Data Sheet
Rev PrA, 6/2006

ACT50

Green Power Off-Line PWM Controller ActiveSwitcher™ IC Family

FEATURES

- Less than 300mW Standby Power:
  Exceeds the Latest CEC, Blue Angle and Energy Star Requirements
- Supports NPN Emitter-Drive for Lowest Total Solution Cost
- Fast Response Current Mode PWM
- Very Low Line/Load Regulation
- 65kHz Switching Frequency
- Line Compensation
- Programmable Current Limit
- 50µA Start Up Current
- Tiny SOT23-5 and DIP-8 Packages

APPLICATIONS

- Battery Chargers
- Power Adapters
- Standby Power Supplies
- Appliances
- Universal Off-Line Power Supplies

GENERAL DESCRIPTION

The ACT50 is a compact, high performance off-line power supply controller that is ideal for use in next generation high performance universal input adapters and chargers. The ACT50 features an advanced current-mode PWM control architecture that achieves the smallest form-factor and fast transient response yet requires less than 300mW of standby power, surpassing even the latest requirements of the California Energy Commission (CEC), the European Union Blue Angel, and US Energy Star standards.

The ACT50 is optimized for use in the flyback topology, and requires just a low cost optocoupler and reference device, such as the '431, to provide fully adjustable CC/CV operation.

This device additionally features a proprietary low EMI driver that can be compatible with both external MOSFET and NPN transistors, and supports emitter-switching to achieve the lowest possible solution cost.

The ACT50 is available in tiny SOT23-5 or DIP-8 packages.

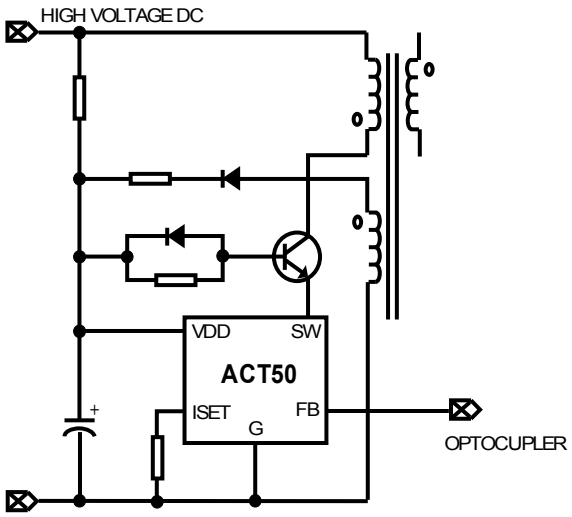
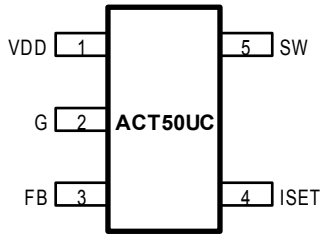


Figure 1. Simplified Application Circuit

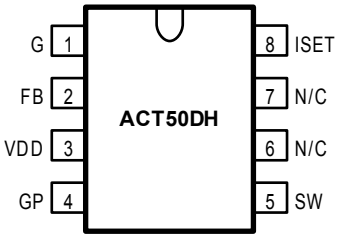
ORDERING INFORMATION

PART NUMBER	TEMPERATURE RANGE	PACKAGE	PINS	PACKING
ACT50UC-T	-40°C to 85°C	SOT23-5	5	TAPE & REEL
ACT50DH	-40°C to 85°C	DIP-8	8	TUBE

PIN CONFIGURATION



SOT23-5



DIP-8

PIN DESCRIPTION

PIN NUMBER		PIN NAME	PIN DESCRIPTION
SOT23-5	DIP-8		
1	3	VDD	Supply Input. VDD is internally clamped at 16.5V.
2	1	G	Ground.
—	4	GP	Power Ground. Always connect to G (for DIP-8 package only).
3	2	FB	Feedback Input. Current flows out of FB into the optocoupler.
4	8	ISET	Current Limit Programming Pin. Connect an external resistor from ISET to G to program the current limit.
5	5	SW	Emitter Drive Switching Node.

ABSOLUTE MAXIMUM RATINGS

(Note: Exceeding these limits may damage the device. Exposure to absolute maximum rating conditions for long periods may affect device reliability.)

