



The ABC's of electronic fluorescent ballasts

A guide to fluorescent ballasts

PHILIPS
ADVANCE

100 years of brighter, more efficient lighting.

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The first fluorescent lamp was patented over 100 years ago by American inventor, Peter Cooper Hewitt. Cooper Hewitt's low pressure mercury arc lamp is the direct parent of today's modern fluorescent lights. Far more efficient than incandescent lamps, fluorescent lamps use electricity to excite molecules of Argon or Krypton together with mercury vapor to create luminescence. Unlike incandescent lamps, a fluorescent lamp cannot be connected directly to electric lines. They require ballasts to stabilize the flow of current or else they quickly become inoperable. A ballast provides the starting voltage for a fluorescent lamp and limits the current passing through it. The ballast also provides proper electrode or filament heating.

For most of the last century, electromagnetic ballasts, sometimes referred to as "core-and-coil" or "magnetic" ballasts, were the only fluorescent lamp ballasts available. Since 1988, when they first began to penetrate the market, electronic ballasts have proven themselves not only as workhorses of efficiency but also as a catalyst for revolutionizing fluorescent lighting system design and specification.

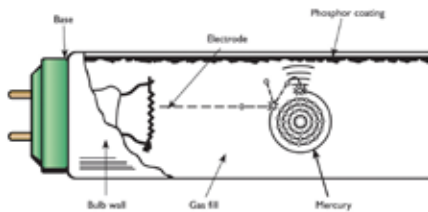
This guide will give you a greater understanding of electronic ballasts, the great many options they offer and the benefits of using various types of electronic ballasts in designing more energy-efficient, economic, innovative and user-friendly lighting systems.

Understanding Light Sources

In order to properly evaluate, specify, purchase or install a lighting system, it is important to understand the variety of lamps available for this purpose in the marketplace today.

Energy-Efficient Fluorescent Lamps

Fluorescent lamps operate at cooler temperatures than incandescent lamps, and convert electrical energy to light more efficiently. Their operation relies upon an electrical arc passing between two electrodes, one on each end of the lamp. This arc passes through a glass tube coated with phosphor in a mixture of vaporized mercury and purified gases – mainly Argon or Krypton. The resulting ultra-violet waves react with the phosphor to produce a glow (fluorescence) and emit visible light.



In evaluating the suitability of various fluorescent lamps for particular applications, it is important to understand some basic lamp characteristics and definitions.

Fluorescent Lamps Types

Fluorescent lamps sold in the United States today are available in a wide variety of shapes and sizes ranging from miniature versions, rated at 4W, 6" in length and 5/8" diameter, to 215W, 96" long and 2" in diameter. Commercially available fluorescent lamp types include T12, T8, and T4 compact and T5-linear and compact. Base types include bi-pin, single pin, several compact bases and recessed double contact.

T12 lamps, which can be operated electronically, but are typically operated by electromagnetic ballasts, are 1 1/2" in diameter and are now outsold by T8 lamps which have a 1" diameter. T8 lamps typically operate by electronic ballasts, but may also operate using magnetic ballasts. T8 lamps produce a better quality light and are dual rated for rapid or instant start operation, which maximizes application flexibility. T4 compact lamps are

special 1/2" diameter, high lumen output, lamps developed to replace incandescent lamps in many down lighting applications. T5 lamps, 5/8" in diameter, provide some application flexibility and enhanced optic design due to its smaller diameter.

Lamp Light Output

Lamp Light Output is measured in lumens. Fluorescent lamps are measured in initial lumens or in design lumens.

- Initial lumens is a measure of the amount of light that the lamp produces after about 100 hours of operation.
- Design lumens tells you the amount of light that the lamp produces after it has operated for approximately 40% of its rated life.

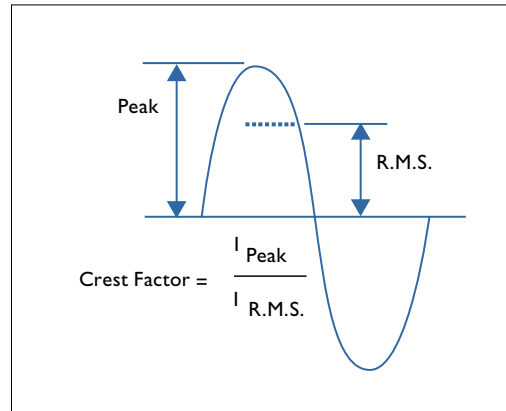
Because light output from a fluorescent lamp diminishes as the lamp is used – a process known as Lamp Lumen Depreciation – a lamp's design lumens (or mean lumens) are always lower than its initial lumens. Lumen maintenance refers to the rate at which light output declines over time and lumen maintenance percentages are typically based on light output at 40% of a lamp's rated life.

Lumens per Watt

Lumens per Watt is a rating of a lamp's light output in relation to the current passing through it or the watts it uses. The more efficient a lamp, then the more lumens it will produce per watt of power consumed. The measurement LPW is also referred to as lamp "efficiency."

Crest Factor

Lamp manufacturers use crest factor to determine ballast performance as it relates to lamp life. Lamp Current Crest Factor is a measurement of current supplied by a ballast to start and operate the lamp. It is basically the ratio of peak current to RMS (average) current. High crest factor currents may cause the lamp electrodes to wear out faster, reducing lamp life. Crest factor requirements are regulated by ANSI (American National Standards Institute) standards and specified by lamp manufacturers. For rapid start and instant start T8 lamps the ratio is 1.7 maximum, and for instant start slimline lamps, it is 1.85 maximum.



Other Types of Lamps

Incandescent Lamps

Even though nearly 90% of the energy consumed by incandescent lamps is dissipated as heat, they are still prevalent in most American homes and are used throughout business and industry. The operation of incandescent lamps is simple and self-regulating: when electricity passes through a lamp filament, it heats the filament until it glows (incandesces) and produces light. The amount of light produced depends on the amount of electrical current passing through the filament. In addition to producing light, the filament also limits the current to safe operating values.



