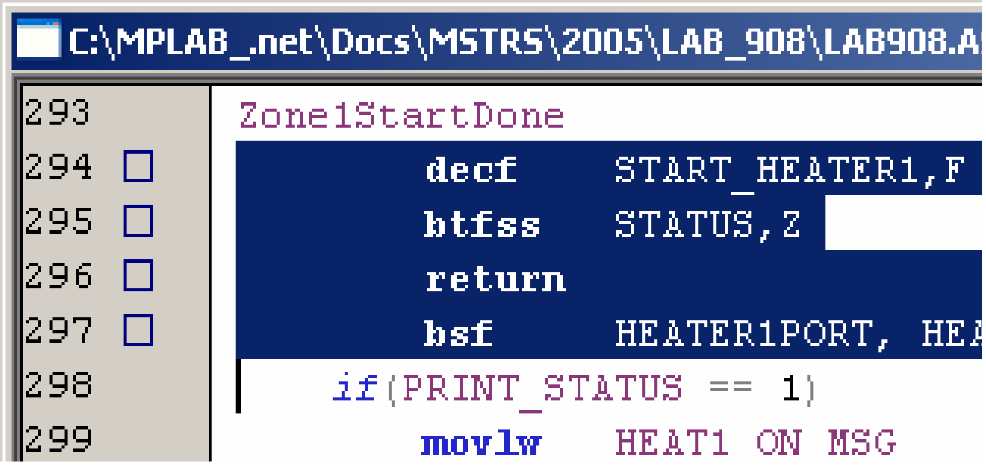
C:\MASTERS\11014\LAB1\LAB1.ASM

```
#include p18f248.inc        ; standard header fo

        movlw 0x7           ; configure PORTA
        movwf ADCON1        ; for digital RA0 in
        bsf T0CON, T0CS     ; use external sourc
        bsf T0CON, T0SE     ; increment TMR0 on
        bsf T0CON, T08BIT   ; TMR0 as 8-bit coun
        clrf TMR0L          ; clear TMR0
        clrf PORTA          ; clear PORTA
; ----------------------------------------------
; infinite loop
; ----------------------------------------------
```

Filter Trace – selective

- **Trace certain lines, e.g. loop** right click→ *Add Filter-in Trace*



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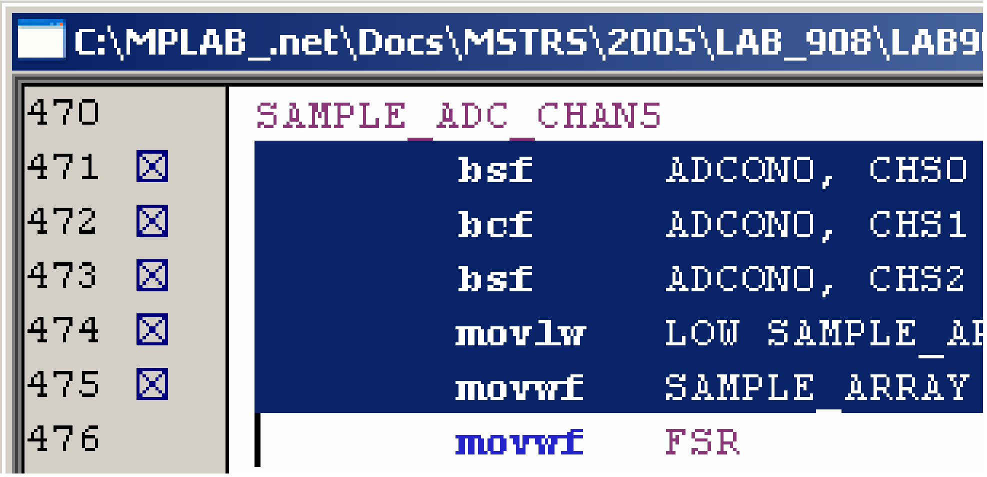
```
  Zone1StartDone
☐         decf      START_HEATER1,F
☐         btfss     STATUS,Z
☐         return
☐         bsf       HEATER1PORT, HEA
      if(PRINT_STATUS == 1)
          movlw     HEAT1 ON MSG
```

- **Not trace some e.g. eliminate wait loops** right click→ *Add Filter-out Trace*



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```
  SAMPLE_ADC_CHANS
☒         bsf       ADCON0, CHS0
☒         bcf       ADCON0, CHS1
☒         bsf       ADCON0, CHS2
☒         movlw     LOW SAMPLE_AR
