Motor Control Units and Drive Amplifiers

Erik van Hilten

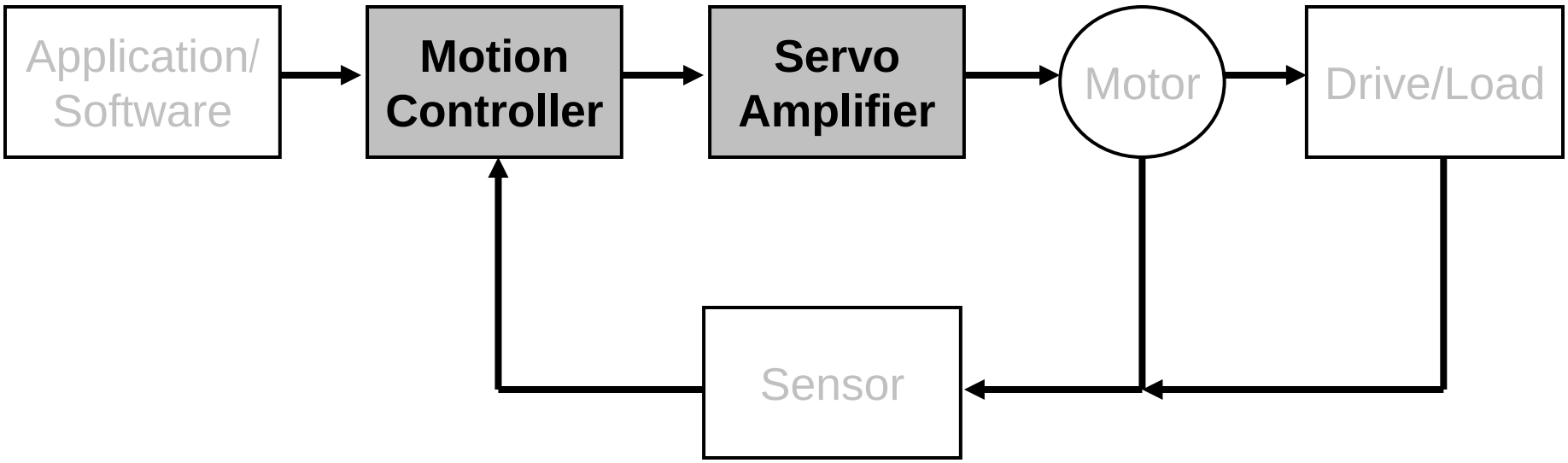
Rik Prins

National Instruments

Agenda

- Drive amplifiers
- Motor control units
  - PC-based motion controllers
  - decentralized motion controllers
  - customized motion controllers

Drive System



Drive Amplifier

- The amplifier must be designed for the respective motor type
  - Example: EC motor needs motor drive amplifier with electronic commutation, …
- The amplifier must provide the suitable
  - peak currents
  - constant currents
  - voltages

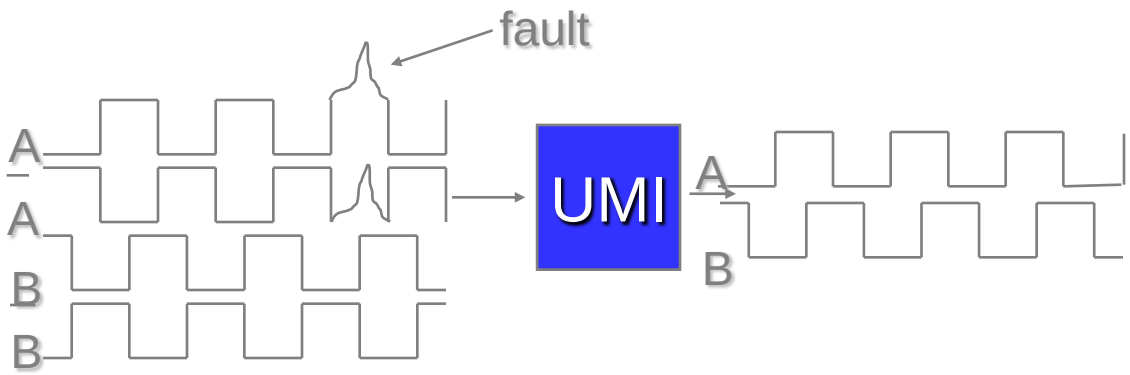
  to the motor
- Offers the connector panel for
  - motors
  - encoders
  - DIO, AIO

Caution

- NI drive amplifiers are not suitable for connection to brushless servo motors

UMI (Universal Motion Interfaces)

- Connects NI controllers with amplifiers of motor manufacturers
- Filters input signals



- Galvanic separation and 24-V level (only UMI-777x)
- Single-ended signals which are processed by NI controllers are created from the usual differential encoder signals.
- Offer inputs for external emergency shutdowns
- Needs an external power supply!

