Laundry machines
Application and product overview

January 2023

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Modern Washing Machines save energy, water and detergent

Modern laundry systems feature improved **energy efficiency, low acoustic noise, saving water and detergent,** while connecting with a smart home

Laundry Machines – Product overview

Drum motor

- **Motor Controller:** PSoC™, XMC™ and iMOTION™ family
- **Inverter**
  - **IPM**: CIPOS™ Mini, CIPOS™ Tiny IM323
  - **Discrete:** IGBTs (TRENCHSTOP™ IGBT6 & RC-D2 series), MOSFETs (CoolMOS™ P7) and EiceDRIVER™ gate drivers ICs (half bridge and 3-phase drivers)
- **Auxiliary power**: CoolSET™ 5th generation

HMI & connectivity

- PSoC™ for **main control, touch sensing and display**
- Bluetooth / Wi-Fi **connectivity** using our AIROC™ solutions
- XENSIV™ MEMS microphone for **voice control**
- OPTIGA™ Trust for **secured communication**

Condition Monitoring

- PSoC™, XMC™ and iMOTION™ family
- XENSIV™ sensors
- AIROC™ for connectivity

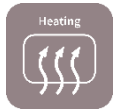
Energy Efficiency

IoT

Drain pump

- **Inverter (IPM)**: CIPOS™ Micro and iMOTION™ IPM
- **Inverter (Discretes)**: IGBTs (TRENCHSTOP™ IGBT6 & RC-D2 series), MOSFETs (CoolMOS™ PFD7), EiceDRIVER™ gate drivers ICs (half bridge and 3-phase drivers)

Heat pumps

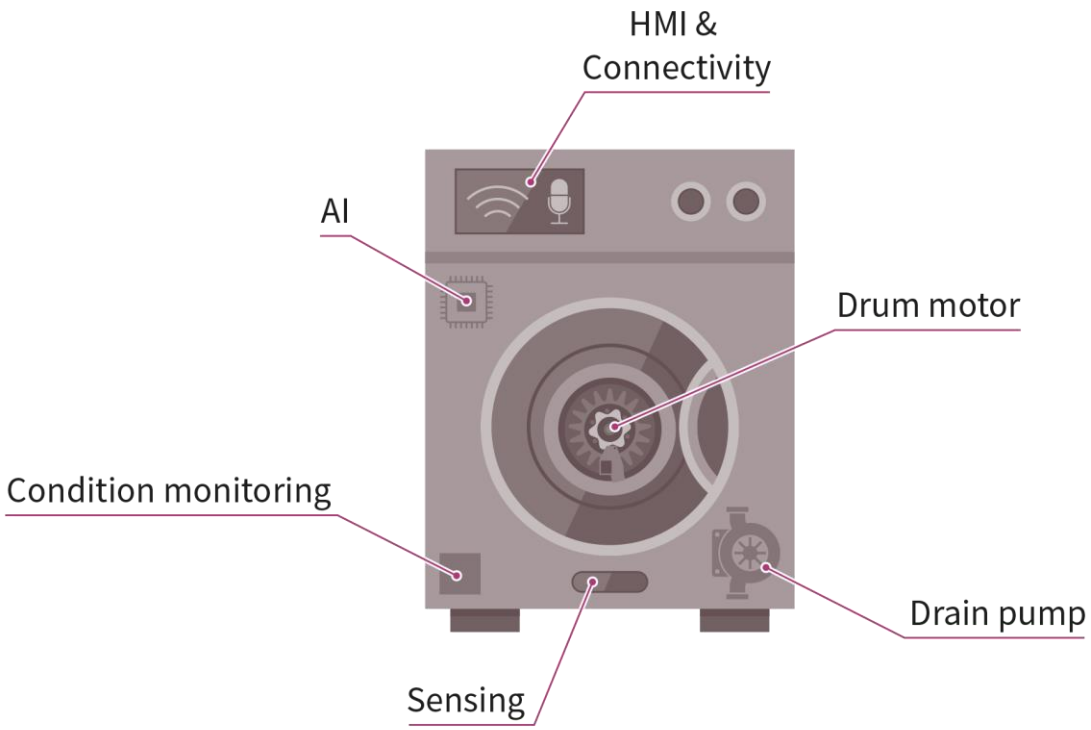


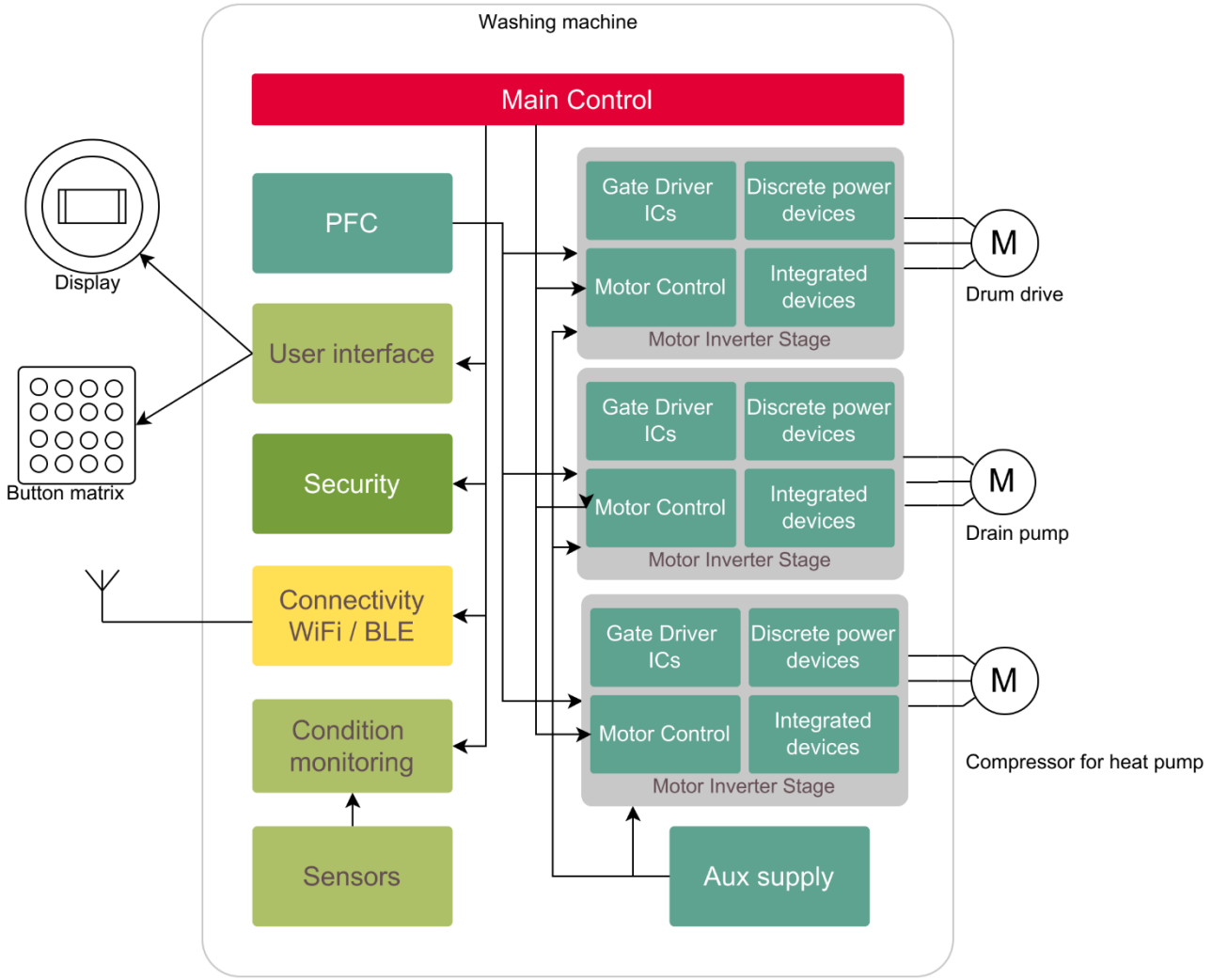
- **Inverter (IPM):** CIPOS™ Mini
- **Inverter (Discretes):** IGBTs (RC-D2 series), EiceDRIVER (half bridge and 3-phase drivers)
- **PFC**: TRENCHSTOP™ 5 IGBTs, CoolSiC™ hybrid discretes, Rapid and CoolSiC™ diodes, CIPOS™ Mini IPMs and PFC gate drivers

Sensing

- **Pressure** sensor for water pressure and filter clockage
- **Radar** for presence detection, gestures and material detection
- **Touch** sensing for water level sensing
- **Hall** sensors for open/close detection
- **3-D Position sensor** for balance and weight sensing

Block diagram – Washing Machine





Washing machines – Focus products

	Selected product families	Key value
Power stage	**CIPOS™** Mini IM564-X6D IPM / Reverse Conducting RC-D2	Highest power density and efficiency
Motor control	**PSoC 4100S**	Full set of features and protections, fast time to market
Smart home system	**PSoC™** 6 family of dual core microcontrollers M4 / M0+ with ultra low power and high performance for smart features, touch control, sensor data processing and connectivity	Full feature set and IoT security
Connectivity	**AIROC™ Wi-Fi® + Bluetooth®** combos with IEEE 802.11a/b/g/n/ac WLAN and Bluetooth in a single-chip solution	Ease of use and full compatibility
Hardware security	**OPTIGA™** family to both verify that genuine parts are used and to establish secured communication to the cloud or other devices	Brand protection and secured communication

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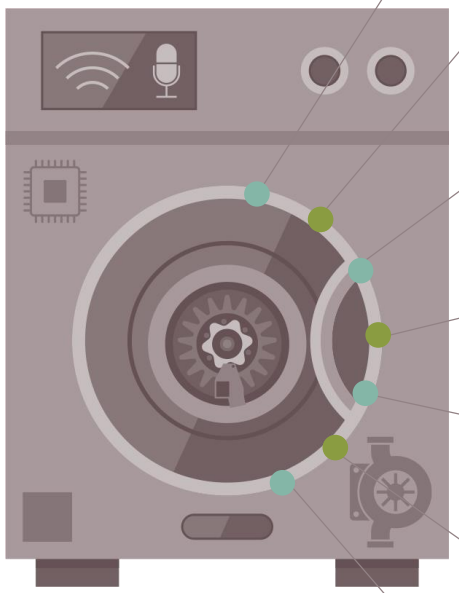
BLDC drum motor – Features and benefits



