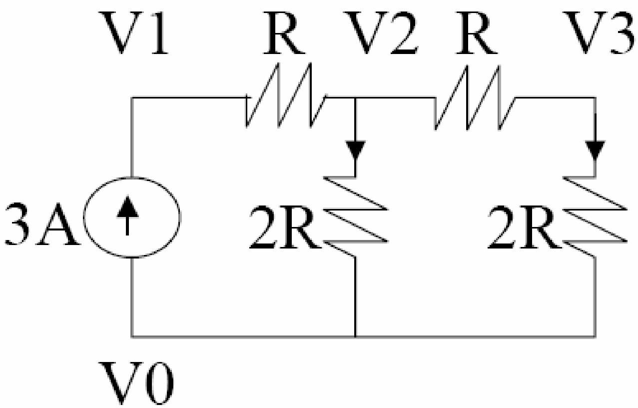
HSPICE

Solution for Linear Network



R=5ohm

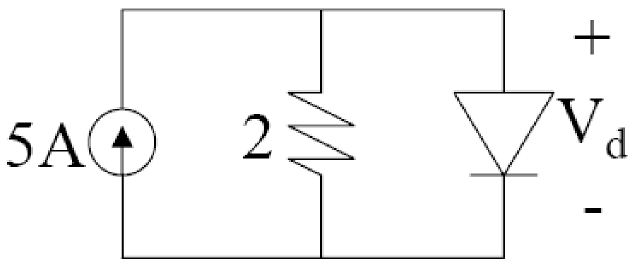
$$\begin{pmatrix} 0.2 & 0 & -0.1 & -0.1 \\ 0 & 0.2 & -0.2 & 0 \\ -0.1 & -0.2 & 0.5 & -0.2 \\ 0 & 0 & -0.2 & 0.2 \end{pmatrix} \begin{bmatrix} V_0 \\ V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} -3 \\ 3 \\ 0 \\ 0 \end{bmatrix}$$

$$\begin{pmatrix} 0.2 & -0.2 & 0 \\ -0.2 & 0.5 & -0.2 \\ 0 & -0.2 & 0.2 \end{pmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 3 \\ 0 \\ 0 \end{bmatrix} \quad V_0 \text{ ground}$$

With Gaussian elimination

$$\begin{pmatrix} 0.2 & -0.2 & 0 \\ 0 & 0.3 & -0.2 \\ 0 & 0 & 0.25 \end{pmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 3 \\ 3 \\ 3 \end{bmatrix}$$

