FOR ENERGY EFFICIENT INNOVATIONS

THINK ON.

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Robotics and the Emerging 48V Ecosystem

Ali Husain, Corporate Marketing & Strategy

Public Information

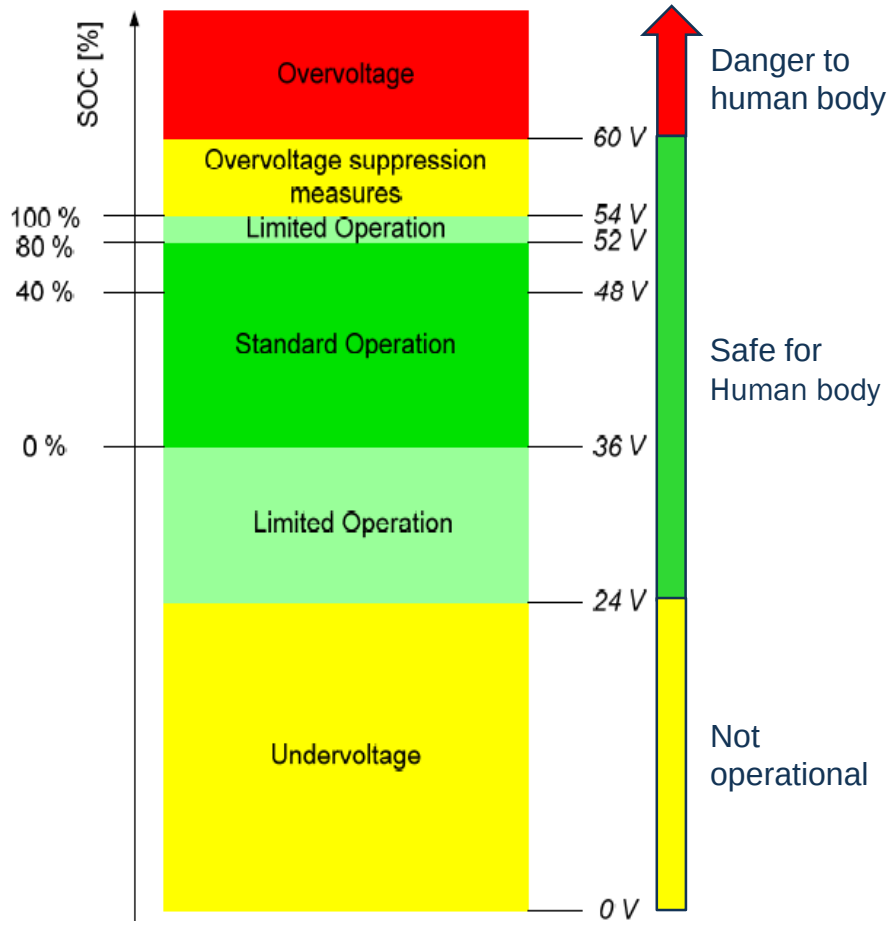
History of 48V

Highest “Safe Voltage”

- Minimize protections
- Minimize conductors or losses
- Often a “nominal” voltage

-48V Power

- Legacy of telephony system
- Minimizes corrosion of conductors and connections when exposed to moisture



