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HIGH CURRENT DC POWER SUPPLIER

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Abstract

This paper presents the design, and experimental validation of a high-output DC current supplier leveraging the advantageous properties of a toroidal transformer. The demand for high-output DC current supplies has grown significantly in various applications such as industrial processes, renewable energy systems, and electric vehicle charging stations. Traditional methods encounter challenges in achieving high efficiency, compactness, and reliability simultaneously. In response, this research proposes a novel approach utilizing toroidal transformer technology to address these challenges effectively.

Index Terms:

Toroidal core ; Transformer; DC current; Rectifier; Winding rule; Winding Gauge; Low DC Voltage.

1. INTRODUCTION

This project is mainly used in low voltage high DC current applications. The design of low voltage and high current DC power supplier involves selecting appropriate components such as transformers, rectifiers and capacitors, to meet the specific voltage and current requirements of the load. The transformer is a key component that step downs the input voltage to the desired low output voltage while providing isolation and voltage regulation. This project consists of a core made up of continuous steel strip that is wound into a construction allows for more effective, lighter and cooler with diminished electromagnetic interferences and lower acoustic noise. And helps to find values of winding required to design a specific transformer with some calculations. This is more efficient when compared to a normal transformer. The main advantage is that the no load losses are substantially reduced.

1.1 Design Principle symbols:

V_p = Primary voltage
V_s = Secondary voltage
I_p = Primary current
I_s = Secondary current
P = Power
D_o = Outer diameter
D_i = Inner diameter
L = Cross sectional length of core
H = Height of core
A = Area of core
T_p = Number of turns for primary
T_s = Number of turns for secondary

1.1.2 Consider input assumptions to design a toroidal transformer:

V_p= 230V, V_s=24V, P=1KVA, D_o=16cm, D_i=7.6cm, H=8cm

1.1.3 Calculation for core:-

Assumptions for design calculation:
D_o = 16cm
D_i = 7.6cm
H = 8cm
Cross sectional length of core
L = (Outer diameter – Inner diameter)/2
= (16 – 7.6)/2 = 4.2cm
Area of core = L×H
= 4.2×8=33.6cm^2

1.1.4 Calculation for Primary side:-

From [1] According to EMF formula,

$$E = V = 4.44 \times f \times Bmax \times A \times N \times 10^{-4} \quad (1)$$

where,
f = frequency = 50Hz
V = Voltage
A = Area of core
B_{max}= Maximum flux density = 1Tesla
N = Number of turns
Therefore,

$$\frac{V}{N} = 4.44 \times f \times Bmax \times A \times 10^{-4} \quad (2)$$

$$\frac{N}{V} = \frac{1}{4.44 \times f \times Bmax \times A \times 10^{-4}} \quad (3)$$

$$\frac{N}{V} = \frac{1}{4.44 \times 50 \times 1 \times A \times 10^{-4}} \quad (4)$$

Number of turns per volt = 45/A
According to 42 transformer winding rule,
Numbers of turns= Turns/volt = 42/A (5)
i.e 42/33.6cm^2= 1.25turns [no. of turns/volt]
From [7]
Primary turns = Primary voltage×(Number of turns/volt) (6)

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T_p = 230×1.25 = 287.5turns = 290turns
Total length of wire required for primary winding = Primary turns×2(L+H)
=290×24.4 =7076cm =71m
Max. current in primary winding

$$Ip = \frac{P}{Vp} \quad (7)$$

=1000/230 =4.34A

1.1.5 Calculation for Secondary side:-

Secondary turns = Secondary voltage × (Number of turns/volt) (8)
T_s = 24×1.25 = 30turns
Total length of wire required for secondary winding = Secondary turns×2(L+H)
=30×24.4 =732cm =7.5m
Max. current in secondary winding

$$Is = \frac{P}{Vs} \quad (9)$$

=1000/24 =41.66A
To make the transformer center tapped determine the center tap point(midpoint of the secondary winding). Connect a wire or terminal at center point. By this the transformer can be used for two circuits at a time.
The center tap point of this transformer is at 15^{th} turn.
Therefore the transformer provides output of 12V-0-12V

1.1.6 Table for gauge of winding wire:-

From [2] the required values of windings are as shown in Table1.1.6.

Table 1.1.6: Values of Windings

Windings	Gauge	Diameter in mm	Ampere
Primary	16	1.29	5.2A
Secondary	2.5	3.5	41A

Wire calculation in grams:

Weight = Diameter×gauge
Weight of primary winding = 1.29×16=20.64g (for 1m)
For, 71m the weight of winding required is =71×20.64 = 1431.36g
Weight of secondary winding = 30.22g(for 1m)
For, 7.5m the weight of winding required is = 30.2×7.5 = 226.5g

1.1.7 Data sheet:-

Table 1.1.7: Parameters and its Values to make Transformer

S.No.	Parameters	Values
1.	Primary voltage	230V
2.	Secondary voltage	24V
3.	Primary current	4.34A
4.	Secondary current	41.66A
5.	Power	1000VA
6.	Outer diameter	16cm
7.	Inner diameter	7.6cm
8.	Height of core	8cm
9.	A = Area of core	33.6cm^2
10.	T_p = Number of turns for primary	290
11.	T_s = Number of turns forsecondary	30 (0-15-30)

1.2 ANALYSIS OF TOROIDAL TRANSFORMER

1.2.1 Design of toroidal transformer:

From [4] Material use for Core is M-15 Steel.
Gauge of primary windings is 16AWG.

