FINAL REPORT
BENGKEL ELEKTROMAGNETIK DAN KOMPONEN ELEKTRONIKA DAYA
“HALF BRIDGE DC-DC CONVERTER”

Nama	: Falia Innocentia Ananda S.
NRP	: 1310181046
Kelas	: 3 D4 Teknik Elektro Industri B
Tanggal	: 18 Juni 2020
Dosen Pembimbing	: Ir. Moh Zaenal Efendi, M.T.

TEKNIK ELEKTRO INDUSTRI
DEPARTEMEN TEKNIK ELEKTRO
POLITEKNIK ELEKTRONIKA NEGERI SURABAYA
2021

I. INTRODUCTION

In recent year, the power converter has been developed for electrical systems. Especially, the power converter was designed such as for small hydro systems, wind turbine energy and photovoltaic systems. The types of power converters that were designed for the energy systems were rectifier circuit, boost converter circuit, buck converter circuit and inverter circuit. The input power varied dependent to the reason of source changing. Many parameters of electrical system inputs vary from sources that affect the electrical control method that is suitable in the condition. This paper presents the simulation of Halfbridge DC-DC Converter by using Proteus and the Halfbridge DC-DC Calculator software.

II. BASIC THEORY

The two switches connect the single transformer primary across the two capacitors alternately. The primary half-bridge voltages and currents are AC. DC current is not drawn from the center-tap of the input supply. Different with the full-bridge topology, no extra capacitor is needed to eliminate the DC bias in the transformer since the two capacitors automatically correct the mismatch of the switching by changing their voltage. Since two capacitors share the input voltage evenly, the voltage stress for the MOSFET is half of the input voltage compared with the case in full-bridge topology. As a result, lower voltage rated MOSFET is qualified for half-bridge topology application. Two half-bridge topologies are widely used in DC-DC converters, i.e., the symmetric half-bridge topology and the asymmetric half-bridge topology.

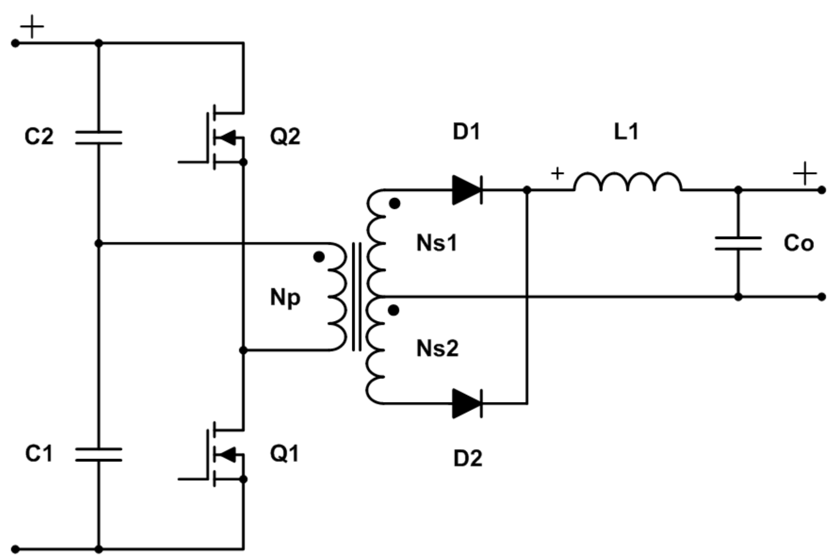


Figure 1 Schematic of a Half-Bridge converter

The full-bridge and half-bridge converters shown in Fig 1 and 2 are similar in operation to the push-pull converter. Assuming that the transformer is ideal, the half-bridge converter of Fig. 2 has capacitors C_1 and C_2 which are large and equal in value.

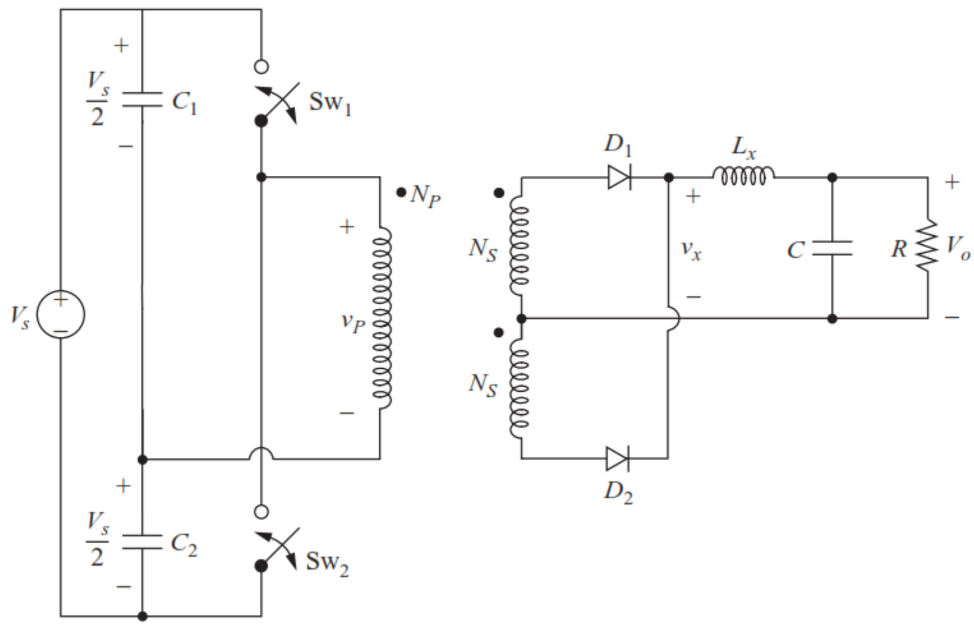
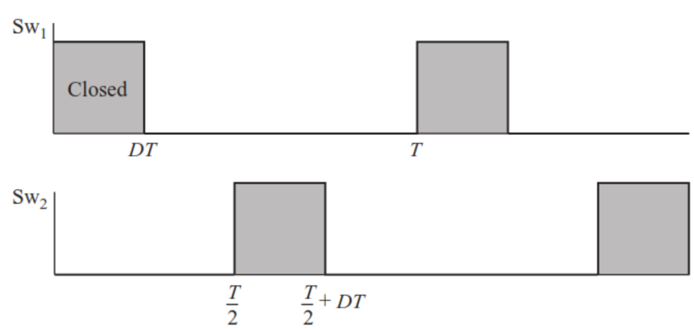
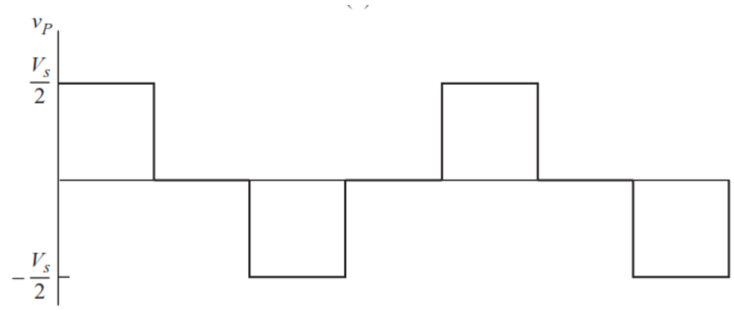


Figure 2 Schematic of a Half-bridge converter

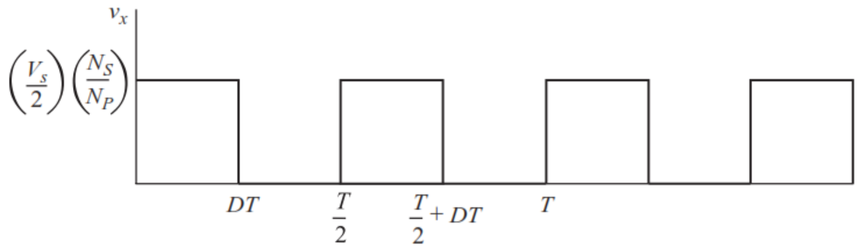
The input voltage is equally divided between the capacitors. Switches SW_1 and SW_2 close with sequence shown, producing an alternating voltage pulse v_p on the transformer primary. The rectified secondary voltage v_x has the waveform shown in Fig. 3*c*. Voltage v_x is the same form as for the push-pull and the full bridge converters, but the amplitude is one-half the value.



(a)



(b)



(c)

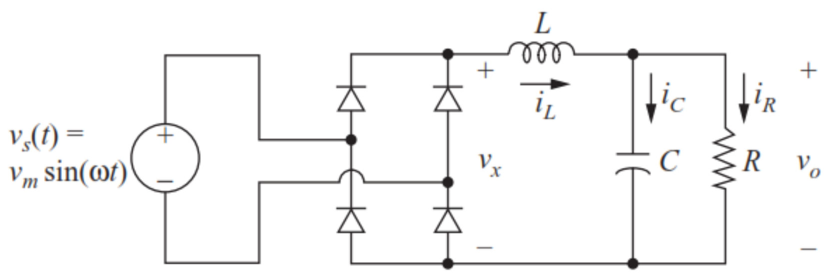
Figure 3 *(a)* Switching sequence; *(b)* Voltage on the transformer primary; *(c)* Voltage v_x.

The relationship between the input and output voltage for the half-bridge converter is where *D* is the duty ratio of *each* switch. The voltage across an open switch for the half-bridge converter is v_s.

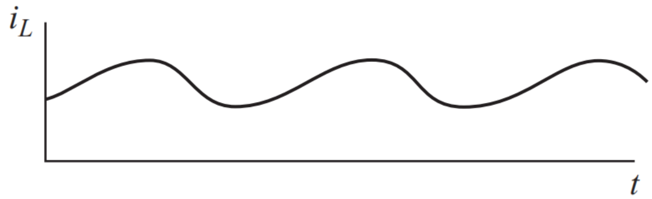
$$Vo = Vs\left(\frac{Ns}{Np}\right)D$$

The half-bridge converter is also used for medium power requirements, up to about 500 W, and has some of the same advantages as the push-pull. The voltage stress on the switches is limited to v_s.

In this project also used full-wave rectifier configuration has an *LC* filter on the right side, as shows in Fig 4*a*. The purpose of the filter is to produce an output voltage that is close to purely dc. The capacitor holds the output voltage at a constant level, and inductor smooths the current from the rectifier and reduces the peak current in the diodes from that of the current.



(a)



(b)

Figure 4 *(a)* Rectifier with *LC* filtered output;
(b) Continous inductor current.

This circuit is operate in the continous-current mode. For continous current, the inductor current is always positive, as illustrated in Fig. 4*b*. For continous current, the voltage v_x in Fig. 4*a* is a full-wave rectified sine wave, which has an average value of $2V_m/\pi$. Since the average voltage across the inductor in the steady state is zero, the average output voltage for continous inductor current is

$$Vo = \frac{2Vm}{\pi}$$

Average inductor current must equal the average resistor current because the average capacitor current is zero.

$$I_R = I_R = \frac{V_o}{R}$$

III. CALCULATION

The Half Bridge DC-DC Converter has following parameters :

V_{in}	100 Volt
V_o	19 Volt
I_o	3 A
Duty Cycle	0,4
Switching Frekuensi (fs)	40 kHz

Components :

$S_1 = S_2$	MOSFET IRFP460
$C_1 = C_2$	470 μF, 400Volt

$D_1 = D_2 = D_3 = D_4$	MUR 1560 (Ultra Fast Recovery Diode)
Inductor (L_x)	Ferrit Core PQ 3230 with Cross sectional are (A_c=1.61cm^2); Bobbin diameter (D_{bob1}=16 mm)
Transformer (TR)	Ferrit Core PQ 3535 with Cross sectional are (A_c=1.96 cm^2); Bobbin diameter (D_{bob2}=17 mm)
C_o	Output capacitor (Calculation), 50 Volt
$R_{s1} = R_{s2}$	Snubber resistor
$C_{s1} = C_{s2}$	Snubber capacitor

High Frequency Inductor Design

a. **Output Voltage**

$$V_o = V_{in} \times \frac{N_2}{N_1} \times D$$

$$19 = 100 \times \frac{N_2}{N_1} \times 0.4$$

$$\frac{N_2}{N_1} = \frac{19}{40}\,;\ \frac{N_2}{N_1} = \underline{0.475}$$

So, the transformer ratio is $N_1 : N_2 = \underline{40:19}$

$$\frac{N_1}{N_2} = \frac{40}{19} = 2.1$$

b. **Filter Inductor**

- Inductor Current riple

$$\Delta i_{Lx} = 20\% \times I_o$$

$$\Delta i_{Lx} = 20\% \times 3 = \underline{0.6\text{ A}}$$

Where :

$$V_{in\,(a)} = \frac{Vin}{2 \times \frac{N_1}{N_2} - 2V_f}$$

$$V_{in\ (a)} = \frac{100}{2 \times 0.475 - 2 \times (1.5)} = \underline{82.61\ \text{Volt}}$$

$V_f = 1.5\ V$ Diode Forward-Voltage (From Datasheet of diode red: MUR1560)

$$L_x = \frac{1}{\Delta i L_x} \times (V_{in\ (a)} - V_o) \times \left(\frac{1}{2f}\right) \times \times \left(\frac{Vo+2V_f}{Vin+2V_f}\right)$$

$$L_x = \frac{1}{0.6} \times (82.61 - 19) \times \left(\frac{1}{2.40k}\right) \times \left(\frac{19 + 2 \times 1.5}{100 + 2 \times 1.5}\right)$$

$$L_x = \underline{0.283\ \text{mH}} \approx 283\ \mu H$$

c. **The Maximum Conductor Current**

$$i_{\text{L(max)}} = i_{\text{L(avg)}} + \frac{\Delta i_{Lx}}{2}; \qquad i_{\text{L(avg)}} = \frac{Vo}{R} = \frac{19}{6.33}$$

$$i_{\text{L(max)}} = 3 + \frac{0.6}{2} = \underline{3.3\ \text{A}}$$

d. **Winding Number of Inductor**

$$n = \frac{L_x \times i_{\text{L(max)}}}{B_{max} \times A_c} \times 10^4; \quad B_{max} = 0.25\ \text{Tesla};\ A_c = 1.61\ \text{cm}^2$$

$$n = \frac{283 \times 10^{-6} \times 3.3}{0.25 \times 1.61} \times 10^4$$

$$n = \underline{23.2} \approx 24$$

e. **Wire Size is based on RMS current of Inductor**

$$i_{L\ (rms)t} = \sqrt{(i_{L(avg)})^2 + \left(\frac{\Delta i_L/2}{\sqrt{3}}\right)^2}$$

$$i_{L\ (rms)t} = \sqrt{(3)^2 + \left(\frac{0.6/2}{\sqrt{3}}\right)^2} = \underline{3.005\ \text{A}}$$

f. **Calculation of Wire Size**

a) Cross Sectional Area of Wire ($q_{w\ (L)}$)

$$q_{w\ (L)} = \frac{\text{iL(rms)t}}{J}; \qquad J = 4.5\ \frac{A}{mm^2}\ \text{(current destiny)}$$

$$q_{w\ (L)} = \frac{3.005}{4.5} = \underline{0.67}\ mm^2$$

b) Diameter of Wire ($d_{w\ (L)}$)

$$d_{w\ (L)} = \sqrt{\frac{4}{\pi} \times q_{w\ (L)}}$$

$$d_{w\ (L)} = \sqrt{\frac{4}{\pi} \times 0.67}$$

$$d_{w\ (L)} = \underline{0.92\ mm}$$

g. **<u>Recalculate when number of split wire ($d_{w\,(L)\,split}$) = 0.4 mm</u>**

a) $d_{w\,(L)\,split} = \sqrt{\frac{4}{\pi} \times q_{w\,(L)\,split}}$

$0.4 = \sqrt{\frac{4}{\pi} \times q_{w\,(L)\,split}}$

$0.4^2 = \frac{4}{\pi} \times q_{w\,(L)\,split}$

$q_{w\,(L)\,split} = \frac{\pi}{4} \times 0.16 = 0.125\ mm^2$

b) $q_{w\,(L)\,split} = \frac{i_{L\,(rms)\,split}}{J}$

$0.125 = \frac{i_{L\,(rms)\,split}}{4.5}$

$i_{L\,(rms)\,split} = 4.5 \times 0.125$

$i_{L\,(rms)\,split} = 0.5625$ A

c) $i_{L\,(rms) split} = \frac{i_{L\,(rms) t}}{\sum \text{split}}$

$0.5625 = \frac{3.005}{\sum \text{split}}$

$\sum \text{split} = \frac{3.005}{0.5625}$

$\sum \text{split} = 5.342 \approx 6\ split$

- **Recalculate by Selected Number of split wire, $\boldsymbol{\Sigma split = 5.342 \approx 6\ split}$**
  - $i_{L(rms)\,split} = \frac{i_{L(rms)}}{\Sigma split_{\,(L)}}$

