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Texas Instruments
TCA5405RUGR

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sales@integrated-circuit.com
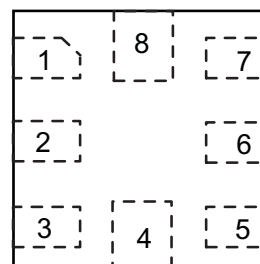
TEXAS INSTRUMENTS

TCA5405

Low Voltage 5-Bit Self-Timed, Single-Wire Output Expander

Check for Samples: TCA5405

FEATURES

- **Operating Power-Supply Voltage Range of 1.65 V to 3.6 V**
- **Five Independent Push-Pull Outputs**
- **Single Input (DIN) Controls State of All Outputs**
- **High-Current Drive Outputs Maximum Capability for Directly Driving LEDs**
- **Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II**
- **ESD Protection Exceeds JESD 22**
    - **2000-V Human-Body Model (A114-A)**
    - **1000-V Charged-Device Model (C101)**

APPLICATIONS

- **Cell Phones**
- **PDAs**
- **Portable Media Players**
- **MP3 Players**
- **Portable Instrumentation**

RUG PACKAGE
(TOP VIEW)

PIN #	NAME	COMMENTS
1	VCC	Supply Voltage
2	DIN	Data Input
3	GND	Ground
4	Q0	GPO
5	Q1	GPO
6	Q2	GPO
7	Q3	GPO
8	Q4	GPO

DESCRIPTION

The TCA5405 is a 5-bit output expander controlled using a single wire input. This device is ideal for portable applications as it has a wide VCC range of 1.65V to 3.6 V. The TCA5405 uses a self-timed serial data protocol with a single data input driven by a master device synchronized to an internal clock of that device. During a Setup phase, the bit period is sampled, then the TCA5405 generates its own internal clock synchronized to that of the Master device to sample the input over a five-bit-period Data Transfer phase and writes the bit states on the parallel outputs after the last bit is sampled. The TCA5405 is available in an 8-pin 1.5mm x 1.5mm RUG uQFN package.

ORDERING INFORMATION

T$_A$	PACKAGE[1]		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	uQFN – RUG	Tape and Reel	TCA5405RUGR	6Y

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

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TCA5405

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These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.
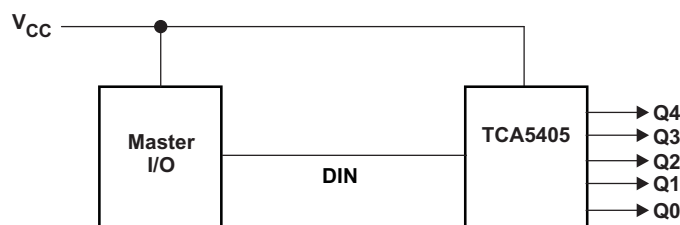
APPLICATION DIAGRAM

Figure 1. TCA5405 Application Diagram

ABSOLUTE MAXIMUM RATINGS[1]

over operating free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
V_{CC}	Supply voltage range		−0.5	4.0	V
V_I	Input voltage range[2]		−0.5	4.0	V
V_O	Output voltage range[2]		−0.5	4.0	V
I_{IK}	Input clamp current	$V_I < 0$		±20	mA
I_{OK}	Output clamp current	$V_O < 0$		±20	mA
I_{OL}	Continuous output low current	$V_O = 0$ to V_{CC}		50	mA
I_{OH}	Continuous output high current	$V_O = 0$ to V_{CC}		50	mA
I_{CC}	Continuous current through GND			200	mA
	Continuous current through V_{CC}			160	
Θ_{JA}	Package thermal impedance[3]	RUG package		243	°C/W
TSTG	Storage temperature range		−65	150	°C

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.
(2) The input negative-voltage and output voltage ratings may be exceeded if the input and output current ratings are observed.
(3) The package thermal impedance is calculated in accordance with JESD 51-7.

