American National Standard

Approved: February 14, 2005 Secretariat: ANSLG – National Electrical Manufacturers Association

for lamp ballasts—

Ballasts for High-Intensity Discharge Lamps – Methods of Measurement

American National Standard

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Printed and distributed by:

Information Handling Services/Global Engineering Documents
15 Inverness Way East, Englewood, CO 80112-5776
Under Contract with National Electrical Manufacturers Association

FOREWORD (This Foreword is not part of American National Standard C82.6-2005)

Suggestions for improvement of this standard will be welcome. They should be sent to Secretariat C82 Committee, American National Standard Lighting Group, 1300 North 17th Street, Suite 1847, Rosslyn, VA 22209.

This standard was processed and approved for submittal to ANSI by the Accredited Standards Committee on Lamp Ballasts, C82, and its Working Group C82 WG 01. Approval of the standard does not necessarily imply that all working group members voted for its approval.

This standard is a revision of ANSI C82.6-1985 and supercedes the aforementioned standard and all supplements. Information concerning the approval of this standard is based on the documents listed in the table below:

	CDV	RV
Revision	CDV C82_m690	RV C82_m691

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FIGURES

AMERICAN NATIONAL STANDARD

for lamp ballasts—

Ballasts for High-Intensity Discharge Lamps – Methods of Measurement

1.0 SCOPE

This standard describes the procedures to be followed and the precautions to be taken in measuring performance of ballasts for high-intensity discharge (HID) lamps. Deviations from the procedures given in this standard are permissible for production or other testing provided that the methods used give the results in substantial agreement with the method given herein. In case of doubt, reference shall be made to the specified methods to establish the validity of the results obtained by any alternate procedure.

2.0 NORMATIVE REFERENCES

The following standards contain provisions, which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI C78.40-1992*, Mercury Lamps—Specifications*

ANSI C78.42--2004, *High Pressure Sodium Lamps*

ANSI C78.43--2004 *Single-Ended Metal-Halide Lamps*

ANSI C78.389-2004, *High-Intensity Discharge— Methods of Measuring Characteristics*

ANSI C82.4-2002*, Ballasts for High-Intensity Discharge and Low Pressure Sodium Lamps (Multiple Supply Type)*

ANSI C82.5-1990 , *Reference Ballasts for High-Intensity Discharge Lamps*

ANSI C82.7-1983, *Mercury Lamp Transformers—Constant Current (Series) Supply Type*

ANSI C82.9-1996*, Definitions for High-Intensity Discharge and Low Pressure Sodium Lamps, Ballasts, and Transformers*

ANSI C84.1-1995*, for Electric Power System and Equipment, Voltage Ratings (60 Hz.)*

ANSI C92.1-1982, *Power Systems—Insulation Coordination.*

ANSI/IEEE 100-1984, *Dictionary of Electrical and Electronic Terms.*

ANSI/UL 1029- 2001, *High-Intensity Discharge Lamp Ballasts*

3.0 DEFINITIONS

Definitions of terms that apply specifically to the subject treated in this standard are given in ANSI C82.9 and C92.1. For additional definitions, see ANSI/IEEE 100.

(1) Stiff Line: A stiff line is defined as a sine wave source that exhibits voltage regulation (change of rms voltage from no load to full load divided by rms voltage at full load) of no more than 0.5%.

4.0 GENERAL CONDITIONS FOR ELECTRICAL PERFORMANCE TESTS

4.1 Power supply. Except for the testing of ballasts designed for use on constant-current supply circuits, the AC voltage supply at the input terminals to the ballast-and-lamp combination shall, throughout the full range of test requirements, have a wave shape such that the rms (root-mean-square) summation of the harmonic components will not exceed 3% of the fundamental component. The impedance of the power source, as measured at the point where the ballast-and-lamp combination is connected, shall not exceed 3% of the ballast impedance. Variable autotransformers or other voltage transformation devices used in the circuits shall have a power rating at least five times the wattage of the lamp intended to be operated on the ballast under test.

4.2 Ballast Conditions. For normal operational tests, the ambient temperature and the temperature of the ballast under test shall be $25^{o}C \pm 5^{o}C$.

4.3 Lamp Position. The lamp position, both for the measurement in the reference-ballast circuit and for the measurement of the commercial ballast being tested, shall be vertical base up unless otherwise designated by the lamp or commercial ballast manufacturer. The characteristics of lamps operating on reference ballasts have been established for vertical and or horizontal operation, the lamp positions most commonly used in ballast measurement work. When a lamp is operated in other than a vertical position the measurement becomes more complicated, and the method outlined in ANSI C78.389 should be followed carefully.

4.4 Lamp Stabilization.

4.4.1. Lamp pre condition:

The lamps used for ballast measurements shall, unless otherwise specified, have been seasoned a minimum of 100 hours prior to their use in the ballast tests.

4.4.2. Basic stabilization method:

Before any measurements are taken, the lamp shall be operated within $\pm$ 3% of rated wattage in an ambient temperature of $25^oC \pm 5^oC$ until the electrical parameters of the lamp cease to change. The lamp burning time required to achieve this lamp stabilization is a minimum of 30 minutes. It could be as much as 6 hours or more for a metal-halide lamp if the lamp is moved while it is still hot or if its orientation is changed. After the stabilization process has begun, the lamp shall not be moved or repositioned until after the testing is complete. In order to avoid heating up the test ballast during lamp stabilization, causing resistance changes and therefore resulting in unrepeatable data, it is necessary to warm up the lamp on a standby ballast. This standby ballast should be a commercial ballast of a type similar to the test ballast in order to be able to switch a stabilized lamp to the test ballast without extinguishing the lamp. A fast-acting switch is recommended; however, a make-before-break switch may be required on a high-pressure-sodium lamp to prevent it from extinguishing during switchover. Once the lamp has been transferred to the test ballast circuit, re-stabilization time is important and is typically 1 minute for mercury and high-pressure-sodium lamps and 3 minutes for metal-halide lamps. To avoid test ballast heat-up, measurements should be taken within 5 minutes after re-stabilization.

If a HPS lamp ballast is under test the lamp wattage with a standby ballast should be adjusted to +/- 2% of the nominal lamp wattage, (see ANSI C78.42) if the ballast does not have a fixed power output design.

(Informative Note: The effect of heat on ballast operation is under consideration by the ad hoc group.)

4.4.3. Alternative Stabilization method:

Because in some cases, such as low frequency electronic ballasts, the transfer from the reference ballast to the ballast under test is undefined, the following alternative method should be followed to ensure testing result reproducibility:

4.4.3.1. The lamp characteristics should be determined with a reference ballast and recorded for future comparison.

4.4.3.2. The same lamp will be driven by the ballast under test for 15 minutes.

4.4.3.3. The electrical measurements should be taken within 2 minutes after the 15-minute stabilization period.

4.5 Instrumentation

CAUTION: Certain instruments connected in parallel with the lamp may be damaged or destroyed when subjected to the starting pulse of ballasts that supply such pulses (such as those for high-pressure sodium and metal-halide pulse-start lamps). It is recommended that such instruments be connected after the lamp is started and that some arrangement be provided to remove the lamp ignitor from the circuit or otherwise prevent the ignitor from unexpectedly operating.
(Note: digital instruments, that meet the requirements described in this standard, are preferred to analog instruments).

