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Performance Analysis of a Blocking Oscillator used for Low Voltage Fluorescent Lighting

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Abstract: The performance analysis of a blocking oscillator used in a low voltage fluorescent lighting was carried out. Javelin fluorescent tube with voltage rating of 12 V and power rating of 8 W and with dimensions of (370×45) mm was used. The performance analysis was carried out to determine the time constant, the pulse duration and the efficiency of the blocking oscillator as well as the turns ratio of the pulse transformer used. Measurements were taken using multimeter and oscilloscope. The results obtained showed that the time constant is 40 μs, the pulse duration is 16 μs, the efficiency is 58.2% and the turns ratio of the pulse transformer is 2:1 at the primary (collector) and secondary (base) and 1:7 at the primary (collector) and tertiary (high voltage) windings. From the results obtained, the efficiency is found to be low and the pulse duration is within the acceptable value of between 0.05 μs to 25 μs specified for blocking oscillators.

Key words: Blocking oscillator, pulse transformer, efficiency, time constants, pulse duration

INTRODUCTION

In order to get a regenerative switching circuit, a single device which may be a Bipolar Junction Transistor (BJT) or a Junction Field Effect Transistor (JFET) is used. One needs not use two transistors, as the second transistor can be replaced with a polarized pulse transformer that is properly phased (Glenn, 1986; Calvert, 2002). Such transformers are supplied with design data for the blocking oscillator circuit. A blocking oscillator transformer is wound to realize a 180° phase shift between primary and secondary (Langford-Smith, 2000). The positive feedback mechanism with a loop gain greater than unity is required because of excessive feedback; however the signal that is produced is not a sine wave but a narrow pulse. A blocking oscillator is a circuit used for generation of short pulses of duration of about 0.05 to 25 μs (Glenn, 1986; Nikolai and Alexander, 2001). The use of pulse transformer is necessary, since for a common emitter stage, phase reversal is needed. The gain is provided by common emitter stage. However, current gain and voltage gain are needed to make a loop gain greater than unity. Stable oscillation frequency is one of the most important characteristics required of oscillators (Borys and Wojtyna, 1993).

The investigation is carried out to know how efficient some of the circuits being designed in the industries and produced for sales to the public for use are. This is with a view to-redesigning the circuit, in order to improve the efficiency.

Blocking oscillator for low voltage fluorescent lighting finds wide applications on caravan, boats, emergency lighting and some other domestic appliances.

Blocking oscillator circuits are used as high energy pulse generators, as frequency dividers, as thyristors trigger pulse generators and as capacitor discharge in time base circuits.

In the circuit under consideration a common emitter configuration is used. Digital multimeter and oscilloscope were use to measure the parameters of the circuit and display the waveforms.

- The time constant is the duration of one cycle.
- The pulse duration is the ON time of the pulse.
- The efficiency is the ratio of the useful power to the available power.

The turns ratio of the pulse transformer is the ratio of the primary (collector) to the secondary (base) winding and primary (collector) winding to the tertiary (high voltage) winding.

MATERIALS AND METHODS

Test and measurement instruments: Power supply unit P59/1 Type L30B, Oscilloscope OS250B, Digital multimeter 8010A, Transistor Analyzer, Digital voltmeter 7010B, Extra High Tension voltage, Signal generator type LFP1, Component meter (Wayne Kerr) and Javelin fluorescent tube ratings 12 V DC, 8 W and of dimensions 370×45 mm.

