Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!

Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
Email & Skype: info@chipsmall.com Web: www.chipsmall.com
Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

TC1221/TC1222

High Frequency Switched Capacitor Voltage Converters with Shutdown in SOT Packages

Features

- Charge Pumps in 6-Pin SOT-23A Package
- 96% Voltage Conversion Efficiency
- Voltage Inversion and/or Doubling
- Operates from +1.8V to +5.5V
- Up to 25mA Output Current
- Only Two External Capacitors Required
- Power-Saving Shutdown Mode
- Fully Compatible with 1.8V Logic Systems

Applications

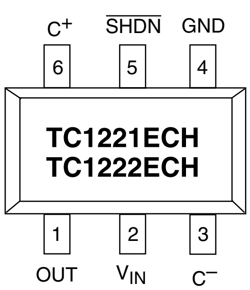
- LCD Panel Bias
- Cellular Phones
- Pagers
- PDAs, Portable Data Loggers
- Battery-Powered Devices

Device Selection Table

Part Number	Package	Osc. Freq. (kHz)	Operating Temp. Range
TC1221ECH	6-Pin SOT-23A	125	-40°C to +85°C
TC1222ECH	6-Pin SOT-23A	750	-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

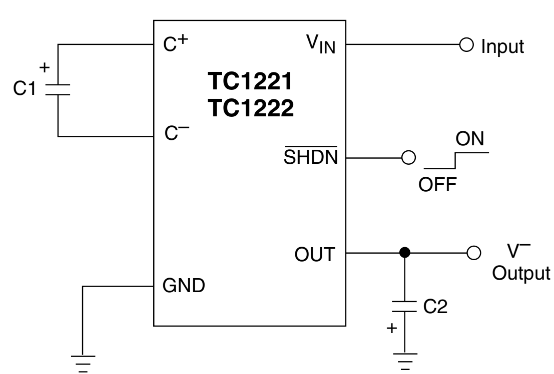
The TC1221/TC1222 are CMOS "charge-pump" voltage converters in ultra-small 6-Pin SOT-23A packages. They invert and/or double an input voltage which can range from +1.8V to +5.5V. Conversion efficiency is typically 96%. Switching frequency is 125kHz for the TC1221, 750kHz for the TC1222. When the shutdown 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.

For standard voltage inverter applications, the device requires only two external capacitors. 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 290µA (TC1221) and 1800µA (TC1222).

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.

TC1121 ELECTRICAL SPECIFICATIONS

Electrical Characteristics: T_A = -40°C to +85°C, V_{IN} = +5V, C1 = C2 = 1µF, (TC1221), C1 = C2 = 0.22µF (TC1222), Typical values are at T_A = +25°C.

Symbol	Parameter	Min	Typ	Max	Units	Device	Test Conditions
I_{DD}	Supply Current	— —	290 1800	600 2800	µA	TC1221 TC1222	
I_{SHDN}	Shutdown Supply Current	—	0.01	1.0	µA		$\overline{SHDN}$ = GND, V_{IN} = 5V (Note 2)
V_{MIN}	Minimum Supply Voltage	1.8	—	—	V		R_{LOAD} = 1kΩ
V_{MAX}	Maximum Supply Voltage	—	—	5.5	V		R_{LOAD} = 1kΩ
F_{OSC}	Oscillator Frequency	81 550	125 750	169 950	kHz	TC1221 TC1222	
V_{IH}	$\overline{SHDN}$ Input Logic High	1.4		—	V		V_{IN} = V_{MIN} to V_{MAX}
V_{IL}	$\overline{SHDN}$ Input Logic Low	—	—	0.4	V		V_{IN} = V_{MIN} to V_{MAX}
P_{EFF}	Power Efficiency	— —	90 70	— —	%	TC1221 TC1222	R_{LOAD} = 1kΩ
V_{EFF}	Voltage Conversion Efficiency	94	96	—	%		R_{LOAD} = ∞
R_{OUT}	Output Resistance	— —	25	65	Ω		I_{LOAD} = 0.5mA to 25mA (Note 1)
TWK	Wake-up Time From Shutdown Mode	— —	80 25	— —	µsec	TC1221 TC1222	R_{LOAD} = 1kΩ

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.