48V System Safety Thresholds

New Applications for 48V Power Architecture

- BSG/ISG
- DC-DC Conversion
- Auxiliary Motors
- Sensing & Computing Loads

Automotive

- Server Backplane
- Cooling Fans
- Telecom Base Station

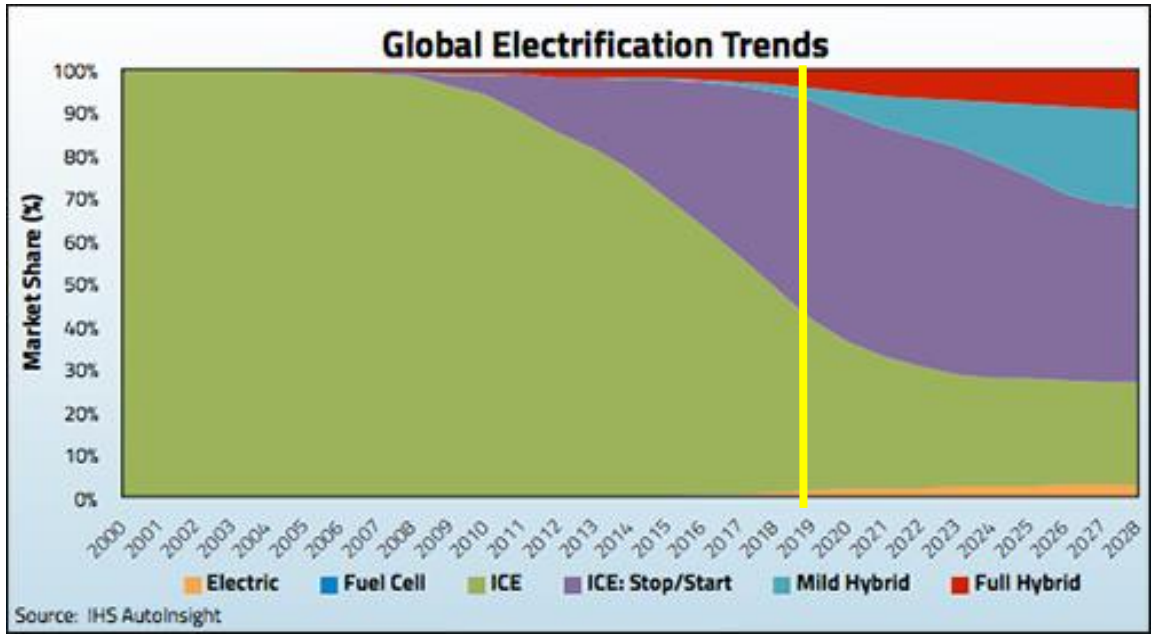
Cloud

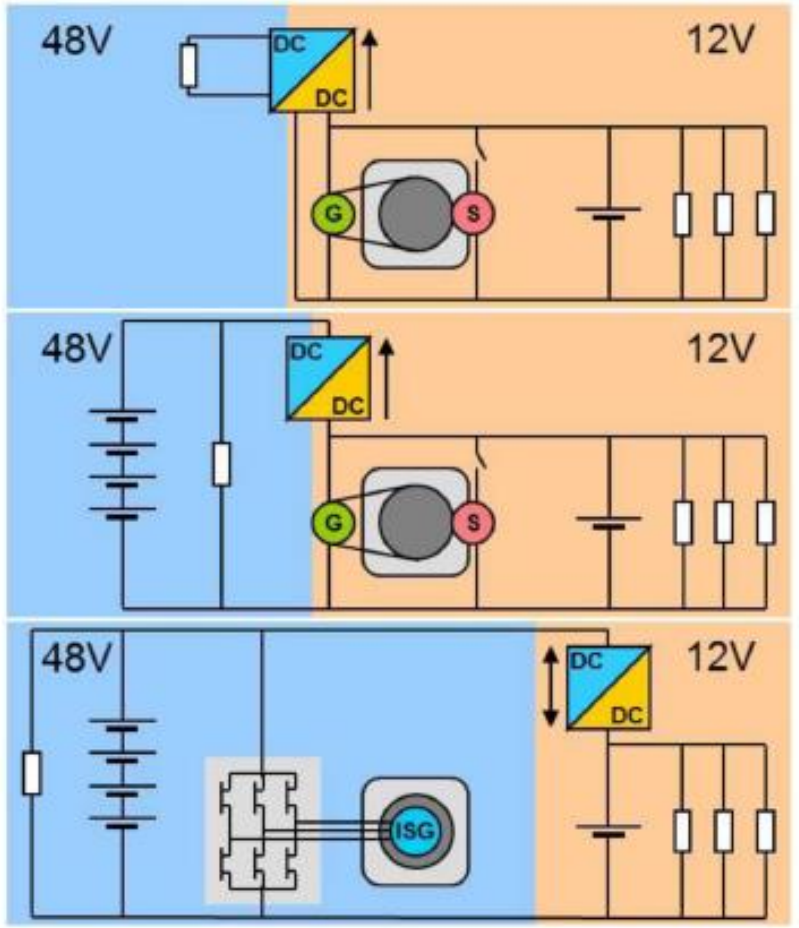
- Factory Automation
- Collaborative Robots
- Home Robots & Automation

Robotics

Public Information

Electrification of Automobiles





Electrified vehicles already dominate

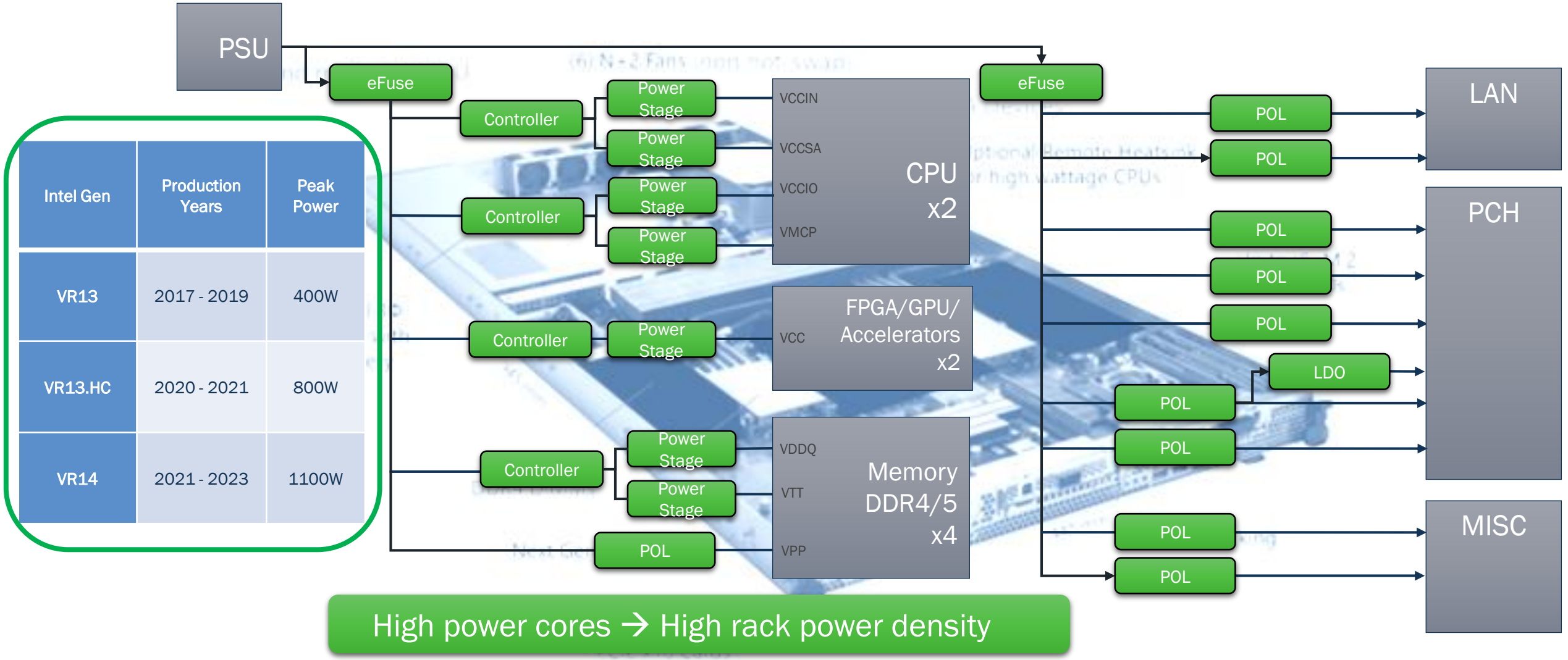
48V bus has a function in all electrified autos

Autonomy & Infotainment will bring additional loads

Public Information

Server Blade Block Diagram

Intel Gen	Production Years	Peak Power
VR13	2017 - 2019	400W
VR13.HC	2020 - 2021	800W
VR14	2021 - 2023	1100W



High power cores → High rack power density

Shifting Cloud Power Architecture

Traditional w/ 2 stage 48V to Load

Utility → Primary Transformer → UPS → Secondary Transformer → In Rack → AC to 48V → 48V to 12V → 12V to PoL

48V to PoL

Possible Optimized Power Path

Utility → Primary Transformer → AC to 400V → In Rack → 400V to 48V → 48V to xxV → xxV to PoL

UPS (48V)

Power supply moves from blade to rack

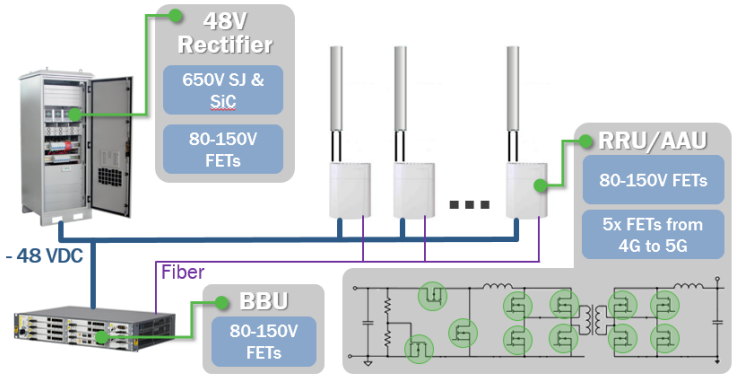
48V gives 16x lower transmission losses

Public Information

Other Applications

5G Networking Power

- Large infrastructure rollout just ramping
- 3-5x more units than 4G
- Massive MIMO has large number of radios
- Server content for software defined radio and edge computing



Power Tools:

- Battery powered devices
- Moving to 48 and 60V batteries
- Especially larger, high power machines like chainsaws and mowers.