    $i_{L(rms)\,split} = \frac{3.005}{5.342}$

    $i_{L(rms)\,split} = 0.5625\ A$
  - $q_{w(L) split} = \frac{i_{L(rms)\,split}}{J}$

    $q_{w(L) split} = \frac{0.5625}{4.5}$

    $q_{w(L) split} = 0.125\ mm^2$
  - $d_{w(L) split} = \sqrt{\frac{4}{\pi} \times q_{w(L) split}}$

$$d_{w(L)split} = \sqrt{\frac{4}{\pi} \times 0.125}$$

$$d_{w(L)split} = 0.4\ mm$$

h. **Air Gap Length**

$$l_g = \frac{\mu_o \times L_x \times I_{max}^2}{B_{max}^2 \times A_c} \times 10^7$$

$$l_g = \frac{4\pi \times 10^{-7} \times 283 \times 10^{-6} \times 3.3^2}{0.25^2 \times 1.61} \times 10^7$$

$$l_g = 3.85 \times 10^{-1}\ mm \approx 0.4\ mm$$

i. **Wire Size**

- **<u>Wire Size when number of split wire (</u>**<u>$d_{w(t)\ split}$</u>**<u>) = 0.4 mm</u>**

  Diameter of Bobbin PQ3230 (D_{bobin1}) = 17 mm = 1.6 cm

  Circumference of Bobin (K_{bobin1}) = **π** × D_{bobin1}

  (K_{bobin1}) = **π** × 1.6 = <u>5.03 cm</u>

  Total Wire Length =
  ($n_{winding}$ × K_{bobin1} × ∑ split) + 40% × ($n_{winding}$ × K_{bobin1} × ∑ split)

  Total Wire Length = (24 × 5.03 × 6) + 40% × (24 × 5.03 × 6)

  Total Wire Length = 724.32 + 289.73 = <u>1014.05 cm</u> **=** <u>10.1 m</u>

1. **High Frequency Transformer Design**

a. **Output Voltage**

$$V_o = V_{in} \times \frac{N_2}{N_1} \times D$$

$$19 = 100 \times \frac{N_2}{N_1} \times 0.4$$

$$\frac{N_2}{N_1} = \frac{\mathbf{19}}{\mathbf{40}}\ ;\ \frac{N_2}{N_1} = \underline{0.475}$$

So, the transformer ratio is N_1 **:** N_2 = <u>40:19</u>

$\frac{N_1}{N_2} = \frac{40}{19} = 2.1$

b. **Numbery of Primary Winding**

$N_{1\ (\text{min})} = \frac{D \times T \times Vin}{2 \times B_{max} \times A_c} \times 10^4$; B_{max} = 0.25 Tesla ; A_c = 1.96 cm^2

$N_{1\ (\text{min})} = \frac{0.4 \times 25\mu \times 100}{2 \times 0.25 \times 1.96} \times 10^4$

$N_{1\ (\text{min})} = \underline{10.204}$

$N_1 = 2 \times N_{1\ (\text{min})}$

$N_1 = 2 \times 10.204$

$N_1 = \underline{20.408} \approx \underline{21}$

c. **Numbery of Secondary Winding**

$N_2 = \text{n} \times N_1$

$N_2 = \frac{19}{40} \times 21 = \underline{9.975} \approx \underline{10}$; n = Winding Ratio

d. **RMS Primary Current**

$I_{1\ (rms)} = \frac{1}{2} \times I_o$

$I_{1\ (rms)} = \frac{19}{40} \times 3$

$I_{1\ (rms)} = \underline{1.425\ \text{A}}$

e. **RMS Secondary Current**

$I_{2\ (rms)} = Io$

$I_{2\ (rms)} = \underline{3\ \text{A}}$

f. **Primary Wire Size**

$d_1 = \sqrt{\frac{4 \times I_{1(rms)}}{\pi \times s}}$; s = 4.5 A/mm^2

$d_1 = \sqrt{\frac{4 \times 1.425}{\pi \times 4.5}} = \underline{0.63}$

g. **Secondary Wire Size**

$d_2 = \sqrt{\frac{4 \times I_{2(rms)}}{\pi \times s}}$; s = 4.5 A/mm^2

$d_2 = \sqrt{\frac{4 \times 3}{\pi \times 4.5}} = \underline{0.92}$

h. **Recalculate when number of split wire ($d_{w\ (L)\ split}$) = 0.4 mm**

a) $d_{w\,(L)\,split} = \sqrt{\frac{4}{\pi} \times q_{w\,(L)\,split}}$

$$0.4 = \sqrt{\frac{4}{\pi} \times q_{w\,(L)\,split}}$$

$$0.4^2 = \frac{4}{\pi} \times q_{w\,(L)\,split}$$

$$q_{w\,(L)\,split} = \frac{\pi}{4} \times 0.16 = 0.125\ mm^2$$

b) $q_{w\,(L)\,split} = \frac{i_{1\,(rms)\,split}}{J}$

$$0.125 = \frac{i_{1\,(rms)\,split}}{4.5}$$

$$i_{1\,(rms)\,split} = 4.5 \text{ x } 0.125$$

$$i_{1\,(rms)\,split} = 0.56 \text{ A}$$

c) $i_{1\,(rms) split} = \frac{i_{1\,(rms)}}{\sum \text{split}}$

$$0.56 = \frac{1.425}{\sum \text{split}}$$

$$\sum \text{split} = \frac{1.425}{0.56}$$

$$\sum \text{split}_P = 2.54 \approx 3\ split$$

- **Recalculate when number of split wire ($d_{w\,(L)\,split}$) = 0.4 mm**

a) $d_{w\,(L)\,split} = \sqrt{\frac{4}{\pi} \times q_{w\,(L)\,split}}$

$$0.4 = \sqrt{\frac{4}{\pi} \times q_{w\,(L)\,split}}$$

$$0.4^2 = \frac{4}{\pi} \times q_{w\,(L)\,split}$$

$$q_{w\,(L)\,split} = \frac{\pi}{4} \times 0.16 = 0.125\ mm^2$$

b) $q_{w\,(L)\,split} = \frac{i_{2\,(rms)\,split}}{J}$

$$0.125 = \frac{i_{2\,(rms)\,split}}{4.5}$$

$$i_{2\,(rms)\,split} = 4.5 \text{ x } 0.125$$

$$i_{2\,(rms)\,split} = 0.56 \text{ A}$$

c) $i_{2\,(rms) split} = \frac{i_{2\,(rms)}}{\sum \text{split}}$

$$0.56 = \frac{3}{\sum \text{split}}$$

$$\sum \text{split} = \frac{3}{0.56}$$

$$\sum \text{split}_P = 5.35 \approx 6\, split$$

i. **Length Of Wire**

Diameter of Bobbin PQ3535 (D_{bobin2}) = 17 mm = 1.7 cm

Circumference of Bobin (K_{bobin2}) = **π** × D_{bobin2}
(K_{bobin2}) = **π** × 1.7 = <u>5.34 cm</u>

$P_p = (N_p \times K_{bobin2} \times \sum \text{split}_p) + 30\%(N_p \times K_{bobin2} \times \sum \text{split}_p)$
$P_p = (\ 20 \times 5.34 \times 3) + 30\%\ (\ 20 \times 5.34 \times 3)$
$P_s =\ 320.4 + 96.12 = 416.52 \text{ cm} \approx 6.4\ m$

$P_p = (N_s \times K_{bobin2} \times \sum \text{split}_s) + 30\%(N_s \times K_{bobin2} \times \sum \text{split}_s)$
$P_p = (\ 10 \times 5.34 \times 6) + 30\%\ (\ 10 \times 5.34 \times 6)$
$P_s =\ 320.4 + 320.7 = 641.1 \text{ cm} \approx 6.4\ m$

j. **Pattern of Winding**

P1S1S2S3 Split -1	P2S4S5S6 Split -2	P3S7S8S9 Split -3	P4S10S11S12 Split -4
P5S13S14S15 Split -5	P6S16S17S18 Split -6		

2. Filter Capasitor Output

$$\frac{\Delta V_O}{V_O} = \frac{1-D}{8 \times L_x \times C_O \times (\ 2f)^2}$$

$$\frac{0.0019}{19} = \frac{1-0.4}{8 \times 0.283 \times 10^{-3} \times C_O \times (\ 2 \times 40k)^2}$$

C_o = <u>41.41 μF</u>

So, for output capacitor has to used 47 <u>μF, 50 V</u>

So, where

ΔV_o = ±0.1% × V_o = 0.0001 x V_o

ΔV_o = 0.0001 × 19 = <u>0.0019 V</u>

- **Snubber Circuit**
  - $V_{off} = V_s$
    $V_{off} = 100$ Volt

  - $I_{in} = \frac{1}{2} I_{in}$

    $I_{in} = I_p$ (Transformator)

    $\frac{V_p}{V_s} = \frac{I_s}{I_p}$

    $\frac{100}{19} = \frac{3}{I_p}$

    I_p = <u>0.57 A</u>

  - $I_{on} = \frac{1}{2} \times 0.57$

    I_{on} = <u>0.285 A</u>

  - $C_{snubber} \approx \frac{I_{on} \times t_{fall}}{2 \times V_{off}}$; t_{fall} = 58 nS (Fall time from IRFP460 datasheet)

    $C_{snubber} \approx \frac{0.285 \times 58n}{2 \times 100}$ = <u>0.8265 pF</u>

    C_{s1} = C_{s2} = <u>0.8265 pF</u>

    So, the capacitor used has a capacity of 1 nF with a voltage of 100 v

  - $R_{snubber} < \frac{DT}{2 \times C_{snubber}}$

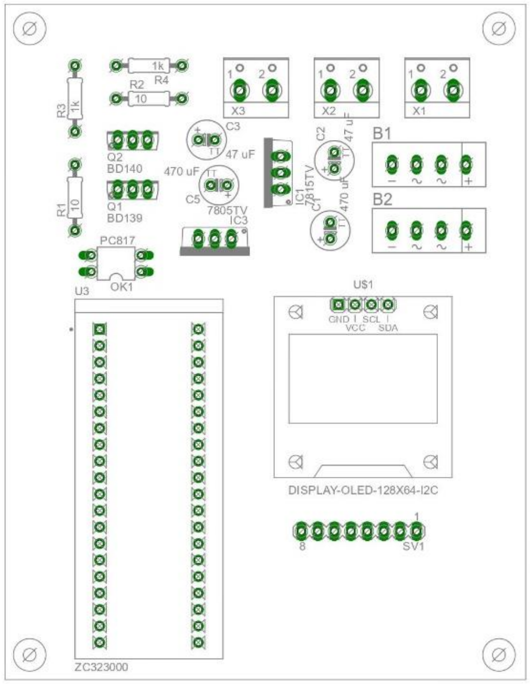
$$R_{snubber} < \frac{0.4 \times 25 \times 10^{-6}}{2 \times 826.5 \times 10^{-9}}$$
$$R_{snubber} < 1550.38\,\Omega$$

so, $R_{snubber}$ value used is $\mathbf{R_{s1}} = \mathbf{R_{s2}} =$ 2 kΩ with a power 10 watt

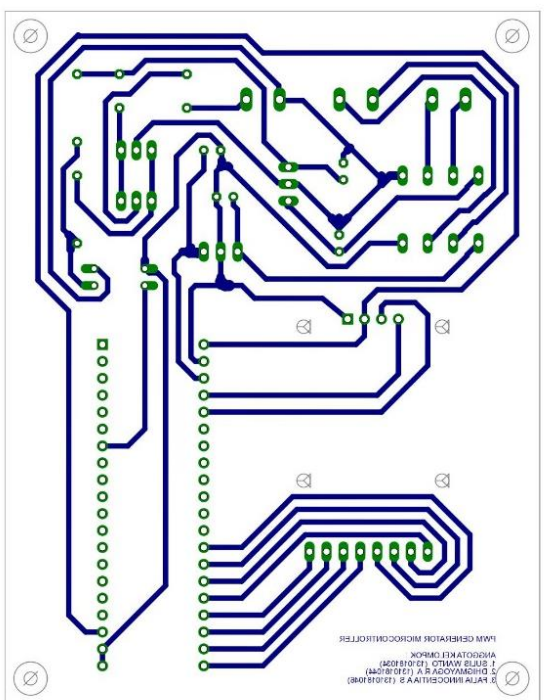
IV. CIRCUIT OF PWM GENERATOR

A. BOARD

a. TOP VIEW



b. BOTTOM VIEW

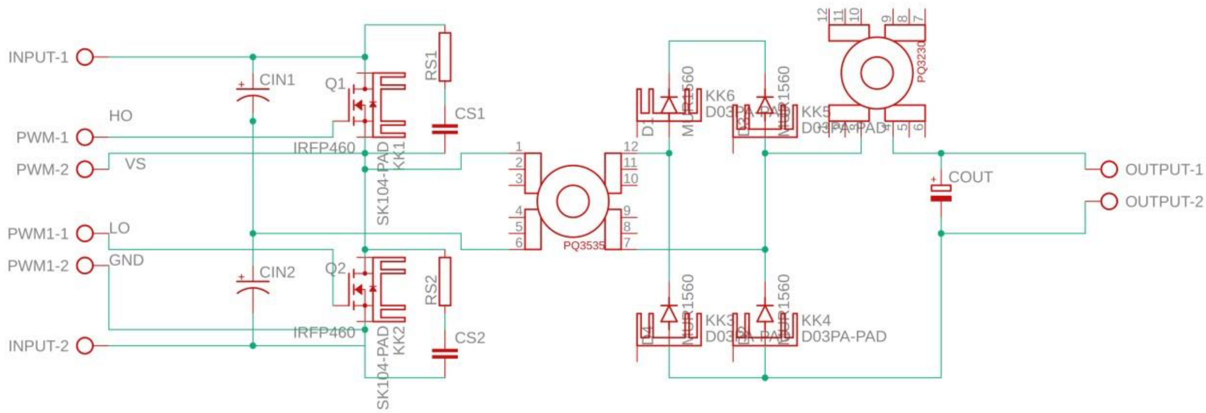


V. MAIN CIRCUIT BOARD (HALFBRIDGE DC-DC CONVERTER)

A. INDIVIDUAL DESIGN

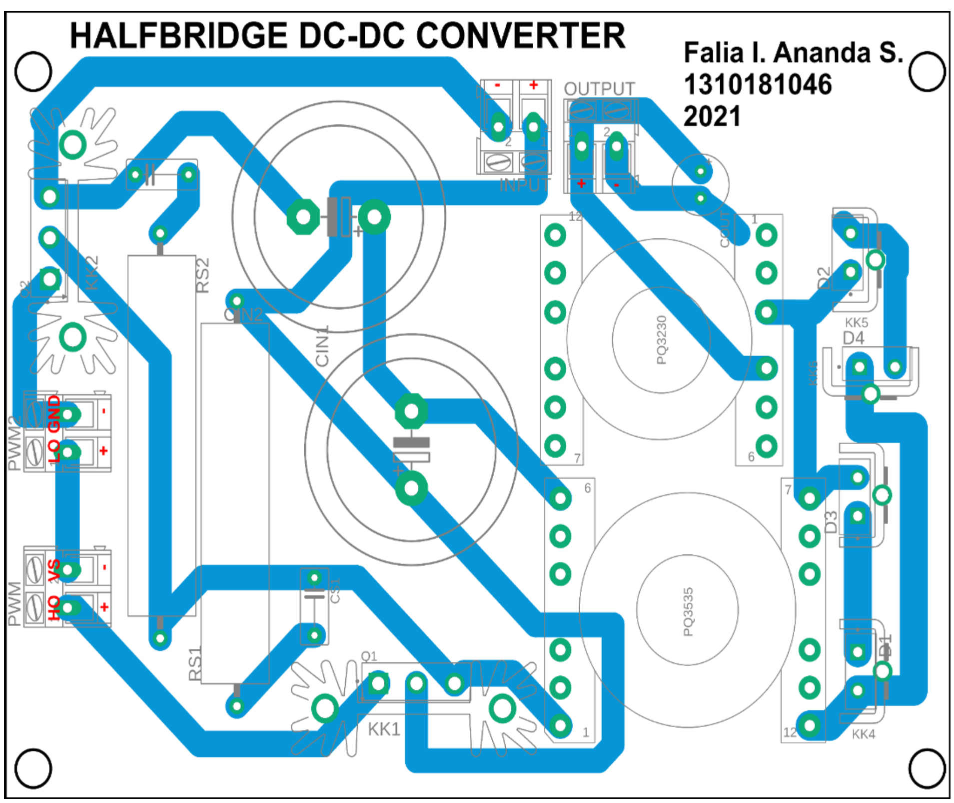
The schematic and main circuit board of Halfbridge DC-DC Converter made on Eagle software.

