MOVING YOUR WORLD

IDEAS IN MOTION CONTROL FROM MOOG INDUSTRIAL

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MOOG

FEATURE ARTICLE

SHAKEN AND STIRRED – MOOG HELPS SINK A BUILDING FOR JAMES BOND

By Rebecca Gunn, Sales & Marketing Co-ordinator (UK)

Box office figures have confirmed that the most recent James Bond film 'Casino Royale' has been one of the most successful in this ever-popular franchise. Although the film steers clear of some of the more traditional gadgets that 'Q' can muster up; it still has a breathtaking array of special effects scenes. One of the biggest, the sinking of a Venetian building, was a unique motion control challenge that involved Moog and its partner EMP Designs Ltd. Moog's role was to ensure the smooth and safe operation of a huge rig that had to sink one of three motion bases, the largest weighing 80,000 Kg (176,370 lbs), into the large water tanks at Pinewood Studios just outside London.

Sinking Venetian house at Pinewood Studios

The sinking building was part of one of the final scenes in the film and required two different camera angles – an external scale model shot against a blue screen to show the building sinking into one of the Venetian canals and a full-scale internal model used to film the actors inside the actual sinking building. The structures themselves, developed under the auspices of special effects supervisor Chris Courbould, had to be controlled with extreme precision so carefully choreographed stunts and action sequences could be filmed. Courbould and his special effects team built the structures and then called in Dan Stanton and his team from EMP Designs, to develop the control systems.

The equipment designed to control the rig centred on an M3000 system, which for this application can be split into the hardware – Moog Servo Controller (MSC); and software – Moog Axis Control Software (MACS). It was used to control six digital Moog Axis Control Valves (ACV), which, in turn operated six hydraulic actuators. Feedback of the actuator position was achieved using a number of wire-driven encoders supplied by the partner company. The digital nature of all of the hardware was a major selling point according to Dan Stanton at EMP Designs who states,"With respect to the hydraulic control, we have worked with other companies in the past, but we wanted to do something special this time. Moog was the only company that could supply what we wanted – a hydraulic system based on digital valve technology".

Moog Servocontroller (MSC)

Mr. Stanton continues, "The digital approach offered us finer control and it also gave us more confidence when it came to the safety aspects as, if anything were to get disconnected or the control was lost, we knew about it as it gets detected immediately. Much of the actuation was also performed in synchronized pairs so digital also gave us far greater control in this respect. Another vital consideration was the amount of radio frequency that exists on film sets, and given the long cable lengths digital is far more resilient so we were less prone to external influences in the control and feedback loops."

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In the application the MSC controller used a CAN link to connect to six Axis Control Valves each of which controlled a cylinder – working in pairs, this gave three axes of motion. The Axis Control Valves then used a CANOpen link to connect to the BTF encoders, which produce a unique digital code for every 0.025 mm (0.00098 in) of travel – providing the precise feedback required for cylinder position. The Axis Control Valves provided remote closed-loop position control for each degree of motion. This reduced the processing load on the MSC allowing it to take care of the safety monitoring and synchronization. The MSC provided all the profile generation for the ACVs over the CAN Bus. "This was a new approach for us but the Moog M3000 offered us a stable, flexible control structure and cost-effective solution for what we were trying to achieve," continues Stanton. "It also offered the capability for us to integrate a 38.1 cm (15 in) touch screen (HMI), which gave us a complete simplistic overview of the system using MACS (Moog Axis Control Software) – which, as well as offering us clear visualizations, allowed us to pinpoint the source of any erroneous readings.

"One important aspect of the software was that it allowed the system to self diagnose," Stanton explains. "We were able to create routines that would highlight any discrepancies or anomalies. This was the first time we had ever used a controller that helped us make the decision of whether to press the 'big red stop button'; if anything deviated it was able to assess the severity and then make a decision based on this figure – it took a lot of the worry out of it for us. The controller also incorporated a 'Watchdog' which reverted to a safe state should any issues arise with the controller."

"There are some very big movies in production at the moment which are also using this technology," Stanton continues. "Indeed there has been significant interest from the movie world with many production companies expressing an interest in what we can do with this digital system. The flexibility of the M3000 system is that it is also designed for electro-mechanical actuation, this allows us to look at other types of film effects including smaller scale animations using small DC motors; once again it is the software that pays dividends. We also have to consider the fact that movie concepts can change over night so flexibility is vital – this is another benefit the digital approach gives us."

About the Author:
Rebecca Gunn is the UK Industrial Sales and Marketing Co-ordinator, based in Tewkesbury. Employed since August 2006, Rebecca is responsible for marketing communications in the UK. Previously self-employed for 5 years supporting UK businesses manufacturing technology associated with learning and development, and prior to that, working 5 years for the McGraw-Hill group as a marketing co-ordinator for their former UK based elearning business. Rebecca is a CIM (Chartered Institute of Marketing) qualified marketer.

About EMP:
EMP Designs Ltd is a design consultancy specializing in projects involving Electronic, Pneumatic, Hydraulic and Mechanical systems. This includes multi-axis closed loop positional systems either servo driven or hydraulic for any scale from needle positioning to 80 ton platform control, PLC driven industrial control, programmable sequence controllers, electronic project/test boards, encrypted radio communication and controls and opto-electronic displays.

In the film industry EMP has designed solutions for camera crews, model makers and special effects teams on many high-profile movies such as 'Casino Royale'.

