工業4.0加速器

智慧工業市場暨技術發展研討會

TOSHIBA

Toshiba Electronic Components Taiwan Corporation
Hitoshi Mizunuma 水沼　仁志
2019.12.12

Acceleration of industry 4.0 business growth

2017 Dec. 12th

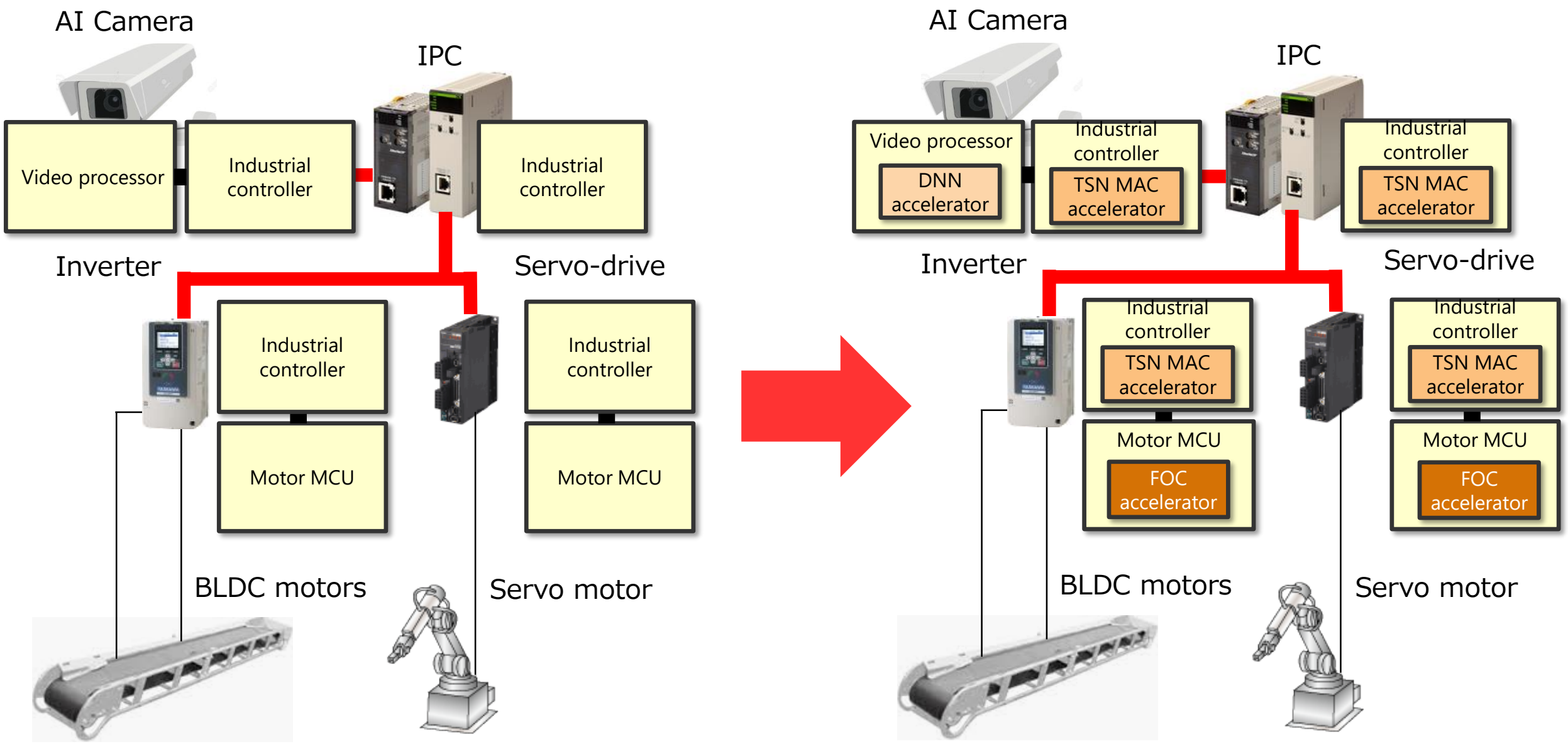
2019 Dec. 12th

Acceleration of industry 4.0 operation

ICs

Toshiba unique IP

Industrial Ethernet



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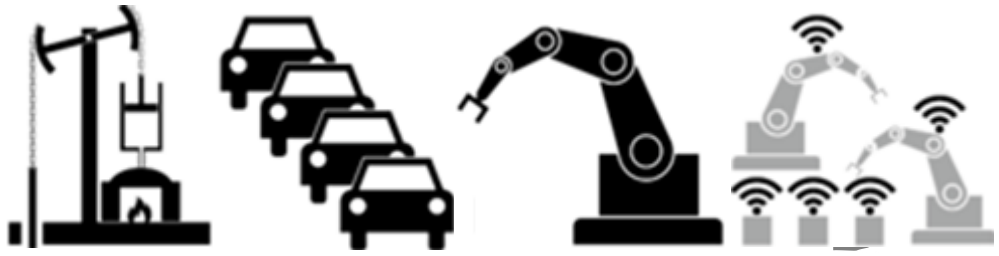
工業4.0現況

Leading countries of the industrial market



1st	2nd	3rd	4th
Mechanization	Mass production	Process automation	Decision automation

■Industries 4.0

- Integrated industrial machinery etc on the CPS (Cyber-Physical System) through the network
- Flexible production according to mass customization
- Cooperation of humans and robots

■Industrial Internet

- Connecting “Industrial equipment” and “Internet”, greatly evolving industrial equipment

■Advanced Manufacturing

- 3D printer, digital manufacturing, material development, robot engineering, etc.

EFFRA (European Factories of the Future Research Association)

HVM (High Value Manufacturing)

France New industries
(La Nouvelle France Industrielle)

Make In India with IoT Policy

- As Make in India is attracting factories, utilize the power of India’s specialty software industry

■Made in China 2025

- Withdrawing from simple labor-intensive manufacturing, convert to advanced manufacturing powerhouse as much as developed countries

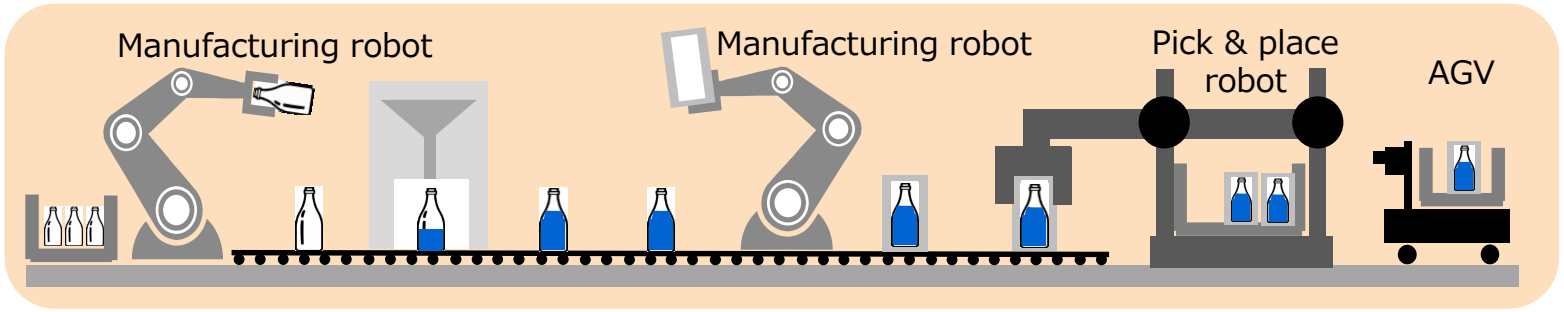
■Robot Revolution Initiative (RRI)

■IVI (Industrial Value-chain Initiative)

■IoT Acceleration Consortium

Smart Factory ≈ Operation Tech. + Information Tech.

Industrial Ethernet



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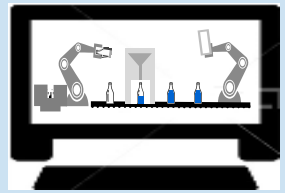
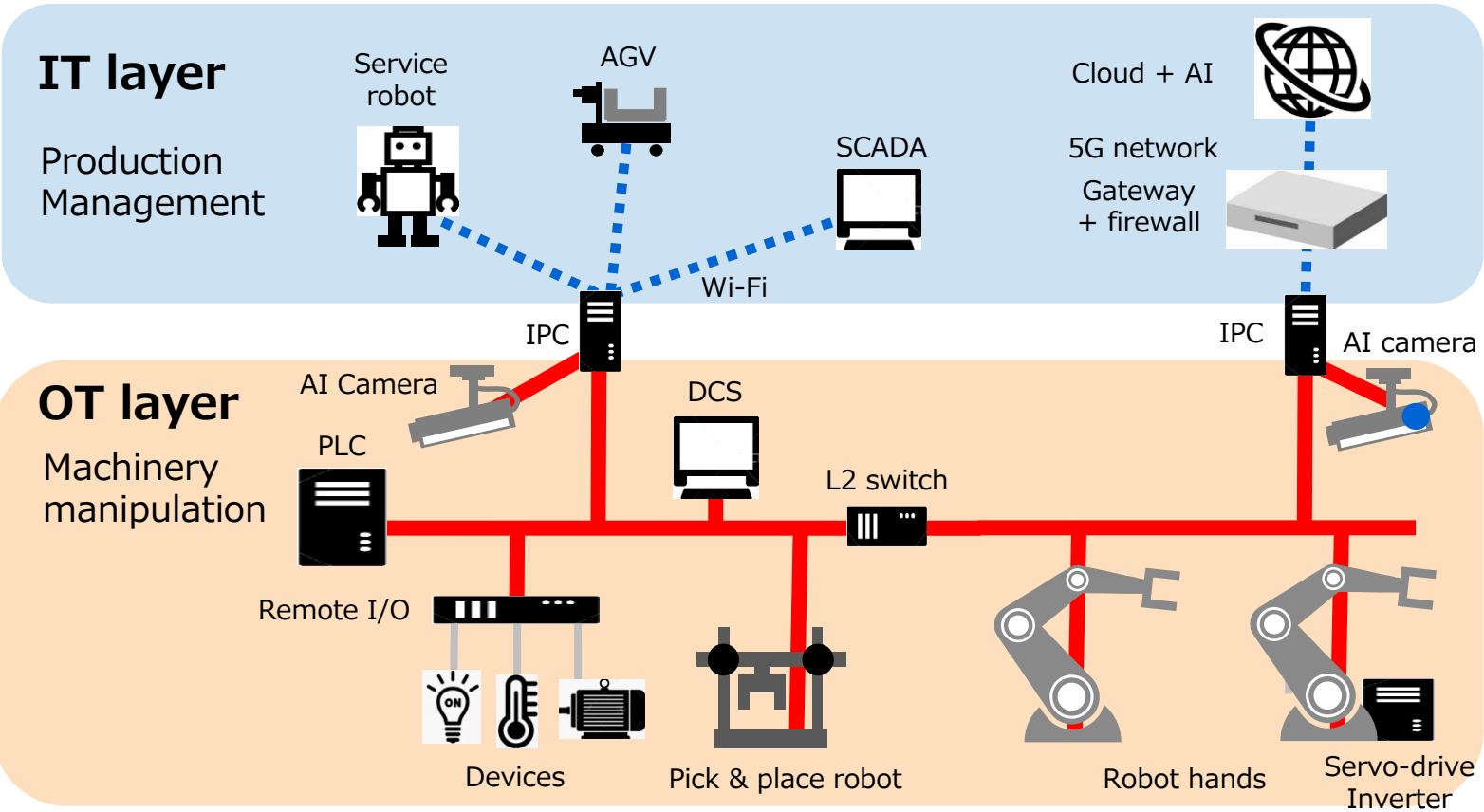


