

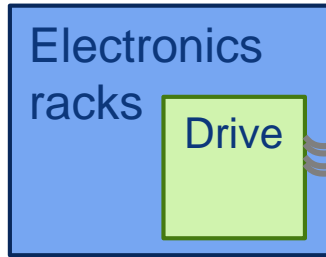
A Closed-Loop Stepper Motor Drive for Use with Long Cables

Mark BUTCHER



Motivation – A CERN Application

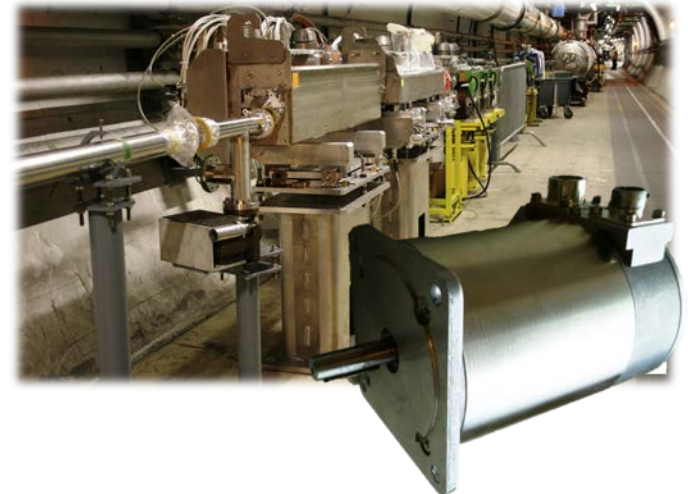
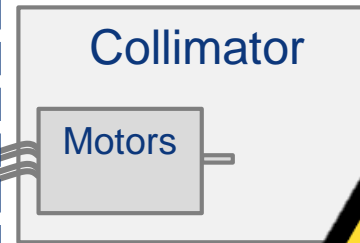
Radiation free area



