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LAMPIRAN

Pemodelan Rangkaian Lampu LED

Rentang arus LED : 20-25 mA

Rentang tegangan kerja LED : 3-3.2 V

Untuk mendapatkan rentang arus yang dibutuhkan LED maka dapat menggunakan persamaan-persamaan sebagai berikut dalam menentukan nilai parameter komponen:

$$X = \frac{1}{2\pi fC}$$

$$Z = \sqrt{R + X}$$

$$i = \frac{V}{Z}$$

Dengan menggunakan nilai C = 1.5uF dan R = 100 kΩ, maka didapatkan:

$$X = \frac{1}{2.3,14.50.1,5x10^{-6}}$$

$$X = 2,123\ k\Omega$$

$$Z = \sqrt{100 + 2,123}$$

$$Z = 10,105\ k\Omega$$

$$i = \frac{230}{10,105} = 0,023\ A = 23\ mA$$

Dari hasil i di atas menunjukkan dengan menggunakan nilai kapasitor sebesar 1.5 uF dan resistor sebesar 100 kΩ dapat mensupply LED sebesar arus 23 mA.

Untuk menghitung arus DC yang dihasilkan menggunakan persamaan-persamaan sebagai berikut:

$$i_m = \frac{V_m}{X} = \frac{230}{2.123} = 108\ \text{mA}$$

Sehingga tegangan V_R=V_C=V_x,

$$V_x = i_m.X = 108x2.123 = 229.284\ \text{V}$$

$$Veff_{(Vx)} = \frac{229.284}{\sqrt{2}} = 162.128 \text{ V}$$

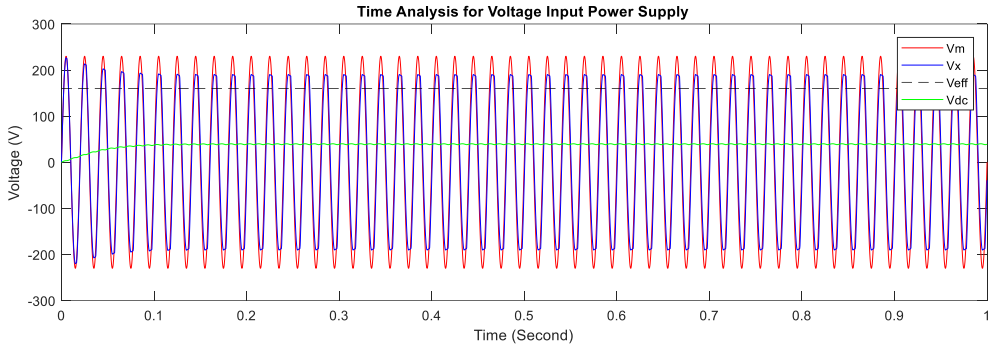
Untuk mendapatkan tegangan DC rata-rata yang dihasilkan menggunakan persamaan 35

$$Vdc = \frac{Vm - Veff_{(Vx)} - 2Vd}{\sqrt{2}}$$

$$Vdc = \frac{230 - 162.128 - 2x0.7}{\sqrt{2}} = 47.002 \text{ V}$$

Sehingga tegangan kapasitor ELCO yang digunakan minimal 50 V.

Berikut adalah hasil simulasi tegangan maksimum, tegangan efektif, dan tegangan DC yang dihasilkan.



Dimana hasil simulasi menunjukkan nilai

Vm = 230 V

Vx = 226.528 V

$Veff_{(Vx)}$ = 160.181 V

Vdc = 40.145 V

- **Konfigurasi 1,6**

$$V_{string} = nxV_{led} = 6x3.2 = 19.2 \text{ V}$$

Dengan demikian nilai dioda zener (V_z) yang dapat digunakan adalah 24 V.

$$R_s = \frac{Vz - V_{string}}{i_{led}}$$

$$R_s = \frac{24 - 19.2}{0.023} = 208.69 \ \Omega$$

Untuk menghitung besar nilai resistor pada Rz maka menggunakan persamaan:

$$V_{Rz} = Vdc - V_z$$

$$V_{Rz} = 47 - 24 = 23 \text{ V}$$

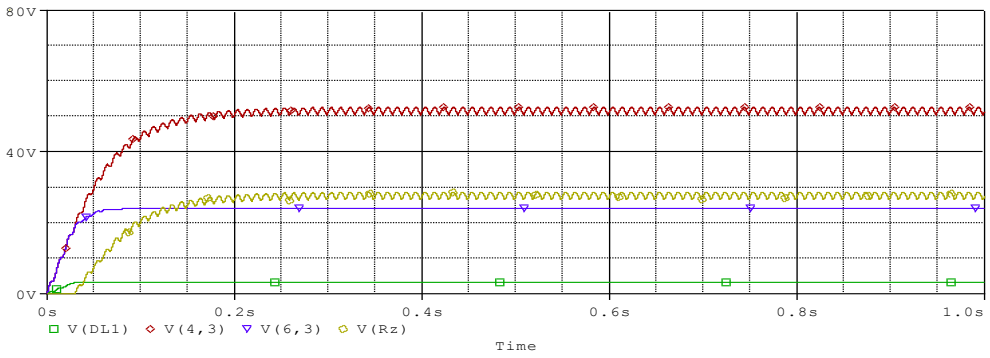
$$i_{Rz} = i_z + i_d$$

$$i_{Rz} = 20.83 + 23 = 43.83 \text{ mA}$$

Sehingga Rz adalah

$$Rz = \frac{V_{Rz}}{i_{Rz}} = \frac{23}{0.04383} = 524.75\ \Omega$$

Berikut adalah hasil simulasi menggunakan nilai parameter yang telah didapatkan sebelumnya:

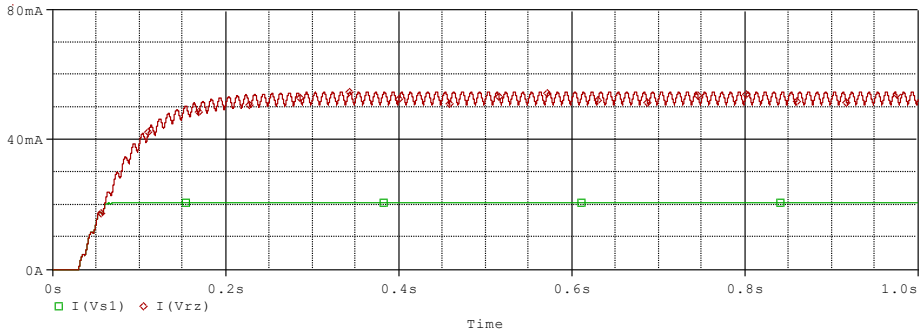


Dimana hasil simulasi menunjukkan nilai:

V(DL1) : Tegangan LED = 3.2737 V

V(4,3) : Tegangan Kapasitor Cout = 52.672 V

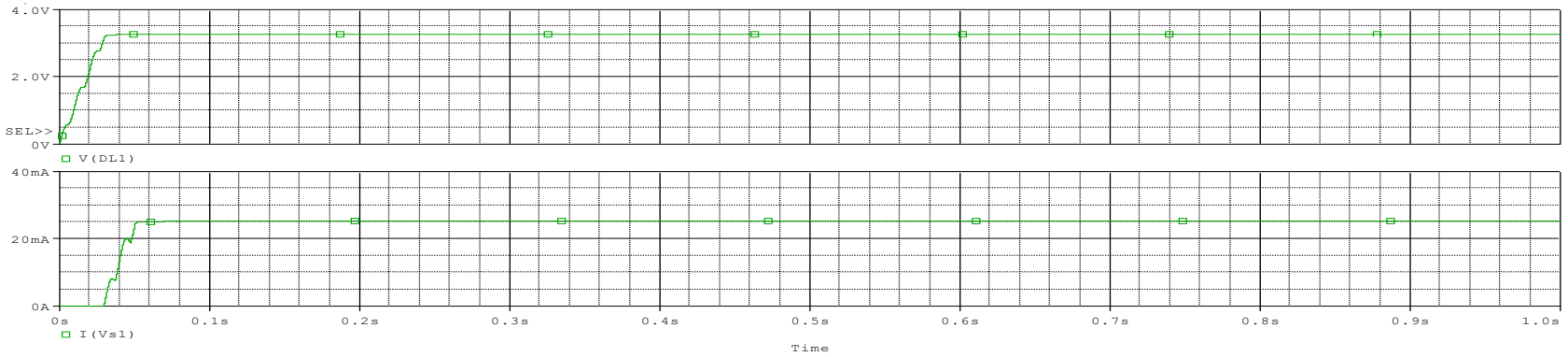
V(6,3) : Tegangan Dioda Zener = 23.967 V



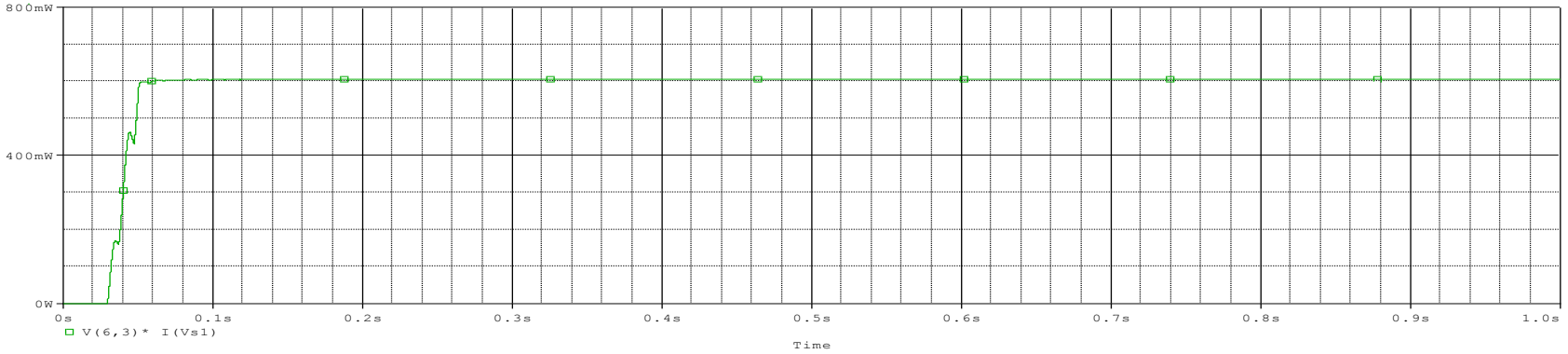
I(Vs1) : arus yang masuk ke LED = 20.725 mA

