Design Idea DI-41

TOPSwitch®-GX 43 W, 100/115 VAC Multi-output Set-top Box Power Supply

Application	Device	Power Output	Input Voltage	Output Voltage	Topology
Set-top Box	TOP247Y	43 W cont. / 57 W pk	90-132 VAC	3.3 V, 5 V, 12 V, 18 V, 33 V	Flyback

Design Highlights

- Low cost, low component count solution
- Excellent output voltage tracking and cross-regulation - no linear regulators required
- High efficiency, >71% at 90 VAC
- Line undervoltage detection (UV) and power system surge protection (OV)
- Meets CISPR22B/EN55022B conducted EMI limits
- Differential and common mode surge immunity to 4 kV (EN61000-4-5)
- 100 kHz ring wave immunity to 4 kV (IEEE C62.41)

Operation

The design in Figure 1 utilizes the TOP247Y and takes advantage of many of the *TOPSwitch-GX* features. Line UV and OV (100 V and 450 V, respectively) are implemented using a single 2 MΩ resistor (R1). Undervoltage eliminates output glitches and overvoltage provides protection for both short duration transients and long duration power system surges. Resistor R4 programs the internal current limit of U1 to 80% of nominal, limiting overload power.

The key performance characteristic of the circuit shown is the excellent output voltage tracking and cross-regulation. Two techniques are used to properly center the output voltages. The extra voltage drop of the ultra-fast rectifier D10 (used instead of a Schottky) centers the 5 V output at precisely 5 V

