

VSC TECHNOLOGY FOR SCR POWER CONTROLLERS

SAVE ELECTRICITY AND OPERATING COSTS
WITH MAINS LOAD OPTIMIZATION

Created by

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Abstract

VSC (voltage sequence control) technology offers the fast response, high control dynamics, and high control resolution per cycle of phase-angle mode—while reducing reactive power, decreasing harmonics, and significantly improving power factor.

For applications with single or multiple transformer-coupled heating zones, Advanced Energy®'s exclusive VSC (voltage sequence control) technology offers the fast response, high control dynamics, and high control resolution per cycle of phase-angle mode—while reducing reactive power, decreasing harmonics, and significantly improving power factor. This mains load optimization capability saves electricity and thus reduces operating costs.



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Thyro-PX VSC



Thyro-PX™...VSC SCR power controller: Like a standard power controller, the VSC connection is controlled via set point. The transformer's two- or three-stage voltages are automatically controlled via algorithm.

Mains Load Optimization for Energy and Cost Savings

- Significant reduction of reactive power and harmonics
- Major improvement of power factor

Applications

- Electric boosting
- Glass applications
- Heating processes
- Melting processes

1. Significantly Improved Power Factor and Reduced Reactive Power

1.1 Three-Stage VSC Connection

VSC connection enables significant improvement of power factor and reduction of reactive power compared to VAR (phase-angle firing) (Figure 1). At a normalized output power of 34%, the power factor for three-stage VSC connection, is in the range of ≥ 0.9 , and at 40%, the power factor is already ≥ 0.97 .

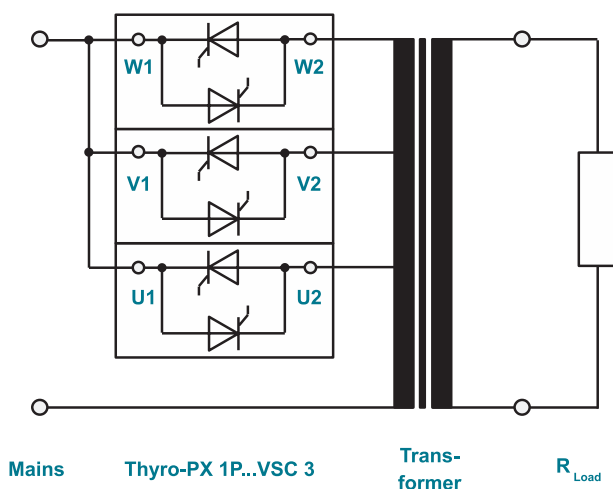


Figure 1. Three-stage VSC connection

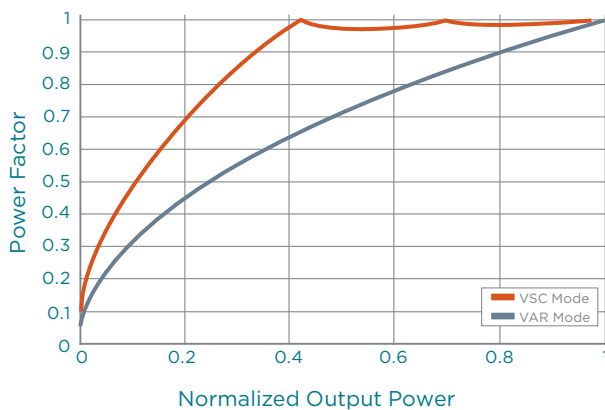


Figure 2. Power factor vs. output effective power (modulation) with three-stage VSC connection

Depending on the process requirements and load characteristics, even better power factor performance is possible in modulation range below 40%, with appropriate projection.

Typically, the electrical power company does not charge for network access until power factor falls below approximately 0.9. For load modulation in the range of 34 to 100%, no network access costs accrue for reactive power (Figure 2).

Figure 3 shows rising reactive power in relation to the required effective power (degree of modulation). The gray-shaded area (Q with $Q/P > 50\%$) above the black line is typically subject to costs. Figures 2 and 3 show that mains load optimization has been especially dimensioned for modulation range $\geq 40\%$. Figure 4 shows the related THDi values for evolving harmonics.

