Obsolete Device

TC125/TC126

PFM Step-Up DC/DC Regulators

Features:

- Assured Start-up at 0.9V
- PFM (100 kHz Max. Operating Frequency)
- 40 µA Maximum Supply Current (V_{OUT} = 3V @ 30 mA)
- 0.5 µA Shutdown Mode (TC125)
- Voltage Sense Input (TC126)
- Requires Only Three External Components
- 80 mA Maximum Output Current
- Small Package: 5-Pin SOT-23

Applications:

- Palmtops/PDAs
- Battery-Operated Systems
- Cameras
- Portable Communicators

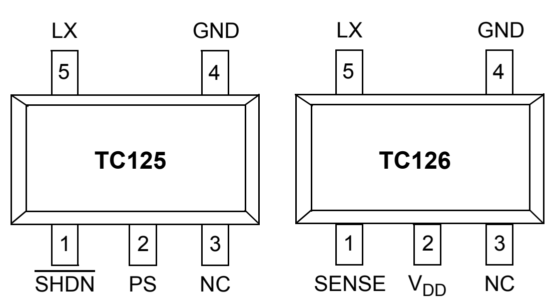
Device Selection Table

Part Number	Output Voltage (V)*	Package	Operating Temp. Range
TC125501ECT	5.0	5-Pin SOT-23	-40°C to +85°C
TC125331ECT	3.3	5-Pin SOT-23	-40°C to +85°C
TC125301ECT	3.0	5-Pin SOT-23	-40°C to +85°C
TC126501ECT	5.0	5-Pin SOT-23	-40°C to +85°C
TC126331ECT	3.3	5-Pin SOT-23	-40°C to +85°C
TC126301ECT	3.0	5-Pin SOT-23	-40°C to +85°C

*Other output voltages are available. Please contact Microchip Technology Inc. for details.

Package Type

5-Pin SOT-23



NOTE: 5-Pin SOT-23 is equivalent to the EIAJ SC-74A

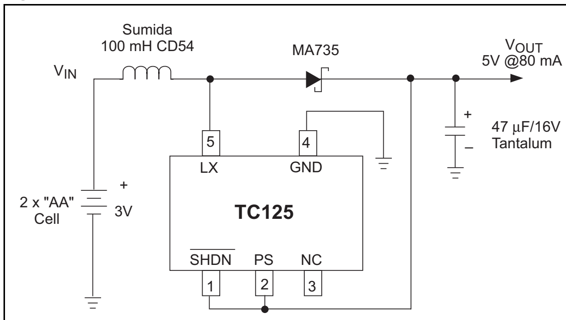
General Description:

The TC125/126 step-up (Boost) switching regulators furnish output currents to a maximum of 80 mA (V_{IN} = 2V, V_{OUT} = 3V) with typical efficiencies above 80%. These devices employ pulse frequency modulation (PFM) for minimum supply current at low loads. They are ideal for battery-operated applications powered from one or more cells. Maximum supply current is less than 70 µA at full output load, and less than 5 µA in standby (V_{OUT} = 3V). Both devices require only an external inductor, diode, and capacitor to implement a complete DC/DC regulator.

The TC126 has separate output voltage sensing and chip power inputs for greater application flexibility. The TC125 combines the output voltage sensing and chip power inputs onto a single package pin, but adds a power-saving Shutdown mode that suspends regulator operation and reduces supply current to less than 0.5 µA when the shutdown control input ($\overline{SHDN}$) is low.

The TC125/TC126 are available in a small 5-Pin SOT-23 package, occupy minimum board space and use small external components. The TC125 accepts input voltages from 2V to 10V. The TC126 accepts input voltages from 2.2V to 10V. Both the TC125 and TC126 have a start-up voltage of 0.9V at light load.

