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Application Note

AN-TDA16850-1-010402

TDA 16850 - synchronizable flyback controller IC supporting different operating modes - Features

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Introduction

TDA 16850 is a high performance off-line flyback controller IC with special features used in SMPS for Monitors, CTVs, Adapters and Chargers. A DIP-8 package is sufficient to include the primary control functions without restrictions in respect to design flexibility. The IC supports designs with off-mode operation with a power consumption less than 250mW as well as designs with standby mode operation with a power consumption less than 1W. A few components only are necessary to operate the IC which is synchronizable in a range between 20kHz to 130kHz. The most important benefit of TDA 16850 is saving system cost.

In the application with off-mode operation the SMPS is started by applying a trigger signal on secondary side input. This signal is transmitted via the same optocoupler that is used for transmitting the feedback signal. The IC requires a source current at control input (Pin 8) of 100µA for more than 7µs via optocoupler for becomming active. Besides a vertical signal a DC signal as it is available from a recharchable battery can be used for making the IC active. From start-up mode the IC reaches the normal mode. During normal mode operation the source current at control input (Pin 8) is in the range between 2mA (no load) and 6mA(nominal load). It never has to be less than 150µA for a time period longer than 70µs in order to stay in normal mode. When the SMPS has to change from normal mode into off-mode a secundary side shutdown signal interrupts the feedback signal via optocoupler. A source current below 150µA at Pin 8 enables the IC to change into off-mode and disables the power supply completely. Thus the feedback signal and the operating status signal are transmitted with a single optocoupler only. The off-mode is the most effective operating mode for energy saving.

In the application with standby mode operation the SMPS is started by fulfilling the start-up conditions at supply voltage input (Pin 7) only. The IC changes from start-up mode into standby mode, if source current at Pin 8 is between 150µA and 2mA. The normal mode operation is characterized by a source current in the range between 2mA and 6mA. In a typical application the source current of the standby mode status is set by a resistor at Pin 8 directly. So the IC changes from normal mode into standby mode by a simple interrupt of the feedback signal.
During standby mode the IC is fed from a separate supply winding which is also used to establish a primary control loop. As this input (Pin 2) is able to handle voltages up to 85V (during normal operation), and controls a level of 11V (during standby operation) we achieve a reduction of the output voltages down to 15% of nominal value during standby mode. A voltage dependend switch between two secundary windings cares for sufficient supply voltage on the voltage regulator’s input. So a powerful and high efficient standby supply is available. In the application with standby mode the feedback signal and the operating status signal as well are transmitted with one optocoupler only.

Without any synchronization signal the IC operates with an internal oscillator at 20kHz during standby operation and at 60kHz during normal operation. For synchronization purposes there is a separate input (Pin 4) with a hysteresis threshold at 1V and clamping structures at +5V/-0,7V with a current capability of +/- 10mA. Synchronisation range is 20kHz to 130kHz which is effective during normal mode and standby mode. The synchronisation operates with positive edge triggering and starts the turn-on of the MOSFET with a delay, which is about 1/20 of the synchronization signal’s period.

The pulse width modulation is done internally at a ramp voltage, which uses the current sense signal amplified by factor of five. Such kind of improved current mode control benefits stabile PWM with duty cycle controllable continuously down to zero.
In addition there is a frequency dependend limitation of the output power. Implementing this feature the maximum duty cycle is controlled by the oscillator that varies the voltage level at softstart capacitor (Pin 1).

Features of TDA 16850

The description of the functionality is standing below following the numbers of the pinout:

Pin 1: SST Softstart

The softstart pin requires a capacitor to ground in the range of 100nF to 220nF. It effects a continuously increasing duty cycle after the IC is becomming active after supply voltage was exceeding the start-up threshold of 22V at Pin 7. Furthermore the level at this Pin changes influenced by the operating frequency in order to limit maximum output power almost independent of operating frequency. The result is a limitation of duty cycle, which achieves a maximum of 0,59 at 120kHz and 80mV/µs increasing speed of the current sense signal. Softstart charging current is 20µA, discharging current is 2,5mA. The voltage level at Pin 1 is typically 3,8V (120kHz) or 6,0V (30kHz). If the level at current sense input exceeds 1,2V, the softstart capacitor is discharged (2,5mA) in order to reduce duty cycle and avoid overload.

