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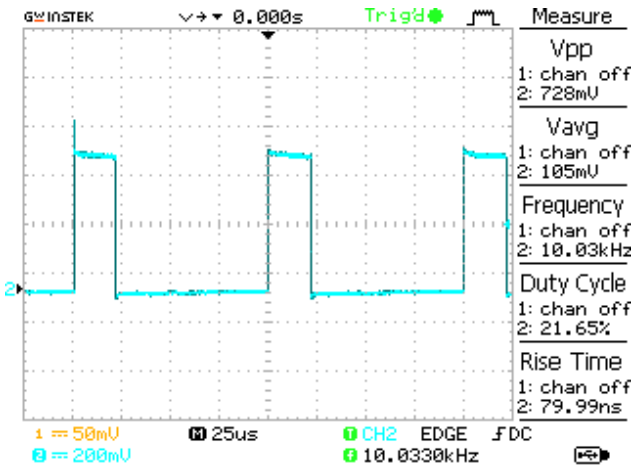
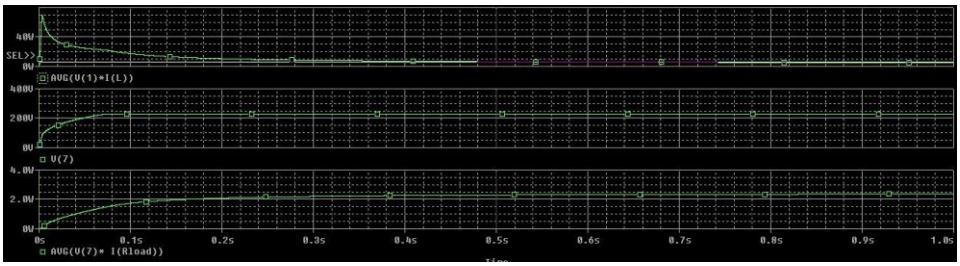
LAMPIRAN



Frekuensi dan *duty cycle* yang digunakan pada pengujian alat



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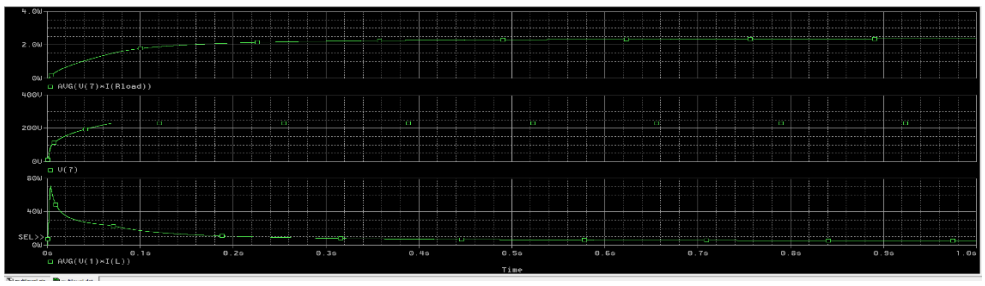
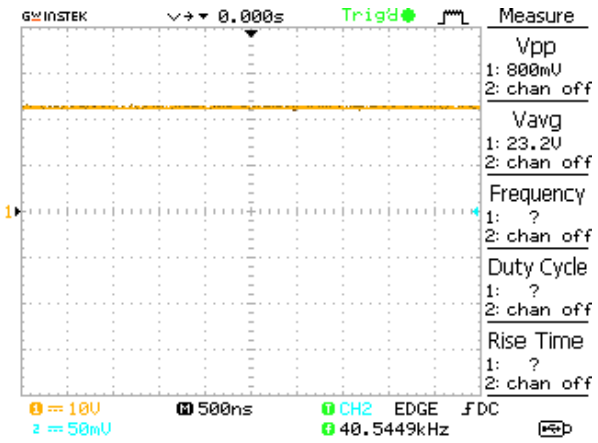


(*Non* Adaptif)

gan *output* simulasi *PSpice multilevel boost converter* pada beban 21,7 *k*Ω



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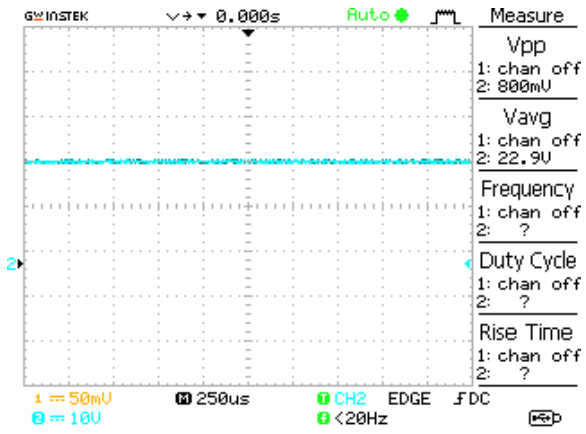

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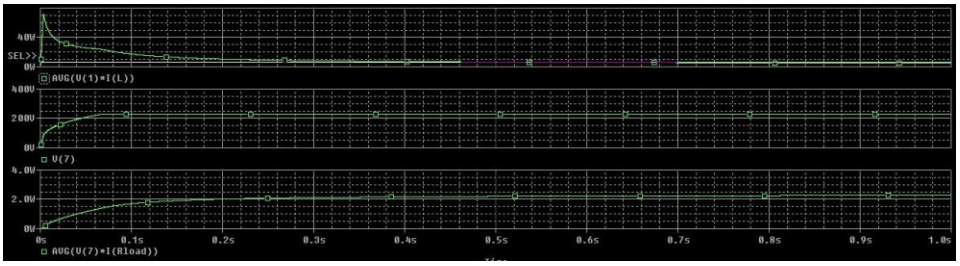
Tegangan *output* pengujian alat *multilevel boost converter* pada beban 21,7 *k*Ω



(Adaptif)

(*Non* Adaptif)

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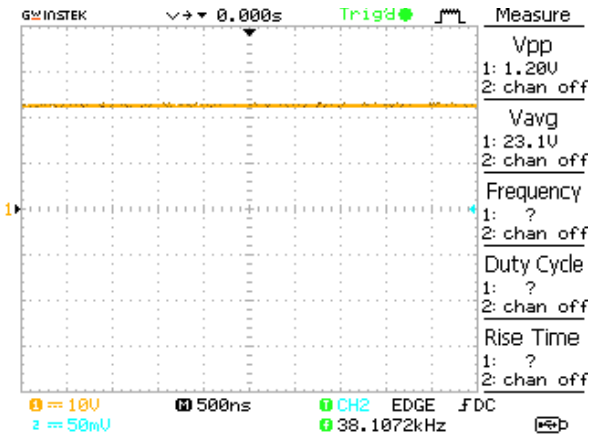

