Assembly Language Programming Atmel Microprocessors using the Linux Operating System

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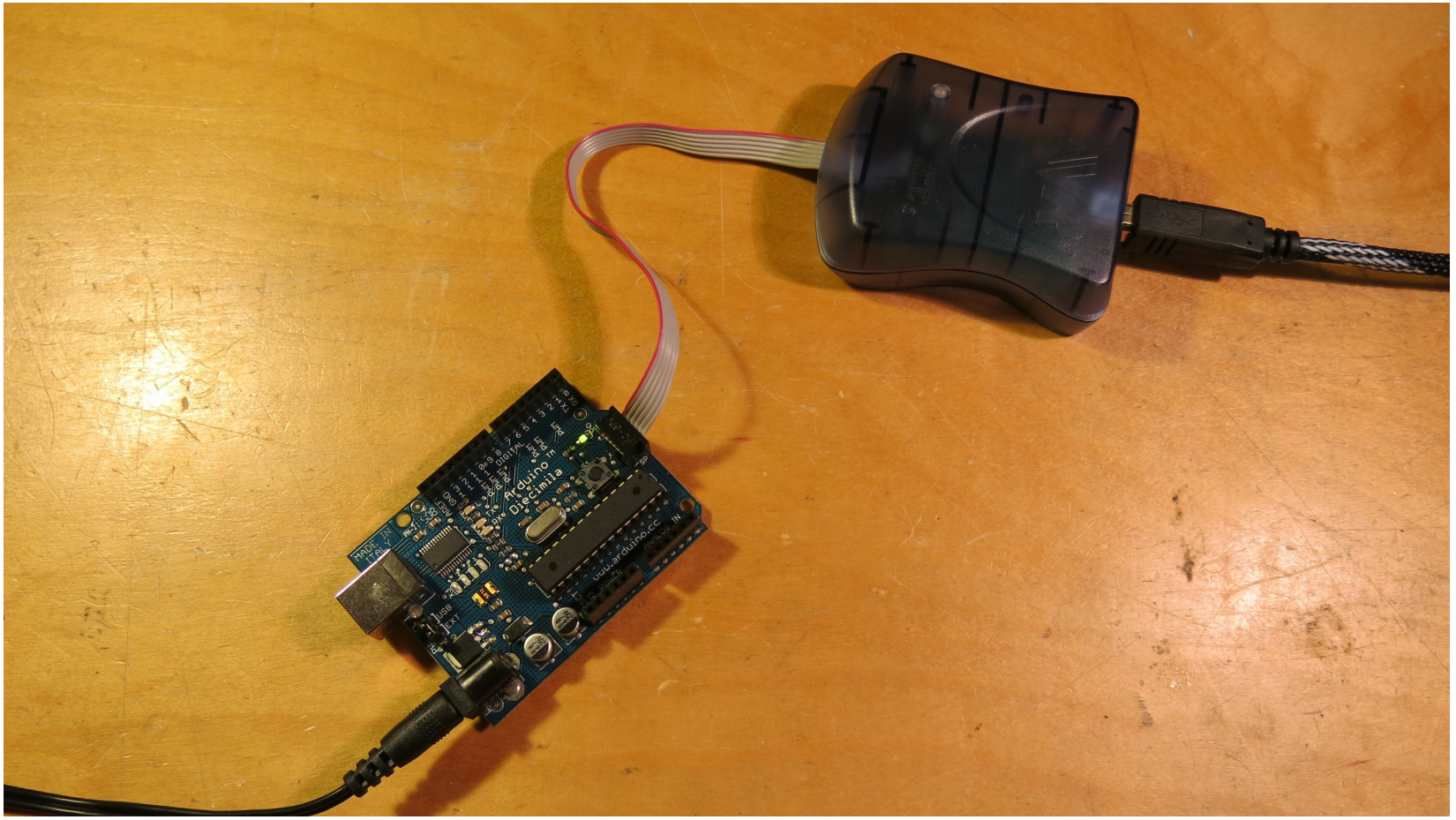
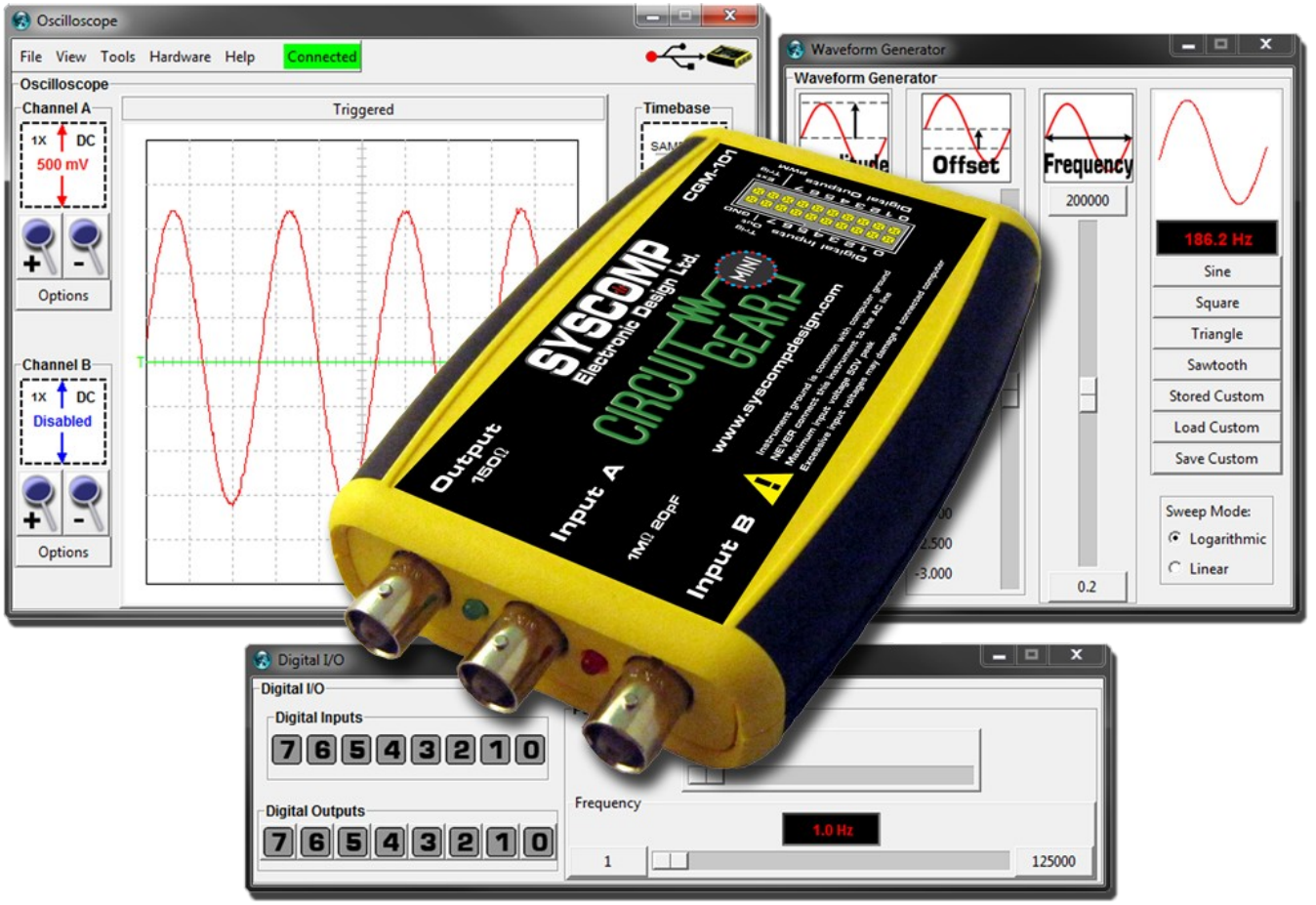
Arduino + AVRISP Programmer



