HIGH EFFICIENCY DC-DC STEP UP CONVERT

FEATURES

- 0.9V start up voltage;
- 0.9V minimum operating voltage;
- Above 95% efficiency;
- Low battery voltage detector;
- Fixed 3.3V and 5V output or adjustable output from 2V to 5V;
- Internal synchronous rectifier;
- Zero shut down current;
- Little external elements
- Ultra small TSSOP8, MSOP8 package;

APPLICATION

- One to three-cell battery powered devices;
- PDA and handheld instruments;
- Cell phones;
- Pagers;
- GPS;
- Digital cameras;

INTRODUCTION

VA7910/VA7920 series circuits are high efficiency DC-DC step up converts, with a few external components to realize the conversion from the battery voltage to the expect output voltage. It can be widely used in PDA、cell phones、hand-held devices and so on.

The start up voltage is guaranteed at above 0.9V input and the device keeps working.

With an internal synchronous P-MOS rectifier, it doesn't require external diode to rectify.

VA7910FF is completely compatible with L6920 of ST Corporation. And VA7910DF is completely compatible with MAX1674/MAX1675 of MAXIM Corporaton.

FUNCTIONAL DIAGRAM

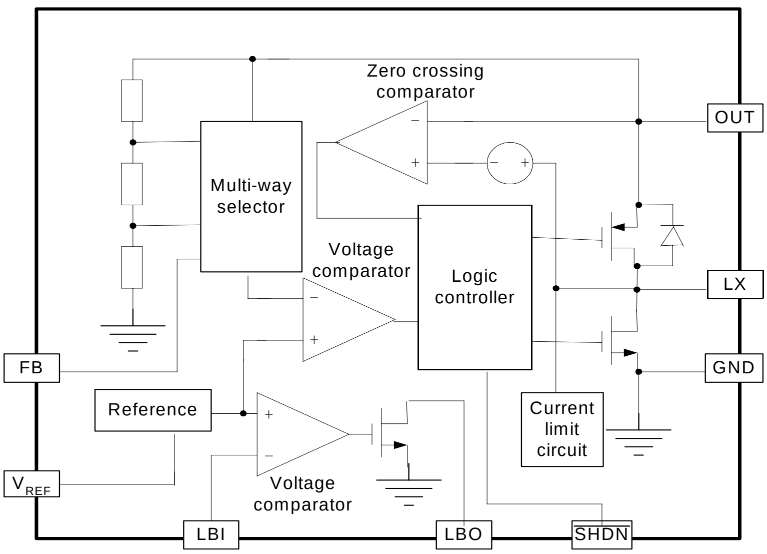
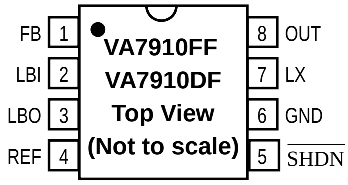


Fig1 Function Diagram

ORDERING INFORMATION

Type	Package	Pin Number	Print Mark
VA7910FF	TSSOP8	8	TBA
VA7910DF	MSOP8	8	TBA

PIN-OUT



TSSOP8
MSOP8

Fig2 Pin-Out Diagram

PIN DESCRIPITION

Pin Name	Pin Num		Pin Function
	VA7910	VA7920	
FB	1	1	Output voltage selected pin. Connect to Ground for 5V output; Connect to OUT for 3.3V output; Connect to a resistor divider for adjustable output from 2V to 5V.
LBI	2		Low battery detector input. Internal detection threshold voltage is 1.15V（VREF）.
LBO	3		Low battery detector output. The output goes low when V_{LBI} is lower than the internal threshold voltage, otherwise, the output shown high impedance. This pin is open drain configuration, it must add an external pull-up resistor in application.
REF	4	3	Reference voltage. Bypass this output to GND with a 0.1μF capacitor for filtering high frequency noise. The maximum current delivered to this pin is 10μA.
$\overline{SHDN}$	5	4	Shutdown Pin. The device will shut down when the voltage of this pin is below 0.3V; The device is operating when the voltage is above 0.6V.
GND	6	6	Ground.
LX	7	5	Connect with external inductor.
OUT	8	2	Power output pin. This pin supplies the power for the internal circuit and it must connect to an external about 10uF to 100uF capacitor for filtering and an about 1uF capacitor for coupling.

