



Advances in Power Quality Requirements for RPPs

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Overview

- Background
- Basic requirements
- Concerns from stakeholders
- Context of concerns
- Apportioning
- Impedance envelope
- Network information
- Assessment clarifications and methods
- Conclusions

Background

- REIPPPP since 2011
- RPP Grid Code first published 2012
- Management of PQ
 - Apportionment
 - Monitoring and enforcing
- Power Quality requirements
 - Concerns from developers
 - Harmonic

Background

- First RPPs nearing completion
- Consultants engaged Eskom:
 - PQ requirements were unclear to consultants
 - difficult to prove and achieve
- Harmonics Working Group established

Basic Requirements

- The basic PQ requirements provided for in the grid code are summarised as follows:
 - Which parameters are to be regulated
 - Assessment shall be done at the POC
 - Responsibilities of stakeholders

Basic Requirements

- Stakeholder responsibilities:
- NSP:
 - Calculate appropriate emission limits
 - Define the network conditions, e.g.
 - PQ levels
 - Network characteristics
 - Fault levels
 - Three-times impedance envelope
- RPP:
 - Ensure the RPP is appropriately designed and operated

Concerns: RPP Developers

- Grid code requirements were unclear
- Few consultants had sufficient PQ background
- Connection agreement terms
 - E.g. harmonic emission mixture of tables and text
- Different requirements to e.g. European countries
 - IEC 61000 apportioning not universally applied
- Compliance is based on the rms harmonic currents
 - Absorb harmonic voltage and current (beneficial)
 - Deemed non-compliant
- Three-times impedance criticized

Concerns: NSP

- NSP is legally responsible
 - Risk
- PQ at each customer point of supply
 - Limiting the impact of any customer on PQ (generally via contracts such as the CUOSA)
 - Coordinating the combined impact of customers at a point of common coupling (PCC)
 - Monitoring the PQ at all PCCs
 - Limiting the network's impact on PQ to customers
 - Communicating to customers on all relevant aspects

Context of Concerns

- Eskom had reasonable experience
- **But**
- Number of new challenges brought by RPPs
- Handful of specialists with experience in contracting

- Municipalities lack
 - staff
 - network information for detailed studies

- Processes to take into account
 - Easy to implement by inexperienced staff.

Context of Concerns

- Framework for customer contracts
 - Flexible
 - Negotiable
 - Managed over time

- Major differences between South African and European networks, e.g.
 - base load
 - transmission lengths
 - overhead ground (affecting)
 - use of capacitors
 - interconnection with other countries



- These factors affect the typical system harmonic impedance.

