

12-Bit Digital-to-Analog Converter with Two-Wire Interface

Features

- 12-Bit Digital-to-Analog Converter
- 2.7-5.5V Single Supply Operation
- Simple SMBus/I²C™ Serial Interface
- Low Power: 350µA Operation, 0.5µA Shutdown
- 8-Pin SOIC and 8-Pin MSOP Packages

Applications

- Programmable Voltage Sources
- Digital Controlled Amplifiers/Attenuators
- Process Monitoring and Control

Device Selection Table

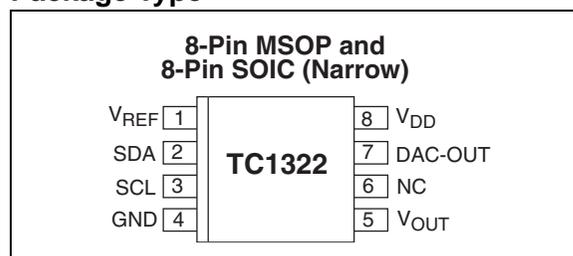
Part Number	Package	Temperature Range
TC1322EOA	8-Pin SOIC (Narrow)	-40°C to +85°C
TC1322EUA	8-Pin MSOP	-40°C to +85°C

General Description

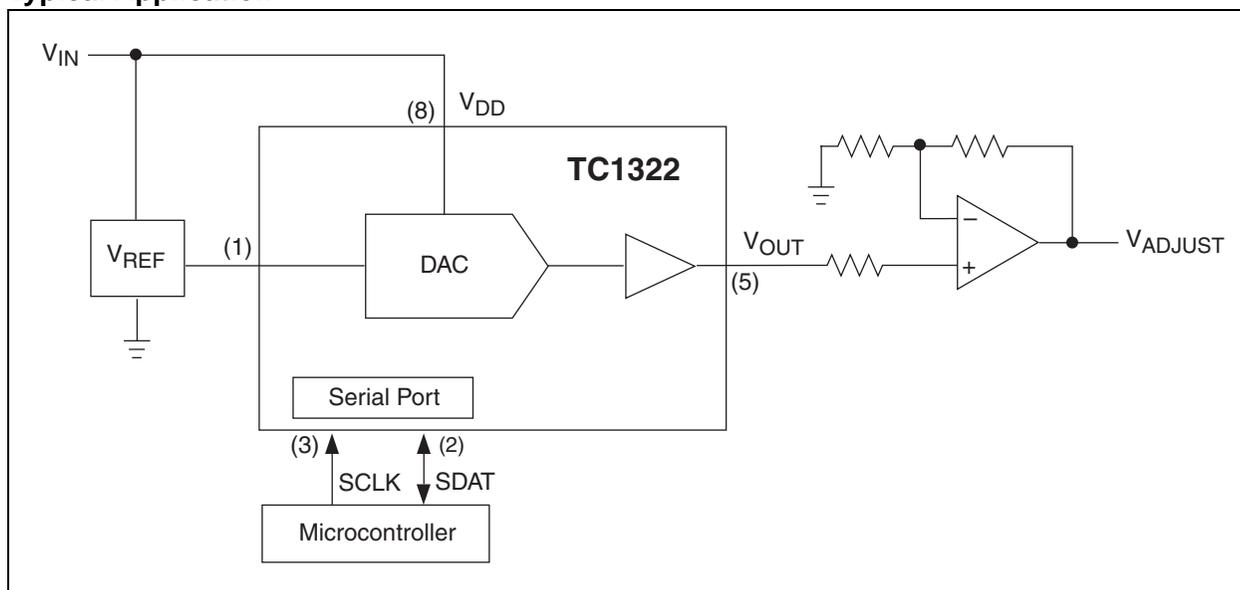
The TC1322 is a serially accessible 12-bit voltage output digital-to-analog converter (DAC). The DAC produces an output voltage that ranges from ground to an externally supplied reference voltage. It operates from a single power supply that can range from 2.7V to 5.5V, making it ideal for a wide range of applications. Built into the part is a Power-on Reset function that ensures that the device starts at a known condition.

Communication with the TC1322 is accomplished via a simple 2-wire SMBus/I²C compatible serial port with the TC1322 acting as a slave only device. The host can enable the SHDN bit in the CONFIG register to activate the Low Power Standby mode.

