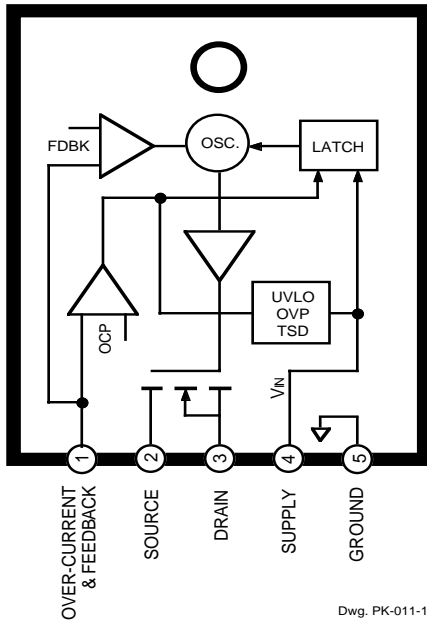


# Series STR-F6600

**INTERIM DATA SHEET**  
(Subject to change without notice)  
February 22, 2000

## OFF-LINE QUASI-RESONANT FLYBACK SWITCHING REGULATORS



### ABSOLUTE MAXIMUM RATINGS at $T_A = +25^\circ\text{C}$

Control Supply Voltage, $V_{IN}$ .....	35 V
Drain-Source Voltage, $V_{DS}$	
Series STR-F6620 .....	450 V
Series STR-F6630 .....	500 V
Series STR-F6650 .....	650 V
Series STR-F6670 .....	900 V
Drain Switching Current, $I_D$ ...	See Table
Peak Drain Current, $I_{DM}$ .....	See Table
Avalanche Energy, $E_{AS}$ .....	See Table
OCP/FB Voltage Range,	
$V_{OCP}$ .....	-0.3 V to +6 V
Package Power Dissipation, $P_D$	
control ( $V_{IN} \times I_{IN(ON)}$ ) .....	0.8 W
total .....	See Graph
FET Channel Temperature, $T_J$ ...	+150°C
Internal Frame Temperature, $T_F$ ...	+125°C
Operating Temperature Range,	
$T_A$ .....	-20°C to +125°C
Storage Temperature Range,	
$T_S$ .....	-40°C to +125°C

The Series STR-F6600 is specifically designed to satisfy the requirements for increased integration and reliability in off-line quasi-resonant flyback converters. The series incorporates a primary control and drive circuit with discrete avalanche-rated power MOSFETs.

Covering the power range from below 25 watts up to 300 watts for 100/115/230 VAC inputs, and up to 150 watts for 85 to 265 VAC universal input, these devices can be used in a range of applications, from battery chargers and set top boxes, to televisions, monitors, and industrial power supply units.

Cycle-by-cycle current limiting, under-voltage lockout with hysteresis, over-voltage protection, and thermal shutdown protects the power supply during the normal overload and fault conditions. Over-voltage protection and thermal shutdown are latched after a short delay. The latch may be reset by cycling the input supply. Low-current startup and a low-power standby mode selected from the secondary circuit completes a comprehensive suite of features. The series is provided in a five-pin overmolded TO-3P style package, affording dielectric isolation without compromising thermal characteristics.

