SIEMENS

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FAQ for SIMOREG 6RA70 and Control Module

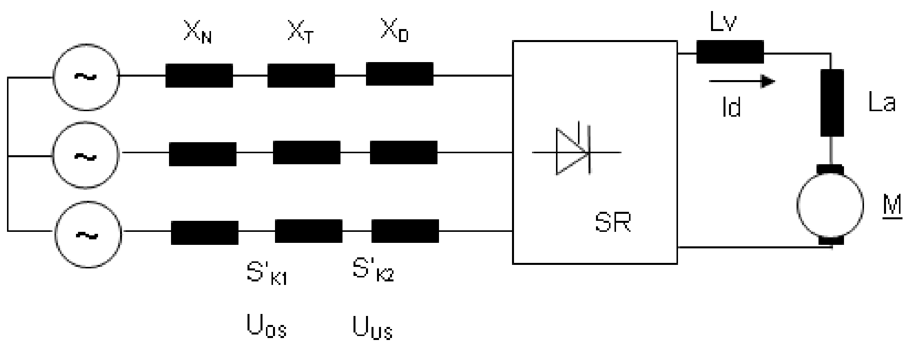
Question:

What requirements apply for line quality and what line interference can occur?

Answer:

Line requirements:

Voltage: rated voltage +10% -20%, (+15% for 400 V and 460 V devices)
Frequency: 45 to 65 Hz (23 to 110 Hz on Request)
Permissible speed of frequency change: 10 Hz/s
Maximum asymmetry of the line: 3%



U_{OS}... Line-to-line voltage of the medium-voltage network on transformer primary side
U_{US}... Line-to-line voltage of the low-voltage side on transformer secondary side

S'_{K1}... Short-circuit power of the medium-voltage network at the connection point of the converter transformer
S'_{K2}... Short-circuit power of the secondary-side busbar of the converter transformer

X_N... Inductive resistance of the network relative to the secondary-side voltage of the transformer
X_T... Inductive resistance of the converter transformer relative to the secondary-side voltage of the transformer
X_D... Inductive resistance of the commutating reactor
X_K... Commutating reactance of the converter, $X_K = X_N + X_T + X_D$
Id... DC current

Lv…Inductance of the smoothing reactor,
La...Inductance of the motor

SR... Converter
M... DC motor

Line interference:
Converters on the network cause two types of line interference:

A) Commutating notches
B) Harmonics

This interference does not destroy the converters but it can have adverse effects on other loads on the same network.

Commutating notches:

Commutation reactor:
If line-commutated current converters are used, commutation induction is always required in the supply circuit. In the simplest case, a commutation reactor is used.
To protect the current converter, a commutation inductance is required that produces a 4% voltage drop at the rated current of the converter; Vimp = 4%. A separate commutation reactor or separate transformer winding with 4 % Vimp must be used for every current converter used on one power system. The permissible Vimp of the reactor/transformer winding for the current converter is 4% to 10% (worst case 15%).
According to DIN EN 61800-3, voltage dips of up to 20% are permissible during commutation.
The following applies: If the short-circuit power of the power system is higher than the connected load of the current converter by at least a factor of 100, commutation notches of maximum 20% of the peak voltage of the network will occur if a 4% commutation reactor is used.
If several current converters are installed on the same power system, it can be assumed that these will not commutate at exactly the same time, so the reactor can be dimensioned for each current converter individually as a function of its power, as described above. Normally the commutation reactor is dimensioned as a function of the rated motor current; this saves costs as the rated current of the device is usually higher. If high acceleration currents are required on the motor, the reactor should be designed for a peak current / 1.6 due to the saturation that occurs during high currents.
The alternating current of the reactor for the armature circuit infeed is:
Direct current Id * 0.816
Help with calculation of the commutation notches:

$$\Delta U[\%] = (x_N + x_T) / (x_N + x_T + x_D) * 100\%;$$

where $x_N + x_T = U_{US}^2 / S'_{k2}$; $x_D = L_D * 2 * \pi * f$; L_D: reactor inductance, f = line frequency,
ΔU: Commutation notch power system at current converter connecting point (line side directly before the commutation reactor) as a percentage.
If only the short-circuit power S'_{k1} on the high-voltage side of the line transformer is known, S'_{k2} can be calculated as follows:
$S'_{k2} = S_T / (u_k + S_T / S'_{k1})$; S_T: Transformer apparent power, u_k: Short-circuit power transformer in p.u. e.g. 0.06 for 6% uk.
Effects of the commutation notches on loads in the same power system:
If several SINAMICS DCM are operated in the same network, they do not usually affect each other, so long as the voltage dip is not higher than that defined by the threshold of the phase-failure monitoring in parameter P353 (factory setting 40% means 60% dip permissible).
However, it cannot be ruled out that these steep-edged voltage dips might damage other loads. Examples of this are switched-mode power supplies for supplying power to automation units, computers and their monitors, but also loads such as fluorescent lamps with electronic starters and power-factor correction capacitors for low-voltage motors.
That is one of the reasons why higher performance current converters are usually supplied via a separate converter transformer, fed from the high-voltage side of the power system. If problems arise with loads on the same network with line-commutated current converters, the

lower-cost solution is usually to provide a separate transformer for the weak network loads rather than implement additional measures on the high-power current converter.

Harmonics:

6-pulse converter:
6-pulse line-commutated converters cause only odd harmonic currents and harmonic voltages that cannot be divided by 3 occur, with the following harmonic numbers v:

v = n * 6 ± 1 where n = 1, 2, 3...
v = 5, 7, 11, 13, 17, 19, 23, 25, 29, 31, 35, 37, 41, 43, 47, 49....

