Introduction Gen5 QR/FF PWM controller for home appliance auxiliary power supply

IFKOR PMM SMD
Albert.kim
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1. Global Efficiency Requirement
2. Gen5 Quasi-Resonant CoolSET Introduce
3. Gen5 Quasi & Fixed Freq. Portfolio Overview
4. Summary
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1. Global Efficiency Requirement
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4. Summary
Global Regulation of Household appliances

- **Energy Efficiency Label**
- **Energy Star program**
- **Energy Rating Label GEMS**
- **ErP (Energy Related Product)**
- **Natural Resources Canada, NRCan**
- **Energy Consumption Efficiency Label E-Standby Program**
Energy Efficiency Requirement (External Power Supplies)

- **DOE Level VI**
  - Required high *average* efficiency; i.e. calculated from the nameplate output power as the arithmetic average of efficiency at 25%, 50%, 75%, 100% load points

<table>
<thead>
<tr>
<th>Nameplate Output Power ($P_{out}$)</th>
<th>Minimum Average Efficiency in Active Mode (expressed as a decimal)</th>
<th>Maximum Power in No-Load Mode (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{out} \leq 1$ W</td>
<td>$\geq 0.5 \times P_{out} + 0.16$</td>
<td>$\leq 0.100$</td>
</tr>
<tr>
<td>$1$ W $&lt; P_{out} \leq 49$ W</td>
<td>$\geq 0.071 \times \ln(P_{out}) - 0.0014 \times P_{out} + 0.67$</td>
<td>$\leq 0.100$</td>
</tr>
<tr>
<td>$49$ W $&lt; P_{out} \leq 250$ W</td>
<td>$\geq 0.880$</td>
<td>$\leq 0.210$</td>
</tr>
<tr>
<td>$P_{out} &gt; 250$ W</td>
<td>$\geq 0.875$</td>
<td>$\leq 0.500$</td>
</tr>
</tbody>
</table>

- 40Watt model minimum Average Efficiency : 87.59% $\Rightarrow$ 83.76%
- Required low standby power (No-Load Mode);
  - $\leq 49$ W Nameplate Power : Stdby $< 100$ mW $\Rightarrow$ 300 mW
  - $> 250$ W Nameplate Power : Stdby $< 500$ mW $\Rightarrow$ no requirement
Energy Efficiency Requirement

› CoC Tier 1 - Voluntary European Requirements

<table>
<thead>
<tr>
<th>Nameplate Output Power (Pout)</th>
<th>Minimum Average Efficiency in Active Mode (expressed as a decimal)</th>
<th>10% Load Average Efficiency in Active Mode (expressed as a decimal)</th>
<th>Maximum Power in No-Load Mode (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3 W ≤ Pout ≤ 1 W</td>
<td>≥ 0.50 \times Pout + 0.146</td>
<td>≥ 0.50 \times Pout + 0.046</td>
<td>≤ 0.150</td>
</tr>
<tr>
<td>1 W &lt; Pout ≤ 49 W</td>
<td>≥ 0.0626 \times \ln(Pout) + 0.646</td>
<td>≥ 0.0626 \times \ln(Pout) + 0.546</td>
<td>≤ 0.150</td>
</tr>
<tr>
<td>49 W &lt; Pout ≤ 250 W</td>
<td>≥ 0.890</td>
<td>≥ 0.790</td>
<td>≤ 0.250</td>
</tr>
<tr>
<td>Pout &gt; 250 W</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

- there are differences in how the DoE and EU define external power supplies and the scope of which classes of supply are included or exempt from these rules.
- Multiple-voltage external power supplies
- Products with power levels > 250 watts
Home Appliance Trends

- Refrigerator Trend
  - Large Display
  - Include IoT feature about internet and Wifi
  - Increase power consumptions

- Customer requirement
  - 3-4 Watt range efficiency
  - Easy design

Display & WiFi

High-End Model

- DC FAN & LED lighting
- Inverter Driving

Middle-End Model

- Display & WiFi

Low-End Model

- DC FAN
- LED

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Infineon 5QR CoolSET  Competitive Advantages
Functional Integration + Silicon Technology