RECOMMENDED OPERATING CONDITIONS

			MIN	MAX	UNIT
V_{CC}	Supply voltage		1.65	3.6	V
V_{IH}	High-level input voltage	DIN	$0.7 \times V_{CC}$	$V_{CC} + 0.5$	V
V_{IL}	Low-level input voltage	DIN	−0.3	$0.3 \times V_{CC}$	V
I_{OH}	High-level output current	Q0–Q4		20	mA
I_{OL}	Low-level output current	Q0–Q4		20	mA
T_A	Operating free-air temperature		−40	85	°C

Product Folder Link(s) :*TCA5405*

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TCA5405

ELECTRICAL CHARACTERISTICS

over recommended operating free-air temperature range, V_{CC} = 1.65 V to 3.6 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	V_{CC}	MIN	TYP	MAX	UNIT
V_{IK}	Input diode clamp voltage	I_I = −18 mA	1.65 V to 3.6 V	−1.2			V
V_{POR}	Power on reset voltage	V_I = V_{CC} or GND, I_O = 0	1.65 V to 3.6 V		1	1.4	V
I_I	DIN	V_I = V_{CC} or GND	1.65 V to 3.6 V			±0.1	µA
I_{CC_STBY}	Standby Supply Current	V_I on DIN = V_{CC} or GND, I_O = 0	1.65 V to 3.6 V		1	2	µA
I_{CC_ACTIVE}	Active current during startup and data transfer					400	µA
C_I	DIN	V_I = V_{CC} or GND	1.65 V to 3.6 V		6	7	pF
V_{OH}	OUT-port high-level output voltage	I_{OH} = −20 mA	1.65 V	1.1			V
			2.3 V	1.7			
			3.6 V	2.5			
V_{OL}	OUT-port low-level output voltage	I_{OL} = 20 mA	1.65 V			0.6	V
			2.3 V			0.3	
			3.6 V			0.25	

TIMING REQUIREMENTS

over recommended operating free-air temperature range, V_{CC} = 1.65 V to 3.6 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	VCC	MIN	TYP	MAX	UNIT
t_{PER}	DIN period		1.65 V to 3.6 V	0.001		10	ms
t_{rise}	DIN rise time		1.65 V to 3.6 V			100	ns
t_{fall}	DIN fall time		1.65 V to 3.6 V			100	ns
f_{MIN}	Maximum switching frequency on DIN		1.65 V to 3.6 V	1			MHz
f_{MAX}	Minimum switching frequency on DIN		1.65 V to 3.6 V			10	kHz

TCA5405

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PRINCIPLES OF OPERATION

The TCA5405 single-wire bus device has a single-bit Data Line Bus input and has five independent parallel push-pull buffered outputs. A single input is used to control the output state for the writing to these five outputs. This single-wire serial interface is similar to a UART type interface but operates over a wide range of values for the bit period.

The TCA5405 uses a self-timed serial data protocol with a single data input driven by a master device synchronized to an internal clock of that device. During a Setup phase, the bit period is sampled, then the TCA5405 generates its own internal clock synchronized to that of the Master device to sample the input over a five-bit-period Data Transfer phase and writes the bit states on the parallel outputs after the last bit is sampled. The Master output bit must be transmitted via a Totem-pole output structure to ensure proper interpretation of the incoming serial burst.

The single-wire unidirectional interface operation is defined in Figure 2.

INTERFACE TIMING
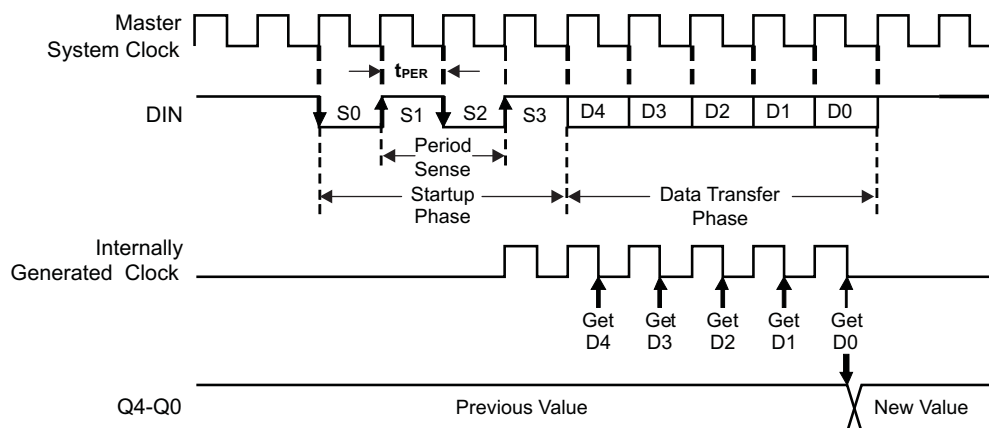
Figure 2. Definition of Single-Wire Interface

To function correctly, the bit period (tPER) of the DIN signal must be constant over the entire data transaction. Therefore, DIN should be driven by a stable periodic signal internal to the Master device (see Figure 2 - Master System Clock). The bit period can be any value between 1µS and 10mS.

