

Residential Aircon
Application and product overview

February 2023

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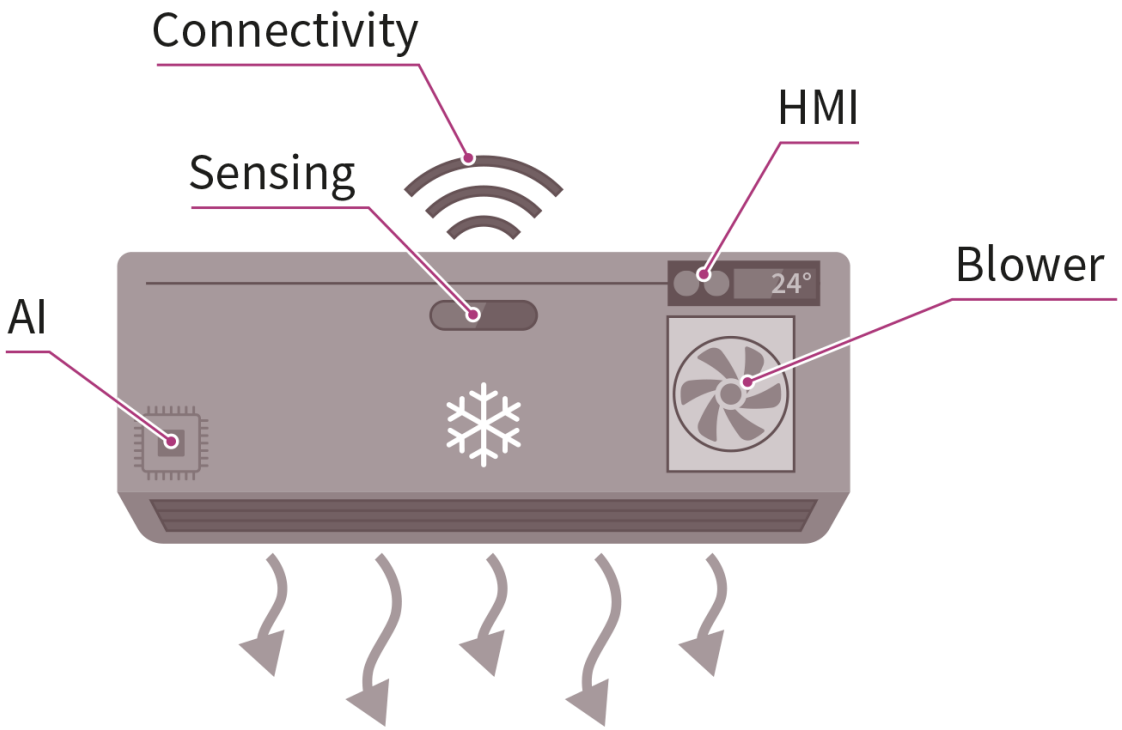
The application residential air conditioning

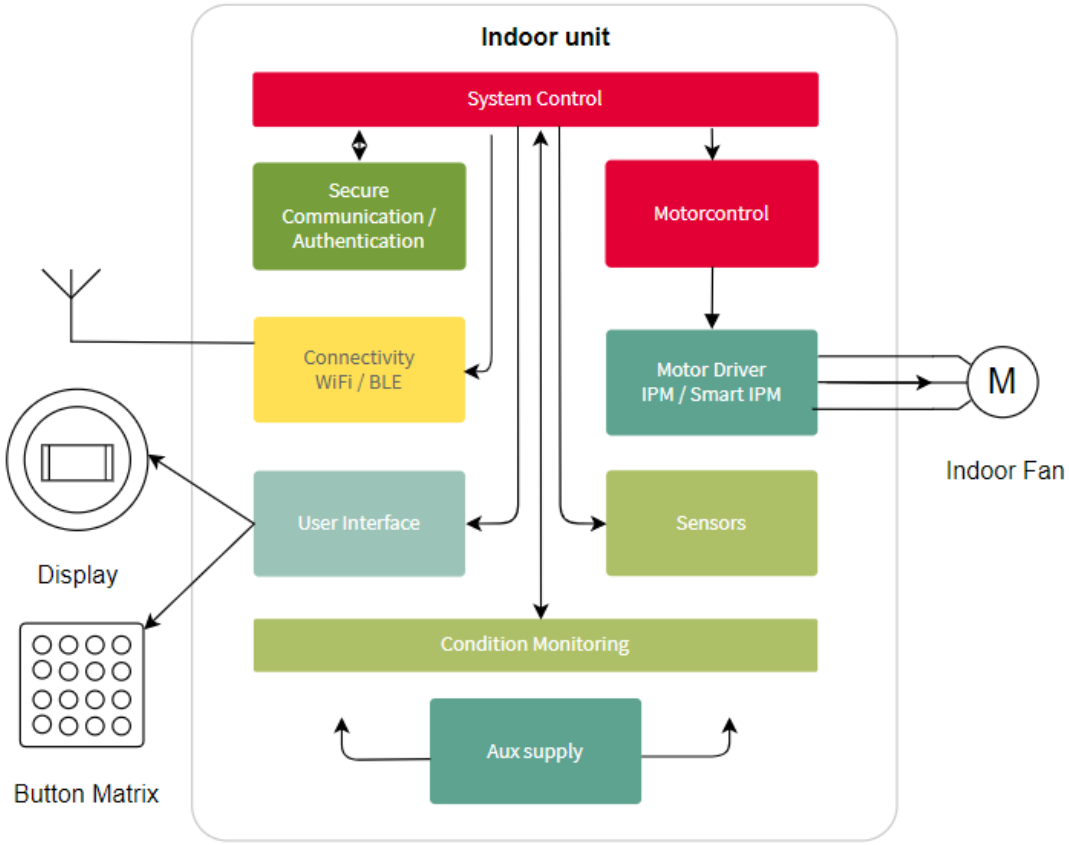


Residential air conditioning helps to control temperature, humidity and air quality in our living spaces, contributing to quality of life.

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Residential aircon indoor unit – Overview



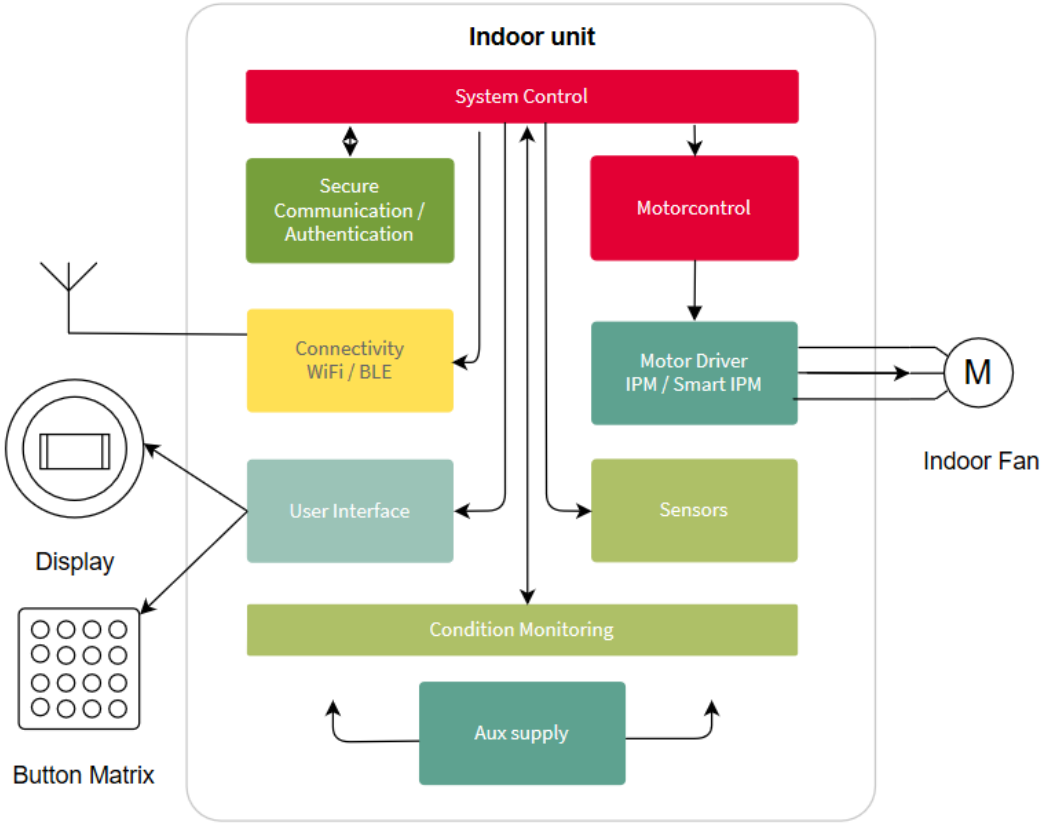


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Residential aircon indoor unit – Key functional blocks

