TOP232-234
TOPSwitch®-FX Family
Design Flexible, *EcoSmart®*, Integrated Off-line Switcher

Product Highlights

Lower System Cost, High Design Flexibility
- Features eliminate or reduce cost of external components
- Fully integrated soft-start for minimum stress/overshoot
- Externally settable accurate current limit
- Wider duty cycle for more power, smaller input capacitor
- Line under-voltage (UV) detection: no turn off glitches
- Line overvoltage (OV) shutdown extends line surge limit
- Line feed forward with maximum duty cycle (DC_{MAX}) reduction rejects ripple and limits DC_{MAX} at high line
- Single resistor sets OV/UV thresholds, DC_{MAX} reduction
- Frequency jittering reduces EMI and EMI filtering costs
- Regulates to zero load without dummy loading
- 132 kHz frequency reduces transformer/power supply size
- Half frequency option for video applications
- Hysteretic thermal shutdown for automatic recovery
- Large thermal hysteresis prevents PC board overheating
- Standard packages with omitted pins for large creepage
- Active-on and active-off remote ON/OFF capability
- Synchronizable to a lower frequency

***EcoSmart®* - Energy Efficient**
- Cycle skipping reduces no-load consumption
- Reduced consumption in remote off mode
- Half frequency option for high efficiency standby
- Allows shutdown/wake-up via LAN/input port

Description

TOPSwitch-FX uses the proven *TOPSwitch* topology and cost effectively integrates many new functions that reduce system cost and, at the same time, improve design flexibility, performance and energy efficiency. Like *TOPSwitch*, the high voltage power MOSFET, PWM control, fault protection and other control circuitry are all integrated onto a single CMOS chip, but with two added terminals. The first one is a MULTI-FUNCTION (M) pin, which implements programmable line OV/UV shutdown and line feed forward/DC_{MAX} reduction with line voltage. The same pin can be used instead to externally set an accurate current limit. In either case, this pin can also be used for remote ON/OFF or to synchronize the oscillator to an external, lower frequency signal. The second added terminal is the FREQUENCY (F) pin and is available only in the Y package. This pin provides the half frequency option when connected to CONTROL (C) instead of SOURCE (S). The features on the new pins can be disabled by shorting them to the SOURCE, which allows the device to operate in a three terminal *TOPSwitch* mode, but with the following new transparent features: soft-start, cycle skipping, 132 kHz switching frequency, frequency jittering, wider DC_{MAX}, hysteretic thermal shutdown and larger creepage. In addition, all critical parameters such as frequency, current limit, PWM gain, etc. have tighter temperature and absolute tolerances compared to the *TOPSwitch-II* family. Higher current limit accuracy and larger DC_{MAX}, when combined with other features allow for a 10% to 15% higher power capability on the *TOPSwitch-FX* devices compared to equivalent *TOPSwitch-II* devices for the same input/output conditions.

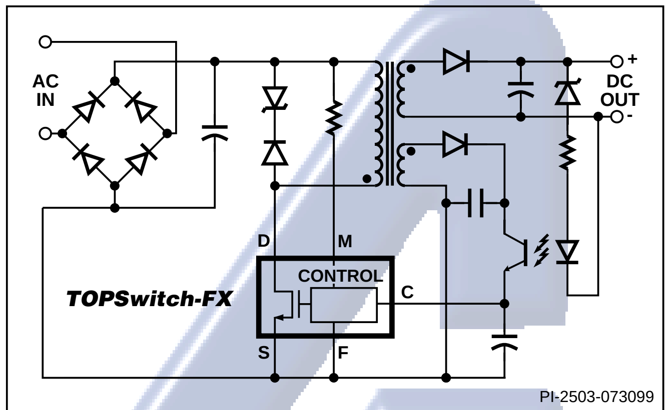

Figure 1. Typical Flyback Application.

OUTPUT POWER TABLE				
PART ORDER NUMBER[3]	230 VAC ±15%		85-265 VAC	
	Adapter[1]	Open Frame[2]	Adapter[1]	Open Frame[2]
TOP232P TOP232G	9 W	15 W	6.5 W	10 W
TOP232Y	10 W	25 W	7 W	15 W
TOP233P TOP233G	13 W	25 W	9 W	15 W
TOP233Y	20 W	50 W	15 W	30 W
TOP234P TOP234G	16 W	30 W	11 W	20 W
TOP234Y	30 W	75 W	20 W	45 W

Table 1. Notes: **1.** Typical continuous power in a non-ventilated enclosed adapter measured at 50 ˚C ambient. **2.** Maximum practical continuous power in an open frame design with adequate heat sinking, measured at 50 ˚C ambient. See key applications section for detailed conditions. **3.** Packages: P: DIP-8B, G: SMD-8B, Y: TO-220-7B.