Digital twin

- Failure analysis
- Parameter auto-tuning
- Predictive maintenance



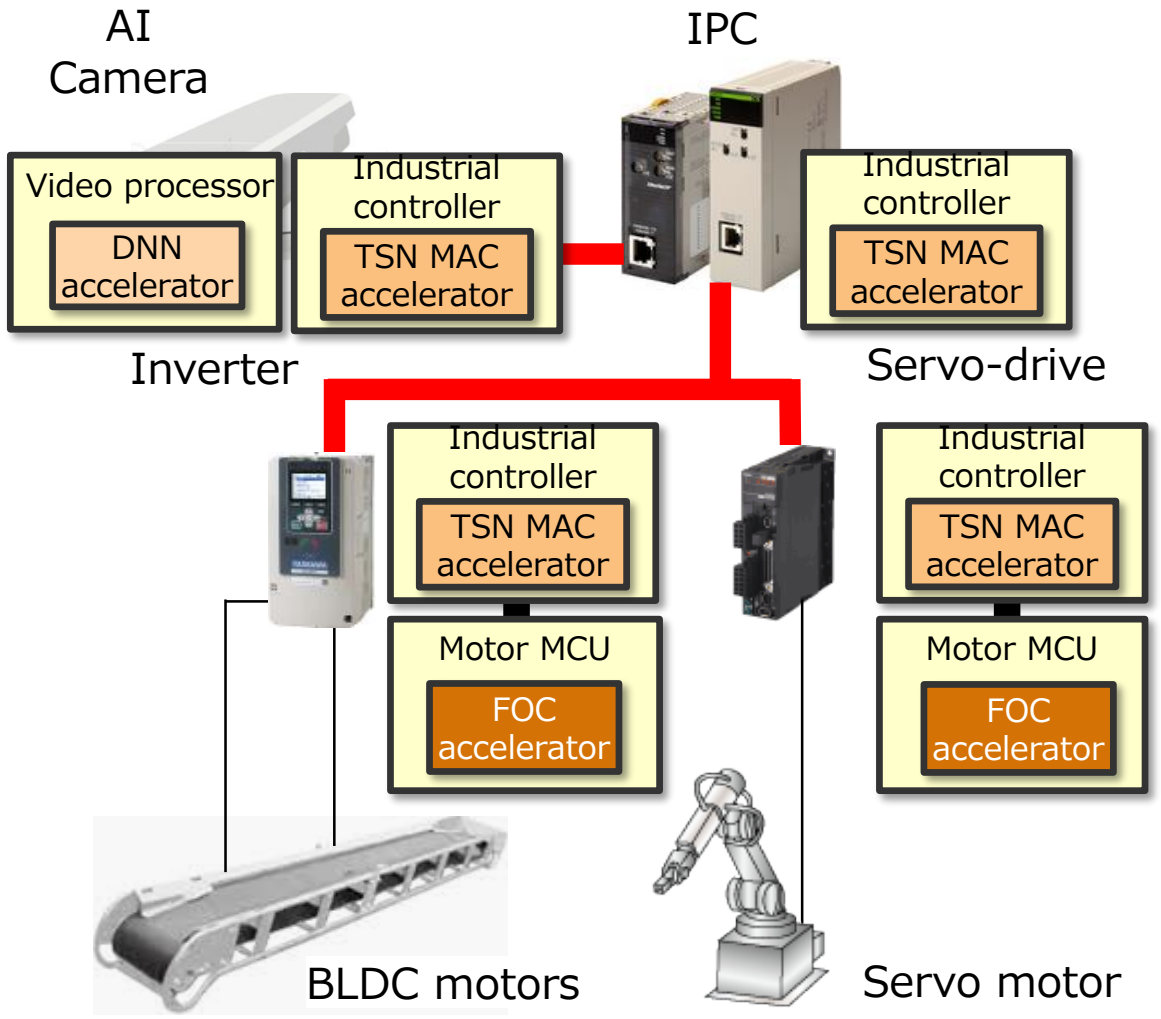
Millisecond time scale

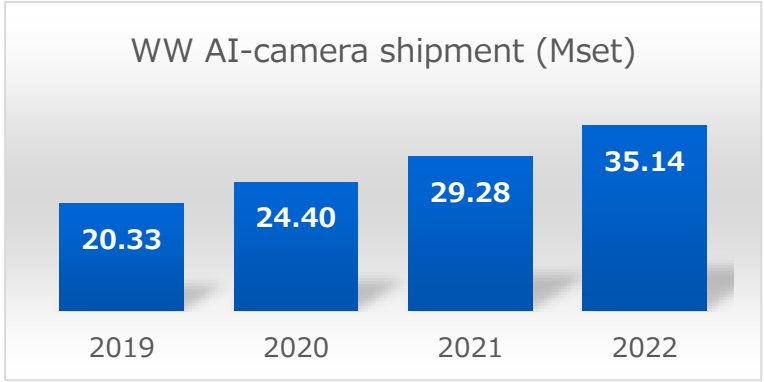
Edge computing

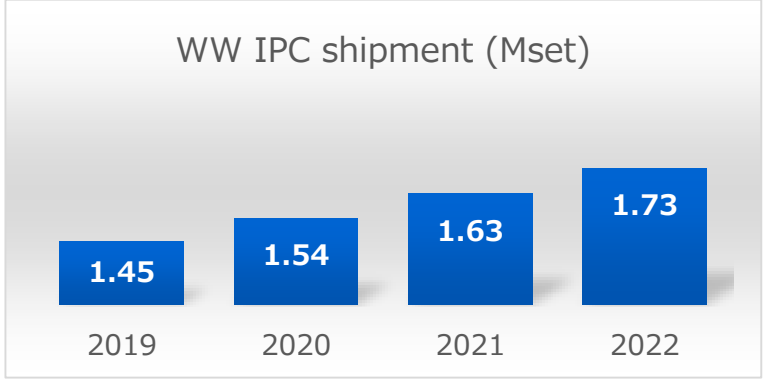
Microsecond time scale

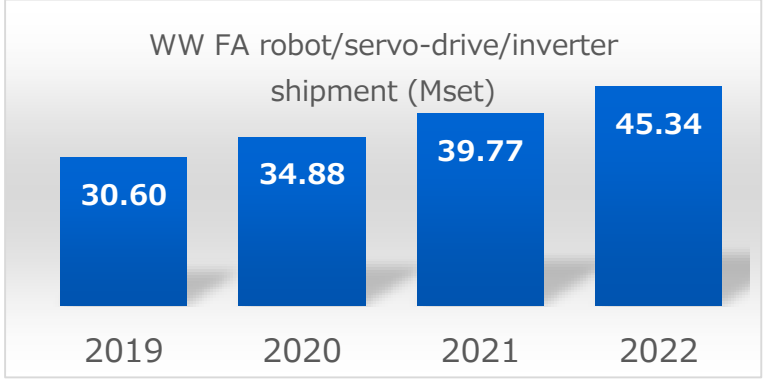
Three target applications in Smart Factory

Industrial Ethernet





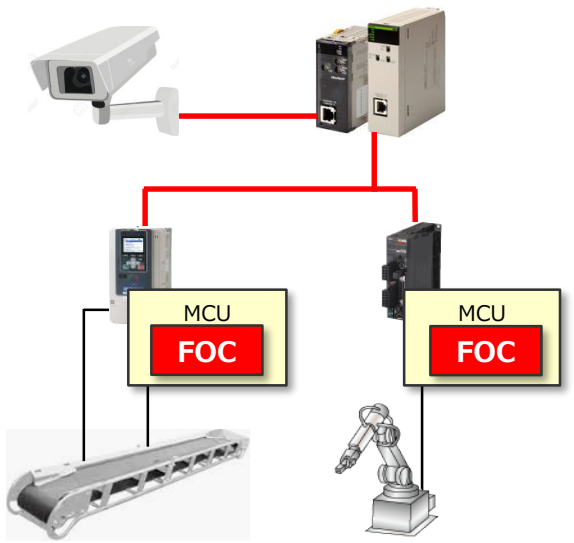




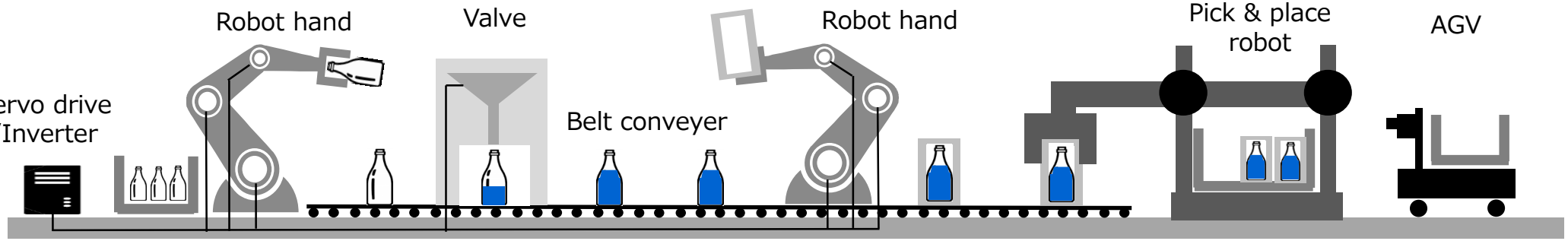
https://www.marketsandmarkets.com/Market-Reports/edge-ai-hardware-market-158498281.html
https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/new-demand-new-markets-what-edge-computing-means-for-hardware-companies, https://www.dri.co.jp/auto/report/mam/mamse4988.html, https://www.meti.go.jp/meti_lib/report/H29FY/000671.pdf + Toshiba own survey

02

工業4.0加速器I “FOC accelerator”



