

Design Idea DI-9

TOPSwitch-FX[®]

Set-top Box (multiple output)



Application	Device	Power Output	Input Voltage	Output Voltage	Topology
Set-top Box	TOP233Y	35 W	230 VAC	3.3 V / 5 V / 18 V / 30 V / -5 V	Flyback

Design Highlights

- High efficiency (>77%)
- Good cross regulation with no linear regulators
- Can deliver 20 W with universal input voltage range
- 132 kHz allow smaller transformer size (EEL25)
- Line under-voltage (UV) and power system surge protection (OV)
- Meets CISPR22 B / EN55022B
- Surge requirements of IEC1000-4-5 (1.2/50 μ s) to:
 - 6 kV differential mode / 4 kV common mode
- Ring wave immunity (IEEE C62.41) to 4 kV

Key Design Points

- R1 (2 M Ω , 1/2 W) sets UV at 100 VDC and OV at 450 VDC. A 1/2 W resistor is required to give a voltage rating $\geq$ 350 VDC.
- OV shut-down protects against long duration line voltage surges (common in some countries). During shut-down the drain voltage does not exceed the DC input voltage (no

output reflected or leakage inductance spike voltages) allowing the AC rail to rise to 495 VAC (700 VDC BV_{DSS} rating) without damaging the TOPSwitch-FX.

- The transformer turns ratio was optimized (including output diode forward drops) to minimize the output voltage error between the 3.3 V and 5 V outputs.
- Feedback is taken from both the 3.3 V and 5 V outputs to the reference (U3) via R9, R10 and R11. Other output voltages are set by the transformer turns ratio. The low power -5 V output is shunt regulated by R5 and Zener diode D13. Pre-load resistor R12 is required to maintain regulation of the 30 V output when lightly loaded.
- A soft-finish characteristic is provided by C17, eliminating output overshoot.
- Second stage LC post-filtering was used on the 3.3 V, 5 V and 18 V high power outputs for low output ripple (L2, L3, L4 and C10, C12, C14).
- Primary clamp components VR1 and D6 limit the leakage inductance induced peak drain voltage to a safe value. A lower value of VR1 (170 V) improves cross regulation by reducing secondary leakage inductance

