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PERFORMANCE OF TOROID CORE PERMANENT MAGNET WITH RLC LOADS

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ABSTRACT

Part of Cuk converter Slobodan, was modified with toroid core, which was used as the controller of the ripple current and load, in watt-meter. So the watt-meter could measure the active, reactive power and power factor. And the result of measurement could be transmitted to the receiver. In order to solve this problem, the real toroid with some models of air gap, surface material must have chosen, to find a better one, and then use the approachment methods from magnetic circuit to electric circuit.

Modified Cuk converter with RLC loads and ripple current around less than 1% has a good geometry of core toroid in Cuk converter Slobodan. The twisted coil winding could be reduce the frequencies, so the ripple current become lower and increase the efficiency.

Toroid core as magnetic circuit could be calculated as approachment method applied to electric circuit where the matterial could be generate the source like air gap, and the real sources coil winding in primary and secondary. Modification conductor in coil winding in primary and scondary was fifty degrees twisted. The Twist could minimize the ripple from 3.2% become 0.21%.

Keywords

Toroid core, Cuk converter, air gap, surface of conductor, low ripple and high frequency.

1. INTRODUCTION

In nano technology era, all devices become smaller, more compact, higher efficiency, lower in ripples and automatically controlled. Cuk Slobodan converter was always used in any system such as in automotive technology, electrical measurement, sound system, home theatre, and etc., but the real of Cuk Slobodan converter has ripple around 30%. In better system, like in industrial applications, the chemical coloring only allowed the ripple current around 3%.

Special design of toroid transformer for winding, shape, material and size with higher permeability could increase the efficiency and minimize the ripple. The good material air gap with low losses could increase the potential as gyrator capacitor. The core magnetic as inductor, capacitor and resistor, as equivalent capacitor and the winding as generated magnetomotance or Gyrator which is control the variable load as variable voltage control current source VVCS or curent controlled voltage source CCVS if the load has variable R,L and C. All of them could be reduce the ripple until 0.3 % and can generate the frequencies become KHz, with paralleling the material like two port and twisted more than one conductor. The winding could increase the frecuencies about GHz. [1]

Before twisted with the radius of conductor about r = 4.10^{-4} m, 8.10^{-4} m, 16.10^{-4} m has efficiences about 3.2 %, 4.3 %, 5% and after twisted be come 81 %, 85 %, 92 %

The output rippel current of Cuk converter where the inductance are 3 μH, 2.27 μH, and 1.83 μH before modification coil winding about 2.5 %, 1.6 %, 1.2 % after modification with twisted about 2.1 %, 1.2 % and 0.98 %, with toroid core become 98 %.

Gyrator capacitor which are increase the energy, could be minimise the losses [2] could be controlled the variable load RL and C .

2. GYRATOR CAPACITOR

Gyrator [3] as generate the voltage as two port could be increase the current source as hybrid circuit like Figure 1.

