DESCRIPTION

A7221A is simple, easy to use, 2A synchronous step-down (Buck) convertor in SOT-26 package, with high efficiency and fast transient response. A7221A operates over a wide input voltage range from 4.5V to 16V and integrates main switch and synchronous switch with very low $R_{DS(ON)}$ to minimize the conduction loss. A7221A adopts the active constant on time PWM architecture to achieve fast transient responses for high step down applications and high efficiency at light loads. In addition, it keeps in constant frequency of 500kHz under heavy load conditions to minimize the size of inductor and capacitor. Fault conditions also include cycle-by-cycle current limit, output under voltage protection, output over current protection, output short-circuit protection and thermal shutdown

The A7221A is available in SOT-26 package.

ORDERING INFORMATION

Package Type	Part Number	
SOT-26	E6	A7221AE6R
		A7221AE6VR
Note	V: Halogen free Package R: Tape & Reel SPQ:3,000pcs/Reel	
AiT provides all RoHS products Suffix “ V “ means Halogen free Package		

FEATURES

- Integrated 130mΩ and 120mΩ FETs
- 4.5~16V input voltage range
- 2A load current capability
- Active constant on time PWM architecture with 500kHz switching frequency
- Internal soft-start limits the inrush current
- 2% 0.6V reference
- Available in SOT-26 Package

APPLICATION

- Set Top Box
- Portable TV
- Access Point Router
- DSL Modem
- LCD TV

TYPICAL APPLICATION

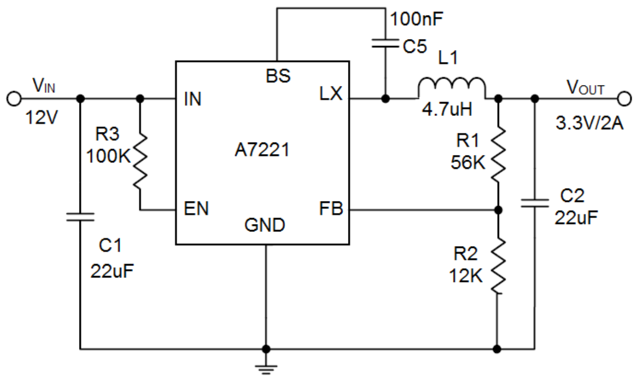
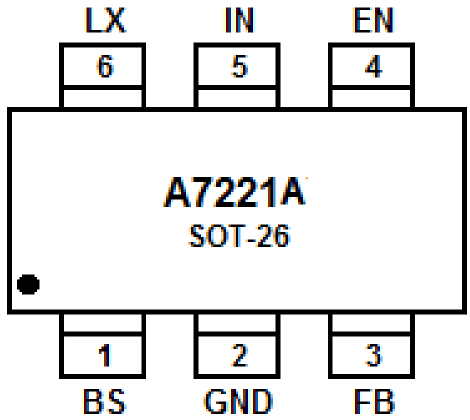


Figure 1. Typical Application Circuit

PIN DESCRIPTION



Top View

Pin #	Symbol	Function
1	BS	Boot-Strap Pin. Supply high side gate driver. Decouple this pin to LX pin with 0.1uF ceramic cap.
2	GND	Ground pin.
3	FB	Output Feedback Pin. Connect this pin to the center point of the output resistor divider (as shown in Figure 1) to program the output voltage: V_{OUT}=0.6x(1+R1/R2).
4	EN	Enable control. Pull high to turn on. Do not float.
5	IN	Input pin. Decouple this pin to GND pin with at least 1uF ceramic cap.
6	LX	Inductor pin. Connect this pin to the switching node of inductor.

ABSOLUTE MAXIMUM RATINGS

V_{IN}, Supply Voltage	-0.3V ~ 18V
V_{SW}, Switch Voltage	-1V ~ V_{IN} + 0.3V
V_{EN}, Enable	-1V ~ V_{IN} + 0.3V
V_{BS}, Bootstrap Voltage	-0.3V ~ +4V
V_{FB}, Feedback Voltage	-0.3V~ +4V
Thermal Resistance NOTE1	
θ_{JA}	100℃/W
θ_{JC}	55℃/W
Junction Temperature	+150℃
Lead Temperature (Soldering, 10s)	+260℃
Storage Temperature	-65℃~+150℃

Stress beyond above listed “Absolute Maximum Ratings” may lead permanent damage to the device. These are stress ratings only and operations of the device at these or any other conditions beyond those indicated in the operational sections of the specifications are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

NOTE1: Measured on approximately 1” square of 1oz copper.

