

World in motion...

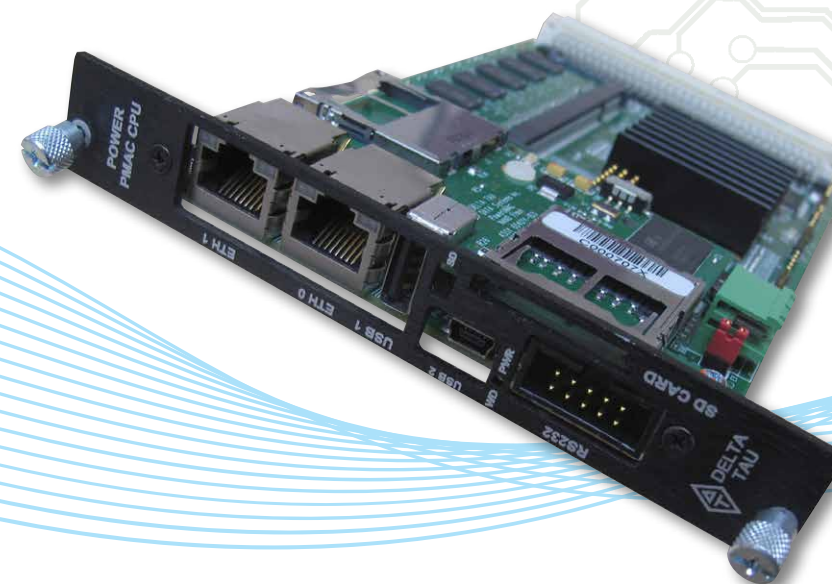
Reaching New Heights
in Motion Technology

FARADAY
MOTION CONTROLS

Precision motion and machine control

One of the big storage ring sextupole magnets at Diamond Light Source.

Image courtesy of Diamond Light Source



For more than a quarter of a century the team at Faraday Motion Controls has consistently and continually set the global benchmarks for precision motion and machine control. Over a million axes of motion installed worldwide in control equipment as diverse as machine tools and medical device manufacturing, robots and the Hubble telescope, packaging machines and Hollywood movie sets. There are few lives untouched by products made using Delta Tau motion controls.

Faraday Motion Controls in the UK has forged specialised services to the high technology and scientific communities. Many Synchrotron and high energy laser and neutron facilities depend on Faraday technology to control their complex multi axes equipment –

Diamond Light Source is the UK's national synchrotron science facility, located at the Harwell Science and Innovation Campus in Oxfordshire and uses Faraday motion Controllers on many of the beamlines there. By accelerating electrons to near light-speed, Diamond generates brilliant beams of light from infra-red to X-rays which are used for academic and industrial research and development across a range of scientific disciplines including structural biology, physics, chemistry, materials science, engineering, earth and environmental sciences.

Despite its scientific pedigree, Faraday also offers the most versatile and flexible multiple axis motor controllers for general purpose machine control and automation tasks. The ability of the PMAC range of products to control different motor types and technologies from a single motion card offers machine builders many practical advantages. Moreover, all the Faraday products are backed by expert technical support right here in the UK .



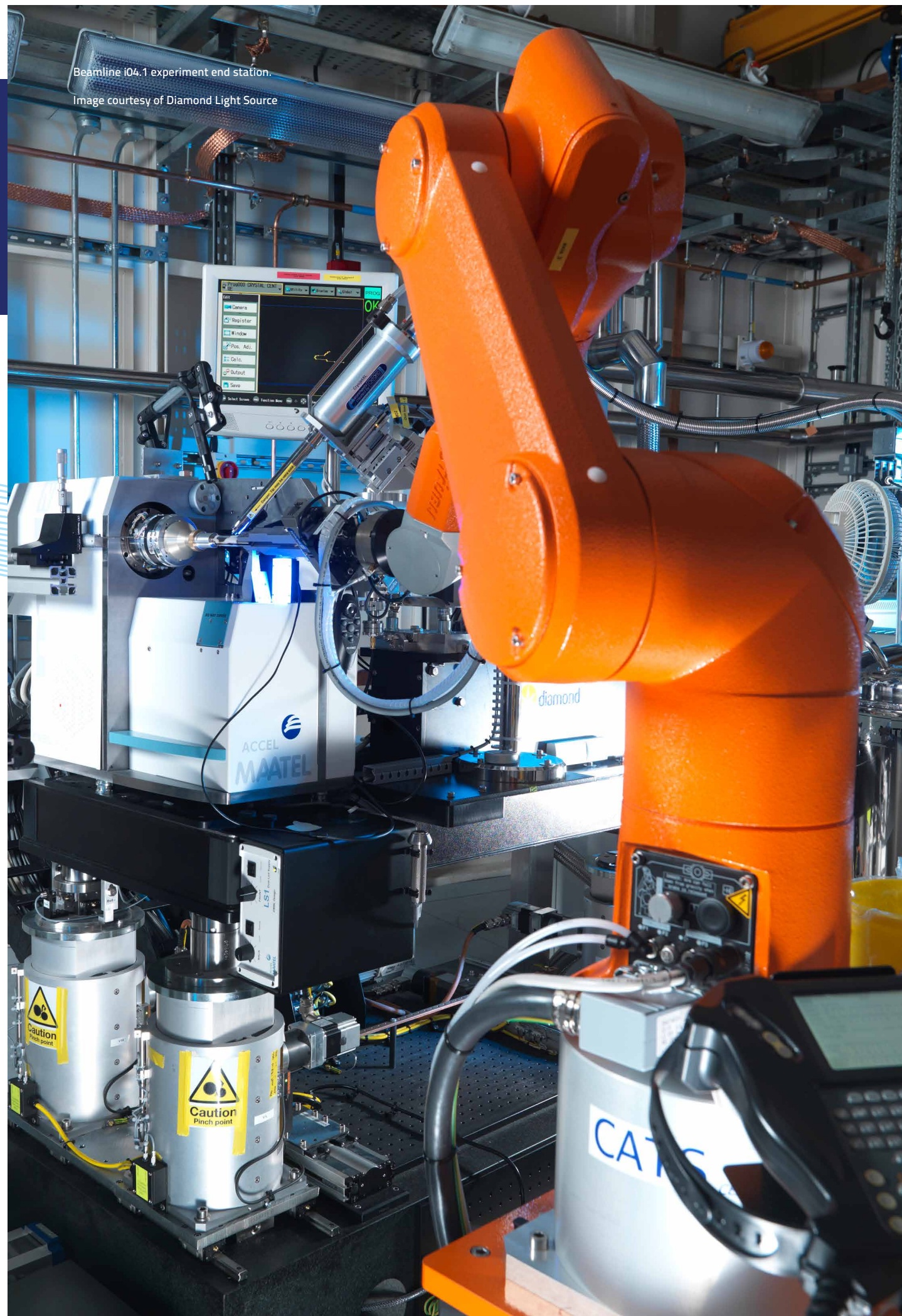
Power Brick LV-IMS



www.faradymotioncontrols.co.uk

Beamline i04.1 experiment end station.

Image courtesy of Diamond Light Source



OMRON DELTA TAU



The Power Brick LV-IMS Motion Computer



Power Brick LV-IMS

The Power PMAC is a Motion Controller and Linux computer rolled into one. Running an open source public domain operating system with a Xenomai real time kernel The PMAC has come of age.

Now with EPICS and TANGO compatibility running onboard or remotely, the new Power Brick LV-IMS offers the scientific communities around the world a powerful integrated package.

