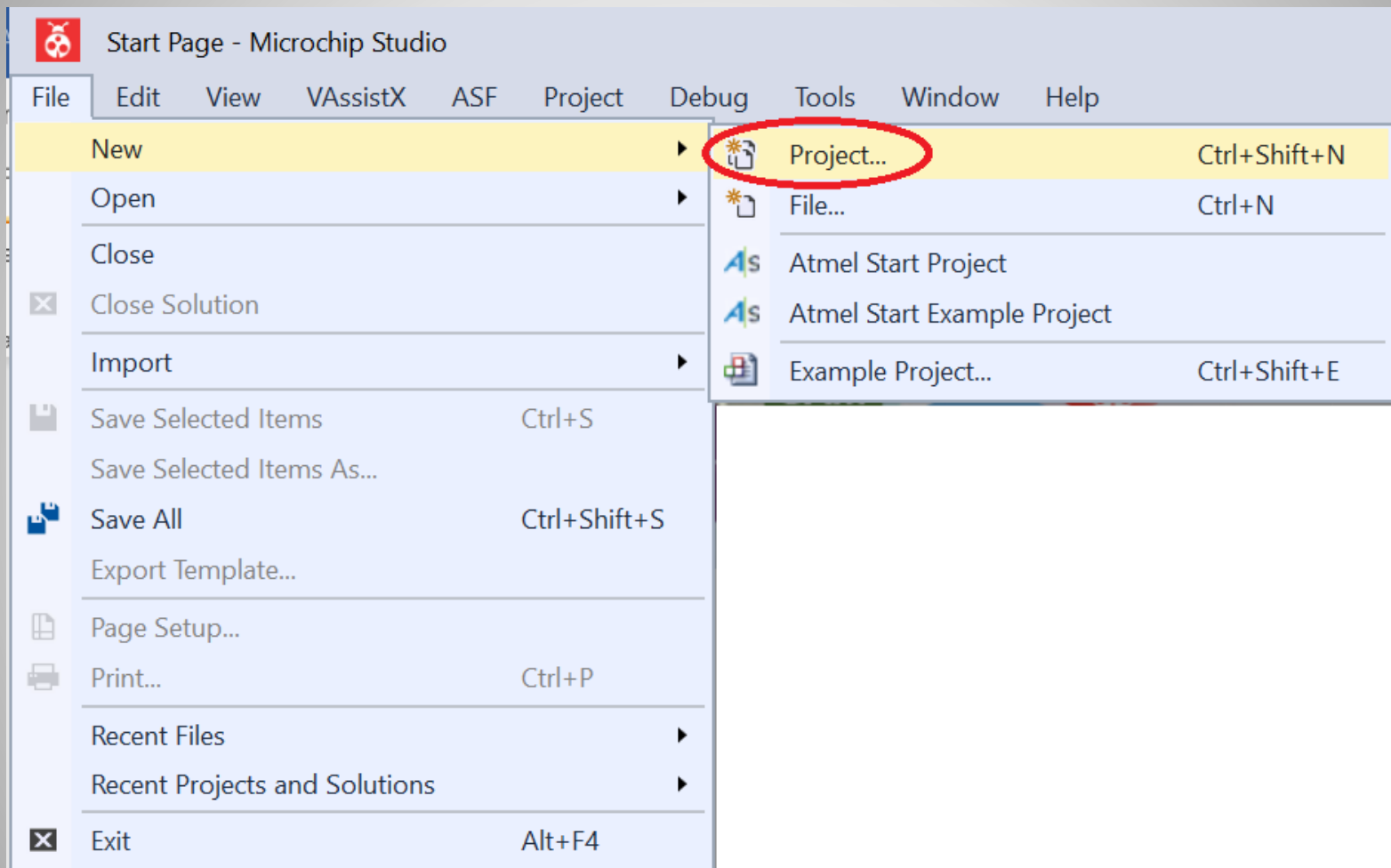
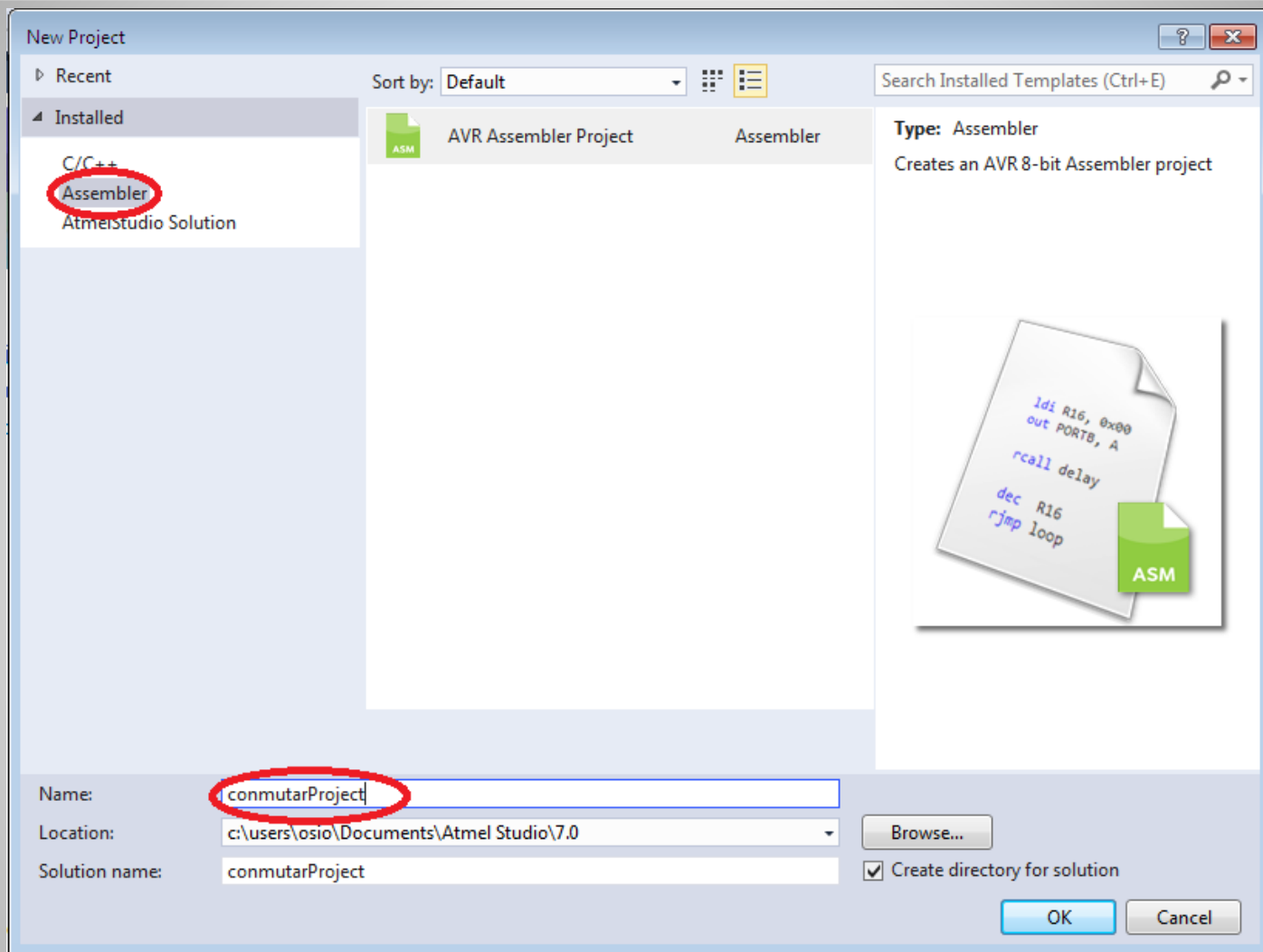


