Ultra-Low Quiescent Synchronous Boost Converters

FEATURES

- Up to 92% Efficiency
- Up to 100mA Output Current from a Single AA Cell
- Low Start-up Voltage: 0.85V
- Internal Synchronous Rectifier
- Output Voltage: 2.2V/3.0V/3.3V/5.0V (Fixed Version)
- Programmable Output Voltage (TMI5120C)
- Low Device Quiescent Current: 20μA
- Shutdown Current: <1μA
- Available in SOT23 (TMI5120), SOT23-6 (TMI5120A and TMI5120E) and SOT23-5 (TMI5120B) and SC-70-6 (TMI5120C) Packages

APPLICATIONS

- One, Two and Three Cell Alkaline and NiMH/NiCd Portable Products
- Single-Cell Li-Ion Powered Devices
- Personal Medical Products
- Wireless Handsets
- Handheld Instruments
- Bluetooth Handsets

GENERAL DESCRIPTION

The TMI5120/5120A/5120B/5120C/5120E are a series of compact, high-efficiency, synchronous step DC-DC Converters. It provides an easy-to-use power by either single-cell, two-cell, or three-cell alkaline, NiCd, NiMH, and single-cell Li-Ion or Li-Polymer batteries.

The boost converter is based on a PFM mode controller topology using synchronous rectification to obtain maximum efficiency at minimal quiescent currents.

The output voltage can be set internally to a fixed output voltage or is programmed by an external resistor divider (TMI5120C).

For standby applications, the device consumes only 20μA from battery while operating at no load, and the device feature low shutdown current of under 1μA.

