TC1219
TC1220

SWITCHED CAPACITOR VOLTAGE CONVERTERS WITH SHUTDOWN IN SOT PACKAGES

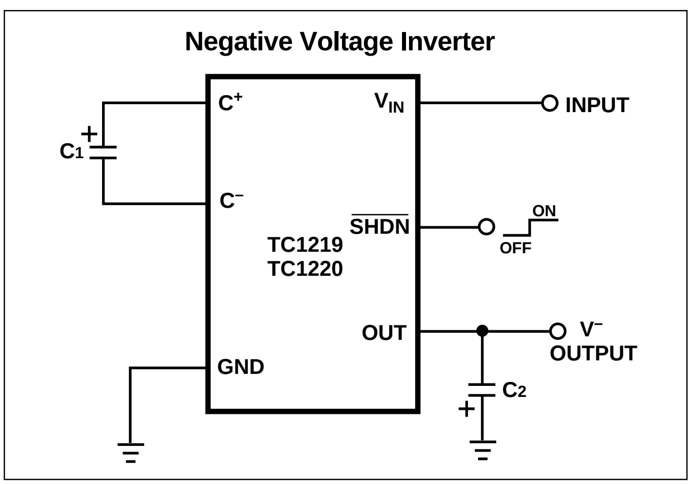
FEATURES

- **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 25 mA Output Current**
- **Only Two External Capacitors Required**
- **Low Power Consumption**
- **Power-Saving Shutdown Mode**
- **TC1220 Compatible with 1.8V Logic Systems**

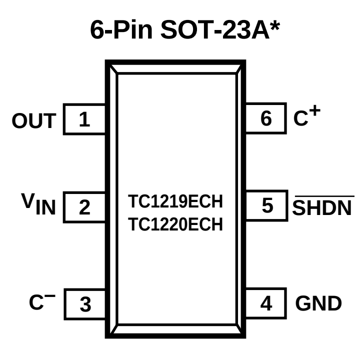
APPLICATIONS

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

TYPICAL OPERATING CIRCUIT



PIN CONFIGURATION



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

GENERAL DESCRIPTION

The TC1219/1220 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 12 KHz for the TC1219, 35 KHz 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 1 µA 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 60 µA (TC1219), 115 µA (TC1220).

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

ORDERING INFORMATION

Part No.	Package	Osc. Freq. (KHz)	Temp. Range
TC1219ECH	6-Pin SOT-23A*	12	– 40°C to +85°C
TC1220ECH	6-Pin SOT-23A*	35	– 40°C to +85°C

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

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 ....50 mA
Short-Circuit Duration – OUT to GND .... Indefinite
Operating Temperature Range .... – 40°C to +85°C
Power Dissipation ($T_A \leq 70°C$)
6-Pin SOT-23A ....240 mW
Storage Temperature (Unbiased) .... – 65°C to +150°C
Lead Temperature (Soldering, 10 sec) .... +260°C

*This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS:

T_A = –40°C to +85°C, V_{IN} = +5V, C1 = C2 = 10 µF (TC1219), C1 = C2 = 3.3µF (TC1220), unless otherwise noted. Typical values are at T_A = +25°C.

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

NOTES: 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.

PIN DESCRIPTION

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.

DETAILED DESCRIPTION

The TC1219/1220 charge pump converters invert the voltage applied to the V_{IN} pin. Conversion consists of a two-phase operation (Figure 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.