FA market in Taiwan



Estimated market size in Taiwan

100K/Y

10K/Y

Pick and place robot

Variable torque

Servo drive /Inverter

Variable torque

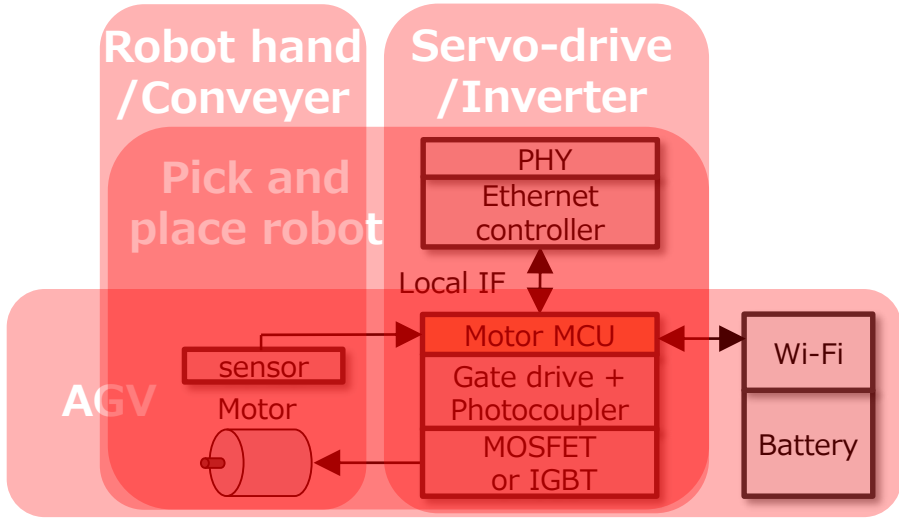
High PWM carrier to suppress ripple

low power

AGV

Robot hand /Conveyer

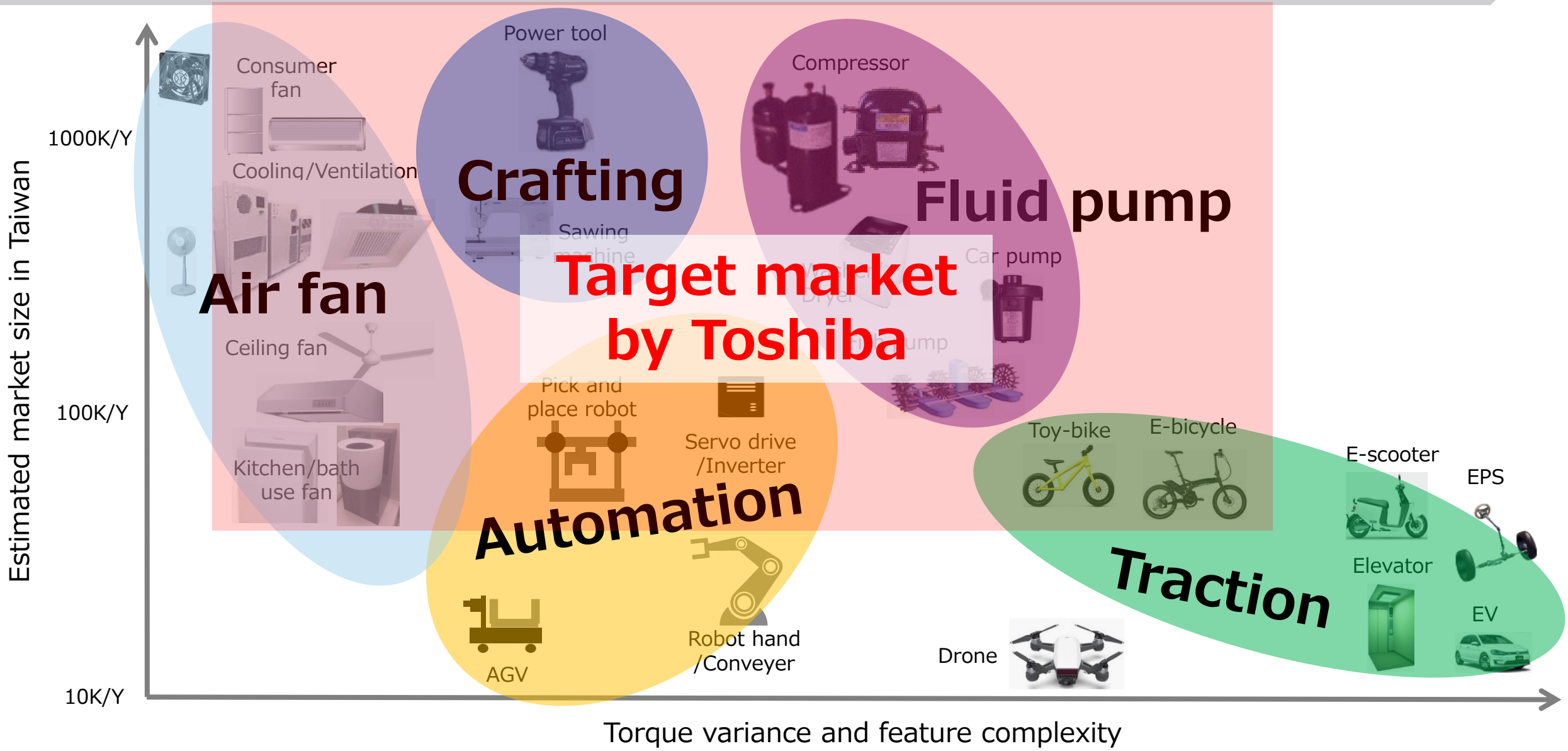
Torque variance and feature complexity



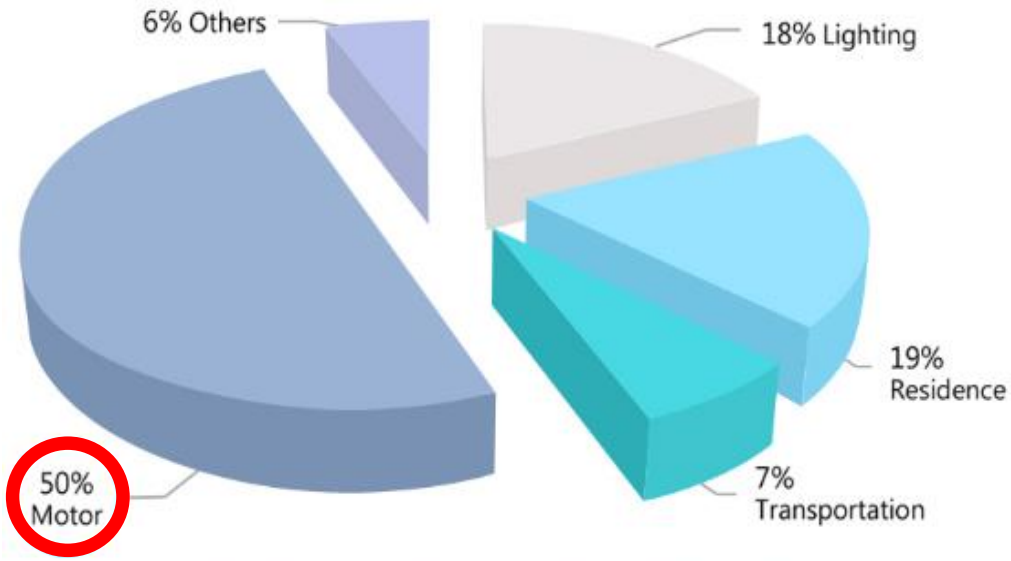
Requirement to motor control algorithm

(a) Lower power consumption
(b) Variable torque control
(c) Higher PWM carrier frequency

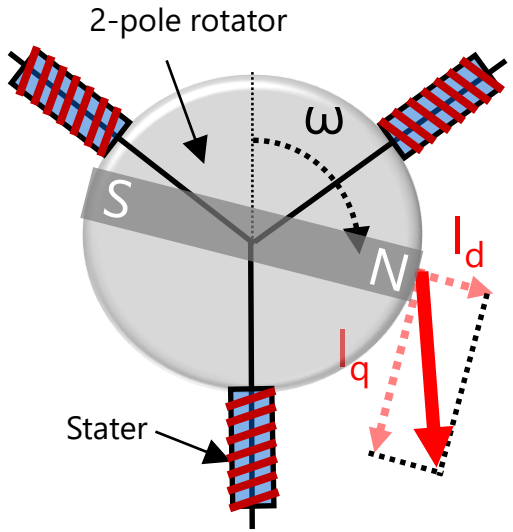
Motor applications in Taiwan



FOC = Field of Control to achieve low-power and torque control

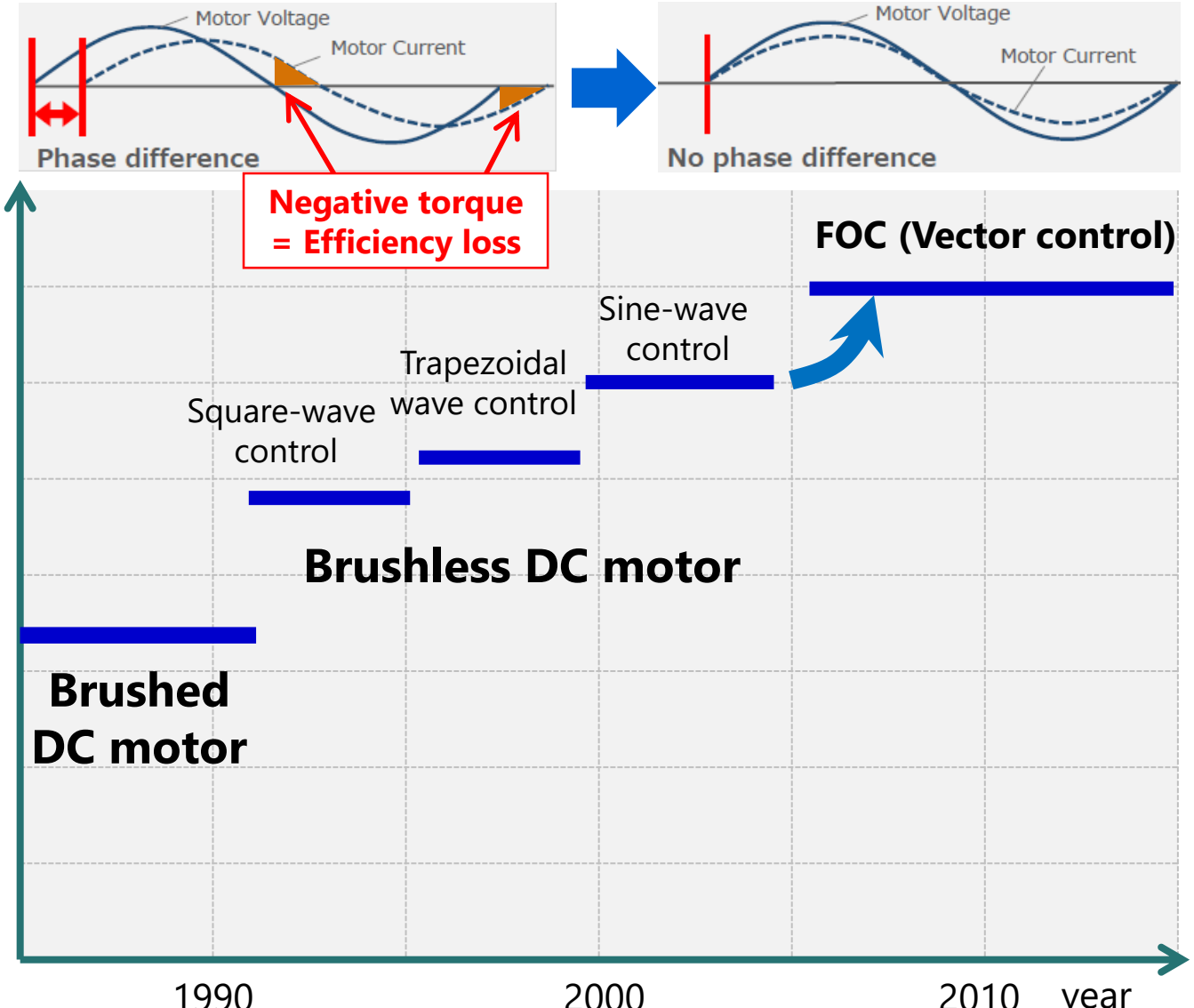


China Electricity Consumption：Motor consumes 70% (More Factories in China)
EU and US Electricity Consumption：Motor consumes 60%
IEA: International Energy Agency