› More durable	› Without brush / commutator erosion. › More extensive life expectancy and maintenance-free experience.
› Quieter	› Without mechanical friction inside the motor. › Noise is dramatically reduced.
› More efficient	› A higher energy efficiency than the conventional universal motors. › Reduces energy consumption by up to 40%.
› More powerful	› Able to work at a desired constant high speed. › Ensures a powerful performance from the start to the end.
› More versatile	› Produces wider speed range and bigger torque.
› Increased working time	› Lower temperature rise so it allows for continuous work.
› Safer	› No sparking as there is no commutator and brushes. › Supported by the housing, so it can be cooled by conduction. › Entirely enclosed and protected from dirt or any foreign subjects

High-level view on the inverter

Motor controller

› Regulates speed and torque of motor by manipulating voltage and current

Gate driver

› Amplifier that accepts low power input from a controller to produce the high current gate drive for a switch

Power switch – IGBT or MOSFET

› Controls current in the motor through on-off operation

Power Factor Correction – Switch-Diode-Inductor

› Improves power factor thus reducing load on the electrical distribution system & increasing energy efficiency

Infineon offers various motor control solutions to choose from

<table>
<tr><th>S/W</th><th>MCU</th><th>Gate driver</th><th>Power switch</th></tr>
<tr><td colspan="2">iMOTION™ controller</td><td rowspan="3">EiceDRIVER™</td><td>IGBT</td></tr>
<tr><td rowspan="2">Customer's own S/W</td><td>XMC™</td><td>HV FET</td></tr>
<tr><td>PSoC™</td><td>LV/MV FET</td></tr>
<tr><td colspan="2">iMOTION™ controller</td><td colspan="2" rowspan="3">CIPOS™ IPM
(thermal sensor inside)</td></tr>
<tr><td rowspan="2">Customer's own S/W</td><td>XMC™</td></tr>
<tr><td>PSoC™</td></tr>
<tr><td colspan="3" rowspan="3">iMOTION™ driver</td><td>IGBT</td></tr>
<tr><td>HV FET</td></tr>
<tr><td>LV/MV FET</td></tr>
<tr><td colspan="4">iMOTION™ IPM (thermal sensor inside)</td></tr>
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Considerations to select a solution

The value proposition of each offering

e.g. SMD package up to 300 W without heatsink, better EMI performance of IGBT, better light road efficiency of MOSFET

Technical requirements of each application

e.g. thermal management since washing machines have a lot of power cycling, high peak current

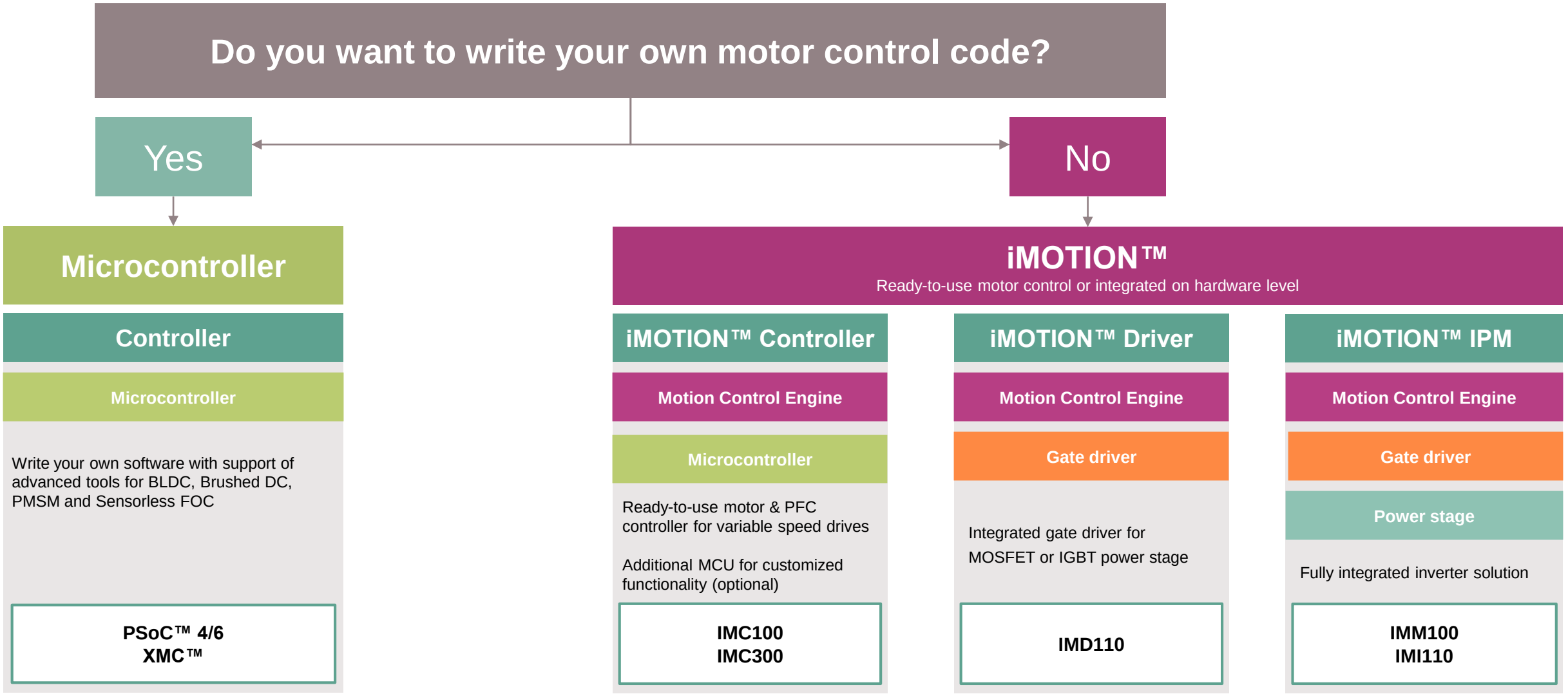
IFX recommended offerings based on customer's preference and system specifications

e.g. switching frequency, power rating, PCB space constraint, assembly process, heatsink-less, multi-source, efficiency, EMI performance, price, high or low voltage motors, internal thermal sensor, control algorithm

Evaluation or simulation results per each application

e.g. loss simulation

Motor Control: iMOTION™ or microcontroller?



Microcontroller portfolio overview

	Selected product families	
System control, HMI and connectivity	**PSoC® 6**	› Highly integrated HMI solution with capacitive touch sensing and TFT display › PSoC™ 6 + Wi-Fi® & BT Combo: Providing the total solution of IoT connectivity & security (Cloud service, Mesh Gateway)
	PSoC® 4	› HMI + system control (2-in-1 solution): Reliable & stable capacitive touch sensing, large pin pitch package, wide voltage range
Motor control	**PSoC® series**	› Integrated with OPA/CMP, TCPWM, reduce BOM cost › Supported by mature, validated and reliable motor control algorithm and total solution for home appliances, short time to market
	XMC series	› Versatile real-time motor and power stage control peripherals › Scalable to various control schemes from single motor up to dual motor and PFC control › 5V supported by XMC1000 series
Ready-to-use, highly integrated motor control	**iMOTION™**	› Integrates all the control and analog interface functions required for sensor-less FOC › Eliminates software coding from the motor control algorithm development process

PSoC™ selection guide for washing machines

	Main control	Connectivity		HMI			Display drive		Motor Control			Additional features	Software
		BT	WiFi	Button	Display LCD	Display TFT	Display LCD	Display TFT	Top load	Front load	Dryer fan control		
PSOC™ 4000S/ 4100S	Only PSoC4100S			<7“			✓		4100S				PSoC™ creator
PSOC™ 4100 Plus/ Max	✓			<7“/9“			✓					2 Capsense blocks	PSoC™ creator/ Modus toolbox
CY8C62x4/5	✓	Host for Wi-Fi		✓			✓	✓				Security (PSoC™ 64)	Modus toolbox
CY8C62x6/7/A/8	✓			✓			<7“					Security (PSoC™ 64)	PSoC™ creator/ Modus toolbox
CY8C63x7/8	✓	BLE		✓			<7“					Security (PSoC™ 64)	PSoC™ creator/ Modus toolbox
PSoC4500H									Rolling and drying (2 motor control with single chip)				Modus toolbox

iMOTION™ selection guide for washing machines

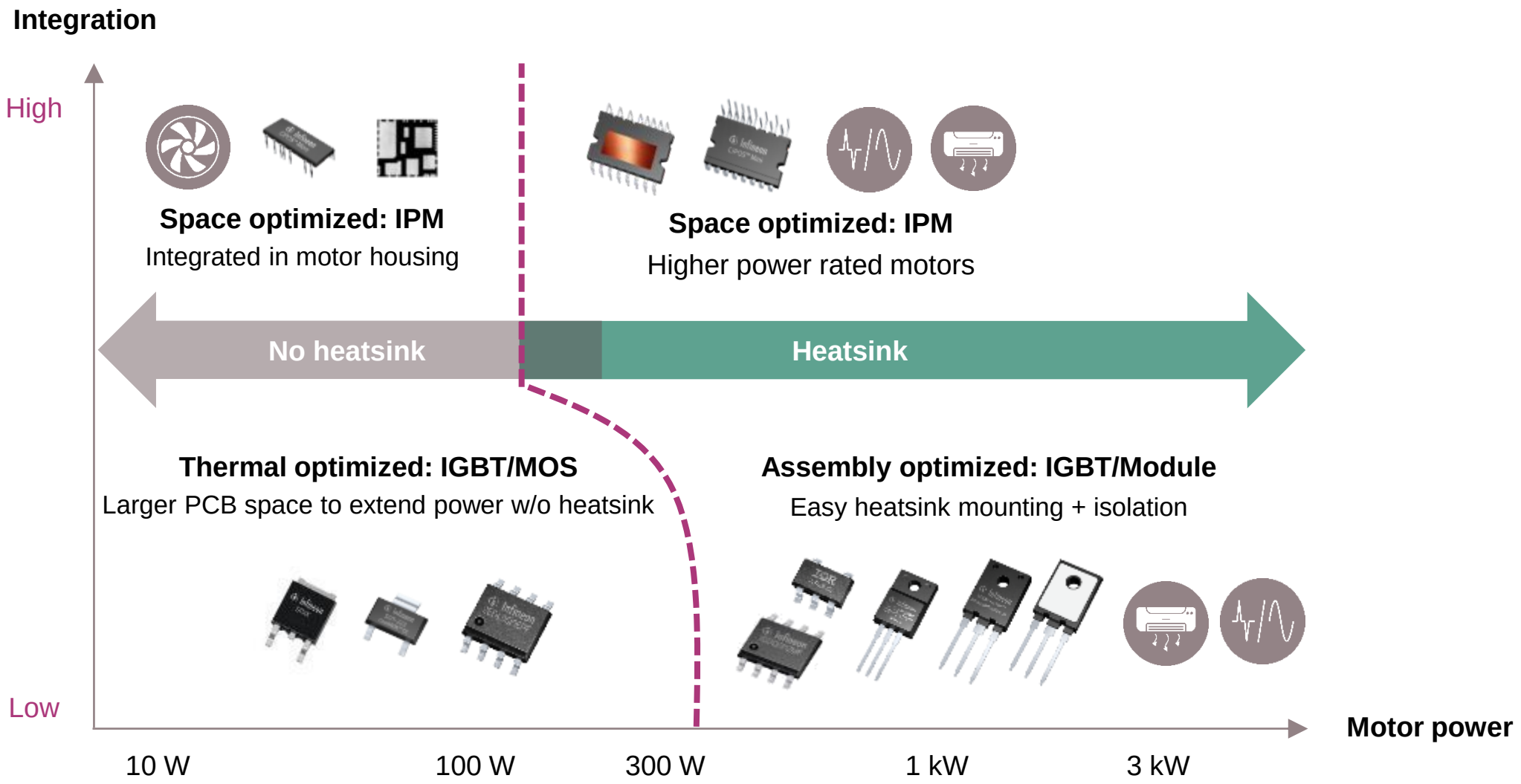
	Main control	Connectivity		HMI			Display drive		Motor Control		Additional features	Software
		BT	Wi-Fi®	Button	Display LCD	Display TFT	Display LCD	Display TFT	Single + PFC	Dual + PFC		
IMC100									✓			Ready to use + Script engine
IMC 300									✓		Additional M0 core	Ready to use + Script engine
IMD110									✓		Integrated GD	Ready to use + Script engine
IMI110*									✓		Integrated GD + Power Stage	Ready to use + Script engine
IMM100*									✓		Integrated GD + Power stage	Ready to use + Script engine

