2 November 2023

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

EEA Power Quality Guidelines

Asset Management Forum

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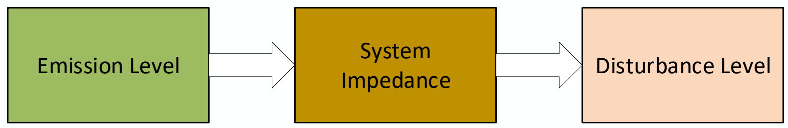
Changes

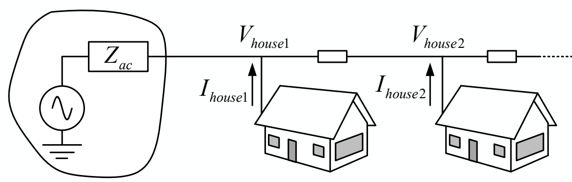
1. Waveforms of harmonic producing equipment given.
2. Interharmonics updated based on latest international trends
   - ❑ Subharmonics
   - ❑ Interharmonics (50<f≤2500 Hz)
   - ❑ High frequency Emissions (Harmonics and Interharmonics above 2.5 kHz)
3. Subgroup concept for interharmonics and harmonics
4. Ferroresonance
5. Geomagnetically induced currents
6. DC Current injection
7. Common mode voltages
8. More background on various phenomena

Fundamentals

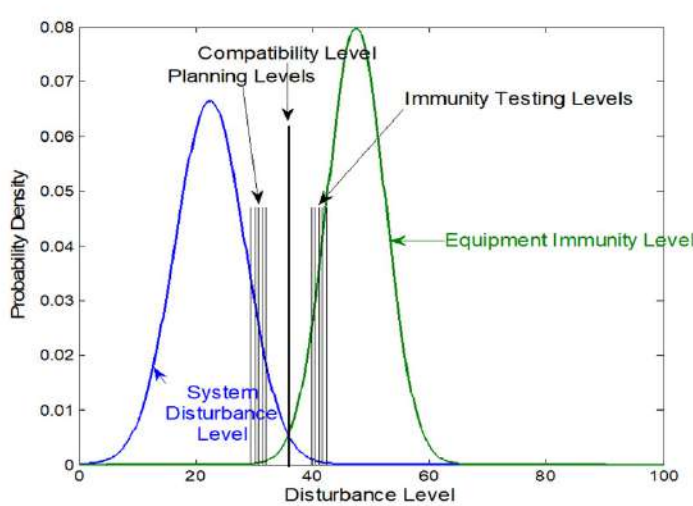


Current
- Fluctuating
- Distorted

Voltage
- Fluctuating
- Distorted



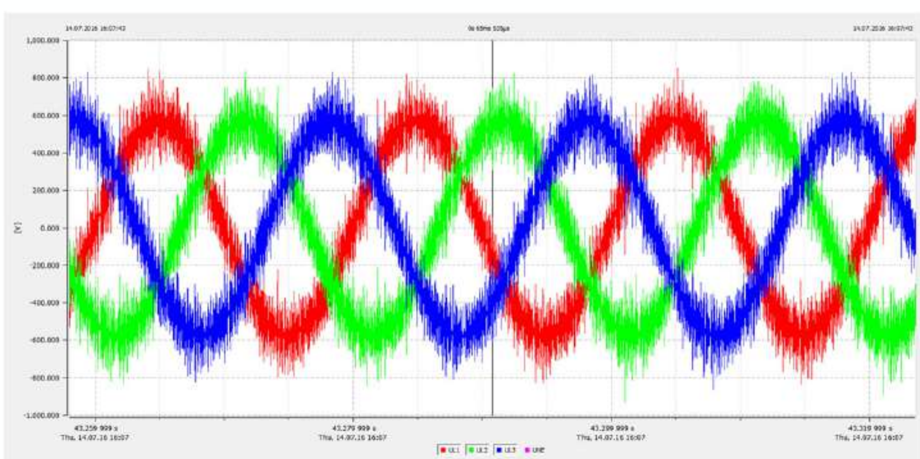
Electromagnetic Compatibility Principles