Using fully programmable four-quadrant four-phase technology in the eight axis amplifier stage, the power PMAC-LV-IMS is capable of running any mix of stepper, AC servo or DC servo motors. Having unique software control of the current in each axis allows the user to fully customise each application. Each block of four axes comes in three different current ratings of: 0.25A continuous 0.75A peak; 1.0A continuous 3.0A peak; and 5.0A continuous 15A peak. All current ranges operate between 12 and 48VDC.

As well as standard quadrature encoder inputs, both versions come complete with a range of serial encoder interfaces. These include Endat 2.2, Hiperface, SSI, Yaskawa Sigma II, and Tamagawa. For more recent and future protocols, not included in the DSPgate3, provision has been made to fit a mezzanine board to facilitate the use of these and analogue sin/cos and resolver feedback devices.

The Delta Tau MACRO (Machine And Control Ring Optical) interface now comes as standard, enabling the controller to control 32 axes. It also allows any Delta Tau MACRO product such as I/O, analogue interfaces or amplifiers to be added to the systems.

MATLAB's Simulink® with Power PMAC Facilitates user-servo code generation for Power PMAC using Simulink's Embedded Coder (previously known as Real-Time Workshop). The objective is to fully automate code generation for Power PMAC's servo loop closure routines (tasks) utilising Simulink's® control blocks.

Sophisticated Firmware Features

Five built-in control algorithms:

- Standard PID only
- PID enhanced with notch filters, deadband filters, lowpass/highpass filters, velocity loop filters, and/or trajectory prefilters
- Standard Gantry Control
- Cross-Coupled Gantry Control
- Adaptive Control
- Programmable input, integrator, and output limits
- Automatic or manual tuning of all motors' current loops and servo loops
- Phasing algorithms for maximizing the torque output of commutated motors
- Commutation algorithms for commutated motors (e.g. DC Brushless, AC Induction, etc.)
- Field weakening algorithm for AC induction motor (through the Motor[x].DtOverRotorTc structure)
- The user can also implement his or her own custom servo and phase algorithms in C
- Look-ahead for dynamic acceleration adjustment for accurate contouring
- Jerk limiting for smooth motion and reducing mechanical wear
- Cutter radius (2D) and shape (3D) compensation for machining
- Position, torque, and backlash compensation
- Multi-threaded general purpose background programs that run asynchronous to motion: Up to 32 in PMAC's Script language, 32 in C
- 0 to 3 multi-threaded general purpose foreground Script programs, 1 general purpose foreground C program, which run asynchronous to motion
- The above programs can be used for whatever purpose the user desires (e.g. safety and status monitoring, servo gain scheduling, data reporting functions, etc.)
- User-programmable, PMAC-Scheduled kinematics subroutines
- Position following (electronic gearing)
- Time-base control (automatic feedrate adjustment based on an external input signal)
- Transformation matrices for coordinate system rotation and translation
- Direct microstepping or pulse and direction (PFM) control for encoderless, open-loop control of stepper motors
- Position Compare with Digital Output at User Programmed encoder positions at 10 MHz, accompanied by an optional user-written interrupt service routine (ISR) that runs at these positions if desired
- Coordinate systems make grouping motors for synchronous motion and converting motor units to engineering units simple
- Multiple-motor axis definitions supported (e.g. for Gantry)
- Synchronous motion move modes: Linear, Circular, Spline, PVT, and Rapid
- 1/T extension for digital enhancement of standard Digital A Quad B encoder resolution
- Automatic move-until-trigger functions with hardware capture
- User-configurable servo clocks (for closing the servo loop at the appropriate sampling frequency), phase clocks (for commutation), PWM clocks (to get the right pulse frequency depending on motor characteristics) and real-time interrupt clocks (for move planning)

Safety Features:

- Hardware and software over-travel limits
- Amplifier enable/fault handshaking
- Following error limits
- Integrated current limit
- Encoder loss detection
- Watchdog timer and relay for safely stopping the machine if the controller freezes.

Quad PSU 1.6kVA



Quad PSU 1.6kVA Power Supplies

Faraday Motion Controls offers a compact switch mode power supply solution for single or multiple IMS systems, called the Quad PSU, that not only reduces cabling for the new Geo Brick LV IMS-II, but also provides reliable power for up to four separate controller crates in a single rack mounted device.

The power supply unit is a low profile 1U configuration with three power supplies plus a Regen unit. It has a universal Input (85 - 265VAC) with built in power factor correction.

Because of the highly efficient nature of the switch mode power supplies used, it runs at a cool 10 degrees above ambient at full load.

The Quad PSU 1.6kVA offers a 48Vdc or 24Vdc motor PSU 150W 24Vdc supply for the I/O and a 300W 24V supply for logic circuits providing the power to up to four motion controllers.

Each motor, Logic and I/O output is individually switched and thermally protected.

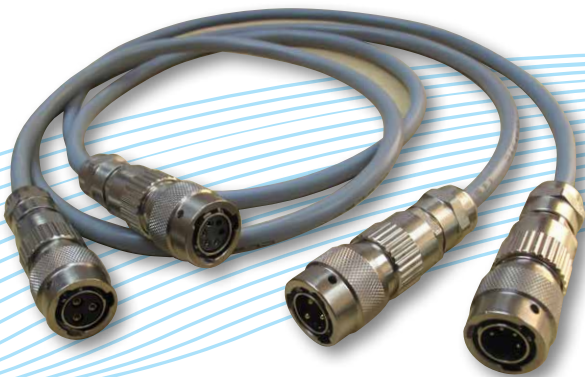
The Motor power supply is additionally protected from over voltage by motor regeneration with an internal electronic circuit and thermally protected regen resistor.

All power supplies are internally protected from over voltage, over current, over temperature and fan failure where fitted.



Cables & Accessories

Faraday Motion Controls offers a full range of mating connectors and interconnecting cables.



TANGO Software

The addition of TANGO software for the Power PMAC provides another option for synchrotron motion control community.

TANGO (TAco Next Generation Object) is a distributed control system, based on object oriented and service oriented approaches to software architecture. It is being actively developed by the collaborative effort of a group of European scientific institutes, including Alba, Desy, Elettra, ESRF, FRM II, Solaris and Soleil.

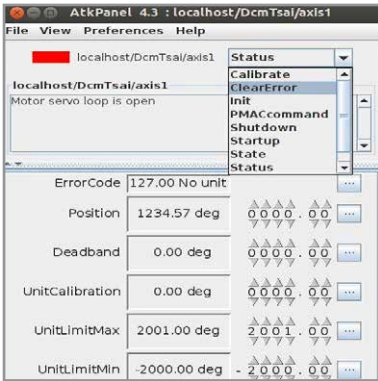
The first user of Observatory Sciences TANGO software library for the Power PMAC will be the Soleil synchrotron – the French national synchrotron which provides a multi-disciplinary instrument and research laboratory. The synchrotron is currently home to a number of high profile research projects.

EPICS Technology

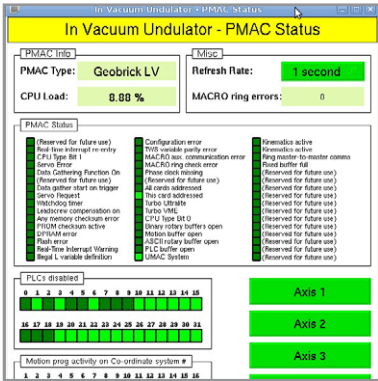
Observatory Sciences has worked with Faraday to integrate its GeoBrick LV controller and the Brick Controller IMS with EPICS to provide the Diamond Light Source synchrotron with its next generation motor controller solution.

