Getting Started

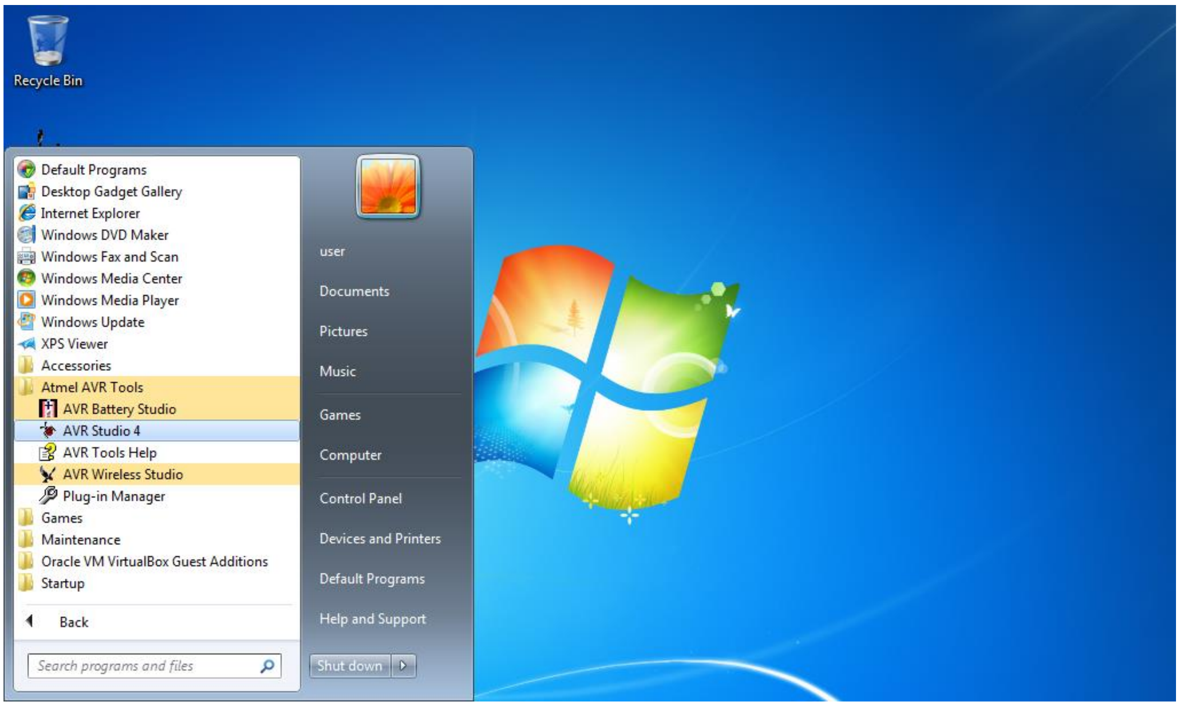
Installing AVR Studio

This is the software we will use to develop and compile AVR programs. It includes an IDE, an assembler, and a simulator.

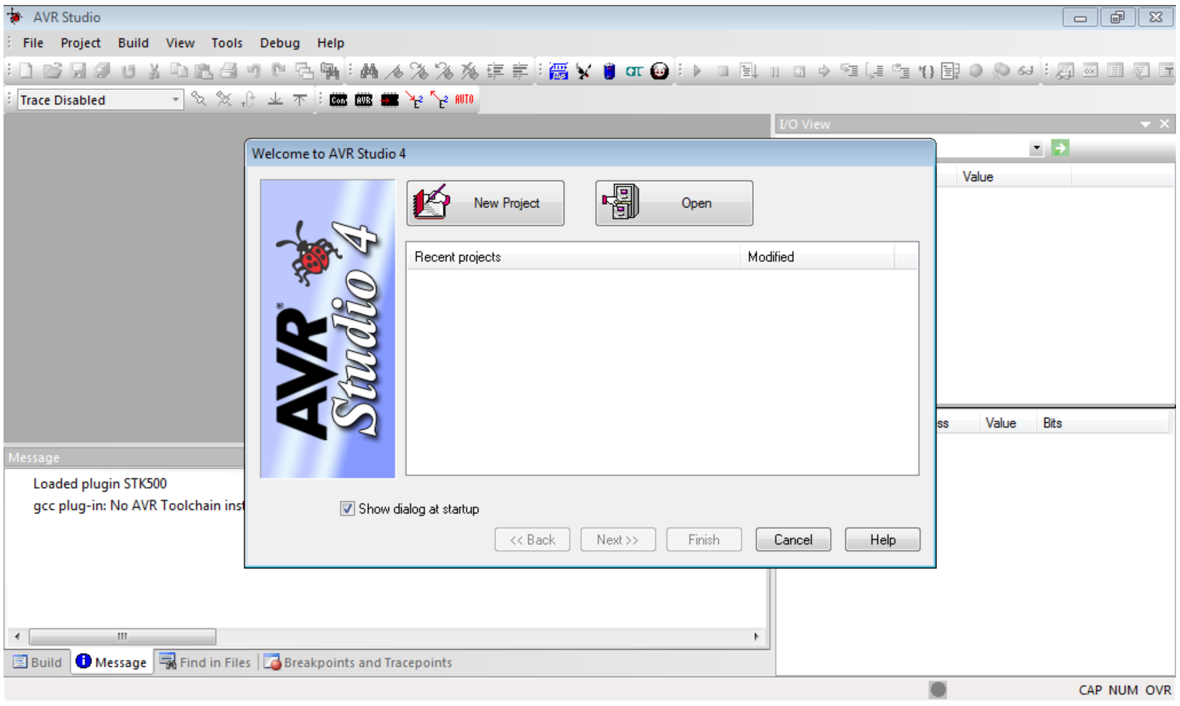
AVR Studio 4.19 can be downloaded from
http://www.cse.unsw.edu.au/~cs2121/AVR/AvrStudio4Setup.exe

Earlier or later versions of AVR Studio or Atmel Studio may not work with the Atmega2560 chip, so use them at your own risk.

Building and Debugging

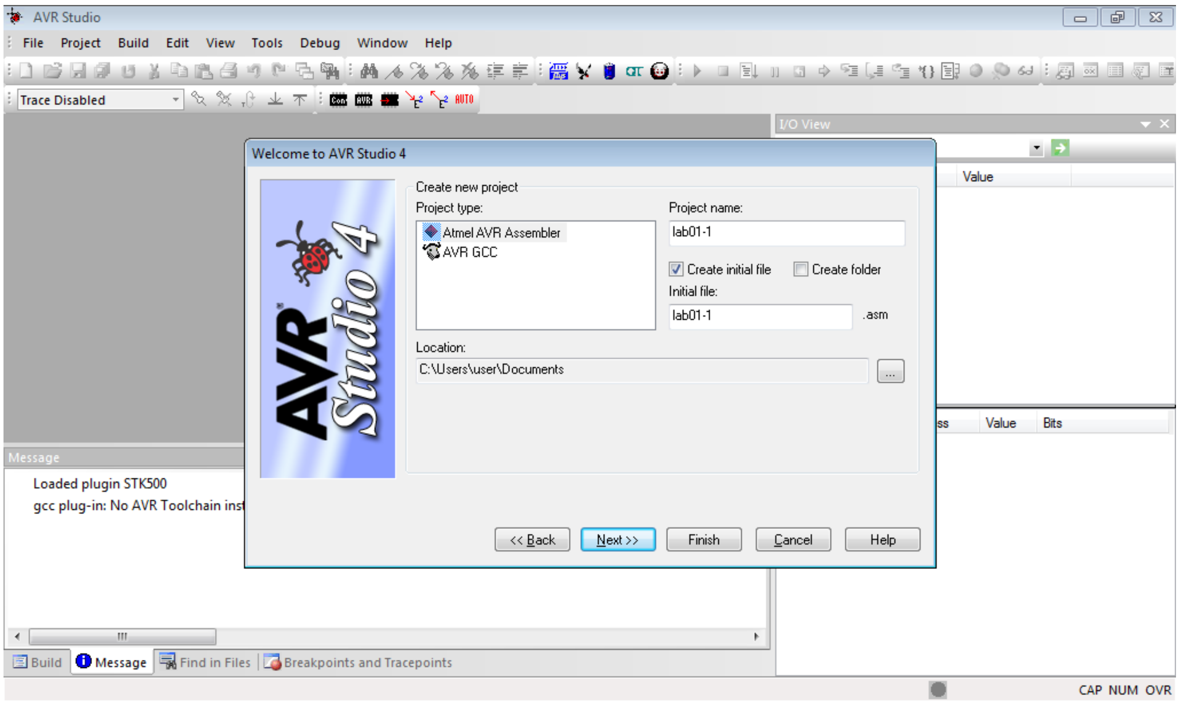


Once installed, launch AVR Studio from the “AVR Studio 4” shortcut.



Loaded plugin STK500
gcc plug-in: No AVR Toolchain ins

On the welcome screen, click the "New Project" button.