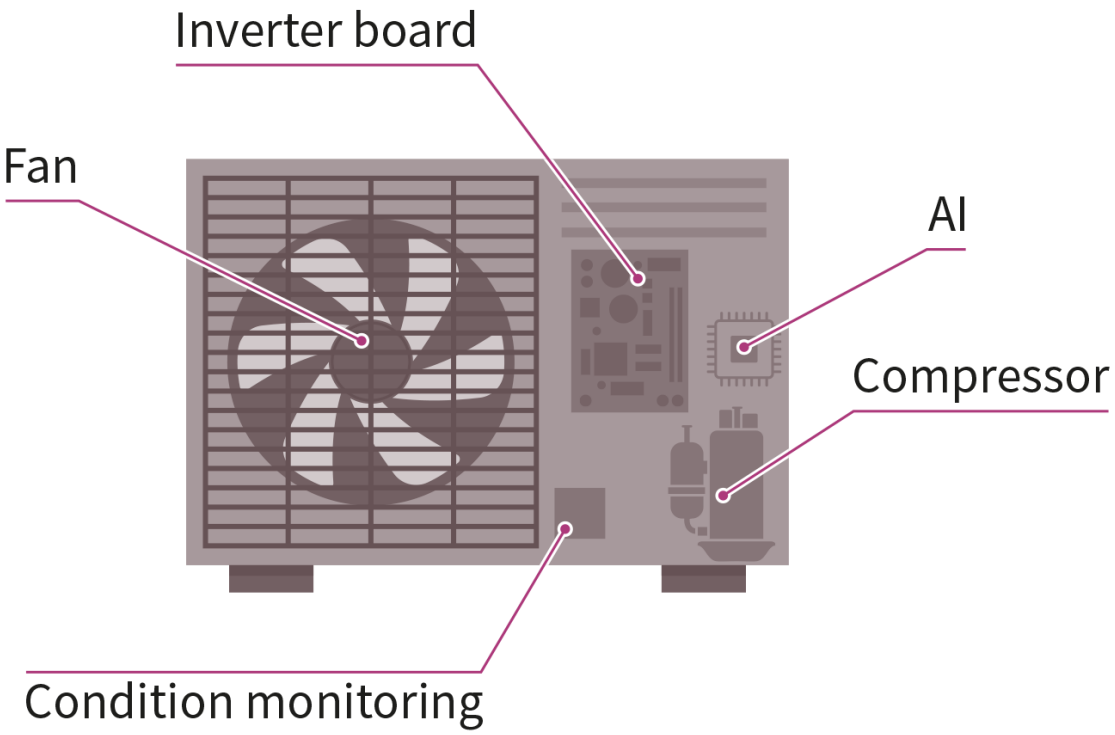
Functional block	Technical description
Indoor fan motor drive	› Variable Speed Drives (VSD) used in IDU fan to control AC motor speed and torque by varying motor input frequency and voltage › Typical power rating: 30 – 100 W
Indoor fan motor control	› An embedded MCU governs the operation of VSD. Basic programming of MCU is provided as firmware to control, protect and monitor the VSD and motor system
System control	› An embedded MCU governs the RAC system operation including motor control, security, connectivity, user interface, aux, and sensors
Connectivity	› Connecting the air-con to the internet or appliances network via Wi-Fi® › Securing the connection to the cloud and protection against counterfeited filters
User interface	› Remote control, thermostat, display or voice control allowing human machine interaction
Sensors	› Sensors to monitor the state of 1: Motor control loop, 2: System e.g., filter usage, 3. Room environment, e.g., air quality or people tracking
Condition monitoring	› Monitor the state of health of the RAC system with the collected sensor data or MCU processing data
AUX supply	› Providing auxiliary control power demand, typically to power up the gate driver, cooling system, sensing, control and communication unit

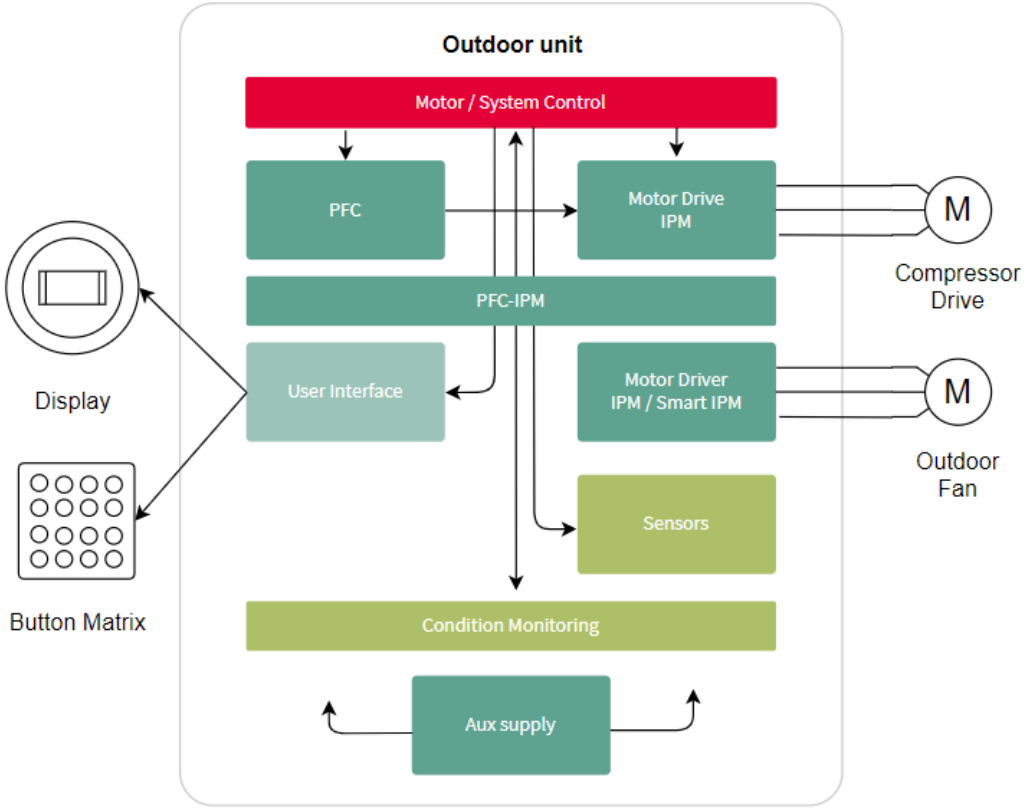
Functional block diagram



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Residential aircon outdoor unit – Overview



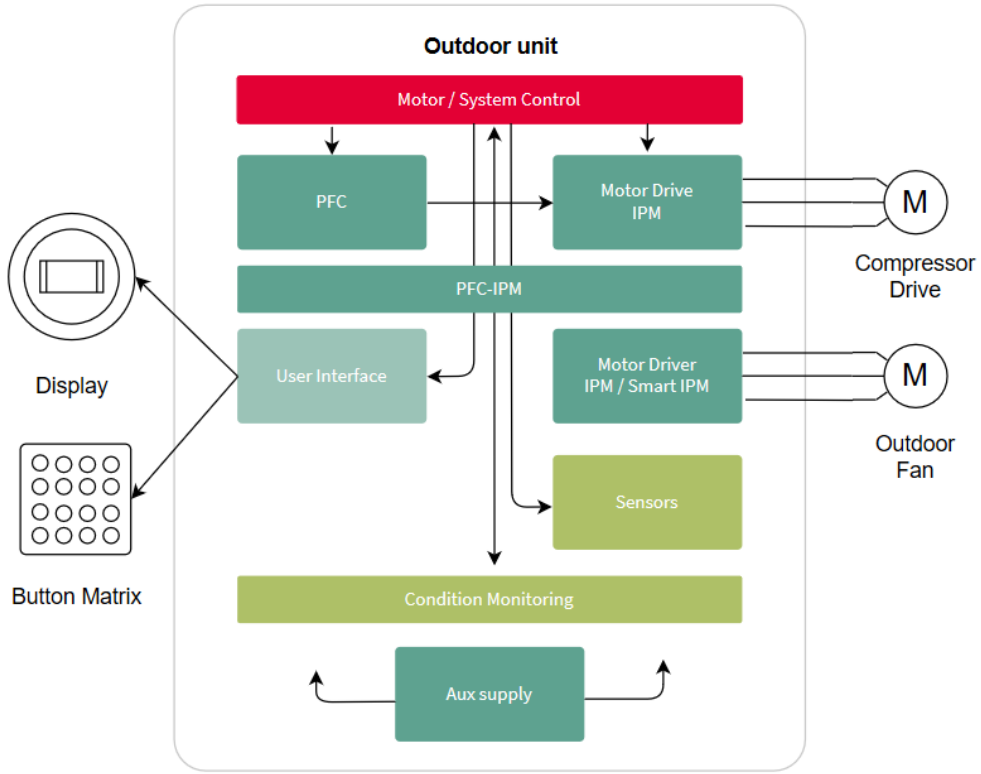


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Residential aircon outdoor unit – Key functional blocks

Functional block	Technical description
Compressor motor drive	› Variable speed drives used in ODU compressor to control AC motor speed and torque by varying motor input frequency and voltage › Typical power rating: 0.5-3 kW with cooling capacity of 0.75-3 hp
Compressor PFC	› Power factor correction (PFC) of compressor motor drives improves the line-side power factor and provides a stable DC bus voltage for the drive. PFC is required when power rating is larger than 1kW.
Outdoor Fan motor drive	› Variable speed drives (VSD) used in ODU fans to control AC motor speed and torque by varying motor input frequency and voltage › Typical power rating: 60-150 W
Motor/System control	› An embedded MCU governs the RAC system operation including motor control, security, connectivity, user interface, AUX and sensors
Condition monitoring	› Monitor the state of health of the RAC system using sensor- or MCU processing data

Functional block diagram



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Residential aircon – Product overview

Compressor



- **Motor Controller:** PSoC™, XMC™ and iMOTION™ family
- **Inverter (IPM)**: CIPOS™ Mini , CIPOS™ Tiny IM323
- **Inverter (Discrete):** IGBTs (IGBT 6 & RC-D series), EiceDRIVER™ gate drivers ICs (half bridge and 3-phase drivers)
- **PFC**: TRENCHSTOP™ 5 IGBTs, CoolSiC™ hybrid discretes, Rapid and CoolSiC™ diodes, CIPOS™ Mini IPMs and PFC gate drivers
- Pressure **sensor** for precise & quick cooling
- **Auxiliary power**: CoolSET™/5QR series

HMI & connectivity



- PSoC™ 6 for **main control, touch sensing and display**
- Bluetooth / Wi-Fi **connectivity** using our AIROC™ solutions
- XENSIV™ MEMS microphone for **voice control**
- OPTIGA™ Trust M for **secured communication**

HEPA filter



- OPTIGA™ Authenticate S for **authentication**
- Pressure sensor to detect if filter is blocked

Outdoor unit

Indoor unit

Outdoor fan



- **Inverter (IPM)**: CIPOS™ Micro
- **Inverter (Discretes)**: IGBTs (IGBT 6 & RC-D series), EiceDRIVER™ gate drivers ICs (half bridge and 3-phase drivers)