Pin 2: VREG Supply and feedback during standby mode

During standby mode the feedback control current via optocoupler from secundary side error amplifier is interrupted. Feedback control is now provided by sensing the voltage level at Pin 2 and controlling its level to 11V. In addition the IC is supplied from this Pin fed from a separate winding. An integrated voltage regulator between Pin 2 and Pin 7 provides a voltage level of about 10V at Pin 7 during standby mode.
This input employs a 85V-capable regulator that enables the IC to withstand high voltage levels at Pin 2 during normal mode. This function allows to reduce transformer's flyback voltage during standby mode to about 15% of the level during normal mode. The factor of voltage reduction between standby mode and normal mode depends on the different transformer ratios of the two separate supply windings for the IC.

There is another function at Pin 2 that monitors overload conditions during start-up. At that point of time when softstart level at Pin 1 achieved a level of 2,6V the level at Pin 2 has to be higher than 3V, otherwise the IC interprets this condition as an overload and restarts after discharching start-up capacitor at Pin 7 to a level of 7V.

Pin 3: CS Current sense

This pin is connected directly to the shunt resistor in order to sense the voltage drop to ground. No external low pass filter is required. An open connecton is detected by an internal pull-up current source (10µA) that activates the overcurrent comparator.
The overcurrent comparator turns off the driver output via flipflop directly as soon as the current sense signal exceeds the threshold of 1,5V. There is a second comparator with a threshold at 1,2V that reduces duty cycle via current sink and softstart capacitor.
The current sense signal is not directly involved to do the pulse width modulation but via constant gain amplifier and internal resistor a ramp voltage with higher amplitude is produced by charging an internal capacitor. So we achieve an improved current mode control with high noise immunity and stabile PWM with duty cycle controllable continuously to zero.

In addition the slope of the current sense signal is used to sense the DC supply voltage in order to monitor undervoltage condition. The minimum increase of the sense voltage is 70mV/µs.

Pin 4: SYNC Synchronization input

The synchronization range is 20kHz up to 130kHz. The leading edge triggering threshold is 1V with a hysteresis down to 0,7V. Clamping levels are –0,7V and 5V at +/- 1mA (max clamp current +/- 10mA) if a current fed signal is used. At higher synchronization frequencies than spezified the operating frequency is half of it. The Gate drive turn on edge starts with a delay of 1/20 of the period of the sync. signal.
Without synchronization signal (input preferred on low level) the TDA 16850 operates with an internal 60kHz oscillator. During standby mode the internal oscillator operates at 20kHz in order to reduce switching losses. A synchronization during standby mode is possible but not the typical operation.

Pin 5: GND Ground

The ground pin is used for power signals and sensing signals as well. An external film or ceramic capacitor between ground pin and Vcc supply Pin 7 is required for bypassing high frequent currents and reducing the source impedance.

Pin 6: Gate Gate driver

The Gate driver includes a Gate voltage limitation (11V) in order to save power consumption of the driver, a modulated turn-on rising edge for soft turn-on switching, a fast turn-off falling edge and an active low state during undervoltage lockout (1V720mA). Typical rise time of the Gate voltage is 150ns, typical fall time is 40ns at a 4,7nF load.