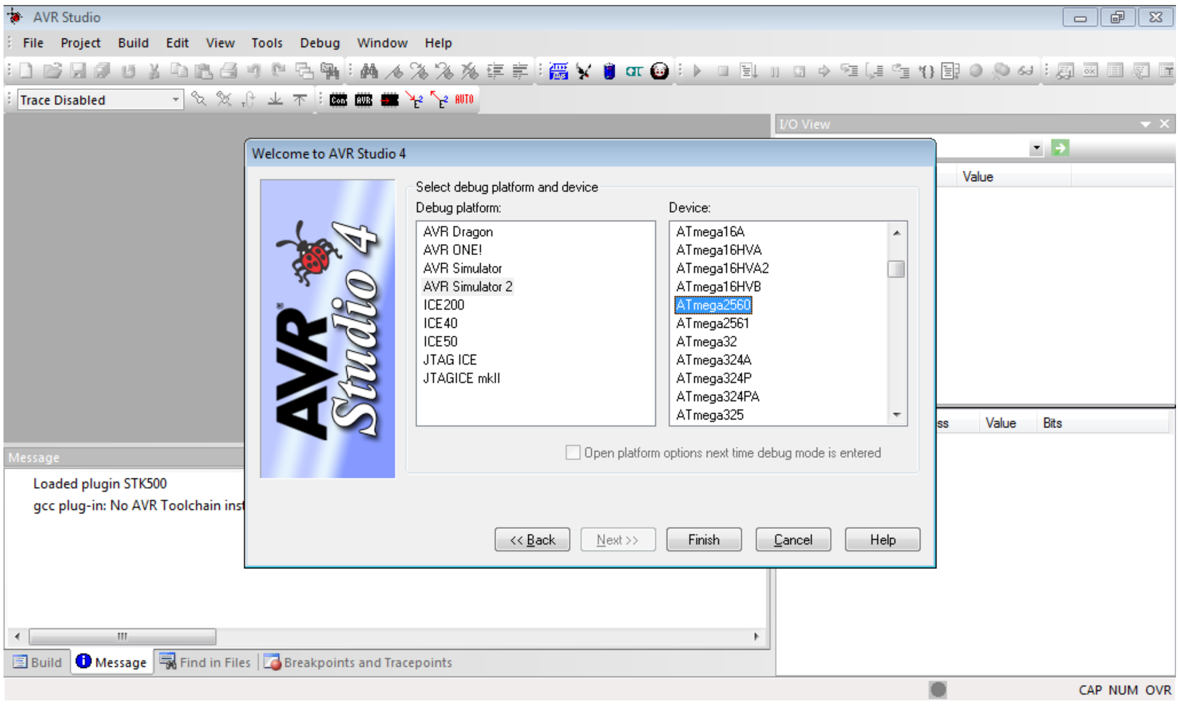


Project name: lab01-1
☑ Create initial file ☐ Create folder
Initial file: lab01-1 .asm
Location: C:\Users\user\Documents

Loaded plugin STK500
gcc plug-in: No AVR Toolchain ins

Choose "Atmel AVR Assembler" as the project type and enter a name for the project, then click "Next".

On the lab machines, the new project is created in program files by default and gives a permission error. Instead, click the "…" next to the location box and select the "Z:" drive or the desktop to create your project.


AVR Studio
File Project Build Edit View Tools Debug Window Help
Trace Disabled
I/O View
Value
Message
Build Message Find in Files Breakpoints and Tracepoints
CAP NUM OVR

Welcome to AVR Studio 4

Select debug platform and device

Debug platform:	Device:
AVR Dragon	ATmega16A
AVR ONE!	ATmega16HVA
AVR Simulator	ATmega16HVA2
AVR Simulator 2	ATmega16HVB
ICE200	ATmega2560
ICE40	ATmega2561
ICE50	ATmega32
JTAG ICE	ATmega324A
JTAGICE mkII	ATmega324P
	ATmega324PA
	ATmega325

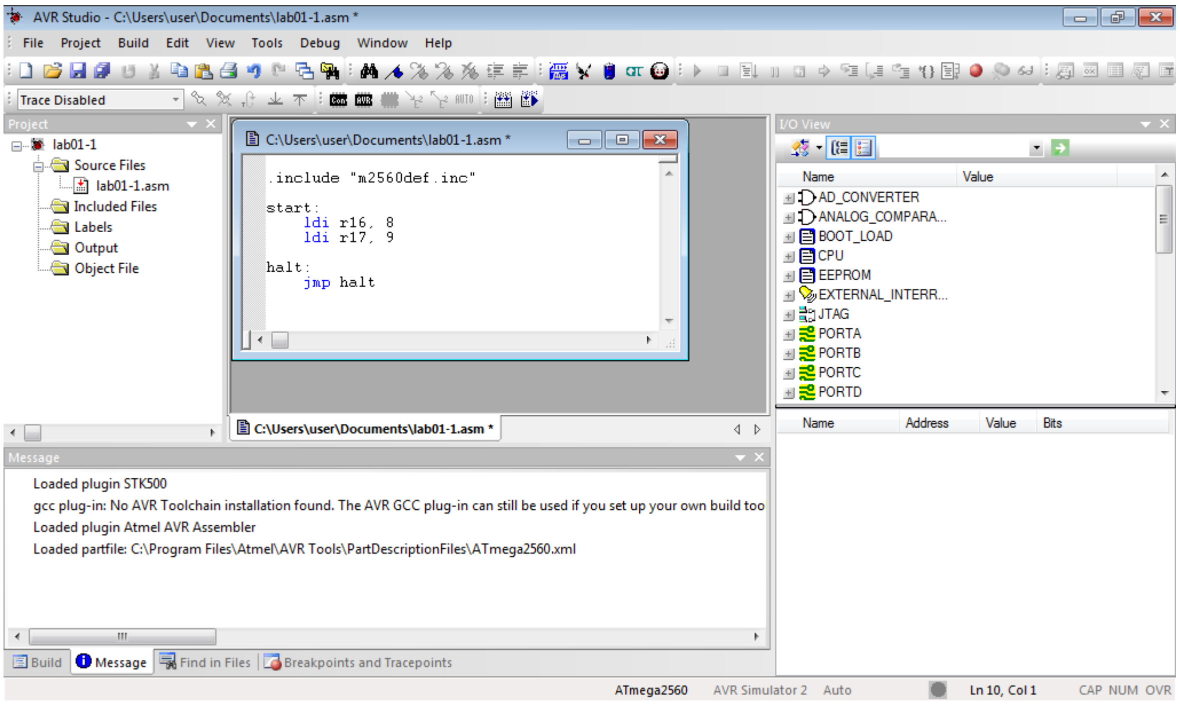
Open platform options next time debug mode is entered

<< Back | Next >> | Finish | Cancel | Help

```
Loaded plugin STK500
gcc plug-in: No AVR Toolchain inst
```

Choose “AVR Simulator 2” as the Debug Platform and “ATmega2560” as the Device, then click “Finish”.

The lab machines have an older version of AVR Studio installed, and give an error when you select “AVR Simulator 2”. Instead select “AVR Simulator” and “ATmega2560”.


AVR Studio - C:\Users\user\Documents\lab01-1.asm *
File Project Build Edit View Tools Debug Window Help
Trace Disabled
Project
lab01-1
Source Files
lab01-1.asm
Included Files
Labels
Output
Object File
C:\Users\user\Documents\lab01-1.asm *
I/O View
Name
Value
AD_CONVERTER
ANALOG_COMPARA...
BOOT_LOAD
CPU
EEPROM
EXTERNAL_INTERR...
JTAG
PORTA
PORTB
PORTC
PORTD
Name Address Value Bits
Message
Build Message Find in Files Breakpoints and Tracepoints
ATmega2560 AVR Simulator 2 Auto Ln 10, Col 1 CAP NUM OVR

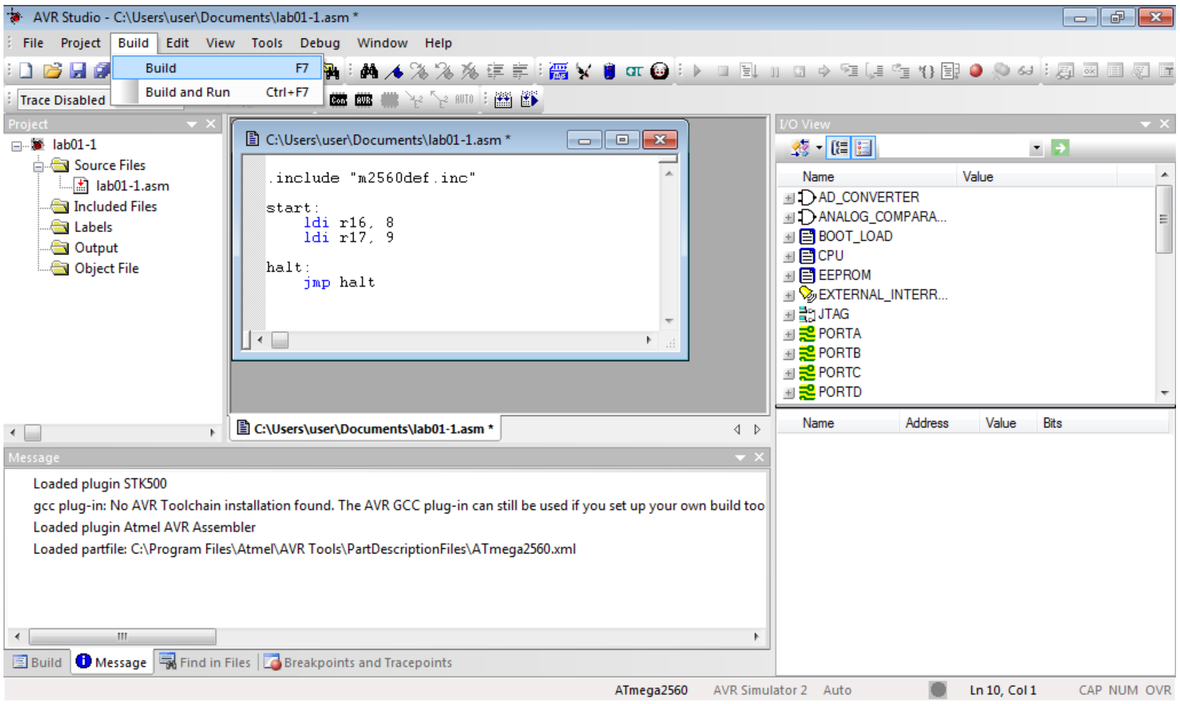
```
.include "m2560def.inc"

start:
    ldi r16, 8
    ldi r17, 9

halt:
    jmp halt
```

```
Loaded plugin STK500
gcc plug-in: No AVR Toolchain installation found. The AVR GCC plug-in can still be used if you set up your own build too
Loaded plugin Atmel AVR Assembler
Loaded partfile: C:\Program Files\Atmel\AVR Tools\PartDescriptionFiles\ATmega2560.xml
```

Now that you’ve created the project, enter the following program into the text editor window.

```
.include "m2560def.inc"

start:
        ldi r16, 8
        ldi r17, 9

halt:
        jmp halt
```

The ".include" works the same way as C's "#include". "m2560def.inc" contains port and register definitions for the Atmega2560 chip, and should be included at the top of every assembler program.



