COMPUTER ORGANIZATION AND ARCHITECTURE

Course Code : CSE 2151

Credits : 04

MICROPROGRAMMED CONTROL UNIT

- Control word: all control signals that can be simultaneously activated are grouped to form the CW.
- Micro operation: A$\leftarrow$0, outbus=A, etc..
- Each CW contains signals to activate one or more microoperations.
- Control memory:
  - Control words are held in separate memory called control memory (CM).
  - Control words are fetched from CM and individual control fields are routed to various functional units to achieve desired task.
- All microinstructions have 2 important fields:
  - Control field
  - Next address field
- Purpose of control field is to indicate which control lines are to be activated.
- Purpose of Next address field is to specify the address of the next microinstruction to be executed.

WILKE'S DESIGN OF MICROPROGRAMMED CONTROL UNIT

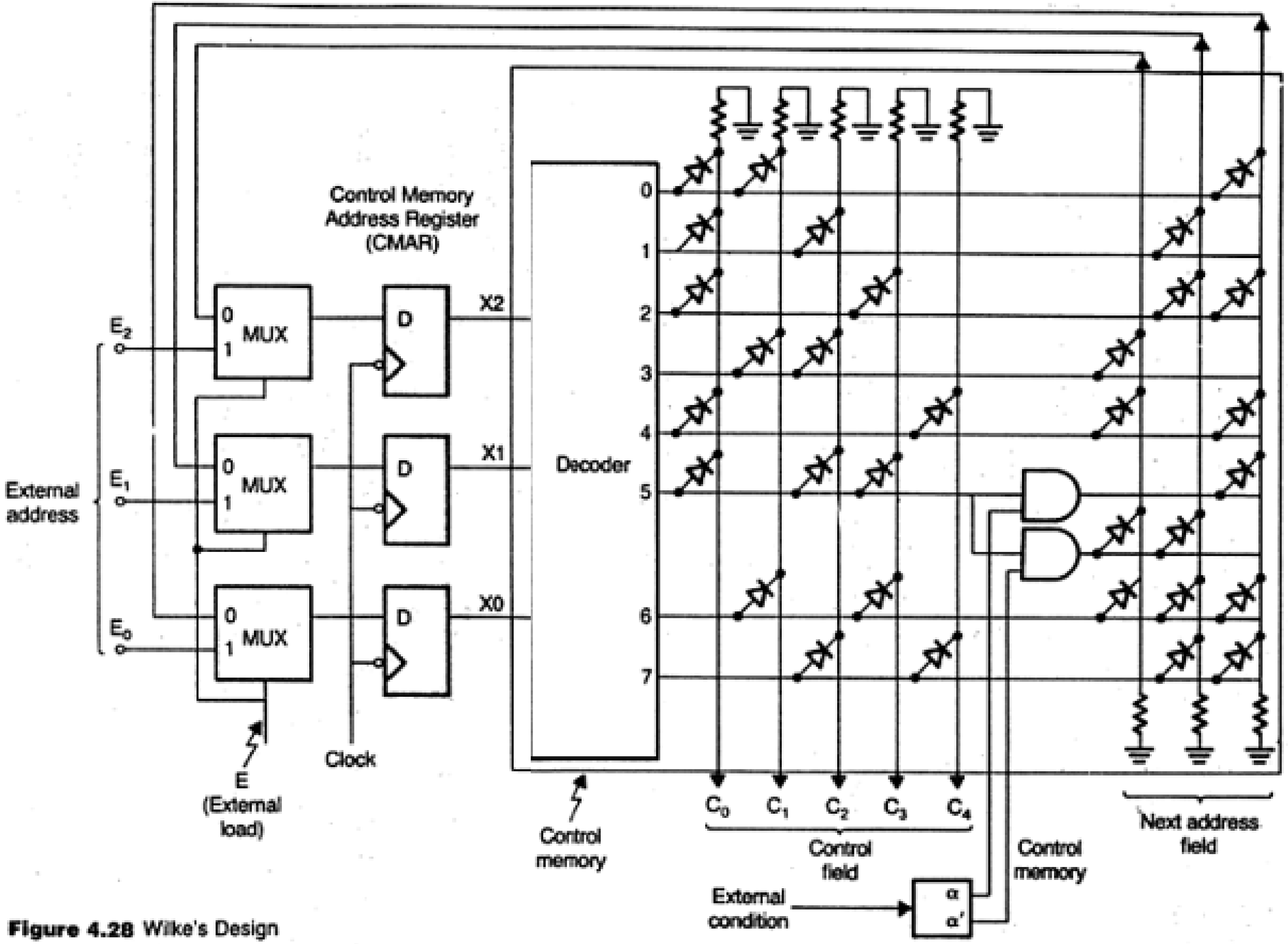


Figure 4.28 Wilke's Design

ENCODING AND DECODING

