TC1219/TC1220

Switched Capacitor Voltage Converters with Shutdown in SOT Packages

Features

- Charge Pumps in 6-Pin SOT-23A Package
- >95% Voltage Conversion Efficiency
- Voltage Inversion and/or Doubling
- Operates from +2.5V to +5.5V
- Up to 25mA Output Current
- Only Two External Capacitors Required
- Low Power Consumption
- Power-Saving Shutdown Mode
- TC1220 Compatible with 1.8V Logic Systems

Applications

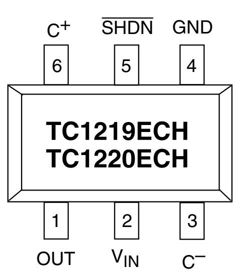
- LCD Panel Bias
- Cellular Phones
- Pagers
- PDAs, Portable Dataloggers
- Battery-Powered Devices

Device Selection Table

Part Number	Package	Osc. Freq. (kHz)	Operating Temp. Range
TC1219ECH	6-Pin SOT-23A	12	-40°C to +85°C
TC1220ECH	6-Pin SOT-23A	35	-40°C to +85°C

Package Type

6-Pin SOT-23A



NOTE: 6-Pin SOT-23A is equivalent to the EIAJ SC-74

General Description

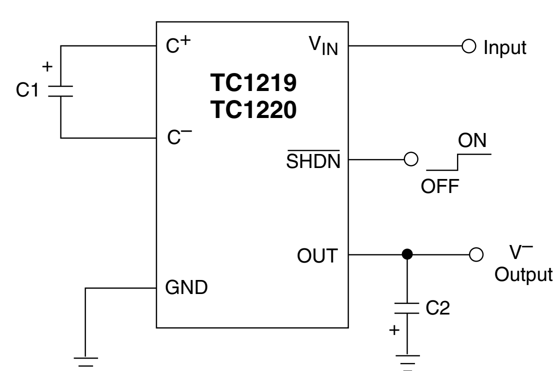
The TC1219/TC1220 are CMOS "charge-pump" voltage converters in ultra-small 6-Pin SOT-23A packages. They invert and/or double an input voltage which can range from +2.5V to +5.5V. Conversion efficiency is typically >95%. Switching frequency is 12kHz for the TC1219, 35kHz for the TC1220. When the shutdown pin is held at a logic low, the device goes into a very low power mode of operation, consuming less than 1µA of supply current.

External component requirement is only two capacitors for standard voltage inverter applications. With a few additional components a positive doubler can also be built. All other circuitry, including control, oscillator, power MOSFETs are integrated on-chip. Typical supply currents are 60µA (TC1219), 115µA (TC1220).

All devices are available in 6-pin SOT-23A surface mount packages.

Functional Block Diagram

Negative Voltage Inverter



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings*

Input Voltage (V_{IN} to GND)....................... +6.0V, -0.3V
Output Voltage (OUT to GND).................. -6.0V, +0.3V
Current at OUT Pin...50mA
Short-Circuit Duration – OUT to GND ....Indefinite
Power Dissipation ($T_A \leq 70°C$)
 6-Pin SOT-23A 240mW
Operating Temperature Range.............-40°C to +85°C
Storage Temperature (Unbiased).......-65°C to +150°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.

TC1219/TC1220 ELECTRICAL SPECIFICATIONS

Electrical Characteristics: T_A = -40°C to +85°C, V_{IN} = +5V, C1 = C2 = 10µF, (TC1219), C1 = C2 = 3.3µF (TC1220), T_A = 25°C unless otherwise noted.

