

Active Input Ballast

Active input ballasts utilize an active semiconductor chopper circuit, usually controlled by an IC, to convert the input AC voltage to DC voltage with acceptable power factor and current harmonics.

Ballast Efficacy Factor (BEF)

The BEF is defined as the average ballast factor of all lamps divided by the power input, in watts, of a fluorescent lamp ballast.

$$\text{Ballast Factor} = \frac{\text{Commercial ballast light output}}{\text{Reference reactor ballast (100\% light output)}}$$

$$\text{Ballast Efficacy Factor} = \frac{\text{Ballast Factor}}{\text{Ballast Watt Input}}$$

BEF numbers are determined by a laboratory measurement which allows for a controlled relative comparison between measured products. BEF numbers can only be used to compare ballasts which operate the same type and quantity of lamps.

The BEFs of two different systems, such as a two-lamp F40T12 and a two-lamp F32T8, have no relationship to each other and cannot be used as a means of comparison.

Ballast Factor

Ballast factor is a new label for an old index formerly referred to as “relative light output”. Ballast factor, expressed as a percent, is the light output of the lamp(s) operated by a commercial ballast divided by the light output of the same lamp(s) operated by a reference ballast, as determined in accordance with the test procedures specified in ANSI standard C82.2, Method of Measurement.

Ballast Factor	Lamp Types
95	0.800A & 1.0A T12, 1.5A T12 & PG17
92.5	17, 25, 32, 40WT8; 30, 40WT10, 40WT12 U shaped 16, 24, 32WT8; 40WT12 single-based lamps, with 2G11 bases 18W, 24-27W, 36-39W, 40W
90	4, 6, 8WT5; 14, 15WT8; 14, 15, 20WT12 circular 20, 22, 32, 40WT9; 32WT10, 40WT10
85	34WT12, electronic operation of 32WT8/RS & IS, 40WT12/RS, 34WT12/RS, 75W96T12/IS, 60W96T12/IS, 110W9612/HO, 40W22T5/RS/2G11

This reference ballast is a laboratory device which can be adjusted to provide specific voltage, current and impedance to the lamps per ANSI specifications. Ballasts which are CBM Certified must have a ballast factor that meets or exceeds the numbers shown in the table and are often referred to as “full light output”.

Fluorescent lamp characteristics are affected by temperature. More efficient operation, such as by electronic ballasts, results in lower lamp temperature and therefore offsets some of the lower ballast factor allowed for electronic ballasts, particularly in enclosed fixtures.

CBM Certification

CBM Certification is the process by which sample ballasts made to ANSI specifications are tested and certified to conform to these rigid performance requirements.

Merely making a ballast to meet these standards isn't enough to enable it to carry the CBM emblem. Before a manufacturer may put CBM Certified on a ballast, samples must be submitted to Intertek Testing Services, Inc. (ETL), an independent testing agency. There, they are subjected to tests and examinations to make sure that every detail of the appropriate ANSI standard, including the electrical requirements of the ANSI C78 specifications for the lamp(s) shown on the ballast label, has been met.

Each manufacturing facility producing CBM Certified ballasts must also pass a Quality Program Audit (QPA) by ETL. This thorough analysis of in-plant quality procedures ensures that the manufacturer has adequate quality controls in place on a continuing basis.

But even passing these original tests at ETL isn't sufficient. Periodically and unannounced, an ETL inspector visits each plant manufacturing CBM Certified ballasts in locations all over the world. The inspector selects CBM ballasts off the production line for tests to make sure the day-to-day production continues to meet the requirements of ANSI standards. Should ballasts fail to meet any requirements, corrective action must be taken and in some instances, certification may be withdrawn until the deficiency is corrected.

Class P Standards

The National Electrical Code (NEC) requires indoor fluorescent fixtures to incorporate ballast thermal protection. Underwriters Laboratories has implemented this requirement by developing a standard encompassing ballast protection. Ballasts meeting this standard for protection are designed class “P”.

Such a ballast is protected internally by a device which will disconnect the ballast from the power line in the event that the temperature limit is exceeded. This protection guards against excessive temperatures which may be caused by abnormal voltage or internal faults that may occur at the end of ballast life. It does not affect normal ballast operating temperatures.

