FLUORESCENT INDUCTION

Electrodeless Lamp

OPENING NEW FRONTIERS FOR LIGHTING

- **IT IS IMPOSSIBLE TO IMAGINE MODERN LIFE WITHOUT ELECTRIC LIGHTING. WITH THE WIDE AVAILABILITY AND AFFORDABILITY OF TODAY'S LIGHTING, PEOPLE THROUGHOUT THE WORLD ARE FREE TO PLAY, AND LEARN VIRTUALLY ANYWHERE, ANYTIME.**

  Continued innovation in lamps and other system components, as well as in design practices, have made lighting progressively more effective, efficient, and economical since Edison's time. Electrodeless Lamps continue to make breakthrough innovations in design and affordability.

Introduction to Induction Lighting

Induction lamps are high frequency (HF) light sources, which follow the same basic principles of converting electrical power into visible radiation as conventional fluorescent lamps. Fig. 1 below shows the operating principle of a fluorescent lamp.

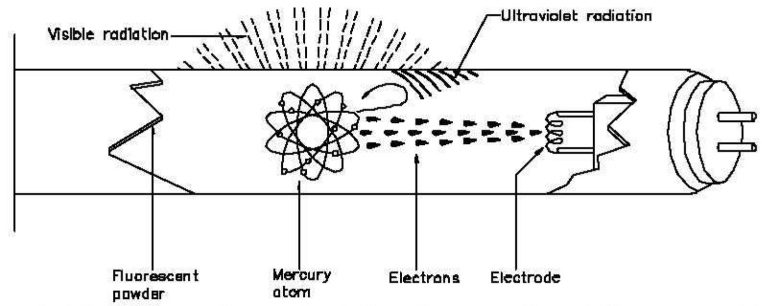


Fig. 1: Basic operating principle of conventional fluorescent lamp

The fundamental difference between induction lamps and conventional lamps is that the Induction Lamps operate without electrodes. Conventional fluorescent lamps require electrodes to connect the discharge plasma to an electrical circuit and inject electrons into the plasma. Fluorescent lamps normally operate on ac current at a frequency of 50 Hz or at HF of 40 to 100 kHz when driven by electronic ballasts. Thus, each electrode operates for one-half period as a cathode and the other half period as an anode. The production of electrons from electrodes is due to thermionic emission. The presence of electrodes in fluorescent lamps has imposed many restrictions on lamp design and performance and is a major factor limiting lamp life.

Introduction to Induction Lighting

Induction lighting is based on the well-known principles of induction and light generation via a gas discharge. Induction is the energy transportation through magnetism. Practical examples are transformers, which consist of ferrite cores or rings with primary coils and secondary rings via the mercury vapour inside the lamps. Fig. 2 and Fig. 3 show two typical induction lamp types, and their principle of operation, which are commercially available today. An alternative current Ip? through the primary coil induces an alternative magnetic field in the ferrite core or coil. The alternative magnetic field in turn induces an alternative secondary current in the secondary coil or ring (Is). The efficiency of the lamp is proportional to the operating frequency of the driving alternative current.

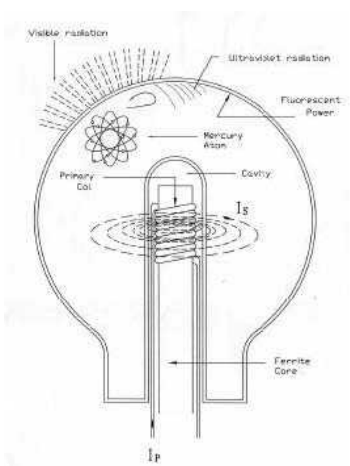


Fig. 2: Cavity Type Induction Lamp

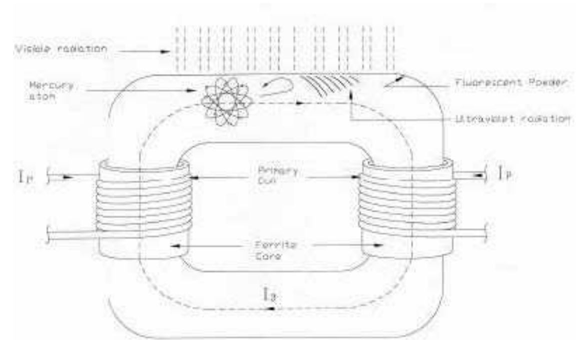


Fig. 3: External-coil Type Induction Lamp

The mercury vapor inside the induction lamp can be regarded as the secondary coil of the system and the induced current circulate through the vapor causing acceleration of free electrons, which collide with the mercury atoms and bring electrons to a higher orbit. Electrons from these excited atoms fall back from this higher energy state to the lower stable level and consequently emit ultraviolet radiations. The UV radiations interact with the fluorescent powder coated inside the lamp and convert to visible light.

