TEST REPORT
IEC 62368-1
Audio/video, information and communication technology equipment
Part 1: Safety requirements

Report Number	**261294**
Date of issue	June 27, 2014
Total number of pages	53
Applicant's name	Power Integrations, Inc.
Address	5245 Hellyer Avenue, San Jose, CA 95138, U.S.A.
Test specification:	
Standard	IEC 62368-1:2014 (Second Edition)
Test procedure	CB scheme
Non-standard test method	N/A
Test Report Form No.	IEC62368_1B
Test Report Form(s) Originator	UL(US)
Master TRF	2014-03

This report is not valid as a CB Test Report unless signed by an approved CB Testing Laboratory and appended to a CB Test Certificate issued by an NCB in accordance with IECEE 02.

General disclaimer:

The test results presented in this report relate only to the object tested.
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Test Item description ....:	IC including capacitor discharge function (ICX)	
Trade Mark ....:	CAPZero	
Manufacturer ....:	Same as Applicant	
Model/Type reference ....:	CAP002DG; CAP003DG; CAP004DG; CAP005DG; CAP006DG; CAP007DG; CAP008DG; CAP009DG; CAP012DG; CAP013DG; CAP014DG; CAP015DG; CAP016DG; CAP017DG; CAP018DG; CAP019DG; SC1143	
Ratings ....:	230V AC nominal (tested for 85-265V AC, 47-63Hz)	
Testing procedure and testing location:		
☒ Testing Laboratory:	Nemko A/S	
Testing location/ address ....:	Gaustadalléen 30, NO - 0373 Oslo, Norway	
☐ Associated Testing Laboratory:		
Testing location/ address ....:		
Tested by (name + signature) ....:	Ole Morten Aaslund	Ole Morten Aaslund
Approved by (name + signature) ....:	Steinar Nygaard	[signature]
☐ Testing procedure: Elsewhere:		
Testing location/ address .... :		
Tested by (name + signature) ....:		
Approved by (name + signature) ....:		

List of Attachments (including a total number of pages in each attachment):

Photos (5 pages)
Data sheet (8 pages)
Application note (10 pages)

Summary of testing:

Equipment under test (EUT) is an Integrated Circuit including capacitor discharge function (ICX). Requirements for such a component are covered by Annex G.16.

Compliance were checked by evaluation of the available data and by conducting tests required by G.16. After tests described in G.16 were performed the capacitor discharge tests were performed according to clause 5.5.2.2 on models CAP002DG, CAP009DG, CAP012DG and CAP019DG. The circuit tested continues to comply with 5.5.2.2. Refer clause 5.5.2.2 for details.

Note that compliance with 5.5.2.2 must also be checked when the ICX forms part of an end product.

In addition to tests of G.16 evaluation of available data from the manufacturer have been made to prove that the discharge function of the ICX remains the same also during single fault conditions:
The ICX has two dedicated pins for the D1 and D2 terminals which add redundancy during single fault testing (short-circuit or open-circuits). Thus if one pin is physically disconnected from the device or PCB, the ICX will continue to function normally. During a short-circuit the outcome is the same as if the ICX had not been used and results in the discharge resistors being connected in series continuously. Refer also “Product Description” and “Additional application considerations”.

Extended surge tests performed by the manufacturer to maximize the voltage stress of the ICX. Tests showed that the ICX continued to function as intended even when exposed to surge levels far beyond its intended application.

Tests performed (name of test and test clause):	**Testing location:**
F.3.10 Test for the permanence of markings 5.4.8 Humidity conditioning 5.5.2.2 Safeguards against capacitor discharge after disconnection of a connector G.16 IC including capacitor discharge function (ICX)	Nemko A/S Gaustadalléen 30, NO-0373 Oslo, Norway

Summary of compliance with National Differences:

All CB member countries except European countries.
(EN 62368-1 (based on IEC 62368-1) is not yet approved for Europe)

☒ **The product fulfils the requirements of IEC 62368-1:2014 (Second Edition)**

Copy of marking plate:

The artwork below may be only a draft. The use of certification marks on a product must be authorized by the respective Certification Bodies that own these marks.

The following markings are printed on the body of the ICX:

- Power Integrations Logo
- Date code
- Part no.
- Serial no.

Calibration	All instruments used in the tests given in this test report are calibrated and traceable to national or international standards. Further information about traceability will be given on request.
Measurement uncertainty	Measurement uncertainties are calculated for all instruments and instrument set-ups given in this report. Calculations are based on the principles given in the standard EA-4/02 (Dec. 1999), IEC Guide 115:2007, Nemko routine L227 and other relevant internal Nemko-procedures. Further information about measurement uncertainties will be given on request.
Evaluation of results	If not explicitly stated otherwise in the standard, the test is passed if the measured value is equal to or below (above) the limit line, regardless of the measurement uncertainty. If the measured value is above (below) the limit line, the test is not passed - ref IEC Guide 115:2007, and Nemko routine L220. The instrumentation accuracy is within limits agreed by IECEE-CTL (ref. Nemko routine L227).

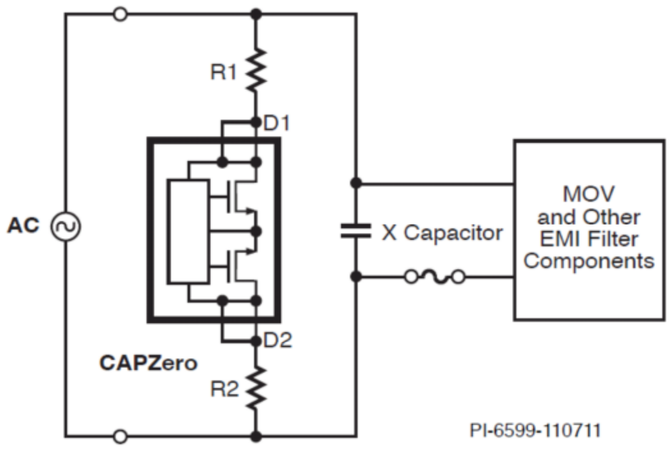
TEST ITEM PARTICULARS:	
Classification of use by .... :	☒ Ordinary person ☒ Instructed person ☒ Skilled person ☐ Children likely to be present
Supply Connection .... :	☒ AC Mains ☐ DC Mains ☐ External Circuit - not Mains connected - ☐ ES1 ☐ ES2 ☒ ES3
Supply % Tolerance .... :	☐ +10%/-10% ☐ +20%/-15% ☐ +____%/ -_____% ☒ Tested for 85-265V
Supply Connection – Type .... :	☐ pluggable equipment type A - ☐ non-detachable supply cord ☐ appliance coupler ☐ direct plug-in ☐ mating connector ☐ pluggable equipment type B - ☐ non-detachable supply cord ☐ appliance coupler ☐ permanent connection ☐ mating connector ☒ other:component for building-in
Considered current rating of protective device as part of building or equipment installation ....:	Not applicable, component for building-in; Installation location: ☐ building; ☒ equipment
Equipment mobility ....:	☐ movable ☐ hand-held ☐ transportable ☐ stationary ☒ for building-in ☐ direct plug-in ☐ rack-mounting ☐ wall-mounted
Over voltage category (OVC) ....:	☐ OVC I ☒ OVC II ☐ OVC III ☐ OVC IV ☐ other: ________
Class of equipment ....:	☐ Class I ☐ Class II ☐ Class III Not applicable, component for building-in
Access location ....:	☐ restricted access location ☒ N/A
Pollution degree (PD) ....:	☐ PD 1 ☒ PD 2 ☐ PD 3
Manufacturer's specified maxium operating ambient:	105°C
IP protection class ....:	☐ IPX0 ☐ IP___ Not applicable, component for building-in
Power Systems ....:	☐ TN ☐ TT ☐ IT - _____ V $_{L-L}$ Not applicable, component for building-in
Altitude during operation (m) ....:	☒ 2000 m or less ☐ _______ m
Altitude of test laboratory (m) ....:	☒ 2000 m or less ☐ _______ m
Mass of equipment (kg) ....:	☒ < 10 g

POSSIBLE TEST CASE VERDICTS:	
- test case does not apply to the test object................:	N/A
- test object does meet the requirement ....:	P (Pass)
- test object does not meet the requirement ....:	F (Fail)
TESTING:	
Date of receipt of test item..:	May 2014
Date (s) of performance of tests.................................:	May 2014
The application for obtaining a CB Test Certificate includes more than one factory location and a declaration from the Manufacturer stating that the sample(s) submitted for evaluation is (are) representative of the products from each factory has been provided ....:	☐ **Yes** ☒ **Not applicable**
When differences exist; they shall be identified in the General product information section.	
Name and address of factory (ies) ....:	Millenium Microtech Shanghai No. 351 Guo Shou Jing Rd., Z.J. Hi Tech Park Pudong New Area, Shanghai, 201203 CHINA
GENERAL PRODUCT INFORMATION:	

Product Description

The equipment under tests is an IC including discharge function (ICX). It is used to cope with environmental issues, as it limits the power consumption in standby conditions. The ICX blocks current through X-capacitor discharge resistor when AC voltage is connected, and it automatically discharges X-capacitor trough discharge resistors when AC is disconnected.

Figure below shows a typical application for the ICX:



Resistors R1+R2 shall be rated for 50% of the system input voltage to allow for the short-circuit of the ICX, D1 to D2 pins, during single fault test.

Model Differences

Models covered by this report are listed in table below. Models CAP002DG, CAP009DG, CAP012DG and CAP019DG were chosen to represent all models. During testing the ICX was mounted on a PCB together with a mains fuse (1A) and discharge resistors. Refer attached Photos. X-capacitor was only mounted during the discharge tests, refer clause 5.5.2.2. Values of X-capacitor and discharge resistors are as per recommendation from the manufacturer. Refer table below:

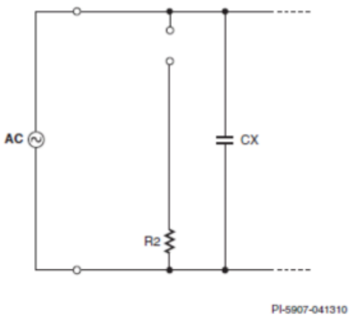
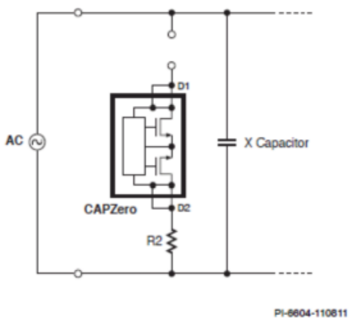
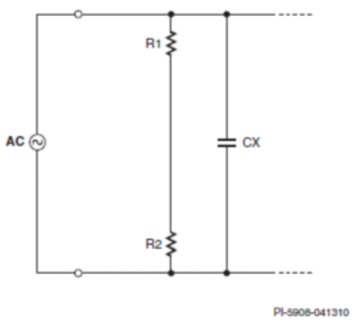
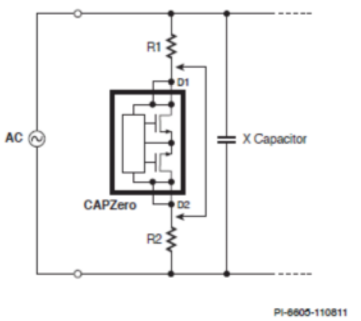
Model/Part No. (ICX)	BV_{DSS}	Maximum total X-capacitance	Total series resistance (R1+R2)
CAP002DG	825V	<= 500nF	1.5MΩ
CAP003DG	825V	750nF	1.02MΩ
CAP004DG	825V	1µF	780kΩ
CAP005DG	825V	1.5µF	480kΩ
CAP006DG	825V	2µF	360kΩ
CAP007DG	825V	2.5µF	300kΩ
CAP008DG	825V	3.5µF	200kΩ
CAP009DG	825V	5µF	150kΩ
CAP012DG	1000V	<= 500nF	1.5MΩ
CAP013DG	1000V	750nF	1.02MΩ
CAP014DG	1000V	1µF	780kΩ
CAP015DG	1000V	1.5µF	480kΩ
CAP016DG	1000V	2µF	360kΩ
CAP017DG	1000V	2.5µF	300kΩ
CAP018DG	1000V	3.5µF	200kΩ
CAP019DG	1000V	5µF	150kΩ
SC1143	1000V	5µF	150kΩ

Table above includes tolerances as referred to in the attached data sheet i.e. 5% for resistors and 20% for total capacitance.

Additional application considerations – (Considerations used to test a component or sub-assembly)

Evaluation of singe fault conditions:

The ICX has two dedicated pins for the D1 and D2 terminals which add redundancy during single fault testing (short-circuit or open-circuits). Thus if one pin is physically disconnected from the device or PCB, the ICX will continue to function normally. During a short-circuit the outcome is the same as if the ICX had not been used and results in the discharge resistors being connected in series continuously. Figure on next page summarizes the results of the worst case single fault tests.

Test	Test With Existing System	CAPZero Equivalent	Comments
Open Circuit: Disconnect one pin of any device to see effect on system			Lifting any one pin of the CAPZero device has no effect as 2 pins are connected to each drain terminal. The only way to create an open circuit is by lifting the leads of one of the discharge resistors. This is therefore equivalent to existing system without CAPZero.
Short Circuit: Short any 2 adjacent pins to see effect on system			Shorting D1 and D2 pins creates a condition equivalent to an existing system not using CAPZero.

Evaluation of maximum ambient temperature:

Extended tests performed by the manufacturer to prove that the ICX is also reliable at the maximum specified ambient temperature (105°C).

Refer also attached Data sheet and Application note from the manufacturer for further details.

ENERGY SOURCE IDENTIFICATION AND CLASSIFICATION TABLE:	
(Note 1: Identify the following six (6) energy source forms based on the origin of the energy.) (Note 2: The identified classification e.g., ES2, TS1, should be with respect to its ability to cause pain or injury on the body or its ability to ignite a combustible material. Any energy source can be declared Class 3 as a worse case classification e.g. PS3, ES3.	
Electrically-caused injury (Clause 5): (Note: Identify type of source, list sub-assembly or circuit designation and corresponding energy source classification) Example: +5 V dc input	ES1
Source of electrical energy	**Corresponding classification (ES)**
Charged X-capacitor ~~ICX~~	ES3, but ES1 after 2 sec (ICX will be located in a circuit classified as ES3, however it complies as a safeguard against capacitor discharge after disconnection of a connector, and therefore considered as ES1 after 2 sec)
Electrically-caused fire (Clause 6): (Note: List sub-assembly or circuit designation and corresponding energy source classification) Example: Battery pack (maximum 85 watts):	PS2
Source of power or PIS	**Corresponding classification (PS)**

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Clause	Requirement + Test	Result - Remark	Verdict

ENERGY SOURCE IDENTIFICATION AND CLASSIFICATION TABLE:	
The ICX will be located in a circuit intended to be supplied from PS3	PS3
Injury caused by hazardous substances (Clause 7) (Note: Specify hazardous chemicals, whether produces ozone or other chemical construction not addressed as part of the component evaluation.) Example: Liquid in filled component	Glycol
Source of hazardous substances	**Corresponding chemical**
N/A	N/A
Mechanically-caused injury (Clause 8) (Note: List moving part(s), fan, special installations, etc. & corresponding MS classification based on Table 35.) Example: Wall mount unit	MS2
Source of kinetic/mechanical energy	**Corresponding classification (MS)**
N/A	N/A
Thermal burn injury (Clause 9) (Note: Identify the surface or support, and corresponding energy source classification based on type of part, location, operating temperature and contact time in Table 38.) Example: Hand-held scanner – thermoplastic enclosure	TS1
Source of thermal energy	**Corresponding classification (TS)**
N/A	N/A
Radiation (Clause 10) (Note: List the types of radiation present in the product and the corresponding energy source classification.) Example: DVD – Class 1 Laser Product	RS1
Type of radiation	**Corresponding classification (RS)**
N/A	N/A

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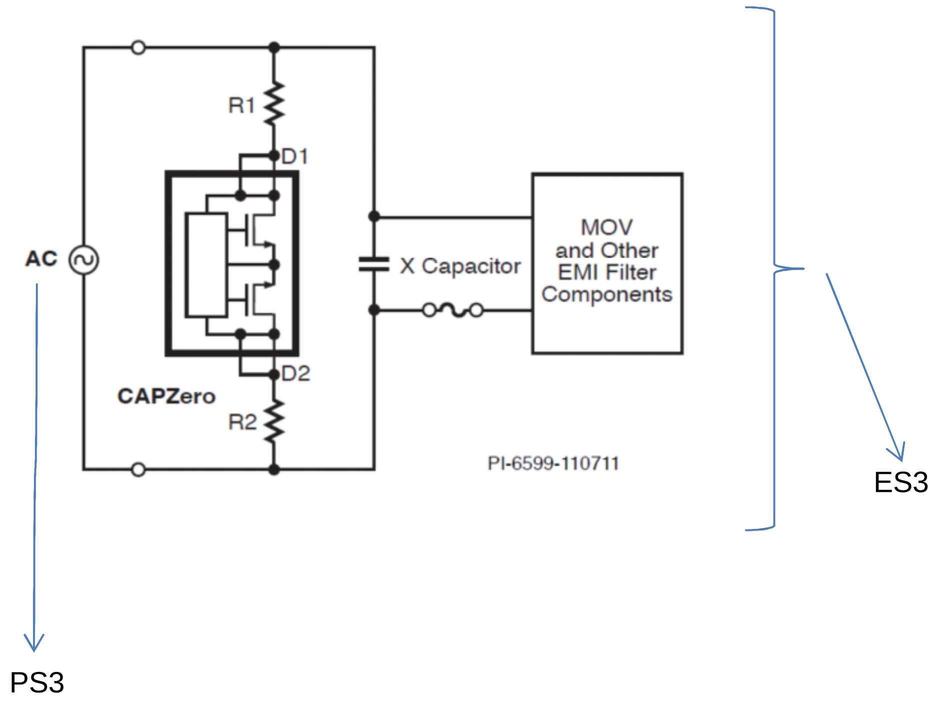
Clause	Requirement + Test	Result - Remark	Verdict

ENERGY SOURCE DIAGRAM
Indicate which energy sources are included in the energy source diagram. Insert diagram below
Χ **ES** Χ **PS** ☐ **MS** ☐ **TS** ☐ **RS**



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Clause	Requirement + Test	Result - Remark	Verdict

OVERVIEW OF EMPLOYED SAFEGUARDS				
Clause	**Possible Hazard**			
5.1	Electrically-caused injury			
Body Part (e.g. Ordinary)	Energy Source (ES3: Primary Filter circuit)	Safeguards		
		Basic	Supplementary	Reinforced (Enclosure)
Ordinary	ES3 (ICX serves as the safeguard, refer Annex G.16 i.e. ES1 after 2 sec)			
6.1	Electrically-caused fire			
Material part (e.g. mouse enclosure)	Energy Source (PS2: 100 Watt circuit)	Safeguards		
		Basic	Supplementary	Reinforced
N/A				
7.1	Injury caused by hazardous substances			
Body Part (e.g., skilled)	Energy Source (hazardous material)	Safeguards		
		Basic	Supplementary	Reinforced
N/A				
8.1	Mechanically-caused injury			
Body Part (e.g. Ordinary)	Energy Source (MS3:High Pressure Lamp)	Safeguards		
		Basic	Supplementary	Reinforced (Enclosure)
N/A				
9.1	Thermal Burn			
Body Part (e.g., Ordinary)	Energy Source (TS2)	Safeguards		
		Basic	Supplementary	Reinforced
N/A				
10.1	Radiation			
Body Part (e.g., Ordinary)	Energy Source (Output from audio port)	Safeguards		
		Basic	Supplementary	Reinforced
N/A				

