The Fundamentals of EMC Compliance Testing

Harmonics, Flicker, and Immunity

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Over 30 years in Test & Measurement industry. Previous roles at Philips, Fluke, Danaher, California Instruments, AMETEK.

Extensive background in **design engineering, engineering management, applications engineering, sales and marketing** positions with a heavy emphasis on AC power test and measurement.

Herman vanEijkelenburg
Product Director, Pacific Power Source

Pacific Power Source

Over 50 years of Experience

Visit Booth # 1

Innovate the Way you Test

Our reputation as a market and technology leader stems from best-in-class products, continual investments in R&D, and exceptional customer support, worldwide.

Global Leader in AC & DC Test Solutions

- AC & DC Power Sources & Loads
- Regenerative Grid Simulators
- Harmonics & Flicker, Immunity Test Systems
- Test Control Software
- Custom System Integration

WEBINAR

1. Power Line Emission & Immunity Compliance Standards Overview

2. Harmonics & Flicker Test Requirements

3. Immunity Test Requirements

4. Criteria for Selecting the Right Test Solution

EMC Test Standards Apply to All Products Connected to the Grid

To **ensure safety, efficiency, and interoperability** of electrical and electronic systems without causing or being affected by electromagnetic interference

Two Common Sub-Types of EMC Standards Testing:

Power Line Emissions	Power Line Immunity
1 Harmonics & Flicker	2 Immunity

Harmonics, Flicker, & Immunity Testing

Power Line Emissions

1 Harmonics

Measure and Analyze:
Harmonics, Interharmonics Current Distortion.

To **prevent excessive harmonic pollution** on the grid.

2 Flicker

Measure and Analyze:
Voltage Fluctuations which may cause flicker

To **prevent adverse effects on humans** with light sensitivities (epilepsy, etc.)

Power Line Immunity

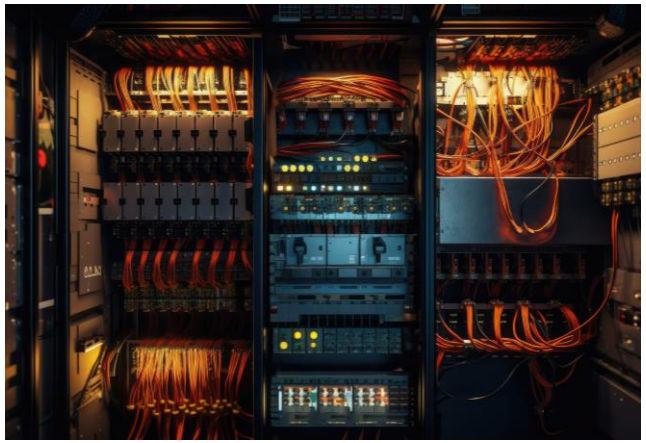
3 Immunity

Measure and Analyze:
Voltage and Frequency anomalies

To **ensure safe operation** and **prevent equipment damage** under grid anomalies

Which Industries Apply?

Renewable Energy



Industrial Equipment

Aerospace
(Immunity Testing Only)

Household Appliances

EV Charging Systems
& Components

Legal Compliance to IEC/EN Standards

if Export to EU and UK

IEC EMC Standards

Voted by member countries for all **European Community countries.** If CENELEC* EC governing body for electrical standards approves, an **EN equivalent is published**

EU, UK	Other Countries
CE **CE Marking Product Label** indicates EU Compliance	**National variation examples** • Japan (JIS-C-61000-3-2) • China, (GB/T 14549) • Mexico has ANCE NMX-J-550/3-2.

Adopted worldwide except USA and Canada.

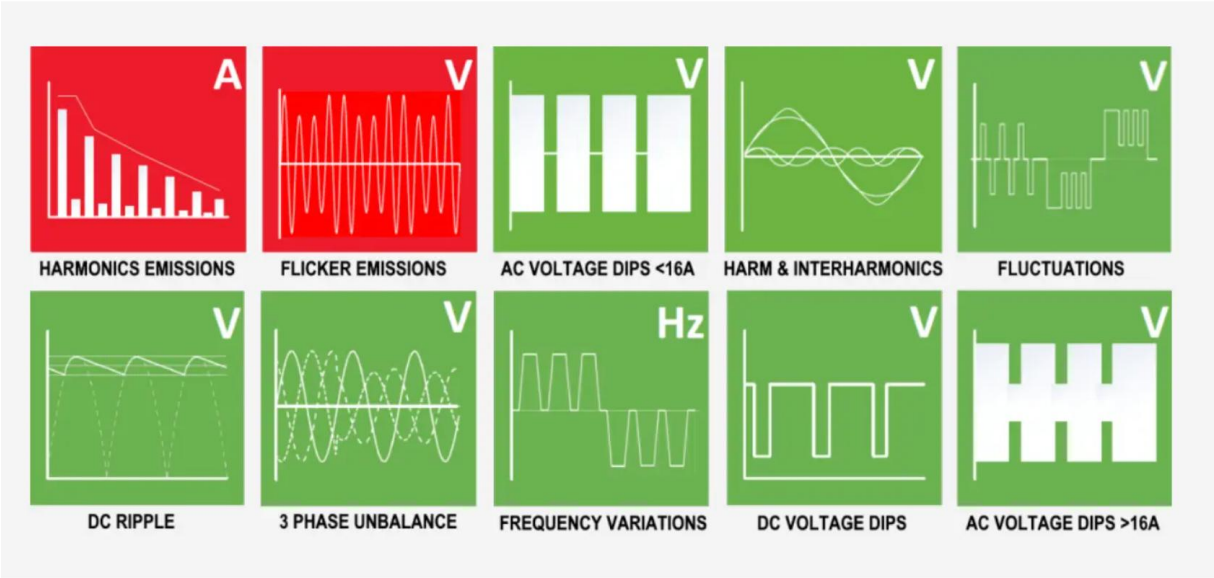
IEC Standards Overview

Emissions Tests

- IEC 61000-3-2 Harmonics and Interharmonics
- IEC 61000-3-12 Harmonics and Interharmonics
- IEC 61000-3-3 Flicker Emissions
- IEC 61000-3-11 Flicker Emissions

Immunity Test

- IEC 61000-4-11 AC Dips and Interruptions -16A
- IEC 61000-4-13 Interharmonics
- IEC 61000-4-14 AC Voltage Fluctuations
- IEC 61000-4-17 DC Ripple
- IEC 61000-4-27 AC Voltage Unbalance 3 phase
- IEC 61000-4-28 Frequency Variations
- IEC 61000-4-29 DC Dips and Interruptions
- IEC 61000-4-34 AC Dips and Interruptions – 75A



Differences between IEC and US Standards

IEC

IEC/EN - 50160

PQ Requirements for public supply networks

Harmonics

IEC/EN 61000-3-2 current limits < 16 Amp

IEC/EN 61000-3-12 current limits up to 75 Amp/phase

Flicker

IEC/EN 61000-3-3 limits < 16 Amp

IEC/EN 61000-3-11 limits up to 75 Amp/phase

US

IEEE-519 (2014) USA PQ standard

Permitted Voltage distortion limits at the PCC

IEEE-1547 & UL-1741

Standards for connecting distributed generation

**US compliance requirement depends on product category

Harmonics

EMISSIONS

Measure Harmonics Caused by Equipment Under Test (EUT)

Test Process

Challenges

- **Provide required voltage & current** to run EUT
- Measure with **sufficient bandwidth and accuracy**
- Acquire data in **real-time / no gaps**
- Process data using **correct algorithms**
- **Accurate** determination of Pass or Fail
- Requires **specialized H&F software**
- H&F System Calibration (**A2LA Accredited**)

IEC 61000-3-2 Product Class Type Determines Test Limits

Class A

Balanced 3-phase equipment and all other equipment, except if specified in other classes

