ITEC FlexDMC motion architecture

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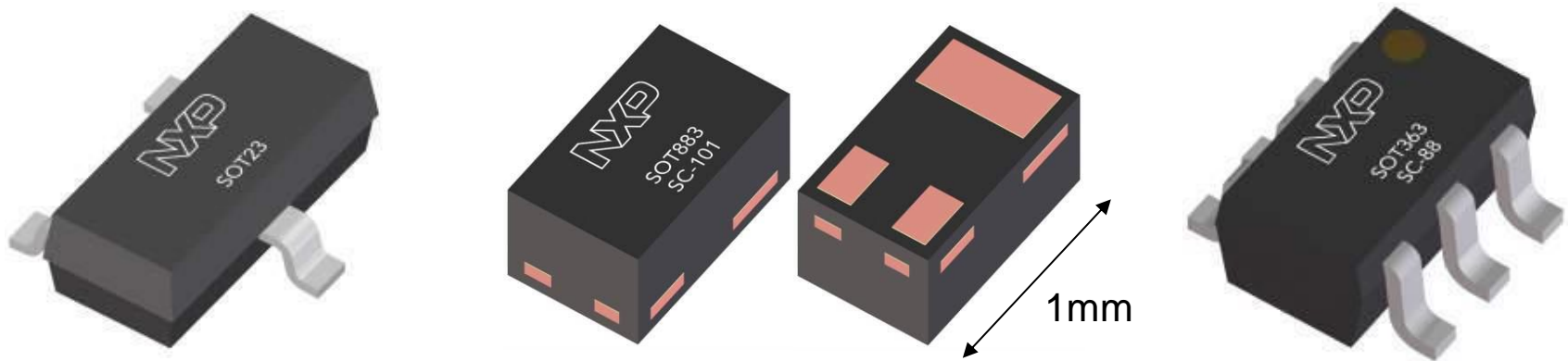
4 June, 2013

48th Systems/software Architecture Study Group Meeting

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- Introduction of ITEC

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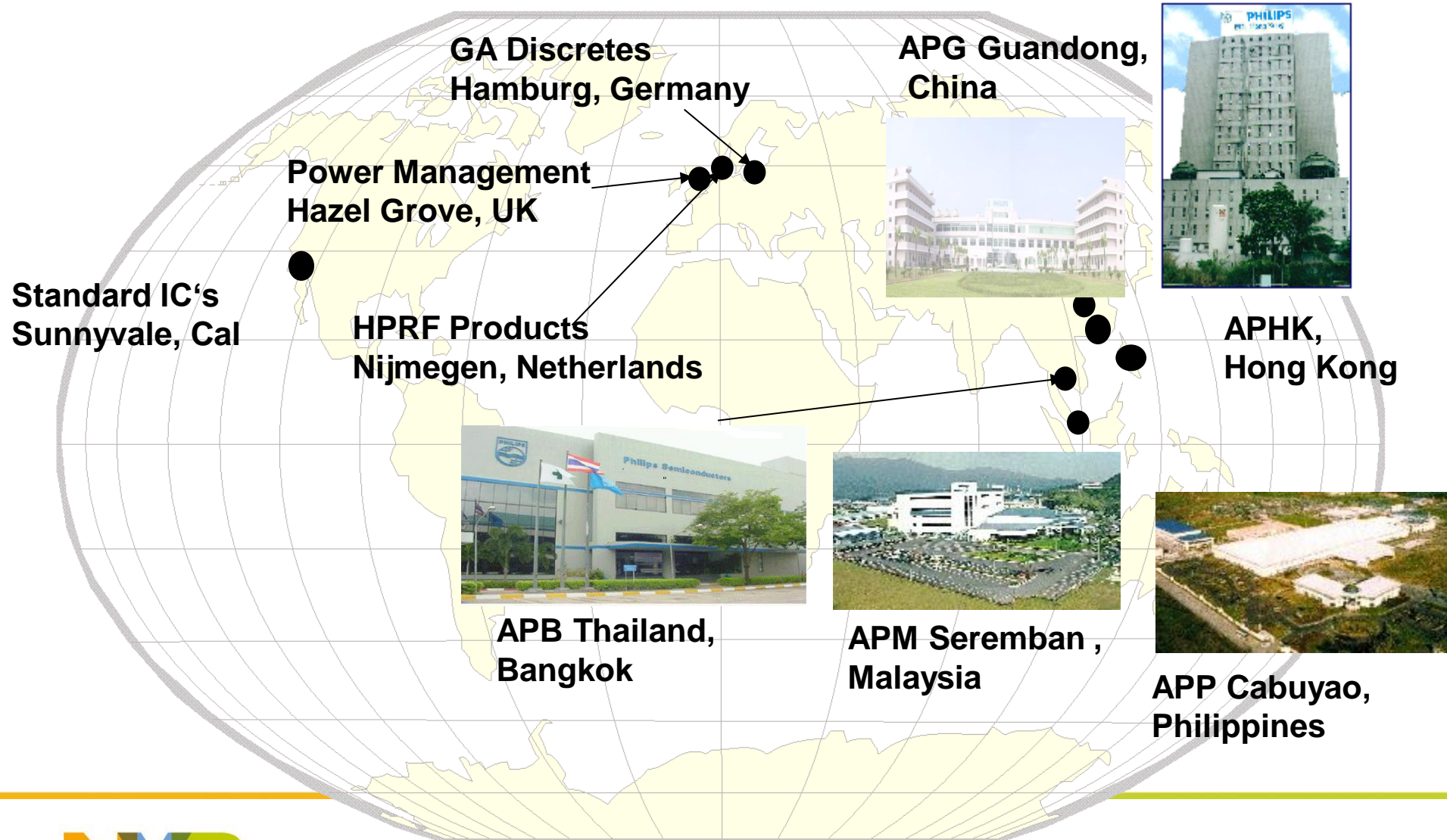
- Scope