4.5.1 Accuracy. It is desirable that instruments be chosen so that the indications to be read will be in the upper third of the range. Instruments should be selected which have a guaranteed accuracy commensurate with the requirements of the test and shall not have an accuracy less than the following:

4.5.1.1 Analog Instruments:

Ammeters and voltmeters: ± 0.5% up to 800 Hertz

Wattmeters: ± ¾ % up to 1000 Hertz for power factors of 50% to 100%; ± 0.5% up to 125 hertz for low-power-factor (0% to 20%) circuits.

4.5.1.2 Digital Instruments: Accuracy (X percentage of the reading + Y percentage of the scale per instrument manufacturer specification.)

DIGITAL INSTRUMENTATION REQUIREMENTS				
	Equipment	**Digits Resolution**	**Basic Accuracy**	**a.c+d.c. True RMS 2kHz.**
	Voltmeter	3½	0.50%	✓ yes
	Ammeter	3½	0.50%	✓ yes
	Wattmeter	3½	0.50%	✓ yes

4.5.2 Impedance Limitations. It is necessary that the potential circuit impedance is high and the current impedance is low to reduce the disturbance of the circuit caused by the presence of the instruments. Instruments connected in parallel with the lamp shall not draw more than 1% of the rated lamp current. Instruments connected in series with the lamp shall have an impedance such that the voltage drop does not exceed 0.5% of rated lamp voltage. Potential circuit amplifiers having high input impedance and an accurately controlled gain may be used to measure ballast and lamp characteristics. The output of such amplifiers must faithfully reproduce the input voltage with respect to rms value (or a multiple thereof), wave shape, and phase relation. When measuring the rms and peak open-circuit voltage of a ballast, the total impedance across the ballast, including the potential measuring instruments used, shall be 5 kΩ per volt or greater. (This does not apply to the pulse height of ballasts that supply ignition pulses.)

4.5.3 Connection of analog instruments in the Circuit. In general, only one instrument at a time shall be connected in the ballast output (lamp) circuit. The one exception to this is the case of reference-ballast measurements, in which it is sometimes desirable to include the ammeter and wattmeter current coils as part of the measured impedance of the reference ballast. When this is done, it is necessary that these coils be left in the circuit at all times.

4.5.4 Root-Mean-Square (rms) Measurements. The voltage across a high-intensity-discharge lamp has a distorted wave shape, which departs considerably from a true sine wave. The lamp current generated by ballast-lamp interaction also deviates from a true sine wave. Therefore, the instruments used in lamp circuits for rms measurements shall be of a type whose response indicates true rms values only and shall have the frequency response as specified in 4.5.1.

4.5.5 Peak Measurements Instruments used for measurements of peak voltage or peak current should be of a type whose deflection, or other indication, is dependent upon true peak values.

The starting pulse of a high-pressure sodium or pulse start metal halide lamp ballast can be considered a voltage pulse because of its sudden rise and fall. Oscilloscopes used for this measurement should have a band pass of 100 megahertz or greater. A peak-reading voltmeter having a band pass of 100 megahertz or greater may be used in place of the oscilloscope.

4.5.6 Current THD Measurement. Instruments used for measurements of current THD should be able to measure the rms values of all individual harmonics up to 33rd order. The total harmonic distortion (THD) is calculated by the following formulas:

$$THD(rms) = \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + \dots}}{I_{rms}} = \frac{THD(fund.)}{\sqrt{1 + THD(fund.)^2}}$$ or

$$THD(fund.) = \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + \dots}}{I_i} = \frac{THD(rms)}{\sqrt{1 + THD(rms)^2}}$$

4.5.7 Oscilloscope requirements:

4.5.7.1: Bandwidth: 100 MHz minimum when used to measure pulses, otherwise 35 MHz minimum required.

4.5.7.2: Sampling rate: 100 Mega samples per second when using a digital scope to measure pulses.

4.5.7.3: Probe: When measuring ignitor pulses, in addition to the 20pf load for the ignitor pulse, the probe input must have an impedance greater than 10Kohm at 1 megahertz.

4.5.8 Equipment to measure starting and sustaining parameters:

(1) "Stiff" line.

(2) Oscilloscope with measurement functions, a storage capability, and a printer or a digital interface.

(3) One 1.0 ohm ± 2% non-inductive resistor and one 5.0 ohm ± 2% low temperature-coefficient resistor capable of carrying appropriate short-circuit current.

5.0 REFERENCE-BALLAST CIRCUITS

5.1 Reference-Ballast Characteristics. The general characteristics of reference ballasts are described in ANSI C82.5. The specific values of impedance, reference current, and rated supply voltage for the reference ballast corresponding to each type and size of high-intensity-discharge lamp are given in the respective lamp standards, ANSI C78.40 , ANSI C78.42, and ANSI C78.43.

5.2 Adjustment and Test. The adjustment and test of the reference ballast should be performed in accordance with the procedure described in ANSI C82.5. As is pointed out in ANSI C82.5, the reference ballast may be set up either with or without the impedance of the wattmeter coil and ammeter included in the measured ballast characteristics. Either method is fully satisfactory, but it is important that instrument correction be determined for the particular method being used. If the ammeter and wattmeter current coils are included in the ballast impedance, then these instrument coils must be left in the circuit at all times (see Figure 1).

5.3 Ballast and Instrument Connections. When a reference ballast is used for the operation of a lamp, the ballast and the instruments should be connected as shown in ANSI C82.5.

6.0 BALLAST MEASUREMENTS (MULTIPLE-SUPPLY-TYPE BALLASTS)

6.1 Input Circuit Measurements

6.1.1 Starting Conditions. The following measurements are pertinent:

(1) rms voltage
(2) rms current

6.1.2 Operating Conditions. The following measurements are pertinent:

(1) rms voltage
(2) rms current
(3) Power
(4) Input current THD
(5) Input power factor.
(6) Input voltage THD.

6.2 Output (Lamp) Circuit Measurements

6.2.1 Starting Conditions. The following measurements are pertinent:

(1) rms open-circuit voltage
(2) Peak open-circuit voltage
(3) Starting pulse parameters for high-pressure-sodium lamps and pulse start Metal Halide lamps
(4) Starting lamp current.
(5) Lamp current crest factor for metal-halide and high-pressure-sodium lamps.