Class B

Portable tools, hand-held products

Class C

Lighting Equipment

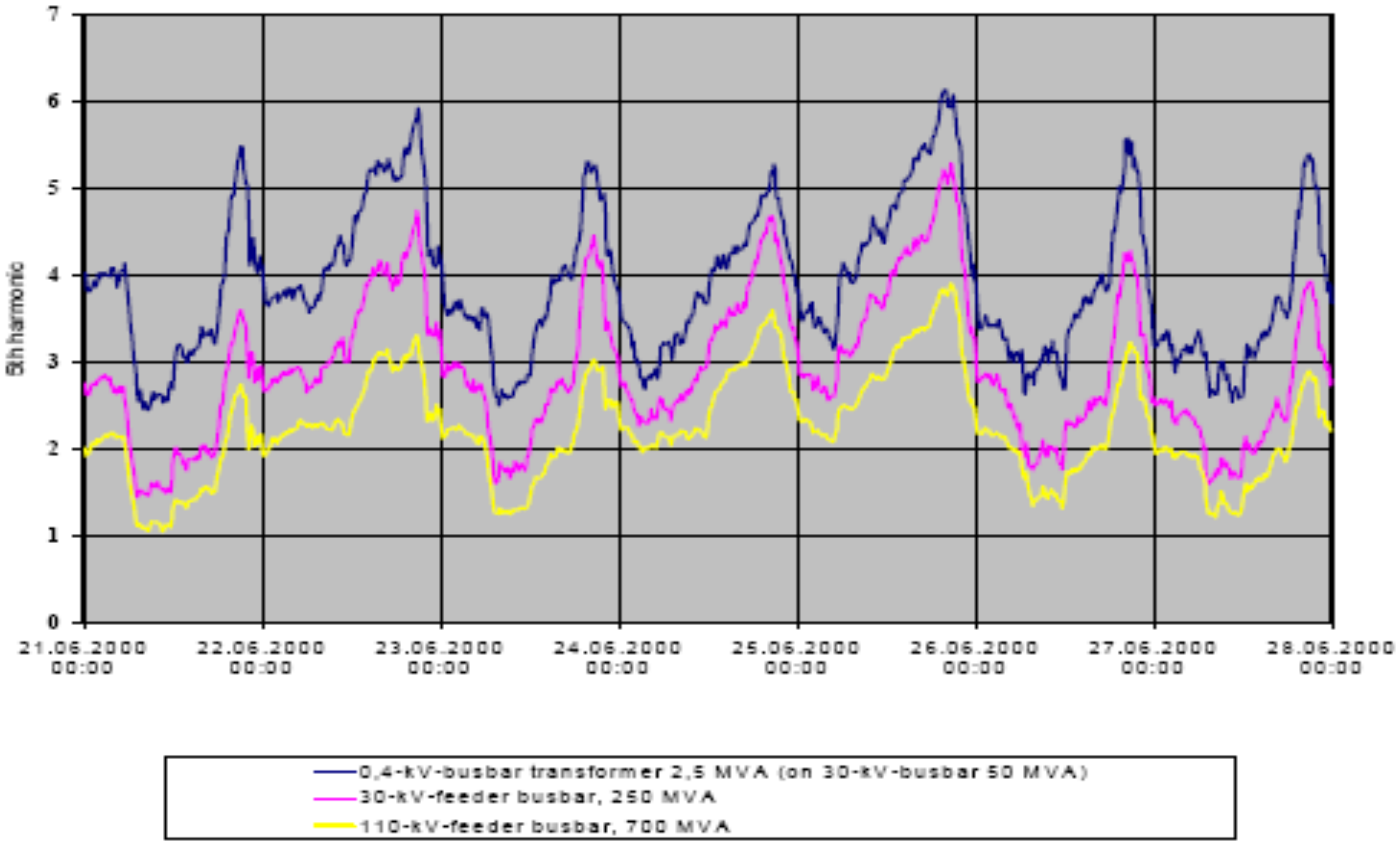
Class D

0-PC monitors, TV’s and VSD based refrigerators in 75-600 Watt

Importance of Testing: Example of Harmonics Pollution

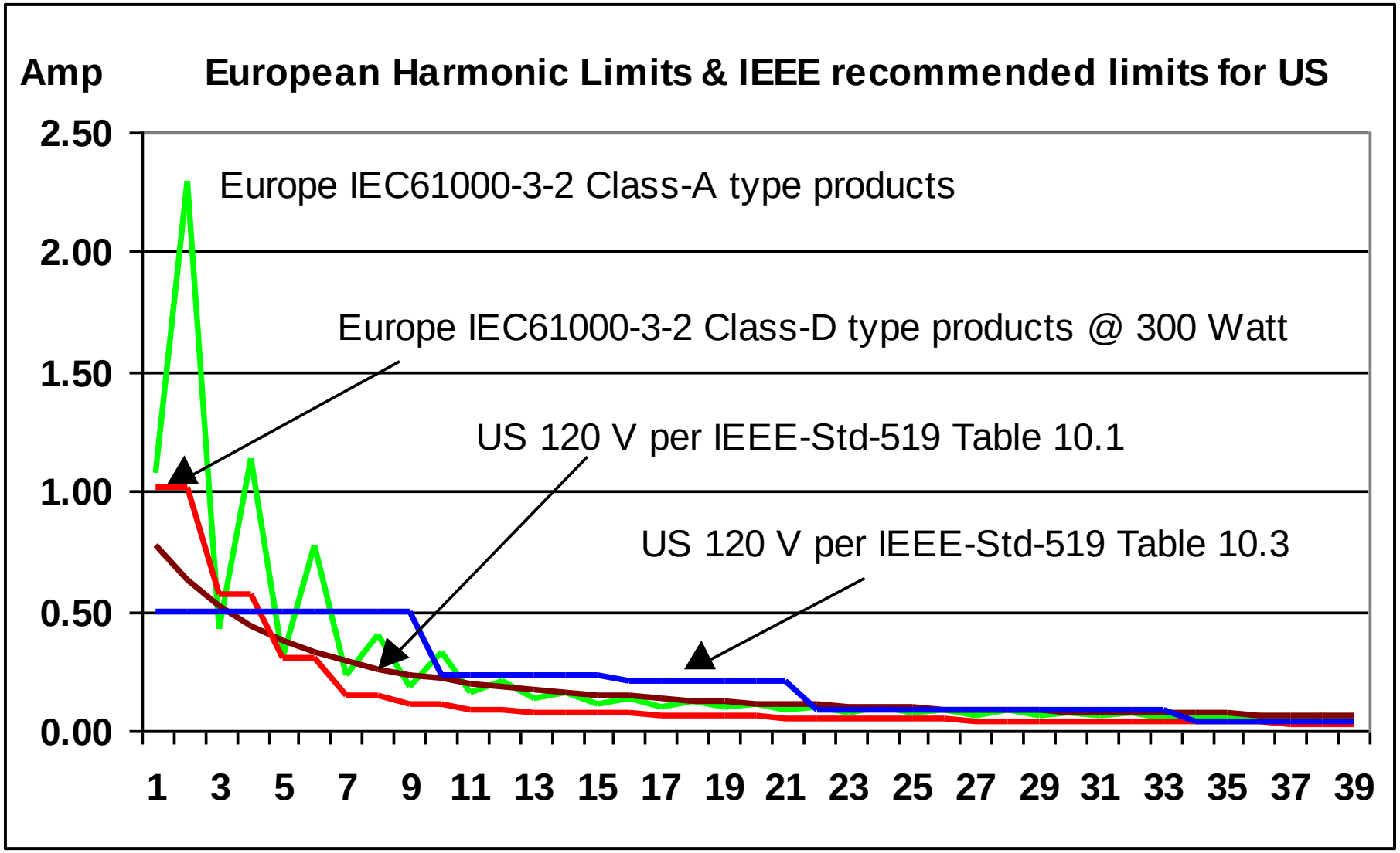
Voltage distortion in Urban Area (H-5) over one week in the London.

The cumulative effect of **home appliances and TVs around 10 – 11 PM** is very visible, and **distortion exceeds EN-50160 power quality requirements**.



