Detection of VLF and LF emissions of fluorescent light for efficient management of power consumption

Sharifah Suhaila bt. Syed Othman, Goh Chin Hock, Farah Hani bt. Nordin, Nur Badariah bt. Ahmad Mustafa, Nagaletchumi Balasubramaniam and Z.A.M. Sharrif

Centre of Signal Processing and Control Systems (SPaCS), College of Engineering, Universiti Tenaga Nasional, Campus Putrajaya, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia

Email: sheermagle@yahoo.co.uk, chinhock@uniten.edu.my, farah@uniten.edu.my

Abstract. In this research work, a detection probe of Very Low Frequency and Low Frequency (LF) emissions of fluorescent light is developed by using low cost loop antenna. The developed loop antenna is able to operate at VLF and LF bandwidth. The developed antenna is tested and measured with signal generator and oscilloscope in order to verify the usefulness of antenna. The developed antenna is subsequently used to detect the signal emitted by the fluorescent light. The antenna probe is located at different distance in order to obtain the peak voltage of received signal. Besides that, the fluorescent light is switch on and off respectively in order to verify the source of signal. From the oscilloscope, the received signal is operating at approximately 28 KHz. Hence, the developed antenna probe can be used for efficient management of power consumption as 28 KHz signal is detected if the light is on.

1. Introduction
The fluorescent light can be found in office, household, factory and commercial building. It has higher efficiency than the tungsten filament bulbs. The fluorescent tube contains an electrode with a gas fill of argon or krypton mixture and a small amount of mercury. A starter is used to discharge the light and controlled by ballast. It controls the current flowing and operates at particular frequency. When the operation is normal, electromagnetic waves emitted from fluorescent lamp occur because of arcing at the electrodes. The operation of a fluorescent lamp at higher frequency leads to a reduction in detectable visual flicker as well as increased ease of dimming in order to increase the efficiency. Hence, electronic switching ballast is used for higher frequency operation in order to meet the requirements. There are lots of fluorescent lights are switched on everyday and energy consumption is high if they are not managed well.

The field of antenna propagation and engineering [1] offers a lot of potential which could be exploited for efficient management of power consumption. In this research work, a detection probe of fluorescent light is developed by using low cost loop antenna. Nearly all VLF and LF antennas are electrically short, shorter than one quarter of the radiated wavelength. Their low radiation resistance makes them inefficient and a very low resistance grounds and conductors is needed to avoid dissipating transmitter power. These electrically short antennas need loading coils of high inductance to bring them into resonance. The small loop antenna is also known as a magnetic loop antenna since it behaves electrically as a coil with a small radiation resistance. Since the small loop antenna as
shown in Figure 2 is essentially a coil, its electrical impedance is inductive, with an inductive reactance much greater than its radiation resistance. A ground connection is an alternative to reduce the response to electric fields of the loop antenna. The grounded loop antenna is operating well on the high frequency bands. An ungrounded loop antenna will substantially attenuate high frequency signal by its equivalent circuit of resistance, distributed shunt capacitance and series inductance [2].

2. Research Methodology
The general steps taken to accomplish this research work are as shown in Figure 1.

![Flowchart of research workflow for electromagnetic wave detection of Fluorescent Light](image)

**Figure 1.** Flowchart of research workflow for electromagnetic wave detection of Fluorescent Light

To design the ultra wideband antenna, it is essential to determine the operating frequency for the antenna structure. In this case, the lowest frequency of low frequency band is chosen. In order to calculate the required wire length the simple wavelength frequency is used as starting point.

\[ \lambda = \frac{c}{10f} \]  

(1)

where  
\[ f = \text{frequency} \]  
\[ c = \text{speed of light} \]  
\[ \lambda = \text{wavelength} \]

3. Test and Measurement
In order to test the developed antenna, function generator and oscilloscope are used as shown in Figure 2. The developed ungrounded loop antenna is tested from 30 KHz to 300 KHz in order to verify its usability in low frequency band.
Figure 2. Testing the loop antenna with function generator and oscilloscope

Figure 3 shows the testing and measurement of the fluorescent light by varying it at fixed interval distance of 0 cm, 5 cm, 10 cm, 15 cm, 20 cm and 25 cm vertically (as shown in arrow). Besides that, a table lamp also tested with the developed antenna. The distance of the antenna is varied at fixed intervals of 0 cm, 5 cm, 10 cm, 15 cm, 20 cm and 25 cm horizontally (as shown in arrow) as shown in Figure 3. As shown in Table 1, all the measured results are recorded and documented with spreadsheet.

Figure 3. Testing the task lamp with the developed ungrounded loop antenna
Table 1. Results of the task lamp and table lamp with the developed ungrounded loop antenna

| Distance | Condition | Task Lamp | Table Lamp |
|----------|-----------|-----------|------------|
|          |           | Frequency (kHz) | Peak to peak voltage, Vpp (mV) | Frequency (kHz) | Peak to peak voltage, Vpp (mV) |
| 0        | off       | -          | -          | -            | -            |
| 5        | off       | -          | -          | -            | -            |
| 10       | off       | -          | -          | -            | -            |
| 15       | off       | -          | -          | -            | -            |
| 20       | off       | -          | -          | -            | -            |
| 25       | off       | -          | -          | -            | -            |
| 0        | on        | 28.70      | 766        | 52.62        | 725          |
| 5        | on        | 28.94      | 756        | 52.76        | 719          |
| 10       | on        | 28.36      | 372        | 52.57        | 688          |
| 15       | on        | 28.35      | 214        | 52.86        | 631          |
| 20       | on        | 28.45      | 123        | 52.51        | 619          |
| 25       | on        | 28.83      | 94         | 52.07        | 306          |

4. Conclusion
An electromagnetic detection probe for fluorescent light is developed by using low cost ungrounded loop antenna is successfully developed. From the obtained measured results, the antenna can be used to characterize and detect [3-5] the electrical appliances which are switched on. Hence, the developed antenna can be further improved and integrated with embedded software for management of power consumption efficiently.

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