**active-semi®**

Solutions for Sustainability

Leader in
Analog Power
&
Intelligent Motor Control

- ➢ Mixed signal semiconductor provider focusing on Power Management and Intelligent Motor Control

- ➢ Founded in 2004 in Silicon Valley, HQ in Dallas, and Shanghai (~130 employees)

- ➢ 157 Patents in analog power & motor drive

- ➢ Proven Products: **1.5 billion power IC's shipped.** 100% Growth in 2016. 100% expected in 2017

- ➢ Multi-foundry strategy, SMIC, TowerJazz, Dongbu…

- ➢ Multiple Assembly/Test: Unisem & JCET…

SSD Power

active-semi ®
Solutions for Sustainability
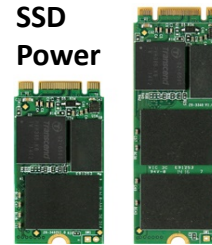
Product Line	Applications
Intelligent Motor Control • FOC & BEMF Capable • Up to 600V	
Modular Power • Battery Mgt • Processor Power • Networking & Storage	SSD

active-semi®
Solutions for Sustainability

- Founded in Silicon Valley in 2004
- Renowned team from TI and Maxim
- Global Organization, Dallas Texas HQ
- ~130 Employees, mainly Engineers

22 Years at TI

CEO
Larry Blackledge
Dallas

VP & GM
Product Lines
David Briggs
Dallas

20 Years at TI

Vice President
R&D & Operations
Wayne Chen
Dallas

17 Years at TI
TI Fellow
M.I.T. M.S.

Vice President
APAC Sales
Hemen Chang
Shenzhen

21 Years at Maxim

Vice President of
Human Resources
Dee Hunter
Dallas

33 Years at TI

CFO
Winston Fu
San Jose

16 Years at USVP

- **Intelligent Motor Control** – PAC52xx (Power Application Controller^{TM})
  - The first single-chip programmable solution for permanent magnet DC motor and variable frequency control. Up to 600 volts.
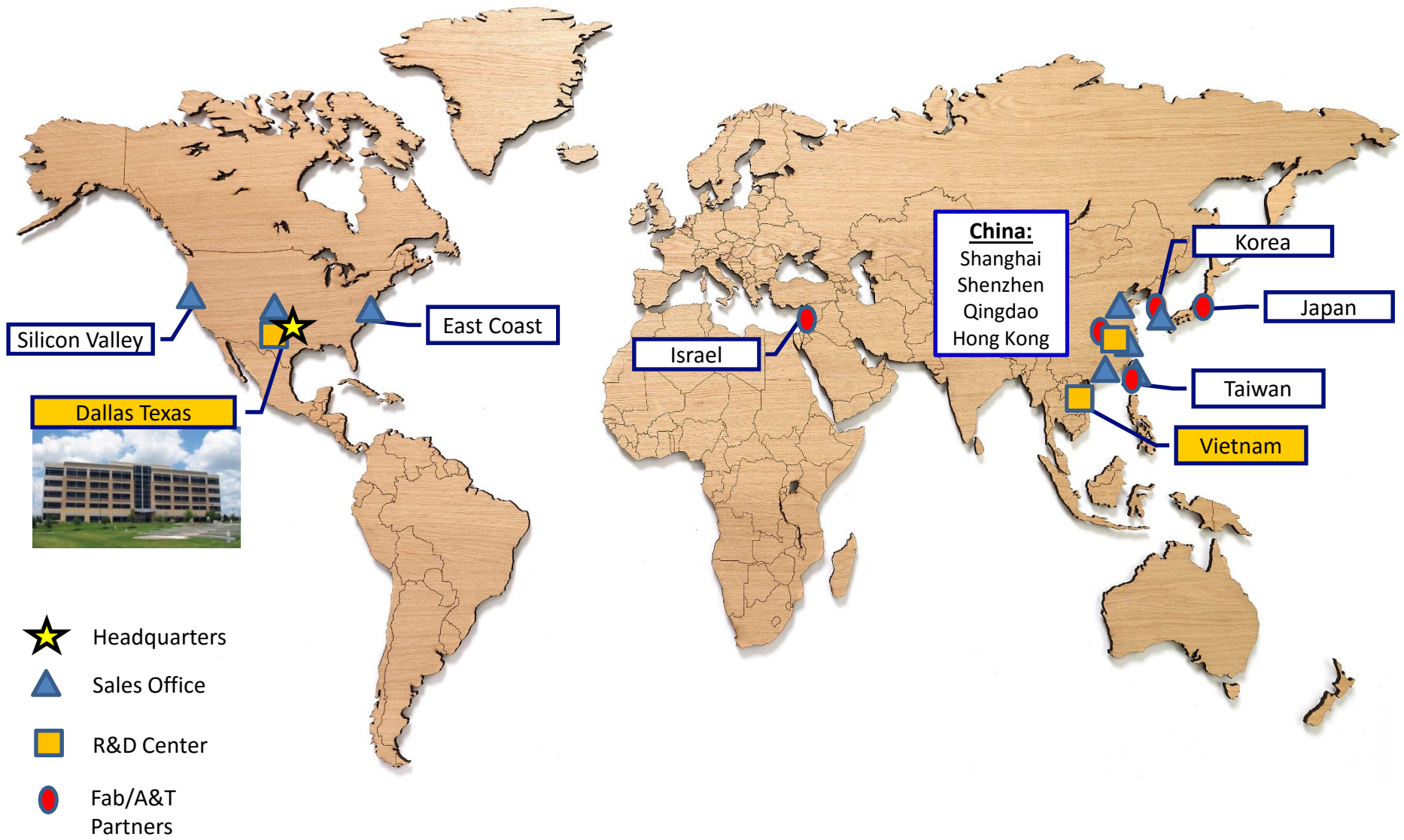 - Off-line power to DC or battery powered tools, drones, white goods, etc.

- **Modular Power** = PMICs powering ARM®, DSP, & Ambarella.   SSD Power
  - Strategically Partnered with ARM®, Atmel, Silicon Motion, and Rockchip (#1 player in Asia) as well as key SSD manufacturers.

- **Battery Management =** ACT280x, Highly-Integrated Battery Mgt,
  - Leader in Greater China; Engaged with leading OEM brands in US

- **Car Charging On-the-Go –** Active's High Power (i.e. DC/DC power & chargers) products enable single/dual port rapid charging up to 5 amps
  - iPad® & iPhone® & Android compatible automobile chargers
  - Quick Charge 2.0, USB-C, USB-PD, and BC 1.2 solutions

Global Organization

active-semi®
Solutions for Sustainability

Silicon Valley

East Coast

Dallas Texas

Israel

China:
Shanghai
Shenzhen
Qingdao
Hong Kong

Korea

Japan

Taiwan

Vietnam

★ Headquarters

▲ Sales Office

▢ R&D Center

⬮ Fab/A&T Partners

Power Application Controller (PAC)

Motor Control Solutions

Power Application Controller™
For Motor Control

- **Brushless DC (BLDC) Motor:** single chip, smallest BLDC and PMSM solution with highest precision, sensor-less BEMF or FOC control, 5V to 600V operation with integrated gate drivers and all-in-one switching power manager.

- **High Voltage Motor Applications:** *Appliances, Pumps, Compressors, Fans, Blowers, Air Cleaners, Ceiling Fan*

- **Low and Medium Voltage Motor Applications:** *Power Tools, Drones, RC, E-Bike*
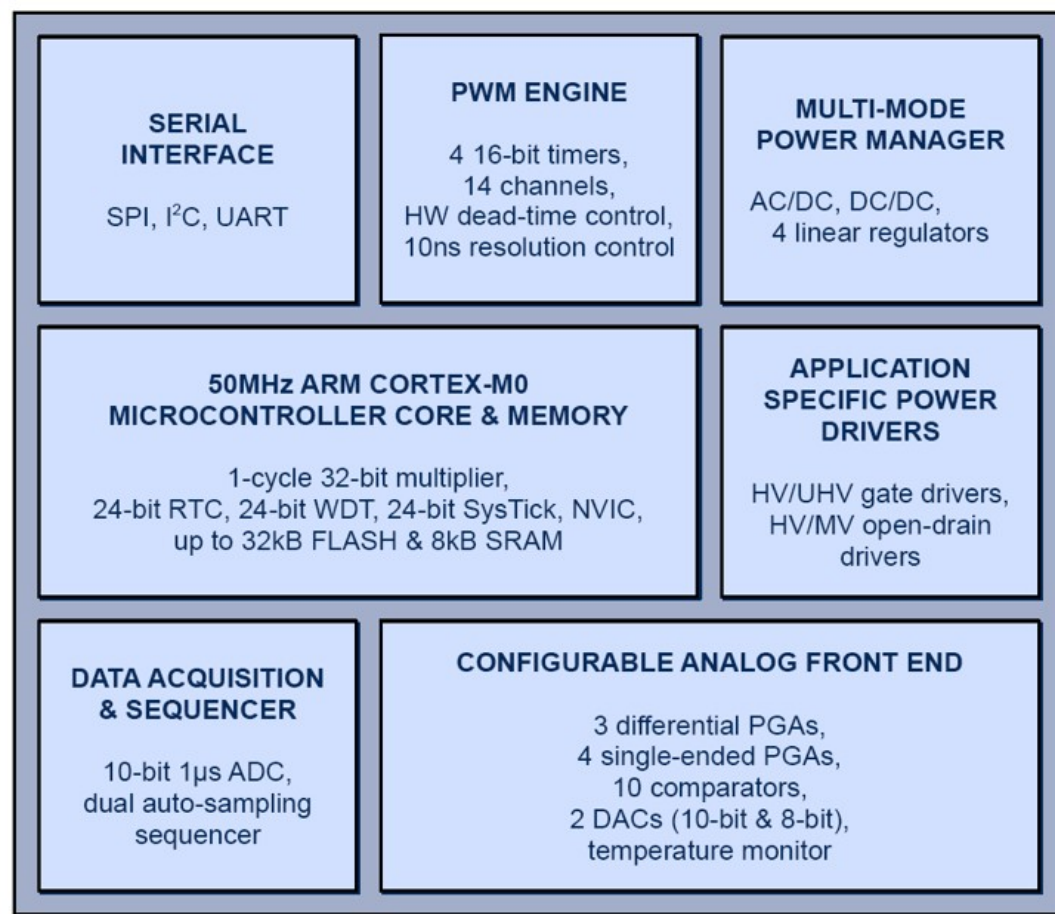
PAC Valued Features

- **Fully Programmable:** 32-bit MCU for complex functions/algorithms, & feature evolution

- **Lowest Standby/Sleep Mode Dissipation:** total system hibernate-mode permitted by complete system IC integration and associated power domain control.