Advantages of Induction Lighting

The loss of cathode emission materials, due to evaporation and sputtering caused by ion bombardment, limits the life of fluorescent lamps to between 5,000 to 20,000 hours, while the life of induction lamps on the market today reaches 100,000 hours. This makes it beneficial to use such lamps in applications where lamp maintenance is expensive

(e.g. High Ceiling Applications where accessibility is costly for building owners or Locations where accessibility for safety reasons are a concern (Fig. 4 & 5)).

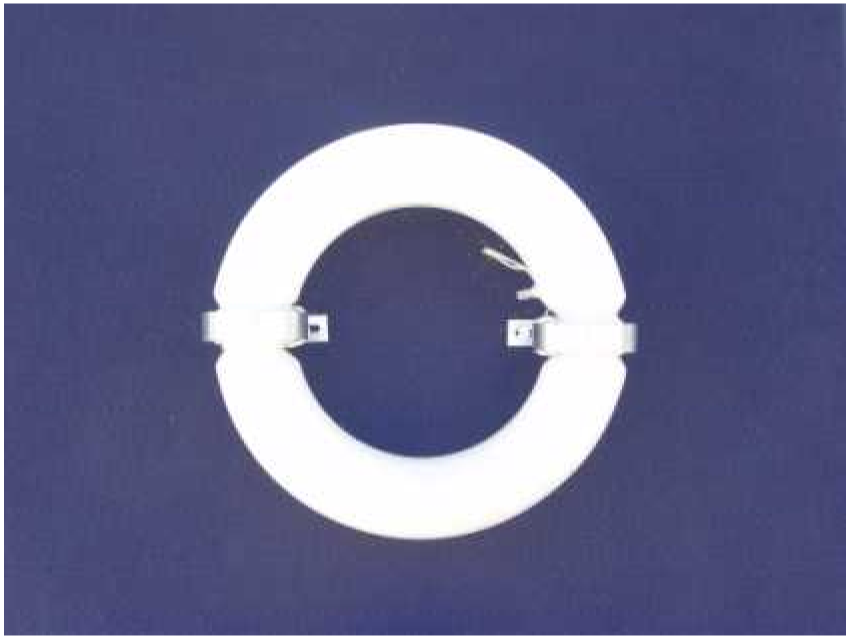
Advantages of Induction Lighting

The elimination of electrodes and their power losses opens up unlimited possibilities in the variety of possible lamp shapes and increases their efficiency respectively. The presence of hot electrodes limits the fill gas pressure and its composition to avoid chemical and physical reactions that destroy the electrodes. There is no such restriction in induction lamps, where gas pressure is optimized for maximum efficiency.

As far as lamp rating of fluorescent lamp is concerned, cathode emission takes place from a tiny spot heated by the discharge current, which cannot be over 1.5A – this limits the maximum power rating and light output of these lamps (e.g. the highest rating of high output T5 lamp is 80W).

Advantages of Induction Lighting

For induction lamps, there is no such restriction and rating of lamp could be up to 200W (e.g. 200W AES Saturn long life lamp as shown in Fig. 6). Theoretically, induction lamps have instant and harmless starting and are more convenient for dimming, as maintenance of high cathode temperatures during dimming are no longer required.



Benefits of Induction Lighting

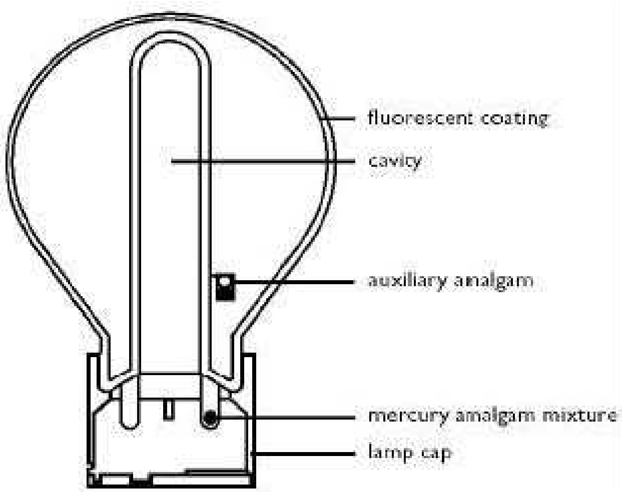
- ***100,000 Hour Life***
- ***.99 Power Factor***
- ***Wide range of Color Temperatures 2700K~6400K***
- ***Instant Start at –35•C***
- ***Instant Re-Strike***
- ***Wide Operating Temperature –35•C~90•C***
- ***System 80-90 Lumens per Watt***
- ***Excellent Lumen Maintenance***
- ***100% Flicker Free***
- ***Excellent CRI (Color Rendering Index) 80-95***

