Faster to light with simpler design: A new multimode flyback LED solution

March 2016
Agenda

1. Trends and solutions
2. IRS2982S in Infineon’s LED portfolio
3. IRS2982S features and benefits
4. IRS2982S value proposition
5. Summary
6. Support material
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More features, high performance/ cost
IRS2982S fits perfectly

- Single stage PFC + flyback
- High level integration for small BOM
- Burst mode minimizing standby loss
- Universal AC line input
- Flyback CrCM mode
- Single stage PFC + flyback
- CC mode with optocoupler
- Tolerable startup time ~ 1 s
- Speedy startup < 0.5 s
- DCM for efficient light load
- Optimizing standby loss
- 0 V-10 V dimming capable
- Speedy startup < 0.2 s
- DCM for efficient light load
- Primary side output current control
- Configurable on the fly, simple GUI

Legacy solution

IRS2982S

Digital solution

Highly integrated
IRS2982S solves key challenges of LED lighting: highest efficiency, low power standby, fast time-to-light

**Application**
- Mid range, high end LED drivers for outdoor, interior, office, industrial lightings
- Wide input voltage: $85 - 305 \, V_{\text{AC}}$

**Block diagram**

- High power quality $\text{PF}>0.95$, $\text{iTHD}<20\%$ (over wide AC input at full load)
- Integrated startup cell, fast startup
- Support mode of startup cell for optimizing light load operation
- High efficiency from three operating modes: CrCM, DCM and burst mode
- IC concept supports multiple topologies
- Ideal for isolated flyback CV mode as well as non-isolated flyback with CC/CV modes
- Supports universal input
- Operates with AC or DC input
- Over voltage protection
- Cycle by cycle over current protection
- Minimum external components to support small form factor designs

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IRS2982S in Infineon’s LED portfolio

**Power conversion**

**AC-DC**
- **ICL5101**
  - PFC + LLC combo controller IC
- **XMC1000**
  - Multiple Topologies
- **IRS2982**
  - PFC/ flyback controller IC (CV)
- **IRS2505**
  - PFC IC
- **ICL8105**
  - PFC/ FB controller IC (CC)
- **ICL8201**
  - Non-isolated buck converter

**DC-DC**
- **XMC1000**
  - DC-DC buck controller + connectivity + light control
- **ILD2111**
  - DC-DC buck controller
- **IRS25411**
  - DC-DC buck controller
- **ILD6000/ ILD4000**
  - DC-DC buck driver IC
- **BCR400**
  - Linear LED driver IC

**Light management**
- **BGT 24 GHz**
  - Radar sensor

**Power** | **Voltage output** | **Current output**
--- | --- | ---
**AC-DC** | **DC-DC** | **Smart lighting**
**600 V CE CoolMOS™** | **800 V CE CoolMOS™** | **600 V CE CoolMOS™**
**IRS2982** | **IRS2505** | **ICL8105**

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**IRS2982S input/ output pins**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV</td>
<td>High voltage startup input</td>
</tr>
<tr>
<td>FB</td>
<td>Feedback input</td>
</tr>
<tr>
<td>COMP</td>
<td>Compensation and averaging capacitor input</td>
</tr>
<tr>
<td>ZX</td>
<td>Zero-crossing &amp; over-voltage detection input</td>
</tr>
<tr>
<td>CS</td>
<td>Current sensing input</td>
</tr>
<tr>
<td>COM</td>
<td>IC power &amp; signal ground</td>
</tr>
<tr>
<td>OUT</td>
<td>Gate driver output</td>
</tr>
<tr>
<td>VCC</td>
<td>Logic &amp; low-side gate driver supply</td>
</tr>
</tbody>
</table>

[SOIC 8 package]
## IRS2982S features and benefits

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
</tr>
</thead>
</table>
| › High voltage startup cell (600 V) | › Fast time to light < 0.5 s  
› Eliminate external components for voltage dividing |
| › CrCM/ DCM operation | › Wide range applications, suitable for dimming LED converter in the current range between 1% up to 100% |
| › Burst mode capability | › Low standby power |
| › Multiple primary side control configurations | › Isolated flyback with CV mode  
› Non-isolated flyback with CC or CV mode |
| › Optimized one stage PFC+ flyback | › Low line power factor > 0.95  
› Low line current THD < 20% |
| › Direct feedback  
› Stable $V_{\text{REF}}$, $V_{\text{CS}}$ over temperature | › Very accurate CV or CC regulation |
| › Recommended dimming circuitry | › Triac dimming capable (with correctly designed converter input) |
| › ZX, CS pins to prevent abnormal conditions | › Over voltage and over current protection |
| › Wide input voltage range | › Covering $85 V_{\text{AC}} \sim 305 V_{\text{AC}}$ |
| › Multiple LED topology configuration: flyback, buck, boost and SEPIC | › Versatile in LED designs |
Key differentiator
High voltage start-up cell

