Infineon Solution for LED TV SMPS

Willion Chen
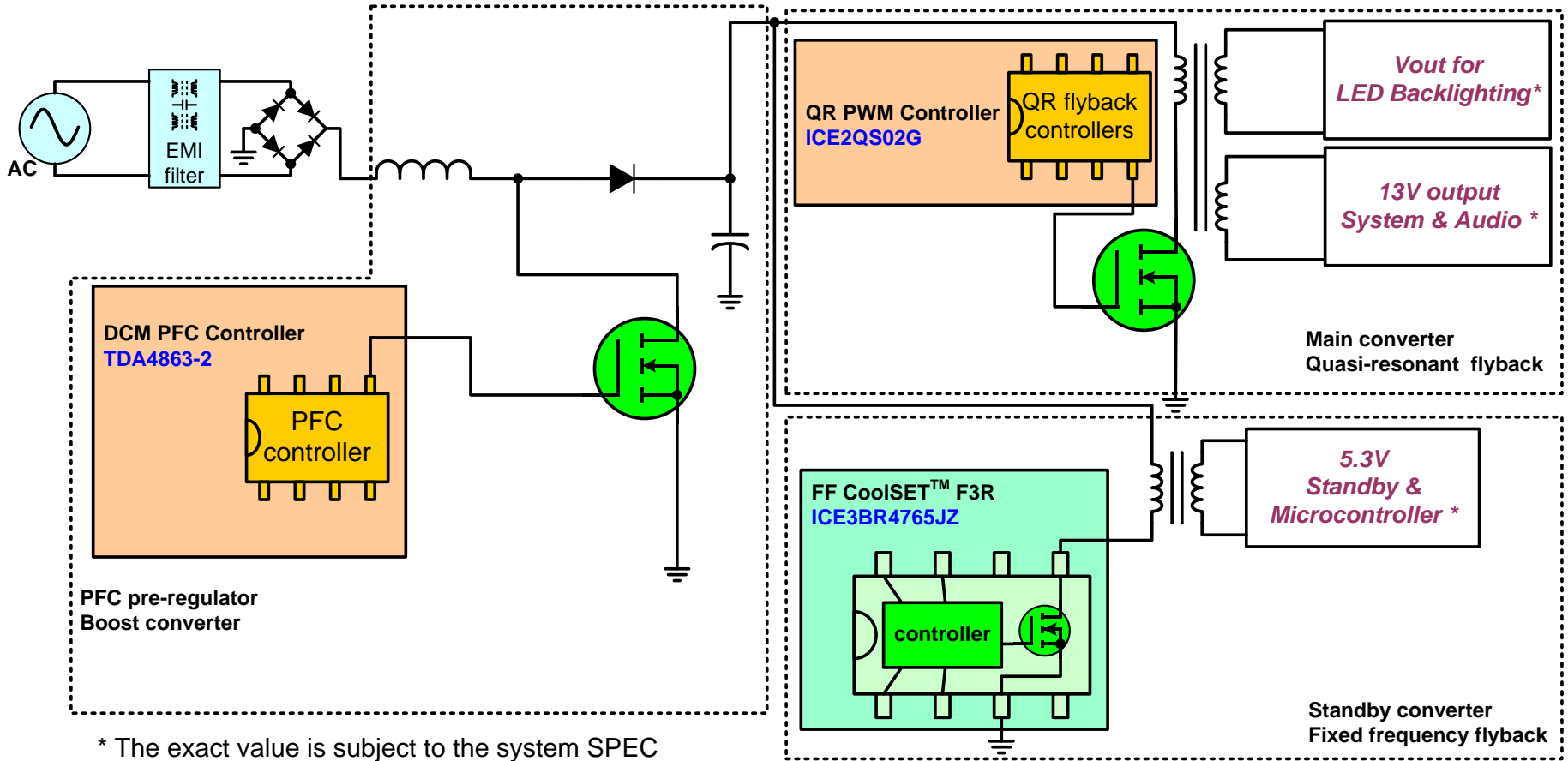
System Application Engineer

ASIC & Power IC
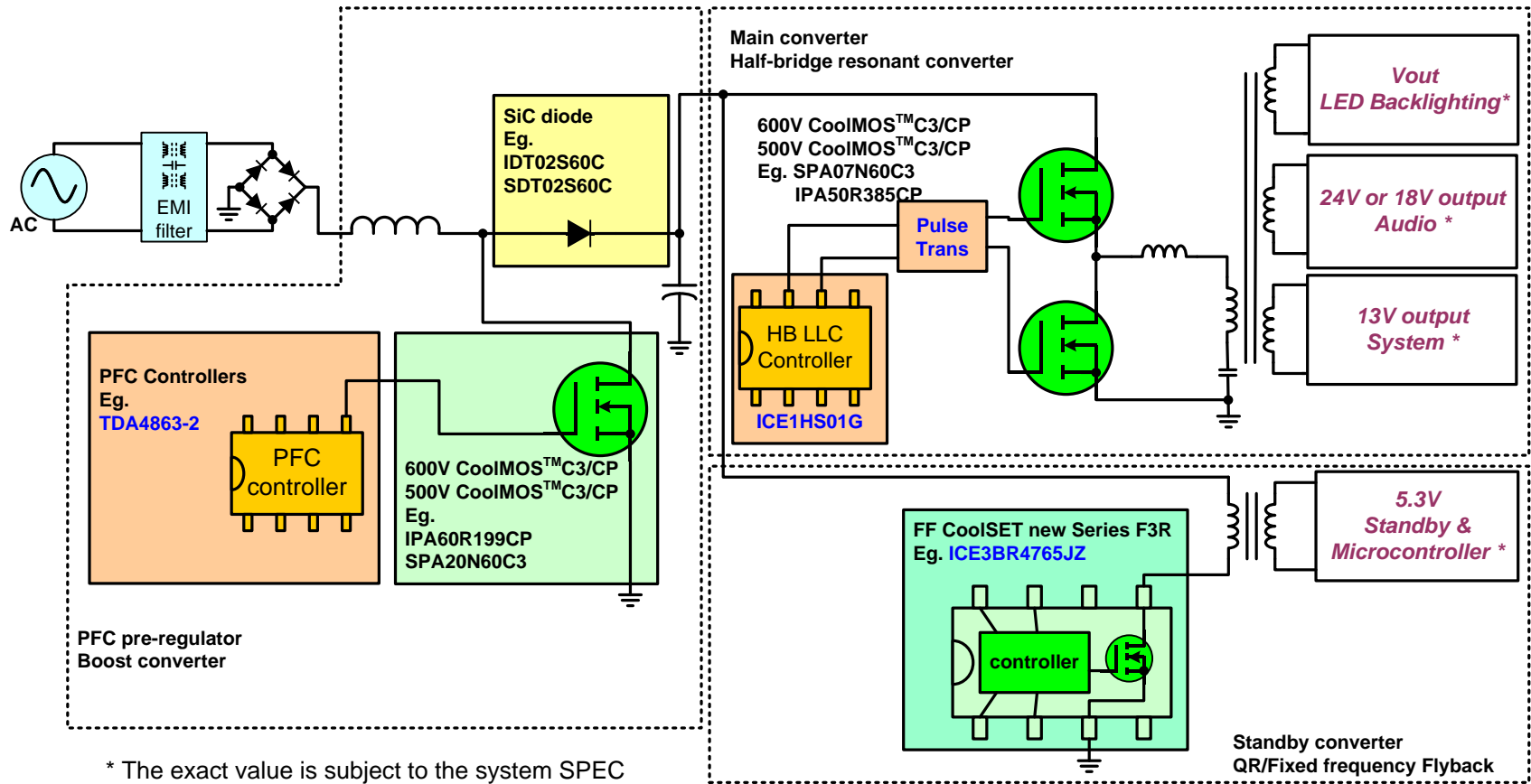
➢Various Solution by power stages
➢PFC controllers introduction
➢LLC controllers introduction
➢Auxiliary Power solution

LED TV SMPS: <100W solution

* The exact value is subject to the system SPEC
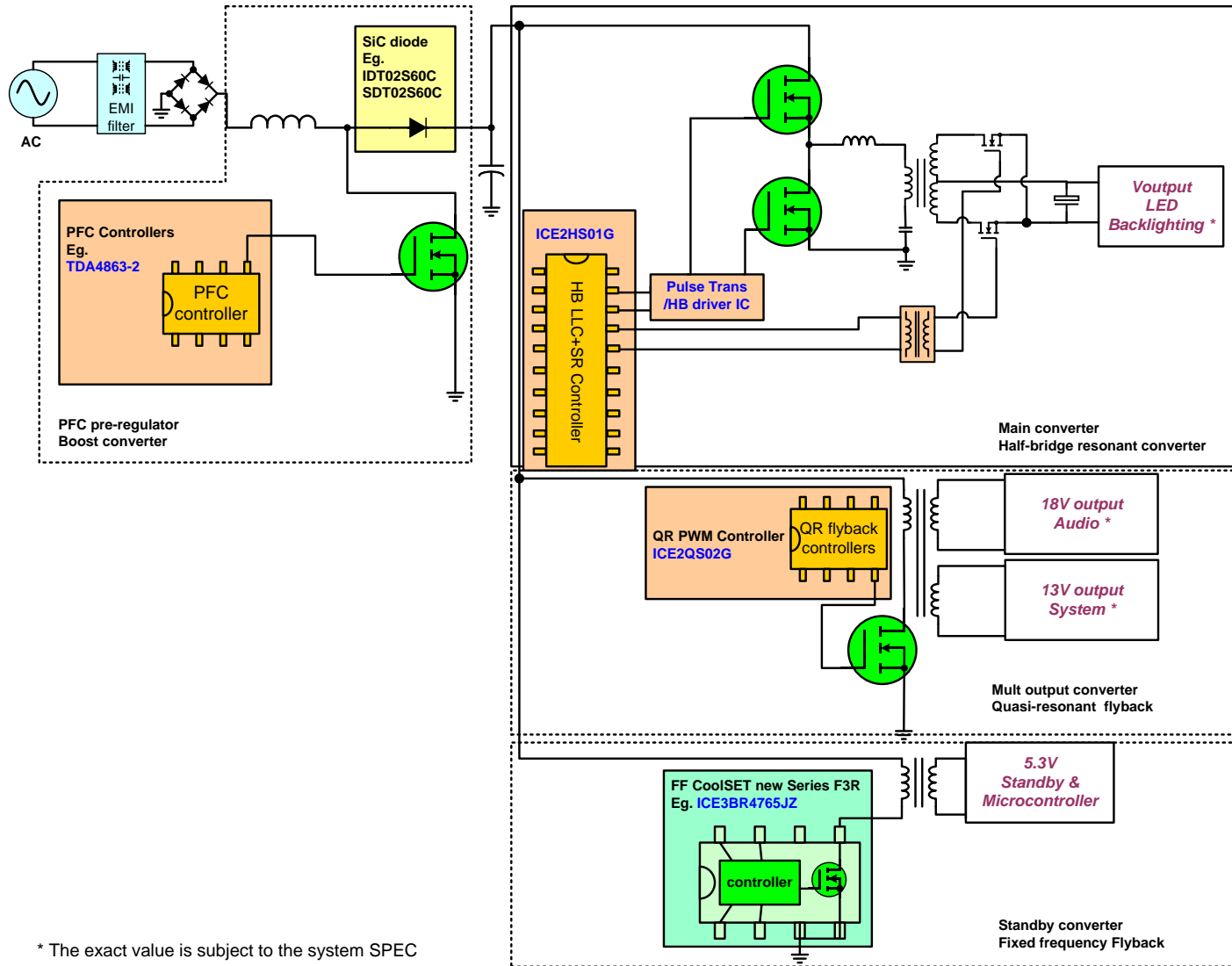
❑ **TDA4863-2:** Few external component , easy design, nearly 1 power factor can be achieved.

