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GENERATION OF LIGHT THROUGH PLASMA USING RADIO FREQUENCY SOURCE IN DISUSED FLUORESCENT TUBE

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Abstract

Light has been generated through Plasma using radio frequency source in 4Ft 40W disused fluorescent tube. As against the thermionic and incandescence source of running a fluorescent tube which is actually difficult to get started due to the resistance of the gases enclosed inside, a Radio Frequency signal of 30MHz generated using a designed Hartley Oscillator is employed. The power of the signal generated is amplified from 231mW to 197.8W using a modeled inverter. The coupled Hartley oscillator and the inverter form an ionizing circuit. The gases inside fluorescent tube consist of mercury Vapor, argon, krypton or Neon. When sufficient energy is supplied to these gases, by the ionizing circuit, ionization and excitation takes place which makes otherwise neutral gases, to change state to a cloud of ionized gas called Plasma. When excited electrons in the gases return to the ground state they lose energy in packets called Photon. This Photon is ultraviolet light which is not visible to the human eye but when it strikes the walls of the tube coated with Phosphor it glows whereby light is generated. The high electric field Radio frequency circuit designed has generated light in a fluorescent tube without the use of starter and ballast. It has also generated light in otherwise “dead” or disused fluorescent bulbs.

Keywords: Oscillator; Radio Frequency; Circuit; Plasma; inverter; Fluorescence.

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1. Introduction

Light energy is the energy carried by waves in the visible region of the electromagnetic (EM) spectrum within the range 400-700nm. This is the region of electromagnetic spectrum that is visible to the human eye.

Light is electromagnetic radiation within a certain portion of the electromagnetic spectrum. The word usually refers to **visible light**, which is visible to the human eye and is responsible for the sense of sight (Buser and Imbert, 1992).

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According to Pal and Pal (2001) Visible light is usually defined as having wavelengths in the range of 400–700 nanometers (nm), or 4.00×10^{-7} to 7.00×10^{-7} m, between the infrared and the ultraviolet . These have longer and shorter wave lengths respectively. This wavelength means a frequency range of roughly 430–750 terahertz (THz).

According to Gregory and Kumar (2006), the term light sometimes refers to electromagnetic radiation of any wavelength, whether visible or not. By implication, It can be concluded that gamma rays, X-rays, microwaves and radio waves are also light. Electromagnetic radiation (EMR) is generally classified into categories in accordance to their respective wavelengths and frequencies with their peculiar behaviours. The higher frequencies radiations have shorter wavelengths and the lower frequencies radiation have longer wavelengths.

Laufer(1996); Bradt(2004) defined visible light as narrowly as 420 to 680nm and Ohannesian and streeter(2001); Ahluwalia and Goyal (2000) defined light as broadly as 380nm to 800nm. According to Shiney,et al (1996), under ideal laboratory conditions people can see infra red up to at least 1050nm. Lynch and Livingston (2001); Madhad and Safya(2009), posited that children may perceive ultraviolet wavelengths to about 310nm to 313nm.

1.1. Sources of Light

There are many sources of light. A body at a given temperature emits a characteristic spectrum of black-body radiation. Aside from the Sun which is the main source of light in the Universe, The concentration of this paper shall be on the source that produce wavelengths from about 390 to 700nm called the visible light. The other sources are Electric Arc, Incandescence, and Luminescence.

The Sun

The Sun is a simple thermal source. According to Lynch and Soffer (1999), the radiation emitted by the chromospheres of the Sun at around 6,000 kelvins (5,730 degrees Celsius; 10,340 degrees Fahrenheit) peaks in the visible region of the electromagnetic spectrum when plotted in wavelength units and roughly 44% of sunlight energy that reaches the ground is visible. The main source of light on Earth is the Sun the light of which supplies the energy that is used by plants in photosynthesis as the main source of energy used by living things.

The Electric Arc

This is as a result of an electrical breakdown in gas causing a continuous discharge. It is mainly caused by thermionic emission of electron from the electrodes supporting the arc. The current through the medium between the conductors which is not ordinarily conductive which may be air or gas produces ionized clouds of charges called plasma. The plasma may invariable produce a visible light. According to Mehta (2005), a drawn arc can be initiated by two electrodes initially in contact and drawn apart.

Incandescence

Incandescence is the emission of electromagnetic radiation; visible light inclusive, from a hot body as a result of its temperature (en.m.wikipedia.org). It is the emission of light by a body that

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has been heated until it glows or radiates light. Thermal radiation typifies incandescence (visible light) with the inclusion of infrared and any other types of radiation.