Symbol	Parameter	Min	Typ	Max	Units	Device	Test Conditions
I_{DD}	Supply Current	— —	60 115	115 325	µA	TC1219 TC1220	
I_{SHDN}	Shutdown Supply Current	—	0.1	1.0	µA		$\overline{SHDN}$ = GND, V_{IN} = 5V (Note 2)
V_{MIN}	Minimum Supply Voltage	2.5	—	—	V		R_{LOAD} = 1kΩ
V_{MAX}	Maximum Supply Voltage	—	—	5.5	V		R_{LOAD} = 1kΩ
F_{OSC}	Oscillator Frequency	6 19	12 35	20 56.3	kHz	TC1219 TC1220	
V_{IH}	$\overline{SHDN}$ Input Logic High	— 1.5 1.8 1.5	— — — —	— — — —	V	 TC1219 TC1220	R_{LOAD} = ∞ V_{IN} = V_{MIN} to 3V V_{IN} = >3V to V_{MAX} V_{IN} = V_{MIN} to V_{MAX}
V_{IL}	$\overline{SHDN}$ Input Logic Low	—	—	0.5	V		V_{IN} = V_{MIN} to V_{MAX}
P_{EFF}	Power Efficiency	— —	96 95	— —	%		R_{LOAD} = 1kΩ
V_{EFF}	Voltage Conversion Efficiency	95	99.9	—	%		R_{LOAD} = ∞
R_{OUT}	Output Resistance	—	25	65	Ω	TC1219/TC1220	I_{LOAD} = 0.5mA to 25mA (Note 1)

Note 1: Capacitor contribution is approximately 20% of the output impedance [ESR = 1/ pump frequency x capacitance].
2: V_{IN} is guaranteed to be disconnected from OUT when the converter is in shutdown..

2.0 PIN DESCRIPTIONS

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

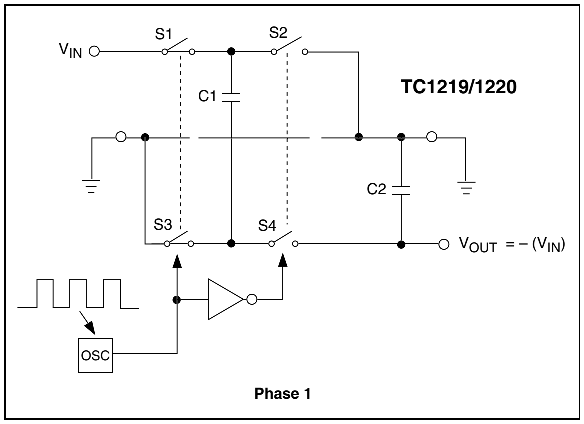
TABLE 2-1: PIN FUNCTION TABLE

Pin No. (6-Pin SOT-23A)	Symbol	Description
1	OUT	Inverting charge pump output.
2	V_{IN}	Positive power supply input.
3	C^-	Commutation capacitor negative terminal.
4	GND	Ground.
5	$\overline{SHDN}$	Shutdown input (active low).
6	C^+	Commutation capacitor positive terminal.

3.0 DETAILED DESCRIPTION

The TC1219/TC1220 charge pump converters invert the voltage applied to the V_{IN} pin. Conversion consists of a two-phase operation (Figure 3-1). During the first phase, switches S2 and S4 are opened and S1 and S3 are closed. During this time, C1 charges to the voltage on V_{IN} and load current is supplied from C2. During the second phase, S2 and S4 are closed, and S1 and S3 are opened. This action connects C1 across C2, restoring charge to C2.

FIGURE 3-1: IDEAL SWITCHED CAPACITOR CHARGE PUMP



4.0 APPLICATIONS INFORMATION

4.1 Output Voltage Considerations

The TC1219/TC1220 perform voltage conversion but do not provide *regulation*. The output voltage will droop in a linear manner with respect to load current. The value of this equivalent output resistance is approximately 25Ω nominal at +25°C and V_{IN} = +5V. V_{OUT} is approximately -5V at light loads, and droops according to the equation below:

$V_{DROP} = I_{OUT} \times R_{OUT}$
$V_{OUT} = -(V_{IN} - V_{DROP})$

4.2 Charge Pump Efficiency

The overall power efficiency of the charge pump is affected by four factors:

1. Losses from power consumed by the internal oscillator, switch drive, etc. (which vary with input voltage, temperature and oscillator frequency).
2. I^2R losses due to the on-resistance of the MOSFET switches on-board the charge pump.
3. Charge pump capacitor losses due to effective series resistance (ESR).
4. Losses that occur during charge transfer (from the commutation capacitor to the output capacitor) when a voltage difference between the two capacitors exists.

Most of the conversion losses are due to factors (2) and (3) above. These losses are given by Equation 4-1(b).

EQUATION 4-1:

a) $P_{LOSS(2,3)} = I_{OUT}^2 \times R_{OUT}$

b) where $R_{OUT} = \left[1 / [f_{OSC}(C1)] + 8R_{SWITCH} + 4ESR_{C1} + ESR_{C2} \right]$

The $1/(f_{OSC})(C1)$ term in Equation 4-1(b) is the effective output resistance of an ideal switched capacitor circuit (Figure 4-1 and Figure 4-2). The value of R_{SWITCH} can be approximated at 0.5Ω for the TC1219/TC1220.