More recently, Observatory Sciences is continuing its work with Brookhaven National Laboratory's Synchrotron Light Source II (NSLS-II) with the latest project for Power PMAC EPICS support.

The ability to use the Power PMAC with both EPICS and now TANGO will enable adoption of these systems at large scientific facilities such as synchrotrons. Observatory Sciences is a recognised leader in EPICS, developing control systems and delivering EPICS training. The EPICS toolkit has been used on many high energy physics facilities as well as on large astronomical telescopes around the world, and EPICS software now provides the core control system for many synchrotron facilities.



TANGO software interface



EPICS interface screen



See page 17 for a more detailed overview of the Power PMAC capabilities

GP Analog Inputs/Outputs- PFM

- The Power Brick LV can carry up to:
- 8 x Pulse and Direction / PFM outputs
 - 8 x 16-bit analog inputs (+/-10V)
 - 8 x 14-bit analog outputs (+/-10V)

Safety & Other Features

- Safe Torque Off (STO) with dynamic braking
- Abort Input for safe stop
- Watchdog output
- Over / Under voltage faults
- Short circuit, overcurrent protection
- Hardware / Software thermal I2T protection
- Motor thermal inputs (PTC)
- Encoder count error and encoder loss detection

- Dedicated brake relays and power input (24V)
- Plus/Minus over-travel, home, user inputs
- Software over-travel limits
- Warning/fatal following error limits
- High speed capture outputs
- Internal and external shunt resistors

Power Brick LV

The Power Brick LV is an integrated fully scalable Machine and Motion Controller combining the brains of the cutting edge Power PMAC processor, the unsurpassed custom-designed Digital Signal Processor Gate3 and the low voltage brawns of the latest high performance MOSFET-based drives technology into one compact 4 or 8-axis servo package drive.

Additional axes are available via MACRO (high speed fibre optic network) and/or EtherCat for a possible total of 104 (8 + 32 MACRO + 64 EtherCat) axes of centralized and coordinated motion control.

Motor Control

The Power Brick LV performs current loop closure, commutation and servo loop closure to drive directly:

- AC/DC Brushless servo (synchronous) linear / rotary motors
- DC Brush and Voicecoil motors
- Low Voltage Stepper motors

Encoder Support

The Power Brick LV can interface with one or a combination of the following types of feedback devices:

- Quadrature
- Sinusoidal x 16K/64K
- Resolver
- Halls (60oe/120oe)
- Kawasaki
- Analog +/- 10VDC
- LVDT / MLDT
- Mitsubishi
- Panasonic
- Yaskawa
- Nikon-D
- BiSS-B/C
- EnDat 2.1/2.2
- Mitutoyo
- Tamagawa
- SSI
- HiperFace

Fieldbus Connectivity

SERVO

- MACRO (Master/Slave)
- EtherCAT (Master)

I/O

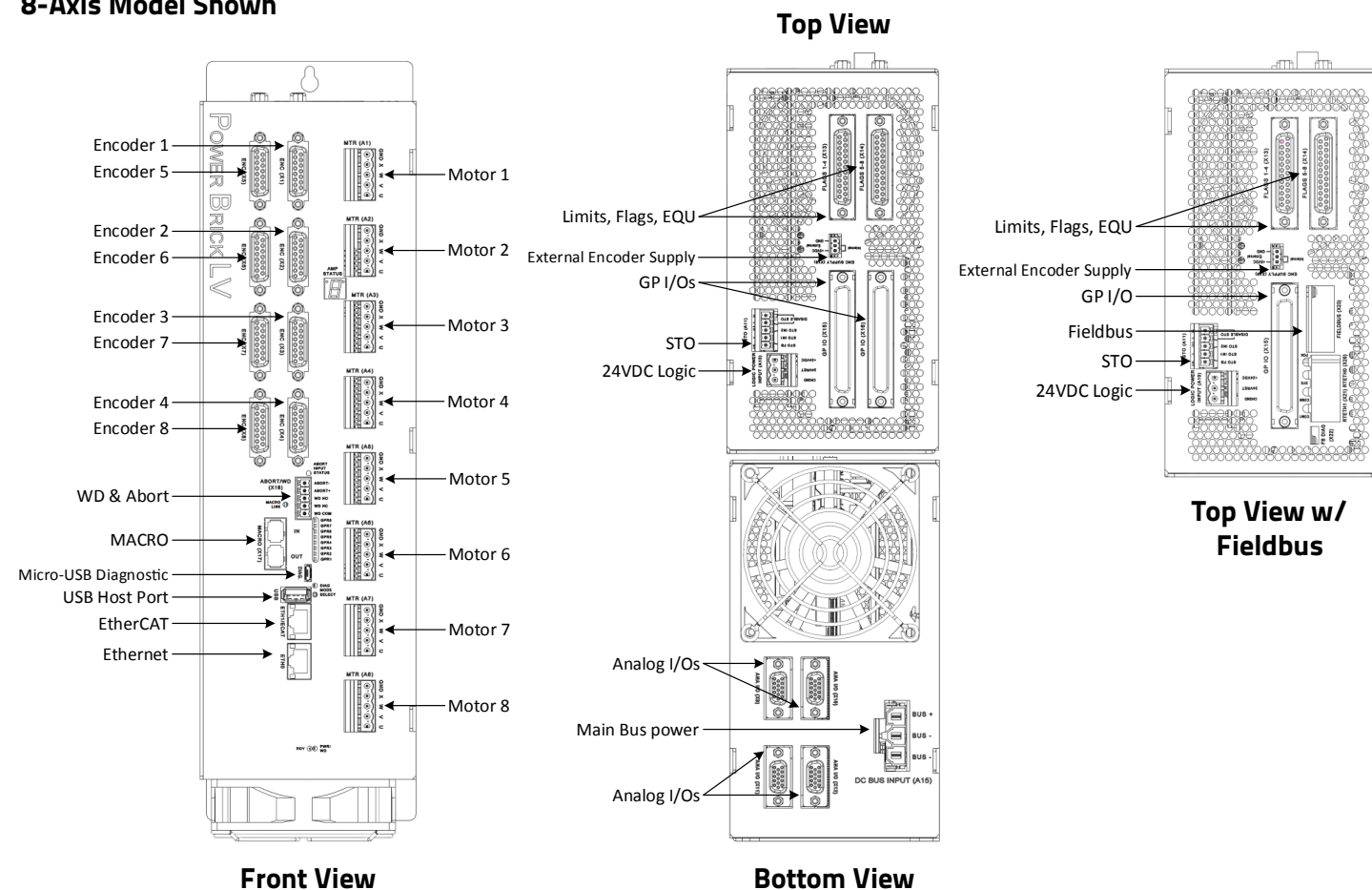
- EtherNet/IP (Scanner/Adapter)
- EtherCAT (Master/Slave)
- Profibus-DP (Master/Slave)
- DeviceNet (Master/Slave)
- CANopen (Master/Slave)
- Open Modbus (Master/Slave)
- CC-Link (Slave)
- Profinet IO RT (Controller/Device)

GP Digital Inputs/Outputs - Relays

- The Power Brick LV can be equipped with:
- 8 x general purpose relays
 - 32 x digital inputs 12-24VDC
 - 16 x digital outputs 12-24VDC 500 mA

All protected and optically isolated. Can be either sinking or sourcing. Thousands of additional digital inputs and outputs can be added via various fieldbus options.

