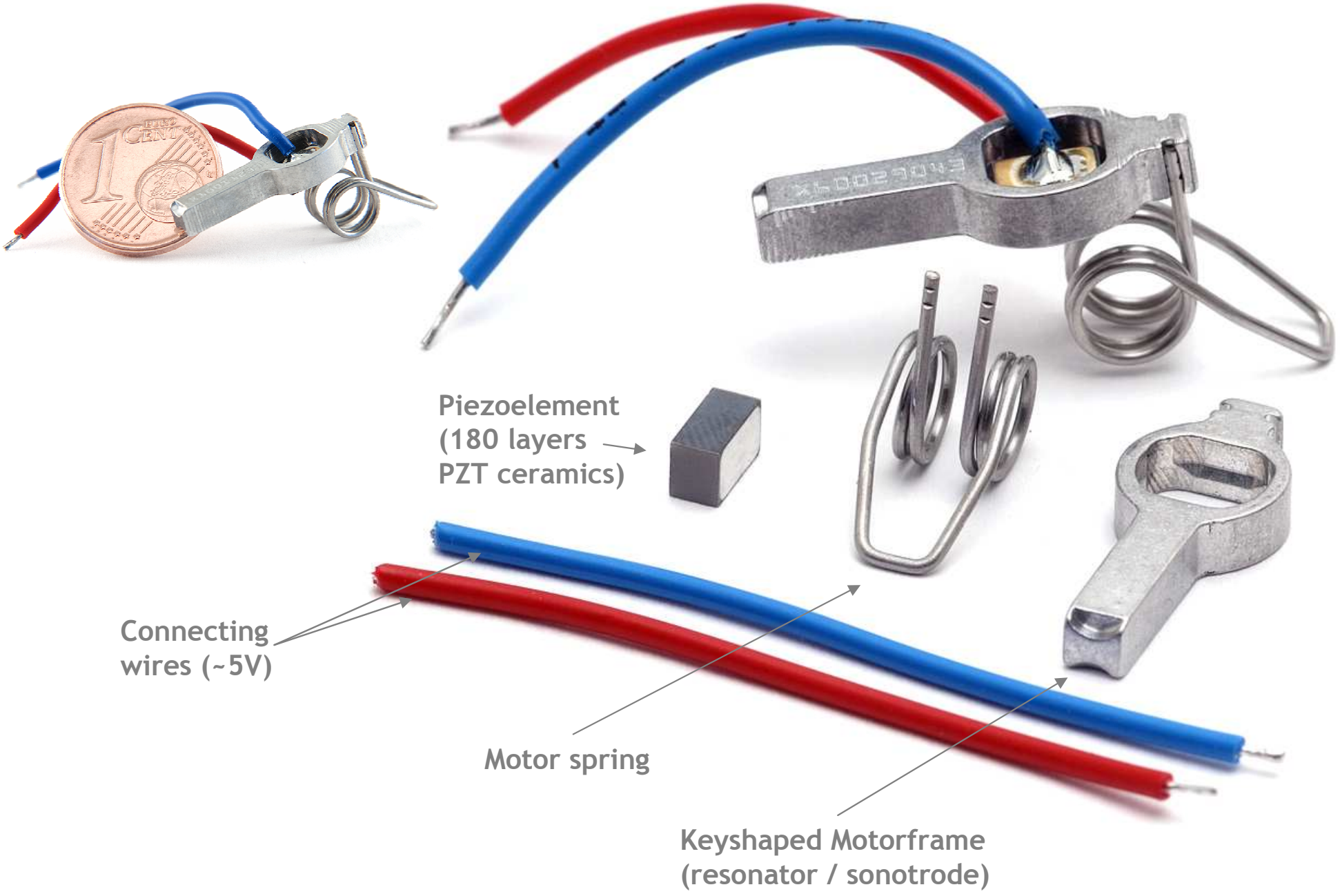
Enhancing Positioning Resolution of Elliptec Motors using New Generation Low-Cost Sensors

