

Lab10

Create an assembly project, type the program in Fig. 9, build it, and answer the questions.

Figure 9: Deliverable program code

```
.EQU SUM = 0x300
LDI R16, 0x25
LDI R17, 0x34
LDI R18, 0x31
ADD R16, R17
ADD R16, R18
LDI R17, 0x74
ADD R16, R17
LDI R20, 0
ADD R16, R20
LDI R21, 0xFF
OUT DDRD, R21
L2: INC R20
OUT PORTD, R20
STS SUM, R20
RJMP L2
```

Answer

1. Use the Atmel Studio debugging functions to find the machine codes for the program in Fig. 9. Make a copy of the machine codes to your report.

```

LDI R16, 0x25
00000000 LDI R16,0x25      Load immediate
LDI R17, 0x34
00000001 LDI R17,0x34      Load immediate
LDI R18, 0x31
00000002 LDI R18,0x31      Load immediate
ADD R16, R17
00000003 ADD R16,R17       Add without carry
ADD R16, R18
00000004 ADD R16,R18       Add without carry
LDI R17, 0x74
00000005 LDI R17,0x74      Load immediate
ADD R16, R17
00000006 ADD R16,R17       Add without carry
LDI R20, 0
00000007 LDI R20,0x00      Load immediate
ADD R16, R20
00000008 ADD R16,R20       Add without carry
LDI R21, 0xFF
00000009 SER R21           Set Register
OUT DDRD, R21
0000000A OUT 0x0A,R21      Out to I/O location
L2: INC R20
0000000B INC R20           Increment
OUT PORTD, R20
0000000C OUT 0x0B,R20      Out to I/O location
STS SUM, R20
0000000D STS 0x0300,R20     Store direct to data space
RJMP L2
0000000F RJMP PC-0x0004    Relative jump

```

2. Identify the opcodes for the instructions in the following table. Report them in binary forms. Leave the digit cross (X) if it is a part of an operand.

Instruction	Opcode
LDI	1110 KKKK dddd KKKK
ADD	0000 11rd dddd rrrr
OUT	1011 1Aar rrrr AAAA
INC	1001 010d dddd 0011

STS	1001 001d dddd 0000 kkkk kkkk kkkk kkkk
IN	1011 0AA d dddd AAAA
SUBI	0101 KKKK dddd KKKK
SBI	1001 1010 AAAA Abbb

3. Observe the value changes in general purpose registers (GPR), status register (SREG), and program counter (PC) “after” the execution of every instruction. Report your observations in a table.

Instruction	PC	SREG	R16	R17	R18	R20	R21
LDI R16,0x25	0x00000001		0x25				
LDI R17,0x34	0x00000002			0x34			
LDI R18,0x31	0x00000003				0x31		
ADD R16,R17	0x00000004		0x59				
ADD R16,R18	0x00000005	V, N	0x8A				
LDI R17,0x74	0x00000006			0x74			
ADD R16,R17	0x00000007	S, N	0xFE				
LDI R20,0x00	0x00000008						
ADD R16,R20	0x00000009						
SER R21	0x0000000A						0xFF
OUT 0x0A,R21	0x0000000B						
INC R20	0x0000000C	EMPTY				0x01	
OUT 0x0B,R20	0x0000000D						
STS 0x0300,R20	0x0000000F						
RJMP PC-0x0004	0x0000000B						

4. Find out how the value of memory address at 0x300 varies? What do you do if you want to store the value of R20 to the addresses of 0x150 instead of 0x300?

Instruction STS store the value in R20 direct to data space (symbol “SUM”). The symbol “SUM” is equal to expression “0x300” which is the address. So if we want to store the value of R20 to 0x150, Just replace 0x300 in the first line to 0x150.