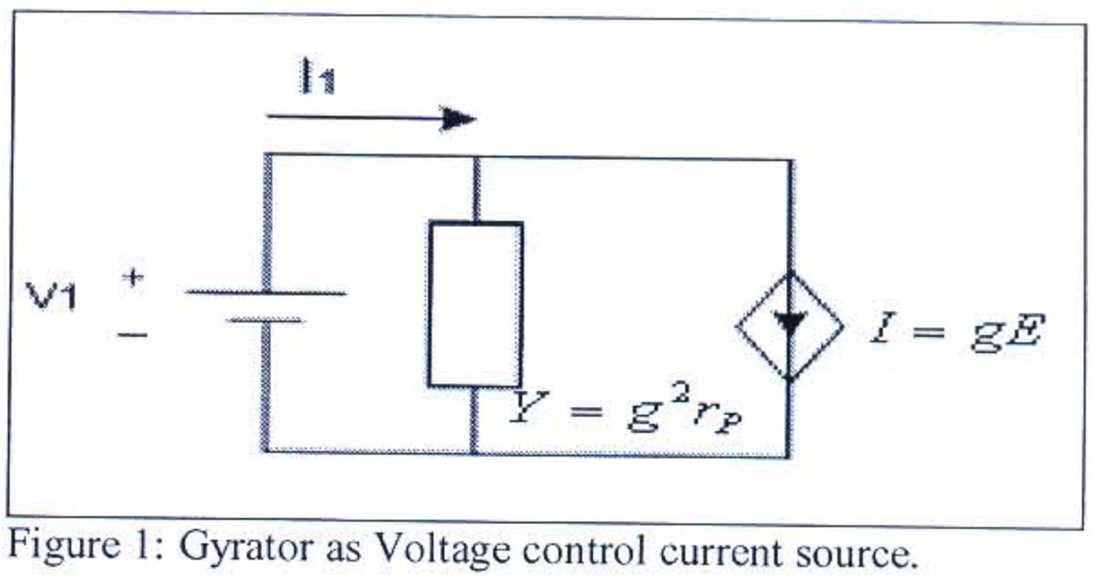

Figure 1: Gyrator as Voltage control current source.

From figure 1, the electric circuit is

$$i_a = V_s g^2 r_P + gE \quad (1)$$

And the gyrator load is

$$i_a = gV_s \quad (2)$$

Where:

r_p	:	The inner resistive.
i_a	:	Load current
i_s	:	Current source
g	:	Conductor of Gyrator.
i_{sc}	:	The short circuit current
RL	:	Resistance load

The sensitivity of current source with voltage system:

$$S_{V_S}^{i_S} \to 0$$

$$S_{E}^{i_S} \to 1$$

$$S_{g}^{i_S} \to 1 \quad (3)$$

3. CAPACITOR

The capacitor, as storage device has loading electricity, it takes from permanent magnetic air gap [4] which is depend on the material, circular mill, the long of magnet permanent, and permeability of magnetic permanent, if the force depend on reluctance it's hybrid of the electric as for hybrid parameter given by

$I_1 = g_{11}V_1 + g_{12}I_2$

$V_2 = g_{21}V_1 + g_{22}I_2 \quad (4)$

The equivalence magnetic circuit to electricity from equation 3 is showed in table 1. From the capacitance of magnetic circuit such as the twisted winding was taken from skin effect of current conductor.

4. DESIGN OF THE TOROIDAL CORE

The design for any type of air gap and the core of toroidal with the twisted conductor, in primary and scondary coil winding, with the angle of twisted, could reduce the qualities and efficiency. For the first step, the inductance of cunductor must be taken from the lentgh, radius, circular mill, resistivity the material of coil winding conductor where the data length of conductor are $l_1 = l_2 = 3$ m, for one conductor which is change with two conductor, $r_1 = r2 = 8.10^{-4}$, 4.10^{-4} , or 16.10^{-4} m, so it could calculated of the effective long l_{1e} wire gauge. The long efective coil winding in primary and scondary l_{1e} are : 1 - 2.7 m, so it could fixing some parameters [5] :

- the length of $l_e = l \cos(\beta/2)$,
- Where $\beta = 50^0$,
- $l_{1e} = 3\cos(50^0/2) = 3 \times 0.9 = 2.7$,
- resistivity of Cu, $\rho = 1.72.10^{-8}$ ohm/m,
- permeability of air $\mu_0 = 4\ \pi^7$ weber/amp,
- frequencies f = 25 KHz,
- conductivities $\sigma = 5.8.10^7$ Ω/m,

so the coupling could be calculated

$$k_1 = r\sqrt{\omega.\mu_0.\pi/2\rho}$$

$$k_1 = 1{,}7$$

The efficiency will depend on the resistance DC of magnetic circuit toroidal from the modify coil winding

$R_{D1} = \rho\, l_1/(\pi\, r_)= 0.1$ Ohm, (5)

Where the resistance DC is as resistance of Gyrator R_G.

