Microprocessor-Based Industrial Controllers

Class 5: Connectivity and Trends

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Louis W. Giokas

DesignNews

CEC CONTINUING EDUCATION CENTER

Presented by: Digi-Key ELECTRONICS

This Week's Agenda

Monday	Concepts and History
Tuesday	Microprocessor Architectures
Wednesday	Controller Examples - 1
Thursday	Controller Examples - 2
Friday	Connectivity and Trends

Course Description

Industrial controllers at the device level have a long history. Over time they have evolved from relay based, to discrete logic and finally to microprocessor based logic. While the functions have remained the same, the capabilities and sophistication have grown enormously. In this class we will look at the history and development of the field and then look into the modern architectures which are currently in use. We will take a deep dive into several examples of controllers, including the algorithms and implementations for several. Finally we will look at connectivity and trends in the industry.

Today's Agenda

- Connectivity
- Future Trends
- ARM Processor
- FPGA
- Conclusion
- Contact Information

Connectivity

- Microprocessor Based Industrial Controllers enable extensive connectivity in due to the presence of the microprocessor
- For enhanced connectivity one typically has to move up to a 32-bit device
  - Typically an ARM processor
- Some devices have built-in protocol stacks

Connectivity

- Smaller devices (8-bit) typically support serial connections
  - This will typically limit them to wired connection
  - Can be enhanced by using a bridge device that connects to multiple devices and then uses higher level protocols to communicate to the rest of the environment
  - A separate Bluetooth device can be added to the controller for that option. These are still small devices and can participate in “mesh networks”