❑ **ICE2QS02G:** Mosfet Valley switching and Frequency reduction ensure high average efficiency >87%.

❑ **ICE3BR4765JZ:** Active burst mode ensures extremely low standby power consumption <0.1W.

LED TV Power: 100~200W solution

The diagram shows a block diagram of an LED TV power solution with the following labeled sections:

PFC pre-regulator / Boost converter section containing:
- EMI filter
- AC input
- SiC diode, Eg. IDT02S60C, SDT02S60C
- PFC Controllers, Eg. TDA4863-2 (PFC controller)
- 600V CoolMOS™C3/CP, 500V CoolMOS™C3/CP, Eg. IPA60R199CP, SPA20N60C3

Main converter / Half-bridge resonant converter section containing:
- 600V CoolMOS™C3/CP, 500V CoolMOS™C3/CP, Eg. SPA07N60C3, IPA50R385CP
- Pulse Trans
- HB LLC Controller, ICE1HS01G
- Vout LED Backlighting*
- 24V or 18V output Audio*
- 13V output System*

Standby converter / QR/Fixed frequency Flyback section containing:
- FF CoolSET new Series F3R, Eg. ICE3BR4765JZ (controller)
- 5.3V Standby & Microcontroller*

* The exact value is subject to the system SPEC

- ❑ **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.
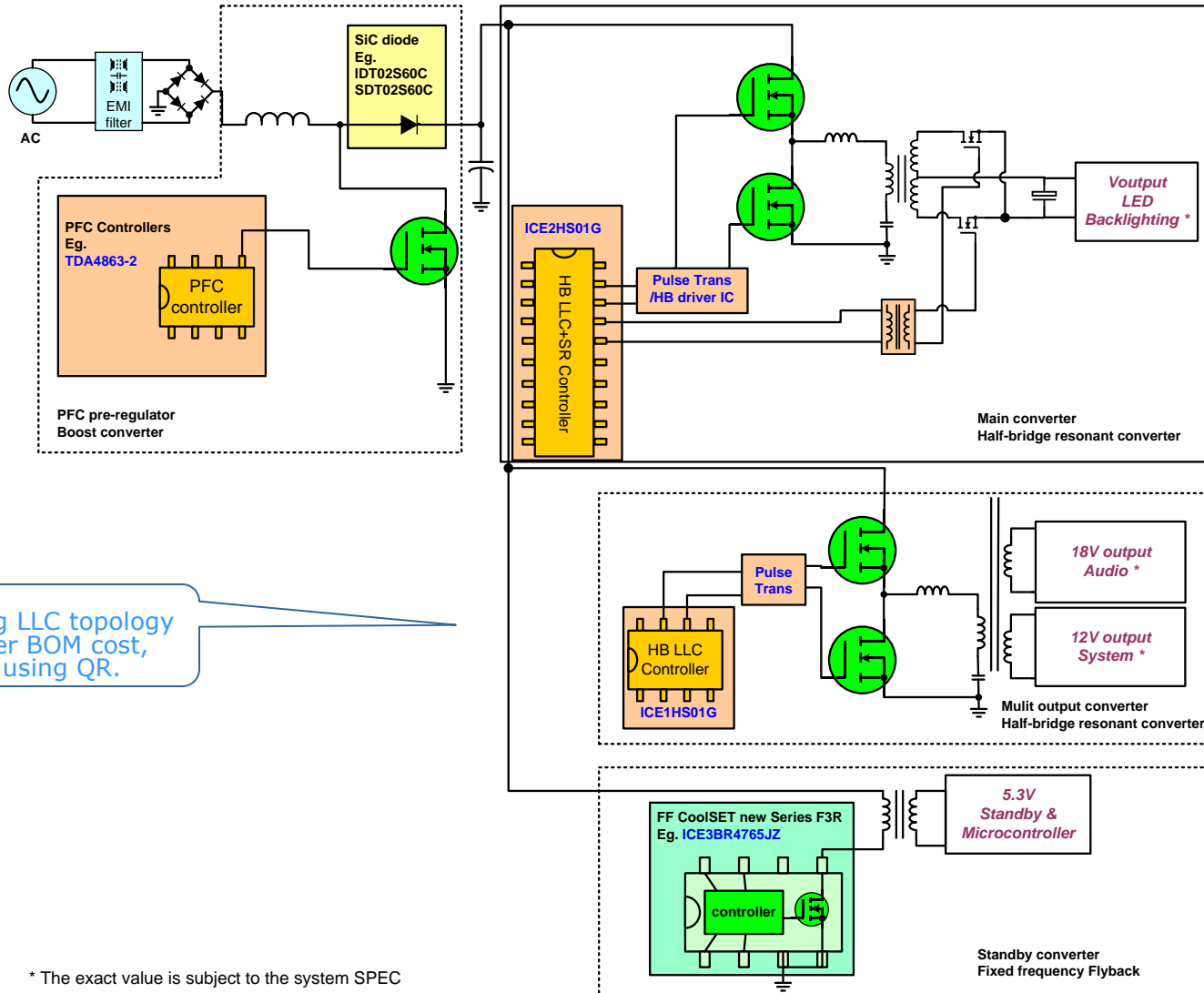
SiC diode
Eg.
IDT02S60C
SDT02S60C

AC

EMI filter

PFC Controllers
Eg.
TDA4863-2

PFC controller

PFC pre-regulator
Boost converter

ICE2HS01G

HB LLC+SR Controller

Pulse Trans /HB driver IC

*Voutput LED Backlighting **

Main converter
Half-bridge resonant converter

QR PWM Controller
ICE2QS02G

QR flyback controllers

*18V output Audio **

*13V output System **

Mult output converter
Quasi-resonant flyback

FF CoolSET new Series F3R
Eg. ICE3BR4765JZ

controller

5.3V Standby & Microcontroller

Standby converter
Fixed frequency Flyback

* The exact value is subject to the system SPEC

❑ **ICE2HS01G: LLC+SR controller further increases the LLC efficiency to a much higher level.**

LED TV Power: High Efficiency 200W solution_ option 2

infineon

Labels within diagram:

- AC
- EMI filter
- **SiC diode Eg. IDT02S60C SDT02S60C**
- **PFC Controllers Eg. TDA4863-2**
- PFC controller
- **PFC pre-regulator Boost converter**
- **ICE2HS01G**
- HB LLC+SR Controller
- **Pulse Trans /HB driver IC**
- *Voutput LED Backlighting ***
- **Main converter Half-bridge resonant converter**
- Multi output using LLC topology may cause lower BOM cost, compared to using QR.
- **Pulse Trans**
- HB LLC Controller
- **ICE1HS01G**
- *18V output Audio ***
- *12V output System ***
- **Mulit output converter Half-bridge resonant converter**
- **FF CoolSET new Series F3R Eg. ICE3BR4765JZ**
- controller
- *5.3V Standby & Microcontroller*
- **Standby converter Fixed frequency Flyback**

* The exact value is subject to the system SPEC

❑ **ICE2HS01G: LLC+SR controller further increases the LLC efficiency to a much higher level.**

Infineon CCM PFC controller History

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

2006 **ICE2PCS0x**

- BiCMOS Technology
- Lower internal reference – 5V

2003 **ICE1PCS0x**

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

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)