- The length of the µinstruction is dependent on factors:
  - The degree of parallelism
  - The control field organization
  - The method by which the address of next µinstruction is specified.
- All µoperations executed in parallel can be specified in a single µinstruction.
- This allows short µprograms to be written.
- If the degree of parallelism increases, then the length of µinstruction increases.
- Similarly short µinstructions have limited capability in expressing parallelism. The overall length of µprogram will increase.
- Various ways of organizing the control information:
- Consider A, B, C, D each communicates with the outbus
  - C0: outbus=A;
  - C1: outbus=B;
  - C2: outbus=C;
  - C3: outbus=D;

ENCODING AND DECODING

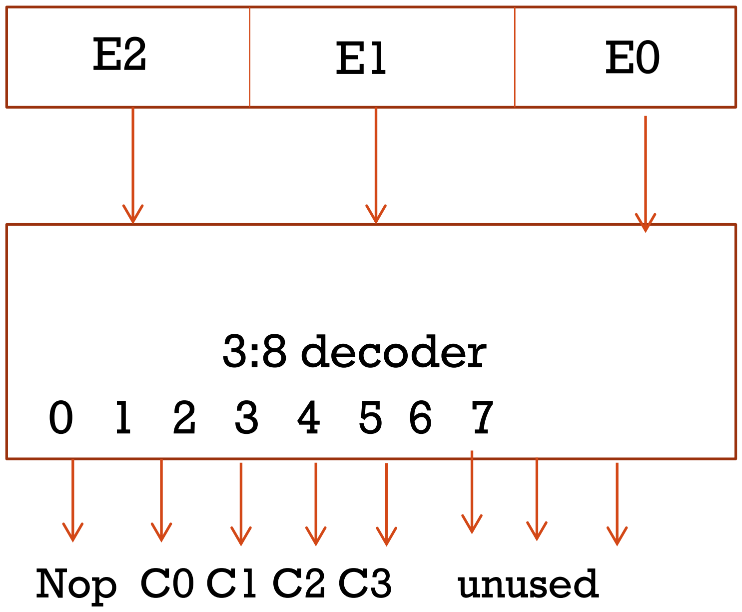
- Here there is no need of decoding the control field.
- This method is known as unencoded format.

C0	C1	C2	C3	
1	0	0	0	Outbus=A
0	1	0	0	Outbus=B
0	0	1	0	Outbus=C
0	0	0	1	Outbus=D
0	0	0	0	NO operation

