TDA 4863 - Getting started with TDA4863

AN-PFC-TDA 4863-2

Author: W. Frank

http://www.infineon.com/pfc

Power Management & Supply

Getting Started with TDA 4863

Revision History:	**29.10.2003**	V1.2
Previous Version:	1.1	

Page	**Subjects (major changes since last revision)**
2	updated

For questions on technology, delivery and prices please contact the Infineon Technologies Offices in Germany or the Infineon Technologies Companies and Representatives worldwide: see our webpage at http://www.infineon.com.

CoolMOS™, CoolSET™ are a trademarks of Infineon Technologies AG.

Edition 29.10.2003

Published by Infineon Technologies AG,
St.-Martin-Strasse 53,
81669 München, Germany

Table of Contents

Page

1 Short Description

This application note gives a brief overview of the fundamental equations which are necessary for a basic design of a power factor correction circuit in boost topology using a TDA 4863. They cover the input and output section as well as the inductor design. Please refer to [1] and [2] for further information. The calculation procedure describes a boost converter for wide input voltage range and 85 W output power. Finally, the paper gives recommendation for design changes of existing systems using competitor part of the TDA 4863 such as L6561, MC33262 and others.

2 Application Circuit Using TDA 4863

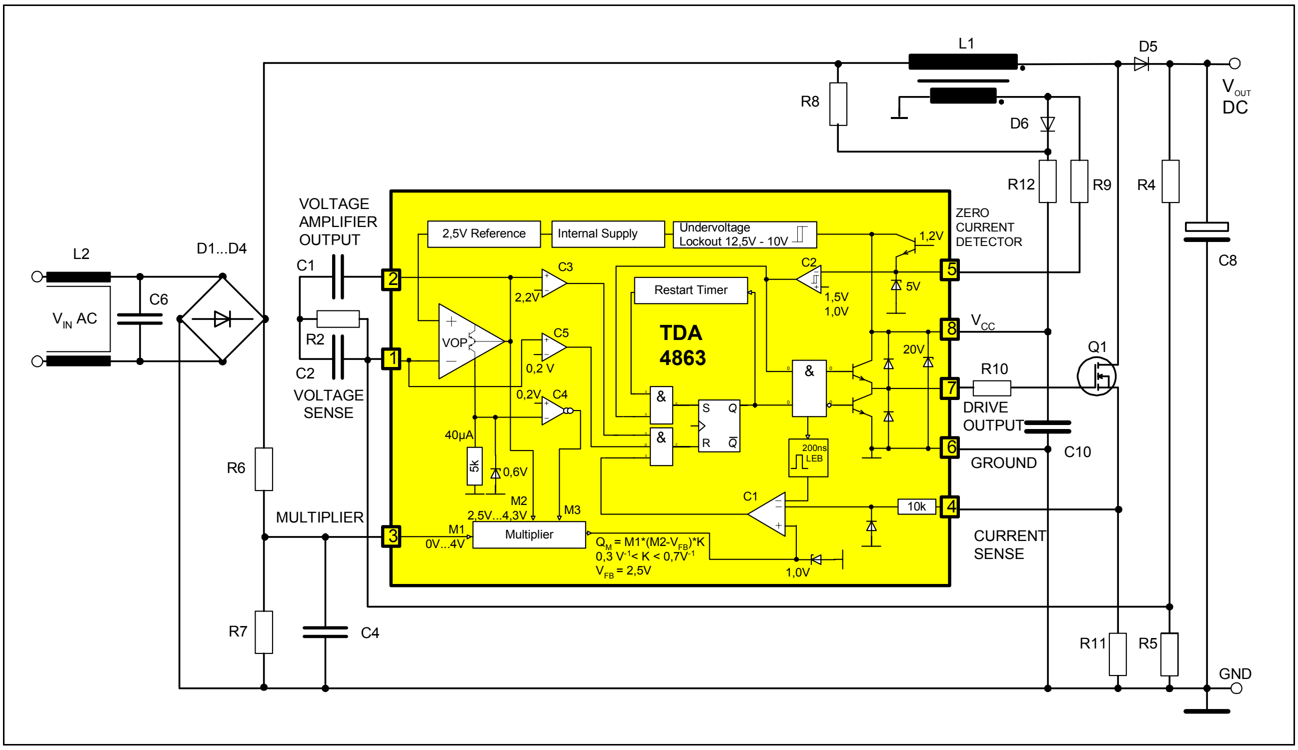

Figure 1 **PFC Circuit with TDA 4863**

2.1 General

The fundamental electrical data of the circuit are the input voltage range, the output power, the output voltage, the overvoltage protection (OVP) level and the lowest switching frequency which may occur during operation. **Table 1** shows the relevant values for the system calculated in this Application Note. The output power of the PFC converter is estimated about 10% higher than the output power of 75 W of a possible subsequent PWM converter.