- Measurement framework

NXP discretes: Assemble for low costs

1mm

- ▸ NXP manufactures and sells billions of standard products each year
  - – Diodes, transistors, logic, zener, regulator,….

- ▸ Extremely cost driven market, continuous price erosion

- ▸ Assembly costs are ~75% of total for BL-GA Discretes products

- ▸ ITEC equipment enables low cost assembly for BL-GA Discretes
  - – Exclusively for NXP
  - – Optimized for low cost / high volume products
  - – Upgrade policy for installed base

ITEC: Internal Customers only
Dedicated to NXP

GA Discretes Hamburg, Germany

APG Guandong, China

Power Management Hazel Grove, UK

Standard IC's Sunnyvale, Cal

HPRF Products Nijmegen, Netherlands

APHK, Hong Kong

APB Thailand, Bangkok

APM Seremban, Malaysia
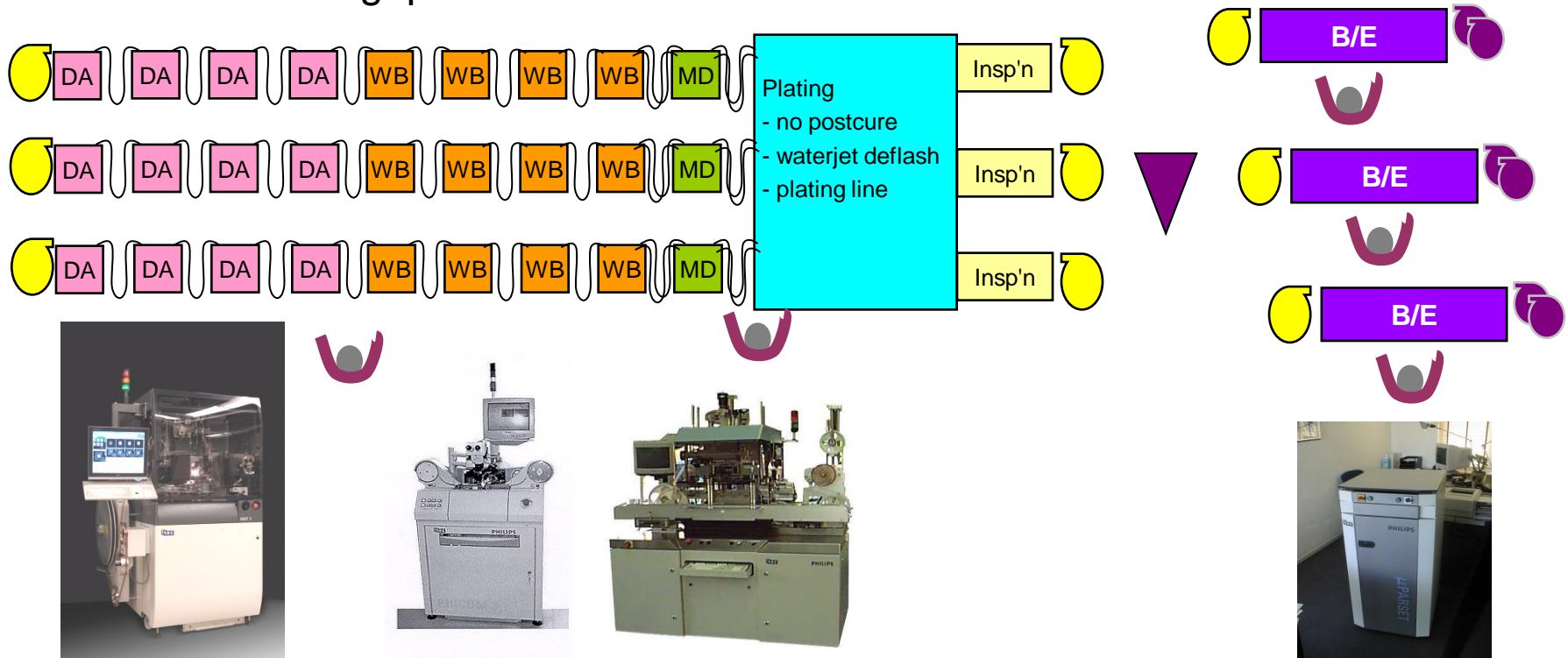
APP Cabuyao, Philippines

