Smart solution for high end stepper motor driver: cSpin family of STMicroelectronics
Sebastiano Yuri Ciardo, Fabio Chelli, Vincenzo Marano

ABSTRACT

The applications in which a bipolar stepper motors are used are increasing thanks to the compactness and the precision of these motors as well as their decreasing cost.

But when dedicated controls with speed and position profiles are needed for the final application, usually complex MCU routines become necessary, and so powerful microcontrollers are included into the design, increasing the complexity of the system.

STMicroelectronics has developed a family of innovative devices, including the new xSPIN, that implement a full motion control engine in Hardware, leaving the microcontroller free to perform other operations or allowing the use of a less powerful microcontroller for microstepping applications.

INTRODUCTION

The high level of integration simplifies motor control design, reduces system BOM and cost, with no compromise on quality, and moreover, the availability of SPI interface (in all the family devices) allows them to work in daisy chain mode, with the result that one microcontroller can control multiple devices, and therefore different motors.

The master MCU only has to send the control commands via SPI in order to program the speed profile and/or the position of the motor; moreover, all the diagnostics and configurations of the devices are managed through the serial channel.

THE CSPIN

The new cSPIN is a single-chip motion controller that engineers can use to design a variety of equipment with quieter, smaller, and lighter precision movement and position systems. The key benefit is the possibility to implement a high-performance stepper motor driver in a very simple, compact, and inexpensive way, while the state-of-the-art technology avoids the need for several ICs and many passive components.

The digital control core can generate user defined motion profiles with acceleration, deceleration, speed or target position easily programmed through a dedicated register set. All commands and data registers, including those used to set analog values (such as current control value, current protection trip point, dead time, PWM frequency) are sent through a 5 Mbit/s SPI. A rich set of protection features (thermal, low bus voltage, overcurrent, motor stall) allows the design of fully protected applications, as required by the most demanding motor control applications.

The digital control core, together with the innovative voltage-mode driving operation, result in a position resolution of up to 128 micro-steps and smoother motion. Reduced resonance, noise and vibration at low speed make the overall application much simpler and lighter.

Many current motion controllers include more than one processor, which generally provides more noise and complexity in equipment design. Multi-chip controllers also often require additional motor-control software, as well as for designers to combine calculation control and interfacing functions after they’ve been developed on separate chips, adding an extra step to the equipment development process.

Because of the integration of the motion engine, cSPIN needs few resources from the host controller (typically a microcontroller): no complex routines need to be implemented in the controller software allowing for faster development cycles and cost savings, especially in multi-motor applications.

Engineers also can develop equipment that is less noisy, which can reduce the environmental impact on people working in places like laboratories and hospitals. The controller’s lightweight and compact design also lends itself to the development of systems that overall are lower cost and more efficient, eliminating the inclusion for shunt resistors and therefore reducing the possibility of energy waste. STMicroelectronics has released two versions of the cSPIN controllers, the L6480, which supports microstepping operation at up to 1/128 steps resolution, and the L6482, which includes the predictive control algorithm and the auto-adaptive decay mode.

To overcame the limit of 100 W typical of the monolithic solutions (which embed the power stage), an external power stage has to be used, the cSpin family has been designed for these kind of applications, and this open door to use the smart driving also with applications up to 800W.

These devices, unique in the market, can work up to 85V bus voltage having embedded an advanced and fully programmable gate driver with miller clamp features, offering extreme accuracy in the positioning and extreme smoothness in motion.

The L6480 is designed for voltage mode controls (offering a microstepping control feature up to 1/128), while the L6482 is designed for current control mode (up to 1/16 microstepping). A dual full-bridge embedded gate driver can drive N-channel MOSFET power stages, delivering up
to 100mA gate current, and offers a non-dissipative programmable overcurrent protection (present in both devices).

The user can easily program a customized speed profile independently defining acceleration, deceleration, maximum and minimum speed values and send (through 5-Mbit/s SPI) high level commands (like constant speed commands, absolute position commands, motion commands and stop commands). All the related movements are performed respecting the limit of acceleration and deceleration imposed, with an active compensation of BEMF applied during acceleration and deceleration phases, and detecting a stall occurrence of the motor without any speed or position sensors.

The overcurrent and undervoltage of the external MOSFETs are managed, and in case of their occurrence, the gates are immediately turn off and an event is returned to the master (thresholds can be set).

Very advanced features are used for the current control mode (for L6482); in fact, the device can automatically select the better decay mode in order to follow the current profile and reduce the current ripple.

A complete and powerful management of the thermal aspects of the application are offered by the cSpin having an integrated thermal sensor designed to work with three different level of intervention: Alarm, Bridge shutdown, and device shutdown.

THE EVALUATION BOARDS

In order to offer an easy way to evaluate the cSpin family devices, two evaluation boards are available: the EVAL6480H and EVAL6482H. Thanks to the high level of integration of the device, the overall BOM of the board is very low and the design is easy to reproduce.

The boards use 100V low RDS MOSFET (33 mOhm) and each phase can work up to 25A rms, resulting in a high power solution for bipolar stepper motor drives; boards are designed to work with a supply voltage range from 10.5 up to 85V.

When using the voltage control features (L6480), the user can directly connect the motor voltage supply to a dedicated ADC input available in the board in order to perform the active motor supply voltage compensation.

Users can create a daisy chain of these boards using the dedicated SPI connector available on the board, and so control many motors as for multi-axial systems.

These boards can be controlled using a dedicated communication board (STEVAL-PCC009V2 based on STM32F103 microcontroller) connected to a Windows-based PC and a dedicated GUI. With the use of the PC Interface, it is possible to send the high level commands for position profiles for each board. This last evaluation board can also be used for all the devices belonging to the xSpin family.

As is standard for every STMicroelectronics board, the EVAL6480H and EVAL6482H come with all the documentation (schematics, BOM, Gerber files, UM ...) necessary for the user to start his own design of the final application quickly and easily.