Posicast Control in Power Electronics

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***Abstract*—This short note presents the basics of Posicast control theory which was invented in the 1950's by Prof. Otto J. Smith in order to dampen the oscillations of a system with manageable overshoot. The applications of Posicast control in power electronics, specifically power converters, are also highlighted in this short note.**

***Index Terms*—Posicast control, PID.**

I. Introduction

Different control techniques and methodologies are currently available in literature concerning their applications to power systems. Some use classical and modern control techniques such as PID [1]-[6], while others, on the other hand, use control strategies based on computational intelligence methods such as fuzzy logic [7]-[8], artificial neural networks [9]-[10], and genetic algorithms [11]-[12]. Despite having a lot of control-related researches for power systems, there are some still that use basic, non-sophisticated control techniques such as Posicast control.

In this short note, the theories behind classical and modern Posicast control techniques are presented and explained. This control strategy, invented and initially presented by Prof. Otto J. Smith in the 1950s is basic, that researchers tend to disregard them as potential controllers for real-world dynamical systems.

Posicast control can be classified as either classical or modern. The first (classical) Posicast control technique developed was the feedforward (half-cycle) Posicast controller that has been proven to control the oscillations of an underdamped system. It has then been improved and applied to different mechanical systems by Prof. Gerald Cook and Dr. Neil C. Singer in the next couple of decades [15]-[17].

The 21st century has been a transition stage for the Posicast control theory. Prof. John Y. Hung presented a way of

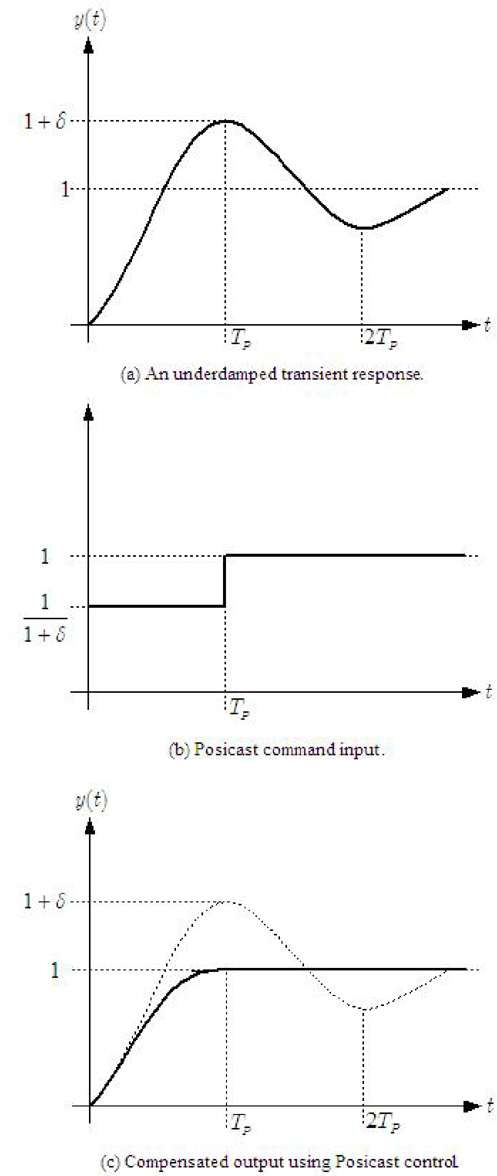

Fig. 1. Unit step response (a), Posicast command input (b), and compensated output using Posicast.

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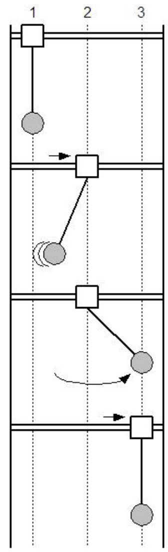

Fig. 2. Sequence of movements in a gantry problem.

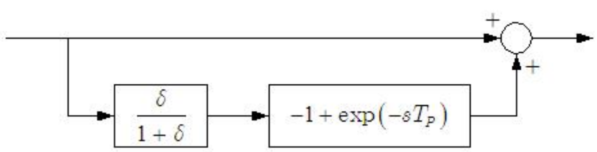

Fig. 3. Block diagram of the half-cycle Posicast controller.

minimizing the sensitivity of the system with a Posicast controller by applying it into a feedback system rather than having it in a feedforward configuration, which is considered as the modern Posicast control methodology.

II. Posicast Models

Consider a lightly damped system with a step response as shown in Fig. 1(a). The step response can be described by two parameters. One parameter is the overshoot of the system described by δ, and the other is the time for the response to reach the peak described by T_P. It is also noted that δ is the normalized overshoot, which ranges from zero to one.

