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Starting of fluorescent tube light by using inverter circuit instead of choke and starter arrangement

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ABSTRACT
A fluorescent tube light generally starts glowing when a large voltage is applied across its terminals at the time of starting for a very short period, once it starts glowing then it will be able to continue with normal supply voltage. Conventionally this needed high voltage, at the time of starting, is provided by the use of choke starter arrangement.On the other hand, the circuit which converts the dc into ac is called inverter circuit. This paper will discuss about an inverter circuit which can be used in place of choke starter arrangement. This inverter circuit develops high voltage at the time of starting and after that its output voltage will come down to the normal rated voltage level. This inverter circuit arrangement not only make the tube light performance faster but also economically preferable.
Keywords–Diode, Fluorescent tube light, Heat sink,Inverter, 2N3055 (N-P-N transistor).

I. INTRODUCTION

In conventional choke starter arrangement a fair amount of energy is wasted in choke and starter during starting process and the fluctuation of light at starting period is also a matter of strain to human eye. This two drawbacks associated with conventional method may be eliminated by using this inverter circuit.In developing countries like India load-shedding is a very common problem. Inverter is a well-known temporary solution during load shedding. This circuit can also fulfill the need of inverterduring load shedding. Simply the same circuit can be used in place of choke starter arrangement in normal time and in load-shedding period this circuit can be energized by battery or other DC source and as a result we get an AC voltage as output for lighting tube light, like normal supply condition.The operation during load-shedding and normal supply condition is controlled by a relay. The block diagram of the operating system of inverter circuit is shown below.

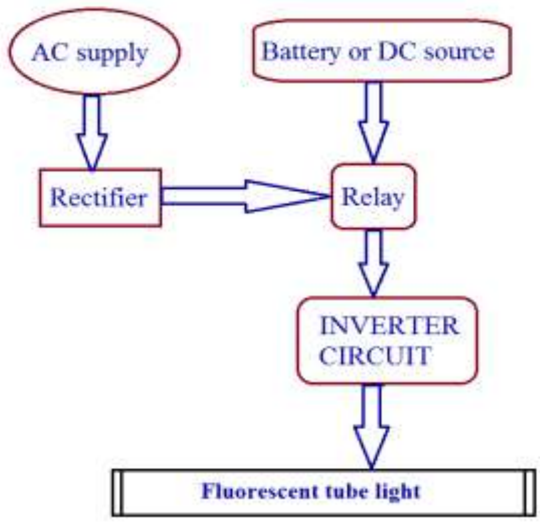

Fig.1 Block diagram of operation of Inverter circuit

II. Conventional starting process of fluorescent tube light

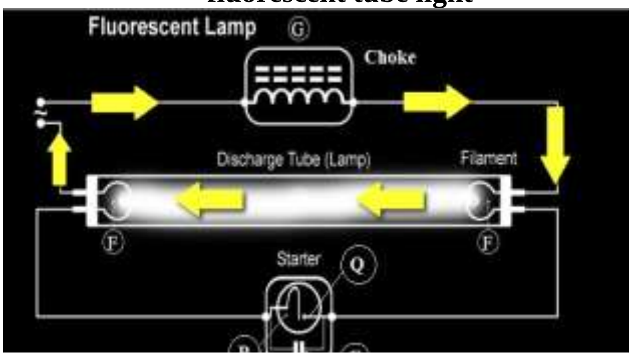

Fig.2 Conventional starting method of fluorescent tube light

In conventional starting method of a fluorescent tube light, a starter and a choke has been connected in the tube light circuit. The purpose of these two accessories is explained as follows.

When AC supply voltage is given to its input terminals full supply voltage appears across the starter electrodes P and Q (shown in Fig.2). This causes discharge in the argon gas with consequent heating (the electrodes are enclosed in a glass bulb filled with argon gas). Due to this bimetallic strip heats up and bends and there by causes contacts P and Q of the starter to close. When this happens, the choke, the filament electrodes FF of the tube and starter becomes connected in series across the supply. A currents flows through the filament electrode FF which heated them. Meanwhile, the discharge in the starter tube disappears and after sometime the electrodes P and Q move apart. The moving part of the electrodes P and Q causes a sudden break in the circuit this cause high value of emf to be induced in the choke.