Source: Eurelectric report 2003

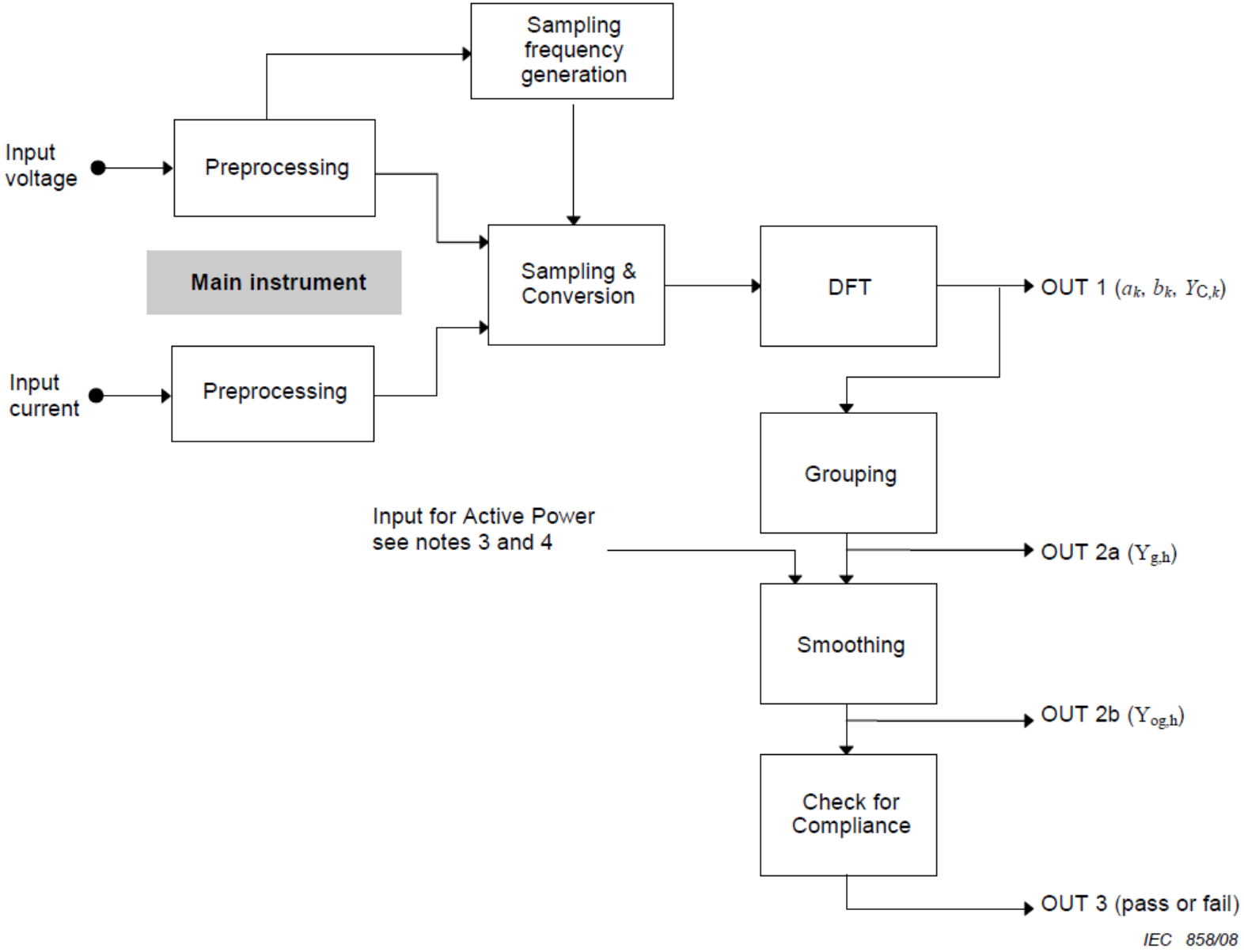
IEC vs IEEE-519 (1992) Limits Vary



Harmonics and Interharmonics Measurement Methods

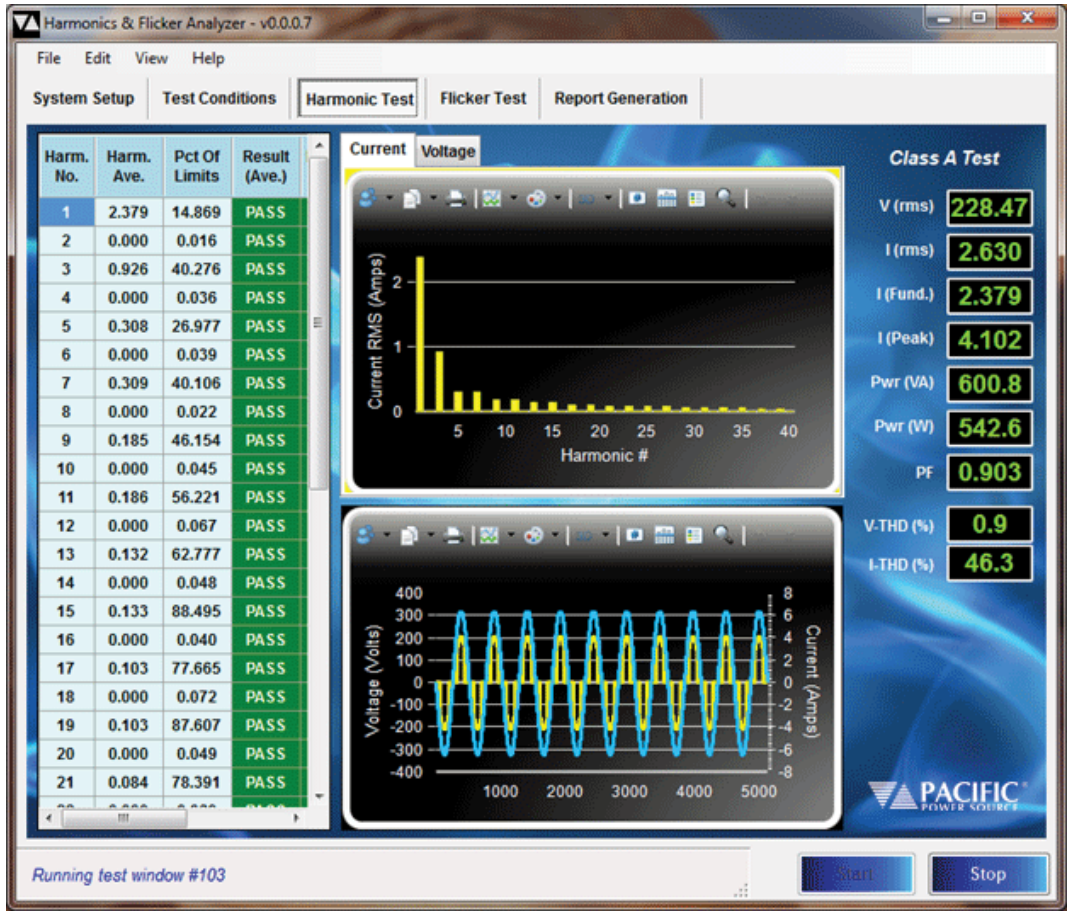
Defined by IEC 61000-4-7

- Grouping
- Smoothing

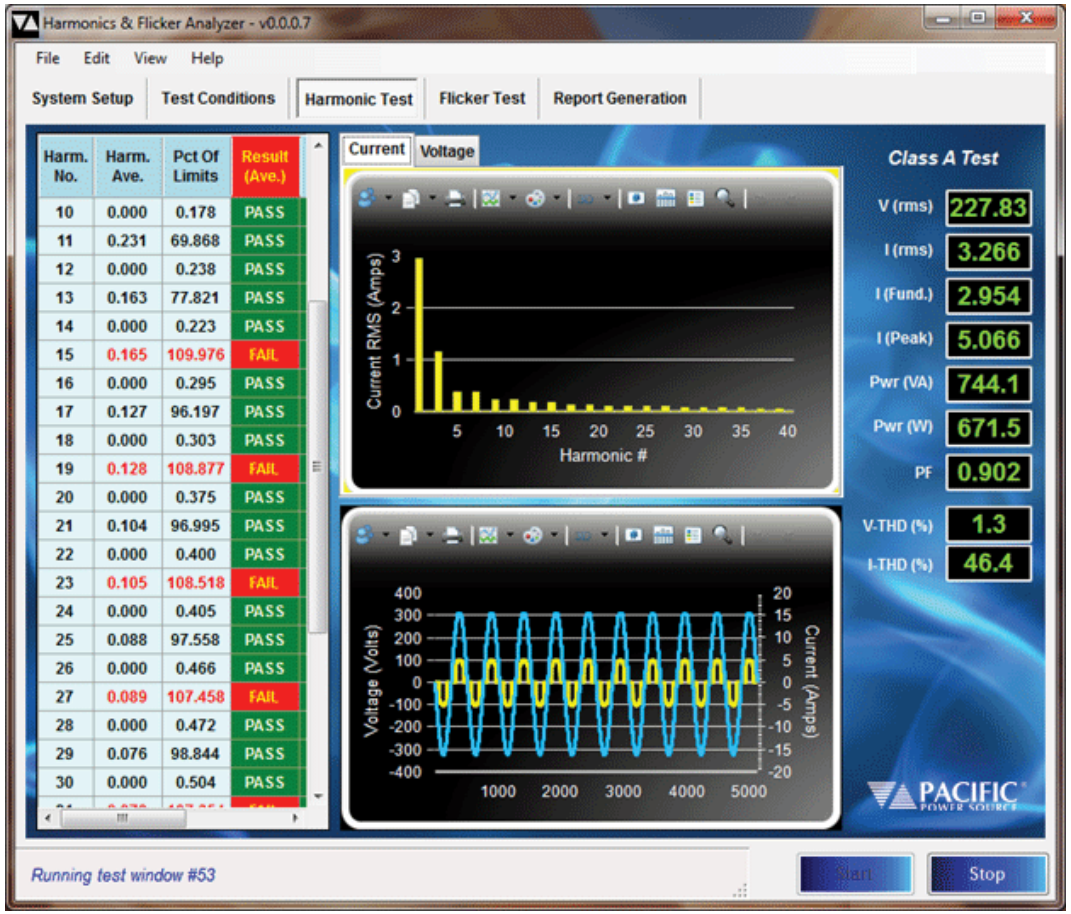


Example: Pass vs. Fail

Class A Product



Pass



Fail

Flicker

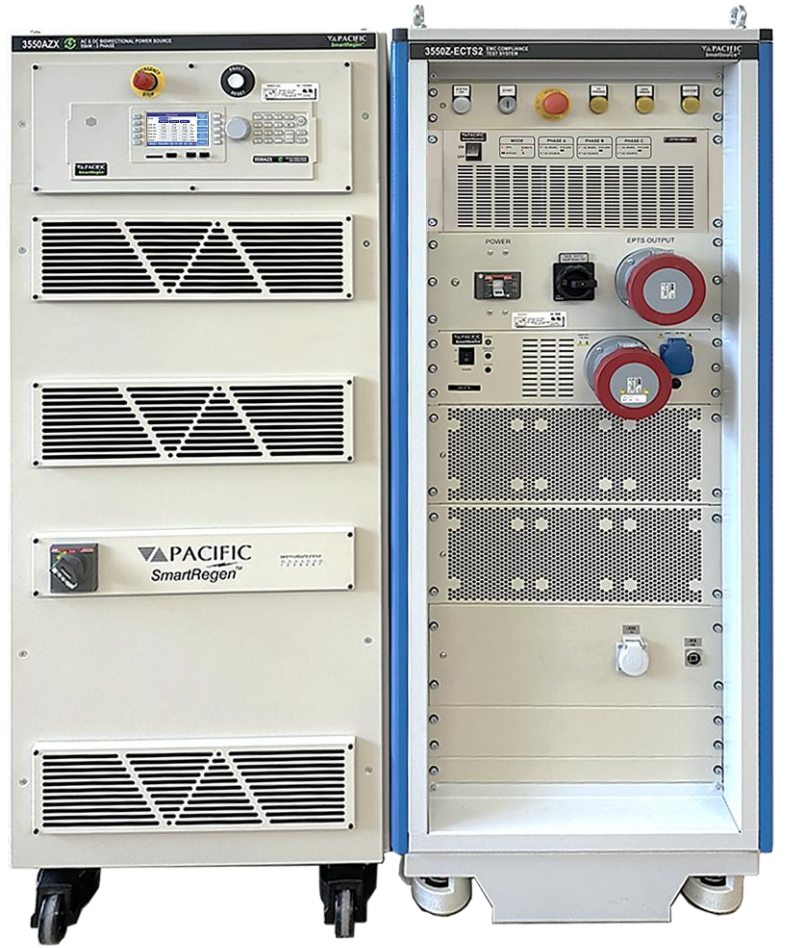
EMISSIONS

Flicker: IEC 61000-3-3

Limit voltage fluctuations to prevent adverse affects on people (triggering epilepsy attacks, seizures)

- Short Term Flicker and Long Term Flicker paired against limits
- Index used to pair against common limits