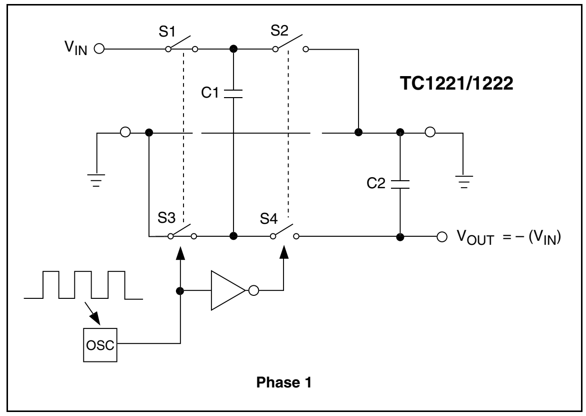
TABLE 2-1: PIN FUNCTION TABLE

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 TC1221/TC1222 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 TC1221/TC1222 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 $R_{OUT} = [\,1 / [f_{OSC}(C1)\,] + 8R_{SWITCH} + 4ESR_{C1} + ESR_{C2}]$

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 TC1221/TC1222.

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:

$$P_{LOSS(4)} = [(0.5)(C1)(V_{IN}^2 - V_{OUT}^2) + (0.5)(C_2)(V_{RIPPLE}^2 - 2V_{OUT}\,V_{RIPPLE})] \times f_{OSC}$$

EQUATION 4-3:

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

FIGURE 4-1: IDEAL SWITCHED CAPACITOR MODEL

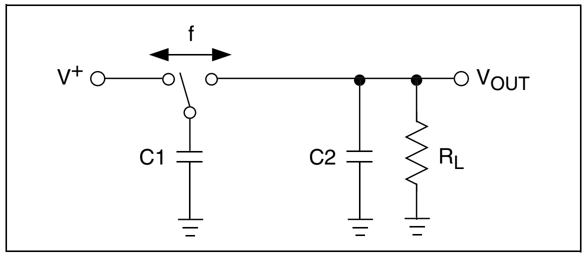
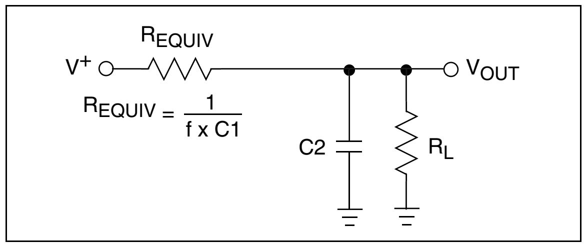


FIGURE 4-2: EQUIVALENT OUTPUT RESISTANCE



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)	TC1221 R_{OUT}(Ω)	TC1222 R_{OUT}(Ω)
0.22	52.9	22.6
0.33	40.8	20.5
0.47	33.5	19.4
1.0	25	17.8

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

C2 (µF)	TC1221 V_{RIPPLE} (mV)	TC1222 V_{RIPPLE} (mV)
0.22	184	32
0.33	123	22
0.47	87	16
1.0	42	9

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 TC1221/TC1222.

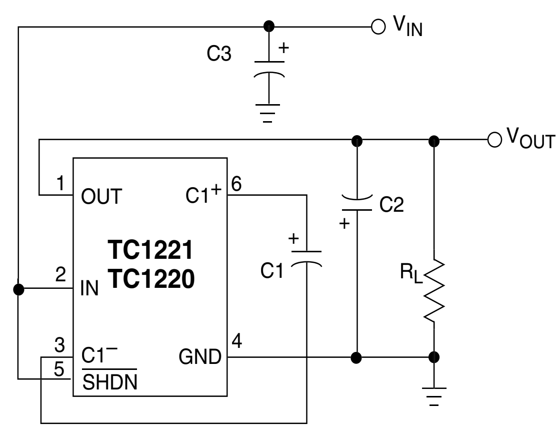
4.5 Shutdown Input

The TC1221/TC1222 is enabled when $\overline{SHDN}$ is high, and disabled when $\overline{SHDN}$ is low. This input cannot be allowed to float. The $\overline{SHDN}$ input should be limited 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
TC1221	1µF	1µF	1µF
TC1222	0.22µF	0.22µF	0.22µF

4.7 Cascading Devices

Two or more TC1221/TC1222 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 TC1221/TC1222'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 TC1221/TC1222. 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 TC1221/TC1222.

