Functioning of Micro-programmed Control Unit:

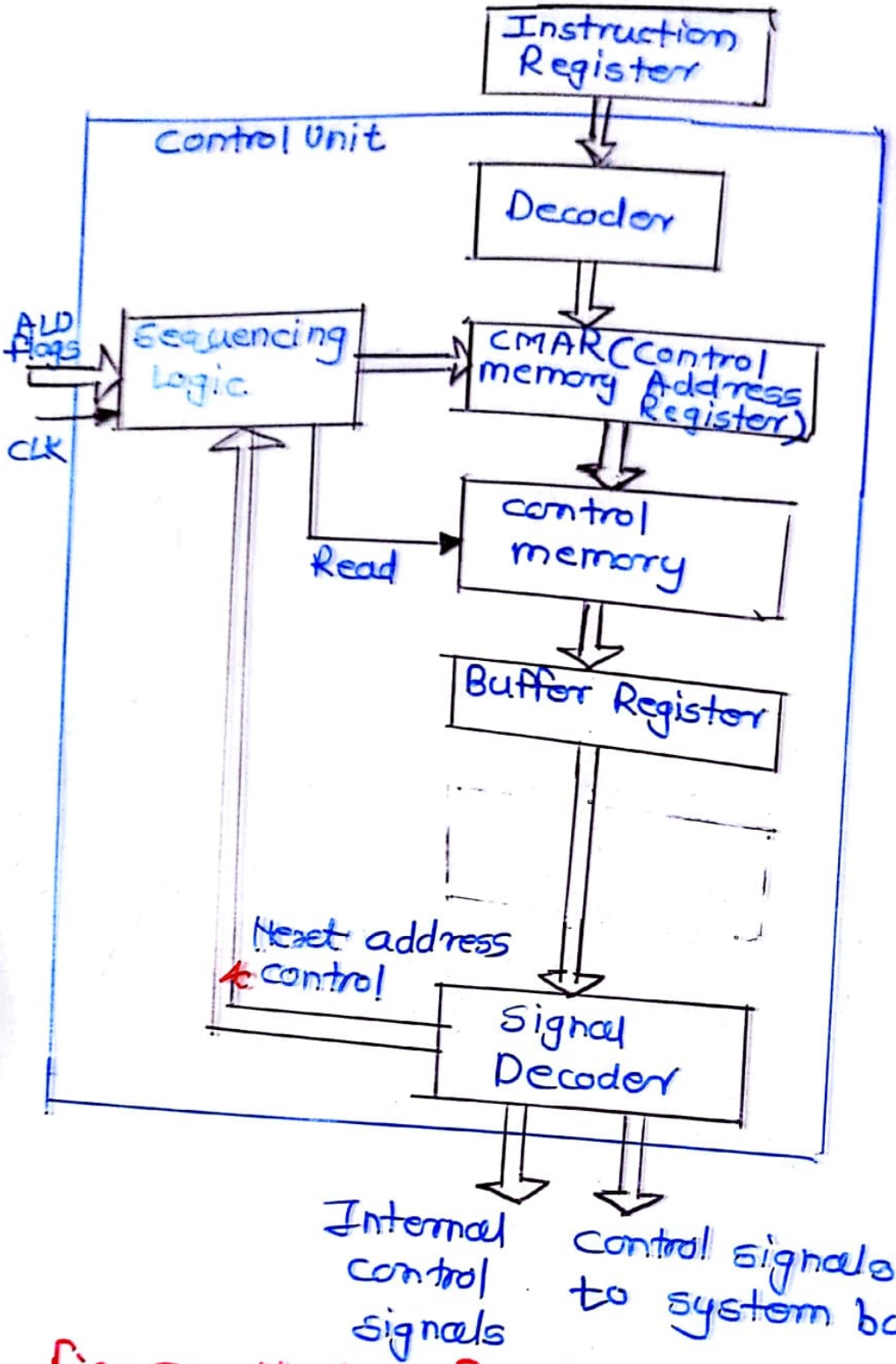


fig: Functioning of micro-programmed control unit

- Micro-program is stored in the control memory of control unit
- The control memory address register contains the address of the next microinstruction to be read.
- When a microinstraction is read from the control memory, it is transferred to buffer register.
- Inputs to control unit are

(1) IR (2) ALU flags (3) Clock.

The controlunit fanctions as follows:

(1) To execute an instruction, the sequencing logic unit issues a READ command to the control memory.

(2) The word whose address is specified by CMAR is read and stored in Buffer register.

(3) The content of buffer register are used to generate control signals and next address information for the sequencing logic unit.

(4) The sequencing logic unit loads a new address into the control address register based on the next-address information from the control buffer register and the ALU flags.