Indoor fan



- **Inverter (IPM):** iMOTION™ IPM, CIPOS™ Nano
- **Inverter (Discretes):** IGBTs (IGBT 6 & RC-D series), EiceDRIVER™ gate drivers ICs (half bridge and 3-phase drivers)

Sensing



- Radar Sensing for presence and people tracking
- CO_2 sensing to increase air quality
- Position sensor for flap control

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Residential aircon – Focus products

	Selected product families	Key value
Power stage	**CIPOS™** Mini 3-phase inverter, PFC + Inverter series **CIPOS™** Tiny IM323-L6G IPM / Reverse Conducting RC-D2	Highest power density and efficiency
Motor control	**iMOTION™** IMC300A dual core motor controller with Class-B certified Motion Control Engine/XMC™/PSoC™	Full set of features and protections, fast time to market
Power factor correction	**TRENCHSTOP™** WR 5/WR6 IGBTs, Rapid and CoolSiC™ diodes for power factor correction	High power density and low EMI
Smart home system	**PSoC™** 6 family of dual core microcontrollers M4/M0+ with ultra low power and high performance	Full feature set and IoT security
Connectivity	**AIROC™ Wi-Fi® + Bluetooth®** combos up to Wi-Fi 6, with integrated support for Matter 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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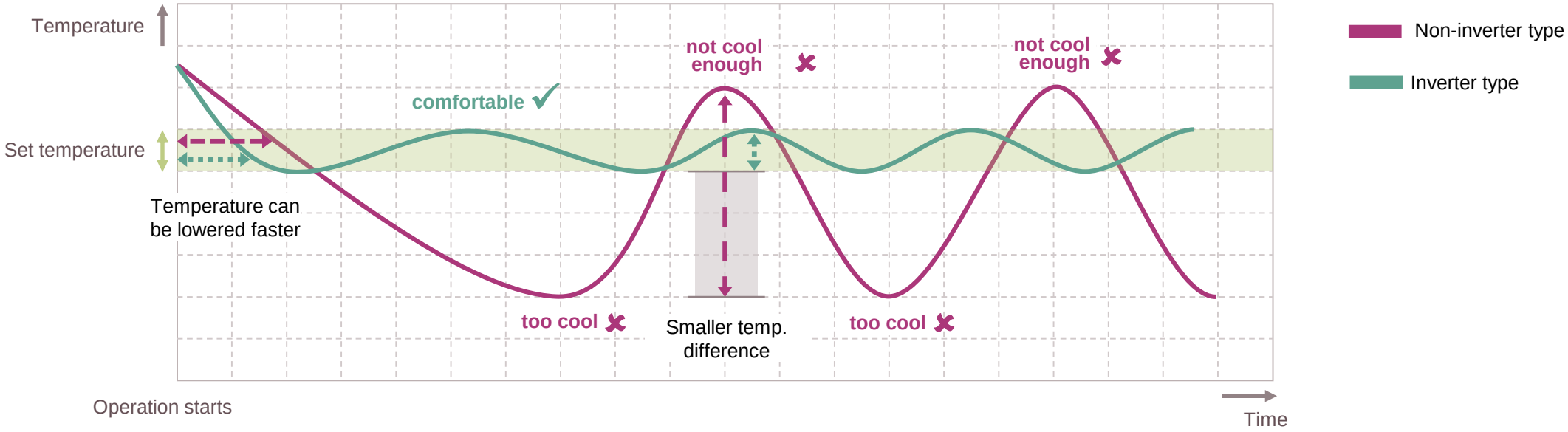
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Inverterization helps air conditioners to achieve optimum performance while saving energy

Inverter technology controls the speed of the motor, finely tuned according to the required load conditions

- Smaller variations of temperatures and optimum comfort
- Reduction of electricity consumption



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High-level view on the inverter

Motor controller	Gate driver
Regulates speed and torque of motor by manipulating voltage and current	Amplifier that accepts low power input from a controller to produce the high current gate drive for a switch
Power switch – IGBT or MOSFET	**Power Factor Correction – Switch-Diode-Inductor**
Controls current in the motor through on-off operation	Improves power factor thus reducing load on the electrical distribution system & increasing energy efficiency

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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>
</table>

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. 30 A IPM is required for a BLDC blender because peak current is higher than in normal motor applications

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

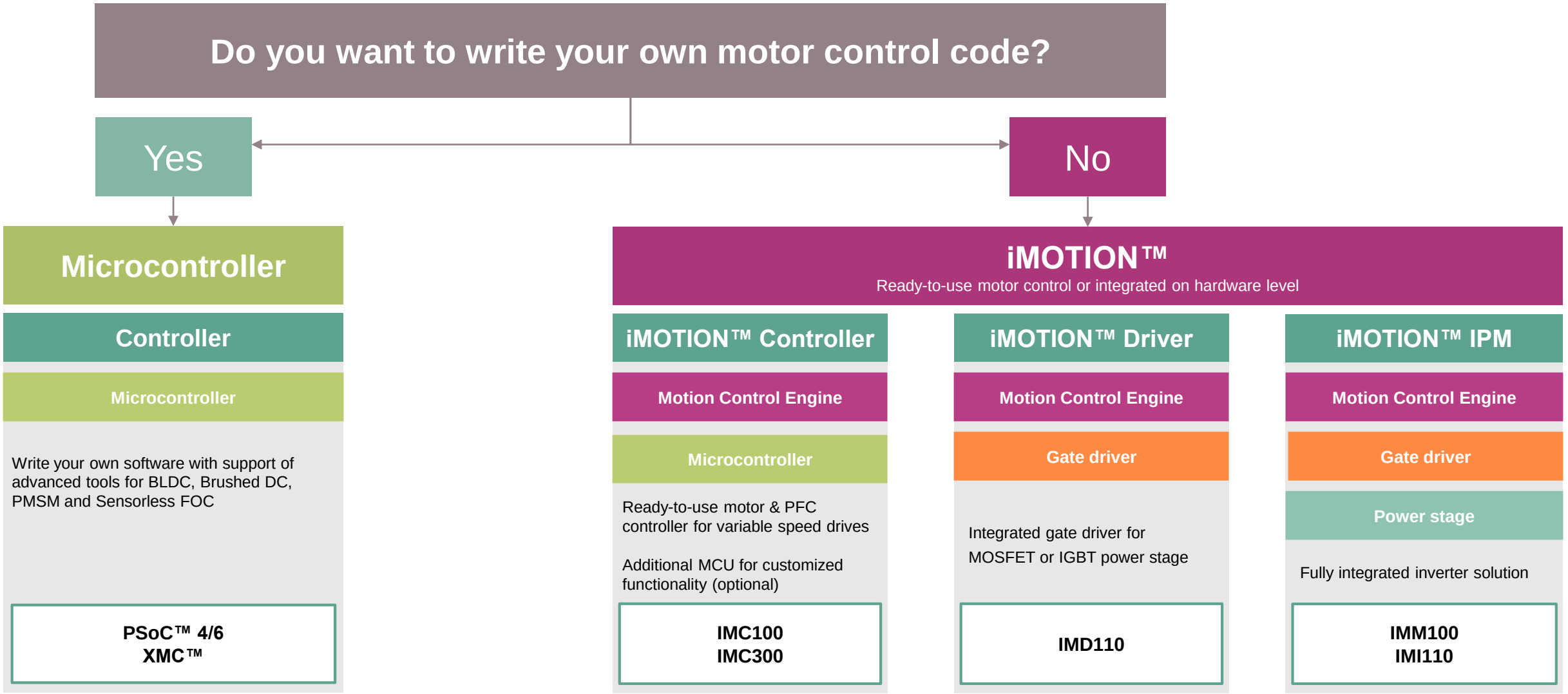
e.g. switching frequency, power rating, PCB space constraint, assembly process, heatsink-less, multi-source, efficiency, EMI performance, price, high or low voltage motors, internal thermal sensor, control algorithm

Evaluation or simulation results per each application

e.g. loss simulation

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Motor Control: iMOTION™ or microcontroller?



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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 › 5 V supported by XMC1000 series
Ready-to-use, highly integrated motor control	**iMOTION™**	› Integrates all the control and analog interface functions required for sensor-less or hall-based FOC › Eliminates software coding from the motor control algorithm development process

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Infineon microcontrollers for home appliances

	XMC / PSoC™	iMOTION™
	Solution Ready MCU	SW/HW Integrated ASSP
Applications	All applications (HMI, System Control, Motor + PFC)	Motor + PFC

Roadmap / Portfolio

Performance approach

- **PSoC™ 6**
  Cortex® M4/ M0+M4
- **XMC™ 4000**
  Cortex® M4
- **XMC™ 1000**
  Cortex® M0
- **PSoC™ 4**
  Cortex® M0/ M0+

Integration approach

- **iMOTION™ IPM**
  MCE **+ 600 V GD + Power Stage**
- **iMOTION™ Driver**
  MCE + **600 V Gate Driver**
- **iMOTION™ Controller**
  MCE

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PSoC™ selection guide for residential aircon

	Main control	Connectivity		HMI			Display drive		Motor Control			Additional features	Software
		BT	Wi-Fi®	Button	Display LCD	Display TFT	Display LCD	Display TFT	Fan CTRL	Dual + HFPFC	Com-pressor		
PSOC™ 4000S/ 4100S	Only PSoC™ 4100S			< 7"			✓		4100S				PSoC™ creator
PSOC™ 4100 Plus/ Max	✓			< 7"/9"			✓				LF PFC	2 Capsense blocks	PSoC™ creator/ Modus toolbox
PSOC™ 4500S											HF PFC		PSoC™ creator/ Modus toolbox
CY8C62x4/5	✓	Host for Wi-Fi®		✓			✓	< 7"				Security (PSoC™ 64)	Modus toolbox
CY8C63x6/7	✓	BLE		✓			✓	< 7"				Security (PSoC™ 64)	PSoC™ creator/ Modus toolbox
CY8C62xA/8	✓	Host for Wi-Fi®		✓			✓	< 7"				Security (PSoC™ 64)	PSoC™ creator/ Modus toolbox
PSOC™ 4500H										✓			Modus toolbox

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iMOTION™ selection guide for residential aircon

	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

*targeting IDU fan

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What is iMOTION™?

