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The Trivial Servomotor and Servo Control System Expressions

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Abstract – **In electrical engineering the technical terms "servomotor" and "servo control system" are used since long decades ago. They are generally accepted and wide-range used denominations worldwide in scientific papers, books, advertisements and other publications. In other words, the above two terms become somewhat self-understanding incontestable parts of our technical language. However, this paper emphasizes the idea to discuss the exact and real meaning of these two terms. This because often it happens that in scientific publications there is no made clear difference between the terms "motor" or "servomotor", respectively "control system" or "servo control system" and that may be a real source of misunderstandings or confusions. For this reason, in first step a thorough overview of the available international scientific literature is presented in the paper in order to evidence the context and conditions in that are used the discussed scientific expressions. Then a careful analysis from technical point of view is unfolded to bring arguments to strengthen the endeavor that a clear difference should be made between the terms "motor" and "servomotor", respectively "control system" and "servo control system" in demanding technical discussions, as well as in scientific publications. Not at least, there is proposed an original definition of the two discussed terms, reflecting a point of view that may contribute to better understanding and utilization in scientific debates and publications.**

Keywords: *electric motor, servomotor, control system, servo control system, mechatronics.*

I. INTRODUCTION

In electrical engineering sciences there are a plenty of consecrated and generally accepted technical terms that are widely used since long decades ago. Among these also may be considered the well-known "servomotor" or "servo control system" expressions. Obviously, engineers and researchers working in related scientific areas are already very familiar with the above technical terms and uses it in their daily activity or published research works. However, even facing with these certitudes, in this paper it is expressed the main idea that the inadequate usage of the world "servo" may lead to serious inconveniences and misunderstandings between electrical engineering scientists. In other words, in a first look the expression "servo" looks so innocent. Some of scientists, engineers, or PhD. students associates this world with "control systems used in automation", "high dynamics automation systems", "high performance electrical drives" or something similar, "high quality electrical drives" or something like this, and so one. But in fact, what it means exactly the worlds "servomotor" or "servo control system"? It is there an exact definition of the world "servo"? In international references has been stated a concise clarification of these terms?

However, without the claim to make an exhaustive analysis regarding the above questions, this paper attempts to discuss the mentioned so trivial expressions. It is emphasized the idea that inside the electrical engineering scientific community a clear distinction should be make between the terms "motor" and servomotor', respectively "control system" and servo control system". In order to reach these goals a brief overview of related international approaches in the topic looks welcome.

II. THE WORLD "SERVO" IN INTERNATIONAL REFERENCES – A BRIEF OVERVIEW

In the related international literature a huge amount of high quality references may be revised that discusses about the "servomotor" or "servo control systems" topics. A few of these will be mentioned or discussed in the followings. As an example, the most general definition is that "a servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration" [1]. In reference [2] it is mentioned that "a servo motor is a self-contained electrical device that rotate parts of a machine with high efficiency and with great precision". Other approach is as follow: "a servomotor (or servo motor) is a simple electric motor, controlled with the help of servomechanism" [3]. An interesting approach also can be found in [4] where it is mentioned that "the term servo refers to the control mechanism" and "servo motors have an encoder (rotational motion detector) that can determine their rotational position and use this information to perform feedback control of motor position". On the website [5] the definition of a servomotor is approached as follow: "a servo motor is a rotational or translational motor to which power is supplied by a servo amplifier and serves to apply torque or force to a mechanical system, such as an actuator or brake". In [6] is mentioned that "a servo motor is a type of motor that can rotate with a great precision". In reference [7] the servomotor definition is as follows: "a power-driven mechanism that supplements a primary control operated by a comparatively feeble force (as in a

servomechanism)". As another example in [8] is written that "servomotors are basically a high performance type of electrical motor". Similar definitions of the servomotor may be found in a plenty of other international references. From the above remarks also it looks that often in scientific publications the word "servo" is used without knowing its real meaning.

Regarding the used "servo control system" definitions, in international references the situation is somewhat similar. Many authors consider that servo control systems are in fact nothing else that high performance control systems (with high dynamics, low system response times, high motion resolution, etc.). Others are with the general opinion that "a servo control system is one of the most important and widely used control systems" [9]. There are other high quality international references where is widely discussed the fundamentals of servo control systems but do not put emphasis to give an explicit and clearly stated definition of these specific systems [10]. In reference [11] is given a little bit more concrete definition of servo control systems: "Servo system: The control system where the outputs are mechanical quantities like acceleration, velocity or position".

