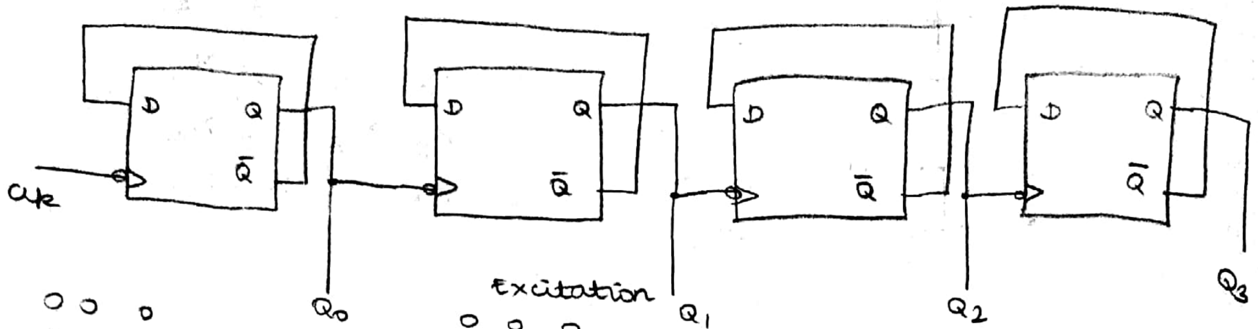
Asynchronous binary ripple counter using D-flip flop



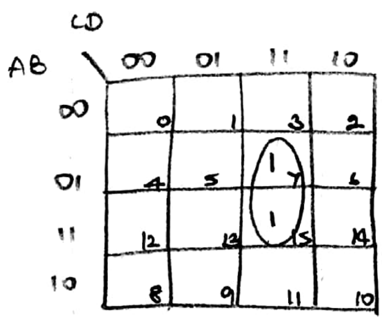
Excitation

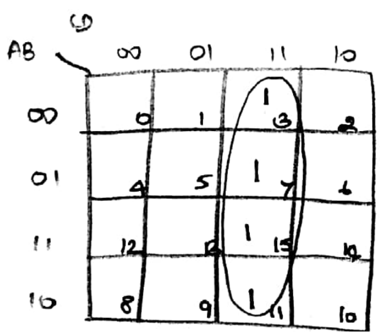
0 0 0
0 1 1
1 0 1
1 1 0

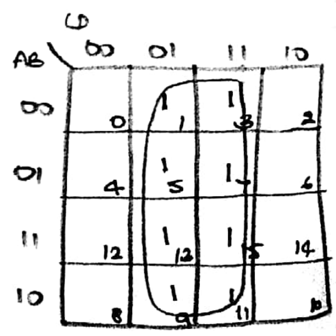
Synchronous binary ripple counter using T-flip flop

