Armónicas en Sistemas Eléctricos
Estandar IEEE-519

Referencia: **Guide for Applying Harmonic Limits on Power Systems**

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Jesús Baez

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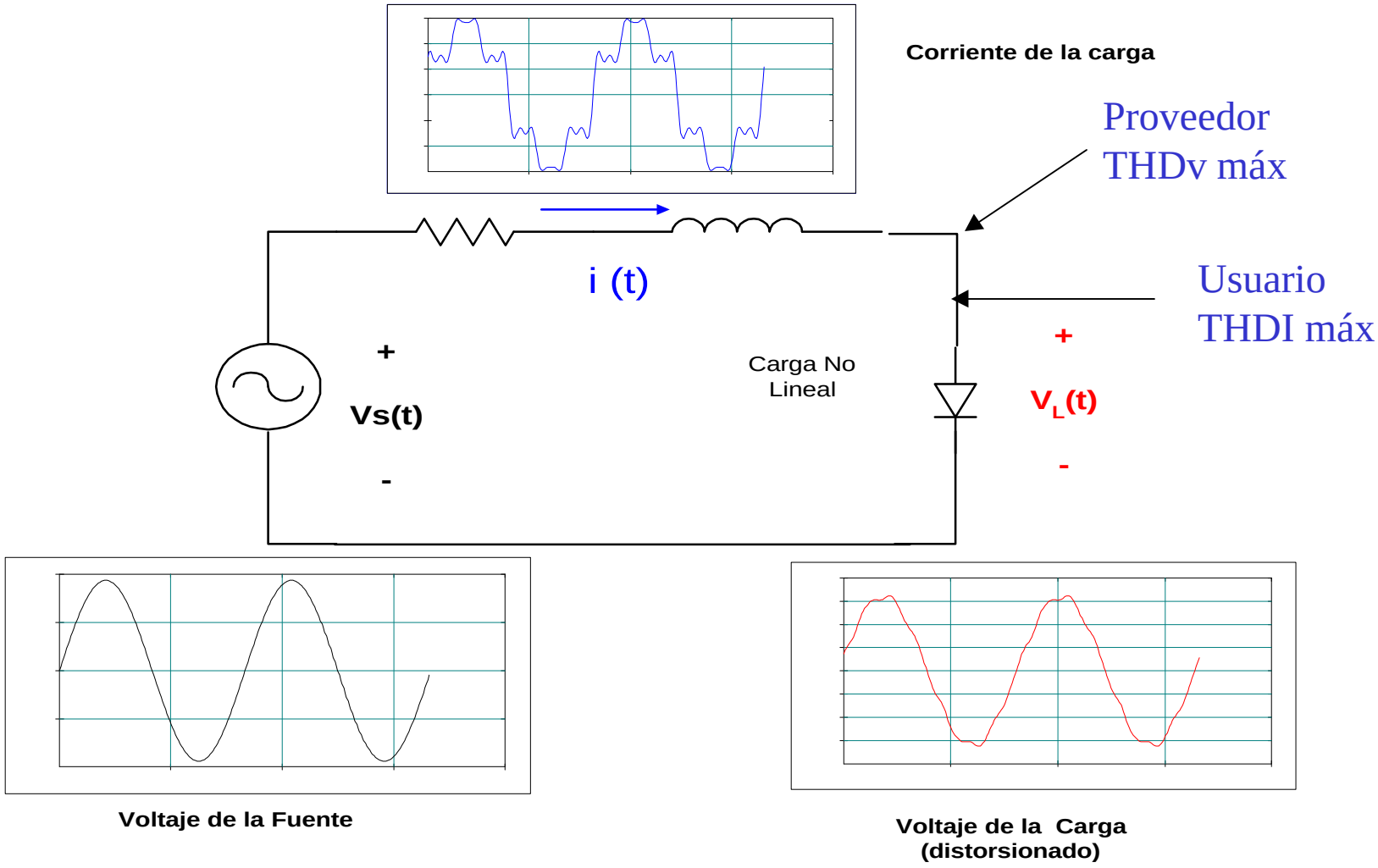
Distorsión de voltaje y distorsión de corriente



IEEE-519

Distorsión de Voltaje

Distorsiones < 5% son recomendables

Distorsiones de voltaje por arriba del 5% provocan efectos negativos en motores, transformadores, relevadores, medidores, etc.