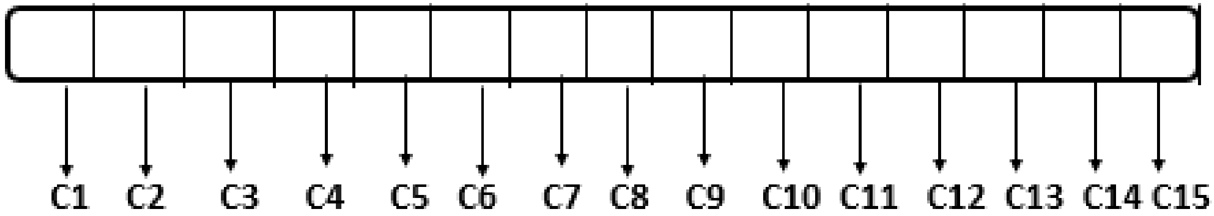
ENCODING AND DECODING

- The above valid 5 binary patterns can be represented as

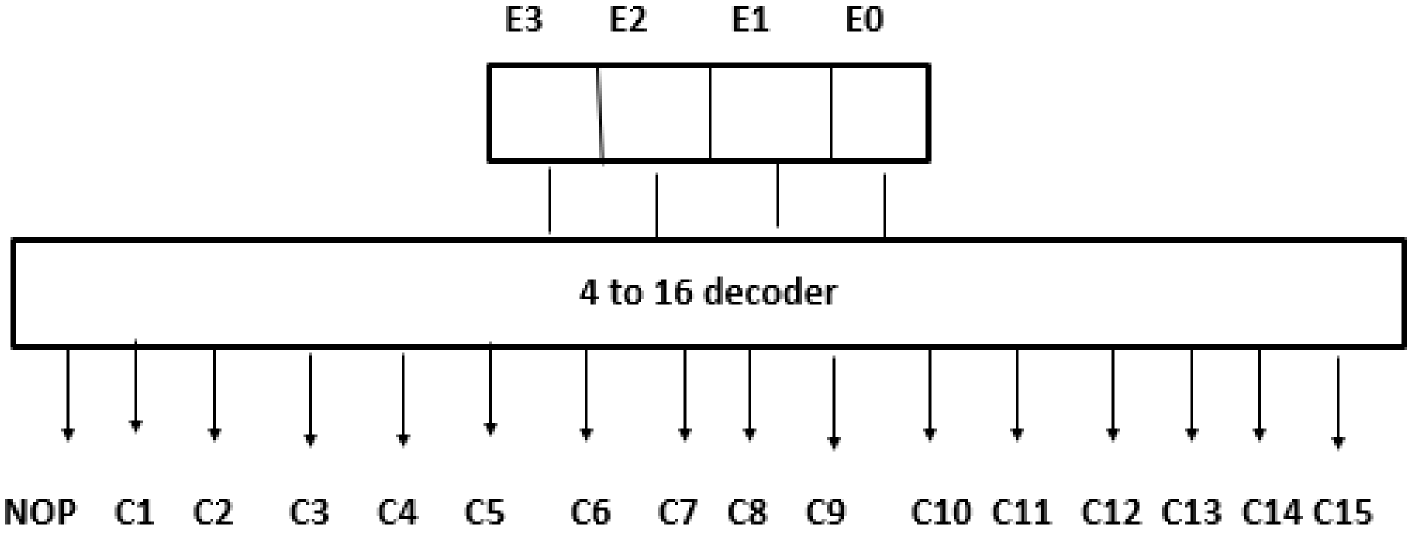
E2	E1	E0	
0	0	0	No operation
0	0	1	Outbus=A
0	1	0	Outbus=B
0	1	1	Outbus=C
1	0	0	Outbus=D