- Calculations are complex, as they involve a 2-D Laplace transfer function.

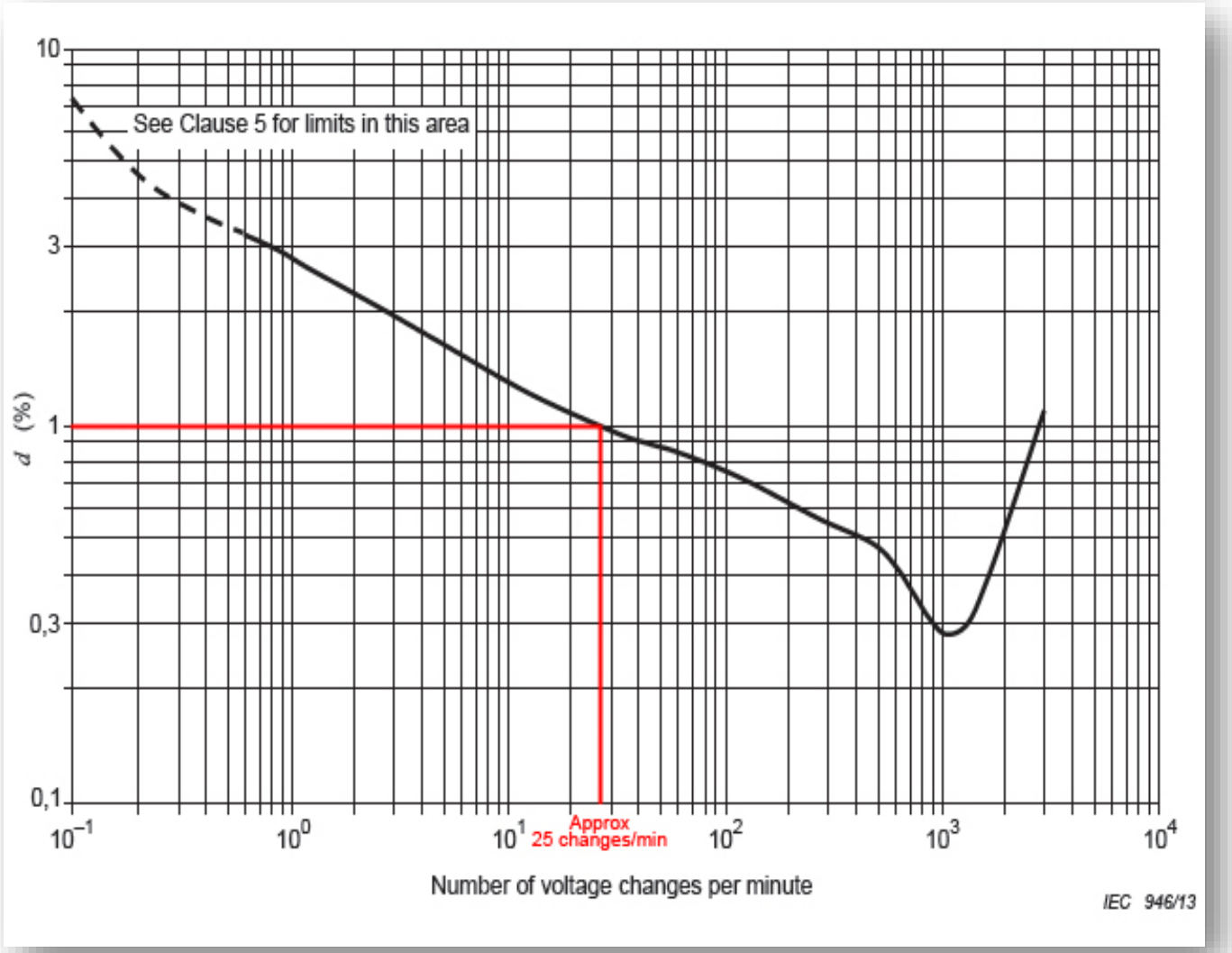
Simplify testing with the right solutions



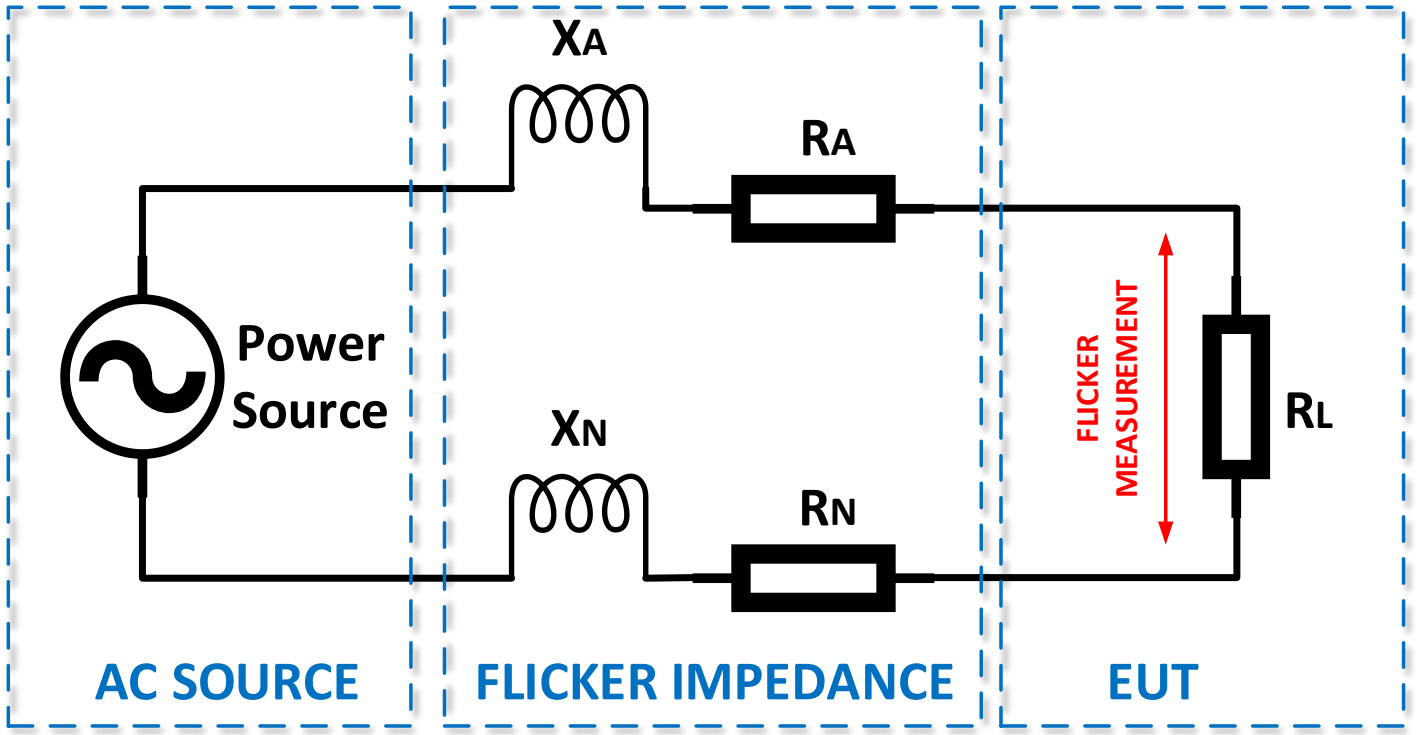
Human Sensitivity to Light Flicker

People are sensitive to the **amplitude and frequency** of light flicker

- The curve was determined where half of the tested persons perceived the light flicker.
- **The most "sensitive" point is at 1052 changes / minute,** where 0.3 % voltage fluctuation results in a Pst = 1.00
- **Flicker is expressed in Pst** (Short Term – 10 min) with a limit of 1.00, and a Plt (Long term - 2 hours) with a limit of 0.65.