Christian Stromberg
Application Development & Technical Support

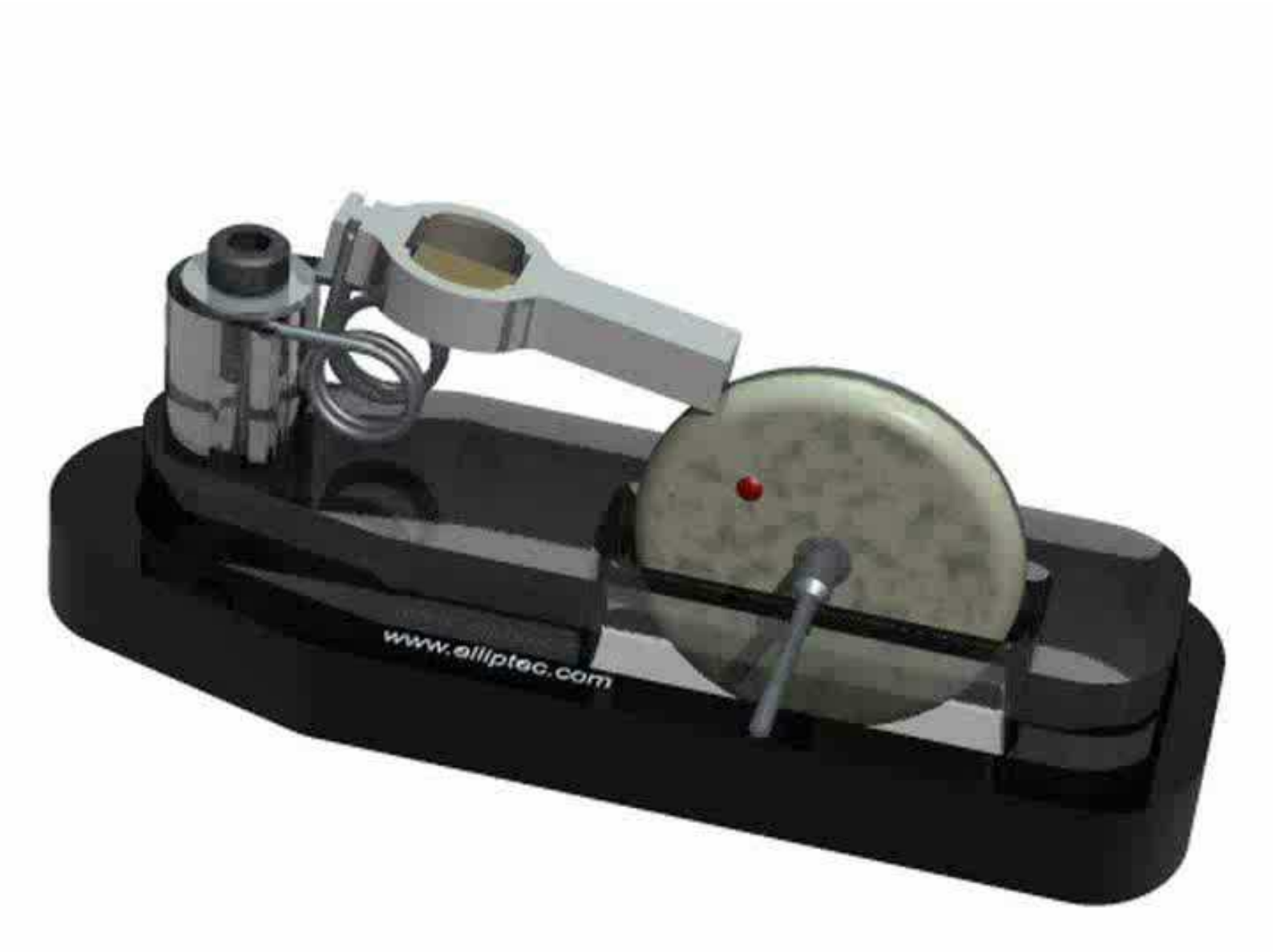
Elliptec AG: Who we are

- Elliptec develops, produces and sells **low cost piezo-motors and -actuators**
- Elliptec offers **engineering services and design-in support** for their products
- Headquarters and production facility is in **Dortmund, Germany**

