Texte zu EU-Regelungen zur umweltgerechten Produktgestaltung und zur Energieverbrauchskennzeichnung in der Beleuchtung – Zusammenstellung [1] des Umweltbundesamtes (UBA), Deutschland

Diskussion über eine künftige Änderungsverordnung (Produktgestaltung und -information)

Informelles Interessensgruppentreffen am 19. Februar 2020: **SVM-Höchstwert: Vortrag von Herrn Peter Bennich, Energimyndigheten**

Hinweis: Bitte beachten Sie, daß der angehängte Text nur in Englisch verfaßt ist.

EN: Information on EU Lighting Regulations – Ecodesign and Energy Labelling – Compilation [1] of the Federal Environment Agency (UBA), Germany

Discussion of a future amending regulation (Product Design and Information)

Informal stakeholder meeting on 19 February 2020: Presentation SVM maximum value: Presentation by Mr. Peter Bennich, Energimyndigheten

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FR: Informations sur réglementations de l'UE concernant l'éclairage – l'écoconception et l'étiquetage énergétique – Compilation [1] de l'Agence Fédérale de l'Environnement (UBA), Allemagne

Discussion d'un futur règlement modificatif (Conception des produits et informations sur les produits)

Réunion informelle des parties prenantes le 19 février 2020 : La valeur maximale du SVM : Exposé par M. Peter Bennich, Energimyndigheten

Indication : Veuillez noter que le présent texte n'est disponible qu'en anglais.

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[1] https://www.eup-network.de/de/eup-netzwerk-deutschland/offenes-forum-eu-regelungen-beleuchtung/dokumente/texte/

DE: ↓ **EN**: → page III **FR** : → page IV

Texte im Offenen Forum (**abc** = vorliegender Text)

- **Bestehende EG- und EU-Regelungen**
- **Studien der EU-Kommission**
- **Regelungsentwürfe**
  - Frühere Entwürfe
  - **Diskussion über künftige Änderungen**
    - Vorab-Stellungnahmen
    - **Informelles Interessensgruppentreffen am 19. Februar 2020**
      - Notizen zu Vorträgen und weiterem Vorgehen; von C. Mordziol, UBA
      - **Vorträge**
        - **SVM-Höchstwert**
          - Małgorzata Perz, Signify
          - Bertrand Hontelé, Signify
          - Ourania Geourgoutsakou, Lighting Europe
          - **Peter Bennich, Energimyndigheten**
        - Andere Themen
- **Öffentliche Konsultationen auf EU-Ebene**
- **Diskussion im Offenen Forum**
- **Weitere Dokumente**

Abkürzungen: ● EG = Europäische Gemeinschaft ● EU = Europäische Union ● SVM : Maß für die Sichtbarkeit des Stroboskopeffektes ● UBA = Umweltbundesamt

EN

Documents in the Open Forum (**abc** = text at hand)

- **Existing EC and EU Regulations**
- **Studies of the European Commission**
- **Draft regulations**
  - Earlier drafts
  - **Discussion on future changes**
    - Comments in advance
    - **Informal stakeholder meeting on 19 February 2020**
      - Notes on presentations and further Procedure; by C. Mordziol, UBA
      - **Presentations**
        - **SVM maximum value**
          - Małgorzata Perz, Signify
          - Bertrand Hontelé, Signify
          - Ourania Geourgoutsakou, Lighting Europe
          - **Peter Bennich, Energimyndigheten**
        - Other issues
- **Public Consultations at EU level**
- **Discussion in the Open Forum**
- **Further documents**

Abbreviations: ● EC = European Communities ● EU = European Union ● SVM = Stroboscopic Visibility Measure ● UBA = Umweltbundesamt (Federal Environment Agency, Germany)

FR

Documents dans le forum ouvert (**abc** = présent document)

- **Règlements existants de la CE et de l'EU**
- **Études de la Commission européenne**
- **Projets de règlements**
  - Projets antérieurs
  - **Discussion sur les changements futurs**
    - Commentaires en avance
    - **Réunion informelle des parties prenantes le 19 février 2020**
      - Notes sur les exposés et la suite de la procédure; par C. Mordziol, UBA
      - **Exposés**
        - **La valeur maximale du SVM**
          - Małgorzata Perz, Signify
          - Bertrand Hontelé, Signify
          - Ourania Geourgoutsakou, Lighting Europe
          - **Peter Bennich, Energimyndigheten**
        - Autres sujets
- **Consultations publiques au niveau de l'UE**
- **Discussion dans le Forum Ouvert**
- **Autres documents**

Abréviations : ● CE = Communauté européenne ● SVM : Indice de visibilité de l'effet stroboscopique ● UBA = Umweltbundesamt (Agence Fédérale de l'Environnement, Allemagne) ● UE = Union européenne

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Es folgt ein unveränderter Originaltext.

EN: The following is an unmodified original text.

FR: Ce qui suit est un texte original.