The direction of induced emf in the choke will be such that it will try to oppose the fall of current in the circuit (according to Lenz's law). Therefore, the polarity of the induced emf in the choke will be such that the voltage appearing across tube terminals will be equal to the addition of the supply voltage and the induced emf in the choke. The voltage thus acting across the electrodes FF is high enough to cause a discharge occur in the gas inside the tube. Thus the fluorescent tube starts giving light. Once the discharge has occurred a much lower voltage (than the value of the supply voltage at starting)is require to maintain the discharge. Thereafter, the choke acts only to reduce the voltage available across the tube. A capacitor C connected across the starter terminals to suppress the electromagnetic waves generated at the gap due to sparking. The whole starting process is shown graphically as follows.

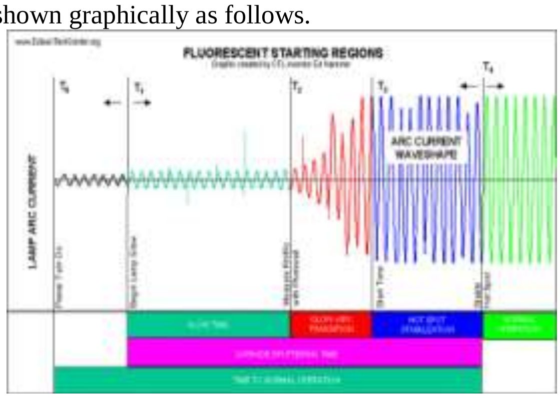

Fig.3 Graphical representation of Conventional starting process of fluorescent tube light(with choke and starter)

From the above it is clear that the necessary condition to start a fluorescent tube light is that we have to apply a very high voltage across the filament electrodes FF at starting to cause a discharge occur in the gas inside the tube. Once the discharge has occurred a much lower voltage (than the value of the supply voltage at starting) is require to maintain the discharge.

III. WORKING PRINCIPLE OF INVERTER

An inverter is a device that changes or inverters direct current (DC) input to alternating current (AC) output. It doesn't "create" or "make" electricity, just changes it from one form to another. DC in is changed to AC out. The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source. DC to AC inverters efficiently transform a DC power source to a high voltage AC source, similar to power that would be available at an electrical wall outlet. Inverters [1] are used for many applications, as in situations where low voltage DC sources such as batteries, solar panels or fuel cells must be converted so that devices can run off of AC power. One example of such a situation would be converting electrical power from a car battery to run a laptop, TV or cell-phone.

Here our inverter circuit is working with the principle of common emitter-biasing of BJT (bipolar junction transistor). Here one n-p-n power transistor (2N3055) is used as BJT. The collector terminals of the transistor is connected with 12V dc and the output signal of the RC oscillatory circuit is given to the base terminal of the transistor. According to this base signal the output is varied and as a result we get an AC voltage as output.

The working diagram of n-p-n transistor (2N3055) is shown below.

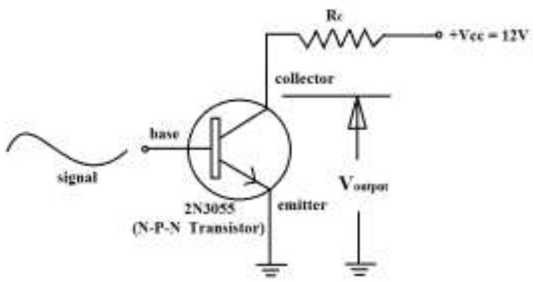

Fig.4 working diagram of n-p-n transistor (2N3055)

This output voltage is then increased to 230V (approximately) with the help of a step-up transformer. During working time n-p-n transistor (2N3055) is heated up. To control this problem we set-up N-P-N transistor (2N3055) on a heat-sink (as shown in Fig.5 and Fig.10).