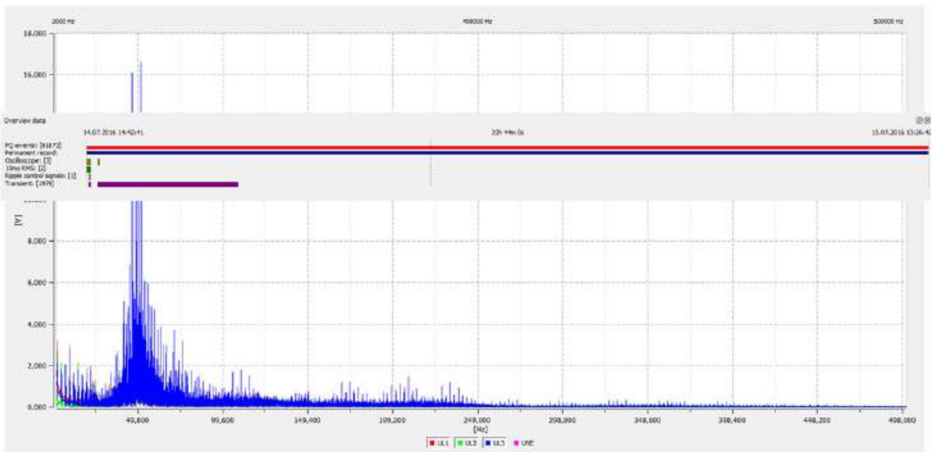
Standards

1. Limits must be matched to the compatibility level of equipment.
2. Rather than setting limits to accommodate the most sensitive devices, work on the lack of immunity for some devices is necessary. Hence the importance of immunity standards.
3. Two types of standards:
   – Installation
   – Device [No enforcement in NZ unlike Australia]