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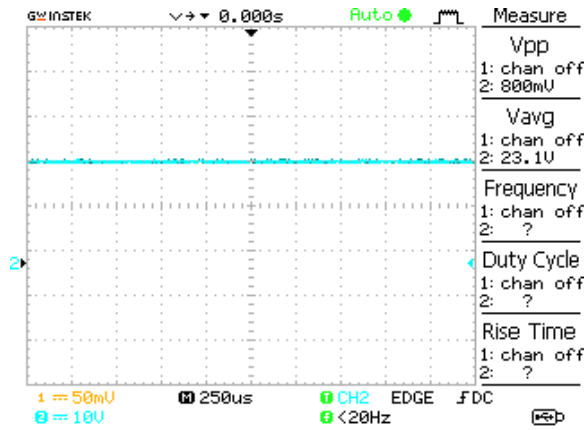

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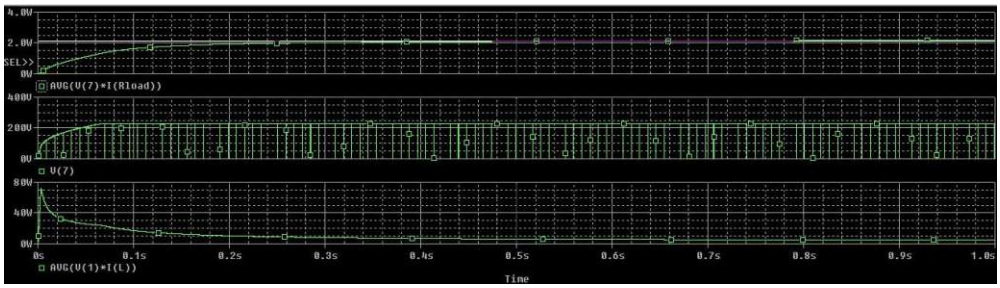
gan *output* pengujian alat *multilevel boost converter* pada beban 22,7 *k*Ω



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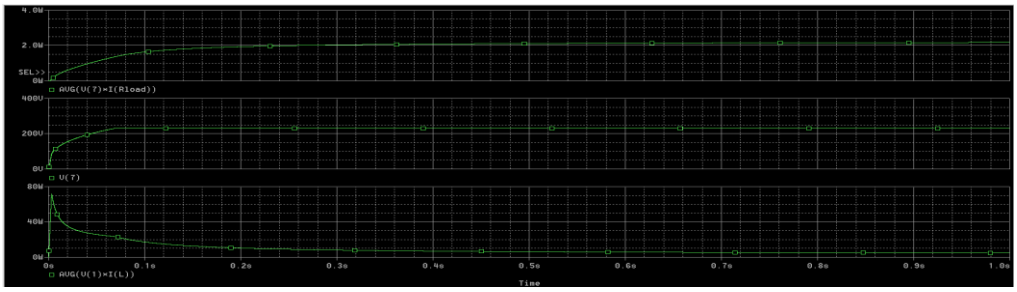

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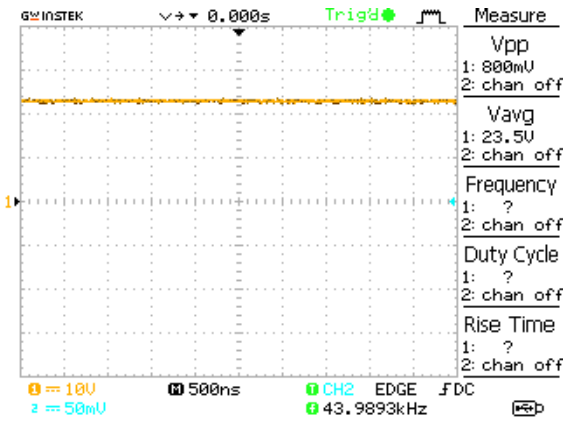

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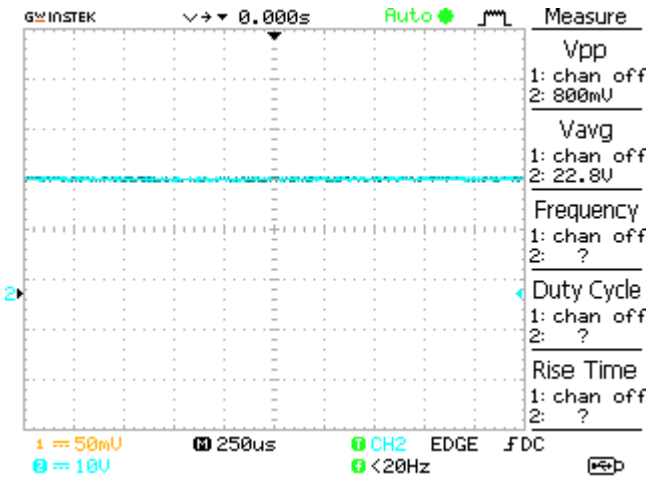
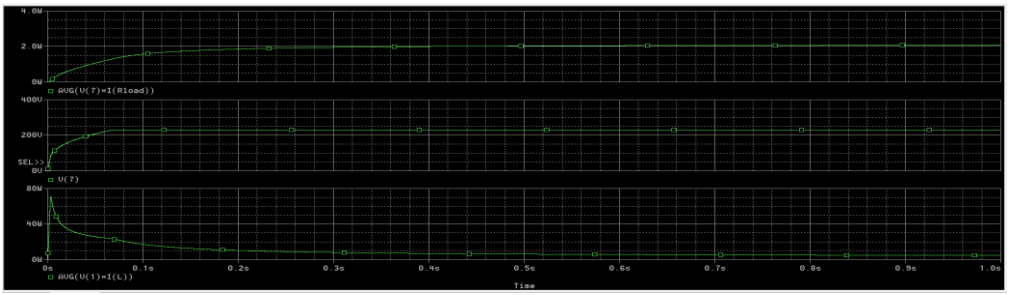


(*Non* Adaptif)

Tegangan *output* pengujian alat *multilevel boost converter* pada beban 23,7 *k*Ω