Of course, all the above mentioned servomotor and servo control system definition approaches may be accepted and used, but inherently occurs the following legitimate question: it is possible to find a common, generally accepted definition also for the servomotor and servo control systems? May be assigned or stated one clear definition for servomotors (and servo control systems) that can become a widely accepted and widespread used designation of these technical terms? Before to try to find answers for the above questions may be useful at a first stage to shortly rank the most important behaviors and characteristics that are expected for example from a typical servomotor.

III. WHAT WE EXPECT FROM A SERVOMOTOR?

Of course, the aim of this paper is not to deal and discusses about concrete servomotor technical issues, but to review their main expected behaviors may be very useful in the followings. So, scientists and specialists involved in the topic usually ranks the next basic servomotor behaviors:

- wide range of speeds in both directions (left and right);
- stable operation at low speeds;
- to operate at very high speeds (example: 10000-100000 rot/min);
- to possess linear control characteristics (linear transfer function);
- a large scale of developed electromagnetic torque (0.1-100 Nm);
- low electrical and mechanical time constants (very important issue);
- convenient speed control:
- to be reliable and with long life time;
- high electromagnetic torque / inertia ratio;
- high developed power / acceleration time ratio:
- to exhibit resistance (to withstand) against environmental factors;
- to support high dynamic loads;
- to have low price, with low price control electronics.

At a first look of the above behaviors, it remains clear that the so called "classical" motors (asynchronous-, synchronous-, and dc motors) cannot fulfill at all these expectations. Therefore, servomotors represents a special category of electrical motors with distinguished properties that strongly differs them from the "classical" ones. Hence, from this point of view it is important to try to capture in an adequate definition the essence of what makes this strong difference.

IV. PROPOSAL FOR SERVOMOTOR AND SERVO CONTROL SYSTEM GENERALIZED DEFINITIONS

Considering all the above issues discussed in the previous paragraphs, this paper attempts to propose a general-type definition for the mentioned two technical terms. At first, a clear and concise electrical servomotor definition is proposed, as follow:

A servomotor is a special or modified construction motor that sends information, therefore its converted energy amount can be neglected.

From this definition results two main conclusions. One is that a servomotor sends (transmits) information, not energy amount. As a result, servomotors are small power actuators. Here the motors with nominal power less then 1kW are considered servomotors (some authors also may consider < 500W). The second conclusion that derives from the above given definition is that a servomotor exhibits some modified construction details (in comparison with the classical asynchronous or synchronous motors). Such modified construction details refers to modified stator- or rotor physical configuration (modified magnetic circuits, different number of poles or teeth, etc.), additional electromagnet pieces (for example: permanent magnets) placement, or other physical construction change in order to reach the behaviors ranked in the previous paragraph. In order to exemplify such modifications, in Fig. 1 is given the electromagnetic circuit structure of a stepping motor.

Figure 1 – Stepping motor electromagnetic circuit [12]

This figure shows that the electromagnetic circuit structure of the servomotor is modified, the magnetic flux has only incremental positions. On the other side, the stepping motor is in fact a synchronous motor. In spite of this it is named servomotor, the term synchronous motor is not really used (or rarely) for it. Other similar situations may be followed in Fig. 2, Fig.3 and Fig. 4.

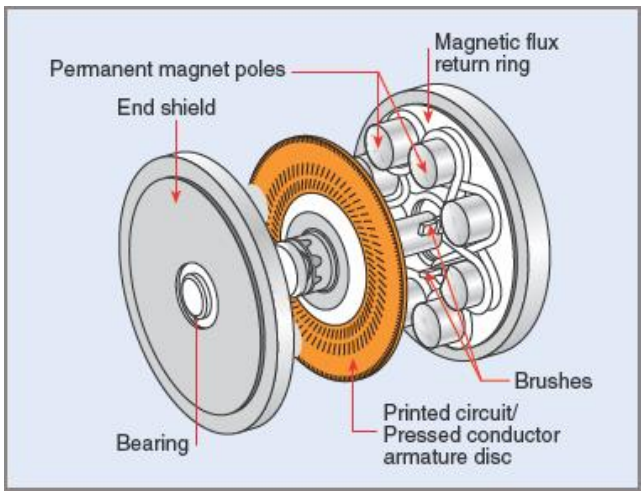

Figure 2 – Disk type rotor – ac motor [13]