1. SCHEMATIC

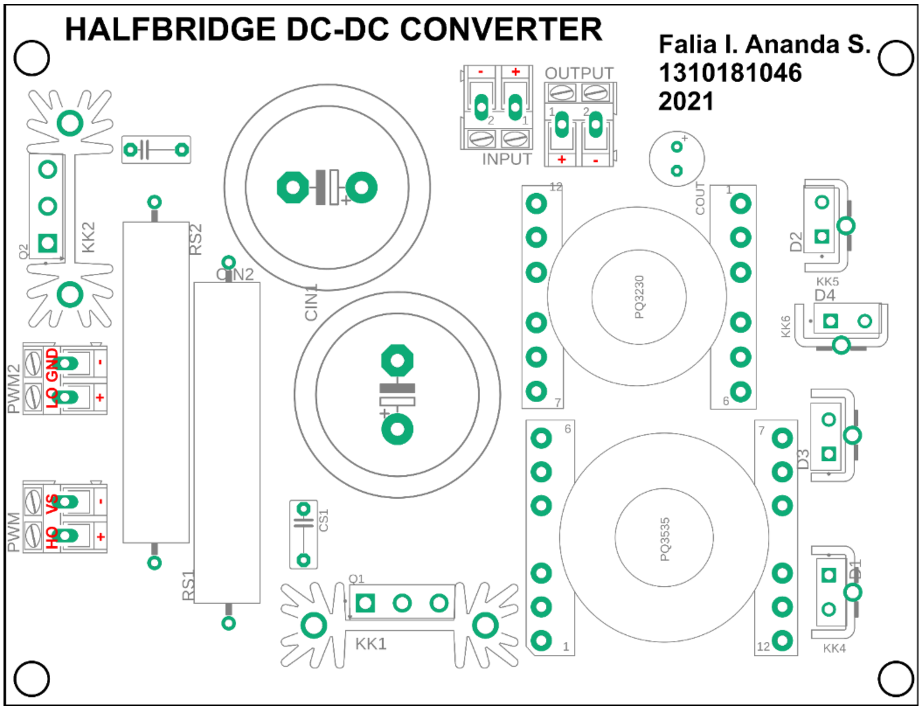


2. BOARD

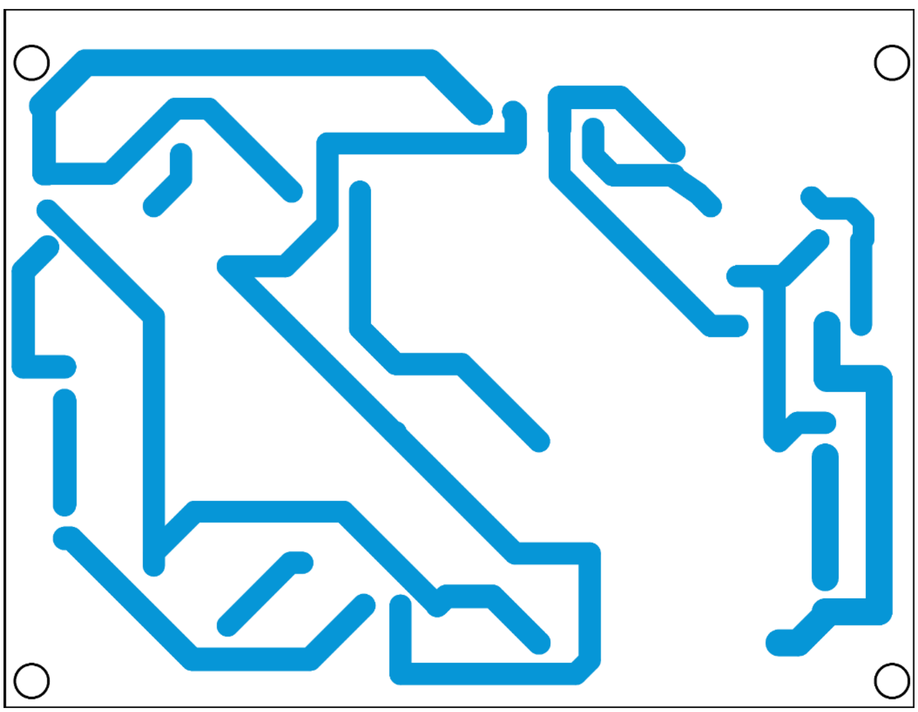
The top view and bottom view of the Halfbridge DC-DC Converter main circuit board. The required polarities and names have been included.



a. TOP VIEW



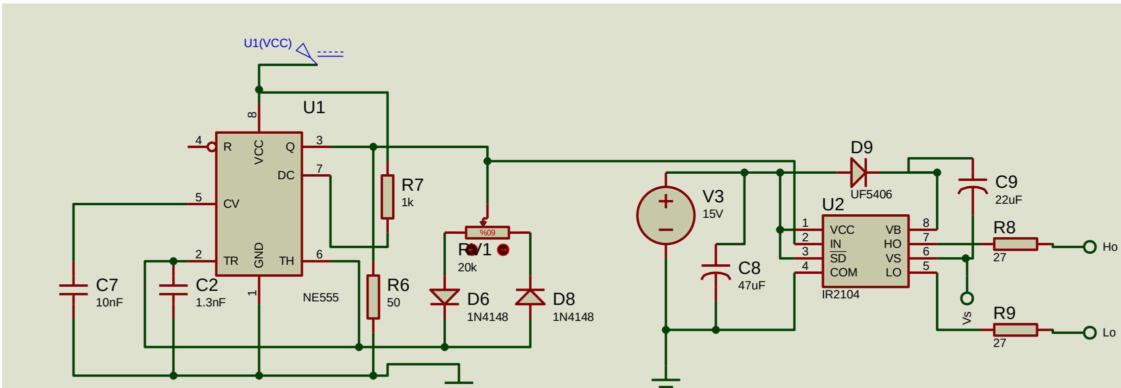
b. BOTTOM VIEW



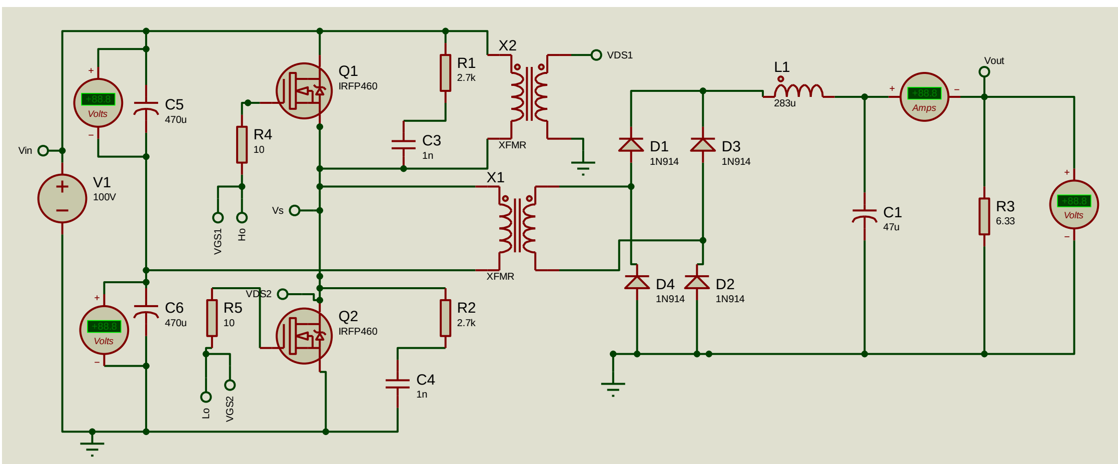
B. DESIGN USING PROTEUS

The simulation of Halfbridge DC-DC Converter has been done by using Proteus Software. The pictures shown in this section are the circuits that has been made in Proteus.

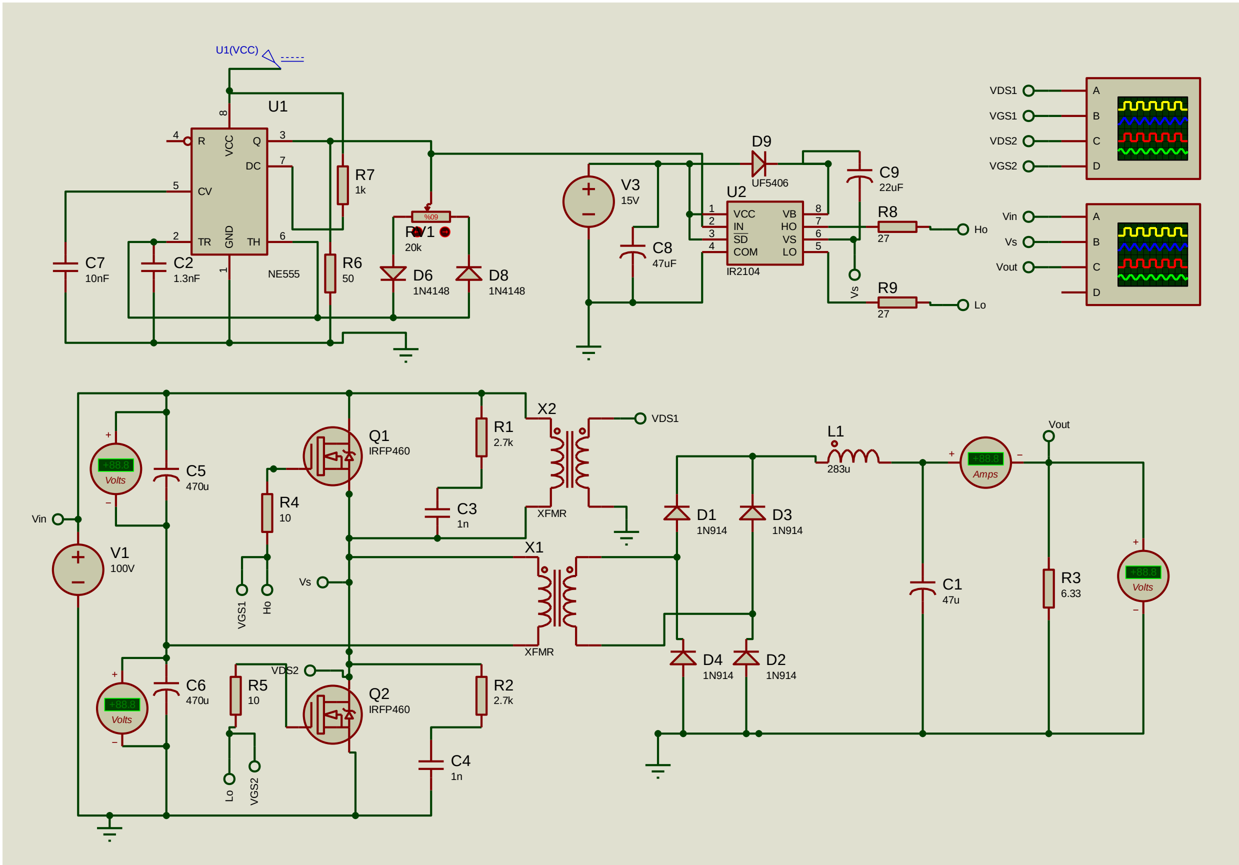
1. **PWM ANALOG**



2. **HALF BRIDGE DC-DC CONVERTER**

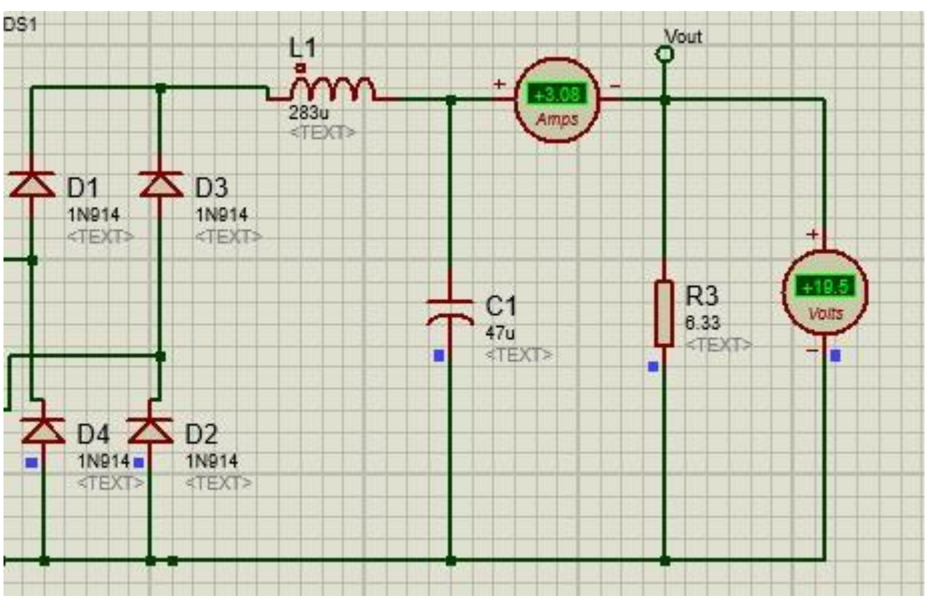


3. **HALF BRIDGE DC-DC CONVERTER WITH PWM ANALOG**
The circuit of the PWM Analog is combined with the Halfbridge DC-DC Converter circuits, where VGS_1 and HO are connected with PWM_1, LO and VGS_2 are connected with PWM_2.