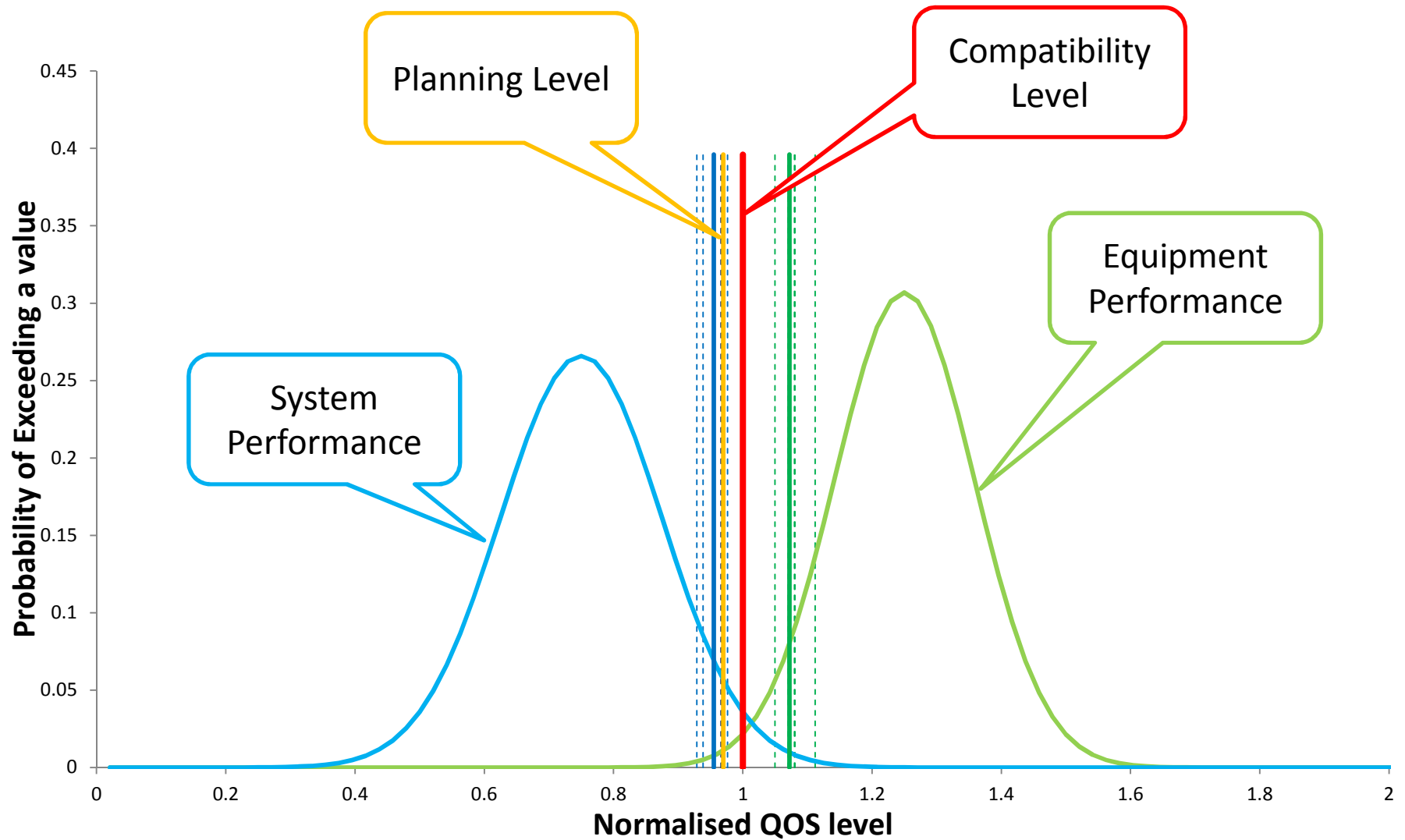
Context of Concerns

- RPPs connecting at relatively weak locations in the network
- Short-circuit ratio ≈ 3 times
- European-based rules and regulations
- Not realistic for South Africa

Apportioning: A brief history

- IEC/TR 61000-3-6/7 and 13
- Describe principles for fair allocation
- Customers and network contribute