Section List

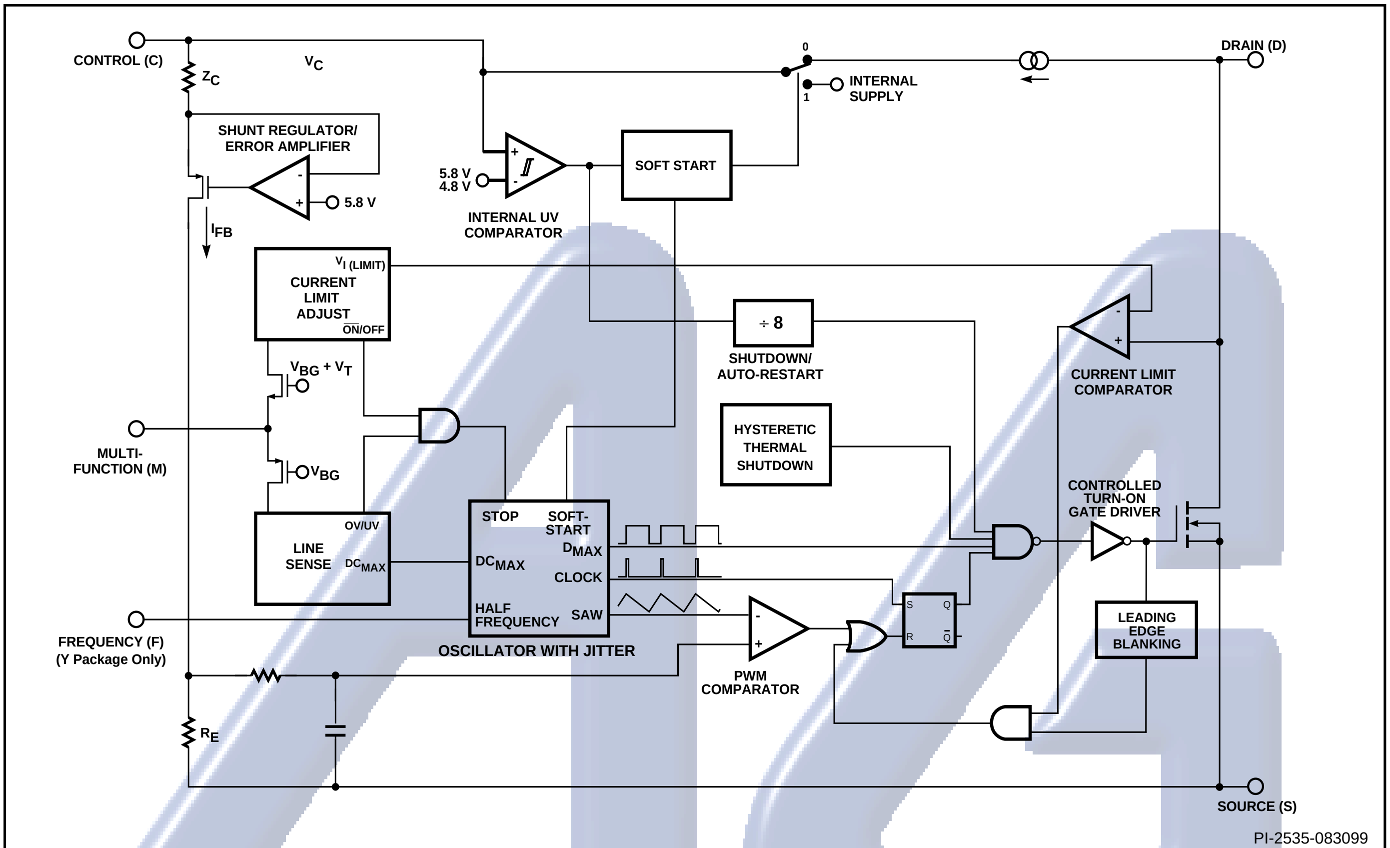

Figure 2. Functional Block Diagram.

Pin Functional Description

DRAIN (D) Pin:
High voltage power MOSFET drain output. The internal start-up bias current is drawn from this pin through a switched high-voltage current source. Internal current limit sense point for drain current.

CONTROL (C) Pin:
Error amplifier and feedback current input pin for duty cycle control. Internal shunt regulator connection to provide internal bias current during normal operation. It is also used as the connection point for the supply bypass and auto-restart/compensation capacitor.

MULTI-FUNCTION (M) Pin:
Input pin for OV, UV, line feed forward with DC_{MAX} reduction, external set current limit, remote ON/OFF and synchronization. A connection to SOURCE pin disables all functions on this pin and makes *TOPSwitch-FX* operate in simple three terminal mode (like *TOPSwitch-II*).

FREQUENCY (F) Pin: (Y package only)
Input pin for selecting switching frequency: 132 kHz if connected to SOURCE pin and 66 kHz if connected to CONTROL pin. The switching frequency is internally set for 132 kHz only operation in P and G packages.

SOURCE (S) Pin:
Output MOSFET source connection for high voltage power return. Primary side control circuit common and reference point.