The objective of Posicast control is to dampen further the oscillations of the output response by applying a Posicast command. This command splits the input step function into two parts, as illustrated in Fig. 1(b). From the initial time, $t = 0$, up to the peak time, T_P, the input step function is attenuated with a value of $1/(1+\delta)$. This ensures that the initial overshoot of the system due to a step function is eliminated, thus having a normalized peak value of 1.0. As the time it reaches T_P, the second part of the command input is then applied, which has a value equal to the original step function. The effect of having this strategy is illustrated in Fig. 1(c) showing response of a compensated system.

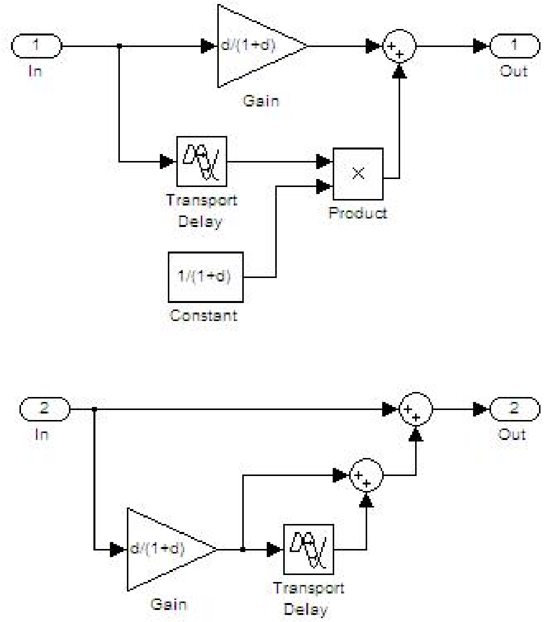

Fig. 4. SIMULINK diagrams of a half-cycle Posicast controller.

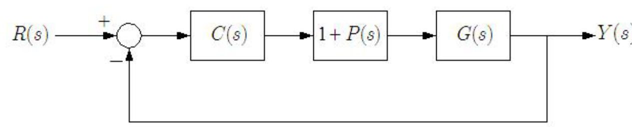

Fig. 5. Block diagram of a Posicast controller within a feedback system.

Posicast control can be best visually described using the gantry problem as illustrated in Fig. 2. Consider the problem of moving a pendulum load suspended by a cable attached to a gantry. The bob of the pole in the beginning is located at position ‘1’. The objective of this problem is to move the bob of the pole at position ‘3’ without the effect of having unwanted damped oscillations. Applying a Posicast command means that the gantry is moved one step-at-a-time until it reaches position ‘3’. First, the gantry is moved to position ‘2’ having a tendency of making the bob swing back and forth along position ‘2’ following a damped sinusoidal sequence. However, as the bob reaches position ‘3’, the gantry is then again moved in to position ‘3’, in effect making the bob rest at its position.

The Posicast control strategy used in the gantry problem is also known as the half-cycle Posicast [13]-[16]. The half-cycle Posicast controller can be described using a frequency-domain block diagram as illustrated in Fig. 3. Two possible SIMULINK models for the half-cycle Posicast controller are presented in Fig. 4.

The use of the half-cycle Posicast controller however has a problem with regards to sensitivity, especially when it comes to mismatched modeling. To reduce this problem, the Posicast controller is applied within a feedback system rather than having it in a classical feedforward configuration [17]-[19], which is illustrated in Fig. 5. This is effective since the overall characteristic polynomial of the system is given by $1+C(s)[1-P(s)]G(s)$, thus canceling undesired poles in the closed-loop response. It is also worth mentioning that the compensator $C(s)$ must be properly designed in order to reduce the effects of imperfections due to the Posicast controller.

III. Posicast Control in Power Electronics

Posicast control has been applied to many different researches pertaining to power electronics especially to power converters. Power converters are nonlinear systems in which natural damping is strongly dependent on the load. Although PID controllers are sufficient enough in dealing with these systems, feedback-based Posicast are still of interest. One of the first power converters that employed a Posicast controller is the DSP-based boost-type dc-dc power converter [20]. The performance of the DSP-based converter showed that the sensitivity of the system's dynamical response to variations in load was better compared to PID-based counterparts. Furthermore, additional advantages that have been experimentally observed include the following [15], [20]:

- The control method produces a very good response that is predictable by the small signal, averaged, continuous time model of the dc-dc converter.
- The key element of the Posicast controller structure is easy to implement in discrete-time hardware, and controller gains are easy to determine.
- The frequency response of the Posicast element inherently reduces high frequency noise, whereas PID control requires additional filtering to limit high frequency content.
- Experiments confirm that the gain margin of the Posicast compensated converter is as good, if not better, than that of a PID compensated converter.

Another Posicast-based power converter has been reported in [21]-[22], employing a three-level Posicast strategy for a low switching frequency current source rectifier. Control of dynamic voltage restorer for use in electric power distribution networks has also been reported using Posicast control [23], as well as the integration of Posicast control into a Z-source current-type inverter using a digital signal processor has also been reported, [24].

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