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Clause	Requirement + Test	Result - Remark	Verdict

Supplementary Information:
(1) See attached energy source diagram for additional details.
(2) “N” – Normal Condition; “A” – Abnormal Condition; “S” Single Fault

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Clause	Requirement + Test	Result - Remark	Verdict
4	**GENERAL REQUIREMENTS**		P
4.1.1	Acceptance of materials, components and subassemblies		P
4.1.2	Use of components		P
4.1.3	Equipment design and construction		P
4.1.15	Markings and instructions.................................:	(See Annex F)	P
4.4.4	Safeguard robustness	Component for building-in. Must be evaluated as part of an end product.	N/A
4.4.4.2	Steady force tests...:		N/A
4.4.4.3	Drop tests ....:		N/A
4.4.4.4	Impact tests ....:		N/A
4.4.4.5	Internal accessible safeguard enclosure and barrier tests...:		N/A
4.4.4.6	Glass Impact tests ....:		N/A
4.4.4.7	Thermoplastic material tests.............................:		N/A
4.4.4.8	Air comprising a safeguard...............................:		N/A
4.4.4.9	Accessibility and safeguard effectiveness		N/A
4.5	Explosion		N/A
4.6	Fixing of conductors	Component for building-in. Must be evaluated as part of an end product.	N/A
4.6.1	Fix conductors not to defeat a safeguard		N/A
4.6.2	10 N force test applied to ....:		N/A
4.7	Equipment for direct insertion into mains socket - outlets	Component for building-in. Must be evaluated as part of an end product.	N/A
4.7.2	Mains plug part complies with the relevant standard...:		N/A
4.7.3	Torque (Nm) ....:		N/A
4.8	Products containing coin/button cell batteries	Component for building-in. Must be evaluated as part of an end product.	N/A
4.8.2	Instructional safeguard		N/A
4.8.3	Battery Compartment Construction		N/A
	Means to reduce the possibility of children removing the battery...:		—
4.8.4	Battery Compartment Mechanical Tests ....:		N/A
4.8.5	Battery Accessibility		N/A
4.9	Likelihood of fire or shock due to entry of	Component for building-in. Must	N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	conductive object...:	be evaluated as part of an end product.	
5	**ELECTRICALLY-CAUSED INJURY**		P
5.2.1	Electrical energy source classifications...............:	Component is intended to be located in areas with ES3.	P
5.2.2	ES1, ES2 and ES3 limits	ES3	P
5.2.2.2	Steady-state voltage and current........................:		N/A
5.2.2.3	Capacitance limits...:	The electrical energy source is considered to be the X-capacitor(s). Values of X-capacitors covered are shown in “Model Differences”. All values exceeds 300nF. Limit for ES1 is 60Vp.	P
5.2.2.4	Single pulse limits ....:		N/A
5.2.2.5	Limits for repetitive pulses ....:		N/A
5.2.2.6	Ringing signals ....:		N/A
5.2.2.7	Audio signals ....:		N/A
5.3	Protection against electrical energy sources	Component for building-in. Must be evaluated as part of an end product.	N/A
5.3.1	General Requirements for accessible parts to ordinary, instructed and skilled persons		N/A
5.3.2.1	Accessibility to electrical energy sources and safeguards		N/A
5.3.2.2	Contact requirements		N/A
	a) Test with test probe from Annex V..................:		N/A
	b) Electric strength test potential (V) ....:		N/A
	c) Air gap (mm) ....:		N/A
5.3.2.4	Terminals for connecting stripped wire		N/A
5.4	Insulation materials and requirements		N/A
5.4.1.2	Properties of insulating material		N/A
5.4.1.3	Humidity conditioning ....:		N/A
5.4.1.4	Maximum operating temperature for insulating materials ....:		N/A
5.4.1.5	Pollution degree ....:		—
5.4.1.5.2	Test for pollution degree 1 environment and for an insulating compound		N/A
5.4.1.5.3	Thermal cycling		N/A
5.4.1.6	Insulation in transformers with varying dimensions		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
5.4.1.7	Insulation in circuits generating starting pulses		N/A
5.4.1.8	Determination of working voltage		N/A
5.4.1.9	Insulating surfaces		N/A
5.4.1.10	Thermoplastic parts on which conductive metallic parts are directly mounted		N/A
5.4.1.10.2	Vicat softening temperature ....:		N/A
5.4.1.10.3	Ball pressure ....:		N/A
5.4.2	Clearances	Component for building-in. Must be evaluated as part of an end product.	N/A
5.4.2.2	Determining clearance using peak working voltage		N/A
5.4.2.3	Determining clearance using required withstand voltage ....:		N/A
	a) a.c. mains transient voltage ....:		—
	b) d.c. mains transient voltage ....:		—
	c) external circuit transient voltage ....:		—
	d) transient voltage determined by measurement ... :		—
5.4.2.4	Determining the adequacy of a clearance using an electric strength test		N/A
5.4.2.5	Multiplication factors for clearances and test voltages ....:		N/A
5.4.3	Creepage distances ....:	Component for building-in. Must be evaluated as part of an end product.	N/A
5.4.3.1	General		N/A
5.4.3.3	Material Group ....:		—
5.4.4	Solid insulation	Component for building-in. Must be evaluated as part of an end product.	N/A
5.4.4.2	Minimum distance through insulation ....:		N/A
5.4.4.3	Insulation compound forming solid insulation		N/A
5.4.4.4	Solid insulation in semiconductor devices		N/A
5.4.4.5	Cemented joints		N/A
5.4.4.6	Thin sheet material		N/A
5.4.4.6.1	General requirements		N/A
5.4.4.6.2	Separable thin sheet material		N/A
	Number of layers (pcs) ....:		N/A
5.4.4.6.3	Non-separable thin sheet material		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
5.4.4.6.4	Standard test procedure for non-separable thin sheet material ....:		N/A
5.4.4.6.5	Mandrel test		N/A
5.4.4.7	Solid insulation in wound components		N/A
5.4.4.9	Solid insulation at frequencies >30 kHz ....:		N/A
5.4.5	Antenna terminal insulation		N/A
5.4.5.1	General		N/A
5.4.5.2	Voltage surge test		N/A
	Insulation resistance (MΩ).................................:		—
5.4.6	Insulation of internal wire as part of supplementary safeguard ....:		N/A
5.4.7	Tests for semiconductor components and for cemented joints		N/A
5.4.8	Humidity conditioning	Refer also G.16 a)	P
	Relative humidity (%)..:	(93±3)%	—
	Temperature (°C) ....:	(40±2)°C	—
	Duration (h) ....:	120h	—
5.4.9	Electric strength test...:		N/A
5.4.9.1	Test procedure for a solid insulation type test		N/A
5.4.9.2	Test procedure for routine tests		N/A
5.4.10	Protection against transient voltages between external circuit		N/A
5.4.10.1	Parts and circuits separated from external circuits		N/A
5.4.10.2	Test methods		N/A
5.4.10.2.1	General		N/A
5.4.10.2.2	Impulse test ....:		N/A
5.4.10.2.3	Steady-state test...:		N/A
5.4.11	Insulation between external circuits and earthed circuitry ....:		N/A
5.4.11.1	Exceptions to separation between external circuits and earth		N/A
5.4.11.2	Requirements		N/A
	Rated operating voltage U_{op} (V).........................:		—
	Nominal voltage U_{peak} (V)..................................:		—
	Max increase due to variation U_{sp} ....:		—
	Max increase due to ageing ΔU_{sa} ....:		—
	$U_{op} = U_{peak} + \Delta U_{sp} + \Delta U_{sa}$ ....:		—

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Clause	Requirement + Test	Result - Remark	Verdict
5.5	Components as safeguards		
5.5.1	General		P
5.5.2	Capacitors and RC units	ICX is tested and complies with Annex G.16.	P
5.5.2.1	General requirement	ICX is tested and complies with Annex G.16.	P
5.5.2.2	Safeguards against capacitor discharge after disconnection of a connector.............................:	(See appended table 5.5.2.2)	P
5.5.3	Transformers		N/A
5.5.4	Optocouplers		N/A
5.5.5	Relays		N/A
5.5.6	Resistors		N/A
5.5.7	SPD's		N/A
5.5.7.1	Use of an SPD connected to reliable earthing		N/A
5.5.7.2	Use of an SPD between mains and protective earth		N/A
5.5.8	Insulation between the mains and external circuit consisting of a coaxial cable.............................:		N/A
5.6	Protective conductor		N/A
5.6.2	Requirement for protective conductors		N/A
5.6.2.1	General requirements		N/A
5.6.2.2	Colour of insulation		N/A
5.6.3	Requirement for protective earthing conductors		N/A
	Protective earthing conductor size (mm^2) ....:		—
5.6.4	Requirement for protective bonding conductors		N/A
5.6.4.1	Protective bonding conductors		N/A
	Protective bonding conductor size (mm^2). ....:		—
	Protective current rating (A) .... :		—
5.6.4.3	Current limiting and overcurrent protective devices		N/A
5.6.5	Terminals for protective conductors		N/A
5.6.5.1	Requirement		N/A
	Conductor size (mm^2), nominal thread diameter (mm). ....:		N/A
5.6.5.2	Corrosion		N/A
5.6.6	Resistance of the protective system		N/A
5.6.6.1	Requirements		N/A
5.6.6.2	Test Method Resistance (Ω)...............................:		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
5.6.7	Reliable earthing		N/A
5.7	Prospective touch voltage, touch current and protective conductor current		N/A
5.7.2	Measuring devices and networks		N/A
5.7.2.1	Measurement of touch current ....:		N/A
5.7.2.2	Measurement of prospective touch voltage		N/A
5.7.3	Equipment set-up, supply connections and earth connections		N/A
	System of interconnected equipment (separate connections/single connection) ....:		—
	Multiple connections to mains (one connection at a time/simultaneous connections) ....:		—
5.7.4	Earthed conductive accessible parts...................:		N/A
5.7.5	Protective conductor current		N/A
	Supply Voltage (V)...:		—
	Measured current (mA).......................................:		—
	Instructional Safeguard.......................................:		N/A
5.7.6	Prospective touch voltage and touch current due to external circuits		N/A
5.7.6.1	Touch current from coaxial cables		N/A
5.7.6.2	Prospective touch voltage and touch current from external circuits		N/A
5.7.7	Summation of touch currents from external circuits		N/A
	a) Equipment with earthed external circuits Measured current (mA).......................................:		N/A
	b) Equipment whose external circuits are not referenced to earth. Measured current (mA).......:		N/A

6	**ELECTRICALLY- CAUSED FIRE**		N/A
6.2	Classification of power sources (PS) and potential ignition sources (PIS)		N/A
6.2.2	Power source circuit classifications	Assumed to be PS3, but must be evaluated in the end product.	N/A
6.2.2.1	General		N/A
6.2.2.2	Power measurement for worst-case load fault ... :		N/A
6.2.2.3	Power measurement for worst-case power source fault .... :		N/A
6.2.2.4	PS1 .... :		N/A
6.2.2.5	PS2 .... :		N/A
6.2.2.6	PS3 .... :		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
6.2.3	Classification of potential ignition sources		N/A
6.2.3.1	Arcing PIS ....:		N/A
6.2.3.2	Resistive PIS ....:		N/A
6.3	Safeguards against fire under normal operating and abnormal operating conditions		N/A
6.3.1 (a)	No ignition and attainable temperature value less than 90 % defined by ISO 871 or less than 300 °C for unknown materials ....:		N/A
6.3.1 (b)	Combustible materials outside fire enclosure		N/A
6.4	Safeguards against fire under single fault conditions		N/A
6.4.1	Safeguard Method		N/A
6.4.2	Reduction of the likelihood of ignition under single fault conditions in PS1 circuits		N/A
6.4.3	Reduction of the likelihood of ignition under single fault conditions in PS2 and PS3 circuits		N/A
6.4.3.1	General		N/A
6.4.3.2	Supplementary Safeguards		N/A
	Special conditions if conductors on printed boards are opened or peeled		N/A
6.4.3.3	Single Fault Conditions...................................... :		N/A
	Special conditions for temperature limited by fuse		N/A
6.4.4	Control of fire spread in PS1 circuits		N/A
6.4.5	Control of fire spread in PS2 circuits		N/A
6.4.5.2	Supplementary safeguards ....:		N/A
6.4.6	Control of fire spread in PS3 circuit		N/A
6.4.7	Separation of combustible materials from a PIS		N/A
6.4.7.1	General...:		N/A
6.4.7.2	Separation by distance		N/A
6.4.7.3	Separation by a fire barrier		N/A
6.4.8	Fire enclosures and fire barriers		N/A
6.4.8.1	Fire enclosure and fire barrier material properties		N/A
6.4.8.2.1	Requirements for a fire barrier		N/A
6.4.8.2.2	Requirements for a fire enclosure		N/A
6.4.8.3	Constructional requirements for a fire enclosure and a fire barrier		N/A
6.4.8.3.1	Fire enclosure and fire barrier openings		N/A
6.4.8.3.2	Fire barrier dimensions		N/A
6.4.8.3.3	Top Openings in Fire Enclosure: dimensions (mm) ....:		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	Needle Flame test		N/A
6.4.8.3.4	Bottom Openings in Fire Enclosure, condition met a), b) and/or c) dimensions (mm) ....:		N/A
	Flammability tests for the bottom of a fire enclosure ....:		N/A
6.4.8.3.5	Integrity of the fire enclosure, condition met: a), b) or c) ....:		N/A
6.4.8.4	Separation of PIS from fire enclosure and fire barrier distance (mm) or flammability rating.........:		N/A
6.5	Internal and external wiring		N/A
6.5.1	Requirements		N/A
6.5.2	Cross-sectional area (mm^2) ....:		—
6.5.3	Requirements for interconnection to building wiring ....:		N/A
6.6	Safeguards against fire due to connection to additional equipment		N/A
	External port limited to PS2 or complies with Clause Q.1		N/A

7	**INJURY CAUSED BY HAZARDOUS SUBSTANCES**		N/A
7.2	Reduction of exposure to hazardous substances	Component for building-in. Must be checked in the end product.	N/A
7.3	Ozone exposure		N/A
7.4	Use of personal safeguards (PPE)		N/A
	Personal safeguards and instructions .... :		—
7.5	Use of instructional safeguards and instructions		N/A
	Instructional safeguard (ISO 7010) ....:		—
7.6	Batteries...:		N/A

8	**MECHANICALLY-CAUSED INJURY**		N/A
8.1	General	Component for building-in. Must be checked in the end product.	N/A
8.2	Mechanical energy source classifications		N/A
8.3	Safeguards against mechanical energy sources		N/A
8.4	Safeguards against parts with sharp edges and corners		N/A
8.4.1	Safeguards		N/A
8.5	Safeguards against moving parts		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
8.5.1	MS2 or MS3 part required to be accessible for the function of the equipment		N/A
8.5.2	Instructional Safeguard .... :		—
8.5.4	Special categories of equipment comprising moving parts		N/A
8.5.4.1	Large data storage equipment		N/A
8.5.4.2	Equipment having electromechanical device for destruction of media		N/A
8.5.4.2.1	Safeguards and Safety Interlocks ....:		N/A
8.5.4.2.2	Instructional safeguards against moving parts		N/A
	Instructional Safeguard...:		—
8.5.4.2.3	Disconnection from the supply		N/A
8.5.4.2.4	Probe type and force (N) ....:		N/A
8.5.5	High Pressure Lamps		N/A
8.5.5.1	Energy Source Classification		N/A
8.5.5.2	High Pressure Lamp Explosion Test.....................:		N/A
8.6	Stability		N/A
8.6.1	Product classification		N/A
	Instructional Safeguard...:		—
8.6.2	Static stability		N/A
8.6.2.2	Static stability test		N/A
	Applied Force ....:		—
8.6.2.3	Downward Force Test		N/A
8.6.3	Relocation stability test		N/A
	Unit configuration during 10° tilt.............................:		—
8.6.4	Glass slide test		N/A
8.6.5	Horizontal force test (Applied Force)......................:		N/A
	Position of feet or movable parts............................:		—
8.7	Equipment mounted to wall or ceiling		N/A
8.7.1	Mounting Means (Length of screws (mm) and mounting surface) ....:		N/A
8.7.2	Direction and applied force....................................:		N/A
8.8	Handles strength		N/A
8.8.1	Classification		N/A
8.8.2	Applied Force ....:		N/A
8.9	Wheels or casters attachment requirements		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
8.9.1	Classification		N/A
8.9.2	Applied force ....:		—
8.10	Carts, stands and similar carriers		N/A
8.10.1	General		N/A
8.10.2	Marking and instructions		N/A
	Instructional Safeguard..:		—
8.10.3	Cart, stand or carrier loading test and compliance		N/A
	Applied force ....:		—
8.10.4	Cart, stand or carrier impact test		N/A
8.10.5	Mechanical stability		N/A
	Applied horizontal force (N) ....:		—
8.10.6	Thermoplastic temperature stability (°C)................:		N/A
8.11	Mounting means for rack mounted equipment		N/A
8.11.1	General		N/A
8.11.2	Product Classification		N/A
8.11.3	Mechanical strength test, variable *N* ....:		N/A
8.11.4	Mechanical strength test 250N, including end stops		N/A
8.12	Telescoping or rod antennas		N/A
	Button/Ball diameter (mm).....................................:		—

9	**THERMAL BURN INJURY**		N/A
9.2	Thermal energy source classifications	Component for building-in. Must be checked in the end product.	N/A
9.3	Safeguard against thermal energy sources		N/A
9.4	Requirements for safeguards		N/A
9.4.1	Equipment safeguard		N/A
9.4.2	Instructional safeguard ....:		N/A

10	**RADIATION**		N/A
10.2	Radiation energy source classification	Component for building-in. Must be checked in the end product.	N/A
10.2.1	General classification		N/A
10.3	Protection against laser radiation		N/A
	Laser radiation that exists equipment:		—
	Normal, abnormal, single-fault............................ :		N/A
	Instructional safeguard .... :		—

