Chattering control of DC-DC PWM boost converter

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Abstract: In the present paper we developed a chattering PWM signal to control a DC-DC PWM Boost Converter. By chattering control we means chattering in the control law that control the high frequency switching in the relay part of the Boost converter. This chattering control produces fast change in the duty ratio from one value to another instead of smooth variation as is traditionally done. The novelty of our controller is the implementation of this chattering control law. We show experimental results.

Resumen: En el presente artículo nosotros desarrollamos un controlador de conmutación rápida en la señal del PWM para regular un convertidor DC-DC del tipo *Boost*. A este sentido, la señal PWM conmuta de un valor de ciclo de trabajo a otro en forma rápida en vez de hacerlo suavemente. La novedad de nuestra propuesta es la implementación de este control conmutado. Se muestra experimentalmente la robustez del controlador propuesto ante variaciones en la carga.

I. Introduction

High frequency switching (or chattering) controllers have been used to improve the performance of a given controller, see for instance [1], [2], [3], [4], and [5]. In [1], the idea to introduce a commutation term (or chattering term) helped to reduce the effects of friction forces on mechanical systems. This idea was bring here to show experimentally that switching controller can control DC-DC PWM Boost converter and can reduce external perturbations, as is shown in our experimental results. This chattering control was implemented to generate a chattering PWM signal producing fast changes in the duty ratio from one value to another instead of smooth variation as is traditionally done. Implementation for the perturbed case, or load variation, was realized using a parallel load, which was connected and disconnected to our load at *1Hz*. So, we have developed a new chattering control law to control the high frequency switching relay of the Boost converter. So, in these words, chattering control law is a discontinuous controller thatgenerates a chattering signal in the PWM applied to the relay term that control the Boost converter.

Roughly speaking, consider the linear system

$$\dot{y} = -ay + bu \qquad (1)$$

and assume that

$$u = -\operatorname{sgn}(y) \qquad (2)$$

where *sgn(.)* is the *signum* function. *u* can represent a signal control input. Because the *signum* function, this is called chattering term. Equation (2) into (1) produces

$$\dot{y} = -ay - b\operatorname{sgn}(y) \qquad (3)$$

Using the next Lyapunov equation

$$V(y) = |y|, \qquad (4)$$

its time derivative along the trajectory of (3) yields

$$\dot{V}(y) = \operatorname{sgn}(y)\dot{y} = -a|y| - b \le -b$$

which, according to [6], produce finite-time convergence of $y(t)$ to zero, that is,

$$\lim_{t \to t_s} y(t) = 0$$

being t_s the settling time. This finite time convergence, and due to chattering presence in (3) (the *signum* term), the system can face uncertainties or/and external perturbations as is shown in [6] and [3]. Basically, the general idea here is addition of the chattering to face with uncertainties or external perturbations. We used this, for the experimental realization to control a DC-DC PWM Boost converter.

2. Experimental Results

The proposed DC-DC Boost converter is shown in Fig. 1, where *R2* is used to model load variation that is activated in parallel with the load (*R1*) using a square signal with *f=1Hz*, and *Vcc=12Volts*. The Objective is to find a chattering PWM signal injected in "*a*" (Fig. 1), such that the dc output *Vo* (Fig. 1) be under regulation. The PWM circuit is shown in Fig. 2, where the IC TL494 is used and programmed to have sampling rate of 50kHz.

The experimental designed controller is illustrated in Fig. 3. The input to this controller is the output voltage to be regulated (*Vo*) and its output is the signal to be injected to the PWM circuit. Observe that after the error signal between the *Vo* and the *set point* appears the chattering term represented with the Operational amplifier in open loop format (see Fig. 3). The other circuits are used to adequate the signal with appropriate scale.

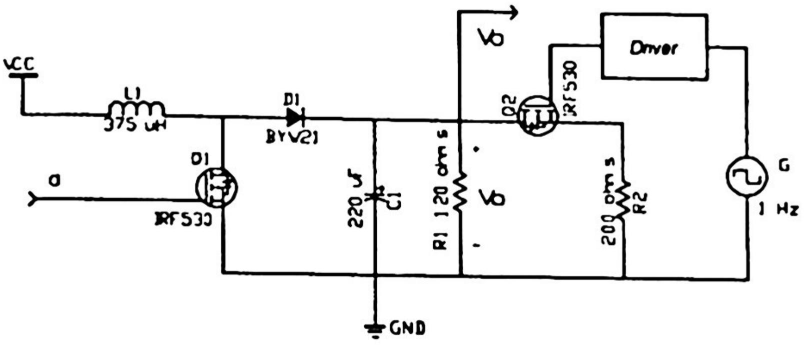

Fig.1 Proposed DC-DC Boost converter.