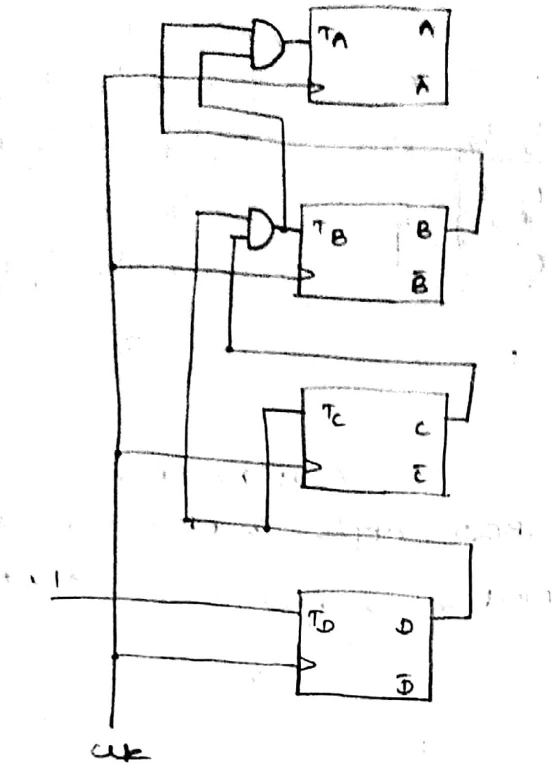
0 0 0
0 1 1
1 0 1
1 1 0

	N.S A	B	C	D	N.S				T_A	T_B	T_C	T_D
0	0	0	0	0	0	0	0	1	0	0	0	1
1	0	0	0	1	0	0	1	0	0	0	1	1
2	0	0	1	0	0	0	1	1	0	0	0	1
3	0	0	1	1	0	1	0	0	0	1	1	1
4	0	1	0	0	0	1	0	1	0	0	0	1
5	0	1	0	1	0	1	1	0	0	0	1	1
6	0	1	1	0	0	1	1	1	0	0	0	1
7	0	1	1	1	1	0	0	0	1	1	1	1
8	1	0	0	0	1	0	0	1	0	0	0	1
9	1	0	0	1	1	0	1	0	0	0	1	1
10	1	0	1	0	1	0	1	1	0	0	0	1
11	1	0	1	1	1	1	0	0	0	1	1	1
12	1	1	0	0	1	1	0	1	0	0	0	1
13	1	1	0	1	1	1	1	0	0	0	1	1
14	1	1	1	0	1	1	1	1	0	0	0	1
15	1	1	1	1	0	0	0	0	1	1	1	1









Up counter

For n-bit counter

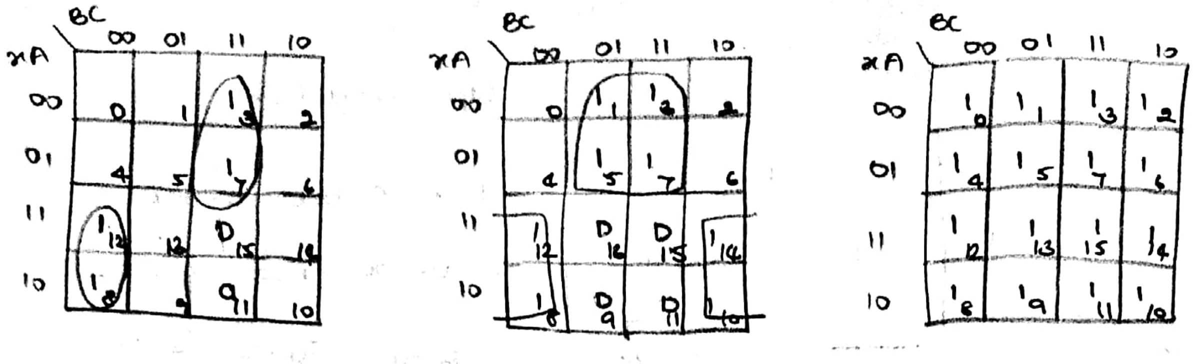
v w x y z

$T_x = yz$ $\quad T_y = z$ $\quad T_z = 1$

$T_w = xyz$ $\quad T_v = wxyz$

Synchronous 3-bit up/down counter using T-flip flop

	P.S			N.S			T-flip flop		
x	A	B	C				T_A	T_B	T_C
0	0	0	0	0	0	1	0	0	1
0	0	0	1	0	1	0	0	1	1
0	0	1	0	0	1	1	0	0	1
0	0	1	1	1	0	0	1	1	1
0	1	0	0	1	0	1	0	0	1
0	1	0	1	1	1	0	0	1	1
0	1	1	0	1	1	1	0	0	1
0	1	1	1	0	0	0	1	1	1
1	1	1	1	1	1	0	0	0	1
1	1	1	0	1	0	1	0	1	1
1	1	0	1	1	0	0	0	0	1
1	1	0	0	0	1	1	1	1	1
1	0	1	1	0	1	0	0	0	1
1	0	1	0	0	0	1	0	1	1
1	0	0	1	0	0	0	0	0	1
1	0	0	0	1	1	1	1	1	1