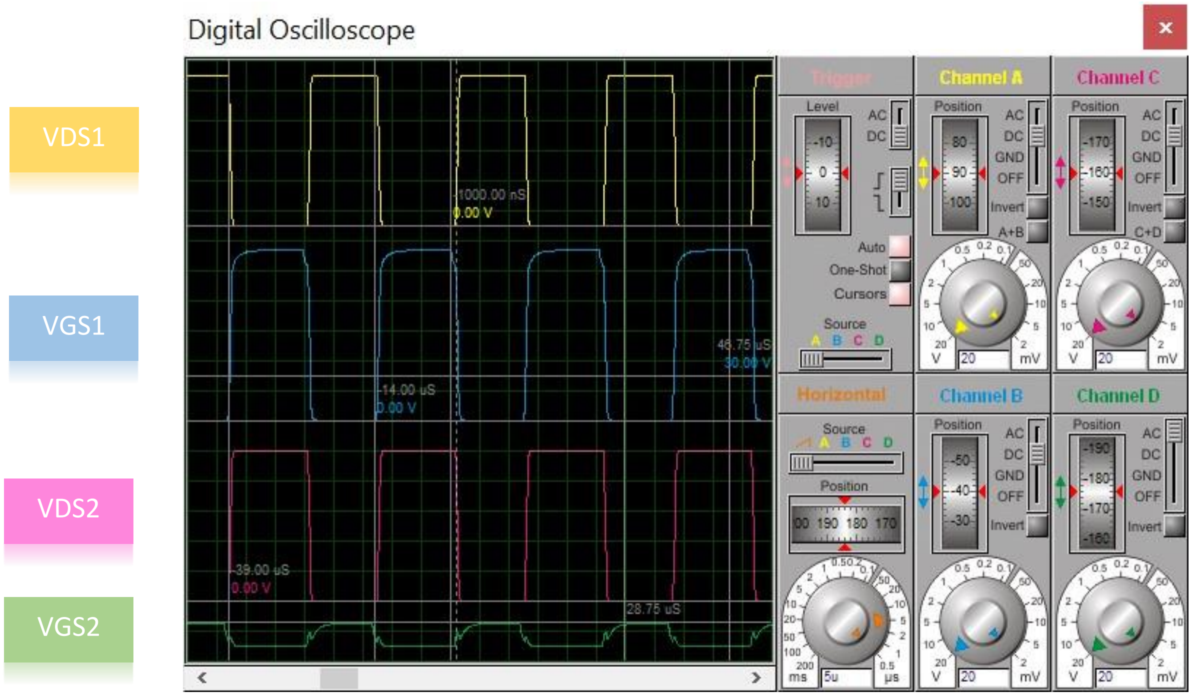
4. SIMULATION TEST RESULT

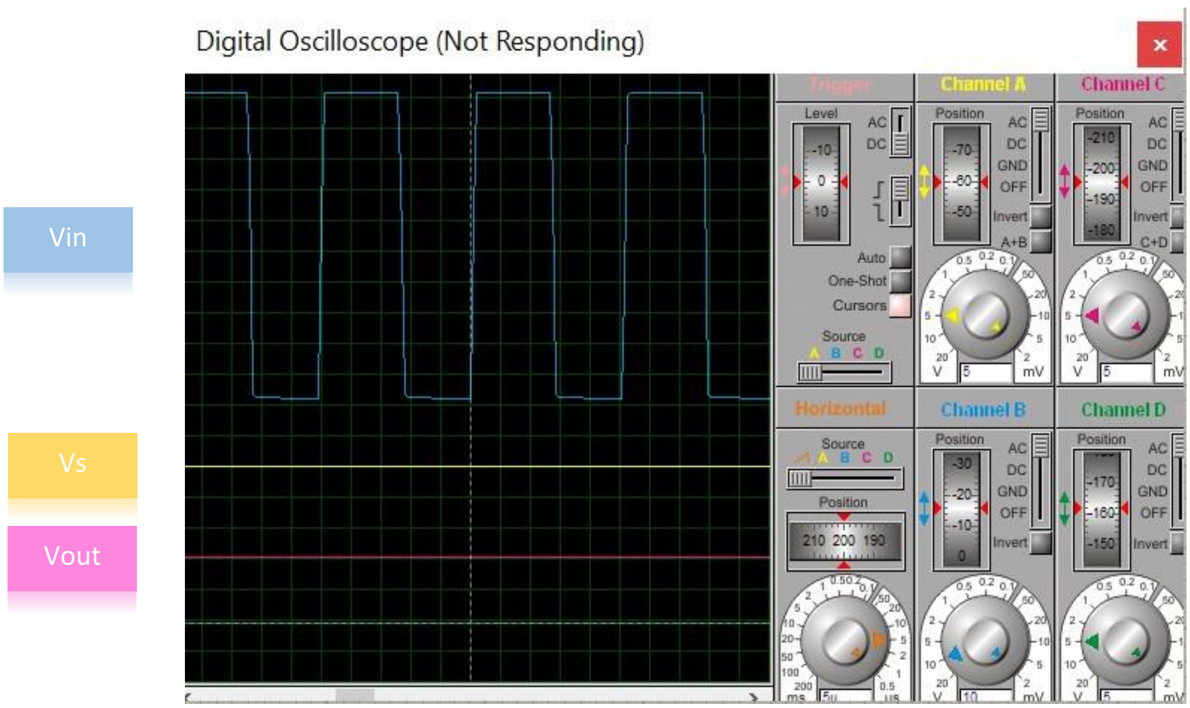
The circuit simulation test has been successfully compiled and could be run without any errors found. The picture below shows the current output and voltage output that are measured by the ampere meter and voltage meter.



5. OUTPUT WAVES

There are 2 oscilloscopes that are being used in this project to see the outputs waves from the circuits. The first oscilloscope shows the output waves of VDS_1, VGS_1, VDS_2, and VGS_2. The second oscilloscope shows the output of Vin, Vs, and $Vout$.





6. ERROR PERCENTAGE CALCULATION

The error percentage calculation has been done to find the differences between the Proteus Simulation of Halfbridge DC-DC Converter output results and the manual calculation work.

No.	Parameter	Manual Calculation	Proteus Simulation	%Error
1	Vo	19 V	19.5 V	2.63%
2	Io	3 A	3.08 A	2.66%

The table shows the comparison between the Proteus Simulation output results and the manual calculation work results. As we can see, the differences between the output results are very small and has the average error percentage of 2.645% (below 3%).

Below are the calculations of the error percentage from the results:

$$\%Error = \left|\frac{Manual\ Calculation - Proteus\ Simulation}{Manual\ Calculation}\right| \times 100$$

$$\%Error\ Vo = \left|\frac{19 - 19.5}{19}\right| \times 100 = 2.63\%$$

$$\%Error\ Io = \left|\frac{3 - 3.08}{3}\right| \times 100 = 2.66\%$$

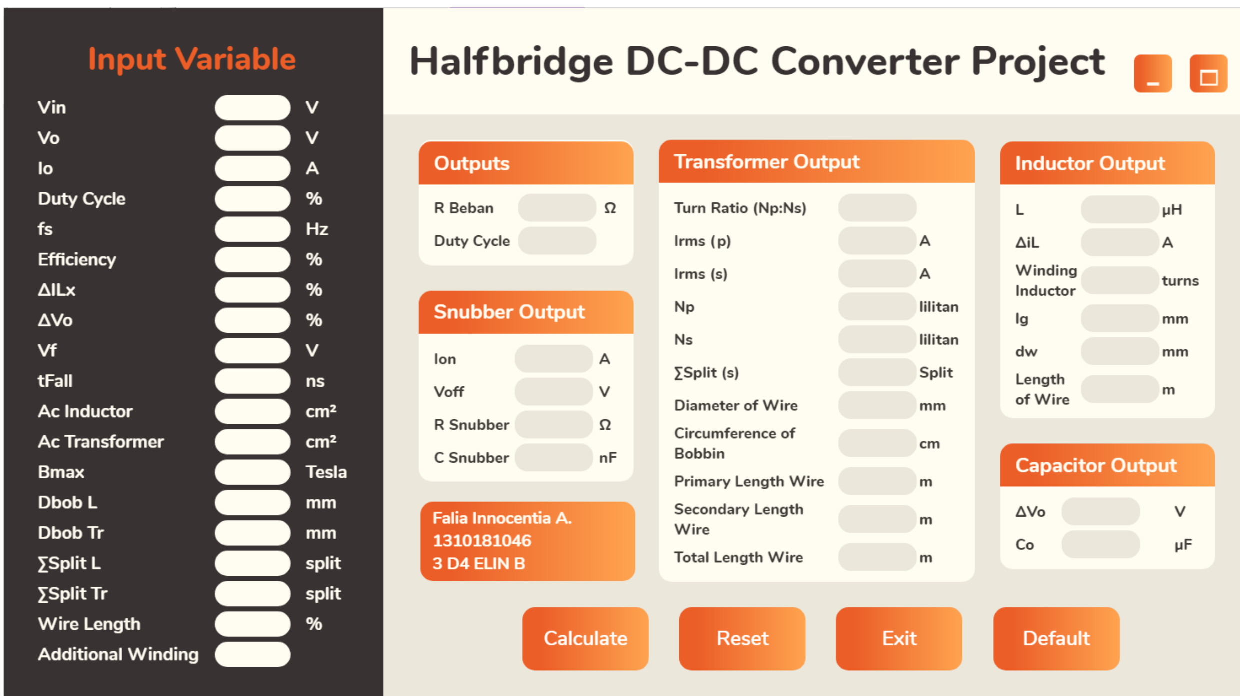
VI. APPLICATION SOFTWARE DESIGN

After making the Halfbridge DC-DC Converter manual calculation work, circuits, and main circuit board, an application software is created with the purpose of creating a Halfbridge DC-DC Converter Calculation Application Software by implementing all of the manual Halfbridge DC-DC Converter calculations that has been done into a program.

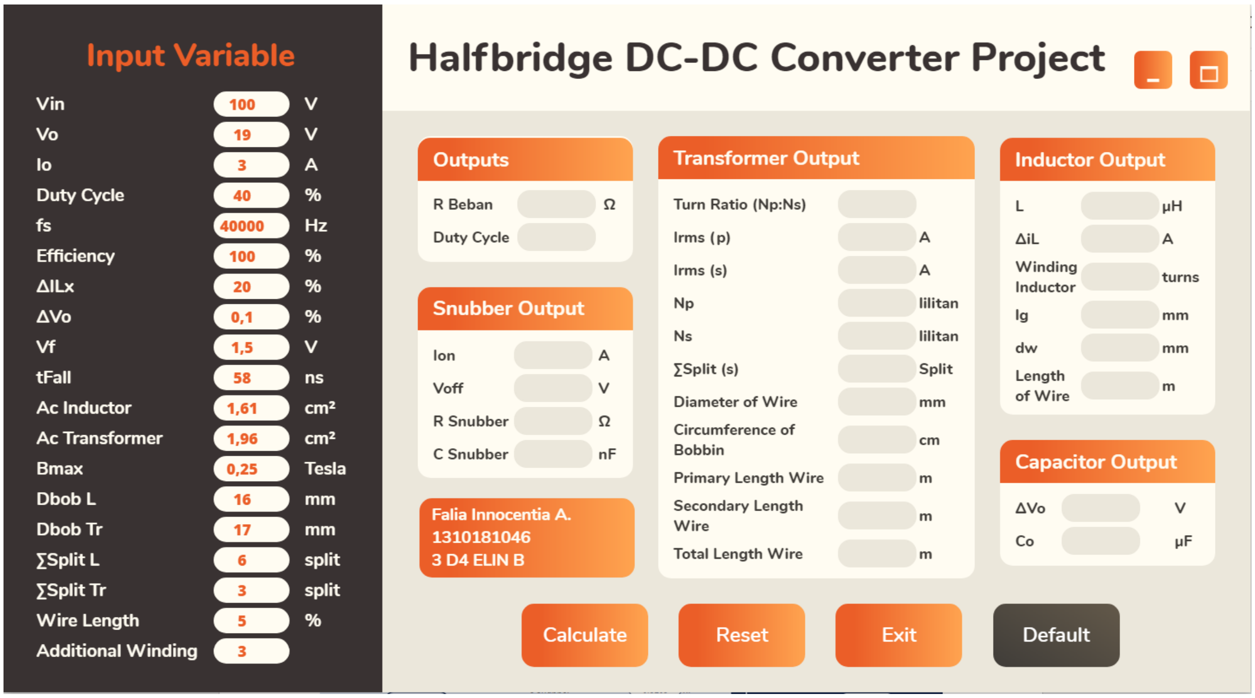
The software that is used to create the Halfbridge DC-DC Converter Calculation software is Electron, which is a framework for building desktop applications using JavaScript, HTML, and CSS.

- **Interface Software Design**

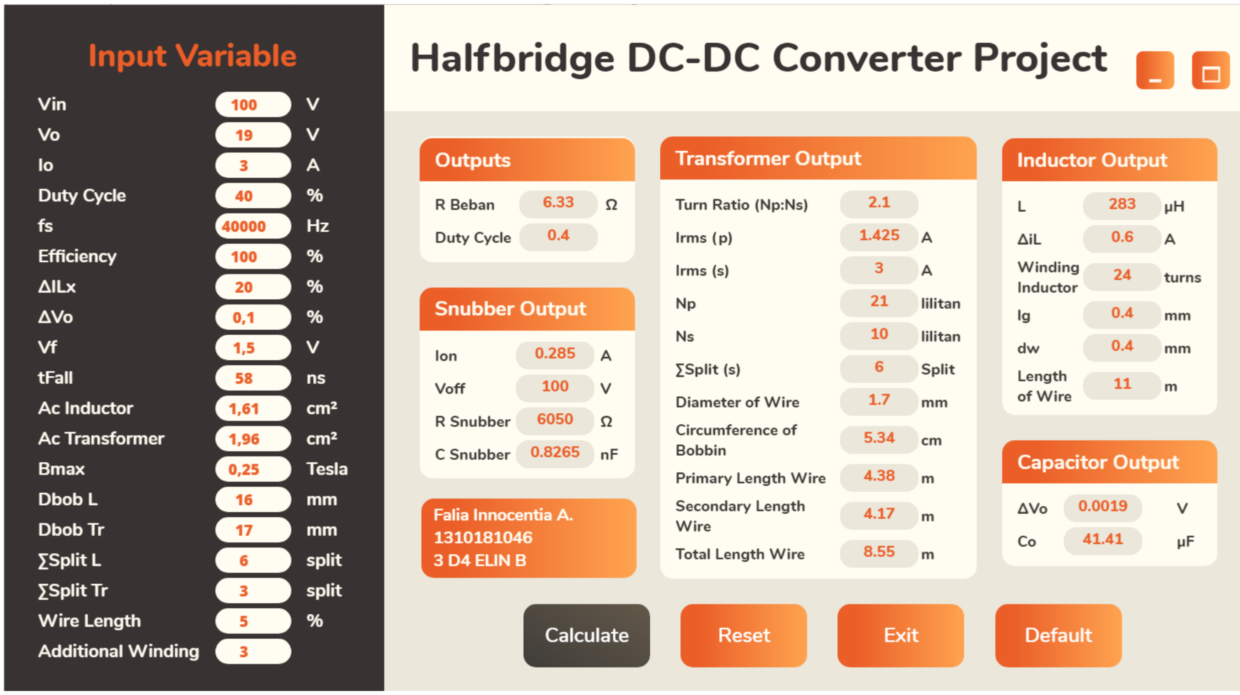
  The interface design of the software is made by using HTML and CSS vanilla. The left side of the interface is the Input Variables. There are 5 outputs (Outputs, Snubber Output, Transformer Output, Inductor Output and Capacitor Output) that are the results of the calculations by inserting the input variables into the required blank input area.



- **Input Default Variable**
  The default button works as an automate inputs into the Input Variables. The input numbers from the default button are from the parameters and the components constant.