XMC™ selection guide for home appliances

	Main control	Connectivity		HMI			Display drive		Motor Control		Additional features	Software
		BT	Wi-Fi®	Button	Display LCD	Display TFT	Display LCD	Display TFT	Single + digital PFC	Dual + digital PFC		
XMC1300									✓		MATH co-processor, 64MHz motor control timers, 5 V	LLD, DAVE Apps for configuration and code generation, Class B safety Lib, XMC Lib
XMC1400									✓		MATH co-processor, 96 MHz motor ctrl timers, 5 V, 4 ACOMP	
XMC4100/200										✓	High resolution motor control timers, 4 ADC, 125°C	

*targeting IDU fan

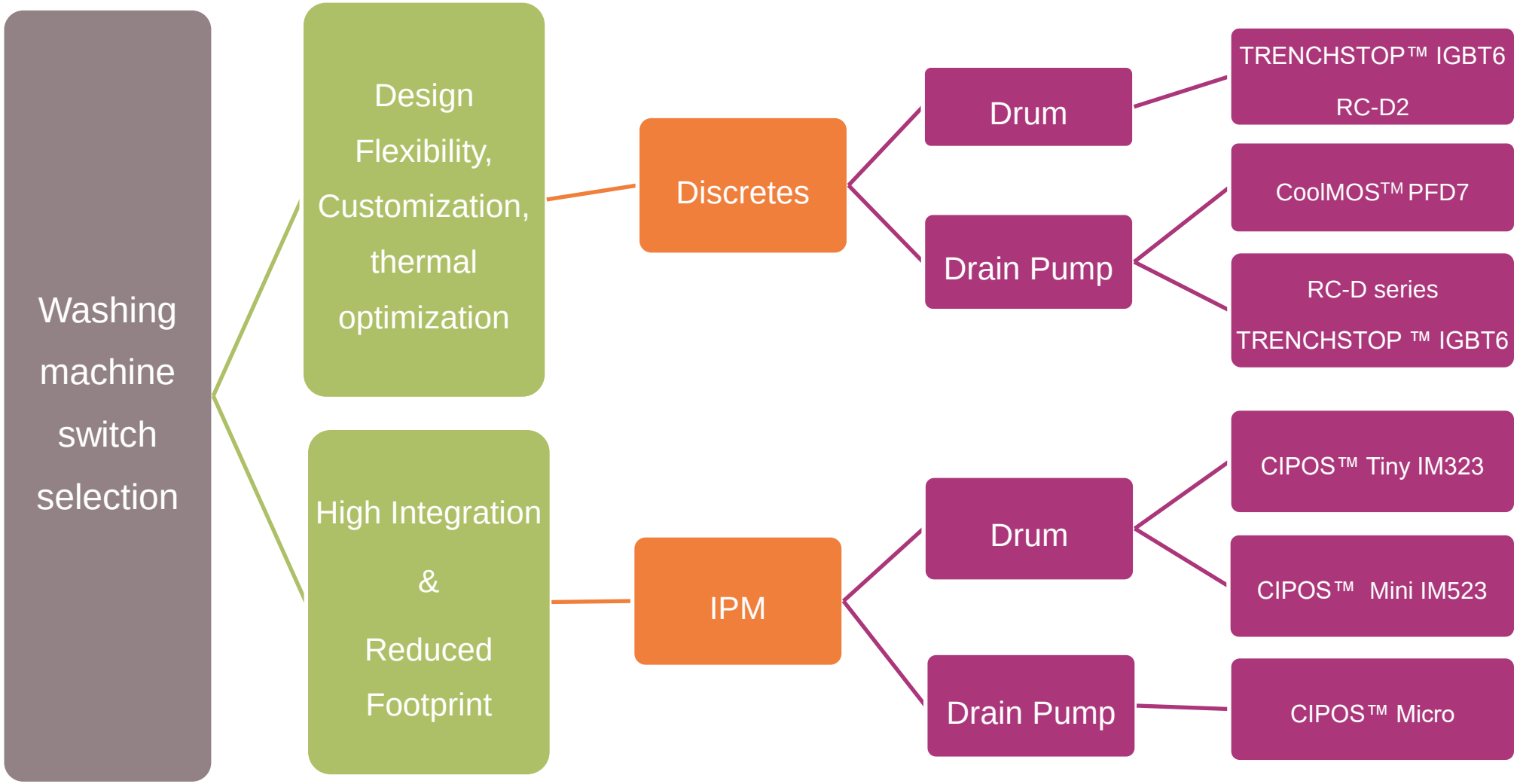
Power stage and Power Factor Correction (PFC) – Discrete or integrated



Power Factor Correction – Topologies

Criteria \ Topology	Partial PFC	CCM Boost PFC	Totem-pole PFC
Suitable power range	› Limited power 1-1.5 kW	› Suitable for >1.5 kW	› Suitable for >2.5 kW
Cost	› Low cost	› Moderate cost	› Affordable for high power
Switching frequency	› Low switching frequency › High harmonics	› High switching frequency › Low harmonics	› High switching frequency › Low harmonics
Efficiency	› Bridge rectifier needed	› Bridge rectifer needed	› No bridge rectifier needed
	› Hardly meets energy regulations	› Meets energy regulations	› Meets energy regulations › Best efficiency near 99%
Power factor	› PF <0.9 › Acceptable harmonics	› PF ~0.99 › Minimized harmonics	› PF ~0.99 Minimized harmonics
Control	› Easy control, but no dedicated controller available	› Easy implementation › Dedicated controller available	› Slightly complex than ordinary boost PFC, and no dedicated controller available
Form factor	› Bulky inductor needed	› Smaller form factor	› Smallest form factor

Switch selection for washing machines



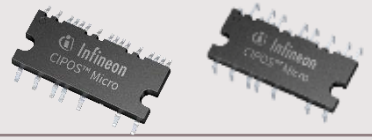
Product Overview: Integrated Power Modules

CIPOS™ Nano

Dimension [mm]	8x9 / 12x10 / 12x12
Configuration	Half-bridge / 3-phase
Voltage Rating	250 V, 500 V
Rdson [max].	0.15 – 6.0 Ω

- Heatsink-less operation
- **Smallest modules** on the market
- **Various topology solutions**; Half-bridge, H-bridge, 3-phase
- Overcurrent protection included

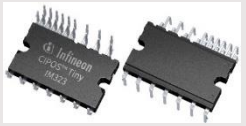
CIPOS™ Micro



Dimension [mm]	29x12x2.9
Configuration	3-phase
Voltage Rating	600V
Current Rating	2, 4, 6 A

- **Compact package size** (20%+ smaller than competitors)
- Wide range of footprint compatible part numbers
- Temperature feedback option
- **Screw hole** available for heatsink mount

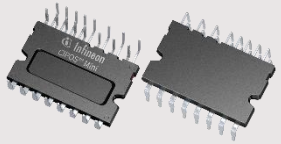
CIPOS™ Tiny IM323



Dimension [mm]	32.8x18.8x3.1
Configuration	3-phase
Voltage Rating	600V
Current Rating	15 A

- Optimized for inverter power rating up to 1.5 hp
- Rugged SOI gate driver technology
- **Latest TRENCHSTOP™ RCD2** technology with max. junction temperature 175°C
- Robust and **pin compatible** design

CIPOS™ Mini IM523



Dimension [mm]	36x21x3.1
Configuration	3-phase
Voltage Rating	600V
Current Rating	6, 10, 15, 17 A

- **Best optimized performance for consumer** and low power drive applications especially under high switching frequency applications
- Latest 600 V **TRENCHSTOP™ RCD2** Technology
- **Market proven and reliable solution** with high volume shipment record

Customer Benefits

- Fast time to market
- System cost savings from smaller footprint and reduced PCB space
- Optimized performance and package options available
- UL certified package

EiceDRIVER™ Gate Drivers for laundry machines

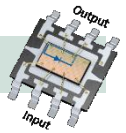
Inverter: 600-700 V Level-shift drivers

- **Level-shift:**
  - **30 years** of product leadership from IRF portfolio (first **HVIC** driver in 1989)
  - State-of-the-art **Infineon SOI** technology for superior operational ruggedness and higher frequency switching