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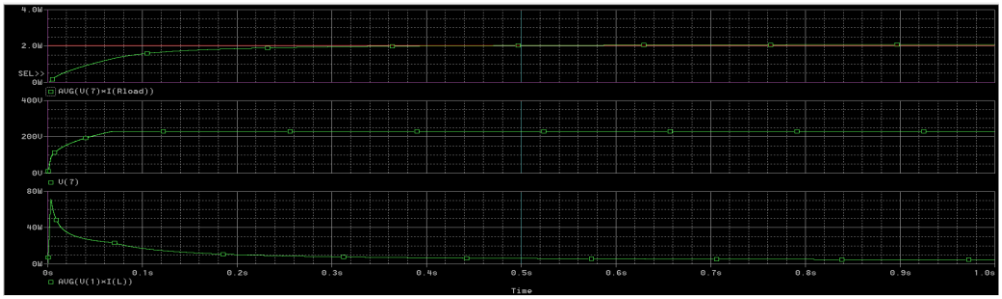
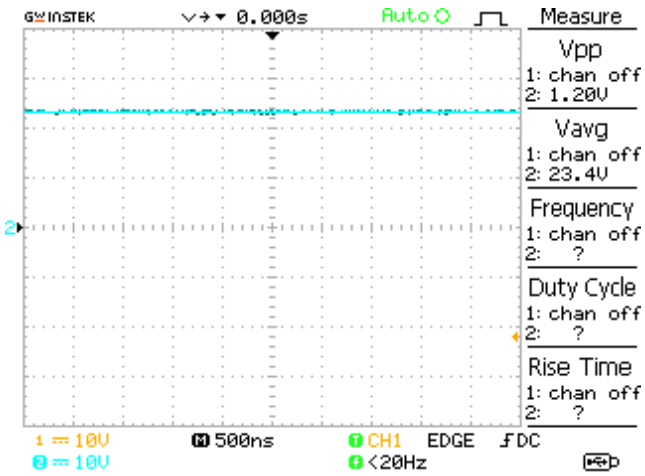


(*Non* Adaptif)

an *output* simulasi *PSpice multilevel boost converter* pada beban 24,65 *k*Ω



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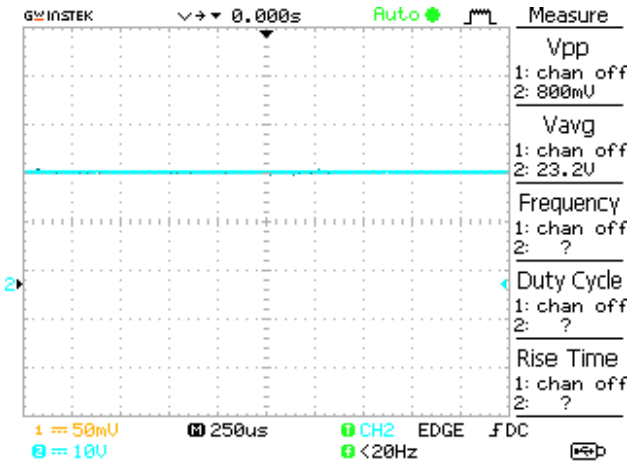

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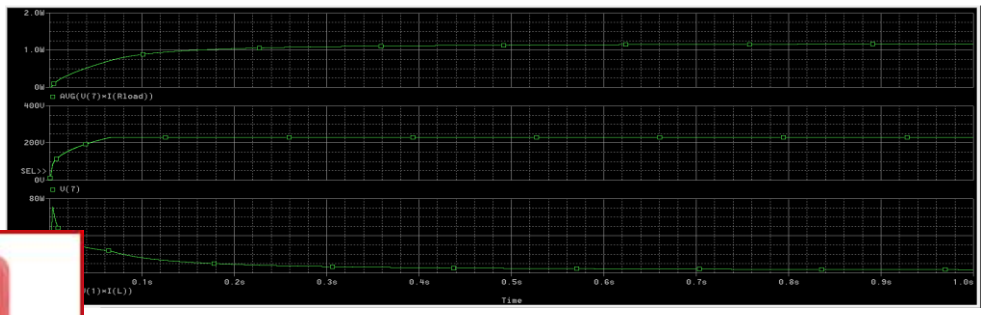
Tegangan *output* pengujian alat *multilevel boost converter* pada beban 24,65 *k*Ω



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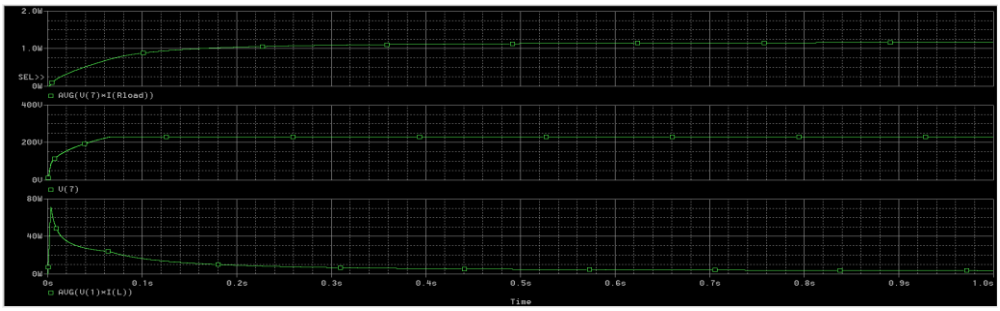


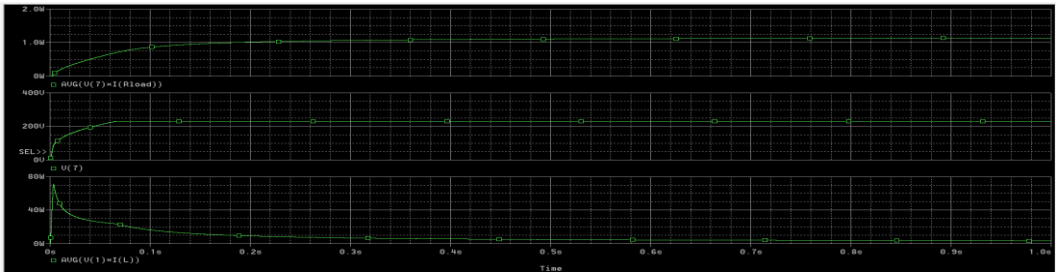
(*Non* Adaptif)

Tegangan *output* simulasi *PSpice multilevel boost converter* pada beban 44,3 *k*Ω

(Adaptif)

