

HIGH FREQUENCY ELECTRONIC BALLASTS

ELECTRONIC
FLUORESCENT

Introduction

High efficiency, high frequency electronic ballasts offer enhanced lighting performance and energy savings. The Electric Power Research Institute estimates that lighting consumes 20-25% of all electric power and that lighting energy accounts for 40% of the average commercial electric bill. The retrofit of existing facilities with modern lighting systems increases productivity and can save over one-half the energy of the original system.

This potential for savings has prompted the EPA (Environmental Protection Agency) to create the Green Lights program. U.S. Corporations, in this voluntary program, retrofit their lighting systems with energy efficient lamps and ballasts whenever economically feasible. The economics of lighting retrofits have never been better. Investment payback is often accelerated by "Demand Side Management" programs from electric utilities that offer incentives in the form of rebates for energy efficient measures.

Ballast Basics

Modern electronic ballasts operate at a frequency above 20,000 Hz. This high frequency operates lamps more efficiently (10-15% more light output) and eliminates the 60 cycle hum and visible flicker normally associated with electromagnetic ballasts. Modern solid-state circuitry makes the electronic ballast practical, reliable and cooler running.

LAMP/BALLAST COMPATIBILITY

Standards and Regulations

Typical lamp specifications include starting voltage, operating current, cathode voltage, crest factor, etc. Electronic ballasts from Advance Transformer are designed to meet the lamp manufacturers specifications and the requirements of:

- ANSI/IEEE C62.41 (American National Standards Institute)
- ANSI C82.11 (American National Standards Institute)
- FCC Part 18 (RFI and EMI)
- UL (Underwriter Laboratories)
- Public Law No. 100-357 (minimum efficiency standards)
- NAECA (National Appliance Energy Conservation Amendments)
- CSA (Canadian Standards Association) where applicable
- The National Electrical Code and all Municipal Electrical Codes.

No fluorescent lighting system will meet expectations unless the lamp and ballasts are properly matched. Proper (electronic ballast/fluorescent lamp/fixture) combinations result in applications with the correct light levels for the task at hand, lamps that provide rated lamp life, and a safe and aesthetically pleasing installation. Advance® electronic ballasts are tested by independent laboratories to ensure compatibility with lamps from all major manufacturers.

Instant Start

Instant start electronic ballasts are the most popular type of electronic ballast today because they provide maximum energy savings and they start lamps without delay or flashing. Since they do not provide lamp electrode heating, instant start ballasts consume less energy than comparable rapid start, program rapid start or programmed start ballasts. As a result, they provide the most energy efficient solution to fluorescent lamp ballasting. The instant start ballast uses 1.5 to 2 watts less energy per lamp than the rapid start alternative.

Instant Start (cont'd)

Instant start electronic ballasts provide a high initial voltage (typically 600V for F32T8 lamps) to start the lamp. This high voltage is required to initiate discharge between the unheated electrodes of the lamp. However, the cold electrodes of lamps operated by an instant start ballast may deteriorate more quickly than the warmed electrodes of lamps operated by a rapid start, program rapid start or programmed start ballast. Lamps operated by instant start ballasts will typically withstand 10-15K switch cycles. Instant start ballasts are typically wired in *parallel*. This means that if one lamp fails, the other lamps in the circuit will remain lit.

Rapid Start

Rapid start ballasts have a separate set of windings which provide a low voltage (approx. 3.5 volts) to the electrodes for one second prior to lamp ignition. A starting voltage somewhat lower than that of instant start ballast (typically 450-550V for F32T8 lamps) is applied, striking an electrical arc inside the lamp. Most rapid start electronic ballasts continue to heat the electrode even after the lamp has started, which results in a power loss of 1.5 to 2 watts per lamp. Lamps operated by a rapid start electronic ballast will typically withstand 15-20K switch cycles. Rapid start ballasts are typically wired in *series*. This means that if one lamp fails, all other lamps in the circuit will extinguish.