Package Type

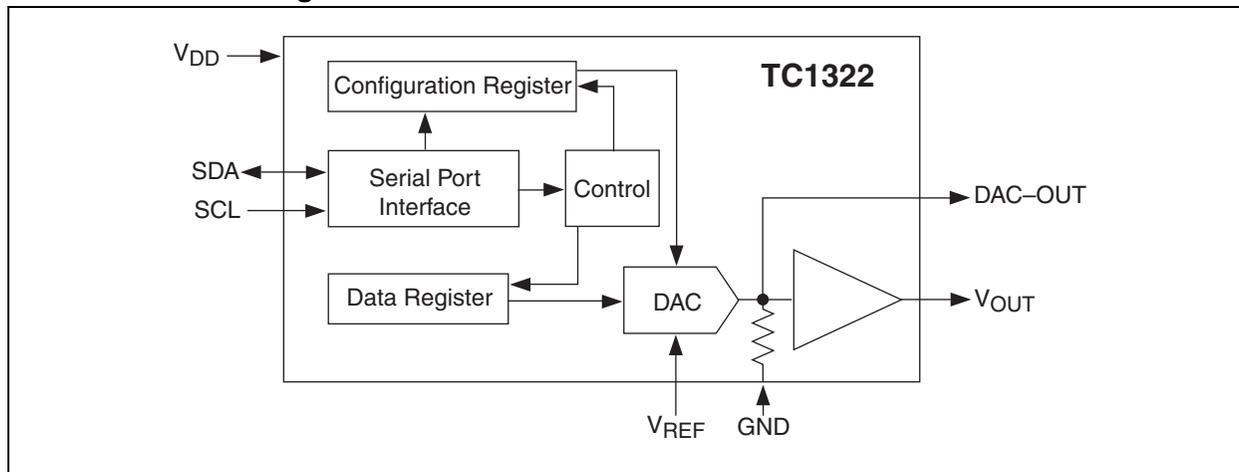


Typical Application



TC1322

Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings*

Supply Voltage (V_{DD}) +6V
 Voltage on any Pin (GND – 0.3V) to (V_{DD} + 0.3V)
 Current on any Pin ± 50 mA
 Package Thermal Resistance (θ_{JA})..... 330°C C/W
 Operating Temperature (T_A)..... See Below
 Storage Temperature (T_{STG})..... -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.

TC1322 ELECTRICAL SPECIFICATIONS

Electrical Characteristics: $V_{DD} = 2.7V$ to $5.5V$, $-40^\circ C \leq T_A \leq +85^\circ C$, $V_{REF} = 1.2V$, $C_L = 80pF$, unless otherwise noted.						
Symbol	Parameter	Min	Typ	Max	Unit	Test Conditions
Power Supply						
V_{DD}	Supply Voltage	2.7	—	5.5	—	
I_{DD}	Operating Current	—	0.35	0.5	mA	$V_{DD} = 5.5V$, $V_{REF} = 1.2V$ Serial Port Inactive (Note 1)
$I_{DD-STANDBY}$	Standby Supply Current	—	0.1	1	μA	$V_{DD} = 3.3V$ Serial Port Inactive (Note 1)
Static Performance - Analog Section						
	Resolution	—	—	10	Bits	
INL	Integral Non-Linearity at FS, $T_A = +25^\circ C$	—	—	± 16	LSB	(Note 2)
FSE	Full Scale Error	—	—	± 3	%FS	
DNL	Differential Non-Linearity, $T_A = +25^\circ C$	—	—	+4	LSB	All Codes (Note 2)
V_{OS}	Offset Error at V_{OUT}	—	± 0.3	± 8	mV	(Note 2)
TCV_{OS}	Offset Error Tempco at V_{OUT}	—	10	—	$\mu V/^\circ C$	
PSRR	Power Supply Rejection Ratio	—	80	—	dB	V_{DD} at DC
V_{REF}	Voltage Reference Range	0	—	$V_{DD} - 1.2$	V	
I_{REF}	Reference Input Leakage Current	—	—	± 1.0	μA	
V_{SW}	Voltage Swing	0	—	V_{REF}	V	$V_{REF} \leq (V_{DD} - 1.2V)$
R_{OUT}	Output Resistance @ V_{OUT}	—	5.0	—	Ω	$R_{OUT} (\Omega)$
I_{OUT}	Output Current (Source or Sink)	—	2	—	mA	
I_{SC}	Output Short-Circuit Current	—	30	50	mA	Source
	$V_{DD} = 5.5V$	—	20	50	mA	Sink
Dynamic Performance						
SR	Voltage Output Slew Rate	—	0.8	—	V/ μs	
t_{SETTLE}	Output Voltage Full Scale Settling Time	—	10	—	μsec	
t_{WU}	Wake-up Time	—	20	—	μs	
	Digital Feed through and Crosstalk	—	5	—	nV-s	SDA = V_{DD} , SCL = 100kHz
Serial Port Interface						
V_{IH}	Logic Input High	2.4	—	V_{DD}	V	
V_{IL}	Logic Input Low	—	—	0.6	—	
V_{OL}	SDA Output Low	—	—	0.4	V	$I_{OL} = 3mA$ (Sinking Current) $I_{OL} = 6mA$
		—	—	0.6	V	
C_{IN}	Input Capacitance SDA, SCL	—	5	0.4	pF	
I_{LEAK}	I/O Leakage	—	—	± 1.0	μA	

