THE EFFECT OF MAINS IMPEDANCE ON HARMONICS AND FLICKER MEASUREMENTS

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THE PROJECT

JRP reference:	TP4.J01 Power & Energy
JRP title:	Next generation of power and energy measuring techniques
TP:	TP4 - Electricity & Magnetism
JRP Coordinator:	Paul Wright
Lead Institute:	NPL, UK
Starting date:	01-Apr-08
Task 6.1:	**Investigate finite bus impedance effects on PQ parameters**
Partners:	**INM, RO and NPL, UK**

MEASUREMENT OF PQ PARAMETERS

Calibration **of** Measurement Equipment
- using laboratory set-ups
- under reference conditions defined in standards (e.g., IEC 61000-3 and IEC 61000-4 standard series)

In-situ Measurements
- under specific conditions of electricity supply network (voltage, current, power, impedance)

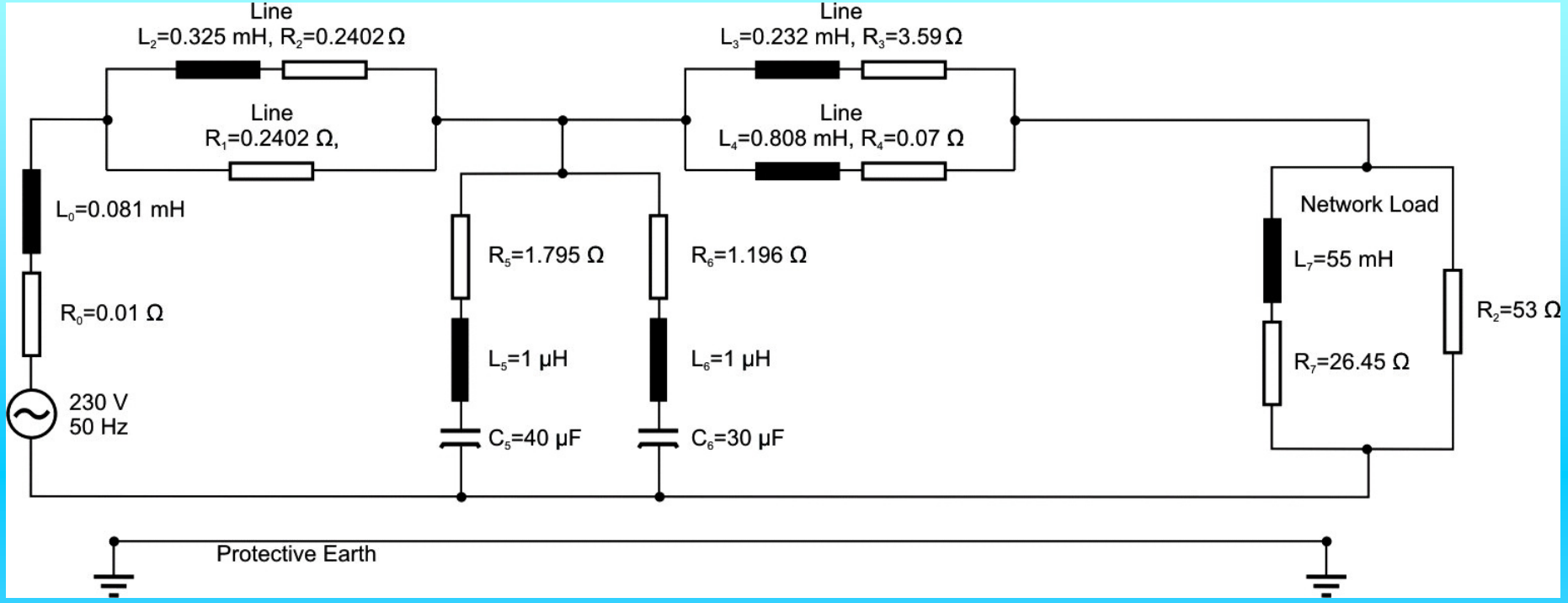
Low-voltage Urban Networks
- systems with “variable geometry”
- various consumers connected or disconnected
- variable number of non-linear, distortion generating consumers
- changes in the supply network impedance likely to occur

CONCERN:	Changes of the impedance during the in-field measurement of the harmonic distortions and of the flicker generating voltage variations may influence the uncertainty associated to the result obtained

GENERAL AIM

- To develop a computer model of a low voltage residential network
- Use a topology that would reflect as much as possible the main characteristics of a real network
- Provide compliance with the constraints resulting from Annex B of the IEC 61000-4-7 A1 standard and from the IEC 77AWG1 Technical Report
- To use the model to simulate and evaluate the effects that possible changes in the network impedance may have on in-situ harmonic distortions and flicker measurements

THE NETWORK MODEL



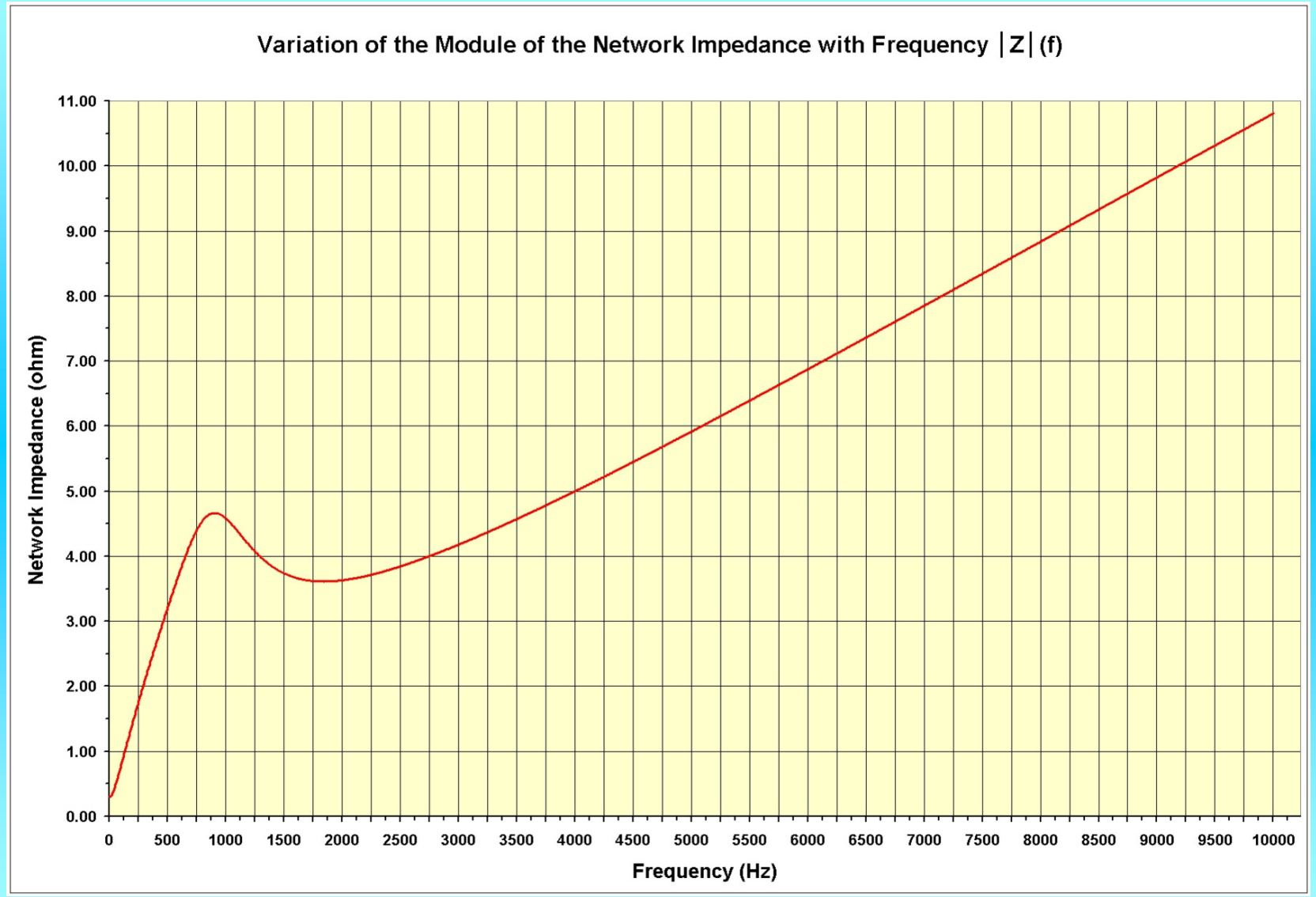
Model

$|Z|_{50\ Hz} = 0.4717\ \Omega$ $|Z|_{2050\ Hz} = 3.6434\ \Omega$ $|Z|_{2450\ Hz} = 3.8159\ \Omega$

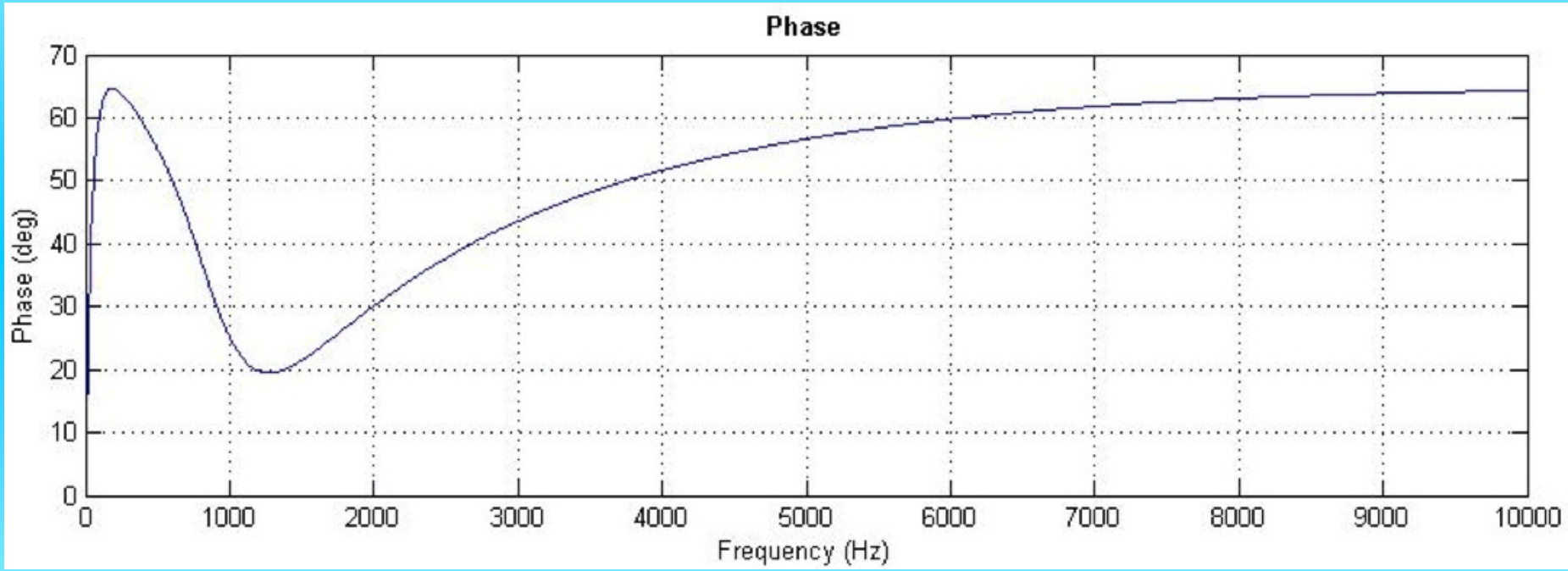
Standard

$|Z|_{50\ Hz} = 0.4717\ \Omega$ $|Z|_{2050\ Hz} = 3.7451\ \Omega \pm 5\ \%$ $|Z|_{2450\ Hz} = 3.8687\ \Omega \pm 5\ \%$