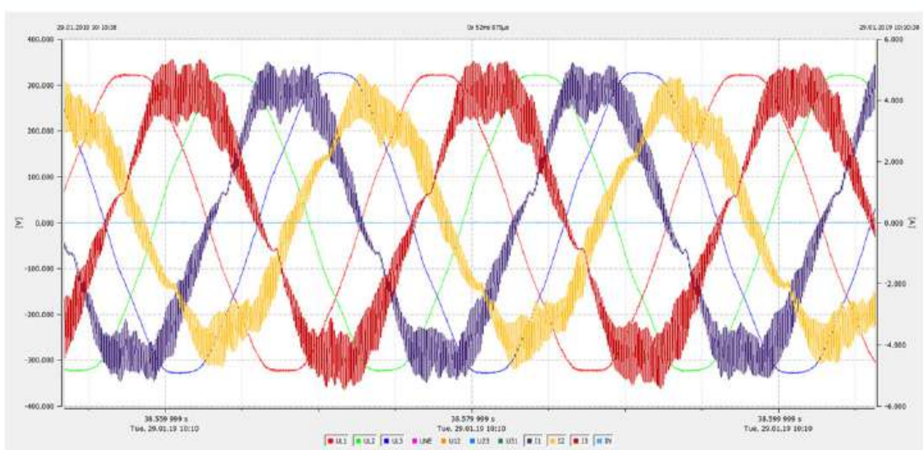
Waveform example 1



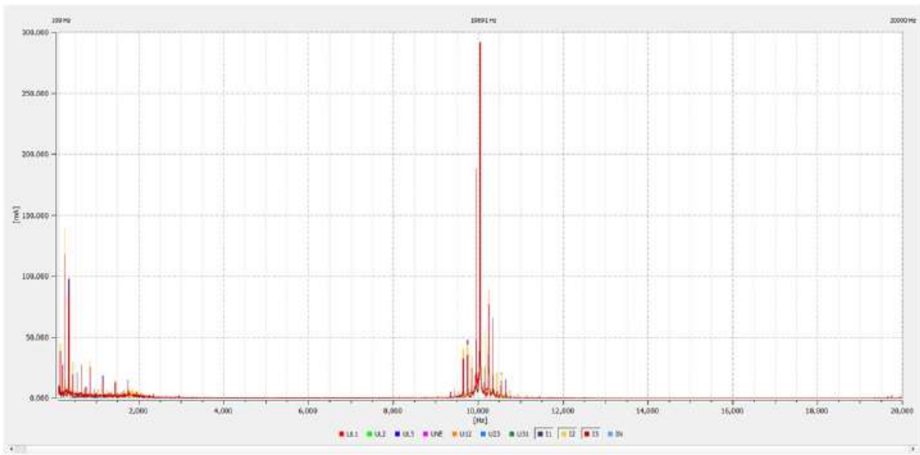
Waveform example 1 Spectrum



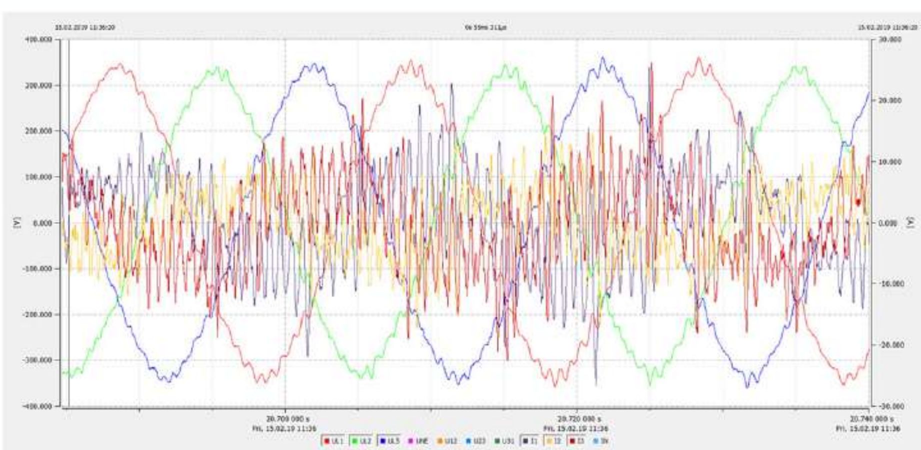
Waveform example 2



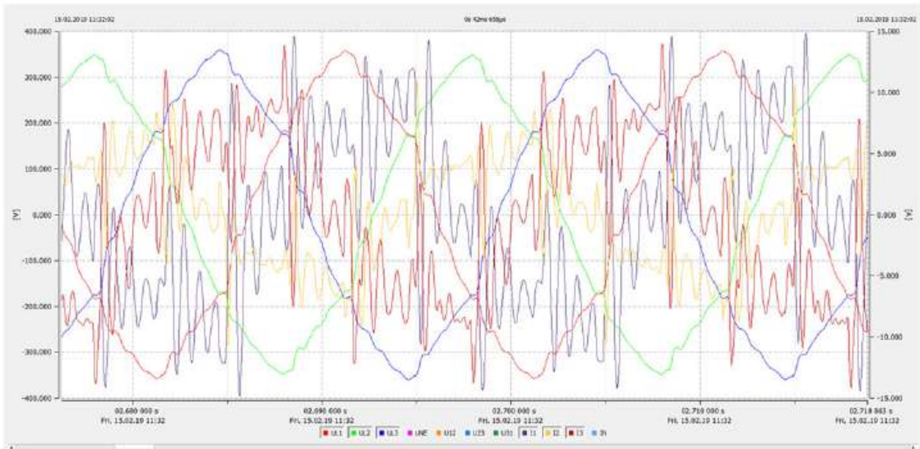
Waveform example 2 Spectrum



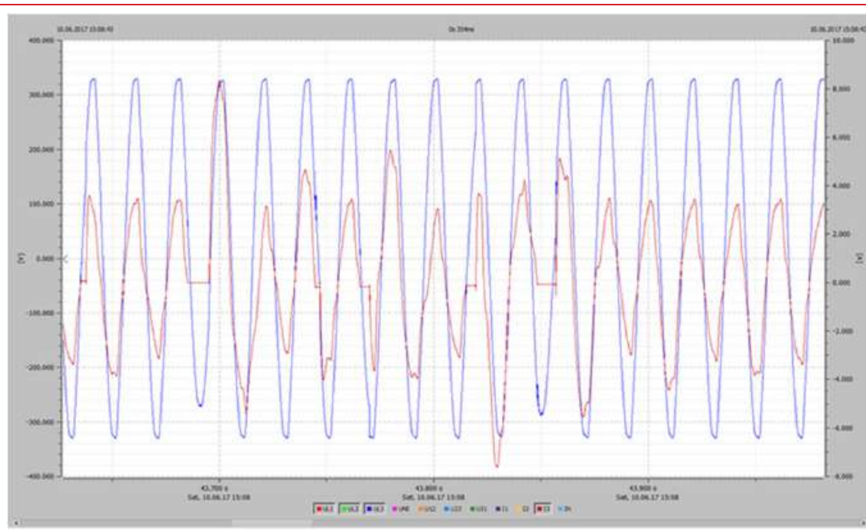
Waveform example 3



Waveform example 4

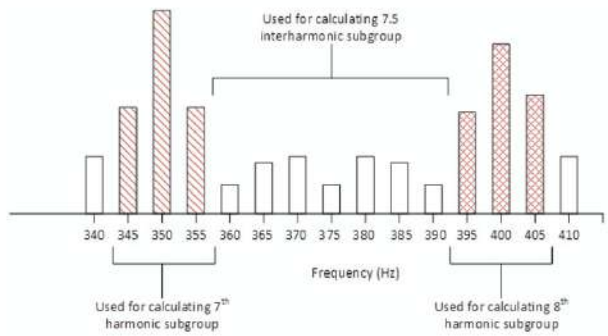


Waveform example 5



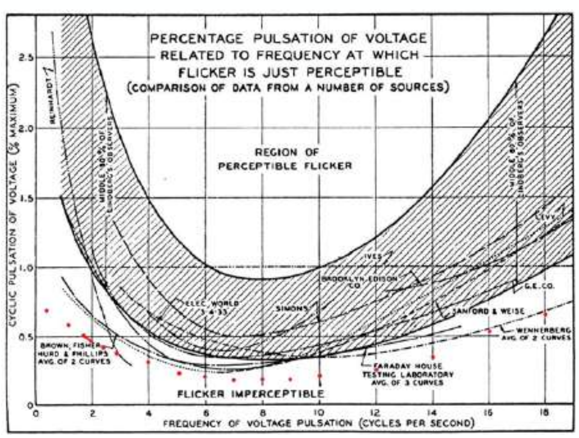
Subgroup concept

The **non-stationary nature of the signal**,
uncertainty in synchronisation,