LED Panels:

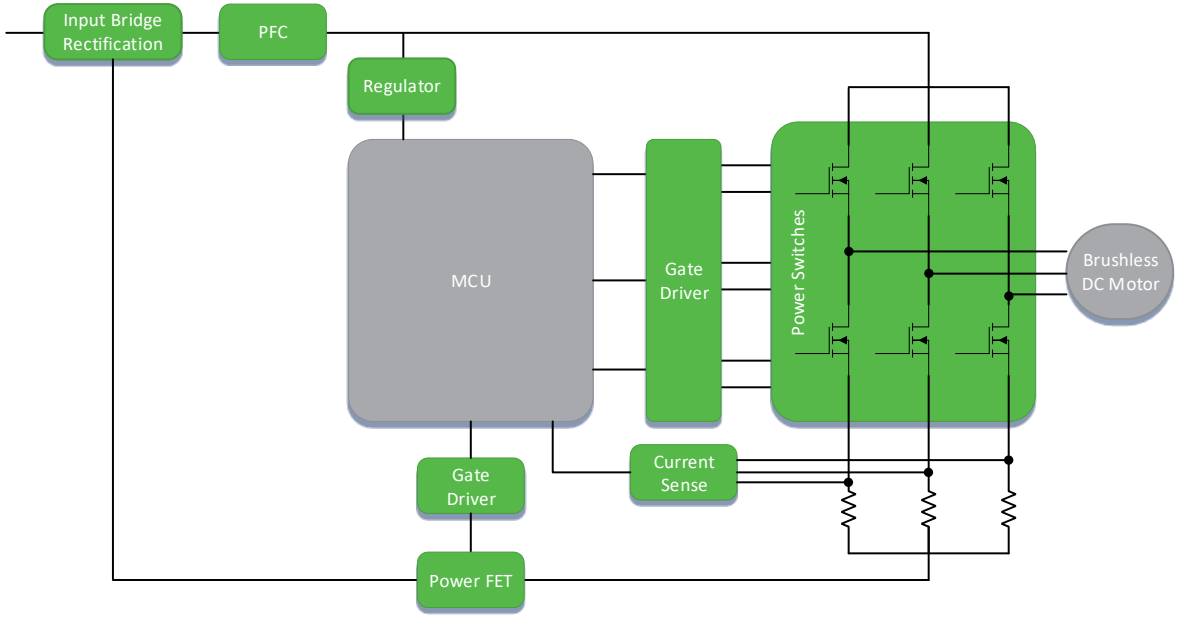
Especially for massive, outdoor displays.

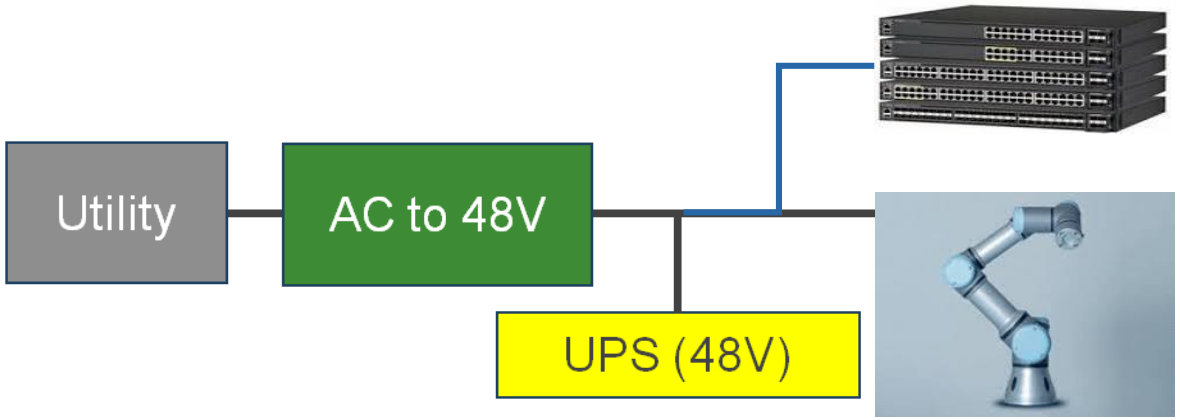
- Lower Power Losses
- Thinner Panels
- Lower Weight
- Lower Thermal Stress
- Higher Reliability