FULLY UNENCODED FORM

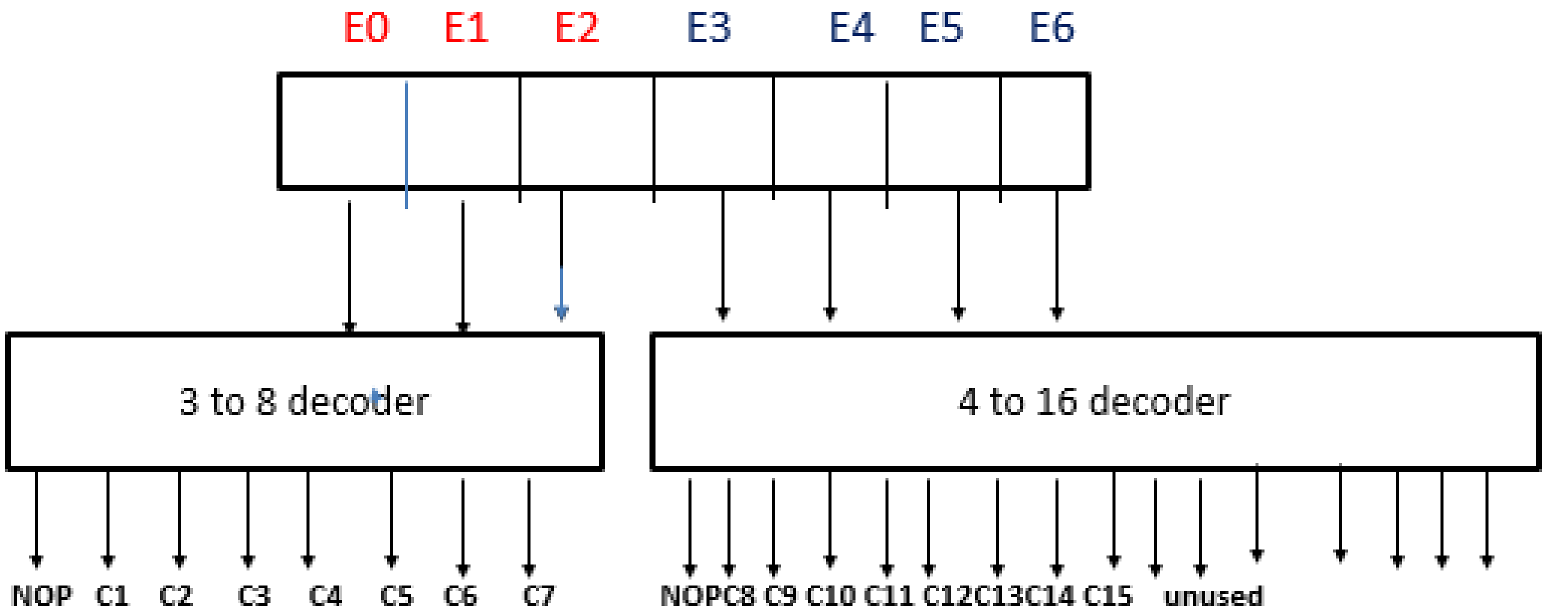


- Encoded form--control field size :4 bits



PARTIALLY ENCODED FORM

- E0 E1 E2 Group1→ C1, C2,C3,C4,C5.C6,C7
  E3 E4 E5 E6 Group2→ C8, C9, C10, C11, C12, C13, C14, C15



