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Design of 3-Level Inverter Using FIXCO

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Abstract

Voltage drops on utility grid transmission and distribution lines result from the movement of reactive energy. Voltage should be kept within a small window around its nominal value (5%). Therefore, reactive power regulation is essential for regulating dynamic voltage fluctuations over a wide range of operating situations in the distribution system. This work seeks to locate a VSI source compensator that can be applied to a fixed three-phase voltage. The purpose of this study is to describe how STATCOM may be used to enhance the efficiency of transmission and distribution lines by enhancing the power factor of the AC system and regulating its voltage. Reactive energy must be produced or absorbed by a STATCOM quick fixed compensator to maintain a proper balance in the transmission and distribution system. An electronic voltage inverter is used in modern reactive power compensation (VSI). As a result of this STATCOM application, the transmission system has reached a unit power factor, decreasing active energy loss by 38.7 percent and so decreasing energy expenses and boosting the transmission system's capacity.

Keywords:

Total Harmonic Distortion, Inverter, Power Factor Correction, Volt-Amp-Revolt, and Volt-Amp-Revolt.

INTRODUCTION;Modern power grids are built to be very reliable and to provide electricity to different load centres on demand. To maximise efficiency, minimise environmental impact, and guarantee worker safety, many power facilities are situated in inaccessible areas [1]. Programmable logic controllers (PLCs) and variable speed drives (VSDs) are only two examples of the many electronic devices used in modern manufacturing. As a result, voltage fluctuations, voltage amplifications, voltage flashing, and harmonics are becoming more intolerable for industrial loads [2]. The most frequent and damaging disruptions in industrial machinery are drops in voltage [3]. Voltage dips may be caused by the introduction of significant loads, but are more often the result of mistakes in the network [4]. System stability is increased, and the existing power infrastructure is better used, thanks to the addition of electronic power-based controllers and other fixed controls in a flexible alternating current transmission system (FACTS) [1]. STATCOM is a piece of hardware used by FACTS. In order to safeguard sensitive loads against voltage dips, a voltage stabiliser inverter (VSI) is used as part of a power electronics regulator that is linked in series or parallel to the grid. Using a DC capacitor, STATCOM may generate its own voltage and engage in interactive power exchange with the network. Maintaining a steady bus voltage is a primary responsibility of the STATCOM [6]. In addition to passively receiving electricity from the

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network, if the DC power source is linked through the capacitor, it may actively deliver part of that power as well. To remedy low power factor and poor voltage control, STATCOM is often used in electrical networks. It also helps maintain a steady voltage across the network. Power factor correction, load balancing, and harmonic elimination from the current source are just a few of the many objectives that may be met at once [7], [8]. Third-level transformers provide many benefits over second-level transformers, including better output voltage quality, greater voltage operability, and less strain on dv/dt. It solves the challenge of building a high-power transformer by removing the need to flip the connections between semiconductor components in series [9]. Third-level transformers are becoming more commonplace in medium/high power applications including electric traction systems, AC power transmission, and far static compensators [10] because of these benefits.

Working Principles

STATCOM circuit design based on a three-phase, three-level neutral voltage reflector is shown in Figure 1. (NPC). Transformer leakage is represented by XL [11], [12], and the inverter, which comprises of 12 switches and 16 diodes coupled to the electrical current, is the essential component.

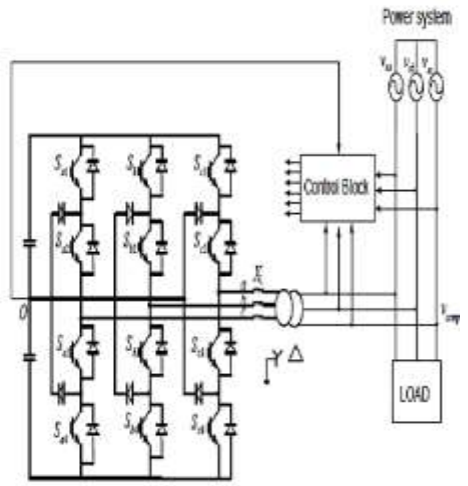

Figure 1. The power-circuit of ASVC, using a 3-level inverter

The compensator cannot function without precise regulation of the DC current voltage. Charging a DC capacitor with an active force will raise the voltage, while discharging some of that active energy will decrease the voltage. DC-bus voltage control is implemented in the synchronous reference frame [13] because, according to pq theory, the DC component in dq coordinates represents active power. See also: Figure 2. Figure 2 depicts the parabolic circuit that forms the foundation of each STATCOM phase. These schematics are useful for elucidating STATCOM's underlying ideas.

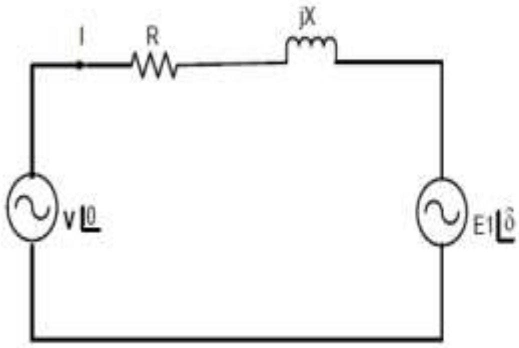

Figure 2. Per-phase equivalent circuit of STATCOM at fundamental frequency

Circuitry for Control

Figure 3 shows a block schematic of the STATCOM control circuit. Components include a counter, a voltage-controlled oscillator (VCO), a switch pattern, and a proportional-plus (PI) controller. The reactive power of the system is determined by transforming the voltage and current at the source into the d-q frame. The var standard is used for comparison. The frequency generated by the VCO is locked in time with the mains current. The request signal var is zero and the switching pattern is stored at the supply frequency fo when the system is in a steady state of operation (= 0). Adjustments to VCO's rate of rotation are made in response to variations in the load factor, which affect the var that is computed.

