Induction heating and motor control in small home appliances – Cooking, cooling, drying

July, 2020
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Overview of home appliances

- Major home appliances
  - Dishwasher
  - Refrigerators and freezers
  - Room air conditioners
  - Washing machines and Dryers

- Small home appliances
  - Blender, mixer, food processor
  - Microwave oven
  - Vacuum cleaner
  - Fans and purifier for air and water

- Induction heating
  - Tabletop / Multi-hob
  - Induction cooker
  - Induction rice cooker

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Efficiency, control, and connectivity: Induction heating is more and more a standard in cooking appliances

Key advantages of induction cooking

- Time saving
- Cooking efficiency
- Safety
- Control
- Design
Different appliances have different requirements: Inverterization of drives helps to fulfill all of them

- **Brushless DC (BLDC) blender**
  - Longer lifetime
  - Less noisy
  - More Efficient

- **BLDC hair dryer**
  - Longer lifetime
  - More powerful airflow
  - Smart heat control

- **Water purifier**
  - No water tank; no bacterial propagation
  - Slim design
  - Cold water by inverterized compressor
  - Hot water by induction heating

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Infineon leads incorporation of market trends in home appliances

- Low acoustic noise
- Certification effort
- Security
- Space constraints
- Lifetime improvement
- Higher versatile

- Wireless connectivity
- User interface
- Platform approach
- Cloud connectivity
- IoT
- Sensor-less FOC

- EMI / robustness
- Predictive maintenance

- Energy efficiency

- System cost reduction

- Faster time-to-market
The right security for connected home appliances: OPTIGA™ product portfolio

Security level

High

Authentication

OPTIGA™ Trust B
e.g. authentication of nodes

OPTIGA™ Trust E
e.g. certified authentication of nodes

OPTIGA™ Trust X
e.g. secure communication to the cloud

Programmable

OPTIGA™ Trust P
e.g. Java for applications to be added

Connected device security

Low

Single function

Advanced

Hardware-based security
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Induction cooking – Resonant switching applications

Application spaces

Advanced features

Reverse conducting IGBTs include monolithically integrated diodes

› 650 V RC-H5 – lowest V CE(sat) as well as lower E off for best efficiency and thermal performance

› 1200V, 1350V & 1600V RC-H5 – Best performance, especially at higher switching frequencies

› 1200V RC-E – Cost effective, optimized for price vs. performance

› IPD Protect – Best performance in class IGBT – 20A 1350V in RC-H5 technology co-packed with driver with protective functions
The evolution of the induction cooker

- **Basic cooking functionality**
- **Pushbuttons – not reliable or waterproof**
- **Thick body designed for airflow and cost**
- **Energy efficiency labeling**
- **Full featured – precision heat control, multiple settings**
- **Wi-Fi ready and additional “smart” features**
- **Safety features, long service life**
- **Sleek, thin design for best appearance, cleaning, waterproof**

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Induction cooking – Application landscape

Half-bridge topology

Most common applications:
- Multi-Hob induction stoves
- Inverterized microwave ovens

Single ended topology

Most common applications:
- Table top induction cooker
- Induction rice cooker
- Inverterized microwave ovens
Extended RC IGBT portfolio for induction cooking appliances

<table>
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<tr>
<th>$I_c$ nom [A]</th>
<th>Features</th>
<th>Price</th>
<th>Performance</th>
<th>Protection</th>
<th>Appliances</th>
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<td>Topology</td>
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<td>Single ended</td>
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<td></td>
<td>Family</td>
<td></td>
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<tr>
<td></td>
<td>Voltage</td>
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<td></td>
<td>Single ended</td>
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<tr>
<td>15</td>
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<td>1200 V</td>
<td>650 V</td>
<td>1200 V</td>
<td>15350 V</td>
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<tr>
<td>20</td>
<td>IHW20N65R5</td>
<td>IHW20N120R5</td>
<td>IHW20N135R5</td>
<td>IEWS20R5135IPB</td>
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<td>IHW30N160R5</td>
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<td>40</td>
<td>IHW40N65R5 (*)</td>
<td>IHW40N120R5</td>
<td>IHW40N135R5</td>
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<tr>
<td>50</td>
<td>IHW50N65R5</td>
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<td>Package</td>
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<td>TO247-3</td>
<td>TO247-3</td>
<td>TO247-3</td>
<td>TO247-6</td>
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<tr>
<td>Recommended Driver IC</td>
<td>1ED44175N01B</td>
<td>2ED218x</td>
<td>1ED44175N01B</td>
<td></td>
<td>Co-packed driver with protection functions</td>
</tr>
</tbody>
</table>

*available also in advanced isolation package: IHFW40N65R5S
Why to use Infineon’s products?