ICE3PCS0xG
Key Features
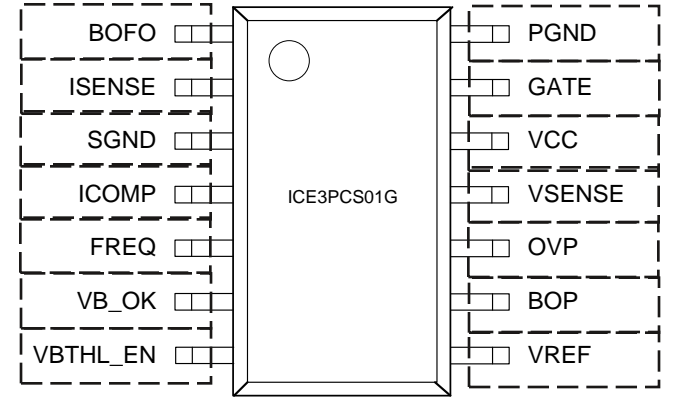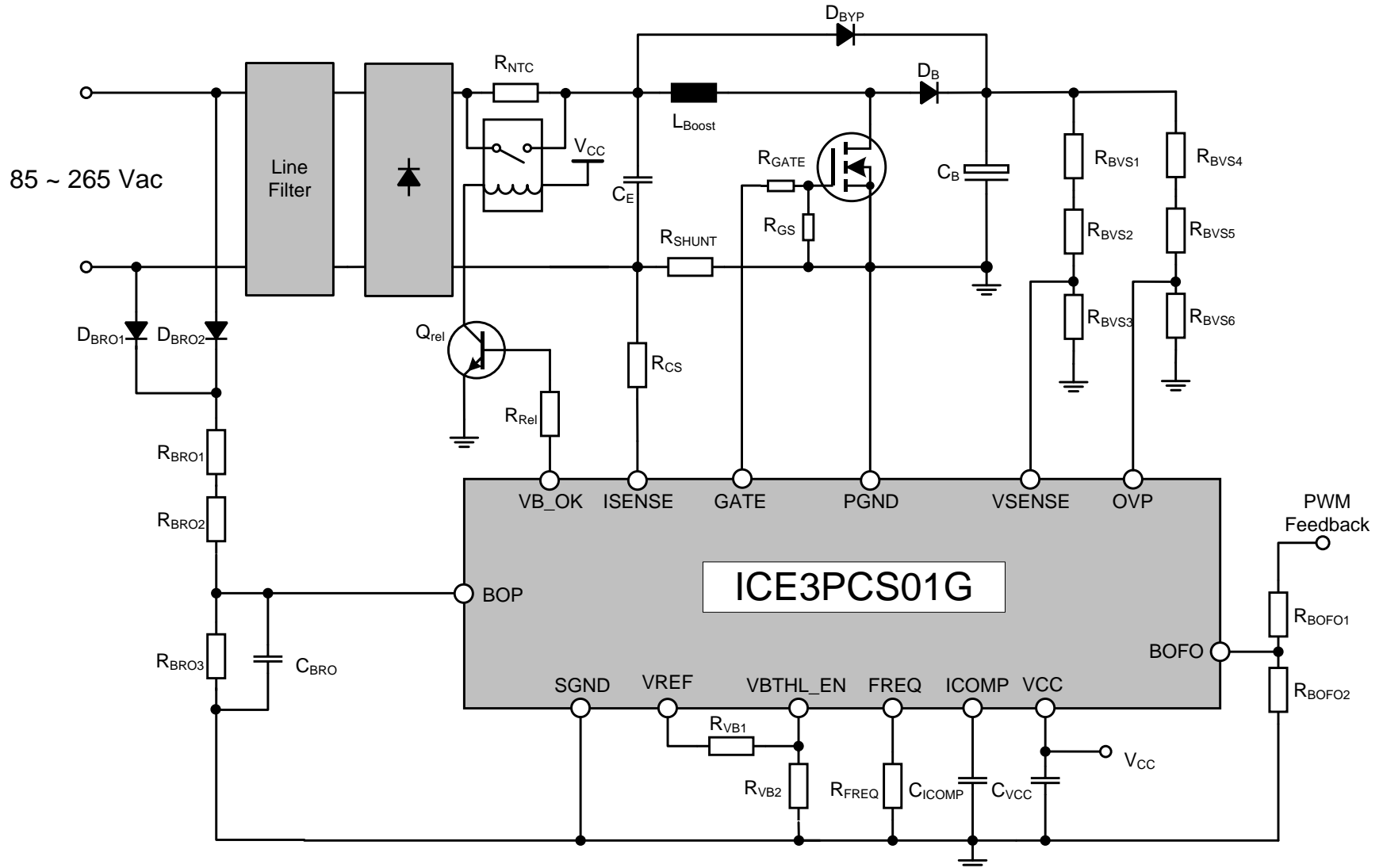
- Low Peak Current Limit (0.2V)
- Average current control without direct sinewave reference signal sensing
- Adjustable operating frequency (20kHz - 250kHz)
- Synchronous frequency (50kHz – 150kHz)
- Boost Follower Mode with adjustable bulk voltage at low step
- Accurate Brown Out protection
- Second 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
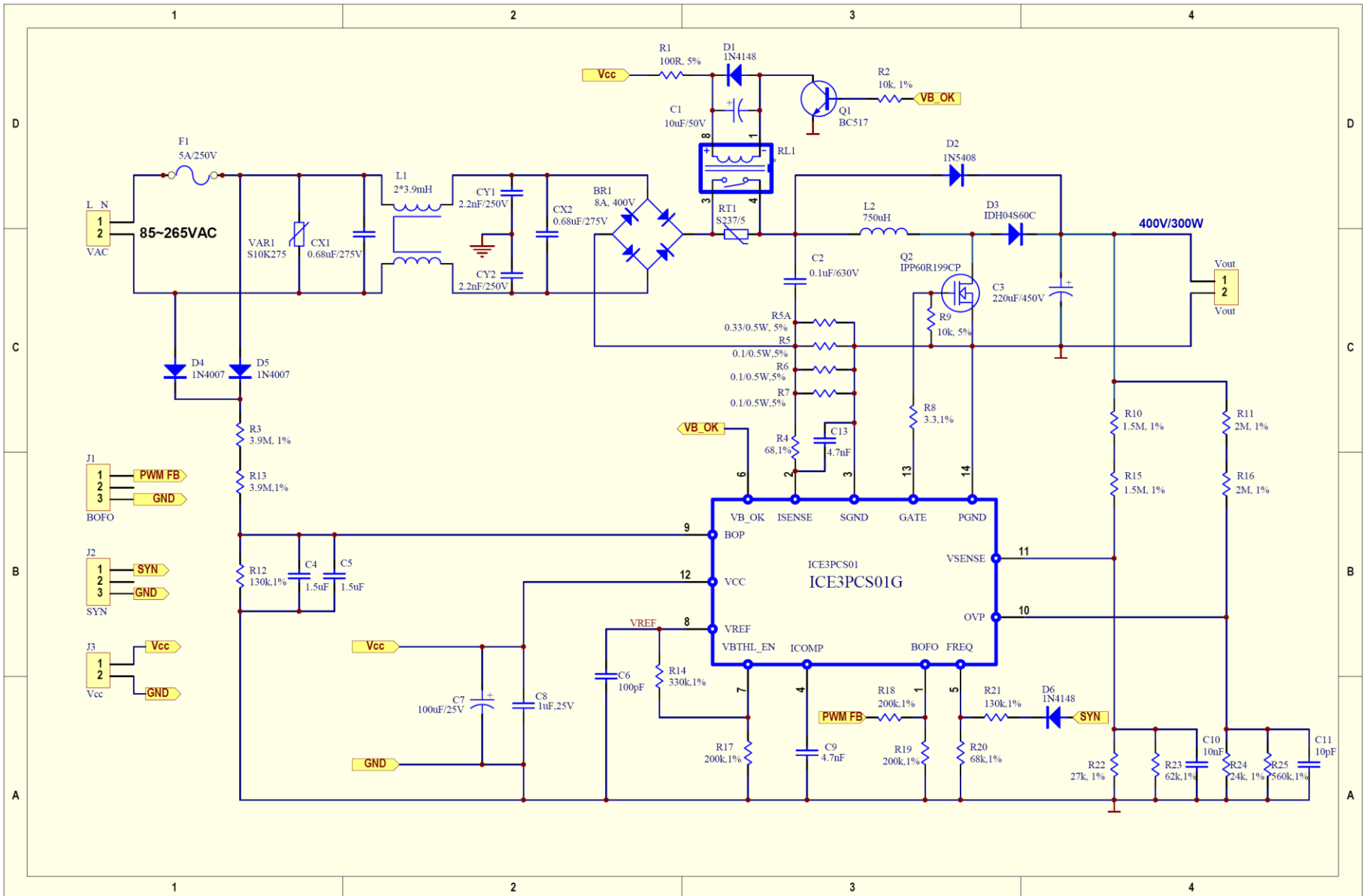
Performance of Evaluation Board
Efficiency Vs Output Power

ICE3PCS01G Efficiency
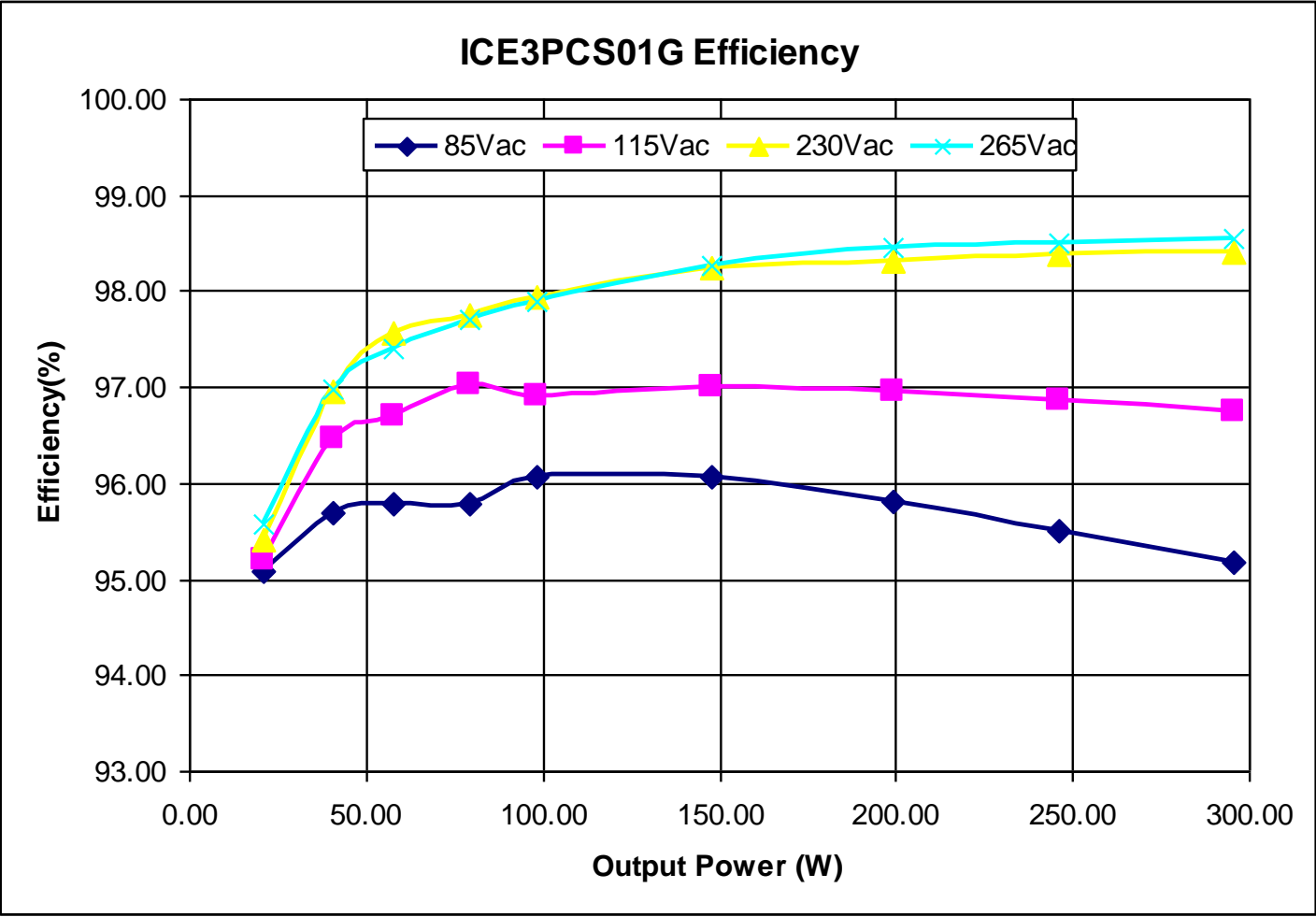
Performance of Evaluation Board
Power Factor Vs. Output Power
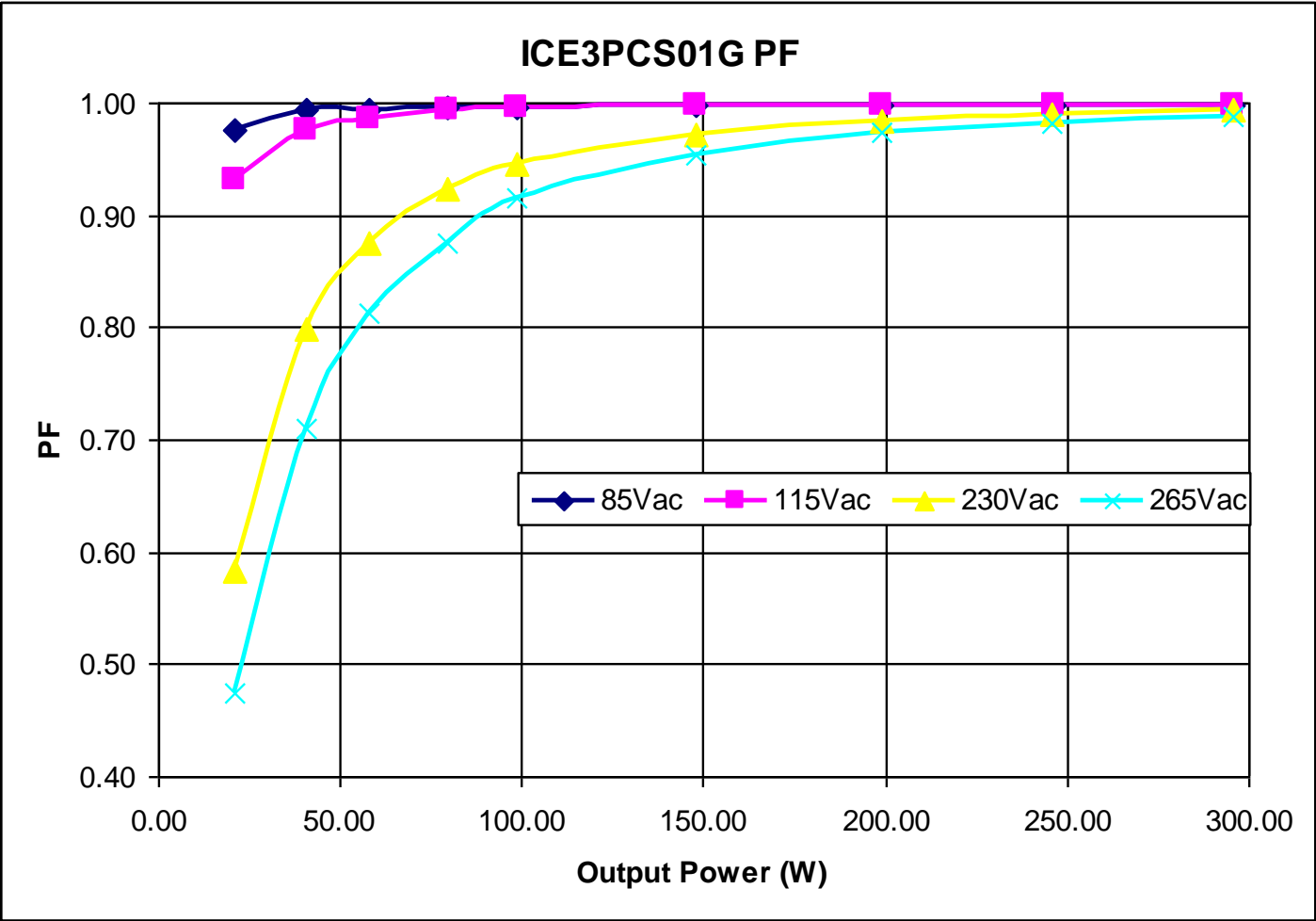
Other ICE3PCS0XG family