All Class “P” magnetic ballasts have thermal protective devices. Electronic ballasts are not

required to have an actual thermal switch for Class “P” listing. Class “P” listing denotes that the case temperature will not exceed a specified value in the event of a component failure. Many electronic ballasts comply with Class “P” requirements by means of “Inherent Thermal Protection” incorporated in the circuitry. Such ballasts are marked accordingly. These ballasts are fully tested to all Class “P” requirements, just as those with thermal protection devices. They comply by virtue of the fact that the circuitry will shut down and inherently stop producing heat, thus resulting in no temperature increase in the event of internal component failures or application abnormalities.

Class “P” requirements are specified by UL, not CBM. A Class “P” ballast may be a CBM ballast, but only if it meets the ANSI performance specifications. The designation Class “P” alone does not signify CBM Certification

Compact Lamp

Compact lamps are single-ended fluorescent lamp devices which are self supporting. They are usually arranged in twin, quad or hex shapes with a variety of base arrangements.

Dimming

Dimming ballasts are devices with either manual or automatic controls to change light output. They are generally more complex and less efficient than standard ballasts and are more expensive. However, they require less energy when the lamps are dimmed.

While no specifications are available to standardize dimming operation, ballasts which meet all the ANSI standards, including meeting the minimum ballast factor requirements at full power, may be CBM Certified for that operation and will be so marked on the label.

Discrete Electronic Ballast

Discrete electronic ballasts consist entirely of separate electronic components to handle the ballast starting and operating functions.

Electromagnetic

Electromagnetic (magnetic) ballasts employ a core and coil and a power capacitor. The core and coil consists of a core of steel laminations surrounded by one, two or more copper or aluminum coils. This unit provides the conditions for starting and controlling the current flow to the fluorescent lamps.

Prior to the 1980's, the choice of materials in the core and the coils was usually driven by economics to minimize the ballast cost, while meeting performance requirements. These ballasts are usually referred to as standard, or conventional, magnetic ballasts. Many of these ballasts are still in service today.

Electromagnetic (cont'd)

During the '80s, more efficient designs started to gain some popularity. These designs, commonly referred to as energy efficient magnetic, are optimized for maximum efficiency using higher-grade core and coil materials and costing more. Since 1990, only energy efficient magnetic ballasts have met the U.S. efficiency regulations for most popular lamp configurations.

The ballast is enclosed in a metal case filled with an asphaltic compound. This compound helps dissipate heat and control ballast sound.

Electronic (high frequency, solid state)

Electronic ballasts operate lamps at high frequencies, using semi-conductor components to change the frequencies, in combination with small inductive and/or capacitive components to provide the starting and regulating function.

Electromagnetic ballasts operate the lamps at line frequency, usually 60 Hertz (Hz). Electronic ballasts convert this line frequency to operate lamps at frequencies between 20 and 60 Kilo-Hertz (KHz). It is a well established fact that low pressure arcs, such as fluorescent lamps, are more efficient when operated from high frequency ballast sources. For many popular lamps, this increase in lamp efficacy is about 10%.

Electronic construction weighs less than core and coil magnetic construction, allowing easier handling during installation, lower structural stress on ceiling supports and lower shipping costs.

Electromagnetic Noise or Interference (EMI)

Electrical equipment is not always noisy, but it is capable of generating electromagnetic noise or interference (EMI). Not to be confused with audible noise, electromagnetic noise is an interference generated by the electrical current of all types of equipment via the power line or through the air. Although both electromagnetic and electronic ballasts can generate EMI, electronic ballasts are more prone to having EMI issues.

There are two types of EMI: conducted and radiated. **Conducted EMI** is fed back into the power system through the ballast input leads and can interfere with any other equipment connected to the same power system. **Radiated EMI** is radiated in all directions from the fixture, typically directly from the lamps, but possibly also from the ballast itself.

Fluorescent lamps, by the very nature of their arc discharge, will radiate some EMI. This is typically increased when they are operated at high frequency on electronic ballasts. Radiated EMI is generally increased as operating frequency is increased. Distortion of lamp current, resulting from higher order harmonics, also increases radiated EMI.

To regulate EMI, the Federal Communications Commission (FCC) has set limits as to the allowable noise levels electrical equipment may generate, both conducted and radiated. Fluorescent lamp systems may be a source of electromagnetic radiation at radio frequencies. High frequency ballasts must comply with FCC regulations, Title 47 of the U.S. Code of Federal Regulations, Part 18.

For ballasts, this has been broken down into two categories or levels: consumer and non-consumer levels. Consumer levels apply to residential applications, while non-consumer levels are required for commercial and industrial applications. All electronic ballasts must comply with the applicable requirement.