Public Information

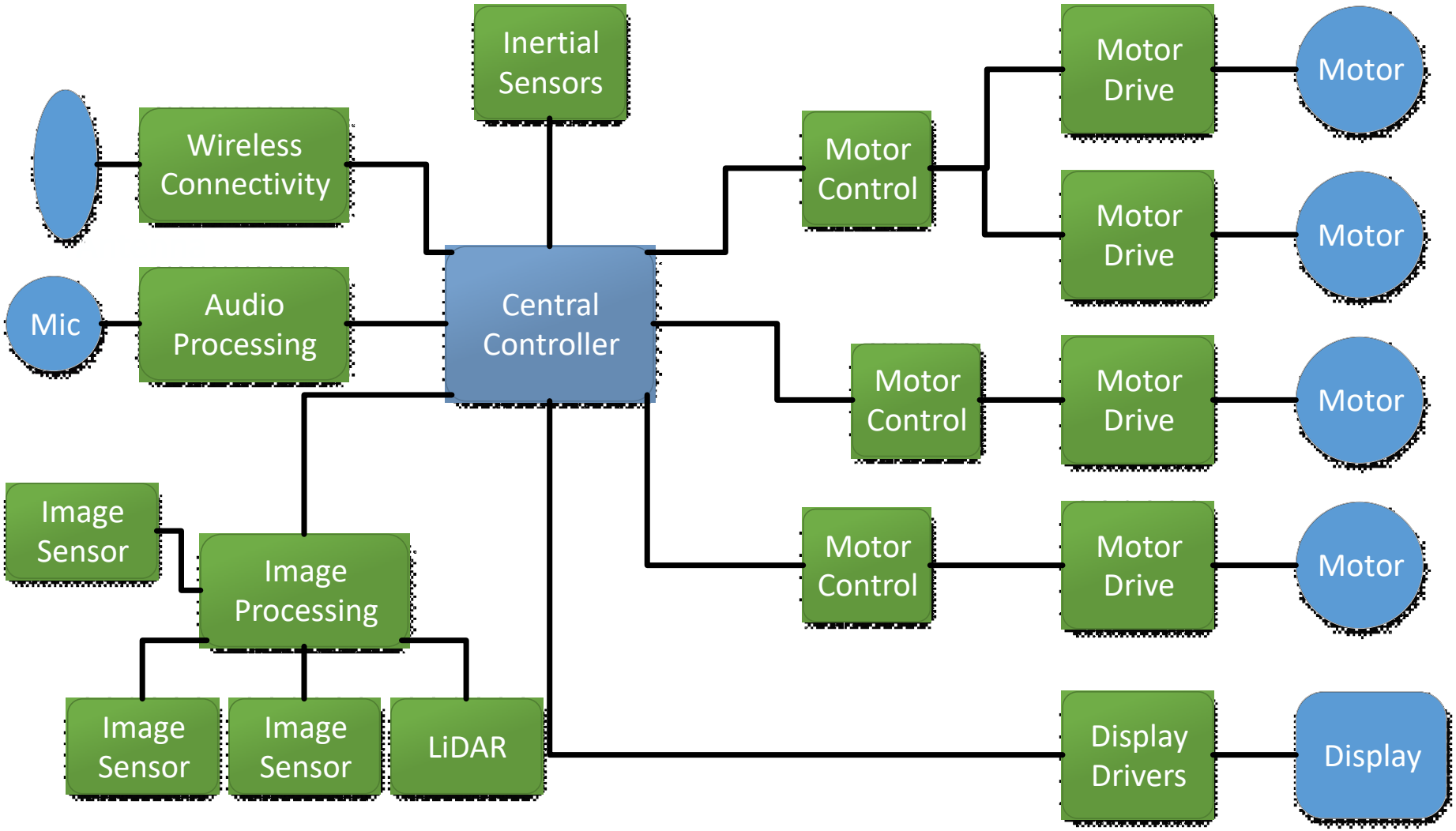
Industrial Automation

- Collaborative Robots
- Delivery
- Drones
- Care Assistants
- Toys & Companions



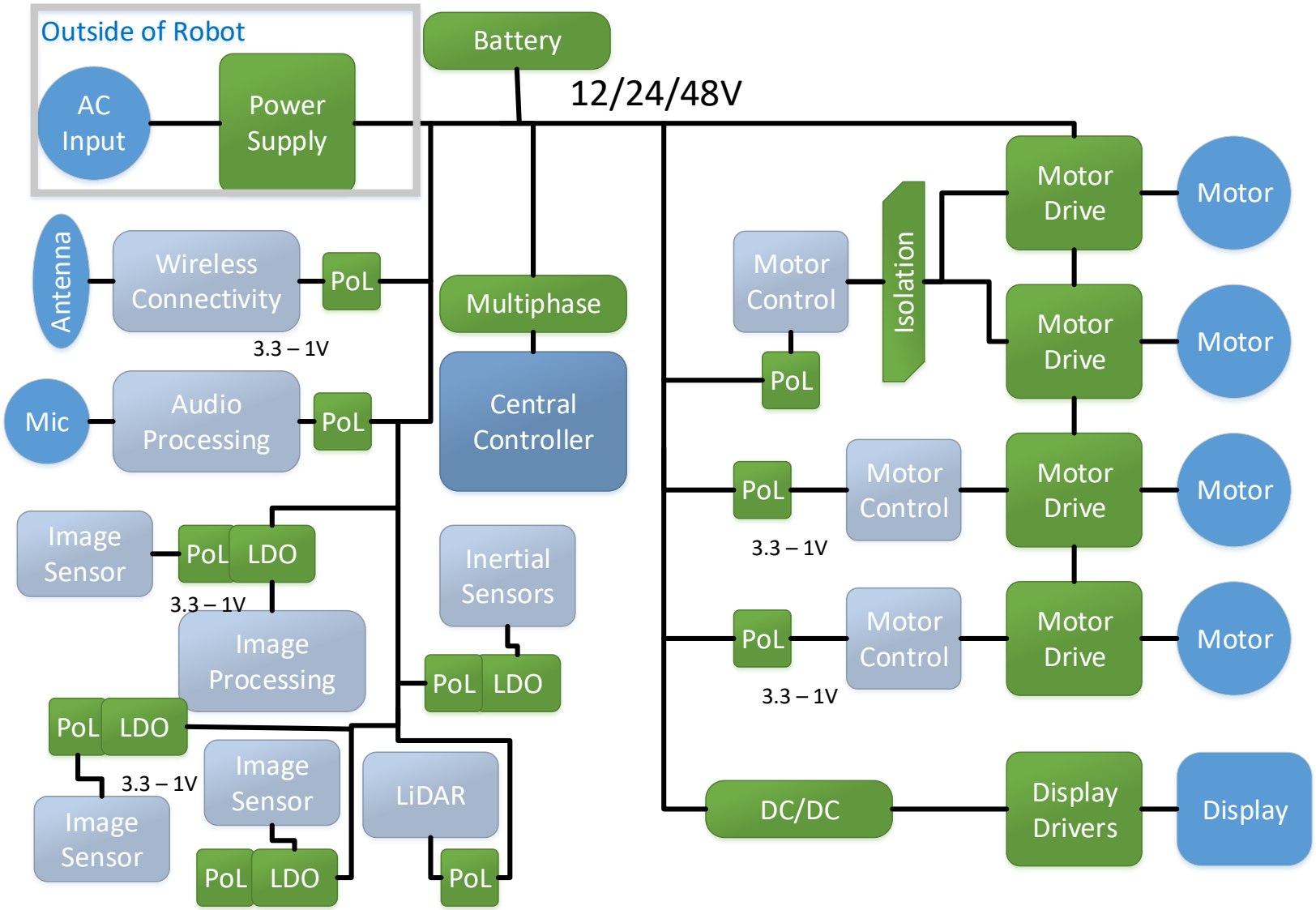


Robot Block Diagram



Public Information

Robot **Power** Block Diagram



- AC/DC Conversion
- Battery Management
- DC/DC Conversion
- Multiphase Converters
- Point-of-Load (PoL)
- Linear Regulators
- Motor Drive

