

PAPER • OPEN ACCESS

Increasing environmental comfort using insect trap windows connected to DC high voltage source

To cite this article: A Syakur *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **623** 012096

View the [article online](#) for updates and enhancements.

You may also like

- [Gradual diffusive capture: slow death by many mosquito bites](#)
S Redner and O Bénichou
- [Stability and global sensitivity analysis of the transmission dynamics of malaria with relapse and ignorant infected humans](#)
Yves Tinda Mangongo, Joseph-Désiré Kyemba Bukweli, Justin Dupar Busili Kampembe et al.
- [Revision of blood-sucking mosquitoes' fauna \(Diptera: Culicidae\) of Tyumen and Kurgan regions](#)
T A Khlyzova



245th ECS Meeting
San Francisco, CA
May 26–30, 2024

PRiME 2024
Honolulu, Hawaii
October 6–11, 2024

Bringing together industry, researchers, and government across 50 symposia in electrochemistry and solid state science and technology

Learn more about ECS Meetings at
<http://www.electrochem.org/upcoming-meetings>

 Save the Dates for future ECS Meetings!

Increasing environmental comfort using insect trap windows connected to DC high voltage source

A Syakur^{1*}, H Afrisal¹, A Jatmika¹, Y H Saragi¹

¹ Department of Electrical Engineering, Faculty of Engineering, Universitas Diponegoro, Semarang, Indonesia

syakur@elektro.undip.ac.id

Abstract. A healthy and comfortable habitation in coastal areas is one of the requirements for establishing a modern society in the increasing number of water and air pollutions. On the one hand, high humidity and temperature levels reduce the convenience of settlements in coastal areas. This condition is even worsened in many houses, which are built with poor air circulation. On the other hand, when the house's windows are opened to allow airflow, many insects such as mosquitoes will enter the room. Mosquitoes are carriers of many diseases in Indonesia, such as dengue fever, malaria, chikungunya and many more. For solving this problem, this paper proposes a solution by designing insect trap of windows connected to a DC high voltage source to exterminate mosquitoes. The source of electricity is obtained from PLN 220 Volt. The voltage from PLN is boosted to reach 3240 Volts. Our prototype has been demonstrated to exterminate a swarm of mosquitoes. When mosquitoes pass through the window trap, they will experience a short circuit, as their body is connected between negative and positive for a short period. The experiment results showed that the applied voltage of 14.6 kV was able to sting mosquitos to death. To prevent its high voltage impact and guarantee the safety of utilization, we provide a safety layer to prevent direct human contact. When it is not in use, the power source can be turned off by using wireless control.

1. Introduction

If a room is poorly ventilated, it can cause the space to become humid, hot, and increase micro-organisms [1,2]. Therefore, ventilation is needed, which will facilitate air movement from outside the room into the room, resulting in air change. With air movement, it is hoped that it can improve air quality and improve the room users' comfort and health. However, when ventilation is open without obstructions, it provides easy entry for insects from outside, such as mosquitoes. Mosquitoes are one of the organisms that live and breed in environments with hot and humid climates, especially in tropical countries such as Indonesia. Most mosquitoes are harmful because they can spread various diseases such as dengue hemorrhagic fever (DHF) and malaria. Therefore, much effort has been made to kill or avoid mosquito bites [3]. One of the dengue endemic areas with high cases in Semarang City is Tembalang District. There are 2 Health Center (Puskesmas) in Tembalang sub-district, namely Rowosari and Kedungmundu Health Centers. The incidence of DBD at the Kedungmundu Health Center was significantly higher than that of the Rowosari Health Center. DBD cases in the Kedungmundu Health Center working area during 2010-2014 were, respectively, IR 782.4/100,000 population in 2010, IR 114.63 in 2011, IR 100.97/100,000 in 2012, IR 259.39/100,000 population in 2013, IR 174.69/100,000 population in 2014 (*Dinkes Kota Semarang*, 2015) [4]. A study has been carried out to overcome the mosquito problem by



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

Ambarita (2015) [5]. To solve this mosquito problem, Ambarita has conducted research using the sterile insect method. The use of AC to increase comfort but has an expensive economic impact and reduces health [6]. This paper presents the design of an insect (mosquito) trap window system to overcome this problem, which can then kill the mosquito due to high voltage. A high voltage trap can be generated using a discharging electric field [7,8]. This mosquito trap window can be applied at home. The mosquito trap window system has several features, which can be switched using wireless, and the system can be operated with AC or DC sources as an alternative source. The benefit of this high voltage trap window is that it is able to reduce the number of mosquitoes that enter the room, thereby increasing the comfort of its residents in the Semarang area.