Up to 800 m

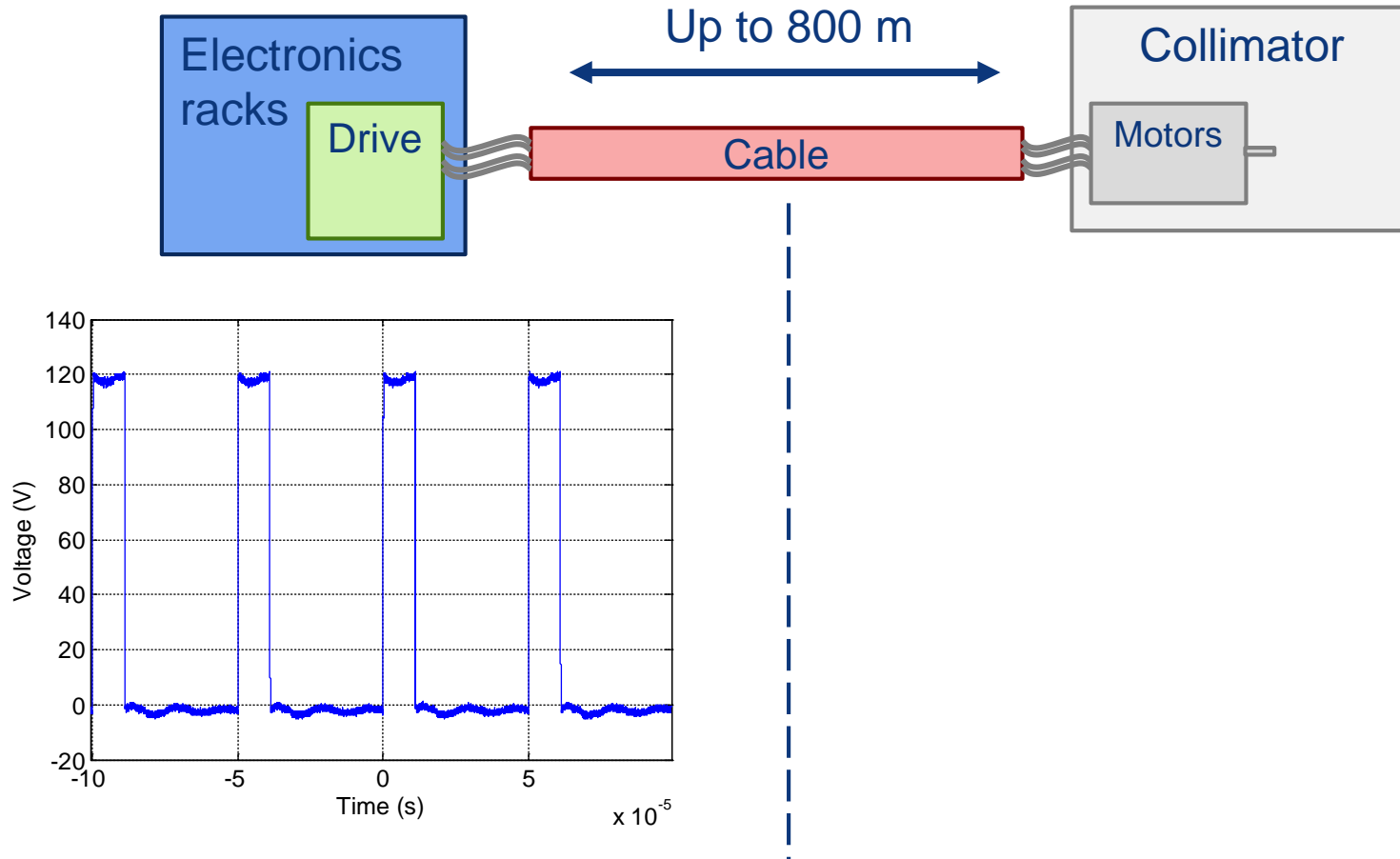


Tunnel – High radiation area



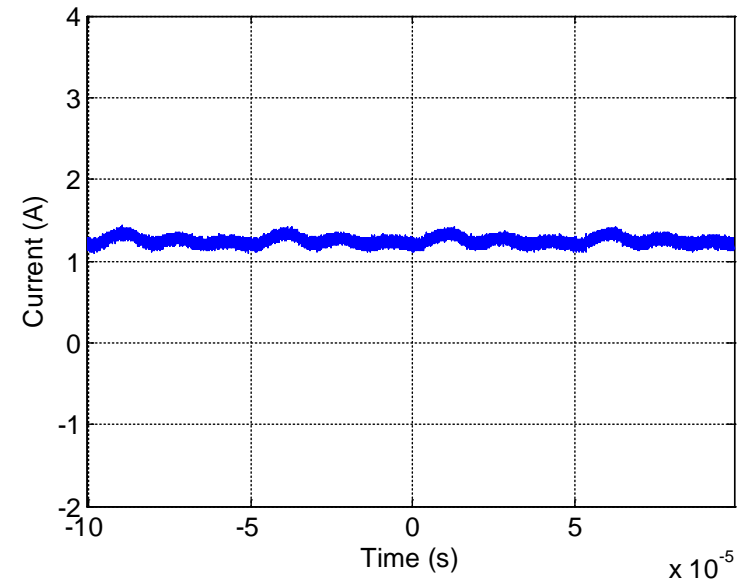
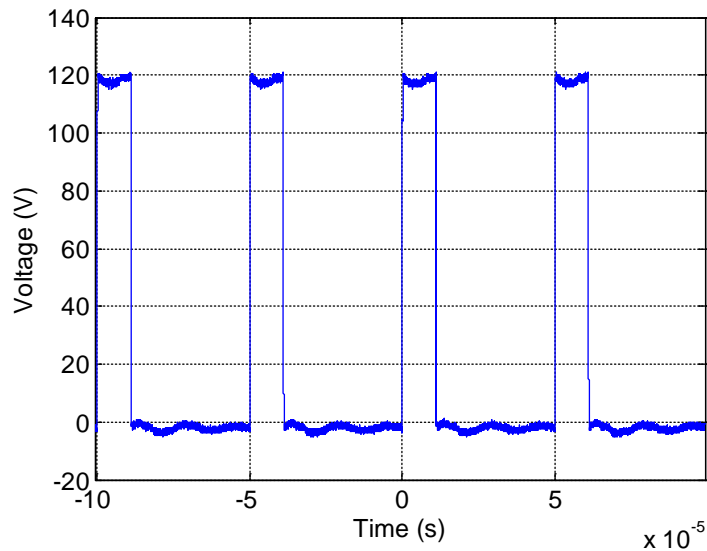
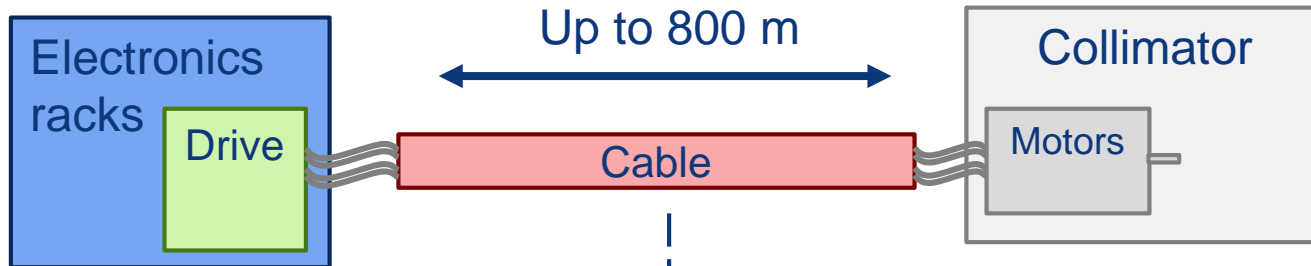
Motivation – Current control problem

Fixed duty cycle, 120 Volts, 20 kHz PWM applied on the drive-side, 720 meter cable



