

TECHNICAL NOTE

# Medium and high voltage generators for diesel and gas engines

## Winding pitch



ABB high voltage (HV) generators up to 7.3 MVA are supplied with 5/6 winding pitch as standard, with 2/3 winding pitch available as an option. The optimum winding pitch depends on the application and how the generator will be used. The main factors to consider are whether the generator will be operated in parallel with others, and what type of grounding system will be used.

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02 Stator of the HV compact generator

The winding pitch of a generator is the number of slots spanned by each coil in the stator winding divided by the number of slots per pole. For example, in a 4-pole generator with a 48-slot stator (12 slots per pole), if each coil in the stator winding spans 12 slots then the ratio is 1/1 and the winding is full pitch.

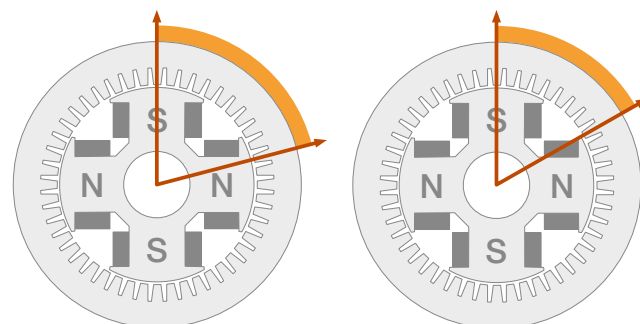
### Varying winding pitch to influence harmonics

The winding pitch of generators is shortened from full pitch – typically reduced to 5/6 or 2/3 – in order to change the harmonic content of the output waveform. At the same time the fundamental component of the output voltage is slightly decreased as well. The reduction in output voltage is then compensated by an increase in field power. A lower pitch winding requires more field power compensation than a higher pitch winding. The result is a decrease in efficiency.

The cross section diagrams show 5/6 and 2/3 winding pitches in 4-pole, 48-slot generators.

ABB's HV compact generator series are engineered to meet users' needs. The generators are therefore offered with 5/6 winding pitch as standard, as this generally enables compact overall sizing. This is because 5/6 winding pitch minimizes the 5th and 7th harmonics, which usually increases overall efficiency. Higher efficiency enables more compact generators to be constructed for the same output power.

### Stator coil configurations for 5/6 and 2/3 winding pitches



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02 Each coil spans 10 slots  
Winding pitch =  $10/12 = 5/6$

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03 Each coil spans 8 slots  
Winding pitch =  $8/12 = 2/3$

### Parallel operation requires similar winding pitches

Generators that are operated in parallel should have the same winding pitch. This is because paralleling generators with different winding pitches will give rise to circulating currents that can cause serious damage to the generators.

The line-to-neutral voltage waveforms of generators with 5/6 and 2/3 winding pitches are slightly different. As a result, when two such generators are connected in parallel, they will produce a line-to-neutral voltage that at any given instant reflects the differences between the two generator voltages. This line-to-neutral voltage will primarily be at the 3<sup>rd</sup> harmonic of the system frequency, for example 150 Hz in a 50 Hz system. It will give rise to 3<sup>rd</sup> harmonic circulating currents, which in this example will be at 150 Hz.

Note that in some cases it is possible to parallel generators with different winding pitches, such as 5/6 and 2/3, by using a neutral reactor. This is connected in the neutral circuit and limits circulating currents to safe levels.

### Solidly grounded systems require 2/3 winding pitch

Solidly grounding the neutral is common in some regions, including the USA. In applications where the neutral point is solidly grounded, a generator with 2/3 winding pitch should be used. This is because the grounded neutral allows 3<sup>rd</sup> harmonic currents to flow in the system, causing additional losses that can result in excessive heating. The 2/3 winding pitch eliminates the 3<sup>rd</sup> harmonic component of the voltage produced in the generator, therefore avoiding the problem of 3<sup>rd</sup> harmonic heating losses.

This also applies to parallel systems – if a number of generators are connected in parallel and their neutrals are solidly grounded, then all the generators must have a 2/3 winding pitch.

Generators with 5/6 winding pitch are preferable in applications where the neutral point is not solidly grounded. This is because a 3<sup>rd</sup> harmonic line-line current cannot flow due to the 120° phase angle between the phases of a three phase generator, so the suppression of this harmonic provided by the 2/3 winding pitch is not needed. Additionally, the 5/6 winding pitch will provide extra benefit by minimizing the 5<sup>th</sup> and 7<sup>th</sup> harmonics.

Winding pitches compared	
5/6 winding pitch	2/3 winding pitch
<ul style="list-style-type: none"><li>• higher power density and better efficiency</li></ul>	<ul style="list-style-type: none"><li>• required for solidly grounded systems</li></ul>
<ul style="list-style-type: none"><li>• lower weight (less electrical steel and copper required for same output)</li></ul>	
<ul style="list-style-type: none"><li>• lower THD% of line-line voltage</li></ul>	<ul style="list-style-type: none"><li>• lower THD% of line-neutral voltage</li></ul>

For more information please visit:

<https://new.abb.com/motors-generators/generators/generators-for-diesel-and-gas-engines>

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