

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

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NOTE: The terms tanning lamps, low power tanning lamps, and high frequency tanning lamps indicate low power high frequency linear tanning lamps, High Frequency (HF) tanning lamps, and will be used interchangeably in this document.

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 linear 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 due to the enclosed design of the ballast. To properly test the HF tanning lamps for UV radiation, FDA's Winchester Engineering and Analytical Center (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 power of UV emitting lamps.

Key Words

Adjustable Resistance Ballast, High Frequency Power Supply, Tanning Lamps, High Frequency Reference Ballast System

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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. The method will be used to test different tanning lamps for ultraviolet (UV) radiation emission according to *IEC 61228:2020 Ed 3.0 - Fluorescent Ultraviolet Lamps used for Tanning – Measurement and Specification Method*. This Laboratory Information Bulletin (LIB) highlights the process of developing the method to test HF tanning lamps. In addition, an experiment was performed and provided in this LIB showing successful testing of tanning lamps in accordance with ANSI and IEC.

Equipment, Methods, and Design

Equipment

- Lisun Group Ltd. (Manufacture No.: HFP-800) High Frequency Power Supply
- Lisun Group Ltd. (Manufacture No.: RB-3) Adjustable Resistance Ballast
- HP Agilent Keysight (Manufacture No.: 34401A) High Precision Digital Multimeter
- Banana Plugs to Alligator Clips
- Banana Plugs to Banana Plugs
- Low Power Tanning Lamps
 - Philips Cleo 15W T5 Bipin tanning lamp
 - LSI Aurora F25W T5 Bipin tanning lamp
- Starting aid
 - McMaster Carr (Catalog No.: 3577N134) Number 2 Premium SPF Softwood Board, 48”L x 2”W x 4”H
 - McMaster Carr (Catalog No.: 9053K77) Multipurpose 110 Copper Sheet Softened Temper, 50”L x 1-1/2”W x 0.0210” Thick
 - 2 x Fisher Scientific (Catalog No.: 501042880) Metalware Set

- Finishing Nails or Screw Nails, any size between 0.25” – 1” in length

Method (Procedures and Parameters)

The method employed the general design for a High Frequency Reference Ballast System (HFRBS) at 25KHz provided in *ANSI C82.3 - Reference Ballasts for Fluorescent Lamps*. The design of the tanning lamp testing circuit followed the high-frequency reference circuit provided in ANSI C82.3. In addition, the method also followed the general design listed in *IEC 60081 - Double-Capped Fluorescent Lamps - Performance Specifications*, and *IEC 60901 - Single-Capped Fluorescent Lamps - Performance Specifications*.

The HFRBS is made up of two major instruments, High Frequency Power Supply (Lisun Group Ltd. HFP-800) and Adjustable Resistance Ballast (Lisun Group Ltd. RB-3), see Figure 1.

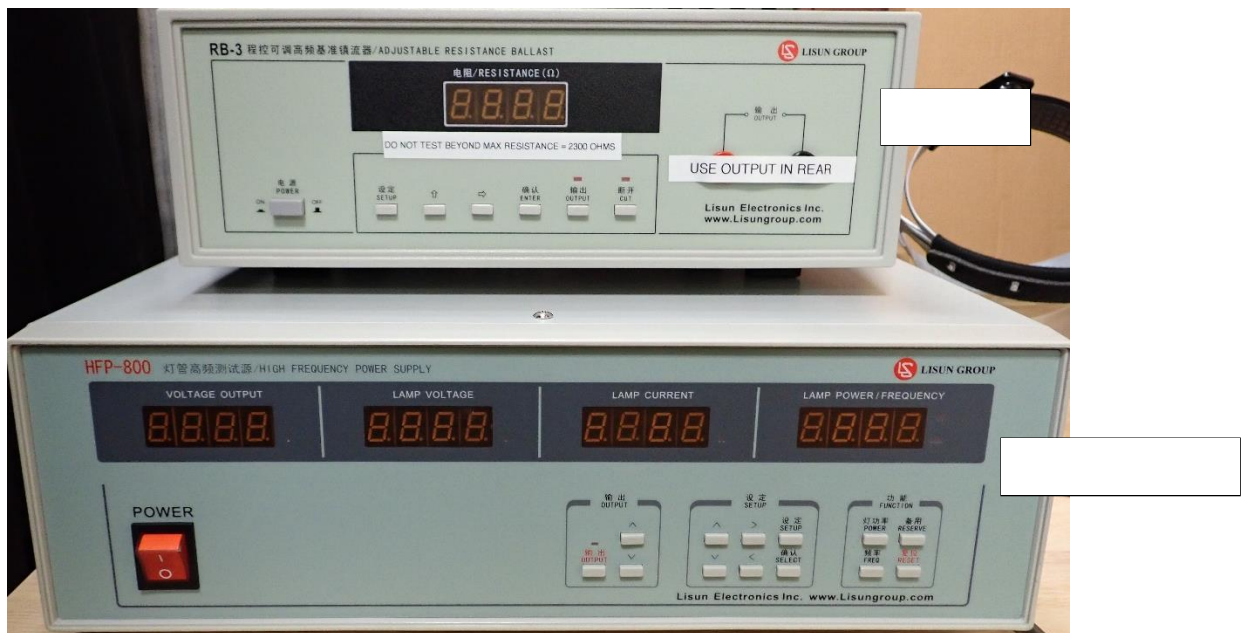


Figure 1. High Frequency Reference Ballast System.