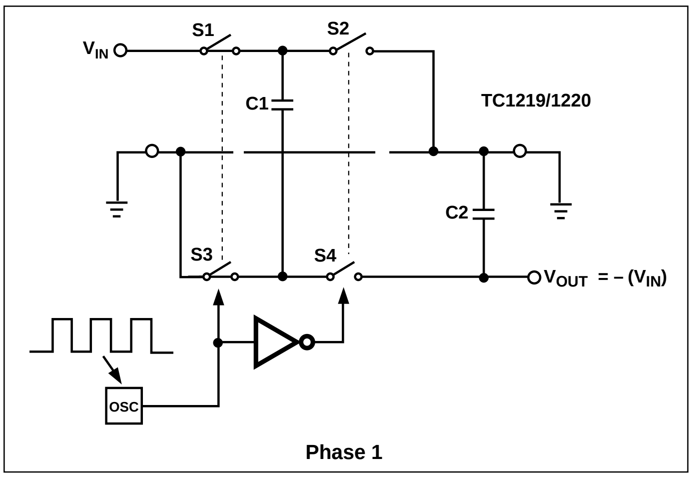


Figure 1. Ideal Switched Capacitor Charge Pump

APPLICATIONS INFORMATION

Output Voltage Considerations

The TC1219/1220 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:

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

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 1(b).

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

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

Equation 1.

The $1/(f_{OSC})(C1)$ term in Equation 1(b) is the effective output resistance of an ideal switched capacitor circuit (Figures 2a, 2b). The value of R_{SWITCH} can be approximated at 0.5Ω for the TC1219/1220.

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

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

Equation 2.

$$V_{RIPPLE} = \frac{I_{OUT}}{(f_{OSC})(C2)} + 2(I_{OUT})(ESR_{C2})$$

Equation 3.

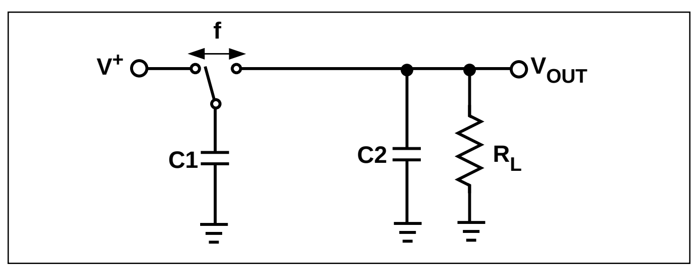


Figure 2a. Ideal Switched Capacitor Model

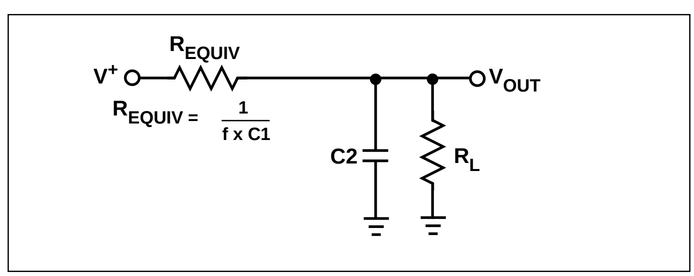


Figure 2b. Equivalent Output Resistance

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. (See Equation 1(b) and Equation 3).

Table 1 shows various values of C1 and the corresponding output resistance values @ +25°C. It assumes a 0.1Ω ESR_{C1} and 2Ω R_{SW}. Table 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 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 2. Output Voltage Ripple vs. C2 (ESR = 0.1Ω) I_{OUT} 10mA

C2 (µF)	TC1219 V_{RIPPLE} (mV)	TC1220 V_{RIPPLE} (mV)
1	835	286
3.3	254	88
10	85	31
30	29.8	11.5

Input Supply Bypassing

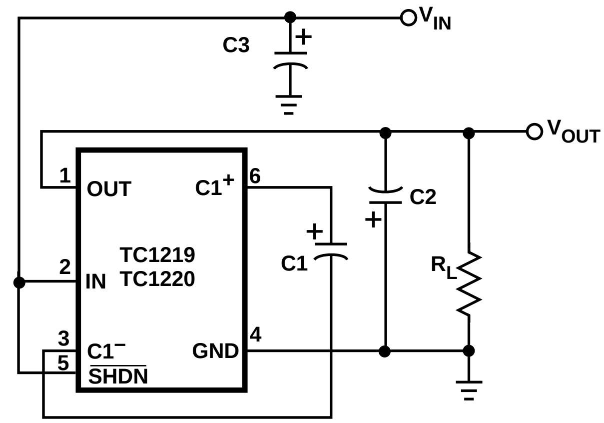
The V_{IN} input should be capacitively bypassed to reduce AC impedance and minimize noise effects due to the switching internal to the device. The recommended capacitor depends on the configuration of the TC1219/1220.