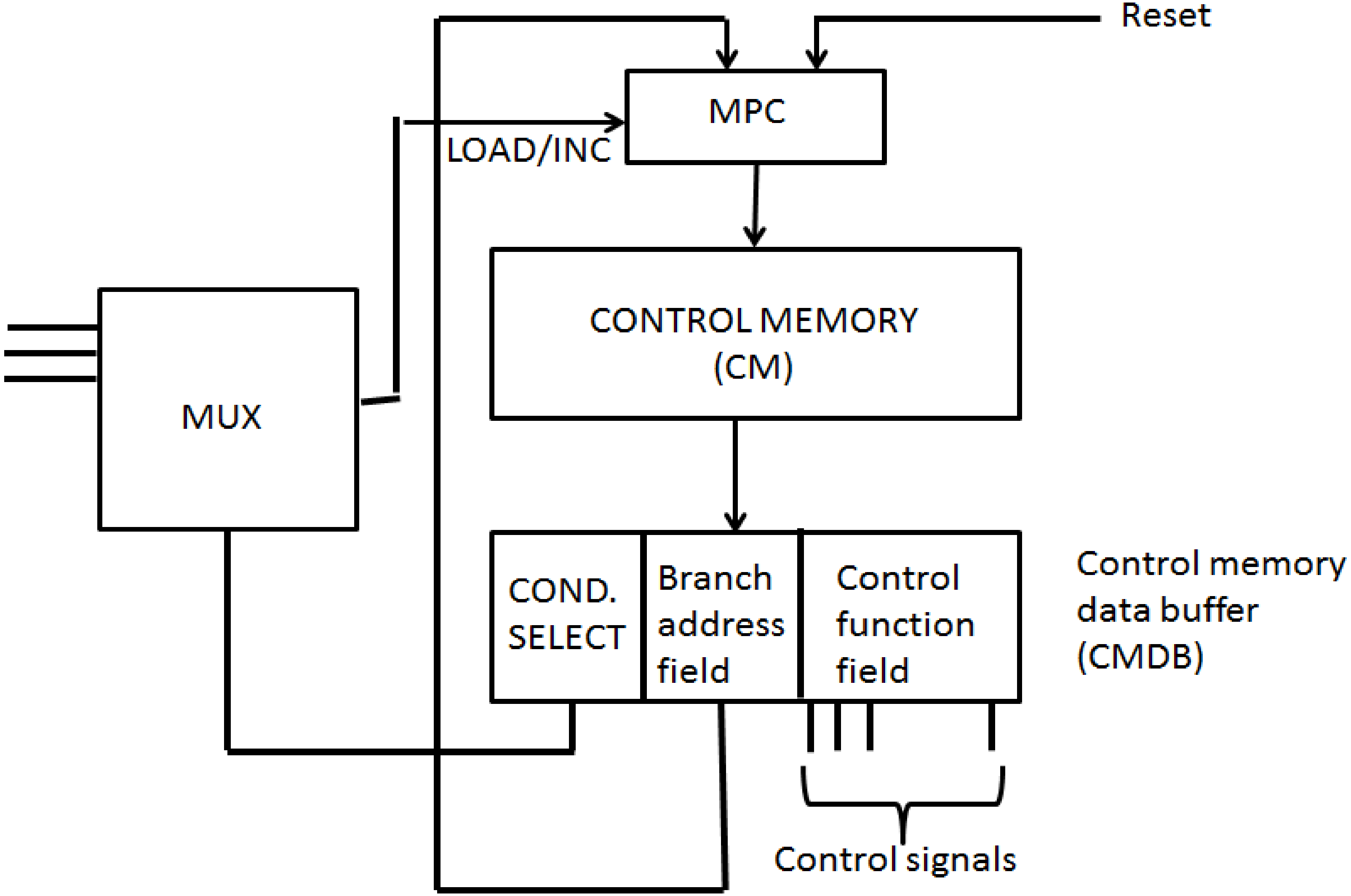
MICROINSTRUCTIONS CLASSIFICATION

- Two groups based which express parallelism and the amount of encoding called
  - Vertical microinstruction
    - Need considerable amount of decoding
    - Short microinstruction
    - Limited scope for expressing parallelism
  - Horizontal microinstruction
    - No decoding required
    - Long microinstruction
    - Capability of expressing a high degree of parallelism

ARCHITECTURE OF MODERN MICROPROGRAMMED CONTROL UNIT

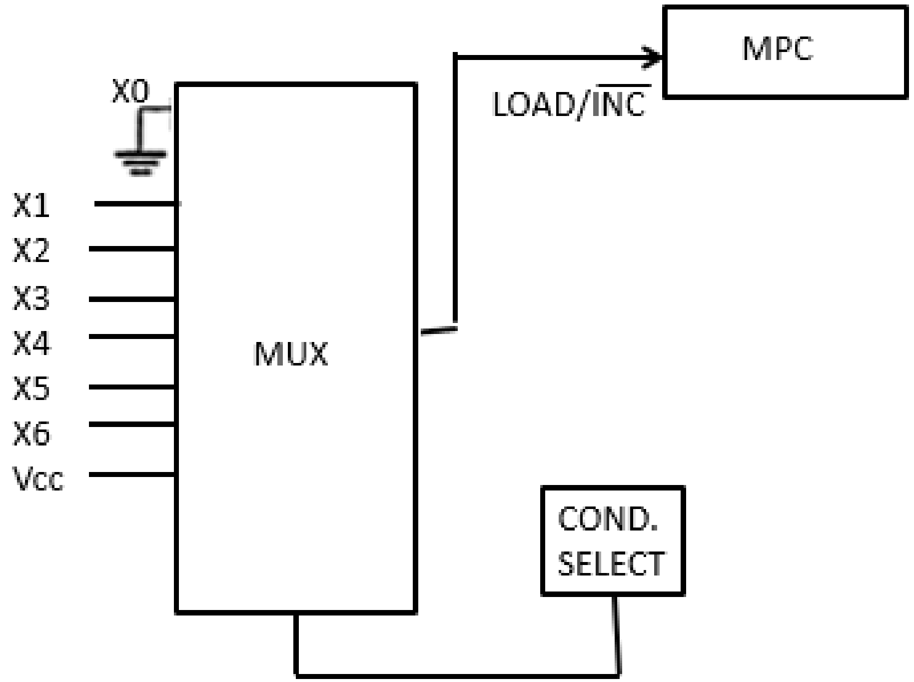
- Next address field from the μinstruction can be eliminated. This pointer is referred as microprogram counter (MPC).
- MPC is functionally identical to PC.
- It points to the μinstruction to be executed next and incremented after each μinstruction fetch.

