Power Quality Issues
from an EMC Point of View

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Overview

- What is EMC?
- How does it apply to power quality?
- The effects of equipment on power quality
- The effects of power quality on equipment
- Some typical requirements
- Hot topics

What is EMC?

- Electromagnetic compatibility is
  - the ability of a product to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbance to anything in that environment
- In simple terms
  - don’t emit too much
  - be sufficiently immune

The three elements

- The source
  - the origin of electromagnetic disturbance (unwanted electromagnetic energy)
- The victim
  - something that may be affected by electromagnetic disturbance
- The coupling path
  - the means by which the disturbance is transferred from source to victim

all three are needed

What is an electromagnetic environment?

- The totality of the electromagnetic energy in a location
  - spectrum considered to be 0 Hz to 300 GHz
  - energy may be conducted or radiated
  - electrostatic discharges
- The topic today is power quality
  - EMC issues related to power supply

Phenomena - 1

- Low frequency
  - power frequency harmonics and interharmonics
  - flicker
  - inrush current
  - mains signalling
  - voltage fluctuations
  - voltage dips and interruptions
  - voltage unbalance
  - power frequency variations

Phenomena - 2

- High frequency
  - radio frequency energy (cw and modulated)
  - transients
  - surges
- New threats
  - powerline communications (digital signals 1 Mbit/s and above)

Legislation for apparatus

- EMC Directive 89/336/EEC (plus amendments)
- EMC Regulations (SI 1992 No. 2372 plus amendments)
- Legal requirement in the UK since 1.1.1996
- “Protection requirements” for products which are
  - properly installed and maintained
  - used for their intended purpose

Protection requirements

- Apparatus shall be so constructed that
  - the electromagnetic disturbance it generates does not exceed a level allowing other relevant apparatus to operate as intended
  - it has a level of intrinsic immunity which is adequate to enable it to operate as intended
- The protection requirements are intended to ensure compatibility between apparatus, equipment, systems and networks