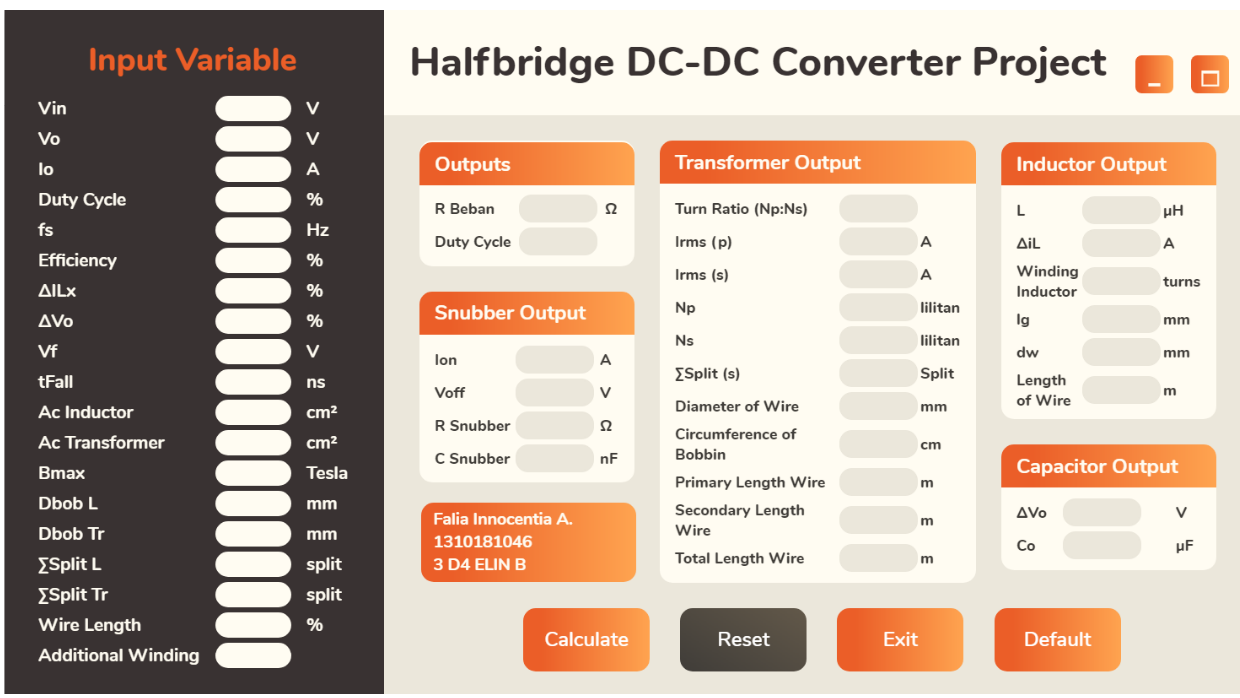


- **Calculation Result**
  The Calculate button shows the calculations results of every main outputs below. The output results have been already set the calculation results to be the exact sum number from the following units by rounding up some of the result calculations to be exactly match with the manual calculation work.



- **Reset**

  The Reset button sets all of the Input Variable blank required input and the results outputs to be back to 0 or none. The previous calculation that has been done will be deleted to count a new calculation from new Input Variables.



Source Code

The programming languages that are used to create this software are HTML, CSS and Javascripts. The main programming language to calculate the Halfbridge DC-DC Converter is Javascripts, which is used to process all the functions, receive the input variables and gives the results outputs of the calculation.

- **Application Window Main Source Code**
  This source code is used to create the new window for the software application, set the width and height, has the main process of creating the new window.

```
const {app, BrowserWindow} = require('electron');
const path = require('path');
const url = require('url');

let win;

function createWindow(){
  win = new BrowserWindow({width: 986, height: 543, icon: __dirname+'/img/icon.pn
g', frame: false});
  win.loadURL(url.format({
    pathname: path.join(__dirname, 'index.html'),
    protocol: 'file:',
    slashes: true
  }));
  win.on('closed', () => {
    win = null;
  });
}

app.on('ready', createWindow);

app.on('window-all-closed', () =>{
  if(process.platform !== 'darwin'){
    app.quit();
  }
});
```

- **Calculation Source Code**
  This source code is the Halfbridge DC-DC Converter Calculation functions that has been converted into the algorithm programming manual function and is used by Javascript.

```
//Tombol reset
```

```
function reset(){
    for(var i = 0; i < document.getElementsByName("input").length; i++){
        document.getElementsByName("input")[i].value="";
    }
    for(var i = 0; i < document.getElementsByClassName("output").length; i++){
        document.getElementsByClassName("output")[i].innerHTML="";
    }
};

//Input default variable dari tombol default
function defaultNum(){
    document.getElementById("Vin").value=100;
    document.getElementById("Vo").value=19;
    document.getElementById("Io").value=3;
    document.getElementById("duty_cycle").value=40;
    document.getElementById("fs").value=40000;
    document.getElementById("Vf").value=1.5;
    document.getElementById("acInductor").value=1.61;
    document.getElementById("acTransformer").value=1.96;
    document.getElementById("Bmax").value=0.25;
    document.getElementById("splitNumberInductor").value=6;
    document.getElementById("splitNumberPrimaryOfTransformer").value=3;
    document.getElementById("Db_L").value=16;
    document.getElementById("Db_T").value=17;
    document.getElementById("tFall").value=58;
    document.getElementById("efficiency").value=100;
    document.getElementById("delta_ilx").value=20;
    document.getElementById("delta_vo").value=0.1;
    document.getElementById("wire_length").value=5;
    document.getElementById("additional_winding").value=3;
};

//START
function jalan(){
    var vo = document.getElementById("Vo").value;
    var io =document.getElementById("Io").value;
    var vin = document.getElementById("Vin").value;
    var fs = document.getElementById("fs").value;
    var vf = document.getElementById("Vf").value;
    var bMax = document.getElementById("Bmax").value;
    var acInductor = document.getElementById("acInductor").value;
    var j = 4.5;
    var splitL = document.getElementById("splitNumberInductor").value;
    var acTr = document.getElementById("acTransformer").value;
```

```
function project(){
    //Kotak Outputs
    //R Beban
    var rBeban = vo/io;
    document.getElementById("r_beban").innerHTML= rBeban.toFixed(2);

    //Duty Cycle
    var dutyCycle = document.getElementById("duty_cycle").value/100;
    document.getElementById("duty_cycle_out").innerHTML=dutyCycle;

    //Turn Ratio N1:N2
    var TR1 = vo/(vin*dutyCycle);

    // Turn Ratio N2:N1
    var TR2 = (vin*dutyCycle)/vo;

    // -------------

    //Kotak Output Snubber
    //Voff
    var voff = vin;
    document.getElementById("Voff").innerHTML=voff;

    //Ion
    var ip = (vo*io)/vin;
    var ion = 0.5*ip;
    document.getElementById("Ion").innerHTML=ion;

    //C Snubber
    var tFall = document.getElementById("tFall").value*0.00000001;
    var cSnubber = ((ion*tFall)/(2*voff))*1000000000;
    document.getElementById("Csnubber").innerHTML=cSnubber;

    //R Snubber
    var T = 1/fs;
    var rSnubber = (dutyCycle*T)/(2*(cSnubber/1000000000));
    document.getElementById("Rsnubber").innerHTML=Math.ceil(rSnubber);

    // -------------

    //Kotak Output Inductor
    var vina = vin/((2*TR2)-(2*vf));
    //Delta ILX
    var deltaILX = (20/100)*io;
```

```
        document.getElementById("delta_il_inductor").innerHTML=deltaILX.toFixed(1
);
        // L
        var L = (1/deltaILX.toFixed(1))*(vina.toFixed(1)-
vo)*(1/(2*fs))*((Number(vo)+Number(2*vf))/(Number(vin)+Number(2*vf)));
        document.getElementById("L").innerHTML=Math.round(L*1000000);
        //Winding Inductor
        var ilAvg = vo/rBeban.toFixed(2);
        var ilMax = (Number(ilAvg)+Number(deltaILX/2)).toFixed(1);
        var n = Math.ceil((L*ilMax*10000)/(bMax*acInductor));
        document.getElementById("winding_inductor").innerHTML=n;
        //dw
        var ilRmst = Math.round(Math.sqrt(Number(ilAvg*ilAvg)+Number(((deltaILX/2
)/Math.sqrt(3))*((deltaILX/2)/Math.sqrt(3)))));
        var ilsplit = ilRmst/splitL;
        //var qwL = (ilRmst/j).toFixed(2);
        var qwL = ilsplit/j;
        var dwL = (Math.sqrt((4/3.14)*qwL)).toFixed(1);
        document.getElementById("dw").innerHTML=dwL;
        //lg (Air Gap)
        var lg = (((4*3.14)*L*(ilMax*ilMax))/((bMax*bMax)*acInductor)).toFixed(1)
;
        document.getElementById("lg").innerHTML=lg;
        //Length of Wire
        var dBob1 = 1.6;
        var kBob1 = (3.14*dBob1).toFixed(2);
        var totalLW = Number(n*kBob1*splitL)+Number(0.4*(n*kBob1*splitL));
        document.getElementById("length_wire").innerHTML=Math.ceil(totalLW/100);

        // ------------

        //Kotak Output Capacitor
        //Delta Vo
        var deltaVo = 0.0001*vo;
        document.getElementById("delta_vo_capacitor").innerHTML=deltaVo;
        //Co
        var co = (vo*(1-dutyCycle))/(8*deltaVo*L*2*fs*2*fs);
        document.getElementById("Co").innerHTML=(co*100000).toFixed(2);

        // ------------

        //Kotak Output Trafo
        //Turn Ratio
        document.getElementById("turn_ratio").innerHTML=(TR2).toFixed(1);
        //NP
```

```
        var N1min = ((dutyCycle*T*vin*10000)/(2*bMax*acTr)).toFixed(3);
        var N1 = Math.ceil(2*N1min);
        document.getElementById("number_of_primary_winding").innerHTML=N1;
        //NS
        var N2 = Math.ceil(TR1*N1);
        document.getElementById("number_of_secondary_winding").innerHTML=N2;
        //Irms (P)
        var i1 = (TR1*io).toFixed(3);
        document.getElementById("rms_primary_current").innerHTML=i1;
        //Irms (S)
        var i2 = io;
        document.getElementById("rms_secondary_current").innerHTML=i2;
        //split (S)
        var dwLT = 0.4;
        var qwT = (3.14/4*dwLT*dwLT).toFixed(3);
        var i1SP = (j*qwT).toFixed(2);
        var sigmaP = Math.ceil(i1/i1SP);
        //document.getElementById("primary_split_value").innerHTML=sigmaP;
        var i2SP = (j*qwT).toFixed(2);
        var sigmaS = Math.ceil(i2/i2SP);
        document.getElementById("secondary_split_value").innerHTML=sigmaS;
        //Diameter of Wire
        var dBob2 = 1.7;
        document.getElementById("diameter_of_wire").innerHTML=dBob2;
        var kBob2 = (3.14*dBob2).toFixed(2);
        document.getElementById("circumference_bobbin").innerHTML=kBob2;
        //Primary Length of Wire
        var pp = Math.ceil(Number(N1*kBob2*sigmaP)+Number(0.3*(N1*kBob2*sigmaP)))
/100;
        document.getElementById("primary_length_wire").innerHTML=pp;
        //Secondary Length of Wire
        var ps = Math.ceil(Number(N2*kBob2*sigmaS)+Number(0.3*(N2*kBob2*sigmaS)))
/100;
        document.getElementById("secondary_length_wire").innerHTML=ps;
        //total length wire
        var total = pp+ps;
        document.getElementById("total_length_wire").innerHTML=total;
    }

    project();
}

function remind(){
    document.getElementById("reminder").style.display="block";
       document.getElementById("cover").style.display="block";
```

```
};

function closeRemind(){
    document.getElementById("reminder").style.display="none";
    document.getElementById("cover").style.display="none";
}
```

- **HTML Source Code**
  The HTML source code is the fundamental part of the interface design of the calculation software.

```
<!DOCTYPE html>
<html lang="en">
<head id="head">
  <meta charset="UTF-8">
  <meta name="viewport" content="width=device-width, initial-scale=1.0">
  <meta http-equiv="X-UA-Compatible" content="ie=edge">
  <title id="title">Half Bridge DC-DC Converter</title>
  <link rel="stylesheet" href="res/css/index.css">
</head>
<body id="body">
<main>
  <div class="inputTable">
    <form>
        <table>
            <tr>
                <td><label for="Vin">Vin</label></td>
                <td><input type="number" id="Vin" name="input"></td>
                <td><p>V</p></td>
            </tr>
            <tr>
                <td><label for="Vo">Vo</label></td>
                <td><input type="number" id="Vo" name="input"></td>
                <td><p>V</p></td>
            </tr>
            <tr>
                <td><label for="Io">Io</label></td>
                <td><input type="number" id="Io" name="input"></td>
                <td><p>A</p></td>
            </tr>
            <tr>
                <td><label for="duty_cycle">Duty Cycle</label></td>
                <td><input type="number" id="duty_cycle" name="input"></td>
                <td><p>%</p></td>
```

```
            </tr>
            <tr>
                <td><label for="fs">fs</label></td>
                <td><input type="number" id="fs" name="input"></td>
                <td><p>Hz</p></td>
            </tr>
            <tr>
                <td><label for="efficiency">Efficiency</label></td>
                <td><input type="number" id="efficiency" name="input"></td>
                <td><p>%</p></td>
            </tr>
            <tr>
                <td><label for="delta_ilx">ΔILx</label></td>
                <td><input type="number" id="delta_ilx" name="input"></td>
                <td><p>%</p></td>
            </tr>
            <tr>
                <td><label for="delta_vo">ΔVo</label></td>
                <td><input type="number" id="delta_vo" name="input"></td>
                <td><p>%</p></td>
            </tr>
            <tr>
                <td><label for="Vf">Vf</label></td>
                <td><input type="number" id="Vf" name="input"></td>
                <td><p>V</p></td>
            </tr>
            <tr>
                <td><label for="tFall">tFall</label></td>
                <td><input type="number" id="tFall" name="input"></td>
                <td><p>ns</p></td>
            </tr>
            <tr>
                <td><label for="acInductor">Ac Inductor</label></td>
                <td><input type="number" id="acInductor" name="input"></td>
                <td><p>cm²</p></td>
            </tr>
            <tr>
                <td><label for="acTransformer">Ac Transformer</label></td>
                <td><input type="number" id="acTransformer" name="input"></td>
                <td><p>cm²</p></td>
            </tr>
            <tr>
                <td><label for="Bmax">Bmax</label></td>
                <td><input type="number" id="Bmax" name="input"></td>
                <td><p>Tesla</p></td>
```

```
            </tr>
            <tr>
                <td><label for="Db_L">Dbob L</label></td>
                <td><input type="number" id="Db_L" name="input"></td>
                <td><p>mm</p></td>
            </tr>
            <tr>
                <td><label for="Db_T">Dbob Tr</label></td>
                <td><input type="number" id="Db_T" name="input"></td>
                <td><p>mm</p></td>
            </tr>
            <tr>
                <td><label for="splitNumberInductor">ΣSplit L</label></td>
                <td><input type="number" id="splitNumberInductor" name="input"></
td>
                <td><p>split</p></td>
            </tr>
            <tr>
                <td><label for="splitNumberPrimaryOfTransformer">ΣSplit Tr</label
></td>
                <td><input type="number" id="splitNumberPrimaryOfTransformer" nam
e="input"></td>
                <td><p>split</p></td>
            </tr>
            <tr>
                <td><label for="wire_length">Wire Length</label></td>
                <td><input type="number" id="wire_length" name="input"></td>
                <td><p>%</p></td>
            </tr>
            <tr>
                <td><label for="additional_winding">Additional Winding</label></t
d>
                <td><input type="number" id="additional_winding" name="input"></t
d>
            </tr>
        </table>
    </form>
</div>
<div class="mainTitle">Halfbridge DC-DC Converter Project</div>

<div class="output_parameter">
    <div class="outputs">
        <form>
            <table>
                <tr>
```

```html
                    <td><p>R Beban</p></td>
                    <td><p id="r_beban" class="output"></p></td>
                    <td>Ω</td>
                </tr>
                <tr>
                    <td><p>Duty Cycle</p></td>
                    <td><p id="duty_cycle_out" class="output"></p></td>
                </tr>
            </table>
        </form>
    </div>
    <div class="snubberParameter">
        <form>
            <table>
                <tr>
                    <td><p>Ion</p></td>
                    <td><p id="Ion" class="output"></p></td>
                    <td>A</td>
                </tr>
                <tr>
                    <td><p>Voff</p></td>
                    <td><p id="Voff" class="output"></p></td>
                    <td>V</td>
                </tr>
                <tr>
                    <td><p>R Snubber</p></td>
                    <td><p id="Rsnubber" class="output"></p></td>
                    <td>Ω</td>
                </tr>
                <tr>
                    <td><p>C Snubber</p></td>
                    <td><p id="Csnubber" class="output"></p></td>
                    <td>nF</td>
                </tr>
            </table>
        </form>
    </div>
    <div class="transformer">
        <form>
            <table>
                <tr>
                    <td><p>Turn Ratio (Np:Ns)</p></td>
                    <td><p id="turn_ratio" class="output"></p></td>
                    <td> </td>
                </tr>
```

```
                <tr>
                    <td><p>Irms (p)</p></td>
                    <td><p id="rms_primary_current" class="output"></p></td>
                    <td>A</td>
                </tr>
                <tr>
                    <td><p>Irms (s)</p></td>
                    <td><p id="rms_secondary_current" class="output"></p></td>
                    <td>A</td>
                </tr>
                <tr>
                    <td><p>Np</p></td>
                    <td><p id="number_of_primary_winding" class="output"></p></td
>

                    <td>lilitan</td>
                </tr>
                <tr>
                    <td><p>Ns</p></td>
                    <td><p id="number_of_secondary_winding" class="output"></p></
td>

                    <td>lilitan</td>
                </tr>
                <tr>
                    <td><p>ΣSplit (s)</p></td>
                    <td><p id="secondary_split_value" class="output"></p></td>
                    <td>Split</td>
                </tr>
                <tr>
                    <td><p>Diameter of Wire</p></td>
                    <td><p id="diameter_of_wire" class="output"></p></td>
                    <td>mm</td>
                </tr>
                <tr>
                    <td><p>Circumference of Bobbin</p></td>
                    <td><p id="circumference_bobbin" class="output"></p></td>
                    <td>cm</td>
                </tr>
                <tr>
                    <td><p>Primary Length Wire</p></td>
                    <td><p id="primary_length_wire" class="output"></p></td>
                    <td>m</td>
                </tr>
                <tr>
                    <td><p>Secondary Length Wire</p></td>
                    <td><p id="secondary_length_wire" class="output"></p></td>
```

```html
                <td>m</td>
            </tr>
            <tr>
                <td><p>Total Length Wire</p></td>
                <td><p id="total_length_wire" class="output"></p></td>
                <td>m</td>
            </tr>
        </table>
    </form>
</div>
<div class="inductor">
    <form>
        <table>
            <tr>
                <td><p>L</p></td>
                <td><p id="L" class="output"></p></td>
                <td>µH</td>
            </tr>
            <tr>
                <td><p>ΔiL</p></td>
                <td><p id="delta_il_inductor" class="output"></p></td>
                <td>A</td>
            </tr>
            <tr>
                <td><p>Winding Inductor</p></td>
                <td><p id="winding_inductor" class="output"></p></td>
                <td>turns</td>
            </tr>
            <tr>
                <td><p>lg</p></td>
                <td><p id="lg" class="output"></p></td>
                <td>mm</td>
            </tr>
            <tr>
                <td><p>dw</p></td>
                <td><p id="dw" class="output"></p></td>
                <td>mm</td>
            </tr>
            <tr>
                <td><p>Length of Wire</p></td>
                <td><p id="length_wire" class="output"></p></td>
                <td>m</td>
            </tr>
        </table>
    </form>
```

```html
    </div>
    <div class="capacitor">
        <form>
            <table>
                <tr>
                    <td><p>ΔVo</p></td>
                    <td><p id="delta_vo_capacitor" class="output"></p></td>
                    <td>V</td>
                </tr>
                <tr>
                    <td><p>Co</p></td>
                    <td><p id="Co" class="output"></p></td>
                    <td>µF</td>
                </tr>
            </table>
        </form>
    </div>
</div>
<div class="tombol">
    <button id="calculate" onclick="jalan()">
        Calculate</button>
    <button onclick="reset()">
        Reset</button>
    <button id="close">
        Exit</button>
    <button class="tombol_default" onclick="defaultNum()">Default</button>
</div>
<div class="input_maintitle">Input Variable</div>

<div class="output_titles">
    <p class="output_titles_output"></p>
    <p class="output_titles_snubber"></p>
    <p class="output_titles_transformer"></p>
    <p class="output_titles_inductor"></p>
    <p class="output_titles_capacitor"></p>
</div>

<div class="output_titles_text">
    <p class="output_titles_output_text">Outputs</p>
    <p class="output_titles_snubber_text">Snubber Output</p>
    <p class="output_titles_transformer_text">Transformer Output</p>
    <p class="output_titles_inductor_text">Inductor Output</p>
    <p class="output_titles_capacitor_text">Capacitor Output</p>
</div>
```

```html
<div id="reminder">
    <p>Harap isi Input Variable!</p>
    <button onclick="closeRemind()">OK</button>
</div>

<div id="cover"></div>

<div class="profile">
    <p>Falia Innocentia A.</p>
    <p>1310181046</p>
    <p>3 D4 ELIN B</p>
</div>

</main>
<div class="togglers">
    <button id="minimize">▁</button>
    <button id="maximize">□</button>
</div>
</body>
  <script src="res/js/aligner.js"></script>
  <script src="res/js/menuHandler.js"></script>
  <script src="res/js/init.js"></script>
  <script src="res/js/project.js"></script>
</html>
```