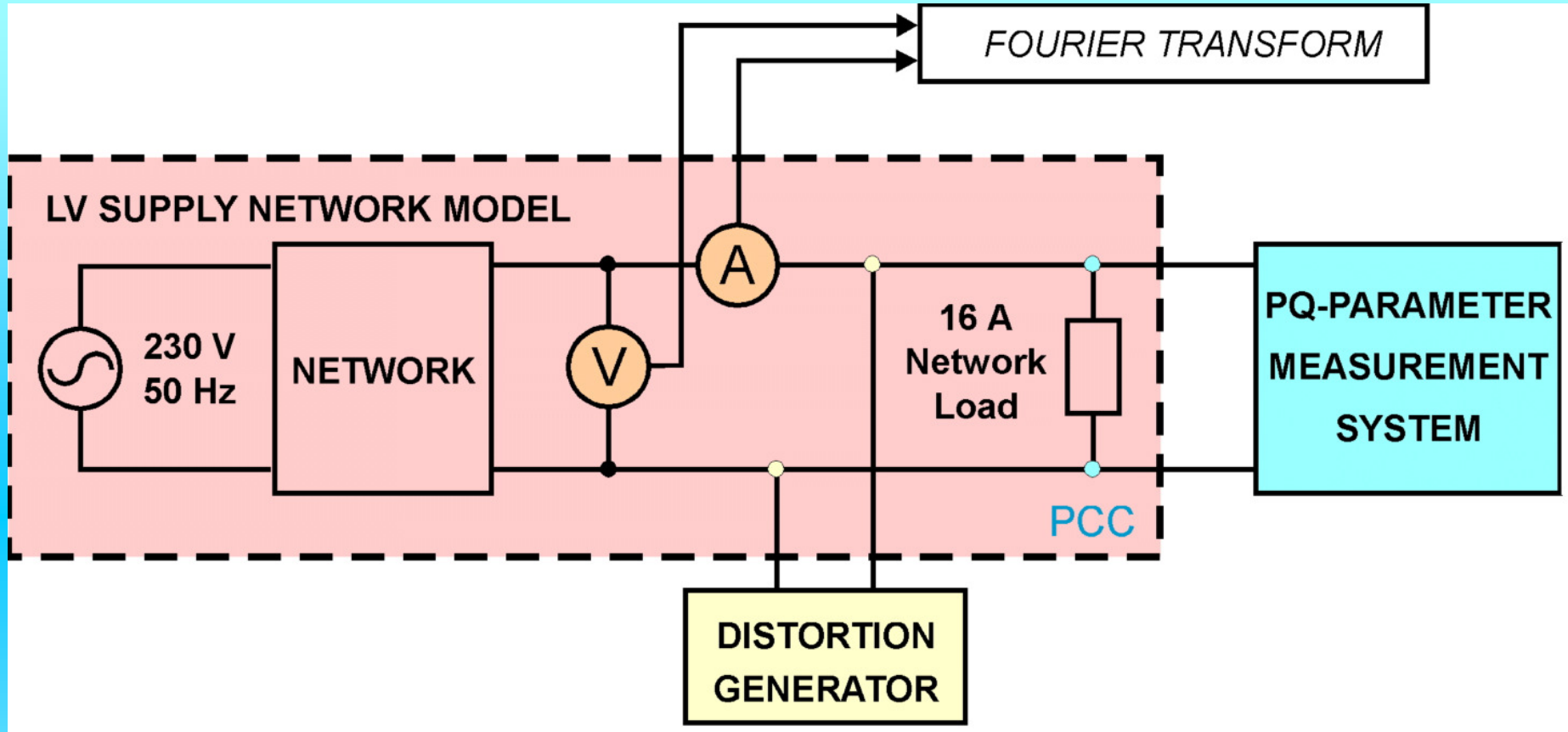
THE MAGNITUDE OF THE NETWORK IMPEDANCE



THE PHASE OF THE NETWORK IMPEDANCE



THE SETUP USED FOR HARMONIC CURRENT



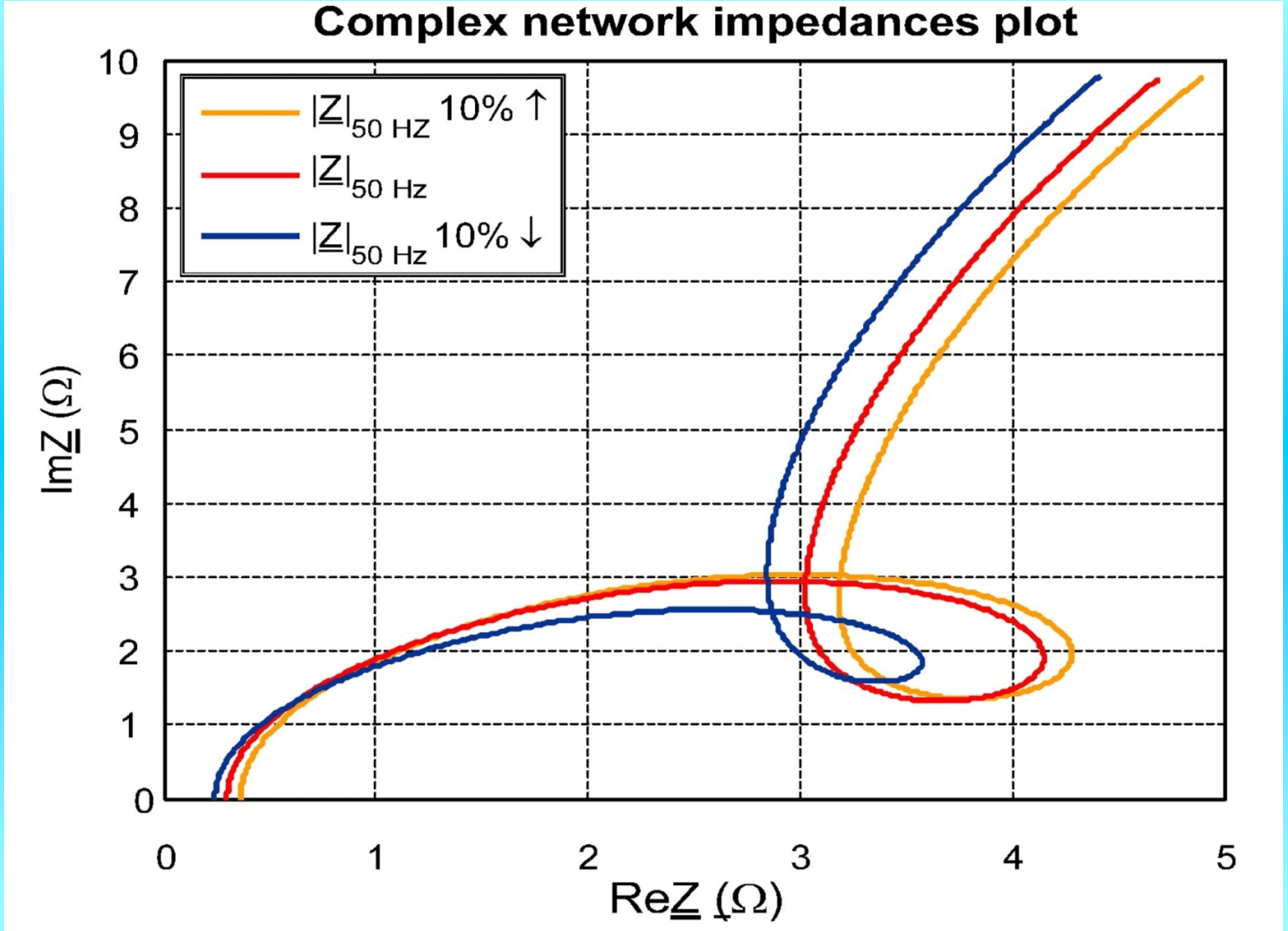
DISTORTION GENERATOR

A. IEC 61000-3-2 Class A waveform mix used in NPL calibration service for harmonic analysers

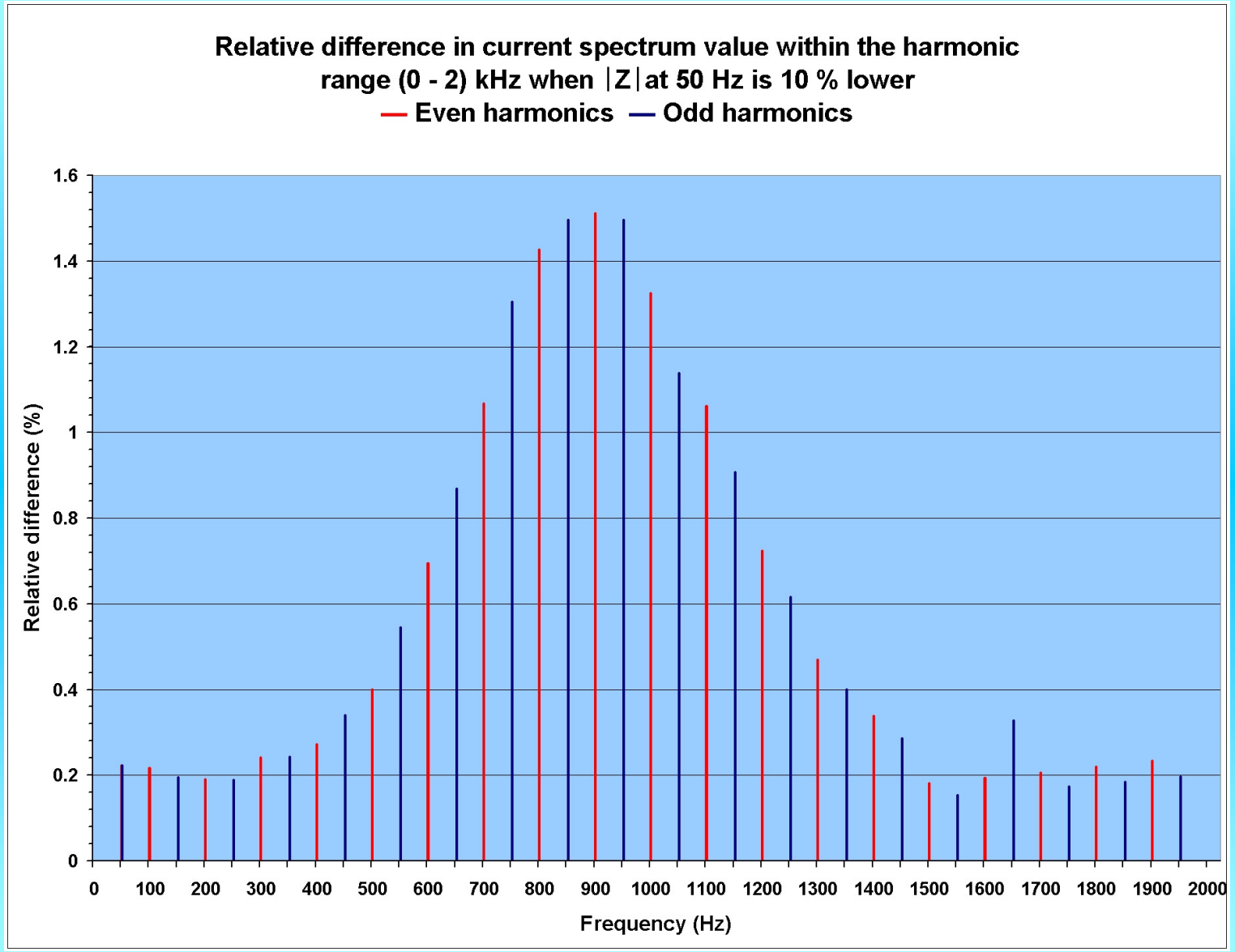
B. Modified rectifier

C. Switched mode power supply based on a buck convertor

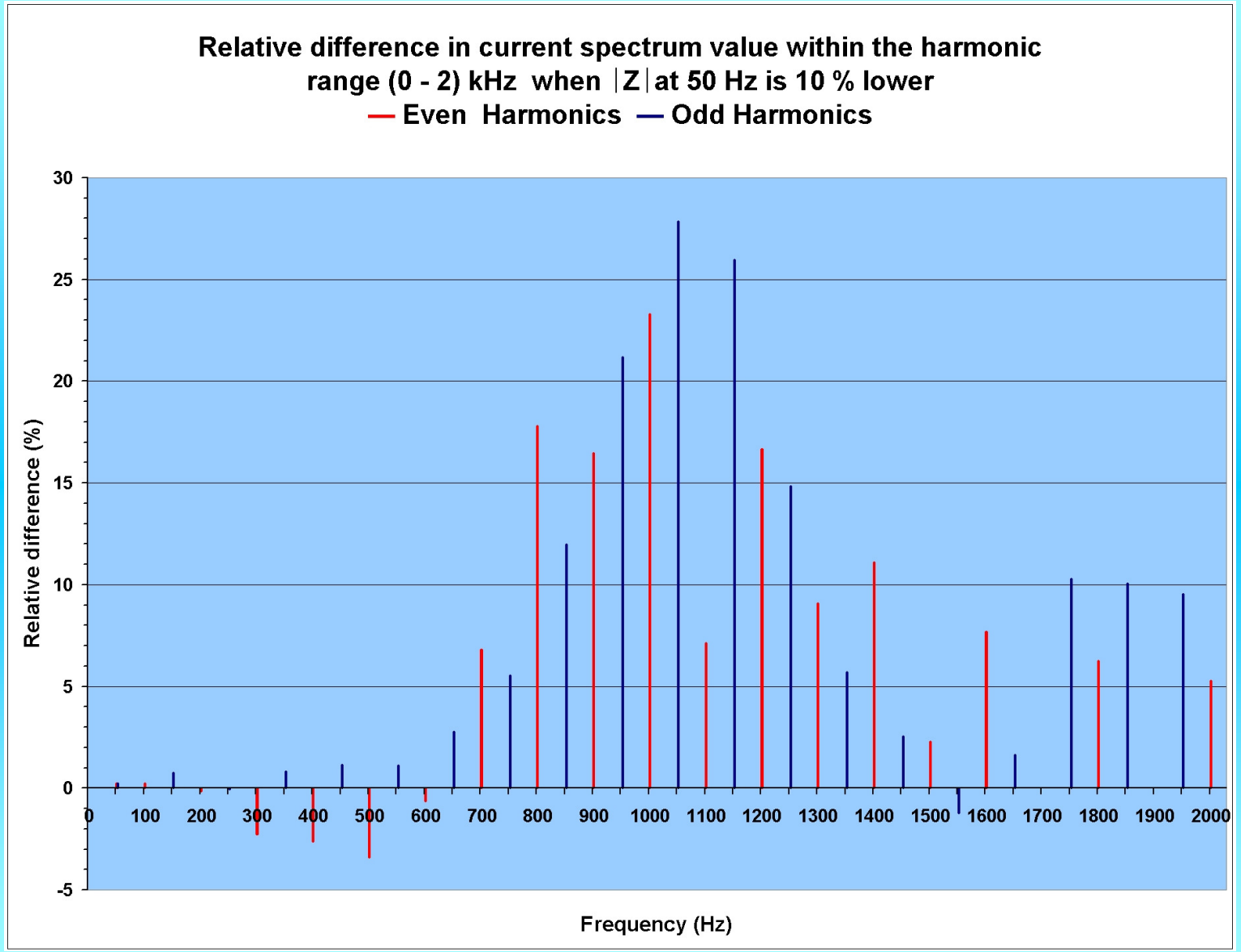