Testing for Pst and SVM of six LED lamp types

Christofer Silfvenius and Peter Bennich

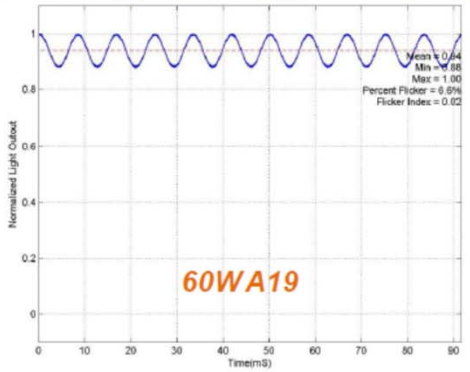
Swedish Energy Agency

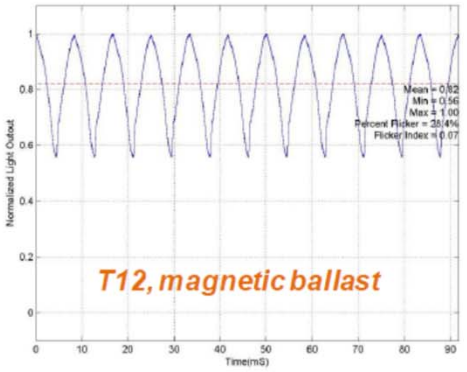
Technical meeting Brussels 19 February 2020

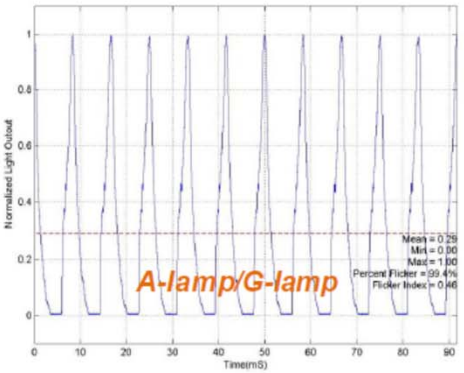
Swedish Energy Agency

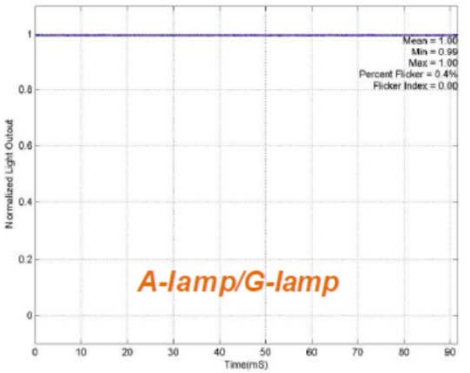
Temporal Light Modulation

- Cyclic variation in light output from a light source or lighting system









Source: M. Poplawski, PNNL

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Background

- There is a need to have product requirements on temporal light modulation (TLM) for consumer protection.
- Pst and SVM have been proposed as appropriate measures and hence included in the revised regulation.
- However, there is still an ongoing discussion about:
  - The actual levels (not to be discussed today)
  - Whether appropriate electronic drivers can be made for all sizes and form factors of lamps
- *This study* has explored whether products are available that already now meet the coming requirements 1st September 2021

Flicker - Pst

Flicker means the perception of visual unsteadiness induced by a light stimulus, the luminance or spectral distribution of which fluctuates with time, for a static observer in a static environment. The fluctuations can be periodic and non-periodic and may be induced by the light source itself, the power source or other influencing factors.

The metric for flicker used in this Regulation is the parameter 'P_{st}^{LM}', where 'st' stands for short term and 'LM' for light flickermeter method, as defined in standards.

A value $P_{st}^{LM} = 1$ means that the average observer has a 50 % probability of detecting flicker.

Requirement in 2019/2020: $P_{st}^{LM} = 1$

Stroboscopic effect - SVM

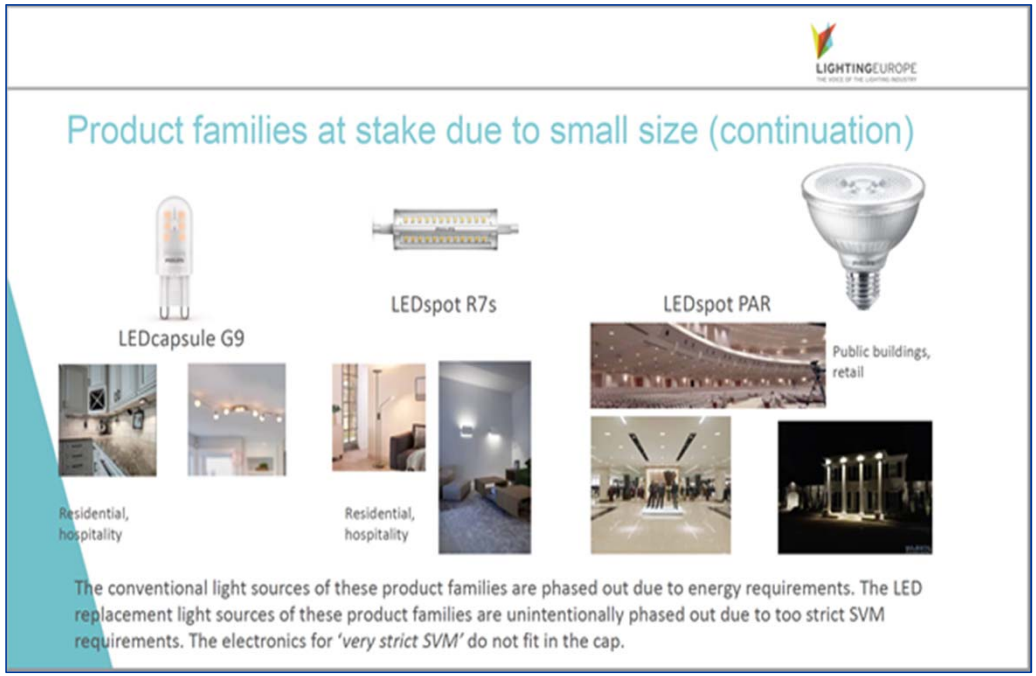
Stroboscopic effect means a change in motion perception induced by a light stimulus, the luminance or spectral distribution of which fluctuates with time, for a static observer in a non-static environment. The fluctuations can be periodic and non-periodic and may be induced by the light source itself, the power source or other influencing factors.