- **CSS Source Code**
  The CSS source code purpose is to beautify the fundamental HTML interface design to be more user friendly and can be used easily by all users.

```css
*{
    padding: 0;
    margin: 0;
}
body{
    width: 985px;
    height: 406px;
    background-color: #EBE7DB;
    font-family: 'Nunito', sans-serif;
}
.mainTitle{
    position: relative;
    z-index: 0;
    margin-top: -543px;
```

```css
    margin-left: 300px;
    padding-left: 20px;
    padding-top: 20px;
    padding-bottom: 20px;
    padding-right: 50px;
    font-size: 32px;
    font-weight: 800;
    color: #393232;
    background-color: #FFFCF2;
    -webkit-app-region : drag;
}
.input_maintitle{
    font-size: 25px;
    font-weight: 800;
    margin-top: -500px;
    margin-left: 66px;
    color: #eb5e28;
}
.title{
    font-size: 16px;
    font-weight: 700;
}

/* INPUT TABLE STYLING */
.inputTable{
    position: inherit;
    background-color: #393232;
    height: 493px;
    width: 300px;
    padding-top: 50px;
}
.inputTable table{
    border: none;
    width: fit-content;
    padding-left: 15px;
    padding-right: 15px;
    padding-bottom: 10px;
    color: #fffcf2;
    font-size: 14px;
    font-weight: 700;
    margin-left: 10px;
    margin-top: 16px;
}
.inputTable table tr{
    height: 22px;
```

```css
}
.inputTable table tr td:nth-child(1){
    padding-right: 10px;
}

table input{
    color: #eb5e28;
    font-weight: 800;
    font-size: 12px;
    font-family: 'Open Sans', sans-serif;
     width: 60px;
     height: 20px;
     outline: none;
     text-align: center;
     border: none;
     background-color: #FFFCF2;
     border-radius: 10px;
}

.inputTable tr td:nth-child(3) p{
    padding-left: 10px;
}

.output_parameter table tr td:nth-child(2) p{
    width: 60px;
    height: 20px;
    border: 1px solid #EBE7DB;
    border-radius: 10px;
    text-align: center;
    background-color: #EBE7DB;
    color: #eb5e28;
}
.output_parameter table{
    font-size: 12px;
    background-color: #FFFCF2;
    border: none;
    border-radius: 10px;
    font-size: 12px;
    font-weight: 800;
    padding-left: 10px;
    padding-right: 10px;
    padding-top: 40px;
    padding-bottom: 5px;
    width: fit-content;
    color: #403d39;
```

```
}
.output_parameter table tr{
    height: 24px;
}
.output_parameter .outputs table{
    width: 170px;
}
.output_parameter .snubberParameter table{
    width: 170px;
}
.output_parameter .inductor table{
    width: 170px;
}
.output_parameter .capacitor table{
    width: 170px;
}
.output_parameter .transformer table{
    width: 250px;
}

.output_parameter{
    margin-left: 8px;
    margin-top: 20px;
}
.outputs{
    margin-left: 320px;
    margin-top: 10px;
}
.snubberParameter{
    margin-left: 320px;
    margin-top: 20px;
}
.transformer{
    margin-left: 510px;
    margin-top: -270px;
}
.inductor{
    margin-left: 780px;
    margin-top: -348px;
}
.capacitor{
    margin-left: 780px;
    margin-top: 20px;
}
```

```css
/*BUTTONS*/
.tombol{
    margin-left: 390px;
    margin-top: 30px;
}
.tombol button{
    border: none;
    background: rgb(255,164,80);
    background: linear-
gradient(270deg, rgba(255,164,80,1) 0%, rgba(235,94,40,1) 86%);
    width: 100px;
    height: 50px;
    border-radius: 10px;
    color: #fff;
    font-family: 'Nunito', sans-serif;
    font-weight: 600;
    font-size: 16px;
    margin-left: 20px;
}
.tombol button:hover{
    cursor: pointer;
    background: rgb(64,61,57);
    background: linear-
gradient(32deg, rgba(64,61,57,1) 0%, rgba(99,89,74,1) 100%);
}

/*Bagian background judul-judul output*/
.output_titles{
    margin-top: 48px;
}
.output_titles p{
    width: 170px;
    height: 34px;
    border-top-left-radius: 10px;
    border-top-right-radius: 10px;
    background: rgb(255,164,80);
    background: linear-
gradient(270deg, rgba(255,164,80,1) 0%, rgba(235,94,40,1) 86%);
}
.output_titles_output{
    margin-left: 328px;
    margin-top: 25px;
}
.output_titles_snubber{
    margin-left: 328px;
```

```css
    margin-top: 84px;
}
.output_titles_transformer{
    margin-left: 518px;
    margin-top: -153px;
    padding-right: 80px;
}
.output_titles_inductor{
    margin-left: 788px;
    margin-top: -33px;
}
.output_titles_capacitor{
    margin-left: 788px;
    margin-top: 205px;
}

/*Bagian text judul-judul output*/
.output_titles_text p{
    color: #FFFCF2;
    font-size: 16px;
    font-weight: 700;
}
.output_titles_output_text{
    margin-left: 340px;
    margin-top: -266px;
}
.output_titles_snubber_text{
    margin-left: 340px;
    margin-top: 96px;
}
.output_titles_transformer_text{
    margin-left: 530px;
    margin-top: -140px;
}
.output_titles_inductor_text{
    margin-left: 800px;
    margin-top: -20px;
}
.output_titles_capacitor_text{
    margin-left: 800px;
    margin-top: 217px;
}

#reminder{
    width: 250px;
```

```
    background: rgb(255,164,80);
    background: linear-
gradient(270deg, rgba(255,164,80,1) 0%, rgba(235,94,40,1) 86%);
    height: 100px;
    border-radius: 15px;
    position: absolute;
    margin-left: 330px;
    margin-top: -20px;
    display: none;
    z-index: 2;
}
#reminder p {
    text-align: center;
    padding-top: 20px;
    font-size: 16px;
    font-weight: 700;
    color: #FFFCF2;
}
#reminder button{
    width: 50px;
    height: 30px;
    border-radius: 10px;
    border: none;
    color: #393232;
    font-weight: 700;
    background-color: #FFFCF2;
    margin-left: 100px;
    margin-top: 10px;
}
#reminder button:hover{
    cursor: pointer;
    background: rgb(64,61,57);
    background: linear-
gradient(32deg, rgba(64,61,57,1) 0%, rgba(99,89,74,1) 100%);
    color: #FFFCF2;
}
#cover{
    width: 985px;
    height: 543px;
    background-color: black;
    margin-top: -370px;
    position: relative;
    z-index: 1;
    display: none;
    opacity: 0.5;
```

```css
}

.profile{
    background: rgb(255,164,80);
    background: linear-
gradient(270deg, rgba(255,164,80,1) 0%, rgba(235,94,40,1) 86%);
    margin-left: 329px;
    font-size: 13px;
    font-weight: 700;
    color: #fffcf2;
    width: 160px;
    height: 59px;
    border-radius: 10px;
    margin-top: 18px;
    padding-left: 10px;
    padding-top: 4px;
}
.togglers button{
    background: rgb(255,164,80);
    background: linear-
gradient(270deg, rgba(255,164,80,1) 0%, rgba(235,94,40,1) 86%);
    width: 30px;
    height: 30px;
    border: none;
    color: #FFFCF2;
    font-size: 18px;
    border-radius: 5px;
    margin-right: 10px;
}
.togglers button:hover{
    cursor: pointer;
    background: rgb(64,61,57);
    background: linear-
gradient(32deg, rgba(64,61,57,1) 0%, rgba(99,89,74,1) 100%);
}
.togglers{
    position: absolute;
    margin-top: -416px;
    margin-left: 894px;
    z-index: 1;
    -webkit-app-region : no-drag;
}
button{
    outline: none;
}
```

- **Menu Handle Source Code**
  This source code is functioned to be the window togglers consisting of the exit, minimize and maximize. Since the window of the calculation software is frameless (has no default windows togglers), an exit button is made and has the same function as the window exit toggle.

```
const $ = require('jquery');
const {remote} = require('electron');
var win = remote.getCurrentWindow();

$('#minimize').click(function(){
  win.minimize();
});

$('#close').click(function(){
  win.close();
});

$('#maximize').click(function() {
  if(win.isMaximized()){
      win.unmaximize();
  }else{
      win.maximize();
  }
  console.log(win.isMaximized());
});
```

VII. ERROR PERCENTAGE

The results from the error percentage calculation of the Electron Calculation Source Code software has the average of **0% Error Percentage**, which means that none errors are found. Below here is the following Error Percentage Function:

$$\%\boldsymbol{Error} = \left|\frac{\boldsymbol{Program\ Calculation - Manual\ Calculation}}{\boldsymbol{Manual\ Calculation}}\right| \times \mathbf{100}\%$$

Here are the calculations of the Error Percentage from the outputs of Electron Calculation Code and the Manual Calculation of Halfbridge DC-DC Converter Work:

1. **Turn Ratio**

   Manual Calculation = 2.1

   Software Calculation = 2.1

   $$\% \text{ Error} = \left|\frac{2.1-2.1}{2.1}\right| \times 100\%$$

   % Error = 0 %

2. $\boldsymbol{I_{rms(p)}}$

   Manual Calculation = 1.425 A

   Software Calculation = 1.425 A

   $$\% \text{ Error} = \left|\frac{1.425-1.425}{1.425}\right| \times 100\%$$

   % Error = 0 %

3. $\boldsymbol{I_{rms(s)}}$

   Manual Calculation = 3 A

   Software Calculation = 3 A

   $$\% \text{ Error} = \left|\frac{3-3}{3}\right| \times 100\%$$

   % Error = 0 %

4. $\boldsymbol{N_p}$

   Manual Calculation = 21 liltan

   Software Calculation = 21 lilitan

   $$\% \text{ Error} = \left|\frac{21-21}{21}\right| \times 100\%$$

   % Error = 0 %

5. $\boldsymbol{N_s}$

   Manual Calculation = 10 lilitan

   Software Calculation = 10 lilitan

   $$\% \text{ Error} = \left|\frac{10-10}{10}\right| \times 100\%$$

   % Error = 0 %

6. **ΣSplit**

   Manual Calculation = 6 split

   Software Calculation = 6 split

   $$\% \text{ Error} = \left|\frac{6-6}{6}\right| \times 100\%$$

% Error = 0 %

7. Diameter of Wire

Manual Calculation = 1.7 mm

Software Calculation = 1.7 mm

$$\% \text{ Error} = \left|\frac{1.7 - 1.7}{1.7}\right| \times 100\%$$

% Error = 0 %

8. Circumference of Bobbin

Manual Calculation = 5.34 cm

Software Calculation = 5.34 cm

$$\% \text{ Error} = \left|\frac{5.34 - 5.34}{5.34}\right| \times 100\%$$

% Error = 0 %

9. Primary Length Wire

Manual Calculation = 4.38 m

Software Calculation = 4.38 m

$$\% \text{ Error} = \left|\frac{4.38 - 4.38}{4.38}\right| \times 100\%$$

% Error = 0 %

10. Secondary Length Wire

Manual Calculation = 4.17 m

Software Calculation = 4.17 m

$$\% \text{ Error} = \left|\frac{4.17 - 4.17}{4.17}\right| \times 100\%$$

% Error = 0 %

11. Wire Length Total

Manual Calculation = 8.55 m

Software Calculation = 8.55 m

$$\% \text{ Error} = \left|\frac{8.55 - 8.55}{8.55}\right| \times 100\%$$

% Error = 0 %

12. I_{on}

Manual Calculation = 0.285 A

Software Calculation = 0.285 A

$$\% \text{ Error} = \left|\frac{0.285 - 0.285}{0.285}\right| \times 100\%$$

% Error = 0 %

13. V_{off}

Manual Calculation = 100 V

Software Calculation = 100 V

$$\% \text{ Error} = \left|\frac{100 - 100}{100}\right| \times 100\%$$

% Error = 0 %

14. $R_{snubber}$

Manual Calculation = 6050 Ω

Software Calculation = 6050 Ω

$$\% \text{ Error} = \left|\frac{6050 - 6050}{6050}\right| \times 100\%$$

% Error = 0 %

15. $C_{snubber}$

Manual Calculation = $0.8265\ nF$

Software Calculation = $0.8265\ nF$

$$\% \text{ Error} = \left|\frac{0.8265 - 0.8265}{0.8265}\right| \times 100\%$$

% Error = 0 %

16. R_{beban}

Manual Calculation = 6.3 Ω

Software Calculation = 6.3 Ω

$$\% \text{ Error} = \left|\frac{6.3 - 6.3}{6.3}\right| \times 100\%$$

% Error = 0 %

17. Duty Cycle (D)

Manual Calculation = 0.4

Software Calculation = 0.4

$$\% \text{ Error} = \left|\frac{0.4 - 0.4}{0.4}\right| \times 100\%$$

% Error = 0 %

18. Inductor (L)

Manual Calculation = $283\ \mu H$

Software Calculation = $283\ \mu H$

$$\%\ \text{Error} = \left|\frac{283-283}{283}\right| \times 100\%$$

$\%$ Error = $0\ \%$

19. $\boldsymbol{\Delta i_L}$

Manual Calculation = $0.6\ A$

Software Calculation = $0.6\ A$

$$\%\ \text{Error} = \left|\frac{0.6-0.6}{0.6}\right| \times 100\%$$

$\%$ Error = $0\ \%$

20. Winding Inductor (n)

Manual Calculation = 24

Software Calculation = 24

$$\%\ \text{Error} = \left|\frac{24-24}{24}\right| \times 100\%$$

$\%$ Error = $0\ \%$

21. Air Gap ($\boldsymbol{l_g}$)

Manual Calculation = $0.4\ mm$

Software Calculation = $0.4\ mm$

$$\%\ \text{Error} = \left|\frac{0.4-0.4}{0.4}\right| \times 100\%$$

$\%$ Error = $0\ \%$

22. $\boldsymbol{d_w}$

Manual Calculation = $0.4\ mm$

Software Calculation = $0.4\ mm$

$$\%\ \text{Error} = \left|\frac{0.4-0.4}{0.4}\right| \times 100\%$$

$\%$ Error = $0\ \%$

23. Length of Wire

Manual Calculation = $11\ m$

Software Calculation = $11\ m$

$$\%\ \text{Error} = \left|\frac{11-11}{11}\right| \times 100\%$$

$\%$ Error = $0\ \%$

24. $\boldsymbol{\Delta V_o}$

Manual Calculation = $0.0019\ V$

Software Calculation = $0.0019\ V$

$$\% \text{ Error} = \left|\frac{0.0019 - 0.0019}{0.0019}\right| \times 100\%$$

% Error = 0 %

25. C$_o$

Manual Calculation = $41.41\ \mu F$

Software Calculation = $41.41\ \mu F$

$$\% \text{ Error} = \left|\frac{41.41 - 41.41}{41.41}\right| \times 100\%$$

% Error = 0 %

VIII. TABLE DATA OF MANUAL AND SOFTWARE CALCULATION

No.	Parameter Name	Kategori	Values		Deviasi	Units	Error (%)
			Manual Calculation	Apps Calculation			
1.	R Beban	Outputs	6.33	6.33	0	Ohm	0
2.	Duty Cycle		0.4	0.4	0	%	0
3.	Ion	Snubber Output	0.285	0.285	0	A	0
4.	Voff		100	100	0	V	0
5.	R Snubber		6050	6050	0	Ohm	0
6.	C Snubber		0.8265	0.8265	0	nF	0
7.	Turn Ratio (Np:Ns)	Transformer Output	2.1	2.1	0		0
8.	Irms (p)		1.425	1.425	0	A	0
9.	Irms (s)		3	3	0	A	0
10.	Np		21	21	0	Lilitan	0
11.	Ns		10	10	0	Lilitan	0
12.	ΣSplit		6	6	0	Split	0
13.	Diameter of Wire		1.7	1.7	0	mm	0
14.	Circumference of Bobbin		5.34	5.34	0	cm	0
15.	Primary Length Wire		4.38	4.38	0	m	0
16.	Secondary Length Wire		4.17	4.17	0	m	0
17.	Total Length Wire		8.55	8.55	0	m	0
18.	L		283	283	0	µH	0

19.	ΔiL	Inductor Output	0.6	0.6	0	A	0
20.	Winding Inductor		24	24	0	Turns	0
21.	Air Gap (lg)		0.4	0.4	0	mm	0
22.	dw		0.4	0.4	0.52	mm	0
23.	Length of Wire		11	11	0	m	0
24.	ΔVo	Capacitor Output	0.0019	0.0019	0	V	0
25.	Co		41.41	41.41	0	μF	0

The table shows the output results comparation from the Halfbridge DC-DC Converter Calculation Software and Halfbridge DC-DC Converter Calculation Manual Work and the error percentage between them. As we can wee that the results from Halfbridge DC-DC Converter Calculation Software has the exact results as the Manual Calculation Work so that the error percentages of the calculation code are 0%.

IX. CONCLUSION

Some conclusions that can be drawn from this report are as follows:

1. The comparison between the Proteus Simulation output results and the manual calculation work results are very small and has the average error percentage of 2.645% (below 3%).
2. From the source code, there are no average error percentage (0% error percentage results) found from the Halfbridge DC-DC Converter Calculation Code, which means that the calculation source code is working very well and is the same as the manual Halfbridge DC-DC Converter Manual Calculation Work.
3. The result calculation of the Halfbridge DC-DC Converter Calculation software has the same result of the Halfbridge DC-DC Converter Manual Calculation Work.
4. Both the Proteus Simulation and the Calculation Software of Halfbridge DC-DC Converter can be run successfully.

X. REFERENCES

1. W. Phetphimoon and K. Bhumkittipich, "Modeling and simulation of bidirectional half bridge dc-dc converter," 2016 13th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON), 2016, pp. 1-6, doi: 10.1109/ECTICon.2016.7561475.
2. Hart, Daniel W, Power Electronics, New York: The McGraw-Hill, Inc, 2011
3. Phetphimoon, Wasan & Bhumkittipich, Krischonme. (2016). Modeling and simulation of bidirectional half bridge dc-dc converter. 1-6. 10.1109/ECTICon.2016.7561475.
4. Deng, S.. “Control And Topology Improvements In Half-bridge Dc-dc Converters.” (2005).

XI. ATTACHMENT

All of the components datasheets are included below this page.

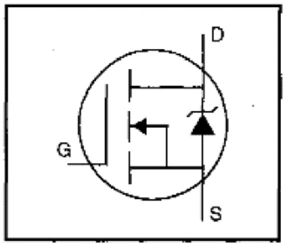
International
IOR Rectifier

PD-9.512B

IRFP460

HEXFET® Power MOSFET

- Dynamic dv/dt Rating
- Repetitive Avalanche Rated
- Isolated Central Mounting Hole
- Fast Switching
- Ease of Paralleling
- Simple Drive Requirements



$V_{DSS} = 500V$

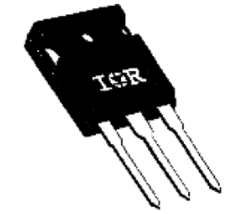
$R_{DS(on)} = 0.27\Omega$

$I_D = 20A$

Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

The TO-247 package is preferred for commercial–industrial applications where higher power levels preclude the use of TO-220 devices. The TO-247 is similar but superior to the earlier TO-218 package because of its isolated mounting hole. It also provides greater creepage distance between pins to meet the requirements of most safety specifications.



TO-247AC

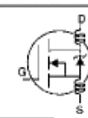
Absolute Maximum Ratings

	Parameter	Max.	Units
I_D @ $T_C = 25°C$	Continuous Drain Current, V_{GS} @ 10 V	20	A
I_D @ $T_C = 100°C$	Continuous Drain Current, V_{GS} @ 10 V	13	
I_{DM}	Pulsed Drain Current ①	80	
P_D @ $T_C = 25°C$	Power Dissipation	280	W
	Linear Derating Factor	2.2	W/°C
V_{GS}	Gate-to-Source Voltage	±20	V
E_{AS}	Single Pulse Avalanche Energy ②	960	mJ
I_{AR}	Avalanche Current ①	20	A
E_{AR}	Repetitive Avalanche Energy ①	28	mJ
dv/dt	Peak Diode Recovery dv/dt ③	3.5	V/ns
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +150	°C
	Soldering Temperature, for 10 seconds	300 (1.6mm from case)	
	Mounting Torque, 6-32 or M3 screw	10 lbf•in (1.1 N•m)	

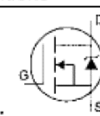
Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	—	—	0.45	°C/W
$R_{\theta CS}$	Case-to-Sink, Flat, Greased Surface	—	0.24	—	
$R_{\theta JA}$	Junction-to-Ambient	—	—	40	

Electrical Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$V_{(BR)DSS}$	Drain-to-Source Breakdown Voltage	500	—	—	V	V_{GS}=0V, I_D= 250μA
$\Delta V_{(BR)DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	0.63	—	V/°C	Reference to 25°C, I_D= 1mA
$R_{DS(on)}$	Static Drain-to-Source On-Resistance	—	—	0.27	Ω	V_{GS}=10V, I_D=12A ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D= 250μA
g_{fs}	Forward Transconductance	13	—	—	S	V_{DS}=50V, I_D=12A ④
I_{DSS}	Drain-to-Source Leakage Current	—	—	25	μA	V_{DS}=500V, V_{GS}=0V
		—	—	250		V_{DS}=400V, V_{GS}=0V, T_J=125°C
I_{GSS}	Gate-to-Source Forward Leakage	—	—	100	nA	V_{GS}=20V
	Gate-to-Source Reverse Leakage	—	—	-100		V_{GS}=-20V
Q_g	Total Gate Charge	—	—	210	nC	I_D=20A
Q_{gs}	Gate-to-Source Charge	—	—	29		V_{DS}=400V
Q_{gd}	Gate-to-Drain ("Miller") Charge	—	—	110		V_{GS}=10V See Fig. 6 and 13 ④
$t_{d(on)}$	Turn-On Delay Time	—	18	—	ns	V_{DD}=250V
t_r	Rise Time	—	59	—		I_D=20A
$t_{d(off)}$	Turn-Off Delay Time	—	110	—		R_G=4.3Ω
t_f	Fall Time	—	58	—		R_D=13Ω See Figure 10 ④
L_D	Internal Drain Inductance	—	5.0	—	nH	Between lead, 6 mm (0.25in.) from package and center of die contact 
L_S	Internal Source Inductance	—	13	—		
C_{iss}	Input Capacitance	—	4200	—	pF	V_{GS}=0V
C_{oss}	Output Capacitance	—	870	—		V_{DS}= 25V
C_{rss}	Reverse Transfer Capacitance	—	350	—		f=1.0MHz See Figure 5

Source-Drain Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	20	A	MOSFET symbol showing the integral reverse p-n junction diode. 
I_{SM}	Pulsed Source Current (Body Diode) ①	—	—	80		
V_{SD}	Diode Forward Voltage	—	—	1.8	V	T_J=25°C, I_S=20A, V_{GS}=0V ④
t_{rr}	Reverse Recovery Time	—	570	860	ns	T_J=25°C, I_F=20A
Q_{rr}	Reverse Recovery Charge	—	5.7	8.6	μC	di/dt=100A/μs ④
t_{on}	Forward Turn-On Time	Intrinsic turn-on time is neglegible (turn-on is dominated by L_S+L_D)				

Notes:

① Repetitive rating; pulse width limited by max. junction temperature (See Figure 11)

② V_{DD}=50V, starting T_J=25°C, L=4.3mH R_G=25Ω, I_{AS}=20A (See Figure 12)

③ I_{SD}≤20A, di/dt≤160A/μs, V_{DD}≤$V_{(BR)DSS}$, T_J≤150°C

④ Pulse width ≤ 300 μs; duty cycle ≤2%.

DIGITRON SEMICONDUCTORS

MUR1505-MUR1560 **15A SCHOTTKY RECTIFIER**

MAXIMUM RATINGS

Rating	Symbol	MUR								Unit
		1505	1510	1515	1520	1530	1540	1550	1560	
Peak repetitive reverse voltage **Working peak reverse voltage** **DC blocking voltage**	V_{RRM} V_{RWM} V_R	50	100	150	200	300	400	500	600	V
Average rectified forward current (Rated V_R)	$I_{F(AV)}$	15 @ T_C = 150°C						15 @ T_C = 145°C		A
Peak repetitive forward current (Rated V_R, square wave, 20 kHz)	I_{FRM}	30 @ T_C = 150°C						30 @ T_C = 145°C		A
Non repetitive peak surge current (Surge applied at rated load conditions, halfwave, single phase, 60Hz)	I_{FSM}	200				150				A
Operating and storage junction temperature range	T_J, T_{stg}	-65 to +175								°C
Maximum thermal resistance Junction to case	$R_{\theta JC}$	1.5								°C/W

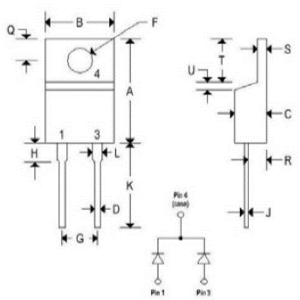
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Parameter	Symbol	MUR								Unit
		1505	1510	1515	1520	1530	1540	1550	1560	
Maximum forward voltage drop [1] (I_F = 15A, T_C = 150°C) (I_F = 15A, T_C = 25°C)	V_F	0.85 1.05				1.12 1.25		1.20 1.50		V
Maximum DC reverse current [1] (Rated dc voltage, T_C = 150°C) (Rated dc voltage, T_C = 25°C)	I_R	500 10						1000 10		µA
Maximum reverse recovery time (I_F = 1.0A, di/dt = 50A/µs)	t_{rr}	35				60				ns

Note 1: Pulse test: Pulse width = 300µs, duty cycle = 2.0%.

MECHANICAL CHARACTERISTICS

Case	TO-220AC
Marking	Alpha-numeric
Pin out	See below



	TO-220AC			
	Inches		Millimeters	
	Min	Max	Min	Max
A	0.595	0.620	15.110	15.750
B	0.380	0.405	9.650	10.290
C	0.160	0.190	4.060	4.820
D	0.142	0.147	3.610	3.730
F	0.142	0.147	3.610	3.730
G	0.190	0.210	4.830	5.330
H	0.110	0.130	2.790	3.300
J	0.018	0.025	0.460	0.640
K	0.500	0.562	12.700	14.270
L	0.045	0.050	1.140	1.270
Q	0.100	0.120	2.540	3.040
R	0.080	0.110	2.040	2.790
S	0.045	0.055	1.140	1.390
T	0.235	0.255	5.970	6.480
U	0.030	0.050	0.760	1.270

144 Market Street
Kenilworth NJ 07033 USA

phone +1.908.245-7200
fax +1.908.245-0555

sales@digitroncorp.com
www.digitroncorp.com

Rev. 20121205

Electrolytic Capacitors

GLR Series

Features:

- Material : Aluminium.
- Low ESR.
- GLR series aluminium electrolytic capacitors are high reliable with low impedance, low ESR and guaranteed 2,000 hours at 105°C.
- Suitable for switching power and automobile industry.

