

16-Bit Low Cost, Low Power $\Sigma - \Delta$ A/D Converter

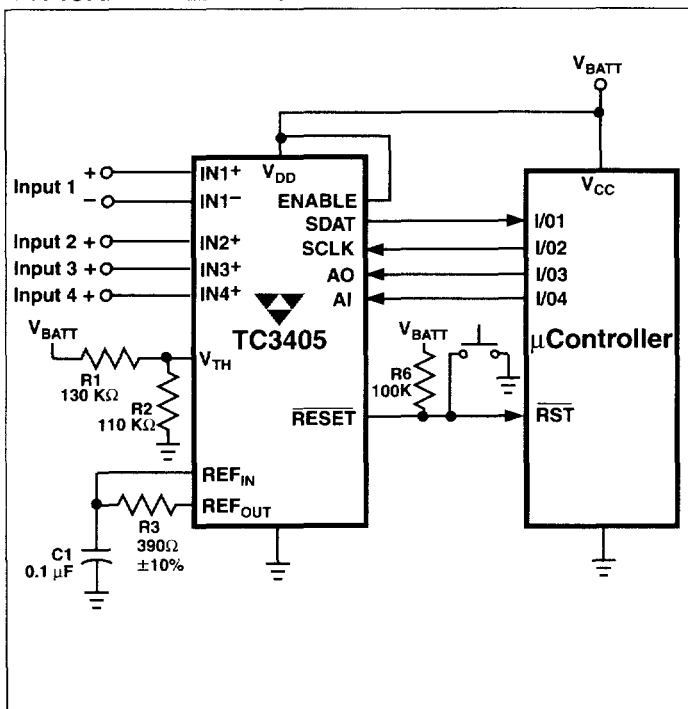
FEATURES

- 16-Bit Resolution at Eight Conversions Per Second, Adjustable Down to 10-Bit Resolution at 512 Conversions Per Second
- 1.8V – 5.5V Operation, Low Power
Operating: 250 μ A; Sleep: 35 μ A
- One Differential and Three Single Ended Inputs with Built-In Multiplexer
- MicroPort™ Serial Bus Requires Only Two Interface Lines
- Uses Internal or External Reference
- V_{DD} Monitor and Reset Generator Operational in Shutdown Mode
- Automatically Enters Sleep Mode When Not In Use
- 16-Pin QSOP and PDIP Packages

TYPICAL APPLICATIONS

- Consumer Electronics, Thermostats, CO Monitors, Humidity Meters, Security Sensors
- Embedded Systems, Data Loggers, Portable Equipment
- Medical Instruments

TYPICAL APPLICATION



GENERAL DESCRIPTION

The TC3405 is a low cost, low power analog-to-digital converter based on TelCom's Sigma-Delta technology. It performs 16-bit conversions (15-bit plus sign) at up to eight per second. The device is optimized for use as microcontroller peripherals in low cost, battery operated systems. A voltage reference is included, or an external reference can be used. A V_{DD} monitor with reset generator provides Power-On Reset and Brown-out protection.

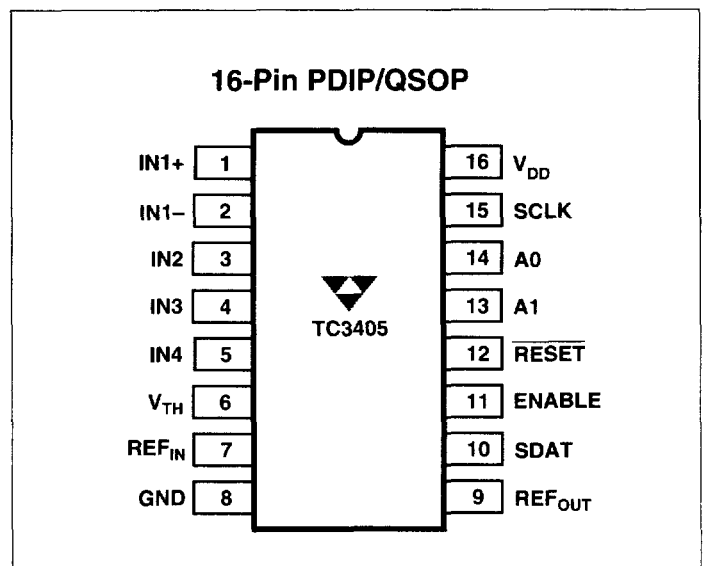
The TC3405's 2-wire MicroPort™ digital interface is used for starting conversions and for reading out the data. Driving the SCLK line low starts a conversion. After the conversion starts, each additional falling edge (up to six) detected on SCLK for t_4 seconds reduces the A/D resolution by one bit and cuts conversion time in half. After a conversion is completed, clocking the SCLK line puts the MSB through LSB of the resulting data word onto the SDAT line, much like a shift register. The parts automatically sleep when not performing a data conversion.

The TC3405 is available in PDIP and QSOP packages.

