ENGINEERING
TOMORROW

Frequency converters and InDEx results

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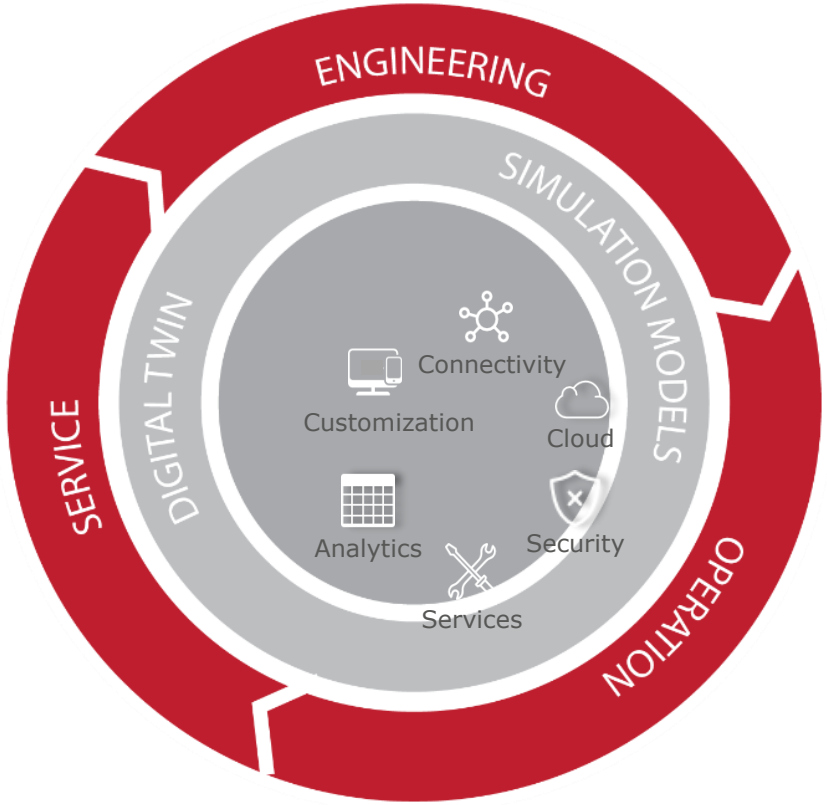
Goal 1: Augmenting the hierarchical Purdue control model

Different data interfaces can be used to separate new concerns from existing control

- Expose machine level sensor and state information
- Use this information in augmenting the factory behavior
  - State driven control
  - Sensor based optimization
  - Reaction to external factors
  - Recipe based control
- Low cost alternative to bring IoT to old factories
- Monitor factory behavior with digital twins
- React to external factors like electricity price or supply chain bottlenecks



InDEx addressed technical, contractual and business aspects

Goals 2: Handle soft elements in supply chain

- Customer defined
  - Application SW,
  - Interface definitions (names, alarms, fieldbus profiles)
  - Parameter (default) values
  - Brand visibility (screens, bar code, branding)
- Digital signatures to confirm authenticity
  - Public key infra
  - Server for customers to sign their contributions
  - Crypto chip based secure id
  - Encrypted elements
  - License based restrictions to protect IP
- Ordering allows also customer made soft elements to be ordered from factory

Technical aspects solved – parts of the automation missing

G1: Data from drive, details

Design what to expose

- MyDrive Designer (programming, customizing)