THE CHANGE OF THE MAGNITUDE OF THE NETWORK IMPEDANCE AT 50 Hz WITH ±10 %



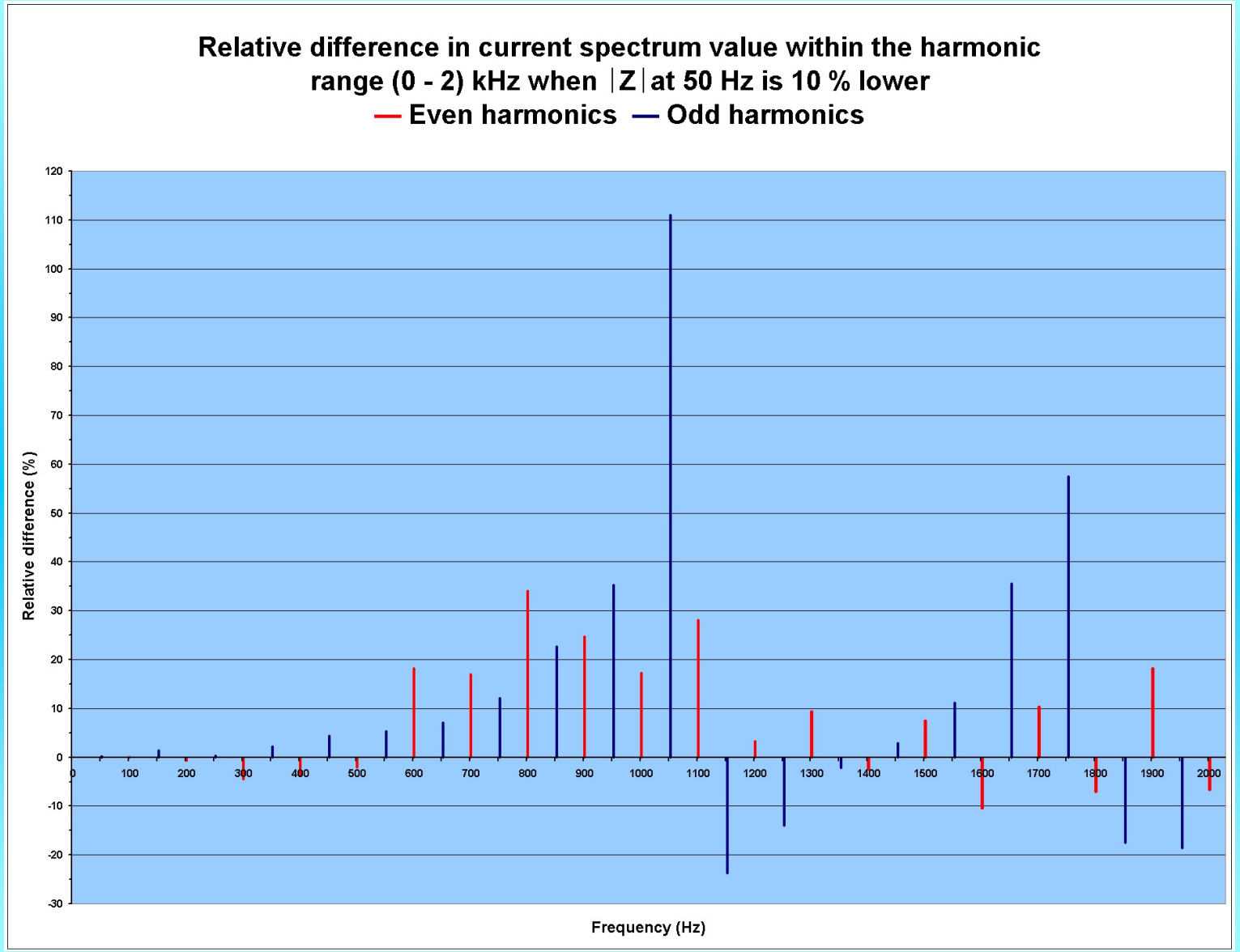
NPL WAVEFORM MIX



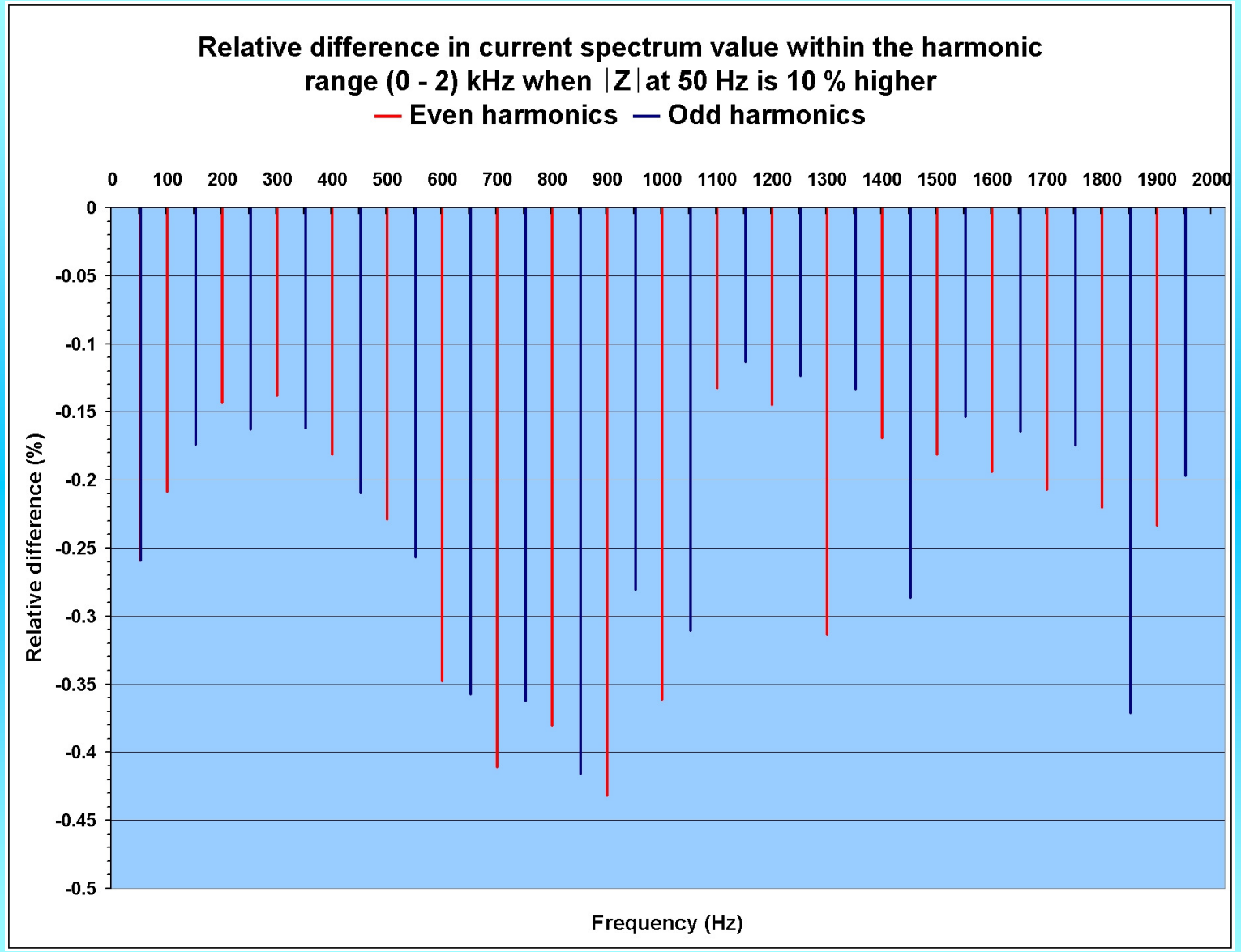
SWITCHED MODE POWER SUPPLY



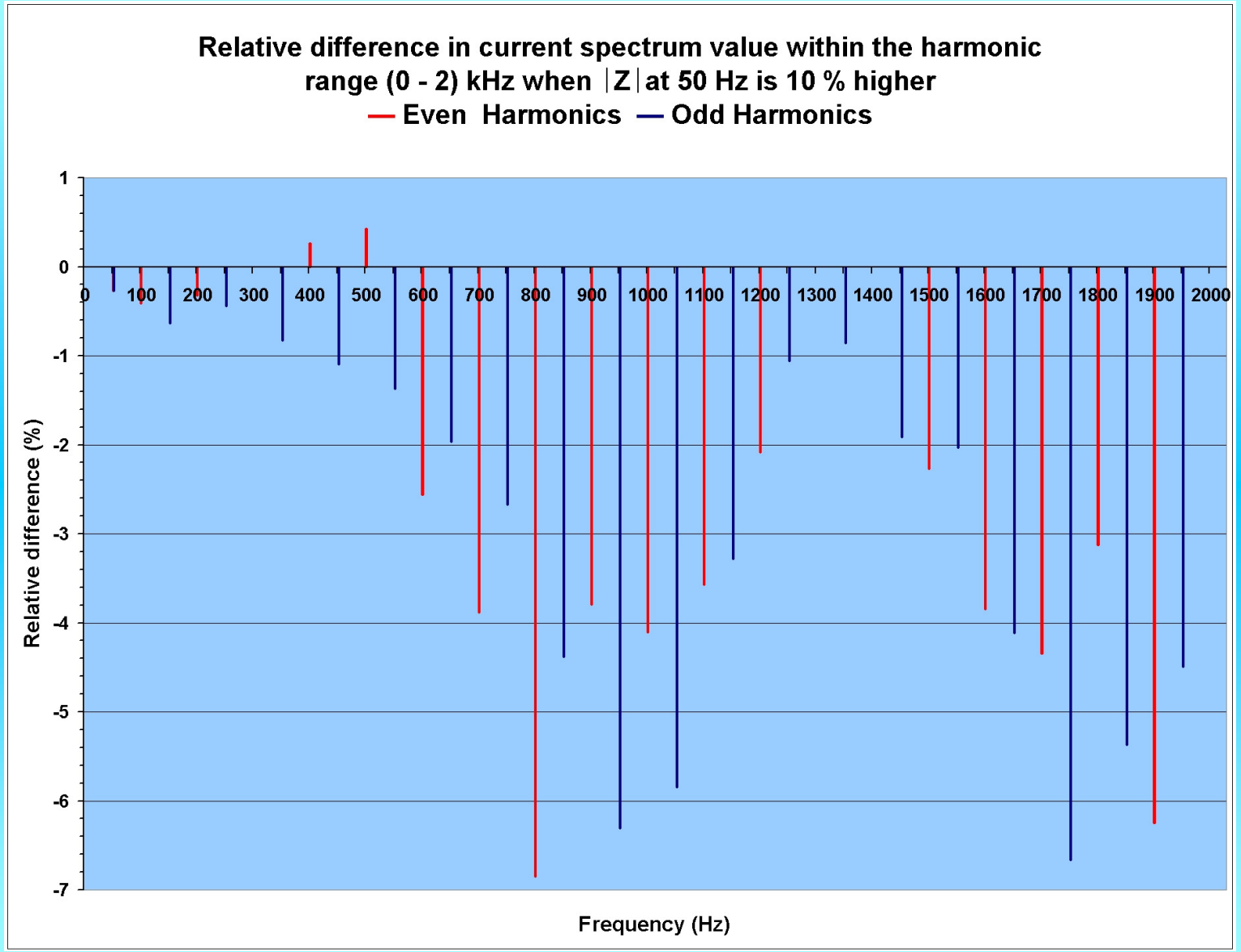
RECTIFIER


Relative difference in current spectrum value within the harmonic range (0 - 2) kHz when |Z| at 50 Hz is 10 % lower
— Even harmonics — Odd harmonics
Relative difference (%)
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Frequency (Hz)

