Journal of Mobile Multimedia, Vol. 11, No.3&4 (2015) 321-329

SIMPLE BLOCKING OSCILLATOR PERFORMANCE ANALYSIS FOR BATTERY VOLTAGE ENHANCEMENT

DEWANTO HARJUNOWIBOWO

ESMART, Physics Education Department, Sebelas Maret University, Indonesia
dewanto_h@fkip.uns.ac.id

RESTU WIDHI HASTUTI

Physics Education Department, Sebelas Maret University, Indonesia
restuwidhi_h@yahoo.com

KENNY ANINDIA RATOPO

Physics Education Department, Sebelas Maret University, Indonesia
kenny_anindia@yahoo.com

ANIF JAMALUDDIN

ESMART, Physics Education Department, Sebelas Maret University, Indonesia
anifjamal@gmail.com

SYUBHAN ANNUR

FKIP MIPA, Lambung Mangkurat University, Indonesia

An application Blocking Oscillator (BO) on a battery to power a system LED lamp light detector has been built and compared with a standard system used phone cellular adapter as the power supply. The performance analysis was carried out to determine the efficiency of the blocking oscillator and its potency to be adopted in an electronic appliance using low voltage and current from a battery. Measurements were taken using an oscilloscope, a multimeter, and a light meter. The results show that the system generates electrical pulses of 1.5 to 7.6 VDC and powering the system normally. The system generates 3.167 mW powers to produce the intensity of 176 Lux. On the contrary, the standard system needs 1.8mW to produce 5 Lux. A LED usually takes at least 60mW to get 7150 Lux. Therefore, the system used a simple blocking oscillator seems potential to provide high voltage for powering electronic appliances with low current.

Key words: blocking oscillator, characteristic, efficiency, LED, pulse

1 Introduction

A design of circuit based on blocking oscillator for light up a LED using waste battery was carried out. The following findings were made; the current drawn from the supply was 0.225 mA, the voltage was 0.98 V, and the efficiency based on intensity produced was 199%. The pulse transformer turns ratio of the collector to the base was 1:1, the time constant was 28.6 μs. It is nearby optimum time constant of blocking oscillator for low voltage fluorescent lighting [1]. The pulse transformer is made to have an 180^{o} phase shift between primary and secondary [2]. This transformer is important because phase reversal is needed for a common emitter stage. Besides that the gain is provided by the common emitter stage.

Blocking Oscillator which is classified to feedback oscillator produces relaxation oscillation type [3] has pulse repetitive rate driven by RC. Reference [4] said that stable frequency of oscillation is very important characteristic required of oscillators. Whereas in this simple blocking oscillator, pulse repetitive rate driven by R, therefore, the frequency was not stable. The resistor R is connected in series with the base of the transistor in order to control the timing, that is, the pulse duration [5]. The pulse width of monostable triggered transistor BO (base timing) may lie in the range of nanoseconds to microseconds [5,6,7].

Blocking oscillator for low voltage fluorescent lighting finds a wide application on some domestic appliances [1]. The experiment is conducted to measure the efficiency of the simple blocking oscillator powers a simple circuit designed by industries and produced for sales to the public. The experimental used a lamp light sensor using simple blocking oscillator and battery type AA, compared with the standard system which used adapter power supply.

The measurements used digital multimeter and oscilloscope to measure some electric variables from the circuit and display the waveform. The effect of light source intensity driven switching transistor of lamp light sensor is used as a trigger to produce an intensity of a white LED. The experiment uses a multimeter and oscilloscope to measure the output current and output voltage on the LED. The LED intensity is measured using lightmeter.

Research on light-emitting-diodes (LEDs) and used as light sources have been widely studied because they could produce monochromatic light with high energy efficiency [9,10]. White LED has voltage forward V_f bias around 3.0-4.0V and If = 20mA [8]. Additionally, some of the commercial instruments and analytical systems used LEDs [11,12,13] because they were more compact and low-cost, e.g., LED-based microscopy [14]. Moreover, many applications also used multi-LED light sources [15,16], since multiple LEDs can deliver plenty of output power while keeping the cost low.