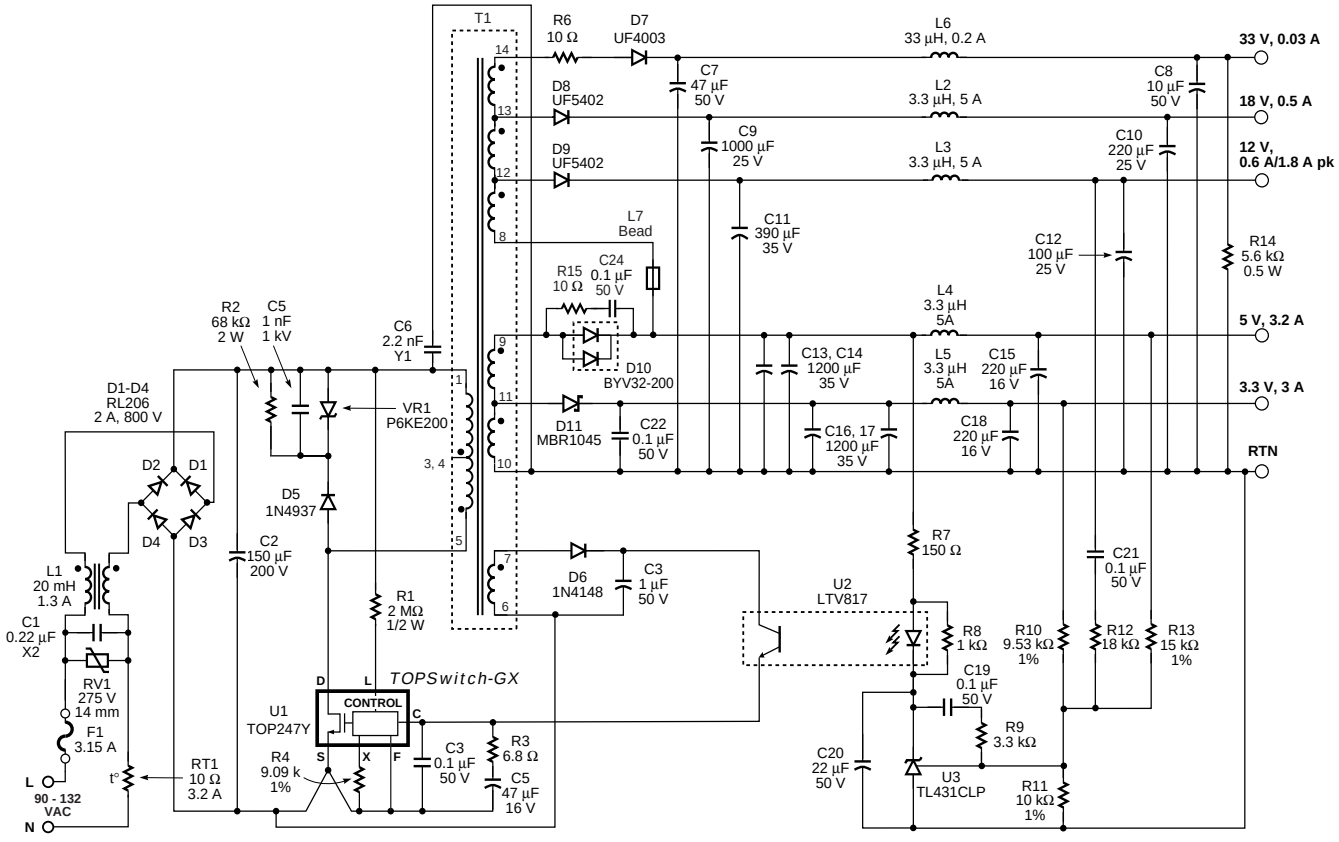

Figure 1. TOPSwitch-GX 43 W Continuous, 57 W Peak Set-Top Box Power Supply.

and DC stacking is used to improve the regulation of 12 V, 18 V, and 30 V outputs. Ferrite bead L7 is placed in series with the 12 V, 18 V and 30 V output windings to improve centering and cross-regulation of these outputs.

Frequency jittering provides large EMI margins with simple filtering. Primary soft-start minimizes component stress during start-up and a soft-finish capacitor (C20) eliminates start-up output overshoot.

Key Design Points

- Use K_{RP} (Ripple-to-peak current ratio) in the range of 0.4–0.6 for higher efficiency, and tighter cross-regulation. Use V_{OR} (reflected output voltage) of 90 V to 110 V for optimum performance.
- PCB traces which carry high switching currents should be short and wide to reduce EMI.
- Reduce leakage inductance and improve cross-regulation by filling each winding layer across the entire width of the bobbin.
- Resistor R14 provides a small amount of pre-load on the 33 V output to prevent peak charging due to leakage spikes.
- R5 and C5 reduce power dissipation in VR1.

Voltage (V)	Load Range (Amp)	Regulation (%)											
		-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3
3.3	1-3												
5	1-3.2												
12	0.3-0.6												
30	0.01-0.03												

Table 2. Worst Case Output Cross Regulation - Outputs Taken from Minimum to Maximum Load and Line from 85 VAC to 132 VAC.

TRANSFORMER PARAMETERS	
Core Material	ERL28, Nippon ceramic NC-2H material or equivalent, gapped for A_{LG} = 128 nH/T^2
Bobbin	ERL28 vertical, 14 pins, Jinbo Industrial JB-0039 or equivalent
Winding Details	Primary: 30T + 23T, 25 AWG Shield: 1T, 0.6" x 0.001" Cu foil Bias: 7T, 2 x 27 AWG 3.3 V: 2T, 0.6" x 0.005" Cu foil 5 V: 1T, 0.6" x 0.005" Cu foil 12 V: 4T, 2 x 27 AWG 18 V: 3T, 2 x 27 AWG 33 V: 6T, 27 AWG (2 x 27 AWG = Bifilar 27 AWG)
Winding Order (Pin Numbers)	Apply 3.2 mm tape margin to both sides of bobbin Primary (4-3), tape, Shield (1-NC), tape, Bias (6-7), 3 x tape, 5 V (9-11), 3.3 V (11-10), tape, 12 V (12-8), 18 V (13-12), 33 V (14-13), 3 x tape, Primary (3-1), 3 x tape
Inductance	Primary: 356 µH, Leakage: 11 µH (maximum)
Primary Resonant Frequency	650 kHz (minimum)

Table 1. Transformer Design Parameters.

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