The HFRBS is used to power tanning lamps from 20KHz to 26KHz, the typical high frequency is usually around 25KHz. The HFRBS can operate most, if not all the HF tanning lamps listed in the following ANSI and IEC standards for electrical lamps:

- ANSI C78.81 - Single-Capped Fluorescent Lamps Dimensional and Electrical Characteristics
- ANSI C78.901 - Single-Based Fluorescent Lamps Dimensional and Electrical Characteristics
- IEC 60081 - Double-Capped Fluorescent Lamps - Performance Specifications
- IEC 60901 - Single-Capped Fluorescent Lamps - Performance Specifications

The HFRBS is designed to meet the ballast performance specifications listed in the following standards:

- ANSI C82.3 - Reference Ballasts for Fluorescent Lamps

- IEC 60081 - Double-Capped Fluorescent Lamps - Performance Specifications
- IEC 60901 - Single-Capped Fluorescent Lamps - Performance Specifications

The following are some of the requirements listed in the standards or provided by the manufacturer which the HFRBS meets:

- Impedance should be $\pm 0.5\%$ at the reference current.
- Series inductance should be less than 0.1mH.
- Parallel capacitance should be less than 1nF.
- Supply voltage regulated to within $\pm 1.0\%$.

Technical specification for each of the instrument is listed below:

Lisun Group Ltd. RB-3 range:

- Impedance Range: ~ 100 to 2300Ω

Lisun Group Ltd. HFP-800 range:

- Output Voltage: 10 – 600V
- Output Current: 0 – 0.65A
- Output Power: 0 – 300W
- Output Frequency: 20KHz – 26KHz $\pm 0.02\%$
- Preheat Current: 0 – 1.5A
- Preheat Time: 0 – 99.99 seconds
- Ballast Input Voltage: 0 – 580V

The Lisun Group Ltd. HFP-800 control panel contains nine controllable functions, F1 to F9. Some of these functions have a specific default setting set by the manufacturer and are not to be changed, see Table 1 below.

Table 1. Functions of Lisun Group Ltd. HFP-800 found on the control panel.

Function Name (Function Value)	Range of Function	Default Setting	Comment
Pre-heat Current (F1)	0 - 1.5A		
Pre-heat Time (F2)	0 - 99.99 seconds		
Drive Frequency (F3)	20KHz - 26KHz		
Open Circuit Voltage (F4)	10 - 600Vac		
Open Voltage Holding Time (F5)	-	0.1 seconds	Do not change
Ballast Input Voltage (F6)	0 - 580Vac		
Output Current (F7)	0 - 0.65A		
Communication Address Range (F8)	0 - 255	48	Do not change
Communication Baud Rate (F9)	-	9600	Do not change

Parameters Required for High Frequency

The following parameters are needed to test the lamps using the HFRBS. Since there is no specific tanning lamp characteristics standard, we have relied on the fluorescent lamp parameters found in ANSI 78.81, ANSI 78.901, IEC 60081, and IEC 60901 to test the tanning lamps.

- Lamp Starting Requirements:
 - Open Circuit Voltage
 - Preheat Time
 - Preheat Current
- Reference Ballast Characteristics:
 - Typical Input Voltage
 - Current
 - Impedance
 - Frequency

Design

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, ANSI C78.901, and IEC 60081 lamp data sheets showed most lamps can operate using any of the three circuits previously mentioned. There were lamps that operate only on PS. The HFRBS can operate all tanning lamps, this is because of the unique design of the Lisun Group Ltd. HFP-800. For example, to operate a lamp in IS or PS the pre-heat time can be set to zero seconds or set based on the pre-heat time in the lamp datasheet respectively. Figure 2 below shows a high-level schematic of the types of start-up circuits for lamps.

