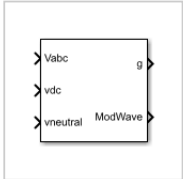


PWM Generator (Three-phase, Three-level)

Generate three-phase, three-level pulse width modulated signal or waveform for gating switching devices

Library: Simscape / Electrical / Control / Pulse Width Modulation



Description

The PWM Generator (Three-phase, Three-level) block controls switching behavior for a three-phase, three-level power converter. The block:

1. Calculates on- and off-gating times based on the block inputs:
 - Three sinusoidal reference voltages
 - A DC-link voltage
 - A DC-link neutral point balance control signal
2. Uses the gating times to generate 12 switch-controlling pulses.
3. Uses the gating times to generate modulation waveforms.

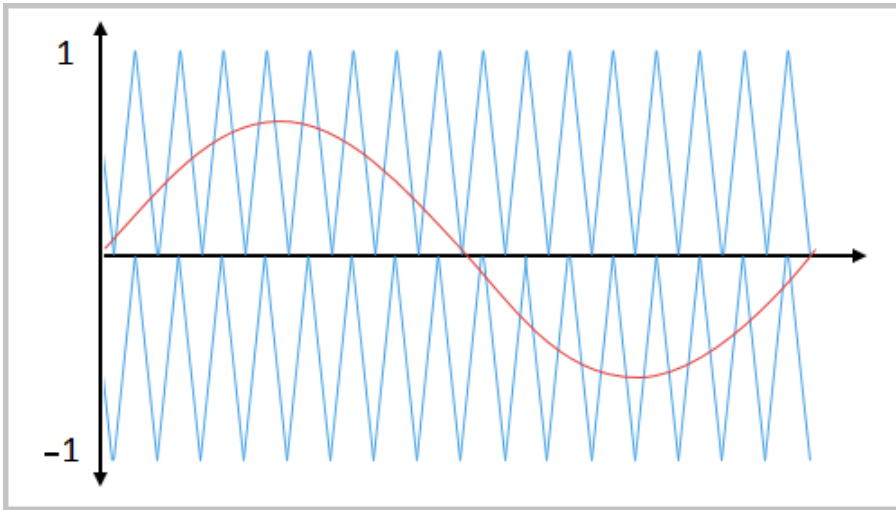
Sampling Mode

This block allows you to choose natural, symmetric, or asymmetric sampling of the modulation wave.

The PWM Generator (Three-phase, Two-level) block does not perform carrier-based pulse width modulation (PWM). Instead, the block uses input signals to calculate gating times and then uses the gating times to generate both the switch-controlling pulses and the modulation waveforms that it outputs.

Carrier-based PWM is, however, useful for showing how the sampling mode that you select relates to the switch-on and switch-off behavior of the pulses that the block generates. A generator that uses a three-level, carrier-based PWM method:

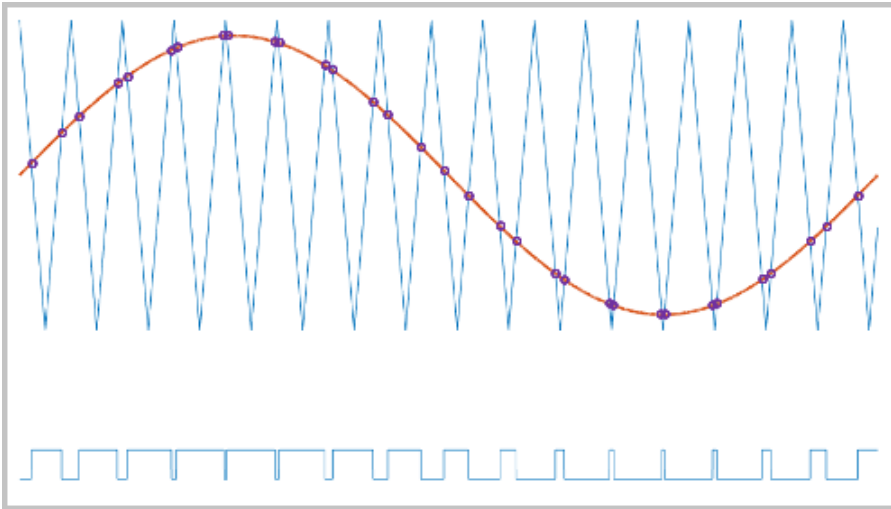
1. Samples a reference wave.
2. Compares the sample to two parallel triangle carrier waves, separated by one level.