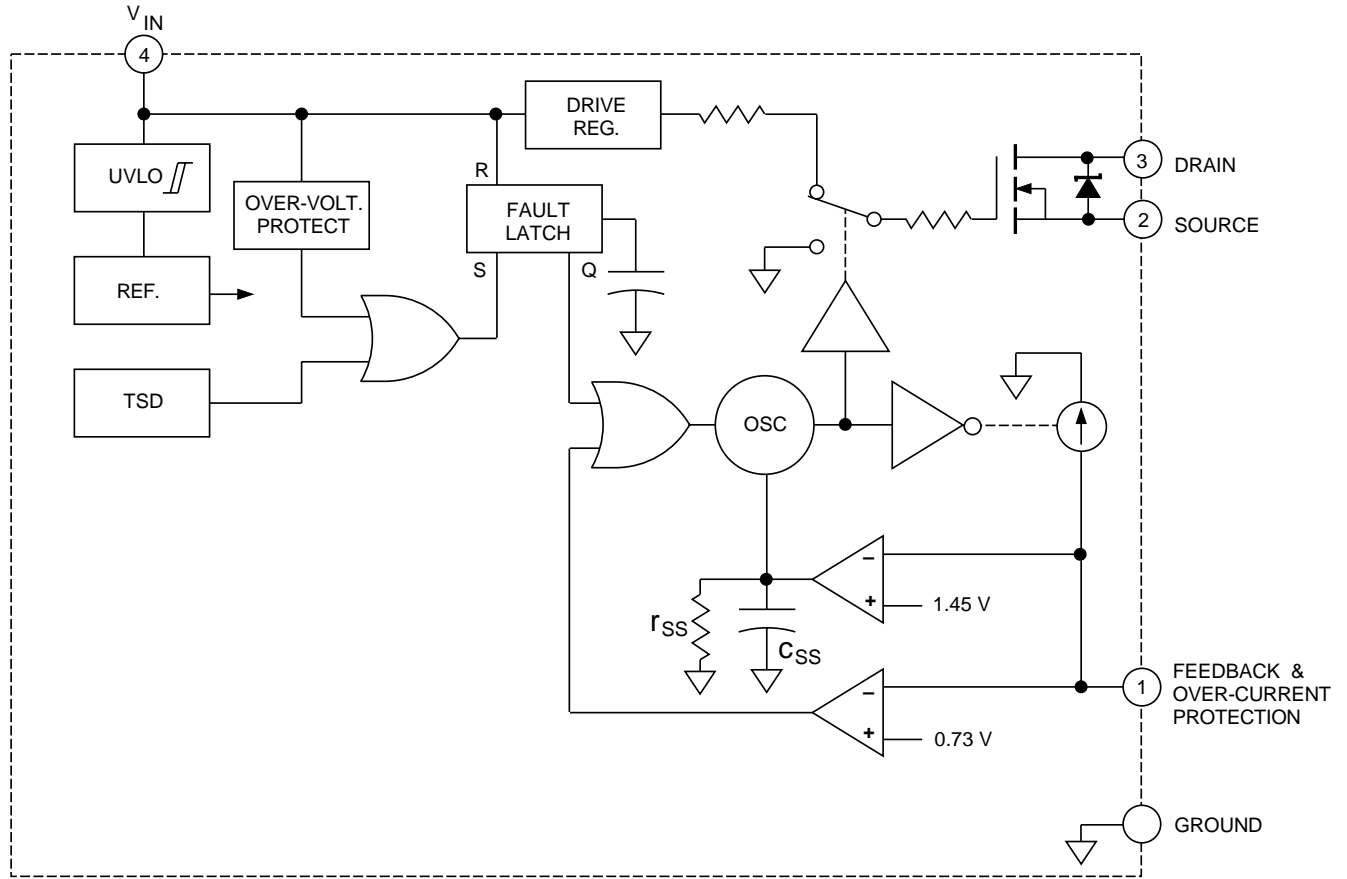
### FEATURES

- Flyback Operation with Quasi-Resonant Soft Switching for Low Power Dissipation and EMI
- Rugged Avalanche-Rated MOSFET
- Choice of MOSFET Voltage and  $r_{DS(on)}$
- Full Over-Current Protection (no blanking)
- Under-Voltage Lockout with Hysteresis
- Over-Voltage Protection
- Direct Voltage Feedback
- Low Start-up Current (<400  $\mu\text{A}$ )
- Low-Frequency, Low-Power Standby Operation
- Overmolded 5-Pin Package

