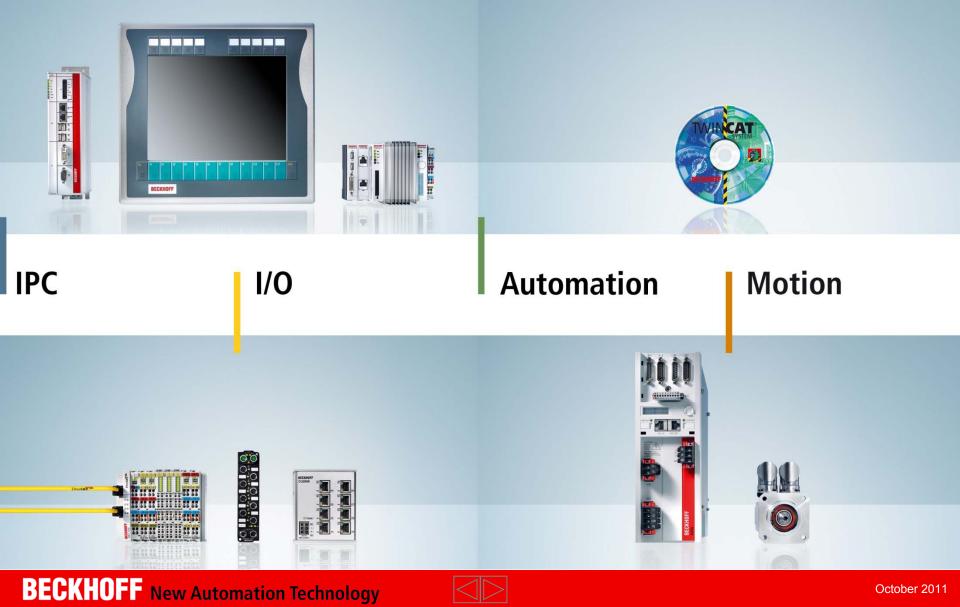
**New Automation Technology** 

#### **XFC – eXtreme Fast Control**



### Simplicity is the ultimate sophistication

### Leonardo da Vinci

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#### XFC – eXtreme Fast Control Introduction

- Goal
  - The goal is to never have the control system be the weak link.
- Can we measure things and react faster than the physical world can keep up?
  - With EtherCAT the answer is YES.
- XFC is how Beckhoff uses EtherCAT in a very deterministic way other vendors have other ways of using it and describing it.



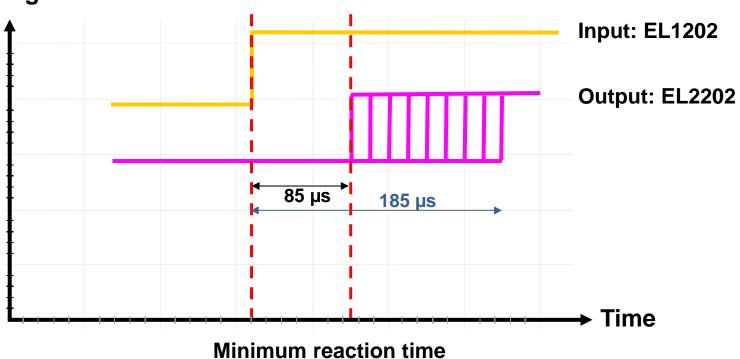
#### XFC – eXtreme Fast Control What Components are necessary?

- Control Hardware
  - Beckhoff IPC's
- Software
  - TwinCAT
- Communications
  - EtherCAT
- I/O
  - On PLC cycle
    - Regular Inputs and Outputs acting on cycles
    - Fast Inputs and Outputs
  - Inbetween PLC cycle
    - Timestamped Inputs and Outputs
    - Oversampled