The metric for the stroboscopic effect used in this Regulation is the 'SVM' (stroboscopic visibility measure), as defined in standards.

SVM = 1 represents the visibility threshold for an average observer.

Requirement in 2019/2020: SVM =< 0.4

Lighting Europe are concerned that six LED lamp types will be phased out due to the SVM requirement level (<=0.4)



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In particular dimmable lamps with small form factor (E14, G9 etc)

Testing report

- Testing Report - Product Testing for PstLM and SVM
- *A report discussing the measured values of short-term light modulation (PstLM) and stroboscopic visibility measure (SVM) for six types of LED retrofit lamp types covered by the new Ecodesign lighting regulation*
- Sweden in lead, working together with Denmark and UK. Australia and Korea did also provide data.

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Test laboratories for P_{st} and SVM

Denmark	Sweden
The Technical University of Denmark – DTU - Fotonik Risø Campus Frederiksborgvej 399 Building 130 4000 Roskilde Denmark	Statens Energimyndighet Testlab Rosenlundsgatan 9 SE-118 53 Stockholm Sweden
United Kingdom	**Australia**
Lux-TSI Unit 1B Pencoed Technology Park Pencoed, Bridgend CF35 5AQ Wales United Kingdom	LEDLab - Light Emission Distribution Laboratory 4/140 George Street Hornsby, NSW, 2077 Australia LightLab International 50 Redcliffe Gardens Drive Clontarf QLD 4019 Australia In addition, some bench-top assessments were conducted by Light Naturally, Suite 1B/17 Peel Street, Brisbane, Australia.

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Test Methods for P_{st} and SVM

Metric	Test Method
P_{st}^{LM}	IEC TR 61547-1:2017 “Technical Report: Equipment for general lighting purposes – EMC immunity requirements – Part 1: An objective voltage fluctuation immunity test method.”
SVM	IEC TR 63158-1:2018 “Technical Report: Equipment for general lighting purposes - Objective test method for stroboscopic effects of lighting equipment.”

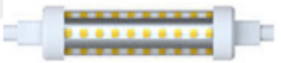
Swedish Energy Agency (SEA) test equipment

(also alternative equipment from National Instruments and Gigaherz-optik)

- Everfine LFA 3000
- 6500USD + 200USD shipping
- Operates standalone or from PC
- Complete measurement takes 3+3 minutes
- Flicker Percent
- Flicker Index
- Modulation Depth
- IEEE risk rating
- Pst (IEC 61547)
- SVM (CIE)
- Measures up to kHz range

Swedish Energy Agency

LED types

Lamp Type Considered	Picture
LEDtube – retrofit LED lamp for a linear fluorescent tube	
LEDspot MV – mains voltage (GU10) spot lamp (PAR16)	
Classic filament LED lamps – mains voltage A-type LED filament lamps	
LEDcapsule G9 – mains voltage LED retrofit for G9 halogen capsules	
LEDspot R7s – LED replacement lamp for linear R7s halogen lamps	
LEDspot PAR – LED retrofit lamp for PAR38 reflector lamp	

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LED retrofit lamps were purchased from retailers (in store and on-line) in the following countries:

- Belgium
- Denmark
- France
- The Netherlands
- Sweden
- United Kingdom
- Australian lamps included if CE-marked
- *1 to 3 samples per model*

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Color coding of results

Shading	Description	Values
	Lamp is compliant with the new draft lighting regulation	$P_{st}^{LM} \leq 1.0$, SVM ≤ 0.4
	Lamp(s) that would be added if LightingEurope's request to raise SVM to 1.6 is adopted	$P_{st}^{LM} \leq 1.0$, SVM ≤ 1.6
	Lamps that fail either P_{st}^{LM} or SVM requirements, even the higher SVM requested by LightingEurope	$P_{st}^{LM} > 1.0$, SVM > 1.6