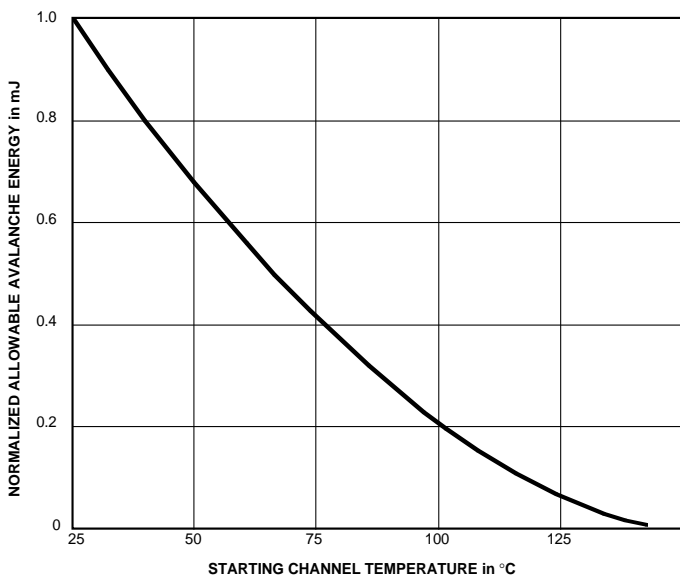
Always order by complete part number, e.g., **STR-F6652**.

**Series STR-F6600**  
**OFF-LINE**  
**QUASI-RESONANT FLYBACK**  
**SWITCHING REGULATORS**

**FUNCTIONAL BLOCK DIAGRAM**



Dwg. FK-002-6



Allowable package power dissipation curves are shown on page 10.

**Series STR-F6600**  
**OFF-LINE**  
**QUASI-RESONANT FLYBACK**  
**SWITCHING REGULATORS**

**OUTPUT MAXIMUM RATINGS at  $T_A = +25^\circ\text{C}$**

Part Number	$V_{DSS}$ (V)	$r_{DS(on)}$ ( $\Omega$ )	$E_{AS}$ (mJ)*	$I_D$ (A)†	$I_{DM}$ (A)	$P_{OUT}$ (W)	at $V_{IN}$ (V rms)
STR-F6624	450	0.92	204	16	19	98 130	100 120
STR-F6626	450	0.58	327	16	26	145 190	100 120
STR-F6628	450	0.35	647	22	36	225 290	100 120
STR-F6632	500	2.54	7.4	9.0	11.2	36 50	100 120
STR-F6652	650	2.8	126	7.9	10	40 86	85-265 220
STR-F6653	650	1.95	260	5.6	14	58 120	85-265 220
STR-F6654	650	1.15	399	9.7	18	92 190	85-265 220
STR-F6656	650	0.71	521	16	25	150 300	85-265 220
STR-F6672	900	7.7	163	4.6	6.4	25 (no heatsink) 50 (with heat sink)	220 220
STR-F6674	900	4.49	242	6.0	9.2	28 76	85-265 220
STR-F6676	900	2.81	275	7.8	12	44 115	85-265 220