ABSOLUTE MAXIMUM RATINGS

Supply voltage (V_{OUT}) .... －0.3V ~ ＋6V

FB、LBI、LBO、LX、$\overline{SHDN}$、

REF input voltage .... －0.3V ~ VOUT＋0.3V

Operation temperature (T_A) .... －40℃ ~ ＋85℃

Storage temperature........................... －65℃ ~ 150℃

Junction temperature..150℃

Power dissipation PD（T_A＝25℃）

TSSOP8（Thermal resistance θ_{JA}=TBD℃/W）.... TBD

MSOP8（Thermal resistance θ_{JA}=TBD℃/W）...... TBD

Leading temperature（Soldering，10s）............. 300℃

ESD（Human body mode）...2kV

Caution: Stresses above those listed parameter may cause permanent damage to the devices. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to the listed ratings for extended periods may affect device reliability.

ELECTRICAL CHARACTERIZATION (1)

（Inductor input voltage: V_{IN}=2V，V_{FB}＝V_{OUT}, unless otherwise noted. Operation temperature with mark "♦" is: －40℃ ≤ T_A ≤ 85℃; without mark "♦" is: T_A＝25℃; The typical values are at T_A＝25℃）

PARAMETER	SYMBOL	TEST CONDITION		MIN	TYP	MAX	UNIT
Minimum input voltage	V_{IN}				0.9		V
Start up voltage					0.9	1.3	V
Start up voltage tempco					-2		mV/℃
Output voltage	V_{OUT}	V_{FB}=V_{OUT}	♦	3.2	3.3	3.4	V
		V_{FB}=0	♦	4.85	5	5.15	
FB voltage	V_{FB}	V_{OUT}=2V~5V	♦	1.13	1.15	1.16	V
FB input current						50	nA
Output voltage range		Connect to external resistor divider		2		5	V
Static output current	I_Q	V_{FB}=1.4V，V_{OUT}=3.3V		14.8	16.9	17.4	μA
Shutdown current into OUT pin	I_{SD}	$V_{\overline{SHDN}}$=0			0.1	1	μA
Reference voltage	V_{REF}	I_{REF}=0	♦	1.13	1.15	1.16	V
		I_{REF}=10μA	♦	1.125	1.145	1.155	
Active switch maximum On-Time	t_{ONMAX}		♦	3.3	5	6.9	μs
Active switch minimum Off-Time	t_{OFFMIN}		♦	0.65	1	1.5	μs
Active switch ON resistance	R_{DSN}	VA7910，I_{LX}=100mA	♦		0.1	0.2	Ω
		VA7920，I_{LX}=100mA	♦		0.1	0.2	Ω
Synchronous rectifier switch ON resistance	R_{DSP}	VA7910，I_{LX}=100mA	♦		0.15	0.3	Ω
		VA7920，I_{LX}=100mA	♦		0.3	0.4	Ω
Active switch current limit	I_{LIM}	VA7910	♦	0.8	1.0	1.2	A
		VA7920	♦	0.8	1.0	1.2	A
LX leakage current	I_{LXOFF}	V_{OUT}＝5.5V， V_{LX}＝5.5V，$V_{\overline{SHDN}}$=0				1	μA

ELECTRICAL CHARACTERIZATION (2)

（Inductor input voltage: V_{IN}=2V， V_{FB} = VOUT, unless otherwise noted. Operation temperature with mark "♦" is: －40℃ ≤ T_A ≤ 85℃； without mark is "♦"： T_A = 25℃； The typical values are at T_A = 25℃ ）

PARAMETER	SYMBOL	TEST CONDITION		MIN	TYP	MAX	UNIT
LBI internal detection threshold			♦	1.13	1.15	1.16	V
LBI input current						50	nA
LBO low output voltage		V_{LBI}=0， I_{SINK}=1mA			0.2	0.4	V
LBO OFF leakage current						1	μA
$\overline{SHDN}$ Input current						1	μA
$\overline{SHDN}$ LOW input voltage	$V_{IL\overline{SHDN}}$					0.3	V
$\overline{SHDN}$ High input voltage	$V_{IH\overline{SHDN}}$			0.6			V

DETAILED DESCRIPTION

VA7910/VA7920 is a high efficiency DC-DC step up convert circuit widely used for the devices powered by one to three-cells Li-ion/ Li-polymer battery or hydro-nickel battery and need a steady high voltage.

The static operating current of VA7910/VA7920 is extra low. With an internal synchronous rectifier to improve the efficiency, the device needn't external diode for rectify that can reduce the board space and save the cost.