Key products

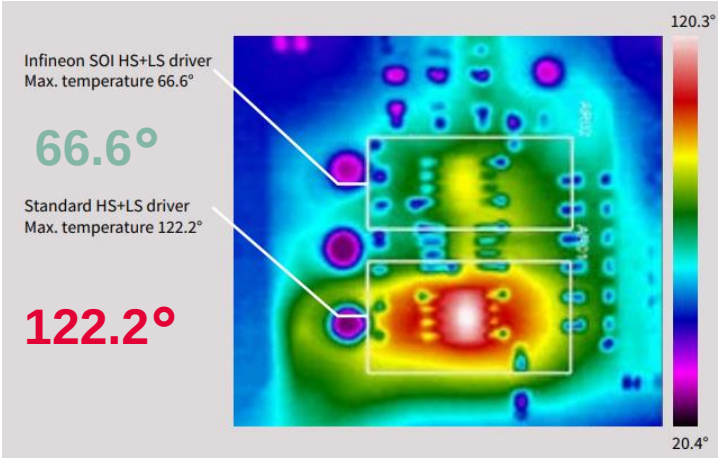
- 2ED2304S06F
- 6EDL04x06xT

Differentiation



- Largest standard portfolio
- Infineon SOI (BSD, $-V_S$, lower losses)

Infineon's SOI Technology for level-shift drivers



- Power loss comparison between Infineon SOI gate driver and standard level-shift gate driver

- Fully operational up to +650 V
- Integrated bootstrap diode (BSD)
- Tolerant to negative transient voltage ($-V_S$) up to 100 V
- Low level-shift loss in high frequency applications (below)

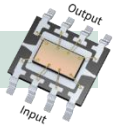
PFC: Low-side drivers

- Comprehensive families of single and dual channel low-side drivers
- New feature-rich families with **accurate (+/-5%), fast, over-current protection** for PFC in home appliances

Key products

- 1ED44173/5/6N01
- **1ED44171N01B**
- IR4427, IRS4427, IRS44273

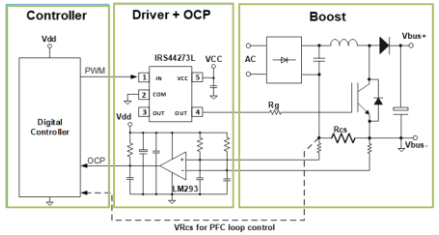
Differentiation



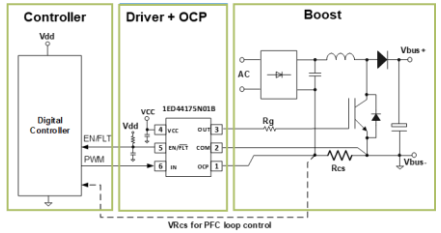
- **Integrated over-current protection (OCP) and fault reporting**
- Cost-effective
- Market-proven

1ED4417x integrated OCP

Current solution



1ED4417x solution



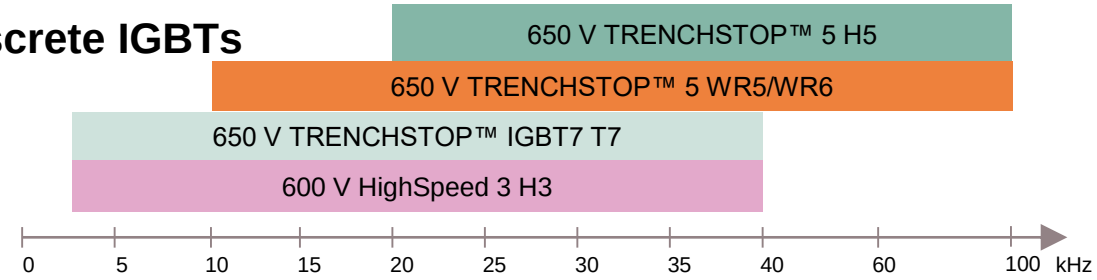
> 20% Cost Saving
> 50% Space Saving

1ED4417x integrates

- *Low side gate driver*
- *Overcurrent protection*
- *Fault output*
- *Programmable fault clear time*
- *Enable input*

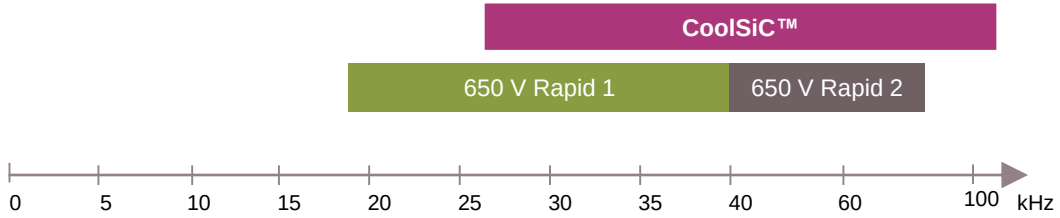
Discrete IGBT & silicon diode solutions in the PFC stage

Discrete IGBTs



No SC rating	TRENCSHTOP™ 5 H5	**Best-in-class high frequency IGBT** Highest efficiency, especially under light load conditions Portfolio: 20 A – 75 A TO-220, TO-247 3/4 pin, Advanced Isolation package
	TRENCHSTOP™ 5 WR5/WR6	**PFC application optimized IGBT** Optimized full rated hard switching turn-off Excellent RG controllability with soft recovery plus low Qrr for diode Portfolio **WR5**: 30A – 50A, TO-247-3 pin & TO-247-3-HCC (30A)**; WR6**: 20 A – 70 A, TO-247-3-HCC
SC rating	IGBT7 T7	**Benchmark low-medium frequency IGBT** Benchmark low $Vce_{(sat)}$ and low V_F IGBT Enhanced controllability for better EMI Portfolio: 30 A – 50 A, TO-247 3 pin
	HighSpeed3 H3	**High speed IGBT** Low E_{off} Lowest switching losses Portfolio: 30 A – 75 A, TO-247 3 pin, Advanced Isolation package

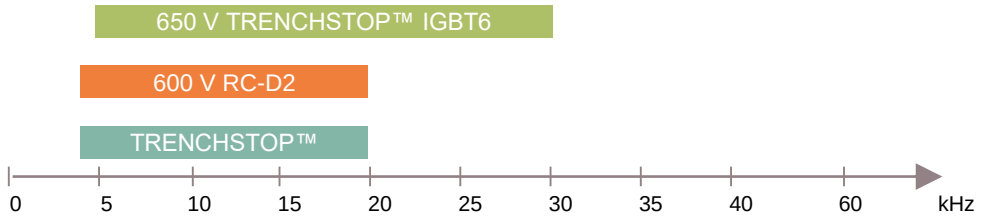
Silicon diodes



Rapid 1	**V_F optimized diode for low frequency applications** 1.35 V temperature-stable forward voltage (VF) Lowest peak reverse recovery current (Irrm) Reverse recovery time (trr) < 100 ns Portfolio: 8 A – 80 A, packages include TO-220FP, TO-247, and Advanced Isolation package
Rapid 2	**Qrr/trr optimized hyperfast diode for high frequency applications** Lowest Qrr : VF ratio for best-in-class performance Lowest peak reverse recovery current (Irrm) Reverse recovery trr < 50 ns Portfolio: 8 A – 40 A, packages include TO-220FP, TO-247
CoolSiC™ Schottky Diode Gen. 5	**Zero diode turn-off loss (no Qrr, no trr)** 40-50% reduction in IGBT turn-on loss 20-30% higher output power in same form factor Benchmark thermal performance Benchmark surge current capability, Best price-performance ratio Portfolio: 2 A - 40 A, packages: TO-220 R2L, TO-247 dual die, TO-247 R2L, DPAK R2L, D²PAK R2L

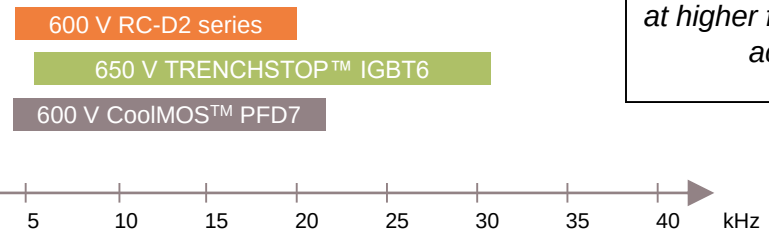
Discrete IGBT & silicon diode solutions in drum and pump

Drum drive



IGBT 6	**Performance optimized up to 30 kHz** Lowest switching losses and improved EMI SC rating up to 3us For medium to high frequency converters Portfolio: 6 A – 15 A, with/out FWD diodes, DPAK, TO-220FP
RC-D2	**Cost optimized monolithically integrated diode in surface mount packages** SC rating up to 3us For low to medium frequency converters Portfolio: 3 A – 15 A DPAK 1 A – 6 A SOT-223
TRENCHSTOP™	**Good low frequency performance** Low $V_{ce(sat)}$ and low switching losses, SC rating up to 5µS Widest variety of packages including SMD and THT Portfolio: 4 A-20 A, D²PAK, TO-220, TO-220FP

Drain Pump

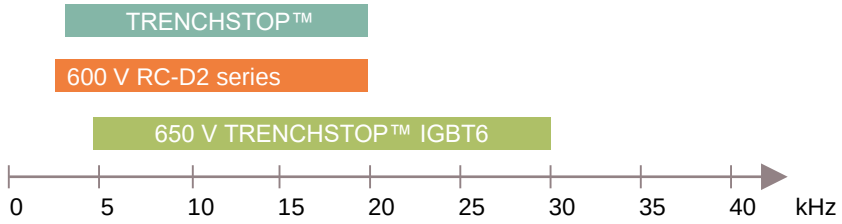


Drain pumps typically operate at higher frequencies to reduce acoustic noise!

