LOW POWER PWM CONTROLLER FOR OFF-LINE BATTERY CHARGER AP3700

General Description

The AP3700 is a green-mode pulse width modulation (PWM) controller. It is specially designed for low power applications such as off-line battery chargers, where the needs for low standby power, space saving and low cost are all required. In a battery charger rated 5V/1A, the maximum standby power is only 0.18Watt.

In normal operation, the AP3700 switches on and off at a fixed switching frequency of 60 kHz. With a current limit capability of 420mA, the AP3700 can directly drive the emitter of high voltage NPN transistor or the source of MOSFET. When output power falls below a given level, the IC enters skip cycle mode to reduce power consumption.

The AP3700 also features under-voltage lockout, over-current and short circuit protections.

The AP3700 is available in TO-92 package.

Features

- Current Mode Control with Skip Cycle Capability
- Lower Operating Current: 0.45mA
- Fixed Switching Frequency: 60 kHz
- Frequency Dither for Low EMI: ±2.5kHz
- Under-Voltage Lockout Protection
- Over-Current Protection
- Internal Short Circuit Protection
- Higher Output Breakdown Voltage
- Lower Total Cost Solution

Applications

- Battery Chargers
- Off-Line Power Supplies

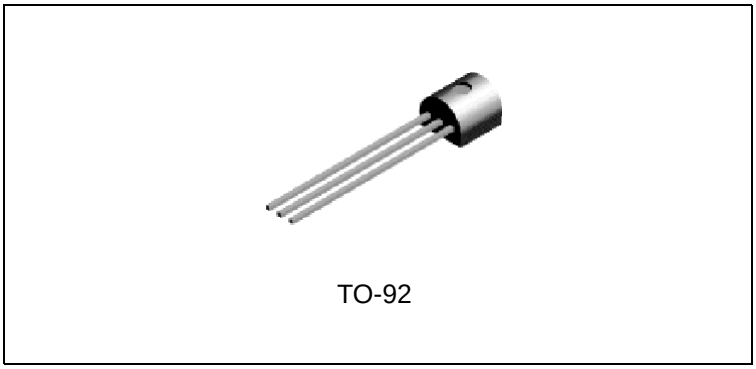


Figure 1. Package Types of AP3700

Pin Configuration

Z Package
(TO-92)

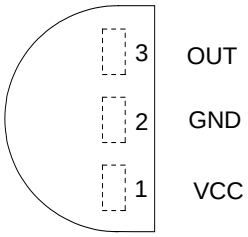


Figure 2. Pin Configuration of AP3700 (Top View)

Pin Description

Pin Number	Pin Name	Function
TO-92		
1	VCC	The power supply of the IC, and is generally connected to opto-coupler's emitter
2	GND	Supply ground
3	OUT	The output pin, connected to the emitter of NPN transistor or the source of MOSFET