ORDERING INFORMATION

Part No.	Package	Temp. Range
TC3405VPE	16-Pin PDIP (Narrow)	0°C to +85°C
TC3405VQR	16-Pin QSOP (Narrow)	0°C to +85°C

PIN CONFIGURATIONS



PART III

New Product Data Sheets

16-Bit Low Cost, Low Power
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TC3405

ABSOLUTE MAXIMUM RATINGS*

Supply Voltage	6.0V
Voltage on Pins:	
RESET	(GND - 0.3V) to 5.5V
Input Voltage (All Other Pins)	
.....	(GND - 0.3V) to (V _{DD} + 0.3V)
Operating Temperature	0°C ≤ 85°C
Maximum Chip Temperature	+150°C
Storage Temperature Range	- 65°C to +150°C
Lead Temperature (Soldering, 10 sec)	+300°C

*Static-sensitive device. Unused devices must be stored in conductive material. Protect devices from static discharge and static fields. 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 operational sections of the specifications is not implied. Exposure to Absolute Maximum Rating Conditions for extended periods may affect device reliability.

DC ELECTRICAL CHARACTERISTICS: T_A = 25°C and V_{DD} = 2.7V, unless otherwise specified. Specifications in Bold type apply over a temperature range of 0°C to 85°C. V_{REF} = 1.25V, Internal Clock Freq. = 520kHz

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
POWER SUPPLY						
V _{DD}	Supply Voltage		1.8	—	5.5	V
I _{DD}	Supply Current, During Data Conversion		—	250	—	μA
I _{DD(SLEEP)}	Supply Current, Sleep Mode		—	35	—	μA
I _{DD(SLEEP)}	Supply Current, Sleep Mode		—	38	50	μA
ACCURACY (Differential Inputs)						
RES	Resolution		—	16	—	Bits
INL	Integral Non-Linearity		—	±.0038	—	%FSR
V _{OS}	Offset Error	IN ⁺ = IN ⁻ = 0V	—	—	±1	%FSR
V _{NOISE}	Referred to input		—	60	—	μVrms
CMR	Common Mode Rejection	at DC	—	75	—	dB
FSE	Full Scale Error		—	0.4	—	%FS
PSRR	Power Supply Rejection Ratio	V _{DD} = 2.5V to 3.5V	—	75	—	dB
IN⁺, IN⁻, IN_n						
V _{IN±}	Differential Input Voltage	(Note 1)	—	—	V _{DD}	V
	Absolute Voltage Range on IN ⁺ , IN ⁻ , IN _n		GND	—	V _{DD}	V
IB	Input Bias Current		—	1	100	nA
C _{IN}	Input Sampling Capacitance		—	2	—	pF
R _{IN}	Differential Input Resistance	(Note 2)	—	2	—	M
REF_{IN}, REF_{OUT}						
V _{REF}	REF _{IN} Voltage Range		0	—	1.25	V
I _{REF}	REF _{IN} Input Current		—	1	—	μA
V _{REFOUT}	REF _{OUT} Voltage		—	1.193	—	V
REF _{SINK}	REF _{OUT} Current Sink Capability		—	10	—	μA
REF _{SRC}	REF _{OUT} Current Source Capability		300	—	—	μA

Notes: 1. Differential input voltage defined as (V_{IN+} - V_{IN-})
2. Resistance from IN_{n+} to IN_{n-} or IN_n to GND.

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Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
SCLK, A0, A1, ENABLE						
V_{IL}	Input Low Voltage		—	—	$0.3 \times V_{DD}$	V
V_{IH}	Input High Voltage		$0.7 \times V_{DD}$	—	—	V
I_{LEAK}	Leakage Current		—	1	—	μA
SDAT, RESET						
V_{OL}	Output Low Voltage	$I_{OL} = 1.5 \text{ mA}$	—	—	0.4	V
V_{OH}	Output High Voltage(SDAT Only)	$I_{SOURCE} = 400\mu\text{A}$ (Note 2)	$0.9 \times V_{DD}$	—	—	V
$V_{DD(MIN)}$	Minimum V_{DD} for RESET Valid		—	1.1	1.3	V
V_{TH}						
V_{THR}	Threshold		—	1.23	—	V
	Threshold Hysteresis		—	30	—	mV
	Threshold Tempco		—	30	—	ppm/ $^\circ\text{C}$
	Input Current		-0.1	.01	0.1	μA

AC ELECTRICAL CHARACTERISTICS: $T_A = 25^\circ\text{C}$ and $V_{DD} = 2.7\text{V}$, unless otherwise specified. Specifications in Bold type apply over a temperature range of 0°C to 85°C . $V_{REF} = 1.25\text{V}$, Internal Clock Freq.= 520kHz