RC-D2	**Cost optimized monolithically integrated diode in surface mount packages** SC rating up to 3us For low to medium frequency converters Portfolio: 1 A – 6 A SOT-223
IGBT 6	**Performance optimized up to 30 kHz** Lowest switching losses & improved EMI, SC rating up to 3us For medium to high frequency converters Portfolio: 6 A – 15 A, with/out FWD diodes, DPAK, TO220FP
600 V CoolMOS™ PFD7	**Integrated fast body diode with ultra low Qrr** Integrated Zener diode for ESD protection (HBM Class 2) Portfolio with wide range of $RDS_{(on)}$ values ≤ 2 Ohm Supporting cost effective designs with SMD solutions

Power Stage – Discrete IGBT/MOS and silicon diode solutions in Washing Machines

Compressor



Typical switching frequency in Europe is 10-15 kHZ whereas it is a bit higher in Asia

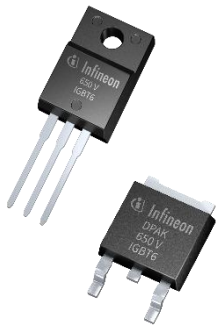
TRENCHSTOP™	**Good low frequency performance** Low $V_{ce(sat)}$ and low switching losses SC rating up to 5µS Widest variety of packages including SMD and THT Portfolio: 4 A-20 A, D²PAK, TO-220, TO-220FP
RC-D2 series	**Cost optimized monolithically integrated diode in surface mount packages** SC rating up to 3µs(RC-D2) For low to medium frequency converters Portfolio: 3 A-15 A in DPAK, RC-D2 also in 1 A-6 A in SOT-223
IGBT 6	**Performance optimized up to 30 kHz** Lowest switching losses and improved EMI SC rating up to 3us For medium to high frequency converters Portfolio: 6 A – 15 A, with/out FWD diodes, DPAK, TO220FP

650 V TRENCHSTOP™ IGBT6

650 V IGBT 6

- Full rated diodes and 3 µs SC capability
- Excellent thermal performance, especially at higher frequencies
- Lower system cost on EMI filtering
- Offered in isolated TO-220 FP and SMD DPAK for compact design
- Optimized for lowest switching losses, but also low conduction losses

650 V IGBT6 is the best choice for premium performance



650 V IGBT6 portfolio

Ic 100°C	DPAK TRENCHSTOP™ IGBT 6	TO-220FP TRENCHSTOP™ IGBT 6
6	IKD06N65ET6	
8	IKD08N65ET6	IKA08N65ET6
10		IKA10N65ET6
15		IKA15N65ET6
Single IGBT		
6	IGD06N65T6	
10	IGD10N65T6	
15	IGD15N65T6	

Recommended for washing machine drums

Recommended for washing machine pumps

600 V Reverse Conducting Drives 2

600 V RC-D2

- Optimized half rated diodes and 3 µs SC capability
- Better controllability over the di/dt in order to further reduce EMI compared to RC-D/DF series
- Improved high voltage humidity robustness
- Easy to design products – drop in replacement RC-D2 available in DPAK and SOT-223
- Low switching losses at competitive price, setting a new price/performance standard

600 V Reverse Conducting Drives 2 is the best choice for price sensitive markets

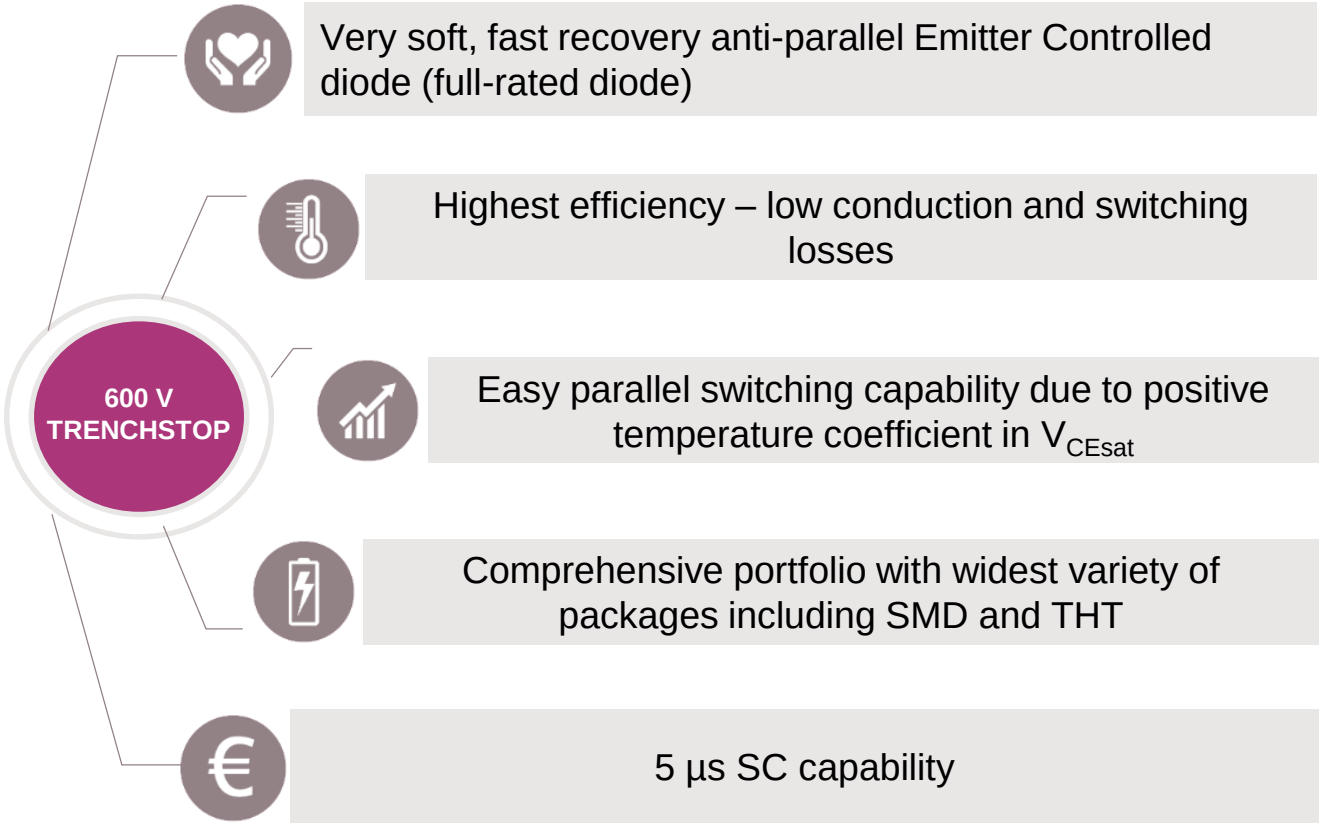
600 V RC-D2 portfolio

Ic 100°C	SOT-223 RC-D2	DPAK RC-D2
1	IKN01N60RC2	
3	IKN03N60RC2	
4	IKN04N60RC2	IKD04N60RC2
6	IKN06N60RC2	IKD06N60RC2
10		IKD10N60RC2
15		IKD15N60RC2

Recommended for washing machine drums

Recommended for washing machine pumps

600 V TRENCHSTOP™



- Very soft, fast recovery anti-parallel Emitter Controlled diode (full-rated diode)
- Highest efficiency – low conduction and switching losses
- Easy parallel switching capability due to positive temperature coefficient in V_{CEsat}
- Comprehensive portfolio with widest variety of packages including SMD and THT
- 5 µs SC capability

600 V TRENCHSTOP™ is perfect for low frequency performance

600 V TRENCHSTOP™ portfolio

Ic 100°C	D²PAK TRENCHSTOP™	TO-220 TRENCHSTOP™	TO-220FP TRENCHSTOP™
4		IKP04N60T	
6	IKB06N60T	IKP06N60T	IKA06N60T
10	IKB10N60T	IKP10N60T	IKA10N60T
15	IKB15N60T	IKP15N60T	IKA15N60T
20	IKB20N60T	IKP20N60T	
Single IGBT			
6		IGP06N60T	
10	IGB10N60T	IGP10N60T	
15	IGB15N60T	IGP15N60T	

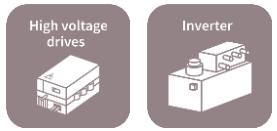
Recommended for washing machine drums

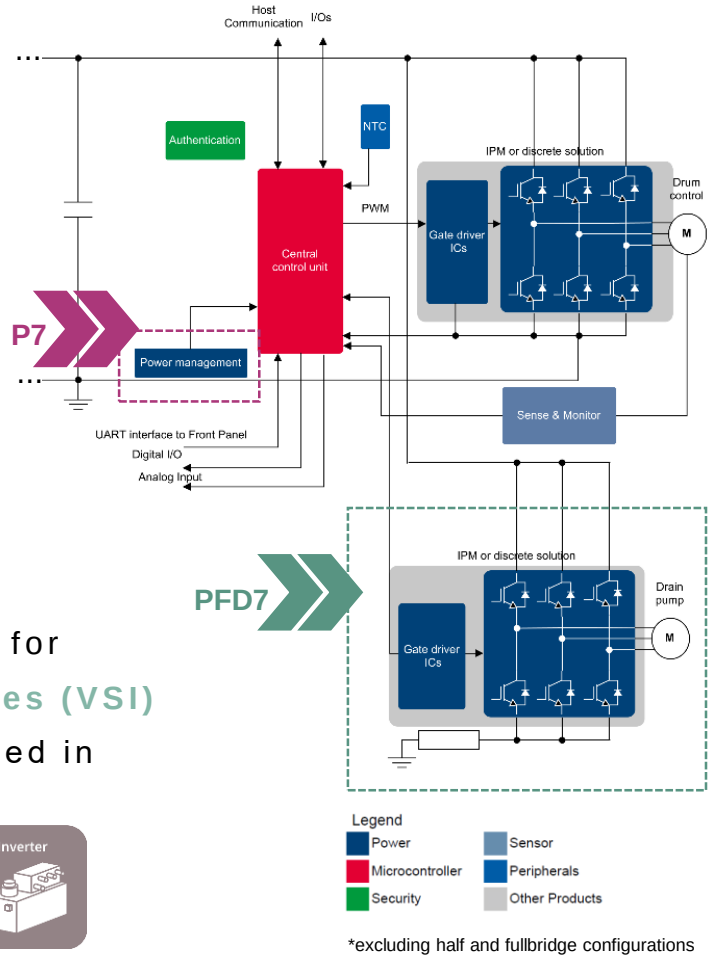
Recommended for washing machine pumps

The unique features of CoolMOS™ 7 SJ MOSFETs address the needs of enhanced energy savings of washing machines

Suitable for **Buck & Flyback topologies*** used in

Suitable for **inverter stages (VSI)** ≤300 W used in





*excluding half and fullbridge configurations

700 - 950 V CoolMOS™ P7

- **Perfect combination** of highest efficiency, excellent ease-of-use and an outstanding portfolio granularity
- Supports **increased switching frequency** to reduce magnetics
- Integrated **Zener diode** for ESD protection ≤ HBM Class 2
- **Price competitiveness** compared to similar technologies

600 V CoolMOS™ PFD7

- Increased design flexibility while maintaining the **industry's fastest reverse recovery time (trr)** optimized for HA motor drives
- Integrated Zener diode for **ESD protection** ≤ HBM Class 2
- **Integrated fast body diode** with ultra low Qrr
  - reduced stress on device while body diode is not fully recovered
  - **extra safety margin** for repetitive hard commutation and **reduced design-in effort**

