Integrated Solution

For Induction Motor Control

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The command speed has an 'S' form, typical in vertical operation systems. The reason for this command speed is that a soft acceleration/deceleration avoids abrupt movements in the elevator cabin, increasing the comfort level. J.L. Mora, F. Barrero, E. Galván, F. Colodro, J.N. Tombs, M. Barranco*, A. Torralba and L.G. Franquelo; Dpto. de Ingeniería Electrónica, Escuela Superior de Ingenieros, Sevilla Spain

A fuzzy-logic based controller for the speed and position control

It is well known that high performance speed regulation of an induction machine requires vector control. By means of a coordinate transformation of measured currents, we can obtain two new current components directly related with the flux and torque of the machine, so we can control the induction motor as a separately excited DC machine. The angle that defines this coordinate transformation must be estimated using the dynamic modelling of the machine which requires a proper knowledge of the rotor time constant.

The operations that must be performed for a vector control algorithm are nowadays implemented in a microprocessor, usually a DSP. This

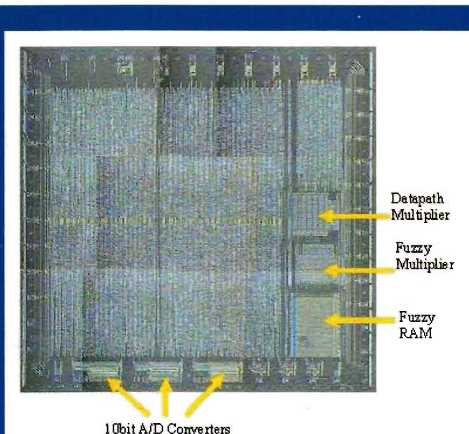

Figure 2: ASITRON, integrates the indirect vector control algorithm, a digital tachometer, a 64-rules built-in fuzzy logic based controller for speed and position regulation, a PWM based current controller and a set of external interfaces, such as A/D converters for current measurements and a microprocessor parallel interface.

Figure 3: block diagram of the ASIC.

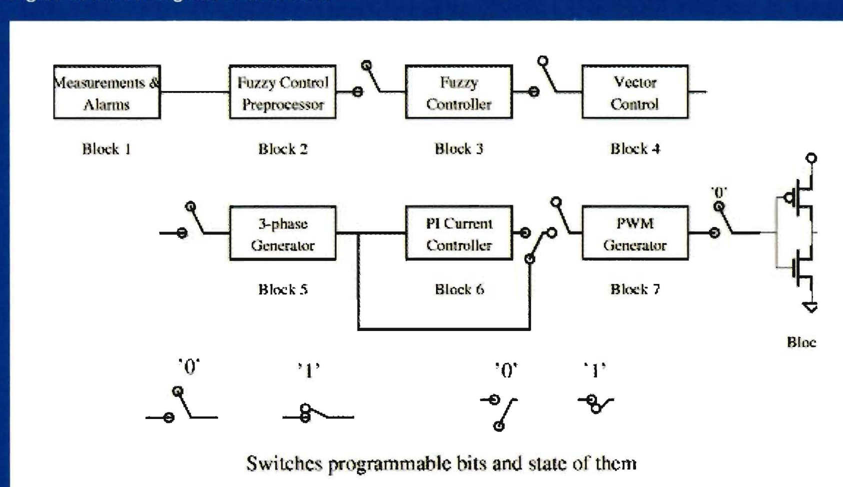

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Figure 1: The ASIC is part of a compact industrial control system.

solution is expensive in development cost, so a specific chip that could perform all the functions required can be an interesting solution.

This article presents an ASIC, named ASITRON that integrates all the logic required for high performance control of induction motors. The ASIC is part of a compact industrial control system for elevators build by Macpuarsa Company (figure 1). In elevator industry, motors are used in a particular way: the motor is operated from zero speed to nominal positive or negative speed and then put back to zero, while positive or negative torque loads are applied.

The comfort feeling of passengers is related with a highly accurate speed and torque control, especially in low speed operation range. This functional operation is accomplished due to ASITRON.

ASITRON, figure 2, integrates the indirect vector control algorithm, a digital tachometer, a 64-rules built-in fuzzy logic based controller for speed and position regulation, a PWM based current controller and a set of external interfaces, such as A/D converters for current measurements and a microprocessor parallel interface. Figure 3 depicts a block diagram of the ASIC, including its programmability. Notice that it can perform a 3-phase PWM current or voltage generator, a classical voltage-frequency controller or to implement a modern vectorial control of the induction motor with a fuzzy-logic based speed and position regulation.

The indirect vector control algorithm, the coordinate change and the current control loop have been implemented using a 13-bits multiplier and an 18-bits adder. Three inputs, the command torque current (obtained from the fuzzy controller), the flux current reference and the mechanical speed (obtained from a speed measurement block) are used to determine the electrical angle, needed for coordinate transformation, and to obtain the reference currents, necessary for the inner current control loop, figure 4.

