

100mA Charge Pump Voltage Converter with Shutdown

Features:

- Optional High-Frequency Operation Allows Use of Small Capacitors
- Low Operating Current (FC = GND):
 - 50 μ A
- High Output Current (100 mA)
- Converts a 2.4V to 5.5V Input Voltage to a Corresponding Negative Output Voltage (Inverter mode)
- Uses Only 2 Capacitors; No Inductors Required
- Selectable Oscillator Frequency:
 - 10 kHz to 200 kHz
- Power-Saving Shutdown Input
- Available in 8-Pin MSOP, 8-Pin PDIP and 8-Pin Small Outline (SOIC) Packages

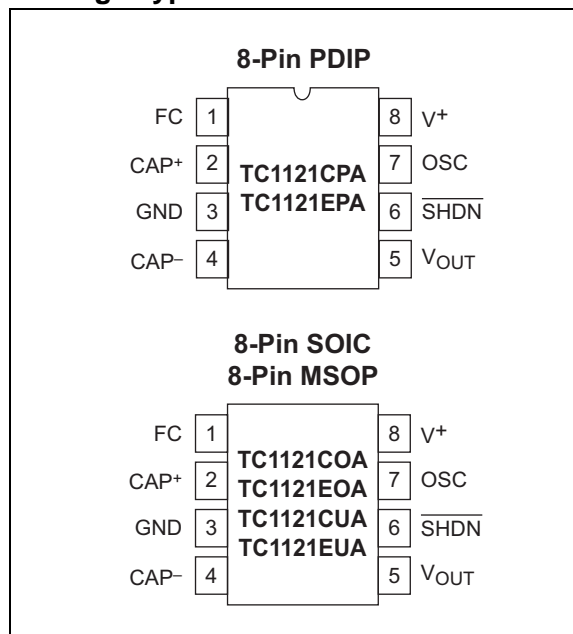
Applications:

- Laptop Computers
- Medical Instruments
- Disk Drives
- μ P-Based Controllers
- Process Instrumentation

Device Selection Table

Part Number	Package	Operating Temp. Range
TC1121COA	8-Pin SOIC	0°C to +70°C
TC1121CPA	8-Pin PDIP	0°C to +70°C
TC1121CUA	8-Pin MSOP	0°C to +70°C
TC1121EOA	8-Pin SOIC	-40°C to +85°C
TC1121EPA	8-Pin PDIP	-40°C to +85°C
TC1121EUA	8-Pin MSOP	-40°C to +85°C

Package Type



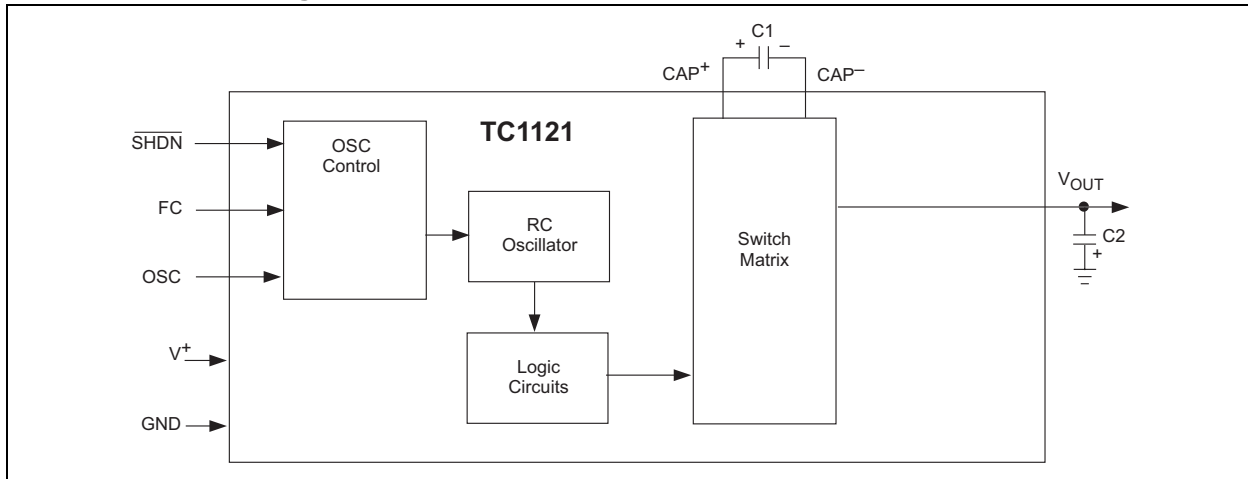
General Description:

The TC1121 is a charge pump converter with 100 mA output current capability. It converts a 2.4V to 5.5V input to a corresponding negative output voltage. As with all charge pump converters, the TC1121 uses no inductors saving cost, size and EMI.