Typical Application



Two Cell to 5V Boost Regulator

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings*

Voltage on V_{DD}, SENSE/V_{DD}, LX, $\overline{SHDN}$ Pins .... -0.3V to +12V
LX Sink Current .... 400 mA pk
Power Dissipation .... 150 mW
Operating Temperature Range .... -40°C to +85°C
Storage Temperature Range .... -40°C to +125°C

*Stresses above 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 above those indicated in the operation sections of the specifications is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

TC125/TC126 ELECTRICAL SPECIFICATIONS

Electrical Characteristics: V_{IN} = V_{OUT} x 0.6, T_A = 25°C, $\overline{SHDN}$ = V_{OUT} (TC125), unless otherwise noted.						
Symbol	**Parameter**	**Min**	**Typ**	**Max**	**Units**	**Test Conditions**
V_{OUT}	Output Voltage	V_R – 2.5%	V_R ± 0.5%	V_R + 2.5%	V	
V_{DD}	Operating Supply Voltage	0.70	—	10.0	V	**Note 4**
V_{START}	Start-Up Supply Voltage	—	0.80	0.90	V	I_{OUT} = 1mA
I_{DD}	Operating Supply Current TC125 TC125/126 TC125/126	 — — —	 14 20 32	 28 40 64	µA	**(Note 2)** V_{OUT} = 2V, I_{OUT} = 10 mA V_{OUT} = 3V, I_{OUT} = 30 mA V_{OUT} = 5V, I_{OUT} = 50 mA
I_{NL}	No Load Supply Current	— — —	5 5 6	9 10 11	µA	I_{OUT} = 0, V_{OUT} = 2V V_{OUT} = 3V V_{OUT} = 5V
I_{STBY}	Standby Supply Current	— — —	2 3 3	4 5 5	µA	V_{IN} = V_{OUT} + 0.5V, V_{IN} = 2V V_{IN} = 3V V_{IN} = 5V
Ishdn	Shutdown Supply Current	—	—	0.5	µA	$\overline{SHDN}$ = V_{IL}, **(Note 2)**
$R_{LX(ON)}$	LX Pin ON Resistance	— — —	10 6 3	14 8 5	W	V_{LX} = 0.4V, V_{OUT} = 2V V_{OUT} = 3V V_{OUT} = 5V **(Note 2)**, **(Note 3)**
I_{LX}	LX Pin Leakage Current	—	—	1	µA	No external components, V_{OUT} = V_{LX} = 10V
D_{CYCLE}	Duty Cycle	70	75	80	%	Measured at LX pin **(Note 2)**
f_{MAX}	Maximum Oscillator Frequency	85	100	115	kHz	**Note 2**
VLX_{LIM}	LX Pin Limit Voltage	0.7	—	1.1	V	**Note 2**
h	Efficiency	— — —	70 80 85	— — —	%	V_{OUT} = 2V V_{OUT} = 3V V_{OUT} = 5V
V_{IH}	$\overline{SHDN}$ Input Logic High	0.75	—	—	V	
V_{IL}	$\overline{SHDN}$ Input Logic Low	—	—	0.20	V	
II_{Nh}	$\overline{SHDN}$ Input Current (High)	—	—	0.25	µA	
II_{Nl}	$\overline{SHDN}$ Pin Input Current (Low)	-0.25	—	—	µA	

Note 1: V_R is the factory output voltage setting.
2: V_{IN} = V_{OUT} x 0.95.
3: V_{DD} input tied to SENSE input for TC126, as shown in Figure 3-2.
4: The V_{PS} input of the TC125 must be operated between 2.0V and 10.0V for spec compliance. The V_{DD} input of the TC126 must be operated between 2.2V and 10.0V for spec compliance.

2.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 2-1.

TABLE 2-1: PIN FUNCTION TABLE

TC125 Pin No. (5-Pin SOT-23)	TC126 Pin No. (5-Pin SOT-23)	Symbol	Description
1	—	$\overline{SHDN}$	Shutdown input. A logic low on this input suspends device operation and supply current is reduced to less than 0.5 µA. The device resumes normal operation when $\overline{SHDN}$ is again brought high.
—	1	SENSE	Voltage sense input. This input provides feedback voltage sensing to the internal error amplifier. It must be connected to the output voltage node, preferably the single point in the system where tight voltage regulation is most beneficial.
2	—	PS	Power and voltage sense input. This dual function input provides both feedback voltage sensing and internal chip power. It should be connected to the regulator output. (See Figure 3-1).
—	2	V_{DD}	Power supply voltage input.
3	3	NC	Not connected.
4	4	GND	Ground terminal.
5	5	LX	Inductor switch output. LX is the drain of an internal N-channel switching transistor. This terminal drives the external inductor, which ultimately provides current to the load.