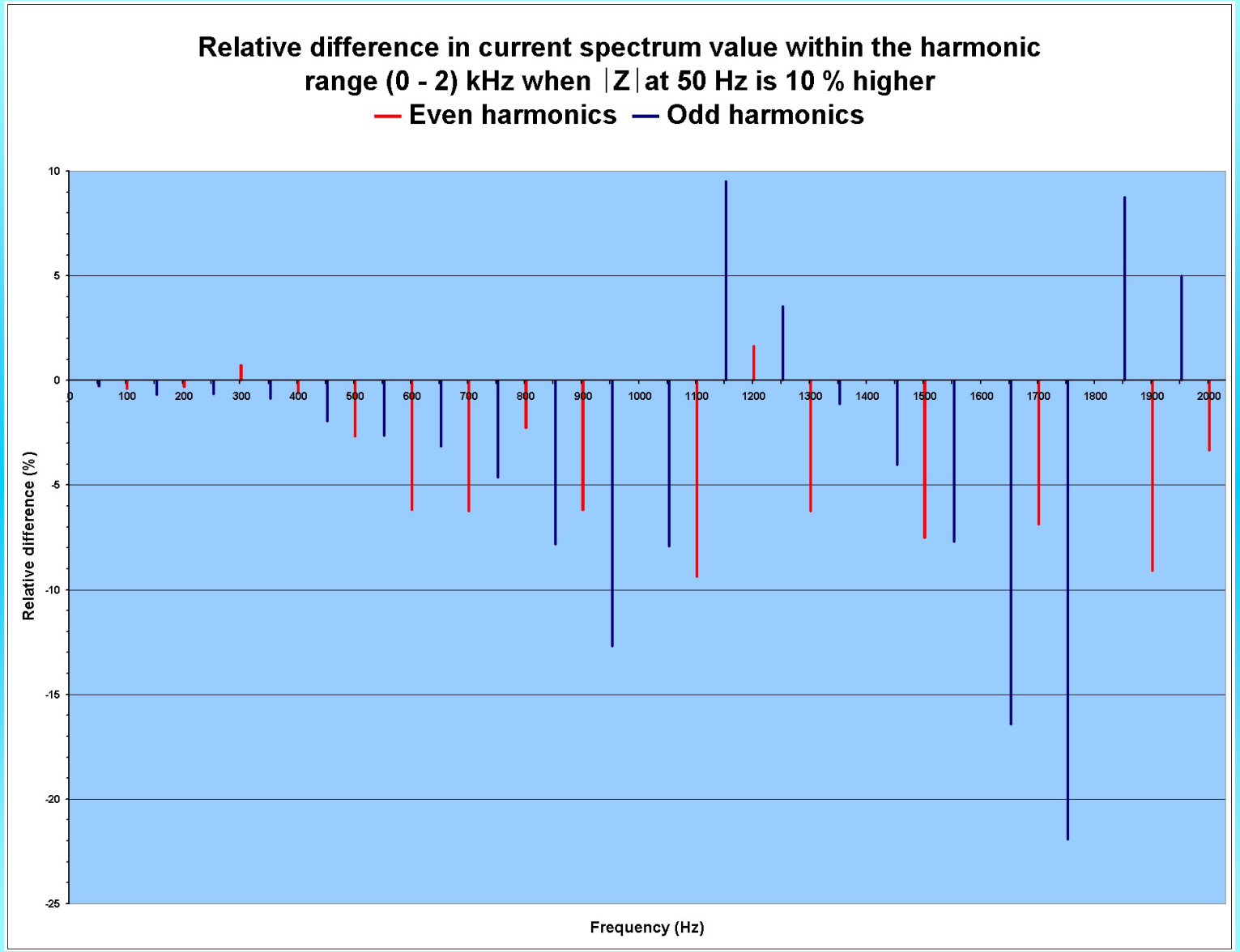
NPL WAVEFORM MIX



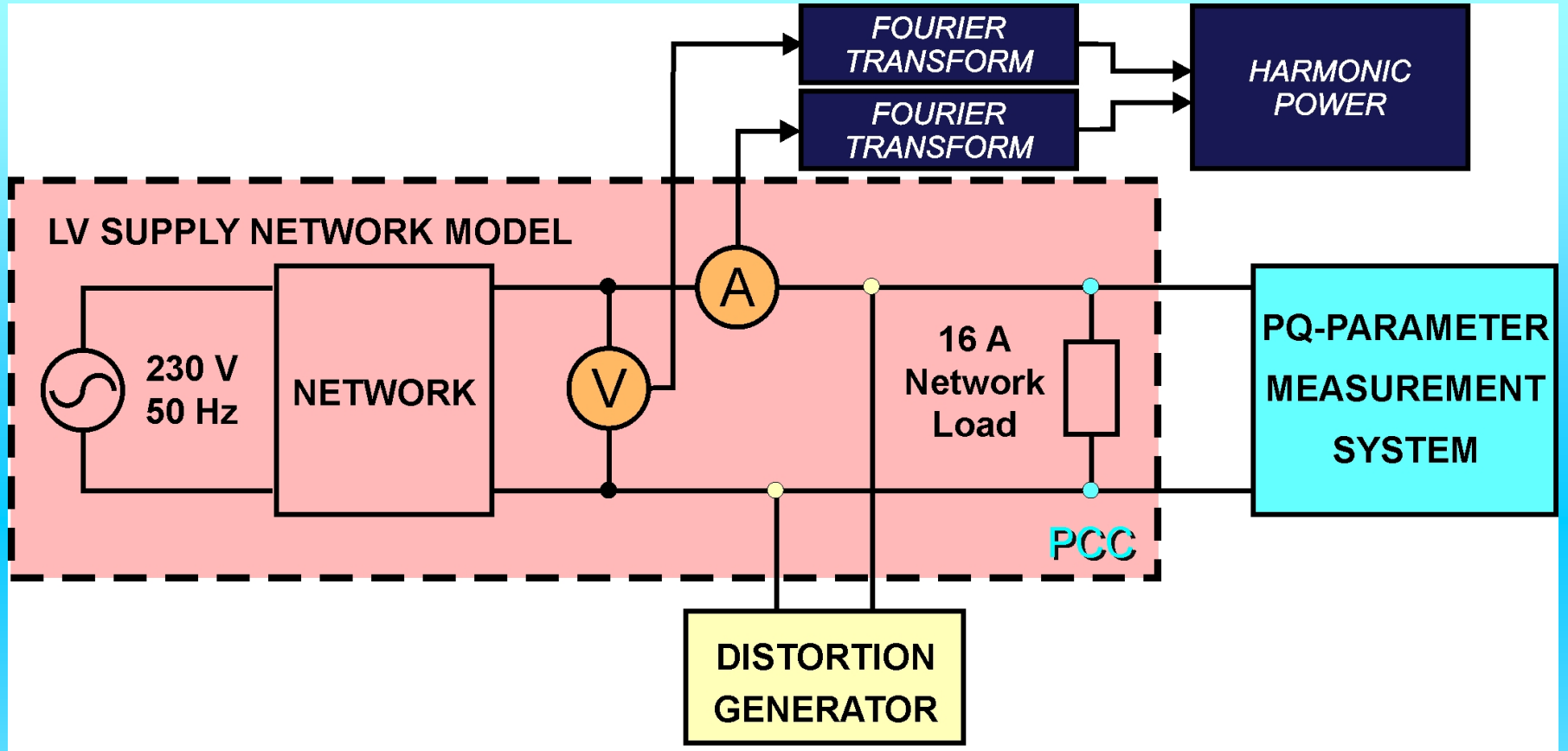
SWITCHED MODE POWER SUPPLY



RECTIFIER


Relative difference in current spectrum value within the harmonic range (0 - 2) kHz when |Z| at 50 Hz is 10 % higher
— Even harmonics — Odd harmonics
Relative difference (%)
10
5
0
-5
-10
-15
-20
-25
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Frequency (Hz)