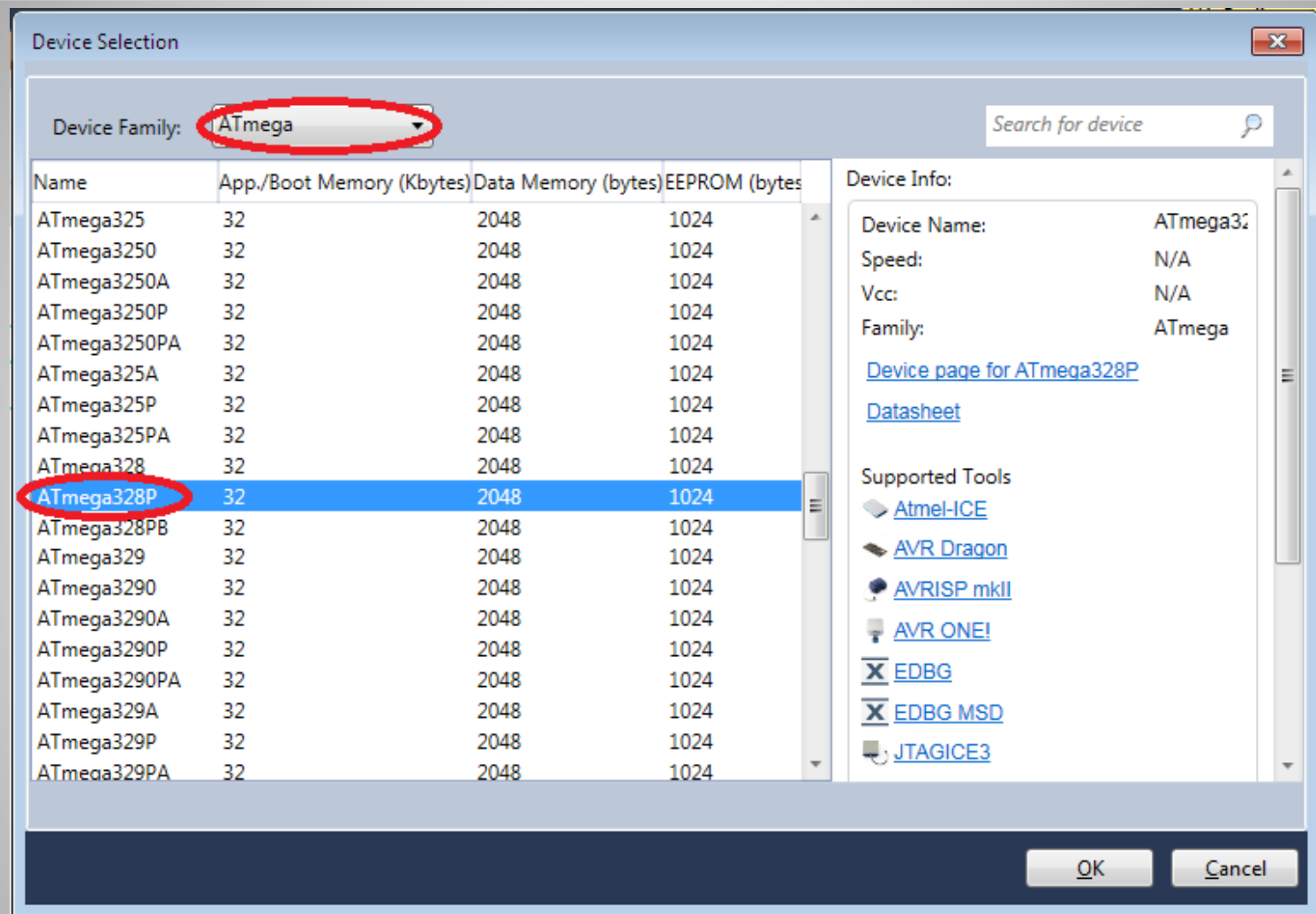
Microchip Studio y
microcontrolador ATMEGA328P



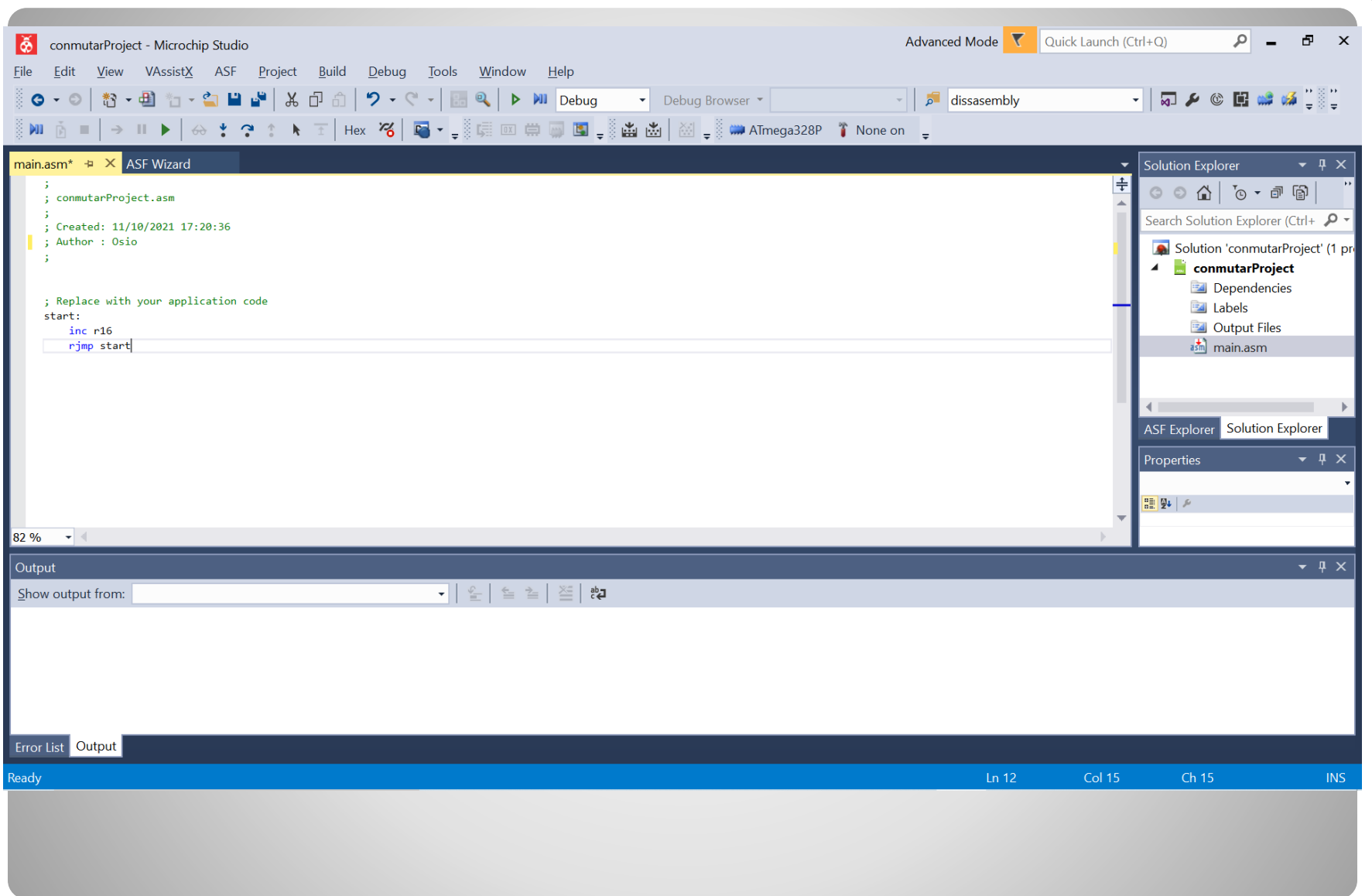
Nuevo Proyecto en assembler



Nuevo Proyecto en assembler



Nuevo Proyecto en assembler



Nuevo Proyecto en assembler

```
.INCLUDE "M328PDEF.INC"
```

```
LDI R16,0xFF
```

```
OUT DDRB,R16
```

```
L1: OUT PORTB,R16
```