3.0 DETAILED DESCRIPTION

The TC125/126 are PFM step-up DC/DC regulators for use in systems operating from two or more cells or in low voltage, line powered applications. Because Pulse Frequency Modulation (PFM) is used, the TC125/126 switching frequency (and therefore supply current) is minimized at low output loads. This is especially important in battery operated applications (such as pagers) that operate in Standby mode most of the time. For example, a TC125/126 with a 3V output and no load will consume a maximum supply current of only 10 µA versus a supply current of 40 µA maximum when I_{OUT} = 30 mA. Both devices require only an external inductor, diode and capacitor to implement a complete DC/DC converter.

The TC125 is recommended for applications requiring Shutdown mode as a means of reducing system supply current. The TC125 is powered from the PS input, which must be connected to the regulated output as shown in Figure 3-1. PS also senses output voltage for closed-loop regulation. Start-up current is furnished through the inductor when input voltage is initially applied. This action starts the oscillator, causing the voltage at the PS input to rise, bootstrapping the regulator into full operation.

The TC126 (Figure 3-2) is recommended for all applications not requiring Shutdown mode. It has separate V_{DD} and SENSE inputs, allowing it to be powered from any source of 2.2V to 10V in the system. The V_{DD} input of the TC126 may be connected to the V_{IN}, V_{OUT}, or an external DC voltage. Lower values of V_{DD} result in lower supply current, but lower efficiency due to higher switch ON resistance. Higher V_{DD} values increase supply current, but drive the internal switching transistor harder (lowering RDS_{ON}), thereby increasing efficiency.

3.1 Low-Power Shutdown Mode

The TC125 enters a low-power Shutdown mode when $\overline{SHDN}$ is brought low. While in shutdown, the oscillator is disabled and the internal switch is shut off. Normal regulator operation resumes when $\overline{SHDN}$ is brought high. Because the TC125 uses an external diode, a leakage path between the input voltage and the output node (through the inductor and diode) exists while the regulator is in shutdown. Care must be taken in system design to assure the input supply is isolated from the load during shutdown.

3.2 Behavior When V_{IN} is Greater Than the Factory-Programmed OUT Setting

The TC125 and TC126 are designed to operate as step-up regulators only. As such, V_{IN} is assumed to always be less than the factory-programmed output voltage setting (V_R). Operating the TC125/126 with V_{IN} > V_R causes regulating action to be suspended (and corresponding supply current reduction) until V_{IN} is again less than V_R. While regulating action is suspended, V_{IN} is connected to the output voltage node through the series combination of the inductor and Schottky diode. Again, care must be taken to add the appropriate isolation (MOSFET series switch or post LDO with shutdown) during system design if this V_{IN}/V_{OUT} leakage path is problematic.

