I²C CONTROLLED 18 CHANNEL GPIO EXPANDER

Check for Samples: TCA6418E

FEATURES

- **Operating Power-Supply Voltage Range of 1.65 V to 3.6 V**
- **18 GPIOs Configurable as Inputs or Outputs**
- **ESD Protection Exceeds JESD 22 on Non-GPIO Pins**
  - **2000-V Human Body Model (A114-A)**
  - **1000-V Charged Device Model (C101)**
- **Low Standby (Idle) Current Consumption: 3 µA**
- **Supports 1-MHz Fast Mode Plus I²C Bus**
- **Open-Drain Active-Low Interrupt Output, Asserted When Key is Pressed or Key is Released**
- **Selectable Debounce Time of 50 µs**
- **Schmitt-Trigger Action Allows Slow Input Transition and Better Switching Noise Immunity at the SCL and SDA Inputs: Typical V_{hys} at 1.8 V is 0.18 V**
- **Latch-Up Performance Exceeds 200 mA Per JESD 78, Class II**
- **Very Small Package**
  - **WCSP (YFP): 2 mm × 2 mm; 0.4 mm pitch**

APPLICATIONS

- **Smart Phones**
- **PDAs**
- **GPS Devices**
- **MP3 Players**
- **Digital Cameras**

DESCRIPTION/ORDERING INFORMATION

The TCA6418E is a 18 channel GPIO expansion device with integrated ESD protection. It can operate from 1.65 V to 3.6 V and has 18 general purpose inputs/outputs (GPIO) that can be used via the I²C interface [serial clock (SCL), serial data (SDA)].

The major benefit of this device is it frees up the processor from having to individually monitor changes in multiple inputs and also frees up the GPIOs on the processor to drive other outputs.. This provides power and bandwidth savings. The TCA6418E is also ideal for usage with processors that have limited GPIOs.

ORDERING INFORMATION(1)

T_A	PACKAGE(2)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	WCSP – YFP	Tape and reel	TCA6418EYFPR	AZ2

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

YFP PACKAGE

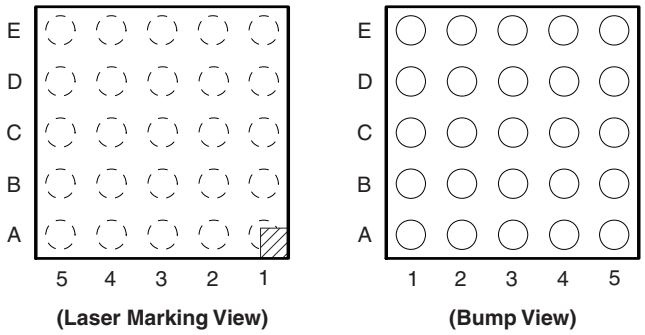


Table 1. YFP Package Terminal Assignments

E	$\overline{INT}$	GND	GPIO13	GPIO8	GPIO4
D	SCL	GPIO17	GPIO12	GPIO7	GPIO3
C	SDA	GPIO16	GPIO11	GPIO6	GPIO2
B	V_{CC}	GPIO15	GPIO10	GND	GPIO1
A	$\overline{RESET}$	GPIO14	GPIO9	GPIO5	GPIO0
	5	4	**3**	**2**	**1**

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TERMINAL FUNCTIONS

TERMINAL		TYPE	DESCRIPTION
NO. WCSP (YFP)	NAME		
A1	GPIO0	I/O	GPIO port
B1	GPIO1	I/O	GPIO port
C1	GPIO2	I/O	GPIO port
D1	GPIO3	I/O	GPIO port
E1	GPIO4	I/O	GPIO port
A2	GPIO5	I/O	GPIO port
B2	GND	-	Ground
C2	GPIO6	I/O	GPIO port
D2	GPIO7	I/O	GPIO port
E2	GPIO8	I/O	GPIO port
A3	GPIO9	I/O	GPIO port
B3	GPIO10	I/O	GPIO port
C3	GPIO11	I/O	GPIO port
D3	GPIO12	I/O	GPIO port
E3	GPIO13	I/O	GPIO port
A4	GPIO14	I/O	GPIO port
B4	GPIO15	I/O	GPIO port
C4	GPIO16	I/O	GPIO port
D4	GPIO17	I/O	GPIO port
E4	GND	–	Ground
A5	$\overline{\text{RESET}}$	I	Active-low reset input. Connect to V_{CC} through a pullup resistor, if no active connection is used.
B5	V_{CC}	Pwr	Supply voltage of 1.65 V to 3.6 V
C5	SDA	I/O	Serial data bus. Connect to V_{CC} through a pullup resistor.
D5	SCL	I	Serial clock bus. Connect to V_{CC} through a pullup resistor.
E5	$\overline{\text{INT}}$	O	Active-low interrupt output. Open drain structure. Connect to V_{CC} through a pullup resistor.

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ABSOLUTE MAXIMUM RATINGS(1)

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

				MIN	MAX	UNIT
V_{CC}	Supply voltage range			–0.5	4.6	V
V_I	Input voltage range(2)			–0.5	4.6	V
V_O	Voltage range applied to any output in the high-impedance or power-off state(2)			–0.5	4.6	V
	Output voltage range in the high or low state(2)			–0.5	4.6	
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	P port, SDA	V_O = 0 to V_{CC}		50	mA
		$\overline{INT}$			25	
I_{OH}	Continuous output High current	P port	V_O = 0 to V_{CC}		50	
T_{stg}	Storage temperature range			–65	150	°C

(1) Stresses beyond 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 beyond those indicated under RECOMMENDED OPERATING CONDITIONS is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) The input negative-voltage and output voltage ratings may be exceeded if the input and output current ratings are observed.

THERMAL CHARACTERISTICS

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

			VALUE	UNIT
θ_{JA}	Package thermal impedance(1)	YFP package	98.8	°C/W

(1) 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	SCL, SDA, GPIO0-17, $\overline{RESET}$	0.7 × V_{CC}	3.6	V
V_{IL}	Low-level input voltage	SCL, SDA, GPIO0-17, $\overline{RESET}$	–0.5	0.3 × V_{CC}	V
I_{OH}	High-level output current	GPIO0-17		10	mA
I_{OL}	Low-level output current	GPIO0-17		25	mA
T_A	Operating free-air temperature		–40	85	°C

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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_{CCP}	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	$V_I = V_{CCP}$ or GND, I_O = 0		1.65 V to 3.6 V		1	1.4	V
V_{OH}	GPIO0-17 high-level output voltage	I_{OH} = –1 mA		1.65 V	1.25			V
		I_{OH} = –8 mA		1.65 V	1.2			
				2.3 V	1.8			
				3 V	2.6			
		I_{OH} = –10 mA		1.65 V	1.1			
				2.3 V	1.7			
				3 V	2.5			
V_{OL}	GPIO0-17 low-level output voltage	I_{OL} = 1 mA		1.65 V			0.4	V
		I_{OL} = 8 mA		1.65 V			0.45	
				2.3 V			0.25	
				3 V			0.25	
		I_{OL} = 10 mA		1.65 V			0.6	
				2.3 V			0.3	
				3 V			0.25	
I_{OL}	SDA	V_{OL} = 0.4 V		1.65 V to 3.6 V	3			mA
	$\overline{INT}$	V_{OL} = 0.4 V		1.65 V to 3.6 V	3			
I_I	SCL, SDA, GPIO0-17, $\overline{RESET}$	$V_I = V_{CCI}$ or GND; Pull-downs disabled for GPIO0-17		1.65 V to 3.6 V			1	µA
r_{INT}	GPIO0-17					55		kΩ
I_{CC}		V_I on SDA, GPIO0–17, = V_{CC} or GND, I_O = 0, I/O = inputs,	f_{SCL} = 0 kHz	1.65 V to 3.6 V			13	µA
			f_{SCL} = 400 kHz				25	
			f_{SCL} = 1 MHz				35	
C_I	SCL	$V_I = V_{CCI}$ or GND		1.65 V to 3.6 V		6	8	pF
C_{io}	SDA	$V_{IO} = V_{CC}$ or GND		1.65 V to 3.6 V		10	12.5	pF
	GPIO0-17					5	6	

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I²C INTERFACE TIMING REQUIREMENTS

over recommended operating free-air temperature range (unless otherwise noted) (see Figure 12)

		STANDARD MODE I²C BUS		FAST MODE I²C BUS		FAST MODE PLUS (FM+) I²C BUS		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
f_{scl}	I²C clock frequency	0	100	0	400	0	1000	kHz
t_{sch}	I²C clock high time	4		0.6		0.26		µs
t_{scl}	I²C clock low time	4.7		1.3		0.5		µs
t_{sp}	I²C spike time		50		50		50	ns
t_{sds}	I²C serial data setup time	250		100		50		ns
t_{sdh}	I²C serial data hold time	0		0		0		ns
t_{icr}	I²C input rise time		1000	$20 + 0.1C_b$ (1)	300		120	ns
t_{icf}	I²C input fall time		300	$20 + 0.1C_b$ (1)	300		120	ns
t_{ocf}	I²C output fall time; 10 pF to 400 pF bus		300	$20 + 0.1C_b$ (1)	300		120	µs
t_{buf}	I²C bus free time between Stop and Start	4.7		1.3		0.5		µs
t_{sts}	I²C Start or repeater Start condition setup time	4.7		0.6		0.26		µs
t_{sth}	I²C Start or repeater Start condition hold time	4		0.6		0.26		µs
t_{sps}	I²C Stop condition setup time	4		0.6		0.26		µs
$t_{vd(data)}$	Valid data time; SCL low to SDA output valid		1		0.9		0.45	µs
$t_{vd(ack)}$	Valid data time of ACK condition; ACK signal from SCL low to SDA (out) low		1		0.9		0.45	µs

(1) C_b = total capacitance of one bus line in pF

RESET TIMING REQUIREMENTS

over recommended operating free-air temperature range (unless otherwise noted) (see Figure 15)

		STANDARD MODE, FAST MODE, FAST MODE PLUS (FM+) I²C BUS		UNIT
		MIN	MAX	
t_W	Reset pulse duration	120(1)		µs
t_{REC}	Reset recovery time	120(1)		µs
t_{RESET}	Time to reset	120(1)		µs

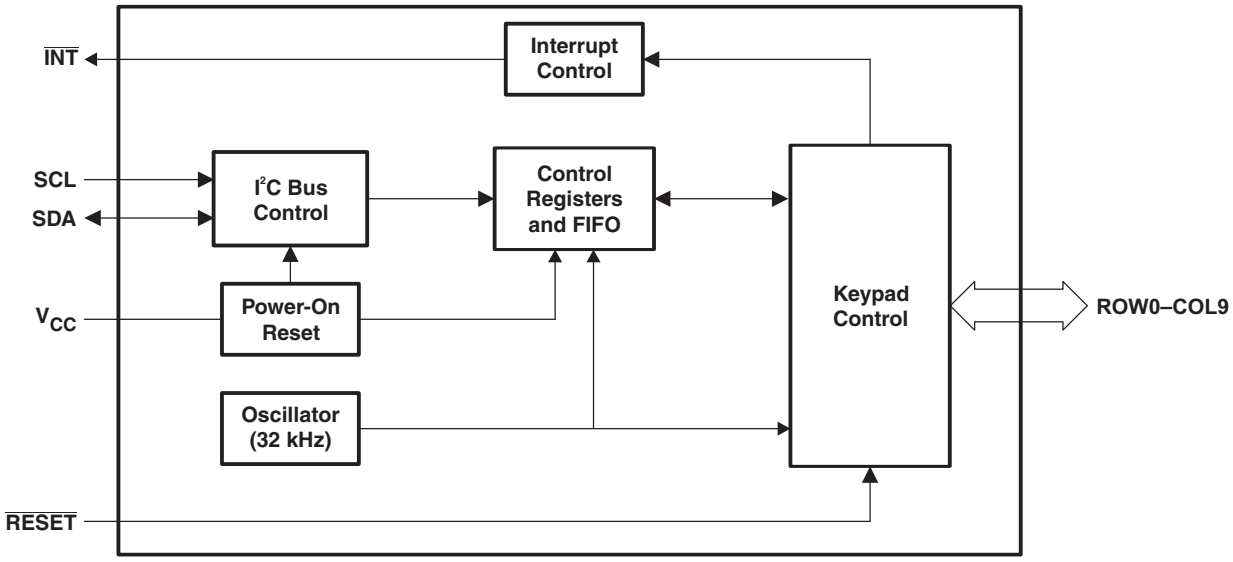
(1) The GPIO debounce circuit uses each GPIO input which passes through a two-stage register circuit. Both registers are clocked by the same clock signal, presumably free-running, with a nominal period of 50uS. When an input changes state, the new state is clocked into the first stage on one clock transition. On the next same-direction transition, if the input state is still the same as the previously clocked state, the signal is clocked into the second stage, and then on to the remaining circuits. Since the inputs are asynchronous to the clock, it will take anywhere from zero to 50 µsec after the input transition to clock the signal into the first stage. Therefore, the total debounce time may be as long as 100 µsec. Finally, to account for a slow clock, the spec further guard-banded at 120 µsec.