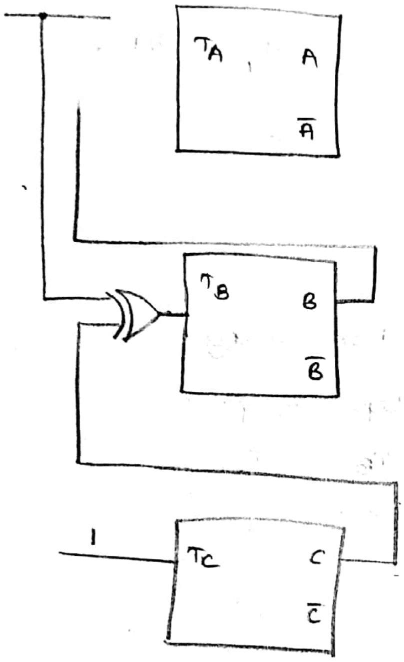
$T_A = BC\oplus\bar{x} +$

$x\bar{B}\bar{C}$ $\quad \bar{x}A + \bar{A}x$

$x \oplus A \quad x \oplus B \oplus C$

$T_B = \cancel{\emptyset} C \oplus x$

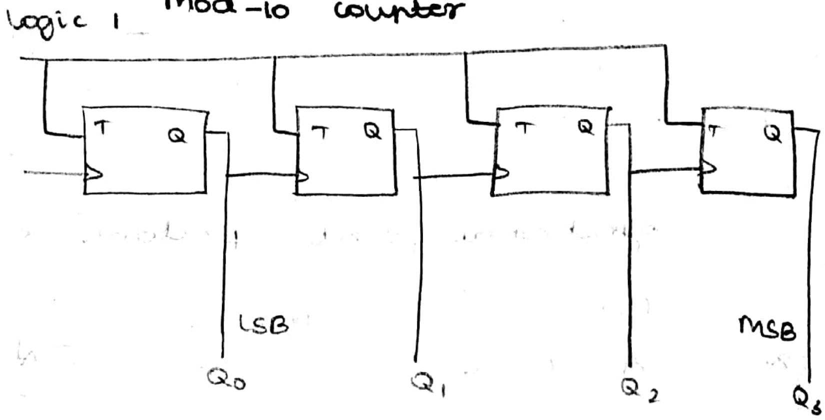
$T_C = 1$



Asynchronous

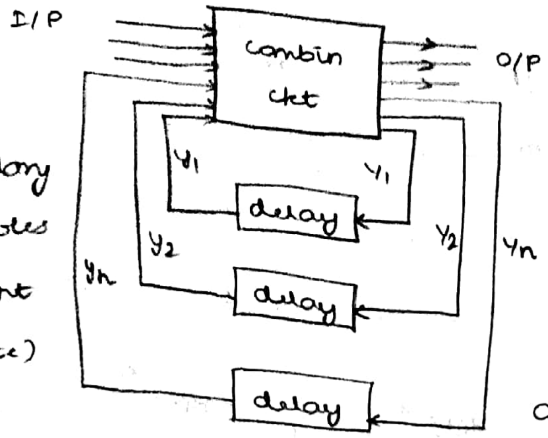
BCD ripple counter (Decade counter)

Mod-10 counter



counts = $0 \rightarrow n-1$ = Mod-n counter

4. Asynchronous sequential circuits



secondary variables (present state)

Excitation variables (Next state)

Only one variable is allowed to change at a time

Two modes of operation:

* Fundamental mode
* Pulse mode

At steady state, $Y_i = y_i$

After achieving steady state only, the input is allowed to change

Stable state

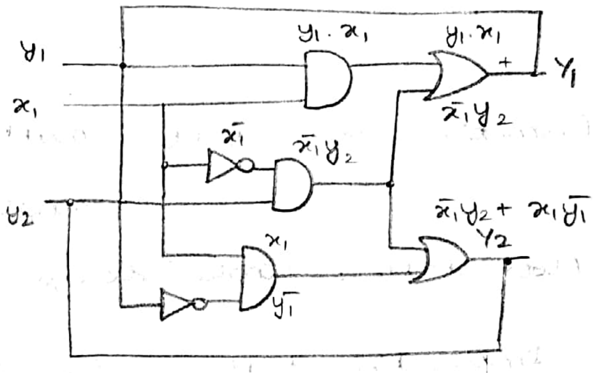
Unstable state

Transition table

Flow table

Race — Noncritical, critical

Hazards — Static, Dynamic, Essential



$$Y_1 = x y_1 + \bar{x} y_2$$

$$Y_2 = \bar{x} y_2 + x \bar{y}_1$$

P.S ↑, I/P →, Y_1

y_1y_2 \ x	0	1
00	0	0
01	1	0
11	1	1
10	0	1

N.S, O/P, Y_2

y_1y_2 \ x	0	1
00	0	1
01	1	1
11	1	0
10	0	0

transition table

change of transition to unstable stable then settles down to stable stable : race