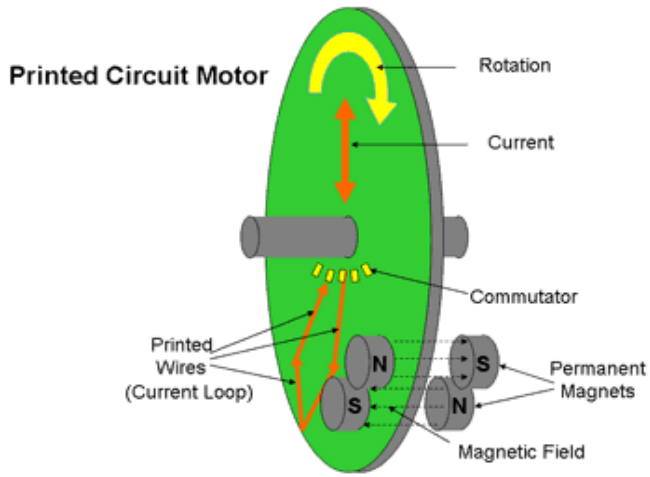

Figure 3 – Printed circuit board motor – ac motor [14]

For example, in Fig. 2 and Fig. 3 are plotted ac motors with disk type rotors, specially designed to reduce the rotor mechanical inertia and to obtain high acceleration time constants. Even they operates on the asynchronous principle such motors are named servomotors and not asynchronous motors. Therefore, the above proposed general-type definition remains also valid for such cases.

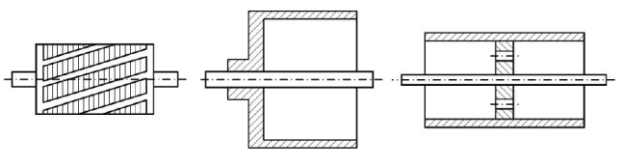

Figure 4 – Glass type rotor – ac motor [15]

The situation is quite similar in case of the ac servomotor with glass type rotor shown in Fig. 4. Of course, more other examples may be taken into account. The most important is that all these are special or modified construction motors that sends information which plays a primordial role against the energy transfer. It means that the definition recommended in this paper covers all these servomotor types and maintains its validity.

In a next step for the "servo control systems" concept will be proposed a general-purpose definition. This is formulated here as follows:

A servo control system is a servomotor actuator-based automation system that processes and transmits mechanical information.

From the above formulation also derives two main conclusions. The first is that the actuator role in a servo control system mandatory is fulfilled by one or more servomotors. The second one is that such a system processes and transmits mechanical information (for example: position, velocity, acceleration, or mechanical force). Obviously, the priority of information transmission (mechanical information) also remains against the energy conversion and sending. Therefore, the amount of converted energy can be neglected.

According to the above definition, a stepping motor-based control system as is presented next in Fig. 5, may be named as a "servo control system" or "servo drive system", but usually for such systems the appellation "synchronous control system" will be avoided. This last denomination is not preferred even being true that the stepping motor that fulfills the actuator role is in fact a synchronous motors.

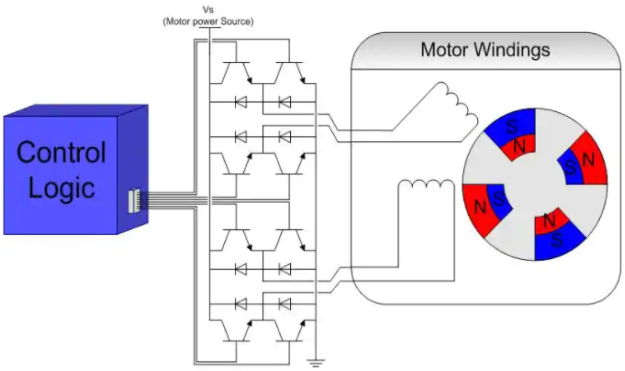

Figure 5 – Stepping motor control system [16]

It is not without importance that the proposed definition does not make confusions with the classical asynchronous or synchronous motor-based control systems. Such systems also may process and transmits mechanical information, but they are based on classical asynchronous or synchronous motors, not servomotors. As example, it is given the block diagram from Fig. 6, where is presented an asynchronous motor control system. In this case, if is used the vector control strategy the ac motor becomes a high dynamics dc motor via the used control strategy.