- **Lower Cost Power Supply:** integrated power manager & higher voltage bus topology reduces cost/PCB size of external power supply circuitry

- **Highly Configurable & Integrated Analog-Front-End (AFE)-** reduces system footprint & cost.

Power Application Controller™ Unique Architecture

Scalable Platform with 32-Bit MCU and Sophisticated Power & Analog Peripherals

SERIAL INTERFACE

SPI, I²C, UART

PWM ENGINE

4 16-bit timers,
14 channels,
HW dead-time control,
10ns resolution control

MULTI-MODE POWER MANAGER

AC/DC, DC/DC,
4 linear regulators

50MHz ARM CORTEX-M0 MICROCONTROLLER CORE & MEMORY

1-cycle 32-bit multiplier,
24-bit RTC, 24-bit WDT, 24-bit SysTick, NVIC,
up to 32kB FLASH & 8kB SRAM

APPLICATION SPECIFIC POWER DRIVERS

HV/UHV gate drivers,
HV/MV open-drain drivers

DATA ACQUISITION & SEQUENCER

10-bit 1µs ADC,
dual auto-sampling sequencer

CONFIGURABLE ANALOG FRONT END

3 differential PGAs,
4 single-ended PGAs,
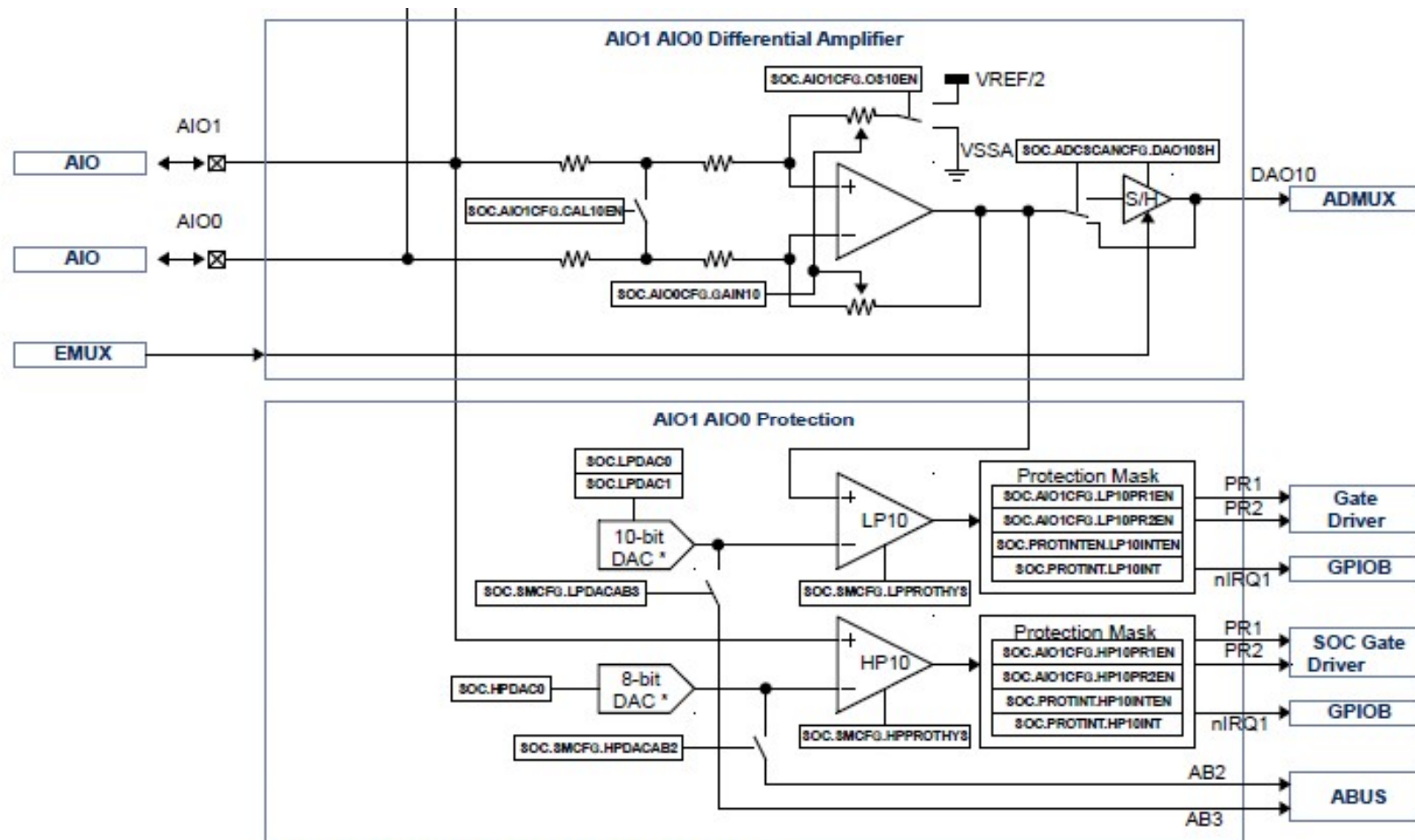10 comparators,
2 DACs (10-bit & 8-bit),
temperature monitor

- Industry-leading 32-bit ARM Cortex™ M0 processor with patented smart peripherals

- Patented all-in-one power conversion solution

- First-in-market integrated high voltage power drivers up to 600V operation (PAC525x)

