



HIGH PERFORMANCE ALGORITHM REALIZATION ON FPGA FOR STEPPER MOTOR CONTROLLER

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ABSTRACT - This paper fixates around focusing on the extraordinary characteristics of stepper motors. Taking into account the association of velocity and power of stepper motors, a unique estimation of velocity profile for stepper motor is proposed for obviously recognizing on field programmable entrance display (FPGA). Missing advances have been a critical issue while applying stepper motors on various fundamental conditions. The clarification of taking missing steps of stepper motors is normal the high velocity slewing. To ease up this difficulty, a shut circle control may be applied, but introducing an amazing arrangement and more cost than open circle one.

Keywords – [Stepper motor, FPGA, SOC, SOPC, CPLD, Velocity profile.]

1. INTRODUCTION

In view of prosperous improvement of pattern setting development, stepper motor controller are as of now mentioned outfitted with rich functionalities, but lessening the real size which is fitting to introduced into a system. Along these lines, the complex programmable reasoning device (CPLD), field programmable entryway bunch (FPGA), and system on programmable chip (SOPC) with wide-spreading drawing in quality has been vivifying the interest for researcher to cultivate the stepper motor controller of interest.

In the controller side of stepper motor, there are two sort controllers of by and large huge: position and speed. They can be stocked base on the velocity profiles, S-twist, direct, and illustrative profiles. For high exactness arranging situation, the velocity profile given by the controller is relied upon to move controlled thing to exact position, thus to moderate the effect existing separated from all the other things of inaction, the direct or possibly illustrative profiles are used by and large; On the other hand, while speed and time are into thought, the profiles of S-twist just as line are embraced.

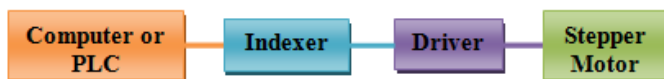


Figure. 1. Typical stepper motor system.

Routinely, without using any analysis signals stepper motor was planned to give exactness position inside various advances. That is, they are open-circle stable to any movement position control, and in this way no info is relied upon to control it. Hence, for performing high precision arranging and smooth turn action,

plan of stepper motor controller is an indispensable issue. The general procedures used to do stepper motor controllers are using PC and programmable reasoning controller (PLC). Critical sorts of cutting edge control devices are: Motor Drivers, Control Links, and Controllers. The designing of these contraptions is shown in Figure 1 schematically.

2. EXISTING METHOD

1. Wang Bangji, Liu Qingxiang, Zhou Lei, Zhang Yanrong, Li Xiangqiang, and Zhang Jianqiong. (2011). Velocity profile calculation acknowledgment on FPGA for stepper motor regulator. To smooth out the open circle control strategy of stepper motor, the velocity profiles of stepper motor were inspected. There are three inescapable utilized velocity profiles: trapezoidal, allegorical, and S-bend profiles. In this paper, trapezoidal velocity profile was picked for extra audit. To precisely produce a discretionary trapezoidal velocity profile, another velocity profile age approach is created. It tells the best way to manage computational intricacy and equilibrium execution against assets necessities utilizing field programmable entryway field (FPGA). Consequently, an elite stepper motor regulator can be accomplished by consolidating a framework on a chip (SOC) with this equipment. Exploratory outcomes confirm the precision and productivity of the proposed approaches. The meaning of the velocity profile lies in progress of the exactness and effectiveness by complex computations and sequential execution of them.

2. Khan Zarrarahmed Zaferullah , Rajesh Bansode , S.N. Pethe , Mandar Vidwans and Kelvin Dsouza (2013). FPGA base Speed Control of Stepper Motor. Stepper motor is utilized in expansive application for speed and position control. In this paper the speed profile of stepper motor is explored reliant upon Field Programmable Gate Implementation (FPGA). As a speed moving motor it should have rising and falling interaction which incorporates missing strides by steps. FPGA gives the diverse control technique for controlling the speed of stepper motor to try not to miss steps. The framework dependent on FPGA has great interfacing in this manner we can interface more than one stepper motors for additional application. The calculation executed on FPGA permits a considerable decline of the same handling time create by various velocity regulator.

