Refrigerators

January 2023

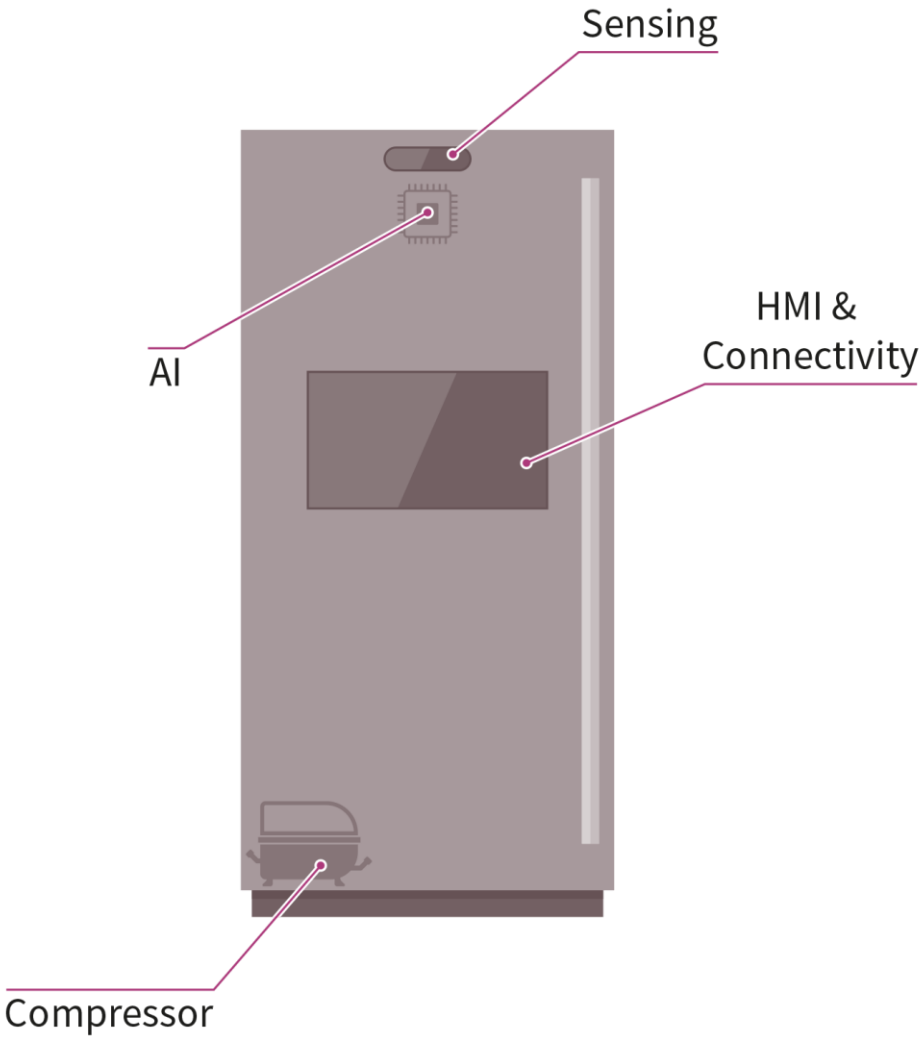
Table of contents

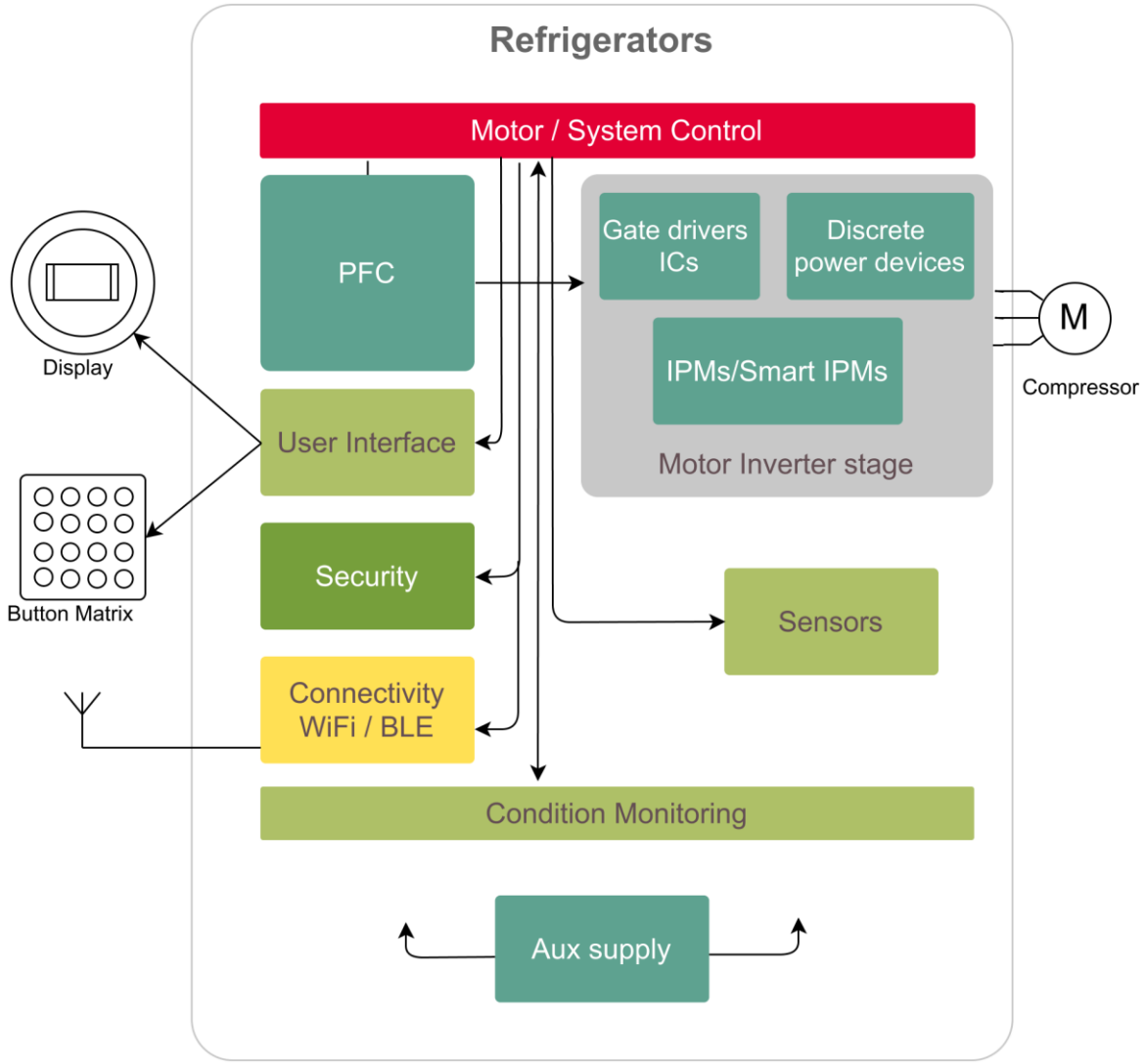
Table of contents

The application refrigerator

Infineon’s complete system solutions for fridges allow to implement smart, compact and energy-saving designs for an innovative end-customer experience

Block diagram – complete refrigerator system

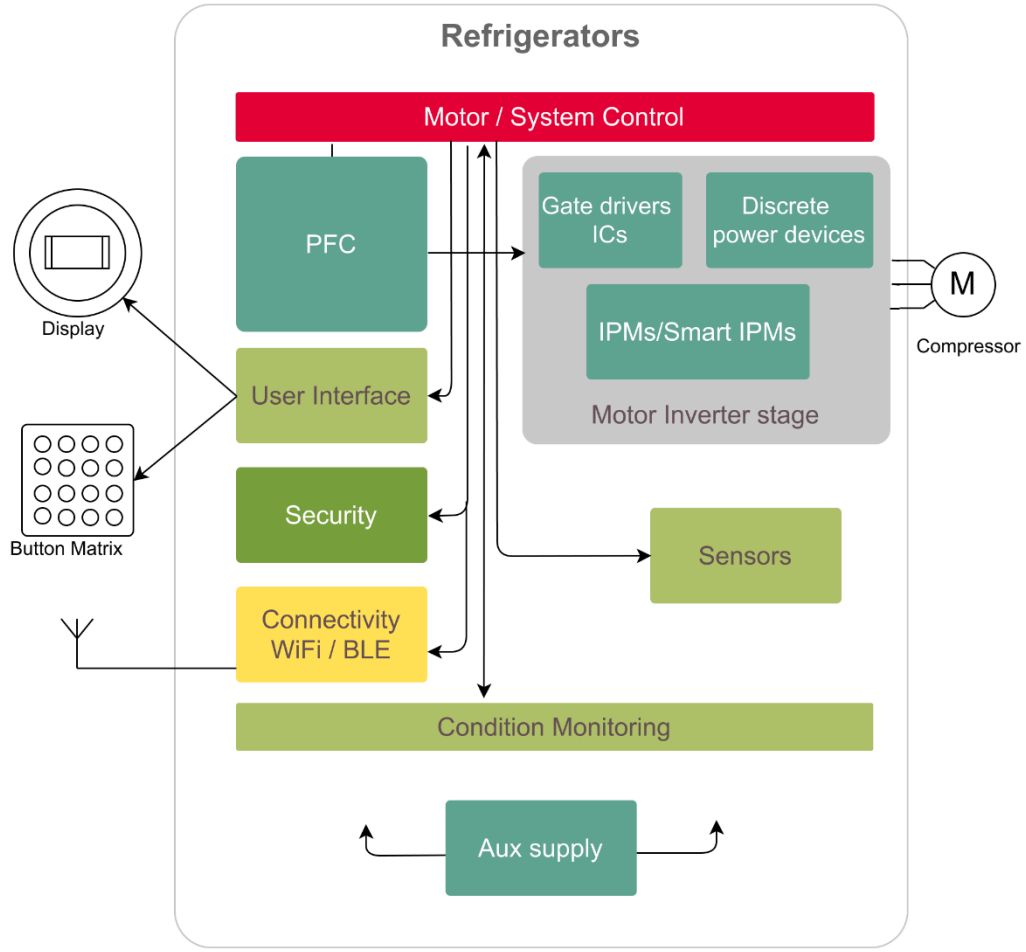




Refrigerator – Key functional blocks

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: Up to 300W
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.
User Interface	› Touch button, touch screen, mechanical buttons, voice or even gesture control.
Motor/System control	› An embedded MCU governs the fridge´s system operation including motor control, security, connectivity, user interface, AUX and sensors
Condition monitoring	› Monitor the state of health of the system using sensor- 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