TYPICAL APPILCATION

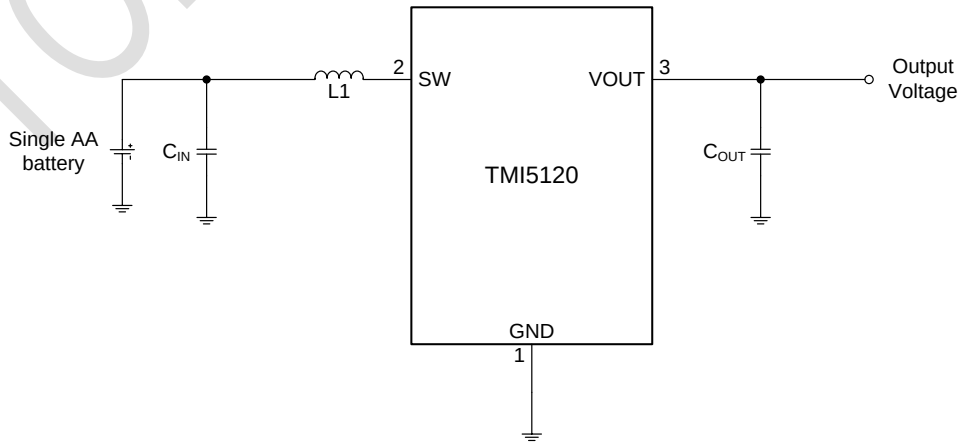


Figure 1. Basic Application Circuit of TMI5120

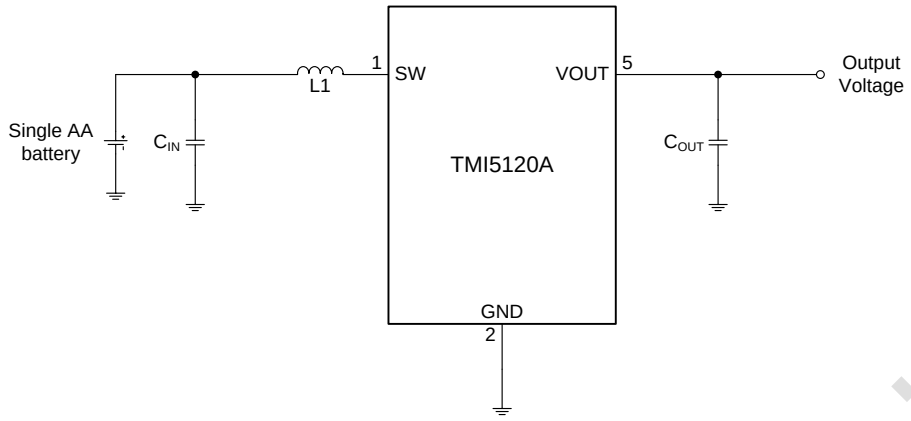


Figure 2. Basic Application Circuit of TMI5120A

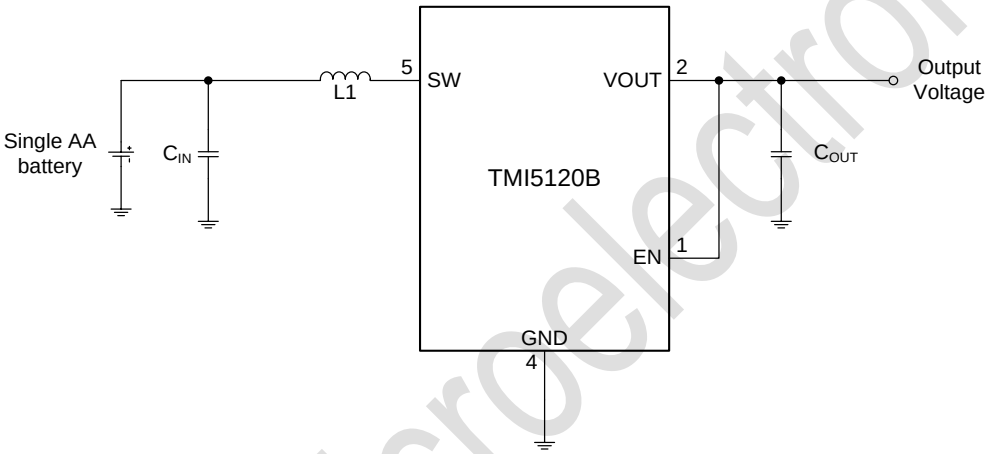


Figure 3. Basic Application Circuit of TMI5120B

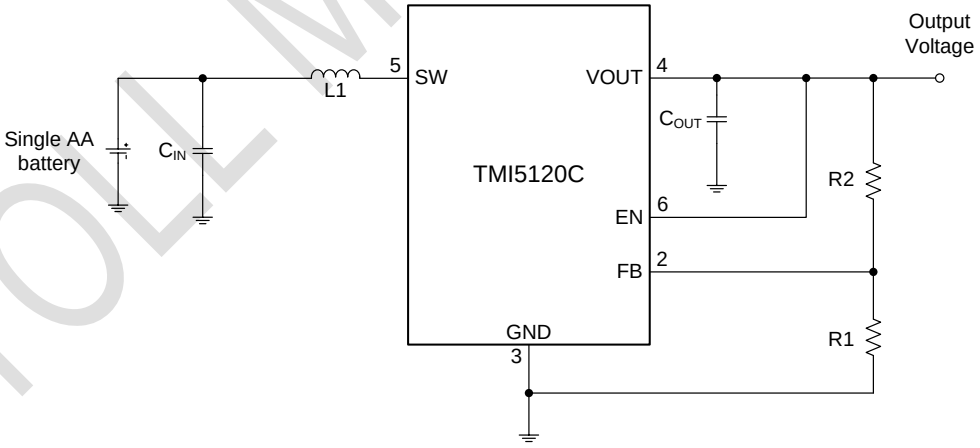


Figure 4. Basic Application Circuit of TMI5120C

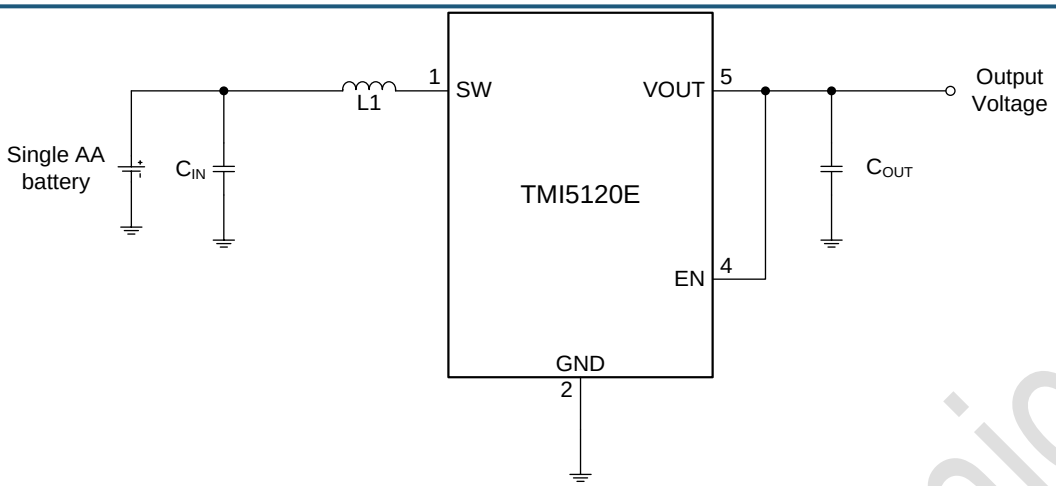


Figure 5. Basic Application Circuit of TMI5120E

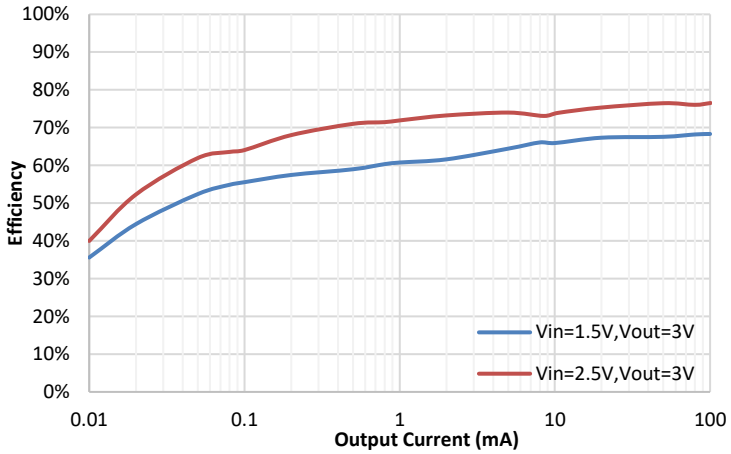
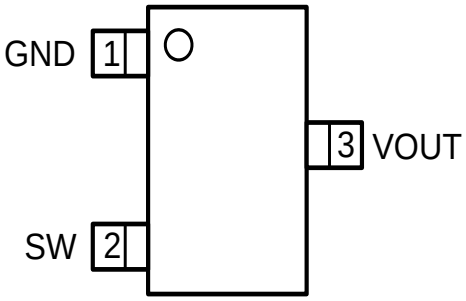


Figure 6. Efficiency of TMI5120-30

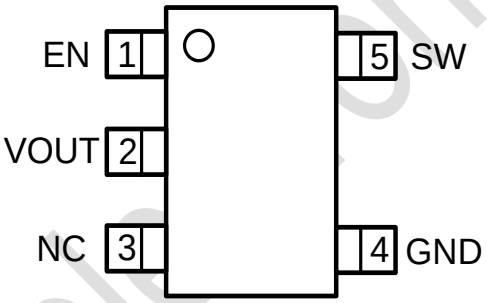
ABSOLUTE MAXIMUM RATINGS (Note 1)

Parameter	Value	Unit
SW Voltage Range	-0.3~5.5	V
VOUT Voltage Range	-0.3~5.5	V
EN Voltage Range	-0.3~5.5	V
Junction Temperature	155	°C
Lead Temperature (Soldering,10 Sec)	260	°C
Power Dissipation	500	mW

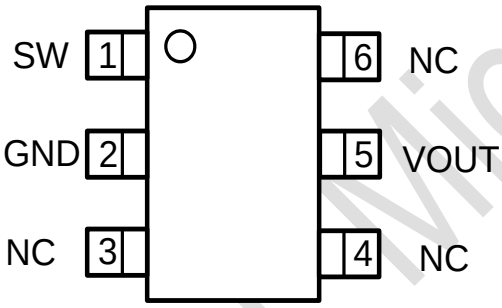
PACKAGE/ORDER INFORMATION



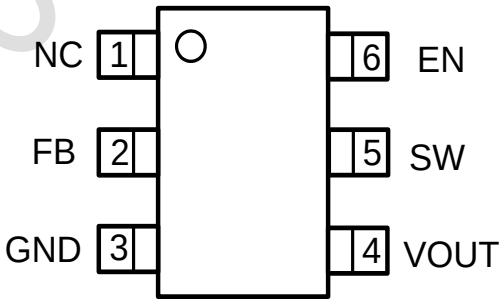
SOT23 (TMI5120)



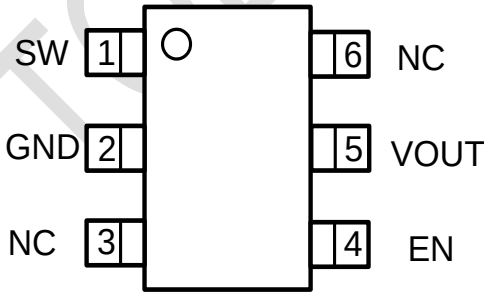
SOT23-5 (TMI5120B)



SOT23-6 (TMI5120A)



SC-70-6 (TMI5120C)



SOT23-6 (TMI5120E)

PIN FUNCTIONS

Pin					Name	Function
SOT23 TMI5120	SOT23-5 TMI5120B	SOT23-6 TMI5120A	SC-70-6 TMI5120C	SOT23-6 TMI5120E		
	1		6	4	EN	The Enable Device Pin. This pin is a logic-level input used to enable or disable device switching and low shutdown current while disabled. A logic high will enable the converter output. A logic low will ensure that the converter is disabled.
3	2	5	4	5	VOUT	The Output Voltage Power Pin Connects the Output Voltage to the Switch Node. Bias is derived from VOUT. PCB trace length from VOUT to the output filter capacitor(s) should be as short and wide as possible. VOUT is held at VIN-0.6V in shutdown due to the body diode of the internal PMOS.
	3	3,4,6	1	3,6	NC	No Connection. No internal connection.
1	4	2	3	2	GND	Signal and Power Ground. Provide a short direct PCB path between GND and the (-) side of the output capacitor(s).
2	5	1	5	1	SW	Switch Pin. Connect the inductor from input voltage to the SW pin. The SW pin carries inductor current. The integrated N-Channel switch drain and integrated P-Channel drain possible to reduce EMI and voltage overshoot.
			2		FB	Feedback Pin