Moreover, the current control loop is based

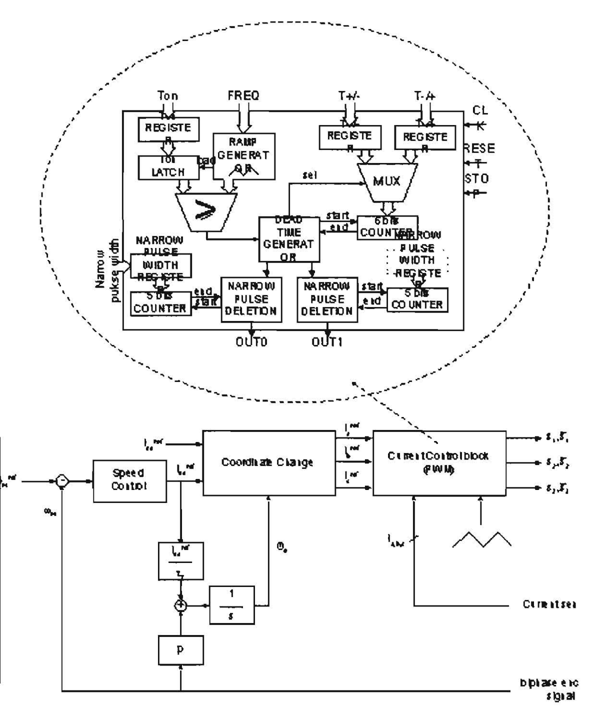

Figure 4: Inner current control loop.

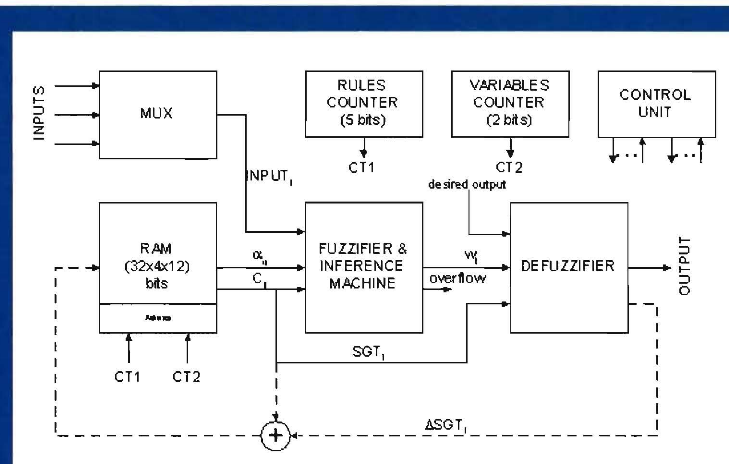

Figure 5: Fuzzy-logic based controller for the speed and position control of an induction motor.

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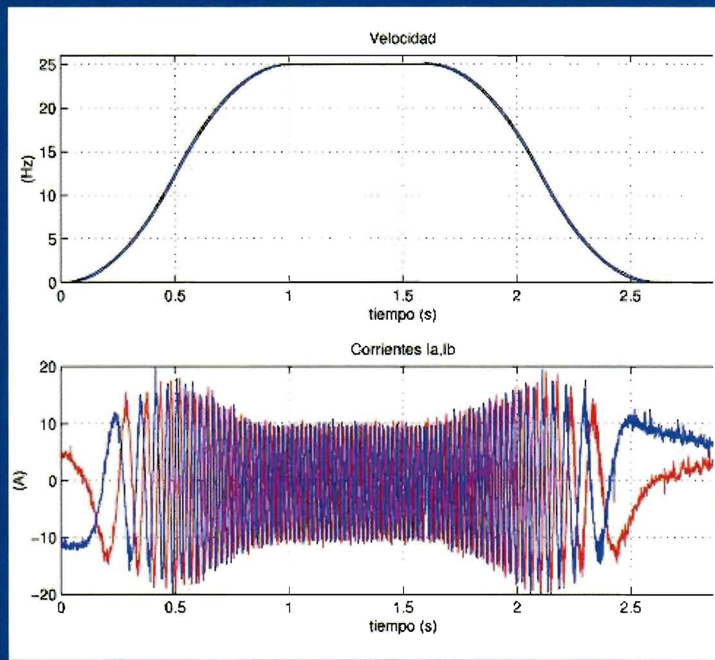

Figure 6: Induction motor controlled using ASITRON from low speed to nominal speed.

on a 10-bits resolution PWM modulation, where the triangular carrier frequency can be set from 5kHz to 43kHz. A programmable PI controller closes the loop. The chip produces 6 digital pulses to drive the gates of a three-phase inverter with programmable dead times (up to 6ms) and narrow pulse deletion (up to 3ms).