Note 1: SDA and SCL must be connected to V_{DD} or GND.

Note 2: Measured at $V_{OUT} \geq 50mV$ referred to GND to avoid output buffer clipping.

TC1322

TC1322 ELECTRICAL SPECIFICATIONS (CONTINUED)

Electrical Characteristics: $V_{DD} = 2.7V$ to $5.5V$, $-40^{\circ}C \leq T_A \leq +85^{\circ}C$, $V_{REF} = 1.2V$, $C_L = 80pF$, unless otherwise noted.						
Symbol	Parameter	Min	Typ	Max	Unit	Test Conditions
Serial Port AC Timing						
f_{SMB}	SMBus Clock Frequency	10	—	100	kHz	
t_{IDLE}	Bus Free Time Prior to New Transition	4.7	—	—	μ sec	
$t_{H(START)}$	START Condition Hold Time	4.0	—	—	μ sec	
$t_{SU(START)}$	START Condition Setup Time	4.7	—	—	μ sec	90% SCL to 10% SDA (for Repeated START Condition)
$t_{SU(STOP)}$	STOP Condition Setup Time	4.0	—	—	μ sec	
t_{H-DATA}	Data In Hold Time	100	—	—	nsec	
$t_{SU-DATA}$	Data In Setup Time	100	—	—	nsec	
t_{LOW}	Low Clock Period	4.7	—	—	μ sec	10% to 10%
t_{HIGH}	High Clock Period	4	—	—	μ sec	90% to 90%
t_F	SMBus Fall Time	—	—	300	nsec	90% to 10%
t_R	SMBus Rise Time	—	—	1000	nsec	10% to 90%
t_{POR}	Power-on Reset Delay	—	500	—	μ sec	$V_{DD} \geq V_{POR}$ (Rising Edge)

Note 1: SDA and SCL must be connected to V_{DD} or GND.

Note 2: Measured at $V_{OUT} \geq 50mV$ referred to GND to avoid output buffer clipping.

2.0 PIN DESCRIPTIONS

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

TABLE 2-1: PIN FUNCTION TABLE

Pin Number	Symbol	Type	Description
1	V_{REF}	Input	Input. Voltage Reference Input can range from 0V to 1.2V below V_{DD} .
2	SDA	Bi-Directional	Bi-directional. Serial data is transferred on the SMBus in both directions using this pin.
3	SCL	Input	Input. SMBus serial clock. Clocks data into and out of the TC1322.
4	GND	Power	Ground.
5	V_{OUT}	Output	Output. Buffered DAC output voltage. This voltage is a function of the reference voltage and the contents of the DATA register.
6	NC	None	No connection.
7	DAC-OUT	Output	Output. Unbuffered DAC output voltage. This voltage is a function of the reference voltage and the contents of the DATA register. This output is unbuffered and care must be taken that the pin is connected only to a high-impedance node.
8	V_{DD}	Power	Input. Positive power supply input. See electrical specifications.

3.0 DETAILED DESCRIPTION

The TC1322 is a monolithic 10-bit digital-to-analog converter that is designed to operate from a single supply that can range from 2.7V to 5.5V. The DAC consists of a data register (DATA), a configuration register (CONFIG), and a current output amplifier. The TC1322 uses an external reference, which also determines the maximum output voltage.

The TC1322 uses a current steering DAC based on an array of matched current sources. This current, along with a precision resistor, converts the contents of the Data register and V_{REF} into an output voltage, V_{OUT} given by:

$$V_{OUT} = V_{REF} (DATA/4096)$$

3.1 Reference Input

The reference pin, V_{REF} , is a buffered high-impedance input and because of this, the load regulation of the reference source needs only to be able to tolerate leakage levels of current (less than $1\mu A$). V_{REF} accepts a voltage range from 0 to $(V_{DD} - 1.2V)$. Input capacitance is typically 10pF.