UMI (Universal Motion Interfaces)

UMI 7764

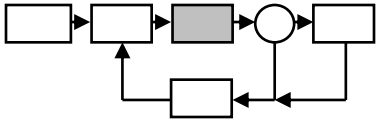
- Screw terminal connection to all the I/Os of up to 4 axis
- 5-V technology for digital signals
- Limit-switch inputs for mechanical switches

UMI 7764

UMI 7774/7772

- Connections for sub-D plugs
- 24-V technology for digital signals
- Optical isolation for digital signals
- Limit-switch inputs for mechanical switches and sensor switches (induction proximity switches)
- Solid metal design

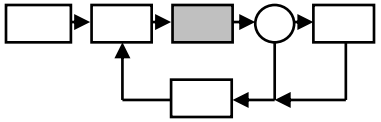
UMI 7774



NI Drive Amplifiers Overview

Amplifier	Controller Type	Output Voltage	Available Current/Axle	No. of Axis
MID-7604 (Stepper)	NI 7330 NI 7340 NI 7350	24 V	0.2 to 1.4 A	4
MID-7602 (Stepper)	NI 7330 NI 7340 NI 7350	24 V	0.2 to 1.4 A	2
MID-7654 (Servo)	NI 7340 NI 7350	48 V	0.8 to 5 A 10 A peak	4
MID-7652 (Servo)	NI 7340 NI 7350	48 V	0.8 to 5 A 10 A peak	2

maxon Drive Amplifiers



DC motor
Speed regulator

EC motor
Commutation and
Speed regulator

DC or EC motor
Position controller

4-Q-DC servo amplifier

- LSC (50 W), ADS (250 W, 500 W)

1-Q to 4-Q EC amplifier

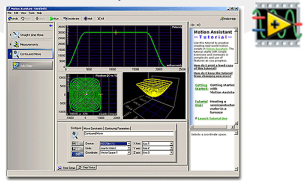
- AECS (sensorless, 100 W)
- DEC (24 W-700 W, Hall sensor), block commutation
- DES (250 W, 700 W), sinusoidal commutation

Position controller

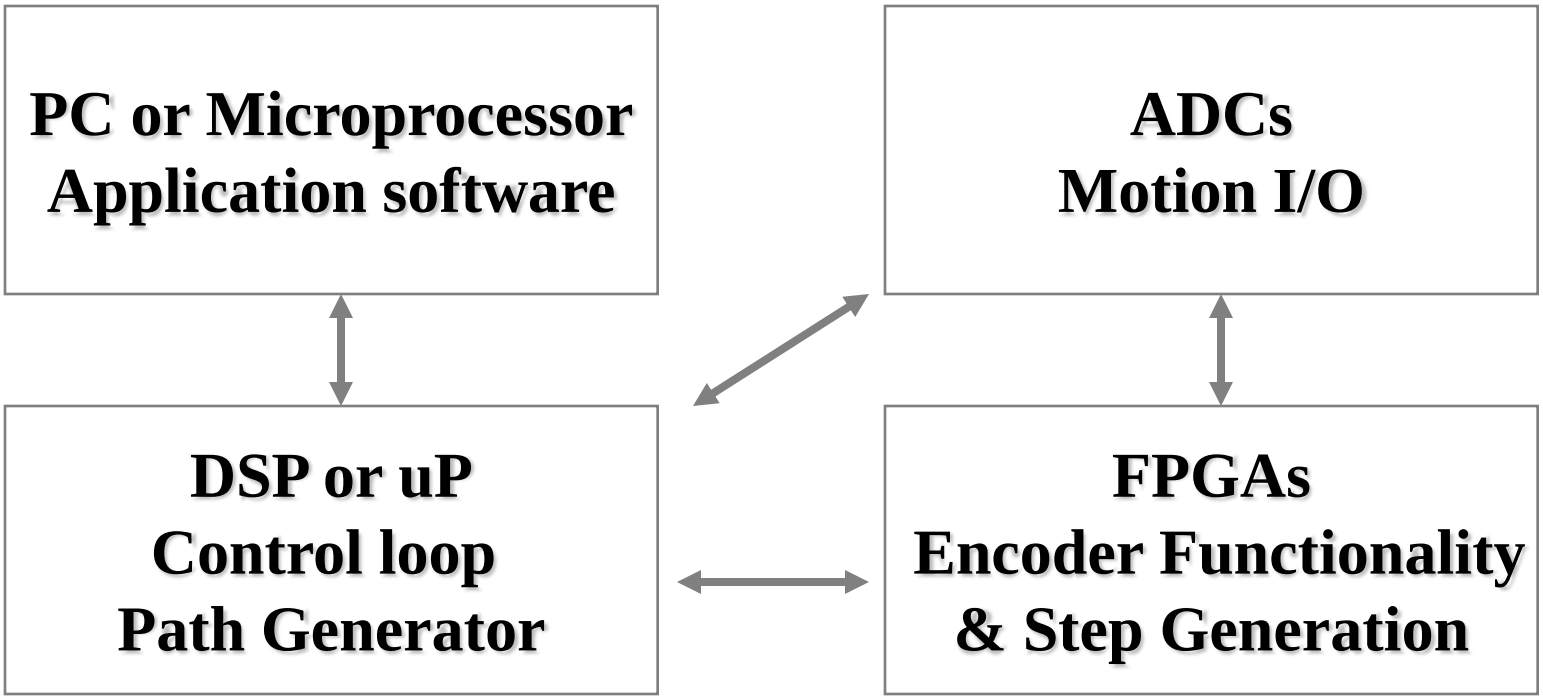
- EPOS (DC or EC, 20 – 700 W), sinusoidal commutation
- MIP (DC or EC, 50 – 500 W), block commutation

Motion Controller

Positioning

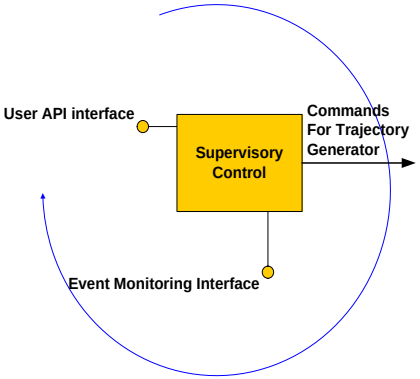
PC-based	Decentralized	Customized
PC based (Plug-In) PCI, PXI	**Distributed** CANopen	**Custom** RTOS, FPGA
		
