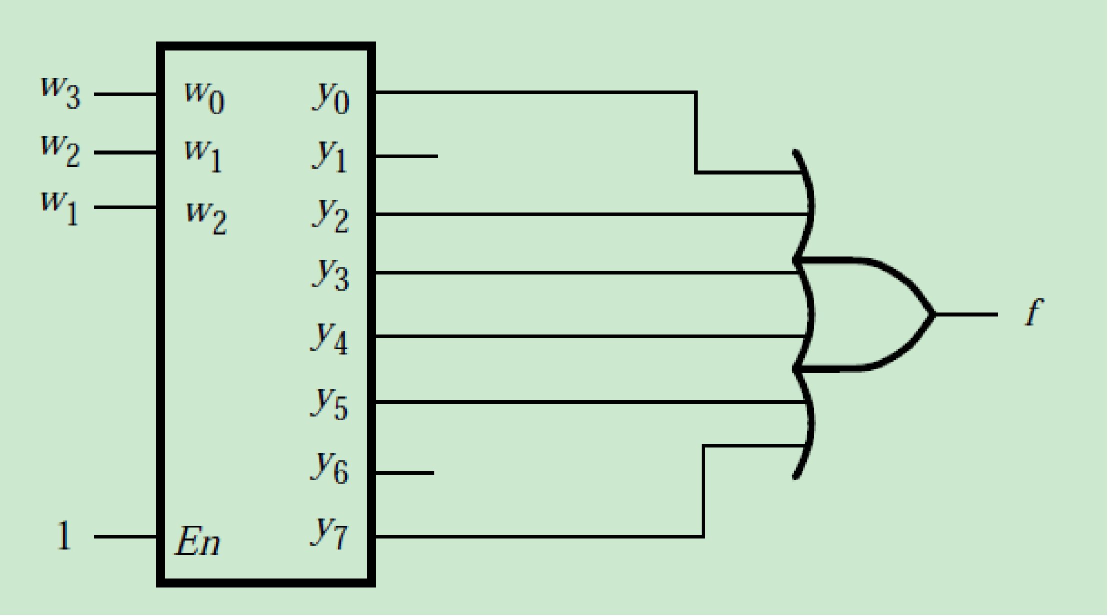
4.1




4.5

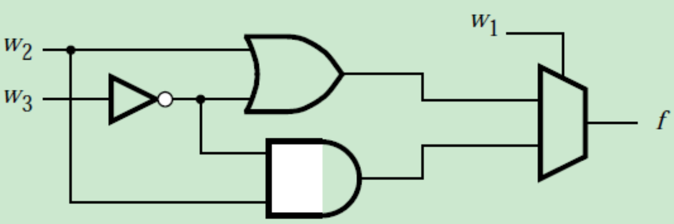
The function $f$ can be expressed as

$$f = \overline{w}_1\overline{w}_2\overline{w}_3 + \overline{w}_1 w_2\overline{w}_3 + \overline{w}_1 w_2 w_3 + w_1 w_2\overline{w}_3$$