The remaining losses in the circuit are due to factor (4) above, and are shown in Equation 4-2. The output voltage ripple is given by Equation 4-3.

EQUATION 4-2:

$$P_{LOSS(4)} = \left[(0.5)(C1)(V_{IN}^2 - V_{OUT}^2) + (0.5)(C2)(V_{RIPPLE}^2 - 2V_{OUT}V_{RIPPLE})\right] \times f_{OSC}$$

EQUATION 4-3:

$$V_{RIPPLE} = [I_{OUT} / 2 \times (f_{OSC})(C2)] + 2(I_{OUT})(ESR_{C2})$$

FIGURE 4-1: IDEAL SWITCHED CAPACITOR MODEL

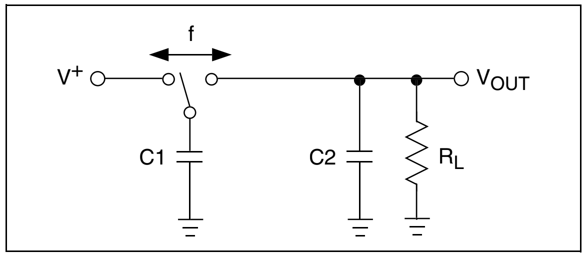
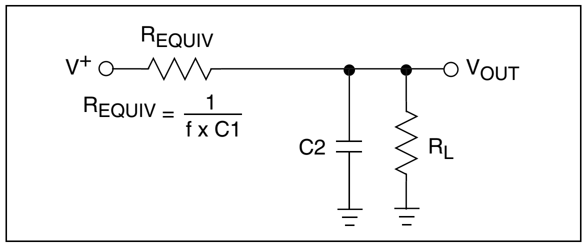


FIGURE 4-2: EQUIVALENT OUTPUT RESISTANCE



4.3 Capacitor Selection

In order to maintain the lowest output resistance and output ripple voltage, it is recommended that low ESR capacitors be used. Additionally, larger values of C1 will lower the output resistance and larger values of C2 will reduce output ripple. (Equation 4-1(b) and Equation 4-3).

Table 4-1 shows various values of C1 and the corresponding output resistance values @ +25°C. It assumes a 0.1Ω ESR_{C1} and 2Ω R_{SWITCH}. Table 4-2 shows the output voltage ripple for various values of C2. The V_{RIPPLE} values assume 10mA output load current and 0.1Ω ESR_{C2}.

TABLE 4-1: OUTPUT RESISTANCE VS. C1 (ESR = 0.1Ω)

C1 (µF)	TC1219 R_{OUT}(Ω)	TC1220 R_{OUT}(Ω)
1	100	45
3.3	42	25
10	25	19.4
30	19.3	17.5

TABLE 4-2: OUTPUT VOLTAGE RIPPLE VS. C2 (ESR = 0.1Ω) I_{OUT} 10mA

C2 (µF)	TC1219 V_{RIPPLE} (mV)	TC1220 V_{RIPPLE} (mV)
1	419	145
3.3	128	45
10	44	16
30	16	7

4.4 Input Supply Bypassing

The V_{IN} input should be capacitively bypassed to reduce AC impedance and minimize noise effects due to the internal switching of the device The recommended capacitor depends on the configuration of the TC1219/TC1220.

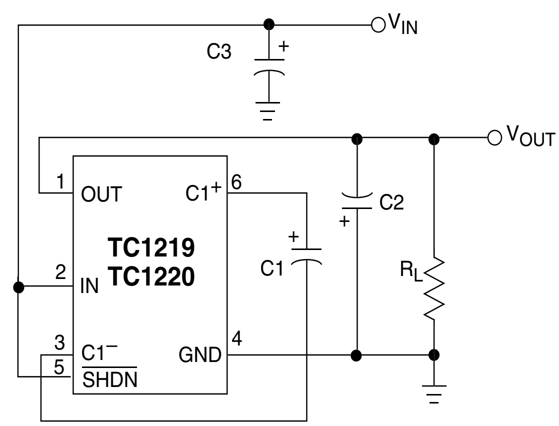
4.5 Shutdown Input

The TC1219/TC1220 is enabled when $\overline{SHDN}$ is high, and disabled when $\overline{SHDN}$ is low. This input cannot be allowed to float. (If $\overline{SHDN}$ is not required, see the TCM828/829 data sheet.) The $\overline{SHDN}$ input can be only driven to 0.5V above V_{IN} to avoid significant current flows.