(*Non Adaptif*)

gan *output* pengujian alat *multilevel boost converter* pada beban 44,3 *k*Ω



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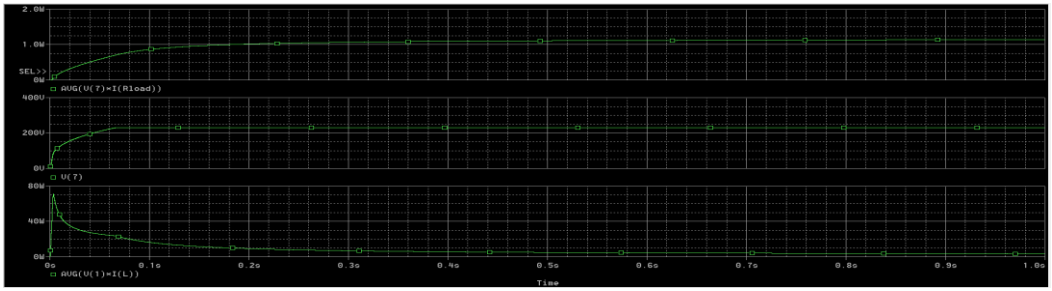

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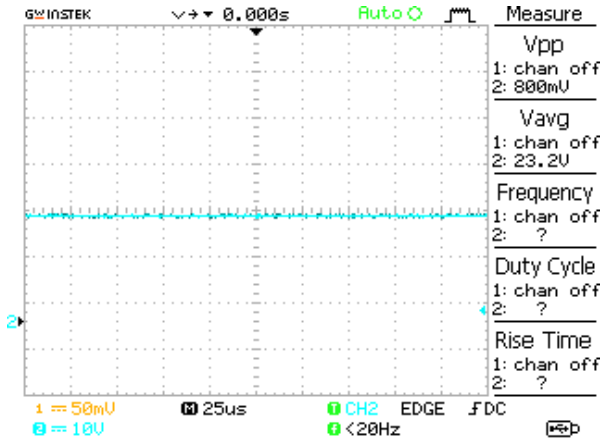
Tegangan *output* simulasi *PSpice multilevel boost converter* pada beban 45,3 *k*Ω



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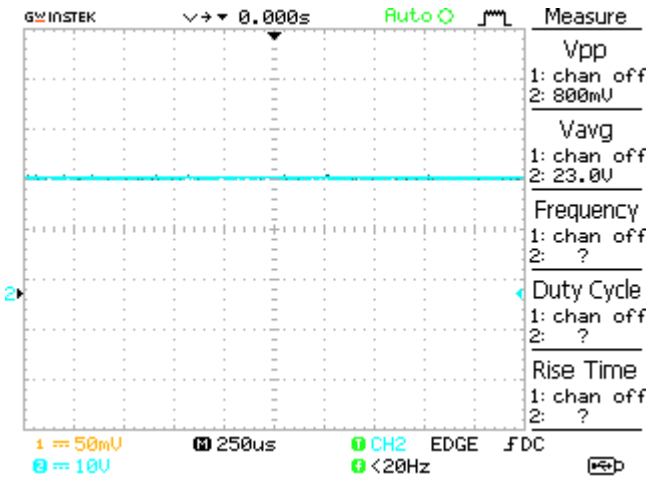
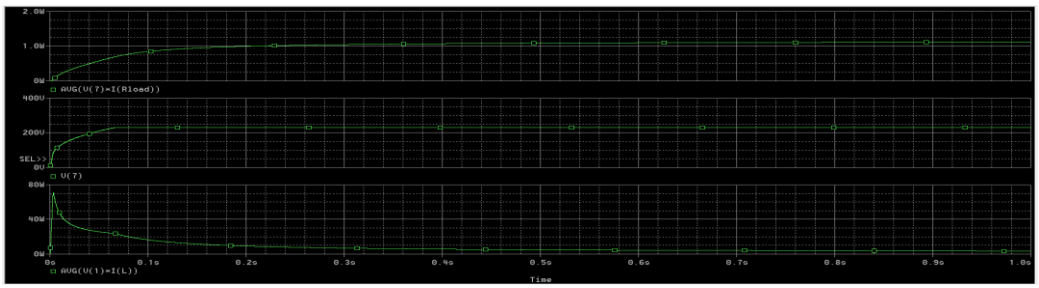


(*Non* Adaptif)

Tegangan *output* pengujian alat *multilevel boost converter* pada beban 45,3 *k*Ω



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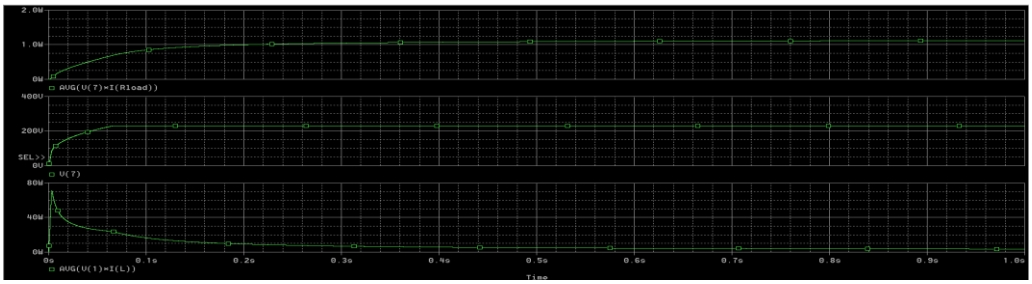
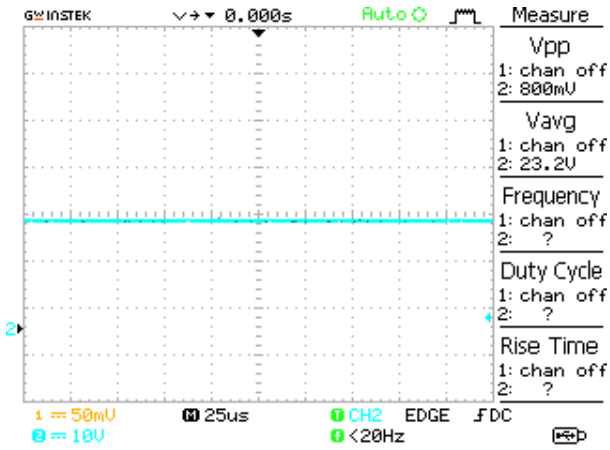