PARAMETER	VALUE	UNIT
VDD to G	-0.3 to 16.5	V
VDD Current	20	mA
FB, ISET to G	-0.3 to 6	V
SW to G	-0.3 to 18	V
Continuous SW Current	1.8	A
Maximum Power Dissipation	0.4	W
Junction to Ambient Thermal Resistance (θ_{JA})	190	°C/W
Operating Junction Temperature	-40 to 150	°C
Storage Temperature	-55 to 150	°C

ELECTRICAL CHARACTERISTICS

(VDD = 14V, T_A = 25°C unless otherwise specified.)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
VDD Turn-On Voltage	V_{DDON}	Rising edge	12	13	14	V
VDD Turn-Off Voltage	V_{DDOFF}	Falling edge	10	11	12	V
VDD Clamp Voltage	V_{CLAMP}	I_{DD} = 5mA	15.5	16.5	17.5	V
Supply Current	I_{DD}	After turn on		0.9	2	mA
	I_{DDSU}	Before turn on		50	100	µA
	$I_{DDHICCUP}$	Hiccup and before turn on		70	140	µA
Switching Frequency	f_{SW}		50	65	85	kHz
FB Open Loop Clamp Voltage	V_{FBC}	I_{FB} = 0, R_{ISET} = 25kΩ	2.8	3.2	3.6	V
FB Input Impedance	Z_{FB}			4		kΩ
FB Bias Current	I_{FB}	V_{FB} = 0, R_{ISET} = 25kΩ		500	800	µA
Maximum Duty Cycle	D_{MAX}	I_{SW} = 10mA	67	75	83	%
Minimum Duty Cycle	D_{MIN}	I_{SW} = 100mA		3.5		%
Current Limit	I_{LIM}	R_{ISET} = 25kΩ	1.2	1.5	1.8	A
Switch On-Resistance	R_{SW}	ISW = 100mA	0.5	0.9	2	Ω
SW Rise Time	t_R	1nF load, 15Ω pull-up		60		ns
SW Fall Time	t_F	1nF load, 15Ω pull-up		40		ns
SW Switch Off Current	I_{SWOFF}	Switch in off-state, V_{SW} = 16V		1	10	µA

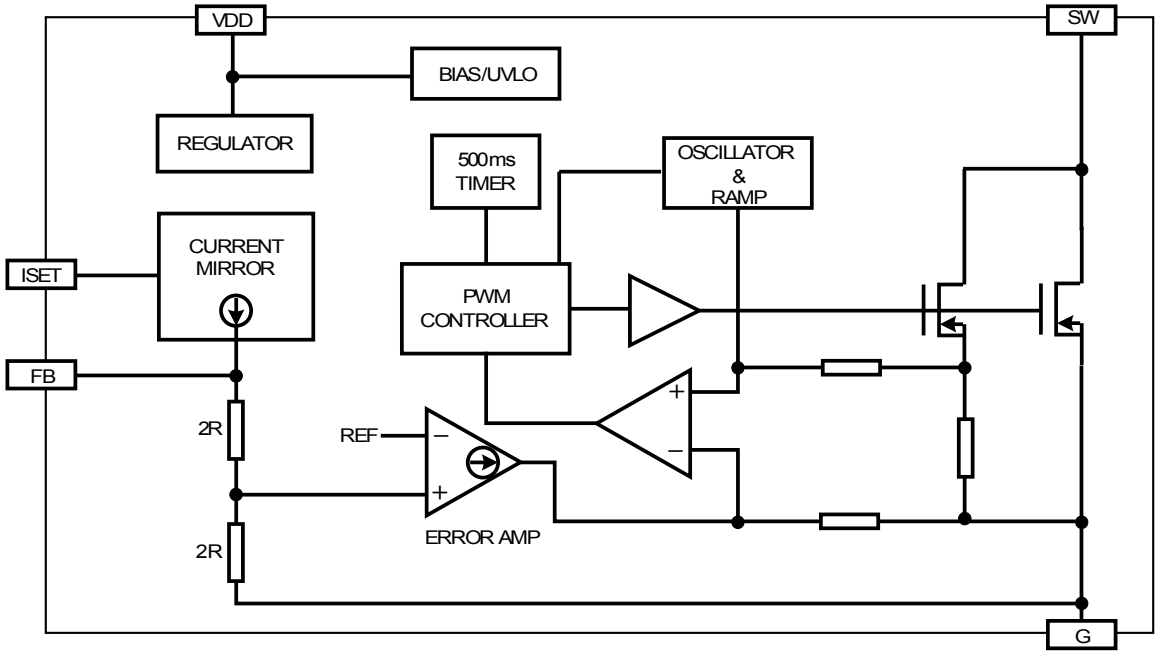


Figure 2. Functional Block Diagram

FUNCTIONAL DESCRIPTION

Figure 2 shows the *Functional Block Diagram* of the ACT50. The main components include current-mode switching control, two on-chip medium-voltage power-MOSFETs with parallel current sensor, an oscillator and ramp current generator, error amp, error comparator, 500ms timer, bias and under voltage lockout, and regulator circuitry.