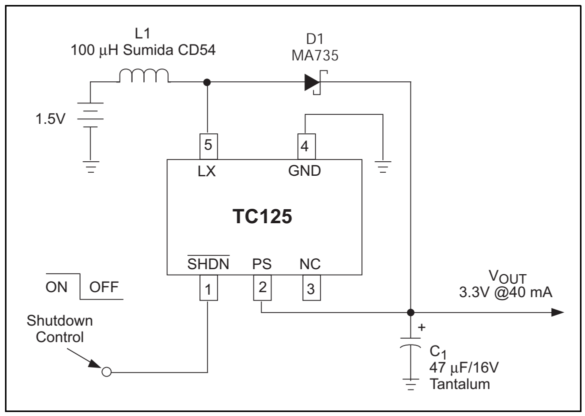


FIGURE 3-1: *Typical TC125 Circuit*

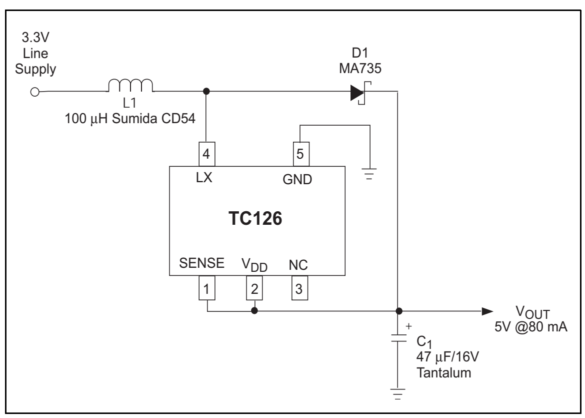


FIGURE 3-2: *Typical TC126 Circuit*

4.0 APPLICATIONS

4.1 Input Bypass Capacitors

Adding an input bypass capacitor reduces peak current transients drawn from the input supply and reduces the switching noise generated by the regulator. The source impedance of the input supply determines the size of the capacitor that should be used.

4.2 Inductor Selection

Selecting the proper inductor value is a trade-off between physical size and power conversion requirements. Lower value inductors cost less, but result in higher ripple current and core losses. They are also more prone to saturate since the coil current ramps to a higher value. Larger inductor values reduce both ripple current and core losses, but are larger in physical size and tend to increase the start-up time slightly. The recommended inductor value for use with the TC125/126 is 100 µH. Inductors with a ferrite core (or equivalent) are recommended. For highest efficiency, use an inductor with a series resistance less than 20 mΩ.

4.3 Internal Transistor Switch Current Limiting

The peak switch current is equal to the input voltage divided by the RDS_{ON} of the internal switch. The internal transistor has absolute maximum current rating of 400 mA with a design limit of 350 mA. A built-in oscillator frequency doubling circuit guards against high switching currents. Should the voltage on the LX pin rise above 1.1V, max while the internal N-channel switch is ON, the oscillator frequency automatically doubles to minimize ON time. Although reduced, switch current still flows because the regulator remains in operation. Therefore, the LX input is not internally current limited and care must be taken never to exceed the 350 mA maximum limit. Failure to observe this will result in damage to the regulator.

4.4 Output Diode

For best results, use a Schottky diode such as the MA735, 1N5817, MBR0520L or equivalent. Connect the diode between the PS and LX pins (TC125) or SENSE and LX pins (TC126) as close to the IC as possible. (Do not use ordinary rectifier diodes since the higher threshold voltages reduce efficiency.)

4.5 Output Capacitor

The effective series resistance of the output capacitor directly affects the amplitude of the output voltage ripple. (The product of the peak inductor current and the ESR determines output ripple amplitude.) Therefore, a capacitor with the lowest possible ESR should be selected. Smaller capacitors are acceptable for light loads or in applications where ripple is not a concern. The Sprague 595D series of tantalum capacitors are among the smallest of all low ESR surface mount capacitors available. Table 4-1 lists suggested components and suppliers.

4.6 Board Layout Guidelines

As with all inductive switching regulators, the TC125/126 generate fast switching waveforms that radiate noise. Interconnecting lead lengths should be minimized to keep stray capacitance, trace resistance, and radiated noise as low as possible. In addition, the GND pin, input bypass capacitor, and output filter capacitor ground leads should be connected to a single point. The input capacitor should be placed as close to power and ground pins of the TC125/126 as possible.