VA7910/VA7920 realizes the high efficiency step up conversion through controlling the internal active switch maximum On-Time and minimum Off-Time and tailoring the inductor maximum current limit. Fig3 and fig 4 shows the typical application circuit. Following is the detailed description.

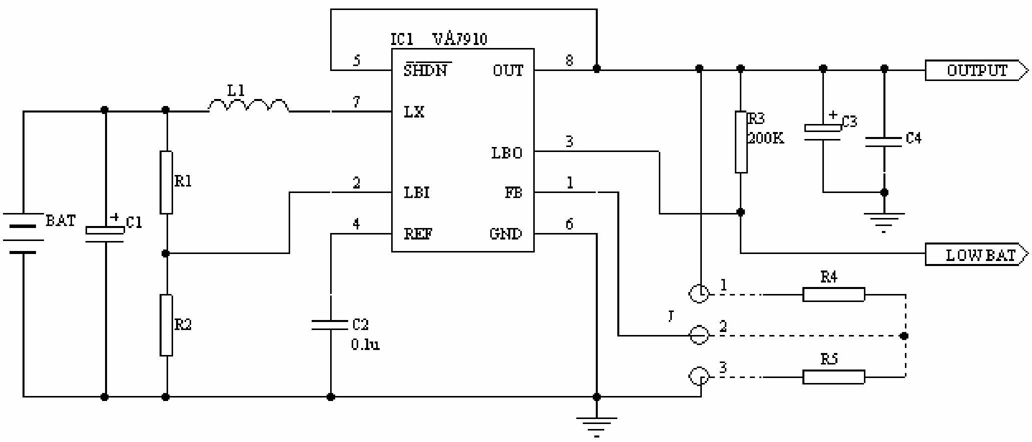


Fig3 VA7910 typical application diagram

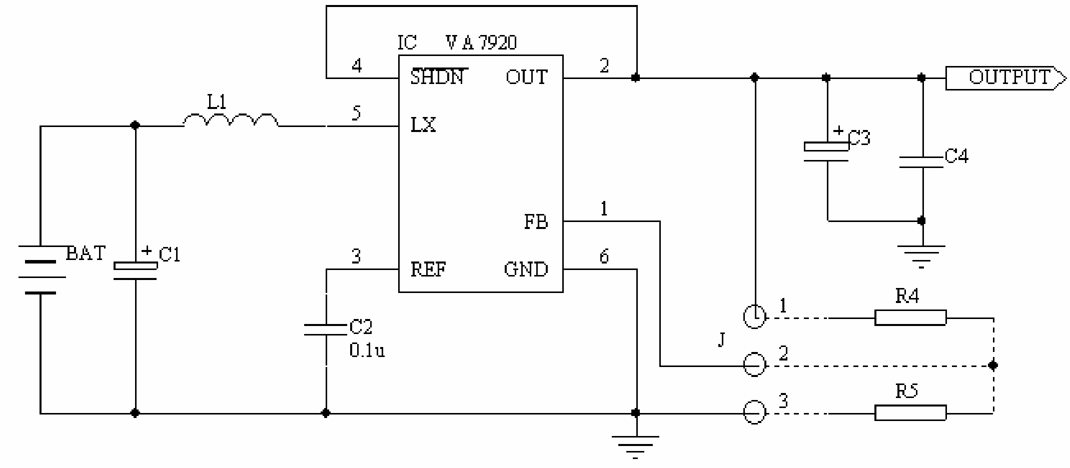


Fig4 VA7920 typical application diagram

1、OPERATION PRINCIPLE

Through controlling the internal N-MOS active switch and P-MOS synchronous rectifier on/off with the external inductor (L1) and output capacitor (C3), VA7910/VA7920 can realize the step-up conversion function.

After the circuit comes into steady state, the internal active N-MOS switch will conduct when the output voltage drops below the expected value and the P-MOS synchronous rectifier turns off, then the external capacitor supply to the load and at the same time, the energy transfers from the battery to the inductor. When the current in the inductor increases above the active switch current limit or the transfer time exceed the active switch maximum On-Time, the N-MOS will turn off.

The internal P-MOS conducts simultaneously with the N-MOS turning off, so the current of the inductor will drop to induce faradism, then the energy of the faradism and the battery transfer to the capacitor and supply the load together. Because the added faradism, the circuit realize the voltage step-up function. In fact, the synchronous rectifier minimum On-Time is equal to the active switch minimum Off-Time (t_{OFFMIN}). after this time, the P-MOS synchronous rectifier turns off as soon as the output voltage goes lower than the expected value or the current flowing of the inductor goes down to zero.