One of the ACT50's key features is its proprietary driver circuitry that can drive either an external N-channel MOSFET or the emitter of an external high voltage NPN transistor. This emitter-driving scheme takes advantage of the high V_{CBO} of NPN transistors, allowing a low cost transistor such as '13003 (V_{CBO} = 700V) or '13002 (V_{CBO} = 600V) to be used for a wide AC input range. This driver also features slew-rate limiting, which when coupled with the turn-off characteristics of an external NPN results in extremely low EMI.

STARTUP SEQUENCE

Figure 1 shows a *Simplified Application Circuit* for the ACT50. During startup, a small current flows through resistor R1 to charge the capacitor C1, increasing the voltage at VDD as well as the voltage at SW through the NPN. The ACT50 begins switching when VDD reaches 13V, and the optocoupler feedback network engages to control the loop as the output voltage reaches the regulation point. The circuit of Figure 1 also utilizes an auxiliary winding to maintain the voltage on C1, providing a further improvement in efficiency.

Choose the proper value of the startup resistor (R1) as a compromise between standby power consumption. Values of up to 2MΩ can be used to achieve very low startup current.

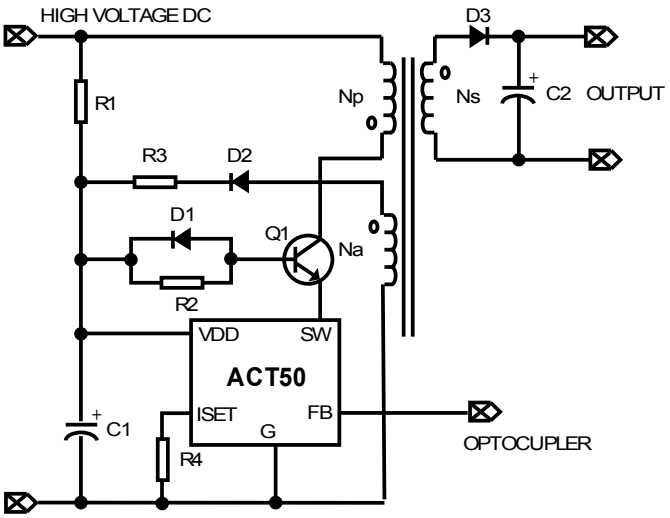


Figure 3. Connection Diagram

ADAPTIVE PWM CONTROL SCHEME

The ACT50's current-mode PWM control circuitry automatically switches operating modes to optimize efficiency across its full output load current range.

Under normal operating conditions, the optocoupler transmits a feedback signal from the secondary side of the transformer as a current injected into the FB pin. The ACT50's current-mode PWM control architecture uses this signal to provide cycle-by-cycle switching control. This results in fixed-frequency operation that achieves excellent line and load transient response.

At light loads, the ACT50 delivers a fixed amount of energy to the output during each switching cycle, resulting in low power pulse-skipping operation that reduces typical standby power consumption to below just 300mW.

At extreme load conditions, such as when the output is short circuited, the ACT50 enters hiccup mode operation to protect itself and the load. Under short circuit conditions, the auxiliary winding is unable to maintain charge on C1, resulting in a collapse of the voltage at VDD. The ACT50 stops switching when VDD drops below 11V, and does not resume switching for the longer of either 500ms or the time required for R1 to charge C1 to above 13V, after which the ACT50 will attempt to resume normal operation. If the short circuit condition persists, the ACT50 will operate in this “hiccup” mode until the short circuit is removed.

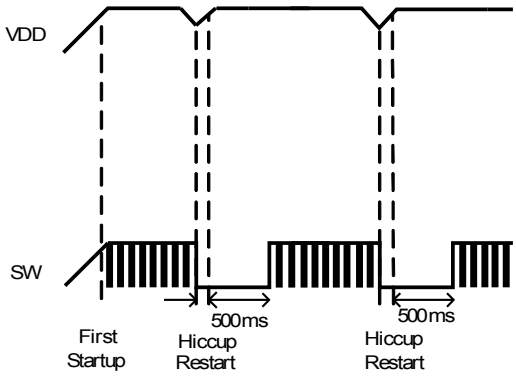


Figure 4. Hiccup Operation

APPLICATION INFORMATION

EXTERNAL POWER TRANSISTOR

The ACT50 allows a low cost high voltage power NPN transistor such as '13003 or '13002 to be used safely in flyback configuration. The required collector voltage rating for V_{AC} = 265V with full output load is at least 600V to 700V. As seen from Figure 5, *NPN Reverse Bias Safe Operation Area*, the breakdown voltage of an NPN is significantly improved when it is driven at its emitter. Table 1 lists the breakdown voltage of some transistors appropriate for use with the ACT50.