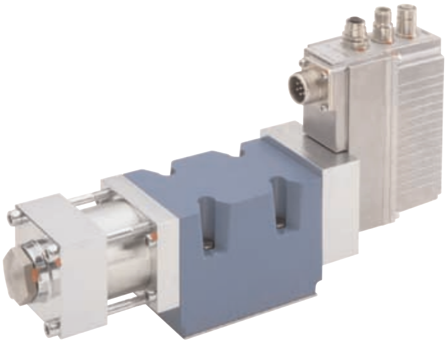
EMP also has in-house machining facilities which enable them to make accurate components, design and manufacture printed circuit boards, and design and build a variety of product housings to complete a project.

Further information can be obtained from www.empdesigns.co.uk or email Dan Stanton on dan@empdesigns.co.uk

PRODUCT SPOTLIGHT

NO LIMITS: HIGHER DYNAMICS WITH NO OPERATIONAL LIMITS FROM NEW SERVOVALVE

By Dirk Hirschberger, Team Leader, Engineering Direct Drive Valves and Lutz Bienemann, Senior Product Engineer

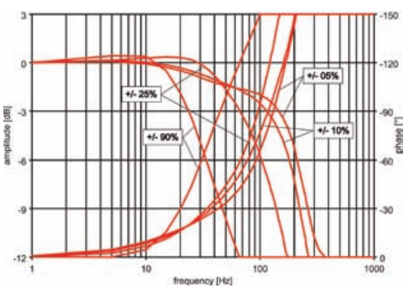


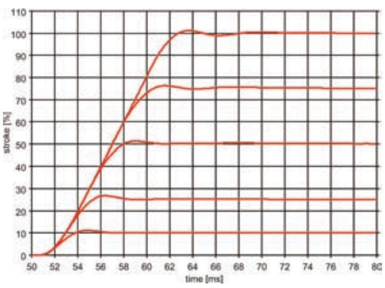
D637/D639 Direct Drive Interface Valve

With the new Direct Drive Digital Interface Valves (D637/ D639), Moog offers the marketplace a wider portfolio of high performance servovalves with reliable digital technology. This new product series is a single stage Direct Drive Servovalve, Size 5 (Cetop 05 mounting pattern according to ISO 4401-05-05-0-05) with sliding spool/bushing design. This flexible valve series is available with flow control (Q-control / D637), pressure control (p-control / D639) and flow and pressure control (pQ-control / D639) functionalities. The D637/D639 Servovalves are tuned for very high dynamic performance and achieve a typical frequency response of 140Hz (for -90° small signal) and 14 ms (100%) step response time. This unique performance is achieved with the combination of an "advanced control algorithm" and the high natural frequency of our permanent magnet linear force motor that drives the valve spool. The same excellent performance is also reflected in the static data where hysteresis is typically less than 0.05%.

Handling Very High Pressure Drops

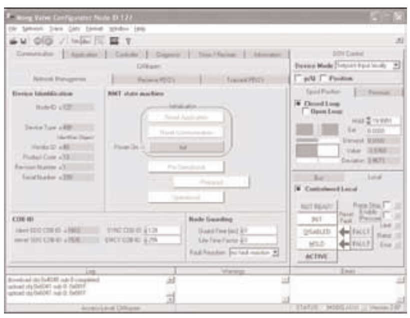
As opposed to many other Direct Drive Valves on the market (e.g. proportional solenoid or voice coil driven), the D637/ D639 Valves do not have operational limits which means that within the pressure rating of the valve it can be operated even at the highest pressure drops in 4-way, 3-way or 2-way modes. This important benefit is a result of the high driving forces of the permanent magnet linear force motor (LFM), the flow force compensation of the spool/bushing unit (each land separately compensated) and control tuning for high stability.





Digital On-Board Electronics

These Digital Direct Drive Valves can be operated with a standard analog signal as well as via a fieldbus. Available fieldbus systems include CANOpen, Profibus DP-VP1 and EtherCAT. Start up and configuration of the valve can be easily implemented via the fieldbus interface of the machine control or by Moog's user-friendly MS Windows-based configuration software. This software represents Moog's commitment to a flexible interface that can be used for our digital valve and pump products lines. An important benefit of fieldbus operation is that control parameter settings (e.g for pressure control (D639 /p-control)) are easy to complete and up to 16 pressure control parameter settings may be saved for activation during operation. These dynamic servovalves can also be requested for higher level axis control such as position, speed, and force-control for special applications.



Moog Valve Configurator Software

The digital onboard electronics (OBE) used on these products have also been used on other valve products in our portfolio such as the D636/D638 Digital Direct Drive Valve Series (Cetop 03) and the pilot-operated D67x Servo-Proportional Valve series where their superior functionality and robust performance have been proven in many different applications. Pre-production valves of the new D637 series have been performing successfully in multiple applications such as position control for water turbines.