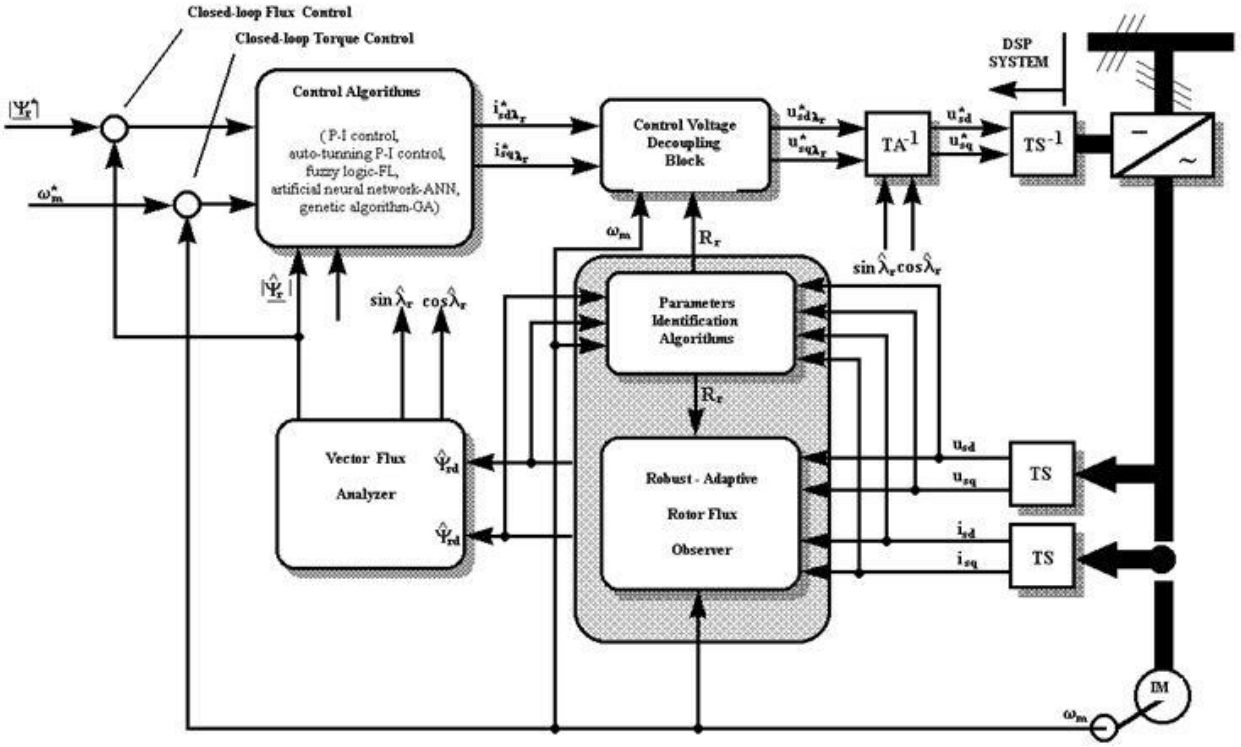

Figure 6 – Block diagram of an asynchronous motor control system [17]

Of course, there also may be used other control strategies, such as robust- , adaptive-, or fuzzy regulators implementation techniques. However, in spite of all these in each case the control system remains an "asynchronous motor control system" and do not becomes a "servo control system".

On the other hand, it is not without importance to remark here, that the terms "asynchronous" and "synchronous" are usually used for classical drive systems. By using modern control strategies in these control systems the ac motors becomes high performance and high dynamics actuators. In accordance with the definition proposed in this paper, in all this situations the used actuators remains high performance, high dynamics, "classical" ac motors and do not becomes servomotors. The problem is that often in some books, web pages, scientific papers, or company advertisings such motors are also named servomotors. This paper emphasizes the idea that in scientific communities it is important to make a clear difference between the used technical terms. In this idea also the correct and adequate usage of the technical term "servo" it is emphasized.

As a last example, it seems that this situation in electrical engineering looks a little bit similar with the use of the word "computer". Is well know that in our daily activity the laptop- and desktop microcomputers are referred (especially between non specialists) with the general word "computer". Or, in fact computer specialists well-known that a laptop is in fact a microcomputer, and they can make a real difference between microcomputer, minicomputer, and computer architectures. In a similar way, to make a real difference between "motor" and "servomotor", respectively "control system" and "servo control system" technical terms looks welcome.

V. Conclusions

The main idea of this paper is to draw attention regarding the problem of how is used the technical term "servo" in electrical engineering publications. Without the claim to find unique possible solution, there are proposed two definitions that may be useful to solve the above uncertainties and emphasizes the idea to difference terms.

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