Table 1. Recommended Power Transistors List

DEVICE	V_{CBO}	V_{CEO}	I_C	H_{FEMIN}	PACKAGE
MJE13002	600V	300V	1.5A	8	TO-126
MJE13003, KSE13003	700V	400V	1.5A	8	TO-126
STX13003	700V	400V	1A	8	TO-92

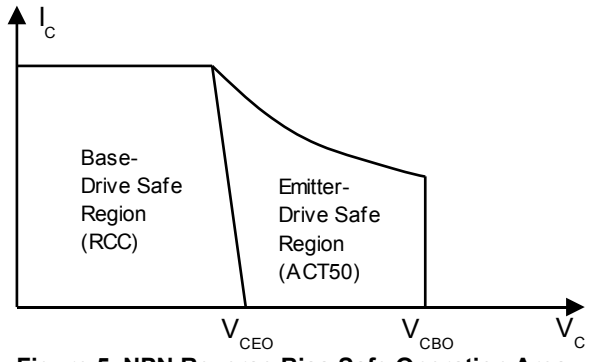


Figure 5. NPN Reverse Bias Safe Operation Area

OUTPUT POWER

The maximum power that can be delivered from the ACT50 depends on several factors including the AC line voltage, the power handling capability of the external high voltage transistor, the thermal design of the system, and transformer construction.

The maximum output power is a function of the current limit, which is programmed by connecting an external resistor (R_{ISET}) from ISET to G. Refer to Figure 6 for more information about the relationship between current limit and R_{ISET}.

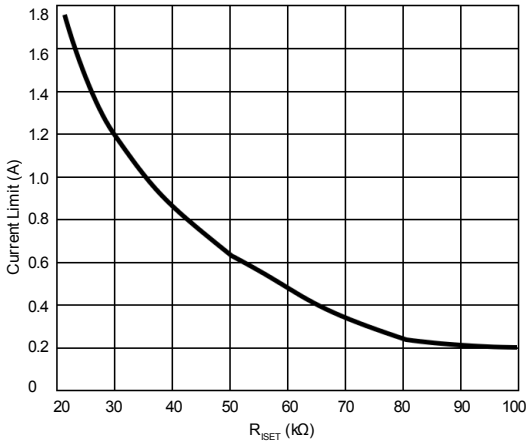


Figure 6. Current Limit vs. R_{ISET}

OUTPUT VOLTAGE SETTING

The output voltage is set by resistors R11 and R12, as shown in Figure 7. If the '431 generates a 2.5V reference voltage, the output voltage is given by:

$$V_{OUT} = 2.5V \cdot (R11 + R12) / R11 \qquad (1)$$

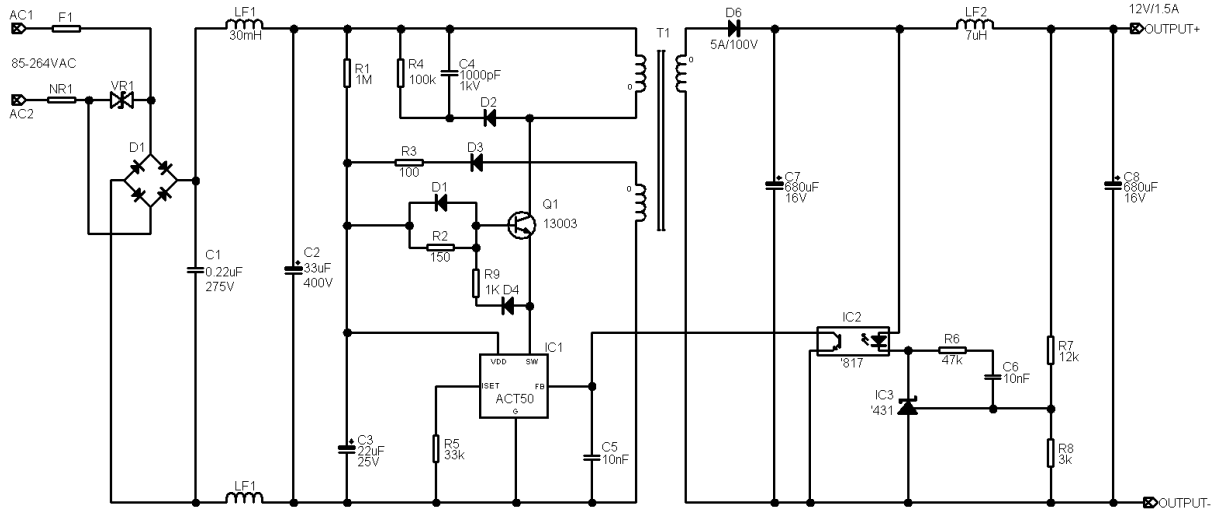


Figure 7. 18W Adapter Application Using ACT50

LAYOUT CONSIDERATIONS

The following should be observed when doing layout for the ACT50:

1. Use a "star point" connection at the GND pin of ACT50 for the VDD bypass components, the input filter capacitor and other ground connections on the primary side.

2. Keep the loop across the input filter capacitor, the transformer primary windings, the high voltage transistor, and the ACT50 as small as possible.

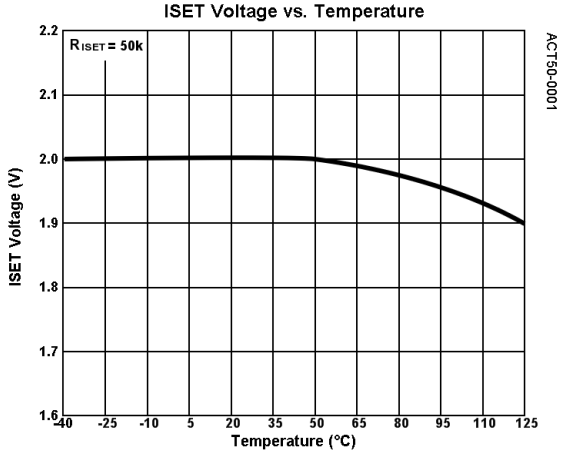
3. Keep ACT50 pins and the high voltage transistor pins as short as possible.

4. Keep the loop across the secondary windings, the output diode, and the output capacitors as small as possible.

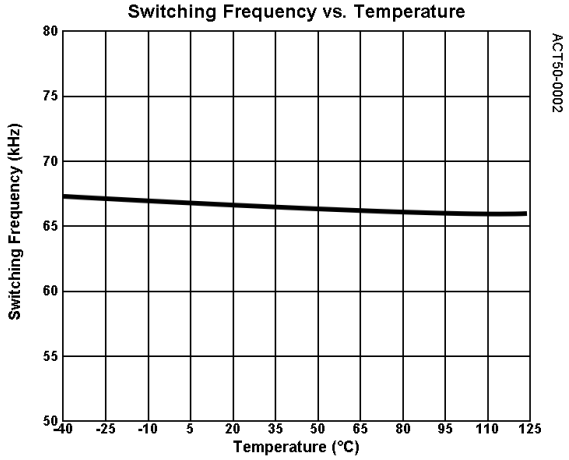
5. Allow enough copper area under the high voltage transistor, output diode, and current shunt resistor for heat sink.