ISENSE — ICE3PCS02G — GATE
GND — VCC
ICOMP — VSENSE
FREQ — OVP

ISENSE — ICE3PCS03G — GATE
GND — VCC
ICOMP — VSENSE
FREQ — BOP
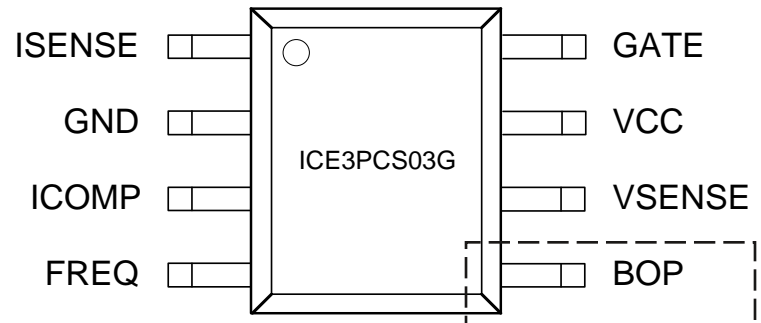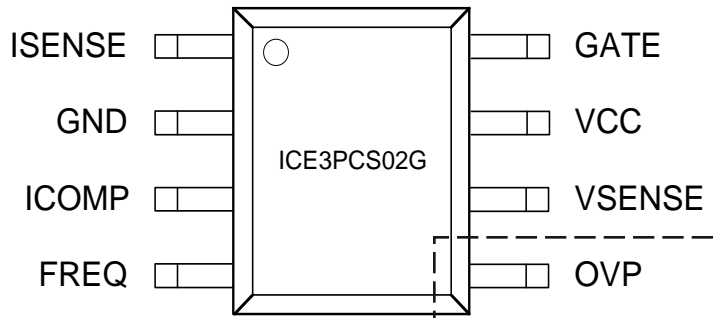
- The difference between ICE3PCS02G and ICE3PCS03G is at pin 5

Load	20%	50%	100%
Efficiency	95.5%	97%	96.5%

LLC stage → ICE2HS01G

Load	20%	50%	100%
Efficiency	95.5%	97%	96.5%

ICE2HS01G PG-DSO-20

Pins (left): Timer, EnA, OCP, LOAD, FREQ, TD, Delay, Vref, Vmc, Vres
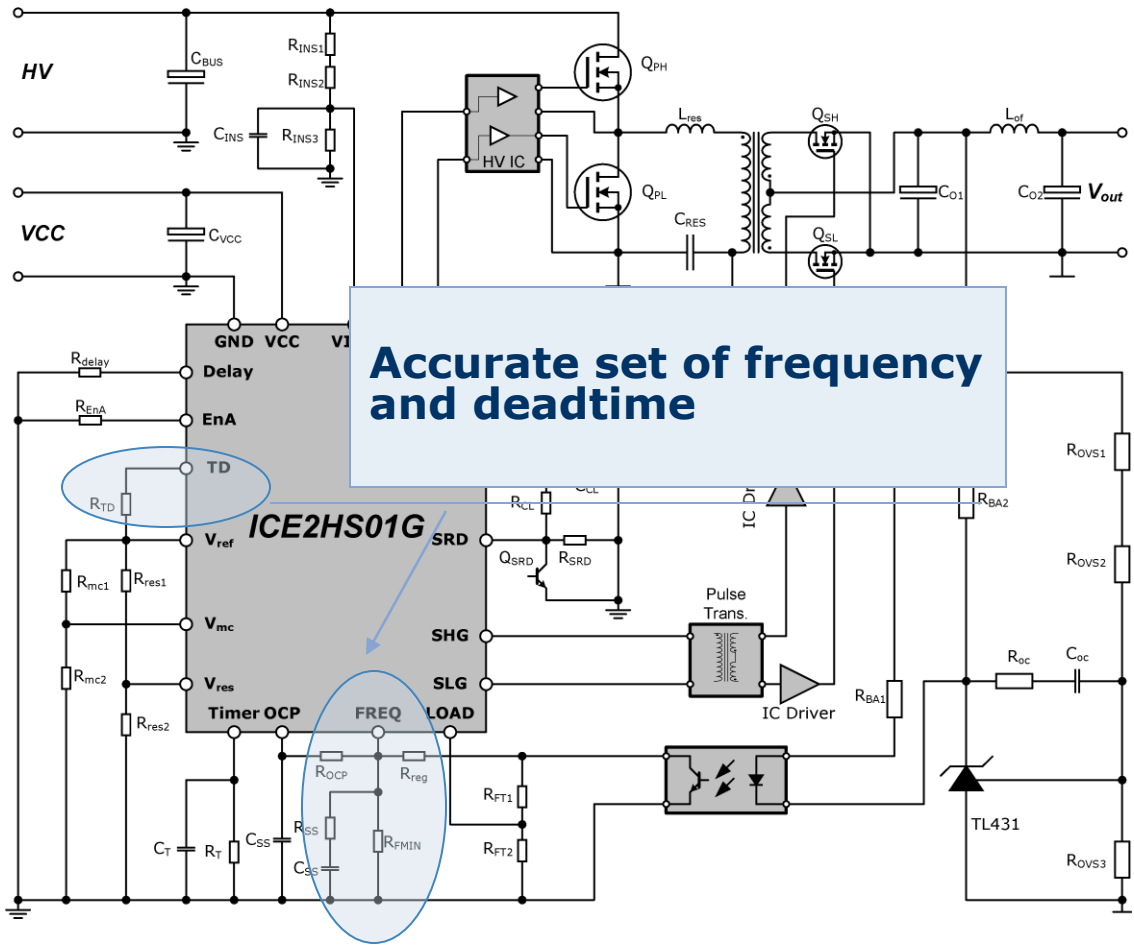Pins (right): VCC, HG, LG, SHG, SLG, GND, SRD, CL, CS, VINS
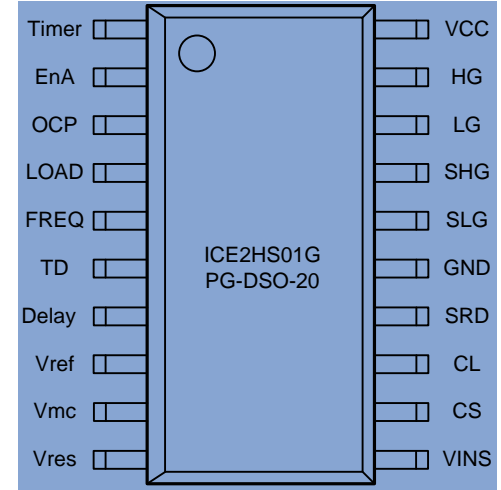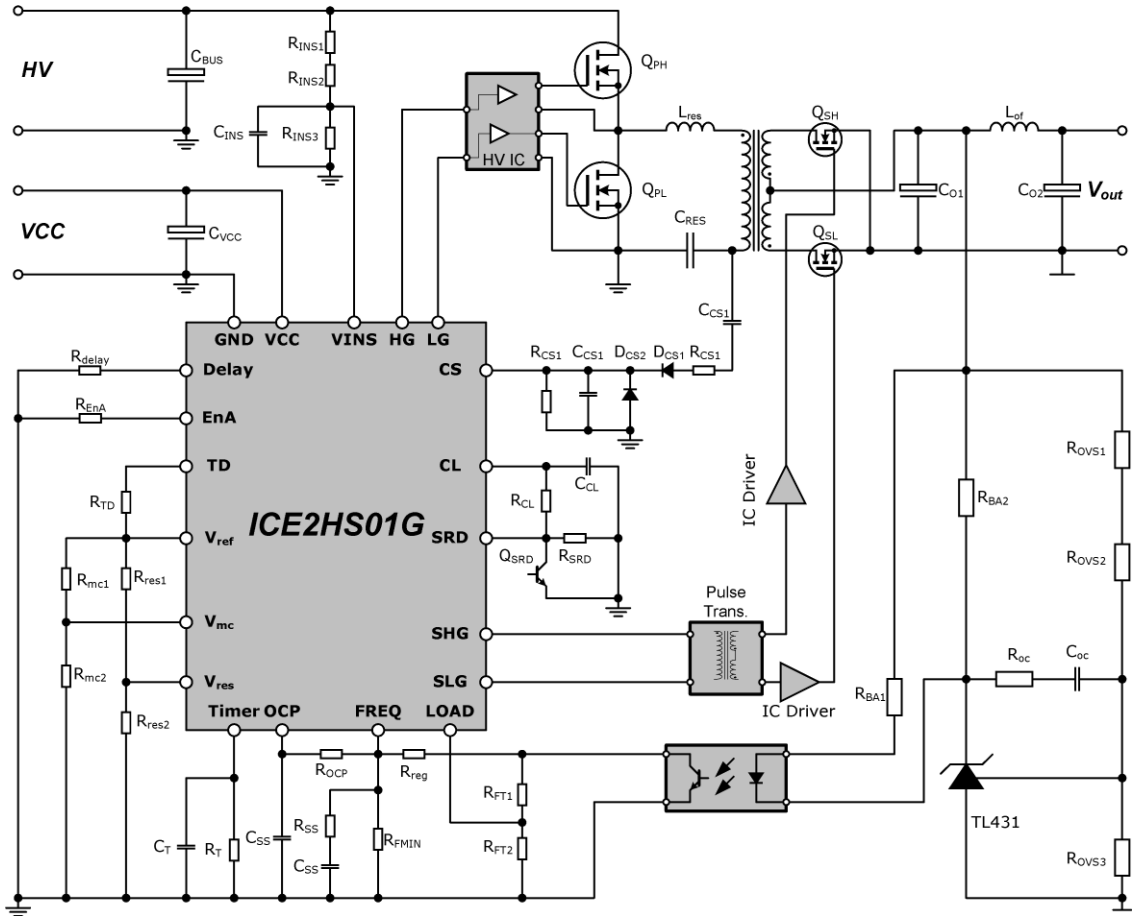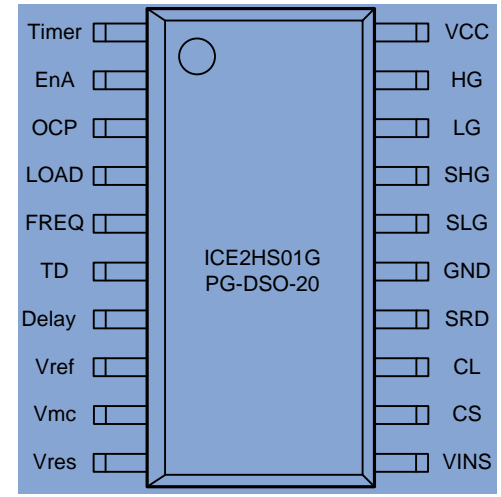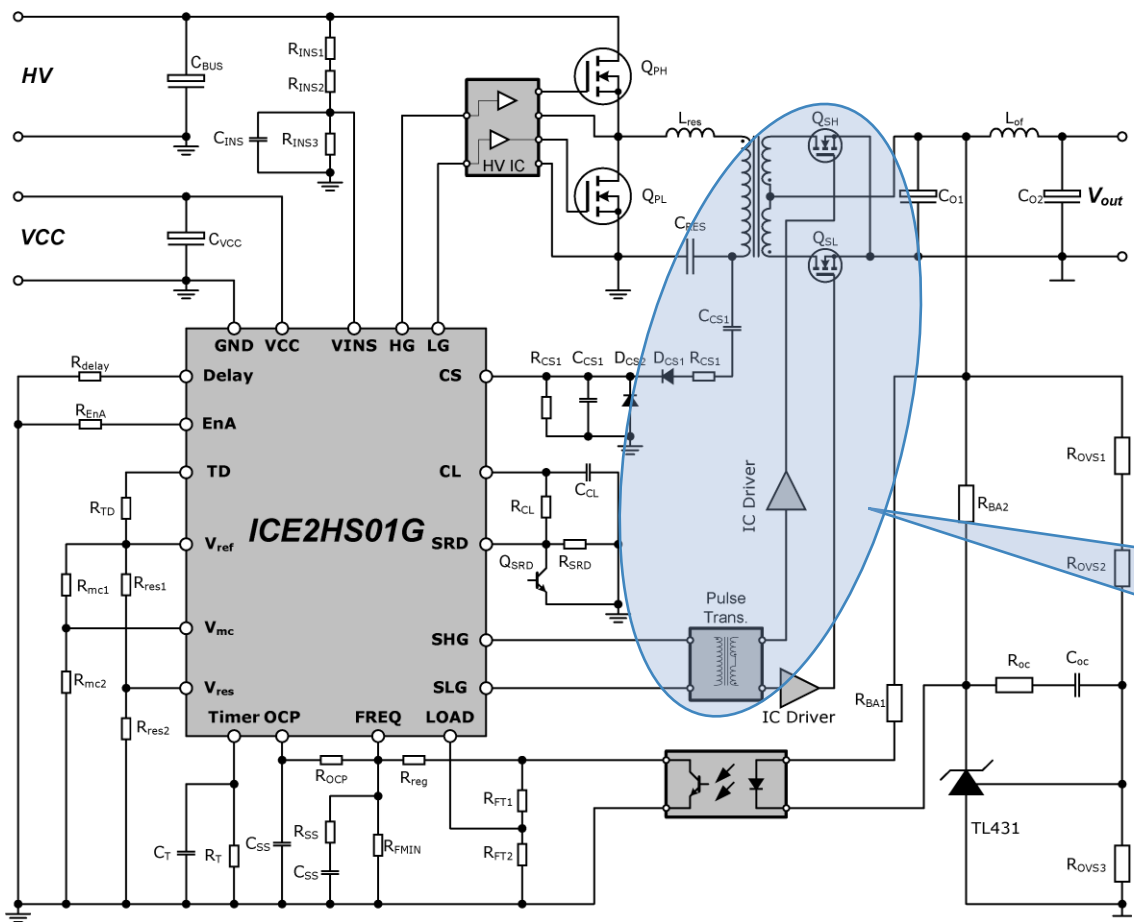
- SR control from primary side for both CCM and DCM
- No need SR IC/Current sense at secondary side