4.6 Voltage Inverter

The most common application for charge pump devices is the inverter (Figure 4-3). This application uses two external capacitors: C1 and C2 (plus a power supply bypass capacitor, if necessary). The output is equal to $-V_{IN}$ plus any voltage drops due to loading. Refer to Table 4-1 and Table 4-2 for capacitor selection.

FIGURE 4-3: VOLTAGE INVERTER TEST CIRCUIT



Device	C1	C2	C3
TC1219	10µF	10µF	10µF
TC1220	3.3µF	3.3µF	3.3µF

4.7 Cascading Devices

Two or more TC1219/TC1220 can be cascaded to increase output voltage (Figure 4-4). If the output is lightly loaded, it will be close to (-2 x V_{IN}) but will droop at least by R_{OUT} of the first device multiplied by the I_Q of the second. It can be seen that the output resistance rises rapidly for multiple cascaded devices.

4.8 Paralleling Devices

To reduce the value of R_{OUT}, multiple TC1219/TC1220's can be connected in parallel (Figure 4-5). The output resistance will be reduced by a factor of N where N is the number of TC1219/TC1220. Each device will require its own pump capacitor (C1), but all devices may share one reservoir capacitor (C2). However, to preserve ripple performance the value of C2 should be scaled according to the number of paralleled TC1219/TC1220.

FIGURE 4-4: CASCADING MULTIPLE DEVICES TO INCREASE OUTPUT VOLTAGE

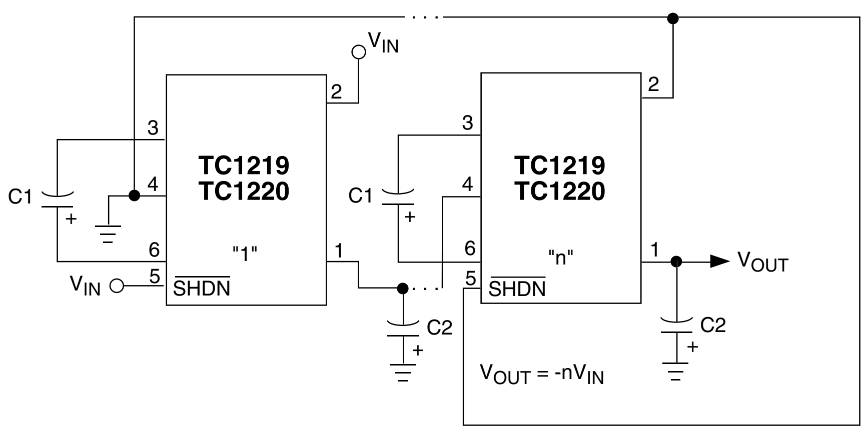
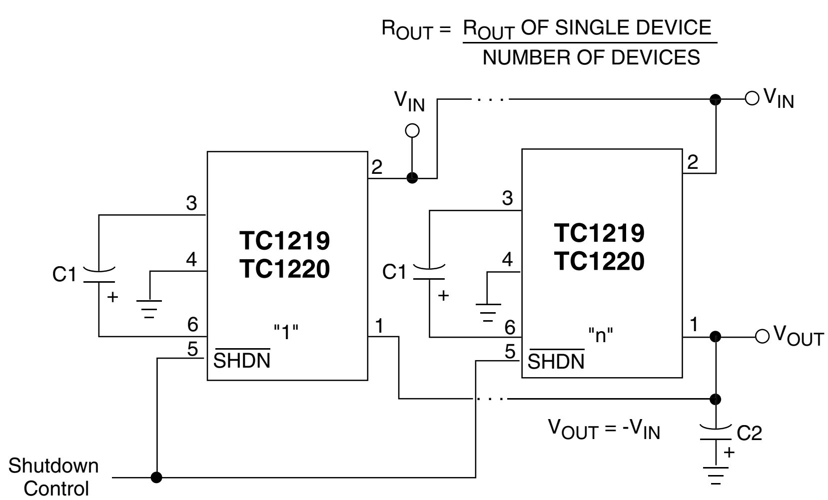