Luminescence

This is the emission of light by a substance not resulting from heat. It is a form of cold-body radiation which can be caused by chemical reactions electrical energy, subatomic motions or stress in crystals. These kinds of emissions are called spontaneous emissions as distinguished from incandescence caused by heating. Cooper, Randle, and Ranjeet (2003) declared that the dials, hands, scales, and signs of aviation and navigational instruments and markings are often coated with luminescent materials in a process known as luminiscing. There are different types of Luminescence, viz:

i. **Chemiluminescence:** The emission of light as a result of a chemical reaction.
ii. **Bioluminescence:** The emission of light as result of biochemical reactions in a living organism.
iii. **Electrochemiluminescence:** The emission as result of electrochemical reaction
iv. **Lyoluminescence:** A result of dissolving a solid (usually heavily irradiated) in a liquid solvent.
v. **Candoluminiscence:** The emission by certain materials at elevated temperatures which different from blackbody emission expected at the temperature in question.
vi. **Crystalloluminescence:** Emission as a result of crystallization.
vii. **Electroluminescence:** Emission as a result of electric current current passed through a substance
viii. **Photoluminescence:** Emissions as a result of photons.
ix. **Fluorescence:** Photoluminescence as a result of singlet-singlet electronic relaxation.
x. **Phosphorescence:** Photoluminescence as result of triplet-singlet electronic relaxation.

It is without doubt that scientist and technologist have researched and are still researching to generate light due to its importance. Hence the interest here is to generate light through Plasma in disused Fluorescent tube using a high electric field Radio Frequency different from the thermionic or incandescence often used. Light generated through radio frequency shall cut the cost of needed starter and ballast in the convectional fluorescent tubes and elongate the life span of the tubes. After the tube is discarded, so long as it is not broken, the electrodes enclosed can be used as antennas to deliver a high frequency radio signal to gas(es) inside to generate Plasma which is responsible for the light.

Plasma

Plasma, often referred to as the fourth state of matter is a special form of ionized gas that conducts electricity. It is a gas in which an important fraction of the atoms is ionized, so that the electrons and the ions are separately free (Hutchinson, 2001). Plasma is an assemblage of positive ions and unbound electrons in which the total number of positive and negative charges is almost exactly equal. It is formed when a gas atom is impacted by a high energy electron which results in liberation of electron(s) from its outermost shell: these electrons so liberated impact other atoms and liberate more electrons. This action continues if there is enough source energy, hence a cloud of ionized atoms are formed.

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Plasma Generation

Plasmas are generated by supplying energy to a neutral gas causing the formation of charge carriers. Electrons and ions are produced in the gas phase when electrons or photons with sufficient energy collide with the neutral atoms and molecules in the feed gas (electron-impact ionization or photo ionization). Plasma is generated by different means viz;

i. Electric Field

A neutral gas inserted between confined electrodes of a different polarity under a strong influence of an electric field will be ionized. Electron released from the mother atom will be accelerated by the existing field knocking off electrons from other atoms and hence creating more cloud of ionized state of matter called plasma.

ii. Using beams

Plasma generation using beams is most frequently accomplished by the use of electron beams and laser beams. A beam-produced plasma discharge (Schmidt et al, 1992) is sustained, for example, by the interaction of an electron beam with a gaseous medium. Collective effects produce turbulent plasma oscillations with high amplitudes. The heating of the plasma electrons in this turbulent field is sufficient to sustain the beam-produced discharge plasma. The energy transfer is very effective as up to 70% of the beam energy can be transferred to the plasma.

iii. Radio Frequency

This refers to any frequency within the electromagnectic spectrum associated with radio wave propagation. Its range is from 3Khz-300Ghz of the E.M spectrum.

When a radio frequency is introduced into a column containing a neutral gas, it has a capability of resonating the particle of the gas hence the detachment of the bonds whereby electrons could be liberated from the mother compound (Korzer et al, 1996). These electrons so liberated could also contribute to the resulting avalanche of ions created. According to Kaufman et al, (1993), Radio frequency energy can be used to generate ions using either by inductive or capacitive coupling to deliver the RF energy to the plasma.