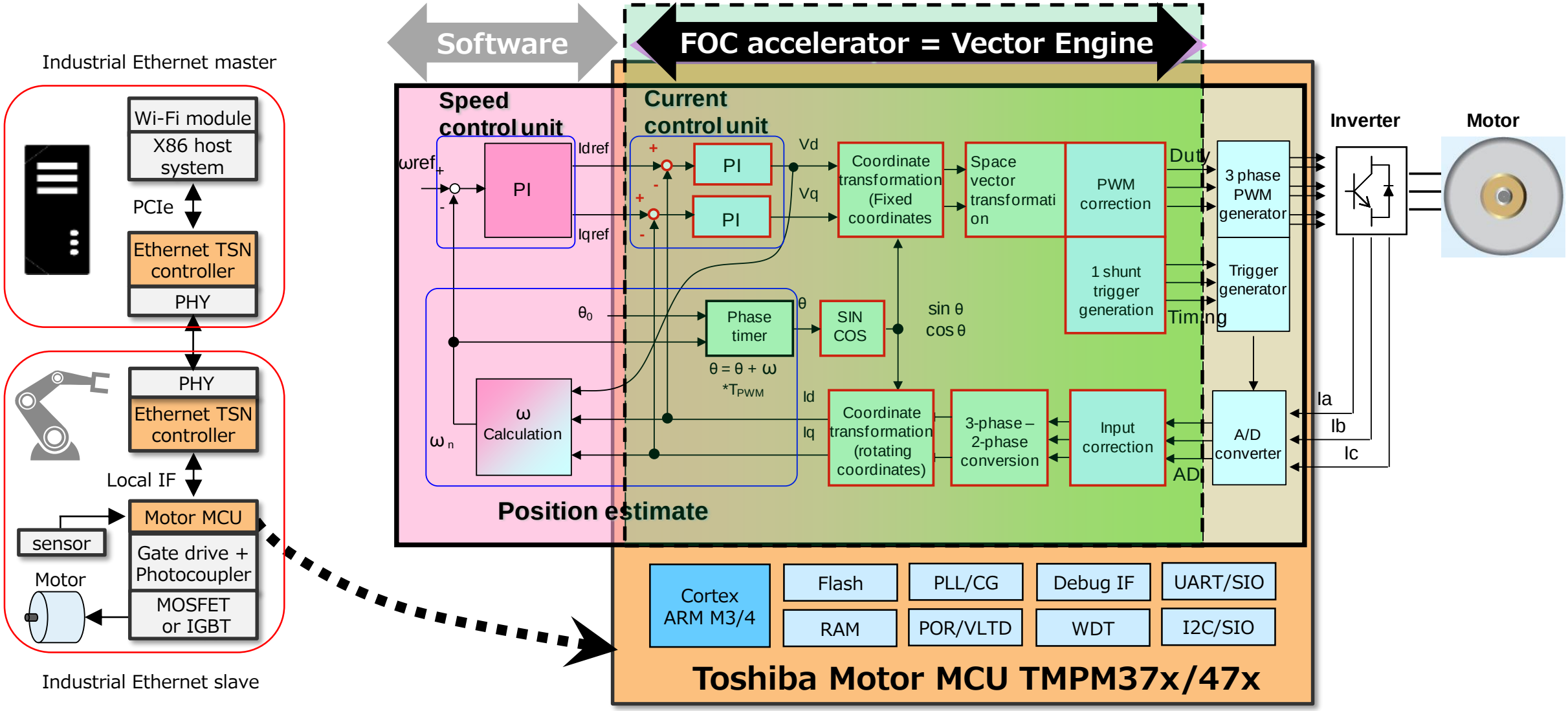


FOC method objective

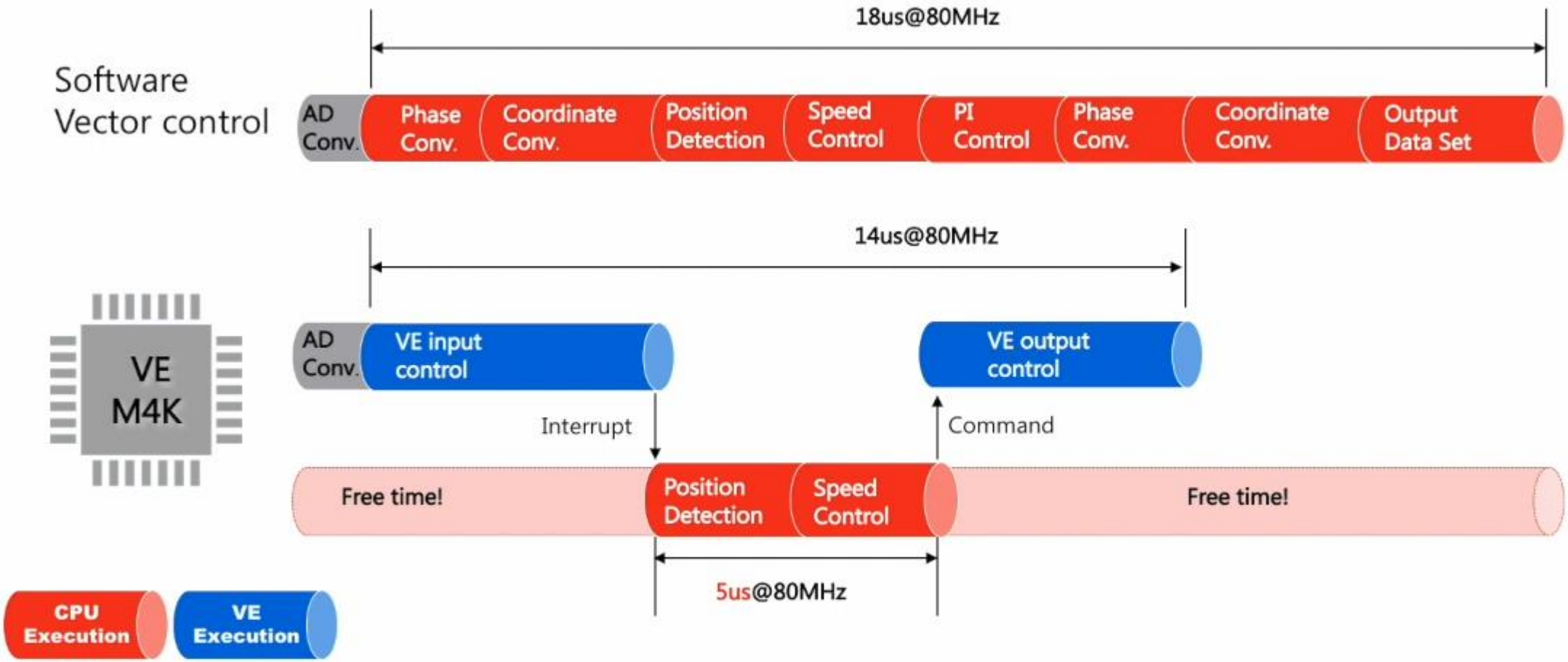
$$I_d \rightarrow 0$$



FOC accelerator = Hardware IP to speed up FOC computation

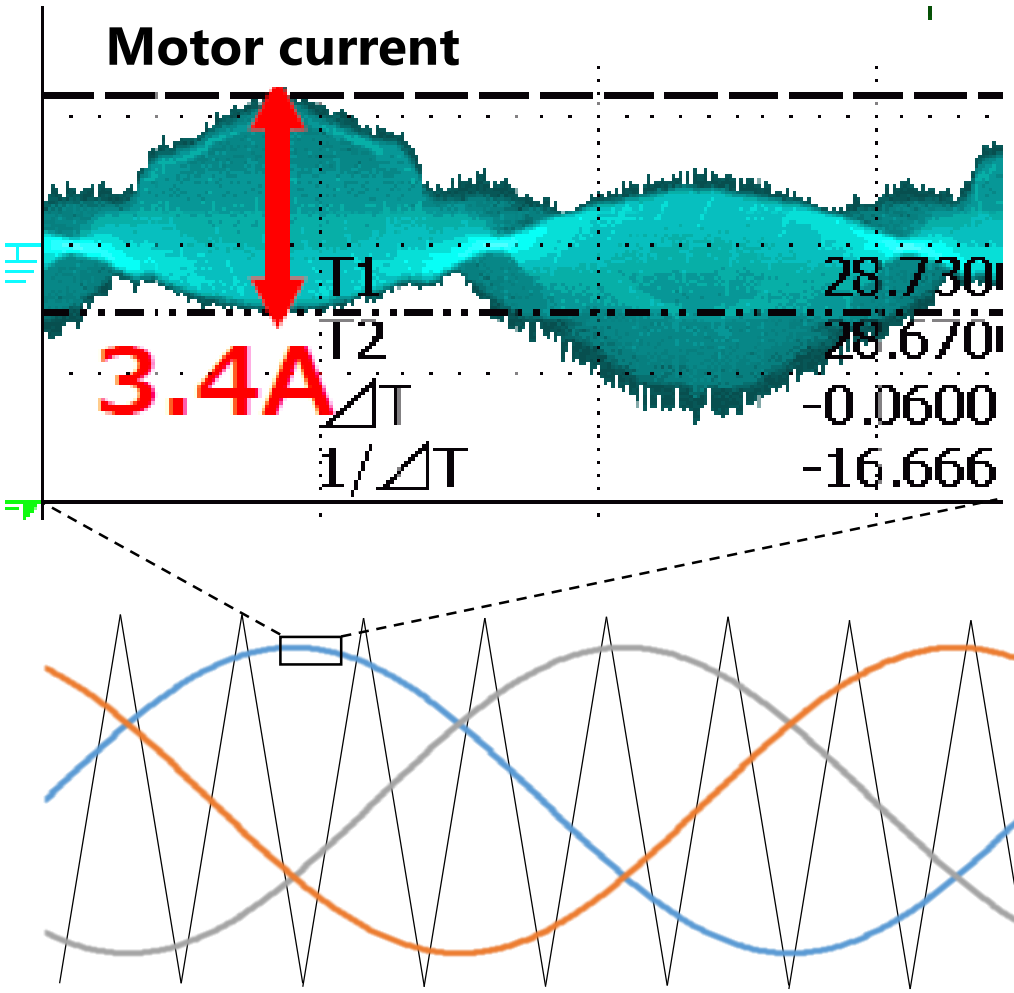


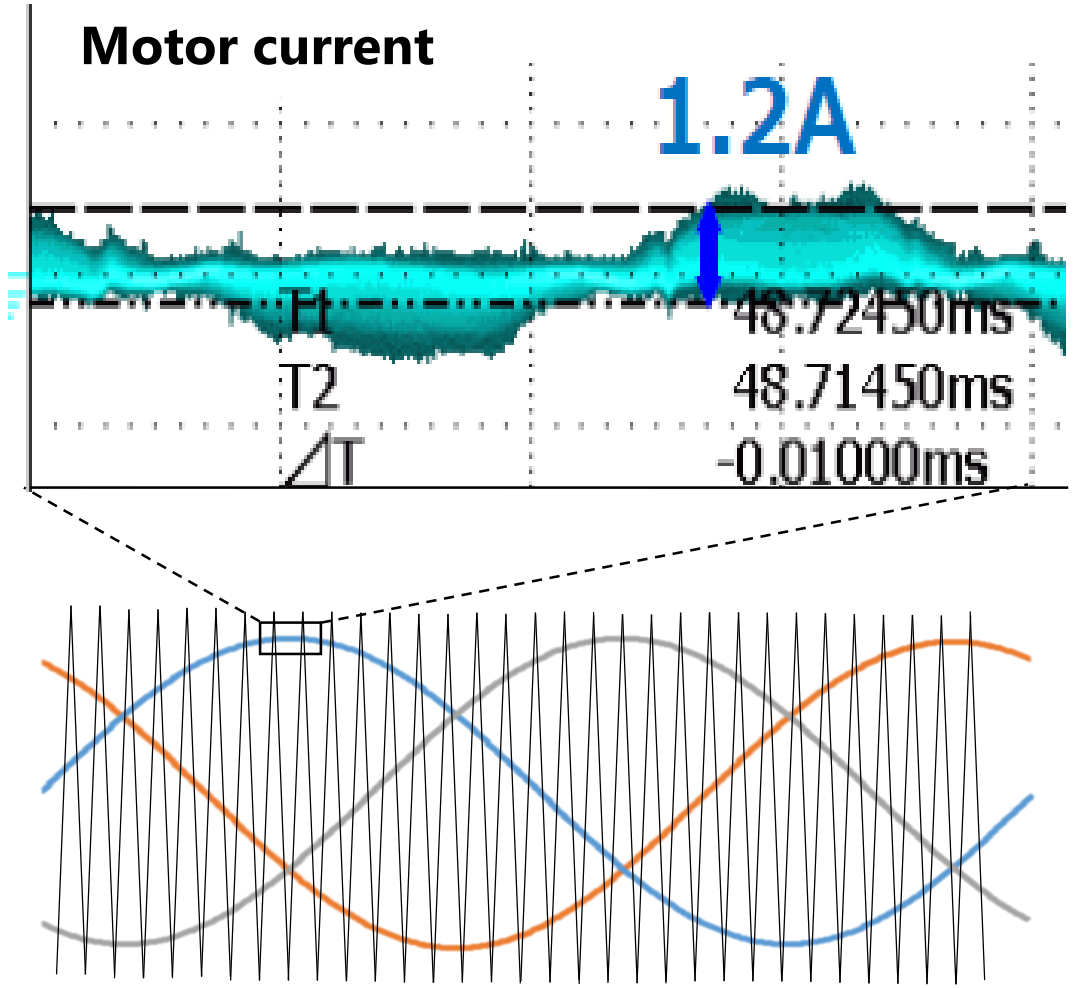
Performance Benefit of FOC accelerator



The Vector Engine reduces CPU load and speeds up processing time

Ripple Reduction Benefit of FOC accelerator

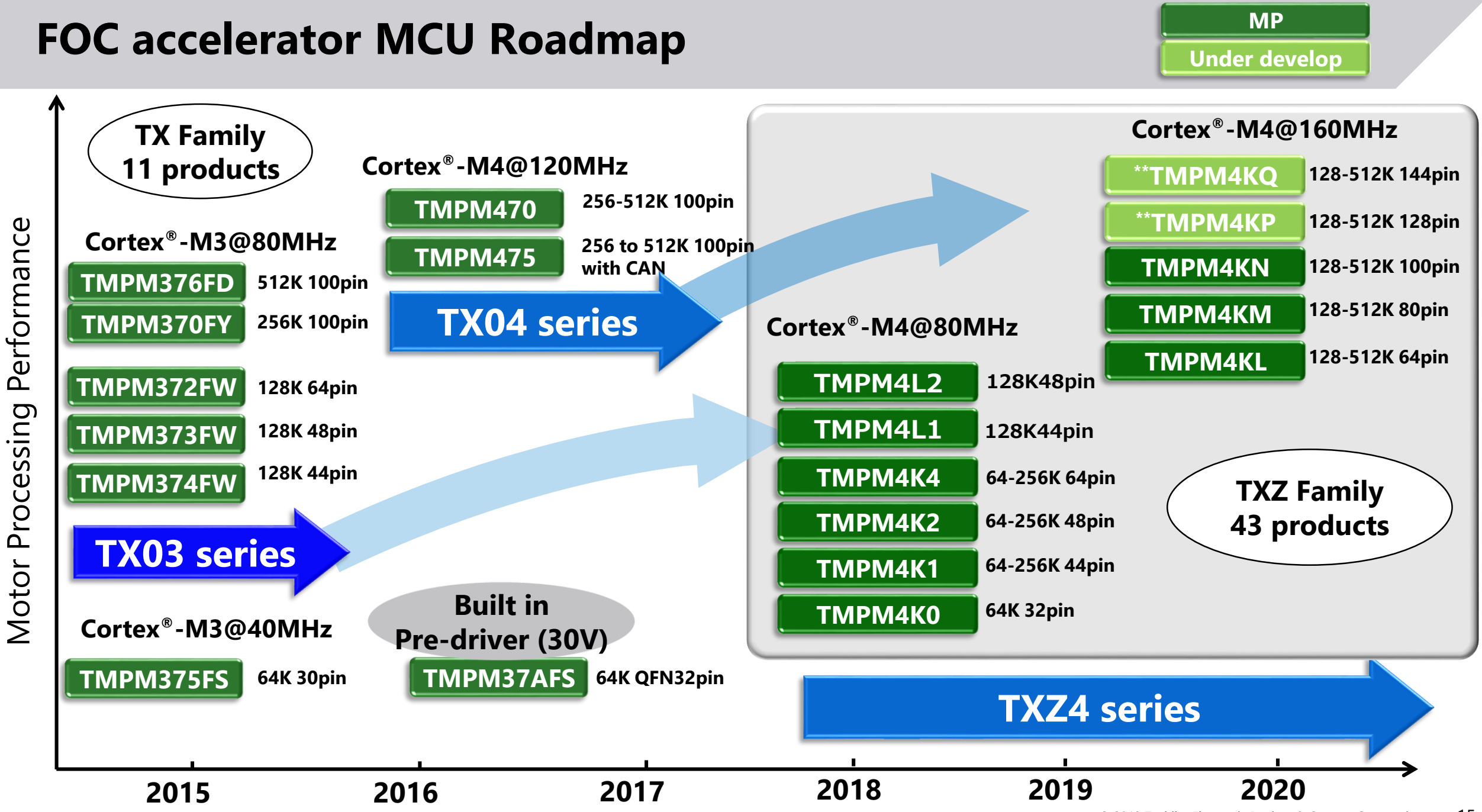




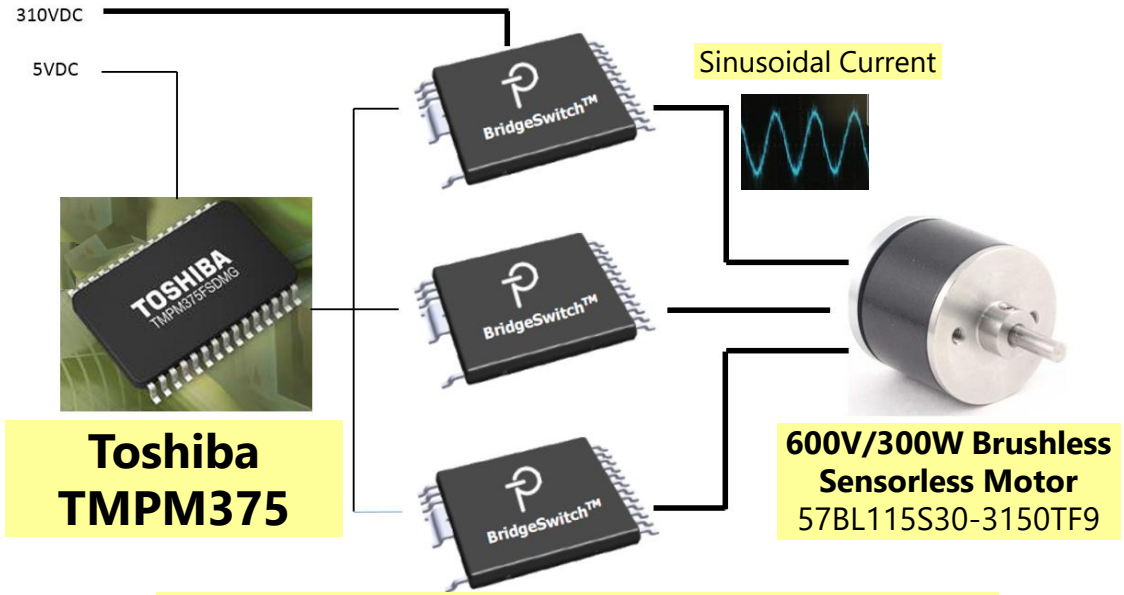
PWM frequency = 16KHz

PWM frequency = 100KHz

FOC accelerator MCU Roadmap



DER-653: Motor MCU reference solution

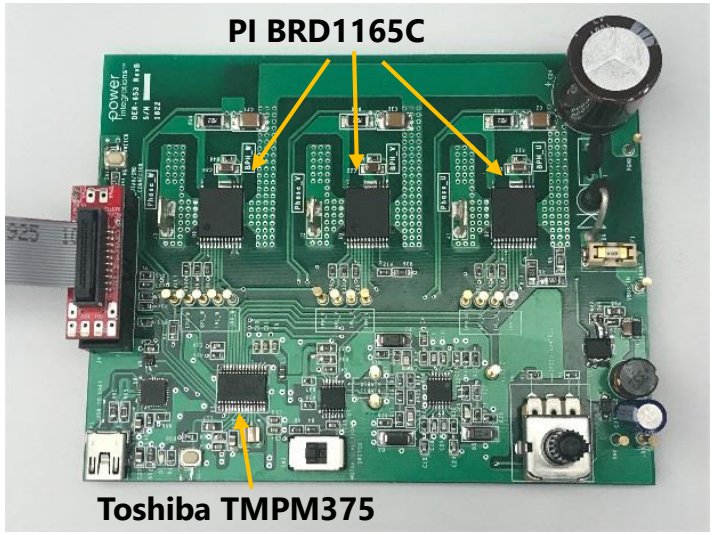


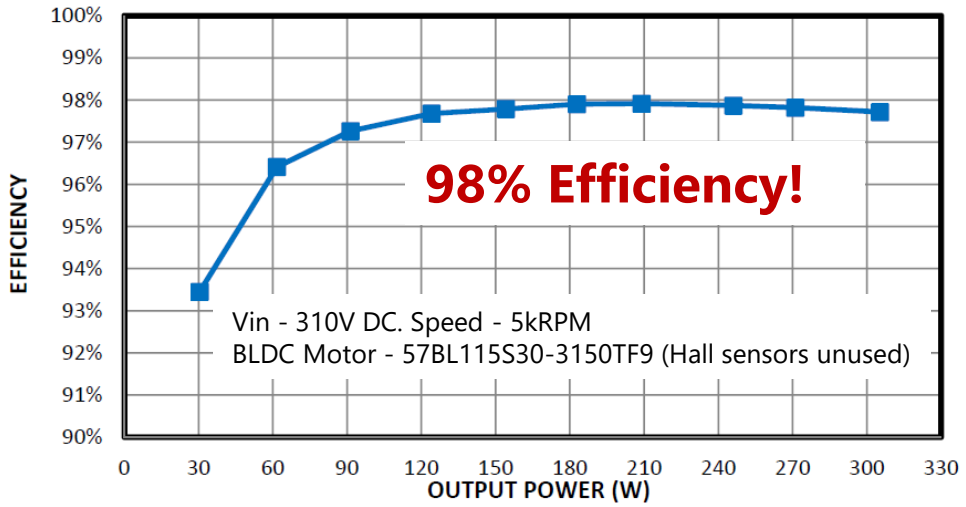
Applications

- Sensor-less/sensor FOC inverter system up to 300W motor