FIGURE 4-5: PARALLELING MULTIPLE DEVICES TO REDUCE OUTPUT RESISTANCE



4.9 Voltage Doubler/Inverter

Another common application of the TC1219/TC1220 is shown in Figure 4-6. This circuit performs two functions in combination. C1 and C2 form the standard inverter circuit described previously. C3 and C4 plus the two diodes form the voltage doubler circuit. C1 and C3 are the pump capacitors and C2 and C4 are the reservoir capacitors. Because both sub-circuits rely on the same switches if either output is loaded, both will droop toward GND. Make sure that the total current drawn from both the outputs does not total more than 40mA.

4.10 Diode Protection for Heavy Loads

When heavy loads require the OUT pin to sink large currents being delivered by a positive source, diode protection may be needed. The OUT pin should not be allowed to be pulled above ground. This is accomplished by connecting a Schottky diode (1N5817) as shown in Figure 4-7.

4.11 Layout Considerations

As with any switching power supply circuit good layout practice is recommended. Mount components as close together as possible to minimize stray inductance and capacitance. Noise leakage into other circuitry can be minimized with the use of a large ground plane.

FIGURE 4-6: COMBINED DOUBLER AND INVERTER

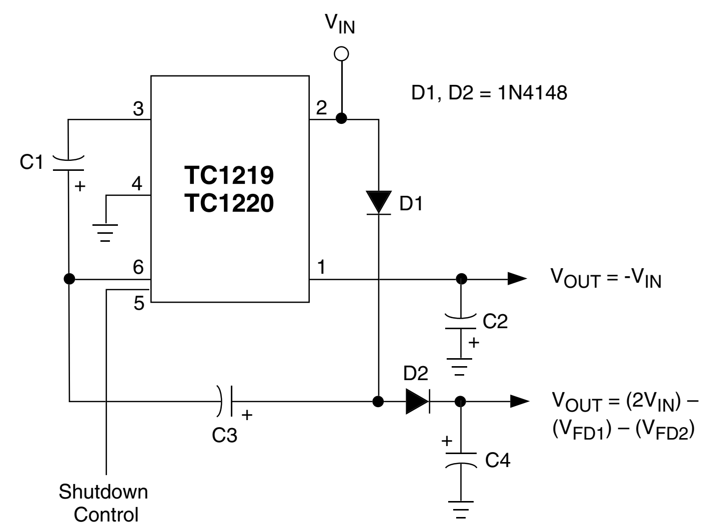
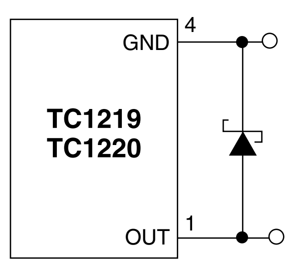