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SWITCHING CHARACTERISTICS

PARAMETER			FROM	TO	STANDARD MODE, FAST MODE, FAST MODE PLUS (FM+) I^2C BUS		UNIT
					MIN	MAX	
t_{IV}	Interrupt valid time	GPI_INT with Debounce Enabled	GPIO0-17	$\overline{INT}$	40	120	µs
		GPI_INT with Debounce Disabled			0	1	
t_{IR}	Interrupt reset delay time		SCL	$\overline{INT}$		1	µs
t_{PV}	Output data valid		SCL	GPIO0-17		400	ns
t_{PS}	Input data setup time	Debounce Disabled	GPIO	SCL	0		ns
t_{PH}	Input data hold time		GPIO	SCL	300		ns

LOGIC DIAGRAM (POSITIVE LOGIC)



At power on, the GPIOs are configured as inputs with internal 50-kΩ pulldown resistors enabled; however, the system master can enable the GPIOs to function as inputs or outputs.

The system master can reset the TCA6418E in the event of a timeout or other improper operation by asserting a low in the $\overline{RESET}$ input, while keeping the V_{CC} at its operating level.

A reset can be accomplished by holding the $\overline{RESET}$ pin low for a minimum of t_W. The TCA6418E registers and I^2C/SMBus state machine are changed to their default state once $\overline{RESET}$ is low (0). When $\overline{RESET}$ is high (1), the I/O levels at the P port can be changed externally or through the master. This input requires a pullup resistor to VCC, if no active connection is used.

The power-on reset puts the registers in their default state and initializes the I^2C/SMBus state machine. The $\overline{RESET}$ pin causes the same reset/initialization to occur without de-powering the part.

The open-drain interrupt ($\overline{INT}$) output is used to indicate to the system master that an input state has changed. $\overline{INT}$ can be connected to the interrupt input of a microcontroller. By sending an interrupt signal on this line, the remote input can inform the microcontroller if there is incoming data on its ports without having to communicate via the I^2C bus. Thus, the TCA6418E can remain a simple slave device.

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Power-On Reset

When power (from 0 V) is applied to V_{CC}, an internal power-on reset holds the TCA6418E in a reset condition until V_{CC} reaches V_{POR}. At that time, the reset condition is released, and the TCA6418E registers and I^2C/SMBus state machine initialize to their default states. After that, V_{CC} must be lowered below 0.2 V and back up to the operating voltage for a power-reset cycle.

Power-On Reset Requirements

In the event of a glitch or data corruption, TCA6418E can be reset to its default conditions by using the power-on reset feature. Power-on reset requires that the device go through a power cycle to be completely reset. This reset also happens when the device is powered on for the first time in an application.

The two types of power-on reset are shown in Figure 1 and Figure 2.

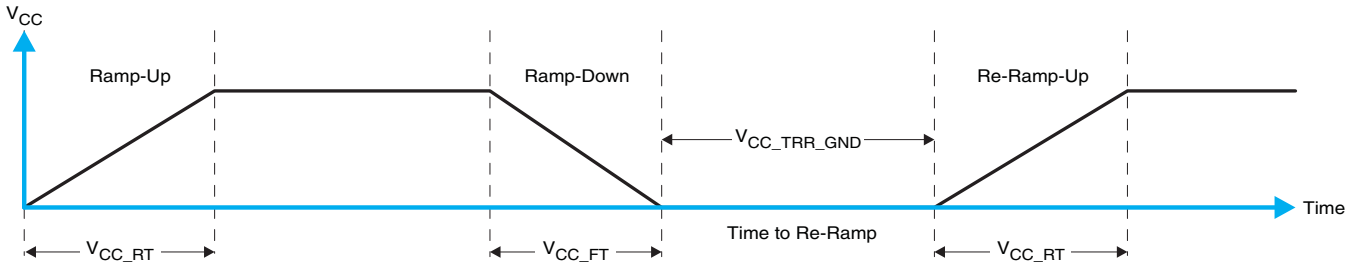


Figure 1. V_{CC} is Lowered Below 0.2 V or 0 V and Then Ramped Up to V_{CC}

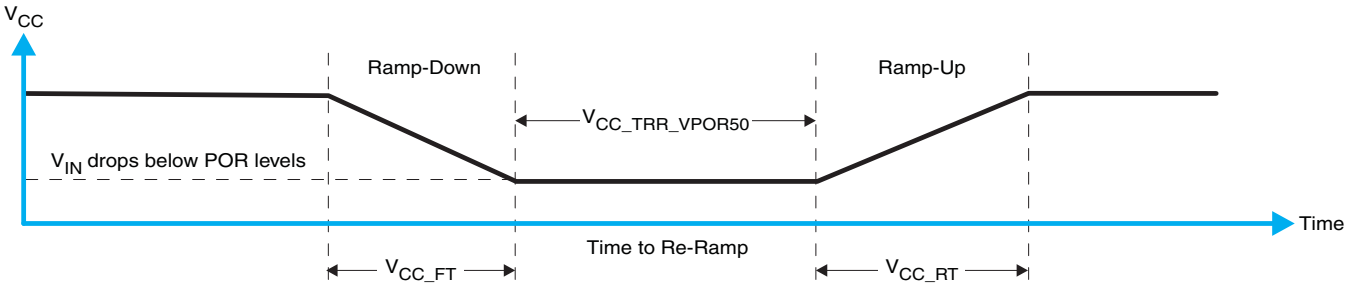


Figure 2. V_{CC} is Lowered Below the POR Threshold, Then Ramped Back Up to V_{CC}

Table 2 specifies the performance of the power-on reset feature for TCA6418E for both types of power-on reset.

Table 2. RECOMMENDED SUPPLY SEQUENCING AND RAMP RATES(1)

PARAMETER			MIN	TYP	MAX	UNIT
V_{CC_FT}	Fall rate	See Figure 1	1		100	ms
V_{CC_RT}	Rise rate	See Figure 1	0.01		100	ms
$V_{CC_TRR_GND}$	Time to re-ramp (when V_{CC} drops to GND)	See Figure 1	0.001			ms
$V_{CC_TRR_POR50}$	Time to re-ramp (when V_{CC} drops to V_{POR_MIN} – 50 mV)	See Figure 2	0.001			ms
V_{CC_GH}	Level that V_{CCP} can glitch down to, but not cause a functional disruption when V_{CCX_GW} = 1 µs	See Figure 3			1.2	V
V_{CC_GW}	Glitch width that will not cause a functional disruption when V_{CCX_GH} = 0.5 × V_{CCx}	See Figure 3				µs
V_{PORF}	Voltage trip point of POR on falling V_{CC}		0.767		1.144	V
V_{PORR}	Voltage trip point of POR on rising V_{CC}		1.033		1.428	V

(1) T_A = –40°C to 85°C (unless otherwise noted)

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Glitches in the power supply can also affect the power-on reset performance of this device. The glitch width (V_{CC_GW}) and height (V_{CC_GH}) are dependent on each other. The bypass capacitance, source impedance, and device impedance are factors that affect power-on reset performance. Figure 3 and Table 2 provide more information on how to measure these specifications.

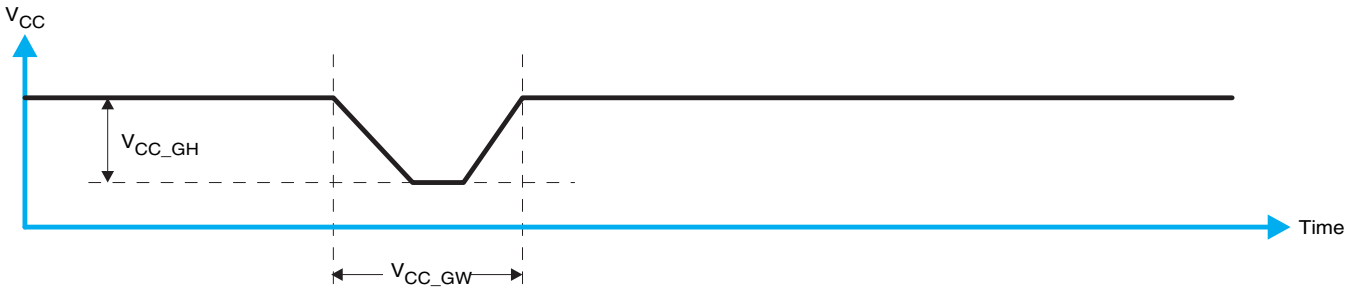


Figure 3. Glitch Width and Glitch Height

V_{POR} is critical to the power-on reset. V_{POR} is the voltage level at which the reset condition is released and all the registers and the I^2C/SMBus state machine are initialized to their default states. The value of V_{POR} differs based on the V_{CC} being lowered to or from 0. Figure 4 and Table 2 provide more details on this specification.

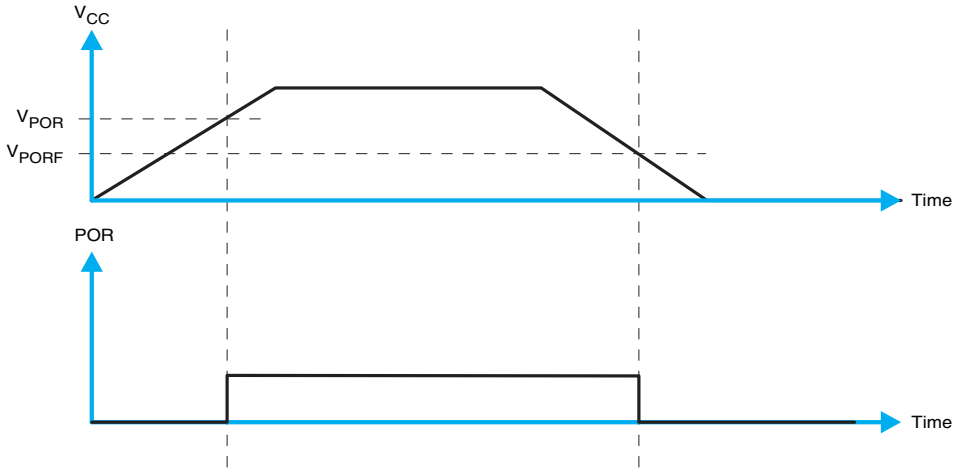


Figure 4. V_{POR}

For proper operation of the power-on reset feature, use as directed in the figures and table above.

Interrupt Output

An interrupt is generated by any rising or falling edge of the port inputs in the input mode. After time t_{iv}, the signal $\overline{INT}$ is valid. Resetting the interrupt circuit is achieved when data on the port is changed to the original setting or data is read from the port that generated the interrupt. Resetting occurs in the read mode at the acknowledge (ACK) or not acknowledge (NACK) bit after the rising edge of the SCL signal. Interrupts that occur during the ACK or NACK clock pulse can be lost (or be very short) due to the resetting of the interrupt during this pulse. Each change of the I/Os after resetting is detected and is transmitted as $\overline{INT}$.

Reading from or writing to another device does not affect the interrupt circuit, and a pin configured as an output cannot cause an interrupt. Changing an I/O from an output to an input may cause a false interrupt to occur, if the state of the pin does not match the contents of the input port register.