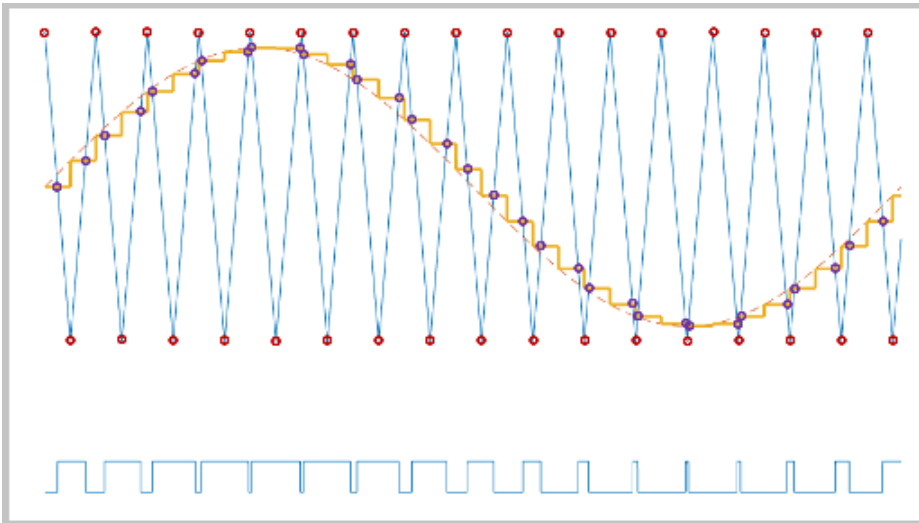
3. Generates a switch-on pulse if a sample is higher than the carrier signal or a switch-off pulse if a sample is lower than the carrier wave.

To determine switch-on and switch-off pulse behavior, a three-level carrier-based PWM generator uses these methods to sample each of the triangle waves:

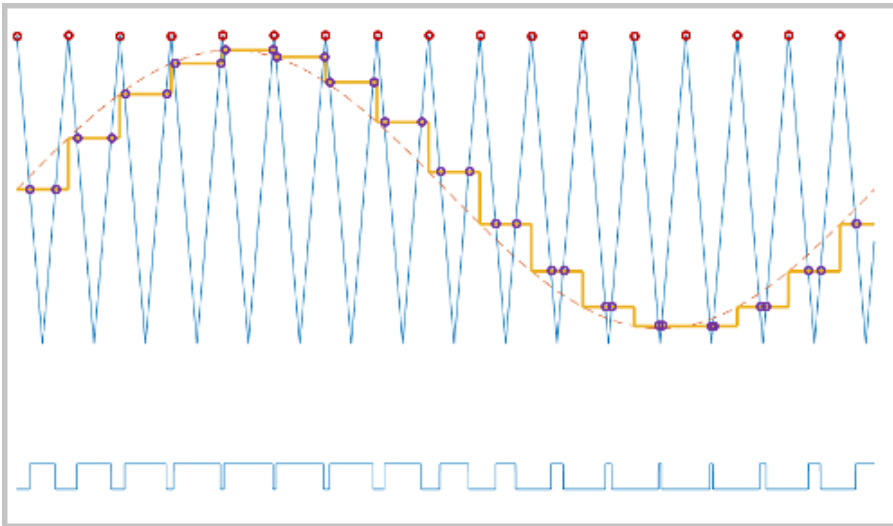
- Natural — The sampling and comparison occur at the intersection points of the modulation wave and the carrier wave.



- Asymmetric — Sampling occurs at the upper and lower boundaries of the carrier wave. The comparison occurs at the intersection that follows the sampling.