Software integration

- **MCE**
  Motion Control Engine
- **Scripting engine**

+

Hardware integration

- **Controller**
- **iMOTION™ Driver**
- **iMOTION™ IPM**

+ **MADK and Reference Designs**



+ **Development tools and documentation**



With the objective of making it….

- **Easier to use than ever!**
- **Faster and cheaper to market!**

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iMOTION™ solution platform dedicated to motor and PFC control

Right-fit products and highest functional integration

Hardware integration	Motion Control Engine
From controller to full inverter in one package	MCE – Ready-2-use motor and PFC control algorithm

- iMOTION™ controller
- iMOTION™ driver
- iMOTION™ IPM

+ Less components
+ Reduced PCB space

+ Minimized SW coding/test
+ Less certification effort

System cost reduction

Fast time to market

Less R&D spending

Markets



Major and small home appliances



Industrial pumps and fans



Motion for building automation

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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

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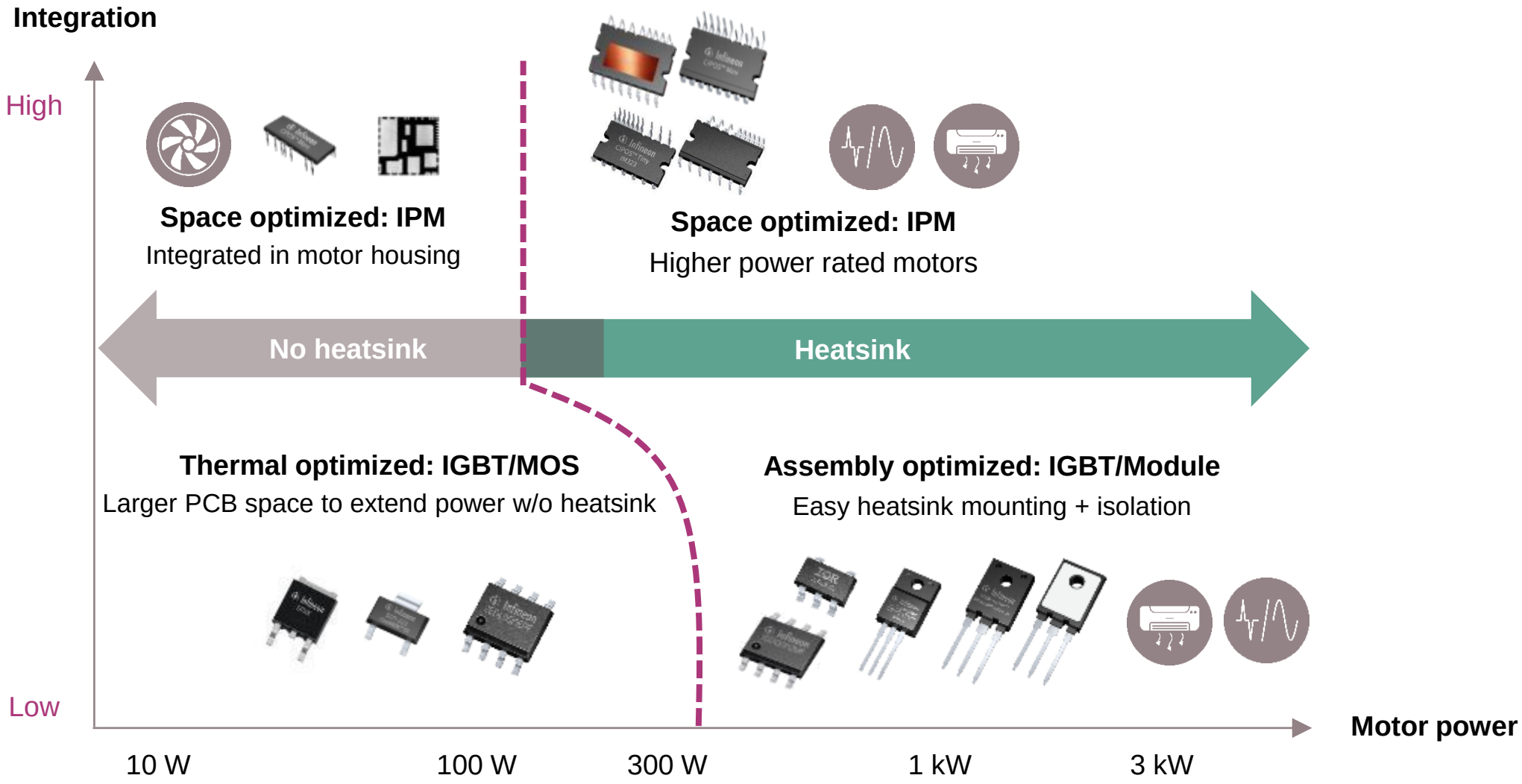
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Power stage and Power Factor Correction (PFC) – Discrete or integrated



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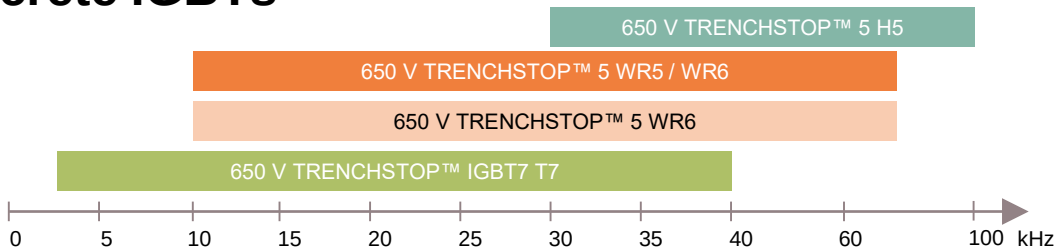
Power factor correction – Topologies

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

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Power factor correction – Discrete IGBTs and silicon diode solutions

Discrete IGBTs



No SC rating

TRENCHSTOP™ 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

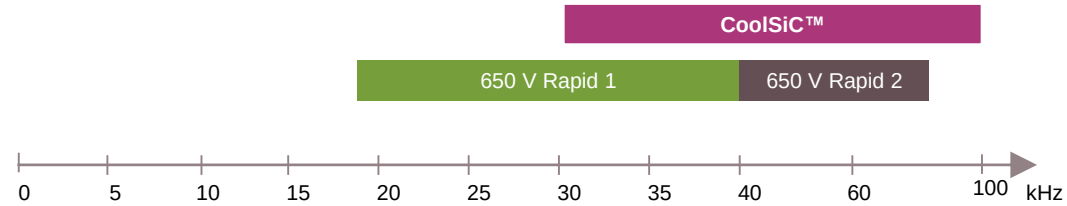
RAC PFC application optimized IGBT
Monolithic diode optimized for PFC applications
Excellent thermal performance enables reduction in heatsink and cooling cost
WR6:Improved reliability against package contamination due to high clearance & creepage package
Portfolio WR5: 30 A-50 A, TO-247-3 pin
Portfolio: 20 A-70 A, TO-247-3 pin in HCC package

SC rating

IGBT7 T7

Benchmark low-medium frequency IGBT
Benchmark low V_{CEsat} and low V_F IGBT
Enhanced controllability for better EMI
Humidity robust design
Portfolio: 30 A-50 A, TO-247 3 pin

Silicon and CoolSiC™ 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 hyper-fast 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, diodes run the coolest among SiC diodes
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

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Motor Drive and PFC product overview – Intelligent Power Modules (IPM)

Indoor unit fan

CIPOS™ Nano

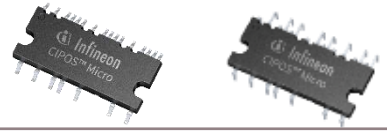


Dimension [mm]	8x9 / 12x10 / 12x12
Configuration	Half-bridge / 3-phase
Voltage Rating	250 V, 500 V
Rdson max.	0.15 – 6.0 Ω

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

Outdoor unit fan

CIPOS™ Micro



Dimension [mm]	29x12x2.9
Configuration	3-phase
Voltage Rating	600 V
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

Compressor

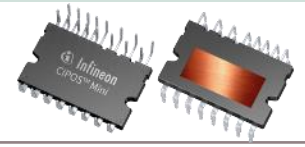
CIPOS™ Tiny



Dimension [mm]	32.8x18.8x3.6
Configuration	3-phase
Voltage Rating	600 V
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



Dimension [mm]	36x21x3.1
Inverter	600 V 10-30 A
PFC + Inverter	600 V 10, 15, 20 A
Interleaved PFC	650 V 20, 30 A

- Rugged SOI gate driver technology
- High integration (bootstrap circuit, thermistor, single boost PFC)

Benefits

- Fast time to market
- System cost savings from smaller footprint and reduced PCB space
- Improved efficiency and power density
- UL certified package and temperature sensor

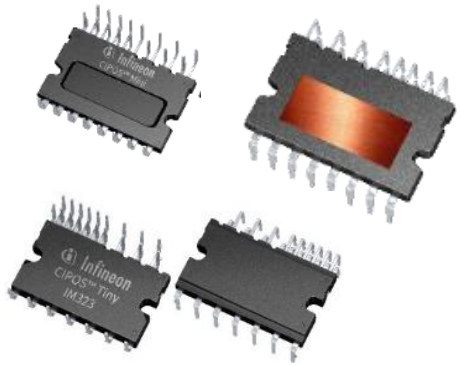
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Power Stage and Power Factor Correction – CIPOS™ Mini IPMs

Broad range of configurations from inverter to PFC

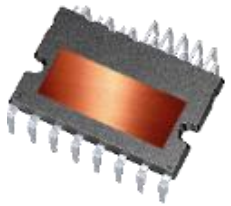
Inverter

- 3 phase inverter
- 4 ~ 30 A
- Home appliances and motor drives motor power up to 3 kW



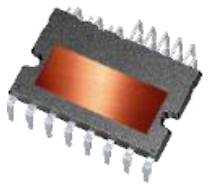
PFC

- 2 or 3 phase interleaved power factor correction (PFC)
- 20 A, 30 A
- Easy heatsink mounting in combination with Mini inverter IPM