Iteration for Nonlinear Network



$$I_d = 1pA*[\exp(40*V_d)-1]$$

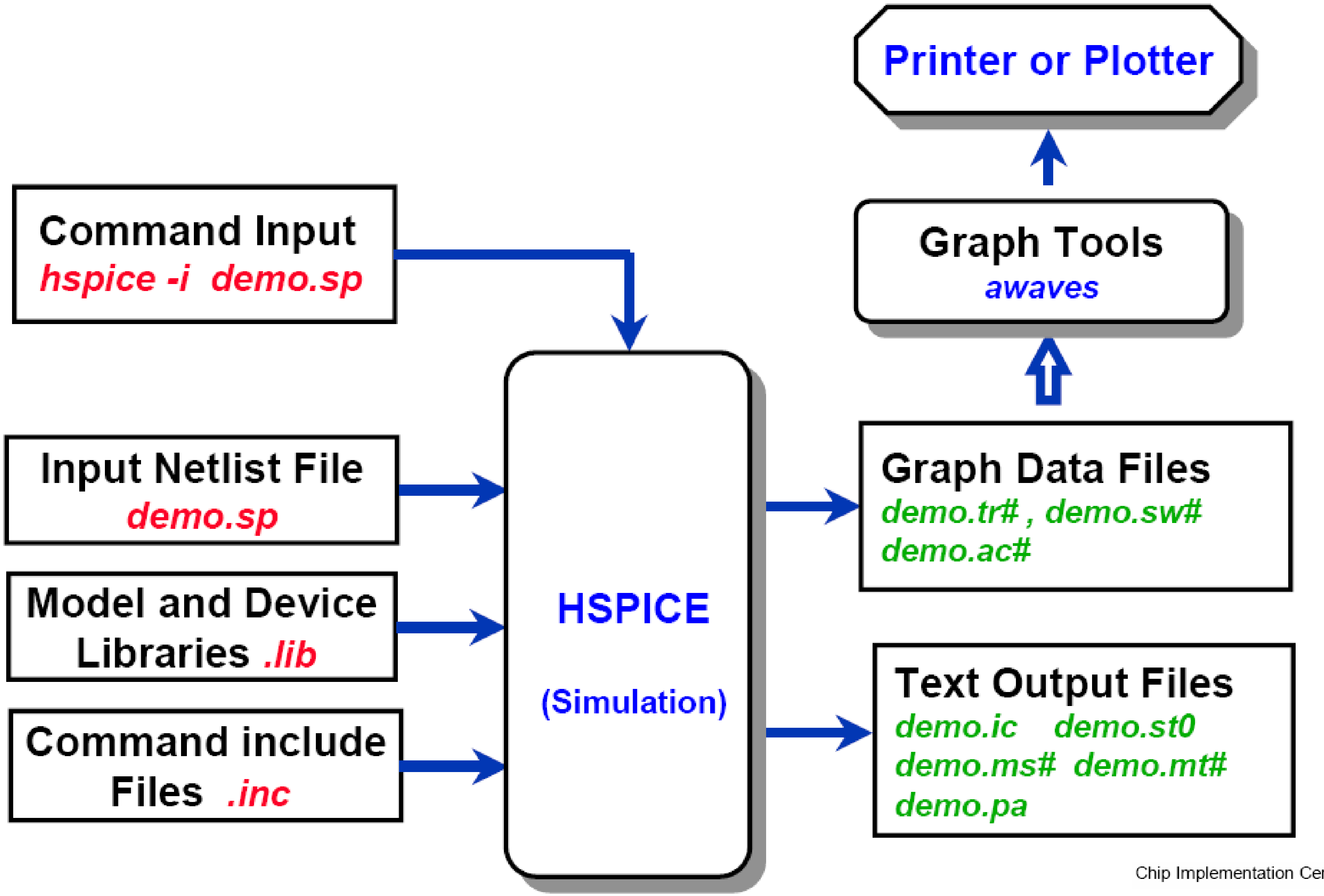
$$5 = V_d/2 + I_d$$

$$5 = V_d/2 + 1pA*[\exp(40*V_d)-1]$$

$$V_{d+1} = V_d - F(V_d)/F'(V_d)$$

	V_d	V_{d+1}	Delta V
1	1	0.975001	0.02499
2	0.975001	0.950002	0.02499
3	0.950002	0.925005	0.02499
4	0.925005	0.900015	0.02499
5	0.900015	0.875041	0.02497
6	0.875041	0.850113	0.02493
7	0.850117	0.825309	0.02481
8	0.825309	0.800838	0.02447
9	0.800838	0.777250	0.02359
10	0.777250	0.755885	0.02136
11	0.755885	0.739445	0.01644
12	0.739447	0.730983	0.00846
13	0.730983	0.729186	0.00179
14	0.729186	0.729119	0.00007

HSPICE Data Flow



Netlist Structure

Title	Title Statement - Ignored during simulation
Controls	.option nomod nopage
	.tran 1 10
	.print v(5) i(r1)
	.plot v(3) v(in)
	* voltage sources
Sources	v3 3 0 dc 0 ac 0 0 pulse 0 1 0 0.1 0.1 4 8
	vin in 0 sin(0 2 10k 0.5 0)
	* Components
Components	c2 2 0 2pf
	r1 1 0 1k
	m1 1 2 3 4 mod L=10u W=30u
	x3 2 3 INV
	*Model & Subcircuit
Models & Subckts	.model... or .LIB or .Subckt
End file	.end

Element Names

C	Capacitor
D	Diode
E,F,G,H	Dependent Current and Voltage Controlled Sources
I	Current
J	JFET or MESFET
K	Mutual Inductor
L	Inductor
M	MOSFET
Q	BJT
R	Resistor
O,T,U	Transmission Line
V	Voltage Source
X	Subcircuit Call

Units and Scale Factors

- **Units:**

R	Ohm	(e.g. R1 n1 n2 1K)
C	Farad	(e.g. C2 n3 n4 1e-12)
L	Henry	(e.g. L3 n5 n6 1e-9)

- **Scale Factors :**

F	1e-15
P	1e-12
N	1e-9
U	1e-6
M	1e-3

K	1e3
Meg	1e6
G	1e9
T	1e12
DB	$20\log_{10}$

Examples:

1pF
1nH
10Meg Hz
vdb(v3)

- **Technology Scaling :** All Length and Widths are in **Meters**

Using .options scale=1e-6 ➡ L=2 W=100

Node Naming Conventions

- **Either Names or Numbers (e.g. data1, n3, 11, ...)**
- **0 (zero) is Always Ground**
- **Trailing Alphabetic Character are ignored in Node Number, (e.g. 5A=5B=5)**
- **All nodes are assumed to be local**
- **Node Names can be may Across all Subcircuits by a .GLOBAL Statement (e.g. .GLOBAL VDD VSS)**

.SUBCKT Statement

```
.SUBCKT  subname  n1 <n2 n3...>  <param=val...>

.ENDS [subname]
```