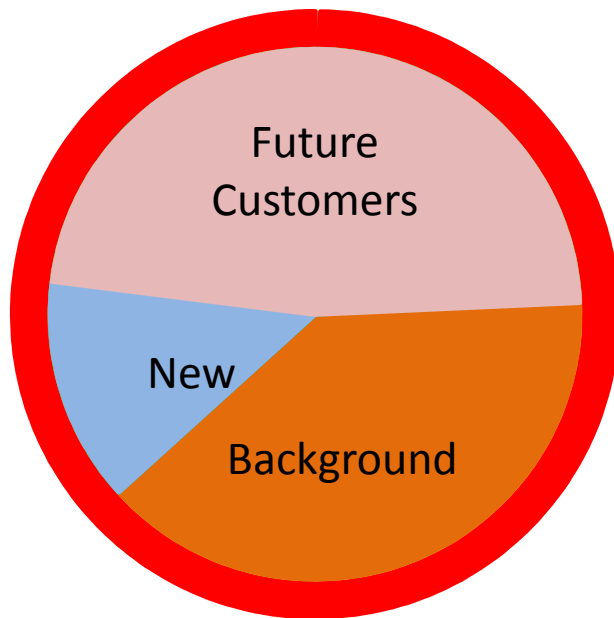
Apportioning: A brief history



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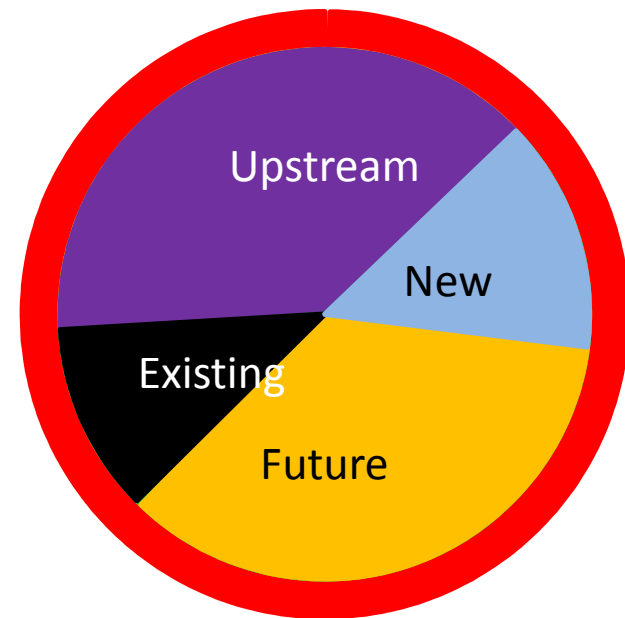
- Edition 1

