Active-Semi

Data Sheet
Rev 1, 6/2006

ACT34

Primary-Side Regulation Off-Line Controller ActiveSwitcher™ IC Family

FEATURES

- Patent-Pending High Efficiency Universal AC Solution
  - Less than 300mW Standby Power
  - 73% Peak Efficiency
  - Exceeds even the Latest CEC, Blue Angel, and Energy Star Requirements
  - Programmable CC/CV Operation
  - Over Power Protection
  - Short Circuit Foldback Current Limit
- Lowest Total Cost Solution
  - Primary Side Feedback
  - No Optocoupler or '431
  - Fewest Secondary Side Components
- Supports NPN Emitter Drive for Lowest Total Solution Cost
- Current Mode PWM Control
  - Very Low Line and Load Regulation
  - 62kHz Switching Frequency
  - No Audible Noise
- Tiny SOT23-6 Package

APPLICATIONS

- Battery Chargers
- Linear Adapter Replacements
- RCC Adapter Replacements
- CEC-Compliant Applications
- Standby Power Supplies
- Appliances

GENERAL DESCRIPTION

The ACT34 belongs to the high performance ActiveSwitcher™ family of universal input AC off-line controllers for adapter and battery-charger applications. The ACT34 was optimized for cost-sensitive applications, and utilizes Active-Semi's patent-pending primary-side feedback to provide accurate, programmable CVCC operation without the need of an optocoupler or a reference device such as the '431.

The ACT34 utilizes an advanced, proprietary 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 Blue Angel, and the US Energy Star Standards.

Additional features include over power protection, and foldback short circuit current limit. The ACT34 is available in a tiny SOT23-6 package.

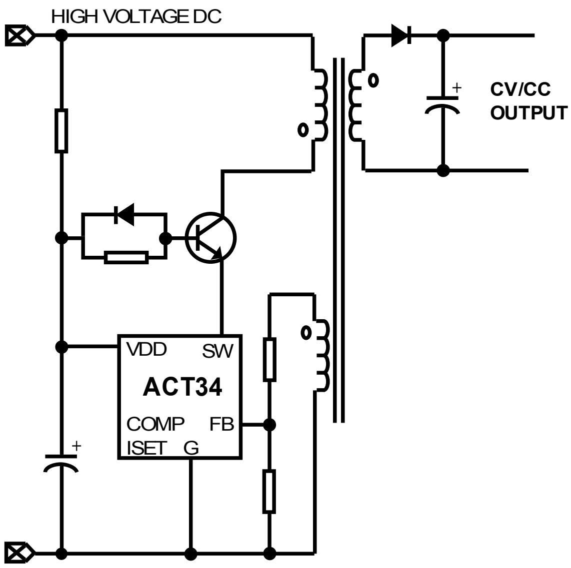
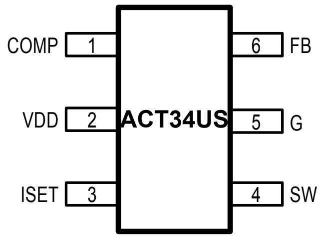


Figure 1. Simplified Application Circuit

ORDERING INFORMATION

PART NUMBER	TEMP RANGE	PACKAGE	PINS	PACKING METHOD	TOP MARK
ACT34US-T	-40°C to 85°C	SOT23-6	6	TAPE & REEL	BMHK

PIN CONFIGURATION



SOT23-6

PIN DESCRIPTION

PIN NUMBER	PIN NAME	PIN DESCRIPTION
1	COMP	Compensation Pin.
2	VDD	Power Supply.
3	ISET	Current Limit Programming Pin. Connect a resistor from ISET to G to program the current limit.
4	SW	Switch Output. Connect to the emitter of the power NPN or source of the power FET.
5	G	Ground.
6	FB	Feedback Pin.

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
Maximum Continuous VDD Current	20	mA
ISET, FB to G	-0.3 to 6	V
SW to G	-0.3 to 18	V
Continuous SW Current	Internally limited	A
Junction to Ambient Thermal Resistance (θ_{JA})	200	°C/W
Maximum Power Dissipation (derate 5mW/°C above T_A = 50°C)	0.5	W
Operating Junction Temperature	-40 to 150	°C
Storage Temperature	-55 to 150	°C
Lead Temperature (Soldering, 10 sec)	300	°C