Shutdown Input

The TC1219/1220 is enabled when SHDN is high, and disabled when SHDN is low. This input cannot be allowed to float. (If SHDN is not required, see the TCM828/829 data sheet.) The SHDN input can be only driven to 0.5V above VIN to avoid significant current flows.

Voltage Inverter

The most common application for charge pump devices is the inverter (Figure 3). This application uses two exterrnal 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 1 and Table 2 for capacitor selection.



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

Voltage Inverter

Figure 3. Test Circuit

Cascading Devices

Two or more TC1219/1220 can be cascaded to increase output voltage (Figure 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.

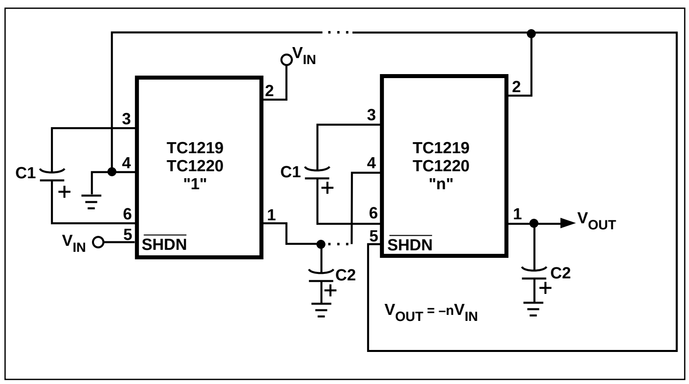


Figure 4. Cascading Multiple Devices to Increase Output Voltage

Paralleling Devices

To reduce the value of R_{OUT}, multiple TC1219/1220 can be connected in parallel (Figure 5). The output resistance will be reduced by a factor of N where N is the number of TC1219/1220. 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 TC1219/1220.

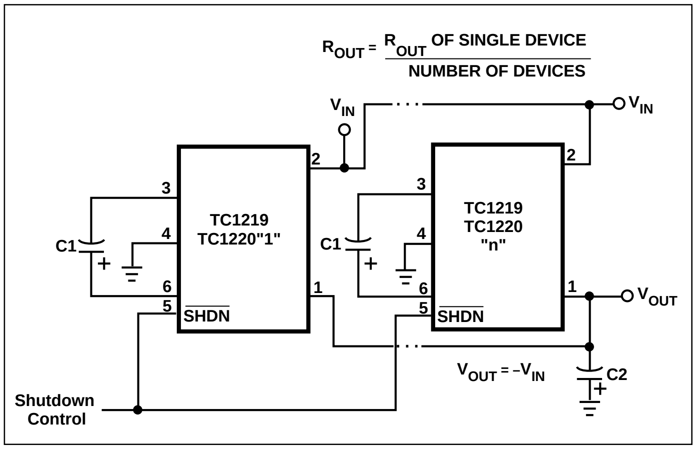


Figure 5. Paralleling Multiple Devices to Reduce Output Resistance

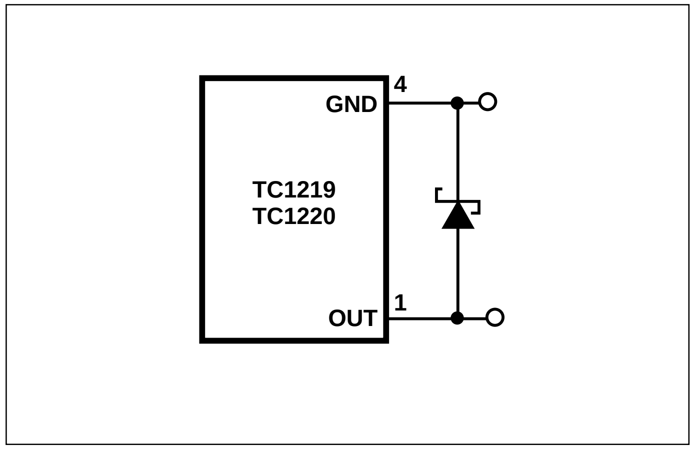


Figure 7. High V^- Load Current

Voltage Doubler/Inverter

Another common application of the TC1219/1220 is shown in Figure 6. This circuit performs two functions in combination. C1 and C2 form the standard inverter circuit described above. 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 40 mA.