Inverter + PFC

- Inverter + PFC in one package
- 10 A, 15 A, 20 A
- System size reduction with PFC integration into inverter module

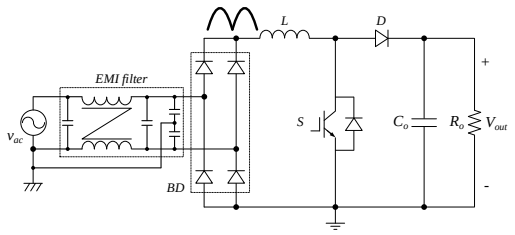


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System value proposition
Power factor correction in air conditioning

Application

› Residential and Commercial Aircon PFC up to 6kW



Product match

Current classes from 30A -5 0A

› IKW__N65WR5/H5 (IGBTs)
› IKFW__N65DH5 (IGBTs AI)
› IDW__C65D1 (Rapid 1 diode)
› IDW__G65C5 (SiC diode)
› 1ED44175/173 (GD)

System value proposition

› System cost reduction of the Aircon PFC by increasing the switching frequency from conventional 20-40kHz up to 60-70kHz.
  › Minimizing PFC inductor size directly affects system cost (inductor on board)
  › Simplifying assembly process
  › Additionally boost the system efficiency by using SiC diode and ferrite core
› Using 1ED44175/173 allows SC protection using non SC devices

Value proposition's quantification

› System cost reduction by 20% using WR5 (IKW30N65WR5) + Rapid 1 (customer feedback)
› High-end aircon can additionally improve efficiency by reducing switching losses by 40% using WR5 + SiC diode (reference parts needed)

Supporting material

› https://www.infineon.com/dgdl/Infineon-AN-2020-19_High_Switching_Frequency_CCM_PFC_Operation-ApplicationNotes-v01_00-EN.pdf?fileId=5546d46275b79adb0175d1b969e45b6f

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System value proposition: Power factor correction using CoolSiC™ Hybrid IGBT (Silicon IGBT, SiC diode)

Application

- Totem-pole (TP) PFC for residential aircons 3-5kW
  - Replacing interleaved PFC with f_{sw} >60kHz

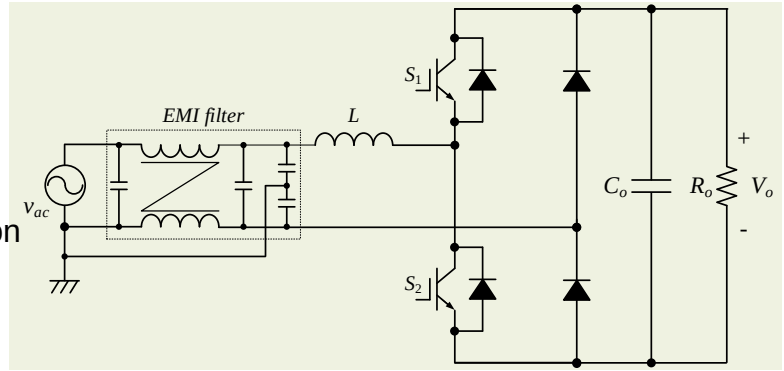
Product match

- **CoolSiC™ Hybrid IGBT**
  - IKW40N65RH5
  - IKW50N65RH5
- **iMotion**
  - IMC102T-F048
  - IMC102T-F064
- **Gate driver**
  - 2ED2182S06F

System value proposition

- Enabling to realize TP PFC for aircons without using WBG devices
  - Eliminating reverse recovery problems using SiC co-pak diodes
  - Eliminating the bridge rectifier stage
- Achieving smaller system form factor
  - TP PFC only requires single inductor while interleaved PFC requires two
  - High switching frequency operation enables to place the inductor on board, or smaller power dissipation of device requires smaller heatsink
- Compared to interleaved PFC, the system cost can be saved through single inductor, removing bridge rectifier stage, and co-packaged SiC diode





Value proposition's quantification

1. Improve the system **efficiency by 0.6~0.7%** by eliminating bridge rectifier
2. **20% lower inductor cost** by single inductor and cheaper power semi:
   - 2 IGBTs + 2 SiC diodes → 2 CoolSiC Hybrid IGBTs

- **50% lower switching losses** than Si FRD enable to increase f_{sw} up to 70kHz

Supportive material

- CoolSiC™ Hybrid Devices - Infineon Technologies
- IMC100 Series - Infineon Technologies
- 2ED2182S06F - Infineon Technologies
  - System level V.P verification is ongoing (by end of Q2)
  - AN will be written after the system level V.P verification is completed

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EiceDRIVER™ Gate Drivers for residential air conditioners

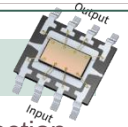
PFC: Low-side drivers

- 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

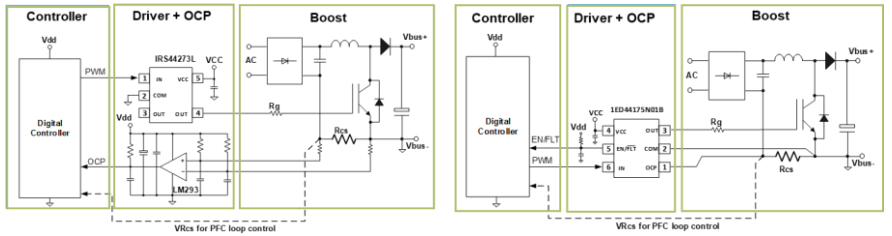
- 1ED44173/5/6N01
- 1ED44171N01B
- IR4427, IRS4427, IRS44273

Differentiation



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

1ED4417x integrated OCP



> 20% Cost Saving

> 50% Space Saving

1ED4417x integrates

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

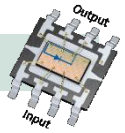
Inverter: 600-700 V Level-shift drivers

- **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
  - For use in power levels up to 10 kW

Key products

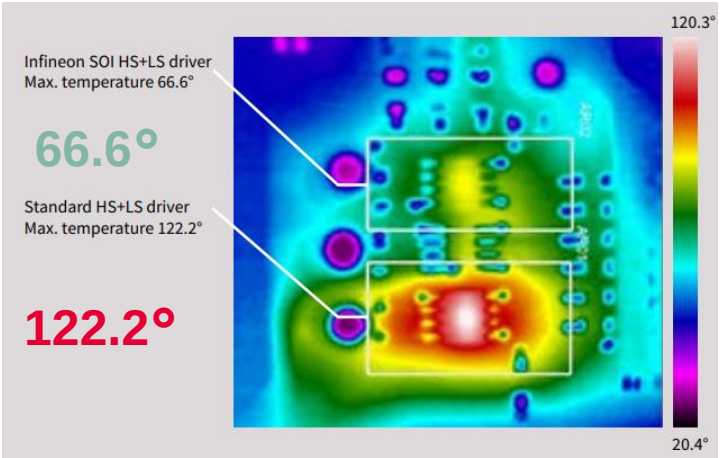
- 2ED2304S06F
- 6EDL04x06xT

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

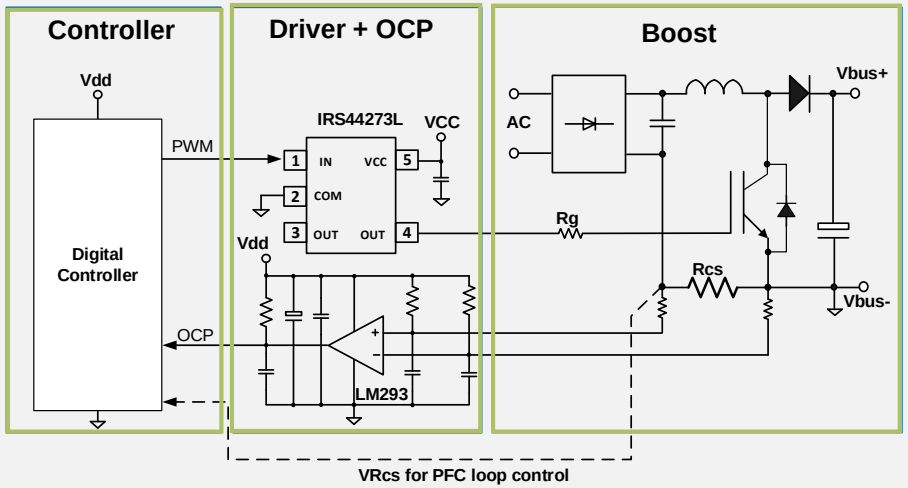
- Fully operational up to +650 V
- Integrated bootstrap diode (BSD)
- Tolerant to negative transient voltage ($-V_S$) up to 100 V
- Low level-shift loss in high frequency applications (below)

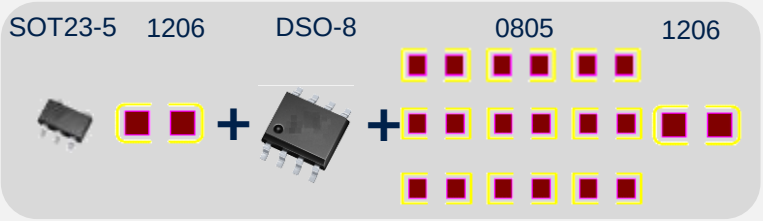
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1ED4417xN01B family advantages in Digital PFC