I(Vrz) : arus yang melewati resistor Rz = 54.701 mA

Hasil Secara Simulasi Tiap Konfigurasi Rangkaian

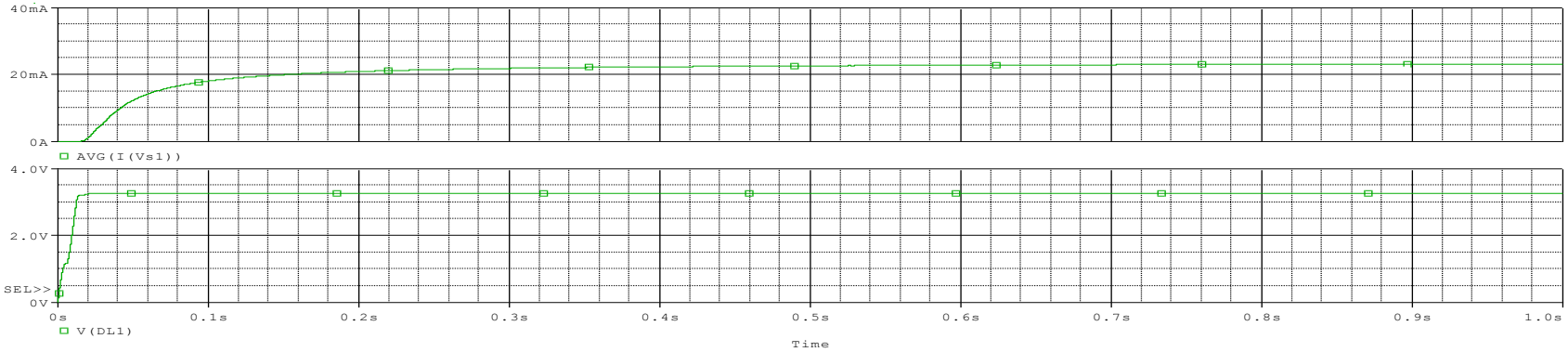


(a) Tegangan dan arus

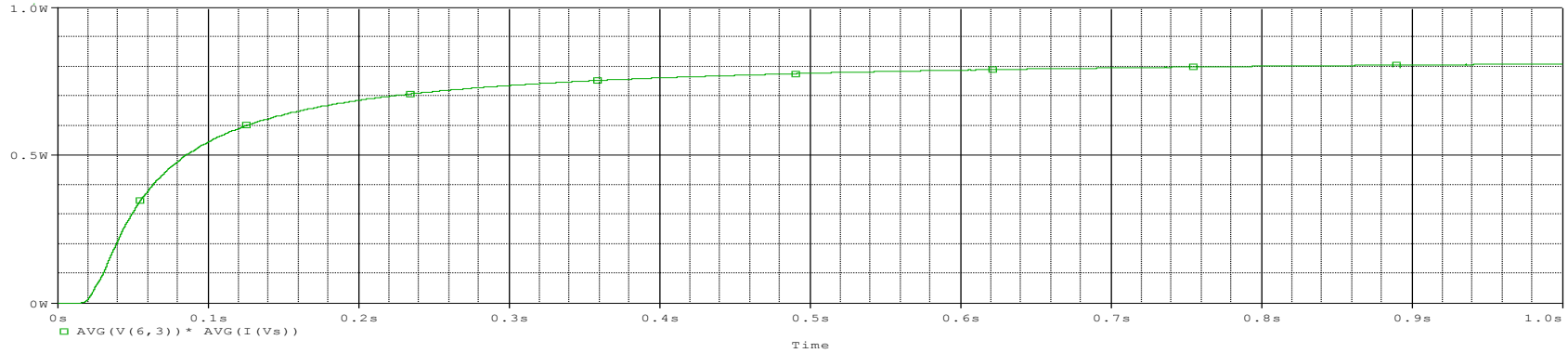


(b) Daya

Hasil simulasi PSpice konfigurasi 1,6 mode tanpa switch

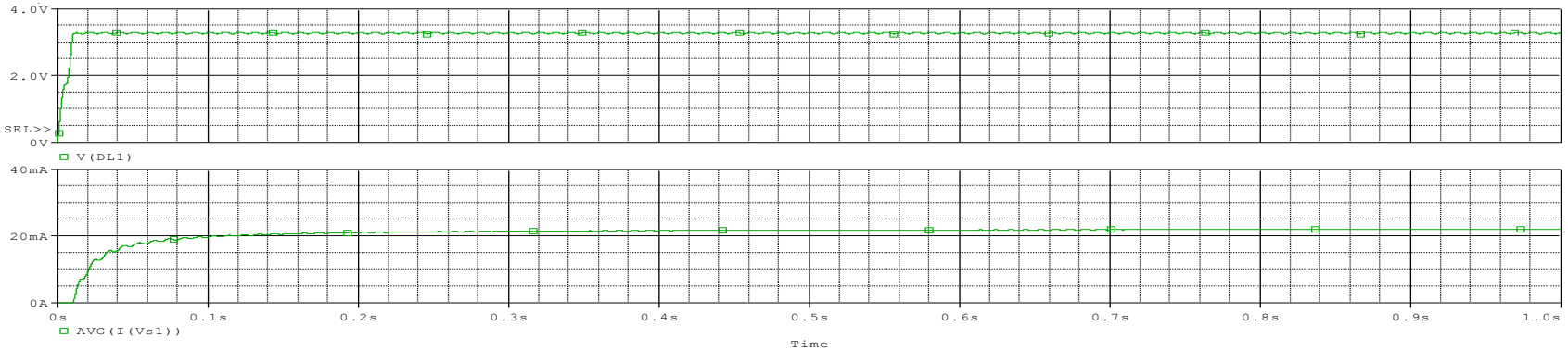


(a) Tegangan dan arus

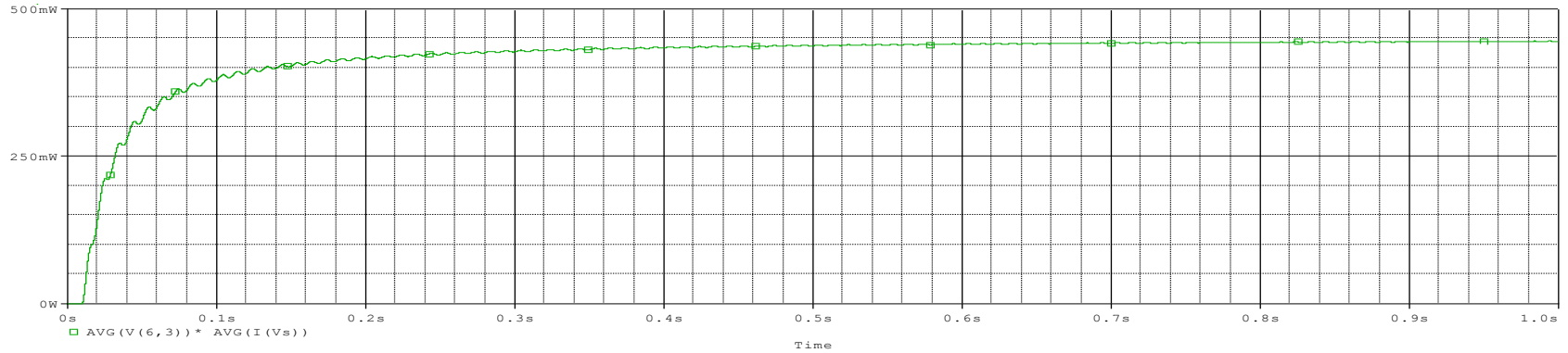


(b) Daya

Hasil simulasi PSpice konfigurasi 2,3 mode tanpa switch

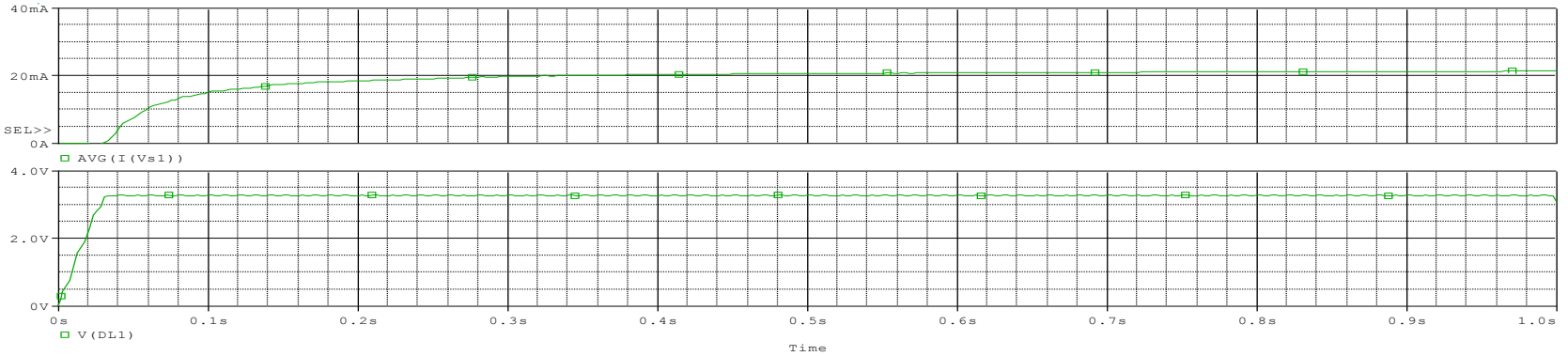


(a) Tegangan dan arus

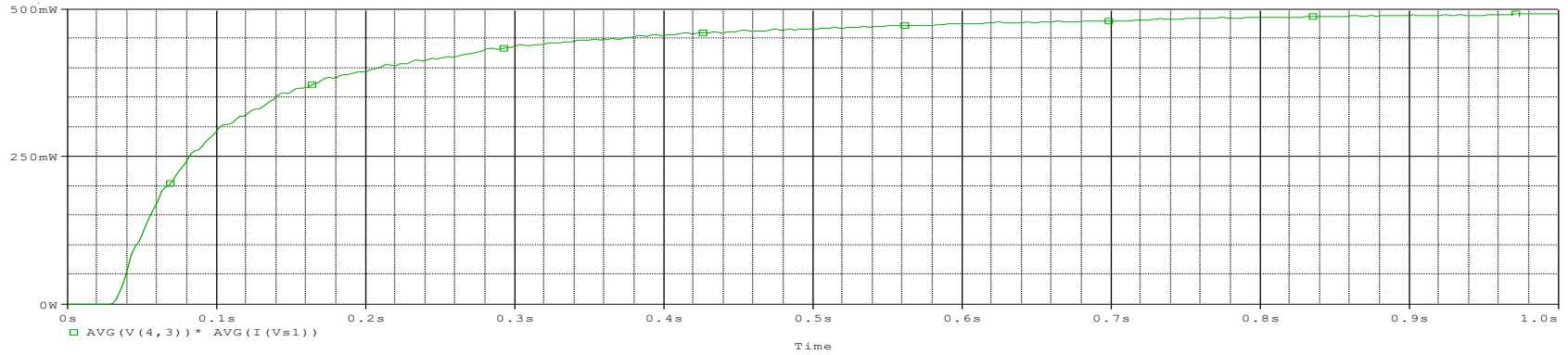


(b) Daya

Hasil simulasi PSpice konfigurasi 3,2 mode tanpa switch

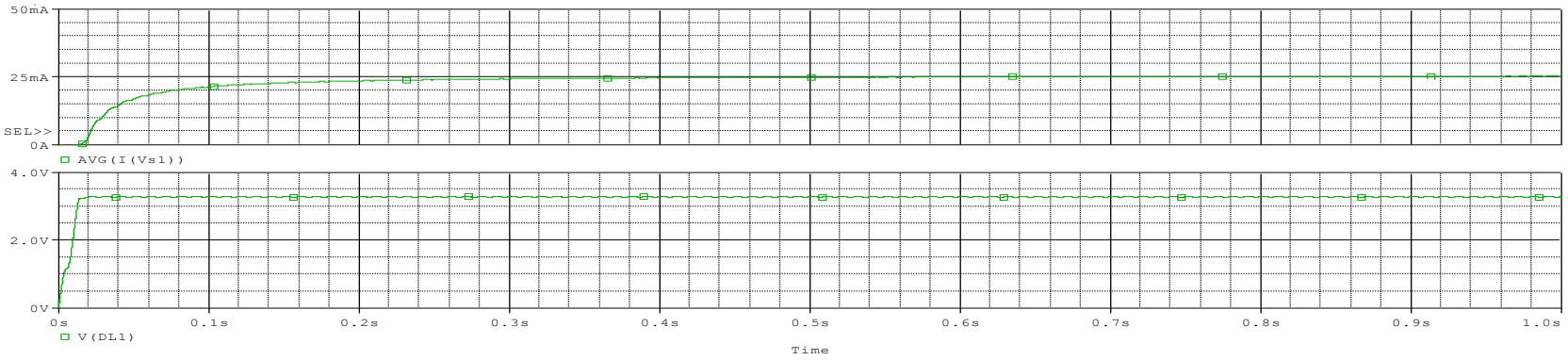


(a) Tegangan dan arus

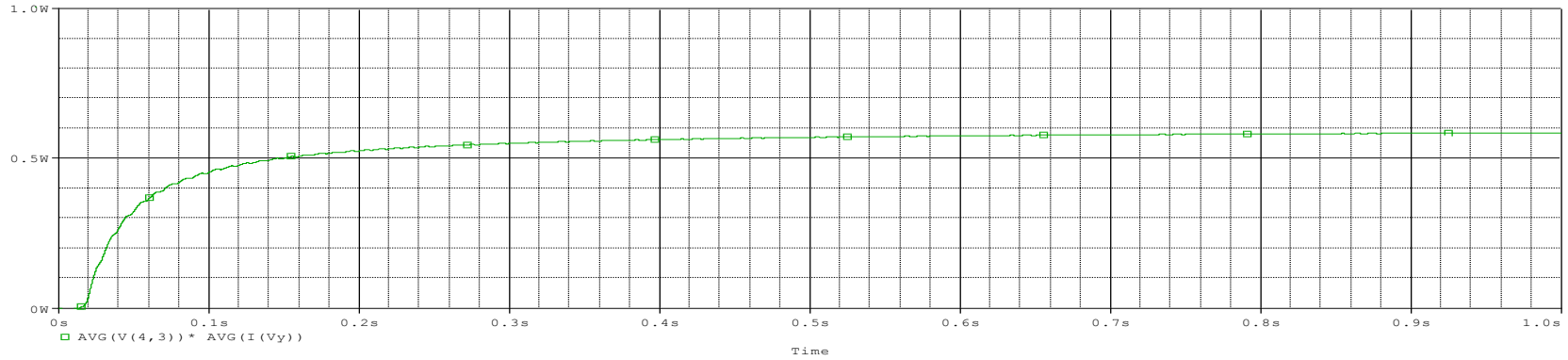