RECOMMENDED OPERATING CONDITIONS NOTE2

Parameter	Symbol	Min.	Max.	Unit
Input Voltage	V_{IN}	4.5	16	V
Operating Temperature		-40	85	℃

NOTE2: The device is not guaranteed to function outside of its operating conditions.

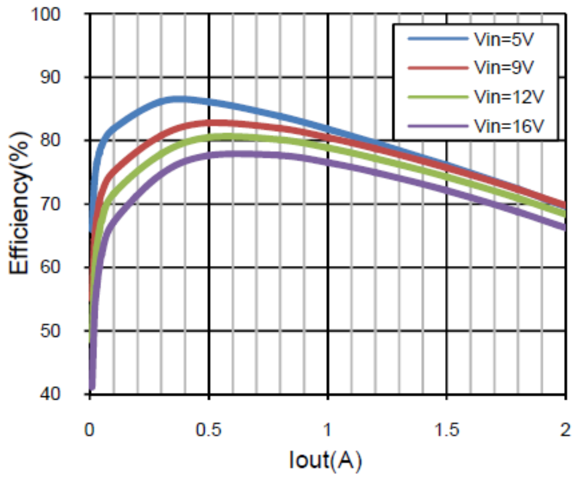
ELECTRICAL CHARACTERISTICS

V_{IN} = 12V, V_{OUT} = 3.3V, L = 4.7uH, T_A = 25°C, unless otherwise specified

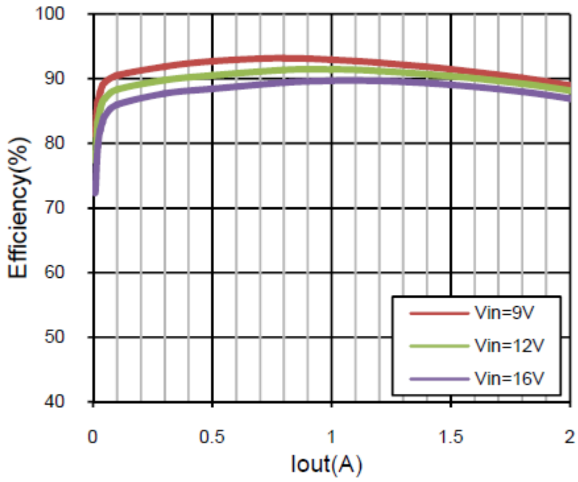
Parameter	Conditions	Min.	Typ.	Max.	Unit
Shutdown Supply Current	V_{EN}=0V		10	20	μA
Supply Current	I_{OUT}=0, V_{FB}=V_{REF}×105%		350		μA
Feedback Voltage	5V<V_{IN}<16V	588	600	612	mV
FB Input Current		-50		50	nA
High-Side Switch-On Resistance			130		mΩ
Low-Side Switch-On Resistance			120		mΩ
High-Side Switch Leakage	V_{EN} = 0V, V_{SW} = 0V		0	10	μA
Upper Switch Current Limit		3.0	3.5		A
Lower Switch Current Limit			1.3		A
Oscillator Frequency			500		kHz
EN Rising Threshold		1.2			V
EN Falling Threshold				0.4	V
Input UVLO Threshold Rising	V_{IN} Rising	3.8	4.2	4.5	V
Input UVLO Threshold Hysteresis			15		mV
Min ON Time			50		ns
Soft-start Time	t_{SS}		0.2		ms
Max Duty Cycle			85		%
Thermal Shutdown			160		℃