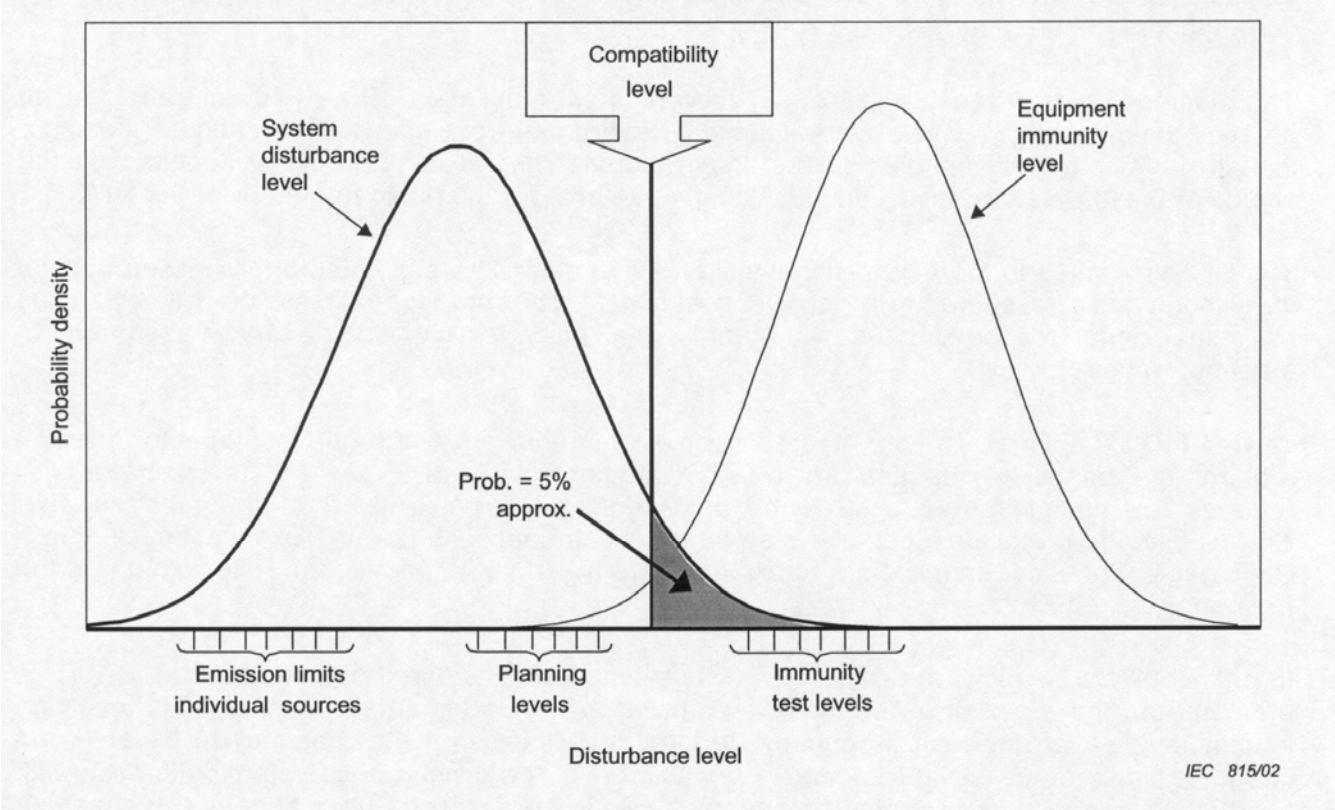
Harmonised standards

- The EMC Directive does not contain technical requirements
- These are contained in harmonised standards
  - product
  - product family
  - generic
- Underpinned by basic standards
  - test methods and guidance

Compatibility levels - 1

- In general, emission limits protect radio receivers
  - they have to be receptive at the wanted frequency
- In general, immunity limits protect against radio transmitters and natural phenomena
  - high levels of disturbances at transmitting antennas
  - electrostatic discharges, lightning
- Not so clear-cut at lower frequencies

Compatibility levels - 2



Emissions from apparatus - 1

- Harmonics (to 40th i.e. 2 kHz)
  - Different limits according to threat
  - Tightest limits on TVs and PCs
  - Most relaxed limits on portable tools
- Flicker (change in voltage caused by change in load)
  - short term (minutes)
  - long term (hours)
  - maximum change (generally switch on/off)

Emissions from apparatus - 2

- Radiofrequency emissions on power supplies
  - generally 150 kHz to 30 MHz (or 300 MHz for household appliances)
  - limits set to protect radio receivers
  - measured using a LISN or clamp
  - rf energy radiates from power cables due to antenna effect
  - above 30 MHz measurements are usually of radiated energy

Emissions from apparatus - 3

- Discontinuous disturbances (clicks)
  - limits for short duration disturbances
  - apply to thermostatically-controlled appliances, automatically controlled machines
  - subjectively less annoying than continuous disturbances
  - limits are relaxed unless there are 30 clicks/minute or more

Immunity

- The power supply may transmit high frequency disturbances as
  - rf energy as cw or modulated signals
  - fast transients from switching
  - surges from lightning
- It may suffer from
  - harmonics, interharmonics, flicker, frequency variations
  - voltage fluctuations, interruptions