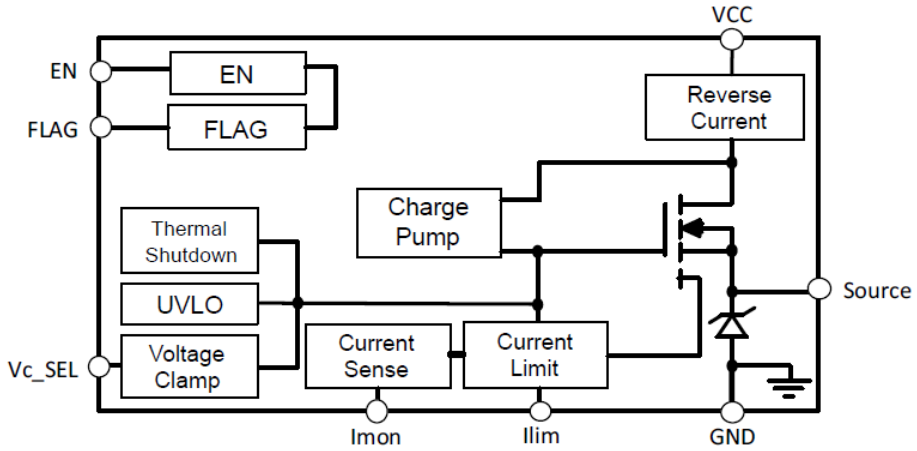
Public Information

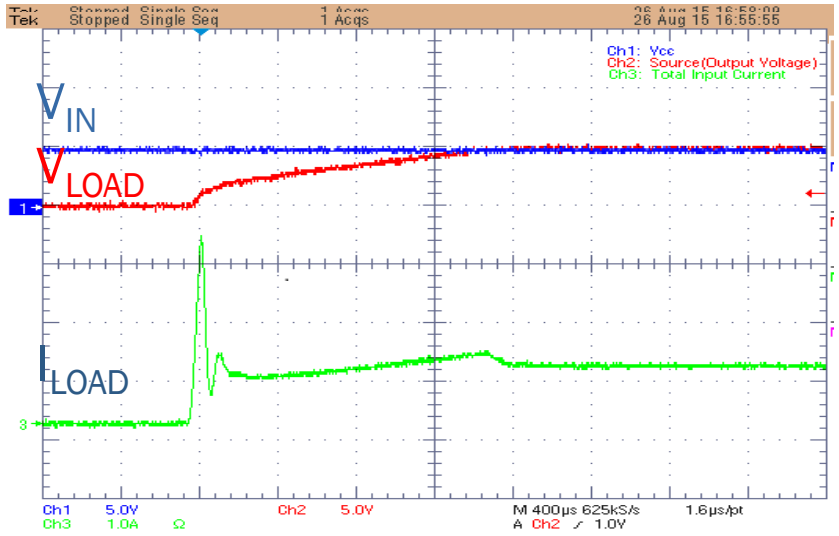
Applications and Solutions

	AC/DC	HV DC/DC	MV DC/DC	Multiphase Buck	Point-of-Load	Motor Drive	eFuse	Battery Management
Automotive	N/A	EV Battery to 48V Bus	48V to 12V	For autonomy, infotainment	Sensors, peripherals computing	BSG/ISG Turbochargers Air Conditioning	Reduce wiring, fusing	48V Battery
Cloud	Server Rack Power	DC Power Distribution?	48V to 12V	48V to core	48V to PoL	Cooling Fans	Hot Swap	In-Rack UPS
Industrial Automation	Mains to Equipment, Battery Charging	N/A	For legacy actuators at 24V, 12V	Computing	Sensors, peripherals, communications	Gripping, lifting, traction, actuation, etc	Modular Robots?	Drones, Non-stationary Robots

eFuse: Features and Functionality

- *Integrated* Power Bus and System *Protection*
- Overvoltage
- Overcurrent protection → Level settable through external resistor
- Reverse current protection → isolation FET (isoFET)
- Adjustable output slew rate → Inrush Current Control
- Output Control (On/Off)
- Fault Report
- Resettable
- Thermal Shutdown

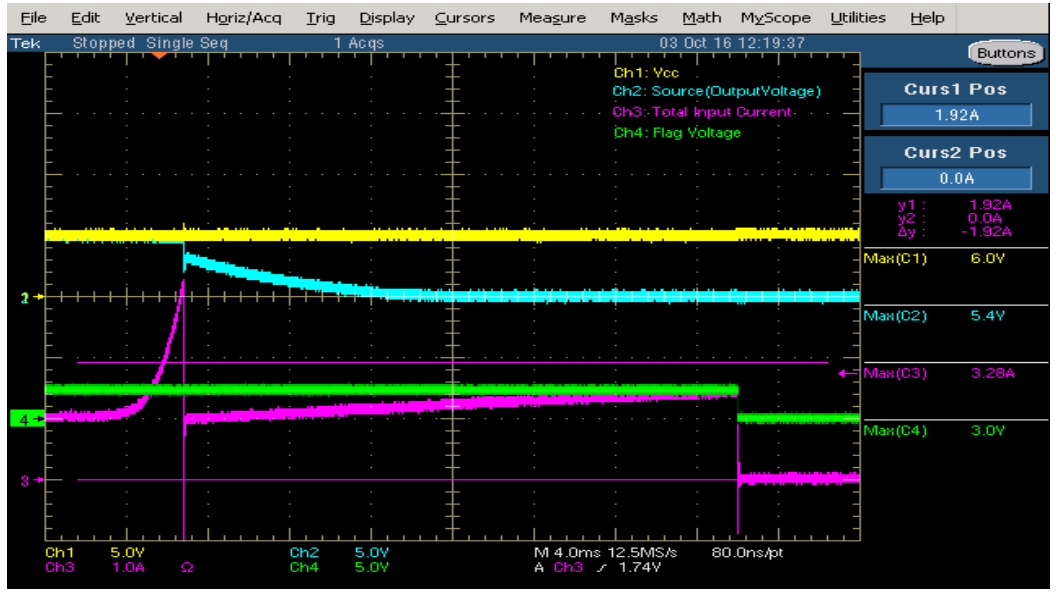




Inrush w/o eFuse

We place the FET in the saturation regime to prevent the load from being starved. Temperature sensing protects the eFuse.

Current Limit Example



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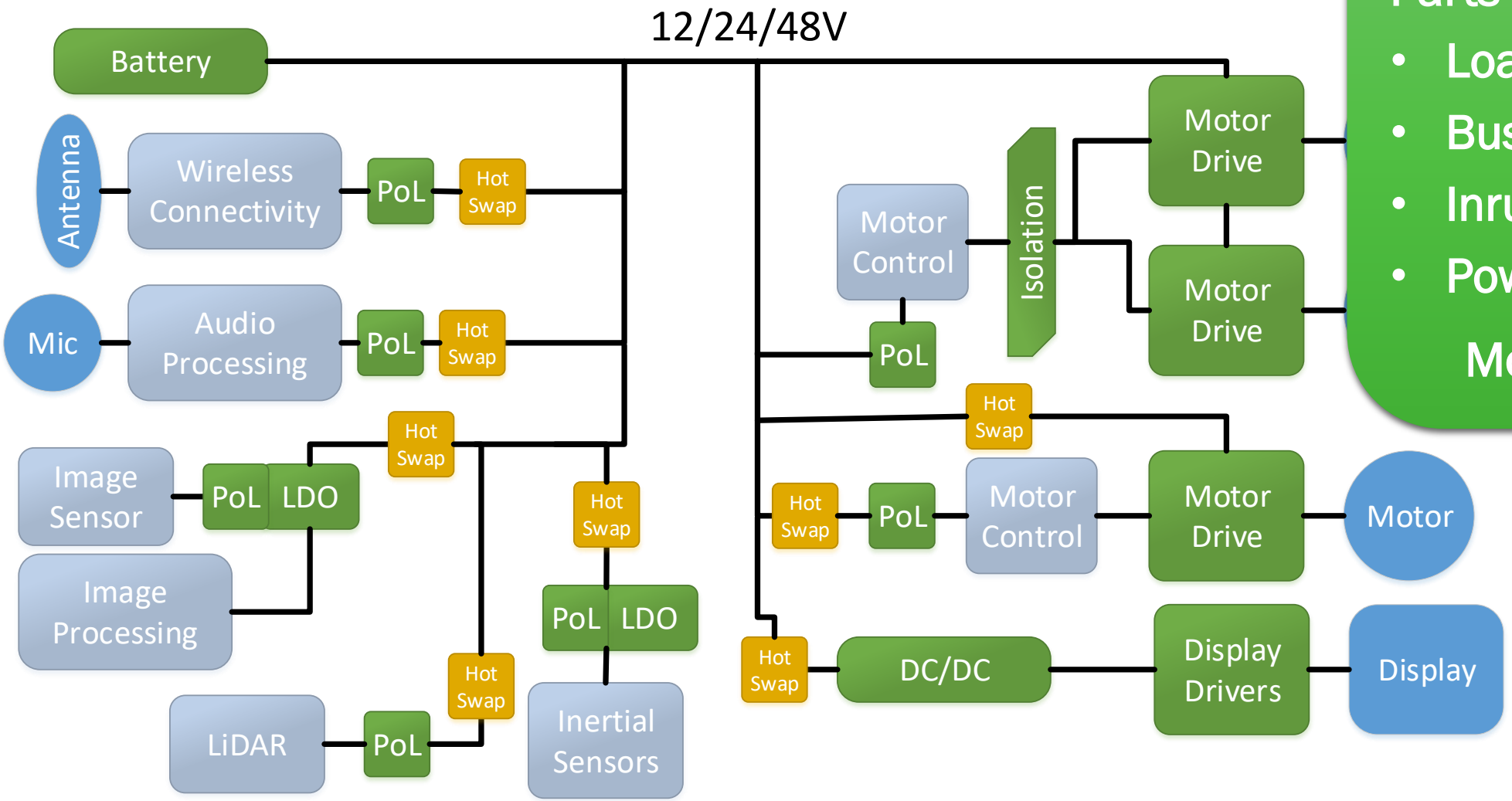
Robot Power Block Diagram w/ Hotswap