Value Propositions

- Supports 310V/300W/5kRPM Brushless Sensorless Motors
- 98% Efficiency, No Heatsink, Reduce PCB HotSpots
- Ultra Quiet and Virtually No Vibration Sinewave Drive
- FOC Accelerator Frees Up CPU of 73% Bandwidth
- Provides Full Motor Torque Capability Even at Low Speed
- Minimum BOM Solution





DER-653 Solution Demo System

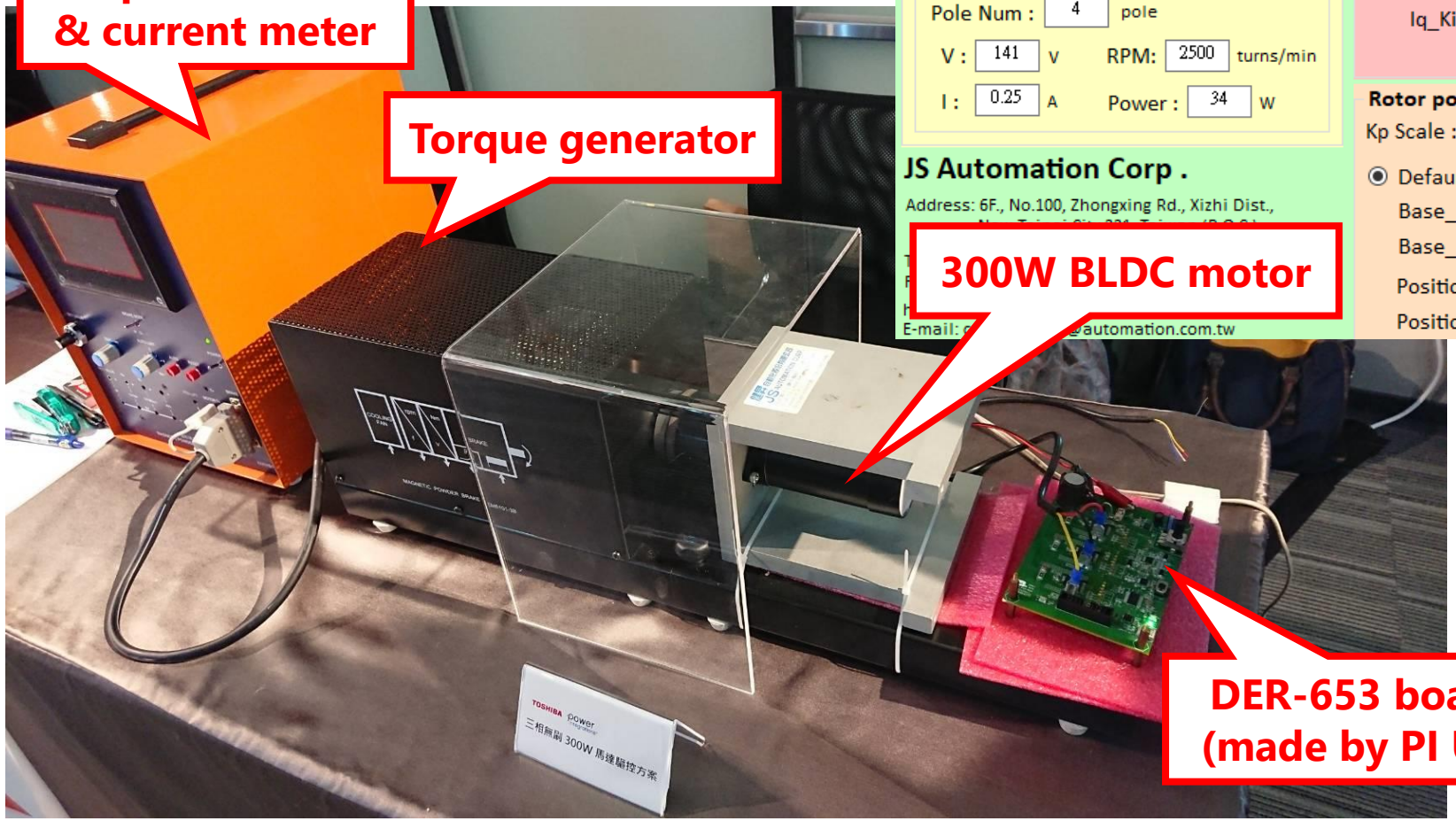
Motor parameter calculation tool (Developed by 3rd party JAC)

Torque controller & current meter

Torque generator

300W BLDC motor

DER-653 board (made by PI US)



Motor Parameters

Module Name : Module_name

DQ Module Parameters

R : 41 Ohm

Ld : 70 mH Lq : 70 mH

Rated rating

Pole Num : 4 pole

V : 141 v RPM: 2500 turns/min

I : 0.25 A Power : 34 W

JS Automation Corp .