Coupling factor in primary winding is alternating current AC resistance R_{A1}, which is depend on the coupling factor. Because of coupling factor in primary K_1 is bigger or equal than 1, the AC resistance AC RA1:

$R_{A1} = R_{D1}\,[(1/4) + k_1 + (1/64)(1/k_1^3)] = 0{,}19\ \Omega$ so

The self inductance in wire gauge primary coil winding L_{i1}:

$L_{i1} = (\mu_0.l_1/2).[(1/k_1) - (1/64)(1/k_1^3)] = 1{,}09\ \mu H$

The mutual inductance M because $l_{1e} \le l_2$,

$M = (\mu_0/2\pi).l_{1e}.\{\log[2.l_{2e}/(r_1+r_2)] - 1 = 1{,}53\ \mu H$

Inductance on in primary in AC L_1,

$L_1 = L_{i1} + (\mu_0/2\pi)l_1.\{\log[2l_1/r_1] - 1\} = 3\ \mu H$

So it cold be calculate the new efficiency

$$\eta = (R_L.M^2.w^2)/\sqrt{\left[L_1L_2w^2 - M^2w^2 - R_{A1}(R_L + R_{A2})\right]^2} + \sqrt{\left[L_1w(R_l + R_{A2} + R_{A1}L_2w\right]^2\left[(L_2w)^2 + (R_L + R_{A2})^2\right]}\cos\phi_1 \quad (6)$$

5. DISCUSSION

For the first condition where's the original Cuk konverter have big rippel like showed in Figure 2.

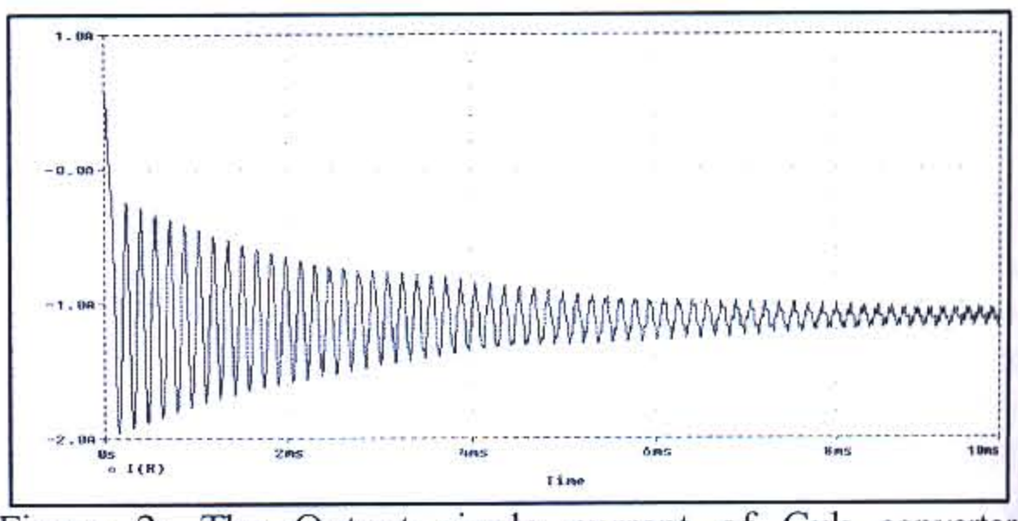

Figure 2: The Output ripple current of Cuk convertor Slobodan.

In figure 2 the output ripple current of Cuk converter Slobodan before the modification is more than 30 %.

After reduced with any component like one inductor coventional with two inductor but still the result was not

reduce the ripple current. After that, two Inductors changed with a special transformator torroidal design. The first is show the capacitance approachment like in Figure 3.

From the new parameter and the result of data input calculation in Pspice simulator software, it is found that the performance of toroidal capacitance is going better. So it will show any capacitance approachment in one shape toroidal.

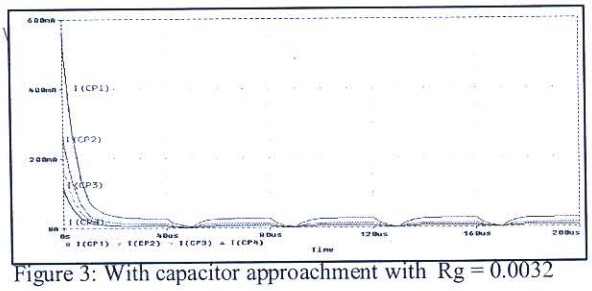

Figure 3: With capacitor approachment with Rg = 0.0032

With some variable, resistance of gyrator depend on the size of toroid shape and air gap. the smaller resistance of gyrator would make the smaller ripple current graphic as shown in figure 4.