The TCA5405 first detects the falling transition on DIN at the beginning of the S0 period to signal the start of an incoming data burst. Next, over the period of S1 and S2, between the two rising edges on DIN, a timer measures the duration of S1/S2 to calculate the bit period of the incoming signal. After that, the TCA5405 uses that value to generate its own internal clock which it uses to sample DIN as near as possible to the center of the subsequent D4-D0 bit periods. After bit D0 is sampled, the five sampled values are sent to the Q4-Q0 outputs. At the end of the D0 bit period, if DIN is not already high, it must be set high to signal the end of the transaction and to prepare for the next one.

TYPICAL CHARACTERISTICS

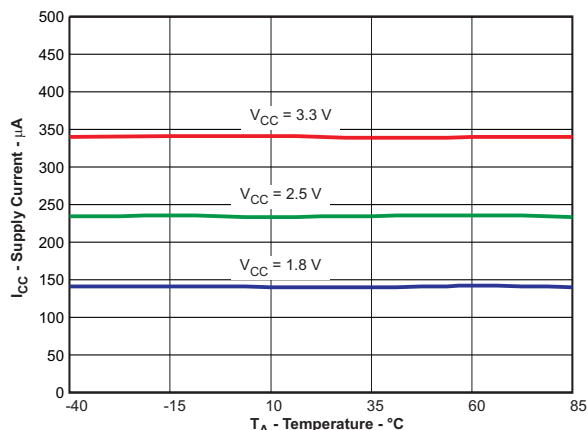$T_A = 25°C$ (unless otherwise noted)
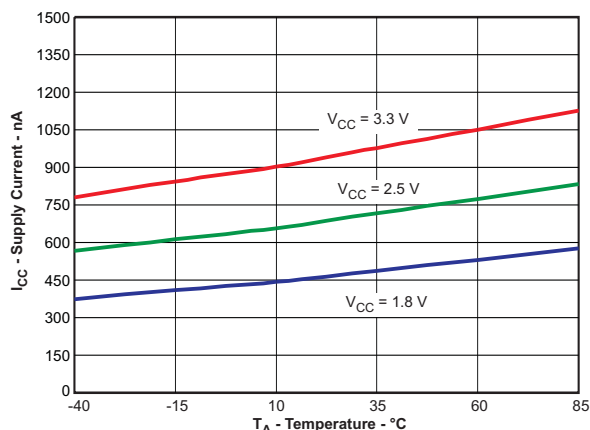
Figure 3. Active Current vs Temperature

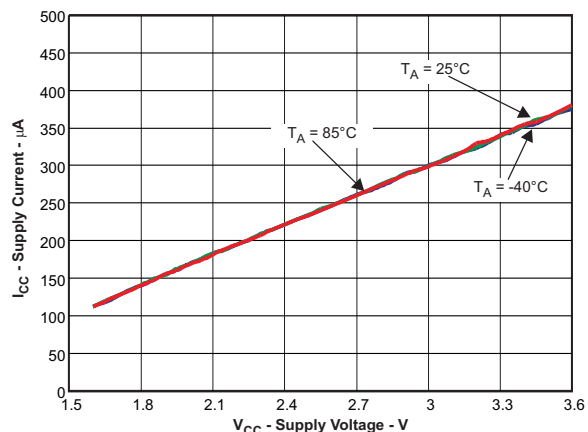Figure 4. Standby Supply Current vs Temperature
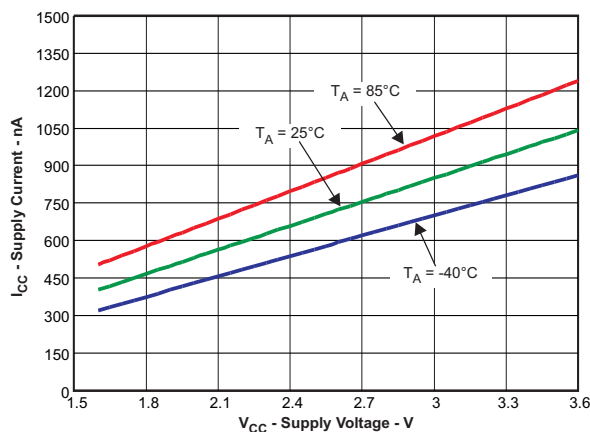
Figure 5. Active Supply Current vs Supply Voltage
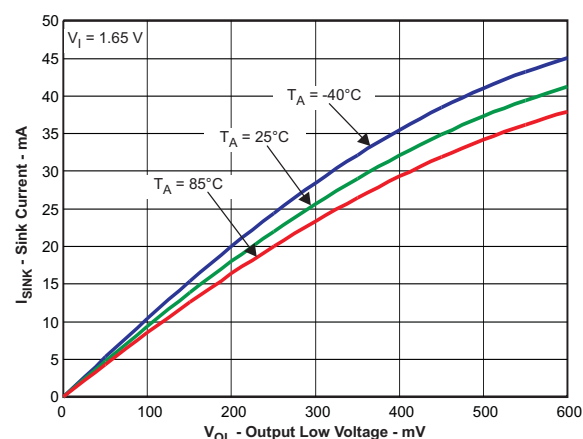
Figure 6. Standby Supply Current vs Supply Voltage