☒         movwf     SAMPLE_ARRAY
          movwf     FSR
```

Code Coverage

Profile

Watch

Trace

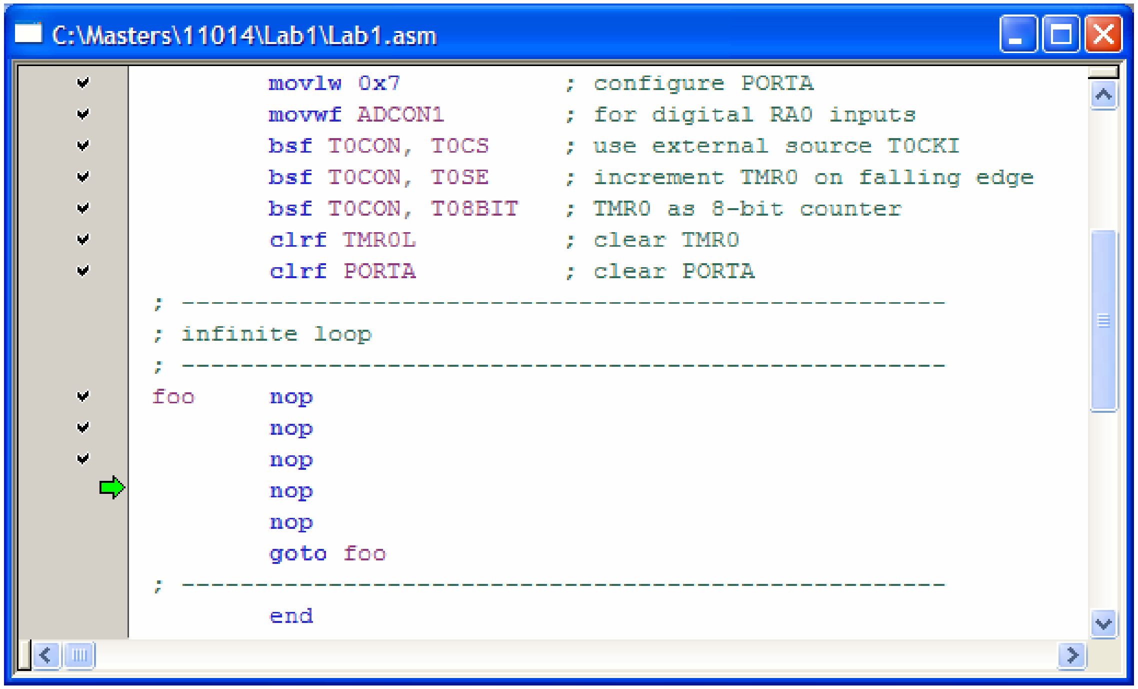
Code Coverage

Stopwatch

Breakpoint

Logic Analyzer

- Visually shows executed code in editor window (checked)
- Identifies unreachable code



C:\Masters\11014\Lab1\Lab1.asm

```
✓          movlw 0x7            ; configure PORTA
✓          movwf ADCON1         ; for digital RA0 inputs
✓          bsf T0CON, T0CS      ; use external source T0CKI
✓          bsf T0CON, T0SE      ; increment TMR0 on falling edge
✓          bsf T0CON, T08BIT    ; TMR0 as 8-bit counter
✓          clrf TMR0L           ; clear TMR0
✓          clrf PORTA           ; clear PORTA
   ; -----------------------------------------------------
   ; infinite loop
   ; -----------------------------------------------------
✓  foo     nop
✓          nop
✓          nop
           nop
           nop
           goto foo
   ; -----------------------------------------------------
           end
```

Stopwatch

Profile

Watch

Trace

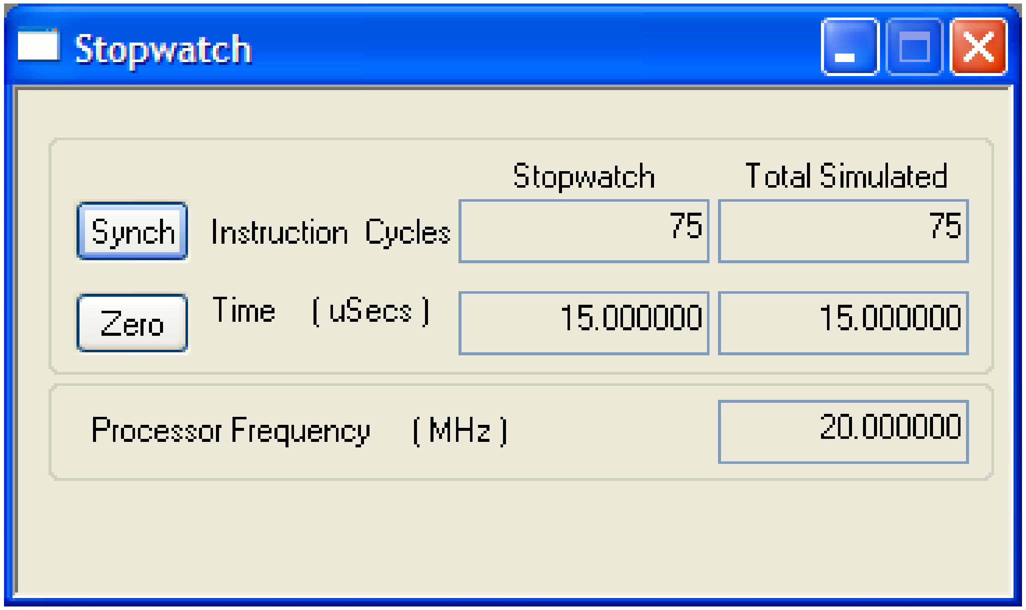
Code Coverage

Stopwatch

Breakpoint

Logic Analyzer

- Measures in cycles & time
- Reset to zero upon reset



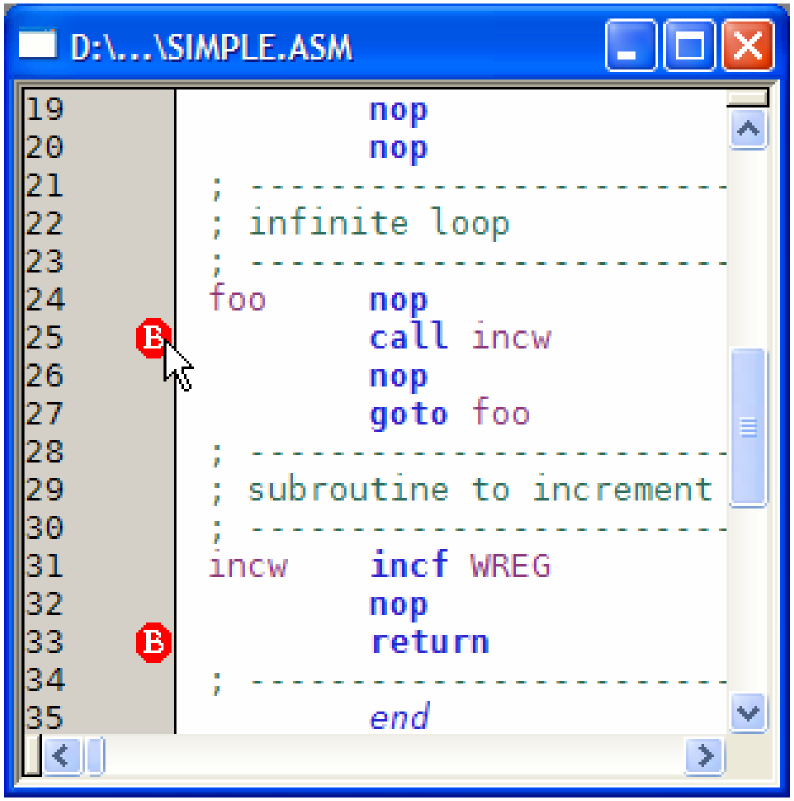
		Stopwatch	Total Simulated