Functional Block Diagram

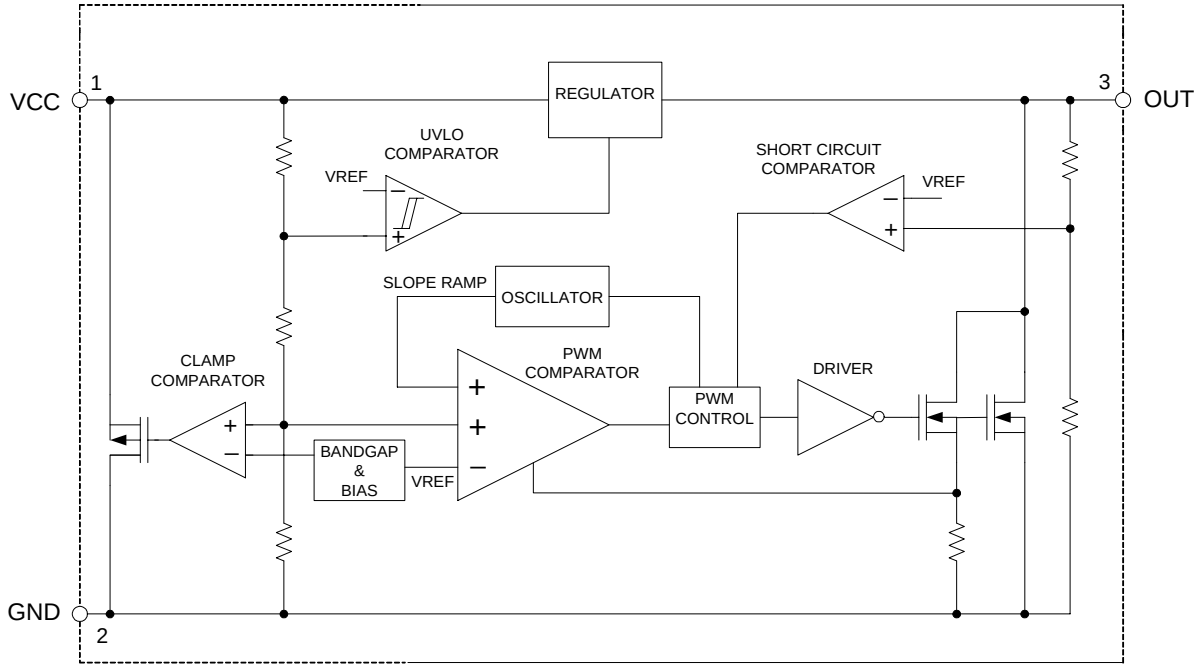
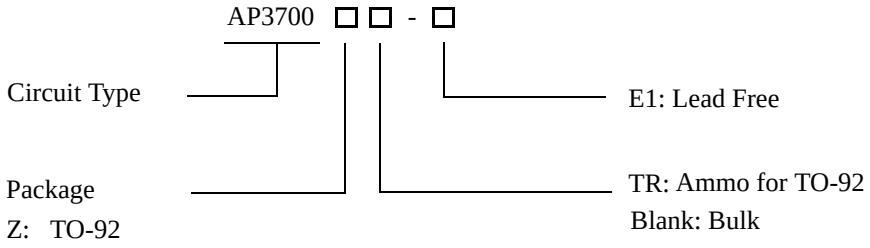


Figure 3. Functional Block Diagram of AP3700

Ordering Information



Package	Switching Frequency	Temperature Range	Part Number	Marking ID	Packing Type
TO-92	60kHz	-40 to 85°C	AP3700Z-E1	3700Z-E1	Bulk
			AP3700ZTR-E1	3700Z-E1	Ammo

BCD Semiconductor's Pb-free products, as designated with "E1" suffix in the part number, are RoHS compliant.

Absolute Maximum Ratings (Note 1)

Parameter	Value	Unit
Supply Voltage	-0.3 to 6.0	V
Voltage at OUT	-0.3 to 40	V
Output Current at OUT	Internally limited	A
Power Dissipation	N/A	W
Operating Junction Temperature	150	°C
Storage Temperature	-65 to 150	°C
Lead Temperature (Soldering, 10s)	300	°C
ESD (Machine Model)	200	V

Note 1: Stresses greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "Recommended Operating Conditions" is not implied. Exposure to "Absolute Maximum Ratings" for extended periods may affect device reliability.

Electrical Characteristics

(V_{CC}=4V, T_J=25°C, unless otherwise specified.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
UVLO SECTION						
Start-up Voltage	$V_{TH\ (ST)}$		5.00	5.25	5.50	V
Minimal Operating Voltage	V_{OPR}(Min)		3.4	3.65	3.9	V
STANDBY CURRENT SECTION						
Start-up Current	I_{ST}	V_{CC}=4V		0.22	0.4	mA
Operating Current	$I_{CC(OPR)}$			0.45	0.7	
V_{CC} Zener Voltage	V_Z	I_{CC}=10mA	6	6.3		V
Dynamic Impedance	R_{VCC}	V_{CC}=3.8 to 4.8V		18		kΩ
INTERNAL OSCILLATOR						
Switching Frequency	F_{SW}		50	60	75	kHz
Frequency Dither			±2	±2.5	±3	kHz
Temperature Stability				5	8	%
DRIVE OUTPUT SECTION						
OUT Start-up Voltage	V_{ST}			8.5	11	V
Short Circuit Threashold Voltage	V_{SC}			6		V
Rise Time	T_R	C_L=1nF, 15Ω pull-up		60		ns
Fall Time	T_F	C_L=1nF, 15Ω pull-up		30		
Maximum Duty Cycle	D_{MAX}	V_{OPR}(Min) + 0.2V	67	75	84	%
Minimum Duty Cycle		V_{CC}=$V_{TH\ (ST)}$-0.2V		3		
Driver OUT On-Resistance	R_{OUT}	I_{OUT}=0.06A		3		Ω
Switch Off Current (OUT)		Driver off, V_{OUT}=10V		20	40	μA
Effective Current Limit	I_{LIM}	V_{CC} = V_{OPR}+0.1V	420			mA
OUT Current Coefficient	G_A			-0.3		A/V