AVR Studio - C:\Users\user\Documents\lab01-1.asm *

C:\Users\user\Documents\lab01-1.asm *

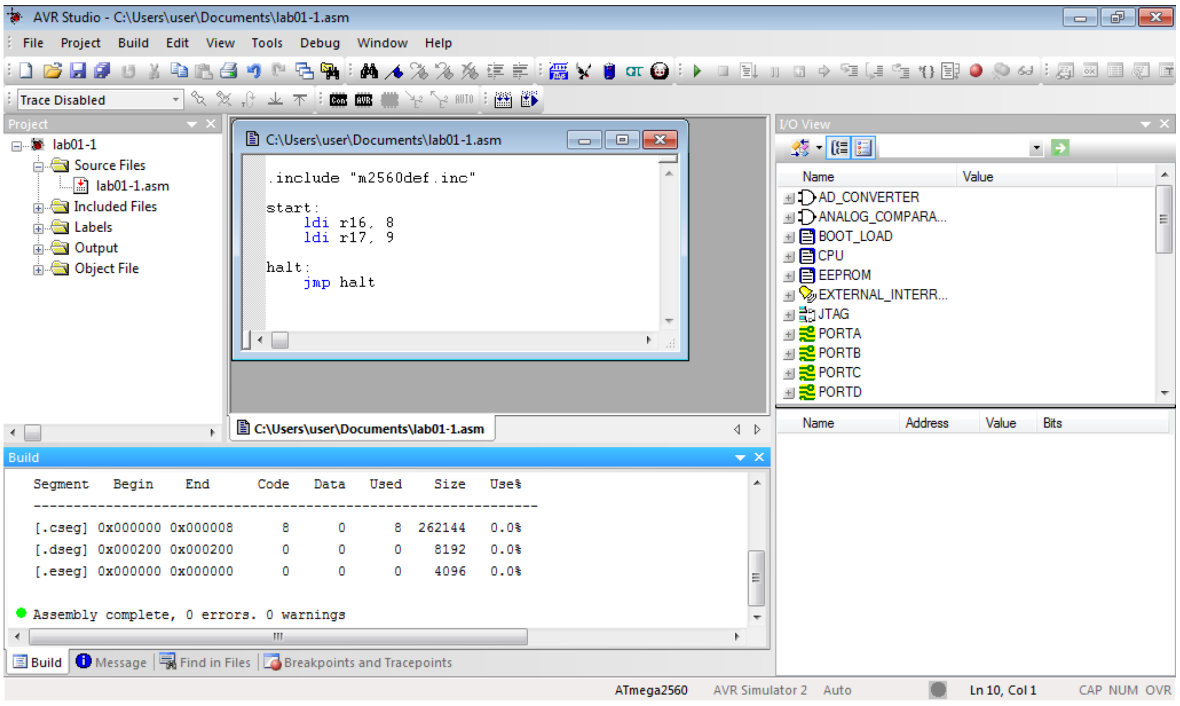
```
.include "m2560def.inc"

start:
     ldi r16, 8
     ldi r17, 9

halt:
     jmp halt
```

Message

```
Loaded plugin STK500
gcc plug-in: No AVR Toolchain installation found. The AVR GCC plug-in can still be used if you set up your own build too
Loaded plugin Atmel AVR Assembler
Loaded partfile: C:\Program Files\Atmel\AVR Tools\PartDescriptionFiles\ATmega2560.xml
```

ATmega2560 AVR Simulator 2 Auto Ln 10, Col 1 CAP NUM OVR

Next, build the program by pressing "F7" or selecting Build->Build from the menu.


AVR Studio - C:\Users\user\Documents\lab01-1.asm
File Project Build Edit View Tools Debug Window Help
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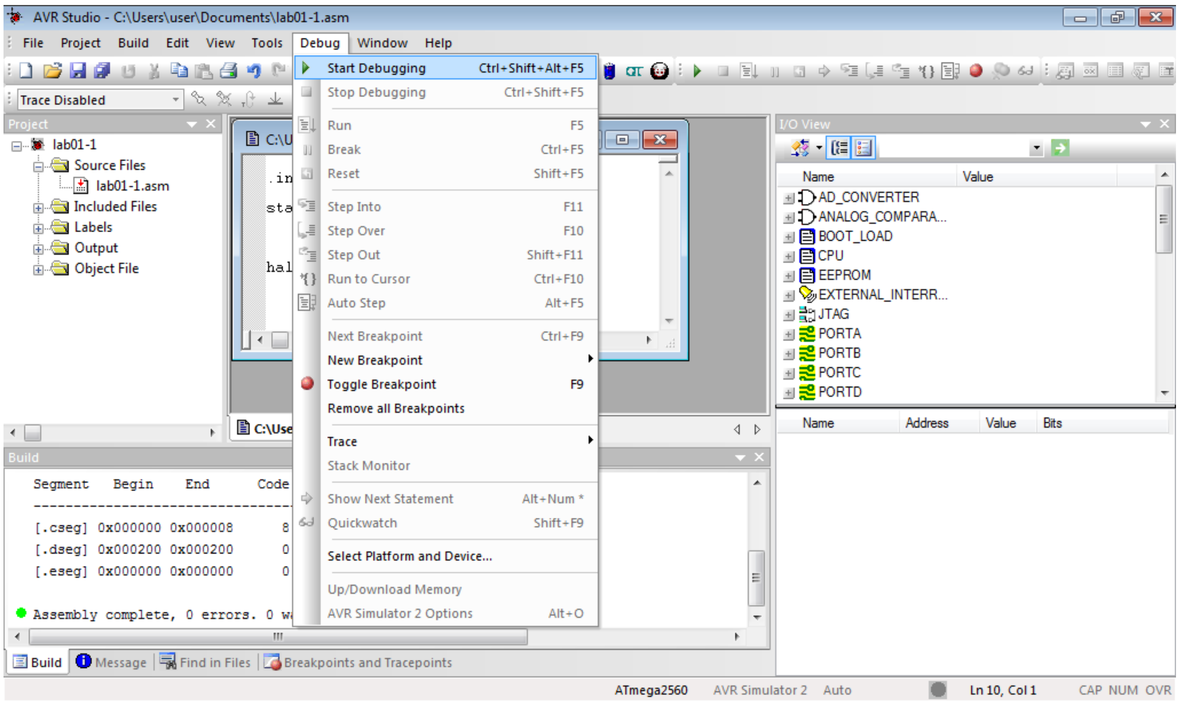
Project
lab01-1
Source Files
lab01-1.asm
Included Files
Labels
Output
Object File
C:\Users\user\Documents\lab01-1.asm
I/O View
Name Value
AD_CONVERTER
ANALOG_COMPARA...
BOOT_LOAD
CPU
EEPROM
EXTERNAL_INTERR...
JTAG
PORTA
PORTB
PORTC
PORTD
Name Address Value Bits
Build
Build Message Find in Files Breakpoints and Tracepoints
ATmega2560 AVR Simulator 2 Auto Ln 10, Col 1 CAP NUM OVR

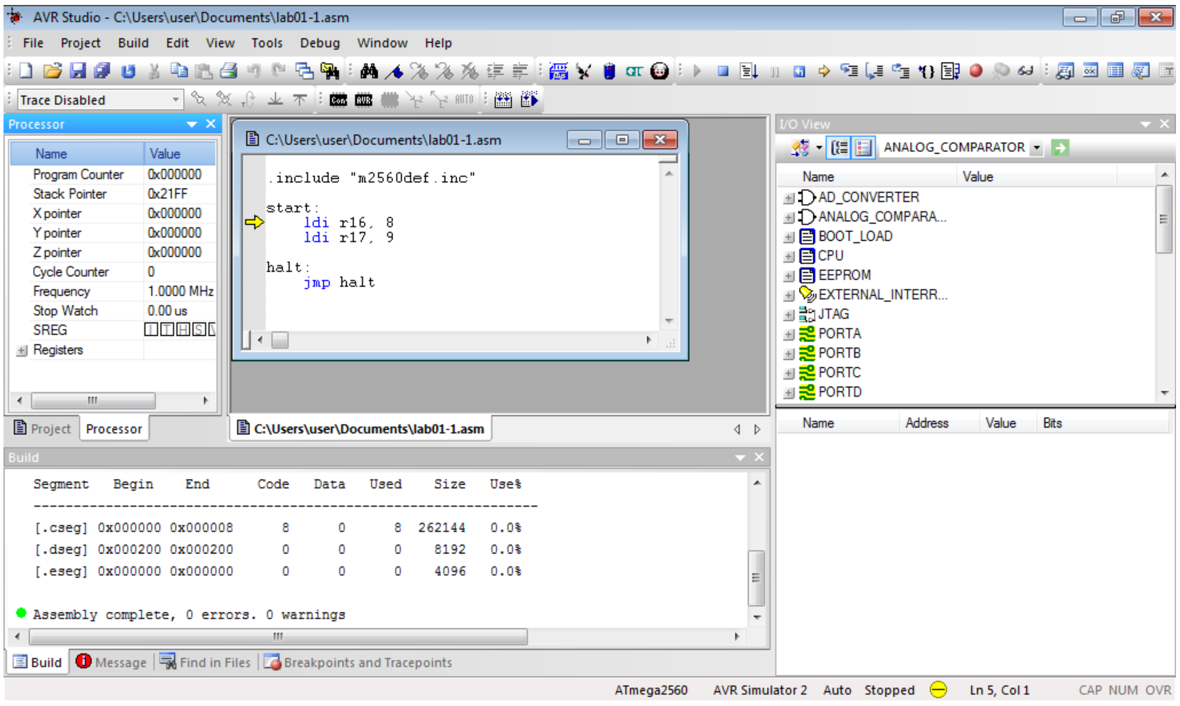
```
.include "m2560def.inc"

start:
    ldi r16, 8
    ldi r17, 9

halt:
    jmp halt
```

```
Segment   Begin    End       Code   Data   Used    Size   Use%
---------------------------------------------------------------
[.cseg] 0x000000 0x000008      8      0      8  262144   0.0%
[.dseg] 0x000200 0x000200      0      0      0    8192   0.0%
[.eseg] 0x000000 0x000000      0      0      0    4096   0.0%

Assembly complete, 0 errors. 0 warnings
```

When the build succeeds, it will display an "Assembly Complete" message in the build window.