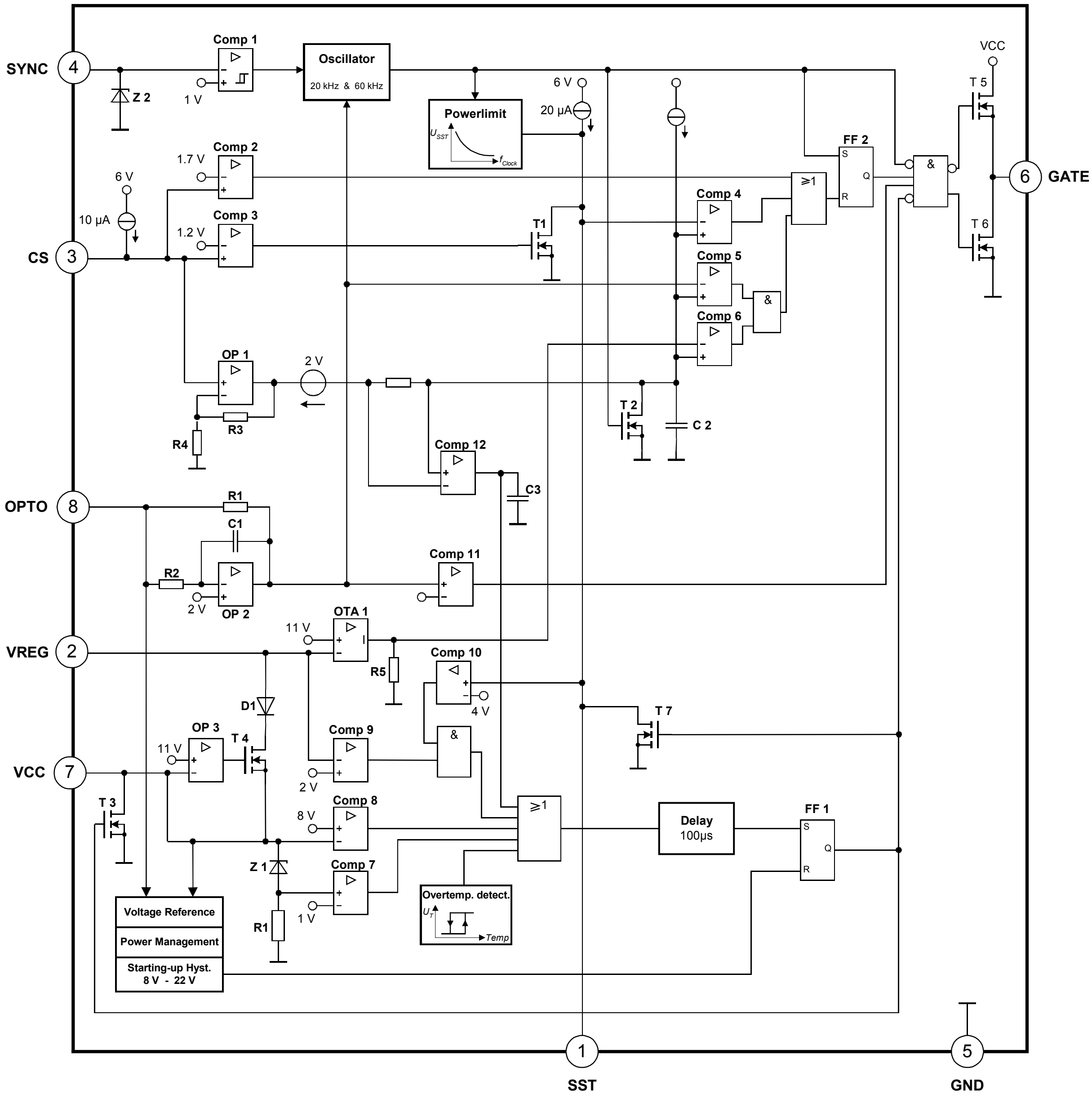

Figure 1: Block diagram of TDA 16850

Pin 7: V_{CC} Supply voltage

This is the supply terminal during normal mode operation. The start-up threshold is 21V, the undervoltage lockout (UVLO) threshold is 8V. Current consumption during UVLO is 200µA (max), quiescent supply current with disabled Gate is 3mA plus output current of the feedback input (Pin 8) across the optocoupler.
There is a zener diode between Pin 7 and ground with a current capability of 4mA. If the zener current exceeds 2mA, the IC runs into protection mode and stopps Gate control. This function can be used as an overvoltage protection in case of a fault in the feedback loop (e.g. with a damaged output diode).