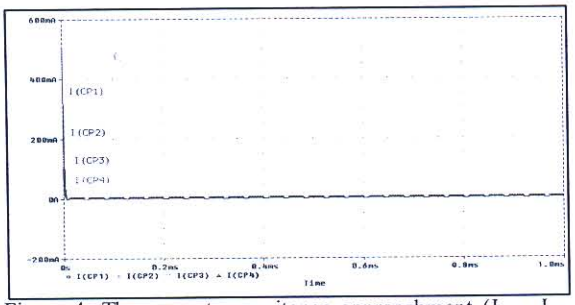

Figure 4: The current capacitance approachment (I_{CP1}, I_{CP2}, I_{CP3}, I_{CP4}) Vs Gyrator resistan R_G = 0.0064 Ohm

In figure 4 the current capacitor approachment, looks like more stable and the ripple is smaller. In condition of RL and C loading (I_{CP1}, I_{CP2}, I_{CP3}, I_{CP4}) vs. R_G =0.0012 ohm. The ripple current is shown in Figure 5.

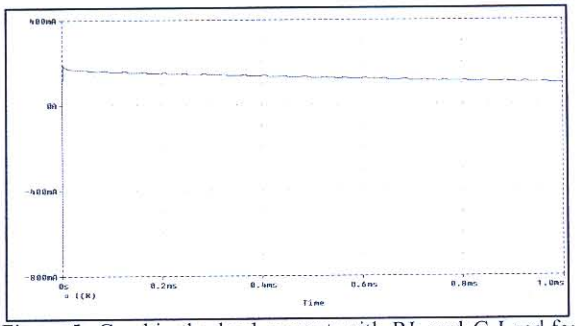

Figure 5: Graphic the load current with RL and C Load.for resistan Gyrator = 0.0012 Ohm.

The polygon curves introduce the output ripple current in twisted moment and the twisted chart is shown in figure 6.

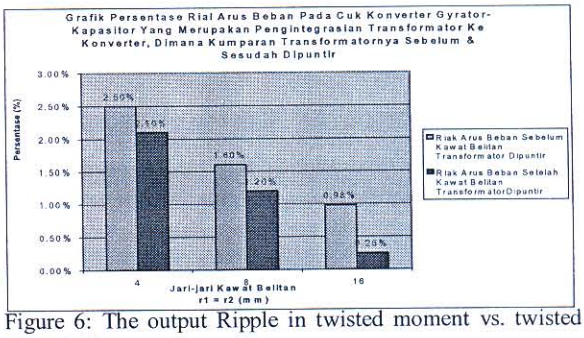

Figure 6: The output Ripple in twisted moment vs. twisted coil winding.

The polygon curve explains the current output of ripple current for the twisted is minimized the ripple current output.

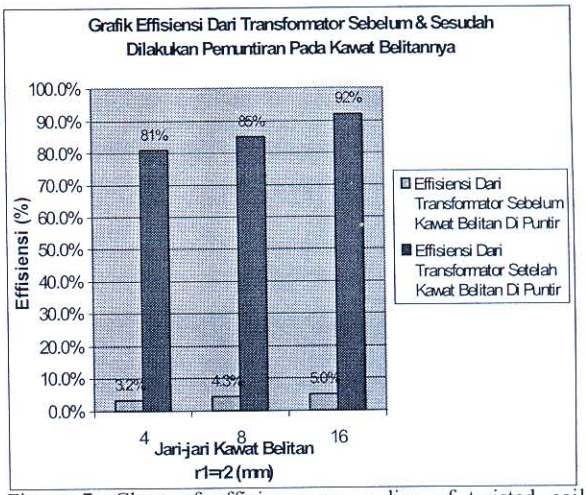

Figure 7: Chart of efficiency vs. radius of twisted coil winding.

In figure 7 the efficiency the cu coil winding after twisted and before twisted. The efficiency is higher when the twisted coil winding.

6. CONCLUSION

The size of toroid core as variable resistance of Gyrator, is causing the less of resistor Gyrator which have lower ripple current and higher efficiency.

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