ICE3PCS01G PFC+TTF control card

Addendum to ANEVAL_201410_PL52_002

Addendum

About this document

Scope and purpose

This document is and addendum to the Infineon application note “300 W General Purpose wide-range SMPS” (ANEVAL_201410_PL52_002), which describes a 300 W switched mode power supply design using ICE1CS02G combi controller IC to implement the PFC and TTF function.

This addendum describes in technical details the alternative control card, which consist in a circuit using the Infineon ICE3PCS01G CCM PFC controller IC in combination with the Texas Instruments LM5021-2 TTF controller IC.

The power board hardware is compatible with both the control cards with minor changes, which are described in this document.

Attention: *This board is intended for evaluation purposes only and is not intended to be an end product.*

Intended audience

Design engineers who are developing a PFC + TTF switched mode power supply.

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1 Board description

The “300 W general purpose wide-range SMPS” application note is the document where most of the information is described. Please refer to this document when replacing the original ICE1CS02G combi IC control card with the ICE3PCS01G control IC card which is described below.

1.1 Block diagram

The following pictures represent the board topology and its partitioning with indication of the main components.

For a better explanation, the power supply can be divided into five parts, shown in Figure 1.

1. The input filter
2. The PFC stage → Originally controlled by combi IC ICE1CS02G → Now replaced by ICE3PCS01G
3. The TTF stage → Originally controlled by combi IC ICE1Cs02G → Now replaced by LM5021-1
4. The output stage
5. The auxiliary supply

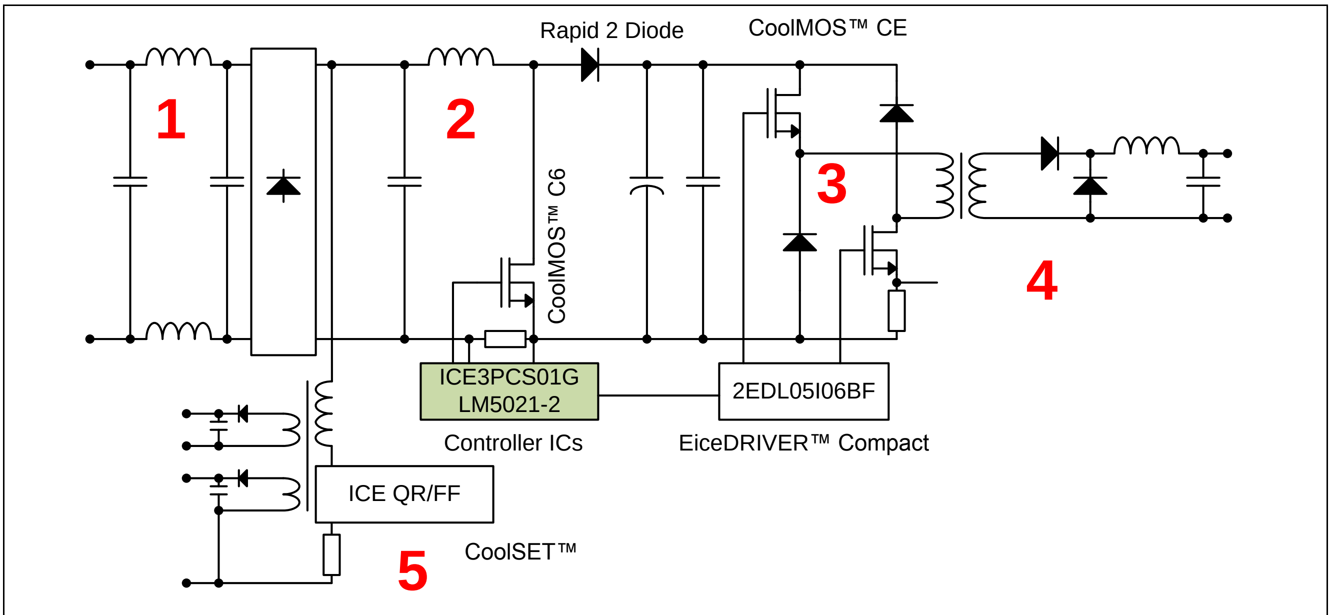


Figure 1 300 W SMPS evalualtion board - simplified schematic

The new control card is put in evidence in green in Figure 1.

1.2 Hardware description

The following sections gives a detailed description of the hardware and how it can be used.