TYPICAL PERFORMANCE CHARACTERISTICS

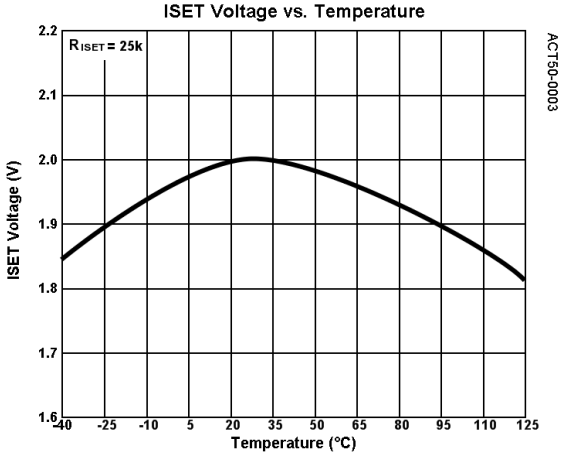
ISET Voltage vs. Temperature



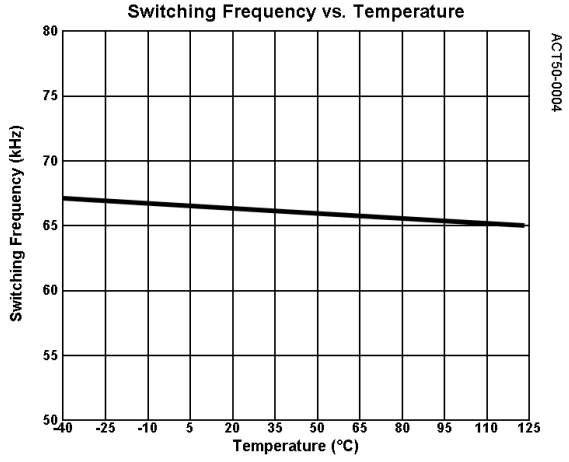
Switching Frequency vs. Temperature



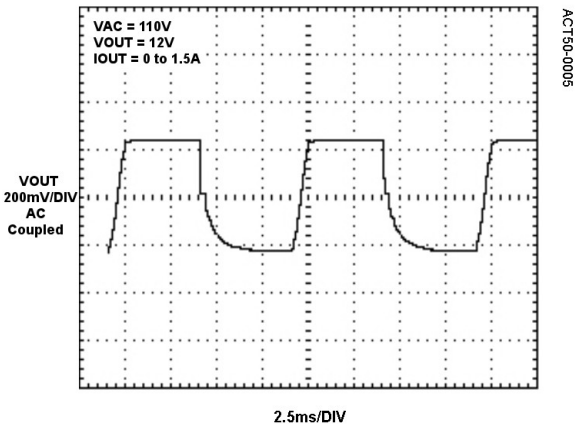
ISET Voltage vs. Temperature



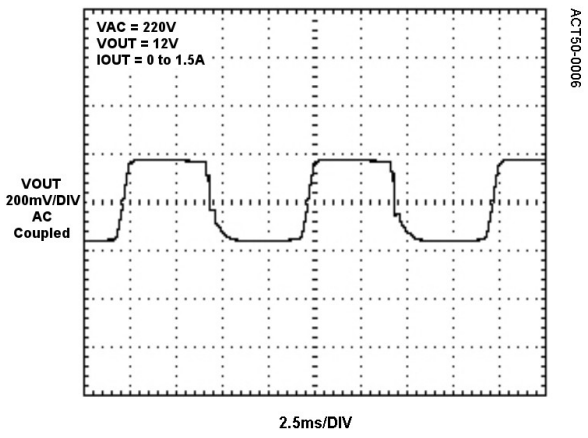
Switching Frequency vs. Temperature



Load Transient

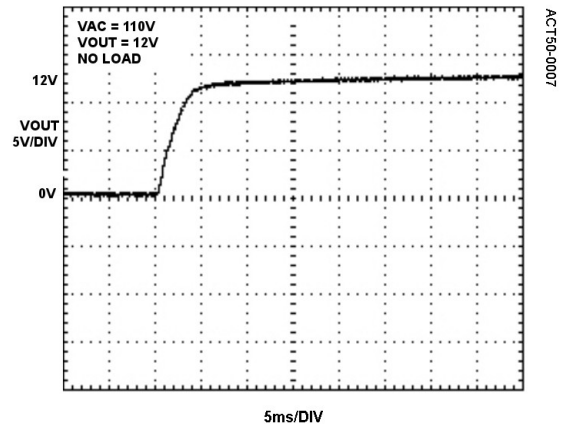


Load Transient

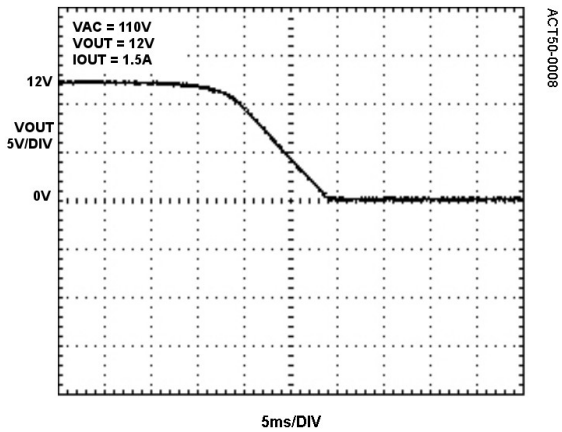


TYPICAL PERFORMANCE CHARACTERISTICS CONT'D