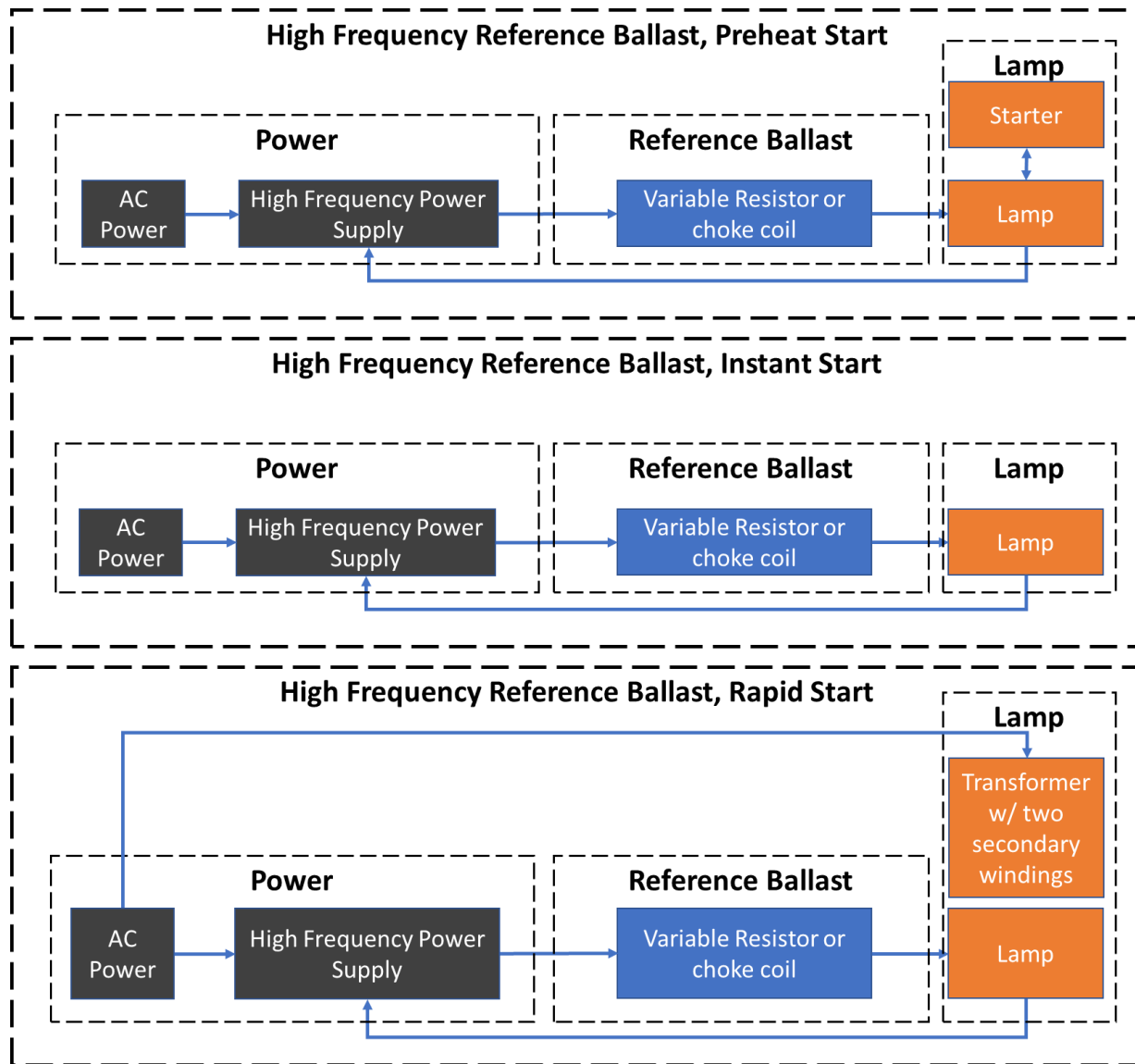


Figure 2. High-level schematics of the start-up circuits for lamps.

A wiring diagram shown in Figure 3 was designed according to ANSI C82.3. The design consists of the following:

- Lisun Group Ltd. HFP-800
- Lisun Group Ltd. RB-3
- Starting aid (Ground Metal Plate)
- Banana Plugs to Banana Plugs
- Banana Plugs to Alligator Clips
- Low Power Tanning Lamps (Lamp)