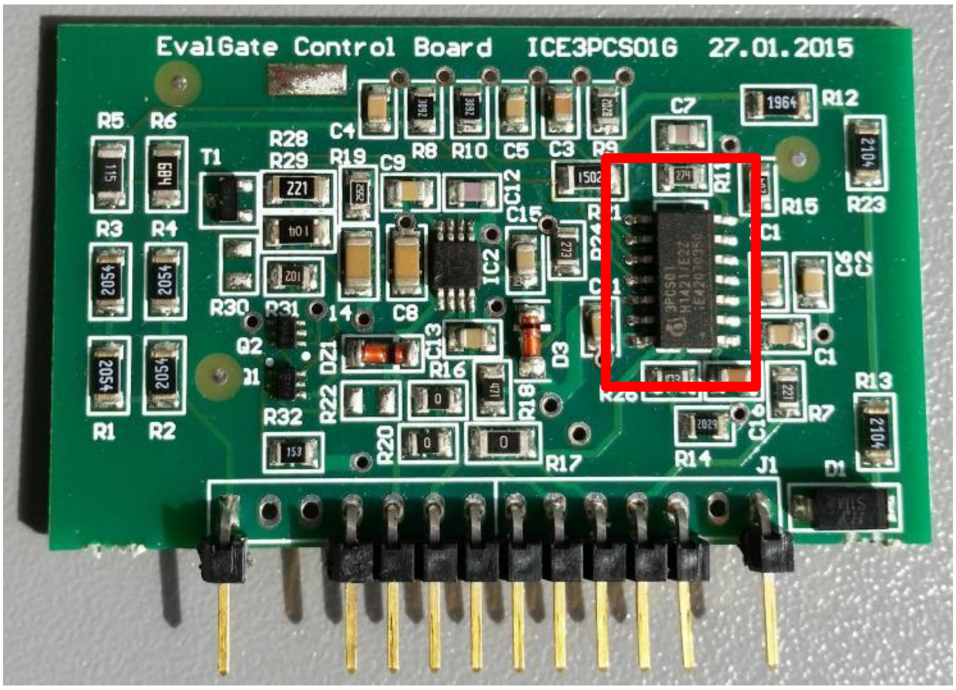


Figure 2 Hardware TOP overview – ICE3PCS01G in evidence

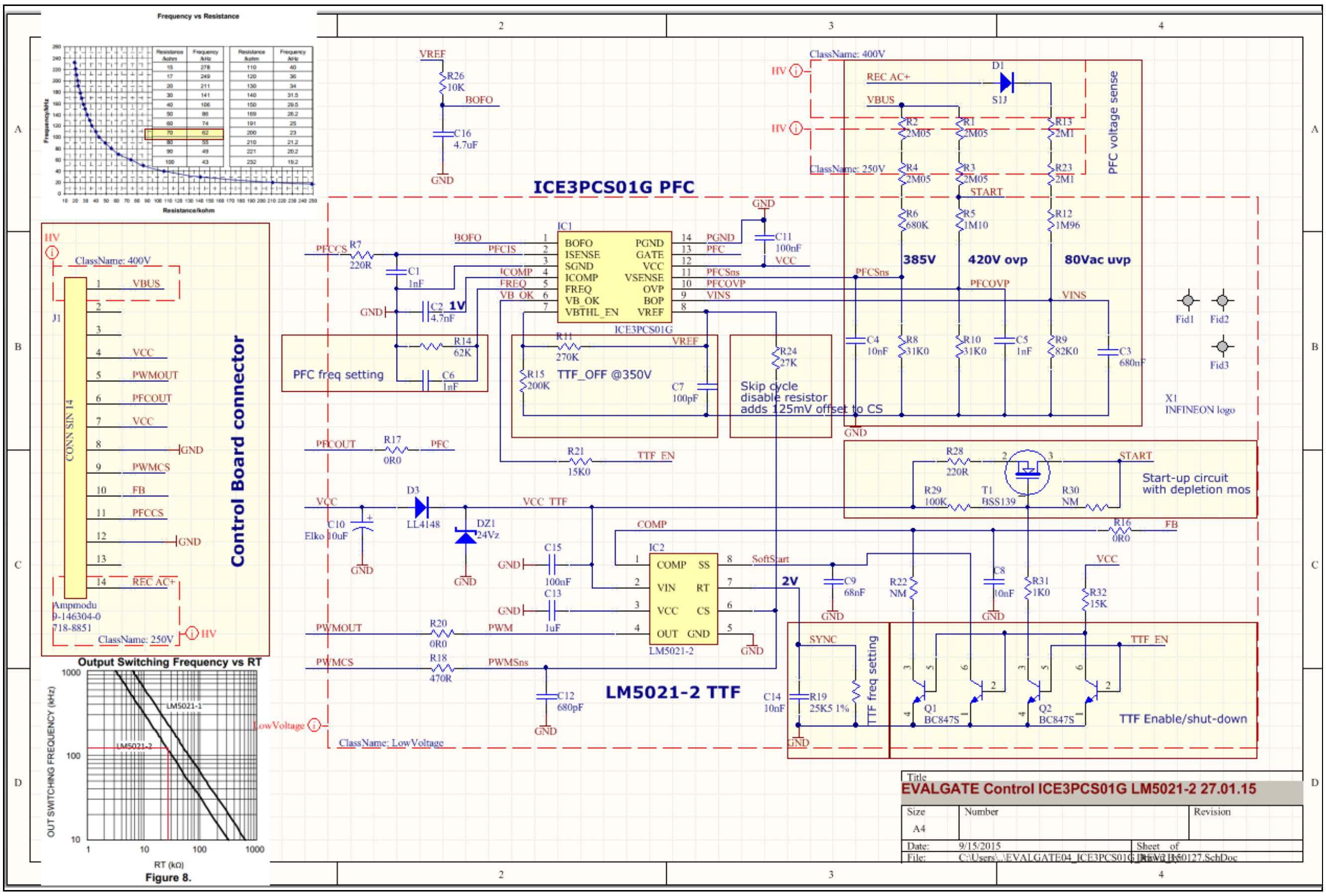


Figure 3 Control card schematic

The connector is described in the following table:

Table 1 Control card connector

1	2	3	4	5	6	7	8	9	10	11	12	13	14
VBUS			VCC	PWMout	PFCout	VCC	GND	PWMcs	FB	PFCcs	GND		RECac+

Pin1 and Pin14 are connected to high voltage, please be careful when handling the control cards while connected to the power board.

1.3 Power board required changes

The use of the alternative control card requires a hardware change in the power board, which is the one hosting the power active components and magnetics.

The only hardware changes needed are the re-sizing of the shunt current sense resistors for both the PFC and the TTF circuits.

1.3.1 PFC current sense – shunt replacement

The PFC current sense sizing is described in chapter 3.3 of the "300 W General Purpose wide-range SMPS" application note.

We are then goin to follow the same rules.

The power board is designed for a typical shunt voltage threshold V_{CSTH}=0.2 V giving the following result:

$$R_{SHUNT\_PFC} \leq \frac{|V_{CSTH}|}{I_{L1max} + \frac{\Delta i_{L1max}}{2}} = \frac{|V_{CSTH}|}{I_{L1max} + \frac{20\% \cdot I_{L1max}}{2}} = \frac{0.2\ V}{5.82\ A_{pk} \cdot (1.1)} = 312\ m\Omega \qquad \textbf{Eq 1}$$