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

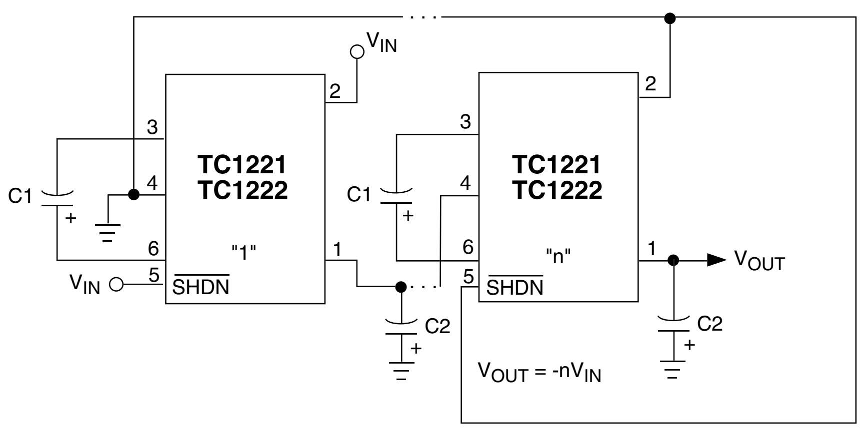
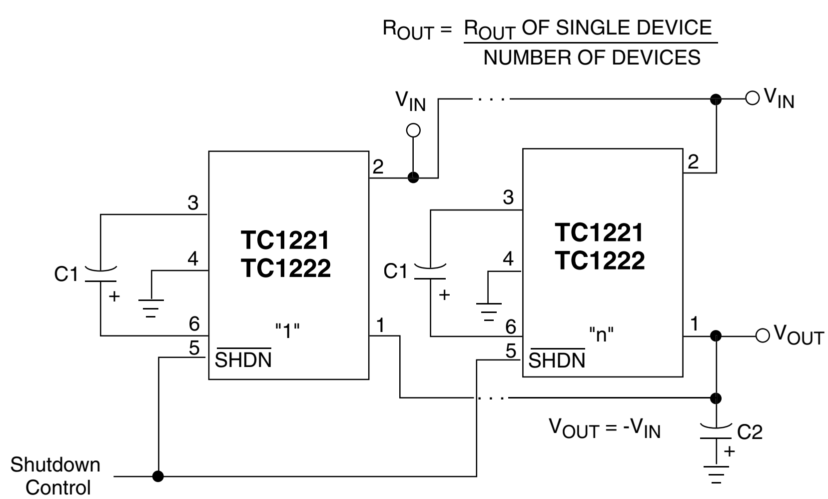


FIGURE 4-5: PARALLELING MULTIPLE DEVICES TO REDUCE OUTPUT RESISTANCE



4.9 Voltage Doubler/Inverter

Another common application of the TC1221/TC1222 is shown in Figure 4-6. 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 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