TYPICAL PERFORMANCE CHARACTERISTICS

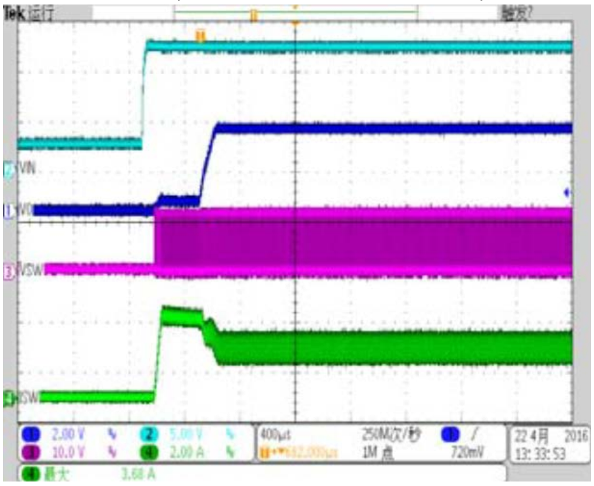
1. Efficiency vs. I_{OUT} @V_{OUT}=1.2V



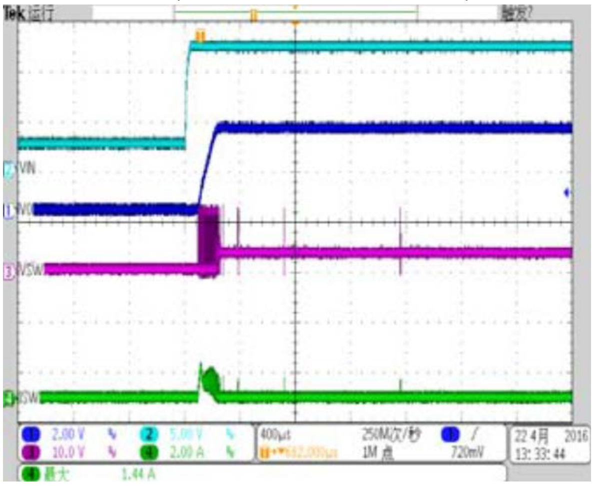
2. Efficiency vs. I_{OUT} @V_{OUT}=5V



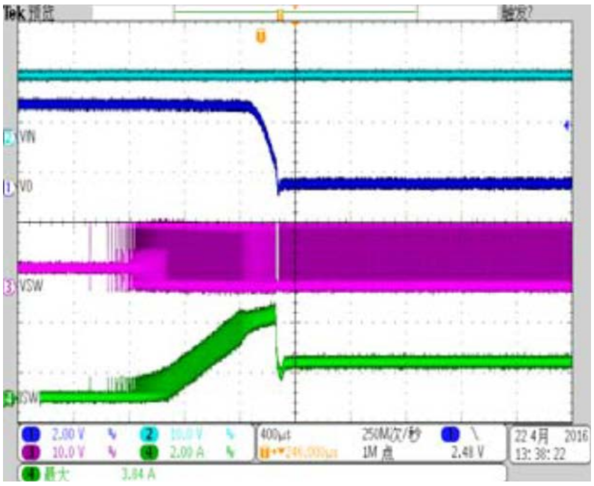
3. Soft-Start (V_{IN}=12V, V_O=3.3V, I_O=2A)



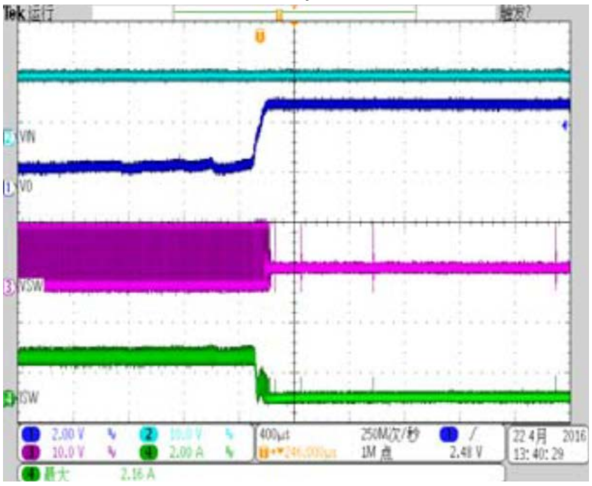
4. Soft-Start (V_{IN}=12V,V_O=3.3V,I_O=0A)