2 Materials and Experimental Method

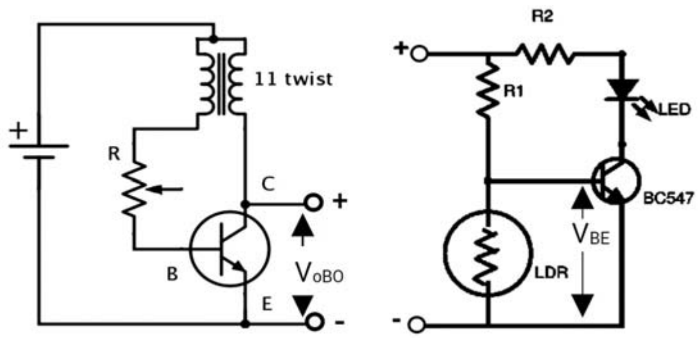
2.1 Materials

Measurements were conducted using Digital Oscilloscope OWON PDS5022T 25 MHz 100MS/s, Digital Multimeter Sanwa CD800a 4000 Count, and Lutron LX-105 Digital Light Meter. A handmade BO system was made using BC547 n-p-n transistors, variable resistors, a black toroid diameter 1 cm from died CFL lamp twisted 11 turns use two Belden RJ 45 cable with ratio 1:1, a white LED 5mm, and a battery 1.5V AA. As circuit appliance tester is a LED lamp light sensor using LDR based on voltage divider to drive switching transistor.

The light source used a 60 W bulb which could be adjusted using a potentiometer and mounted in a black box altogether with the LED and the lightmeter. The devices used in this experiment as indicated in Figure 1 were built on Protoboard.

2.2. Experimental Method

Using oscilloscope and multimeter, voltage system on specific parts were measured with and without blocking oscillator and tabulated on Table 1. While, V output (V_{LED}) was also measured on LED and V input (V_i) from 1.5 VDC AA. The light meter was used to measure the intensity from LED produced by both systems.



(a) (b)

Figure 1. Schematic; a. Simple blocking oscillator, b. Lamp light sensor.

The efficiency will be depicted by comparison of standard system and simple blocking oscillator system then presented in Table 1. The results will be shown in graphs. The efficiency is defined as the ratio of the generated power to the available power.

3 Results and Discussion

To figure out the efficiency, system based on blocking oscillator compared with standard system, the changes value of LDR resistance (R_{LDR}), transistor saturated voltage (V_{BE}), output voltage of LED (V_{LED}) and its current (i_{LED}), the power on LED (P_{LED}), and LED intensity (I_{LED}) were measured. The system will work or light on the LED maximum if LDR did not receive light intensity.

Table 1. Result of measurements for Standard and BO system

I_{LDR}	Standard						Blocking Oscillator					
	R_{LDR}	V_{BE}	V_{LED}	i_{LED}	P_{LED}	I_{LED}	R_{LDR}	V_{ppBE}	V_{ppLED}	i_{LED}	P_{LED}	I_{LED}
(lux)	(kΩ)	(V)	(V)	(mA)	(mW)	(lux)	(kΩ)	(V)	(V)	(mA)	(mW)	(lux)
0	226.20	0.747	3.64	38.4	139.8	780	220.00	0.933	3.80	0.833	3.167	176
10	3.78	0.702	3.40	26.5	90.0	442	3.44	0.907	3.00	0.40	1.200	111
20	2.97	0.660	3.11	9.8	30.4	260	3.09	0.900	2.80	0.34	0.952	101
30	2.80	0.650	3.09	9.5	29.2	98	2.52	0.806	2.60	0.22	0.572	81
40	2.36	0.630	2.83	2.5	7.0	64	2.08	0.792	2.40	0.18	0.432	23
50	2.28	0.580	2.68	1.1	2.9	17	1.70	0.790	2.20	0.04	0.088	0.0
60	2.01	0.518	2.58	0.0	0.0	0.0	1.60	0.650	2.16	0.00	0.0	0.0
70	1.89	0.500	2.56	0.0	0.0	0.0	1.60	0.650	2.08	0.00	0.0	0.0
80	1.71	0.470	2.52	0.0	0.0	0.0	1.57	0.650	1.60	0.00	0.0	0.0