(*Non Adaptif*)

gan *output* simulasi *PSpice multilevel boost converter* pada beban 46,2 *k*Ω



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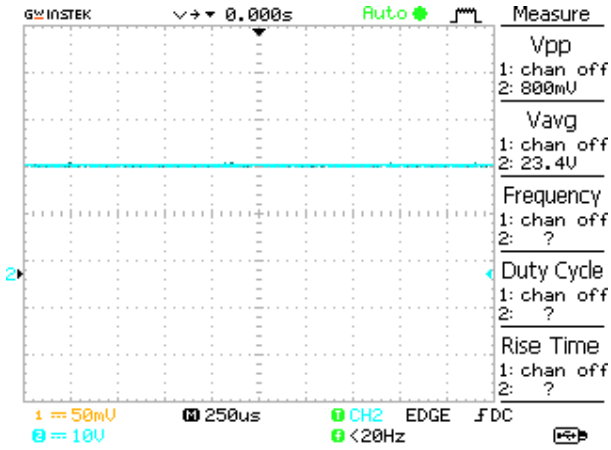
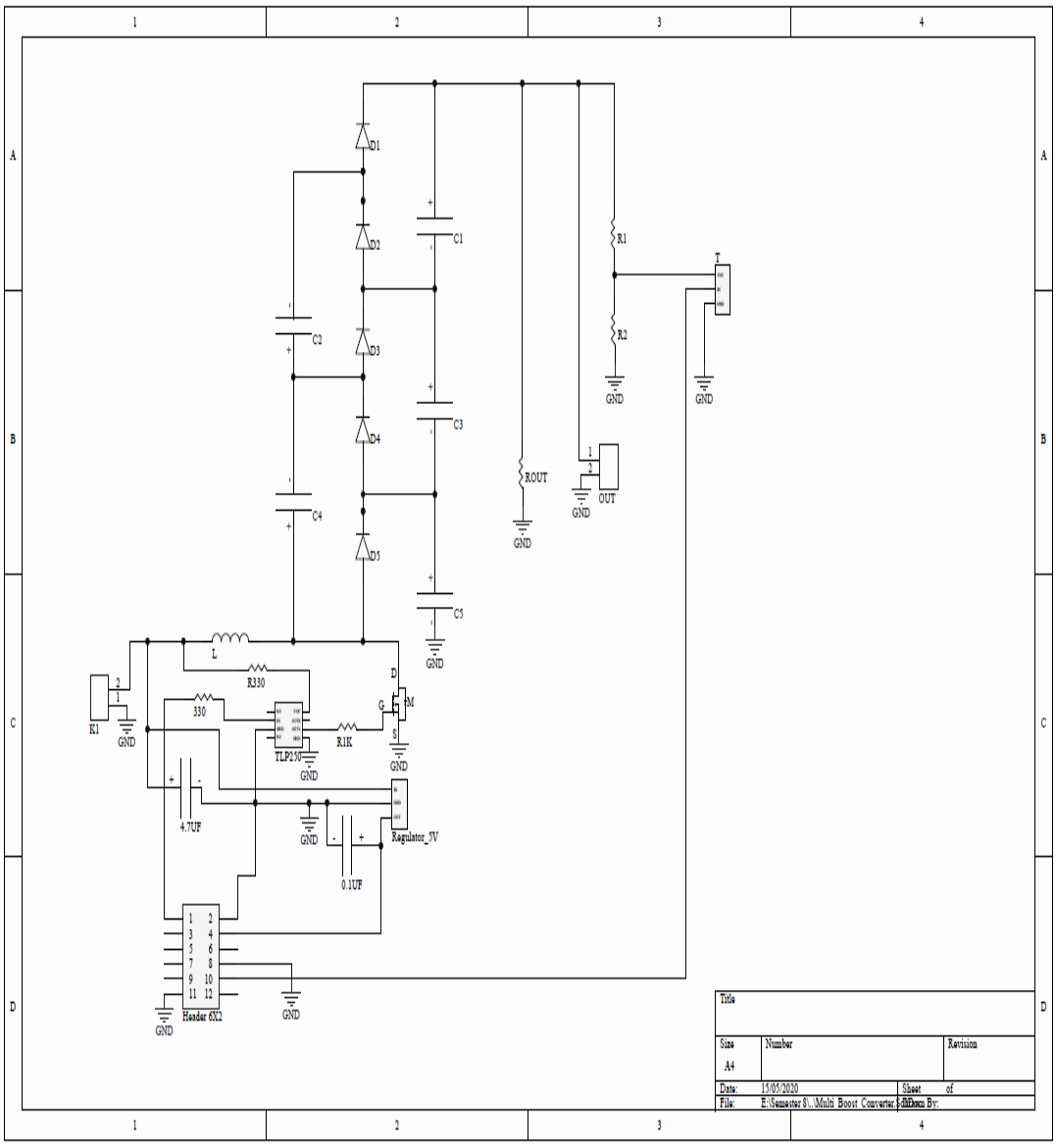
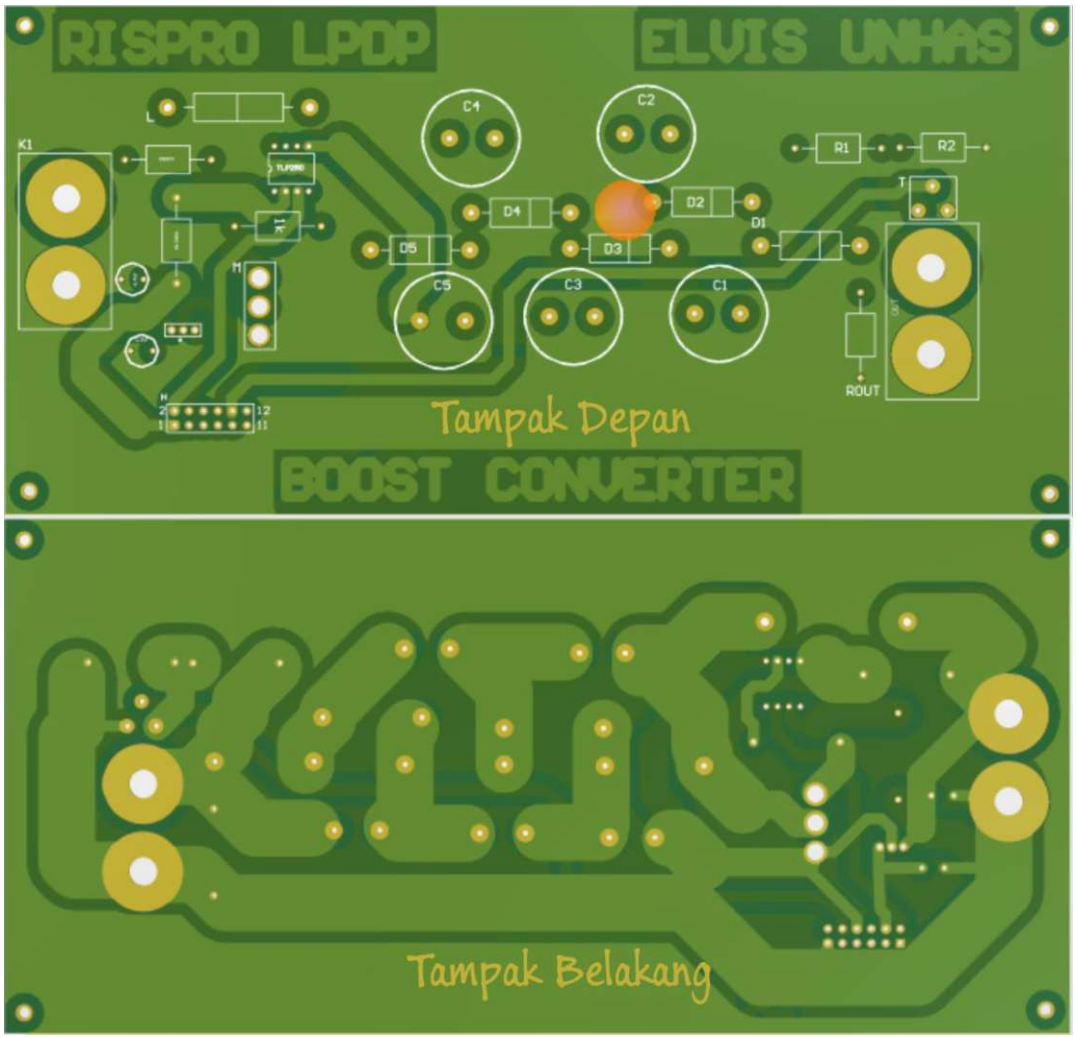


