Technical Requirements for Electronic Pet Training and Containment Collars

ECMA Electronic Collar Manufacturer's Association
Rev 6.0 10th April 2012

Table of contents

Revision History

Rev.	Date in Force	Changes
	2004	Original ECMA **Charter**: Defined electrical output limits of 100mA or 15mA r.m.s. without reference to the method of measurement. No value for the resistive load was quoted.
3.1	20-Aug-07	Working Draft to define test criteria.
3.2	20-Nov-07	Correction to measurement wiring and statement on invalid animals.
3.3	5-March-2008	Added an explanation of the limit shown in Figure 3. The limit of energy in a worst case second was changed from 2.0 to 2.5J to more closely follow the IEC. The wording of sections in 3.3 was changed to improve readability. Section numbers were corrected to show their logical order.
4.0	15-May-2008	Changed measurement of peak voltage and current to use RMS relative to the limits of current and pulse duration. This brings this document more in line with the IEC. Added to 4.1 clarifications that the training instruction may be provided in the form of a DVD or Cassette. This version includes all feedback to date from all ECMA members, and represents a fully ratified version within ECMA.
5.0	28-Feb-2010	Changed format and added references to the IEC standards 60335-1:2002 and 60335-2-76:2002+A1:2006

Revision History (continued)

Rev	Date in Force	Changes
6.0	**02-Apr-2012**	Reference IEC standard 60335-2-76, Household and similar electrical appliances – Safety – Part 2-76: Particular requirements for electric fence energizers. Edition 2.1, 2006-04 (IEC 60335-2-76:2002+A1:2006) (ISBN 2-8318-8579-5). For testing protocols. Reference IEC standard 60990 (Edition 2.0 1999-08) Methods of measurement of touch current and protective conductor current. Reference IEC standards 60479-1 (Edition 4.0 2005-07) Effects of current on human beings and livestock – Part 1: General aspects and 60479-2 (Edition 3.0 2007-05) Effects of current on human beings and livestock – Part 2: Special aspects. For electrical output limits. Reference IEC standard 60050-103-02-03 International Electrotechnical Vocabulary. Definition of RMS current for a given time interval. Addition and description of optimised resistive loads for assessment of energy output per single impulse duration. Addition and description of measurement of peak current output and define peak current output limit. Addition of requirement for devices not to make an automatic, sound prior to impulse discharge, this does not include tone. Addition of a defined 'off-period' in the electrical stimulation time-out. Reference to ECMA Code of Practice where appropriate. Record of chronological steps for the introduction of technical requirement revisions, grandfathering and latest compliance dates.

Introduction

The Electronic Collar Manufacturer's Association (ECMA) technical requirements are a voluntary product specific association standard. It makes reference to International Electrotechnical Commission (IEC) standards but it is not created nor endorsed by the IEC. The IEC documents referenced here, IEC 60335-2-76:2002+A1:2006, IEC 60990, IEC 60479-1, IEC 60479-2, IEC60050-103-02-03 are available from the IEC web store at http://webstore.iec.ch/

The technical requirements take into consideration the maximum electrical outputs necessary to achieve efficacy in training and establishes these as the limits. The limit is intended to achieve a balance between providing an electronic collar which will work in most reasonably applications, while not providing unnecessary output to be transferred to the animal. This ethical standard meets the ECMA stated objective:

> *To produce efficacious electronic collars which do not provide unnecessary electrical output that would be available to a person who may misuse a devise.*

The output limits in this standard are more stringent than those required for electrical safety described in IEC 60335-2-76:2002+A1:2006, IEC 60479-1 and IEC 60479-2.

Summary of Electrical Output Tests and Limits and Definitions

The test procedures are constructed with the intention of producing the worst/highest possible peak current, rms current and energy per second outputs from the devices under test. The test procedures are defined and resistive loads are adjusted in each situation to produce the worst/highest possible result. For a device to pass the technical requirement, its outputs must be below the limits for all of the outputs tested.

The test procedures use resistive test loads which represent the worst (of any value between 500Ω and 100kΩ) resistive loads likely to be encountered in the skin of a cat or dog between the dermal contacts which will produce the worst/highest possible output measurements.

Where a devise produces a range of possible single impulses or a range of different impulse cycles the technician must select the single impulses or impulse cycles which provide the worst/highest possible output measurements.

Summary definitions:

Optimised resistive load.