- Other PAC ICs support medium voltages of 54V and 70V

- Sophisticated yet easily configurable analog frontend

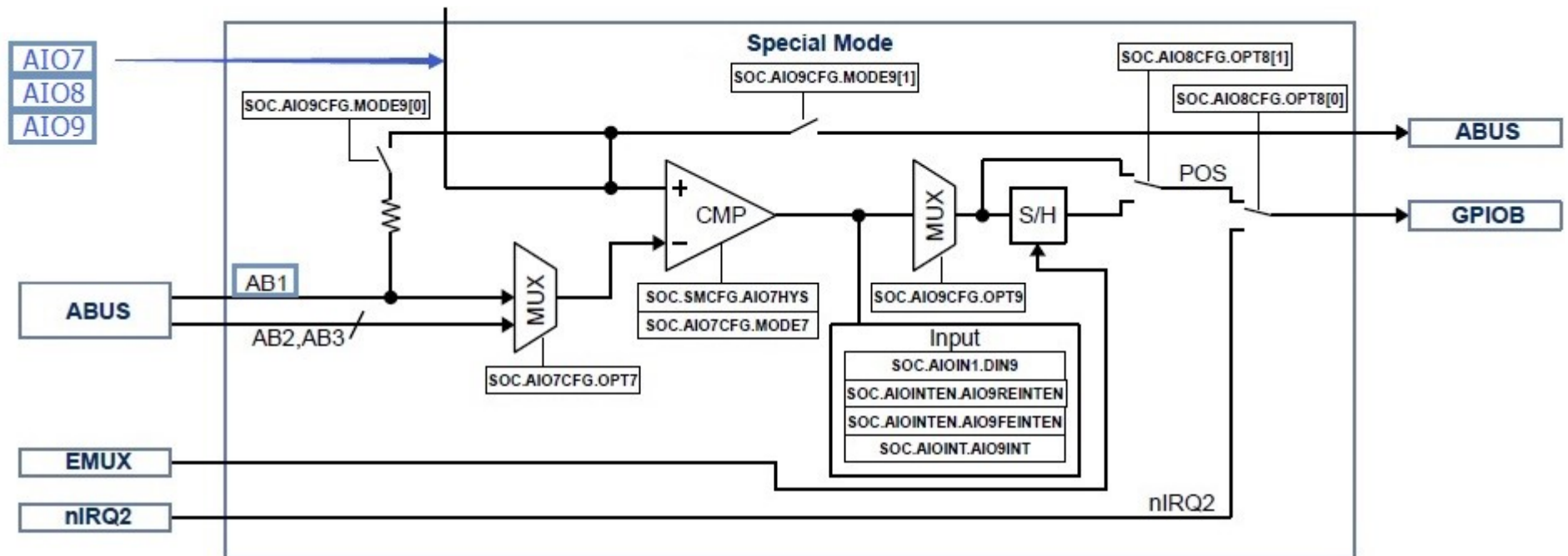- Proven analog array methodology allows quick silicon spins
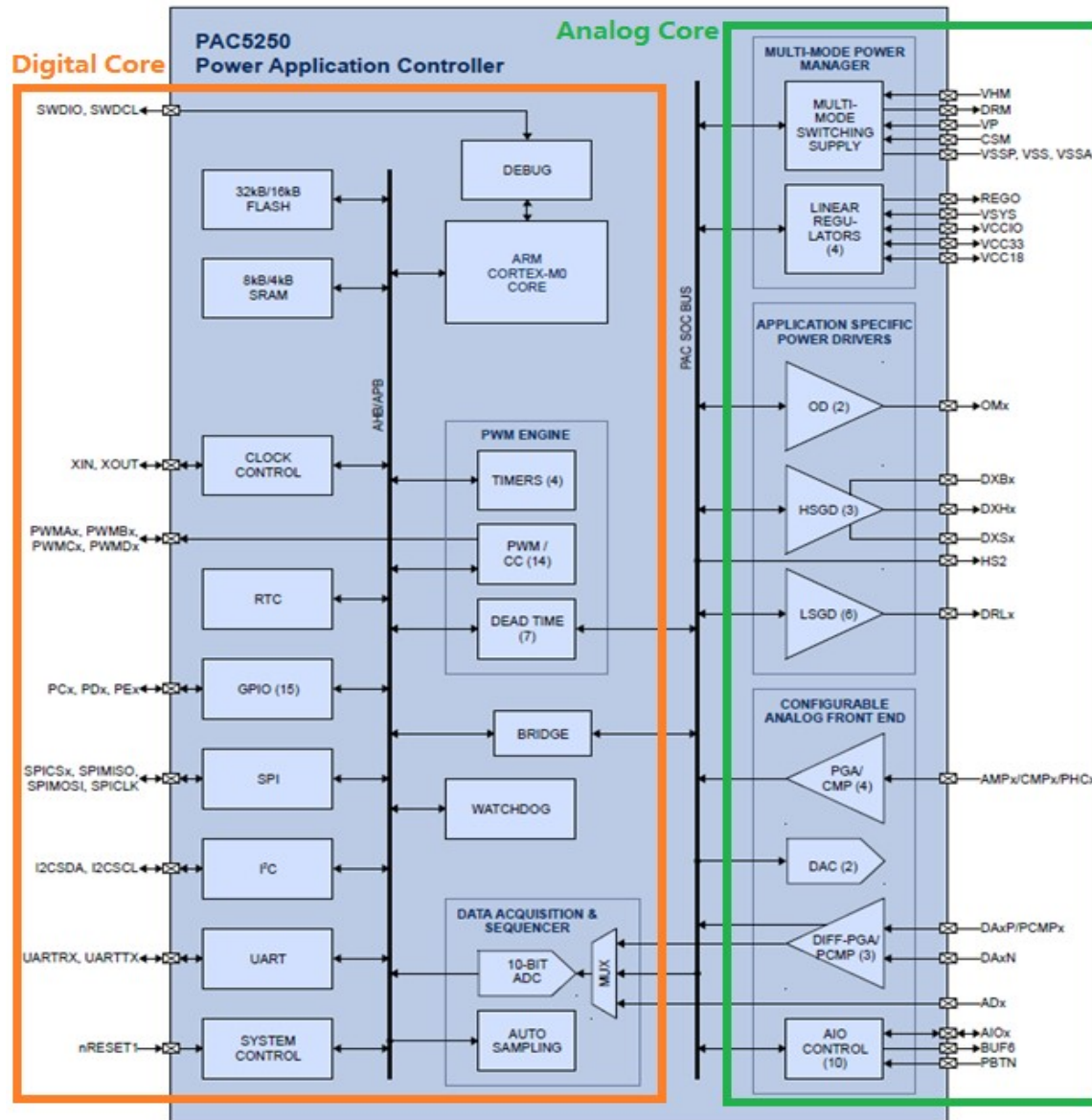
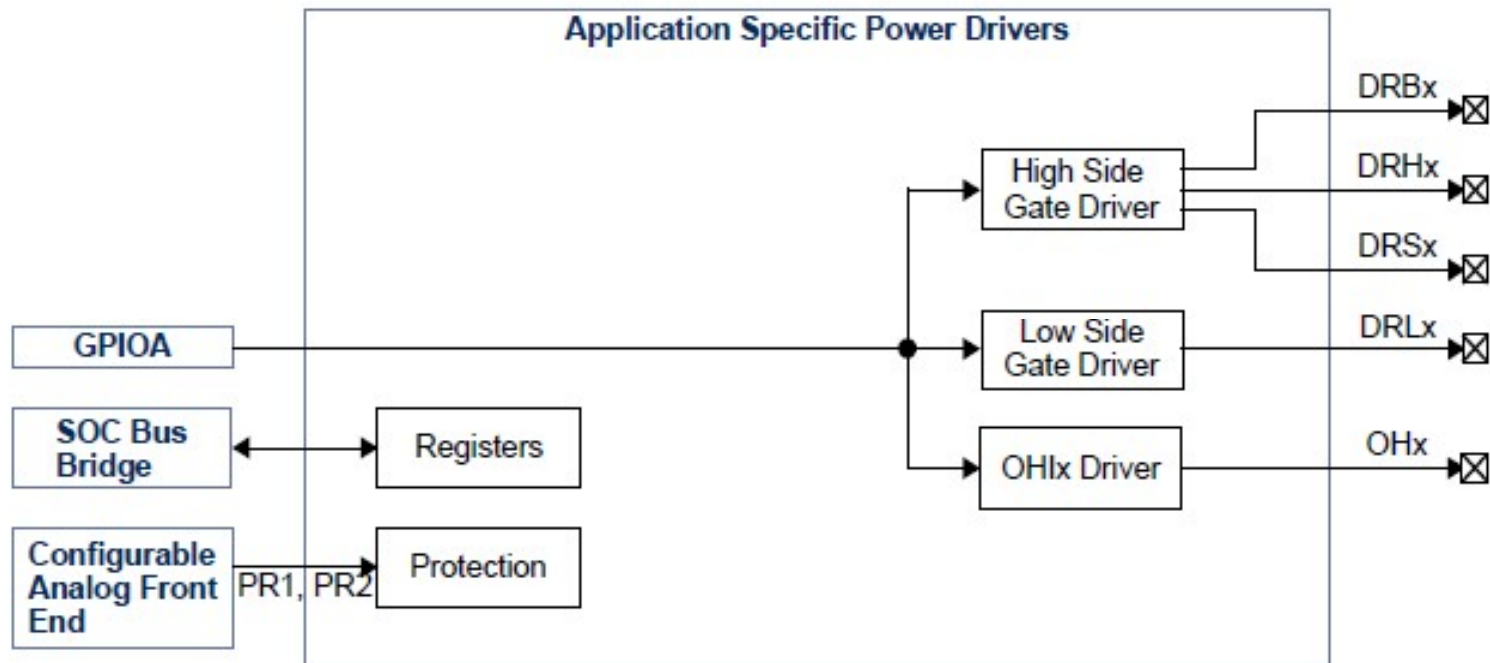**1 Switching Mode Power Controller & 4 Low Dropout Regulator**