Typical Performance Characteristics

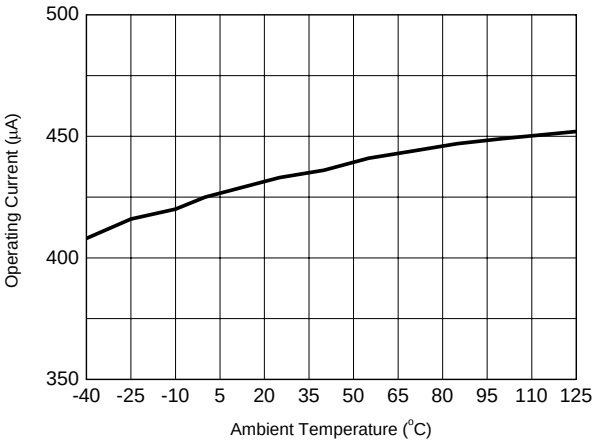


Figure 4. Operating Current vs. Ambient Temperature

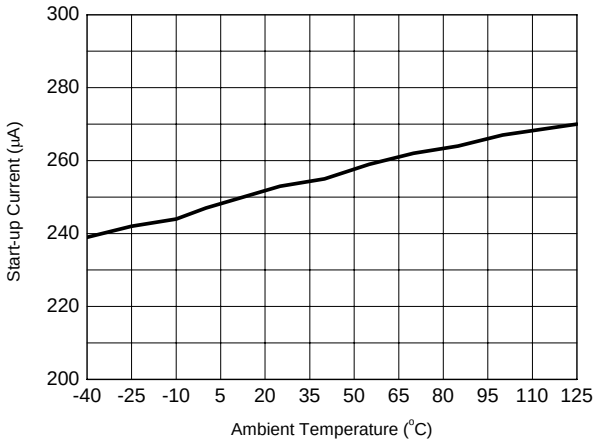


Figure 5. Start-up Current vs. Ambient Temperature

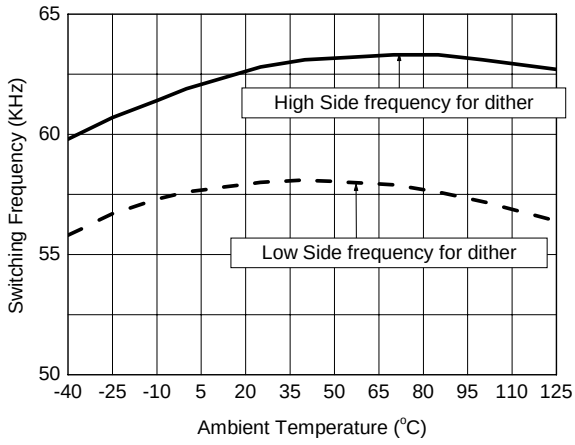


Figure 6. Switching Frequency vs. Ambient Temperature

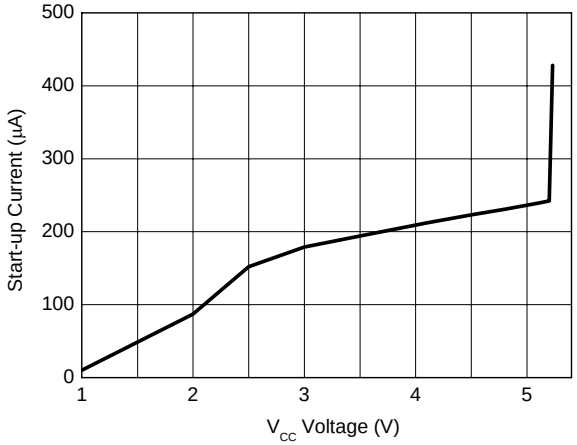


Figure 7. Start-up Current vs. V_{CC} Voltage

Function Description

1. Startup Circuit

Figure 3 is the functional block diagram of AP3700, and there are 3 external pins: the VCC pin, the OUT pin and GND pin. In typical application shown by Figure 10, the VCC pin is used for both bias supply and feedback control. The OUT pin directly drives external NPN transistor or MOSFET, and also provides initial bias power for UVLO comparator. When the IC works in PWM mode, the auxiliary winding will supply the V_{CC} enough operating current.