Leading Edge Controller Technology
- Novel Quasi-Resonant ➔ Ease EMI filter design
- Functional Integration ➔ BOM Saving
- Cadcode Start up ➔ Fast startup

CoolMOS Switching Transistor
- Smallest RDson at a given silicon area ➔ reduced cost, increased output power, lower stdby power
- Avalanche Protected

Packages: DIP-7, DSO-12
Proven track record from more than 19 years of technology leadership

<table>
<thead>
<tr>
<th>Year</th>
<th>Series</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>S5 series</td>
<td>1st series of CoolMOS™ 600 Volt</td>
</tr>
<tr>
<td>2001</td>
<td>C3 series</td>
<td>„Working horse“ of portfolio 600 Volt</td>
</tr>
</tbody>
</table>
| 2004 | CFD series        | 1st CoolMOS™ 600 Volt
|      |                   | Fast Body Diode technology                                                  |
| 2005 | CP series         | Best-in-class performance 600 Volt                                         |
| 2009 | C6/E6 series      | Ease-of-use technology as C3 successor 600/650 Volt                         |
| 2011 | CFD2 series       | 2nd CoolMOS™ 650 Volt Fast Body Diode technology                             |
| 2012 | CE series         | Optimized for consumer applications (LCD/PDP TV), PC power and lighting 500 Volt |
| 2013 | P6 series         | Balanced Technology between ease-of-use and high efficiency 600 Volt       |
| 2013 | C7 series         | Power density at its best; Lowest $R_{DS(on)}$/package in the world 650 Volt |
| 2014 | CE series         | Best price/performance ratio compared to standard MOSFETs 600/650/800 Volt  |
| 2015 | C7 series         | Stepping stone towards GaN 600V                                            |
| 2017 | P7 series         | Ease-of-use price/performance 700V / 800V                                  |
ICE5QRxx70x/ICE5QRxx80x

Key Features

› Advanced Technology for QR PWM controller
  › Fast Startup achieved with Cascode Configuration
  › Digital Frequency reduction up to 10th valley @ high line for better light load efficiency
  › Novel quasi-resonant operation and proprietary implementation for low EMI

› Integrated 700V/800V CoolMOS®
  › 700 V / 800 V avalanche rugged CoolMOS™
  › Latest P7 version MOSFET

› Protections
  › Robust line protection with Adjustable input OVP and Brownout Protection
  › All protection to be auto-restart
  › Comprehensive protection features to protect the IC and the system from various fault conditions

› Easy used
  › Improved Active Burst Mode with selectable entry/exit thresholds to lower standby power
5th Novel Quasi Resonant CoolSET Example – Block Diagram

- **Input OVP and Brownout Protection Mode Control**
- **Zero Crossing detector and digital frequency reduction Control**
- **Switching High voltage FET**
- **Cascod Low voltage FET**
- **Gate Driver & FET Switching Control**
- **Selectable entry/exit Active burst Mode control**
- **Current Sensing & Current Control**
Schematic of Gen5

- Input OVP and Brownout Protection
- OCP
- Drain
- Vcc circuit
- Selectable entry/exit
- ZCD detection and Stat up
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   - Cascode Startup Operation
   - Advanced Feature and Protection
   - Demoboard Test Results

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4. Summary
Quasi Resonant Flyback Converter Introduction

- **QR (Quasi Resonant) flyback converter:**
  - Flyback converter + DCM operation + valley switching

**Benefits:**
- Lower switching losses & Higher average efficiency
- Lower switching interference & Lower EMI

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QR Flyback Converters:

- **Very high switching frequency at light load condition**
  - Higher losses @ increased frequencies ➔ significant efficiency reduction

- **Competitor solution**
  - Maximum switching frequency limitation with fixed minimum off time/switching period
  - This can cause jittering/modulation problems at certain load conditions, thus creating audible noise and/or EMI problems
  - Fixed switching frequency at medium and light load (effective FF PWM)
  - Limits the range of QR operation ➔ usually lower efficiency and greater EMI contribution

- **IFX solution**
  - **Digital Frequency Reduction** with decreasing load
    - Defined frequency reduction/increase path with Hysteresis ➔ No jittering/modulation and related problems
    - Higher efficiency from QR operation over wide load range
Gen2 digital frequency reduction

- IFX QR can provide up to 7 zero crossing (valley switching) at light load. Beyond the 7th zero crossing, the system will go into active burst mode.