ELECTRICAL CHARACTERISTICS

(V_{DD} = 14V, T_A = 25°C unless otherwise specified.)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
VDD Turn-On Voltage	V_{DDON}	Rising edge	11	11.7	12.4	V
VDD Turn-Off Voltage	V_{DDOFF}	Falling edge	9	9.6	10.2	V
VDD Clamp Voltage	$V_{DDCLAMP}$	10mA	15.7	16.4	17.1	V
Supply Current	I_{DD}			1	1.5	mA
Start Up Supply Current	I_{DDST}	V_{DD} = 10V, before turn-on		15	60	µA
Switching Frequency	f_{SW}	FB in regulation, V_{COMP} = 1.5V	56	62	68	kHz
Effective FB Feedback Voltage	V_{FB}		1.24	1.26	1.28	V
Maximum Duty Cycle	D_{MAX}	I_{SW} = 10mA	67	75	83	%
Minimum Duty Cycle	D_{MIN}	I_{SW} = 100mA		3.5		%
ISET Pin Voltage	V_{ISET}	R_{ISET} = 20kΩ		1.24		V
Switch Current Limit	I_{LIM}	R_{ISET} = 20kΩ	304	320	336	mA
Ratio of I_{LIM} to ISET Pin Current	β			5.1		A/mA
Switch On-Resistance	R_{ON}	I_{SW} = 50mA		3.6		Ω
SW Rise Time		1nF load, 15Ω pull-up		30		ns
SW Fall Time		1nF load, 15Ω pull-up		20		ns
SW Switch Off Current		Switch in off-state, V_{SW} = 18V		1	10	µA

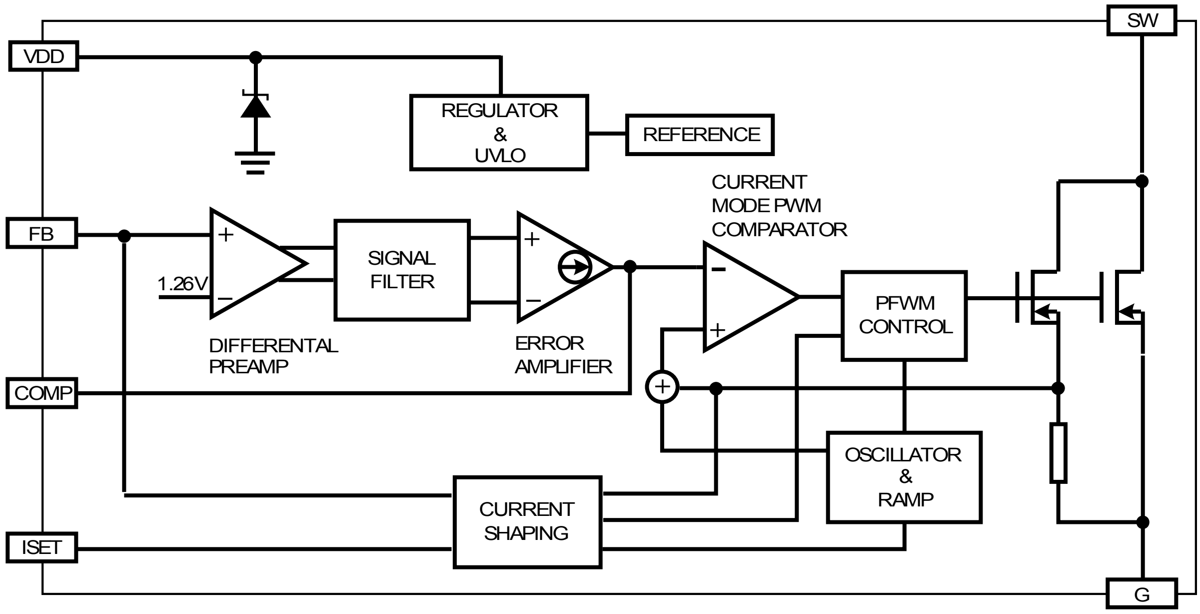


Figure 2. Functional Block Diagram

FUNCTIONAL DESCRIPTION

Figure 2 shows the *Functional Block Diagram* of the ACT34. Feedback regulation is done via current mode PWM control. The external COMP pin allows optimal trade off between stability and transient response performance. The ISET pin permits external programmability of the power switch peak current and, together with the Current Shaping circuitry, produces a constant current (CC) profile when the secondary output reaches current limit.

SW is a driver output that drives the emitter of an external high voltage NPN transistor or N-channel MOSFET. This emitter-drive method takes advantage of the high V_{CBO} of the transistor, 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.

STARTUP MODE

During startup, a small current flows through resistor R1 to charge the capacitor C1, increasing the voltage on VDD as well as the voltage at SW through the NPN. The ACT34 begins switching when the voltage at VDD reaches 11.7V, and the feedback loop engages to control the loop as the output voltage reaches the regulation point.