Synch	Instruction Cycles	75	75
Zero	Time (uSecs)	15.000000	15.000000

Processor Frequency (MHz) 20.000000

Breakpoint

- Profile
- Watch
- Trace
- Code Coverage
- Stopwatch
- Breakpoint
- Logic Analyzer

- Set unlimited # of breakpoints
- Double click in editor margin to set



```
            nop
            nop
; -----------------------
; infinite loop
; -----------------------
foo         nop
            call incw
            nop
            goto foo
; -----------------------
; subroutine to increment
; -----------------------
incw        incf WREG
            nop
            return
; -----------------------
            end
```

Complex Breakpoints

Profile

Watch

Trace

Code Coverage

Stopwatch

Breakpoint

Logic Analyzer

- Provides great flexibility when to halt execution
- Break on Program Memory or Data Memory R/W
- Anded Breakpoints

  A & B must happen same time
- Sequenced Breakpoints

  A then B must happen in order

Logic Analyzer

- Profile
- Watch
- Trace
- Code Coverage
- Stopwatch
- Breakpoint
- Logic Analyzer

- Display I/O port data graphically
- Uses data in trace buffer
- Trace MUST be enabled (Trace All selected in settings)
- Max. 32 channels
- Bus (collection of I/O pins) e.g. PORTB = RB0...RB7