GENERAL PURPOSE MICROPROGRAMMED CONTROL ORGANIZATION



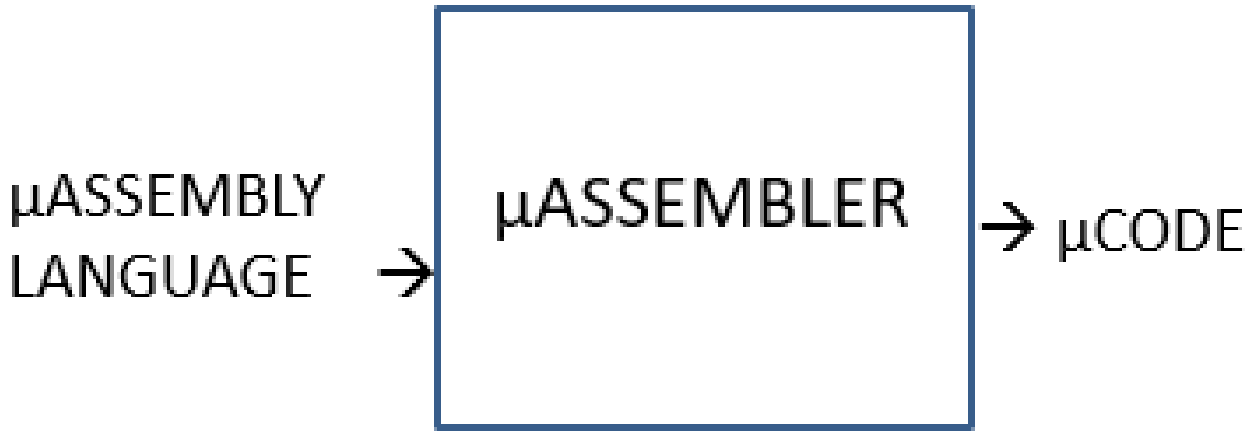
GP MICROPROGRAMMED CONTROL ORGANIZATION

- Suppose 6 external conditions X1, X2, X3, ..X6 are to be tested.
- Cond select field and MUX can be organized as:
  - If cond sel 000 then MUX o/p 0. MPC incremented. No branch.
  - If cond sel 111 MUX o/p 1. Unconditional branching.
  - If cond sel 001 MUX o/p is same as value of X1. Now MPC will be loaded with branch addr when X1=1 else it is incremented.



GP MICROPROGRAMMED CONTROL ORGANIZATION

- Writing μprogram is like writing ALP.
- μprogrammer must have more thorough knowledge about system architecture
- To speedup the development of μcode, →μassembly language.
- These μcodes are held in CM.



DESIGN OF MICROPROGRAMMED CU FOR 4X4 BOOTH'S MULTIPLIER

- STEP1: Write μprogram in a symbolic form.
- **Control Mem Addr** **Control Word**

Control Mem Addr		Control Word
0	START:	A←0, M ← Inbus, L ← 4;
1		Q[4:1] ← Inbus, Q[0] ← 0;
2	LOOP:	If Q[1:0]=01 then goto ADD;
3		If Q[1:0]=10 then goto SUB;
4		goto RSHIFT;
5	ADD:	A ← A+M;
6		Goto RSHIFT;
7	SUB:	A ← A-M;
8	RSHIFT:	ASR(A$Q), L ← L-1;
9		If Z=0 then goto LOOP
10		outbus=A;
11		outbus=Q[4:1];
12	HALT:	goto HALT

- CM holds 13 words, requiring a 4-bit branch address field.