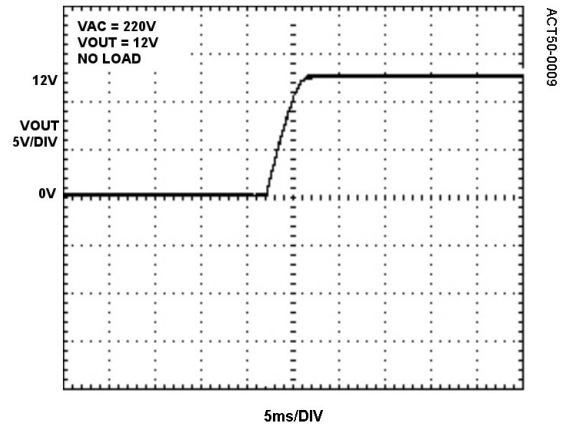
Turn On Transient



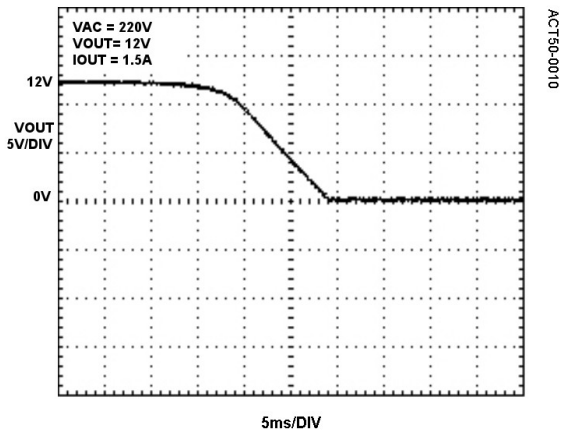
Turn Off Transient



Turn On Transient

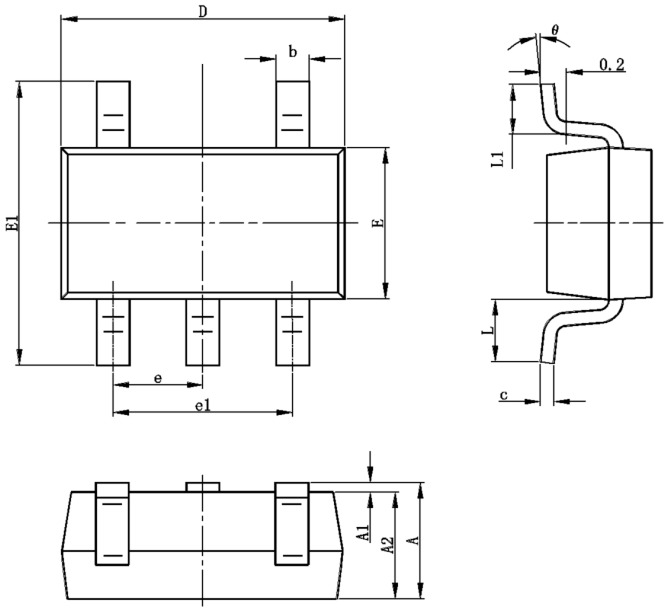


Turn Off Transient



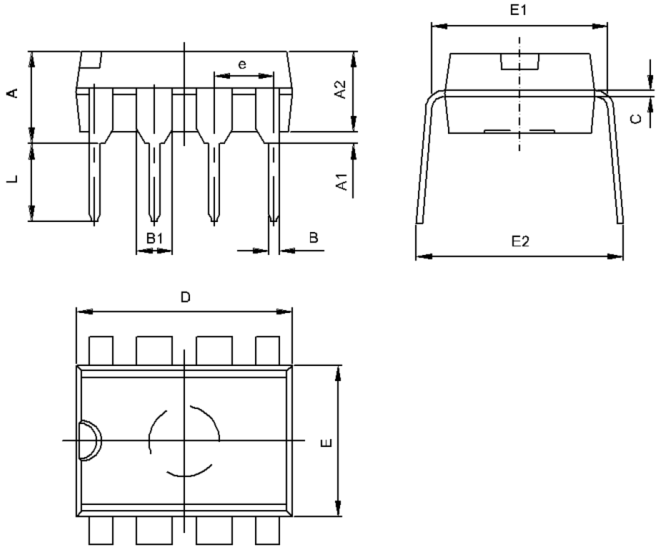
PACKAGE OUTLINE

SOT23-5 PACKAGE OUTLINE AND DIMENSIONS



SYMBOL	DIMENSION IN MILLIMETERS		DIMENSION IN INCHES	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 TYP		0.037 TYP	
e1	1.800	2.000	0.071	0.079
L	0.700 REF		0.028 REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