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PRODUCT SPOTLIGHT *continued from page 3*

Technical Data

Model Number	**D637/D639 Servovalves**
Valve construction type	Single stage, sliding spool with bushing
Mounting pattern	In accordance with ISO 4401-05-05-0-05 (with or without leakage port Y)
∅ Diameter of the ports	11.5mm
Valve configuration	2-way, 3-way, 4-way and 2x2-way operation
Actuation	Directly with permanent magnet linear force motor
Pilot oil supply	None required
Rated flow Q_N	60 100 l/min (dependent on model /for Δp=35bar/land)
Max. leakage flow Q_L *	1.2 2.0 l/min (dependent on model)
Max. flow	185 l/min
Spool lap	Zero lap, <3% or 10% positive overlap (dependent on model)
Step response time for 0 to 100% stroke	14ms (typical)
Hysteresis *	<0.05% (typical) max. 0.10% (Q-function)
Null shift	<1.5% at ΔT=55K (Q-function)
Linearity of pressure control (D639)	<0.5%

* at operating pressure p_p==140bar, oil viscosity ν=32mm²/s and oil temperature 40°C

About the Authors:

Dirk Hirschberger is the Team Leader, Engineering Direct Drive Valves and has worked for Moog in Product Development since 1991 based in Germany. He studied mechanical engineering in Esslingen, Germany.

Lutz Bienemann, has been Senior Product Engineer responsible for Digital Direct Drive Valves since 1999. He studied mechanical engineering in Zwickau, Germany.

DID YOU KNOW?

WHIPPING UP A STORM WITH ADVANCED HYDRAULIC TECHNOLOGY

By Dieter Kleiner, Hydraulic Controls Engineering, Moog GmbH
and Ulf Rasmusson, Business Manager North & North-East Europe

In order to help a company provide the advanced simulation requirements demanded by the marine industry, Moog has supplied advanced hydraulic technology to MARINTEK, a Norwegian Marine Technology Research Institute, located in Trondheim, Norway.

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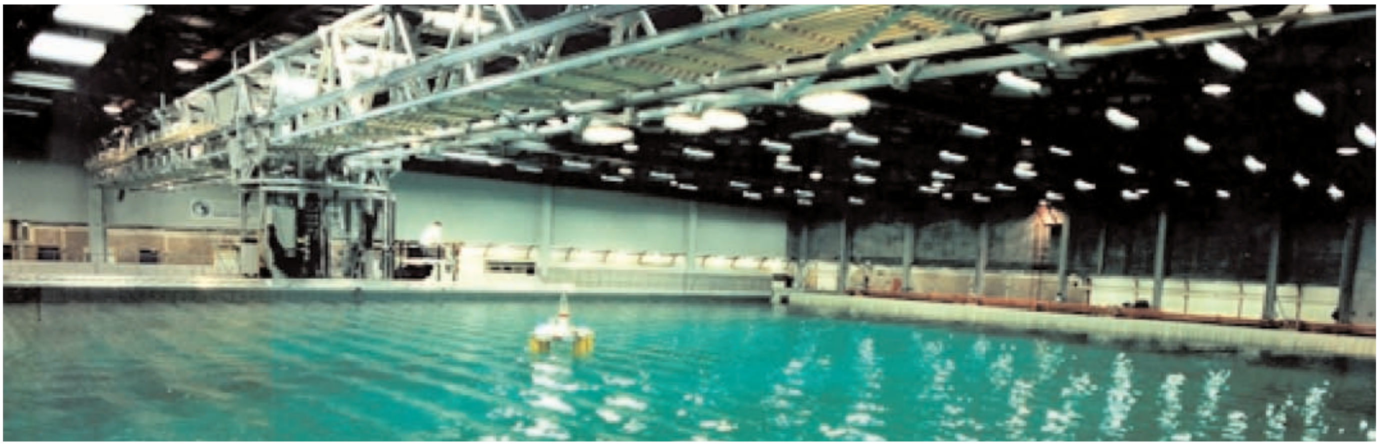

MARINTEK's ocean-basin laboratory in Trondheim, Norway

DID YOU KNOW?

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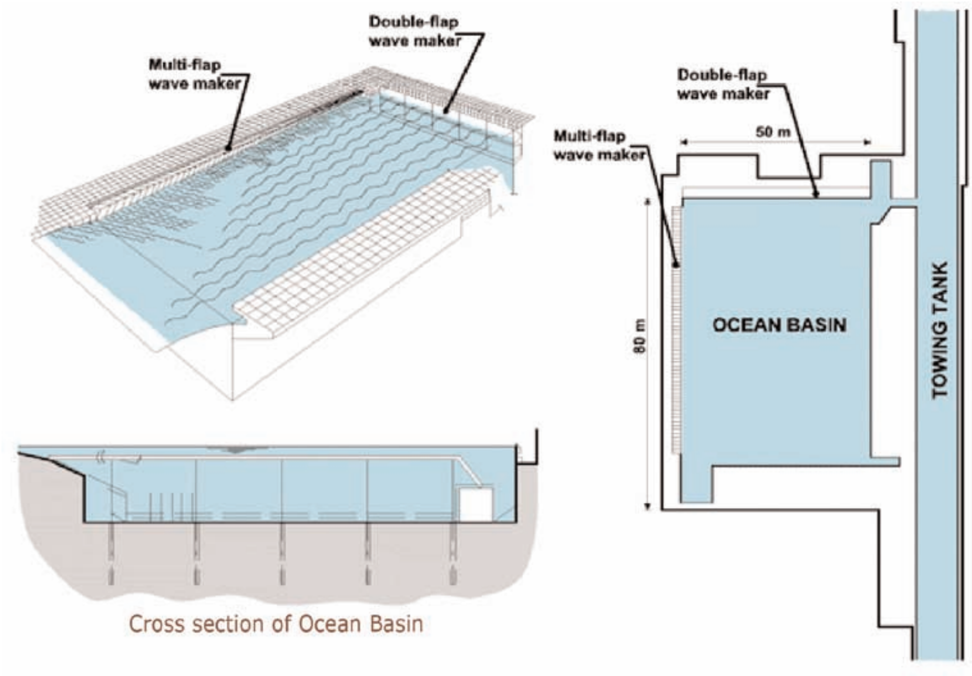
With marine technology advancing on an almost daily basis, there is a huge demand for model testing facilities capable of running highly accurate and reproducible tests. MARINTEK offers one of the biggest ocean-basin laboratories in the world: 80m (262 ft) long, 50 m (164 ft) wide and an adjustable depth of 0 to 10 m (33 ft), it recreates sea conditions using an array of flaps – two on the end and 144 single flaps along its length. In addition, the basin is equipped with a carriage system that caters to free-running models at speeds of up to 5 m/s (16.4 ft/s) at any angle to the waves.