Startup mode

IHV vs. VHV over temperature

IHV at 25C
IHV at -25C
IHV at 125C

Startup mode
Support mode
The IRS2982S normally operates in critical conduction mode (CrCM), also known as transition or boundary mode. The IRS2982S includes a minimum off time limit (tOFFMIN) of ~3 µs so that if the ZX pin input transitions high and then low before tOFFMIN expires, the gate drive output will not transition high again until the end of this period (DCM mode).

This function extends the operating range of the converter allowing operation down to very low duty cycles. This thereby enables dimming designs to be implemented as well as limiting operating frequency to prevent overheating of the circuit inductor, MOSFET and snubber components.
Burst mode to minimize standby power

Gate drive (yellow), VCOMP (blue), VZX (red)
Non-isolated flyback
Constant current regulation

- Can be used in some non-isolated LED lamps/ bulbs needing high PF and accurate current
- Triac dimming is also possible with bleed and damper network
Non-isolated flyback
Constant voltage regulation
Isolated flyback key application
Constant voltage regulation

AC Line Input

RFB1
RFB2
CIN
CIN

BR1

IRS2982

IC1

CVCC

VCC

DZ

HZ

2

3

4

5

6

7

8

RVCC

DVCC

RSN

CSN

T1

DFB

+VOUT

CVOUT

ROUT

-DVOUT

M1

RZX1

RZX2

CS

CG

DV

CF

RCS

RG

RF

RZ

CS

VCC

COMP

OUT

FB

COMP

DZ

HD

1

2

3

4

5

6

7

8

728

729

730

March 2016

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$V_{\text{REF}}$ and $V_{\text{CS}}$ over temperature for accurate CV and CC regulation

- $V_{\text{REF}}$ vs. temperature
- $V_{\text{CS}}$ vs. temperature

- $V_{\text{REF}}$ tolerance $\pm 2\%$
- $V_{\text{CS}}$ tolerance $\pm 5\%$
IRXLED04
50 W flyback evaluation board

› Isolated flyback with CV
› 100 to 265 V\textsubscript{AC} input, 55 V nominal output up to 1 A
› High power factor, low iTHD over wide line/load range
› Board size 4.4” (112 mm) x 2.2” (56 mm)
IRS2982S efficiency (50 $V_{\text{OUT}}$, 55 W)

- Low line efficiency > 90% starting 20% load
- High line efficiency > 90% starting 40% load
> 0.9 PF and < 20% iTHD for low line

### Power factor

<table>
<thead>
<tr>
<th>Voltage (VAC)</th>
<th>Power factor</th>
<th>Output current (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1.0</td>
<td>0.1</td>
</tr>
<tr>
<td>120</td>
<td>0.95</td>
<td>0.2</td>
</tr>
<tr>
<td>230</td>
<td>0.90</td>
<td>0.3</td>
</tr>
<tr>
<td>265</td>
<td>0.85</td>
<td>0.4</td>
</tr>
</tbody>
</table>

### iTHD

<table>
<thead>
<tr>
<th>Voltage (VAC)</th>
<th>iTHD</th>
<th>Output current (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>10</td>
<td>0.1</td>
</tr>
<tr>
<td>120</td>
<td>15</td>
<td>0.2</td>
</tr>
<tr>
<td>230</td>
<td>20</td>
<td>0.3</td>
</tr>
<tr>
<td>265</td>
<td>25</td>
<td>0.4</td>
</tr>
</tbody>
</table>
### Harmonic limits EN61000-3-2
#### Class C (Lighting)

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Harmonics Limits Class C according EN 61000-3-2 for System Power &gt; 25W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harmonics order ( n )</td>
<td>Maximum value expressed as a percentage of the fundamental input current</td>
</tr>
<tr>
<td>2</td>
<td>&lt;2%</td>
</tr>
<tr>
<td>3</td>
<td>&lt;30 ( \lambda ) %</td>
</tr>
<tr>
<td>5</td>
<td>10%</td>
</tr>
<tr>
<td>7</td>
<td>&lt;7%</td>
</tr>
<tr>
<td>9</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>11 ( \leq n \leq 39 )</td>
<td>&lt;3%</td>
</tr>
</tbody>
</table>