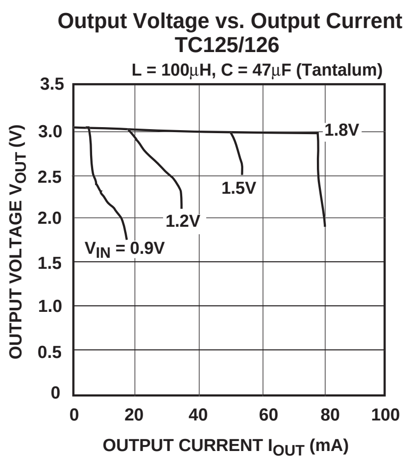
TABLE 4-1: SUGGESTED COMPONENTS AND SUPPLIERS

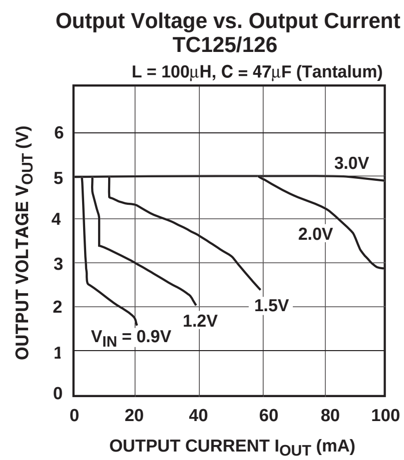
Type	Inductors	Capacitors	Diodes
Surface Mount	Sumida CD54 Series CDR125 Series Coiltronics CTX Series Murata LQN6C Series	Matsuo 267 Series Murata GRM200 Series Sprague 595D Series Nichicon F93 Series	Nihon EC10 Series Matsushita MA735 Series
Through-Hole	Sumida RCH855 Series RCH110 Series Renco RL1284-12	Sanyo OS-CON Series Nichicon PL Series	ON Semiconductor 1N5817-1N5822

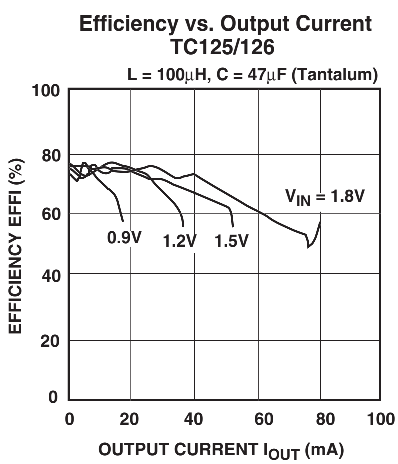
5.0 TYPICAL CHARACTERISTICS

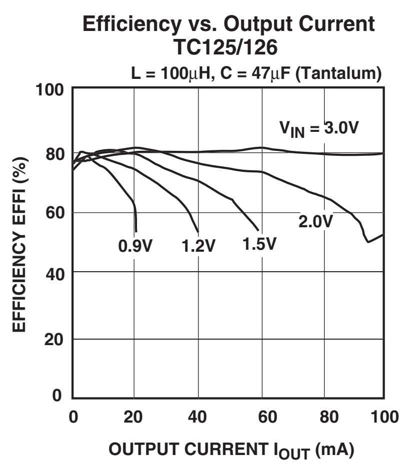
(Unless Otherwise Specified, All Parts Are Measured At Temperature = 25°C)

Note:	The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.



