Power Quality: a Requirement for GSLs

FORTALECIMIENTO DE ESTÁNDARES DE EFICIENCIA ENERGÉTICA EN ILUMINACIÓN
Primera Reunión y Taller Presencial del Grupo Técnico de Eficiencia Energética (GTEE)

Steve Coyne
6 Nov 2019

Table of Contents

What are the components of Power Quality?

- Power Factor
- Displacement Factor
- Harmonic Distortion

What is Power Factor?

- Power Factor (PF):
- ratio of the actual power to apparent power
  PF = W / V.A (For a resistive load, the PF is 1.0)

- Active and reactive power:
  - Average power in a circuit is called “active power” or “real power”.
  - Power that supplies the stored energy in reactive elements is called ‘reactive power’
  - Inductive loads cause the current to lag behind the voltage, making the wave form of voltage and current to become “out of phase” with each other.
    - The more out of phase, the lower the PF.
- LEDs – Displacement Factor and Harmonics

What is Displacement Factor?

- Displacement Factor (DF) – the component of power factor due to the phase shift between voltage and current at the fundamental line frequency (60Hz for Central America).

- For sinusoidal (non-distorted) currents, the displacement power factor is the same as the apparent power factor.

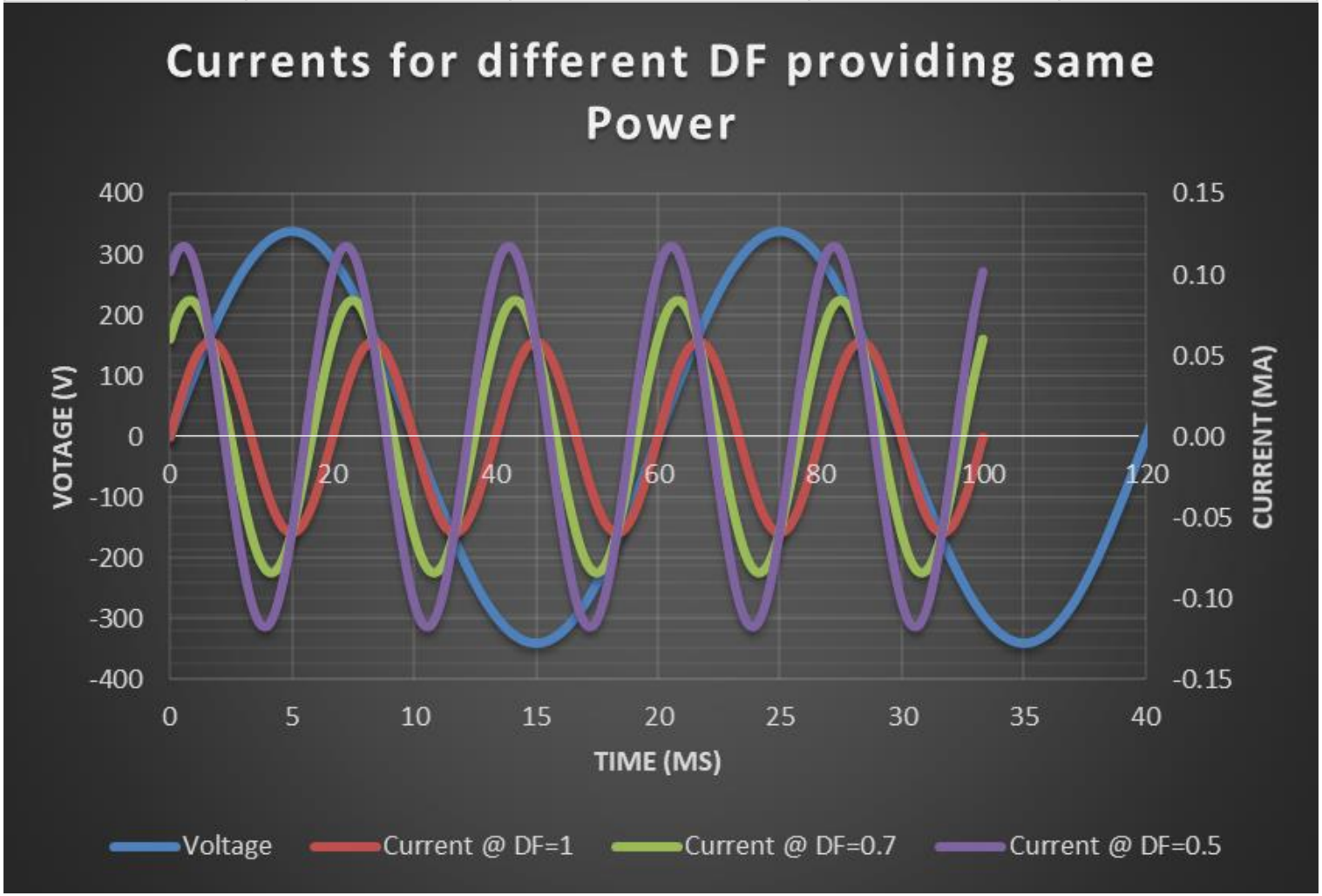
$$DF = \cos(\theta)$$

where θ is the phase angle between the fundamental voltage and current.

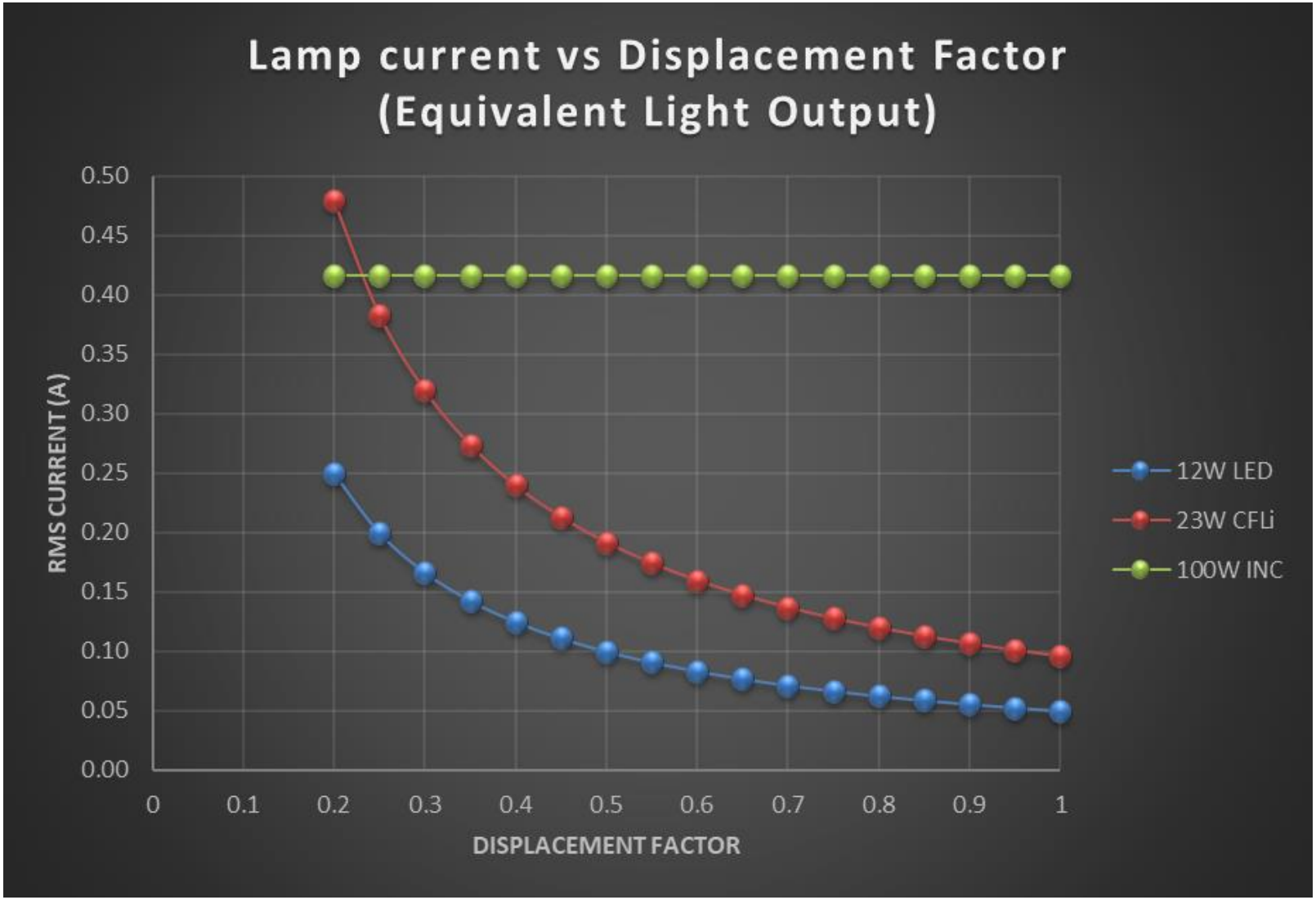
- Inductive loads cause current to lag behind voltage
- Capacitive loads cause current to lead voltage