- MOSFET will be turned on at 1st, 2nd, 3rd up to 7th zero crossing point so that the switching frequency will drop at light load instead of increasing.
Quasi-Resonant switching control scheme in 2Q

**Limitation of today Gen2 Quasi Resonant Series**

- Only 7 Zero crossing counters
  - FYI → Higher the number of zero crossing counter, the lower the switching frequency can be achieved during load reduction → Hence, lower switching loss and higher light load efficiency
- Operation independent of line input condition
  - High switching frequency spread between High/Low line input
    - Higher EMI signature at this condition → undesirable

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**2Q CoolSET**

- **High Line**
- **Low Line**

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Switching Frequency (kHz)

Output Power [%]

- 120 Vdc (Decreasing Load)
- 375 Vdc (Decreasing Load)

52 kHz
5th Novel Quasi Resonant Flyback Converter

2nd generation CoolSET

5th generation CoolSET

All way used 1st valley

High line at max load (3rd-10th)

Low line at max load (1st-8th)

With the introduction of Novel Quasi Resonant Switching scheme, 5Q is able to minimize the switching frequency spread between low and high line.

For 5Q, the switching frequency between high line and low line full load is just 4 kHz (52 kHz for 2Q).

### Frequency Reduction with Load (Q5)

- 5Q CoolSET

### Frequency Reduction with Load (Q2)

- 2Q CoolSET

<table>
<thead>
<tr>
<th></th>
<th>Low Line</th>
<th>High Line</th>
<th>HL - LL</th>
</tr>
</thead>
<tbody>
<tr>
<td>5Q</td>
<td>67 kHz</td>
<td>71 kHz</td>
<td>4 kHz</td>
</tr>
<tr>
<td>2Q</td>
<td>64 kHz</td>
<td>116 kHz</td>
<td>52 kHz</td>
</tr>
<tr>
<td>5Q - 2Q</td>
<td>3 kHz</td>
<td>-45 kHz</td>
<td></td>
</tr>
</tbody>
</table>
Using the $V_{IN}$ pin, the controller is able to differentiate between High/Low AC line input to set the boundary of ZC counter operation $\rightarrow V_{VIN_{REF}}$

- For low line, the Zero Crossing counter is allow to work within 1~8 count
- For high line, the Zero Crossing counter is allow to work within 3~10 count
- The hysteresis region is determine by $R1_{1}$ and $R1_{2}$ settings
- Maximum ZC count during Active Burst Mode

**Goal:** To increase efficiency @ High Line and reduce switching frequency spread between High/Low Line
1. Global Efficiency Requirement

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   - Novel Quasi Resonant Operation
   - Cascode Startup Operation
   - Advanced Feature and Protection
   - Demoboard Test Results

3. Gen5 Quasi & Fixed Freq. Portfolio Overview

4. Summary
Fast & robust start-up with cascode configuration

**Gen5**
Cascode structure

QR Gen5 CoolSET™ (ICE5QR4780AZ)

- $V_{IN} = 85 \, V_{AC}$, Full load
- $R_{STARTUP} = 45 \, M\Omega$, $t_{STARTUP} = 260$ ms

**Gen2**
Parallel structure

QR Gen2 CoolSET™ (ICE2QR4780Z)

- $V_{IN} = 85 \, V_{AC}$, Full load
- $t_{STARTUP} = 495$ ms

**Result**
- Gen2 → 495 msec
- Gen5 → 260 msec

**Conclusion**
- Gen5 start-up can be 1.9x faster than Gen2
Startup Operation with Cascode Configuration

**Startup Phase (Red arrow)**

1. A pull up resistor $R_{\text{STARUP}}$ is connected to the gate driver circuit of CoolMOS $M_0$.
   - When input voltage ($V_{\text{BULK}}$) is applied, the gate voltage of upper side power MOSFET is charged up by $R_{\text{STARUP}}$.
   - This will turn on $M_0$.