\( \lambda = \text{power factor} \)
Harmonics at 120 V_{AC}

120 V_{AC}, 50% load, line current harmonics (%)

120 V_{AC}, 100% load, line current harmonics (%)

Tested using an electronic pure sine wave AC source, IRS2982S easily meets the standard
Harmonics at 230 V<sub>AC</sub>

230 V<sub>AC</sub>, 50% load, line current harmonics (%)

230 V<sub>AC</sub>, 100% load, line current harmonics (%)

Tested using an electronic pure sine wave AC source, IRS2982S easily meets the standard.
Stable line and load regulation

**Line regulation**

![Line regulation graph]

**Load regulation**

![Load regulation graph]
IRS2982
Triac dimmable flyback LED driver

Active damper and passive bleed circuits enables triac dimming!
IRS2982
Stable and flicker free dimming

**Dimming curve**

<table>
<thead>
<tr>
<th>Load</th>
<th>Vin(V)</th>
<th>Pin(W)</th>
<th>PF</th>
<th>THD(%)</th>
<th>Vout (V)</th>
<th>iout (mA)</th>
<th>Pout (W)</th>
<th>Eff(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>27V LED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>4.507</td>
<td>0.959</td>
<td>15.3</td>
<td>27</td>
<td>134.1</td>
<td>3.62</td>
<td>80.34</td>
<td></td>
</tr>
<tr>
<td>220</td>
<td>4.6</td>
<td>0.949</td>
<td>17</td>
<td>27.01</td>
<td>136.5</td>
<td>3.69</td>
<td>80.15</td>
<td></td>
</tr>
<tr>
<td>242</td>
<td>4.713</td>
<td>0.937</td>
<td>19</td>
<td>27.04</td>
<td>139.2</td>
<td>3.76</td>
<td>79.86</td>
<td></td>
</tr>
<tr>
<td>265</td>
<td>4.846</td>
<td>0.923</td>
<td>21</td>
<td>27.07</td>
<td>142.2</td>
<td>3.85</td>
<td>79.43</td>
<td></td>
</tr>
<tr>
<td>220</td>
<td>32</td>
<td>no load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Over voltage protection through ZX input

The ZX input is a multi-functional, used for zero crossing detection and output over voltage limiting. If the load becomes disconnected in a flyback or boost converter the output voltage can become very high causing damage to components as well as presenting an electrical hazard. In order to protect against this the IRS2982 senses the output voltage indirectly through the ZX input connected to the auxiliary winding, which is proportional to the output voltage. If the ZX input voltage exceeds VOVTH when the MOSFET switches off, the gate drive remains switched off for a period $t_{WD}$ (~ 100 $\mu$s) before starting the next cycle regardless of when the ZX voltage transitions low. The IRS2982 also discharges the COMP capacitor to so that the next cycle will begin at minimum duty cycle and ramp up slowly. This protection scheme allows the load to be “hot” connected and disconnected from the converter output without risk of damaging the circuit by high voltages appearing at the output. Care should be taken however to avoid damage to LED loads due to output capacitor discharge.
Over current protection through CS input

Primary MOSFET current is sensed through a shunt resistor (RCS) connected from the source of the flyback MOSFET switch to the DC bus return. This current waveform is a high frequency ramp rising from zero at the beginning of each switching cycle to reach a peak level at the point the MOSFET is switched off and remaining at zero during the off time. At very low input voltages the voltage or current regulation loop would demand a very high peak current, which may exceed the maximum rating of the transformer. To prevent saturation from occurring, the IRS2982 provides cycle by cycle primary current limiting with a threshold VCSTH at the CS pin input. Under low line or fault conditions where the MOSFET current is abnormally high the gate drive is switched off after the blanking time tBLANK. Leading edge blanking is necessary to avoid false triggering due to the fast high current switch on transient that occurs at switch on of the MOSFET resulting from discharge of parasitic capacitances.
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## IRS2982S value arguments

<table>
<thead>
<tr>
<th>Benefits</th>
<th>IFX LED flyback controller IRS2982S</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strong arguments</strong></td>
<td></td>
</tr>
<tr>
<td>Fast light delivery</td>
<td>› High voltage regulator enables time to light within 0.5 second</td>
</tr>
<tr>
<td>and simpler design</td>
<td>› High voltage startup cell, DCM modes eliminates 5~ 10 external components</td>
</tr>
<tr>
<td>Low standby power</td>
<td>› Burst mode capability reduce standby power to less than 500 mW</td>
</tr>
<tr>
<td>Low light load loss</td>
<td>› DCM operation enables wider operation range from 1 to 100%</td>
</tr>
<tr>
<td><strong>Medium arguments</strong></td>
<td></td>
</tr>
<tr>
<td>Versatile in LED designs</td>
<td>› IRS2982S is suitable for multiple topologies including: flyback, buck, boost and sepic</td>
</tr>
<tr>
<td><strong>Soft arguments</strong></td>
<td></td>
</tr>
<tr>
<td>Capacity</td>
<td>› Infineon has the biggest power semiconductor capacity within the industry and is by far the biggest investor in capacity for power semiconductors</td>
</tr>
<tr>
<td>Product portfolio</td>
<td>› Infineon provides both LED controllers, high voltage MOSFET, sensors as well as microcontrollers</td>
</tr>
<tr>
<td>Robustness</td>
<td>› Infineon offers highly ruggedized performance and proven reliability</td>
</tr>
</tbody>
</table>
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Summary