Pin 8: OPTO Feedback and operating mode control

This terminal is used for the feedback control via optocoupler and for the control of the operating modes. The level of this Pin of an active IC is 2V. The status of operation is controlled by the source current , internally limited at 6mA.
Without any source current out of Pin 8 the IC is not active, it is in off-mode. During off-mode the current consumption is that one for the start-up only.
A source current that exceeds 100µA for more than 7µs at Pin 8 enables the IC to switch into start-up mode, even when the source current is reduced to zero again after 7µs. During start-up mode the IC operates at a frequency of 20kHz (without synchronization) and produces output voltages in a way that at Pin 2 a primary controlled voltage of 11V is established. The start-up mode is very similar to the standby mode, on which we observe the same operating conditions. The only difference between start-up mode and standby mode is the higher source current (150µA to 2mA in standby mode) at Pin 8. The standby mode of the IC can be used to realize a power supply with a power consumption of less than 1W during standby mode. If a system uses standby mode, the source current (200µA) at Pin 8 is set by an external 6,8k resistor to ground.
The normal mode is set by a source current more than 2mA. This current usually is controlled via optocoupler by the error amplifier placed on secundary side. During normal mode the IC operates with the internal oscillator at 60kHz.
To leave the normal mode the source current at Pin 8 has to be reduced below 2mA in order to reach the standby mode. In a typical design the opto diode of the optocoupler is bypassed with a switch. If the source current at Pin 8 is less than 160µA, the IC reaches the power down mode (active IC with about 3mA current consumption, driver signal on active low level) and in the next step due to missing power supply or detecting this status as a failure (turn-off after 75µs) the IC reaches the off mode with a current consumption of less than 100µA.
In typical applications two combinations of operating modes are used: switching between off-mode and normal mode or between standby mode and normal mode

Monitoring and protective functions

There are a couple of functions that improve reliability and save system costs.

Primary peak current is sensed via shunt resistor and is limited at two levels. A first level at 1,2V reduces duty cycle by discharging softstart capacitor dependend on duration of overcurrent. A sense signal above 1,5V turns off the MOSFET immediately.
The following conditions have to last for 70µs, before the shut down becomes effective.

Undervoltage of IC supply turns off the MOSFET at a level of 8V, at a level of 7,5V immediately.

Overload during start-up or standby control loop failure (at Pin 2) is detected by evaluating the levels at Pin 2 (more than 3V) at a softstart level of 4V at Pin 1.

Undervoltage of mains is detected by sensing the slope of the current sense signal. The shut down rising speed is 70mV/µs.

Overvoltage of IC supply becomes active as soon as the supply voltage at Pin 7 exceeds the zener threshold of 23V and develops a zener current more than 2mA. This function can be used for overvoltage protection during a feedback loop failure.

Overtemperature of IC activates the protection mode at a junction temperature more than 160°C.

All these failures except overcurrent have to be effective for at least 70µs, then the IC changes into protection mode. In protection mode the driver is stopped immediately and the supply voltage at Pin 7 has to be discharged to a level below 7V with a current of 13mA typically. Then the IC changes into off-mode and moves on into start-up mode, if start-up conditions are fulfilled.