6.2.2 Operating Conditions. The following measurements are pertinent:

(1) rms lamp voltage
(2) rms lamp current
(3) Lamp current crest factor
(4) Lamp power
(5) Power Losses.
(6) Ballast Factor

6.2.3 Resistive Load:

A. Sustaining voltage for a MH Lamp
B. Current slope for a MH LAMP
C. Max Peak current for a MH Lamp
D. Current OFF time for a MH and HPS lamp

6.3 Circuit Connections. For the measurement of the ballast operating characteristics, the ballast and electrical instruments are connected as shown in Figure 2. This diagram also includes the additional reference-ballast circuit from which the lamp is transferred to the test ballast circuit. It is necessary that the transfer switch be fast acting so that the lamp will be transferred from the reference ballast circuit (or standby ballast circuit in the case of high-pressure sodium lamps) without being extinguished. If the transfer switch is a make-before-break switch, it is essential to maintain the same polarity in the two ballast circuits that are being connected together.

A) Mercury Lamps. Mercury lamps can be transferred from the reference ballast to the test ballast as mentioned in the preceding paragraph.

B) Metal Halide Lamps. Metal-halide lamps also can be transferred from a reference ballast to a test ballast, but the transfer switch must be a make-before-break switch.

C) High-Pressure-Sodium Lamps. High-pressure-sodium lamps are very difficult to transfer from a reference ballast to any other kind. A more convenient procedure is to take the readings on a reference ballast first, turn the lamp off, and then restart it in a circuit employing a standby ballast of the same type as the ballast being tested. The lamp can then be transferred from the standby ballast to the test ballast without extinguishing. A make-before-break switch must be used.

6.3.1 Circuit and Equipment Grounding.

6.3.1.1 In order to minimize the possibility of shock hazard, it is essential that careful attention be paid to the proper grounding of the electrical circuit and also of certain instruments that may be used. It is especially important to make sure that oscilloscopes or other electronic instruments having exposed metal cases or terminals have the *exposed metal parts connected to ground.*

6.3.1.2 In the circuit given in clause 6.3.1.2 and Figure 2, the power supply is shown as a two-wire system connected to the test circuit through an isolation transformer. The power supply used may or may not have one of the phase conductors at ground potential; either type of supply can be used satisfactorily, since the isolating transformer separates the measurement circuit from the power source. The instrument side of the measurement circuit may be grounded, or if all the instrument terminals are adequately insulated, it may be left "floating" (that is, neither side connected to ground).

6.3.1.3 Oscilloscopes and peak-reading voltmeters usually have to have one of the input terminals at ground potential. The use of the isolating transformer described in Figure 1 allows one to connect any part of the test circuit to ground.

6.3.1.4 To eliminate the possibility of ground loops it is essential that a *single* ground connection be used to ground the exposed metal case of the instrument, the instrument input terminal ground, and the measurement circuit.

6.3.1.5 Wherever the circuit permits, the screw shell of the lamp holder shall be connected to the grounded side of the measurement circuit.

6.4 Measurement of Starting and Sustaining Parameters of Peak Lead High-Intensity-Discharge Lamp Ballasts.

6.4.1 Current Slope and Off-Time Measurements. Connect a 5.0 ohm ± 2% resistive dummy load across the ballast output. Take a hardcopy or a digital image of the wave shape appearing on the oscilloscope connected across the resistor with the test ballast operating at 90% supply voltage. The oscilloscope should be in the dc input mode, and the sensitivity should be such that the scope trace through zero approaches a straight line. This may require clipping of the signal in order to boost vertical gain. The slope of the current as it goes through zero is the ratio of an increase current to an increase time taken at the time the current passes through zero at the end of a half cycle. The time window is defined in the appropriate ANSI lamp standards.

"Off-time"(See Figure 3) is that period of time of low current level at the end of the current half cycle prior to transition to the next half cycle. This period is defined as the interval from the point of intersection of the tangent to the descending current trace and the tangent to the low current trace to the end of the half cycle. See Figure 3. The acceptable limits are specified in the appropriate lamp standards. For HPS lamps the off time is specified at short circuit and at the nominal lamp operating current. To evaluate at nominal current, a resistor should be used that brings the current within 5% of the nominal.

6.4.2 Current Overshoot Measurement. Connect a 1.0 ohm ± 2% resistive dummy load across the test ballast output with 110% supply voltage. Take a hardcopy or a digital image of the wave shape appearing on the oscilloscope connected across the resistor. The current overshoot is that portion of the current waveform that extends across the zero axis before the end of the half cycle. Take the average value of the overshoot of both half cycles. See Figure 4. The acceptable limits are specified in the appropriate lamp standards. If the overshoot does not cross the zero axis, then the value should be noted as a negative value, measured from the zero axis.

6.4.3 Sustaining Voltage Measurements. Sustaining voltage measurements should be taken with a 5.0 ohm ± 2% resistor to simulate the lamp load and operated at 90% of the line voltage. This permits repeatable measurements to be made, since lamp variability is removed.

A typical procedure is to use an oscilloscope having dual trace capability with a differential amplifier and a single-ended input amplifier with the vertical mode de-coupled. Connections to the ballast are made as shown in the wiring diagram, Figure 5. The scope trigger source is synchronized to the AC line and no adjustments should be made between measurements. The phase relations between the open-circuit voltage, capacitor voltage, and current waveform must be maintained. (Using the chopped synchronized position quite often facilitates synchronization.) Store the open-circuit voltage waveform in the scope memory. The 5-ohm resistor is placed on the secondary, and the capacitor voltage and current waveform (resistor voltage) are acquired. Sustaining voltage is measured at the point where the current waveform goes through zero. See Figure 6.

$$V_{ss} \approx \left[Vc - OCV\right]_{i=0}$$

6.4.4 Peak Current

Connect a 1 ohm ± 2% resistive dummy load across the ballast output. Take a hardcopy or a digital image of the wave shape appearing on the oscilloscope connected across the resistor with the test ballast operating at 110% line voltage. The oscilloscope should be in the dc input mode. Register the highest peak.

6.5 Measurement of Starting Pulse Parameters

6.5.1 Measurement of the starting pulse of a ballast is difficult to duplicate unless the following practices are closely followed:

(1) An oscilloscope is necessary to measure pulse parameters, with special care taken when an isolating transformer is used between line and ballast. See 6.3.1.

(2) A 0.5-microfarad capacitor of extended foil construction having good high-frequency characteristics and suitable voltage rating should be connected across the output of the main power isolation transformer to bypass high frequencies.

(3) A 20-picofarad capacitor shall be connected across the ballast output leads to simulate the lamp load (this capacitance should consider the high voltage probe capacitance). The capacitance of the conductor between the simulated lamp load and the ballast/starter combination shall be adjusted to equal the ballast/starter capacitive load rating specified by the ballast manufacturer. The capacitor(s) used for this test shall have good high-frequency characteristics and suitable voltage ratings.