Table 1 **Data of Boost Converter**

Input voltage	90 V... 265 V
Lowest switching frequency	25 kHz
Output voltage	400 V
OVP level	440 V
Output power	85 W

2.2 Rectifier Bridge

In order to obtain 85 W output power at 90 V minimum input voltage, the maximum input rms current is $i_{inmax} = P_{out}/(V_{inmin}\ \eta) = 1.05$ Arms with a peak value of $i_{inPkmax} = \sqrt{2}\ i_{in} = 1.48$ A. For these values a rectifier bridge with an average current capability of 1.2 A or higher is a good choice.

2.3 Boost Inductor

The inductance of L_1 according to **Figure 1** is calculated in order to obtain pulse frequencies higher than 25 kHz at maximum peak input voltage and twice of nominal output power and at minimum peak input voltage and twice of nominal output power. That means

$$L_P < \frac{V^2_{inPkmax} \cdot (V_{out} - V_{inPkmax}) \cdot \eta}{V_{out} \cdot f_p \cdot 2 \cdot 2P_{out}} =$$

$$= \frac{(265\text{ V}\sqrt{2})^2 \cdot (400\text{ V} - 265\text{ V}\sqrt{2}) \cdot 0{,}9}{400\text{ V} \cdot 25\text{ kHz} \cdot 2 \cdot 2 \cdot 85\text{ W}} = 0.936\text{ mH}$$

and

$$L_P < \frac{V_{inPkmax}{}^2 \cdot (V_{out} - V_{inPkmax}) \cdot \eta}{V_{out} \cdot f_p \cdot 2 \cdot 2P_{out}} =$$

$$= \frac{(90\text{ V}\sqrt{2})^2 \cdot (400\text{ V} - 90\text{ V}\sqrt{2}) \cdot 0{,}9}{400\text{ V} \cdot 25\text{ kHz} \cdot 2 \cdot 2 \cdot 85\text{ W}} = 1{,}169\text{ mH}$$

We therefore select $L_P < 0{,}936$ mH, which is realised with a E36-core (gap = 2 mm, 93 turns).

2.4 Setting and Limitation of Output Voltage

Both the output voltage as well as the overvoltage protection level are set with the same voltage divider represented by R_4 and R_5 in **Figure 1**.

$$R_5 = \frac{V_{ref}}{\Delta I} \cdot \frac{V_{OVP} - V_{out}}{V_{out} + V_{ref}} = \frac{2.5\text{ V} \cdot (440\text{ V} - 400\text{ V})}{40\ \mu\text{A} \cdot (400\text{ V} - 2.5\text{ V})} = 6289\ \Omega \text{ and}$$

$$R_4 = \frac{V_{OVP} - V_{ref}}{\Delta I + V_{ref}/R_5} = \frac{440\text{ V} - 2.5\text{ V}}{40\ \mu\text{A} + (2.5\text{ V}/6289\ \Omega)} = 1000000\ \Omega$$

with the reference voltage $V_{ref} = 2.5$ V. The value of 40 µA is the regulation current of the overvoltage protection. The real resistor values are taken from the E96 series (1% tolerance) which are $R_4 = 6.34$ kΩ and $R_5 = 2.499$ kΩ. These values lead to a resulting output voltage and overvoltage level of 396 V and 436 V, respectively.

2.5 Multiplier Input (line regulation)

The signal at pin 3 of the TDA 4863 is necessary in order to obtain a sinusoidal input current shape. It is internally multiplied with the output of the voltage error amplifier of the IC. The result is the reference level for the current sense comparator which defines the turn-off level of the power switch. The input signal is generated by the resistive voltage divider consisting of R_6, R_{61} and R_7 according to **Figure 1** and must meet the range between 0 V and 4 V (typ.). R_6 and R_{61} are to be seen as the upper resistor of the divider which is split into two resistors of (nearly) the same value due to high voltage stress. The corresponding equation is

$$\frac{V_{\mathrm{MULTIN}}}{V_{\mathrm{Bus}}} = \frac{R_7}{R_6 + R_{61} + R_7}$$

Usually the bottom resistor R_7 is chosen freely. In respect of low dissipation power R_7 is set to 9.1 kΩ. Then the sum of the top resistors is

$$R_6 + R_{61} = R_7 \frac{V_{\mathrm{Bus}}}{V_{\mathrm{MULTIN}}} - R_7$$

It is suitable to consider a small margin of the input range of 4 V of the multiplier input. The design value of the divider is therefore V_{MULTIN} = 3.6 V. With the values 470 kΩ, 470 kΩ and 9.1 kΩ for R_6, R_{61} and R_7 this target is hit properly.