The Fluorescent

Fluorescent lamps are gas discharge lamps i.e they use the principle of making a gas electrically conductive thereby emitting light. A fluorescent lamp is a low pressure mercury vapour gas-discharge lamp that uses fluorescence to produce visible light. An electric current in the gas excites mercury vapour which produces shortwave ultra violet light that causes a phosphor coating on the inside of the lamp to glow.(www.en.m.wikipedia.org/flourescent)

Fluorescent tube is made of glass that contains a low pressured mercury vapour and argon or Krypton atom. It has electrodes on both sides. The inside of the tube is coated with phosphor that gives out light whenever the ultraviolet light from the ionized gas or plasma strikes it. The construction of a fluorescent is shown in Figure 1.0

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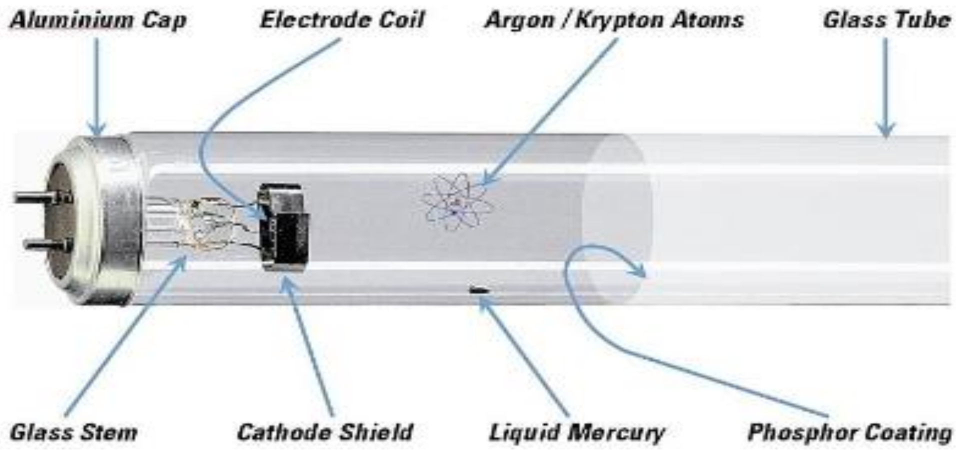

Figure 1: Construction of a fluorescent Tube.

2. Methodology

The methods here involves the design of a circuit that supplies a high electric field radio frequency signal to irradiate the gas(es) enclosed in a fluorescent tube thereby generating cloud of charges called Plasma whereby light is generated.

2.1. The Circuit Design

A Hartley Oscillator is employed here to generate the radio frequency signal. Fig 2.0 shows the circuit of the Hartley Oscillator.

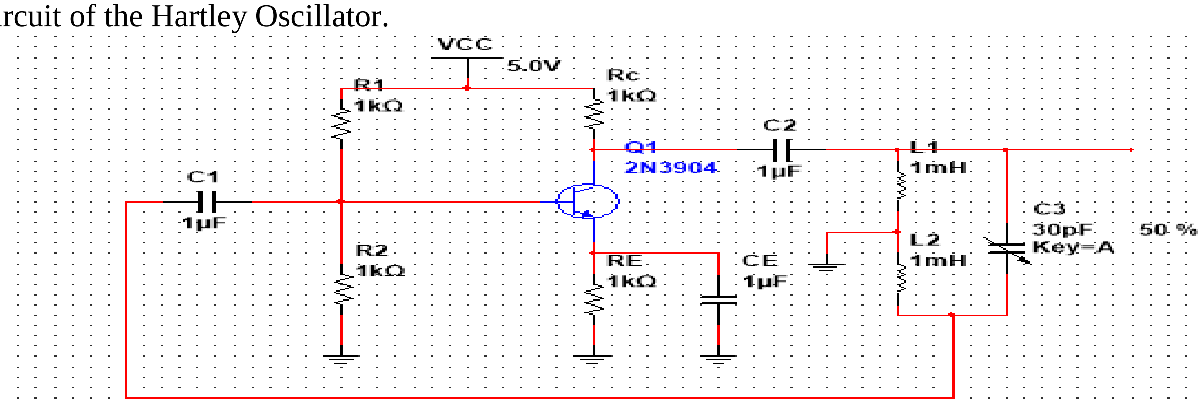

Figure 2: A Hartley Oscillator Circuit modeled with Multism 13.0 (Mehta &Mehta, 2009).

The Hartley Oscillator consists of a tank circuit containing two (2) inductors L_1 and L_2 in series connected in Parallel with a capacitor C_3

When the circuit is turned on, the capacitor is charged. When this capacitor is fully charged, it discharges through coils L_1 and L_2 setting up oscillations of frequency determined by

$$F = \frac{1}{2\Pi\sqrt{CL_T}} \qquad (1.0)$$

Where $L_T = L_1 + L_2$ and C is the Capacitance.

The output voltage of the amplifier appears across L_1 and feedback voltage across L_2. The voltage across L_2 is 180^0 out of phase with the voltage developed across L_1.