(b) Daya

Hasil simulasi PSpice konfigurasi 1,6 mode switch

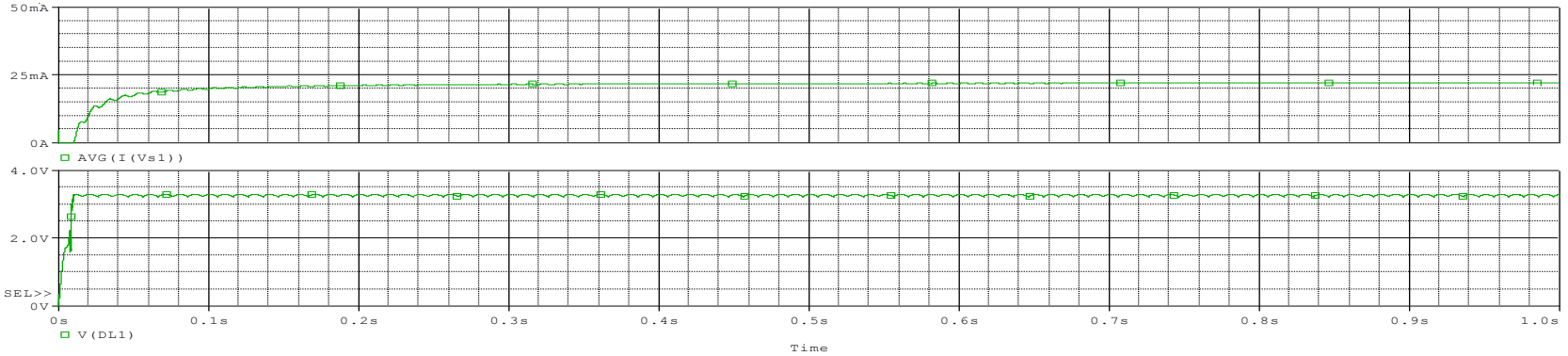


(a) Tegangan dan arus

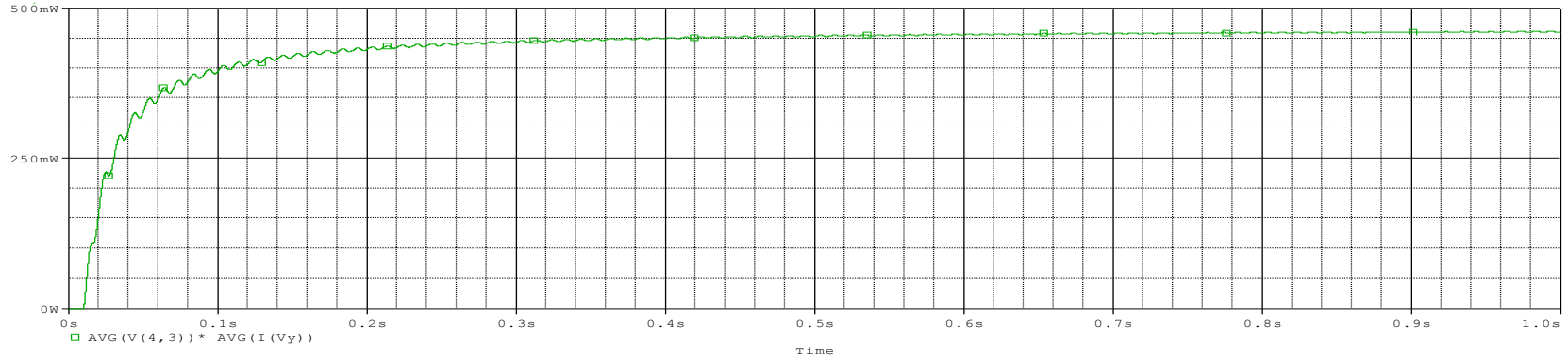


(b) Daya

Hasil simulasi PSpice konfigurasi 2,3 mode switch



(a) Tegangan dan arus



(b) Daya

Hasil simulasi PSpice konfigurasi 3,2 mode switch

```
Rangkaian LED

*----------------------PARAMETER----------------
.param R 170
*.STEP PARAM R list 5 10 30 50
.param Rz 220
.param Rx 100k
.param Cx 1.5uF
.param Cout 100uF
*-----------------------------------------------
Vin 1 0 SIN (0 230 50 0 0 0)
Vs1 6 7a DC 0V  ;arus total
Vrz 4 4a DC 0V  ;arus yang melewati resistor Rz
Vs2 2a 2 DC 0V  ;arus sebelum penyearah
Rx 1 2a {Rx}
Cx 1 2a {Cx}
Cout 4 3 {Cout}
Dz 3 6 Zener
