USING ADMC401 PROCESOR IN ELECTRICAL MOTORS VECTOR CONTROL

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Abstract. *The vector control philosophy started to be developed around 1970. Several types of vector control are possible: rotor-oriented, rotor-flux-oriented, stator-flux-oriented and magnetizing-flux-oriented. Here, only the rotor-flux-oriented type of vector control, also termed "Field-Oriented Control" (FOC), is considered. Figure 1 shows the basic speed control scheme for ac motor drives with FOC. The ADMC401 is a single chip DSP motor controller optimized for standalone motor control applications.*
Keywords: *vector control, DSP,.*

Introductions

The goal of FOC is to maintain the amplitude of the rotor flux linkage Ψ_r at a fixed value, except for field-weakening operation or flux optimization, and only modify a torque-producing current component in order to control the torque of the ac machine. Considering a complete decoupling of torque and flux, a linear relation between torque T_{el} and torque producing current i_q is achieved and the torque in the ac machine can be expressed as:

$$T_{el} = c \cdot \Psi_r \cdot i_q \qquad (1)$$

Thus, the electromagnetic torque generated by the motor can be controlled by controlling the q-axis current. In speed control mode, the torque reference $T_{el}*$ is calculated by a speed controller. The rotor flux is controlled directly by controlling the d-axis current.

Motor currents are measured in two phases. These measurements feed the '3⇒2 - *transformation*' module. The outputs of this projection are designated i_α and i_β. These two current components are the inputs of the Park transformation giving the current in the d/q rotating reference frame. The current components i_d, i_q are compared to the reference currents i_d* controlling flux and torque generation, respectively.