\* Derate per graph, page 2

† Derate per graph, page 12

**Series STR-F6600**  
**OFF-LINE**  
**QUASI-RESONANT FLYBACK**  
**SWITCHING REGULATORS**

**ELECTRICAL CHARACTERISTICS at  $T_A = +25^\circ\text{C}$ ,  $V_{IN} = 18\text{ V}$  (unless otherwise specified).**

Characteristic	Symbol	Test Conditions	Limits			Units
			Min.	Typ.	Max.	
On-State Voltage	$V_{INT}$	Turn-on, increasing $V_{IN}$	14.4	16	17.6	V
Under-Voltage Lockout	$V_{INQ}$	Turn-off, decreasing $V_{IN}$	9.0	10	11	V
Over-Voltage Threshold	$V_{OVP(th)}$	Turn-off, increasing $V_{IN}$	20.5	22.5	24.5	V
Drain-Source Breakdown Voltage	$V_{BR(DSS)}$	$I_D = 300\ \mu\text{A}$	$V_{DS\ max}$	–	–	V
Drain Leakage Current	$I_{DSS}$	At $V_{DS\ max}$	–	–	300	$\mu\text{A}$
On-State Resistance	$r_{DS(ON)}$	$V_S = 10\text{ V}$ , $I_D = 0.9\text{ A}$ , $T_J = +25^\circ\text{C}$	–	–	see table	$\Omega$
Maximum Off Time	$t_{off}$	Drain waveform high	45	–	55	$\mu\text{s}$
Minimum Pulse Duration for Input of Quasi-Resonant Signals	$t_{w(th)}$	Drain waveform high <sup>1</sup>	–	–	1.0	$\mu\text{s}$
Minimum Off Time	$t_{off}$	Drain waveform high <sup>1</sup>	–	–	1.5	$\mu\text{s}$
Feedback Threshold Voltage	$V_{FDBK}$	Drain waveform low to high <sup>1</sup>	0.68	0.73	0.78	V
		Oscillation synchronized <sup>2</sup>	1.3	1.45	1.6	V
Over-Current Protection/Feedback Sink Current	$I_{OCP/FB}$	$V_{OCP/FB} = 1.0\text{ V}$	1.2	1.35	1.5	mA
Latch Holding Current	$I_{IN(OVP)}$	$V_{IN}$ reduced from 24.5 V to 8.5 V	–	–	400	$\mu\text{A}$
Latch Release Voltage	$V_{IN}$	$I_{IN} \leq 20\ \mu\text{A}$ , $V_{IN}$ reduced from 24.5 V	6.6	–	8.4	V
Switching Time	$t_f$	$V_{DD} = 200\text{ V}$ , $I_D = 0.9\text{ A}$	–	–	250	ns
Supply Current	$I_{IN(ON)}$	Operating <sup>3</sup>	–	–	30	mA
	$I_{IN(OFF)}$	Increasing $V_{IN}$ prior to oscillation	–	–	100	$\mu\text{A}$
Insulation RMS Voltage	$V_{WM(RMS)}$	All terminals simultaneous reference to a metal plate against the backside	2000	–	–	V
Thermal Resistance	$R_{\theta JM}$	Output channel to mounting frame	–	–	1.75	$^\circ\text{C/W}$
Thermal Shutdown	$T_J$		140	–	–	$^\circ\text{C}$

Notes: Typical Data is for design information only.

1. Feedback is square wave,  $V_{IM} = 2.2\text{ V}$ ,  $t_h = 1\ \mu\text{s}$ ,  $t_l = 35\ \mu\text{s}$ .

2. For quasi-resonant operation, the input signal must be longer than  $t_{w(th)}$  and greater than  $V_{FDBK}$ .

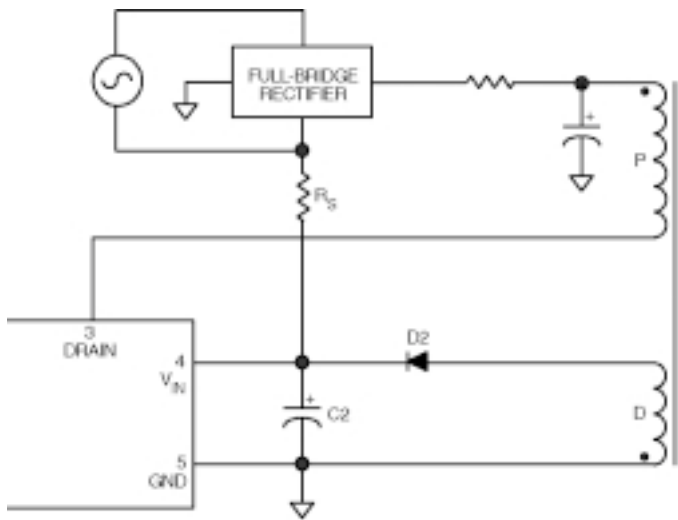
3. Feedback is square wave,  $V_{IM} = 2.2\text{ V}$ ,  $t_h = 4\ \mu\text{s}$ ,  $t_l = 1\ \mu\text{s}$ .