Power Manager Output
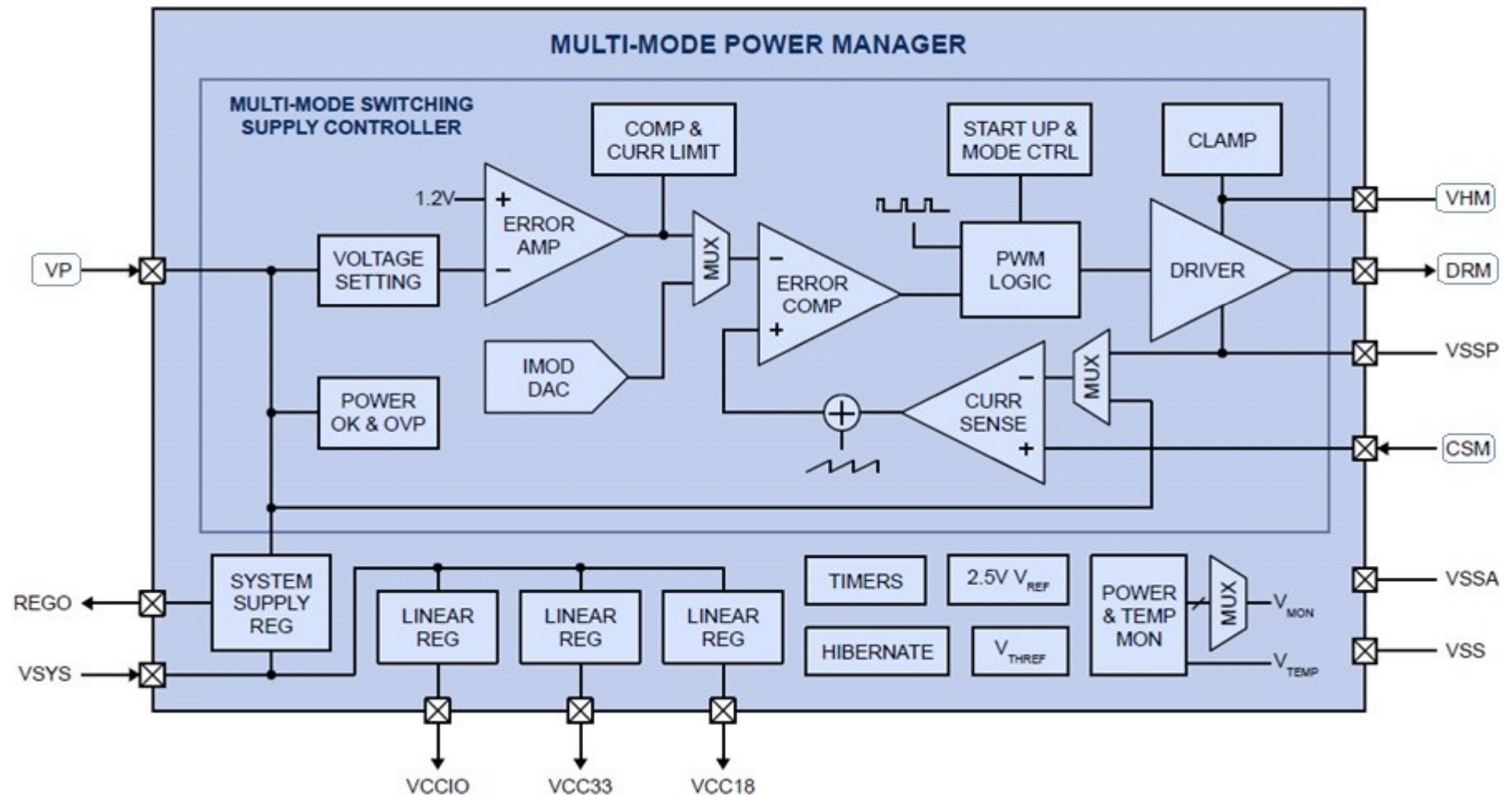
Supply	Function	Current	Voltage	Register
VP	I/O Driver	600mA or higher	5-15V, default 12V	CFGPWR0
VSYS	System	450mA	5V fixed	
VCCIO	I/O	80mA	2.85-5V, default 3.3V	CFGPWR1
VCC33	DDA	80mA	2.5-3.3V, default 3.3V	CFGPWR1
VCC18	Core	80mA	1.2-1.8V, default 1.8V	CFGPWR1

Dual Auto S&H Sequencer

Catalog MCU:

ADC:

ADC Conversion Sequence (2 channels)	
ADC Channel 1	**ADC Channel 2**

MUX switch Sample Convert/ Write result   MUX switch Sample Convert/ Write result

CPU drives ADC conversion process. CPU has to change MUX, enforce delays, store samples between sequences. CPU much more busy.

ADC Trigger (Firmware)

CPU:

MUX CMD Delay AD Start   INT   ISR *Store ADC Result Sequence X* MUX CMD Delay AD Start   INT   ISR *Process Results, run control loop*

ADC Trigger (HW Timer)

PAC:

ADC:

ADC Conversion Sequence (1 sequencer, 2 channels)	
ADC Channel 1	**ADC Channel 2**

MUX switch Delay Sample Convert/ Write result   MUX switch Delay Sample Convert/ Write result

All processing for ADC conversions done in hardware. Single INT when complete. CPU can be idle while ADC processing.
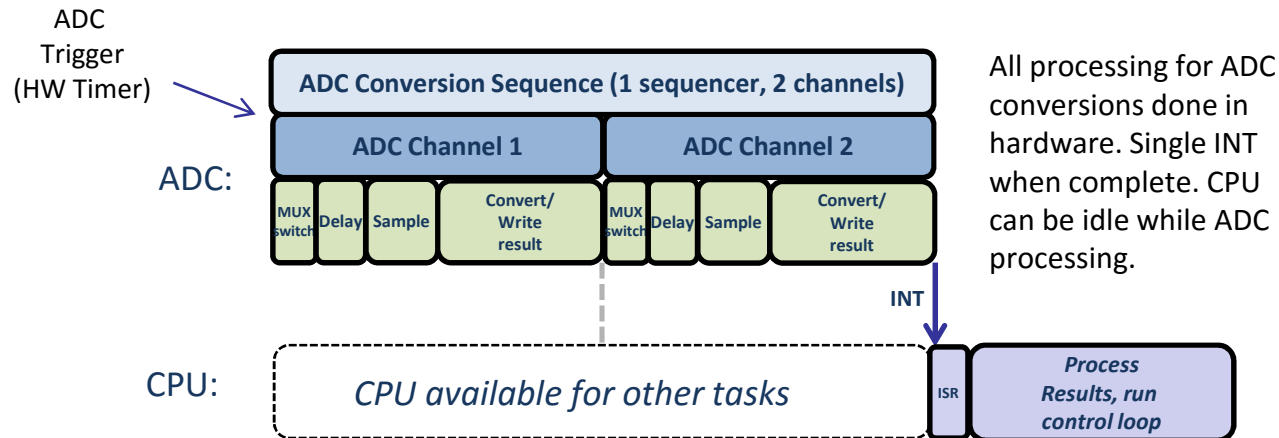
CPU:

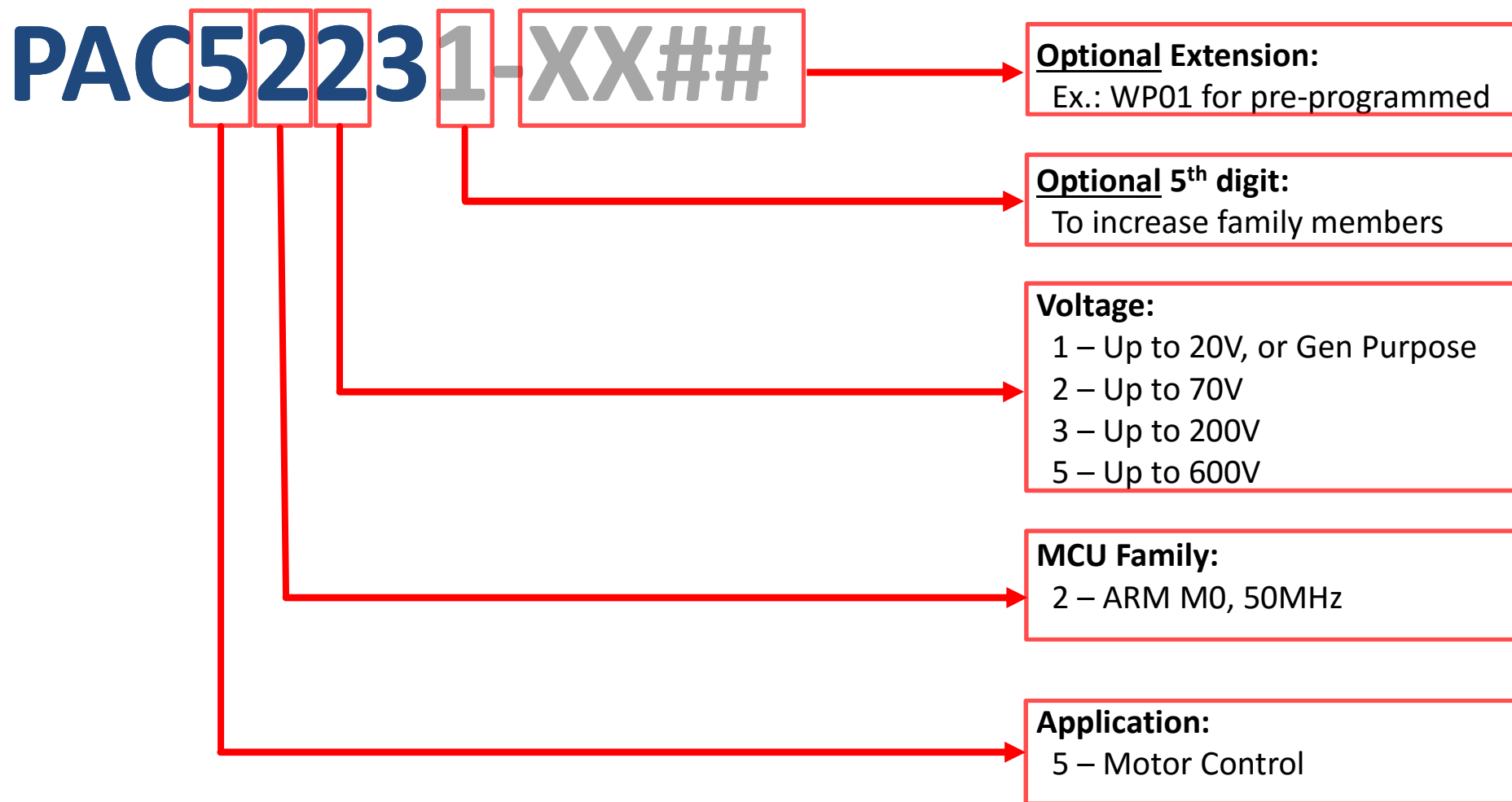*CPU available for other tasks*   INT   ISR *Process Results, run control loop*

- Two independent task data sequencers, each can support up to 8 samples.
- Up to 18 hardware trigger sources for each sequencer