- **Low power losses**
  - High energy efficiency

- **Highest quality standards**
  - High system reliability

- **Soft switching slopes**
  - Excellent EMI behavior

- **State-of-the art technologies**
  - Competitive appliances
Induction cooking topologies

Half-bridge topology

Single-switch topology
# Infineon solution overview for induction heating

<table>
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<th>Component</th>
<th>Description</th>
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<tr>
<td>Inverter switches</td>
<td>TRENCHSTOP™ RC-H5 IGBTs</td>
</tr>
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<td></td>
<td>IPD Protect</td>
</tr>
<tr>
<td>Gate driver ICs</td>
<td>650 V SOI Level shift gate driver ICs</td>
</tr>
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<td></td>
<td>Single channel low side driver ICs</td>
</tr>
<tr>
<td>Microcontrollers</td>
<td>XMC™ / Cypress PSoC® 4 series</td>
</tr>
<tr>
<td>Driver &amp; auxiliary power</td>
<td>Integrated power stage – CoolSET™</td>
</tr>
<tr>
<td>supply</td>
<td>Linear voltage and DC/DC switching regulators</td>
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<tr>
<td>C. sensors</td>
<td>XENSIV™ - high-precision coreless current sensors for industrial applications</td>
</tr>
<tr>
<td>Security</td>
<td>OPTIGA™ Trust product family</td>
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</table>
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Constantly growing feature set in home appliance applications
Solutions for consumer motor drives: Discretes or IPM inverters

- **Motor power**
  - 10 W
  - 100 W
  - 300 W
  - 1 kW
  - 3 kW

- **Integration**
  - **high**
    - Space optimized: IPM
      - Integrated in motor housing
  - **low**
    - Thermal optimized: IGBT/MOS
      - Larger PCB space to extend power w/o heatsink
    - Assembly optimized: IGBT/Module
      - Easy HS mounting + isolation

- **No Heatsink**
- **Heatsink**
Infineon’s comprehensive offering for motor control

- Thermal simulation
- Electric simulation
- Sensor simulation
- PDH
- Complete solution

**Products**
- iMOTION™
- CIPOS™
- Discrete, Gate Drivers
- SMPS, sensors

**Simulation**
- Controller board
- Power board

**MADK**
- On-site engineering support
- Short flows for customized products

**SOLUTION**

**CUSTOMER**
Motor control: iMOTION™ or Microcontroller?

Does the customer want to write or has motor control code? Is the customer able to write motor control codes?

Yes

Microcontroller

Controller

Microcontroller

Customer writes his own software with support of advance tools for BLDC, Brushed DC, PMSM and Sensorless FOC

PSOC® 4/6 / FM4 XMC™

No

iMOTION™

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

TurnKey

Motion control engine

Ready-to-use Motor controller for variable speed drives

IRMCK099 IMC100

MCE + Controller

Motion control engine

Additional MCU for customer functionality, available with Flash and OTP memory

IMC300

Smart IPM

Motion control engine

Driver & power stage

Fully integrated inverter solution

IMM100 / IMD100

Yes

Microcontroller

Controller

Microcontroller

Customer writes his own software with support of advance tools for BLDC, Brushed DC, PMSM and Sensorless FOC

PSOC® 4/6 / FM4 XMC™
iMOTION™ reduces significantly time & resource needs in the overall motor & PFC software development cycle

**Concept**

**Implementation**

**Testing**

**Production**

**Certification**

Easy product selection – no matching between MCU performance/peripherals and system requirements needed

**Conventional SW development flow**

- Drivers/Module Library/Demo SW
- Algorithm development incl. test
- System adaption
- System test
- Class B product & system

Development Start

**iMOTION™ products**

**Class B product**

**System adaption**

**System test**

**Class B system**

Time gain

**Major benefits – Significant time to market improvement**

- Simplified product selection
- State of the art algorithms – production ready & UL/ClassB pre-certified
- RnD cost savings of ~$180k (Assumption: 12 MM a $15k)
# Microcontroller portfolio for small home appliance

<table>
<thead>
<tr>
<th>User Case</th>
<th>Range hood</th>
<th>Water heater</th>
<th>Water purifier</th>
<th>Air purifier</th>
<th>MWO</th>
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<tr>
<td><strong>Part numbers</strong></td>
<td>CY8C4025/S1 CY8C4126/S2</td>
<td>CY8C4014/S0 CY8C4025/S1 CY8C4126/S2</td>
<td>CY8C4025/S1 CY8C4126/S2 CY8C4127/S3</td>
<td>CY8C4014/S0 CY8C4147/S3</td>
<td>CY8C4014/S0 CY8C4148/S3</td>
</tr>
<tr>
<td><strong>Key features</strong></td>
<td>Good capsense performance Ease use turnkey Support OTA, 5V power supply, 32bit M core</td>
<td>Good capsense performance Ease use turnkey Enable LCD 5V Power supply</td>
<td>Good Capsense performance Ease use turnkey Support OTA, 5V power supply</td>
<td>Good Capsense performance, Support OTA, 5V power supply, 32bit M core</td>
<td>Good Capsense performance, Support OTA, 5V power supply, 32bit M core</td>
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## Infineon selection guide for motor drive inverter power stage <300 W