The feedback is provided by the voltage (Vout) across L_2 and it is positive feedback. A phase shift of 180^0 is produced by $L_1 - L_2$ voltage divider. This results in the feedback producing continuous undamped oscillations as a further 180^0 Phase shift is provided by amplifier (Transistor) thereby making the feedback positive.

In Hartley oscillator, the feedback voltage is across L_2 and output voltage is across L_1.

2.2. Tank circuit Design

Choosing the inductor and the capacitor

The combined inductor value is chosen to be $L_T = 11\mu H : L_1 = 6\mu H, L_2 = 5\mu H$
The desired radio frequency is 30Mhz
Using equation (1.0),
$C = (f^2 4\pi^2 L_T)^{-1}$
For 30MHz
$C = \left[(30x10^6)^2 x4(3.142)^2 x11x10^{-6}\right]^{-1}$
$= \left[3.91x10^{11}\right]^{-1} = 2.56pF$

The amplifier and Biasing Method

For a good Hartley oscillator, an amplifier with a low noise, high gain and a good reasonable collector current is required. Typical 2N3904 is chosen as it fits the above description. It has a high gain of 300 in common emitter configuration; 200ma collector current at a transition frequency of 300MHz Maximum (Galandanci & Ewansiha, 2013).

The output current of this transistor flows for a full cycle of the input signal, hence it is a class an amplifier which allows for linear operation of the A.C signal with a reduced to minimum distortion when correctly biased. The strength of the tank circuit must be raised without any change in its general shape, a process called faithful amplification. To ensure the faithful amplification, the following basic conditions must be satisfied:

i. Proper Zero signal Collector current;
ii. Minimum Proper base emitter voltage (V_{BE}) at any instant;
iii. Minimum Proper Collector-Emitter (V_{CE}) at any instant. (Mehta &Mehta, 2009)

The biasing method chosen for this Design is Voltage divider Biasing.

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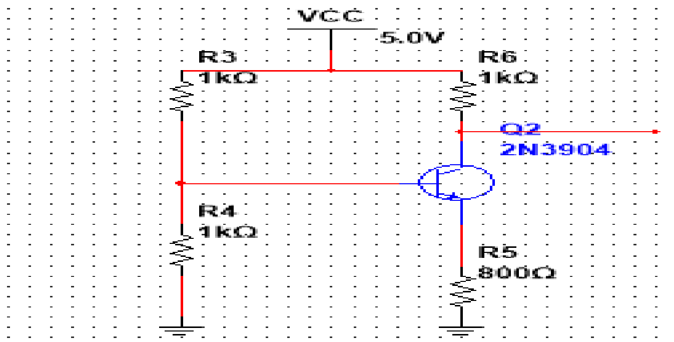

Figure 3: Voltage Divider Transistor Biasing Modeled with Multism 13.0

According to Mehta & Mehta (2009), the voltage divider biasing is the most widely used method of providing biasing and stabilization of a transistor. R_1 & R_2 are connected across the voltage V_{CC} or V_1 and they are responsible for the biasing.

2.3. Oscillator Amplifier Design

Assumptions,
V_E = 10% OF V_{CC} for temperature stability.
H_{FE} = 100
V_{CC} =6V
I_C = 1.2mA
2N3904 is Silicon transistor, we assume a V_{BE} of 0.7V for more stability (Schuler 1999)

$$V_B = V_{BE} + V_E \tag{1}$$

$$V_E = I_E R_E \tag{2}$$

$$\beta = \frac{I_C}{I_B} \tag{3}$$

$$V_E = 10\% X\, 6.0V = 0.6V$$

$$\therefore V_B = 0.7 + 0.6 = 1.3V$$

$$I_E = I_B + I_C \tag{4}$$

But $I_C >> I_B$ therefore, $I_E \approx I_C$ = 1.2Ma

$$\beta = \frac{I_c}{I_B} \Rightarrow 100 = \frac{1.2x10^{-3}}{I_B}$$

$$I_B = \frac{1.2x10^{-3}}{100} = 1.2x10^{-5} = 12\mu A.$$

Choosing R_E

$$R_E = \frac{V_E}{I_E} = \frac{0.6V}{1.2mA} = 500\Omega$$

Choosing $R_1 \& R_2$
Voltage across R_2 in the voltage divider arrangement in the bias circuit is given by;

$$V_B = \frac{V_{CC}}{R_1 + R_2} x R_2 \tag{5}$$

While the voltage across R_1 is given by;

$$V_{CC} - V_B = \frac{V_{CC}}{R_1 + R_2} x R_1 \tag{6}$$

Looking for the ratio of $\frac{R_2}{R_1}$ from equation (5) & (6);

