New Method to Power High Frequency Tanning Lamps with Varied Parameters for Measuring Ultraviolet Radiation Lamp Output Power

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Abstract

The ultraviolet (UV) radiation from UV lamps used in tanning beds/booths have been known to pose serious health risks. A 2009 report by the World Health Organization International Agency for Research on Cancer concluded that tanning devices were more dangerous than previously thought. Exposure to UV radiation can cause skin cancer, erythema, premature skin aging, and eye damage. In the UV lamp market, the public can find a plethora of UV lamps with a range of operating parameters such as output power, preheat current, preheat time, ballast voltage input, and frequency. In recent years, low power high frequency tanning lamps (HF tanning lamps) emerged in the market. The testing of each of these HF tanning lamps would require a unique high frequency electrical ballast, which would be costly and hard to measure. To properly test the HF tanning lamps for UV radiation, WEAC developed and established a single varied power source for powering a variety of HF tanning lamps following the parameters listed in the American National Standards Institutes (ANSI) and International Electrotechnical Commission (IEC) for electrical lamps. This High Frequency Power Supply and an Adjustable Resistance Ballast were customized according to the general design for high-frequency reference ballast at 25KHz provided in standard ANSI C82.3 - Reference Ballasts for Fluorescent Lamps. A Starting Aid was designed and assembled in-house to safely start the lamps and to accommodate all lamp sizes. Demonstration of the successful operation of the High Frequency Reference Ballast System is shown by operating a 15 W face tanning lamp and 25 W shoulder tanning lamp. Results showed the 15 W and 25 W lamps operated at 11.8 W and 21.5 W respectively using the maximum allowed current set in the standard for the design of those lamps. The input ballast voltage, ballast output current, impedance and frequency were measured and compared to the standards used. The lamp output current and power were also measured and compared to manufacturer's specifications. This work demonstrates the utility of the High Frequency Reference Ballast System in testing the output of UV emitting lamps.

Introduction

For tanning lamps to output the specified radiation without harming the user, they must operate at the proper parameters (e.g., output voltage and current, ballast input voltage) specified by the applicable standards. FDA's Winchester Engineering and Analytical Center (WEAC) established a method for powering a variety of HF tanning lamps with parameters listed in the American National Standards Institutes (ANSI) and International Electrotechnical Commission (IEC) for electrical lamps. This method that has been established will be used in the future to test different tanning lamps for ultraviolet (UV) radiation emission. HF tanning lamps are normally operated by ballasts with specific start-up circuits. Three types of ballast start-up circuits can be found in literature, Pre-heat start (PS), Instant Start (IS), and Rapid Start (RS). *ANSI C78.81 - Single-Capped Fluorescent Lamps Dimensional and Electrical Characteristics*, and *IEC 60081:2003 - Double-Capped Fluorescent Lamps - Performance Specifications* lamp data sheets showed most lamps can operate using any of the three circuits previously mentioned. The High Frequency Reference Ballast System (HFRBS) can operate all tanning lamps and act as a universal ballast, this is because of the unique design of the High Frequency Power Supply (HFP-800) and the Adjustable Resistance Ballast (RB-3), Figure 1.

This poster highlights the process of developing the method and successfully powering two different tanning lamps.

Figure 1. HFP-800 and RB-3.

Equipment and Methods

Equipment

- Lisun Group Ltd. High Frequency Power Supply (Manufacture No.: HFP-800) and Adjustable Resistance Ballast (Manufacture ID.: RB-3)
- HP Agilent Keysight Digital Multimeter (Manufacture No.: 34401A)
- Banana Plugs to Alligator Clips and Banana Plugs to Banana Plugs
- Bipin tanning lamps (Philips Cleo 15W T5 and LSI Aurora F25W T5)
- Starting aid: 2x4 board, copper sheet, Metalware Set, Screw Nails

Method and Design

The method employed the general design for a HFRBS at 25KHz depicted by the high-frequency reference circuit provided in *ANSI C82.3 - Reference Ballasts for Fluorescent Lamps*. See the wiring diagram shown in Figure 2.