A second point to keep in mind is the power dissipation:

$$P_{SHUNT\_PFC} = |V_{CSTH}| \cdot I_{D(rms)Q1} = 0.2 \cdot 3.55\ A = 0.71\ W \qquad \textbf{Eq 2}$$

In order to fulfill both requirements, three shunt resistors of 100 mΩ in parallel have been used. The choice is on 1 W SMD resistors, type "2512" resistors to keep also low the stray inductance, which would cause spikes on the sensed voltage.

Chosen values are R6=R7=R11=0.1Ω.

1.3.2 TTF current sense – shunt replacement

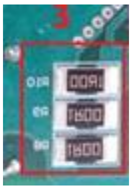
The same procedure as explained in chapter 4 in "300 W General Purpose wide-range SMPS" application note is applied here.

The power board is designed for a shunt voltage threshold V_{csth}=0.5 V giving the following result:

$$R_{SHUNT\_TTF} \leq \frac{|V_{CSTH}|}{I_{MOS(max)}} = \frac{0.5\ V}{2.63\ A_{pk}} = 190\ m\Omega \qquad \textbf{Eq 3}$$

A second point to keep in mind is the power dissipation:

$$P_{SHUNT\_TTF} = |V_{CSTH}| \cdot I_{MOS(rms)} = 0.5\ V \cdot 2\ A = 1\ W$$



Eq 4

In order to fulfill both requirements, and to keep some flexibility, two shunt resistors of 0.402 mΩ in parallel have been used. The choice is on 1 W SMD resistors, type “2512” to keep also low the stray inductance, which would cause spikes on the sensed voltage.