High Intensity Discharge Lamps

High Intensity Discharge, known as HID, refers to lighting technology that produces light by passing an electric current through a gas or vapor at high pressure. The current produces a high intensity arc or discharge of light that is very efficient. HID lighting has been used for years in roadway lighting, industrial and warehouse high and low bay applications, and sports arenas and stadiums around the country. The technology is increasingly being used in specialty applications such as automotive headlamps.



Light Emitting Diodes

Commonly called an LED, a Light Emitting Diode is a semiconductor device that illuminates by the movement of electrons in the material. Unlike incandescent or fluorescent bulbs, LEDs do not have filaments that burn out, so they last many times longer than traditional light sources. LEDs are very small, making them ideal for use as indicator lights or in cell phones and flash lights. Collected together, they can form images on a jumbo television screen or illuminate a traffic light or car taillight. Advances in technology are making LEDs less expensive and brighter, giving them great potential for use as a general lighting source in the future.



Electronic Ballast Fundamentals



What does a ballast do

In all fluorescent lighting systems, the ballast's basic tasks include:

- Providing the proper voltage to establish an arc between the two electrodes.
- Regulating the electric current flowing through the lamp to stabilize light output.

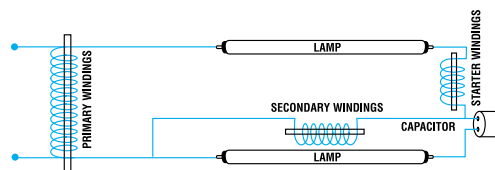
In some fluorescent lighting systems, the ballast also provides a controlled amount of electrical energy to heat the lamp electrodes. This is required to prevent electrode filaments deteriorating prematurely and shortening the lamp life. To receive peak performance from fluorescent lamp ballasts – the heart of the fluorescent future – match precisely the requirements of the lamp it is designed to operate.

Starting Methods

For many years there were only three types of lighting systems: preheat, rapid start and slimline instant start. Two additional types of lighting system circuits have been added: instant start for T8 lamps and programmed start. Each requires a special ballast design to operate the lamps in the circuit properly.

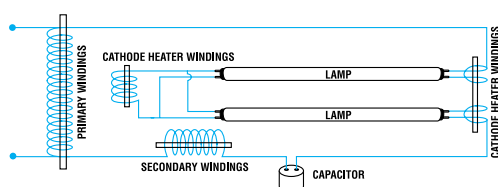
Instant start electronic ballasts

Start lamps without delay (<0.1 seconds) or flicker by providing a starting voltage that is sufficiently high to start a discharge through the lamps without the need for heating lamp electrodes. For F32T8 systems, the starting voltage is about 600V. The elimination of electrode heating maximizes energy savings – typically saving two watts per lamp compared to rapid start ballasts. Instant start ballasts are best suited for applications with limited switches each day. Lamps operated by instant start ballasts typically operate 10,000 to 15,000 switch cycles before failure.



Rapid start electronic ballasts

Start lamps quickly (0.5 – 1.0 seconds) without flicker by heating the lamp electrodes and simultaneously applying a starting voltage. The starting voltage of about 500V for F32T8 systems is sufficient to start a discharge through the lamps when the electrodes have reached an adequate temperature. Electrode heating continues during operation and typically consumes two watts per lamp. Lamps operated by rapid start ballasts typically operate 15,000 to 20,000 switch cycles before failure.



Programmed start electronic ballasts

Also start lamps quickly (1.0 -1.5 seconds) without flicker. Programmed start ballasts are designed to provide maximum lamp life in frequent lamp starting applications such as in areas where occupancy sensor controls are used. Programmed start electronic ballasts precisely heat the lamp electrodes, tightly controlling the preheat duration before applying the starting voltage. This enhancement over rapid start ballasts minimizes electrode stress and depletion of emitter material, thereby maximizing lamp life. Lamps operated by programmed start ballasts typically operate up to 50,000 switch cycles before failure.

Programmed Start is also used for most compact lamp systems and electronic dimming systems to provide proper starting of lamps when starting in the dimmed mode.



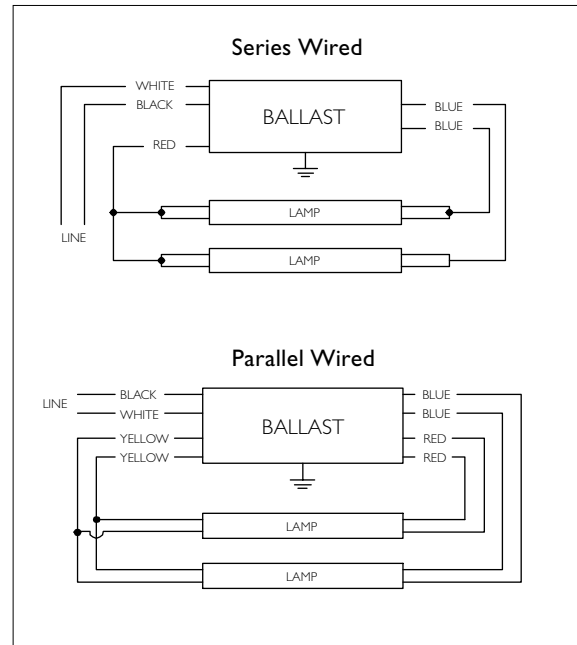
Philips Advance Optanium® ballasts include the first high-efficiency programmed start electronic ballasts to offer the same energy savings as their instant start counterparts without sacrificing lamp life.

Circuits

Series vs. Parallel

Lighting systems are typically wired in a series or parallel circuit. When a ballast is operating multiple lamps in a series circuit, if one lamp fails, the circuit is opened and all the lamps will extinguish. When a ballast operates multiple lamps in a parallel circuit, the lamps operate independently of each other so, if one lamp fails, the others can keep operating as the circuit between them and the ballast remains unbroken.

Generally, rapid start ballasts are wired with the lamps in series. Programmed start ballasts are also typically wired with lamps in series. However, some three- and four-lamp ballasts feature series-parallel operation; so that when a single lamp in one branch fails, the lamp(s) in the parallel branch will continue to operate. Instant start ballasts are typically wired with the lamps in parallel.