2. During startup phase, the high side gate driver stage driving the gate of $M_0$ are de-activated and the lower side power MOSFET $M_1$ is turned off.

3. When $M_0$ is turned on, a current will flow from the mains through the primary winding and $M_0$ to charge up the VCC.
   - The VCC charging current is regulated by the integrated current regulator.

**Normal Operation Phase (Green arrow)**

1. During startup phase, the high side gate driver stage driving the gate of $M_0$ are activated and $M_1$ is turned on.

2. VCC is maintained using the auxiliary winding through resistor $R_0$ and diode $D_0$. 
1. In this product, 2 VCC charging current level is implemented.

2. Feature Description
   - During low VCC level (VCC<1.1V), the charging current is regulated at a lower level (300uA typ) than target (3mA typ).
   - When VCC charges above 1.1V typically, the charging current is increased to 3mA typically for a fast charging time.

3. VCC shorted to GND Protection  
   - Under the abnormal situation of VCC shorted to ground, the charging current is regulated at a lower current level.
   - Hence the power dissipation is less than the package allowable dissipation.
   - As a result, the device is protected from any damage.

**Condition:**
- Pullup resistor $R_{\text{STARTUP}} = 50\,\Omega$
- Input voltage is $85V_{\text{AC}}$
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4. Summary
Robust Line Input Protection

Limitation of today Gen2 Quasi Resonant Series

- Lack of brown in/out protection against low AC line input
  - External implementation required 10 components
  - Example → 35 W/19 V adapter reference solution based on ICE2QS03G

- Lack of line over voltage protection
  - External implementation required 10 components

Gen5 introduce both LOVP & Brown IN/OUT protection feature with in build hysteresis on a single pin with 3 external resistors for setting threshold

**Conclusion:** Robust line input protection with easy implementation and low BOM count
Selectable Active Burst Mode

Limitation of Gen2 QR Burst Mode

› Non selectable burst mode entry/exit
  › Potential early entry @ highline result in audible noise

Test Result using same demoboard between Gen2 & Gen5 CoolSET™

<table>
<thead>
<tr>
<th>Gen2 – ICE2QR4780Z</th>
<th>Burst IN</th>
<th>Burst OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Line</td>
<td>1.2 W</td>
<td>3.3 W</td>
</tr>
<tr>
<td>Highline</td>
<td>2.0 W</td>
<td>4.4 W</td>
</tr>
<tr>
<td>ΔPower</td>
<td>66%</td>
<td>33%</td>
</tr>
</tbody>
</table>

Low Line Burst IN/OUT %

<table>
<thead>
<tr>
<th>Gen5 – ICE5QR4780AZ</th>
<th>Burst IN</th>
<th>Burst OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>#Default option</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Line</td>
<td>1.2 W</td>
<td>2.4 W</td>
</tr>
<tr>
<td>Highline</td>
<td>1.3 W</td>
<td>3.0 W</td>
</tr>
<tr>
<td>ΔPower</td>
<td>8%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Low Line Burst IN/OUT %

Conclusion: Novel QR is able to limit the spread of burst IN/OUT between high/low line input, thus, it’s able to operate at lower input power during burst mode which minimize the possibility of audible noise.

Flexibility is achieved with a different entry/exit profile by setting resistor externally

Insertion of 620 KΩ @ FB pin to select optional profile
New Protection: VCC pin short to ground

- Fault condition: VCC pin shorted to ground
- Outcome ➔ Controller IC or CoolSET™ may damage in prolong exposure

Conclusion: Gen5 increases system robustness with protection against abnormal pin operation
New Protection: CS pin short to ground

- Fault condition: CS pin shorted to ground
  - Outcome → Controller IC or CoolSET™ will be damaged by excessive current in short period of time

**Gen5**
Cascode structure

Controller will monitor the development of voltage level at every switching cycle to detect abnormal pin operation

**Conclusion:** Gen5 increases system robustness with protection against abnormal pin operation
Improved OTP Handling

**Limitation of today Gen2 Quasi Resonant Series**

› Over temperature protection activate @ controller die $T_j=140^\circ C$ without hysteresis
  › System will resume operation once temperature goes below $140^\circ C$
  › Result in system entering/exiting protection mode continuously if fault condition is not resolved

![Diagram](Image)

› Measured surface temp. > $140^\circ C$, it enters non switch Auto Restart and resumes operation at < $95^\circ C$.