This is a resistive load which gives the worst measurement (of any value between 500Ω and 100kΩ) result in each assessment situation. The **optimised resistive load** may be different for the measurement of energy output per pulse for different devices. For this technical requirement measurement is taken across the entire optimised resistive load which is a deviation from IEC 60335-2-76:2002+A1:2006 standard load 3.118. where measurements are made across the 500Ω component of the standard load.

Single Impulse Duration.

This is defined as the shortest duration of time of a single impulse which contains 95% of its overall energy. This is the shortest interval of integration of $I^2\Delta(t)$ that gives 95% of the integration of $I^2\Delta(t)$ over the total impulse duration. Where variable single impulses are encountered within an electrical discharge from a devise, the impulse which gives the worst/highest result must be selected. This is compliant with IEC 60335-2-76:2002+A1:2006 impulse duration 3.116.

Impulse Cycle Period

This is the length of time in seconds that an impulse cycle takes to repeat itself from start to finish. Where variable impulse cycles are encountered within an electrical discharge from a devise, the impulse cycle which gives the worst/highest result must be selected. It includes both the time when current is flowing and the time when current is not flowing. Fig.89. If the impulse cycle does not repeat then the period is defined as being that of a **Single Impulse Duration**.

Summary electrical output tests and limits derived from:

- IEC 60990, Annex D (informative), Choice of current limits. D2. Choice of limits, indicates that for perception, and therefore pain, peak current is significant and for electrical burns rms current is important.

- IEC 60479-1, Figure 20 – Conventional time/current zones of effects of a.c. currents (15 Hz to 100 Hz) on persons for a current path corresponding to left hand to feet; Safety and animal welfare are assured by restricting electrical output to zones AC-1, AC-2 and AC-3.

- IEC 60479-2, Figure 22 – Conventional time/current zones of effects of d.c. currents on persons for a longitudinal upward current path; Safety and animal welfare are assured by restricting electrical output

to zones DC-1, DC-2 and DC-3.

1) Measurement of **RMS output current** (mA RMS) into fixed resistive load of 500Ω for an **impulse cycle period**. The limit for **RMS output current** limit into a fixed resistive load of 500Ω for an **impulse cycle period** is 30mA RMS. If the impulse cycle does not repeat then the period is defined as being that of a **Single Impulse Duration**.

2) Measurement of **energy output** (mJ) per **single impulse duration** into an **optimised resistive load**. The limit for **energy output** per **single impulse duration** into an **optimised resistive load** limit is 5mJ.

3) Measurement of **energy output per second** (mJ/S) into an **optimised resistive load**. Calculated by multiplying the **energy output** per **single impulse duration** into an **optimised resistive load**, from above, then multiplying it by the **highest number of impulses recorded in one second.** The limit for **energy output per second** (mJ/S) into an **optimised resistive load** is 500mJ/S.

4) Measurement of **peak current output** (mA) of a **single impulse duration** into fixed resistive load of 500Ω. The limit for **peak current output** (mA) of a **single impulse duration** into fixed resistive load of 500Ω is 150mA.

1.0) Scope

This point 1.0 of IEC 60335-2-76:2002+A1:2006 is *replaced* by the following.

This technical regulation deals with the safety of electronic training and containment **receiver collar** systems, intended for use with domestic animals and utilising static impulse electrical stimulation (ES) technology.

Examples of electronic collars that come within the scope of this standard:

- radio controlled electronic training **receiver collars**;
- electronic bark control **receiver collars**;
- electronic **receiver collars** associated with a radio perimeter containment system;
- electronic **receiver collars** associated with an area protection system;
- Transmitters and inductive based control sources for the electronic **receiver collars** mentioned above;
- systems mentioned above, including those powered from primary or rechargeable batteries or cells, as well as those powered directly from the AC mains.

2.0) Normative References

This point of 2.0 of IEC 60335-2-76:2002+A1:2006 is applicable**.**

3.0) Definitions

This point of IEC 60335-2-76:2002+A1:2006 is applicable except as follows:

3.1.1 *Addition:*

For electronic **receiver collars**, the **rated voltage** of the **receiver collar** is the **rated voltage** for the battery supply.

3.1.9 *Addition:*

For a containment transmitter the containment loop is simulated by a 30 Ω resistive load.

3.2.1 *Addition*

Oscilloscope (O-scope)

For the purpose of determining the output characteristics of the static pulse, an oscilloscope with a bandwidth of no less than 100MHz. As an alternative, the trace may be captured into test automation software and the calculation made external to the O-scope, however if this method is used, the software must be included in the test report for review. A mathematical estimation based on the general wave shape, a triangle for example, may be used; however measurement data will take precedence in cases of disagreement.