Impact of Displacement Factor

Power (rms)	Voltage (rms)	Current 1 (rms)	Current 2 (rms)	Current 3 (rms)
10	240	0.04	0.06	0.08

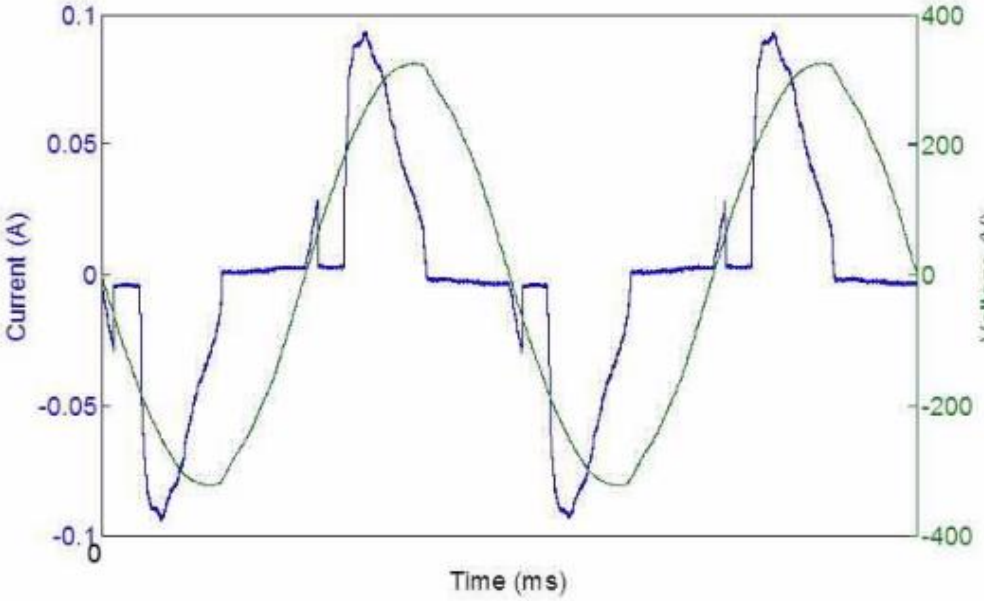


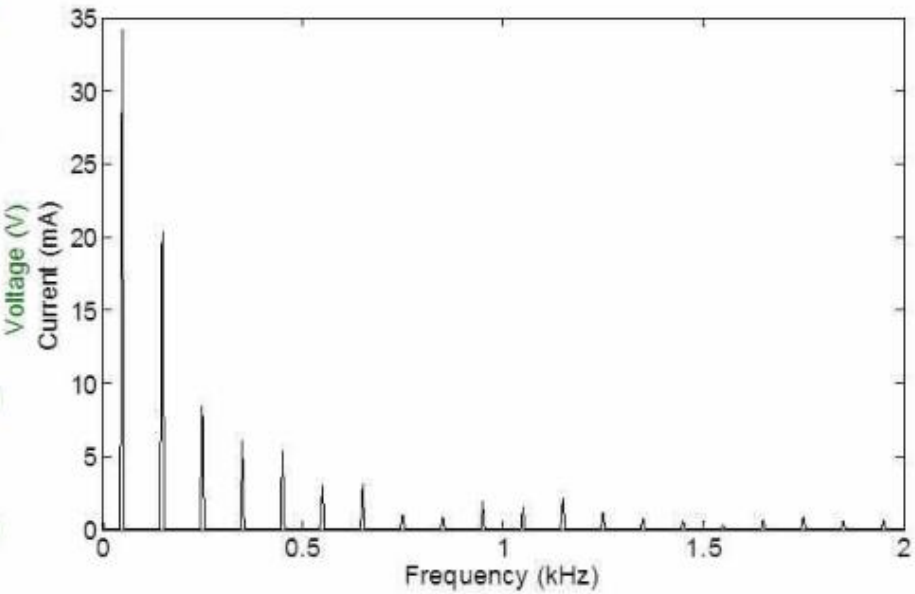
Impact of Displacement Factor



What are Harmonics?

- A harmonic is a wave with a frequency that is an integer multiple of the frequency of the original wave, known as the fundamental frequency.
- Many harmonic frequencies at different amplitudes may be required to constitute a waveform
- Typically odd harmonics are present in electronic circuits





Total Harmonic Distortion and Distortion Power Factor

- Metric which incorporates all the harmonics is Total Harmonic Distortion, THD. (percentage is relative to the fundamental current)

$$THD(I) = \frac{1}{I_1}\sqrt{\sum_{n=2}^{max}(I_n)^2} \times 100\%$$

- Distortion Factor