Elliptec Motor X15G – only 3 functional parts

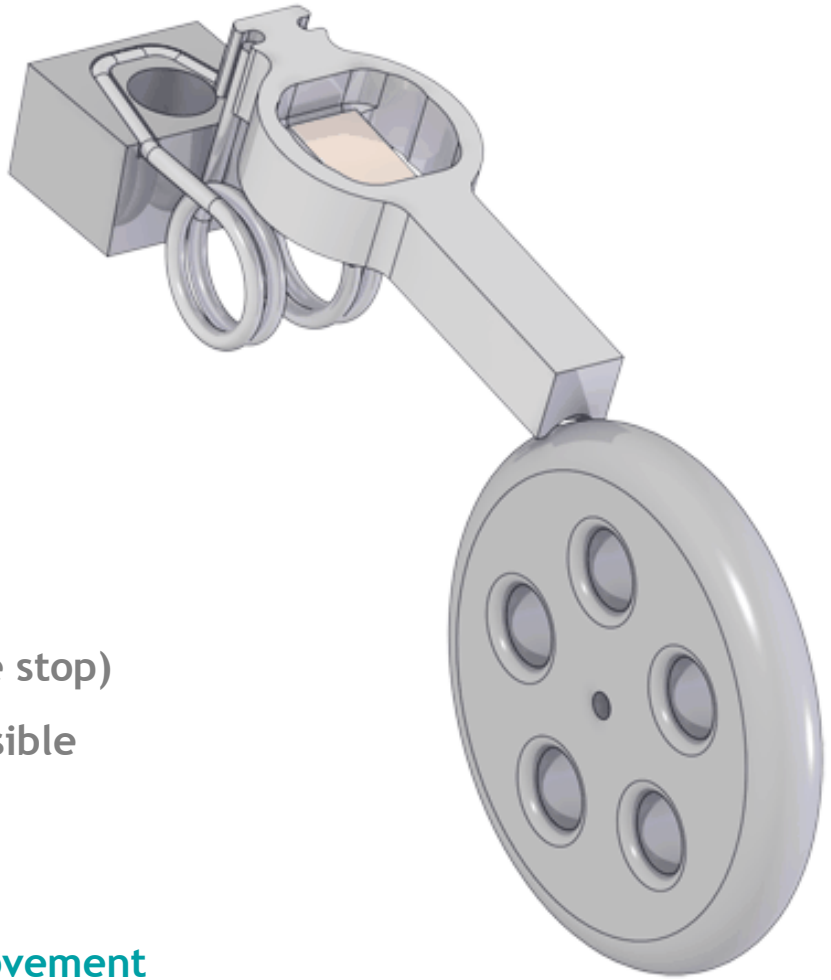


Elliptec Motor X15G – how it works



Elliptec Motor X15G – unique performance

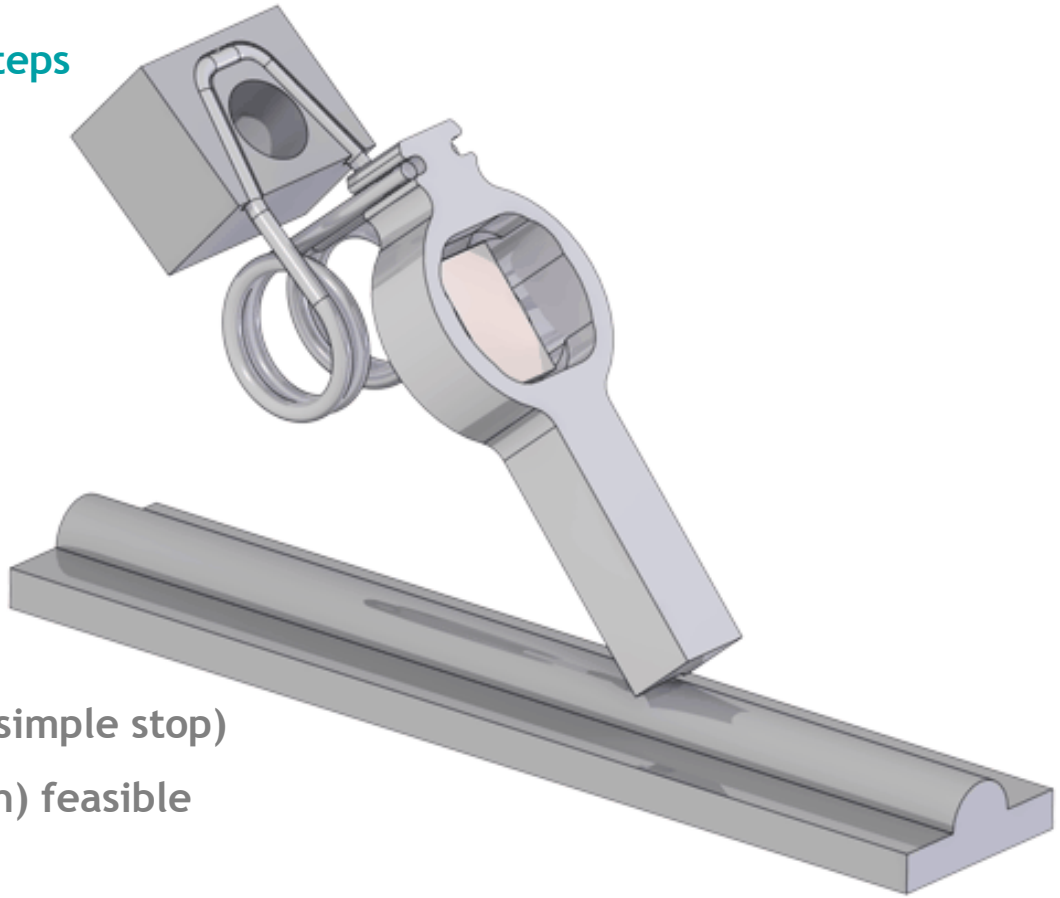
- Driving by small resonant steps
- Driving by friction
- FWD @ 80kHz
- BWD @ 100kHz
- Fast: 350mm/s !



- Precise: < 15µm accuracy (simple stop)
- Higher precision (submicron) feasible
- Dynamic: start/stop < 5ms
- Low cost
- Direct linear, rotational or XY movement

Elliptec Motor X15G – unique performance

- Driving by small resonant steps
- Driving by friction
- FWD @ 80kHz
- BWD @ 100kHz
- Fast: 350mm/s !



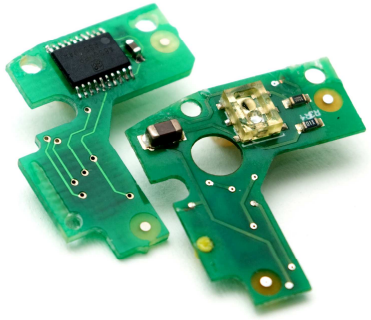
- Precise: < 15µm accuracy (simple stop)
- Higher precision (submicron) feasible
- Dynamic: start/stop < 5ms
- Low cost
- Direct linear, rotational or XY movement

Low Cost Concept = Low Cost System

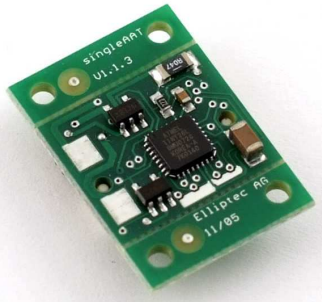
Low Cost Concept

means

- Low Cost Motor
- Low Cost Sensor
- Low Cost Controller



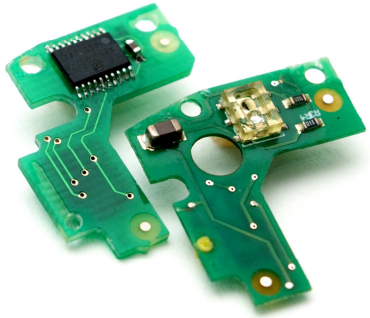
sensor requirements vs. controller capability

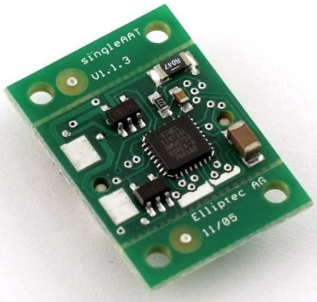


Demands - (1)

