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Application Note

AN-SMPS-ICE3DS01-1

CoolSET™

ICE3DS01 Current Mode Controller for OFF – Line Switch Mode Power Supply (SMPS)

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Power Management & Supply

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Contents:

Introduction

The **ICE3DS01** is a SMPS Current Mode Controller based on ICE2XXXX family with some new additional features. This Application Note describes how to use this new feature set of this IC. All other functions and calculations can be made according to **AN-SMPS-ICE2AXXX-1** [2].

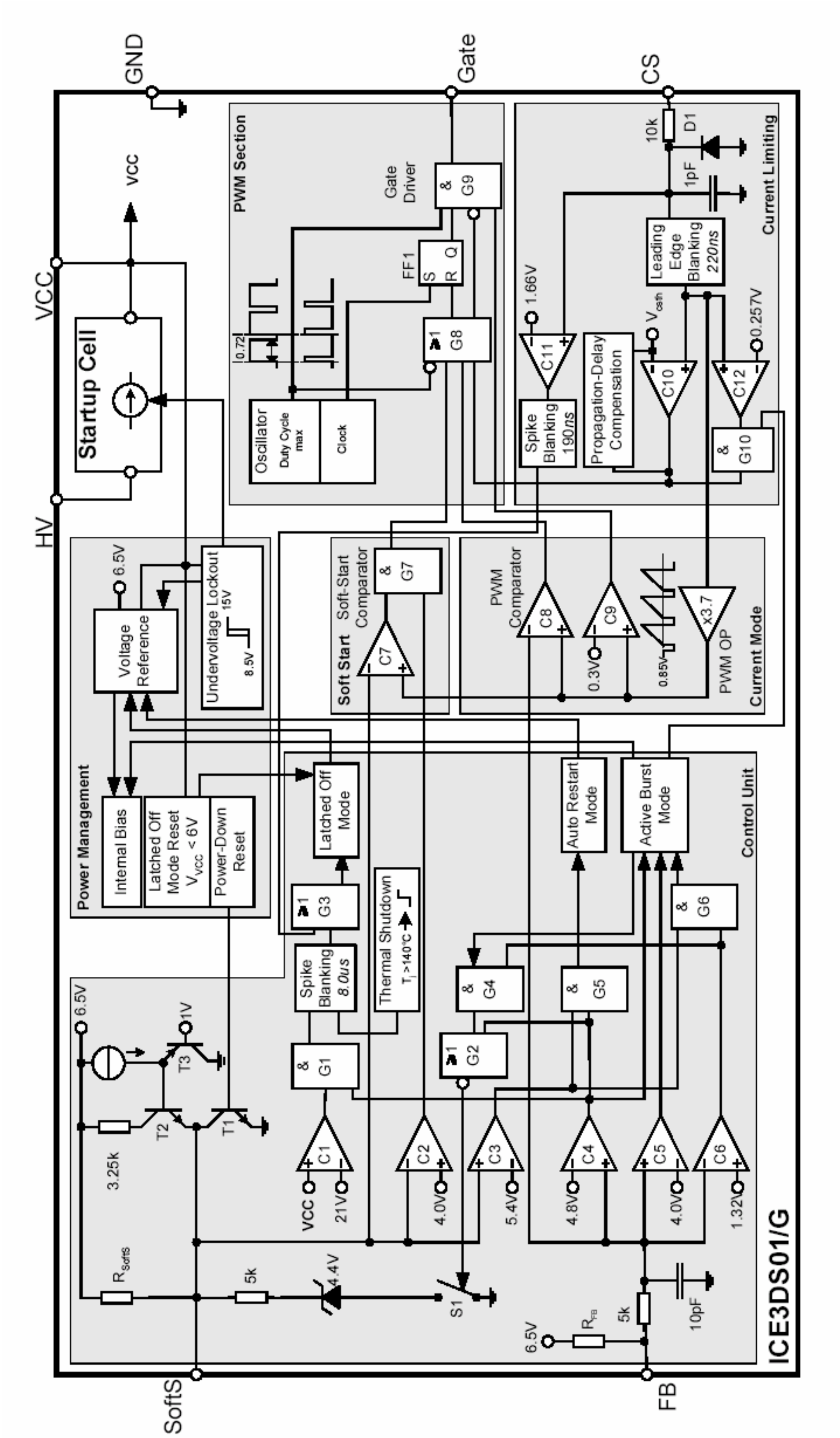
Additional to the ICE2XXXX features this controller provides **Active Burst Mode** to meet lowest Standby Power Requirements. The continous monitoring of Feedback Input leads to immediate response in case of a load jump on the output.
The point of entering and leaving the Burst Mode is only a function of the Feedback Voltage.

An **Integrated Startup Cell** allows to supply the VCC capacitor with regulated current taken from the high voltage DC input. This Startup Cell is only switched on to charge up the VCC capacitor and for supplying the IC during Latched OFF Mode.

Furthermore this Controller incorporates a **Latched Off Mode** function in case of Overvoltage due to Open-Loop, Short Winding and Overtemperature failures. For resetting this Off Mode the mains voltage has to be switched off until the VCC voltage declines below 6V.