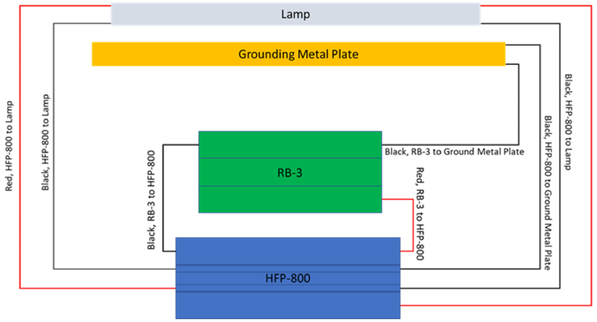

Figure 2. HFRBS Wiring Diagram

The following are some of the requirements listed in ANSI C82.3 or provided by the manufacturer which the HFRBS meets:

- Impedance should be ±0.5% at the reference current.
- Series inductance should be less than 0.1mH.
- Supply voltage regulated to within ±1.0%.

The RB-3 has a range of ~100 to 2300Ω.

Some of HFP-800's functions and range is shown below:

Output Voltage: 10 – 600V	Output Current: 0 – 0.65A
Output Power: 0 – 300W	Preheat Current: 0 – 1.5A
Preheat Time: 0 – 99.99 sec.	Ballast Input Voltage: 0 – 580V

A starting aid was designed and assembled in-house per ANSI C78.81 and manufacturer recommendation, see Figure 3. The starting aid is meant to operate as a grounded conductor for certain start-up circuits (e.g., RS circuit). The starting aid was created to accommodate all linear tanning lamp sizes including and not limited to T5, T8, and T12. The specifications such as the distance from the lamp to the starting aid are obtained from ANSI C78.81.

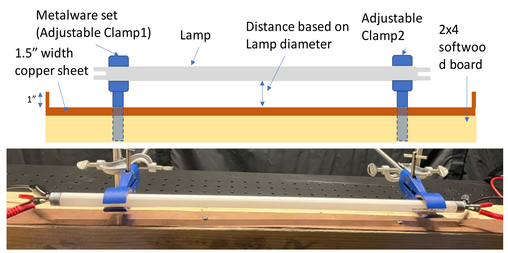

Figure 3. Starting aid.

Results and Discussion

Face and shoulder tanning lamps (15 and 25 Watts) were purchased and successfully tested, Figure 4 shows the successful operation of the 25 W shoulder tanning lamp. ANSI C78.81 was used to obtain the ballast resistance (R), frequency (F), output voltage (V_{oc}), input ballast voltage (V_{in}), lamp current (I_{out}), pre-heat time (t_{ph}), and pre-heat current (I_{ph}). Testing procedure for HF tanning lamps was according to manufacturer's instructions, ANSI C78.81 and ANSI C82.3.

First, the RB-3 and HFP-800 were warmed up for five minutes. The RB-3 was set to 1500Ω for both lamps and waited ~30 seconds for it to stabilize to that resistance. A calibrated DMM was used to measure the resistance percent error after stabilization. The RB-3 was then connected to the HFP-800. The ballast parameters from ANSI C78.81 mentioned above were entered into HFP-800. Note, ANSI C78.81 requires V_{in} tolerance of ±10%, I_{out} range of 0.155-0.32 A and a t_{ph} of 0.4 to 1.5 s for both 15 W and 25 W lamps. In this poster we discuss the results using the typical and maximum allowed I_{out} for 15 W and 25 W.

All measurements were taking after the lamp stabilized for five minutes. The RB-3 percent error at the set current was measured to be 0.247% for both lamps which met the tolerance of ±0.5% set by ANSI C82.3 and the manufacturer.