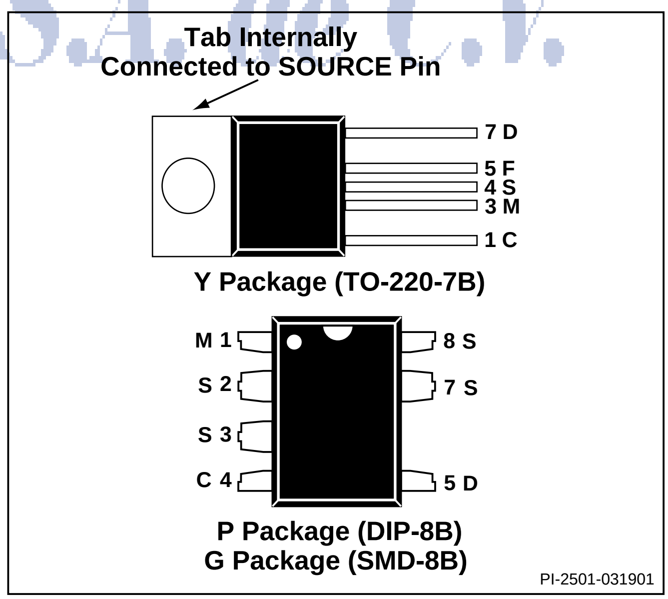

Figure 3. Pin Configuration.

TOPSwitch-FX Family Functional Description

Like *TOPSwitch*, *TOPSwitch-FX* is an integrated switched mode power supply chip that converts a current at the control input to a duty cycle at the open drain output of a high voltage power MOSFET. During normal operation the duty cycle of the power MOSFET decreases linearly with increasing CONTROL pin current as shown in Figure 4.

In addition to the three terminal *TOPSwitch* features, such as the high voltage start-up, the cycle-by-cycle current limiting, loop compensation circuitry, auto-restart, thermal shutdown, etc., the *TOPSwitch-FX* incorporates many additional functions that reduce system cost, increase power supply performance and design flexibility. A patented high voltage CMOS technology allows both the high voltage power MOSFET and all the low voltage control circuitry to be cost effectively integrated onto a single monolithic chip.

Two terminals, FREQUENCY (available only in Y package) and MULTI-FUNCTION, have been added to implement some of the new functions. These terminals can be connected to the SOURCE pin to operate the *TOPSwitch-FX* in a *TOPSwitch*-like three terminal mode. However, even in this three terminal mode, the *TOPSwitch-FX* offers many new transparent features that do not require any external components:

1. A fully integrated 10 ms soft-start reduces peak currents and voltages during start-up and practically eliminates output overshoot in most applications.
2. DC_{MAX} of 78% allows smaller input storage capacitor, lower input voltage requirement and/or higher power capability.
3. Cycle skipping at minimum pulse width achieves regulation and very low power consumption at no load.
4. Higher switching frequency of 132 kHz reduces the transformer size with no noticeable impact on EMI or on high line efficiency.
5. Frequency jittering reduces EMI.
6. Hysteretic over-temperature shutdown ensures automatic recovery from thermal fault. Large hysteresis prevents circuit board overheating.
7. Packages with omitted pins and lead forming provide large DRAIN creepage distance.
8. Tighter absolute tolerances and smaller temperature variations on switching frequency, current limit and PWM gain.

The MULTI-FUNCTION pin is usually used for line sensing by connecting a resistor from this pin to the rectified DC high voltage bus to implement line over-voltage (OV)/under-voltage (UV) and line feed forward with DC_{MAX} reduction. In this mode, the value of the resistor determines the OV/UV thresholds and the DC_{MAX} is reduced linearly starting from a line voltage above the under-voltage threshold. In high efficiency applications, this pin can be used in the external current limit mode instead, to reduce the current limit externally (to a value

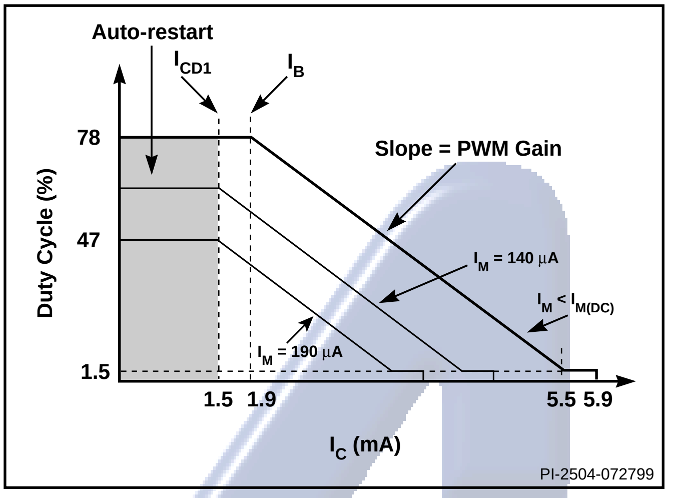

Figure 4. Relationship of Duty Cycle to CONTROL Pin Current.

close to the operating peak current), by connecting the pin to SOURCE through a resistor. The same pin can also be used as a remote ON/OFF and a synchronization input in both modes. The FREQUENCY pin in the TO-220 package sets the switching frequency to the default value of 132 kHz when connected to SOURCE pin. A half frequency option can be chosen by connecting this pin to CONTROL pin instead. Leaving this pin open is not recommended.

CONTROL (C) Pin Operation

The CONTROL pin is a low impedance node that is capable of receiving a combined supply and feedback current. During normal operation, a shunt regulator is used to separate the feedback signal from the supply current. CONTROL pin voltage V_C is the supply voltage for the control circuitry including the MOSFET gate driver. An external bypass capacitor closely connected between the CONTROL and SOURCE pins is required to supply the instantaneous gate drive current. The total amount of capacitance connected to this pin also sets the auto-restart timing as well as control loop compensation.