IEC 60725 Reference Impedance Required

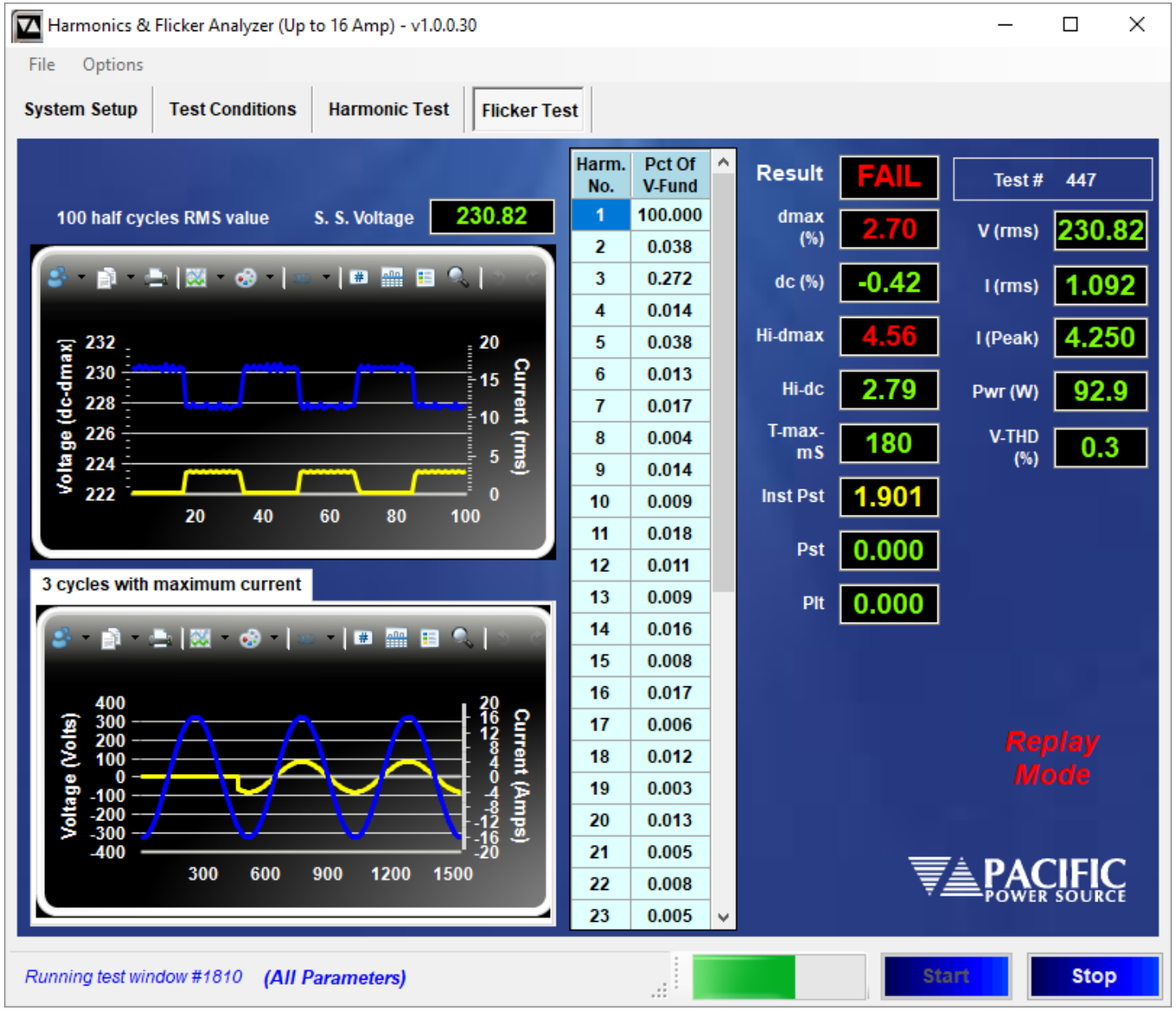


IEC 61000-3- Flicker Limits 16A	**Impedance = 0.40 + j0.25 Ω**
IEC 61000-3- Flicker Limits 75A	**Impedance = 0.25 + j0.25 Ω**

Reduced Impedance to limit power dissipation

Example of Typical Flicker Measurement

- Compare gainst the Pst-Plt-dc-dmax-T-max limits
- Voltage fluctuations are caused by products turning all or part of their load On/Off (5 amp in this example).
- The software automates the process of comparing against product class limits to determine Fail or Pass.



Immunity

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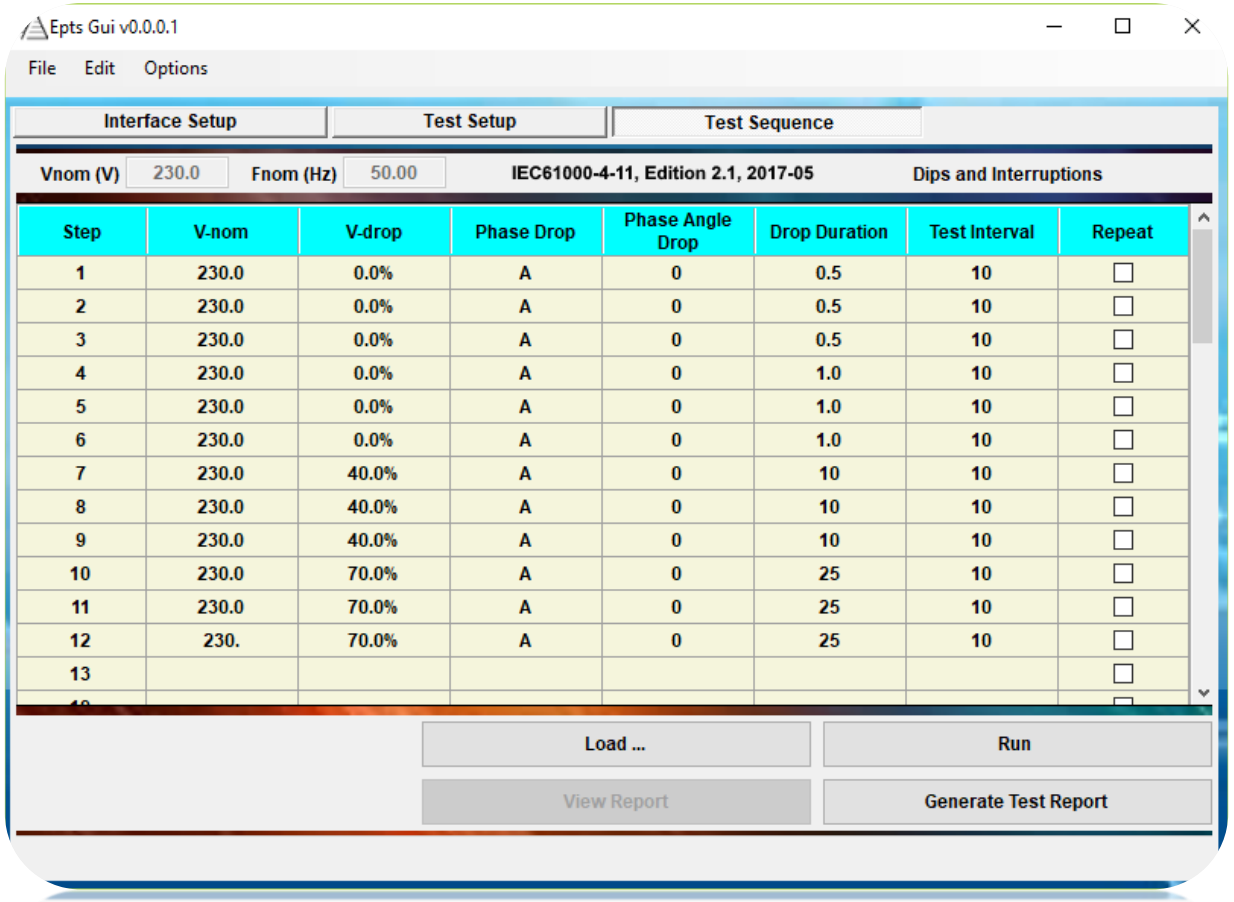
Immunity Testing Measures Voltage and Frequency Anomalies