An on-board oscillator operates at a typical frequency of 10 kHz (at V⁺ = 5V) when the frequency control input (FC) is connected to ground. The oscillator frequency increases to 200 kHz when FC is connected to V⁺, allowing the use of smaller capacitors. Operation at sub-10 kHz frequencies results in lower quiescent N_Scurrent and is accomplished with the addition of an external capacitor from OSC (pin 7) to ground. The TC1121 also can be driven from an external clock N_Sconnected OSC. Typical supply current at 10 kHz is 50 μ A, and falls to less than 1 μ A when the shutdown input is brought low, whether the internal or an external clock is used. The TC1121 is available in 8-pin SOIC, MSOP and PDIP packages.

TC1121

Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings*

Supply Voltage (V_{DD})	6V
OSC, FC, SHDN Input Voltage	-0.3V to ($V^+ + 0.3V$)
Output Short Circuit Duration	10 Sec.
Package Power Dissipation ($T_A \leq 70^\circ\text{C}$)	
8-Pin PDIP	730 mW
8-Pin SOIC	470 mW
8-Pin MSOP	333 mW
Operating Temperature Range	
C Suffix	0°C to +70°C
E Suffix	-40°C to +85°C
Storage Temperature Range	-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: $T_A = 0^\circ\text{C}$ to 70°C (C suffix), -40°C to $+85^\circ\text{C}$ (E suffix), $V^+ = 5V \pm 10\%$ $C_{OSC} = \text{Open}$, $C1, C2 = 10 \mu\text{F}$, $\text{FC} = V^+$, $\text{SHDN} = V_{IH}$, typical values are at $T_A = 25^\circ\text{C}$ unless otherwise noted.						
Symbol	Parameter	Min	Typ	Max	Units	Test Conditions
I_{DD}	Active Supply Current	—	50 0.6	100 1	μA mA	$R_L = \text{Open}$, $\text{FC} = \text{Open}$ or GND $R_L = \text{Open}$, $\text{FC} = V^+$
$I_{SHUTDOWN}$	Shutdown Supply Current	—	0.2	1.0	μA	$\text{SHDN} = 0V$
V^+	Supply Voltage	2.4	—	5.5	V	
V_{IH}	SHDN Input Logic High	$V_{DD} \times 0.8$	—	—	V	
V_{IL}	SHDN Input Logic Low	—	—	0.4	V	
I_{IN}	Input Leakage Current	-1 -4	—	1 4	μA	SHDN, OSC FC pin
R_{OUT}	Output Source Resistance	—	12	20	Ω	$I_{OUT} = 60 \text{ mA}$
I_{OUT}	Output Current	60	100			$V_{OUT} = \text{more negative than } -3.75V$
F_{OSC}	Oscillator Frequency	5 100	10 200	— —	kHz	Pin 7 Open, Pin 1 Open or GND $\text{SHDN} = V_{IH}$, Pin 1 = V^+
P_{EFF}	Power Efficiency	— 93 94 —	— 97 97 92	— — —	%	$\text{FC} = \text{GND}$ for all $R_L = 2k$ between V^+ and V_{OUT} $R_L = 1k\Omega$ between V_{OUT} and GND $I_L = 60 \text{ mA}$ to GND
V_{EFF}	Voltage Conversion Efficiency	99	99.9	—	%	$R_L = \text{Open}$

Note 1: Connecting any input terminal to voltages greater than V^+ or less than GND may cause destructive latch-up. It is recommended that no inputs from sources operating from external supplies be applied prior to "power up" of the TC1121.