Distorsiones arriba del 10% son **INACEPTABLES**

El Estandar IEEE-519 recomienda que las compañías suministradoras mantengan los niveles de distorsión de voltaje de acuerdo a la tabla de la siguiente página y que losclientes mantengan la inyección de corriente debajo de valoresque dependen de la rigidez del sistema.
Los límites establecidos para la corriente son fijados de tal manera que si todos los usuarios los respetan, la compañía suministradora puede mantener la distorsión por debajo de los límites marcados por el estándar

3.1 Basic Responsibilities

Harmonics are created by nonlinear loads and devices on the power system. There are a wide variety of devices that generate harmonics and they can be connected to the power system at any voltage level. The one line diagram in Figure 3.1 provides a conceptual system illustrating the interconnection of different harmonic-producing devices on the power system. The procedures outlined in IEEE 519-1992 are designed to limit harmonic currents from individual customers and equipment so that harmonic voltage levels on the overall power system will be acceptable. The approach involves a divided responsibility between the customer and the utility.

1. **The customer**. For individual customers, the revised standard limits the level of harmonic current injection at the point of common coupling between the customer and the utility. Recommended limits are provided for individual harmonic components and for the Total Demand Distortion (TDD). These limits are expressed as a percentage of the customer's demand current level, rather than as a percentage of the fundamental, in order to provide a common basis for evaluation over time.

2. **The utility**. The utility system is the transmission and/or distribution system that serves multiple customers. The utility is responsible for the voltage distortion at the point of common coupling. For most systems (below 69 kV), the Total Harmonic Distortion (THD) should be less than 5%. This means that the utility must make sure that system resonance conditions do not result in unacceptable voltage distortion levels, even if all customers are within the recommended guidelines for harmonic current generation.

Límites en distorsión de voltaje

Bus Voltage at PCC (V_n)	Individual Harmonic Voltage Distortion (%)	Total Voltage Distortion - THD_{Vn} (%)
$V_n \le 69kV$	3.0	5.0
$69kV < V_n \le 161kV$	1.5	2.5
$V_n > 161kV$	1.0	1.5

$$THD_{V_n} = \frac{\sqrt{\sum_{h=2}^{\infty} V_h^2}}{V_n} \times 100\%$$

where:

V_h = magnitude of individual harmonic components (rms volts)
h = harmonic order
V_n = nominal system rms voltage (rms volts)

Límites en distorsión de corriente

Table 3.3.2
Harmonic current distortion limits (I_h) in % of I_L

I_{sc} / I_L	$h < 11$	$11 \le h < 17$	$17 \le h < 23$	$23 \le h < 35$	$35 \le h$	*TDD*
$V_n \le 69kV$						
<20	4.0	2.0	1.5	0.6	0.3	5.0
20-50	7.0	3.5	2.5	1.0	0.5	8.0
50-100	10.0	4.5	4.0	1.5	0.7	12.0
100-1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0
$69kV < V_n \le 161kV$						
<20*	2.0	1.0	0.75	0.3	0.15	2.5
20-50	3.5	1.75	1.25	0.5	0.25	4.0
50-100	5.0	2.25	2.0	1.25	0.35	6.0
100-1000	6.0	2.75	2.5	1.0	0.5	7.5
>1000	7.5	3.5	3.0	1.25	0.7	10.0
$V_n > 161kV$						
<50	2.0	1.0	0.75	0.3	0.15	2.5
≤ 50	3.5	1.75	1.25	0.5	0.25	4.0