The Language Of Ballasts

Supply Voltage

(dedicated vs. multiple voltage and frequency)

Most ballasts are designed to operate at the specific nominal voltage shown on the label. Newer electronic ballasts, including Philips Advance models that use IntelliVolt® technology, offer much greater input voltage and frequency flexibility and other advantages such as inventory reduction. Today's increasing demands on electrical utilities can cause wide voltage variations during load demand changes which in turn cause light output from lamps operated on dedicated input voltage electronic and electromagnetic ballasts to vary with the input voltage changes.

Input Watts/ANSI Watts

Input watts published by ballast manufacturers are the total watts consumed by both the ballast and the lamps it operates. ANSI watts are the rating given for a ballast measured under the strict testing procedures specified by ANSI standards and are the only dependable measure of this performance. Energy savings can be determined by comparing the input watts of different lighting systems.

Ballast Factor (BF)

Ballast Factor (BF) is the ratio of light output from a lamp operated on a commercial ballast to the light output of that same lamp operated on a "reference ballast" as

specified by ANSI standards. Light output ratings published by lamp manufacturers, are based on this "reference ballast".

BF is a measure of light output best thought of as a 'multiplier'. Multiplying the BF times rated lumens will determine actual light output of a given lamp ballast combination.

Ballast Efficacy Factor (BEF)

Ballast Efficacy Factor (BEF) is the ratio of ballast factor to input watts. This measurement is generally used to compare the efficiency of various lighting systems – higher numbers being more efficient.

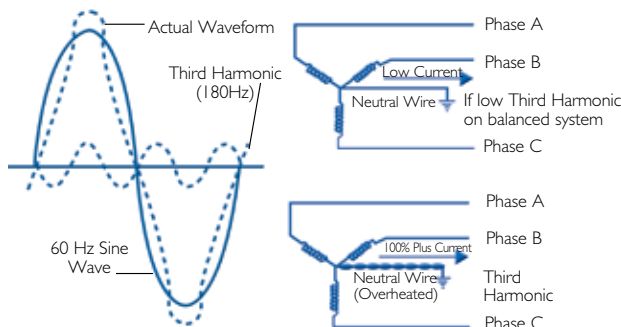
$$BF = \frac{\text{light output of lamp operated on commercial ballast}}{\text{light output of lamp operated on reference ballast}}$$

This comparison is only valid, however, for ballasts operating the same number and type of lamps. In order to compare different types of lighting systems, the lumen output of the lamps must also be used. For more information, see the section on "High-Efficiency Ballasts" under "Lamp Ballast System Applications" later in this brochure.

$$\text{Ballast Efficacy Factor} = \frac{\text{Ballast Factor} \times 100}{\text{Input Watts}}$$

Total Harmonic Distortion (THD)

Harmonic distortion occurs when the wave-shape of current or voltage varies from a pure sine wave. Except for a simple resistor, all electronic devices, including electromagnetic and electronic ballasts, contribute to power-line distortion. For ballasts, THD is generally considered the percent of harmonic current the ballast adds to the power distribution system. The ANSI standard for electronic ballasts specifies a maximum THD of 32%. However, most electric utilities now require that the THD of electronic ballasts be 20% or less. Almost all Philips Advance electronic ballasts are rated for either less than 20% THD or less than 10% THD.



Power Factor (PF)

Power Factor (PF) is the measurement of how effectively a ballast converts the voltage and current supplied by the power source into watts of usable power delivered to the ballast and lamps. Perfect power utilization would result in a power factor of one.

$$PF = \frac{\text{Input Watts}}{\text{Input Current} \times \text{Input Voltage}}$$

A ballast's power factor may be classified under any one of the following categories:

High Power Factor (HPF)	0.90 or greater
Power Factor Corrected (PFC)	0.80 to 0.89
Normal (Low) Power Factor (NPF)	0.79 or less

Power factor measurements pertain only to the effective use of power supplied to the ballast. They are not an indication of the ballast's ability to supply light through the lamps. Because low power factor ballasts require about twice the current needed by high power factor ballasts,

they allow fewer fixtures per circuit and create added wiring costs. Commercial lighting applications generally specify high power factor ballasts.

Thermal Protection

Almost all indoor fluorescent fixtures must incorporate ballast thermal protection according to the National Electrical Code (NEC). Ballasts meeting thermal protection requirements are designated "Class P" by Underwriters Laboratories, Inc (UL).

Class P magnetic ballasts incorporate a thermal protector within the ballast case. Operation of this thermally actuated, automatic resetting, protective device will disconnect the ballast from the power source in the event of over temperature.

Electronic ballasts are also "Class P" rated but may not incorporate the thermal protector in their design. These ballasts inherently limit their case temperature below the "Class P" limits as require by UL.

"Class P" rated ballasts help protect against excessive supply voltage, internal ballast short circuiting, inadequate lamp maintenance and improper fixture application. They also reduce the need for individual fixture fusing. "Class P" ballasts should be replaced with the same type to not void the fixture safety rating by UL.

EMI/RFI

Because they operate at high frequency, electronic ballasts may produce electromagnetic interference (EMI) or radio frequency interference (RFI). RFI frequencies are a subset of EMI frequencies. EMI issues cover all possible operating frequencies while RFI is only concerned with radio and television frequencies. This interference could affect the operation of sensitive electrical equipment, such as radios, televisions or medical equipment. All Philips Advance electronic ballasts incorporate features necessary to afford maximum protection for the operating environment and operate well within regulatory limits. For more information, see the section on "FCC Regulations – EMI/RFI" in the "Reference Section" of this brochure.

Ballast Noise

The slight “humming” sound associated with fluorescent lighting systems results from vibration caused by the inherent electromagnetic action in the core-and-coil assembly of the ballasts. All electromagnetic and some electronic ballasts make this sound. Ballasts are assigned a sound rating, “A” through “F”, based on the amount of sound produced, with “A” being the quietest. Generally, the larger the lamp and ballast, the higher the sound level and the sound rating will be. Because electronic ballasts have smaller components, they have the lowest sound rating. Some electronic ballasts make almost no sound. There is no ANSI standard for this rating and it is left up to the manufacturer to rate their ballasts.