Program Rapid Start

The Advance *Centium*® Program Rapid Start (PRS) electronic ballasts have been designed for use with occupancy switches by providing up to 30,000 lamp starts. PRS electronic ballasts precisely heat the lamp cathodes to 650°C with virtually no glow current before applying arc voltage to the lamp. Program rapid start ballasts are typically wired in *series*. However, The Advance *Centium*® PRS ballasts also feature series-parallel lamp operation for the 3 and 4 lamp units. This means that 1 or 2 lamps will continue to operate normally in the event of a single lamp failure.

Programmed Start

Programmed start (PS) electronic ballasts provide maximum lamp life in frequent starting conditions (up to 50,000 starts). PS ballasts like the Advance Smartmate, Mark 5™, Mark 7® 0-10V, Mark 10® *Powerline*, and ROVR use a custom integrated circuit (IC) which monitors lamp and ballast conditions to ensure optimal system lighting performance. Like Program rapid start ballasts, PS ballasts also precisely heat the lamp cathodes. However, PS ballasts heat the lamp cathodes to 700°C prior to lamp ignition. This puts the least amount of stress on the lamp electrodes, resulting in maximum lamp life regardless of the number of lamp starts. Programmed start ballasts are typically wired in *series*.

Ballast Factor

Light output ratings published by lamp manufacturers are based on powering the lamp with a "reference ballast" as specified by ANSI standards. The ballast factor of a particular ballast provides a measure of expected light output.

Advance Transformer offers electronic ballasts with several different ballast factors. This enables the lighting system designer to adjust the lighting level to meet the requirements of a particular application. The lighting system designer can trade watts for lumens by selecting the appropriate ballast.

$$\text{Ballast Factor} = \frac{\text{Lumen output of lamp operated by rated ballast}}{\text{Lumen output of lamp operated by "reference ballast"}}$$



Crest Factor

Fluorescent lamp manufacturers specify the ratio of peak current to R.M.S. current in the waveform driving the cathode in rapid start lamps (see figure A). When the electronic ballast provides current with a crest factor below the maximum specifications set by the lamp manufacturer, lamp life will not be increased. Ballasts that provide power to the lamp with high crest factors reduce the life of the lamp. Many Advance electronic ballasts have the lowest crest factors in the industry (as low as 1.4).

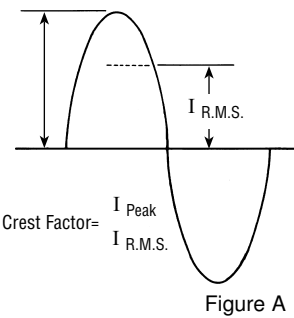


Figure A

POWERLINE INTERFACE

Voltage Regulation

Electric Utilities attempt to maintain constant line voltages; however, in some locations, wide swings may occur during peak power periods. Advance Standard, Centium, Mark 10[®] *Powerline* and Smartmate electronic ballasts operate at $\pm 10\%$ voltage variation. The Advance Mark 5[™] and Mark 7[®] *0-10V* electronic ballasts maintain light output of $\pm 1\%$ through input voltage changes of $\pm 10\%$, and operate over a wide voltage range.

EMI/RFI

Because they operate at high frequency, electronic ballasts may produce radio frequency interference (RFI) or electromagnetic interference (EMI). This interference could affect the operation of sensitive electrical equipment, such as radios, televisions or medical 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 (industrial/commercial) and a more strict one for Consumer (residential). Advance electronic ballasts meet the requirements of the Federal Communications Commission (FCC) for non-consumer applications.

IEEE and ANSI Requirements

Electronic components are sensitive to sudden surges of high voltage. These surges (or transients) may be caused by lightning strikes to nearby transformers, overhead lines or the ground. Transients may also be caused by switching of loads such as motors or compressors and by short circuits or utility system switching. Although these surges typically last for less than a second, they may cause electronic ballast failure unless the ballast is designed to protect against these surges. Advance electronic ballasts can withstand the conditions specified in ANSI/IEEE C62.41, Cat. A.