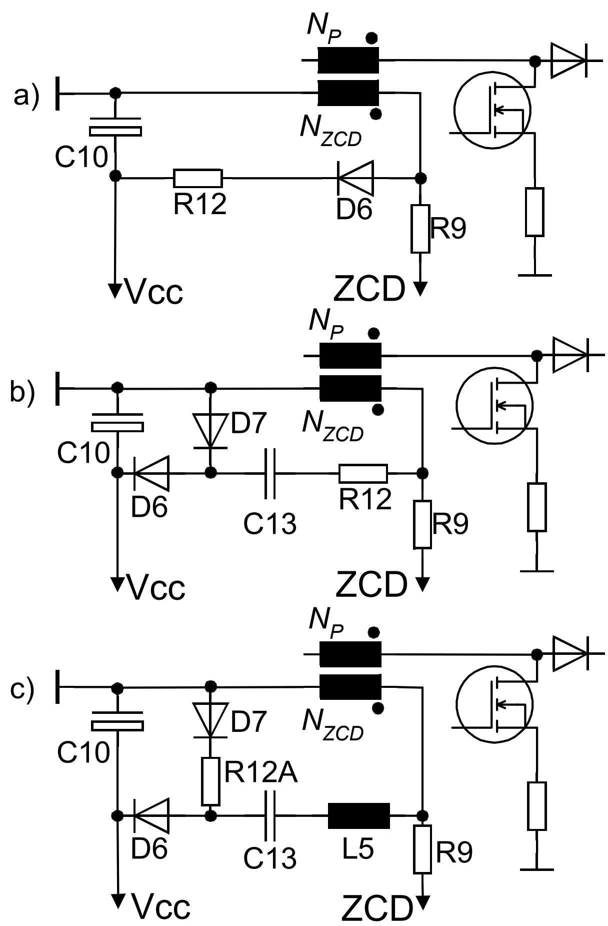

Figure 2 IC Supply Circuit Realized with Rectifier (a) and Charge Pump (b and c)

2.6 Detector and IC Supply

A second winding (detector winding) on the choke provides an image of the drain voltage in the ratio $N_{det}/N_{boost} = V_{ZCD}/(V_{out} - V_{innom})$. The ratio is set so that V_{ZCD} is about 22 V to 24 V followed by a supply circuitry and detector resistor according to a) of **Figure 2**.

For a 400 V output voltage and a nominal input voltage of V_{innom} = 265 V, the detector winding contains 15 turns and requires a high ohmic resistor R_9 (10 kΩ to 47 kΩ) in series before being connected to pin 5. Clamping structures are available in the IC which limit the voltage at the input to +6 V and +0.4 V, respectively, at ±10 mA maximum.

There are also other rectification topologies for the IC supply possible which are shown in b) and c) of **Figure 2**. They are further explained in **[2]**.

2.7 Opamp Compensation Design

The design of the compensation network of PFC controller is a very sensitive topic, because it highly influences the performance of the circuit in terms of the total harmonic distortion (THD) of the input current. For further information please refer to [2]. Table 2 gives a recommendation of suitable values for the compensation circuit according to Figure 1.

Table 2 Component Values for PI- or PIT1-Compensation

Compensation	C_1	C_2	R_2
PI	2.2 µF		16 kΩ
PIT1	2.2 µF	1 µF	33 kΩ

2.8 Shunt Resistor

The maximum current sense voltage is limited to $V_{ISENSEM}$ = 1.0 V to which the shunt resistor R_{11} must be designed to at maximum inductor current. This is given in the following equation

$$R_{11} = \frac{V_{ISENSEM} \cdot V_{inmin} \cdot \eta}{2 \cdot \sqrt{2} \cdot P_{out}} = \frac{1.0\ \text{V} \cdot 90\ \text{V} \cdot 0{,}9}{2 \cdot \sqrt{2} \cdot 85\ \text{W}} = 0.34\ \Omega$$

3 Design Change from Competitors to TDA 4863

There is a wide variety of discontinuous conduction mode PFC controllers available. Many of them are even pin compatible. Nevertheless, there is still some design effort necessary if a change of the controller IC is palnned. In the following sections the most important differences to pin- and PCB-compatible competitors are worked out and design recommendations are given as far as possible. However, this does not free you from a dedicated fine tuning of the PFC system which is not described in this paper.