ORDER INFORMATION

TMI5120X-XX

Output Voltage

Blank: Adj
22 : 2.2V
30 : 3.0V
33 : 3.3V
50 : 5.0V
…. : Voltage

Package

Blank: SOT23
A : SOT23-6
B : SOT23-5
C : SC-70-6
E : SOT23-6

ORDER INFORMATION (Continued)

Part Number	Package	Top mark	Quantity/ Reel
TMI5120-22	SOT23	TeAXXX	3000
TMI5120-30	SOT23	TeBXXX	3000
TMI5120-33	SOT23	TeCXXX	3000
TMI5120-50	SOT23	TeDXXX	3000
TMI5120-25	SOT23	TeOXXX	3000
TMI5120-28	SOT23	TePXXX	3000
TMI5120A-22	SOT23-6	TeEXXX	3000
TMI5120A-30	SOT23-6	TeFXXX	3000
TMI5120A-33	SOT23-6	TeGXXX	3000
TMI5120A-50	SOT23-6	TeHXXX	3000
TMI5120B-22	SOT23-5	TeNXXX	3000
TMI5120B-30	SOT23-5	TeJXXX	3000
TMI5120B-33	SOT23-5	TeKXXX	3000
TMI5120B-50	SOT23-5	TeLXXX	3000
TMI5120C	SC-70-6	TeMXXX	3000
TMI5120E-33	SOT23-6	TeSXXX	3000

ESD RATING

Items	Description	Value	Unit
V_{ESD}	Human Body Model for all pins	±2000	V

JEDEC specification JS-001

RECOMMENDED OPERATING CONDITIONS

Items	Description	Min	Max	Unit
T_J	Operating Junction Temperature Range	-40	125	°C

ELECTRICAL CHARACTERISTICS

(C_{IN}=4.7μF, C_{OUT}=10μF, L=4.7μH, T_A = 25°C, unless otherwise noted.)

Parameter	Test Conditions	Min	Typ	Max	Unit
Minimum Start-Up Voltage	V_{OUT}=3.3V, I_{OUT}=1mA		0.85	1	V
Minimum Operating Voltage (Note 3)			0.5	0.65	V
Feedback Voltage (only TMI5120C)		485	500	515	mV
Output Voltage Range		2.2		5.0	V
Maximum Output Current	V_{IN}=1.5V, V_{OUT}=3.3V		100		mA
	V_{IN}=0.9V, V_{OUT}=3.3V		50		mA
Line Regulation	$(\Delta V_{OUT}/V_{OUT})/\Delta V_{IN}$	-3	0.01	3	%
Load Regulation	$\Delta V_{OUT}/V_{OUT}$, I_{OUT}=25mA to 100mA, V_{IN}=1.5V	-3	0.01	3	%
Quiescent Current (No Load)	V_{IN}=1.5V, V_{OUT}=3.3V		20	30	μA
NMOS Switch Leakage	V_{SW}=5V		0.1	5	μA
PMOS Switch Leakage	V_{SW}=0V		0.1	5	μA
NMOS Switch On Resistance	V_{OUT} = 3.3V		0.45		Ω
PMOS Switch On Resistance	V_{OUT} = 3.3V		0.65		Ω
NMOS Current Limit		0.6	0.85		A
Duty Cycle		74	90		%
Switching Frequency			300		kHz
EN Input High	VIN≤1.5V	0.6xV_{OUT}			V
	5V＞VIN>1.5V	1			V
EN Input Low	VIN≤1.5V			0.2xV_{OUT}	V
	5V>VIN>1.5V			0.3	V

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula: $T_J = T_A + (P_D) \times \theta_{JA}$.

Note 3: Minimum VIN operation after start-up is limited by the battery's ability to provide the necessary power as it enters a deeply discharged state.

OPERATION

The TMI5120/5120A/5120B/5120C/5120E are a series of high performance, highly efficient switching boost converters. To achieve high efficiency, the power stage is realized as a synchronous-boost topology. The device is capable of low start-up voltage and delivers high efficiency over a wide load range for single-cell, two-cell, or tree-cell alkaline, NiCd, NiMH and single-cell Li-Ion battery inputs. For the power switching, two actively-controlled low-R_{DSon} power MOSFETs are implemented. A high level of integration lowers total system cost, eases implementation and reduces board area.

