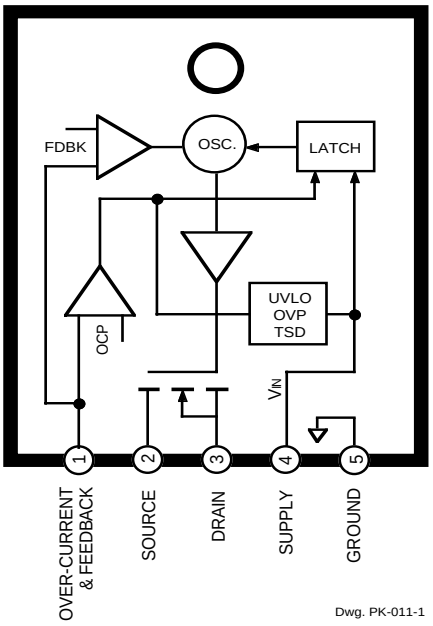
Series STR-F6600

Data Sheet
28102.8

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°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} x $I_{IN(ON)}$) . . . . . **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 µA)
- Low-Frequency, Low-Power Standby Operation
- Overmolded 5-Pin Package

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

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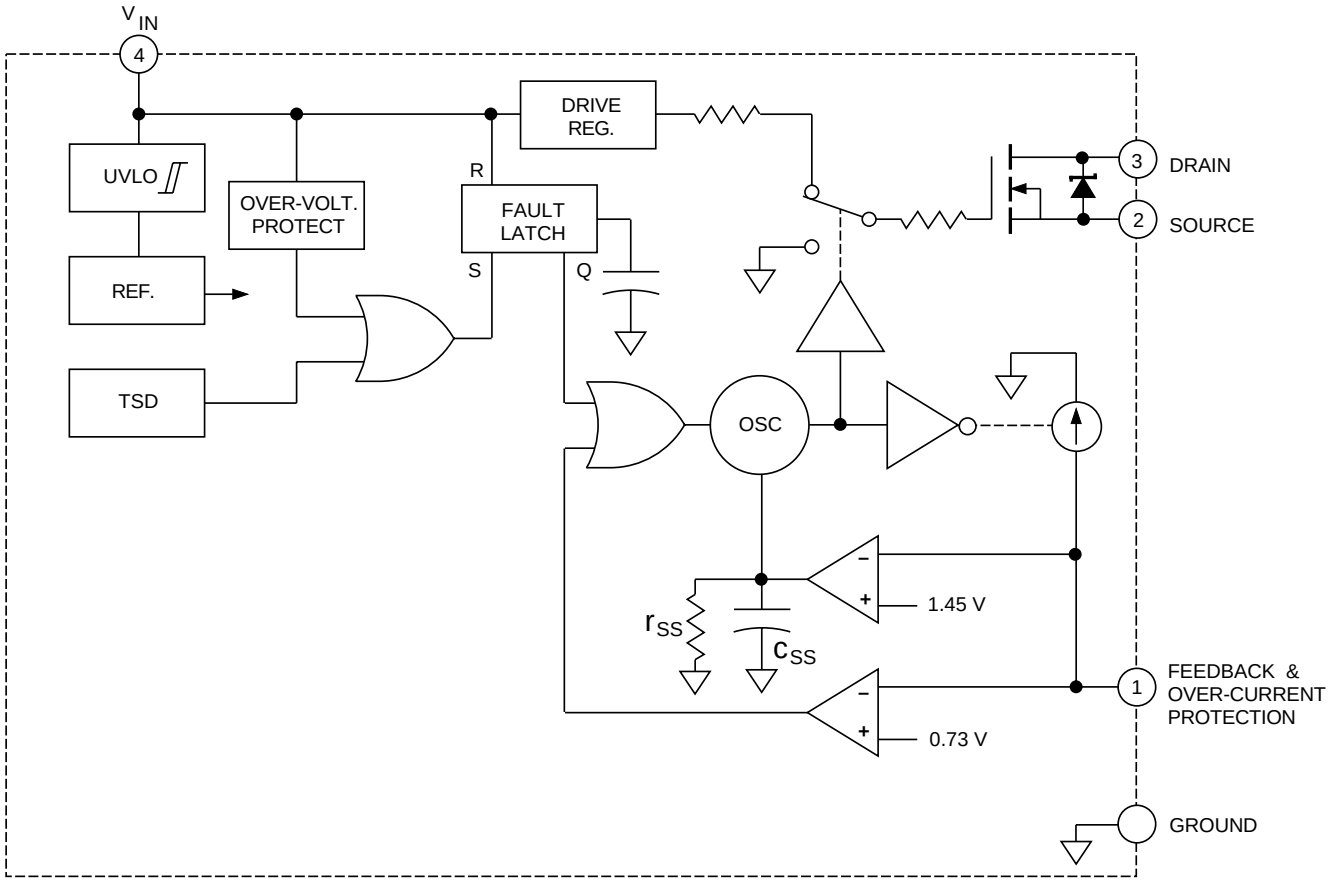
FUNCTIONAL BLOCK DIAGRAM