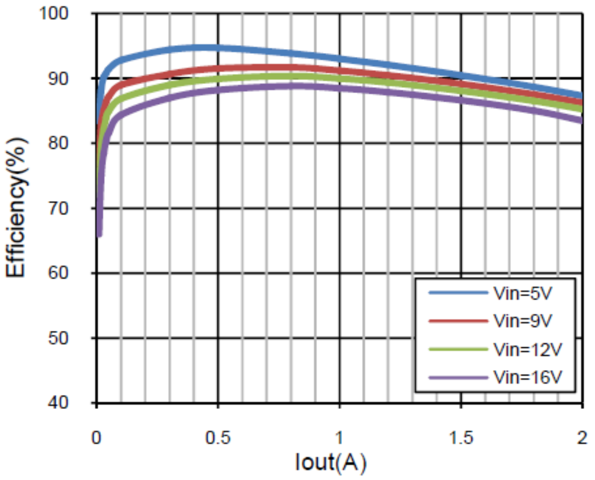
5. Short Circuit



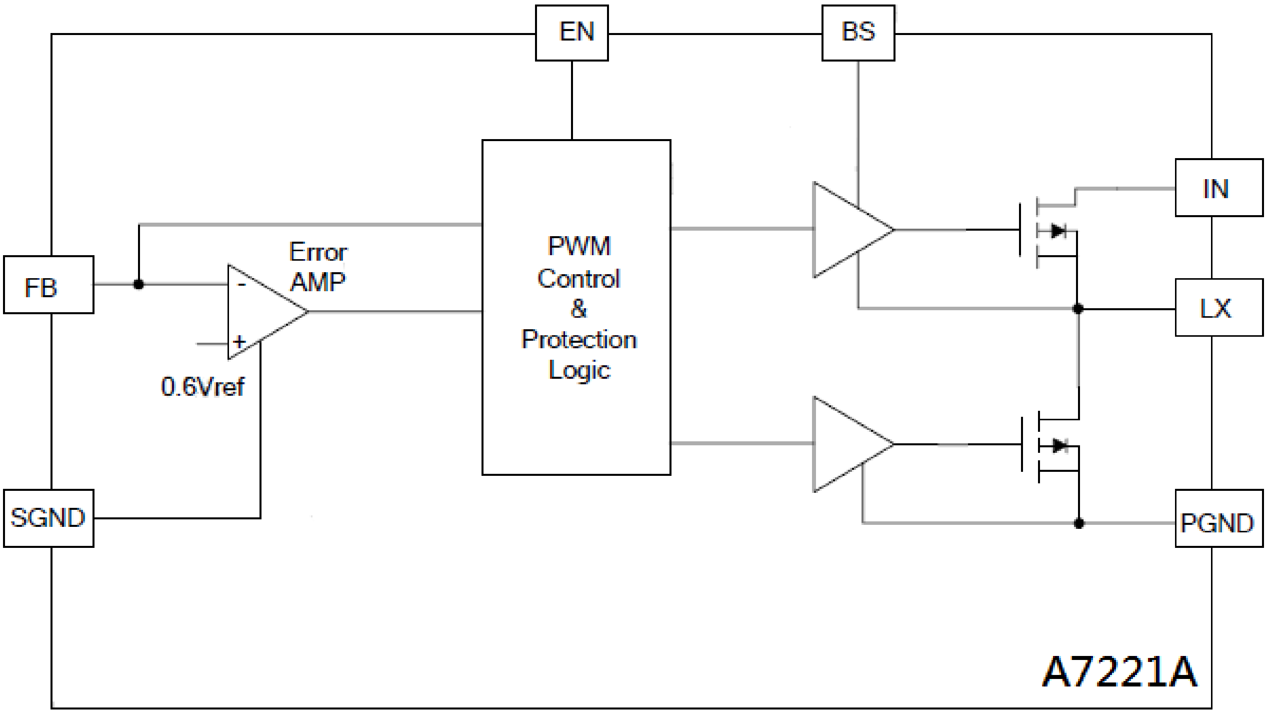
6. Short Circuit Recovery



7. Efficiency vs. I_{OUT} @V_{OUT}=3.3V



BLOCK DIAGRAM



DETAILED INFORMATION

Operation

Functional Description

The A7221A is a synchronous rectified, current-mode, step-down regulator. It regulates input voltages from 4.5V to 16V down to an output voltage as low as 0.6V, and supplies up to 2A of load current.

The A7221A uses current-mode control to regulate the output voltage. The output voltage is measured at FB through a resistive voltage divider and amplified through the internal transconductance error amplifier. The converter uses internal N-Channel MOSFET switches to step-down the input voltage to the regulated output voltage.

Application Information

Setting the Output Voltage

The output voltage is set using a resistive voltage divider from the output voltage to FB (see Typical Application circuit on page 1). The voltage divider divides the output voltage down by the ratio:

$$V_{FB} = V_{OUT} \times \frac{R2}{R1+R2}$$

Where V_{FB} is the feedback voltage and V_{OUT} is the output voltage.