BIM lines

▸ Reel to reel BIM lines for:
- Lower Cost
- Higher Quality
- Lower Throughput Times

Latest version (SOT23 at APG):
- 4 row high density leadframe
- 24k track speed

Adat 48k DBSG

ITEC ADAT3 DBSG
48k UPH

Development Octopus
ITEC proposition
19, April 2010

ITEC software development

▸ Between 10-12 software developers

▸ All code written in Ada (about 1.6Msloc)

▸ Using Ada since 1994 when started with Windows NT
  – Now Ada 2012 on Windows 7 64bit

▸ Example A3 DBSG real-time control:
  – Machine runs 13 products / second !!!
  – About 70 tasks
  – Controls 25 servo axis
  – Has 4 cameras for positioning and inspection
  – Real-time control done using Windows XP embedded on 1 PC:
    • Control generates all trajectory (25 * 2 * 8kHz) 400_000 setpoints/sec
    • Control evaluates all pictures (13*4) 52 pictures/sec
   • Typical response times 20us (500-1000 interrupts /sec)

Software architecture

▸ Support all hardware versions (5 ..10) of a type of equipment with 1 executable.

▸ Use APIs for common functionality

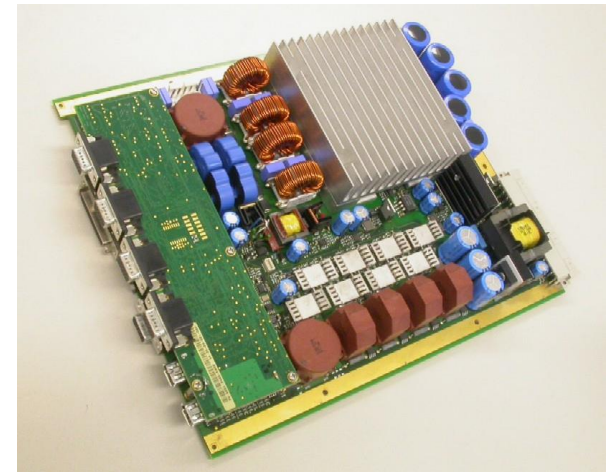| Application				
Motion	Vision	IO	Scope	Others
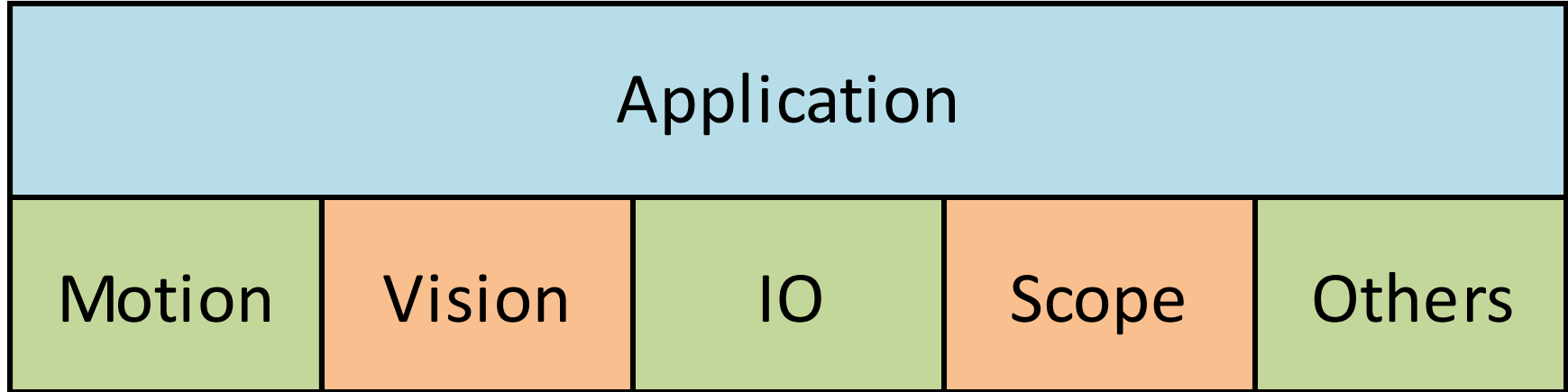
▸ The functions in an API support are supported for as much hardware platforms a possible
  – Typically all hardware platforms are supported
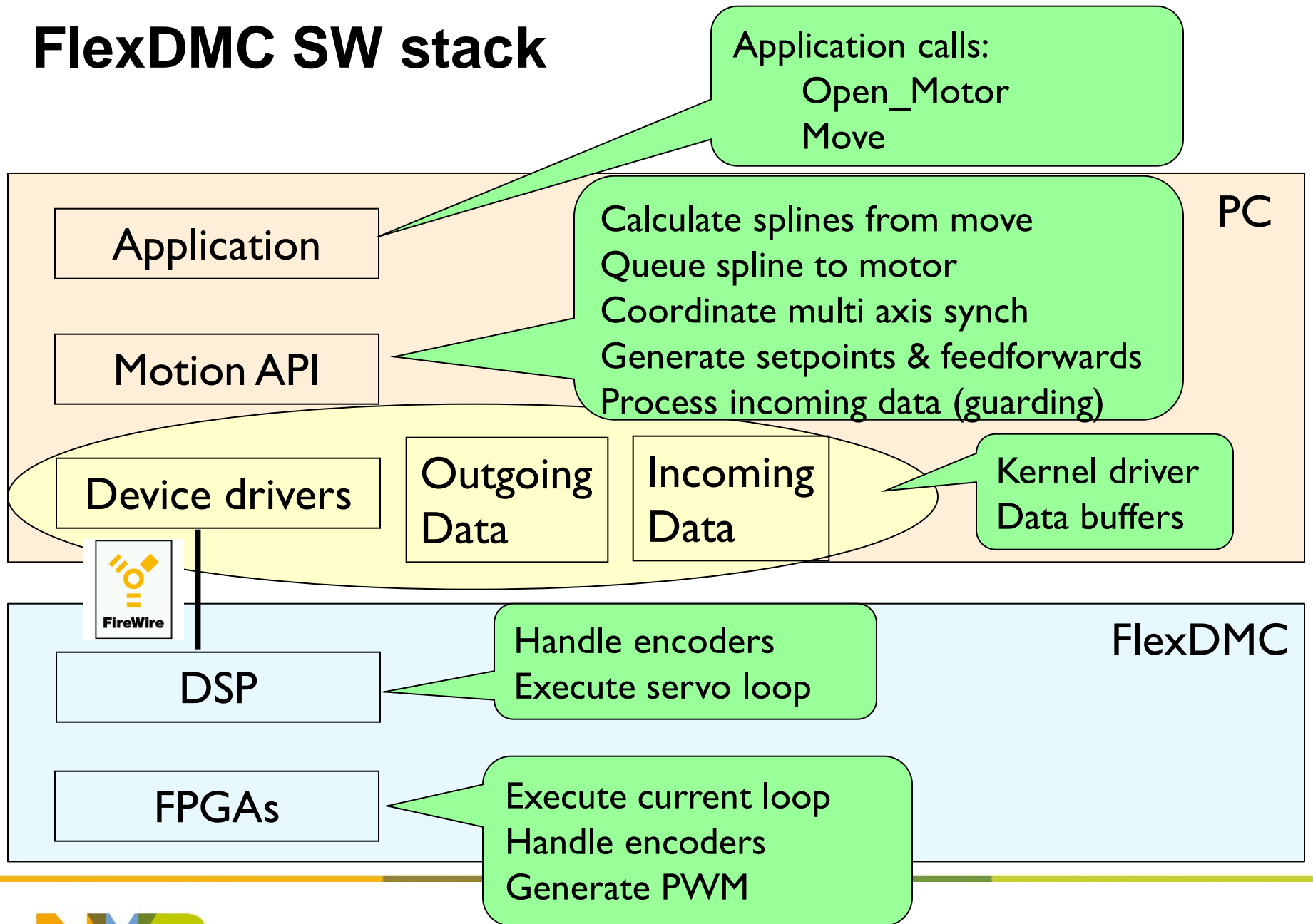
Motion API
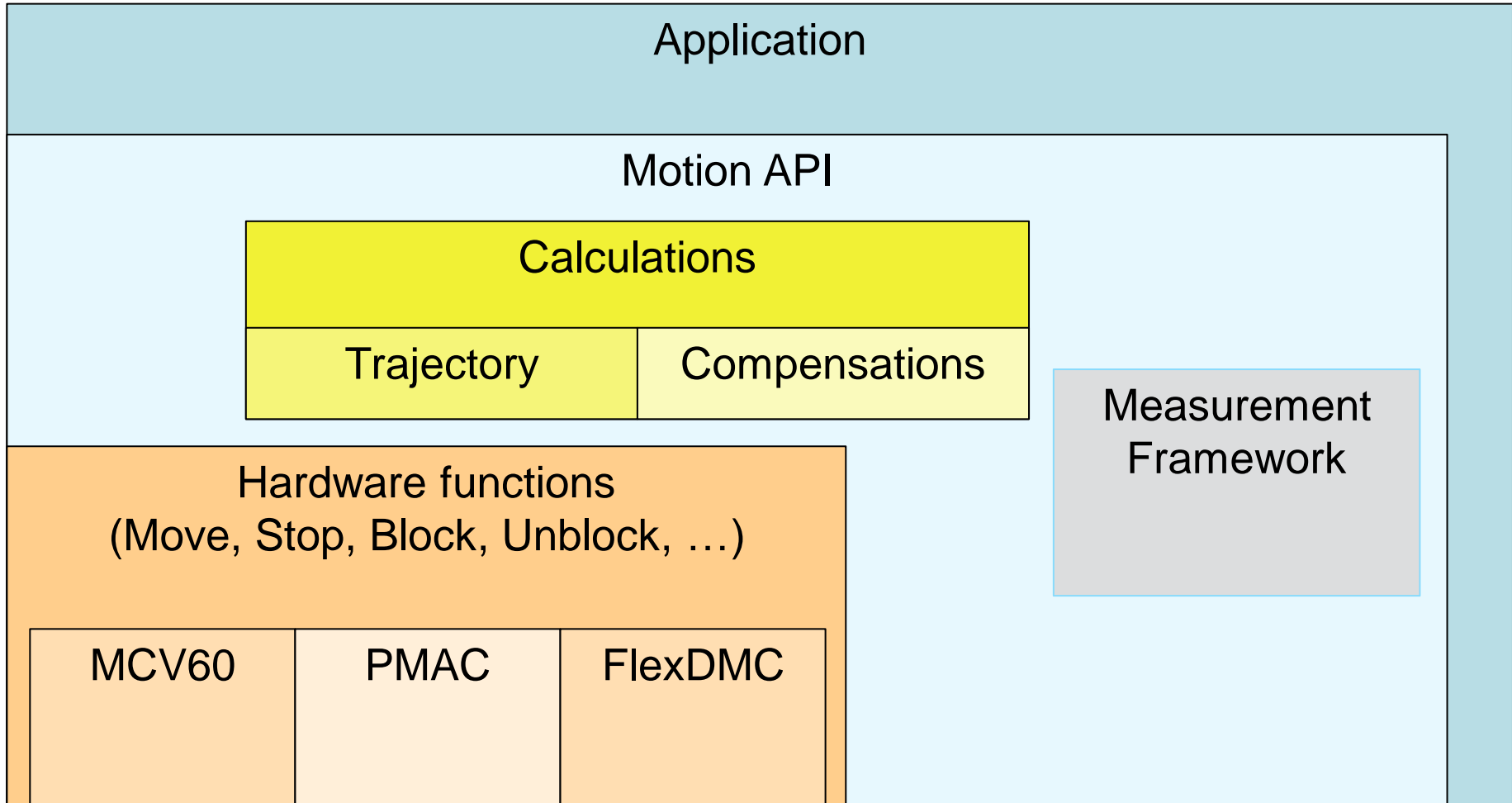
FlexDMC