3.1 Replacing TDA 4862 [3] (Siemens / Infineon) by TDA 4863

The first three items of **Table 5** are very important for the startup behaviour of the PFC circuit and the overall efficiency. The startup time is defined by the V_{CC} turn-on threshold and the value of the startup resistor R_8. Even though the turn-on level is higher at TDA 4863, the startup time is certainly in the same range, when using the same startup resistor. The current consumption during startup is significantly lower with TDA 4863 and therefore more current is available to charge the electrolytic capacitor of the IC supply.

Table 3 Most Important Data Deviation of TDA 4863

Part	TDA 4862	TDA 4863
V_{CC} turn-on threshold	11 V	13 V
V_{CC} turn-off threshold	8.5 V	9.5 V
Startup current (max.)	200 µA	100 µA
OVP regulation current	30 µA	40 µA
Max. current sense threshold (typ.)	1.25 V	1 V

The startup current is usually set with a startup resistor which is effective throughout the whole area of operation. A high startup current will therefore lower the system efficiency significantly at low load operation. For TDA 4863 a startup resistor of 220 kΩ or even higher is still sufficient.

TDA 4863 has a higher OVP regulation current, meaning that the output voltage divider has to be changed according **Section 2.4** and also the shunt resistor has to be redesigned according **Section 2.8**.

3.2 Replacing L6561 (STM) by TDA 4863

Generally speaking, both components are very close together regarding the basic data [4]. Nevertheless there are still some differences which cause design changes. They are listed in **Table 4**.

Table 4 Most Important Data Deviation of L6561

Part	L6561	TDA 4863
Multiplier input (typ)	0 to 3.5 V	0 to 4 V
Max. current sense threshold (typ.)	1.7 V	1 V

First of all, the input range of the multiplier input is a little smaller. This effects the design of the corresponding voltage divider R_6, R_{61} and R_7 according to **Figure 1** and **Section 2.5**.

Another big issue is the current limitation threshold which is set to 1.7 V at L6561. This leads to a larger shunt resistor and therefore also to larger power losses in the shunt. The equation for the shunt resistor is given in **Section 2.8**.

Since the overvoltage protection works on the same principle and with the same thresholds, a L6561 design should work fine when considering the changes mentioned below.

3.3 Replacing FAN7527 (Fairchild) by TDA 4863

This part is also very close to the L6561, so that the multiplier input range and the current sense threshold have to be taken into consideration again only.

Table 5 Most Important Data Deviation of FAN7527

Part	FAN7527	TDA 4863
Multiplier input (typ)	0 to 3.8 V	0 to 4 V
Max. current sense threshold (typ.)	1.8 V	1 V

The voltage range of the multiplier input is close enough to the TDA 4863 according to the datasheet **[5]** so that the corresponding voltage divider (see **Section 2.5**) needs not to be recalculated mandatorily. But so is the shunt resistor according to **Section 2.8** with a current sense threshold of $V_{\mathrm{ISENSE,th}}$ = 1.0 V

Please note, that FAN7527 has larger tolerances in respect of the current sense threshold and the overvoltage protection limit. Hence, any system will run more reliably with TDA 4863.

Fairchild also offers other parts (KA7524, KA7526) which are pin compatible with TDA 4863, but they are not very wide spread and therefore not under consideration here.

3.4 Replacing MC33261 (ON Semiconductor) by TDA 4863

The first three items of **Table 6** are very important for the startup behaviour of the PFC circuit and the overall efficiency. The startup time is defined by the V_{CC} turn-on threshold and the startup resistor R_8. Even though the threshold is higher at TDA 4863, the startup time is certainly shorter because the current consumption during startup is significantly lower and more current is available to charge the electrolytic capacitor of the IC supply.

Table 6 Most Important Data Deviation of MC33261

Part	MC33261	TDA 4863
V_{CC} turn-on threshold	10.8 V	13 V
V_{CC} turn-off threshold	7 V	9.5 V
Startup current (max.)	500 µA	100 µA
Multiplier input (typ)	0 to 3.5 V	0 to 4 V
Max. current sense threshold (typ.)	1.1 V	1 V

The startup current is usually set with a startup resistor which is effective throughout the whole area of operation. A high startup current will therefore lower the system efficiency significantly, especially during low load operation. For TDA 4863 a startup resistor of 220 kΩ or even higher is still sufficient.