**Figure 7. I/O Sink Current vs
Output Low Voltage VCC = 1.65V**

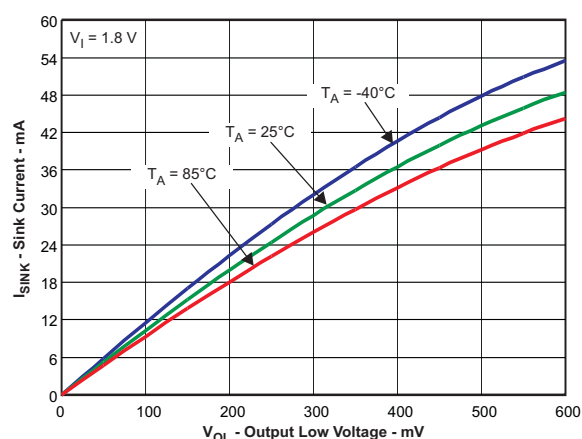**Figure 8. I/O Sink Current vs
Output Low Voltage VCC = 1.8 V**

TYPICAL CHARACTERISTICS (continued)

$T_A = 25°C$ (unless otherwise noted)
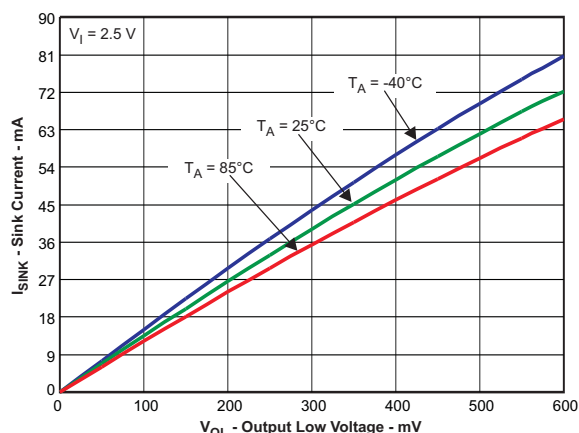
**Figure 9. I/O Sink Current vs
Output Low Voltage VCC = 2.5V**
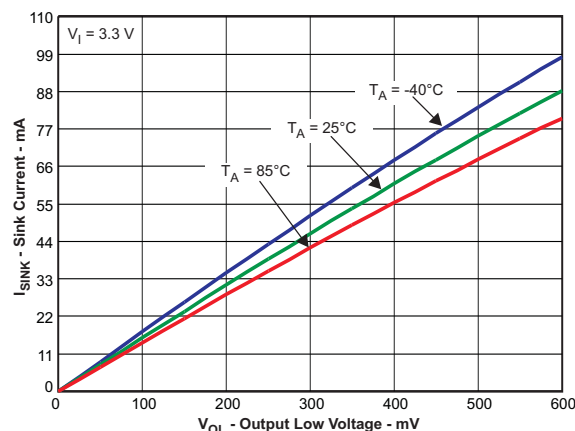
**Figure 10. I/O Sink Current vs
Output Low Voltage VCC = 3.3V**
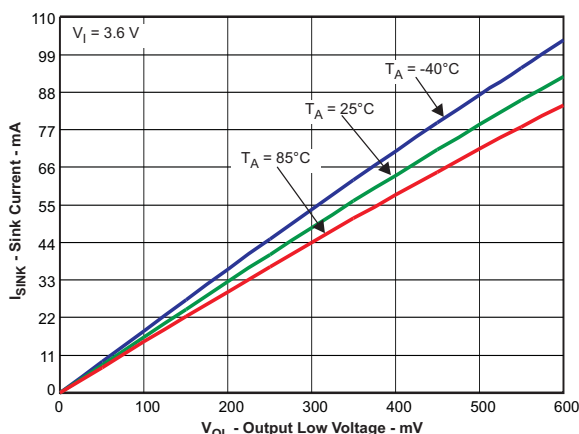
**Figure 11. I/O Sink Current vs
Output Low Voltage VCC =3.6V**