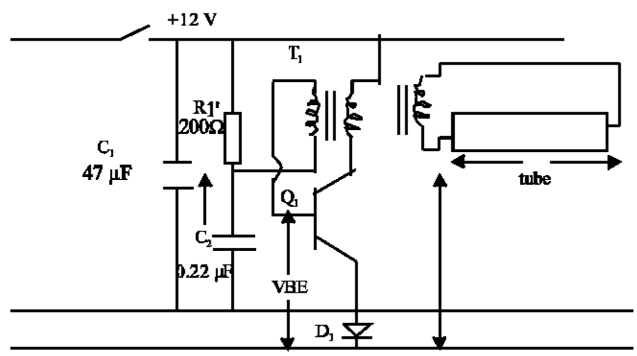

Fig. 1: Analysed blocking oscillator for low voltage fluorescent lighting

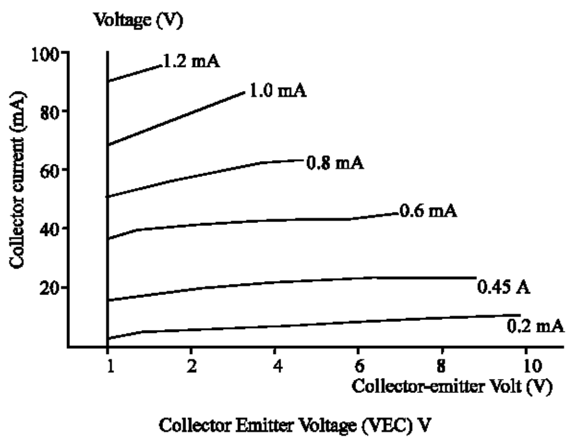

Fig. 2: Output characteristics of power transistor TD234

Measurements: Figure 1 is the analysed blocking oscillator used for low voltage fluorescent lighting. In this analysis, a transistor analyzer is used to display the output characteristic curves of the power transistor type TD234 as shown in Fig. 2. These output characteristics of TD234 transistor show the minimum and maximum operating base currents of the transistor to be as 0.1 and 1.2 µA, respectively and the minimum and maximum collector currents of the transistor as 5 and 88 mA.

The following measurements were taken

- DC supply voltage and current.
- The voltage across and the current through the fluorescent tube.
- The voltage across the primary (collector), Secondary (base) and tertiary (high voltage) windings of the transformer.
- The collector voltage, the base voltage, the capacitor voltage and the fluorescent tube voltage.
- The collector current and the base current.
- The time constant and the pulse duration.

RESULTS AND DISCUSSION

The following readings were obtained and are as presented in Table 1.

In order to measure the secondary and the tertiary voltage of the pulse transformer, a signal of 49.9 mV at a frequency of 1 kHz was injected across the primary (collector) winding using a signal generator. The following readings were obtained as shown in Table 2.

Voltage-time relationship waveforms: The voltage time relationship waveforms for collector, base, capacitor and fluorescent tube were obtained as displayed on the oscilloscope as shown in Fig. 3. And the following readings were obtained form the collector, base, capacitor and fluorescent tube as shown in Table 3.

Voltage-time relationship waveforms: A resistor of 0.22 Ω was connected for measurement purposes in series with the collector and the base. The voltage-time relationship waveform for the collector and the base were obtained as displayed on the oscilloscope as shown in Fig. 4 based on a scale of V = 20 mV/Div×10 probe and t = 10 µs/DIV. The following readings were obtained from the collector voltage waveforms as displayed on the oscilloscope in Fig. 4 and as shown in Table 4.

Calculations:

- Determination of the time constant and the pulse duration of the blocking oscillator. From Fig. 3, we make use of collector voltage waveforms for direct measurement of the time constant and pulse duration from the display on the scope. Based on the scale of V = 2 mV/Div × 10 probe and t = 10 µs/Div

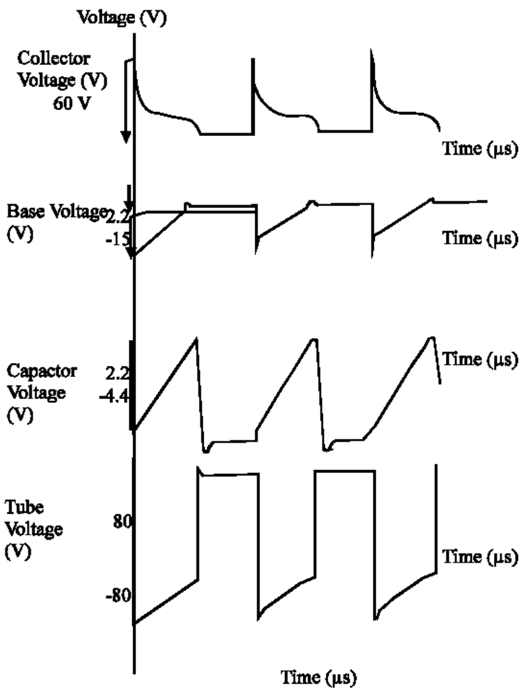

Fig. 3: Collector, base, capacitor and tube voltages against time

Table 1: Supply and fluorescent tube voltages and currents

DC supply volt (V)	DC supply current (A)	Fluorescent tube volt (V)	Fluorescent tube current (A)
11.98	0.8	56.7	0.0984

Table 2: Pulse transformer winding voltages

Collector (primary) mV	Base (secondary) mV	High volt (tertiary) mV
49.9	20.7	326.0

Table 3: Collector, base, capacitor and fluorescent tube voltages at different time intervals

Voltages V	Time t = 0 µs	t = 17 µs	t = 20 µs	t = 24 µs
Collector voltage	60.0	13.0	14.0	0.0
Base voltage	-15.0	2.0	2.2	2.2
Capacitor voltage	-4.4	1.6	2.2	1.1
Fluorescent tube voltage	-80.0	30.0	80.0	80.0

Table 4: Collector voltages at different time intervals

Time (µs)	Collector voltage (mV)
0	300
15	500

For 4 divisions

The time constant = 4 × 10 = 40 µs

The pulse duration = 1.6×⌈∏10 µs

= 16 µs

= 16 µs

- To calculate the efficiency of the circuit; efficiency is the ratio of the output power to the input power. From the readings in Table 1.