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<th>CoolMOS™</th>
<th>CIPOS™</th>
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<td>TRENCHSTOP™ RCD (DPAK)</td>
<td>CoolMOS™ PFD7 (SOT223, DPAK)</td>
<td>iMOTION™ Smart IPM (PQFN) &lt;80W</td>
</tr>
<tr>
<td>TRENCHSTOP™ RCD2* (DPAK, SOT223)</td>
<td>CoolMOS™ CFD (DPAK)</td>
<td>CIPOS™ Nano (PQFN) &lt;205W</td>
</tr>
<tr>
<td>TRENCHSTOP™ IGBT6* (DPAK)</td>
<td></td>
<td>CIPOS™ Micro (DIP, SOP) &lt;400W</td>
</tr>
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</table>

### Features

- Better thermal management, easier to dissipate the losses in the PCB without heatsink
- Better cost position (second sourcing, discrete are cheaper)
- Flexible EMI noise vs. performance tuning by gate resistance selection
- Best EMI noise controllability
- Best efficiency

### CIPOS™

- Higher integration, reducing PCB/system size and BOM
- Shorter time to market
- Increased reliability

### CoolMOS™

- Fridge Compressors, Ceiling Fans, Hair Drier, Circulation Pumps, Air Purifier, HVAC Fans
- Heat dissipation without the Heatsink
- Usually Active PFC stage is not used
- Usually sensor-less motor control
- Current is sensed using single shunt in DC- or two shunts in the inverter branches

### iMOTION™/ PSoC® 4/6 / XMC™

- Better thermal management, easier to dissipate the losses in the PCB without heatsink
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* Available in Q1-2020
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## Infineon solution overview for blenders

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<td>Inverter switches</td>
<td>TRENCHSTOP™ 5 S5 in TO-220-3</td>
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<td>TRENCHSTOP™ IGBT 6 - 650V</td>
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<td>Gate driver ICs</td>
<td>650 V SOI Level shift gate driver ICs</td>
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<td>600 V JI Level shift gate driver ICs</td>
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<tr>
<td>IPM</td>
<td>CIPOS™ Mini</td>
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<td>Microcontrollers</td>
<td>iMOTION™ IMC1100/PSoC 4/6</td>
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<td>Driver &amp; auxiliary supply</td>
<td>Integrated power stage – CoolSET™</td>
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<td>Linear voltage and DC/DC switching regulators</td>
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<td>M. sensors</td>
<td>Hall Switches and angle sensors</td>
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<td>Security</td>
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<td>Blender</td>
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Infineon solution overview for water purifier

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<th>Water purifier - compressor</th>
<th>90 W</th>
<th>120 W</th>
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<tr>
<td>Inverter switches</td>
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<tr>
<td>TRENCHSTOP™ IGBT6 / RCD2 IGBTs</td>
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<tr>
<td>CoolMOS™ PFD7</td>
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<td>CoolMOS™ CE</td>
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<td>IPM</td>
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<td>CIPOS™ Nano/Micro</td>
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<tr>
<td>Microcontrollers</td>
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<td>iMOTION™ / PSoC4/6 / XMC™</td>
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<td>Driver &amp; auxiliary supply</td>
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<td>Integrated power stage – CoolSET™</td>
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<td>Linear voltage regulators for Industrial application</td>
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## Infineon solution overview for ceiling fan

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<th>Ceiling fan</th>
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<td>50 W</td>
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<tr>
<td>Inverter switches</td>
<td>RCD2 IGBTs</td>
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<td>CoolMOS™ PFD7</td>
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<td>CoolMOS™ CE</td>
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<td>PFC switches</td>
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<td>Gate driver ICs</td>
<td>650 V SOI Level shift gate driver ICs</td>
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<td>600 V JI Level shift gate driver ICs</td>
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<tr>
<td>IPM</td>
<td>CIPOS™ Nano/Micro / iMOTION™ Smart IPM</td>
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<tr>
<td>Microcontrollers</td>
<td>iMOTION™ / PSoc4/6 / XMC™</td>
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Conclusion and take-aways

- Infineon has the most comprehensive portfolio among competitors: One-stop-shop.
- Infineon offers energy efficient solutions, with different levels of integration to meet any customer needs.
- We can offer a competitive and complete system solution for traditional and new consumer drive applications.
- Smart functionality is offered beyond energy efficiency.
- Add hardware-based security already at product design and benefit from Infineon's support for an easy and fast integration.
- We are working together with our customers to grow into the future!
Part of your life. Part of tomorrow.