DESIGN OF MICROPROGRAMMED CU FOR 4X4 BOOTH'S MULTIPLIER

- STEP2: Q[1]Q[0]=01, Q[1]Q[0]=10 and Z=0 are checked.
- These conditions are applied as i/ps to condition select MUX.
- MUX must have atleast 5 data i/ps and 8:1 data selector.
- 3-bit cond sel field is used to encode 5 diff cond:

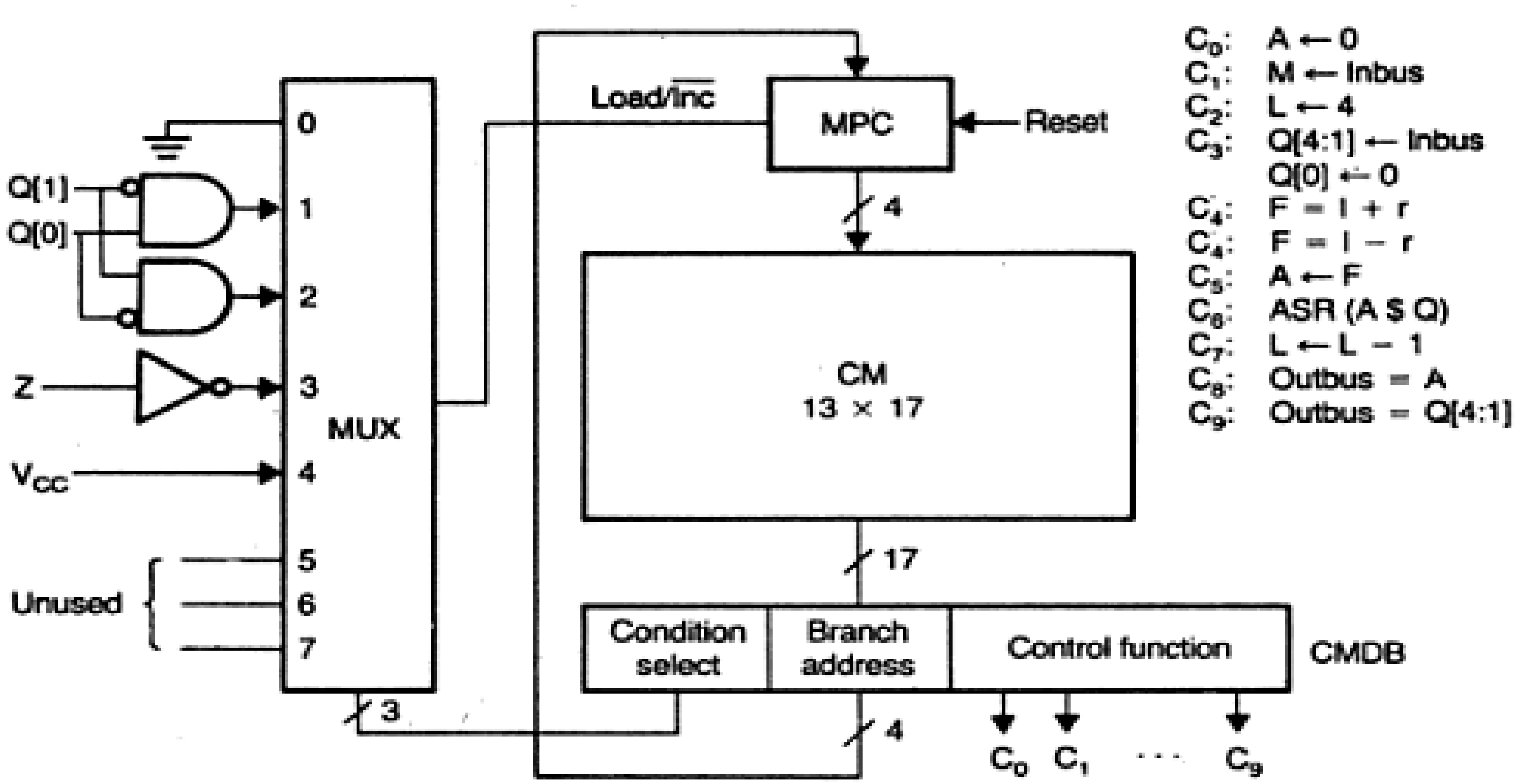
Cond Select Field	Action Taken
0 0 0	No branching
0 0 1	Branch if Q[1]Q[0]=01
0 1 0	Branch if Q[1]Q[0]=10
0 1 1	Branch if Z=0
1 0 0	Unconditional branch