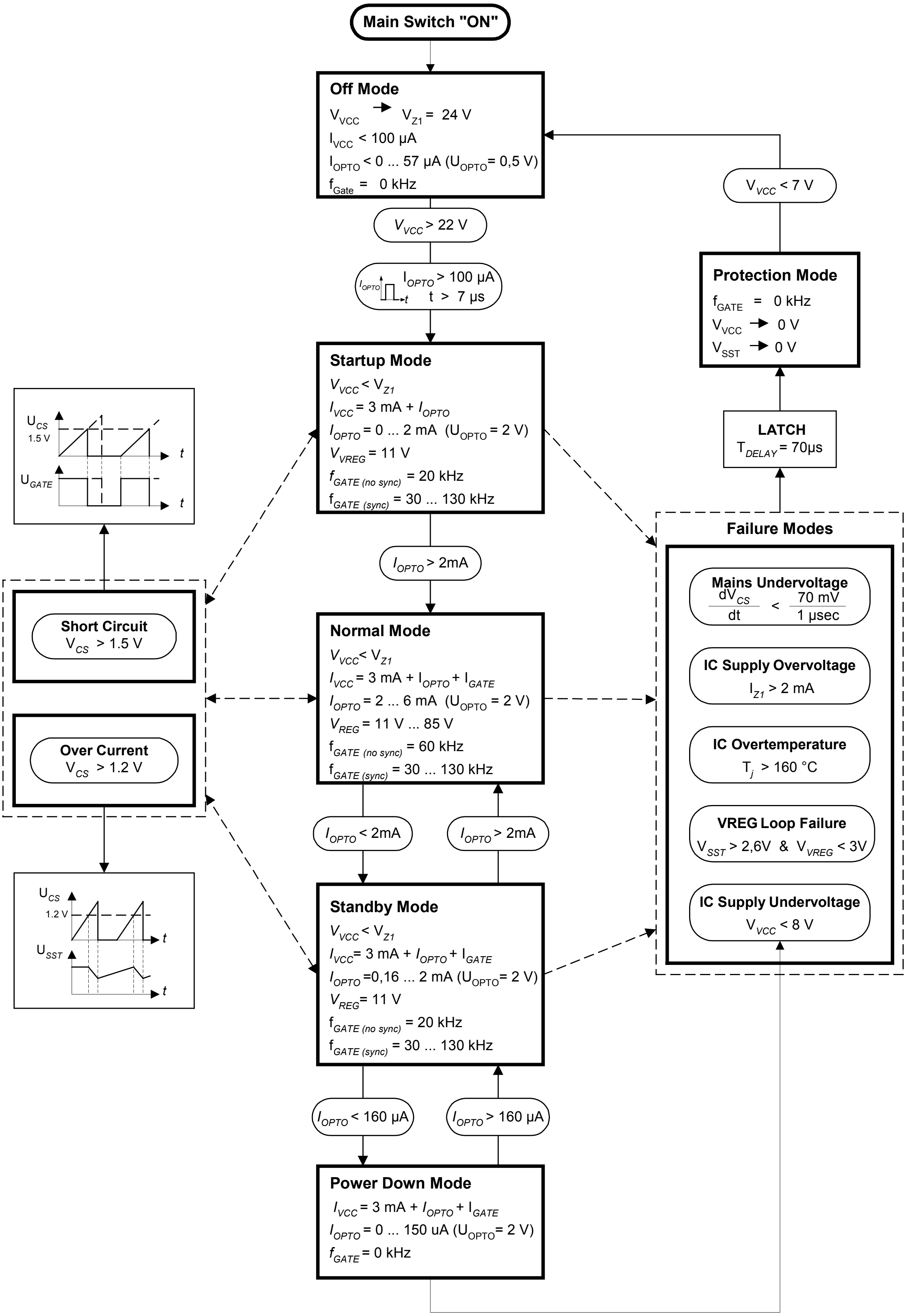

Figure 2: Flow chart of operating modes

Application with off-mode operation

The start-up conditions at supply input (Pin 7, 22V) are fulfilled with start-up resistor R13 and capacitor C23. The standby mode supply input (Pin 2) is not required in the off-mode application, but the overload monitoring compares the level of Pin 1 and Pin 2 (V_{PIN1} > 2,6V & V_{PIN2}> 3V) during start-up. So we need diode D24 and capacitor C25 fed from the same winding n3. The feedback and status control (Pin 8) is directly controlled by the optocoupler. We use an optocoupler CNY 17F-3 or similar types with a current transfer ratio close to 100%.
In order to start the SMPS we feed the vertical synchronisation signal (or DC level 2,5V to 5V) into the secundary side input (sync), limited by R73. The signal supplies the optocoupler via T72 with a current in the range between 100 - 300µA. That enables the IC via Pin 8 (source current > 100µA for > 7µs) to change from off-mode into start-up mode (20kHz).
The output voltages increase and provide via IC51 a 5V-supply for the feedback control and sensitive control circuitries. The feedback control IC62 becomes active and feeds a current to the optocoupler entering the normal mode operation. The vertical synchronisation signal is blocked by T72 as the basis level is higher than the emitter level as soon as the 5V are available.
Changing from normal into off mode is done by switch S2 that bypasses the control current of the optocoupler diode. During off mode S2 becomes inactive and allows a restart via sync input on secundary side.

