Problem 1

a) \( \bar{F} = g(C, B, A) = [B(A'+C) : (A+B'C')']' \)

b) \( \bar{F} = (B(A'+C))' + (A+B'C') = \)

\[ = B' + (A'+C)' + A + B'C' = \]

\[ = B' + A C' + A + B'C' = A(1+C') + B'(1+C') = \]

\[ = A + B' \]

c) \( \bar{F} = A + B' = (A+B')'' \)

d) \[
\begin{array}{ccc|c}
C & B & A & F = A + B' \\
0 & 0 & 0 & 1 \\
0 & 0 & 1 & 1 \\
0 & 1 & 0 & 0 \\
0 & 1 & 1 & 1 \\
1 & 0 & 0 & 1 \\
1 & 0 & 1 & 1 \\
1 & 1 & 0 & 1 \\
1 & 1 & 1 & 1 \\
\end{array}
\]

\( \bar{F} = \prod_{i=2}^{6}(C + B' + A)(C' + B' + A) \)
Problem 2  (Similar problem from 1819 and 22)

(a) So, now the input data is integer in 8-bit 2C

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>N</th>
<th>GT</th>
<th>EQ</th>
<th>LT</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>14</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>222</td>
<td>222</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>231</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>231</td>
<td>14</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>150</td>
<td>150</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Radix-2 unsigned decimal

10 \rightarrow (00001010) \_2
14 \rightarrow (00001110) \_2
6 \rightarrow (00000110) \_2
222 \rightarrow (11111110) \_2
231 \rightarrow (11110011) \_2
150 \rightarrow (10010110) \_2

Integer \rightarrow Signed decimal

+10 \leftrightarrow \[ \begin{array}{c}
0 \\
0 \\
1 \\
0 \\
0 \\
1 \\
0 \\
0
\end{array} \]
+14 \leftrightarrow \[ \begin{array}{c}
0 \\
0 \\
1 \\
1 \\
1 \\
0 \\
0 \\
0
\end{array} \]
+6 \leftrightarrow \[ \begin{array}{c}
0 \\
0 \\
1 \\
1 \\
1 \\
1 \\
1 \\
0
\end{array} \]
-34 \leftrightarrow \[ \begin{array}{c}
1 \\
1 \\
0 \\
1 \\
1 \\
1 \\
1 \\
0
\end{array} \]
-25 \leftrightarrow \[ \begin{array}{c}
1 \\
1 \\
1 \\
0 \\
0 \\
1 \\
1 \\
1
\end{array} \]
-106 \leftrightarrow \[ \begin{array}{c}
0 \\
0 \\
1 \\
1 \\
0 \\
1 \\
1 \\
0
\end{array} \]

e etc.

The idea is that with a \( n=8 \) it is only possible to represent signed integers in \( 2C \) from \(-128 \leq A, B, \leq 127\)

and radix-2 numbers from \( 0 \leq A, B \leq 255 \)
This circuit may be designed using the plan C2 because it is too large and using smaller chips is simpler than other ways (at this introductory level).

Using this architecture

\[ \Rightarrow 6 \text{ VHDL files} \]

\[ \Rightarrow \text{VHDL} \Rightarrow 3 \text{ files} \]

Combination circuit depending on the algorithm with sign bits

\[ \Rightarrow \text{VHDL} \Rightarrow 2 \text{ files} \]
Thus, if PlanA has to be used, and canonical equations based on maxterms, we have to find how many maxterms GT, EQ, and LT have.

\[ \begin{array}{c|c}
  \text{GT} & M_8, M_9, M_{10}, M_{11}, M_{12}, M_{13}, M_{14}, M_{15} \\
  \text{EQ} & 12 \text{ maxterms} \\
  \text{LT} & 12 \text{ maxterms} \\
\end{array} \]

(assuming that other terms don't care are considered '1', like 00110, 00101, 00111)
Problem 3

\[ k = AB' \]

\[ y = (k + C)' = (AB' + C)' \]

\[ (A B')' \cdot C' = (A' + B) \cdot C' = A'C' + B C' \]

\[ y = A'B'C' + A'B'C' + ABC' + A'B'C' \]

\[ y = m_{0,0} + m_{0,0,0} + m_{1,0} + m_{0,0} \]

\[ y = f(A, B, C) = \sum m(0, 2, 6) \]

from which the timing diagram can be represented immediately.