Visualizing

- MyDrive Insight

Exposing

- FieldBus, WiFi, DDI
- OPC UA
- IDS

Attaching meaning

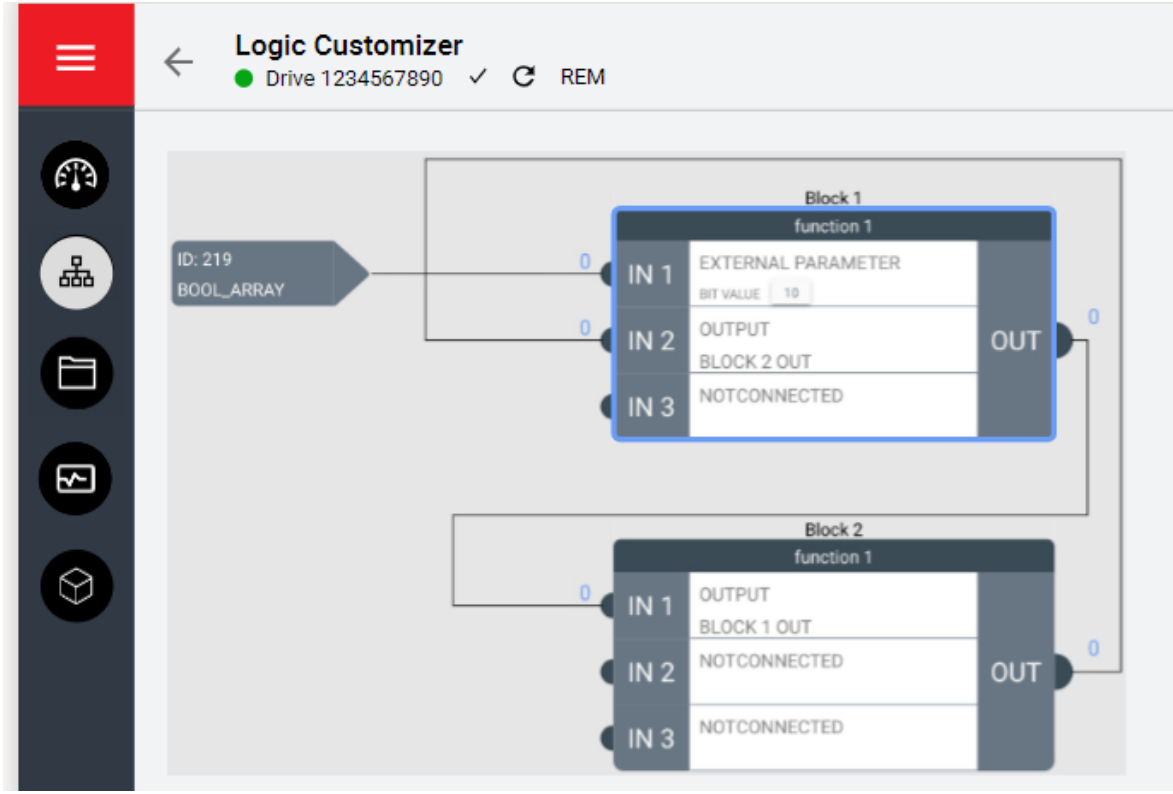
- Drive and System Modeling

Using it for something

Turning it into business

Getting the drive to provide the data that you need in correct format

- Selecting from predefined data points and parameters
- Application SW programmable with Matlab/Simulink tool chain (experimental)
- Application SW programmable with IEC standard PLC languages (supported)
- Five fold increase in application runtime performance demonstrated
- Application SW interface customizable with MyDrive Logic and Sequence Customizer (experimental)



Visualizing data

MyDrive Insight tool kit

- Multiple platforms
- Able to connect over network (as long as drives are discoverable)

Standard format

- Visualization in Matlab

MyDrive® Ingisht— Mobile and Desktop product

Use IDS to expose data for analytics, logistics and control (OPC/UA within factory domain)

- Drive is programmable intelligent sensor that can correlate internal sensor input with external signals and commands
- IDS is suitable for communication out of the secure network and can provide different views to different users
  - Improved logistics
  - Offline analysis
  - System optimization
- With intelligent drives it is possible to instrument existing machines and factories

In a world of connected products security becomes important. **IDS helps to protect both drive and data** against unauthorized access. With on-board crypto chip we are very engaged to bring the most secure drive to connect to any network.

Data from drive can be used to detect specific application behaviors or critical events. All **data** to be **forwarded to external targets**

We have **build-in** surveillance features to **monitor drive, motor and grid conditions**

Your **digital drive twin** is with you all the way **from pre-order to end of life**

CLIENT MODE for direct connection between devices Devices connect to an **ACCESS POINT** Can be both, wired or wireless

Built-in fieldbus standards
IoT protocol support, OPC UA & MQTT

Use OPC UA in factory (standard profiles for interoperability)

OPC UA experiment as part of VDMA/ZVEI/university industry 4.0 demonstrator (https://youtu.be/nNnB-rbSkrE)