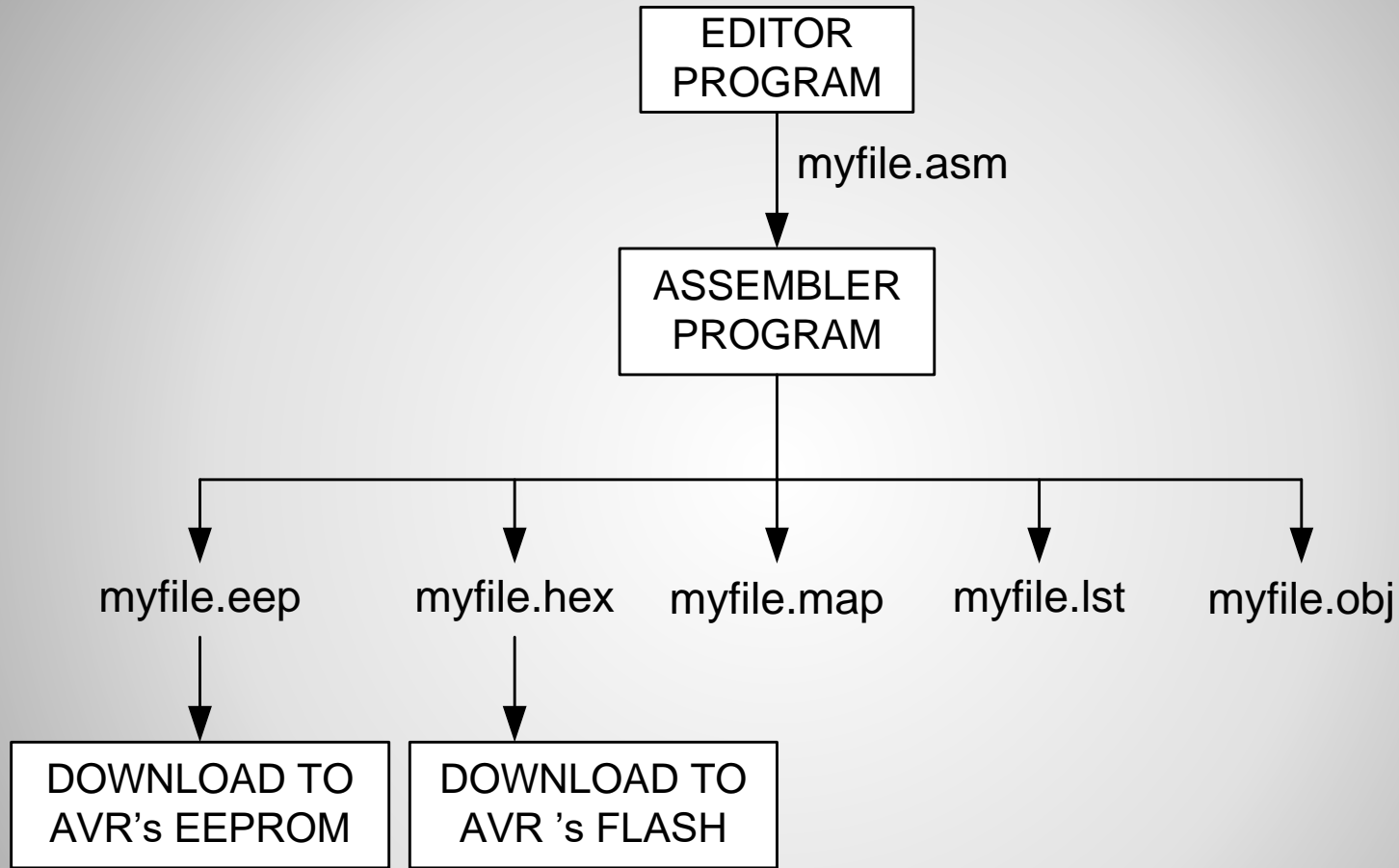
```
LDI R20,0
```

```
OUT PORTB,R20
```

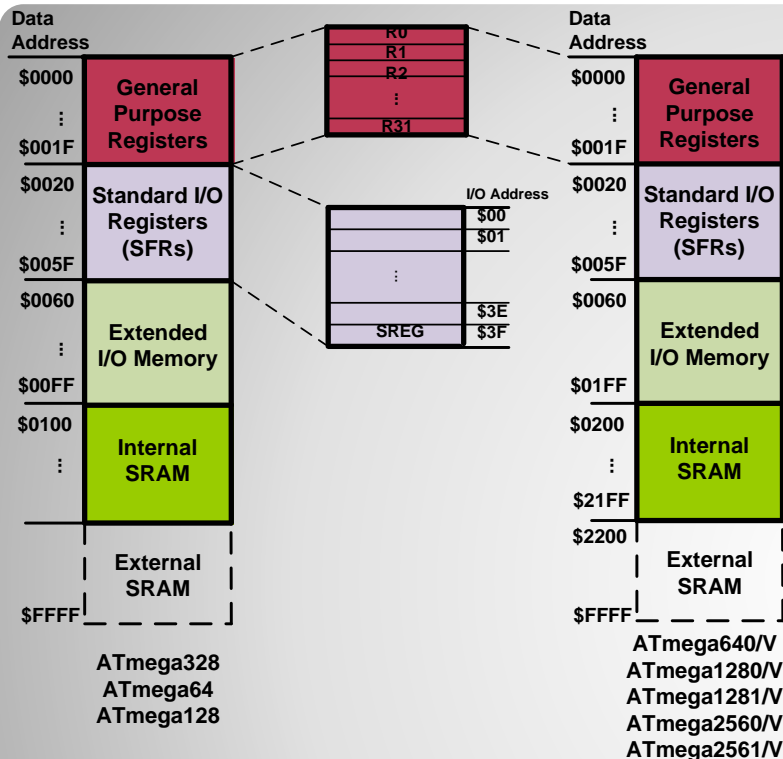
```
RJMP L1
```

- Presione F7 para compilar, o seleccione Build Solution
- - ubicación del archivo "M328PDEF.INC"
- C:\Program Files
(x86)\Atmel\Studio\7.0\packs\atmel\ATmega_DFP\1.6.364\avrasm\inc