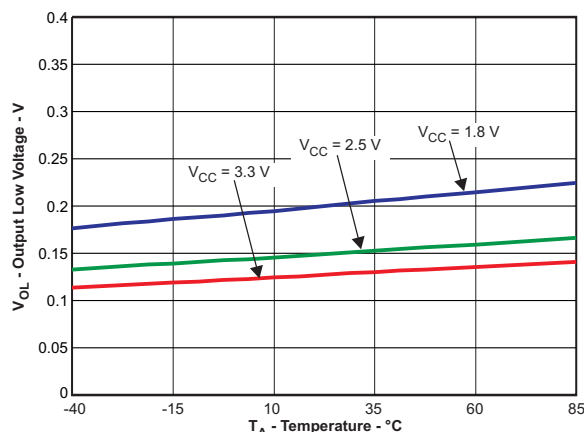
**Figure 12. I/O Low Voltage vs
Temperature VCC = 3.3V at 20 mA**
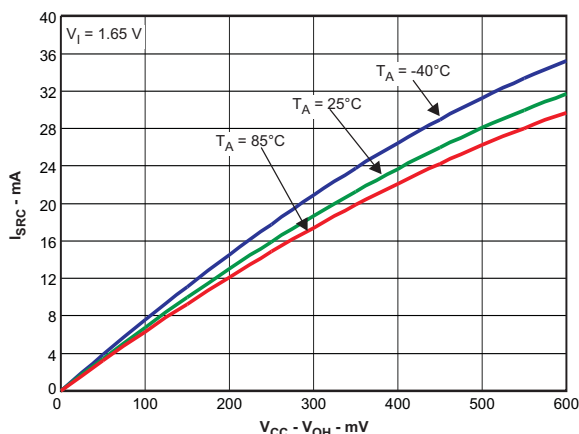
**Figure 13. I/O Source Current vs
Output High Voltage VCC = 1.65V**
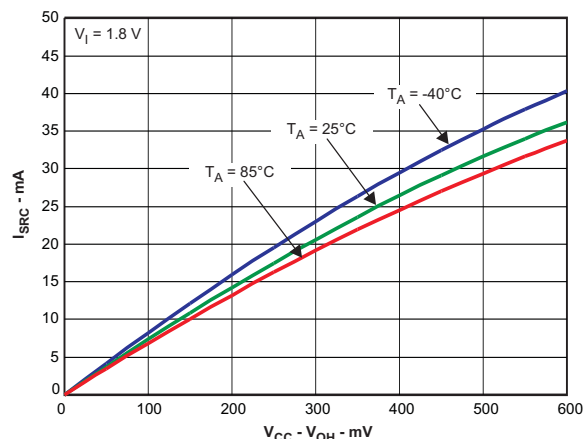
**Figure 14. I/O Source Current vs
Output High Voltage VCC = 1.8V**

Product Folder Link(s) :*TCA5405*

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TCA5405

TYPICAL CHARACTERISTICS (continued)

$T_A = 25°C$ (unless otherwise noted)