Ensures product safety and operation

Immunity Test

- IEC 61000-4-11 AC Dips and Interruptions -16A
- IEC 61000-4-13 Interharmonics
- IEC 61000-4-14 AC Voltage Fluctuations
- IEC 61000-4-17 DC Ripple
- IEC 61000-4-27 AC Voltage Unbalance 3 phase
- IEC 61000-4-28 Frequency Variations
- IEC 61000-4-29 DC Dips and Interruptions
- IEC 61000-4-34 AC Dips and Interruptions – 75A

Example: IEC 61000-4-11 Test Sequences

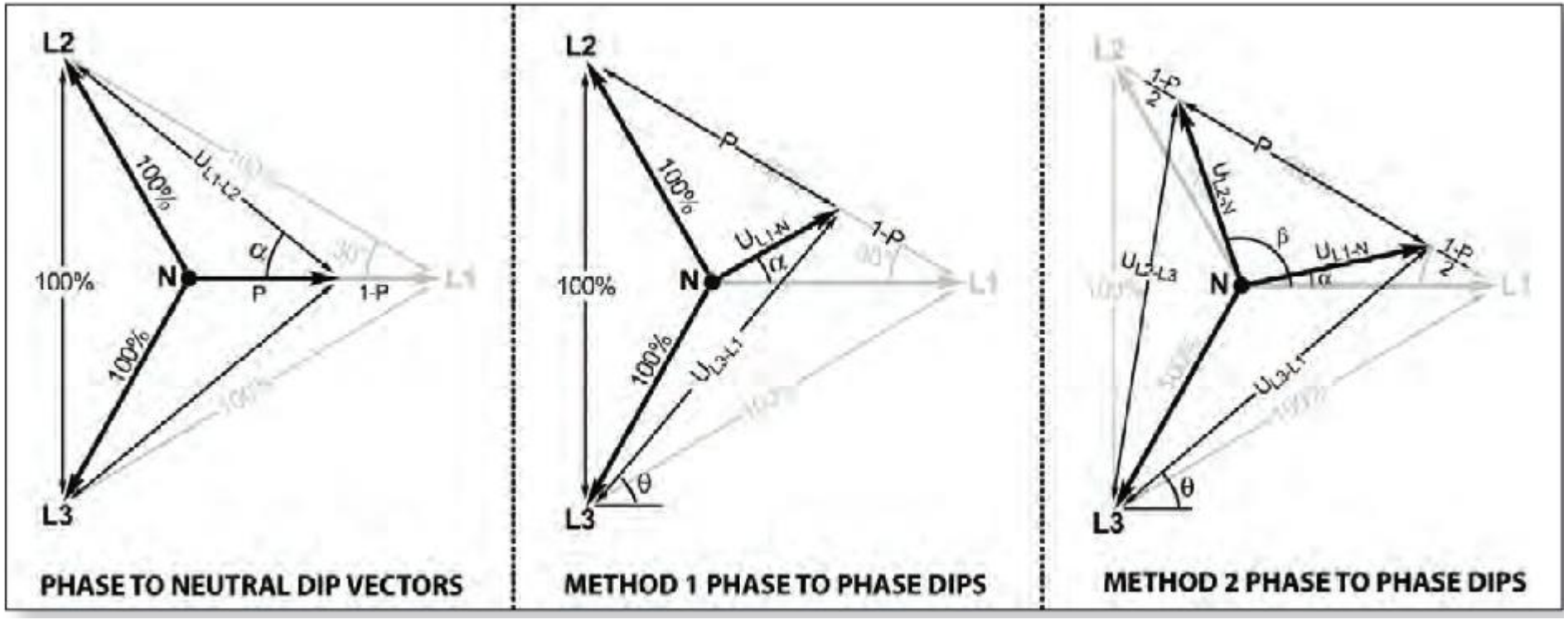


Step	V-nom	V-drop	Phase Drop	Phase Angle Drop	Drop Duration	Test Interval	Repeat
1	230.0	0.0%	A	0	0.5	10	☐
2	230.0	0.0%	A	0	0.5	10	☐
3	230.0	0.0%	A	0	0.5	10	☐
4	230.0	0.0%	A	0	1.0	10	☐
5	230.0	0.0%	A	0	1.0	10	☐
6	230.0	0.0%	A	0	1.0	10	☐
7	230.0	40.0%	A	0	10	10	☐
8	230.0	40.0%	A	0	10	10	☐
9	230.0	40.0%	A	0	10	10	☐
10	230.0	70.0%	A	0	25	10	☐
11	230.0	70.0%	A	0	25	10	☐
12	230.	70.0%	A	0	25	10	☐
13							☐

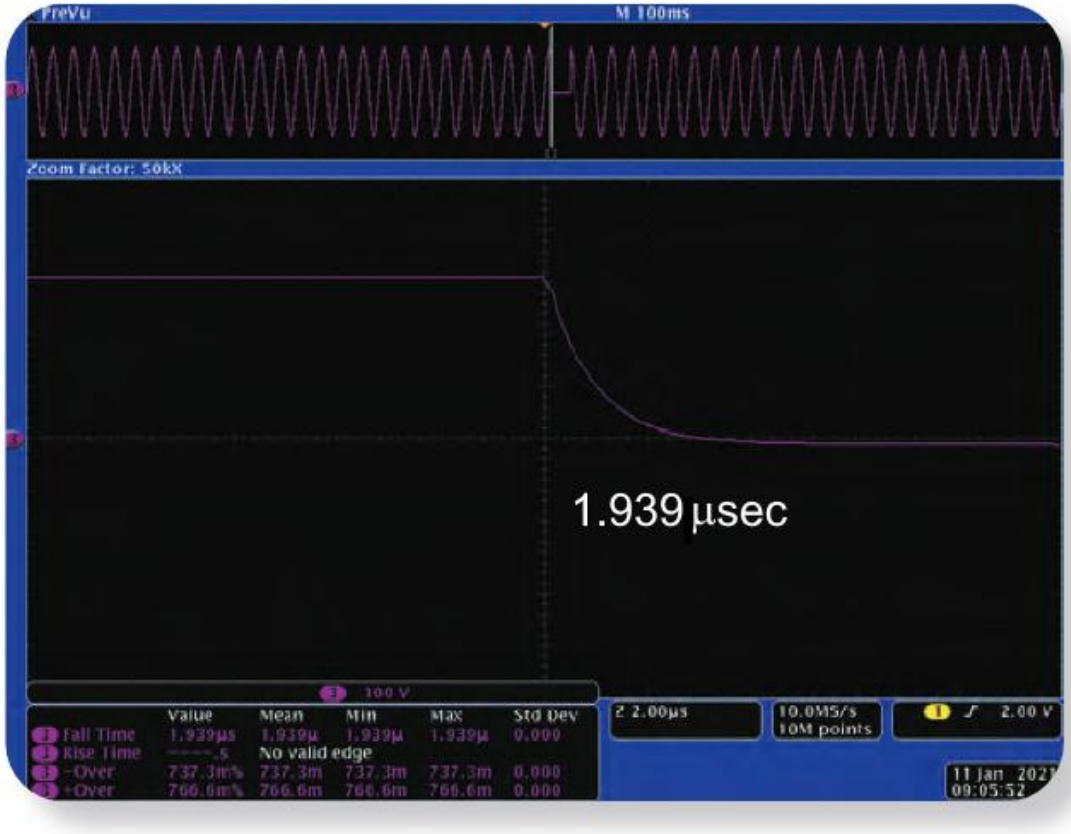
IEC61000-4-11, IEC61000-4-34: Test Dips and Interruptions

For 3-Phase EUT's, **voltages dips** must be applied using several phase vector methods to meet full compliance

Three Phase Voltage Dips



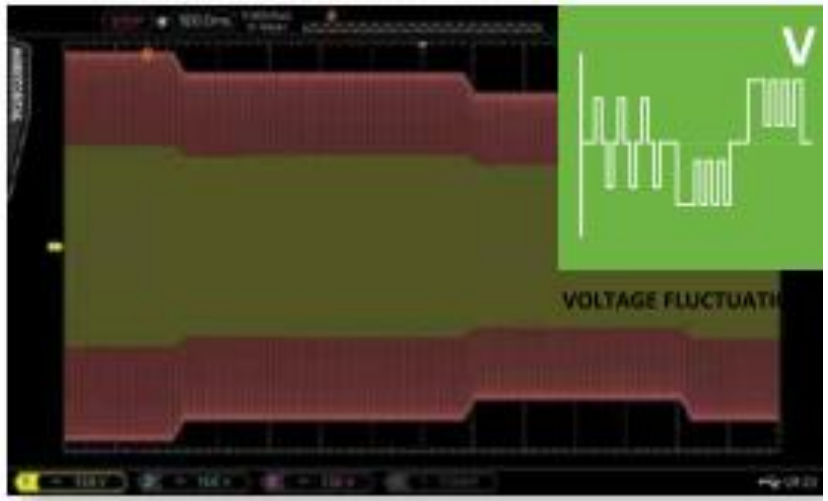
Test Rise & Fall Times < 5 μsec with no over/undershoot