It can be seen from Table 1 that simple blocking oscillator and standard system have similar characteristic on work principle. When the LDR received light intensity brightly the resistance decreases, therefore, current would not flow to the base transistor i_b, as the result the transistor keeps on cut-off condition. Since it was on cut off, the collector and emitter were disconnected as the result the LED could not light on (Figure 1).

In detail, Figure 2 depicts that LDR resistance decreasing on both systems exactly the same since the parameters and the light source are from the same light bulb. Figure 3, however, shows a bit difference on graphs display that simple blocking oscillator system has saturation voltage V_{BE} value higher than the other even though their characteristic is similar.

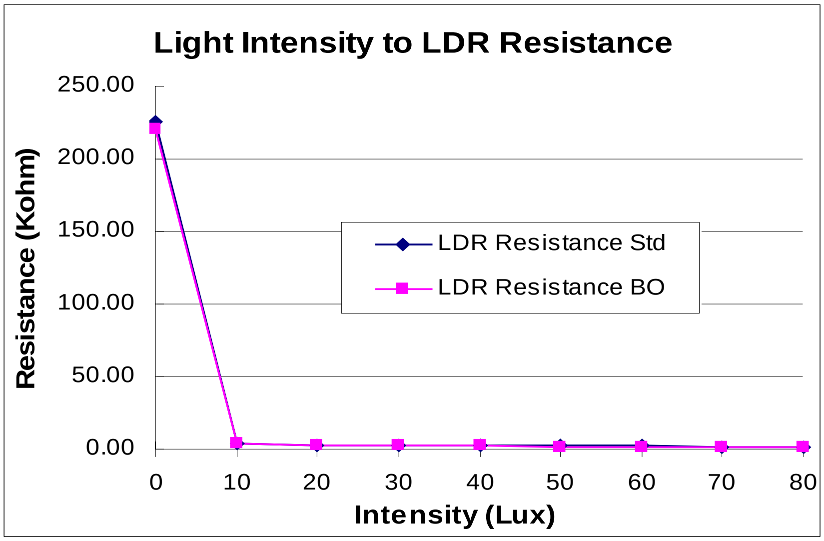


Figure 2. LDR characteristic affected by light source

The intensity received by LDR changed the value of its resistance. The resistance goes fall if the intensity is high and vice versa. This change affects to base-emitter voltage V_{BE} which control the transistor as a switch. The mechanism of V_{BE} value changes follows the working principle of a voltage divider which was used in the lamp light sensor system.

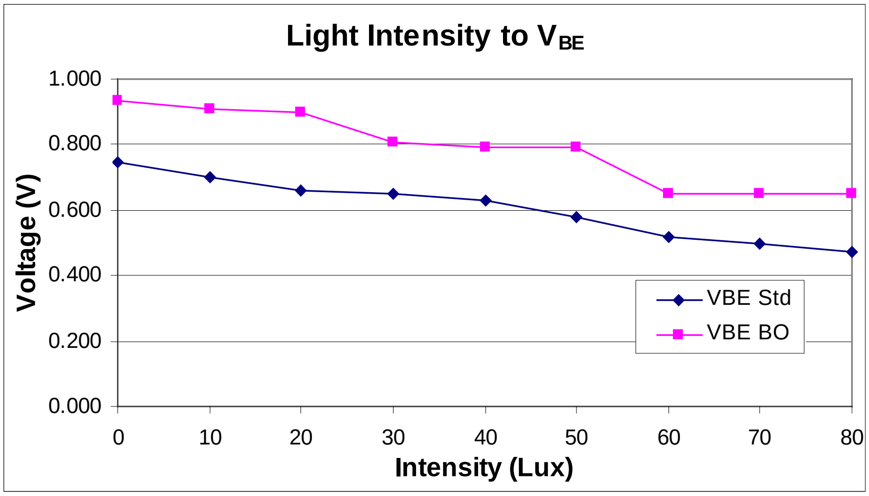


Figure 3. Intensity effected saturation voltage

The V_{BE} depends on the value of LDR resistance, R1, and input voltage from blocking oscillator voltage output, which was determined by Eq. (1).

