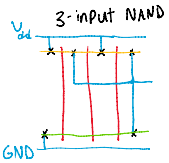
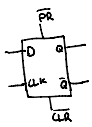
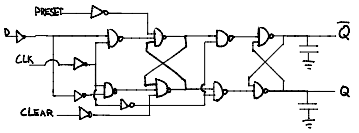
Final project

Thursday, November 3, 2022 4:29 PM





Design 1



Truth Table

PR	CLR	D	CLK	Q	Q̄
0	1	X	X	1	0
1	0	X	X	0	1
0	0	X	X	X	X
1	1	0	0	0	1
1	1	0	1	0	1
1	1	1	0	0	1
1	1	1	1	1	0

Logical Effort

$G = \Pi g_i$

$G_{NOT} = 1$

$G_{2NAND} = 4/3$

$G_{3NAND} = 5/3$

Calculations w/out $\overline{PRESET}$ & $\overline{CLEAR}$ on slave (truth table remains same)

Logical Effort

$G = (1)(1)(1)\left(\frac{4/3}{5/3}\right)\left(\frac{4/3}{5/3}\right)\frac{320}{81}$

Electrical Effort

$H = \frac{45+4}{3} = \frac{49}{3}$

Branching Effort

$\frac{C_{on\text{-}path} + C_{off\text{-}path}}{C_{on\text{-}path}} = \left(\frac{3+4}{3}\right)\left(\frac{4+5}{4}\right)(1)(1) = \frac{63}{12}$

Parasitic Delay

$p = 1+1+2+3+2+2 = 11$

Path Effort

$F = GBH = \left(\frac{320}{81}\right)\left(\frac{63}{12}\right)\left(\frac{49}{3}\right)$

$\frac{27,440}{81}$

Best stage Effort

$f = \sqrt[4]{F} = \sqrt[4]{\frac{27440}{81}} = 2.64$

Delay

$D = Nf + P$

$6\left(\sqrt[4]{\frac{27440}{81}}\right) + 11$

$D = 26.8$

Sizing

$C_{in} = \frac{C_{out} \cdot g_i}{\hat{f} \cdot g_i}$

$C_{in_Z} = \frac{45 \cdot (4/3)}{2.64 \cdot 4/3} = 45$

$C_{in_Y} = \frac{45.9 \cdot (4/3)}{2.64} = 23.18$

$C_{in_X} = \frac{23.18 \cdot (5/3)}{2.64 - 5/3} = 39.69$

$C_{in_W} = \frac{(39.69)(4/3)}{2.64} = 20.04$

$C_{in_V} = \frac{(20.04)(1)}{2.64} = 7.59$

$C_{in_U} = \frac{(20.04+7.59)(1)}{2.64} = 10.47$

Recalculating after Sizing

Logical Effort

Does not change,

$= \frac{320}{81}$

Electrical Effort

$H = \frac{45+45.9}{3} = \frac{90.9}{3}$

Branching Effort

$B = \left(\frac{C_{in_W} + C_{in_V}}{C_{in_V}}\right)\left(\frac{C_{in_X} + C_{in_Y}}{C_{in_Y}}\right)$

$= \left(\frac{20.04 + 7.59}{7.59}\right)\left(\frac{39.69 + 23.18}{23.18}\right)$

$= 9.87$

Parasitic Delay

$P = 1+1+2+3+2+2 = 11$

Path Effort

$F = GBH = \left(\frac{320}{81}\right)(9.87)\left(\frac{90.9}{3}\right)$

$= 1181.8$

Best Stage Effort

$\hat{f} = \sqrt[6]{1181.8}$

$= 3.25$

Delay

$D = NF^{1/N} + P$

$= 6(3.25) + 11$

$= 30.5$

Sizing

$C_{in_Z} = \frac{(45)(4/3)}{(3.25) \cdot 4/3} = 31.27$

$C_{in_Y} = \frac{(31.27)(4/3)}{(3.25)} = 12.83$

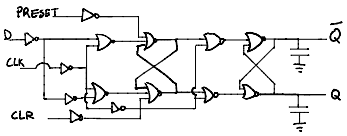
$C_{in_X} = \frac{(12.83)(5/3)}{3.25 - 5/3} = 13.49$

$C_{in_W} = \frac{(13.49)(4/3)}{3.25} = 5.53$

$C_{in_V} = \frac{(5.53)(1)}{3.25} = 1.7$

$C_{in_U} = \frac{(0.53+1.7)(1)}{(3.25)} = 2.22$

Design 2



Truth Table

PR	CLR	D	CLK	Q	Q̄
0	1	X	X	1	0
1	0	X	X	0	1
0	0	X	X	X	X
1	1	0	⌀	0	1
1	1	0	⌀	0	1
1	1	1	0	0	1
1	1	1	1	1	0

Logical Effort

$G = (1)(1)(5/3)(5/3)(5/3) = \frac{875}{81}$

Electrical Effort

$H = \frac{45+5}{3} = \frac{50}{3}$

Branching Effort

$B = \left(\frac{3+5}{3}\right)\left(\frac{7+5}{5}\right) = \frac{32}{5}$

Parasitic Delay

$P = 1+1+2+3+2+2 = 11$

Path Effort

$F = GBH = \left(\frac{875}{81}\right)\left(\frac{50}{3}\right)\left(\frac{32}{5}\right)$