3.6.4 *Replacement:*

live part replace text with:

conductive part that may cause an electric shock, the **output dermal contacts** are not considered to be live parts when all requirements of this standard are met.

3.101 *Replacement:*

electric fence energiser replaced with titles and text:

> **receiver collar**
> appliance that is intended to deliver an electrostatic impulse(s) to an animal for the purpose of training the animal, or assisting in keeping an animal within an established boundary.
>
> **remote transmitter**
> different from a containment device, a **remote transmitter** produces an electrostatic impulse when authorised by remote control by the pet owner or dog trainer.

3.116 *Applies: but the term impulse duration is replaced with the term single impulse duration for clarity.*

single impulse duration
This section of IEC 60335-2-76:2002+A1:2006 applies and is referred to above in the summary definition as a **single impulse duration** for clarity. It is defined as:

> *Duration of that part of the impulse that contains 95% of the overall energy and is the shortest interval of integration of $I^2(t)$ that gives 95% of the integration of $I^2(t)$ over the total impulse.*
>
> *NOTE $I^2(t)$ is the impulse current as a function of time.*

3.117 *Deviation:*

RMS output current
This section of IEC 60335-2-76:2002+A1:2006 is amended. It is redefined by deriving from IEC 60050-103-02-02 as:

> *r.m.s. value of the output current calculated over the **impulse cycle period**.*

3.118 *Replacement of the term standard load with resistive test loads to include both fixed and optimized resistive loads.*

standard load is replaced by **resistive test loads** and replace text with:
The resistive test loads are potentially different for each of the electrical output parameters being assessed hence 3.118 is divided into 3.118.1 and 3.118.2. The resistive test loads must have sufficient voltage rating to adhere to the maximum voltage produced by the device under test.

3.118.1
Resistive test load for RMS output current and peak output current
This resistive load is a non-inductive resistor of 500Ω +/- 2.5Ω.

3.118.2
Resistive test load for energy output (mJ) known as an optimised resistive load.
This is a resistive load which gives the worst/highest measurement result in each assessment situation. For this technical requirement measurement is taken across the entire optimised resistive load which is a deviation from IEC 60335-2-76:2002+A1:2006 standard load 3.118.

The test shall be repeated and the load varied between 500 Ω and 100 kΩ to find worst/highest case output. The method of varying the load shall utilise fixed resistors. A bracketing technique may be employed to quickly determine the worst/highest case output point. The bracketing would involve starting at 500 Ω, then 100k Ω, then perhaps 30k Ω, then adjust the value of the resistor in the direction of

the maximum, using as many steps as are required. This process is continued until a load is found that yields the highest output and the load value is determined to within 10%. The final test load used, and the result, shall be recorded in the test report for **energy output**.

3.121 *Replacement*

electronic animal fence replace text with:
a virtual fence created by any method, including by electromagnetic coupling, utilising a **receiver collar** worn device to provide a containment or exclusion boundary via an electric pulse or series of pulses.

3.122 *Replacement*

electric security fence replaced with **output dermal contact** and replace text with:
the connection component that makes contact with the animal's skin, used to impart the stimulation impulse to the animal.

4.0) General requirement
This clause of Part 1 of IEC 60335-2-76:2002+A1:2006 is applicable.

5.0) General conditions for the tests
This clause of Part 1 of IEC 60335-2-76:2002+A1:2006 is applicable.

5.11.1 Conditioning of Test Sample *Addition, see also Annex B.*

5.11.2 Rechargeable Batteries
All electrical tests on battery operated equipment powered by a secondary or rechargeable battery shall be conducted using a fully charged battery following a conditioning cycle of 5 discharges and recharges. Charges/recharges shall be carried out using charging units supplied by the manufacturer. Discharges shall be from the receiver collars via a constant current draw.

The battery may be conditioned by removing it from the product and carrying out the discharge/recharge cycles at a rate not to exceed C/1, where C=capacity in AHr, or the maximum allowed by the battery specification, whichever is lower. The battery may be provided for test pre-conditioned by the manufacturer.

If regulated voltage is supplied to the static output circuit, then the battery conditioning is not required, in this case tests shall be conducted using a fully charged battery.

5.11.3 Primary Batteries

Electrical systems that utilise a primary or non-rechargeable battery type instead of a rechargeable battery, shall have electrical tests performed using a fresh, unused battery.

6.0) Classification

This clause of Part 1 of IEC 60335-2-76:2002+A1:2006 is applicable except as follows.

