CURRENT REGULATION OF PWM INVERTER USING STATIONARY FRAME REGULATOR

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Abstract: PWM Inverters need an internal current feedback loop to maintain desired current level. The current feedback scheme helps in providing desired current to ac loads connected to the inverter. The performance of the inverter depends largely on the quality of the applied current control strategy. Various current regulation schemes include stationary frame regulators and synchronous frame regulators. The synchronous frame regulator is more complex, as it requires a means of transforming a measured stationary frame ac current to rotating frame dc quantities, and transforming the resultant control action back to the stationary frame for execution. This information can introduce errors if the synchronous frame identification is not accurate. In this paper, the stationary frame regulator developed for single-phase system using Fuzzy logic controller. Regulation of current waveform is achieves accurate current regulation and zero steady state error.

Key words: *FLC fuzzy logic controller SPWM sinusoidal pulse width modulation ? E derivative error.*

1. Introduction:

Current regulation is an important issue for Power electronic converters and it has particular application for high performance motor drives and pulse width modulated (PWM) rectifiers. The various current control schemes include Stationary frame regulators[1] and Synchronous frame regulators [2]. These regulators are implemented by applying ac machine rotating field theory [3][4]. Normally 3? Stationary frame regulators are regarded as used. But their performance is unsatisfactory. Since, a conventional PI regulator suffers from significant steady-state amplitude and phase errors. However, Synchronous frame regulators provide zero steady-state error. The complexity involved in designing a synchronous frame regulator proves to be a hindrance. Because, it requires a means of transforming a measured stationary frame ac current (or error) to rotating frame dc quantities, and transforming the resultant control action back to the stationary frame for execution. This transformation can introduce errors if the synchronous frame identification is not accurate. Stationary frame regulator was implemented by using a Fuzzy logic control. Concepts taken from [1][5] are used to develop a fuzzy logic control for achieving minimized steady-state error.

Single 3? stationary frame regulators achieve virtually the steady-state and transient performance as that of the synchronous frame regulator. The stationary frame linear current PI regulator instead of the ac current error to more stables and has a superior transient performance.

2. Basic Scheme of Current regulation of PWM:

The main task of the current regulation of PWM converter is to force the currents in a single phase load to follow the reference signals. By comparing reference the current and measured current, the current regulation generates the switch states for the converter power devices which decrease the current errors. Hence, generating the current regulation implements two tasks; error compensation (decreasing errors) and modulation (determination of switching states)

3. Basic requirements and performance criteria:

The accuracy of the current regulation can be evaluated with reference to basic requirements. Basic requirements of a current regulation are the following:

4. PWM constraint:

A fundamental constraint of PWM systems is other the maximum rate of change of the reference should not be equal or exceed that of the carrier signal or for digital systems that maximum frequency of the reference should be less than half the sample frequency of the reference should be less than half the sample frequency. For an analog system this requirement must met for a fixed PWM switching frequency for the simple proportional feedback system and as analog sine-triangle PWM system, the critical gain is,

$$k_p\,(max) = \frac{4\,L\,fcarrier}{v_{dc}\,carrier}$$

L ✍ system inductance

carrier ✍ carrier frequency of the PWM system v_{dc} ✍ dc bus voltage

of the load is purely resistive a LPF can be placed after the et sensor or as part of the compensator to restrict the rate of change the error signal.

No phase and amplitude errors (ideal tracking) over a wide output frequency range

To provide high dynamic response of the system.

Limited or constant switching frequency to guarantee safe operation of converter semiconductor power devices

Low harmonic content.

Good dc-link voltage utilization

5. Current regulation Schemes:

Various current regulation schemes include stationary frame PI regulators and synchronous frame PI regulators. The new trends in the current regulation is Neural networks and Fuzzy-logic based controllers reputation system will totally determined by the term while the steady-state response is determined by the integral team.