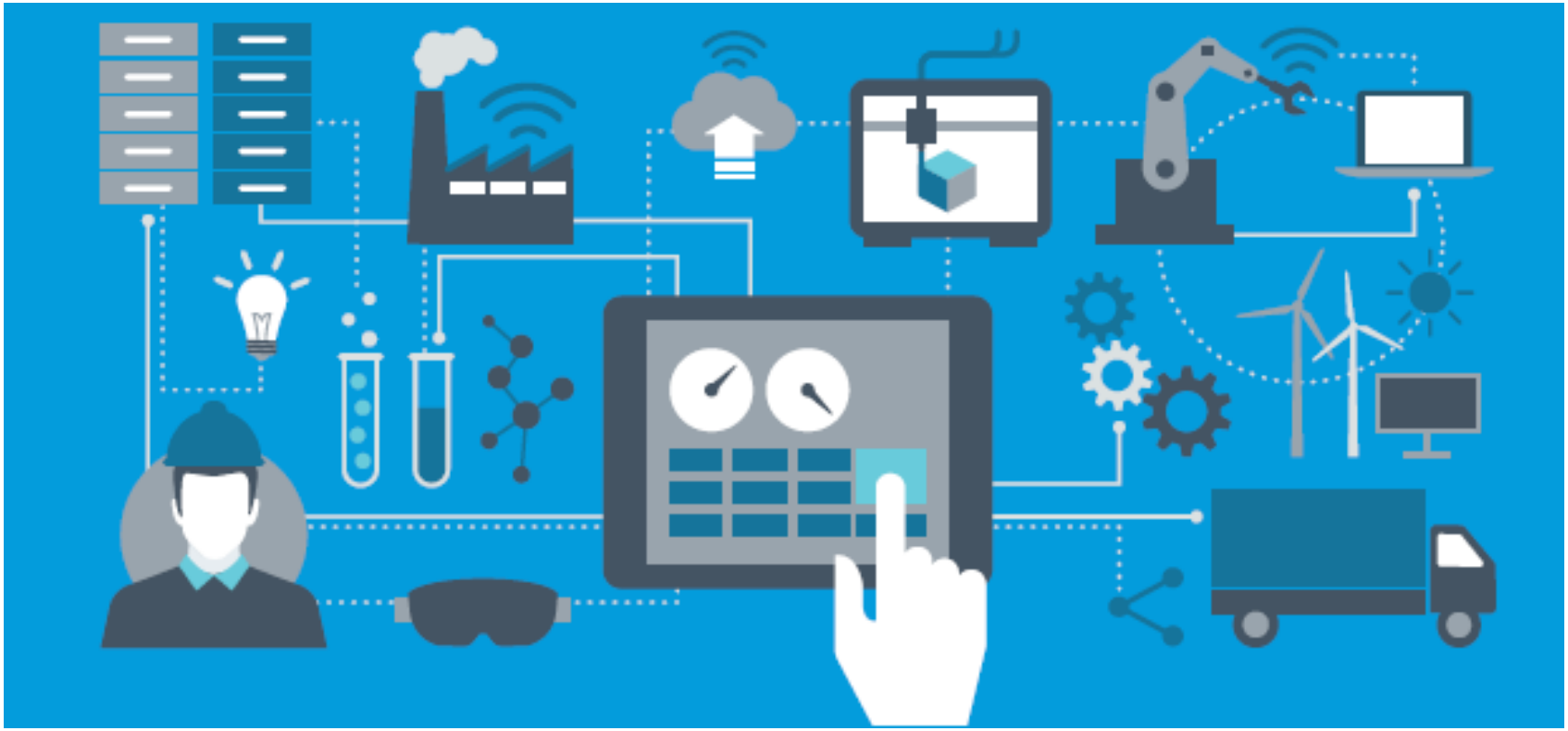
Connectivity

- Higher power devices (e.g., ARM) have built into them a protocol stack which enables Ethernet right on the chip
- Thus, they support:
  - CAN
  - SPI
  - USART
  - I2C
  - These can connect the controller to other chips for other communication protocols

Connectivity

- Connecting microprocessor-based industrial controllers in a group allows for complex processes, where the controllers cooperate
  - This might not necessarily be part of the control logic, but might consist of supervisory operations
- We have seen some examples of this already, but did not discuss connectivity
  - Typically would be wired, but can also include wireless options

Connectivity



Future Trends

- The future consists of smarter, more connected machinery in the industrial setting
- The future of microprocessor-based industrial controllers is tightly tied to the microcontroller itself
- As we have seen, 8-bit processors, at a cost of pennies, are still a viable option
- 32-bit devices, such as ARM, geared toward the controller market grow in capability and are still very affordable (down to about $3.20 in quantity, $6.29 in single quantity on Digi-Key for a STM32F4)

Future Trends

- Market Trends
  - 8-bit
    - 4.42% CAGR
    - Key players: Microchip, STMicro, NXP, Renesas, Cypress, Silicon Labs
  - 32-bit (ARM)
    - 8.6% CAGR
    - Key players: Microchip, STMicro, NXP, Renesas, Cypress, Silicon Labs, Analog Devices, TI, Atmel, Maximum Integrated, Toshiba

Future Trends

- Other technologies are making their way into this market, including different computing platforms and communications
  - FPGA technology, usually with an on-chip ARM processor for high bandwidth signals
  - Mesh networking, in Bluetooth and WiFi
  - Sensor improvements
  - Integration with cloud computing

ARM Processor

- The ARM M series s specifically targeted at the microcontroller market
- Combines standard instructions with floating point and DSP (Digital Signal Processing) and SIMD (Single Instruction, Multiple Data) instructions
- Vendors add the I/O and other components needed to make a viable industrial microcontroller