From eqn (5)

$$V_{CC} R_2 = V_2 (R_1 + R_2)$$

$$R_2 = \frac{V_B (R_1 + R_2)}{V_{CC}} \tag{7}$$

From eqn (6)

$$R_1 = \frac{V_{CC} - V_B (R_1 + R_2)}{V_{CC}} \tag{8}$$

$$\frac{R_2}{R_1} = \frac{V_B (R_1 + R_2)}{V_{CC}} x \frac{V_{CC}}{V_{CC} - V_B (R_1 + R_2)}$$

$$= \frac{V_B}{V_{CC} - V_B} \tag{9}$$

The Parallel Resistance of the circuit should be less than or equal to:

$\frac{1}{10} R_{in(base)dc}$ (Paul, 2007)

$$i.e \frac{R_1 R_2}{R_1 + R_2} \leq \frac{1}{10} R_{in(base)dc} \tag{10}$$

$$but R_{in(base)dc} = h_{FE} R_E \tag{11}$$

$$h_{FE} = 100, R_E = 500\Omega$$

$$R_{in(base)dc} = 100 x 500 = 50000 = 50 k\Omega$$

From eqn (3.23),

$$\frac{R_1}{R_2} = \frac{V_B}{V_{CC} - V_B} = \frac{1.3}{6.0 - 1.3} = \frac{1.3}{5.7}$$

$$i.e 1.3 R_1 = 5.7 R_2$$

$$R_1 = 4.38 R_2 \tag{12}$$

Using eqn (12) in eqn (10),

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$$\frac{R_1 R_2}{R_1 + R_2} = \frac{1}{10} x 50000$$

$$i.e \frac{4.38 R_2 x R_2}{4.38 R_2 + R_2} = 5000$$

$$4.38 R_2 = 5000 x 5.38$$

$$R_2 = 6.14 k\Omega$$

Substituting for R_2 in eqn(3.26) yields;

$$R_1 = 4.38 x 6.14 k\Omega = 26.89 k\Omega$$

Choosing Rc

For Maximum symmetrical swing,

$$V_C = \frac{1}{2} V_{CC}$$

$$i.e V_C = \frac{1}{2} x 6.0 = 3.0V$$

$$R_C = \frac{V_{CC} - V_C}{I_C} = \frac{6.0 - 3.0}{1.2 x 10^{-3}} = 2.5 k\Omega$$

R_C is the load resistor on the collector of the amplifier. For the requisite Oscillator, choke RFC was used at the collector to provide d.c Load for the collector and prevent a.c current out of the d.c supply (Theraja,2005)

To determine the value of the inductor for the choke,

$$R_C = R_L = 2\pi f L$$

$$L = \frac{R_L}{2\pi f} = \frac{2.5 x 10^3}{2 x 3.142 x 100 x 10^6} = 3.92 x 10^{-6}$$

$$L = 3.92 \mu H$$

This is using the maximum required frequency.

Choosing the coupling capacitor

Capacitive reactance,

$$X_C = \frac{1}{2\pi f C}. \tag{13}$$

Where f is the frequency of Oscillation and C is the capacitance.

According to Schuler (1999), the capacitance is selected to have one-tenth (1/10) of the reactance of the concerned resistors.

i.e $$X_{C_1} = \frac{R_{in}}{10} = \frac{1}{2\pi f C_1} \tag{14}$$

Where f is the maximum frequency of oscillation and C is the capacitance of the coupling capacitor.

From eqn (14),

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$$C_1 = \frac{10}{2\pi f R_{in}} \tag{15}$$

R_{in} is the combined resistors of the biasing potential divider and the internal resistance of the amplifier.

$$\frac{1}{R_{in}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_{in(base)a.c}} \quad (16)$$

(Paul,2007) (16)

$$R_{in(base)a.c} = h_{FE}\left(\frac{R_E R_L}{R_E + R_L}\right)$$

$R_C = R_L$ since the output cannot draw more current than current allowable through R_C.