**Figure 15. I/O Source Current vs
Output High Voltage VCC = 2.5V**
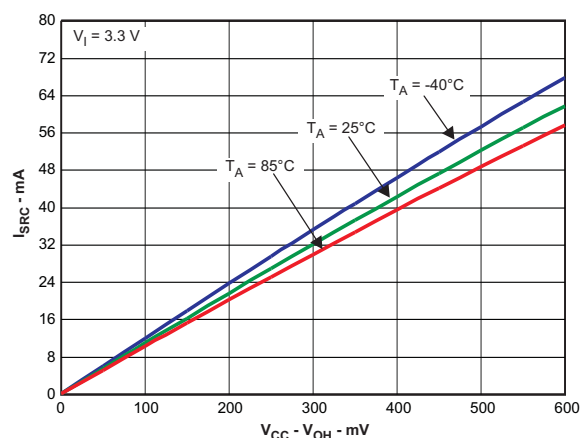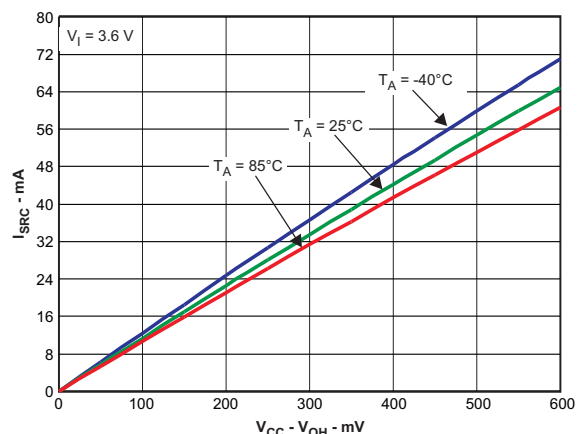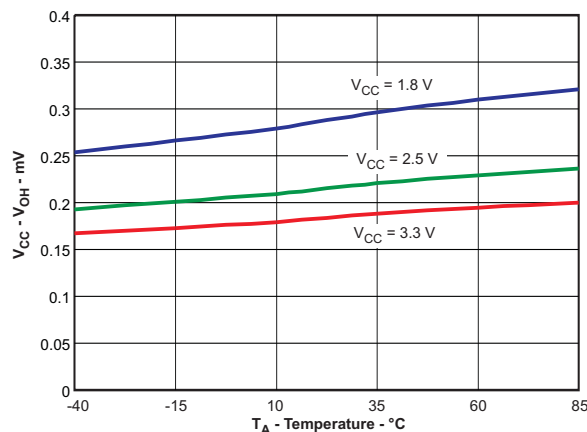

**Figure 16. I/O Source Current vs
Output High Voltage VCC = 3.3V**

**Figure 17. I/O Source Current vs
Output High Voltage VCC = 3.6V**

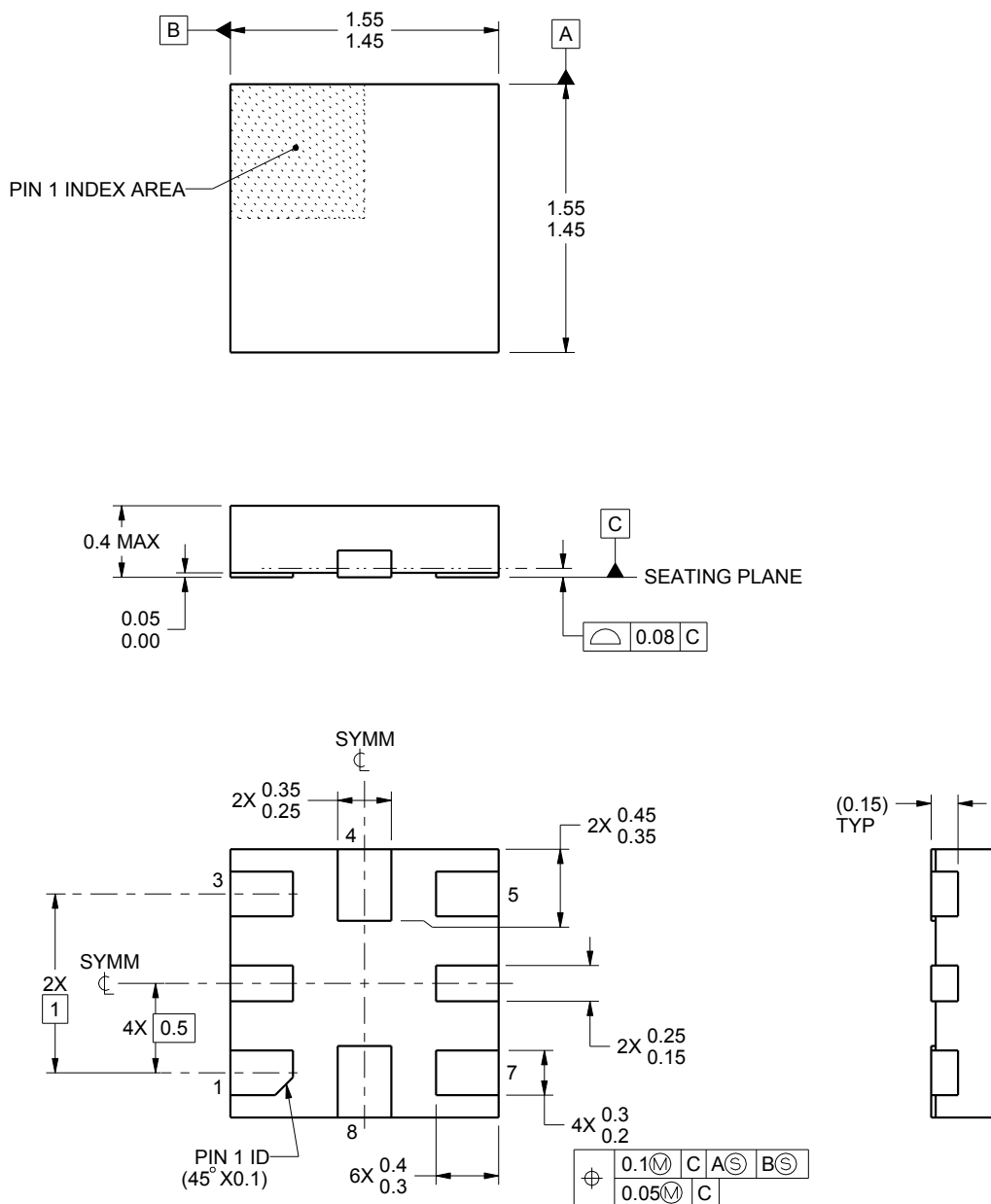**Figure 18. I/O High Voltage vs
Temperature VCC = 3.3V at 20 mA**