Rz 4a 6 {Rz}
R1 76 3 {R}
*R2 86 3 {R}

DL1 7a 71 LED
DL2 71 72 LED
DL3 72 73 LED
DL4 73 74 LED
DL5 74 75 LED
DL6 75 76 LED

*DL11 7c 81 LED
*DL22 81 82 LED
*DL33 82 83 LED
*DL44 83 84 LED
*DL55 84 85 LED
*DL66 85 86 LED

D1 3 2 DMOD
D2 2 4 DMOD
D3 0 4 DMOD
D4 3 0 DMOD
*---------------------MODEL----------------------
.MODEL DMOD D(IS=10E-15 N =1E-03 RS =0.1 CJO =100E-15)
.MODEL Zener D(IS=2.22E-15 BV=24V IBV=12E-2 CJO=2PF TT=1US)
.MODEL LED D(IS=2.22E-57 BV=4V IBV=25E-3 CJO=2PF TT=1US)
*----------------------RESULT--------------------
.PROBE V(1,0) I(Vs1) V(4,3) V(6,3) V(Rz) V(2,4) V(1,2) I(Vs2) I(DL2)
.PROBE V(DL1), V(DL2), V(DL3), V(DL4), V(DL5), V(DL6) I(Vrz) V(R1) I(DL1)
*.PROBE I(Vin) I(R1)
.TRAN 1us 1000ms 0 10us
.END
```