The two train pulses of an optical encoder are used to determine speed with 16 bits resolution. A multirange CET method is implemented to cover a wide speed range (0 to ±82 Hz) with a limited absolute error depending on the number of pulses per revolution of the encoder.

ASITRON implements a fuzzy-logic based controller for the speed and position control of an induction motor, figure 5. This controller has three inputs (the speed error, the integral speed error and another one externally programmed) and one output (the command torque current). The different rules (up to 63) that define the control surface are stored in a built-in RAM. Using this controller, an improvement in speed control can be obtained when compared with a classical PI regulator.

Figure 6 shows an induction motor controlled using ASITRON from low speed to nominal speed and, then, put back to low speed without load torque. Mechanical speed and motor currents have been depicted. Notice that the command speed has an 'S' form, typical invertical operation systems. The reason for this command speed is that a soft acceleration/deceleration avoids abrupt movements in the elevator cabin, increasing the comfort level. The motor response, applying a rated speed step is shown in figure 7. Finally, figure 8 presents the system response when a rated torque step is applied at a mechanical speed of 25Hz. The results have been obtained using a 10kW ac-motor test-rig controlled with ASITRON that has been programmed to perform both, an indirect vector and a fuzzy logic based speed regulation.

In this article, a highly programmable ASIC to control 3-phase ac-machines has been presented. ASITRON can be configured to perform 3-phase PWM current (voltage) generator, a classical voltage-frequency controller or to implement a modern vectorial control of the induction motor with a fuzzy-logic based speed and position regulation. The chip has been fabricated using a 0.7 mm CMOS digital technology and it is presently the core of a high-performance AC-drive for elevators manufactured by the Macpuarsa Company. Many units are working today showing excellent results. ◆

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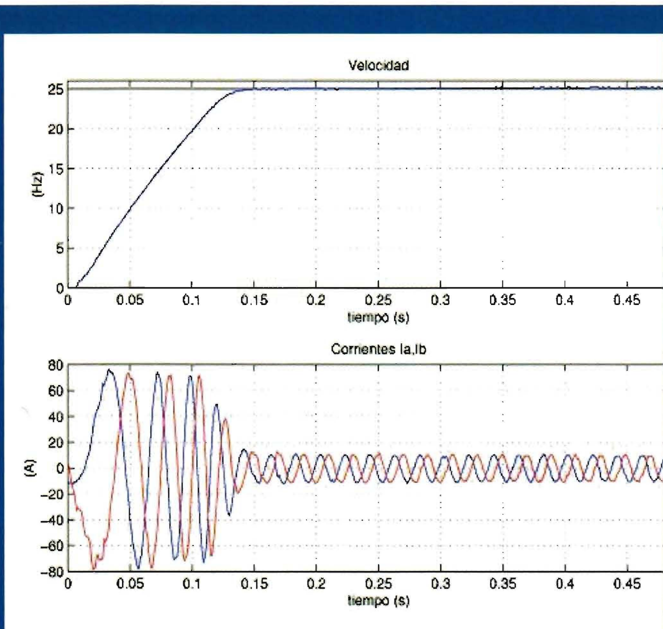

Figure 7:The motor response, applying a rated speed step.

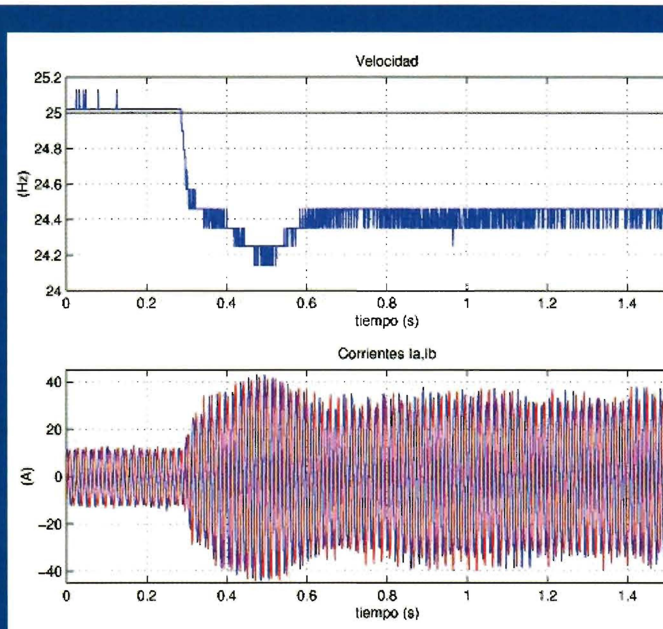

Figure 8: System response when a rated torque step is applied at a mechanical speed of 25Hz.