For supporting applications which need peak power for limited time (switching on capacitive loads), the **ICE3DS01** offers a **Blancking Window** which delays the Overload Protection. During this time frame the SMPS delivers the peak power which is set by the sense resistor.

Block Diagram



Protection Functions

The **ICE3DS01** provides several protection functions which lead to two different failure modes. Overload, Short Circuit and VCC Undervoltage lead to **Auto- Restart-Mode**. If the IC enters this mode, it is immediately switched off and starts operation again automatically after discharging the VCC capacitor down to 8,5V and then charging up to 15V.

Overvoltage, Open Loop, Overtemperature and Short Winding lead to **Latched OFF Mode**.
Within this mode the IC is also switched off immediately but will not start again automatically. The internal current source is used to supply the IC in order to keep it latched off.
To leave this mode usually the power supply has to be plugged off of the mains for a certain time to discharge the Bulk- and VCC capacitor.

Function	Limit	Protection	Condition
Overload	V_{FB} > 4,8V	Auto-Restart-Mode	Blanking window til VSS > 5,35V
Short Circuit	V_{FB} > 4,8V	Auto- Restart -Mode	
VCC Undervoltage	VCC < 8,5V	Auto- Restart- Mode	
Overvoltage Open Loop	VCC ≥ 21V	Latch Mode	V_{FB} > 4,8V
Overtemperatur	T_{jSD} > 140 °C	Latch Mode	
Short Winding	V_{CS} > 1,66V	Latch Mode	

If not otherwise mentioned all values are typical values taken from the datasheet

For resetting the Latch Mode Function the voltage at VCC pin has to decline below 6V.

Calculation of resetting time:
$$t_{Reset} \approx \frac{C_{IN} * (V_{DC\max} - V_{CCPD})}{I_{VCClatch}} \qquad \textbf{(Eq 1)}$$

Auto- Restart- Mode

In Auto- Restart- Mode the transferred power is reduced according the Duty cycle shown below. Due to the internal startup current source the charging time of the VCC capacitor is independent of the input voltage. This means also that the transferred power is independent of the input voltage.

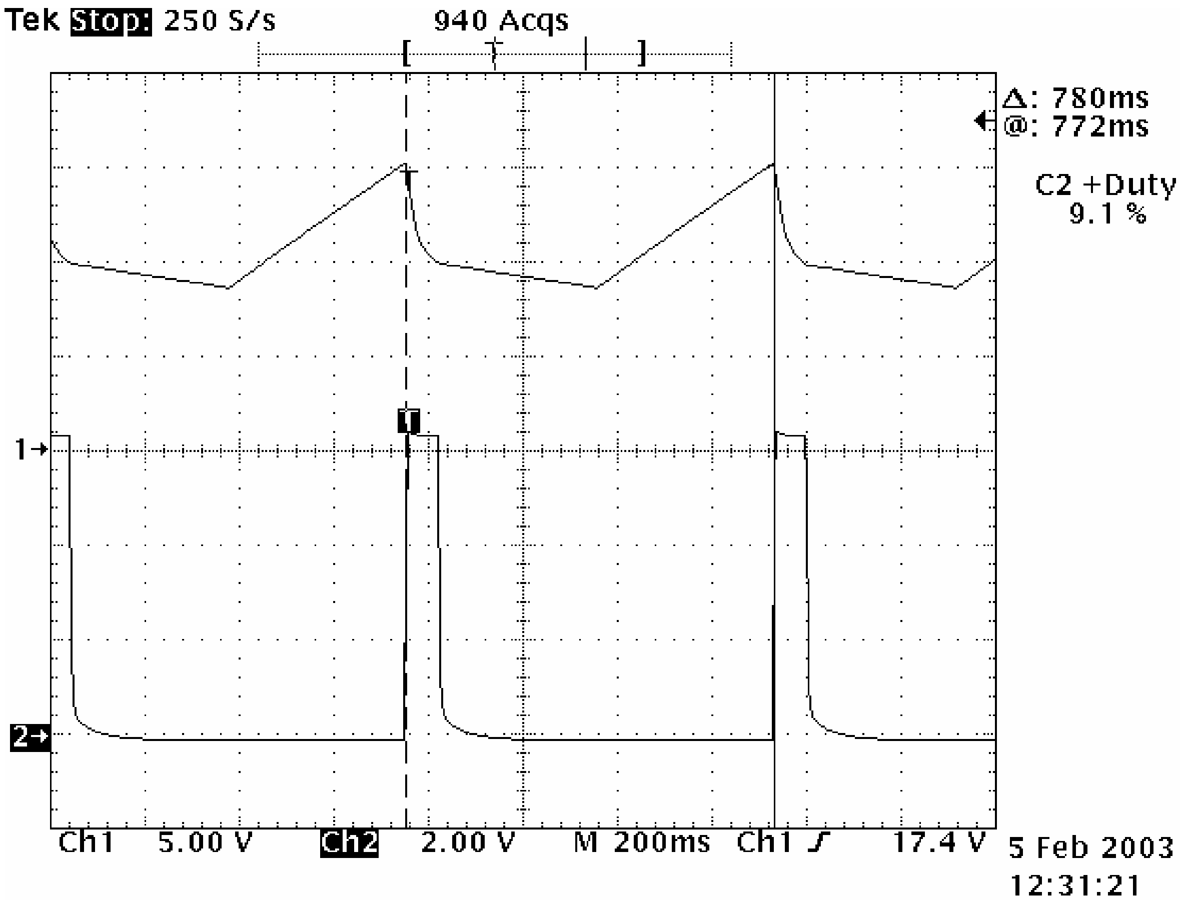


Fig. 1: Short Circuit @ Output

(measured with a 80W, 24V application)