Expansion in terms of $w_1$ produces

$$f = \overline{w}_1(w_2 + \overline{w}_3) + w_1(w_2\overline{w}_3)$$

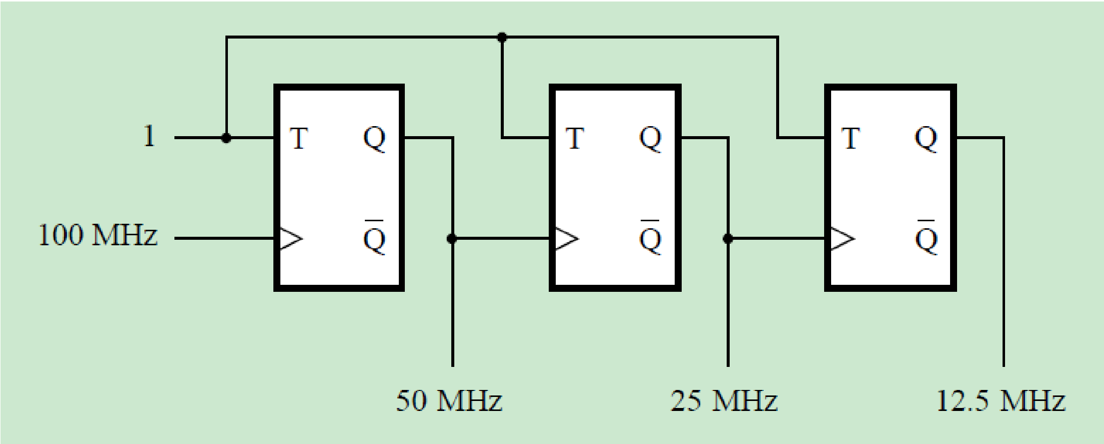
The corresponding circuit is

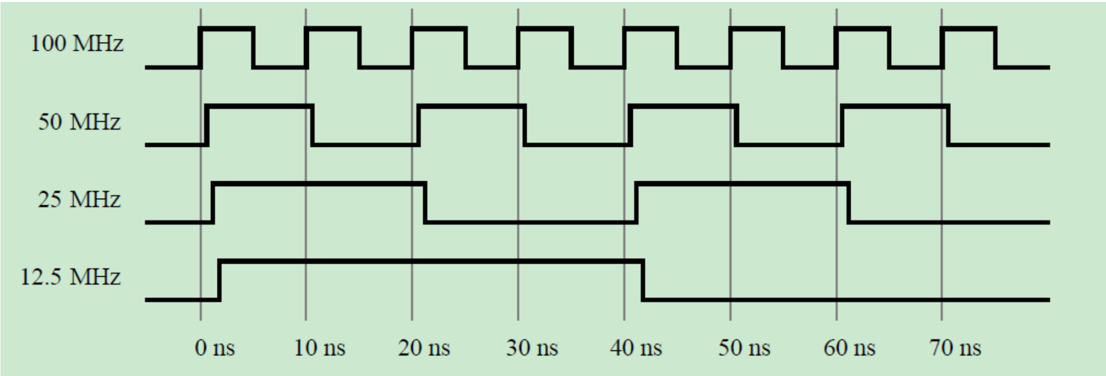


4.19

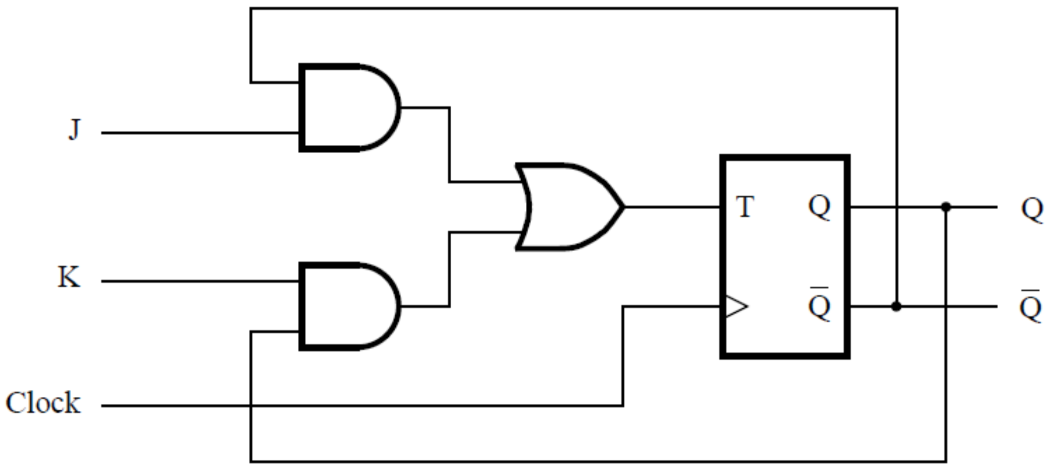
```
module prob4_19 (W, f);
  input [1:3] W;
  output reg f;

  always @(W)
    case (W)
      3'b001: f = 1;
      3'b010: f = 1;
      3'b011: f = 1;
      3'b101: f = 1;
      3'b110: f = 1;
      default: f = 0;
    endcase

endmodule
```

5.4



5.7



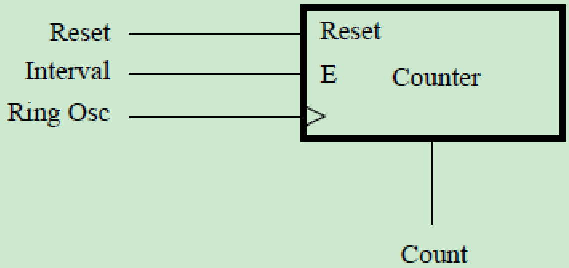
5.13

```verilog
// Universal shift register. If Dir = 0 shifting is to the left.
module universaln (R, L, Dir, w0, w1, Clock, Q);
    parameter n = 4;
    input [n-1:0] R;
    input L, Dir, w0, w1, Clock;
    output reg [n-1:0] Q;
    integer k;

    always @(posedge Clock)
        if (L)
            Q <= R;
        else
        begin
            if (Dir)
            begin
                for (k = 0; k < n-1; k = k+1)
                    Q[k] <= Q[k+1];
                Q[n-1] <= w0;
            end
            else
            begin
                Q[0] <= w1;
                for (k = n-1; k > 0; k = k-1)
                    Q[k] <= Q[k-1];
            end
        end

endmodule
```

5.24

($a$) Period $= 2 \times n \times t_p$

($b$)




The counter tallies the number of pulses in the 100 ns time period. Thus

$$t_p = \frac{100 \text{ ns}}{2 \times Count \times n}$$