- Measure and allocate remaining part



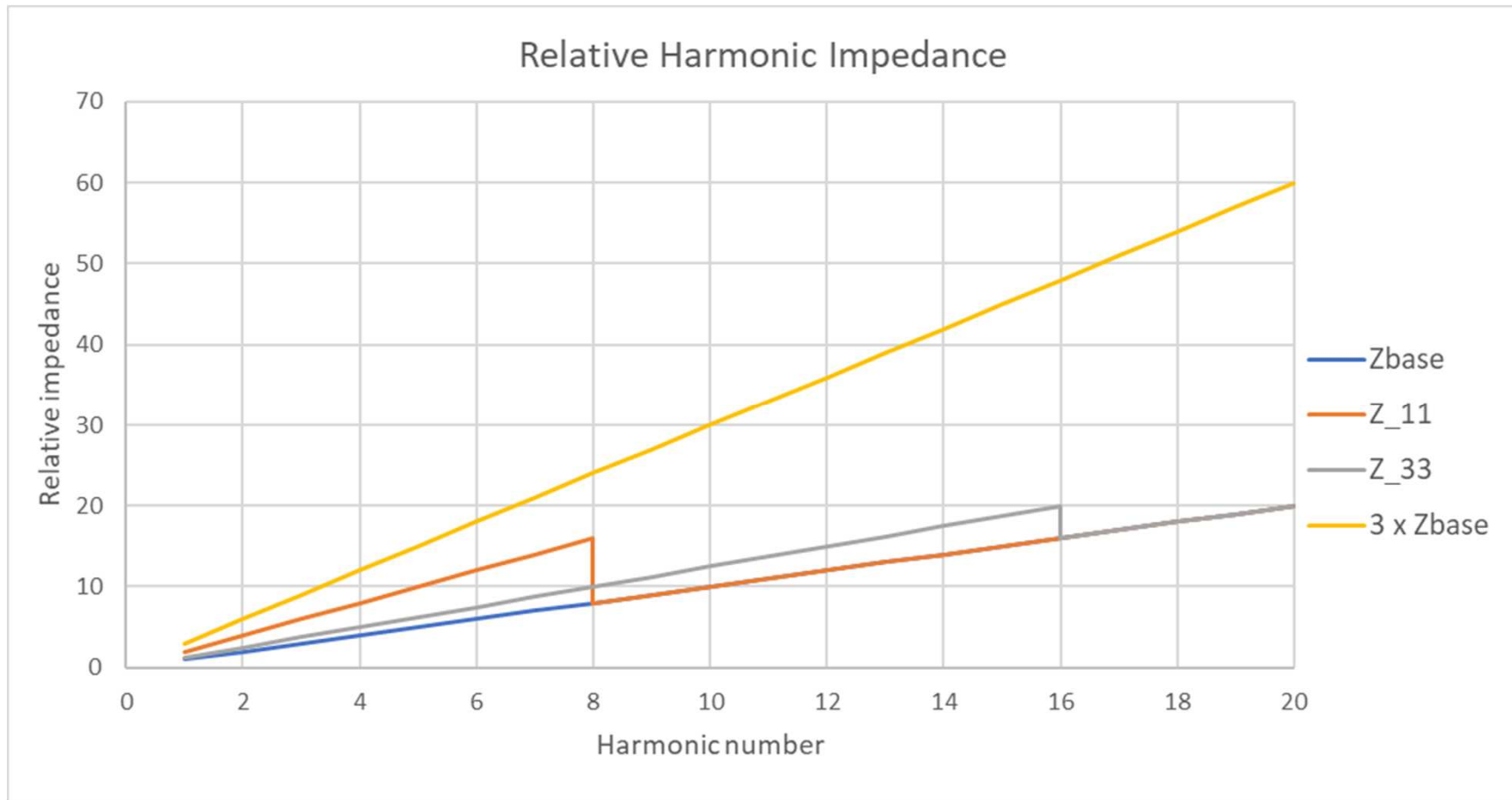
- Edition 2