Hot Swap-able Robot Parts

- Load Switch
- Bus Protection
- Inrush control
- Power Sequencing

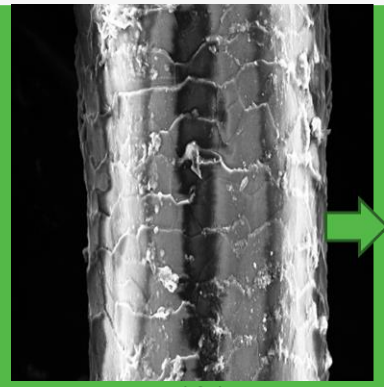
Modular Robots!

Public Information

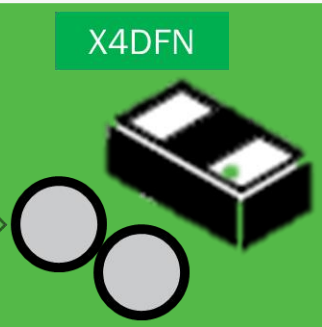
ON Semiconductor Today

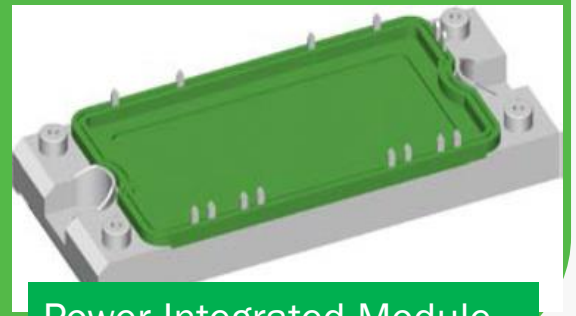
Headquarters: Phoenix, AZ
Employees: 32,000 globally
Revenue: ~$5.9Bn(1)
Market Capitalization: ~$9.1Bn(2)
Ticker: ON
Founded: Spun-off from Motorola 1999, IPO 2000

- 23 Owned Manufacturing Sites
- 130+ Contract Manufacturing Sites
- Ship Nearly 80B units/yr!
- 70% Produced Internally
- Very Wide Range of Products, Processes, Packages



Human Hair 181 microns





Power Integrated Module

(1) Based upon 2018 results; (2) as of 4/29/19; Sector % based on 1Q19

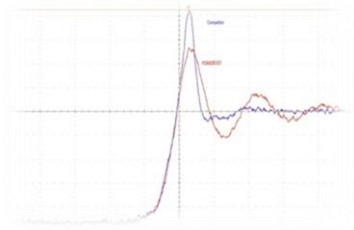
ON Semiconductor®

ON Semiconductor Solutions

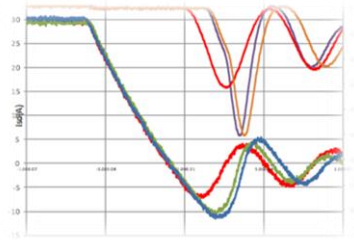
For 48V Applications

Public Information

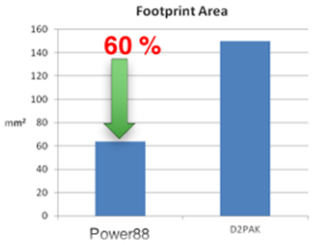
MV MOSFETs for all Systems



Reduced EMI



Low Qrr/trr



Reduced Board space

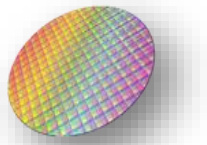
Value Proposition

Power Density

Reduced System Cost

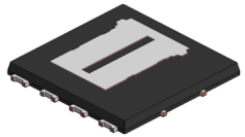
- Lower conduction loss
- Lower switching loss
- Simpler gate drive
- Reduced EMI
- Reduced voltage spike
- No gate bounce
- Power Density
- Reduced Cost

Technology Developement



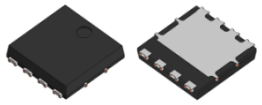
Silicon

- ✓ Lower Rds(on) T6, T8, PTNG
- ✓ Reduce Qrr/trr T8, PTNG
- ✓ Lower Ciss T8, PTNG
- ✓ Improved Qgd/Qgs T8, PTNG
- ✓ Lower Rg T6, T8, PTNG

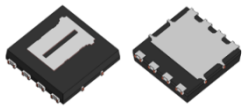


Packaging

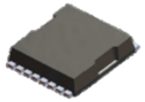
- ✓ Improve die to package ratio PQFN: 8x8, 5x6, 3x3
- ✓ Reduce parasitic inductance Power Clips: 8x8, 5x6 3x3
- ✓ Improve thermal performance Dual Cool Packaging
- ✓ Increase current capability 8x8, D2Pak7L, TOLL