High sensor resolution

to exploit Elliptec Motor X15G positioning capabilities

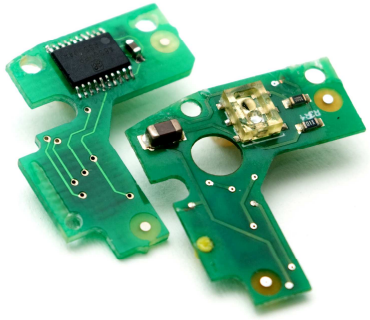


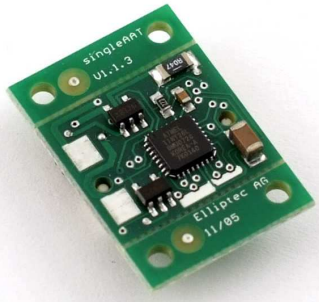


Demands - (2)

Quadrature incremental output

for simple signal processing by controller

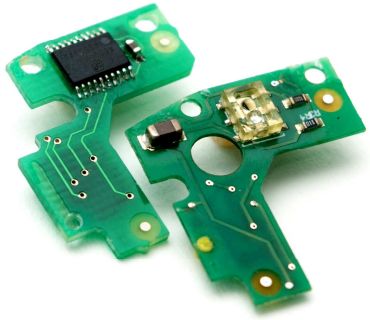


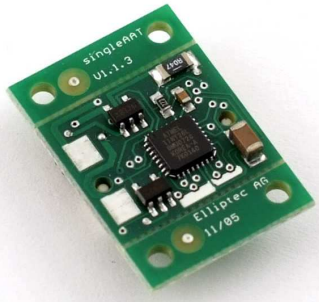


Demands - (3)

Index pulse

to allow tracking positioning signals even at high speed without high CPU load on controller

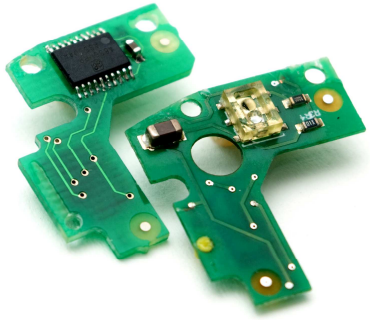


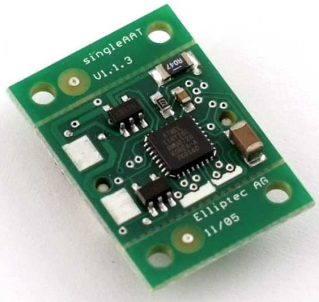


Demands - (4)

Processing Speed

to allow the use of intelligent positioning algorithms for driving the motor and to process sensor signals

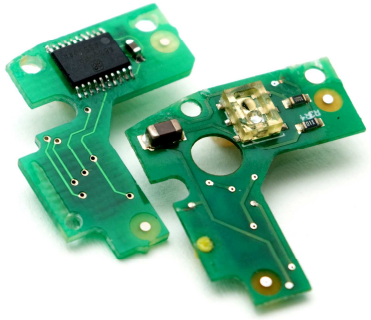


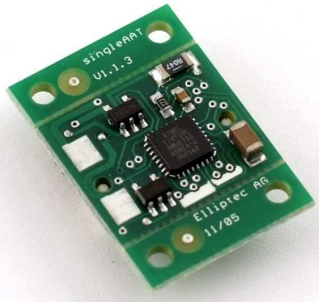


Demands - (5)

Small packaging size

to contribute to the small form factor of Elliptec Motor X15G and Elliptec Controller

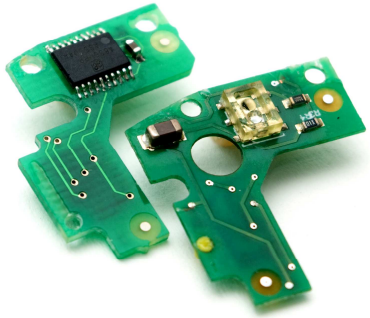


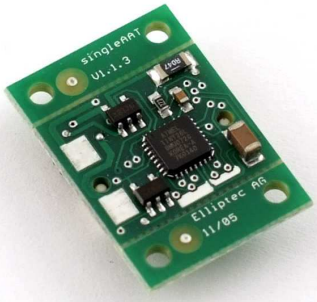


Demands - (6)

Low Cost

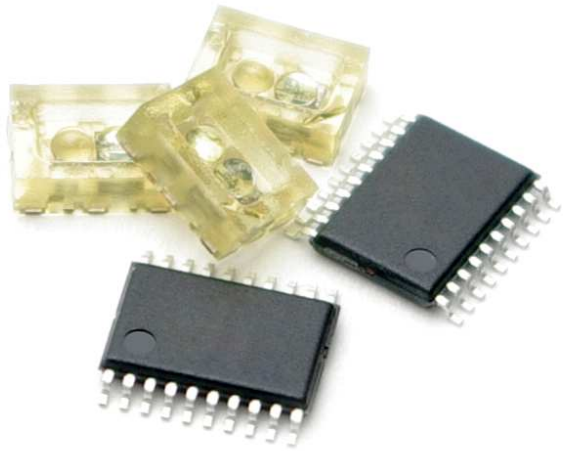
costs should not exceed the controller itself