The $\overline{INT}$ output has an open-drain structure and requires a pullup resistor to V_{CC} depending on the application. For more information on the interrupt output feature, see Control Register and Command Byte and Typical Applications.

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I²C Interface

The bidirectional I²C bus consists of the serial clock (SCL) and serial data (SDA) lines. Both lines must be connected to a positive supply through a pullup resistor when connected to the output stages of a device. Data transfer may be initiated only when the bus is not busy.

I²C communication with this device is initiated by a master sending a Start condition, a high-to-low transition on the SDA input/output, while the SCL input is high (see Figure 5). After the Start condition, the device address byte is sent, most significant bit (MSB) first, including the data direction bit (R/$\overline{W}$).

After receiving the valid address byte, this device responds with an acknowledge (ACK), a low on the SDA input/output during the high of the ACK-related clock pulse. The address (ADDR) input of the slave device must not be changed between the Start and the Stop conditions.

On the I²C bus, only one data bit is transferred during each clock pulse. The data on the SDA line must remain stable during the high pulse of the clock period, as changes in the data line at this time are interpreted as control commands (Start or Stop) (see Figure 6).

A Stop condition, a low-to-high transition on the SDA input/output while the SCL input is high, is sent by the master (see Figure 5).

Any number of data bytes can be transferred from the transmitter to receiver between the Start and the Stop conditions. Each byte of eight bits is followed by one ACK bit. The transmitter must release the SDA line before the receiver can send an ACK bit. The device that acknowledges must pull down the SDA line during the ACK clock pulse, so that the SDA line is stable low during the high pulse of the ACK-related clock period (see Figure 7). When a slave receiver is addressed, it must generate an ACK after each byte is received. Similarly, the master must generate an ACK after each byte that it receives from the slave transmitter. Setup and hold times must be met to ensure proper operation.

A master receiver signals an end of data to the slave transmitter by not generating an acknowledge (NACK) after the last byte has been clocked out of the slave. This is done by the master receiver by holding the SDA line high. In this event, the transmitter must release the data line to enable the master to generate a Stop condition.

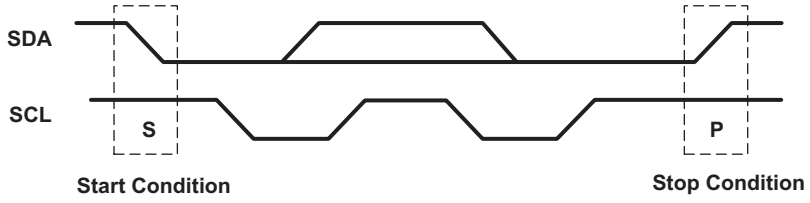


Figure 5. Definition of Start and Stop Conditions

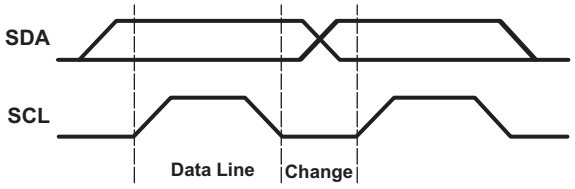


Figure 6. Bit Transfer

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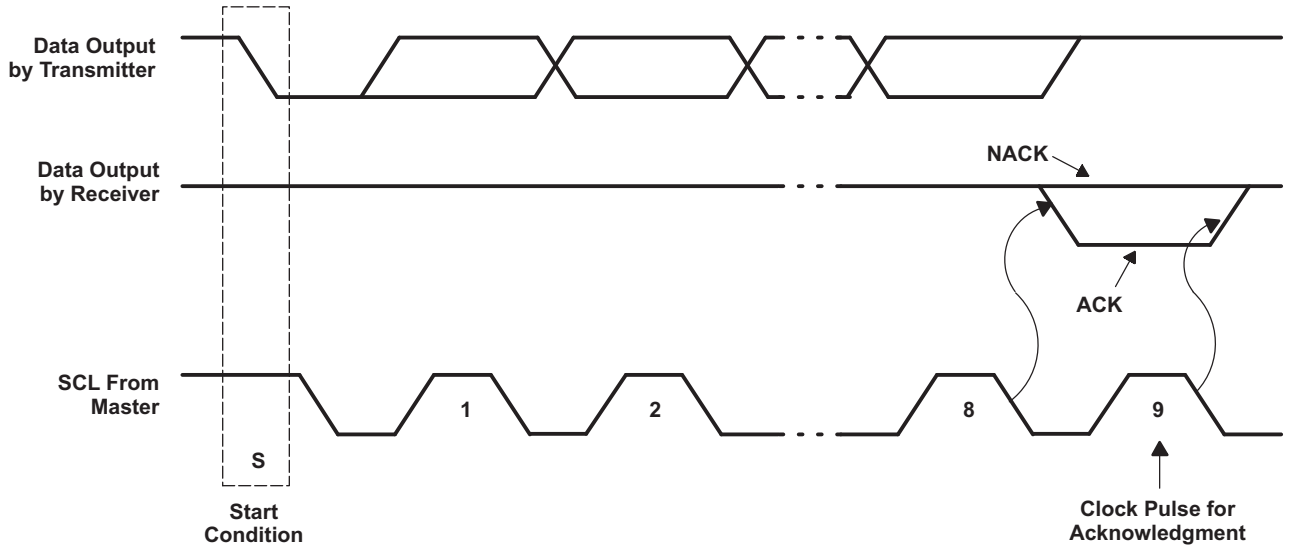


Figure 7. Acknowledgment on the I^2C Bus

Device Address

The address of the TCA6418E is shown in Table 3.

Table 3.

BYTE	BIT							
	7 (MSB)	6	5	4	3	2	1	0 (LSB)
I^2C slave address	0	1	1	0	1	0	0	R/$\overline{W}$

The last bit of the slave address defines the operation (read or write) to be performed. A high (1) selects a read operation, while a low (0) selects a write operation.

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Control Register and Command Byte

Following the successful acknowledgment of the address byte, the bus master sends a command byte, which is stored in the control register in the TCA6418E. The command byte indicates the register that will be updated with information. All registers can be read and written to by the system master.

Table 4 shows all the registers within this device and their descriptions. The default value in all registers is 0.

Table 4. Register Descriptions

ADDRESS	REGISTER NAME	REGISTER DESCRIPTION	7	6	5	4	3	2	1	0
0×00	Reserved	Reserved								
0×01	Reserved	Reserved								
0×02	INT_STAT	Interrupt status register	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	GPI_INT	N/A 0
0×03	Reserved	Reserved								
0×04	Reserved	Reserved								
0×05	Reserved	Reserved								
0×06	Reserved	Reserved								
0×07	Reserved	Reserved								
0×08	Reserved	Reserved								
0×09	Reserved	Reserved								
0×0A	Reserved	Reserved								
0×0B	Reserved	Reserved								
0×0C	Reserved	Reserved								
0×0D	Reserved	Reserved								
0×0E	Reserved	Reserved								
0×0F	Reserved	Reserved								
0×10	Reserved	Reserved								
0×11	GPIO_INT_STAT1	GPIO interrupt status	GPIO0 0	GPIO1 0	GPIO2 0	GPIO3 0	GPIO4 0	GPIO5 0	GPIO6 0	GPIO7 0
0×12	GPIO_INT_STAT2	GPIO interrupt status	GPIO15 0	GPIO14 0	GPIO13 0	GPIO12 0	GPIO11 0	GPIO10 0	GPIO9 0	GPIO8 0
0×13	GPIO_INT_STAT3	GPIO interrupt status	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	GPIO17 0	GPIO16 0
0×14	GPIO_DAT_STAT1 (read twice to clear)	GPIO data status	GPIO0 0	GPIO1 0	GPIO2 0	GPIO3 0	GPIO4 0	GPIO5 0	GPIO6 0	GPIO7 0
0×15	GPIO_DAT_STAT2 (read twice to clear)	GPIO data status	GPIO15 0	GPIO14 0	GPIO13 0	GPIO12 0	GPIO11 0	GPIO10 0	GPIO9 0	GPIO8 0
0×16	GPIO_DAT_STAT3 (read twice to clear)	GPIO data status	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	GPIO17 0	GPIO16 0
0×17	GPIO_DAT_OUT1	GPIO data out	GPIO0 0	GPIO1 0	GPIO2 0	GPIO3 0	GPIO4 0	GPIO5 0	GPIO6 0	GPIO7 0
0×18	GPIO_DAT_OUT2	GPIO data out	GPIO15 0	GPIO14 0	GPIO13 0	GPIO12 0	GPIO11 0	GPIO10 0	GPIO9 0	GPIO8 0
0×19	GPIO_DAT_OUT3	GPIO data out	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	GPIO17 0	GPIO16 0
0×1A	GPIO_INT_EN1	GPIO interrupt enable	GPIO0 0	GPIO1 0	GPIO2 0	GPIO3 0	GPIO4 0	GPIO5 0	GPIO6 0	GPIO7 0

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Table 4. Register Descriptions (continued)

ADDRESS	REGISTER NAME	REGISTER DESCRIPTION	7	6	5	4	3	2	1	0
0×1B	GPIO_INT_EN2	GPIO interrupt enable	GPIO15 0	GPIO14 0	GPIO13 0	GPIO12 0	GPIO11 0	GPIO 10 0	GPIO9 0	GPIO8 0
0×1C	GPIO_INT_EN3	GPIO interrupt enable	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	GPIO17 0	GPIO16 0
0×1D	Reserved	Reserved								
0×1E	Reserved	Reserved								
0×1F	Reserved	Reserved								
0×20	Reserved	Reserved								
0×21	Reserved	Reserved								
0×22	Reserved	Reserved								
0×23	GPIO_DIR1	GPIO data direction 0: input 1: output	GPIO0 0	GPIO1 0	GPIO2 0	GPIO3 0	GPIO4 0	GPIO 5 0	GPIO6 0	GPIO7 0
0×24	GPIO_DIR2	GPIO data direction 0: input 1: output	GPIO15 0	GPIO14 0	GPIO13 0	GPIO12 0	GPIO11 0	GPIO 10 0	GPIO9 0	GPIO8 0
0×25	GPIO_DIR3	GPIO data direction 0: input 1: output	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	GPIO17 0	GPIO16 0
0×26	GPIO_INT_LVL 1	GPIO edge/level detect 0: low 1: high	GPIO0 0	GPIO1 0	GPIO2 0	GPIO3 0	GPIO4 0	GPIO 5 0	GPIO6 0	GPIO7 0
0×27	GPIO_INT_LVL 2	GPIO edge/level detect 0: low 1: high	GPIO15 0	GPIO14 0	GPIO13 0	GPIO12 0	GPIO11 0	GPIO 10 0	GPIO9 0	GPIO8 0
0×28	GPIO_INT_LVL 3	GPIO edge/level detect 0: low 1: high	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	GPIO17 0	GPIO16 0
0×29	DEBOUNCE_DIS 1	Debounce disable 0: enabled 1: disabled	GPIO0 0	GPIO1 0	GPIO2 0	GPIO3 0	GPIO4 0	GPIO 5 0	GPIO6 0	GPIO7 0
0×2A	DEBOUNCE_DIS 2	Debounce disable 0: enabled 1: disabled	GPIO15 0	GPIO14 0	GPIO13 0	GPIO12 0	GPIO11 0	GPIO 10 0	GPIO9 0	GPIO8 0
0×2B	DEBOUNCE_DIS 3	Debounce disable 0: enabled 1: disabled	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	GPIO17 0	GPIO16 0
0×2C	GPIO_PULL1	GPIO pulldown 0: pulldown enabled 1: pulldown disabled	GPIO0 0	GPIO1 0	GPIO2 0	GPIO3 0	GPIO4 0	GPIO 5 0	GPIO6 0	GPIO7 0
0×2D	GPIO_PULL2	GPIO pulldown 0: pulldown enabled 1: pulldown disabled	GPIO15 0	GPIO14 0	GPIO13 0	GPIO12 0	GPIO11 0	GPIO 10 0	GPIO9 0	GPIO8 0
0×2E	GPIO_PULL3	GPIO pulldown 0: pulldown enabled 1: pulldown disabled	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	N/A 0	GPIO17 0	GPIO16 0
0×2F	Reserved									

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Interrupt Status Register, INT_STAT (Address 0×02)

GPI_INT (BIT1) reflects the status of the $\overline{INT}$ pin. If GPI_INT is 1, $\overline{INT}$ is asserted. Write 0x02 to INT_STAT register to clear interrupt.

