

**LOW-POWER OFF-LINE PRIMARY SIDE REGULATION CONTROLLER AP3703****General Description**

The AP3703 is a high performance AC/DC power supply controller for battery charger and adapter applications. The device uses Pulse Frequency Modulation (PFM) method to build discontinuous conduction mode (DCM) flyback power supplies.

The AP3703 provides accurate constant voltage, constant current (CV/CC) regulation while removing the opto-coupler and secondary control circuitry. It also eliminates the need of loop compensation circuitry while maintaining stability. The AP3703 achieves excellent regulation and high average efficiency, yet meets the requirement for no-load consumption less than 100mW.

The AP3703 is available in SOT-23-5 package.

**Features**

- Primary Side Control for Rectangular Constant Current and Constant Voltage Output
- Secondary CV/CC Control Circuitry Eliminating Opto-Coupler
- No Need for Control Loop Compensation Circuitry
- Flyback Topology in DCM Operation
- Random Frequency Modulation to Reduce System EMI
- Built-in Soft Start
- Open Feedback Protection
- Over Voltage Protection
- Short Circuit Protection
- Small SOT-23-5 package to achieve compact size and less component

**Applications**

- Adapters/Chargers for Cell/Cordless Phones, PDAs, MP3 and Other Portable Apparatus
- Standby and Auxiliary Power Supplies
- LED Driver

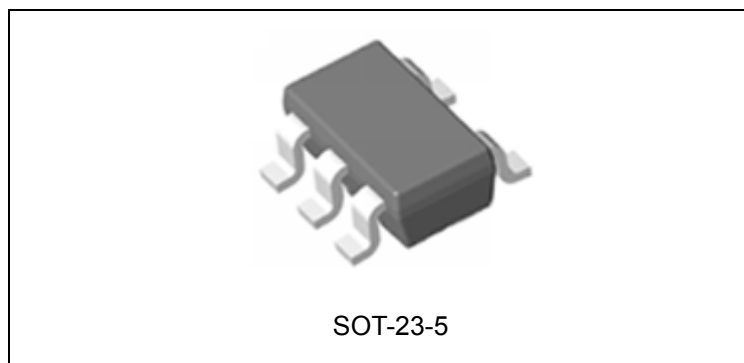


Figure 1. Package Type of AP3703

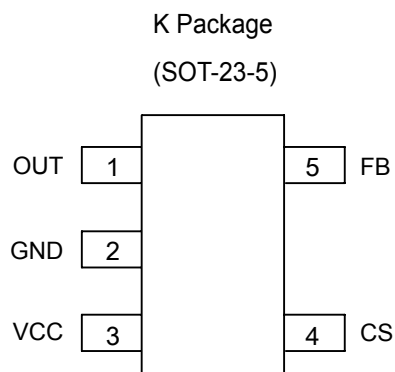
**LOW-POWER OFF-LINE PRIMARY SIDE REGULATION CONTROLLER AP3703**
**Pin Configuration**


Figure 2. Pin Configuration of AP3703 (Top View)

**Pin Description**

Pin Number	Pin Name	Function
1	OUT	This pin drives the base of external power NPN switch
2	GND	Ground
3	VCC	Supply voltage
4	CS	The primary current sense
5	FB	The voltage feedback from the auxiliary winding



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**Functional Block Diagram**