Inrush Current

All electrical devices including ballasts have an initial current surge that is greater than their steady-state operating current. A new standard published by the National Electrical Manufacturers Association (NEMA) – NEMA 410 – Performance Testing for Lighting Controls and Switching Devices with Electronic Fluorescent Ballasts – covers worst-case ballast inrush currents. All circuit breakers and light switches are designed for inrush currents. The electrical system should be designed with this issue in mind.

Weight and Size Advantages

Since electronic components in electronic ballasts are smaller and lighter than the core-and-coil assembly in electromagnetic ballasts, electronic ballasts can weigh less than half as much as comparable electromagnetic models. Almost all Philips Advance electronic ballasts have a smaller cross-section than electromagnetic ballasts but maintain the same mounting dimensions. This means that they can fit into all new fixture designs and can be easily retrofitted into existing fluorescent lighting systems.



Electronic Ballasts



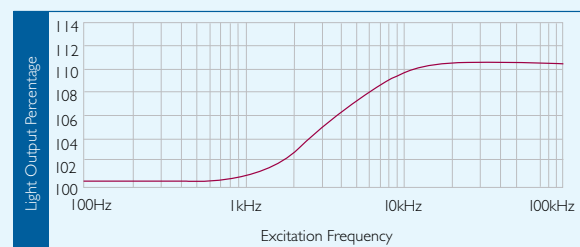
Magnetic Ballasts

Ballast Life

Philips Advance fluorescent electronic and magnetic ballasts are designed and manufactured to engineering standards correlating to an average life expectancy of 50,000 hours of operation at maximum rated case temperature (70°C for electronic and 90°C for magnetic). Since Philips Advance ballasts operate below their maximum case temperature in the majority of applications, increased ballast life can be expected. Ballast life is doubled for every 10°C reduction in ballast case operating temperature. However, there are many variables, such as input voltage, ambient temperature, etc. which affect ballast operating temperatures, and therefore ballast life.

Lamp Operating Frequency

Electromagnetic ballasts and the lamps connected to them operate at an input voltage frequency of 60 Hertz (Hz), 60 cycles per second—which is the standard alternating voltage/current frequency provided in the United States. Electronic ballasts, on the other hand, convert this 60 Hz input to operate lamps at much higher frequencies above 20 Kilohertz (kHz), 20,000 cycles per second. Advance designs operate above 20 kHz, but avoid certain ranges such as 30-40 kHz (infrared) and 54-62 kHz (theft deterrent systems) due to interference issues.



Because electronic ballasts function at high frequency, the fluorescent lighting systems that they operate can convert power to light more efficiently than systems operated by electromagnetic ballasts (see chart below). For example, lamps operated on electronic ballasts can produce over 10 percent more light than if operated on electromagnetic ballasts at the same power levels. In effect, today’s electronic ballasts provide additional energy savings by matching the light output from electromagnetic ballasts while operating the lamps at lower power. This is the main reason why electronic ballast systems are more efficient than magnetic ballast system.



You can control fluorescent lighting using three choices in controllable ballasts – ROVR™, Mark 7® 0-10V and Mark 10® Powerline – providing controllable options for any application, for a long time to come.

Controllability

The ability of a building's occupants to control how they light their space is becoming an increasingly important factor for organizations in determining what real estate they will lease, buy or invest in. The ability to dim the lights or easily shut them off completely is a trend fueled not just by a desire to help the environment, but also by significant economic benefits. These benefits include greater energy efficiency – in terms of reduced HVAC costs as well as energy savings for lighting – more comfortable and productive working environments, and compliance with ever tighter energy efficiency regulations. Philips Lighting Electronics offers three families of electronic controllable ballasts – ROVR, Mark 7 0-10V and Mark 10 Powerline – that can provide up to 65% energy savings over standard T8 fixed light output systems.



New Applications for Fluorescent Lighting

Conventional metal halide lamps have been the light source of choice for decades in high bay applications such as warehouses, industrial buildings, gymnasiums and other high-ceiling buildings. Now, however, T5 high output (T5/HO) lighting systems offer an alternative that is ideal for use in high bay applications. Assuming equal hours of operation, T5/HO lighting systems often provide energy savings of nearly 53% compared to conventional metal halides.

T5/HO systems are energy efficient and offer higher color rendition, better lumen maintenance and more even light distribution. Since T5/HO systems do not require any time to re-strike the lamps, they can be combined with lighting control strategies (e.g. occupancy sensors) to further reduce energy consumption and costs.



Lamp Ballast System Applications

The electronic ballast revolution has resulted in dramatic improvements in ballast performance. The electronic ballast is based on an entirely different technology than traditional electromagnetic ballasts. It starts and regulates fluorescent lamps with electronic components rather than the traditional core-and-coil electromagnetic assembly. The end results are dramatic differences in efficiency, reliability and flexibility to accommodate various lamp types and sizes.

There are also differences in the suitability of particular electronic ballasts for various applications. To receive peak performance from a fluorescent lighting system, it is essential that the fluorescent lamp ballast match the requirements of the lamp or lamps it operates. A basic lighting system consists of a fixture/reflector; one or more fluorescent lamps; the ballast or ballasts used to operate the lamps; and the controls that switch current on and off, or, in some cases, dim the lamps as required.

In order to specify the most efficient system to meet the lighting requirements of a specific area, it is important to evaluate the suitability of the ballasts you will use. The following are questions and answers that will help you narrow down the correct ballasts for your lighting application.



What do I need the lighting system to deliver?

More light ...without an increase in energy consumption?

Same light ...while delivering energy savings?

Less light ...with maximum energy savings?

The answers to these questions, and those that follow, will insure that the correct lamp-ballast combination is elected for a specific application.

Will occupancy sensors be used? Consider using programmed start ballasts in frequent switching applications.

Other factors for ballast assessment:

Anti-Arc? UL Type CC Rating is a stringent designation of protection against arcing in electrical devices that can damage lamps, ballasts and sockets. This is usually a requirement in refrigeration equipment with vertically mounted lamps.

Anti-Striation? Striation – often referred to as spiraling or swirling – is typically associated with operation of new energy-saving T8 lamps (primarily 25 & 28W versions). Striations typically occur in krypton-filled lamps like energy-saving T8 and T12 lamps when operated at low current or low temperature. Anti-striation technology used in many Philips Advance ballasts eliminates the maintenance issues caused by striating lamps, providing a flicker-free and worry free environment.