$R_C = 2.5K\Omega$, $R_E = 500\Omega$ $h_{FE} = 100$

$$R_{in(base)a.c} = h_{FE}\left(\frac{R_E R_L}{R_E + R_L}\right) = 100\left(\frac{500x2500}{500x2500}\right) = 416.6\Omega$$

Using Eqn (3.30)

$$R_1 = 26.89k\Omega, R_2 = 6.14k\Omega, R_{in(base)a.c} = 416.6\Omega$$

$$\frac{1}{R_{in}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_{in(base)a.c}} = \frac{1}{26890} + \frac{1}{6140} + \frac{1}{416.6} = 2.6004x10^{-3}$$

$$\Rightarrow R_{in} = 384.6\Omega$$

From Eqn (3.29)

$$C_1 = \frac{10}{2\pi f R_{in}} = \frac{10}{2x3.142x100x10^6x384.6} = 41.4pF$$

Choosing C_2

$$C_2 = \frac{10}{2\pi f_{\min} R_c} = \frac{10}{2x3.142x10x10^6x2500} = 63.7pF$$

Choosing C_E

$$C_E = \frac{10}{2\pi f_{\min} R_E} = \frac{10}{2x3.142x10x10^6x500} = 0.31nF$$

Summarily,

V_{CC} =6.0V, V_C = 3.0V, $I_C = I_E$ = 1.2mA, I_B = 12µA, R_1 =26.89kΩ, R_2 =6.14kΩ, R_E = 500Ω, $R_C = R_L$= 2.5kΩ,

RFC = 3.92µH, C_1 = 41.4pF, C_2 = 63.7pF, C_E = 0.31nF

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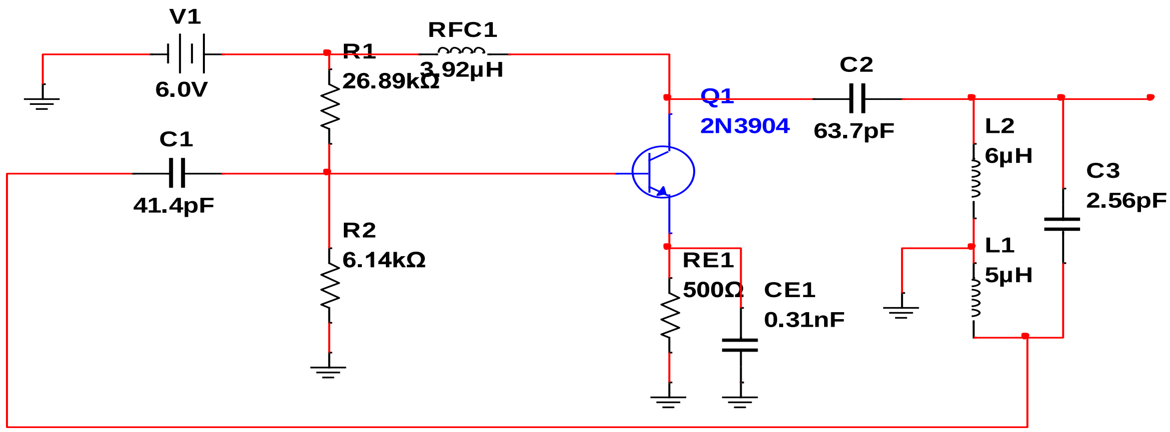

Figure 4: Radio frequency signal Generator Circuit modeled with Multism 13.0

Radio Frequency Power

In the designed oscillator, the RF power is given by

$$P = \frac{V_{rms}^{2}}{R_L} \tag{17}$$

The V_{p-p} for 30MHZ .is 34volts and the R_L is 2.5kΩ. Hence,

$$P = \frac{V_{rms}^{2}}{R_L} = \frac{(V_{P-P}\, X\, 0.707)^2}{R_L} = \frac{(34 \;\; X\, 0.707)^2}{2.5X10^3\,\Omega} = \frac{577.83}{2.5X10^3}$$

$$= 0.231W = 231mW.$$

This RF signal power is very small hence the need for amplification. In reference to equation (17) above, there is the need to increase the value of the signal V_{rms} with reference to the resistance of the RF output signal. In other words, any increase in the value of the voltage will increase the value of the power and invariably increase the value of the ionization power of the radio frequency. The principle of an inverter was employed to model the RF power amplifier.An inverter gives a high voltage alternating current from a low voltage direct current with the input frequency from an oscillator.

The RF power amplifier

In the design of the RF power amp, a fixed base bias transistor circuitry is employed in the design (fig 5.0)

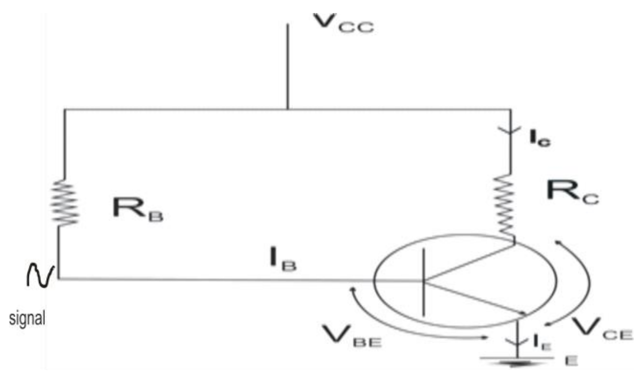

Figure 5: Fixed Base Biased Transistor.