Power Factor

The power factor of a ballast is the measurement of how effectively it converts the voltage and current supplied by the power source into watts of usable power delivered to the lamp. Perfect power utilization would result in a power factor of unity. Advance electronic ballasts operate at very near unity (1.0 or 100%).

$$\text{Power Factor} = \frac{\text{Input Watts}}{\text{Line Volts} \times \text{Line Amps}}$$

ELECTRONIC BALLAST HARMONIC DISTORTION AND CURRENT

The exponential growth of electronic equipment and associated line harmonics over the last two decades have raised concerns about overheating transformers and neutral conductors in alternating current power systems. Most electric utilities now require that the Total Harmonic Distortion (THD) of electronic ballasts be below 20%. THD is the measurement of the magnitude of the input current harmonics compared with the amplitude of the fundamental frequency current (see figure B). However, electronic ballasts with THD ratings of 32%, as required by the American National Standards Institute (ANSI), present no problems to a power distribution system. All Advance electronic ballasts are rated for either less than 20% THD (*Standard series*) or less than 10% THD (*Centium series* and *Mark 5[™]*, *Mark 7[®] 0-10V* or *Mark 10[®] Powerline series*).

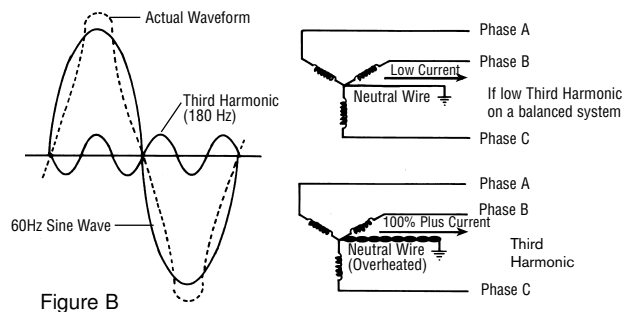


Figure B

Non-Dimming Applications

When selecting a ballast for a lighting application, the Total Harmonic Current (THC) rating of the ballast is more significant than Total Harmonic Distortion (THD). This is because the absolute value of harmonic current, not the percentage, affects the electrical power distribution system. As can be seen in the table on page 2-4, the THC rating of our *Standard* 2-lamp electronic T8 lamp ballast is well below that of both the conventional and energy-saving magnetic T12 lamp ballasts it replaces. Moreover, the THC rating of our *Centium* electronic ballast is even lower.

Dimming Applications

Mark 7[®] 0-10V

Traditional 0-10 Vdc controlled ballasts like the Mark 7[®] *0-10V* typically produce less than 10% THD at full light output and less than 20% THD throughout the entire dimming range, but require extra wires for the control circuit. THC is always lower than that of the conventional or energy-saving magnetic system.



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Mark 10® Powerline

Mark 10® Powerline electronic dimming ballasts are controlled by 2-wire modified powerline phase-cut style line voltage dimmers. Whenever the ballast is dimmed, the input voltage is cut or "chopped", causing the THD and THC to increase and the Power Factor to decrease.

Mark 10® Powerline electronic dimming systems (ballast and controller) have similar THD and Power Factor levels as the conventional lighting systems they replace. Since a much smaller load is required by the Mark 10® Powerline electronic dimming system to achieve the same illumination level as a magnetic ballast system (20-30% less), the total input current will be considerably less. As a result, the magnitude of the total harmonic current will be less.