THE SETUP USED FOR HARMONIC POWER



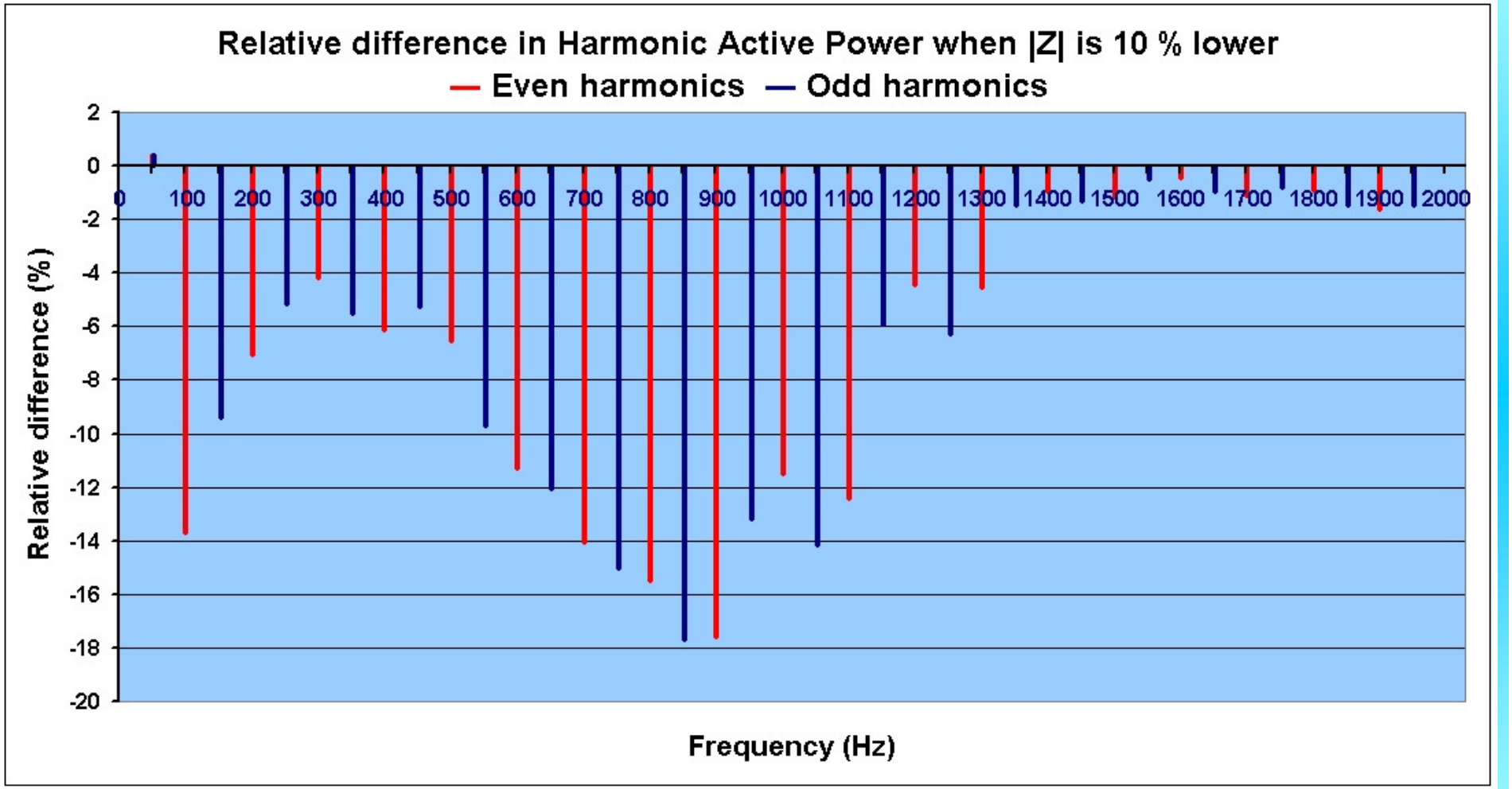
DISTURBANCE GENERATOR

A. IEC 61000-3-2 Class A waveform mix used in NPL calibration service for harmonic analysers

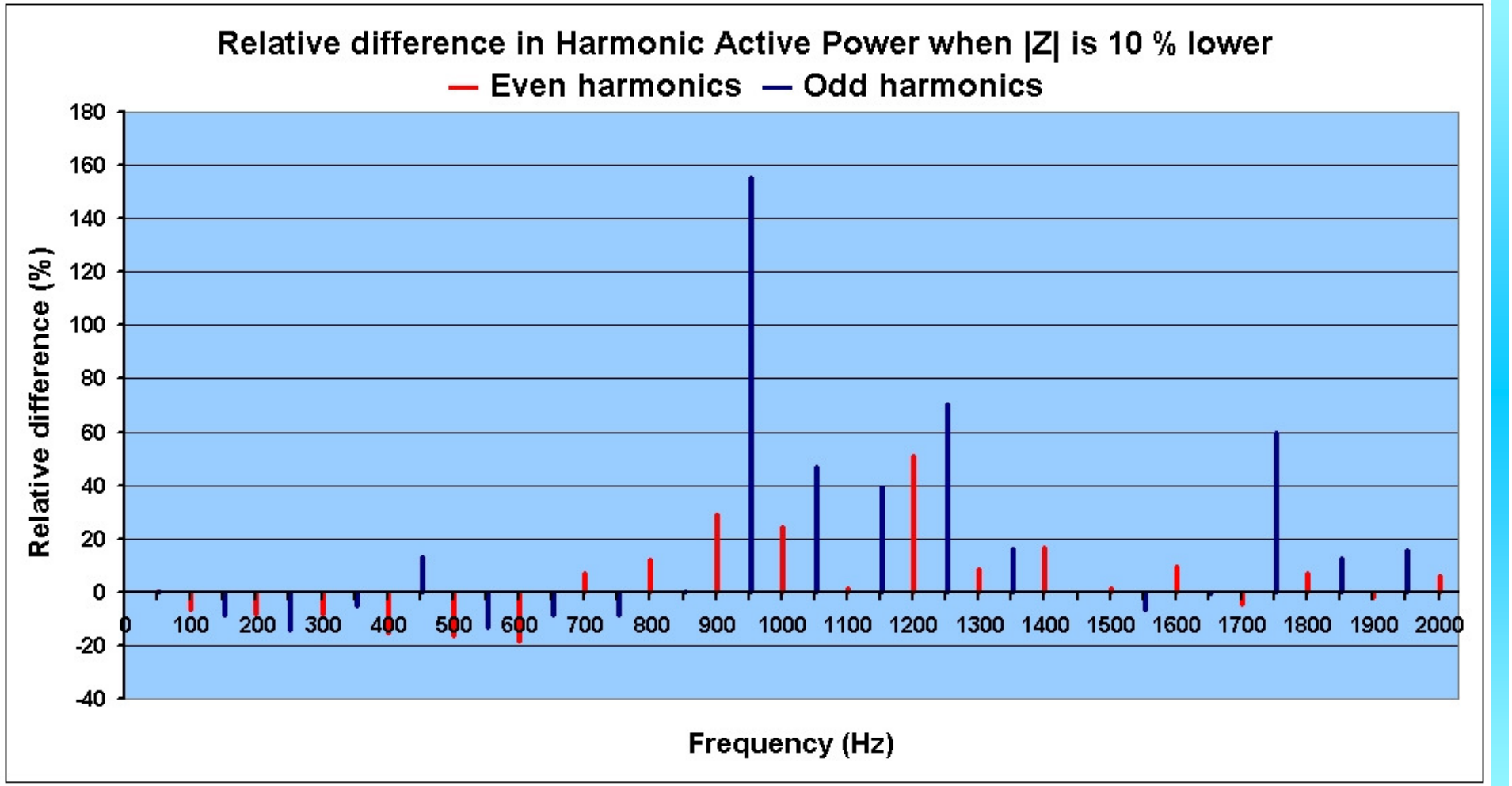
B. Distorting rectifier

C. Distorting switched mode power supply

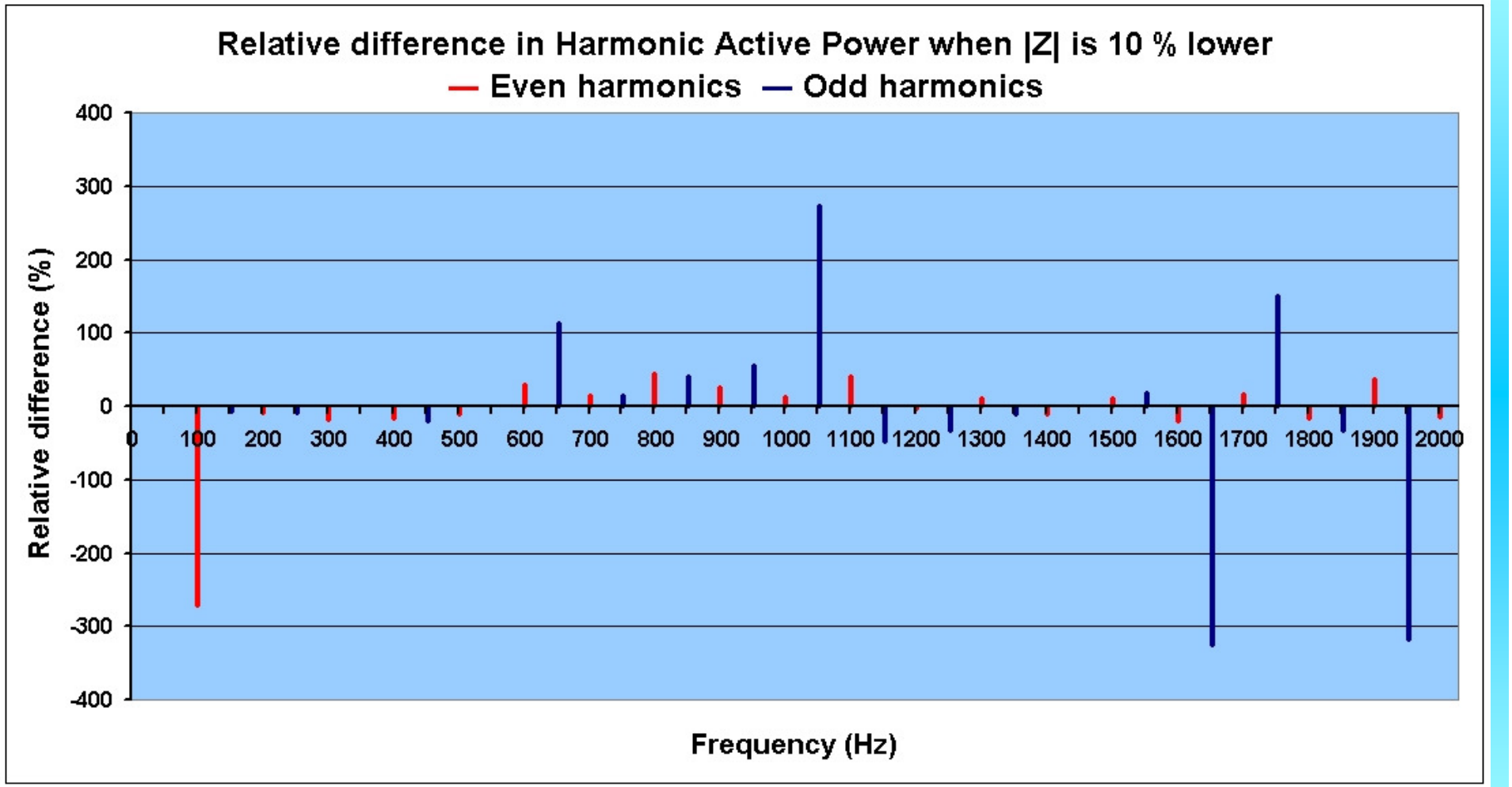
NPL WAVEFORM MIX