Nuevo Proyecto en assembler



Nuevo Proyecto en assembler



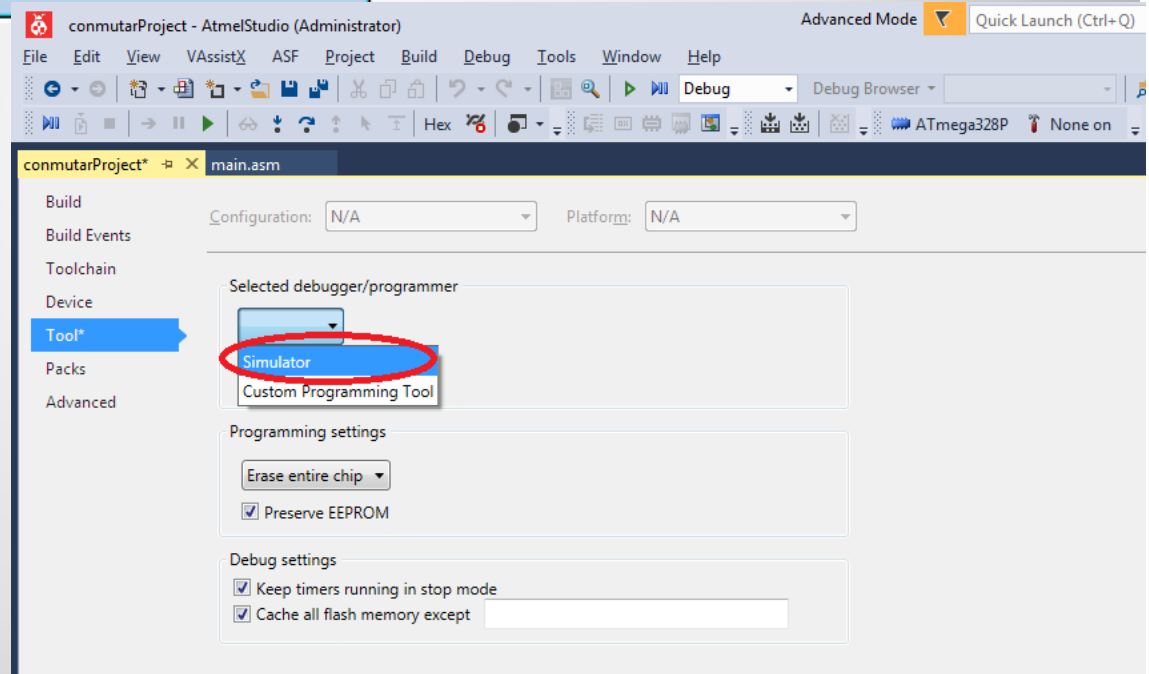
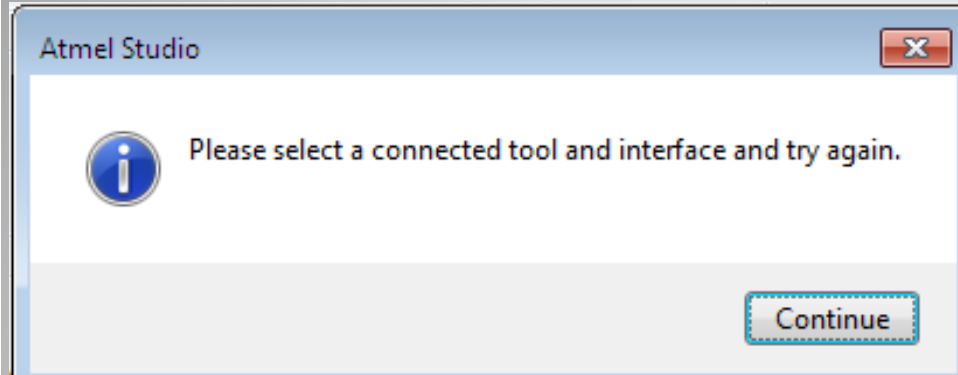
Address		Name
Mem.	I/O	
\$20	\$00	-
\$21	\$01	-
\$22	\$02	-
\$23	\$03	PINB
\$24	\$04	DDRB
\$25	\$05	PORTB
\$26	\$06	PINC
\$27	\$07	DDRC
\$28	\$08	PORTC
\$29	\$09	PIND
\$2A	\$0A	DDRD
\$2B	\$0B	PORTD
\$2C	\$0C	-
\$2D	\$0D	-
\$2E	\$0E	-
\$2F	\$0F	-
\$30	\$10	-
\$31	\$11	-
\$32	\$12	-
\$33	\$13	-
\$34	\$14	-
\$35	\$15	TIFR0

Address		Name
Mem.	I/O	
\$36	\$16	TIFR1
\$37	\$17	TIFR2
\$38	\$18	-
\$39	\$19	-
\$3A	\$1A	-
\$3B	\$1B	PCIFR
\$3C	\$1C	EIFR
\$3D	\$1D	EIMSK
\$3E	\$1E	GPIOR0
\$3F	\$1F	EEDR
\$40	\$20	EEDR
\$41	\$21	EEARL
\$42	\$22	EEARH
\$43	\$23	GTCCR
\$44	\$24	TCCR0A
\$45	\$25	TCCR0B
\$46	\$26	TCNT0
\$47	\$27	OCR0A
\$48	\$28	OCR0B
\$49	\$29	-
\$4A	\$2A	GPIOR1
\$4A	\$2A	GPIOR2

Address		Name
Mem.	I/O	
\$4C	\$2C	SPCR0
\$4D	\$2D	SPSR0
\$4E	\$2E	SPDR0
\$4F	\$2F	-
\$50	\$30	ACSR
\$51	\$31	DWDR
\$52	\$32	-
\$53	\$33	SMCR
\$54	\$34	MCUSR
\$55	\$35	MCUCR
\$56	\$36	-
\$57	\$37	SPMCSR
\$58	\$38	-
\$59	\$39	-
\$5A	\$3A	-
\$5B	\$3B	-
\$5C	\$3C	-
\$5D	\$3D	SPL
\$5E	\$3E	SPH
\$5F	\$3F	SREG

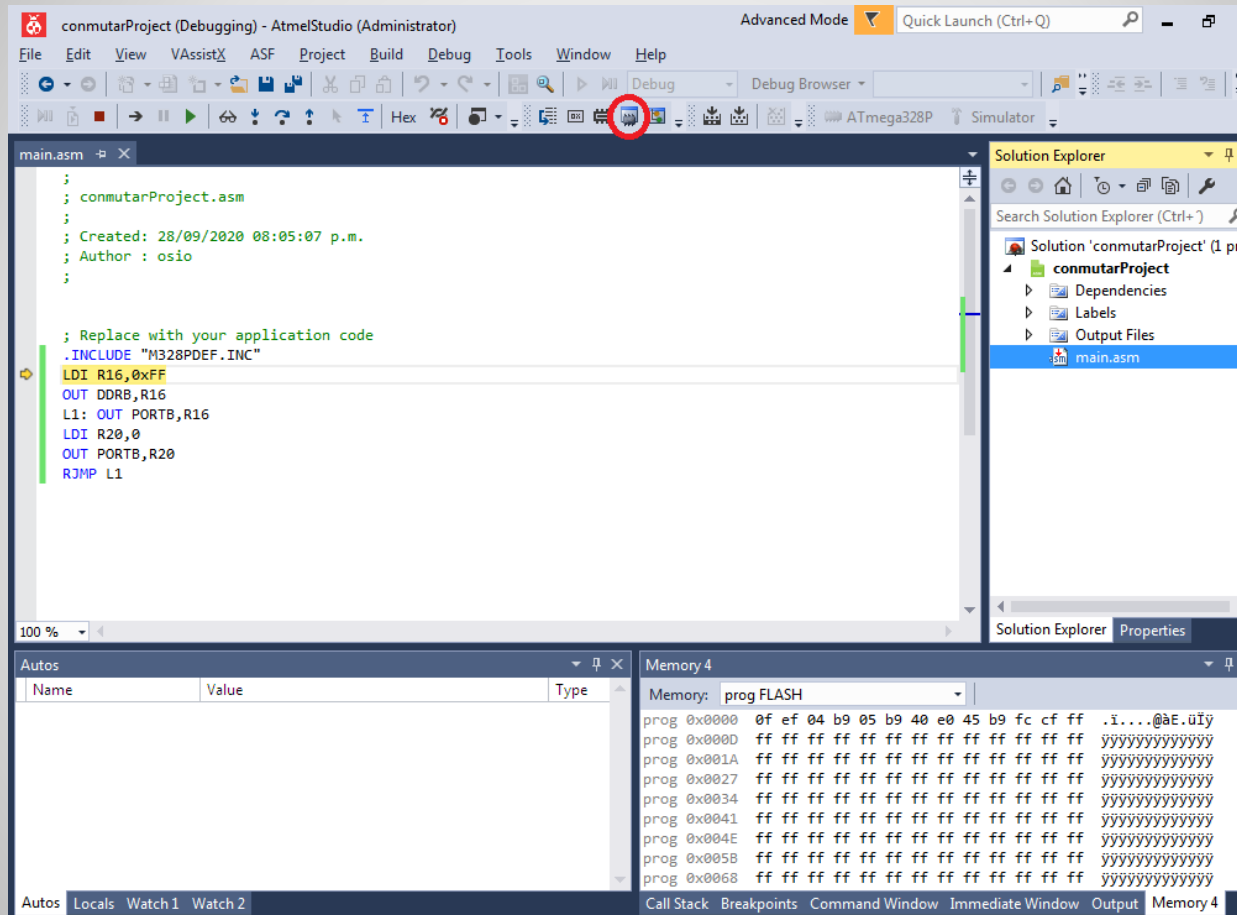
Espacios de memoria

- Para iniciar el debugging, presione **Alt+F5** o seleccione **Start Debugging and Break** desde el menú **Debug**.