TC1121

2.0 PIN DESCRIPTIONS

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

TABLE 2-1: PIN FUNCTION TABLE

Pin No. (8-Pin MSOP, PDIP, SOIC)	Symbol	Description
1	FC	Frequency control for internal oscillator, FC = open, $F_{OSC} = 10 \text{ kHz typ}$; FC = V^+ , $F_{OSC} = 200 \text{ kHz typ}$; FC has no effect when OSC pin is driven externally.
2	CAP ⁺	Charge-pump capacitor, positive terminal.
3	GND	Power-supply ground input.
4	CAP ⁻	Charge-pump capacitor, negative terminal.
5	OUT	Output, negative voltage.
6	$\overline{\text{SHDN}}$	Shutdown.
7	OSC	Oscillator control input. An external capacitor can be added to slow the oscillator. Take care to minimize stray capacitance. An external oscillator also may be connected to overdrive OSC.
8	V^+	Power-supply positive voltage input.

3.0 APPLICATIONS

3.1 Negative Voltage Converter

The TC1121 is typically used as a charge-pump voltage inverter. C1 and C2 are the only two external capacitors used in the operating circuit (Figure 3-1).

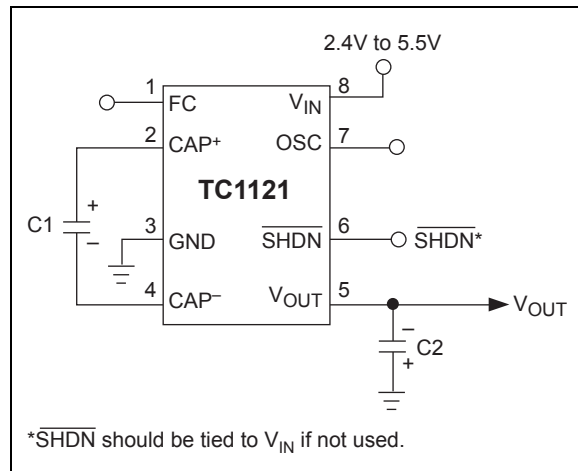


FIGURE 3-1: Charge Pump Inverter

The TC1121 is not sensitive to load current changes, although its output is not actively regulated. A typical output source resistance of 11.8Ω means that an input of +5V results in -5V output voltage under light load, and only decreases to -3.8V typ with a 100 mA load.

The supplied output current is from capacitor C2 during one-half the charge-pump cycle. This results in a peak-to-peak ripple of:

$$V_{\text{RIPPLE}} = I_{\text{OUT}}/2(f_{\text{PUMP}}) (C2) + I_{\text{OUT}} (ESR_{C2})$$

Where f_{PUMP} is 5 kHz (one half the nominal 10 kHz oscillator frequency), and $C2 = 150 \mu\text{F}$ with an ESR of 0.2Ω, ripple is about 90 mV with a 100 mA load current. If C2 is raised to 390 μF, the ripple drops to 45 mV.

3.2 Changing Oscillator Frequency

The TC1121's clock frequency is controlled by four modes:

TABLE 3-1: OSCILLATOR FREQUENCY MODES

FC	OSC	Oscillator Frequency
Open	Open	10 kHz
FC = V ⁺	Open	200 kHz
Open or FC = V ⁺	External Capacitor	See Typical Operating Characteristics
Open	External Clock	External Clock Frequency

The oscillator runs at 10 kHz (typical) when FC and OSC are not connected. The oscillator frequency is lowered by connecting a capacitor between OSC and GND, but FC can still multiply the frequency by 20 times in this mode.

An external clock source that swings within 100 mV of V⁺ and GND may overdrive OSC in the Inverter mode. OSC can be driven by any CMOS logic output. When OSC is overdriven, FC has no effect.

Note that the frequency of the signal appearing at CAP⁺ and CAP⁻ is half that of the oscillator. In addition, by lowering the oscillator frequency, the effective output resistance of the charge-pump increases. To compensate for this, the value of the charge-pump capacitors may be increased.

Because the 5 kHz output ripple frequency may be low enough to interfere with other circuitry, the oscillator frequency can be increased with the use of the FC pin or an external oscillator. The output ripple frequency is half the selected oscillator frequency. Although the TC1121's quiescent current will increase if the clock frequency is increased, it allows smaller capacitance values to be used for C1 and C2.