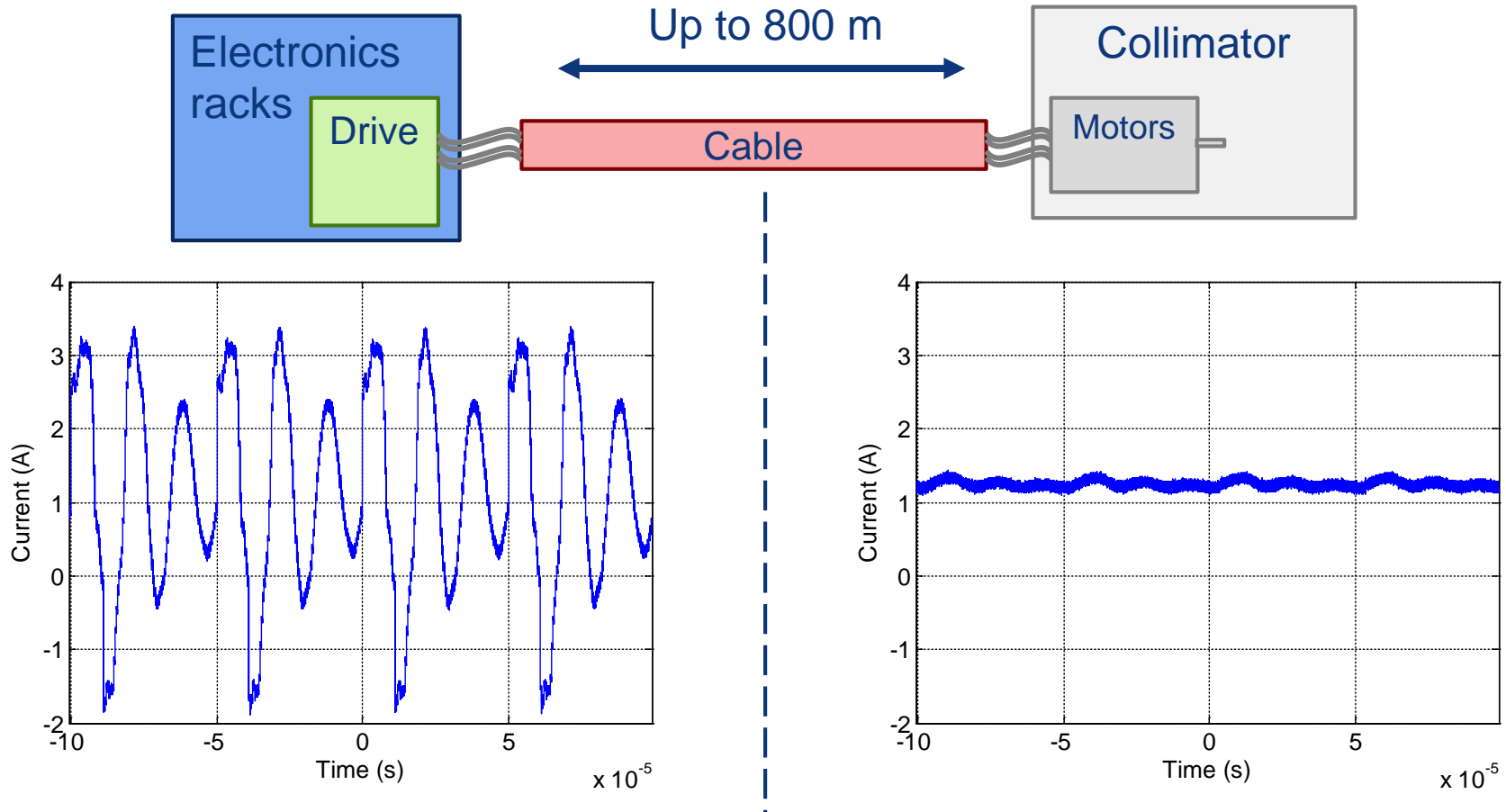
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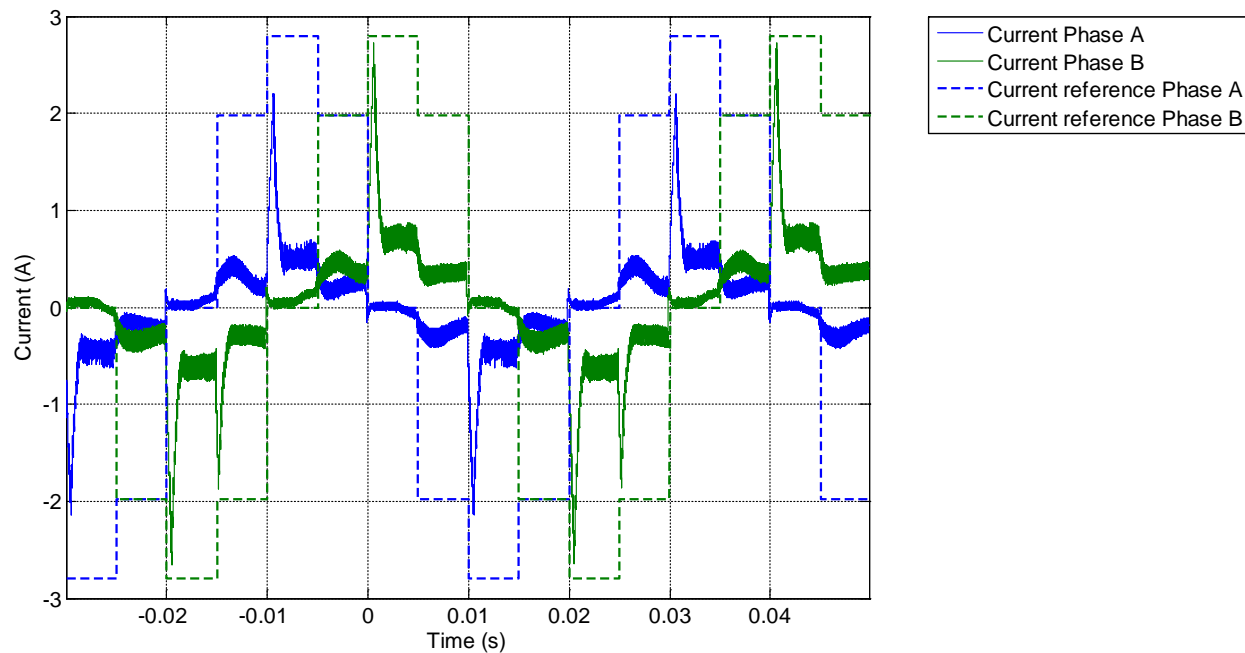
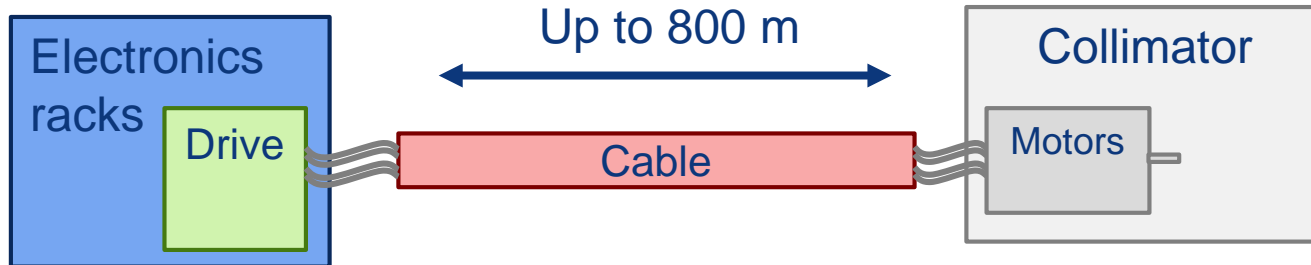