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Determining the value of R_B
V_{cc} =6V, I_C=5A, β =250

$$V_{BE} = V_B = V_{CC} - I_B R_B \quad (18)$$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} \quad (19)$$

But

$$I_C = \beta I_B \quad (20)$$

At Saturation,

$$I_{B'} = 10 I_B = 10x20X10^{-3} = 200mA$$

For silicon transistor,

$$V_{BE} = 0.7V$$

.

$$R_B = \frac{V_{CC} - V_{BE}}{I_B} \quad (21)$$

$$R_B = \frac{6 - 0.7}{200X10^{-3}} = 26.5\Omega.$$

2.4. The Transformer Design

Primary Voltage = 34V
Secondary Voltage =1000V
Secondary current = 500ma
Core Area = $1.152x\sqrt{V_0 X I_0}$

$$= 1.152\sqrt{1000X500x10^{-3}}$$
$$== 1.152X22.36$$
$$= 25.76cm^2$$

To determine the number of turns in the Primary and secondary, the turns per volt must be determined Viz;
Turn per volt $N_T V^{-1}$ = ¼.44 x Frequency x Core area x Flux density
= ¼.44xFxA_{core}Xb_{max} (Theraja, 2005)
F = 60Hz, B_{Max}= 1.3 Tesla, A_{core} = 25.76cm^3

$$N_T V^{-1} = 1/4.44X10^{-4}X60X25.76X1.3$$

$$= 1/0.892 = 1.12.$$

The Maximum Current that can be taken by the Transformer under design is determined as follows:

The Primary current $I_P = \frac{V_0 I_0}{V_{IN} X \varepsilon}$

Where V_0 is the output voltage i.e the secondary Voltage;
I_0 is the output current i,e the secondary Current
V_{IN} is the Input Voltage i,e the Primary Voltage.
Ɛ is the efficiency of the transformer.

Taking Ɛ as 85%,

$$I_P = \frac{1000 X 500 X 10^{-3}}{36 X 0.85}$$

$$= \frac{500}{30.6} = 16.34A$$

Determining the number of Primary turn;

$$N_P = N_T V^{-1} X V_{IN} (V_P)$$

$$= 1.12 X 34$$

$$= 38.08.$$

The number of secondary turn is determined by;

$$N_s = 1.03 x N_T V^{-1} x V_s$$

$$= 1.03 x 1.12 x 1000$$

$$1153.6 \approx 1154$$

Stacking Factor = 1.03.

The transformer is a step up one with the following parameters
Input Voltage = 34V
Input Current = 16.34A
Output Voltage = 1000V
Output Current = 500mA.

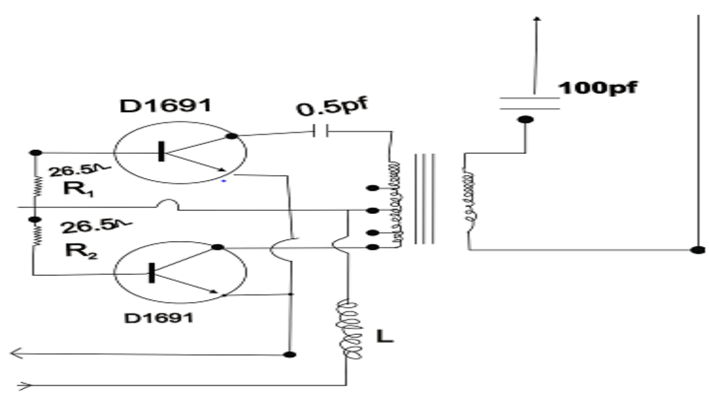

Figure 6: The Inverter and R.F Power Amplifier.