Example:

```
.SUBCKT  INV   IN  OUT   WN=2u  WP=8u
M1   OUT  IN  VDD  VDD  P  L=0.5u  W=WP
M2   OUT  IN   0      0     N  L=0.5u  W=WN
R1   OUT    4      1K
R2       4    5    10K
.ENDS    INV
*
X1   1     2     INV    WN=5u    WP=20u
X2   2     3     INV    WN=10u  WP=40u
```

Sources

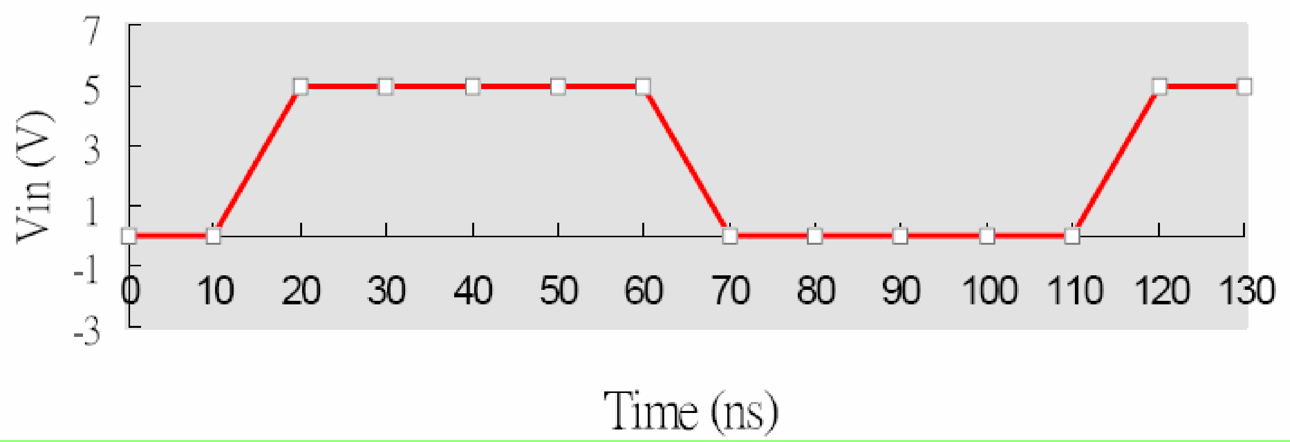
Transient Sources - PULSE

- **Syntax :**

PULSE (V1 V2 < Tdelay Trise Tfall Pwidth Period >)

- **Example :**

Vin 1 0 PULSE (0V 5V 10ns 10ns 10ns 40ns 100ns)



Transcient Sources - SIN

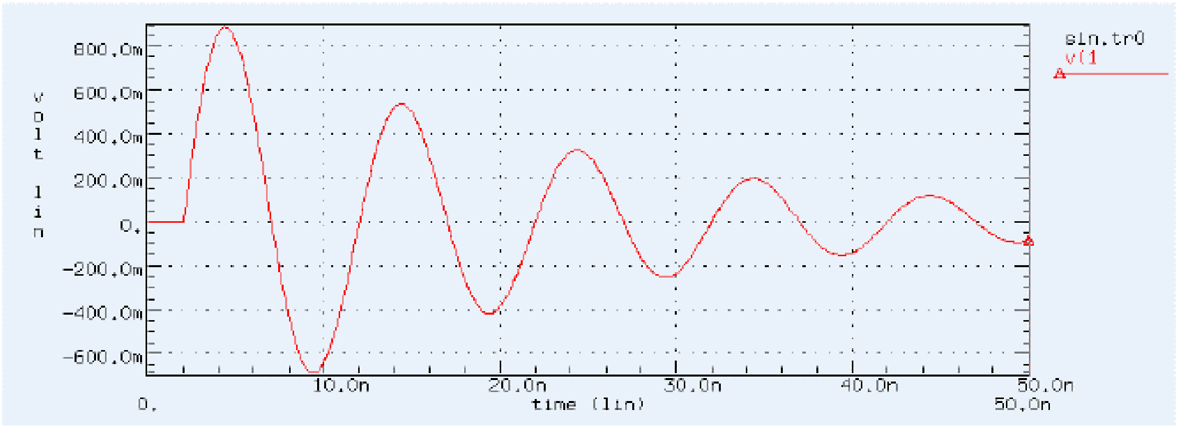
- **Syntax :**

SIN (Voffset Vacmag < Freq Tdelay Dfactor >)

$Voffset + Vacmag * e^{-(t-TD)*Dfactor} * \sin(2\pi\, Freq(t-TD))$

- **Example :**

Vin 3 0 SIN (0V 1V 100Meg 2ns 5e7)