GPIO Interrupt Status Registers, GPIO_INT_STAT1–3 (Address 0×11–0×13)

These registers are used to check GPIO interrupt status and are cleared on read.

GPIO Data Status Registers, GPIO_DAT_STAT1–3 (Address 0×14–0×16)

These registers show GPIO state when read for inputs and outputs.

GPIO Data Out Registers, GPIO_DAT_OUT1–3 (Address 0×17–0×19)

These registers contain GPIO data to be written to GPIO out driver; inputs are not affected. This is needed so that the value can be written prior to being set as an output.

GPIO Interrupt Enable Registers, GPIO_INT_EN1–3 (Address 0×1A–0×1C)

These registers enable interrupts for GP inputs only.

GPIO Data Direction Registers, GPIO_DIR1–3 (Address 0×23–0×25)

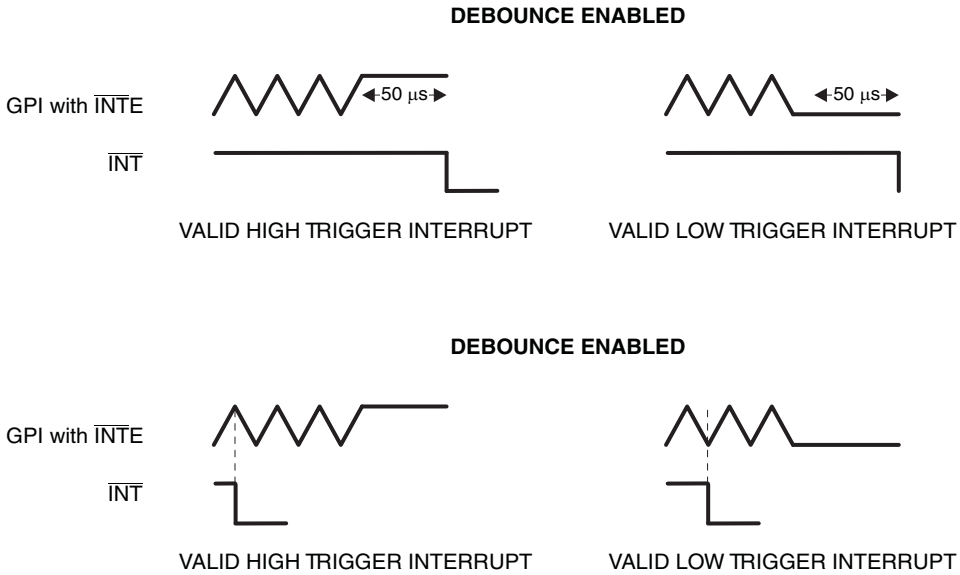
A bit value of '0' in any of the unreserved bits sets the corresponding pin as an input. A '1' in any of these bits sets the pin as an output.

GPIO Edge/Level Detect Registers, GPIO_INT_LVL1–3 (Address 0×26–0×28)

A bit value of '0' indicates that interrupt will be triggered on a high-to-low transition for the inputs in GPIO mode. A bit value of '1' indicates that interrupt will be triggered on a low-to-high value for the inputs in GPIO mode.

Debounce Disable Registers, DEBOUNCE_DIS1–3 (Address 0×29–0×2B)

This is for pins configured as inputs. A bit value of ‘0’ in any of the unreserved bits enables the debounce while a bit value of ‘1’ disables the debounce.



The reset line always has a 50-µs debounce time.

The 50 µs debounce time for inputs is the time required for the input to be stable to be noticed.

GPIO Pull Disable Register, GPIO_PULL1–3 (Address 0×2C–0×2E)

This register enables or disables pulldown registers from inputs.

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Bus Transactions

Data is exchanged between the master and TCA6418E through write and read commands.

Writes

Data is transmitted to the TCA6418E by sending the device address and setting the least significant bit (LSB) to a logic 0. The command byte is sent after the address and determines which register receives the data that follows the command byte. There is no limitation on the number of data bytes sent in one write transmission.

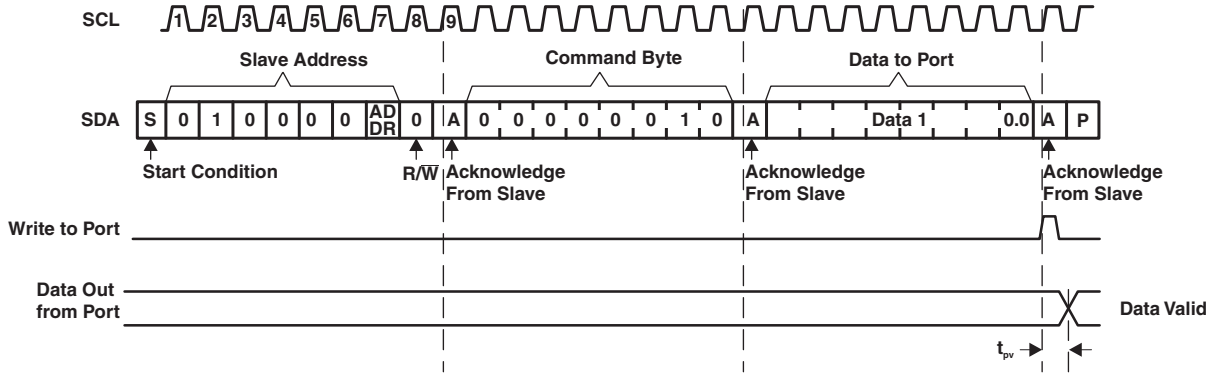


Figure 8. Write to Output Port Register

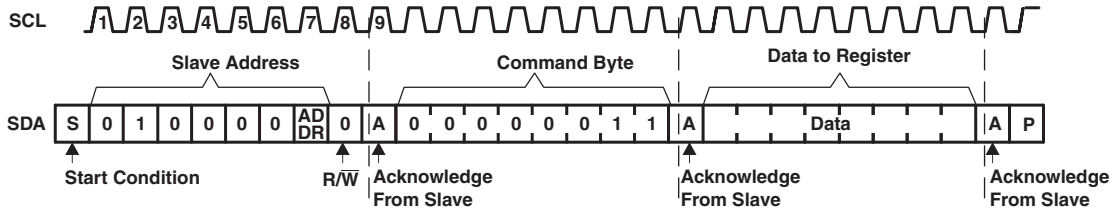


Figure 9. Write to Configuration or Polarity Inversion Register

Reads

The bus master first must send the TCA6418E address with the LSB set to a logic 0. The command byte is sent after the address and determines which register is accessed. After a restart, the device address is sent again but, this time, the LSB is set to a logic 1. Data from the register defined by the command byte then is sent by the TCA6418E (see Figure 10 and Figure 11). Data is clocked into the register on the rising edge of the ACK clock pulse.

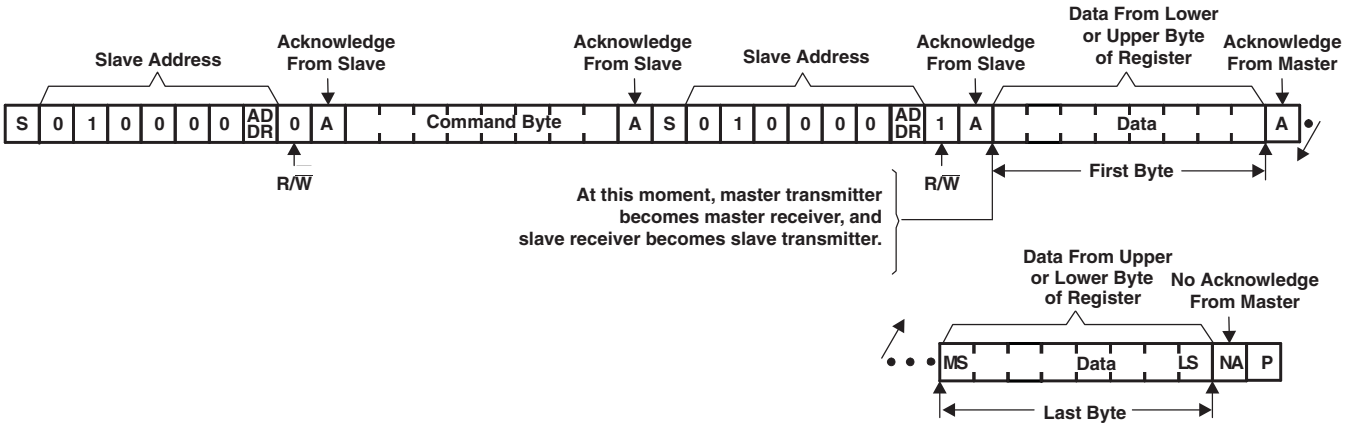


Figure 10. Read From Register

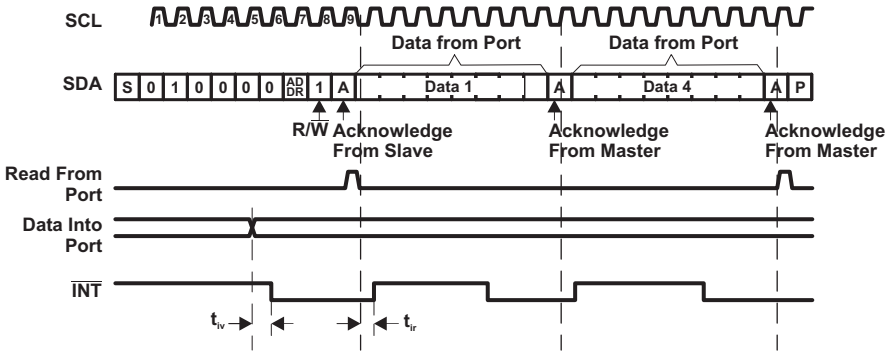


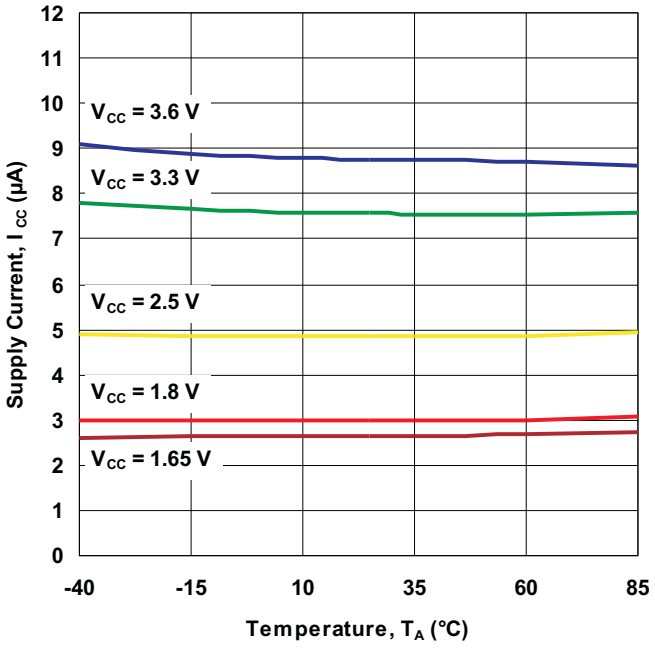
Figure 11. Read From Input Port Register

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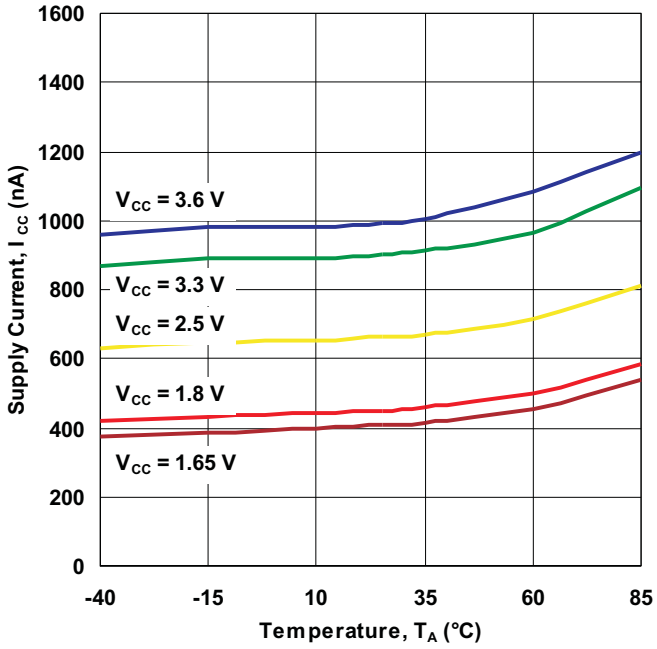
TYPICAL CHARACTERISTICS