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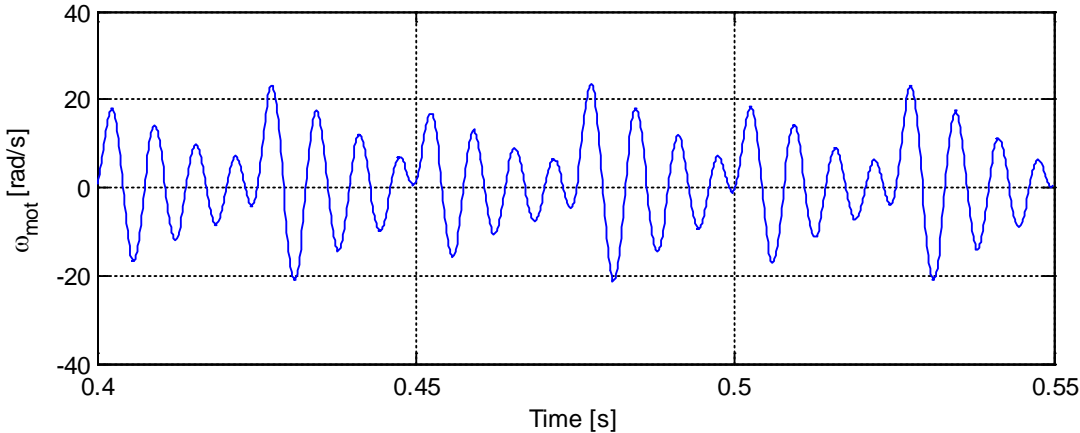
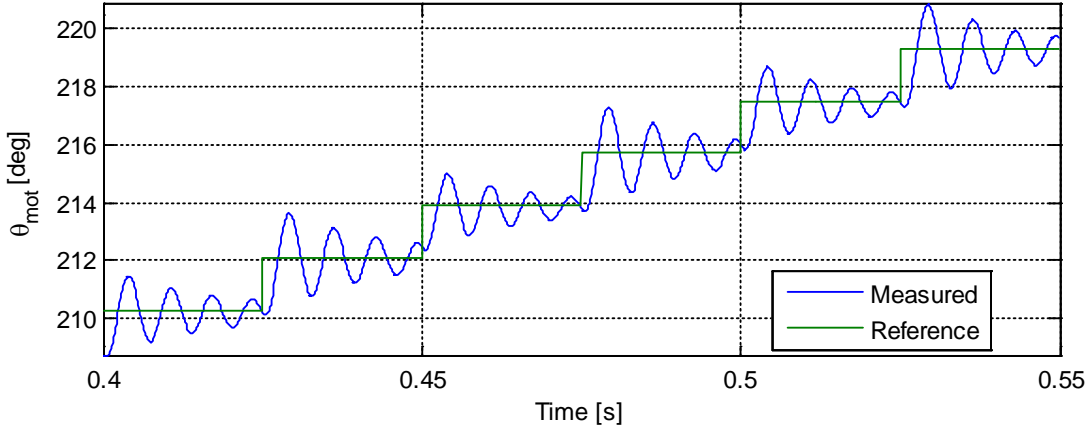
Motivation – Current control problem