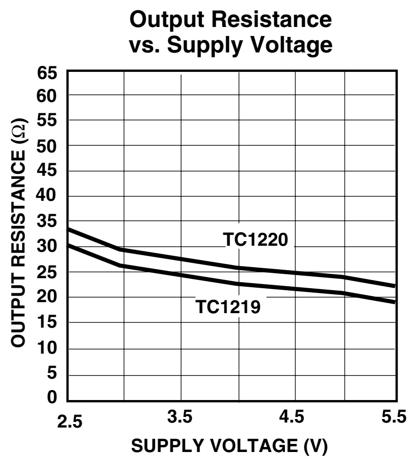
FIGURE 4-7: HIGH V– LOAD CURRENT

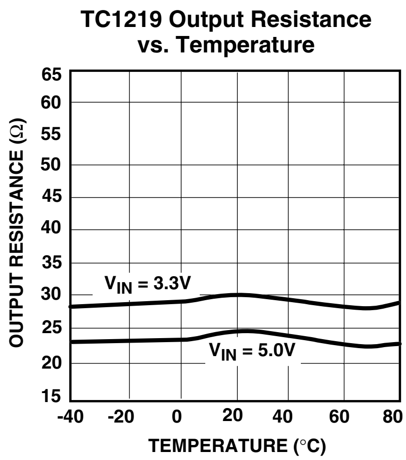


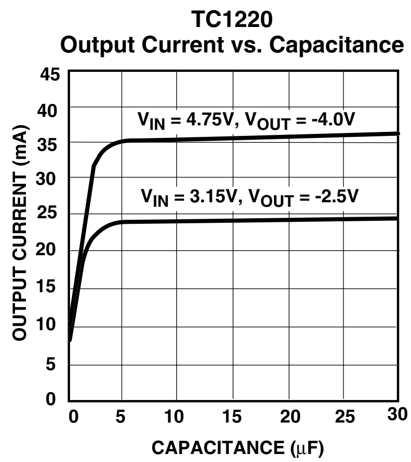
5.0 TYPICAL CHARACTERISTICS

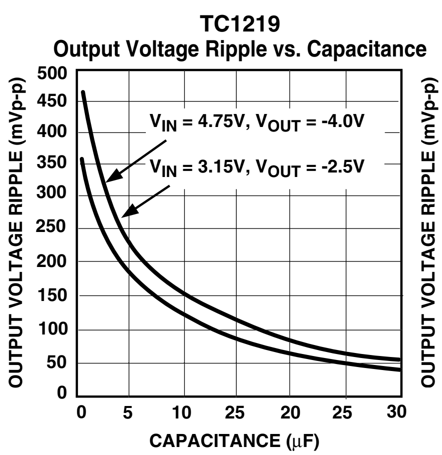
Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside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

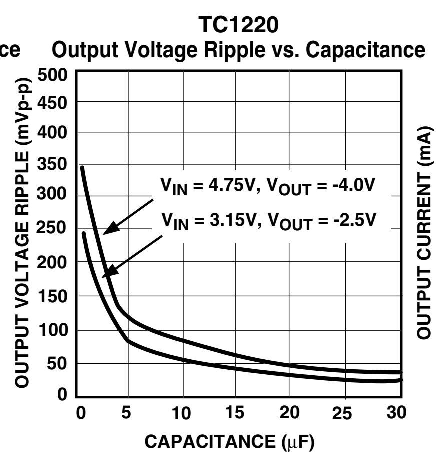
Circuit of Figure 4-3, V_{IN} = +5V, C1 = C2 = C3, T_A = 25°C unless otherwise noted.