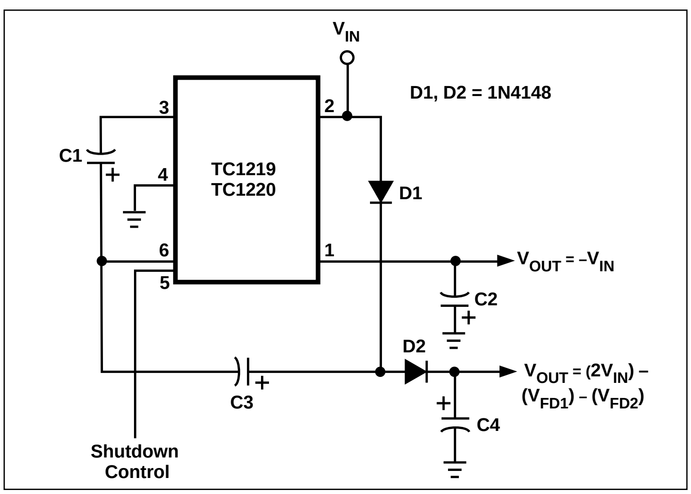


Figure 6. Combined Doubler and Inverter

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 7.

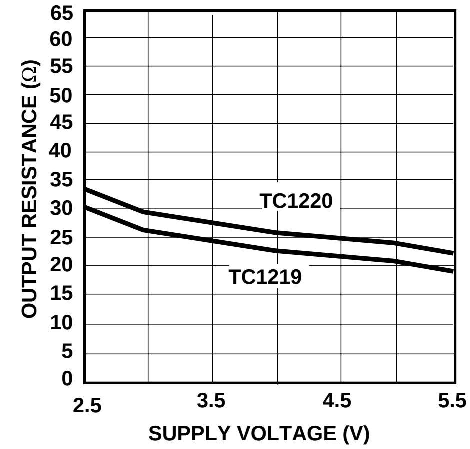
Layout Considerations

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. Also use a large ground plane to minimize noise leakage into other circuitry.