CONNECTOR LAYOUT 8-Axis Model Shown



Control Through Industrial Network/Fieldbus Connectivity



Power UMAC



Power UMAC

The Power UMAC a motion computer with the latest hardware and software technology, providing the most high-performance, flexible machine controller in the world. The Power PMAC is a general-purpose embedded computer. It runs under a hard real-time Linux OS with a sophisticated motion and machine control application built in. With the capability for a full operator interface, the Power PMAC eliminates the need for a separate PC. Users can also program in the easy-to-use Script language or the standard C language, leveraging its sophistication and flexibility.

Dynamic Multi-Block Lookahead

- Evaluates planned trajectory against motor limits
- Slows just enough to stay within position, velocity, acceleration limits
- Executes fastest possible traversal within machine constraints

Forward and Inverse Kinematics

- Simplifies programming for non-Cartesian mechanisms
- User routines convert between tool tip and actuator mechanisms
- Permits direct specification of tool tip path

S-curve Acceleration

- Automatically limits rate of change of acceleration (jerk)
- Specified by jerk magnitude or S-curve time
- Provides smooth profiles with reduced high-frequency content

Position Capture and Compare

- Specialised circuitry tying encoder counts to I/O
- I/O on exact count (w/sub-count interpolation) at any speed
- For probing, registration, measurement trigger, laser firing

Gantry Control with Skew Correction

- Multiple motors automatically slave commanded trajectory
- Automatic removal of power-on skew in homing search sequence
- Optional cross-coupling servo correction

Electronic Gearing and Cams

- Powerful master/slave techniques
- Position following (gearing) requires no program for motion
- External time base (cam) keeps full trajectory flexibility

Multiple Coordinate Systems

- Axes acting together should be in same Coordinate System
- Axes acting independently should be in separate Coordinate Systems
- Separate Coordinate Systems act as independent machines

Blended and Splined Moves

- Automatic on-the-fly transition for multiple programmed moves
- Controlled, specified, acceleration of transitions
- For single-axis profiles or multi-axis paths

CONTROL EVERYTHING:

Delta Tau's Open Architecture Platform provides complete flexibility to choose multiple types of motors, feedback devices, encoders and fieldbuses so you can create a system perfect for your application. Additional axes, feedback, I/O and/or fieldbus interfacing is obtained by sliding accessory cards into the 3U rack system, available in 3 choices of rack widths (largest 21-slot version pictured on the left).



Power Compact UMAC CPU

Power UMAC

POWER UMAC 465 CPU

Single/Dual Core, Multiple Speeds, Linux RTOS with optional Video output

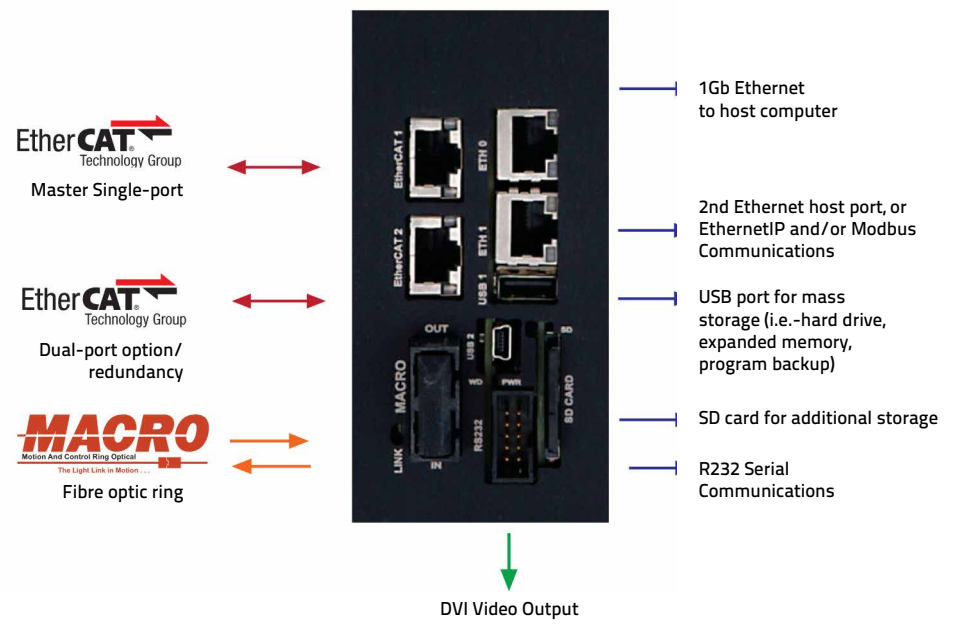
POWER COMPACT UMAC CPU

Linux RTOS
Custom Designs

Power PMAC CPU Capabilities

- Up to 1.2 GHz Single/Dual Core
- Full real-time Operating System (Linux OS w/ real-time kernel)
- Full file management system (programs, data, files, etc.)
- Dedicated controller runs in the RT Linux environment
- Full 32/64-bit architecture
- Hardware 64-bit double precision floating point math
- Support for large memory
 - 1GB or 2GB DDRAM active memory with error correction
 - 64MB NOR flash for Kernel and Bootloader
 - 512MB or 1/4/8 GB built-in NAND flash for user project (built-in)
 - Interface for SD Card (SDHC, 32GB support)
 - Interface for USB 2.0 Devices (Hard drive, USB Stick, Keyboard, Mouse, etc.)
- 2 ethernet 1Gbps ports
- Built in USB2.0 Interface
- Optional 4x PCI Express (PCIe) port
- Optional Direct Video Interface (DVI Output)
- DVI output, 2 extra USB ports

MULTIPLE TYPES OF COMMUNICATION SIMULTANEOUSLY



See page 23 for a more detailed overview of the Power PMAC capabilities



NY512



NY532

Industrial PC Platform NY-series and IPC Machine Controller

Our IPC Machine Controller combines proven machine automation with the freedom to use PC technology: working together but independently. So you can leverage Big Data, NUI and IoT to explore manufacturing innovation with no compromise on traditional PLC reliability and robustness. It makes engineers unstoppable and machines innovative yet reliable.