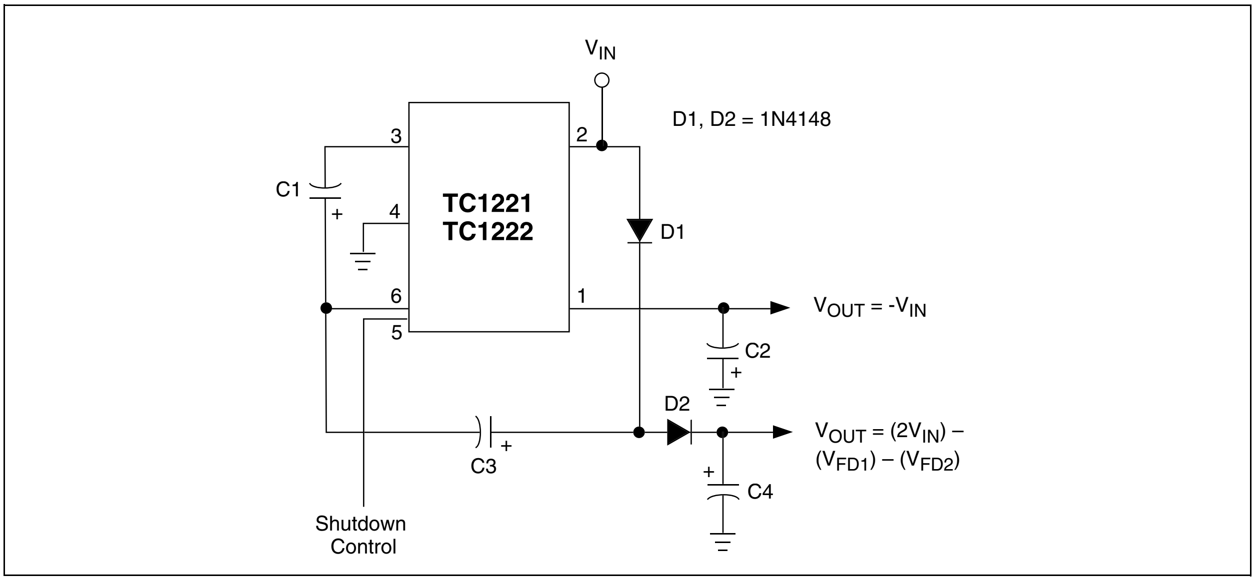
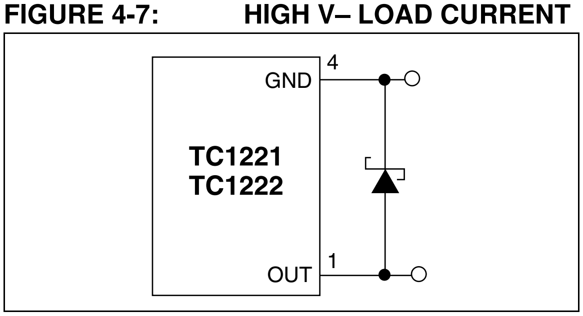


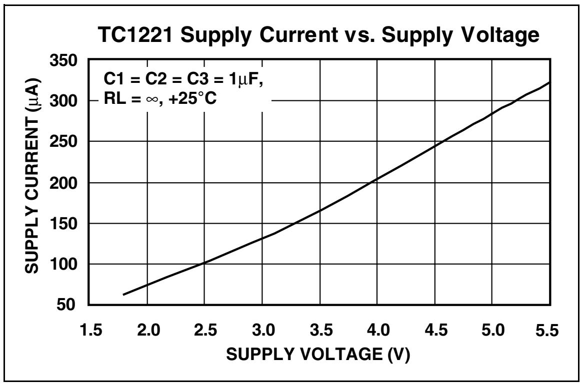
FIGURE 4-7: HIGH V– LOAD CURRENT



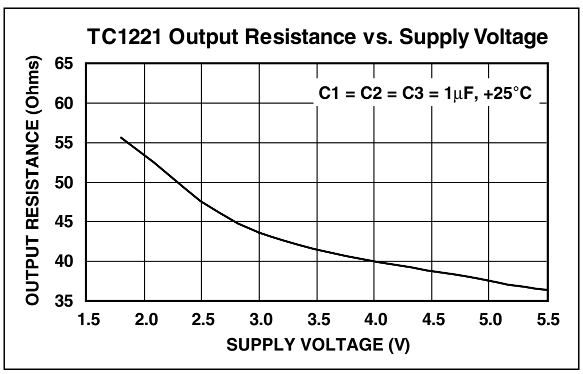
5.0 TYPICAL CHARACTERISTICS

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.

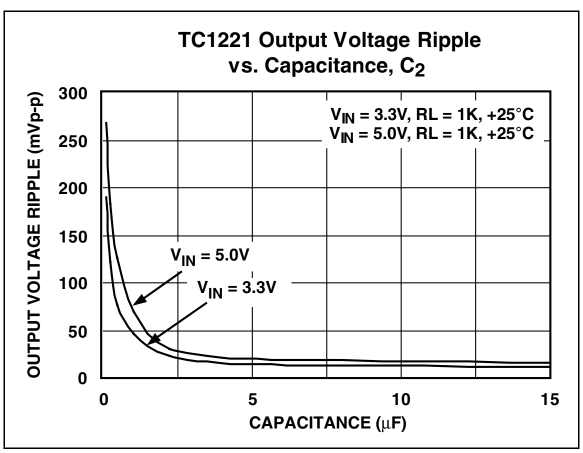
Circuit of Figure 4-3, V_{IN} = +5V, C1 = C2 = C3, T_A = 25°C unless otherwise noted.