Refrigerator – Product overview

Compressor

- **Motor Controller:** PSoC™, XMC™ and iMOTION™ family
- **Inverter (IPM)**: CIPOS™ Micro
- **Inverter (Discrete):** IGBTs (RC-D2 series), MOSFETs (600 V CoolMOS™ PFD7), EiceDRIVER™ gate drivers ICs
- **PFC**: TRENCHSTOP™ IGBTs, Rapid and CoolSiC™ diodes and PFC gate drivers, MOSFETs (600 V CoolMOS™ P7)
- Pressure **sensor** for precise & quick cooling
- **Auxiliary power**: CoolSET™/ 5QR series, MOSFETs (600 V CoolMOS™ P7)

Motor control

Fan

- **Inverter (IPM):** iMOTION™ IPM , CIPOS™ Nano, CIPOS™ Micro
- **Inverter (Discretes):** IGBTs (IGBT 6 & RC-D series), EiceDRIVER™ gate drivers ICs (half bridge and 3-phase drivers), MOSFETs (600 V CoolMOS™ PFD7)

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

Smart Home

Sensing

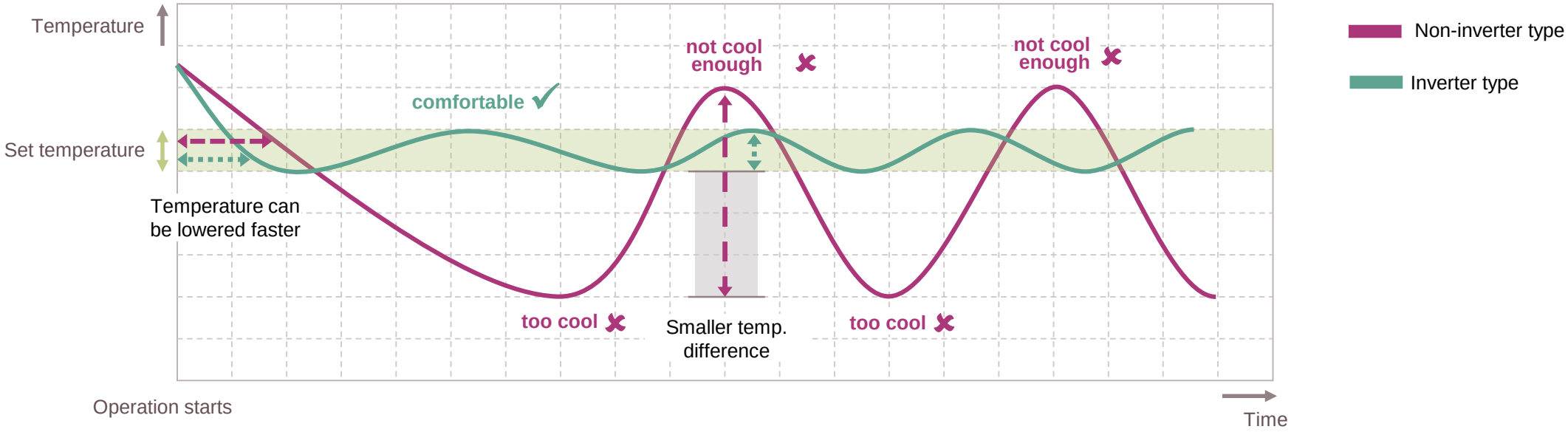
- XENSIV™ magnetic hall sensors for angle / position / 3D sensing
- XENSIV™ CO_2 sensor for air quality monitoring
- XENSIV™ radar sensors for presence detection

Table of contents

Inverterization helps refrigerators 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



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 power switch

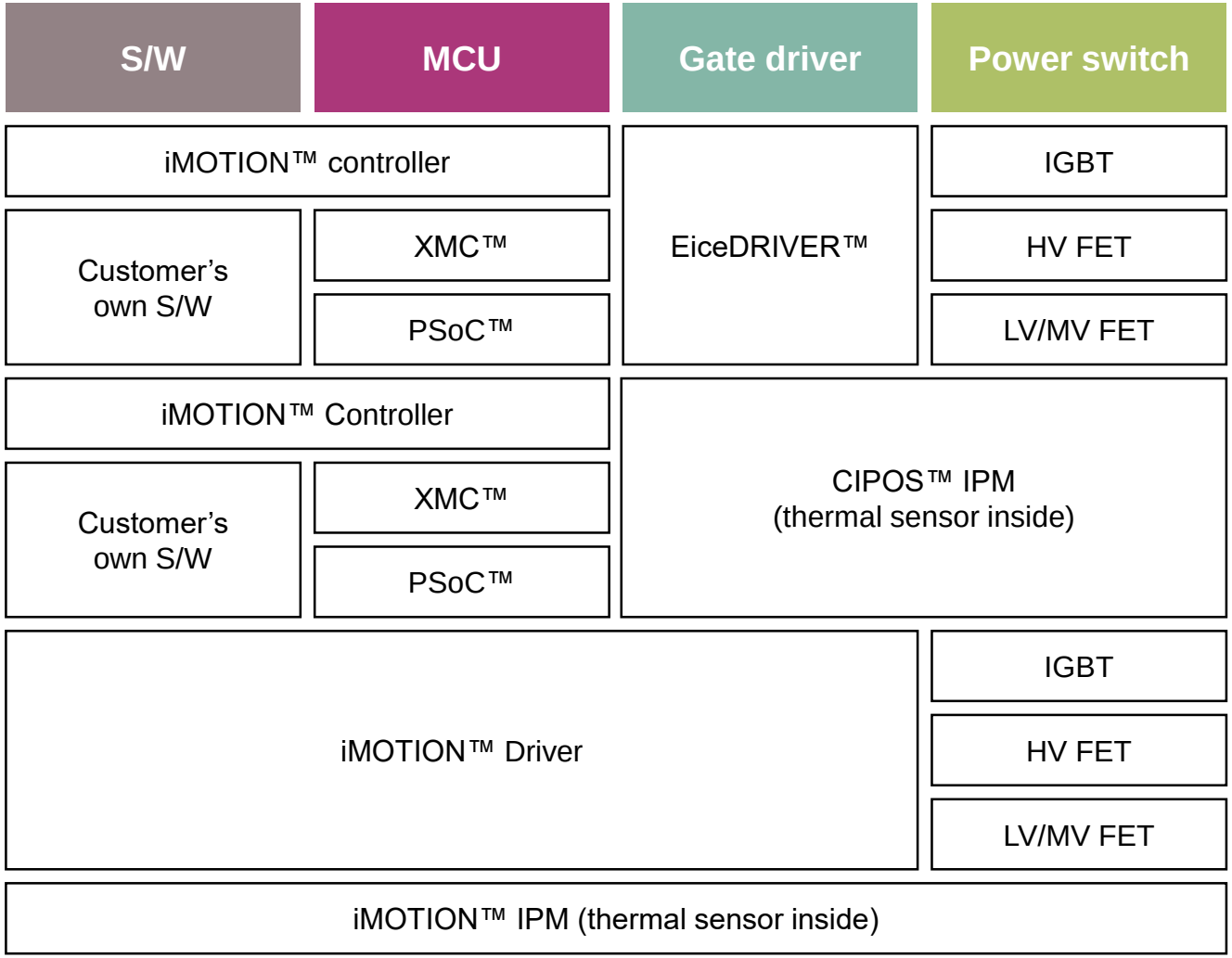
Power switch – IGBT or MOSFET

› Controls current in the motor through switching 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



Considerations to select a solution

- **The benefit of the semiconductor solution**
  - e.g. SMD package up to 300 W without heatsink, better EMI performance of IGBT, better light load efficiency of MOSFET
- **Technical requirements of each application**
  - e.g Power MOSFETs usually lead to lower yearly inverter losses as fridge operates more than 90% of the time at less than 50% of the rated power load
- **IFX recommended offerings based on customer's preference and system specifications**
  - e.g. switching frequency, power rating, PCB space constraints, 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

Table of contents

Motor Control: iMOTION™ or microcontroller?

Do you want to write your own motor control code?

Yes → Microcontroller

Controller

Microcontroller

Write your own software with support of advanced tools for BLDC, Brushed DC, PMSM and Sensorless FOC

PSoC™ 4/6
XMC™

No → iMOTION™

Ready-to-use motor control or integrated on hardware level

iMOTION™ Controller

Motion Control Engine

Microcontroller

Ready-to-use motor & PFC controller for variable speed drives

Additional MCU for customized functionality (optional)

IMC100
IMC300

iMOTION™ Driver

Motion Control Engine

Gate driver

Integrated gate driver for MOSFET or IGBT power stage

IMD110

iMOTION™ IPM

Motion Control Engine

Gate driver

Power stage

Fully integrated inverter solution

IMM100
IMI110

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

PSoC™ selection guide for refrigerators

	Main control	Connectivity		HMI			Display drive		Motor Control	Additional features	Software
		BT	WiFi	Button	Display LCD	Display TFT	Display LCD	Display TFT	Compressor control		
PSOC™ 4000S/ 4100S	Only PSoC4100S			<7“			✓		4100S		PSoC™ creator
PSOC™ 4100 Plus/ Max	✓			<7“/9“			✓			2 CapSense® blocks	PSoC™ creator/ Modus toolbox
PSOC™ 4500S									HPFC + Compressor	Security (PSoC™ 64)	PSoC™ creator/ Modus toolbox
CY8C62x4/5	✓	Host for Wi-Fi		✓			✓	✓		Security (PSoC™ 64)	Modus toolbox
CY8C62x7/8	✓			✓			<7“			Security (PSoC™ 64)	PSoC™ creator/ Modus toolbox
CY8C63x7/8	✓	BLE		✓			<7“			Security (PSoC™ 64)	PSoC™ creator/ Modus toolbox

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 aim of making it….