Depending on the value of the ALU flags and the buffer register, one of the three decision is made:

1) Get the next microinstraction: increment CMAR by 1
2) Jump to a new routine based on a jump microinstruction load the address fields of the buffer register into the control memory address register (CMAR)

3) Jump to a machine instruction routine: load the control address register based on the Opcode in the IR.

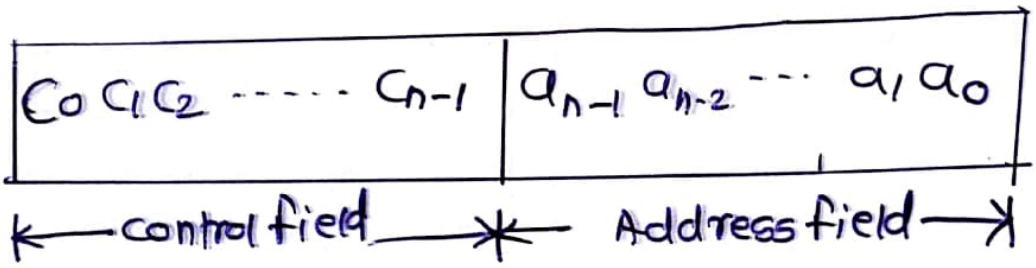
Upper decoder translates the opcode of the IR into a control memory address. The lower decode is not used for horizontal microinstructions but is used for vertical microinstructions.

(As mentioned earlier, in a horizontal microinstructio a code is used for each action to be performed [e.g MAR ← (PC)], and the decoder translates this code into individual control signals. The advantage of vertical microinstructions is that they are more compact (fewer bits) than horizontal microinstructions, at the expense of a small additional amount of logic and time delay.)