- Allocate proportionally

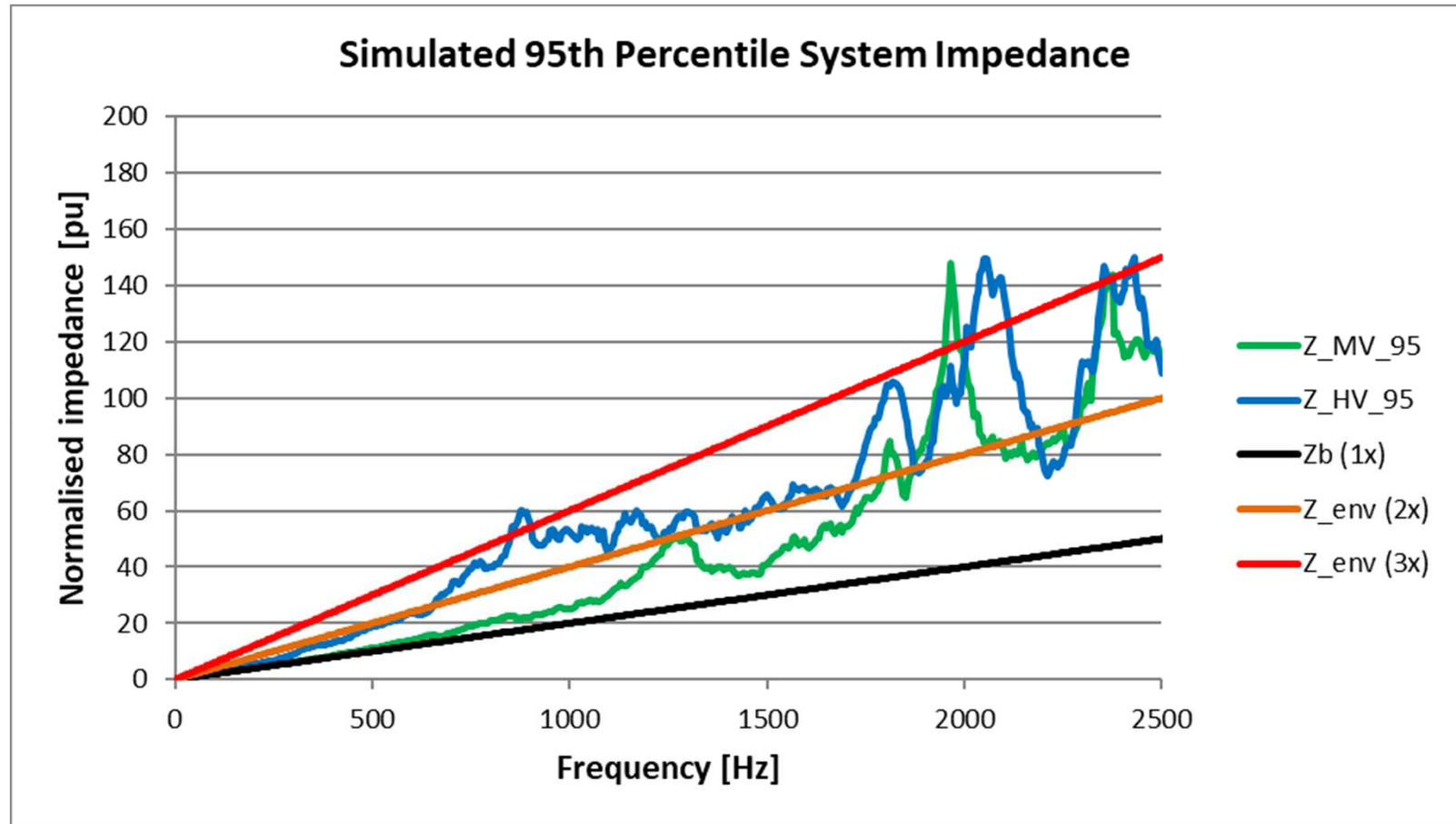


- Legacy customers?