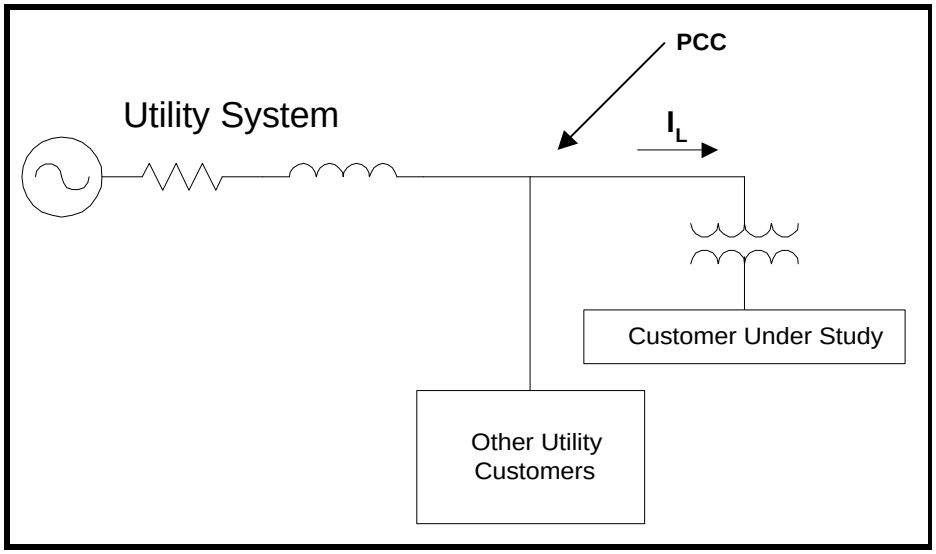
Niveles de distorsión permitidos por el estándar IEEE-519

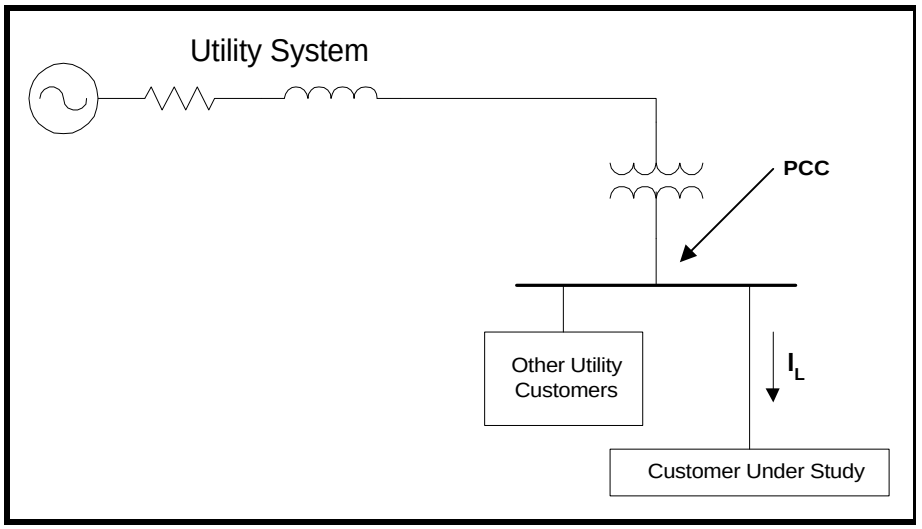
Distorsión en Corriente (Responsabilidad del usuario)

$$Icc(kA) = \frac{MVA_{CC}}{\sqrt{3}[kV_{LL}]} \qquad \text{TDD}_{h}(\%) = 100\left[\frac{I_h}{I_L}\right] \qquad \text{TDD}\ (\%) = 100\left[\frac{\sqrt{\sum_{h=2}^{h=h_{max}} I_h^{\,2}}}{I_L}\right]$$