Auto-Restrike? The auto-restrike capability of almost all Philips Advance ballasts eliminates the need to reset power mains after failed lamps are replaced.

Lamp End-of-Life (EOL Protection)? Lamp EOL protection circuitry, enhances safety by removing power to the lamp as it reaches its end-of-life, preventing lamp overheating.

What is the starting temperature required? Low temperature applications can affect lamp starting and operation. Lamp-ballast combinations are rated for minimum starting temperatures to ignite the lamps. However, the lumen ratings for fluorescent lamps apply to operation at a temperature of 25°C (77°F). While many fluorescent lamps and ballasts are designed to give their best performance at 25°C, they will provide reasonably good light output at temperatures as low as 10°C (50°F) for standard lamps and 16°C (60°F) for energy-saving lamps. Further decreases in temperature will result in decreased light output. The 800mA HO and 1500mA VHO lamps are recommended for most efficient cold temperature operations.

Would high-efficiency ballasts be appropriate? In order to compare the efficiency of different types of lighting systems, the total lumen output of the lamps and total input watts must be used to determine system lumens per watt. This will allow comparison between different lamp types and also between the different ballasts designed to operate them.

$$\text{Efficiency (measured in system lumens per watt)} = \frac{\text{rated lumens} \times \text{number of lamps} \times \text{Ballast Factor}}{\text{Input Watts}}$$

A ballast may have one ballast factor for operating standard lamps and a different ballast factor for operating energy-saving lamps. Philips Advance offers a variety of different ballast options for operating the same lamp or lamps. These different ballasts have their own specific ballast factors. So Philips Advance enables lighting system designers to trade watts for lumens without specifying different lamps—simply by choosing the Philips Advance ballast option that best meets the lighting requirements of their particular application.



Daylight harvesting using controllable lighting cut absenteeism at Lockheed by 15%.

[Colorado Sustainability Summit, 1999.]

By cutting lighting operational costs up to 65%, Philips Advance controllable ballasts produce a fast payback for their initial cost, making an investment in controllable lighting a very bright idea.

Is a system warranty required? Philips Advance electronic ballasts come with reliable Philips Advance quality, backed by warranties of 5, 3 or 2 years depending on product and limitations. With many of its ballasts, Philips Advance also offers an exclusive PLUS 90 Protection® – combination Lamp and Ballast System Limited Warranty that provides an additional 90 days protection, subject to restrictions, to both the lamps and ballasts when installed as a system combining Philips Advance ballasts with lamps manufactured by GE Lighting, Osram-Sylvania, Philips Lighting or Venture Lamp. For more details on Philips Advance warranties, visit www.philips.com/advance and refer to Philips Advance PLUS 90 Protection Warranty.

Which system delivers the lowest Total Cost of Ownership? In When calculating a lighting system's Total Cost of Ownership (TCO), energy efficiency is only one of the factors to consider. Maintenance costs and costs of compliance with government and other regulations – such as recycling and disposal requirements – are also very important factors to consider. These “life-cycle” costs are at least as, if not more, important to consider as the system's upfront costs of equipment and installation.

What about the need for controllability? Controllable lighting saves energy, improves productivity, promotes sustainable building design and adds tangible value to real estate of all kinds. Philips Advance's innovative controllable electronic ballasts give specifiers, architects, property and facility managers, and end-users maximum choice and flexibility in controlling lighting environments. Philips Advance controllable electronic ballasts deliver paybacks through daylight harvesting – using daylight to supplement the artificial light provided by the lighting system – compatibility with the use of occupancy sensors, load shedding, and light output tailored to the task and/or time of day.

Studies show that controllable lighting designs provide significantly lower life-cycle costs (TCO) than conventional lighting systems. In addition to lower energy costs, controllable lighting systems reduce cooling loads which significantly lower the operational costs of HVAC systems. High-quality, energy-efficient controllable lighting systems that utilize natural and electric sources have also proved to provide a comfortable, visually interesting and more productive environment for occupants. Creating controllable lighting designs that cost little more than conventional lighting, yet are energy-efficient, environmentally friendly and aesthetically beautiful is now a real possibility. Philips Advance's brochure on Controllable Fluorescent Lighting can provide you with more information on the many advantages and options for controllable lighting.

Legislation

Federal Ballast Energy Law (Public Law 100-357) enacted in 1988 set the first national standards for fluorescent ballasts most commonly used in commercial lighting installations. In 2005 a revision to the law went into effect requiring more efficient fluorescent lighting systems. The first part of the U.S. Department of Energy (DOE) ruling took effect on April 1, 2005, requiring that all ballasts manufactured for use in new fixtures in the United States for operation of F40T12 and F96T12 lamps (and sold after July 1, 2005) must meet new BEF requirements, as shown in the table below.

Light Source	Input Voltage	Min. BEF
(1) F40T12 lamp	120/277	2.29
(2) F40T12 lamps	120/277	1.17
(2) F96T12 lamps	120/277	0.63
(2) F96T12/HO lamps	120/277	0.39

As of April 1, 2006, lighting fixture manufacturers were no longer able to integrate ballasts that did not meet new efficacy standards into new fixtures. Exceptions to the rule include ballasts for F96T12/HO lamps used in outdoor signs, ballasts that have a power factor less than 0.90 that are designed and labeled “for residential use” and ballasts dimmable to 50% or less. T8 lamps are not covered by the rule, as there are several applications, such as electronic sensitive areas, where electronic ballasts would not be used. Ballasts meeting the old ballast efficacy standards will continue to be manufactured for replacement use, limited to short leads and quantities of ten or less. They will be marked, “FOR REPLACEMENT USE ONLY”. These ballasts will be available until July 1, 2010.

Philips Advance electronic ballasts comply with both the 1988 and 2005 fluorescent energy requirements.



Regulatory Requirements

ANSI High Frequency Ballast Requirements

Electrical manufacturers of lamps and ballasts create common standards to ensure compatibility between lamps and ballasts and interchangeability of products between manufacturers. These performance standards allow manufacturers to design products to industry standards rather than individual manufacturer's requirements. Advance electronic ballasts meet ANSI C82.11 for High Frequency Fluorescent Lamp Ballasts.

