

Power Electronics Application of Kalman Filter

Girish S. Kavathekar¹, Swapnil P Mane²

^{1,2}Assistant professor, Dr.J.J.Magdum College of Engineering, Jaysingpur, 416106, India

Abstract: In today's industrial applications we are mainly using independent voltage as well as current sources for controlling the drivers and the other circuit performance. In this paper we discuss the realization of power electronics voltage sources with application of Kalman filter.

Keywords: Kalman filter, controlled voltage source, Adaptive filter

1. Introduction

In the field of power electronics the basic task is transfer of electrical energy received from accessible sources of energy with specified voltage and frequency into voltage and the frequency required by receivers of the electrical energy.

In power electronics the independent sources of voltage & current find large applications as system realizing i.e. the optimal control of converter drives. Such systems have to meet higher requirements connected with mapping of reference specified signals in defined frequency band, both in static and dynamic states. It is also essential to assure required quality of voltage of controlled sources, feeding receivers of the electrical energy. The paper presents possibility of realization of power electronic broadband voltage source as a system controlled with application of Kalman filters.

2. General Form of Broadband Voltage Source

Broadband power electronic voltage source should generate voltage of desired parameters on energetic output. Such task can fulfill inverter which enables linear transfer of a reference signal (in specified frequency band with assumed level of map error and good static and dynamic properties). General structure of such system is shown in figure 1.

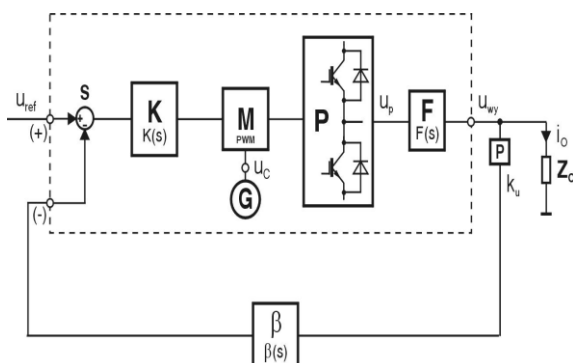


Figure 1: Block diagram of power electronic independent controlled energy source.

Structure of such power electronic voltage source is a closed system, controlled in PWM modulation with constant carrier frequency. Feedback loops fulfill required task (depending on destination of the system) in shaping output signals of desired properties. In general structure of the system can be specified by the following elements: Adder (S), modulator

PWM (M), power electronic inverter (P) with control system and protections as well as measure transducer (P-ku) of signals required for realization of suitable feedback loops. The most essential elements of the system in view of control quality are: filter $K(s)$ in the main circuit, passive output filter $F(s)$ which structure depends on destination and filter $\beta(s)$ in loop feedback which shapes the frequency characteristic of the system to desired form.

The system contains strongly nonlinear elements, like modulator (M) and inverter (P). It has unfavorable influences on stability of the closed system. These nonlinearities have to be compensated in an optimal way by use of two filters: input K (in the main circuit) and output passive filter F . Task of the passive filter F is effective suppression of components with higher frequencies, particularly products of PWM modulation in the waveforms of output voltage. Structure and frequency characteristic of this filter depends on application of the system – as a voltage or current source. Application of filters F with possibly simple structure has a practical reason – it decreases its dimensions and weight. To provide maximum fidelity in the mapping of reference signals, in the possible wide frequency band, the independent power electronic voltage source should have closed structure with transmittance copying frequency characteristic of the low-pass ideal filter. To approximate this characteristic we can use Butterworth or Chebyshev filters.

However because of delay caused by the switching elements of inverter we proposed approximation of transmittance of the ideal filter in the form

$$G(s) = \frac{\exp(-sT_c)}{(1+s\tau) + \beta(s)\exp(-sT_c)} \quad (1)$$

Where, T_c – the period of the PWM modulation, τ – the time-constant. Period T_c has essential influence on the transfer band, while time-constant τ – on the shape of the frequency characteristics.

From figure 1. The transmittance of the filter $K(s)$ of the main circuit is in general form

$$K(s) = \frac{1}{1+s\tau} \frac{1}{F(s)} \quad (2)$$

where $F(s)$ – transmittance of the exit filter including the influence of parameters of the receiver.

A task of the filter $K(s)$ is to compensate influence of delays caused by inverter (P), output passive filter F and a receiver (in general case nonlinear and nonstationary) on transmittance of the closed system. Parameters of this filter should change in a way which provides the desired shape of attenuation and phase characteristic and could ensure possible wide transfer band at possibly large value of gain and suitable margin of stability of the closed system. Figure 2 shows waveforms of reference and output voltages, generated by the voltage source

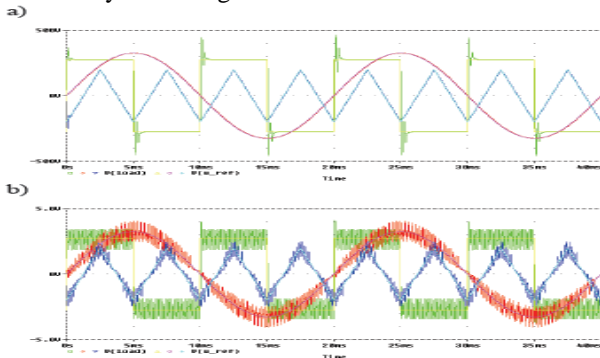


Figure 2: Waveforms of output voltage of voltage source for reference signals with different parameters

3. Application of the Kalman Filter

The obtainment of the required quality of parameters of inverter output signals at changing parameters of component elements of the system (e.g. the passive filter F or the receiver) demands the adaptive correction of parameters of the control filter K . This assignment, inclusive realization of the lineal transfer of signals by the power electronic voltage source can be realized by the use of adaptive digital filters, i.e. the Kalman filter.

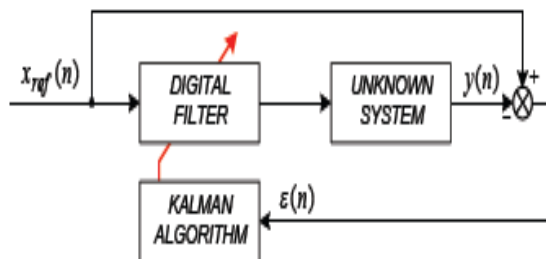


Figure 3: Adaptive control structure based on Kalman Filter

The task for Kalman filter as an adaptive control algorithm is to generate a proper reference signal for PWM inverter for the purpose of mapping references signal on output system.

4. Conclusion

At present we can observe considerable interest in modern, effective methods and systems which decrease level of deformations of voltages in receivers of electric energy. These are converters controlled usually with application of different methods of PWM modulation. It gives opportunity of maximal utilization of transfer band, limited by carrier frequency of PWM modulation, with preservation of indispensable margin of stability of the closed system.

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