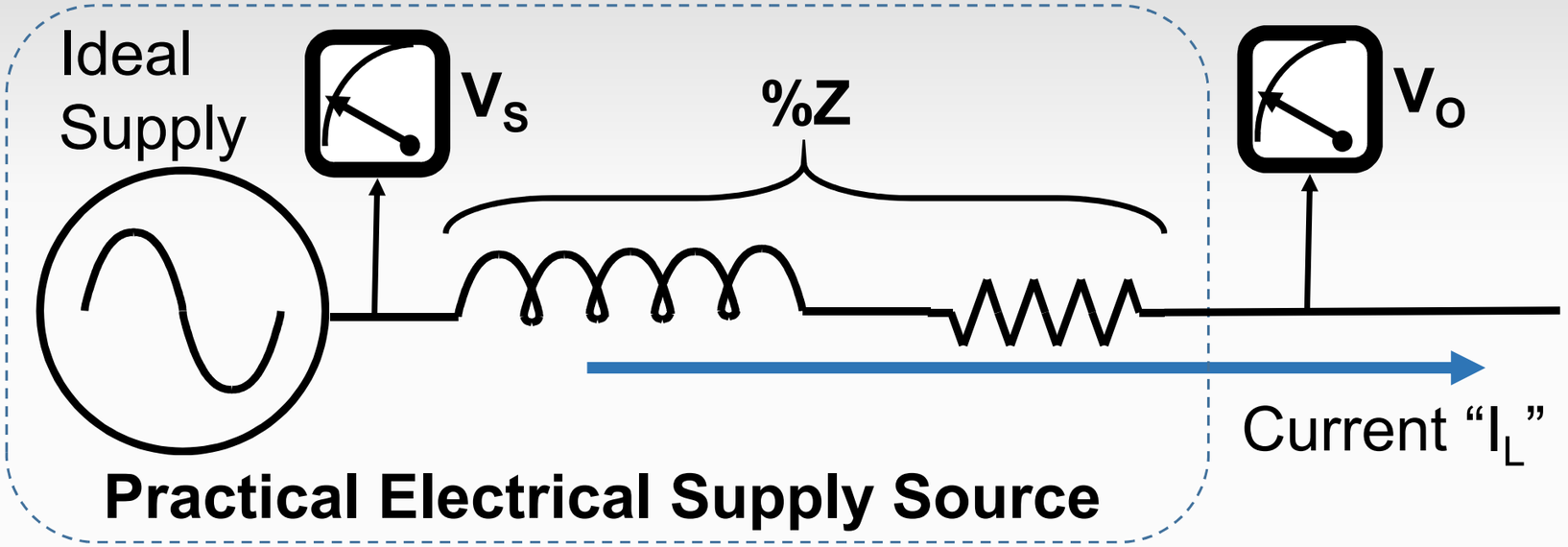
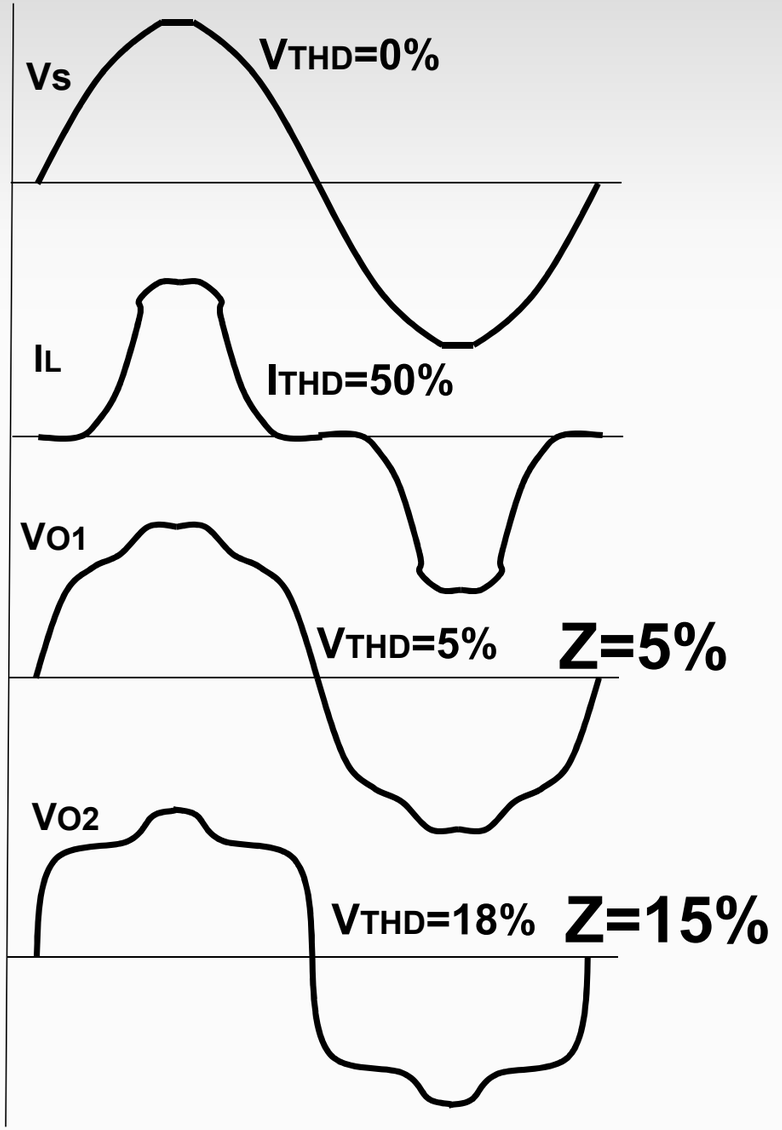
Power Quality (PQ) Standards IEEE-519™-2014 applicable for Industrial & Commercial Supply System