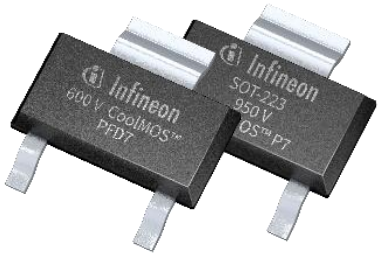
Recommended CoolMOS™ 7 SJ MOSFETs portfolio for laundry machines

Drain pump inverters

Series: **600 V CoolMOS™ PFD7**
Packages: DPAK, SOT-223
$R_{DS(on)}$ max: 1.0 - 2.0 Ω
Examples: IPD60R1K0PFD7S, IPN60R1K5PFD7S

AUX Power

Series: **700 - 950 V CoolMOS™ P7**
Packages: DPAK, SOT-223
$R_{DS(on)}$ max: 0.6 - 4.5 Ω
Examples: IPN80R4K5P7, IPD70R2K0P7S



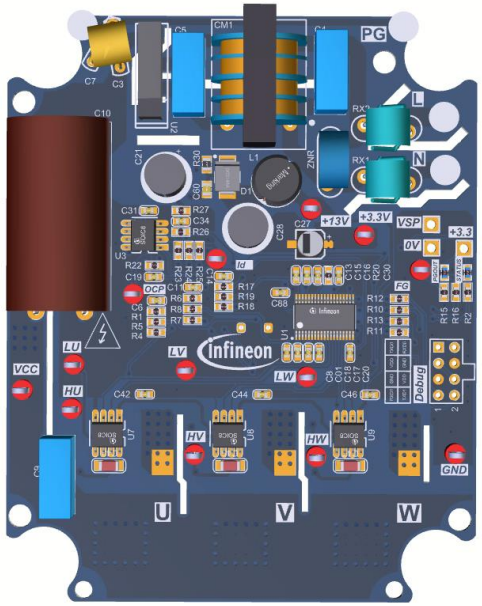
Recommended package

SOT-223, the cost-effective drop-in replacement for DPAK

http://www.infineon.com/p7
http://www.infineon.com/600V-pfd7
http://www.infineon.com/sot-223

Infineon provides state-of-the-art evaluation boards to ensure a fast time-to-market

EVAL_DRIVE_3PH_PFD7



OPN: EVALDRIVE3PHPFD7TOBO1
Learn more: IFX product website

Three-phase inverter power stage with half-bridge gate-driver IC based on 600 V CoolMOS™ PFD7, the latest Infineon's SJ technology with fast body diode:

- **Compact 3-phase motor drive system** up to 100 W
- Designed for **sensorless FOC** motor control
- **Spin your motor** with easy-to-use GUI
- The hardware board and motor control software provides:
  - Synchronous rectification algorithm to reduce reverse-current hard-commutation stress
  - Sensor-less speed controlled direct FOC startup
  - 3PH / 2PH SVM
  - Over-current protection by CTRAP

Summary of benefits

- High efficiency
- Cost effective solution
- Simplified design
- Smooth startup
- Download software free of charge

List of components

- 600 V CoolMOS™ PFD7 (IPN60R1K5PFD7S)
- 2ED EiceDRIVER™ (2ED28073J)
- iMOTION™ microcontroller (IMC101)

5th generation CoolSET™ for auxiliary SMPS

Robustness

- Integrated 700 V, 800 V or 950 V superjunction MOSFET
- Comprehensive protection features
- Auto-restart scheme to minimize interruption

Ease of design

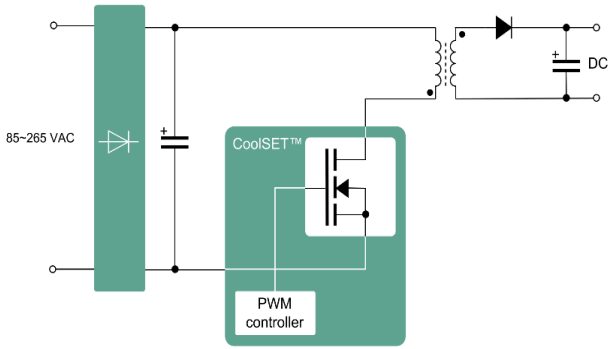
- Numerous design examples
- Design tools, guide and application note
- Reference designs

Broad portfolio

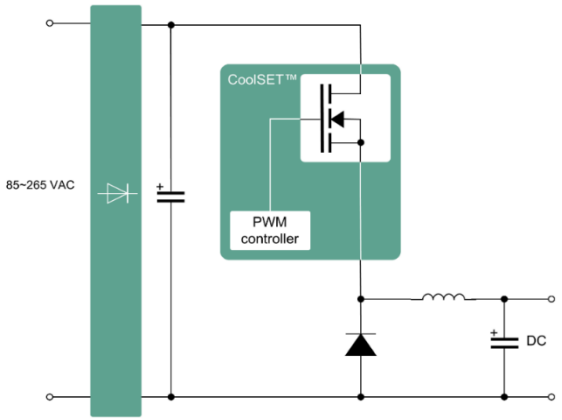
- Choice of fixed- frequency or quasi-resonant switching scheme
- Isolated flyback or non-isolated buck topology
- Highest power delivery up to 43 W
- Available in DIP-7 or SMD DSO-12 package

Auxiliary SMPS in Flyback or buck topology to perform AC/DC power conversion to power the various system blocks in home appliances.

Flyback



Buck



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Heat pumps in dryers

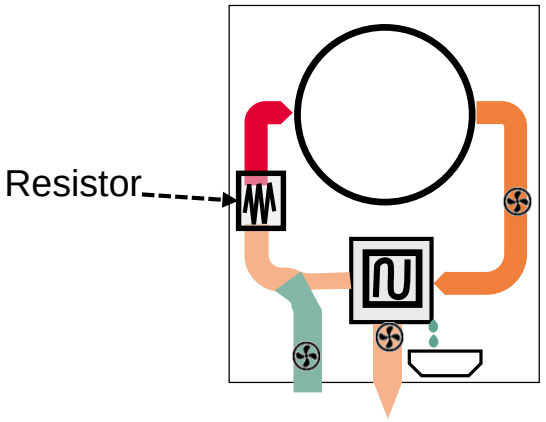
Traditional heating technologies: best case 100% of electrical energy converted to heat (e.g. Resistive heating elements)

100% energy conversion

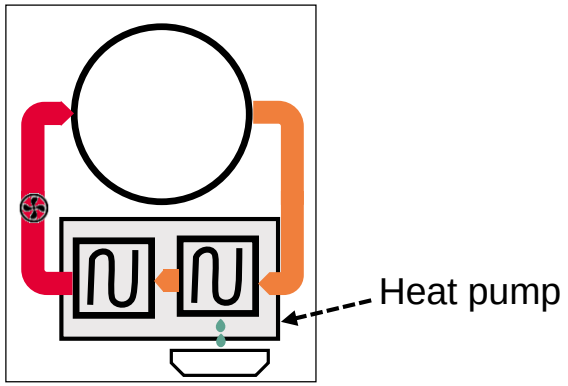
Heat pumps: Can transfer same heat as conventional heating with just a fraction of the electrical energy requirement. Depending on the Coefficient of performance (CoP), heat pump scan be 5 times more efficient than resistive heating.

Up to 500% more efficient

In traditional tumble dryers: hot air used to dry the clothes gets first condensed to remove the moisture and then partially expelled in the ambient. 'New' air is therefore continuosly heated-up by means of resistive heater.

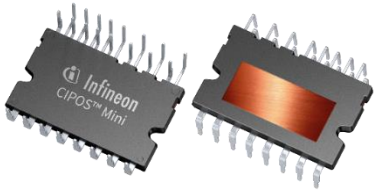


In heat-pump tumble dryers: hot air gets first condensed, as for conventional tumble dryers and it is then completely re-heated by means of the heat pump.



Inverter for heat pumps: Integrated and discrete solutions

Integrated solution



CIPOS Mini
IKCM20L60GD

- Excellent thermal performance
- Higher power capability

Motor Controller:
IMC301

- dual core device
- Incorporates MCE

Discrete solution

Gate Driver:
6EDL04N06PT

- Integrated bootstrap diode
- Over current protection
- Enable and fault reporting

IGBT: RC-D2
IKD10N60RC2

- Monolithically integrated diode
- Cost-optimized solution

Motor Controller:
XMC1402

- Focus on low-cost embedded control applications

PFC

Gate driver:
1ED44175N01B

- Cost and space savings by integrating the comparator
- best-in-class fault reporting accuracy

SiC Diode:
IDW30G65C5

- Improved thermal characteristics
- Lower figure of merit (Q c x V f)

CoolMOS:
IPP60R120P7

- Best-in-class Rdson
- Inherently low gate charge

IGBT:
IKWH20N65WR6

- Lowest VCEsat
- Lowest switching losses

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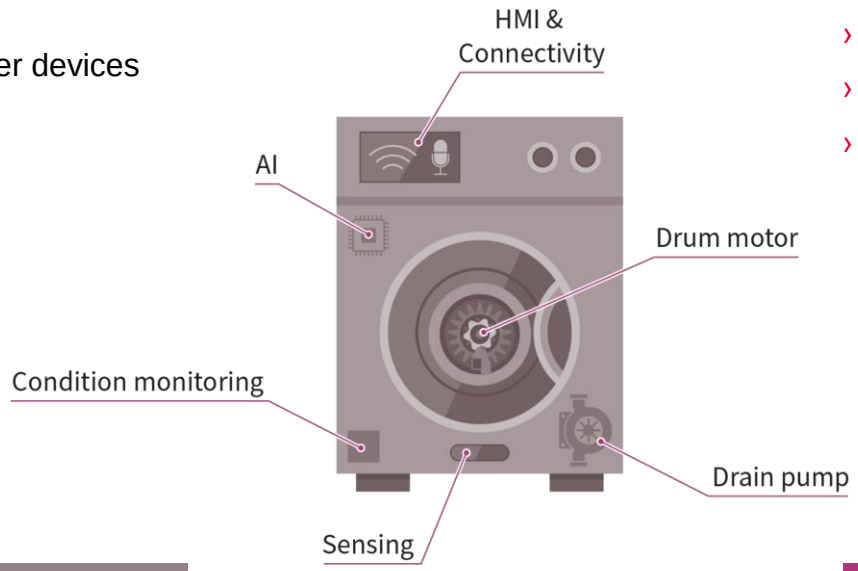
Smart laundry systems: Trends, use cases and Infineon's offering