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LED-Tube replacements. 54% pass SVM <0.4 (11 models tested)

Lab ID#	Type	Dimmable	P_{st}^{LM}	SVM
TP0029	T8	No	0.007	0.030
TP0022	T8	Not declared	0.022	0.053
TP0023	T8	Not declared	0.042	0.055
TP0024	T5	No	0.034	0.127
LNLED180	T8	No	0.686	0.160
LNLED184	T8	No	0.861	0.172
LNLED182	T8	No	0.983	1.185
LNLED181	T8	No	1.113	1.818
TP0020	T8	No	0.131	1.893
TP0026	T8	No	0.139	3.366
TP0021	T8	No	0.170	3.471

6 models (54%)

1 model (9%)

4 models (36%)

Non-dimmable mains GU10 LED, 75% pass SVM < 0.4 (16 models)

Row Labels	Type	Dimmable?	P_{st}^{LM}	SVM	
LNLED179	PAR16	No	0.921	0.000	
3286-1	PAR16	No	0.017	0.002	
LNLED003	PAR16	No	0.053	0.002	
3307-1	PAR16	No	0.011	0.003	
LNLED129	PAR16	No	0.015	0.006	
LNLED153	PAR16	No	0.037	0.006	12 models (75%)
TP0004	PAR16	No	0.009	0.006	
SB5	PAR16	No	0.025	0.008	
LNLED099	PAR16	No	0.033	0.008	
LNLED128	PAR16	No	0.024	0.011	
3279-1	PAR16	No	0.019	0.013	
LNLED097	PAR16	No	0.079	0.013	
LNLED177	PAR16	No	1.072	0.119	2 models (12%)
LNLED174	PAR16	No	0.822	0.916	
LNRD017	PAR16	No	0.084	1.446	2 models (12%)
LNRD019	PAR16	No	0.087	1.976	

Dimmable Mains GU10 (PAR16) Spot Lamps (20 models)

Row Labels	Type	Dimmable?	P_{st}^{LM}	SVM
LNRD036	PAR16	Yes	0.017	0.002
3275-1	PAR16	Yes	0.024	0.002
3275-3	PAR16	Yes	0.025	0.003
TP0005	PAR16	Yes	0.037	0.004
TP0001	PAR16	Yes	0.033	0.004
TP0002	PAR16	Yes	0.029	0.004
3350-1	PAR16	Yes	0.009	0.011
3349-3	PAR16	Yes	0.015	0.026
LNLED189	PAR16	Yes	0.189	0.055
LNRD018	PAR16	Yes	0.034	0.335
LNLED146	PAR16	Yes	0.055	0.632
LNLED098b	PAR16	Yes	0.051	0.634
TP0003	PAR16	Yes	0.045	0.664
3306-3	PAR16	Yes	0.023	0.712
3306-1	PAR16	Yes	0.030	0.758
3305-1	PAR16	Yes	0.031	0.782
TP0030	PAR16	Yes	0.072	0.791
LNRD035	PAR16	Yes	0.065	0.926
LNLED035	PAR16	Yes	0.766	1.096
TP0000	PAR16	Yes	0.158	1.869

10 models (50%)

9 models (45%)

1 model (5%)

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Non-Dimmable, Clear A-Type Lamps, LED Filament (17 models)

Row Labels	Type	Dimmable?	P_{st}^{LM}	SVM
LNRD009	A type, filament	No	0.023	0.002
TI-20101(DE14)	A type, filament	No	0.015	0.003
TI-20124(FR9)	A type, filament	No	0.017	0.003
TI-20124(FR14)	A type, filament	No	0.015	0.003
TI-20101(DE19)	A type, filament	No	0.013	0.004
TI-20124(FR20)	A type, filament	No	0.017	0.004
TI-20124(FR8)	A type, filament	No	0.022	0.004
TI-20101(DE2)	A type, filament	No	0.015	0.004
TI-20124(FR5)	A type, filament	No	0.016	0.005
TI-20101(DE3)	A type, filament	No	0.013	0.006
TI-20101(DE13)	A type, filament	No	0.020	0.008
TI-20101(DE17)	A type, filament	No	0.014	0.012
TI-20124(FR19)	A type, filament	No	0.021	0.059
LNLED170(a-k)	A type, filament	No	0.928	0.152
TI-20019(UK18)	A type, filament	No	0.117	0.273
LNLED169(a-k)	A type, filament	No	1.020	4.790
LNLED171(a-k)	A type, filament	No	0.832	5.600

15 models (88%)

2 models (12%)

Swedish Energy Agency

Dimmable Clear A-Type Lamps, LED Filament (8 models)

Row Labels	Type	Dimmable?	P_{st}^{LM}	SVM
3272-1	A type, filament	Yes	0.014	0.016
3272-3	A type, filament	Yes	0.012	0.017
LNRD002	A type, filament	Yes	0.069	0.119
TI-20101(DE15)	A type, filament	Yes	0.039	1.199
LNRD042	A type, filament	Yes	0.088	1.677
3348-1	A type, filament	Yes	0.046	2.008
TI-20124(FR10)	A type, filament	Yes	0.053	2.430
3347-1	A type, filament	Yes	0.103	5.016