2. Methodology

Hardware design for DC high voltage generation by utilizing a flyback converter. The design block diagram can be seen in figure 1. From figure 1, it can be explained that to produce a high voltage from a flyback transformer using a DC voltage source. On the other hand, to regulate the incoming signal to the flyback transformer using Zero Voltage Switching (ZVS) from the MOSFET driver supplied from the DC-DC Module with a 12 Volt battery voltage source.

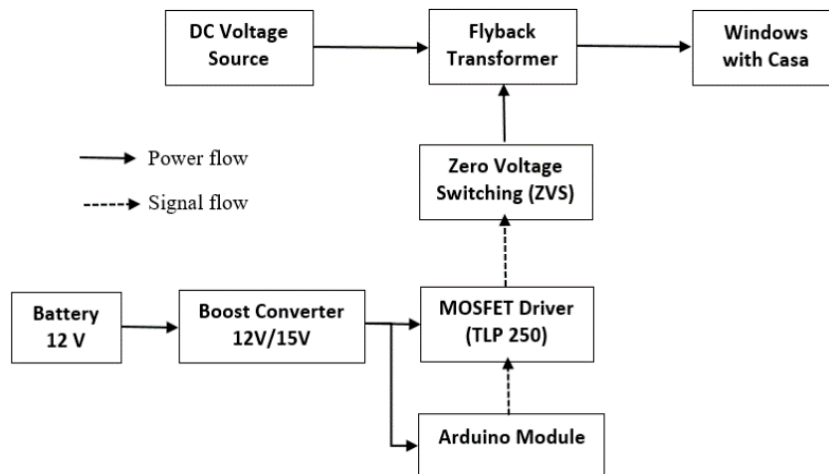


Figure 1. Schematic diagram for generating controllable DC high voltage.

2.1 DC Voltage Source

A steady DC voltage source is used as a voltage supply for the flyback transformer's power circuit. The input voltage is 24 Vdc, transformed by a flyback transformer into a high voltage. The voltage source to be used is two batteries of 12 volts, which are combined in parallel to produce a voltage of 24 volts, as presented in figure 2 (a).

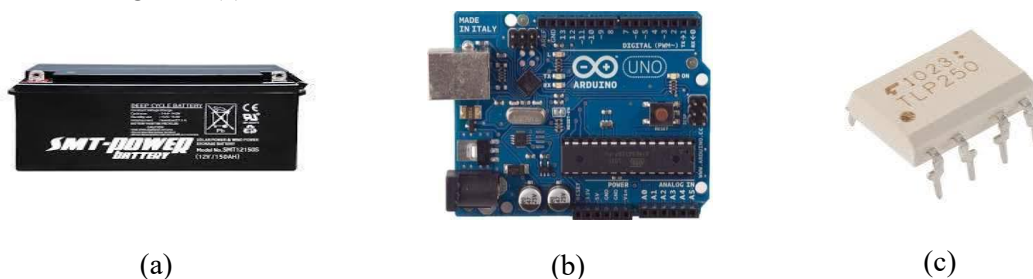


Figure 2. (a) 12 Volt Battery as the source of DC Voltage, (b) Arduino Uno Module as the controller, and (c) MOSFET Driver TLP250.

2.2 PWM Control Circuit Design of Arduino Uno Module

In this paper, the Arduino Uno Module is used to generate a Pulse Width Modulation (PWM) signal for controlling the MOSFET Driver TLP250. The switching process is applied with T_{on} (time when the switch is closed) and T (pulse period time) or the so-called duty cycle. MOSFET triggering is carried out at high frequencies. The PWM signal generation circuit by the Arduino Uno Module [9] can be seen in figure 2 (b).

2.3 Designing the TLP250 MOSFET Driver

The TLP250 driver MOSFET circuit, as displayed in figure 2 (c), is used to isolate and amplify the output signal from the Arduino Uno control module. TLP250 can be used for high voltage MOSFET drivers. The TLP250 MOSFET driver circuit gets a 15 Vdc supply voltage from the buck converter circuit. Based on the TLP250 datasheet, the required voltage supply range for TLP250 is 10-35 V, so that a voltage of 15 V is sufficient to supply TLP250. This voltage is also sufficient to trigger the MOSFET used.