Connect to the internet for wireless control

- Be informed when program is finished
- Update firmware and download new washing programs
- Remotely turn on washing machine
- Have washing machine communicate with other devices such as dryer



Sense environment, machine and content

- Presence detection: Is someone in the room to interact with?
- Fabric detection
- Weight measurement
- Filter clogging
- Water flow and pressure measurement
- Water level measurement
- Foam detection

Condition monitoring

- Detect defects before they happen to inform maintenance service

User interface

- Intuitive display to control washing machine
- Voice control
- Gesture control

Value proposition AIROC™ connectivity solutions

Wi-Fi® 4	Wi-Fi® 5/6		Wi-Fi® 6
Lowest cost	High data throughput	Congestion/future proof	Low power consumption

Interoperability	Home Appliances must work on all continents: Broadcom is leader in routers and Cypress bought their IoT group. Thus the connectivity components have highest interoperability.
Co-existence	Many applications use BT and Wi-Fi, which can interfere with each other. Our AIROC™ devices have best in class, configurable Co-Existence engines to optimise for multi protocol operation.
Operating system	We support a variety of RTOS solutions including FreeRTOS, MBED OS, etc. We also support Linux and Android natively using our FMAC driver.
Tech support	We have dedicated Applications and Field Applications support locally that can help debug any issues, as well as a large community support site where you can find answers to common questions.
Long distance	Our high RX sensitivity coupled with our tuning for maximum output power per region, offers greater distance and improved coverage over the deployed location, increasing the reliability and performance of the connection.
High integration	Our MCU solutions can drive touch button/screen,whilst also serving as the main control and as a host to the Wi-Fi solution.
End-customer analytics	Product analytics that improve the performance, the reliability and connectivity of the appliance by providing real-time visibility into the performance of the washing machine.

Value proposition of individual AIROC™ products

Wi-Fi® 4	Wi-Fi® 5/6		Wi-Fi® 6
Lowest cost	High data throughput	Congestion/future proof	Low power consumption
Wi-Fi® 4: CYW43439	Wi-Fi® 5 (11AC): CYW4373/E	Wi-Fi® 6/5G: CYW55571/2/3	
› Unique home appliances solution offering Wi-Fi® 4, Bluetooth® 5 and WPA 3 allowing smart home certification (WFA certificate)	› Wi-Fi® 5 dual band (2.4 GHz and 5 GHz) › Capable of beam-forming for increased range › External PA (E-version) on module also increasing range	› Tri-band, (2.4 GHz, 5 GHz, 6 GHz) › Target wake time (TWT): Today router is master, but it allows end device to negotiate with the router when to wake up › Higher modulation schemes: Even higher data through-put	

AIROC™ selection guide

Type	Wi-Fi®		Wi-Fi® + Bluetooth®	BT only	BT (BLE) in µC
µC	Integrated processor	External host	External host	Integrated processor	Integrated processor
SW	Library/Modus Toolbox	Drivers for all major µC available	Drivers for all major µC available	SDK	SDK
Products and functions	Wi-Fi® 4: CYW43907	CYW43364	Wi-Fi® 4: CYW43438/9 › WPA3 security › Voice command	BT 5.0: CYW20735	
	Wi-Fi® 5: CYW54907		Wi-Fi® 4: CYW43012 › Low Power Wi-Fi® + Bluetooth®	BT5.2: CYW20829	
			Wi-Fi® 5: CYW4373/E › Audio/Video Transfer		PSoC™ 63xx › M0+ and M4 › Capsense › Motor Control › Main Control
			Wi-Fi® 6/5G: CYW55572 › Audio/Video Transfer		

Make your washing machine become a part of the smart home eco system with Matter

Matter is a framework that standardizes the protocol regardless of the medium (e.g. Bluetooth). Protocol and stack reside on the MCU.

The biggest global companies came together

c|net

Google, Amazon, Apple back Matter standard so smart home devices cooperate

Smart lightbulbs, door locks, thermostats and other items should be easier to install and interconnect, and Google will upgrade many current products with Matter software updates.

https://www.cnet.com/home/smart-home/google-amazon-apple-back-matter-standard-so-smart-home-devices-cooperate/

Infineon is the leading provider for key technologies

- AIROC™ Wi-Fi® combos
- AIROC™ Bluetooth and Multi-protocol SoCs
- PSoC™ 62 and 64 MCUs
- OPTIGA™ Trust anchor

With a new open-source approach to interoperability

- Today's Smart Home is often too complex, insecure, and incompatible
- Matter enables a smoother and easier experience for consumers (onboarding, control…) and manufacturers
- User interoperability – products from all Matter members should work together
- Strong security

Infineon's support for Matter

- Integration of Matter Open Source and Open Thread into Modus Toolbox
- Customers can integrate using these tools for AIROC™ Wi-Fi® combos
- Security will be integrated into SoC to offer options of internal or external security processor for maximum flexibility
- Long term assurance across Wi-Fi® and 15.4 products

Develop highly capable graphics and deploy to PSoC 6 with Embedded Wizard

Accelerate Graphics Development on PSoC 6

Embedded Wizard Studio Powering PSoC 6 Graphics

- No royalties, just tool license
- Reduces lines of code to write
- Wide range of code examples

What Features are available

- Embedded Wizard Studio allows the deployment of graphics onto the device without writing any code
- Has callbacks* which can be used to link touch and voice
- Very low resources used meaning a very low footprint
- With hardware modification, supports DMA** mode for better refresh rate

* Multiple user touch points
** Direct Memory Access: A method of moving data across CPU peripherals.

Getting Started Links and Collateral

- For information on the product, please visit:
  - https://www.embedded-wizard.de/platforms/infineon-psoc6
- For getting started visit, please visit
  - https://doc.embedded-wizard.de/getting-started-psoc-62s2
- Also supports the Smart Home Reference Design

Touch control: Implement touch with the leading provider of touch solutions

Replace mechanical buttons

Implement touch screens

1 Replace mechanical buttons with the world's easiest touch solution — MBR3 – configurable touch controllers

2 Complex touch HMI interfaces in single MCU platform with connectivity — PSoC™ 4 touch controllers

3 Dual-core high performance touch solution with IoT edge compute capabilities — PSoC™ 6 touch controllers

Why use Infineon touch solutions in your appliance?

Proven	› #1 provider of touch solutions for many years
Most robust solution	› Water tolerance – Even works with wet fingers › Works in the noisiest environments
Most sensitive solution	› Appliances usually have thick plastic overlays. The sensitivity of our solution allows you to sense more accurately than any other solution out there.
Ease of integration	› The SmartSense tool helps you to layout your PCB. It will sense the size and the capacitance of buttons to make implementation easy.
Touch on metal	› The inductive sensing (MagSense™) technology enables sensing of metal objects (e.g. proximity) . A single chip to support hybrid sensing advanced HMI.
High integration	› We offer a wide variety of integrated features such as wired and wireless connectivity, audio and additional compute capabilities for IoT edge

Main security concerns for our customers

Identity protection against **fake devices**

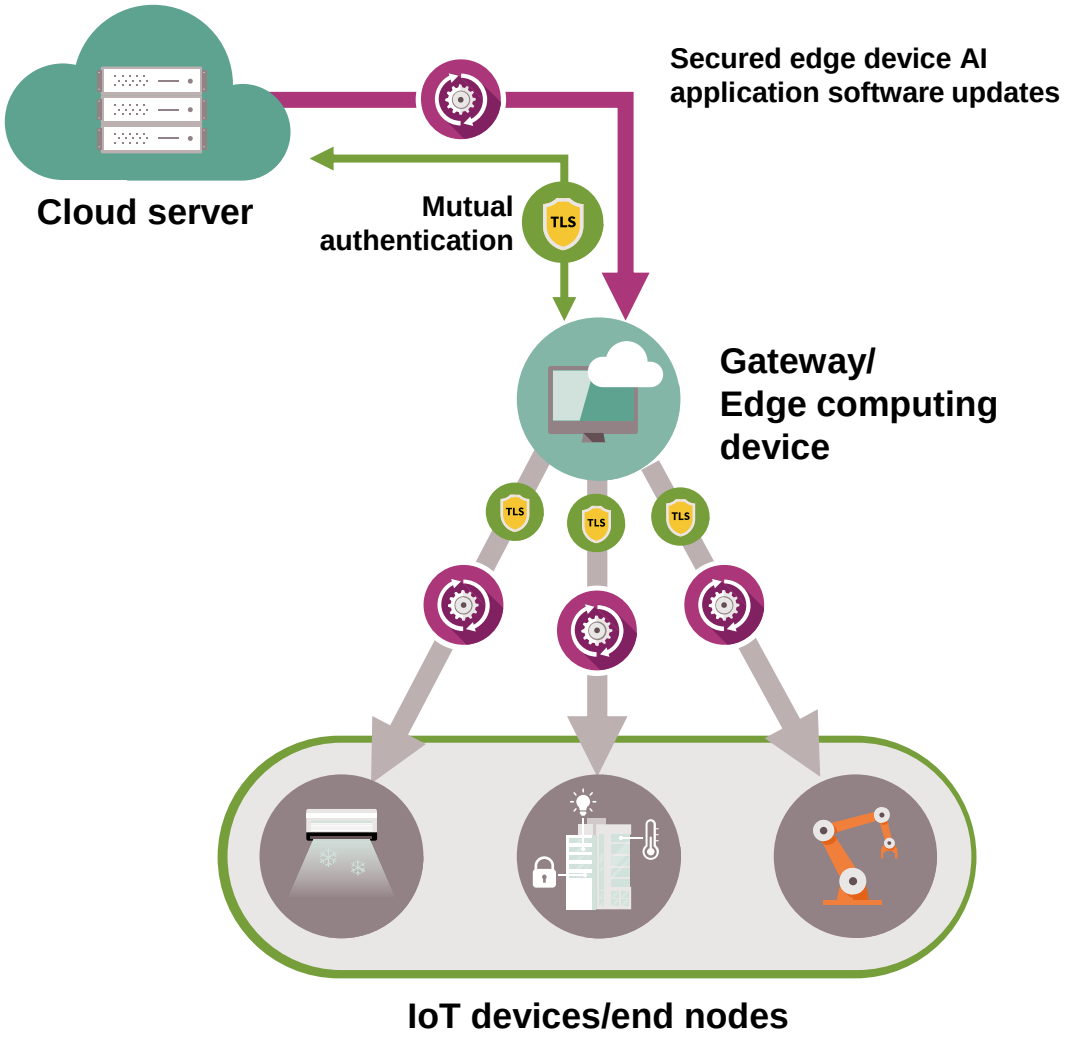
Protection against **eaves dropping**

Protection against **the manipulation of the data**

Protection against **illegal update of firmware**

Don't let your smart laundry system be the weakest point in the system.