$$Distortion\ Factor = \frac{1}{\sqrt{1 + THD^2}}$$

Lack of information in Power Factor

$$Power\ Factor = \frac{real\ power}{active\ power}$$

$$= Displacement\ Factor \times Distortion\ Factor$$

$$Power\ Factor = \frac{Displacement\ Factor}{\sqrt{1 + THD^2}}$$

Why does Power Quality matter?

- Low power factor can result in higher losses (older network power (current) meters assume a set power factor for metered charges)
- If many drivers of the same low PF are on a circuit, in-rush starting currents can be high and result in breakers tripping to protect the wires
- Harmonics can interfere with equipment that uses power line control signalling.
- Low order harmonics have damaging effects on transformers in the network.

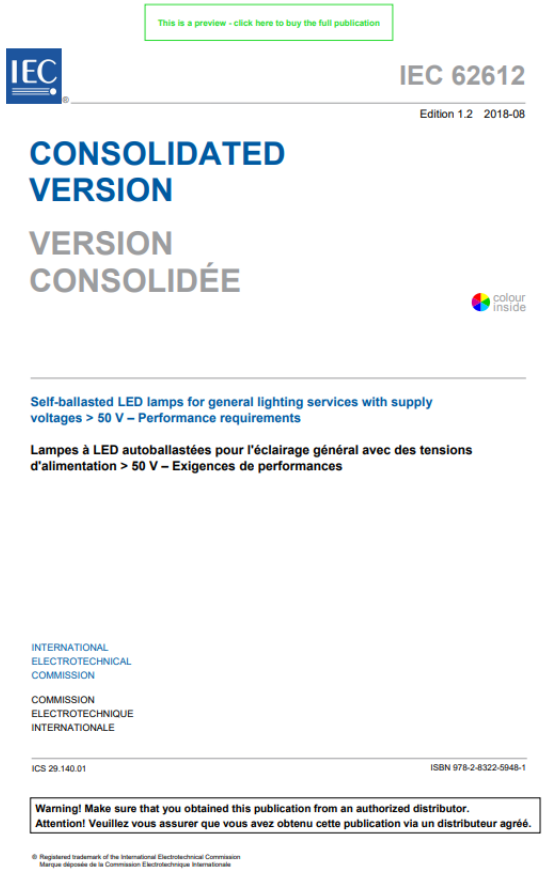
Table of Contents

What are the International Standards?