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

iMOTION™ selection guide for refrigerators

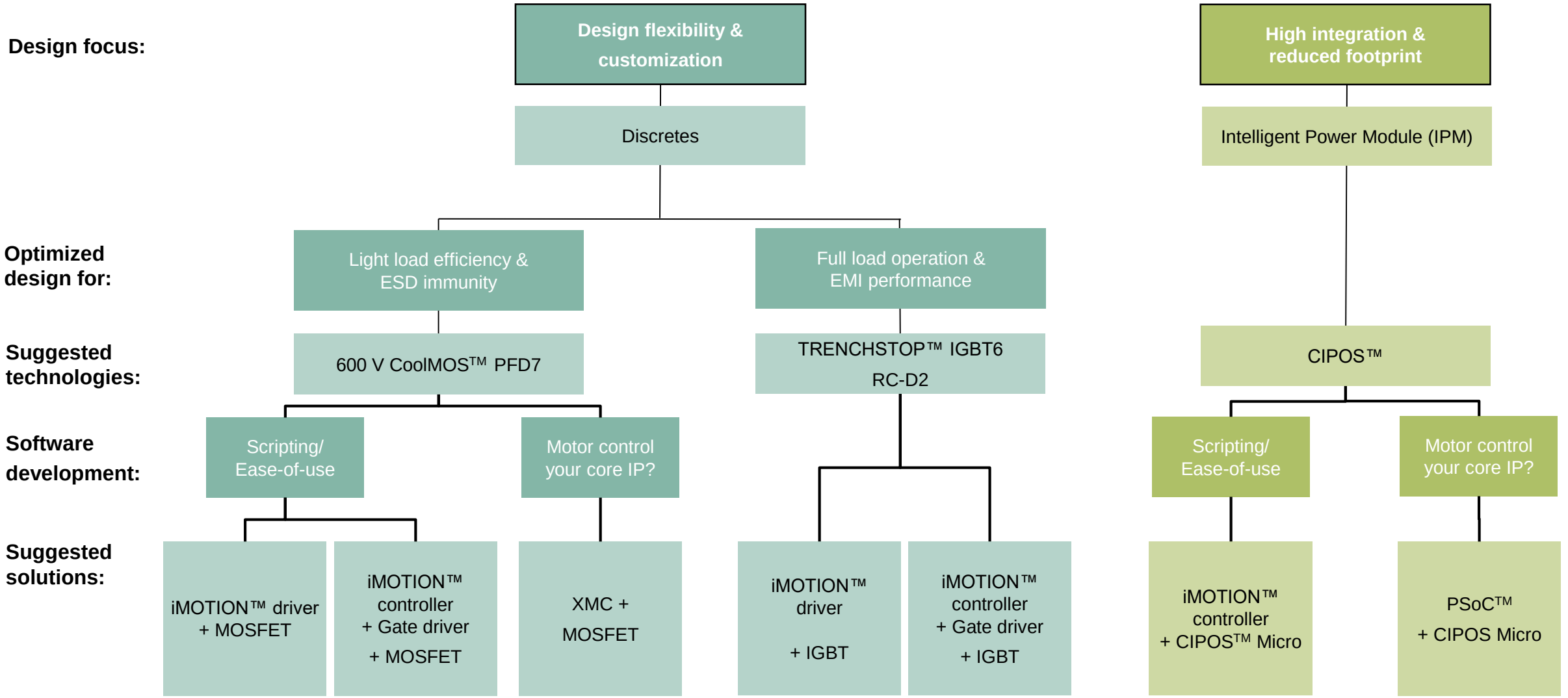
	Main control	Connectivity		HMI			Display drive		Motor Control		Additional features	Software
		BT	Wi-Fi®	Button	Display LCD	Display TFT	Display LCD	Display TFT	Single + PFC	Dual + PFC		
IMC100									✓	✓		Ready to use + Script engine
IMC 300									✓		Additional M0 core	Ready to use + Script engine
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 fridges

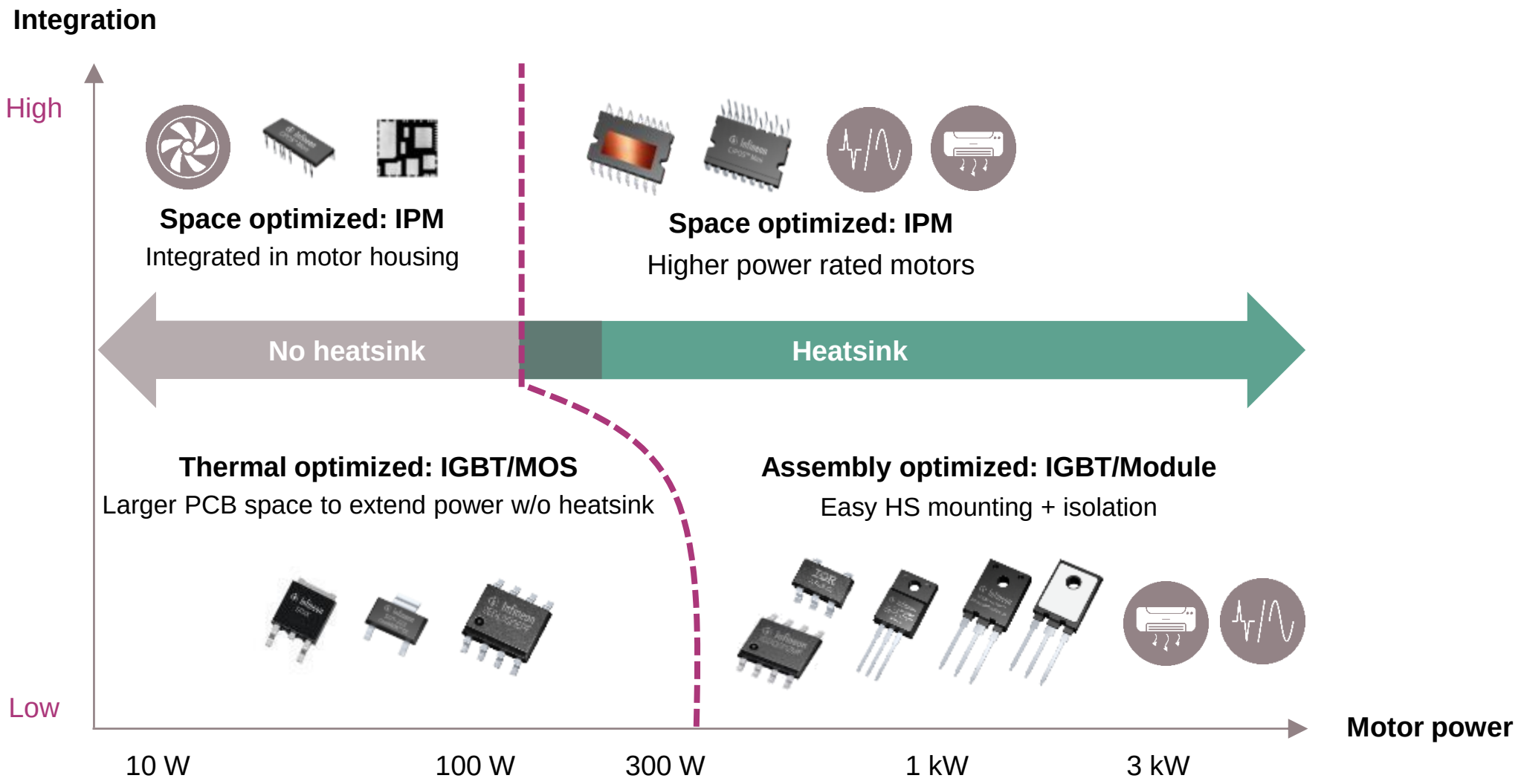
	Main control	Connectivity		HMI			Display drive		Motor Control		Additional features	Software
		BT	WiFi	Button	Display LCD	Display TFT	Display LCD	Display TFT	Single + digital PFC	Dual + digital PFC		
XMC 1300									✓		MATH co-processor, 64MHz motor control timers, 5V	LLD, DAVE Apps for configuration and code generation, Class B safety Lib, XMC Lib
XMC 1400									✓		MATH co-processor, 96MHz motor control timers, 5V, 4 ACOMP	
XMC 4100/200										✓	High resolution motor control timers, 4 ADC, 125°C	

Table of contents

Infineon offers solutions from low to high integration choice: space, thermals & cost or assembly optimization



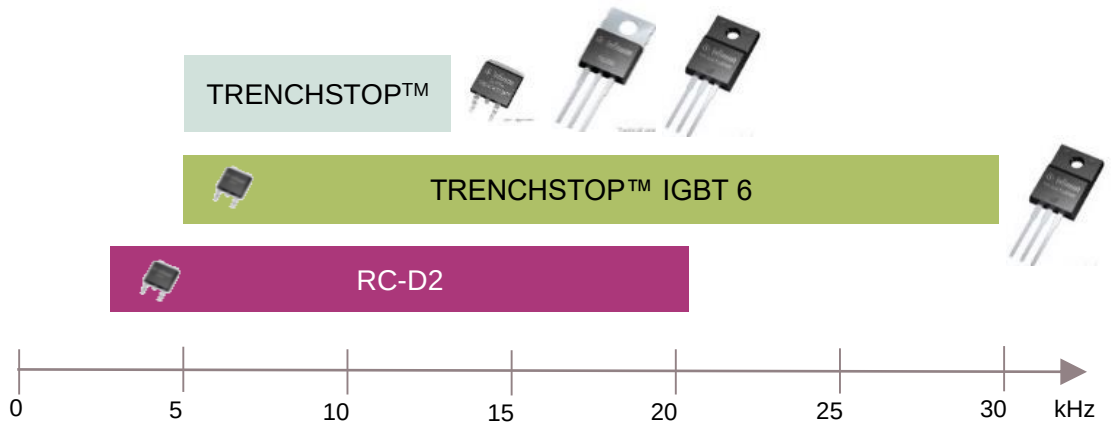
Power stage and power factor control (PFC) – Discrete or integrated