$$V_{BE} = \frac{R_{LDR}}{R_{LDR} + R_1} V_{iBO} \tag{1}$$

The light source intensity was arranged from 0 to 80 lux. Figure 3 shows that V_{BE} of blocking oscillator system higher than standard system but it would not damage the transistor because the excessive power was very low.

Based on datasheet, white LED has voltage forward V_f from 3.0-4.0 volts and current forward I_f 20 mA. Figure 4 reveals that the experiment generated maximum voltage measured around 3.50 volts as well. Otherwise, the current I_f of standard system reached almost 40 mA much higher than blocking oscillator system which less than 1 mA (Figure 5).

Too much power which passed the LED could decrease the lifetime of LED itself and worse thing could happen is broke the LED. Unless the excessive power is still under tolerance for LED dissipate specification.

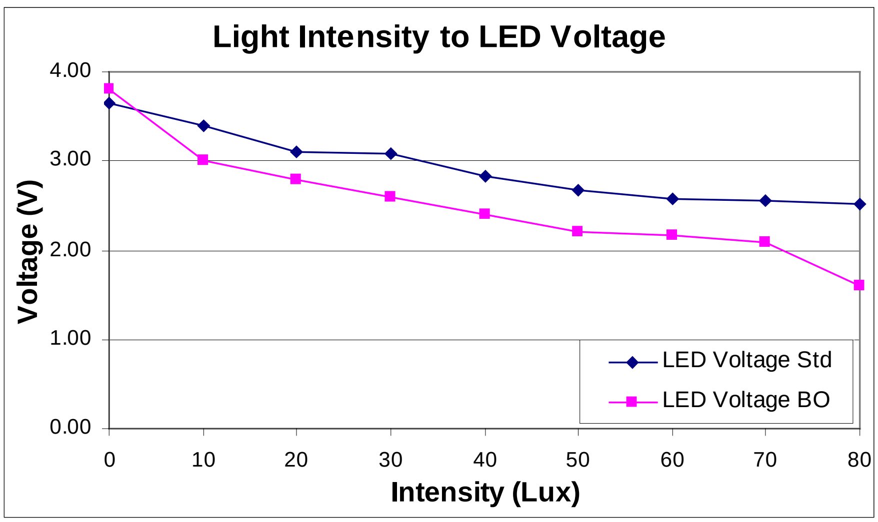


Figure 4. LED voltage flows in LED

Even though, simple blocking oscillator could reach 7.6 volts on its output (V_O) but the current was too low. Ideally, a LED needs at least 3 volts and 20 mA hence it could light on brighter. On maximum power, the system has pulse duration 0.29 μs which is still in range determined that for blocking oscillator uses short pulses around 0.05 to 25 μs [6,7].

In order to optimize the power needed by LED by increase the current but the excess voltage would not being dissipated into heat thus the output voltage needs to be limited. There are two options could be taken, firstly, the number of secondary toroid turns which was connected to collector being reduced just enough to fulfill the voltage needed by LED. Second, the system uses higher input voltage for the power supply.