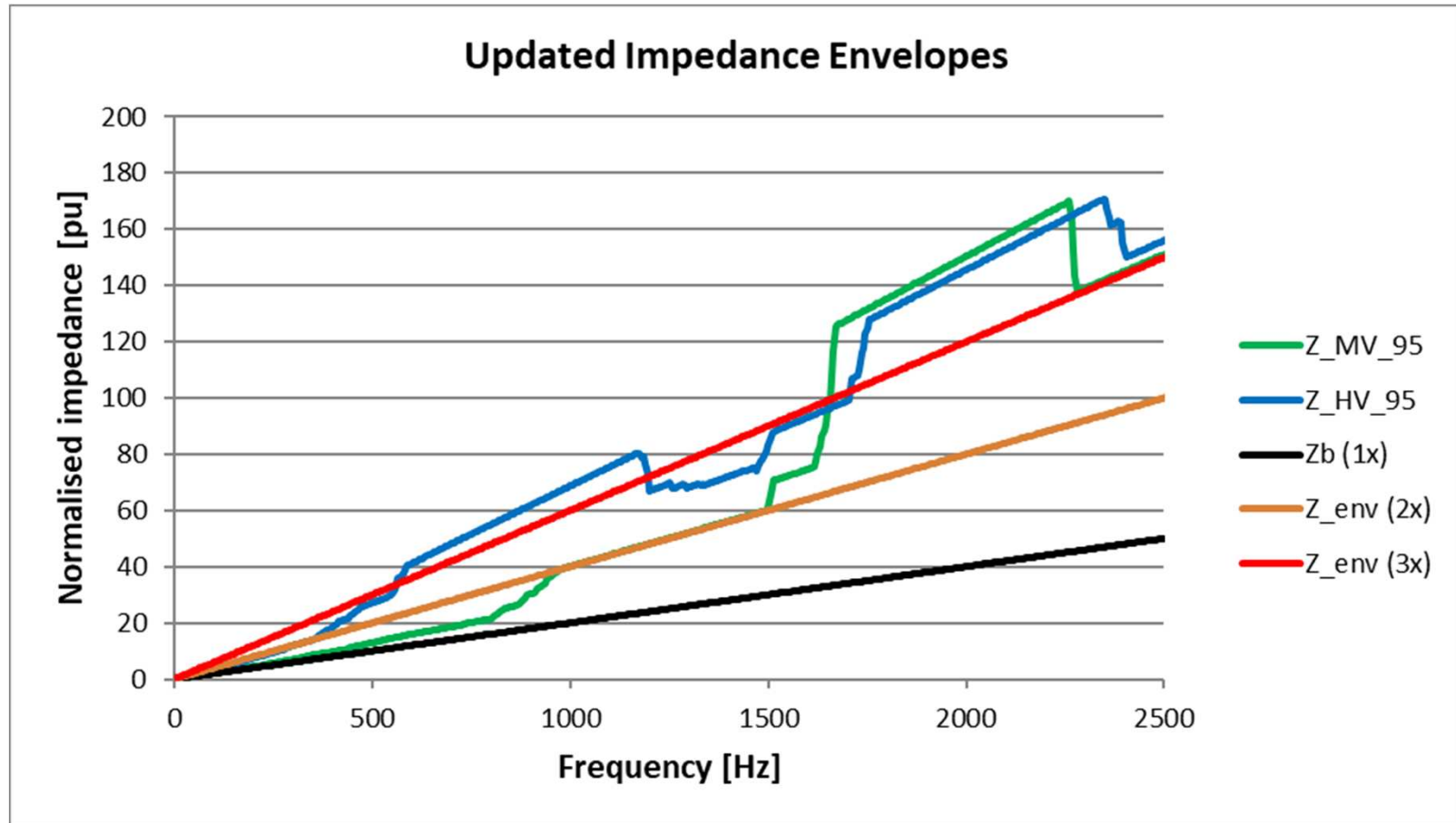
Impedance Envelope: Allowance



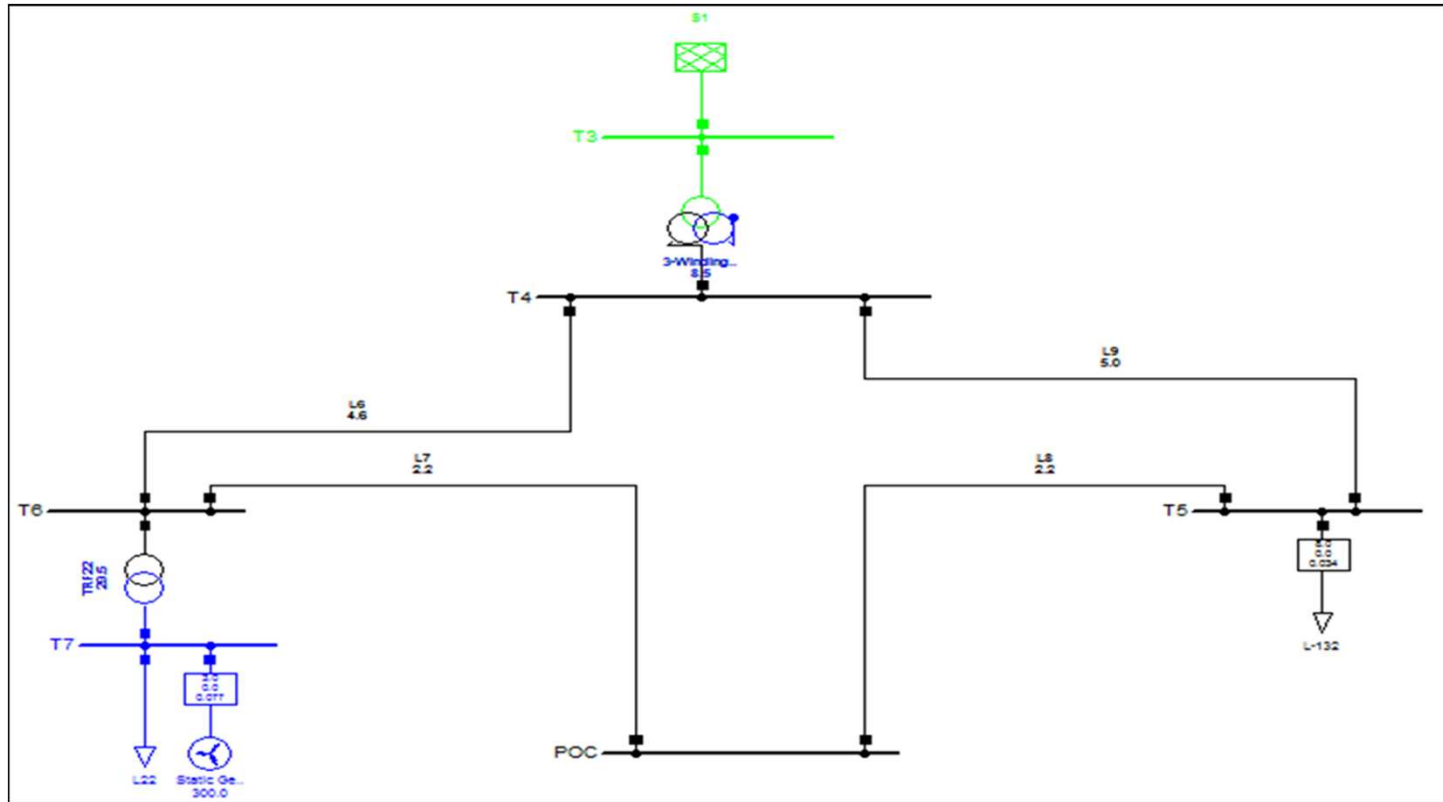
Impedance Envelope Simulations



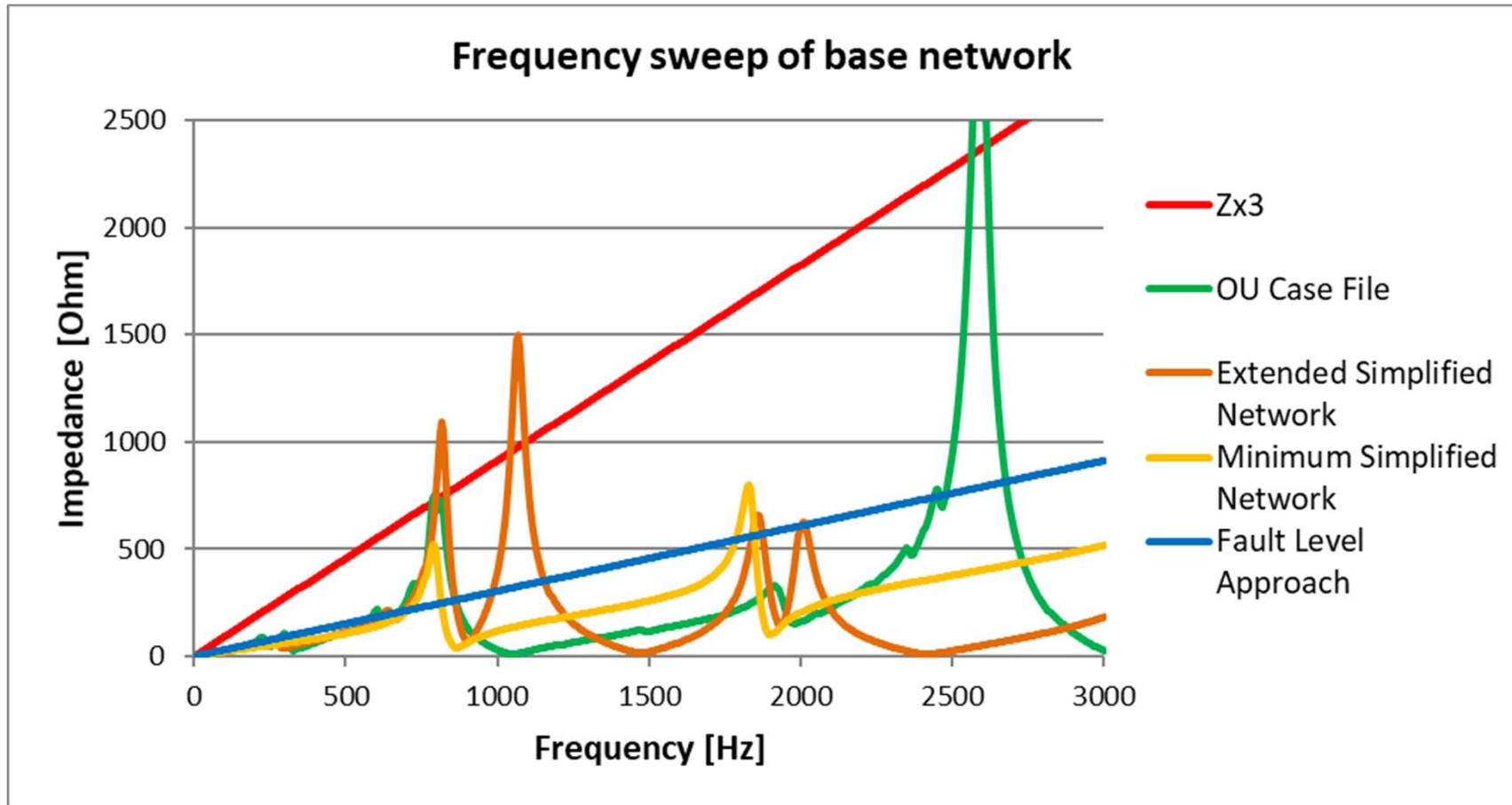
Impedance Envelope Simulations



Network Information Provided

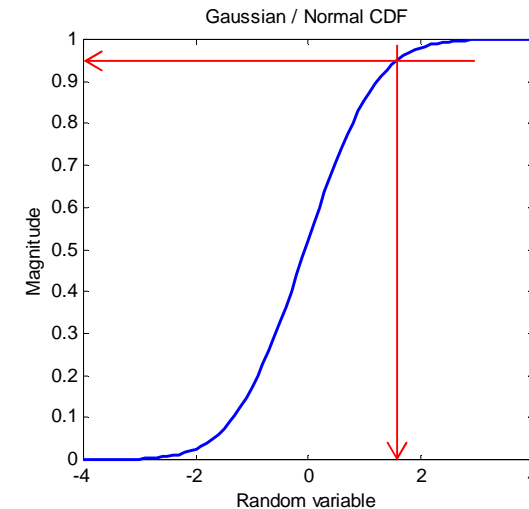
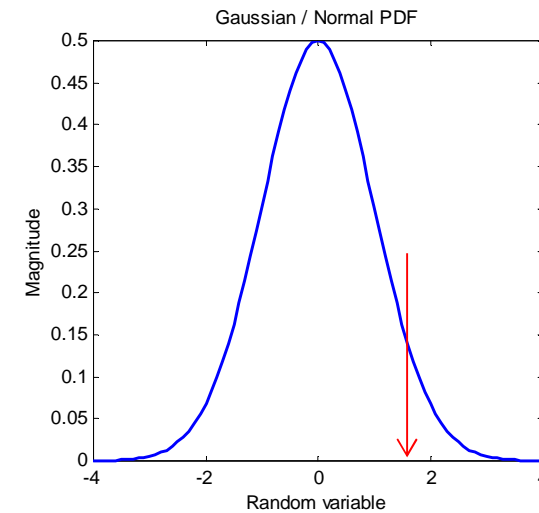


Network Information Provided



Assessment Clarifications

- Basic Assessment
 - NRS 048-2
 - One week
 - 95th percentile
 - Representative



Assessment Clarifications

- Harmonic Voltage vs. Harmonic Current
 - IEC 61000-3-6/7/13
 - Voltage emission limits
 - Current and Ohm's law
 - Network changes
 - Impedance envelope
 - Current driving force and
 - Critical assessment criterion

Assessment Clarifications

- CT and VT accuracy