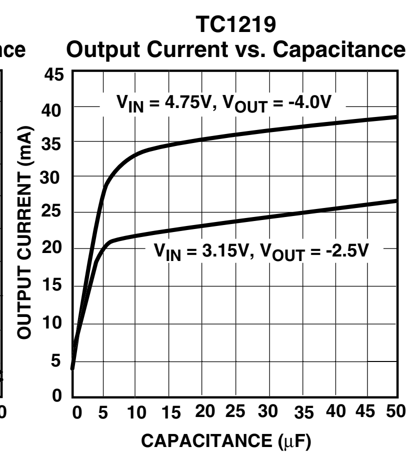


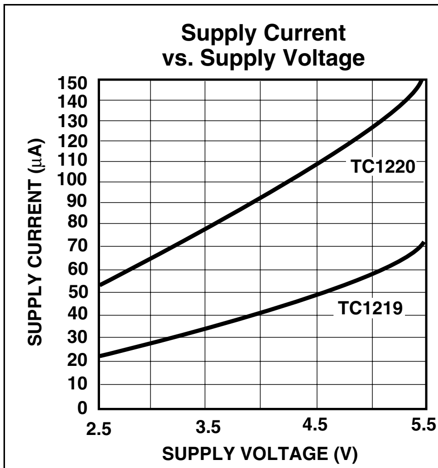


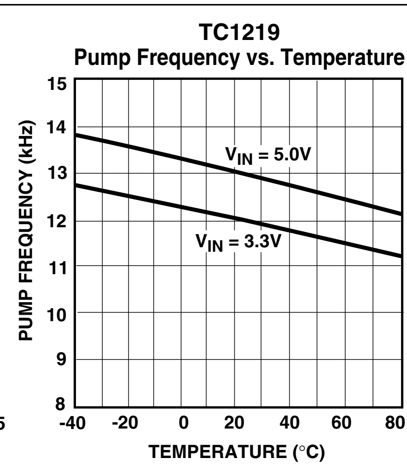


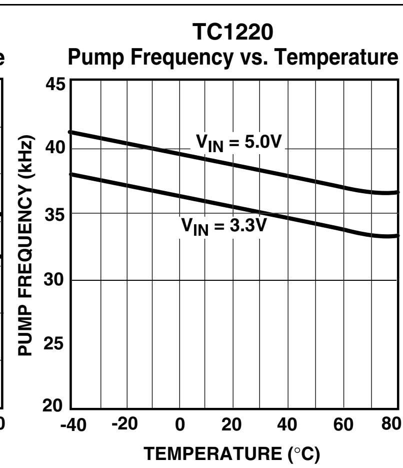




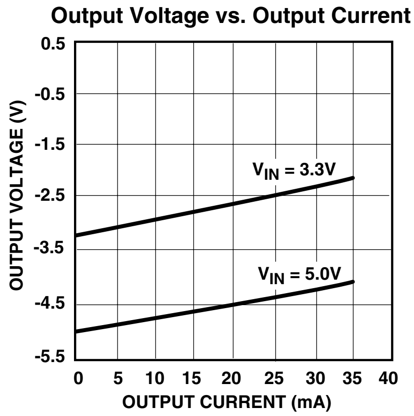


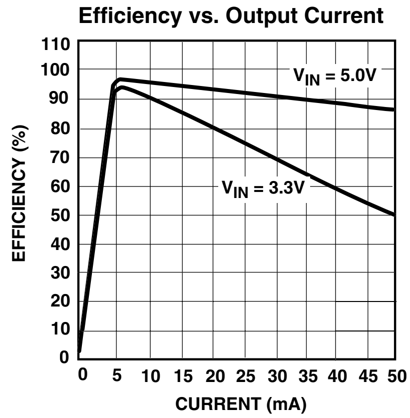






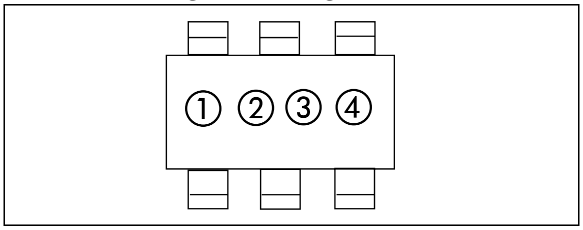
TYPICAL CHARACTERISTICS (CONTINUED)





6.0 PACKAGING INFORMATION

6.1 Package Marking Information



① & ② = part number code + temperature range
(two-digit code)