2.4 Flyback Transformer

In this circuit, the flyback transformer functions to transform a low-value input voltage into a higher value output voltage [7, 10]. The flyback transformer used in this project comes from a CRT monitor. The flyback transformer uses a ferrite core. Figure 3 shows the realization of the modified flyback transformer.

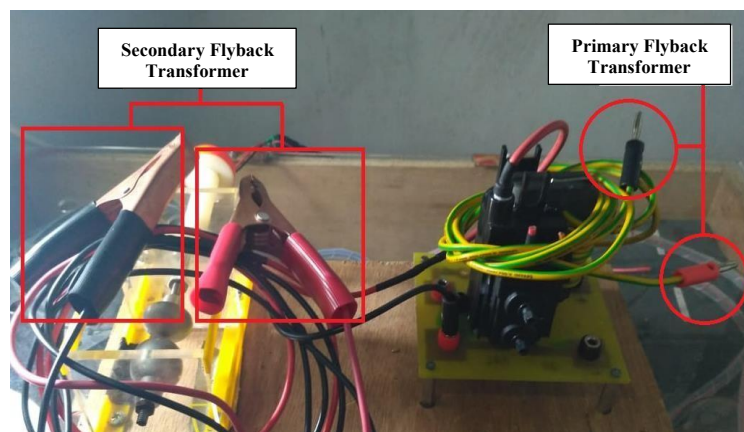


Figure 3. Modified flyback transformer.

2.5 Instruments for Testing and Measuring

For measurement and data collection purposes, several measuring instruments are used as follows,

- Digital multimeter PC5000a to measure the voltage at the input and output sides.
- Digital oscilloscope OWON to see the voltage waveform on each block of equipment.
- LCR meter for measuring inductance and capacitance values.
- High voltage probe 1: 1000 Volt it can be read by oscilloscope and multimeter.
- An oscilloscope probe to take the output waves of each block of equipment.
- Current probe to take the I_{Lr} output waveform.

3. Results and discussion

In this section, testing and analysis of the flyback converter's duty cycle and frequency are carried out. The tests carried out include testing each hardware block and testing the hardware as a whole. This test aims to determine system performance without closing the possibility of deficiencies in the system that has been made. Tests on research on the effect of duty cycle, frequency and input voltage on flyback converters for high voltage generation include:

- Testing the frequency and duty cycle of the control circuit output waves
- Testing the effect of duty cycle on the output voltage of the flyback converter MOSFET

3.1 Results of testing the frequency and duty cycle of the control circuit output waves

Testing the control circuit aims to determine the output pulse waveform of the Arduino uno module, which is used to trigger the MOSFET on the flyback converter. Measurements are made by connecting the positive oscilloscope probe to the TLP250 output as the MOSFET driver and the negative probe connected to the ground. The control circuit measurement scheme is shown in figure 4. Based on the results of measurements using an oscilloscope, a voltage of 15 V. The amount of voltage is within the allowable voltage range, which is 10-35 Volts.

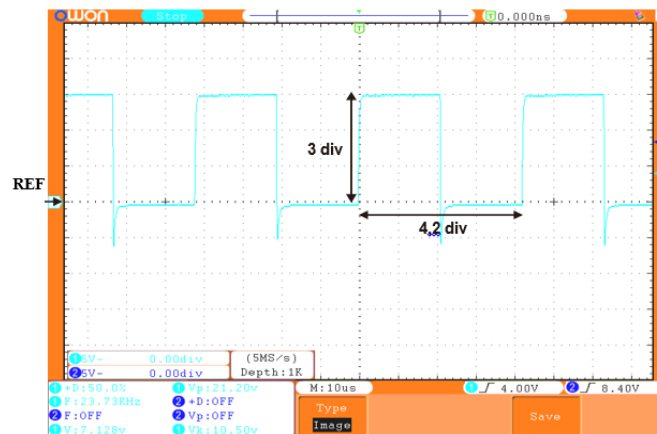


Figure 4. Output wave, V/div = 5 V, T/div = 10 μ s/div.

3.2 Results of testing the effect of duty cycle on the output voltage of the flyback converter

Testing MOSFET switching on the flyback converter includes testing the MOSFET switching mode and measuring the output voltage. In testing the flyback converter MOSFET switching mode, the output waveform of the resonant capacitor voltage (V_{Cr}) and the resonant inductor current (I_{Lr}) was observed to determine the switching process. In measuring the output voltage, testing the effect of the duty cycle (40-60%) and frequency (24-28 kHz) on the MOSFET output voltage on the flyback converter that has been made.