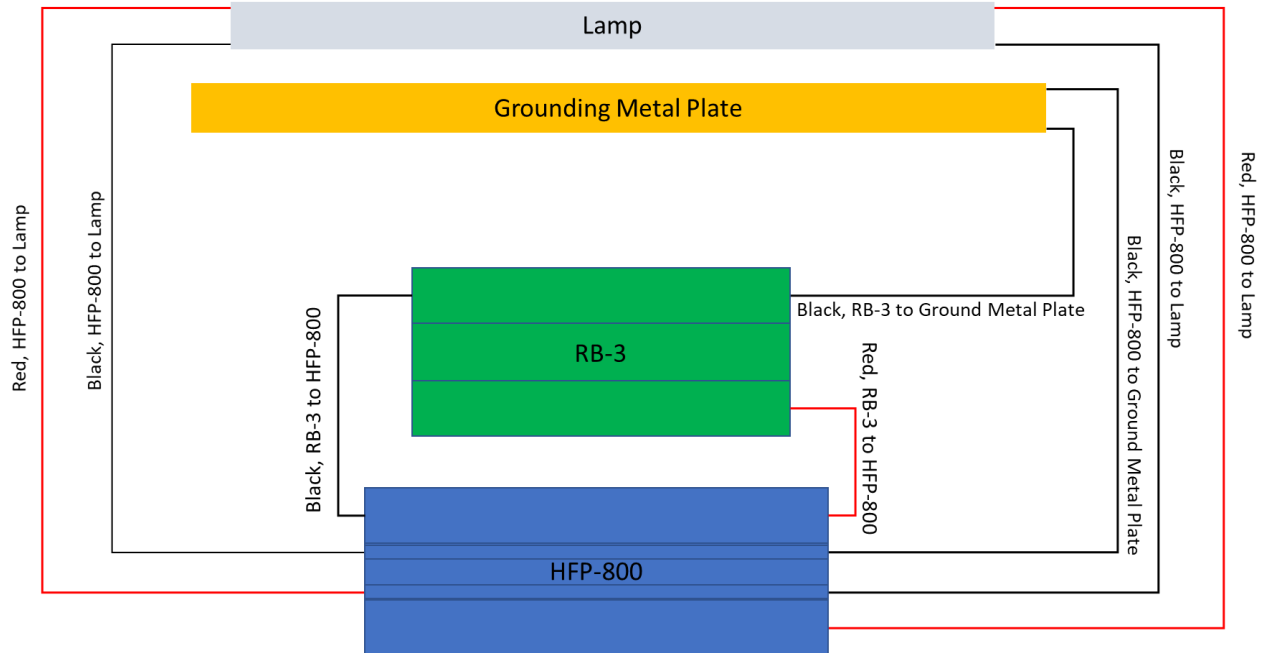


Figure 3. Wiring Diagram.

A starting aid was designed and assembled in-house per ANSI C78.81 and ANSI C78.901 requirements. The starting aid is meant to operate as a grounded conductor for certain start-up circuits (e.g., Rapid Start circuit) and is included as part of the customization and design of the HFRBS. 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 in the aforementioned documents were followed when testing the lamp. Figure 4 shows a simple design of the starting aid and one of the starting aids used in a test.

To make the starting aid shown in Figure 4, start by cutting the 1-1/2" copper sheet to a length of 50". Center and align the copper sheet on top of the 48" long 2x4 softwood board (for lamps longer than 48", use 96" 2x4 softwood board), make sure to leave one inch of copper sheet on each side. Using nails or screws, attach the copper sheet to the board, make sure the copper sheet is flat on the board. Next, bend the one-inch copper sheet on each side so that it is facing upwards, see Figure 4. Adjust the metalware set (adjustable clamp) based on the length of the lamp. Using the metalware knobs, adjust the distance from the lamp to the copper sheet.