Power factor control for refrigerators – Topologies

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

Refrigerator drives: Discrete IGBTs



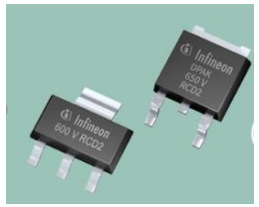
TRENCHSTOP™	**Great low frequency performance** Low $V_{ce(sat)}$ Low switching losses
TRENCHSTOP™ IGBT 6	**Performance optimized up to 30 kHz** **Co-packed with and without diodes** Lowest **switching losses and improved EMI** SC rating up to 3µs
RC-D2	**Cost optimized in surface mount packages** **Monolithically integrated diode** 3 A up to 15 A 600 V in SOT-223 and DPAK SC rating up to 3µs

600 V Reverse Conducting Drives 2

600 V RC-D2

- Optimized half rated diodes and 3 us 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 loses on competitive price -> 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
3	IKN03N60RC2	
4	IKN04N60RC2	IKD04N60RC2
6	IKN06N60RC2	IKD06N60RC2
8		
10		IKD10N60RC2
15		IKD15N60RC2

Fan

Compressor

The unique features of CoolMOS™ 7 SJ MOSFETs bring excellent benefits for refrigerator compressors

600 - 950 V CoolMOS™ P7

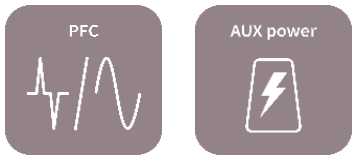
Consumer

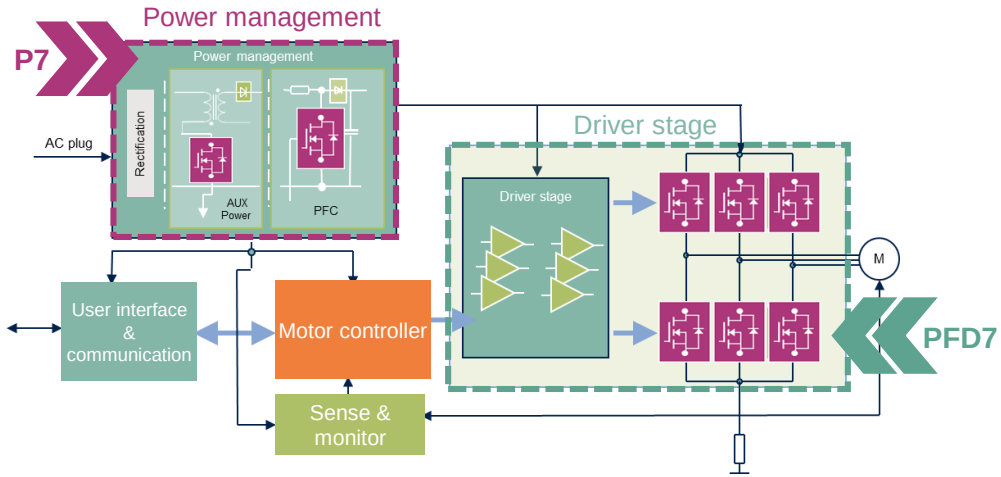
600 V CoolMOS™ PFD7

Suitable for

PFC & Flyback

topologies

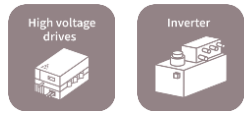




Suitable for **light load** efficient

inverters

up to 300 W



to address Major & Small **Home Appliances**

Technology corner stones:

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

Technology corner stones:

- **Improved efficiency** in hard & soft switching due to reduced E_{oss} & Q_{oss}
- Integrated **Zener diode** for ESD protection (HBM Class 2)
- **Integrated fast body diode** with ultra low Q_{rr}
  - reduced stress on device while body diode is not fully recovered
  - **extra safety margin** for repetitive hard commutation and **reduced design-in effort**
- Portfolio with wide range of $R_{DS(on)}$ values ≤ 2 Ohm
- Supporting cost effective designs with SMD solutions like SOT-223

Recommended CoolMOS™ 7 SJ MOSFETs portfolio for fridges

Compressor inverters

Series: **600 V CoolMOS™ PFD7**
Packages: DPAK, SOT-223
$R_{DS(on)}$ max: 0.36 - 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 HB gate driver: 2ED2304S06F

- Supporting a **cost attractive solution**
- Enabling **ease of use**
- **Reducing** overall **BOM** count

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

Fridge fan

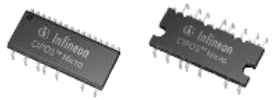
CIPOS™ Nano

Dimension [mm]	12x12
Configuration	3-phase
Voltage Rating	500 V
Rdson max.	1.7, 2.2 Ω

- Heatsink-less operation
- Smallest modules on the market
- Wide range of footprint compatible parts
- Overcurrent protection included

Fridge compressor

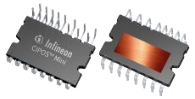
CIPOS™ Micro



Dimension [mm]	29x12x2.9	
Configuration	3-phase	
Voltage Rating	250 V, 500 V	600 V
Rdson max	0.45 - 6.0 Ω	IGBT (4/6 A)

- Wide range of footprint compatible part numbers
- Temperature feedback option
- 3 lead-form options
- Compatible with mass-market TO-2xx heat sinks and clips

CIPOS™ Mini



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

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

Fridge 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

Fridge compressor

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

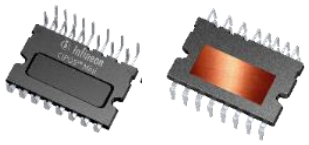
Benefits

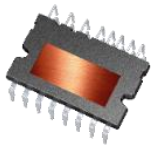
- Fast time to market
- System cost savings from smaller footprint and reduced PCB space
- Improved efficiency and power density
- UL certified package and temperature sensor

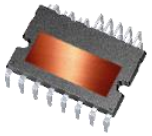
Power Stage and Power Factor Control – CIPOS™ Mini IPMs

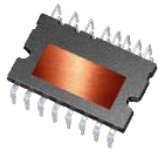
Broad range of configurations from inverter to PFC

Inverter	Asymmetric Inverter	PFC	Inverter + PFC
› 3 phase inverter › 4 ~ 30 A › Home appliances and motor drives motor power up to 3 kW	› 2 phase asymm. inverter for switch reluctance motor (SRM) › 15A, 20A	› 2 or 3 phase interleaved power factor correction (PFC) › 20A or 30A › Easy heatsink mounting in combination with Mini inverter IPM	› Inverter + PFC in one package › 10A, 15A, 20A › System size reduction with PFC integration into inverter module









EiceDRIVER™ Gate Drivers for refrigerators

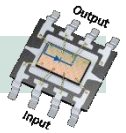
Inverter: 600-700 V Level-shift drivers

- **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

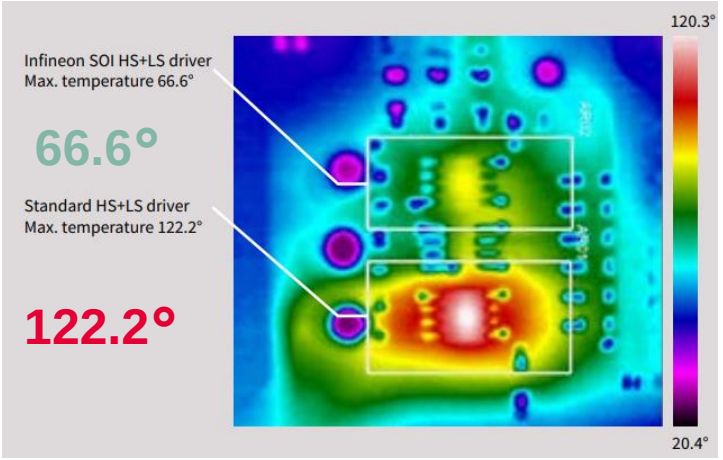
- 2ED2304S06F
- 6EDL04x06xT

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

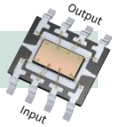
- Comprehensive families of single and dual channel low-side drivers
- New feature-rich families with **accurate (+/-5%), fast, over-current protection** for PFC in home appliances

Bold = New products

Key products

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

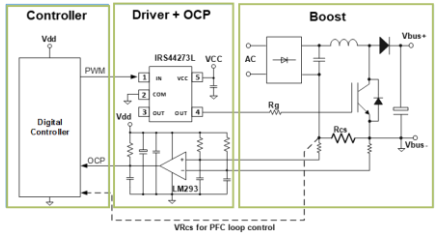
Differentiation



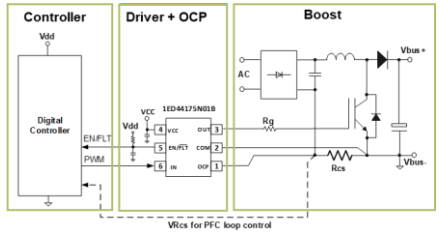
- **Integrated over-current protection (OCP) and fault reporting**
- Cost-effective
- Market-proven

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*

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

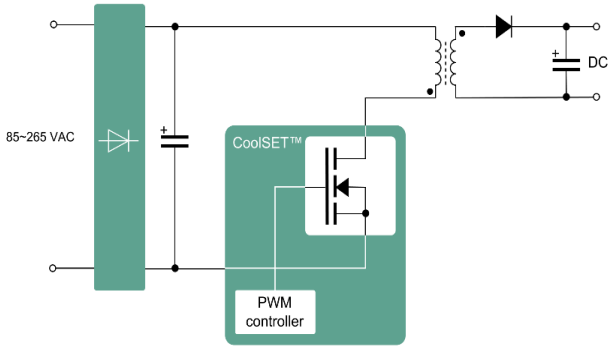
- Numerous design examples
- Design tools, guide and application note
- Reference designs