Flow table

$Y_1 Y_2$

y_1y_2 \ x	0	1
00	00	01
01	11	01
11	11	10
10	00	10

y_1y_2 \ x	0	1
a	a	b
b	d	b
d	d	c
c	a	c

When input (x) changes, any one of the P.S changes faster than the other

Non critical race : (One steady state) - Final stable state doesn't depend on the state variable change

critical race : Final stable state depend on the state variable change. (multiple stable state)

Cycle : Changes to unstable state starting from stable state but doesn't settle down to stable state.

$y_1y_2 \backslash x$	0	1
00	00	11
01		11
11		11
10		11

00 → 11 mostly ×
00 → 01 → 11
00 → 10 → 11

$y_1y_2 \backslash x$	0	1
00	00	11
01		01
11		01
10		11

00 → 11 → 01
00 → 01 ×
00 → 10 → 11

$y_1y_2 \backslash x$	0	1
00	00	11
01		01
11		11
10		10

00 → 11
00 → 01
00 → 10

$y_1y_2 \backslash x$	0	1
00	00	11
01		11
11		11
10		10

00 → 11
00 → 10
00 → 01 → 11

Primitive flow table : multiple steady states on a single row
↓
Flow table : Single steady state in a row

Implication table → Merger diagram

Design a gated latch with two I/P G (gate), D (data) and one O/P Q. Binary information present at the D is transferred to Q when G is equal to 1. The Q O/P will follow the I/P D as long as G = 1 When G=0, O/P Q is retained

G=1 : Q = D
↓
G = 0 : Q = retained

State	Input D	Input G	Output Q	comments
a	0	0	0	after b, c
b	0	1	0	after a, d, f
c	1	0	0	after a, ~~d~~
d	1	1	1	after b, c, e
e	1	0	1	after d, f
f	0	0	1	after a

Non critical race : (One steady state). Final stable state doesn't depend on the state variable change

Critical race : Final stable state depend on the state variable change. (multiple stable state)

Cycle : Changes to unstable state starting from stable state but doesn't settle down to stable state.

y_1y_2 \ x	0	1
00	00	11
01		11
11		11
10		11

00 → 11 mostly ×

00 → 01 → 11

00 → 10 → 11

y_1y_2 \ x	0	1
00	00	11
01		01
11		01
10		11

00 → 11 → 01

00 → 01 ×

00 → 10 → 11

y_1y_2 \ x	0	1
00	00	11
01		01
11		11
10		10

00 → 11

00 → 01

00 → 10

y_1y_2 \ x	0	1
00	00	11
01		11
11		11
10		10

00 → 11

00 → 10

00 → 01 → 11

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G = 1 : Q = D

↓

G = 0 : Q = retained

State	Input D	Input G	output Q	comments
a	0	0	0	after b, c
b	0	1	0	after a, d, f
c	1	0	0	after a ~~d~~
d	1	1	1	after b, c, e
e	1	0	1	after d, f
f	0	0	1	after e

y \ DG	00	01	11	10
a	a,0	b,∅	-,-	c,-
b	a,-	b,0	d,-	-,-
c	a,-	-,-	d,-	c,0
d	-,-	b,-	d,1	e,-
e	f,-	-,-	d,-	e,1
f	f,1	b,-	-,-	e,-

DG	00	01	11	10
a,b,c	a,0	b,0	d,-	c,0
d,e,f	f,1	b,-	d,1	e,1

DG	00	01	11	10
a	a,0	a,0	d,-	a,0
d	d,1	a,-	d,1	d,1

Y, Z

y \ DG	00	01	11	10
0	0,0	0,0	1,-	0,0
1	1,1	0,-	1,1	1,1

Y

y \ DG	00	01	11	10
0	0	0	1	0
1	1	0	1	1

$Y = DG + y\bar{G}$

Z

y \ DG	00	01	11	10
0	0	0	1	0
1	1	0	1	1

$Z = DG + y\bar{G}$