Next, start the simulator by pressing "Ctrl+Shift+Alt+F5" or selecting Debug->Start Debugging from the menu.


AVR Studio - C:\Users\user\Documents\lab01-1.asm

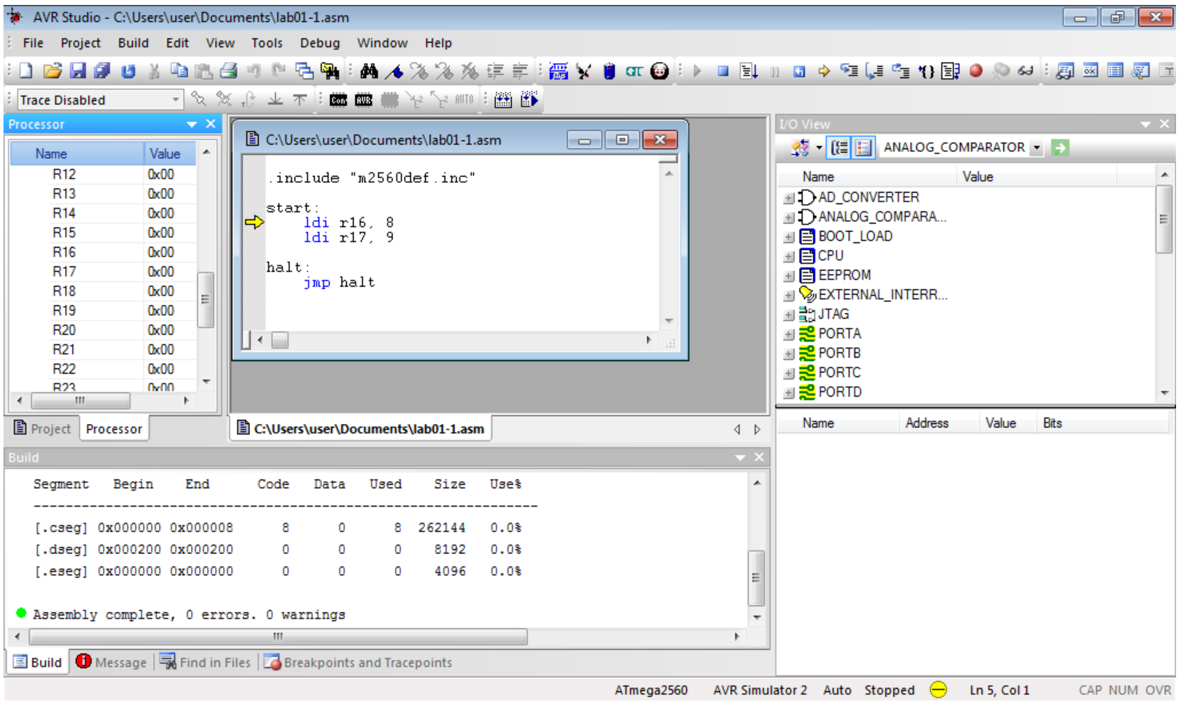
Name	Value
Program Counter	0x000000
Stack Pointer	0x21FF
X pointer	0x000000
Y pointer	0x000000
Z pointer	0x000000
Cycle Counter	0
Frequency	1.0000 MHz
Stop Watch	0.00 us
SREG	
Registers	

```
.include "m2560def.inc"

start:
    ldi r16, 8
    ldi r17, 9

halt:
    jmp halt
```

```
Segment   Begin    End       Code   Data   Used    Size    Use%
---------------------------------------------------------------
[.cseg] 0x000000 0x000008      8      0      8   262144   0.0%
[.dseg] 0x000200 0x000200      0      0      0     8192   0.0%
[.eseg] 0x000000 0x000000      0      0      0     4096   0.0%

Assembly complete, 0 errors. 0 warnings
```

ATmega2560 AVR Simulator 2 Auto Stopped Ln 5, Col 1 CAP NUM OVR

A yellow arrow will appear next to the first instruction, and the Processor toolbar will appear on the left. The Processor toolbar contains information about the processor’s internal state, including register contents.


AVR Studio - C:\Users\user\Documents\lab01-1.asm

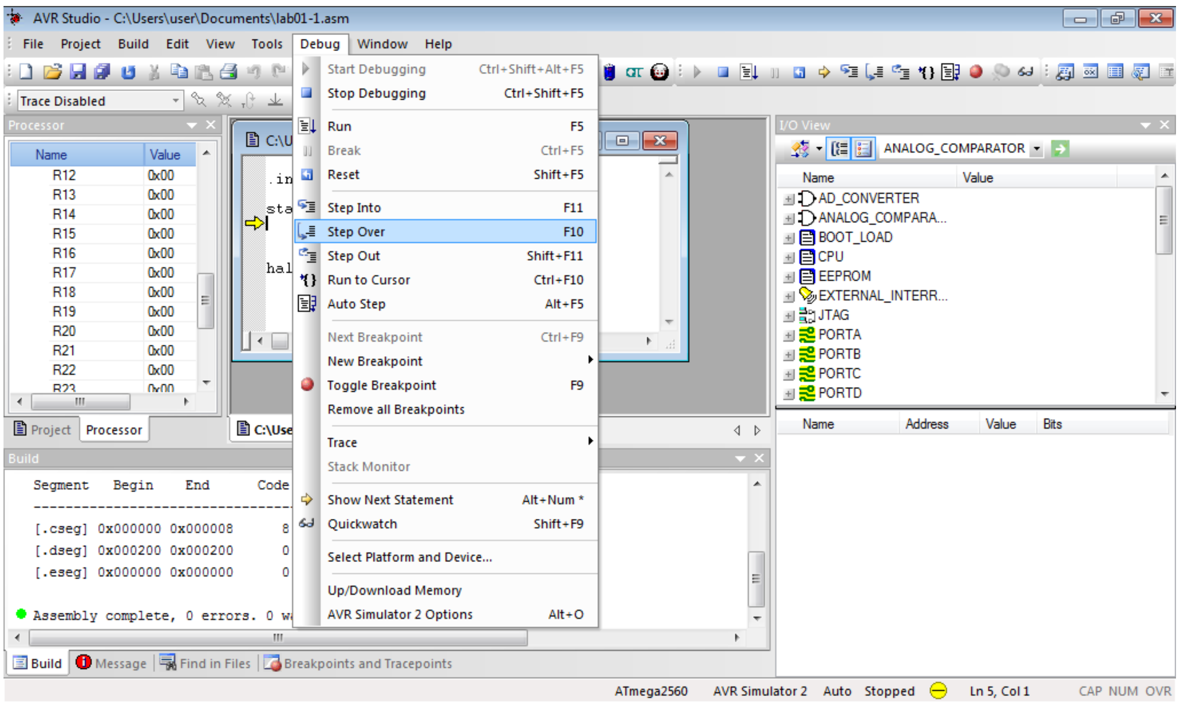
Name	Value
R12	0x00
R13	0x00
R14	0x00
R15	0x00
R16	0x00
R17	0x00
R18	0x00
R19	0x00
R20	0x00
R21	0x00
R22	0x00
R23	0x00

```
.include "m2560def.inc"

start:
    ldi r16, 8
    ldi r17, 9

halt:
    jmp halt
```

```
Segment   Begin    End       Code   Data   Used    Size    Use%
---------------------------------------------------------------
[.cseg] 0x000000 0x000008      8      0      8   262144   0.0%
[.dseg] 0x000200 0x000200      0      0      0     8192   0.0%
[.eseg] 0x000000 0x000000      0      0      0     4096   0.0%

Assembly complete, 0 errors. 0 warnings
```

ATmega2560 AVR Simulator 2 Auto Stopped Ln 5, Col 1 CAP NUM OVR

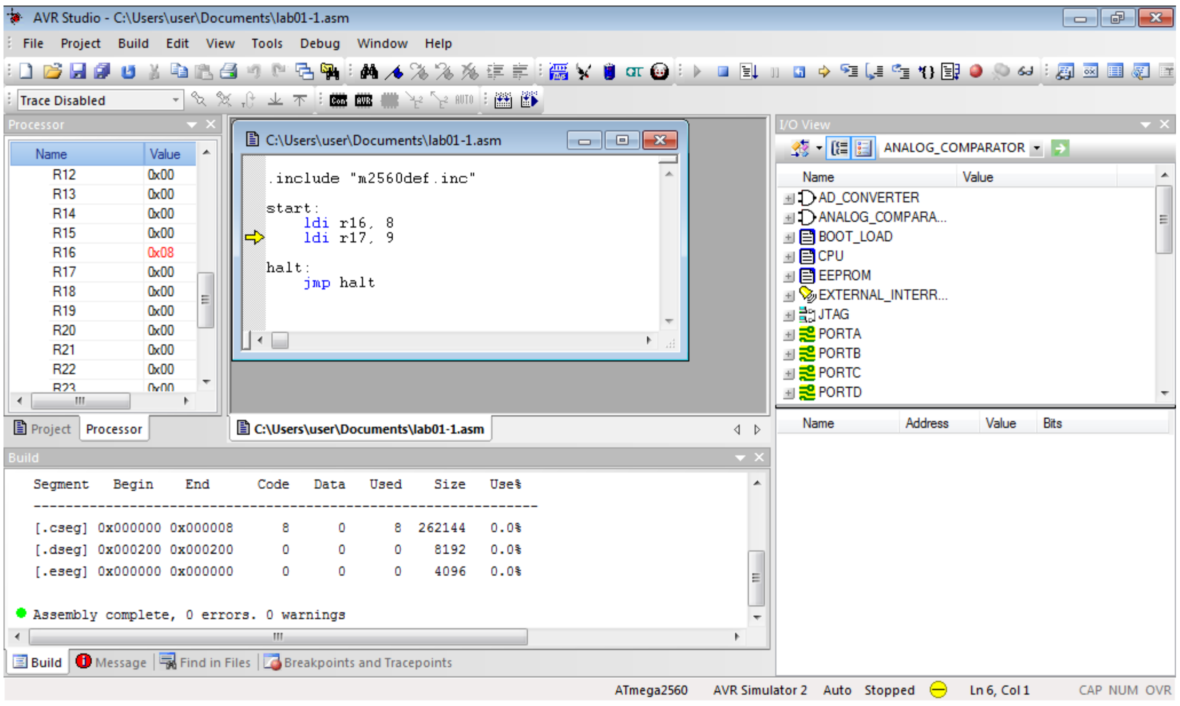
Click on the “+” next to “Registers” in the Processor toolbar and scroll down to r16. All register values should be 0x00 initially.