3.2 Output Amplifier

The TC1322 DAC output is buffered with an internal unity gain rail-to-rail input/output amplifier with a typical slew rate of $0.8V/\mu sec$. Maximum full scale transition settling time is $10\mu sec$ to within $\pm 1/2LSB$ when loaded with $1k\Omega$ in parallel with 100pF.

3.3 Standby Mode

The TC1322 allows the host to put it into a Low Power ($I_{DD} = 0.5\mu A$, typical) Standby mode. In this mode, the D/A conversion is halted. The SMBus port operates normally. Standby mode is enabled by setting the SHDN bit in the CONFIG register. The table below summarizes this operation.

TABLE 3-1: STANDBY MODE OPERATION

SHDN Bit	Operating Mode
0	Normal
1	Standby

3.4 SMBus Slave Address

The TC1322 is internally programmed to have a default SMBus address value of $1001\ 000b$. Seven other addresses are available by custom order (contact factory). See Figure 3-1 for location of address bits in SMBus protocol.

FIGURE 3-1: SMBus PROTOCOLS

Write 1-Byte Format

S	Address	R/W	ACK	Command	ACK	Data	ACK	P
	7-Bits	0		8-Bits		8-Bits		

Slave Address

Command Byte: selects which register you are writing to.

Data Byte: data goes into the register set by the command byte.

Write 2-Byte Format

S	Address	R/W	ACK	Command	ACK	Data	ACK	Data	ACK	P
	7-Bits	0		8-Bits		8-Bits		8-Bits		

Slave Address

Command Byte: selects which register you are writing to.

Data Byte: data goes into the register set by the command byte.

Read 1-Byte Format

S	Address	R/W	ACK	Command	ACK	S	Address	R/W	ACK	Data	NACK	P
	7-Bits	0		8-Bits			7-Bits	1		8-Bits		

Slave Address

Command Byte: selects which register you are reading from.

Slave Address: repeated due to change in data flow direction.

Data Byte: reads from the register set by the command byte.

Read 2-Byte Format

S	Address	R/W	ACK	Command	ACK	S	Address	R/W	ACK	Data	ACK	Data	NACK	P
	7-Bits	0		8-Bits			7-Bits	1		8-Bits		8-Bits		

Slave Address

Command Byte: selects which register you are reading from.

Slave Address: repeated due to change in data flow direction.

Data Byte: reads from the register set by the command byte.

Receive 1-Byte Format

S	Address	R/W	ACK	Data	NACK	P
	7-Bits	1		8-Bits		

S = START Condition

P = STOP Condition

Shaded = Slave Transmission

Data Byte: reads data from the register commanded by the last read byte or write byte transmission.

Receive 1-Byte Format

S	Address	R/W	ACK	Data	ACK	Data	NACK	P
	7-Bits	1		8-Bits		8-Bits		

S = START Condition

P = STOP Condition

Shaded = Slave Transmission

Data Byte: reads data from the register commanded by the last read byte or write byte transmission.

TC1322

4.0 SERIAL PORT OPERATION

The Serial Clock input (SCL) and bi-directional data port (SDA) form a 2-wire bi-directional serial port for programming and interrogating the TC1322. The following conventions are used in this bus architecture:

TABLE 4-1: TC1322 SERIAL BUS CONVENTIONS

Term	Explanation
Transmitter	The device sending data to the bus.
Receiver	The device receiving data from the bus.
Master	The device which controls the bus: initiating transfers (START), generating the clock, and terminating transfers (STOP).
Slave	The device addressed by the master.
START	A unique condition signaling the beginning of a transfer indicated by SDA falling (High - Low) while SCL is high.
STOP	A unique condition signaling the end of a transfer indicated by SDA rising (Low - High) while SCL is high.
ACK	A Receiver Acknowledges the receipt of each byte with this unique condition. The Receiver drives SDA low during SCL high of the ACK clock pulse. The Master provides the clock pulse for the ACK cycle.
Busy	Communication is not possible because the bus is in use.
Not Busy	When the bus is IDLE, both SDA and SCL will remain high.
Data Valid	The state of SDA must remain stable during the High period of SCL, in order for a data bit to be considered valid. SDA only changes state while SCL is low during normal data transfers. (See START and STOP conditions.)

All transfers take place under control of a host, usually a CPU or microcontroller acting as the Master, which provides the clock signal for all transfers. The TC1322 *a/ways* operates as a Slave. The serial protocol is illustrated in Figure 3-1. All data transfers have two phases; all bytes are transferred MSB first. Accesses are initiated by a START condition (START), followed by a device address byte and one or more data bytes. The device address byte includes a Read/Write selection bit. Each access must be terminated by a STOP condition (STOP). A convention called *Acknowledge* (ACK) confirms receipt of each byte. Note that SDA can change only during periods when SCL is LOW (SDA changes while SCL is HIGH are reserved for START and STOP conditions).