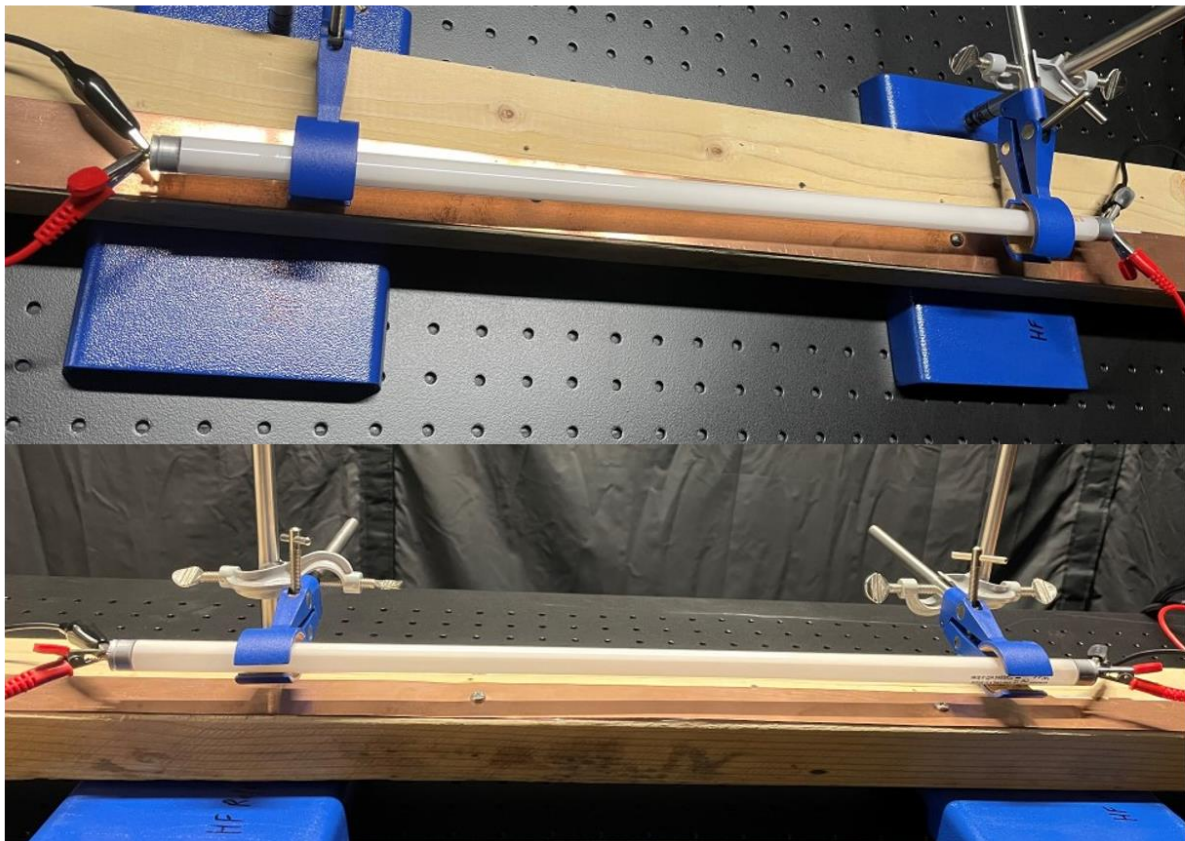
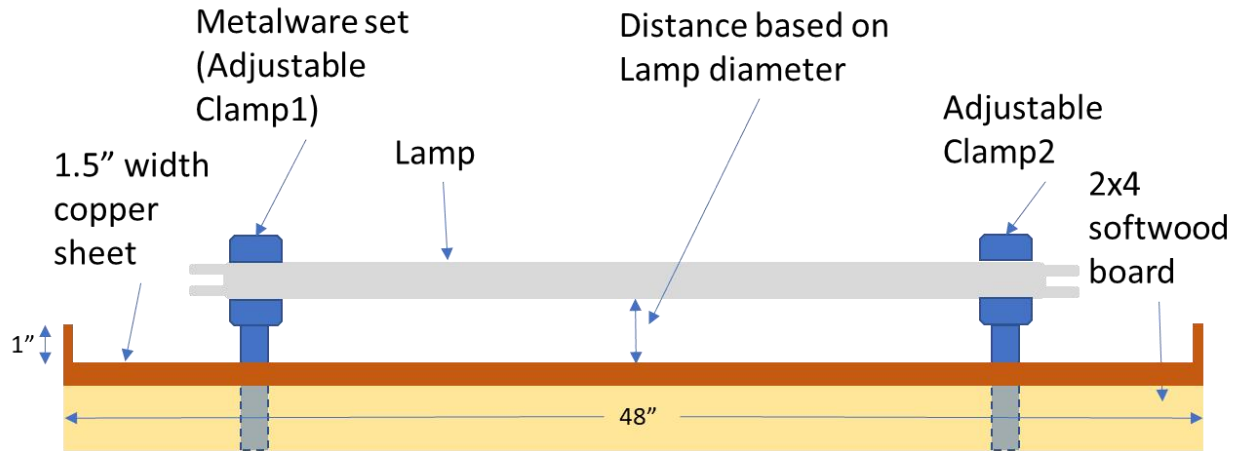


Figure 4. Starting aid

Calibration and Verification

High Frequency Power Supply

The Lisun Group Ltd. HFP-800 was received calibrated from the manufacturer and is on an annual calibration schedule using a US based calibration laboratory, Transcat Calibration Laboratories accredited by ANSI National Accreditation Board. The Lisun Group Ltd. HFP-800 goes through an ISO/IEC 17025 accredited calibration with the recognized Accreditation Body’s symbol and

includes as-received data and uncertainties. The Lisun Group Ltd. HFP-800 goes through function verification after return from calibration as well as a minor function verification prior to each official use to verify its output.

Adjustable Resistance Ballast

The Lisun Group Ltd. RB-3 is verified annually through a rigorous in-house function verification procedure using a calibrated high precision digital multimeter (DMM). Among the verifications performed is resistance check to determine whether the output meets the percent error of $\pm 0.5\%$ as stated in ANSI C82.3:2016 and the Lisun Group Ltd. RB-3 manufacturer’s verification requirements. For this test, range of resistance values were selected from ANSI C78.81:2016 and additional resistance values we added to verify the entire resistance range, see R column in Table 2. The procedure starts by connecting the Lisun Group Ltd. RB-3 resistance output to a calibrated DMM, this step mimics the connection from Lisun Group Ltd. RB-3 to HFP-800. Next, the resistance values from the R column in Table 2 are entered in Lisun Group Ltd. RB-3 and measured on the DMM. The values from the DMM are recorded as $R_{measured}$. Finally, the percent error is calculated using the R and $R_{measured}$ values to determine pass or fail which is noted by green or orange colors respectively. See Table 2 below for the most recent function verification. In addition, the Lisun Group Ltd. RB-3 also goes through a minor function verification prior to each official use, where the user would verify the resistance prior to testing. This is an important step to confirm the Lisun Group Ltd. RB-3 outputs the correct resistance for testing.