Infineon System Solution for LED TV
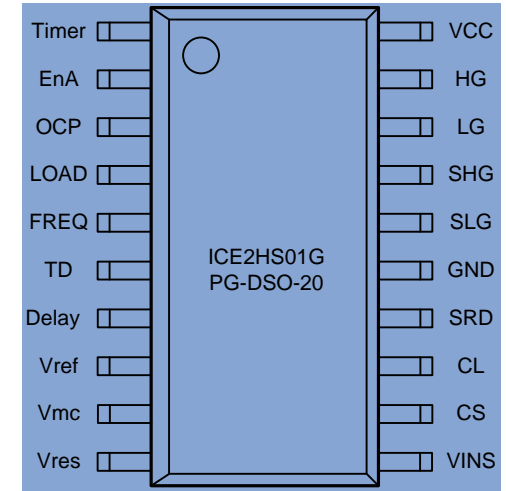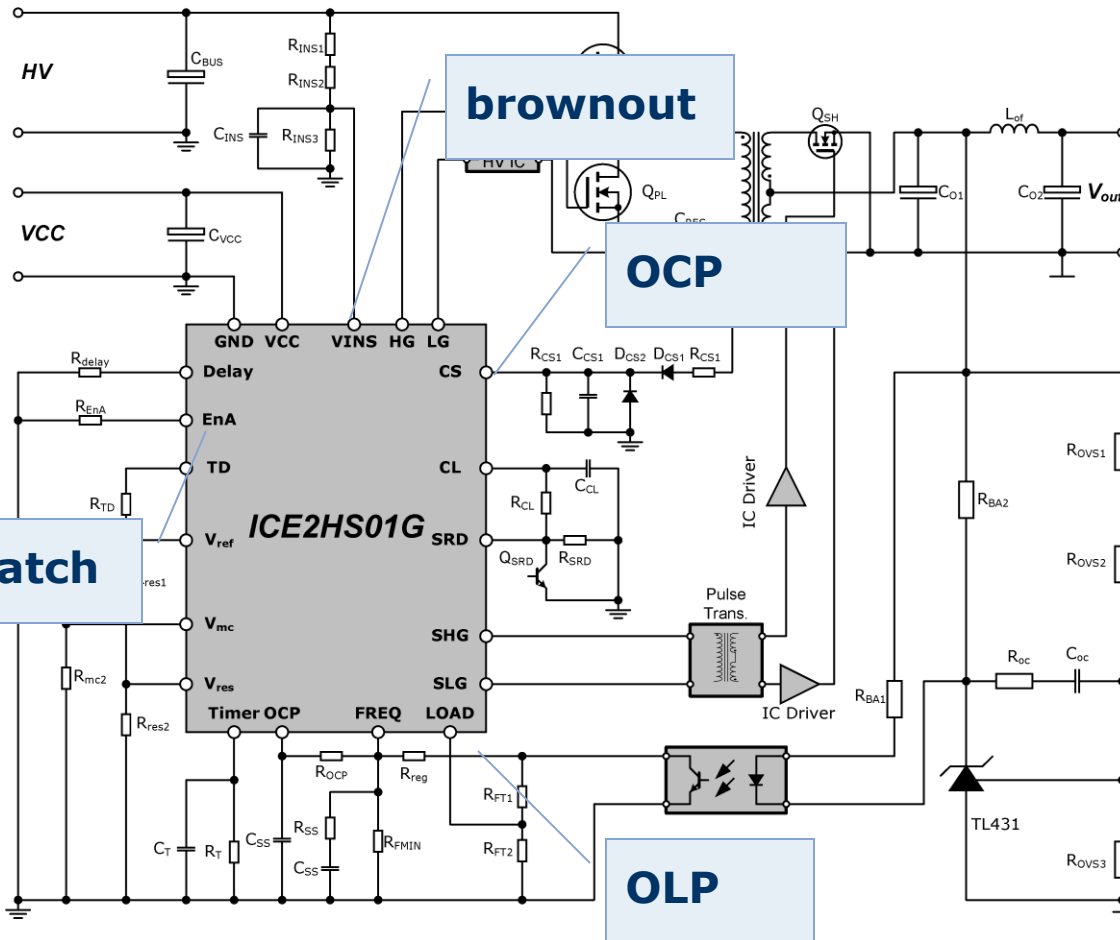## LLC stage → ICE2HS01G

Load	20%	50%	100%
Efficiency	95.5%	97%	96.5%

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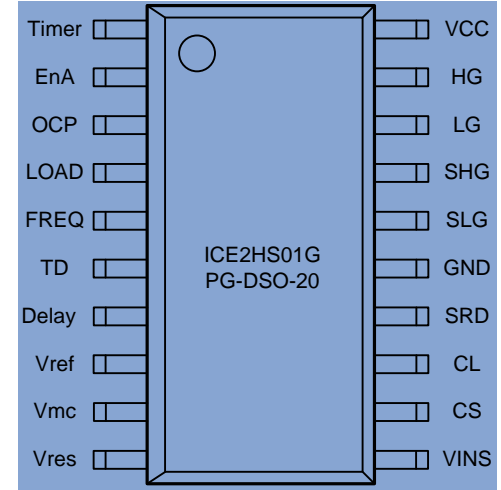
Infineon System Solution for LED TV
LLC stage → ICE2HS01G

| Load	20%	50%	100%
Efficiency	95.5%	97%	96.5%

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**

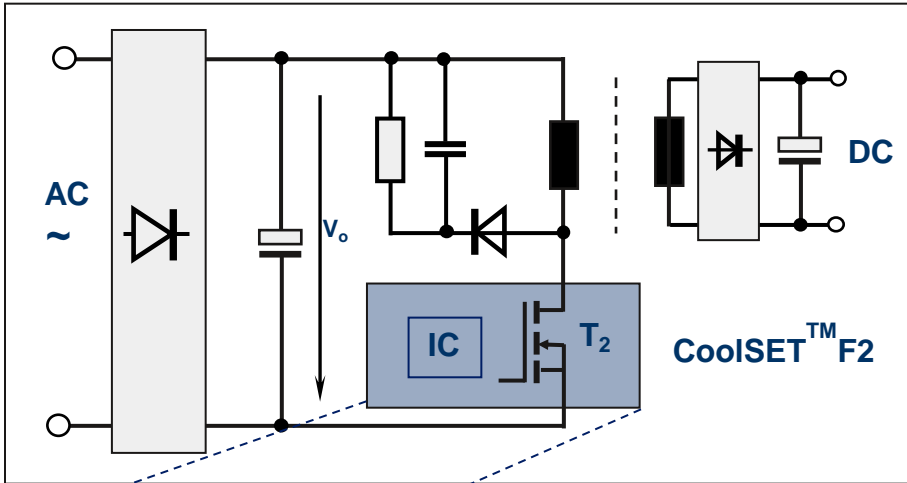# Infineon Integrated Power IC – F3 & Quasi. CoolSET®