FEATURES

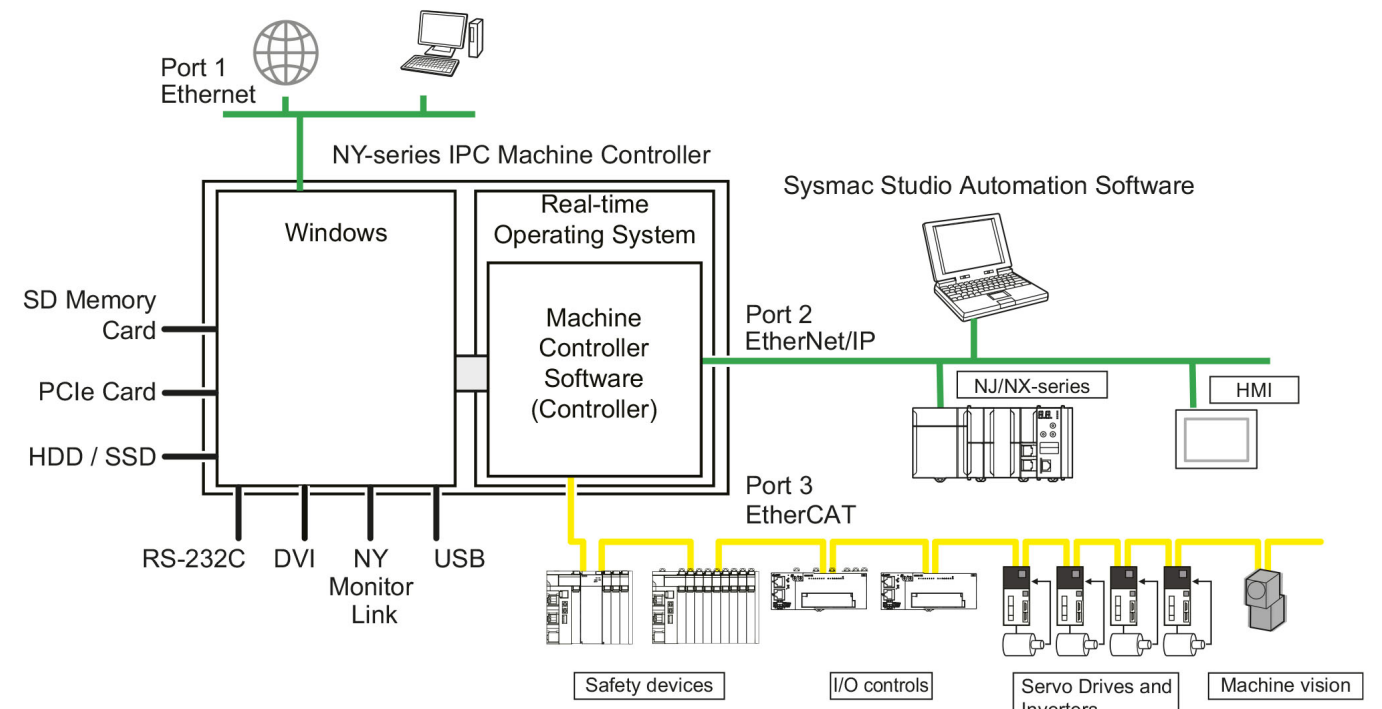
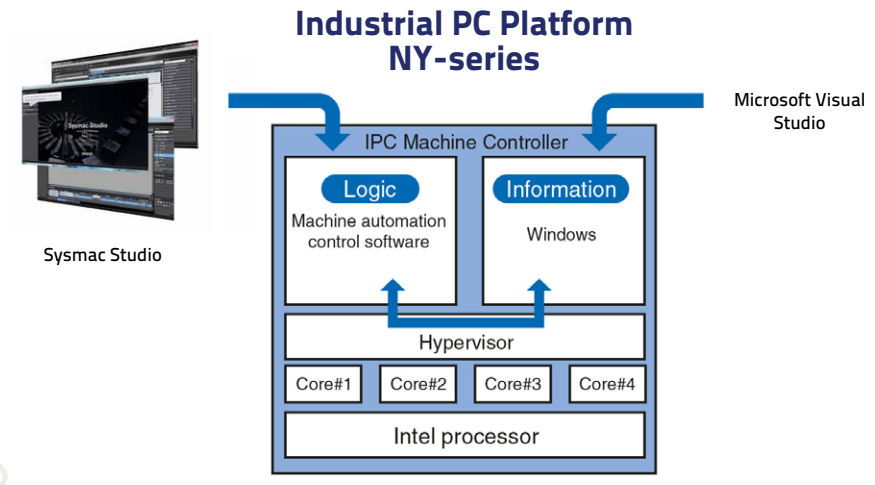
Standard models

- OS independency allows controller to continue to control if a Windows OS crashes
- Primary task period 500 µs/24 axes
- Retain/non-retain variables 4 MB/64 MB
- 16 to 64 axes
- 192 EtherCAT slaves

- Secure boot and recovery methods
- Powerful 4th-generation CPU technology for optimum performance
- No internal cables in the PC part eliminates faults, maximizes uptime
- Unique simplified thermal design to cut downtime
- Two Gbps Ethernet, one EtherCAT, one DVI, one UPS I/O connector
- Two USB2.0 and two USB3.0 for fast data-transmission

C integrated models

- Integrate NY-series IPC Machine Controller with Numerical Control (NC) functions.
- Realize high-accuracy synchronization motion control (MC) and numerical control (NC) functions by ONE controller.
- Realize the collaboration of machining process and other processes (loader/unloader, press, assembly).
- Support G codes for numerical control.



Based on the renowned Power PMAC from Delta Tau this open source controller comes with two operating system options, Linux or Windows.

The Power PMAC kernel is embedded into this industrial PC leveraging the flexibility of a multi port hardware platform.

User written HMI code can run alongside and seamlessly integrate into the Power PMAC features to realise a highly integrated machine control system.



CK3E

Programmable Multi-Axis Controller

A powerful, flexible and cost-effective motion controller.

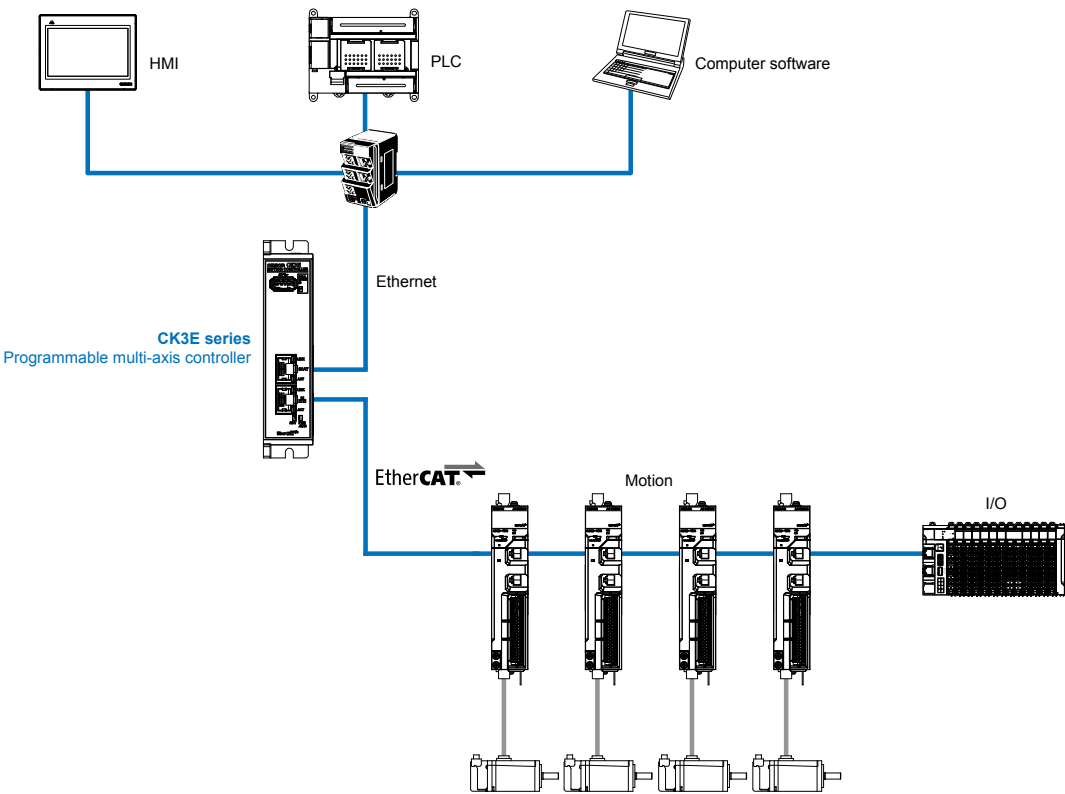
FEATURES

- Up to 32 axes motion control
- 250 µs motion control period
- Flexible function development capability enables high-precision curve machining
- EtherCAT for flexible system configuration

