

**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:  $\pm 2.5$ kHz
- 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)

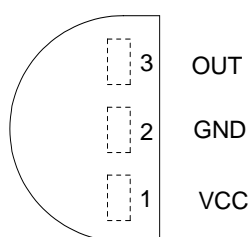


Figure 2. Pin Configuration of AP3700 (Top View)

## 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 |



**LOW POWER PWM CONTROLLER FOR OFF-LINE BATTERY CHARGER** **AP3700**

**Functional Block Diagram**

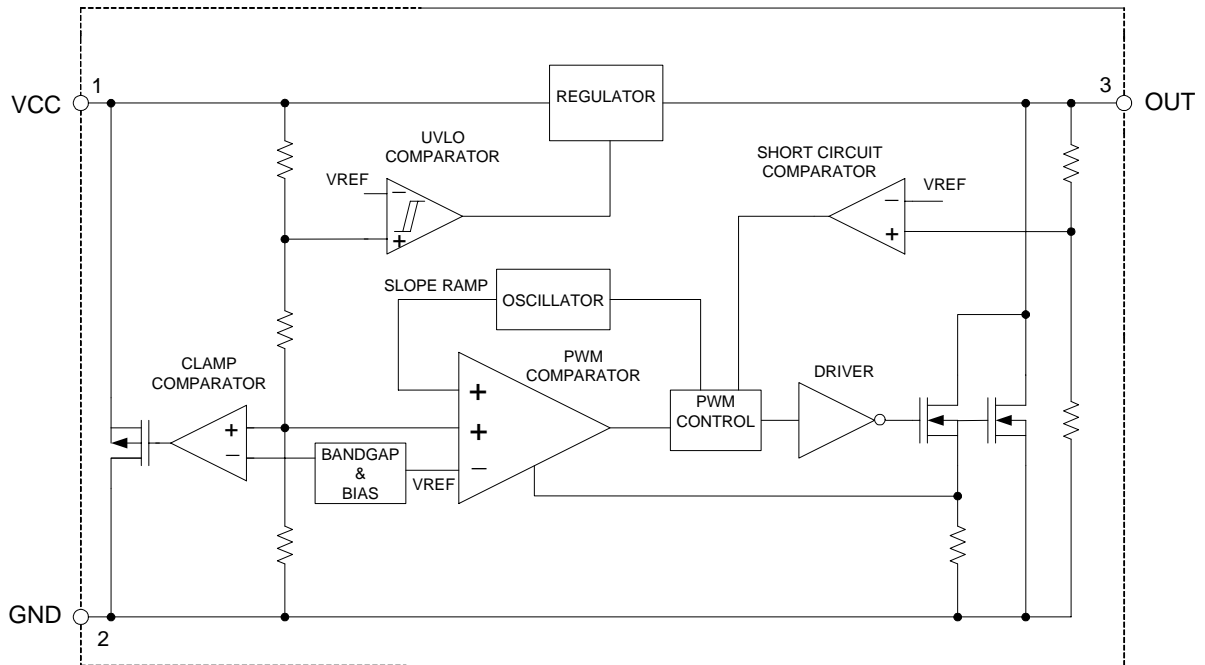
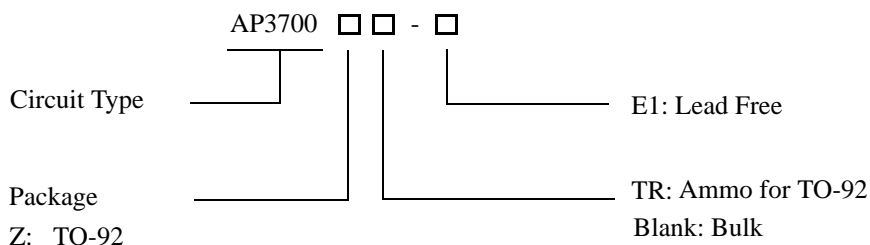


Figure 3. Functional Block Diagram of AP3700

**LOW POWER PWM CONTROLLER FOR OFF-LINE BATTERY CHARGER****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.



**LOW POWER PWM CONTROLLER FOR OFF-LINE BATTERY CHARGER AP3700**

**Electrical Characteristics**

( $V_{CC}=4V$ ,  $T_J=25^{\circ}C$ , unless otherwise specified.)