- Displacement Factor:

  IEC 62612: 2018 “Self-ballasted LED lamps for general lighting services with supply voltages > 50 V - Performance requirements” Webstore link

  - Annex C: Measurement of Displacement Factor



What are the International Standards?

- EMC Harmonic Emissions:

  IEC 61000-3-2: 2018
  “Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤16 A per phase)” Webstore link

IEC 61000-3-2: 2018

Harmonics (for SSL Power ≤ 25W)

Must meet one of the following three requirements:

1. the harmonic currents shall not exceed the power-related limits of Table 3, column or:

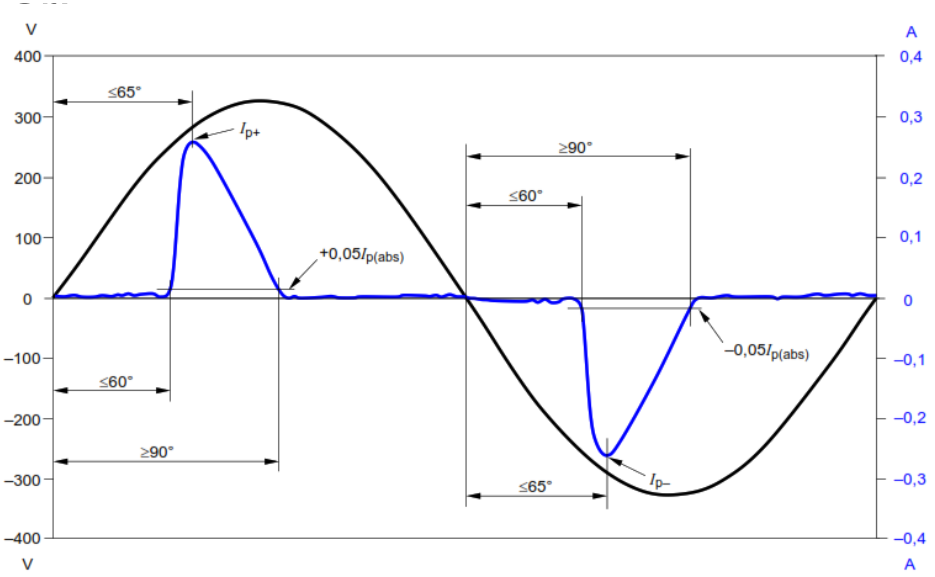
Table 3 – Limits for Class D equipment

Harmonic order n	Maximum permissible harmonic current per watt mA/W	Maximum permissible harmonic current A
3	3,4	2,30
5	1,9	1,14
7	1,0	0,77
9	0,5	0,40
11	0,35	0,33
$13 \leq n \leq 39$ (odd harmonics only)	$\frac{3,85}{n}$	See Table 1

IEC 61000-3-2: 2018

2. As well as the limits in table below, the waveform of the input current shall be such that it reaches the 5 % current threshold before or at 60º, has its peak value before or at 65º and does not fall below the 5 % current threshold before 90º, referenced to any zero crossing of the fundamental supply voltage. The current threshold is 5 % of the highest absolute peak value that occurs in the measurement window, and the phase angle measurements are made on the cycle that includes this absolute peak value. Components of current with frequencies above 9 kHz shall not influence this evaluation

Current Harmonic	Limit
3	86%
5	61



IEC 61000-3-2: 2018

3. The THD shall not exceed 70%, and individual harmonics as per table.

Current Harmonic	Limit
3	35%
2	5%
5	25%
7	30%
9	20%
11	20%

If the lighting equipment includes means for control (e.g. dimming, colour), or is specified to drive multiple loads, then the measurement is made only at the control setting and the load of lamps that gives the maximum active input power.