Address: 6F., No.100, Zhongxing Rd., Xizhi Dist.,

E-mail: [redacted]automation.com.tw

Current Control Parameters

ωn : 660 rad/s ζ : 1

◉ Default ○ Manual Keyin

Id_Kp = 51.4 V/A

Id_Ki = 30492 V/As

Iq_Kp = 51.4 V/A

Iq_Ki = 30492 V/As

Calc

Rotor position control

Kp Scale : 1 Ki Scale : 1

◉ Default ○ Manual Keyin

Base_Kp = 0.66269 Hz/V

Base_Ki = 0.00331 Hz/Vs

Position_Kp = 0.66269 Hz/V

Position_Ki = 0.66269 Hz/Vs

Speed Loop Parameters

Motor Working Parameters

I : 0.25 A RPM : 2500 turns/min

Power : 34 W

Rotor D : 5 cm ζ : 2.5

Rotor L : 3 cm ωn : 40 rad/s

J_Load : 0 %

◉ Default ○ Manual Keyin

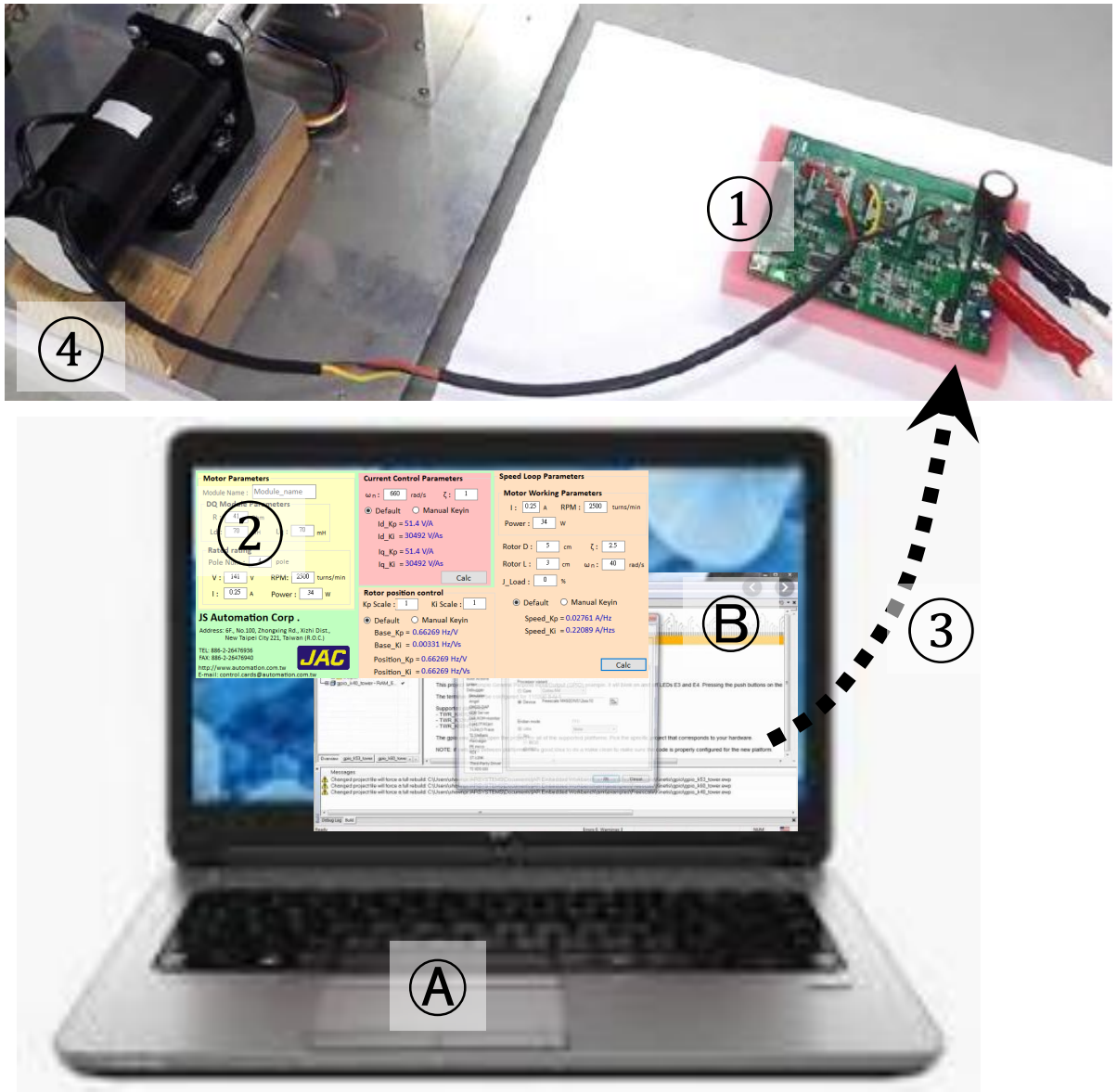
Speed_Kp = 0.02761 A/Hz

Speed_Ki = 0.22089 A/Hzs

Calc

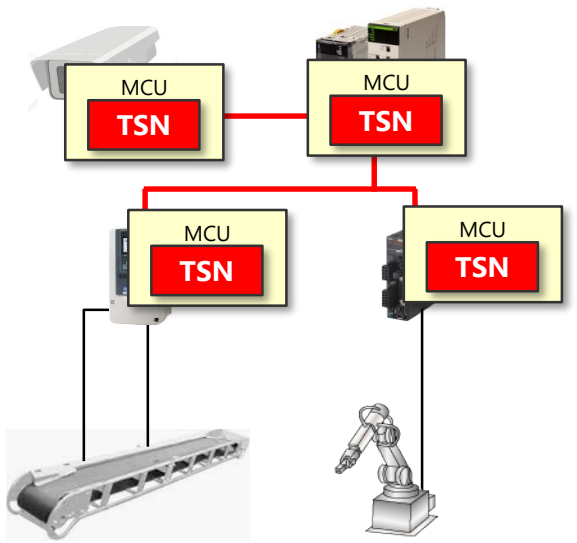
Half-day DER-653 solution workshop announcement