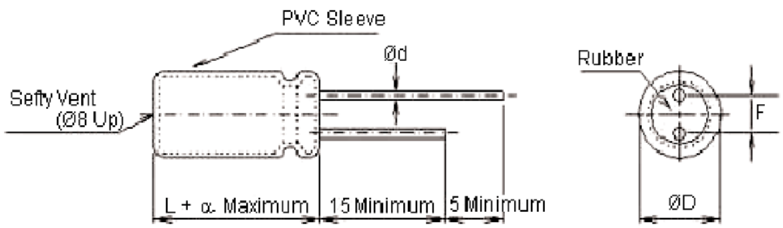
Specification Table

<table>
<tr><th>No.</th><th>Item</th><th>Performance</th></tr>
<tr><td>1</td><td>Operating Temperature Range</td><td>-55 to +105°C</td></tr>
<tr><td>2</td><td>Rated Working Voltage Range</td><td>10 - 100 V dc</td></tr>
<tr><td>3</td><td>Nominal Capacitance Range</td><td>0.47 - 4,700 µF</td></tr>
<tr><td>4</td><td>Capacitance Tolerance</td><td>±20% (at +20°C, 120 Hz)</td></tr>
<tr><td>5</td><td>Leakage Current</td><td>I ≤ 0.01 CV or 2 (µA) after two mins.
Application of rated working voltage at +20°C</td></tr>
<tr><td>6</td><td>Dissipation Factor
(tan δ)
(120 Hz / +20°C)</td><td><table>
<tr><th>Working Voltage (V)</th><td>10</td><td>16</td><td>25</td><td>35</td><td>50</td><td>100</td></tr>
<tr><th>tan δ Max.</th><td>0.12</td><td>0.1</td><td>0.08</td><td>0.07</td><td>0.06</td><td>0.05</td></tr>
</table></td></tr>
<tr><td>7</td><td>Characteristics at
Low Temperature
(Stability at 120 Hz)</td><td><table>
<tr><th>Working Voltage (V)</th><td>10</td><td>16</td><td>25</td><td>35</td><td>50</td><td>100</td></tr>
<tr><th>-25°C / +25°C</th><td>3</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td></tr>
<tr><th>-55°C / +25°C</th><td>4</td><td>3</td><td>3</td><td>3</td><td>3</td><td>4</td></tr>
</table></td></tr>
<tr><td>8</td><td>High Temperature
Loading</td><td>After 5,000 hours application of DC rated working voltage at +105°C,
The capacitor shall meet the following limits:
Post test requirements at +20°C.<table>
<tr><td>Leakage current</td><td>≤ the initial specified value</td></tr>
<tr><td>Capacitance change</td><td>≤ ±15% of initial measured value</td></tr>
<tr><td>Dissipation factor (tan δ)</td><td>≤ 150% of initial specified value</td></tr>
</table></td></tr>
<tr><td>9</td><td>Shelf Life</td><td>After storage for 1,000 hours at +105°C with no voltage applied.
Post test requirements at +20°C same limits as high temperature loading.</td></tr>
<tr><td>10</td><td>Solvent Proof</td><td>This capacitor can withstand circuit-board cleaning within 5 mins.
dipped in Freon TE,TES, at 40ºC (ultrasonic also permitted) or in the steam of these cleaners.</td></tr>
</table>

Electrolytic Capacitors

GLR Series

Diagram of Dimensions



ØD (+ 0.5 Maximum)	10	16
F (±0.5)	5	7.5
Ød (±0.02)	0.6	0.8

Dimensions : Millimetres

Case Size Table ØD × L (mm)

<table>
<tr><th>W V (SV)
µF</th><th>10
(13)</th><th>16
(20)</th><th>25
(32)</th><th>35
(44)</th><th>50
(63)</th><th>100
(125)</th></tr>
<tr><td>0.47</td><td>-</td><td>-</td><td>-</td><td>-</td><td rowspan="6">5 × 11</td><td rowspan="3">6.3 × 11</td></tr>
<tr><td>1</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>2.2</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>3.3</td><td>-</td><td>-</td><td>-</td><td>-</td><td rowspan="2">8 × 11</td></tr>
<tr><td>4.7</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>10</td><td>-</td><td>-</td><td>-</td><td>5 × 11</td><td>10 × 13</td></tr>
<tr><td>22</td><td>-</td><td>-</td><td>5 × 11</td><td rowspan="3">6.3 × 11</td><td>6.3 × 11</td><td>10 × 16</td></tr>
<tr><td>33</td><td>-</td><td>5 × 11</td><td rowspan="2">6.3 × 11</td><td>8 × 11</td><td>10 × 21</td></tr>
<tr><td>47</td><td>5 × 11</td><td>6.3 × 11</td><td rowspan="2">8 × 16</td><td>10 × 26</td></tr>
<tr><td>68</td><td rowspan="4">8 × 16</td><td rowspan="3">8 × 16</td><td rowspan="2">8 × 16</td><td rowspan="2">8 × 16</td><td>13 × 26</td></tr>
<tr><td>100</td><td>10 × 13</td><td>13 × 32</td></tr>
<tr><td>220</td><td>10 × 13</td><td>10 × 21</td><td>10 × 26</td><td>16 × 36</td></tr>
<tr><td>330</td><td>10 × 13</td><td>10 × 21</td><td>10 × 26</td><td>13 × 26</td><td>18 × 42</td></tr>
<tr><td>470</td><td>10 × 13</td><td>10 × 21</td><td>10 × 26</td><td>13 × 26</td><td>13 × 32</td><td>-</td></tr>
<tr><td>680</td><td rowspan="2">10 × 21</td><td>10 × 26</td><td>13 × 26</td><td>13 × 32</td><td>13 × 42</td><td>-</td></tr>
<tr><td>1,000</td><td>13 × 26</td><td>13 × 32</td><td>13 × 42</td><td>16 × 42</td><td>-</td></tr>
<tr><td>2,200</td><td>13 × 26</td><td>13 × 32</td><td>13 × 42</td><td>16 × 42</td><td>-</td><td>-</td></tr>
<tr><td>3,300</td><td>13 × 25</td><td>13 × 42</td><td>16 × 42</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>4,700</td><td>16 × 32</td><td>16 × 42</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
</table>

Dimensions : Millimetres

Aluminum Electrolytic Capacitors Power Ripple Miniature Snap-In

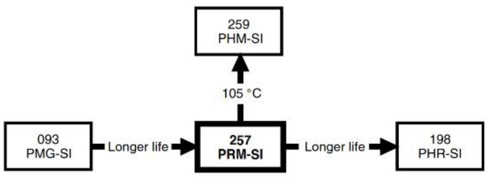


Fig. 1

FEATURES

- Up to 500 V
- Useful life: 5000 h at 85 °C
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Large types, very small dimensions, cylindrical aluminum case, insulated with a blue sleeve
- Keyed polarity version available
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free
RoHS
COMPLIANT

APPLICATIONS

- General purpose, industrial and audio / video systems
- Smoothing and filtering
- Standard and switched mode power supplies

MARKING

The capacitors are marked (where possible) with the following information:

- Rated capacitance (in μF)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for ± 20 %)
- Rated voltage (in V)
- Date code (YYMM or in 2 digits according to IEC 60062)
- Name of manufacturer
- Code for factory of origin
- "-" sign to identify the negative terminal, visible from the top and side of the capacitor
- Code number, last 8 digits 257 xxxxx
- Climatic category in accordance with IEC 60068

QUICK REFERENCE DATA		
DESCRIPTION	**VALUE**	
Nominal case sizes (Ø D x L in mm)	22 x 25 to 35 x 60	
Rated capacitance range, C_R	56 μF to 3300 μF	
Tolerance on C_R	± 20 %	
Rated voltage range, U_R	200 V to 450 V	500 V
Category temperature range	-40 °C to +85 °C	-25 °C to +85 °C
Endurance test at 85 °C	3000 h	
Useful life at 85 °C	5000 h	
Shelf life at 0 V, 85 °C	1000 h	
Based on sectional specification	IEC 60384-4 / EN 130300	
Climatic category IEC 60038	40 / 85 / 56	25 / 85 / 56

SELECTION CHART FOR C_R, U_R, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)

C_R (μF)	U_R (V)				
	200	**250**	**400**	**450**	**500**
56	-	-	-	-	22 x 25
68	-	-	-	22 x 25	-
82	-	-	22 x 25	-	22 x 30
	-	-	-	-	25 x 25
100	-	-	-	22 x 30	22 x 35
	-	-	-	25 x 25	25 x 30

SELECTION CHART FOR C_R, U_R, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)					
C_R (µF)	U_R (V)				
	200	250	400	450	500
120	-	-	22 x 30	22 x 35	22 x 40
	-	-	25 x 25	25 x 30	30 x 25
150	-	-	22 x 35	22 x 40	25 x 35
	-	-	-	30 x 25	-
180	-	-	22 x 40	25 x 35	25 x 40
	-	-	25 x 30	-	30 x 30
	-	-	30 x 25	-	35 x 25
220	-	22 x 25	22 x 45	25 x 45	25 x 50
	-	-	25 x 35	30 x 30	30 x 35
	-	-	-	35 x 25	35 x 30
270	-	25 x 25	25 x 40	25 x 50	30 x 40
	-	-	30 x 30	30 x 35	-
	-	-	35 x 25	35 x 30	-
330	22 x 25	22 x 30	25 x 45	30 x 40	30 x 45
	-	-	30 x 35	-	35 x 35
390	22 x 30	22 x 35	30 x 40	30 x 45	30 x 50
	25 x 25	25 x 30	35 x 30	35 x 35	35 x 40
470	22 x 35	22 x 40	30 x 45	35 x 40	35 x 45
	25 x 30	30 x 25	35 x 35	-	-
	30 x 25	-	-	-	-
560	22 x 35	22 x 45	30 x 50	35 x 45	35 x 50
	25 x 30	25 x 35	35 x 40	-	-
	30 x 25	30 x 30	-	-	-
680	22 x 40	25 x 45	35 x 45	35 x 55	35 x 60
	25 x 35	30 x 35	-	-	-
	-	35 x 25	-	-	-
820	22 x 45	25 x 50	35 x 50	-	-
	25 x 40	35 x 30	-	-	-
	30 x 30	-	-	-	-
	35 x 25	-	-	-	-
1000	25 x 45	30 x 40	35 x 60	-	-
	30 x 35	-	-	-	-
1200	25 x 50	30 x 45	-	-	-
	30 x 35	35 x 35	-	-	-
	35 x 30	-	-	-	-
1500	30 x 45	35 x 45	-	-	-
	35 x 35	-	-	-	-
1800	30 x 50	35 x 50	-	-	-
	35 x 40	-	-	-	-
2200	35 x 45	35 x 55	-	-	-
2700	35 x 50	-	-	-	-
3300	35 x 60	-	-	-	-

Aluminum Electrolytic Capacitors
Power Ultra Miniature Snap-In

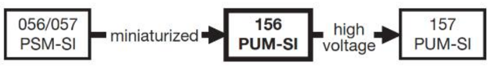


Fig. 1

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Nominal case size (Ø D x L in mm)	22 x 25 to 35 x 60
Rated capacitance range (E6 series), C_R	1000 μF to 22 000 μF
Tolerance on C_R	± 20 %
Rated voltage range, U_R	16 V to 100 V
Category temperature range	-40 °C to +85 °C
Endurance test at 85 °C	2000 h
Useful life at 85 °C	5000 h
Useful life at 40 °C and 1.4 x I_R applied	90 000 h
Shelf life at 0 V, 85 °C	500 h
Based on sectional specification	IEC 60384-4 / EN130300
Climatic category IEC 60068	40 / 085 / 56

FEATURES

- Long useful life: 5000 h at 85 °C
- Low ESR
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Large types, very small dimensions, cylindrical aluminum case, insulated with a blue sleeve
- Charge and discharge proof
- High ripple current capability
- Keyed polarity version available
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

APPLICATIONS

- General purpose, industrial and audio / video systems
- Smoothing and filtering
- Standard and switched mode power supplies
- Energy storage in pulse systems

MARKING

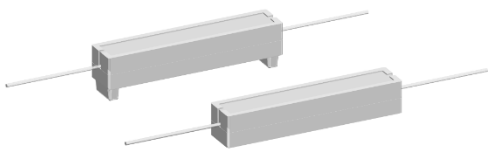
The capacitors are marked (where possible) with the following information:

- Rated capacitance (in μF)
- Tolerance code on rated capacitance, code letter in accordance with IEC 60062 (M for ± 20 %)
- Rated voltage (in V)
- Date code (YYMM)
- Name of manufacturer
- Code for factory of origin
- "-" sign to identify the negative terminal, visible from the top and side of the capacitor
- Code number
- Climatic category in accordance with IEC 60068

SELECTION CHART FOR C_R, U_R, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)

C_R (μF)	U_R (V)						
	16	25	40	50	63	80	100
1000	-	-	-	-	-	-	22 x 30
1200	-	-	-	-	-	-	22 x 35
1500	-	-	-	-	22 x 25	22 x 30	25 x 30
1800	-	-	-	-	25 x 25	-	-
2200	-	-	-	22 x 25	22 x 30	25 x 30	25 x 40
	-	-	-	-	25 x 25	-	30 x 30
2700	-	-	22 x 25	-	25 x 30	-	30 x 35
3300	-	-	22 x 30	22 x 30	25 x 35	25 x 40	30 x 40
	-	-	25 x 25	-	-	-	35 x 30
3900	-	-	-	25 x 30	25 x 40	-	-
4700	-	-	25 x 30	25 x 35	22 x 50	30 x 40	30 x 50
	-	22 x 25	-	-	30 x 30	-	35 x 40

Wirewound Resistors, Commercial Power, Axial Lead



FEATURES

- High performance for low cost
- Meets or exceeds requirements of EIA Standard RS-344
- High power to size ratio
- Ceramic cases are available with circuit board stand-offs (designated with a -3 model ending)
- Special inorganic potting compound and ceramic case provide high thermal conductivity in a fireproof package
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free Available
e3
RoHS COMPLIANT
HALOGEN FREE Available
GREEN (5-2008) Available

STANDARD ELECTRICAL SPECIFICATIONS

GLOBAL MODEL	POWER RATING $P_{40\ °C}$ W	RESISTANCE RANGE Ω	TOLERANCE ± %	WEIGHT (TYPICAL) g
CP0002	2	0.1 to 1K	5, 10	2.0
CP0002...3	2	0.1 to 1K	5, 10	2.2
CP0003	3	0.1 to 2K	5, 10	3.4
CP0003...3	3	0.1 to 2K	5, 10	3.6
CP0005	5	0.1 to 2.4K	5, 10	4.8
CP0005...3	5	0.1 to 2.4K	5, 10	5.0
CP0007	7	0.1 to 7K	5, 10	6.8
CP0007...3	7	0.1 to 7K	5, 10	7.0
CP0010	10	0.1 to 11K	5, 10	9.5
CP0010...3	10	0.1 to 11K	5, 10	9.9
CP0015	15	0.1 to 11K	5, 10	16.8
CP0015...3	15	0.1 to 11K	5, 10	17.4
CP0020	20	0.1 to 16K	5, 10	22.8
CP0020...3	20	0.1 to 16K	5, 10	23.6
CP0022	22	0.1 to 16K	5, 10	24.5
CP0022...3	22	0.1 to 16K	5, 10	25.3
CP0025	25	0.1 to 16K	5, 10	37.0

TECHNICAL SPECIFICATIONS

PARAMETER	UNIT	CHARACTERISTICS
Temperature Coefficient	ppm/°C	± 300 1 Ω and above; ± 600 below 1 Ω
Short Time Overload	-	5 x rated power for 5 s
Terminal Strength	lb	10 minimum
Operating Temperature Range	°C	-65 to +275
Dielectric Withstanding Voltage	V_{AC}	1000
Maximum Working Voltage	V	$(P \times R)^{1/2}$

Note

- Wirewound CP resistors can reliably function as a fuse and as a resistor. Such components involve compromise between fusing and resistive functions; therefore, each design should be tailored to the application to ensure optimum performance. Contact factory by using the e-mail address at the bottom of this page for design assistance