AC ~

V_o

IC T_2

Quasi CoolSET®

DC
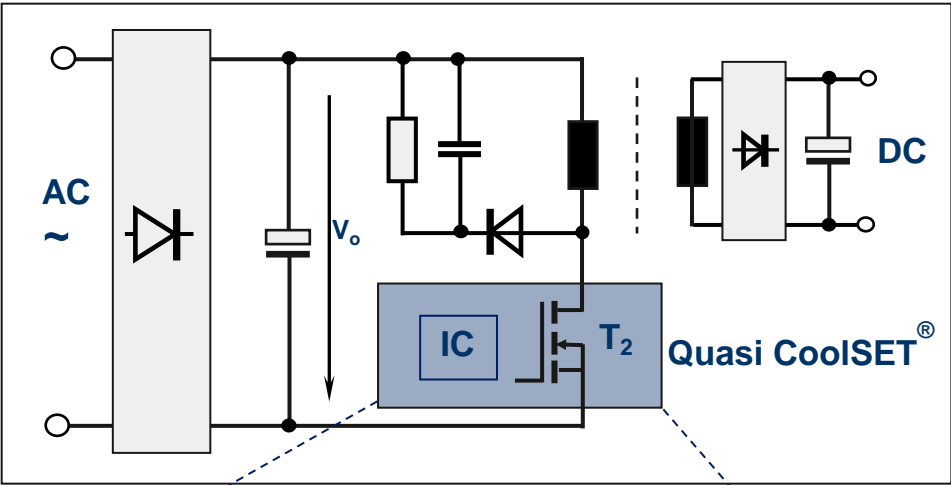
Quasi. PWM IC   **CoolMOS**
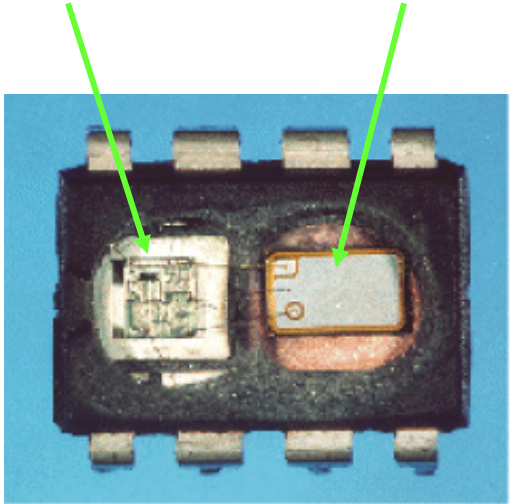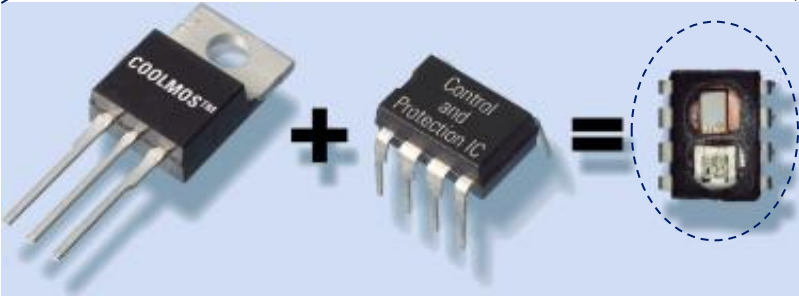
Typical SMPS topology for AC/DC conversion with CoolSET

AC ~

V_o

IC T_2

CoolSET™F2

DC

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

NEW!

GND

Control Chip

CoolMOS

DCB-Isolation

Lead frame is connected to GND
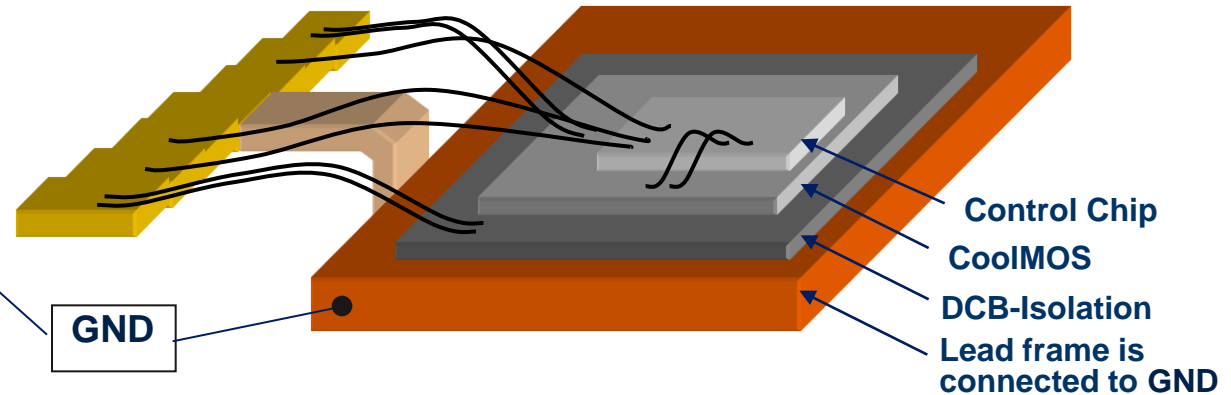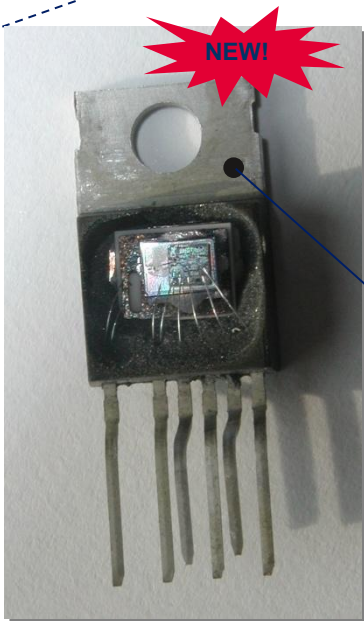
TO-220-6 ISOdrain
ISOLATED Package w. LOW Thermal Resistance

CoolSET Naming System

Infineon AC/DC IC

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

Vds rating:
divided by 10

Latch

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

ICE **3** **A** **20** **65** **E** **L** **J** **Z**

Generation:
2: 2nd
3: 3rd

ESD

Jitter

xx: current, multipled by 10
Rxx: Rdson, multipled by 10
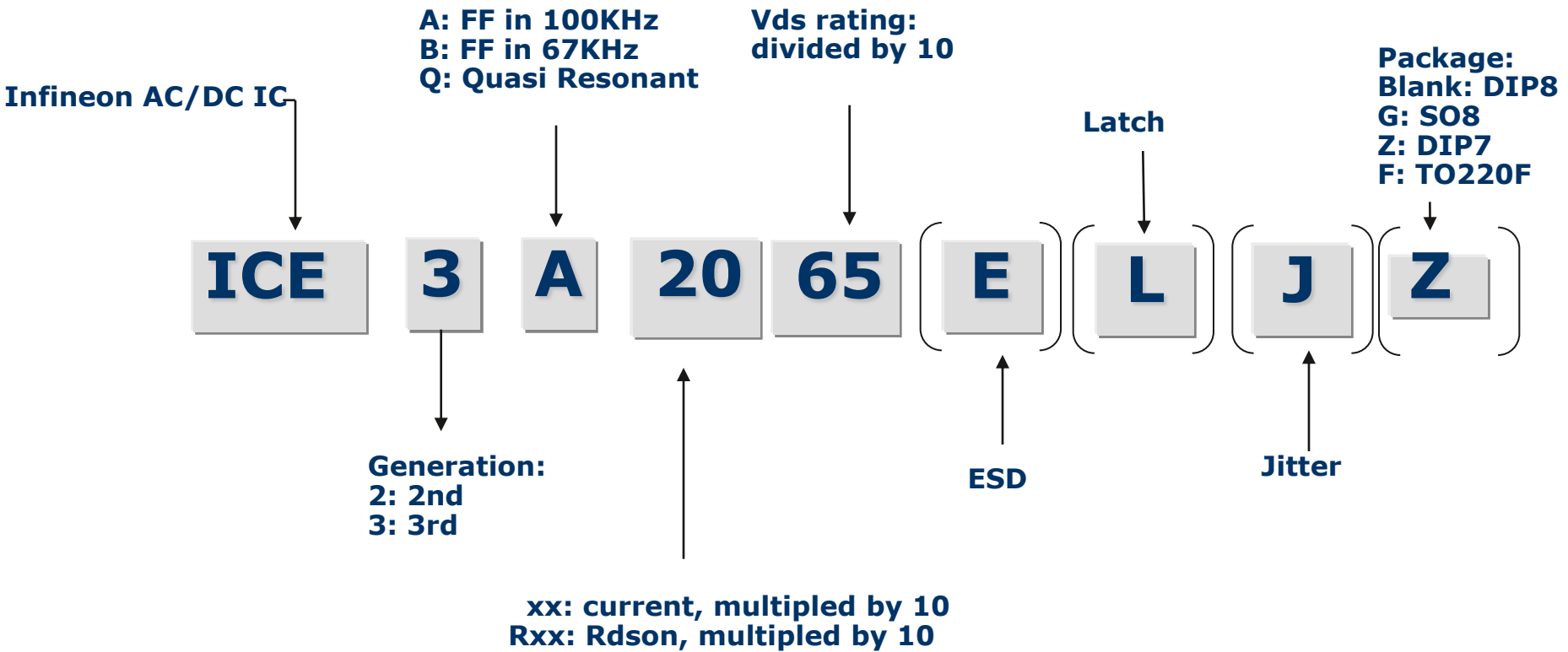
Fixed Switching CoolSET and Pin Assignment