3 models (37%)

1 model (12%)

4 models (50%)

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Non dimmable G9 capsule LED lamps (7 models)

Row Labels	Type	Dimmable?	P_{st}^{LM}	SVM
LNRD039	Capsule	No	0.000	0.000
3310-1	Capsule	No	0.011	0.003
LNRD023	Capsule	No	0.026	0.006
3309-1	Capsule	No	0.004	0.006
TP0006	Capsule	No	0.009	0.006
LNRD021	Capsule	No	0.075	2.063
LNRD022	Capsule	No	0.183	4.596

5 models (71%)

2 models (29%)

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Dimmable G9 capsule LED lamps (16 models)

Row Labels	Type	Dimmable?	P_{st}^{LM}	SVM	
3343-1	Capsule	Yes	0.032	0.046	2 models (12%)
3343-3	Capsule	Yes	0.030	0.051	
TP0007	Capsule	Yes	0.048	0.890	1 model (6%)
3093-15	Capsule	Yes	0.071	1.788	
3093-16	Capsule	Yes	0.055	1.985	
LNRD038	Capsule	Yes	0.130	1.998	
3344-1	Capsule	Yes	0.048	2.267	
TP0008	Capsule	Yes	0.088	2.366	
TP0009	Capsule	Yes	0.101	3.420	4 models (81%)
TP0011	Capsule	Yes	0.166	3.835	
TP0010	Capsule	Yes	0.106	3.971	
LNRD041	Capsule	Yes	0.181	4.063	
LNRD034	Capsule	Yes	0.189	4.698	
3342-1	Capsule	Yes	0.096	4.787	
LNRD033	Capsule	Yes	0.200	5.073	
LNRD040	Capsule	Yes	0.183	5.175	

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Non-Dimmable and Dimmable R7s LED Lamps (5 models)

Row Labels	Type	Dimmable?	P_{st}^{LM}	SVM	
TP0017	R7s	No	0.021	0.003	2 models (40%)
3345-1	R7s	Yes	0.024	0.007	
TP0018	R7s	Yes	0.060	0.879	2 models (40%)
TP0015	R7s	Yes	0.136	0.931	
TP0016	R7s	Yes	0.061	1.966	1 models (20%)

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Non-Dimmable and Dimmable PAR38 LED Lamps (7 models)

Row Labels	Type	Dimmable?	P_{st}^{LM}	SVM
3282-1	PAR38	No	0.000	0.000
TP0012	PAR38	No	0.527	0.024
TP0014	PAR38	No	0.081	0.833
LNLED187b	PAR38	No	0.050	1.322
LNLED188b	PAR38	Yes	0.114	0.000
TP0019	PAR38	Yes	0.029	0.017
TP0013	PAR38	Yes	0.105	0.572

4 models (57%)

3 models (42%)

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Conclusion

Products found in all six categories that already now comply with the future requirements

Relaxing SVM to = 1.6 wouldn´t change the outcome in this study very much

Factor and Requirement	LED T8 Tubes	GU10 PAR16	A-Type Filament	G9 Capsule	R7s Retrofit	PAR38 LED	Total
Total number of models in the sample	11	36	25	23	5	7	107
Models with $P_{st}^{LM} \leq 1.0$ and SVM ≤ 0.4	6 (54%)	22 (62%)	18 (72%)	7 (30%)	2 (40%)	4 (57%)	59 (55%)
Additional models if $P_{st}^{LM} \leq 1.0$ and SVM ≤ 1.6	1 (9%)	11 (30%)	1 (4%)	1 (4%)	2 (40%)	3 (43%)	19 (18%)
Models with $P_{st}^{LM} > 1.0$ or SVM > 1.6	4 (36%)	3 (8%)	6 (24%)	15 (65%)	1 (20%)	0 (0%)	29 (27%)
Total number of dimmable models in the sample	0	20	8	16	4	3	51
Models with $P_{st}^{LM} \leq 1.0$ and SVM ≤ 0.4	n/a	10 (50%)	3 (38%)	2 (12%)	1 (25%)	2 (66%)	18 (35%)
Additional models if $P_{st}^{LM} \leq 1.0$ and SVM ≤ 1.6	n/a	9 (45%)	1 (12%)	1 (6%)	2 (50%)	1 (33%)	14 (27%)
Models with $P_{st}^{LM} > 1.0$ or SVM > 1.6	n/a	1 (5%)	4 (50%)	13 (81%)	1 (25%)	0 (25%)	19 (37%)

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Displacement factor

Displacement factor (DF, cos φ1) at power input Pon for LED and OLED MLS:

No limit at Pon ≤ 5 W,
DF ≥ 0,5 at 5 W < Pon ≤ 10 W,
DF ≥ 0,7 at 10 W < Pon ≤ 25 W
DF ≥ 0,9 at 25 W < Pon

Compare with e.g. 1194/2012 (LED and directional lamps):