ARM Processor

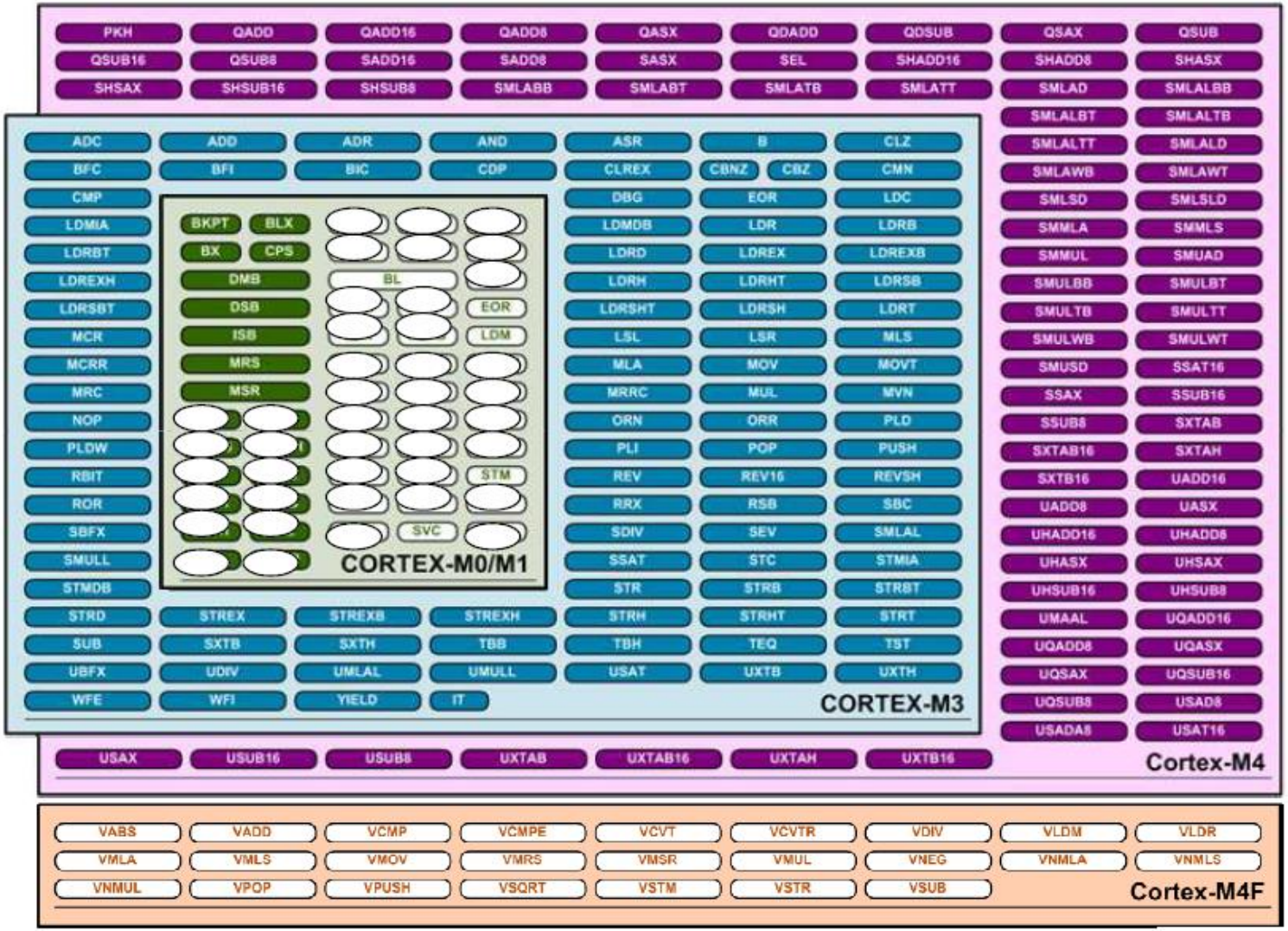
56 instruction

+ 57 instruction

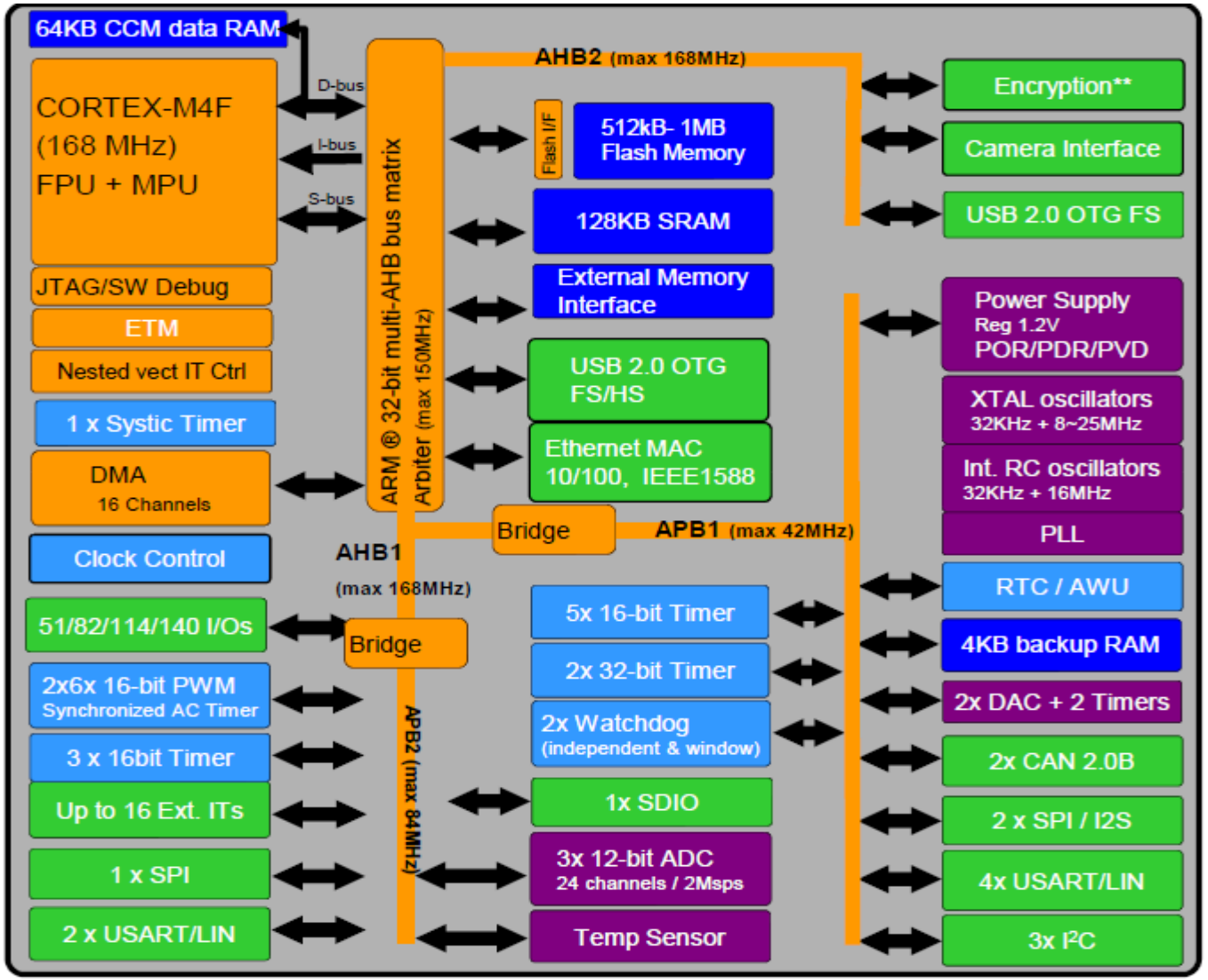
+ 80 instruction

+ 25 instruction

Total of 218 instruction for the Cortex-M4F



ARM Processor



ARM Processor

- Data rates can vary from 24MHz to 300MHz in typical devices
  - Lower range are typically for low power operation and do not include extended instructions
- Memory ranges, typical
  - RAM: 32 KB to 192KB
