Title: Latest Trends in Light Source Systems  
Subtitle: Electronic Lighting System for HID Lamps and Lighting Unit for Electrodeless Fluorescent Lamps

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1. Preface

In recent years electronic ballast circuits for discharge lamps have made rapid progress in improving their operating efficiency. Their functions have also improved by the use of on/off and dimming controllers, thus contributing to a more comfortable lighting environment. In Japan, electronic ballasts for fluorescent lamps first introduced to home lighting appliances because of their higher brightness and instant start features. Later, improved functions such as dimming and remote control, as well as lower cost and compactness have caused them to spread quickly into shops and offices. It has long been known that high frequency operating of HID lamps have a serious problem of acoustic resonance phenomena, which makes it difficult to put them to practical use. In order to solve this problem, we examined many different operating systems. Finally we have developed a better operating system: a unique circuit, generating low frequency rectangular waveform operating circuit.

The electrodeless lamp lighting unit, which to emit light applies a high frequency electromagnetic field to the electrodeless discharge bulb, is drawing attention today as a new light source. Practical electrodeless lamp systems for general lighting purposes have been the topic of research for a long time.

In this symposium, we will report on the HID lamp electronic lighting system, and the electrodeless fluorescent lamp lighting unit, we have newly developed.

2. Electronic Operating System for HID Lamps

2-1 Problems Inherent in Electronic Operating Systems for HID Lamps.

The electronic ballasts for HID lamps differ from those in fluorescent lamps in that they have special problems such as acoustic resonance phenomena when operated with high frequency power, slow running-up of luminous flux, difficulty in hot restarting and dimming etc. especially, acoustic resonance phenomena causes a fluctuation of the discharge arc, resulting in flickering, or bulb breakage in the worst cases. It is one of the most serious problems.

2-2 Operating Systems Avoiding Acoustic Resonance Phenomena

Several papers have already reported methods to avoid acoustic resonance. These can be categorized roughly into: (1) Low or high frequency operations avoiding acoustic resonant frequencies. (2) D.C. operation or low frequency rectangular wave drive. (3) Other wave form operations. Table 1 shows various operating methods avoiding the acoustic resonance phenomena.

2-3 Operating Method by Superimposing Low Frequency Rectangular Wave

Among the various operating methods shown in Table 1, we examined: (1) High frequency
Table 1. Operating Methods Avoiding the Acoustic Resonance Phenomena

<table>
<thead>
<tr>
<th>Item</th>
<th>Operating Methods</th>
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<tbody>
<tr>
<td>1. Low or High frequency operations</td>
<td>(1) Commercial frequency (50' 60Hz)</td>
</tr>
<tr>
<td>operations avoiding acoustic</td>
<td>(2) Low frequency (1' 10kHz)</td>
</tr>
<tr>
<td>resonance frequencies</td>
<td>(3) High frequency 1. (10' 50kHz)</td>
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<td></td>
<td>(4) High frequency 2. (200kHz)</td>
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<tr>
<td>2. DC operation or Low frequency</td>
<td>(1) DC</td>
</tr>
<tr>
<td>Rectangular wave operation</td>
<td>(2) Low frequency Rectangular wave</td>
</tr>
<tr>
<td>3. Other wave form operations</td>
<td>(1) Quasi Rectangular wave (Acoustic and Non-acoustic frequencies)</td>
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<tr>
<td></td>
<td>(2) Time-Sharing (Acoustic and Non-acoustic frequencies)</td>
</tr>
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<td></td>
<td>(3) Superimposing (Acoustic and Non-acoustic frequencies)</td>
</tr>
</tbody>
</table>

operating; (2) D.C. - high frequency time-sharing operating; (3) D.C. - superimposed high frequency operating; (4) 1 kHz low frequency - high frequency time-sharing operating; (5) Low frequency rectangular wave - superimposed high frequency operating; (6) Low frequency rectangular wave - high frequency time-sharing operating; etc. By using operating frequencies of several tens of kHz, it provides us advantages with respect to circuit efficiency and acoustic and electric noises. Figure 1 shows the result, superimposition of a high frequency on a low frequency rectangular wave for the lamp current marking the best overall performance. Figure 2 shows the basic circuit design of a full-bridge superimposed low frequency rectangular wave operating.