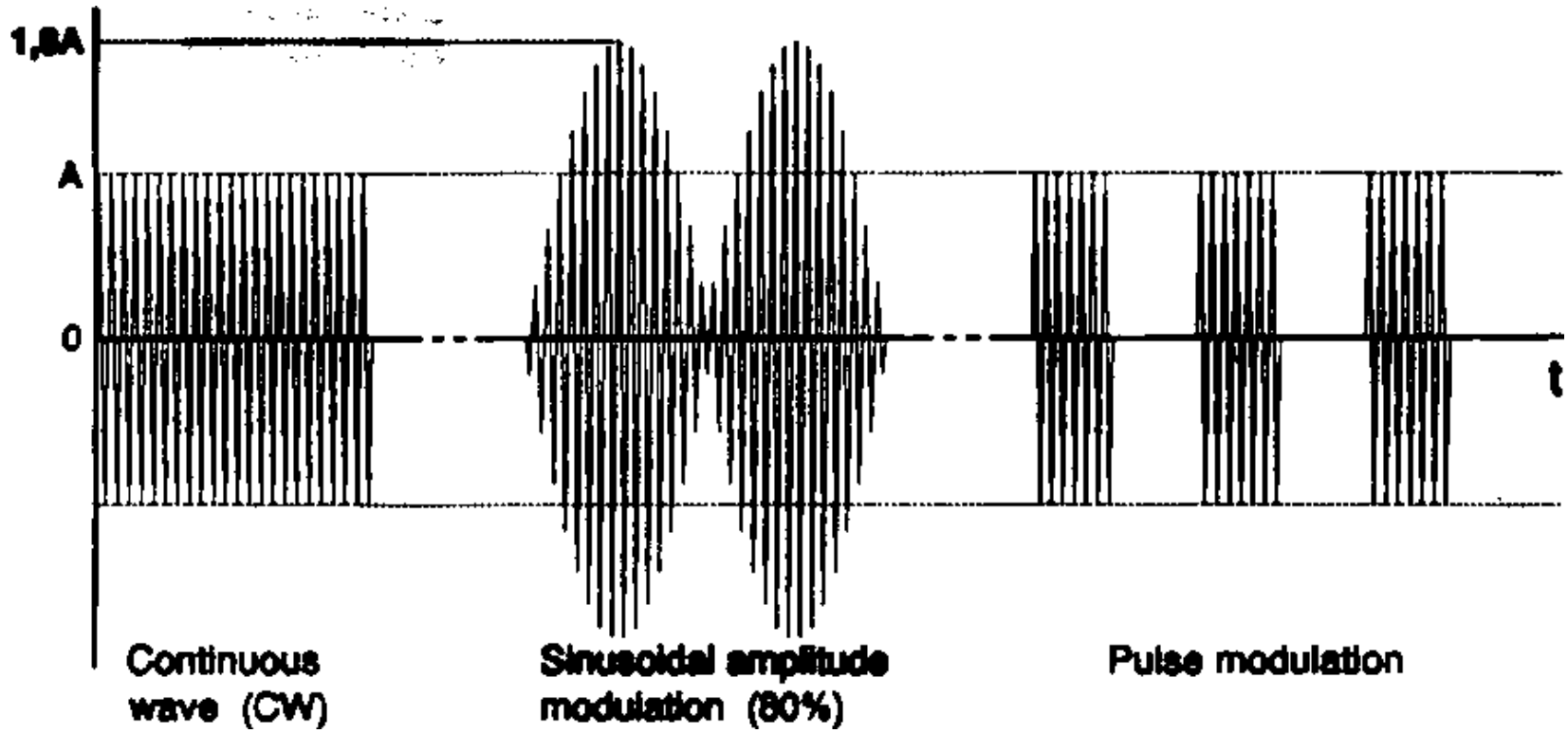
Immunity for apparatus

- Basic standards exist for testing all these phenomena
- Not all are applied in product standards
  - cost of testing
  - products immune to one phenomenon are often immune to others
  - some threats are low
- We will look at some typical requirements

Radiofrequency immunity

- Generally 150 kHz to 80 MHz
  - modulated 1 kHz 80% amplitude (next slide)
  - swept or steps of 1%
- 3 V rms domestic, 10 V rms industrial
- Applied by coupling network, a clamp, or directly to the screen of screened cables
- Test are performed on all cable types
  - cable by cable