–Tushar Mogre.

Why Harmonics Affect the Supply System?





Step down supply transformers:

LV (220V to 1000V) supply transformer: **4% to 6.5%**

MV (1kV to 6.6kV) supply transformer: **6% to 9%**

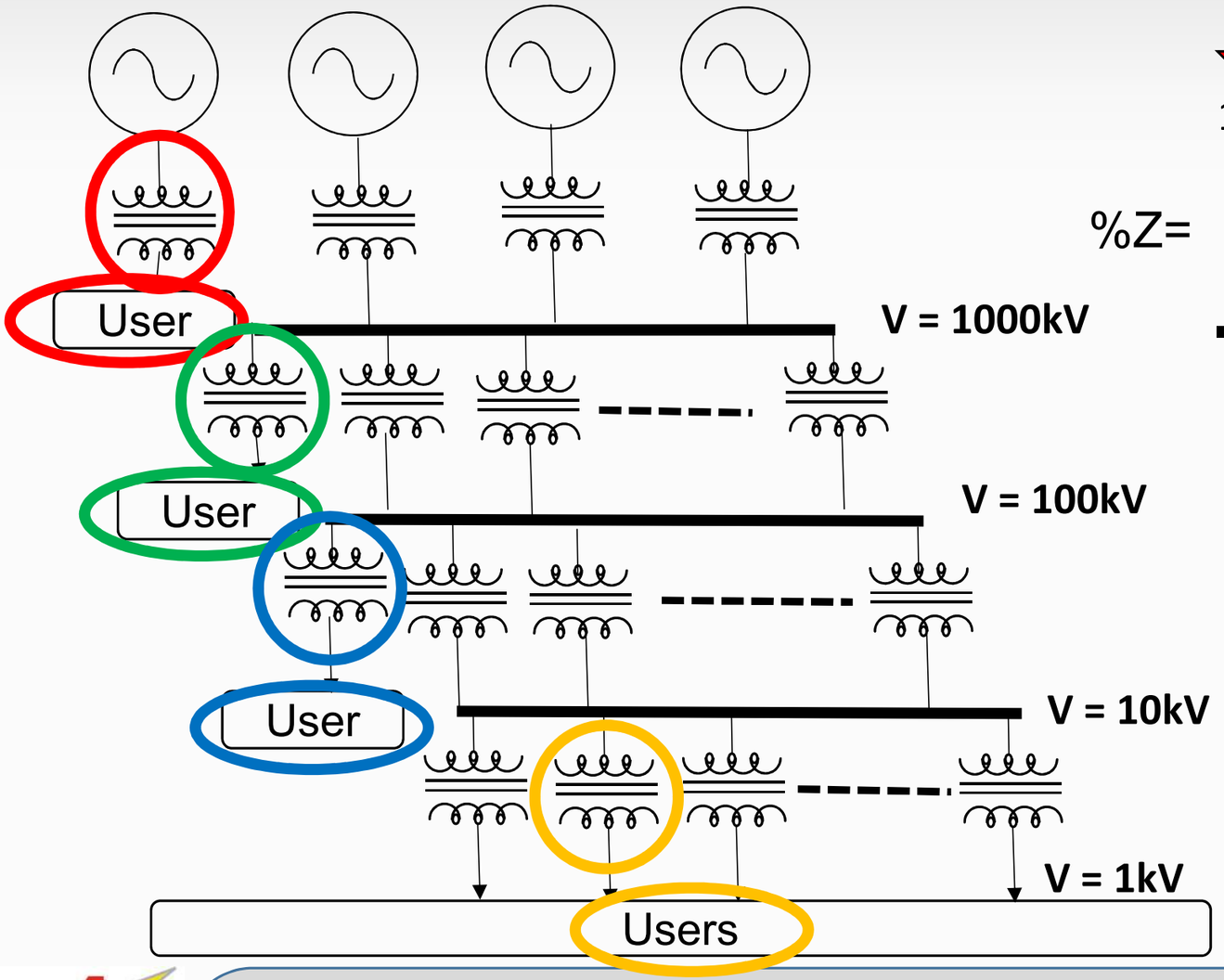
HV (11kV to 66kV) supply transformer: **7% to 11%**