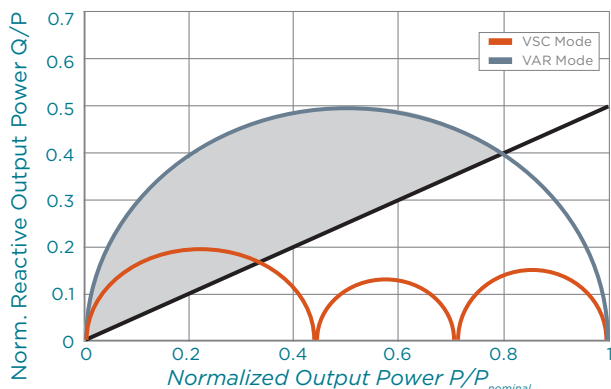


Figure 3. Reactive power as function of the released effective power with three-stage VSC connection

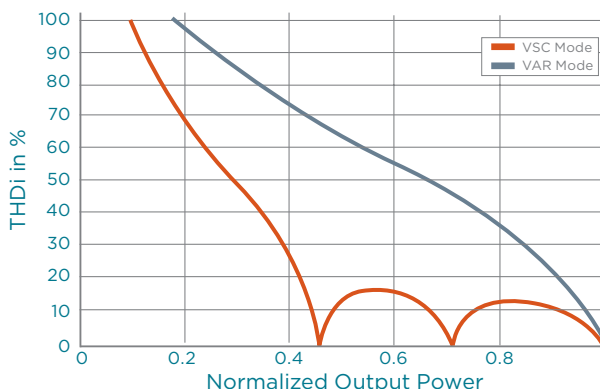


Figure 4. THDi values of curves in Figures 2 and 3

1.2 Two-Stage VSC Connection

Slightly more cost effective, two-stage VSC connection can be used depending on the load characteristics and operating range, as well as requirements for power factor and reactive power.

Figure 5 shows a two-stage, primary VSC connection. Figure 10, on page 6, shows additional connection diagrams for VSC technology.

Figure 6 shows the power factor characteristics for two-stage VSC connection. Starting from a load modulation of $> 53\%$, the power factor is ≥ 0.9 so that typically no network access costs accrue for reactive power.

Figure 7 shows relationship between rising reactive power and needed effective power (degree of modulation) for a two-stage VSC connection.

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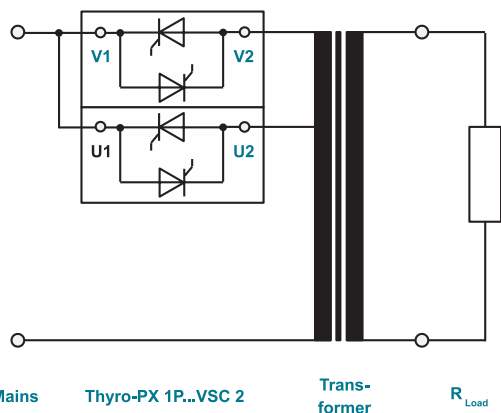


Figure 5. Two-stage VSC connection

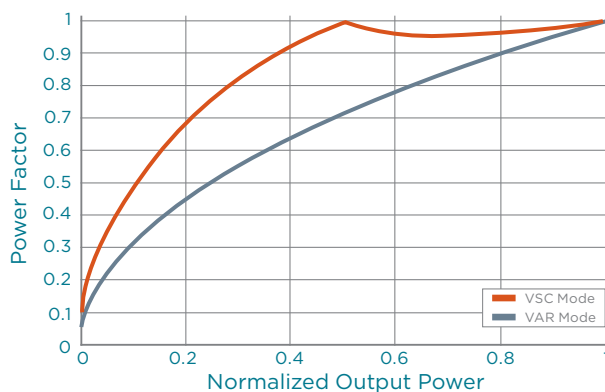


Figure 6. Power factor related to output effective power (modulation) of two-stage VSC connection