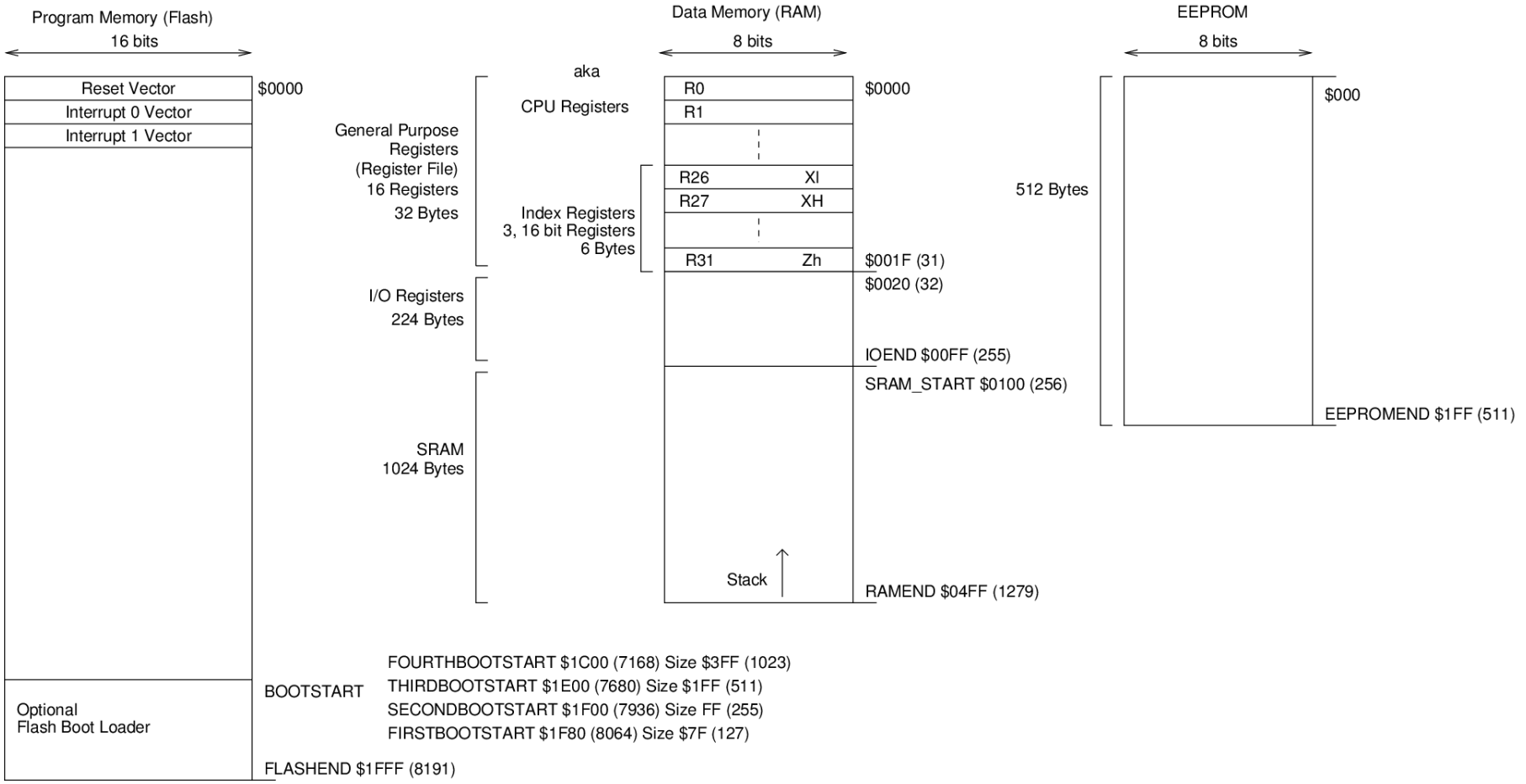
Why Atmel?