# Series STR-F6600 OFF-LINE QUASI-RESONANT FLYBACK SWITCHING REGULATORS

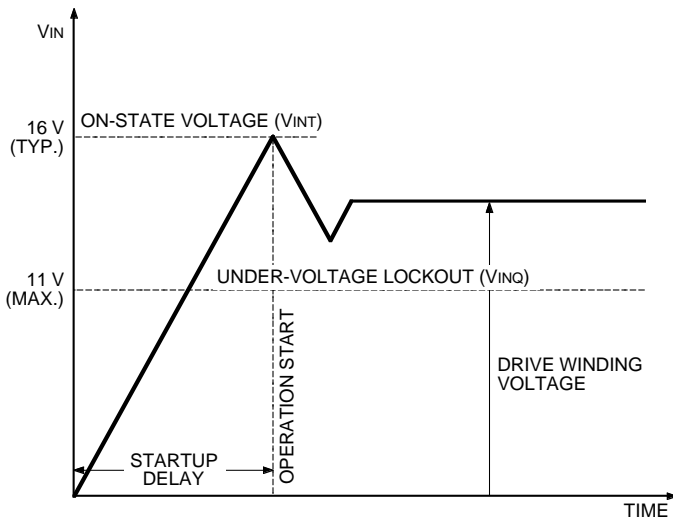
## Functional Description and Operation

The voltage on the  $V_{IN}$  terminal (pin 4) controls startup and shutdown of the Series STR-F6600 devices.

Figure 1 shows a typical start up circuit. The  $V_{IN}$  terminal voltage during startup is shown in figure 2.



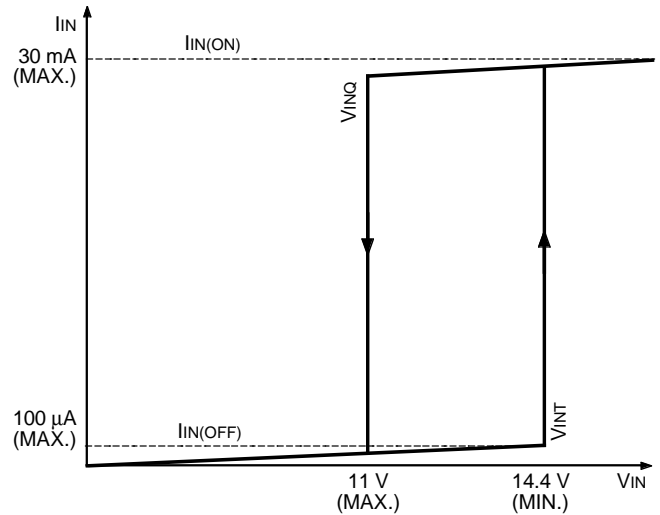
**Figure 1 – Start-Up Circuit**



**Figure 2 – Waveform of  $V_{IN}$  Terminal Voltage at Startup**

At startup, C2 is charged through the startup resistor  $R_S$ . When the  $V_{IN}$  terminal voltage reaches 16 V (typ.), the control circuit enables regulator operation. Once the regulator starts, it draws up to 30 mA from C2 causing the voltage on C2 to fall momentarily. Once the regulator output voltage is established, the drive winding D starts to charge C2 via D2. The voltage on C2 thus recovers to the nominal drive voltage (18 V).

As shown in figure 3, the input current is below 100  $\mu\text{A}$  (at  $T_M = 25^\circ\text{C}$ ) prior to control circuit turn on. The latch circuit holding current is 400  $\mu\text{A}$  (max.). To ensure latch operation, the current in  $R_S$  at the lowest ac input voltage should be at least 500  $\mu\text{A}$ .



**Figure 3 – Supply Terminal Current,  $I_{IN}$**

The value of  $R_S$  thus determines the charge time of C2 and thus the startup delay.  $R_S$  is typically 68 k $\Omega$  for wide operation (90 V ac to 265 V ac) and 100 k $\Omega$  for 220 volt ac operation.

The choice of C2 is a compromise between an acceptable startup delay (in conjunction with  $R_S$ ) and a hold-up time sufficient to keep pin 4 above its under-voltage shutdown threshold of 11 V. Typically C2 is in the range of 47  $\mu\text{F}$  to 100  $\mu\text{F}$ .

continued, next page...