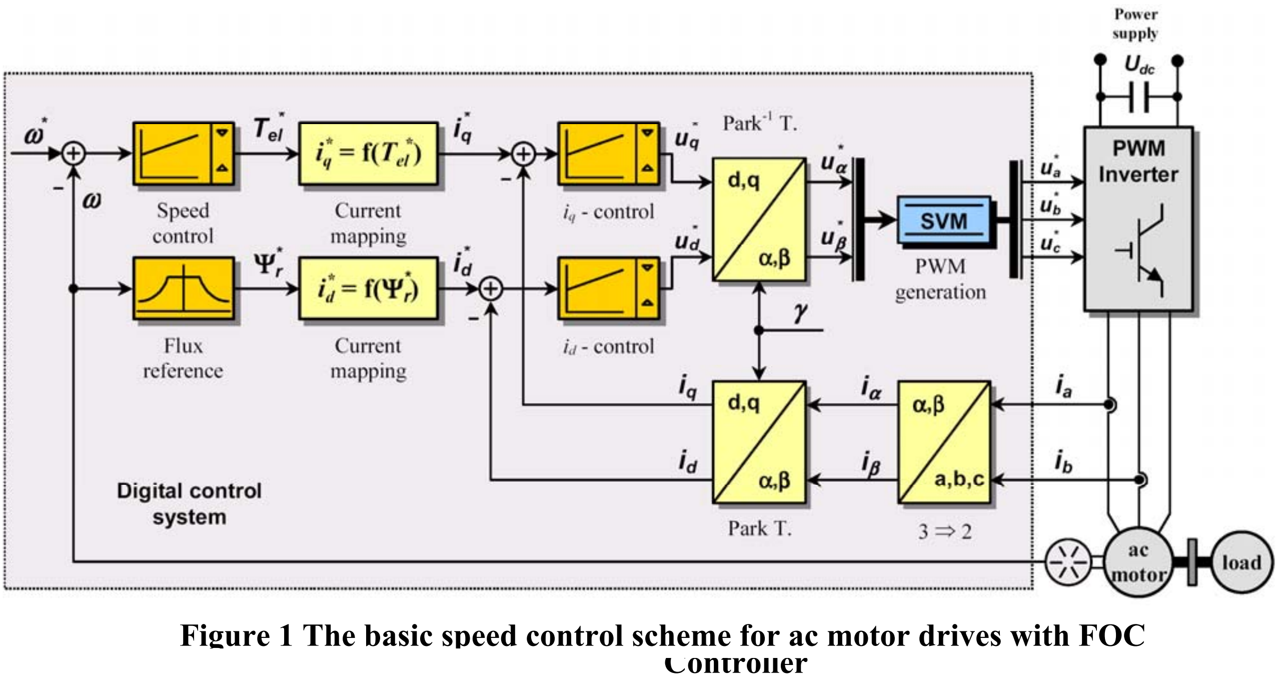


Figure 1 The basic speed control scheme for ac motor drives with FOC Controller

The ADMC401 is a single chip DSP motor controller optimized for standalone motor control applications. The device combines a 26MHz fixed point ADSP-2171 core with on-chip memory, two serial ports, a programmable timer, and a set of on-chip motor control peripherals. In addition, the address and data bus of the DSP core are connected to package leads allowing external memory and peripheral expansion.

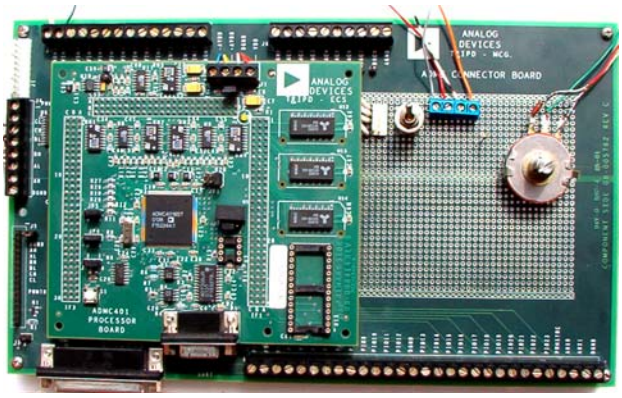


Figure 2 ADMC401 Evaluation Board

The ADMC401 contains a fast, high accuracy, multiple-input analog-to-digital conversion system with simultaneous sampling capabilities. This A/D conversion system permits the fast, accurate conversion of currents, voltages and other signals needed in high performance motor control systems. A functional block diagram of the entire ADC system is shown in Figure 2. All analog inputs can be converted in under 2 µs (at 26 MHz) through a single 12-bit pipeline flash ADC.

The PWM generator block of the ADMC401 is a flexible, programmable, three-phase PWM waveform generator that can be programmed to generate the required switching patterns to drive a three-phase voltage source inverter for ac induction (ACIM) or permanent magnet synchronous (PMSM) motor control. In addition, the PWM block contains special functions that considerably simplify the generation of the required PWM switching patterns for control of the electronically commutated motor (ECM) or brushless dc motor (BDCM). A special mode for switched reluctance motors (SRM) exists as well, enabled by a dedicated pin.

A functional block diagram of the PWM controller is shown in Figure 3. The generation of the six output PWM signals on pins AH ÷ CL is controlled by four important blocks:

The Three-Phase PWM Timing Unit, which is the core of the PWM controller, generates three pairs of complemented and dead time adjusted center based PWM signals.

The Output Control Unit allows the redirection of the outputs of the Three-Phase Timing Unit for each channel to either the high side or the low side output. In addition, the

Output Control Unit allows individual enabling/disabling of each of the six PWM output signals.

The Gate Drive Unit provides the correct polarity output PWM signals based on the state of the PWMPOL pin. The Gate Drive Unit also permits the generation of the high frequency chopping frequency and its subsequent mixing with the PWM signals.

The PWM Shutdown Controller takes care of the various PWM shutdown modes (via the PWMTRIP pin, the PIO lines or the PWMSWT register) and generates the correct RESET signal for the Timing Unit. [1], [3], [4]