Name	Value
R12	0x00
R13	0x00
R14	0x00
R15	0x00
R16	0x00
R17	0x00
R18	0x00
R19	0x00
R20	0x00
R21	0x00
R22	0x00
R23	0x00

```
Segment  Begin    End      Code
-------------------------------
[.cseg] 0x000000 0x000008     8
[.dseg] 0x000200 0x000200     0
[.eseg] 0x000000 0x000000     0

Assembly complete, 0 errors. 0 w
```

Press “F10” or select Debug -> Step Over in the menu to execute the first instruction.

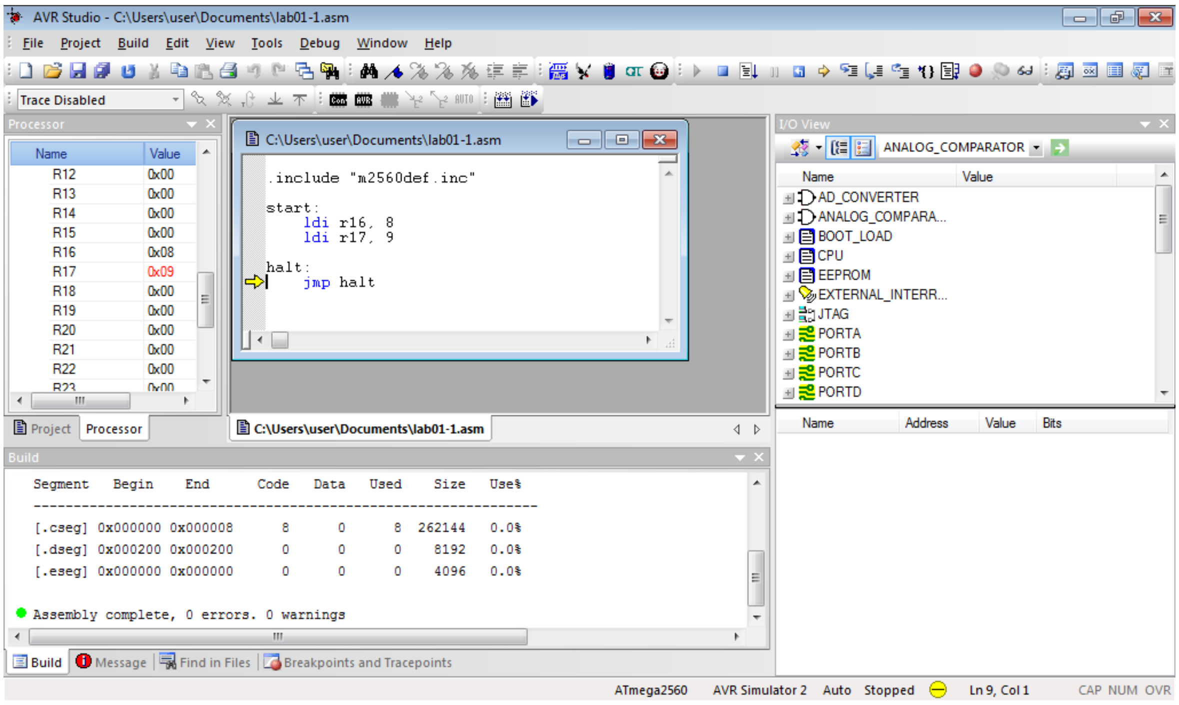

AVR Studio - C:\Users\user\Documents\lab01-1.asm
File Project Build Edit View Tools Debug Window Help
Trace Disabled
Processor
C:\Users\user\Documents\lab01-1.asm
I/O View
ANALOG_COMPARATOR
AD_CONVERTER
ANALOG_COMPARA...
BOOT_LOAD
CPU
EEPROM
EXTERNAL_INTERR...
JTAG
PORTA
PORTB
PORTC
PORTD
Project Processor
Build Message Find in Files Breakpoints and Tracepoints
ATmega2560 AVR Simulator 2 Auto Stopped Ln 6, Col 1 CAP NUM OVR

Name	Value
R12	0x00
R13	0x00
R14	0x00
R15	0x00
R16	0x08
R17	0x00
R18	0x00
R19	0x00
R20	0x00
R21	0x00
R22	0x00
R23	0x00

```
.include "m2560def.inc"

start:
    ldi r16, 8
    ldi r17, 9

halt:
    jmp halt
```

```
Segment  Begin    End      Code   Data   Used    Size   Use%
---------------------------------------------------------------
[.cseg] 0x000000 0x000008     8      0      8  262144   0.0%
[.dseg] 0x000200 0x000200     0      0      0    8192   0.0%
[.eseg] 0x000000 0x000000     0      0      0    4096   0.0%

Assembly complete, 0 errors. 0 warnings
```

The yellow arrow will move to the next instruction, and the value of r16 will change to 0x08, and will be coloured red. Press “F10” again to run the next instruction.

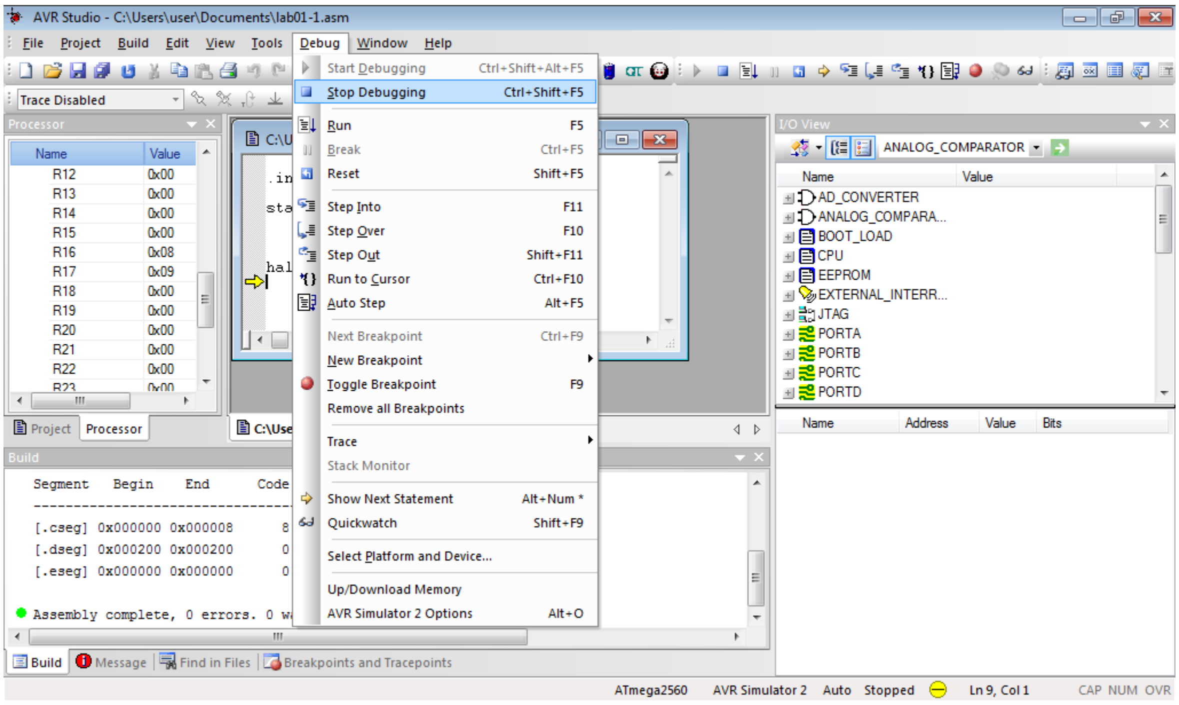

AVR Studio - C:\Users\user\Documents\lab01-1.asm
File Project Build Edit View Tools Debug Window Help
Trace Disabled
Processor
I/O View
ANALOG_COMPARATOR
AD_CONVERTER
ANALOG_COMPARA...
BOOT_LOAD
CPU
EEPROM
EXTERNAL_INTERR...
JTAG
PORTA
PORTB
PORTC
PORTD
Name Address Value Bits
Project Processor
Build Message Find in Files Breakpoints and Tracepoints
ATmega2560 AVR Simulator 2 Auto Stopped Ln 9, Col 1 CAP NUM OVR

Name	Value
R12	0x00
R13	0x00
R14	0x00
R15	0x00
R16	0x08
R17	0x09
R18	0x00
R19	0x00
R20	0x00
R21	0x00
R22	0x00

```
.include "m2560def.inc"

start:
    ldi r16, 8
    ldi r17, 9

halt:
    jmp halt
```

```
Segment   Begin    End       Code   Data   Used    Size   Use%
---------------------------------------------------------------
[.cseg] 0x000000 0x000008      8      0      8  262144   0.0%
[.dseg] 0x000200 0x000200      0      0      0    8192   0.0%
[.eseg] 0x000000 0x000000      0      0      0    4096   0.0%

Assembly complete, 0 errors. 0 warnings
```

Now r17 has changed value to 0x09 and is coloured red.