6. Stationary frame PI regulator:

Any stationary frame PI regulator that does achieve zero steady-state error can be applied directly to ac signals. The principle is to transform a desired dc compensation n/w into as equivalence ac compensation n/w, so that it has the same frequency response characteristic in the B.W of concern. The required exact transformation is

$$H_{AC}(a) = \frac{H_{DC}(s+jw0) + H_{DC}(s-jw0)}{2}$$

if HDC(s) is a low-pass transfer block, this transformation results in a low-pass to band-pass or frequency shifting transformation to the frequency w_0.

An alternative is, when the reference signal is small in comparison to the reference frequency itself, then it is to use the low pass to band-pass technique developed in n/w synthesis (i.e.)

$$H_{AC}(s) = H_{DC}\left(\frac{S^2 + w0^2}{2^S}\right)$$

A stationary frame controller implemented using the T.F. $H_{AC}(s)$ will have an equivalent frequency response to a synchronous frame controller implemented using the T.F. $H_{DC}(s)$. therefore, the transient response of the two controller implementations will be identical regardless of whether they are implemented in the stationary frame as an ac compensator or in the synchronous frame as a dc for these controllers, the integral term provides infinite gain at dc and ? achieves zero steady-state error. The proportional term is frequency independent and so it is implemented wide or outside the frequency transformation is decided by convenience. For smaller integral gains, the transient response of the by

The stationary regulator also called the ramp comparison current regulator, uses PI error compensators to produce the voltage for a sinusoidal PWM. In keeping with the principle of sinusoidal PWM, comparison with the triangular carrier signal generates control signals for the inverter switches. Although this controller is directly derived from the original triangular sub oscillation PWM, the behaviour is quite different, because the output current ripple is fed back and influences the switching times. The integral part of the PI compensator minimizes errors at low frequency, while proportional gain and zero placements are related to the amount of ripple. The maximum slope of the voltage should never exceed the triangle slope.

Additional problems may arise from multiple crossing of triangular boundaries. As a consequence, the controller performance is satisfactory only if the significant harmonics of current and the load EMF are limited at a frequency well below the carrier. The main disadvantage of this technique is an inherent tracking (amplitude and phase) error. To achieve compensation, use of additional phase locked loop (PLL) circuits or feed forward correction is also made.

Their combined effect need only be taken into account when considering the system stability.

7. Synchronous frame PI regulator:

The synchronous frame regulator, which uses two PI compensators of current vector components defined in rotating synchronous coordinates d-q. The PI compensators reduce the errors of the fundamental component to zero. It consist of two integrators and multipliers, which always produce reference voltage for the PWM modulator, even when in the steady state, the current error signals are zero.

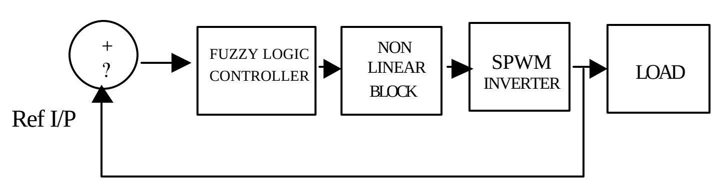
8. Neural network based controllers:

The main advantages of NN are parallel processing, learning ability, robustness and generalization. The layer of the feed forward NN with sigmoidal non linearity before using as a controller were trained using a back propagation algorithm with randomly selected data from the output pattern of the optimal controller. After training the performance of the layer NN based controllers, it differs only slightly from that of the optimal regulator. Thus the NN based controller can be used in regular PWM converter output current without a need for the on-line calculation required for an optimal controller.

9. Fuzzy logic based controllers:

The Fuzzy logic controller is used as a substitute for the conventional PI compensator. The current error E and its derivative error ? E are the FL controller input crisp values. The reference voltage for the PWM modulator are the FL control crisp output U. When an FL controller is used as a current controller, the tracking error and transient overshoots of PWM current control can be considerably reduced

GENERAL BLOCK DIAGRAM



Block diagram

The reference input will be an input signal proportional to desired output.