T_A = 25°C (unless otherwise noted)

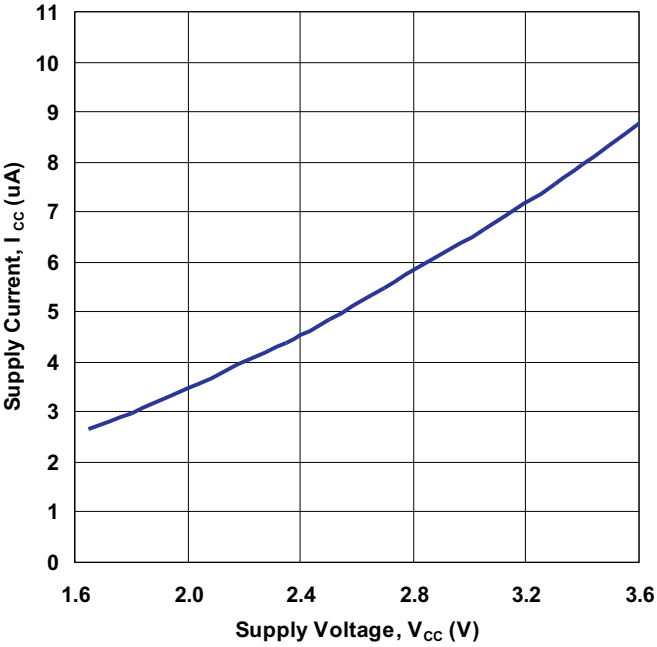
SUPPLY CURRENT
vs
TEMPERATURE



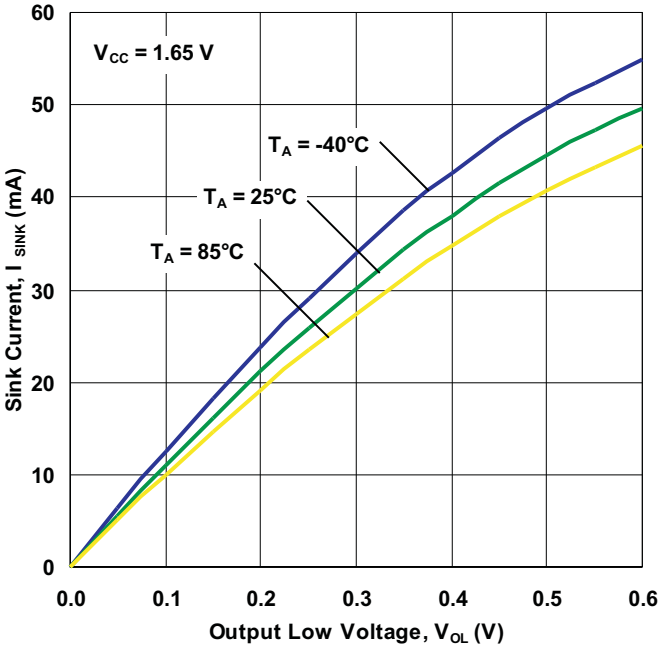
STANDBY SUPPLY CURRENT
vs
TEMPERATURE



SUPPLY CURRENT
vs
SUPPLY VOLTAGE



I/O SINK CURRENT
vs
OUTPUT LOW VOLTAGE

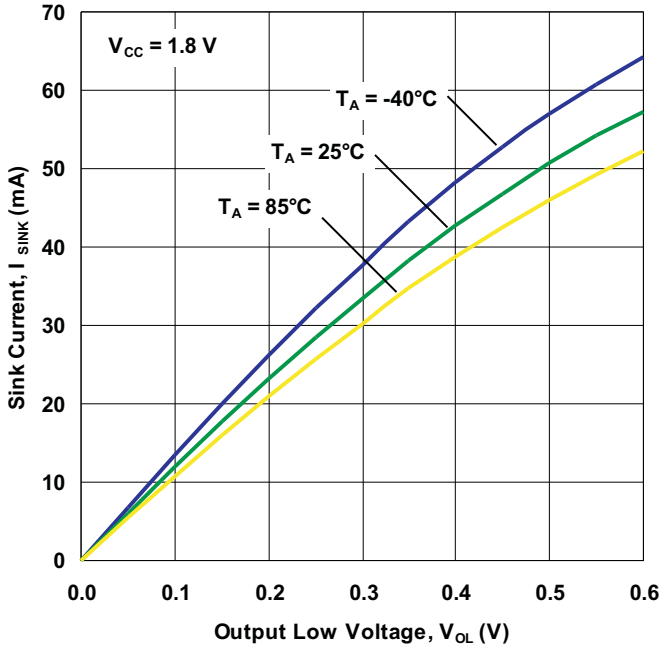


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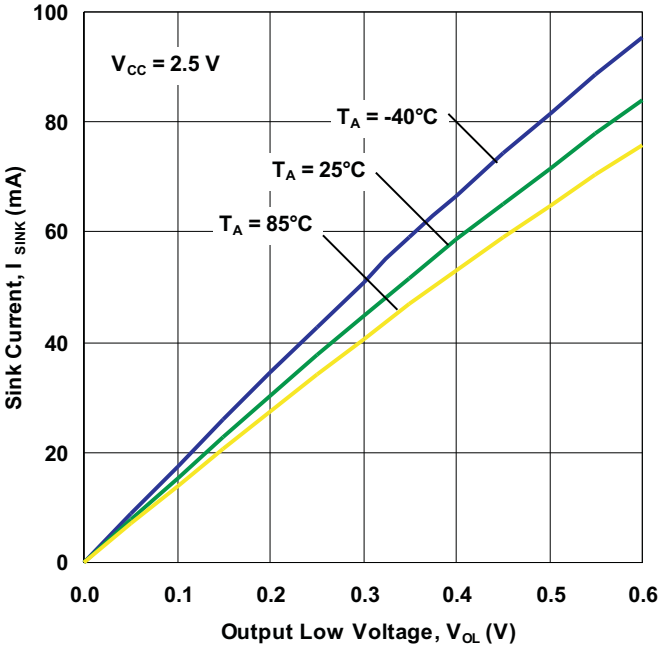
TYPICAL CHARACTERISTICS (continued)

T_A = 25°C (unless otherwise noted)

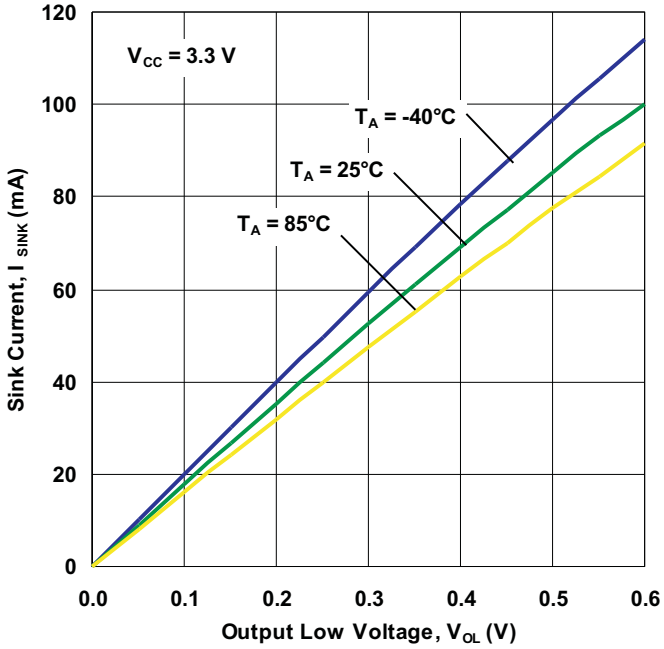
I/O SINK CURRENT
vs
OUTPUT LOW VOLTAGE



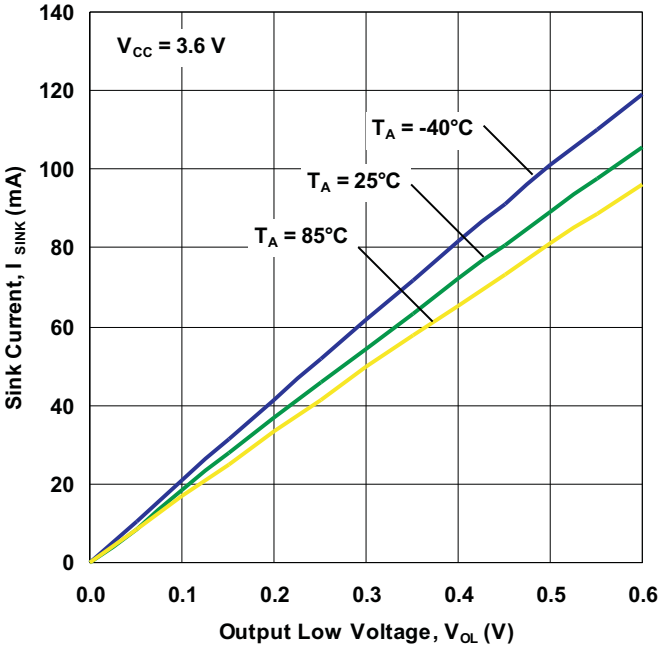
I/O SINK CURRENT
vs
OUTPUT LOW VOLTAGE



I/O SINK CURRENT
vs
OUTPUT LOW VOLTAGE



I/O SINK CURRENT
vs
OUTPUT LOW VOLTAGE

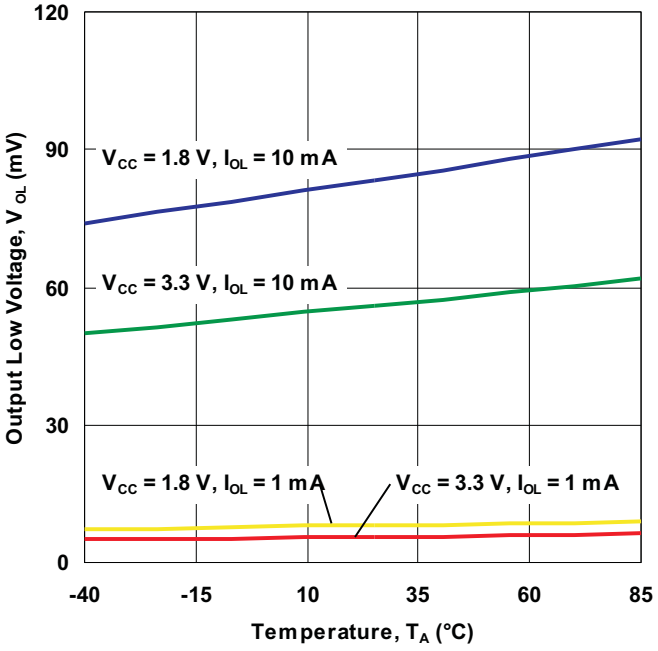


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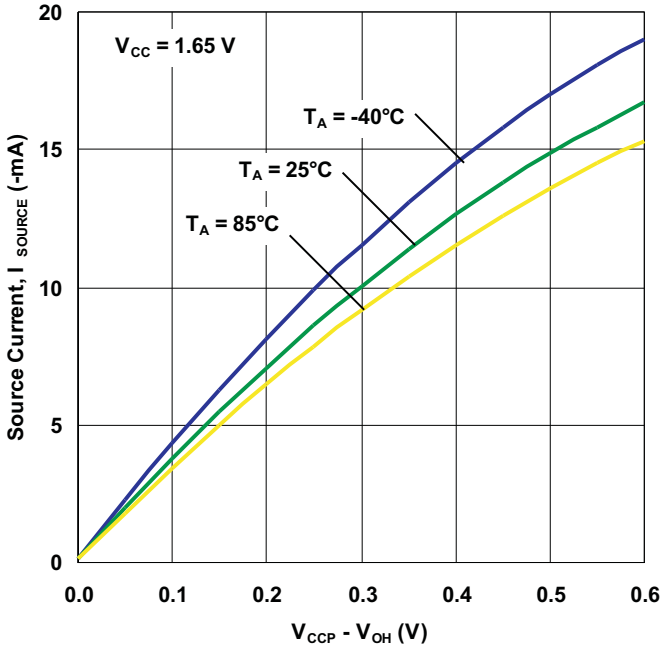
TYPICAL CHARACTERISTICS (continued)