GENERAL SPECIFICATIONS

Item	Specifications
Enclosure	Mounted in a panel
Grounding method	Ground to less than 100 Ω
Dimensions (H x W x D)	130.4mm x 28.6mm x 170.9mm
Weight	540g
Unit power supply rated voltage	24 VDC (20.4 to 26.4 VDC)
Unit power supply current consumption	660 mA or less
Environmental specifications	
Ambient operating temperature	0 to 45°C
Ambient operating humidity	10 to 95% RH (without condensation and icing)
Ambient storage temperature	-25 to 70°C (without condensation and icing)
Atmosphere	Must be free from corrosive gases
Vibration resistance	Conforms to IEC 60068-2-6. 5 to 8.4 Hz with amplitude of 3.5 mm, 8.4 to 150 Hz, acceleration of 9.8 m/s ² 100 min each in X, Y and Z directions (10 sweeps of 10 min each = 100 min total)
Shock resistance	Conforms to IEC 60068-2-27. 147 m/s ² , 3 times each in X, Y and Z directions
Applicable standards	EU: EN 61326, RCM

System Configuration



PERFORMANCE SPECIFICATIONS

Model		CK3E-1210	CK3E-1310	CK3E-1410
Motion control	Number of controlled axes	8 axes	16 axes	32 axes
	Motion control period	250 µs min.		
	Control method	Issuing control commands using EtherCAT communications		
Memory		Main memory: 1 GB Flash memory: 1 GB		
External terminals		Communications connectors ▪ For EtherCAT communications, RJ45 x 1 (shield supported) ▪ For Ethernet communications, RJ45 x 1 (shield supported) Power supply input terminal ▪ For unit power supply x 1 USB port ▪ For external memory connection, USB 3.0 host x 1 Type A		
Communications	EtherCAT port	Protocol	EtherCAT protocol	
		Baud rate	100 Mbps	
		Physical layer	100BASE-TX (IEEE 802.3)	
		Topology	Line, daisy chain and branching	
		Transmission media	Twisted-pair cable of category 5 or higher (double-shielded straight cable with aluminum tape and braiding)	
		Transmission distance	Distance between nodes: 100 m max.	
	Ethernet port	Number of slaves	32 max.	
		Range of node addresses that can be set	1 to 32	
		Physical layer	1000BASE-T/100BASE-TX	
		Frame length	1,514 bytes max.	
		Media access method	CSMA/CD	
		Modulation	Baseband	
	USB port	Topology	Star	
		Transmission media	Twisted-pair cable of category 5, 5e or higher (shielded cable)	
		Transmission distance	100 m max. (distance between Ethernet switch and node)	
		Cascade connections	There are no restrictions if an Ethernet switch is used	
		Physical layer	USB 3.0 compliant A-type connector	
		Transmission distance	Output voltage 5 V, 0.9 A max. 3m max.	



OMRON DELTA TAU

CK3M

Power PMAC Overview

The power and flexibility of the Power PMAC allows the integration of the Power PMAC Features into virtually any kind of industrial motion control application.

Motor Servo Control

- Extremely fast update rates (Phase and Servo)
- Standard PID with full feedforward model
- Powerful automatic tuning and analyser tools
- Analog, Pulse Width Modulated (PWM), Pulse Frequency Modulated (PFM), MACRO or EtherCAT Outputs
- Vibration suppression filters
- Multiple 7th order notch and low pass filters
- Adaptive control for varying loads
- Cascaded loops (force, height, camera auto-focus control)
- Support for custom-written commutation routines
- Support for custom-written servo routines
- Custom routines directly in C or from MATLAB®/Simulink®

Coordinate Systems / Forward and Inverse Kinematics

- Up to 256 axes of coordinated or independent motion
- Up to 128 independent coordinate systems
- Up to 32 independent axes per coordinate system
- Dynamic axes transformations (e.g. offsets, rotations, mirroring)
- Forward/Inverse kinematics for non-linear mechanisms
 - User defined routines convert between tool tip coordinates and actuator positions
 - Permits direct specification of tool tip path

Trajectory Generation - Motion Programs

- Auto-coordination of multiple sets of axes
- Linear, circular, rapid, position-velocity-time (PVT), LIN to PVT (curve fit), Spline move modes
- Seamless blending between linear, circular and PVT modes
- Automatic move until trigger (hardware input)
- True S-Curve accel / decel
- All move modes supported with user kinematics
- Dynamic multi-block lookahead with velocity/acceleration control and jerk limit
- Sub-millisecond segmentation time
- Negative feedrate for true motion reversal in lookahead
- Move block execution rate up to 10,000 blocks/sec
- G-code, M-code, and T-code ready
- Calculations and I/O synchronous to motion
- Tool radius compensation, 2D or 3D

Programmable Logic Control (PLCs)

- Access to all registers
- Trigonometric, transcendental, vector and matrix functions
- 64-bit floating-point architecture optimized math
- Executive functions for standalone operation
- Data gathering of up to 128 hardware/software registers per servo cycle
- Program in PMAC Script
- Program in ANSI C:
 - Real time with pre-emptive kernel routines
 - General purpose routines
 - MATLAB®/Simulink® Embedded Coder® generated code

Compensation Tables

- Position/torque compensation tables in 1D, 2D, or 3D with rollover and mirroring options
- 1st/3rd order interpolation between points every servo cycle
- Up to 256 compensation tables (64K each)
- Support for superimposed compensation table results
- Backlash compensation, fixed or in tables
- Hardware Position Capture and Compare
- Specialised circuitry tying encoder counts to digital I/O
- I/O on exact count (w/sub-count interpolation) at any speed (within 10 nanoseconds)
- For probing, registration, measurement trigger, laser firing

Gantry Control

- Follower motor(s) executes leader's trajectory
- Automatic skew removal on homing
- Automatic gantry cross-coupling servo correction

Electronic Gearing and Cams

- Powerful master/slave techniques
- Position following (gearing) requires no program for motion
- External time base (cam) keeps full trajectory flexibility (non-returning, limited reversal, e.g. moving web application)
- Up to 256 cam tables (16k points each)
 - Position/torque profile(s)
 - Returning, forward/reverse travel
 - Extremely precise synchronized outputs

Programmable Multi-Axis Controller CK3M-series CPU Unit

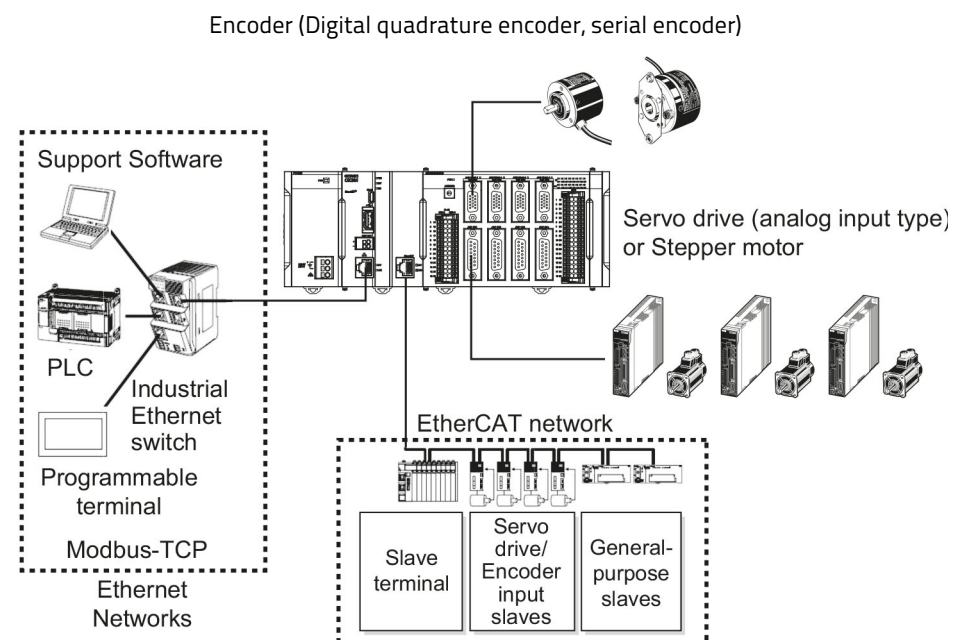
Controls analog servo drives at high speeds of up to 50 μ s/5 axes, enabling high-precision processing