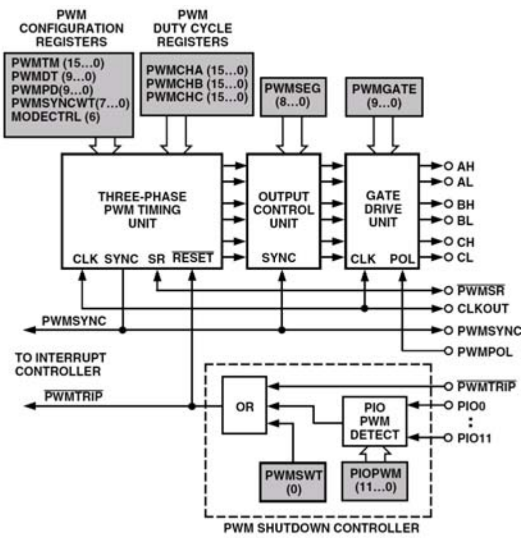


Figure 3 ADMC401 - PWM Generator Blocks

The ADMC401 incorporates a powerful encoder interface to incremental shaft encoders that are often used for position feedback in high performance motion control systems. The functional block diagram of the entire encoder interface system of the ADMC401 is shown in figure 4.

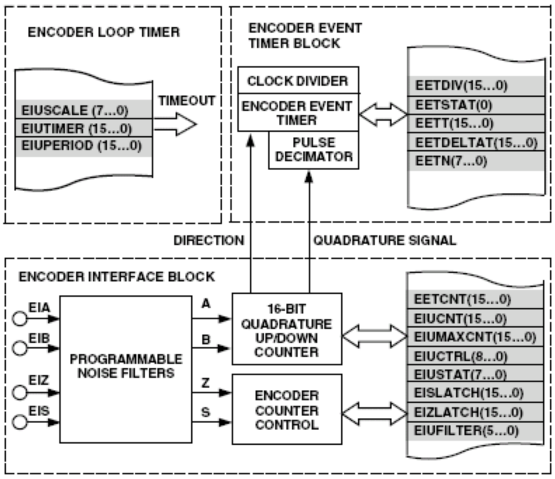
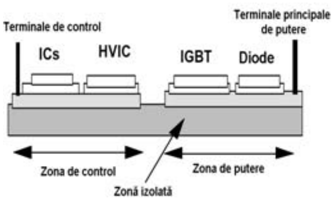


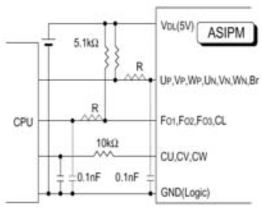
Figure 4 ADMC401 - EIU

The encoder interface unit (EIU) includes a 16-bit quadrature up/down counter, programmable input noise filtering of the encoder input signals and the zero markers, and has four dedicated pins on the ADMC401.

Experimental results

The power module used, is realized with ASIPM – PS12017 (Application Specific Intelligent Power Module), by Mitsubishi Electric. This ASIPM is designed to acoustic noise-less 3.0kW/AC400V Class 3-phase inverter and other motor control applications. [6], [7]





a) b)

Figure 5 ASIPM

Figure 5.a presents internal construction of a ASIPM and figure 5.b shows recommended I/O interface circuit. The block diagram of a PS12017 is illustrated in figure 6.

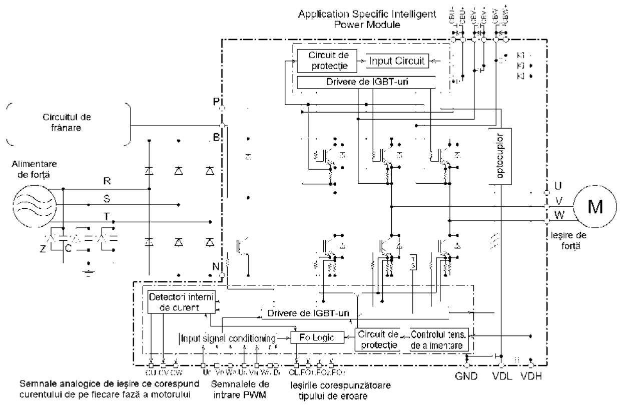


Figure 6 ASIPM – Block Diagram

The experimental results is obtains used the arrangements shows in figure 7.