(*Non* Adaptif)

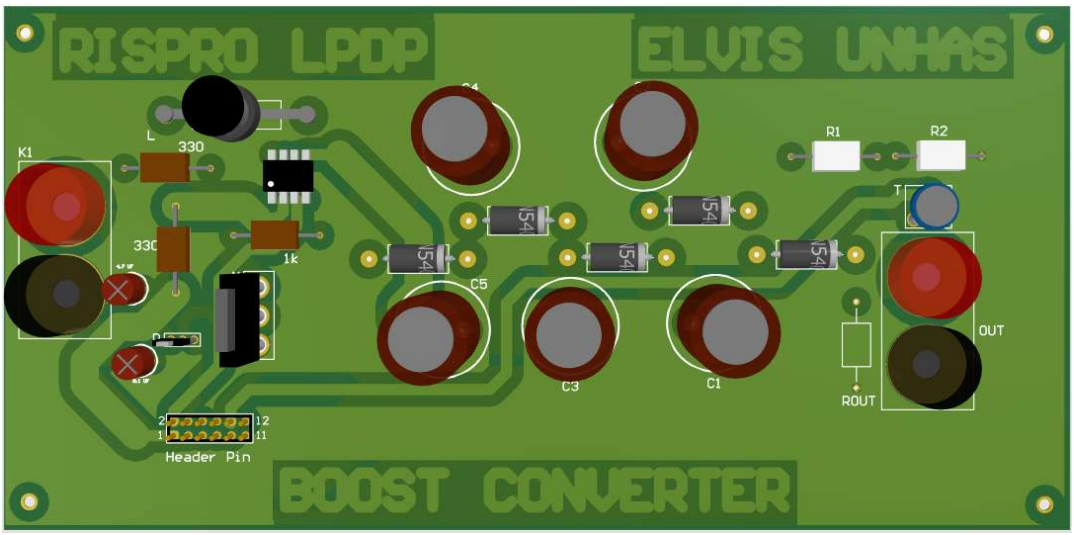
Tegangan *output* pengujian alat *multilevel boost converter* pada beban 46,2 *k*Ω