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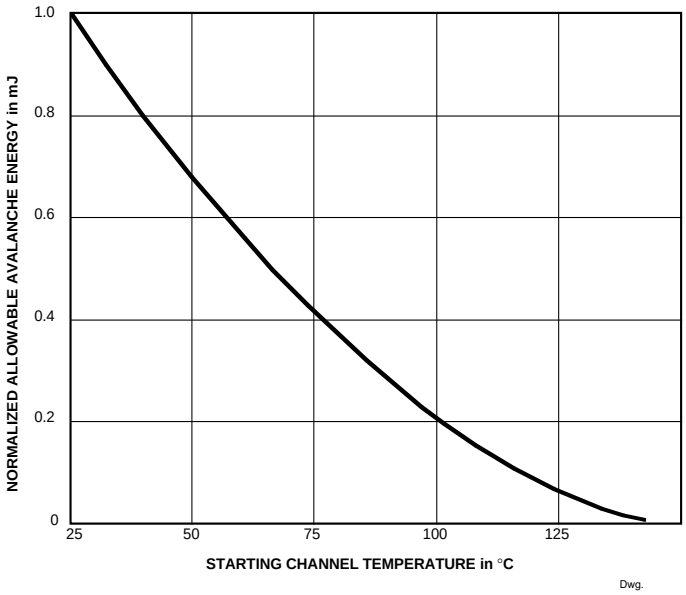

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Allowable package power dissipation curves are shown on page 10.

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OUTPUT MAXIMUM RATINGS at T_A = +25°C

Part Number	V_{DSS} (V)	$r_{DS(on)}$ (Ω)	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

ELECTRICAL CHARACTERISTICS at T_A = +25°C, V_{IN} = 18 V (unless otherwise specified).

Characteristic	Symbol	Test Conditions	Limits			
			Min.	Typ.	Max.	Units
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 µA	V_{DS} max	–	–	V
Drain Leakage Current	I_{DSS}	At V_{DS} max	–	–	300	µA
On-State Resistance	$r_{DS(ON)}$	V_S = 10 V, I_D = 0.9 A, T_J = +25°C	–	–	see table	Ω
Maximum Off Time	t_{off}	Drain waveform high	45	–	55	µs
Minimum Pulse Duration for Input of Quasi-Resonant Signals	$t_{w(th)}$	Drain waveform high[1]	–	–	1.0	µs
Minimum Off Time	t_{off}	Drain waveform high[1]	–	–	1.5	µs
Feedback Threshold Voltage	V_{FDBK}	Drain waveform low to high[1]	0.68	0.73	0.78	V
		Oscillation synchronized[2]	1.3	1.45	1.6	V
Over-Current Protection/Feedback Sink Current	$I_{OCP/FB}$	$V_{OCP/FB}$ = 1.0 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	µA
Latch Release Voltage	V_{IN}	$I_{IN} \leq$ 20 µA, V_{IN} reduced from 24.5 V	6.6	–	8.4	V
Switching Time	t_f	V_{DD} = 200 V, I_D = 0.9 A	–	–	250	ns
Supply Current	$I_{IN(ON)}$	Operating[3]	–	–	30	mA
	$I_{IN(OFF)}$	Increasing V_{IN} prior to oscillation	–	–	100	µA
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	°C/W
Thermal Shutdown	T_J		140	–	–	°C

Notes: Typical Data is for design information only.

1. Feedback is square wave, V_{IM} = 2.2 V, t_h = 1 µs, t_l = 35 µs.
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 V, t_h = 4 µs, t_l = 1 µs.

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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.

