Q1

Break the problem into two pieces :-

① When A & B have diff sign

② " " " " same "

When A & B have diff. sign $(A_3 \oplus B_3)$

A>B if A +ve (& B is -ve)

When A & B have same sign

$A-B \geq 0 \Rightarrow A \geq B$

Compute $A-B=S$.

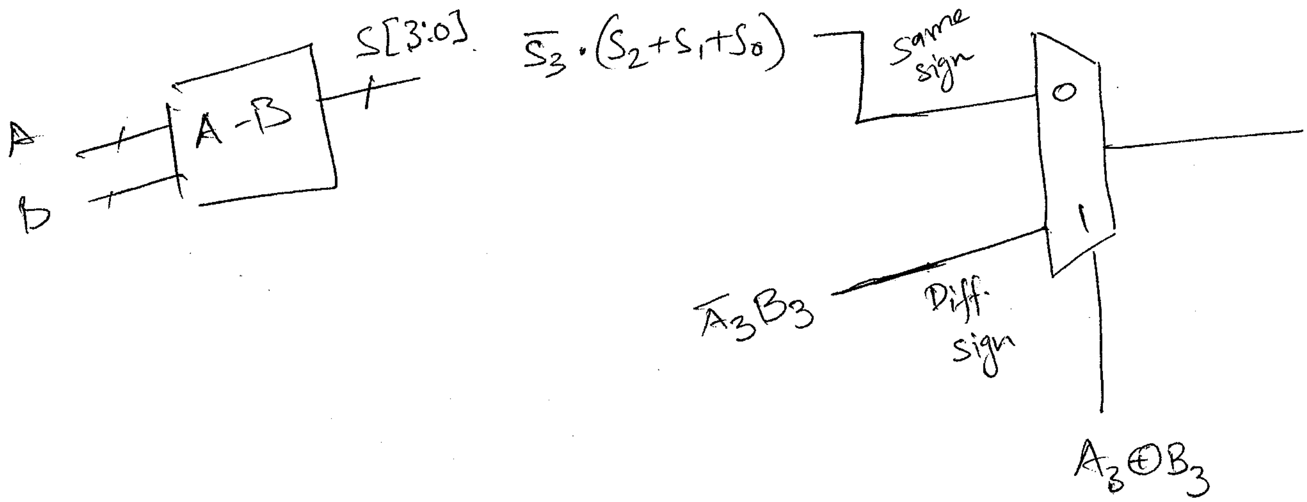
or $S[3:0] = A[3:0] - B[3:0]$

if $S[3] == 0$, $S \geq 0$.

We have to account for $A=B$ ($\Rightarrow A-B=0$)

$\therefore$ $S_2 + S_1 + S_0 = 1 \Rightarrow A-B \neq 0$

$\overline{S_3}(S_2+S_1+S_0)$



Q2.

If $A < B$, $F1 = A$.

else $F1 = B$.

If $C < D$ $F2 = C$

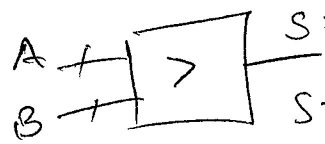
else $F2 = D$.