3.3 Capacitor Selection

In addition to load current, the following factors affect the TC1121 output voltage drop from its ideal value 1) output resistance, 2) pump (C1) and reservoir (C2) capacitor ESRs and 3) C1 and C2 capacitance.

The voltage drop is the load current times the output resistance. The loss in C2 is the load current times C2's ESR; C1's loss is larger because it handles currents greater than the load current during charge-pump operation. Therefore, the voltage drop due to C1 is about four times C1's ESR multiplied by the load current, and a low (or high) ESR capacitor has a greater impact on performance for C1 than for C2.

In general, as the TC1121's pump frequency increases, capacitance values needed to maintain comparable ripple and output resistance diminish proportionately.

TC1121

3.4 Cascading Devices

To produce greater negative magnitudes of the initial supply voltage, the TC1121 may be cascaded (see Figure 3-2). Resulting output resistance is approximately equal to the sum of individual TC1121 R_{OUT} values. The output voltage (where n is an integer representing the number of devices cascaded) is defined by $V_{OUT} = -n (V_{IN})$.

3.5 Paralleling Devices

To reduce output resistance, multiple TC1121s may be paralleled (see Figure 3-3). Each device needs a pump capacitor $C1$, but the reservoir capacitor $C2$ serves all devices. The value of $C2$ should be increased by a factor of n (the number of devices).

