A NEMA Lighting Systems Division Document

Interaction of Infrared Controls And Fluorescent Lamp/Ballast Systems In Educational Facilities

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Table of Contents

Figures

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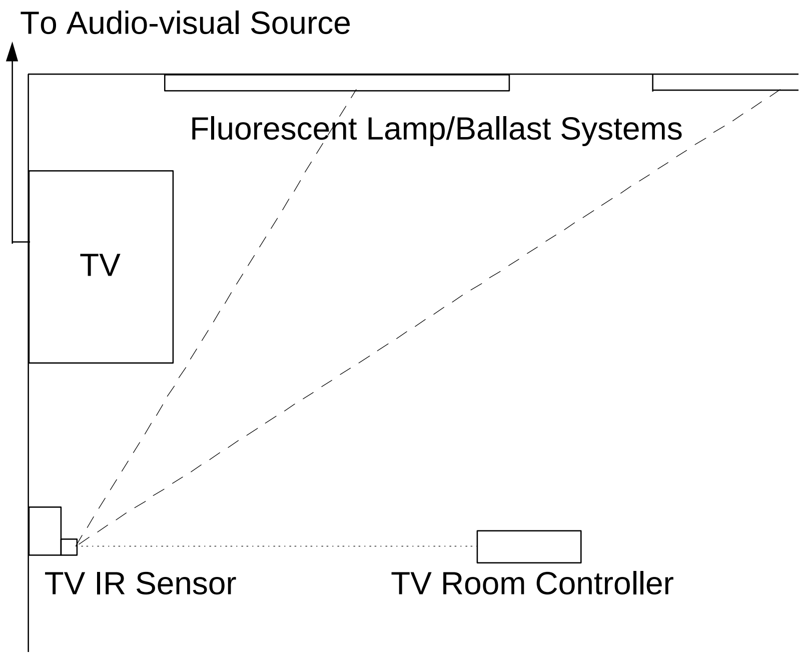
Introduction

The use of infrared radiation (IR) for the transmission of audio, video, data, and control signals is rapidly growing. Applications using infrared transmission include TV, VCR, and cable remote controls, wireless LAN networks, video-conferencing, computer peripherals, medical equipment, and personnel and equipment locating monitors. Also, because of increased energy conservation awareness and economic benefits, compact fluorescent lamps and linear fluorescent lamps with electronic ballasts are commonly found in homes, commercial office buildings, schools, and health care facilities. Therefore, representatives from the Lamp and Ballast Sections of NEMA (National Electrical Manufacturers Association) formed a working group to define specifically the possible interactions between lamp/ballast systems and equipment in educational institutions communicating within the infrared spectral region.

This working group reviewed various known potential interference situations, such as the interaction between linear fluorescent lamps with electronic ballasts and audio-visual equipment remote controls in schools. Many classrooms have televisions mounted in close proximity to the ceiling and to linear fluorescent lamps with electronic ballasts. As a general rule, the televisions are mounted such that they are at least 84 inches above the floor where interaction has been reported. The TVs are controlled with an in-room transmitter operating below 400 kHz with an IR sensor usually wall-mounted below the TV. See Figure 1. At times these interactions reportedly render television remote controls inoperable or result in random channel changing and volume increases and decreases.

