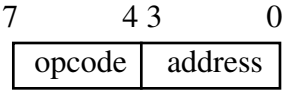
SOME NOTES ON THE SAP-1

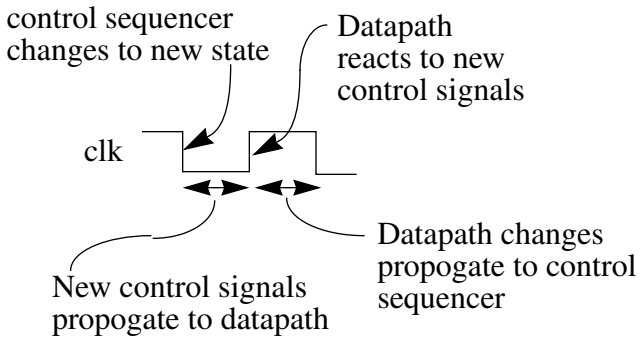
SAP-1 Instruction Format:



SAP-1 Instruction Set:

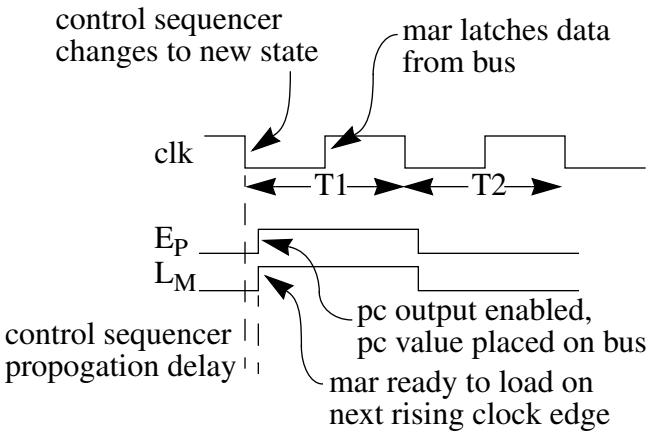
Instruction	opcode	operation
lda	0000	Load the data in M[address] into the accumulator register.
add	0001	Add the value stored in M[address] to the value in the accumulator.
sub	0010	Subtract the value stored in M[address] from the value in the accumulator.
out	1110	Copy the data in the accumulator to the output register
hlt	1111	Stop instruction execution.

Control Sequencer is Negative-Edge Triggered:

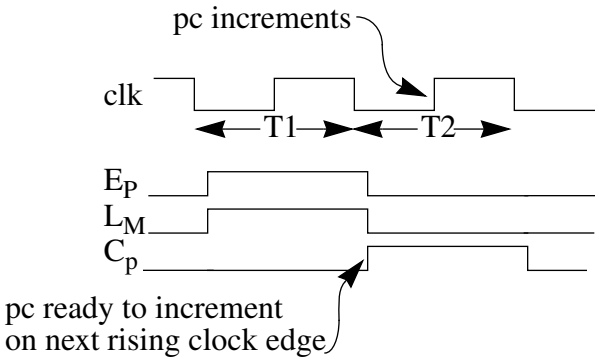


SAP-1 INSTRUCTION FETCH CLOCK CYCLES

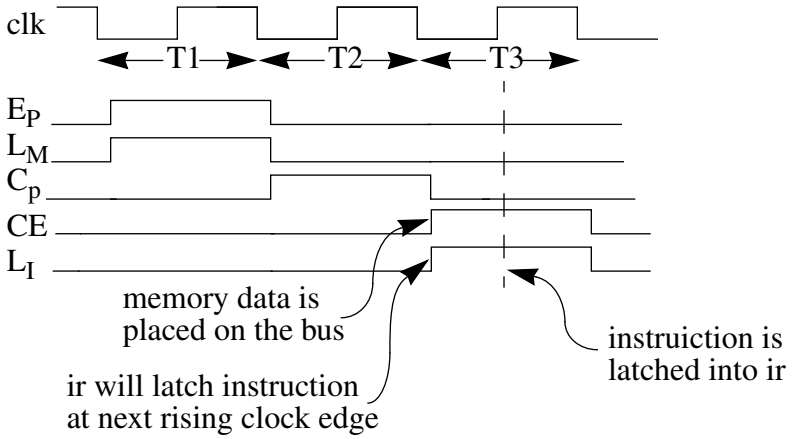
1. mar <- pc



2. pc <- pc +1

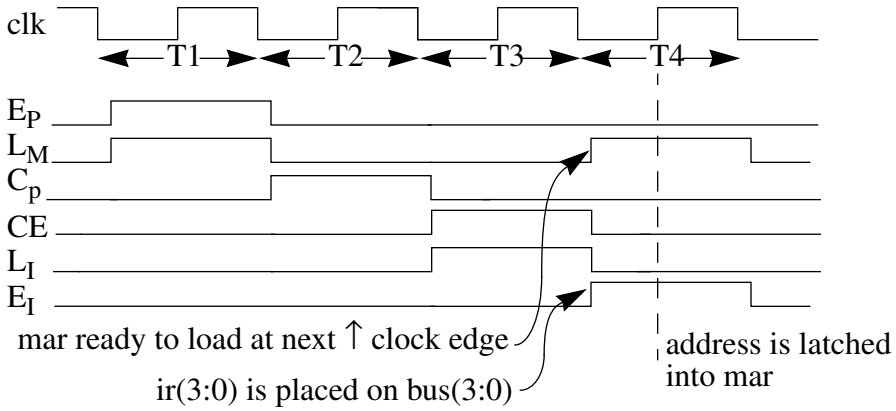


3. ir <- M[mar]

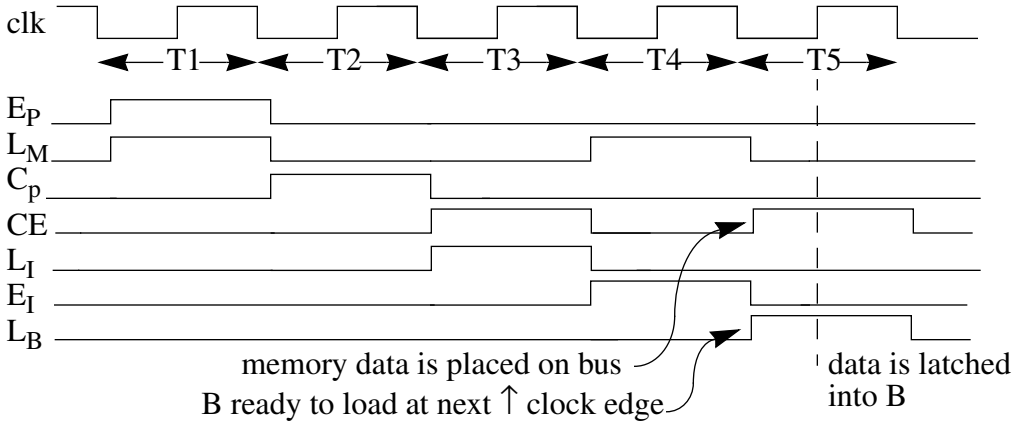


SAP-1 INSTRUCTION EXECUTION CLOCK CYCLES: sub

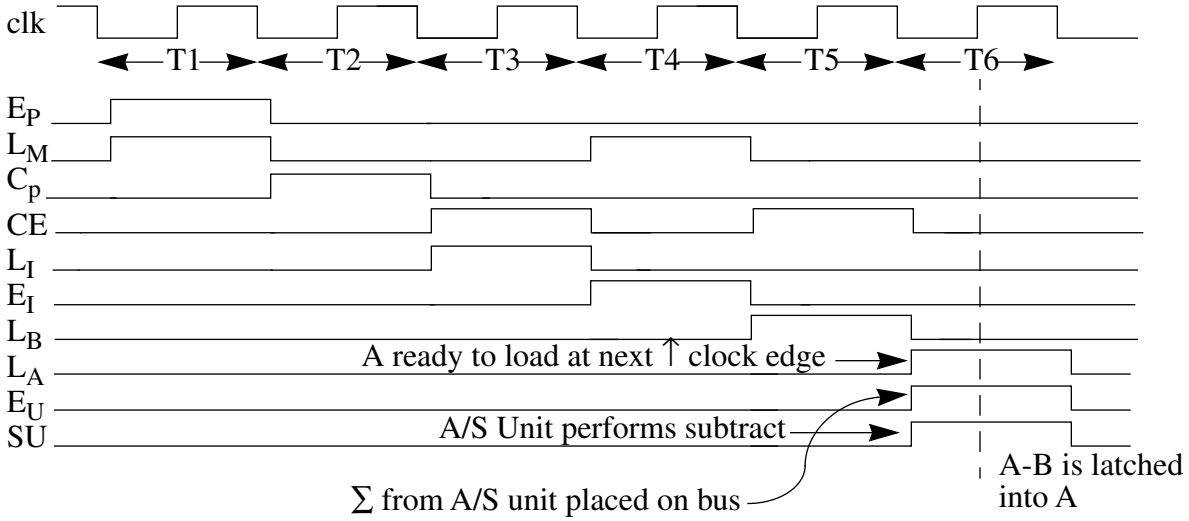
4. mar <- ir(3:0)