Ch1: Voltage at VCC Pin

Ch2: Voltage at Feedback Pin

Overvoltage Protection

In case of overvoltage behaviour the VCC voltage has to rise from a normal level of about 15V to 21V in order to trigger the overvoltage comparator. As it can be seen on Fig.2 this needs a certain time to charge the VCC capacitor to this value. It has to be considered that during this time the output voltage also rises up to a higher level.

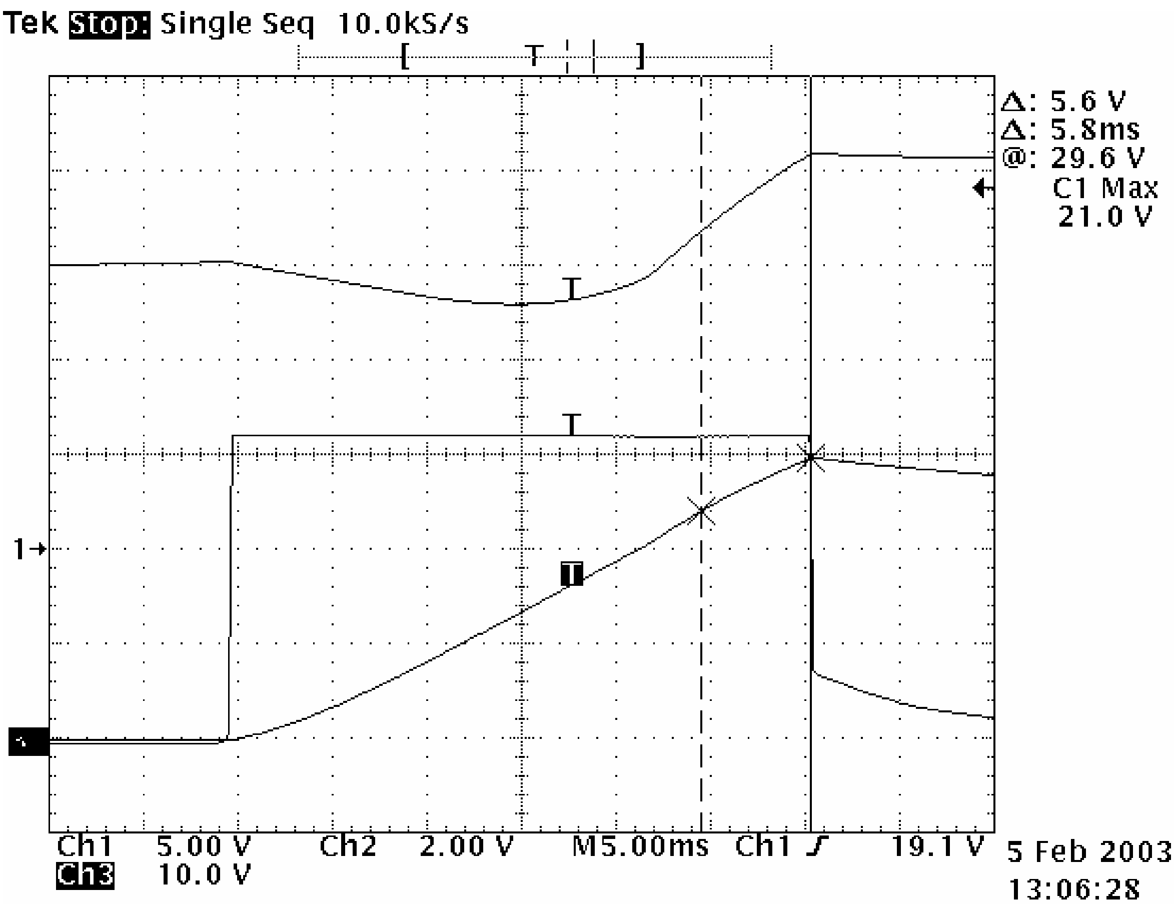


Fig. 2: Overvoltage due to Open Loop

(measured with a 80W, 24V application)

Ch1: Voltage at VCC Pin

Ch2: Voltage at Feedback Pin

Ch3: Output Voltage

Active Burst Mode

In order to get lowest input power values during low-/noload condition, the **ICE3DS01** provides a **Active Burst Mode** function.

The burst duty cycle and burst frequency is only controlled by the voltage at Feedback pin.

The Burst Cycle starts if the voltage at feedback pin stays below 1,32V typ. for a timeframe set by the blancking time .

The Burst Cycle stops if this voltage exceeds 4,0V typ.

If feedback voltage exceeds 4,8V typ. the IC changes immediately over to normal mode operation.

This function ensures, that if during the inactive state a load jump occurs (V_{FB} >4,8V) the IC switches back into active mode without any delay.