The device has feature of low start-up voltage, PFM mode operation, low Iq, integrated synchronous switch. The operation of the TMI5120/5120A/5120B/5120C/5120E can be understood by referring to the block diagram of Figure 7. The TMI5120/5120A/5120B/5120C/5120E operates in a PFM mode with peak current control scheme. The converter monitors the output voltage through the feedback network which is connected to the error comparator. As soon as the feedback voltage falls below the internal reference voltage, the internal power NMOSFET turns on and the inductor current ramps up. The power NMOSFET turns off as soon as the inductor current reaches the setting peak current limit. As the power NMOSFET turns off, the internal power PMOSFET turns on and delivers the inductor current to the output. After the inductor current drops to zero, the TMI5120/5120A/5120B/5120C/5120E compares the feedback voltage with the reference voltage. Once the feedback voltage falls below the reference voltage, the switch power MOSFETs turns on again. In this way, the TMI5120/5120A/5120B/5120C/5120E regulates the output voltage at the target value.

Using this PFM peak current control scheme, the converter operates in discontinuous conduction mode (DCM) where the switch frequency depends on the output current. This regulation scheme is inherently stable, allowing a wide selection range for the inductor and output capacitor.

APPLICATION INFORMATION

Programming the Output Voltage

The output voltage of the TMI5120C is adjusted with an external resistor divider. The typical value of the voltage at the FB pin is 500mV. The maximum recommended value for the output is 5.0V. The current through the resistive divider should be 100 times greater than the current in the FB pin. The typical current into the FB pin is 10nA, and the voltage across R1 is typically 500mV. Therefore, the value for R1 is recommended lower than 500kΩ, in order to set the current flowing the divider higher than 1μA. From that, the value of R2, depending on the needed output voltage, is calculated in Equation 1:

$$R2 = R1 * \left(\frac{VOUT}{VFB} - 1 \right) \qquad \text{(Equation 1)}$$

Inductor Selection

The TMI5120/5120A/5120B/5120C/5120E is designed to be used with small surface-mount inductors, the inductance value of 4.7μH is recommended to achieve a good balance between inductor size, converter load transient response and minimized noise.

The selected inductor should have a saturation current that is larger than the maximum peak current of the converter. Use the minimal value of selected current limit for this calculation.

Another important inductor parameter is the dc resistance. The lower the dc resistance, the higher the efficiency of the converter.

To minimize radiated noise, use a shielded bobbin inductor.

Capacitor Selection

Low ESR (equivalent series resistance) capacitors should be used to minimize the output voltage ripple. Multilayer ceramic capacitors are an excellent choice as they have extremely low ESR and are available in small footprints. A 10μF to 22μF output capacitor is sufficient for most applications. Larger values may be used to obtain lower output ripple and improve transient response. X5R and X7R dielectric material are preferred for their ability to maintain capacitance over wide voltage and temperature ranges.

Low ESR input capacitors reduce input switching noise and reduce the peak current drawn from the battery. It follows that ceramic capacitors are also a good choice for input decoupling and should be located as close as possible to the device. A 4.7μF to 10μF input capacitor is sufficient for most application. Larger values may be used without limitations.

Layout Consideration

- For best performance of the TMI5120/5120A/5120B/5120C/5120E, the following guidelines must be strictly followed.
- Input and Output capacitors should be placed close to the IC and connected to ground plane to reduce noise coupling.
- The GND should be connected to a strong ground plane for heat sinking and noise protection.
- Keep the main current traces as possible as short and wide.
- SW node of the converter is with high frequency voltage swing. It should be kept at a small area.