FCC Regulations—EMI/RFI

Because electronic ballasts operate at high frequency, high frequency energy may feed back into the power system or radiate from the ballast, wiring or lamps. This interference could affect the operation of sensitive equipment. The Federal Communications Commission (FCC) regulates electromagnetic frequencies from 450 kilohertz (kHz) to 300 megahertz (MHz). For electronic ballasts, the limits and regulations are listed in the Code of Federal Regulations, Title 47, Part 18, Subpart C entitled RF Lighting Devices. Tables are published for absolute levels of radio frequency voltage that is required at certain frequencies. There are two levels given: one for non-consumer applications and a stricter one for consumer applications. Most Philips Advance electronic ballasts provide performance that already falls within the non-consumer (Class A) limitation, assuring their suitability for commercial and industrial applications. Some special electronic ballasts are available which meet the more stringent consumer (Class B), or residential EMI limits.

ANSI Transient Requirements

Electronic components are more sensitive to sudden surges of high voltage than are core-and-coil assemblies. These surges (or transients) may be caused by lightning strikes to nearby transformers, overhead lines or to the ground. Transients may also be caused by load switching such as motors or compressors and by short circuits or utility system switching. Some facilities have power back-up generating or UPS systems that switch in and out to provide constant power to hospitals, etc. Transients are generated when these systems are activated and deactivated. Although these surges sometimes last less than a second, they may cause electronic ballast failure due to the energy in the transients. All Philips Advance electronic ballasts are designed to withstand the conditions of ANSI C62.41, Category A for transient protection.

Safety Requirements

Philips Advance electronic ballasts meet all safety requirements of UL 935 established for fluorescent ballasts. Many models also meet CSA safety requirements for Canada.

Basic Troubleshooting

For information on troubleshooting, please refer to our *Pocket Guide To Fluorescent Lamp Ballasts* available at www.philips.com/advance.

Innovation, reliability and unrivalled product range make Philips Advance the most trusted name in electronic ballasts.

Electronic ballasts brought an era of unprecedented economy and versatility to fluorescent lighting. Representing a truly revolutionary development in the history of modern lighting technology. Even the most basic electronic ballast offers many advantages over electromagnetic ballasts. Philips Advance is an industry leader in electronic ballast design and manufacture. Even basic Philips Advance electronic ballasts consume less energy, are lighter and operate more quietly than their magnetic counterparts. In addition, sophisticated Philips Advance electronic ballasts offer several more advantages, including multiple lamp type operation, special circuit protection, and operation through a wide range of voltages. In general, Philips Advance electronic fluorescent ballasts are designed to:

- Provide maximum power savings while sustaining optimum lighting levels.
- Maintain lamp manufacturers' recommended filament voltage (where applicable) to assure maximum lamp life.
- Offer optimum reliability.

Philips Advance electronic ballasts also incorporate features necessary to afford maximum protection to the operating environment. Philips Advance electronic ballasts can be easily fitted into all new fixtures as well as retrofitted into existing fluorescent lighting systems. No special tools are required and no modification of fixtures is necessary because Philips Advance electronic ballasts are physically interchangeable with comparable electromagnetic models and have the same lead wire connections in most cases.



Philips Advance has a family of electronic fluorescent ballasts for every application.

Standard Electronic The broadest line of high-frequency electronic ballasts for all types of fluorescent lighting. These ballasts offer energy efficient, reliable, quiet and flicker-free operation and a quick payback on investment. Advance Standard Electronic ballasts are also rated for less than 20% total harmonic distortion.

Centium® High frequency electronic ballasts with less than 10% total harmonic distortion. These ballasts are specially useful in applications such as computer rooms and hospitals where current harmonics must be minimized. Some Centium models also feature IntelliVolt® technology which allows the ballast to operate on any input voltage from 120 through 277V.

Optanium® High-efficiency, high frequency electronic ballasts with less than 10% total harmonic distortion. These ballasts are ideal for applications where maximum energy savings are required. Optanium programmed start ballasts also offer the energy saving advantages of instant start models without sacrificing lamp life.



Mark 5® These premium electronic ballasts provide programmed starting for longer lamp life and silent operation. Featuring IntelliVolt technology, Mark 5 ballasts are able to operate over a wide voltage range. Mark 5 ballasts are also designed with <10% THD on all lamp types, with power factors very close to 1.0.

Mark 7 0-10V and Mark 10 Powerline These controllable ballasts are integrated circuit, programmed start ballasts that have similar characteristics to the Mark 5 ballast with the added ability to continuously dim from 100% to 5% (or from 100% to 1% for T5/HO) for Mark 10 Powerline, and 100% to 3% (T5/HO to 1%) for Mark 7 0-10V. These ballasts provide flexibility to lighting systems through control strategies such as daylight harvesting and load shedding.

ROVR® This new series of digital addressable controllable ballasts has intelligence inside the ballast, transforming it into a “smart” device that offers unprecedented lighting flexibility and two-way communication between lighting devices, Building Management Systems and even PCs. ROVR is fully compatible with the industry-standard digital communication protocol known as DALI (Digital Addressable Lighting Interface). It can be individually controlled (addressed) as well as belong to any or all of 16 different control groups at the same time. ROVR also features IntelliVolt allowing the ballast to operate on any input voltage from 120 through 277V. For more information, please refer to *The ABCs of DALI* available at www.philips.com/advance.

SmartMate® These high frequency electronic ballasts for 13 through 120W compact fluorescent lamps (CFLs) are packed with innovative features. Included are the exclusive color-coded dual entry connectors for both bottom and side lead connections in a single ballast as well as IntelliVolt multiple-voltage technology.



Ambistar Today’s fixed and dimmable fluorescent fixtures offer greater flexibility and energy savings for residential and hospitality settings than ever before, thanks to Philips Advance AmbiStar™ electronic ballasts. No matter what type of fluorescent lighting you’re considering, these ballasts help create warm, inviting interiors while providing Class B FCC EMI Rating – a requirement for the EPA ENERGY STAR® residential lighting fixtures – at a very competitive price.

AmbiStar dimming ballasts are designed to work with most incandescent dimmers, so they are easy to install with new or existing dimming systems.