Figure 4. LSI Aurora F25W T5 Bipin shoulder tanning lamp under test

Philips Cleo 15W T5 Bipin Tanning Lamp

HFP-800 was set to the parameters listed in Table 1 'Entered Values' column and typical current of 0.232A. Results showed the 15W lamp operated at lamp voltage (V_{lamp}) of 44.6V and lamp power of 10.4W. The typical lamp power operating characteristic listed in the standard ANSI C78.81 was 11W. This shows the lamp operated at the expected wattage. The current was raised to 0.320A, the output power measured was 11.8W, see Table 1.

LSI Aurora F25W T5 Bipin tanning lamp

HFP-800 was set to the parameters listed in Table 2 'Entered Values' column and typical current of 0.218A. Results showed the 25W lamp operated at V_{lamp} of 79.6V and lamp power of 17.3W. The typical lamp power operating characteristic listed in the standard ANSI C78.81 was 22.4W. This shows the lamp operated at a lower wattage than expected. When the current was raised to 0.320A, the output power measured was 21.5W, see Table 2.

Table 1. I_{out} set to the typical current and constant maximum current in the standard for Philips Cleo 15W T5 Bipin tanning lamp.

	Entered Values	Result @ Iout = 0.232A	Entered Values	Result @ Iout = 0.320A
F (Hz) (F3)	25000.00	25000.09	25000.00	25000.09
Voc (V) (F4)	465.00		465.00	
Vin (V) (F6)	401.00	389.10	401.00	513.00
Iout (A) (F7)	***0.234***	0.232	***0.320***	0.320
R (Ω)	1500.00	1496.30	1500.00	1496.30
Vlamp (V)		44.60		37.00
Plamp (W)		10.40		11.80
t_{ph} (s)	0.80		0.80	
I_{ph} (A)	0.01		0.01	

Table 2. I_{out} set to the typical current and constant maximum current in the standard for the LSI Aurora F25W T5 Bipin tanning lamp.

	Entered Values	Result @ Iout = 0.218A	Entered Values	Result @ Iout = 0.320A
F (Hz) (F3)	25000.00	25000.09	25000.00	25000.09
Voc (V) (F4)	465.00		465.00	
Vin (V) (F6)	430.00	403.20	430.00	543.50
Iout (A) (F7)	***0.218***	0.218	***0.320***	0.320
R (Ω)	1500.00	1496.30	1500.00	1496.30
Vlamp (V)		79.60		67.20
Plamp (W)		17.30		21.50
t_{ph} (s)	0.80		0.80	
I_{ph} (A)	0.01		0.01	

Discussion

Lamp characteristics from ANSI C78.81.

The lamp characteristics were obtained from ANSI C78.81, which is a standard for fluorescent lamps rather than tanning lamps. Currently, there are no standards with tanning lamp characteristics, and because of this, the data provided could be improved if the specific tanning lamp characteristics were known. The tanning lamps themselves do not contain specific characteristics, rather, the manufacturer would provide a list of the tanning bed the lamp can work with. Take the 15W 12" T5 tanning lamp for example, it was determined the closest matched characteristics were that of a 15 W 18" length T8 lamp. It is not known whether the length (12" vs 18") or the diameter (T5 (0.625") vs T8 (1.0")) would make a difference in lamp power output, this is a research point for future work.

Tanning lamp efficiency.

One important element when it comes to testing any type of lamp is the power efficiency of the lamp, which was not considered in this testing. The tanning lamp efficiencies can vary based on the electrical design of the lamp. In the case of the testing performed, the lamps used were brand new and were assumed to have been through an approved verification procedure by the manufacturer. The tanning lamp power efficiency and how it affects ultraviolet A (UVA) and ultraviolet B (UVB) output is another potential research point for future work.

Conclusion

Both tanning lamps were operated successfully at their typical and maximum current as provided in ANSI C78.81. There were some factors that could have affected the output of the lamps and these are discussed in the discussion section. Nevertheless, the goal of this work was to power different lamps using a universal ballast, and this was successfully completed using the High Frequency Power Supply and an Adjustable Resistance Ballast customized according to the High Frequency Ballast design found in C82.3

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