PART #	PIN	POWER MANAGER	CONFIGURABLE ANALOG FRONT END				APPLICATION SPECIFIC POWER DRIVERS		MICRO-CONTROLLER		PRIMARY APPLICATION	STATUS
		INPUT VOLTAGE	DIFF-PGA	PGA	COMPARATOR	ADC CHANNEL	POWER DRIVER	PWM CHANNEL	GPIO	INTERFACE		
PAC5210	56-pin 8x8 TQFN	5-52V	3	4	10	11	3 OD (24V/50mA)	14 GPIO	36	SPI I2C UART SWD	IPM control or general purpose control	In Production
PAC5220	56-pin 8x8 TQFN	5-52V	3	4	10	11	3 LS (1A/1A) 3 HS (1A/1A) 2 OD (40V/50mA)	6 GD 6 GPIO	28	SPI I2C UART SWD	3 half bridge, 3-phase control, Buck Configuration	In Production
PAC5223	48-pin 6x6 TQFN	4.5-70V	3	4	10	10	3 LS (1A/1A) 3 HS (1A/1A)	6 GD 6 GPIO	25	SPI I2C UART SWD	3 half bridge, 3-phase control	In Production
PAC5225	48-pin 6x6 TQFN	4.5-70V	3	4	10	10	3 LS (1A/1A) 3 HS (1A/1A)	6 GD 6 GPIO	25	SPI I2C UART SWD	3 half bridge, 3-phase control, Class B Optimized	In Production
PAC5232	51-pin 6x6 TQFN	24V-200V	3	4	10	10	3 LS (2A/2A) 3 HS (2A/2A)	6 GD 6 GPIO	29	SPI I2C UART SWD	3 half bridge, 3-phase control, Class B Optimized	In Production
PAC5250	57-pin 10x10 TQFN	5-600V	3	4	10	9	6 LS (1A/1A) 3 HS (0.25A/0.5A) 2 OD (24V/50mA)	9 GD 5 GPIO	25	SPI I2C UART SWD	UHV 3 half bridge, 3-phase control	In Production
PAC5253	43-pin 8x8 TQFN	5-600V	3	4	10	9	4 LS (1A/1A) 3 HS (0.25A/0.5A)	7GD	20	SPI I2C UART SWD	UHV 3 half bridge, 3-phase control	In Production
PAC5255	57-pin 10x10 TQFN	5-600V	3	4	10	9	6 LS (1A/1A) 3 HS (0.25A/0.5A) 2 OD (24V/50mA)	9 GD 5 GPIO	25	SPI I2C UART SWD	UHV 3 half bridge, 3-phase control, Class B Optimized	In Production

Optimized for IPM

Optimized for Battery Powered BLDC

Optimized for AC Powered

PAC5223**1**-XX##

Optional Extension:
 Ex.: WP01 for pre-programmed

Optional 5th digit:
 To increase family members

Voltage:
 1 – Up to 20V, or Gen Purpose
 2 – Up to 70V
 3 – Up to 200V
 5 – Up to 600V

MCU Family:
 2 – ARM M0, 50MHz

Application:
 5 – Motor Control

- **Class B (with independent second clock resource) support for current platform:**
  PAC5225: PAC5223 + CLASS B product (sample in March and RTM June 2017)
  PAC5255: PAC5250 + CLASS B product (MP already)

- **New analog core with configurable advance features:**
  Configurable power Manager (CPM):
  > HV DC/DC buck input range 24Vdc~200Vdc
  > MV DC/DC buck from 12Vdc/15Vdc to fixed 5Vdc
  > Linear Regulators

  Application Specific Power Drivers (ASPD) are 200V power drivers designed for half bridge, H-bridge, 3-phase, and general purpose driving.

PAC products have broad cover range from 4.5~48Vdc @70V technology, 24~160Vdc @200V technology to 100Vac~220Vac @600 technology

PAC Firmware and Software IP Support

PAC Software Development Kit (SDK), BLDC Software & Firmware Solutions

PAC SDK

Integrated Development Environment (IDE)

Tool Chain
[Compiler, Assembler, etc.]

PAC5XXX FLASH Programmer

PAC5XXX Device Header Files

PAC5XXX API and Driver

PAC5XXX Peripheral Examples

PAC5XXX Application Examples

SDK Documentation
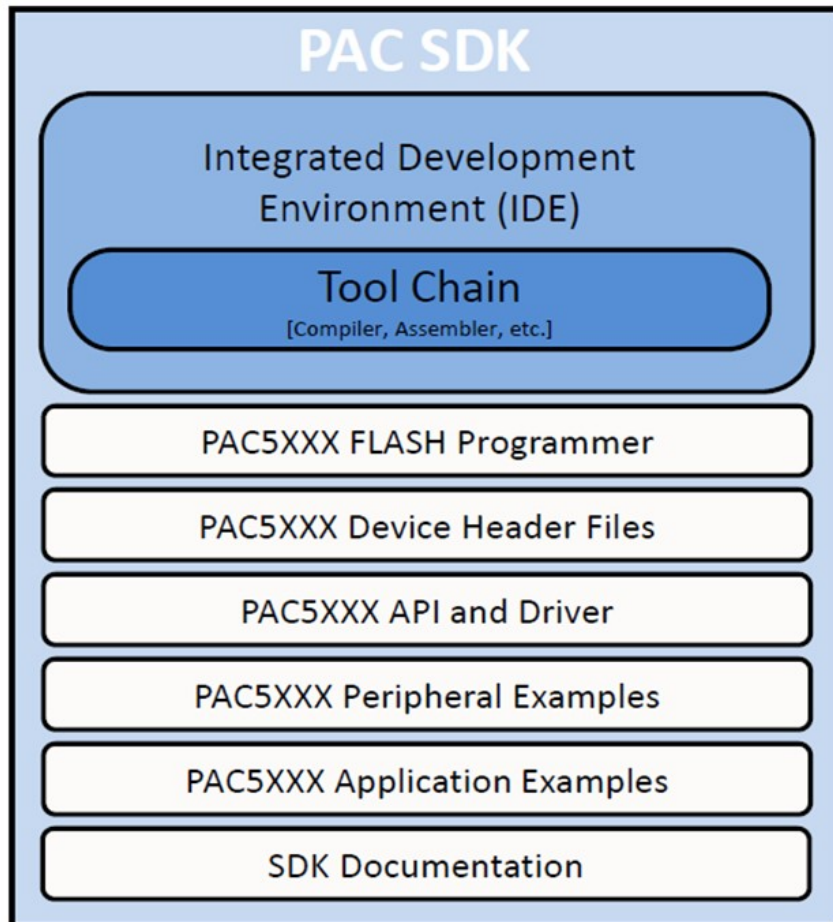
- **IDE**
  - 3rd Party Vendor (IAR, Keil, CooCox)

- **Tool chain**
  - Industry Standard Back-end
  - 3rd Party Vendor (GNU, GCC, ARM etc.)

- **Active-Semi Components**
  - Firmware, Software Components for Development & Evaluation
  - Applications, Drivers, Device Support
 - "Quick-Start" Evaluation
  - Software & Installation Collateral & Documentation

Complete BLDC Software GUI and Firmware Available for Sensored and Sensorless modes using BEMF and FOC Control

VDE (reference number 5019124-4970-0001/204282 AS6/swa).

EN 60335-1
DIN EN 60335-1 (VDE 0700-1):2012-10
DIN EN 60335-1 Ber.1 (VDE 0700-1 Ber.1):2014-04

EN 60335-1:2012
EN 60335-1:2012/AC:2014
EN 60335-1:2012/A11:2014

Anhang R

Annex R

EN 60730-1
DIN EN 60730-1 (VDE 0631-1):2012-10

EN 60730-1:2011

Anhang H

Annex H

IEC 60335-1
IEC 60335-1(ed.5);am1

Anhang R

Annex R

IEC 60730-1
IEC 60730-1(ed.5)

Anhang H

Annex H

Functional safety package based on Standard Peripheral libraries to achieve IEC 60730 Class B certification with the PAC52xx

BLDC Motor Solutions for Sensored/Sensorless BEMF &FOC Motor Control

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PAC5220 / 3 IC Replaces Multiple ICs Included in Dotted line Box.