IV. STARTING OF FLUORESCENT TUBE LIGHT WITH THE INVERTER CIRCUIT

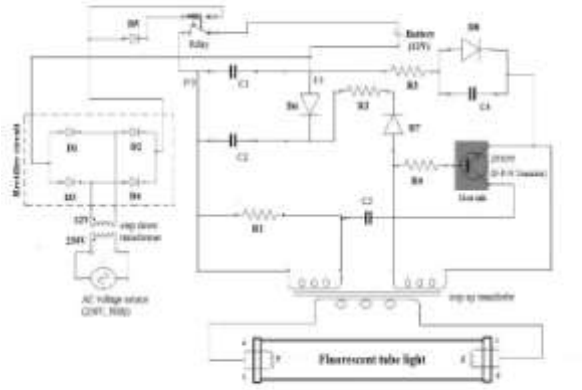

Fig.5The whole connection diagram of the inverter circuit

In the previous para we are discussing the normal operating function for running the tube light after starting. But during starting there are certain things happen which increase the output voltage or secondary terminal voltage of the step-up transformer very high (nearly thousand volts) than the normal rated value of voltage which is about 230 V in this case. In the circuit diagram it is shown there are four capacitor of different values are connected. When the switch of the supply is closed these capacitors are immediately going to charging mode and a very high current than normal rated value flow through the several paths provided to the circuit including through the coils of the two primary windings of the step-up transformer. Here the step up transformer has two primary windings and one secondary winding.Now we will see how these high currents, flow through the coils of the two primary windings of the step-up transformer cause to increase the voltage of the secondary winding at a very high value for a very short period (few millisecond) at starting.

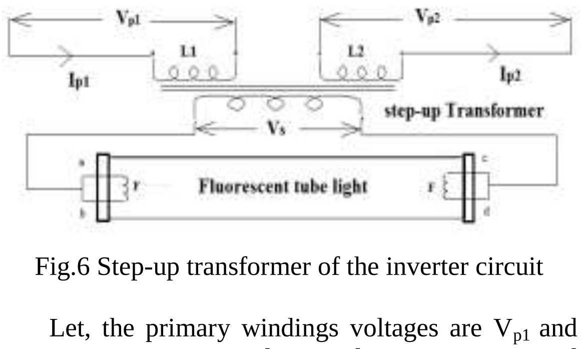

Fig.6 Step-up transformer of the inverter circuit

Let, the primary windings voltages are V_{p1} and $V_{p2,}$ currents are I_{p1} and I_{p2}, inductances are L1and L2.

For simplicity consider voltage, Vp $=V_{p1}=V_{p2}$; current, Ip = $I_{p1} = I_{p2}$ and inductance Lp = L1 = L2.

So, Vp = Lp (dIp/dt)…………. (1)

Let, the starting process is completed during the time period t_0 to t_1.

We can rewrite the equation (1) as follows,

Vp = Lp (ΔIp/Δt) (As we measure the change from point t_0 to t_1)

Here the starting process is completed several times faster than the conventional method.

We can assume $t_0 = 0$ (just at switch on)

and $t_1 = 0^+$ (just after the switch on)

So,Δt = (t_1- t_0) = very very small

At t = t_0, let Ip = I_0 but at the time of just switch on there is no current flows through the primary winding coils of the step-up transformer. Therefore, the primary winding current is zero. So, $I_0 = 0$.

At t = t_1, let Ip = I_1; here at t_1(just after the switch on) the current flows through the primary winding coils (Lp) is very high as the capacitor are immediately going to charging mode and the charging currents mainly flow through the two primary winding coils (Lp1 and Lp2).So, I_1 is very high.

So,ΔIp = (I_1- I_0) = I_1 - 0 = very high

Here, ΔIp is very high and Δt is extremely small.

So, the ratio (ΔIp/Δt) is very high.

Therefore, primary side voltage,

Vp = Lp (ΔIp/Δt) is very high.

As the transformer is step-up with transformation ratio, a = (Vs / Vp) = (230/12) = 19.17 ~ 20 (for simplicity)

Then the secondary or output voltage of the inverter circuit, Vs = a Vp ~ 20 * Vp (about twenty times higher than primary) becomes very high.

So, a very high voltage (nearly thousand volts) is appeared across the secondary side of the step-up transformer for a very short duration at the time of starting which is the most important condition for startinga tube light. Here in the Fig.6 it is shown that the two terminals of each filament (F) of the tube light in both side are short circuited. So, this high voltage of the secondary side of the step-up transformer directly appeared between the two filaments FF shown in the Fig.6. The voltage thus acting across the electrodes FF is high enough to cause a discharge occur in the gas inside the tube. Thus the fluorescent tube starts giving light. After that the output voltage of the inverter circuit is come down to its normal rating voltage. Once the discharge has occurred a much lower voltage (than the value of the supply voltage at starting) is require to maintain the discharge.

Now we will see the graphical character of supply voltage, output voltage both at starting and running.