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Clause	Requirement + Test	Result - Remark	Verdict
	Tool...:		—
10.4	Protection against visible, infrared, and UV radiation		N/A
10.4.1	General		N/A
10.4.1.a)	RS3 for Ordinary and instructed persons ....:		N/A
10.4.1.b)	RS3 accessible to a skilled person......................:		N/A
	Personal safeguard (PPE) instructional safeguard...:		—
10.4.1.c)	Equipment visible, IR, UV does not exceed RS1 . :		N/A
10.4.1.d)	Normal, abnormal, single-fault conditions ....:		N/A
10.4.1.e)	Enclosure material employed as safeguard is opaque...:		N/A
10.4.1.f)	UV attenuation ....:		N/A
10.4.1.g)	Materials resistant to degradation UV ....:		N/A
10.4.1.h)	Enclosure containment of optical radiation..........:		N/A
10.4.1.i)	Exempt Group under normal operating conditions...:		N/A
10.4.2	Instructional safeguard ....:		N/A
10.5	Protection against x-radiation		N/A
10.5.1	X- radiation energy source that exists equipment :		N/A
	Normal, abnormal, single fault conditions		N/A
	Equipment safeguards..:		N/A
	Instructional safeguard for skilled person............ :		N/A
10.5.3	Most unfavourable supply voltage to give maximum radiation ....:		—
	Abnormal and single-fault condition .... :		N/A
	Maximum radiation (pA/kg)................................. :		N/A
10.6	Protection against acoustic energy sources		N/A
10.6.1	General		N/A
10.6.2	Classification		N/A
	Acoustic output, dB(A).. :		N/A
	Output voltage, unweighted r.m.s...................... :		N/A
10.6.4	Protection of persons		N/A
	Instructional safeguards .... :		N/A
	Equipment safeguard prevent ordinary person to RS2... :		—
	Means to actively inform user of increase sound pressure.. :		—

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Clause	Requirement + Test	Result - Remark	Verdict
	Equipment safeguard prevent ordinary person to RS2 .... :		—
10.6.5	Requirements for listening devices (headphones, earphones, etc.)		N/A
10.6.5.1	Corded passive listening devices with analog input		N/A
	Input voltage with 94 dB(A) L_{Aeq} acoustic pressure output.. :		—
10.6.5.2	Corded listening devices with digital input		N/A
	Maximum dB(A) .... :		—
10.6.5.3	Cordless listening device		N/A
	Maximum dB(A) .... :		—

B	NORMAL OPERATING CONDITION TESTS, ABNORMAL OPERATING CONDITION TESTS AND SINGLE FAULT CONDITION TESTS		P
B.2	Normal Operating Conditions	Tested according to the requirements of Annex G.16.	P
B.2.1	General requirements .... :		P
	Audio Amplifiers and equipment with audio amplifiers .... :		N/A
B.2.3	Supply voltage and tolerances		N/A
B.2.5	Input test... :		N/A
B.3	Simulated abnormal operating conditions		N/A
B.3.1	General requirements .... :		N/A
B.3.2	Covering of ventilation openings		N/A
B.3.3	D.C. mains polarity test		N/A
B.3.4	Setting of voltage selector .... :		N/A
B.3.5	Maximum load at output terminals ....:		N/A
B.3.6	Reverse battery polarity		N/A
B.3.7	Abnormal operating conditions as specified in Clause E.2.		N/A
B.3.8	Safeguards functional during and after abnormal operating conditions		N/A
B.4	Simulated single fault conditions		N/A
B.4.2	Temperature controlling device open or short-circuited .... :		N/A
B.4.3	Motor tests		N/A
B.4.3.1	Motor blocked or rotor locked increasing the internal ambient temperature .... :		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
B.4.4	Short circuit of functional insulation		N/A
B.4.4.1	Short circuit of clearances for functional insulation		N/A
B.4.4.2	Short circuit of creepage distances for functional insulation		N/A
B.4.4.3	Short circuit of functional insulation on coated printed boards		N/A
B.4.5	Short circuit and interruption of electrodes in tubes and semiconductors		N/A
B.4.6	Short circuit or disconnect of passive components		N/A
B.4.7	Continuous operation of components		N/A
B.4.8	Class 1 and Class 2 energy sources within limits during and after single fault conditions		N/A
B.4.9	Battery charging under single fault conditions ... :		N/A
C	**UV RADIATION**		N/A
C.1	Protection of materials in equipment from UV radiation		N/A
C.1.2	Requirements		N/A
C.1.3	Test method		N/A
C.2	UV light conditioning test		N/A
C.2.1	Test apparatus		N/A
C.2.2	Mounting of test samples		N/A
C.2.3	Carbon-arc light-exposure apparatus		N/A
C.2.4	Xenon-arc light exposure apparatus		N/A
D	**TEST GENERATORS**		N/A
D.1	Impulse test generators		N/A
D.2	Antenna interface test generator		N/A
D.3	Electronic pulse generator		N/A
E	**TEST CONDITIONS FOR EQUIPMENT CONTAINING AUDIO AMPLIFIERS**		N/A
E.1	Audio amplifier normal operating conditions		N/A
	Audio signal voltage (V) ....:		—
	Rated load impedance (Ω) ....:		—
E.2	Audio amplifier abnormal operating conditions		N/A
F	**EQUIPMENT MARKINGS, INSTRUCTIONS, AND INSTRUCTIONAL SAFEGUARDS**		P
F.1	General requirements		P
	Instructions – Language ....:	English	—
F.2	Letter symbols and graphical symbols		N/A
F.2.1	Letter symbols according to IEC60027-1		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
F.2.2	Graphic symbols IEC, ISO or manufacturer specific		N/A
F.3	Equipment markings		P
F.3.1	Equipment marking locations	On the body of the ICX.	P
F.3.2	Equipment identification markings	Refer below:	P
F.3.2.1	Manufacturer identification ....:	The logo of Power Integrations applied.	—
F.3.2.2	Model identification ....:	CAP002DG; CAP003DG; CAP004DG; CAP005DG; CAP006DG; CAP007DG; CAP008DG; CAP009DG; CAP012DG; CAP013DG; CAP014DG; CAP015DG; CAP016DG; CAP017DG; CAP018DG; CAP019DG; SC1143	—
F.3.3	Equipment rating markings	Not for direct connection to the mains. No ratings marked on the component itself.	P
F.3.3.1	Equipment with direct connection to mains		N/A
F.3.3.2	Equipment without direct connection to mains		P
F.3.3.3	Nature of supply voltage ....:	Intended for AC, but not marked.	—
F.3.3.4	Rated voltage ....:	Rated nominal voltage is declared to be 230V AC. Tested for 85-265V AC, 47-63Hz.	—
F.3.3.4	Rated frequency...:	Tested for 85-265V AC, 47-63Hz.	—
F.3.3.6	Rated current or rated power ....:	Not rated.	—
F.3.3.7	Equipment with multiple supply connections		N/A
F.3.4	Voltage setting device		N/A
F.3.5	Terminals and operating devices		N/A
F.3.5.1	Mains appliance outlet and socket-outlet markings... :		N/A
F.3.5.2	Switch position identification marking .... :		N/A
F.3.5.3	Replacement fuse identification and rating markings... :		N/A
F.3.5.4	Replacement battery identification marking....... :		N/A
F.3.5.5	Terminal marking location		N/A
F.3.6	Equipment markings related to equipment classification	Component for building-in. Classification must be considered for the end product.	N/A
F.3.6.1	Class I Equipment		N/A
F.3.6.1.1	Protective earthing conductor terminal		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
F.3.6.1.2	Neutral conductor terminal		N/A
F.3.6.1.3	Protective bonding conductor terminals		N/A
F.3.6.2	Class II equipment (IEC60417-5172)		N/A
F.3.6.2.1	Class II equipment with or without functional earth		N/A
F.3.6.2.2	Class II equipment with functional earth terminal marking		N/A
F.3.7	Equipment IP rating marking ....:		—
F.3.8	External power supply output marking		N/A
F.3.9	Durability, legibility and permanence of marking		P
F.3.10	Test for permanence of markings		P
F.4	Instructions		N/A
	a) Equipment for use in locations where children not likely to be present - marking		N/A
	b) Instructions given for installation or initial use		N/A
	c) Equipment intended to be fastened in place		N/A
	d) Equipment intended for use only in restricted access area		N/A
	e) Audio equipment terminals classified as ES3 and other equipment with terminals marked in accordance F.3.6.1		N/A
	f) Protective earthing employed as safeguard		N/A
	g) Protective earthing conductor current exceeding ES 2 limits		N/A
	h) Symbols used on equipment		N/A
	i) Permanently connected equipment not provided with all-pole mains switch		N/A
j)	j) Replaceable components or modules providing safeguard function		N/A
F.5	Instructional safeguards		N/A
	Where “instructional safeguard” is referenced in the test report it specifies the required elements, location of marking and/or instruction		N/A
G	**COMPONENTS**		P
G.1	**Switches**		N/A
G.1.1	General requirements		N/A
G.1.2	Ratings, endurance, spacing, maximum load		N/A
G.2	**Relays**		N/A
G.2.1	General requirements		N/A
G.2.2	Overload test		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
G.2.3	Relay controlling connectors supply power		N/A
G.2.4	Mains relay, modified as stated in G.2		N/A
G.3	**Protection Devices**		N/A
G.3.1	Thermal cut-offs		N/A
G.3.1.1a) &b)	Thermal cut-outs separately approved according to IEC 60730 with conditions indicated in a) & b)		N/A
G.3.1.1c)	Thermal cut-outs tested as part of the equipment as indicated in c)		N/A
G.3.1.2	Thermal cut-off connections maintained and secure		N/A
G.3.2	Thermal links		N/A
G.3.2.1a)	Thermal links separately tested with IEC 60691		N/A
G.3.2.1b)	Thermal links tested as part of the equipment		N/A
	Aging hours (H) .... :		—
	Single Fault Condition .... :		—
	Test Voltage (V) and Insulation Resistance (Ω). :		—
G.3.3	PTC Thermistors		N/A
G.3.4	Overcurrent protection devices		N/A
G.3.5	Safeguards components not mentioned in G.3.1 to G.3.5		N/A
G.3.5.1	Non-resettable devices suitably rated and marking provided		N/A
G.3.5.2	Single faults conditions ....:		N/A
G.4	**Connectors**		N/A
G.4.1	Spacings		N/A
G.4.2	Mains connector configuration ....:		N/A
G.4.3	Plug is shaped that insertion into mains socket-outlets or appliance coupler is unlikely		N/A
G.5	**Wound Components**		N/A
G.5.1	Wire insulation in wound components................		N/A
G.5.1.2 a)	Two wires in contact inside wound component, angle between 45° and 90°		N/A
G.5.1.2 b)	Construction subject to routine testing		N/A
G.5.2	Endurance test on wound components		N/A
G.5.2.1	General test requirements		N/A
G.5.2.2	Heat run test		N/A
	Time (s) ....:		—
	Temperature (°C) ....:		—

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Clause	Requirement + Test	Result - Remark	Verdict
G.5.2.3	Wound Components supplied by mains		N/A
G.5.3	**Transformers**		N/A
G.5.3.1	Requirements applied (IEC61204-7, IEC61558-1/-2, and/or IEC62368-1) ....:		N/A
	Position...:		—
	Method of protection ....:		—
G.5.3.2	Insulation		N/A
	Protection from displacement of windings ....:		—
G.5.3.3	Overload test.. :		N/A
G.5.3.3.1	Test conditions		N/A
G.5.3.3.2	Winding Temperatures testing in the unit		N/A
G.5.3.3.3	Winding Temperatures - Alternative test method		N/A
G.5.4	**Motors**		N/A
G.5.4.1	General requirements		N/A
	Position ....:		—
G.5.4.2	Test conditions		N/A
G.5.4.3	Running overload test		N/A
G.5.4.4	Locked-rotor overload test		N/A
	Test duration (days) ....:		—
G.5.4.5	Running overload test for d.c. motors in secondary circuits		N/A
G.5.4.5.2	Tested in the unit		N/A
	Electric strength test (V).....................................:		—
G.5.4.5.3	Tested on the Bench - Alternative test method; test time (h) ....:		N/A
	Electric strength test (V).....................................:		—
G.5.4.6	Locked-rotor overload test for d.c. motors in secondary circuits		N/A
G.5.4.6.2	Tested in the unit		N/A
	Maximum Temperature ....:		N/A
	Electric strength test (V) ....:		N/A
G.5.4.6.3	Tested on the bench - Alternative test method; test time (h) ....:		N/A
	Electric strength test (V).....................................:		N/A
G.5.4.7	Motors with capacitors		N/A
G.5.4.8	Three-phase motors		N/A
G.5.4.9	Series motors		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	Operating voltage ....:		—
G.6	**Wire Insulation**		N/A
G.6.1	General		N/A
G.6.2	Solvent-based enamel wiring insulation		N/A
G.7	**Mains supply cords**		N/A
G.7.1	General requirements		N/A
	Type ....:		—
	Rated current (A)...:		—
	Cross-sectional area (mm^2), (AWG) .... :		—
G.7.2	Compliance and test method		N/A
G.7.3	Cord anchorages and strain relief for non-detachable power supply cords		N/A
G.7.3.2	Cord strain relief		N/A
G.7.3.2.1	Requirements		N/A
	Strain relief test force (N) ....:		—
G.7.3.2.2	Strain relief mechanism failure		N/A
G.7.3.2.3	Cord sheath or jacket position, distance (mm)....:		—
G.7.3.2.4	Strain relief comprised of polymeric material		N/A
G.7.4	Cord Entry .... :		N/A
G.7.5	Non-detachable cord bend protection		N/A
G.7.5.1	Requirements		N/A
G.7.5.2	Mass (g) .... :		—
	Diameter (m) ....:		—
	Temperature (°C) ....:		—
G.7.6	Supply wiring space		N/A
G.7.6.2	Stranded wire		N/A
G.7.6.2.1	Test with 8 mm strand		N/A
G.8	**Varistors**		N/A
G.8.1	General requirements		N/A
G.8.2	Safeguard against shock		N/A
G.8.3	Safeguard against fire		N/A
G.8.3.2	Varistor overload test ....:		N/A
G.8.3.3	Temporary overvoltage ....:		N/A
G.9	**Integrated Circuit (IC) Current Limiters**		N/A
G.9.1 a)	Manufacturer defines limit at max. 5A.		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
G.9.1 b)	Limiters do not have manual operator or reset		N/A
G.9.1 c)	Supply source does not exceed 250 VA ....:		—
G.9.1 d)	IC limiter output current (max. 5A) ....:		—
G.9.1 e)	Manufacturers' defined drift ....:		—
G.9.2	Test Program 1		N/A
G.9.3	Test Program 2		N/A
G.9.4	Test Program 3		N/A
G.10	**Resistors**		N/A
G.10.1	General requirements		N/A
G.10.2	Resistor test		N/A
G.10.3	Test for resistors serving as safeguards between the mains and an external circuit consisting of a coaxial cable		N/A
G.10.3.1	General requirements		N/A
G.10.3.2	Voltage surge test		N/A
G.10.3.3	Impulse test		N/A
G.11	**Capacitor and RC units**		N/A
G.11.1	General requirements		N/A
G.11.2	Conditioning of capacitors and RC units		N/A
G.11.3	Rules for selecting capacitors		N/A
G.12	**Optocouplers**		N/A
	Optocouplers comply with IEC 60747-5-5:2007 Spacing or Electric Strength Test (specify option and test results)..:		N/A
	Type test voltage Vini ....:		—
	Routine test voltage, Vini,b ....:		—
G.13	**Printed boards**		N/A
G.13.1	General requirements		N/A
G.13.2	Uncoated printed boards		N/A
G.13.3	Coated printed boards		N/A
G.13.4	Insulation between conductors on the same inner surface		N/A
	Compliance with cemented joint requirements (Specify construction)..:		—
G.13.5	Insulation between conductors on different surfaces		N/A
	Distance through insulation.................................:		N/A
	Number of insulation layers (pcs) ....:		—

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Clause	Requirement + Test	Result - Remark	Verdict
G.13.6	Tests on coated printed boards		N/A
G.13.6.1	Sample preparation and preliminary inspection		N/A
G.13.6.2a)	Thermal conditioning		N/A
G.13.6.2b)	Electric strength test		N/A
G.13.6.2c)	Abrasion resistance test		N/A
G.14	**Coating on components terminals**		N/A
G.14.1	Requirements ....:		N/A
G.15	**Liquid filled components**		N/A
G.15.1	General requirements		N/A
G.15.2	Requirements		N/A
G.15.3	Compliance and test methods		N/A
G.15.3.1	Hydrostatic pressure test		N/A
G.15.3.2	Creep resistance test		N/A
G.15.3.3	Tubing and fittings compatibility test		N/A
G.15.3.4	Vibration test		N/A
G.15.3.5	Thermal cycling test		N/A
G.15.3.6	Force test		N/A
G.15.4	Compliance		N/A
G.16	**IC including capacitor discharge function (ICX)**		P
a)	Humidity treatment in accordance with sc5.4.8 – 120 hours	Humidity treatment for 120 h at a temperature of (40±2)°C and a relative humidity of (93±3)%	P
b)	Impulse test using circuit 2 with Uc = to transient voltage ....:	Impulse tests as described performed on models CAP002DG, CAP009DG, CAP012DG and CAP019DG. Uc = 2500Vpeak. X-capacitor was only mounted during the discharge tests, refer Product Description/Model Differences and clause 5.5.2.2.	P
C1)	Application of ac voltage at 110% of rated voltage for 2.5 minutes	A voltage of 253V AC applied for 2.5 minutes on models CAP002DG, CAP009DG, CAP012DG and CAP019DG.	P
C2)	Test voltage ....:	253V	—
D1)	10,000 cycles on and off using capacitor with smallest capacitance resistor with largest resistance specified by manufacturer	10 000 cycles of power on and off (cycle time is 1 s) performed on models CAP002DG and CAP012DG.	P
D2)	Capacitance ....:	Refer Model Differences.	—