3. Chiu-Keng Lai *, Bo-Wei Lin, Hsiang-Yueh Lai and Guan-You Chen (2021) FPGA-Based Hybrid Stepper Motor Drive System Design by Variable Structure Control. A stepper motor is generally worked in position open-circle control for

straightforwardness. In any case, to further develop the transient and consistent state exhibitions of the stepper motor-based drive framework, an elite stepper motor drive framework is typically intended to take care of the encoder signal back to shape a shut circle framework like an overall servo motor drive, and superior position and speed circle regulator would then be able to be utilized to beat the nonlinear attributes of the motor, for example, the cogging power and effects from outer burden. Then again, the existed cogging power of the crossover stepper motor should be tackled to build the situating accuracy. The variable design control (VSC) is inhumane toward the limited vulnerability and burden unsettling influence, and has been known as an elite regulator. A predefined sliding surface is utilized to shape the framework exhibitions, and fuse with changing control to accomplish the power property. In this manner, we applied the VSC to execute the stepper motor drive framework about the position and speed control, and the exchanging control is utilized to beat the cogging power. The field programmable door cluster (FPGA) is a decent choice to be utilized to understand a motor drive framework by thinking about its programmable capacity and various planning climate. The equipment framework carried out on FPGA for the variable design regulator and PI regulator are checked by useful examination for the stepper motor drive framework with the trapezoidal velocity profile requirement, and the drive framework is finished worked on the predefined profile. With the outcomes, it shows that a DSP-or chip based control framework can be supplanted by an equipment regulator acknowledged by FPGA.

4. Farid Alidoust Aghdam and Siamak Saeidi Haghi (2013). Execution of High Performance Micro venturing Driver Using FPGA fully intent on acknowledging Accurate Control on a Linear Motion System. FPGA-based microstepping driver which drives an immediate development system with a smooth and careful way. Proposed driver based on a Spartan3 FPGA (XC3S400 center) advancement board from Xilinx. Execution of driver acknowledged by a FPGA and utilizing Verilog equipment portrayal language in the Xilinx ISE climate. The driver's control conduct can be adjusted just by changing Verilog scripts. What's more, a direct movement framework created (with 4 mm development for every motor upset) and coupled it to the stepper motor. The presentation of the driver is tried by estimating the distance went on direct movement system. The test results checked using hardware in-circle Matlab and Xilinx cosimulation technique. This driver accomplishes a firm and careful control and is responsive. The double H-span converter is wanted to drive the two-stage stepper motor. The model of the current regulator and gains of the PI regulator for ideal control are determined utilizing Matlab programming. In our plan, the FPGA is utilized to develop an elite miniature venturing driver without utilizing any microcontroller, DSP, or driver chip; also in light of the fact that every one of the calculations are written in Verilog equipment portrayal language, it is viable with moving proposed plan to an ASIC and mass creation strategies.

3. PROPOSED METHODOLOGY

Variable Speed Control

As a result of arrangement of stepper motor, expecting we need to drive motor slewing in high velocity, it ought to be driven in torpid speed, and extended progressively to fast to do

whatever it takes not to miss step. In speed increment mode side, there are three wide used modes: illustrative, trapezoidal, and S-twist.

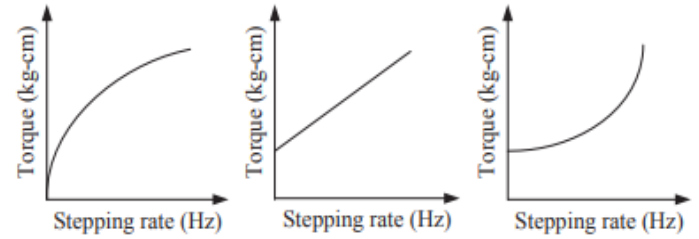


Figure.2. Acceleration mode: parabolic, trapezoidal, and s-curve from left to right respectively.