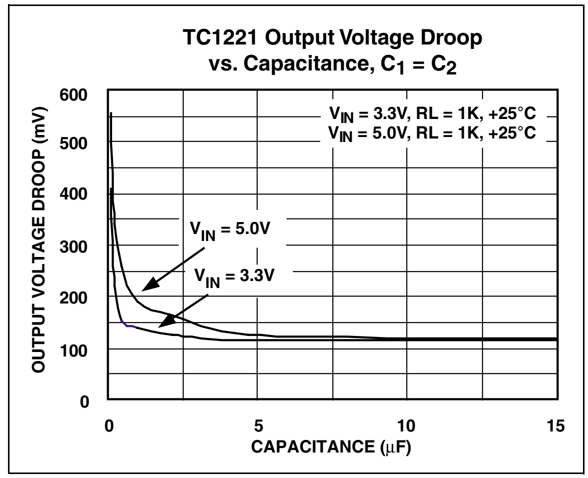
TC1221 Supply Current vs. Supply Voltage



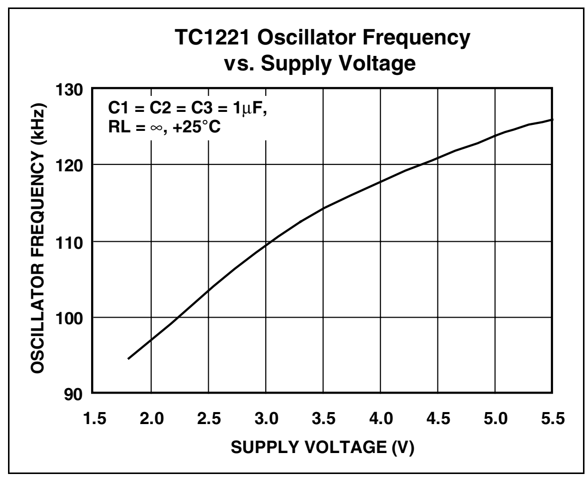
TC1221 Output Resistance vs. Supply Voltage



TC1221 Output Voltage Ripple vs. Capacitance, C_2



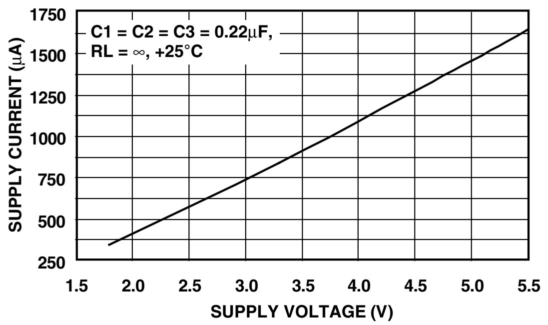
TC1221 Output Voltage Droop vs. Capacitance, C_1 = C_2



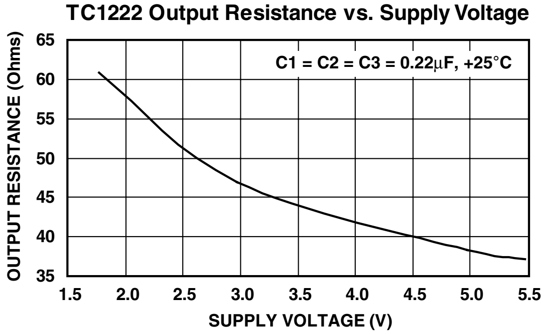
TC1221 Oscillator Frequency vs. Supply Voltage

5.0 TYPICAL CHARACTERISTICS (CONTINUED)

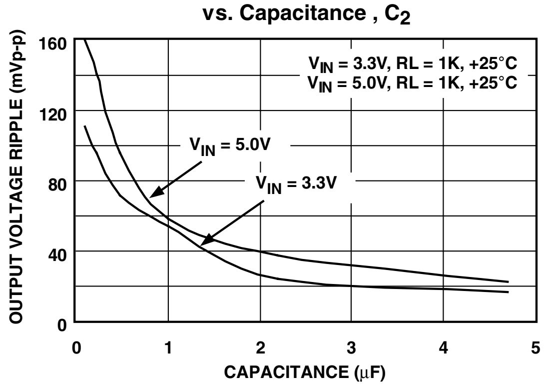
TC1222 Supply Current vs. Supply Voltage