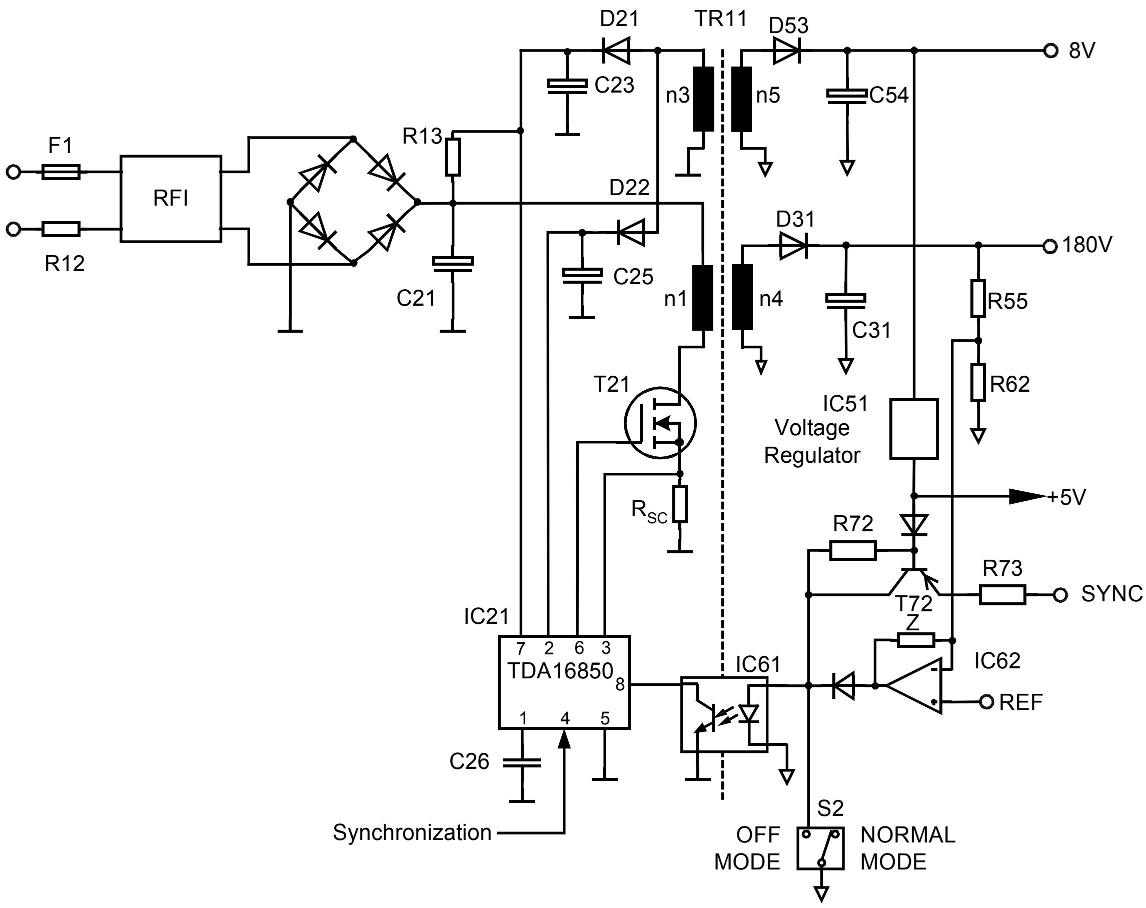

Figure 3: Typical circuitry required for off-mode operation

Application with standby mode operation

The start-up conditions at supply input (Pin 7) are fulfilled with start-up resistor R13 and capacitor C23. The feedback and status control (Pin 8) is connected with the optocoupler and in addition with resistor R25 to ground, which sets the source current for the standby status (160µA). As soon as a AC input voltage is available, the SMPS will start and change into standby mode.
During standby mode the IC is supplied at Pin 2 from a separate transformer winding via D22 and C25. Input Pin 2 is able to handle input voltages up to 85V. It is used as an supply and control input. During standby operation the voltage at Pin 2 is controlled to a level of 11V. During normal mode the IC is fed via Pin 7, so the voltage at Pin 2 can be e.g. six times higher. Therefor during standby operation the levels at all windings are reduced by a factor of six in order to reduce power consumption.
The auxiliary supply during standby mode is done with a voltage dependend switch (S1) which feeds the voltage regulator IC51 either from a 45V output (during standby 7V) or from a 8V output (during standby 1V).
The feedback control circuit operates in the same way like in the off-mode application. Different is the way how the SMPS generates the standby status information. The resistor R25 at Pin 8 sets the current that is specified for standby operation (worst case 240µA). So the only required function is a switch that opens the feedback control loop. In a typical design a transistor (S2) bypasses the emitter diode of the optocoupler in order to eliminate the control current. Under these conditions the TDA 16850 operates in standby mode.
Such a control of standby power supply is powerful and efficient. With a 120W SMPS we get a standby output power of 5W at an input power less than 7W. At a standby load of 5V/30mA the power consumption is less than 1W.