Figure 1. Lamp current waveform

Figure 2. Main circuit composition for 75W metal halide lamp

2-4 Half-bridge Superimposed Low Frequency Rectangular Wave Circuit.

To penetrate the market for electronic ballasts, the circuit should be made more compact and lower in cost. For this purpose we have developed the half-bridge superimposed low frequency rectangular wave circuit shown in Figure 3. Semiconductor switches Q1 and Q2 are operated at low frequency to supply a low frequency rectangular current. In this circuit, switching elements for the igniter are neglected. This is made possible by operating Q1 and Q2 alternately at high frequency, to serve as an inverter at every phase-inverting moment of the rectangular wave when starting a lamp, as lamp voltage wave shown in Figure 4. As well, we constructed a chopper circuit, using choke coil L and switch Q3, to eliminate input current distortion thus approximating the current to a sine wave, and achieving a high power-factor.
2-5 Example of Practical Electronic Lighting System for HID Lamps

(a) Spotlights for Shops

Compared with conventional magnetic ballasts, the electronic ballast for HID lamps offers advantages of much less weight, no flicker, resistance to unintended extinction by sudden reduction in the power supply voltage, and the like. Because of these advantages and the fact that the lamps are integral with the ballasts, use of the system for downlights or spotlights in shops has increased.

(b) Large-screen Liquid Crystal Projection T.V.

Since there is a limit to the maximum size of a conventional cathode ray tube, liquid crystal projection T.V. has been put to practical use. Its use is also anticipated for high-definition television. For the light source, short arc metal halides lamps having an output of 150 to 250 W have been introduced, and an electronic lighting system suitable for the lamp has come into demand. As to the stable control of output power, the proper method is superimposed rectangular wave operating, but the problems of the rapid running-up of luminous flux and instant restarting must be solved.

(c) Automobile Headlights

Halogen lamps are usually used as for the light source in automobiles headlights. In order to thin the headlight body and increase the quantity of light, and for high color rendition, 35 W micro-miniature metal halides lamps have been introduced for headlights, and an electronic lighting system therefore has come into demand. Since rapid running-up of luminous flux and instant restarting are required, we expect rapid progress in the technology.

3 Electrodeless Lamp Lighting Unit

3-1 Principle

E, H, and microwave discharging phenomena are well known as methods of realizing electrodeless discharge. We employed electromagnetic discharge for our lighting application. We designed a structure with an air-cored coil of several windings in contact with the lamp circumference.

3-2 Operating Circuit

A prototype of the electrodeless fluorescent lamp lighting circuit consists of power supply, oscillation, power amplification circuits, matching network, and an on/off control circuit. A lamp coil is connected to the output of the matching circuit as shown in the block diagram in Figure 5. For the
starting ability, it is preferable to apply a higher frequency electromagnetic field to the lamp. But to keep the power consumption of the operating circuit to a minimum, a lower frequency is better. Accordingly, considering a compromise between two factors and the effects of EMI noise, we chose separate excitation, using a 13.56 MHz quartz-controlled oscillator.

3-3 Characteristics of the Lighting Unit

To ignite an electrodeless lamp, pre-heating of the electrodeless is not necessary. With application of a high frequency voltage, glow discharge shifts to arc discharge in a very short time. Figure 6 shows the responsibility of luminous output flux of the electrodeless lamp, in comparison with those of fluorescent lamp and incandescent lamp.

3-4 Developed Electrodeless Lighting Unit

In view of its long life, the developed unit can be used for illumination lights embedded on the outside walls of buildings. It is also expected to find practical applications in various signal lights, indicators, and street furniture.

4. Conclusion

The lighting system for HID lamps and the electrodeless lighting unit mentioned in this report are expected to find increasing use in general and special lighting, along with rapid progress in operating circuit technology. In conclusion, we deeply thank the people concerned for their invaluable help.

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