6.2 *Addition:*

Any component intended to be used or located permanently out of doors shall be of at least IPX4.

7.0) Marking and Instructions

This clause of IEC 60335-2-76:2002+A1:2006 is applicable except as follows:

7.12 *Addition:*

Instructions shall include the following or equivalent:

- Refer to the ECMA **Code of Practice** for the latest instructions.
- ES training products must only be used with animals which are greater than 6 months old, and never on invalid or injured animals without professional assistance;
- a description of pressure necrosis shall be included and advice regarding the avoidance of pressure necrosis shall be included. As shall recommendations that the collar is not worn continually, that the collar fit is checked regularly, and the animal's neck is checked often;
- training and guidance to the animal owner on the proper use of the training or containment system, to include a recommended training method for training the animal. This may include, but is not limited to, providing an educational book or CD to explain or demonstrate the proper techniques for training. Such information shall be provided in a format and language appropriate to the intended market.
- the packaging will carry information regarding the receiver collars maximum electrical output for **peak current output** (mA), **RMS output current** (mA rms) and **energy per second** (mJ/s).

8.0) Protection against access to live parts

This clause of IEC 60335-2-76:2002+A1:2006 is applicable except as follows:

8.1.4 *Addition:*

The **output dermal contacts** of the electronic collar are not considered to be a **live part**.

9.0) Starting of motor-operated appliances

This clause of IEC 60335-2-76:2002+A1:2006 is not applicable.

10.0) Power input and current

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

11.0) Heating

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

12.0) Void

13.0) Leakage current and electric strength at operating temperature

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

14.0) Transient overvoltages

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

15.0) Moisture resistance test

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

16.0) Leakage current and electric strength

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

17.0) Overload protection of transformers and associated circuits

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

18.0) Endurance

This clause of IEC 60335-2-76:2002+A1:2006 is not applicable.

19.0) Abnormal operation

This clause of IEC 60335-2-76:2002+A1:2006 is applicable except as follows:

19.101 Operation in the presence of electromagnetic fields

Testing to EN/IEC 61000-4-3 Immunity to RF fields shall be conducted at the 10V/m level with a 1 kHz 80% AM modulation applied.

In addition to the immunity required in EN/IEC 61000-4-3, a similar test shall

be carried out using a 1 kHz FM modulation with a deviation equal to the typical deviation of the DUT if the device uses FM modulation, if the device under test does not use FM modulation, then 10 kHz deviation shall be used on the test signal. The frequency range to investigate shall begin at a frequency equal to the lowest operating frequency minus 10x the operating bandwidth and continuing to a frequency equal to the highest frequency used plus 10 times the operating bandwidth.

During these test the **receiver collar** shall not produce an output impulse at any time when the unwanted signal is applied.

19.102 Remote transmitter and receiver collar codes
The activation code between the transmitter and receiver will be sufficiently rare to reduce the probability of inadvertent activation by another transmitter an extremely unlikely event.

20.0) Stability and mechanical hazards
This clause of IEC 60335-2-76:2002+A1:2006 is not applicable.

21.0) Mechanical strength
This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

22.0) Construction
This clause of IEC 60335-2-76:2002+A1:2006 is applicable except as follows.

22.46 Software used in protective circuits *Addition*
This clause of IEC 60335-2-76:2002+A1:2006 is applicable except as follows:

Software used to comply with 22.103 and 22.104 shall be considered class A for the purpose of this clause.

22.100 Output dermal contact profile *Replacement*
The tip of the output dermal contact with touches the skin shall be round in profile with a radius of curvature of not less than 1.5mm.

22.101 Spacing of output dermal contacts *Replacement*
Spacing between electronic collar dermal contacts, when measured from center to center, shall not exceed 60mm.

22.102 Nature of pulse current *Replacement*
Output shall be one impulse, or a series of impulses separated by off intervals. Impulse may be DC or AC in nature.

22.103 electrical stimulation output timeout *Replacement*

22.103.1 Stimulation period in a remote trainer shall be limited by an automatic timeout. The maximum stimulation time before automatic timeout functions take effect shall not exceed 10 seconds followed by an off period of at least 5 seconds. The system timeout function shall not reset until the receiver has ceased to receive the transmitted command.

22.103.2 Stimulation period in an electronic containment system shall be limited by an automatic timeout. The maximum stimulation time before automatic timeout functions take effect shall not exceed 15 seconds followed by an off period of no less than 5 seconds. The system shall provide a lock-out function that enables within no more than 60 seconds after stimulation initially begins and remains enabled until the collar is within the established boundary again before resuming normal operation. Alternatively, the maximum stimulation time before automatic timeout functions take effect shall not exceed 30 seconds followed by a lock-out function that remains enabled until the collar is within the established boundary again before resuming normal operation.