Figure 8 shows the start-up sequence of the V_{CC} and the V_{OUT}.

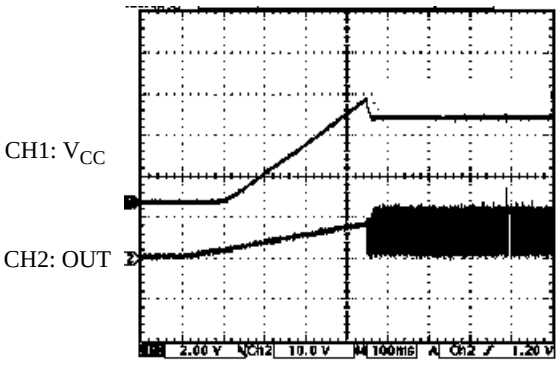


Figure 8. Start-up Sequence of V_{CC} and V_{OUT}

2. V_{CC}/Feedback Control

An opto-coupler and secondary constant voltage/ current controller consists of voltage feedback network. When load is heavy, the voltage on VCC will be lower to enlarge duty cycle; on the contrary, if load drops, the voltage on VCC will rise to reduce duty cycle.

3. Frequency Dither

Frequency dither is performed by periodically spreading a single switching frequency into adjacent frequency band, so the peak energy is spread. This technique can improve EMI by reducing both quasi-peak and average EMI emissions.

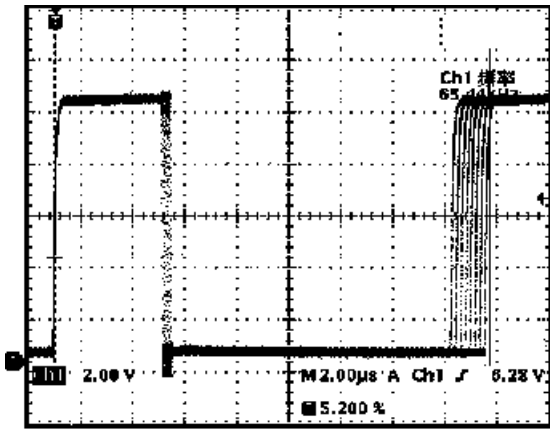


Figure 9. Frequency Dither Influences the Swithcing Cycle

AP3700 has reference switching frequency of 60 kHz, and its frequency deviation is ±2.5kHz in period of 2ms. Figure 9 shows the frequency dither influence to the waveform .

4. Current Limit Control

The AP3700 employs current mode control to improve transient response and voltage stability. In Figure 10, the external inductor current through the OUT pin is converted to a voltage by an internal resistor, and this voltage will participate to control duty cycle and peak inductor current.