Notes that, the N-MOS active switch may not conduct as soon as the internal P-MOS synchronous rectifier turns off unless the output voltage also drops below the expected value. So, the active switch and synchronous rectifier turns off simultaneously is possible.

When the load of the device is lighter，the current flowing in the inductor L1 rises and falls smoothly, the device actually works in PFM mode. With the increasing of the current of the load, the current in the inductor are overlapped in the course of rising and smooth in the course of falling. The current flowing in the inductor all goes down to zero under these two conditions, and the internal active switch and synchronous rectifier turns off simultaneously possibly, the device works in discontinuous mode. When the current increases to induce that the inductor current can't drop to zero, the stored energy of the inductor during the period of the active switch maximum On-Time is equal to the transferred energy during the period of the synchronous rectifier minimum On-Time. At this time, the active switch and synchronous rectifier becomes on and off by turns, the device works in continuous mode. Works in this mode, the larger the current of the load is, the nearer the ripple current of the inductor closes to the active switch current limit. The load current limit is defined by the following relationship:

$$I_{LOAD\text{-}LIM} = \frac{V_{IN}}{V_{OUT}} \times \left(I_{LIM} - T_{OFFMIN} \times \frac{V_{OUT} - V_{IN}}{2L} \right) \times \eta \quad (1)$$

Where η is the efficiency.

If the load current rises above the limit $I_{LOAD\text{-}LIM}$, the device output voltage will be variable to induce a failing step-up conversion.

2、START-UP

One of the key features of VA7910/VA7920 is the startup at the supply voltage down to 1V (The star-up voltage relates to the load)

VA7910/7920 will change the startup mode into operation mode as soon as the output voltage goes over 1.8V. During the startup, the internal P-MOS synchronous rectifier is off and the energy transferred to the capacitor (C3) and the load from the battery and inductor (L1) through its intrinsic body diode.

During startup, the internal N-MOS active switch turns on/off at a given frequency and duty. The active switch with a very low R_{DSON} thanks to the internal charge pump used to power the MOS gate. The energy transferred to inductor L1 from the battery when the active switch is on, and when it is off, the energy transferred to the capacitor C3 and load from the battery and L1.

Current limit and zero crossing detection are still available during the startup. If the current in inductor is detected over the active switch current limit, the active switch turns off at once; otherwise, if the current in the inductor drops to zero, the active switch turns on at once.

3、SHUT DOWN

VA7910/VA7920 includes a shutdown control pin（$\overline{SHDN}$ pin）.In shutdown mode (the pin pulled low), all the internal circuits are turned off, ultra low leakage current delivered to the battery (The typical value is 100nA).

Notes that, in shutdown mode, the P-MOS synchronous rectifier body diode causes a parasitic path between the power supply and output pin. And at that moment, the battery current can't be avoided if the output connected with a load.

4、LOW BATTERY DETECTION

VA7910 also includes low battery detector comparator, comparing the LBI voltage and the internal reference voltage. There is a 3% internal hysteresis to avoid the oscillation in LBO.

LBO is an open drain output, so a pull up resistor is required for a proper use.

APPLICATION ISSUES

1、OUTPUT VOLATGE SELECTION

Output voltage is selected depending on FB pin. There are three connecting choices available for FB.

a） FB connected to GND The output voltage is an invariable value of 5V. Please refer to the typical application as shown in fig 3 and fig 4. Connect 2 and 3 of J with a shunt. R4 and R5 is not used.

b） FB connected to OUT pin The output voltage is an invariable value of 3.3V. Please refer to the typical application as shown in fig 3 and fig 4. Connect 1 and 2 of J with a shunt. R4 and R5 also is not used.

c） FB connected to an external resistor divider The output voltage is adjustable from 2V to 5V. Please refer to the typical application as shown in fig 3 and fig 4. Let R4 be connected between 1 and 2 and R5 be connected between 2 and 3 of J. And the output voltage is defined by the following relationship:

$$V_{OUT}=1.15V(1+R4/R5) \quad (2)$$

R4 and R5 should be selected as larger as possible to minimize power consumption to improve the efficiency. But due to current sunk by FB pin to affect the calculation precision, R4 and R5 should selected between 150 kΩ~4MΩ, thus the current in R4 and R5 is between 1uA and 5uA.