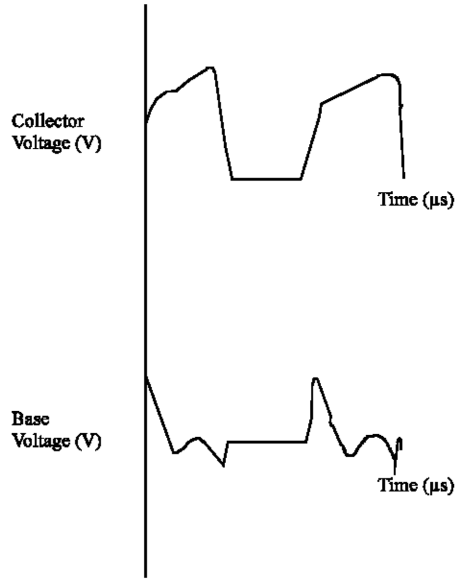

Fig. 4: Collector and base voltages against time

DC supply voltage = 11.98 V

DC supply current` = 0.80 A

Fluorescent tube voltage = 56.7 V

Fluorescent tube current = 0.0984 A

$$\begin{aligned} \text{Effeciency} &= \frac{\text{Power output}}{\text{Power input}}\times 100 \\ &= \frac{I_0 V_0}{\text{Iin vin}}\times 100 \\ &= \frac{98.4\times 10^{-3}\times 56.7}{11.98\times 0.80}\times 100 \\ &= 58.2\% \\ &= 58.2\% \end{aligned} \quad (1)$$

- Determination of the pulse transformer turns ratio: From Table 2, the voltage at the primary winding = 49.9 mV. The voltage at the secondary = 20.7 mV The voltage at the tertiary = 326 mV From the transformer principles;

$$\frac{V_2}{V_1} = \frac{N_2}{N_1} = \frac{I_1}{I_2} \quad (2)$$

Where, V_2, V_1, N_2, N_1, I_2, I_1 represent the transformer secondary and primary voltages, turns ratio and currents, from the above measured voltages.

Primary (collector) to secondary (base) ratio = 49.9/20.7 = 2.4/1 = 2: 1

Primary (collector) to tertiary (high voltage) ratio = 49.9/326 = 1/65 = 1: 7

The performance analysis of a blocking oscillator used for a low voltage fluorescent lighting was carried out and the efficiency of the blocking oscillator was calculated to be 58.2%. The circuit had to be re-designed in order to improve the efficiency.

The graph of voltages-time relationship waveforms for the collector, base, the capacitor and the fluorescent tube is showed in Fig. 3 and the readings obtained at different time intervals are shown in Table 3. At t = 0 μs and t = 24 μs, the transistor is in the cut off and saturated regions. The cut off period lasts until the capacitor is fully discharged and charges back to the voltage at t = 17 μs before the transistor can switch ON again.

From Fig. 3, the time constant and the pulse duration were calculated to be 40 and 16 μs. The pulse duration of 16 μs is within the acceptance limit of between 0.05 and 25 μs specified for blocking oscillators.

The current drawn from the supply and the current through the fluorescent tube were found to be 0.8 A and 98.4 mA. The turns ratio of the pulse transformer were found to be 2:1 at primary (collector) to secondary (base) and also 1: 7 at the primary (collector) to tertiary (high voltage) winging.The efficiency obtained was found to be 58.2%, which is very low.

CONCLUSION

In this study, the performance analysis of a blocking oscillator used for a low voltage fluorescent lighting was carried out. Based on the results obtained, the following conclusions are made:

- The time constant is 40 μs and the pulse duration is 16 μs.
- The current drawn from the supply is 0.8 A.
- The efficiency is 58.2%.
- The turns ratio of the primary (collector) to secondary (base) is 2:1 and primary (collector) to tertiary (high voltage) is 1:7.
- The efficiency could be increased if the circuit is re-designed to achieve the turns ratio of 1: 1 for primary (collector) to secondary (base) windings.
- Some of the circuits being designed in the industries and produced for sale to the public have low efficiency.

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