- Symmetric — Sampling occurs only at the upper boundary of the carrier wave. The comparison occurs at the intersection that follows the sampling.



Overmodulation

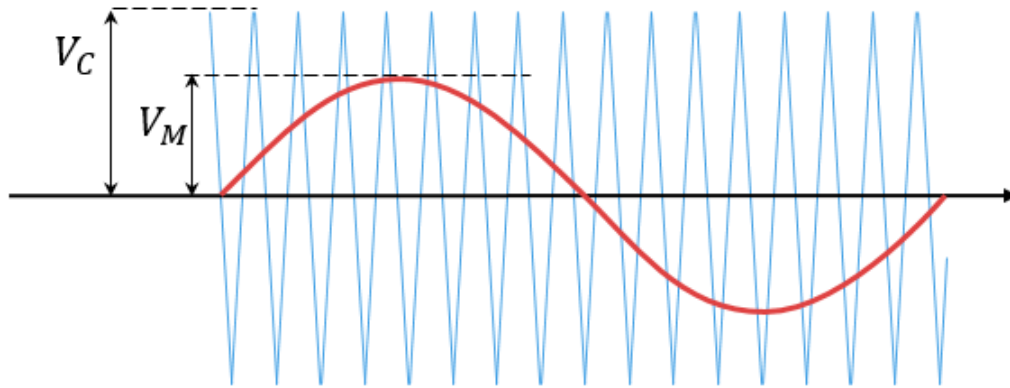
The modulation index, which measures the ability of the power converter to output a given voltage, is defined as

$$m = \frac{V_M}{V_C},$$

where

- m is the modulation index.
- V_m is the peak value of the modulation wave.

- V_c is the peak value of the triangle carrier wave.



For three-phase SPWM,

$$V_{peak} = m \frac{v_{dc}}{2},$$

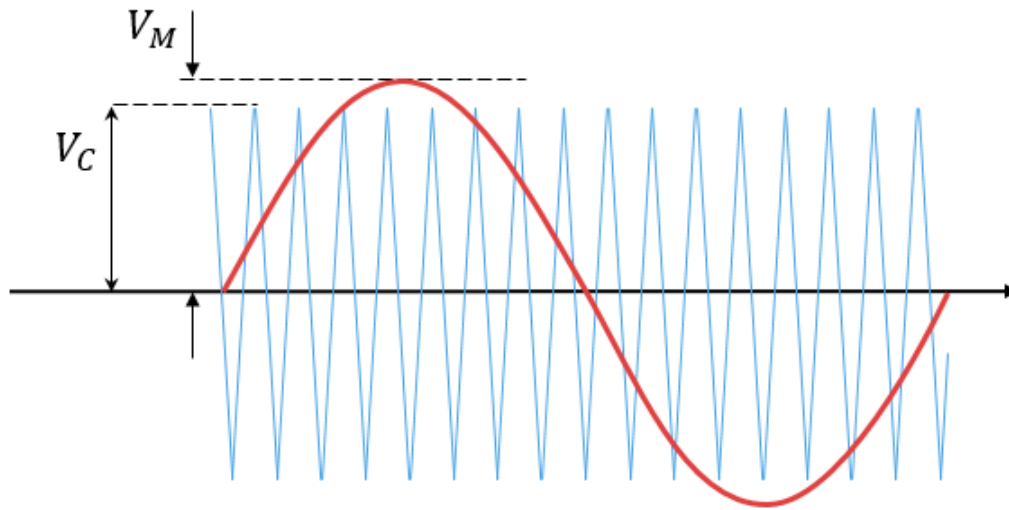
where

- V_{peak} is the peak value of the fundamental component of the phase-to-neutral voltage.
- v_{dc} is the DC-link voltage.