In addition, System Power Management is simplified too
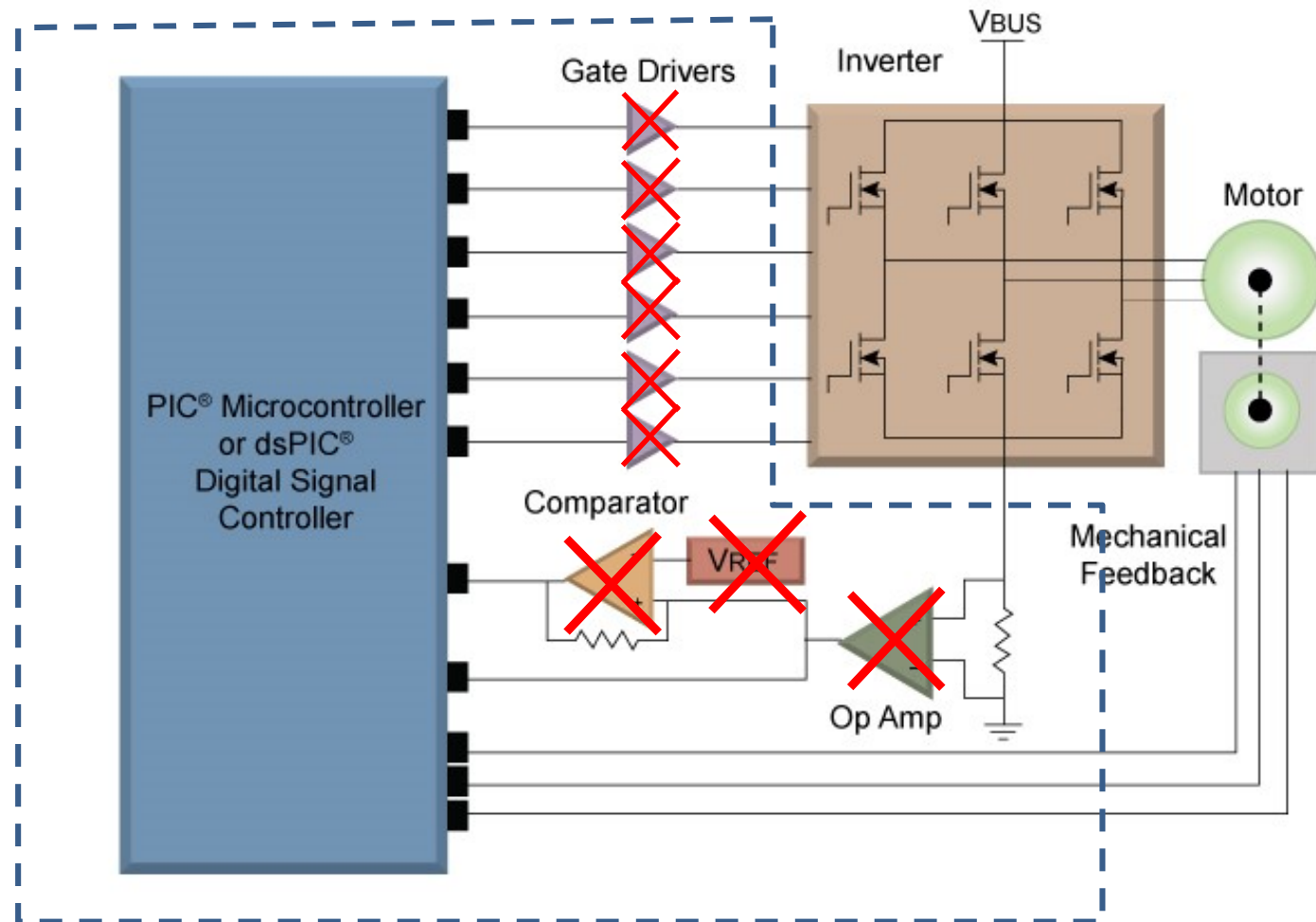
✗ The parts would be eliminated if PAC was used

- No sensor-less control
- Power blocks not shown

BLDC Solution (Sensored or Sensorless) using single-IC (PAC5220 or PAC5223) with fully integrated 3-HS/3LS Gate Drivers, Power Management Control, AFE etc.
No additional ICs needed for motor control, power management or driver stages
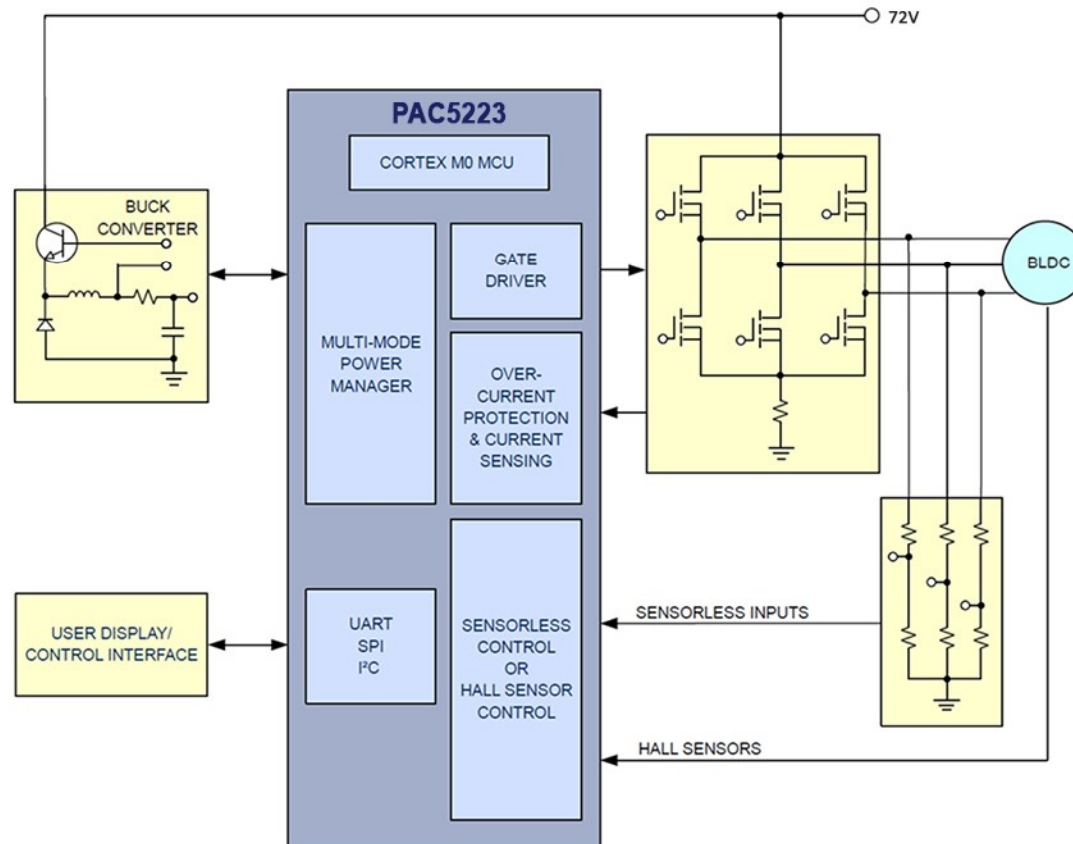
Complete BLDC Software GUI and Firmware Available for Sensored and Back-EMF Sensorless modes using Trapezoidal and FOC Control

"Tiny" BLDC Reference Design with PAC5223

- **Very efficient reference design for 3-phase BLDC**
  - Only ICs:PAC5223 + FETs
  - Can be used for BLDC/BEMF or PMSM/FOC
  - Complete firmware and libraries (source code)
  - GUI for configuration, tuning and debugging
  - Vin: 4.5V-18V

Front
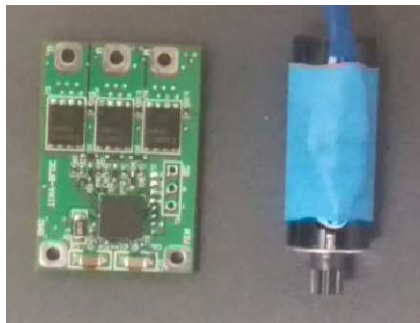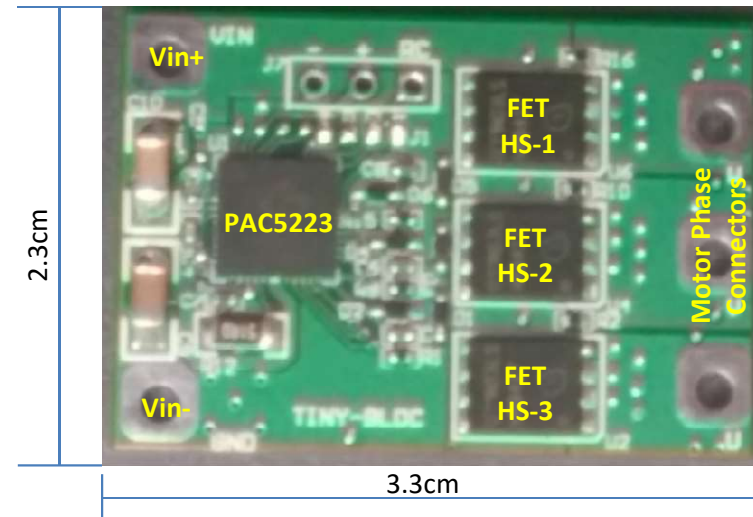
"Tiny" BLDC with drone motor

Back
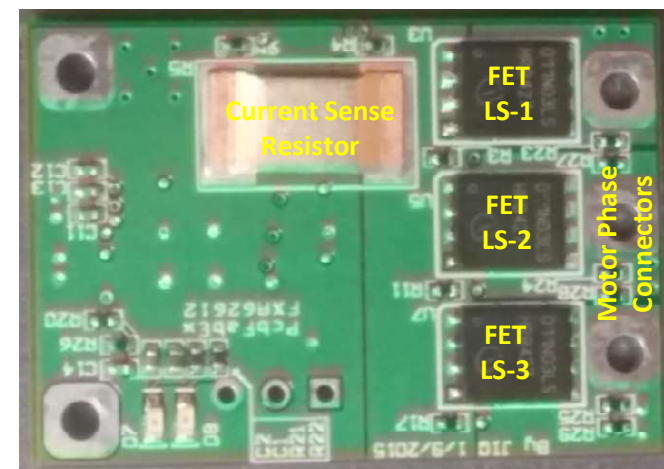
AFSC 1.7Q Oscillating Saw

PD 2G 10.8-EC
Order number: 418.013

Features:

- PAC5220QS
- Sensor less BEMF
- 20V battery

www.fein.com/de_de/oszillieren/superc ut-automotive/afsc-17-q-0343900/

Features:

- PAC5223QM
- Sensor less BEMF
- 10.8V battery

https://www.flex- tools.com/de/Produkte/Akku- Maschinen/index.php?navid=6

Features:
- PAC522x base
- Sensorless BEMF/FOC for ESC
- Sensorless FOC for Gimbal
- The smallest size and weight
- *Take main share in Globe Drone market*
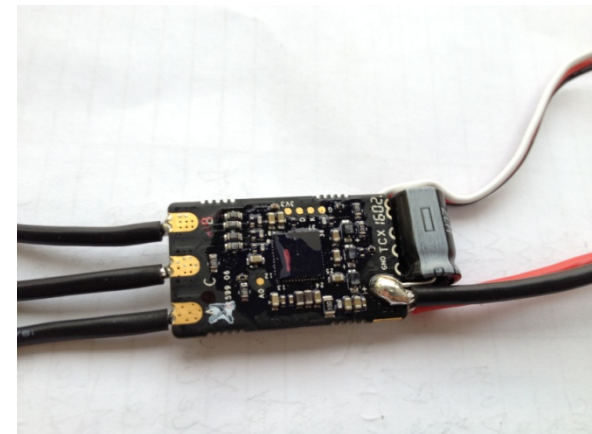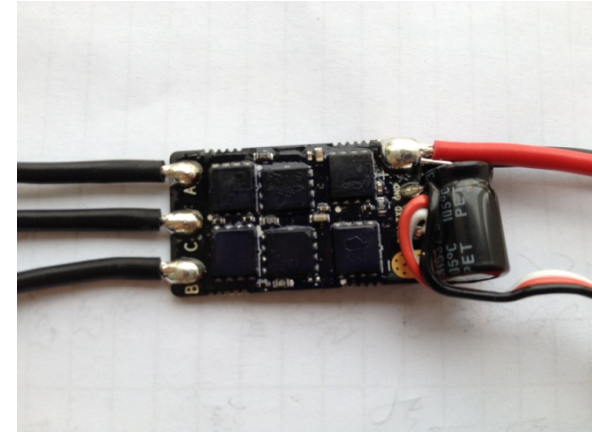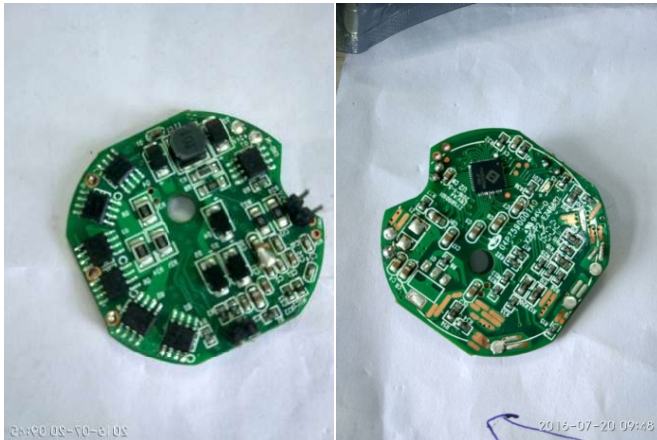
Features:

- PAC5223QM
- Sensorless FOC solution
- Small PCB size Φ46mm for motor embedded appliance
- Critical testing requirement @100℃ hot water and max 80Watt for 168 hours running
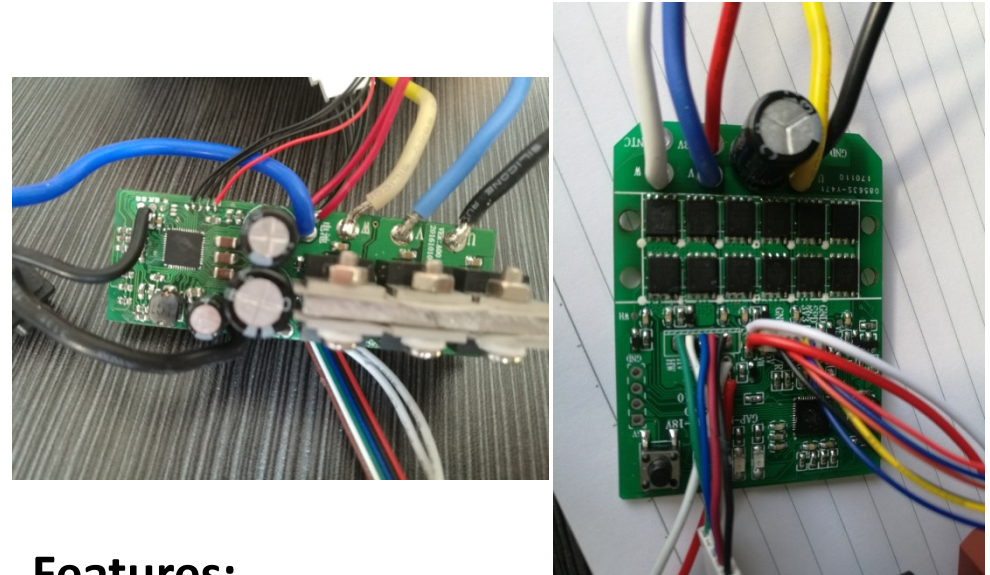
Features:

- PAC5223QM
- Sensorless BEMF solution
- High integration boards

High-Voltage PMSM and
AC Induction Motor Control using
Field Oriented Control (FOC)

Variable Frequency Drive (VFD) Typical Solution

- Issues with current "bag of chips" design approaches
- Expensive – both BOM and R&D costs
- Unnecessary tradeoffs between performance and cost
- Too many components increase cost, size and reduce system reliability
- Standard MCU and analog parts offer little system-level differentiation

PAC5250 IC replaces multiple ICs contained in the dotted line box
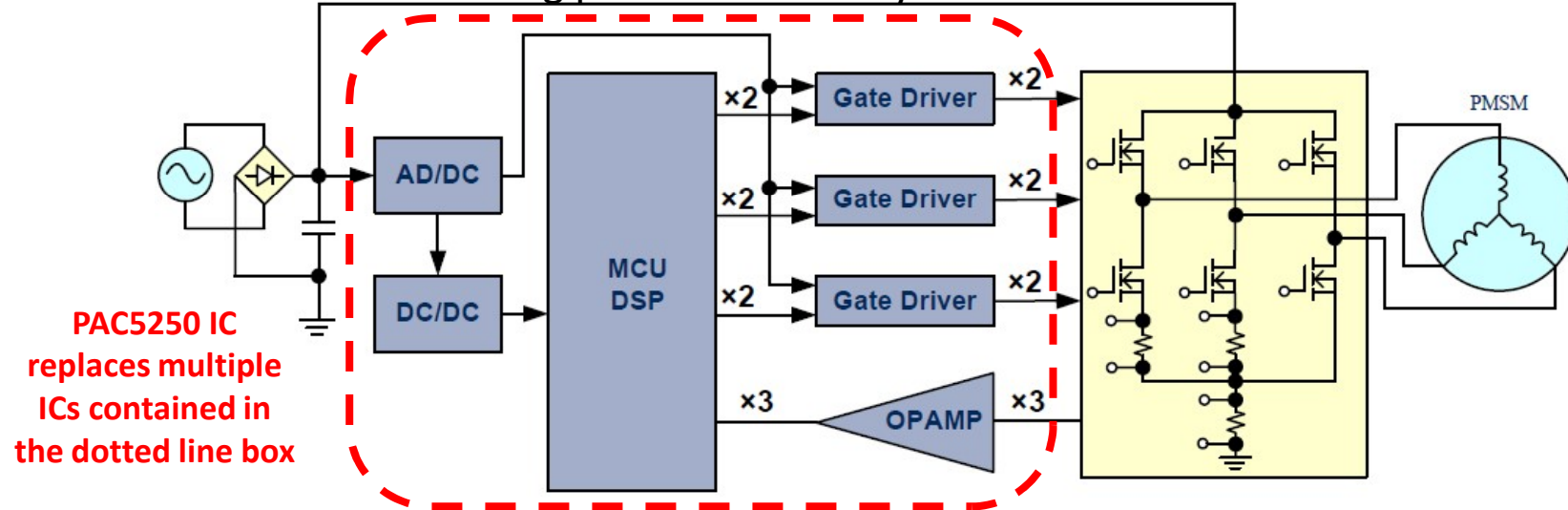
Item	Solution	Description	# Chips	Cost
1	Discrete	AC/DC, DC/DC, MCU, Gate Driver x3, OPAMP	7	Medium
2	IPM	AC/DC, DC/DC, MCU, IPM, OPAMP	5	High
3	PAC	PAC5250, PAC5253, PAC5255	1	Low