| Parameter                       | Symbol         | Conditions                     | Min     | Typ       | Max     | Unit       |
|---------------------------------|----------------|--------------------------------|---------|-----------|---------|------------|
| <b>UVLO SECTION</b>             |                |                                |         |           |         |            |
| 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          |
| <b>STANDBY CURRENT SECTION</b>  |                |                                |         |           |         |            |
| 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        |         | k $\Omega$ |
| <b>INTERNAL OSCILLATOR</b>      |                |                                |         |           |         |            |
| Switching Frequency             | $F_{SW}$       |                                | 50      | 60        | 75      | kHz        |
| Frequency Dither                |                |                                | $\pm 2$ | $\pm 2.5$ | $\pm 3$ | kHz        |
| Temperature Stability           |                |                                |         | 5         | 8       | %          |
| <b>DRIVE OUTPUT SECTION</b>     |                |                                |         |           |         |            |
| OUT Start-up Voltage            | $V_{ST}$       |                                |         | 8.5       | 11      | V          |
| Short Circuit Threshold Voltage | $V_{SC}$       |                                |         | 6         |         | V          |
| Rise Time                       | $T_R$          | $C_L=1nF$ , $15\Omega$ pull-up |         | 60        |         | ns         |
| Fall Time                       | $T_F$          | $C_L=1nF$ , $15\Omega$ 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         |         | $\Omega$   |
| Switch Off Current (OUT)        |                | Driver off, $V_{OUT}=10V$      |         | 20        | 40      | $\mu A$    |
| Effective Current Limit         | $I_{LIM}$      | $V_{CC} = V_{OPR}+0.1V$        | 420     |           |         | mA         |
| OUT Current Coefficient         | $G_A$          |                                |         | -0.3      |         | A/V        |