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Clause	Requirement + Test	Result - Remark	Verdict
D3)	Resistance ....:	Refer Model Differences.	—
H	**CRITERIA FOR TELEPHONE RINGING SIGNALS**		N/A
H.1	General		N/A
H.2	Method A		N/A
H.3	Method B		N/A
H.3.1	Ringing signal		N/A
H.3.1.1	Frequency (Hz) ....:		—
H.3.1.2	Voltage (V) ....:		—
H.3.1.3	Cadence; time (s) and voltage (V) ....:		—
H.3.1.4	Single fault current (mA): ....:		—
H.3.2	Tripping device and monitoring voltage ....:		N/A
H.3.2.1	Conditions for use of a tripping device or a monitoring voltage complied with		N/A
H.3.2.2	Tripping device		N/A
H.3.2.3	Monitoring voltage (V) ....:		—
J	**INSULATED WINDING WIRES FOR USE WITHOUT INTERLEAVED INSULATION**		N/A
	General requirements		N/A
K	**SAFETY INTERLOCKS**		N/A
K.1	General requirements		N/A
K.2	Components of safety interlock safeguard mechanism		N/A
K.3	Inadvertent change of operating mode		N/A
K.4	Interlock safeguard override		N/A
K.5	Fail-safe		N/A
	Compliance ....:		N/A
K.6	Mechanically operated safety interlocks		N/A
K.6.1	Endurance requirement		N/A
K.6.2	Compliance and Test method ....:		N/A
K.7	Interlock circuit isolation		N/A
K.7.1	Separation distance for contact gaps & interlock circuit elements (type and circuit location) ....:		N/A
K.7.2	Overload test, Current (A)..................................:		N/A
K.7.3	Endurance test		N/A
K.7.4	Electric strength test ....:		N/A
L	**DISCONNECT DEVICES**		N/A
L.1	General requirements		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
L.2	Permanently connected equipment		N/A
L.3	Parts that remain energized		N/A
L.4	Single phase equipment		N/A
L.5	Three-phase equipment		N/A
L.6	Switches as disconnect devices		N/A
L.7	Plugs as disconnect devices		N/A
L.8	Multiple power sources		N/A
M	**EQUIPMENT CONTAINING BATTERIES AND THEIR PROTECTION CIRCUITS**		N/A
M.1	General requirements		N/A
M.2	Safety of batteries and their cells		N/A
M.2.1	Requirements		N/A
M.2.2	Compliance and test method (identify method) .. :		N/A
M.3	Protection circuits		N/A
M.3.1	Requirements		N/A
M.3.2	Tests		N/A
	- Overcharging of a rechargeable battery		N/A
	- Unintentional charging of a non-rechargeable battery		N/A
	- Reverse charging of a rechargeable battery		N/A
	- Excessive discharging rate for any battery		N/A
M.3.3	Compliance .... :		N/A
M.4	Additional safeguards for equipment containing secondary lithium battery		N/A
M.4.1	General		N/A
M.4.2	Charging safeguards		N/A
M.4.2.1	Charging operating limits		N/A
M.4.2.2a)	Charging voltage, current and temperature ....:		—
M.4.2.2 b)	Single faults in charging circuitry ....:		—
M.4.3	Fire Enclosure		N/A
M.4.4	Endurance of equipment containing a secondary lithium battery		N/A
M.4.4.2	Preparation		N/A
M.4.4.3	Drop and charge/discharge function tests		N/A
	Drop		N/A
	Charge		N/A
	Discharge		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
M.4.4.4	Charge-discharge cycle test		N/A
M.4.4.5	Result of charge-discharge cycle test		N/A
M.5	Risk of burn due to short circuit during carrying		N/A
M.5.1	Requirement		N/A
M.5.2	Compliance and Test Method (Test of P.2.3)		N/A
M.6	Prevention of short circuits and protection from other effects of electric current		N/A
M.6.1	Short circuits		N/A
M.6.1.1	General requirements		N/A
M.6.1.2	Test method to simulate an internal fault		N/A
M.6.1.3	Compliance (Specify M.6.1.2 or alternative method) .... :		N/A
M.6.2	Leakage current (mA) .... :		N/A
M.7	Risk of explosion from lead acid and NiCd batteries		N/A
M.7.1	Ventilation preventing explosive gas concentration		N/A
M.7.2	Compliance and test method		N/A
M.8	Protection against internal ignition from external spark sources of lead acid batteries		N/A
M.8.1	General requirements		N/A
M.8.2	Test method		N/A
M.8.2.1	General requirements		N/A
M.8.2.2	Estimation of hypothetical volume *Vz* (m^3/s)....... :		—
M.8.2.3	Correction factors.. :		—
M.8.2.4	Calculation of distance *d* (mm) .... :		—
M.9	Preventing electrolyte spillage		N/A
M.9.1	Protection from electrolyte spillage		N/A
M.9.2	Tray for preventing electrolyte spillage		N/A
M.10	Instructions to prevent reasonably foreseeable misuse (Determination of compliance: inspection, data review; or abnormal testing) .... :		N/A
N	**ELECTROCHEMICAL POTENTIALS**		N/A
	Metal(s) used .... :		—
O	**MEASUREMENT OF CREEPAGE DISTANCES AND CLEARANCES**		N/A
	Figures O.1 to O.20 of this Annex applied.......... :		—

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Clause	Requirement + Test	Result - Remark	Verdict

P	**SAFEGUARDS AGAINST ENTRY OF FOREIGN OBJECTS AND SPILLAGE OF INTERNAL LIQUIDS**		N/A
P.1	General requirements		N/A
P.2.2	Safeguards against entry of foreign object		N/A
	Location and Dimensions (mm) ....:		—
P.2.3	Safeguard against the consequences of entry of foreign object		N/A
P.2.3.1	Safeguards against the entry of a foreign object		N/A
	Openings in transportable equipment		N/A
	Transportable equipment with metalized plastic parts ....:		N/A
P.2.3.2	Openings in transportable equipment in relation to metallized parts of a barrier or enclosure (identification of supplementary safeguard) ....:		N/A
P.3	Safeguards against spillage of internal liquids		N/A
P.3.1	General requirements		N/A
P.3.2	Determination of spillage consequences		N/A
P.3.3	Spillage safeguards		N/A
P.3.4	Safeguards effectiveness		N/A
P.4	Metallized coatings and adhesive securing parts		N/A
P.4.2 a)	Conditioning testing		N/A
	Tc (°C)...:		—
	Tr (°C) ....:		—
	Ta (°C)...:		—
P.4.2 b)	Abrasion testing ....:		N/A
P.4.2 c)	Mechanical strength testing ....:		N/A
Q	**CIRCUITS INTENDED FOR INTERCONNECTION WITH BUILDING WIRING**		N/A
Q.1	Limited power sources		N/A
Q.1.1 a)	Inherently limited output		N/A
Q.1.1 b)	Impedance limited output		N/A
	- Regulating network limited output under normal operating and simulated single fault condition		N/A
Q.1.1 c)	Overcurrent protective device limited output		N/A
Q.1.1 d)	IC current limiter complying with G.9		N/A
Q.1.2	Compliance and test method		N/A
Q.2	Test for external circuits – paired conductor cable		N/A
	Maximum output current (A) ....:		—

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Clause	Requirement + Test	Result - Remark	Verdict
	Current limiting method......................................:		—
R	**LIMITED SHORT CIRCUIT TEST**		N/A
R.1	General requirements		N/A
R.2	Determination of the overcurrent protective device and circuit		N/A
R.3	Test method Supply voltage (V) and short-circuit current (A)). ....:		N/A
S	**TESTS FOR RESISTANCE TO HEAT AND FIRE**		N/A
S.1	Flammability test for fire enclosures and fire barrier materials of equipment where the steady state power does not exceed 4 000 W		N/A
	Samples, material ....:		—
	Wall thickness (mm)...:		—
	Conditioning (°C)..:		—
	Test flame according to IEC 60695-11-5 with conditions as set out		N/A
	- Material not consumed completely		N/A
	- Material extinguishes within 30s		N/A
	- No burning of layer or wrapping tissue		N/A
S.2	Flammability test for fire enclosure and fire barrier integrity		N/A
	Samples, material ....:		—
	Wall thickness (mm)...:		—
	Conditioning (°C)..:		—
	Test flame according to IEC 60695-11-5 with conditions as set out		N/A
	Test specimen does not show any additional hole		N/A
S.3	Flammability test for the bottom of a fire enclosure		N/A
	Samples, material ....:		—
	Wall thickness (mm)...:		—
	Cheesecloth did not ignite		N/A
S.4	Flammability classification of materials		N/A
S.5	Flammability test for fire enclosures and fire barrier materials of equipment where the steady state power does not exceed 4 000 W		N/A
	Samples, material ....:		—
	Wall thickness (mm)...:		—

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Clause	Requirement + Test	Result - Remark	Verdict
	Conditioning (test condition), (°C) ....:		—
	Test flame according to IEC 60695-11-20 with conditions as set out		N/A
	After every test specimen was not consumed completely		N/A
	After fifth flame application, flame extinguished within 1 min		N/A
T	**MECHANICAL STRENGTH TESTS**		N/A
T.1	General requirements		N/A
T.2	Steady force test, 10 N ....:		N/A
T.3	Steady force test, 30 N ....:		N/A
T.4	Steady force test, 100 N ....:		N/A
T.5	Steady force test, 250 N ....:		N/A
T.6	Enclosure impact test		N/A
	Fall test		N/A
	Swing test		N/A
T.7	Drop test ....:		N/A
T.8	Stress relief test ....:		N/A
T.9	Impact Test (glass)		N/A
T.9.1	General requirements		N/A
T.9.2	Impact test and compliance		N/A
	Impact energy (J)..:		—
	Height (m) ....:		—
T.10	Glass fragmentation test ....:		N/A
T.11	Test for telescoping or rod antennas		N/A
	Torque value (Nm) ....:		—
U	**MECHANICAL STRENGTH OF CATHODE RAY TUBES (CRT) AND PROTECTION AGAINST THE EFECTS OF IMPLOSION**		N/A
U.1	General requirements		N/A
U.2	Compliance and test method for non-intrinsically protected CRTs		N/A
U.3	Protective Screen ....:		N/A
V	**DETERMINATION OF ACCESSIBLE PARTS (FINGERS, PROBES AND WEDGES)**		N/A
V.1	Accessible parts of equipment		N/A
V.2	Accessible part criterion		N/A

4.1.2	TABLE: List of critical components				N/A
Object / part No.	Manufacturer/ trademark	Type / model	Technical data	Standard	Mark(s) of conformity[1]
- Description[2)] :					
- Description[2)] :					
- Description[2)] :					
- Description[2)] :					
- Description[2)] :					

Supplementary information:

[1)] Provided evidence ensures the agreed level of compliance. See OD-CB2039.

[2)] Description line content is optional. Main line description needs to clearly detail the component used for testing

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Clause	Requirement + Test	Result - Remark	Verdict

4.8.4, 4.8.5	TABLE: Lithium coin/button cell batteries mechanical tests		N/A
(The following mechanical tests are conducted in the sequence noted.)			
4.8.4.2	TABLE: Stress Relief test		—
Part	Material	Oven Temperature (°C)	Comments
4.8.4.3	TABLE: Battery replacement test		—
Battery part no. ....:			—
Battery Installation/withdrawal		Battery Installation/Removal Cycle	Comments
		1	
		2	
		3	
		4	
		5	
		6	
		8	
		9	
		10	
4.8.4.4	TABLE: Drop test		—
Impact Area	Drop Distance	Drop No.	Observations
		1	
		2	
		3	
4.8.4.5	TABLE: Impact		—
Impacts per surface	Surface tested	Impact energy (Nm)	Comments
4.8.4.6	TABLE: Crush test		—
Test position	Surface tested	Crushing Force (N)	Duration force applied (s)
Supplementary information:			

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Clause	Requirement + Test	Result - Remark	Verdict

4.8.5	TABLE: Lithium coin/button cell batteries mechanical test result		N/A
Test position	**Surface tested**	**Force (N)**	**Duration force applied (s)**
Supplementary information:			

5.2	Table: Classification of electrical energy sources						
5.2.2.2 – Steady State Voltage and Current conditions							
No.	Supply Voltage	Location (e.g. circuit designation)	Test conditions	Parameters			ES Class
				U (Vrms or Vpk)	I (Apk or Arms)	Hz	
1			Normal				
			Abnormal				
			Single fault – SC/OC				
			Normal				
			Abnormal				
			Single fault – SC/OC				

5.2.2.3 - Capacitance Limits						
No.	Supply Voltage	Location (e.g. circuit designation)	Test conditions	Parameters		ES Class
				Capacitance, nF	Upk (V)	
			Normal			
			Abnormal			
			Single fault – SC/OC			

5.2.2.4 - Single Pulses							
No.	Supply Voltage	Location (e.g. circuit designation)	Test conditions	Parameters			ES Class
				Duration (ms)	Upk (V)	Ipk (mA)	
			Normal				
			Abnormal				
			Single fault – SC/OC				

IEC 62368-1			
Clause	Requirement + Test	Result - Remark	Verdict

5.2.2.5 - Repetitive Pulses							
No.	Supply Voltage	Location (e.g. circuit designation)	Test conditions	Parameters			ES Class
				Off time (ms)	Upk (V)	Ipk (mA)	
			Normal				
			Abnormal				
			Single fault – SC/OC				

Test Conditions:

Normal –

Abnormal -

Supplementary information: SC=Short Circuit, OC=Short Circuit

5.4.1.4, 6.3.2, 9.0, B.2.6	**TABLE: Temperature measurements**					N/A
	Supply voltage (V) .... :					—
	Ambient T_{min} (°C) .... :					—
	Ambient T_{max} (°C) .... :					—
	Tma (°C) .... :					—
Maximum measured temperature T of part/at:		T (°C)				Allowed T_{max} (°C)

Supplementary information:

Temperature T of winding:	t_1 (°C)	R_1 (Ω)	t_2 (°C)	R_2 (Ω)	T (°C)	Allowed T_{max} (°C)	Insulation class

Supplementary information:

Note 1: Tma should be considered as directed by appliable requirement

Note 2: Tma is not included in assessment of Touch Temperatures (Clause 9)

IEC 62368-1			
Clause	Requirement + Test	Result - Remark	Verdict

5.4.1.10.2	TABLE: Vicat softening temperature of thermoplastics		N/A
Penetration (mm)... :			—
Object/ Part No./Material	Manufacturer/trademark	T softening (°C)	
supplementary information:			

5.4.1.10.3	TABLE: Ball pressure test of thermoplastics		N/A
Allowed impression diameter (mm) .... :	≤ 2 mm		—
Object/Part No./Material	Manufacturer/trademark	Test temperature (°C)	Impression diameter (mm)
Supplementary information:			

5.4.2.2, 5.4.2.4 and 5.4.3	TABLE: Minimum Clearances/Creepage distance						N/A
Clearance (cl) and creepage distance (cr) at/of/between:	Up (V)	U r.m.s. (V)	Frequency (kHz)[1]	Required cl (mm)	cl (mm)[2]	Required[3] cr (mm)	cr (mm)

Supplementary information:

Note 1: Only for frequency above 30 kHz
Note 2: See table 5.4.2.4 if this is based on electric strength test
Note 3: Provide Material Group

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Clause	Requirement + Test	Result - Remark	Verdict

5.4.2.3	TABLE: Minimum Clearances distances using required withstand voltage		N/A
	Overvoltage Category (OV):		
	Pollution Degree:		
Clearance distanced between:	Required withstand voltage	Required cl (mm)	Measured cl (mm)
Supplementary information:			

5.4.2.4	TABLE: Clearances based on electric strength test		N/A
Test voltage applied between:	Required cl (mm)	Test voltage (kV) peak/ r.m.s. / d.c.	Breakdown Yes / No
Supplementary information:			

5.4.4.2, 5.4.4.5 c) 5.4.4.9	TABLE: Distance through insulation measurements				N/A
Distance through insulation di at/of:	Peak voltage (V)	Frequency (kHz)	Material	Required DTI (mm)	DTI (mm)
Supplementary information:					

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Clause	Requirement + Test	Result - Remark	Verdict

5.4.9	TABLE: Electric strength tests		N/A
Test voltage applied between:	Voltage shape (AC, DC)	Test voltage (V)	Breakdown Yes / No
Functional:			
Basic/supplementary:			
Reinforced:			
Routine Tests:			
Supplementary information:			

5.5.2.2	TABLE: Stored discharge on capacitors				P
Supply Voltage (V), Hz	Test Location	Operating Condition (N, S)	Switch position On or off	Measured Voltage (after 2 seconds)	ES Classification
CAP002DG: Vpeak: 356V / 50Hz	Phase to Phase	N	No switch	28V	ES1
CAP009DG: Vpeak: 352V / 50 Hz	Phase to Phase	N	No switch	28V	ES1
CAP012DG: Vpeak: 356V / 50 Hz	Phase to Phase	N	No switch	26V	ES1
CAP019DG: Vpeak: 358V / 50 Hz	Phase to Phase	N	No switch	29V	ES1

Supplementary information:

X-capacitors installed for testing are: Refer Model Differences for values of X-capacitance

☐ bleeding resistor rating:

☐ ICX: Equipment under test is an ICX component

Notes:

A. Test Location:

Phase to Neutral; Phase to Phase; Phase to Earth; and/or Neutral to Earth

B. Operating condition abbreviations:

N – Normal operating condition (e.g., normal operation, or open fuse); S –Single fault condition

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Clause	Requirement + Test	Result - Remark	Verdict

5.6.6.2	**TABLE: Resistance of protective conductors and terminations**				N/A
Accessible part	Test current (A)	Duration (min)	Voltage drop (V)	Resistance (Ω)	
Supplementary information:					

5.7.2.2, 5.7.4	**TABLE: Earthed accessible conductive part**	N/A
Supply voltage ....:		—
Location	Test conditions specified in 6.1 of IEC 60990 or Fault Condition No in IEC 60990 clause 6.2.2.1 through 6.2.2.8, except for 6.2.2.7	Touch current (mA)
	1	
	2*	
	3	
	4	
	5	
	6	
	8	

Supplementary Information:

Notes:
[1] Supply voltage is the anticipated maximum Touch Voltage
[2] Earthed neutral conductor [Voltage differences less than 1% or more]
[3] Specify method used for measurement as described in IEC 60990 sub-clause 4.3
[4] IEC60990, sub-clause 6.2.2.7, Fault 7 not applicable.
[5] (*) IEC60990, sub-clause 6.2.2.2 is not applicable if switch or disconnect device (e.g., appliance coupler) provided.

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Clause	Requirement + Test	Result - Remark	Verdict

6.2.2	Table: Electrical power sources (PS) measurements for classification				N/A
Source	Description	Measurement	Max Power after 3 s	Max Power after 5 s*)	PS Classification
A		Power (W) :			
		V_A (V) :			
		I_A (A) :			
B		Power (W) :			
		V_A (V) :			
		I_A (A) :			
C		Power (W) :			
		V_A (V) :			
		I_A (A) :			
D		Power (W) :			
		V_A (V) :			
		I_A (A) :			
Supplementary Information: (*) Measurement taken only when limits at 3 seconds exceed PS1 limits					

6.2.3.1	Table: Determination of Potential Ignition Sources (Arcing PIS)			N/A
Location	Open circuit voltage After 3 s (Vp)	Measured r.m.s current (Irms)	Calculated value (V_p x I_{rms})	Arcing PIS? Yes / No
Supplementary information: An Arcing PIS requires a minimum of 50 V (peak) a.c. or d.c. An Arcing PIS is established when the product of the open circuit voltage (V_p) and normal operating condition rms current (I_{rms}) is greater than 15.				

IEC 62368-1			
Clause	Requirement + Test	Result - Remark	Verdict

6.2.3.2	Table: Determination of Potential Ignition Sources (Resistive PIS)				N/A
Circuit Location (x-y)	Operating Condition (Normal / Describe Single Fault)	Measured wattage or VA During first 30 s (W / VA)	Measured wattage or VA After 30 s (W / VA)	Protective Circuit, Regulator, or PTC Operated? Yes / No (Comment)	Resistive PIS? Yes/No

Supplementary Information:

A combination of voltmeter, VA and ammeter IA may be used instead of a wattmeter.

If a separate voltmeter and ammeter are used, the product of (VA x IA) is used to determine Resistive PIS classification.

A Resistive PIS: (a) dissipates more than 15 W, measured after 30 s of normal operation, or (b) under single fault conditions has either a power exceeding 100 W measured immediately after the introduction of the fault if electronic circuits, regulators or PTC devices are used, or has an available power exceeding 15 W measured 30 s after introduction of the fault.