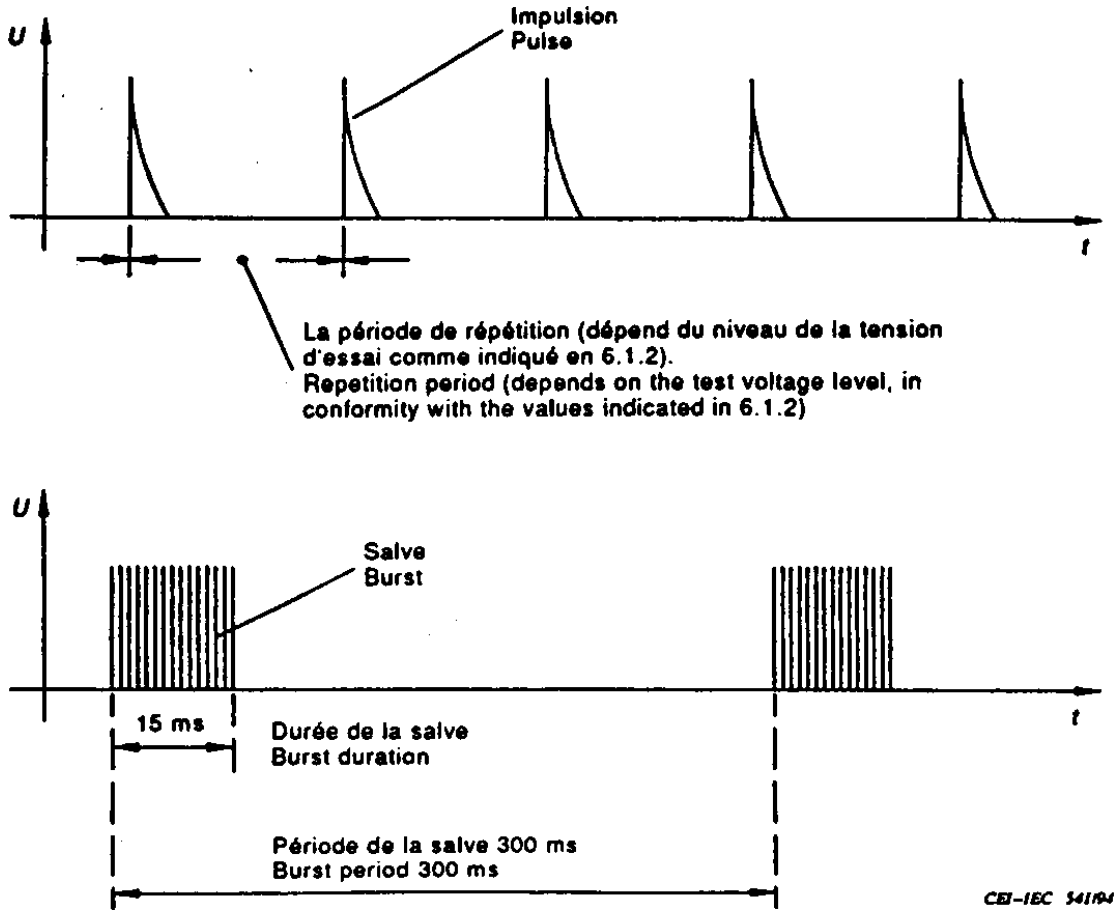
RF immunity modulation



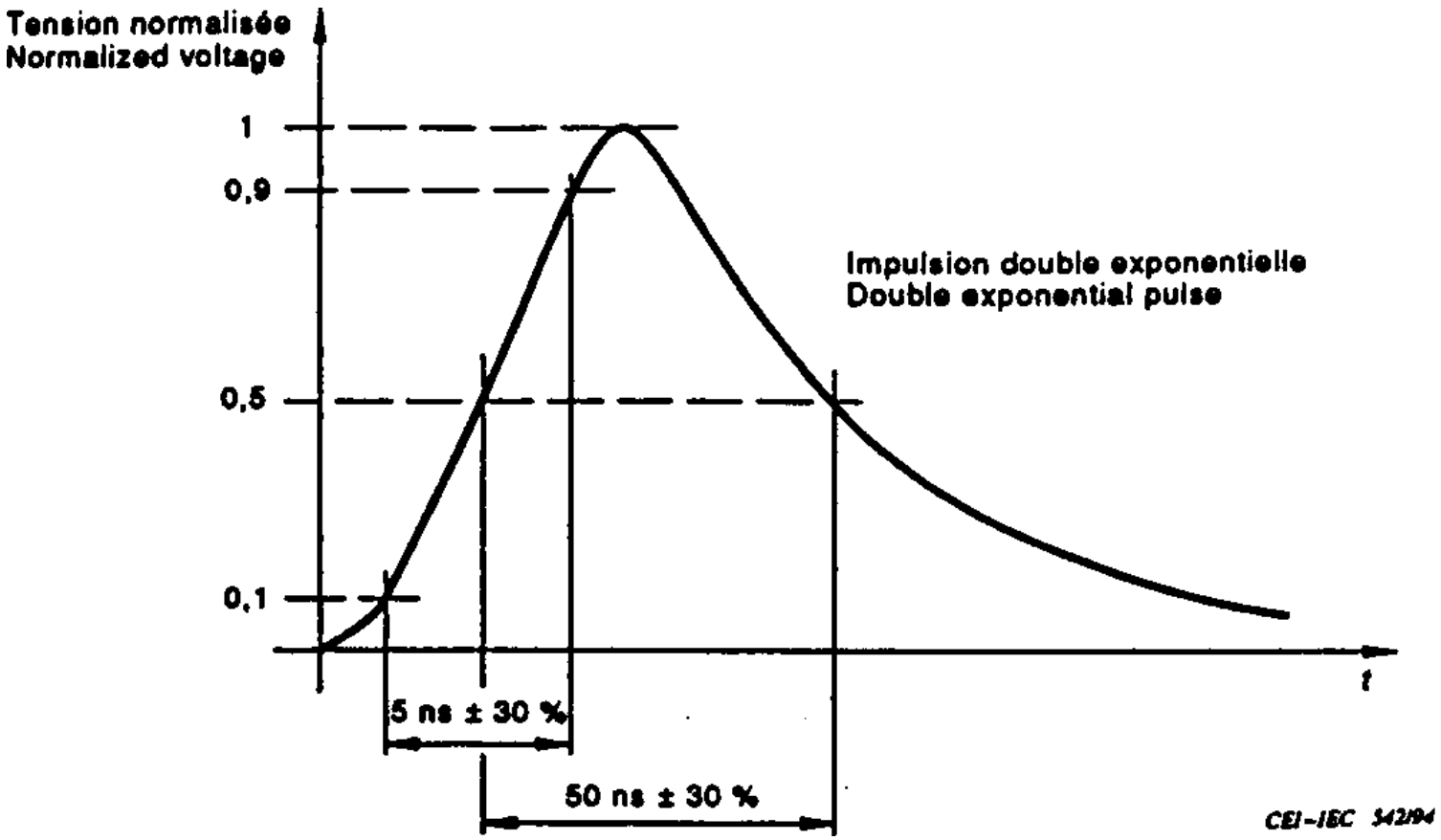
Fast transients

- Pulses caused by opening switches, relays, etc.
  - in bursts
- Typically 1 kV on domestic ac mains, 2 kV on industrial mains
- Applied in positive and negative polarities
- Coupling network on mains supplies
- Capacitive clamp on signal lines

Burst repetition