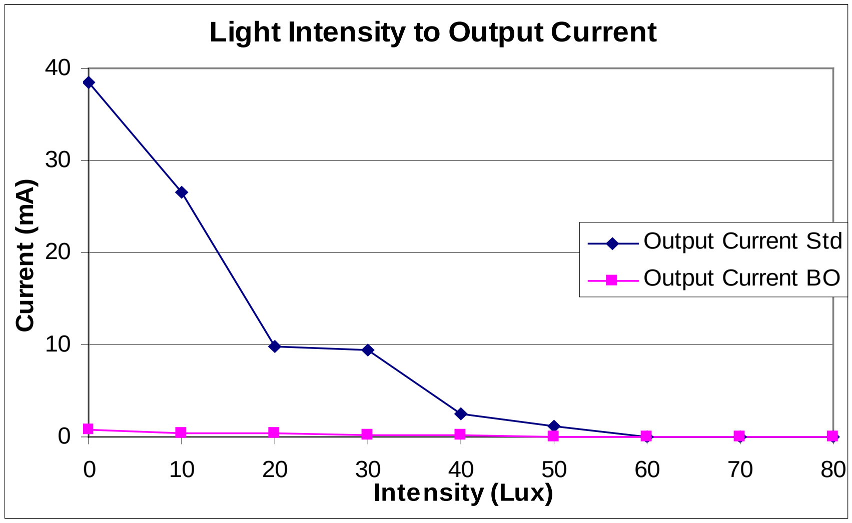


Figure 5. Current output generated by systems to light on the LED

The voltage, number of turns and current are correlated to each other and obey to Eq. (2) [17].

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{i_p}{i_s} \tag{2}$$

If the collector-emitter voltage V_s could be decreased by secondary turns N_s limitation on the inductor as the result the output current is would increase automatically. In addition, the base-emitter voltage V_{BE} should be adjusted to saturation voltage about 0.7 volts for silicon type [18]. Furthermore, when input voltage V_{in} of blocking oscillator uses new battery or higher voltage but no more then voltage needed by the load and the input current ip also raise as well, consequently the output current is would increase.

The next investigation is to know the effect of power which used by systems to light on the LED among standard and simple blocking oscillator systems. A white LED will have optimum intensity and life long if given with an appropriate voltage forward V_f and current forward V_f. The lowest amount of voltage and current needed by LED are 3.0 V and 20 mA, respectively [8] hence the minimum power P should be 60mW per LED.

LED performance is affected by ambient heat surrounding LED and drive current because it changes the junction temperature of the LED [19,20]. Latterly, it is found that the LED lifetime decrease mostly affected by the increasing junction temperature caused by drive current than ambient heat [21].

Table 1 and Figure 6 reveals that the standard systems using input voltage V_i 5 volts reached 3.64 volts for drop voltage forward V_f and 38.4 mA for its current forward I_f. Therefore the LED powered with 139.8 mW which is too high than is needed for a LED which maximum 80mW [8]. Moreover, the excessive power 59.8mW will be dissipated into heat which mean it is not efficient and economics.