T_A = 25°C (unless otherwise noted)

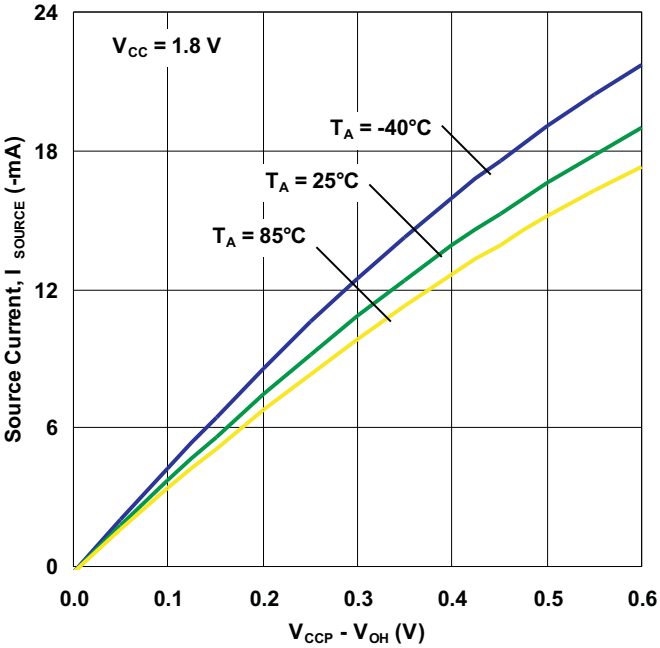
I/O LOW VOLTAGE vs TEMPERATURE



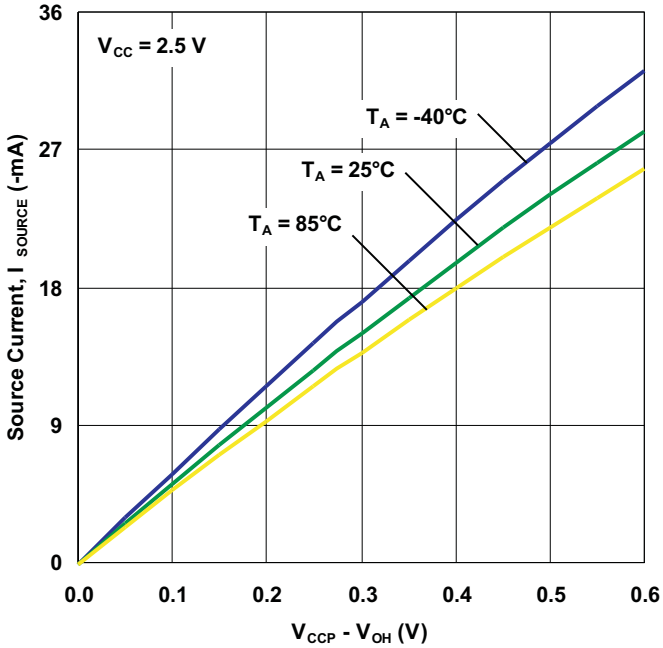
I/O SOURCE CURRENT vs OUTPUT HIGH VOLTAGE



I/O SOURCE CURRENT vs OUTPUT HIGH VOLTAGE



I/O SOURCE CURRENT vs OUTPUT HIGH VOLTAGE

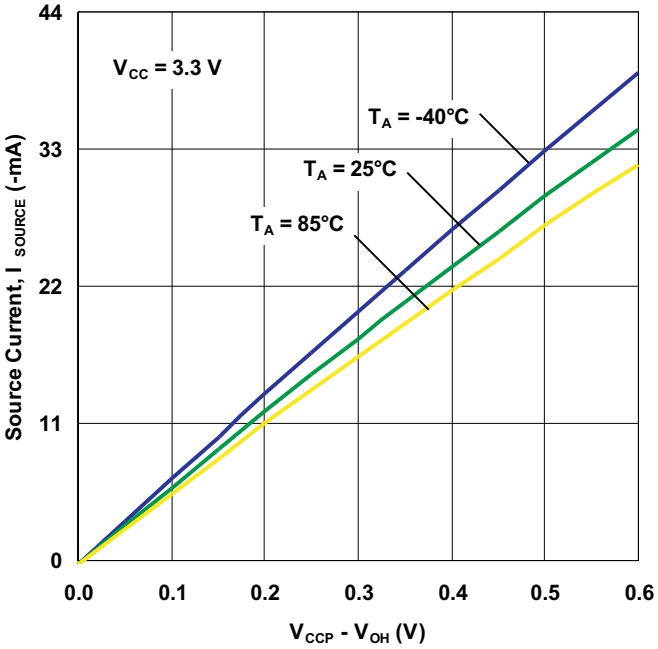


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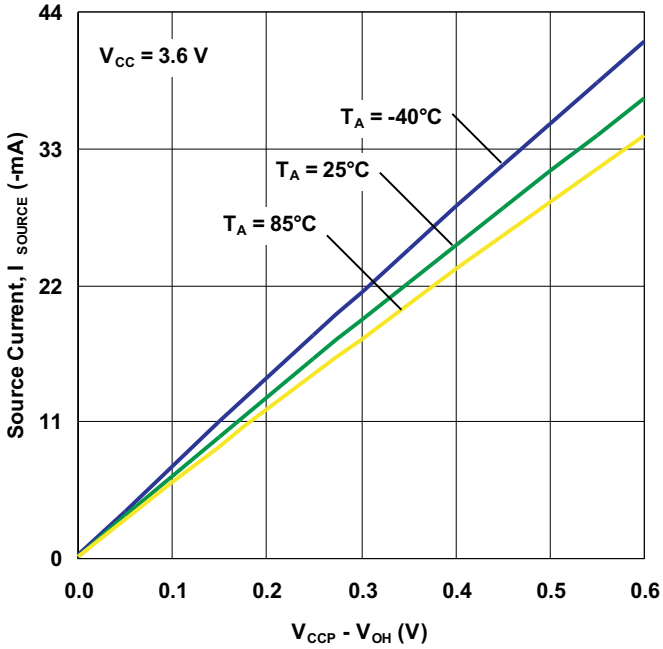
TYPICAL CHARACTERISTICS (continued)

T_A = 25°C (unless otherwise noted)

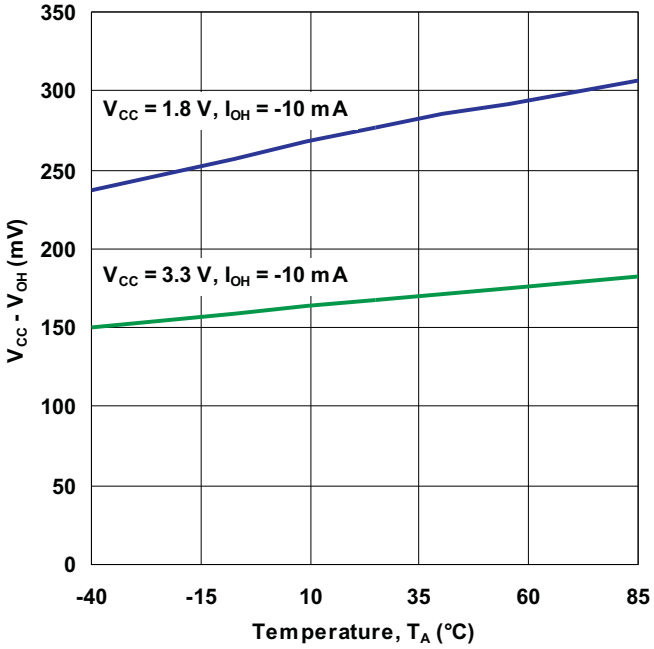
I/O SOURCE CURRENT
vs
OUTPUT HIGH VOLTAGE



I/O SOURCE CURRENT
vs
OUTPUT HIGH VOLTAGE

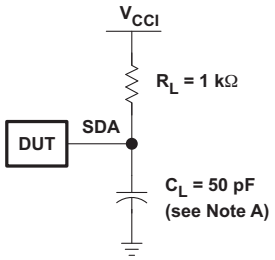


I/O HIGH VOLTAGE
vs
TEMPERATURE

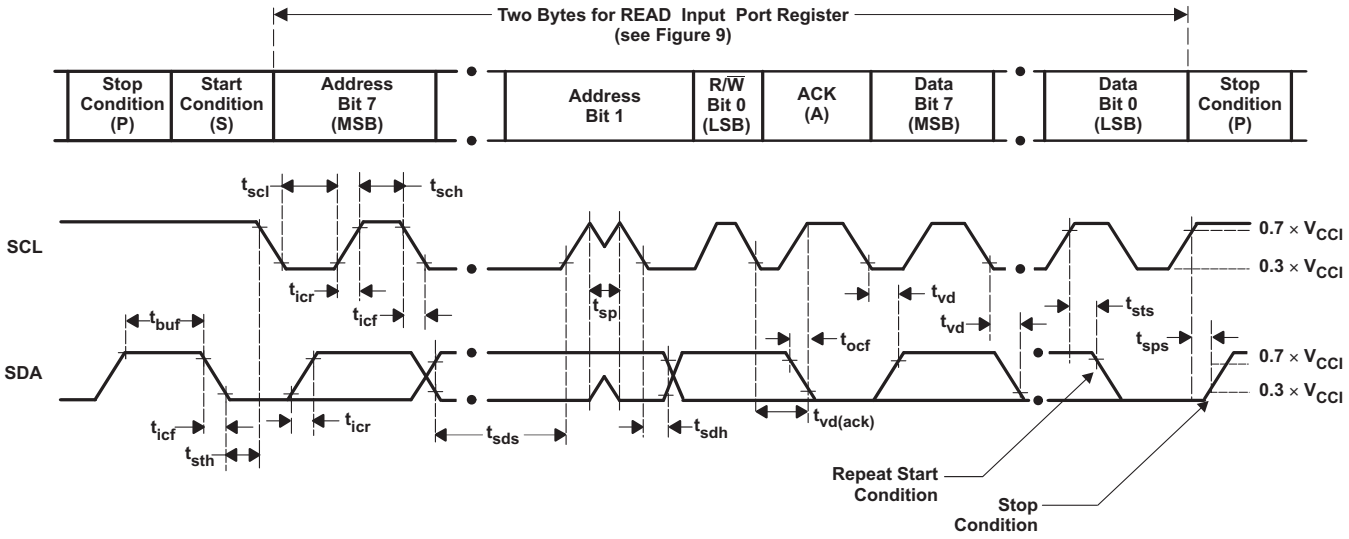


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PARAMETER MEASUREMENT INFORMATION



SDA LOAD CONFIGURATION



VOLTAGE WAVEFORMS

BYTE	DESCRIPTION
1	I^2C address
2	Input register port data

A. C_L includes probe and jig capacitance. t_{ocf} is measured with C_L of 10 pF or 400 pF.

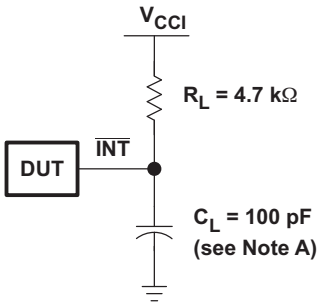
B. All inputs are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r/t_f ≤ 30 ns.