Transient waveshape

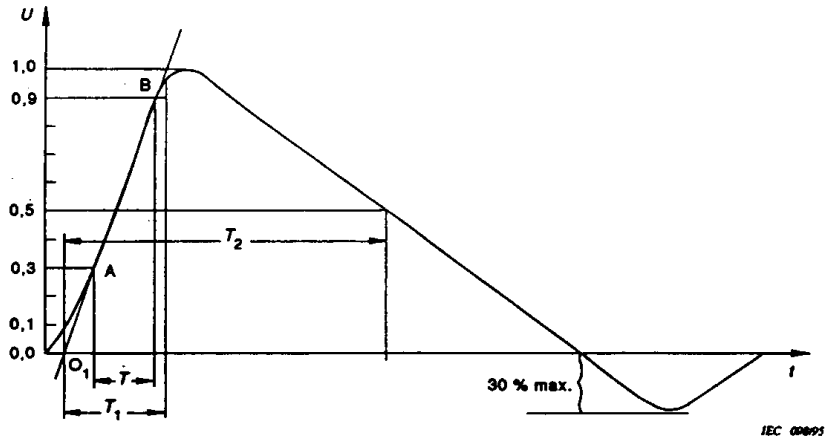


Surges

- Slower pulses induced in cables by lightning strikes in the vicinity
- 2 kV line - earth and 1 kV line - ground
  - domestic and industrial
  - plus “let-through” of any primary protection
- Applied by coupling networks to mains supplies
  - at 0, 90, 180, 270 degrees
  - positive and negative surges