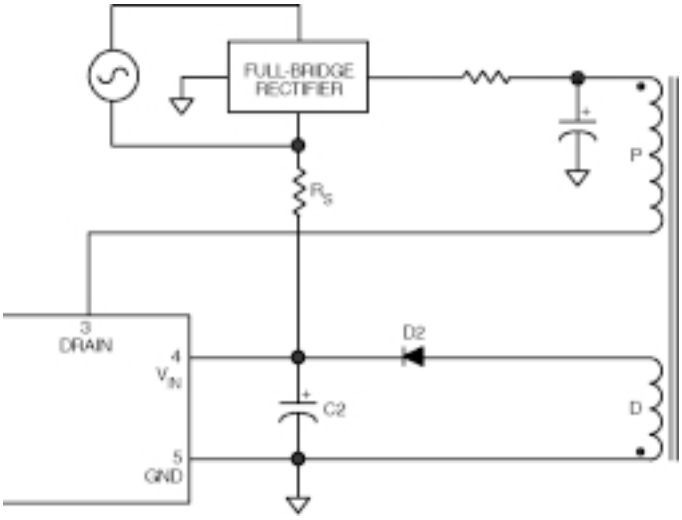

Figure 1 – Start-Up Circuit

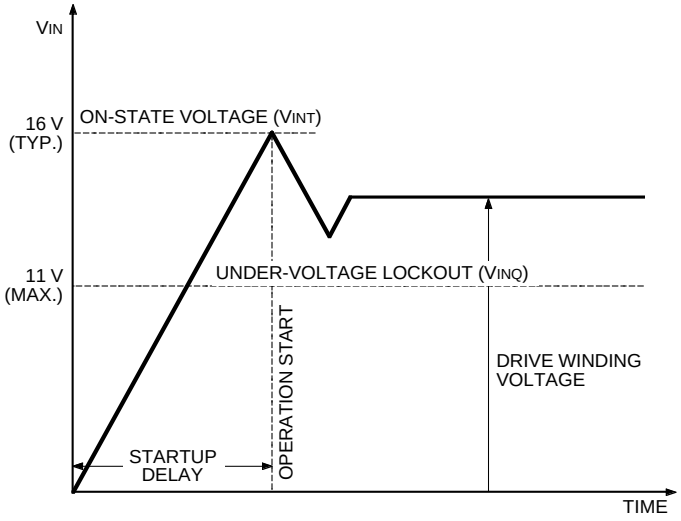

Figure 2 – Waveform of V_{IN} Terminal Voltage at Startup

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

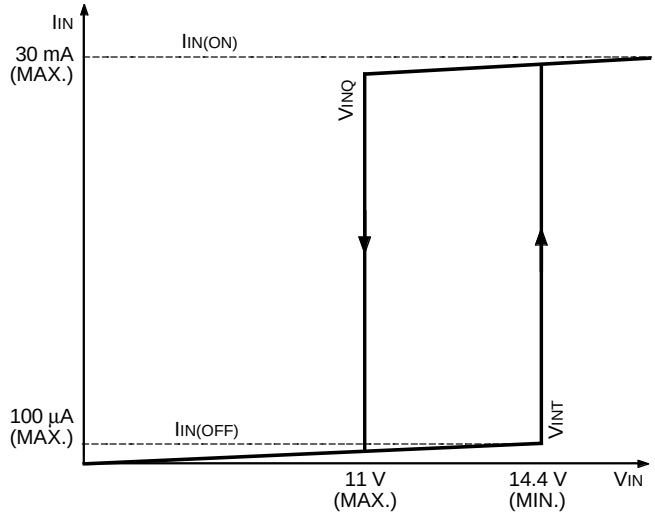

Figure 3 – Supply Terminal Current, I_{IN}

The value of R_S thus determines the charge time of C2 and thus the startup delay. R_S is typicaly 68 kΩ for wide operation (90 V ac to 265 V ac) and 100 kΩ 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 µF to 100 µF.

continued, next page...

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.

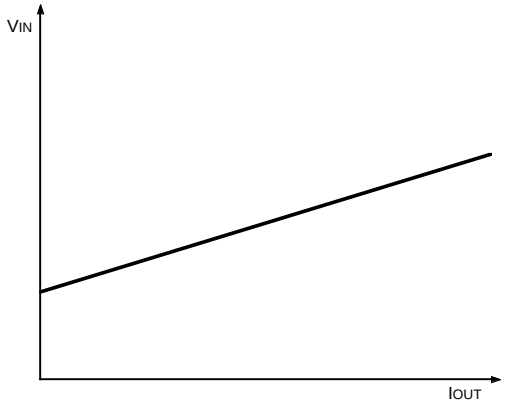

Figure 4 – Output Current I_{OUT} – Terminal Voltage V_{IN}

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 µs 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/OCP 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 µs 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