#### XFC – eXtreme Fast Control Fast I/O terminals

• 1 µs Ton/Toff

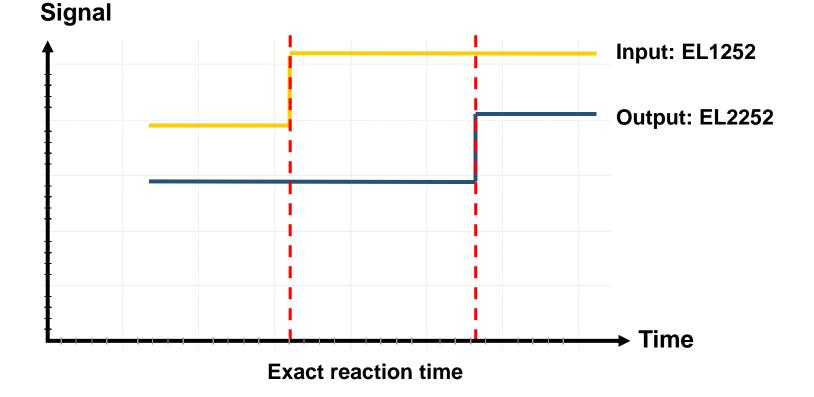




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#### XFC – eXtreme Fast Control Timestamping

- Exact time resolution
- Syncronized responses



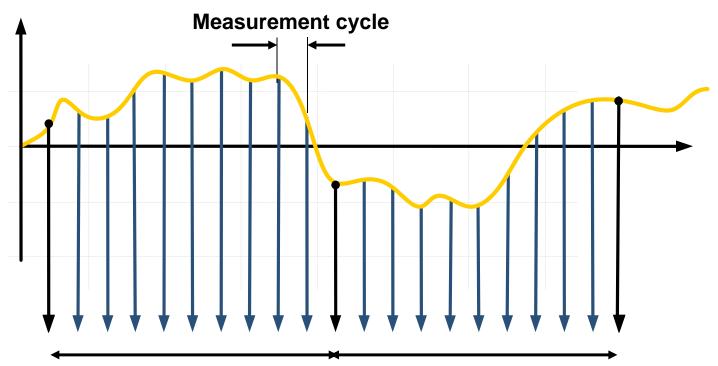


#### $\times$

#### XFC – eXtreme Fast Control Oversampling

- Fast signal sampling
- Analog value recording

#### **Oversampling – eXtreme measurements**





#### XFC – eXtreme Fast Control Oversampling

- Fast digital signal sampling
- Output of short pulses

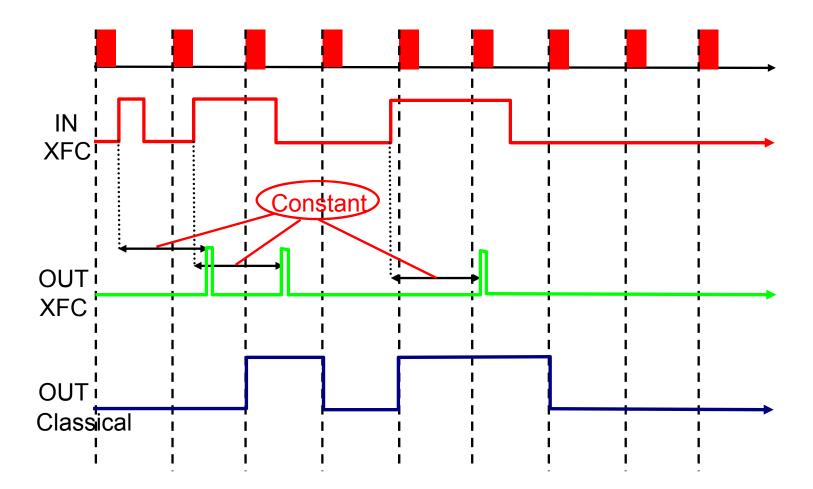
# Signal Input: EL1262 Output: EL2262 Time

Exact output pulses



#### XFC – eXtreme Fast Control Benefits of XFCvs Classical Control

Measure and react inside PLC cycles





#### XFC – eXtreme Fast Control Performance

- System Performance
  - Cycle time 100 μs (min. 50 μs)
  - I/O response time 85 µs (185µs)
- Distributed Clocks
  - Resolution 10ns
  - Accuracy < 100ns</li>
- Timestamping resolution
  - Resolution 10ns
  - Accuracy < 100ns</li>
- Oversampling
  - Sample rate 1MHz
  - Time Resolution 1µs
  - Accuracy < 100ns</li>