# Series STR-F6600

## OFF-LINE

### QUASI-RESONANT FLYBACK

### SWITCHING REGULATORS

## Functional Description and Operation (cont'd)

The drive winding voltage is set such that in normal operation the C2 voltage is above the specified maximum shutdown voltage (11 V) and below the specified minimum over-voltage threshold (20.5 V).

In applications where there is a significant variation in load current, the  $V_{IN}$  terminal voltage may vary, as shown in figure 4. This is due to peak charging of C2. In this case, adding a resistor in the range of a few ohms to tens of ohms in series with the rectifier diode D2 will bring the voltage variation within limits.

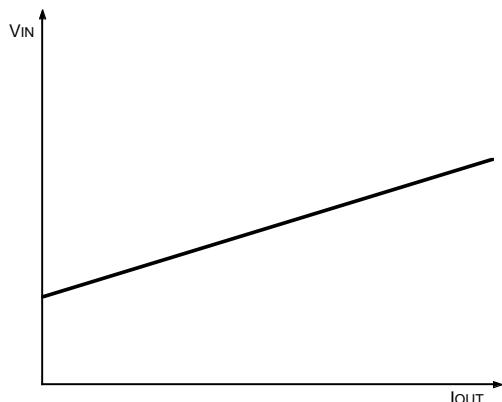


Figure 4 – Output Current  $I_{OUT}$  – Terminal Voltage  $V_{IN}$

### Soft Start, Quasi Resonant and Voltage Regulation

Refer to the Functional Block Diagram and the Typical Application Diagram (figure 6). The internal oscillator uses the charge/discharge of an internal 4700 pF capacitor ( $c_{SS}$ ) to generate the MOSFET drive signals.

The regulator has two modes of operation:

1. fixed 50  $\mu$ s off time (soft start) and
2. demagnetization sensing quasi-resonant mode — normal operation.

In both cases, voltage regulation is achieved by taking the composite optocoupled voltage error and superimposed drain current ramp (current-mode control) and comparing this to an internal 0.73 V reference. The FBK/OC

comparator output pre-terminates the oscillator, which turns off the MOSFET drive signal.

The MOSFET is turned on again when either  $c_{SS}$  discharges or a quasi-resonance signal is detected on pin 1.

### Fixed 50 $\mu$ s Off-Time: Soft-Start Mode

This is the mode of operation in the absence of a quasi-resonance signal on pin 1 (see figure 5), and occurs at