Transient Sources - PWL

- **Syntax :**

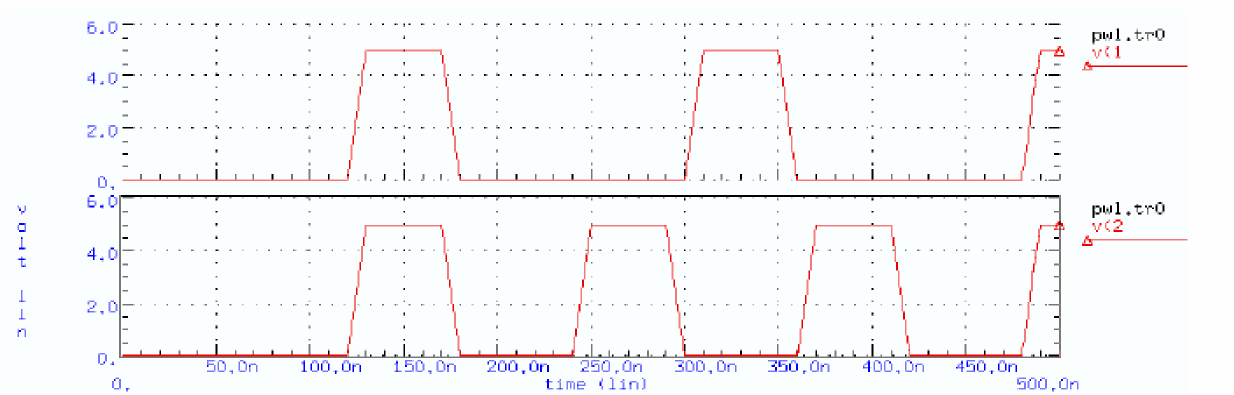
PWL (<t1 v1 t2 v2 ......> <R<=repeat>> <Tdelay=delay>)

$ R=repeat_from_what_time TD=time_delay_before_PWL_start

- **Example :**

V1 1 0 PWL 60n 0v, 120n 0v, 130n 5v, 170n 5v, 180n 0v, R 0

V2 2 0 PL 0v 60n, 0v 120n, 5v 130n, 5v 170n , 0v 180n , R 60n



AC and DC Sources

Example of DC Sources

```
V1   1   0   DC=5V
V2   2   0   5V
I3   3   0   5mA
```

Example of AC Sources

```
V4   4   0   AC=10V, 90
V5   5   0   AC  1.0   180
```

Example of Mixed Sources

```
V6   6   0   5V   AC=1V, 90
V7   7   0   0.5V  AC  1.0 SIN (0 1 1Meg)
```

Dependent Sources

Voltage Controlled Voltage Sources (VCVS) --- E Elements

Voltage Controlled Current Sources (VCCS) --- G Elements

Current Controlled Voltage Sources (CCVS) --- H Elements

Current Controlled Current Sources (CCCS) --- F Elements

E(name)	N+	N-	NC+	NC-	(Voltage Gain Value)
Eopamp	3	4	1	2	1e6
Ebuf	2	0	1	0	1.0

Analysis Type

Analysis Type

- **DC Operating Point :** ***First Calculated for ALL Analysis Types***

  .OP .IC .NODESET

- **DC Sweep & DC Small Signal Analysis :**

  .DC .TF .PZ .SENS

- **AC Sweep & Small Signal Analysis :**

  .AC .NOISE .DISTO .SAMPLE .NET

- **Transient Analysis:**

  .TRAN .FOUR (UIC)

DC Sweep

.DC var1 start1 stop1 incr1 < var2 start2 stop2 incr2 >)

.DC var1 start1 stop1 incr1 < SWEEP var2 DEC/OCT/LIN/POI np start2 stop2 >)

Example:

.DC VIN 0.25 5.0 0.25

.DC VDS 0 10 0.5 VGS 0 5 1

.DC TEMP -55 125 10

.DC TEMP POI 5 0 30 50 100 125

.DC xval 1k 10k 0.5k SWEEP TEMP LIN 5 25 125

Transient and AC Analysis

.TRAN tincr1 tstop1

.TRAN 1NS 100NS

.AC DEC/OCT/LIN/POI np fstart fstop

.AC DEC 10 1K 100MEG

Element Models

R1 12 17 1K TC1=1.3e-3 TC2=-3.1e-7

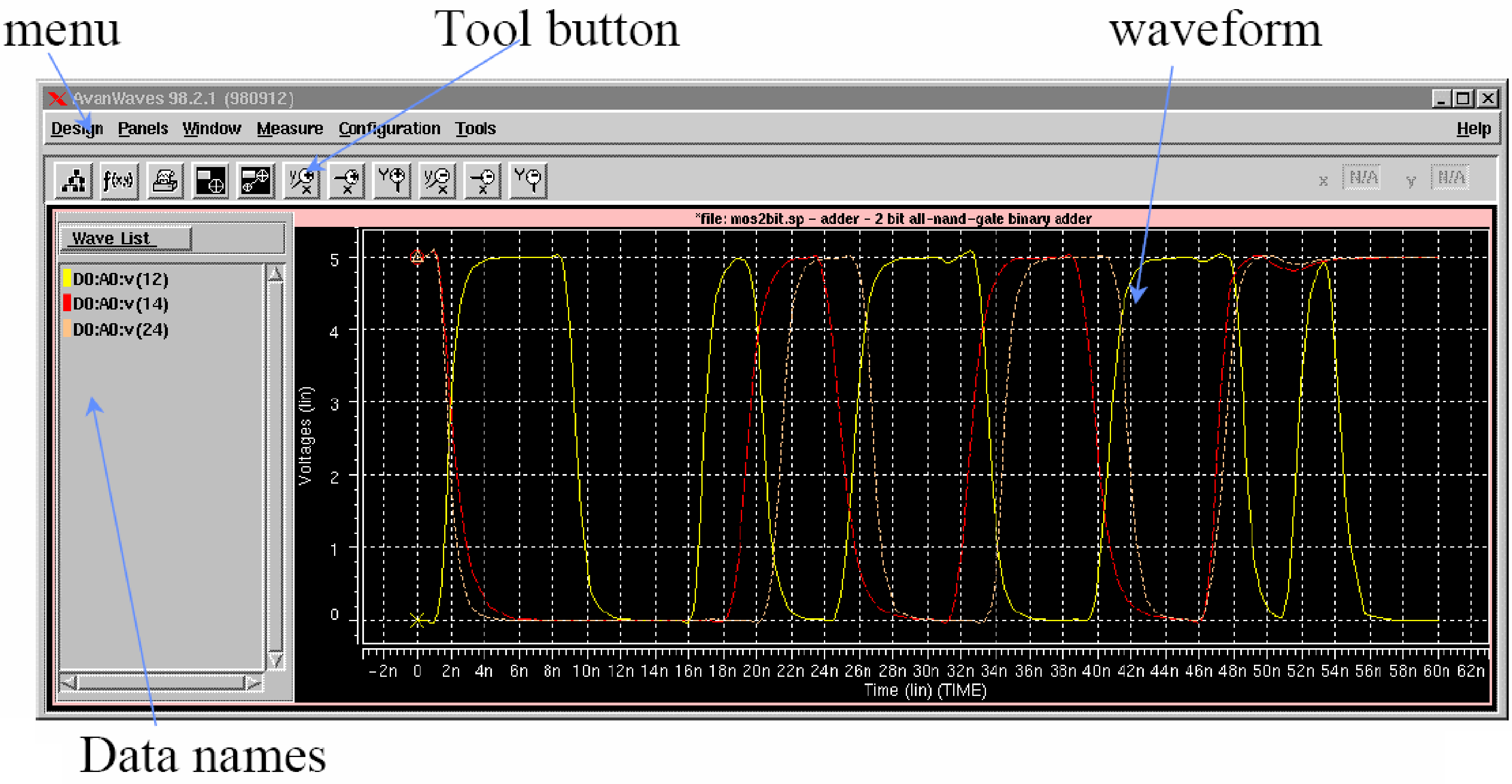
C2 7 8 0.6pf IC=5V