  - ROM: 512 KB to 1 MB

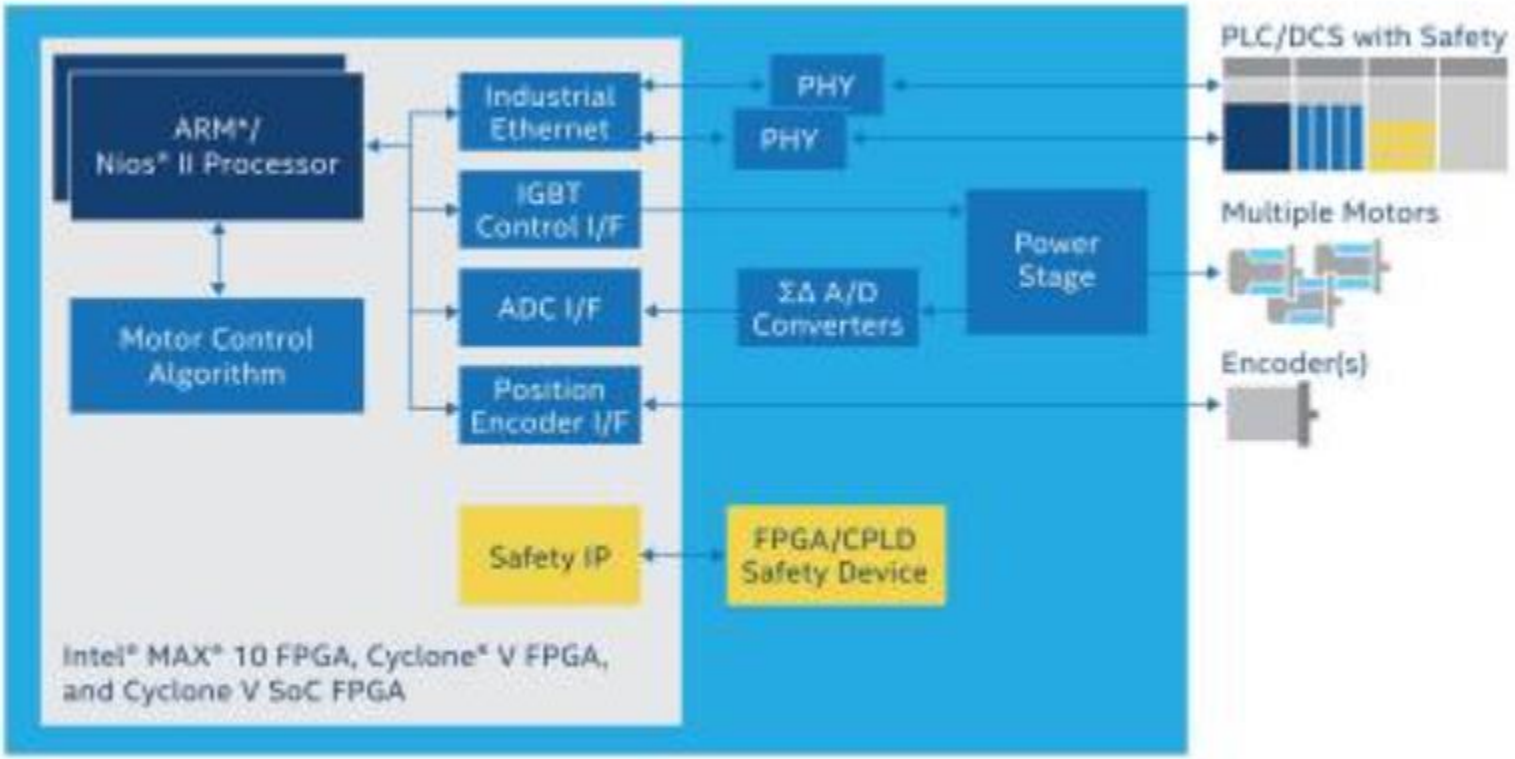
FPGA

- Various vendors offer Field Programable Gate Array (FPGA) devices
  - These consist of a logic fabric that is set by the user through a design process similar to an ASIC
  - Any computational structure can be implemented, including CPUs (not very efficient)
    - Today separate CPUs are put on the same chip as the FPGA fabric
  - SoC's targeted at the industrial controller market are available