Cost effective, space saving, accurate, and fast T2M solutions

Current solution

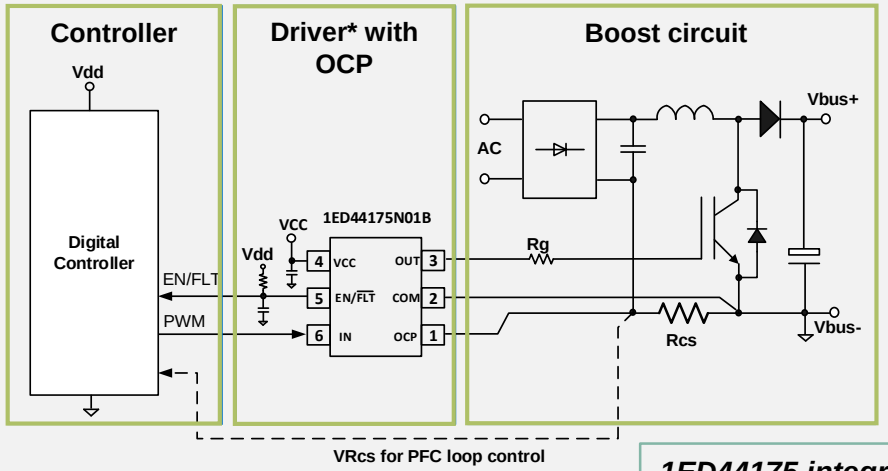


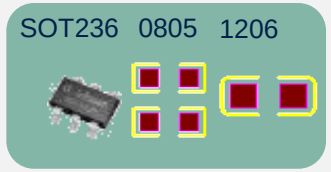


Boost PFC IGBT or MOSFET gate driver with OCP in Residential air-conditioning application

- ✓ > 20% Cost Saving
- ✓ > 50% Space Saving
- ✓ Integrated fast OCP

New solution advantages – smaller size, lower BOM, OCP





1ED44175 / 1ED44173
Simplify system design

1ED44175 integrates
- ✓ *Low side gate driver*
- ✓ *Overcurrent protection*
- ✓ *IGBT UVLO levels*
- ✓ *Enable Input / Fault output*
- ✓ *Programmable fault clear time*

1ED44173 integrates
- ✓ *Low side gate driver*
- ✓ *Overcurrent protection*
- ✓ *MOSFET UVLO levels*
- ✓ *Enable Input / Fault output*
- ✓ *Programmable fault clear time*

* - example circuit with 1ED44175N01

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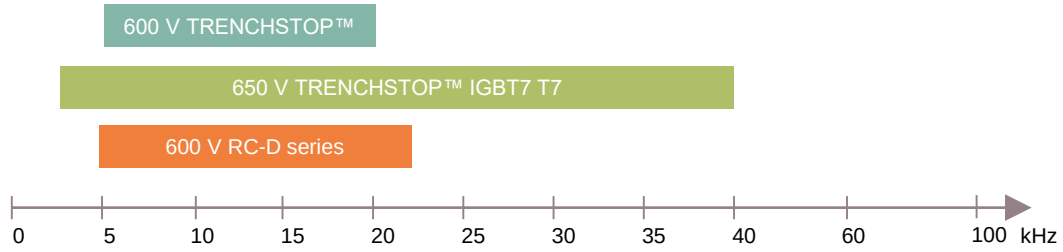
Wide Band Gap 40

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

Compressor



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-120 A, D²PAK, TO-220, TO-220FP

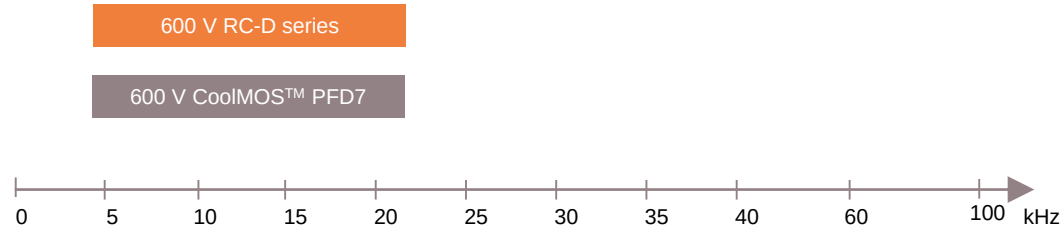
IGBT7 T7

Best low-medium frequency IGBT
Benchmark low $V_{ce(sat)}$ and low V_F IGBT
Enhanced controllability for better EMI
Portfolio: 20 A-75 A, TO-247-3 pin

RC-D series

Cost optimized monolithically integrated diode in surface mount packages
SC rating up to 3µs (RC-D2) and up to 5µs (RC-D(F))
For low to medium frequency converters
Portfolio: 3 A-15 A in DPAK, 1 A-6 A in SOT-223

Indoor Fan/Outdoor Fan



RC-D series

Cost optimized monolithically integrated diode in surface mount packages
SC rating up to 3µs (RC-D2) and up to 5µs (RC-D(F))
For low to medium frequency converters
Portfolio: 3 A-15 A DPAK, 1 A-6 A in SOT-223

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 like SOT-223

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Auxiliary power – 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 covering both indoor and outdoor aircon
- Design tools, guide and application note
- Reference designs

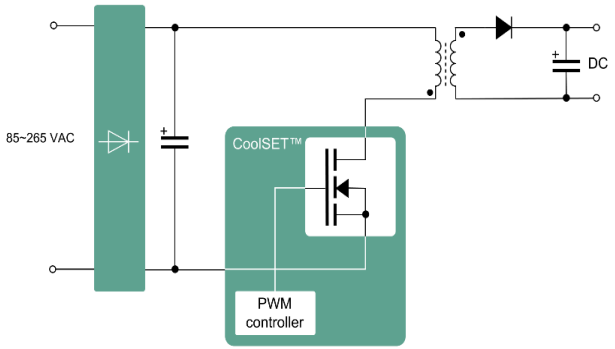
Broad portfolio

- 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

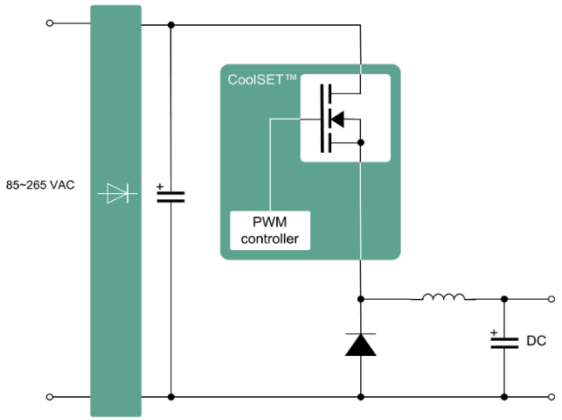


Auxiliary SMPS in Flyback or buck topology to perform AC/DC power conversion to power the various system blocks in home appliances.

Flyback



Buck











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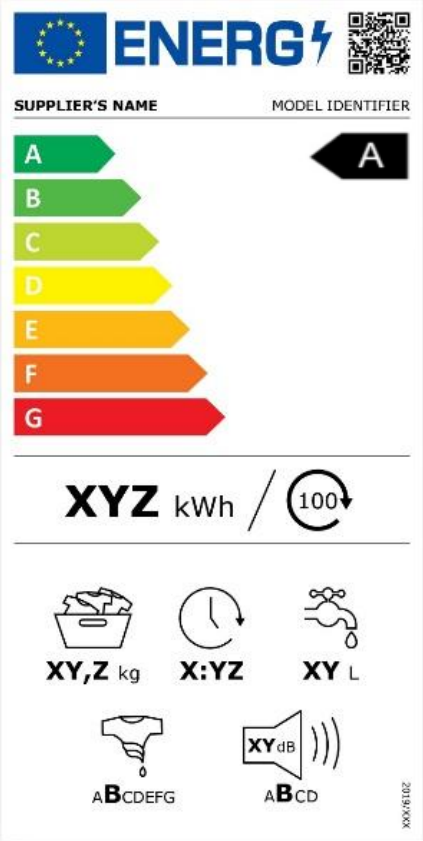
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Infineon 600 V and 650 V Wide Bandgap allows increasing energy efficiency even further



New EU energy efficiency label (2021)

Energy efficiency

Reduction of electricity consumption required, making the way we live and work greener.

Disruptive innovation

Highly efficient inverters for driving brushless DC motors and others – set benchmark by technological leadership.

Exceptional performance

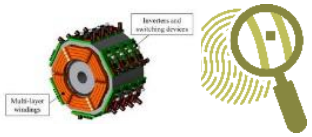
Maximizing power density in same footprint, making you spend less for more.

Superb quality

Inverterized system performing just as required, less susceptible to failure, prolonging product lifetime/ warranty.