VFD HV Motor Controller Block Diagram
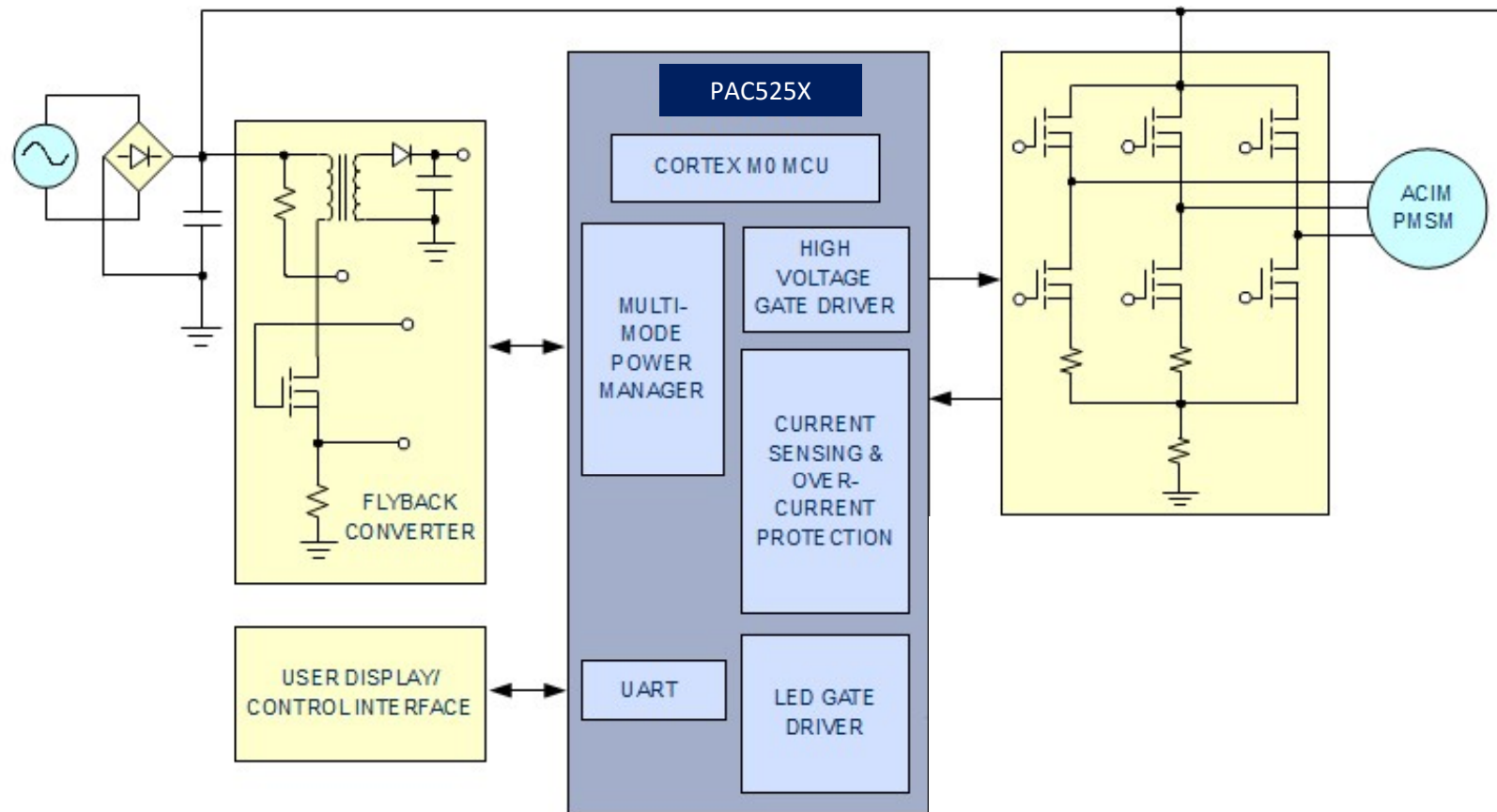
Single-IC HV Motor control solution based on PAC5250 or PAC5253 offers the highest performance, smallest footprint, smallest BOM solution.

Firmware/software GUIs for motor control available to reduce development time
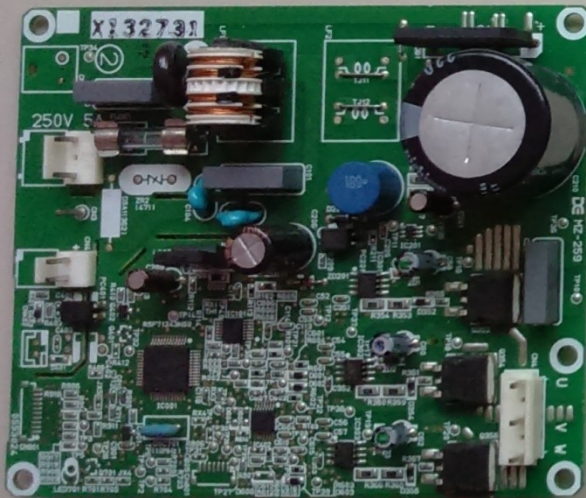
active-semi®
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PAC™ Solution
➢ Standby 0.1W
   via Total Hibernate Mode™
➢ FOC
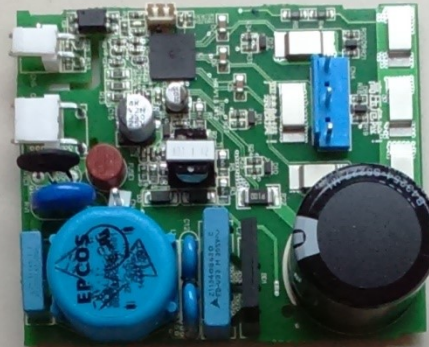
➢ Board size: ~50% down
➢ PCBA cost: ~35% down
➢ Higher reliability due to component reduction

Existing Solution A
Standby 0.7W
FOC
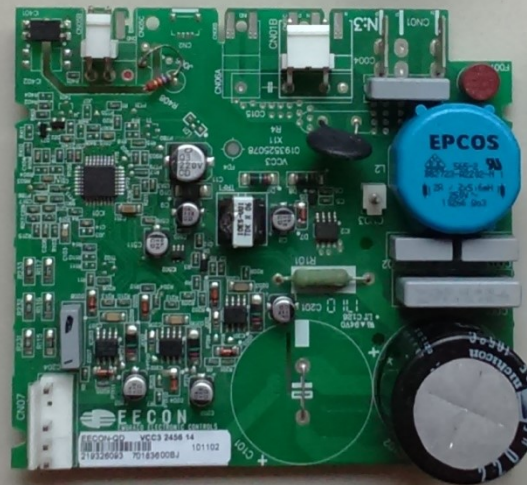
Existing Solution B
Standby 0.65W
BEMF
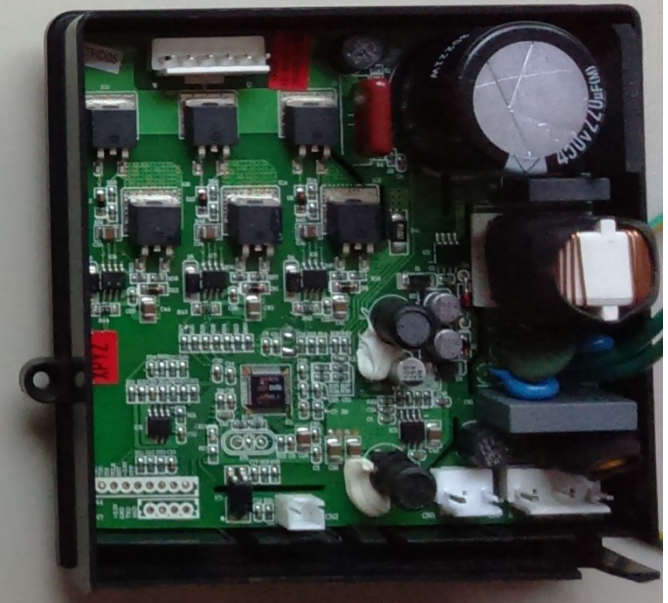
Existing Solution C
Standby 0.45W
FOC

The biggest white goods brand in the world and leading position on inverter technology in home appliance
PAC solution have move to product in the market and the modules cover from 200L to 600L

Features:
- FOC technology with the best standby power consumption
- Competitive BOM cost
- Excellent system performance
- High system reliability

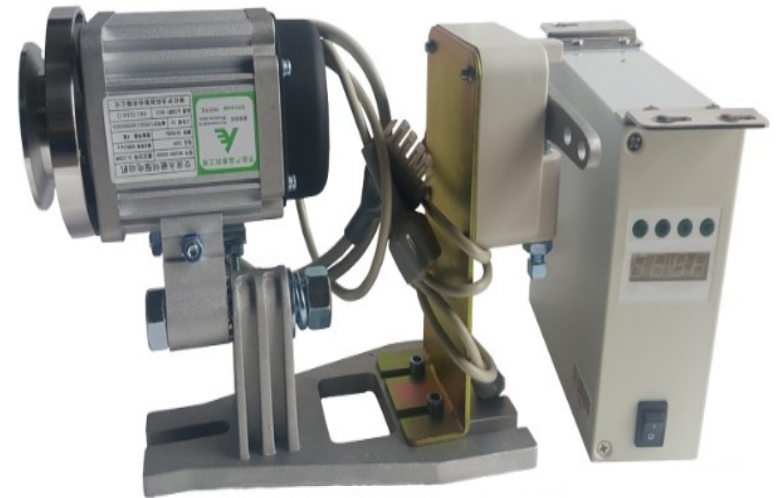# Success appliances sharing- Garden tools

Features:
- PAC525xQF
- Sensorless solution bring benefits
- Competitive system performance and reliability

Industrial appliance - Sewing Machine

Features:

- PAC525x

- BEMF with HALL sensors

- Extend operation temperature 105℃

Ceiling Fan

Features:

- PAC525x

- Sensorless FOC solution

- Smaller PCB size for better industrial design

- Lower standby power

- Additional LED drive for dimming function

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Let create more possibility together

Thanks