(4) The core, power capacitors, starter, and enclosure (if used) should be grounded.

(5) The vertical scale of the oscilloscope should be calibrated before measurements are taken.

(6) When using a 1000:1 probe, the square wave response should be adjusted at the time base used during the test (0.5 or 1 μsec/div).

6.5.2 Pulse height, width, repetition rate and position, are specified in the appropriate lamp standards.

6.6 Lamp Operating Limits. A lamp of the appropriate type is first placed in the reference-ballast circuit and, with rated voltage applied to the ballast circuit, the lamp voltage, current, and wattage are read. The values obtained shall fall within the range permitted for a reference lamp in the appropriate lamp standards.

In the case of mercury and metal-halide lamps, the lamp is next transferred to the test ballast circuit without letting the lamp extinguish. High-pressure-sodium lamps usually have to be turned off, transferred to a standby ballast circuit, and then restarted. After further warm-up they can be transferred to the test ballast circuit without extinguishing.

6.6 Regulation

6.7.1 For mercury and metal-halide lamp regulation measurements, use a stabilized reference lamp as defined in ANSI C82.9. These lamps are voltage stable and require only that the normal testing procedures herein described be followed for repeatable and accurate results.

To determine regulation, readings of lamp wattage are taken at one value of supply voltage above rated voltage and one value of supply voltage below rated voltage as specified in the requirements given in ANSI C82.4.

6.7.2 High-pressure-sodium lamps are not voltage stable; thus, the lamp influences the regulation measurement. To include the effect of lamp voltage rise, a low-voltage lamp can be used and a voltage increase forced by placing an aluminum foil sleeve down over the high-pressure-sodium lamp or by directing a variac controlled infrared (IR) lamp on the arc tube end (on the cold spot). A lamp operating volt-watt trace shall be recorded for both low- and high-supply voltage settings, using the sleeve or IR method to cause the trace to be generated until the lamp drops out. The low and high wattage traces shall not fall outside of the lamp trapezoid as specified in the appropriate lamp standards.

6.8 Extinction Voltage Test

6.8.1 Preferred Method. The extinction voltage is one measure of the ability of a ballast to operate a lamp in a stable manner. The extinction voltage of a ballast can be measured as follows:

(1) Connect the ballast under test to a reference lamp mounted in the desired position, with a voltmeter connected to measure the supply voltage.

(2) Apply rated voltage to the ballast and allow the lamp to warm up for at least 15 minutes.

(3) Reduce the supply voltage to the ballast at a continuous rate of 2%-3% per second until the lamp extinguishes. The supply voltage at this point is the extinction voltage.

6.8.2 Alternate Method (No Reference Lamp Available). The alternate method of measuring the extinction voltage of a ballast is as follows:

(1) Use a sampling of at least five, preferably ten, lamps.

(2) Determine the operating voltage of each lamp when operated from the appropriate reference ballast.
(3) For each lamp apply rated voltage to the ballast and allow the lamp to warm up for at least 15 minutes.
(4) Reduce the supply voltage to the ballast at a continuous rate of 2%-3% per second until the lamp extinguishes.
(5) Plot the extinction voltage (4) versus the lamp operating voltage (2). The nominal extinction voltage will be the value at which the line thus plotted crosses the center rated voltage for the lamp type being tested.

6.9 Lamp Current Crest Factor.

Limits of current crest factor are found in the appropriate lamp standards.
The determination of current crest factor requires the measurement of both the peak current and the rms current.

The crest factor is then calculated as the ratio of the peak to the rms value. Maximum current can be measured with a peak reading analog or digital ammeter, or an oscilloscope with shunt or current coil.

RMS current may be read with an analog or digital meter or an oscilloscope with shunt or current coil.

The meters must be consistent with 4.5.1 and 4.5.2 for accuracy and impedance. When using different meters for the peak and rms current, it is recommended to check the calibration with a sine wave current source of relevant value (see Figure 7).

6.10 Ballast Power Loss. The power loss should be determined by the wattmeter (power analyzer) difference method, in which the output power is subtracted from the input power. If the instruments are connected as shown in Figure 2, either the voltmeter should be disconnected when the reading of input wattage is taken or a correction should be made to compensate for the power consumed by the voltmeter. It should also be noted that with the connections shown in Figure 2 the wattmeter reading will include the power consumed by the wattmeter potential coil. This power in the potential coil, therefore, must be calculated and subtracted to obtain the actual input power. To minimize deviations in power loss calculations, it is recommended that where feasible the same wattmeter and the same potential and current ranges be used to measure both input and lamp watts. Note that in determining ballast losses it must be kept in mind that, when one accurate number is subtracted from a nearly equal accurate number, the percent error of difference may be very great. The deviation in watts loss figures may be as high as ± 10%-15% when wattmeters with a stated accuracy of ± 0.5% are employed.

6.11 Input Power Factor. The power factor is determined by dividing input watts by input volt-amperes. In the case of high-power-factor ballasts, the input power factor may be very close to unity. Unless the voltmeter, ammeter, and wattmeter readings are very accurate and the power supply sinusoidal, the calculated power factor may show values in excess of unity.

Input power factor can also be determined with a digital power analyzer.

6.12 Ballast Factor. The ballast factor is determined by dividing the lamp power obtained when the lamp is driven by the commercial ballast by the lamp power when the lamp is driven by the reference ballast (see 6.10).

7.0 MERCURY LAMP CONSTANT CURRENT SERIES SUPPLY TYPE TRANSFORMER MEASUREMENTS

7.1 Input Circuit Measurements

7.1.1 Starting Conditions. With the secondary open circuited, the following measurements are pertinent:

(1) rms voltage
(2) rms current

7.1.2 Operating Conditions. The following measurements are pertinent:

(1) rms voltage
(2) rms current
(3) Power (true power – Watts, and apparent power – VA)
(4) Input current THD

7.2 Output (Lamp) Circuit Measurements

7.2.1 Starting Conditions. The following measurements are pertinent:

(1) rms open circuit voltage
(2) Peak open circuit voltage
(3) Lamp starting current

CAUTION: Output voltage peaks as high as 4000 volts may occur across the ballast output terminals during lamp starting.

7.2.2 Operating Conditions. The following measurements are pertinent:

(1) rms lamp voltage
(2) rms lamp current
(3) Lamp current crest factor
(4) Lamp power (True power – Watts)

7.3 Power Supply. The power source shall be a constant current transformer of the moving coil type, rated 10 kilowatts or more, and adjusted to provide rated primary current to the transformer under test. The current wave shape of the constant current supply shall have the rms summation of the harmonic component less than 3% of the fundamental component.

7.4 Transformer Input Connections. For the measurement of the transformer operating characteristics, the transformer and the electrical instruments are connected as shown in Figure 8. The transfer switch must be a fast acting make-before-break type to insure the lamp is transferred from the reference ballast circuit to the transformer test circuit without extinguishing. See 5.4.