When rectified DC high voltage is applied to the DRAIN pin during start-up, the MOSFET is initially off, and the CONTROL pin capacitor is charged through a switched high voltage current source connected internally between the DRAIN and CONTROL pins. When the CONTROL pin voltage V_C reaches approximately 5.8 V, the control circuitry is activated and the soft-start begins. The soft-start circuit gradually increases the duty cycle of the MOSFET from zero to the maximum value over approximately 10 ms. If no external feedback/supply current is fed into the CONTROL pin by the end of the soft-start, the high voltage current source is turned off and the CONTROL pin will start discharging in response to the supply current drawn by the control circuitry. If the power supply is designed properly, and no fault condition such as open loop or shorted output exists, the feedback loop will close, providing external

CONTROL pin current, before the CONTROL pin voltage has had a chance to discharge to the lower threshold voltage of approximately 4.8 V (internal supply under-voltage lockout threshold). When the externally fed current charges the CONTROL pin to the shunt regulator voltage of 5.8 V, current in excess of the consumption of the chip is shunted to SOURCE through resistor R_E as shown in Figure 2. This current flowing through R_E controls the duty cycle of the power MOSFET to provide closed loop regulation. The shunt regulator has a finite low output impedance Z_C that sets the gain of the error amplifier when used in a primary feedback configuration. The dynamic impedance Z_C of the CONTROL pin together with the external CONTROL pin capacitance sets the dominant pole for the control loop.

When a fault condition such as an open loop or shorted output prevents the flow of an external current into the CONTROL pin, the capacitor on the CONTROL pin discharges towards 4.8 V. At 4.8 V auto-restart is activated which turns the output MOSFET off and puts the control circuitry in a low current standby mode. The high-voltage current source turns on and charges the external capacitance again. A hysteretic internal supply under-voltage comparator keeps V_C within a window of typically 4.8 to 5.8 V by turning the high-voltage current source on and off as shown in Figure 5. The auto-restart circuit has a divide-by-8 counter which prevents the output MOSFET from turning on again until eight discharge/charge cycles have elapsed. This is accomplished by enabling the output MOSFET only when the divide-by-8 counter reaches full count (S7). The counter effectively limits *TOPSwitch-FX* power dissipation by reducing the auto-restart duty cycle to typically 4%. Auto-restart mode continues until output voltage regulation is again achieved through closure of the feedback loop.

Oscillator and Switching Frequency

The internal oscillator linearly charges and discharges an internal capacitance between two voltage levels to create a sawtooth waveform for the pulse width modulator. The oscillator sets the pulse width modulator/current limit latch at the beginning of each cycle.

The nominal switching frequency of 132 kHz was chosen to minimize transformer size while keeping the fundamental EMI frequency below 150 kHz. The FREQUENCY pin (available only in TO-220 package), when shorted to the CONTROL pin, lowers the switching frequency to 66 kHz (half frequency) which may be preferable in some cases such as noise sensitive video applications or a high efficiency standby mode. Otherwise, the FREQUENCY pin should be connected to the SOURCE pin for the default 132 kHz. Trimming of the current reference improves oscillator frequency accuracy.

To further reduce the EMI level, the switching frequency is jittered (frequency modulated) by approximately ±4 kHz at 250 Hz (typical) rate as shown in Figure 6. Figure 28 shows the typical improvement of EMI measurements with frequency jitter.

Pulse Width Modulator and Maximum Duty Cycle

The pulse width modulator implements voltage mode control by driving the output MOSFET with a duty cycle inversely proportional to the current into the CONTROL pin that is in excess of the internal supply current of the chip (see Figure 4). The excess current is the feedback error signal that appears across R_E (see Figure 2). This signal is filtered by an RC network with a typical corner frequency of 7 kHz to reduce the effect of switching noise in the chip supply current generated by