FUNCTION BLOCK DIAGRAM

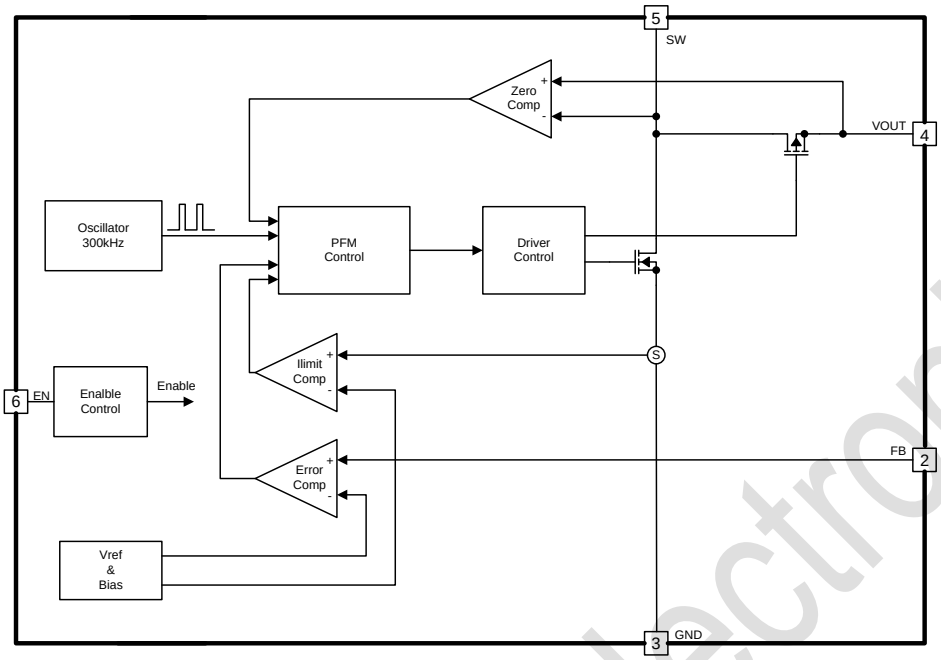
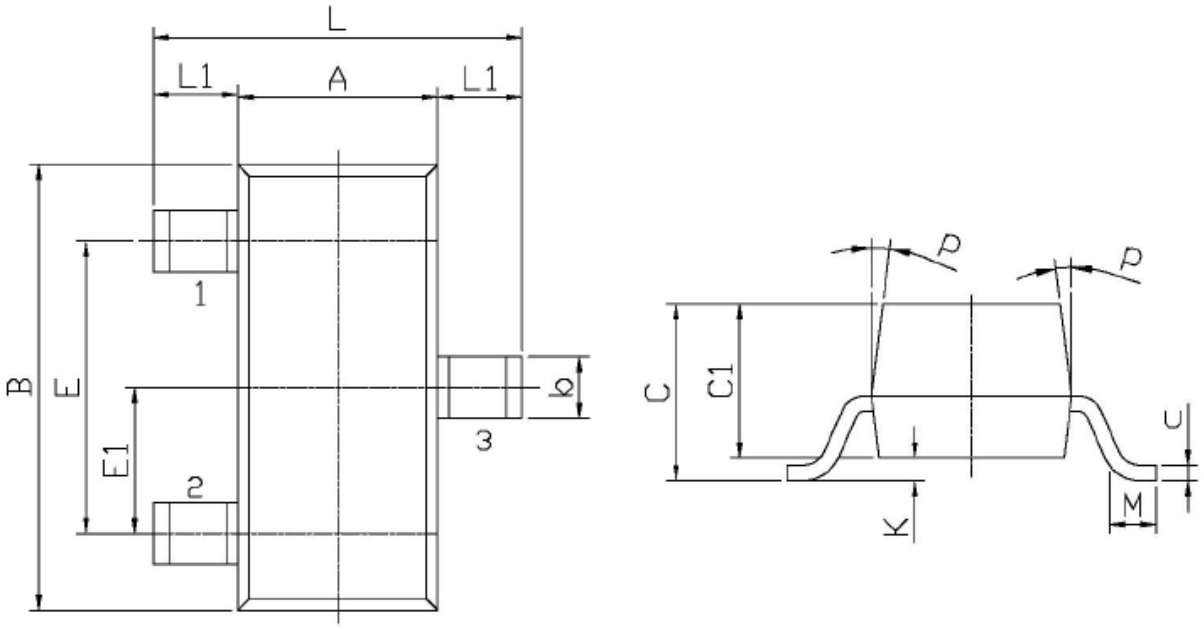