LSHUNT 23 51 10UH 0.01 1 IC=15.7mA

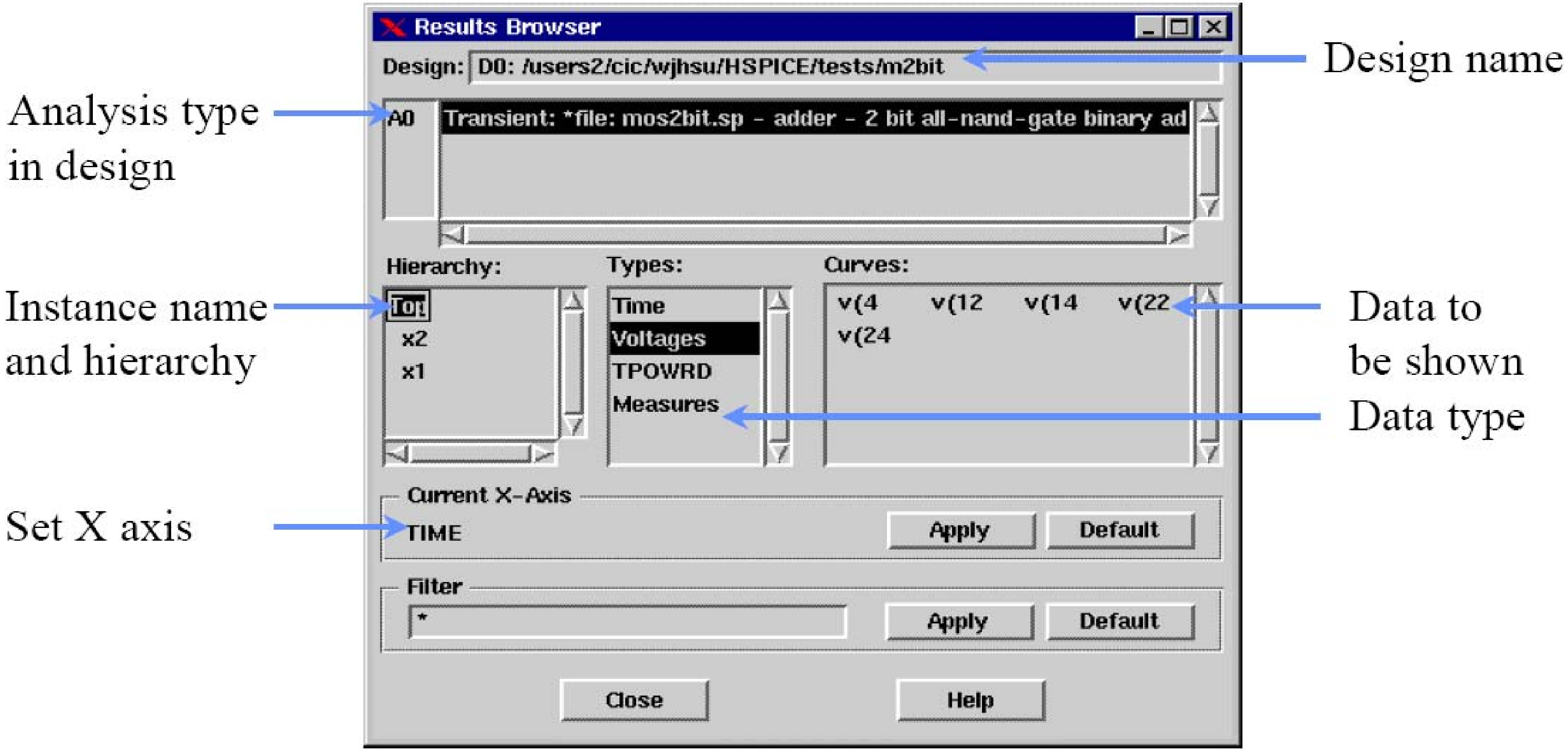
K4 Laa Lbb 0.9999

Graphic Tool - AWAVES

AWAVES Window

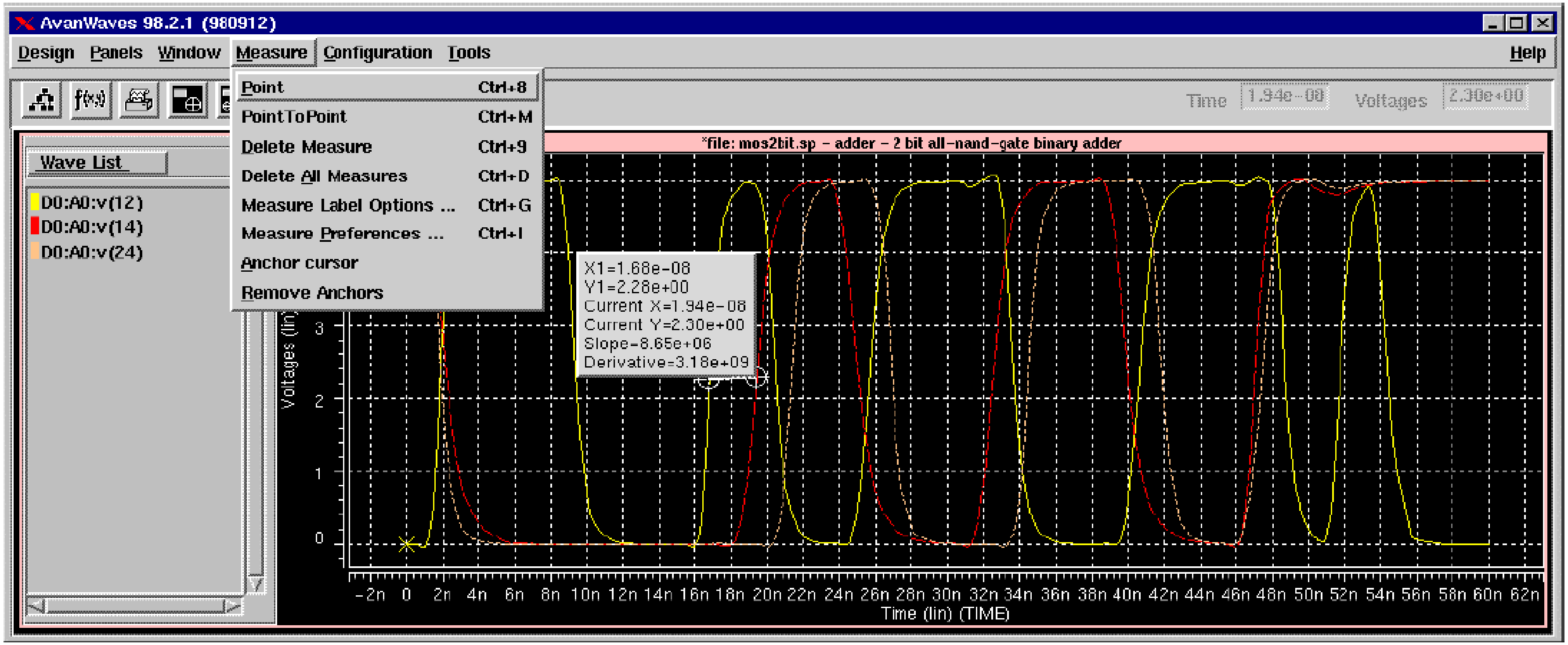


Result Browser



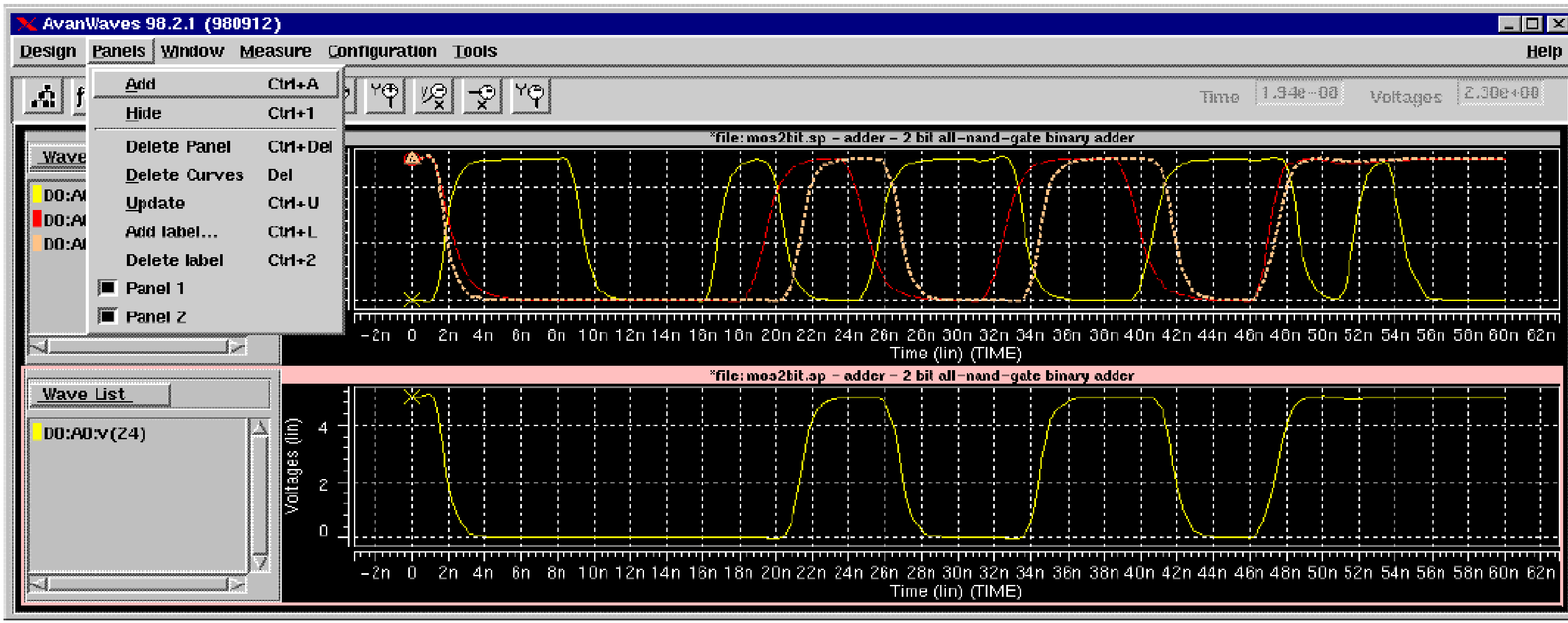
Measurement

On window measurement function

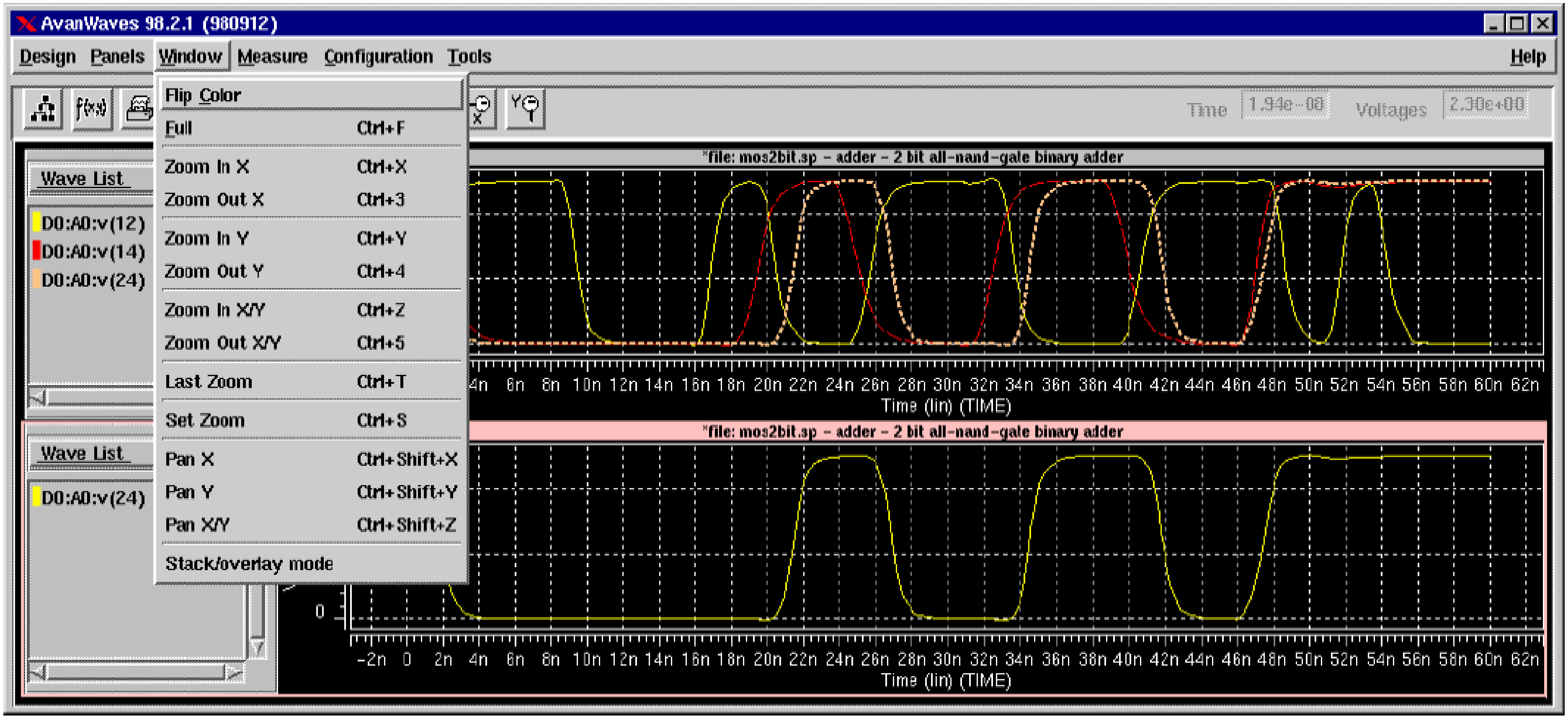


Multiple Panels

Multiple panels can be displayed on window
