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Mitigating Power Quality using Adaptive Control Schemes in AC-DC-AC boost Converters

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Abstract:

Power Quality or Power factor correction for a grid is expensive, hence lot of governments or power companies, and hesitate to invest in RPC or APF or FACTS. But the significance of the use of Mitigating power quality, in power systems is systematically increasing. The alternative being proposed takes advantage of the fact that, most of the commercially available power factor correction circuits, used for residential applications are based on uni-directional AC-DC converter topologies. We just include an external DC-AC boost converter based PFC to maintain power quality in house hold applications.

Keywords: FACTS, HCC, RPC, PFC, Power Quality, Control Schemes.

Introduction:

How we are doing it: PFC(Power Factor Correction) Circuit.

We use Harmonic Current Compensation and Reactive Power Compensation within this uni-directional AC-DC-AC topology.

Power quality analysis in ac power systems is concerned with deviations of the voltage or current from the desired ideal sinusoid of constant amplitude and frequency. Un filtered harmonics cause interferences in other electric facilities, creating abnormal and undesirable behavior of electrical equipment and transformer overheating. Uncontrolled reactive power increases transmission conduction losses and deteriorates the performance of voltage regulation. Therefore, it is desired to reduce these effects through adequate means, i.e., harmonic current compensation (HCC) and reactive power compens ation (RPC). Several technologies, typically having high power capacities, based on power electronics theory have aimed to improve grid power quality and compensate reactive power at the transmission and distribution system level. Flexible alternating current transmission systems (FACTS) have been studied by industrial and academic researchers since 1990s .Alternating current transmission systems incorpora ting power electronics-based compensators and other static controllers generally enhance controllability and increase power transfer capability.

To find more economical solutions, the demands of power quality mitigation have continuously encoura ged power electronics engineers to include HCC and RPC capabilities as ancillary services in bidirectional power converters.

As power converters for renewable energy sources become more popular in ac power systems, the potential for HCC and RPC will increase, as these control schemes can be employed in existing topologies without hardware changes.

Despite the increased utility and cost savings, the number of renewable power converters capable of fulfilling these functions is still limited.

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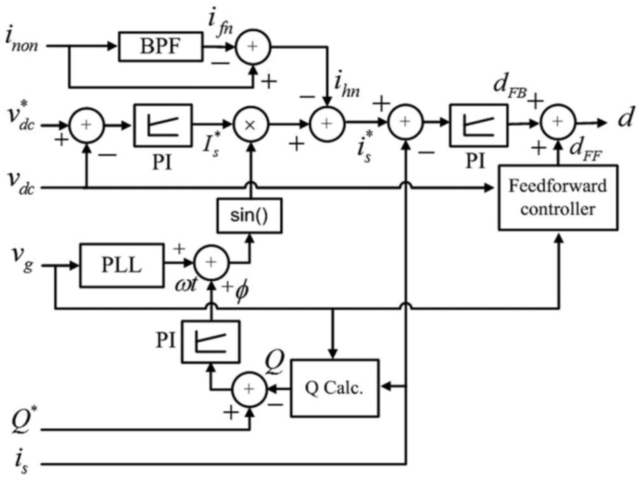
Proposed Model



Control Strategy for APF Functionality

The proposed control strategy of the unidirectional ac–dcconverter including a feedforward controller, HCC, and RPC isshown in Figure, Two control blocks for HCC and RPC have been added to the conventional control algorithm in Figure Thus,the final current reference for a versatile control strategy basedon (5) and (10) can be expressed as

$$i_s^* = I_s^* \sin(\omega t + \phi) - i_{\mathrm{hn}}.$$

Extended Cusp Distortion in the Capacitive Current

Figure depicts the comparison of the current waveforms during capacitive power compensation. It can be observed in above Figure that there are two distortion periods: the zero-current distortion and the cusp distortion regions. Due to the unidirectional power flow capabilities of the converter, the current is periodically uncontrollable when signs of the input voltage andcurrent reference are opposite, which creates the zero-currentdistortion region f. In addition, the current drastically increasesafter the grid voltage crosses zero, which leads to the cuspdistortion common to all PFC circuits using boost converter configurations [32]. This occurs because the inductor voltage islimited in its ability to drive its current up, even with the switch closed during this time.