- Many different parts available: ATTiny to ATXMega.
- Excellent feature set.
- Readily available, reasonable price.
- Large ecosystem: eg, Arduino boards, open-source software, hundreds of hardware *shields* (interfaces).
- Low and medium complexity units have DIP package.
- Inexpensive development tools: eg, AVRISP $39
- Clean, regular archictecture (mostly)

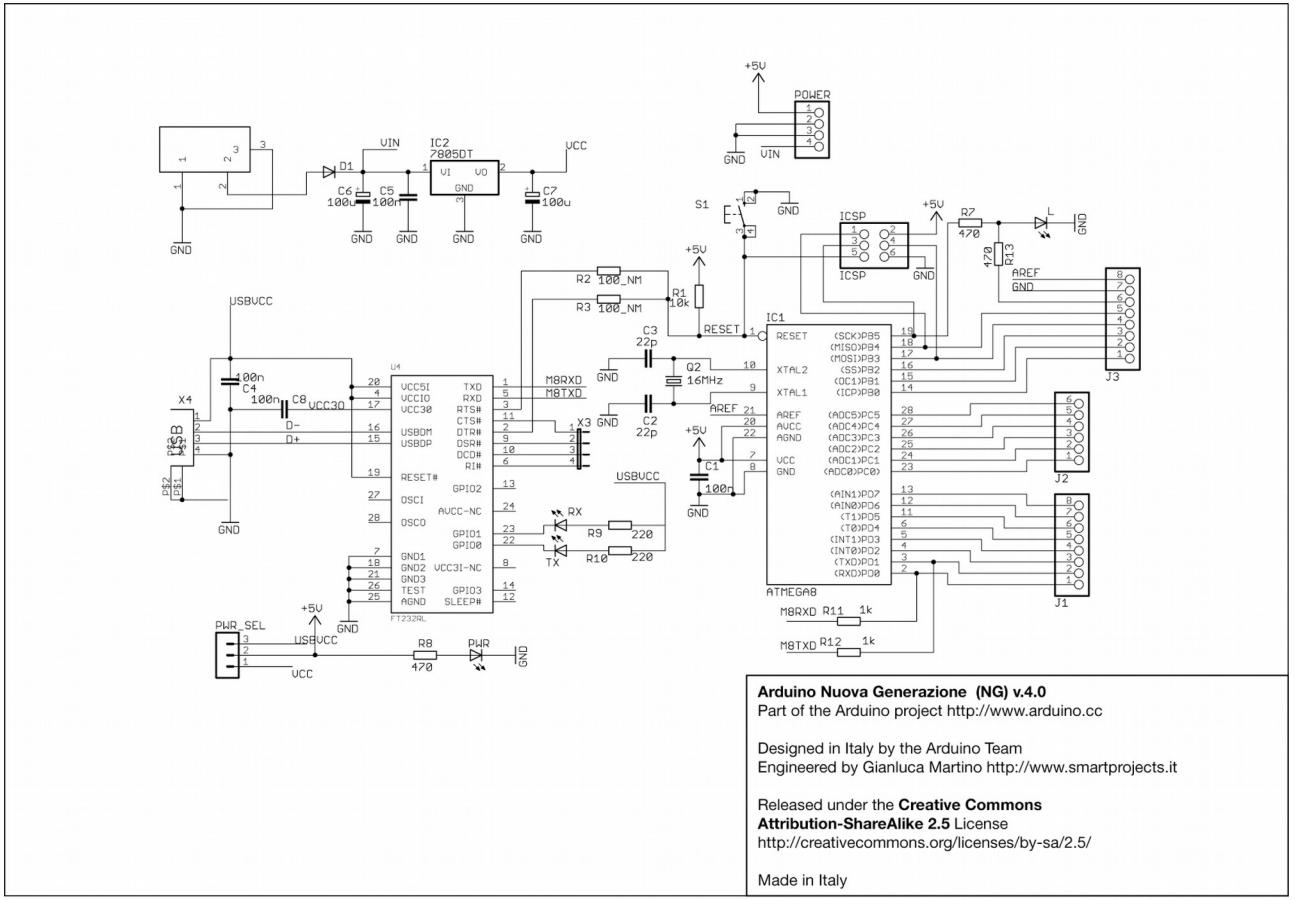
Syscomp Circuitgear Mini uses ATXmega processor



Memory Map for Atmel Microprocessor Harvard Architecture



Typical Arduino Schematic



Why Assembly Language?