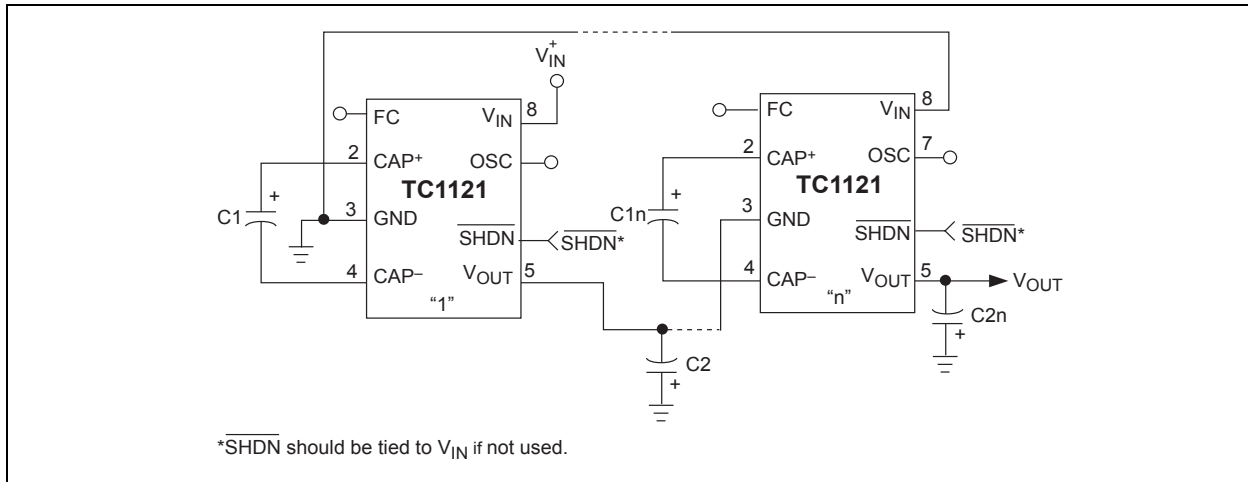


FIGURE 3-2: Cascading TC1121s to Increase Output Voltage

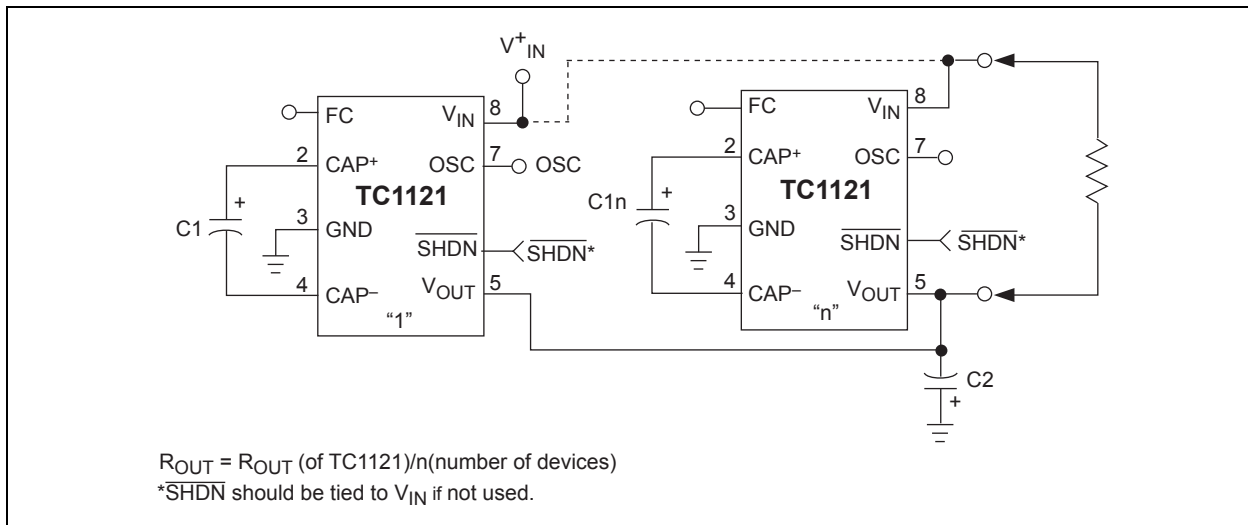


FIGURE 3-3: Paralleling TC1121s to Reduce Output Resistance

3.6 Combined Positive Supply Multiplication and Negative Voltage Conversion

Figure 3-4 shows this dual function circuit, in which capacitors C1 and C2 perform pump and reservoir functions to generate negative voltage. Capacitors C3 and C4 are the respective capacitors for multiplied positive voltage. This particular configuration leads to higher source impedances of the generated supplies due to the finite impedance of the common charge-pump driver.

