

ACT29 EFFICIENT LOW POWER OFF-LINE CONTROLLER

FEATURES

- Lowest Total Cost Solution
- Current Mode PWM
- Low Power Pulse-skipping at Light Load
- Over-Current Protection
- Under-voltage Protection with Auto-restart
- Emitter Drive of External NPN
- Low EMI
- TO-92 Package
- 65kHz Switching Frequency

APPLICATIONS

- Battery Chargers
- Power Adaptors
- Standby Power Supplies
- Appliances
- Universal Off-line Power Supplies

GENERAL DESCRIPTION

The ACT29 is a current-mode PWM power supply controller that drives an external NPN transistor for high voltage switching. This architecture enables many advanced features to be integrated into a 3-pin TO-92 package, resulting in lowest total cost solution.

Operating at 65kHz switching frequency, the ACT29 is capable of delivering up to 5W yet consumes only 0.25W in standby. Its safety features include over-current and under-voltage protection mechanisms.

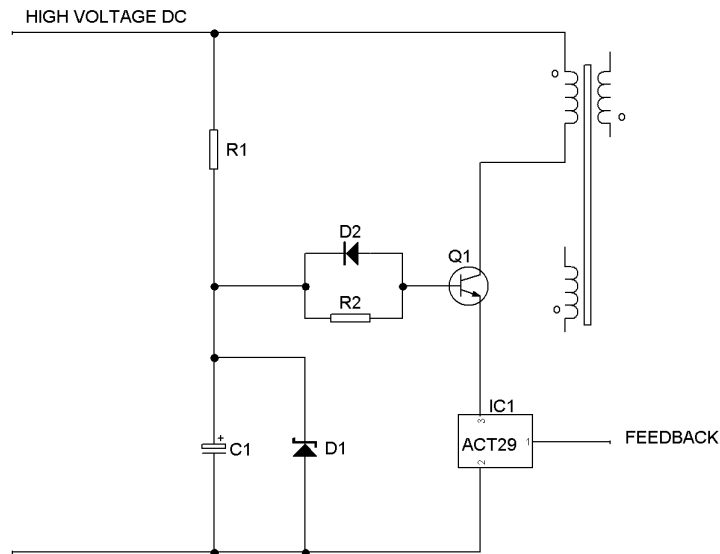


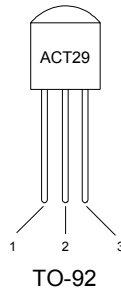
Figure 1. Simplified Application Circuit

ORDERING INFORMATION

PART NUMBER	SWITCHING FREQUENCY ¹	TEMPERATURE RANGE	PACKAGE	PINS
ACT29HT	65kHz	-40°C to 85°C	TO-92	3

¹ Other switching frequencies available. Contact factory for details.

PIN CONFIGURATION



PIN DESCRIPTION

PIN NUMBER	PIN NAME	PIN DESCRIPTION
1	FB/VDD	Feedback Input and Supply Voltage. Connect to opto-coupler's emitter. Internally limited to 5.5V.
2	GND	Ground
3	SW	Switch Output. Connect to emitter of the high voltage NPN.

ABSOLUTE MAXIMUM RATINGS

(Note: Do not exceed these limits to prevent damage to the device. Exposure to absolute maximum rating conditions for long periods may affect device reliability.)

PARAMETER	VALUE	UNIT
FB/VDD Supply Voltage	-0.3 to 6	V
FB/VDD Current	20	mA
SW Voltage	-0.3 to 18	V
Continuous SW Current	Internally limited	A
Maximum Power Dissipation	0.6	W
Junction to Ambient Thermal Resistance (θ_{JA})	200	°C/W
Operating Junction Temperature	-40 to 150	°C
Storage Temperature	-55 to 150	°C
Lead Temperature (Soldering, 10 sec)	300	°C