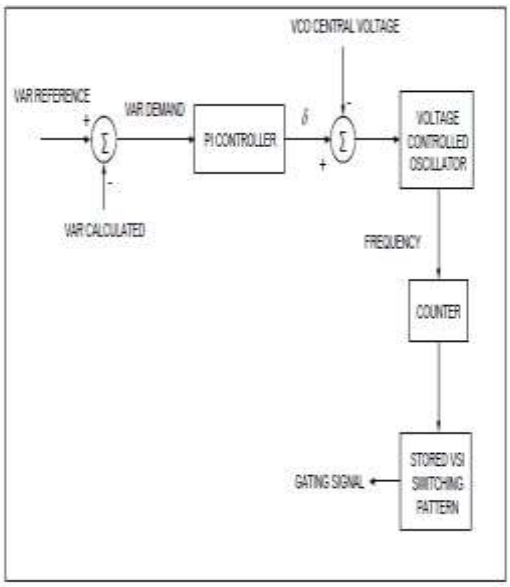

Figure 3. The δ Phase-shift control block diagram

Baseband Frequency Modulation (FFM)

When using a switching mechanism to acquire the output voltage in a three-level reflector, as shown in Figure 4, both the line and line waveforms are broken up when the output is zero. The amplitude is regulated by determining the interval on both sides of the pulse so that the sum is zero.

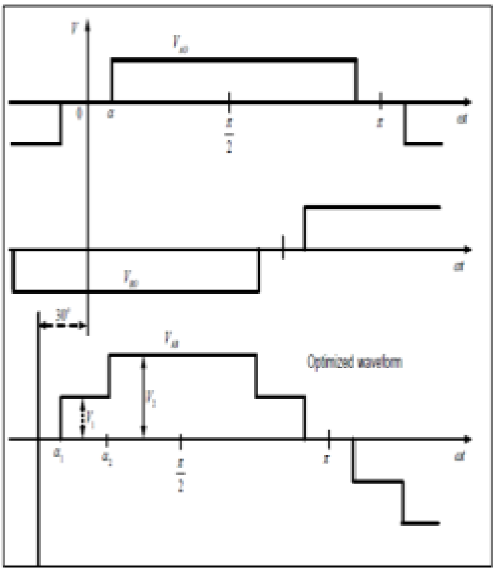

Figure 4. Typical FFM phase and line voltages in three-level inverter

In Fig.4, the phase voltage VOA is given by the Fourier expression:

$$V_{OA} = \sum_{n=1}^{\infty} b_n \sin n\omega t \qquad \text{--------}\rightarrow 1$$

Were,

$$b_n = \frac{4V_i}{n\pi} \cos n\alpha. \qquad \text{----------}\rightarrow 2$$

A further benefit of this three-level voltage is that it outperforms its two-level equivalents in terms of wave quality, Total Harmonic Distortion (THD), and electromagnetic interference (EMI). You may compare the harmonic amplitudes of the standard waveform and the improved waveform in Table 1.

The table shows that the suggested system reduces THD from 31.08 to 16.86 while keeping the same average power output as a traditional PWM inverter at two different settings. Table 1 displays the values of proportional amplification for the percentage of voltage that results from the inverter voltage.

Harmonic Number	$\frac{b_n}{b_1}$ % (conventional)	$\frac{b_n}{b_1}$ % (optimized)
1	100	100
5	20	0
7	14.28	3.8
11	9.09	9.09
13	7.69	7.69
17	5.88	1.58
19	5.26	1.41
23	4.35	4.35
25	4.0	4.0
29	3.45	0.92
31	3.22	0.86
35	2.86	0.86
THD %	31.08	16.86

DESIGN OF STATCOM

System power factor can be improved by installing STATCOM near load. Taking MI = 0.8 and R = 0.5Ω, (22) were solved to obtain the values of δ and L that met the requirements for voltage regulation and power factor(pf)oftheacsystem,

i.e. 0.96 <pf<1.0. So, for the unit power factor, Figure 5 shows th

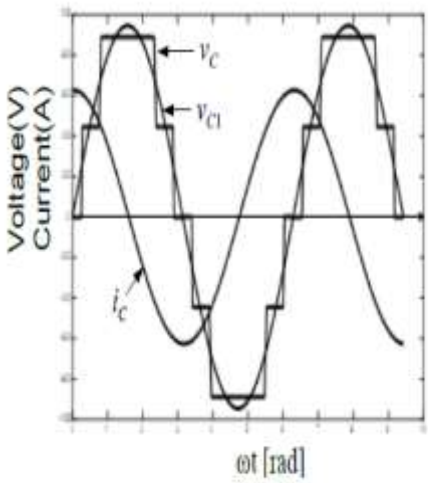

Figure 5. Compensator output voltage and current vc– output voltage vc1–fundamental component ic –output current.

CONCLUSION

In this work, we demonstrate how to use STATCOM to the inverter of the FFM voltage source in order to enhance the performance of the AC system. By boosting the system's power factor from 0.76 to the unit, the power line's current was lowered from 112.75A to 88.3A, thereby decreasing energy loss by 38.7 percent, which led to lower energy expenses and a larger transmission capacity. Online interactive power flow was similarly lowered by the presence of STATCOM, from 2.791 MVAr per stage (qL in Figure 5) to 1745 VAr per stage. As a result, it is clear that the voltage produced by STATCOM has increased the receiving end voltage at the loading conveyor from 60kV to 66kV.

The power factor (pf) can be found from:

$$pf = \cos\left[\tan^{-1}\left(\frac{1745.}{3.27 * 10^6}\right)\right] = 1.0$$

It can be seen that the reactive elements (L and C) are small.

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