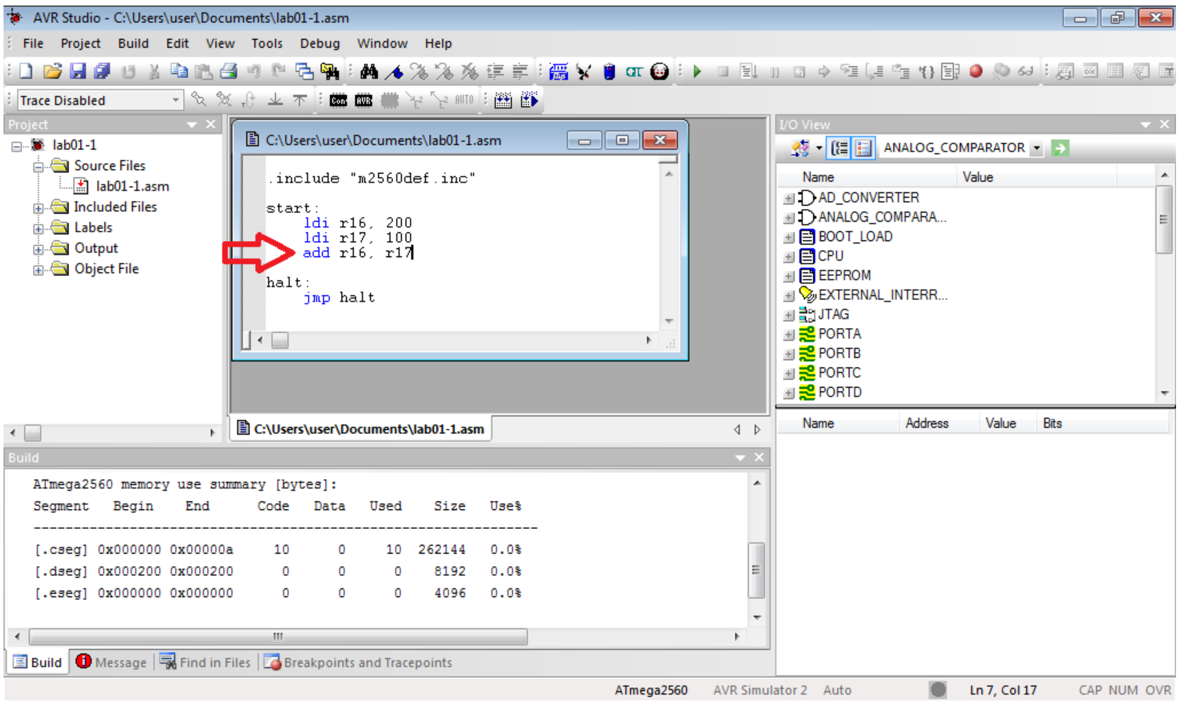

AVR Studio - C:\Users\user\Documents\lab01-1.asm
File Project Build Edit View Tools Debug Window Help
Start Debugging Ctrl+Shift+Alt+F5
Stop Debugging Ctrl+Shift+F5
Run F5
Break Ctrl+F5
Reset Shift+F5
Step Into F11
Step Over F10
Step Out Shift+F11
Run to Cursor Ctrl+F10
Auto Step Alt+F5
Next Breakpoint Ctrl+F9
New Breakpoint
Toggle Breakpoint F9
Remove all Breakpoints
Trace
Stack Monitor
Show Next Statement Alt+Num *
Quickwatch Shift+F9
Select Platform and Device...
Up/Download Memory
AVR Simulator 2 Options Alt+O
ATmega2560 AVR Simulator 2 Auto Stopped Ln 9, Col 1 CAP NUM OVR

End the debugging session by pressing “Ctrl+Shift+F5” or selecting Debug -> Stop Debugging from the menu.

Breakpoints and the status register

First, enter the following assembly program into the editor.

```
.include "m2560def.inc"

start:
      ldi r16, 200
      ldi r17, 100
      add r16, r17

halt:
      jmp halt
```

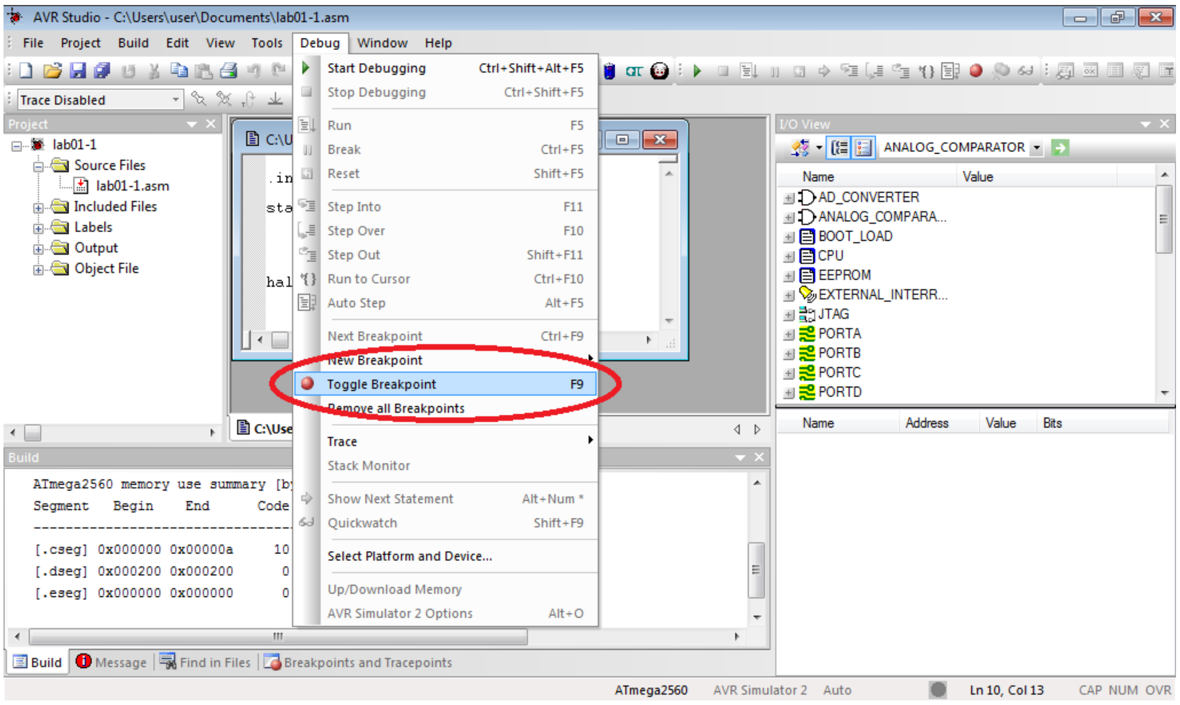


C:\Users\user\Documents\lab01-1.asm

```
.include "m2560def.inc"

start:
    ldi r16, 200
    ldi r17, 100
    add r16, r17

halt:
    jmp halt
```

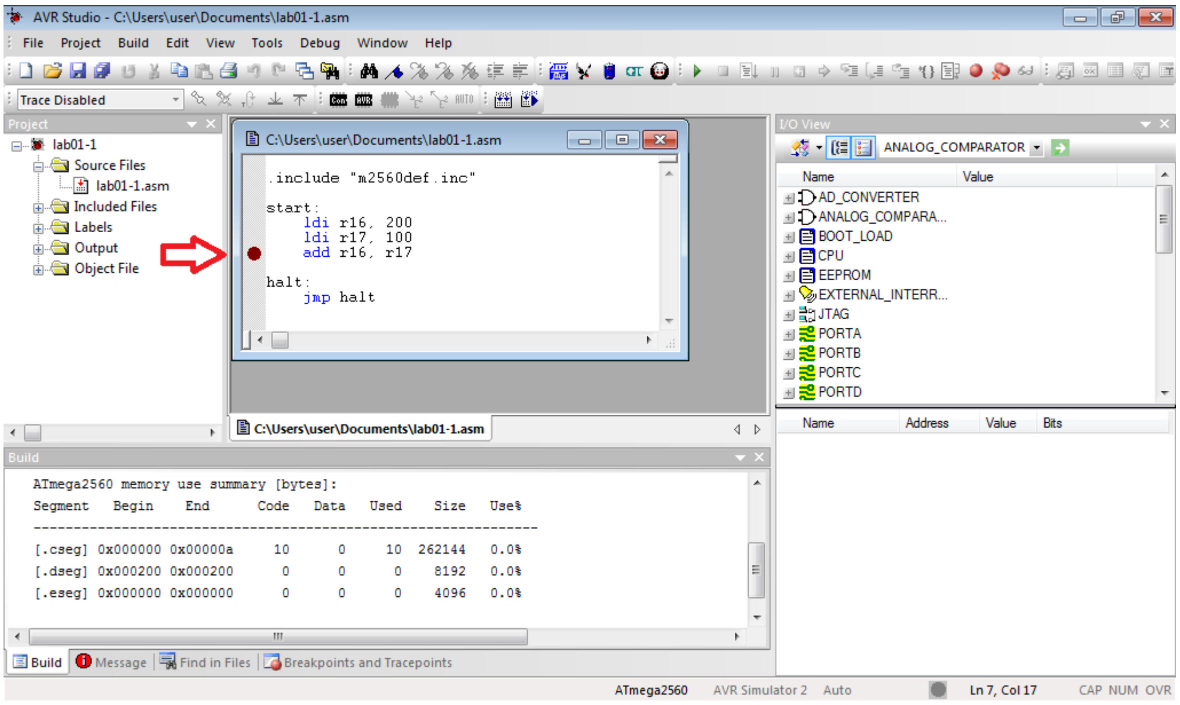
```
ATmega2560 memory use summary [bytes]:
Segment   Begin    End      Code   Data   Used    Size   Use%
---------------------------------------------------------------
[.cseg] 0x000000 0x00000a     10      0     10  262144   0.0%
[.dseg] 0x000200 0x000200      0      0      0    8192   0.0%
[.eseg] 0x000000 0x000000      0      0      0    4096   0.0%
```

When debugging, the simulator can be told to stop only on specific instructions using breakpoints. We are going to put a breakpoint on the add instruction.



```
ATmega2560 memory use summary [b
Segment    Begin    End      Code
---------------------------------
[.cseg] 0x000000 0x00000a      10
[.dseg] 0x000200 0x000200       0
[.eseg] 0x000000 0x000000       0
```