C. All parameters and waveforms are not applicable to all devices.

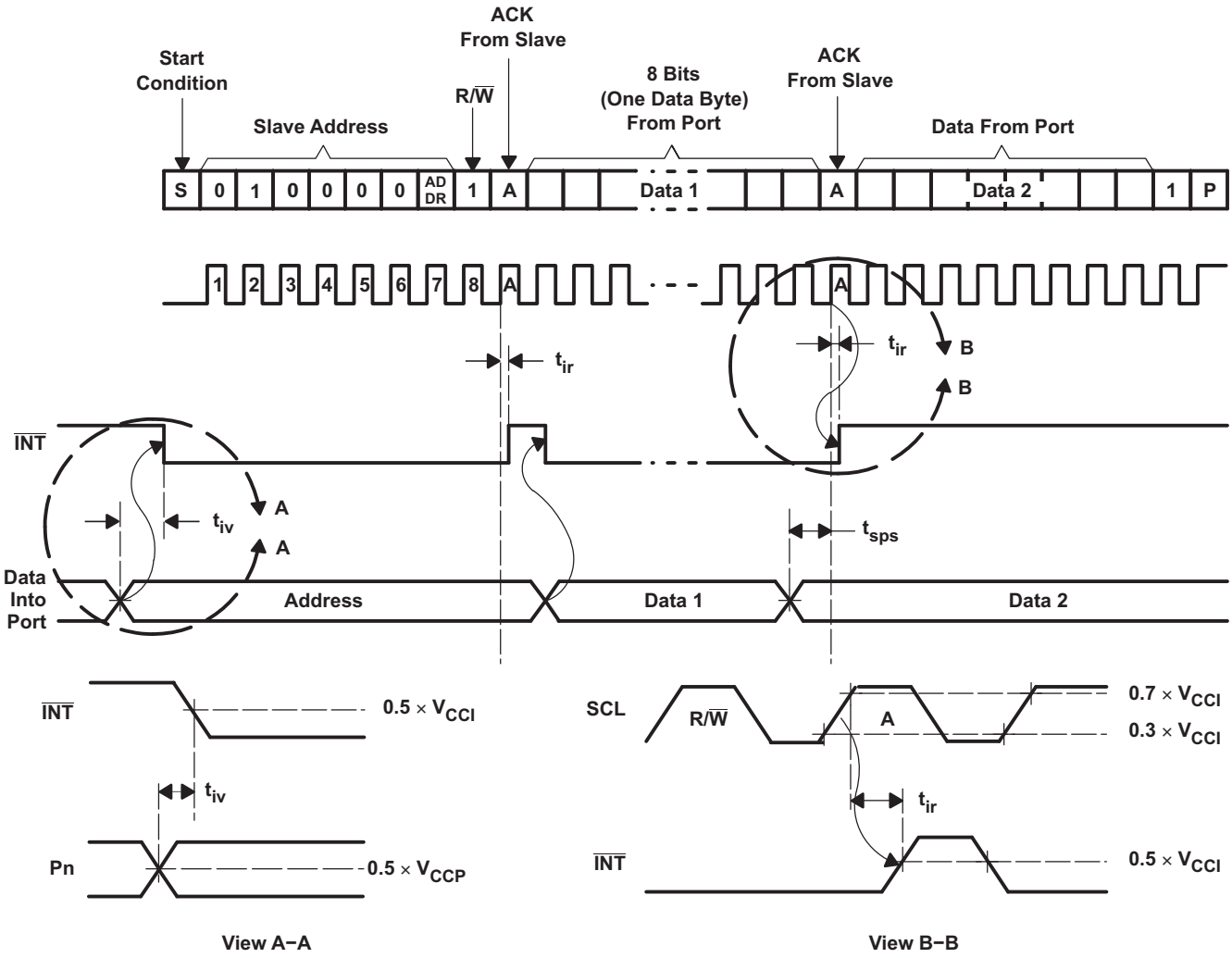
Figure 12. I^2C Interface Load Circuit and Voltage Waveforms

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PARAMETER MEASUREMENT INFORMATION (continued)



INTERRUPT LOAD CONFIGURATION



A. C_L includes probe and jig capacitance.

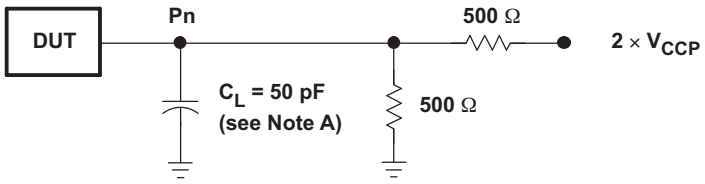
B. All inputs are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r/t_f ≤ 30 ns.

C. All parameters and waveforms are not applicable to all devices.

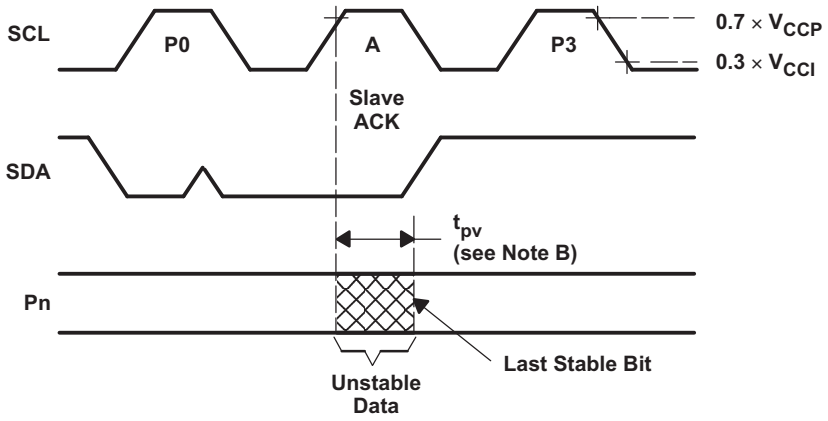
Figure 13. Interrupt Load Circuit and Voltage Waveforms

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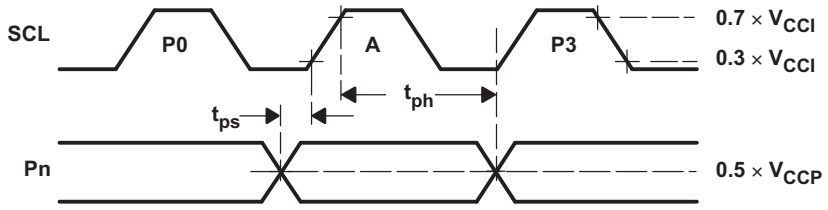
PARAMETER MEASUREMENT INFORMATION (continued)



P-PORT LOAD CONFIGURATION



WRITE MODE (R/$\overline{W}$ = 0)



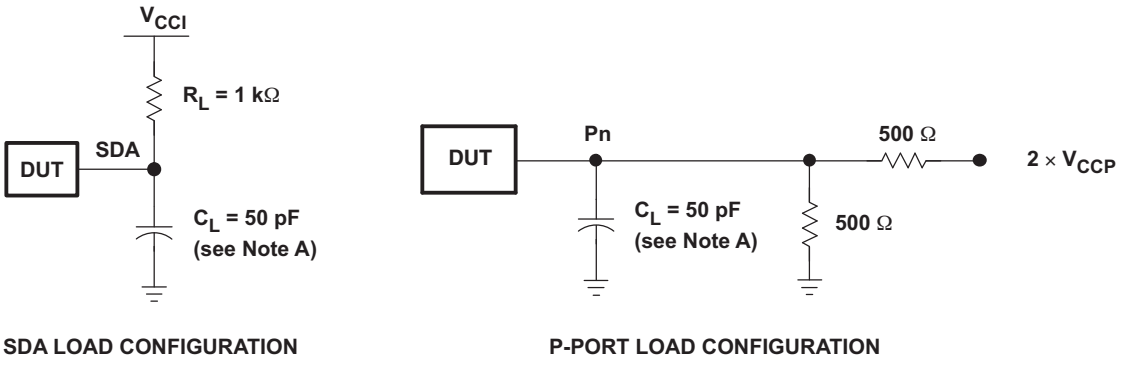
READ MODE (R/$\overline{W}$ = 1)

A. C_L includes probe and jig capacitance.
B. t_{pv} is measured from 0.7 × V_{CC} on SCL to 50% I/O (Pn) output.
C. All inputs are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r/t_f ≤ 30 ns.
D. The outputs are measured one at a time, with one transition per measurement.
E. All parameters and waveforms are not applicable to all devices.

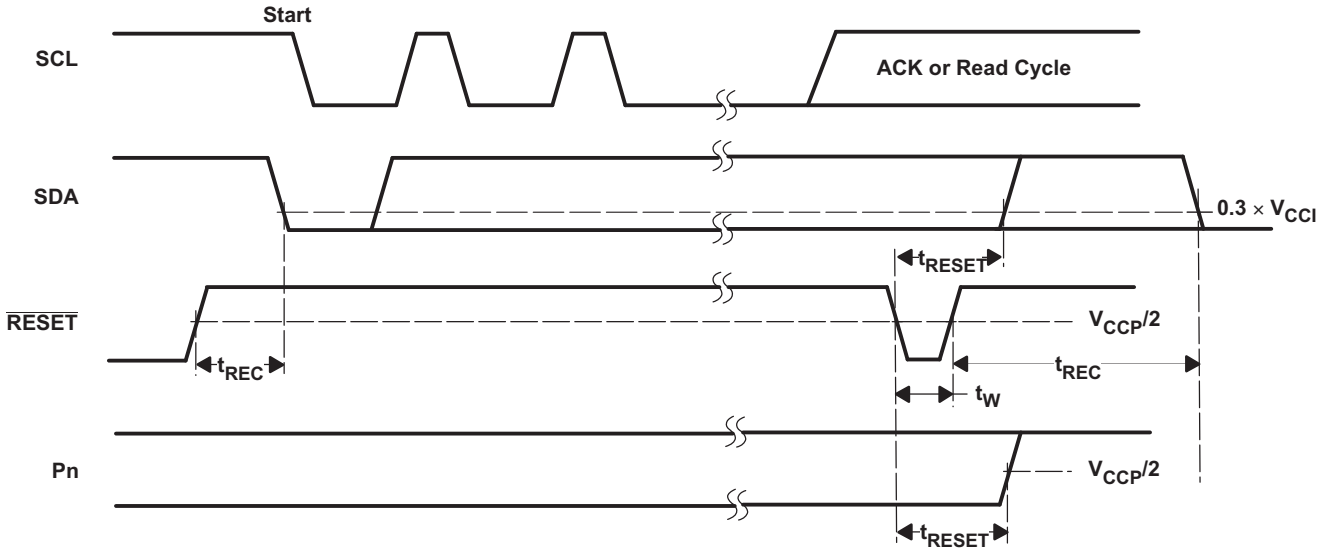
Figure 14. P Port Load Circuit and Timing Waveforms

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PARAMETER MEASUREMENT INFORMATION (continued)



SDA LOAD CONFIGURATION P-PORT LOAD CONFIGURATION



A. C_L includes probe and jig capacitance.

B. All inputs are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r/t_f ≤ 30 ns.

C. The outputs are measured one at a time, with one transition per measurement.

D. I/Os are configured as inputs.

E. All parameters and waveforms are not applicable to all devices.

Figure 15. Reset Load Circuits and Voltage Waveforms

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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
TCA6418EYFPR	ACTIVE	DSBGA	YFP	25	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	(AZ2 ~ AZN)	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.