ELECTRICAL CHARACTERISTICS

($V_{FB/VDD} = 4V$, $T_J = 25^\circ C$ unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
FB/VDD Start Voltage	V_{START}	Rising edge	4.75	5	5.25	V
SW Start Voltage		SW must be higher than this voltage during start up in order to charge FB/VDD to V_{START}		7.6	10	V
FB/VDD Under-voltage Threshold	V_{UV}	Falling edge	3.15	3.4	3.55	V
FB/VDD Clamp Voltage		10mA	5.2	5.5	5.8	V
Supply Current	I_{DD}			0.6	1	mA
Switching Frequency	f_{SW}			65		kHz
Maximum Duty Cycle	D_{MAX}	$V_{FB/VDD} = 4V$, $I_{SW} = 10mA$	70	75	80	%
Minimum Duty Cycle	D_{MIN}	$V_{FB/VDD} = 4.6V$, $I_{SW} = 100mA$		3.5	6	%
Current Limit	I_{LIM}	$V_{FB/VDD} = V_{UV} + 0.1V$		400		mA
FB/VDD to SW Current Gain	G_{FB}			-0.29		A/V
FB/VDD Dynamic Impedance	$R_{FB/VDD}$			9		k Ω
Switch On-Resistance	R_{SW}	$I_{SW} = 0.05A$	$T_J = 25^\circ C$	3.6		Ω
			$T_J = 125^\circ C$	5		
SW Rise Time		1nF load, 15 Ω pull-up		30		ns
SW Fall Time		1nF load, 15 Ω pull-up		20		ns
SW Switch Off Current		Switch in off-state, $V_{SW} = 10V$		12	30	μA

FUNCTIONAL DESCRIPTION

Figure 2 is a Functional Block Diagram of the ACT29. The main components include a current-mode PWM control circuitry, an on-chip 3.6Ω power MOSFET, a bandgap reference, an oscillator, and voltage detector circuitry.

The power MOSFET drives the emitter of an external high voltage NPN transistor. This allows faster switching action because the external device turn-off storage time is reduced. In addition, the emitter-drive method takes advantage of the high V_{CBO} of the transistor, allowing a low cost transistor such as 13002 ($V_{CBO} = 700V$) to be used for AC input up to 265V. An additional advantage of using an external NPN is lower EMI.

STARTUP SEQUENCE

Figure 1 shows a Simplified Application Circuit for the ACT29. Initially, the small current through resistor R1 charges up the capacitor C1, and the BJT or N-MOSFET acts as a follower to bring up the SW voltage. An on-chip switch pulls FB/VDD voltage towards SW. When FB/VDD voltage reaches the $V_{START} = 5V$, the internal SW-FB/VDD startup switch opens and FB/VDD starts decreasing due to its current consumption. As FB/VDD voltage decreases below 4.8V, the IC starts to enter constant frequency PWM mode with increasing switch current for lower FB/VDD voltage. When the output voltage reaches regulation point, the opto-coupler supplies

FB/VDD current from C1. The switching action also allows the auxiliary windings to take over in supplying the C1 capacitor. Figure 3 shows a typical startup sequence for the ACT29.

CURRENT-MODE FEEDBACK CONTROL

The current-mode feedback function is accomplished by connecting FB/VDD to the emitter of the opto-coupler to detect the regulation voltage. The FB/VDD voltage controls the MOSFET peak current according to the following transfer function equation:

$$I_{SWPEAK} = -0.29A/V \cdot (4.8V - V_{FB/VDD})$$

for $V_{FB/VDD} < 4.8V$ and duty cycle $< 50\%$

When the output voltage is lower than regulation, the current into FB/VDD pin is zero and FB/VDD voltage decreases. At $V_{FB/VDD} = V_{UV} = 3.4V$, the peak SW current has maximum value of 400mA.

PULSE-SKIPPING

In standby (no load), the FB/VDD voltage is around 4.8V. The energy delivered by each switching cycle (with minimum on time of 500ns) to the output causes FB/VDD voltage to increase slightly above 4.8V and the IC stops switching until FB/VDD is below 4.8V again. This pulse-skipping action results in low power consumption in standby mode because the switching frequency is reduced.