Product Folder Link(s) :*TCA5405*

PACKAGE OUTLINE

RUG0008A

X2QFN - 0.4 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

B
1.55
1.45
A

PIN 1 INDEX AREA

1.55
1.45

0.4 MAX

0.05
0.00

C

SEATING PLANE

0.08 C

SYMM

2X 0.35
0.25

4

2X 0.45
0.35

3

5

SYMM

2X 1

4X 0.5

2X 0.25
0.15

1

7

PIN 1 ID
(45° X0.1)

8

4X 0.3
0.2

6X 0.4
0.3

(0.15)
TYP

0.1 Ⓜ C AⓈ BⓈ
0.05 Ⓜ C

4222060/A   05/14/2015

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

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EXAMPLE BOARD LAYOUT

RUG0008A

X2QFN - 0.4 mm max height

PLASTIC QUAD FLATPACK - NO LEAD
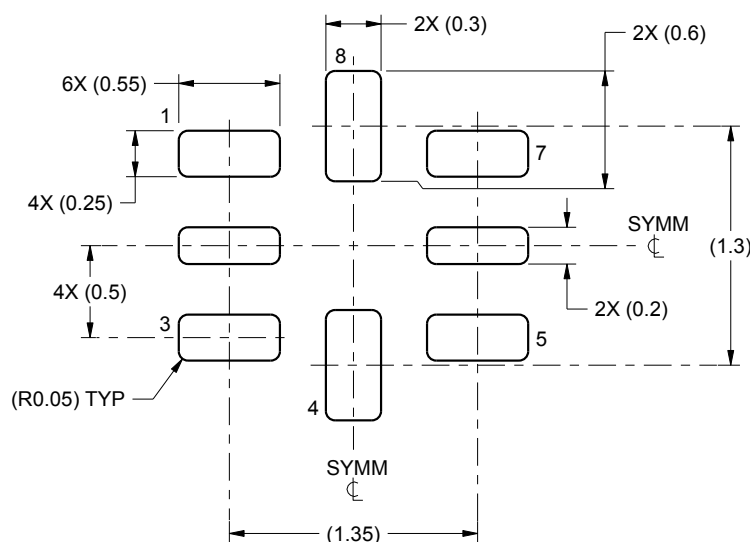
LAND PATTERN EXAMPLE
SCALE:25X
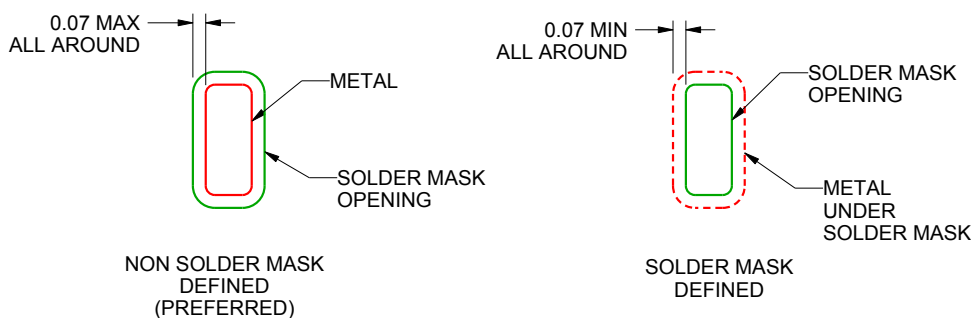
SOLDER MASK DETAILS
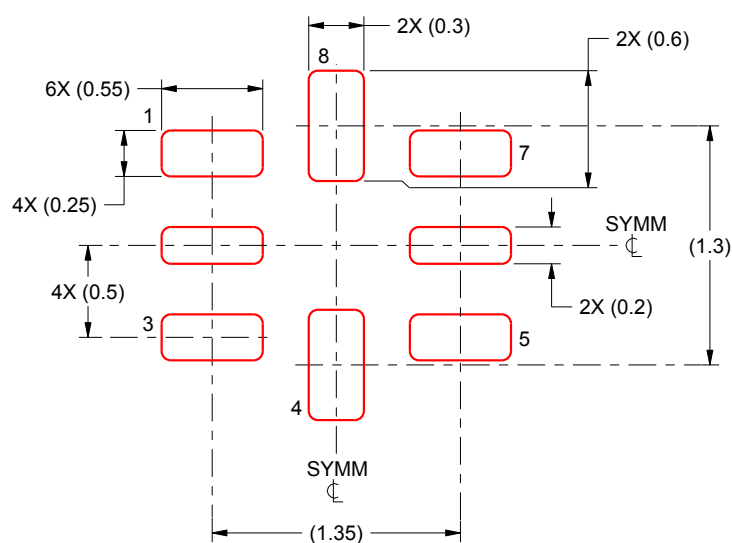NOT TO SCALE