DIP-8 PACKAGE OUTLINE AND DIMENSIONS



SYMBOL	DIMENSION IN MILLIMETERS		DIMENSION IN INCHES	
	MIN	MAX	MIN	MAX
A	3.710	4.310	0.146	0.170
A1	0.510		0.020	
A2	3.200	3.600	0.126	0.142
B	0.360	0.560	0.014	0.022
B1	1.524 TYP		0.060 TYP	
C	0.204	0.360	0.008	0.014
D	9.000	9.400	0.354	0.370
E	6.200	6.600	0.244	0.260
E1	7.620 TYP		0.300 TYP	
e	2.540 TYP		0.100 TYP	
L	3.000	3.600	0.118	0.142
E2	8.200	9.400	0.323	0.370

1270 Oakmead Parkway, Suite 310, Sunnyvale, California 94085-4044, USA

ACT50 18W solution

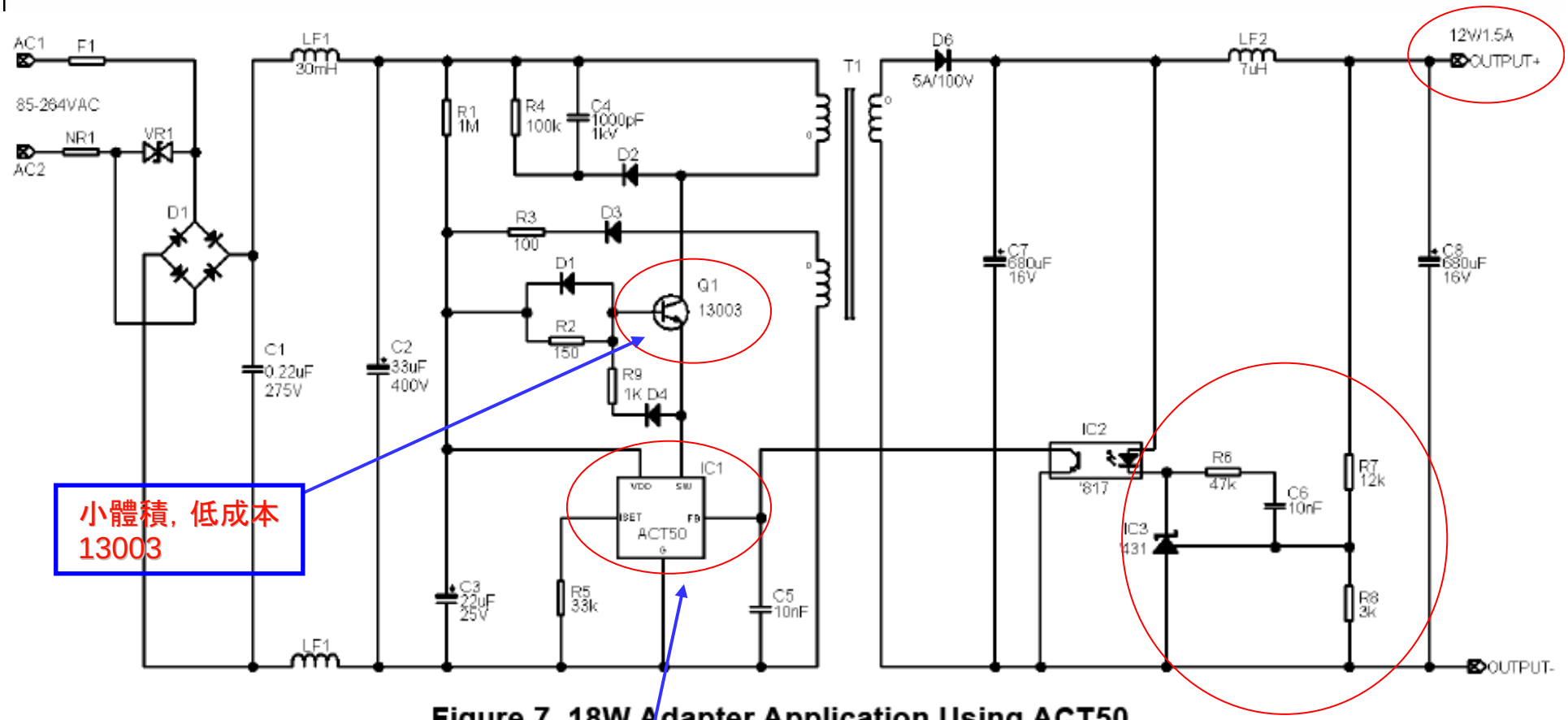


Figure 7. 18W Adapter Application Using ACT50