OPTIGA™ Trust M – Protecting the IoT from cloud to end nodes



TLS **Secured connectivity**

Secured cloud authentication

Secured software update over-the-air

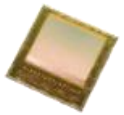
Value proposition OPTIGA™ Trust family in washing machines

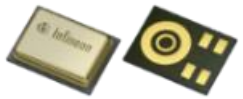
Shorter time to market	› By using Infineon's PKI* infrastructure including root CA and HSM infrastructure certificate authorities you are able to drastically reduce your cost and effort for your smart air con system.
Cost reduction	› With Infineon's OPTIGA™ Trust solution you are able to make use of a one-stop-shop turnkey solution which perfectly matches future requirements of smart air con systems.
Zero touch provisioning	› With Infineon's optimized processes you get the ability for easy certificate based device registration to all major cloud service providers. It is an automated cloud provisioning of your smart air con without your involvement.
Protection	› Infineon's OPTIGA™ Trust family provides an anchor of trust for connecting your smart air con device to the cloud, protects your critical data transferred over your network and thus your application running on your smart air con.
Future proven	› As the #1 supplier in embedded secure elements we are able to professionally solve our customers' biggest problems and concerns even in difficult security relevant areas like industry or automotive.

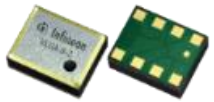
*) PKI = Public Key Infrastructure

Devices become smart by imitating human senses

Radar	Presence detection	Material detection	Speed	Weight, vibration, imbalance and liquid flow	Lid open/ closed	
				Air quality measurement	CO_2	
ToF	Track people Count people Gesture sensing		Listen to user's voice command Noise anomaly detection	Detect clogged filter		
			MEMS microphone	**Pressure**		







Our wide sensor portfolio enables smart home appliance use cases

	Sensors				
	Radar	**Microphone**	**Pressure**	**CO_2**	**Magnetics**
Unique selling propositions	Plug and Play for motion detection	Highest SNR to detect voice in noisy devices and from long distances	Very rugged (IPX8 certified) even for A/C outdoor use	Plug & Play: Direct data output	Smallest 3D Hall sensor in the market in WLB package
	Proven reliability: First radar in a consumer product	Global market leader	Small size	Highest performance/ data quality	Broadest portfolio in the market: Hall switches and latches 3D, Linear Hall and angle sensors
	Ongoing A/C and fridge projects		World's best resolution	Smallest form factor	High end to cost efficiency – all products provide benchmark quality at their level

Interact with user with XENSIV™ radar solutions for presence detection

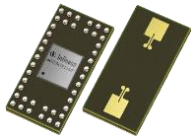
Determine if a person is present in the room, even if the person is not moving

Example: Interact with user approaching washing machine

Sense presence up to 10 m (very high sensitivity, even recognizes breathing and tiny motions)

Sense motion up to 10 m without using a microcontroller

BGT60TR13C for highest sensitivity



BGT60LTR11AIP for lowest cost, motion detection

Infineon offer

- Software solution and turnkey solution available for high-end presence detection
- 60 GHz with integrated antennas to reduce design-effort

Door contact, weight and imbalance measurements using XENSIV™ hall sensors

Determine open/close of door, drum load and imbalances

Example 1: Door Contact – disable door opening while in operation (Hall Switch)

Example 2: Detect drum load and imbalance (Hall Switch, 3D)

Smallest 3D Hall sensor

Infineon offer

Hall

- Contactless measurement principle minimizing wear and tear
- Better design flexibility as with mechanical/resistive solution

3D

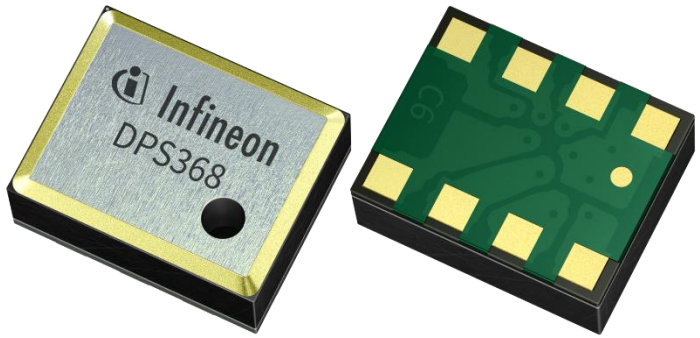
- Improved mechanical design flexibility with 3D hall technology
- Push and rotation functionality with a single sensor (e.g. HMI interfaces)
- 3D sensor in WLB package: Extremely small size, slim PCB design, high design flexibility (lateral, vertical)

- Software modules supporting XMC™ and PSoC™

Detect filter clogging with XENSIV™ pressure sensors

Detect if filters are clogged to alert user or inform maintenance service

Example: Pressure sensor detects if filter is clogged



Infineon offer

- Software solution and turnkey solution available for high-end presence detection
- IPX8 certified for additional robustness (water, dust, humidity)
- High precision and accuracy:
  Precision: ±0.002 hPa
  Rel. accuracy: ± 0.06 hPa
- Small size

XENSIV™ – magnetic switch applications in washing machines

Position / level sensing	Motor commutation	Speed and direction
› Door position	› Water pump	› Rotating drum
› Load detection	› Drum motor	
› Dial position	› Heat pump	
› Flow meter	› Circulation pump	
› Detergent/water level		
› Inlet/drain valves		

Sensor solution

TLx4961/4/8-xM/xL
Family of magnetic switches and latches in standardized leaded and SMD packages

TLx4966-xG/xL
Speed and direction detection in one sensor

Customer value

Contactless, reliable and cost-efficient sensor with wide operating temperature range

Please see presentation „XENSIV™ - magnetic switch sensor solutions for home appliances" on our appliances website for more details

Tank and water level measurements using XENSIV™ sensors and CapSense® technology

Determine fill rate of water tank or drain pan

Keep water from overflowing, stop water inflow or inform the user accordingly.
Water tanks for the water dispenser at the right level
Avoid water leakage from the drain pan

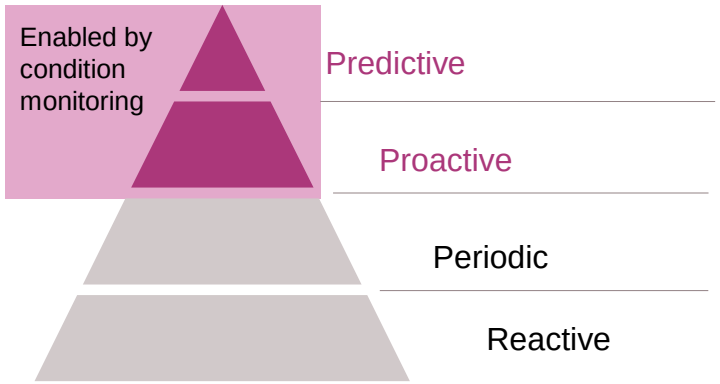
Infineon offers several options to detect water depending on your needs

Infineon offer

- CapSense® Liquid Level Sensing Shield (Link)
- XENSIV radar sensor
- MEMS microphone for ultrasonic measurements

Condition monitoring and predictive maintenance

Predictive maintenance can help **prevent failures** before they happen by **monitoring a device's condition.**



Detect and fix defects at an early stage and use advanced analytics to predict machine failures before they happen	Additional business value
Fix the machines when the equipment is down or have scheduled maintenance in place	Traditional approach

Infineon offering

XENSIV™ DPS368 Barometric Pressure Sensor	› **Air flow measurement** in the system
XENSIV™ TLI4971 Current Sensor	› **Current measurement** at fan and compressor
XENSIV™ TLI493D-W2BW 3D Magnetic Sensor	› **Position monitoring** of components
XENSIV™ TLx496x Hall Sensors	› **Open/close lid detection**
XENSIV™ TLI4966G Double Hall Sensor	› **Speed & direction monitoring** of components
XENSIV™ TLE4997E2 Linear Hall Sensor	› **Linear movement and vibration**
XENSIV™ PAS CO2 Sensor	› **CO_2 level monitoring** for indoor quality monitoring
XENSIV™ IM69D130 MEMS Microphone	› **Noise monitoring** at motor and compressor
PSoC™ 6, PSoC™ 4, XMC4000	› **Data processing and system management**
OPTIGA™ Trust M	› **Secured connection & communication**
Wi-Fi® and Bluetooth Combo controller	› **Connectivity for remote management**

Infineon, AWS and Klika Tech developed a joint evaluation kit for enabling predictive maintenance in HVAC systems

- Kit includes different **set of sensors** including microcontroller and embedded security **for holistic condition monitoring** of HVAC systems

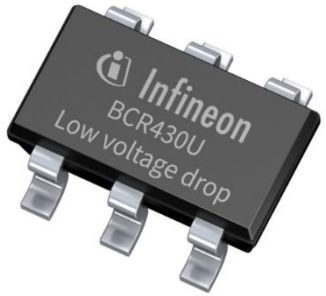
- Infineon's **hardware content:**
  - Pressure sensors
  - MEMS microphones
  - 3D magnetic sensors
  - Hall sensors
  - Current sensors
  - Microcontroller
  - Embedded security solution

- **All required software** for a basic setup of collecting data at the edge, preprocessing it and sending it to the AWS Cloud is part of the kit
  - https://github.com/Infineon/pred-main-xmc4700-kit

- AWS CloudFormation template and Quick Start guides **simplify setup** for testing

- Kit **ideal starting point** for customization and next steps towards a final solution for production

UV-C LEDs can eliminate bacteria and viruses to equip washing machines with water purification functions



- UV-C LEDs sterilize airborne contaminants such as bacteria and viruses by disinfecting the surface of the evaporator
- Infineon offers the optimal LED driver ICs for UV-C LEDs

Value proposition

- Constant current enables **homogenous light** output
- Controlling the UV-C LED current ensures **long lifetime** of the UV-C LEDs and the entire product
- Current reduction at increasing ambient or UV-C LED temperature enhances the **reliability** of the UV-C LED product
- Compared to discrete constant current circuits BCR ensures a pretested **easy to use** and cost effective device
- Best solution for space-constrained UV-C LED applications
- Best solution to drive multiple UV-C LEDs

Part of your life. Part of tomorrow.