For example, a typical Mark 10® Powerline electronic ballast and dimmer control might draw a line current of .058A at 15% THD at full light output. If the light level is reduced to 5% of the maximum, the input power is decreased to 0.19A at 95% THD. While the THD level may seem

alarmingly high at the 5% maximum light output setting, the total harmonic current is still lower (0.13A) than the conventional T12 magnetic system (0.20A). Moreover, the overall heating effect on the wires and the distribution transformer is never higher than the existing conventional or energy saving T12 magnetic systems.¹

Conclusions

Our analysis demonstrates that a simple ballast retrofit to electronic ballasts *will not* cause harmonic problems if none existed before the retrofit. Also, in new fixture applications, total harmonic distortion should not be a concern when specifying electronic ballasts. Finally, it is important to remember that electronic ballasts are not the greatest source of THD in an electrical distribution system. Other electronic devices such as computers, laser printers, and other electronic equipment can draw current with more than 100% THD in some cases.

Table 1: Comparison of THD and THC Levels

| Advance Part No. | Ballast Type | Light Output Setting | Lamp Type | Input Current | % THD | %THC ² |
|----------------------------|-------------------------------------|-------------------------------|------------|---------------|-------|-------------------|
| RQM-2S40-TP | Conventional Magnetic | 100% (Ballast Factor is 0.98) | (2) F40T12 | 0.84A | <25% | 0.20A |
| R2S40-TP | Energy Saving Magnetic | 100% (Ballast Factor is 0.95) | (2) F34T12 | 0.63A | <20% | 0.12A |
| REL-2P32-SC | Standard Electronic | 100% (Ballast Factor is 0.88) | (2) F32T8 | 0.49A | <20% | 0.10A |
| RCN-2P32-SC | Centium Electronic | 100% (Ballast Factor is 0.87) | (2) F32T8 | 0.49A | <10% | 0.05A |
| RZT-2S32 + Dimming Control | Mark 7® 0-10V Electronic | 100% (Ballast Factor is 0.88) | (2) F32T8 | 0.54A | <10% | 0.05A |
| RZT-2S32 + Dimming Control | Mark 7® 0-10V Electronic | 5% (Ballast Factor is 0.05) | (2) F32T8 | 0.12A | <20% | 0.02A |
| REZ-2S32 (Ballast Only) | Mark 10® Powerline Electronic | 100% (Ballast Factor is 1.0) | (2) F32T8 | 0.58A | <10% | 0.06A |
| REZ-2S32 + Dimming Control | Mark 10® Powerline Ballast + Dimmer | 100% (Ballast Factor is 1.0) | (2) F32T8 | 0.58A | <15% | 0.09A |
| REZ-2S32 + Dimming Control | Mark 10® Powerline Ballast + Dimmer | 5% (Ballast Factor is 0.05) | (2) F32T8 | 0.19A | <95% | 0.13A |

¹ For a more technical study demonstrating that a Mark 10® Powerline electronic dimming system produces less transformer heating over its entire dimming range than does an energy saving magnetic system that it replaces, see the article *THD in Advance Mark 10® Powerline Electronic Dimming Systems* by O.C. Morse. Copies may be obtained through the Advance Technical Support Dept. at tel. (800) 372-3331.

² The Total Harmonic Current (THC) of a ballast is calculated by the following equation:

$$\frac{\text{Ballast Input Current}}{\text{Square Root of } (1 + 1/\text{THD}^2)}$$

An approximation of THC may be obtained by simply multiplying the ballast input current by %THD.



ANSI Watts

The American National Standards Institute (ANSI) has a prescribed standard for the measurement of ballast characteristics (C82.2). This standard sets forth these requirements:

1. Ballast and lamps are in a room at $25^{\circ}\text{C} \pm 1/2^{\circ}\text{C}$ ($77^{\circ}\text{F} \pm 1^{\circ}\text{F}$).
2. Minimal draft across lamps (airflow of 1 ft./min. or less is optimum).
3. Lamps should be horizontally mounted, and should be separated by at least 9 inches to prevent mutual heating.
4. Lamps should be seasoned test lamps and operated on a reference ballast until stabilization (15 minutes) before switching to the ballast under test.
5. Measurements shall be taken within 30 seconds after switching in the ballast under test.