It should be noted in Figure that the duration of the cuspdistortion is extended up to t

Cin capacitive power compensation,

$$i_s(t) = \frac{V_g}{L}\int_0^{t_c} \sin(\omega t)dt = \frac{V_g}{X}(1 - \cos(\omega t_c))$$

where X = ωL and Vgis the peak input voltage. The cuspdistortion continues until the actual current meets the capacitivecurrent reference

$$\frac{V_g}{X}(1 - \cos(\omega t_c)) = I_s \sin(\omega t_c + \phi).$$

$$\omega t_c = \tan^{-1}\left(\frac{\sqrt{X^2 I_s^2 + 2V_s I_s X \sin\phi}}{V_g}\right) + \tan^{-1}\left(\frac{I_s \cos\phi}{I_s \sin\phi + V_g/X}\right)$$

is the dc value (zero under a perfect ac waveform, i.e.,awhere aoo=0), aNand bare the amplitudes of the *n*th cosine-term andsine-term harmonics, respectively. Regarding the fundamentalcontent of the capacitive current in (15), the Fourier series coefficientat the fundamental frequency can be solved as

$$a_1 = \frac{1}{2\pi}\begin{pmatrix} I_s(\cos(\phi + 2\omega t_c) - \cos\phi \\ +2(\pi - \phi - \omega t_c)\sin\phi) \\ -\frac{V_s}{X}(\sin(2\omega t_c) - 4\sin(\omega t_c) + 2\omega t_c) \end{pmatrix}$$

$$b_1 = \frac{1}{2\pi}\begin{pmatrix} I_s(\sin(\phi + 2\omega t_c) + \sin\phi \\ +2(\pi - \phi - \omega t_c)\cos\phi) \\ +\frac{2V_s}{X}(\cos(\omega t_c) - 1)^2. \end{pmatrix}$$

$$I_{s\mathrm{rms}} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} i_s^2(t)dt} = \sqrt{\frac{1}{4\pi}\begin{pmatrix} I_s^2(2(\pi - \phi - \omega t_c) + \sin(2\phi + 2\omega t_c)) \\ +\frac{V_s^2}{X^2}(6\omega t_c + \sin(2\omega t_c) - 8\sin(\omega t_c)) \end{pmatrix}}$$

Reactive Power Compensation

Before RPC mode is enabled, the grid powerfactor decreases to 0.963 due to this capacitive load, even underthe unity power factor of the converter as shown in Figures

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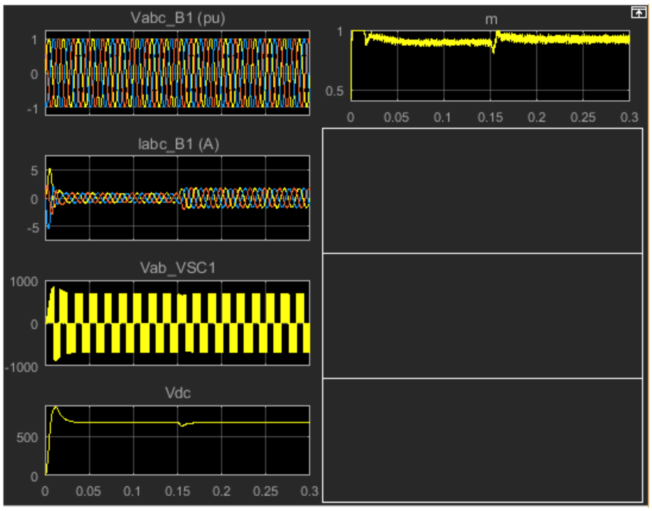
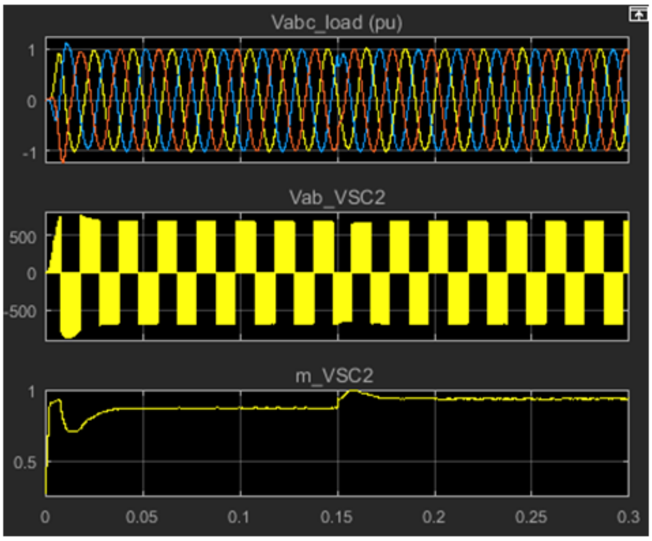
After RPC mode is enabled, the converter consumes 300 Var. Itcan be observed that the power factor of the grid is improvedfrom 0.963 to 0.992. However, the THDof the grid current increases from 1.89% to 3.93%.

Results

Control Parameters



LOAD Parameters



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