Lamp power factor for lamps with integrated control gear
Power > 25 W: ≥ 0,9
Power ≤ 25 W: ≥ 0,5

Note that DF >= PF (PF do include harmonics, whereas DF only concerns the fundamental frequency) -> 2029/2020 is stricter for Pon >= 5 W

EMC Testing of LED Lamps

In order to check whether the SVM requirement resulted in a problem on electromagnetic compatibility (EMC), we selected and shipped twenty different lamps to Korea to be tested at the Korea Institute of Lighting and ICT (KILT)

They conducted three tests on each of the products:

- Main Terminal Disturbance Voltage Measurement
- Radiated disturbance (9 kHz to 30 MHz) Measurement
- Radiated disturbance (30 MHz to 300 MHz) Measurement

EMC Testing of LED Lamps

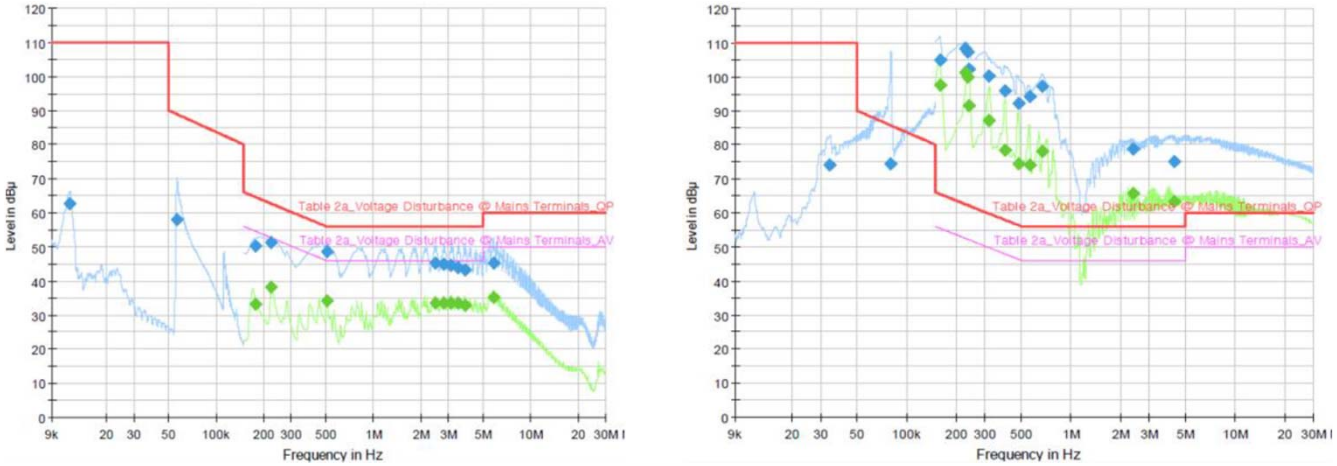

Figure 15. Disturbance Voltage Test for Passing G9 (a) and Failing G9 (b) LED lamps

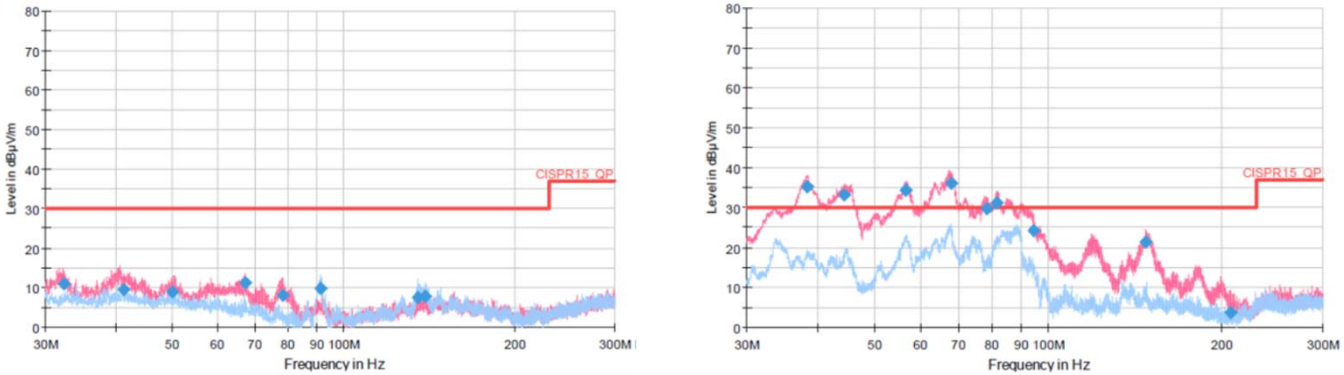

Figure 16. Radiated Disturbance (30 MHz to 300 MHz) Test for Passing G9 (a) and Failing G9 (b) LED lamps

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No obvious correlation between SVM and EMC performance