Standard commercial drive performance



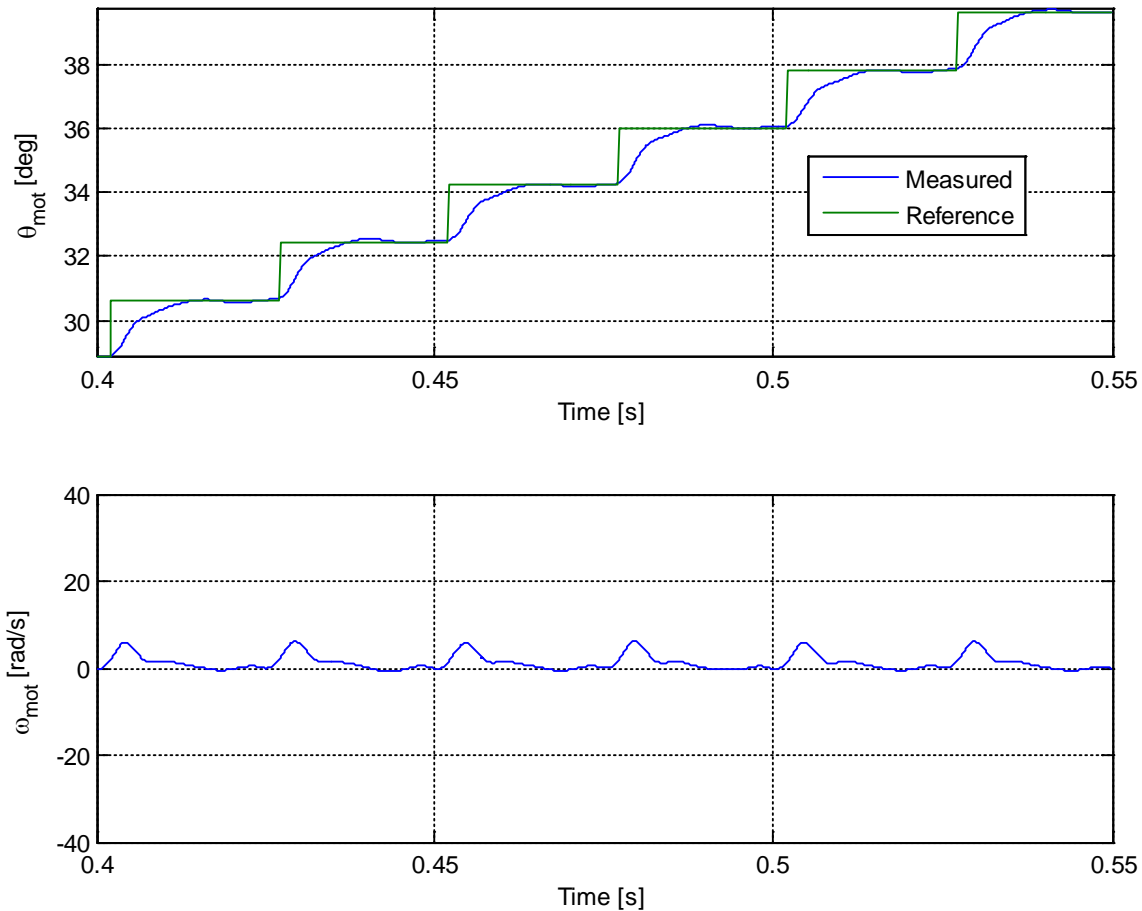
Motivation – Open-loop positioning problem

Open-loop position control



Motivation – Closed-loop reliability problem

Closed-loop position control with position sensor



Our solution

A drive that has the:



Our solution

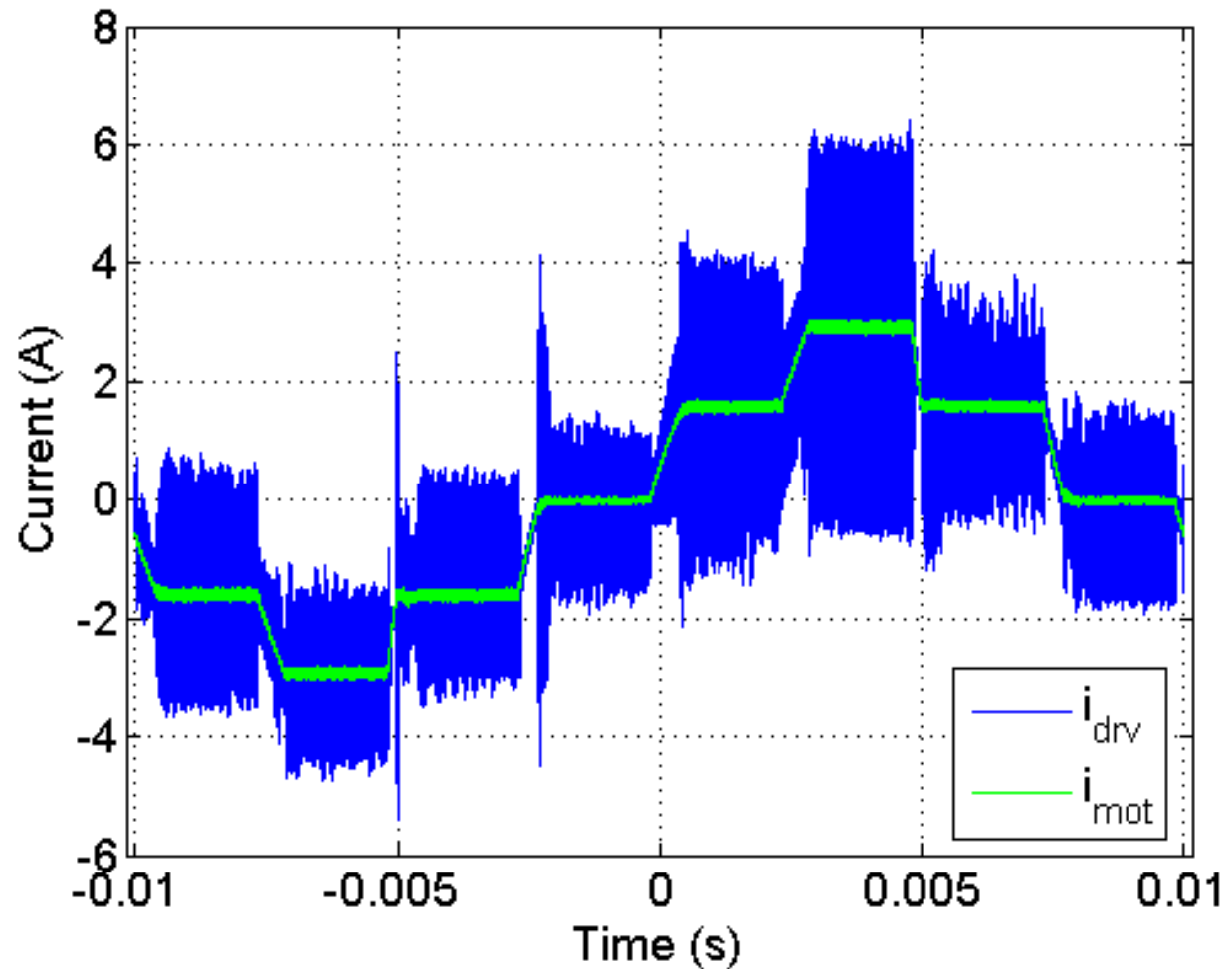
A drive that has the:

1. Ability to work in all modes with up to 1km of cable



Current control performance

- PWM @ 50 kHz
- 720 meter cable



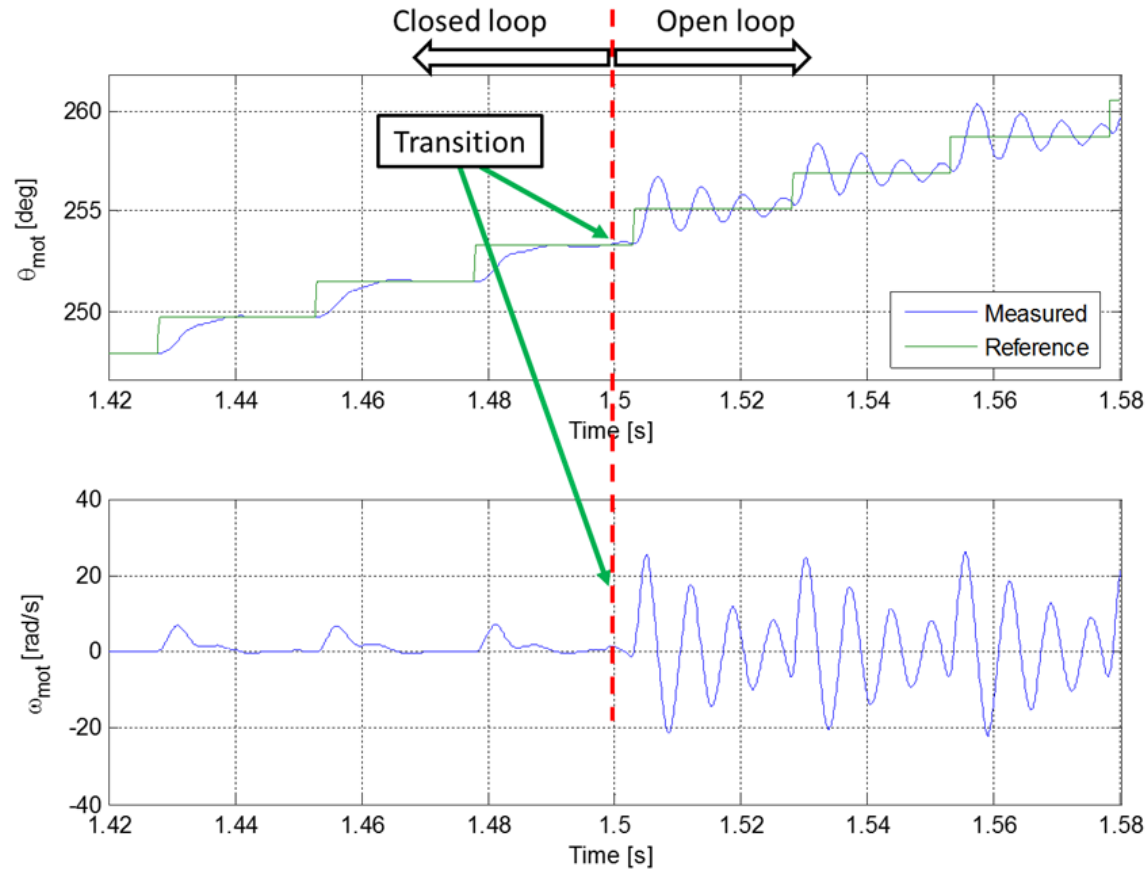
Our solution

A drive that has the:

1. Ability to work in all modes with up to 1km of cable
2. Ability to switch online from closed- to open-loop position control without step loss



Online closed to open position loop switch



Developed drive characteristics

- Key specification:
 - 2-phase Stepper Motor control.
 - Maximum current per phase 7 Amps RMS.
 - DC Voltage up to 170 Volts.
 - Stepping mode from full step to micro stepping.
 - Works with cables up to 1 km long.
 - Two operating modes:
 - Standard stepping mode (open-loop position control).
 - Field Oriented Control (closed-loop position control).
 - Communications:
 - Stepper interface (Step, Direction, Enable).
 - Serial communication RS-485 with Modbus.
 - Profibus.
 - PWM and controller frequency configurable up to 60 kHz.
 - Controller parameters fully configurable.
 - Up to 2 kHz current control bandwidth.
 - Automatic cable length estimation.
 - Quadrature encoder interface.



State of the Art

- To our knowledge no commercial drives exist that can work with such long cables
- Drives exist that can work in open- and closed-loop mode but none that foresee sensor failure
 - 2 patents propose switching between closed and open loop to avoid motor hunting in steady state but do not discuss sensor failure
 - <http://www.google.com/patents/US4591774>
 - <http://www.google.com/patents/US20070040529>

Possible alternative application areas

- Anywhere **precise, reliable positioning** is needed
- Anywhere step motors must operate **far** from their drives:
 - in hostile environments:
 - Underwater (Underwater vehicles, pumps,...)
 - Nuclear power plants
 - High temperatures
 - in clean environments:
 - Food processing plants
 - where payload counts:
 - Aerial vehicles

Acknowledgements

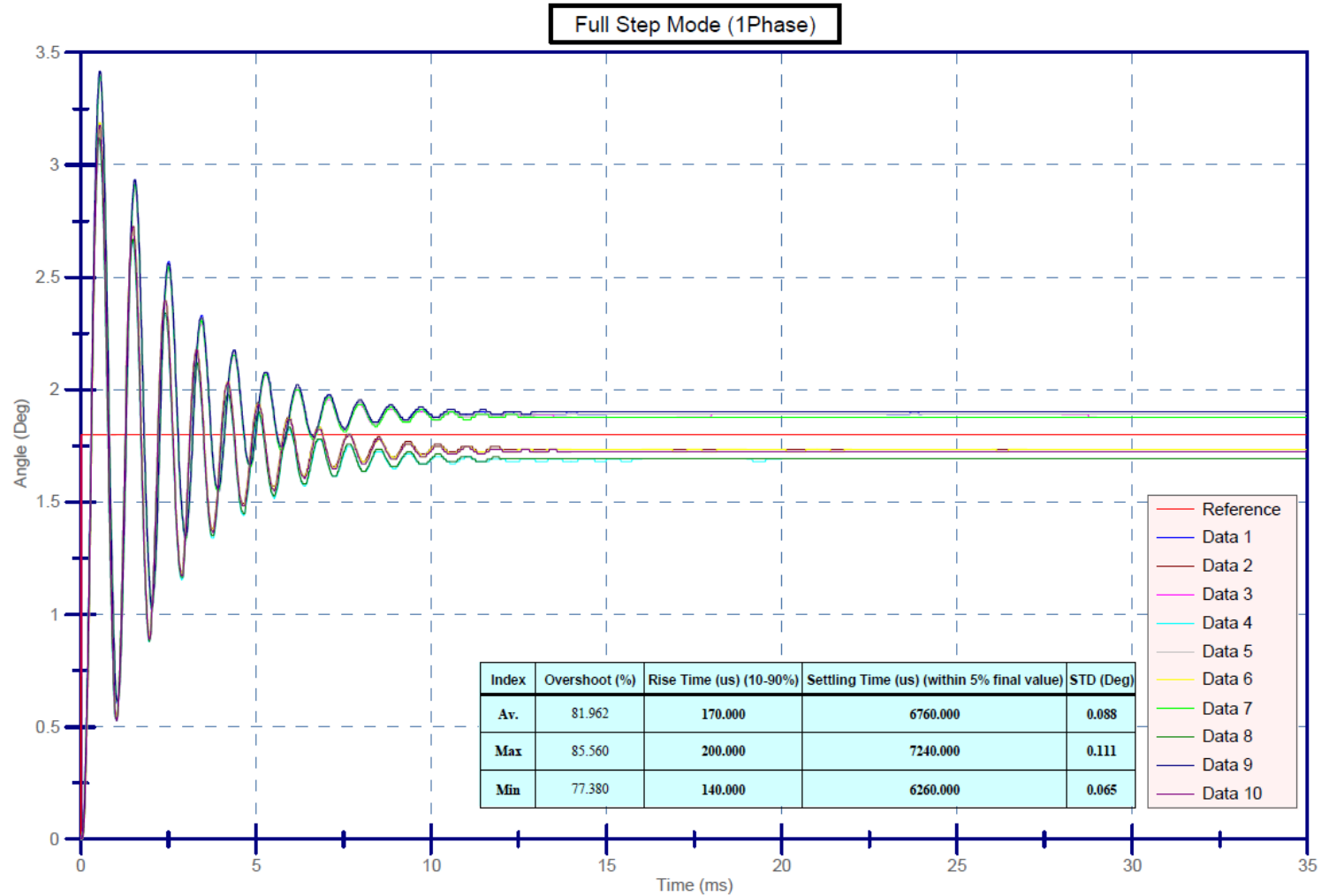
- Alessandro Masi
- Ricardo Picatoste
- Paul Peronnard
- Pablo Serrano Galvez
- Michele Martino