Figure 1. Relative Location of Audio-visual Equipment in a Classroom



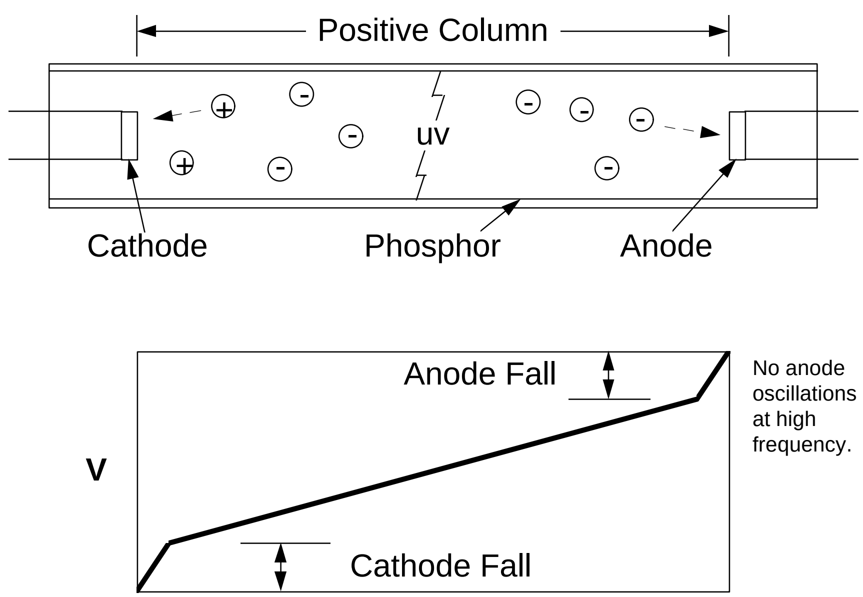
Where interactions occur, solutions can be as simple as deactivating the lighting fixtures nearest the TV receiver. Other solutions included separating the operating frequency ranges of the linear fluorescent lamp/electronic ballast systems from the remote controls or improving receiver circuitry. To accomplish the latter two, some manufacturers have altered the design of both receiver and ballast products.

Potential Sources of Interference

Present linear fluorescent lamp circuits drive the lamp or lamps at frequencies between 18,000 and 100,000 Hertz (one Hertz equals one cycle per second, abbreviated as Hz). This is the excitation frequency. In addition to visible light, the lamp also emits a small amount of IR and ultra-violet (UV) radiation. The infrared radiation is emitted at wavelengths between 800 and 1200 nanometers (one-nanometer equals 0.000000001 meters or 10^{-9} meters, abbreviated as nm). These wavelengths fall within the sensitivity band, or range, of IR receivers used for TV, cable boxes, VCRs, etc.

Within linear fluorescent lamp/ballast systems, two major sources account for IR emissions: (1) spectral lines from the inert gas fill near both electrodes, the anode and cathode, and (2) mercury lines from the main discharge or positive column. See Figure 2. The main discharge, or positive column, is contained within the phosphor coated lamp walls and between the electrodes. During the first five minutes of lamp operation, or start-up, the IR emissions from the inert gas fill in the 800 to 850 nm band dominate. After five to ten minutes of operation, during steady state operation, the 1015-nm mercury line emission becomes dominant.

Figure 2. Lamp Discharge Physics

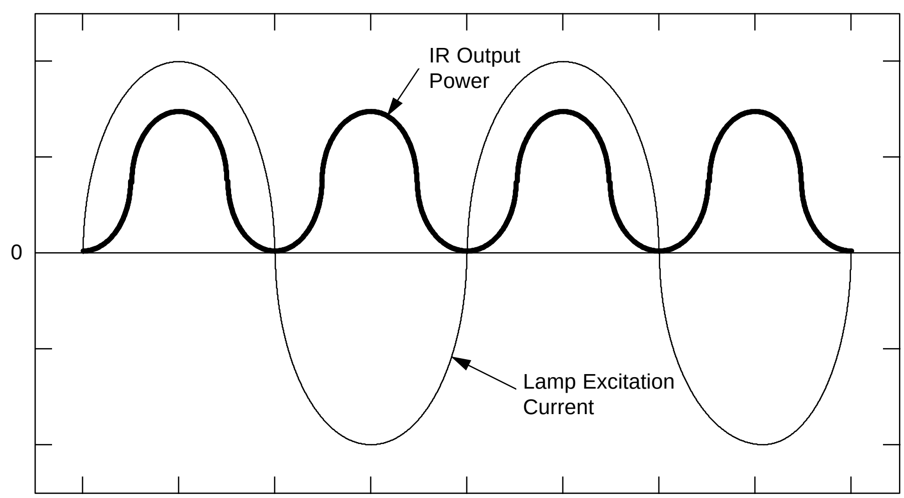


Typical Fill Gas ~2 Torr Argon + Mercury

Two observations have been made with regard to infrared radiation from a typical linear fluorescent lamp. First, the region near each of the two electrodes in a typical linear fluorescent lamp emits infrared radiation once every cycle of the drive waveform. The emission from the region near both electrodes viewed from a distance then appears at the lamp excitation frequency.