- Specification at fundamental
 - VTs up to 25th harmonic
- CT ratio error: 0.2%
- Emission limit minimum
 - Voltage: 0.1%
 - Current: 0.1 A → 0.1%

Assessment Methods

- The impedance slope method
- Negative correlation: harmonic current and voltage
- Zero harmonic voltage measured throughout the measurement period
 - allowing for up to 300% of the current emission limit
- The impedance scaling method
 - measured harmonic voltage scaled
 - ratio of the three-times impedance envelope vs. the simulated system impedance
- Group harmonic distortion levels
 - individual harmonic emissions may exceed the emission limit by up to 50%.

Summary

- RPPGC version 2.9 towards the end of 2016
- Key improvements are:
 - the clarification of the requirements
 - high-level guidance for simulating and measuring compliance
 - relaxation of emission limits under certain conditions
 - emission limits for rapid voltage changes and inter-harmonics have been removed
 - group harmonic emission limit was introduced with allowance up to 150% of individual emission limits when the group harmonic emission limit is met.
 - preferred analysis methods from the CIGRE C4.109 brochure are discussed
 - without restricting the analysis methods that may be used



Conclusions

- Significant learning curve
- Guideline available
- PQ requirements and guideline not yet perfect
- Further research and analysis
- Updates will be published as better solutions are found

- Thank you
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