Control Unit Design

Control Unit of Basic Computer

There are two major types of control (units)organization viz.:

1. **Hardwired control unit:** When the control signals are generated by hardware using conventional logic design techniques, the control unit is said to be hardwired .In the hardwired organization, the control logic is implemented with gates, flip-flops, decoders, and other digital circuits. It has the advantage that it can be optimized to produce a fast mode of operation.
2. **Micro programmed control unit:** In the microprogrammed organization, the control information is stored in a control memory. The control memory is programmed to initiate the required sequence of microoperations.

A hardwired control will require changes in the wiring among the various components if the design has to be modified or changed whereas in the microprogrammed control the required changes or modifications can be done by updating the microprogram in control memory.

Hardwired control unit of Basic Computer

Let us design a hardwired control unit for basic computer as depicted in the following figure

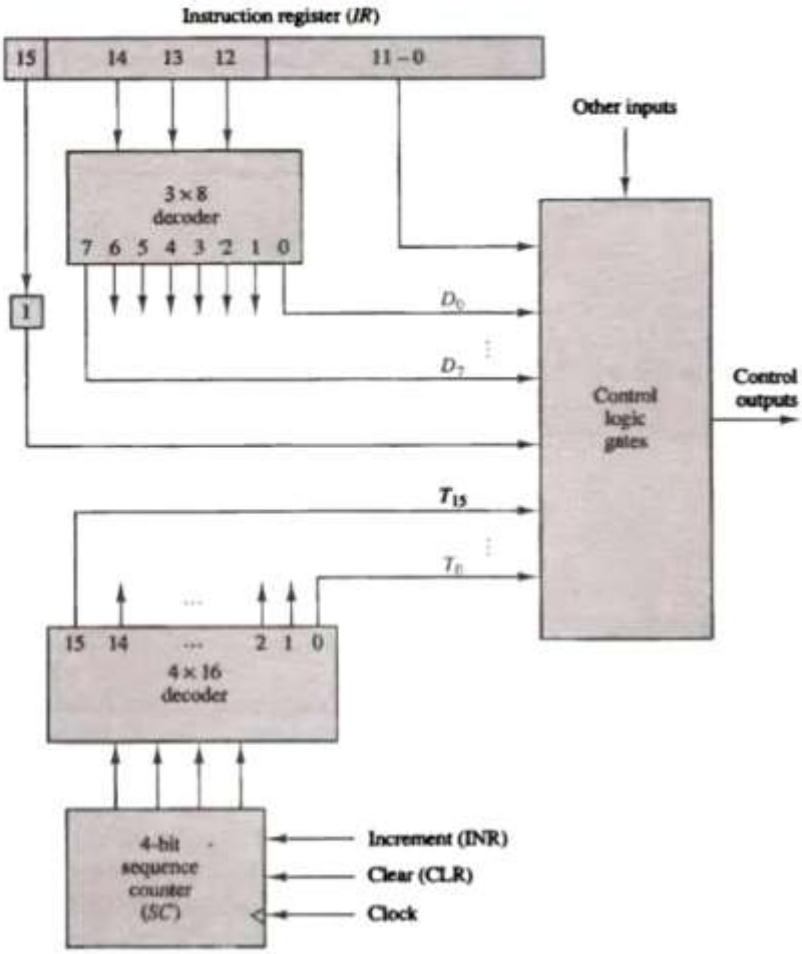

Figure 1: Control Unit of Basic Computer

It consists of two decoders, a sequence counter, and a number of control logic gates. Its working is:

1. An instruction read from memory is placed in the instruction register (IR). Let the instruction register be divided into three parts viz. the I-bit, the operation code, and bits 0 through 11.
2. The operation code in bits 12 through 14 are decoded with a 3 X 8 decoder.
3. The eight outputs of the decoder are designated by the symbols D0 through D7. The subscripted decimal number is equivalent to the binary value of the corresponding operation code.
4. Bits 15 of the instruction is transferred to a flip-flop designated by the symbol I.
5. Bits 0 through 11 are applied to the control logic gates. The 4-bit sequence counter can count in binary from 0 through 15.
6. The outputs of the counter in the above figure of control unit of basic computer are decoded into 16 timing signals T_0 through T_{15}.

Timing & Control

The timing for all registers in the basic computer is controlled by a master clock generator. The clock pulses are applied to all flip-flops and registers in the system, including the flip-flops and registers in the control unit. The clock pulses do not change the state of a register unless the register is enabled by a control signal. The control signals are generated in the control unit and provide control inputs for the multiplexers in the common bus, control inputs in processor registers, and microoperations or the accumulator.

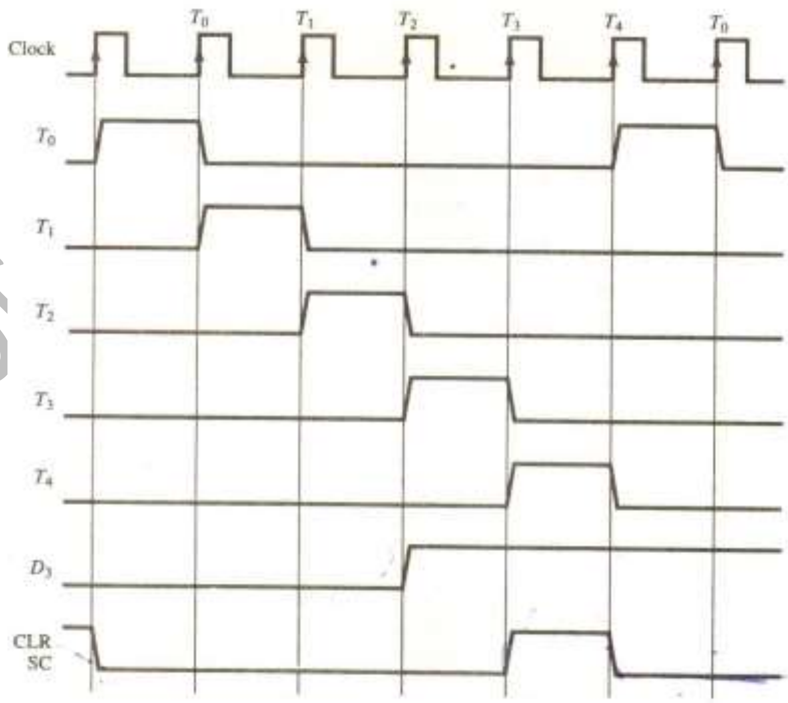

Figure 2: Example of Timing & Control Signal

To fully comprehend the operation of the computer, it is crucial that one understands the timing relationship between the clock transition and the timing signals. For example, the register transfer statement

$$T_0: \quad AR \leftarrow PC$$

specifies a transfer of the content of PC into AR if timing signal T0 is active during an entire clock cycle interval. During this time the content of PC is placed onto the bus (with $S_2\ S_1\ S_0$= 010) and the LD (load) input of AR is enabled. The actual transfer does not occur until the end of the clock cycle when the clock goes through a positive transition. This same positive clock transition increments the sequence counter SC from 0000 to 0001. The next clock cycle has T_1 active and T_0 inactive.