7.5 Lamp Operating Limits. A lamp of the appropriate type is first placed in the reference ballast circuit and then, with rated current applied to the series ballast circuit, the lamp voltage, current and wattage are measured. The obtained values must fall within the range permitted for a reference lamp. See the appropriate lamp standards.

7.6 Lamp Current Crest Factor. See 6.9.

7.7 Ballast Power Loss. The power loss may be determined by the wattmeter difference method. See 6.10.

8.0 LEAKAGE CURRENT MEASUREMENT

8.1 General. The purpose of this test is to provide a measurement of the leakage current of high-intensity-discharge lamp ballasts and associated circuitry normally rated for distribution circuits of 600 volts or less. Leakage current refers to all the currents, including resistive and capacitive currents that may flow from accessible parts to an earth ground.

8.2 This method is described in ANSI/UL 1029.

9.0 TEMPERATURE RISE TEST (BENCH TEST)

This method is described in ANSI/UL 1029.

10.0 DIELECTRIC TESTS

10.1 General. Dielectric tests, as required, shall be performed while the ballast is hot from the thermal performance tests.

10.2 Applied Potential Test (Hi Pot).

This method is described in ANSI/UL 1029.

10.3 Transient Insulation Level (TIL) Test. The output of a impulse generator, IG, providing a standard full impulse voltage wave as defined in ANSI C92.1, shall be impressed on the ballast under test as indicated in 10.3.1 through 10.3.7 and Figures 9 through 13, as applicable. The polarity of the standard full impulse wave may either be positive or negative.

10.3.1 Reactor Ballasts – Normal Power Factor. Test between the input terminal of the ballast and the lamp terminal with the lamp terminal and core grounded as indicated in Figure 9.

NOTE: Unless one terminal or one lead of the reactor ballast is labeled "line", the test should also be made with the two connections from the reactor reversed.

10.3.2 Reactor Ballasts – High Power Factor. Test the ballast in the manner described in 10.3.1, except with the capacitor(s) disconnected. Test capacitor(s) separately as indicated in 10.3.6. (See fig 12)

10.3.3 Autotransformer Ballasts – Normal Power Factor (Lag). The following tests shall apply:

(1) Test between highest potential input terminal and the common terminal with common terminal and core grounded as indicated in Figure 10a.
(2) Same as (1) above except with the grounded lead from the impulse generator connected to the lowest potential input terminal as indicated in Figure 10b.

EXCEPTION: For ballasts designed for operation from a grounded supply and where one terminal or lead is specifically labeled as the grounded terminal, the condition specified in (2) is not applicable.

10.3.4 Autotransformer Ballasts – High Power Factor (Lag). The following tests shall apply:

(1) Where the power factor correction capacitor(s) is connected across the input terminals, test ballast in the manner described in 10.3.3, except with the capacitor(s) disconnected. Test capacitor(s) separately as indicated in 10.3.6.
(2) Requirements for ballasts utilizing power factor correction capacitors connected across an extended portion of the autotransformer primary are not yet established.

10.3.5 Autotransformer Ballasts – Lead Type. The following tests shall apply:

(1) Test between the highest potential input terminal and common terminal with the common terminal, core, and capacitor case(s) grounded. Capacitor(s) should be connected in their normal circuit position. See Figure 11a.
(2) Same as (1) above, except with the grounded lead from the impulse generator connected to the lowest potential input terminal as indicated in Figure 11b.

EXCEPTION: For ballasts designed for operation from a grounded supply and where one terminal or lead is specifically labeled as the grounded terminal, the condition specified in (2) is not applicable.

10.3.6 Capacitors Used Across Input Terminals of the Ballast. Test between the shorted input terminals and the case with the case grounded, as indicated in Figure 12.

10.3.7 Insulated Winding Ballasts. Connect the capacitors in their normal operating position in the circuit.

(1) Test between the input terminals with one input terminal, core, capacitor case, and output winding grounded as indicated in Figure 13a and 13b.
(2) Same as 1 above, except with the grounded lead from the impulse generator connected to the other input terminal as indicated in Figure 13c and 13d.
(3) For ballasts with series-parallel primaries, the TIL requirement shall be met for both modes of connection.
(4) For ballasts with tapped primary winding, the TIL requirements shall be met when the impulse wave is impressed between any primary input terminal and the common terminal, with one terminal, core, capacitor case, and output lead grounded.
(5) Same as 4 above, except with the grounded lead of the impulse generator connected to the other terminal.

