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Power Control Strategy for Unity Power Factor

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Abstract. With the introduction of recent standards on limitation of harmonic pollution of electrical power distribution system, three-phase PWM converters are considered as prime candidates to interface high-power electronic equipment to power supply lines. In these applications, converters can provide input currents without distortion and with the unity power factor. In this paper, a unified discrete event model is given for power electronic circuits, based on a hybrid system theory. Based on this model, FPGA switching control strategy for a three phase converter is developed. The functionality of a three phase converter is discussed from a discrete-event point of view. Recently developed hybrid based approach for modeling of discrete event systems is applied for modeling, simulations and implementation of a power factor control, protection and steering functionality three-phase converter. A DSP / FPGA based digital control platform for converter system, built in the laboratory, is presented and discussed.

Key words

Unity power factor, Hybrid switching control, Three phase converter, FPGA.

1. Introduction

The conventional ac/dc power converters that are connected to the line through full wave rectifiers draw a sinusoidal input ac current. Harmonic content in a current waveform that flows through the impedances in the electric utility distribution system can create harmonic voltages. These harmonics distort the local voltage waveform, which might potentially interfere with other electrical equipment connected to the same electrical service. Also, a distorted ac input current waveform prohibits the extraction of the maximum possible real power from the utility service. Unity power factor converters employ active wave shaping of the ac input current to ensure a sinusoidal current slope, while they deliver a constant dc output voltage [1].
Typical control schemes employed in state-of-the-art unity power factor converters have fairly low bandwidth in order to limit the impact of output voltage ripple on input power factor. In such controllers, disturbances are attended by control actions taken at most in the order of twice per line cycle [2].
The fast controller, presented here, executes control action at a much faster rate. As a result, the fast controller achieves a fast response time to disturbances. A key feature of our controller is its ability to reject feedback of the ripple on the dc bus capacitor by actively canceling it, so that high bandwidth control can be maintained without distorting the input ac current during steady state operation [3].
Special attention is paid to the new current control principle where traditional scheme, which consists of discrete-time current controller and pulse-width modulator, is replaced with a new discrete-event current controller [4]. The key idea, used for the event-driven current control approach, is to evaluate the transistor switching pattern directly from the phase current errors. The idea originates from the hysteresis current control principle. In this paper, the initial idea is further developed with the introduction of switching pattern sequences for the switching frequency reduction. Additionally, systematic design methodology is introduced for the design of multivariable sequential discrete event-driven systems (DES) control principle. Same formalism is also used for design of functionality, which provides the management and the protection of the converter.
Lyapunov theory has for long time been an important tool in linear as well as nonlinear control. However, its use within the nonlinear control has been changed by the difficulties to find the Lyapunov function for a given system. If one can be found, the system is known to be stable, but the task of finding such function has often been left to the imagination and experience of the designer [5].
The aim of this paper is the design of a control law for a three-phase boost rectifier to achieve good power and grid current control in steady state and transient operating conditions. The feedback system is globally asymptotically stable in the sense of the Lyapunov stability theory. Therefore we are interested in an extension of the Lyapunov function concept. This concept used such a scalar function, which contains a logical discontinuous input switching function that penalizes the grid current control error, which enhances the stability.
The paper starts with a brief discussion of hybrid modeling for the discrete event-driven systems. The case study starts with the three-phase boost converter current controller design and the design of inverter steering and protection functions. Evolved models are checked with simulations using MATLAB / Simulink and are experimentally confirmed. During the experiment, mapping of the obtained models into the FPGA executable code is presented [6]. The findings and the comments of the presented approach are discussed in the conclusion.