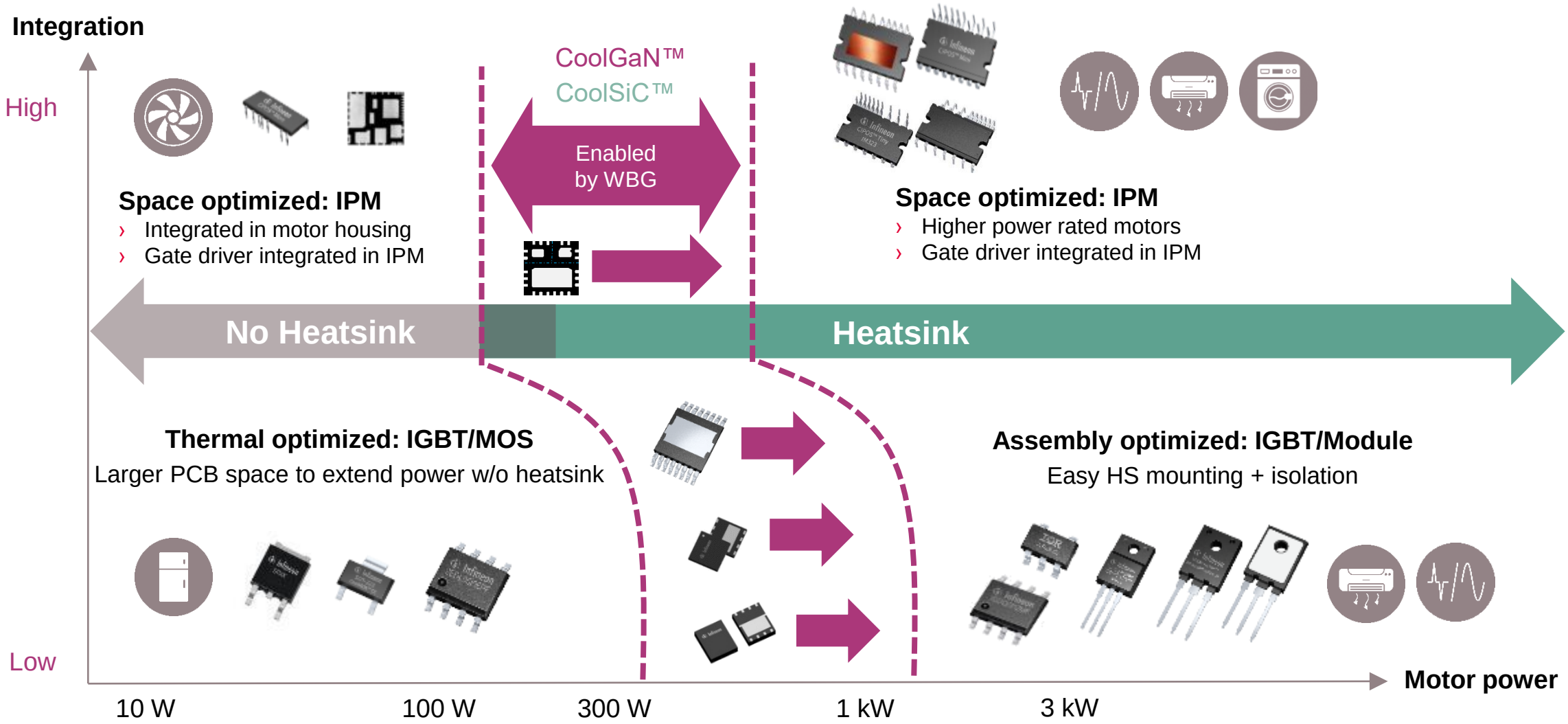
Compact and space critical designs

Enabling system topology simplification, reduction of cooling effort and total bill of material, opening up design options never seen before.



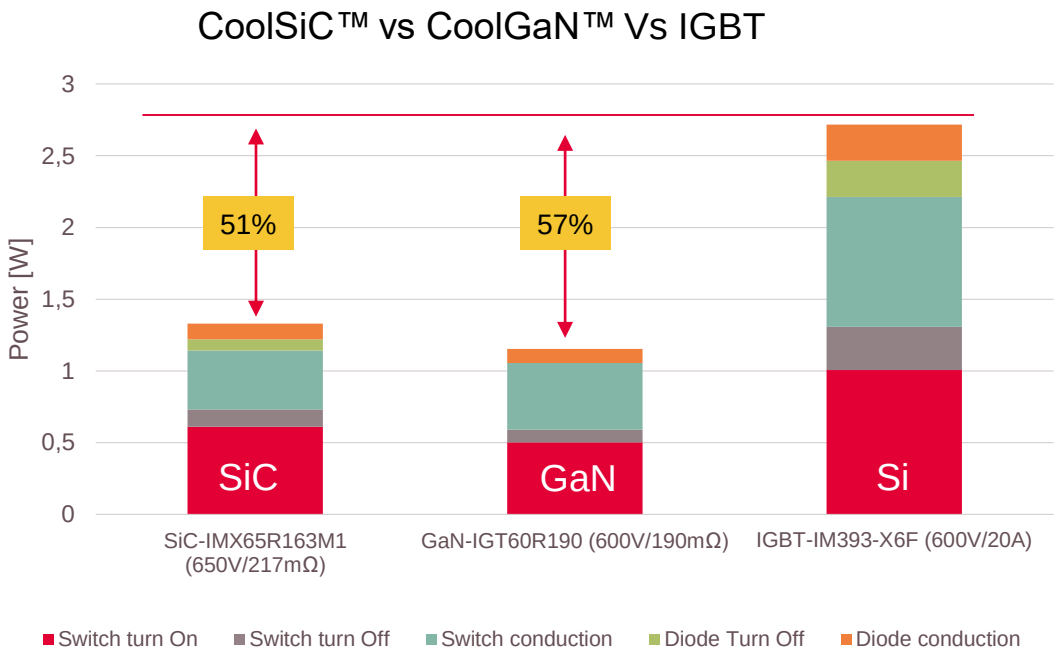
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Discretes or IPMs for inverter solutions? Wide Bandgap (WBG) can increase output power for the same thermal system

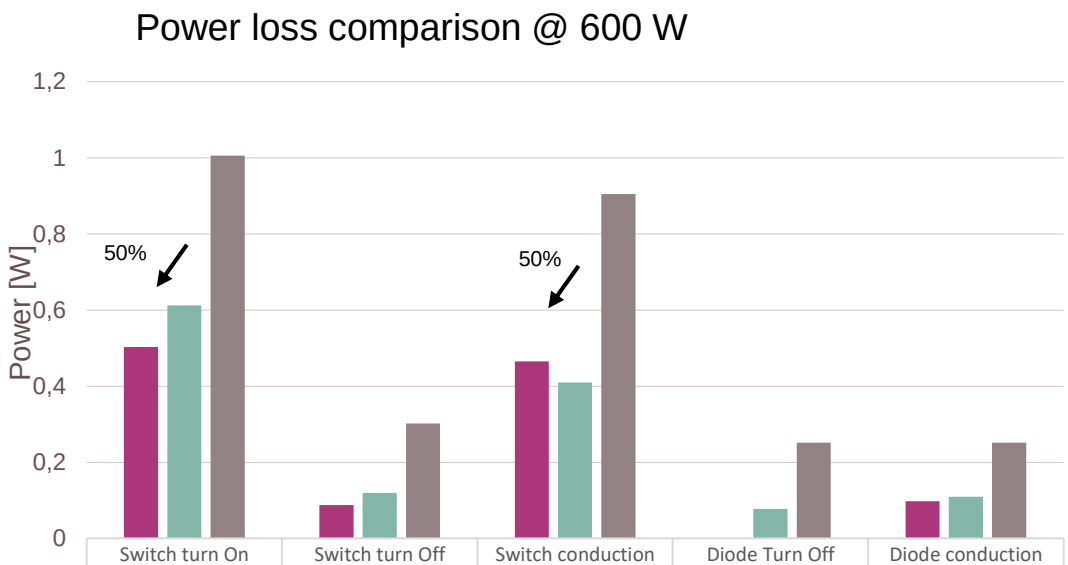


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Wide Bandgap has significant > 50% less power dissipation advantage over Si solutions (IGBT)



*Washing machine example



	Switch turn On	Switch turn Off	Switch conduction	Diode Turn Off	Diode conduction
GaN-IGT60R190 (600V/190mΩ)	0,503	0,088	0,465	0	0,098
SiC-IMX65R163M1 (650V/217mΩ)	0,612	0,12	0,41	0,078	0,11
IGBT-IM393-X6F (600V/20A)	1,006	0,302	0,905	0,252	0,252

Wide Bandgap solution has significantly better power dissipation that can be leveraged to:

- Get significantly more output power out of the same thermal system
- Shrink the power stage → miniaturization
- Removing the heatsink
- Meet new efficiency regulations

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



Connect to the internet for wireless control

- Turn on AC on your way home
- Integrate AC in your smart home, e.g. control via Alexa
- Use phone as remote control

Sense environment for intuitive and autonomous use

- Is someone in the room?
- How many people are in the room?
- Where are people in the room?
- What are people doing?
- How are people in the room doing?
- How is the air quality?

Condition monitoring

- Detect defects before they happen

User interface

- Intuitive display to control the entire smart home
- Voice control
- Gesture control

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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 the aircon's 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 aircon.

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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	

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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		

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Make your aircon 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

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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

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



Remote Control



Indoor Unit



Thermostat

1. Replace mechanical buttons with the world's easiest touch solution — MBR3 – configurable touch controllers
2. Complex touch HMI interfaces in single MCU platform — PSoC™ 4 touch controllers
3. Dual-core high performance touch solution with IoT edge compute capabilities — PSoC™ 6 touch controllers

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Why use Infineon touch solutions in your aircon system?

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. No more need for tuning
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

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Main security concerns for our customers