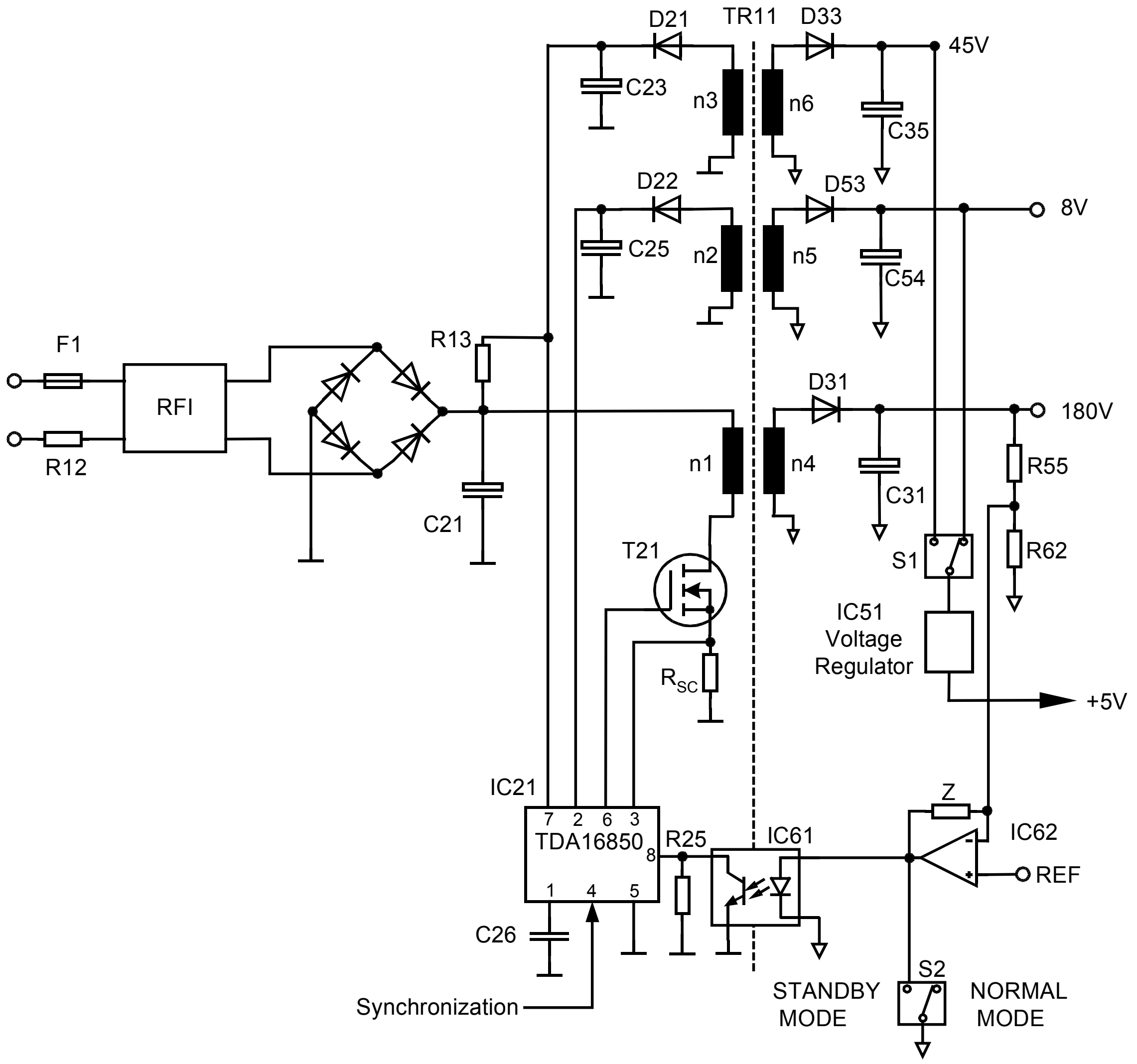

Figure 4: Typical circuitry required for standby mode operation.

Duty Cycle versus operating frequency and dV/dt at current sense input

The control behaviour of TDA 16850 in respect to duty cycle can be calculated approximately according the following equations.

Maximum current sense threshold @ 20kHz: $V_{CSMAX20KHZ}$ = 1,2V
Minimum current sense slew rate for undervoltage shut down threshold: dV_{CSMIN} / dt = 70mV/µs

Maximum on-time at 20kHz: $$T_{ONMAX20KHZ} = \frac{V_{CSMAX20KHZ}}{dV_{CSMIN}/dt} = \frac{1{,}2V}{70mV/\mu s} = 17\mu s$$

Relation between slew rate at current sense input dV_{CS}/dt, Shunt R_{SHUNT} , input voltage V_L , primary inductance L_{PRIM} and current in the primary inductance i_L .