Electronic Ballast Feature Comparison (fixed light output)

Feature	BALLAST					
	Standard Electronic	Centium®		Mark 5™	Optanium™	
Starting Method	Instant	Instant	Program Rapid	Programmed	Instant	Programmed
THD%	<20%	<10%	<10%	<10%	<10%	<10%
IntelliVolt®		✓		✓	✓	✓
Ballast Factor	Low Normal High	Low Normal	Normal	Low Normal High	Low Normal	Normal
Lamp Auto-Restrike Circuitry	✓	✓	✓	✓	✓	✓
Starting Temp	0°	0°	32°	0°	0°	0°
UL Type CC (anti-arcing)			✓		✓	✓
Anti-Striation					✓	✓
High Efficiency					✓	✓

Electronic Ballast Feature Comparison (controllable)

Feature	BALLAST		
	Mark 7 0-10V	Mark 10 Powerline	ROVR
Starting Method	Programmed	Programmed	Programmed
IntelliVolt®	✓		✓
Dimming Range	100 — 3% (T5/HO to 1%)	100 — 5% (T5/HO to 1%)	100 — 3% (T5/HO to 1%)
Dimming Interface	0 — 10 Volt DC	Powerline	DALI
Two-Way Addressable			4
Lamp Auto-Restrike Circuitry	✓	✓	✓
Circuit Type	Analog	Analog	Digital

Glossary

AC (Alternating Current) — Current that passes from the generator in one direction and then the other, alternately.

Ambient Sound Levels — “Background noise” generated by electrical and mechanical equipment operating in a building. Low ambient sound levels are desirable for hospitals, libraries and similar applications where high noise levels are unacceptable.

Ambient Temperature — The temperature of the atmosphere in the surrounding environment.

ANSI (American National Standards Institute) — Group that generates voluntary product performance standards for many U.S. industries.

Anti-Arc — Circuitry used to detect and limit arcing of ballast output leads.

Anti-Striation — Circuitry used to prevent striations or spiraling in energy-saving lamps due to low temperature or low current operation.

Arc — Intense luminous discharge formed by the passage of electric current across a space between two electrodes.

Auto-Restrike — Circuitry used to restart the lamps without resetting the power to the ballast.

Ballast — Device for starting and regulating fluorescent and high intensity discharge (HID) lamps.

Ballast Cycling — Intermittent operation due to high temperature conditions of the ballast or ambient temperature, which causes the thermal protector to open and turn off the ballast. After cooling down, the thermal protector closes, turning on the ballast and starts the heating cycle over again.

Ballast Efficacy Factor (BEF) — Measure used to compare various ballasts based upon light output and input power. $BEF = \text{Ballast Factor} \times 100 / \text{Input Watt}$.

Ballast Factor (BF) — Measure of light output from lamp operated by commercial ballast, as compared to laboratory standard reference ballast specified by ANSI.

Ballast Losses — Power that is supplied to the ballast but is not converted into light energy.

Ballast Noise “Hum” — Sound made by operating Core & Coil assemblies in both electromagnetic and some electronic ballasts, generated by the vibration of laminations in the electromagnetic field that transforms the voltage and current used by discharge lamps. The sound made by high frequency electronic ballasts is lower than electromagnetic ballasts with some designs virtually inaudible.

Capacitor — Device in ballast that stores electrical energy.

Centigrade (C) — Celsius temperature scale where $0^{\circ}\text{C} = 32^{\circ}\text{F}$ and $100^{\circ}\text{C} = 212^{\circ}\text{F}$.

Circle-E — Marking on ballast that shows compliance with Federal Ballast Energy Law.

Coil — Windings of copper or aluminum wire around the core in electromagnetic ballast that transforms the voltage from input to output.

Conformal Coating — Material that surrounds and adheres to components and protects them.

Core — Steel laminations of electromagnetic ballast that transforms electrical power from input to output.

Core-and-Coil Ballast — Another term for electromagnetic ballast.

Crest Factor (Lamp Current Crest Factor) — Ratio of peak lamp current to RMS average lamp current.

CSA (Canadian Standards Association) — Association that generates product performance and safety standards for many Canadian industries.

CSA-E Marking on ballast that shows compliance with Canadian Ballast Energy Law.

Decibel (dB) — Unit of sound measurement.

Design Lumens — The amount of light that the lamp produces after it has operated for approximately 40 percent of its rated life. Also called Mean Lumens.

Discharge Lamp — A device that produces light by using an electric arc, rather than a filament, to create illumination.

Efficacy — Lumen output per unit of power supplied to the lamp, measured in lumens per watt.

Electrode — See "Filament".

Electromagnetic Ballast — Low frequency (50 or 60 Hz) ballast that uses a "Core & Coil" assembly to transform electrical energy (voltage and current) to start and operate fluorescent and high intensity discharge (HID) lamps.

Electronic Ballast — A ballast that, with the aid of electronic components, converts 50 — 60 Hz input voltage and current to high frequency (>20,000 Hz) to operate fluorescent and high intensity discharge (HID) lamps.

EMI (Electromagnetic Interference) — Any type of electrical interference.

ETL — Independent electrical testing laboratory that performs ballast testing.

FCC Regulations (Federal Communications Commission) — Legally enforceable U.S. government standards for EMI and RFI that must be met by high frequency electronic devices used in this country for Non—Consumer (Class A Industrial) or Consumer (Class B Residential) applications.

Filament — Coated coil of special wire that emits electrons or light when heated.

Filament voltage — Voltage applied to heat the lamp filament coil. Also called electrode or filament heating.

Fluorescent lamp — Gas filled lamp in which light is produced by the interaction of an arc with phosphors lining the lamp's glass tube.

Fluorescence — Emission of visible light by the absorption of energy from another source.

Foot Candles — Measure of light level on a surface that is being illuminated.

Frequency — The number of times per second that an alternating current system reverses from positive to negative and back to positive, expressed in cycles per second or hertz, Hz.

Harmonic Distortion — A measurement of the magnitude of voltage or current harmonics as compared with the amplitude of the fundamental frequency voltage or current.

Harmonics — Refers to components of the overall frequency, an integral multiple of the fundamental sine wave frequency.