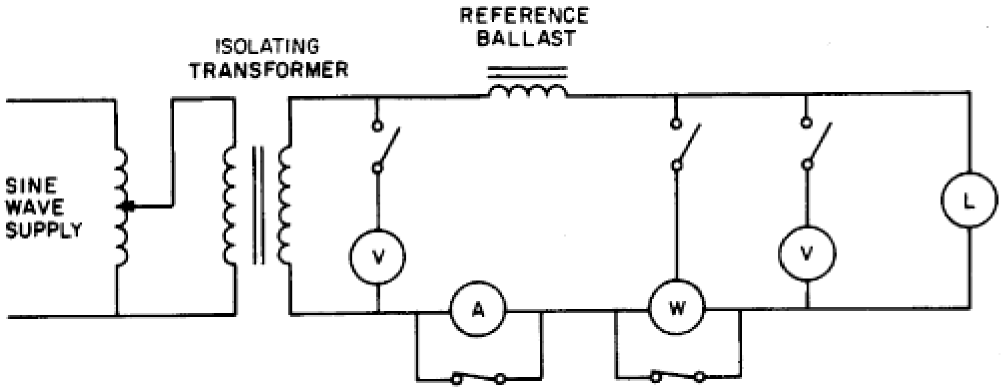


Figure 1
Reference Ballast Circuit for HID Lamps

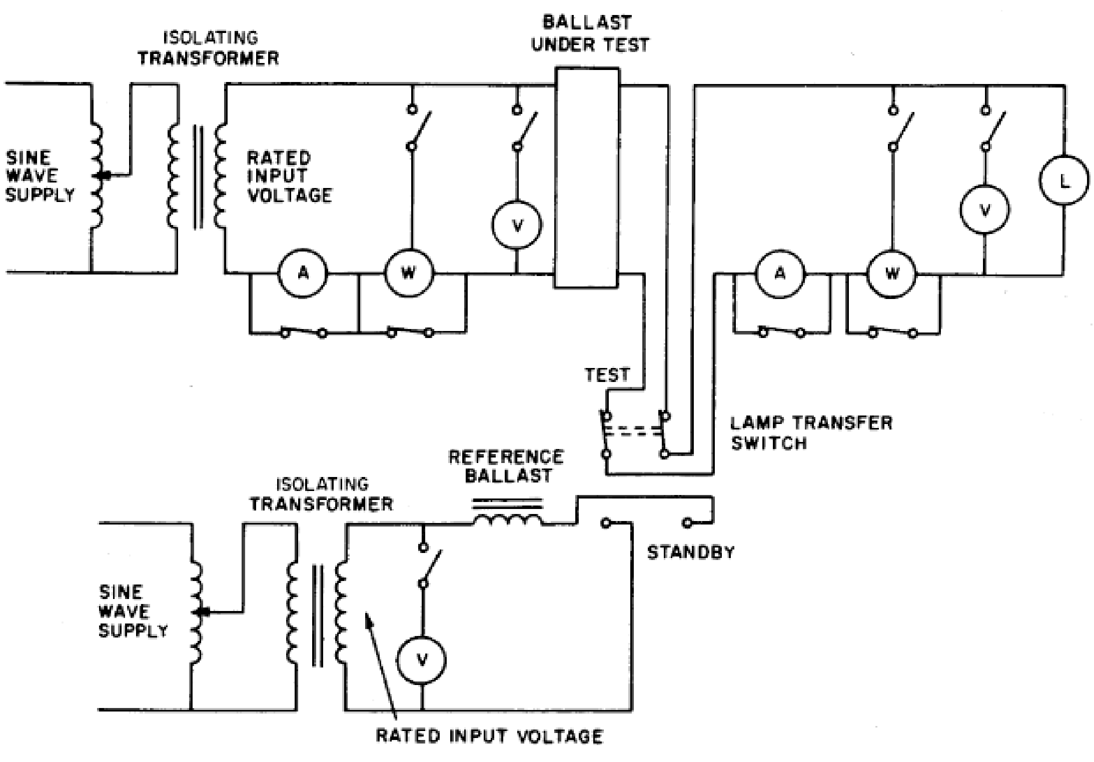


Figure 2
Multiple-circuit Ballast Test Connections

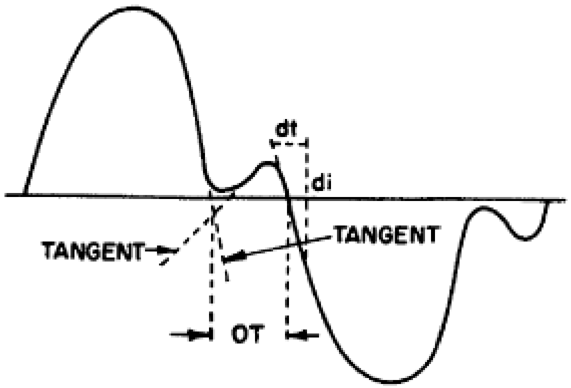


Figure 3
Current slope (*di/dt*) and off time (OT)

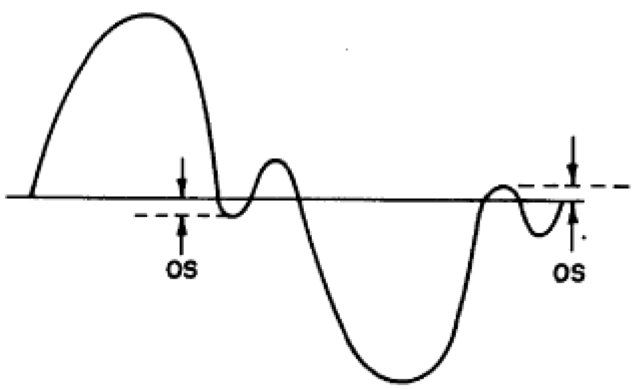


Figure 4
Overshoot (OS)

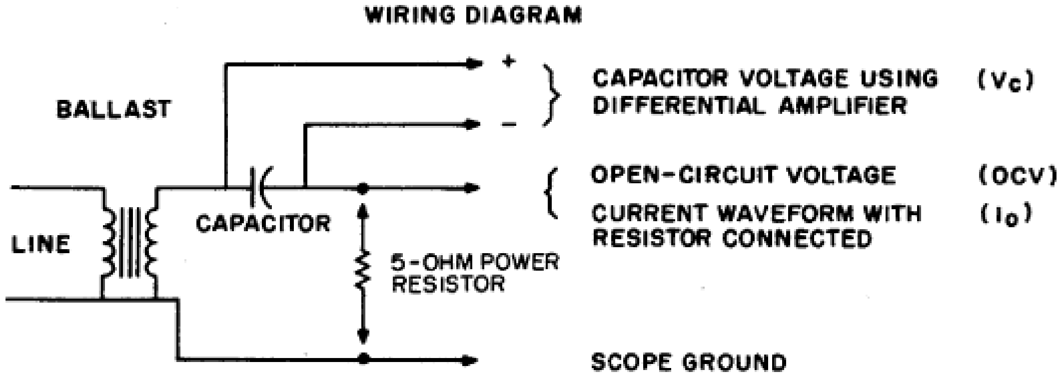


Figure 5
Sustaining Voltage Measurement Wiring Diagram

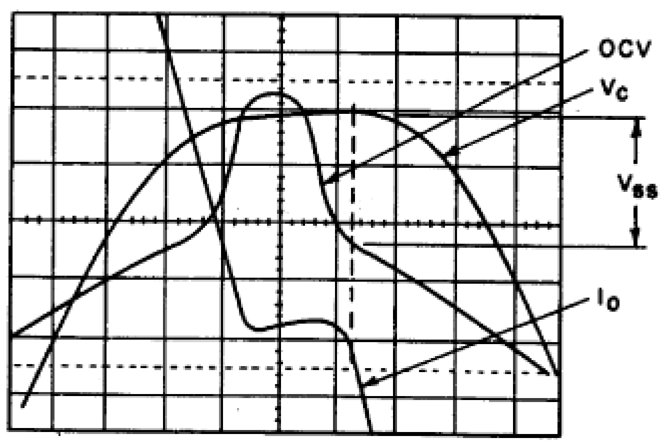


Figure 6
Sustaining Voltage (*Vss*)