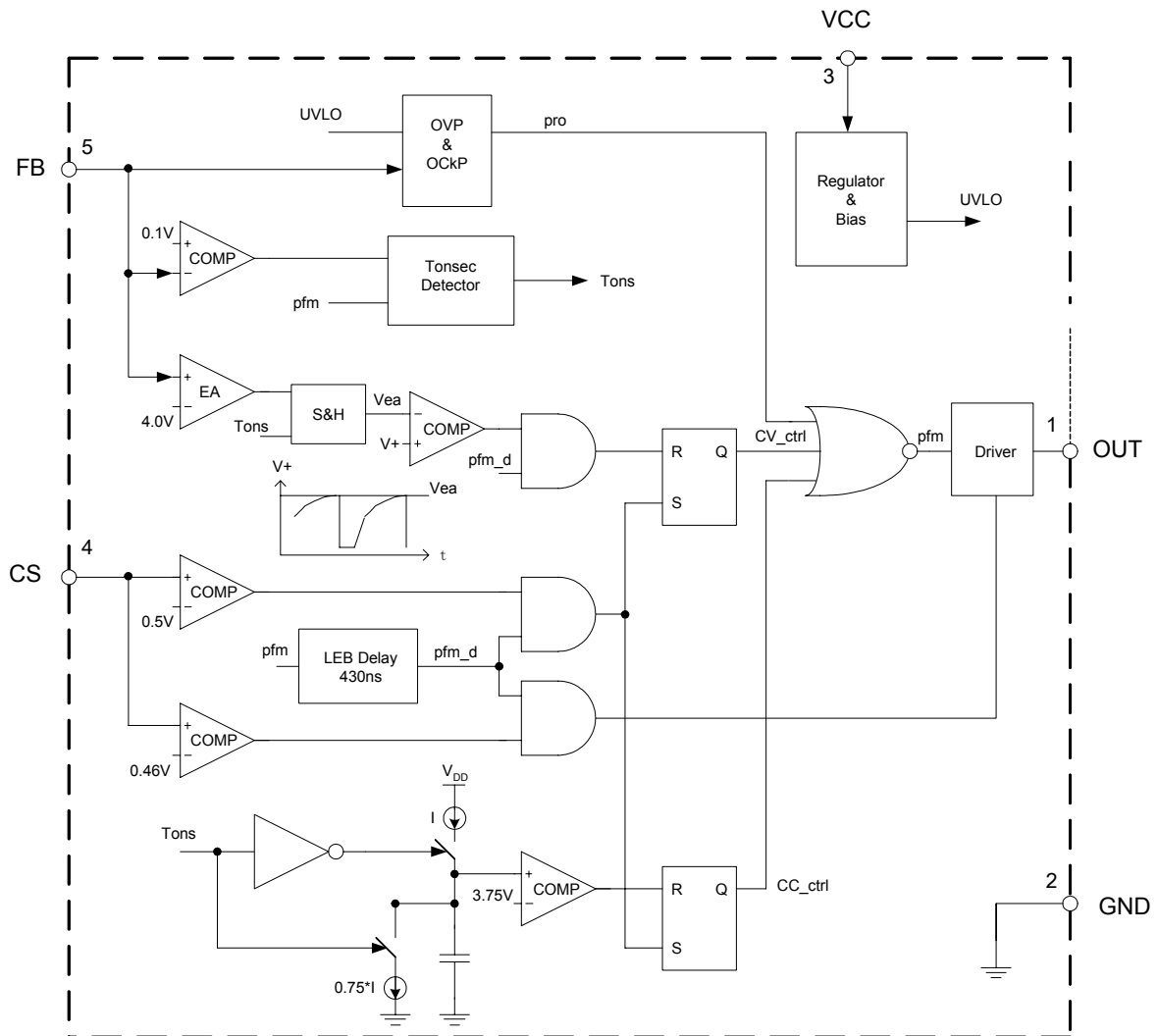
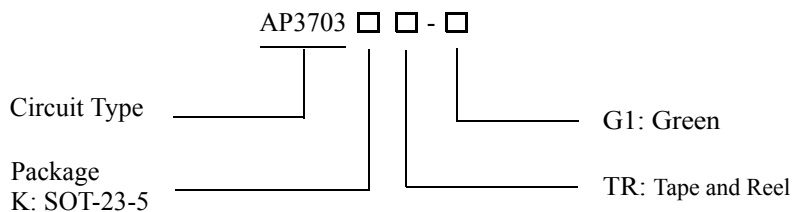


Figure 3. Functional Block Diagram of AP3703

**LOW-POWER OFF-LINE PRIMARY SIDE REGULATION CONTROLLER AP3703****Ordering Information**

Package	Temperature Range	Part Number	Marking ID	Packing Type
SOT-23-5	-40 to 85°C	AP3703KTR-G1	GAT	Tape & Reel

BCD Semiconductor's products, as designated with "G1" suffix in the part number, are RoHS compliant and Green.