During Burst Mode the peak current is limited to 25% of maximal peak current.

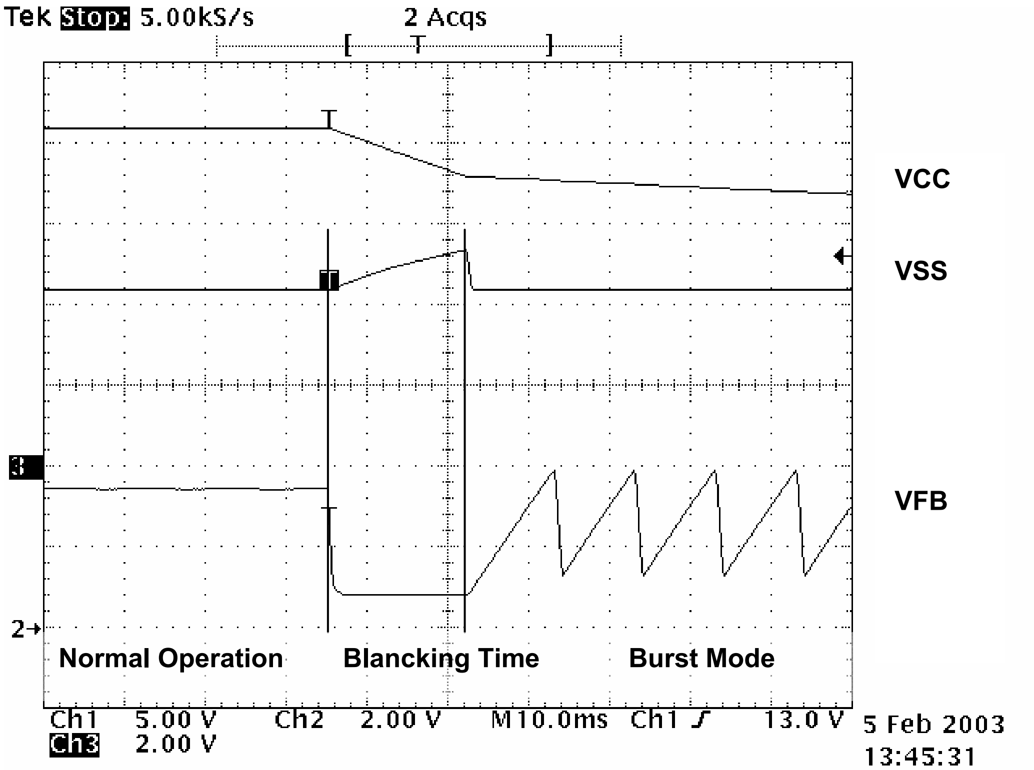


Fig. 1: Jump from normal operation to Burst Mode

(measured with a 80W, 24V application)

Ch1: Voltage at VCC Pin

Ch2: Output Voltage

Ch3: Voltage at Feedback Pin

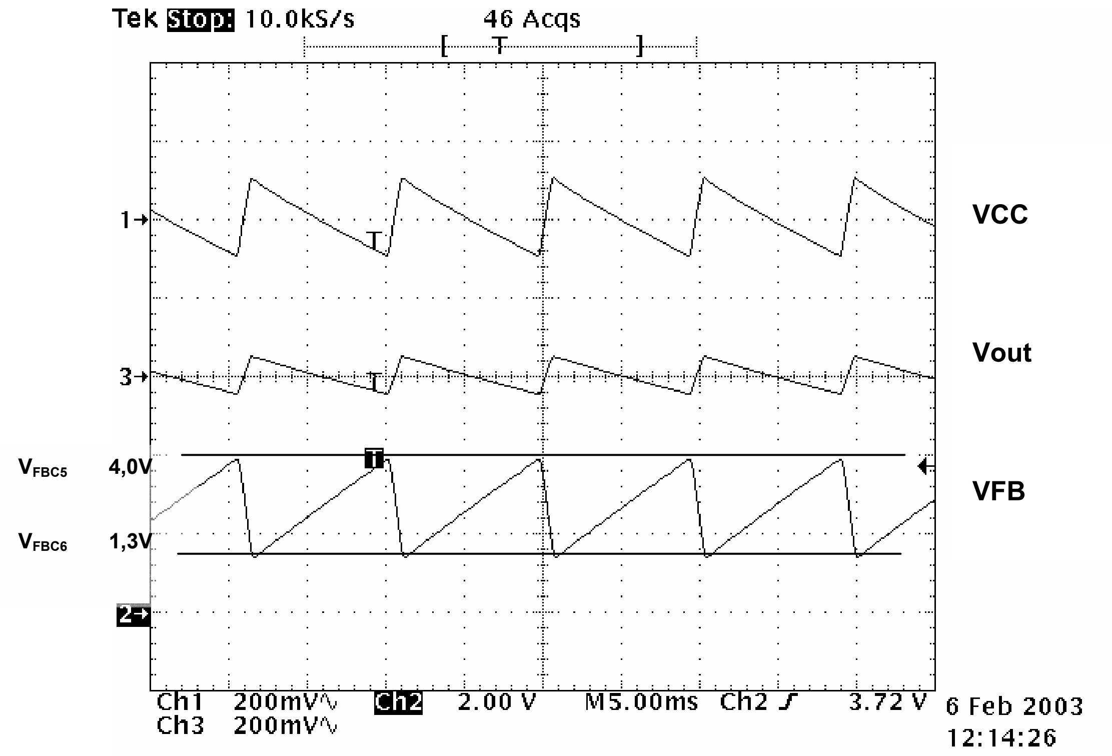


Fig. 2: Burst Mode operation at 85Vac with lowload condition

(measured with a 80W, 24V application)