Assembly Code Example

```
USART_Receive:

   ; Wait for data to be received
   in    r17, UCSR0A
   sbrs  r17, RXC
   rjmp USART_Receive

   ; Get and return received data from buffer
   in    r16, UDR0
   ret
```

C Code Example

```
unsigned char USART_Receive( void )
{
   /* Wait for data to be received */
   while ( !(UCSR0A & (1<<RXC)) )
      ;
   /* Get and return received data from buffer
*/
   return UDR0;
```

Why Assembly Language (2)?

- For small programs acting as a 'hardware replacement', not much difference between Assembly Language and C.
- Better approach when teaching microprocessor hardware
- Easier understanding code timing issues.
- Simpler programming environment:
- Assembler vs Compiler-Libraries-Assembler-Linker
- Explicit control over parameter structures in call-return sequence.

Development Process

- Write the program using a text editor: foo.asm
- Assemble the program using an assembler: avra or gavrasm: foo.hex
- Upload foo.hex into the hardware using AVRDUDE program and AVRISP hardware or equivalent.
- Run the program.
- Debug using a serial monitor program.

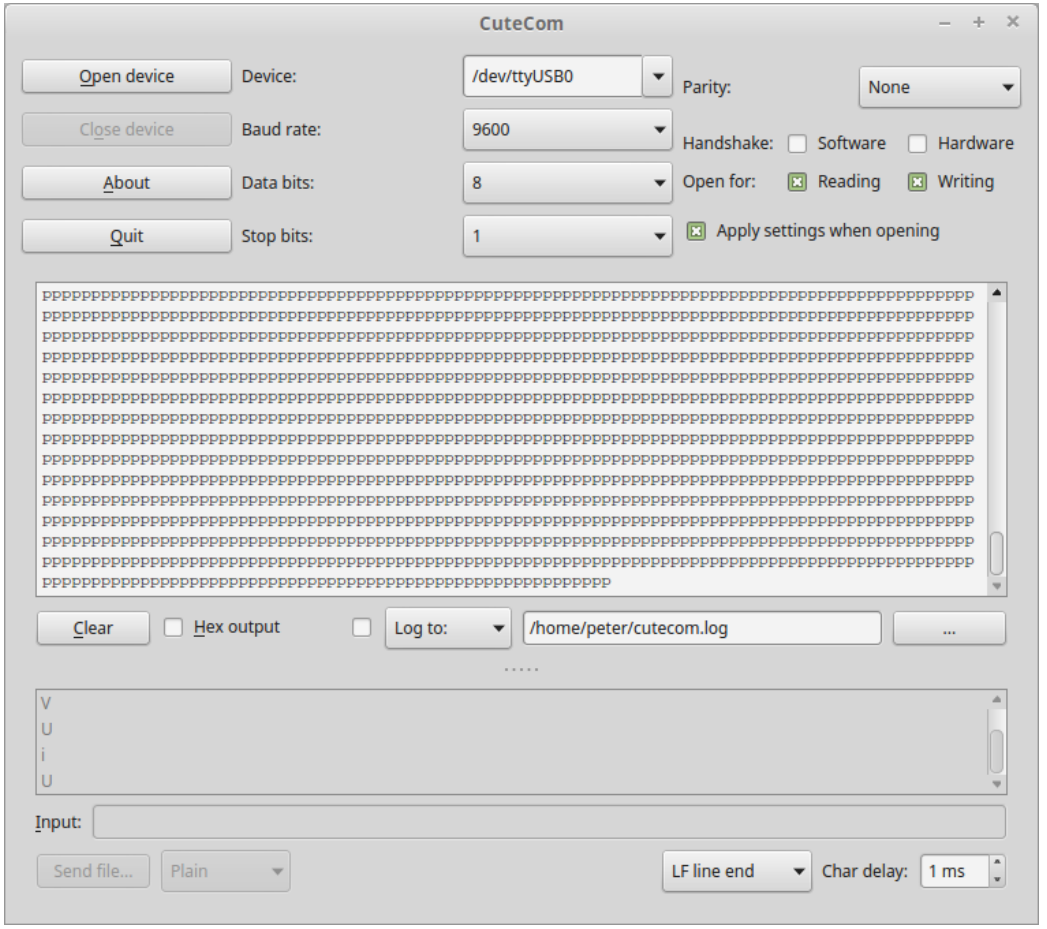
Hello World for Assembly Language

```
; Send Character
; This program sends a character out the serial port. The purpose is to
; establish that the microprocessor UART and the computer terminal program
; are configured correctly.
; Terminal program on the host Linux computer: cutecom
; Configuration: 8N1, 9600 baud.
; Reference:
; ATmega168 datasheet, page 237

; Assemble the program.
; Use the AVRISP II programmer to program the Diecimila circuit board
; with the file 'send-char.hex'.
