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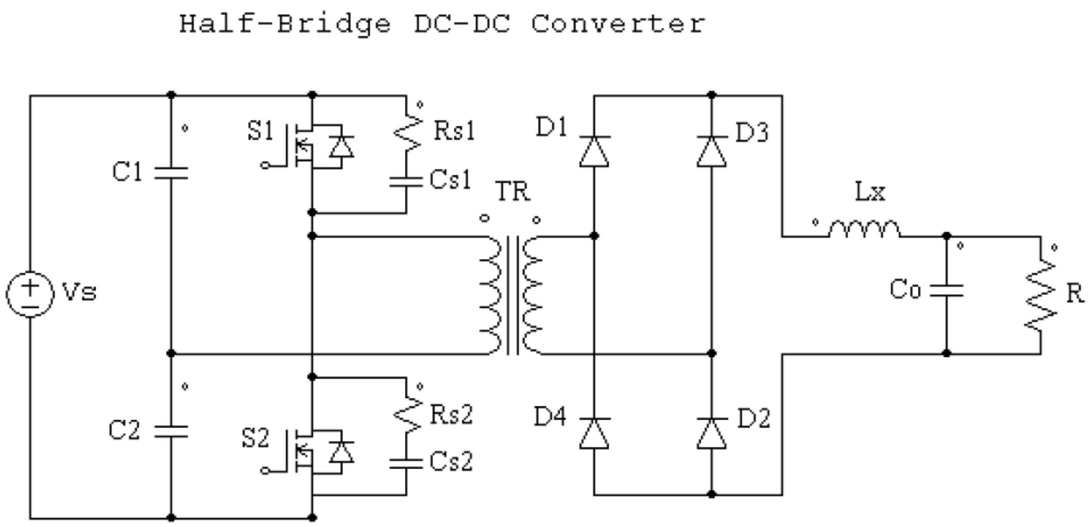
PROJECT WORK HALF-BRIDGE DC-DC CONVERTER 2021
(UNTUK NRP GENAP)

The Half-Bridge DC-DC Converter has following parameters :
V_s = 100 Volt
V_o = 19 Volt
I_o= 3 A
Duty cycle = 0.4
Switching Frekuensi (f_s) = 40 kHz



Component:

$S_1 = S_2$: MOSFET IRFP460(tf=75 ns based on datasheet)
$C_1 = C_2$: 470uF, 400 Volt
$D_1 = D_2 = D_3 = D_4$: MUR 1560 (Ultra Fast Recovery Diode) Vf = 1,2 volt(based on datashet MUR1560)
Inductor (L_x) : Ferrit Core PQ 3230 with Cross sectional are (A_c=1.61cm2);
Bobbin diameter (D_{bob1} = 16 mm)
Transformer (TR) : Ferrit Core PQ 3535 with Cross sectional are (A_c=1.96cm2);
Bobbin diameter (D_{bob2} = 17 mm)
C_o : Output capacitor (Calculation), 50 Volt
$R_{s1} = R_{s1}$: Snubber resistor (??, 5-10 watt)
$C_{s1} = C_{s1}$: Snubber capacitor (??, 1 kVolt)

SOLUTION:

A. HIGH FREQUENCY INDUCTOR DESIGN

- **Ouput Voltage:**

  Vo=Vin x $\frac{N2}{N1}$ x D

  19=100 x $\frac{N2}{N1}$ x 0,4

  $\frac{N2}{N1} = \frac{19}{40} = 0{,}475$

  $\frac{N1}{N2} = \frac{40}{19}$ =2,1

- **Filter inductor**

  Lx = $\frac{1}{\Delta iLx}$x(Vin(α) – Vo)x [$\frac{1}{2f}$] x [$\frac{Vo+2Vf}{Vin+2Vf}$]

  Where:

  Vin(α) = $\frac{Vin}{2x\frac{N1}{N2}-2Vf}$

  Vin(α) = $\frac{100}{2x2{,}1-2{,}4}$ = $\frac{100}{4{,}2-2{,}4}$= 55,55 volt

  ΔiLx = 20%xIo ; Vf= 1,2 v

  ΔiLx = 20%x3 A=0,6 A

  Lx = $\frac{1}{0{,}6}$x(55,55 – 19)x [$\frac{1}{2x40k}$] x [$\frac{19+2{,}4}{100+2{,}4}$]

  Lx = 1,66x36,55x 0,0000125 x 0,21

  Lx=0,000159=0,159 mH

- **The maximum inductor current**

  iL(max) = iL(avg)+ $\frac{\Delta iL}{2}$;

  iL(avg) = $\frac{Vo}{R}$

  Io = $\frac{Vo}{R}$=iL (avg) = 3A

  iL(max) = 3+ $\frac{0{,}6}{2} = 3 + 0{,}3 = 3{,}3\ A$

- **Winding number of inductor**

  n=$\frac{LxiL(max)}{Bmax\ xAc}$ x10^4 ; Bmax=0,25 Tesla;Ac =1,61 in cm2

  n=$\frac{0{,}000159x3{,}3}{0{,}25\ x\ 1{,}61}$ x10^4

  n=$\frac{0{,}0005247}{0{,}4025}$ x10^4 = 13,03

- **Wire size is based on RMS current of inductor**

  iL(rms)t=$\sqrt{(iL(avg))^2 + (\frac{\Delta iL/2}{\sqrt{3}})^2}$

  iL(rms)t=$\sqrt{(3)^2 + (\frac{0{,}3}{\sqrt{3}})^2}$

  iL(rms)t=$\sqrt{9 + (0{,}173)^2}$

  iL(rms)t=$\sqrt{9 + 0{,}03}$

  iL(rms)t=$\sqrt{9{,}03}$ = 3,005 A

- **Calculation of Wire Size**
  - Cross sectional Area of Wire(qw)

    qw(t) = $\frac{iL(rms)t}{J}$; J = 4,5 A/mm^2 (current density)

    qw(t) = $\frac{3,005}{4,5}$ =0,667
  - Diameter of Wire(dw)

    dw(t)= $\sqrt{\frac{4}{\pi} x\ qw(t)}$

    dw(t)= $\sqrt{1,27x\ 0,667}$=$\sqrt{0,85}$ = 0,92 mm

  - Recalculate by assuming number of split wire(Σsplit)=10?

    iL (rms) split = $\frac{iL(rms)t}{\Sigma\text{split}}$ = $\frac{3,005}{10}$ =0,3

    qw(t)split = $\frac{iL(rms)split}{\text{J}}$ = $\frac{0,3}{3,4}$ = 0,066 mm

    dw(t)split = $\sqrt{\frac{4}{\pi} x\ qw(t)split}$ mm2

    dw(t)split = $\sqrt{1,27x\ 0,066} = \sqrt{0,0838} = 0,289$

- **Wire size**

  Diameter of bobbin PQ3230(Dbob1)=16mm=1.6cm

  Circumference of Bobin(Kbob1) = π x Dbob1

  Circumference of Bobin = π x 1,6 = 5,024

  Total Wire Length = (n(winding)xKbob1x Σsplit)+40%x(n(winding)xKbob1x Σsplit)

  Total Wire Length = (13x5,024x 10)+40%x(13x0,24x 10)

  Total Wire Length = (653,12)+40%x(653,12) =914,36 cm

B. HIGH FREQUENCY TRANSFORMER DESIGN

- **Ouput Voltage:**

  Vo=Vin x $\frac{N2}{N1}$ x D

  19=100 x $\frac{N2}{N1}$ x 0,4

  $\frac{N2}{N1} = \frac{19}{40} = 0,475$

  $\frac{N1}{N2} = \frac{40}{19}$ =2,1
- **Number of primary winding:**

  N1(min) = $\frac{DxTxVin}{2xBmaxxAc}$ x 10^4 Bmax=0,25 Tesla Ac in cm^2

  T=$\frac{1}{f}$ = $\frac{1}{40k}$ = 0,000025 s

  N1(min) = $\frac{0,4x0,000024x100}{20,25x1,96}$ x 10^4

  N1(min) = $\frac{0,001}{0,98}$ x 10^4 =10,2

N1 = 2xN1(min)
N1 = 2x10,2=20,4

- **Number of secondary winding:**
  N2=nxN1; n = winding ratio
  N2=0,475x20,4 = 9,69