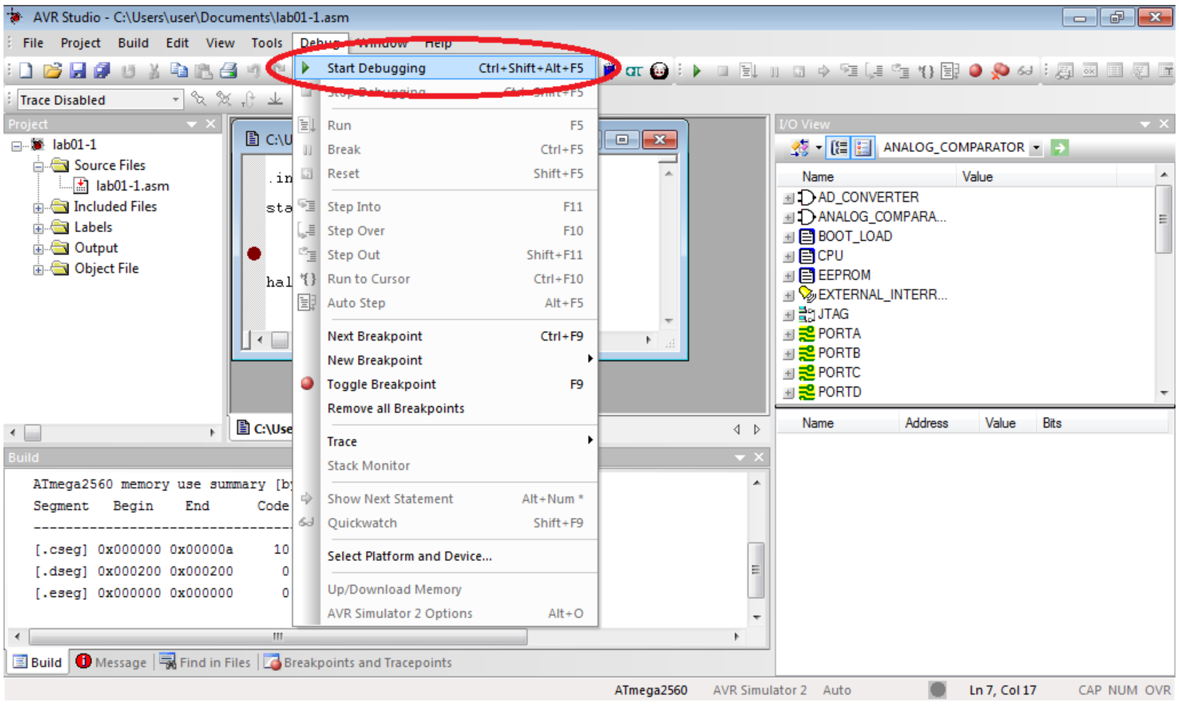
To add a breakpoint, move the cursor to the instruction you want to stop on and press “F9”, or select Debug -> Toggle Breakpoint in the menu.


AVR Studio - C:\Users\user\Documents\lab01-1.asm
File Project Build Edit View Tools Debug Window Help
Trace Disabled
Project
lab01-1
Source Files
lab01-1.asm
Included Files
Labels
Output
Object File
C:\Users\user\Documents\lab01-1.asm
I/O View
ANALOG_COMPARATOR
Name Value
AD_CONVERTER
ANALOG_COMPARA...
BOOT_LOAD
CPU
EEPROM
EXTERNAL_INTERR...
JTAG
PORTA
PORTB
PORTC
PORTD
Name Address Value Bits
Build
Build Message Find in Files Breakpoints and Tracepoints
ATmega2560 AVR Simulator 2 Auto Ln 7, Col 17 CAP NUM OVR

```
.include "m2560def.inc"

start:
     ldi r16, 200
     ldi r17, 100
     add r16, r17

halt:
     jmp halt
```

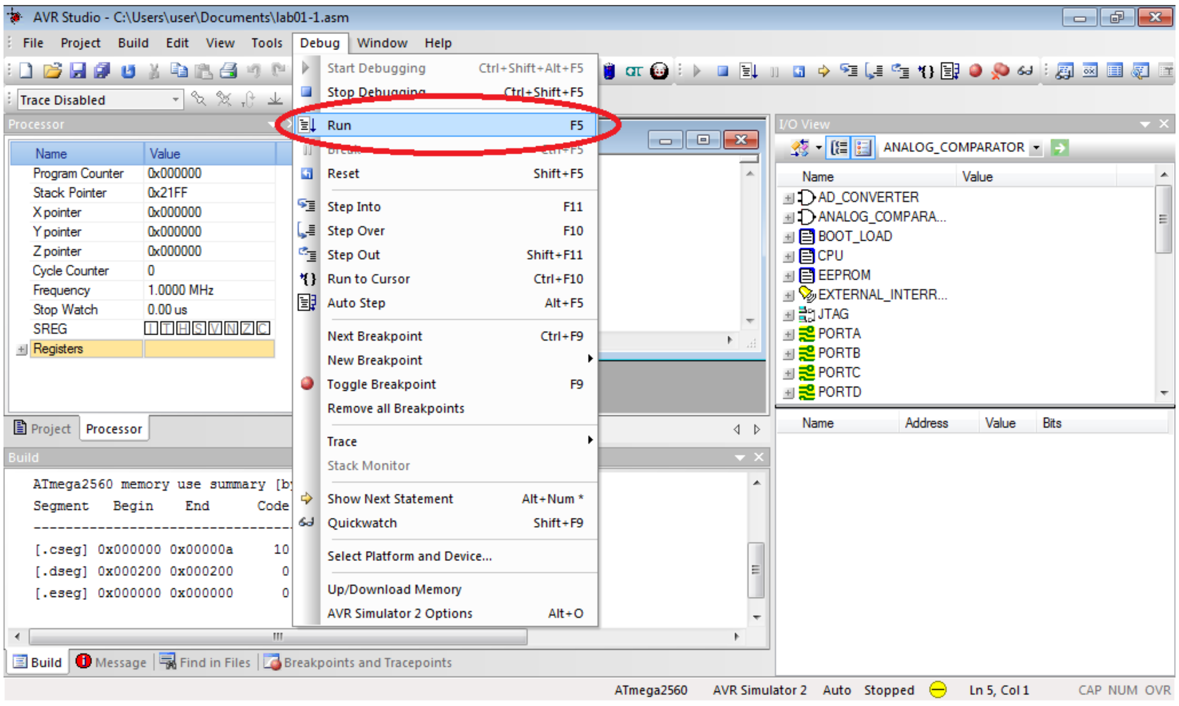
```
ATmega2560 memory use summary [bytes]:
Segment    Begin    End      Code   Data   Used    Size   Use%
---------------------------------------------------------------
[.cseg] 0x000000 0x00000a      10      0     10  262144   0.0%
[.dseg] 0x000200 0x000200       0      0      0    8192   0.0%
[.eseg] 0x000000 0x000000       0      0      0    4096   0.0%
```

A brown dot will appear in the left margin to show where the breakpoint is. Breakpoints can also be added by right-clicking the margin where the dot is and selecting “Toggle Breakpoint”.



```
ATmega2560 memory use summary [b
Segment   Begin    End      Code
--------------------------------
[.cseg] 0x000000 0x00000a    10
[.dseg] 0x000200 0x000200     0
[.eseg] 0x000000 0x000000     0
```

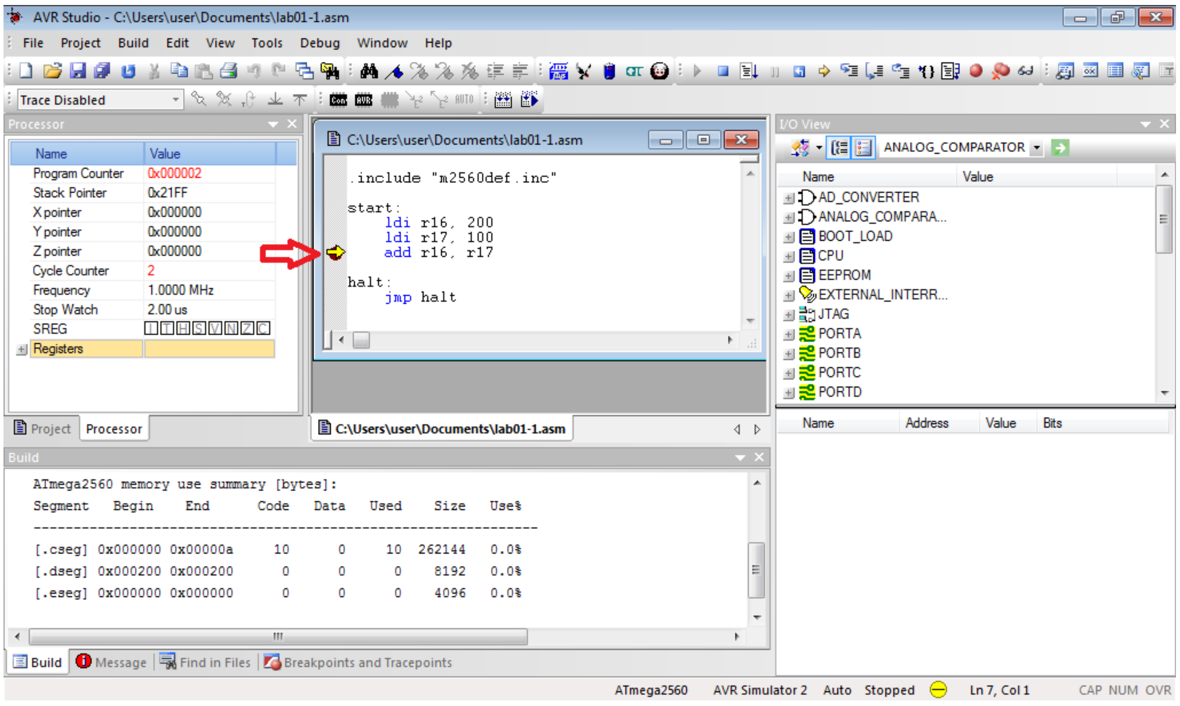
Start the simulator again by pressing “Ctrl+Shift+Alt+F5”.



Name	Value
Program Counter	0x000000
Stack Pointer	0x21FF
X pointer	0x000000
Y pointer	0x000000
Z pointer	0x000000
Cycle Counter	0
Frequency	1.0000 MHz
Stop Watch	0.00 us
SREG	ITHSVNZC
Registers	

```
ATmega2560 memory use summary [b
Segment   Begin    End      Code
--------------------------------
[.cseg] 0x000000 0x00000a    10
[.dseg] 0x000200 0x000200     0
[.eseg] 0x000000 0x000000     0
```

Instead of single-stepping, press “F5” or select Debug -> Run from the menu to run until the breakpoint.