Coding PSpice konfigurasi rangkaian 1,6 dengan mode tanpa switch

```
Rangkaian LED

*-----------------------PARAMETER----------------
.param R 330
*.STEP PARAM R list 11 12 13
.param Rz 10
.param Rx 100k
.param Cx 1.5uF
.param Cout 100uF
*-----------------------------------------------
Vin 1 0 SIN (0 230 50 0 0 0)
Vs 6 7 DC 0V
Vs1 7 01 DC 0V
Vs2 7 02 DC 0V
Rx 1 2 {Rx}
Cx 1 2 {Cx}
Cout 4 3 {Cout}
Dz 3 6 Zener
Rz 4 6 {Rz}
R1 13 3 {R}
R2 23 3 {R}

DL1 01 11 LED
DL2 11 12 LED
DL3 12 13 LED
DL4 02 21 LED
DL5 21 22 LED
DL6 22 23 LED

D1 3 2 DMOD
D2 2 4 DMOD
D3 0 4 DMOD
D4 3 0 DMOD
*----------------------MODEL----------------------
.MODEL DMOD D(IS=10E-15 N =1E-03 RS =0.1 CJO =100E-15)
.MODEL Zener D(IS=2.22E-15 BV=18V IBV=12E-2 CJO=2PF TT=1US)
.MODEL LED D(IS=2.22E-57 BV=3 IBV=25E-3 CJO=2PF TT=1US)
*----------------------RESULT-------------------
.PROBE V(1,0) V(6,3) V(DL1) V(DL2) V(DL3) V(DL4) V(DL5) V(DL6)
.PROBE I(Vs) I(Vin) I(R1) I(R2) V(R1) V(R2)
.PROBE I(DL1) I(DL2) I(DL3) I(DL4) I(DL5) I(DL6) I(Vs1) I(Vs2)
.TRAN 1us 1000ms 0 10us UIC
.END
```

Coding PSpice konfigurasi rangkaian 2,3 dengan mode tanpa switch

```
Rangkaian LED

*-----------------------PARAMETER----------------
.param R 10
*.STEP PARAM R list 210 220 230 240 250
.param Rz 10
.param Rx 100k
.param Cx 1.5uF
.param Cout 100uF
*-------------------------------------------------
Vin 1 0 SIN (0 230 50 0 0 0)
Vs 6 7 DC 0V
Vs1 7 01 DC 0V
Vs2 7 02 DC 0V
Vs3 7 03 DC 0V
Rx 1 2 {Rx}
Cx 1 2 {Cx}
Cout 4 3 {Cout}
Dz 3 6 Zener
Rz 4 6 {Rz}
R1 12 3 {R}
R2 22 3 {R}
R3 32 3 {R}

DL1 01 11 LED
DL2 11 12 LED
DL3 02 21 LED
DL4 21 22 LED
DL5 03 31 LED
DL6 31 32 LED

D1 3 2 DMOD
D2 2 4 DMOD
D3 0 4 DMOD
D4 3 0 DMOD
*----------------------MODEL----------------------
.MODEL DMOD D(IS=10E-15 N =1E-03 RS =0.1 CJO =100E-15)
.MODEL Zener D(IS=2.22E-15 BV=10V IBV=12E-2 CJO=2PF TT=1US)
.MODEL LED D(IS=2.22E-57 BV=4 IBV=25E-3 CJO=2PF TT=1US)
*----------------------RESULT--------------------
.PROBE V(1,0) V(6,3) V(DL1) V(DL2) V(DL3) V(DL4) V(DL5) V(DL6)
.PROBE I(Vin) I(Vs) V(R1) V(R2) V(R3) I(Vs1) I(Vs2) I(Vs3)
.PROBE I(DL1) I(DL2) I(DL3) I(DL4) I(DL5) I(DL6)
.TRAN 1us 1000ms 0 10us UIC
.END
```