- Size of CW = Size of Cond sel field + Size of branch(size of address bits) + No of functions field

  = 3 + 4 + 10

  = 17 bits
- Size of CMDB is 17 bits and CM is 13 x 17 =221bits

DESIGN OF MICROPROGRAMMED CU FOR 4X4 BOOTH'S MULTIPLIER



DESIGN OF MICROPROGRAMMED CU FOR 4X4 BOOTH'S MULTIPLIER

ROM ADDRESS		CONTROL WORD											
In Dec	In Binary	COND SELECT	BRANCH ADDRESS	CONTROL FUNCTION									
				C0	C1	C2	C3	C4	C5	C6	C7	C8	C9
0	0 0 0 0	0 0 0	0 0 0 0	1	1	1	0	0	0	0	0	0	0
1	0 0 0 1	0 0 0	0 0 0 0	0	0	0	1	0	0	0	0	0	0
2	0 0 1 0	0 0 1	0 1 0 1	0	0	0	0	0	0	0	0	0	0
3	0 0 1 1	0 1 0	0 1 1 1	0	0	0	0	0	0	0	0	0	0
4	0 1 0 0	1 0 0	1 0 0 0	0	0	0	0	0	0	0	0	0	0
5	0 1 0 1	0 0 0	0 0 0 0	0	0	0	0	1	1	0	0	0	0
6	0 1 1 0	1 0 0	1 0 0 0	0	0	0	0	0	0	0	0	0	0
7	0 1 1 1	0 0 0	0 0 0 0	0	0	0	0	0	1	0	0	0	0
8	1 0 0 0	0 0 0	0 0 0 0	0	0	0	0	0	0	1	1	0	0
9	1 0 0 1	0 1 1	0 0 1 0	0	0	0	0	0	0	0	0	0	0
10	1 0 1 0	0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	1	0
11	1 0 1 1	0 0 0	0 0 0 0	0	0	0	0	0	0	0	0	0	1
12	1 1 0 0	1 0 0	1 1 0 0	0	0	0	0	0	0	0	0	0	0

Binary listing of µprogram for 4 X 4 Booth's Multiplier

HARDWIRED APPROACH V/S MICROPROGRAMMED CU:

- Microprogrammed approach is more expensive.
- Control memory may reduce the overall speed of the machine, since microinstructions retrieval process takes significant amount of time.
- Microprogramming provides a well-structured control organization.
- With Microprogramming, many additions and changes are made by simply changing the microprogram in Control memory, whereas a small change in hardwired approach may lead to redesign the entire system.
- Cost of the control logic increases with system complexity though hardwired logic is economical for simple control algorithm. In microprogrammed implementation cost of the simplest system is higher though adding new features requires additional control memory.

EXERCISE

Consider the following register transfer description algorithm

Declare Registers: A[8], B[8], C[8];

START: $A \leftarrow 0$;
$B \leftarrow 00001010$;
LOOP: $A \leftarrow A + B$;
$B \leftarrow B - 1$;
If $B <> 0$ then go to LOOP;
$C \leftarrow A$;
HALT: Go to HALT

A. Design the processing section for implementing the above algorithm identifying all the control points.

B. Draw a neat state diagram. Write the operations performed and the control signals to be activated in each state

C. Design controller using decoder, counter and sequence controller and draw the diagram

D. Draw the PLA diagram for implementing the sequence controller

D. Design a Modern Microprogrammed control unit and give the binary listing of the microprogram

TOPICS COVERED FROM

- Textbook 3:
  - Chapter 4: 4.3.2