		
PCI/PXI Motion Controller	EPOS	cRIO, cFP, DAQ

Components of a Motion Controller



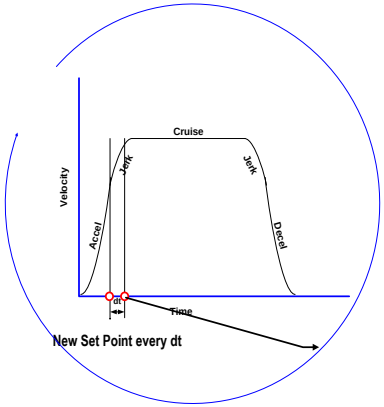
The Looping of a Motion Controller

Supervisory Loop (ms)



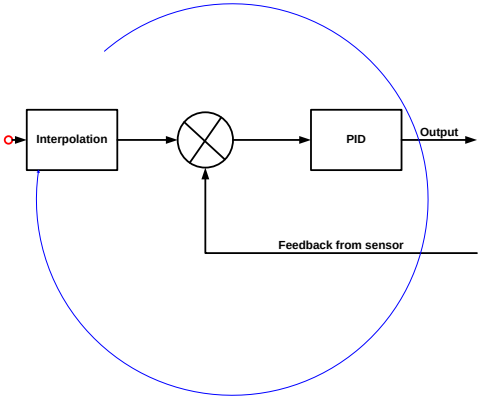
Updates the trajectory generator based on I/O and user entries

Path Generator (ms)



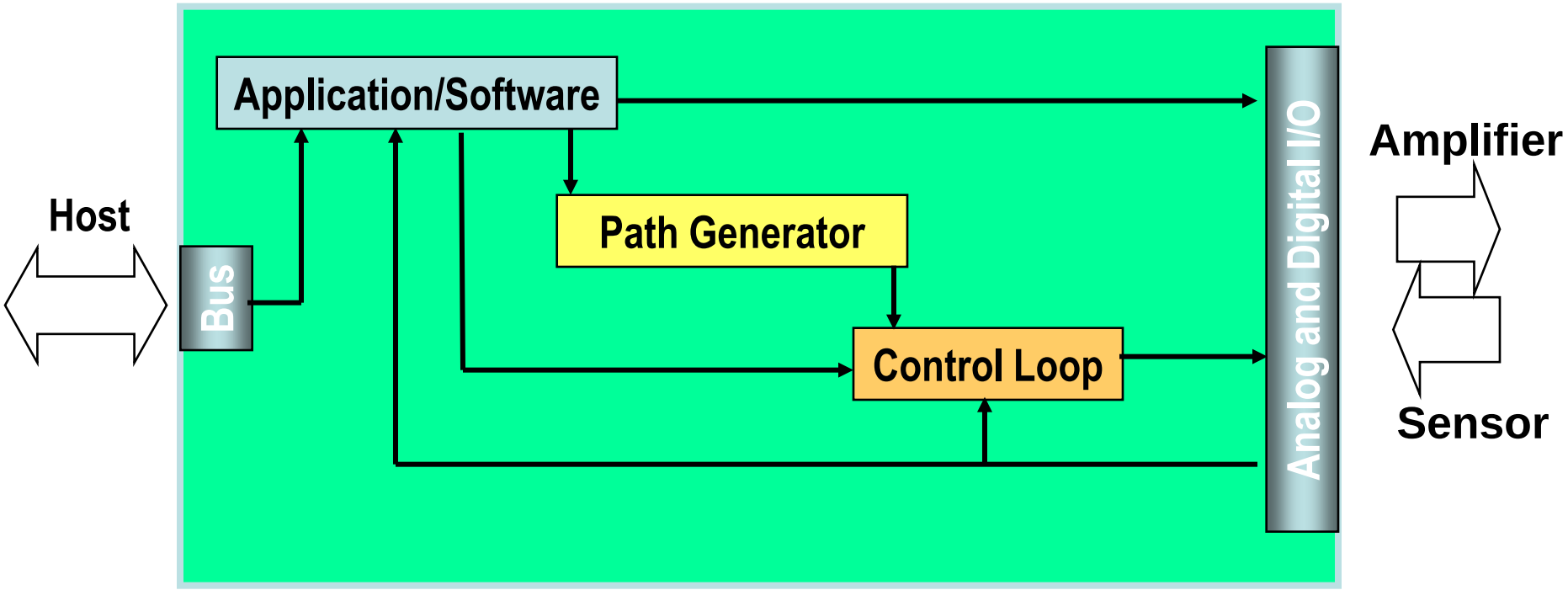
Calculates new setpoints

Control Loop (us)



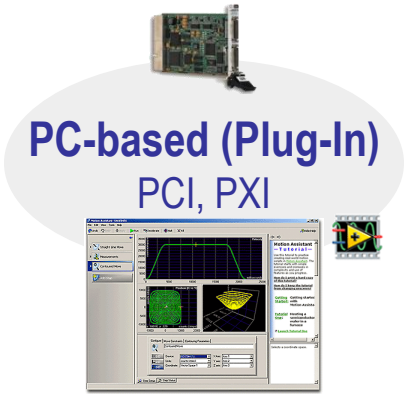
Interpolates between the setpoints and controls the actual position