22.103.3 Stimulation period in a bark control collar shall be limited by an automatic timeout. Stimulation following a single bark event shall not exceed 2 seconds followed by a time off period of no less than 2 seconds.

(Exemption: 22.103 does not apply to tone only output)

22.104 Electronic collar output characteristics *Replacement*

when measured at the dermal contacts, the output shall be such that:

- the **single impulse duration** of a single impulse into a 500 Ω resistive load shall not exceed 10mS;

- the **RMS output current** as measured per 22.105 shall not exceed 30mA RMS

- the integral of the power over the worst/highest case **single impulse duration** into the worst case value (between 500 Ω and 100 kΩ) of the **optimised resistive load** for **energy output** per **single impulse duration** measured as per 22.105 shall not exceed 5 mJ;

- the integral of the power over the worst/highest case **single impulse duration** into the worst case value (between 500 Ω and 100 kΩ) of the **optimised resistive load** for energy output per impulse multiplied

by the **highest number of impulses** in a one second interval of operation, measured as per 22.105, shall not exceed 500 mJ/S.

- the **peak output current** for a **single impulse duration** into fixed resistive load of 500Ω, measured as 22.105, shall not exceed 150mA.

22.105 Output characteristic measurement method *Replacement*

The device under test is connected to:

i) a non inductive **resistive test load**;
ii) with a 1 Ω current shunt connected in series with the non-inductive restive load (i).

A high voltage scope probe is used to measure the voltage developed across the non-inductive **resistive test load** (i), while the voltage across the 1Ω load (ii), is used to provide current flow information. The high voltage scope probe shall have a high impedance (≥ 1MΩ) and an adequate bandwidth.

RMS Output current
an output current is measured across the **output dermal contacts** using a non-inductive, 500 Ω +/-2.5 Ω, resistive load as shown in Figure 90. The R.M.S. value shall be measured over an **impulse cycle period** without regard to the direction of current flow as shown in Figure 93.

Energy output per **single impulse duration**
energy per **single impulse duration** dissipated in the total **optimised resistive load** connected across the **output dermal contacts** is measured using the measuring arrangement illustrated in Figure 91. The **optimised resistive** load value is measured after it is adjusted to maximize the measured **energy output** per **single impulse duration**, the value of this optimised resistive load is measured and recorded. The **energy output** is measured over the **single impulse duration** without regard to the direction of current flow as shown in Figure 93.

Energy output per second
Energy output per second dissipated into the total **optimised resistive load** connected across the **output dermal contacts** is calculated using the **energy output** per **single impulse duration** (calculated above) multiplied by the **highest number of impulses in a one second** interval of operation. The value of this **optimised resistive load** is measured and recorded as is the **highest number of impulses in one second**.

Peak output current
is measured for a single impulse duration through a non-inductive, 500 Ω +/-2.5 Ω, resistive load connected across the **output dermal contacts** is

measured using the measuring arrangement illustrated in Figure 92.

22.106 variable electrical stimulation intensity levels *Replacement*

electronic collars shall have variable electrical stimulation intensity levels of correction to suit the needs of the animal and the situation.

(Exemption: Devices used exclusively for in an electronic animal fence or in a bark control collar are exempt from this requirement.)

22.107 automatic audible emission *Addition*

electronic collar receiver units must not make automatic audible emissions that could be perceived by a dog prior to an impending impulse discharge.

(Exemption: 22.107 does not apply to tone only output)