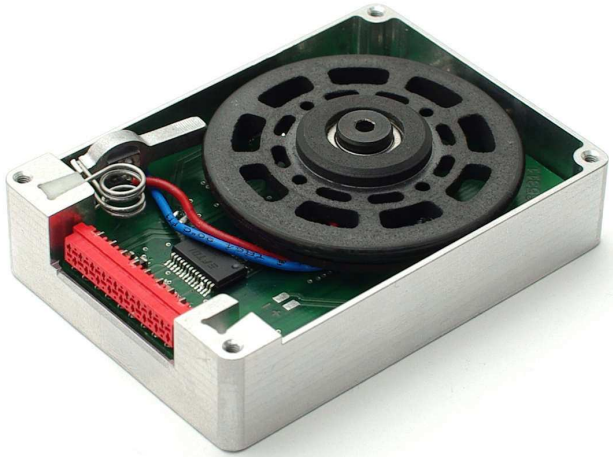
The Solution

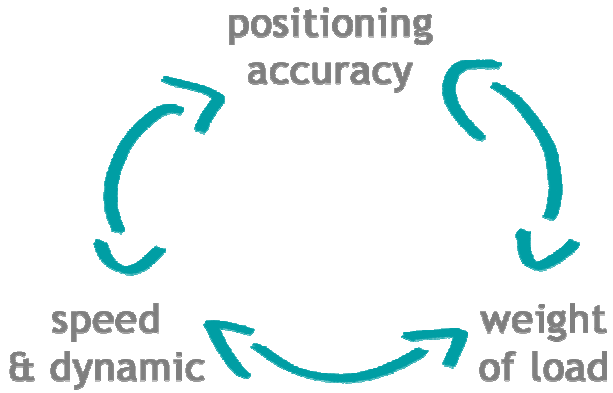
New Generation high precision low cost sensors



- high resolution - 0.5µm ✓
- quadrature output - by sensor ✓
- index pulse - every 2mm ✓
- small packaging size - 7x7mm ✓
- low cost - <<10€ ✓

Bringing together sensor and motor technology

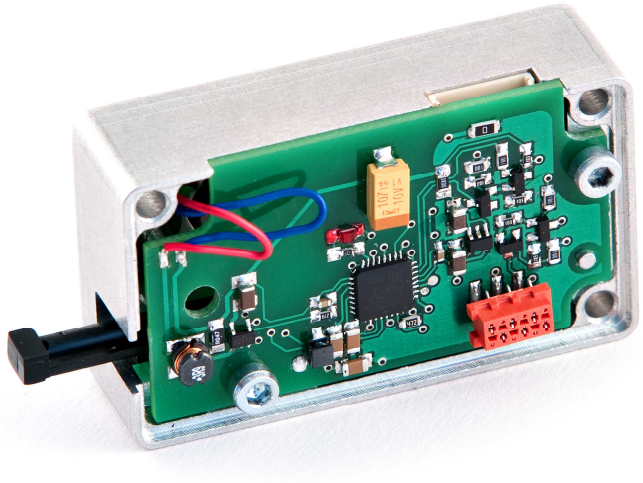


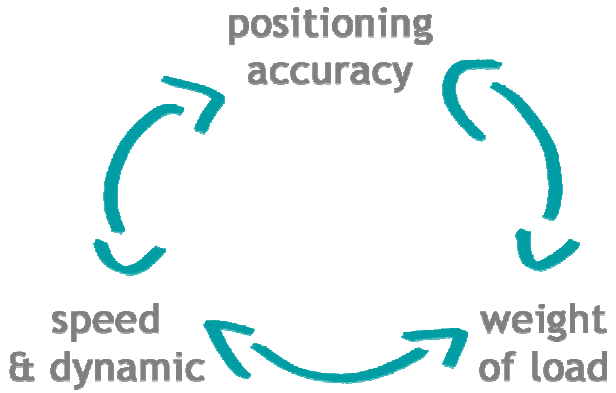


- higher resolution → shorter distance between positions for breaking / compensating load inertia
- increasing load exacerbates braking problem by higher inertia = higher kinetic energy to absorb
- higher speeds exacerbates braking problem by higher kinetic energy to absorb

→ Requirements for intelligent positioning algorithms

Bringing together sensor and motor technology





- higher resolution → higher influence of mechanical tolerances
- finer steps → less friction required for smooth acceleration