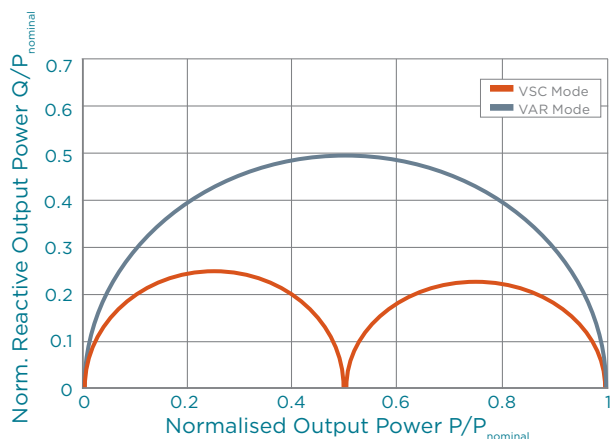


Figure 7. Reactive power as function of released effective power of two-stage VSC connection

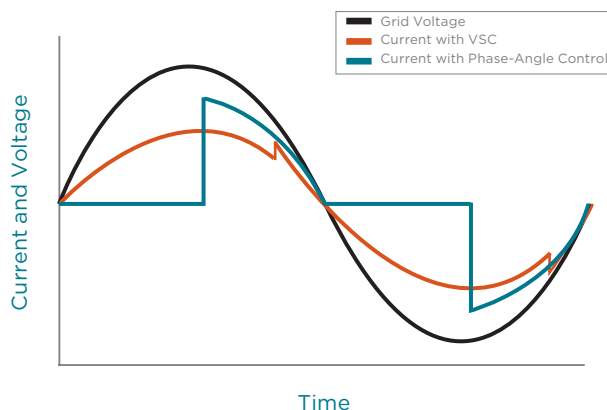


Figure 8. Comparison of phase-angle firing (VAR) and VSC (voltage sequence control) with same effective current value

1.3 OPERATING METHOD

Figure 8 shows the standard operating method of phase-angle firing (VAR) and voltage sequence control (VSC). The gray curve is the load current trend over time in standard phase-angle firing. The high peak and distortion of the curve cause poor power factor, high harmonics ratio of harmonics, and generated reactive power.

The orange curve shows the current trend of a VSC connection. It has the same effective value as the gray curve, however, it is a nearly sinusoidal curve with a low point at the end of each half wave. This results in excellent power factor, a small harmonics ratio, and minimal reactive power.

Like a standard power controller, the VSC connection is controlled by an effective set point. The power controller's automatic controls algorithm control the two- or three-stage voltages of the transformer.

Potential Savings

2.1 Estimate 1

Within the load's modulation range, it is possible to improve the medium power factor from 0.8 up to 0.9 or even better at the operating point. For a 112 kW load, this means a cost saving of approx. 2698 € per annum (at 100% ED) of operating costs. The outcomes of this are payback periods < 0.5 years for two-stage VSC and < 1.2 years for three-stage VSC.

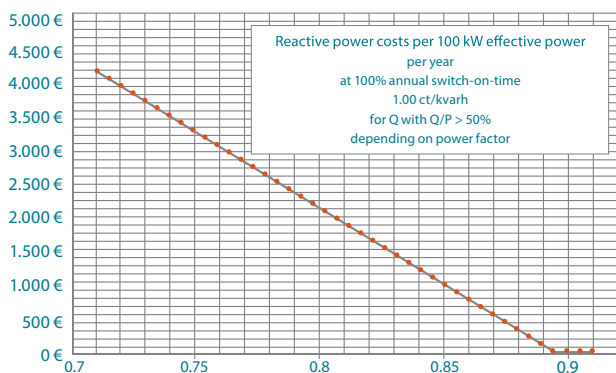


Figure 9. Example for standardized reactive power costs

Due to the improvement in power factor, the apparent power decreases in the system from 140 to 125 kVA, so that only a small transformer is necessary. This decreases capital expenditure for new systems. If a transformer already exists, it is less stressed so that additional components can be connected to it.

Because currents are reduced from 280 to 240 A, it might be possible to choose smaller units when components are added, which saves additional investment costs.

If the power controller operates in a system with a total power factor of $\lambda < 0.9$, then the total power factor of system itself improves as well. Thus, with VSC technology, it's possible to save on reactive power costs for the whole system.