**Absolute Maximum Ratings (Note 1)**

Parameter	Value	Unit
Supply Voltage VCC	-0.3 to 30	V
Voltage at CS, OUT to GND	-0.3 to 7	V
FB input (Pin 5)	-40 to 10	V
Output Current at OUT	Internally limited	A
Operating Junction Temperature	150	°C
Storage Temperature	-65 to 150	°C
Lead Temperature (Soldering, 10s)	300	°C
Thermal Resistance Junction-to-Ambient	250	°C/W
ESD (Machine Model)	200	V
ESD (Human Body Model)	2000	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.



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**Electrical Characteristics**

( $V_{CC}=15V$ ,  $T_A=25^{\circ}C$ , unless otherwise specified.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
<b>UVLO SECTION</b>						
Start-up Threshold	$V_{TH(ST)}$		16.5	19.5	22.5	V
Minimal Operating Voltage	$V_{OPR(min)}$		6.5	8	9.5	V
<b>STANDBY CURRENT SECTION</b>						
Start-up Current	$I_{ST}$	$V_{CC} = V_{TH(ST)} - 0.5V$ , Before start-up		45	60	$\mu A$
Operating Current	$I_{CC(OPR)}$	Static		240	300	$\mu A$
<b>DRIVE OUTPUT SECTION</b>						
OUT Maximum Current	Sink	$I_{OUT}$	50			mA
	Source		24	30	36	
<b>CURRENT SENSE SECTION</b>						
Current Sense Threshold	$V_{CS}$		450	485	530	mV
Pre-Current Sense	$V_{CS(PRE)}$		350	395	440	mV
Leading Edge Blanking				430		ns
<b>FEEDBACK INPUT SECTION</b>						
Feedback Pin Input Leakage Current	$I_{FB}$	$V_{FB}=4V$	2.3	2.7	3.1	$\mu A$
Feedback Threshold	$V_{FB}$		3.65	3.95	4.25	V
Enable Turn-on Voltage	$V_{FB(EN)}$		-2.0	-1.5	-1.0	V
Over Voltage Protection	$V_{FB(OVP)}$		6.4	8	9.6	V