Simulación

- Presione **Alt+F5** nuevamente. Aparecerá una ventana de visualización de **Memoria**, en donde se muestra el contenido de la memoria flash.



Simulación

conmutarProject (Debugging) - AtmelStudio (Administrator) Advanced Mode Quick Launch (Ctrl+Q)

File Edit View AssistX ASE Project Build Debug Tools Window Help

Debugging Step over Simulation Continúa Step into Step Out

```
; conmutarProject.asm
;
; Created: 28/09/2020 08:05:07 p.m.
; Author : osio
;

; Replace with your application code
.INCLUDE "M328PDEF.INC"
LDI R16,0xFF
OUT DDRB,R16
L1: OUT PORTB,R16
LDI R20,0
OUT PORTB,R20
RJMP L1
```

Datos del Procesador

Name	Value
Program Counter	0x00000000
Stack Pointer	0x08FF
X Register	0x0000
Y Register	0x0000
Z Register	0x0000
Status Register	0x00000000
Cycle Counter	0
Frequency	1,000 MHz
Stop Watch	0,00 µs
Registers	
R00	0x00
R01	0x00
R02	0x00
R03	0x00
R04	0x00
R05	0x00
R06	0x00
R07	0x00
R08	0x00
R09	0x00

100 %

Name	Value	Type
------	-------	------

Memory 4

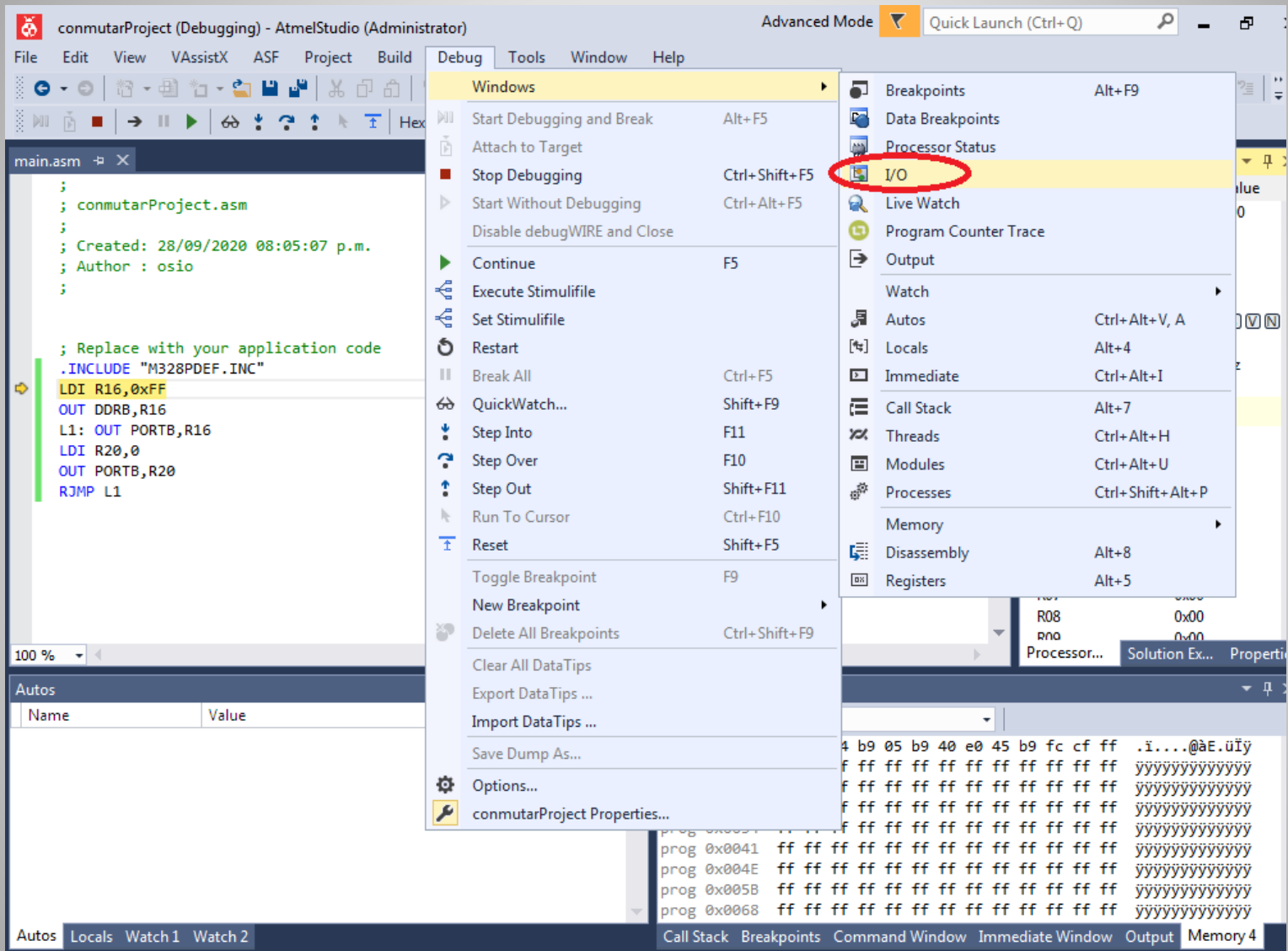
Memory: prog FLASH

Address	Value
prog 0x0000	0f ef 04 b9 05 b9 40 e0 45 b9 fc cf ff .i...@àE.üÿ
prog 0x000D	ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
prog 0x001A	ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
prog 0x0027	ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
prog 0x0034	ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
prog 0x0041	ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
prog 0x004E	ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
prog 0x0058	ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
prog 0x0068	ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff

Call Stack Breakpoints Command Window Immediate Window Output Memory 4

Stopped

Simulación



Simulación

conmutarProject (Debugging) - AtmelStudio (Administrator) Advanced Mode Quick Launch (Ctrl+Q)

File Edit View VAssistX ASF Project Build Debug Tools Window Help

Debug Browser ATmega328P Simulator

main.asm

```
;
; conmutarProject.asm
;
; Created: 28/09/2020 08:05:07 p.m.
; Author : osio
;

; Replace with your application code
.INCLUDE "M328PDEF.INC"
LDI R16,0xFF
OUT DDRB,R16
L1: OUT PORTB,R16
LDI R20,0
OUT PORTB,R20
RJMP L1
```

Processor Status

Name	Value
Program Counter	0x00000000
Stack Pointer	0x08FF
X Register	0x0000
Y Register	0x0000
Z Register	0x0000
Status Register	0x0000
Cycle Counter	0
Frequency	1,000 MHz
Stop Watch	0,00 µs

Registers

R00	0x00
R01	0x00
R02	0x00
R03	0x00
R04	0x00

I/O

Name	Value
EEPROM (EEPROM)	
External Interrupts (EXINT)	
I/O Port (PORTB)	
I/O Port (PORTC)	
I/O Port (PORTD)	
Serial Peripheral Interface (...)	