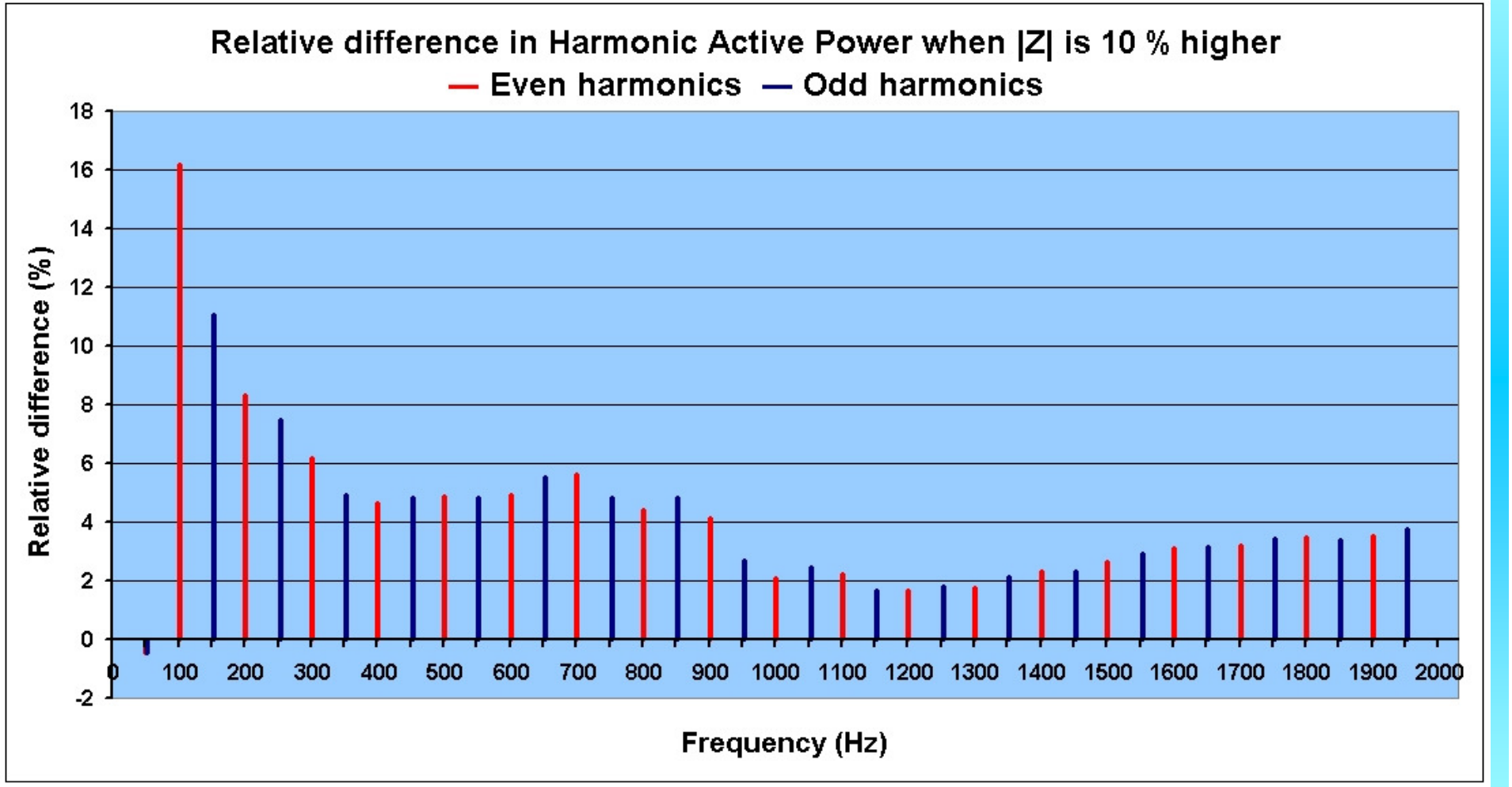
SWITCHED MODE POWER SUPPLY



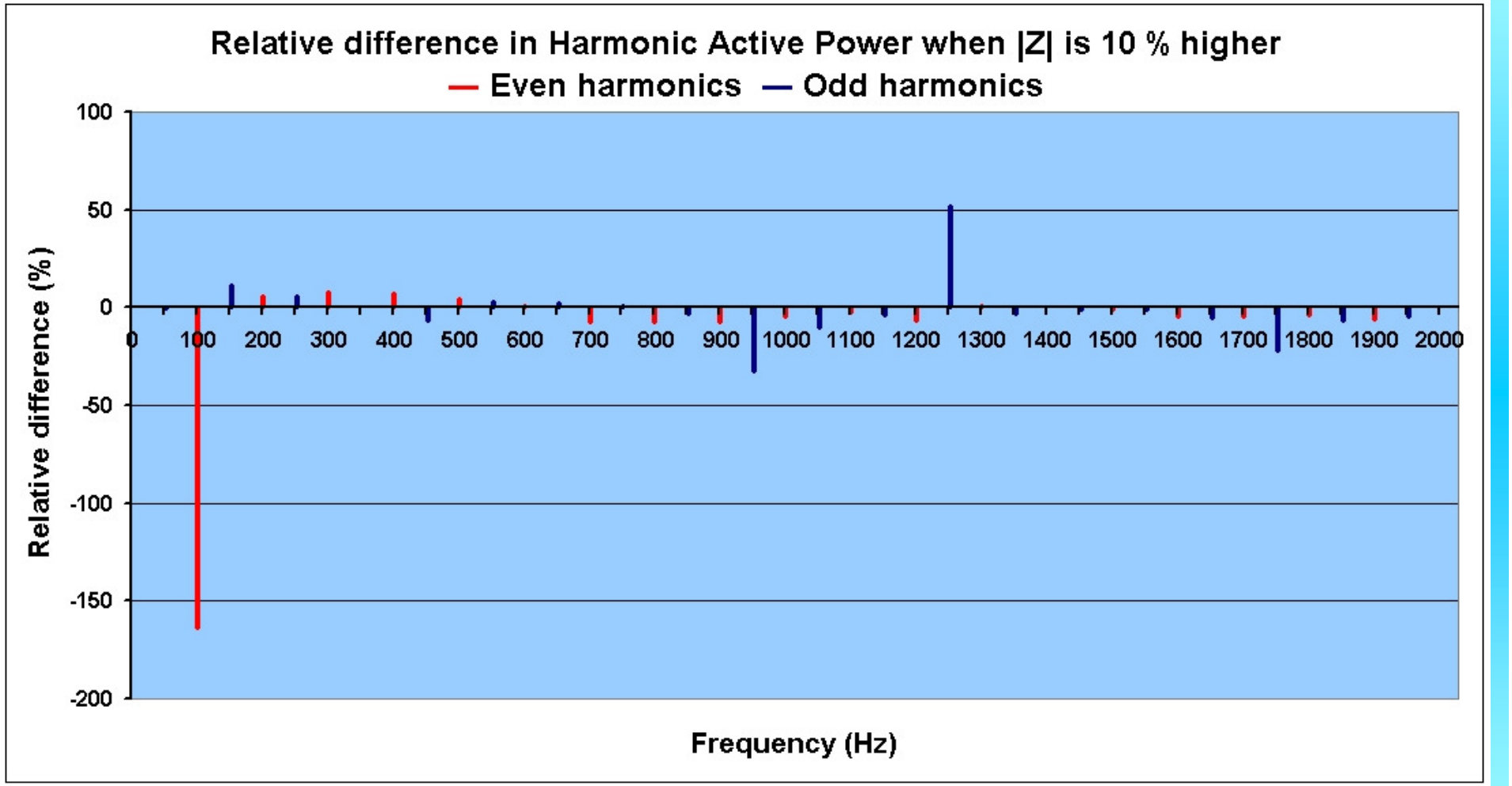
RECTIFIER


Relative difference in Harmonic Active Power when |Z| is 10 % lower
Even harmonics
Odd harmonics
Relative difference (%)
400
300
200
100
0
-100
-200
-300
-400
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Frequency (Hz)