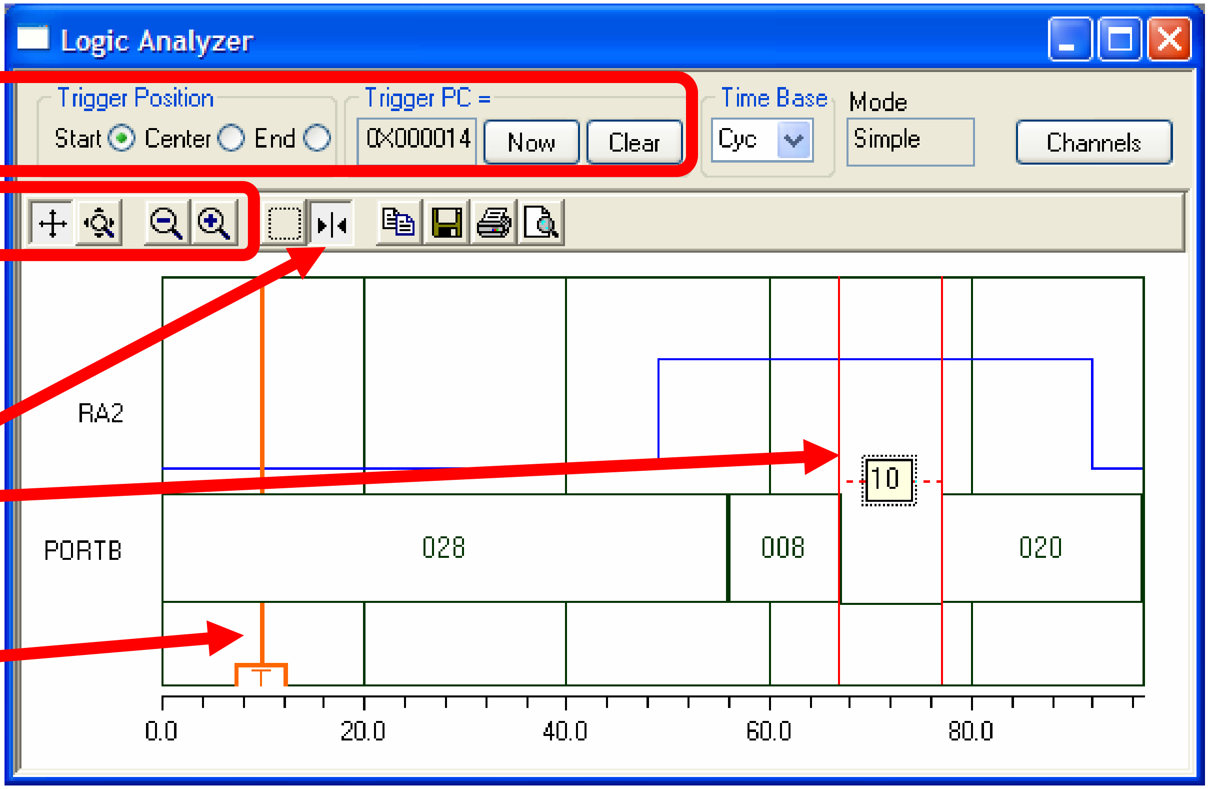
Logic Analyzer (Cont’d)

- Profile
- Watch
- Trace
- Code Coverage
- Stopwatch
- Breakpoint
- Logic Analyzer

- Simple Trigger on a PC
  - Start: history after trigger
  - End: history before trigger
  - Center: history before and after trigger
- May stop at trace buffer full
- Cursors for time measurement
- Printable displays

Logic Analyzer (Cont'd)

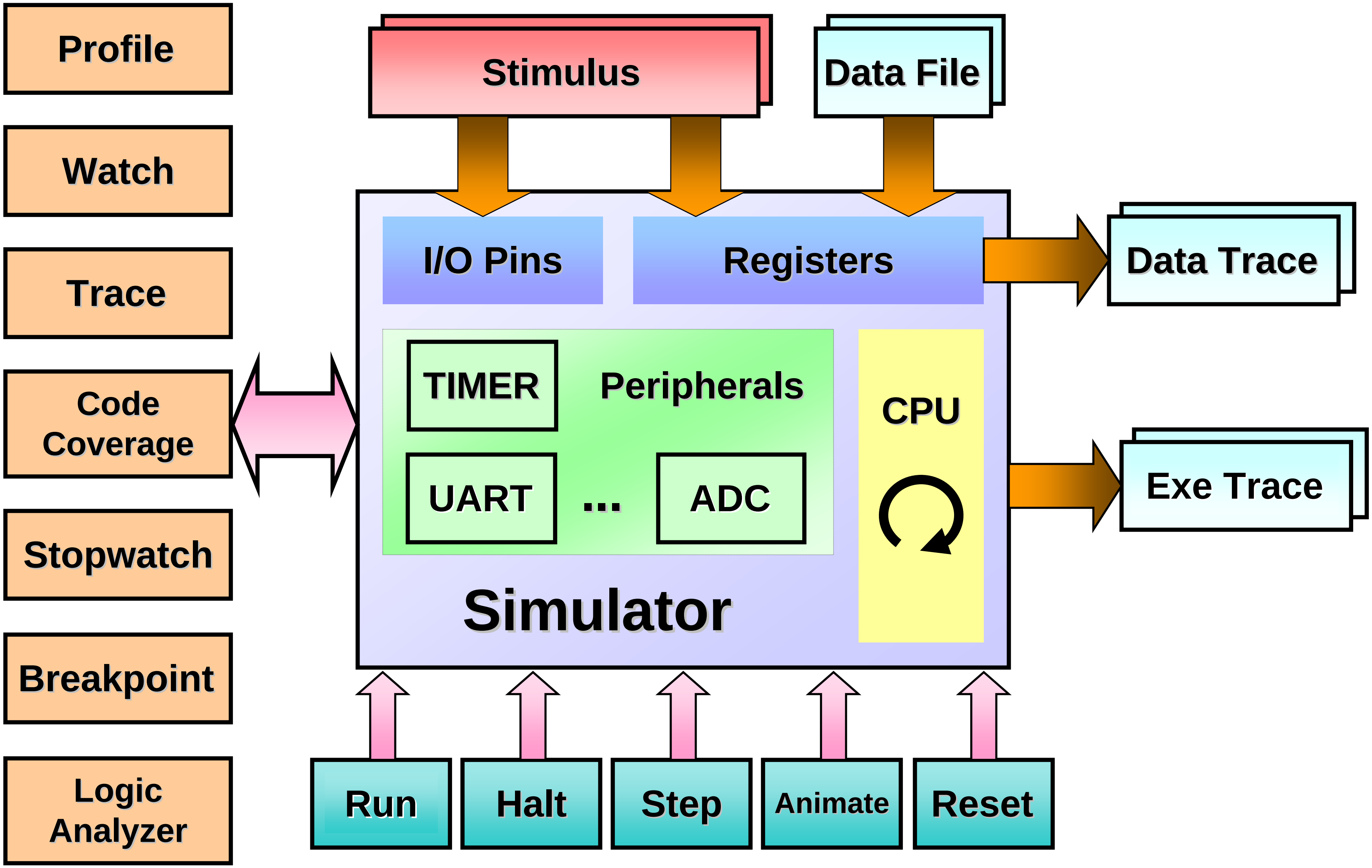
- *View>Simulator Logic Analyzer*
- Simple Trigger Definition
- Zoom
- Cursor
- Trigger



Lab 2: Logic Analyzer

C:>Masters>11014>Lab2>Lab2.mcw

Summary


Profile
Watch
Trace
Code Coverage
Stopwatch
Breakpoint
Logic Analyzer
Stimulus
Data File
I/O Pins
Registers
Data Trace
TIMER
Peripherals
UART
...
ADC
CPU
Exe Trace
Simulator
Run
Halt
Step
Animate
Reset

Summary

- **MPLAB® IDE and Simulator**
- **Stimulus**
  - Asynchronous
  - Simple Synchronous
- **Tools in Simulator**
  - Trace
  - Logic Analyzer

Where to find out more

- **MPLAB® IDE Help**
  - Topic: MPLAB SIM
- **Forums / Webinars**
  - **http://forum.microchip.com**
  - **http://techtrain.microchip.com/webseminars**

Useful Links

- Microchip Change Notification (good way to keep up to date on latest MPLAB® IDE and C18/C30 releases, as well as important Dev Tool notifications);