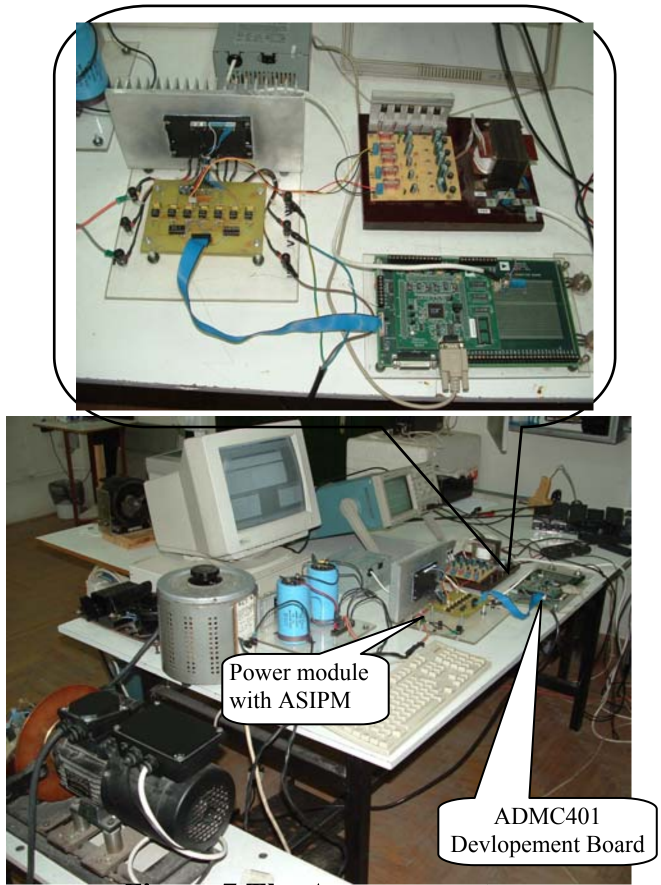
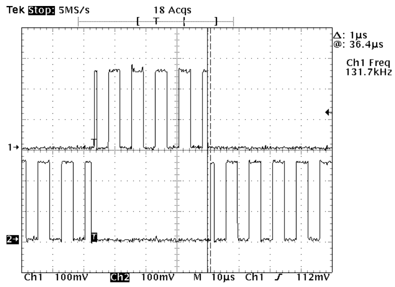


Figure 7 The Arrangements

Figure 8 shows signals AH and AL, with and without PWMGATE active. The chopping frequency set in PWMGARE register is, in this case, 130 kHz and dead time is defined to 1μs by writing this value in PWMDT register.



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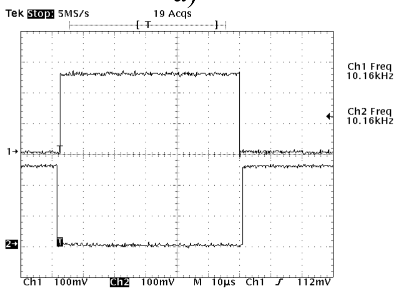

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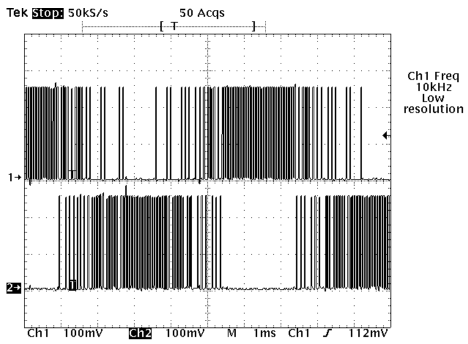
Figure 8 – AH & AL with / without PWMGATE active

Figure 9 illustrate the PWM signals AH and AL with PWMGATE active, for different time set to oscilloscope.



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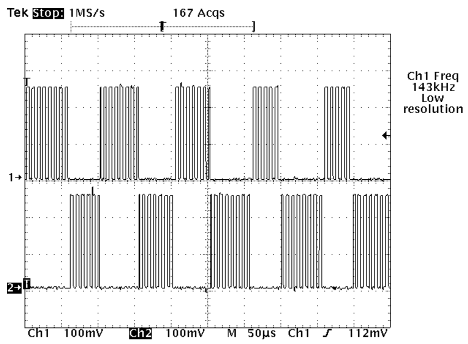
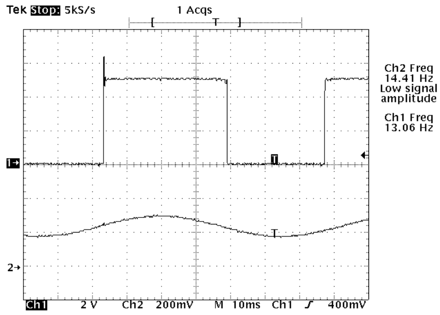


b)

Figure 9 – AH & AL with PWMGATE active

With ADMC401 can realize speed control of induction motor drives. Speed control by means of frequency (and voltage) variation also allows the capability to operate not only at speeds below the rated speed, but also at above the rated speed.