4.1 START Condition (START)

The TC1322 continuously monitors the SDA and SCL lines for a START condition (a HIGH to LOW transition of SDA while SCL is HIGH), and will not respond until this condition is met.

4.2 Address Byte

Immediately following the START condition, the host must transmit the address byte to the TC1322. The 7-bit SMBus address for the TC1322 is 1001000. The 7-bit address transmitted in the serial bit stream must match for the TC1322 to respond with an Acknowledge (indicating the TC1322 is on the bus and ready to accept data). The eighth bit in the Address Byte is a Read-Write bit. This bit is a 1 for a read operation or 0 for a write operation. During the first phase of any transfer, this bit will be set = 0 to indicate that the command byte is being written.

4.3 Acknowledge (ACK)

Acknowledge (ACK) provides a positive handshake between the host and the TC1322. The host releases SDA after transmitting eight bits, then generates a ninth clock cycle to allow the TC1322 to pull the SDA line LOW to acknowledge that it successfully received the previous eight bits of data or address.

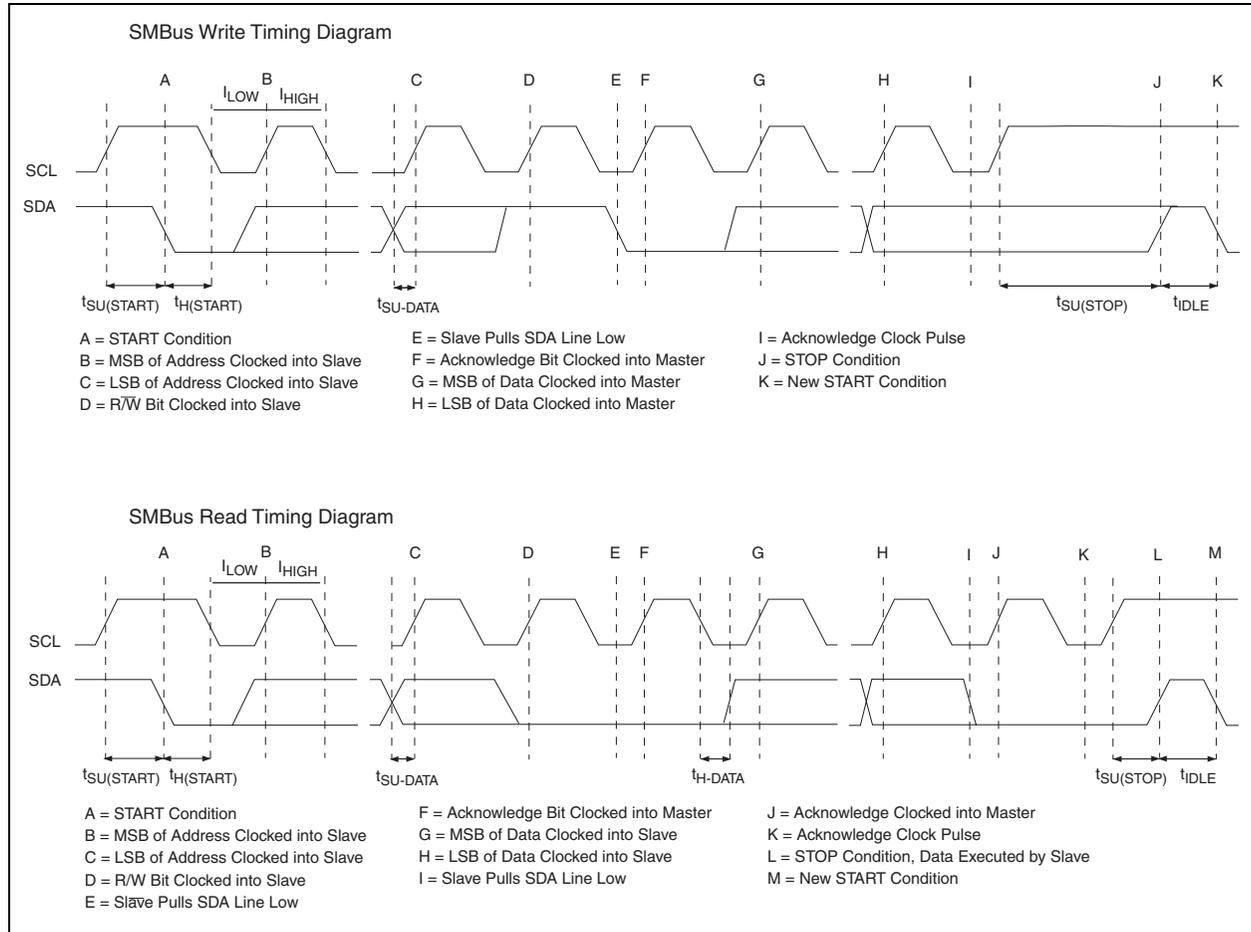
4.4 Data Byte

After a successful ACK of the address byte, the host must transmit the data byte to be written or clock out the data to be read. (See the appropriate timing diagrams.) ACK will be generated after a successful write of a data byte into the TC1322.

4.5 STOP Condition (STOP)