$= \frac{280000}{243}$

Best Stage Effort

$\hat{f} = \sqrt[N]{F} = \sqrt[6]{\frac{280000}{243}}$

$= 3.238$

Delay

Sizing

After Resizing

Logical Effort

Does not change

$G = \frac{560}{81}$

Electrical Effort

$H = \frac{45 + 47.73}{3} = 30.9$

Branching Effort

$B = \left(\frac{C_{in_W} + C_{in_V}}{C_{in_V}}\right)\left(\frac{C_{in_X} + C_{in_Y}}{C_{in_Y}}\right)$

$B = \left(\frac{32.63 + 10.08}{10.08}\right)\left(\frac{63.98 + 24.97}{24.97}\right)$

$B = 15.17$

Parasitic Delay

$P = 1+1+2+3+2+2 = 11$

Path Effort

$F = GBH = \left(\frac{560}{81}\right)(15.17)(30.9)$

$= 3241.9$

Best Stage Effort

$\hat{f} = \sqrt[N]{F} = \sqrt[6]{3241.9}$

$= 3.847$

Delay

$D = N\hat{f} + P = 6(3.847) + 11$

$= 34.08$

Sizing

$C_{in} = \frac{C_{out} \cdot g_i}{\hat{f} \cdot g_i}$ at latches

$C_{in_U} = 45 \cdot (5/3)$

$= 24.397$

Logical Effort

Does not change

$G = \frac{560}{81}$

Electrical Effort

$H = \frac{45 + 34.397}{3} = 26.47$

Branching Effort

$B = \left(\frac{C_{in_W} + C_{in_V}}{C_{in_V}}\right)\left(\frac{C_{in_X} + C_{in_Y}}{C_{in_Y}}\right)$

$B = \left(\frac{9.95 + 2.587}{2.587}\right)\left(\frac{22.97 + 14.9}{14.9}\right) = 7.389$

Parasitic Delay

$P = 1+1+2+3+2+2 = 11$

Path Effort

$F = \left(\frac{560}{81}\right)(26.47)(7.389)$

$= 1351.89$

Best Stage Effort

$\hat{f} = \sqrt[6]{1351.89}$

$= 3.325$

Delay

$D = N\hat{f} + P$

$= 6(3.325) + 11$

Sizing

$C_{in_Z} = \frac{45 \cdot (5/3)}{\hat{f} \cdot 5/3} = 45.22$

$= \frac{280000}{243}$

$= 3.238$

Delay

$D = N(\hat{f}) + P$

$= 6(3.238) + 11$

$= 30.427$

Sizing

$C_{in} = \frac{C_{out} \cdot g_i}{\hat{f} \cdot g_i}$ at Latches, no g_i w/out Latches

$C_{in_z} = \frac{(45)(5/3)}{\hat{f} - 5/3} = 47.73$

$C_{in_y} = \frac{(47.73)(5/3)}{\hat{f}} = 29.57$

$C_{in_x} = \frac{(29.57)(7/3)}{\hat{f} - 7/3} = 63.38$

$C_{in_w} = \frac{(63.38)(5/3)}{\hat{f}} = 32.63$

$C_{in_v} = \frac{(32.63)(1)}{\hat{f}} = 10.08$

$C_{in_u} = \frac{(10.08 + 32.63)(4)}{\hat{f}} = 131.9$

$D = N\hat{f} + P = 6(3.238) + 11$

$= 34.08$

$\log_{3.59}(3241.9) = 6.32$

Sizing

$C_{in} = \frac{C_{out} \cdot g_i}{\hat{f} \cdot g_i}$ at latches

$C_{in_z} = \frac{45 \cdot (5/3)}{\hat{f} - 5/3} = 34.397$

$C_{in_y} = \frac{(34.397)(5/3)}{\hat{f}} = 14.9$

$C_{in_x} = \frac{(14.9)(7/3)}{\hat{f} - 7/3} = 22.97$

$C_{in_w} = \frac{(22.97)(5/3)}{\hat{f}} = 9.95$

$C_{in_v} = \frac{(9.95)(1)}{\hat{f}} = 2.587$

$C_{in_u} = \frac{(2.587 + 9.95)(1)}{\hat{f}} = 3.259$

Delay

$D = N\hat{f} + P$

$= 6(3.325) + 11$

$= 30.95$

$\log_{3.59}(1361.89) = 5.6$

Sizing

$C_{in_z} = \frac{45 \cdot (5/3)}{\hat{f} - 5/3} = 45.22$

$C_{in_y} = \frac{(45.22)(5/3)}{\hat{f}} = 22.66$

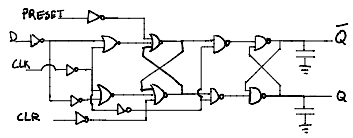
$C_{in_x} = \frac{(22.66)(7/3)}{\hat{f} - 7/3} = 53.31$