8.5.5	TABLE: High Pressure Lamp	N/A
Description	Values	Energy Source Classification
Lamp type...:		—
Manufacturer ....:		—
Cat no. ....:		—
Pressure (cold) (MPa).....................................:		MS_
Pressure (operating) (MPa) ....:		MS_
Operating time (minutes) ....:		—
Explosion method ....:		—
Max particle length escaping enclosure (mm) .:		MS_
Max particle length beyond 1 m (mm)..............:		MS_
Overall result ....:		

Supplementary information:

IEC 62368-1			
Clause	Requirement + Test	Result - Remark	Verdict

B.2.5	TABLE: Input test						N/A
U (V)	I (A)	I rated (A)	P (W)	P rated (W)	Fuse No	I fuse (A)	Condition/status
Supplementary information: Equipment may be have rated current or rated power or both. Both should be measured							

B.3	TABLE: Abnormal operating condition tests							N/A
Ambient temperature (°C) ....:								—
Power source for EUT: Manufacturer, model/type, output rating ..:								—
Component No.	Abnormal Condition	Supply voltage, (V)	Test time (ms)	Fuse no.	Fuse current, (A)	T-couple	Temp. (°C)	Observation
Supplementary information: Test table is provided to record abnormal and fault conditions for all applicable energy sources including Thermal burn injury. Column “Abnormal/Fault.” Specify if test condition by indicating “Abnormal” then the condition for a Clause B.3 test or “Single Fault” then the condition for Clause B.4.								

IEC 62368-1			
Clause	Requirement + Test	Result - Remark	Verdict

B.4	TABLE: Fault condition tests							N/A
Ambient temperature (°C) .... :								—
Power source for EUT: Manufacturer, model/type, output rating .:								—
Component No.	Fault Condition	Supply voltage, (V)	Test time (ms)	Fuse no.	Fuse current, (A)	T-couple	Temp. (°C)	Observation
Supplementary information:								

Annex M	TABLE: Batteries									N/A
The tests of Annex M are applicable only when appropriate battery data is not available										N/A
Is it possible to install the battery in a reverse polarity position?........................ :										N/A
	Non-rechargeable batteries			Rechargeable batteries						
	Discharging		Un-intentional charging	Charging		Discharging		Reversed charging		
	Meas. current	Manuf. Specs.		Meas. current	Manuf. Specs.	Meas. current	Manuf. Specs.	Meas. current	Manuf. Specs.	
Max. current during normal condition										
Max. current during fault condition										
Test results:										Verdict
- Chemical leaks										N/A
- Explosion of the battery										N/A
- Emission of flame or expulsion of molten metal										N/A
- Electric strength tests of equipment after completion of tests										N/A
Supplementary information:										

IEC 62368-1			
Clause	Requirement + Test	Result - Remark	Verdict

Annex M.4	**Table: Additional safeguards for equipment containing secondary lithium batteries**				N/A
Battery/Cell No.	Test conditions	Measurements			Observation
		U	I (A)	Temp (C)	
	Normal				
	Abnormal				
	Single fault –SC/OC				
	Normal				
	Abnormal				
	Single fault – SC/OC				
Supplementary Information:					

Battery identification	Charging at T_{lowest} (°C)	Observation	Charging at $T_{highest}$ (°C)	Observation
Supplementary Information:				

Annex Q.1	**TABLE: Circuits intended for interconnection with building wiring (LPS)**					N/A
Note: Measured UOC (V) with all load circuits disconnected:						
Output Circuit	Components	U_{oc} (V)	I_{sc} (A)		S (VA)	
			Meas.	Limit	Meas.	Limit
Supplementary Information: SC=Short circuit, OC=Open circuit						

IEC 62368-1			
Clause	Requirement + Test	Result - Remark	Verdict

T.2, T.3, T.4, T.5	TABLE: Steady force test				N/A
Part/Location	Material	Thickness (mm)	Force (N)	Test Duration (sec)	Observation
Supplementary information:					

T.6, T.9	TABLE: Impact tests			N/A
Part/Location	Material	Thickness (mm)	Vertical distance (mm)	Observation
Supplementary information:				

T.7	TABLE: Drop tests			N/A
Part/Location	Material	Thickness (mm)	Drop Height (mm)	Observation
Supplementary information:				

T.8	TABLE: Stress relief test				N/A
Part/Location	Material	Thickness (mm)	Oven Temperature (°C)	Duration (h)	Observation
Supplementary information:					

Photos

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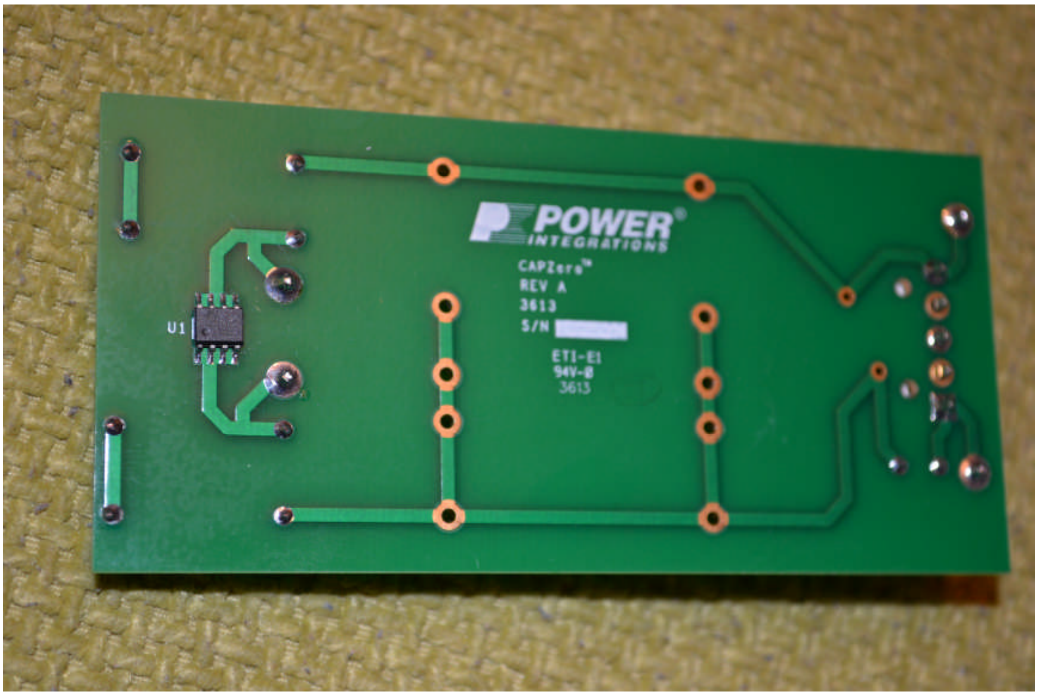
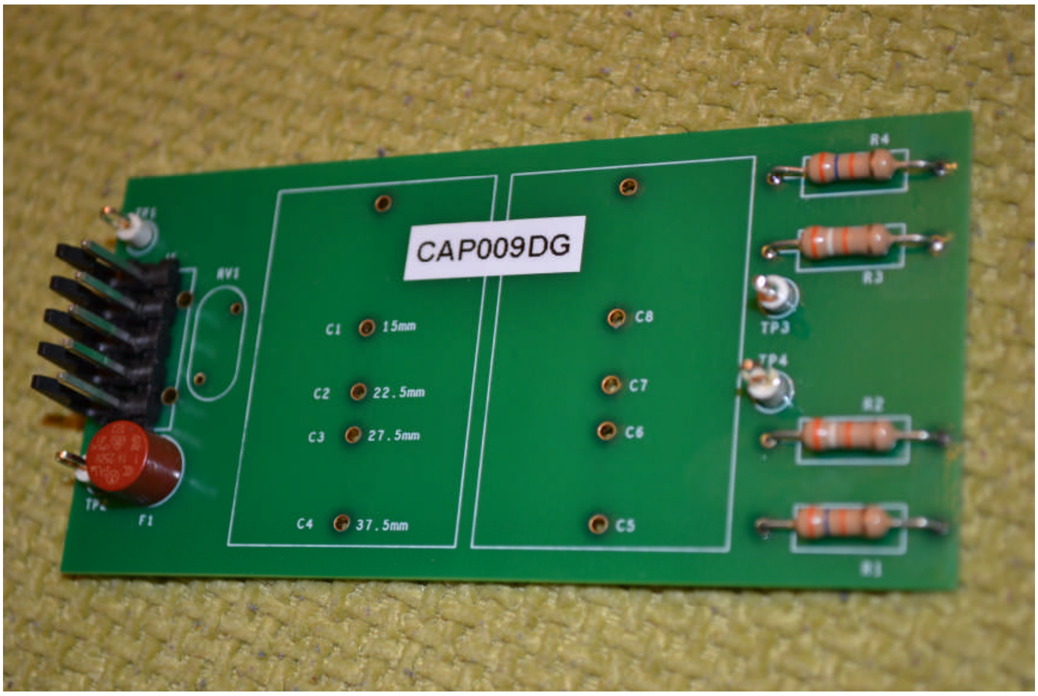
Test board of CAP012DG



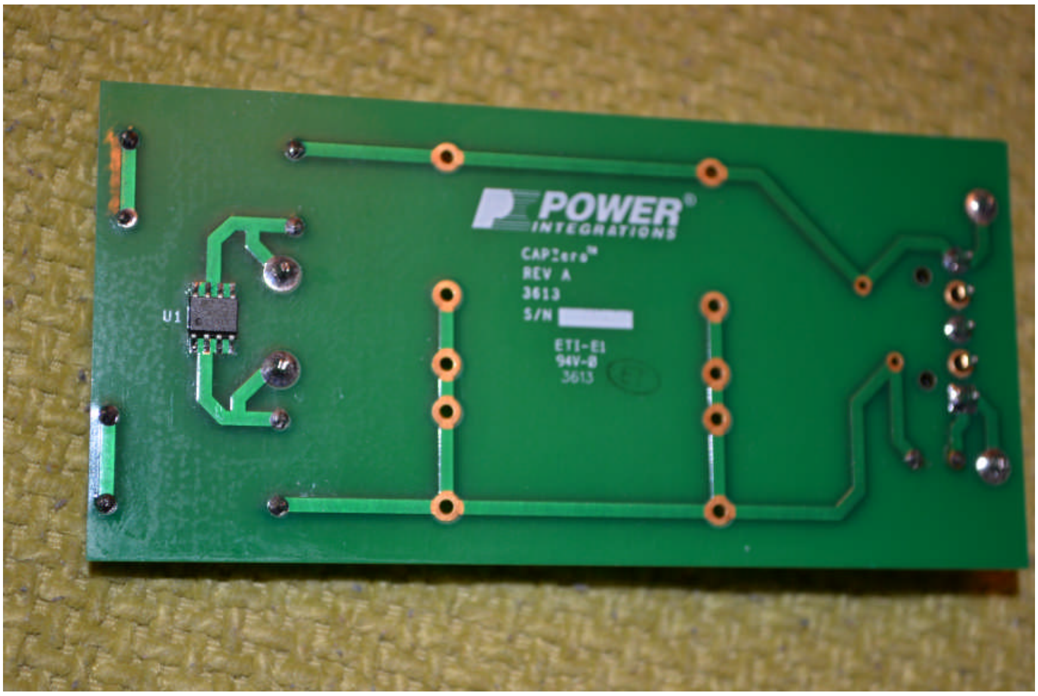
Test board of CAP012DG
(U1 = ICX)

Photos

Report No. 261294



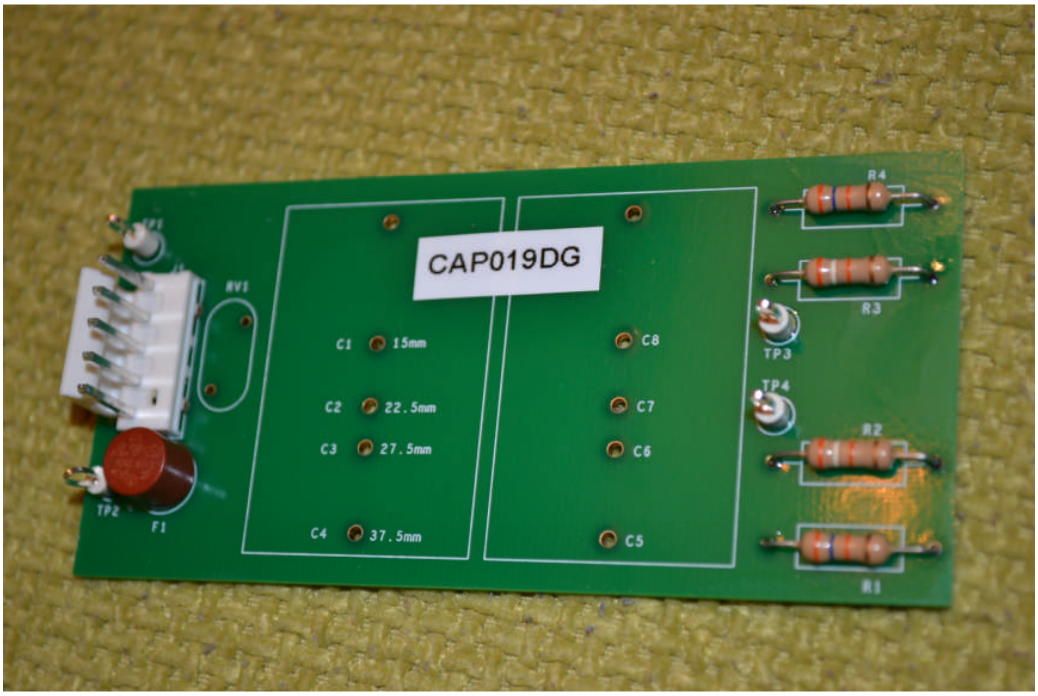
Test board of CAP009DG



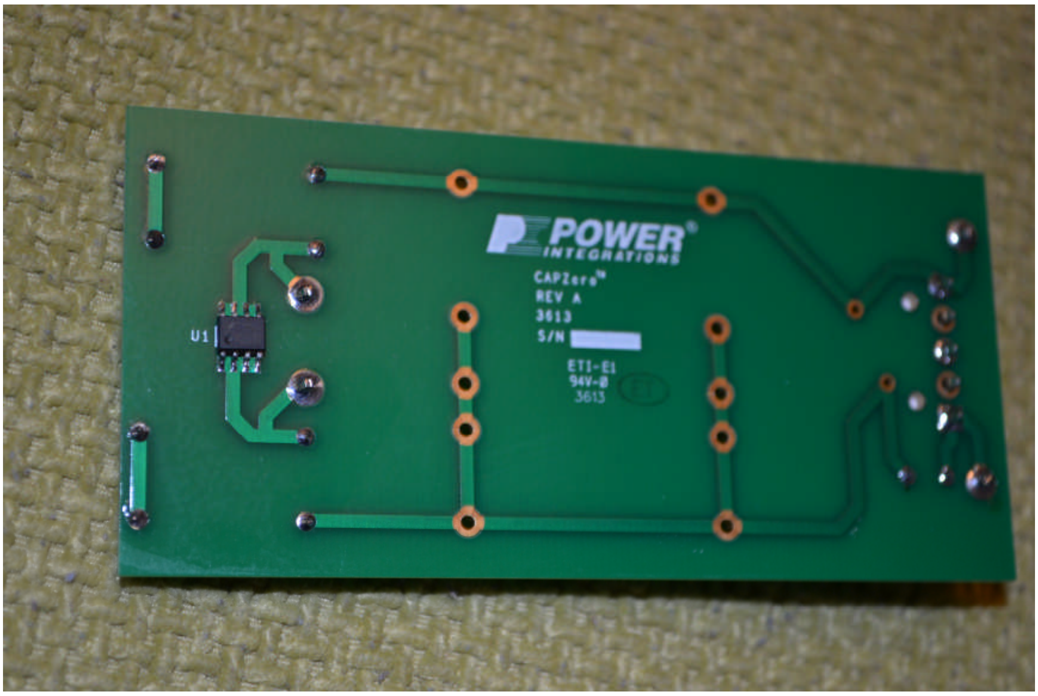
Test board of CAP009DG
(U1 = ICX)

Photos

Report No. 261294



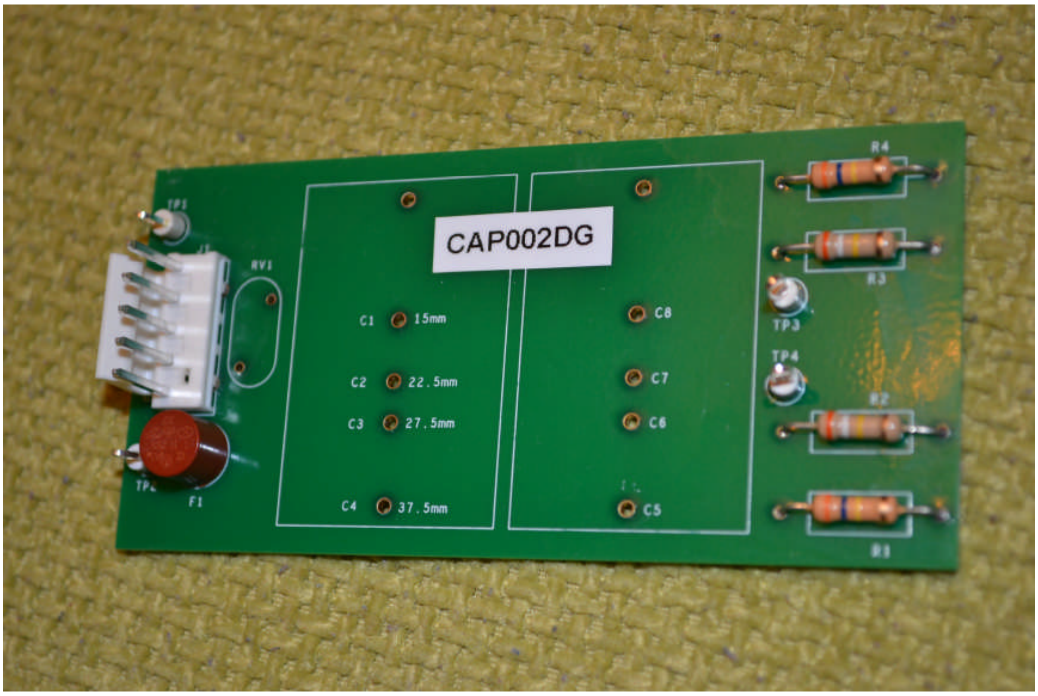
Test board of CAP019DG



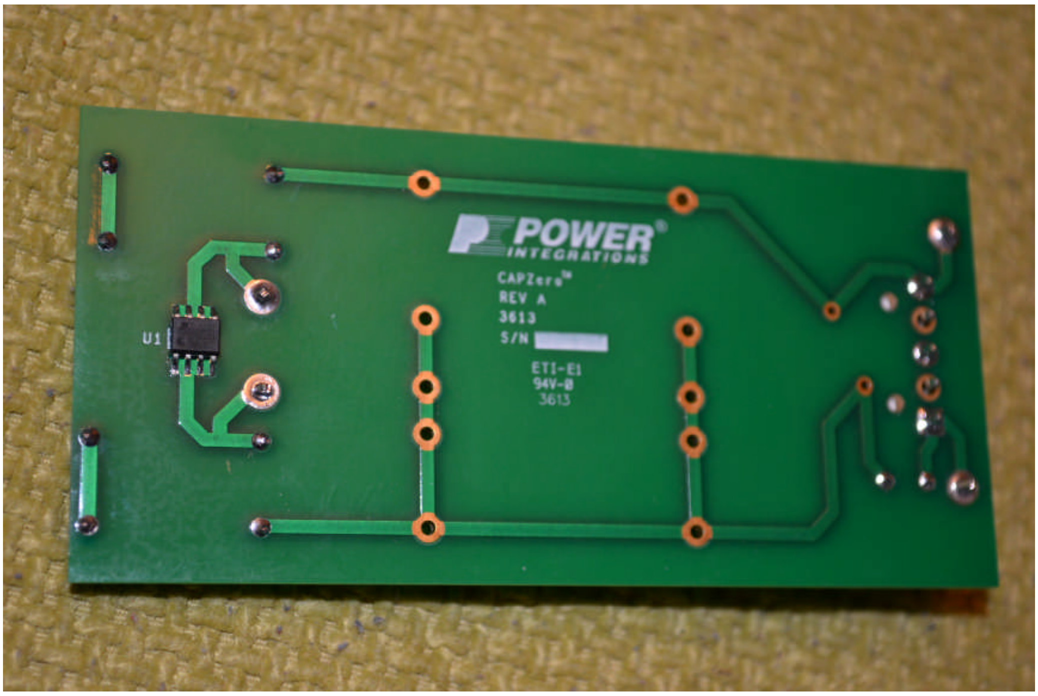
Test board of CAP019DG
(U1 = ICX)