12-pulse converter:
Due to the phase shift of 30° between the two secondary voltages, the harmonic currents with harmonic numbers v = 5, 7, 17, 19, 29, 31, 41, 43, ... , which are still present in the input currents of the 6-pulse rectifiers, compensate one another so that theoretically only odd harmonic currents and voltages that cannot be divided by 3 with the following v numbers occur at the point of common coupling (PCC) on the primary side of the transformer:

v = n * 12 ± 1 where n = 1, 2, 3...
v = 11, 13, 23, 25, 35, 37, 47, 49....

Which harmonics are acceptable?

The following standards governing harmonics are applicable:

EN 61000-2-2; Compatibility levels for low-frequency conducted disturbances and signaling in public low-voltage power supply systems.
Applies to a frequency range from 0 to 9 kHz.
For rated voltages up to 420 V single-phase and 690 V three-phase.
The compatibility levels are valid for the point of common coupling (PCC) with the public supply system.
Limits for harmonic currents are not defined.
The compatibility level for the total harmonic distortion factor of the voltage:
THD(V) is 8%.

EN61000-2-4: Compatibility levels for low-frequency conducted disturbance variables in industrial plants.
Applies to a frequency range from 0 to 9 kHz.
Class 1: Refers to the operation of equipment which is highly sensitive to disturbances in the power supply.
Class 2: This class generally applies to points of common coupling (PCCs) with the public supply system and to internal points of coupling (IPCs) with industrial or other private supply systems.
Class 3: This class applies to internal points of coupling (IPCs) in industrial environments.
This class should be considered, for example, if one of the following conditions applies:
• The main part of the load is supplied via converters
• Welding machines are present
• Large motors are started frequently
• Loads vary quickly

Standard EN 61000-2-4 does not define limits for harmonic currents. Limits are only specified for harmonic voltages and the total harmonic distortion of the voltage THD(V).

Harmonic number v	Class 1 U_v in %	Class 2 U_v in %	Class 3 U_v in %
5	3	6	8
7	3	5	7
11	3	3.5	5
13	3	3	4.5
17	2	2	4
>17 to 49	2.27 * 17 / v – 0.27	2.27 * 17 / v – 0.27	4.5 * 17 / v – 0.5

	Class 1	Class 2	Class 3
THD(V)	5%	8%	10%

SIMOREG are normally operated in classes 2 and 3.

SIMOREG are not affected by supply systems with a high harmonic content; the purpose of the classes specified above is therefore to define permissible values for other equipment connected to the point of common coupling (PCC).

IEEE 519: IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

This standard is applied in the USA, Canada and many countries in Asia. It specifies limits for harmonic voltages and currents for both individual consumers and also for the sum of all consumers at the point of common coupling (PCC).

Permissible harmonic voltages and THD(V).
These limits are determined by the ratio between maximum demand load current of the individual consumer and the supply short-circuit current (averaged over 15 or 30 minutes).
Permissible voltage levels at the PCC for each individual consumer:

Ratio short-circuit current / max. demand load current	Permissible values for each individual harmonic voltage	Typical users
10	2.5 – 3%	Special customers with special agreement
20	2.0 – 2.5%	1–2 large consumers
50	1.0 – 1.5%	A few high energy consumers
100	0.5 – 1%	5–20 medium energy consumers
1000	0.05 – 0.1%	A large number of low energy consumers

Permissible voltage level at the PCC for the sum of all consumers:

Voltage at the PCC	Permissible value for each individual harmonic voltage	Permissible value for THD(V)
$U_{Supply} \leq 69$ kV	3%	5%

Permissible harmonic currents and permissible total harmonic distortion of current THD(I): The limits depend on the ratio between the supply short-circuit current and the maximum demand load current at the PCC (averaged over 15 or 30 minutes).

Permissible harmonic currents at the PCC in relation to the maximum demand load current at the PCC

Ratio of short-circuit current/ max. demand load current	**< 11**	**11 ≤ v < 17**	**17 ≤ v < 23**	**23 ≤ v < 35**	**35 ≤ v**	**THD(I)**
< 20	4%	2.0%	1.5%	0.6%	0.3%	5%
20 < 50	7%	3.5%	2.5%	1.0%	0.5%	8%
50 < 100	10%	4.5%	4.0%	1.5%	0.7%	12%
100 < 1000	12%	5.5%	5.0%	2.0%	1.0%	15%
> 1000	15%	7.0%	6.0%	2.5%	1.4%	20%

The limit values specified in IEEE519, especially those for low harmonic orders, are in some cases significantly lower than the limits defined by EN 61000-2-4.

As a general rule, 6-pulse connections can operate within the specified limits only when a very low percentage of the total transformer load is made up of converter load. The high amplitude of the 5th and 7th harmonics typical of a 6-pulse converter makes compliance particularly difficult.
The possibility of using a 12-pulse circuit must be examined, as this may comply with the limits specified by IEEE519.

The harmonics will be calculated by the Siemens Technical Support; the following data are required to do this:

a) Short-circuit power of the medium-voltage network
b) Transformer data: input and output voltage, apparent power and uk.
c) Line frequency f
d) Inductance of the commutation reactor
e) Inductance of the smoothing reactor and the motor
f) Rated current and rated voltage of the motor
g) 6-pulse or 12-pulse converter operation