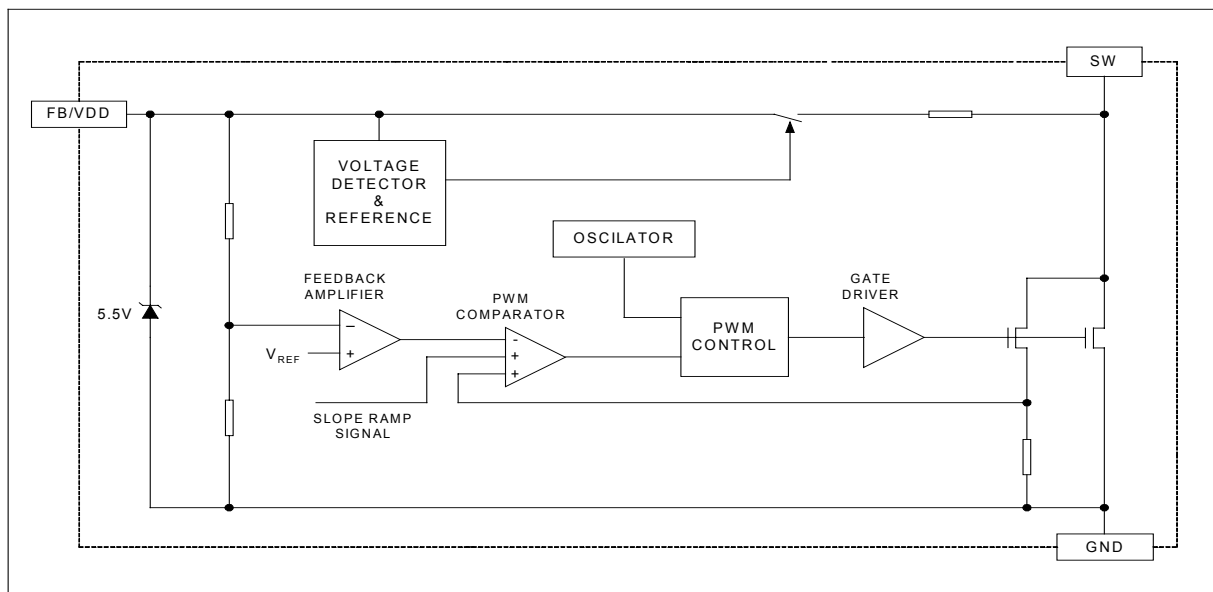


Figure 2. Functional Block Diagram

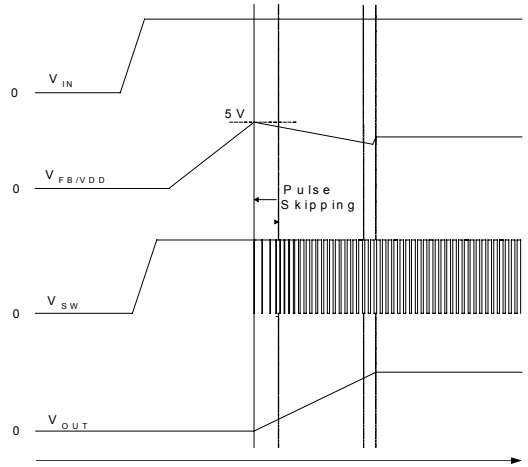


Figure 3. Startup Waveforms

APPLICATION INFORMATION

EXAMPLE 1

For lowest component count, the application circuit in Figure 4 provides a constant voltage output with constant current limit determined by $V_{BE_{Q1}} \cdot (1 / R8 + 1 / R9)$. The output voltage can be adjusted by selecting R14 as follows:

$$R14 = R13 \cdot (V_{OUT} / 2.5V - 1)$$

The performance of this circuit is summarized in Table 1.