- http://cn.microchip.com/sales/product_change.nsf

- Microchip Dev Tools Getting Started (series of many tutorials and overviews):
- http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=2122

- Microchip archives:
- http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1406&dDocName=en023073

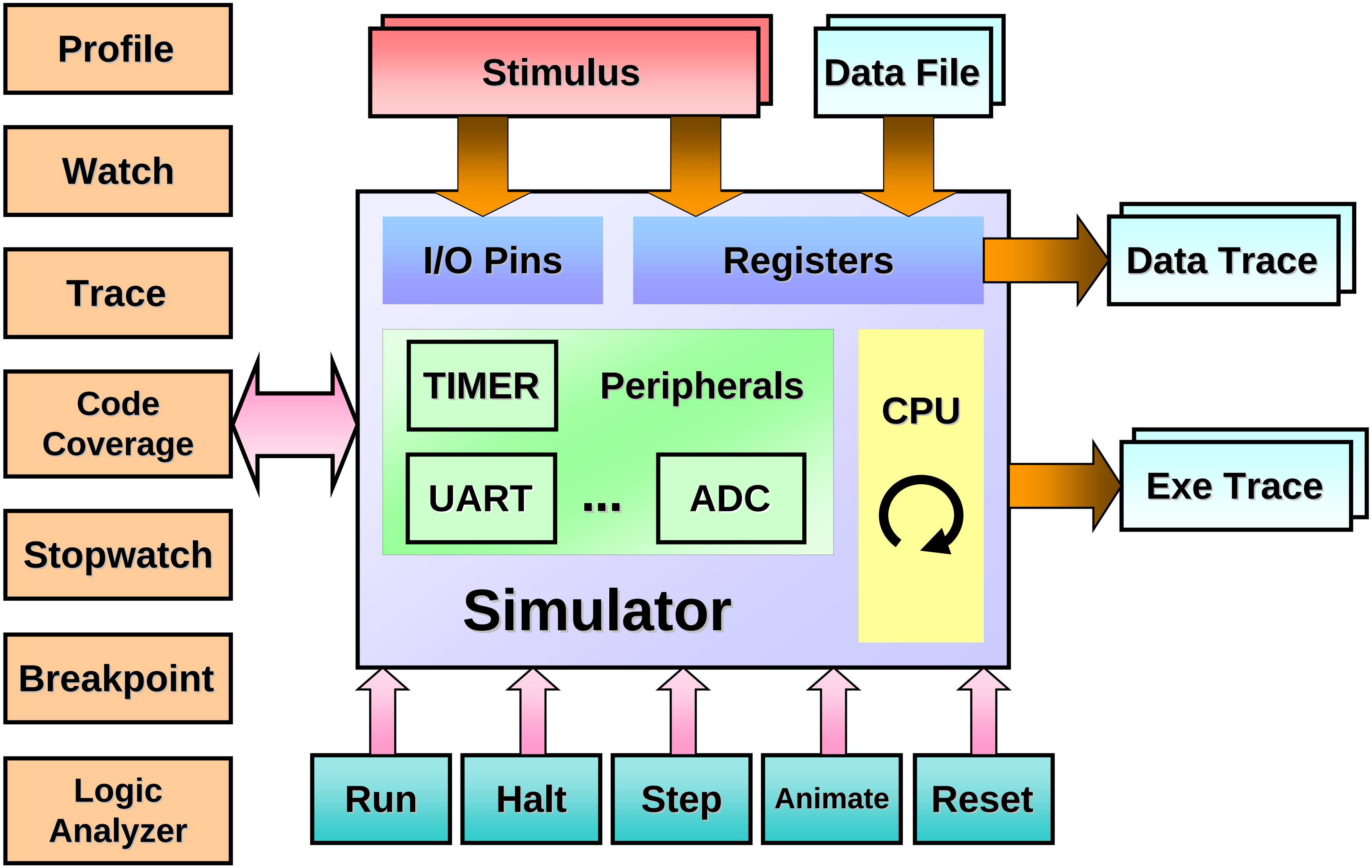
- Development Tool Selector (to find out tool support, accessories, adapteres, etc.):
- http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1496

- Third Party Development Tools:
- http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1926&type=-1&label=A

- MPLAB download page:
- http://www.microchip.com/mplab

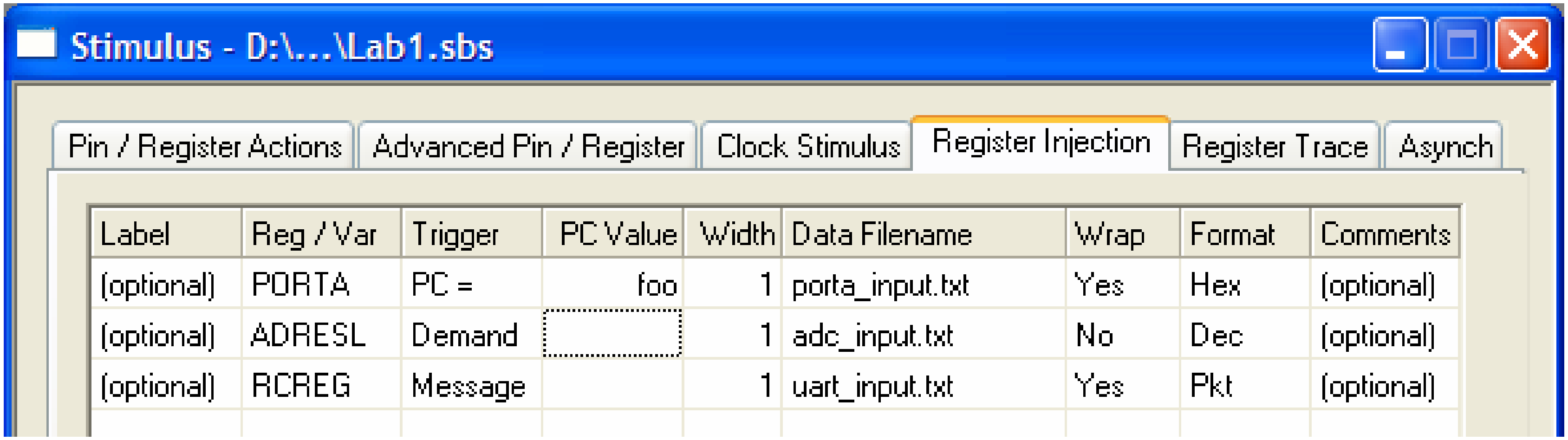
THANK YOU!

Block Diagram of Simulator



Register Injection

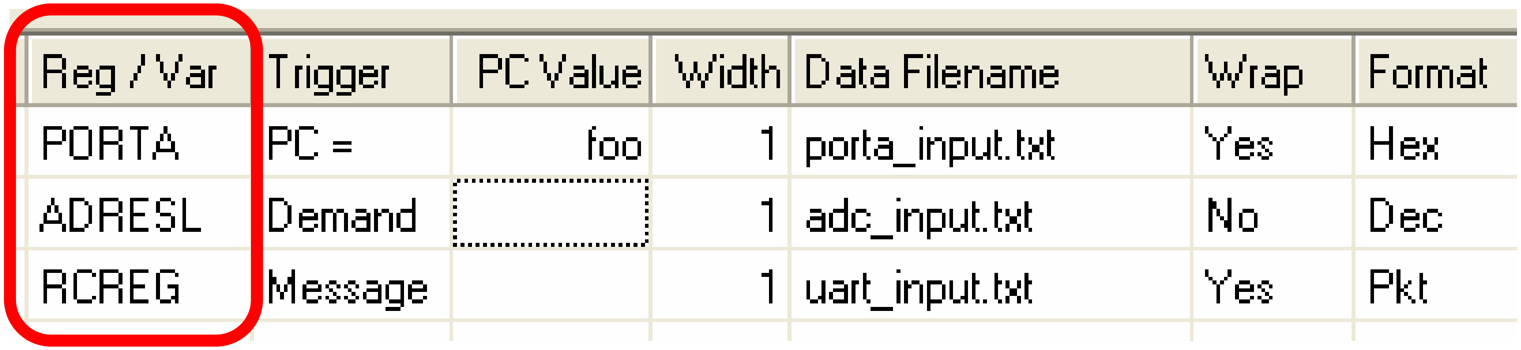
- **Inject values from data file**



Label	Reg / Var	Trigger	PC Value	Width	Data Filename	Wrap	Format	Comments
(optional)	PORTA	PC =	foo	1	porta_input.txt	Yes	Hex	(optional)
(optional)	ADRESL	Demand		1	adc_input.txt	No	Dec	(optional)
(optional)	RCREG	Message		1	uart_input.txt	Yes	Pkt	(optional)

- **Can inject a message to UART**
  Select Trigger = Message
- **Can inject to GPR (variable) also**

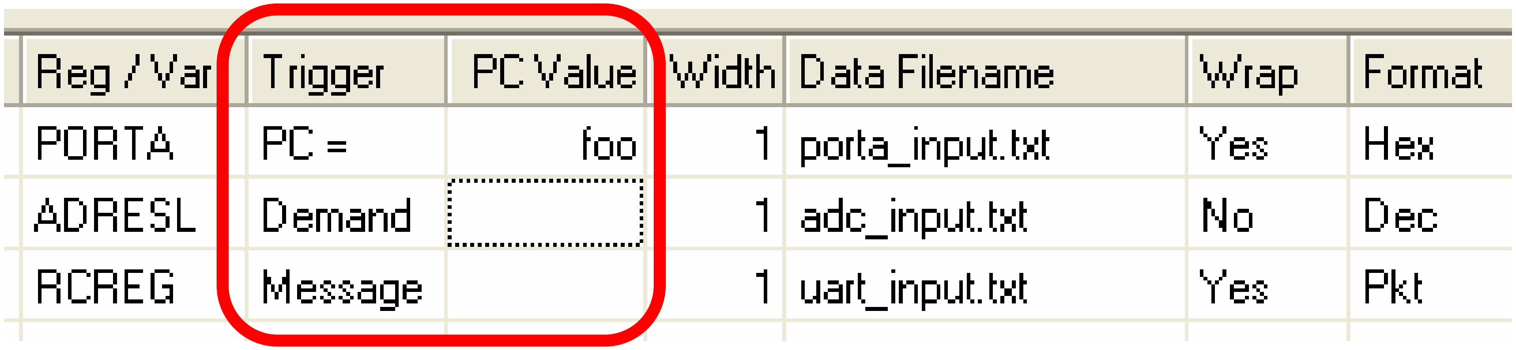