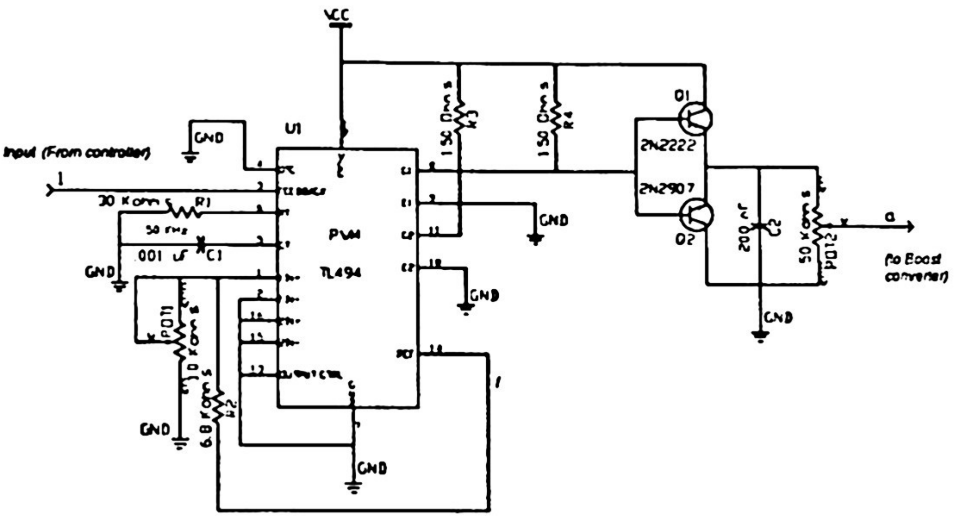

Fig. 2 PWM circuit realization.

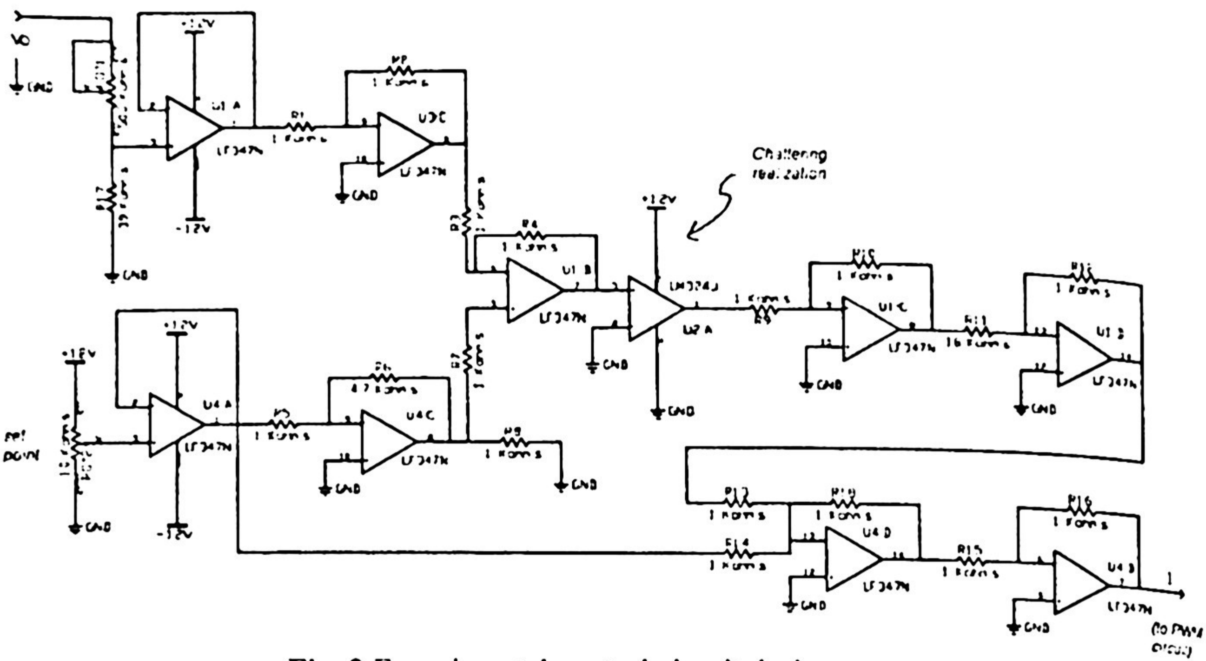

Fig. 3 Experimental control circuit design.