Thus the output voltage is:

$$V_{OUT} = 0.6 \times (1+\frac{R1}{R2})$$

Inductor

The inductor is required to supply constant current to the output load while being driven by the switched input voltage. A larger value inductor will result in less ripple current that will result in lower output ripple voltage. However, the larger value inductor will have a larger physical size, higher series resistance, and/or lower saturation current. A good rule for determining the inductance to use is to allow the peak-to-peak ripple current in the inductor to be approximately 30% of the maximum switch current limit. Also, make sure that the peak inductor current is below the maximum switch current limit. The inductance value can be calculated by:

$$L = \frac{V_{OUT}}{F_S \times \Delta I_L} \times (1-\frac{V_{OUT}}{V_{IN}})$$

Where V_{OUT} is the output voltage, V_{IN} is the input voltage, f_S is the switching frequency, and ΔI_L is the peak-to-peak inductor ripple current.

Choose an inductor that will not saturate under the maximum inductor peak current. The peak inductor current can be calculated by:

$$I_{LP} = I_{LOAD} + \frac{V_{OUT}}{2 \times F_S \times L} \times \left(1-\frac{V_{OUT}}{V_{IN}}\right)$$

here I_{LOAD} is the load current.

The choice of which style inductor to use mainly depends on the price vs. size requirements and any EMI requirements.

Vendor	P/N	L(μH)	DCR(mΩ)	I_{sat}(A)
AiT-Components	PIA6045-100MA	10	48	3.2
AiT-Components	PIA5040-4R7N	4.7	30	3.5

Table 1. Recommended Inductors

Input Capacitor

The input current to the step-down converter is discontinuous, therefore a capacitor is required to supply the AC current to the step-down converter while maintaining the DC input voltage. Use low ESR capacitors for the best performance. Ceramic capacitors are preferred, but tantalum or low-ESR electrolytic capacitors may also suffice. Choose X5R or X7R dielectrics when using ceramic capacitors. Since the input capacitor absorbs the input switching current it requires an adequate ripple current rating. The RMS current in the input capacitor can be estimated by:

$$I_{C1} = I_{LOAD}\sqrt{\left(1-\frac{V_{OUT}}{V_{IN}}\right) \times \frac{V_{OUT}}{V_{IN}}}$$

The worst-case condition occurs at $V_{IN} = 2V_{OUT}$, where $I_{CIN} = I_{LOAD}/2$. For simplification, choose the input capacitor whose RMS current rating greater than half of the maximum load current. The input capacitor can be electrolytic, tantalum or ceramic. When using electrolytic or tantalum capacitors, a small, high quality 0.1uF ceramic capacitor should be placed as close to the IC as possible. When using ceramic capacitors, make sure that they have enough capacitance to provide sufficient charge to prevent excessive voltage ripple at input. The input voltage ripple for low ESR capacitors can be estimated by:

$$\Delta V_{IN} = \frac{I_{LOAD}}{C1 \times F_S} \times \frac{V_{OUT}}{V_{IN}} \times \left(1-\frac{V_{OUT}}{V_{IN}}\right)$$

Where C1 s the value of the input capacitor.

Output Capacitor

The output capacitor is required to maintain the DC output voltage. Ceramic, tantalum, or low ESR electrolytic capacitors are recommended. Low ESR capacitors are preferred to keep the output voltage ripple low. The output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{F_S \times L} \times \left(1-\frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR}+\frac{1}{6.28 \times F_S \times C2}\right)$$

Where C2 is the output capacitance value and R_{ESR} is the equivalent series resistance (ESR) value of the output capacitor. In the case of ceramic capacitors, the impedance at the switching frequency is dominated by the capacitance. The output voltage ripple is mainly caused by the capacitance. For simplification, the output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{6.28 \times F_S^2 \times L \times C2} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

In the case of tantalum or electrolytic capacitors, the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated to:

$$\Delta V_{OUT} = \frac{V_{OUT}}{F_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times R_{ESR}$$

The characteristics of the output capacitor also affect the stability of the regulation system. The A7221A can be optimized for a wide range of capacitance and ESR values. For A7221A normal operation, the input and output can be an electrolytic capacitor in parallel.