Overall, the trapezoidal mode is then again called the straight speed increment; moreover it is used comprehensively in various applications. Regardless of anything else, we will research the immediate speed increment.

Is beat each second (PPS). The stepper motor practical is good for starting at the beat rate off_min. Every heartbeat timing implies PPS. Acknowledge the starting rate is f_min, most raised rate is f_max, and accelerating time is t_max. In this manner, the speed increment an is

$$a = \frac{f_{max} - f_{min}}{t_{max}} \quad (1)$$

The mth beat relating timing can be addressed by Eq. (2):

$$t_m = \frac{\sqrt{2am} + f_{min}^2 f_{min}}{a} \quad (2)$$

The beat span from the (m-1)th heartbeat to mth still up in the air as

$$\Delta t_m = t_{m+1} - t_m \quad (3)$$

As of now we can use the Eq. (2) enlisting the situation of (m+1)th beat. Finally, we can change the beat timing.

$$\Delta t_m = \frac{\sqrt{2am} + f_{min}^2} {a} - \frac{\sqrt{2a(m-1)} + f_{min}^2} {a} \quad (4)$$

To avoid the missing development sway, every one of the more low frequencies are crucial. In addition, the opening between the two frequencies can't be unnecessarily immense. As demonstrated by these situations, we can calculate the repeat and relating beat timing. As a result of the deceleration part is identical to speed increment just inverse. Meanwhile, we can see the conditions are unpredictable for enrolling. To deal with these plans, we ought to reconsider the velocity profile.

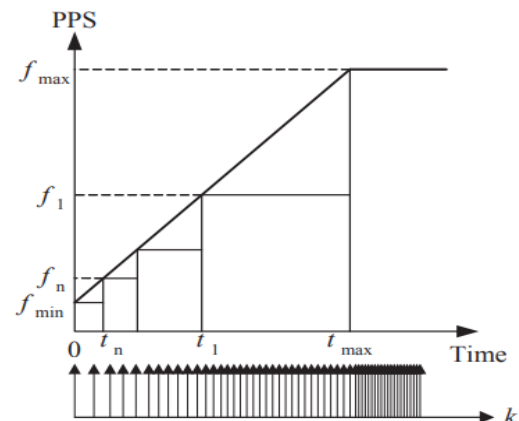


Figure. 3. A new approach velocity profile.

Number of steps in Δt_n interval. The k_n really settled as follow:

$$k_n = f_n \cdot \Delta t_n. \quad (8)$$

As indicated by these situations, this calculation can be revamped as

$$\begin{cases} t_{n+1} = \frac{t_{max}}{2^{n+1}} \\ f_{n+1} = \frac{f_n - f_{min}}{2} + f_{min}, n = 0, 1, 2, \dots, \\ k_{n+1} = f_{n+1} \cdot \Delta t_{n+1} \end{cases} \quad (9)$$

wheret₀ = t_{max} and f₀ = f_{max}.

This computation is trapezoidal profile; similarly it is a recursive estimation. In case speed increment mode ought to be changed, basically the limit β will be brought into Eq. (7). Thusly, the Eq. (7) can be formed as

$$f_{n+1} = \beta \left(\frac{f_n - f_{min}}{2} \right) + f_{min}. \quad (10)$$

Where β is defined as

$$\begin{cases} 0 < \beta < 1, & S - Curve \\ \beta = 1, & Trapezoidal. \\ 1 < \beta < 2, & Parabolic \end{cases} \quad (11)$$

Hardware Implementation

Upon this recursive computation, the implementation of this estimation in hardware is essential. Two generators are associated with the designing of this computation, which are repeat and timing generator independently

Additionally, the situation generator correspondingly as repeat generator does. Fig. 8 shows the stream chart of timing generator. It simply a qualification with repeat is early on worth of n adds 1 first, then, calculating the situation and number of steps.