Fig.7 AC supply voltage (230V and 50Hz)

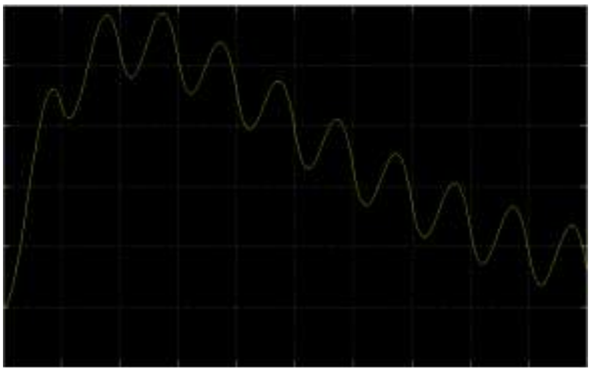

Fig.8 output voltage value of the inverter circuit during starting (voltage level coming down from high voltage to normal rated voltage)

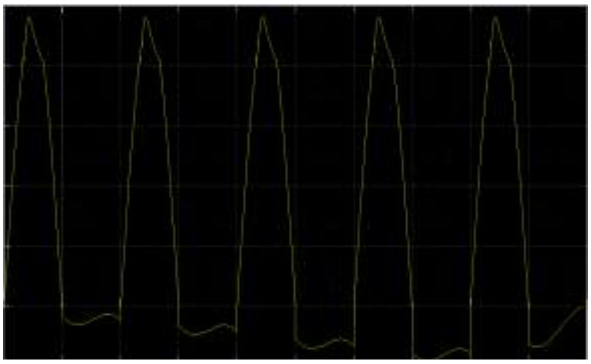

Fig.9 output voltage of the inverter circuit during normal running condition (after starting the tube light the voltage remains nearly 230V, 50Hz)

Here the output voltage waveform in normal running condition is not exactly sinusoidal this may not cause any problem during normal running operation of the tube lightbut it can creates problem in nearby connected communication devices. This wave shape can be improved by using proper filter circuit.

Table: List of the components used in the inverter circuits

Sl. no.	Name of the apparatus	Specification	Quantity
1.	Step-up transformer	12V (primary) to 230V(secondary)	1
2.	Diode		3
3.	Capacitor	C1=C2= 16V,1000microf; C3= 104kf, 100V; C4= 0.1pf	4
4.	Pin-board		1
5.	Resistor	R1=R2=R3=R4= 150 ohm	4
6.	Transistor	N-P-N (2N3055)	1
7.	Heat sink	Aluminum	1

REAL TIME IMAGE OF INVERTER CIRCUIT

Fig.10 Real time image of the inverter circuit

V. CONCLUSION

Here one thing is that at normal supply condition first the AC (230V and 50Hz) is converted into DC (12V) by a rectifier circuit then this DC is given to the inverter circuit for lighting tube light. During, load-shedding this inverter circuit is energized directly by battery (12V) or other dc source. Here, the operation is controlled by a relay which connects the rectifier circuit to the inverter when the supply is ON and connects the battery or DC source when supply is OFF (during load-shedding period). The whole process is controlled automatically. Where the places are free from load shedding problems,there the use of this inverter circuit is not so economicalas the cost of the inverter circuit is just slightly less than conventional choke-starter arrangement but one can also get a faster operation experience with this circuit. The working life of this inverter circuit is more than conventional choke-starter arrangement and during running condition the losses are slightly less thantheconventional choke-starter arrangement. The circuit construction is very complex than conventional choke-starter arrangement but this is the matter of concern for the manufacturers. On the other hand, conventional choke-starter arrangement connection with the tube is complicated, one cannot easily make the connection without prior knowledge but on can easily connect the tube with the output terminals of this inverter circuit. The real benefits of this circuit can be gotten when we use it in areas associated with load-shedding problems. Here no need to install double arrangements one for normal supply and other for the load-shedding period, the single circuit can performs the same task smoothly in both the conditions and the result is that installation cost come down about half of the conventional method. The main drawback of this circuit is that the output voltage waveform in normal running condition is not uniform or exactly sinusoidal and sometimes it may produce spike in output voltage wave, this may not cause any problem during normal running operation of the tube light butit can creates problem in nearby connected communication devices. This thing can be improved by using proper filter circuit.

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Author's Biography

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