Cross section of Ocean Basin

MARINTEK chose Moog as their partner to upgrade the Ocean Basin, built in 1981, with new technology. Their aim was to not only make the system more robust and more reliable but also to provide enhanced capabilities, such as larger waves over a wider area of the basin and more directional flexibility. The most important driver for the upgrade was the need to increase overall performance. Indeed, an accuracy of 0.1 degrees for all flaps was requested to guarantee the creation of highly reproducible waves with a height of up to 0.4 m (1.3 ft) in as little as every 1.6 seconds.

Another major requirement was the capability to self-monitor – taking into account not only the cost-per-hour, but also the impact of the test results obtained on human safety and the investments required to build the resulting ships and platforms. The solution had to integrate into the existing environment, especially the waveform computation system and measurement equipment while also offering flexibility to cater for future expansion. Due to the existing 700kW (952 HP) hydraulic infrastructure a hydraulic solution was the obvious answer.

The solution is built up of 144 hydraulic cylinders, each controlled by a Moog D636 Axis Control Valve (ACV) – a servovalve with axis control capability. With the position sensor of each cylinder being connected directly to the servovalve, the D636 closes the position loop and offers additional features such as self-monitoring of the control loops and the position sensor.

Each group of 12 ACV servovalves is connected via CANopen to a Moog Servo Controller (MSC), a freely programmable motion controller with multiple interfaces such as CANopen, Ethernet and Profibus-DP. The MSC offers two independent CAN interfaces each controlling 6 valves. The 12 MSCs are connected to the waveform computation system, distributing the set points and the actual position and status information from each valve. In addition to the hardware, the Moog Axis Control Software (MACS) – an IEC 61131-compliant development environment – was used to create the application programs.

Initially, a test system comprising one hydraulic cylinder, a position sensor, an Axis Control Valve and a MSC controller was installed to verify the calculated accuracy and dynamics. Subsequently, with the results fulfilling all requirements, the upgrade of the whole basin commenced.

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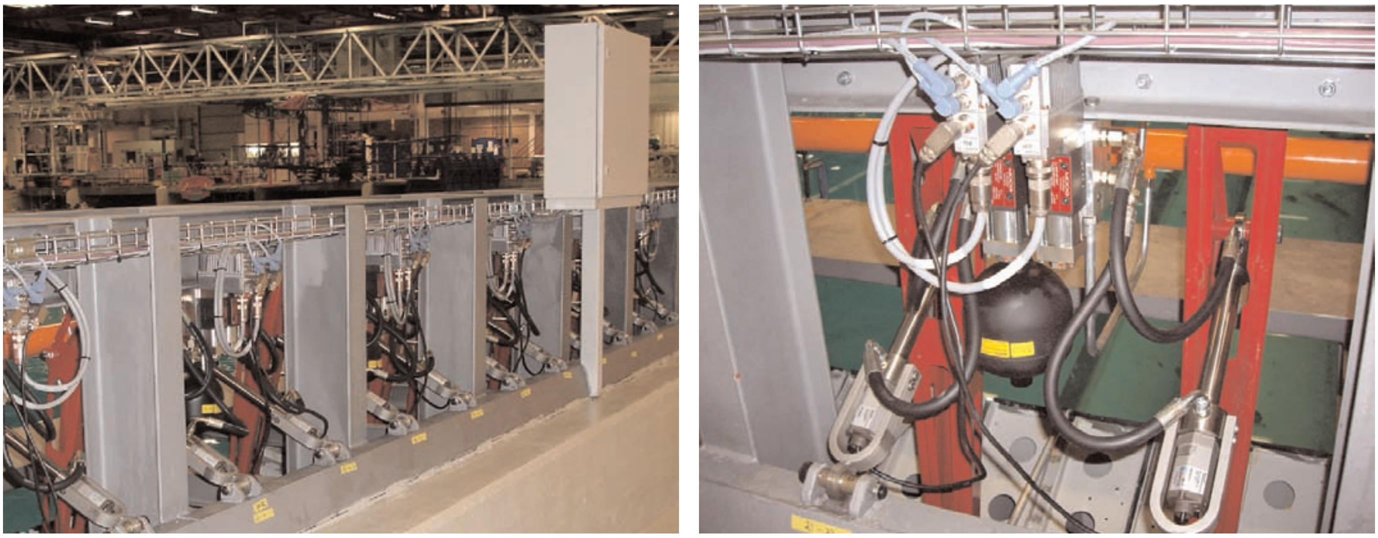
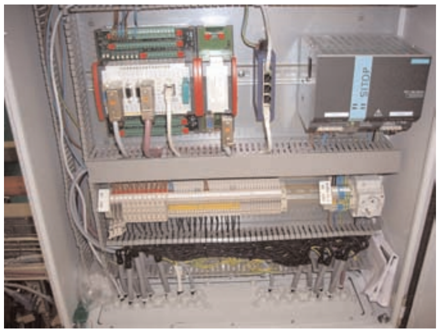