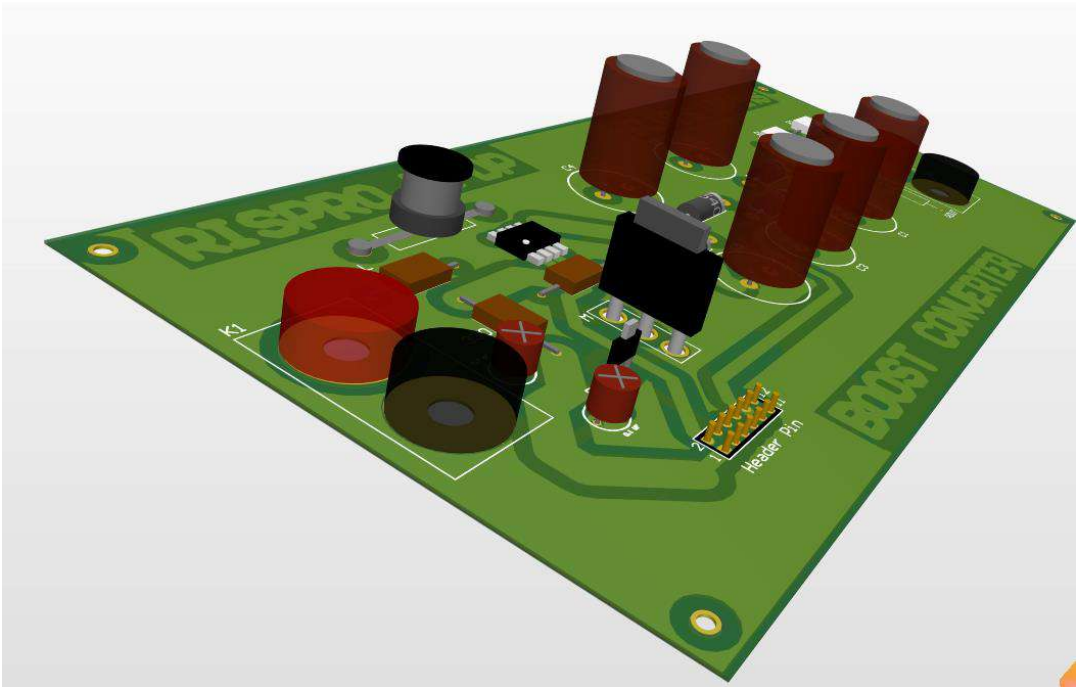


Skematik Rangkaian *Multilevel Boost Converter* 3 Tingkat



Layout PCB Multilevel Boost Converter





Tampilan 3D *PCB Multilevel Boost Converter*

```
double p=0;
double i=0;
double Kp = 30;//untuk 21,7k-22,7k
double Ki = 5;
double KP = 20;//untuk 22,7k-24,65k
double KI = 4;
double kP = 18.5;//untuk 44,3;45,3 dan 46,2;
double kI = 5;
double kp = 0.5;
double ki = 3;
double kpp = 7;
double kii  = 10;

unsigned long currentTime;
unsigned long elapsedTime;
unsigned long previousTime;
double cumError, outMax, outMin, SampleTime, error;
double  output, outputSum, lastInput, inp;
double input, setPoint;
#define feedback A0
#define pinpwm 3

void setup() {
  TCCR2A=0;// timer pin 3 arduino
  TCCR2B=0;
  TCCR2A = 0b00100011; // _BV(COM2B1) | _BV(WGM21) | _BV(WGM20);
     2B = 0b00001010;//8-100KHZ
     A = 198;
     2=0;
```

```
  SampleTime = 100;
  previousTime = millis()-SampleTime;
  //bataskeluaran(25,29);
  bataskeluaran(36,40); //bataskeluaran(36,60); //bataskeluaran(36,70);
  setPoint=920;
  Serial.begin(9600);
}
void bataskeluaran(double Min, double Max)
{
  Min >=0;
  Max <=255;
  if(Min >= Max) return;
  outMin = Min;
  outMax = Max;
  }
void loop() {
  input = analogRead(feedback);
  double rentangerror = abs(setPoint-input);
    if (rentangerror >25)
  {
    output = komputasi(input);
    }
 else if (rentangerror <= 5)
  {
   output = komputasiPI(input);
   }
   (rentangerror >5 && rentangerror <=7)


   t = komputasiPI1(input);
```

```
   }
  else if (rentangerror >7 && rentangerror <=9)
  {
    output = komputasiPI2(input);
    }
 else if (rentangerror >9 && rentangerror <=15)
   {
    output = komputasiPI3(input);
    }
else if (rentangerror >15 && rentangerror <=25)
   {
    output = komputasiPI4(input);
    }
  analogWrite(pinpwm, output);
  Serial.println(input);
  Serial.println(setPoint);
  Serial.println(rentangerror);
}

double komputasi(double inp){
  currentTime=millis();
  elapsedTime=(currentTime - previousTime);
  if(elapsedTime>=SampleTime){
    error=setPoint-inp;
    outputSum += error*elapsedTime;
    if(outputSum > outMax)
      tSum= outMax;
      f(outputSum < outMin)
      tSum= outMin;
```

```
    double out = p* error + i*outputSum ;
    if(out > outMax)
    out= outMax;
    else if(out < outMin)
    out= outMin;
    previousTime=currentTime;
    return out;
  }
}

double komputasiPI(double inp){
  currentTime=millis();
  elapsedTime=(currentTime - previousTime);
  if(elapsedTime>=SampleTime){
    error=setPoint-inp;
    outputSum += error*elapsedTime;
    if(outputSum > outMax) outputSum= outMax;
    else if(outputSum < outMin) outputSum= outMin;
    double out = Kp* error + Ki*outputSum ;
    if(out > outMax) out= outMax;
    else if(out < outMin) out= outMin;
    previousTime=currentTime;
    return out;
  }
}

 komputasiPI1(double inp){
Time=millis();
```

```
 elapsedTime=(currentTime - previousTime);
 if(elapsedTime>=SampleTime){
  error=setPoint-inp;
  outputSum += error*elapsedTime;
  if(outputSum > outMax) outputSum= outMax;
  else if(outputSum < outMin) outputSum= outMin;
  double out = KP* error + KI*outputSum ;
  if(out > outMax) out= outMax;
  else if(out < outMin) out= outMin;
  previousTime=currentTime;
  return out;
 }

}
 double komputasiPI2(double inp){
 currentTime=millis();
 elapsedTime=(currentTime - previousTime);
 if(elapsedTime>=SampleTime){
  error=setPoint-inp;
  outputSum += error*elapsedTime;
  if(outputSum > outMax) outputSum= outMax;
  else if(outputSum < outMin) outputSum= outMin;
  double out = kP* error + kI*outputSum ;
  if(out > outMax) out= outMax;
  else if(out < outMin) out= outMin;
  previousTime=currentTime;
  return out;
```

```
double komputasiPI3(double inp){
 currentTime=millis();
 elapsedTime=(currentTime - previousTime);
 if(elapsedTime>=SampleTime){
  error=setPoint-inp;
  outputSum += error*elapsedTime;
  if(outputSum > outMax)
  outputSum= outMax;
  else if(outputSum < outMin)
  outputSum= outMin;
  double out = kp* error + ki*outputSum ;
  if(out > outMax)
  out= outMax;
  else if(out < outMin)
  out= outMin;
  previousTime=currentTime;
  return out;
 }
}

double komputasiPI4(double inp){
 currentTime=millis();
 elapsedTime=(currentTime - previousTime);
 if(elapsedTime>=SampleTime){
  error=setPoint-inp;
  outputSum += error*elapsedTime;
  putSum > outMax)
  tSum= outMax;
  (outputSum < outMin)
```

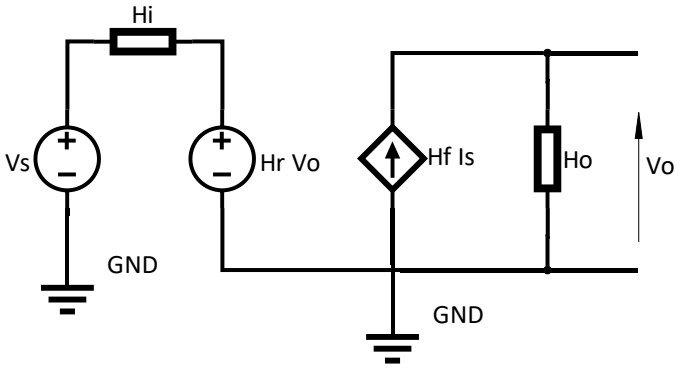
```
    outputSum= outMin;
    double out = kpp* error + kii*outputSum ;
    if(out > outMax)
    out= outMax;
    else if(out < outMin)
    out= outMin;
    previousTime=currentTime;
    return out;
  }
}
```