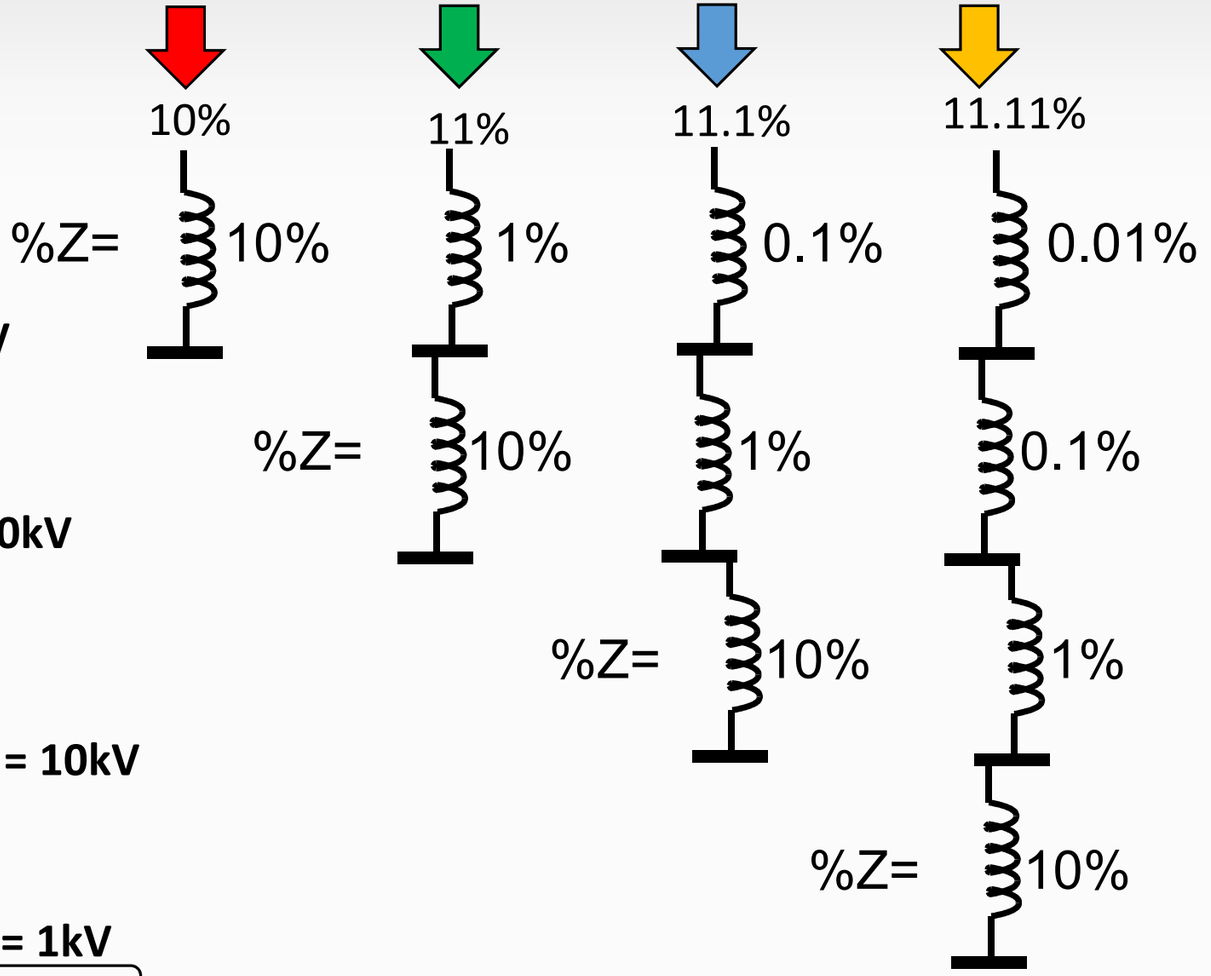
Generators:

LV (220V to 1000V) : **12% to 21%**

Why Harmonics Affect the Supply System?

Transmission & Distribution of Supply – Supply Impedances seen.





IEEE-519™-2014 Standard for Harmonics

Title: IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems.

"Recommended Practice Standard" – Applicable for "Electrical Power Supply Systems".

NOT a standard for any specific product.

Many "Electrical Supply System company" makes it as a Mandatory standard to be observed by the User of the Electricity.

Knowing the bad effects of Harmonics on Electrical supply system and its connected loads, it's a good standard to observe for all electricity users.

IEEE-519™-2014 Standard for Harmonics

The limits in this recommended practice represent a shared responsibility for harmonic control between system owners or operators and users.

This means,

The harmonic generating Load should not cause the harmful interference with other loads connected on the supply system.

It can be interpreted from electricity supply view point as:

One user should not generate harmonics so that those can cause harmful interference with other users on the electric supply feeders.

It can be interpreted from user view point as:

Harmonic generating electrical equipment should not cause harmful effect on other electrical equipment.

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Some Important terms to be understood.

"I_{SC} / I_L" ratio:

I_{SC} is the short circuit current of the given supply system.
I_L is "Maximum Demand Load Current".

Why this ratio is important?

I_{SC} is also a measure of source impedance %Z. The %Z primarily defines the Short Circuit current of the supply system.

I_L: This current value should be taken as the sum of the currents corresponding to the maximum demand during each of the twelve previous months divided by 12.

Continued……..

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Some Important terms to be understood.

Meaning of I_L:

Monthly peak demand seen is I_{MD-n} then one needs to even take look at previous 11 months value too.

Thus, **Total Maximum Demand Current**

$$I_{MD-n} = \sum_{n}^{n-11} I_{MD-n} / 12.$$ (n = month number)

is calculated for purpose of I_{SC}/I_L value or the term “TDD” (total demand distortion).

Continued……..

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Some Important terms to be understood.

Higher the I_{SC}/I_L ratio means:

- Either %Z value is lower.

  AND / OR

- Maximum Demand Load current is much lower than the rated / installed capacity of supply system.

Vice-Versa in case with Lower I_{SC}/I_L ratio.

Thus, with higher I_{SC}/I_L ratio, the voltage distortion is much lesser than the system with lower I_{SC}/I_L ratio.

Thus, IEEE-519* standard defines the current harmonics limits as per I_{SC}/I_L ratio.

Higher the ratio, higher is the permissible harmonic limit and lower the ratio, lower is the permissible limit.

IEEE-519™-2014
Some Important terms to be understood.

PCC – Point of Common Coupling:

The standards definition is:
Point on a public power supply system, electrically nearest to a particular load, at which other loads are, or could be, connected. The PCC is a point located upstream of the considered installation.