› LED driver customers are demanding more features, low power loss at light load and standby, while trying to maintain system cost

› IRS2982S’s HV startup, CrCM/ DCM/ Burst mode, versatile configurations enables fast to light with less component counts as well as better efficiency overall
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IRS2982S pairs with CoolMOS™ CE for price-driven applications
Superjunction technology at the price of a planar MOSFET

**Why CoolMOS™ CE?**

› **Superjunction device** (SJ): as such it delivers low conduction and switching losses, improves efficiency and ultimately reduces power consumption

› **Broad portfolio**: 500 V, 600 V, 650 V, 700 V and 800 V devices available, best fitting LED lighting

› **Attractive price position**: with no compromise on proven CoolMOS™ quality

› **Flexibility**: suitable for hard and soft switching applications

› **Fast design-in**: ease of use enables customers to reduce the design in cycle and compete in dynamic markets
## Top 7 reasons for choosing Infineon beyond product performance

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Provided by our CE solution...</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 Product portfolio</strong></td>
<td>› We own a broad portfolio covering 5 voltage classes in both TH and SMD packages and exceed by &gt; 3 times our closest competitor</td>
</tr>
</tbody>
</table>
| **2 Capacity**          | › We own the world’s largest capacity for power devices, with 3 dedicated frontends and 4 backends  
                           | › We secure supply during market upswing                                                        |
| **3 Lead times**        | › We understand lighting market’s dynamics and offer ≤ 6 weeks lead time                        |
| **4 Delivery performance** | › Our delivery performance is constantly ≥ 95%                                              |
| **5 Quality**           | › Our field failure rates are on average < 0.2 PPM*                                          |
| **6 Price competitiveness** | › With full implementation in 300 mm we gained economy of scale and improved our cost structure |
| **7 Design-in support** | › We have a large field application engineering team to provide professional & flexible support for your design |

Note: *1 PPM = 1 failure per 1 Million pcs shipped*
# Recommendations for mid & low power QR flyback topologies

<table>
<thead>
<tr>
<th>$R_{DS(ON)}$ [mΩ]</th>
<th>TO-220 FullPAK</th>
<th>TO-252 DPAK</th>
<th>TO-251 IPAK</th>
</tr>
</thead>
<tbody>
<tr>
<td>800 V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2800</td>
<td>IPA80R2K8CE</td>
<td>IPD80R2K8CE</td>
<td>IPU80R2K8CE</td>
</tr>
<tr>
<td>1400</td>
<td>IPA80R1K4CE</td>
<td>IPD80R1K4CE</td>
<td>IPU80R1K4CE</td>
</tr>
<tr>
<td>1000</td>
<td>IPA80R1K0CE</td>
<td>IPD80R1K0CE</td>
<td>IPU80R1K0CE</td>
</tr>
<tr>
<td>650</td>
<td>IPA80R650CE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>460</td>
<td>IPA80R460CE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>310</td>
<td>IPA80R310CE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Support material

### Collaterals and brochures
- Presentations
- PMM DCDC PL16 sharepoint site
- PMM pool presentations

### Technical material
- Application notes
- Datasheets
- Eval boards IRXLED04
- IRS2982S datasheet
- ANEVAL_201602_PL16_017_IRXLED04

### Videos

### Contact
- Product manager
- Application manager
- Josh.feng@infineon.com
- Peter.Green@infineon.com
Features

- Input voltage range: 85–265 V<sub>AC</sub>
- Input voltage frequency: 47–63 Hz
- Regulated main output voltage: 55 V<sub>DC</sub> / 0.9 A
- Harmonics: according to EN61000-3-2 Class-C
- EMI: according to EN55015
- Safety: according to EN61347-2-13
- Replaces IRXLED03
- Board dimensions: 4.4” (L) x 2.2” (W)
- Available in April 2016
Part of your life. Part of tomorrow.