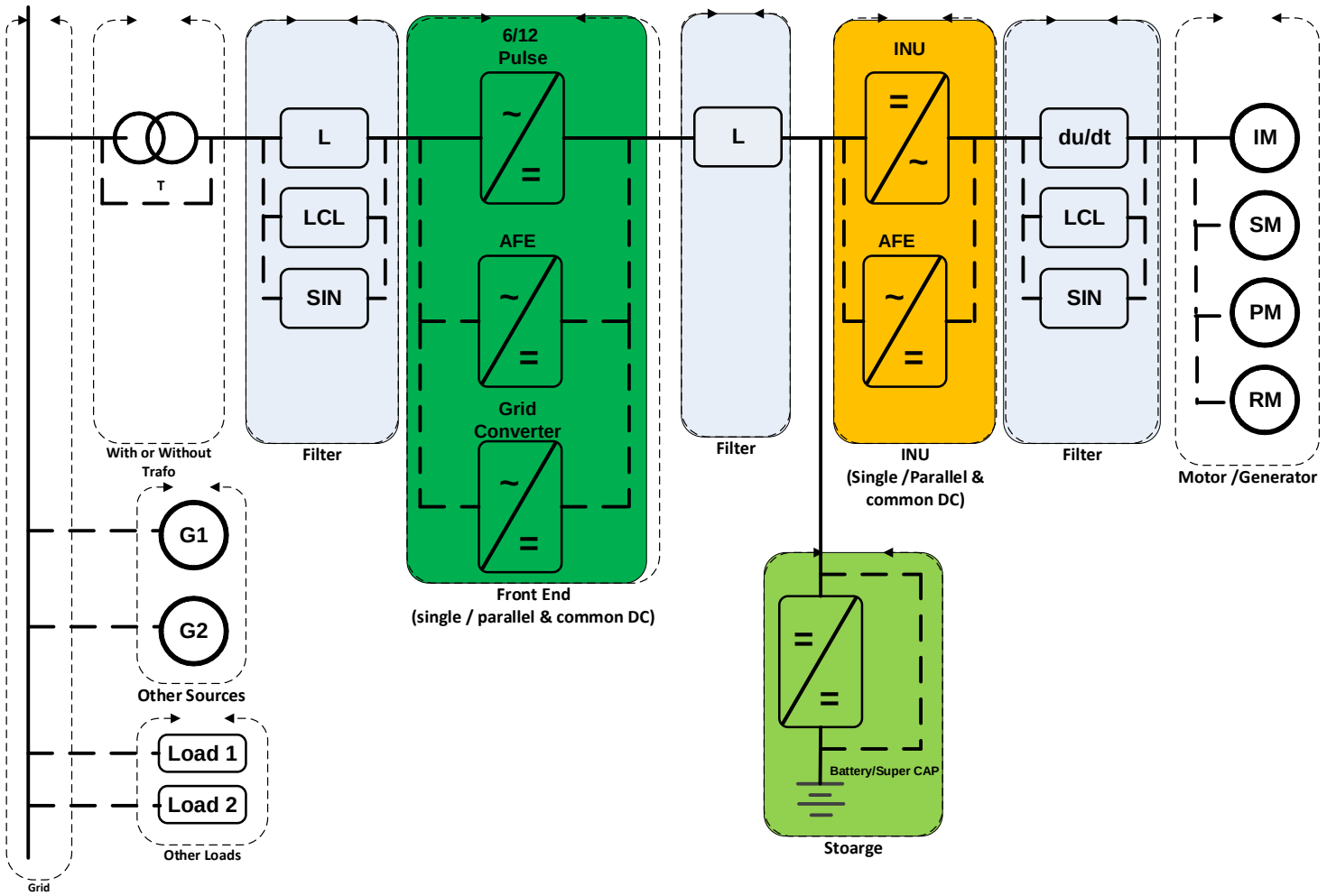
Implementing OPC protocol (subset) and newly defined drive profile with E-class information model (start/stop, interface to data capturing via data logger)

Express sematics with system and drive models

Model would show each data point

- Sematics would be carried by the model
- Different drives could be easily distinguisable
- Different data sources could be combined

Density of the time series is an issue. High density leads to very large data amounts and overhead. Low density misses many phenomens



Using drive to analyze controlled machine

Maintenance use cases seem to drive early adoption

- Issues related to supply grid, AC drive and the motor being controlled are rather generic. Common issues with motors include leak currents, wiring and bearings
- With Tampere University we have been looking at more efficient ways of *detecting bearing faults*. Bearing faults have the highest frequency of occurrence and are one of the most challenging to detect and diagnose.
- Based on this study one-dimensional self-organized operation neural network with the generative neuron model for bearing fault severity classification seem to work best.
- The comparison shows that this technique is especially good in differentiating medium and severe faults. Computational complexity is low enough for real-time application.

Business development aspects

Driven by University of Turku and Aalto University

Model contracts

- Model terms for data sharing has been distributed among partners
- SITRA rulebook feedback workshops have been organized and feedback given to SITRA

Look into business opportunities

- Data sharing interviews have been conducted
- Service creation workshops based on customer needs have been organized
- The results have been shared with the project partners

Improved digital services at Danfoss

DrivePro Remote Monitoring

- Realtime monitoring of drives by collected data
- Parameters and measurement values
- Stores in cloud, buffers in gateway if needed
- Data based services (trouble shooting, back-up / restore)
- Can be connected to customer cloud

Data is always owned by customer

DrivePro® Remote Monitoring

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