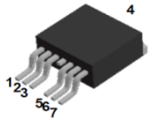
PQFN8x8



Dual Cool

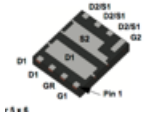


TOLL



D2Pak-7L

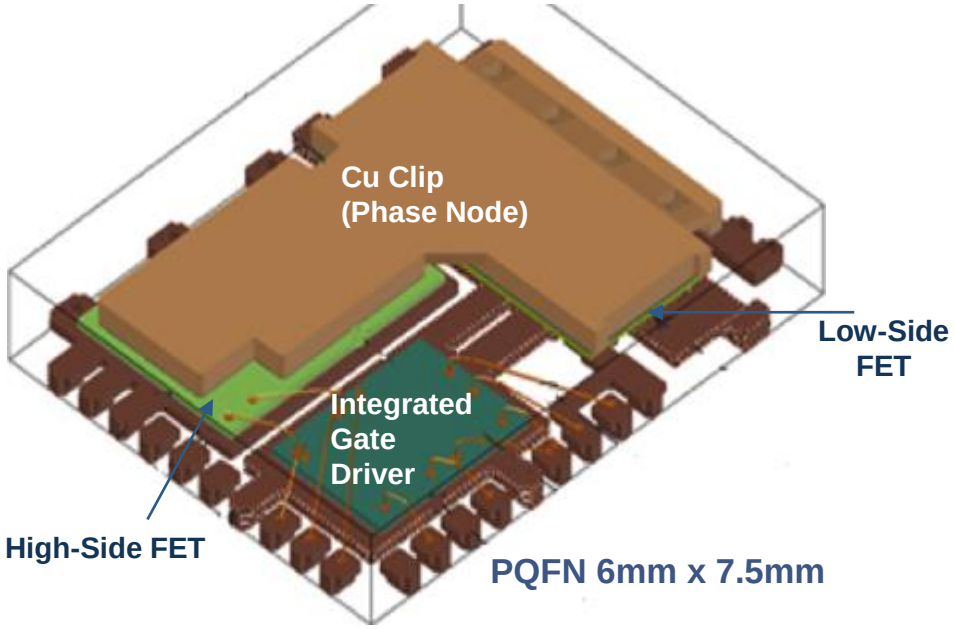
LFPAK

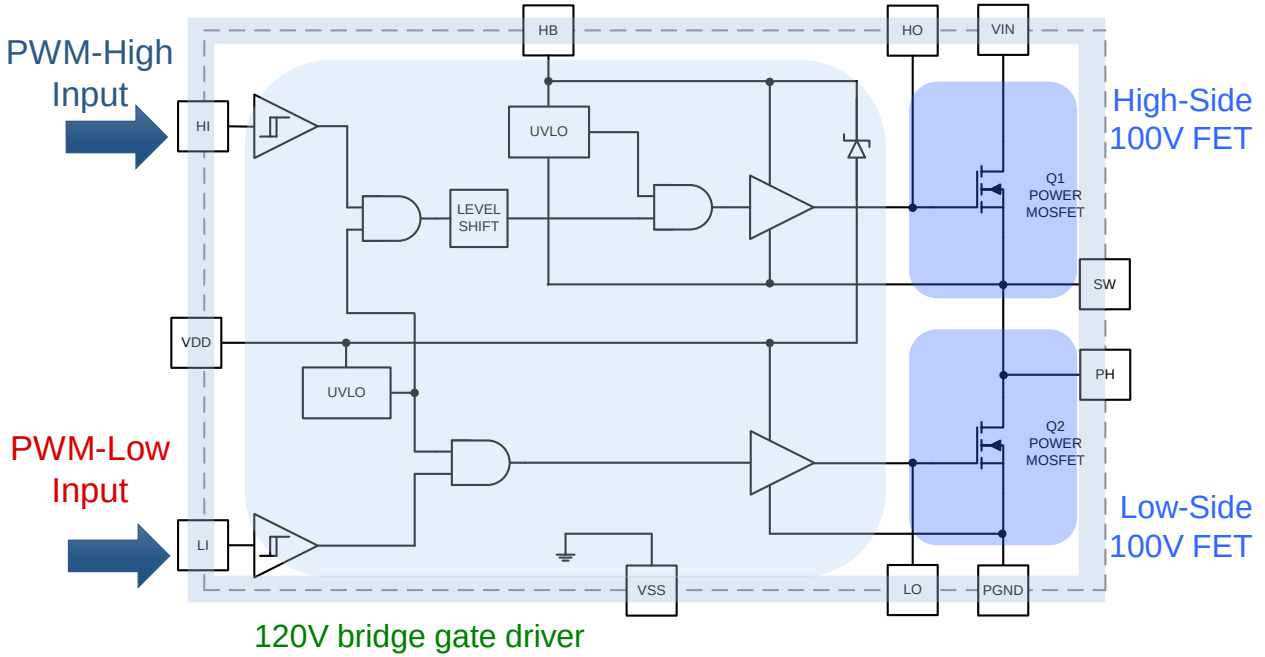


HB Duals

Public Information

FDMF8811: 100V Power Stage





Higher Density

- 6.0 mm x 7.5 mm PQFN Package
- Integrated 120V Gate Driver
- Integrated Bootstrap Diode

High Efficiency

- Ultra-Low On-Resistance 100V Power MOSFETs

High Reliability

- Low Voltage stress

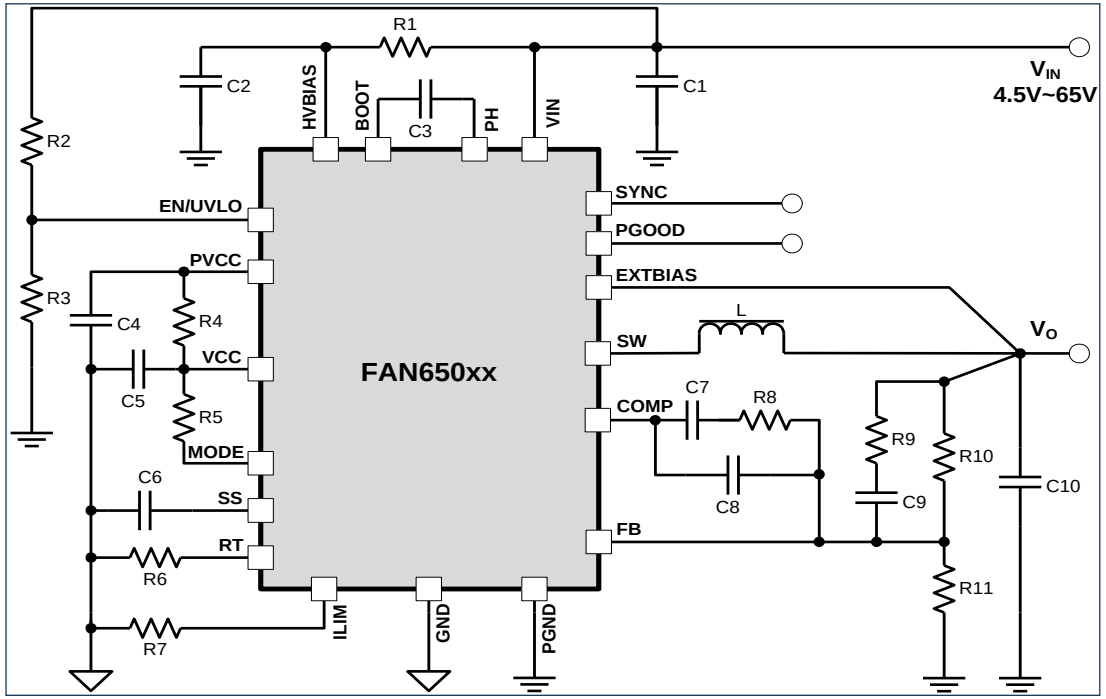
Public Information

FAN65xxx Overview

Features

- VIN Voltage Range
  - Wide range: 4.5V to 65V
- VOUT Continuous output current
  - 6A (FAN65004B)
  - 8A (FAN65005A)
  - 10A (FAN65008B)
- Buck Regulator
  - Constant frequency voltage mode PWM control
  - Programmable frequency 100kHz – 1MHz
  - Frequency Synchronization with external clock
  - High Performance Error Amp for tight output regulation
  - 0.6V reference, ±1.0% over temp
  - DCM or PWM mode at light load condition
- Additional Features
  - High voltage LDO for single supply operation
  - VOUT LDO to reduce power losses
  - Adjustable Soft-start
  - Bootstrap MOSFET for low VIN
- Protection
  - VIN Adj. UVLO & VOUT UV & OV
  - Adjustable output current limit
  - Thermal shutdown
- Package
  - PQFN 6x6mm