For example:

\[ y(111) = (1 \cdot 1' + 1)' = (0 + 1)' = 0 \]

\[ y(110) = (1 \cdot 1' + 0)' = (0 + 0)' = 1 \]

\[ y(011) = (0 \cdot 1' + 1)' = 1' = 0 \]

Simulation time \( \approx 8 \cdot \text{Min-Pulse} + 9 \cdot \text{Min-Pulse} \approx 30 \mu s \)
Problem 4

a) Power consumption: \(5V \times 1\mu A \times 64 = 320\mu W\)

\[
\text{Vcc} = 5V
\]

\[
\text{I}_{\text{LED}} = 5\mu A
\]

64 gates

\[
V_{\text{om}} = V_{\text{in}} - V_{\text{LED}}
\]

\[
R_L = \frac{V_{\text{om}}}{I_{\text{LED}}} = \frac{4.95V - 1.65V}{5\mu A}
\]

\[
R_L = 471.42 \approx 470\Omega
\]

b) Number of gate levels means the length of the circuit from input to output, determining the circuit's propagation delay. Approx:

- \(S_1 \rightarrow 6\)
- \(S_2 \rightarrow 10\)
- \(S_3 \rightarrow 11\)
- \(S_4 \rightarrow 19\) → For example, from B to S4
- Cost \(\rightarrow 11\)

c) From A or B to S = \(t_p = 2\, \mu\text{s}\)

If we consider 14 levels of gates:

\[
D = \frac{2\, \mu\text{s}}{14}
\]

This circuit can perform a maximum number of operations\(\frac{1}{2\times10^6} = 476,190\) operations/s

d) Gate-level simulation allows the simulation of the flattened technology schematic synthesized into a target chip of a given vendor.

e) \(A\) \quad \(B\)

\[
F = (A\oplus B, (A\oplus B)B)'
\]

\[
AB | G \times F = G'
\]

\[
\begin{array}{cccc}
0 & 0 & 1 & 1
1 & 0 & 1 & 0
1 & 1 & 0 & 1
1 & 1 & 1 & 1
\end{array}
\]

\[
F = (A \oplus B)'
\]

\[
G = M_i \oplus M_o
\]
Problem 5

\[ y = T \cdot M(0, 1, 3, 5, 7, 9, 10, 13, 14) \]

\[ y = f(x_1, x_2, x_3) \]

a) Plan B: means capturing the truth table directly in VHDL.

In this case, there is no need for a signal because the input is already expressed as the vector \( x(3,0) \).

architecture planB of cc is
begin
    process (x)
        begin
            case x is
                when "0000" => y <= '0';
                when "0001" => y <= '1';
                when "0010" => y <= '1';
                when "0011" => y <= '0';
                when others => y <= 'x';
            end case;
    end process;
end;
and cc;

Truth table:

\[ y = f(x) = \sum m(2, 3, 5, 7, 13, 15) \]

6) Method of Decoder (MoD)

C) Method of multiplexers (MoM) using a MUX-4

Representations of the CC truth table subdivided in 4 channels:

- \( \text{Cho} \)
  \[ y = x_3 \cdot x_2 \cdot y_1 \cdot x_0 \]
  \[ g_0 = x_2 \cdot x_0 \]
  \[ g_1 = x_3 \cdot x_2 \cdot y_1 \cdot x_0 \]
  \[ g_2 = x_1 \cdot x_0 \]
  \[ g_3 = (x_3 \cdot y_1) \cdot x_0 \]

- \( \text{Ch1} \)
  \[ y = x_2 \cdot x_0 \]
  \[ g_0 = x_2 \cdot x_0 \]
  \[ g_1 = x_1 \cdot x_0 \]
  \[ g_2 = x_1 \cdot x_0 \]

- \( \text{Ch2} \)
  \[ y = x_2 \cdot x_0 \]
  \[ g_0 = x_2 \cdot x_0 \]
  \[ g_1 = x_1 \cdot x_0 \]
  \[ g_2 = x_1 \cdot x_0 \]

- \( \text{Ch3} \)
  \[ y = x_2 \cdot x_0 \]
  \[ g_0 = x_2 \cdot x_0 \]
  \[ g_1 = x_1 \cdot x_0 \]
  \[ g_2 = x_1 \cdot x_0 \]
e) \[ y = \sum_{i=0}^{4} \bar{C}(X) = \sum_{i=0}^{4} TM(0, 1, 3, 6, 8, 9, 10, 13, 14) \]

Solve the function using the MoM and a MUX_16.

Let's connect the truth table to the corresponding channel.