The watts obtained from this test method are listed as ANSI watts in the Advance Atlas, and will be the highest out of these 3 commonly-listed categories.

1. ANSI watts
2. Open fixture watts
3. Enclosed fixture watts

The maximum light output and wattage of a fluorescent lamp is obtained when the bulb wall temperature of the lamp is 100°F . When the bulb wall temperature is greater or less than that optimum, light output and wattage will decrease.

Heat generated by lamps and ballasts in an open fixture is usually sufficient to increase bulb wall temperature above 100°F , thereby decreasing light output and input watts by approximately 5%. Enclosing the fixture with a lens will result in higher temperatures, decreasing light output and wattage by approximately 10%.

Ballast Fusing

All Advance electronic ballasts are internally fused to protect the building electrical system against catastrophic failure of the ballast.

No PCB's

Advance electronic ballasts contain no PCB's or other hazardous materials.

Thermal Potting Compound

Some Advance electronic ballasts are filled with a specially formulated potting material designed to transfer heat away from critical components, eliminate thermal hot spots and provide resistance against rough handling.

Cool Operation

Electronic ballasts generate less waste heat than comparable magnetic ballasts. Typically, electronic ballasts will operate $20^{\circ}\text{--}30^{\circ}\text{C}$ cooler than its magnetic counterpart. Advance electronic ballasts are designed and warranted for optimal life at a case temperature of 70°C unless otherwise specified. Ballasts should not be operated in an environment when the case temperature will exceed 75°C . Cooler operation results in longer ballast life and reduced air-condition requirements.

Acoustic Noise

Advance electronic ballasts operate at sound levels lower than electromagnetic ballasts (up to 75% quieter).

Inrush Current

All ballasts have an initial current surge that is greater than its steady-state operating current. The electrical system should be designed with this issue in mind.

Compatibility With Powerline Carrier Systems

A powerline carrier system (PLC) uses electronic wiring devices to send information via a high frequency signal over the 120V or 277V electrical power distribution system of a building. For example, PLC systems are used in automatic clock systems (master time systems) to synchronize all of the clocks in a building or reset the time after a power outage. They eliminate the need for maintenance personnel to reset hundreds of clocks throughout a facility.

In a PLC system, a generator is used to impose a 1 to 4V high frequency signal on top of the existing voltage sine wave (60 Hz). This signal is generally in the 2500 to 9500Hz range, with some older systems operating at 19,500Hz or higher. Some electronic ballasts which are capacitive can absorb the signal from a PLC system. As a result, the signal becomes too weak to be "heard" by the receiver (like a timeclock) connected to the powerline.

Most Advance Standard (REL-/VEL-) ballasts are inductive and do not absorb the PLC signals that are sent through the powerline. However, other Advance brands may be incompatible with existing PLC systems. These include: Centium™ (RCN-/VCN-), Mark 5™ (RIC-/VIC-), Mark 7™ 0-10V (RZT-/VZT-), and Mark 10™ Powerline (REZ-/VEZ-). To find out which Advance electronic ballasts are compatible with PLC systems, contact our Technical Support department.

0°F Lamp Ignition with Electronic Instant Start Ballasts

Advance Transformer warrants that Advance Transformer electronic ballast will ignite Philips, GE, and OSRAM/Sylvania lamps at a temperature of 50°F . In addition, Advance Transformer has determined that Philips, GE, and OSRAM/Sylvania will ignite at 0°F satisfactorily given the following conditions:

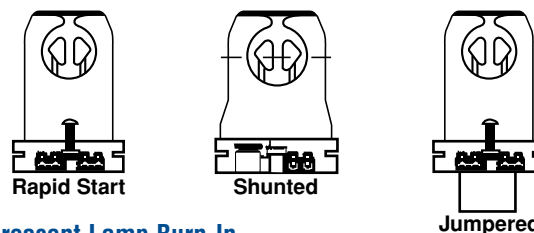
- The ballast is operated at the rated nominal line voltage
- Ballast-to-lamp distance does not exceed the standard lead lengths
- Ballast is not tandem wired

The Advance Mark 5™ series ballasts provide maximum lamp life in 0°F starting applications with their programmed-start design.