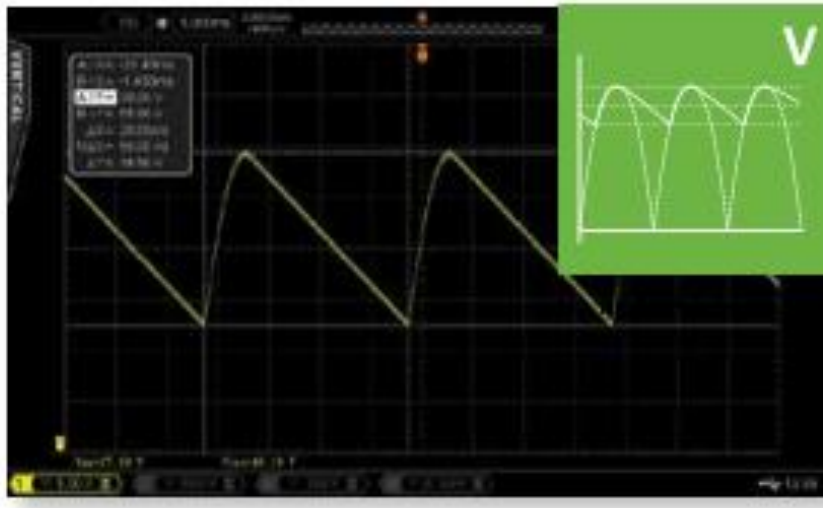


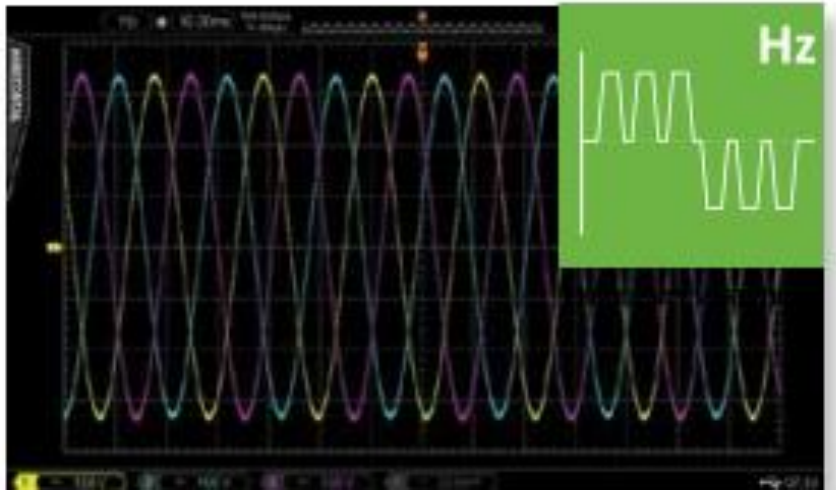
Fall Time < 5 μsec with no undershoot

Rise Time < 5 μsec with no overshoot

IEC 61000-4-13: Test Harmonics and Interharmonics

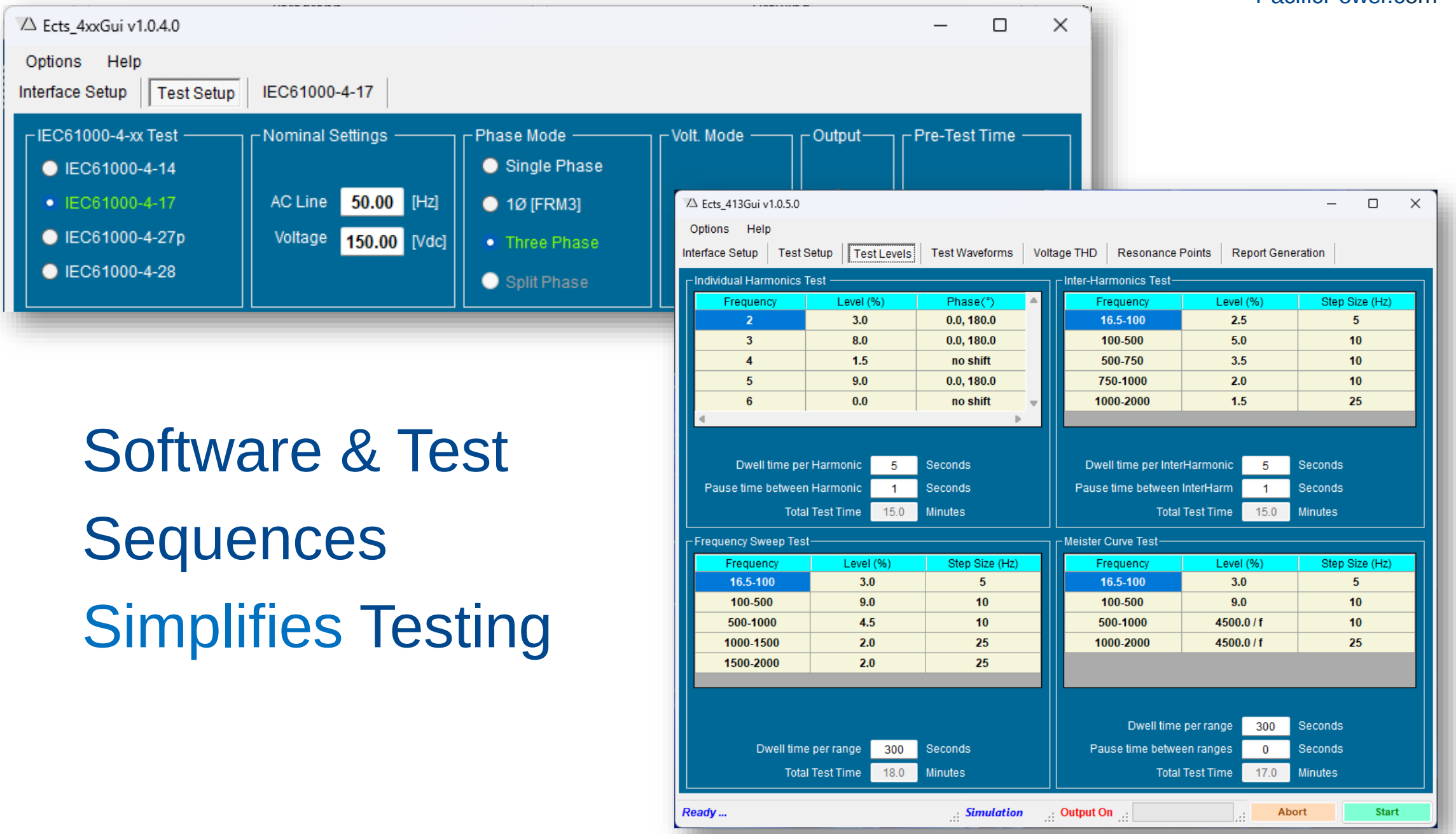






IEC 61000-14: Interharmonics Option

IEC 61000-4-13 Table	Test	Voltage V_{LN} / V_{LL} (V_{RMS})	Frequency (Hz)	Class/Test Level	Phase Mode
Table 1, 2 & 3	Odd Harmonics	115 / 208Vac	60 Hz	Class 1, 2 & 3	1ø , 3ø
		230 / 400Vac	50 Hz	Class 1, 2 & 3	1ø , 2ø, 3ø
Table 4	Inter Harmonics	115 / 208Vac	60 Hz	Class 1, 2 & 3	1ø , 3ø
		230 / 400Vac	50 Hz	Class 1, 2 & 3	1ø , 2ø, 3ø
Table 7	Flat Curve	115 / 208Vac	60 Hz	Class 1, 2 & 3	1ø , 3ø
		230 / 400Vac	50 Hz	Class 1, 2 & 3	1ø , 2ø, 3ø
Table 8	Over Swing	115 / 208Vac	60 Hz	Class 1, 2 & 3	1ø , 3ø
		230 / 400Vac	50 Hz	Class 1, 2 & 3	1ø , 2ø, 3ø
Table 9	Frequency Sweep	115 / 208Vac	60 Hz	Class 1, 2 & 3	1ø , 3ø
		230 / 400Vac	50 Hz	Class 1, 2 & 3	1ø , 2ø, 3ø
Table 11	Meister Curve	115 / 208Vac	60 Hz	Class 2	1ø , 3ø
		230 / 400Vac	50 Hz	Class 2	1ø , 2ø, 3ø
		230 / 400Vac	50 Hz	Class 2	1ø , 2ø, 3ø