Ch1: Voltage at VCC Pin

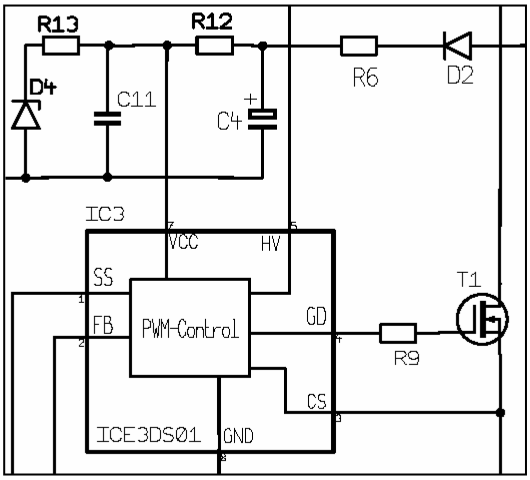
Ch2: Output Voltage

Ch3: Voltage at Feedback Pin

VCC Supply during Burst Mode Operation

During Burst Mode operation with noload condition at the output, the supply voltage for VCC has to be designed for being above V_{VCCoff} limit. This can lead to a high voltage at VCC pin during max load operation. If the voltage exceeds 21V typ. the overvoltage detection will become active and switches off the IC immediately.
The insertion of an resistor (R12) between the electrolytic VCC capacitor (C4) and the ceramic capacitor (C12) at the VCC pin can help to overcome this problem.
During normal mode operation a current of $I_{VCCsup1}$ + I_{Gate} is drawn from the VCC supply winding. At the resistor R12 the voltage drops according the resistor value.

During Burst Mode operation the average value of the VCC current drops down with the ratio of the burst duty cycle. In this case also the voltage drop at R12 is reduced and the VCC voltage level can stay above the UVLO limit. Additional a zener diode can be used to make sure that the voltage on VCC pin never exceeds the V_{VCCmax} voltage of 22V.



Calculation of R12:

$$R12 = \frac{(U_{C4\max} - V_{VCCOVP})}{(I_{VCC\sup 1} + I_{Gate})} \qquad \textbf{(Eq 2)}$$

U_{C4max} = maximum voltage at capacitor C4 (has to be measured in the real application)