Table 1. System Performance of Circuit in Figure 4

	110VAC	220VAC
Total Standby Power (including LED)	0.3W	0.25W
Full Load Efficiency	60%	61%
Load Regulation	0.6%	0.6%

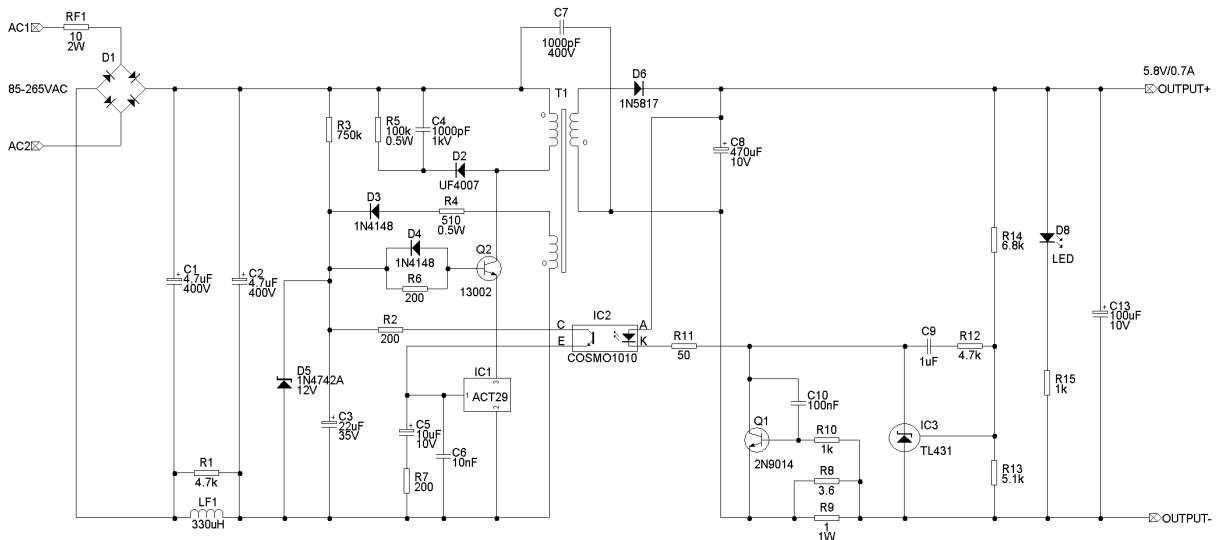


Figure 4. Charger Adaptor Circuit Using '431 on Secondary Side

EXAMPLE 2

Another example of a constant output voltage, constant output current adaptor is depicted in Figure 5. This circuit uses half of an LM358 to compare output voltage and another half to compare current. In addition, the output voltage resistor divider resistors R20, R21, and R22 are connected in such a way that the output voltage increases slightly as the load increases. This method can be used to compensate for the resistance of the line from the adaptor to the load.

The recommended values for R12, R13, R21 are as indicated in Figure 5. To adjust output current limit and output voltage, follow the following steps.

1. Set current limit by choosing proper values for R8 and R9:

$$I_{OUTMAX} = 2.5V \cdot R13 / R12 \cdot (1 / R8 + 1 / R9)$$

2. Determine the total line resistance R_{LINE} from the adaptor to the load (both output and ground lines) that needs compensation. Calculate resistor divider values:

$$R20 = (R21 \cdot R8 \cdot R9) / [R_{LINE} \cdot (R8 + R9)]$$

$$R22 = R21 / (V_{OUT} / 2.5V - R21 / R20 - 1)$$

The circuit of Figure 5 assumes $R_{LINE} = 1\Omega$.

The performance of this circuit is summarized in Table 2.

Table 2. System Performance of Circuit in Figure 5

	110VAC	220VAC
Total Standby Power (including LED)	0.22W	0.28W
Constant Voltage Efficiency at Full Load	62%	61%
Constant Current Efficiency at 4.2V	58%	58%

OUTPUT POWER

The maximum power deliverable from ACT29 depends on the AC line voltage and several factors including the power handling capability of the external high voltage transistor, thermal management, and the transformer selection. Experiments demonstrate that up to 5W output power can be obtained from the universal AC input voltage range (85V to 265V AC) using a 13002 NPN in TO-126 package.