Coding PSpice konfigurasi rangkaian 3,2 dengan mode tanpa switch

```
*-----------------------PARAMETER--------------------
.param Vin = 230V           ;Vin Parameter
.param Fd = 50hz            ;frekuensi fundamental
.param RL = 170             ;Rload Parameter
.param C = 100uF        ;Capasitor Parameter
.param VRef = 0V        ;Vref Parameter
.param Fs = 100khz      ;Frequency Parameter
.param T = 100u             ;Periodic Parameter
.param D = 0.6          ;Duty Cycle
*.STEP PARAM D list 10u 25u 50u 75u
.param Td =0us          ;Time delay
.param Tf =0.1n             ;Time Fall
.param Tr =0.1n             ;Time Rise
.Param Vgate = 10V      ;Vgate Parameter

*-----------------------PWM----------------------
Vpulse1 111 3 PULSE ({VRef}{Vgate} {Td} {Tr}{Tf}{D}{T})


*=========================CIRCUIT=========================
VS 1 0 SIN (0 {Vin} {Fd})
Vy 4 55 DC 0V
Vs1 55 01 DC 0V
*Vs2 55 02 DC 0V
*Vs3 55 03 DC 0V
*Vx 2 66 DC 0V
Rxf 1 25 100k
Cxf 1 25 1.5u
Dz 3 4 Zener
C1 4 3 {C}
M1 5 111 6 6      IRFP460 ; MOSFET with a model IRFP040
*M2 7 111 8 8     IRFP040 ; MOSFET with a model IRFP040
*M3 9 111 10 10 IRFP040 ; MOSFET with a model IRFP040
R1 6 3 {RL}
*R2 8 3 {RL}
*R3 10 3 {RL}

DL1 01 11 LED
DL2 11 12 LED
DL3 12 13 LED
DL4 13 14 LED
DL5 14 15 LED
DL6 15 5 LED
*=================================================================
======

*-----------------------MOSFET MODEL-----------------------
.MODEL IRFP460 NMOS (VTO=2.831 KP=31.2u L=1u W=30m CGDO=3.358N
CGSO=18.054N)
*-----------------------DIODE FAST RECOVERY--------------------
*.model D1N3883           D(Is=1.058E-18 Rs=11.56m Ikf=2.349 N=1 Xti=14 Eg=1.11
Cjo=113.2p
*+                  M=.2834 Vj=.75 Fc=.5 Isr=994.9n Nr=2 Tt=369.9n)
```

```
.MODEL Zener D(IS=2.22E-15 BV=24V IBV=12E-2 CJO=2PF TT=1US)

*-----------------------------DIODA LED -----------------------
*.MODEL LO_5436-typ D
*+ IS=980.13E-40
*+ N=1.6749
*+ RS=1.6217
*+ IKF=7.1402E-3
.MODEL LED D(IS=2.22E-57 BV=4V IBV=25E-3 CJO=2PF TT=1US)

*------Subcircuit Diode Full Bridge---------
d1 3 25 DMOD
d2 25 4 DMOD
d3 0 4 DMOD
d4 3 0 DMOD
.MODEL DMOD D(IS=10E-15 N =1E-03 RS =0.1 CJO =100E-15)
*-----------------------------------------------------------

*-------------------------VIEW RESULT----------------------
.TRAN 0us 1s 10uS UIC
.OPTIONS ABSTOL=1uA CHGTOL=0.01nC ITL2=100 ITL4=150 RELTOL=0.1
VNTOL=0.1
.PROBE  V(1,0) V(4,3) , I(Vy) I(VS) I(Vs1)
.PROBE V(DL1) V(DL3) V(DL5) V(DL2) V(DL4) V(DL6) V(R1) VGS(M1)
.PROBE I(DL1) I(DL2) I(DL3) I(DL4) I(DL5) I(DL6) I(R1)
.END
```

Coding PSpice konfigurasi rangkaian 1,6 dengan mode switch

```
*----------------------PARAMETER--------------------
.param Vin = 230V           ;Vin Parameter
.param Fd = 50hz            ;frekuensi fundamental
.param RL = 70ohm           ;Rload Parameter
.param C = 100uF        ;Capasitor Parameter
.param VRef = 0V        ;Vref Parameter
.param Fs = 100khz      ;Frequency Parameter
.param T = 10u              ;Periodic Parameter
.param D = 75u          ;Duty Cycle
*.STEP PARAM D list 10u 25u 50u 75u
.param Td =0us          ;Time delay
.param Tf =0.1n             ;Time Fall
.param Tr =0.1n             ;Time Rise
.Param Vgate = 10V      ;Vgate Parameter

*----------------------PWM----------------------
Vpulse1 111 3 PULSE ({VRef}{Vgate} {Td} {Tr}{Tf}{D}{T})


*=========================CIRCUIT=========================
VS 1 0 SIN (0 {Vin} {Fd})
Vy 4 55 DC 0V
Vs1 55 01 DC 0V
Vs2 55 02 DC 0V
*Vs3 55 03 DC 0V
*Vx 2 66 DC 0V
Rxf 1 25 100kohm
Cxf 1 25 1.5uF
Dz 3 4 Zener
C1 4 3 {C}
M1 5 111 6 6      IRFP460 ; MOSFET with a model IRFP040
M2 7 111 8 8      IRFP460 ; MOSFET with a model IRFP040
*M3 9 111 10 10 IRFP040 ; MOSFET with a model IRFP040
R1 6 3 {RL}
R2 8 3 {RL}
*R3 10 3 {RL}

DL1 01 11 LED
DL2 11 12 LED
DL3 12 5 LED
DL4 02 21 LED
DL5 21 22 LED
DL6 22 7 LED
*=================================================================
======

*----------------------MOSFET MODEL-------------------------
.MODEL IRFP460 NMOS (VTO=2.831 KP=31.2u L=1u W=30m CGDO=3.358N
CGSO=18.054N)
*----------------------DIODE FAST RECOVERY--------------------
*.model D1N3883           D(Is=1.058E-18 Rs=11.56m Ikf=2.349 N=1 Xti=14 Eg=1.11
Cjo=113.2p
*+                  M=.2834 Vj=.75 Fc=.5 Isr=994.9n Nr=2 Tt=369.9n)
.MODEL Zener D(IS=2.22E-15 BV=12V IBV=12E-2 CJO=2PF TT=1US)
```

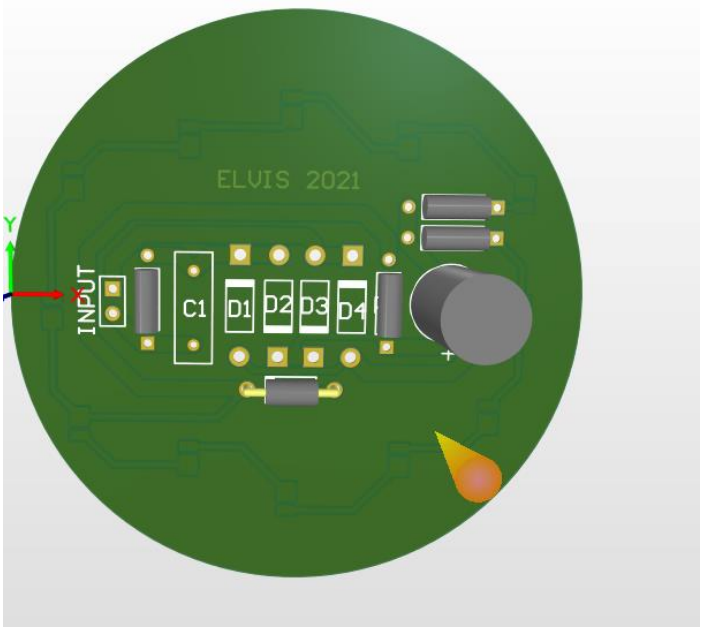
```
*----------------------------DIODA LED ----------------------
*.MODEL LO_5436-typ D
*+ IS=980.13E-40
*+ N=1.6749
*+ RS=1.6217
*+ IKF=7.1402E-3
.MODEL LED D(IS=2.22E-57 BV=4V IBV=25E-3 CJO=2PF TT=1US)

*------Subcircuit Diode Full Bridge---------
d1 3 25 DMOD
d2 25 4 DMOD
d3 0 4 DMOD
d4 3 0 DMOD
.MODEL DMOD D(IS=10E-15 N =1E-03 RS =0.1 CJO =100E-15)
*-----------------------------------------------------------

*-------------------------VIEW RESULT----------------------
.TRAN 0us 1s 10uS UIC
.OPTIONS ABSTOL=1uA CHGTOL=0.01nC ITL2=100 ITL4=150 RELTOL=0.1
VNTOL=0.1
.PROBE  V(1,0) V(4,3) , I(Vy) I(VS) I(Vs1) I(Vs2)
.PROBE V(DL1) V(DL3) V(DL5) V(DL2) V(DL4) V(DL6) V(R1)
.PROBE I(DL1) I(DL2) I(DL3) I(DL4) I(DL5) I(DL6) I(R1)
.END
```