if $F1 < F2$

$F = F1$

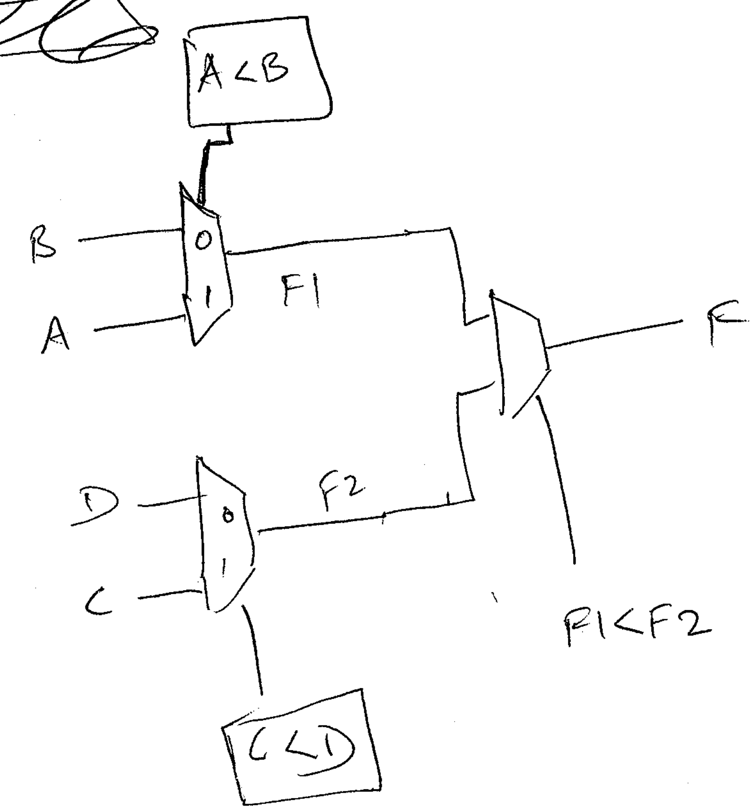
else $F2$.

Assume predesigned magnitude comparators. & muxes.



$S = 0$ if $A \leq B$

$S = 1$ if $A > B$



Q3. $f = xy + xz + yz$.

(a) $f_x = f(x=1) = y + z + yz = y + z$.

$f_{\bar{x}} = f(x=0) = 0 + 0 + yz = yz$.

$f_x \cdot f_{\bar{x}} = (y+z)(yz) = yz$.

(b) Prove. $f = (x + f_{\bar{x}})(\bar{x} + f_x)$

$= \underbrace{x \cdot \bar{x}}_{0} + x f_x + \bar{x} f_{\bar{x}} + f_x \cdot f_{\bar{x}}$

$= \underbrace{x f_x + \bar{x} f_{\bar{x}}}_{} + f_x \cdot f_{\bar{x}}$

↳ we know this is 'f', by Shannon's expansion

So $f = f + f_x \cdot f_{\bar{x}}$

Note $f_x \cdot f_{\bar{x}} \neq 0$ (as shown in (a))

$\therefore$ $f = f + f_x \cdot f_{\bar{x}}$ is possible only if $f_x \cdot f_{\bar{x}}$ is contained in f

$\therefore f = x f_x + \bar{x} f_{\bar{x}} + f_x \cdot f_{\bar{x}}$

$= x f_x + \bar{x} f_{\bar{x}} + 1 \cdot f_x \cdot f_{\bar{x}}$

$(x + \bar{x})$

$$f = x f_x + \bar{x} f_{\bar{x}} + (x + \bar{x})\, f_x \cdot f_{\bar{x}}$$

$$= x f_x + \bar{x} f_{\bar{x}} + x f_x f_{\bar{x}} + \bar{x} f_x f_{\bar{x}}$$

✓ ✗ ✓ ✗

$$= x f_x (1 + f_{\bar{x}}) + \bar{x} f_{\bar{x}} (1 + f_x)$$

$$= x f_x \cdot 1 + \bar{x} f_{\bar{x}} \cdot 1$$

$$= x f_x + \bar{x} f_{\bar{x}} = \underline{\underline{f}}.$$

Note $f_x \cdot f_{\bar{x}}$ = contained in f.

$\downarrow$ $\underline{\underline{yz}}$. $\downarrow$ $xy + \underline{\underline{yz}} + xz$

$f_x \cdot f_{\bar{x}}$ = that component of f which is independent of x.

$f = xy + yz + xz$

$\underline{f_x \cdot f_{\bar{x}} = yz}$ = independent of x

&

contained in f.

Q4 Note:→ There is a "typo" in the question.