LAYOUT CONSIDERATIONS

The following should be observed when doing layout for the ACT29:

1. Use a "star point" connection at the GND pin of ACT29 for the FB/VDD bypass components (R7 and C6 in Figure 4), the input filter capacitor (C2 in Figure 4) and other ground connections on the primary side.
2. Keep the loop accross the input filter capacitor, the transformer primary windings, and the high voltage transistor, and the ACT29 as small as possible.
3. Keep ACT29 pins and the high voltage transistor pins as short as possible.
4. Keep the loop accross 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 heatsink.

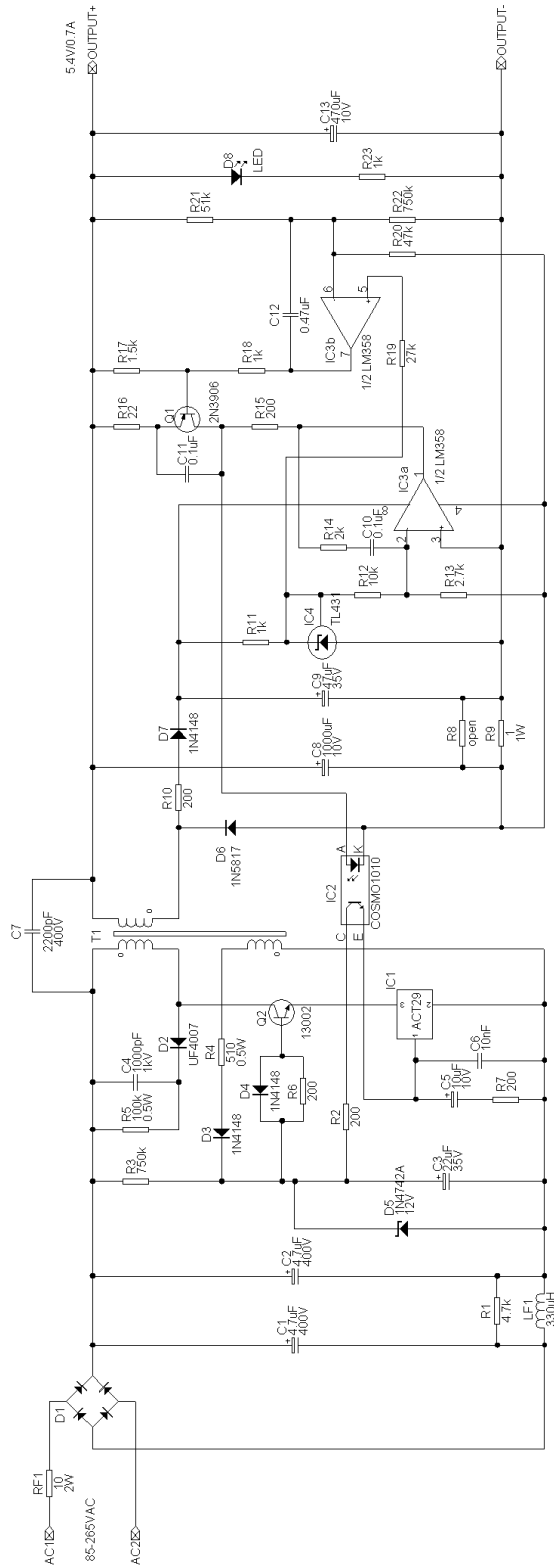
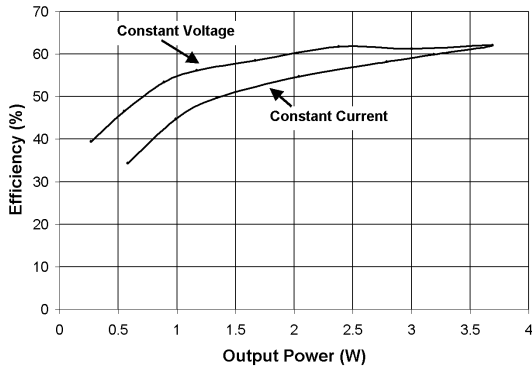