**Conclusion:** Gen5 improvised OTP handling by introducing $\sim 40^\circ C$ hysteresis to avoid system from looping in/out of protection mode
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# 42Watt Model Design Example

<table>
<thead>
<tr>
<th>Specification</th>
<th>Specification Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage and frequency</td>
<td>85 V AC (60 Hz) ~ 300 V AC (50 Hz)</td>
</tr>
<tr>
<td>Output voltage, current and power</td>
<td>(12 V x 3.41 A) + (5 V x 0.2 A) = 42 W</td>
</tr>
<tr>
<td>Dynamic load response</td>
<td>±5% of nominal output voltage</td>
</tr>
<tr>
<td>(5 V at 0.2 A and 12 V load change from 10% to 100%, slew rate at 0.4 A/μs, 100 Hz)</td>
<td></td>
</tr>
<tr>
<td>Output ripple voltage (full load, 85 V AC ~ 300 V AC)</td>
<td>5 V(_{\text{ripple, p-p}}) &lt; 100 mV</td>
</tr>
<tr>
<td></td>
<td>12 V(_{\text{ripple, p-p}}) &lt; 100 mV</td>
</tr>
<tr>
<td>Active mode four point average efficiency (25%, 50%, 75%, 100% load)</td>
<td>&gt; 85% at 115 V AC and 230 V AC</td>
</tr>
</tbody>
</table>
Efficiency vs AC line input voltage

Active-Mode Efficiency versus AC Line Input Voltage

- Full load Efficiency
- Average Efficiency (25%, 50%, 75%, 100%)
Standby power at no load and 30 mW load vs AC line input voltage

Standby Power versus AC Line Input Voltage

- No load with X cap resistor 3 MΩ
- POut=30mW with X cap resistor 3 MΩ
Line Regulation

Line Regulation: Output voltage @ max. load versus AC line input voltage

AC Line Input Voltage [V_{AC}]

85VAC/60Hz  115VAC/60Hz  230VAC/50Hz  265VAC/50Hz  300VAC/50Hz

Output Voltage [V]

12.05  12.05  12.05  12.05  12.05


Vo5 @ max. load  Vo12 @ max. load

Line Regulation: Output voltage @ typ. load versus AC line input voltage

AC Line Input Voltage [V_{AC}]

85VAC/60Hz  115VAC/60Hz  230VAC/50Hz  265VAC/50Hz  300VAC/50Hz

Output Voltage [V]

12.04  12.04  12.04  12.04  12.04

4.98  4.98  4.98  4.98  4.98

Vo5 @ typ. load  Vo12 @ typ. load
Load Regulation

Load Regulation: Output voltage versus output power

Output Voltage [V]

Output Power [%]

Vo5 @ 115V
Vo5 @ 230V
Vo12 @ 115V
Vo12 @ 230V

Load Regulation: Output voltage versus output power

Output Voltage [V]

Output Power [%]

Vo5 @ 85V
Vo5 @ 265V
Vo5 @ 300V
Vo12 @ 85V
Vo12 @ 265V
Vo12 @ 300V

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Conducted emissions at 230Vac and Maximum load
Thermal measurement