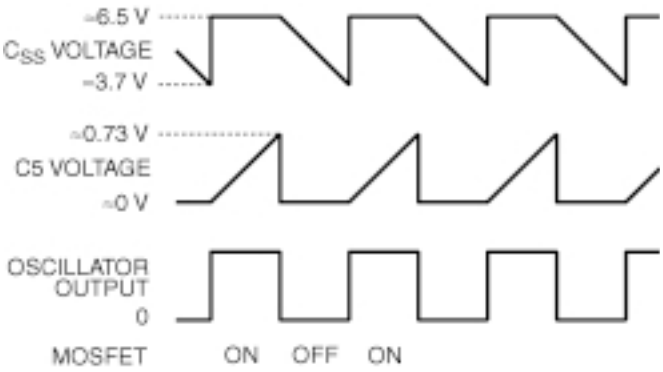

Figure 5 – Soft-Start Operation

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/OCP comparator changes state, shutting down the oscillator and turning off the MOSFET. Thus the voltage on c_{SS} is held high (6.5 V) by the comparator. When the comparator changes state, c_{SS} discharges via r_{SS}; the voltage on c_{SS} ramps down until it reaches 3.7 V. The oscillator turns on the MOSFET. This ramp-down time is internally trimmed to 50 µs. The comparator changes state again and the cycle repeats. Thus in the absence of feedback, the current-sense resistor R5 accurately controls the MOSFET maximum current.

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Functional Description and Operation (cont'd)

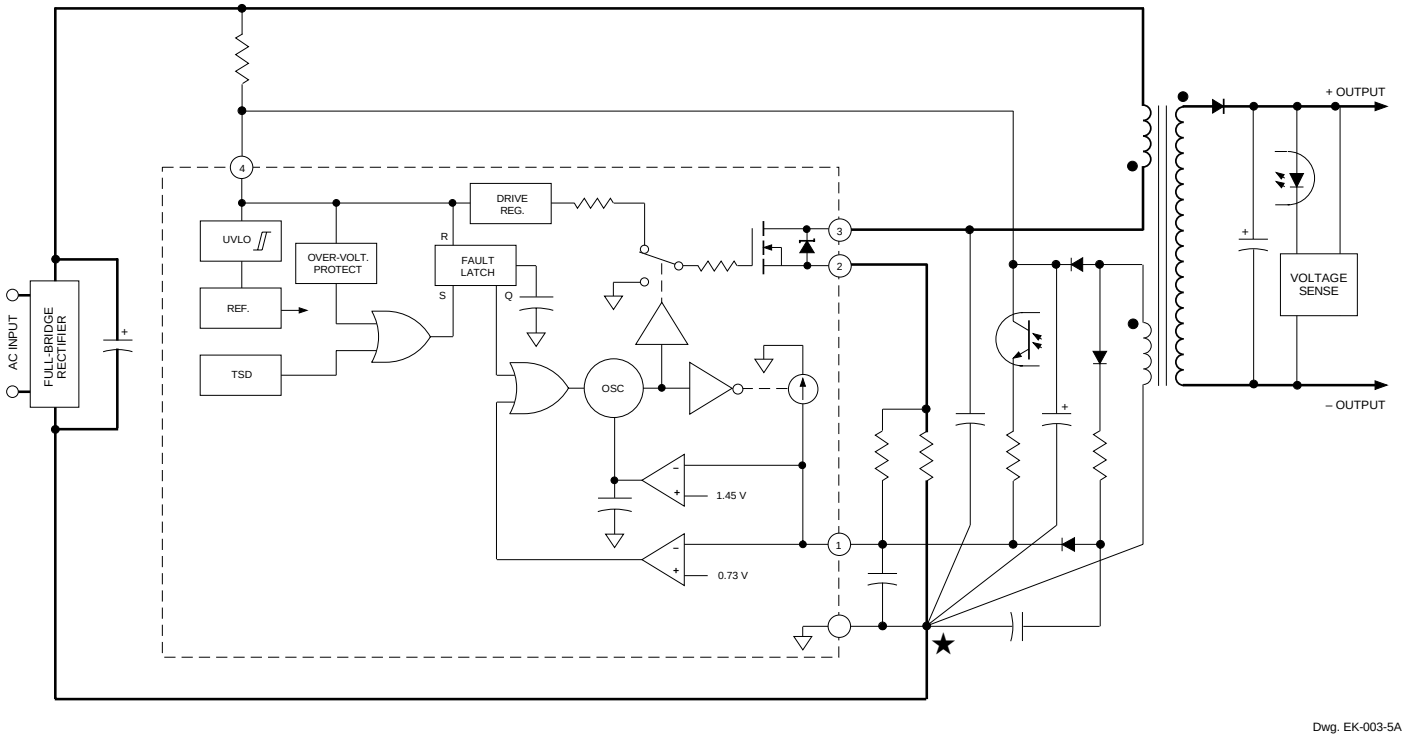

Figure 6 – Series STR-F6600 Typical Application

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.