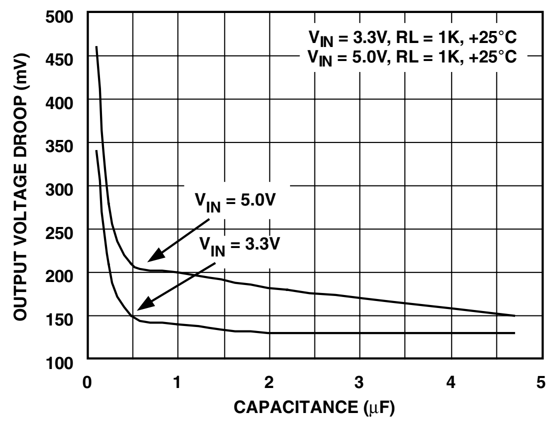
TC1222 Output Resistance vs. Supply Voltage



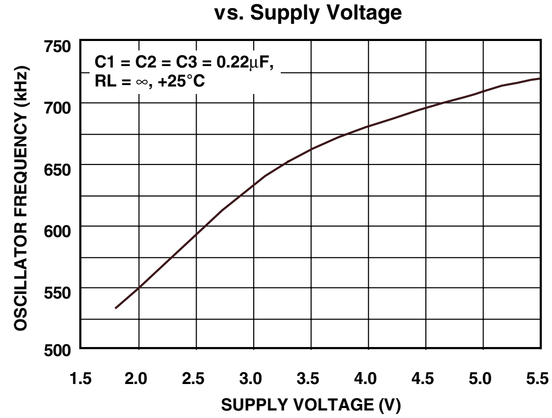
TC1222 Output Voltage Ripple vs. Capacitance , C_2



