Infineon Solution for LED TV SMPS

Willion Chen
System Application Engineer
ASIC & Power IC
Infineon Solution for LED TV SMPS Agenda

- Various Solution by power stages
- PFC controllers introduction
- LLC controllers introduction
- Auxiliary Power solution
LED TV SMPS: <100W solution

- **TDA4863-2**: Few external component, easy design, nearly 1 power factor can be achieved.
- **ICE2QS02G**: Mosfet Valley switching and Frequency reduction ensure high average efficiency >87%.
- **ICE3BR4765JZ**: Active burst mode ensures extremely low standby power consumption <0.1W.

* The exact value is subject to the system SPEC
LED TV Power: 100~200W solution

- **TDA4863-2**: Few external component, easy design, nearly 1 power factor can be achieved.
- **ICE1HS01G**: LLC resonant converter ensures high efficiency >95% and low EMI radiation.
- **ICE3BR4765JZ**: Active burst mode ensures extremely low standby power consumption <0.1W.
ICE2HS01G: LLC+SR controller further increases the LLC efficiency to a much higher level.

* The exact value is subject to the system SPEC
ICE2HS01G: LLC+SR controller further increases the LLC efficiency to a much higher level.

* The exact value is subject to the system SPEC

Multi output using LLC topology may cause lower BOM cost, compared to using QR.
Infineon CCM PFC controller History

2003
ICE1PCS0x

- First Infineon standalone CCM PFC
- Adjustable gate switching frequency
- Brownout protection

2006
ICE2PCS0x

- BiCMOS Technology
- Lower internal reference – 5V

2010
ICE3PCS0XG

- Improve dynamic response
- Efficiency above 95%
- Digital control voltage loop
- Synchronous frequency
- Boost follower mode
- Accurate Brownout protection sensing
- Lowest internal reference – 2.5V
Pin Layout ICE3PCS01G

Pin1  = Boost Follower Setting (BOFO)
Pin2  = Current Sense Input (ISENSE)
Pin3  = Signal Ground (SGND)
Pin4  = Current Loop Compensation (ICOMP)
Pin5  = Switching Frequency Setting (FREQ)
Pin6  = Bulk Voltage OK Signal
Pin7  = PFC Enable Function (VBTHL_EN)
Pin8  = Voltage reference (VREF)
Pin9  = Brownout Protection (BOP)
Pin10 = Over Voltage Protection (OVP)
Pin11 = Bulk Voltage Sense (VSENSE)
Pin12 = IC Supply Voltage (VCC)
Pin13 = Gate Drive (GATE)
Pin14 = Power Ground (PGND)
Typical Application Circuit

85 ~ 265 Vac

Line Filter

ICE3PCS01G

PWM Feedback

PGND

VSENSE

OVP

VCC

ICOMP

Freq

VBTHL_EN

VREF

VSENSE

BOFO

BOF01

BOF02

Vcc

RFB

CICOMP

RVB1

RVB2

RVB3

RVFREQ

RVCC

Qrel

CIBRO

DBRO1

DBRO2

RBO1

RBO2

RBO3

RNTC

VIN

VOUT

LBoost

CS

RGATE

RGSO

CE

RGATE

CH

DBYP

DB

RCS

RBVS1

RBVS2

RBVS3

RBVS4

RBVS5

RBVS6

VCC

SGND

VCC
ICE3PCS0xG
Key Features

- Low Peak Current Limit (0.2V)
- Average current control without direct sinewave reference signal sensing
- Adjustable operating frequency (20kHz - 250kHz)
- Synchronous frequency (50kHz – 150kHz)
- Boost Follower Mode with adjustable bulk voltage at low step
- Accurate Brown Out protection
- Second Over Voltage protection (OVP2)
- PFC enable function
- Enhanced dynamic response without current distortion
- Digital Control Voltage Loop
- Simple and easy design with very few external components reduces system and assembling cost.
- Supports the trends: High efficiency, High power factor, High Power Density and Low System Cost
- Target Applications: PC, Server, TV, gaming console, Adapter
Schematic of ICE3PCS01G Demoboard
ICE3PCS01G’s 300W Demoboard
Performance of Evaluation Board Efficiency Vs Output Power

ICE3PCS01G Efficiency

- 85Vac
- 115Vac
- 230Vac
- 265Vac

Output Power (W)

Efficiency (%)
Performance of Evaluation Board
Power Factor Vs. Output Power

ICE3PCS01G PF

Output Power (W)

PF

85Vac 115Vac 230Vac 265Vac
The difference between ICE3PCS02G and ICE3PCS03G is at pin 5
LLC stage \(\rightarrow\) ICE2HS01G