But the terms used in this definition like “Public Power Supply System” or “a particular load” can be interpreted by different personnel / agencies differently. And this is where there is some confusion.

Thus, one has to see the Electrical point in the system with their own perspective.

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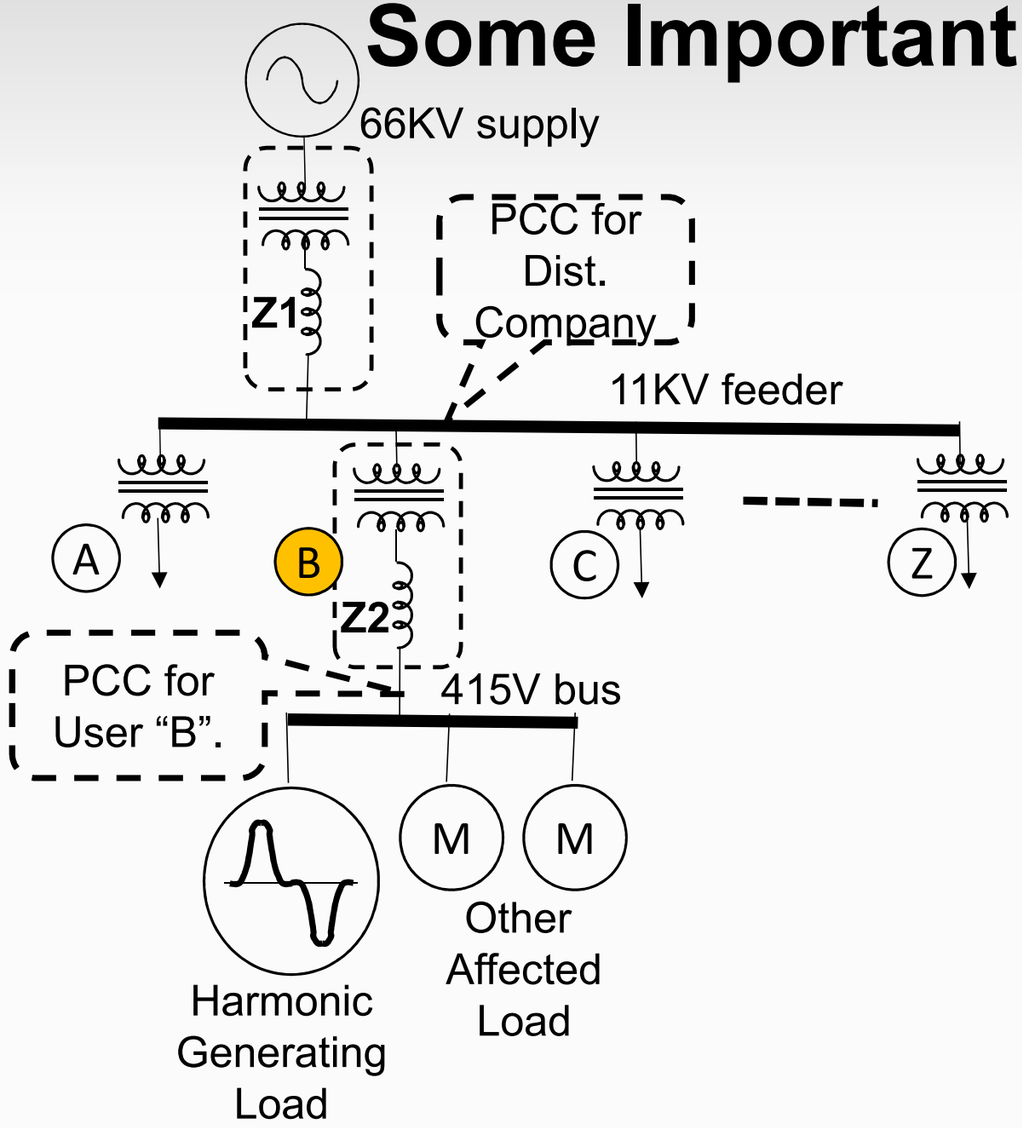
Some Important terms to be understood.