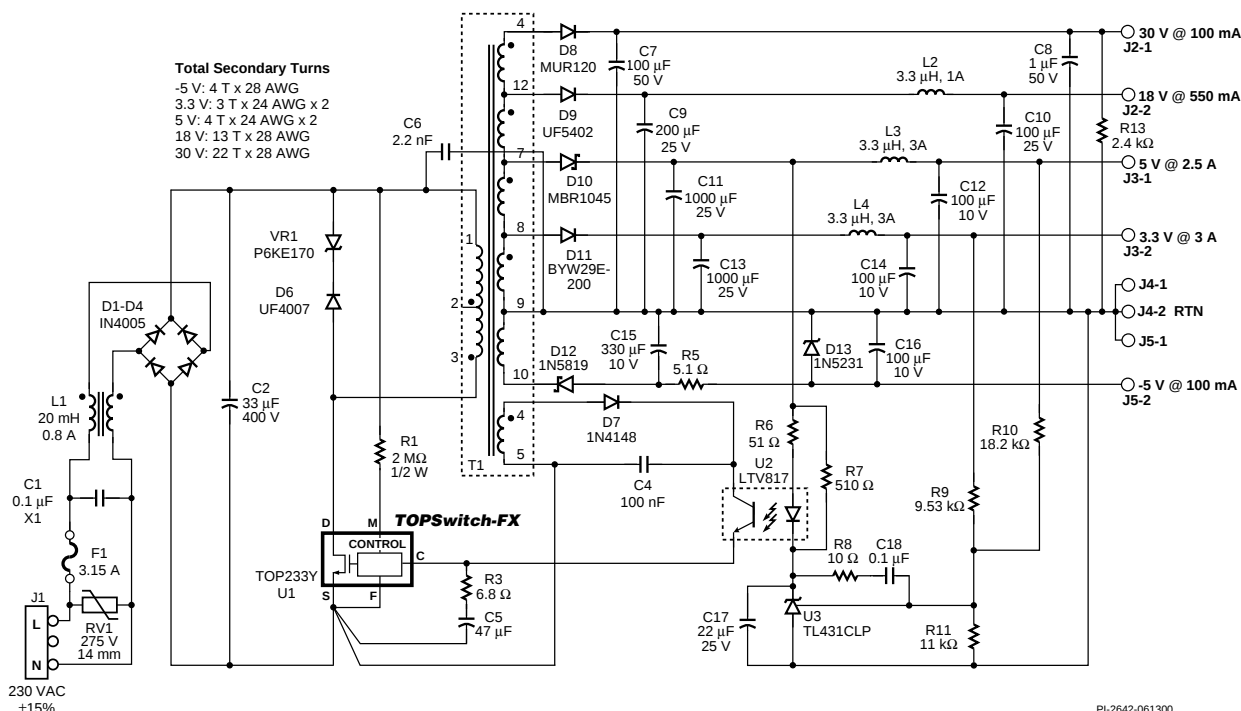


Figure 1. TOPSwitch-FX 35 W Set-top box supply schematic

PI-2642-061300

spikes. This is only possible due to a low V_{OR} of 116 V at the expense of slightly higher clamp dissipation.

- Extended duty cycle range allows low value input capacitor (33 μ F for 20 W universal input).
- Jittering provides large EMI margins with simple EMI filtering.

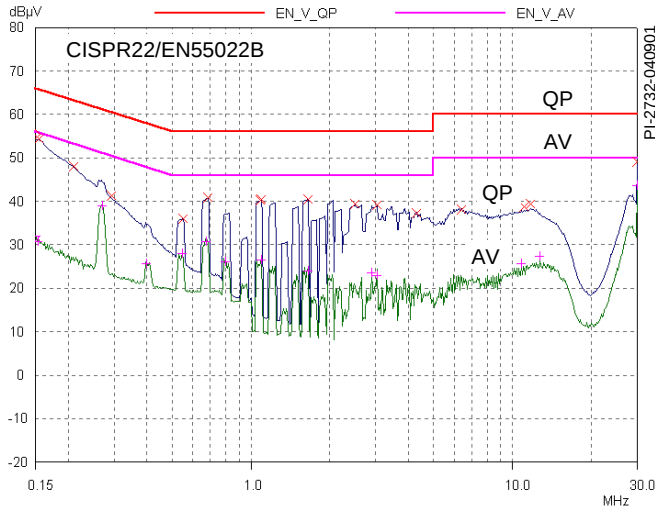


Figure 2. Conducted EMI (230 VAC, 35 W)

	3.3 V	5.1 V	18 V	30 V	-5 V
Min.	3.15	4.91	17.24	28.71	-4.93
Max.	3.36	5.34	19.01	30.76	-5.23
Spec.	± 0.16	± 0.25	± 1.35	± 2.25	± 0.375

Table 1. Output cross regulation
(all outputs from min to max load, 20 samples)

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Transformer Parameters

Core Material	Nicera EEL25.4 NC-2H or equiv. Gap for A_L of 155 nH/T ²
Bobbin	Yih Hwa YW-384 or equivalent
Winding Order	Half primary (3-2), Bias (4-5), 3 layers tape, 30 V (11-12), 18 V (12-7), 1 layer tape, 5 V bifilar (7-9), 3.3 V bifilar (8-9), -5 V (9-10), 3 layers tape, Half primary (2-1), 1 layer tape
Primary Inductance (pins 1-3, all others open)	1100 μ H $\pm 10\%$
Primary Resonant Frequency (pins 1-2, all others open)	1.5 MHz (minimum)
Leakage Inductance (pin 1-2, with pins 5-7 shorted)	12 μ H (maximum)

Table 2. Transformer construction information

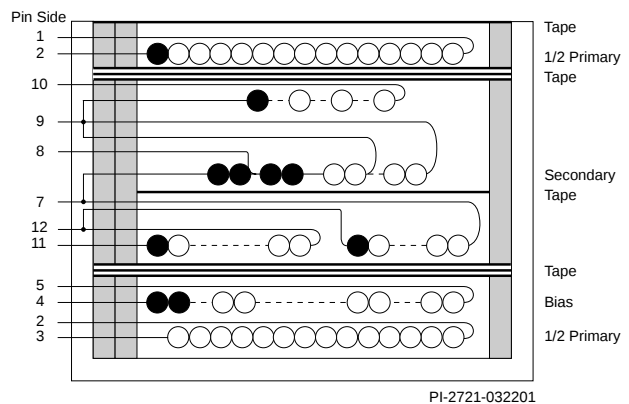


Figure 3. Transformer build diagram