3.2.1 Results of the Flyback Converter MOSFET Output Voltage test. The voltage test on the MOSFET on the flyback converter is done by adjusting the frequency value and the control circuit's duty cycle. The variation of the frequency used is 24-28 kHz, and the variation of the duty cycle used is 40-60%. Measurement of the MOSFET output voltage on the flyback converter is carried out without load. The schematic of output voltage measurement is shown in figure 5 (a). High voltage measurements are carried out using a high voltage probe so that the output voltage can be read on the oscilloscope. The results of high DC voltage measurements are shown in figure 5 (b).

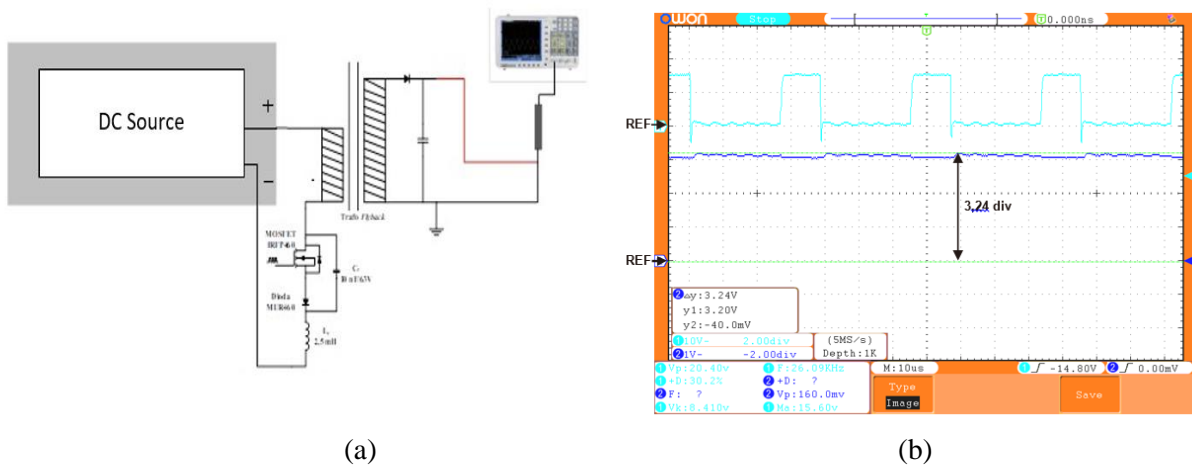


Figure 5. (a) Schematic of Output Voltage Testing from flyback Converter MOSFET, (b) Output Voltage Wave on Flyback Converter with $f_s = 26.09$ kHz.

Figure 5 (b) shows the MOSFET output voltage waveform on a flyback converter with a switching frequency of 26.09 kHz. The MOSFET output voltage wave on the flyback converter is indicated by a dark blue wave (below), and the PWM wave is indicated by a light blue wave (above). Figure 5 (b) shows that the output voltage of the MOSFET on the flyback converter is a high voltage DC filtered as the flyback transformer used has a capacitor component. The output voltage value shown in figure 5 (b) can be calculated using equation (1) as follows,

$$V_{out} = div\ vertical \times V/div \times multiplier\ probe \tag{1}$$

With a known value of div vertical is 3.24, and the multiplier probe is equal to 1,000, then V_{out} can be calculated. Based on the calculation, it can be obtained that the MOSFET output voltage on the flyback converter in figure 5 (b) is 3240 V.

3.2.2 Application of High Voltage DC to the Prototype Window. The application of the high DC voltage in the prototype window aims to determine the applied voltage function. The voltage is adjusted so that the value is 6.97-kilo volts using a frequency of 26 kHz and a 50% duty-cycle. Figure 6 results from testing of a Trap Window that stings insects/mosquitoes that pass through the screen using the high voltage output of the flyback.