5. B <- M[mar]



6. A <- A-B



CONTROL STEP SEQUENCES FOR EACH INSTRUCTION: SAP-1

lda (opcode 0000_2)

Step	Action	Control Points
T1	mar ← pc	E_P, L_M
T2	pc ← pc+1	C_P
T3	ir ← M[mar]	CE, L_I
T4	mar ← ir(3:0)	E_I, L_M
T5	A ← M[mar]	CE, L_A
T6	noop	

out (opcode 1110_2)

Step	Action	Control Points
T1	mar ← pc	E_P, L_M
T2	pc ← pc+1	C_P
T3	ir ← M[mar]	CE, L_I
T4	out ← A	E_A, L_O
T5	noop	
T6	noop	

add (opcode 0001_2)

Step	Action	Control Points
T1	mar ← pc	E_P, L_M
T2	pc ← pc+1	C_P
T3	ir ← M[mar]	CE, L_I
T4	mar ← ir(3:0)	E_I, L_M
T5	B ← M[mar]	CE, L_B
T6	A ← A+B	E_U, L_A

sub (opcode 0010_2)

Step	Action	Control Points
T1	mar ← pc	E_P, L_M
T2	pc ← pc+1	C_P
T3	ir ← M[mar]	CE, L_I
T4	out ← A	E_A, L_O
T5	B ← M[mar]	CE, L_B
T6	A ← A-B	E_U, SU, L_A

hlt (opcode 1111_2)

Step	Action	Control Points
T1	mar ← pc	E_P, L_M
T2	pc ← pc+1	C_P
T3	ir ← M[mar]	CE, L_I
T4	noop	
T5	noop	
T6	noop	

INSTRUCTION CONTROL SIGNALS: SAP-1

$LDA = \overline{ir(7)} \cdot \overline{ir(6)} \cdot \overline{ir(5)} \cdot \overline{ir(4)}$

$OUT = ir(7) \cdot ir(6) \cdot ir(5) \cdot \overline{ir(4)}$

$ADD = \overline{ir(7)} \cdot \overline{ir(6)} \cdot \overline{ir(5)} \cdot ir(4)$

$SUB = \overline{ir(7)} \cdot \overline{ir(6)} \cdot ir(5) \cdot \overline{ir(4)}$

$HLT = ir(7) \cdot ir(6) \cdot ir(5) \cdot ir(4)$

CONTROL SIGNAL LOGIC BASED ON INSTRUCTION SIGNALS: SAP-1

$L_M = T1 + T4 \cdot (LDA + ADD + SUB)$

$E_P = T1$

$CE = T3 + T5 \cdot (LDA + ADD + SUB$

$C_P = T2$

$E_I = T4 \cdot (LDA + ADD + SUB)$

$L_I = T3$

$L_A = T5 \cdot LDA + T6 \cdot (ADD + SUB$

$E_A = T4 \cdot OUT$

$L_B = T5 \cdot (ADD + SUB)$

$E_U = T6 \cdot (ADD + SUB)$

$SU = T6 \cdot SUB$

$L_O = T4 \cdot OUT$

A SIMPLE SAP-1 PROGRAM

```
; Assembly language code to perform op1 - op2 and display the result

add2:   lda     op1             ; A <- op1
        sub     op2             ; A <- A - op2 = op1 - op2
        out                     ; display the result
        hlt                     ; stop execution

op1:    db      4bH
op2:    db      27H
```

LISTING FILE GENERATED FROM add2 PROGRAM

```
; Assembly language code to perform op1 - op2 and display the result

0       0f      add2:   lda     op1             ; A <- op1
1       2e              sub     op2             ; A <- A - op2 = op1 - op2
2       e0              out                     ; display the result
3       f0              hlt                     ; stop execution

e       4b      op1:    db      4bH
f       27      op2:    db      27H
```