The feedback signal is a signal proportional to current output of the system.

The error detector compares the reference input and feedback signal and if there is a difference it produces an error signal.

The controller modifies the error signal for better control action. The operation of a Fuzzy controller consists of four stages.

(i) A measurement must be taken of the state variables to be monitored during the process. The Fuzzy controller is designed to process fuzzy quantities only.

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(ii) All the crisp input values must be converted to fuzzy sets, by the process of fuzzification. This process is nothing but, finding out which two fuzzy sets, the given input crisp value belongs to and their degree of memberships.

(iii) The control signal is evaluated depending on the fuzzy control rules, which are activated, or "fired". The result of the application of the rules is itself a fuzzy set defined on the universe of discourse of possible control action.

(iv) This output of the fuzzy controller is converted to a crisp value required by the plant by de-fuzzification process which can be done by a number of methods of which the center-of-gravity and height methods are common

In non-linearity the output is proportional to input for a limited range of input signals. When the input exceeds this range, the output tends to become nearly constant.

The comparison of SPWM inverter with the triangular carrier signal generates control signals for the inverter switches.

This process is continuous as long as there is a difference between reference input and feedback signal. If the difference is zero, then there is no error signal and the output settles at the desired value.

10. Design Of Fuzzy Controller:

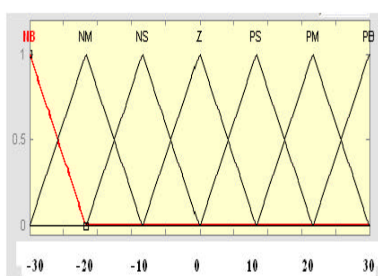
10.1. Fuzzy Control Design:

The value of reference input current R(K) and actual current C(K) are sampled. The value of error E(K) and change P_n error CE(K) are calculated

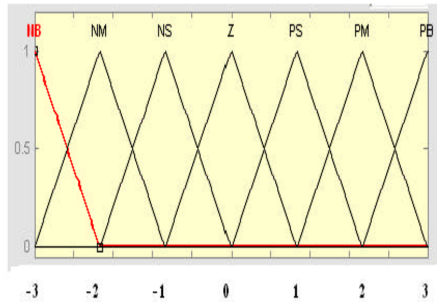
$$E(K) = R(K) - C(K)$$
$$C(K) = E(K) - E(K-1)$$

Where K = sampling interval

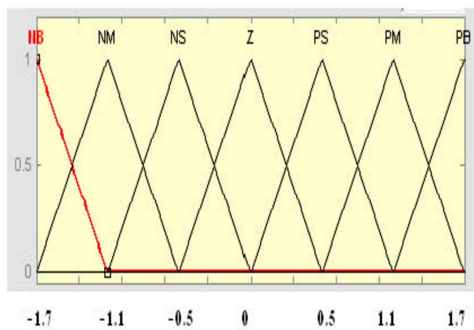
E(K) and CE(K) are the two input variables considered in the fuzzy rule base. The no. of linguistic variables varies according to the application usually an odd number is used. A reasonable no is seven. A set of membership is defined for seven linguistic variables NB, NM, NS, Z, PS, PM, PB.



Membership function for error



Membership Function for change in error



Membership Function for Fuzzy Output

10.2. Rule base matrix for Fuzzy Controller

Ce · e	NB	NM	NS	Z	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	Z
NM	NB	NB	NB	NM	NS	Z	PS
NS	NB	NB	NM	NS	Z	PS	PM
Z	NB	NM	NS	Z	PS	PM	PB
PS	NM	NS	Z	PS	PM	PB	PB
PM	NS	Z	PS	PM	PB	PB	PB
PB	Z	PS	PM	PB	PB	PB	PB

11. Conclusion:

The closed loop system was designed for linear applications using Fuzzy logic control method. The stationary frame current regulator with theoretically identical performance was implemented by hardware and simulated on MATLAB. The result is that the stationary frame current regulator achieves minimized steady state error.

12. References:

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