The lamp manufacturer should be consulted for lamp specifications and operating characteristics at temperatures below 50°F .

Instant Start vs Rapid Start Sockets

When retrofitting to Advance rapid start, program rapid start and programmed start electronic ballast into existing fixtures, sockets must be RAPID START. Many fixtures with T8 Instant Start electronic ballasts use a pre-jumpered, or "shunted" Instant Start socket. Instant Start sockets are designed to accept only one wire from the ballast, while the Mark 7 and Mark 10 Programmed Start ballasts require two distinctly separate wires for each lamp socket. If you encounter shunted or jumpered sockets in a retrofit application, they must be removed and replaced with Rapid Start sockets.



Fluorescent Lamp Burn-In

Today, most lamp manufacturers do not require the burn-in of linear fluorescent lamps prior to dimming in order to attain rated lamp life and stable electrical measurements. However, compact fluorescent lamp sources do require a 100 hour burn-in prior to dimming. Consult your lamp manufacturer for their latest requirements.



HIGH FREQUENCY ELECTRONIC BALLASTS

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ORDERING INFORMATION

How to Order

Advance Transformer has developed the industry's broadest distribution system for electronic ballasts. More than 3000 stocking distributors nationwide. For information on the distributor best able to serve your needs, please call 800-372-3331.

Electronic Ballast Part Number Breakdown

| I | CF | - | 2 | S | 26 | - | H1 | - | LD |
|--|----|---|---|---|----|---|----|---|----|
| <p>CFL Mounting/Connector Options BS = Bottom mounting studs with single entry color coded connectors LD = Length mounting feet with SmartMate™ dual entry color coded connectors LS = Length mounting feet with single entry color coded connectors QS = QuikStart</p> <p>Linear Fluorescent Mounting/Connector Options TP* = Thermal Protected 2LS = 2 Level Switching</p> | | | | | | | | | |
| <p>CFL Can Description H1 = Hybrid metal / plastic case, size 1 L2 = Linear M1 = Metal case, size 1 M2 = Metal case, size 2 M3 = Metal case, size 3 M4 = Metal case, size 4 M5 = Metal case, size 5 S1 = Square, style 1 S2 = Square, style 2 SC = Small can</p> <p>Linear Fluorescent Can Description 90C = 90°C maximum case temperature rating HL = High light output LW = Low watt MC = Micro can RH* = Reduced harmonics S = Slimline SC = Small can</p> | | | | | | | | | |
| <p>Lamp Watts (Primary lamp)</p> | | | | | | | | | |
| <p>Wiring Configuration D = 2D, series M = Modified parallel** P = Parallel Q = Quad CFL, series S = Series T = Triple CFL, series TTS = Long twin tube, series TTP = Long twin tube, parallel</p> | | | | | | | | | |
| <p>Maximum Number of Lamps</p> | | | | | | | | | |
| <p>Family Name CF = Compact Fluorescent CN = Centium DA = ROVR DA & DL = ROVR EL = Standard EZ = Mark 10® Powerline IC = Mark 5® MB = Matchbox OP = Optanium ZT = Mark 7® 0-10V</p> | | | | | | | | | |
| <p>Input Voltage G = 347V H = IntelliVolt-Hi (347V through 480V, 50/60 Hz) I = IntelliVolt™ (120V through 277V, 50/60 Hz) R = 120V V = 277V X = 220V</p> | | | | | | | | | |

Corporate Offices
(800) 322-2086

Press 1

To reach Customer Service

Press 2

If you know the last name and you will reach the spell by name directory

Press 0

Or stay on the line to be connected to the operator

You may dial the four digit extension of the person you want to reach at any time