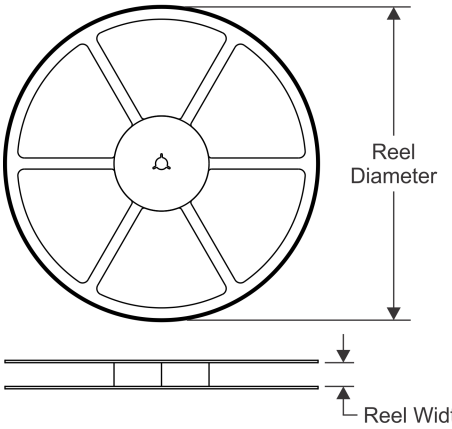
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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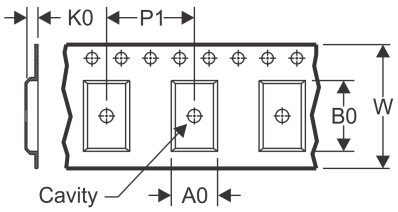
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TAPE AND REEL INFORMATION

REEL DIMENSIONS

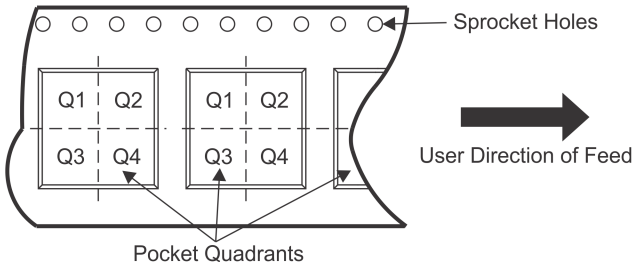


TAPE DIMENSIONS



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

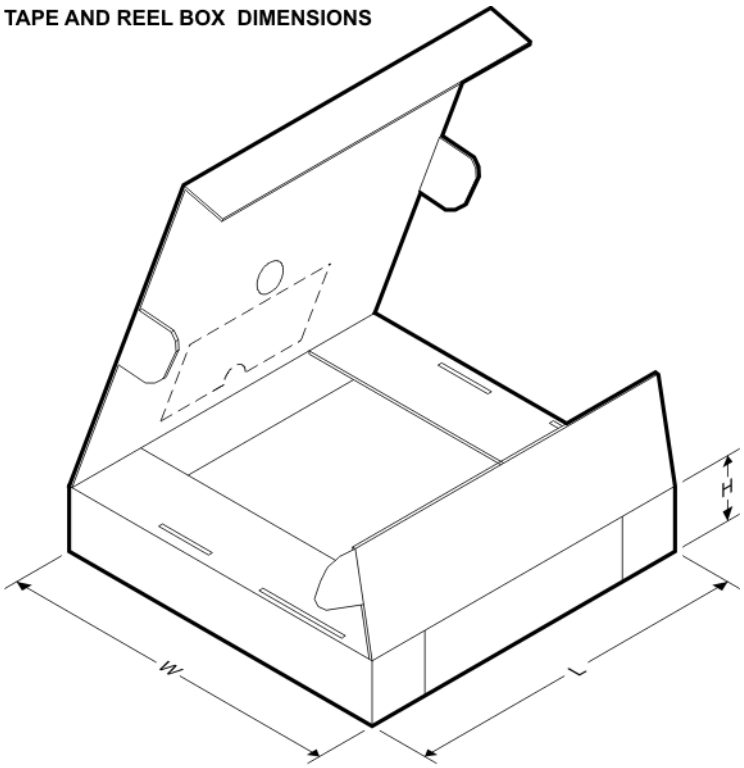
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TCA6418EYFPR	DSBGA	YFP	25	3000	178.0	9.2	2.09	2.09	0.62	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

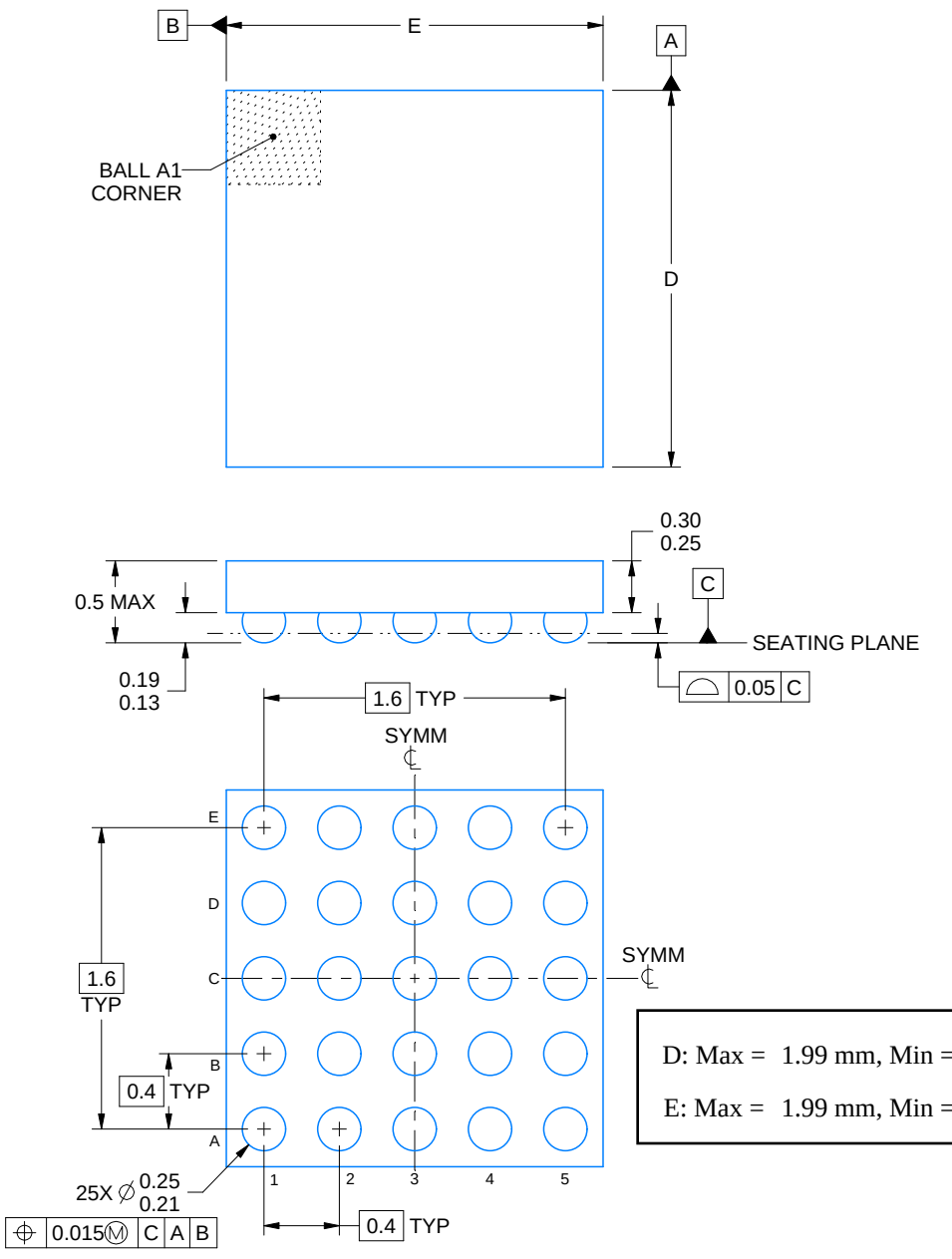
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TCA6418EYFPR	DSBGA	YFP	25	3000	220.0	220.0	35.0

PACKAGE OUTLINE

YFP0025

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



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NOTES:

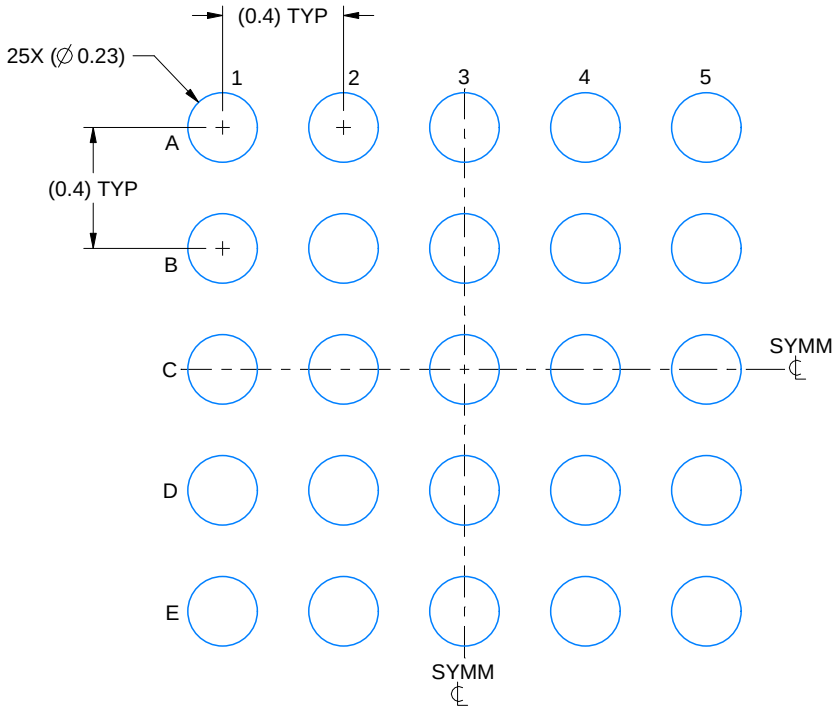
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

EXAMPLE BOARD LAYOUT

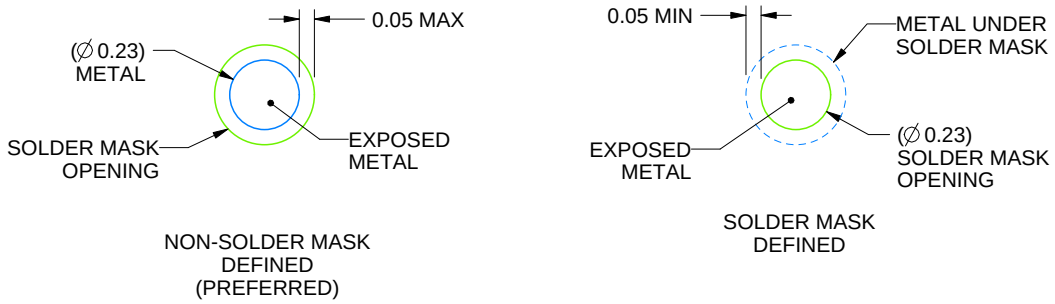
YFP0025

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 40X



SOLDER MASK DETAILS
NOT TO SCALE

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NOTES: (continued)

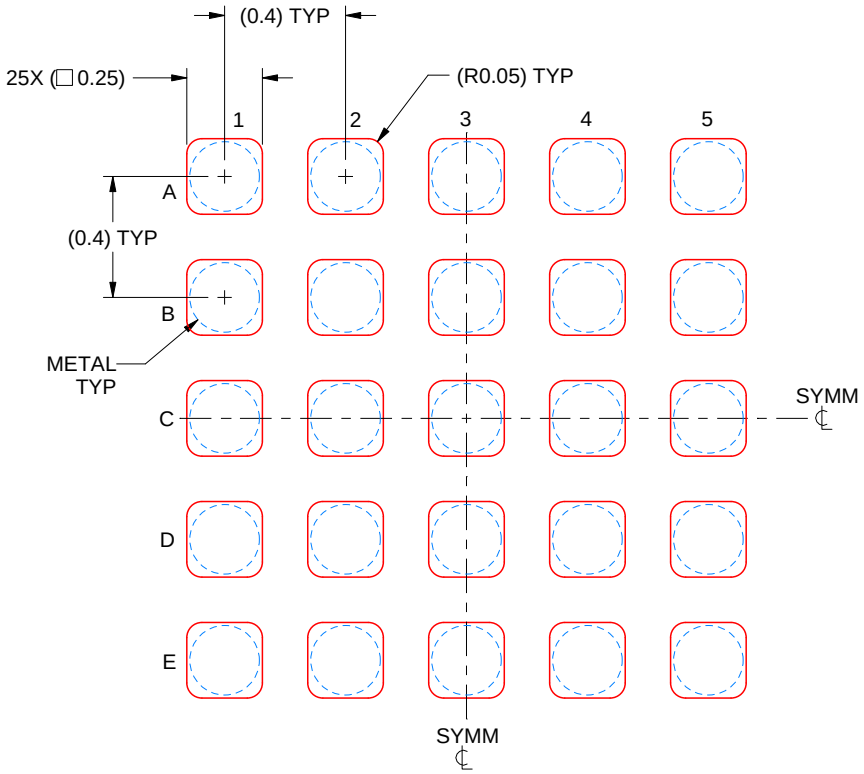
3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints.
   See Texas Instruments Literature No. SNVA009 (www.ti.com/lit/snva009).

EXAMPLE STENCIL DESIGN

YFP0025

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE: 40X

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NOTES: (continued)

4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

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