CONSTANT VOLTAGE (CV) MODE

In constant voltage operation, the ACT34 monitors the auxiliary flyback signal at FB pin (through a resistor divider pair R3 and R4 as shown in Figure 3, *Connection Diagram*). An error signal representing the difference between the voltage at FB and the reference voltage is generated by Active-Semi's patent-pending feedback circuitry, which is then integrated by the Error Amplifier and used to control switching duty cycle.

The output voltage is determined by the following relationship:

$$V_{OUTCV} = 1.26V\left(1+\frac{R_3}{R_4}\right)\left(\frac{N_S}{N_A}\right) - V_F \qquad (1)$$

where R_3 and R_4 are top and bottom feedback resistor values, N_S and N_A are numbers of transformer secondary and auxiliary turns, and V_F is the rectifier diode forward drop voltage at approximately 0.1A bias.

CONSTANT CURRENT (CC) MODE

When the secondary-side output current reaches the limit set by ISET, the ACT34 operates in the constant-current mode and the secondary output voltage is allowed to fall out of regulation. The flyback voltage decreases with the output voltage, and the ACT34's Current Shaping circuitry adjusts the switching frequency in order to regulate secondary-side output current.

The energy transfered to the output during each switching cycle is ½(L_P•I_{PK}^2)•η, where L_P is the transformer primary inductance, I_{PK} is the primary peak current, and η is the conversion efficiency. From this formula, the constant output current is given by:

$$I_{OUTCC}=\frac{1}{2}L_P\left(\frac{V_{ISET}\cdot 5100}{R_5}\right)^2\frac{\eta\cdot f_{SW}}{V_{OUTCV}} \quad (2)$$

where f_{SW} is the nominal switching frequency and V_{OUTCV} is the nominal secondary output voltage given by equation (1).

LIGHT LOAD OPERATION

As a current-mode controller, the voltage at the COMP pin decreases with decreasing load current. The ACT34 monitors the COMP voltage, and if it reaches 0.9V the ACT34 reduces its switching frequency in order to minimize standby power consumption and meet all current green energy standards.

The ACT34 internally limits the switching frequency to 5kHz minimum. The actual switching frequency at no load can be increased by adding a small dummy load resistor at the output. Choose this dummy load as a compromise between higher standby switching frequency (to avoid audible noise) and lower standby power. A dummy load of about 330Ω is generally optimal.

SHORT CIRCUIT OPERATION

When the secondary side output is short circuited, the ACT34 operates in “hiccup mode” to minimize power consumption. When the output is short-circuited, the auxiliary supply voltage collapses and the VDD voltage drops. When VDD drops below 9.6V, the ACT34 is disabled, and C1 is charged through R1 until VDD exceeds 11.7V again, at which point the ACT34 is enabled and attempts to start up. If the short circuit conditions persists, the ACT34 will operate in “hiccup” mode as it repeatedly cycles between start up and shutdown, resulting in very low duty cycle operation and very low short circuit current.