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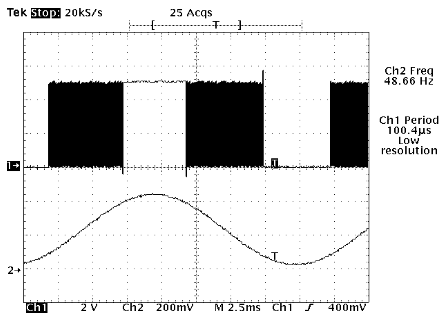


b)

Fig.10 – AH & VrefA at 12 Hz and 50 Hz

Figure 10 shows Ah and VrefA for speeds below the nominal (rated) value and figure 11 illustrate same signals for speed above the rated value (150 Hz). Figure 12 shows the waveforms of the line-to-line voltage (from the inverter) and motor current for different modulation index and different switching frequency 15kHz (figure 12.a) and 10kHz (figure 12.b).

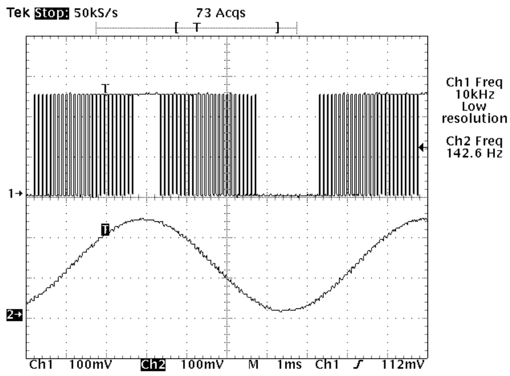
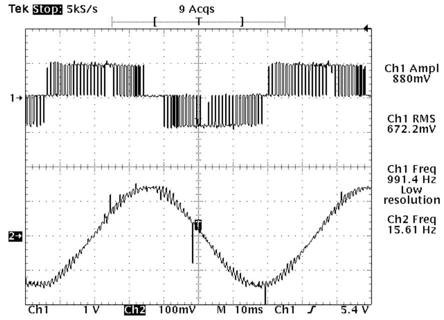


Figure 11 – AH & VrefA at 150 Hz



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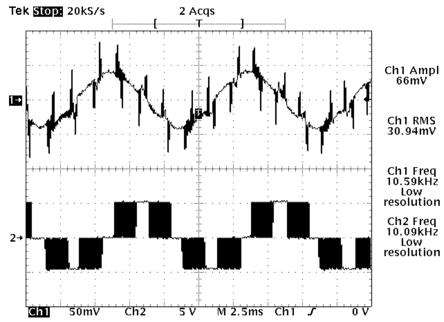

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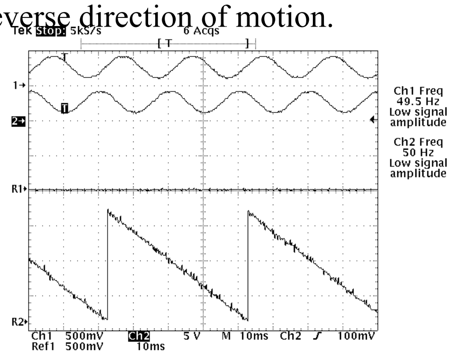
Figure 12 – AH & VrefA at 150 Hz

Figure 13 shows two line-to-line voltages, the speed and the rotor position of the induction motor in two different cases: forward and reverse direction of motion.