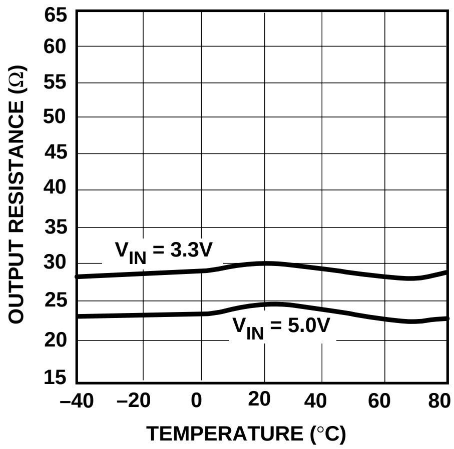
TYPICAL CHARACTERISTICS

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

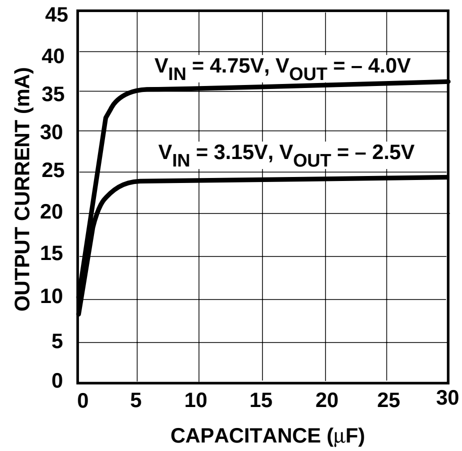
Output Resistance vs. Supply Voltage



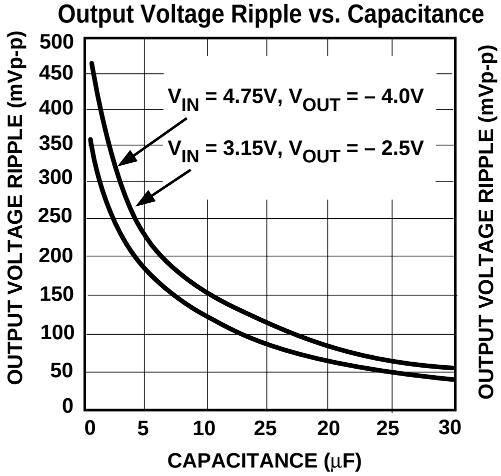
TC1219
Output Resistance vs. Temperature



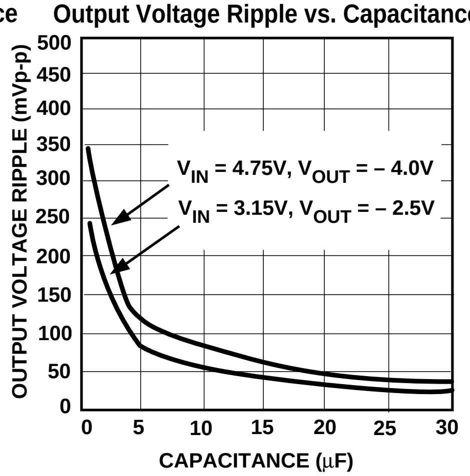
TC1220
Output Current vs. Capacitance



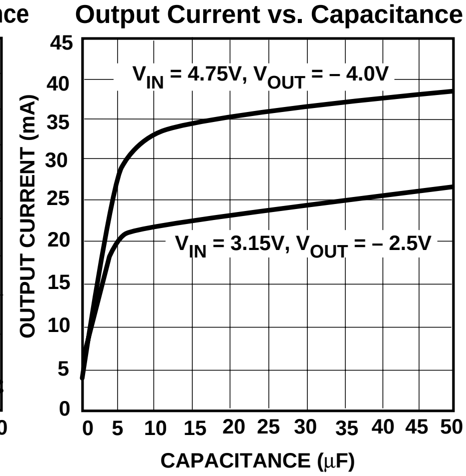
TC1219
Output Voltage Ripple vs. Capacitance



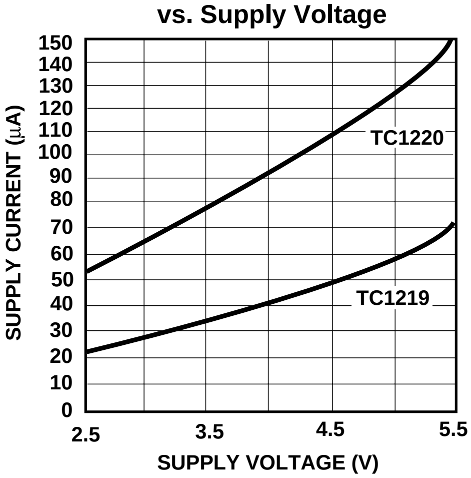
TC1220
Output Voltage Ripple vs. Capacitance