- ▸ Motor interfaces
  - – 2 x 60V / 6A stage
  - – 2 x 150V / 15A stage
  - – Class D amplifiers with filtered (DC) output
  - – Stages can be combined for 3 phase or double current operation

- ▸ Encoder interfaces
  - – 4 encoder interfaces
  - – Quadrature or Sin/Cos encoders

- ▸ Control loops
  - – PID control + 2 x 2th order filter
  - – Setpoints and feedforwards received from the PC via firewire
  - – Current loops for current setpoint to PWM control

- ▸ Analog and Digital I/O

FlexDMC SW stack

Application calls:
- Open_Motor
- Move

PC

Application

- Calculate splines from move
- Queue spline to motor
- Coordinate multi axis synch
- Generate setpoints & feedforwards
- Process incoming data (guarding)

Motion API

Device drivers

Outgoing Data

Incoming Data

Kernel driver
Data buffers

FireWire

FlexDMC

DSP

Handle encoders
Execute servo loop

FPGAs

Execute current loop
Handle encoders
Generate PWM

Mechatronics

▸ Feedback control is always slow and we have short trajectories so:

▸ **Make the feedforwards do all the work (as precise as possible)**

▸ Using feedforwards, we compensate for:
  – Mechanics => Springs, Friction, Inertia
  – Position dependent motor constants
  – Position dependent disturbances (cogging, springs)
  – Non optimal Sin/Cos encoders
  – Non rigid body behavior

▸ These compensations can be determined automatically by the application

▸ For the calibration of these compensations we need a measurement infrastructure

Scope tool

▸ Use circular buffers to store events with the corresponding time
  - > 500.000 events per second (without locks).
  - Application can store boolean, integer and floating point values
  - To get timestamps, we use rdtsc of pentium (takes <<1µs)
  - Application can read back data from these buffers.

▸ Application has server thread that allows the scope client to retrieve the data

▸ Scope client:
  - Extract data from application
  - Can store / read data in file
  - Shows data graphically like oscilloscope
  - Can compare scope data sets
  - Computes mathematics on signals (+, -, *, derivate, FFT)
 - Frequency domain: characterizing mechatronics & servo tuning