2 Protections

2.1 Brown-out protection

Brown-out protection is set by: R13=R23=2.1 Meg; R12=1.96 Meg; R9=82 K.

See below the brown-out input DC voltages

$$V_{INon} = V_{BOP\_L2H} \cdot \left(1 + \frac{R13 + R23 + R12}{R9}\right) = 1.25\,V \cdot \left(1 + \frac{6.16\,M}{82\,K}\right) = 95\,V \quad \text{Eq 5}$$

$$V_{INoff} = V_{BOP\_H2L} \cdot \left(1 + \frac{R13 + R23 + R12}{R9}\right) = 1\,V \cdot \left(1 + \frac{6.16\,M}{82\,K}\right) = 76\,V \quad \text{Eq 6}$$

2.2 Bus over-voltage protection

Bus overvoltage protection is set by: R1=R3= 2.05 Meg; R5=1.1 Meg; R10=31 K.

See below the BUS Overvoltage values:

$$V_{INon} = V_{OVP\_L2H} \cdot \left(1 + \frac{R1 + R3 + R5}{R10}\right) = 2.7\,V \cdot \left(1 + \frac{5.2\,M}{31\,K}\right) = 455\,V \quad \text{Eq 7}$$

$$V_{INoff} = V_{OVP\_H2L} \cdot \left(1 + \frac{R1 + R3 + R5}{R10}\right) = 2.5\,V \cdot \left(1 + \frac{5.2\,M}{31\,K}\right) = 421\,V \quad \text{Eq 8}$$

2.3 Bus under-voltage protection

TTF stage is turned on via VB_OK digital signal. ICE3PCS01G monitors the bus voltage and turns off VB_OK when VSense is below VBTHL_EN pin voltage.

In this controller card VBTHL_EN is set to disable the TTF stage at Vbus=330 V:

$$V_{BTHL\_EN} = V_{ref} \cdot \left(\frac{R15}{R15 + R11}\right) = 5\,V \cdot \left(\frac{200\,K}{200\,K + 270\,K}\right) = 2.13\,V \quad \text{Eq 9}$$

$$V_{DCoff} = V_{BTHL\_EN} \cdot \left(1 + \frac{R2 + R4 + R6}{R8}\right) = 2.13V \cdot \left(1 + \frac{5.2\,M}{31\,K}\right) = 330\,V \quad \text{Eq 10}$$

$$V_{DCoff} = V_{VBOK\_on} \cdot \left(1 + \frac{R2 + R4 + R6}{R8}\right) = 2.375\,V \cdot \left(1 + \frac{5.2\,M}{31\,K}\right) = 368\,V \quad \text{Eq 11}$$

2.4 PFC overcurrent protection and TTF overcurrent protection

ICE3PCS01G protects the power supply by interrupting the PWM pattern at each cycle if overcurrent is detected. As soon as Bus voltage drops, the VB_OK pin is pulled-down and the TTF stage stopped. This protection is not latched.

TTF is protecting the power supply by interrupting the PWM pattern and enters hic-up mode in case of continuous overload condition. Please see ICE3PCS01G and LM5021-2 datasheets for more details.

3 References and proposed links

[1] CoolMOS™ high voltage MOSFETs product main page
www.infineon.com/coolmos

[2] thinQ™! Silicon Carbide Schottky Diodes main page
www.infineon.com/sic

[3] Rapid Silicon Diodes main page
http://www.infineon.com/cms/en/product/transistor-and-diode/diode/silicon-power-diode/channel.html?channel=ff80808112ab681d0112ab6a527f04a6

[4] CoolSET™ auxiliary and SMPS controller ICs main page
www.infineon.com/coolset

[5] ICE1CS02G application note: "300W Evaluation board using ICE1CS02":
http://www.infineon.com/dgdl?folderId=5546d4694909da4801490a2652e6286a&fileId=db3a30431c69a49d011c8e8e3df1048f

[6] ICE1CS02G datasheet from Infineon product page
http://www.infineon.com/dgdl?folderId=5546d4694909da4801490a07012f053b&fileId=db3a30431c69a49d011c8e917a2d0494

[7] Application Note - 300 W general purpose wide range SMPS
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Revision History

Major changes since the last revision

Page or Reference	Description of change
--	First Release

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