2、LOW BATTERY DETECTOR

Low battery detection is realized by comparing the voltage between LBI pin and the reference (V_{REF}=1.15V). We can use external resistor divider to realize the battery detection which above the 1.15V reference voltage (as shown in Fig 3 and Fig 4)

Supposing V_{TRIP} as the to be detected voltage, we can defined the relationship with R1 and R2 as following formula:

$$V_{TRIP}=1.15V(1+R1/R2) \quad (3)$$

Based on the same consideration of R4 and R5 selection, R1 and R2 should be selected between 150 kΩ~4MΩ.

3、OUTPUT CAPACITOR SELECTION

The output capacitor affects the efficiency and output ripple directly, so its choice has to be considered particularly carefully.

Output capacitor should be selected between 10uF~100uF. In order to get higher efficiency and smaller output ripple, a very low ESR capacitor should be chosen. Ceramic capacitors are the lowest ESR capacitor but they are expensive. Another possible choice is low ESR tantalum capacitor.

An additional, smaller, low ESR capacitor can be used in parallel for higher frequency filtering. The typical value is around 1uF(as shown in ig3 and Fig4).

4、INDUCTOR SELECTION

Usually, a recommended inductor range is 5uH~40uH, which can adapt to most of applications. Small value inductor leads small physical size and guarantee a faster transient response to load but a larger output ripple will be generated, in fact the output ripple voltage is direct rationed by I_{PEAK} multiplied by ESR. Furthermore, as shown in equation (1), the inductor value affects the maximum current delivered to the load.

Also, lower ESR inductor is suggested for high efficiency and smaller output ripple. Additionally, the saturation current of the inductor should be larger than the current limit of the active switch (I_{LIM}).

5、PCB LAYOUT GUIDELINES

The PCB board layout is most important to minimize and eliminate the problems of the noise, high frequency resonance and electromagnetic interference and so on.

To reduce the radiation and high frequency resonance, it is essential to keep the high current switch circulating paths as small as possible. So the input and output capacitor should be very close to the device.

If use an external resistor divider, it should be very close to the relative pin (FB pin and LBI pin) and kept away from the high current paths to reduce the noise.

The trace of the high current should be as wide as possible and polygon plane is required if possible.

PACKEGE DIMENSION:

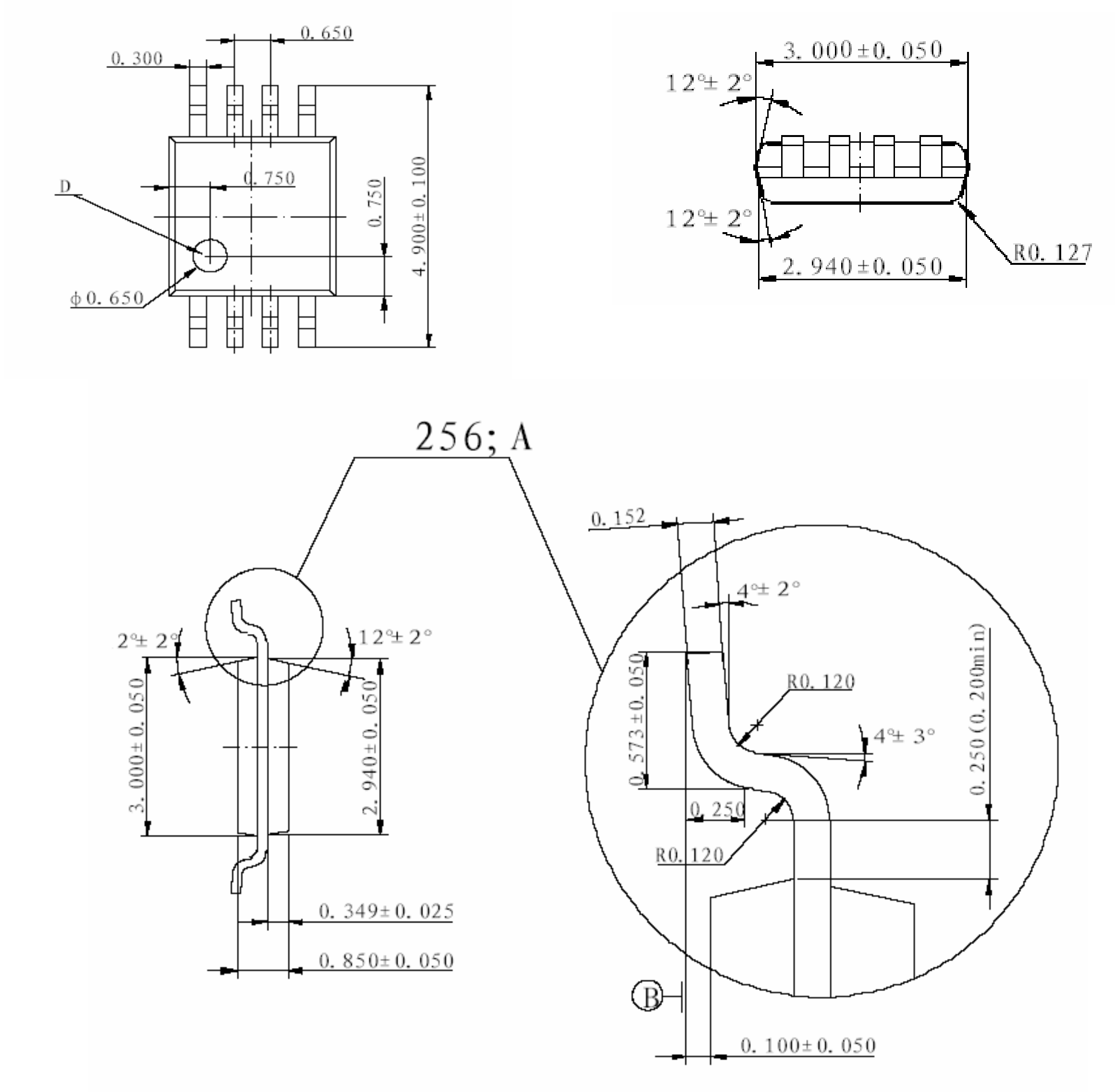


Fig5 MSOP8 Package Dimension Diagram

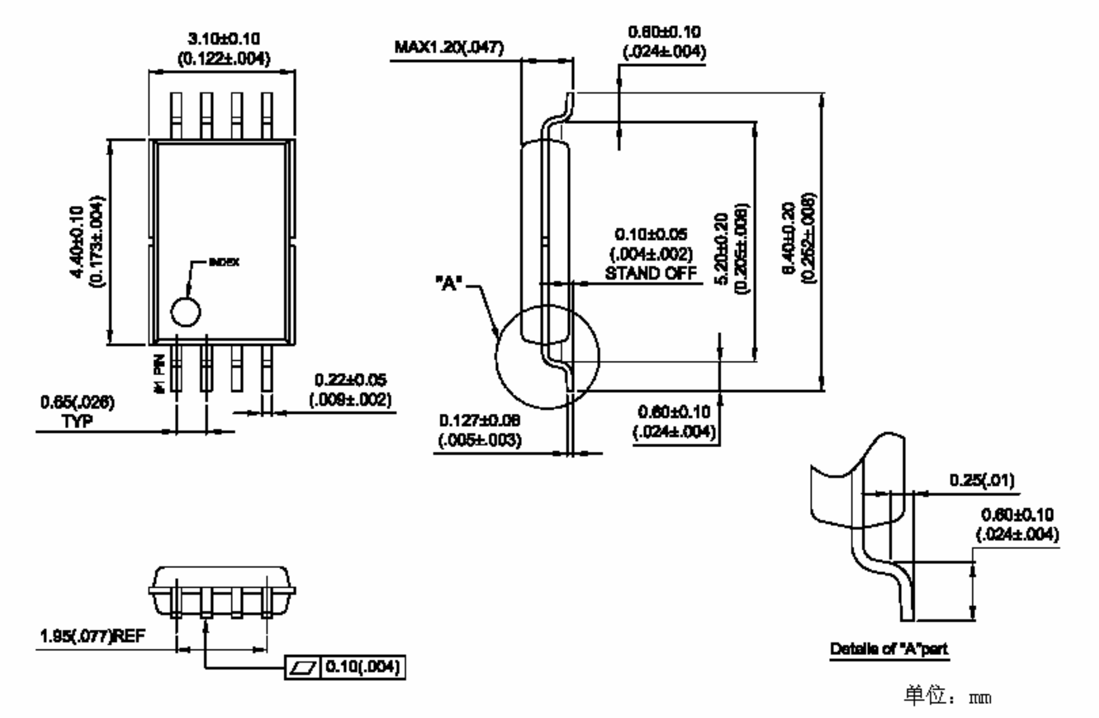


图 **6　TSSOP-8 Package Dimension Diagram**