I wanted you to design an up counter, that counts modulo-6. ["Down" counting %6 really doesn't mean anything. While such a "down" counter can be designed, it is better done using DFFs rather than TFFs]

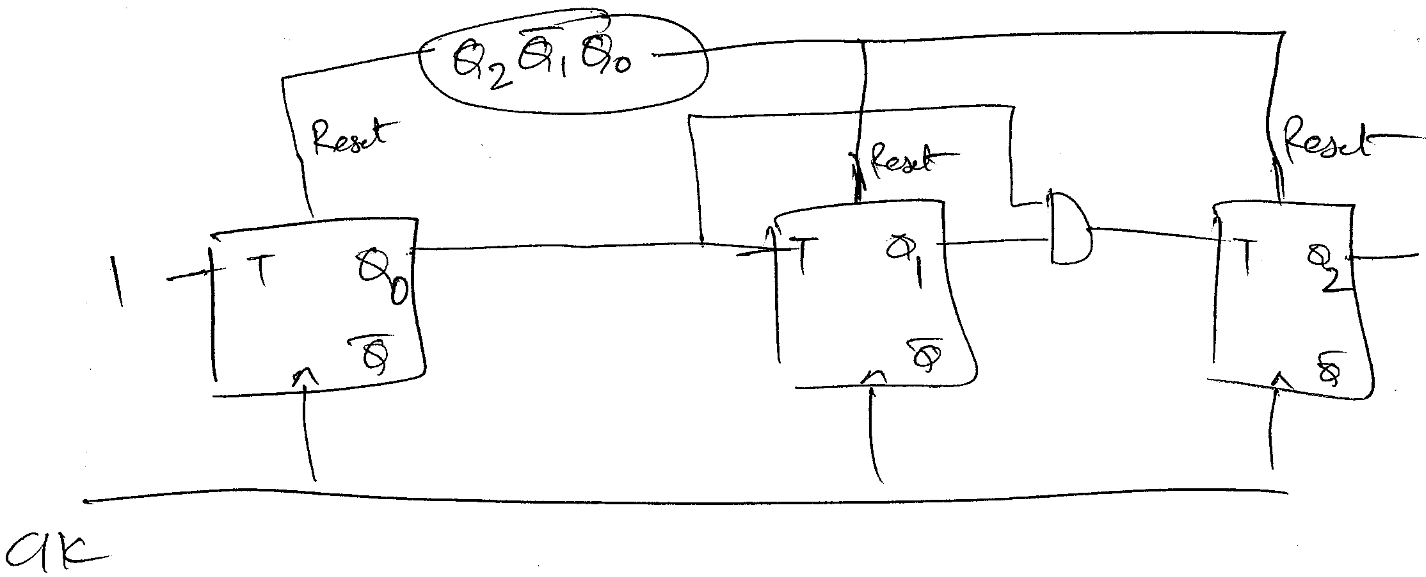
→ You count as:-

$000 \rightarrow 001 \rightarrow 010 \rightarrow 011 \rightarrow 100 \rightarrow 101$

Think of this design as a regular up counter, with a specific reset logic. When $q_2q_1q_0 = 101$, then in the next cycle, you reset the TFFs.

this works when reset is synchronous.

When reset is asynchronous, you would rather that the counter count to 110 (6), and as soon as $q_2q_1q_0 = 110$, reset logic resets the TFFs immediately to '000' & repeat



Q5

$T_{su} = 3$

$T_h = 1\,ns$

$T_{prop} = 1\,ns.$

Since $T_{prop} = T_h$, we won't really see hold time violations.

So $T_{delay} = T_{\text{combinational logic}} + T_{prop} + T_{su}$

↓

longest path

↓

$Q_0 \rightarrow$ 3 And gates $\rightarrow$ XOR $\rightarrow$ MUX $\rightarrow$ to the D-input of last DFF.

$= \underline{5ns}$.

$T_{delay} = 5 + 3 + 1 = \underline{9ns}$