Communications must be terminated by a STOP condition (a LOW to HIGH transition of SDA while SCL is HIGH). The STOP Condition must be communicated by the transmitter to the TC1322. Refer to Figure 4-1, Timing Diagrams for serial bus timing.

FIGURE 4-1: TIMING DIAGRAMS



TC1322

4.6 Register Set and Programmer's Model

TABLE 4-2: TC1322 COMMAND SET (SMBus READ_BYTE AND WRITE_BYTE)

Command Byte Description		
Command	Code	Function
RWD	00h	Read/Write Data (DATA)
RWCR	01h	Read/Write Configuration (CONFIG)

TABLE 4-3: CONFIGURATION REGISTER (CONFIG), 8-BIT, READ/WRITE

Configuration Register (CONFIG)							
D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
Reserved							SHDN
Bit	POR	Function	Type	Operation			
D[0]	0	Standby Switch	Read/Write	1 = Standby 0 = Normal			
D[7]-D[1]	0	Reserved; Always returns Zero when Read	N/A	N/A			

TABLE 4-4: DATA REGISTER (DATA), 12-BIT, READ/WRITE

Data Register (DATA) for 1st Byte							
D[11]	D[10]	D[9]	D[8]	D[7]	D[6]	D[5]	D[4]
MSB	X	X	X	X	X	X	LSB
Data Register (DATA) for 2nd Byte							
D[3]	D[2]	D[1]	D[0]	X	X	X	X
X	X	X	LSB	X	X	X	X

The DAC output voltage is a function of reference voltage and the binary value of the contents of the register DATA. The transfer function is given by the expression:

EQUATION 4-1:

$$V_{OUT} = V_{REF} \times \left[\frac{DATA}{4096} \right]$$

4.7 Register Set Summary

The TC1322's register set is summarized in Table 4-5 below. All registers are 12-bits wide.