PCC – Point of Common Coupling:

The PCC location for "Electricity Distribution company" and for "one user – B" as an example can be seen.

Electricity Distribution company is concerned about the all its consumers from A, B, C,--- Z. Thus, PCC for them is as shown. Here I_{SC}/I_L ratio would be calculated on the basis of impedance "Z1".

But for a LV user "B" is not concerned about other users A, C --- Z. But this user is concerned about other affected loads in own establishment. Thus, PCC for user B is as shown. Here I_{SC}/I_L ratio would be calculated on the basis of impedance "Z2" (neglecting the small effect of reflected Z1).

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Some Important terms to be understood.

PCC – Point of Common Coupling:

From Electricity Supply Perspective for User assessment of Harmonics.

user 1 and user 2 are supplied by Electricity Distribution Company from same 11kV feeder. The Maximum Demand Load current for user 1 is I_{L1} and for user 2 is I_{L2}.

Here, I_{SC} is mainly function of Zs (neglecting cable impedance) so for both users – A & B, $\mathbf{I_{SC}}$ value is almost same.

But values of I_{L1} and I_{L2} would be different for these users. Therefore I_{SC}/I_L ratios for two different users would be different and current harmonic permissible levels can be different for two different users as per the standards.

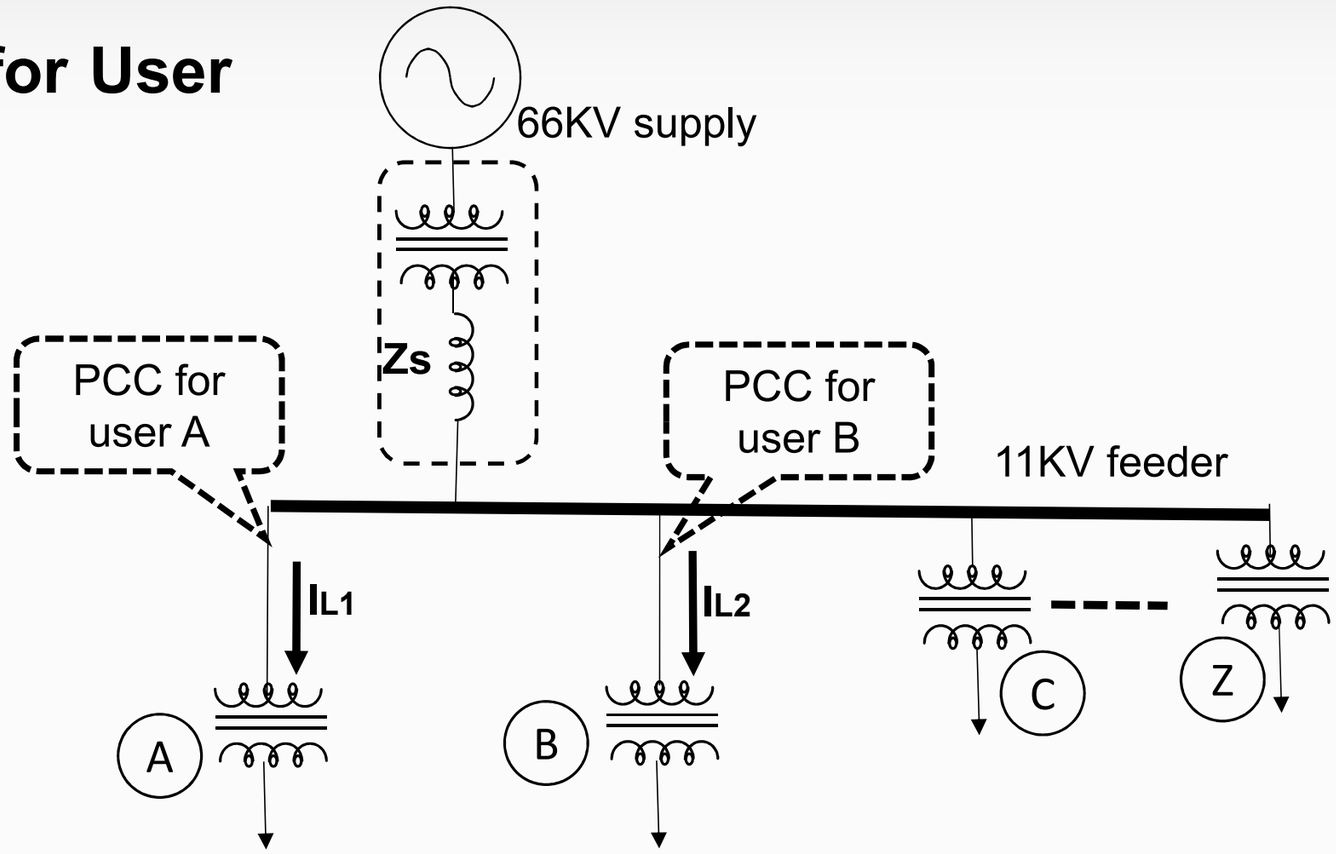

Table 1—Voltage distortion limits

Bus voltage V at PCC	Individual harmonic (%)	Total harmonic distortion THD (%)
$V \leq 1.0$ kV	5.0	8.0
1 kV $< V \leq 69$ kV	3.0	5.0
69 kV $< V \leq 161$ kV	1.5	2.5
161 kV $< V$	1.0	1.5[a]

[a]High-voltage systems can have up to 2.0% THD where the cause is an HVDC terminal whose effects will have attenuated at points in the network where future users may be connected.

Table 2—Current distortion limits for systems rated 120 V through 69 kV

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (odd harmonics)[a, b]						
I_{SC}/I_L	$3 \leq h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h \leq 50$	TDD
< 20[c]	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

[a]Even harmonics are limited to 25% of the odd harmonic limits above.

[b]Current distortions that result in a dc offset, e.g., half-wave converters, are not allowed.

[c]All power generation equipment is limited to these values of current distortion, regardless of actual I_{sc}/I_L

where