Software & Test Sequences Simplifies Testing

PACIFIC POWER SOURCE

Top Selection Criteria

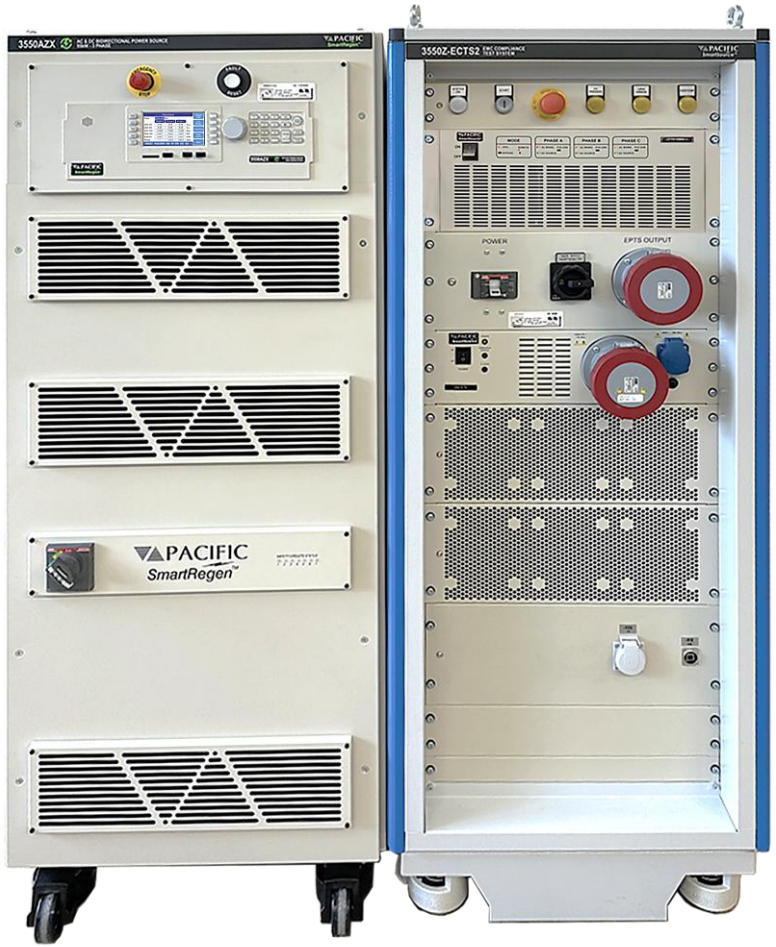
Top Criteria for Selecting a Test Solution

1. Pre- or Full Compliance
2. Measurement Accuracy and Range
3. Proven, Robust and Reliable
4. Easy to use Software, built-in playback
5. Customizable Test Sequences
6. Regenerative for bidirectional products
7. A2LA Accredited Calibration Availability

Power Source Requirements

1. AC or AC, DC and DC+AC
2. Single phase OR Single, Split and Three phase
3. Frequency required
4. Power and Current Ratings

Emissions & Immunity



Test in full compliance with the IEC standards.

Smart Control

- All tests are computer-controlled for ease of use and precision.
- The software guides the operator through all necessary steps.
- Eliminate operator errors and ensure consistent testing

Documentation & Reporting

- Data is collected to the PC drive for record-keeping.
- Comprehensive test reports are generated at the end of the test for compliance documentation.

User-friendly Windows-Based Software

- Intuitive, enhanced visualization tools are used to simplify testing.
- View data in real-time, while testing is in progress.

EMC Test System Solutions

Ideal for harmonics & flicker, immunity compliance testing.

Sophisticated Harmonics and Flicker measurement system and flicker impedance options.

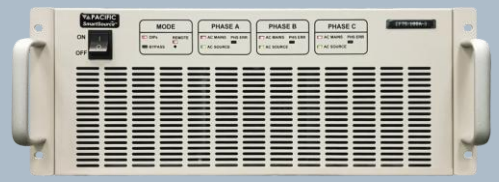
- 1, 2, and 3 phase output
- AC or AC and DC
- Wide Range of Power Levels Available
- Current and Power Limit Protection
- EMC Test Software
- Detailed test reports to file EUT compliance

ECTS2 Series

IEC Harmonics & Flicker Test Systems

- 750VA to 100kVA+
- 0 up to 440Vac L-N/762Vac L-L or ±650Vdc
- DC, 15-1000Hz

EPTS Option



Electronic Power Transfer Switch Option

Supports voltage rise and fall slew rates for IEC AC Voltage dips and Interruptions and Voltage Unbalance immunity testing per IEC61000-4-11, IEC61000-4-27 and IEC61000-4-34.

Compatible Regenerative AC Power Sources

High Power Regenerative AZX Series

30kW up to 550kW

30, 45, 55kW, paralleled up to 550kW

- Voltage: 0-240 Vac L-N / 0-415 Vac L-L and 0-480 Vac-LN / 0-830 Vac-LL; 0-340 Vdc and 0-680 Vdc
- 15-1000Hz; Extended 1 – 10,000Hz

- High power EMC test app that require Regenerative power to return power back to the grid.
- Supports AC and DC IEC test standards.
- **Three-phase,** available **up to 100Arms per phase**.
- These are all dual cabinet configurations.

Mid to High Power AGX Series

6kW to 21kW per 4U
Parallel up to 252W

- Voltage: 0-350 VAC L-N 1ø / 0-606 VAC L-L 3ø; -500Vdc to +500Vdc
- 15 – 1200Hz; Extended Option -1 – 3000Hz

- Med to high power EMC test app that require Regenerative power to return power back to the grid.
- Compact, high density
- Supports AC and DC IEC test standards.
- **Three-phase,** available **up to 100Arms per phase**.

Compatible AC Power Sources

Mid to High Power
AFX Series

6kW to 15kW; up to 180W

15 – 1,200 Hz; Extended:1 – 3,000 Hz

Voltage: 0 up to 333Vac L-N/576Vac L-L or 425Vdc

- Med to high power EMC test app that do not require regenerative power.
- Compact, high density
- Supports AC and DC IEC test standards.
- **Single phase and three phase** systems **up to 130Arms per phase**.

Low Power, Very High Frequency
Linear LMX Series – AC Only

500 VA up to 30kVA

500 VA to 6000 VA; Parallel up to 30kW

Voltage: 0 up to 600VAC; Transformer Option

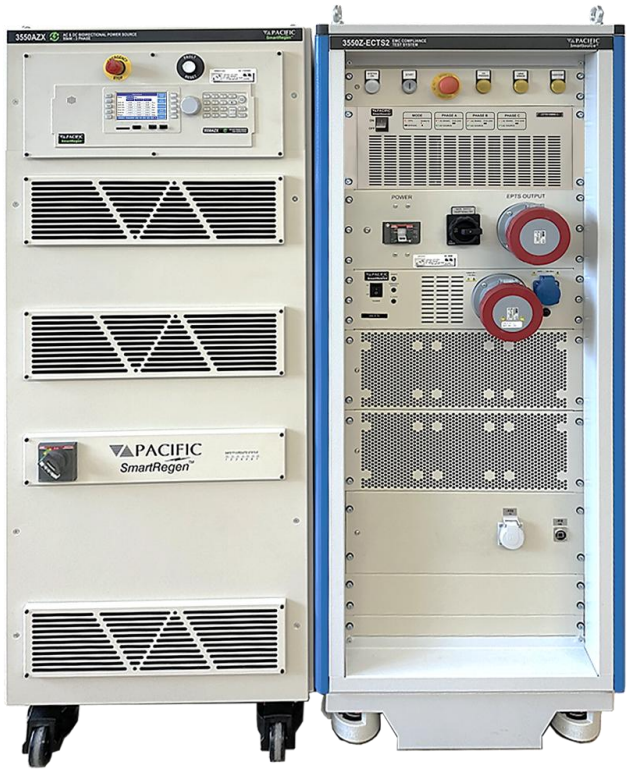
15 – 5,000Hz

- Lower power, very high frequency applications where high EUT currents not present.
- Linear power / High bandwidth and very low voltage distortion, well below IEC 61000-3-2 requirements
- **Single phase and three phase** systems **up to 16Arms per phase**.

Why Pacific Power Source?

Booth # 1

- **Proven, reliable solution** that meets all requirements
- **Excellent support** pre & post sales
  (On-site support, training and commissioning)
- **Full-featured smart tools** to investigate failures & ensure adequate margin
- **Easy-to-use** software simplifies test
- **Comprehensive** testing and reporting
- **Upgrade Later** – start with pre-compliance and upgrade to full-compliance, if needed later



The PPS Advantage

- High Performance & Reliability
- Best-in-Class User Experience
- Versatility & Future-Proofing
- Customized System Solutions
- Fast Lead Times
- Application Expertise
- Excellent Customer Service

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