For three-phase space-vector PWM (SVM),

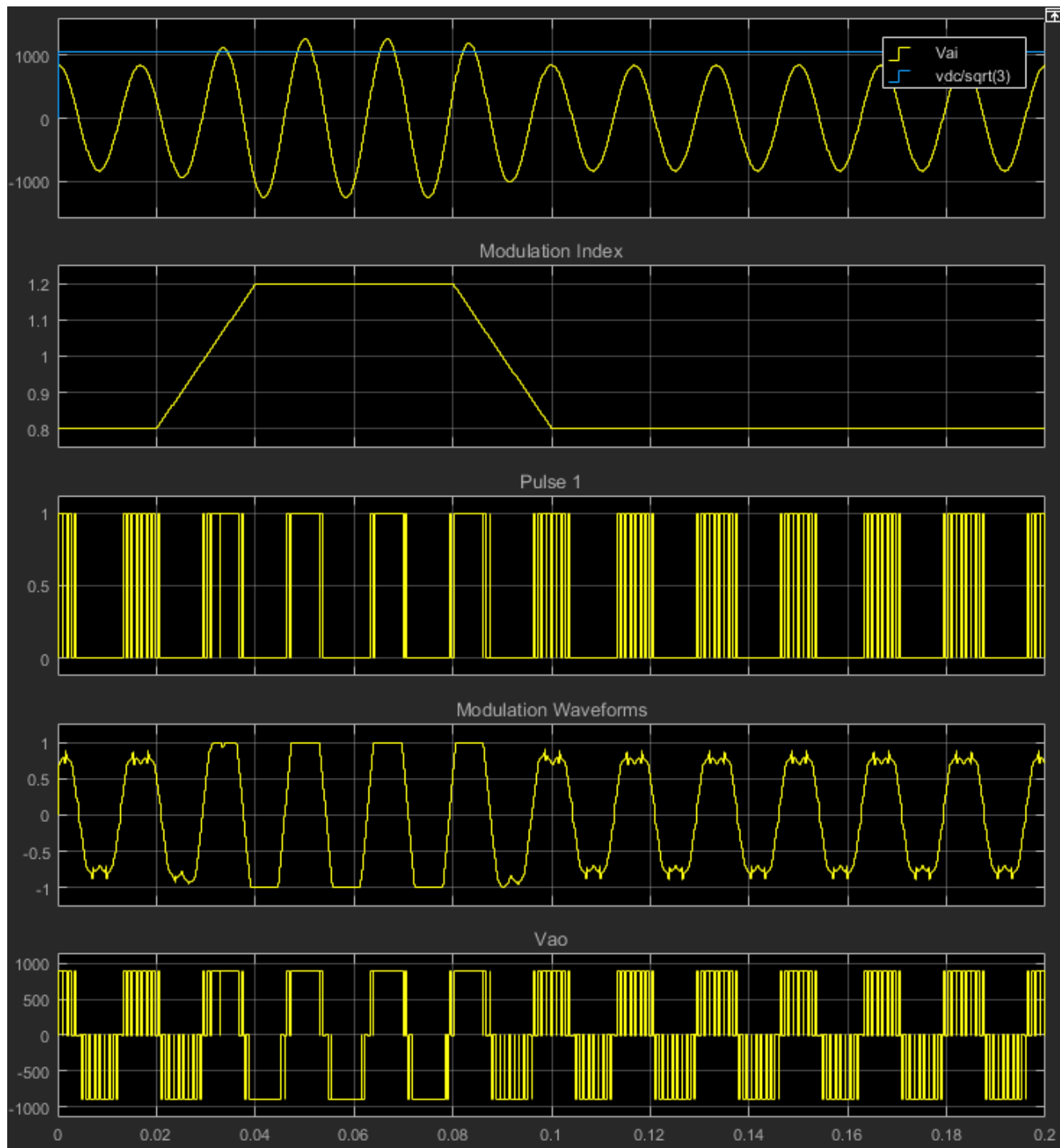
$$V_{peak} = m \frac{v_{dc}}{\sqrt{3}}.$$

For normal steady-state operation, $0 < m \leq 1$. If a transient, such as a load increase, causes the amplitude of V_m to exceed the amplitude of V_c , overmodulation ($m > 1$) occurs



If overmodulation occurs, the output voltage of the power converter clamps to the positive or negative DC rail.