TC1222 Output Voltage Droop vs. Capacitance, $C_1 = C_2$

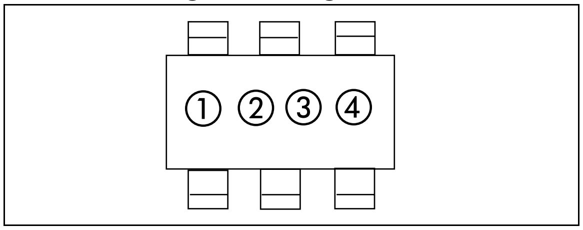


TC1222 Oscillator Frequency vs. Supply Voltage



6.0 PACKAGING INFORMATION

6.1 Package Marking Information



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

TC1221/TC1222	**Code**
TC1221ECH	GA
TC1222ECH	GB

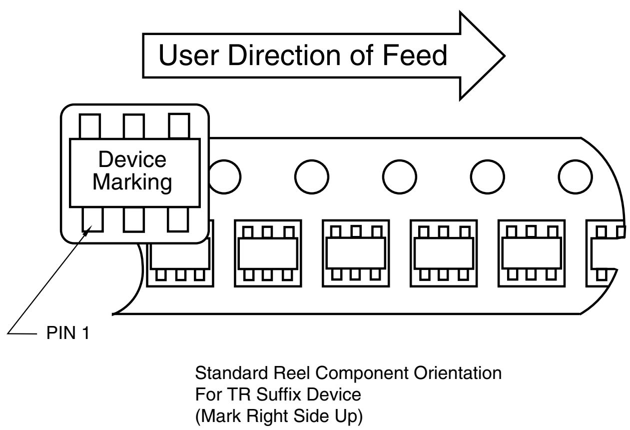
ex: 1221ECH = Ⓖ Ⓐ ◯ ◯
1222ECH = Ⓖ Ⓑ ◯ ◯

③ represents year and 2-month code

④ represents production lot ID code

6.2 Taping Form

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

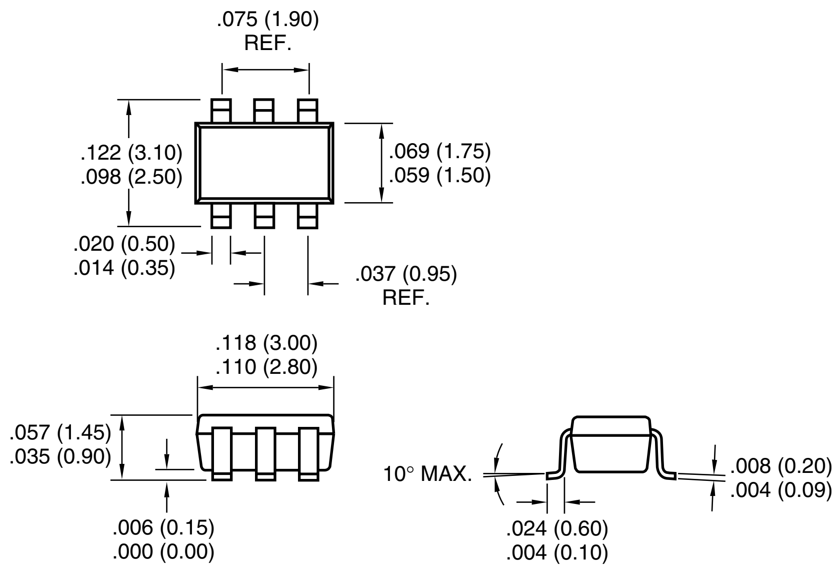


Carrier Tape, Number of Components Per Reel and Reel Size

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

SOT-23A-6



Dimensions: inches (mm)

Sales and Support

Data Sheets
Products supported by a preliminary Data Sheet may have an errata sheet describing minor operational differences and recommended workarounds. To determine if an errata sheet exists for a particular device, please contact one of the following:

1. Your local Microchip sales office
2. The Microchip Corporate Literature Center U.S. FAX: (480) 792-7277
3. The Microchip Worldwide Site (www.microchip.com)

Please specify which device, revision of silicon and Data Sheet (include Literature #) you are using.

New Customer Notification System
Register on our web site (www.microchip.com/cn) to receive the most current information on our products.

NOTES:

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

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

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

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

Kokomo
2767 S. Albright Road
Kokomo, Indiana 46902
Tel: 765-864-8360 Fax: 765-864-8387

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

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

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

China - Beijing
Microchip Technology Consulting (Shanghai)
Co., Ltd., Beijing Liaison Office
Unit 915
Bei Hai Wan Tai Bldg.
No. 6 Chaoyangmen Beidajie
Beijing, 100027, No. China
Tel: 86-10-85282100 Fax: 86-10-85282104

China - Chengdu
Microchip Technology Consulting (Shanghai)
Co., Ltd., Chengdu Liaison Office
Rm. 2401, 24th Floor,
Ming Xing Financial Tower
No. 88 TIDU Street
Chengdu 610016, China
Tel: 86-28-6766200 Fax: 86-28-6766599

China - Fuzhou
Microchip Technology Consulting (Shanghai)
Co., Ltd., Fuzhou Liaison Office
Unit 28F, World Trade Plaza
No. 71 Wusi Road
Fuzhou 350001, China
Tel: 86-591-7503506 Fax: 86-591-7503521

China - Shanghai
Microchip Technology Consulting (Shanghai)
Co., Ltd.
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

China - Shenzhen
Microchip Technology Consulting (Shanghai)
Co., Ltd., Shenzhen Liaison Office
Rm. 1315, 13/F, Shenzhen Kerry Centre,
Renminnan Lu
Shenzhen 518001, China
Tel: 86-755-2350361 Fax: 86-755-2366086

Hong Kong
Microchip Technology Hongkong Ltd.
Unit 901-6, 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, O'Shaugnessey Road
Bangalore, 560 025, India
Tel: 91-80-2290061 Fax: 91-80-2290062

Japan
Microchip Technology Japan K.K.
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 135-882
Tel: 82-2-554-7200 Fax: 82-2-558-5934

Singapore
Microchip Technology Singapore Pte Ltd.
200 Middle Road
#07-02 Prime Centre
Singapore, 188980
Tel: 65-6334-8870 Fax: 65-6334-8850

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

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

03/01/02