<table>
<thead>
<tr>
<th>Load</th>
<th>20%</th>
<th>50%</th>
<th>100%</th>
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<tbody>
<tr>
<td>Efficiency</td>
<td>95.5%</td>
<td>97%</td>
<td>96.5%</td>
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</tbody>
</table>

ICE2HS01G PG-DSO-20

Timer  EnA  OCP  LOAD  FREQ  TD  Delay  Vref  Vmc  Vres
VCC  HG  LG  SHG  SLG  GND  SRD  CL  CS  VINS
LLC stage → ICE2HS01G

<table>
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<tr>
<th>Load</th>
<th>20%</th>
<th>50%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>95.5%</td>
<td>97%</td>
<td>96.5%</td>
</tr>
</tbody>
</table>

- SR control from primary side for both CCM and DCM
- No need SR IC/Current sense at secondary side
Infineon System Solution for LED TV
LLC stage → ICE2HS01G

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<th>Load</th>
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<th>100%</th>
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</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>95.5%</td>
<td>97%</td>
<td>96.5%</td>
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</table>

Accurate set of frequency and deadtime
Infineon System Solution for LED TV
LLC stage → ICE2HS01G

<table>
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<tr>
<th>Load</th>
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<th>50%</th>
<th>100%</th>
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<tbody>
<tr>
<td>Efficiency</td>
<td>95.5%</td>
<td>97%</td>
<td>96.5%</td>
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</tbody>
</table>

**Diagram Details**

- **ICE2HS01G**: Infineon System Solution for LED TV LLC stage
- **brownout**: ICE2HS01G brownout
- **OCP**: ICE2HS01G OCP
- **Latch**: ICE2HS01G Latch
- **OLP**: ICE2HS01G OLP

**Connections**

- Timer: PG-DSO-20
- EnA
- OCP
- LOAD
- FREQ
- TD
- Delay
- Vref
- Vmc
- CS
- VINS

**IC Details**

- **ICE2HS01G**: PG-DSO-20
- **VCC**: Brownout
- **HG**: OCP
- **LG**: OL
- **SHG**: OCP
- **SLG**: OL
- **GND**: OL
- **CL**: OL
- **LG**: OL
- **SHG**: OL
- **VCC**: H
- **HG**: H
- **CS**: S
- **VINS**: V

**Notes**

- 11.07.2008 version 1.0
Infineon system solution for LED TV
ICE2HS01G Key Features

- Flexible LLC operation
  - Adjustable frequency for Min, Max, OCP and SS → Easy design
  - Maximum switching frequency up to 1MHz → High power density
  - Adjustable and adaptive dead time control → Easy design

- Novel SR operation mode with various protections (patent pending)
  - Can be operated at boost region with SR → Highest achievable efficiency
  - Variable protections for SR operation → Easy and Reliable design
  - Control SR from primary controller → No need of SR IC, low system cost
  - Tight tolerance control → Feasibility for mass production

- Accurate setting of switching frequency and dead time
  - Simple system design
  - Optimized system efficiency

- Various protections
  - OTP, OLP, OCP, Latch-off Enable → Easy system design
Infineon Integrated Power IC – F3 & Quasi. CoolSET®

Quasi. PWM IC  
CoolMOS
**CoolSET™**

Application - Isolated TO220-6 & Fullpak Package

Typical SMPS topology for AC/DC conversion with CoolSET

Photo and schematic of CoolSET in TO-220-6 ISODRAIN package

NEW!

TO-220-6 ISODrain ISOLATED Package w. LOW Thermal Resistance
CoolSET Naming System

Infineon AC/DC IC

**ICE**

A: FF in 100KHz
B: FF in 67KHz
Q: Quasi Resonant

Vds rating: divided by 10

**3**

Generation:
2: 2nd
3: 3rd

**A**

**20**

**65**

Rxx: Rdson, multiplied by 10

xx: current, multiplied by 10

**E**

Latch

**L**

ESD

**J**

Jitter

**Z**

Package:
Blank: DIP8
G: SO8
Z: DIP7
F: TO220F

version 1.0

11.07.2008
Fixed Switching CoolSET and Pin Assignment

- Package: DIP-7 / DIP-8

- Pin assignment:

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Function</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>BBA</td>
<td>Brownout, extended Blanking time and external Auto-restart enable</td>
</tr>
<tr>
<td>2</td>
<td>FBB</td>
<td>FeedBack and Burst entry control</td>
</tr>
<tr>
<td>3</td>
<td>CS</td>
<td>Current Sense</td>
</tr>
<tr>
<td>4</td>
<td>N.C.</td>
<td>No Connection</td>
</tr>
<tr>
<td>5</td>
<td>Drain</td>
<td>Drain</td>
</tr>
<tr>
<td>6</td>
<td>No pin</td>
<td>No pin</td>
</tr>
<tr>
<td>7</td>
<td>Vcc</td>
<td>Vcc</td>
</tr>
<tr>
<td>8</td>
<td>GND</td>
<td>Ground</td>
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</table>
**Quasi. CoolSET and Pin Assignment**

**Package PG_DIP-8**

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<th>Pin</th>
<th>Symbol</th>
<th>Function</th>
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<tbody>
<tr>
<td>1</td>
<td>ZC</td>
<td>Zero Crossing</td>
</tr>
<tr>
<td>2</td>
<td>FB</td>
<td>Feedback</td>
</tr>
<tr>
<td>3</td>
<td>CS</td>
<td>Current Sense/ 650V(^1) Depl. CoolMOS(^\circledR) Source</td>
</tr>
<tr>
<td>4, 5</td>
<td>Drain</td>
<td>650V(^1) Depl. CoolMOS(^\circledR) Drain</td>
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<tr>
<td>6</td>
<td>n.c.</td>
<td>Not connected</td>
</tr>
<tr>
<td>7</td>
<td>VCC</td>
<td>Controller Supply Voltage</td>
</tr>
<tr>
<td>8</td>
<td>GND</td>
<td>Controller Ground</td>
</tr>
</tbody>
</table>

\(^1\) at \(T_j=110^\circ\)C
Block diagram of ICE3A/BRXXXJ Fixed Switching Frequency CoolSET

# : optional external components;
#1: *C*<sub>BK</sub> is used to extend the Blanking Time
#2: *R*<sub>BO1</sub> & *R*<sub>BO2</sub> are used for brownout feature; *R*<sub>BO1</sub> tie to *Vcc* if no brownout feature
#3: *T*<sub>AE</sub> is used to enable the external Auto-restart feature
CoolSET® F3 product family introduction

- CoolSET® F3 (ICE3xxx65(L)(Z)(G)(P))
  - 1st F3 CoolSET® products, **Bipolar** technologies
  - Full power range series with DIP-8, DIP-7, DSO-16/12 and TO-220 isodrain.

- CoolSET® F3J (ICE3Bxx65J(G))
  - Cost reduction F3 CoolSET® (C1), **BiCMOS** technologies
  - For low power application and with **frequency jitter**
  - Only DIP-8 and DSO-16/12 packages

- CoolSET® F3LJ (ICE3A1065LJ)
  - **Latch version** of F3J with extra features (latch enable and extendable blanking time for over load)
  - Only DIP-8 package

- CoolSET® F3R (ICE3BR4765J)
  - Non-latch version / Only Auto restart
  - Replace the F3 CoolSET® series
  - Change **naming nomenclature** to specify \( R_{dson} \) instead of \( I_d \) current
  - DIP-8 package
Enable BrownOut, EBO : Add R18, R19, R1100 and delete R17;
Disable BrownOut, DBO : Add R17 and delete R18, R19 and R100;
EBO and DBO would not happen at the same time.

30W 12V SMPS Demoboard with ICEAR0680JZ(V0.7)
Kyaw Zin Min, Eric Kokl  31 Mar 2010
Standby Input Power at 0W and 0.5W load – using Yokogawa WT210 in integration timer mode

Measurement based on demo board 30W 12V using ICE3AR0680JZ

Standby Power @ no-load versus AC Line Input Voltage

Standby Power Efficiency @ 0.5W

Standby Power @ 0.5W load versus AC Line Input Voltage

Standby Power Efficiency @ 0.5W
Standby power at different $C_{FB}$ for no load and 0.5W load

Measurement based on demo board 30W 12V using ICE3AR0680JZ

### Input standby power at no load with different $C_{FB}$

<table>
<thead>
<tr>
<th>Pin (mW) Enable Brownout</th>
<th>Pin (mW) Disable Brownout</th>
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<tbody>
<tr>
<td>85Vac</td>
<td>115Vac</td>
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<tr>
<td>$C_{FB}=6.8\text{nF}$</td>
<td>37.34</td>
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<td>$C_{FB}=1\text{nF}$</td>
<td>36.55</td>
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<tr>
<td>$C_{FB}=330\text{pF}$</td>
<td>36.46</td>
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<tr>
<td>$C_{FB}=100\text{pF}$</td>
<td>108.57</td>
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### Input standby power at 0.5W load with different $C_{FB}$