Details of multi-flap wave maker showing hydraulic cylinders and Moog Axis Control Valves

In total, 12 cabinets were installed along the length of the basin; each containing one MSC, connected via CANopen to 12 D636 Axis Control Valves. Due to the use of a fieldbus, the installation effort was surprisingly low considering the number of devices and the physical size of the system. Indeed, CANopen was selected because of its multi-master capability, its flexibility and functional safety.



1 of 12 cabinets containing a Moog Servocontroller (MSC)

"The biggest surprise for me was how easy it was to program this system with all the 144 axes," explains Frank Andersson, senior engineer at MARINTEK. Andersson was involved in the software development from the start of the project, as he wanted to be able to extend the system by himself in the future. As a result of the upgrade, the usable length of the basin for wave testing has been increased – thanks to the accuracy of the flapper movement – a major advance for testing high-speed ships and ferries as the number of test sequences can be reduced.

With the advanced feedback capabilities now available from Moog's ACV range, designers and engineers no longer have to trade force for accuracy and vice versa. Moog's servovalve capabilities are well known throughout the industry and this new technology only serves to reinforce the company's position within the hydraulic market.

About the Authors:

Dieter Kleiner is responsible for customer support and training of M3000 products. He has been working on software development projects for control systems used in industrial and military applications.

Ulf Rasmusson is the Business Manager of North and North-East Europe based in Gothenburg, Sweden. Employed since May 2004, he is responsible for developing and managing the Moog business in the Nordic Area. He holds a Master of Science degree in Electrical Engineering from the Lund University (Sweden) and over 20 years of experience in the Automation Industry.

MSD SERVODRIVE PROVIDES HIGHEST LEVELS OF DYNAMIC RESPONSE

By Andreas Noll, Engineering Manager Drives

Moog introduced its Modular Multi-Axis Programmable Motion Control Servodrive (MSD) System at the SPS/IPC/Drives Exhibition (November 27 -29 2007) in Nuremberg, Germany. This new family of MSD Servodrives enables us to address unique application requirements of our customers with performance-based, tailored motion control solutions. The MSD system consists of the Moog Motion Controller, Servodrive and a shared power supply unit. This system was developed to meet the demands of key industrial applications such as plastics and metal forming industries for higher productivity, higher accuracy and the flexibility to share technologies across multiple machine types.

Flexibility and High Performance

Some of the primary benefits of the MSD for customers that are testing this system are its flexibility and high performance characteristics. With the freely programmable Motion Controller, the MSD system is able to meet the toughest demands in the targeted industries. Due to its modular architecture, the system is able to control a wide range of servomotors such as brushless PM AC motors, torque motors, linear motors and asynchronous motors, allowing for flexibility in machine design. The MSD meets our customers' demand for increased machine output through many high-performance features.

- Fast update rates of current, position and velocity control loops for highest levels of dynamic response and machine precision
- Support for multiple communication protocols via fieldbus connection for an open architecture and machine versatility
- High speed internal communication via EtherCAT for control and coordination across multiple axes
- Comprehensive software package with IEC 61131 programming for quick and simple realization of the control software
- Support for up to three feedback devices like sin/cos single and multi-turn encoders for precise positioning
- User-friendly GUI for PC supported parameterization
- High safety functions according to IEC 61508

The MSD System

The main modules of the MSD system feature some key technologies and provide many benefits when used as a stand-alone product or a system.

The MSD Motion Controller (Figure 1) is based on a 32-bit, 400MHz microprocessor. The Motion Controller can coordinate and synchronize axes, and implements the communication to host computers and other PLCs. With its PLC functionality, it may