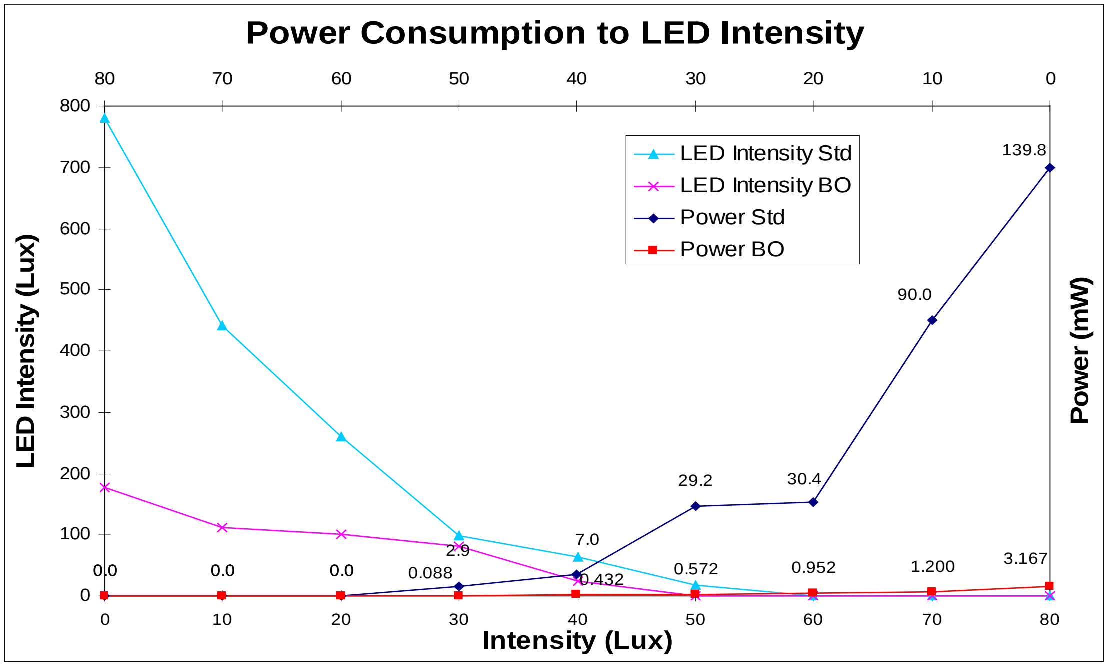


Figure 6. Comparison of power used to produce LED intensity

If the heat continuously happens and there is no space for heat to flow outward consequently the temperature junction is going up and decrease the lifetime of LED [21]. The LED light output L has exponential decreasing in nature over time which can be expressed as in Eq (3).

$$L = L_o e^{-\alpha t} \quad (3)$$

Whereas α is the light output degradation rate, t is the operation time, and the L_o is the initial light output which is normalized to 1. The highest power for standard system was 139.8 mW which resulted 780 lux, whereas the lowest power was 2.9 mW to emitted 17 lux. Differently, simple blocking oscillator using battery 1.5 volts and current 1.8 mA generated highest power 3.167 mW and got 176 lux where the drop voltage forward was 3.80 volts and current 0.833 mA. Afterwards the lowest power produced from the system was 0.432 mW and had intensity 23 lux.

The efficiency calculation from systems was done by comparing the output power with input power which was fed into systems. The calculation was determined by Eq. (4).

$$efficiency = \frac{output\ power}{input\ power} 100\% \quad (4)$$

Consequently, the maximum efficiency of standard system is,

$$efficiency = \frac{139.8}{4000} 100\% = 3.495\%$$

Likewise, the maximum efficiency of system used simple blocking oscillator is,

$$efficiency = \frac{3.167}{2.7}100\% \ = 117.3\%$$

Clearly be seen that system based on simple blocking oscillator having higher efficiency compared with standard system. Even though it is not real 117.3%, since the limitation of the instruments (oscilloscope) could not record the input current for each pulse except just for every second using other current logger, therefore it looks like being recorded as the output power and higher than the input power. Additionally, if the electrical power needed between two systems is compared then system with simple blocking oscillator could produce LED intensity 55.57 lux per mW. Meanwhile, the standard system only emitted 5.579 lux of LED intensity per mW. Therefore, if system with simple blocking oscillator could produce power as high as 60 mW then it has potency to have light intensity of LED about 3334.2 lux half from datasheet [8].

4 Conclusions

Performance analysis of system using simple blocking oscillator to powered simple electronic appliances has been done. The system has higher efficiency to 117.3% to be used for appliances electronics than other system used universal adapter because of its eco-friendly and potential to produce 55.57 lux per mW. To get optimum result to light on LEDs it needs to redesign in order to increase the output power.

Acknowledgement

The research is supported by ESMART Research Group, PNBP Sebelas Maret University Grant no. 624/UN27.11/PL/2015. We also thank you to DIKTI funding with scheme of DIKTI Scholarship no 138.15/E4.4/2015.