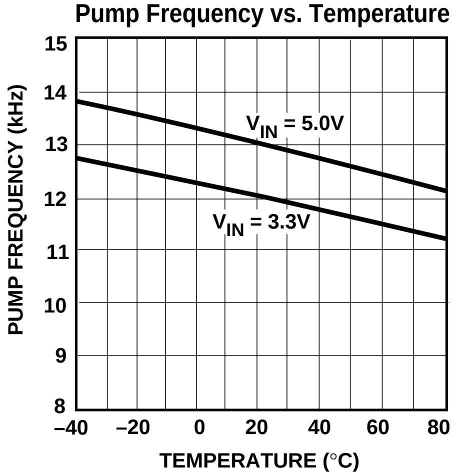
TC1219
Output Current vs. Capacitance



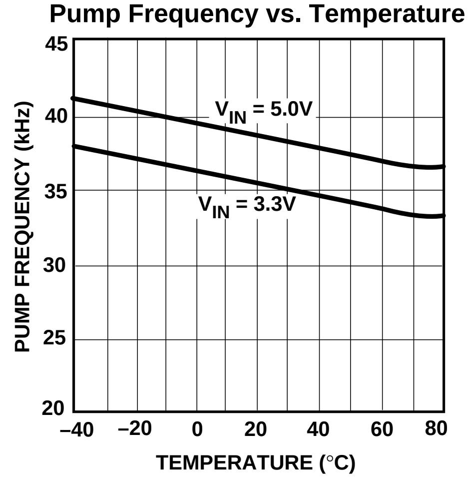
Supply Current vs. Supply Voltage



TC1219
Pump Frequency vs. Temperature



TC1220
Pump Frequency vs. Temperature

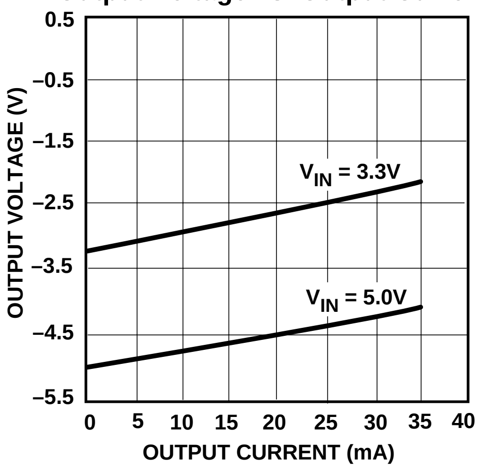


TC1219/1220-3 8/20/99

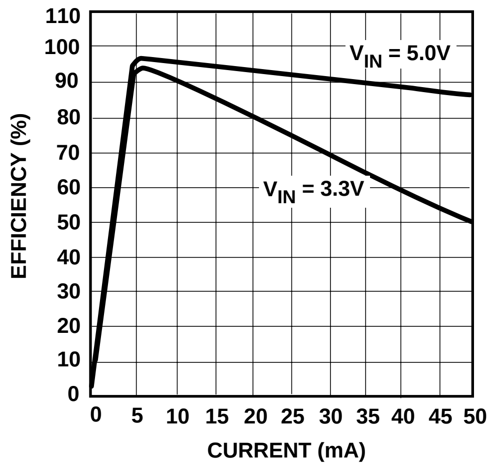
TYPICAL CHARACTERISTICS (Cont.)