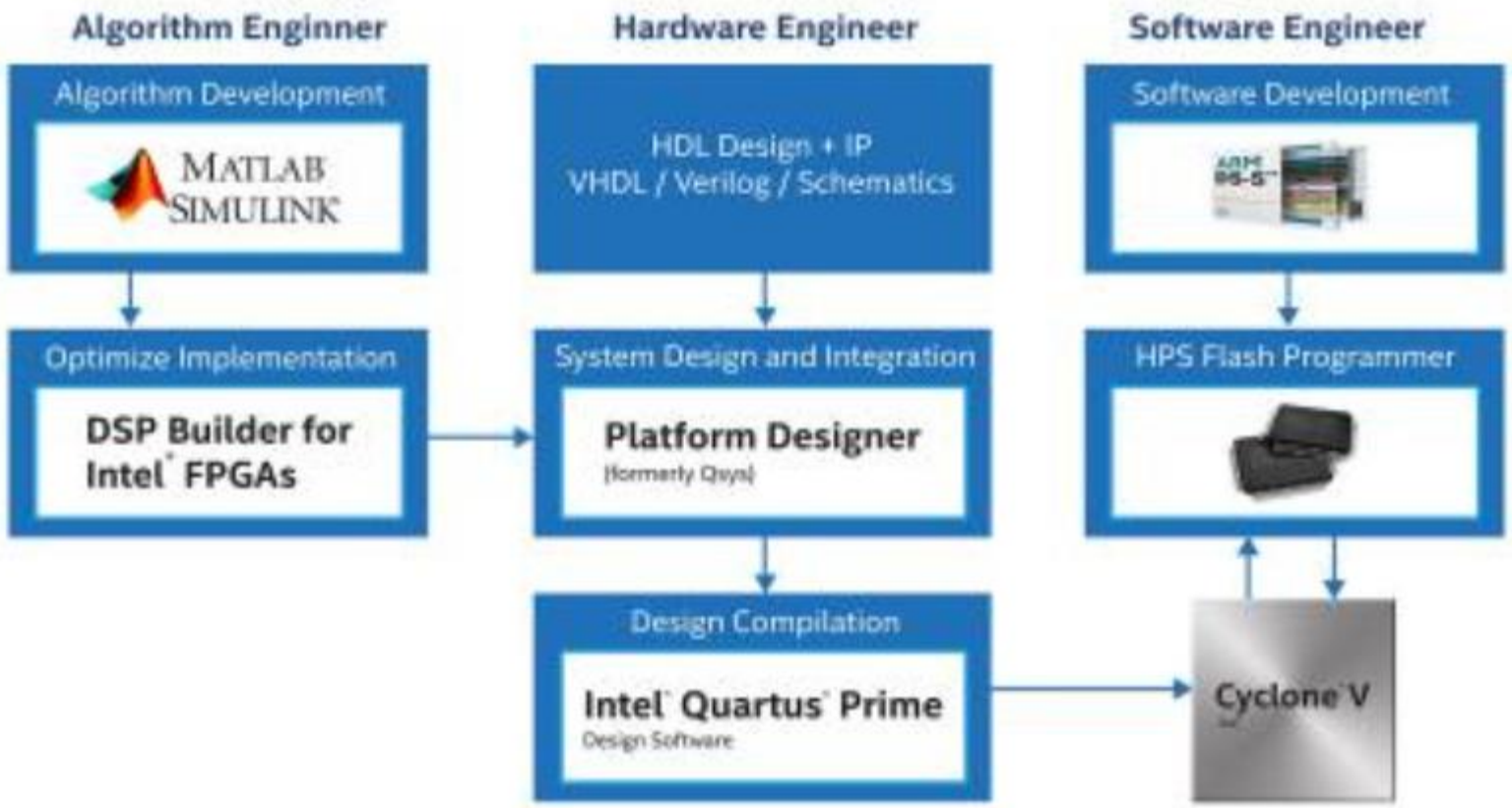
FPGA

- Various vendors produce these including Intel, Cypress and MicroSemi
- Can be used for application that we have already seen, such as motor control
  - Powerful enough to control a number of motors “together”
  - Powerful tools for other technologies such as image processing
    - Used in robotics and inspection tasks