→ Requirements for refined precision miniature ball bearings

Example: Algorithm
Compensating PositionJitter and Overshoot

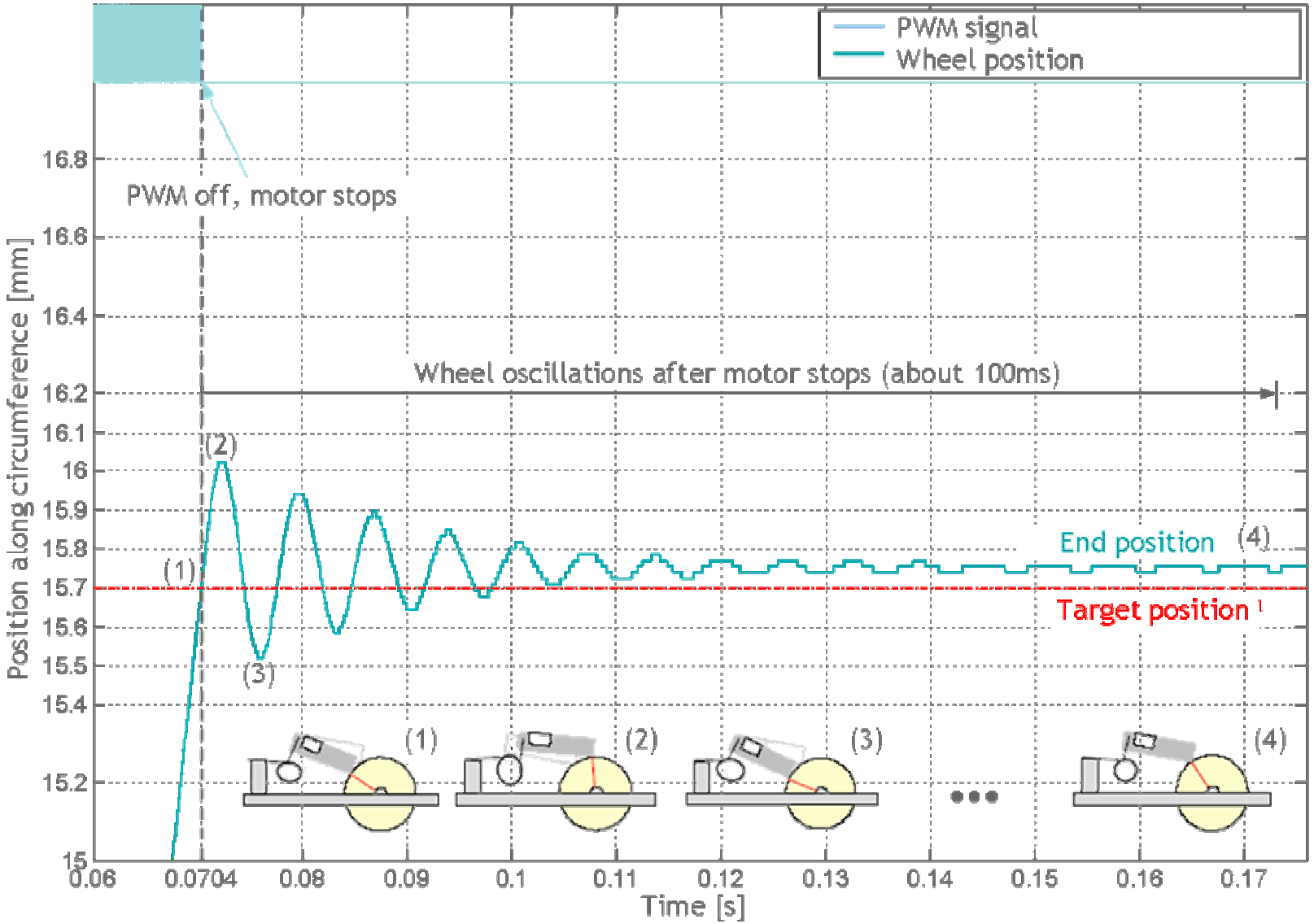


Fig. 1: Settling oscillations after the motor has been stopped in mid-operation.

Example: Algorithm
Compensating PositionJitter and Overshoot

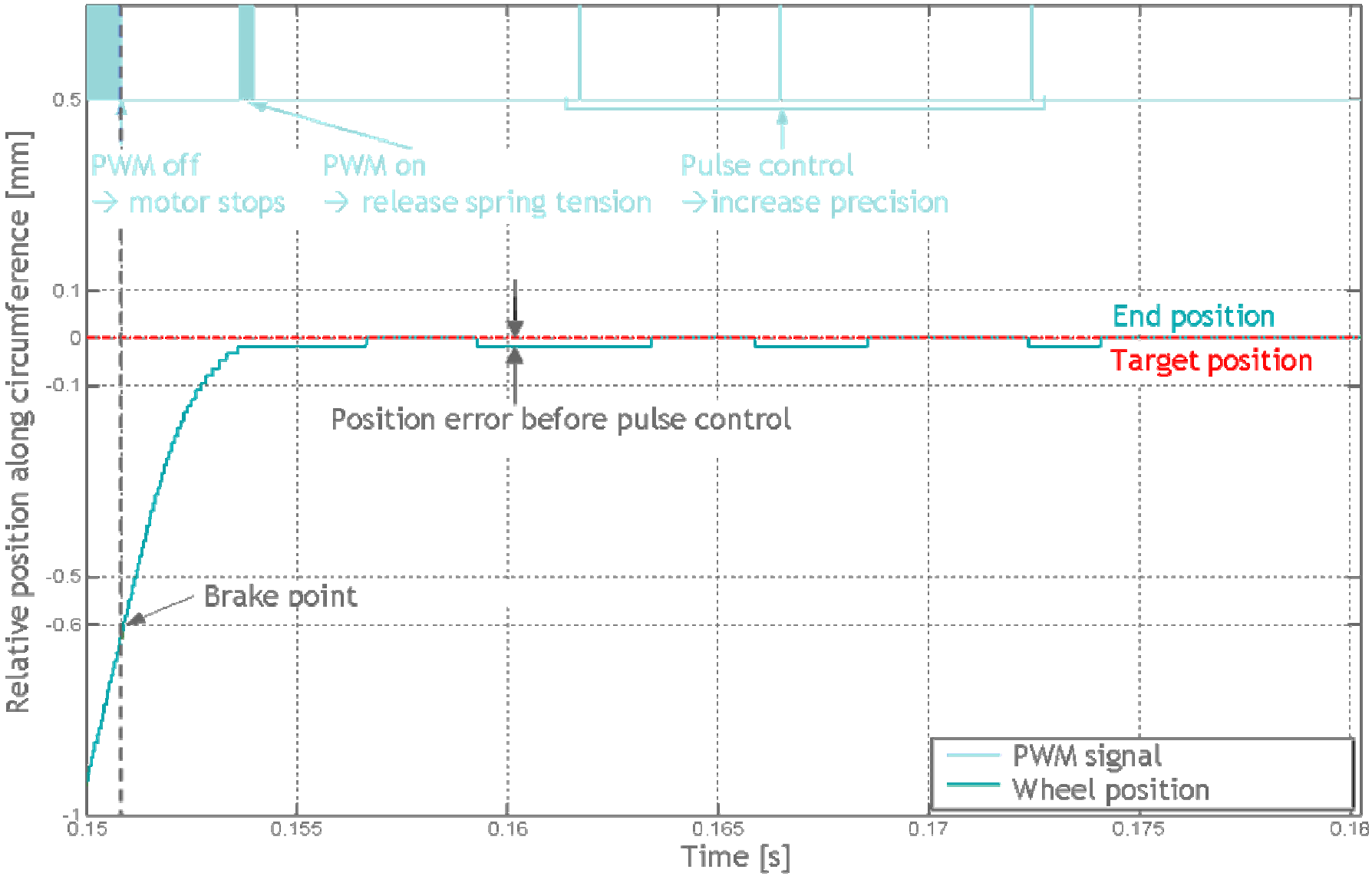
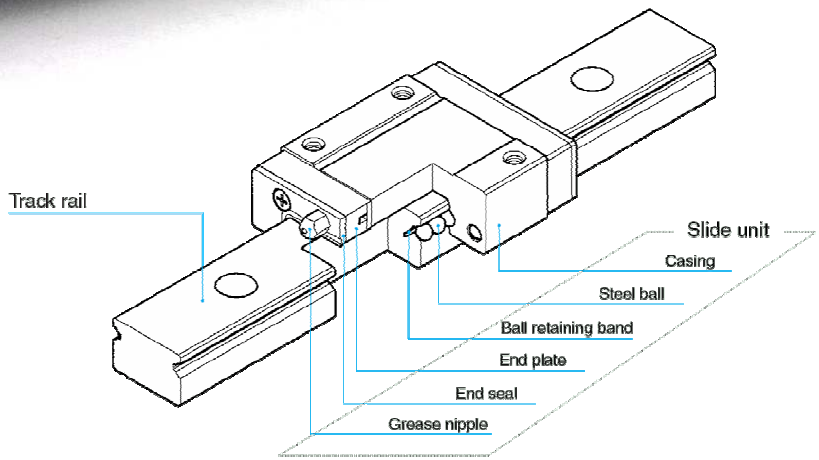