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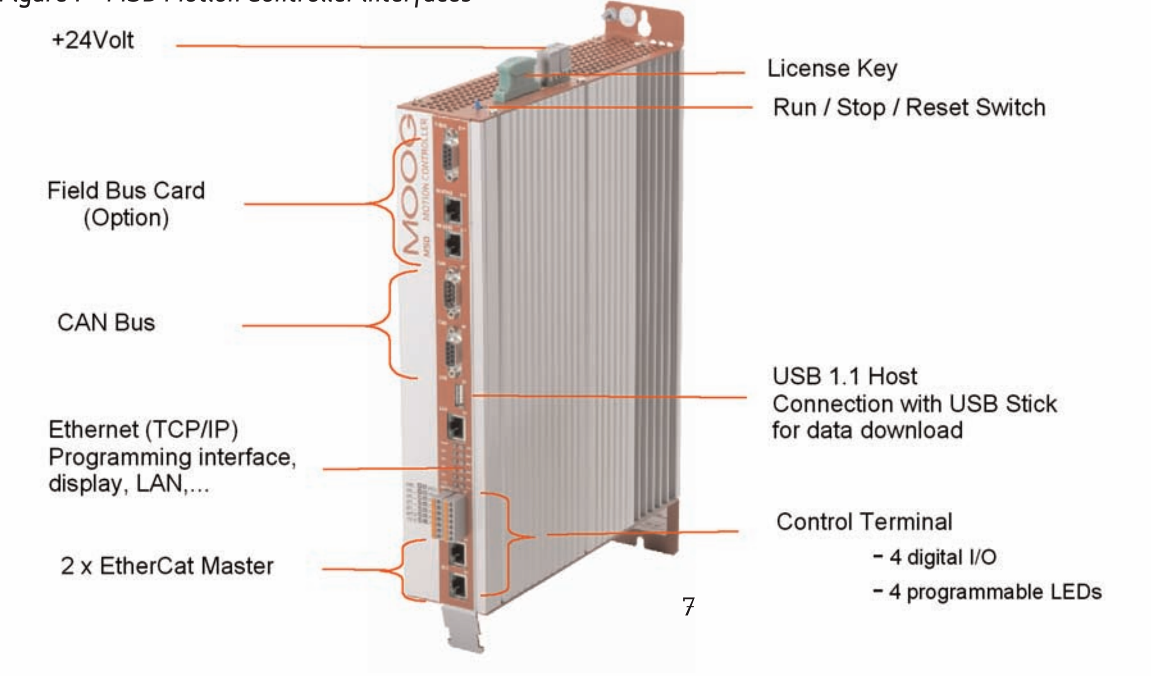
Figure 1 – MSD Motion Controller interfaces

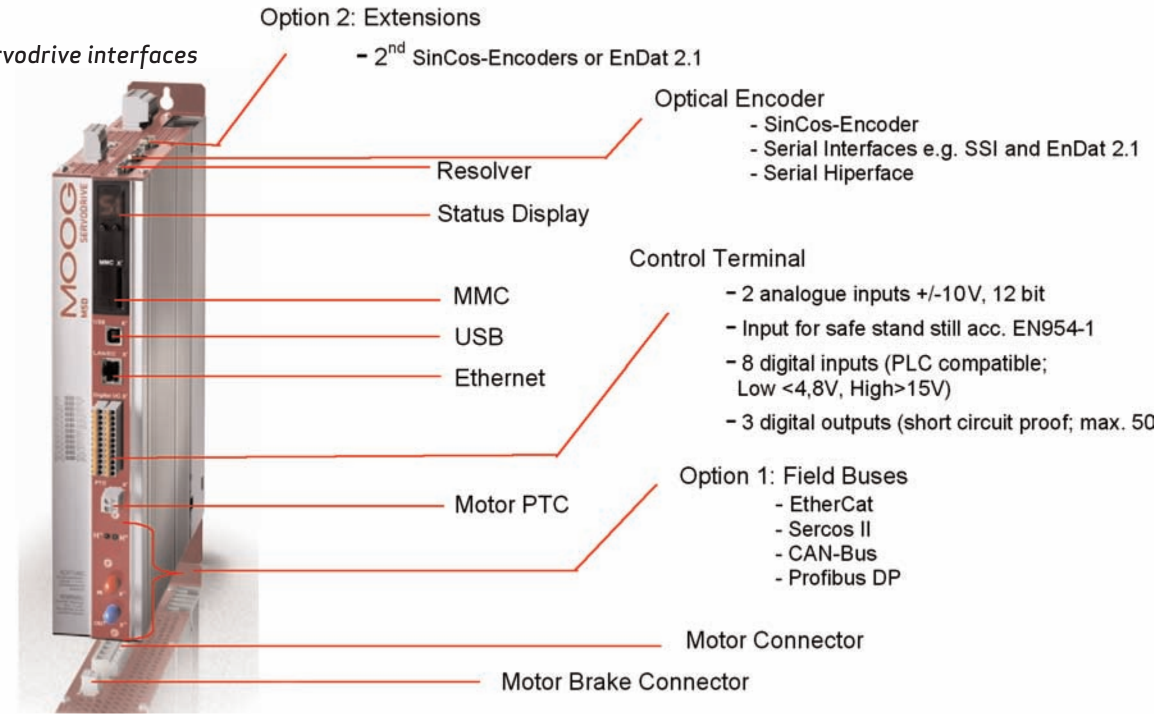


itself control processes of the machine or parts of it. It may close velocity and position loops for up to 30 axes. Additionally, it is able to control input and visualization devices. It supports various communication protocols such as EtherCAT, SERCOS III, CANopen, CC Link, PROFIBUS DP and PROFINET. Internal communication takes place via EtherCAT buses.

The Motion Controller supports IEC 61131 programming in a visual environment with embedded libraries for easy use. For "Advanced Control", programming of custom control loops using MathWorks/C/C++ is possible, which enables the creation of application-specific templates for deeper integration into the machine.

The **MSD Servodrive** (Figure 2) closes current loops (PWM frequencies 4, 8, 12 and 16 kHz) and is also able to close velocity and position control loops. For high-performance control loops, high update rates are supported: the MSD operates at cycle times of 62.5 µs for current and 125 µs for velocity and position loops. Currently, 7 mechanical sizes, based on output power, are available, ranging from 4 Arms up to 250 Arms. It supports feedback devices such as Resolver, EnDat and Hiperface as standard (customer application specific position feedback is possible upon request). Besides air-cooling as standard; cold plate and liquid cooling are available as options.