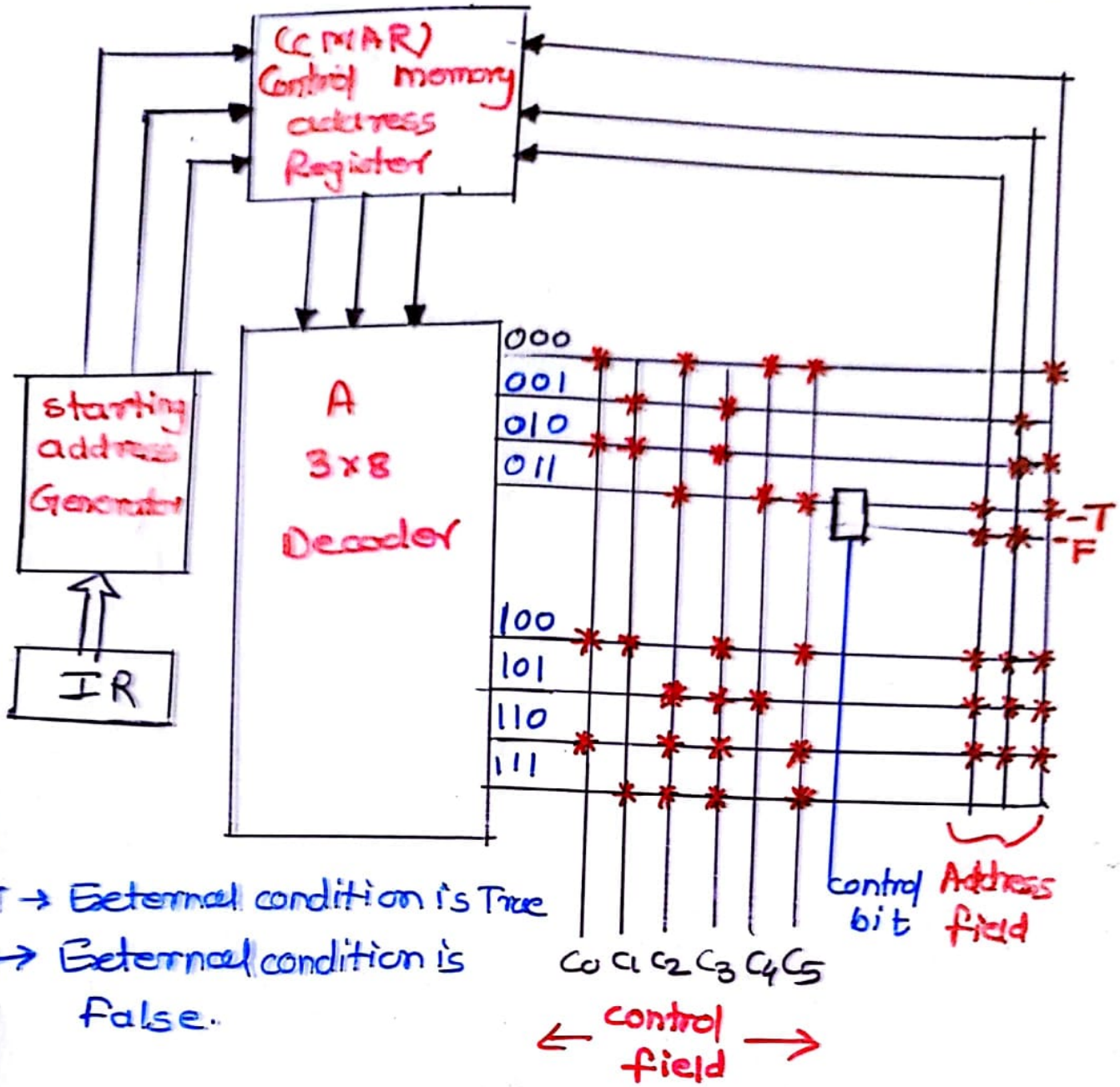
Wilkes control

First working model of a micro-programmed control unit was proposed by wilke's in 1952. Here microinstruction has two major component

- Control field
- Address field.



A typical microinstruction



T → External condition is True

F → External condition is false.

Fig: Wilkes control

If a microinstruction is encoded as given below

C0	C1	C2	C3	C4	C5	C6	A2	A1	A0
0	1	0	0	1	1	0	0	1	0

Then the control information 0100110 indicates that on execution of above microinstruction, control signals C1, C4 and C5 will be activated. Address field contains the address of the next microinstruction. Thus after execution of the above

instruction, the next instruction to be executed is one which is at the address 010. The control field tells the control signals which are to be activated and the address field provides the address of the next microinstruction to be executed.

- In wilkes control, control memory is organized as a program logic array.
- The control memory Address Register (CMAR) can be loaded from an external source (instruction register) as well as from the address field of a microinstruction. A machine instruction typically provides the starting address of a micro-program in control memory.
- On the basis of starting address from instruction register, decoder activates one of the eight output lines.
- This activated line, in turn, generates control signals and the address of the next microinstruction to be executed.
- This address is once again fed to the CMAR resulting in activation of another control line and address field.
- This cycle is repeated till the execution of the instruction is achieved.

For example as shown below, if the machine instruction under execution causes the decoder to have an entry address for a machine instruction in control memory at line 000. The decoder activates the lines in the sequence given in

Table as below.

Line activated	control signal generated	Address of next microinstructio
000	C_0, C_2, C_4, C_5	001
001	C_4, C_3	010
010	C_0, C_1, C_3	011
011	C_2, C_4, C_5	2

On execution of microinstruction at address 011, address of the next microinstruction depend on the external condition. If the condition is true then the address 101 will be selected else the address 110 will be selected.

Micro-programmed Control Unit

Basic Concept - microprogrammed control unit is implemented using programming approach. A sequence of micro-operations are carried out by executing a program consisting of microinstructions.

- Micro-program, consisting of microinstructions is stored in the control memory of the control unit.
- Execution of a microinstruction is responsible for generation of a set of control signals.
- A microinstruction can cause execution of one or more micro-operation and a sequence of microinstructions (a micro-program) can cause execution of an instruction.

Memory address	control field	Address field
	$C_0\ C_1\ C_2\ C_3\ C_4\ C_5\ C_6\ C_7\ C_8\ C_9\ C_{10}$	
1 0000	0 1 1 0 0 1 0 1 1 0 0	0001
2 0001	1 0 0 1 1 1 0 0 1 0 1	0010
3 0010	1 1 0 0 0 1 1 0 0 1 0	0011

Micro-program

- On execution of microinstructions ~~at memory~~ at memory address 0000, $C_1, C_2, C_5, C_7/C_8$ will be generated.
- A microinstruction consists of
  - One or more micro-operation to be executed
  - Address of the next microinstruction to be executed.

Advantages of micro-programmed control unit:

Since the micro-program can be changed relatively easily, therefore, microprogrammed control units are flexible in comparison to hardwired control units.

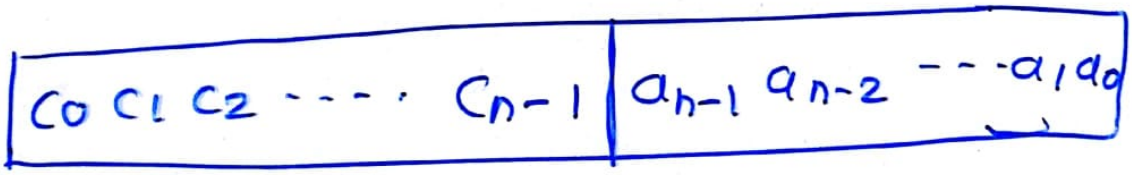
Disadvantages:

- Hardware cost is more because of the control memory and its access circuitry.
- This is slower than hardwired control unit because the microinstructions are to be fetched from the control memory which is time consuming.

Wilkes Control

First working model of microprogrammed control unit was proposed by wilkes in 1952. In the above design, a microinstruction has two major components.

- Control field
- Address field



A typical microinstruction.