23.0) Internal wiring

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

24.0) Components

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

25.0) Supply connection and external flexible cords

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

26.0) Terminals for external conductors

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

27.0) Provision for earthing

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

28.0) Screws and connections

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

29.0) Clearances, creepage distances and solid insulation

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

30.0) Resistance to heat and fire

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

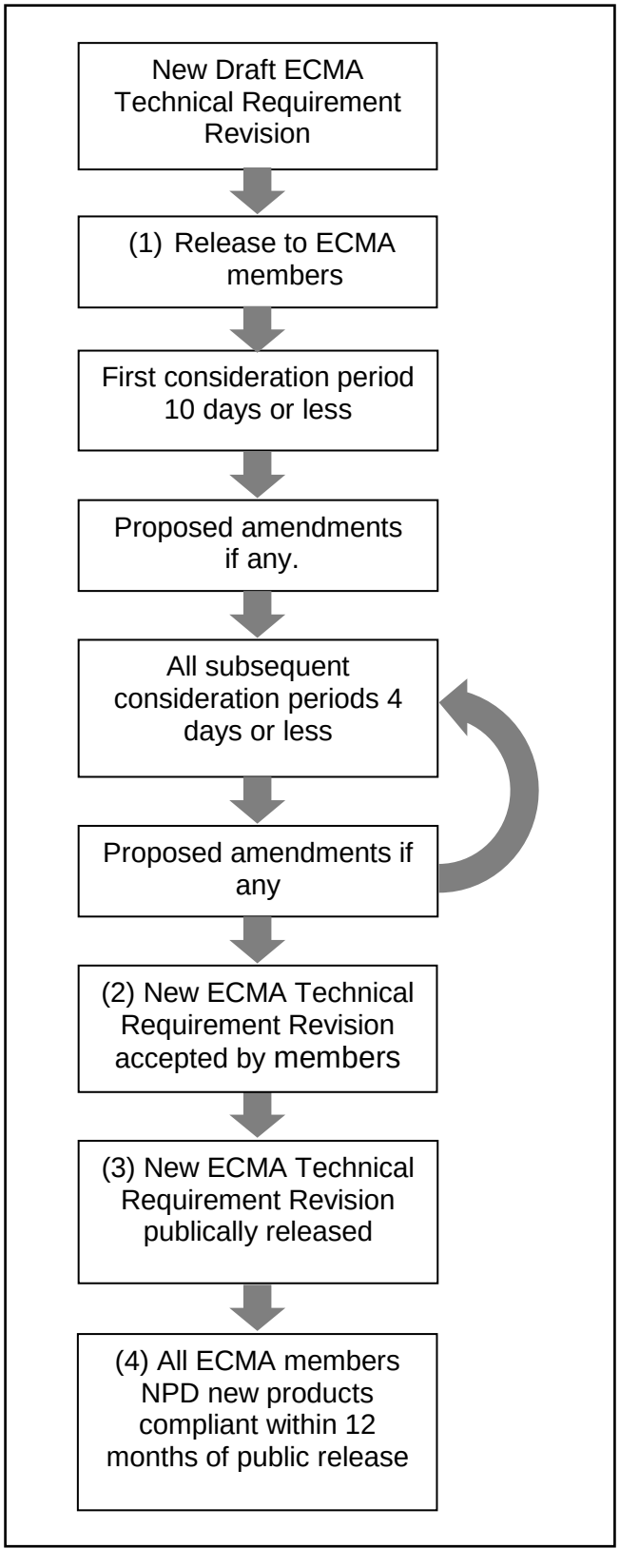
31.0) Resistance to rusting

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

32.0) Radiation, toxicity and similar hazards

This clause of IEC 60335-2-76:2002+A1:2006 is applicable.

Chronology of events for new ECMA technical requirement revisions



Notes:

- The ECMAs technical requirements are reviewed annually at the last ECMA meeting of the year and new draft revisions are produced if it is assessed there is a need.
- Dates of events (1 to 4) in the creation of new revisions are recorded by the secretary.
- Existing production remains compliant with the previous revision grandfathering period which extends to the life of that product.
- All NPD new products must be compliant with the new revision within 12 months of the new revisions public release.
- Days mean working days.
- **Failure to respond within 14 working days will be deemed as an acceptance of the new revision**.

Event	Date
(1) New draft revision release to members	22/02/12
(2) New revision accepted by members	02/04/12
(3) New revision publicly released	01/05/12
(4) All production compliant within 12 months	