spectral leakage due to frequency components that are not multiples of 5 Hz (picket fence effect),
aliasing
→ all result in inaccuracies in the spectral component magnitudes (e.g. spill-over to neighbouring spectral components either side of the harmonic).
The use of subgroups collect the major part of the energy in the signal in a band of frequencies



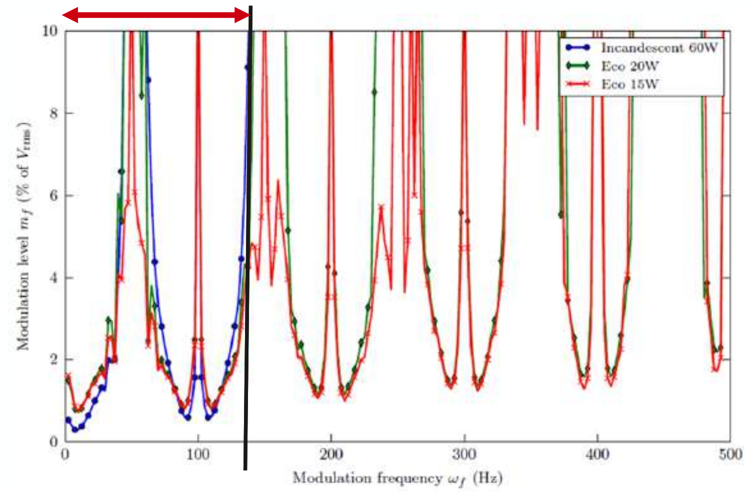
The international community is moving towards the use of the interharmonic subgroup concept of *IEC 61000-4-7 Ed. 2* instead of individual interharmonic components.