Photos

Report No. 261294



Test board of CAP002DG



Test board of CAP002DG
(U1 = ICX)

Photos

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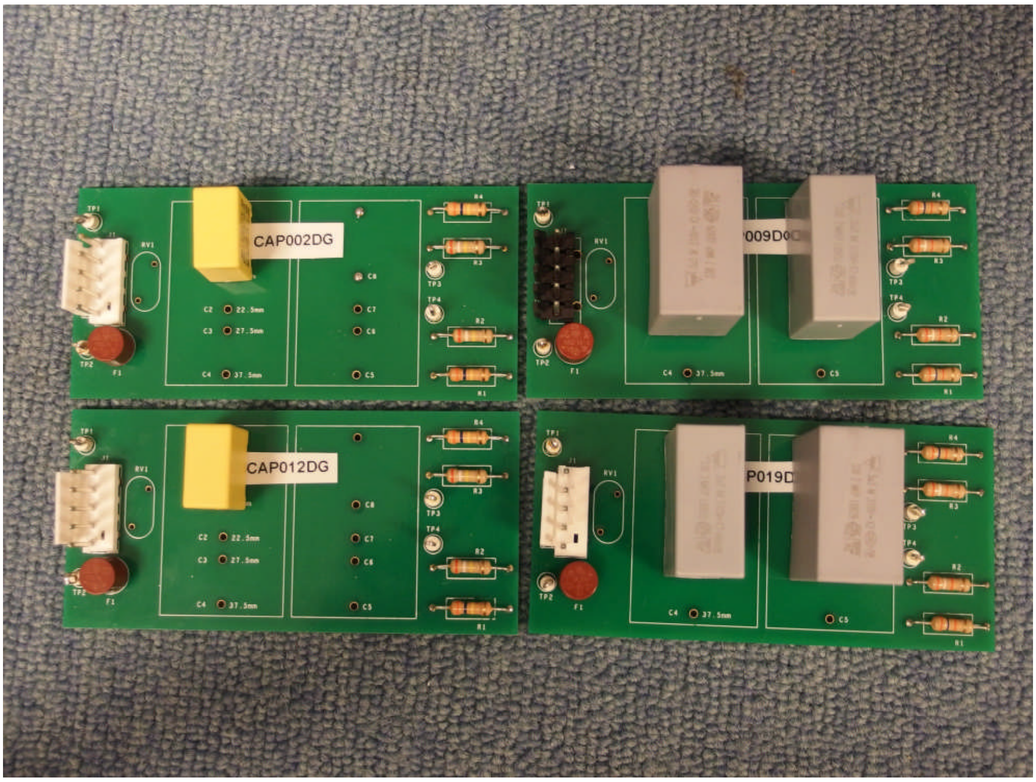
X-capacitors mounted during discharge tests:



Data sheet

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CAPZero™ Family

POWER INTEGRATIONS®

Zero[1] Loss Automatic X Capacitor Discharge IC

Product Highlights

- Blocks current through X capacitor discharge resistors when AC voltage is connected
- Automatically discharges X capacitors through discharge resistors when AC is disconnected
- Simplifies EMI filter design – larger X capacitor allows smaller inductive components with no change in consumption
- Only two terminals – meets safety standards for use before or after system input fuse
- >4 mm creepage on package and PCB
- Self supplied – no external bias required
- High common mode surge immunity – no external ground connection
- High differential surge withstand – 1000 V internal MOSFETs

EcoSmart® – Energy Efficient

- <5 mW consumption at 230 VAC for all X capacitor values

Applications

- All ACDC converters with X capacitors >100 nF
- Appliances requiring EuP Lot 6 compliance
- Adapters requiring ultra low no-load consumption
- All converters requiring very low standby power

Description

When AC voltage is applied, CAPZero blocks current flow in the X capacitor safety discharge resistors, reducing the power loss to less than 5 mW, or essentially zero[1] at 230 VAC. When AC voltage is disconnected, CAPZero automatically discharges the X capacitor by connecting the series discharge resistors. This operation allows total flexibility in the choice of the X capacitor to optimize differential mode EMI filtering and reduce inductor costs, with no change in power consumption.

Designing with CAPZero is simply a matter of selecting the appropriate CAPZero device and external resistor values in Table 1 for the X capacitor value being used. This design choice will provide a worst case RC time constant, when the AC supply is disconnected, of less than 1 second as required by international safety standards.

The simplicity and ruggedness of the two terminal CAPZero IC makes it an ideal choice in systems designed to meet EuP Lot 6 requirements.

The CAPZero family has two voltage grades: 825 V and 1000 V. The voltage rating required depends on surge requirement and circuit configuration of the application. See Key Applications Considerations section for details.

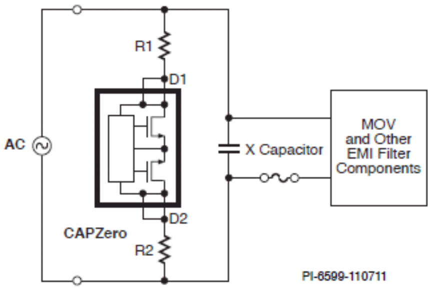

Figure 1. Typical Application – Not a Simplified Circuit.

Component Selection Table

Product[3]	BV_{DSS}	Maximum Total X Capacitance	Total Series Resistance[2] (R1 + R2)
CAP002DG	825 V	≤ 500 nF	1.5 MΩ
CAP012DG	1000 V		
CAP003DG	825 V	750 nF	1.02 MΩ
CAP013DG	1000 V		
CAP004DG	825 V	1 μF	780 kΩ
CAP014DG	1000 V		
CAP005DG	825 V	1.5 μF	480 kΩ
CAP015DG	1000 V		
CAP006DG	825 V	2 μF	360 kΩ
CAP016DG	1000 V		
CAP007DG	825 V	2.5 μF	300 kΩ
CAP017DG	1000 V		
CAP008DG	825 V	3.5 μF	200 kΩ
CAP018DG	1000 V		
CAP009DG	825 V	5 μF	150 kΩ
CAP019DG	1000 V		

Table 1. Component Selection Table.

Notes:
1. IEC 62301 clause 4.5 rounds standby power use below 5 mW to zero.
2. Values are nominal. RC time constant is <1 second with ±20% X capacitor and ±5% resistance from these nominal values.
3. Packages: D: SO-8.

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Pin Functional Description

The pin configuration of Figure 2 ensures that the width of the SO-8 package is used to provide creepage and clearance distance of over 4 mm.

Although electrical connections are only made to pins 2, 3, 6 and 7, it is recommended that pins 1-4 and pins 5-8 are coupled together on the PCB – see Applications Section.

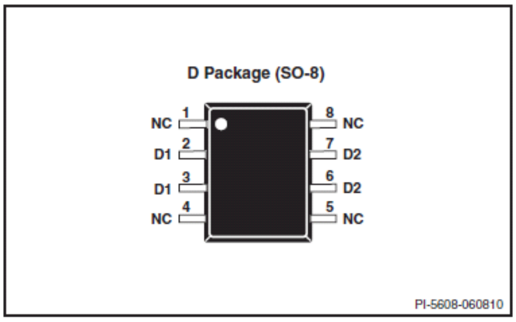

Figure 2. Pin Configuration.

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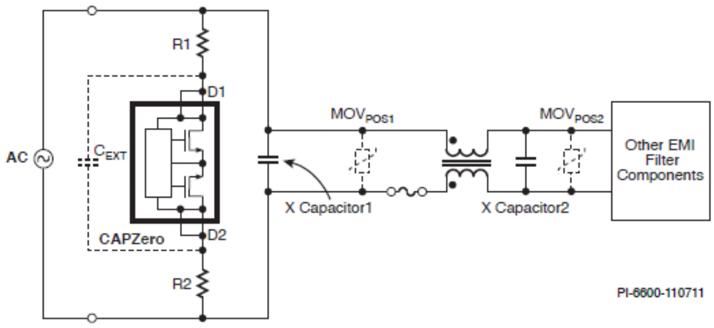

Figure 3. Placement Options of MOV and C_{EXT}.

Key Application Considerations

Breakdown Voltage Selection

Figure 3 illustrates possible system configurations influencing the choice of CAPZero breakdown voltage. The system configuration variables include the placement of the system MOV and X capacitor(s) as well as the differential surge voltage specifications of the application.

As shown in Table 1, each device in the CAPZero family has a 825 V or 1000 V option. For applications where the system MOV is placed in position 1 (MOV_{POS1} in Figure 3), the 825 V option will typically provide adequate voltage withstand for surge requirements up to 3 kV or more. The 1 kV CAPZero would be recommended for higher surge requirements or if additional voltage margin is required.

For MOV placement that is not directly across the X Capacitor1 (for example MOV_{POS2} in Figure 3) the 1000 V CAPZero devices can be used up to a surge specification of 1.5 kV. For differential surge voltage specifications of >1.5 kV it is recommended that the MOV is always placed in the location shown in Figure 3 as MOV_{POS1}.

It is always recommended that the peak voltage between terminals D1 and D2 of CAPZero is measured during surge tests in the final system. Measurements of peak voltage across CAPZero during surge tests should be made with oscilloscope probes having appropriate voltage rating and using an isolated supply to the oscilloscope to avoid ground currents influencing measurement results. When making such measurements, it is recommended that 50 V engineering margin is allowed below the breakdown voltage specification (for example 950 V with the 1000 V CAPZero).

If the measured peak Drain voltage exceeds 950 V, an external 1 kV ceramic capacitor of value up to 47 pF can also be placed between D1 and D2 terminals to attenuate the voltage applied between the CAPZero terminals during surge. This optional external capacitor placement is shown as C_{EXT} in Figure 3. It should be noted that use of an external capacitor in this way will increase power consumption slightly due to the C_{EXT} charge/discharge currents flowing in R1 and R2 while AC is connected. A C_{EXT} value of 33 pF will add approximately 0.5 mW at 230 VAC, 50 Hz.

PCB Layout and External Resistor Selection

Figure 4 shows a typical PCB layout configuration for CAPZero. The external resistors in this case are divided into two separate surface mount resistors to distribute loss under fault conditions – for example where a short-circuit exists between CAPZero terminals D1 and D2. R1 and R2 values are selected according to Table 1.

Under a fault condition where CAPZero terminals D1 and D2 are shorted together, each resistor will dissipate a power that can be calculated from the applied AC voltage and the R1 and R2 values. For example in an application using CAP004 or CAP014, R1=R2=390 kΩ. If CAPZero is shorted out at 265 VAC R1 and R2 will each dissipate 45 mW.

Resistors R1 and R2 should also be rated for 50% of the system input voltage again to allow for the short-circuitry of CAPZero D1 to D2 pins during single point fault testing.

If lower dissipation or lower voltage across each resistor is required during fault tests, the total external resistance can be divided into more discrete resistors, however the total resistance must be equal to that specified in Table 1.

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CAPZero Family

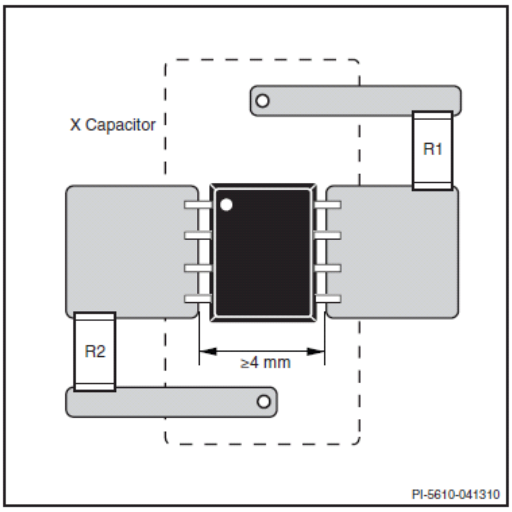

Figure 4. Typical PCB Layout.

Safety

CAPZero meets safety requirements even if placed before the system input fuse. If a short-circuit is placed between D1 and D2 terminals of CAPZero, the system is identical to existing systems where CAPZero is not used.

With regard to open circuit tests, it is not possible to create a fault condition through a single pin fault (for example lifted pin test) since there are two pins connected to each of D1 and D2. If several pins are lifted to create an open circuit, the condition is identical to an open circuit X capacitor discharge resistor in existing systems where CAPZero is not used. If redundancy against open circuit faults is required, two CAPZero and R1 / R2 configurations can be placed in parallel.

Discharge Operation

To meet the safety regulations, when the AC supply is disconnected, CAPZero will discharge the X capacitor to the safety extra low voltage (SELV) levels according to the above functional description. Although there are no specific safety requirements below SELV, CAPZero still continues the discharge until the X capacitor is fully discharged. As such CAPZero can be safely used at low input voltages such as the common industrial 18 VAC and 24 VAC supply rails while retaining X capacitor discharge when the AC source is disconnected.

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Absolute Maximum Ratings[4]

DRAIN Pin Voltage[1] CAP002-CAP009 ....825 V
CAP012-CAP019 ....1000 V
DRAIN Peak Current[2] CAP002/CAP012 .... 0.553 mA
CAP003/CAP013 ....0.784 mA
CAP004/CAP014 ....1.026 mA
CAP005/CAP015 ....1.667 mA
CAP006/CAP016 .... 2.222 mA
CAP007/CAP017.....................2.667 mA
CAP008/CAP018 .... 4.000 mA
CAP009/CAP019 .... 5.333 mA
Storage Temperature .... -65 °C to 150 °C
Lead Temperature[3]...260 °C
Operating Ambient Temperature..................... -10 °C to 105 °C
Maximum Junction Temperature..................... -10 °C to 110 °C

Notes:
1. Voltage of D1 pin relative to D2 pin in either polarity.
2. The peak DRAIN current is allowed while the DRAIN voltage is simultaneously less than 400 V.
3. 1/16 in. from case for 5 seconds.
4. The Absolute Maximum Ratings specified may be applied one at a time without causing permanent damage to the product. Exposure to Absolute Maximum Rating conditions for extended periods of time may affect product reliability.

Parameter	Symbol	Conditions T_A = -10 to 105 °C (Unless Otherwise Specified)	Min	Typ	Max	Units
Control Functions						
AC Removal Detection Time	t_{DETECT}	Line Cycle Frequency 47-63 Hz		22	31.4	ms
Drain Saturation Current[A,B]	I_{DSAT}	CAP002/012	0.25			mA
		CAP003/013	0.37			
		CAP004/014	0.48			
		CAP005/015	0.78			
		CAP006/016	1.04			
		CAP007/017	1.25			
		CAP008/018	1.88			
		CAP009/019	2.5			
Supply Current	I_{SUPPLY}	T_A = 25 °C			21.7	μA

Notes
A. Saturation current specifications ensure a natural RC discharge characteristic at all voltages up to 265 VAC pk with the external resistor values specified in Component Selection Table 1.
B. Specifications are guaranteed by characterization and design.

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Typical Performance Characteristics

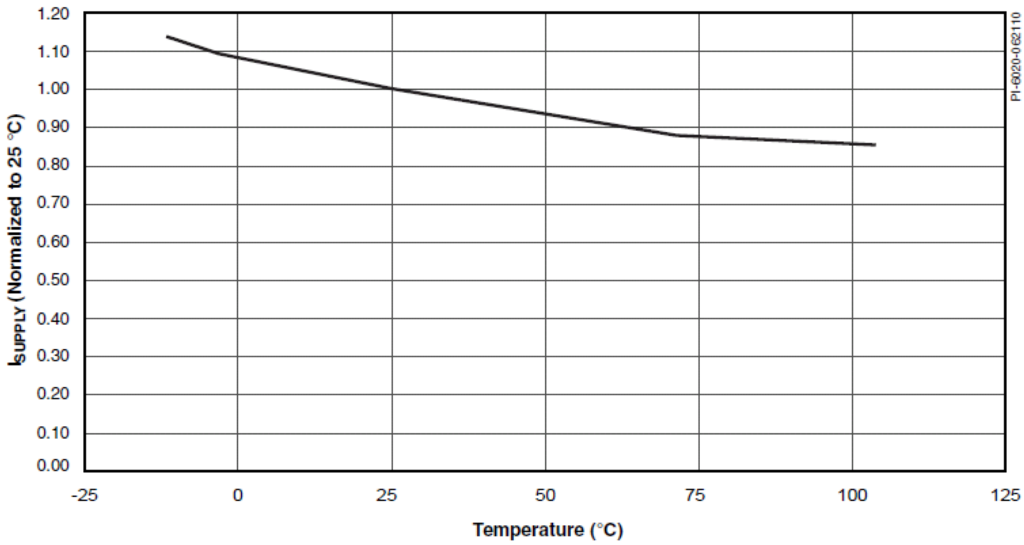

Figure 5. I_{SUPPLY} vs. Temperature.