Surge waveshape

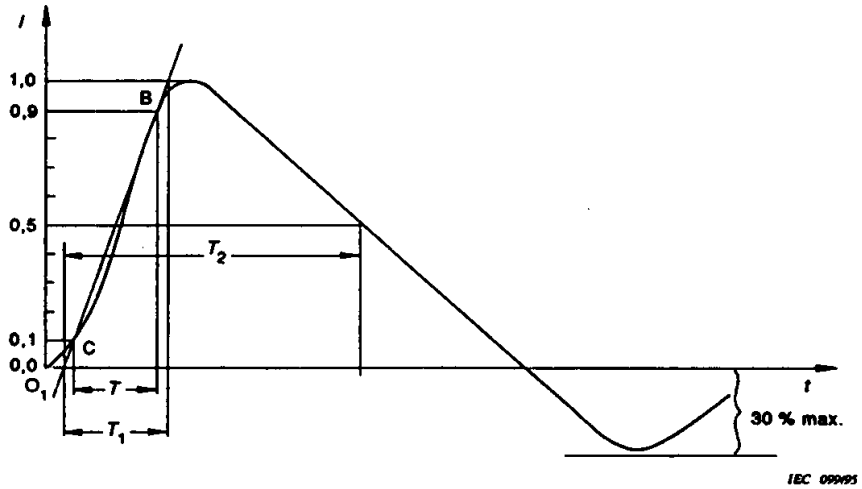
open circuit



Front time: $T_1 = 1{,}67 \times T = 1{,}2\ \mu s \pm 30\ \%$

Time to half-value: $T_2 = 50\ \mu s \pm 20\ \%$.

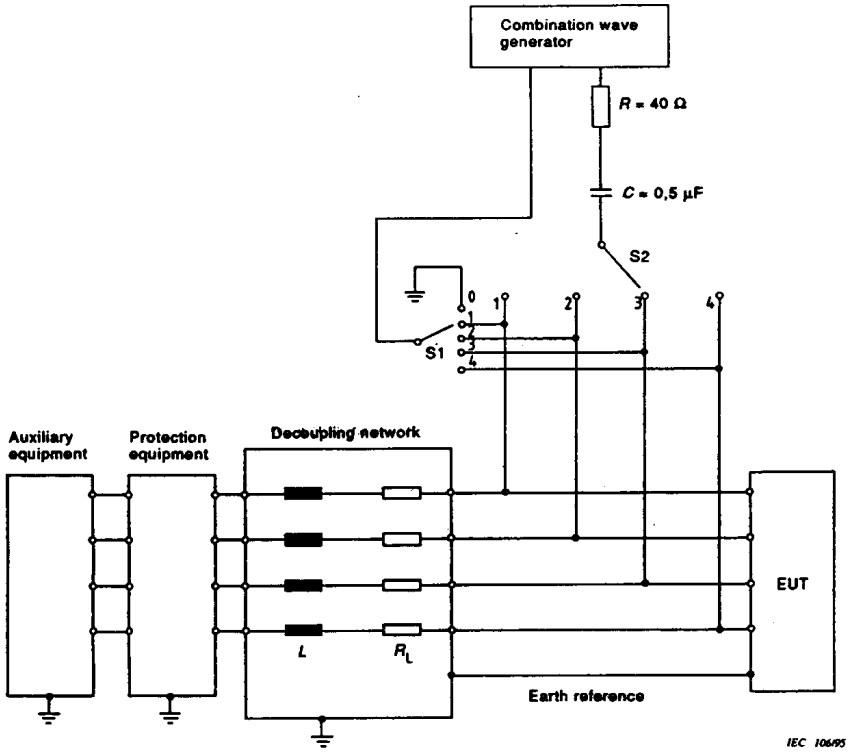
short circuit



Front time: $T_1 = 1{,}25 \times T = 8\ \mu s \pm 20\ \%$

Time to half-value: $T_2 = 20\ \mu s \pm 20\ \%$.