TABLE 4-5: TC1322 REGISTER SET SUMMARY

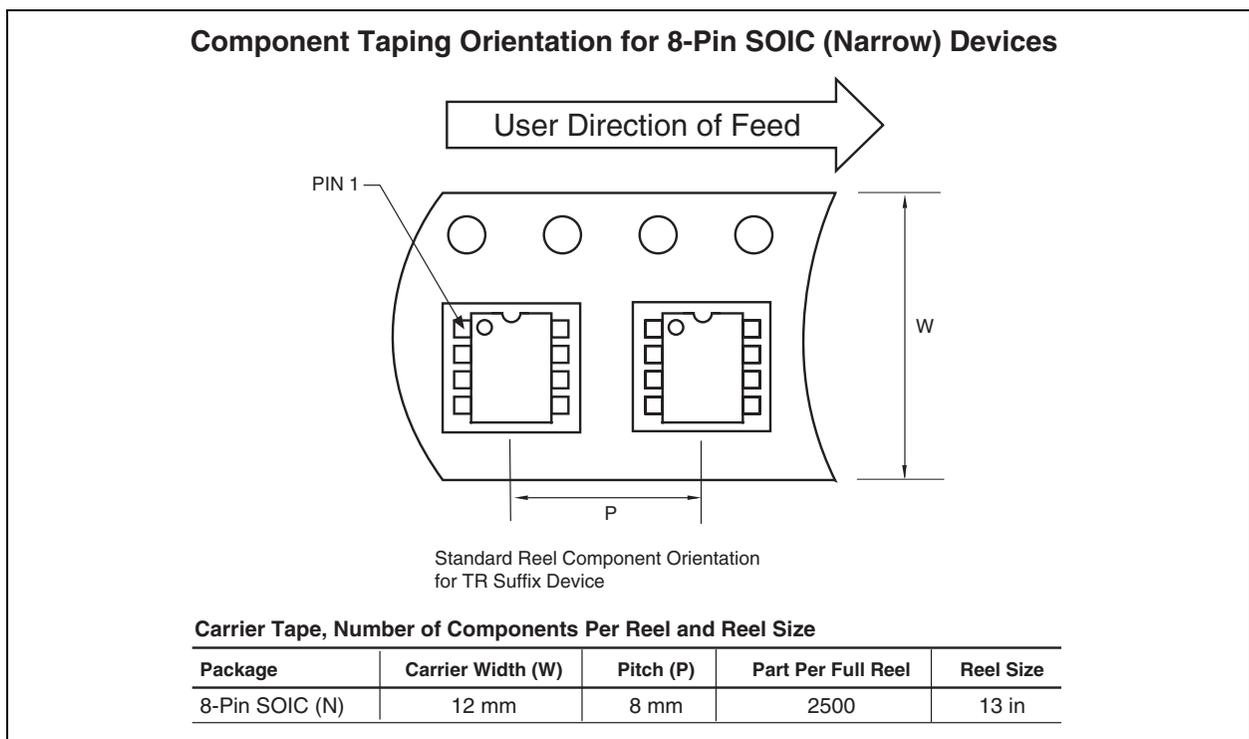
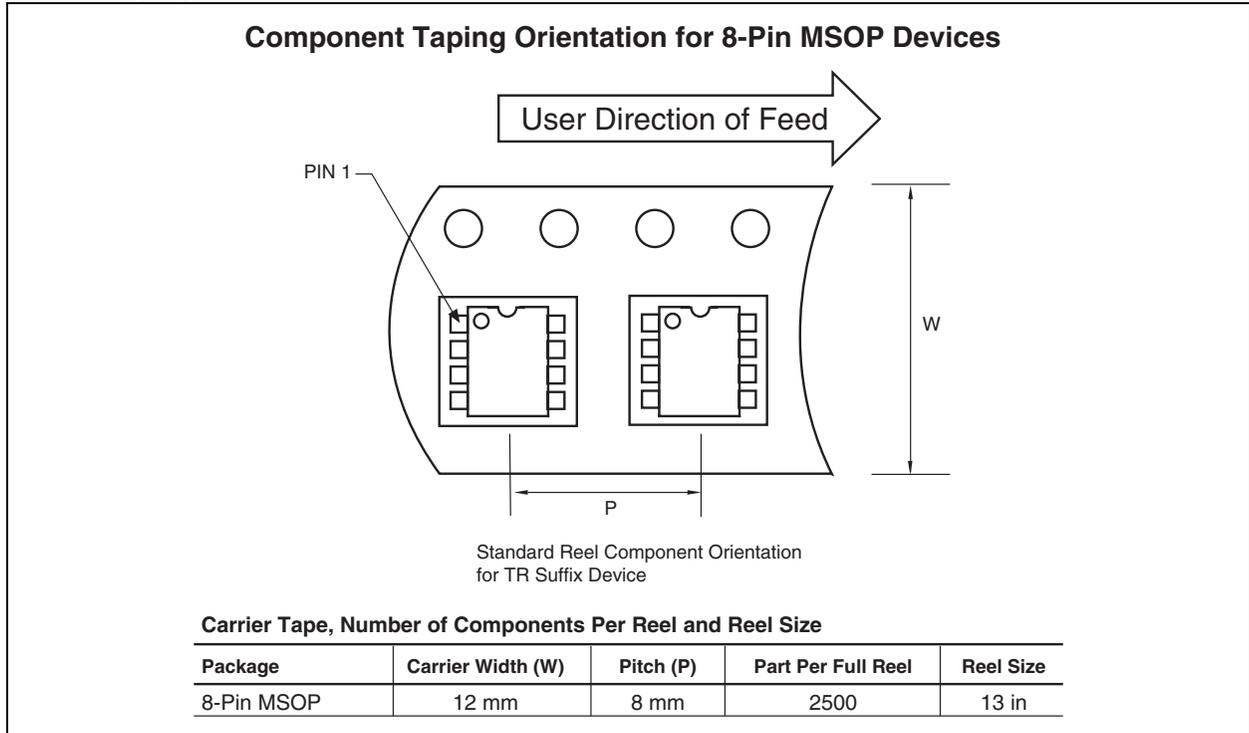
Name	Description	POR State	Read	Write
Data	Data Register (2-Byte Format)	000000000000b	X	X
Config	CONFIG Register	0000 0000b	X	X

5.0 PACKAGING INFORMATION

5.1 Package Marking Information

Package marking data not available at this time.