Typical Motion Controller Architecture



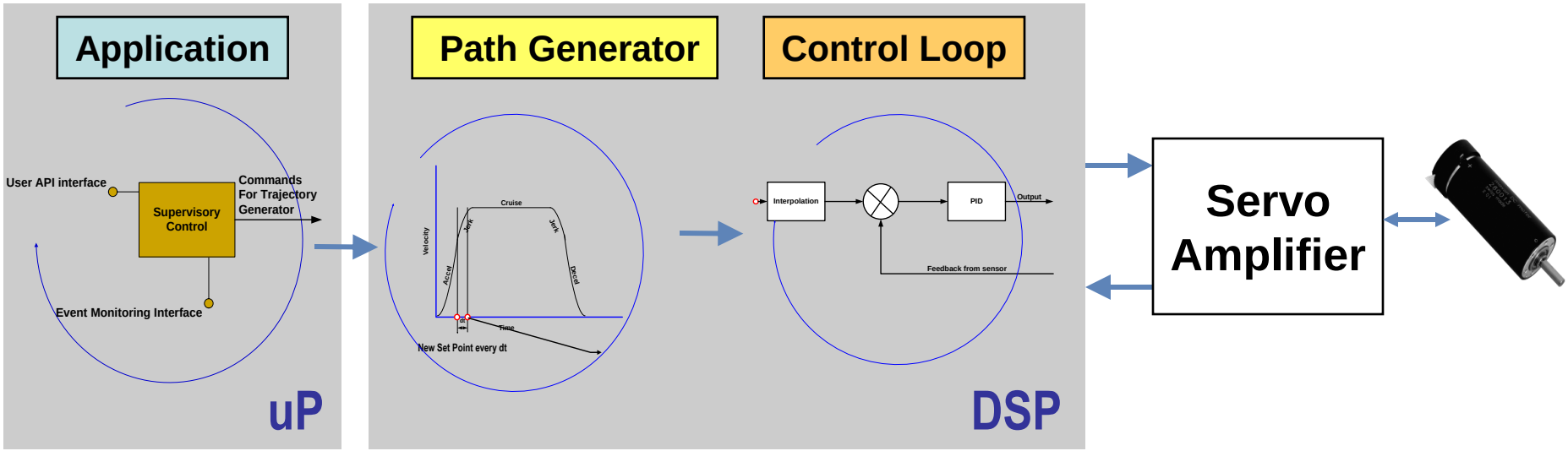
Microcontroller with RTOS/DSPs/FPGA

PC-Based Motion Controller



- Are integrated in standard or industrial PCs
- Simple integration
- Synchronization of several axis
- Synchronization with components such as Vision, DAQ, …

PC-Based Motion Controller



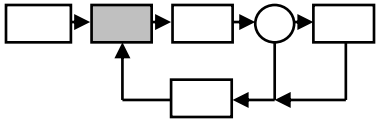
High-performance stepper and servomotor control

- available for PCI and PXI
- up to eight axles individually configurable for servo or stepper motors
- for stepper and servomotor control, hydraulic and piezo electronic control
- up to eight universal analog inputs for simple data acquisition
- up to 64 DIO channels

NI Motion Controller Hardware

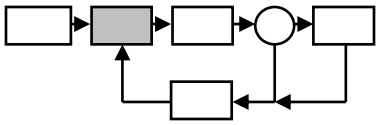
- NI-7350 Family (high-performance) NEW
  - up to eight servo or stepper axles
  - buffered position detection and trigger generation
  - onboard programming possibility
- NI-7340 Family (mid-range)
  - up to four servo or stepper axles
  - onboard programming possibility
  - PCI, PXI bus interface
- NI-7330 Family (low-cost)
  - up to four stepper axles

NI Motion Controller Overview



Type	NI 735x	NI 734x	NI 733x
Platform	PXI/CPCI	PCI, PXI/CPCI	PCI, PXI/CPCI
Total axis number	2, 4, 6, 8	2, 4	2, 4
Stepper motor axis	up to 2, 4, 6, 8	up to 4	2, 4
Servomotor axis	up to 2, 4, 6, 8	up to 4	-
Electr. Commutated	up to 1, 2, 3, 4	-	-
Limit switch	Fwd, Rev, Home	Fwd, Rev, Home	Fwd, Rev, Home
Encoder inputs	8	4	4
Analog inputs	8 (16 bit)	2, 4 (12 bit)	2, 4 (12 bit)
Calibratable als	✔	-	-
Digital I/O	64	32	32
PID controller frequency	62,5 µs per 2 axles	62,5 µs per axle	-
RTSI synchronization	✔	✔	✔

Functionality



Typ	NI 7350	NI 7340	NI 7330
Point-to-point run	✔	✔	✔
Linear 2D/3D vector interpolation	✔	✔	✔
Circular, helical, spherical interpolation	✔	✔	-
S-curve acceleration	✔	✔	✔
Contour motion	✔	✔	-
Electronic transmission	✔	✔	-
Position breakpoint/output rate	✔ 4 MHz periodic, 2 kHz buffered	✔ Onboard: ~200 Hz	✔ system-dependent
Highspeed capturing/	✔	✔	✔
Onboard programming	✔	✔	-

Motion Setups – PCI/PXI (PC-based)