**LOW POWER PWM CONTROLLER FOR OFF-LINE BATTERY CHARGER AP3700**

**Typical Performance Characteristics**

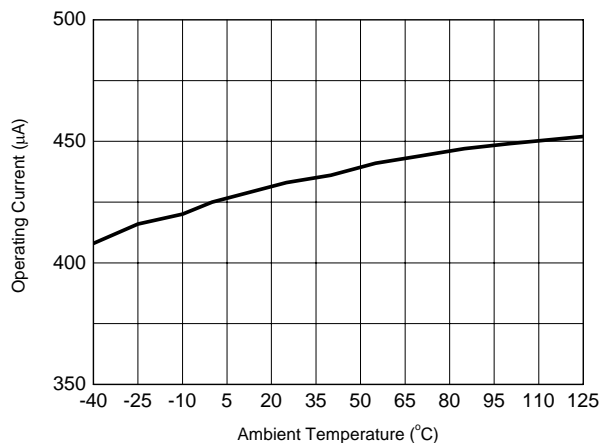


Figure 4. Operating Current vs. Ambient Temperature

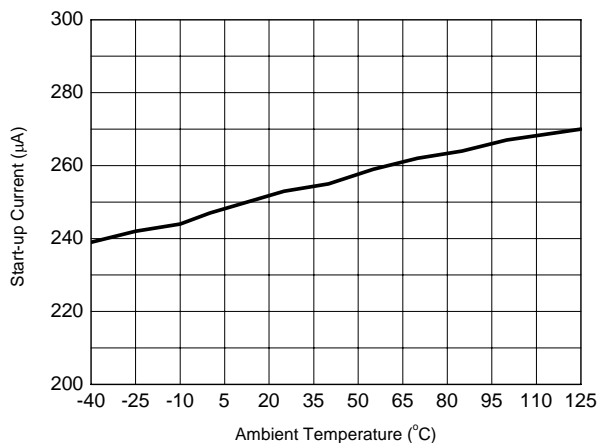


Figure 5. Start-up Current vs. Ambient Temperature

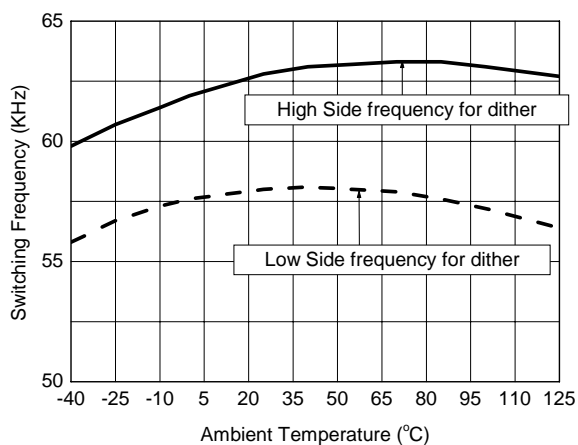


Figure 6. Switching Frequency vs. Ambient Temperature

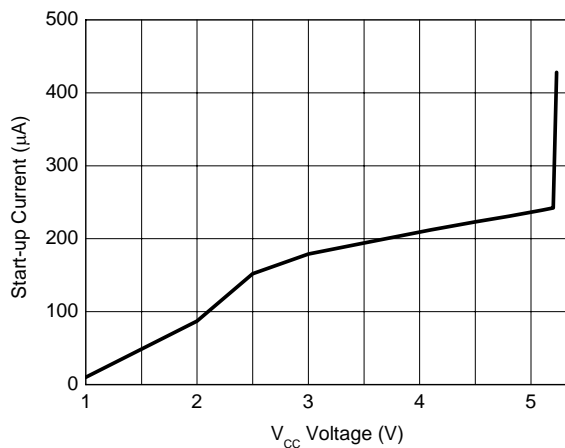


Figure 7. Start-up Current vs. V<sub>CC</sub> Voltage



## 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  $V_{OUT}$ .

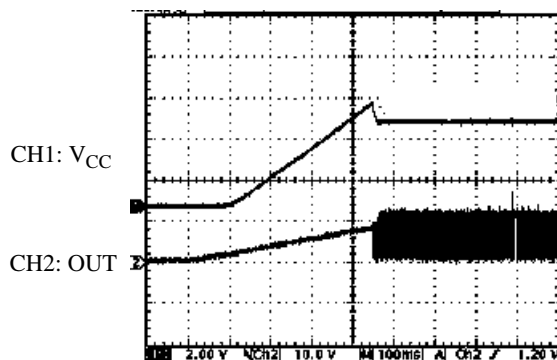


Figure 8. Start-up Sequence of  $V_{CC}$  and  $V_{OUT}$

### 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.

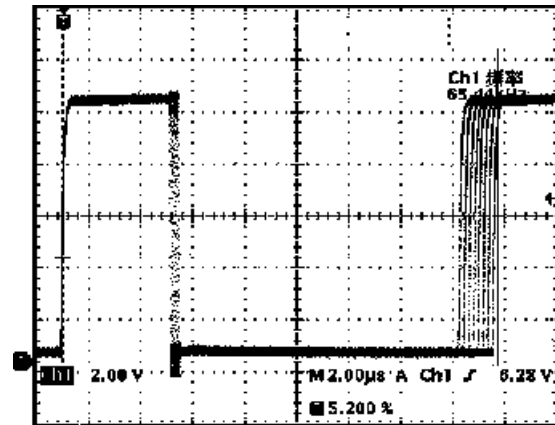


Figure 9. Frequency Dither Influences the Switching Cycle

AP3700 has reference switching frequency of 60 kHz, and its frequency deviation is  $\pm 2.5$  kHz 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.