#### XFC – eXtreme Fast Control Performance

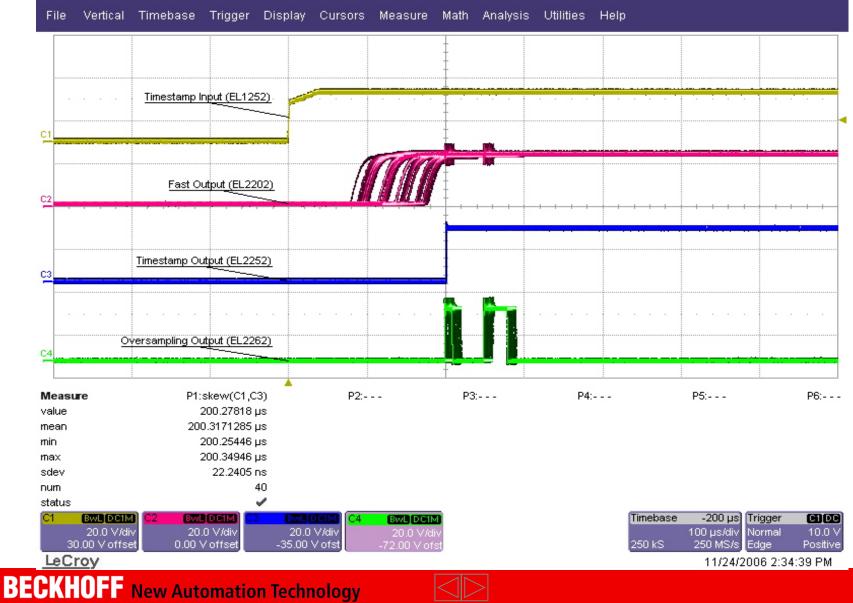
- XFC numbers in perspective
  - Speed of light 300,000km/s
  - Light travels 3m in 10ns

- We have entered the era of Control Relativity
  - The speed of light becomes a design consideration for extreme applications.