DC Motors

Motion Controller

NI Drive

Motor

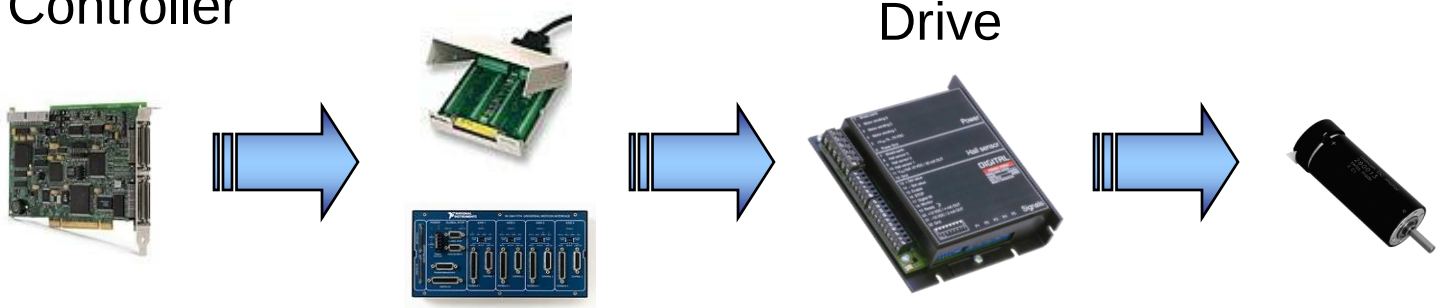
DC and EC Motors

Universal Motion Interface

Motion Controller

maxon Drive

Motor

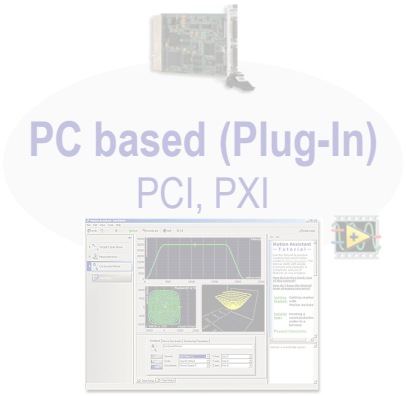


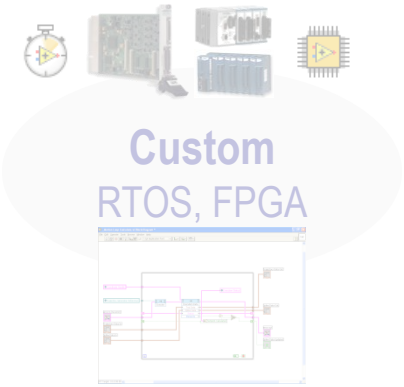
Demo

- XY Demo

Synchronization in Motion Controllers

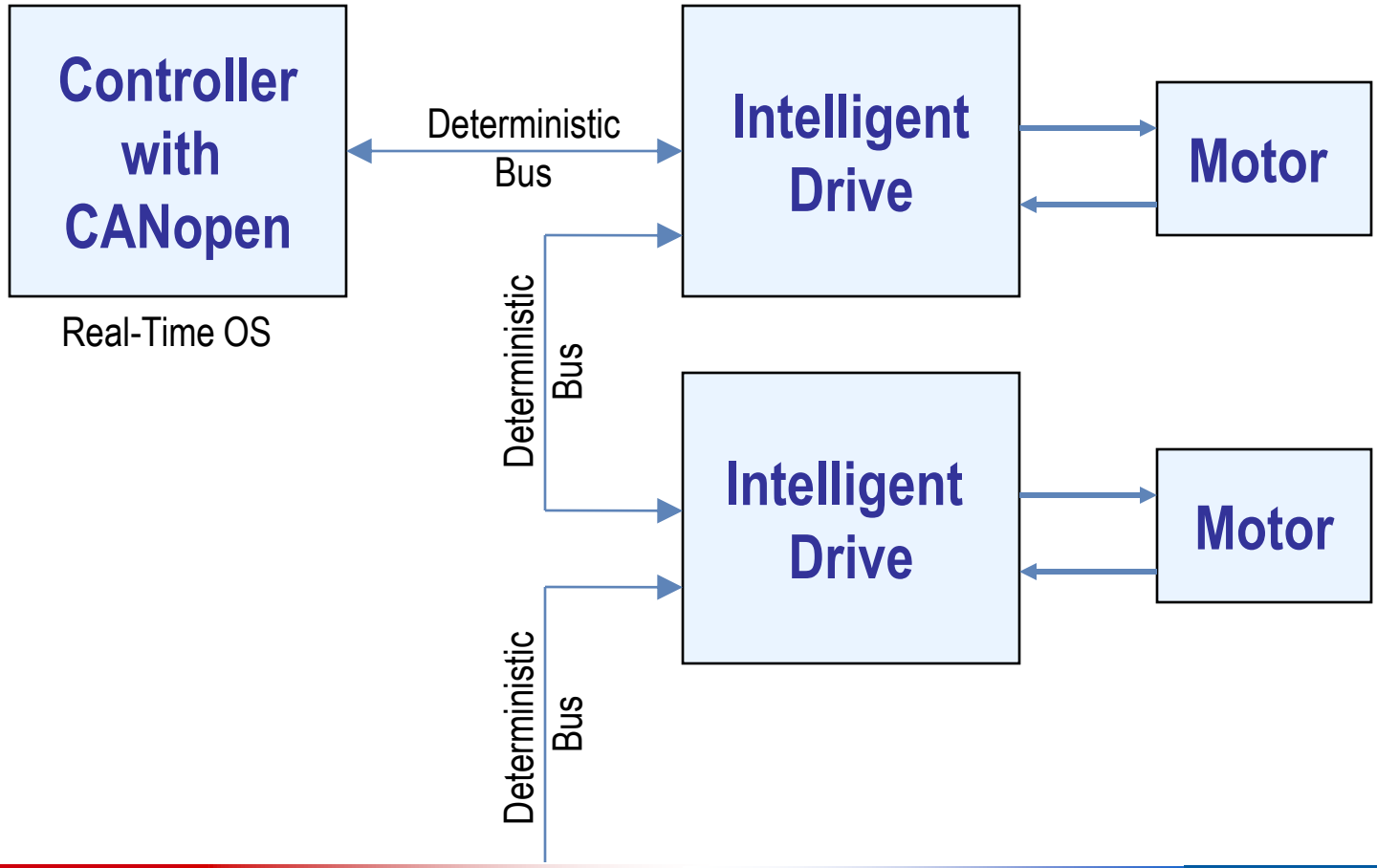
Decentralized Motion Controller



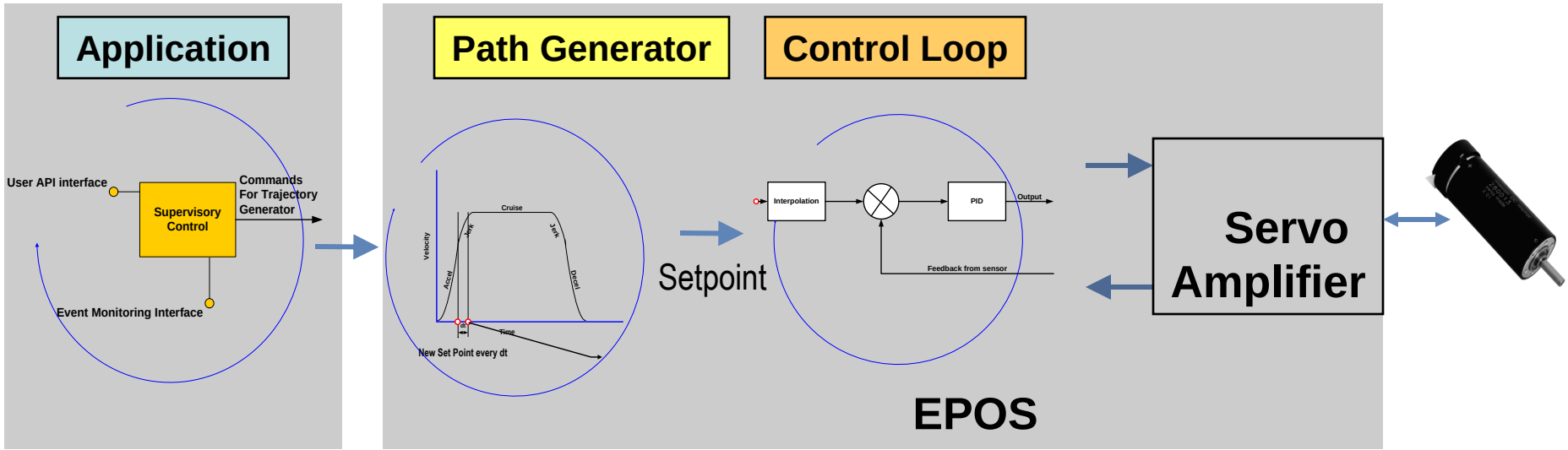


- are addressed via communication buses (e.g. CAN)
- long distance between computer and drive
- small cabling expenditure

Decentralized Motion Controller



Decentralized Motion Controller



Host Computer & RT OS

•LabVIEW real-time target platform with CAN

Intelligent Drive/EPOS

• Motion Controller for maxon DC and EC motors with encoder as per CANopen standard

maxon EPOS

- various performance variables
- DC and EC motors
  - sinusoidal commutation

EPOS 70/10
- 11 V – 70 V
- 10 A/25 A

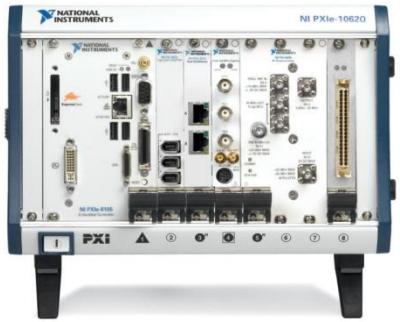
EPOS 24/1
- 9V – 24V
- 1 A/2 A

EPOS 24/5
- 11 V – 24 V
- 5 A/10 A

Motion Setups (decentralized)