Winding turns are 290 for primary side.
Gauge of secondary windings is 6AWG.
Winding turns are 30 for secondary.
Insulating medium is tape, varnish.

Figure 1.2.1: Toroidal Core

1.2.2 Primary winding parameter:

From [8] The analysis of primary windingparameter:
Total current is 4.34amp.
Voltage drop is 0.753V.
With 290turns

Figure 1.2.2(a): Primary winding

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From [5] Primary after insulation with varnishing and insulation cloth.

Figure 1.2.2(b): Insulated primary

1.2.4 Secondary winding parameter:

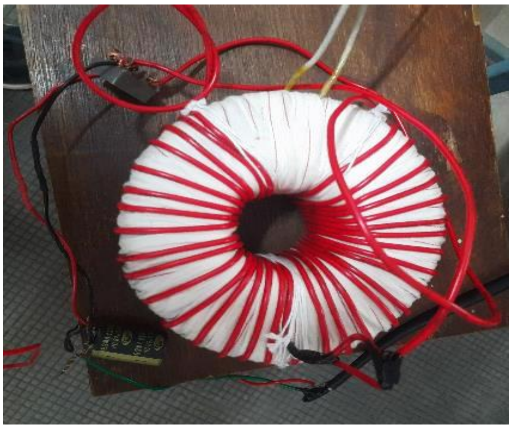

Figure 1.2.4: Secondary winding

The analysis of secondary winding parameter:
Total current is 41.66amp.
Voltage drop is 0.57V.
With 30turns.
Used an insulated copper wire to reduce insulation costs and to make process easier and faster.

2. Hardware Implementations:

2.1 Toroidal Transformer:

In this figure we can see that toroidal transformer hardware Completed with winding of the core. In which on one terminal, the input given is 230 volts results in an output of 110 volts. In the figure the white sleeved wire is a input terminal and the red wire is output terminal. The insulation is provided between core and windings and between the windings.

The insulation type is the paper insulation, varnish & outer body covered by the plastic tap & insulation cloth. The total weight of transformer is 8.35kg and the weight of core is 6.5kg. the copper wire which are use for transformer is 1.85kg.

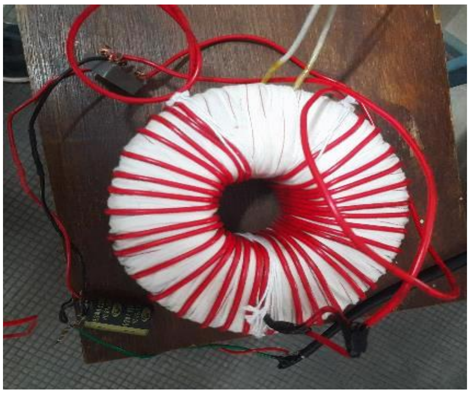

Figure 2.1: Toroidal Transformer

2.3 Toroidal Transformer Input & output:

In this figure we can see that in input terminal we applied 230volts. And as per our requirement it steps down the voltage to 12volts (due to centre tapping at 15 turns).

Figure 2.3: Output Voltages

3. Converting AC to DC:

By using a device called rectifier AC is converted into DC. There are different types of rectifiers like half-wave rectifier, full-wave rectifier and bridge rectifier. In this project we use bridge rectifier due to its efficiency.

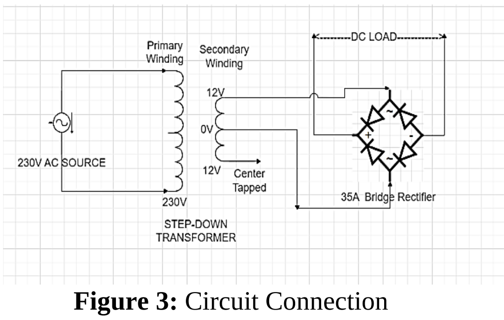

Figure 3: Circuit Connection

From this the required low voltage and high DC current can be obtained.

CONCLUSION

This project ingeniously transforms 230V AC into a robust 12V DC with an impressive high current output.

High-current systems power electric vehicles, charging stations, and various automotive systems, ensuring efficient and reliable performance.

Welding machines use high current to generate the heat needed for melting metals and creating strong, durable bonds.

Industrial furnaces and electric heating systems use high current to generate heat for various applications, including metal smelting and material processing.

Various motors like PMDC motor, Brushed DC motor, DC gear motor etc., can be turned on using this high current output.

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