Figure 7. TMI5120C Block Diagram

PACKAGE INFORMATION

SOT23



Unit: mm

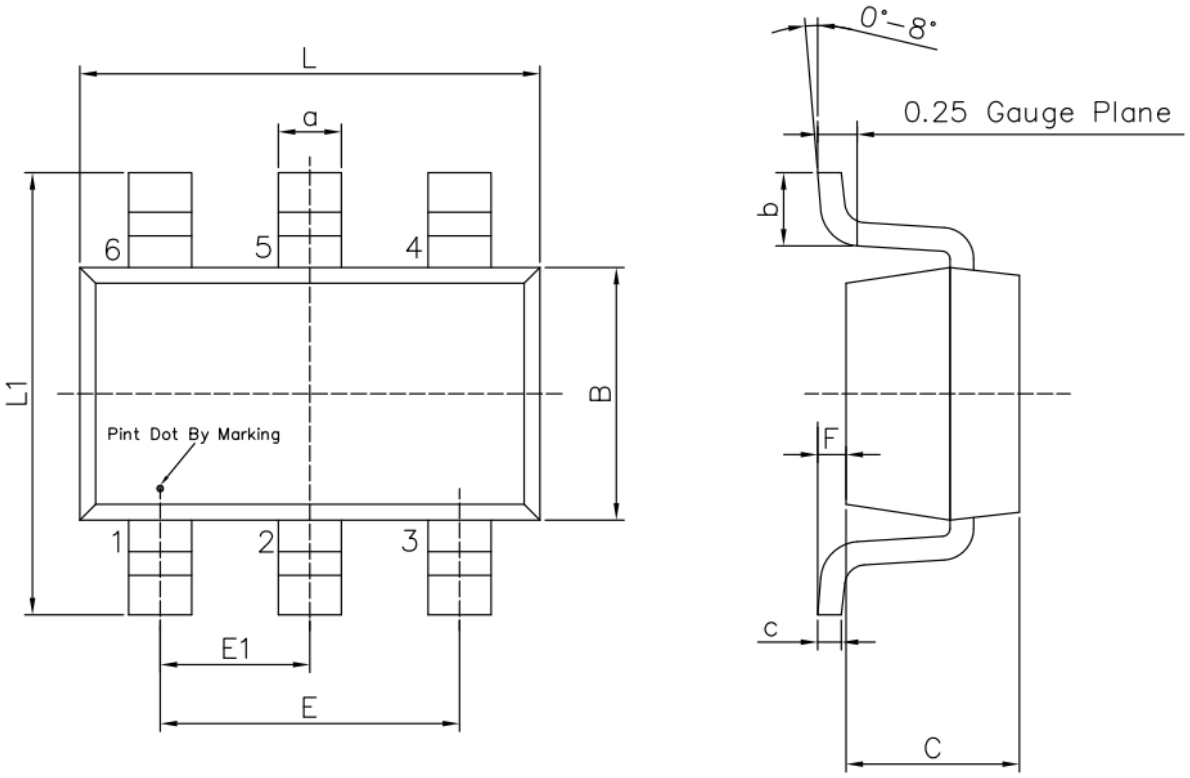
Symbol	Dimensions In Millimeters		Symbol	Dimensions In Millimeters	
	Min	Max		Min	Max
L	2.2	2.7	C	1.30 MAX	
L1	0.45	0.65	C1	0.90	1.20
A	1.15	1.50	c	0.05	0.20
B	2.70	3.10	K	0	0.10
E	1.70	2.10	M	0.20 MIN	
E1	0.85	1.05	P	7°	
b	0.35	0.55			

Note:

1) All dimensions are in millimeters.
2) Package length does not include mold flash, protrusion or gate burr.
3) Package width does not include inter lead flash or protrusion.
4) Lead popularity (bottom of leads after forming) shall be 0.10 millimeters max.

PACKAGE INFORMATION

SOT23-6



Unit: mm

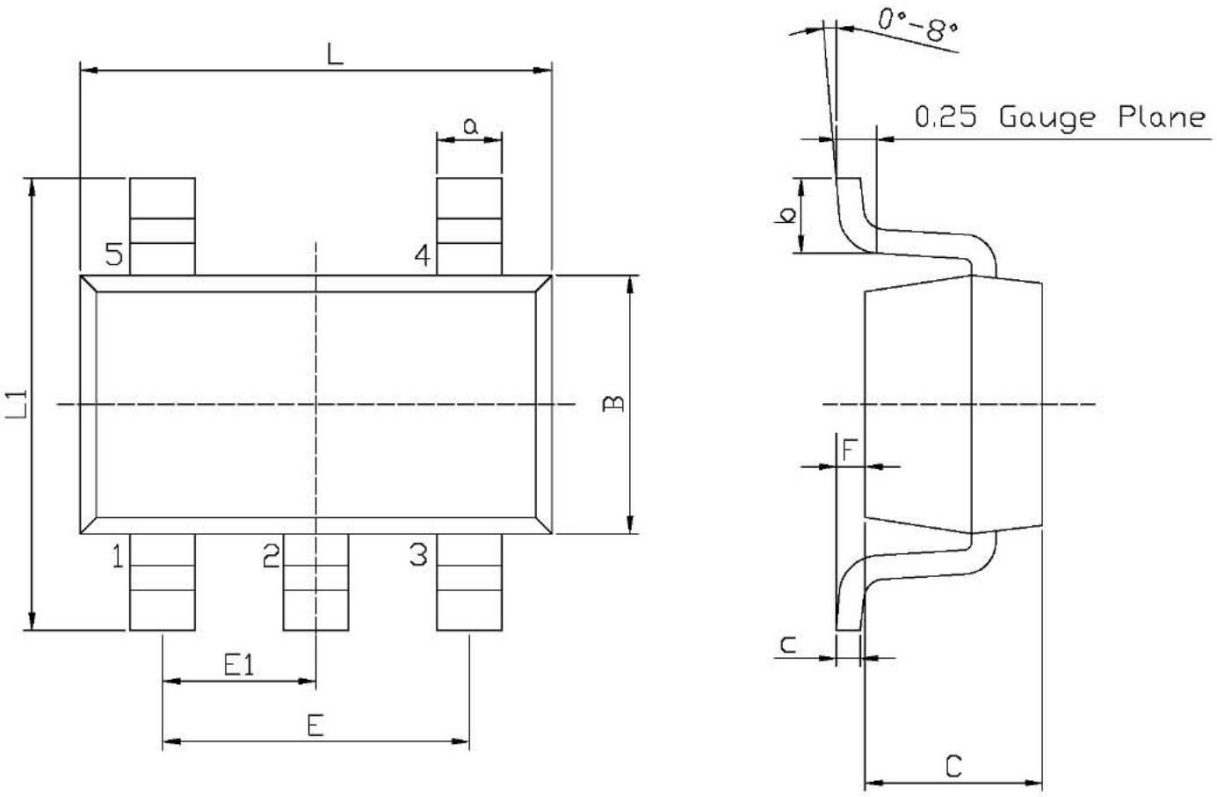
Symbol	Dimensions In Millimeters		Symbol	Dimensions In Millimeters	
	Min	Max		Min	Max
L	2.82	3.02	E1	0.85	1.05
B	1.50	1.70	a	0.35	0.50
C	0.90	1.30	c	0.10	0.20
L1	2.60	3.00	b	0.35	0.55
E	1.80	2.00	F	0	0.15