DC and EC Servo motors

CAN



EPOS

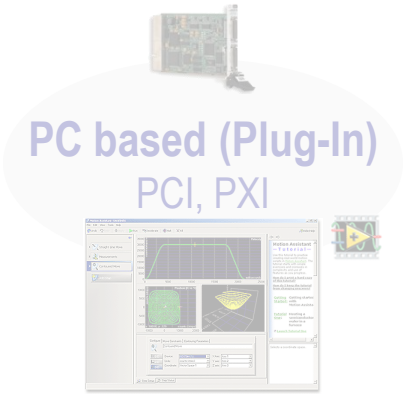
Drive

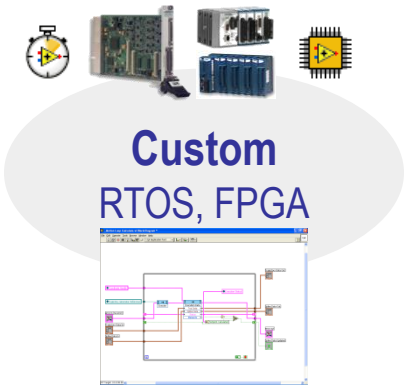
Motor

Demo

EPOS

Customized Motion Controller



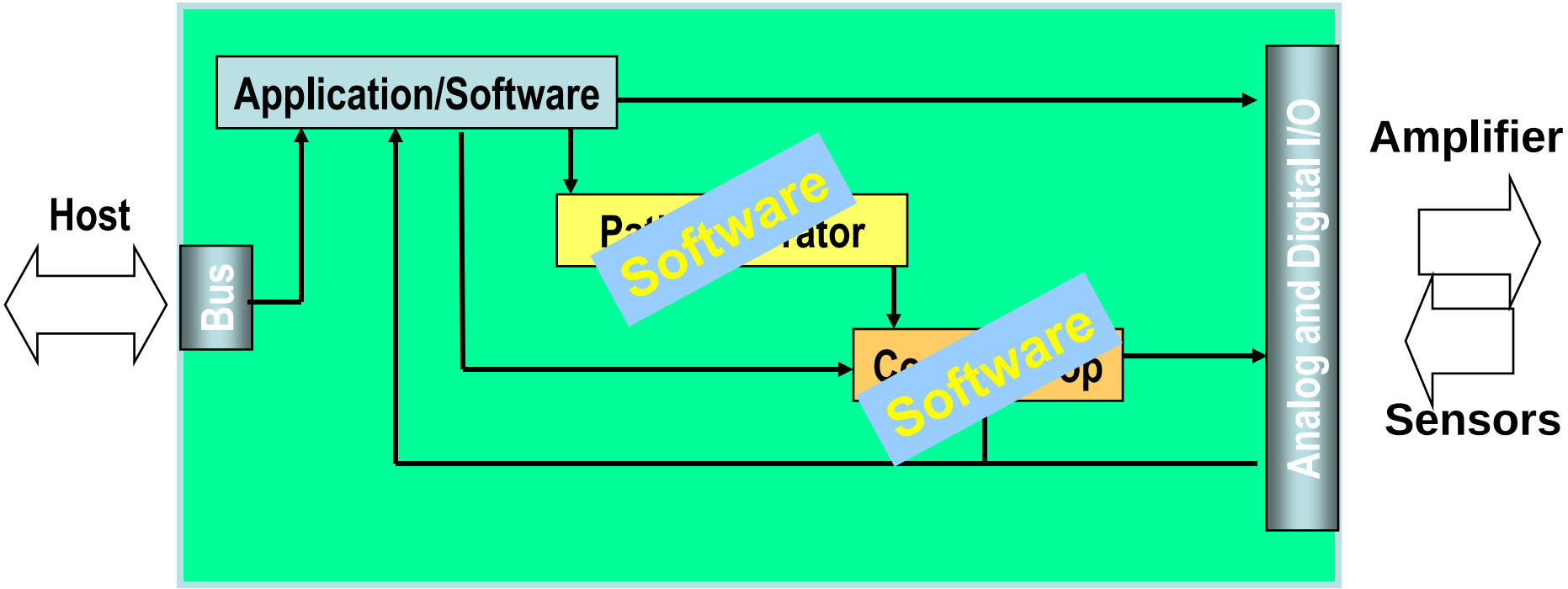


- Use of standard components and technologies
- Free programmability for controllers and feedback signals
- Depending on hardware very high controller frequencies possible

Programmable Automation Controller

- Open software architecture with Real-Time and FPGA technologies
- Scalable hardware (multifunction I/O, Vision, Motion, …)
- Very robust and compact

Typical Motion Controller Architecture



Requirement:
Microcontroller with RTOS, DSPs, FPGA

Motion Setups (customized)