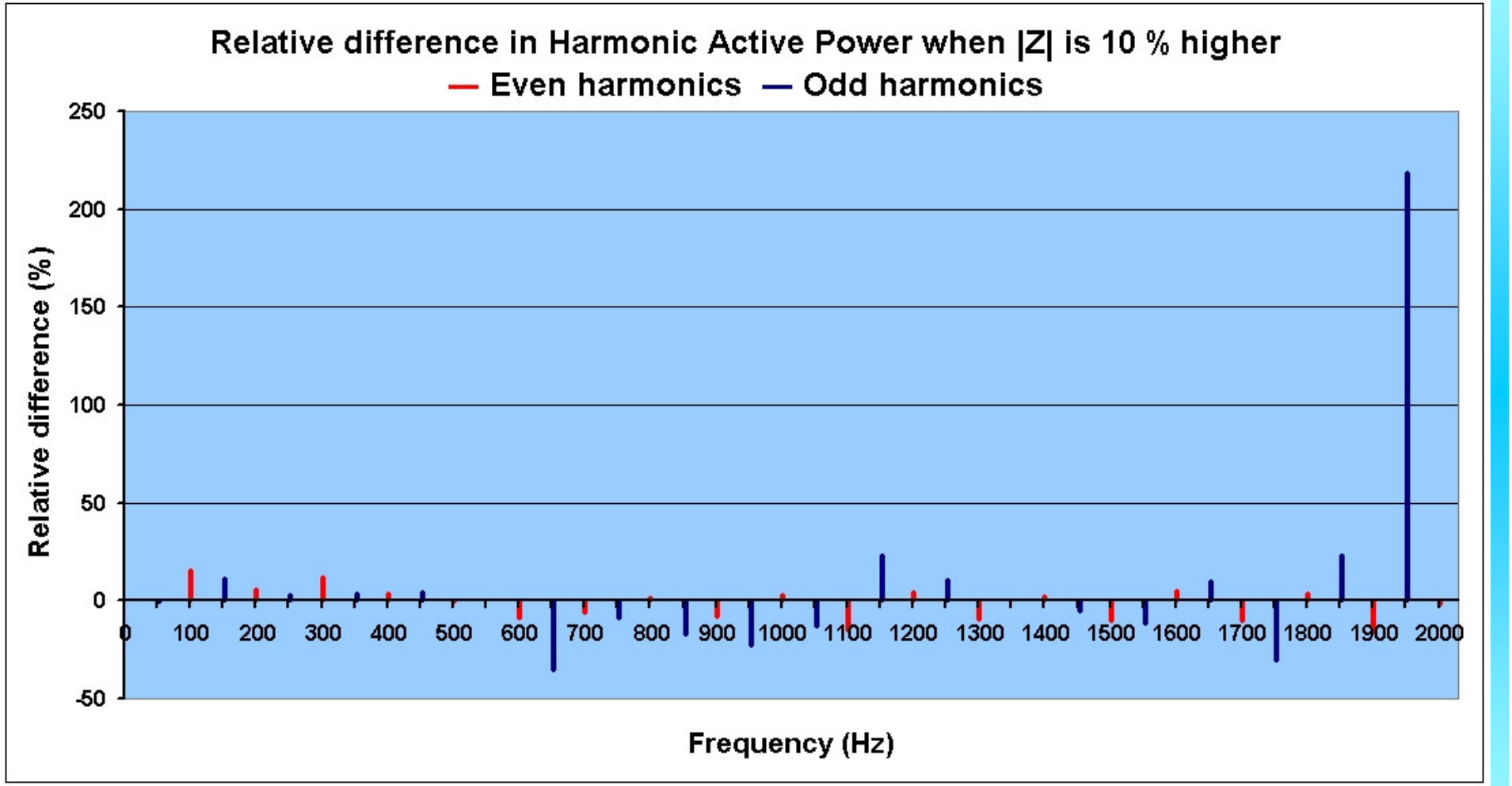
NPL WAVEFORM MIX



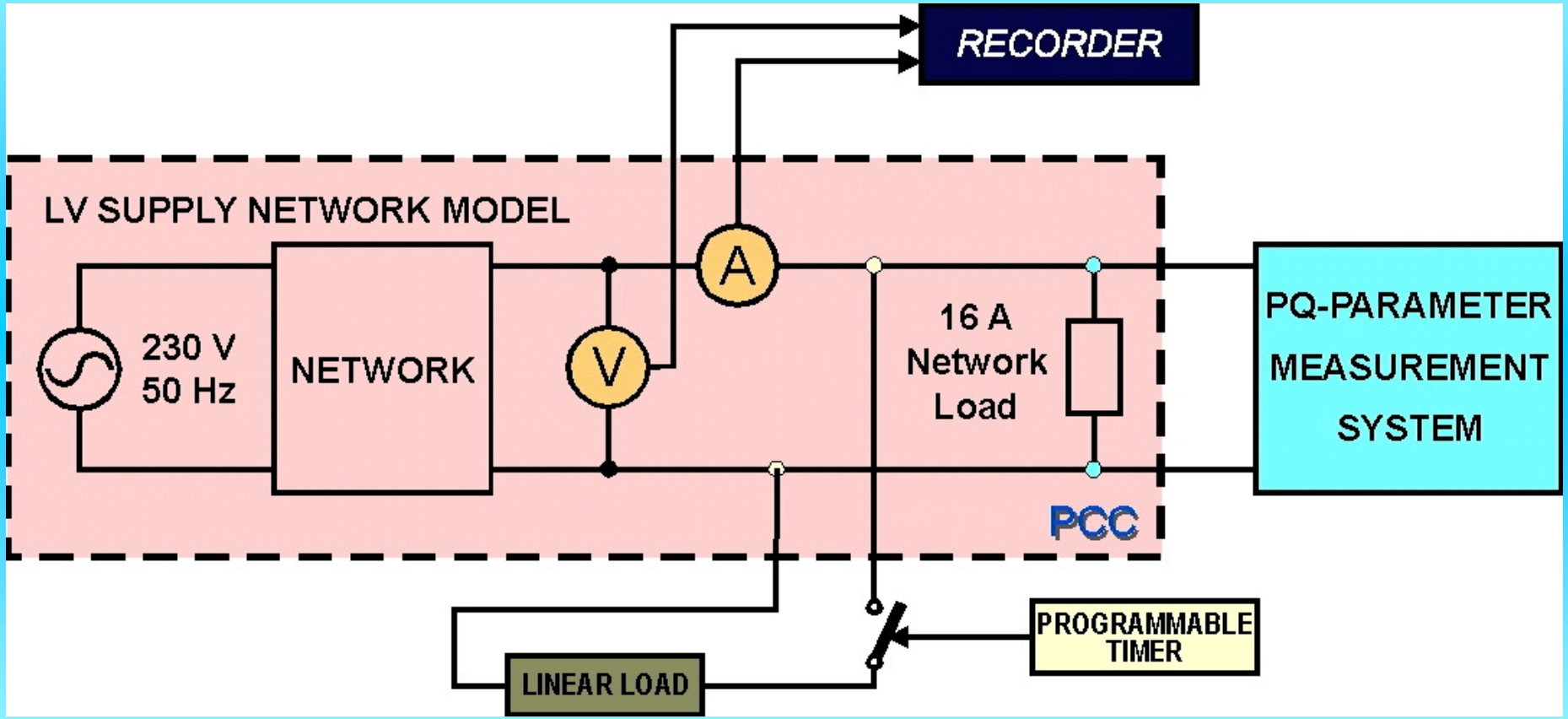
SWITCHED MODE POWER SUPPLY



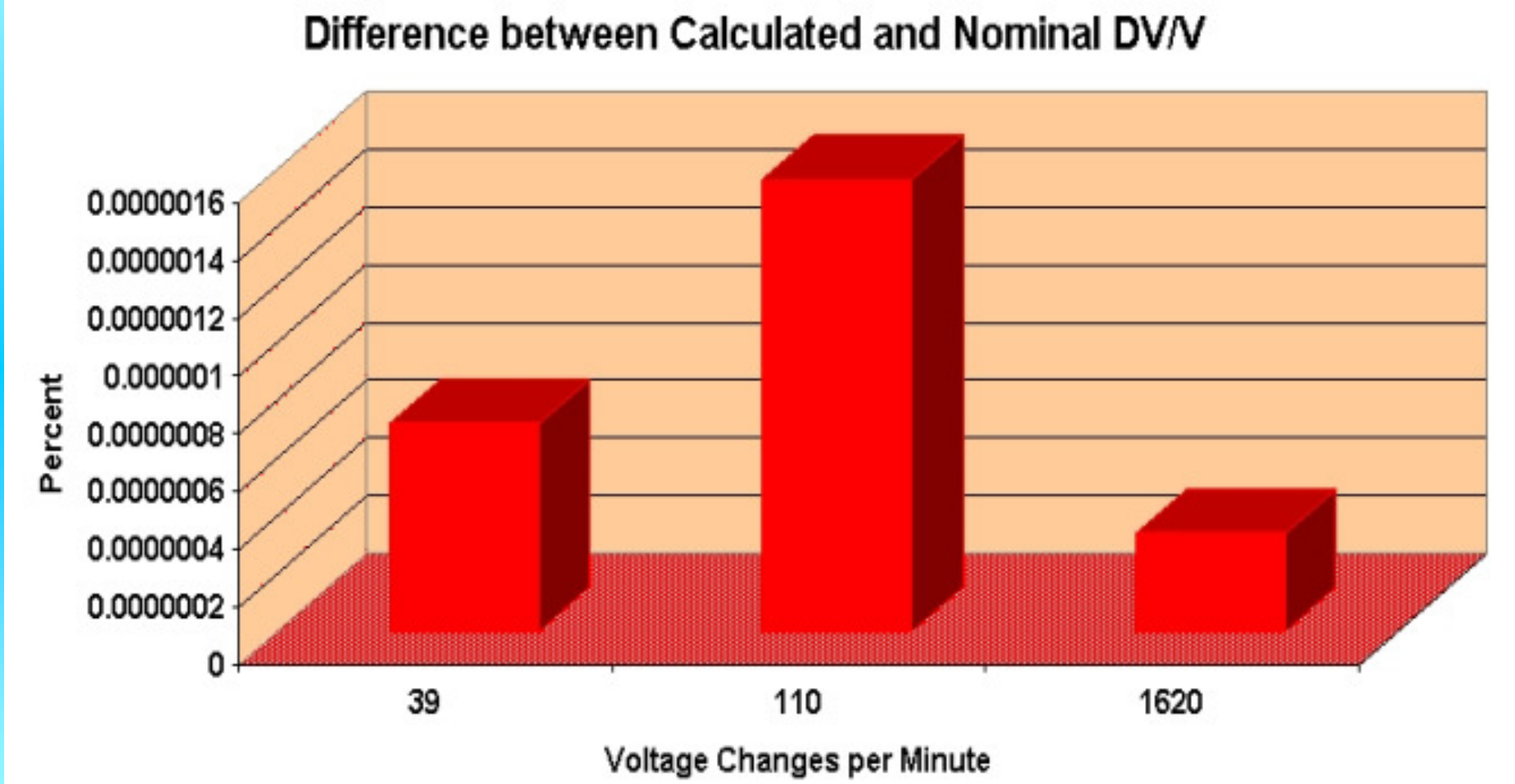
RECTIFIER


Relative difference in Harmonic Active Power when |Z| is 10 % higher
Even harmonics
Odd harmonics
Relative difference (%)
250
200
150
100
50
0
-50
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Frequency (Hz)