Typical Application

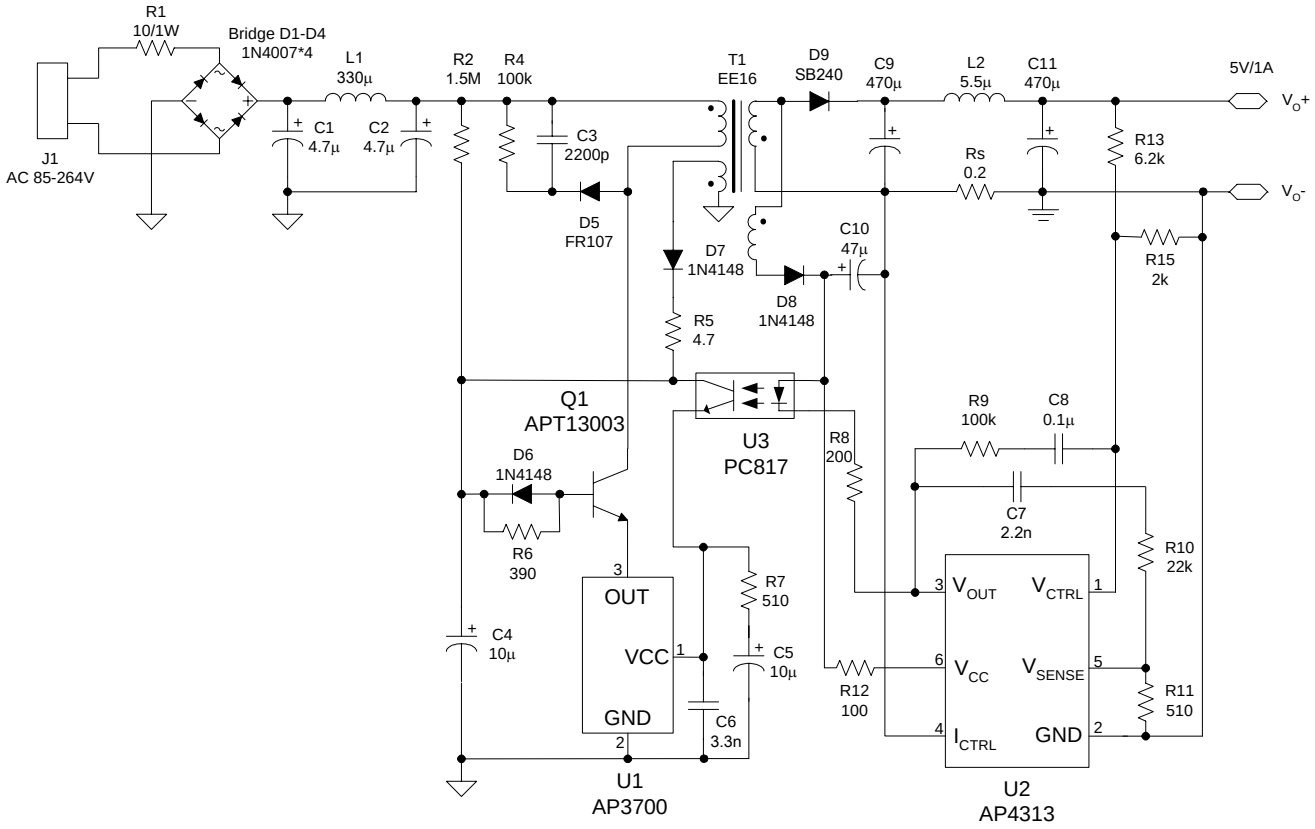
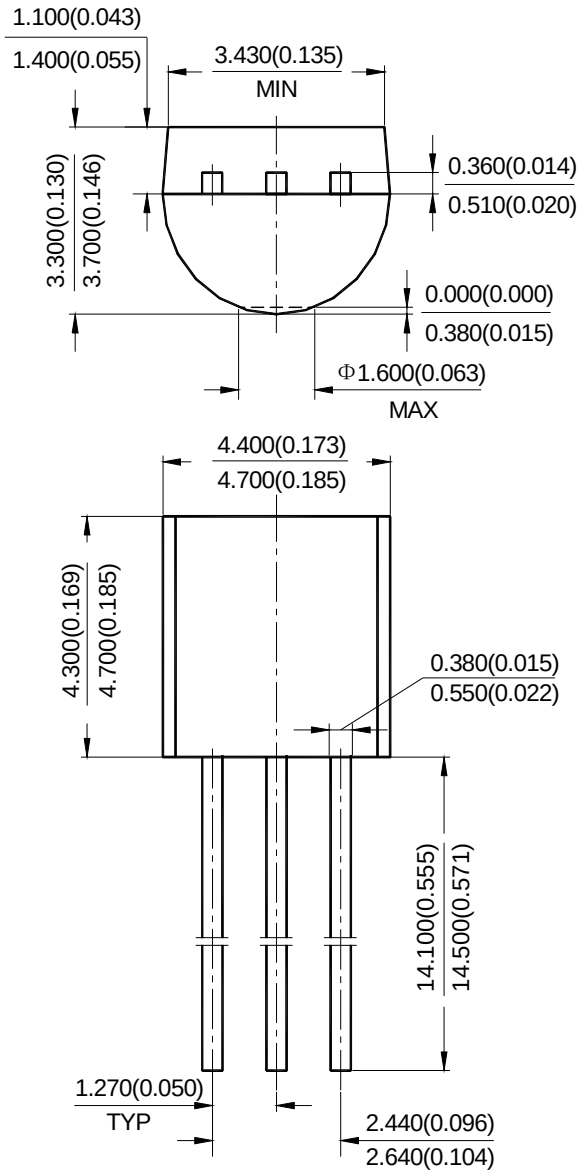


Figure 10. 5V/1A Output for Battery Charger of Mobile Phone

Mechanical Dimensions

TO-92 **Unit: mm(inch)**





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