Thank you!

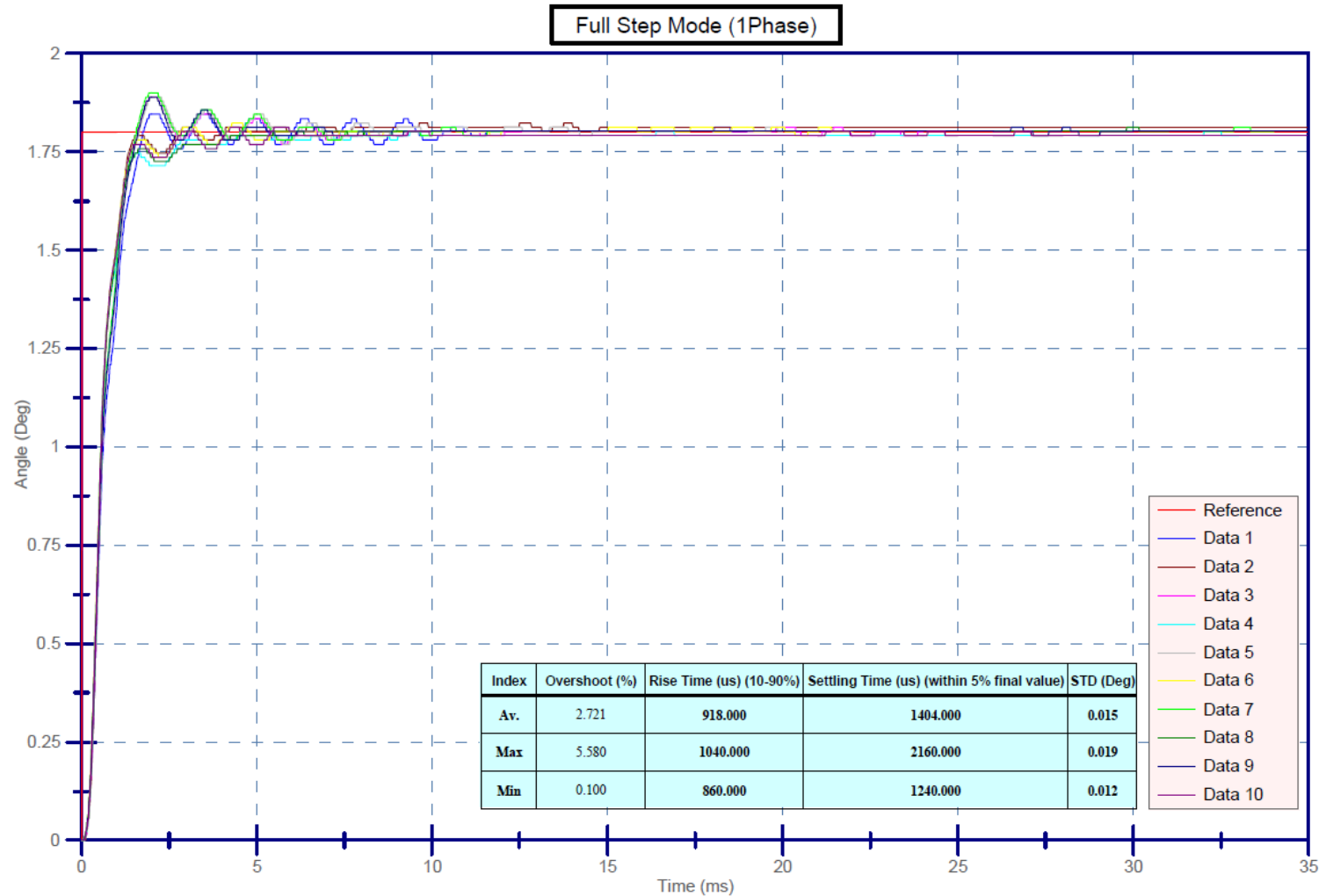


Additional Slides

Comparison – open-loop position control



Comparison – closed-loop position control



Online closed to open position loop switch