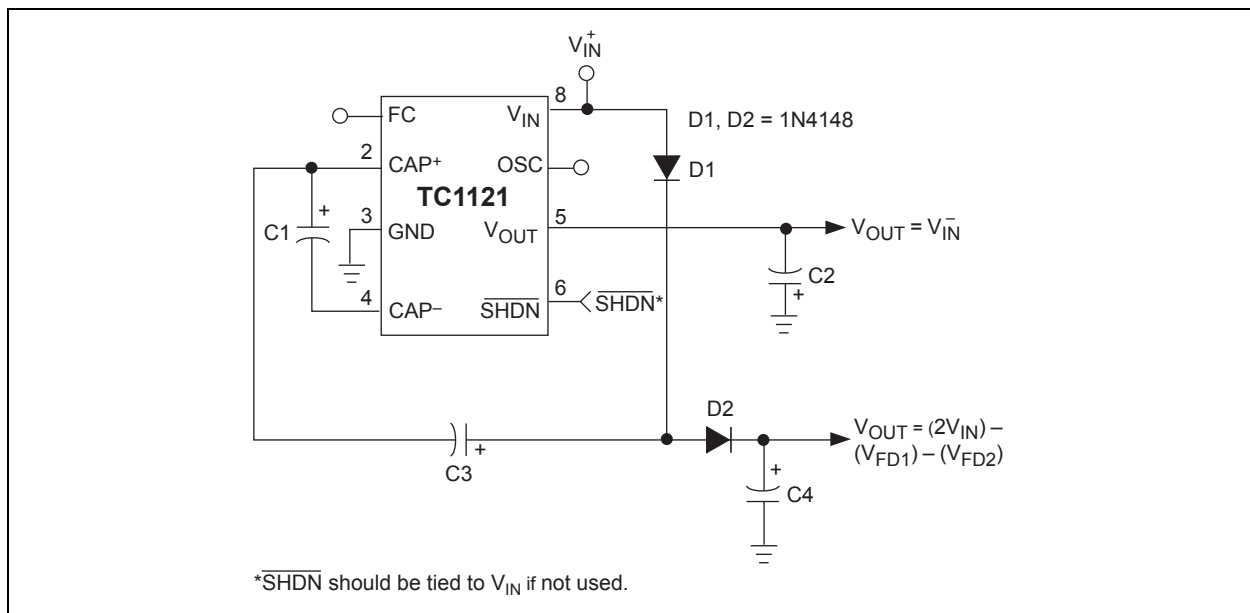


FIGURE 3-4: Combined Positive Multiplier and Negative Converter

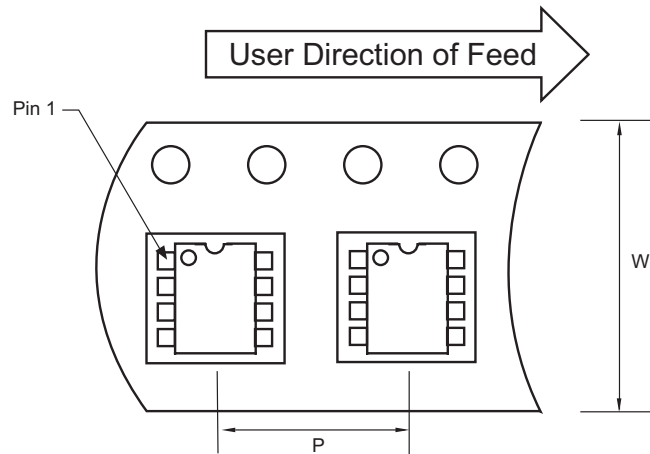
4.0 PACKAGING INFORMATION

4.1 Package Marking Information

Package marking data not available at this time.

4.2 Taping Form

Component Taping Orientation for 8-Pin MSOP Devices

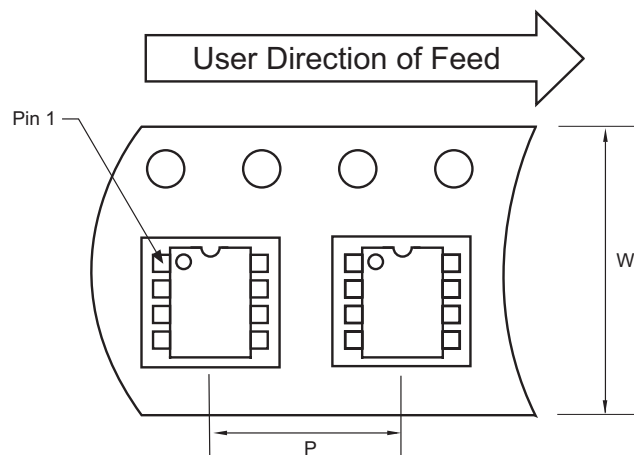


Standard Reel Component Orientation
for 713 Suffix Device

Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin MSOP	12 mm	8 mm	2500	13 in

Component Taping Orientation for 8-Pin SOIC (Narrow) Devices



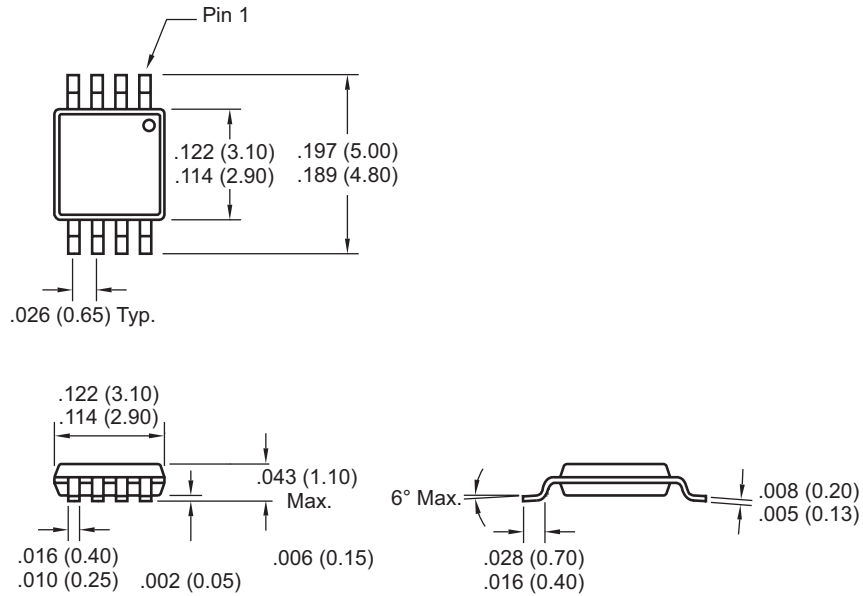
Standard Reel Component Orientation
for 713 Suffix Device

Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin SOIC (N)	12 mm	8 mm	2500	13 in

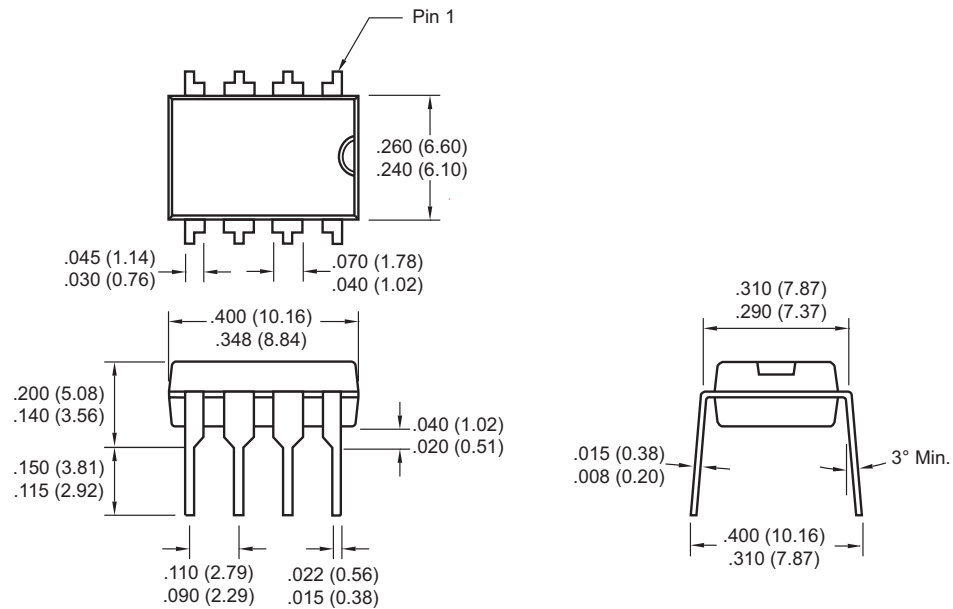
4.3 Package Dimensions

8-Pin MSOP



Dimensions: inches (mm)

8-Pin Plastic DIP

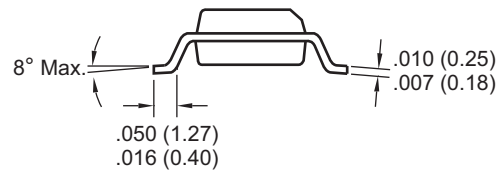
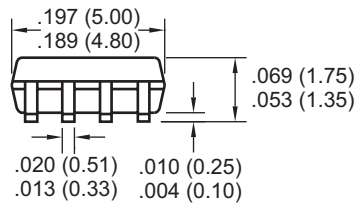
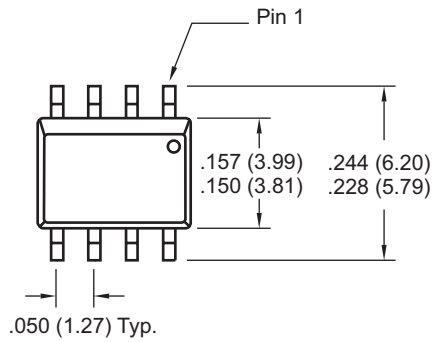


Dimensions: inches (mm)

TC1121

Package Dimensions (Continued)

8-Pin SOIC



Dimensions: inches (mm)

THE MICROCHIP WEB SITE

Microchip provides online support via our WWW site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQ), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip web site at www.microchip.com, click on Customer Change Notification and follow the registration instructions.

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support
- Development Systems Information Line

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the web site at: <http://support.microchip.com>

TC1121

READER RESPONSE

It is our intention to provide you with the best documentation possible to ensure successful use of your Microchip product. If you wish to provide your comments on organization, clarity, subject matter, and ways in which our documentation can better serve you, please FAX your comments to the Technical Publications Manager at (480) 792-4150.