Surge coupling network



1) *Switch S1*
   – line to earth: position 0
   – line to line: positions 1 to 4

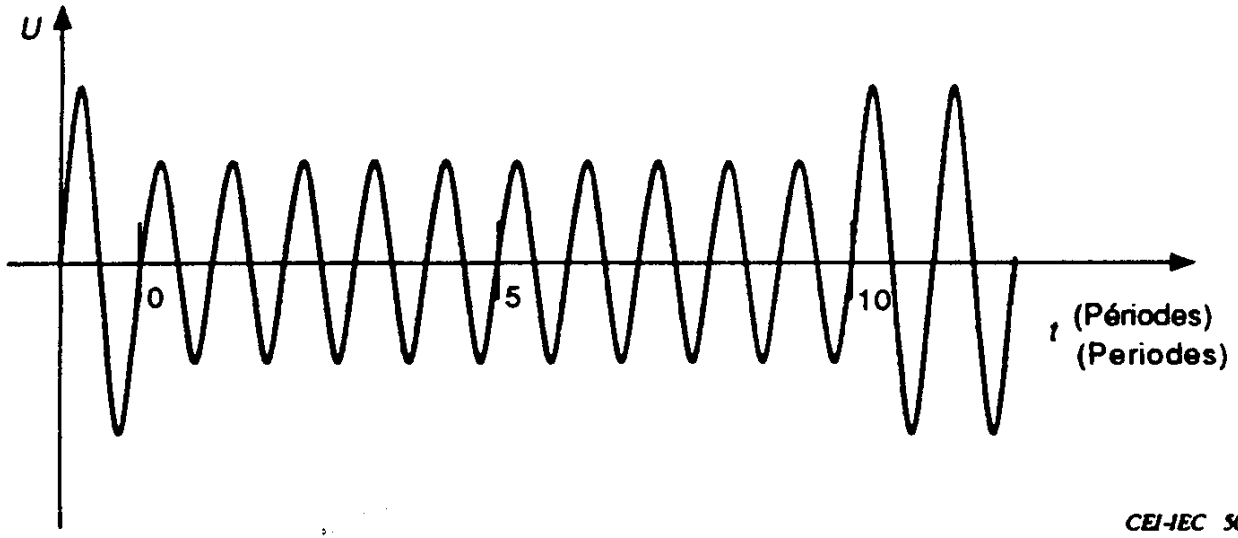
2) *Switch S2*
   – during the test positions 1 to 4, but not in the same position with switch S1

3) L = 20 mH, R_L represents the resistive part of L

Voltage dips and interruptions

- Dips
  - short term reduction of voltage to non-zero level and restoration
  - percentage reduction varies from standard to standard
- Interruptions
  - short term reduction to zero and restoration
- Step change is made at zero crossing