Item	Description
Date & Time	2019/12/26 (Thu) 14:00-17:00
Location	Toshiba Taiwan office 台北市南京東路3段168號4樓 L1 & L2
Fee	Free
Target attendees	Motor system EE engineers Software engineers
Quota	12 people
Hands-on activities	① DER-653 board usage ② FOC tooling usage ③ FW build/debug with EWARM ④ Motor operation using 300W BLDC
Items prepared by attendees	Ⓐ Notebook PCs Ⓑ EWARM pre-installation (one-month evaluation version)
Contact window	cindy2.kuo@toshiba.co.jp

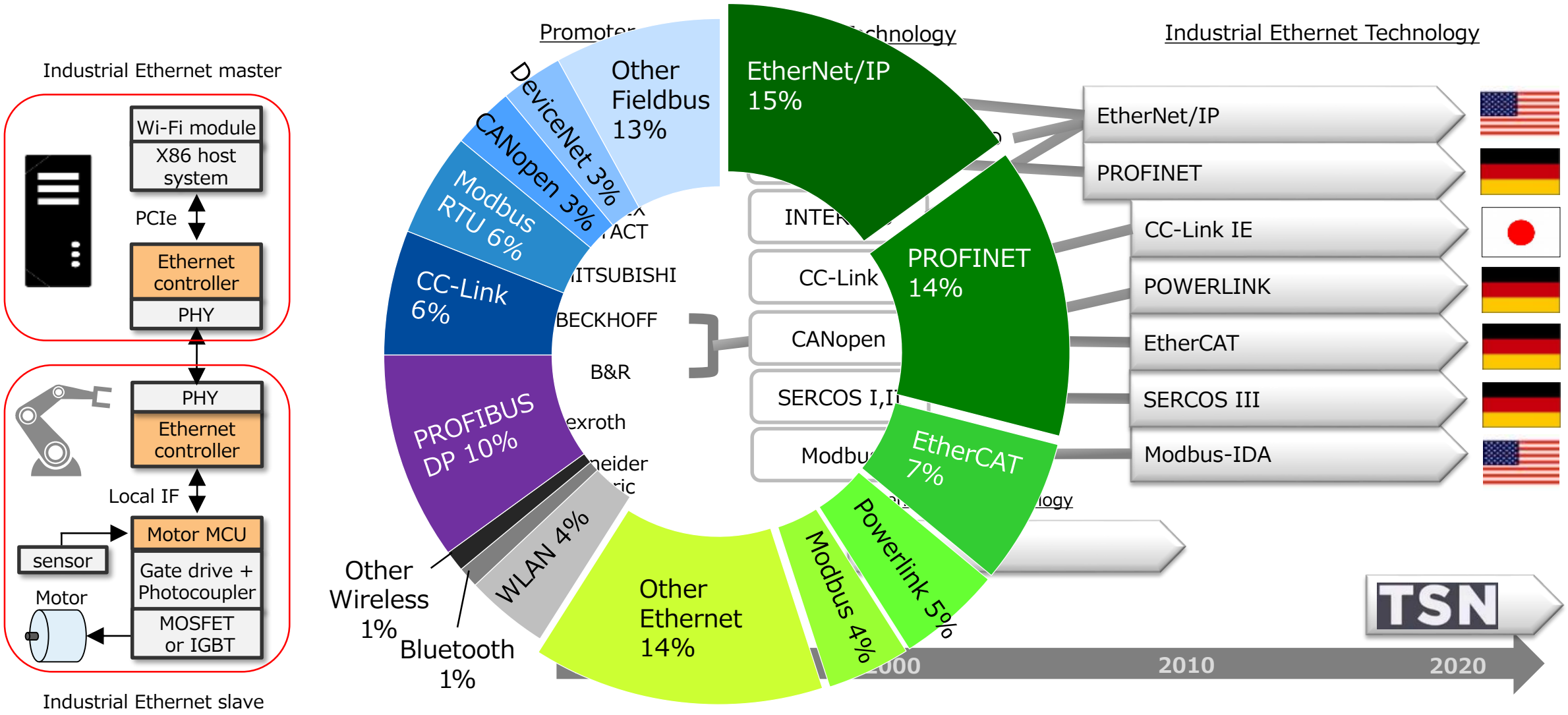


03

工業4.0加速器II “TSN accelerator”

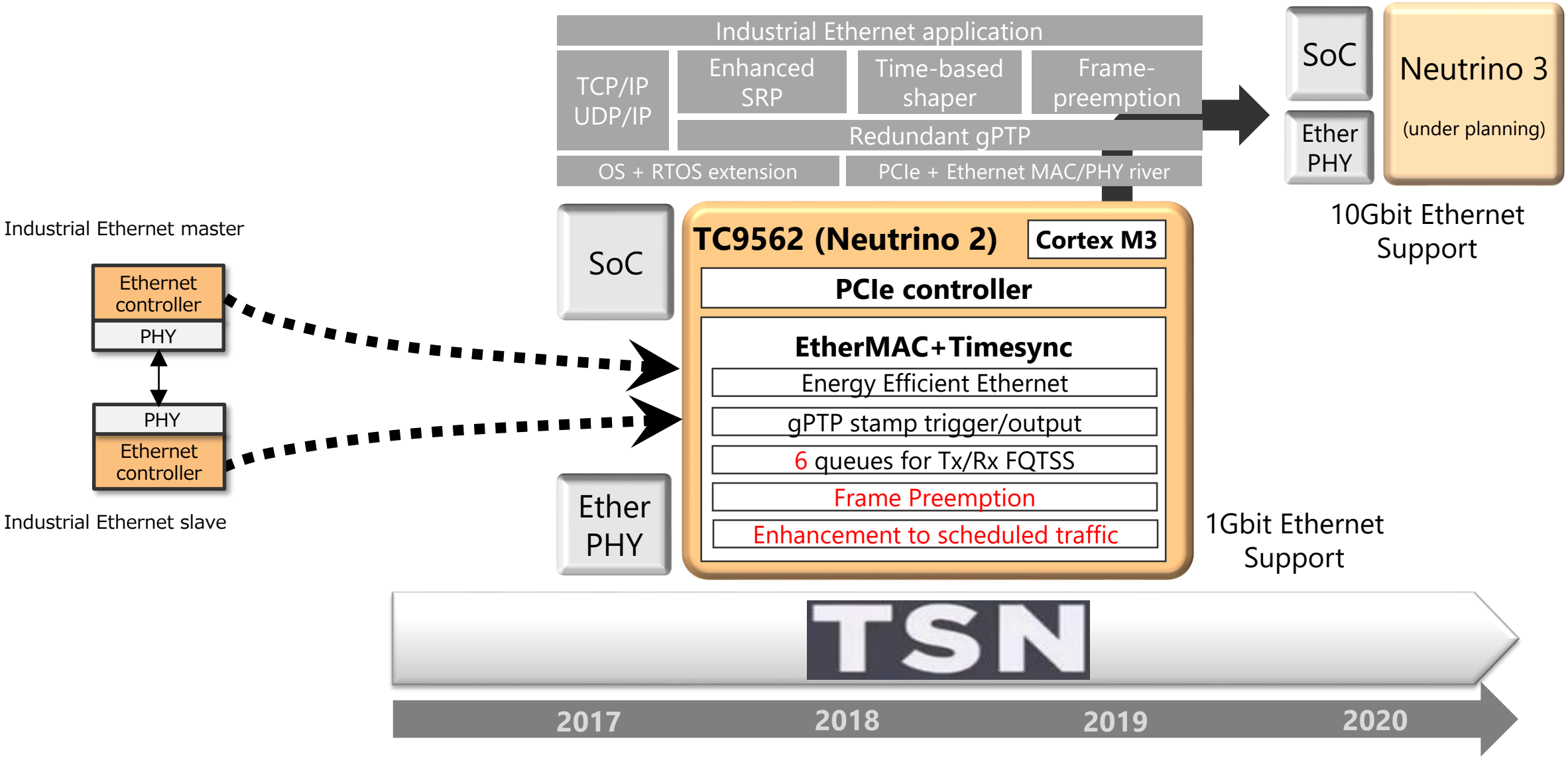


Industrial Ethernet market



https://www.hms-networks.com/news-and-insights/news-from-hms/2019/05/07/industrial-network-market-shares-2019-according-to-hms

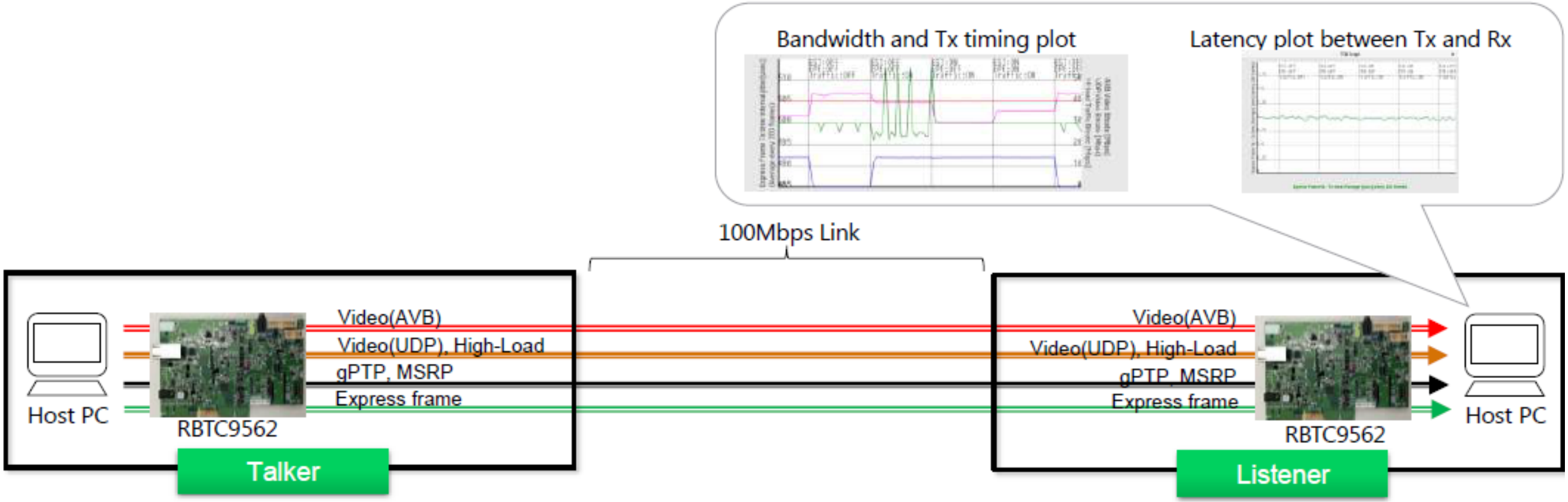
Ethernet TSN bridge IC product lineup



Neutrino is a pet name of Toshiba Ethernet TSN bridge products

Neutrino 2 hardware function test suite and demo

TSN test application is for confirming EST (Enhancements to Scheduled Traffic) & FPE (Frame preemption) features.
This application transmit the Express frame of 214 Byte every 500 usec from Talker, and periodic switching EST & FPE on/off with every 10 sec.