Second, the positive column emits radiation during both halves of the high frequency cycle at twice the lamp excitation frequency called the lamp power frequency (Figure 3). The positive column is the major region of the discharge where UV is emitted resulting in the excitation of the phosphor coating on the lamp wall. The excitation of the phosphor coating ultimately causes the emission of visible light from the phosphor. In addition to the IR at the fundamental excitation and power frequencies, the harmonics (or integer multiples) of the excitation frequency or power frequency can also cause an interference if they fall into the carrier frequency range of an IR receiver. There are instances of linear fluorescent lamps operating between 18 and 30 kHz (1 kHz equals 1,000 Hertz) interfering with IR receivers at 38 kHz and 56 kHz.

Figure 3. Lamp Frequencies



IR Output Power Frequency = 2 X Excitation Frequency

IR receivers often found in educational facilities typically operate with maximum sensitivities around 930 nm and operate at a carrier frequency between 33 and 40 kHz or from 50 to 60 kHz. The center frequency and the tuning characteristics of the IR receiver determine the particular excitation frequency of a linear fluorescent lamp that is most likely to cause interference. Recent industry research has shown that various linear fluorescent lamp/ballast systems and TV receivers indicate that an undesirable interaction can occur shortly after lamp switch-on or during the steady state operation of a lamp.

Why Does Interference Occur?

Linear fluorescent lamp/ballast circuits can interact with IR receiving equipment operation when either the lamp excitation frequency or the lamp power frequency is within the carrier frequency band of the receiving equipment. Linear fluorescent lamp excitation frequencies generally range from 18 to 100 kHz. IR remote controls in educational facilities in the United States typically operate from 33 to 40 kHz and at about 56 kHz. Thus lamps with excitation frequencies in the range of 18 to 40 kHz are capable of interfering with IR remote controls. Symptoms of linear fluorescent lamp interference include the total loss of remote control operation, random operation of volume controls, on-off switching, channel scanning, lockout of manual operation, and reduced operating range.

What Can Be Done to Reduce Interference?

<u>Solutions for the Installed Base</u>

End-users can do the following things:

1. Switch to another lamp and ballast combination with a different frequency. (IR interference most often occurs when there is a match of the linear fluorescent lamp output IR frequency to that of the IR receiver carrier frequency passband.)
2. Deactivate linear fluorescent fixtures within close proximity to the IR receiver.
3. Re-locate the nearest lighting fixture farther from the IR receiver.
4. Relocate or shield the IR receiver, or TV receiver, to prevent direct line-of-sight between IR receiver and luminaire.
5. Contact the IR receiver manufacturer for assistance. Add-on optical filters, provided by some manufacturers, have proven effective in some cases.

6. Re-wire the nearest lighting fixtures so that they can be temporarily switched off when audio-visual activities are in progress.
7. Replace the ballasts in the nearest lighting fixtures with high efficiency electromagnetic types. These ballasts operate the lamp at power line frequencies that are too low to interact at even the lowest IR control frequencies.

Before attempting any of these solutions, it is first recommended that the interaction be investigated sufficiently to determine which lighting fixtures nearest the receiver are involved in the interaction. Once the fixtures are identified, many of the solutions can better be considered for practicality in the installation.

Solutions Going Forward

A dual frequency approach to remote control transmissions has been found to be one way to make IR systems less susceptible to this type of interaction. This approach is currently being utilized by some TV receiver companies. Some consumer and commercial applications require IR transmitting and receiving equipment to operate over a range greater than twenty feet in the presence of fluorescent lamps. Variations in the dual frequency approach include the following:

1. Use two IR receivers, one at 38 kHz and one at 56 kHz. The transmitter and the equipment containing the receiver would initially be set to the 56 kHz frequency. If needed, they could both be reset to the 38 kHz frequency.
2. A single IR receiver would be used with a control line added to the IR receiver to select between the two frequencies.
3. A transmitter would be designed to transmit first at the 56 kHz frequency and then the 38 kHz frequency. This would eliminate the need to set up the transmitter.

The most effective option for manufacturers of IR communications equipment is to locate IR communication frequencies at or above 400 kHz. This altogether avoids undesirable interactions with lighting equipment utilizing linear fluorescent lamps and even compact fluorescent lamps. It will also avoid undesirable interactions with newer light sources, such as electrodeless lamps, since recent research into the interaction phenomena shows that very little modulation of the lamp discharge can occur at frequencies above 100 kHz.