- **RMS Primary Current**:
  I1,rms=$\frac{N2}{N1}$ x Iox$\sqrt{D}$
  I1,rms=0,475 x 3x$\sqrt{0,4}$
  I1,rms=1,425x0,63 = 0,9 A

- **RMS secondary current:**
  I2,rms= $\frac{1}{2}$ xIo x $\sqrt{1+D}$
  I2,rms= $\frac{1}{2}$ x3 x $\sqrt{1+0,4}$ = 1,5x$\sqrt{1,4}$ =1,18

- **Primary wire size**
  d1=$\sqrt{\frac{4x\ I1\ rms}{\pi xs}}$; s=4,5 A/mm^2
  d1=$\sqrt{\frac{4x\ 0,9}{\pi x4,5}}$ = $\sqrt{\frac{3,6}{14,3}}$ = 0,5 mm2
- **Secondary wire size:**
  d2=$\sqrt{\frac{4x\ I2\ rms}{\pi xs}}$; s=4,5 A/mm^2
  d2=$\sqrt{\frac{4x\ 1,18}{\pi x4,5}}$= $\sqrt{\frac{4,72}{14,3}}$ = 0,33 mm^2
- **Length of wire**
  Diameter of bobbin PQ3535(Dbob2)=17 mm =1,7 cm
  Pp = (Np x Kbobin2 x split) +30%
  Ps = (Ns x Kbonin2 x split) +30%

C. **FILTER CAPASITOR OUPUT**

$\frac{\Delta Vo}{Vo} = \frac{1-D}{8\ x\ Lx\ x\ Co\ x(2f)^2}$

$\Delta Vo = \pm$ 0,1% x Vo = 0,001 x Vo

$\Delta Vo = \pm$ 0,1% x Vo = 0,001 x 19 = 0,019

$\frac{0,019}{19} = \frac{1-0,4}{8\ x\ 0,000158\ x\ Co\ x(2x40k)^2}$

0,001= $\frac{0,6}{0,001264\ x\ Co\ x6400000000}$

0,001= $\frac{0,6}{8089600Co}$

8089,6co=0,6

Co = 74,1 µF

- **Rsnubber**

Kondisi off-state(S1)

Voff = Vc1-V_{LX}-Vo

Voff =Vs/2 - Lx$\frac{diL}{dt}$ -Vo

Voff = Vs/2- Lx$\frac{\Delta iL}{\Delta t}$ -Vo

Voff = Vs/2 - Lx$\frac{\Delta iL}{DT}$ -Vo

Kondisi on-State(S1)

Ion = IL(avg) = Io

Voff = 50-0,000159 $\frac{0,6}{0,4x0,000025} - 19$ = 50-0,000159x$\frac{0,6}{0,00001}$ -19

Voff = (50-0,000159x60000)-19=50-9,54-19 = 40,462 -19=21,462 v

Ion = Io = 3A

T=$\frac{1}{f}$ = $\frac{1}{40k}$ = 0,000025 s

Csnubber = $\frac{Ionxtfall}{2xVoff}$ = $\frac{3xtfall}{2xVoff}$

Csnubber = $\frac{3x75ns}{2x21,46}$ = $\frac{225}{42,92}$ = 5,24nF

Rsnubber <$\frac{DT}{2xCsnubber}$

Rsnubber < $\frac{0,4x0,000025}{2x5,24nF}$

Rsnubber < $\frac{0,00001}{10,48nF}$

Rsnubber < $\frac{10000}{10,48}$

Rsnubber < $954,2\ ohm$