Coding PSpice konfigurasi rangkaian 2,3 dengan mode switch

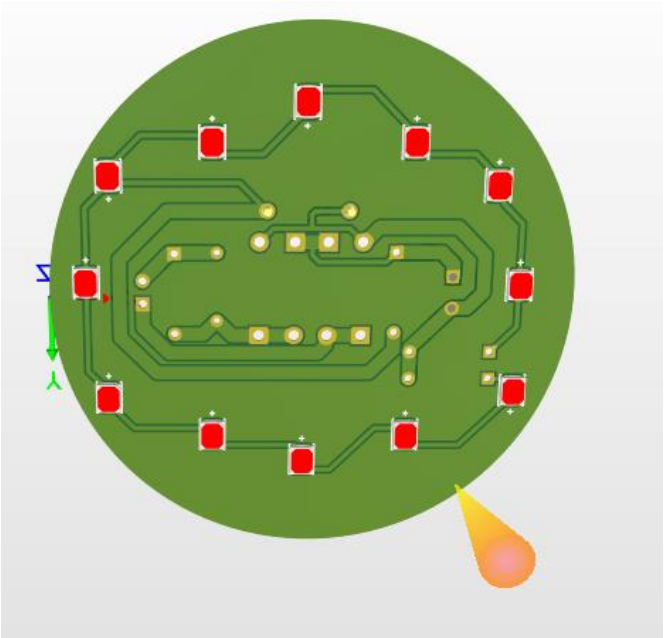
```
*----------------------PARAMETER--------------------
.param Vin = 230V           ;Vin Parameter
.param Fd = 50hz            ;frekuensi fundamental
.param RL = 20ohm           ;Rload Parameter
.param C = 100uF        ;Capasitor Parameter
.param VRef = 0V        ;Vref Parameter
.param Fs = 100khz      ;Frequency Parameter
.param T = 10u              ;Periodic Parameter
.param D = 70u          ;Duty Cycle
*.STEP PARAM D list 10u 25u 50u 75u
.param Td =0us          ;Time delay
.param Tf =0.1n             ;Time Fall
.param Tr =0.1n             ;Time Rise
.Param Vgate = 10V      ;Vgate Parameter

*----------------------PWM----------------------
Vpulse1 111 3 PULSE ({VRef}{Vgate} {Td} {Tr}{Tf}{D}{T})


*=========================CIRCUIT=========================
VS 1 0 SIN (0 {Vin} {Fd})
Vy 4 55 DC 0V
Vs1 55 01 DC 0V
Vs2 55 02 DC 0V
Vs3 55 03 DC 0V
*Vx 2 66 DC 0V
Rxf 1 25 100kohm
Cxf 1 25 1.5uF
Dz 3 4 Zener
C1 4 3 {C}
M1 5 111 6 6      IRFP460 ; MOSFET with a model IRFP040
M2 7 111 8 8      IRFP460 ; MOSFET with a model IRFP040
M3 9 111 10 10   IRFP460 ; MOSFET with a model IRFP040
R1 6 3 {RL}
R2 8 3 {RL}
R3 10 3 {RL}

DL1 01 11 LED
DL2 11 5 LED
DL3 02 21 LED
DL4 21 7 LED
DL5 03 31 LED
DL6 31 9 LED
*=========================================================================
====

*----------------------MOSFET MODEL-----------------------
.MODEL IRFP460 NMOS (VTO=2.831 KP=31.2u L=1u W=30m CGDO=3.358N
CGSO=18.054N)
*----------------------DIODE FAST RECOVERY-------------------
*.model D1N3883           D(Is=1.058E-18 Rs=11.56m Ikf=2.349 N=1 Xti=14 Eg=1.11
Cjo=113.2p
*+                  M=.2834 Vj=.75 Fc=.5 Isr=994.9n Nr=2 Tt=369.9n)
.MODEL Zener D(IS=2.22E-15 BV=10V IBV=12E-2 CJO=2PF TT=1US)
```

```
*-----------------------------DIODA LED ------------------------
*.MODEL LO_5436-typ D
*+ IS=980.13E-40
*+ N=1.6749
*+ RS=1.6217
*+ IKF=7.1402E-3
.MODEL LED D(IS=2.22E-57 BV=4V IBV=25E-3 CJO=2PF TT=1US)

*------Subcircuit Diode Full Bridge---------
d1 3 25 DMOD
d2 25 4 DMOD
d3 0 4 DMOD
d4 3 0 DMOD
.MODEL DMOD D(IS=10E-15 N =1E-03 RS =0.1 CJO =100E-15)
*-------------------------------------------------------

*-------------------------VIEW RESULT----------------------
.TRAN 0us 1s 10uS UIC
.OPTIONS ABSTOL=1uA CHGTOL=0.01nC ITL2=100 ITL4=150 RELTOL=0.1 VNTOL=0.1
.PROBE  V(1,0) V(4,3) , I(Vy) I(VS) I(Vs1) I(Vs2)
.PROBE V(DL1) V(DL3) V(DL5) V(DL2) V(DL4) V(DL6) V(R1)
.PROBE I(DL1) I(DL2) I(DL3) I(DL4) I(DL5) I(DL6) I(R1)
.END
```

Coding PSpice konfigurasi rangkaian 3,2 dengan mode switch



Layout PCB tampak atas



Layout PCB tampak bawah