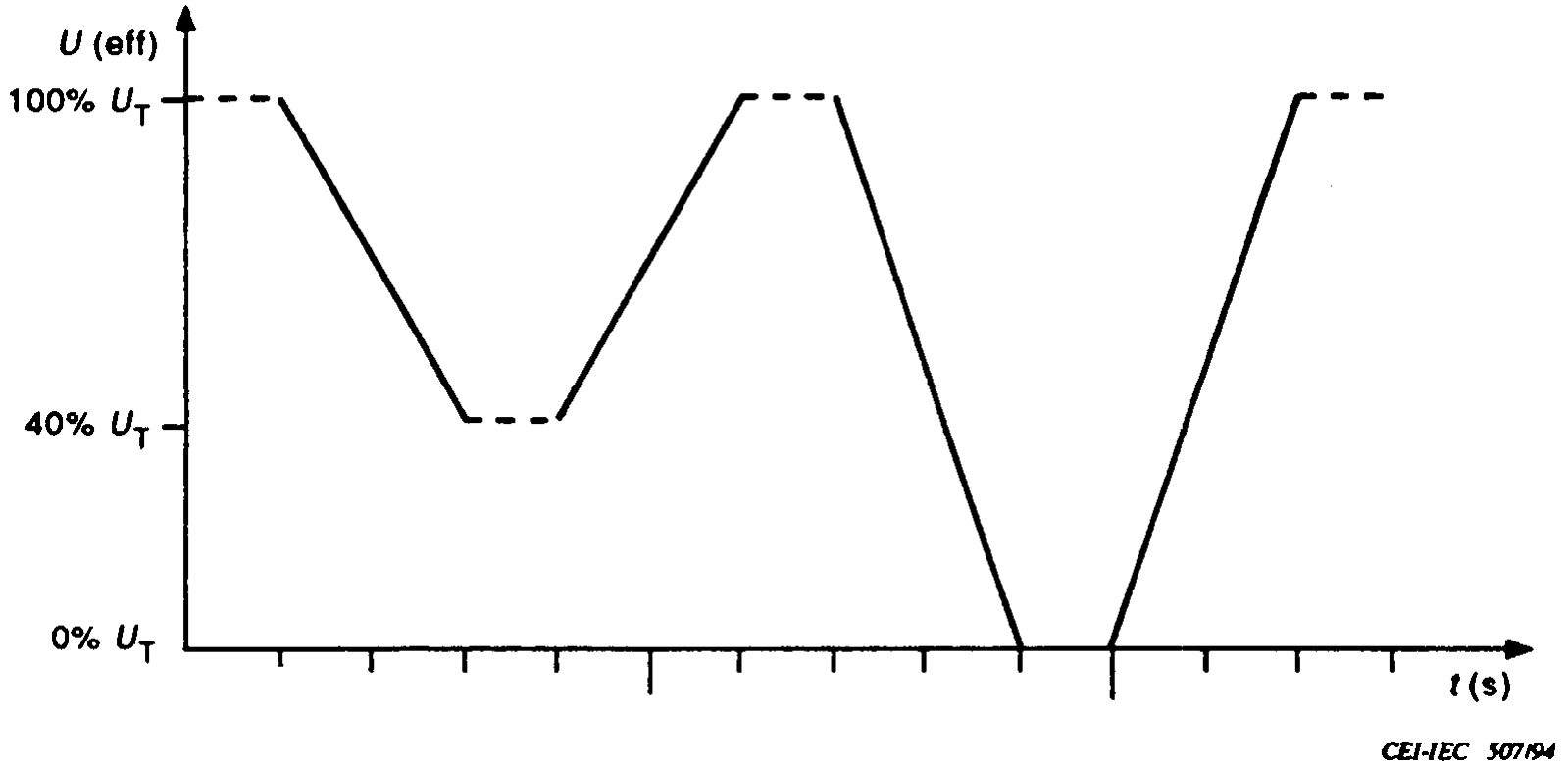
Typical waveshape - dips



NOTE – La tension d'alimentation diminue à 70 % pendant 10 périodes. Démarrage au passage par zéro.

NOTE – The voltage decreases to 70 % for 10 periods. Step at zero crossing.

Voltage variation



Performance criteria

- Three criteria
- Criterion A
  - operate as intended during and after test
- Criterion B
  - operate as intended after the test
  - degraded performance allowed during the test
- Criterion C
  - temporary loss of function allowed
  - self recoverable or by operation of controls

Generic standards requirements

- RF immunity A
- Fast transients B
- Surges B
- Voltage dips
  - short periods (half cycle) B
  - long periods (five cycles) C
- Voltage interruptions C

Hot topics

- Harmonics requirements for TVs and PCs
  - too onerous?
- Power Line (Tele)Communications PLT/PLC
  - broadband over the (unbalanced) mains network
  - needs a signal-to-noise ratio to function
  - therefore signals need to be higher than current emissions limits
  - but current emissions limits protect radio services
  - outcome unclear!
- EN 50160 Voltage characteristics of electricity supplied by public distribution systems
  - parameters not specified for 100% of the time

Thank you for listening

Questions?

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