PUBLIC 14

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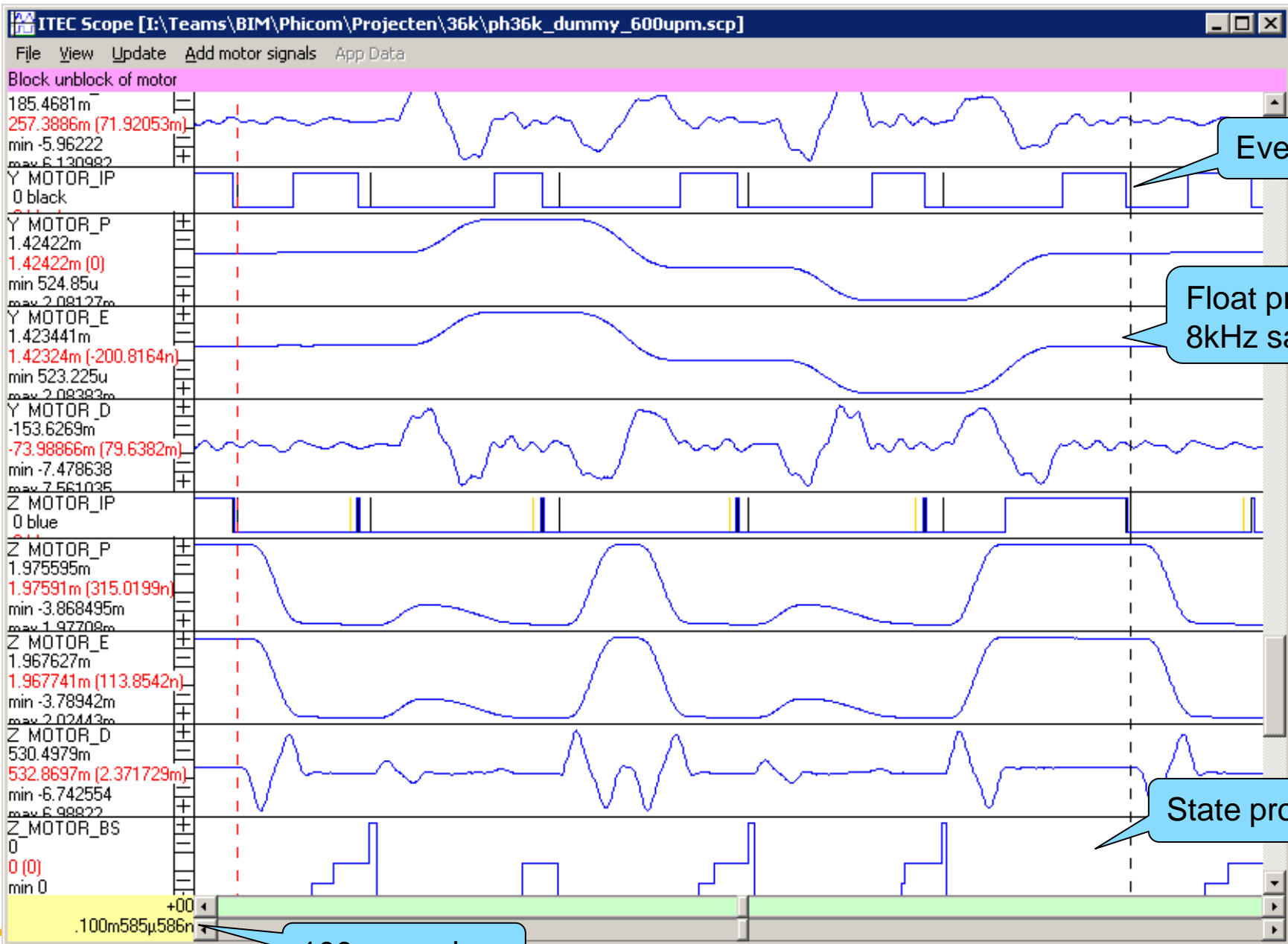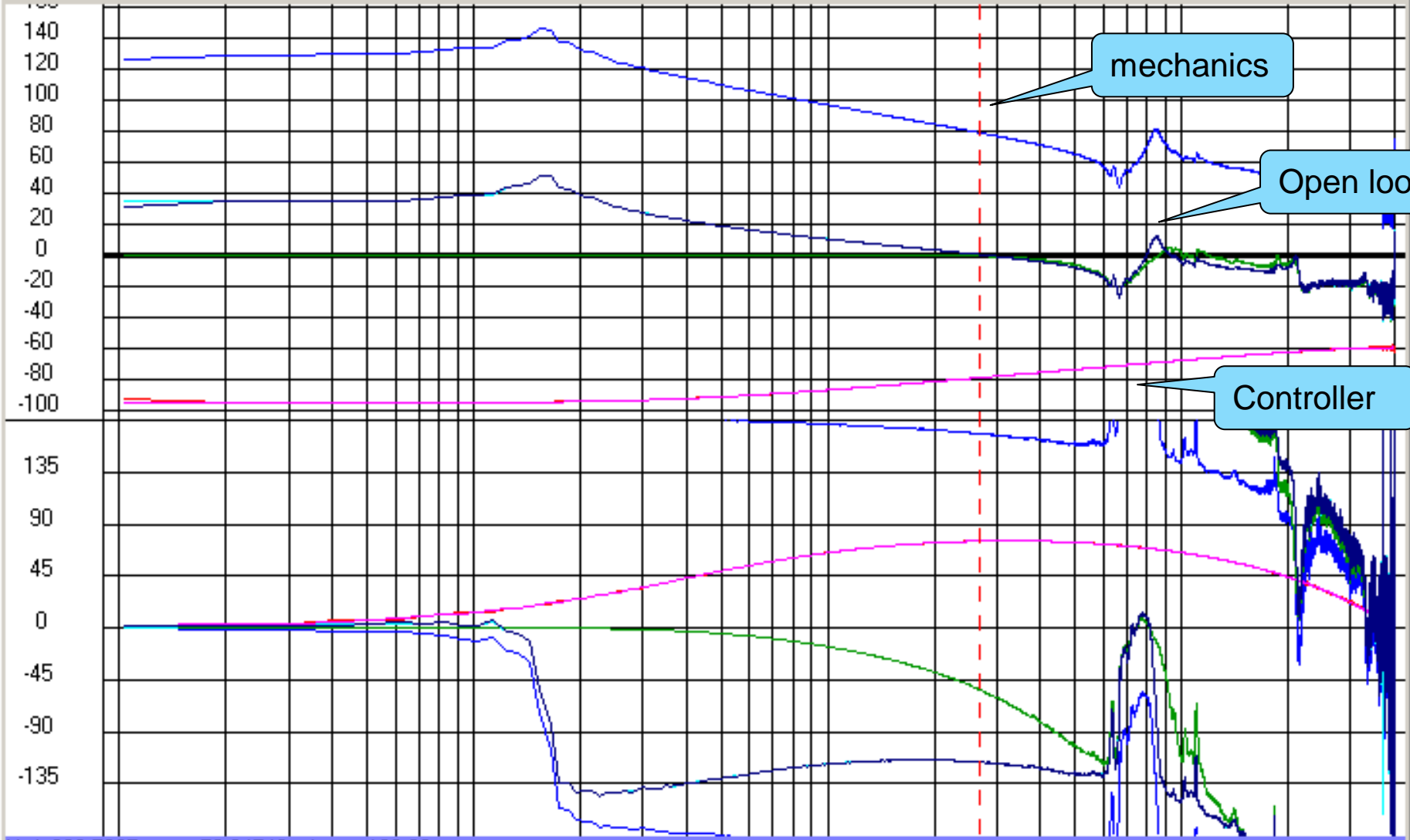
Measurement framework