Lab ID Code	Base	Watts	CCT	Life	Dimmable?	Rated Lumens	Rated Voltage	PstLM	SVM	Disturbance Voltage	Radiated disturbance (9 kHz to 30 MHz)	Radiated disturbance (30 MHz to 300 MHz)
3349-3	GU10	5,0	2200-2700	15 000	Yes	350	220-240	0,015	0,026	Pass	Pass	Pass
3343-3	G9	3,6	2700	25 000	Yes	360	230	0,030	0,051	Fail	Pass	Fail
3351-3	GU5.3	5,0	2700	15 000	Yes	380	12V	0,025	0,018			
3306-3	GU10	7,0	4000	30 000	Yes	550	220-240V	0,023	0,712	Pass	Pass	Pass
3297-3	E27	7,5	2700	15 000	Yes	806	220-240	0,063	2,943	Pass	Pass	Pass
3272-3	E27	7,0	2700	15 000	Yes	800	230V	0,012	0,017	Pass	Pass	Pass
3275-3	GU10	6,5	3000	25 000	Yes	500	230V	0.025	0,003	Pass	Pass	Pass
3277-3	GU10	4,1	2700	25 000	Yes	230	220-240		0,020	Pass	Pass	Pass
3290-3	E27	4,0	2700	15 000	Yes	400			0,120	Pass	Pass	Pass
3302-3	E14	5,5	:200-2500-270(	15 000	3-way		220-240	0,007	0,002	Pass	Pass	Pass
L31690	E27	14,5	2700	25 000	Yes	1035	220-240	0,030	0,020	Pass	Pass	Pass
L31627	GU10	5,0	3000	25 000	Yes	500	220-240	0,033	0,000	Pass	Pass	Pass
L31639	GU10	4,5	6500	35 000	Yes	290	220-240	0,035	0,000	Pass	Pass	Pass
L31684	R7s	7,5	3000	15 000	No	950	220-240	0,022	0,000	Pass	Pass	Pass
L31681	R7s	11,5	2700	15 000	Yes	1521	220-240	0,063	2,030	Pass	Pass	Pass
L31654	G9	4,0	2700	30 000	Yes	220	230	0,106	3,970	Pass	Pass	Pass
L31642	G9	2,6	4000	15 000	No	320	220-240	0,009	0,010	Pass	Pass	Pass
L31630	GU10	5,0	2700	15 000	Yes	330	220-240	0,029	0,000	Pass	Pass	Pass
L31624	GU10	6,0		25 000	Yes	400	220-240	0,138	1,820	Pass	Pass	Pass
TI-20101(DE16)	E27	9,0	2700	50 000	Yes	800	220-240	0,013	0,007	Pass	Pass	Pass
TI-20019(UK15)	E27	8,5	2200-2700	25 000	Yes	806	220-240	0,021	0,517	Pass	Pass	Pass

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All-in-all: Table 21: The Black Swans Table

Table 21. The "Black Swans" – Lamps that Already Meet the Ecodesign Requirements

Lab ID Code	Type	Dimmable ?	P_{st}^{LM}	SVM	PF	DF	EMC
TP0029	T8	No	0.007	0.030		--	--
TP0022	T8	Not declared	0.022	0.053		--	--
TP0023	T8	Not declared	0.042	0.055		--	--

Lab ID Code	Type	Dimmable ?	P_{st}^{LM}	SVM	PF	DF	EMC
TP0024	T5	No	0.034	0.127		--	--
LNLED180	T8	No	0.686	0.160	0.92	0.93	--
LNLED184	T8	No	0.861	0.172	0.863	0.99	--
LNLED179	PAR16	No	0.921	0.000	0.480	0.90--	--
3286-1	PAR16	No	0.017	0.002	0.598	0.893	--
LNLED003	PAR16	No	0.053	0.002	--	--	--
3307-1	PAR16	No	0.011	0.003	0.511	0.968	--
LNLED129	PAR16	No	0.015	0.006	--	--	--
LNLED153	PAR16	No	0.037	0.006	0.448	0.84	--
TP0004	PAR16	No	0.009	0.006		--	--
SB5	PAR16	No	0.025	0.008		--	--
LNLED099	PAR16	No	0.033	0.008	--	--	--
LNLED128	PAR16	No	0.024	0.011	--	--	--
3279-1	PAR16	No	0.019	0.013	0.505	0.889	--
LNLED097	PAR16	No	0.079	0.013	--	--	--
LNRD036	PAR16	Yes	0.017	0.002	--	--	--
3275-1	PAR16	Yes	0.024	0.002	0.822	0.863	--
3275-3	PAR16	Yes	0.025	0.003	0.814	0.858	Pass
TP0005	PAR16	Yes	0.037	0.004		--	--
TP0001	PAR16	Yes	0.033	0.004		--	--
TP0002	PAR16	Yes	0.029	0.004		--	--

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All-in-all: Table 21: The Black Swans Table