Register Injection



Reg / Var	Trigger	PC Value	Width	Data Filename	Wrap	Format
PORTA	PC =	foo	1	porta_input.txt	Yes	Hex
ADRESL	Demand		1	adc_input.txt	No	Dec
RCREG	Message		1	uart_input.txt	Yes	Pkt

- **Destination**
  - SFR (e.g. ADRESL, RCREG), or
  - GPR (aka. Variable)
    - **Select variable from drop down**
    - **Type address directly (2C0) in hex**

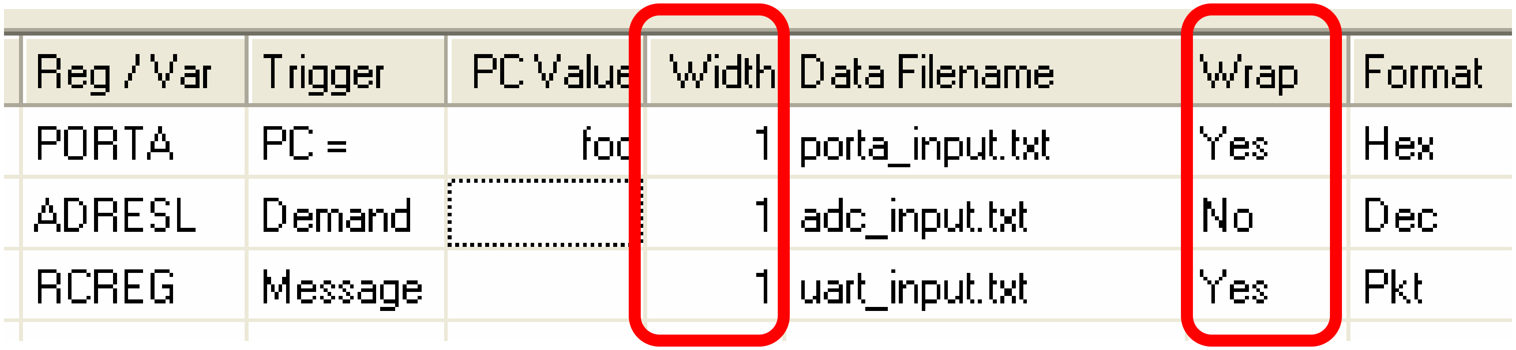
Register Injection



Reg / Var	Trigger	PC Value	Width	Data Filename	Wrap	Format
PORTA	PC =	foo	1	porta_input.txt	Yes	Hex
ADRESL	Demand		1	adc_input.txt	No	Dec
RCREG	Message		1	uart_input.txt	Yes	Pkt

- **Trigger**
  - **PC=**
    when PC reaches a location, e.g. *foo*
  - **On Demand**
    when the program reads register/variable
  - **Message (UART only)**
    data injected to RCREG per baud rate

Register Injection



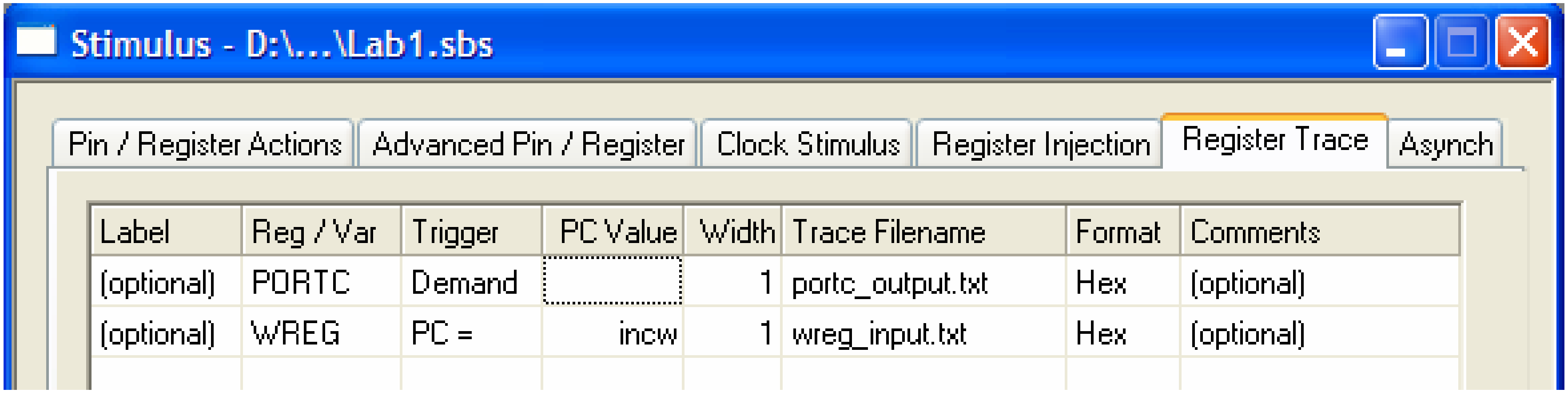
Reg / Var	Trigger	PC Value	Width	Data Filename	Wrap	Format
PORTA	PC =	foc	1	porta_input.txt	Yes	Hex
ADRESL	Demand		1	adc_input.txt	No	Dec
RCREG	Message		1	uart_input.txt	Yes	Pkt

- **Width (bytes)**
  - SFR (dsPIC® DSC: 2, others: 1)
  - GPR (user-specified)
- **Wrap**
  - Wrap-around at the end of input file

Register Injection Summary

- **Difference than Pin/Reg Actions Tab**