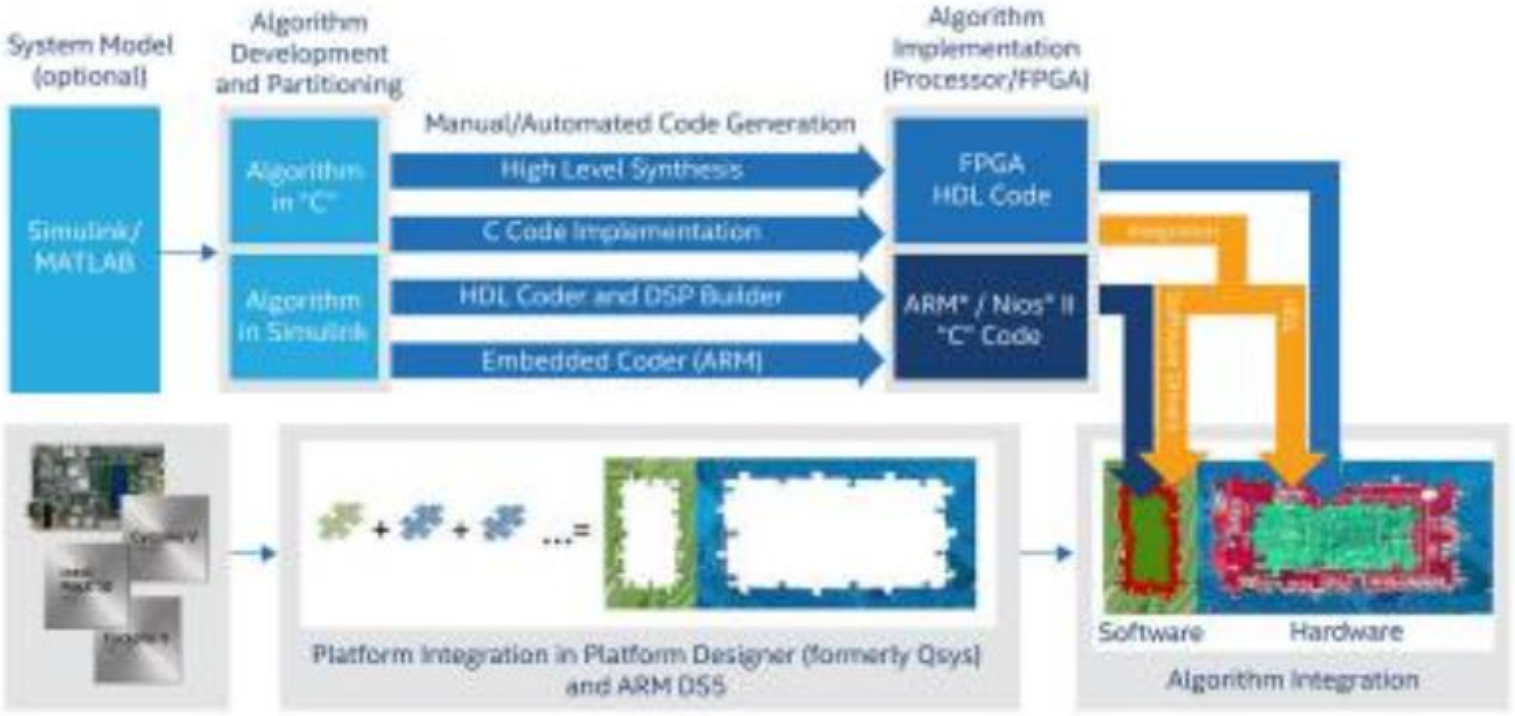
FPGA


ARM*/
Nios* II Processor
Motor Control Algorithm
Industrial Ethernet
IGBT Control I/F
ADC I/F
Position Encoder I/F
Safety IP
PHY
PHY
ΣΔ A/D Converters
Power Stage
FPGA/CPLD Safety Device
Intel* MAX* 10 FPGA, Cyclone* V FPGA, and Cyclone V SoC FPGA
PLC/DCS with Safety
Multiple Motors
Encoder(s)