TP0001	PAR16	Yes	0.033	0.004		--	--
TP0002	PAR16	Yes	0.029	0.004		--	--
3350-1	PAR16	Yes	0.009	0.011	0.522	0.964	--
3349-3	PAR16	Yes	0.015	0.026	0.842	0.927	Pass
LNLED189	PAR16	Yes	0.189	0.055		0.79	--
LNRD018	PAR16	Yes	0.034	0.335		--	--
LNRD009	A type, filament	No	0.023	0.002		--	--
TI-20101(DE14)	A type, filament	No	0.015	0.003	0.54	--	--
TI-20124(FR9)	A type, filament	No	0.017	0.003	0.485	--	--
TI-20124(FR14)	A type, filament	No	0.015	0.003	0.529	--	--
TI-20101(DE19)	A type, filament	No	0.013	0.004	0.53	--	--
TI-20124(FR20)	A type, filament	No	0.017	0.004	0.54	--	--
TI-20124(FR8)	A type, filament	No	0.022	0.004	0.59	--	--

Lab ID Code	Type	Dimmable ?	P_{st}^{LM}	SVM	PF	DF	EMC
TI-20101(DE2)	A type, filament	No	0.015	0.004	0.525	--	--
TI-20124(FR5)	0.52A type, filament	No	0.016	0.005	0.53	--	--
TI-20101(DE3)	A type, filament	No	0.013	0.006	0.52	--	--
TI-20101(DE13)	A type, filament	No	0.020	0.008	0.53	--	--
TI-20101(DE17)	A type, filament	No	0.014	0.012	0.51	--	--
TI-20124(FR19)	A type, filament	No	0.021	0.059	0.52	--	--
LNLED170(a-k)	A type, filament	No	0.928	0.152		0.93	--
TI-20019(UK18)	A type, filament	No	0.117	0.273	0.87	--	--
3272-1	A type, filament	Yes	0.014	0.016	0.829	0.929	--
3272-3	A type, filament	Yes	0.012	0.017	0.824	0.927	Pass
LNRD002	A type, filament	Yes	0.069	0.119		--	--
LNRD039	Capsule	No	0.000	0.000		--	--
3310-1	Capsule	No	0.011	0.003	0.500	0.964	--
LNRD023	Capsule	No	0.026	0.006		--	--
3309-1	Capsule	No	0.004	0.006	0.519	0.950	--
TP0006	Capsule	No	0.009	0.006		--	--
3343-1	Capsule	Yes	0.032	0.046	0.669	0.999	--
3343-3	Capsule	Yes	0.030	0.051	0.721	0.999	Fail
TP0017	R7s	No	0.021	0.003		--	--
3345-1	R7s	Yes	0.024	0.007	0.940	0.968	--
3282-1	PAR38	No	0.000	0.000	0.471	0.971	--
TP0012	PAR38	No	0.527	0.024		--	--
LNLED188b	PAR38	Yes	0.114	0.000	–	0.90	--
TP0019	PAR38	Yes	0.029	0.017		--	--

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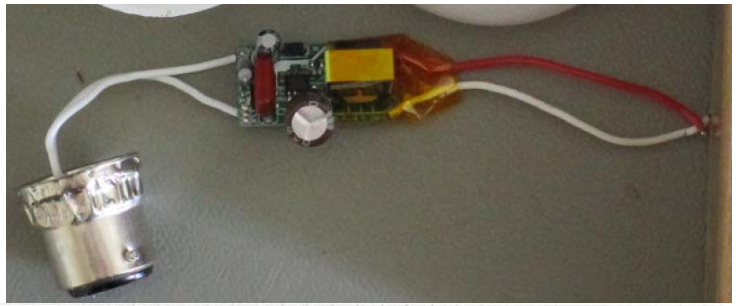
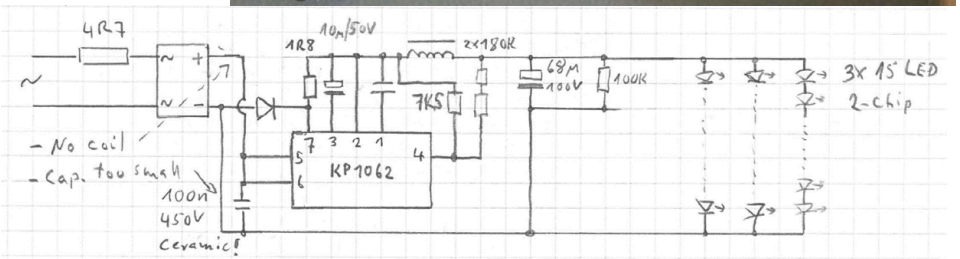
Investigated driver designs





- Commonly three types of designs
  - Buck converter
  - Fly-back converter
  - Linear regulator
- Lamps with low SVM regardless of design, have one or more capacitors of at least 4.4 uF. Ceramic capacitors can be made very small (2x1.5x1.5 mm) and very cheap (purchase price less than 5 Euro-cent).
- Lamps with low SVM also had lower PF (might be of interest to follow up further)
- Very little extra cost for a proper driver design: less than 0.10 Euro-cent

Summary

- Products available on the market that *already* meet Pst and SVM requirements two years before the requirements coming into force
- Increase SVM level from 0.4 to 1.6 would have limited impact
- Driver design:
  - Virtually no extra cost for proper design
  - No relation between SVM and EMC, but
  - Trade-off between SVM and PF/DF?

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