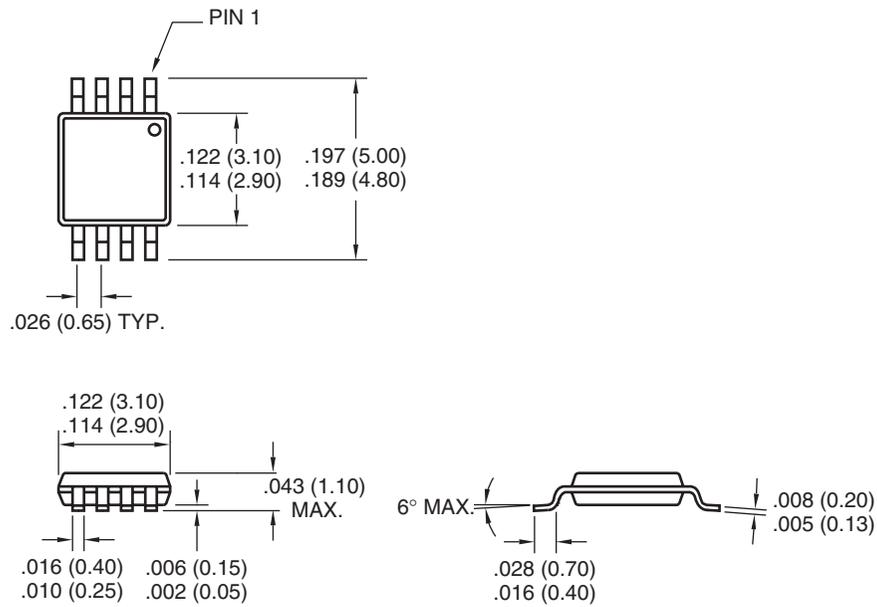
5.2 Taping Forms



TC1322

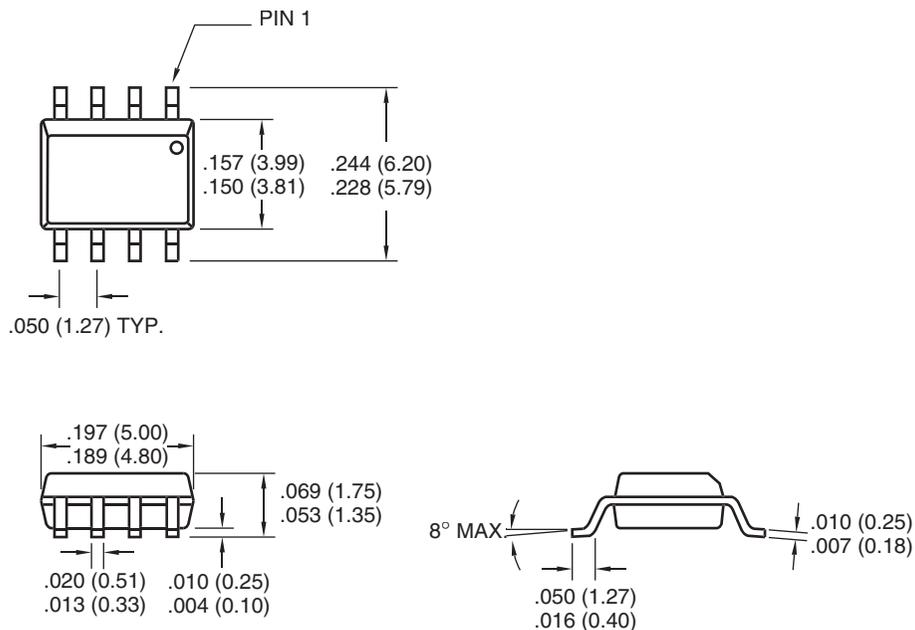
5.3 Package Dimensions

8-Pin MSOP



Dimensions: inches (mm)

8-Pin SOIC



Dimensions: inches (mm)

NOTES:

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.

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's products as critical components in life support systems is not authorized except with express written approval by Microchip. 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, rPIC, and SmartShunt are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

AmpLab, FilterLab, Migratable Memory, MXDEV, MXLAB, PICMASTER, 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, MPASM, MPLIB, MPLINK, MPSIM, PCKIT, PICDEM, PICDEM.net, PICLAB, PICtail, PowerCal, PowerInfo, PowerMate, PowerTool, rLAB, rPICDEM, Select Mode, Smart Serial, SmartTel, Total Endurance and WiperLock 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.

© 2005, 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 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona and Mountain View, California in October 2003. 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: 91-80-2229-0061
Fax: 91-80-2229-0062

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