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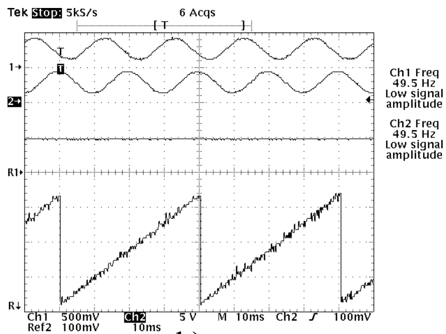

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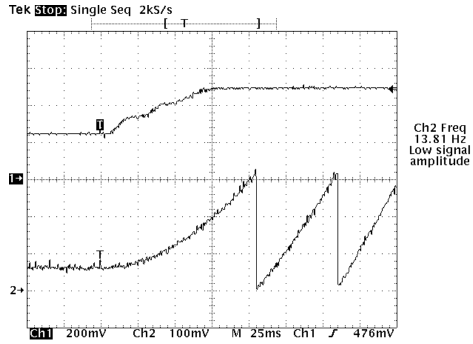
Figure 13 – Forward and reverse direction of motion



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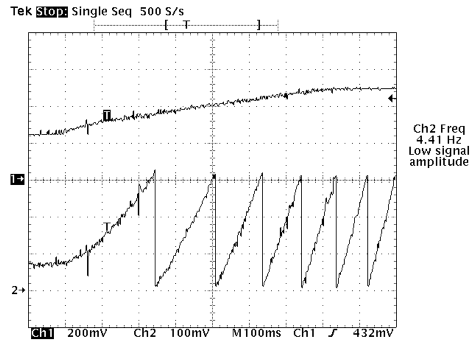

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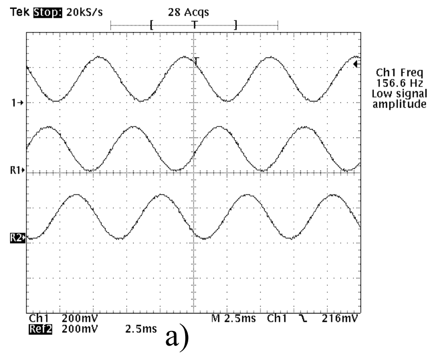
Figure 14 – Speed and rotor positions for different acceleration

Speed and rotor positions for different acceleration a presented in Figure 14.



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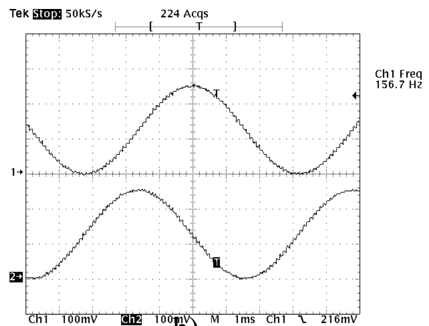

b)

Figure 15 Clarke transformation

Figure 15 illustrate the three-phase to two-phase

transformation (Clarke transformation) Figure 15.a shows three-phase system of the motor currents and figure 15.b shows two-phase system obtain with Clarke transformation.
The second transformation use in vector control is Park transformation, presented in figure 16 for two different angles between reference frame for the rotor and the stator of the electrical motor.

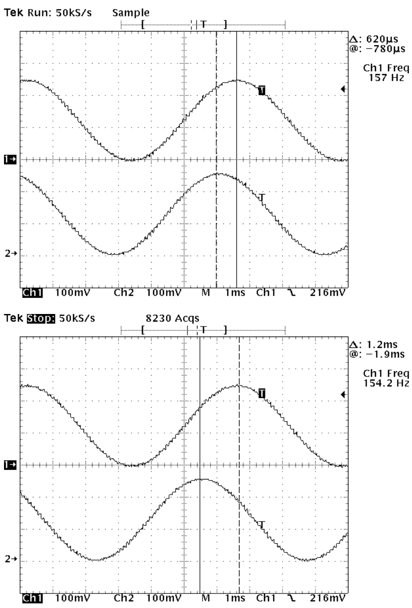

Figure 16 i_α şi i_d signals

CONCLUSIONS

The ADMC401 is a single chip DSP motor controller that included all motor control peripherals necessary for standalone motor control applications. Implementing the control solution in software brings all the advantages of easy upgrading, repeatability, and maintainability, when compared with older hardware solutions.

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