New Concept

— servo motor with integrated controller

The next generation of the digital AC servo controller has arrived. With built-in encoder, driver and positioning controller, this revolutionary new product has been developed by Danish company JVL Industri Elektronik who are calling it a world sensation.

The innovative R&D department at the Danish company JVL Industri Elektronik A/S has developed a completely new concept in motion control: the MAC motor.The MAC motor is a complete AC servo motor and controller in a single compact unit. It additionally offers previously unseen low-price and operational economy. Incorporating electronics in a motor has been achieved previously, for example with frequency converters, but never before with AC Servos in such a compact unit that can offer true servo performance. In the MAC motor, the servo motor, Hall sensor, encoder and controller circuitry have been specially developed by JVL to provide an integrated unit in which the power driver is mounted behind the motor in a sealed housing.

JVL's new MAC motor is being hailed as a global sensation.

Numerous advantages

The advantages of this solution are that system "intelligence" is decentralised and that there are no cabling between the motor and driver, thus making installation very simple. Nor does this compact unit take space in a control cabinet, and with industry-standard 28-48 VDC powering, operational costs are low. Regulation and powering are based on switching technology, but since switching noise is confined within the unit, the MAC is EMC compliant, and CE marked.
There are many possibilities for interfacing to the MAC motor:

- From a PC/PLC using operating commands via the RS232/RS485 interface.
- Pulse/direction, or incremental inputs. Gear mode.
- 10-bit ±10V input for velocity or torque control.
- Module for register mode via 8 inputs and 4 outputs.
- Module for µPLC with built-in IF THEN ELSE statements.
- Module for Field-bus, Profibus, Canbus, Devicenet, Ethernet, Modbus and more.

Controller and electronic gearing

The MAC motor can be either velocity or torque controlled using ±10V, with encoder feedback to the overall motion controller. In addition, the MAC motor can be used as a direct replacement in any step- or servo system that is based on pulse/direction signals, without modifying the PLC/PC control software. Electronic gearing is built-in so that the MAC motor can simulate any conceivable step resolution.

Re-setting the motor can be achieved either via sensors or mechanically by torque limiting. In addition, CW and CCW end-of-travel inputs and software limits are included.
The MAC motor is available in three different models: 46, 92 or 134W. A NEMA23 flange is standard so that the MAC motor can replace a step motor directly without mechanical modifications. The MAC motor parameters are set-up via the RS232 port using windows-based MacTalk software.

Optimised motor

The motor consists of a brushless ▶

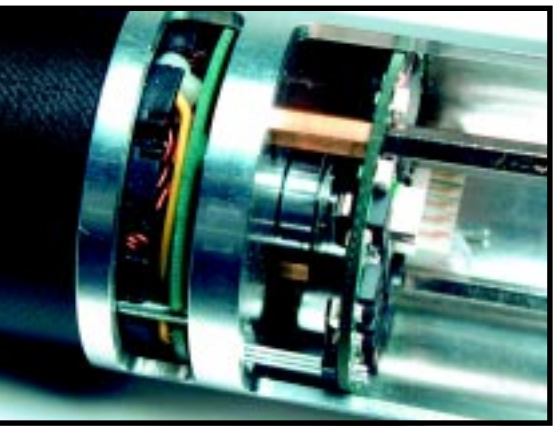
A MAC motor consists of a complete AC servo motor and controller in a single unit, and offers previously unseen low-price and operational economy.

servo motor, hall sensors and encoder. The rotor is constructed of powerful magnets. Hall feedback and a 4096 pulse encoder are mounted at the rear of the rotor. Hall feedback is used during start-up to provide signals to the control circuitry about the angle of the rotor magnets. This information is used for correct commutation of the motor, i.e. to adjust the voltage in the three motor phases correctly so that magnetic alignment is optimised to produce the maximum torque for the minimum current. After start-up, the encoder is used exclusively for feedback and motor operation is 100% digital.

Robust, digital circuitry

The control circuitry of the MAC motor consists of a digital driver and controller to regulate the motor's torque, velocity and position. The vital nerve-centre of this circuitry is a single, very powerful microprocessor that controls all functions. It receives commands via the serial interface and performs digital current regulation and velocity and positioning control — all depending on which of the 8 operating modes of the MAC motor has been selected.

Signals from the HP optical encoder are used for velocity and positioning feedback. The Hall sensors are only used during start-up and for index pulse generation.



The MAC motor is built-up of a Hall-sensor PCB, an encoder and a driver stage, as seen in this cut-away model.

Analogue input signals are very rapidly digitised in a specially designed A/D converter. All components are surface mounted devices and have been especially selected for their ability to withstand high ambient temperature and vibration.

Power supply

Powering of the MAC motor is extremely simple. It need only be connected to a single supply of between 24 and 48V.

Advanced switching technology ensures energy economy and minimises heat generation when the voltage is regulated down to 12V and 5V.

Regulation filter with new 4th-order filter

Normally a PID regulator is used for each of a system's 3 regulation loops (torque, velocity and position). A PID-based system however is only a 1nd-order regulator.

And it is in this area that JVL has developed and implemented a new regulator. It is based on purely mathematical models from textbooks — i.e. a theoretically perfect regulator. It requires knowledge of the mechanical system. Once this is known, it is possible to calculate the precise regulator for a specific system. Such a regulator is based on the ability to determine the poles and zeroes of the mechanical system, after which the equation can be keyed into the motor.

This however is unacceptably complex for users and JVL has therefore developed a technique that calculates the required parameters based on a 4th-order regulation filter and saves the data in the motor. In contrast to a PID regulator, a 4th-order system is better able to handle non-linear and undamped systems.

Higher order regulators are something that JVL has worked on for many years and which the company has developed specifically for the larger Servo Controller model AMC20, which can be used with motors up to 3kW. In this system, a 7th-order filter consisting of more than 50 parameters is used.

Adjust 1 parameter, achieve 5 benefits

A common feature of all JVL regulators is that the user need only adjust a single parameter. This is called the "load factor", since it is only dependent on the inertia of the system. The larger the inertia of the motor, the larger the load factor. For the expert, it is still possible to tune very complex and undamped systems via a mathematical model. The MAC motor's 4th-order regulator described above gives the user the following benefits:

- Shorter installation and system commissioning times.
- A stiffer system with shorter positioning times.
- Inexperienced users can readily set up a system.
- Oscillations due to non-linear mechanical systems are avoided.
- Minimum positioning error during operation and halt.

Five modular solutions

Since no two customer's requirements are exactly the same, JVL provides several modules that offer the following:

- NanoPLC, which enables simple positioning using, for example, register mode.
- Advanced µPLC including provision for programming.
- Field bus, Profibus, CANbus, Ethernet, and more.
- Dsub connector, IP67 sealed connector or outgoing cable.

In addition, all motors offer provision for mounting a planetary gear with ratios of 3, 5, 10, 20 or 100:1.

About the author

The author is the director and co-owner of JVL Industri Electronik A/S. He is Sales Director at JVL and holds a degree in electronic engineering (1990).