We programmed the *set point* to regulated *Vo* at *21 Vdc*. Fig. 4 shows *Vo* for the unperturbed case. Fig. 5 shows the PWM signal inject in "*a*". Figures 6 and 7 show the experimental results for the perturbed case (i.e., when the perturbation load connected and disconnected in parallel with the load at *1Hz*). From these experimental results we can appreciate the robustness of the chattering controller in the same manner as been illustrated for mechanical applications ([1], [2], [3] and [4]).

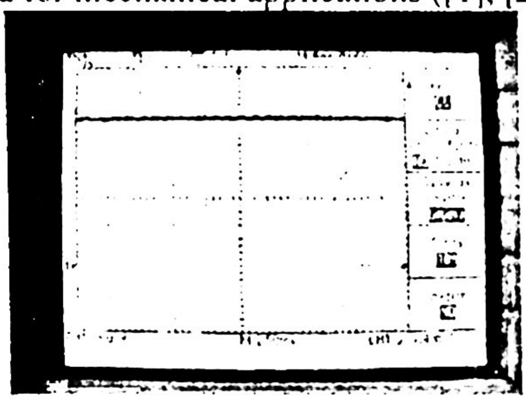

Fig. 4 Experimental result showing *Vo* (approx. 21.8 Vdc) for the unperturbed case.

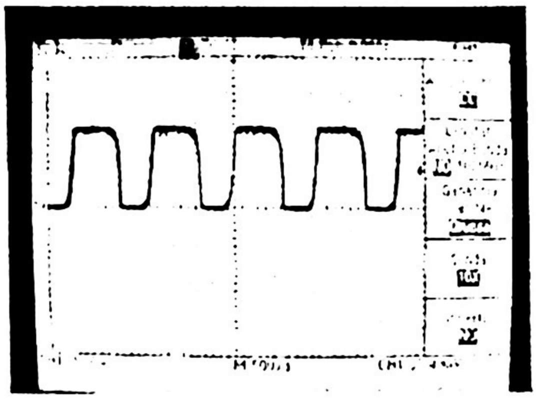

Fig. 5 PWM signal (unperturbed case), 5vdc per division.

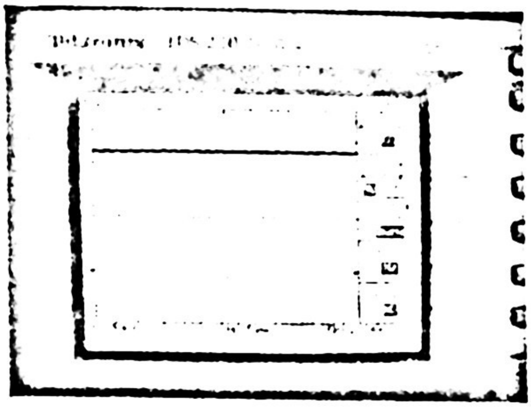

Fig. 6 Experimental result showing *Vo* approx. 21.8 Vdc (perturbed case).

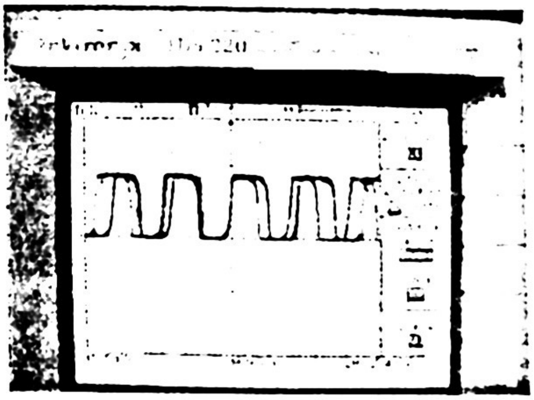

Fig. 7 chattering PWM signal (perturbed case), 5vdc per division.

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