# Standardization documents on pulse measurements and measurement receivers

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- JRP protocol:

Task 3.1 will provide traceability for the calibration of pulse generators, which are used for the calibration of measuring receivers with a quasi-peak (QP) detector. The output of this will be a recommendation for the best method for the calibration of pulse generators.

- methods of calibration of pulse generators generally described in standards, unfortunately without technical details, measurement uncertainty calculation only briefly indicated

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## Overview of standards

- measurement receivers with QP detector mainly discussed in European CISPR documents (CISPR – Comité International Spécial des Perturbations Rádioélectriques) and US standards ANSI 63.2 (QP parts derived from CISPR)

- in the last years, standards are being harmonized (international and national standards committees) and updated to reflect the current status of technology

- terminology sometimes not unique and confusing, however all used quantities have dimensional units **V/Hz** or its mathematical equivalent

# Overview of standards

| year | CISPR | European | US |
|---|---|---|---|
| 1977 | 16 ed. 1<br>+A1 (1980), A2 (1983) | | |
| 1987 | 16 ed. 2 | | ANSI C63.2-1987 |
| 1993 | 16-1 ed. 1<br>+A1 (1997) | | |
| 1996 | | | ANSI C63.2-1996 |
| 1999 | 16-1 ed. 2<br>+A1 (2002), A2 (2003) | | |
| 2003 | 16-1-1 ed. 1<br>+A1 (2005) | | |
| 2004 | | EN 55016-1-1 ed. 1<br>+A1 (2005) | |
| 2006 | 16-1-1 ed. 2<br>+A1 (2006), A2 (2007) | | |
| 2007 | | EN 55016-1-1 ed. 2<br>+A1 (2007), A2 (2008) | |

# Overview of standards

| year | CISPR | European | US |
|---|---|---|---|
| 2009 | | | ANSI C63.2-2009 |
| 2010 | 16-1-1 ed. 3<br>+A1 (2010), A2 (2014) | EN 55016-1-1 ed. 3<br>+A1 (2010), A2 (2014) | |
| 2015 | 16-1-1 ed. 4 | | |
| 2016 | | | ANSI C63.2-2016 |

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- Introduction
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- **QP detector calibration**
- Pulse generator calibration

QP detector calibration related quantities (CISPR 16/EN 55016/ANSI):

**spectrum amplitude** $S(f) = 2 \cdot |V(f)|$

- mostly used quantity in literature, $V(f)$ is the Fourier transform of the $v(t)$ signal in the time-domain
- rectangular pulse with amplitude $A$ and duration $T$: for low frequencies ($f << 1/T$) we can use

$$S(f) = 2 \cdot A \cdot T$$

- measure of the amplitude spectrum at certain frequency, expressed in µV/MHz or dB(µV/MHz)

QP detector calibration related quantities (CISPR 16/EN 55016/ANSI):

**spectrum amplitude** $S(f) = 2 \cdot |V(f)|$

- definition, see, e.g.

Andrews, J. R.; Arthur, M. G.: Spectrum Amplitude – Definition, Generation and Measurement; National Bureau of Standards; 1977

IEEE Standard for the Measurement of Impulse Strength and Impulse Bandwidth; IEEE Std. 376-1975 **inactive – withdrawn**

QP detector calibration related quantities (CISPR 16/EN 55016/ANSI):

**impulse area** $$A_{imp} = \int_{-\infty}^{+\infty} v(t)dt$$

- voltage-time area of a pulse defined by the integral
- sometimes referred to as impulse strength
- typically expressed in μVs or dB(μVs)
- related to spectral density (see later)

QP detector calibration related quantities (CISPR 16/EN 55016/ANSI):

**spectral intensity** $S(f) = 2 \cdot A_{imp}$

$$\int_{-\infty}^{\infty} V^2(t)\,dt = \int_{-\infty}^{\infty} |A(f)|^2 df = 2\int_{0}^{\infty} |A(f)|^2 df$$

- term found in EN 55016-1-1 and IEEE Std. 376-1975

QP detector calibration related quantities (CISPR 16/EN 55016/ANSI):

**spectral density** $D(\mu V/MHz) = \sqrt{2} \cdot 10^6 \cdot A_{imp}(\mu Vs)$

- defined in 55016-1-1
- alternative term “impulse strength” can be found
- term √2 stands for peak to RMS conversion

QP detector calibration related quantities (CISPR 16/EN 55016/ANSI):

**impulse bandwidth**

$$B_{imp} = \frac{A(t)_{max}}{2G_0 \times A_{imp}}$$

$A(t)_{max}$ = peak of the envelope at the IF output of the receiver with an impulse area $A_{imp}$ applied at the receiver input

$G_0$ = gain of the circuit at the centre frequency

- CISPR 16-1-1 defines:

The response of a measuring receiver to pulses having an impulse area of 0.022 μVs, having a uniform spectrum up to at least 1000 MHz, repeated at a frequency of 100 Hz, shall for all frequencies of tuning, be equal to the response to an unmodulated sine-wave signal at the tuned frequency having an r.m.s. value of 1 mV (60 dB(μV)).

The impulse area produced by the generator shall be known with an error not greater than ±0.5 dB. The pulse repetition frequency shall be known with an error not greater than 1 %.

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- **Pulse generator calibration**

- CISPR 16-1-1 / EN 55016-1-1 Annex B:
  **Determination of pulse generator spectrum**
  - the generator should be capable of producing pulses of adequate impulse area with a spectrum up to 1 GHz as uniform as possible
  - impulse area known with ±0.5 dB and the repetition frequency to 1 %

- CISPR 16-1-1 / EN 55016-1-1 Annex C:
  **Accurate measurement of the output of nanosecond pulse generators**
  - measurement of impulse area
    - area method
    - standard transmission line method
    - harmonic measurement
    - energy method
  - pulse generator spectrum

- particular methods will be explained in detail in following presentations

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# Thank you for attention