- Package : DIP-7 / DIP-8

- Pin assignment :
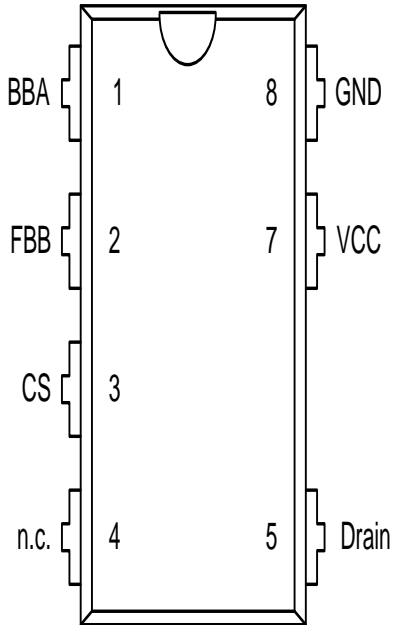
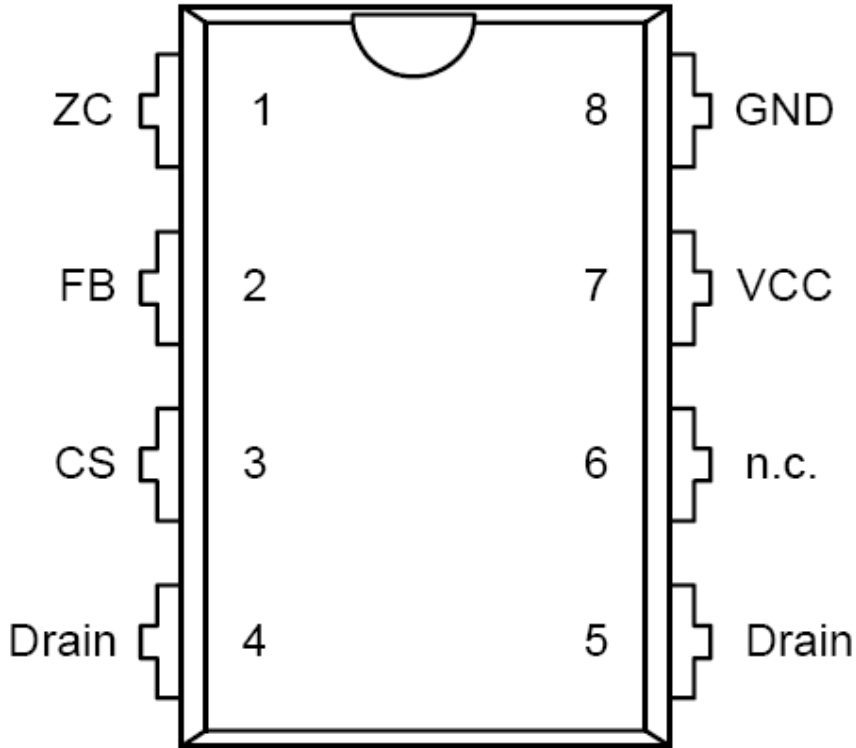| Pin	Name	Function
1	BBA	Brownout, extended Blanking time and external Auto-restart enable
2	FBB	FeedBack and Burst entry control
3	CS	Current Sense
4	N.C.	No Connection
5	Drain	Drain
6	No pin	No pin
7	Vcc	Vcc
8	GND	Ground

Quasi. CoolSET and Pin Assignment

Package PG_DIP-8

ZC — 1
FB — 2
CS — 3
Drain — 4

8 — GND
7 — VCC
6 — n.c.
5 — Drain

Pin	Symbol	Function
1	ZC	Zero Crossing
2	FB	Feedback
3	CS	Current Sense/ 650V[1] Depl. CoolMOS® Source
4, 5	Drain	650V[1] Depl. CoolMOS® Drain
6	n.c.	Not connected
7	VCC	Controller Supply Voltage
8	GND	Controller Ground

[1] at $T_j = 110°C$

: optional external components;
#1 : C_{BK} is used to extend the Blanking Time
#2 : R_{BO1} & R_{BO2} are used for brownout feature; R_{BO1} tie to Vcc if no brownout feature
#3 : T_{AE} is used to enable the external Auto-restart feature

CoolSET® F3 product family introduction
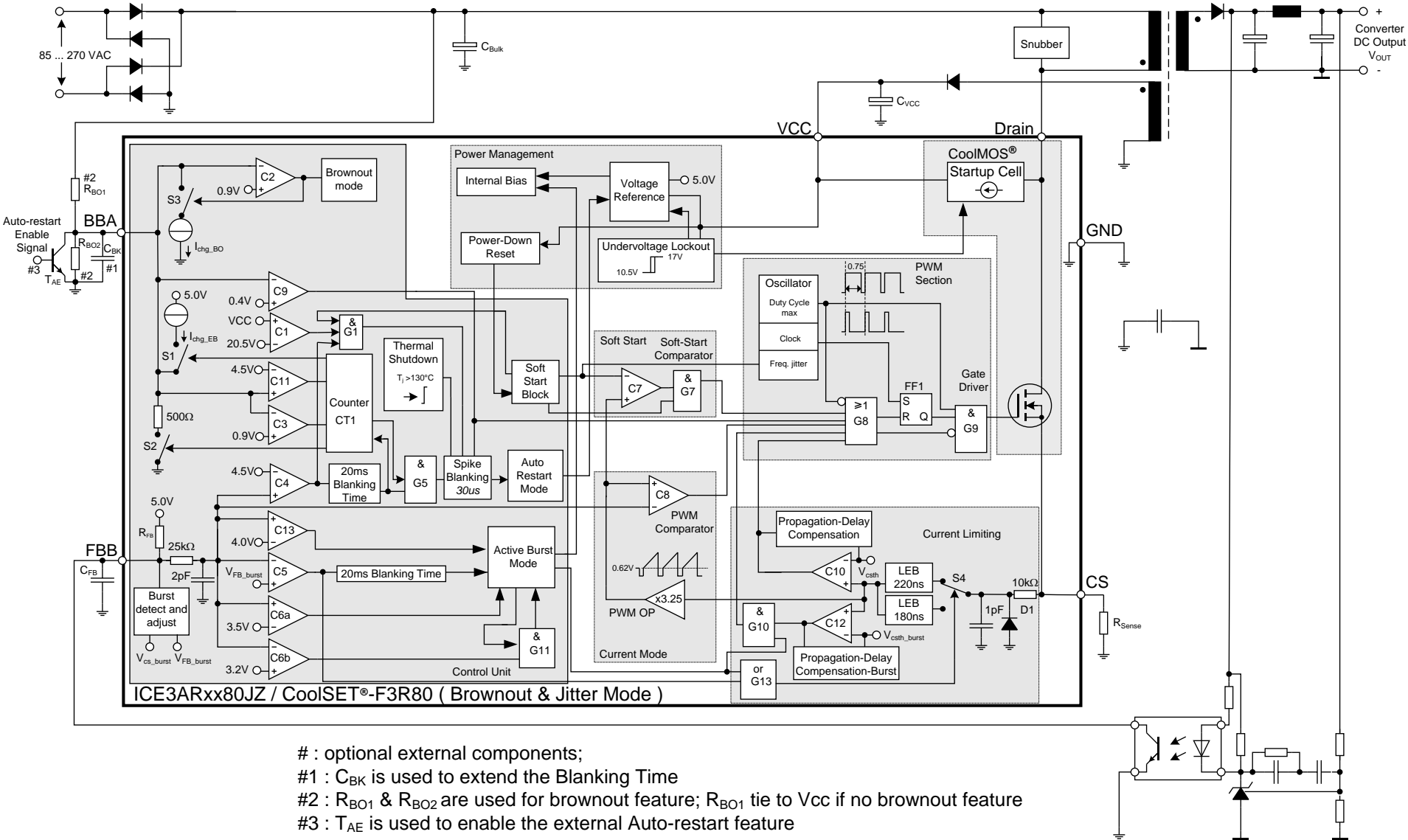
- **CoolSET® F3 (ICE3xxx65(L)(Z)(G)(P))**
  - ☐ 1st F3 CoolSET® products, **Bipolar** technologies
  - ☐ Full power range series with DIP-8, DIP-7, DSO-16/12 and TO-220 isodrain.
- **CoolSET® F3J (ICE3Bxx65J(G))**
  - ☐ Cost reduction F3 CoolSET® (C1), **BiCMOS** technologies
  - ☐ For low power application 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

Evaluation Board Circuit Diagram
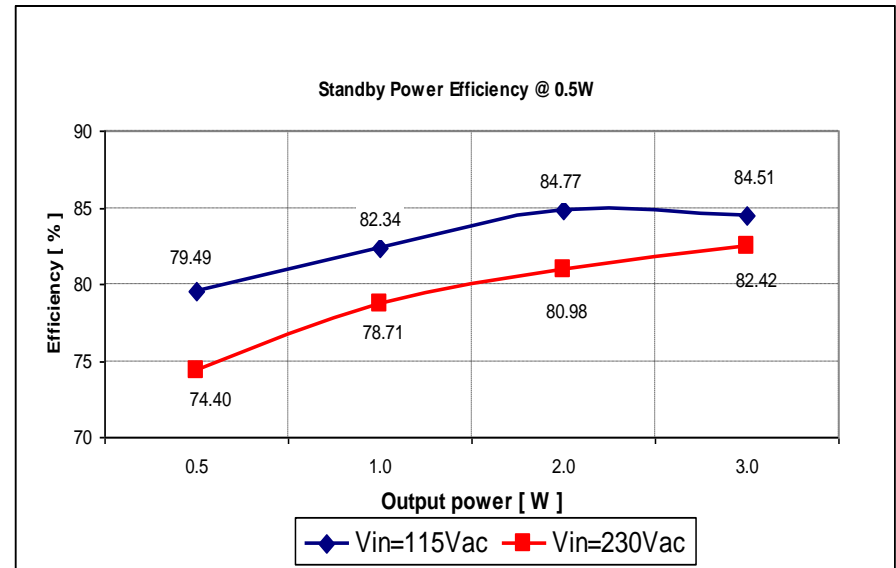# 12V 30W (Vin= 85Vac ~ 282Vac) using ICE3AR0680JZ

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.
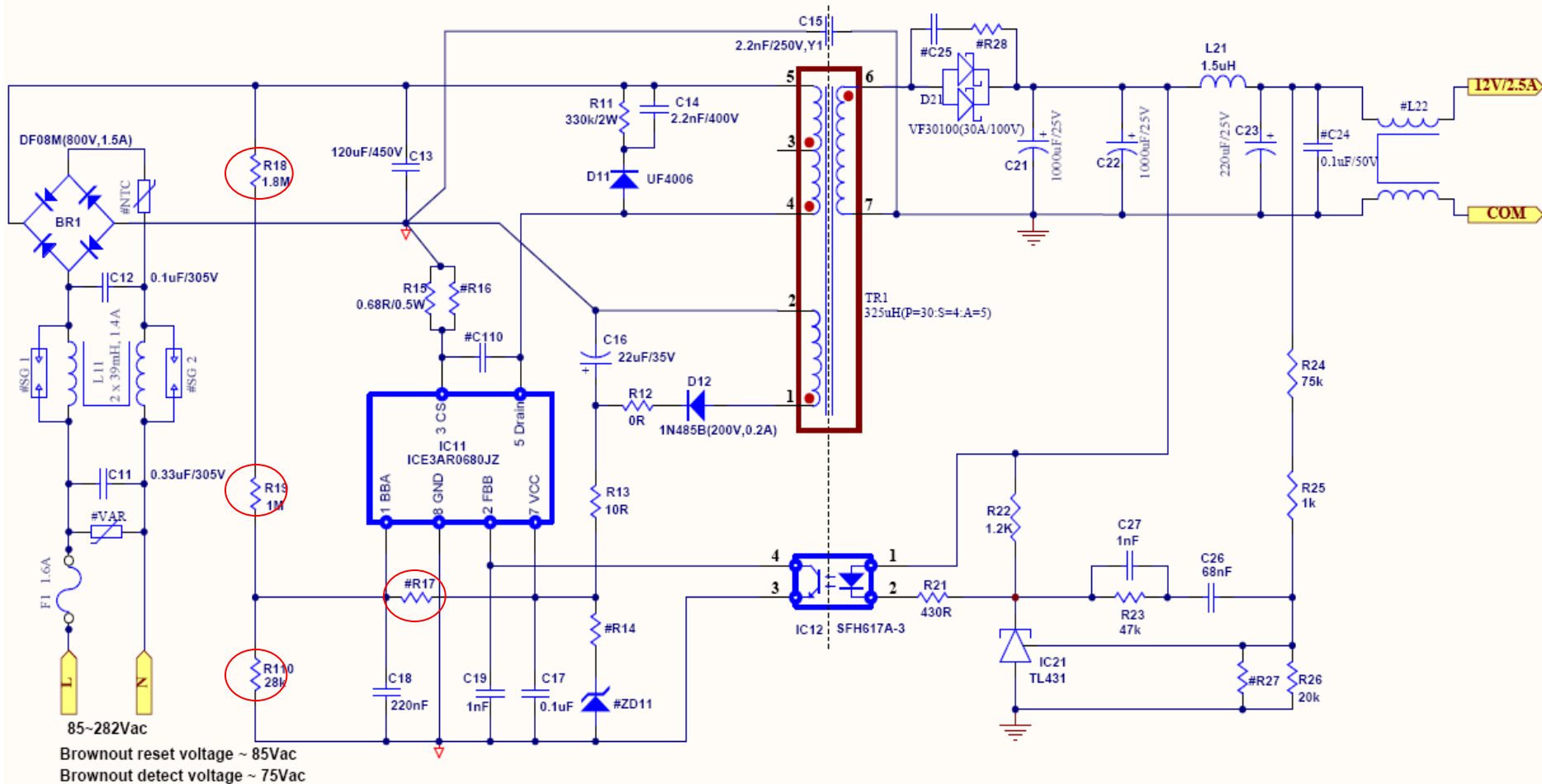
30W 12V SMPS Demoboard with ICEAR0680JZ(V0.7)