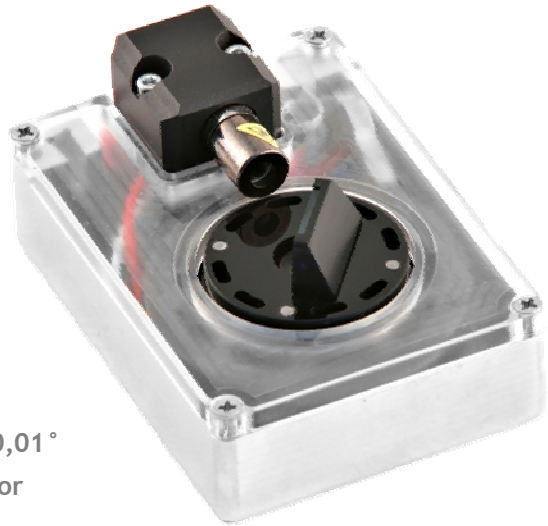
Fig. 2: Pre-compensation of settling vibrations.

Example: Bearing
Low Friction and High Accuracy



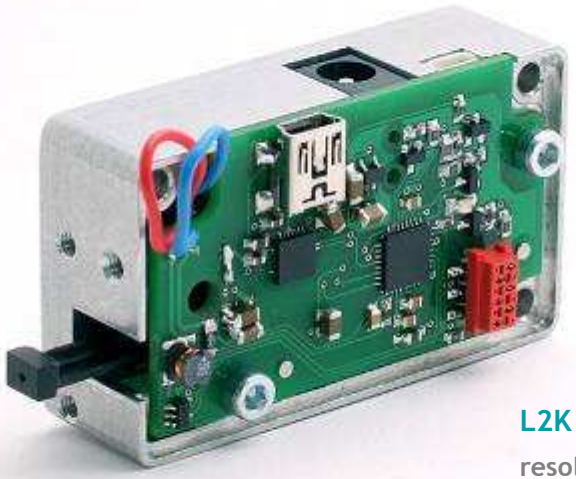
- Miniature size
- High accuracy achieved by eliminating the number of potential errors using a simple design
- Stainless steel with high corrosion resistance
- Flexible assortment with extensive amount of variations for multiple purposes
- “Ball retained”-types available even in miniature sizes

Result: New Elliptec Standard Products



R2K Module

resolution: < 0,01°
magnetic sensor
USB interface
R2K-001



L2K Modul

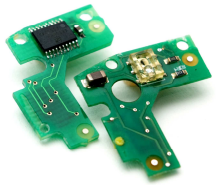
resolution: <1 µm
magnetic sensor
USB interface
L2K-001

Symbol	Parameter	Ratings			Unit
		min.	typ.	max.	
Vcc	Supply Voltage for Powerstage	4,5	5	5,5	V
M_H	Unpowered Holding Torque	10	16	20	mNm
	Supply Current @ maximum Speed		450	600	mA
Icc	Supply Current during Calibration			900	mA
	Supply Current in Idle Mode			60	mA
$T_{ambient}$	Operating Temperature	-10	20	65	°C
j	Angular Resolution		~0.01		°