I_{sc} = maximum short-circuit current at PCC

I_L = maximum demand load current (fundamental frequency component) at the PCC under normal load operating conditions

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Harmonics standards IEEE-519™2014 for Electrical Supply

–Tushar Mogre.

Table 3—Current distortion limits for systems rated above 69 kV through 161 kV

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (odd harmonics) [a, b]						
I_{sc}/I_L	$3 \leq h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h \leq 50$	TDD
< 20 [c]	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	0.75	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

[a] Even harmonics are limited to 25% of the odd harmonic limits above.

[b] Current distortions that result in a dc offset, e.g., half-wave converters, are not allowed.

[c] All power generation equipment is limited to these values of current distortion, regardless of actual I_{sc}/I_L.

where

I_{sc} = maximum short-circuit current at PCC

I_L = maximum demand load current (fundamental frequency component) at the PCC under normal load operating conditions

Table 4—Current distortion limits for systems rated > 161 kV

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (odd harmonics)[a, b]						
I_{sc}/I_L	$3 \le h < 11$	$11 \le h < 17$	$17 \le h < 23$	$23 \le h < 35$	$35 \le h \le 50$	TDD
< 25[c]	1.0	0.5	0.38	0.15	0.1	1.5
$25 < 50$	2.0	1.0	0.75	0.3	0.15	2.5
≥ 50	3.0	1.5	1.15	0.45	0.22	3.75

[a]Even harmonics are limited to 25% of the odd harmonic limits above.

[b]Current distortions that result in a dc offset, e.g., half-wave converters, are not allowed.

[c]All power generation equipment is limited to these values of current distortion, regardless of actual I_{sc}/I_L

where

I_{sc} = maximum short-circuit current at PCC

I_L = maximum demand load current (fundamental frequency component) at the PCC under normal load operating conditions

It is recommended that the values given can be increased by a multiplying factor when actions are taken by a user to reduce lower-order harmonics. The multipliers given in the second column here under are applicable when steps are taken to reduce the harmonic orders given in the first column.

Table 5—Recommended multipliers for increases in harmonic current limits

Harmonics orders limited to 25% of values given in Table 2, Table 3, and Table 4	Multiplier
5, 7	1.4
5,7,11,13	1.7
5,7,11,13,17,19	2.0
5,7,11,13,17,19,23,25	2.2
↓	↓

Thank You