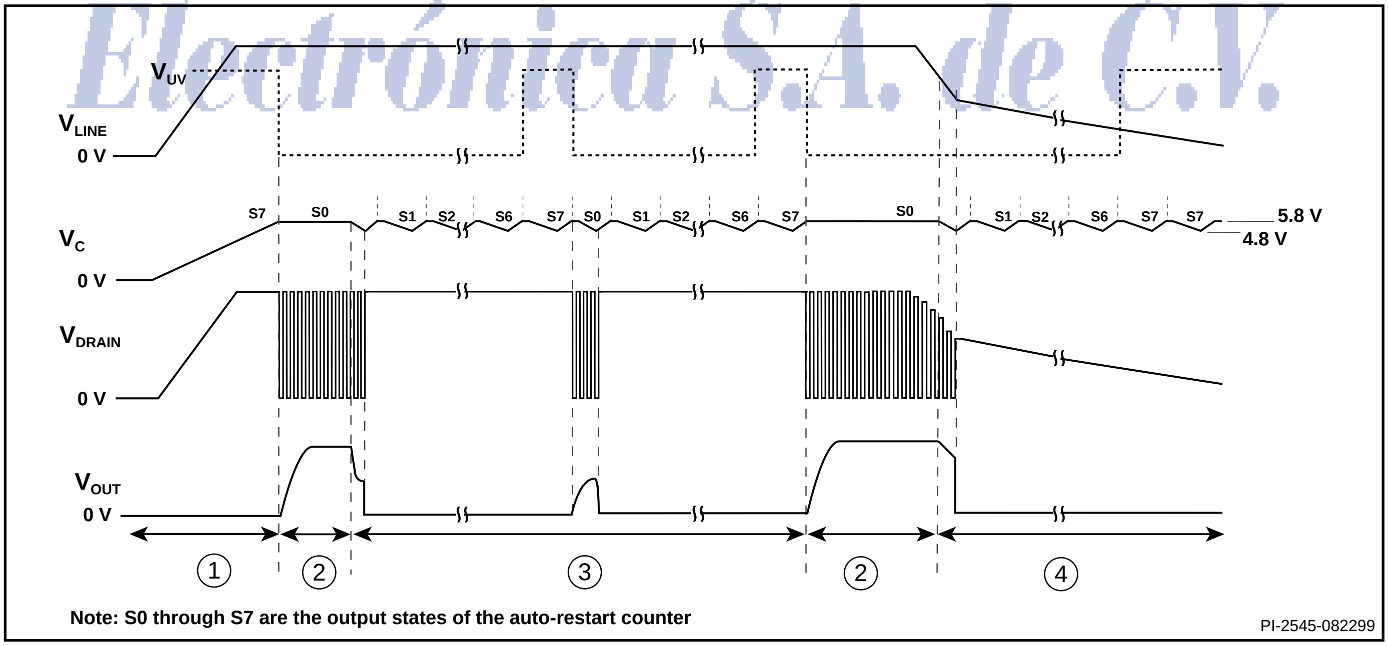

Figure 5. Typical Waveforms for (1) Power Up (2) Normal Operation (3) Auto-restart (4) Power Down .

the MOSFET gate driver. The filtered error signal is compared with the internal oscillator sawtooth waveform to generate the duty cycle waveform. As the control current increases, the duty cycle decreases. A clock signal from the oscillator sets a latch which turns on the output MOSFET. The pulse width modulator resets the latch, turning off the output MOSFET. Note that a minimum current must be driven into the CONTROL pin before the duty cycle begins to change.

The maximum duty cycle, DC_{MAX}, is set at a default maximum value of 78% (typical). However, by connecting the MULTI-FUNCTION pin to the rectified DC high voltage bus through a resistor with appropriate value, the maximum duty cycle can be made to decrease from 78% to 38% (typical) as shown in Figure 8 when input line voltage increases (see line feed forward with DC_{MAX} reduction).

Minimum Duty Cycle and Cycle Skipping

To maintain power supply output regulation, the pulse width modulator reduces duty cycle as the load at the power supply output decreases. This reduction in duty cycle is proportional to the current flowing into the CONTROL pin. As the CONTROL pin current increases, the duty cycle reduces linearly towards a minimum value specified as minimum duty cycle, DC_{MIN}. After reaching DC_{MIN}, if CONTROL pin current is increased further by approximately 0.4 mA, the pulse width modulator will force the duty cycle from DC_{MIN} to zero in a discrete step (refer to Figure 4). This feature allows a power supply to operate in a cycle skipping mode when the load at its output consumes less power than the power that *TOPSwitch-FX* delivers at minimum duty cycle, DC_{MIN}. No additional control is needed for the transition between normal operation and cycle skipping. As the load increases or decreases, the power supply automatically switches between normal operation and cycle skipping mode as necessary.

Cycle skipping may be avoided, if so desired, by connecting a minimum load at the power supply output such that the duty cycle remains at a level higher than DC_{MIN} at all times.

Error Amplifier

The shunt regulator can also perform the function of an error amplifier in primary feedback applications. The shunt regulator voltage is accurately derived from a temperature-compensated bandgap reference. The gain of the error amplifier is set by the CONTROL pin dynamic impedance. The CONTROL pin clamps external circuit signals to the V_C voltage level. The CONTROL pin current in excess of the supply current is separated by the shunt regulator and flows through R_E as a voltage error signal.

On-chip Current Limit with External Programmability

The cycle-by-cycle peak drain current limit circuit uses the output MOSFET ON-resistance as a sense resistor. A current limit comparator compares the output MOSFET on-state drain to source voltage, $V_{DS(ON)}$ with a threshold voltage. High drain current causes $V_{DS(ON)}$ to exceed the threshold voltage and turns the output MOSFET off until the start of the next clock cycle. The default current limit of *TOPSwitch-FX* is preset internally. However, with a resistor connected between MULTI-FUNCTION pin and SOURCE pin, current limit can be programmed externally to a lower level between 40% and 100% of the default current limit. Please refer to the graphs in the typical performance characteristics section for the selection of the resistor value. By setting current limit low, a *TOPSwitch-FX* that is bigger than necessary for the power required can be used to take advantage of the lower $R_{DS(ON)}$ for higher efficiency. With a second resistor connected between the MULTI-FUNCTION pin and the rectified DC high voltage bus providing a small amount of feed forward current, a true power limiting operation against line variation can be implemented. When using an RCD clamp, this feed forward technique reduces maximum clamp voltage at high line allowing for higher reflected voltage designs. The current limit comparator threshold voltage is temperature compensated to minimize the variation of the current limit due to temperature related changes in $R_{DS(ON)}$ of the output MOSFET.