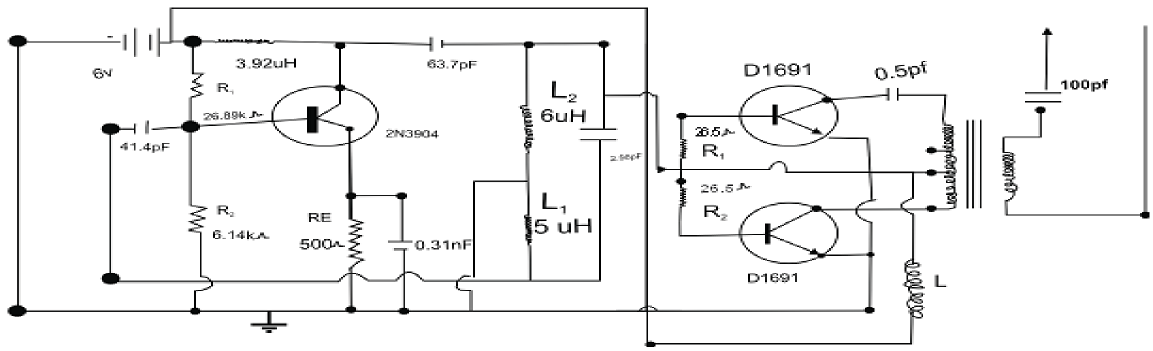

Figure 7: The Radio frequency ionizing circuit.

The modified and constructed radio frequency signal generator is coupled into the base of the modeled amplifier as shown in Figure 7.0 This constitutes the ionizing circuit.

Determination of the Ionization Power

The ionization power (P_{ion}) of the RF amplifier circuit is determined by

$$P_{(ion)} = \frac{V_{rms}^2}{R_L}$$

$V_0 = 1000V$, $V_{rms} = 1000x\ 0.7071 = 707.1V$

$R_L = 2.5\ x10^3 + 26.5 = 2526.5\Omega$

$$P_{(ion)} = \frac{V_{rms}^2}{R_L} = \frac{(707.1)^2}{2526.5}$$

$$= 197.8W$$

TEST: Generation of light in a disused Fluorescent Tube.

The circuit in Figure 7.0 connected to a disused fluorescent tube 4Ft 40W produced light.

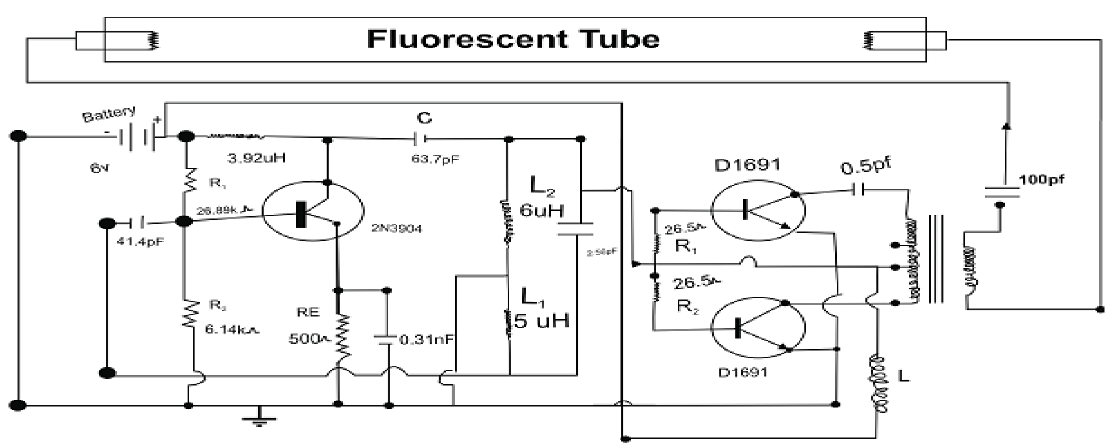

Figure 8: Schematic of the ionizing circuit connected to a disused fluorescent tube.

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3. Results, Discussion and Conclusion

The designed and constructed circuit above connected to disused fluorescent tubes and energy bulbs of different shapes produced light of different luminance. The bulbs used were certified "dead" bulbs. The filaments enclosed inside the bulbs acted like antenna that delivered the high electric field radio frequency signal to the gases enclosed inside the tubes. The gases were ionized by the Radio frequency of 30MHz. The gases ionized and excited inside the tube formed cloud of electrons and ions called Plasma. The excited electrons returning back to their ground state loses packet of energy called Photon in the ultra violet section of the electromagnetic spectrum. The Ultra violet light is not visible to the human eye but when it strikes the walls of the tube coated with phosphor, it glows. Hence the source of light.

Conclusion

Light has been generated from disused 4ft, 40W fluorescent bulb using a high electric field Radio frequency of 30MHz. The bulbs used were disused ones but they were still useful when irradiated with a Radio Frequency. The disused fluorescent tube used produced light without the use of starter and ballast. These are notable achievements. It was however discovered that the luminance of the light in the tube reduced with time; this can be improved if the output can be tapped, rectified and fed back to the battery.

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