Symbol	Parameter	Description	Min	Typ	Max	Unit
t_1		Width of SCLK (Negative)	1	—	—	μsec
t_2	Resolution Reduction Clock Width	Width of SCLK (Positive)	1	—	—	μsec
t_3	Conversion Time (15-Bit Plus Sign)	16-bit conversion, $T_A = 25^\circ\text{C}$ (Note 1)	—	125	—	msec
	Conversion Time (14-Bit Plus Sign)	15-bit conversion	—	$t_3/2.0$	—	msec
	Conversion Time (13-Bit Plus Sign)	14-bit conversion	—	$t_3/4.0$	—	msec
	Conversion Time (12-Bit Plus Sign)	13-bit conversion	—	$t_3/7.8$	—	msec
	Conversion Time (11-Bit Plus Sign)	12-bit conversion	—	$t_3/15.1$	—	msec
	Conversion Time (10-Bit Plus Sign)	11-bit conversion	—	$t_3/28.6$	—	msec
	Conversion Time (9-Bit Plus Sign)	10-Bit conversion	—	$t_3/51.4$	—	msec
t_4	Resolution Reduction Window	Width of SCLK	—	$t_3/85.7$	—	msec
t_5	SCLK to Data Valid	SCLK falling edge to SDAT valid	1000	—	—	nsec
t_6	Address Setup	Address valid to SCLK	0	—	—	nsec
t_7	Address Hold	SCLK to address valid hold	1000	—	—	nsec
t_8	Acknowledge Delay	SCLK to SDAT delay	—	—	1000	nsec
t_9	RESET Active Timeout Period	Delay from POR or brown-out recovery to RESET = V_{OH}	—	$t_3 \times 2$	—	msec
t_{11}	RESET Delay	Delay for V_{TH} falling at 10 V/msec to RESET low	5	—	64	μsec

Notes: 1. Nominal temperature drift is -2830 ppm/ $^\circ\text{C}$ for temperature less than 25°C and -1340 ppm/ $^\circ\text{C}$ for temperature greater than 25°C .
 2. At $V_{DD} = 1.8\text{V}$, $I_{SOURCE} \leq 200\mu\text{A}$

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TC3405

PIN DESCRIPTION

TC3405		
Pin No.	Name	Description
1	IN1 ⁺	Analog Input. This is the positive terminal of a true differential input consisting of IN1 ⁺ and IN1 ⁻ . $V_{IN(1)} = (IN1^+ - IN1^-)$. (See <i>Electrical Characteristics</i> .)
2	IN1 ⁻	Analog Input. This is the negative terminal of a true differential input consisting of IN1 ⁺ and IN1 ⁻ . $V_{IN(1)} = (IN1^+ - IN1^-)$. IN1 ⁻ can swing to, but not below, ground. (See <i>Electrical Characteristics</i> .)
3,4,5	INn	Analog Input. This is the positive terminal of a true differential input with the negative input tied internally to GND. (See <i>Electrical Characteristics</i> .)
6	V _{TH}	Analog Input. This is the positive input to the internal comparator used to monitor the voltage supply. The negative input is tied to an internal reference. When V _{TH} falls below the internal reference, the reset generator drives $\overline{\text{RESET}}$ low as specified in the <i>Electrical Characteristics</i> section.
7	REF _{IN}	Analog Input. The converter's reference voltage is the differential between this pin and ground times two. It may be tied directly to REF _{OUT} or scaled using a resistor divider. Any user supplied reference voltage or the power supply rail may be used in place of REF _{OUT} .
8	GND	Ground Terminal.
9	REF _{OUT}	Analog Output. The internal reference connects to this pin. It may be scaled externally, if desired, and tied to the REF _{IN} input to provide the converter's reference voltage. Care must be taken in connecting external circuitry to this pin. This pin is in a high impedance state during the sleep mode. R ₃ in the Typical Application must be 390 ±10%. (See <i>Electrical Characteristics</i> .)
10	SDAT	Digital Output (push-pull). This is the MicroPort™ serial data output. SDAT is driven low while the TC3405 is converting data, effectively providing a "busy" signal. After the conversion is complete, every high-to-low transition on the SCLK pin puts a bit from the resulting data word on the SDAT pin (from MSB to LSB).
11	ENABLE	Digital Input. When this input control is pulled low, the part is internally restarted. That is, any data conversion or data read sequence is cleared and the part goes into sleep mode. When ENABLE returns high, the part resumes normal operation.
12	$\overline{\text{RESET}}$	Digital Output (open drain). This is the output of the V _{DD} monitor reset generator. $\overline{\text{RESET}}$ is driven low when a power-on reset or brown-out condition is detected. (See <i>AC Electrical Characteristics</i> .)
13	A1	Digital Input. Controls analog multiplexer in conjunction with A0 to select one of four Input channels. This address is latched at the falling edge of the SCLK, which starts an A/D conversion. A1,A0 = 00 = Input 1; 01 = Input 2; 10 = Input 3; 11 = Input 4.
14	A0	Digital Input. Controls analog multiplexer in conjunction with A1 to select one of four Input channels. This address is latched at the falling edge of the SCLK, which starts an A/D conversion. A1,A0 = 00 = Input 1; 01 = Input 2; 10 = Input 3; 11 = Input 4.
15	SCLK	Digital Input. This is the MicroPort™ serial clock input. The TC3405 comes out of sleep mode and a conversion cycle begins when this pin is driven low. After the conversion starts, each additional falling edge (up to six) detected on SCLK for t ₄ seconds reduces the A/D resolution by one bit. When the conversion is complete, the data word can be shifted out on the SDAT pin by clocking the SCLK pin.
16	V _{DD}	Power Supply Input.