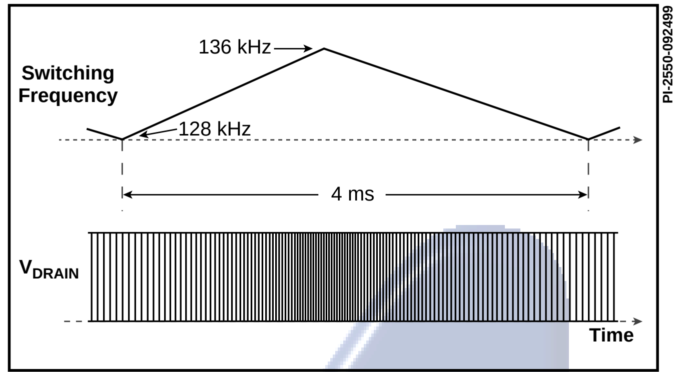

Figure 6. Switching Frequency Jitter.

The leading edge blanking circuit inhibits the current limit comparator for a short time after the output MOSFET is turned on. The leading edge blanking time has been set so that, if a power supply is designed properly, current spikes caused by primary-side capacitances and secondary-side rectifier reverse recovery time will not cause premature termination of the switching pulse.

The current limit can be lower for a short period after the leading edge blanking time as shown in Figure 33. This is due to dynamic characteristics of the MOSFET. To avoid triggering the current limit in normal operation, the drain current waveform should stay within the envelope shown.

Line Under-Voltage Detection (UV)

At power up, UV keeps *TOPSwitch-FX* off until the input line voltage reaches the under-voltage threshold. At power down, UV prevents auto-restart attempts after the output goes out of regulation. This eliminates power down glitches caused by the slow discharge of input storage capacitor present in applications such as standby supplies. A single resistor connected from the MULTI-FUNCTION pin to the rectified DC high voltage bus sets UV threshold during power up. Once the power supply is successfully turned on, UV is disabled to allow extended input voltage operating range. Input voltage is not checked again until the power supply loses regulation and attempts another turn-on. This is accomplished by enabling the UV comparator only when the divide-by-8 counter used in auto-restart reaches full count (S7) which is also the state that the counter is reset to at power up (see Figure 5). The UV feature can be disabled independent of OV feature as shown in Figure 16.

Line Overvoltage Shutdown (OV)

The same resistor used for UV also sets an overvoltage threshold which, once exceeded, will force *TOPSwitch-FX* output into off-state. The ratio of OV and UV thresholds is preset at 4.5 as can be seen in Figure 8. This feature turns off the *TOPSwitch-FX* power MOSFET when the rectified DC high voltage exceeds the OV threshold. When the MOSFET is off, the rectified DC high voltage surge capability is increased to the voltage rating of the MOSFET (700 V), due to the absence of the reflected voltage and leakage spikes on the drain. Small amount of hysteresis is provided on the OV threshold to prevent noise triggering. The OV feature can be disabled independent of UV feature as shown in Figure 15.

Line Feed Forward with DC_{MAX} Reduction

The same resistor used for UV and OV also implements line voltage feed forward which minimizes output line ripple and reduces power supply output sensitivity to line transients. This feed forward operation is illustrated in Figure 4 by the different values of I_M. Note that for the same CONTROL pin current, higher line voltage results in smaller operating duty cycle. As an added safety measure, the maximum duty cycle DC_{MAX} is also reduced from 78% (typical) at a voltage slightly higher than the UV threshold to 38% (typical) at the OV threshold (see Figures 4, 8). DC_{MAX} of 38% at the OV threshold was chosen to ensure that the power capability of the *TOPSwitch-FX* is not restricted by this feature under normal operation.

Remote ON/OFF and Synchronization

TOPSwitch-FX can be turned on or off by controlling the current into or out from the MULTI-FUNCTION pin (see Figure 8). This allows easy implementation of remote ON/OFF control of *TOPSwitch-FX* in several different ways. A transistor or an optocoupler output connected between the MULTI-FUNCTION pin and the SOURCE pin implements this function with "active-on" (Figure 19) while a transistor or an optocoupler output connected between the MULTI-FUNCTION pin and the CONTROL pin implements the function with "active-off" (Figure 20).

When a signal is received at the MULTI-FUNCTION pin to disable the output through any of the MULTI-FUNCTION pin functions such as OV, UV and remote ON/OFF, *TOPSwitch-FX* always completes its current switching cycle as illustrated in Figure 7 before the output is forced off. The internal oscillator is stopped slightly before the end of the current cycle and stays there as long as the disable signal exists. When the signal at the MULTI-FUNCTION pin changes state from disable to enable, the internal oscillator starts the next switching cycle. This approach allows the use of this pin to synchronize *TOPSwitch-FX* to any external signal with a frequency lower than its internal switching frequency.