Figure 10, below, can be used to estimate the variable reactive power cost and related savings possible when power factor is improved, if the variable reactive power costs are calculated starting from a ratio of $Q/P > 50\%$.

The curve is standardized for effective power of 100 kW operating 100% per year. Costs for reactive power are assumed to be 1.00 ct/kvarh. Therefore, the reactive power costs are linear for a real application (with $Q/P > 50\%$) and can be easily calculated.

2.2 Estimate 2

A 1000 kW heater would be used with a power factor λ of 0.83, which results in costs of approximately 15000 € per annum according to Figure 9.

With an improvement of $\lambda = 0.9$, the cost savings would be 15000 € per annum for each heater.

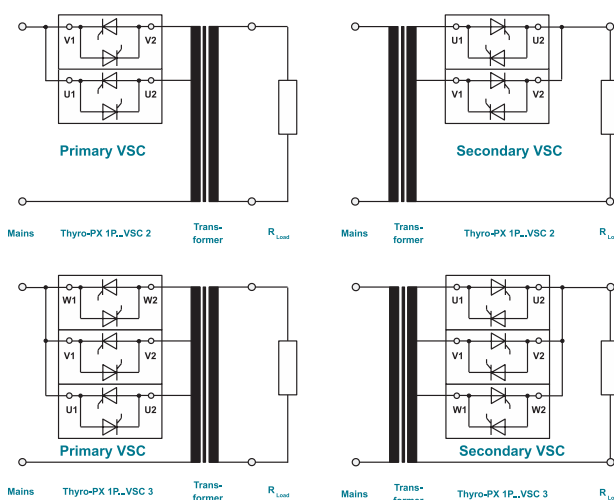


Figure 10. VSC connection options

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VSC Connection Variations

Besides the two- or three-stage VSC options, Thyro-PX 1P..VSC offers the ability to use it in primary or secondary connections.

If the power controller is directly connected to the mains, prior to the transformer, then it is a primary VSC connection. If the power controller is after the transformer, directly on the load, then it is a secondary VSC connection.

Specifications		
Thyro-PX 1P..VSC 2 and...VSC 3	400/500	V 690 V
Rated Current	16 A/37 A/75 A/110 A/130 A/170 A/280 A/495 A/650 A/1000 A/1500 A/2100 A/2900 A	80 A/200 A/300 A/500 A/780 A/1400 A/2000 A/2600 A
Frequency	47 to 63 Hz	
Type of Connection	› Primary VSC: two-stage, three-stage › Secondary VSC: two-stage, three-stage	
Operating Mode	VSC with VAR (phase angle firing)	
Control Mode	V, V ² , I, I ² , P	
Interfaces	As standard Thyro-P: › LBA-2 › Bus › Analog I/O › Relays	
UL/UR Certification	› UL 16 A/37 A/75 A/110 A/130 A/170 A/280 A	› UL 80 A/200 A
	› UR 495 A/650 A	› UR 300 A

Transformer Specifications

If you are installing a Thyro-PX 1P..VSC power controller for the first time, Advanced Energy® can provide the electric transformer specification, e.g. the power factor λ to be achieved.

VSC Connection For Loads of Alternating Current

The named type ranges are designed for single-phase applications. VSC connections for alternating current are available up on request.

NOTE: The power factor $\lambda = |P|/S$ is often referred to as $\cos w$ by mistake, even though $\cos \lambda$ is only specified for sinusoidal quantities.



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ABOUT ADVANCED ENERGY

Advanced Energy (AE) has devoted more than three decades to perfecting power for its global customers. AE designs and manufactures highly engineered, precision power conversion, measurement and control solutions for mission-critical applications and processes.

AE's power solutions enable customer innovation in complex semiconductor and industrial thin film plasma manufacturing processes, demanding high and low voltage applications, and temperature-critical thermal processes.

With deep applications know-how and responsive service and support across the globe, AE builds collaborative partnerships to meet rapid technological developments, propel growth for its customers and power the future of technology.

PRECISION | POWER | PERFORMANCE

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