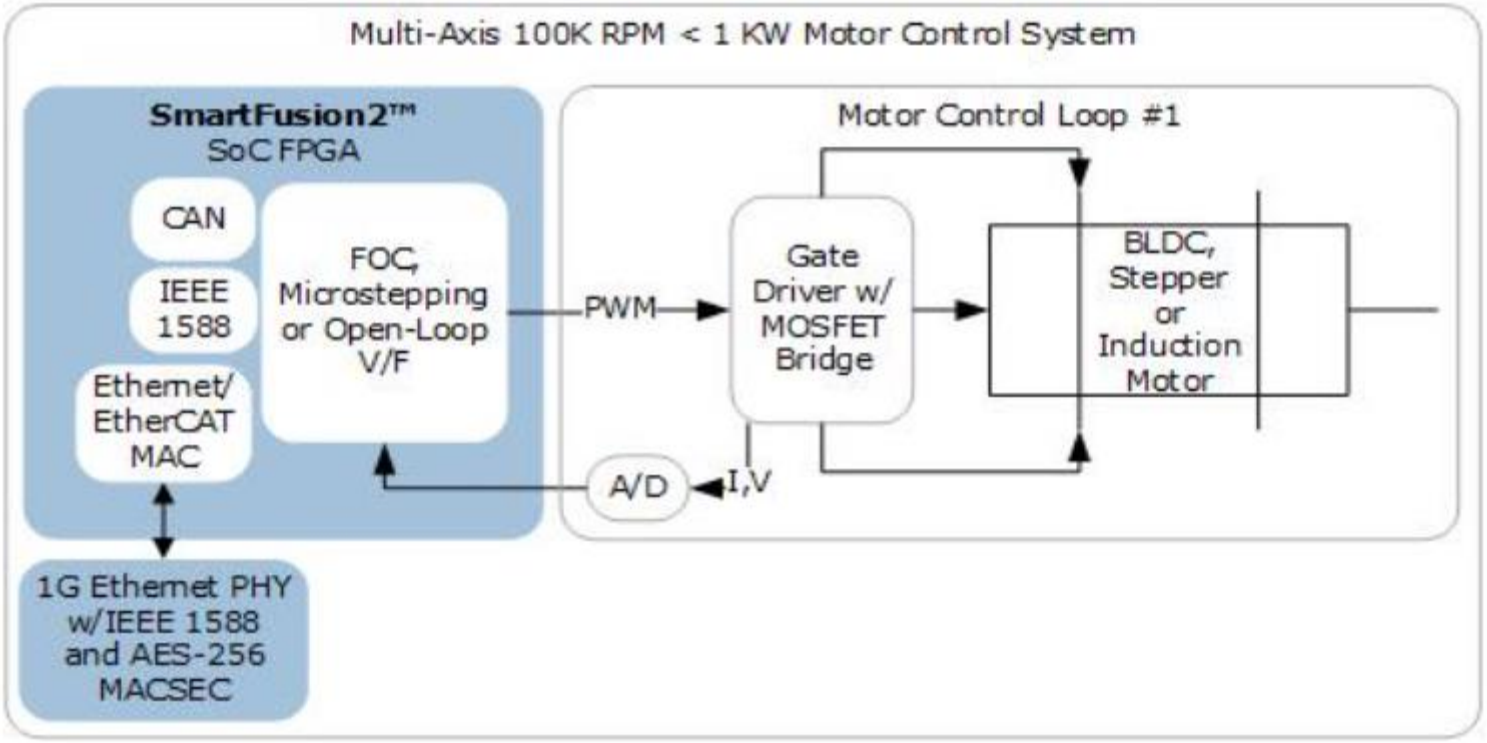
FPGA


Algorithm Enginner
Hardware Engineer
Software Engineer
Algorithm Development
MATLAB
SIMULINK
HDL Design + IP
VHDL / Verilog / Schematics
Software Development
Optimize Implementation
DSP Builder for
Intel FPGAs
System Design and Integration
Platform Designer
(formerly Qsys)
HPS Flash Programmer
Design Compilation
Intel Quartus Prime
Design Software
Cyclone V