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

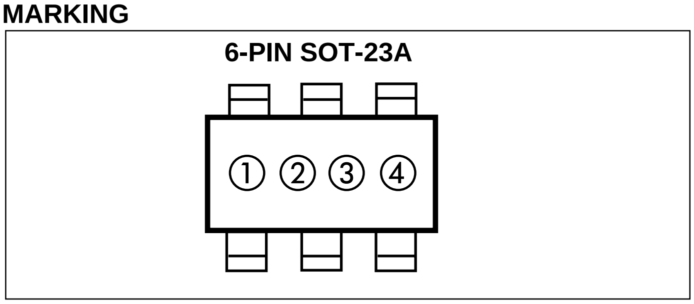
Output Voltage vs. Output Current



Efficiency vs. Output Current



MARKING



Part Numbers and Part Marking

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

TC1219/1220	Code
TC1219ECH	AM
TC1220ECH	AN

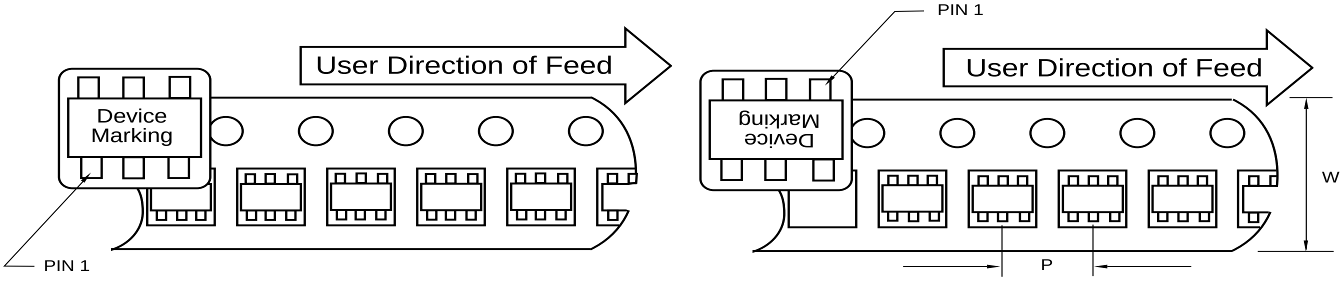
ex: 1219ECH = Ⓐ Ⓜ ◯ ◯

③ represents year and quarter code

④ represents lot ID number

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)

Reverse Reel Component Orientation
For RT Suffix Device
(Mark Upside Down)

Carrier Tape, Number of Components Per Reel and Reel Size

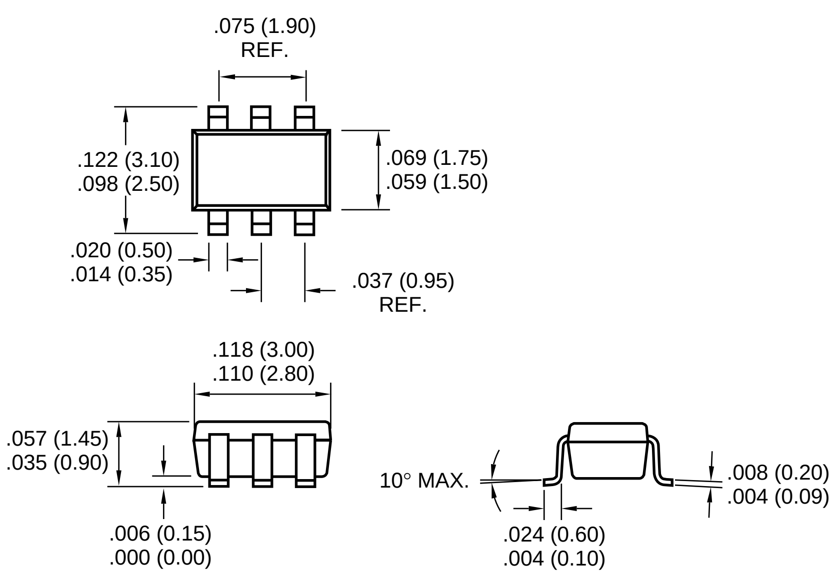
Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
6-Pin SOT-23A	8 mm	4 mm	3000	7 in

Tape & Reel Specifications Table

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

PACKAGING INFORMATION

6-PIN SOT-23A (EIAJ SC-74)



Dimensions: inches (mm)

WORLDWIDE SALES AND SERVICE

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200 Fax: 480-792-7277
Technical Support: 480-792-7627
Web Address: http://www.microchip.com

Rocky Mountain
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7966 Fax: 480-792-7456

Atlanta
500 Sugar Mill Road, Suite 200B
Atlanta, GA 30350
Tel: 770-640-0034 Fax: 770-640-0307

Austin
Analog Product Sales
8303 MoPac Expressway North
Suite A-201
Austin, TX 78759
Tel: 512-345-2030 Fax: 512-345-6085

Boston
2 Lan Drive, Suite 120
Westford, MA 01886
Tel: 978-692-3848 Fax: 978-692-3821