Application Diagram

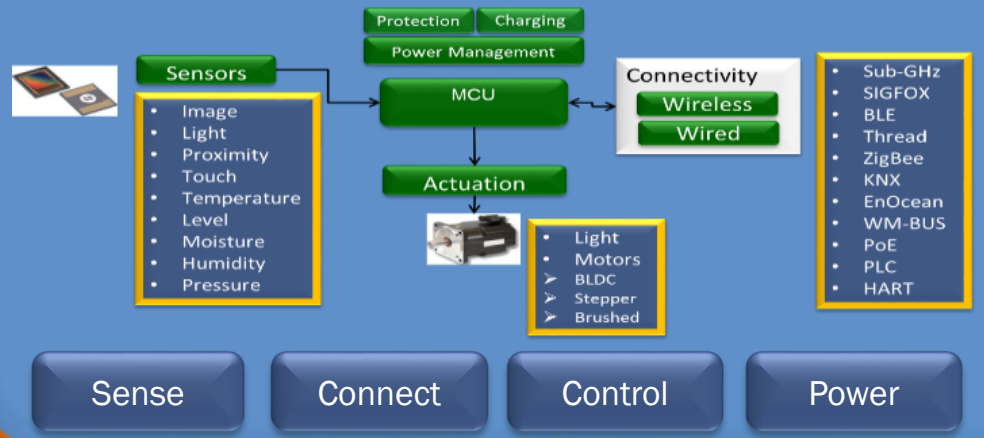


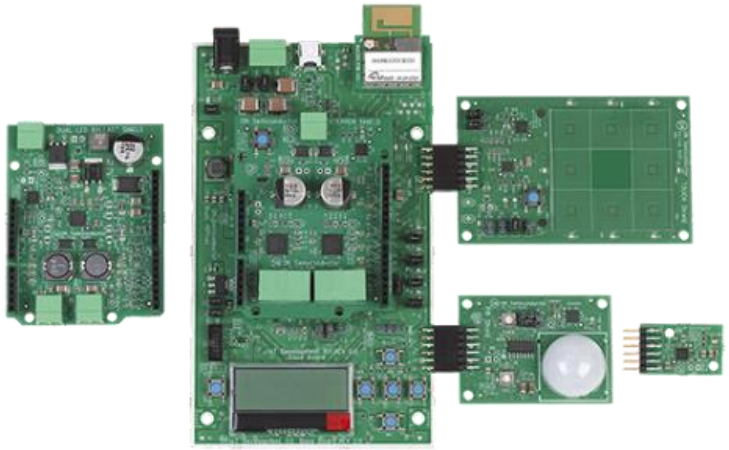
Applications

- Telecom infrastructure & Baseband Boards
- Industrial automation
- DC/DC Modules
- General Purpose PoL

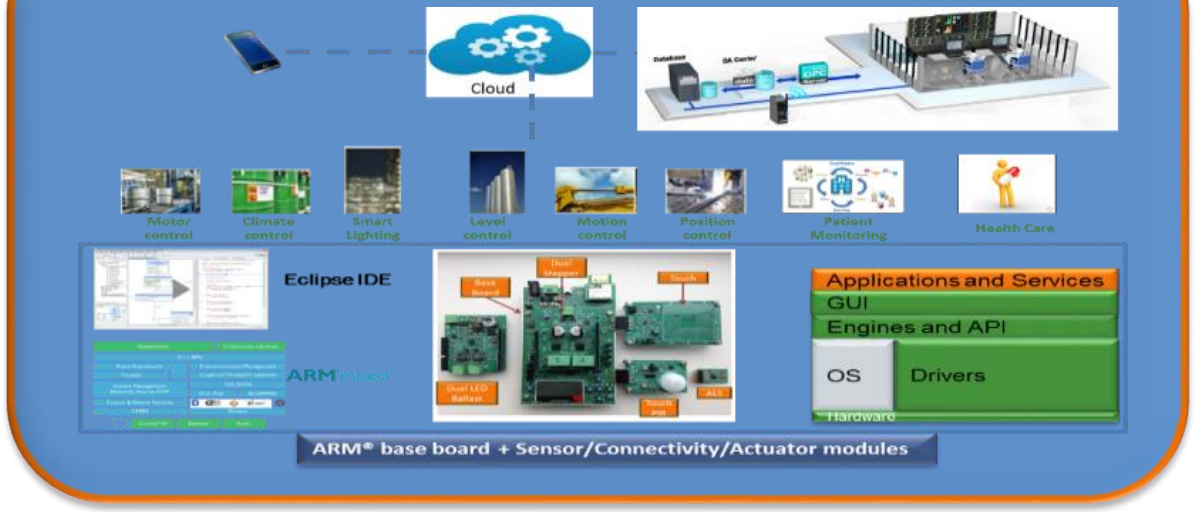
Enabling Connected Devices

Key Building Blocks





Node to Cloud Development Kits



RSL10

Industry's lowest power Bluetooth® Low Energy technology

Widest Portfolio for Machine Vision

Industrial

- High Speed, Scalable Portfolio
- CCD for Demanding Performance

PYTHON 25K
25MP 4.5um

PYTHON 5000
5MP 4.8um

PYTHON 1300
1.3MP 4.8um

PYTHON 480
VGA 4.8um

KAI-47
KAI-43
KAI-29 CCD
29MP 5.5um

MV & ITS

- Performance, Price, Speed
- 20mm Cameras, System Solutions

XGS 45000
45MP 3.2um

XGS 12000
12MP 3.2um

XGS 5000
5MP 3.2um

Edge AI

- Small Sensors, Low Power
- NIR optimized

AR0234
(1920 x 1200)
2.3MP 3.0m

AR0135
(1280 x 960)
1.2MP 3.75um GS

AR0144
(1280 x 800)
1.0MP 3.0um GS

AR0521
(2592 x 1944)
5.0MP 2.2um

AR0430
(2317 x 1746)
4.0MP 2.0um

MV Everywhere

- Event Detection
- Very low power, Flexible states

ARX3A0
(560 x 560)
VGA 2.2um pGS

Public Information

Summary

The requirements of multiple markets will result in a diverse 48V ecosystem with improved performance and system costs.

- BSG/ISG
- DC-DC Conversion
- Auxiliary Motors
- Sensing & Computing Loads

Automotive

- Server Backplane
- Cooling Fans
- Telecom Base Station

Cloud

- Factory Automation
- Collaborative Robots
- Home Robots & Automation

Robotics

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Thank You

Public Information