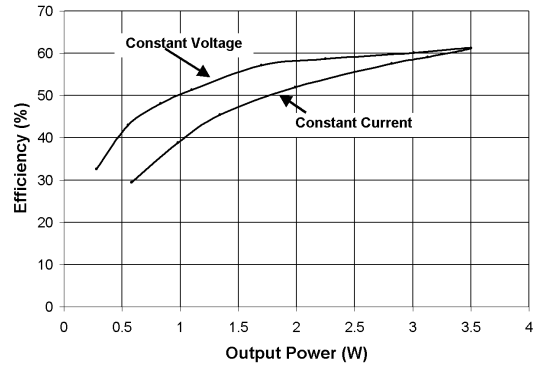
Figure 5. Application Circuit Using '431 and '358 on Secondary Side

TYPICAL PERFORMANCE CHARACTERISTICS

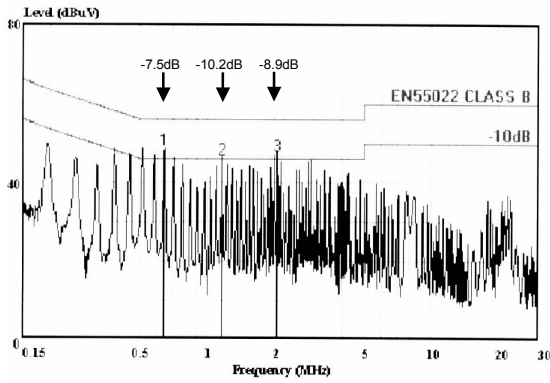
System Efficiency at 110V AC Input



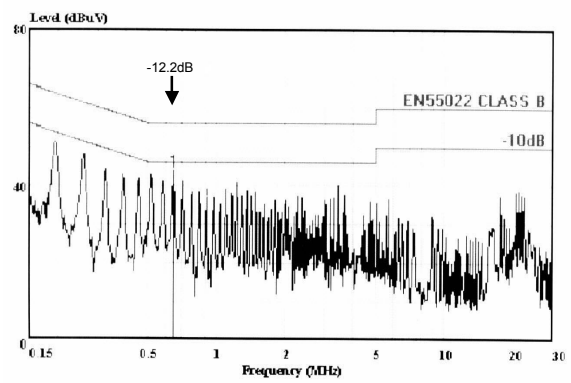
System Efficiency at 220V AC Input



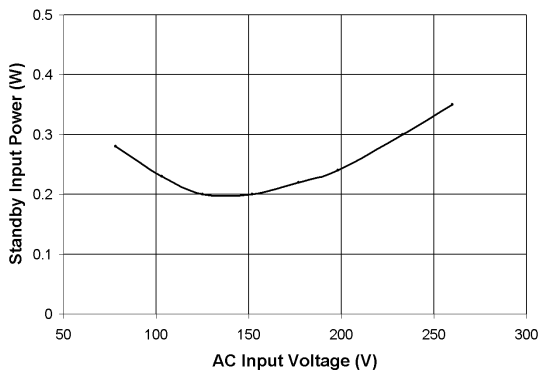
Line EMI at Full Load



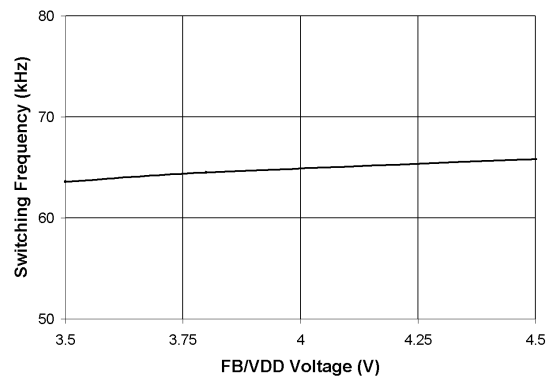
Neutral EMI at Full Load



Standby Input Power (Circuit of Figure 5)



Switching Frequency vs. FB/VDD Voltage



PACKAGE OUTLINE**TBD**

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