References

1. Adegbemile, A. A. Performance Analysis of a Blocking Oscillator used for Low Voltage Fluorescent Lighting. International Journal of Electrical and Power Engineering 2.1 (2008): 35-38.
2. Smith, L. Cutting off the plate current by a high negative bias on the Radiotron Designers Handbook, McGraw-Hill, New York. (2000):1398.
3. Gottlieb, Irving. Practical oscillator handbook. Elsevier, (1997): 129-131.
4. Borys, A., and R. Wojtyna. RC oscillators with oscillation frequency independent of the op.-amp. gain-bandwidth product. International Journal of Electronics Theoretical and Experimental 75.5 (1993): 887-895.
5. J. Milman., H. Taub. Pulse, Digital, and Switching Waveforms: Devices and circuits for their generation and processing. McGraw-Hill Book Company (1965): 597-601.
6. Glen, M.G. Analogue Electronics Circuits. New York: Prentice Hall Inc. 1986.
7. Rulkov, Nikolai F., and Alexander R. Volkovskii. Generation of broad-band chaos using blocking oscillator. Circuits and Systems I: Fundamental Theory and Applications, IEEE Transactions on 48.6 (2001): 673-679.
8. Everlight, Technical Data Sheet 5 mm Round White LED (T-13/4), 2006: 1-9. Information on http\\:www.everlight.com.
9. Bergh, Arpad A. Blue laser diode (LD) and light emitting diode (LED) applications. Physica Status Solidi (a) 201.12 (2004): 2740-2754.

10. Pimputkar, Siddha, James S. Speck, Steven P. DenBaars, and Shuji Nakamura. Prospects for LED lighting. Nature Photonics 3.4 (2009): 180-182.
11. Buah-Bassuah, Paul K., Hubertus M. von Bergmann, Ebenezer T. Tatchie, and Christine M. Steenkamp. A portable fibre-probe ultraviolet light emitting diode (LED)-induced fluorescence detection system. Measurement Science and Technology 19.2 (2008): 72–83.
12. Dasgupta, P. K., Eom, I. Y., Morris, K. J., & Li, J. "Light emitting diode-based detectors: Absorbance, fluorescence and spectroelectrochemical measurements in a planar flow-through cell." Analytica Chimica Acta 500.1 (2003): 337-364.
13. Hauser, Peter C., Christina L. C. Liang, and B. Muller. A solid-state instrument for fluorescence chemical sensors using a blue light-emitting diode of high intensity. Measurement Science and Technology 6.8 (1995): 1081-1085.
14. Herman, P., Maliwal, B. P., Lin, H. J., & Lakowicz, J. R. Frequency-domain fluorescence microscopy with the LED as a light source. Journal of Microscopy 203.2 (2001): 176-181.
15. Albert, H., Manabe, Y., Lukyamuzi, G., Ademun, P., Mukkada, S., Nyesiga, B., Joloba, M., Paramasivan, C.N., & Perkins, M. D. Performance of three LED-based fluorescence microscopy systems for detection of tuberculosis in Uganda. PLoS One 5.12 (2010): e15206.
16. Davitt, K., Song, Y. K., Patterson III, W., Nurmikko, A., Gherasimova, M., Han, J., Pan, Y.L., & Chang, R. 290 and 340 nm UV LED arrays for fluorescence detection from single airborne particles. Optics express 13.23 (2005): 9548-9555.
17. Adegbemile, A. A. Design of a Blocking Oscillator for Low Voltage Fluorescent Lighting. Int. J. Elee. Power Eng 2.2 (2008): 71-76.
18. Fairchild. BC546/BC547/BC548/BC549/BC550-NPN Epitaxial Silicon Transistor. Fairchild Semiconductor Corporation. Rev.1.1.0. www.fairchildsemi.com. 2002: 1-6.
19. Egawa, T., Ishikawa, H., Jimbo, T., & Umeno, M. Optical degradation of InGaN/AlGaN light-emitting diode on sapphire substrate grown by metalorganic chemical vapor deposition. Applied physics letters 69.6 (1996): 830-832.
20. Yanagisawa, T. The degradation of GaAlAs red light-emitting diodes under continuous and low-speed pulse operations. Microelectronics Reliability 38.10 (1998): 1627-1630.
21. Gu, Y., Narendran, N., & Freyssinier, J. P. White LED performance. Optical Science and Technology, the SPIE 49th Annual Meeting. International Society for Optics and Photonics, (2004):119-124.