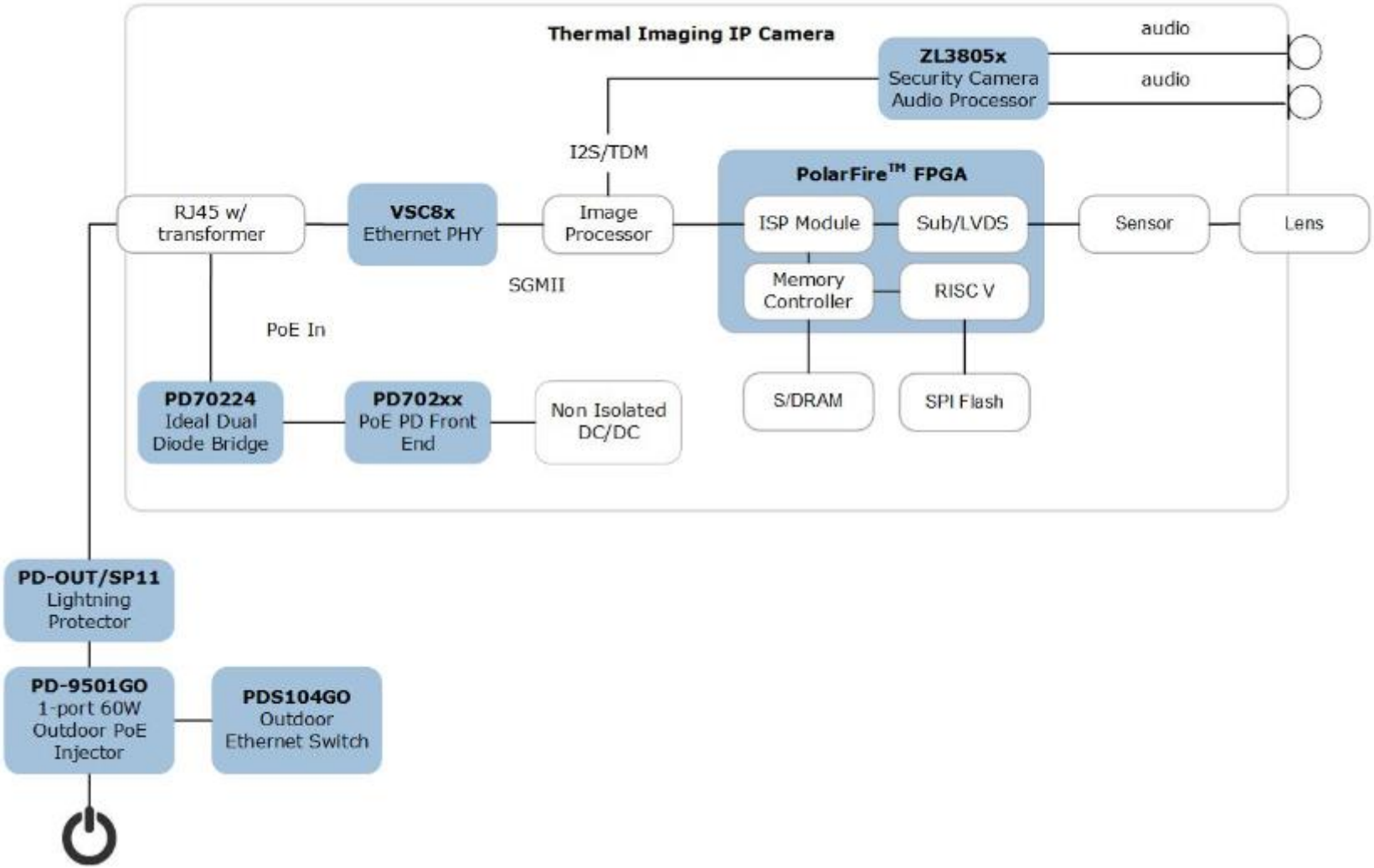
FPGA


System Model (optional)
Simulink/ MATLAB
Algorithm Development and Partitioning
Algorithm in "C"
Algorithm in Simulink
Manual/Automated Code Generation
High Level Synthesis
C Code Implementation
HDL Coder and DSP Builder
Embedded Coder (ARM)
Algorithm Implementation (Processor/FPGA)
FPGA HDL Code
ARM* / Nios* II "C" Code
Platform Integration in Platform Designer (formerly Qsys) and ARM DS5
Software
Hardware
Algorithm Integration

FPGA


Multi-Axis 100K RPM < 1 KW Motor Control System
SmartFusion2™
SoC FPGA
CAN
IEEE 1588
Ethernet/ EtherCAT MAC
FOC, Microstepping or Open-Loop V/F
PWM
Gate Driver w/ MOSFET Bridge
BLDC, Stepper or Induction Motor
Motor Control Loop #1
A/D
I,V
1G Ethernet PHY w/IEEE 1588 and AES-256 MACSEC

FPGA


Thermal Imaging IP Camera
ZL3805x
Security Camera
Audio Processor
audio
audio
I2S/TDM
PolarFire™ FPGA
RJ45 w/
transformer
VSC8x
Ethernet PHY
Image
Processor
ISP Module
Sub/LVDS
Sensor
Lens
Memory
Controller
RISC V
SGMII
PoE In
PD70224
Ideal Dual
Diode Bridge
PD702xx
PoE PD Front
End
Non Isolated
DC/DC
S/DRAM
SPI Flash
PD-OUT/SP11
Lightning
Protector
PD-9501GO
1-port 60W
Outdoor PoE
Injector
PDS104GO
Outdoor
Ethernet Switch

Conclusion

- Today we have covered connectivity, future trends, the ARM processor and the FPGA in the Microcontroller-Based Industrial Controller environment
- Over the week we have looked at history, microcontroller architecture, algorithms, and many examples of these devices in application

Contact Information

- Email – lgiokas@outlook.com
- Twitter - @naperlou or #DNCEC
- LinkedIn – Louis Giokas (the one in the Chicago Area)