**LOW-POWER OFF-LINE PRIMARY SIDE REGULATION CONTROLLER AP3703**

**Typical Performance Characteristics**

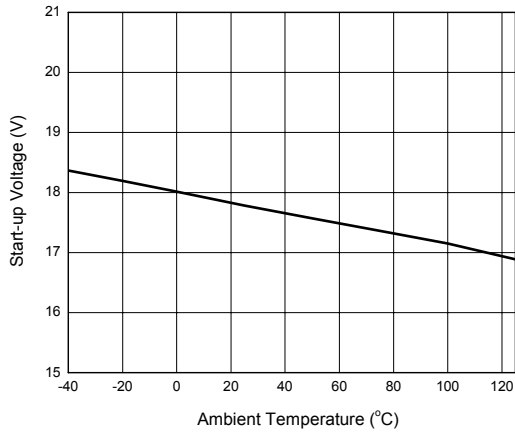


Figure 4. Start-up Voltage vs. Ambient Temperature

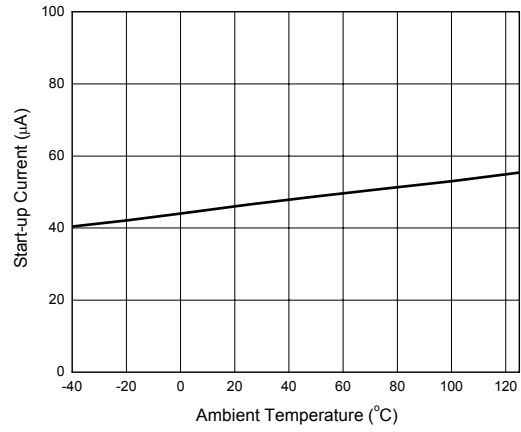


Figure 5. Start-up Current vs. Ambient Temperature

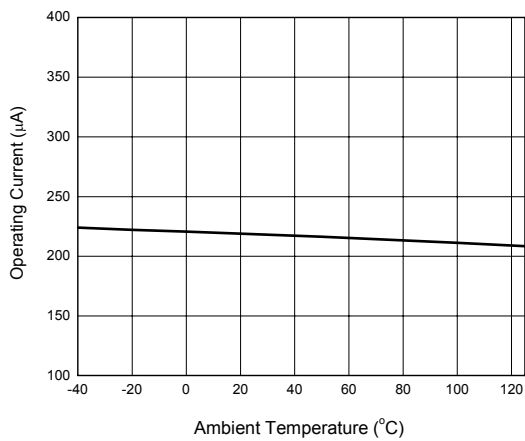


Figure 6. Operating Current vs. Ambient Temperature

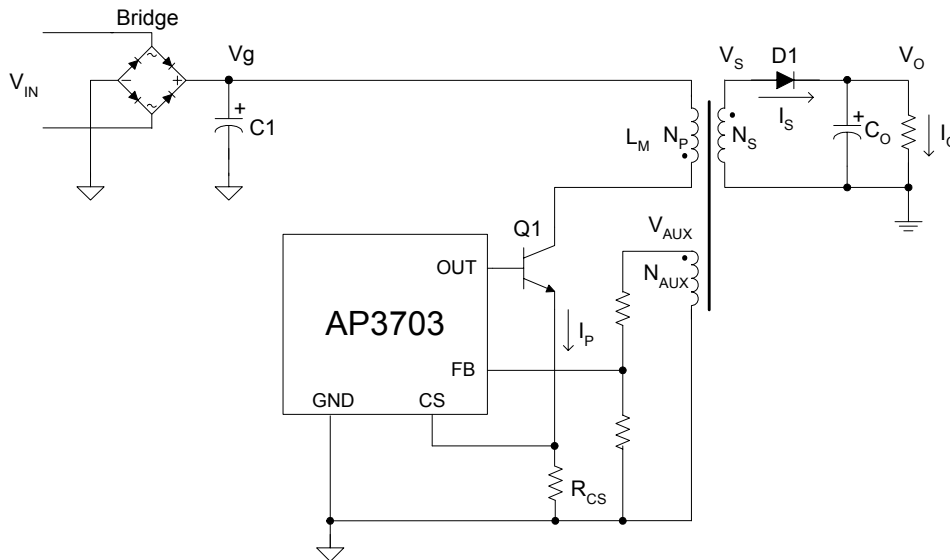
**LOW-POWER OFF-LINE PRIMARY SIDE REGULATION CONTROLLER AP3703**
**Operation Description**


Figure 7. Simplified Flyback Converter Controlled by AP3703

Figure 7 illustrates a simplified flyback converter controlled by AP3703.

**Constant Primary Peak Current**

The primary current  $i_p(t)$  is sensed by a current sense resistor  $R_{CS}$  as shown in Figure 7.

The current rises up linearly at a rate of:

$$\frac{di_p(t)}{dt} = \frac{vg(t)}{L_M} \quad \text{.....(1)}$$

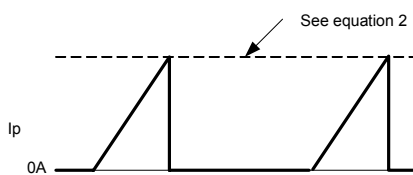


Figure 8. Primary Current Waveform

As illustrated in Figure 8, when the current  $i_p(t)$  rises up to  $I_{pk}$ , the switch Q1 turns off. The constant peak current is given by:

$$I_{pk} = \frac{V_{cs}}{R_{cs}} \quad \text{.....(2)}$$

The energy stored in the magnetizing inductance  $L_M$  each cycle is therefore:

$$E_g = \frac{1}{2} \times L_M \cdot I_{pk}^2 \quad \text{.....(3)}$$

So the power transferring from the input to the output is given by:

$$P = \frac{1}{2} \times L_M \times I_{pk}^2 \times f_{sw} \quad \text{.....(4)}$$

Where the  $f_{sw}$  is the switching frequency. When the peak current  $I_{pk}$  is constant, the output power depends on the switching frequency  $f_{sw}$ .