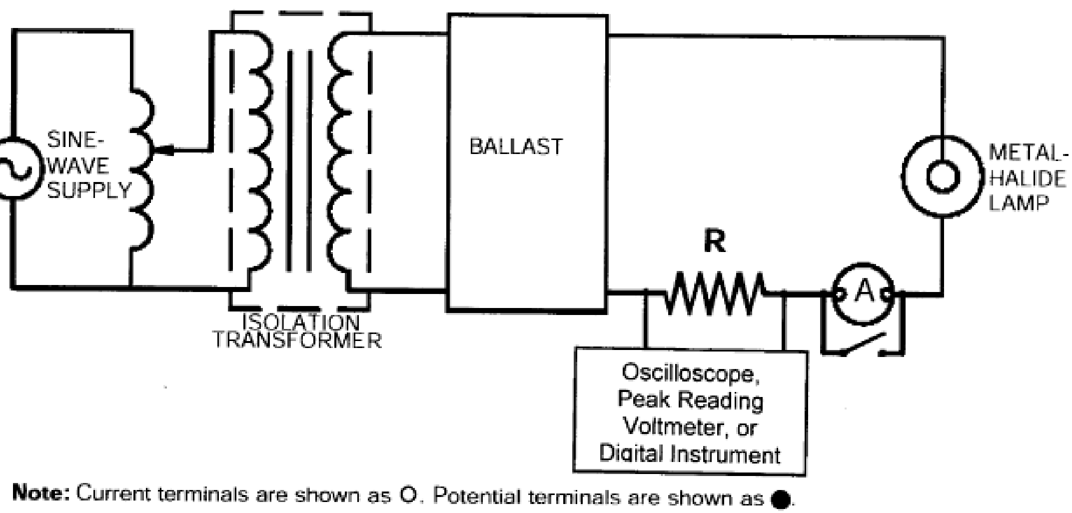
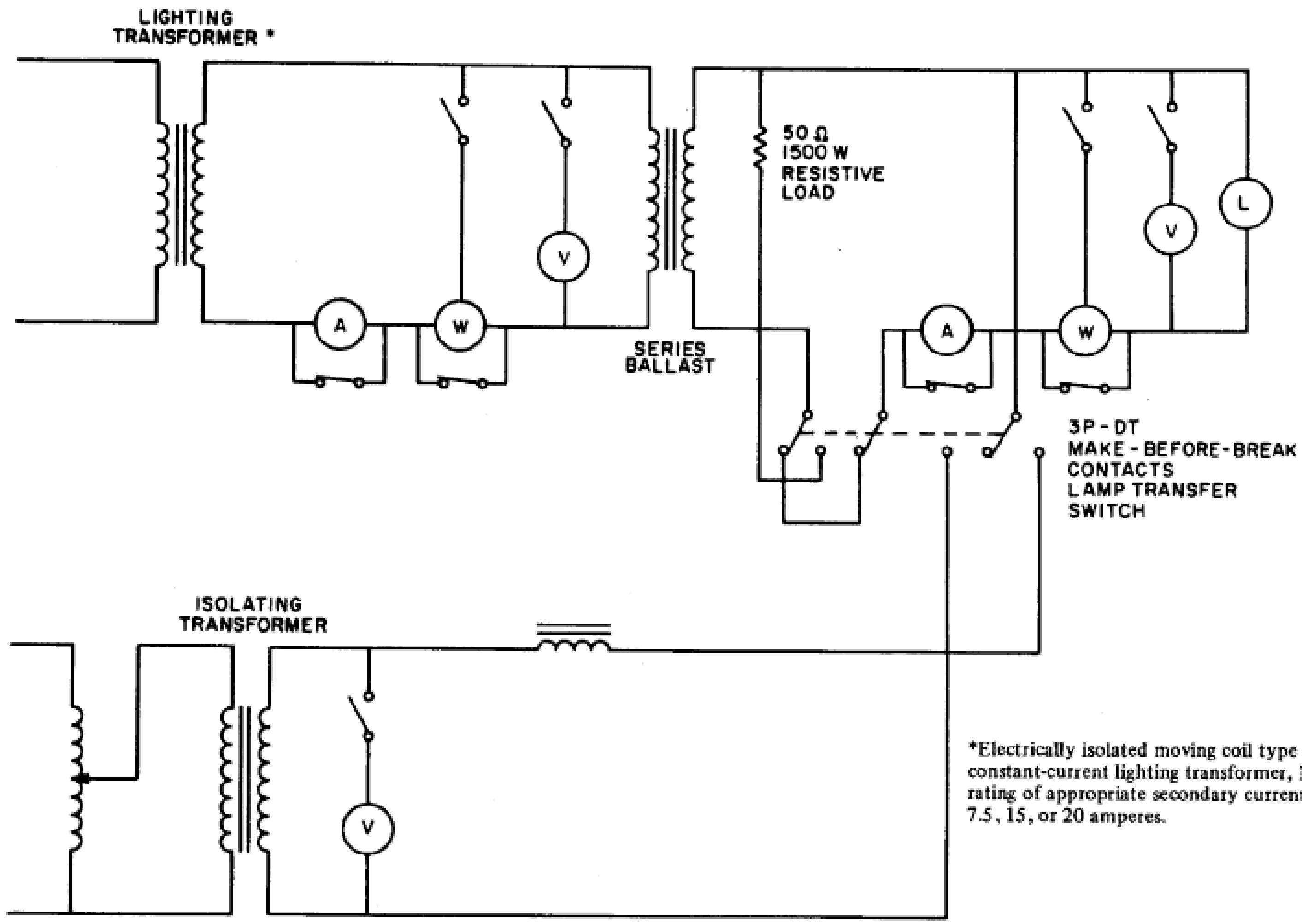


Figure 7
Circuit for Measurement of Lamp Current Crest Factor



*Electrically isolated moving coil type (vs. harmonic) constant-current lighting transformer, 10 kW minimum rating of appropriate secondary current rating – 6.6, 7.5, 15, or 20 amperes.

WARNING: Refer to Section 5.4 for circuit and equipment grounding procedures.

Figure 8
Series-Type Transformer Test Connections

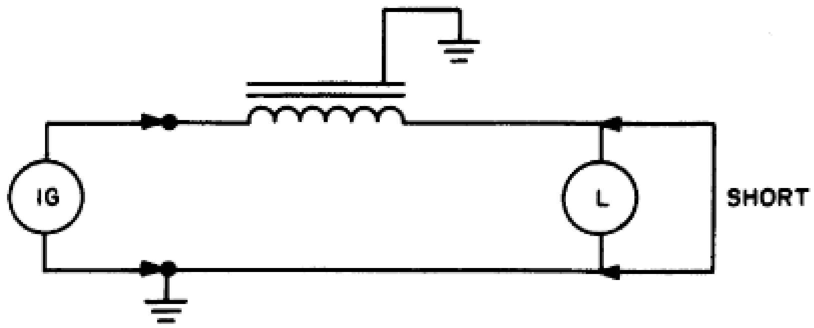
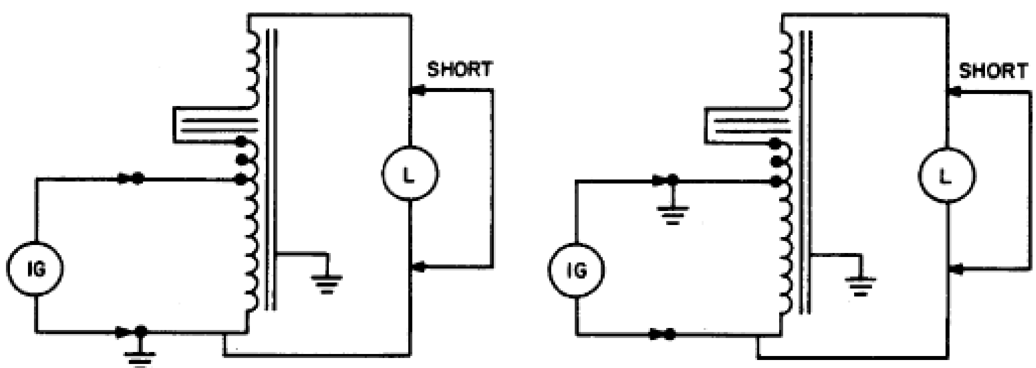