Broad portfolio

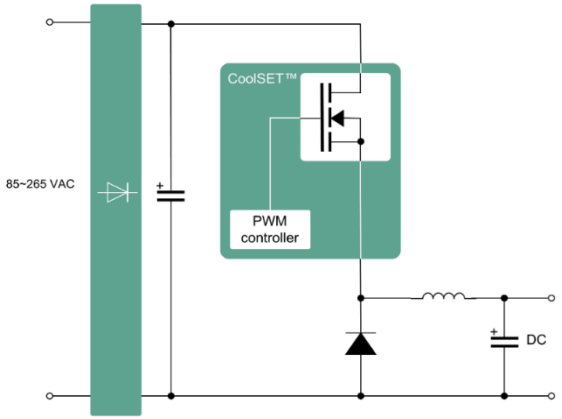
- Choice of fixed- frequency or quasi-resonant switching scheme
- Isolated flyback or non-isolated buck topology
- Highest power delivery up to 43 W
- Available in DIP-7 or SMD DSO-12 package

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

flyback



buck



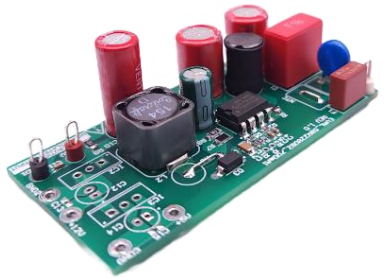


Table of contents

Refrigerators: Trends, use cases and Infineon‘s offering

Connect to the Internet for wireless control

- Be informed if you forgot to close the fridge
- Look into the fridge remotely
- Be informed about the fridge´s content

Sense environment for intuitive and autonomous use

- Is someone in the room?
- How is the air quality in the fridge?
- Food and content sensing

Condition Monitoring & Predictive Maintenance

- Detect defects before they happen

User interface

- Intuitive display to control the entire smart home
- 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 the 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 appliance

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 fridge 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

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

Why use Infineon touch solutions in your fridge?

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

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 fridge be the weakest point in the system.

Devices become smart by imitating human senses

Radar

Presence detection

Material detection

Magnetic

Speed

Weight, vibration, imbalance and liquid flow

Lid open/ closed

ToF

Track people

Count people

Gesture sensing

Listen to user´s voice command

Noise anomaly detection

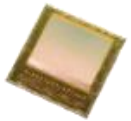
Air quality measurement

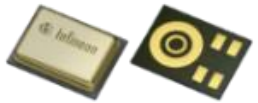
CO2

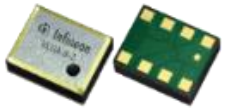
Detect clogged filter

MEMS microphone

Pressure







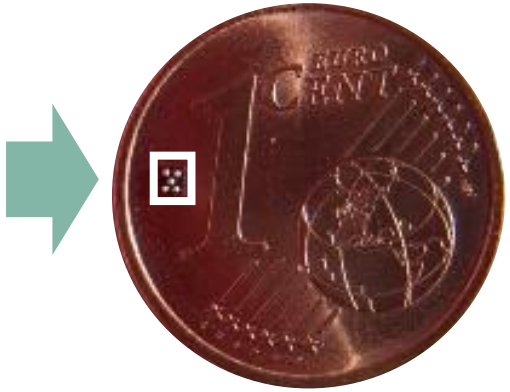
Door sensor using XENSIV™ hall sensors

Determine if door is open or closed

Detect open-close event without mechanical switches: When the door is open, the hall sensor turns on the light as the magnet in door is out of range.

Sensors not visible

No physical contact required, therefore no mechanical wear



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™

XENSIV™ – magnetic switch applications in refrigerators

Position sensing

- Refrigerator door position
- Drawer/compartment door position
- Temperature dials control position and buttons

Level sensing

- Ice bucket fill-level
- Drain pan level
- Water and ice dispenser level

Motor commutation

- Pump
- Cooling fan
- Ice maker pump
- Ice auger motor

Sensor solution

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

Customer value

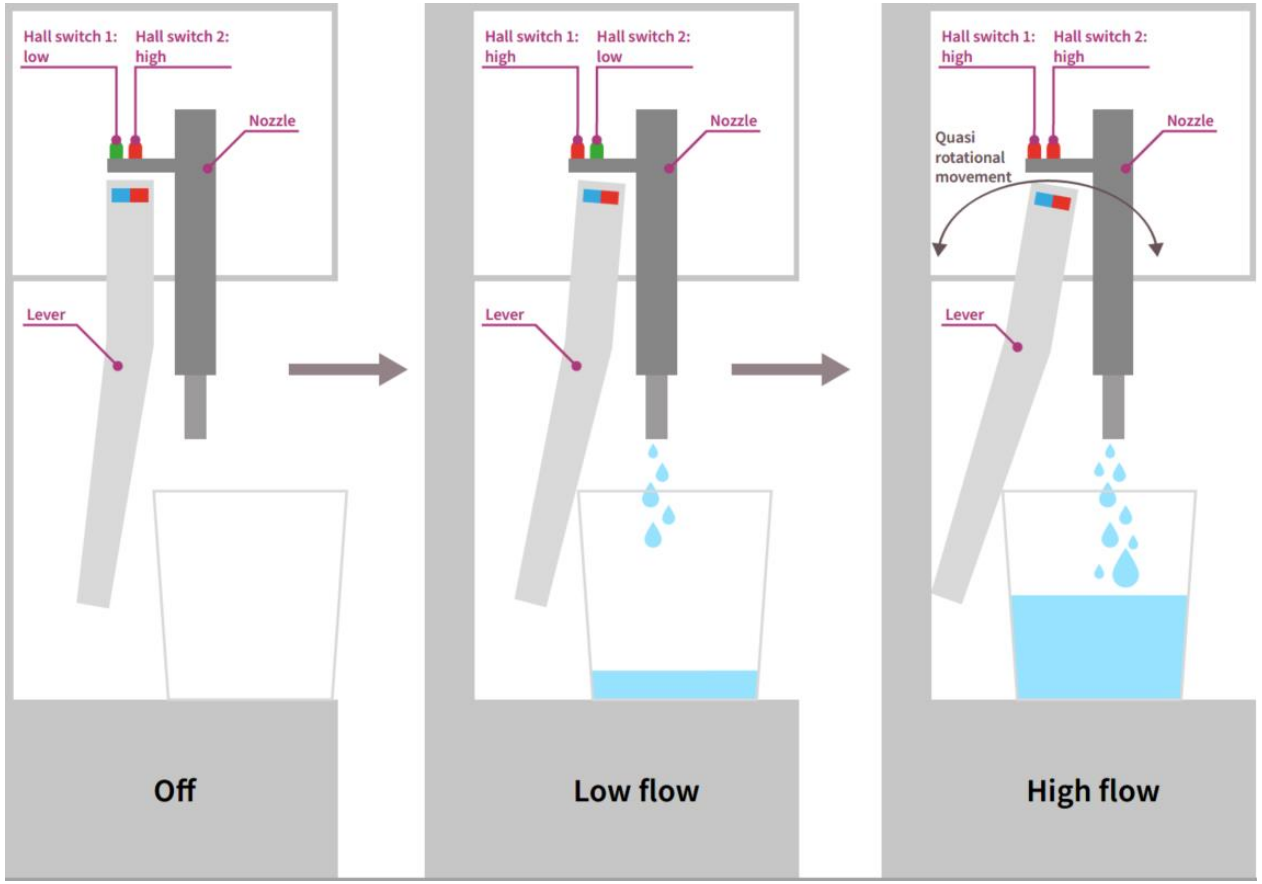
Contactless, reliable and cost-efficient sensor with wide operating temperature range

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

Water and ice dispenser positioning with XENSIV™ hall sensors

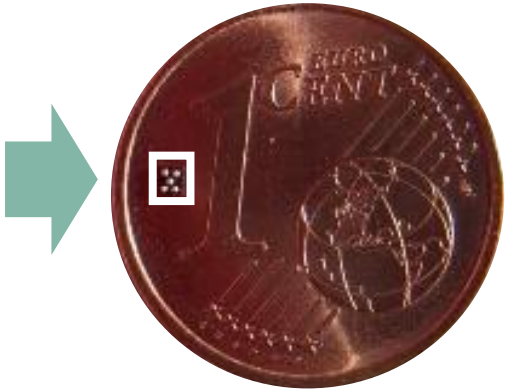
Determine position of lever to dispense ice or water

Detect the position of the lever to dispense ice or water at variable speed: The hall sensor detects the distance of the magnet mounted to the lever.



Sensors not visible

No physical contact required, therefore no mechanical wear



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™

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

Temperature control dials: Position sensor and touch sensing

Implement human-machine-interface to control temperature

User adjusts temperature with a rotary control dial, mechanical buttons, touch buttons or touch screens. Infineon offers solutions for each of these options.