**Constant Voltage Operation**

The AP3703 captures the auxiliary winding feedback voltage at FB pin and operates in constant-voltage (CV) mode to regulate the output voltage. Assuming the secondary winding is master, the auxiliary winding is slave during the D1 on-time and the auxiliary voltage is given by:

$$V_{AUX} = \frac{N_{AUX}}{N_S} \times (V_o + V_d) \quad \text{.....(5)}$$

**LOW-POWER OFF-LINE PRIMARY SIDE REGULATION CONTROLLER AP3703**
**Operation Description (Continued)**

where the  $V_d$  is the diode forward drop voltage.

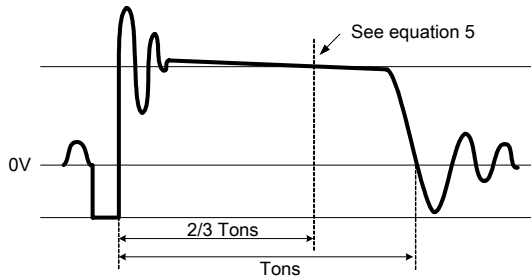


Figure 9. Auxiliary Voltage Waveform

The output voltage is different from the secondary voltage in a diode forward drop voltage that depends on the current. If the secondary voltage is always detected at a fixed secondary current, the difference between the output voltage and the secondary voltage will be a fixed  $V_d$ . For AP3703, the voltage detection point is at two-thirds of the D1 on-time, which means the secondary voltage is detected at a fixed secondary current of one-third of  $I_{pks}$ . The CV loop control function of AP3703 then generates a D1 off-time to regulate the output voltage.

**Constant Current Operation**

Figure 10 shows the secondary current waveforms.

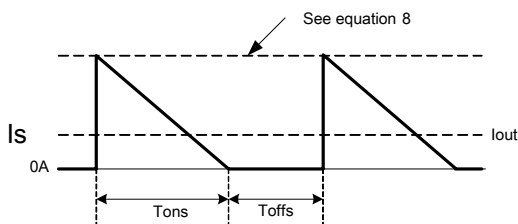


Figure 10. Secondary Current Waveform

In CC operation, the CC loop control function of AP3703 will keep a fixed proportion between D1 on-time  $T_{ons}$  and D1 off-time  $T_{offs}$  by discharging or charging a capacitor embedded in the IC. The fixed proportion is:

$$\frac{T_{ons}}{T_{offs}} = \frac{4}{3} \quad \text{.....(6)}$$

The relationship between the output constant-current and secondary peak current  $I_{pks}$  is given by:

$$I_{out} = \frac{1}{2} \times I_{pks} \times \frac{T_{ons}}{T_{ons} + T_{offs}} \quad \text{.....(7)}$$

At the instant of D1 turn-on, the primary current transfers to the secondary at an amplitude of:

$$I_{pks} = \frac{N_p}{N_s} \times I_{pk} \quad \text{.....(8)}$$

Thus the output constant-current is given by:

$$I_{out} = \frac{1}{2} \times \frac{N_p}{N_s} \times I_{pk} \times \frac{T_{ons}}{T_{ons} + T_{offs}} = \frac{2}{7} \times \frac{N_p}{N_s} \times I_{pk} \quad \text{.....(9)}$$

**Leading Edge Blanking**

When the power switch is turned on, a turn-on spike will occur on the sense-resistor. To avoid false-termination of the switching pulse, a 430ns leading-edge blanking is built in. During this blanking period, the current sense comparator is disabled and the gate driver can not be switched off.