Name	Address	Value	Bits
PINB	0x23	0x00	00000000
DDRB	0x24	0x00	00000000
PORTB	0x25	0x00	00000000

Memory 4

Memory: prog FLASH

prog 0x0000	0f ef 04 b9 05 b9 40 e0 45 b9 fc cf ff	.i...@àE.üÿ
prog 0x0000	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x001A	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0027	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0034	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0041	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x004E	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0058	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0068	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0075	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0082	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x008F	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x009C	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x00A9	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy

Call Stack Breakpoints Command Window Immediate Window Output Memory 4

Simulación

conmutarProject (Debugging) - AtmelStudio (Administrator) Advanced Mode Quick Launch (Ctrl+Q)

File Edit View VASistX ASF Project Build Debug Tools Window Help

Debug Debug Browser ATmega328P Simulator

main.asm

```
;
; conmutarProject.asm
;
; Created: 28/09/2020 08:05:07 p.m.
; Author : osio
;

; Replace with your application code
#include "M328PDEF.INC"
LDI R16,0xFF
OUT DDRB,R16
L1: OUT PORTB,R16
LDI R20,0
OUT PORTB,R20
RJMP L1
```

Processor Status

Name	Value
Program Counter	0x00000004
Stack Pointer	0x08FF
X Register	0x0000
Y Register	0x0000
Z Register	0x0000
Status Register	0x0000
Cycle Counter	8
Frequency	1,000 MHz
Stop Watch	8,00 µs
Registers	
R00	0x00
R01	0x00
R02	0x00
R03	0x00
R04	0x00

I/O

Name	Value
EEPROM (EEPROM)	
External Interrupts (EXINT)	
I/O Port (PORTB)	
I/O Port (PORTC)	
I/O Port (PORTD)	
Serial Peripheral Interface (...)	

Name	Address	Value	Bits
PINB	0x23	0xFF	
DDRB	0x24	0xFF	
PORTB	0x25	0xFF	

Memory 4

Memory: prog FLASH

prog 0x0000	0f ef 04 b9 05 b9 40 e0 45 b9 fc cf ff	.i...@àE.üÿ
prog 0x000D	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x001A	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0027	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0034	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0041	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x004E	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x005B	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0068	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0075	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0082	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x008F	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x009C	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x00A9	ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy

Call Stack Breakpoints Command Window Immediate Window Output Memory 4

Simulación

comutarProject (Debugging) - AtmelStudio (Administrator) Advanced Mode Quick Launch (Ctrl+Q)

File Edit View VAssistX ASF Project Build Debug Tools Window Help

main.asm

```
;
; conmutarProject.asm
;
; Created: 28/09/2020 08:05:07 p.m.
; Author : osio
;
Breakpoint
; Replace with your application code
.INCLUDE "M328PDEF.INC"
LDI R16,0xFF
OUT DDRB,R16
L1: OUT PORTB,R16
LDI R20,0
OUT PORTB,R20
RJMP L1
```

Processor Status

Name	Value
Program Counter	0x00000004
Stack Pointer	0x08FF
X Register	0x0000
Y Register	0x0000
Z Register	0x0000
Status Register	0x00000000
Cycle Counter	8
Frequency	1,000 MHz
Stop Watch	8,00 µs
Registers	
R00	0x00
R01	0x00
R02	0x00
R03	0x00
R04	0x00

I/O

Name	Value
EEPROM (EEPROM)	
External Interrupts (EXINT)	
I/O Port (PORTB)	
I/O Port (PORTC)	
I/O Port (PORTD)	
Serial Peripheral Interface (...)	

Name	Address	Value	Bits
PINB	0x23	0xFF	11111111
DDRB	0x24	0xFF	11111111
PORTB	0x25	0xFF	11111111

Memory 4

Memory: prog FLASH

prog 0x0000	0f ef 04 b9 05 b9 40 e0 45 b9 fc cf ff	.i....@àE.üÿ
prog 0x000D	ff ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x001A	ff ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0027	ff ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0034	ff ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0041	ff ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x004E	ff ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x005B	ff ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0068	ff ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0075	ff ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x0082	ff ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x008F	ff ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x009C	ff ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy
prog 0x00A9	ff ff ff ff ff ff ff ff ff ff ff ff ff	yyyyyyyyyyyy

I/O Autos Locals Watch 1 Watch 2

Call Stack Breakpoints Command Window Immediate Window Output Memory 4

Simulación

Medición de tiempo

The screenshot displays the Atmel Studio interface in Advanced Mode, showing the execution of assembly code for an ATmega328P. The main window shows the assembly code in `main.asm`:

```
.INCLUDE "M328PDEF.INC"
LDI R16,0xFF
OUT DDRB,R16
L1: OUT PORTB,R16
LDI R20,0
OUT PORTB,R20
RJMP L1
```

A red bracket on the right side of the code, labeled "Instrucciones ejecutadas", highlights the instructions from `LDI R16,0xFF` to `RJMP L1`.

The Processor Status window on the right shows the following values:

Name	Value
Program Counter	0x00000005
Stack Pointer	0x08FF
X Register	0x0000
Y Register	0x0000
Z Register	0x0000
Status Register	0x00000000
Cycle Counter	4
Frequency	1,000 MHz
Stop Watch	4,00 µs

Red arrows point from the text "Nº ciclos" to the Cycle Counter value (4) and from "Tiempo de ejecución" to the Stop Watch value (4,00 µs). Both values are circled in red.

The I/O window at the bottom left shows the state of various hardware modules, including the Analog Comparator (AC), Analog-to-Digital Converter (ADC), CPU Registers (CPU), Clock Prescaler Select (1), Sleep Mode Select Bits (0), MCUSR (0x54, 0x01), MCUCR (0x55, 0x00), SPMCR (0x57, 0x00), SP (0x5D, 0x08FF), and SREG (0x5E, 0x00).

The Memory window at the bottom right shows the contents of the program flash memory, starting from address 0x0000 and ending at 0x00A9. The memory is filled with hexadecimal values, mostly 0xFF, indicating that the program has not yet been executed.

The status bar at the bottom indicates the simulation is "Stopped" at line 16, column 1, character 1.

Simulación

	Ejemplo
+	LDI R20,5+3 ;LDI R20,8
-	LDI R30,9-3 ;LDI R30,6
*	LDI R25,5*7 ;LDI R25,35
/	LDI R19,8/2 ;LDI R19,4

	Ejemplo
&	LDI R20,0x50&0x10 ;LDI R20,0x10
	LDI R25,0x50 0x1 ;LDI R25,0x51
^	LDI R23,0x50^0x10 ;LDI R23,0x40

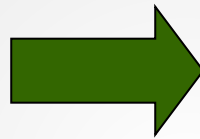
	Ejemplo
<<	LDI R16, 0x10<<1 ;LDI R16,0x20
>>	LDI R16, 0x8 >>2 ;LDI R16,0x2

Directivas en Assembler

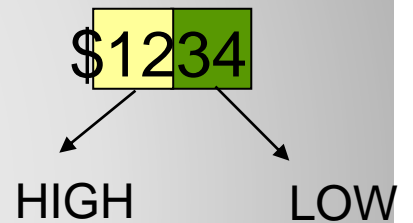
DATO1: .DB 28	;DECIMAL(1C in hex)
DATO2: .DB 0b00110101	;BINARY (35 in hex)
DATO3: .DB 0x39	;HEX
DATO4: .DB 'Y'	;single ASCII char
DATO6: .DB "Hello ALI"	;ASCII string

Tipos de datos en assembler

LDI R20, LOW(0x1234)
LDI R21, HIGH(0x1234)