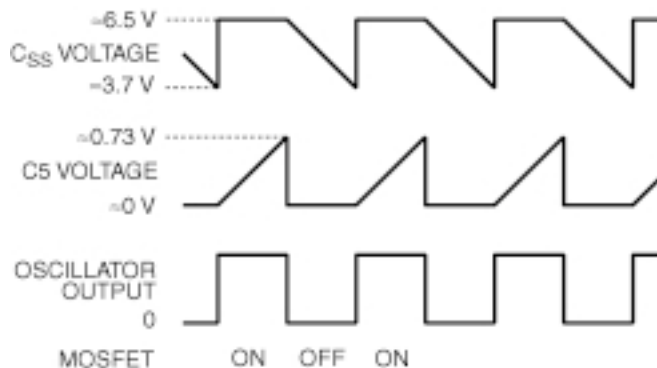


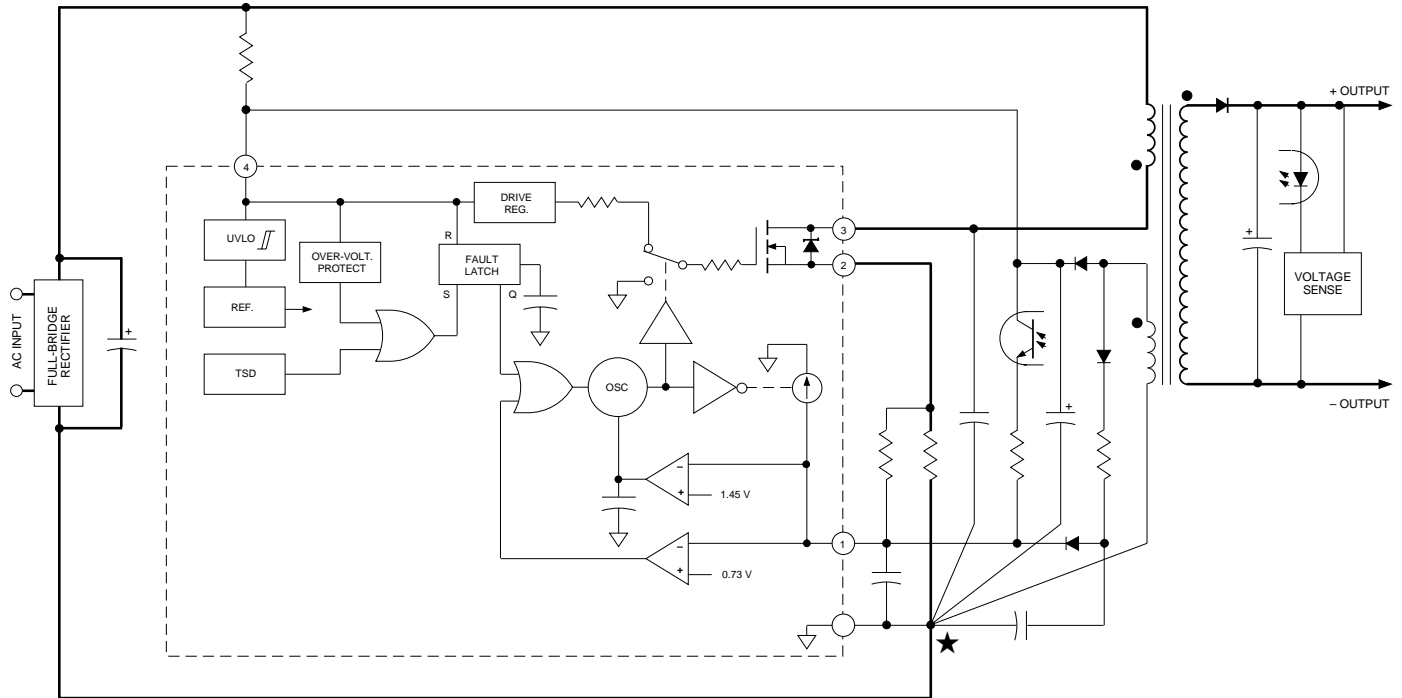
Figure 5 – Soft-Start Operation

startup and in overload. It also can be commanded externally to provide low-power standby operation.

In the absence of a feedback signal (such as at startup, or a short circuit) the drain current ramp, sensed across R5 and noise filtered by R4/C5 appears on pin 1. When the ramp voltage on C5 exceeds the 0.73 V reference signal, the FBK/OC

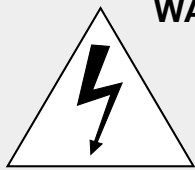
# Series STR-F6600 OFF-LINE QUASI-RESONANT FLYBACK SWITCHING REGULATORS

## Functional Description and Operation (cont'd)



Dwg. EK-003-5A

**Figure 6 – Series STR-F6600 Typical Application**



**WARNING** — These devices are designed to be operated at lethal voltages and energy levels. Circuit designs that embody these components must conform with applicable safety requirements. Precautions must be taken to prevent accidental contact with power-line potentials. Do not connect grounded test equipment.

The use of an isolation transformer is recommended during circuit development and breadboarding.

### Soft Start with Voltage Feedback (refer to figure 7)

Output voltage control is achieved by sensing the opto-coupled feedback current (proportional to the output voltage error signal) across resistor R4 and summing this with the drain current ramp on R5. The signal on pin 1 is therefore the opposite of the output voltage error signal and the drain current ramp. The dc bias signal across R4 is thus a function of the load. Consequently at light load, the bias signal on R4 is closer to the threshold voltage of the comparator.

To eliminate the possibility of false shutdown at MOSFET turn on (when there is a current spike due to the discharge of primary capacitance), a constant-current sink of 1.35 mA is turned on, effectively lowering the input impedance on pin 1, and momentarily increasing the shutdown threshold.