V_{VCCOVP} = Overvoltage detection limit

$I_{VCCsup1}$ = IC supply current

I_{Gate} = Mosfet gate drive current : Qg * fs

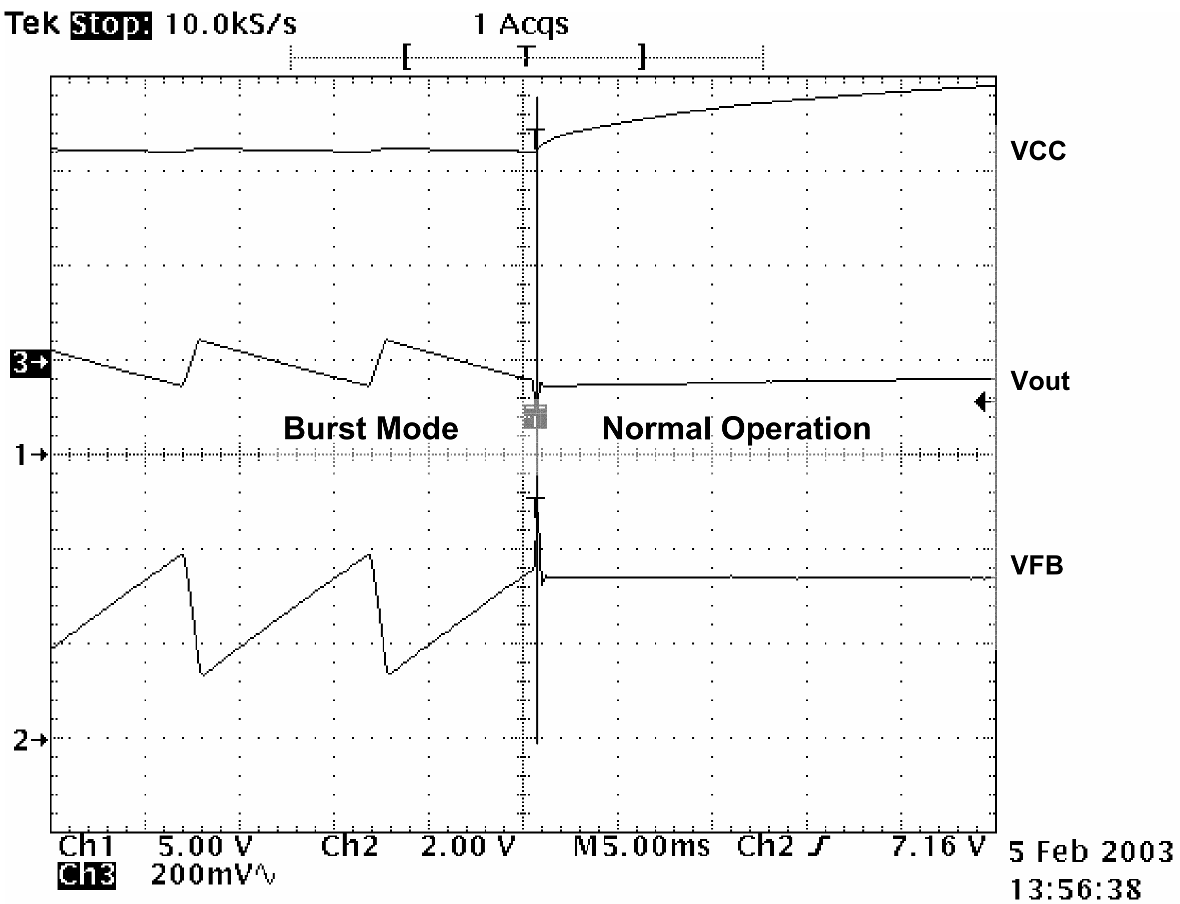


Fig. 3: Load Jump from low load to nominal load.

(measured with a 80W, 24V application)

Ch1: Voltage at VCC Pin

Ch2: Output Voltage

Ch3: Voltage at Feedback Pin

Calculation of Burst Mode Operation boundaries

Operating point of entering Burst Mode:

Condition: $V_{FB} < 1{,}32V$

$$P_{Burst\,\min} = 0{,}5 * Lp * \left[\frac{(V_{FBC6} - V_{Max-Ramp})}{R_{Sense} * A_V}\right]^2 * f \qquad \textbf{(Eq 3)}$$

Operating point of leaving Burst Mode:

Condition: V_{FB} > 4,8V

$$P_{Burst\max} = 0{,}5 * Lp * (V_{CS2} * \frac{1}{R_{Sense}})^2 * f \qquad \textbf{(Eq 4)}$$

During Burst Mode operation the peak current is limited to 25% of maximal value. As this peak current is not compensated, the internal delay leads to a input voltage dependent overshoot. This leads to a higher transferred power at 230V mains compared to 85V mains voltage.

Calculation of sensevoltage – time ratio:

$$\frac{dV_{Sense}}{dt} = \frac{Vdc\max}{Lp} * R_{Sense} \qquad \textbf{(Eq 5)}$$

Fig. 6 of the datasheet describes this dependency. For the accurate calculation of the maximal power in Burst Mode operation (**Eq. 4**) the V_{CS1} value has to be multiplied with a factor out of the diagram below using the dotted line.

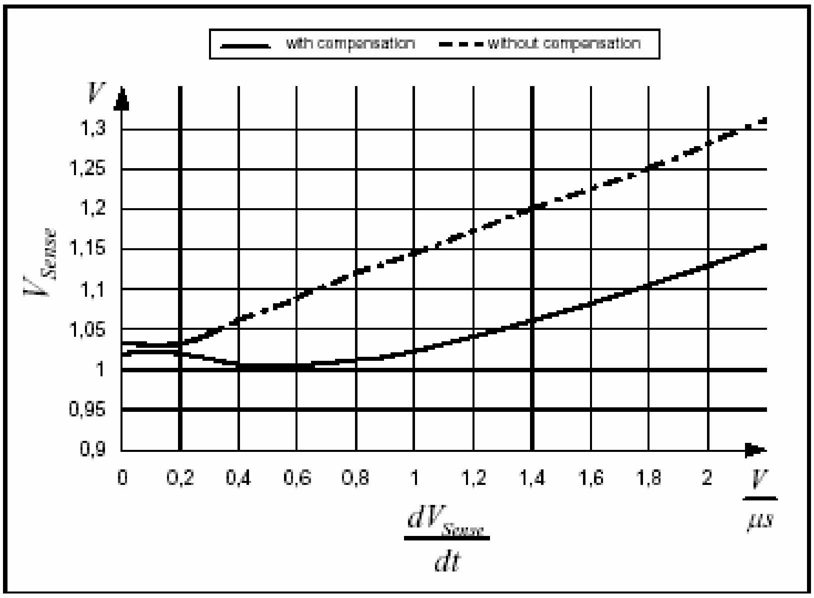


Fig. 4: Peak Current Limitation

Softstart

During the Softstart Phase the Mosfet Drain Current is limited to the voltage at the Softstart Pin. If this voltage reaches $V_{SoftSC2}$ (4,00V typ.) the peak current limit is released to the value set by the voltage at Feedback Pin or limited to the value which is set with the sense resistor. If the Softstart is finished and no overload occurs the voltage is clamped to (4,4V typ.).