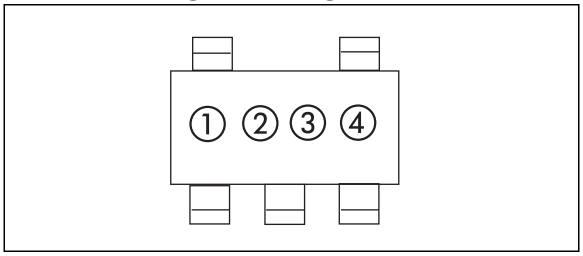






6.0 PACKAGING INFORMATION

6.1 Package Marking Information



① represents product classification; TC125 = L
TC126 = N

② represents first integer of voltage

Symbol (100 kHz)	Voltage
1	1
2	2
3	3
4	4
5	5
6	6
7	7

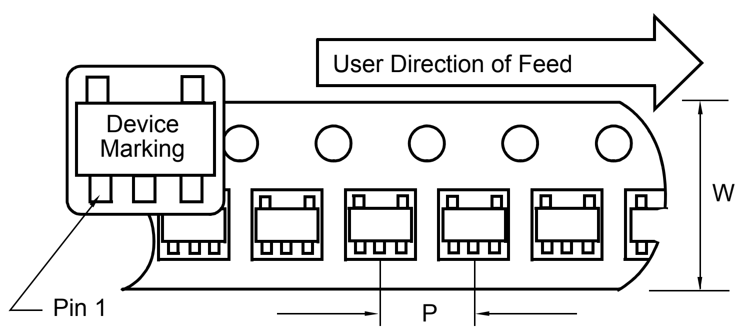
③ represents first decimal of voltage

Symbol (100 kHz)	Voltage
0	.0
1	.1
2	.2
3	.3
4	.4
5	.5
6	.6
7	.7
8	.8
9	.9

④ represents production lot ID code

6.2 Taping Form

Component Taping Orientation for 5-Pin SOT-23 (EIAJ SC-74A) Devices



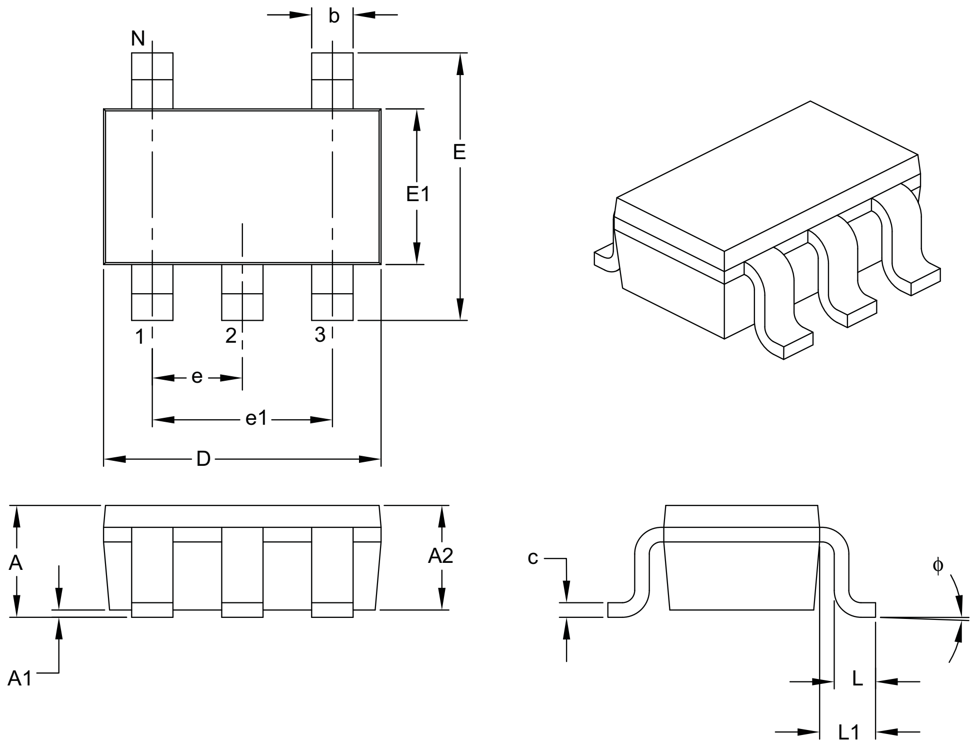
Standard Reel Component Orientation
TR Suffix Device
(Mark Right Side Up)

Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
5-Pin SOT-23	8 mm	4 mm	3000	7 in

5-Lead Plastic Small Outline Transistor (OT or CT) [SOT-23]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N	5		
Lead Pitch	e	0.95 BSC		
Outside Lead Pitch	e1	1.90 BSC		
Overall Height	A	0.90	–	1.45
Molded Package Thickness	A2	0.89	–	1.30
Standoff	A1	0.00	–	0.15
Overall Width	E	2.20	–	3.20
Molded Package Width	E1	1.30	–	1.80
Overall Length	D	2.70	–	3.10
Foot Length	L	0.10	–	0.60
Footprint	L1	0.35	–	0.80
Foot Angle	φ	0°	–	30°
Lead Thickness	c	0.08	–	0.26
Lead Width	b	0.20	–	0.51

Notes:

1. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127 mm per side.
2. Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-091B

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