$C_{in_w} = \frac{(53.31)(5/3)}{\hat{f}} = 26.72$

$C_{in_v} = \frac{(26.72)(1)}{\hat{f}} = 8.04$

$C_{in_u} = \frac{(8.04 + 26.72)(1)}{\hat{f}} = 10.45$

Design 3



Logical Effort

$G = (1)(1)(5/3)(7/3)(4/3)(4/3)$

$= \frac{560}{81}$

Electrical Effort

$H = \frac{45+4}{3} = \frac{49}{3}$

Branching Effort

$B = (3+5)\left(\frac{24}{4}\right) = \frac{22}{5}$

Parasitic Delay

$P = 1+1+2+3+2+2$

$= 11$

Path Effort

$F = GBH = \left(\frac{560}{81}\right)\left(\frac{22}{5}\right)\left(\frac{49}{3}\right) = \frac{603680}{729}$

Best Stage Effort

$\hat{f} = \sqrt[N]{F} = \sqrt[6]{\frac{603680}{729}} = 3.06$

Delay

$D = N\hat{f} + P = (6)(2.897) + 11$

$= 28.38$

Sizing

$C_{in_z} = \frac{(45)(4/3)}{\hat{f} - 4/3} = 34.66$

$C_{in_y} = \frac{(34.66)(4/3)}{\hat{f}} = 15.08$

$C_{in_x} = \frac{(15.08)(7/3)}{\hat{f} - 7/3} = 48.13$

$C_{in_w} = \frac{(48.13)(5/3)}{\hat{f}} = 26.18$

$C_{in_v} = \frac{(26.18)(1)}{\hat{f}} = 8.5$

$C_{in_u} = \frac{(26.18 + 8.5)(4)}{\hat{f}} = 111.33$

Logical Effort

$G = (1)(1)(5/3)(7/3)(4/3)(4/3)$

$= \frac{560}{81}$

Electrical Effort

$H = \frac{45+34.66}{3} = 26.55$

Branching Effort

$B = \left(\frac{C_{in_z} + C_{in_y}}{C_{in_y}}\right)\left(\frac{C_{in_x} + C_{in_w}}{C_{in_w}}\right)$

$B = \left(\frac{15.08 + 48.13}{15.08}\right)\left(\frac{26.18 + 8.5}{8.5}\right)$

$= 5.338$

Parasitic Delay

$P = 1+1+2+3+2+2$

$= 11$

Path Effort

$F = GBH = \left(\frac{560}{81}\right)(5.338)(26.55)$

$= 979.9$

Best Stage Effort

$\hat{f} = \sqrt[6]{979.9}$

$= 3.15$

Delay

$D = N\hat{f} + P$

$= 6(3.15) + 11$

$= 29.91$

Sizing

$C_{in_z} = \frac{(45)(4/3)}{\hat{f} - 4/3} = 32.998$

$C_{in_y} = \frac{(32.998)(4/3)}{\hat{f}} = 13.96$

$C_{in_x} = \frac{(13.96)(7/3)}{\hat{f} - 7/3} = 39.81$

$C_{in_w} = \frac{(39.81)(5/3)}{\hat{f}} = 21.05$

$C_{in_v} = \frac{(21.05)(1)}{\hat{f}} = 6.68$

$C_{in_u} = \frac{(21.05 + 6.68)(4)}{\hat{f}} = 87.99$

Logical Effort

$G = (1)(1)(5/3)(7/3)(4/3)(4/3)$

$= \frac{560}{81}$

Electrical Effort

$H = \frac{45+32.998}{3} = 26$

Branching Effort

$B = \left(\frac{C_{in_z} + C_{in_y}}{C_{in_y}}\right)\left(\frac{C_{in_x} + C_{in_w}}{C_{in_w}}\right)$

$B = \left(\frac{39.81 + 13.96}{13.96}\right)\left(\frac{21.05 + 6.68}{6.68}\right)$

$= 8$

Parasitic Delay

$P = 1+1+2+3+2+2$

$= 11$

Path Effort

$F = GBH = \left(\frac{560}{81}\right)(26)(8)$

$= 1438.558$

Best Stage Effort

$\hat{f} = \sqrt[6]{1438.558}$

$= 3.36$

Delay

$D = N\hat{f} + P$

$= 6(3.36) + 11$

$= 31.16$

Sizing

$C_{in_z} = \frac{(45)(4/3)}{\hat{f} - 4/3} = 29.607$

$C_{in_y} = \frac{(29.61)(4/3)}{\hat{f}} = 11.75$

$C_{in_x} = \frac{(11.75)(7/3)}{\hat{f} - 7/3} = 26.71$

$C_{in_w} = \frac{(26.71)(5/3)}{\hat{f}} = 13.25$

$C_{in_v} = \frac{(13.25)(1)}{\hat{f}} = 3.94$

$C_{in_u} = \frac{(13.25 + 3.94)(4)}{\hat{f}} = 51.12$