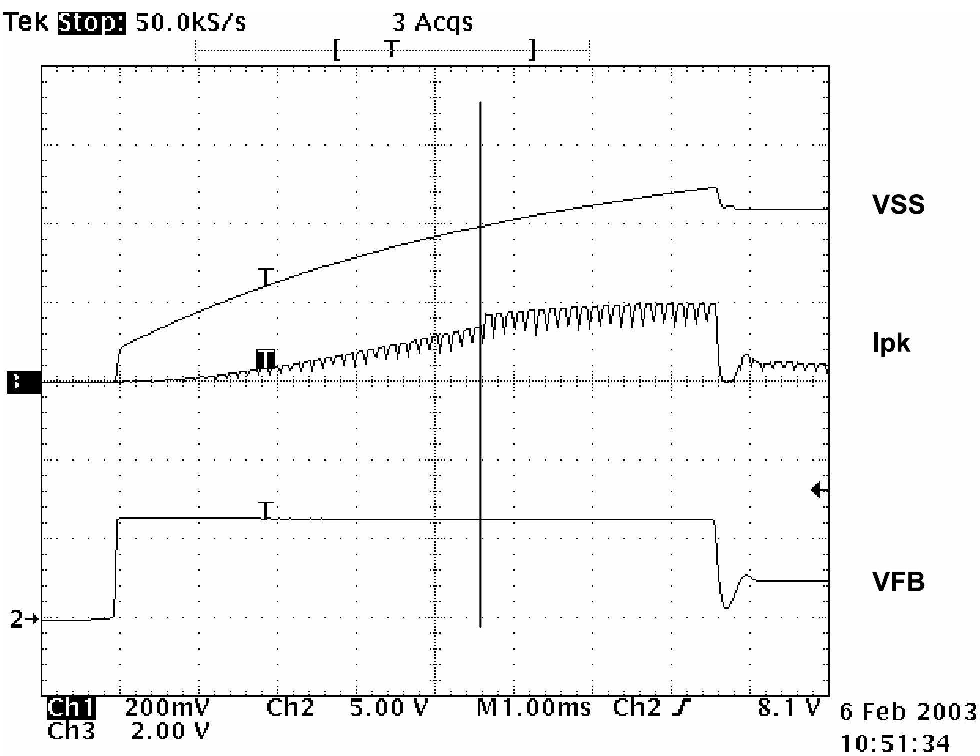


Fig. 3: Softstart behaviour with nominal load

(measured with a 80W, 24V application)

Ch1: Voltage at Softstart Pin

Ch2: Voltage at Current Sense Pin

Ch3: Voltage at Feedback Pin

Fig. 5 Example for Css = 100nF

The maximum Startup time can be calculated:

$$tss\max = R_{Softs} * C_{SS} * 1{,}52 \qquad \textbf{(Eq 6)}$$

Blanking Window for Load Jump

In case of Load Jumps the Controller provides a blanking window before activating the Overvoltage Protection and entering the Auto Restart Mode. This time is generated by charging up the Softstart capacitor from 4.4V to max. 5.35V

Within this timeframe the voltage at feedback pin can rise up above 4.8V, without switching off due to overload protection.

During this operation the transferred power is limited to the maximum peak current defined by the value of the sense resistor.

The time for the blanking window can be calculated:

$$tbl = R_{Softs} * C_{SS} * 0{,}51 \qquad \textbf{(Eq 7)}$$

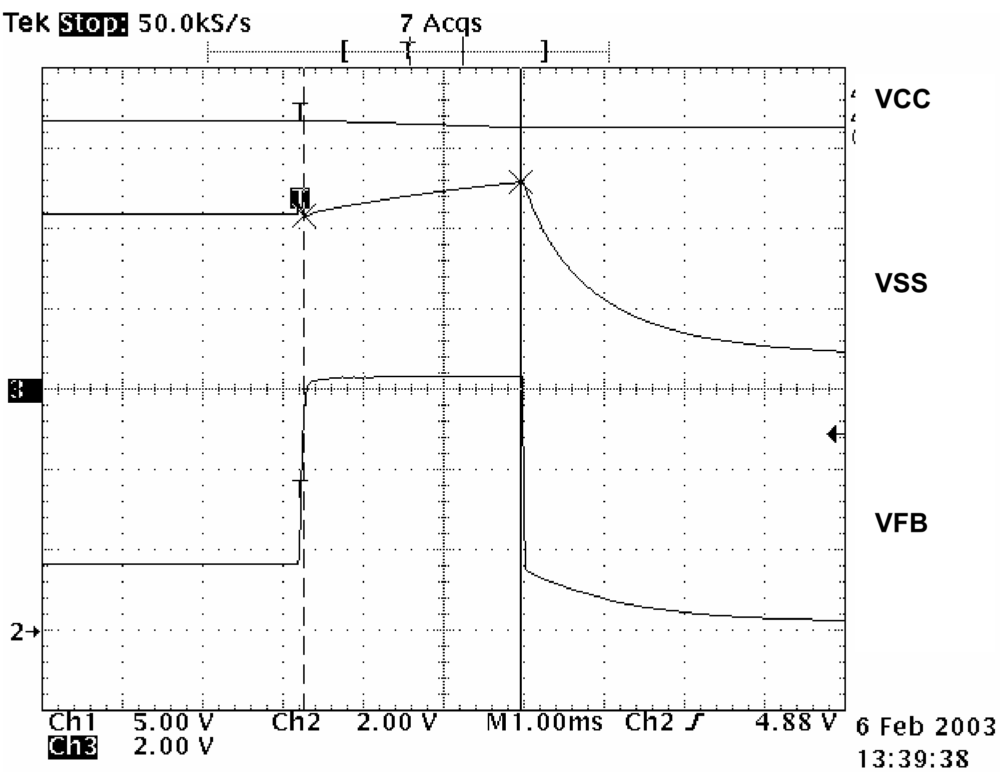


Fig. 3: Load Jump Behaviour

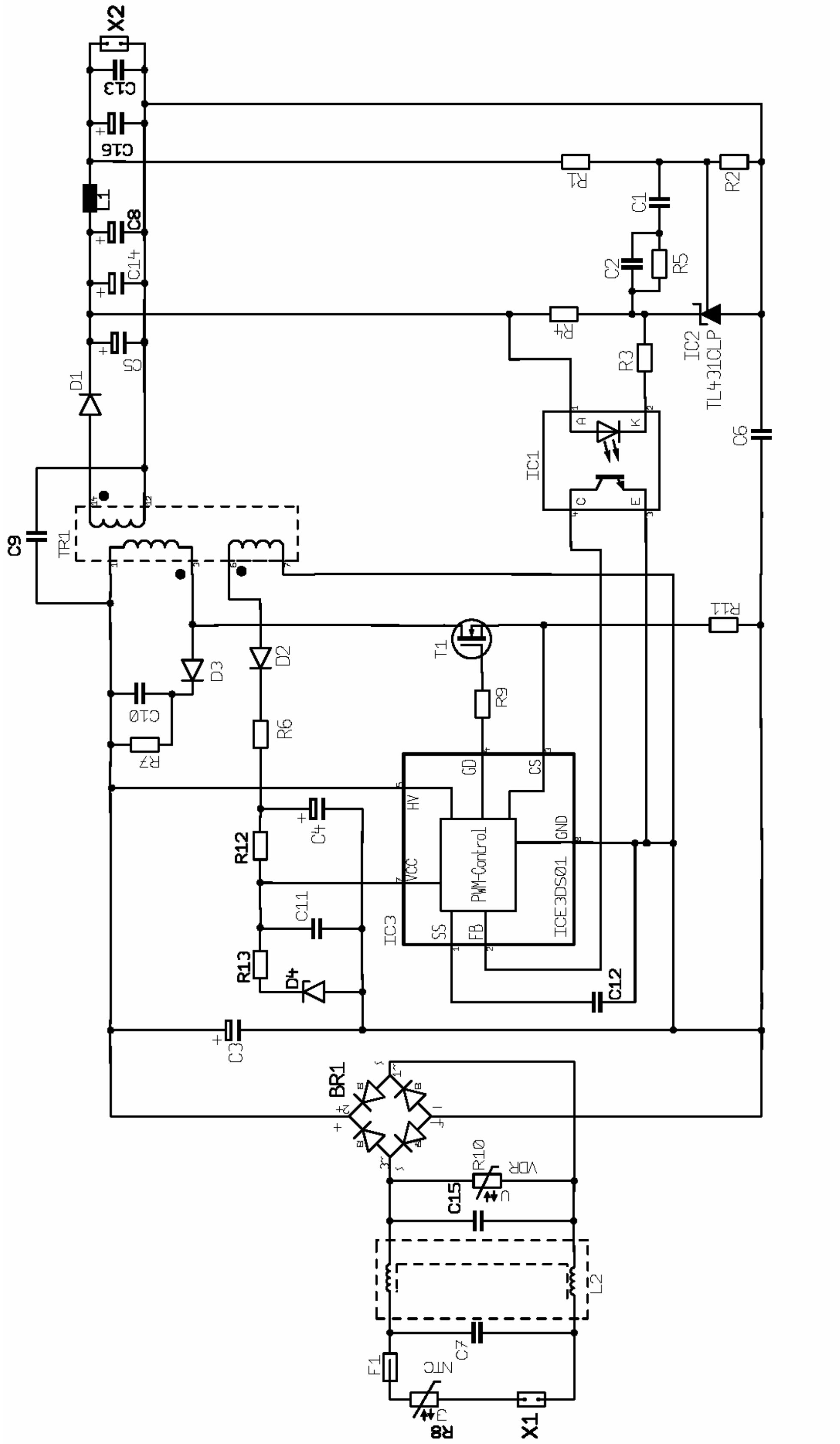
(measured with a 80W, 24V application)

Ch1: Voltage at VCC Pin

Ch2: Voltage at Softstart Pin

Ch3: Voltage at Feedback Pin

Typical Application



References:

[1] **Infineon Technologies**, Datasheet
F3 ICE3DS01
Off-Line SMPS Current Mode Controller with integrated 500V Startup Cell

[2] **Infineon Technologies**, Application Note
AN-SMPS-ICE2AXXX-1
CoolSET
ICE2AXXX for Off-Line Switch Mode Power Supply (SMPS)

Revision History		
Application Note AN-SMPS-ICE3DS01-1		
Actual Release: V1.0 Date:026.03.2003		Previous Release: V1.0
Page of actual Rel.	Page of prev. Rel.	Subjects changed since last release
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