Light Flicker



Perceptibility to voltage fluctuations (Red markers indicating IEC levels)

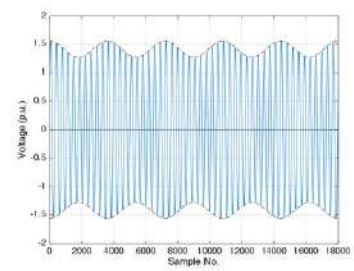
Light Flicker



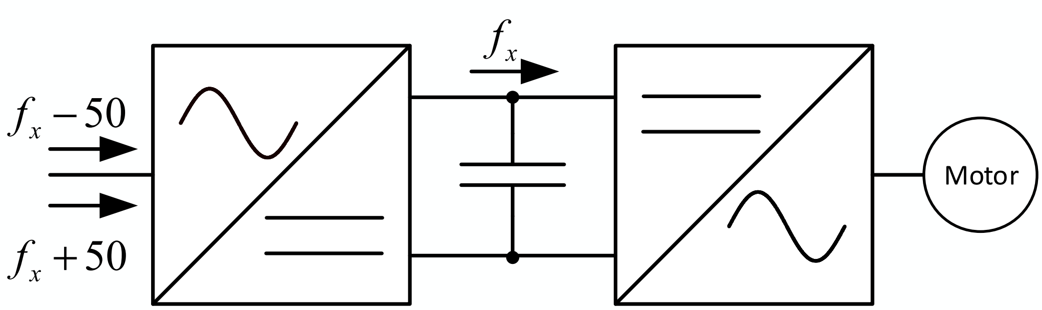
$$v(t) = \sqrt{2}(1 + m\,cos(\omega_2 t))\,cos(\omega_1 t + \phi_1)$$

$$= \sqrt{2}\,cos(\omega_1 t + \psi_1)$$

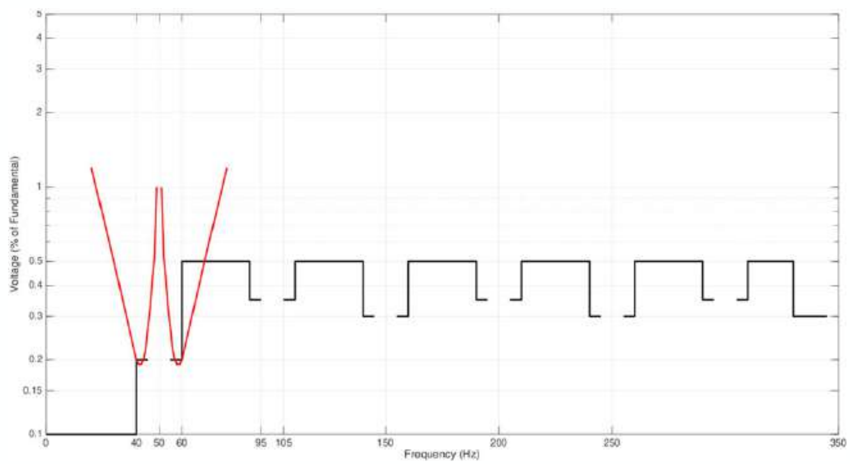
$$+ \frac{m}{2}[cos((\omega_1 + \omega_2)t + \phi_1) + cos((\omega_1 - \omega_2)t + \phi_1)]$$



Converter as a Modulator (translates frequencies)



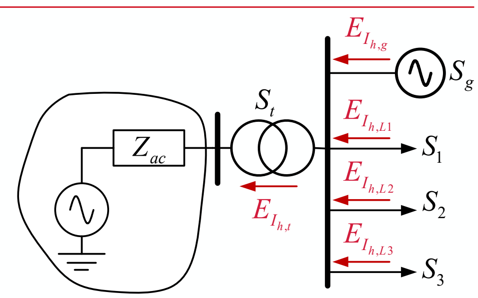
Interharmonics Limits



Wrinkles

1. Allocation with Embedded generation

   A method outlined in the Guidelines but needs further refining.



2. Diversity/Summation exponents for modern power electronic equipment. Dealing with spread-spectrum devices.

3. Light-based flickermeter.

Diversity/Summation exponents

Diversity/Summation exponents incorporate two types of diversity:

- ***Phase angle*** and ***time diversity***

Indicative values means typical but can be changed based on knowledge of the situation. Note 1 of AS/NZS 61000.3.6 makes this clear.