4222060/A   05/14/2015

NOTES: (continued)

3. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).

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EXAMPLE STENCIL DESIGN

RUG0008A

X2QFN - 0.4 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICKNESS
SCALE:25X

4222060/A   05/14/2015

NOTES: (continued)

4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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PACKAGE OPTION ADDENDUM

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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TCA5405RUGR	ACTIVE	X2QFN	RUG	8	3000	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 85	6Y	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

PACKAGE OPTION ADDENDUM

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PACKAGE MATERIALS INFORMATION

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TAPE AND REEL INFORMATION

REEL DIMENSIONS

Reel Diameter

Reel Width (W1)

TAPE DIMENSIONS

Cavity

A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE

Sprocket Holes

User Direction of Feed

Pocket Quadrants

*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TCA5405RUGR	X2QFN	RUG	8	3000	180.0	8.4	1.7	1.7	0.7	4.0	8.0	Q2

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PACKAGE MATERIALS INFORMATION

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18-Aug-2014

TAPE AND REEL BOX DIMENSIONS
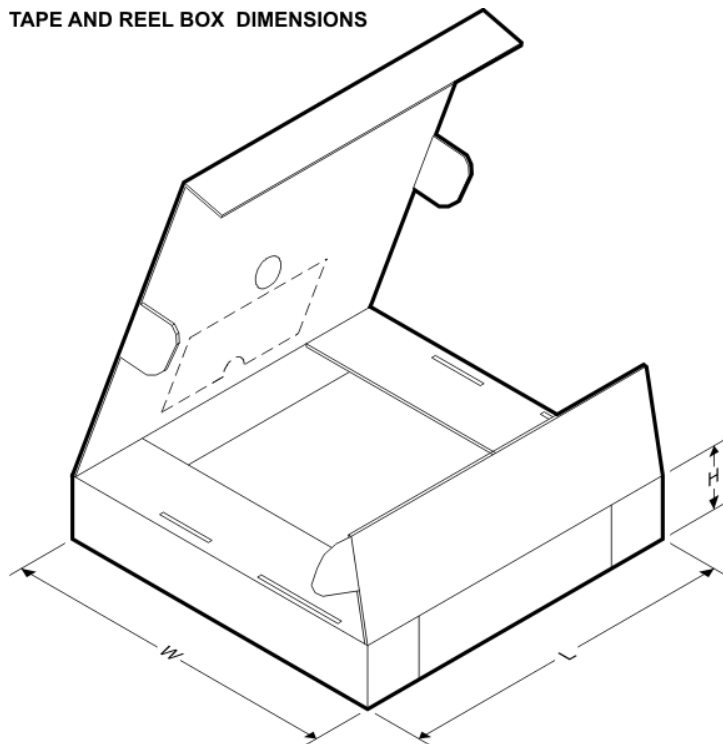
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TCA5405RUGR	X2QFN	RUG	8	3000	202.0	201.0	28.0

IMPORTANT NOTICE

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
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RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		