Figure 9
Impulse Test Circuit for Reactor Ballasts



(a) (b)

Figure 10
Impulse Test Circuit for Autotransformer Ballasts

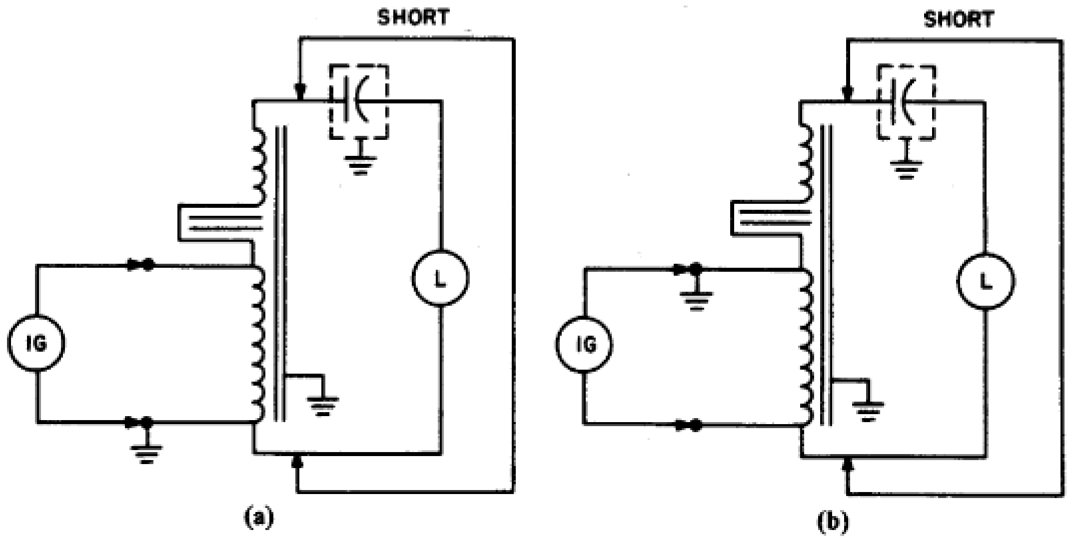


Figure 11
Impulse Test Circuit for Autotransformer Ballasts – Lead Type

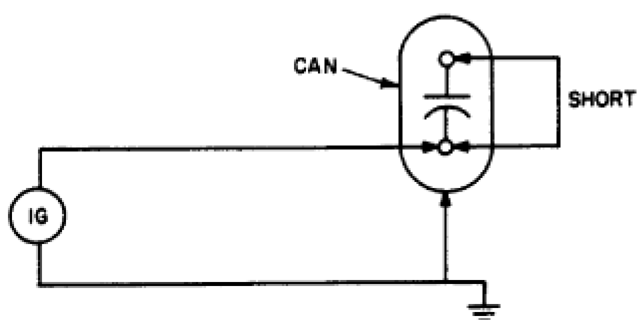


Figure 12
Impulse Test Circuit for Capacitors Used for Power Factor Correction

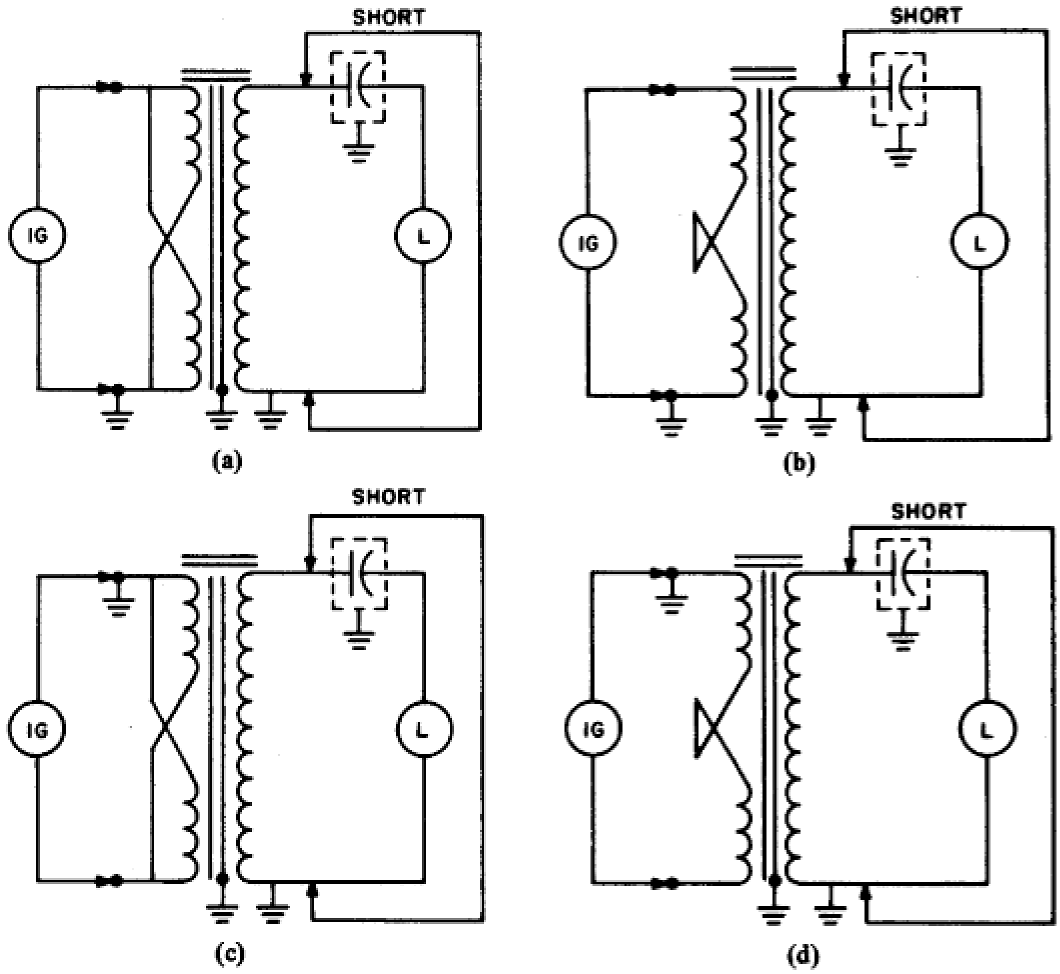


Figure 13
Impulse Test Circuit for Insulated Winding Ballasts