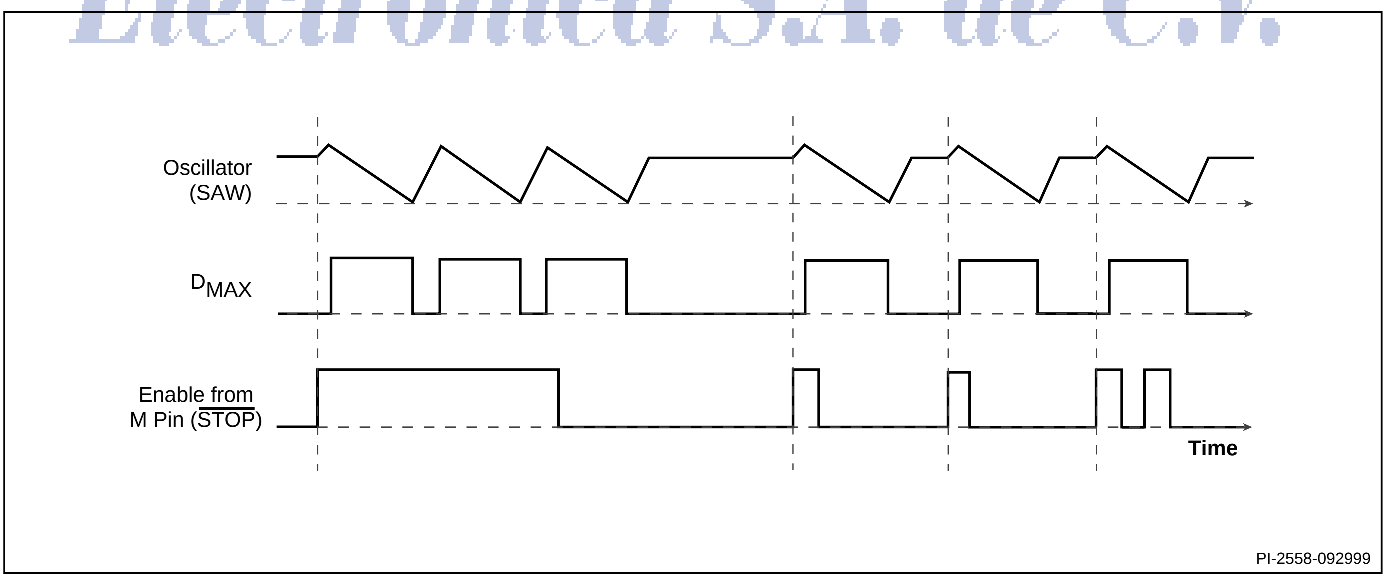

Figure 7. Synchronization Timing Diagram.

As seen above, the remote ON/OFF feature allows the *TOPSwitch-FX* to be turned on and off instantly, on a cycle-by-cycle basis, with very little delay. However, remote ON/OFF can also be used as a standby or power switch to turn off the *TOPSwitch-FX* and keep it in a very low power consumption state for indefinitely long periods. If the *TOPSwitch-FX* is held in remote off state for long enough time to allow the CONTROL pin to dishcharge to the internal supply under-voltage threshold of 4.8 V (approximately 32 ms for a 47 µF CONTROL pin capacitance), the CONTROL pin goes into the hysteretic mode of regulation. In this mode, the CONTROL pin goes through alternate charge and discharge cycles between 4.8 V and 5.8 V (see CONTROL pin operation section above) and runs entirely off the high voltage DC input, but with very low power consumption (160 mW typical at 230 VAC with M pin open). When the *TOPSwitch-FX* is remotely turned on after entering this mode, it will initiate a normal start-up sequence with soft-start the next time the CONTROL pin reaches 5.8 V. In the worst case, the delay from remote on to start-up can be equal to the full discharge/charge cycle time of the CONTROL pin, which is approximately 125 ms for a 47 µF CONTROL pin capacitor. This reduced consumption remote off mode can eliminate expensive and unreliable in-line mechanical switches. It also allows for microprocessor controlled turn-on and turn-off sequences that may be required in certain applications such as inkjet and laser printers. See Figure 27 under application examples for more information.

Soft-Start

An on-chip soft-start function is activated at start-up with a duration of 10 ms (typical). Maximum duty cycle starts from zero and linearly increases to the default maximum of 78% at the end of the 10 ms duration. In addition to start-up, soft-start is also activated at each restart attempt during auto-restart and when restarting after being in hysteretic regulation of CONTROL pin voltage (V_C), due to remote off or thermal shutdown conditions. This effectively minimizes current and voltage stresses on the output MOSFET, the clamp circuit and the output rectifier, during start-up. This feature also helps minimize output overshoot and prevents saturation of the transformer during start-up.

Shutdown/Auto-Restart

To minimize *TOPSwitch-FX* power dissipation under fault conditions, the shutdown/auto-restart circuit turns the power supply on and off at an auto-restart duty cycle of typically 4% if an out of regulation condition persists. Loss of regulation interrupts the external current into the CONTROL pin. V_C regulation changes from shunt mode to the hysteretic auto-restart mode described above. When the fault condition is removed, the power supply output becomes regulated, V_C regulation returns to shunt mode, and normal operation of the power supply resumes.