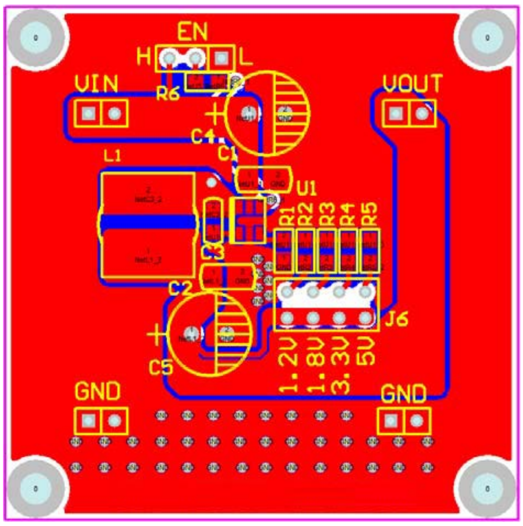
V_{OUT}	R1(kΩ)	R2(kΩ)	L1(uH)	C1(uF)	C2(uF)
5.0V	91	12	4.7	22	22
3.3V	53.6	12	4.7	22	22
2.5V	39	12	4.7	22	22
1.8V	24	12	4.7	22	22
1.5V	18	12	4.7	22	22
1.2V	12	12	4.7	22	22
1.0V	8.2	12	4.7	22	22

Table 2 Recommended Component Values for typical Output Voltage

Layout Guidance

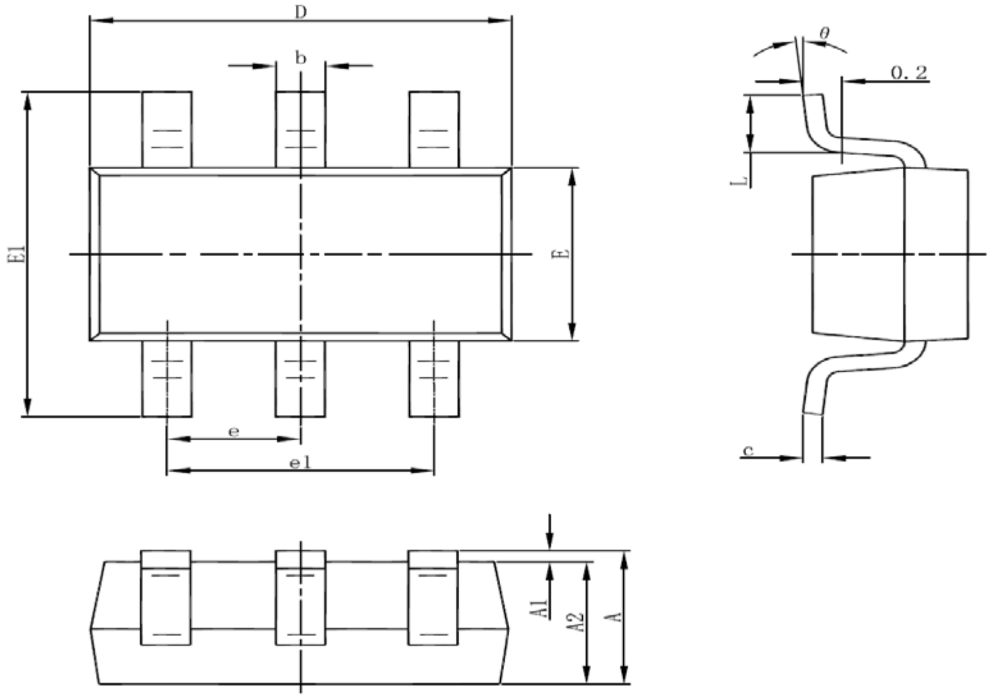
When laying out the PCB board, the following suggestions should be taken to ensure proper operation of the A7221A.

1. The power traces, including the GND trace, the SW trace and the V_{IN} trace should be kept short, direct and wide.
2. The FB pin should be connected directly to the feedback resistor. The resistive divider R1/R2 must be connected between the (+) plate of C2 and ground.
3. Connect the (+) plate of C1 to the IN pin of A7221A as closely as possible. This capacitor provides the AC current to internal power MOSFET.
4. Keep the switching node, SW, away from the sensitive V_{FB} node.
5. Keep the (-) plates of C1 and C2 as close as possible.


EN
H
L
R6
VIN
VOUT
C4
C1
L1
U1
R1
R2
R3
R4
R5
C3
C2
J6
C5
1.2V
1.8V
3.3V
5V
GND
GND

PACKAGE INFORMATION

Dimension in SOT-26 Package (Unit: mm)



Symbol	Millimeters		Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

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