  - Data is not defined in the workbook
  - Use Excel-generated data
  - Can switch test data set easily
- **Possible uses:**
  - A/D simulation (ADRES)
  - Zero-crossing – covered in **Advanced Stimulus (11015 MS2)**

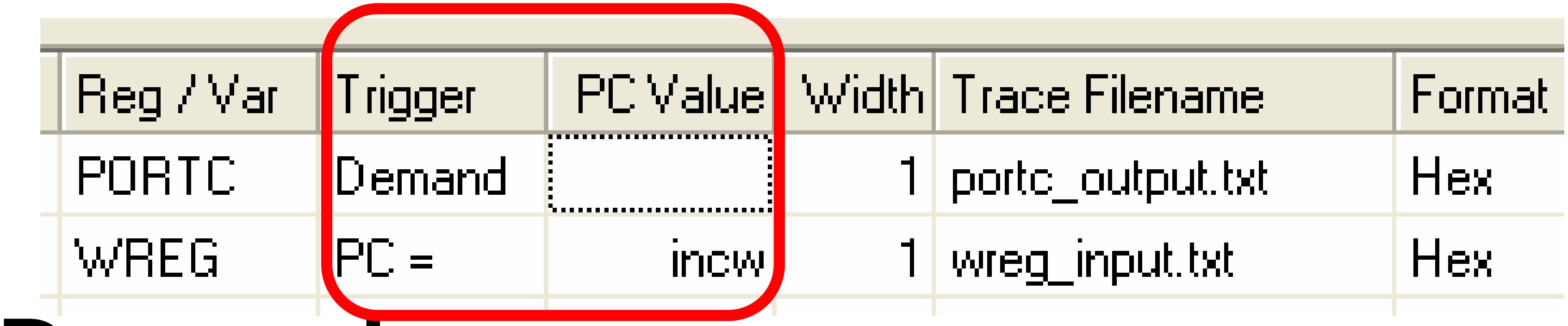
Register Trace



Label	Reg / Var	Trigger	PC Value	Width	Trace Filename	Format	Comments
(optional)	PORTC	Demand		1	portc_output.txt	Hex	(optional)
(optional)	WREG	PC =	incw	1	wreg_input.txt	Hex	(optional)

- **Similar to Register Injection Tab**
- **Sends register value to output file**
- **Supports GPR / variable**
- **No Wrap column**

Register Trace



Reg / Var	Trigger	PC Value	Width	Trace Filename	Format
PORTC	Demand		1	portc_output.txt	Hex
WREG	PC =	incw	1	wreg_input.txt	Hex

- **Demand**
  - Every time the program changes the register/variable
- **PC=**
  - Every time PC reaches a location
  - e.g. label *incw* or address 2C0

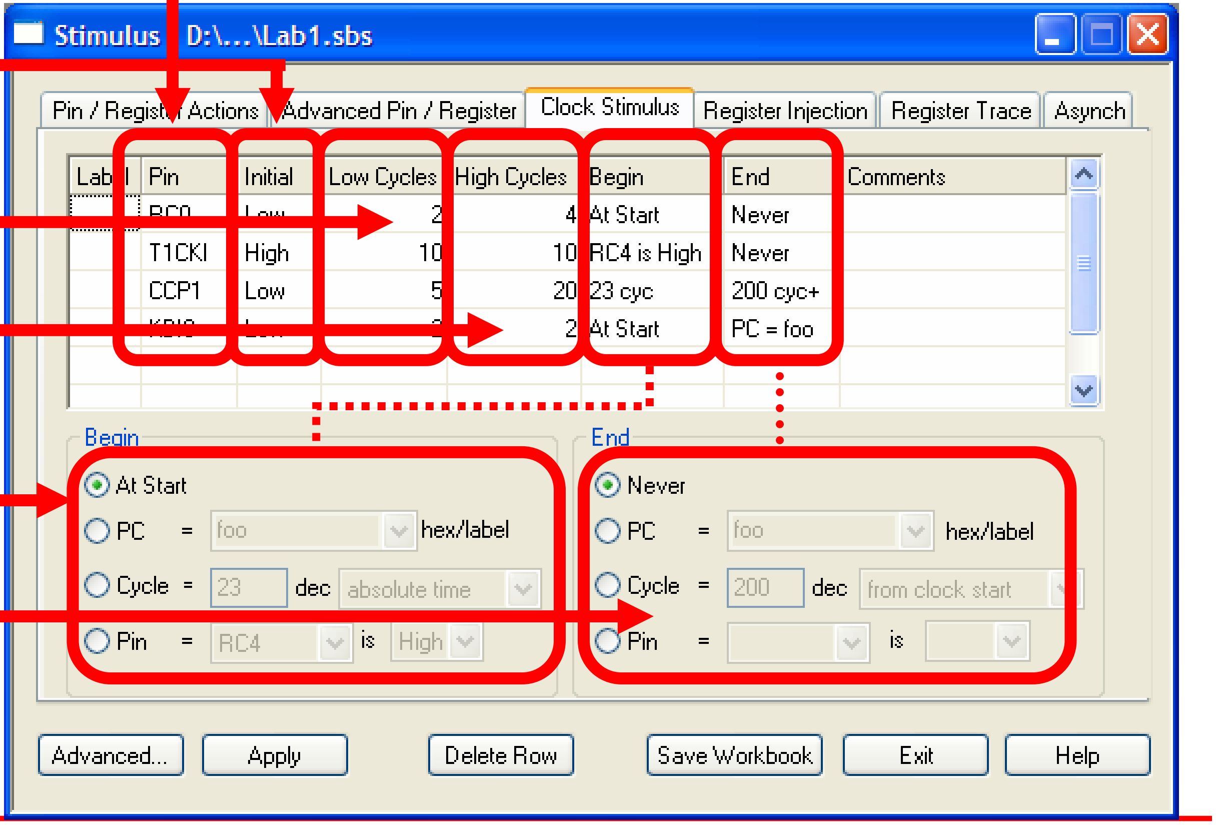
Register Data File Formats

- Format
  - **Hex**: white space delimited hex value e.g. **`1FF  AC  53`**
  - **Dec**: white space delimited dec value e.g. **`128  75  145`**
  - **Raw**: binary data recorded as-is
  - **Packet:** only for UART buffer
    - **Combo of Hex and “string”**
    - **Wait time**

```
wait 2 ms
61 62 62 20