Hysteretic Over-Temperature Protection

Temperature protection is provided by a precision analog circuit that turns the output MOSFET off when the junction temperature exceeds the thermal shutdown temperature (135 ˚C typical). When the junction temperature cools to below the hysteretic temperature, normal operation resumes. A large hysteresis of 70 ˚C (typical) is provided to prevent overheating of the PC board due to a repeating fault condition. V_C is regulated in hysteretic mode and a 4.8 V to 5.8 V (typical) sawtooth waveform is present on the CONTROL pin when the power supply is turned off.

Bandgap Reference

All critical *TOPSwitch-FX* internal voltages are derived from a temperature-compensated bandgap reference. This reference is also used to generate a temperature-compensated current reference which is trimmed to accurately set the switching frequency, MOSFET gate drive current, current limit, and the line OV/UV thresholds. *TOPSwitch-FX* has improved circuitry to maintain all of the above critical parameters within very tight absolute and temperature tolerances.

High-Voltage Bias Current Source

This current source biases *TOPSwitch-FX* from the DRAIN pin and charges the CONTROL pin external capacitance during start-up or hysteretic operation. Hysteretic operation occurs during auto-restart, remote off and over-temperature shutdown. In this mode of operation, the current source is switched on and off with an effective duty cycle of approximately 35%. This duty cycle is determined by the ratio of CONTROL pin charge (I_C) and discharge currents (I_{CD1} and I_{CD2}). This current source is turned off during normal operation when the output MOSFET is switching.

Using FREQUENCY and MULTI-FUNCTION Pins

FREQUENCY (F) Pin Operation

The FREQUENCY pin is a digital input pin available in TO-220 package only. Shorting the FREQUENCY pin to SOURCE pin selects the nominal switching frequency of 132 kHz (Figure 10) which is suited for most applications. For other cases that may benefit from lower switching frequency such as noise sensitive video applications, a 66 kHz switching frequency (half frequency) can be selected by shorting the FREQUENCY pin to the CONTROL pin (Figure 11). In addition, an example circuit shown in Figure 12 may be used to lower the switching frequency from 132 kHz in normal operation to 66 kHz in standby mode for very low standby power consumption.

MULTI-FUNCTION (M) Pin Operation

When current is fed into the MULTI-FUNCTION pin, it works as a voltage source of approximately 2.6 V up to a maximum current of +400 µA (typical). At +400 µA, this pin turns into a constant current sink. When current is drawn out of the MULTI-FUNCTION pin, it works as a voltage source of approximately 1.32 V up to a maximum current of –240 µA (typical). At –240 µA, it turns into a constant current source. Refer to Figure 9.

There are a total of five functions available through the use of the MULTI-FUNCTION pin: OV, UV, line feed forward with DC_{MAX} reduction, external current limit and remote ON/OFF. A short circuit between the MULTI-FUNCTION pin and SOURCE pin disables all five functions and forces *TOPSwitch-FX* to operate in a simple three terminal mode like *TOPSwitch-II*. The MULTI-FUNCTION pin is typically used for line sensing by connecting a resistor from this pin to the rectified DC high voltage bus to implement OV, UV and DC_{MAX} reduction with line voltage functions. In this mode, the value of the resistor determines the line OV/UV thresholds, and the DC_{MAX} is reduced linearly with rectified DC high voltage starting from just above the UV threshold. In high efficiency applications this pin can be used in the external current limit mode instead, to reduce the current limit externally to a value close to the operating peak current, by connecting the pin to the SOURCE pin through a resistor. The same pin can also be used as a remote on/off and a synchronization input in both modes. Please refer to Table 2 for possible combinations of the functions with example circuits shown in Figure 13 through Figure 23. A description of specific functions in terms of the MULTI-FUNCTION pin I/V characteristic is shown in Figure 8. The horizontal axis represents MULTI-FUNCTION pin current with positive polarity indicating currents flowing into the pin. The meaning of the vertical axes varies with functions. For those that control the on/off states of the output such as UV, OV and remote ON/OFF, the vertical axis represents the enable/disable states of the output. UV triggers at I_{UV} (+50 µA typical) and OV triggers at I_{OV} (+225 µA typical). Between +50 µA and +225 µA, the output is enabled. For external current limit and line feed forward with DC_{MAX} reduction, the vertical axis represents the magnitude of the I_{LIMIT} and DC_{MAX}. Line feed forward with DC_{MAX} reduction lowers maximum duty cycle from 78% at $I_{M(DC)}$ (+90 µA typical) to 38% at I_{OV} (+225 µA). External current limit is available only with negative MULTI-FUNCTION pin current. Please see graphs in the typical performance characteristics section for the current limit programming range and the selection of appropriate resistor value.

MULTI-FUNCTION PIN TABLE*

Figure Number ▶	13	14	15	16	17	18	19	20	21	22	23
Three Terminal Operation	✔										
Under-Voltage		✔	✔								✔
Overvoltage		✔		✔							✔
Line Feed Forward (DC_{MAX})		✔									✔
Line Feed Forward (I_{LIMIT})						✔					
External Current Limit					✔	✔			✔	✔	
Remote ON/OFF							✔	✔	✔	✔	✔

*This table is only a partial list of many MULTI-FUNCTION pin configurations that are possible.

Table 2. Typical MULTI-FUNCTION Pin Configurations.