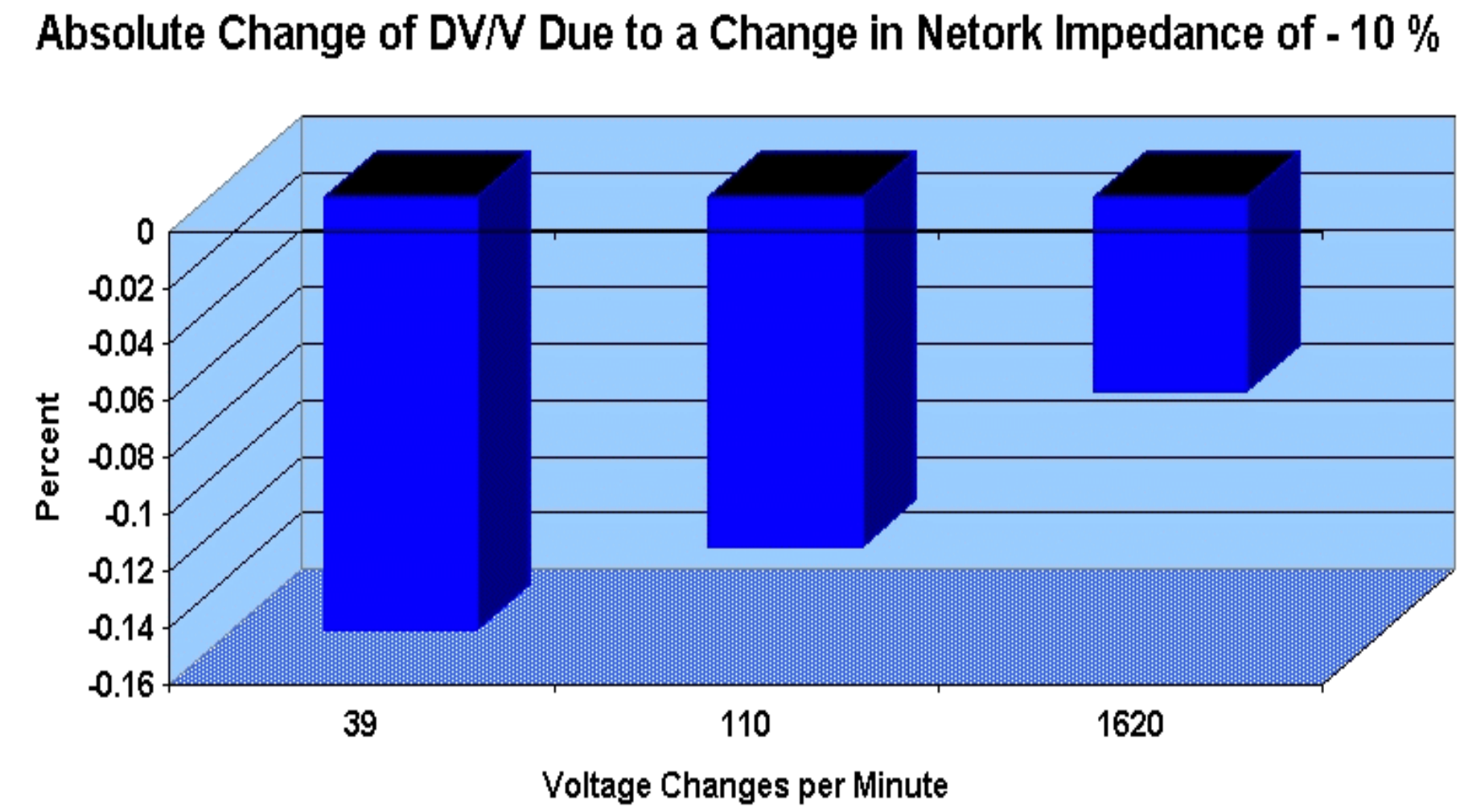
THE SETUP USED FOR FLICKER SIMULATIONS



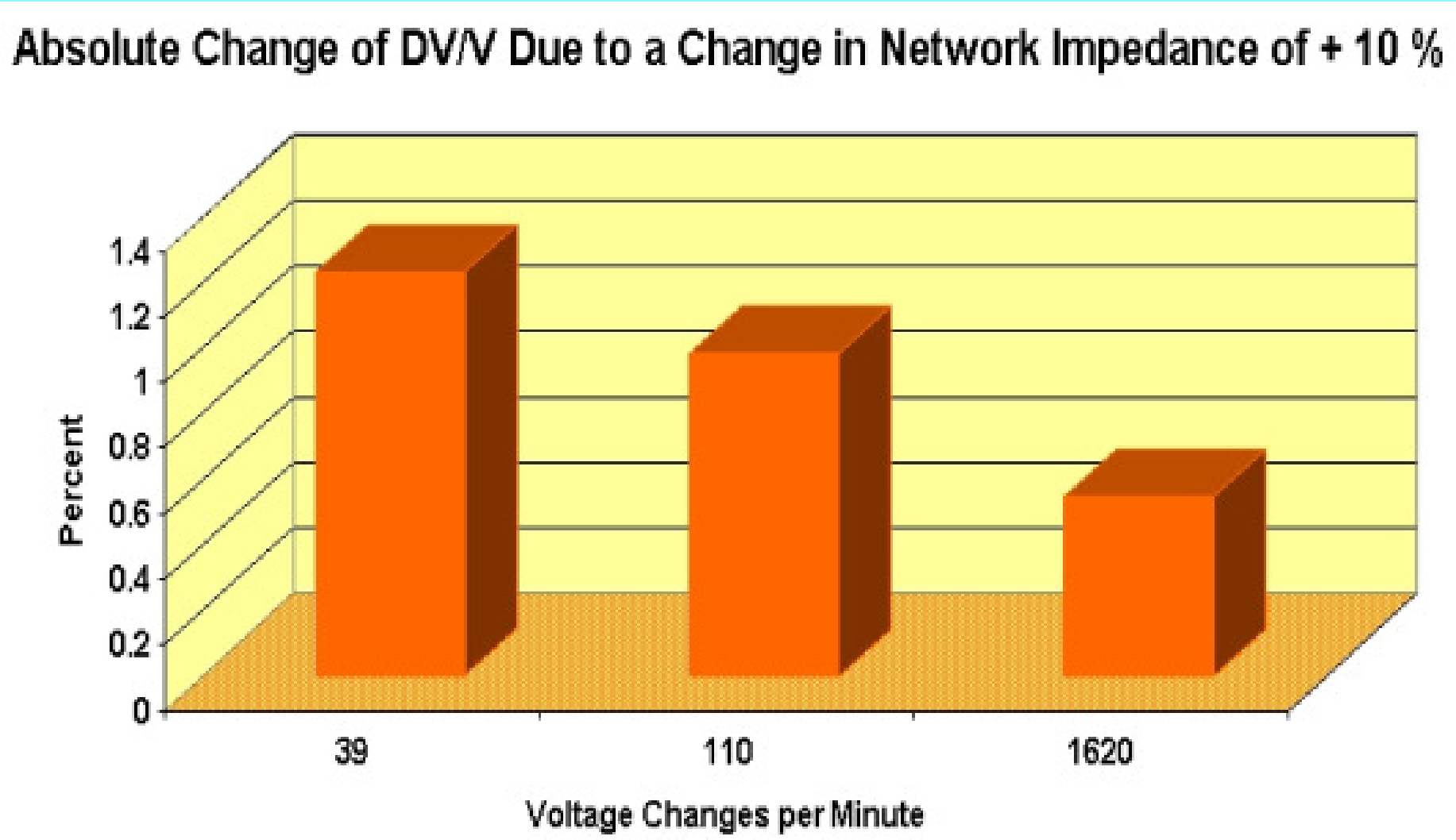
THE COMPLIANCE WITH THE SQUARE MODULATION WAVEFORMS USED AT NPL



THE INFLUENCE OF NETWORK IMPEDANCE ON FLICKER MEASUREMENTS



THE INFLUENCE OF NETWORK IMPEDANCE ON FLICKER MEASUREMENTS



CONCLUSIONS AND IMPACT

- Changes in the network impedance may induce alterations of the spectral distributions of current and of power.
- In some cases, these alterations appear to be quite significant, both within the harmonic range, i.e., the frequency interval (0 ... 2000) Hz, and beyond the harmonic range, i.e., the frequency interval (2 … 10) kHz.
- It is possible to have significant errors when in-field measurements of the harmonic distortions are performed, using harmonic analysers, which were calibrated in laboratory conditions using reference, standardised values for the network impedance.

CONCLUSIONS AND IMPACT

- Changes in the network impedance may induce alterations of the flicker measurements.
- When the magnitude of the network impedance at 50 Hz is 10 % lower or higher, the same combinations of modulation frequency and voltage changes per minute lead to significantly different values of the nominal applied $\Delta V/V$□, resulting in different values of the indicated P_{st}.
- It is therefore possible to have significant errors when in-field flicker measurements are performed, using flickermeters, which were calibrated in laboratory conditions, using reference, standardised values for the network impedance.

CONCLUSIONS AND IMPACT

- Gathering information regarding the network impedance at the point of connection, and on the limits within which it may vary, could be considered as a safeguard for reliable in-field measurements of power quality parameters.
- Assuming that the influence of the changes in the network impedance at the point of connection is negligible, and therefore its contribution to the evaluation of the measurement uncertainty may be also neglected, may not always appropriate.

THANK YOU FOR YOUR ATTENTION!