Coding* program kontrol *multilevel boost converter

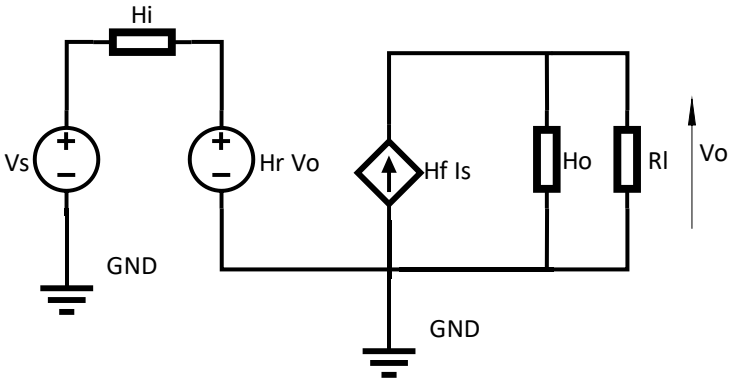
```
.param Rload=23.7k ;22.7k , 21.7k, 24.65k, 44.3k, 45.3k, 46.2k
.param rgate=1k
.param vref=230V
.param VGATE =20V
.param Freq = 10.03k ; frequency
.param T = {1/Freq}          ; periode
.param _HIGH =5V             ; high voltage
.param _LOW = 0V             ; low voltage
.param Td = 0us              ; time delay
.param Tr = 0.1us            ; time rise
.param Tf = 0.1us            ; time fall
.param kp=20
.param ki=5
Vin 1 0 PWL REPEAT FOREVER (0ms 0)(3ms 24)(5ms 24)(5ms 24)(10ms
24)(15ms 24)(20ms 24)(20ms 24)(30ms 24)(40ms 24) ENDREPEAT
L 1 2 124uh
C6 1 0 21.6uF TC=0,0
C4 3 2 90.2uf TC=0,0
C2 4 3 91.2uf TC=0,0
D5 2 5 DMOD
D4 5 3 DMOD
D3 3 6 DMOD
D2 6 4 DMOD
D1 4 7 DMOD
C5 5 0 90.9uf TC=0,0
C3 6 5 90.8uf TC=0,0
C1 7 6 90.7uf TC=0,0
                0 {Rload}
                0 IRFP460
```

```
RG 9 8 {rgate}

.model DMOD D(IS=10.000000E-15 N =1.000000E-03 RS =.1 CJO
=100.000000E-15)

.MODEL IRFP460 NMOS (VTO=2.831 KP=31.2u L=1u W=30m
CGDO=3.358N CGSO=18.054N)

*Vsensor

Esensor 14 0 7 0 0.0217391304          ; comparision sensor 5:230V

*VRef

Vref 15 0 DC {Vref*0.0217391304}

*Verror

Eerror 16 0 VALUE {(V(15)- V(14))}

EdeltaV 17 0 VALUE {V(1) - Vref}

* when input 24V

E24 51 0 VALUE={if({V(1)}==24, V(58),0)}

EKp52  52 0 VALUE={V(16)*kp}

*control Integral

EKp55 55 0 LAPLACE  {V(16)} = {(ki)/(s)}

Econtrol 58 0 VALUE {(V(52)+V(55))}

Ebatas 28 0 VALUE {LIMIT(V(58),0.01*_HIGH,0.2165*_HIGH)}

;Ebatas 28 0 VALUE {LIMIT(V(58),0.01*_HIGH,0.71*_HIGH)}

*signal sawtooths

Vger  30 0 PULSE  ({_LOW} {_HIGH} {Td} {T-(2*Tf)} {Tf} {Tf} {T})

*PWM out

Epwm  9 0 VALUE ={IF(V(28)-V(30)>0, {VGATE},0)}

*.step param Rload 100 1k 200

.TRAN 1ms 1000ms 0 0.1us UIC

.PROBE V(7) V(1) V(16) V(17) V(16) V(58) V(2) I(L) I(Rload)
```


Coding* program PSpice *multilevel boost converter



Tanpa Beban



Dengan Beban

Persamaan Tanpa Beban

$$Vs - IsHi - HrVo = 0 \quad (1)$$

$$Vo = HfIs * \frac{1}{Ho} \quad (2)$$

Persamaan Dengan Beban

$$Vs - IsHi - HrVo = 0 \quad (3)$$

$$Rl = \frac{Vo}{HfIs + HoVo} \quad (4)$$

Dengan Menggunakan Persamaan Tanpa Beban dan Dengan Beban, maka dilakukan Perhitungan dengan Menggunakan Data Sebagai Berikut :

Tanpa Beban :

Vo = 229,37 V ; Is = 488,889 mA

Loop I Tanpa Beban

$$Vs - IsHi - HrVo = 0$$

$$IsHi = Vs - HrVo$$

$$Hi = \frac{Vs - HrVo}{Is} = \frac{24 - 229{,}37Hr}{0{,}488889}\ Persamaan\ (I)$$

Loop II Tanpa Beban

$$Vo = HfIs * \frac{1}{Ho}$$

$$229{,}37 = \frac{Hf\ 0{,}488889}{Ho}$$

$$Hf = 469{,}1658024\ Ho \text{ Persamaan (II)}$$

Dengan Beban :

Rl = 500 Ω ; Vo = 229,56 V; Is = 5,3945 A

Loop I Dengan Beban

$$Vs - IsHi - HrVo = 0\ Substitusi\ Persamaan\ (I)$$

$$24 - 5{,}3945\left(\frac{24 - 229{,}37Hr}{0{,}488889}\right) - 229{,}56Hr = 0$$

$$\boldsymbol{Hr = \frac{240{,}82084}{2301{,}35492} = 0{,}104643068}$$

$$\boldsymbol{Hi = \frac{24 - 229{,}37Hr}{0{,}488889} = \frac{-0{,}0019805017}{0{,}488889} = -0{,}00405103}$$

Loop II Dengan Beban

$$Rl = \frac{Vo}{HfIs + HoVo} Substitusi\ Persamaan\ (II)$$

$$500 = \frac{229{,}56}{469{,}1658024Ho * 5{,}394 + 229{,}56Ho}$$

$$500 = \frac{229{,}56}{2760{,}47492Ho}$$

$$\boldsymbol{Ho = 0{,}000166318949}$$

$$Hf = 469{,}1658024Ho = 469{,}1658024 * 0{,}000166318949$$

$$\boldsymbol{Ho = 0{,}0780311632}$$

Maka didapatkan nilai parameter-parameter sebagai berikut:

Hi = -0,00405103

Hr = 0,104643068

Hf = 0,0780311632

Ho = 0,000166318949