ANSI standards and CBM Certification requirements for magnetic ballasts cover EMI by requiring the use of specific EMI suppression capacitors in some circuits.

In some special applications, radio interference suppression line filters may be specified to be added in series with magnetic ballasts to eliminate possible EMI noise that is generated by the lamp. These filters, which are designed for use with magnetic ballasts, are not necessary for most typical applications.

Hybrids

This designation refers to ballasts which start like rapid-start ballasts, but reduce or remove the electrode heating after the lamp is in full operation. Such products are sometimes referred to as hybrid or cathode cutout ballasts. Some lamps have slightly reduced lamp-life ratings when operated on these modified rapid-start ballasts.

IC Electronic Ballast

IC electronic ballast designs incorporate the function of multiple components in a single integrated circuit.

There are two input configurations that are commonly used in electronic ballasts: passive input and active input.

Inrush Current

Inrush current is the surge of current that takes place when power is applied to a ballast. With magnetic ballasts, this inrush current is typically 10 to 20 times the steady state rms current of the ballast. With electronic ballasts, this inrush current may be significantly higher.

This high inrush current is a result of the initial charging of the storage capacitors in an electronic ballast. Depending upon the circuitry that the electronic ballast incorporates, this inrush surge may be as high as 100 times the steady state current.

Electronic ballasts can be generally subdivided into two classes: those with "passive" input

circuits and those with "active" input circuits. Passive input circuits typically have inrush currents up to 30 times steady state with durations measured in milliseconds.

Active input circuits typically have inrush currents up to 100 times steady state, but with durations measured in microseconds. It is important to recognize that inrush current of multiple ballasts on a circuit do not directly add. Since high inrush current may damage power switching components such as light switches, relays, circuit breakers and occupancy sensors, evaluation of the lighting system is advisable.

Instant Start

Instant-start ballasts deliver an initial high voltage to light the instant-start lamp. The arc current heats the filament by bombardment to provide easy electron emission. Instant-start lamps are usually identified by the single pin base. No preheating of the filament is required for this lamp to light. The starting interval is very short, always less than 200 milliseconds, and typically less than 100 milliseconds.

Lamp Current Crest Factor

Lamp current crest factor is a ratio of the peak lamp current divided by the rms lamp current. The crest factor is a function of the ballast. Maximum allowable values for crest factor have been specified by ANSI standards. If the crest factor is above these values, lamp life may be reduced. CBM Certification requires that the ballast's crest factor be equal to or lower than the ANSI values.

Low Temperature

Fluorescent lamps are harder to start at lower temperatures. ANSI and lamp manufacturer specifications for lower temperature starting usually call for higher ballast open circuit and starting-aid voltages. Rapid-start ballasts, designed for low-temperature operation, may result in instant starting of the lamp(s) and reduced amp life when used at normal room temperatures. All ballasts are marked with the minimum acceptable operating temperature.

Ratings commonly used are 60°F, 50°F, 32°F, 0°F and -20°F. In general, the absolute minimum temperatures of some popular lamp groups are: 60°F for energy-saving lamps; 0°F for other 430 ma or less lamps; and -20°F for 800 ma and 1500 ma lamps, regardless of ballast characteristics.

The most popular and most efficient ballasts available for standard indoor lighting are rated for minimum temperatures of 50°F with standard lamps and 60°F for energy-saving lamps.

Since light output changes with temperature, all CBM light output testing is done at a standardized ambient temperature of 77°F.

Modified Rapid Start

Modified rapid start ballasts start the lamps in a rapid-start mode, but then turn off or reduce the filament heat after the lamps have started.

Passive Input Ballast

Passive input ballasts usually depend on inductance and capacitance in conjunction with the rectifier to convert the input AC voltage to DC voltage with acceptable power factor and current harmonics. The inductance is frequently a laminated core choke.

Power Factor

Power factor indicates how efficiently power generation and distribution systems will be utilized. By definition, it is the ratio of real power to apparent power delivered into any electrical system with "real power" being input watts (measured by wattmeter) and "apparent power", the product of volts multiplied by amperes supplied by the power line.

$$\text{Power Factor} = \frac{\text{Watts input}}{\text{Line volts} \times \text{line amps}}$$

High power factor	90% or greater
Power Factor Corrected	85-89%
Normal (low) Power Factor	84% or less

High power factor ballasts are defined as those that have a power factor of 0.9 (90%) or higher. The power factor is the simple ratio of watts/ (volts x amps). All CBM Certified ballasts are high power factor ballasts.