Boston
Analog Product Sales
Unit A-8-1 Millbrook Tarry Condominium
97 Lowell Road
Concord, MA 01742
Tel: 978-371-6400 Fax: 978-371-0050

Chicago
333 Pierce Road, Suite 180
Itasca, IL 60143
Tel: 630-285-0071 Fax: 630-285-0075

Dallas
4570 Westgrove Drive, Suite 160
Addison, TX 75001
Tel: 972-818-7423 Fax: 972-818-2924

Dayton
Two Prestige Place, Suite 130
Miamisburg, OH 45342
Tel: 937-291-1654 Fax: 937-291-9175

Detroit
Tri-Atria Office Building
32255 Northwestern Highway, Suite 190
Farmington Hills, MI 48334
Tel: 248-538-2250 Fax: 248-538-2260

Los Angeles
18201 Von Karman, Suite 1090
Irvine, CA 92612
Tel: 949-263-1888 Fax: 949-263-1338

Mountain View
Analog Product Sales
1300 Terra Bella Avenue
Mountain View, CA 94043-1836
Tel: 650-968-9241 Fax: 650-967-1590

New York
150 Motor Parkway, Suite 202
Hauppauge, NY 11788
Tel: 631-273-5305 Fax: 631-273-5335

San Jose
Microchip Technology Inc.
2107 North First Street, Suite 590
San Jose, CA 95131
Tel: 408-436-7950 Fax: 408-436-7955

Toronto
6285 Northam Drive, Suite 108
Mississauga, Ontario L4V 1X5, Canada
Tel: 905-673-0699 Fax: 905-673-6509

ASIA/PACIFIC

China - Beijing
Microchip Technology Beijing Office
Unit 915
New China Hong Kong Manhattan Bldg.
No. 6 Chaoyangmen Beidajie
Beijing, 100027, No. China
Tel: 86-10-85282100 Fax: 86-10-85282104

China - Shanghai
Microchip Technology Shanghai Office
Room 701, Bldg. B
Far East International Plaza
No. 317 Xian Xia Road
Shanghai, 200051
Tel: 86-21-6275-5700 Fax: 86-21-6275-5060

Hong Kong
Microchip Asia Pacific
RM 2101, Tower 2, Metroplaza
223 Hing Fong Road
Kwai Fong, N.T., Hong Kong
Tel: 852-2401-1200 Fax: 852-2401-3431

India
Microchip Technology Inc.
India Liaison Office
Divyasree Chambers
1 Floor, Wing A (A3/A4)
No. 11, OíShaugnessey Road
Bangalore, 560 025, India
Tel: 91-80-2290061 Fax: 91-80-2290062

Japan
Microchip Technology Intl. Inc.
Benex S-1 6F
3-18-20, Shinyokohama
Kohoku-Ku, Yokohama-shi
Kanagawa, 222-0033, Japan
Tel: 81-45-471- 6166 Fax: 81-45-471-6122

Korea
Microchip Technology Korea
168-1, Youngbo Bldg. 3 Floor
Samsung-Dong, Kangnam-Ku
Seoul, Korea
Tel: 82-2-554-7200 Fax: 82-2-558-5934

ASIA/PACIFIC (continued)

Singapore
Microchip Technology Singapore Pte Ltd.
200 Middle Road
#07-02 Prime Centre
Singapore, 188980
Tel: 65-334-8870 Fax: 65-334-8850

Taiwan
Microchip Technology Taiwan
11F-3, No. 207
Tung Hua North Road
Taipei, 105, Taiwan
Tel: 886-2-2717-7175 Fax: 886-2-2545-0139

EUROPE

Australia
Microchip Technology Australia Pty Ltd
Suite 22, 41 Rawson Street
Epping 2121, NSW
Australia
Tel: 61-2-9868-6733 Fax: 61-2-9868-6755

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

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

Germany
Analog Product Sales
Lochhamer Strasse 13
D-82152 Martinsried, Germany
Tel: 49-89-895650-0 Fax: 49-89-895650-22

Italy
Arizona 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

01/09/01