TC1219/TC1220	Code
TC1219ECH	AM
TC1220ECH	AN

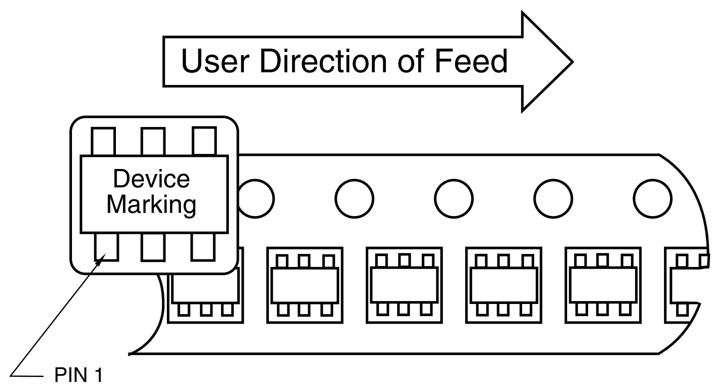
ex: 1219ECH = Ⓐ Ⓜ ◯ ◯

③ represents year and quarter code

④ represents production lot ID code

6.2 Taping Form

Component Taping Orientation for 6-Pin SOT-23A (EIAJ SC-74) Devices

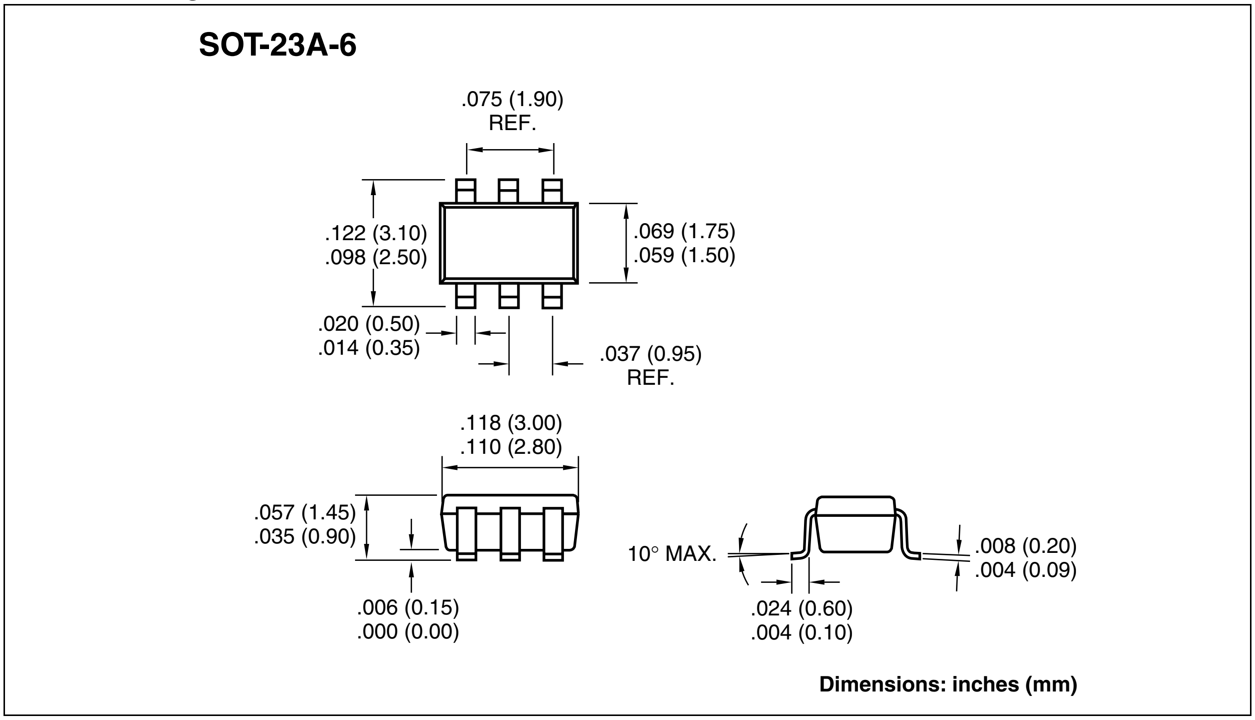


Standard Reel Component Orientation
For TR Suffix Device
(Mark Right Side Up)

Carrier Tape, Number of Components Per Reel and Reel Size

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

6.3 Package Dimensions



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Microchip Technology Consulting (Shanghai) Co., Ltd., Beijing Liaison Office
Unit 915
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Beijing, 100027, No. China
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Taipei, 105, Taiwan
Tel: 886-2-2717-7175 Fax: 886-2-2545-0139

EUROPE

Denmark
Microchip Technology Nordic ApS
Regus Business Centre
Lautrup hoj 1-3
Ballerup DK-2750 Denmark
Tel: 45 4420 9895 Fax: 45 4420 9910

France
Microchip Technology SARL
Parc d'Activite du Moulin de Massy
43 Rue du Saule Trapu
Batiment A - ler Etage
91300 Massy, France
Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79

Germany
Microchip Technology GmbH
Gustav-Heinemann Ring 125
D-81739 Munich, Germany
Tel: 49-89-627-144 0 Fax: 49-89-627-144-44

Italy
Microchip Technology SRL
Centro Direzionale Colleoni
Palazzo Taurus 1 V. Le Colleoni 1
20041 Agrate Brianza
Milan, Italy
Tel: 39-039-65791-1 Fax: 39-039-6899883

United Kingdom
Arizona Microchip Technology Ltd.
505 Eskdale Road
Winnersh Triangle
Wokingham
Berkshire, England RG41 5TU
Tel: 44 118 921 5869 Fax: 44-118 921-5820

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OCEAN CHIPS

Океан Электроники

Поставка электронных компонентов

Компания «Океан Электроники» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Поставка оригинальных импортных электронных компонентов напрямую с производств Америки, Европы и Азии, а так же с крупнейших складов мира;
- Широкая линейка поставок активных и пассивных импортных электронных компонентов (более 30 млн. наименований);
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения **«JONHON»**, а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов **«FORSTAR»**.

«JONHON» (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели, кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).

Телефон: 8 (812) 309-75-97 (многоканальный)
Факс: 8 (812) 320-03-32
Электронная почта: ocean@oceanchips.ru
Web: http://oceanchips.ru/
Адрес: 198099, г. Санкт-Петербург, ул. Калинина, д. 2, корп. 4, лит. А