<table>
<thead>
<tr>
<th>Pin (W) Enable Brownout</th>
<th>Pin (W) Disable Brownout</th>
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</thead>
<tbody>
<tr>
<td>85Vac</td>
<td>115Vac</td>
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<tr>
<td>$C_{FB}=6.8\text{nF}$</td>
<td>0.584</td>
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<tr>
<td>$C_{FB}=1\text{nF}$</td>
<td>0.611</td>
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<tr>
<td>$C_{FB}=330\text{pF}$</td>
<td>0.606</td>
</tr>
<tr>
<td>$C_{FB}=100\text{pF}$</td>
<td>0.857</td>
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## CoolSET™ F3
### Product Overview

<table>
<thead>
<tr>
<th><strong>R(_{\text{DSon}})</strong></th>
<th><strong>ICE3B0365JG</strong></th>
<th><strong>ICE3B0565JG</strong></th>
<th><strong>PUR1max</strong></th>
<th><strong>ICE3A0365</strong></th>
<th><strong>ICE3B0365J</strong></th>
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<tr>
<td>6.5(\Omega)</td>
<td><strong>ICE3B0365JG</strong></td>
<td><strong>ICE3B0565JG</strong></td>
<td><strong>9W/17W</strong></td>
<td><strong>ICE3A2065</strong></td>
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<td>4.7(\Omega)</td>
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<td><strong>12W/21W</strong></td>
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<td>3.0(\Omega)</td>
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<td><strong>15W/25W</strong></td>
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<td><strong>20W/32W</strong></td>
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<td><strong>27W/41W</strong></td>
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<td>1.5(\Omega)</td>
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<td><strong>31W/46W</strong></td>
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### ISODrain
- **Isolated**
- **low R\(_{\text{th}}\)**

**POUTmax**
- **SO-16**
  - 55W/90W
  - 68W/125W
  - 80W/144W
  - 100W/180W
  - 110W/200W
- **DIP-8**
  - 9W/17W
  - 12W/21W
  - 15W/25W
  - 20W/32W
  - 27W/41W
  - 31W/46W
- **TO-220-6**
  - 55W/90W
  - 68W/125W
  - 80W/144W
  - 100W/180W
  - 110W/200W
- **I\(^2\)-Pak**
  - 9W/17W
  - 12W/21W
  - 15W/25W
  - 20W/32W
  - 27W/41W
  - 31W/46W

**Notes:**
- A version: \(f = 100\text{kHz}\)
- B version: \(f = 67\text{kHz}\)
## CoolSET™ F3R & 2QR Product Overview

### Device Options
- **SO-16**
- **DIP-7/8**

### Power Output (P_{OUT}\text{max})

<table>
<thead>
<tr>
<th>R_{DSon}</th>
<th>P_{OUT}\text{max}</th>
<th>R_{DSon}</th>
<th>P_{OUT}\text{max}</th>
</tr>
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<tbody>
<tr>
<td>10.0Ω</td>
<td>9W/17W</td>
<td>2.5Ω</td>
<td>55W/90W</td>
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<tr>
<td>4.7Ω</td>
<td>12W/21W</td>
<td>1.5Ω</td>
<td>68W/125W</td>
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<td>2.2Ω</td>
<td>15W/28W</td>
<td>1.0Ω</td>
<td>80W/144W</td>
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<tr>
<td>1.7Ω</td>
<td>20W/32W</td>
<td>0.65Ω</td>
<td>110W/200W</td>
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<tr>
<td>0.65Ω</td>
<td>31W/46W</td>
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</table>

### Fullpak Features
- Isolated
- Low R_{th}

### Product Overview
- **ICE3BR4765J**
- **ICE2QR4765**
- **ICE3AR4780JZ**
- **ICE2QR4780Z**
- **ICE3AR2280JZ**
- **ICE2QR2280Z**
- **ICE3BR1765J**
- **ICE2QR1765**
- **ICE3BR0665J**
- **ICE2QR0665**
- **ICE3AR0680JZ**
- **ICE3BR0680JZ**
- **ICE2QR0680Z**
- **ICE3B4765JG**
- **ICE2QR0665G**
- **ICE3BR2565JF**
- **ICE3BR1565JF**
- **ICE3BR1065JF**
- **ICE3BR0665JF**
### SMPS IC’s at a glance

**Focus Product Portfolio**

<table>
<thead>
<tr>
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11.07.2008 version 1.0
ENERGY EFFICIENCY
MOBILITY
SECURITY

Innovative semiconductor solutions for energy efficiency, mobility and security.