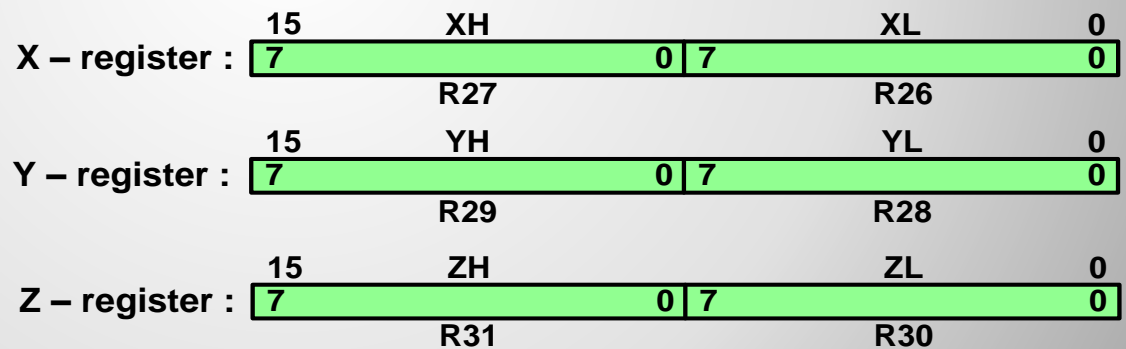
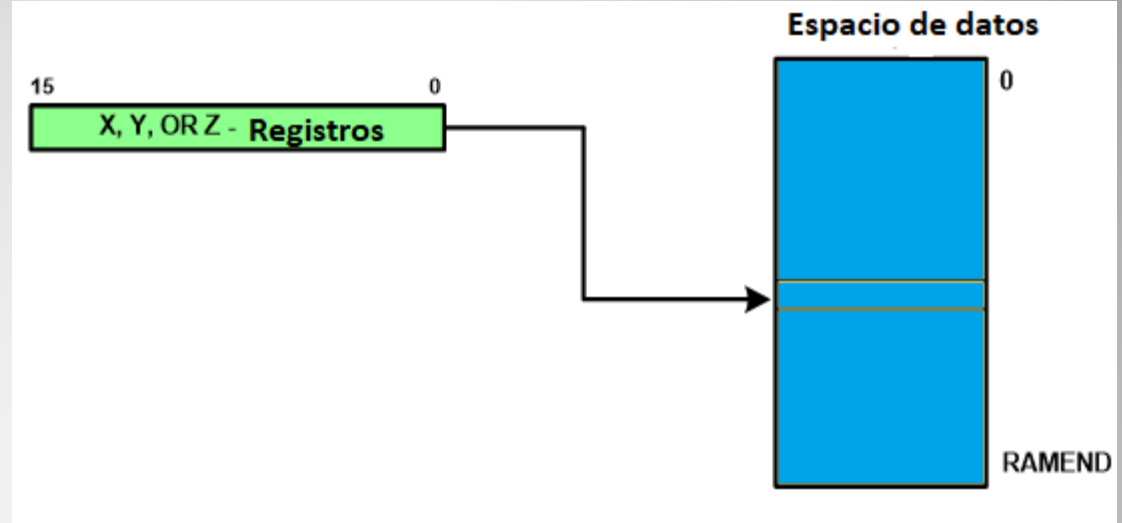


LDI R20, \$34
LDI R21, \$12



HIGH y LOW

- LD Rd,X
 - LD R24,X
 - LD R19,Y
 - LD R20,Z
- ST X,Rd
 - ST X,R18
 - ST Y,R20



Modo de direccionamiento indirecto

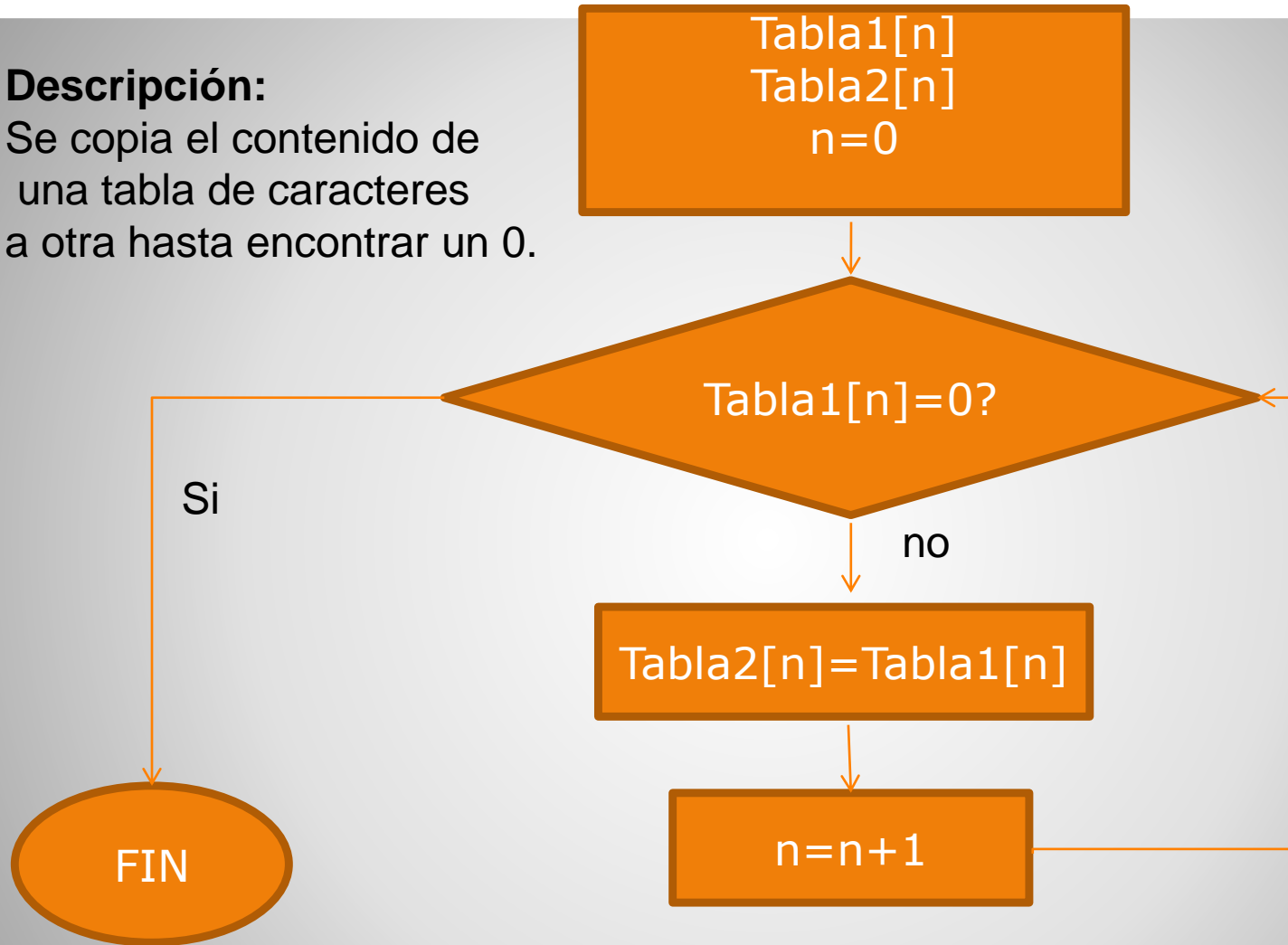
- Programa que copia el valor \$33 en las direcciones de \$140 a \$144

LDI R19,0x5	;R19 = 5 (R19 var contador)
LDI R16,0x33	;carga R16 con el 0x33
LDI YL,0x40	;carga la parte baja de Y con 0x40
LDI YH,0x1	;carga la parte alta de Y con 0x1
L1: STY,R16	;copia R16 a la dirección 0x140
INC YL	;incrementa parte baja de Y
DEC R19	;decrementa contador
BRNE L1	;salta hasta que Contador = cero

Ejemplo 1: direccionamiento indirecto

Descripción:

Se copia el contenido de una tabla de caracteres a otra hasta encontrar un 0.