Kyaw Zin Min, Eric Kok/ 31 Mar 2010

Measurement based on demo board 30W 12V using ICE3AR0680JZ

Stanby Power @ no-load versus AC Line Input Voltage

Po = 0W(Enable Broownout)   Po=0W(Disable Brownout)

Standby Power @ 0.5W load versus AC Line Input Voltage

Po=0.5W

Standby Power Efficiency @ 0.5W

Vin=115Vac   Vin=230Vac
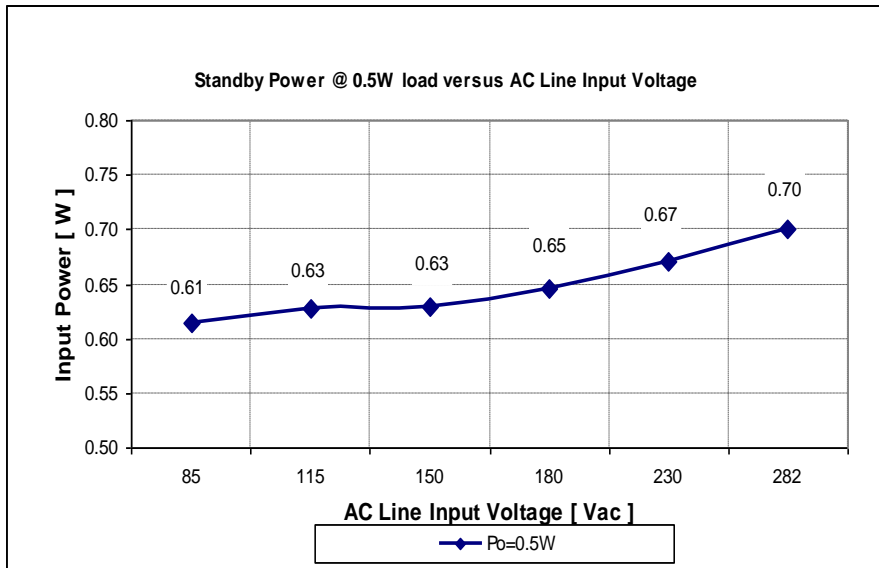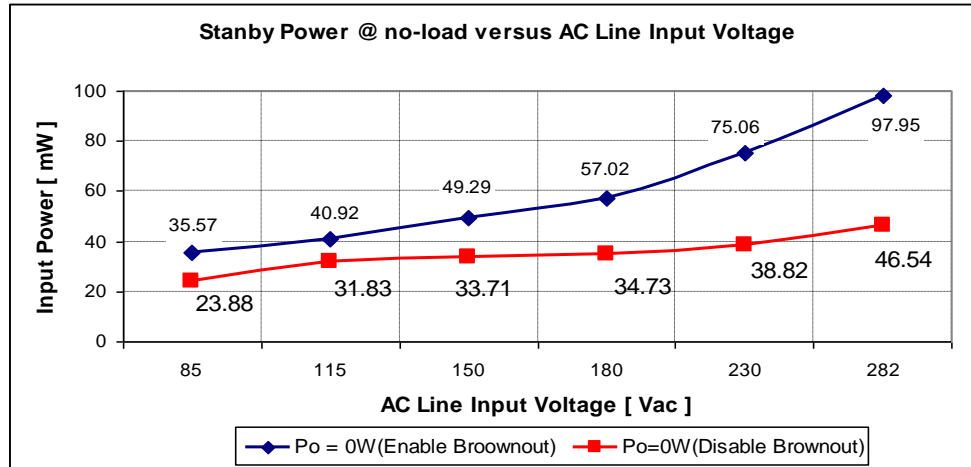
Standby power at different C$_{FB}$ for no load and 0.5W load

Measurement based on demo board 30W 12V using ICE3AR0680JZ

■ **Input standby power at no load with different C$_{FB}$**

	Pin (mW) Enable Brownout						Pin (mW) Disable Brownout					
	85Vac	115Vac	150Vac	180Vac	230Vac	282Vac	85Vac	115Vac	150Vac	180Vac	230Vac	282Vac
C$_{FB}$=6.8nF	37.34	42.48	49.79	59.34	78.94	99.96	32.94	34.21	36.19	38.99	44.89	56.26
C$_{FB}$=1nF	36.55	41.29	50.83	56.23	76.35	96.54	32.56	33.48	36.42	38.86	43.83	55.79
C$_{FB}$=330pF	36.46	41.95	49.02	57.73	76.53	98.93	33.19	34.63	36.19	38.73	44.58	55.42
C$_{FB}$=100pF	108.57	104.48	105.77	114.59	128.02	149.37	97.52	80.17	87.36	88.81	92.49	100.84

■ **Input standby power at 0.5W load with different C$_{FB}$**

	Pin (W) Enable Brownout						Pin (W) Disable Brownout					
	85Vac	115Vac	150Vac	180Vac	230Vac	282Vac	85Vac	115Vac	150Vac	180Vac	230Vac	282Vac
C$_{FB}$=6.8nF	0..584	0.595	0.610	0.625	0.638	0.664	0.581	0.596	0.605	0.606	0.612	0.628
C$_{FB}$=1nF	0.611	0.625	0.630	0.633	0.650	0.679	0.585	0.601	0.606	0.619	0.629	0.647
C$_{FB}$=330pF	0.606	0.614	0.637	0.642	0.668	0.682	0.589	0.602	0.614	0.620	0.630	0.652
C$_{FB}$=100pF	0.857	0.812	0.796	0.804	0.826	0.869	0.840	0.782	0.772	0.76	0.77	0.79

CoolSET™ F3 Product Overview
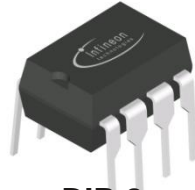
- A version: f = 100kHz
- B version: f = 67 kHz
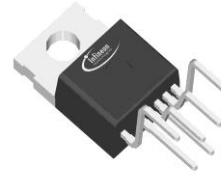
ISODrain
- Isolated
- low R_{th}

R_{DSon}	SO-16	DIP-8	POUTmax	TO-220-6	I²-Pak	POUTmax
6.5Ω	ICE3B0365JG	ICE3A0365 ICE3B0365J ICE3A0565	9W/17W			
4,7Ω	ICE3B0565JG	ICE3B0565J ICE3A1065 ICE3B1065	12W/21W			55W/90W
3,0Ω			15W /25W	ICE3A2065P ICE3B2065P ICE3A3065P ICE3B3065P	ICE3A2065I ICE3B2065I ICE3A3065I ICE3B3065I	68W/125W
2,1Ω		ICE3B1565J ICE3A1565 ICE3B1565				
1,7Ω			20W/32W	ICE3A3565P ICE3B3565P ICE3A5065P ICE3B5065P ICE3A5565P ICE3B5565P	ICE3A3565I ICE3B3565I ICE3A5065I ICE3B5065I ICE3A5565I ICE3B5565I	
1,5Ω		ICE3A2065 ICE3B2065	27W/41W			80W/144W
0,95Ω		ICE3A2565 ICE3B2565				100W/180W
0,8Ω			31W /46W			110W/200W
0,65Ω						

CoolSET™ F3R & 2QR
Product Overview

infineon

SO-16
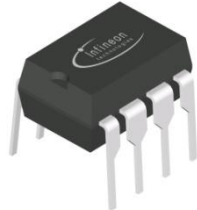
DIP-7/8

- A version:
  f = 100kHz
- B version:
  f = 67 kHz
- Quasiresonant

TO-220-6

Fullpak
- Isolated
- low R_{th}

R_{DSon}	SO-16	DIP-7/8	P_{OUTmax}	R_{DSon}	TO-220-6	P_{OUTmax}
			9W/17W			55W/90W
10.0Ω	ICE3B4765JG	ICE3BR4765J	12W/21W	2,5Ω	ICE3BR2565JF	
4,7Ω		ICE2QR4765 ICE3AR4780JZ ICE2QR4780Z				
2,2Ω		ICE3AR2280JZ ICE3BR2280JZ ICE2QR2280Z	15W/28W	1,5Ω	ICE3BR1565JF	68W/125W
1,7Ω	ICE2QR0665G	ICE3BR1765J ICE2QR1765	20W/32W	1,0Ω	ICE3BR1065JF	80W/144W
0,65Ω		ICE3BR0665J ICE2QR0665 ICE3AR0680JZ ICE3BR0680JZ ICE2QR0680Z	31W /46W	0,65Ω	ICE3BR0665JF	110W/200W

SMPS IC's at a glance
Focus Product Portfolio

Infineon

FF CoolSET	ICE3BR4765J	ICE3BR1765J	ICE3BR0665J			
	ICE3BR4765JZ	ICE3BR1765JZ	ICE3BR0665JZ			
	ICE3BR4765JG					
	ICE3BR2565JF	ICE3BR1565JF	ICE3BR1065JF	ICE3BR0665JF		
	ICE3A1065ELJ	ICE3A2065ELJ				
	ICE3AR4780JZ	ICE3AR2280JZ	ICE3AR0680JZ			
FF PWM IC	ICE3BS03LJG	ICE3AS03LJG				
QR CoolSET	ICE2QR4765	ICE2QR1765	ICE2QR0665			
QR PWM IC	ICE2QS01	ICE2QS02G	ICE2QS03	ICE2QS03G		
Res LLC HB	ICE1HS01G	ICE2HS01G				
CCM PFC IC	ICE2PCS01	ICE2PCS02	ICE2PCS03	ICE2PCS04	ICE2PCS05	ICE2PCS06
	ICE2PCS01G	ICE2PCS02G	ICE2PCS03G	ICE2PCS04G	ICE2PCS05G	ICE2PCS06G
	ICE3PCS01G	ICE3PCS02G	ICE3PCS03G			
PFC+TTF	ICE1CS02	ICE1CS02G				

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