Extract from AS/NZS 61000.3.6:2012

On the basis of the information available to date, the following set of exponents can be adopted in the absence of further specific information:

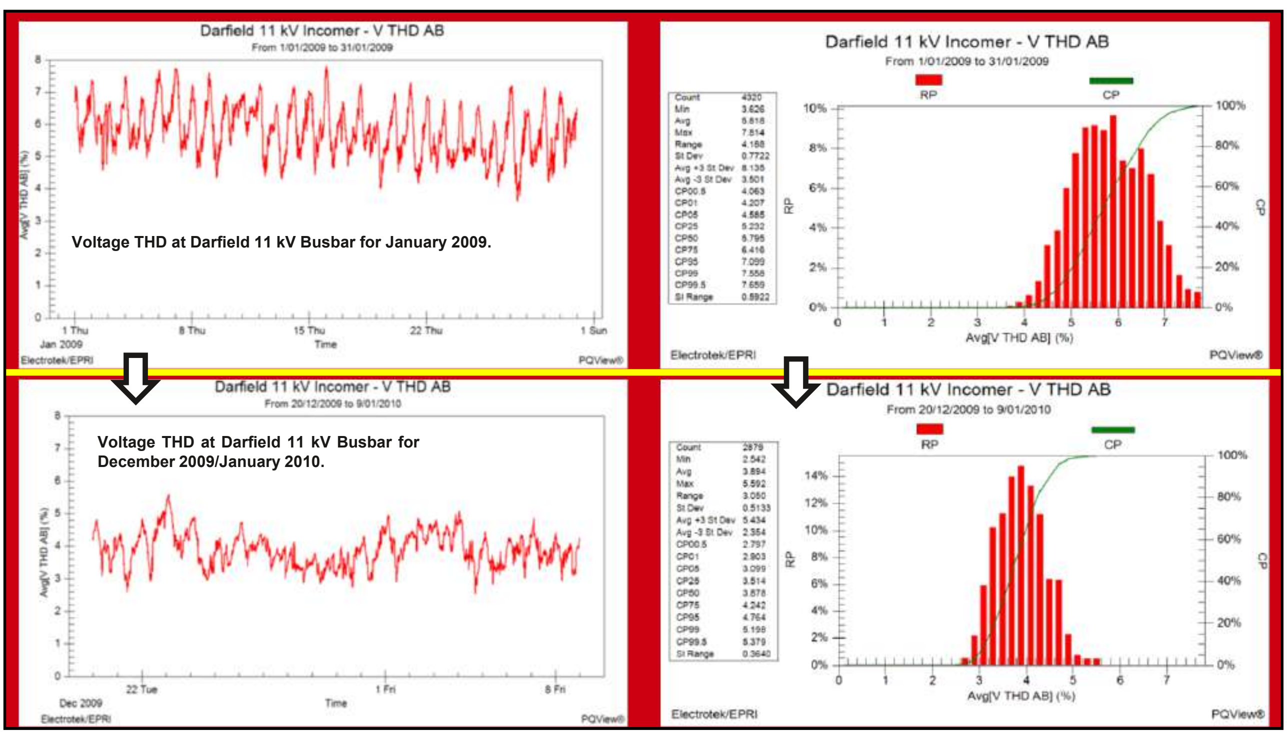
Table 3 – Summation exponents for harmonics (indicative values)

Harmonic order	α
$h < 5$	1
$5 \le h \le 10$	1,4
$h > 10$	2

NOTE 1 When it is known that the harmonics are likely to be in phase (i.e. phase angle differences less than 90°), then an exponent $\alpha = 1$ should be used for order 5 and above.

NOTE 2 Conversely, some low order non-characteristic harmonics (e.g. 3[rd]) may have different causes that are unlikely to produce in-phase harmonics, therefore an exponent higher than 1 could be used for these cases (e.g. $\alpha = 1,2$).

NOTE 3 Higher summation exponents can be used for even harmonics that are less likely to be in phase (for $h \le 10$).



Thank you for your attention!