DC Motors

Interface to Drive

Motor

DI **DO**

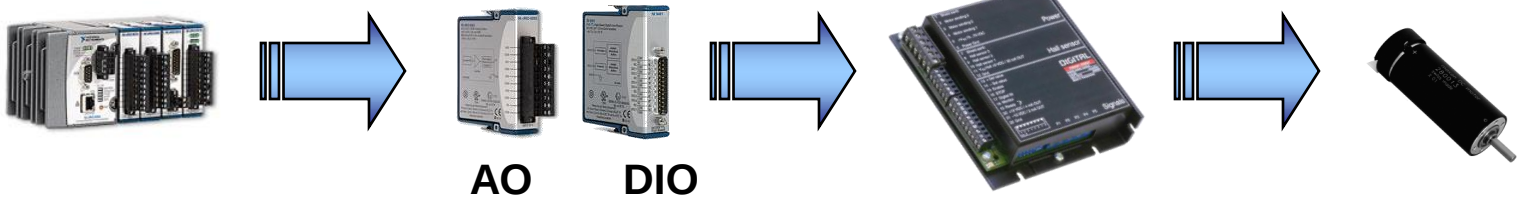
NI 9411 NI 9474

DC and EC Motors

Interface to Drive

maxon Drive

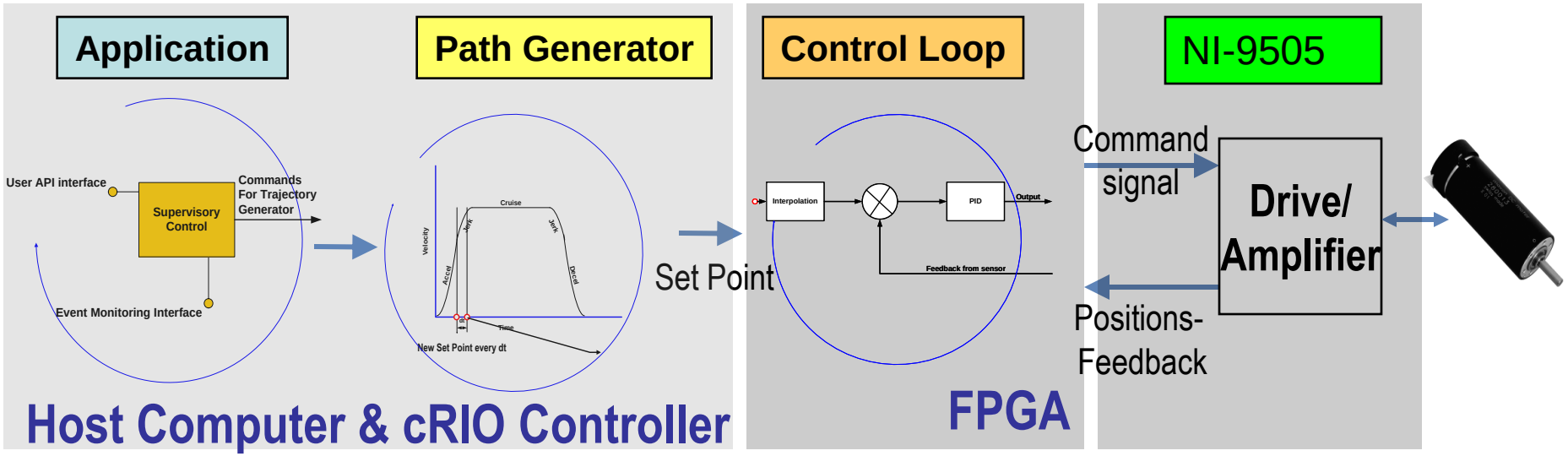
Motor

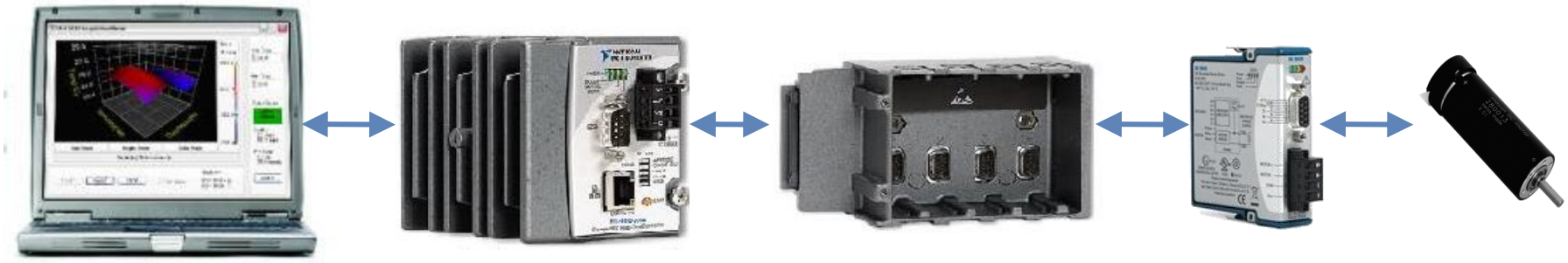


AO **DIO**

NI 9263 NI 9401

Example


Application
Path Generator
Control Loop
NI-9505
User API interface
Supervisory Control
Commands For Trajectory Generator
Event Monitoring Interface
Cruise
Velocity
Time
New Set Point every dt
Set Point
Interpolation
PID
Output
Feedback from sensor
Command signal
Drive/ Amplifier
Positions-Feedback
Host Computer & cRIO Controller
FPGA

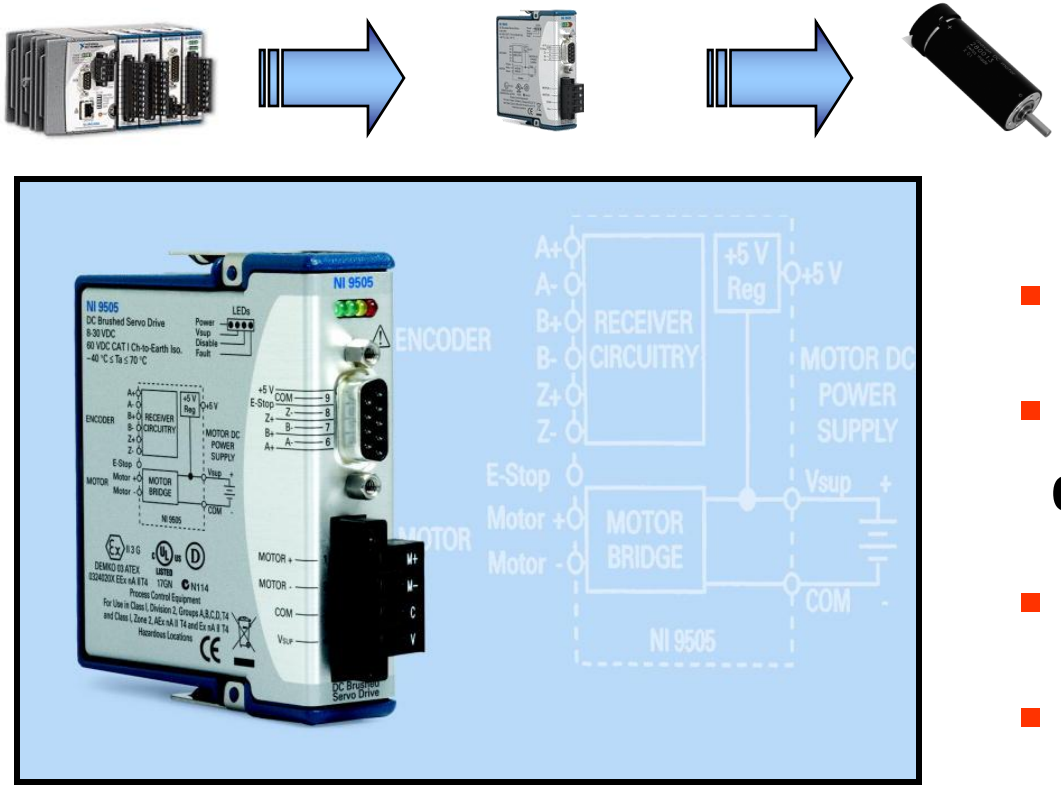


Motion Setups (customized)

DC Motors

Drive
NI 9505

Motor



- **NI 9505**
- **Drive for servo drives up to 60 W**
- **Encoder input**
- **Motor connection**

Demo

- CompactRIO-Demo