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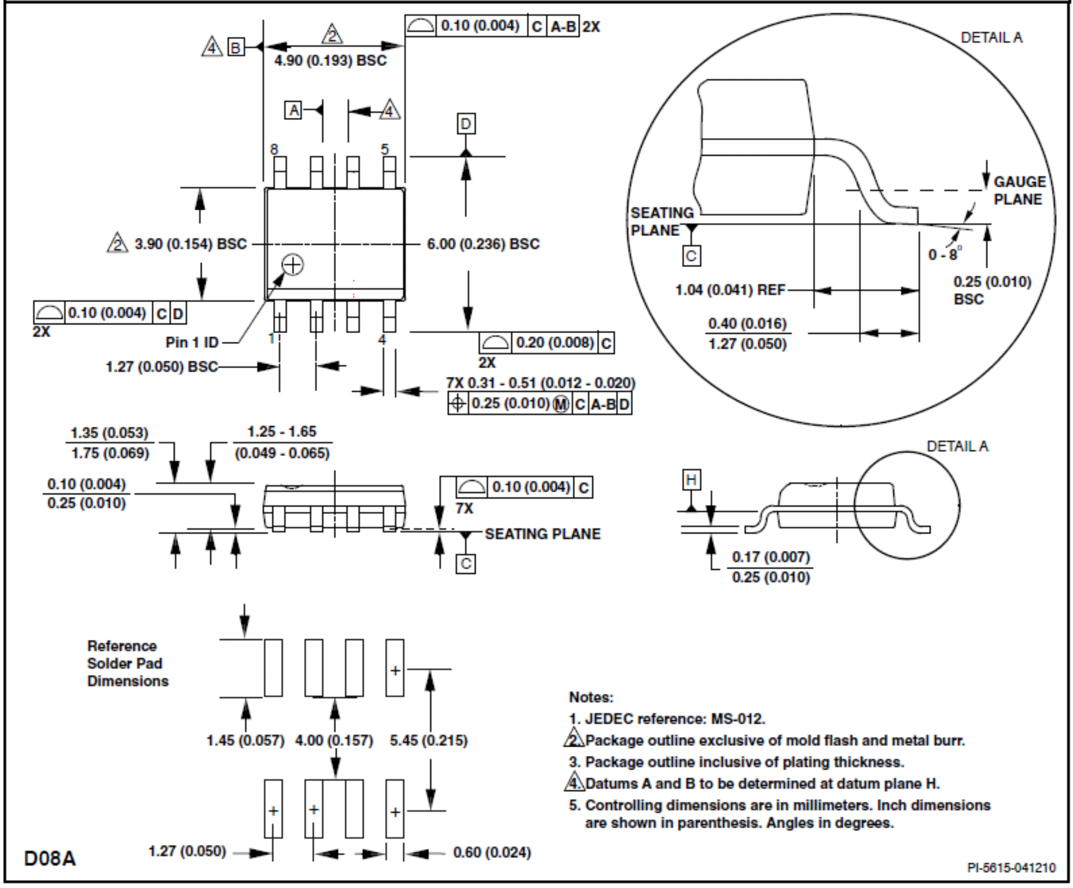
SO-8 (D Package)



Notes:

1. JEDEC reference: MS-012.
2. Package outline exclusive of mold flash and metal burr.
3. Package outline inclusive of plating thickness.
4. Datums A and B to be determined at datum plane H.
5. Controlling dimensions are in millimeters. Inch dimensions are shown in parenthesis. Angles in degrees.

Part Ordering Information

- CAPZero Product Family
- 002 Series Number
- Package Identifier
  - D | Plastic SO-8
- Package Material
  - G | GREEN: Halogen Free and RoHS Compliant
- Tape & Reel and Other Options
  - Blank | Standard Configurations
  - TL | Tape & Reel, 2.5 k pcs.

CAP 002 D G - TL

Data sheet

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Revision	Notes	Date
A	Code A release.	04/14/10
B	Updated I_{SUPPLY} condition. Added figure 5. Parameter T_{DETECT} was updated.	06/08/10
C	Updated Table 1. Updated Note 1 in Table 1. Added "Discharge Operation" paragraph. Updated Absolute Maximum Ratings Table.	02/11
C	Added Maximum Junction Temperature specification.	04/11
D	Updated Figures 1 and 3.	11/07/11

For the latest updates, visit our website: www.powerint.com

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Application note

Report No. 261294

Application Note AN-48
CAPZero™ Family

Design Considerations

Introduction

CAPZero is a family of self powered ICs designed to reduce the losses associated with the input filter capacitor discharge resistors when the AC voltage is present. Designed to be connected in series with existing discharge resistors each CAPZero device contains an integrated loss of AC detector and back-to-back MOSFETs in an SO-8 package.

When the AC input voltage is present, CAPZero remains in an OFF state, blocking current flow in the discharge path and eliminating power losses. When the AC is removed the CAPZero turns on, thereby switching in the resistors and allowing discharge of the input filter capacitance. CAPZero is self powered from the AC line with a power consumption of less than 5 mW at 230 VAC.

Given the small footprint of the package, it is possible to place the CAPZero IC on the bottom side of the printed circuit board (PCB) directly beneath the X capacitor. This eliminates the need for a major redesign of the PCB allowing existing designs to quickly benefit from reduced power consumption.

Background

Applications that contain off-line switching power electronics, for example motor drives, domestic appliances, industrial equipment and power supplies in general, have high voltage and high current switching waveforms that generate Electro Magnetic Interference (EMI).

To reduce this electro magnetic interference (EMI) a filter stage is included at the AC input (Figure 1). As part of this filter, capacitors are commonly placed directly across the AC input terminals to reduce differential mode EMI. Due to their location safety agency recognized X class capacitors are typically selected. X capacitors are rated to withstand the line surges that appear across the AC line with the numerical suffix indicating the specific voltage rating (X1, X2 or X3).

As the capacitor appears across the input terminals a voltage, up the peak of the incoming AC, can appear across the input prongs of the AC plug. This could potentially cause an electric shock to the user if touched or sparks should the prongs of the AC plug be shorted.

To prevent these risks once the supply is unplugged, safety agencies mandate that capacitance values above 100 nF be discharged automatically with a time constant of <1 second. Typically this is achieved by placing discharge resistors directly across the capacitor. The value of the resistance is selected to meet the 1 second time constant requirement and two resistors are usually connected in series to meet safety agency single point failure testing. Should one resistor become shorted then the presence of the second prevents a short circuit across the AC input.

The presence of discharge resistors results in a constant power loss while AC is applied. With more stringent no-load and standby input power requirements, this power loss has become a significant portion of the overall power budget. For example, a power supply that uses a capacitance of 1 μF across the incoming AC will require a maximum discharge resistance value of 1 MΩ which dissipates 53 mW at 230 VAC independent of the output load. Figure 2 shows typical dissipation in the discharge resistors as a function of the X capacitor value with a 0.75 second RC time constant. The value of 0.75 seconds provides margin to account for capacitor and resistor tolerances such that the maximum time constant is <1 second.

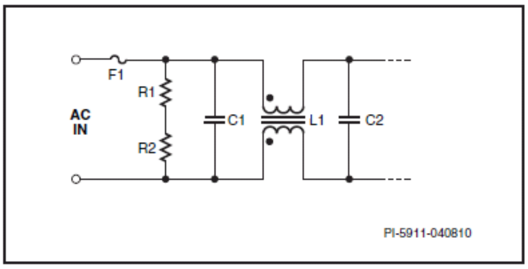

Figure 1. Example EMI Filter Stage of a Switching Power Converter Using Two X Class Capacitors (C1, C2) and Discharge Resistors (R1, R2).

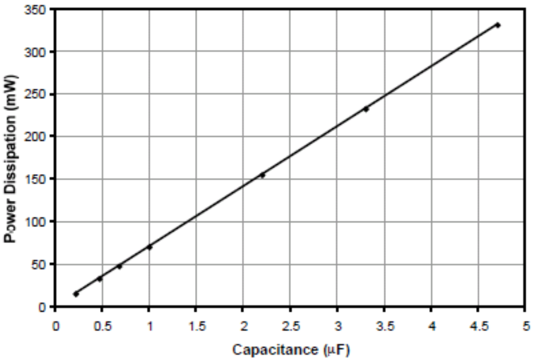

Figure 2. Losses in X Capacitor Discharge Resistors vs Line Voltage. Data Plotted for RC Time Constant of 0.75 Seconds.

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Quick Start

Step – 1 Selecting the Correct CAPZero Device Size and Discharge Resistor Value

Select CAPZero device and discharge resistors from Table 1 based on the total input stage capacitance. Table 1 accounts for 5% tolerance of resistors and a 20% tolerance of the total capacitance by using a RC time constant of 0.75 seconds.

Component Selection Table

Product	BV_{DSS}	Max Total X Capacitance	Total Series Resistance (R1 + R2)
CAP002DG	825 V	500 nF	1.5 MΩ
CAP012DG	1000 V		
CAP003DG	825 V	750 nF	1.02 MΩ
CAP013DG	1000 V		
CAP004DG	825 V	1 µF	780 kΩ
CAP014DG	1000 V		
CAP005DG	825 V	1.5 µF	480 kΩ
CAP015DG	1000 V		
CAP006DG	825 V	2 µF	360 kΩ
CAP016DG	1000 V		
CAP007DG	825 V	2.5 µF	300 kΩ
CAP017DG	1000 V		
CAP008DG	825 V	3.5 µF	200 kΩ
CAP018DG	1000 V		
CAP009DG	825 V	5 µF	150 kΩ
CAP019DG	1000 V		

Table 1. Component Selection Table.

Step 2 – Selecting the Appropriate CAPZero Voltage Rating

CAPZero is available in two voltage ratings, 825 V and 1 kV. The 825 V rating is ideal for most consumer applications with Metal Oxide Varistor (MOV) located in position 1 (see Figure 5 for MOV_{POS1}), where the differential line surge requirement is up to 3 kV. CAPZero devices with a 1 kV rating are applicable for <1 kV level without MOV, and for >3 kV with MOV at position 1 together with an optional external ceramic capacitor C_{EXT} to lower the surge stress voltage. For applications with no MOV for >1 kV and up to 3 kV level, either a 825 V or 1 kV rated part can be used depending on measured surge voltage across the CAPZero together with an external ceramic capacitor C_{EXT} of up to 47 pF.

Differential Mode	CAPZero Voltage			Comments
	MOV_{POS1}	MOV_{POS2}	No MOV	
<1 kV	825 V		1000 V	C_{EXT} up to 47 pF, 1 kV increases Drain voltage margin
1 to 1.5 kV	825 V	1000 V	825 V or 1000 V with C_{EXT}	
1.5 to 3 kV	825 V	825 V or 1000 V with C_{EXT}		
>3 kV	825 V or 1000 V + C_{EXT} (option)	Not Recommended		

Table 2. Selection of CAPZero Voltage Ratings vs Differential Surge Withstand Requirement. See Figure 5 for MOV position.

Tips for Design

Recommended Circuit Locations for CAPZero

For differential surge levels above 1 kV the use of a MOV is recommended. The presence of the MOV substantially reduces the voltage stress on both the X capacitor as well as the CAPZero. This can be seen from Figure 3 which shows the maximum voltage across the CAPZero device with differential surge voltages ranging from 1 kV to 3 kV.

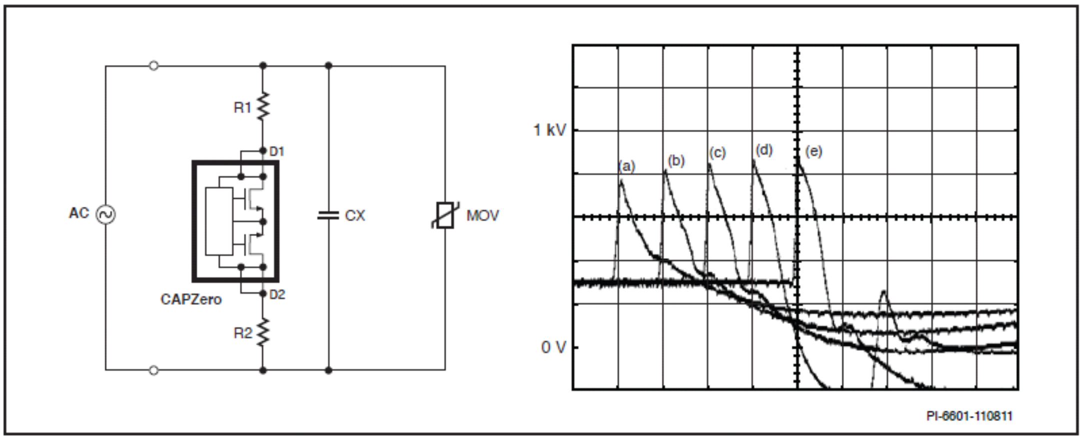

Figure 3. Recommended Position of CAPZero for a Single Stage EMI Filter. Waveforms Show Peak Voltage Across CAPZero in Presence of MOV. 200 V / Division and Time Base = 50 µs / div. Waveforms (a) Through (e) Represent Voltage Measured Across the CAPZero Device Under Differential Mode Input Surge Voltages of 1, 1.5, 2, 2.5 and 3 kV Respectively. MOV Used was 14 mm 275 VAC.

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As large currents flow through the MOV when it is clamping there can be significant voltage drops across filter components in the input stage. Therefore it is recommended that the CAPZero be located close to the MOV to minimize the voltage across the device during differential surge events. For designs where the MOV is placed at the input side of the power supply (Figure 3), before any inductive filter components, the CAPZero can be placed directly underneath the X capacitor. For designs where the MOV is placed after a common-mode choke, differential choke or other EMI filter components (Figure 4), it is recommended that if possible the CAPZero also be placed after the common mode choke and be physically close to the MOV allowing the 825 V device to be used up to 3 kV differential surge. If CAPZero cannot be placed after the common mode choke, the 1000 V device is recommended up to a surge level of 1.5 kV. For surge levels greater than 1.5 kV, it is always recommended to have the MOV located on the same side of the common-mode choke as the CAPZero.

One exception is if the X capacitor is on the AC input side of a system input fuse. In these cases if the X capacitor is greater than 100 nF, to meet safety requirements, the CAPZero must typically also be placed before the system input fuse directly across the X capacitor and voltage ratings. CAPZero is designed to meet safety requirements in this position – see 'Safety Considerations' section below.

Adding an External Parallel Capacitor to Reduce CAPZero Voltage Stress

While the use of a MOV is recommended, an external capacitor C_{EXT} (Figure 5) may be placed across the CAPZero to reduce surge voltage stress and may be sufficient in some design. This capacitor does not have to be an X class type, since it is not directly placed across the AC input terminals, but should be rated at or above the CAPZero being used. Figure 6 shows the effect of adding external capacitance directly across a CAPZero device in a design without a MOV. With no external capacitor at

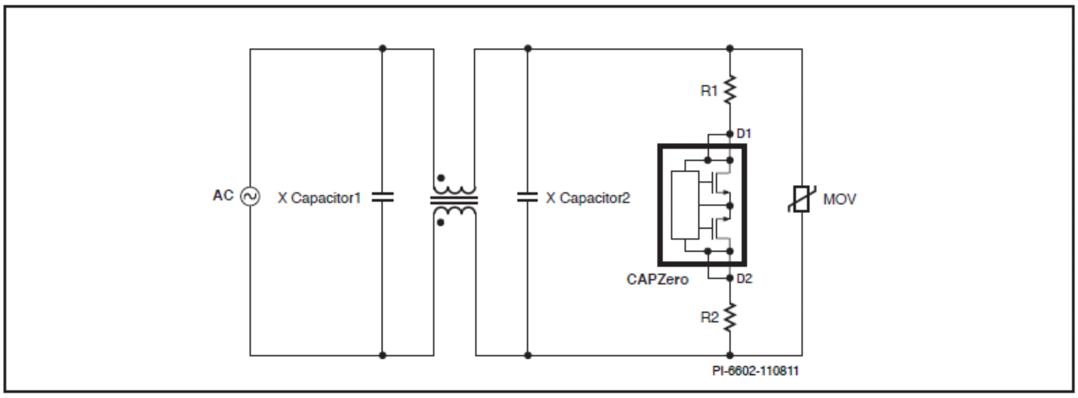

Figure 4. Recommended Location of CAPZero for a Two Stage EMI Filter With a MOV Located After Input Common Mode Choke.

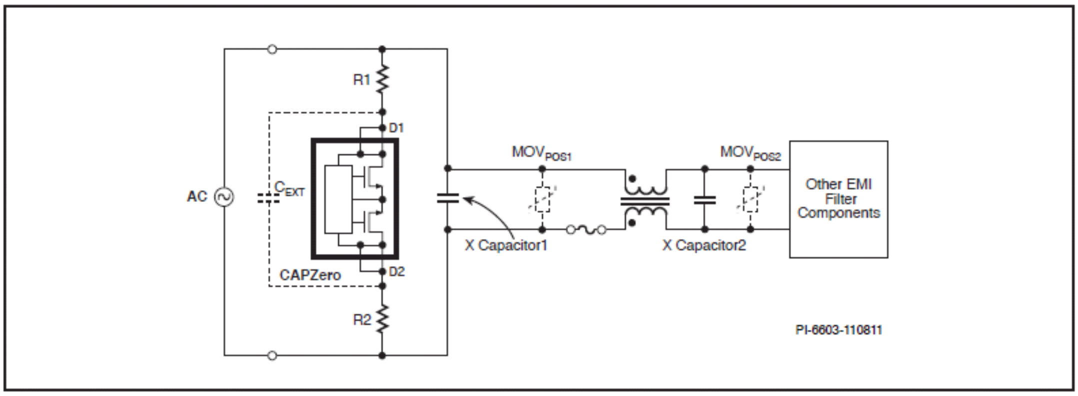

Figure 5. The Addition of an External Capacitor Across the CAPZero can Reduce Voltage Stress Across the Device During a Surge Event.

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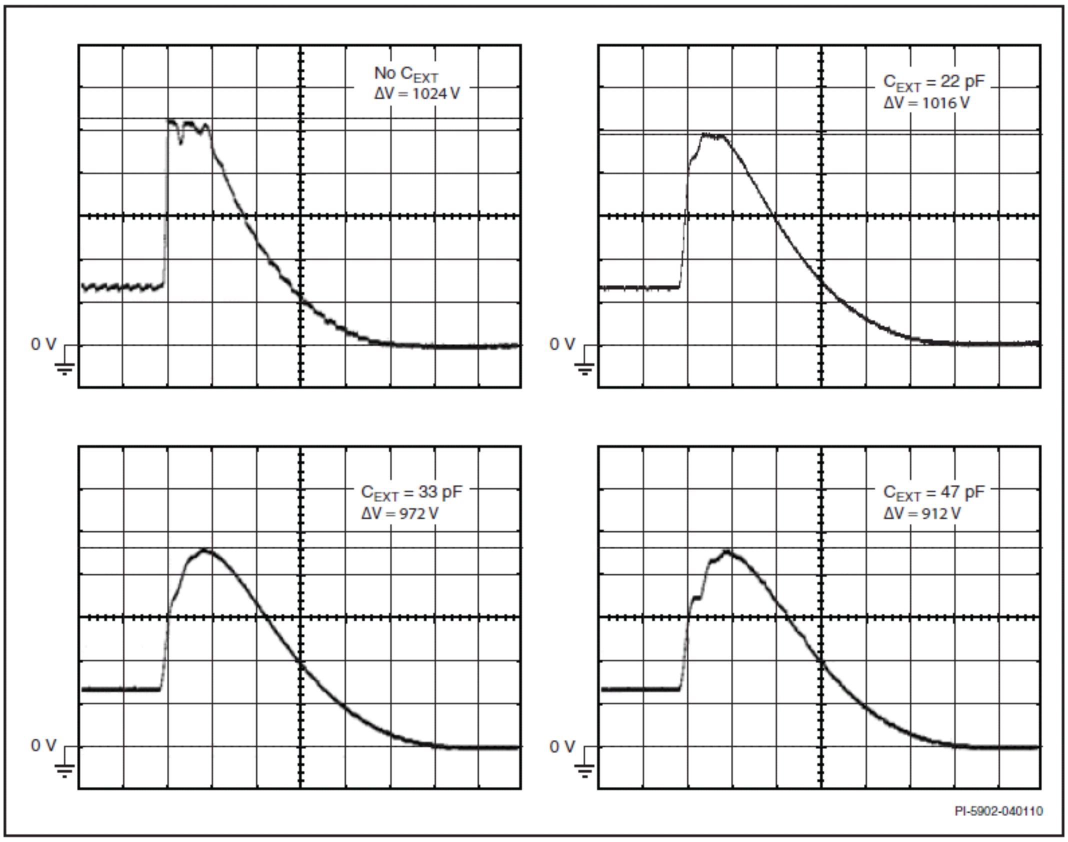

Figure 6. External Capacitor Placed Across CAPZero May Reduce Peak Voltage During Surge Event. No MOV present, 1.5 kV surge. 200 V / div., Time Base = 50 µs / div.

a 1.5 kV surge level, the CAPZero device exceeds its BV_{DSS} rating however as the value of C_{EXT} is increased to voltage level reduces.