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procedure VPG( $f_{max}, f_{min}, t_{max}, N, \beta$ )
  : velocity profile generator
   $f_{max} :=$  maximum frequency
   $f_{min} :=$  minimum frequency
   $t_{max} :=$  maximum timing
   $N :=$  total segments of acceleration or deceleration
   $\beta :=$  profile control parameter
   $t_0 := t_{max}$ 
   $f_0 := f_{max}$ 
  if  $n := 0$  then
     $t_{n+1} := t_{max} / 2$ 
     $f_{n+1} := \beta * ((f_{max} - f_{min}) / 2) + f_{min}$ 
  else if  $0 < n \leq N$  then
     $t_{n+1} := t_{max} / 2^{(n+1)}$ 
     $f_{n+1} := \beta * ((f_n - f_{min}) / 2) + f_{min}$ 
     $k_{n+1} := f_{n+1} * (t_n - t_{n+1})$ 
  else
     $t_{n+1} := 0$ 
     $f_{n+1} := f_{min}$ 
     $k_{n+1} := f_{min} * t_N$ 
  end if
end procedure

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Figure.4. Pseudo-code for presented recursive algorithm.

4. EXPERIMENTAL RESULTS

The implementation of proposed velocity profile generator depends on a FPGA based structure. To survey the presentation of this structure, the estimation was executed in an Altera FPGA DE2. This device can surrender the clock rate to 50 MHz and has a cutoff 35,000 LEs.

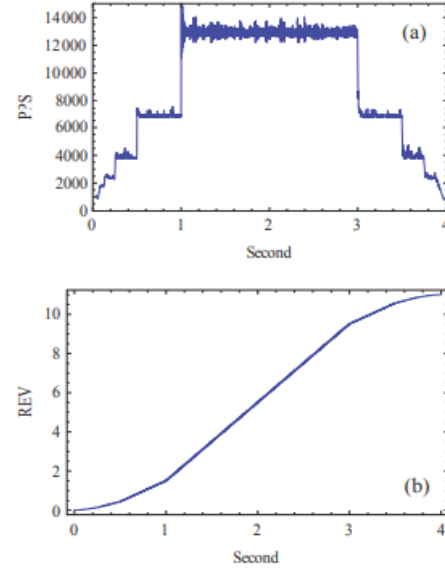


Figure.5. Velocity (a) and position (b) profile with microstep based on FPGA.

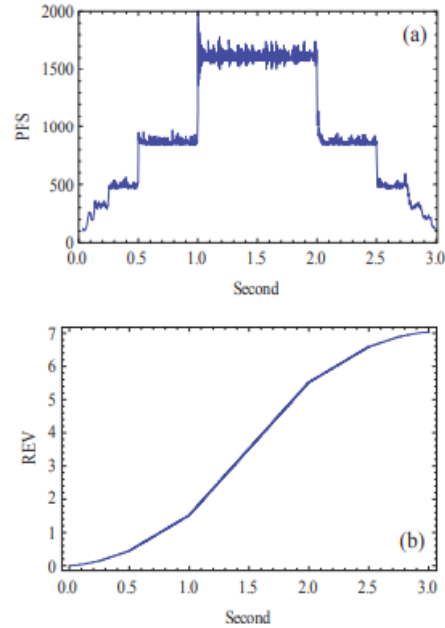


Figure.6. Velocity (a) and position (b) profile with full step based on FPGA.

CONCLUSION

This regulator relies upon FPGA, which can make an emotional velocity profile depends upon different applications, thusly perform quick and smooth development. Moreover, this regulator is a smaller contraption, cost reduced and hardware area saving. In the progression field, this computation can be not hard to do on FPGA, moreover decrease period of progress. For the smoothing velocity profile, this computation can be applied recursively, which ensure each velocity stage has adequate

advances. Thusly, the high-precision arranging can be refined. The implementation of this regulator can be joined with embedded structure. In the preliminary of this paper, stepper motor was worked without stacking associated. While stacking interfaces with stepper motor, the velocity profile will change fittingly.

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