AVR Studio - C:\Users\user\Documents\lab01-1.asm
File Project Build Edit View Tools Debug Window Help
Trace Disabled
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ANALOG_COMPARATOR
Project Processor
Build Message Find in Files Breakpoints and Tracepoints
ATmega2560 AVR Simulator 2 Auto Stopped Ln 7, Col 1 CAP NUM OVR

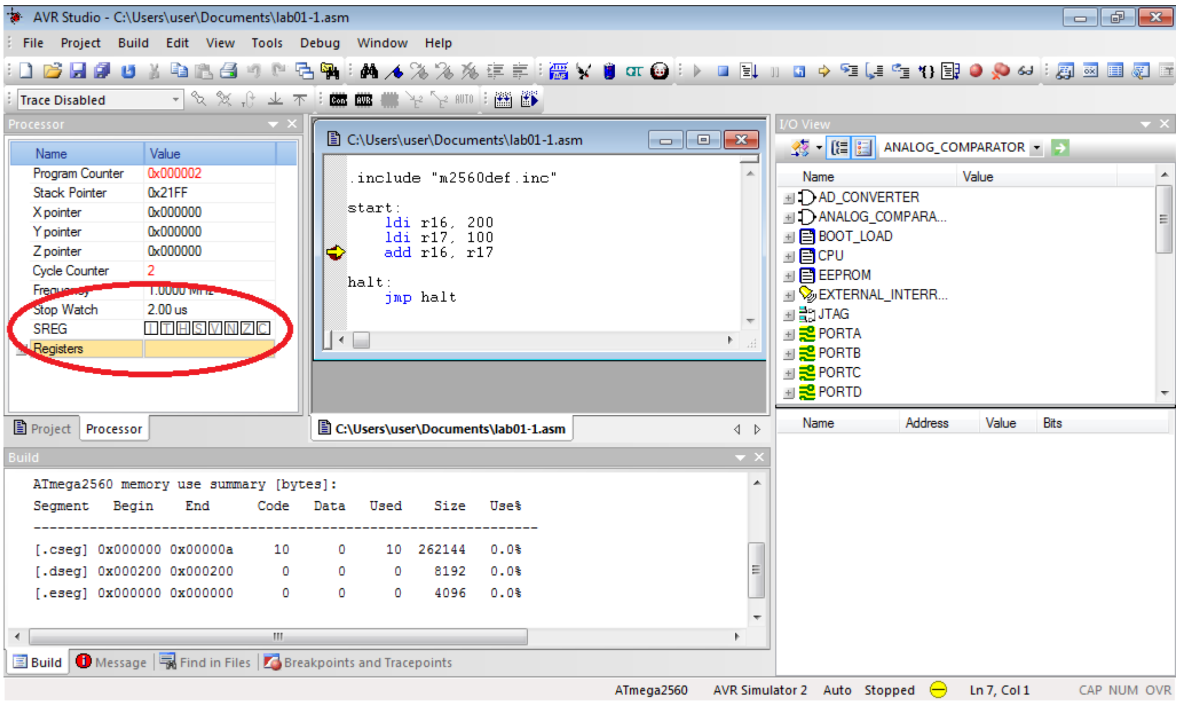
Name	Value
Program Counter	0x000002
Stack Pointer	0x21FF
X pointer	0x000000
Y pointer	0x000000
Z pointer	0x000000
Cycle Counter	2
Frequency	1.0000 MHz
Stop Watch	2.00 us
SREG	I T H S V N Z C
Registers	

```
.include "m2560def.inc"

start:
    ldi r16, 200
    ldi r17, 100
    add r16, r17

halt:
    jmp halt
```

Name	Value
AD_CONVERTER	
ANALOG_COMPARA...	
BOOT_LOAD	
CPU	
EEPROM	
EXTERNAL_INTERR...	
JTAG	
PORTA	
PORTB	
PORTC	
PORTD	

```
ATmega2560 memory use summary [bytes]:
Segment   Begin    End      Code   Data   Used    Size   Use%
---------------------------------------------------------------
[.cseg] 0x000000 0x00000a     10      0     10  262144   0.0%
[.dseg] 0x000200 0x000200      0      0      0    8192   0.0%
[.eseg] 0x000000 0x000000      0      0      0    4096   0.0%
```

The debugger will stop on the ‘add’ line, instead of stopping on the next instruction.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Build Message Find in Files Breakpoints and Tracepoints
ATmega2560 AVR Simulator 2 Auto Stopped Ln 7, Col 1 CAP NUM OVR

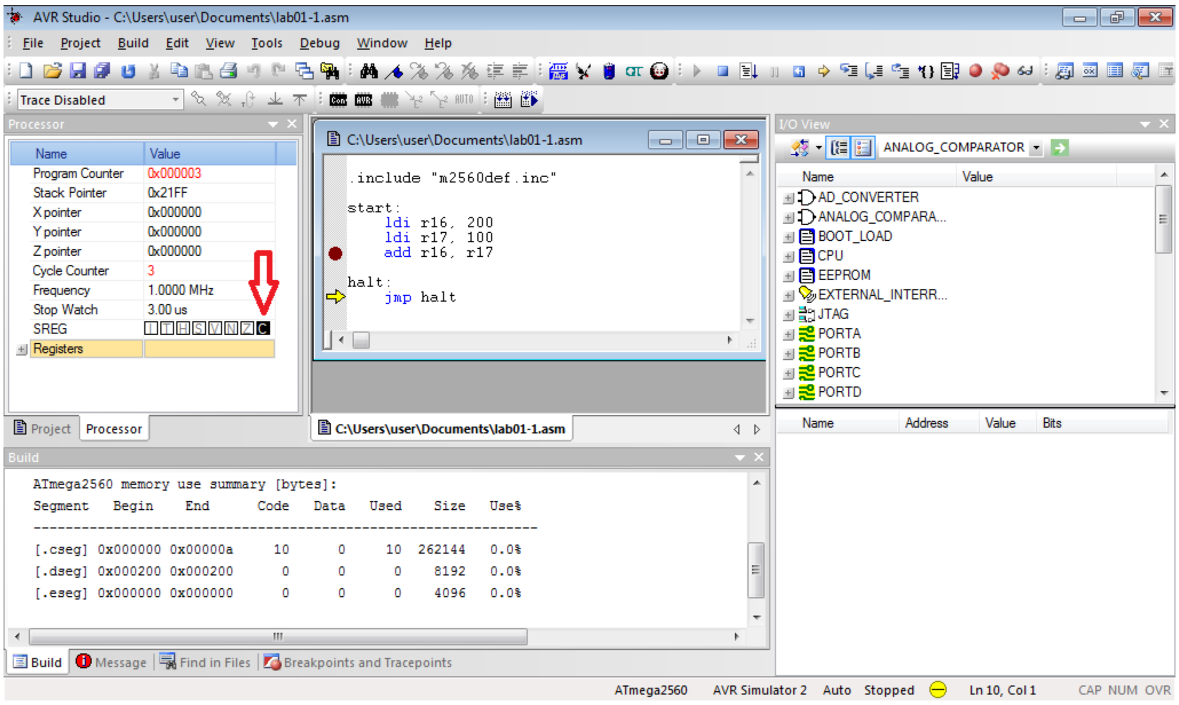
Name	Value
Program Counter	0x000002
Stack Pointer	0x21FF
X pointer	0x000000
Y pointer	0x000000
Z pointer	0x000000
Cycle Counter	2
Frequency	1.0000 MHz
Stop Watch	2.00 us
SREG	I T H S V N Z C
Registers	

```
.include "m2560def.inc"

start:
    ldi r16, 200
    ldi r17, 100
    add r16, r17

halt:
    jmp halt
```

Name	Value
AD_CONVERTER	
ANALOG_COMPARA...	
BOOT_LOAD	
CPU	
EEPROM	
EXTERNAL_INTERR...	
JTAG	
PORTA	
PORTB	
PORTC	
PORTD	

```
ATmega2560 memory use summary [bytes]:
Segment   Begin    End      Code   Data   Used    Size   Use%
---------------------------------------------------------------
[.cseg] 0x000000 0x00000a     10      0     10  262144   0.0%
[.dseg] 0x000200 0x000200      0      0      0    8192   0.0%
[.eseg] 0x000000 0x000000      0      0      0    4096   0.0%
```

The state of the status register is visible on the left. At this point, all the boxes are white, indicating that none of the flags are set. Press “F10” to execute the ‘add’ instruction.


AVR Studio - C:\Users\user\Documents\lab01-1.asm
File Project Build Edit View Tools Debug Window Help
Trace Disabled
Processor
I/O View
ANALOG_COMPARATOR
AD_CONVERTER
ANALOG_COMPARA...
BOOT_LOAD
CPU
EEPROM
EXTERNAL_INTERR...
JTAG
PORTA
PORTB
PORTC
PORTD
Project
Processor
Build
Message
Find in Files
Breakpoints and Tracepoints
ATmega2560 AVR Simulator 2 Auto Stopped Ln 10, Col 1 CAP NUM OVR

Name	Value
Program Counter	0x000003
Stack Pointer	0x21FF
X pointer	0x000000
Y pointer	0x000000
Z pointer	0x000000
Cycle Counter	3
Frequency	1.0000 MHz
Stop Watch	3.00 us
SREG	I T H S V N Z C
Registers	

```
.include "m2560def.inc"

start:
    ldi r16, 200
    ldi r17, 100
    add r16, r17

halt:
    jmp halt
```

```
ATmega2560 memory use summary [bytes]:
Segment   Begin    End      Code   Data   Used    Size   Use%
---------------------------------------------------------------
[.cseg] 0x000000 0x00000a     10      0     10  262144   0.0%
[.dseg] 0x000200 0x000200      0      0      0    8192   0.0%
[.eseg] 0x000000 0x000000      0      0      0    4096   0.0%
```

The ‘C’ flag is now black, showing that the carry flag has been set. This happened because the addition overflowed.