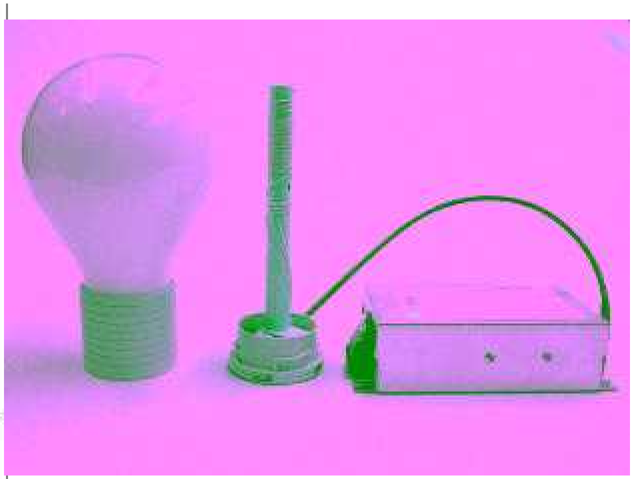
TYPES OF INDUCTION LIGHT SOURCES

There are several commercial available induction lamps in the lighting market currently. The development of induction lamps involve decades of effort in researches on relevant gas discharge physics, solid-state physics, material science and electronic ballasts. The outcome is to bring the induction lighting concepts to engineering and to products in the commercial markets today. Advances in diverse technology fronts promise to drive down the cost and multiply the capabilities of microchips and photovoltaics, opening the way to new levels of performance and freedom of standard design practices.

TYPES OF INDUCTION LIGHT SOURCES

The cavity design has the advantage of reassembling the shape of an incandescent lamp. The cavity at the centre of the lamp is used to accommodate the induction core and coils (Fig. 7).





This electrodeless fluorescent induction lamp operates at 2.65 MHz with system power 55W and an efficacy of about 70 lm/W. The 2.65 MHz is specifically allocated in according to IEC regulations, for industrial application as radio frequency lighting devices. Lamps having the higher rating of 85W and 165W are also available for application where high intensity lighting is required. The lamp is filled with argon at 0.25 Torr. Mercury pressure is controlled by two amalgams: one is for lamp starting and the other maintain optimal mercury pressure over a wide range of ambient temperature. The induction coil of the lamp is wound on a ferrite core and is housed within the lamp cavity. The ferrite core has an internal copper conductor rod connected to the lamp base for cooling of the induction cool and cavity. These lamps are driven by remote ballasts connected to the lamps by coaxial cables.

TYPES OF INDUCTION LIGHT SOURCES

Another version of cavity induction lamp is designed to integrate the RF generating ballast into the lamp (Fig. 8). This kind of induction lamp looks similar to a compact fluorescent lamp and could be used to directly replace an incandescent reflector lamp with much higher efficacy and longer service life. The lamps operate at the same frequency of 2.65 MHz but have lower lamp power of 23W at 48 lm/W efficacy, and the lamp life is rated up to 15,000 hours. EMI is the major restriction of using these lamps in sensitive areas and significant efforts have been made for suppressing magnetic and electric components to comply with existing EMC regulations. The cost of the lamp is over $50.00 at the moment and is relatively much higher than those of tungsten and compact fluorescent lamps.

Fig. 8: Self-ballasted Cavity Induction Lamp

TYPES OF INDUCTION LIGHT SOURCES

The external-coil induction lighting system is shown in Fig. Fig. 9. The likeness to a standard transformer of this lamp is more apparent than for any other induction lamps. The lamp is made from a 54 mm diameter tube encircled by two closed ferrite cores. The lamp rating available are 15W~200W at an efficacy of up to 95 lm/W. The designed operating frequency is 250 kHz only, which is not governed by the radio frequencies allocated for industrial applications such as 2.65, 13.56, 27.12 and 40.68 MHz. The decrease in working frequency has virtually eliminated EMI problems, ballast complexity, and cost as compared to other induction lamps working at 2.65 MHz.

Due to the closed magnetic path of the ferrite cores, the power-transfer efficiency and efficacy of this lamp are extremely high; they are 98% and 95 lm/W respectively. The rated life of this induction lighting system is 100,000 hours, which is determined by the life of electronic ballast but not the lamp. The high system efficiency is achieved by the distributed power deposition along the lamp in contrast with the cavity induction lamp where power transfer is localized around the coupling induction coil, causing local thermal stress and overheating that limits maximum lamp power.

Fig. 9: External-coil induction lamp