Slew rate at current sense input $$\frac{dV_{CS}}{dt} = \frac{di_L}{dt} \cdot R_{SHUNT} = \frac{V_L}{L_{PRIM}} \cdot R_{SHUNT}$$

On-time dependend on frequency and input voltage

$$T_{ON} = T_{ONMAX20KHZ} \cdot \frac{dV_{CSMIN}/dt}{V_L} \cdot \frac{L_{PRIM}}{R_{SHUNT}} \cdot \sqrt{\frac{20kHZ}{f}}$$

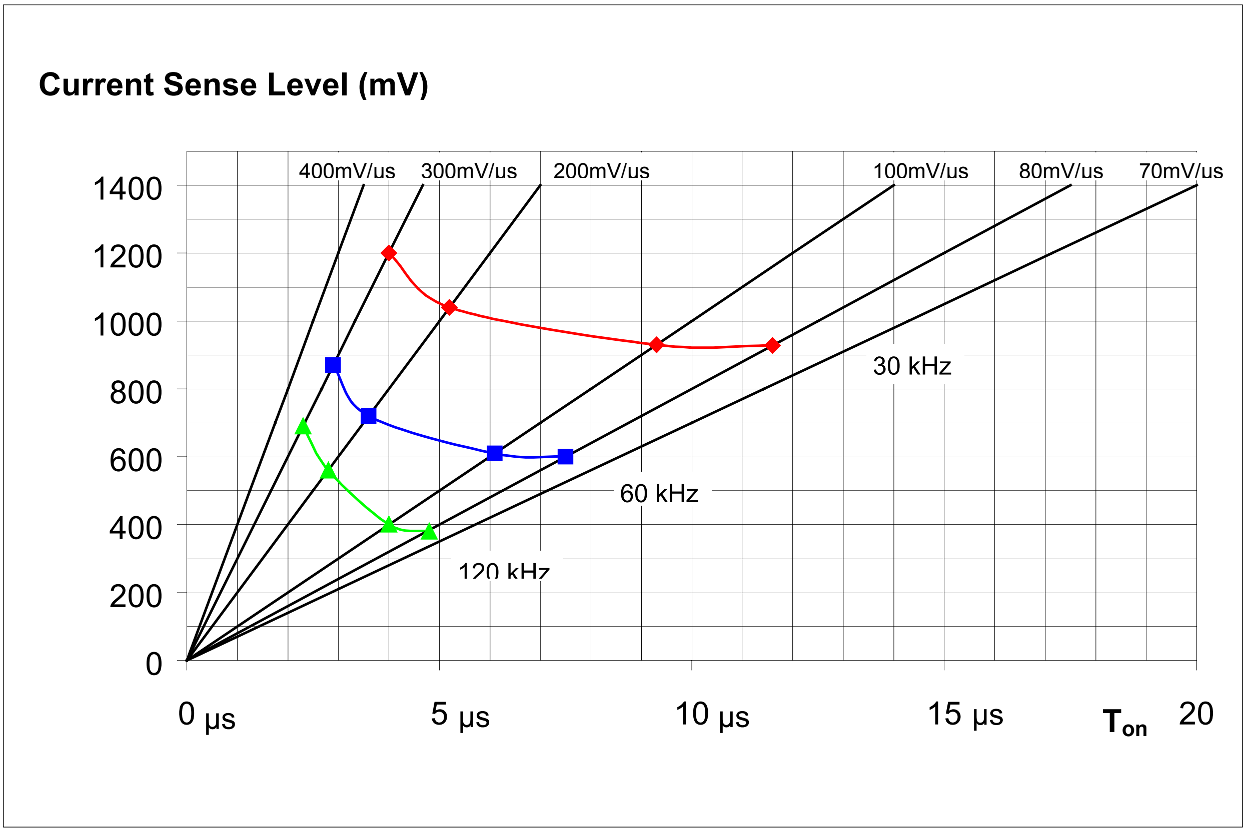

Figure 5: Controlled on-time versus operating frequency and dV/dt at current sense input.

References:

[1]

Revision History		
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Actual Release: V1.1 Date:		Previous Release: V0.1
Page of actual Release	Page of prev. Release	Subjects changed since last release

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