85 V AC full load and 25°C ambient

300 V AC full load and 25°C ambient
## Gen5 Quasi & Fixed Freq. CoolSET and Standalone controller family

Max Pout: 85~300vac, Ta=50°C

<table>
<thead>
<tr>
<th>Max Pout</th>
<th>15-16W</th>
<th>22-24W</th>
<th>25-26W</th>
<th>33W</th>
<th>40-45W</th>
<th>60W</th>
</tr>
</thead>
<tbody>
<tr>
<td>85~300</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ta=50°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DSO-8</th>
<th>ICE5QSAG</th>
<th>ICE5ASAG</th>
<th>ICE5GSAG</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIP-7</td>
<td>ICE5QR4770AZ</td>
<td>ICE5QR2270AZ</td>
<td>ICE5QR1070AZ</td>
</tr>
<tr>
<td></td>
<td>ICE5QR4780AZ</td>
<td>ICE5QR2280AZ</td>
<td>ICE5QR4770AG</td>
</tr>
<tr>
<td></td>
<td>ICE5GR4780AG</td>
<td>ICE5GR2280AG</td>
<td>ICE5GR1680AG</td>
</tr>
<tr>
<td></td>
<td>ICE5QR1070AZ</td>
<td>ICE5QR0680AZ</td>
<td>ICE5QR0680AG</td>
</tr>
<tr>
<td>DSO-12</td>
<td>ICE5QR4770AG</td>
<td>ICE5QR2270AZ</td>
<td>ICE5QR1070AZ</td>
</tr>
<tr>
<td></td>
<td>ICE5QR4780AZ</td>
<td>ICE5QR2280AZ</td>
<td>ICE5GR1680AG</td>
</tr>
<tr>
<td></td>
<td>ICE5QR0680AZ</td>
<td>ICE5QR0680AG</td>
<td>ICE5AR0680AG</td>
</tr>
</tbody>
</table>

### 5th Generation PWM Controller

#### Frequency Switching Scheme
- **Q**: Quasi-Resonant
- **A**: fixed 100KHz
- **B**: fixed 65KHz
- **G**: fixed 125KHz

#### Variant
- **S**: Controller only
- **R**: CoolSET

### Auto-restart

#### Package
- **Z**: DIP-7
- **G**: DSO-12/16

#### VDS of the integrated MOSFET
- **70 = 700V**
- **80 = 800V**

#### Typ. **Rds**(ON) of the integrated MOSFET
- **Eg. 2.2Ω**

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5th Generation Fixed Frequency
Product / System Overview

System / Application Overview

Descriptions

Latest iteration of Fixed Frequency Flyback controller offering high level of integration with enhanced and comprehensive suite of protection.

Key Features

- Support both isolated and non-isolated topologies with up to 350Vac input
- Support both DCM and CCM current control mode
- Eco mode with frequency reduction
- In System Protection against abnormal pin fault condition
- Ability to detect abnormal line input condition
- Minimize interruption to operation with auto resume mode
- Integrated with latest generation of Superjunction P7 CoolMOS
- High Power integrated offering up to 42W in SMD package

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### 5th Generation Fixed Frequency Portfolio

<table>
<thead>
<tr>
<th>Max Pout (85\text{~}300\text{vac}) (Ta=50^\circ\text{C})</th>
<th>15W</th>
<th>22W</th>
<th>26W</th>
<th>42W</th>
<th>60W</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSO-8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ICE5ASAG, ICE5GSAG</td>
</tr>
<tr>
<td>DSO-12</td>
<td>ICE5AR4770AG, ICE5GR4780AG</td>
<td>ICE5GR2280AG</td>
<td>ICE5GR1680AG</td>
<td>ICE5AR0680AG</td>
<td></td>
</tr>
</tbody>
</table>

**PWM Controller**

- **Q/A/B/G**
  - Q: Quasi-Resonant
  - A: fixed 100KHz
  - B: fixed 65KHz
  - G: fixed 125KHz

- **Variant**
  - S: Controller only
  - R: CoolSET

- **Typ. \(Rds_{(ON)}\)** of the integrated MOSFET
  - 70 = 700V
  - 80 = 800V

**Typ. \(VDS\)** of the integrated MOSFET

- 45

**Package**

- Z = DIP-7
- G = DSO-12/16

**Auto-restart**

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Performance
- Ground up design with targeted market in mind
- Integrated with Infineon latest generation P7 CoolMOS™
- Infineon first implementation of flyback platform in cascode configuration

Ease of Use
- Expanded portfolio to include a true 700V avalanche capable integrated MOSFET
- Flexibility with selectable active burst mode entry/exit point
- Novel QR switching scheme to ease EMI filter and system design
- Comprehensive Design Guide for 5th Gen PWM Controller & CoolSET

Protection
- Line Over Voltage Protection
- Brown IN/OUT Protection
- True Output Over Voltage Protection
- VCC short to Ground Protection
- Current Sense Short to Ground Protection
- Over Temperature Protection with hysteresis
Part of your life. Part of tomorrow.