The greatest impact of power factor is the fact that line current is minimized with high power factor ballasts. This maximizes the number of fixtures that can be installed on a circuit and minimizes wiring costs.

Low power factor equipment draws higher line current and loads your circuits and those of the utility. (Sometimes it also results in a penalty charge from the utility.) Because low power factor ballasts require up to twice the line current of high power factor ballasts, there will be fewer fixtures on a fully-loaded circuit which increases wiring costs.

Pre-heat

Pre-heat operation requires use of a starter or manual switch to establish the circuit through the ballast to pre-heat the lamp filaments. When the filaments have heated up, the starter opens and the ballast then provides a suitable voltage to light the lamp and limits the current flow to the proper value. Several seconds may be required to complete the starting operation.

Programmed Rapid Start

Programmed rapid start ballasts apply filament heat initially and delay application of sufficient open circuit voltage to start the lamps until after the filaments have been heated adequately.

Rapid Start

Rapid-start ballasts provide the proper energy levels to heat the lamp filaments continuously through small, low-voltage filament windings. The open circuit voltage of the ballast is adequate to start the lamp only after the filaments have heated to emission temperature. A grounded reflector close to the lamp, together with a grounded line circuit, is required to provide a capacitive starting-aid effect between lamps and fixture and assist ionization in the starting process.

Rapid Start/Instant Start

Today's popular T8 lamps are bi-pin lamps designed and intended for use interchangeably on magnetic or electronic rapid-start ballasts. Although electronic instant-start systems are more efficient, lamp life is slightly less with instant start operation.

Safety Listings

UL Listing: This term is used to describe ballasts which comply with Underwriters Laboratories, Inc. requirements for fluorescent lamp ballasts (ANSI/UL 935) and have usually been tested and listed by UL.

Today, any laboratory accredited by OSHA as a Nationally Recognized Testing Laboratory (NRTL) for safety testing in particular product areas can provide listing service equivalent to UL. ETL and CSA are active in the ballast field and can provide this listing.

A parallel program exists in Canada using CAN/CSA C22.2 #74 and it is also recognized for safety by the CBM program.

What does "UL" cover? The charter of Underwriters Laboratories says: "By scientific investigation, study, experiment and test, UL does its part in helping to prevent the loss of life and property from the hazards of fire, casualty and crime." The UL emblem relates to the safety aspects of ballast operation and application.

The safety listing label, such as UL, ETL or CSA, does not require meeting ANSI performance specifications. These are tested separately under the CBM program.

With CBM Certified ballasts, you benefit from both; since they must carry both the CBM emblem for fine performance and a safety listing emblem showing compliance with ANSI/UL 935, CAN/CSA C22.2 #74, or both.

Transient Immunity

Electronic ballasts are more susceptible to damage caused by power line transients than electromagnetic ballasts. These transients come in the form of voltage or current spikes and surges that may be high in amplitude but very short in duration. The transients may be generated in any number of ways including load switching, failure of other equipment, main power disruption or lighting. The ability to withstand these transients at some level is referred to as transient immunity.

The topic of transient protection is addressed by IEEE in their document called "Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuit", also known as ANSI/IEEE C62.41. This document provides transient level recommendations that equipment designers can use to test with for given applications and locations. Testing to these recommendations is required for CBM Certification of electronic ballasts.

It is important to note that although these products conform to the standards on a stand-alone basis, they are normally installed with a large number of other ballasts and other electrical equipment along the same parallel circuit. This allows the surge suppression characteristics of each to act together, further increasing the level of immunity of each individual ballast.

Unfortunately, there is no level of protection that will absolutely ensure protection from a direct lightning strike or other extreme transient. Even if it was technically feasible, it would likely not be economically practical, given the extremely low probability of such an event.

It is possible to increase the level of system transient immunity by installing category "B" (major feeders) surge suppression at the service panel of the building. However, such extreme measures are not normally necessary except in areas prone to unusually high lightning activity.

Trigger Start

Trigger start is a term used for ballasts which operate pre-heat start lamps in a rapid-start manner. They supply higher filament voltages to heat the electrodes to start the pre-heat lamps, to simulate the rapid-start system.

All industry definitions were excerpted from the "Fluorescent Lamp Ballast Primer" with permission from Certified Ballast Manufacturers (CBM). Participation in CBM, an association devoted to quality, is open to anyone who wishes to qualify.



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