Identity protection against **fake devices**



Protection against **eaves dropping**



Protection against **the manipulation of the data**

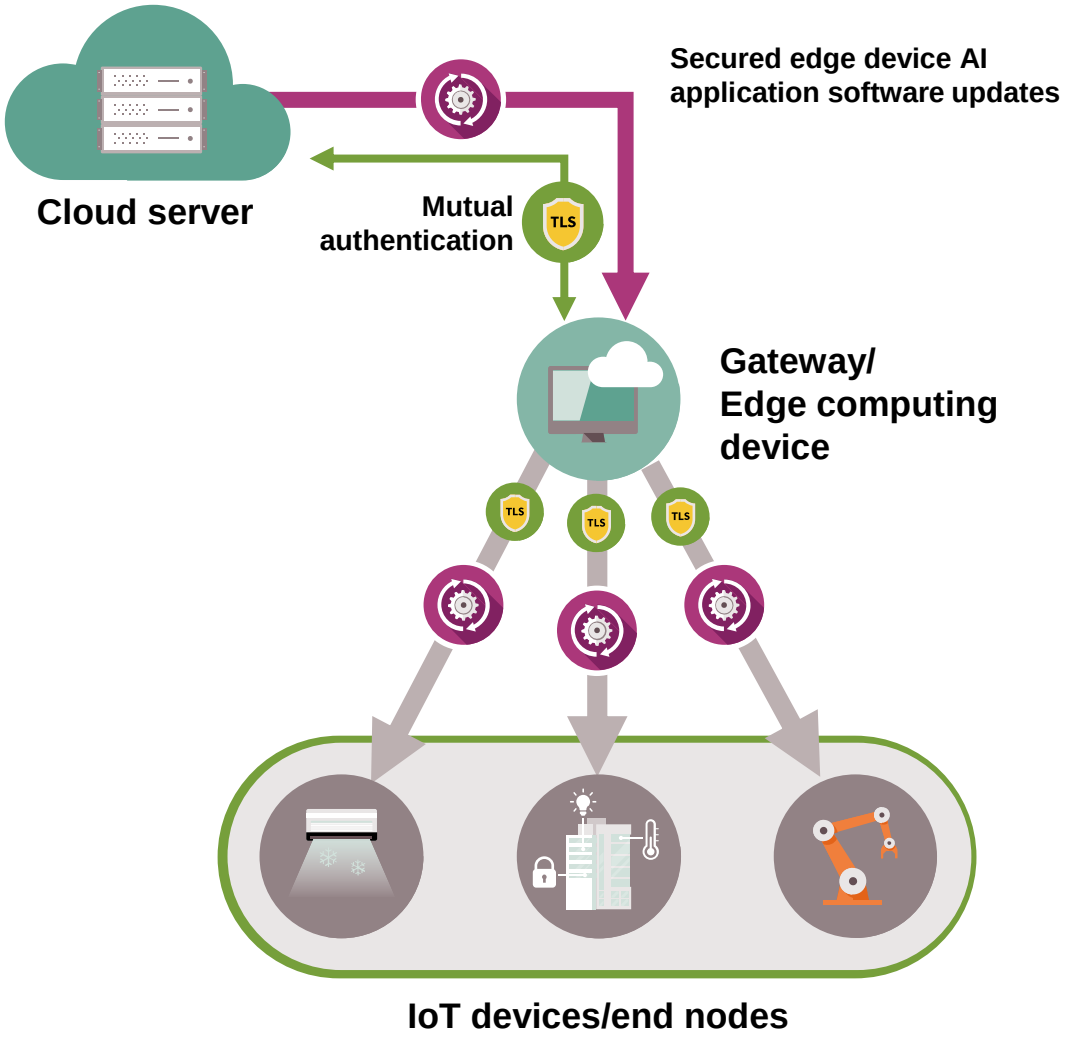


Protection against **illegal update of firmware**

Don't let your smart residential air con be the weakest point in the system.

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



TLS **Secured connectivity**

Secured cloud authentication

Secured software update over-the-air

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Value proposition OPTIGA™ Trust family in aircon systems

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

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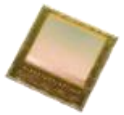
Devices become smart by imitating human senses

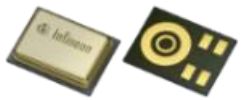


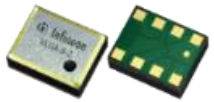


Radar	Presence detection	Material detection	Speed	Weight, vibration, imbalance and liquid flow	Lid open/ closed	
				Magnetic		
ToF	Track people Count people Gesture sensing		Listen to user's voice command Noise anomaly detection	Air quality measurement	CO_2	
			MEMS microphone	Detect clogged filter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









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Our wide sensor portfolio enables smart home appliance use cases

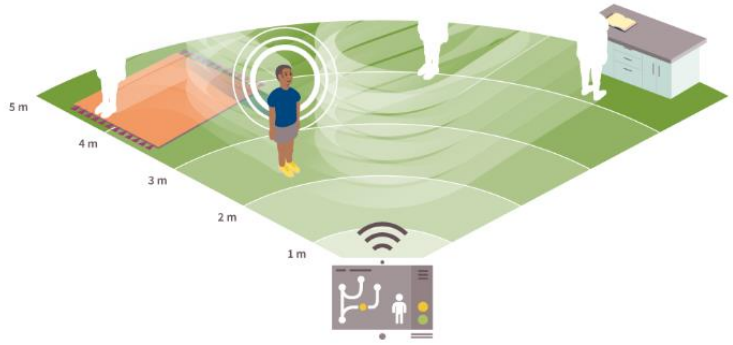
	Sensors				
	Radar	**Microphone**	**Pressure**	**CO_2**	**Magnetics**
Unique selling propositions	Plug and Play for motion detection	Highest SNR to detect voice in noisy devices and from long distances	Very rugged (IPX8 certified) even for A/C outdoor use	Plug & Play: Direct data output	Smallest 3D Hall 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

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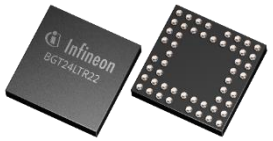
People tracking with XENSIV™ radar solutions: Know where people are

Control air-flow based on a person's position in the room

Example 1: Direct air-flow towards left if person is on the left side



Determine **precise position or a specific zone** of up to three people

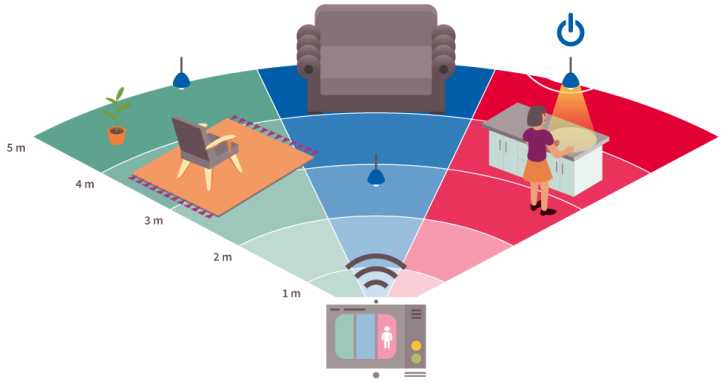


BGT24LTR22
for longest range

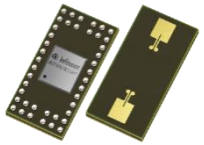


BGT60TR13C
for high resolution

Example 2: Decrease fan speed if person is very close to the device and increase if far away



Determine the **distance** of a person to the device



BGT60LTR11AIP
for lowest cost and distance measurement

Infineon offer

- Software solution for distance measurement and zoning
- 60 GHz MMIC with integrated antennas to reduce design-effort

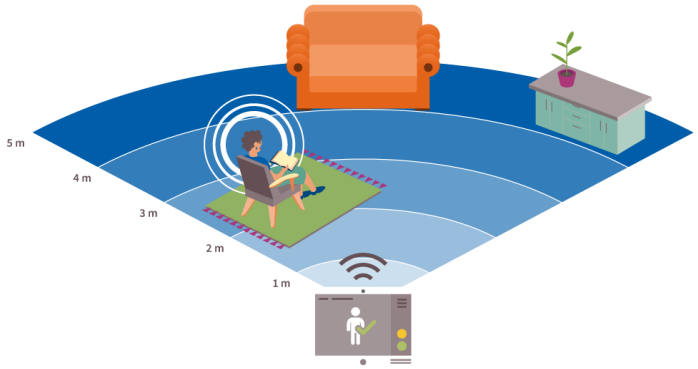
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Save energy using XENSIV™ radar solutions for presence detection

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

Example 1: Turn on air-con once person enters a room

Example 2: Keep air-con running only while someone is present in the room

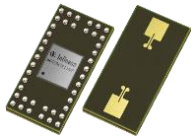


Sense presence up to 10 m (very high sensitivity, even recognizes breathing and tiny motions)

Sense motion up to 10 m without using a microcontroller



BGT60TR13C for highest sensitivity



BGT60LTR11AIP for lowest cost, motion detection

Infineon offer

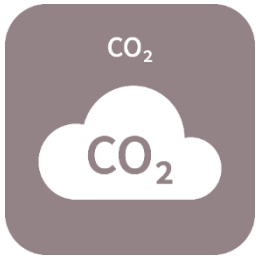
- Software solution and turnkey solution available for high-end presence detection
- 60 GHz with integrated antennas to reduce design-effort

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Improve air quality using XENSIV™ CO_2 sensors

Determine CO_2 level of the surrounding air

Example 1: Turn on the air-con's air purifier or air exchange at a pre-defined CO_2 level



Example 2: Adjust speed of fan for air exchange based on CO_2 level



Measure CO_2



Infineon offer

- Plug and Play solution, directly streaming out CO_2 ppm values
- Small size

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Precise flap control using XENSIV™ hall sensors

Determine position of flap to control air flow precisely

Example 1: Direct air-flow towards or away from people based on radar sensor's input

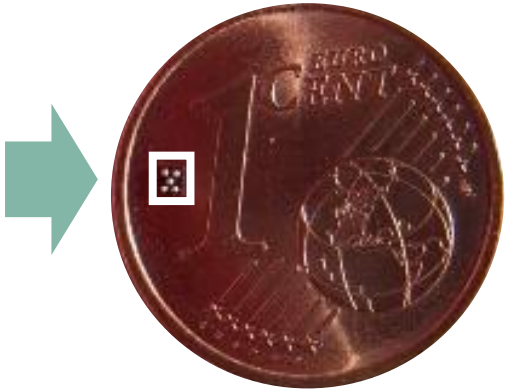
Example 2: Manual air-flow control



Sense position of air-con flaps and adjust position using a stepper motor

Infineon offer

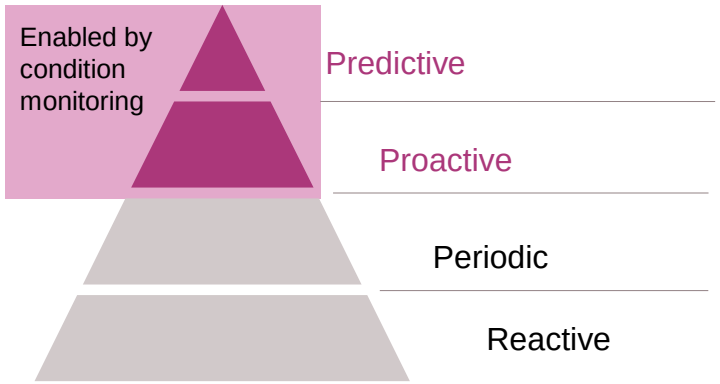
- Smallest 3D Hall sensor
- Ultra low power modes and bus capability
- Several demo boards with different application use cases available
- Software modules supporting XMC™ and PSoC™



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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**

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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

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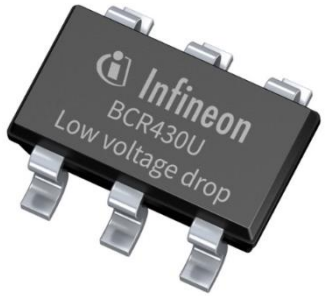
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UV-C LEDs can eliminate bacteria and viruses to equip air conditioners with air purification functions



- 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

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Part of your life. Part of tomorrow.