#### XFC – eXtreme Fast Control **XFC** Verified

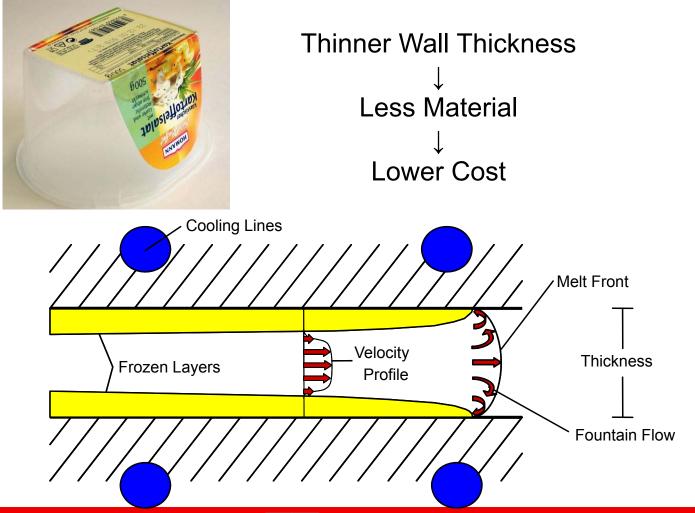


#### Husky HyPAC Injection Molding Machine

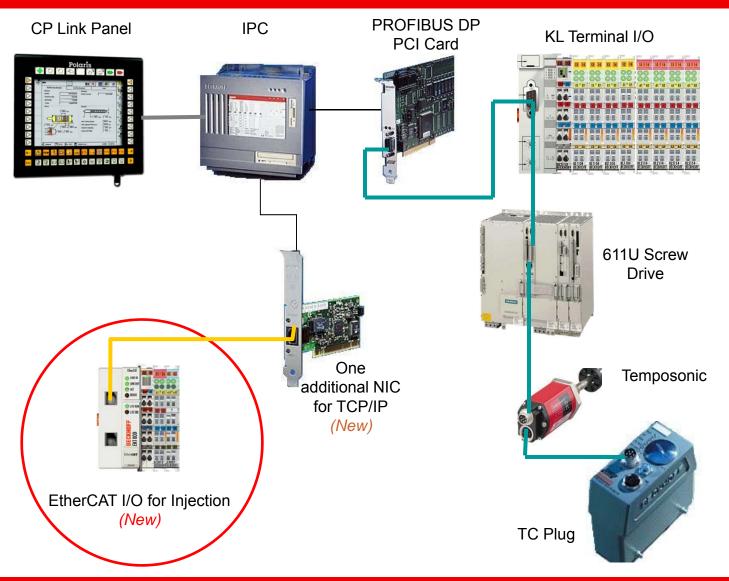




Challenge – make thinner wall and save plastic



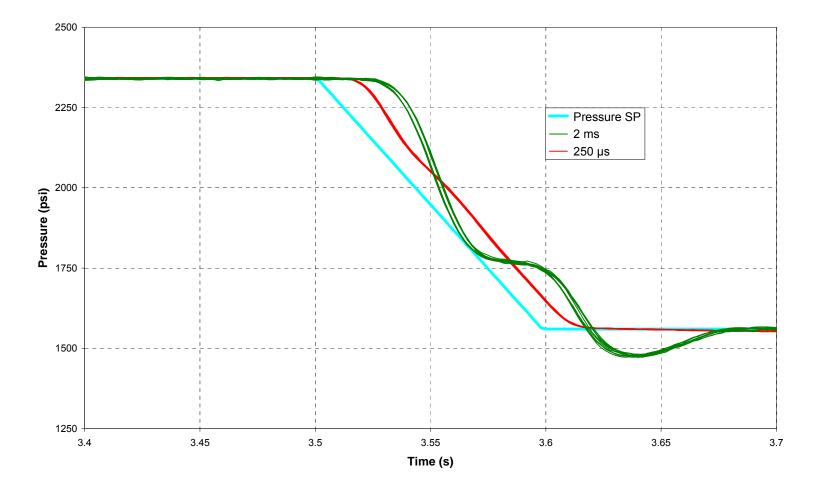




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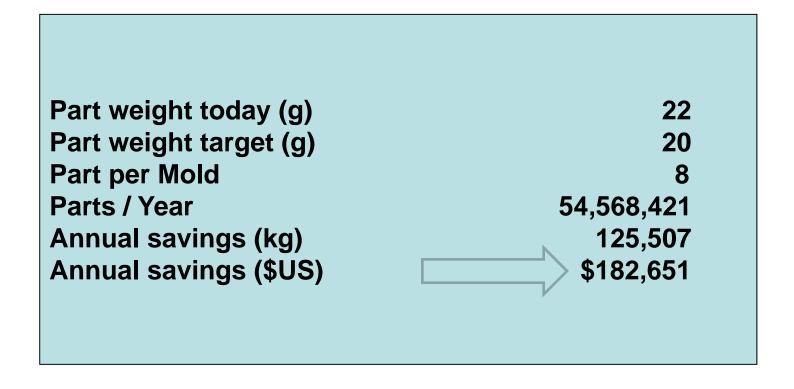


Transition Pressure Control





- Benefit
  - Reduces part weight





#### XFC – eXtreme Fast Control The Future

- Beckhoff IPC's use Intel processors
  - Massive Intel R&D
  - Moore's law remains valid

16-Core SPARC T3 Six-Core Core i7 Six-Core Xeon 7400 2,600,000,000 10-Core Xeon Westmere-EX Dual-Core Itanium 20 ore POWER7 AMD K10. 1,000,000,000 Quad-Core Itanium Tukwila 3-Core Xeon Nehalem-EX POWER6 Itanium 2 with 9MB cache 
AMD K10 Six-Core Opteron 2400 Core i7 (Quad) Core 2 Duo Itanium 2 100,000,000 -AMD K8 Barton Atom Pentium 4 AMD K7 AMD K6 curve shows transistor Transistor count 10,000,000 -Pentium II count doubling every two years AMD K5 Pentium 804864 1,000,000 80386 80286 100,000 68000 ● 80186 8086 • ● 8088 10,000 6800 6809 8080 780 8008 •MOS 650; 2,300 -4004 • 1971 1980 1990 2000 2011 Date of introduction

Microprocessor Transistor Counts 1971-2011 & Moore's Law





#### XFC – eXtreme Fast Control The Future

- EtherCAT + XFC + lots of computation bandwidth
  - What is possible when you imagine highly deterministic communication to I/O and multiple, many cores of computation?





XFC – eXtreme Fast Control The Future

### www.scientificautomation.com

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