"abc"
```

Clock Stimulus

- **Generates waveform to pin**
- Target Pin
- Initial State
- Low Cycles
- High Cycles
- Begin cond.
- End cond.



Label	Pin	Initial	Low Cycles	High Cycles	Begin	End	Comments
	RC0	Low	2	4	At Start	Never	
	T1CKI	High	10	10	RC4 is High	Never	
	CCP1	Low	5	20	23 cyc	200 cyc+	
	KBI0	Low	2	2	At Start	PC = foo	

Begin
● At Start
○ PC = foo hex/label
○ Cycle = 23 dec absolute time
○ Pin = RC4 is High

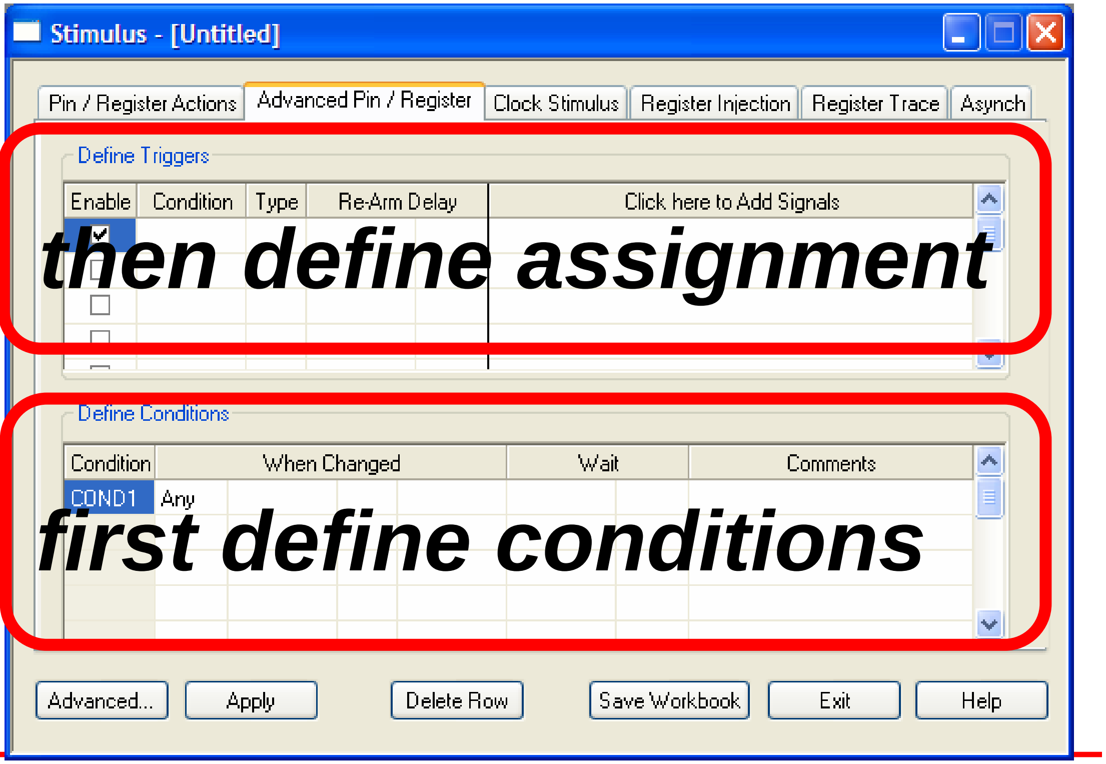
End
● Never
○ PC = foo hex/label
○ Cycle = 200 dec from clock start
○ Pin = is

Clock Stimulus

- **Any type of clocking signals**
- **Possible uses:**
  - TMR external clock signals T0CKI
  - Key bounce – covered in **Advanced Stimulus (11015 MS2)**

Advanced Pin/Register

- Pin/Register assignment with **conditional** control
- Condition
  - -If TMR2 is E0
  - -If INT1IF is ‘1’
- Assignment
  - -Triggered once
  - -Whenever cond happens



Advanced Pin/Register

- **Provides flexibility with gating**
  - Complex pin and register stimulus based on other signals
- **Possible uses:**
  - Set IRQ flags based on clock stimulus
  - Pulse train – covered in **Advanced Stimulus (12025 MS2)**

11014 MS1

MPLAB Simulator Fundamentals

(END)

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