▸ For a motor, data can be retrieved from the scope buffers into a measurement object:
- Position (Setpoint & Encoder)
- Current
- Feedforward
- Noise

▸ Measurements can be concatenated

▸ Measurement object provides easy functions to extract the data, which are used by the compensation functions

▸ This provides a clear separation between gathering the data and calculations on the data

| Motion | → | Scope buffers | → | Measurement object | → | Compensation calculations |
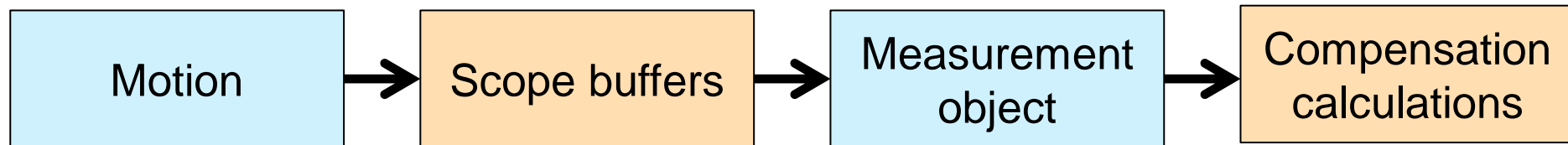
Conclusion

▸ Measuring is key!!!
Investing in it significantly increases the development speed

▸ The scope application is a very important debugging and mechatronic tool for ITEC.

▸ The measurement framework allows better code by separating data collection and processing.

▸ The motion API provides a uniform interface on all platforms, allowing easy software development.

▸ The FlexDMC offers ITEC the right combination of real time behavior on the drive and flexibility on the PC.

Questions??

Thank you