Please list the following information, and use this outline to provide us with your comments about this document.

To: Technical Publications Manager
RE: Reader Response
From: Name _____
Company _____
Address _____
City / State / ZIP / Country _____
Telephone: (_____) _____ - _____ FAX: (_____) _____ - _____

Application (optional):

Would you like a reply? ___Y ___N

Device: TC1121

Literature Number: DS21358C

Questions:

1. What are the best features of this document?

2. How does this document meet your hardware and software development needs?

3. Do you find the organization of this document easy to follow? If not, why?

4. What additions to the document do you think would enhance the structure and subject?

5. What deletions from the document could be made without affecting the overall usefulness?

6. Is there any incorrect or misleading information (what and where)?

7. How would you improve this document?

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

Trademarks

The Microchip name and logo, the Microchip logo, Accuron, dsPIC, KEELOQ, microID, MPLAB, PIC, PICmicro, PICSTART, PRO MATE, PowerSmart, rfPIC, and SmartShunt are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

AmpLab, FilterLab, Migratable Memory, MXDEV, MXLAB, SEEVAL, SmartSensor and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, Application Maestro, dsPICDEM, dsPICDEM.net, dsPICworks, ECAN, ECONOMONITOR, FanSense, FlexROM, fuzzyLAB, In-Circuit Serial Programming, ICSP, ICEPIC, Linear Active Thermistor, Mindi, MiWi, MPASM, MPLIB, MPLINK, PICkit, PICDEM, PICDEM.net, PICLAB, PICtail, PowerCal, PowerInfo, PowerMate, PowerTool, REAL ICE, rFLAB, rfPICDEM, Select Mode, Smart Serial, SmartTel, Total Endurance, UNI/O, WiperLock and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

© 2006, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

 Printed on recycled paper.

**QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
== ISO/TS 16949:2002 ==**

Microchip received ISO/TS-16949:2002 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona, Gresham, Oregon and Mountain View, California. The Company's quality system processes and procedures are for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.



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:
<http://support.microchip.com>
Web Address:
www.microchip.com

Atlanta
Alpharetta, GA
Tel: 770-640-0034
Fax: 770-640-0307

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Farmington Hills, MI
Tel: 248-538-2250
Fax: 248-538-2260

Kokomo
Kokomo, IN
Tel: 765-864-8360
Fax: 765-864-8387

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608

San Jose
Mountain View, CA
Tel: 650-215-1444
Fax: 650-961-0286

Toronto
Mississauga, Ontario,
Canada
Tel: 905-673-0699
Fax: 905-673-6509

ASIA/PACIFIC

Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Tel: 86-10-8528-2100
Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8676-6200
Fax: 86-28-8676-6599

China - Fuzhou
Tel: 86-591-8750-3506
Fax: 86-591-8750-3521

China - Hong Kong SAR
Tel: 852-2401-1200
Fax: 852-2401-3431

China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

China - Shanghai
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8203-2660
Fax: 86-755-8203-1760

China - Shunde
Tel: 86-757-2839-5507
Fax: 86-757-2839-5571

China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

China - Xian
Tel: 86-29-8833-7250
Fax: 86-29-8833-7256

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-4182-8400
Fax: 91-80-4182-8422

India - New Delhi
Tel: 91-11-5160-8631
Fax: 91-11-5160-8632

India - Pune
Tel: 91-20-2566-1512
Fax: 91-20-2566-1513

Japan - Yokohama
Tel: 81-45-471-6166
Fax: 81-45-471-6122

Korea - Gumi
Tel: 82-54-473-4301
Fax: 82-54-473-4302

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Malaysia - Penang
Tel: 60-4-646-8870
Fax: 60-4-646-5086

Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Hsin Chu
Tel: 886-3-572-9526
Fax: 886-3-572-6459

Taiwan - Kaohsiung
Tel: 886-7-536-4818
Fax: 886-7-536-4803

Taiwan - Taipei
Tel: 886-2-2500-6610
Fax: 886-2-2508-0102

Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

EUROPE

Austria - Wels
Tel: 43-7242-2244-399
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

UK - Wokingham
Tel: 44-118-921-5869
Fax: 44-118-921-5820

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

«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