FEATURES

- Controls up to eight analog servo drives via two CK3W-AX Style Axial Interface Units
- The CK3M-CPU121 controls up to eight EtherCAT servo drives
- G-Code/ANSI C/original programming language
- EtherCAT slaves including vision and I/O can be connected
- Compact design (1/3 the size of conventional models*1)
- The EtherCAT network reduces wiring and machine size

*1. Compared with UMAC from OMRON's Delta Tau Data Systems, Inc.

System Configurations Basic System Configuration





DAC20-MACRO

High Resolution Analogue Output Module +/-10V, 20 bit

The FMC Macro DAC analogue output module generates signals in the range of -10 V to +10 V.

The voltage is supplied to the process level with a resolution of 20 bits. The output channels of the module have a common ground potential

TECHNICAL SPECIFICATIONS

Technical data	MACRO DAC
Connection technology	Delta Tau MACRO Interface
DAC technology	R-2R network
Number of DAC outputs	2
Output voltage range	±10V
Distributed Clocks	NA
Maximum cable length to the sensor	TBA
Accuracy Distributed Clocks	NA
Load	TBA
Output impedance	10Ω
Measuring error	±1LSB (< ±20µV)
Resolution	20 bit DAC giving 20µV per DAC bit
Electrical isolation	None
Conversion time	130nSec
Settling time	10µSec
Maximum full-scale error	< ±140µV
Linearity	< ±20µV
DC offset	< 1mV
Maximum DAC clock frequency	25MHz
Maximum phase clock frequency	88KHz
Power requirement	10-30Vdc @ 250mA
Current consumption via E-bus	
Permissible ambient temperature range during operation	-25°C .. +60°C (extended temperature range)
Permissible ambient temperature range during storage	-40 °C .. +85 °C
Permissible relative air humidity	95 %, none condensing
Operating altitude	max. 2,000 m
Dimensions (W x H x D)	167 x 55 x 167
Pollution degree	2
Weight	
Mounting	
Mounting position	
Vibration / shock resistance	Conforms to EN 60068-2-6 / EN 60068-2-27 (with corresponding signal distribution board)
EMC immunity / emission	Conforms to EN 61000-6-2 / EN 61000-6-4 (with corresponding signal distribution board)
Protection class	EJ module: IP20 EJ system: dependent on the signal distribution board and housing
Approval	CE

Connectors:

- Power:**

Control:

2 channel Amp enable + Amp fault:

2 channels quadrature encoders:

2 channels of Limits + Home + user flags:

Output DACs:
- 3 pin phoenix connector

SC Duplex Optical link (MACRO)

15 pin D connector

25 pin D connector

15 pin D connector

3 pin Lemo connector



25-PIN D CONNECTORS (ENCODERS)

PIN#	SYMBOL	FUNCTION	DESCRIPTION	NOTES
1	CHA+	Input	Channel A Positive Signal	
2	CHB+	Input	Channel B Positive Signal	
3	CHC+	Input	Channel C Positive Signal	
-	-			
5	-			
6	CHU	Input	Hall sensor U	
7	CHW	Input	Hall sensor W	
8	-			
9	-			
10	-			
11	-			
12	ENC POWER	Output		
13	ENC 0V	Common		

PIN#	SYMBOL	FUNCTION	DESCRIPTION	NOTES
14	CHA-	Input	Channel A Negative Signal	
15	CHB-	Input	Channel B Negative Signal	
16	CHC-	Input	Channel C Negative Signal	
17	-			
18	-			
19	CHV	Input	Hall sensor V	
20	CHT	Input	Sensor T	
21	-			
22	-			
23	-			
24	ENC POWER	Output		5V @ 0.5 Amp
25	ENC 0V	Common		

15-PIN D FLAGS CONNECTOR (FLAGS 1 & 2)

PIN#	SYMBOL	FUNCTION	DESCRIPTION	NOTES
1	USER 1	Input	Gen. purpose capture flag	
2	NEG LIMIT 1		Negative limit flag	
3	FLAG RETURN 1	Input		
4	USER 2	Input	Gen. purpose capture flag	
5	NEG LIMIT 2	Input	Negative limit flag	
6	FLAG RETURN 2	Input		
7	N.C.			
8	N.C.			
9	PLUS LIMIT 1	Input	Positive limit flag	
10	HOME 1	Input	Home capture flag	
11	N.C.			
12	PLUS LIMIT 2	Input	Positive limit flag	
13	HOME 2		Home capture flag	
14	N.C.			
15	N.C.			

15-PIN D AMP CONNECTORS (AMP1 & AMP2)

PIN#	SYMBOL	FUNCTION	DESCRIPTION	NOTES
1	DAC+ (OPTION)			
2	N.C.			
3	AMP ENABLE NC			
4	AMP ENABLE NO			
5	AMP FAULT -			
6	N.C.			
7	N.C.			
8	A GND			
9	DAC- (OPTION)			
10	N.C.			
11	AMP ENABLE COM			
12	AMP FAULT +			
13	N.C.			
14	A GND			
15	N.C.			

3-PIN LEMO CONNECTOR OPTION (DAC1 & DAC2)

PIN#	SYMBOL	FUNCTION	DESCRIPTION	NOTES
1	DAC +	Output		
2	DAC -	Output		
3	AGND	Common	Analog ground	

3-PIN PHOENIX CONNECTOR (POWER)

PIN#	SYMBOL	FUNCTION	DESCRIPTION	NOTES
1	+24 V	Power input		
2	24V RETURN (0V)	Power input		
3	FRAME GROUND	Frame ground		

FMC 1040

QUAD CORE ARM CPU

A powerful, flexible and cost-effective motion controller.