Figure 2 – MSD Servodrive interfaces



Some of the high-performance features of the MSD Servodrive are listed below:

- Feed forward structure for higher response time and reduced tracking error
- Compensation of friction torque and cogging torque
- Compensation of mechanical ballscrew errors for both directions
- Patented method (**G**ain **P**hase **O**ffset **C**orrection - **GPOC**) with correlation technique to compensate encoder and resolver errors (Figure 3)

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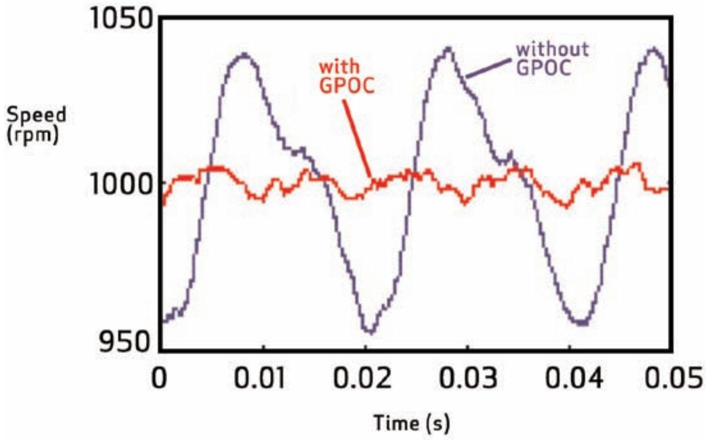
Figure 3 – GPOC used on resolver



- Velocity observer (Figure 4): Instead of a filter for the actual value of the velocity an observer can be used. The observer reduces the noise like a velocity filter but with less delay of the velocity signal. It ensures not only higher gain for the velocity - and position controllers and reduced tracking error, but also makes tuning simple with only one parameter.

Figure 4 – Velocity observer

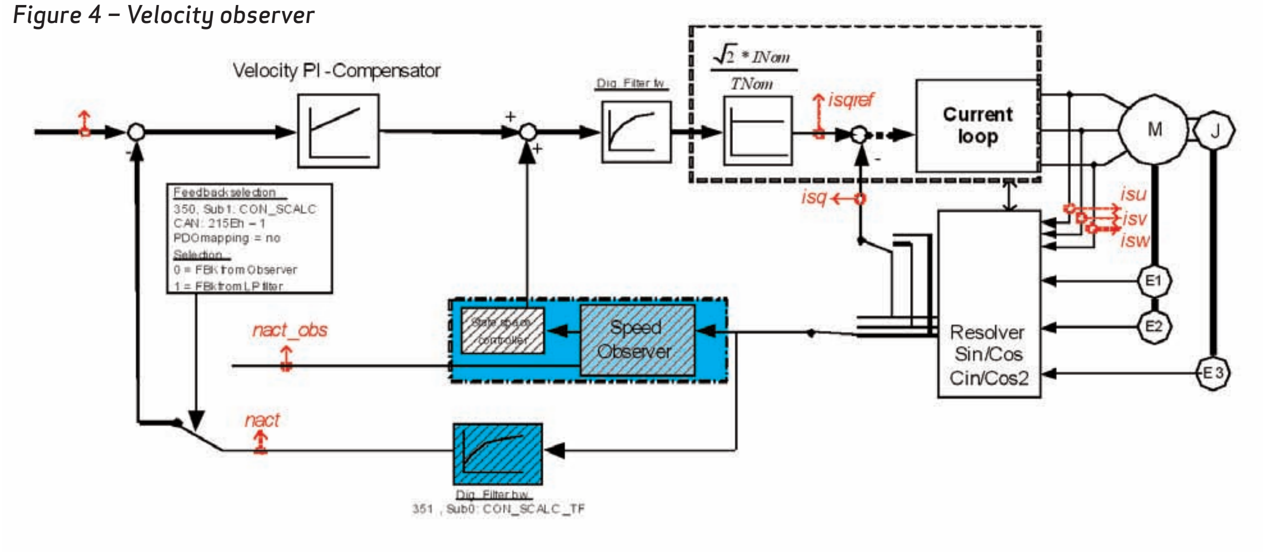


Figure 5 gives an overview of the currently available Servodrive sizes and their specifications.

Figure 5 – MSD Servodrive specifications

	Size 1		Size 2		Size 3		Size 4		Size 5			Size 6		Size 6a	
Continuous current effective [Arms] at 8kHz PWM	4	6	8	12	16	20	24	32	45	60	72	90	110	143	170
Max current [Arms] for 10 seconds	8	12	16	24	32	40	48	64	90	120	144	135	165	215	255
Rated Voltage	3 x 230V, 3 x 400V, 3 x 460V or 3 x 480V ± 10%														
Certification	CE, cUL														
Dimensions (W x H x D) [mm] without connector	58.5 x 295 x 224		90 x 295 x 224		130 x 295 x 224		175 x 295 x 224		190 x 345 x 240			280 x 540 x 242		280 x 540 x 322	

To ensure cost advantages for our customers with complex applications, we are developing a shared Power Supply Unit (PSU) of different sizes as an integral part of our MSD system. The PSU will enable our customers to achieve economies of scale by saving energy and ensuring high-precision current supply for their applications. The PSU unit with active regeneration capabilities allows regeneration of energy in the electrical supply network, and it ensures additional power for applications by boosting up the DC voltage to 750 VDC.