; Connect the USB port on the Diecimila board to the host computer.
; Run cutecom at 8N1, 9600 baud, connected (probably) to ttyUSB0
; Reset the Diecimila board, characters should appear on the terminal.

; Assemble with: gavrasm send-char.asm
; Download with: avrdude -p m168 -c avrisp2 -U flash:w:send-char.hex
; Tested operational 7 March 2017

.DEVICE ATmega168
.CSEG ; strictly speaking not necessary
.ORG 0
        rjmp main ; reset vector points to Main
.ORG 0x100
; stack is not used so SP not initialized.
main:
; Calculate the baud rate constant and set the baud rate
; fosc = 16000000 ; Diecimila crystal oscillator, 16MHz
; baud = 9600
; baudconst = (fosc / (16 x baud) ) -1 ; Calculate the baud constant
.equ baudconst = 103
.equ baudlo = low(baudconst)
.equ baudhi = high(baudconst)
```

Hello World for Assembly Language

```
; Set the Tx port line PD1 to output
        ldi r16, 0b00000010
        out ddrb, r16

; Set the baud rate register
        ldi r16, baudlo
        sts UBRR0L,r16
        ldi r16, baudhi
        sts UBRR0H,r16

; Enable the receiver and transmitter
        ldi r16, 0b00011000
        sts UCSR0B,r16

; Set the frame format: 8 data bits, one stop bit, no parity
        ldi r16, 0b00000110
        sts UCSR0C,r16

; Now send a stream of the same character.
USART_Transmit:
        lds r17, UCSR0A

; Wait for empty transmit buffer
        sbrs r17, UDRE0         ; Skip if bit UDRE is set, transmit is complete
        rjmp USART_Transmit

        ldi r16, "p"            ; Send the character
        sts UDR0, r16
wait:   inc r18
        brne wait

; Delay between characters
        rjmp USART_Transmit     ; and repeat forever
```