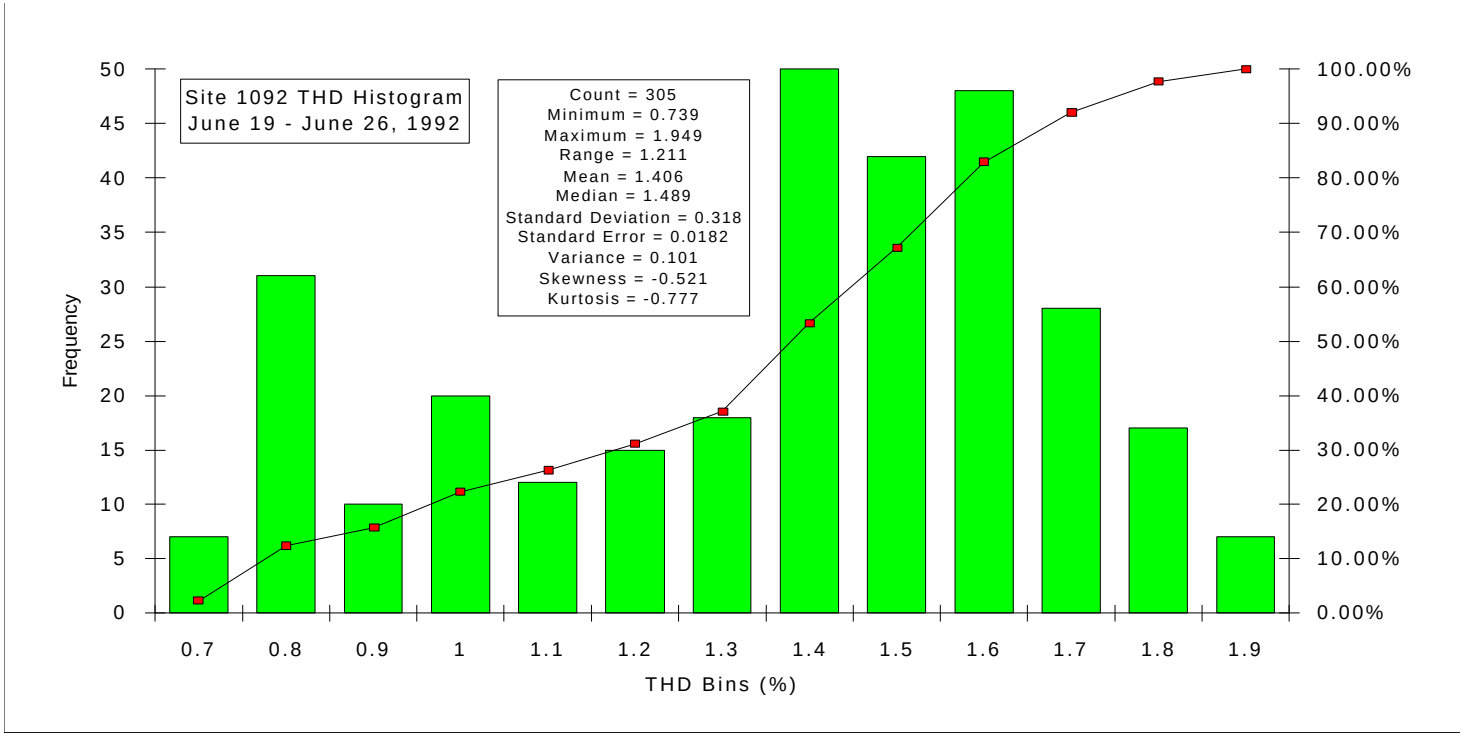
$\mathbf{I_L}$ representa el valor de corriente correspondiente al valor promedio de la demanda máxima que se ha presentado en los últimos doce meses

Estándar IEEE-519 (Elección del punto de acoplamiento común)