**CCM Protection**

The AP3703 is designed to operate in discontinuous conduction mode (DCM) in both CV and CC modes. To avoid operating in continuous conduction mode (CCM), the AP3703 detects the falling edge of the FB input voltage on each cycle. If a 0.1V falling edge of FB is not detected, the AP3703 will stop switching.

**OVP & OckP**

The AP3703 includes output over-voltage protection (OVP) and open circuit protection (OckP) circuitry as shown in Figure 11. If the voltage at FB pin exceeds 8V, 100% above the normal detection voltage, or the -1.5V falling edge of the FB input can not be monitored, the AP3703 will immediately shut off and enters hiccup mode. The AP3703 sends out a fault detection pulse every 24ms in hiccup mode until the fault has been removed.



**LOW-POWER OFF-LINE PRIMARY SIDE REGULATION CONTROLLER AP3703**

**Operation Description (Continued)**

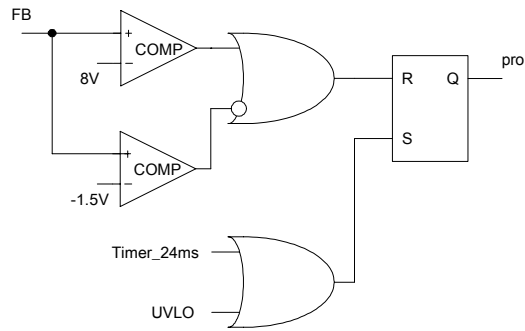


Figure 11. OVP and OCP Function Block

**Typical Application**

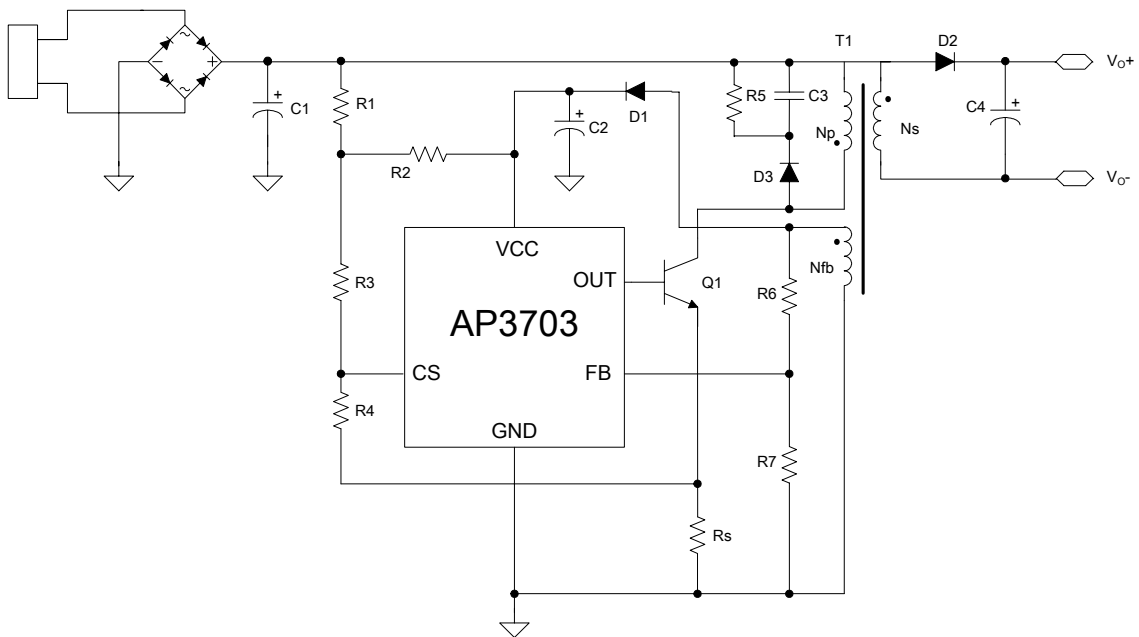


Figure 12. 5V/500mA Output for Battery Charger of Mobile Phone

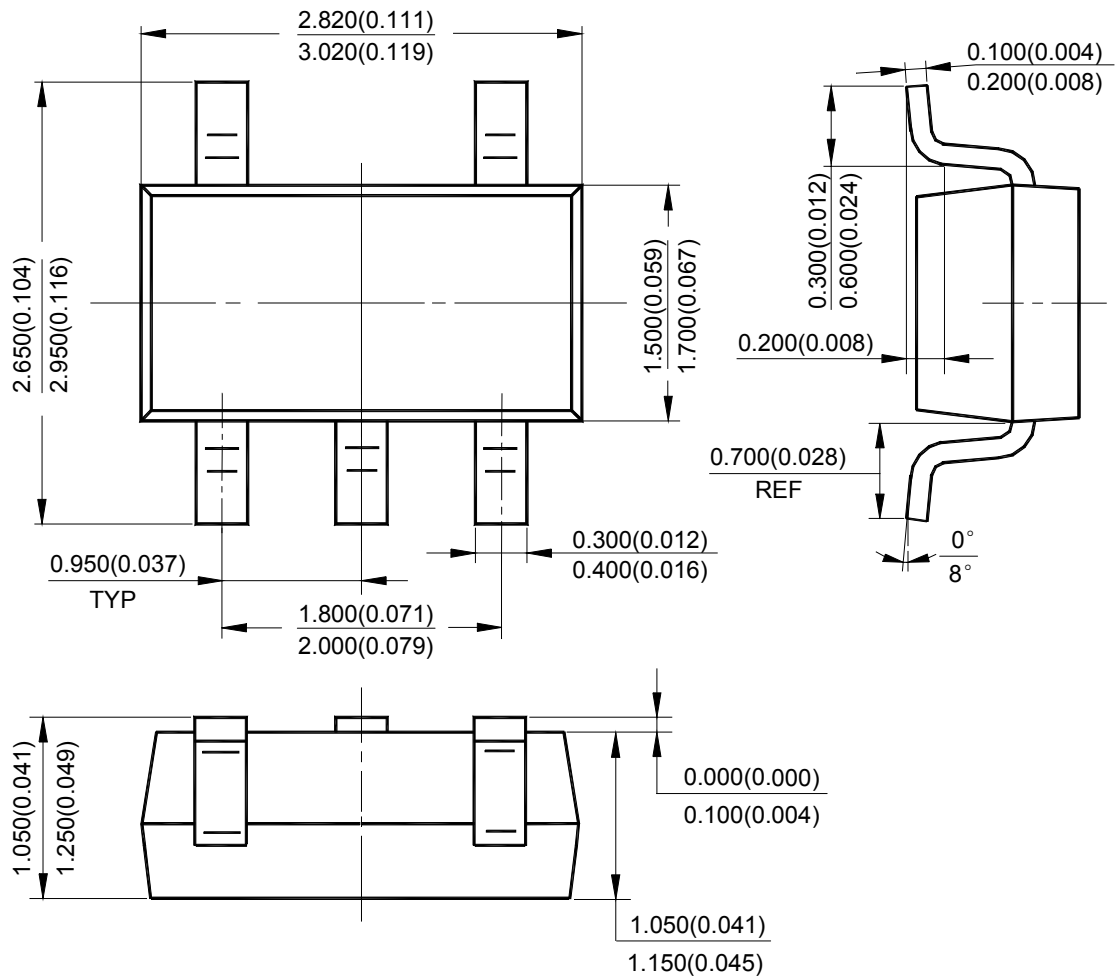


**LOW-POWER OFF-LINE PRIMARY SIDE REGULATION CONTROLLER AP3703**

**Mechanical Dimensions**

**SOT-23-5**

**Unit: mm(inch)**





## **BCD Semiconductor Manufacturing Limited**

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