Visit our web site at

www.advancetransformer.com

Customer Support/
Technical Service

(800) 372-3331

+1 (847) 390-5000 (International)

Dial the four digit extension of the person you want to reach

Press 1

For customer support

Press 2

For technical applications,
or warranty information

Press 4

To dial by name

- Plan your lighting installation carefully; consider using the services of a qualified lighting designer
- Consult your local electric utility regarding demand side management rebate programs.
- Select the Advance electronic ballast which best matches the requirements of your application. The technical specifications in this catalog (located on pages 8-14 to 8-30) will be useful in obtaining bids from electrical contractors.
- Contact your local Advance distributor. You will find them to be a helpful supplier of both products and information.

* Many current and all future electronic ballast part numbers will not use the "RH-TP" suffixes even though these ballasts will be thermally protected.

** Parallel Wiring Configuration. However, if one lamp fails, all other lamps in the circuit will extinguish.



HIGH FREQUENCY ELECTRONIC BALLASTS

T8

Rapid Start, Normal Light Output Series



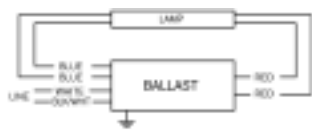
HIGH POWER FACTOR SOUND RATED A

Centium®

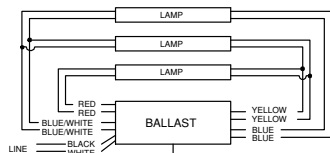
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CENTIUM®

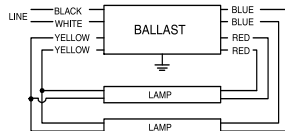
| Lamp Data | | Min. Starting Temp. (°F/°C) | Input Volts | Catalog Number | Certifications | | Line Current (Amps) | Input Power ANSI (Watts) | Ballast Factor | Max. THD % | Power Factor | Dim./ Wiring Diagram |
|---------------------------------|-------|-----------------------------|-------------|----------------|----------------|-----|---------------------|--------------------------|----------------|------------|--------------|----------------------|
| Number | Watts | | | | UL | CSA | | | | | | |
| F25T8, FB024T8 | | | | | | | | | | | | |
| 1 | 25 | 50/10 | 347 | GCN-1S32 | | ✓ | 0.09 | 31 | 0.97 | 20 | 0.98 | Fig. A/20 |
| 2 | 25 | 50/10 | 347 | GCN-2S32 | | ✓ | 0.16 | 57 | 1.00 | 20 | 0.98 | Fig. A/21 |
| 3 | 25 | 50/10 | 347 | GCN-3S32 | | ✓ | 0.25 | 82 | 1.02 | 20 | 0.97 | Fig. A/30 |
| F32T8, FB031T8, F32T8/U6 | | | | | | | | | | | | |
| 1 | 32 | 50/10 | 347 | GCN-1S32 | | ✓ | 0.10 | 34 | 0.87 | 10 | 0.98 | Fig. A/20 |
| 2 | 32 | 50/10 | 347 | GCN-2S32 | | ✓ | 0.18 | 63 | 0.90 | 10 | 0.99 | Fig. A/21 |
| 3 | 32 | 50/10 | 347 | GCN-3S32 | | ✓ | 0.28 | 94 | 0.92 | 10 | 0.98 | Fig. A/30 |



Diag. 20



Diag. 30



Diag. 21

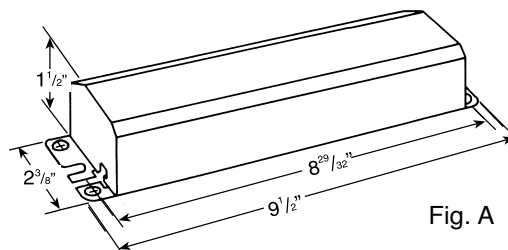


Fig. A

Refer to pages 8-32 to 8-41 for lead lengths and shipping data