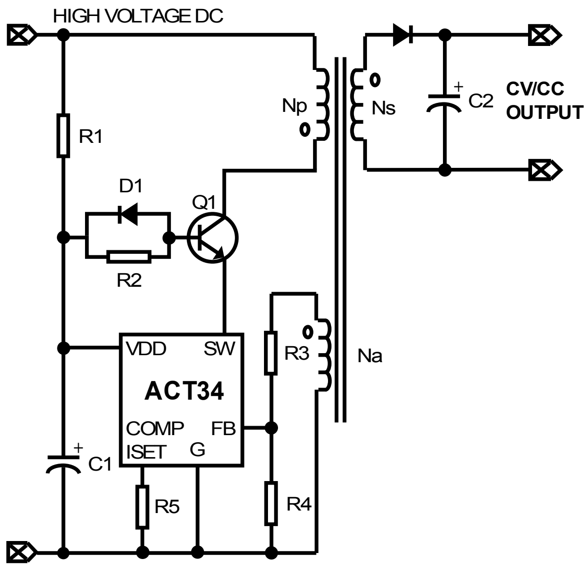


Figure 3. Connection Diagram

APPLICATION INFORMATION

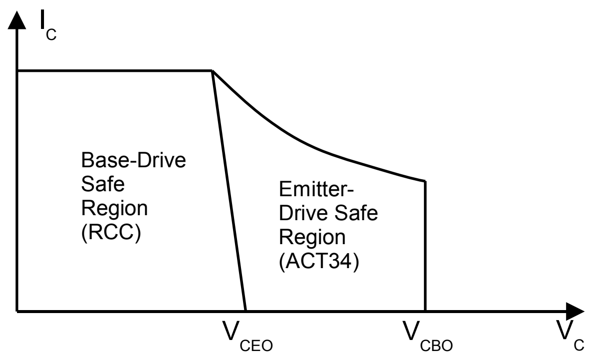


Figure 4. NPN Reverse Bias Safe Operation Area

EXTERNAL POWER TRANSISTOR

The ACT34 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 4, *NPN Reverse Bias Safe Operation Area*, the breakdown voltage of an NPN is significantly improved when it is driven at its emitter. Thus, the ACT34+'13002 or '13003 combination meet the necessary breakdown safety requirement even though RCC circuits using '13002 or '13003 do not. Table 1 lists the breakdown voltage of some transistors appropriate for use with the ACT34.

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

The power dissipated in the NPN transistor is equal to the collector current times the collector-emitter voltage. As a result, the transistor must always be in saturation when turned on to prevent excessive power dissipation. Select an NPN transistor with sufficiently high current gain (h_{FEMIN} > 8) and a base drive resistor (R2 in Figure 3) low enough to ensure that the transistor easily saturates ($I_b \cdot h_{FEMIN} > I_C$).

LAYOUT CONSIDERATIONS

The following should be observed when doing layout for the ACT34:

1. Use a "star point" connection at the G pin of ACT34. Divide primary side ground into Analog Ground side (for V_{DD} bypass capacitor, feedback resistor, ISET resistor, compensation network) and Power Ground side (for bulk capacitors, auxiliary turns, and other high current components). The Analog Ground and Power Ground sides meet at the star ground point which is the IC's G pin. (Refer to Figure 5.)

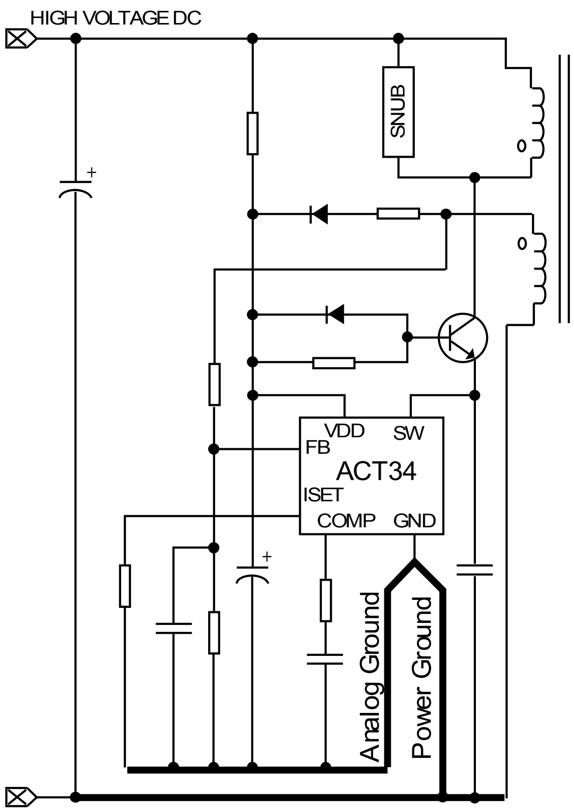


Figure 5. Analog and Power Grounds Separation

2. Keep the loop across the input filter capacitor, the transformer primary windings, and the high voltage transistor, and the ACT34 as small as possible.

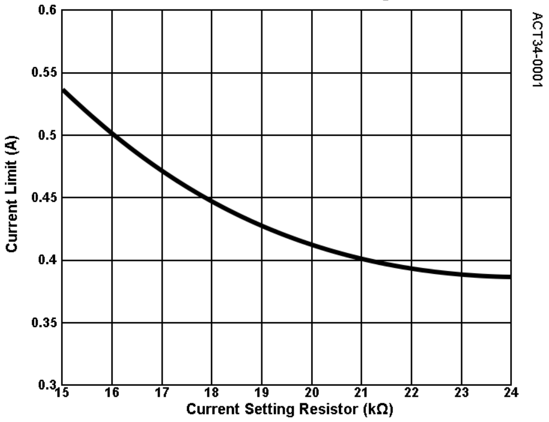
3. Keep ACT34 pins and the high voltage transistor pins as short as possible.