Hello World for Assembly Language

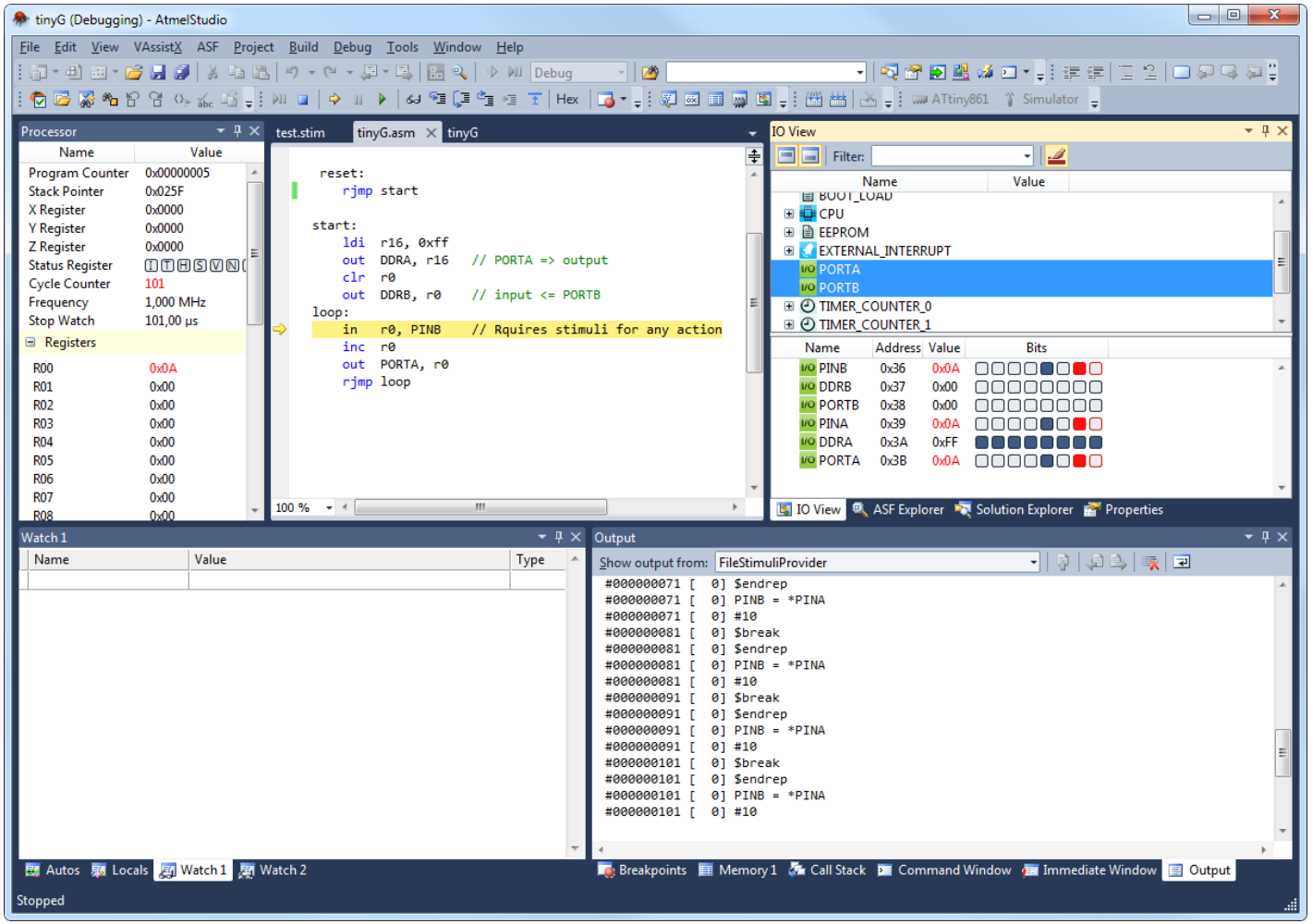


Serial Monitor for Debugging

- A small program (usually written in assembler) that resides in memory with the program under test.
- Can dump memory locations, test hardware, set breakpoints etc.
- Requires some machine resources: serial port, small amount of memory.
- Can reside in protected memory so it survives reset and reprogramming.
- Communicates with a serial terminal on the host (cutecom).

Alternative Environment
AVR Studio: Windows Only (maybe)

http://www.avrfreaks.net/sites/default/files/HOWTO-AVRStudio%20in%20Ubuntu.pdf



Alternative Environment

C Language Programming
Atmel microprocessors
under Linux:

gcc-avr

https://gcc.gnu.org/wiki/avr-gcc