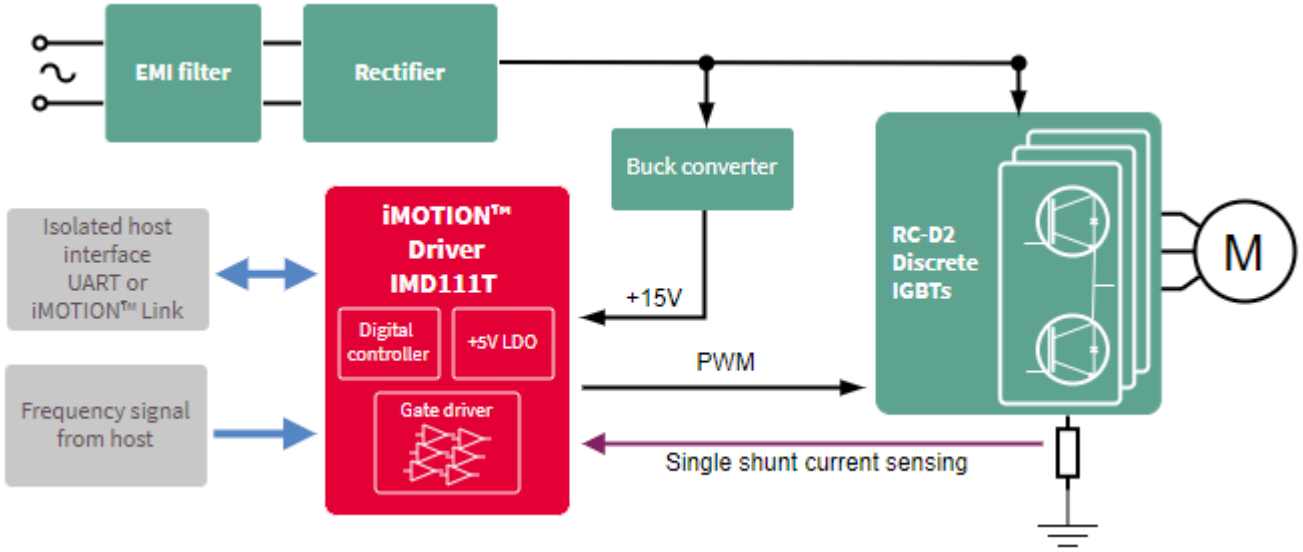
Infineon offer

- 3D magnetic sensors for rotary control dials and buttons can be easily implemented with Infineon´s 3D magnetic sensor 2Go kits
- Touch buttons and touch screens: Infineon´s PSoC controllers offer the most robust, sensitive and integrated solutions in the market

Table of contents

Fridge compressor up to 300 W using a discrete IGBT solution

Device	Details	Part #	Pcs
iMOTION™ driver	Controller with scripting functionality and integrated driver	IMD111	1
IGBT RC-D2	600 V Reverse Conducting IGBT Drives 2 in TO-252 package	IKD04N60RC2	6



Key features and benefits

- iMOTION™ Smart Driver + discrete IGBT
- Cost optimized
- Good efficiency at all load levels
- Low EMI
- System solution enable compact and scalable designs optimized for low losses in pull-down mode and EMI performance
- Designed for sensor-less FOC motor control using single shunt
- Easy to design-in – fast time to market

Application assumptions

Full load operation important, due to high thermal constraints

Stringent cost vs. EMI trade-off

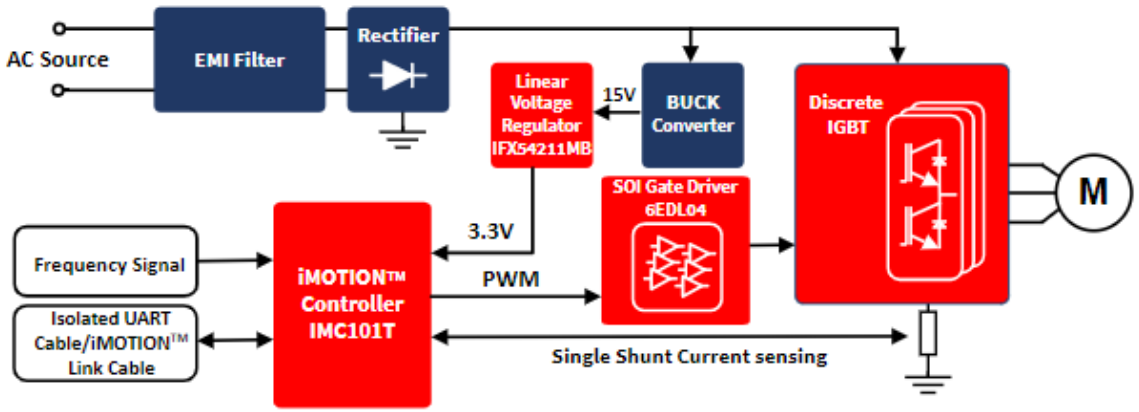
Integration is a valuable feature, but with the possibility to tune the EMI performances of the switch

Fridge compressor up to 300 W using a discrete IGBT solution REF_FRIDGE_C101T_6ED

Device	Details	Part #	Pcs
iMOTION™	Controller with scripting functionality	IMC101T-T038	1 1
Gate driver	3-phase gate driver with over current protection	6EDL04I06PT	1
IGBT	600 V Reverse Conducting IGBT Drives 2 in SOT-223 package	IKD04N60RC2	6
Voltage regulator	Regulates input voltage up to 18V. Good for low standby currents	IFX54211MD	1

Key features and benefits

- iMOTION™ controller + gate driver + IGBT
- Highest customization possible as all components can be flexibly chosen
- Eases second sourcing
- Good efficiency at all load levels
- Cost optimized
- System solution enable scalable designs optimized for low losses in pull-down mode and EMI performance
- Designed for sensor-less FOC motor control using single shunt



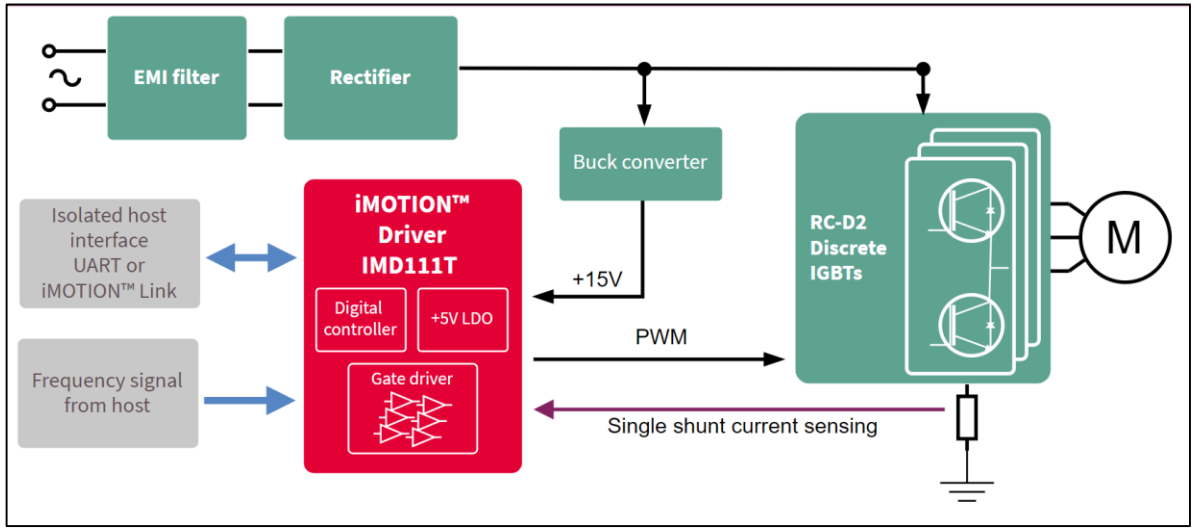
Application assumptions

- Flexibility is a must at the cost of lower integration
- Customers have the experience and preference to design and optimize the gate driver stage for highest EMI performance
- Second sourcing is a must-have requirement
- Customers want to use own code (possible only with XMC™ and PSoC™)

Link to reference design

Fridge compressor up to 300 W using a discrete MOSFET solution

Device	Details	Part #	Pcs
iMOTION™ Driver	Controller with scripting functionality and integrated driver	IMD111T-6F040	1
MOSFET: 600 V CoolMOS™ PFD7	SJ MOSFET with integrated fast body diode, tailored for light load efficiency in low power inverters ≤300 W, available in DPAK and SOT-223	IPN60R600PFD7S	6



Key features and benefits

- iMOTION™ Driver + discrete MOSFET
- Efficiency optimized @light load
- Particularly robust towards ESD (>2kV)
- System solution enable compact and scalable designs optimized for light load efficiency Designed for sensor-less FOC motor control using single shunt
- Motor control easy to design-in – fast time to market

Application assumptions

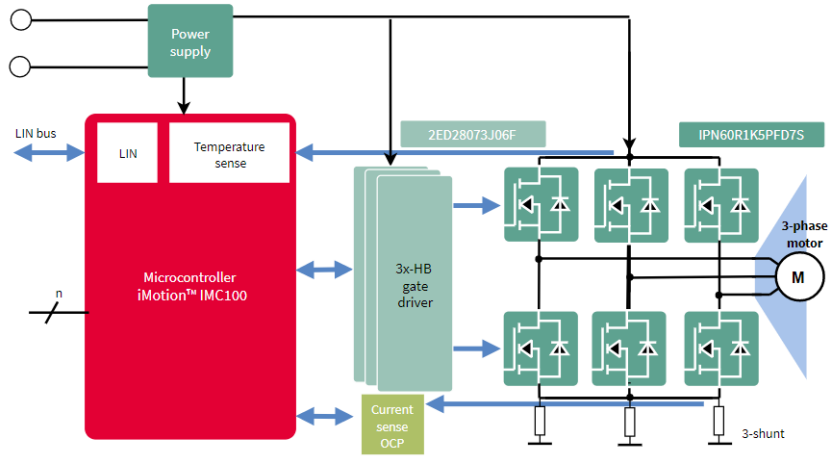
- Light load operation important, to improve energy labeling by ~1%*
- High ESD capability device level is of particular importance
- High integration solution featuring iMOTION™ Smart Driver

*compared to IGBT based solution. Reduction of yearly energy losses estimated for a typical refrigerator profile with an overall energy consumption of 214 kWh per year

Link to reference design

Fridge compressor up to 150 W using a discrete MOSFET solution

Device	Details	Part #	Pcs
iMOTION™ controller	Controller with scripting functionality	IMC101T-T038	1
MOSFET: 600 V CoolMOS™ PFD7	SJ MOSFET with integrated fast body diode, tailored for light load efficiency in low power inverters ≤300 W, available in DPAK and SOT-223	IPN60R1K5PFD 7S	6
Gate driver	600 V half-bridge gate driver with integrated bootstrap diode	2ED28073J06F	3
Diode	Silicon Schottky Diode	BAT54-03W	1
Voltage regulator	Monolithic integrated fixed NPN type voltage regulator	IFX1117ME V33	1



Key features and benefits

- iMOTION™ controller + gate driver + MOSFET
- Efficiency optimized @light load
- Highest customization possible as all components can be flexibly chosen
- Eases second sourcing

Application assumptions

- Light load operation important, to improve energy labeling by ~1%*
- Flexibility is a must at the cost of lower integration
- Second sourcing is a must-have requirement
- Customers have the experience and preference to design and optimize the gate driver stage, to improve EMI vs. losses trade-off