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

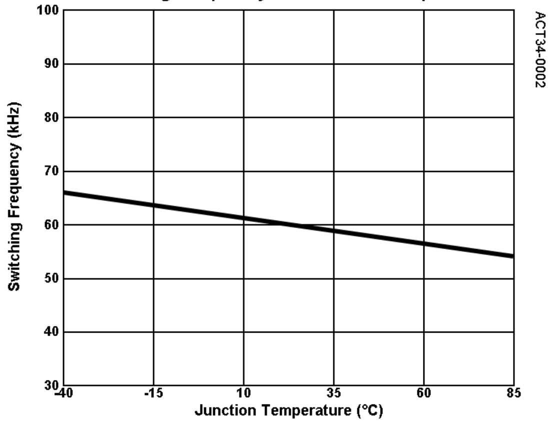
5. Allow enough copper area under the high voltage transistor, output diode, and current shunt resistor for heat sink.

TYPICAL PERFORMANCE CHARACTERISTICS

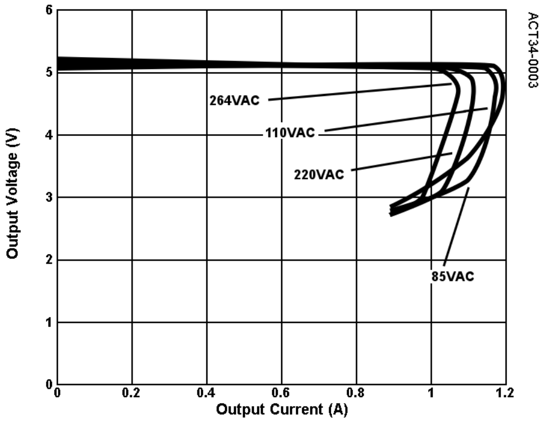
Current Limit vs. Current Setting Resistor



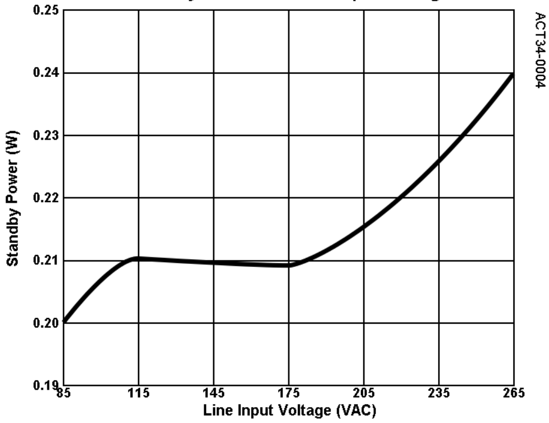
Switching Frequency vs. Junction Temperature



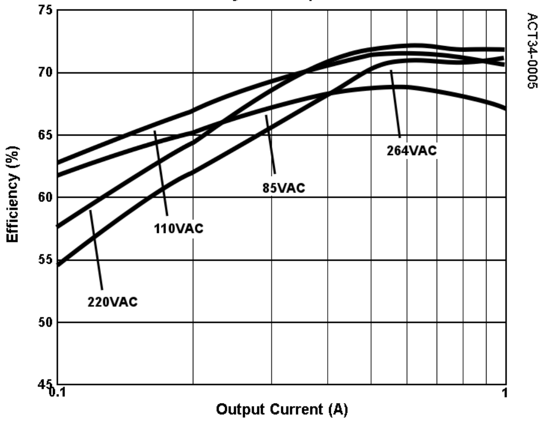
CV/CC Control Characteristics



Standby Power vs. Line Input Voltage

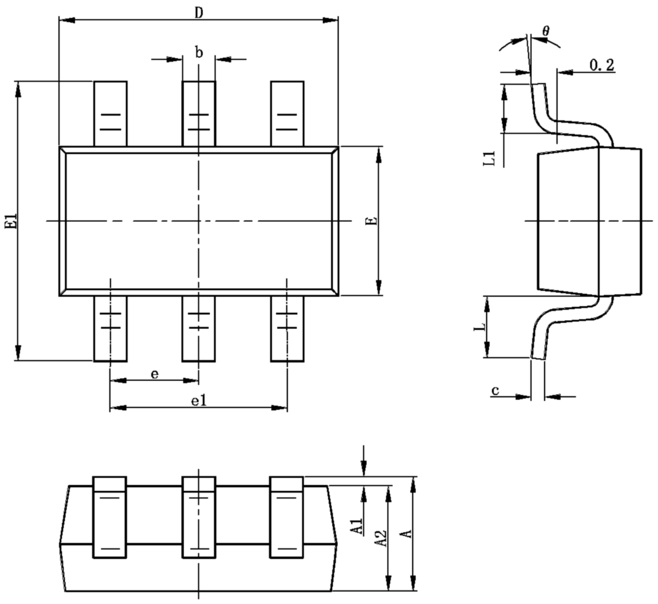


Efficiency vs. Output Current



PACKAGE OUTLINE

SOT23-6 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°