Table 2. Shows the most recent function verification performed with the Lisun Group Ltd. RB-3 passing the % error of $\pm 0.5\%$ at the selected values from ANSI C78.81 and other resistance values.

Resistance Values taken from ANSI C78.81				Other Resistance Values			
R (Ω)	$R_{Entered}$ (Ω)	$R_{Measured}$ (Ω)	% error	R (Ω)	$R_{Entered}$ (Ω)	$R_{Measured}$ (Ω)	% error
179	179	178.95	0.03	100	100	100.37	0.37
244	244	243.91	0.04	550	550	549.87	0.02
325	325	325.05	0.02	600	600	599.79	0.04
476	476	475.46	0.11	750	750	748.91	0.15
650	650	649.2	0.12	850	850	848.91	0.13
1025	1025	1023.4	0.16	1150	1150	1148.2	0.16
1280	1280	1277.1	0.23	1350	1350	1347.1	0.21
1500	1500	1496.7	0.22	1650	1650	1646.9	0.19
1960	1960	1955.5	0.23	1800	1800	1795.9	0.23
2150	2150	2145.4	0.21	2300	2300	2295	0.22

Results



Figure 5. LSI Aurora F25W T5 Bipin tanning lamp

Face and shoulder tanning lamps (15 and 25 Watts) were purchased and successfully tested, Figure 5 shows the successful operation of the 25 W shoulder tanning lamp. The expected operating data for tanning lamps were obtained from ANSI C78.81. The standard was used to obtain the lamp operating current, voltage, resistance, pre-heat time, and pre-heat current. Testing procedure for HF tanning lamps was according to manufacturer's manual, ANSI C78.375A and ANSI C82.3. The wiring connection diagram shown in Figure 3 was created and used following the manufacturer's procedure and standards.

The Philips Cleo 15W T5 Bipin tanning lamp was used for testing. The Lisun Group Ltd. RB-3 was set to 1500Ω per ANSI C78.81:2016, a calibrated DMM was used to measure the resistance after ~30 seconds. The resistance percent error was calculated using the measured and entered value. The percent error was 0.247% which met the tolerance of $\pm 0.5\%$ set by ANSI C82.3:2016 and the manufacturer. The Lisun Group Ltd. RB-3 was then connected to the Lisun Group Ltd. HFP-800 and the lamp parameters from the ANSI standard were entered. Lisun Group Ltd. RB-3 and Lisun Group Ltd. HFP-800 warmed up for five minutes before use. All lamp measurements were taken approximately five minutes after the tanning lamp stabilized. See Figure 6 below.

Lamp name: Philips Cleo 15W T5 Bipin Tanning Lamp			
Tanning Lamp data from ANSI C78.81 for 15 W 18 inch T8 Fluorescent Lamp			
Voc: 465 V			
I _{out} range: 0.155 - 0.32 A, 0.234 A typical.			
t _{ph} : 0.4 to 1.5 s			
I _{ph} : 0.01 A (max)			
Vin: 401 V			
Frequency, F: 25 KHz			
Resistance, R: 1500 Ω	Resistance tolerance: ±0.5% (Per ANSI C82.3 and Manufacturer)		
Notes:			
Measurements taking after lamp stabilized at ~ 5 minutes			
Resistance measured after RB-3 stabilized at ~ 30 s			
Calculations:			
Resistance meets tolerance:			
(ABS(1500-1496.3)/1500)*100% =		0.247 %	

Figure 6. Shows an excerpt of the data used and collected for the Philips Cleo 15W T5 Bipin tanning lamp.

Several experimental scenarios were approached and taken to determine the output of the lamp during typical input parameters as well as experimental parameters to reach maximum tanning lamp performance. The results of the 15W experiments were broken down to three tables shown below.

In the first table, Table 3, the output current (I_{out}) was set to 0.234A which is the typical value found in the standard for a 15W fluorescent lamp. At this typical current, the lamp was limited in reaching its maximum current draw and did not reach the expected ballast input voltage (V_{in}). See Table 3 for the measured values.

Even though the entered V_{in} voltage was set to the design value provided in ANSI C78.81, the measured value showed the lamp did not operate at that voltage. The entered ballast voltage was 401V, and the measured value was 389.1V. Nevertheless, 389.1V is still within the allowed tolerance of ±10% stated in ANSI C78.81. Therefore, V_{in} at 389.1V can be used as a ballast voltage for the 15W tanning lamp.

Table 3. I_{out} set to the typical value (0.234A) in the standard for Philips Cleo 15W T5 Bipin tanning lamp.

	Entered Values	Measured Values
F (Hz) (F3)	25000.00	25000.09
Voc (V) (F4)	465.00	
Vin (V) (F6)	401.00	389.10
Iout (A) (F7)	0.234	0.232
R (Ω)	1500.00	1496.30
Vlamp (V)		44.60
Plamp (W)		10.40
t _{ph} (s)	0.80	
I _{ph} (A)	0.01	

To allow V_{in} to reach its typical design voltage and its maximum current draw at that voltage, the entered I_{out} value was increased. Note, the standard specifies the I_{out} range from 0.155A to 0.320A, any current value within this range will meet the ballast design. I_{out} was set to maximum output current of 0.320A, it was observed the lamp was able to operate at the expected V_{in} of 401V. Note in Table 4, I_{out} was measured to be 0.242A and V_{in} was 401.10V.