Hertz (Hz) — Current or voltage operating frequency, equal to cycles per second.

High—Frequency Ballast — Electronic ballast that operates the lamps above 20 kHz (20,000 cycles per second).

High Power Factor Ballast (HPF Ballast) — Ballast with a power factor of 0.90 or greater.

IEEE (Institute of Electrical and Electronics Engineers) — Organization of engineers that establishes standards for electrical and electronics industries.

IES (Illuminating Engineering Society) — Group of professional lighting engineers and designers.

Incandescent Lamp — Lamp in which light is produced by a filament heated by an electric current.

Incandescence — Emission of visible light by a heated material.

Initial Lumens — The amount of light that a lamp produces after it has been operating 100 hours.

Input Power — See "Input Watts".

Input Voltage — Voltage, from the power line, which the ballast uses to power fluorescent lamps.

Inrush Current — Initial surge of current when an electrical device is turned on.

Instant Start ballast — Electromagnetic or electronic ballast that ignites the lamps without heating the lamp filaments.

Instant Start lamp — Fluorescent lamp that requires no filament heating before igniting and producing light.

IntelliVolt — Multi—voltage feature of Advance electronic ballasts that allows the ballast to operate from an input voltage range of 120 to 277V.

Kilohertz (kHz) — 1,000 Hertz (cycles per second).

Laminations — Layers of thin steel making up the "core" of a Core & Coil assembly.

Glossary

Lamp Filament — See “Filament”.

Lamp Flicker — Rapid visible light change occurring in fluorescent lighting systems.

Lamp Watts — Power used to operate a lamp.

Lead—Lag Slimline Ballast — Electromagnetic ballast that operates slimline lamps independently of one another.

Low Power Factor Ballast (LPF Ballast) — Ballast with a power factor of 0.79 or less — also called normal power factor ballast (NPF ballast). LPF ballast requires about twice the line current of HPF ballast so fewer LPF ballasts can be installed on a circuit, which increases installation cost.

Lumens — Measurement of light emitted by a lighted lamp.

Lumen Depreciation — The decrease in lumen output of a light source over time. Also called Lumen Maintenance.

Lumens Per Watt — Units of light produced per unit of power.

Lumen Maintenance — See “Lumen Depreciation”.

Mean Lumens — See “Design Lumens”.

NEC (National Electric Code) — Safety requirements for electrical wiring and equipment in all types of buildings.

Normal Power Factor Ballast (NPF Ballast) — See “Low power factor ballast”.

Parallel Circuit — Ballast circuit in which the lamps connected to one ballast will operate independently of one another — if one lamp fails, the rest will stay on.

PCB (Polychlorinated Biphenyls) — Chemical pollutant used in oil-filled capacitors outlawed by the EPA in 1978.

Phosphor — Material, lining the interior of a fluorescent lamp, which emits light when energized.

Power Factor (PF) — A measurement of how efficiently an electrical device uses power supplied by the power line.
 $PF = \text{Watts} / (\text{Volts} \times \text{Current})$.

Power Factor Corrected Ballast (PFC ballast) — Ballast with a power factor from 0.80 to 0.89.

Preheat Ballast — Electromagnetic ballast that requires separate starter in order to ignite the lamp.

Preheat Lamp — A fluorescent lamp in which the filaments must be heated before the lamp ignites.

Programmed Start Ballast — Electronic ballast that provides precise heating of the lamp filaments and tightly controls the pre—heat duration before applying starting voltage to ignite the lamp.

Rapid Start Ballast — Electromagnetic or electronic ballast that provides both filament heating and starting voltage to the lamp at the same time in order to ignite the lamp.

Rapid Start Lamp — Fluorescent lamp that requires filament heating before igniting and producing light.

Reference Ballast (Standard Reactor) — Laboratory device used to provide ANSI specified operating parameters for fluorescent and HID lamps.

RFI (Radio Frequency Interference) — Form of electromagnetic interference with radio communications as defined by the FCC.

Series Circuit — Ballast circuit in which the lamps connected to one ballast will operate as a group — if one lamp fails, all lamps in the circuit will turn off.

Series—Parallel Circuit — Ballast circuit in which the lamps connected to one ballast will operate both as a group and independently — if one lamp in the series connected section fails, the rest of the lamps in that section will also turn off but the lamps in the parallel circuit will stay on.

Series-Sequence Slimline Ballast — Electromagnetic ballast that operates slimline lamps in series, with the lamps starting in sequence.

Sine Wave — A mathematical function used to represent AC voltage and current.

Slimline Lamp — Fluorescent lamp, which has single pin contacts, that requires no filament heating to ignite.

Striation — Spiraling or swirling of fluorescent lamps at initial turn on or energy-saving lamps at low temperature or low current.

T12, T10, T8, T5 — Industry standard names for fluorescent lamps (T= tubular with the number that follows representing the diameter in 1/8 inch increments).

THD (Total Harmonic Distortion) — The combined effect of Harmonic Distortion on the AC waveform produced by the ballast or other electrical devices.

Thermal Protector — A self resetting switch that disconnects power to the ballast if internal temperatures rise above the trip point — typically 105°C. Thermal protectors are used in some ballasts to limit maximum case temperature and meet UL Class P safety standards.

Third Harmonic — Third multiple of the fundamental frequency that will add in the neutral wire of a three-phase, 4 wire system and could cause over-heating of the neutral wire.

Three-phase, 4-wire — Most popular electrical wiring system for building wiring in use today.

Three-phase current — Current delivered through three wires of a transformer with each wire serving as the return for the other two.

Transients — Transients are sudden but significant deviations from normal voltage levels — voltage spikes.

Trigger Start Ballast — Electromagnetic ballast that starts and operates preheat lamps similar to a rapid start lamp. No separate starter is needed to ignite the lamp.

UL (Underwriters' Laboratories, Inc.) — Laboratory that sets safety standards for building materials, electrical appliances and other products.

Voltage — A measure of electrical potential, express in volts (V).

Voltage Sag — Drop in voltage levels of electrical distribution system, which interferes with the operation of electrical and electronic equipment. Also called "Brownout," results when demand for electricity exceeds capacity of the distribution system.

Watts (W) — Unit for measuring electrical power.





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