**LOW POWER PWM CONTROLLER FOR OFF-LINE BATTERY CHARGER AP3700**

**Typical Application**

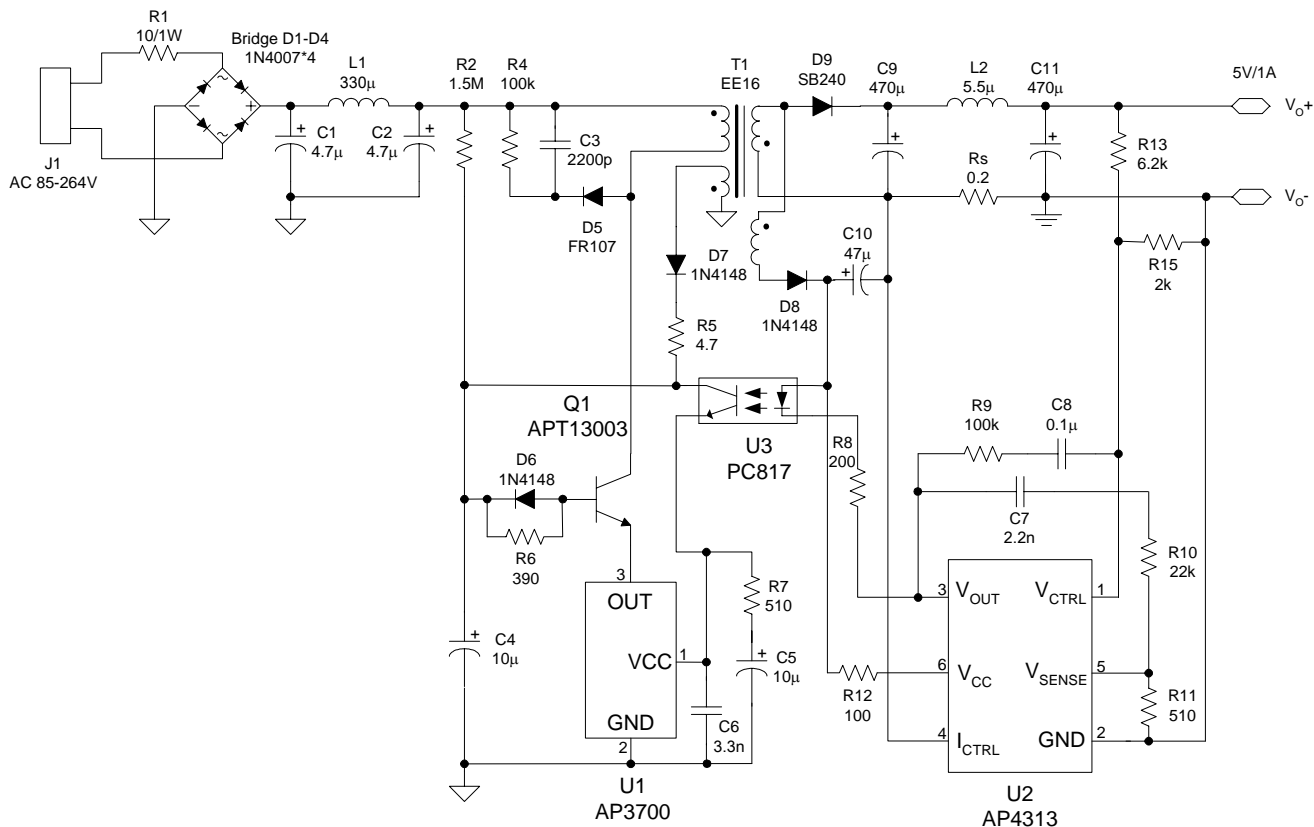


Figure 10. 5V/1A Output for Battery Charger of Mobile Phone





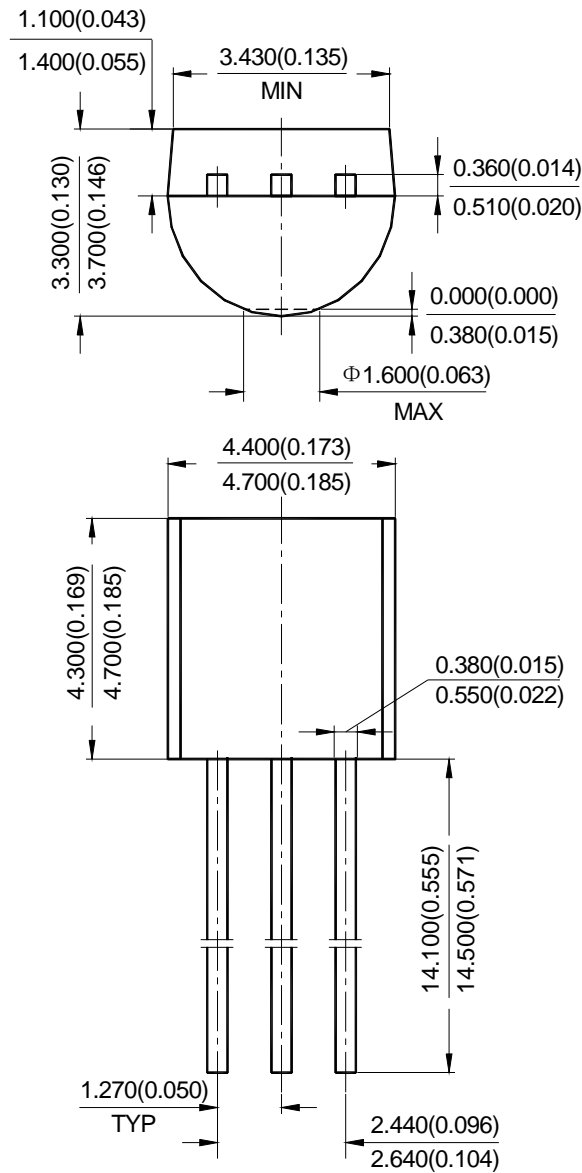
**LOW POWER PWM CONTROLLER FOR OFF-LINE BATTERY CHARGER**

**AP3700**

**Mechanical Dimensions**

**TO-92**

**Unit: mm(inch)**





BCD Semiconductor Manufacturing Limited

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