Annex A (informative)
Routine tests

Figure 89. Impulse Cycle Period

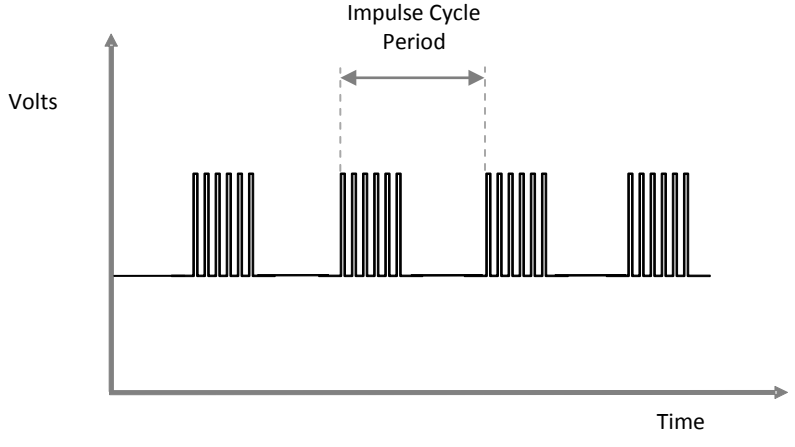


Figure 90. RMS Output Current assessment

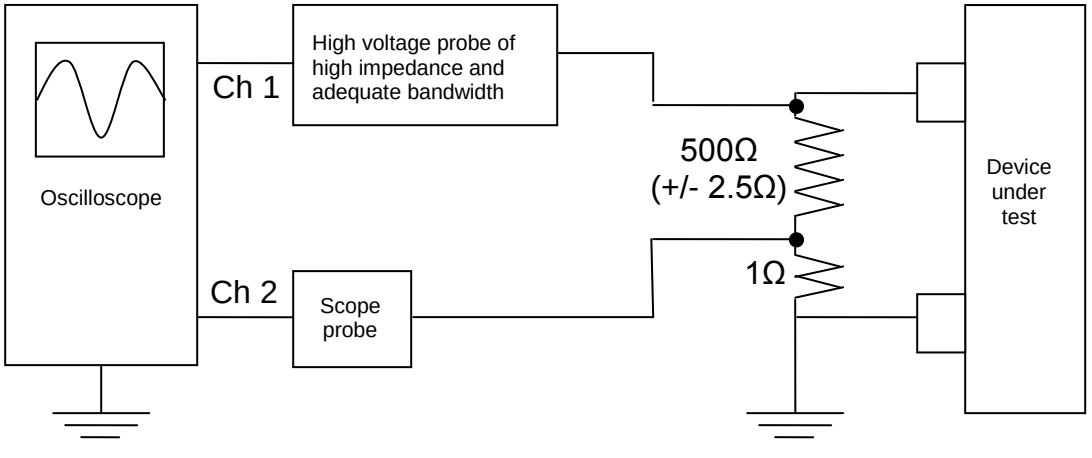


Figure 91. Energy Output per impulse assessment

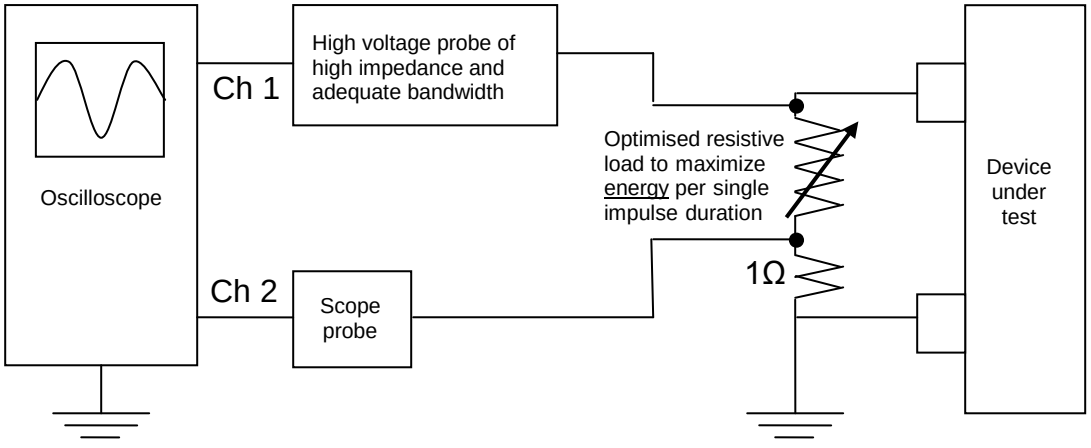


Figure 92. Peak Current Output assessment

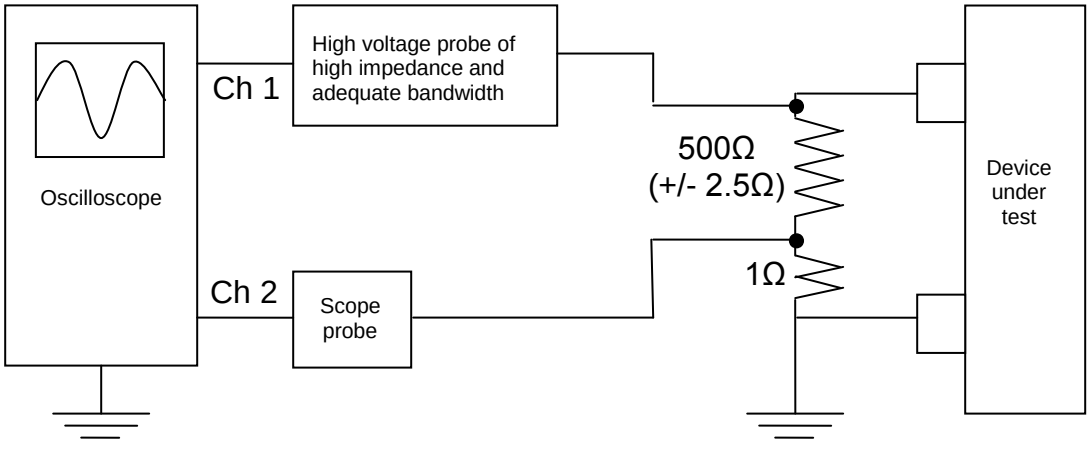
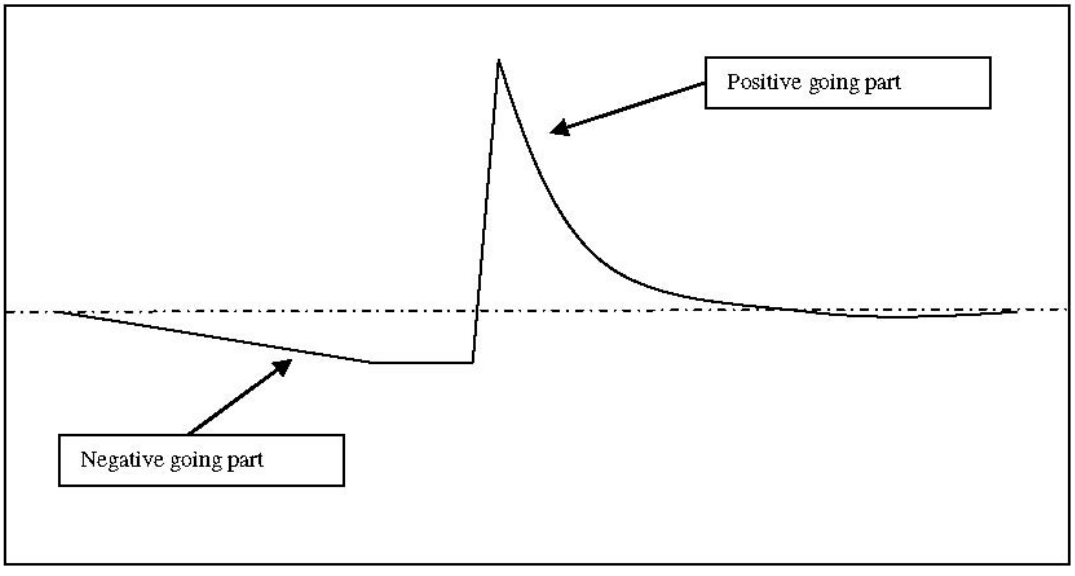


Figure 93. Typical Impulse



Annex B

(normative)

Appliances powered by rechargeable batteries

This clause of IEC 60335-2-76:2002+A1:2006 is applicable except as follows.

5.11.1 Conditioning of Test Sample *Addition:*
Tests shall be conducted using a fully charged battery following a conditioning cycle of 5 discharges and recharges. If regulated voltage is supplied to the static output circuit, then the battery conditioning is not required, in this case tests shall be conducted using a fully charged battery. The battery may be conditioned by removing it from the product and carrying out the discharge/recharge cycles at a rate not to exceed C/1, where C=capacity in AHr, or the maximum allowed by the battery specification, whichever is lower. The battery may be provided for test pre-conditioned by the manufacturer.

Annex C

Presentation of results for each device under test

1) **Single impulse duration** (mS), the shortest duration which contains 95% of the overall energy of a single impulse. **Limit 10mS.**

2) **RMS Output current** (mA R.M.S.) per **impulse cycle period** through 500Ω +/- 2.5Ω. **Limit 30 mA r.m.s**.

3) a) **Optimised resistive load** (Ω) to maximize **energy output** per single impulse duration (+/- 10%).

   b) **Energy output** (mJ) per **single impulse duration** dissipated into the total **optimised resistive load** (3a). **Limit 5 mJ**

   c) **Highest number of impulses in a one second** interval of operation.

   d) **Energy output per second** (mJ/s) [3b x 3c]. **Limit 500mJ**

4) **Peak current output** (mA) per **single impulse duration** through 500Ω +/- 2.5Ω. **Limit 150mA**