What are the International Standards?

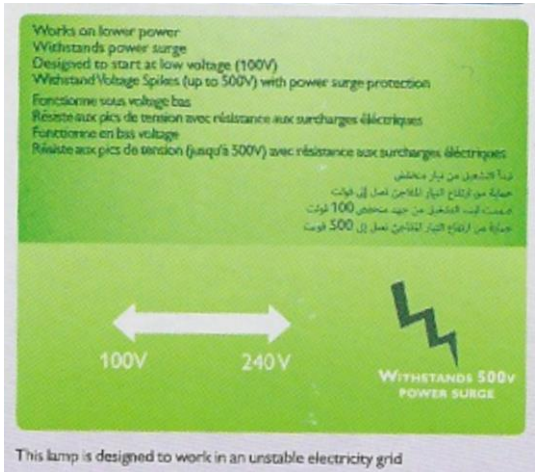
- Electromagnetic compatibility (EMC) emissions and immunity:

  IEC 61547-1:2009 “Equipment for general lighting purposes - EMC immunity requirements” Webstore link

What about Voltage Surge Protection?

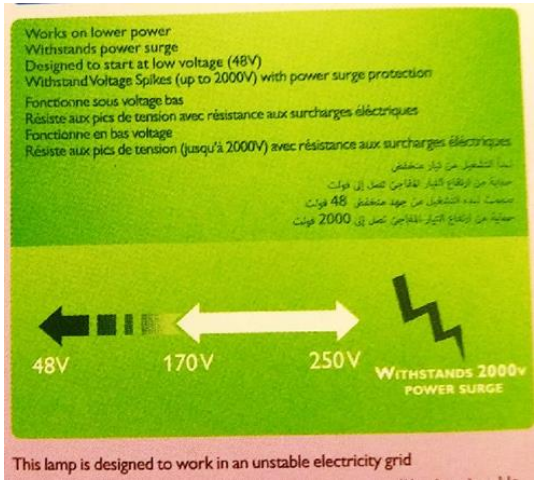
Important where there is unstable electricity supply network

Operation under variable voltage supply situations



Philips Lighting
Lamp #1

Voltage: 100 – 240V
Power surge: 500V
“Designed to work in an unstable electricity grid”



Philips Lighting
Lamp #2

Voltage: 48 – 250V
Power surge: 2000V
“Designed to work in an unstable electricity grid”

Table of Contents

Recommended requirements?

- The table below is taken from the draft regulation:

Metric	Mandatory Requirements
EMC emissions	Compliance with IEC 61000-3-2
EMC immunity	Compliance with IEC 61547
Harmonics	Compliance with IEC 61000-3-2

- The levels are as follows:

4.2. **Fundamental Power Factor (Also called Displacement Factor or Cos φ_1)**

All GSLs shall have a fundamental power factor as stipulated in Table 4:

Table 4: Fundamental power factor

Rated Input Power for the lamp P in W	Fundamental Power Factor
P ≤ 2W	Not applicable
2W < P ≤ 5W	≥ 0.4
5W < P ≤ 10W	≥ 0.5
10W < P ≤ 25W	≥ 0.7
P > 25W	≥ 0.9

Table of Contents

Discussion and Next Steps

- Coverage in any other regulations
- Limits

Thank you, any questions?

Steve Coyne
Consultant

Director
Light Naturally
T: +61 413 314 346
E: steve@ligthnaturally.com.au

Michael Scholand
Senior Advisor

Policy & Analysis Team
CLASP | Europe
T: +44-7931-701-568
E: mscholand@clasp.ngo