Symbol	Parameter	Ratings			Unit
		min.	typ.	max.	
Vcc	Supply Voltage for Powerstage	4,5	5	5,5	V
F_H	Unpowered Holding Force	0,5	0,8	1,2	mN
v_0	No-Load Speed	200	300	450	mm/s
F_B	Maximum Blocking Force	200	300	500	mN
F_O	Motor Driving Force	100	200	300	mN
	Supply Current @ maximum Speed		450	600	mA
Icc	Supply Current during Calibration			900	mA
	Supply Current in Idle Mode			60	mA
I_{motor}	Peak Current			1,5	A
$T_{ambient}$	Operating Temperature	-10	20	65	°C
n	Linear Resolution		0,48		µm°
H	Linear Stroke		20		mm

Application Development: Product Portfolio

Adopted sensors & linear guides



sensor integration
optical:
Resolution 30µm
magnetic:
Resolution 0,48µm

encoder strip
Rotary: (∅ 16mm, 300 lines)
Linear: (200mm, 2500 lines)

precise linear guide with ball bearing
various sizes, eg. 25mm

simple linear guide
length: 36mm

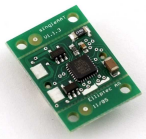
Wheels and other driven geometries

wheels
diameter: 20mm
diameter: 14mm

wheel segments
radius: 5mm
radius: 8.5mm
radius: 14.5mm

R40 accessories
knop, mirror, axis

Motioncontrollers

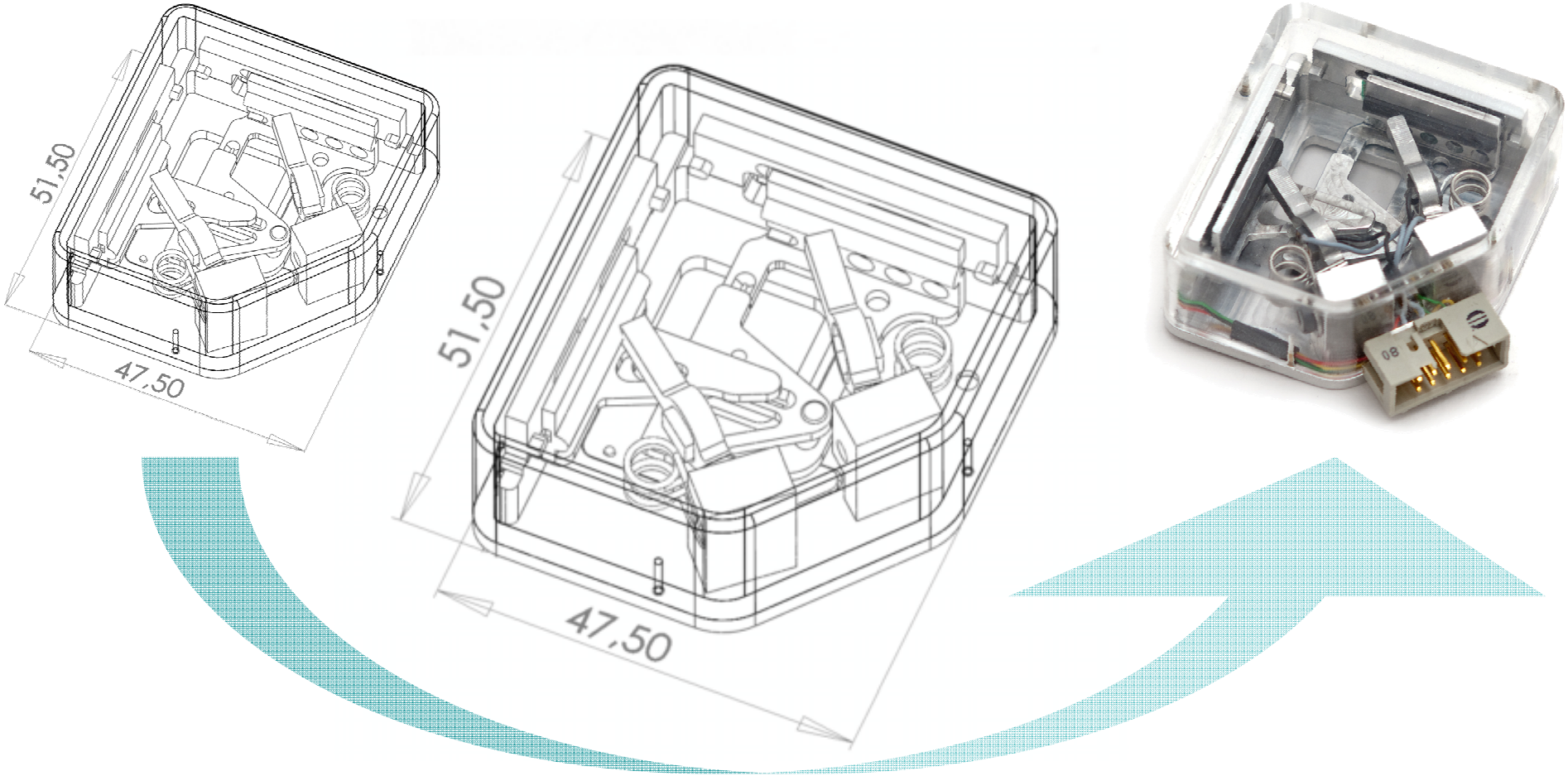


Elliptec Controller
std. control unit

1-motor-controller
with USB Interface
remote accessible via command set

2-motor-controller
with USB Interface
remote accessible via command set

New concepts become real



For development and integration, Elliptec Engineering Services are available.

- See more applications
- Discuss your application
- Visit us at booth **H16** (**hall 6**)