Tolerancias en niveles de distorsión

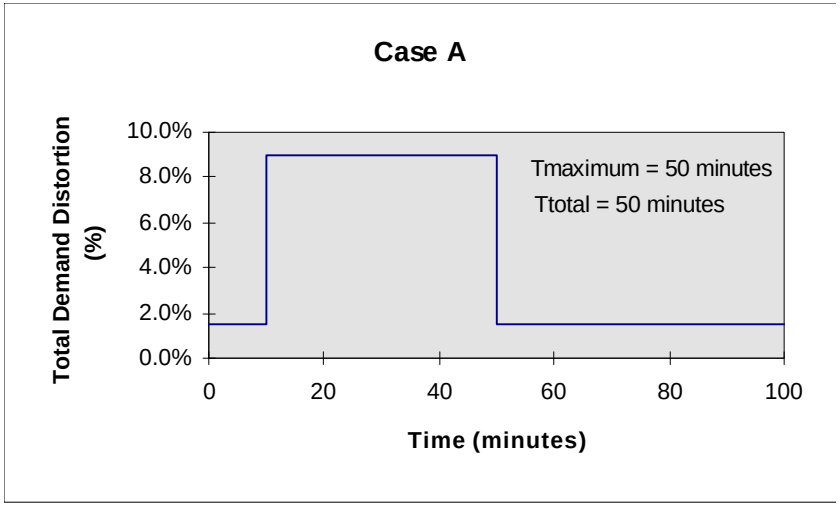


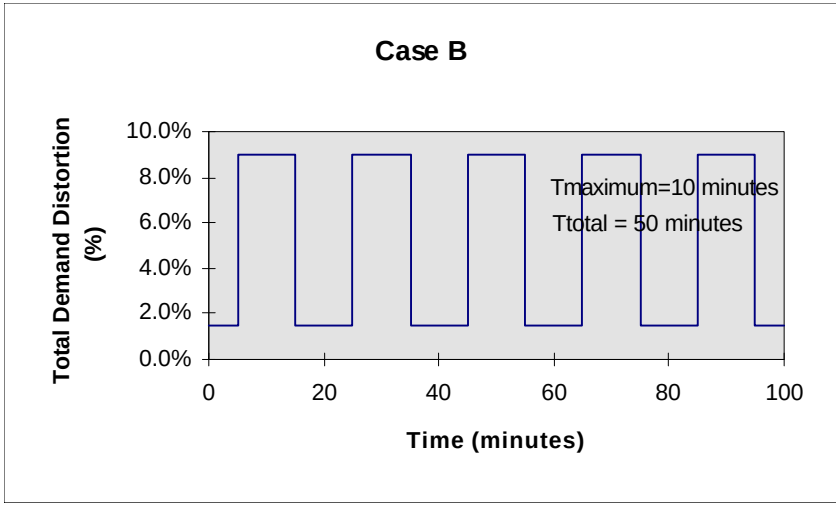
IEEE 519-1992 states that the steady state harmonic limits can be exceeded by 50% for short periods of time (up to one hour per day). One hour per day is approximately 4% of the time. Therefore, this limitation is consistent with using the design limits as the 95% probability of not being exceeded. The higher limit (1.5 x the design limits) can be compared with the measured harmonic level that is not exceeded 99% of the time (the 99% probability point).

Tolerancias en niveles de distorsión

4.2.2 Magnitude/Duration Limits for Short Duration Harmonic Levels

The probability distributions do not distinguish between many short bursts of harmonics and one longer burst of harmonics that may exceed a specified threshold. Figure 4.2.2 provides an exaggerated comparison of two time trends of harmonic levels illustrating the difference. Both of the cases have the same total duration where the harmonics exceed a threshold (e.g. 8%) but they may have significantly different impacts on motor or transformer heating.





Tolerancias en niveles de distorsión

There are two indices that can be calculated to characterize the time varying nature of the harmonics and take into account both of these cases:

1. The total duration of harmonic bursts (T_{total}) is the summation of all the time intervals in which the measured level exceeds a particular level during a specified measurement period.

2. The maximum duration of a single burst ($T_{maximum}$) is the longest time interval in which the measured distortion level continuously exceeded a particular level during the specified measurement period.

Both T_{total} and $T_{maximum}$ are functions of the threshold selected. Specific limits can be developed for ranges of these indices and then the limits can be plotted on a magnitude duration plot (see example in Section 5) for comparison with the measurement results. Table 4.2.1 provides example magnitude/duration limits that can be used to include the time varying nature of harmonics in the evaluation [6]. They use the steady state limits from IEEE 519-1992 as a basis (referred to as design limits in the table). Note that harmonic bursts with durations less than 5 seconds are ignored. While these short duration bursts of harmonics could be very important, it is difficult to apply steady state limits to control them. While reference [6] uses 5 seconds as the defining period for these short bursts, it may be desirable to use 3 seconds since that is the sampling period used in IEC 1000-4-7.

Table 4.2.1. Short duration harmonic distortion limits based on a 24 hour measurement period.

Acceptable harmonic distortion level (individual or TDD)	**Maximum duration of a single harmonic burst ($T_{maximum}$)**	**Total duration of all harmonic bursts (T_{total})**
3.0 x (design limits)	1 sec < $T_{maximum}$ < 5 sec	15 sec < T_{total} < 60 sec
2.0 x (design limits)	5 sec < $T_{maximum}$ < 10 min	60 sec < T_{total} < 40 min
1.5 x (design limits)	10 min < $T_{maximum}$ < 30 min	40 min < T_{total} < 120 min
1.0 x (design limits)	30 min < $T_{maximum}$	120 min < T_{total}

Procedimiento para la evaluación de límites de armónicas