Ejemplo 2: Diagrama de Flujo

- Suponga que el espacio de ROM que inicia en \$500 contiene el mensaje "Las promesas incumplidas". Se escribe un programa para leer el mensaje desde la CPU de a un byte a la vez y colocar los bytes en ubicaciones de RAM a partir de la dirección \$140

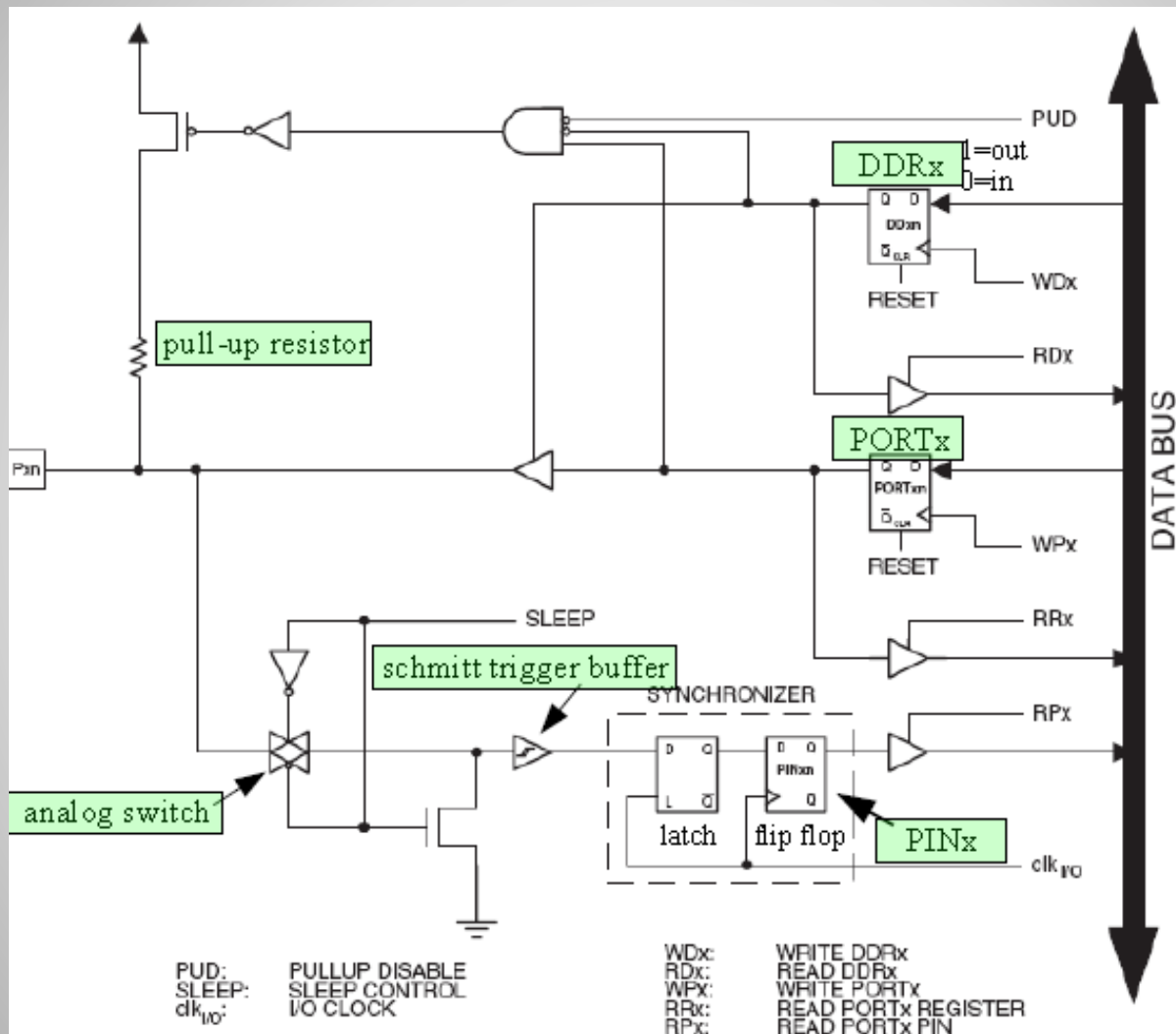
```
.ORG 0                                ;El Código se escribe a partir de la dirección 0
    LDI    ZL, LOW(MYDATA<<1)        ;R30 = 00 low-byte de la direcc.
    LDI    ZH, HIGH(MYDATA<<1)       ;R31 = 0A, high-byte de la direcc
    LDI    XL, LOW(0x140)             ;R26 = 40, low-byte direcc. RAM
    LDI    XH, HIGH(0x140)           ;R27 = 1, high-byte direcc. RAM
bucle: LPM    R16, Z+                  ;lee la tabla, y luego incrementa Z
        CPI    R16,0                  ;compara R16 con 0
        BREQ   END                    ;salta a END si se lee un cero
        ST     X+, R16                ;guarda R16 en RAM e incrementa X
        RJMP   bucle
END:    RJMP   END
.ORG    0x500                        ;datos en memoria desde la dirección 0x500
MYDATA: .DB "Las promesas incumplidas",0
```

Ejemplo 2



Kit ATMEGA

Esquema de pin de E/S ATMEGA128



Registros de Configuración:

- Dirección
- Pull Up/Down

Control de los puertos con tres registros

- DDR_x (ej., DDR_B es el registro de dirección del *port B*)
- PORT_x (ej. PORT_B es el registro de salida del *port B*)
- PIN_x (ej. PIN_B registro de entrada del *port B*)

DDRB: 1 1 1 1 1 1 1 1
PORTB: 1 1 1 1 1 1 1 1

PORT _x \ DDR _x	0	1
	0	1
0	Alta impedancia	Out 0
1	Pull-up	Out 1

```
LDI R20,0xFF ;R20 = 11111111
OUT PORTB,R20 ;PORTB = R20
OUT DDRB,R20 ;DDRB = R20
```

Registros de Entrada / Salida

```
LDI  R16,0xFF ;R16 = 0xFF = 0b11111111
OUT  DDRB,R16 ;pone Port B como salida(1111 1111)
L1: LDI  R16,0x55 ;R16 = 0x55 = 0b01010101
OUT  PORTB,R16 ;pone 0x55 en port B
CALL DELAY
LDI  R16,0xAA ;R16 = 0xAA = 0b10101010
OUT  PORTB,R16 ;pone 0xAA en port B
CALL DELAY
RJMP L1
```

Programa ejemplo

- Se pueden usar los leds conectados a los pines 13 (ptb5- enciente en alto), 0(pth0- enciente en bajo) y 1(pth1- enciente en bajo)
- El pulsador conectado al pin 11 (PB3)

Label	Port
A0	PC0{ADC0}
A1	PC1{ADC1}
A2	PC2{ADC2}
A3	PC3{ADC3}
A4	PC4{ADC4}
A5	PC5{ADC5}

Label	Port
SCL	PC5{ADC5/SCL}
SDA	PC4{ADC4/SDA}
AREF	AREF
GND	GND
13	PB5{SCK}
12	PB4{MISO}
11	PB3{MOSI}
10	PB2{OC1B}
9	PB1{OC1A}
8	PB0
7	PD7
6	PD6
5	PD5
4	PD4
3	PD3{INT1}
2	PD2{INT0}
1	PD1{TXD}
0	PD0{RXD}

Leds y pulsadores en el kit