Note:

1) All dimensions are in millimeters.
2) Package length does not include mold flash, protrusion or gate burr.
3) Package width does not include inter lead flash or protrusion.
4) Lead popularity (bottom of leads after forming) shall be 0.10 millimeters max.
5) Pin 1 is lower left pin when reading top mark from left to right.

PACKAGE INFORMATION

SOT23-5



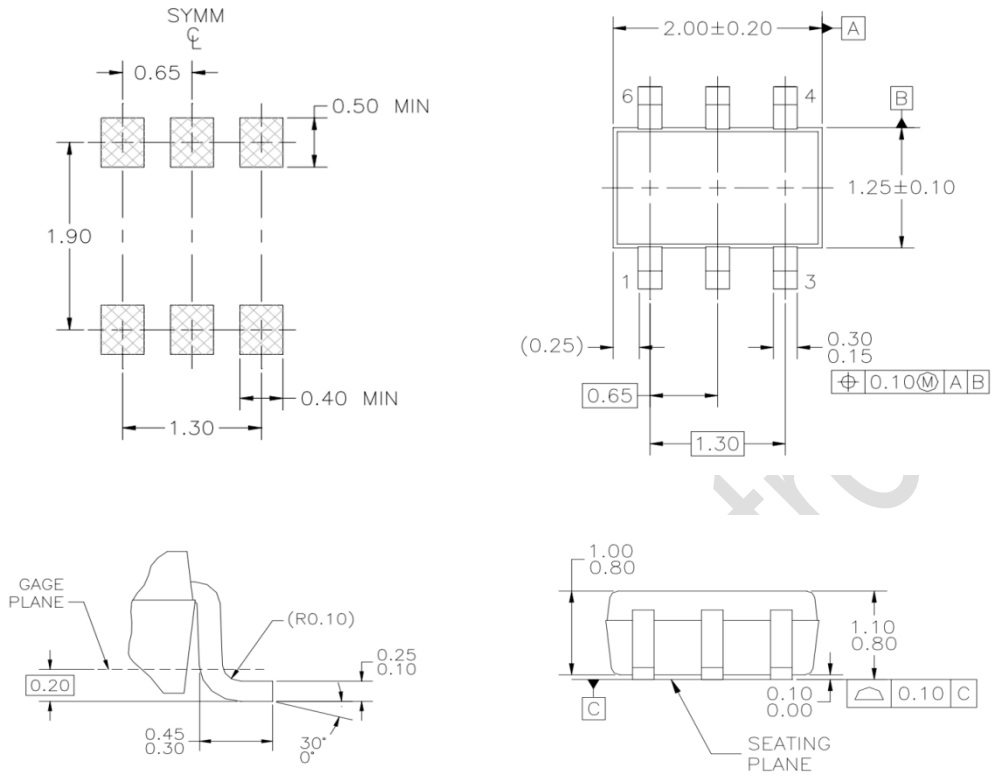
Unit: mm

Symbol	Dimensions In Millimeters		Symbol	Dimensions In Millimeters	
	Min	Max		Min	Max
L	2.82	3.02	E1	0.85	1.05
B	1.50	1.70	a	0.35	0.50
C	0.90	1.30	c	0.10	0.20
L1	2.60	3.00	b	0.35	0.55
E	1.80	2.00	F	0	0.15

Note:

1) All dimensions are in millimeters.
2) Package length does not include mold flash, protrusion or gate burr.
3) Package width does not include inter lead flash or protrusion.
4) Lead popularity (bottom of leads after forming) shall be 0.10 millimeters max.
5) Pin 1 is lower left pin when reading top mark from left to right.

PACKAGE INFORMATION



SC-70-6