Recommended values of C_{EXT} are between 22 pF and 47 pF. The use of 47 pF capacitor is not recommended in applications where the ambient temperature is in excess of 85 °C. Values above 47 pF are not recommended.

The presence of the external capacitor can for example reduce the voltage stress on the CAPZero by up to 100 V with 2 x 390 kΩ external resistors (1 µF X capacitor) and 47 pF C_{EXT}. It should be also noted that the use of C_{EXT} will cause a slight increase in no load power consumption.

Measuring Device Voltage Stress

To measure the voltage stress across the CAPZero IC during differential line surge testing, it is recommended that the CAPZero be placed such that one terminal (D1 or D2) is connected to AC neutral. This reduces any effects due to common-mode noise. The area between the oscilloscope probe tip and the ground lead should be minimized. Finally it is necessary to float the oscilloscope or to use a battery powered oscilloscope while performing the surge tests. Please note that if using a floating scope proper care must be exercised as the scope chassis will assume high potential with respect to earth ground.

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Class	Differential Mode Surge	Common Mode Surge	Comments
	Z_{OUT} = 2 Ω	Z_{OUT} = 12 Ω	
1	No requirement	0.5 kV	Protected environment
2	0.5 kV	1 kV	Electrical environment where cables are well separated
3	1 kV	2 kV	Electrical environment where cables (power and electronic) run in parallel (residential environment)
4	2 kV	4 kV	Electrical environment where cables (power and electronic) run in parallel (industrial environment)
5	>2 kV	>4 kV	Severe surge environment (rural/sparsely populated areas)

Table 3. Surge Voltage Levels.

Ensure that the surge voltage measured across the CAPZero device is less than its BV_{DSS} rating.

Surge Severity

The severity of the surge signal is defined in the IEC61000-4-5 standard published by the International Electrotechnical Commission (IEC). The surge voltage levels are described in Table 3 depending on the operating environment of the power supply.

Certain applications may require surge levels higher than those described in Class 4. For surge voltages greater than 3 kV the use of external capacitors across the CAPZero will help reduce voltage stress across its terminals by a few hundreds of volts as discussed above. It should be noted that at higher surge voltages the energy involved is very high and the MOV should be appropriately selected to handle this excess energy. Varistors have a energy rating which should exceed the applied energy to the system to ensure that this energy can be safely absorbed by the MOV.

Use in DC Input Environments

Since CAPZero relies on detecting the AC voltage at the input, under DC input the CAPZero will remain on all the time. This is a perfectly acceptable mode of operation for CAPZero although this operation will remove any energy savings from the use of CAPZero.

Use with Uninterruptable Power Supplies (UPS)

UPS systems often have a pseudo square wave output waveform, which although AC in nature are not sinusoidal. CAPZero can accept this type of input waveform.

Safety Considerations and Single Point Failure Testing

As with all offline power supplies, all safety requirements must

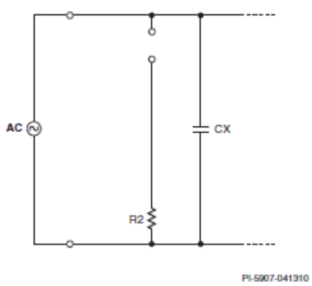
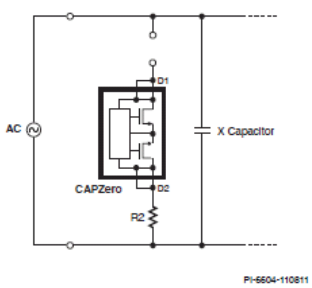
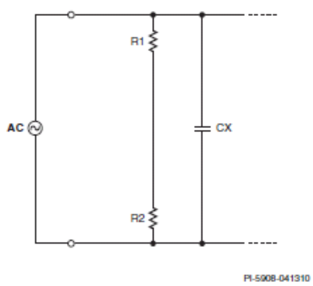
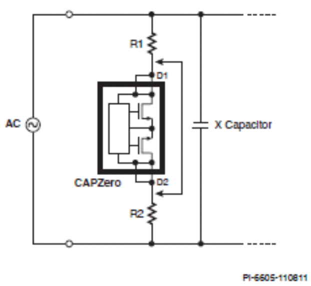
Test	Test With Existing System	CAPZero Equivalent	Comments
Open Circuit: Disconnect one pin of any device to see effect on system			Lifting any one pin of the CAPZero device has no effect as 2 pins are connected to each drain terminal. The only way to create an open circuit is by lifting the leads of one of the discharge resistors. This is therefore equivalent to existing system without CAPZero.
Short Circuit: Short any 2 adjacent pins to see effect on system			Shorting D1 and D2 pins creates a condition equivalent to an existing system not using CAPZero.

Table 4. Single Point of Failure (SPOF) Tests as Pertaining to Failure Modes of CAPZero. CAPZero Passes Both Tests.

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still be met when including CAPZero. To achieve this CAPZero has two dedicated pins for the D1 and D2 terminals which add redundancy during single point of failure testing (pin short / pin open testing). Thus if one pin is physically disconnected from the device or PCB, the IC will continue to function normally. During pin shorting the outcome is the same as if CAPZero had not been used and simply results in the discharge resistors being connected in series continuously; a safe condition. Table 4 summarizes the results of single point fault testing.

Accurate Measurement of No-load Input Power

X capacitors do not consume real power but they to cause a substantial reactive current to flow from the AC source. This reactive current leads to real power loss in the cables that connect the power supply to the AC source and power meter as shown in Figure 7. This cable loss can cause inaccurate measurements of no-load and light load input power. Normally the consumption of the discharge resistors is much larger as compared to this loss. However when CAPZero is used, and this loss is eliminated, the cable loss may become the most dominant component of no-load losses.

Also, at such low levels of input power, the leakage current of the MOV must also be considered. Typically this leakage current is approximately 10 µA and is large enough to increase no-load consumption by 1 – 2 mW at 265 VAC.

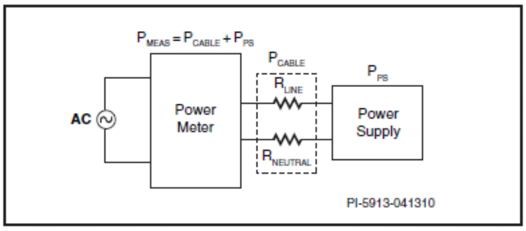

Figure 7. Measured Power can be Misleading Due to Significant RMS Current Resulting in Measurable Power Loss in Cables.

To measure the power consumption of a CAPZero IC, the X capacitor and the MOV (if used) should therefore be physically disconnected from the circuit.

Also ensure that the power meter is configured such that the current drawn by the voltage sensing element is not included in the measurement.

CAPZero Selection for Different X Capacitor Discharge Time Constants

In cases where a faster discharge time constant is required the curves of Figure 8 can be used to the select CAPZero for worst case discharge time constants and X capacitor values ranging

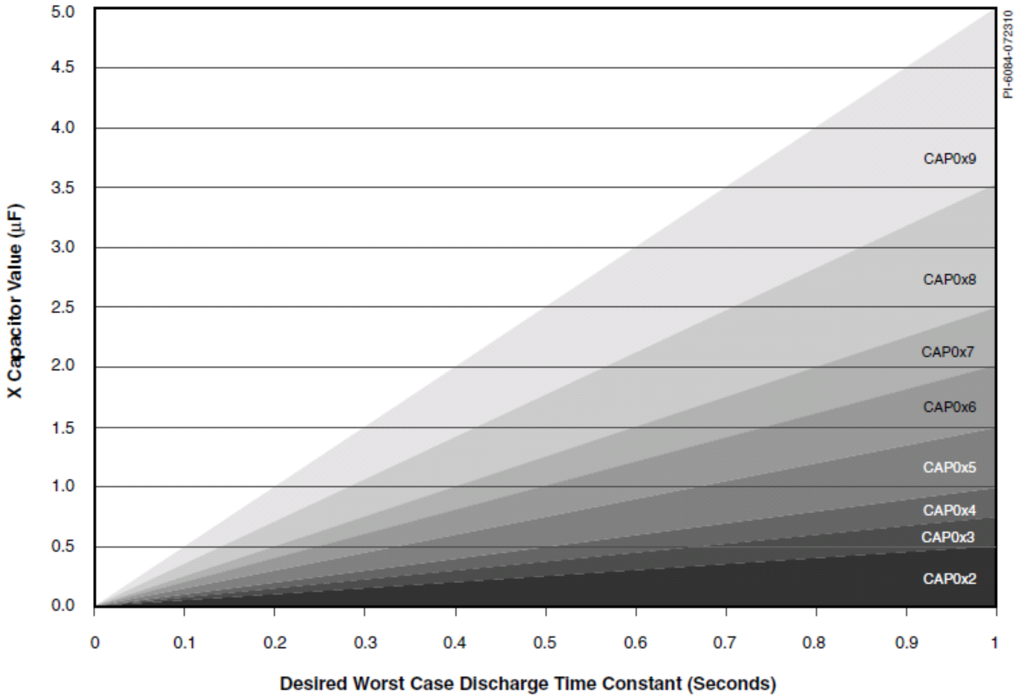

Figure 8. Required Worst Case Discharge Time Constant vs X Capacitor Value.

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from 0 to 5 uF. Although safety standards do not generally require discharge resistors for X capacitors values up to 100 nF, data to zero capacitance is included for completeness.

The use of the curves is best demonstrated by an example. Referring to Figure 9, an example is illustrated for a 680 nF X capacitor with a desired worst case discharge time constant of 0.5 seconds. The solid arrows illustrate how the intersection of the 680 nF (on Y axis) and 0.5 seconds (on X axis) provide the CAP0x5 as the correct device. The dotted lines shows the CAP0x3 recommendation as provided on the data sheet which assumes a worst case discharge time constant of 1 second.

The discharge resistor value can be determined from Table 1 based on the required CAPZero. In this example, the CAP0x5 external discharge resistance is 480 kΩ. This choice of external resistance will actually provide a worst case discharge time constant of about 0.45 seconds as illustrated by the dotted arrow in Figure 9. Since this has no impact on the power consumption, it is recommended to use the Table 1 resistor choice for simplicity.

Note that the Y axis of Figures 8 and 9 are the typical X capacitor value. However, the CAPZero recommendations allow for worst case X capacitor and discharge resistor tolerances to provide a worst case discharge time constant as shown on the X axis. Typical discharge time constants will be –30% lower than this.

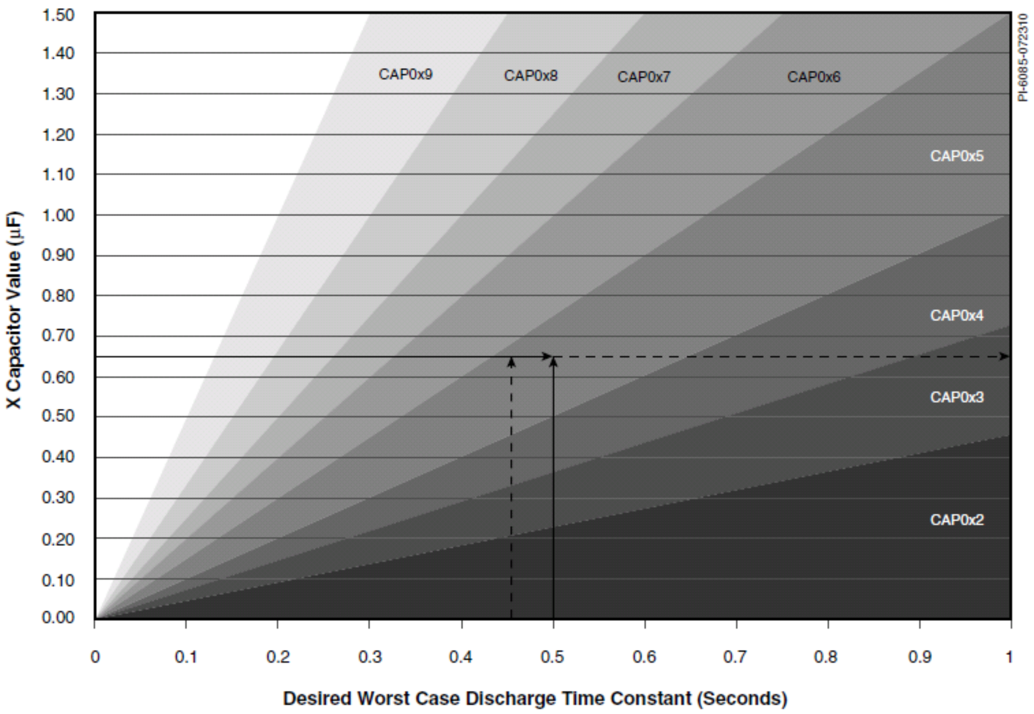

Figure 9. Magnified View of Figure 8 for 0 to 1.5 µF.

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Use of CAPZero for AC Line Voltage Zero-Crossing Detection

Any CAPZero can be used for AC line voltage zero-crossing detection when an AC voltage is present. At the same time it can be used as an X capacitor discharging circuit when the AC voltage is removed. The zero-crossing detection circuit uses CAPZero supply current with no additional power consumption in a non-isolated system (it consumes slightly more power when detector circuit is used in an isolated system).

A simple example of CAPZero used as a zero-crossing detector in a non-isolated application is shown in Figure 10. The zero-crossing signal is generated by a low voltage Zener diode (VR1) which is placed in between the CAPZero device and the AC neutral. The voltage across the Zener is used to drive a small signal MOSFET thereby obtaining the zero crossing signal. Figure 11 shows an example where the zero crossing detection circuit is required with isolation from the input line. While the concept of generating the signal remains the same, an opto-coupler and a bias supply are required for isolation.

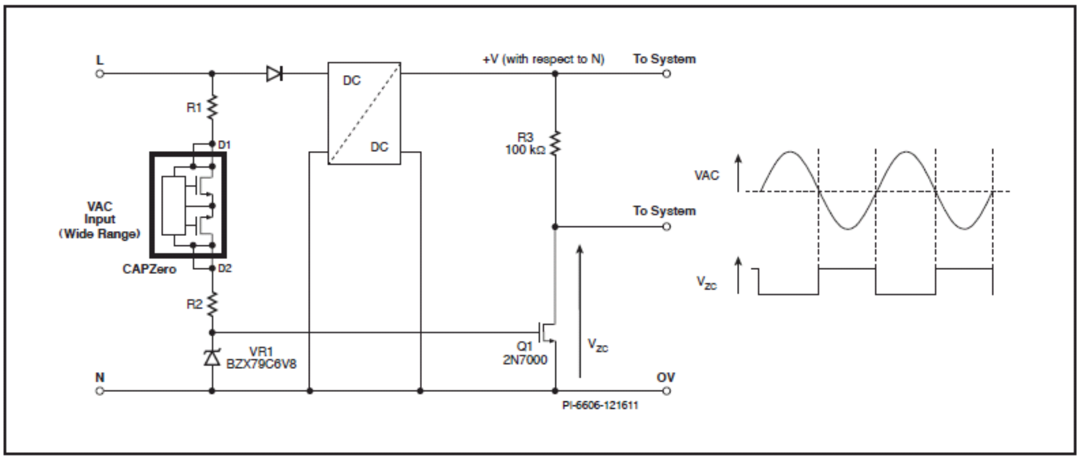

Figure 10. Example of CAPZero for AC Line Voltage Zero-Crossing Detection in a Non-Isolated System.

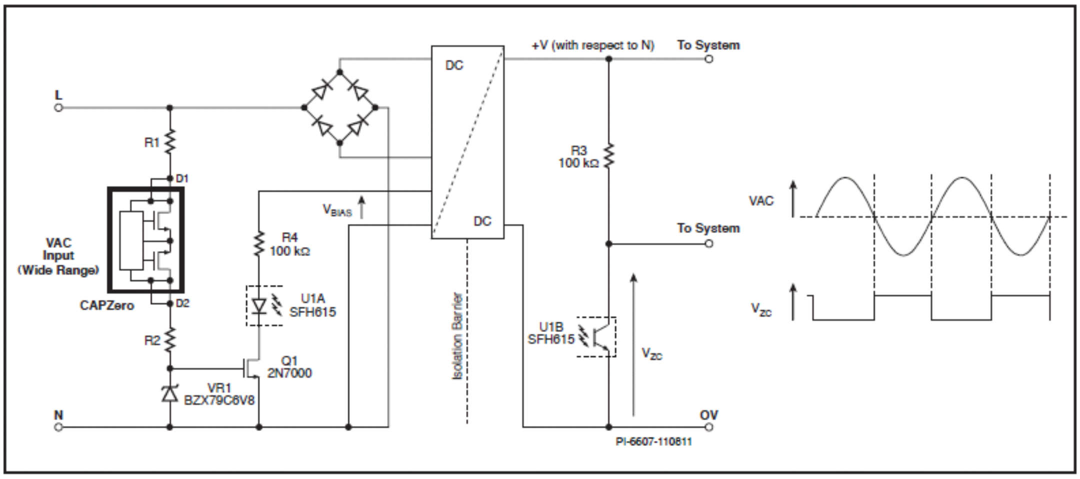

Figure 11. Example of CAPZero for AC Line Voltage Zero-Crossing Detection in an Isolated System.

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Revision	Notes	Date
A	Initial Release	04/14/10
B	Updated Surge Application Information. Added Discharge Resistor Selection Information.	07/28/10
C	Updated Step 2 paragraph and Table 2 on page 2.	9/28/10
D	Updated Figures 3, 4, 5 and Table 4. Added ZCD section.	12/16/11

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