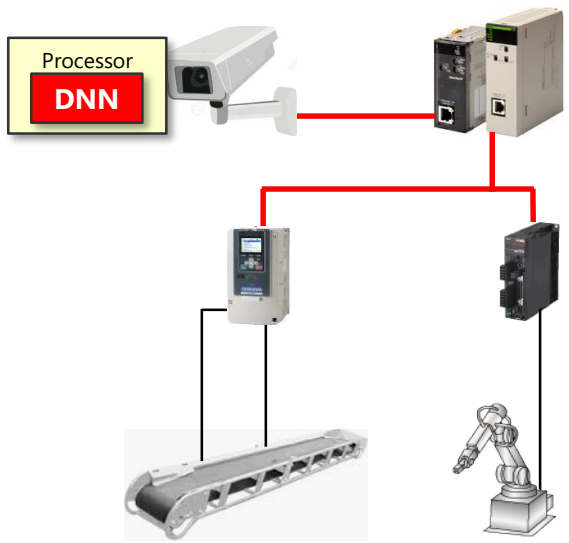


The following features can be confirmed with this application.

- Toggle EST on/off to confirm Express frame transmit complete timing
- Validate FPE improvement of Total bandwidth

04

工業4.0加速器III “DNN accelerator”



Visconti 5 is Toshiba's first AI processor focusing ADAS first

Image recognition processor

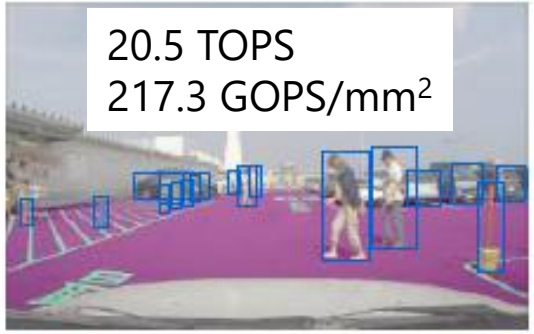
Visconti3-Quartetto
Visconti2-Quartetto
Visconti2-Duetto
Visconti2-Solo

Visconti4-Quartetto

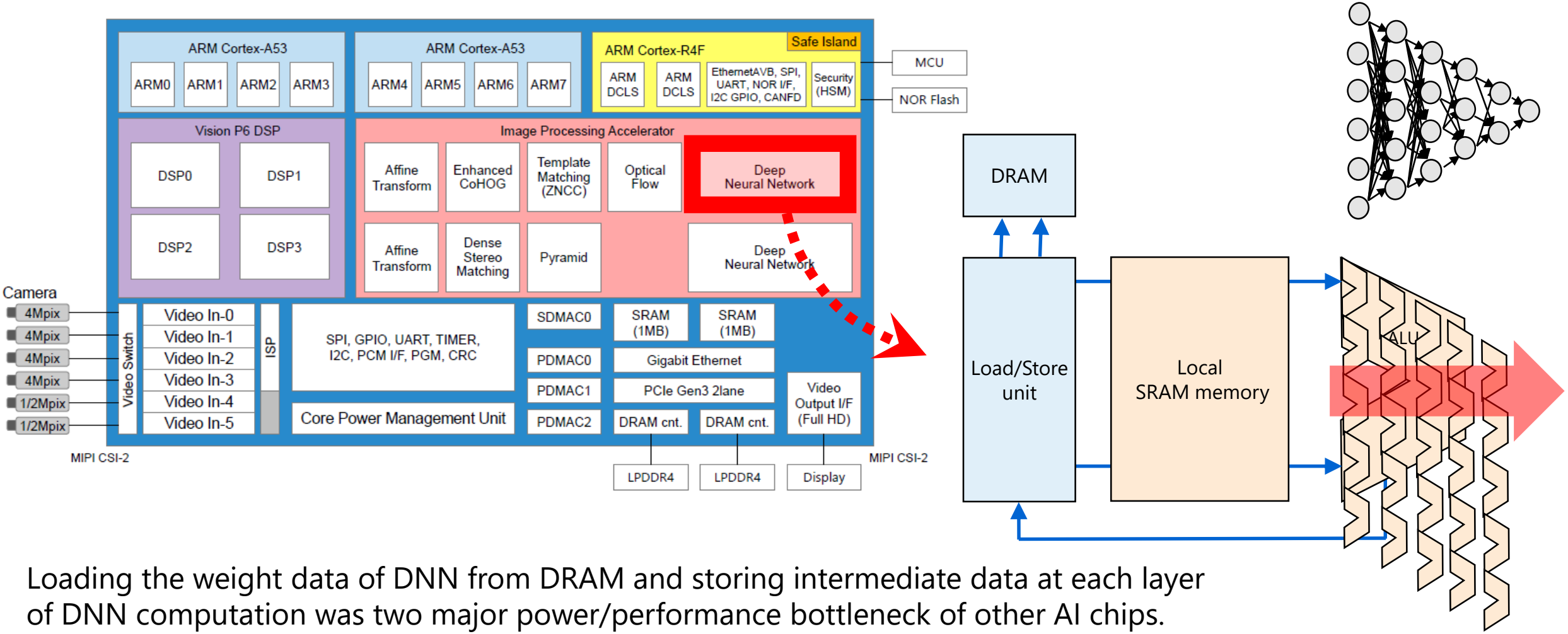
Visconti5-Sextetto
Visconti5-Duetto

Next generation

AI processor

Visconti2/3 (EuroNCAP2016)	Visconti4 (EuroNCAP2018)	Visconti5 (EuroNCAP2020)	Next generation (EuroNCAP202x)
Mono Front/Rear sensing (Daytime)	Mono Front/Rear sensing (Daytime & Night)	Mono/Stereo + Milli wave Front sensing 360° surround sensing Auto parking	Autonomous driving (recognition + judgement) Mono + Milli wave or LiDAR Front sensing Mono + Milli wave 3D view + surround sensing Auto parking
			

Visconti 5 architecture



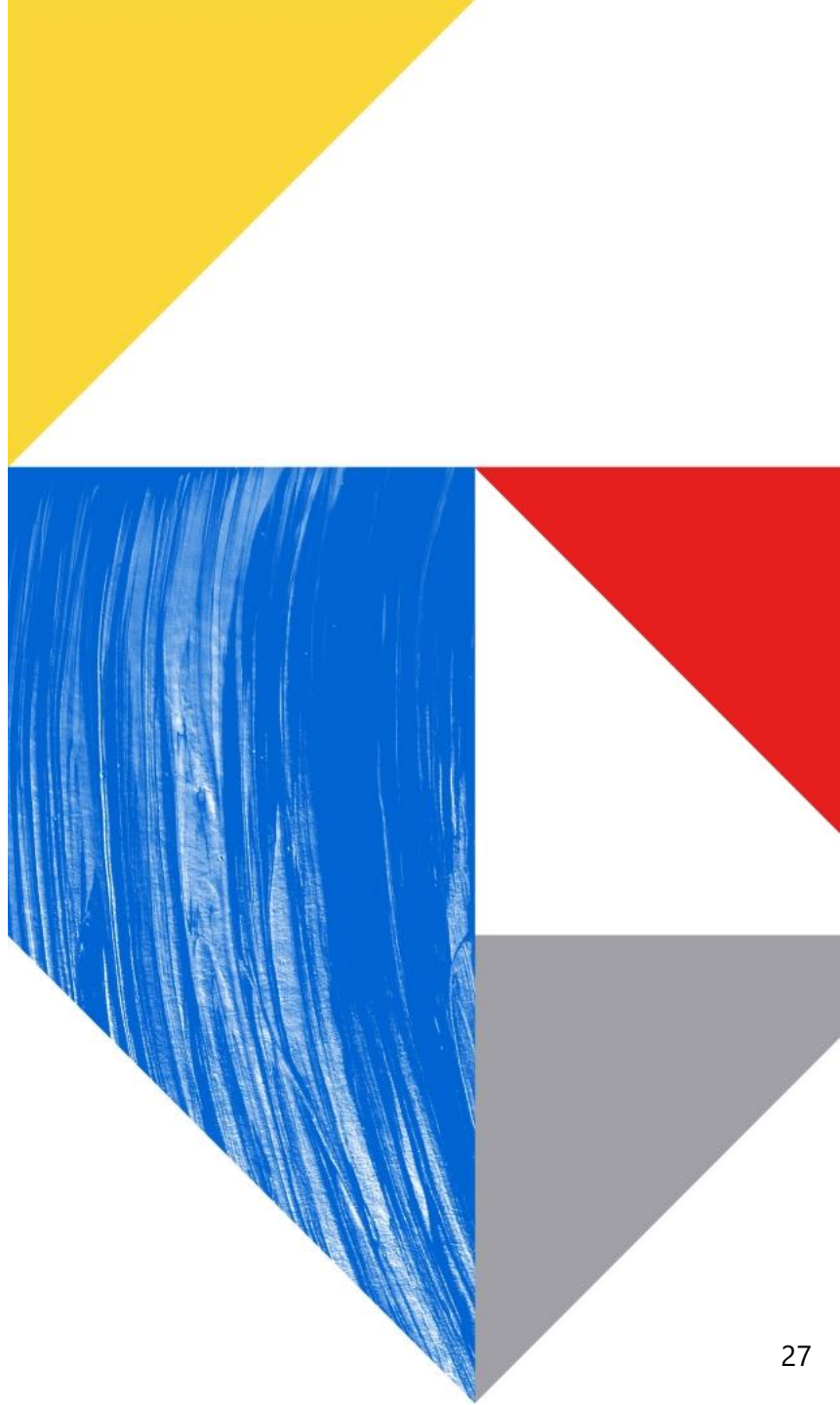
Loading the weight data of DNN from DRAM and storing intermediate data at each layer of DNN computation was two major power/performance bottleneck of other AI chips.

Our DNN accelerator (1) Adds SRAM to store weight data,
(2) Create 256 ALUs to be able to load weight data for constructing DNN
(3) Use pipeline to execute DNN computation sequentially without accessing load/store unit

Deep Neural Network demo video

05

示範平臺



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