FEATURES

- Up to 64 axes motion control
- 250 µs motion control period
- Flexible function development capability enables high-precision curve machining
- EtherCAT for flexible system configuration

Coordinate Systems / Forward and Inverse Kinematics

- Up to 256 axes of coordinated or independent motion Up to 128 independent coordinate systems
- Up to 32 independent axes per coordinate system
- Dynamic axes transformations (e.g. offsets, rotations, mirroring)
- Forward/inverse kinematics for nonlinear mechanisms
 - User defined routines convert between tool tip coordinates and actuator positions
 - Permits direct specification of tool tip path

Compensation Tables

- Position/torque compensation tables in 1D, 2D, or 3D with rollover and mirroring options
- 1st/ 3rd order interpolation between points every servo cycle
- Up to 256 compensation tables (64K each)
- Support for superimposed compensation table results
- Backlash compensation, fixed or in tables

Trajectory Generation - Motion Programs

- Auto-coordination of multiple sets of axes
- Linear, circular, rapid, position-velocity time (PVT), LIN to PVT (curve fit), Spline move modes
- Seamless blending between linear, circular and PVT modes
- Automatic move until trigger (hardware input)
- True S-Curve acceleration / deceleration
- All move modes supported with user kinematic
- Dynamic multi-block lookahead with velocity/ acceleration control and jerk limit
- Sub-millisecond segmentation time
- Negative feedrate for true motion reversal in lookahead
- Move block execution rate up to 10,000 blocks/sec
- G-code, M-code, and T-code ready
- Calculations and I/O synchronous to motion
- Tool radius compensation, 2D or 3D

Gantry Control

- Follower motor(s) executes leader's trajectory
- Automatic skew removal on homing

Programmable Logic Control (PLCs)

- Access to all registers
- Trigonometric, transcendental, vector and program for motion matrix functions
- 64-bit floating-point architecture optimized maths
- Executive functions for standalone operation
- Data gathering of up to 128 hardware software registers per servo cycle
- Program in PMAC Script
- Program in ANSI C:
 - Real time with pre-emptive kernel routines
 - General purpose routines
 - MATLAB®/Simulink® Embedded Coder® generated code

Electronic Gearing and Cams

- Position following (gearing) requires no program for motion
- External time base (cam) keeps full trajectory flexibility (non-returning limited reversal, e.g. moving web application)
- Up to 256 cam tables (16k points each)
 - Position/torque profile(s)
 - Returning, forward/reverse travel
 - Extremely precise synchronized outputs



GENERAL SPECIFICATIONS

Item	Specifications
Enclosure	Mounted in a panel
Grounding method	Ground to less than 222 (+13) Ω
Dimensions (H x W x D)	125mm x 50mm x 225mm
Weight	1kg
Unit power supply rated voltage	24 VDC (10.0 to 30.0 VDC)
Unit power supply current consumption	660 mA
Environmental specifications	
Ambient operating temperature	0 to 45°C
Ambient operating humidity	10 to 95% RH (without condensation and icing)
Ambient storage temperature	-25 to 70°C (without condensation and icing)
Atmosphere	Must be free from corrosive gases
Vibration resistance	Conforms to IEC 60068-2-6. 5 to 8.4 Hz with amplitude of 3.5 mm, 8.4 to 150 Hz, acceleration of 9.8 m/s ² 100 min each in X, Y and Z directions (10 sweeps of 10 min each = 100 min total)
Shock resistance	Conforms to IEC 60068-2-27. 147 m/s ² , 3 times each in X, Y and Z directions
Applicable standards	EU: EN 61326, RCM

PERFORMANCE SPECIFICATIONS

Model	FMC 1040-16		FMC 1040-32	FMC1040-64
Motion control	Number of controlled axes	16 axes	32 axes	64 axes
	Motion control period	250 µs min.		
Memory	Control method	Issuing control commands using EtherCAT communications		
		Main memory: 2 GB Flash memory: 4 GB		
External terminals		Communications connectors - For EtherCAT communications, RJ45 x 1 (shield supported) - For Ethernet communications, RJ45 x 1 (shield supported)		
		Power supply input terminal - For unit power supply x 1 USB port - For external memory connection, USB 3.0 host x 1 Type A		
Communications	EtherCAT port	Protocol	EtherCAT protocol	
		Baud rate	100 Mbps	
		Physical layer	100BASE-TX (IEEE 802.3)	
		Topology	Line, daisy chain and branching	
		Transmission media	Twisted-pair cable of category 5 or higher (double-shielded straight cable with aluminum tape and braiding)	
		Transmission distance	Distance between nodes: 100 m max.	
	Ethernet port	Number of slaves	64 max.	
		Range of node addresses that can be set	1 to 64	
		Physical layer	1000BASE-T/100BASE-TX	
		Frame length	1,514 bytes max.	
		Media access method	CSMA/CD	
		Modulation	Baseband	
	USB port	Topology	Star	
		Transmission media	Twisted-pair cable of category 5, 5e or higher (shielded cable)	
		Transmission distance	100 m max. (distance between Ethernet switch and node)	
		Cascade connections	There are no restrictions if an Ethernet switch is used	
		Physical layer	USB 3.0 compliant A-type connector	
		Transmission distance	Output voltage 5 V, 0.9 A max. 3m max.	

LA4805 Linear Amplifier

The LA4805 is a Voltage Mode Analogue Linear Amplifier, with selectable current limit (0.5A steps) and short circuit protection.



Technical Specifications:

Technical data	LA4805
Supply Voltage	Single Rail, 48V
Output Voltage (Max)	40V
Output Current (Max)	5A
Output Power (Max, typical)	100W into 8 Ω load. (Motor and drive signal dependant, see output power section)
Analogue Inputs	±10V Differential input.
Voltage Gain	x2 (fixed)
Bandwidth	5 kHz
Minimum Motor Resistance	0.5 Ω (see output power section)
Minimum Motor Inductance	0.0 mH
Dimensions (W x H x D)	56mm x 170mm x 187mm

Connectors:

Power/Motor (Phoenix MSTB 2,5/ 4-GF-5,08 – 1776524)

PIN	FUNCTION	DESCRIPTION
1	Ground	Common Ground. (Connected internally to Analogue Gnd)
2	Supply	Positive Power Supply (nominally 48V)
3	Motor A	Isolated motor connected between Motor A and B
4	Motor B	

Analogue Input (3-pin LEMO EPG.0B.303.HLN)

PIN	FUNCTION	DESCRIPTION
1	Ground	Common Ground. (Connected internally to Power Ground)
2	Analogue A	Positive of ±10V Differential input
3	Analogue B	Negative of ±10V Differential input



Connectors contd:

Flags (DB9: Opto-Isolator Inputs, 9-Way DA Dsub)

PIN	FUNCTION	DESCRIPTION
1	Amp Enable	Selectable +5 or +24V Opto-isolator input.
2	Amp Enable Return	
3	Amp Fault	Volt-free Opto-isolator output (20mA max).
4	Amp Fault Return	
5	Ground	
6, 7, 8, 9	N.C.	

Output Power and Internal Dissipation

Maximum output power is limited by the maximum internal dissipation, and the ratio of output power to internal dissipation is determined by the motor resistance. A very low resistance motor will cause the full supply voltage to be dropped across the output transistors, causing considerable internal power dissipation to occur. The maximum output power is thus limited by the maximum heatsink temperature, above which the amplifier will automatically lock-out.

Example Output Powers (Sine-wave test drive signal, resistive load)

LOAD RESISTANCE	OUTPUT Vpp	OUTPUT Ipeak	OUTPUT POWER P(rms)	APPROXIMATE TIME TO OVER-TEMP TRIP
8 Ω	40V	5A	100W	None (runs continuously)
5 Ω	25V	5A	62.5W	5 minutes
2 Ω	5V	5A	12.5W	2.5 minutes

Additional Features

SOFTWARE PROTECTION	
Current Limiting	Software current limiting algorithm reduces output voltage to Limit output current. Selectable by front panel rotary switch, steps of 0.5A between 0.5A and 5A
Short Circuit	Lock-out on fast current spikes > 5.5A
Over-Temperature	Front panel Warning at Heat-sink 65° C, lock-out at 70° C
Under Voltage	Lock-out when supply voltage falls below 32V

ENVIRONMENTAL CHANGES	
Operating Temperature range	0° C ... +40° C
Humidity	95 %, no condensation
Protection class	IP20
Approval	CE / UKCA



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