In the [Three-Phase Three-Level PWM Generator](#) example, the **Three-Level Controller** subsystem contains a 1800-V DC-link input, and a modulation index, m , of 0.8. For SVM, the maximal input voltage is $1800 / \sqrt{3}$ V, that is 1039.23 V. To demonstrate overmodulation, a transient is added at the beginning of the simulation. The transient forces the amplitudes of the reference voltages to exceed the amplitude of $1 / \sqrt{3}$ of the DC-link voltage. To highlight overmodulation, the scope includes simulation results for only one of the 12 output pulses and only the α -phase of the reference voltages, modulation waveforms, and output voltages.



The modulation index is greater than one between 0.03–0.09 seconds. During overmodulation:

- The pulse remains in the on or off position.
- The output voltage clamps to the positive or negative DC rail.

Ports

Input

[collapse all](#)



Vabc — Three-phase sinusoidal reference signal
vector

Specify the three sinusoidal voltages, one per phase, that you want the attached converter to output.



vdc — DC-link voltage signal
scalar

Specify a positive real number for the DC-link voltage of the converter.



vneutral — DC-link neutral point balance control
scalar

This signal is the output from a feedback-control loop that balances the DC supply. The value of the signal must be a real number between -1 and +1.

Output

[collapse all](#)



g — Gate control
vector

12 pulse waveforms that determine switching behavior in the attached power converter.



ModWave — Modulation wave
vector

If you are generating code for a platform that has hardware with PWM capability, you can deploy the modulation wave to the hardware. Otherwise, this data is for reference only.

Parameters

[collapse all](#)

Continuous PWM — Continuous pulse width modulation method
SPWM: sinusoidal PWM (default) | SVM: space vector modulation

Specify the waveform technique.

Sampling mode — Wave-sampling method
Natural (default) | Asymmetric | Symmetric

The sampling mode determines whether the block samples the modulation waveform when the waves intersect or when the carrier wave is at one or both of its boundary conditions.

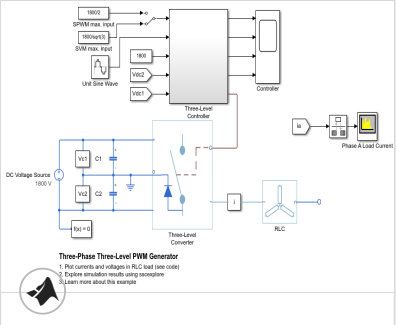
Switching frequency (Hz) — Switching rate
1e3 (default) | positive number

Specify the rate at which you want the switches in the power converter to switch.

Sample time (s) — Block sample time
5e-5 (default) | positive number

Specify the time interval between successive block executions (output calculations). To ensure adequate resolution in the generated signal, set this value to be less than or equal to $1/(50 \cdot F_{sw})$, where F_{sw} is the **Switching frequency (Hz)**.

Model Examples



Three-Phase Three-Level PWM Generator

Use the PWM Generator (Three-phase, Three-level) to control a Three-Level Converter. The upper and lower supply voltages are input

References

[1] Chung, D. W., J. S. Kim, and S. K. Sul. "Unified Voltage Modulation Technique for Real Time Three-Phase Power Conversion." *IEEE Transactions on Industry Applications*, Vol. 34, No. 2, 1998, pp. 374–380.

[2] Seo, J. H., C. H. Choi, and D. S. Hyun. "A new simplified space-vector PWM method for three-level inverters." *IEEE Transactions on Power Electronics*, Vol. 16, No. 4, 2001, pp. 545-550.

Extended Capabilities

C/C++ Code Generation

Generate C and C++ code using Simulink® Coder™.

See Also

Simscape Blocks

[Converter \(Three-Phase\)](#)

Blocks

[PWM Generator](#) | [PWM Generator \(Three-phase, Two-level\)](#) | [Thyristor 6-Pulse Generator](#)

Introduced in R2016b