Table 4. Shows I_{out} was set to 0.320A and the lamp drew 0.242A and operated at 10W.

	Entered Values	Measured Values
F (Hz) (F3)	25000.00	25000.09
Voc (V) (F4)	465.00	
Vin (V) (F6)	401.00	401.10
Iout (A) (F7)	0.320	0.242
R (Ω)	1500.00	1496.30
Vlamp (V)		41.20
Plamp (W)		10.00
t _{ph} (s)	0.80	
I _{ph} (A)	0.01	

Measured values in Table 3 and Table 4 show the Philips Cleo 15W T5 Bipin tanning lamp operated at ~10W, the typical lamp power operating characteristic listed in the standard ANSI C78.81 was 11W. Two potential factors for the one wattage difference could be the tanning lamp efficiency and tanning lamp vs fluorescent lamp characteristics, see Discussion section for more on this.

To further explore the power behavior of the tanning lamp and ballast design characteristics, the Philips Cleo 15W T5 Bipin tanning lamp was provided with a maximum constant current of 0.320A. This is achieved by adjusting the current while the lamp is in operation, this is one of the unique features of the Lisun Group Ltd. HFP-800. The tanning lamp was operated at 0.320A, this raised the lamp wattage to 11.8W. This shows the lamp can operate at the typical lamp wattage of

11W and up to 11.8W. In addition, it shows the lamp can operate beyond the V_{in} tolerance and most importantly, it can operate at the maximum current listed in the standard. See Table 5.

Table 5. Data of the Philips Cleo 15W T5 Bipin tanning lamp running at 0.320A.

	Entered Values	Measured Values
F (Hz) (F3)	25000.00	25000.09
Voc (V) (F4)	465.00	
Vin (V) (F6)	401.00	513.00
Iout (A) (F7)	0.320	0.320
R (Ω)	1500.00	1496.30
Vlamp (V)		37.00
Plamp (W)		11.80
t _{ph} (s)	0.80	
I _{ph} (A)	0.01	

For the 25W test, an LSI Aurora F25W T5 Bipin tanning lamp was used for testing. Similarly, to the 15W lamp, the Lisun Group Ltd. RB-3 was set to 1500 Ω , a calibrated DMM was used to measure the resistance after ~30 seconds. The resistance percent error was calculated using the measured and entered value. The % error value was 0.247% which meet the tolerance of $\pm 0.5\%$ set by ANSI C82.3:2016 and the manufacturer. The Lisun Group Ltd. RB-3 was then connected to the Lisun Group Ltd. HFP-800 and the lamp parameters from the ANSI standard were entered. The Lisun Group Ltd. RB-3 and HFP-800 were warmed up for five minutes before use. All lamp measurements were taken approximately five minutes after the tanning lamp stabilized. See Figure 7 below.

Lamp name: LSI Aurora F25W T5 Bipin Tanning Lamp	
Tanning Lamp data from ANSI C78.81 for 25 W 36 inch T8 Fluorescent Lamp	
Voc: 465 V	
Iout range: 0.155 - 0.32 A, 0.218 A typical.	
t _{ph} : 0.4 to 1.5 s	
I _{ph} : 0.01 A (max)	
Vin: 430 V	
Frequency, F: 25 KHz	
Resistance, R: 1500 Ω	Resistance tolerance: ±0.5% (Per ANSI C82.3 and Manufacturer)
Notes:	
Measurements taking after lamp stabilized at ~ 5 minutes	
Resistance measured after RB-3 stabilized at ~ 30 s	
Calculations:	
Resistance meets tolerance:	
(ABS(1500-1496.3)/1500)*100% =	0.247 %

Figure 7. Data for the LSI Aurora F25W T5 Bipin tanning lamp test.

Likewise, three experimental scenarios were approached and taken to determine the output of the LSI Aurora F25W T5 Bipin tanning lamp during typical input parameters as well as experimental parameters to reach maximum tanning lamp performance of the 25W lamp.

In the first table, Table 6, the output current (I_{out}) was set to 0.218A which is the typical value found in the standard for a 25W fluorescent lamp. At this typical current, the lamp did not reach the expected ballast V_{in}. V_{in} was set to 430V as provided in provided in ANSI C78.81 and the measured value was 403.2V. With that said, the 403.2V is still within the allowed tolerance of ±10% and can be used to power the tanning lamp.

Table 6. I_{out} set to the typical value in the standard for the LSI Aurora F25W T5 Bipin tanning lamp.