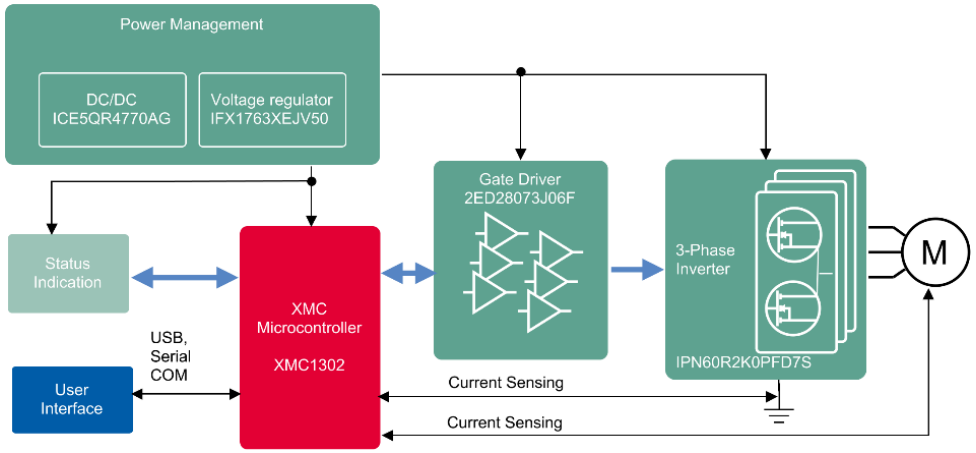
*compared to IGBT based solution.

Reduction of yearly energy losses estimated for a typical refrigerator profile with an overall energy consumption of 214 kWh per year

Link to eval board

Fridge compressor up to 100 Watt using a discrete MOSFET solution

Device	Details	Part #	Pcs
XMC™	32-bit Microcontrollers with ARM® Cortex®-M0 with focus on low-cost embedded control applications	XMC1302	1
MOSFET: 600 V CoolMOS™ PFD7	SJ MOSFET with integrated fast body diode, tailored for light load efficiency in low power inverters ≤300 W, available in DPAK and SOT-223	IPN60R2K0 PFD7S	6
Gate driver	600 V half-bridge gate driver with integrated bootstrap diode	2ED28073J 06F	3
CoolSet™ Gen5	Integrated flyback controller and power switch	ICE5AR477 0	1



Key features and benefits

- Compact 3-phase motor drive system
- Designed for sensor-less FOC and Block Commutation motor control
- Speed controlled using µC/Probe™ GUI's

Furthermore, the hardware in the board and the motor control software provide:

- A synchronous rectification algorithm to reduce reverse-current hard-commutation stress
- A complete optimizable code based on customers application requirements
- 3-phase or 2-phase Space Vector Modulation (SVM)
- Hardware & software overcurrent protection

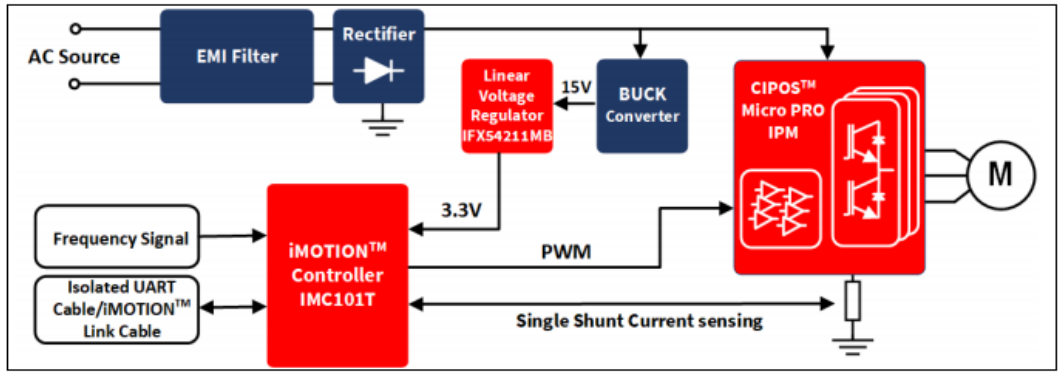
Application assumptions

- Flexible platform with open source code
- Customers want to develop/use own code
- Flexibility is a must at the cost of lower integration
- Second sourcing is a must-have requirement

Link to reference design

Fridge compressor up to 400 W using an integrated solution

Device	Details	Part #	Pcs
iMOTION™ Controller	Controller with scripting functionality	IMC101T-T038	1
CIPOS Micro IPM	Integrated Gate driver and IGBTs	IM241-S/M6T2J	1
Voltage regulator	Regulates input voltage up to 18 V. Good for low standby currents	IFX54211	1



Key features and benefits

- iMOTION™ Controller + IPM
- Power density optimized
- Good efficiency at all load levels
- Takes lowest space
- Short time-to-market
- Slow switching speed of IPM improves EMI emissions

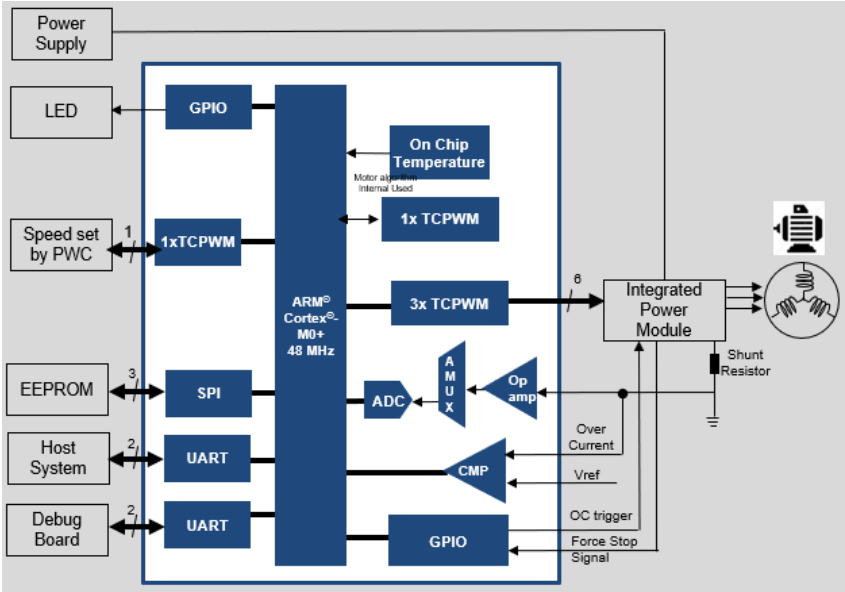
Application assumptions

- Full load operation important, due to high thermal constraints
- Stringent cost vs. EMI trade-off
- Small system size to maximize cooled volume
- Scalable platform for different refrigerator sizes, using IPMs with identical pinout

Link to reference design

Fridge compressor up to 400 W using an integrated solution

Device	Details	Part #	Pcs
PSoC™ controller	32-bit Microcontrollers with ARM® Cortex®-M0	CY8C4146AZI-S423 (PSoC 4100S)	1
CIPOS™ Micro IPM	IPM for Compressor with IGBT	IM231-L6S1B	1
CoolSet™ Gen5	Integrated flyback controller and power switch	ICE5AR4770	1



Key features and benefits

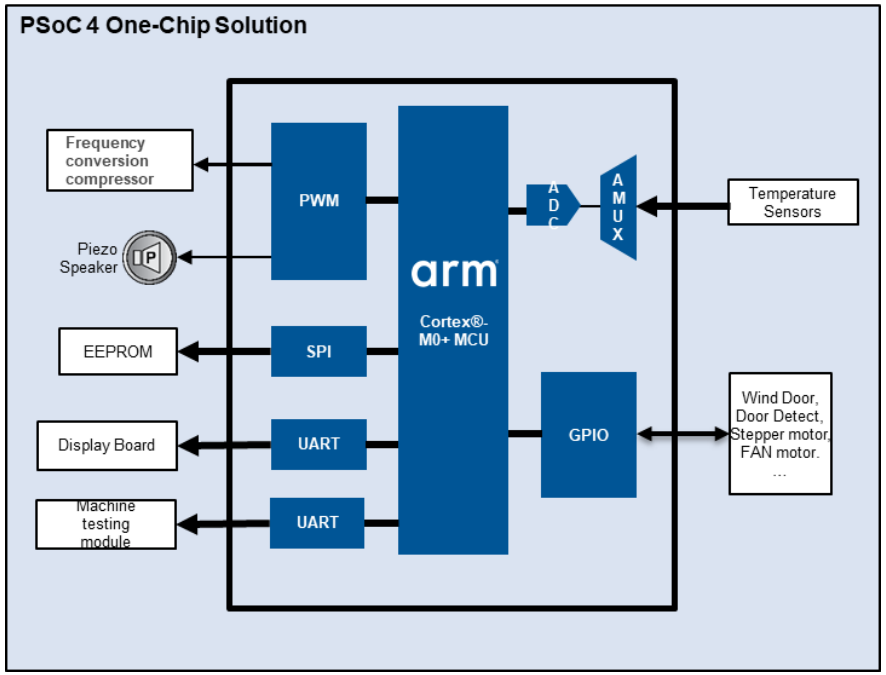
- PSoC™ for motor control which can also be used for additional system control and HMI.
- Short time-to-market, Flexible SW benefitting the individual startup performance and integrated with FOC compressor control
- Optimized SVPWM with 4us, 1-shunt sampling
- Competitive BOM cost with integrated CMP/OPA in MCU
- Directly close loop startup without open loop drag, no stop clamping, closed-loop smooth running at full speed.
- Full scale protection: over/under voltage, over current (phase current and AC input), motor running power real-time calculation and protection, IPM over temperature, sample hardware fault, phase loss, rotor lock.

