Embedded Systems
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Tutorial 4 – From Assembly to C + Gates

1. (a) From the following fragment of assembly code, complete the table:

1. LDS R16, $0050
2. LDI R17, $51
3. STS $004A, R16
4. STS $004B, R17

Registers and Mem.	Initial Values	After 1.	After 2.	After 3.	After 4.
(PC)	$00				
(R16)	$00				
(R17)	$FF				
($004A)	$3C				
($004B)	$1D				
($0050)	$42				
($0051)	$B9				

(b) What is the value in the following registers and/or memory locations after executing the following instructions?

1. LDS R16, $0400

Before	*After*
R16 =$76	R16 =
[$0400] =$89	[$0400] =

2. LDI R16, $04

Before	*After*
R16 =$76	R16 =
[$0400] =$89	[$0400] =

3. CPI R16, $76

Before	*After*
R16 =$76	R16 =
[$0400] =$89	[$0400] =
--	Flags: Overflow, Negative, Zero, Carry = _ _ _ _

4. LDS R16, $0400
   STS $0401, R16

Before	*After*
R16 =$76	R16 =
[$0400] =$89	[$0400] =
[$0401] =$00	[$0401] =

5. ADD R16, R17

Before	*After*
R16 =$76	R16 =
R17 =$12	R17 =

6. AND R16, R17

Before	*After*
R16 =$76	R16 = 0111 0110 AND 0001 0010 =
R17 =$12	R17 =

7. OR R16, R17

Before	*After*
R16 =$76	R16 = 0111 0110 OR 0001 0010 =
R17 =$12	R17 =

8. INC R30

Before	*After*
R30 =$79	R30 =

9. DEC R30

Before	*After*
R30 =$00	R30 =

10. CLR R30

Before	*After*
R30 =$FF	R30 =

2. Translate the following Assembly program into C

```
; Project: Moving LEDs
.include "m169def.inc"

main: LDI R16, 0xFF   ; D is output
      OUT DDRD, R16
      LDI R16, 1      ; init count

loop: OUT PORTD, R16  ; display LED
      CALL wait
      LSL R16         ; shift left
      BRNE loop
      LDI R16,1           ; if 0 -> 1
      JMP loop

wait:      LDI  R31, 255 ; init cnt
waitloop:  DEC  R31
           BRNE waitloop
           RET
```

3. Review the gates required for building a hardware adder

(a) Half-Adder requires 1 x AND and 1 x XOR.
How can you build this circuit using only NAND and NOR gates?

(b) How do you connect an LED to a chip output?
Do you need a resistor and if so, which size?

(c) Review the 74HC283 Adder chip.
Which additional parts do you need to build a 2 x 4-bit adder?