	Entered Values	Measured Values
F (Hz) (F3)	25000.00	25000.09
Voc (V) (F4)	465.00	
Vin (V) (F6)	430.00	403.20
Iout (A) (F7)	0.218	0.218
R (Ω)	1500.00	1496.30
V _{lamp} (V)		79.60
P _{lamp} (W)		17.30
t _{ph} (s)	0.80	
I _{ph} (A)	0.01	

The I_{out} value was then set to 0.320A to allow for the LSI Aurora F25W T5 Bipin tanning lamp to draw enough current to reach the typical V_{in} voltage of 430V. During operation, it was observed the LSI Aurora F25W T5 Bipin tanning lamp was able to operate at the expected V_{in} . See Table 7, where I_{out} was measured to be 0.237A and V_{in} was 430.1V. As previously noted in Figure 7, I_{out} ranged from 0.155A to 0.320A and any current value within this range will meet the ballast design.

Table 7. Shows I_{out} was set to 0.320A and drew 0.237A to operate at the typical V_{in} with LSI Aurora F25W T5 Bipin tanning lamp.

	Entered Values	Measured Values
F (Hz) (F3)	25000.00	25000.09
Voc (V) (F4)	465.00	
Vin (V) (F6)	430.00	430.10
Iout (A) (F7)	0.320	0.237
R (Ω)	1500.00	1496.30
Vlamp (V)		77.80
Plamp (W)		18.40
t_{ph} (s)	0.80	
I_{ph} (A)	0.01	

The typical lamp power operating characteristic listed in the standard ANSI C78.81 for a 25W T8 lamp was 22.4W. The two tables above show the lamp operated around ~18 W. Similar to the previous lamp tested, tanning lamp efficiency and tanning lamp vs fluorescent lamp characteristics can be a potential factor that affects the output wattage.

To further explore the power behavior of the tanning lamp and ballast design characteristics, the LSI Aurora F25W T5 Bipin tanning lamp was operated with a maximum constant current of 0.320A. This raised the lamp wattage to 21.5W. See Table 8 below.

Table 8. Data of the LSI Aurora F25W T5 Bipin tanning lamp running at 0.320A.

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

Discussion

The selection of Lisun Group Ltd. HFP-800 and RB-3 to operate the lamps.

The general main goal of the project started with the thought of how to operate a range of lamps with different parameters such as voltage, current, pre-heat time, pre-heat current among other parameters, using a single adjustable ballast system. The selection of the Lisun Group Ltd. HFP-800 and RB-3 came from information shared by National Electrical Manufacturers Association (NEMA) via email when asked about potential devices/instruments to assemble the circuit found in ANSI C82.3. The Lisun Group Ltd. HFP-800 and RB-3 can operate most if not all lamps that are meant to operate at high frequency (25KHz) as stated in ANSI C78.81.

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. There are no standards with tanning lamp characteristics, 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.

Ohm's Law was observed between the Lisun Group Ltd. HFP-800 and RB-3 while adjusting the V_{in} , resistance, and I_{out} to reach a set lamp wattage. The equations derived while observing how the values change are $V_{in} = R * I_{out}$, and $P_{lamp} = I_{out} * V_{in}$. Although these equations were expected since the test set up is based on the circuit found in ANSI C82.3 shown in Figure 8, it was directly observed and confirmed through testing.

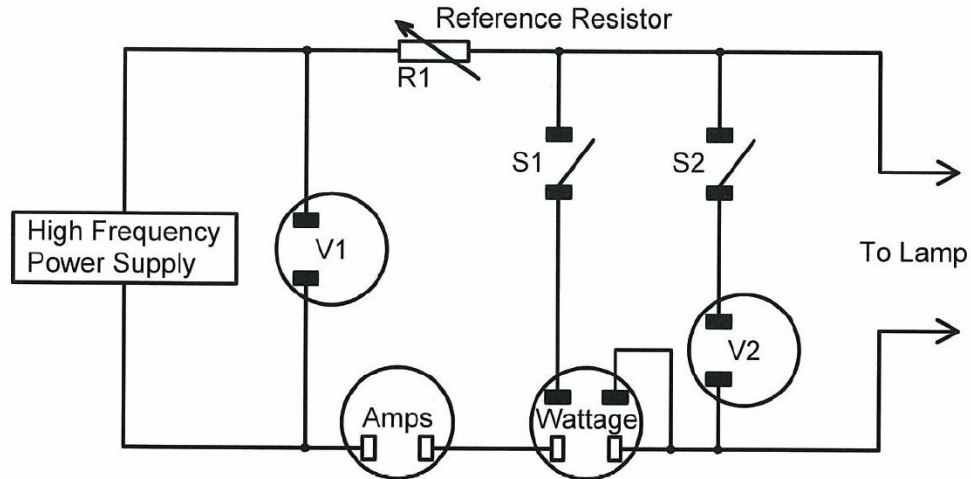


Figure 8. High frequency reference circuit as shown in ANSI C83.2.

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