The typical multiplier input range is the same as for L6561, but it is also necessary to consider the minimum range of 0 to 2.5 V. This effects a change of the multiplier input voltage divider according to **Section 2.5** when using TDA 4863. For a precise output power limitation a recalculation of the shunt resistor is also recommended.

According to the datasheet **[6]** the MC33261 does not have an effective overvoltage protection. Therefore the output voltage divider should be redesigned according to **Section 2.4** in order to obtain the projected pretection levels.

3.5 Replacing MC33262 (ON Semiconductor) by TDA 4863

The basics of the startup behaviour are nearly the same as for MC33261, but the V_{CC} turn-on threshold is even higher than with TDA 4863. Therefore, the same issues must be considered as for MC33261.

Table 7 Most Important Data Deviation of MC33262

Part	MC33262	TDA 4863
V_{CC} turn-on threshold	14.5 V	13 V
V_{CC} turn-off threshold	7 V	9.5 V
Startup current (max.)	400 µA	100 µA
Multiplier input (typ)	0 to 3.5 V	0 to 4 V
Max. current sense threshold (typ.)	1.5 V	1 V

However, the MC33262 contains a overvoltage protection, but it is not adjustable but fixed to a level of 8% over rated bus voltage according to [7]. This means that in MC33262 systems the output voltage divider does not care for the overvoltage protection. Hence, the output voltage divider must be recalculated according **Section 2.4** for the use of TDA 4863.

Please note, that MC33262 is **not** PCB compatible, because its feedback of the error amplifier is referenced to ground. For a replacement by TDA 4863 it is necessary to reference the feedback to pin 1 (V_{SENSE}) which means that a PCB change is necessary.

4 Summary of Used Nomenclature

Physics:

General identifiers:

A..........cross area
b, B......magnetic inductance
d, D .....duty cycle
f...........frequency
i, I........current
N ....number of turns
p, P......power
t, T.......time, time-intervals
v, V......voltage
W.........energy
η..........efficiency

K_1, K_2 ..ferrite core constants

big letters: constant values and time intervals
small letters: time variant values

Special identifiers:

A_L........... inductance factor
$V_{(BR)CES}$ .. collector-emitter breakdown voltage of IGBT
V_F........... forward voltage of diodes
V_{rrm} .... maximum reverse voltage of diodes

Components:

C ....capacitance
D ....diode
IC ....integrated circuit
L..........inductance
R..........resistor
TR ....transformer

Indices:

AC.......alternating current value
DC.......direct current value
BE ....basis-emitter value
CS.......current sense value
OPTO..optocoupler value
P ....primary side value
Pk........peak value
R........... reflected from secondary to primary side
S ....secondary side value
Sh ....shunt value
UVLO..undervoltage lockout value
Z..........zener value

fmin......... value at minimum pulse frequency
i ....running variable
in ....input value
max ....maximum value
min ....minimum value
off ....turn-off value
on ....turn-on value
out ....output value
p ....pulsed
rip ....ripple value

1, 2, 3 .....on-going designator

5 References

[1] **Infineon Technologies AG:** TDA 4863 - Power factor and boost converter controller for high power factor and low THD; Preliminary data sheet; Infineon Technologies AG; Munich; Germany; 07/01.

[2] **M. Herfurth, W. Frank:** TDA 4863 - Technical description; Application Note AN-PFC-TDA4863-1; Infineon Technologies; Munich; Germany; 02/02.

[3] **Siemens AG:** TDA4862 - Power factor controller IC for high power factor and active harmonic filter; data sheet; Siemens / Infineon Technologies AG; Munich; Germany; 02/1998.

[4] **ST Microelectronics:** L6561 - Power factor corrector; data sheet; ST Microelectronics; Italy; 02/01.

[5] **Fairchild Semiconductor:** FAN7527 - Power factor corrector controller; data sheet; Rev. 1.0.2; Fairchild Semiconductor corporation; USA; 12/01.

[6] **ON Semiconductor:** MC33261, MC34261 - Power factor controllers; data sheet; Rev. 2; ON Semiconductor; USA; 03/01.

[7] **ON Semiconductor:** MC33262, MC34262 - Power factor controllers; data sheet; Rev. 1; ON Semiconductor; USA; 1996.

Infineon goes for Business Excellence

“Business excellence means intelligent approaches and clearly defined processes, which are both constantly under review and ultimately lead to good operating results.

Better operating results and business excellence mean less idleness and wastefulness for all of us, more professional success, more accurate information, a better overview and, thereby, less frustration and more satisfaction.”

Dr. Ulrich Schumacher

www.infineon.com

Published by Infineon Technologies AG