Application assumptions

- Full load operation important, due to high thermal constraints
- Stringent cost vs. EMI trade-off
- Small system size to maximize cooled volume
- Scalable platform for different refrigerator sizes, using IPMs with identical pinout
- PSoC: Integrated with OpAmp to reduce BOM cost
- Reliable motor control algorithms

Fridge system control

Device	Details	Part #	Pcs
PSo™ controller	32-bit Microcontrollers with ARM® Cortex®-M0	CY8C4146 AZI-S423	1



Key features and benefits

- One chip solution for system control
- Integrates all main control functions and communication interfaces in a powerful Arm® Cortex® - M0
- Includes up to 256 KB Flash to store configuration profiles
- Provides class B library for safe operation
- Integrated CapSense and segLCD features to support system control and HMI 2in1 solution.

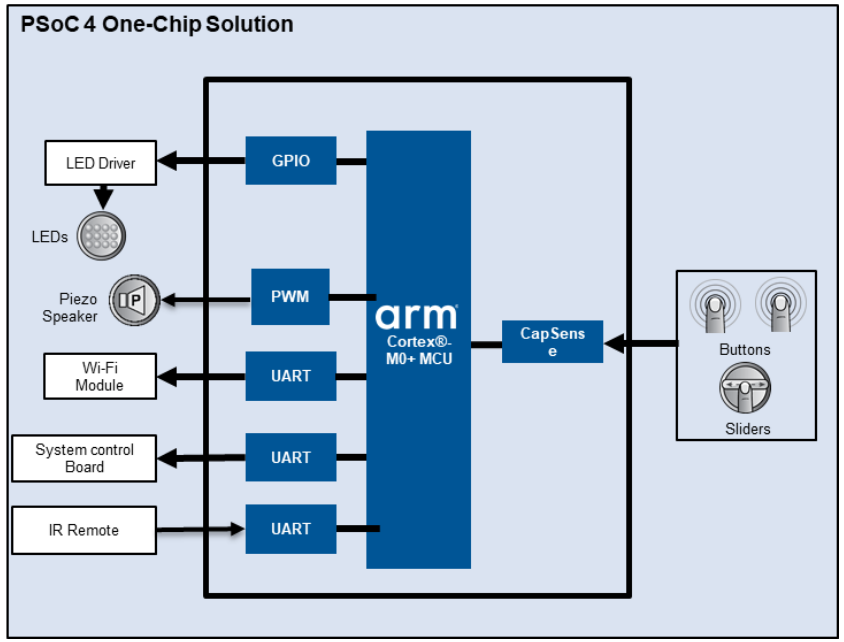
Application assumptions

- Implement all main control functions and communication interfaces in single chip.
- Requires Class B certification
- Integrated system control and HMI in single chip.

Link to demo board

Fridge touch display using CapSense® and display 2-in-1 HMI

Device	Details	Part #	Pcs
PSoC™ controller	32-bit Microcontrollers with ARM® Cortex®-M0	CY8C4025 AZI-S413	1



Key features and benefits

- PSoC™ 4 integrate the SegLCD and CapSense® user interfaces to implement 2in1 HMI one-chip solution.
- Includes up to 256 KB Flash to store configuration profiles and Support OTA feature.
- Provides class B library for safe operation.

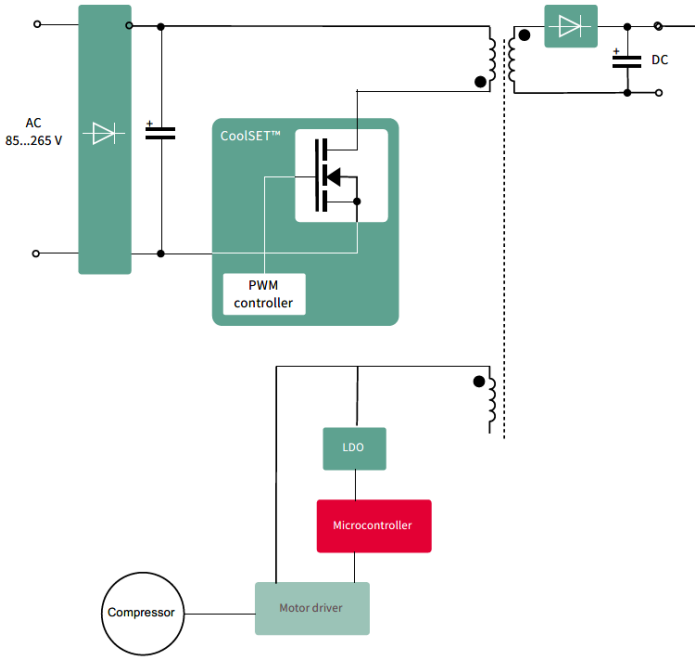
Application assumptions

- Implement all HMI functions and communication interfaces in single chip.
- Requires Class B certification
- High density Flash to support OTA
- Seems it's a trend to integrated system control and HMI in single chip.

Link to demo board

33 W refrigerator auxiliary power supply

Device	Details	Part #	Pcs
CoolSET™	Quasi-resonant flyback controller with integrated 700 V MOSFET	ICE5QR1070AZ	1



Key features and benefits

- Auxiliary power, PWM controller and MOSFET in one package
- High power delivery in SMD package up to 42 W
- Very low dpm rate
- Efficiency: 84%
- Input frequency: 47-64 Hz
- Output power of ref design: 33 W

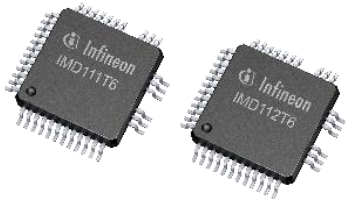
Application assumptions

- Robust line input protection
- High efficiency
- Cost efficient with multi-output SMPS design

Link to reference design

Table of contents

iMOTION™ Driver turning any motor



Key features SmartDriver IMD110		Key value
Flexibility	The SmartDriver can drive **almost any MOSFET or IGBT** in a variable speed drive inverter	**Design re-use** for multiple power ratings
Ready to use	Field proven Motion Control Engine (MCE) provides **motor and PFC control algorithm**	**Shortest time-2-market**
Robustness and Reliability	**Rugged and reliable** SOI gate driver and package with improved **creepage and clearance**	**Robust and reliable** drive inverter
Cost optimization	High integration and small package for **reduced BOM cost**	**Reduced system costs**
Functional safety	Full set of **protections** in hard- and software and support for safety acc. to **IEC 60335 ('class B')**	**Protection in design and application stage**

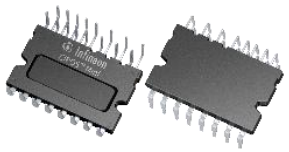
Focus product / 650 V TRENCHSTOP™ IGBT6
Performance optimized for low power drive up to 300 W

Key features **650 V TRENCHSTOP™ IGBT6**		**Key value**
Lowest V_{CEsat} & low switching losses	Optimized for low conduction losses, best-in-class efficiency in low power motor drives up to 1 kW	**Low losses** to meet energy efficiency requirements
Best-in-class controllability	Great trade-off between controllability and switching losses	**Lower system cost** on EMI filtering
650 V breakdown voltage	Increased reliability	**Additional headroom** for unstable grid voltages

Focus product / 600 V RC-D2
Optimized for low power drive < 300 W

Key features **600 V RC-D2**		**Key value**
New price/ performance standard	Optimized for consumer drives	**Great** trade-off between price and performance
Broad portfolio	DPAK: offered in 4 variants with a collector current IC ranging from 4 to 15 A; SOT 223 package variants available in Q4 2021	Drop in **replacement**
Improved EMI	Enhanced controllability to reduce EMI noise compared to previous RC-D technologies	**Easy to design in**
HV-H3TRB ruggedness	HV humidity ruggedness improvement to protect the system	**High system reliability**

CIPOS™ Mini IM51x-series IPM with CoolMOS™ MOSFETs



Key features **CIPOS™ Mini IM51x-series**		**Key value**
High efficiency	High efficient intelligent power modules that integrate CoolMOS™ MOSFETs to improve power efficiency of applications, such as compressors, pumps, and fans, or other motor drives up to up to 600 W	Improved energy efficiency
Excellent light load efficiency	The integrated CoolMOS™ MOSFETs offer significant lower switching and conduction losses comparing to IGBTs. It enables IM512x-series to reduce power consumption, especially under light load conditions.	Reduced power consumption
2 or 3-phase inverter configuration	IM51x-series offer low on-resistance of 310 mΩ and 10 A at 25°C with 600 V break down voltage. Full-bridge (IM512) and 3-phase (IM513) inverter configuration are available for easy implementation.	Ease of use
Enhanced reliability	The system reliability is further enhanced by the built-in NTC for temperature monitoring, integrated under-voltage lock-out function, and an over-current protection (OCP) features..	Stable system reliability

Focus product / 600 V CoolMOS™ PFD7
Optimized for light-load performant low power drives < 300 W

Key features **600 V CoolMOS™ PFD7**		**Key value**
 **Light-load efficiency up to 300 W**	Attractive solution for refrigerator compressors, offering **improved efficiency,** especially at steady state & **light load conditions below 300 W**	Increased **efficiency** and improved **thermal behaviour**
 **Best-in-class fast body diode**	Integrated robust **fast body diode** with ultra low Q_{rr} & industry's **fastest recovery time** (T_{rr})	**Robustness** and **reliability** Reduced **switching losses**
 **Integrated ESD protection**	**Integrated Zener diode** for ESD protection ≤ 2 kV (HBM Class 2)	Eliminated **ESD related yield losses**
 **Right-fit portfolio**	Wide range of $R_{DS(on)}$ values ≤ 2 Ohm and industry-leading SMD package offering (e.g. SOT-223)	**BOM cost** reduction & **PCB savings** **Easy manufacturing**

Focus product / Gen 5 CoolSET™
High efficiency & low standby for HA aux power solutions


Key features **Gen 5 CoolSET™**		**Key value**
Broad portfolio	Highest power delivery up to 43W in DIP & DSO package	BOM savings
Higher performance	High light-mid load efficiency and low standby	High performance design
Ease of design	Numerous aux power reference designs with design tools/guide & application notes	Faster time to market
Highest quality & system robustness	Integrated with 700V or 800V superjunction mosfet and comprehensive protection features	Reliable supplier

Part of your life. Part of tomorrow.