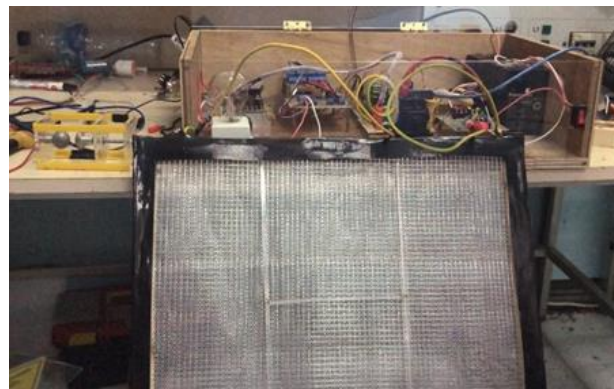


Figure 6. Windows trap connecting to DC high voltage source.

Table 1. Experiment of DC High Voltage Discharge with applied voltage variation.

Voltage Applied (kV)	Phenomena
1.1	<i>No Discharge</i>
2.9	<i>No Discharge</i>
3.6	<i>No Discharge</i>
4.9	<i>No Discharge</i>
5.8	<i>No Discharge</i>
6.7	<i>No Discharge</i>
8.2	<i>No Discharge</i>
14.6	<i>Discharge</i>

This test is carried out by connecting the high DC voltage to the hemispherical electrode and the ground connected to the spherical electrode. The electrode spacing is 10 mm. Schematic and high-voltage discharge test data with a variation of the electrode distance of 10 mm. Results of testing high voltage discharge can be seen in table 1 below. From table 1, it can be seen that the voltage is 1.1 kV; 2.9 kV; 3.6 kV; 4.9 kV; 5.8 kV, 6.7 kV; and 8.2 kV no discharge reaction. The results show that the electric field generated from the sphere's voltage is not sufficient for discharge to occur. The discharge process is detected at a voltage of 14.6 kV. The higher the voltage applied, the greater the resulting electric field resulting in a discharge. This discharge voltage is used to catch and kill mosquitoes when they break through a window with a trap.

4 Conclusion

Based on the results of measurement, testing and discussion, it can be concluded as follows:

1. The output voltage of the MOSFET measured and calculated is 3240 Volt.
2. The results of the discharge voltage test using a sphere and hemisphere electrode spacing 10 mm showed a discharge at a voltage of 14.6 kV
3. There is no discharge at 1.1 kV up to 8.2 kV test voltages due to insufficient voltage to create a high electric field that is able to penetrate the air to discharge.
4. This discharge voltage is applied to the windows to catch and exterminate mosquitoes attempting to break through them.

Acknowledgment

The author would like to thank the Dean of the Faculty of Engineering, Universitas Diponegoro, who has provided funding for this research so that the research can be carried out to completion.

References

- [1] Rachmatantri I, Hadiwidodo M, and Huboyo H S 2015 *Pengaruh Penggunaan Ventilasi (Ac Dan Non-ac) Terhadap Keberadaan Mikroorganisme Udara Di Ruang Perpustakaan (Studi Kasus: perpustakaan Teknik Lingkungan Dan Perpustakaan Biologi Fakultas Mipa Universitas Diponegoro Semarang)* (Semarang: Universitas Diponegoro)
- [2] Saini J, Dutta M, and Marques G 2020 *Sustainable Environment Research* **30(6)** 1
- [3] Millati F F and Sofian F F 2018 *Farmaka* **16(2)** 572
- [4] Kusuma A P and Sukendra D M 2016 *Unnes J. Public Health* **(1)** 48-56
- [5] Ambarita L P 2015 *Balaba* **11(2)** 111-8
- [6] Adekayanti R, Santoso T B, and Pudjianto M 2015 *Pengaruh Penggunaan Air Conditioner Terhadap Gangguan Kesehatan yang berdampak Terhadap Kebugaran Pelajar* (Surakarta: Universitas Muhammadiyah Surakarta)
- [7] Habibi A, Syakur A, and Warsito A 2007 *Pembangkitan Tegangan Tinggi Bolak-Balik Frekuensi Tinggi Menggunakan Kumparan Tesla* (Semarang: Jurusan Teknik Elektro Fakultas Teknik

Universitas Diponegoro)

- [8] Kusakari S I, Okada K, Shibao M, and Toyoda H 2020 *Insects* **11(7)** 447
- [9] Hapsari N T 2012 *Perancangan Sistem Kendali Jarak Jauh Peralatan Listrik Rumah Tangga Dengan Kontrol Wireless Pada Orange House Menggunakan Mobile Application Berbasis Android* (Bandung: Institut Teknologi Telkom)
- [10] Shi F and Song D 2019 *Electronics* **8(12)** 1426