Maximum number of panels displayed depends on window size
Waveforms can be dragged and drop into other panels



Zoom In


AvanWaves 98.2.1 (980912)
Design Panels Window Measure Configuration Tools Help
Flip Color
Full Ctrl+F
Zoom In X Ctrl+X
Zoom Out X Ctrl+3
Zoom In Y Ctrl+Y
Zoom Out Y Ctrl+4
Zoom In X/Y Ctrl+Z
Zoom Out X/Y Ctrl+5
Last Zoom Ctrl+T
Set Zoom Ctrl+S
Pan X Ctrl+Shift+X
Pan Y Ctrl+Shift+Y
Pan X/Y Ctrl+Shift+Z
Stack/overlay mode
Wave List
D0:A0:v(12)
D0:A0:v(14)
D0:A0:v(24)
*file: mos2bit.sp – adder – 2 bit all-nand-gate binary adder
Time (lin) (TIME)
Wave List
D0:A0:v(24)
*file: mos2bit.sp – adder – 2 bit all-nand-gate binary adder
-2n 0 2n 4n 6n 8n 10n 12n 14n 16n 18n 20n 22n 24n 26n 28n 30n 32n 34n 36n 38n 40n 42n 44n 46n 48n 50n 52n 54n 56n 58n 60n 62n
Time (lin) (TIME)