Flexible Architecture

Two main scenarios are described here to illuminate the architectural flexibility of the MSD system:

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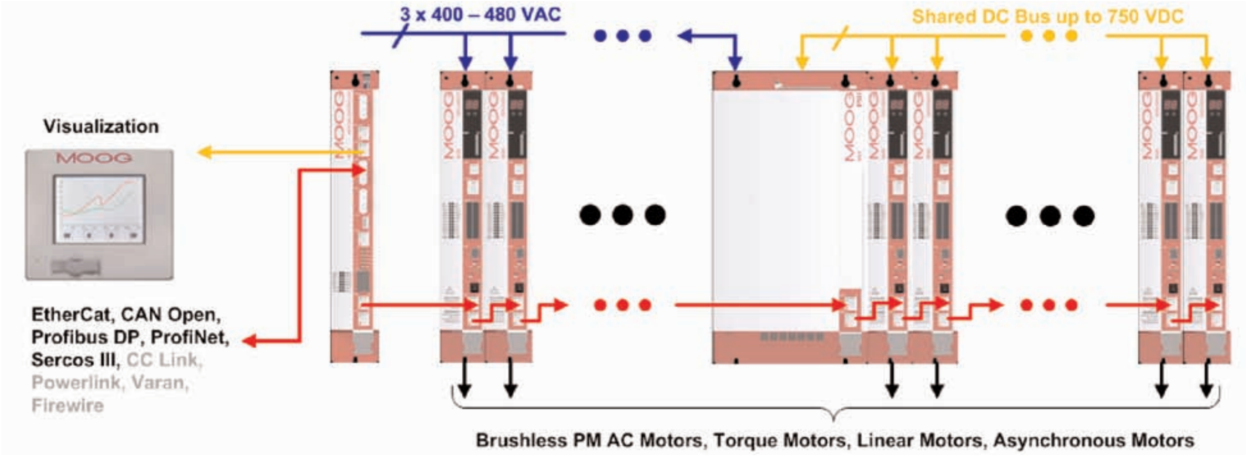
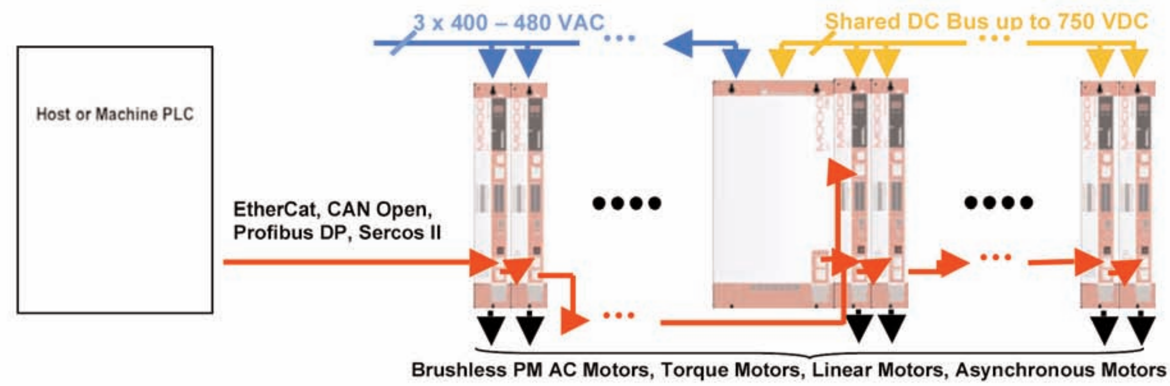
In the first scenario (Figure 6), the modules of the highly flexible MSD system control process cycles and close current, velocity and position loops for the required number of axes. Control of the process cycles and the closing of position and velocity loops are carried out either by the MSD Motion Controller or the MSD Servodrive, or both. The MSD system offers a comprehensive software package with motion control functionality to suit the needs of high performance machine applications. MSD supports different communication protocols via fieldbus (EtherCAT, CANopen, Profibus DP and Sercos, etc.), or even customer-specific protocols

Figure 6 – Scenario 1 with an MSD Motion Controller, MSD Servodrives and the MSD Power Supply Unit.



In the second scenario (Figure 7), the MSD system acts as an integration platform between various types of servomotors and an external host or machine PLC module from any 3rd party provider. Due to the great number of supported field bus communication protocols, the MSD system can seamlessly work together with existing control modules and motors used by our customers. The control of the process cycles is carried out by the superimposed host or machine PLC module. The MSD Servodrive may in this case close current, as well as velocity and position loops.

Figure 7 – Scenario 2 with MSD Servodrives, the MSD Power Supply Unit and an external PLC



About the Author:

Andreas Noll, Dipl. Ing., has extensive experience in product development in Servomotors and Servodrives. From 1992 to 2002 , he worked as the Engineering Manager for Moog Aerospace, Defence and Transportation (ADT), today's Defence Control Systems (DCS). Between 2002 and 2006, he gained experience as a Product Manager Motors and Drives in the industrial drives market. Since April 2006 he has been the Engineering Manager Drives, and has been responsible for new servodrive developments in the product line.

For further information on the MSD system, please contact your local Moog sales or send an email to anoll@moog.com