

## REAL-TIME CLOCK (RTC)

 Check for Samples: [BQ32000](#)

### FEATURES

- Automatic Switchover to Backup Supply
- I<sup>2</sup>C Interface  
Supports Serial Clock up to 400 kHz
- Uses 32.768-kHz Crystal  
With –63-ppm to +126-ppm Adjustment
- Integrated Oscillator-Fail Detection
- 8-Pin SOIC Package
- –40°C to 85°C Ambient Operating Temperature

### APPLICATIONS

- General consumer electronics

### DESCRIPTION

The bq32000 device is a compatible replacement for industry standard real-time clocks.

The bq32000 features an automatic backup supply with integrated trickle charger. The backup supply can be implemented using a capacitor or non-rechargeable battery. The bq32000 has a programmable calibration adjustment from –63 ppm to +126 ppm. The bq32000 registers include an OF (oscillator fail) flag indicating the status of the RTC oscillator, as well as a STOP bit that allows the host processor to disable the oscillator. The time registers are normally updated once per second, and all the registers are updated at the same time to prevent a timekeeping glitch. The bq32000 includes automatic leap-year compensation.

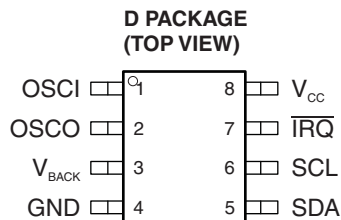
### ORDERING INFORMATION<sup>(1)</sup>

T <sub>A</sub>	PACKAGE <sup>(2)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	SOIC – D	Reel of 2500	BQ32000DR	bq32000 xx y zzzz <sup>(3)</sup>

- (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](http://www.ti.com).
- (2) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).
- (3) xx = date code, y = assembly site, zzzz = lot code

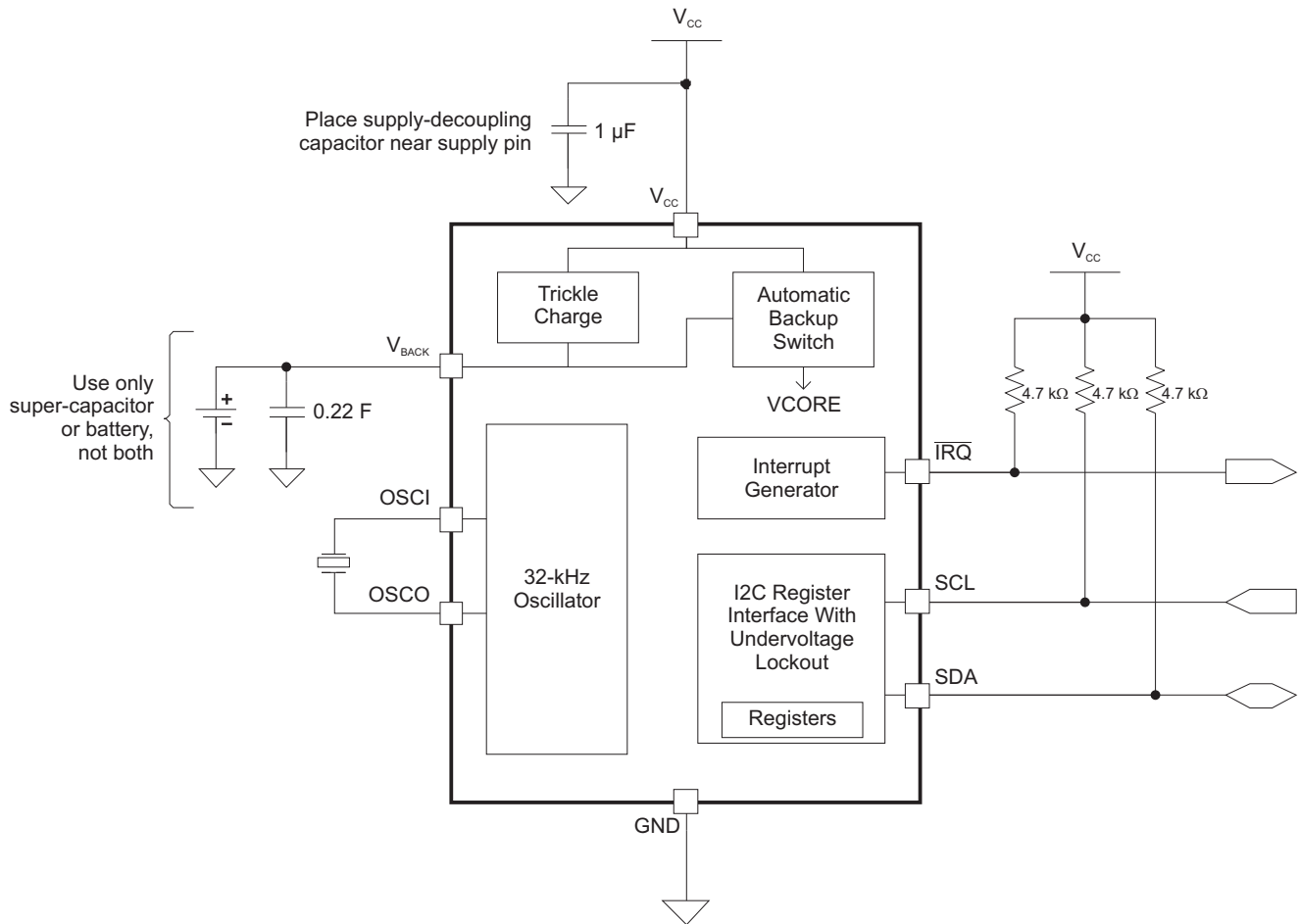


Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

**TERMINAL FUNCTIONS**

NAME	NO.	TYPE	DESCRIPTION
<b>Power and Ground</b>			
$V_{CC}$	8	-	Main device power
GND	4	-	Ground
$V_{BACK}$	3	-	Backup device power
<b>Serial Interface</b>			
SCL	6	I	I <sup>2</sup> C serial interface clock
SDA	5	I/O	I <sup>2</sup> C serial data
<b>Interrupt</b>			
$\overline{IRQ}$	7	O	Configurable interrupt output. Open-drain output.
<b>Oscillator</b>			
OSCI	1	-	Oscillator input
OSCO	2	-	Oscillator output

FUNCTIONAL BLOCK DIAGRAM AND APPLICATION CIRCUIT



NOTE: All pullup resistors should be connected to V<sub>CC</sub> such that no pullup is applied during backup supply operation.

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

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

		LIMIT	UNIT	
V <sub>IN</sub>	Input voltage	V <sub>CC</sub> to GND	-0.3 to 4	V
		All other pins to GND	-0.3 to V <sub>CC</sub> + 0.3	V
T <sub>J</sub>	Operating junction temperature	-40 to 150	°C	
T <sub>STG</sub>	Storage temperature range after reflow	-60 to 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.

## RECOMMENDED OPERATING CONDITIONS

		MIN	TYP	MAX	UNIT
V <sub>CC</sub>	Supply voltage, V <sub>CC</sub> to GND	3		3.6	V
T <sub>A</sub>	Operating free-air temperature	-40		85	°C
f <sub>o</sub>	Crystal resonant frequency		32.768		kHz
R <sub>S</sub>	Crystal series resistance			40	kΩ
C <sub>L</sub>	Crystal load capacitance		12		pF

## ELECTRICAL CHARACTERISTICS

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

PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT	
<b>Power Supply</b>						
I <sub>CC</sub>	V <sub>CC</sub> supply current		100		μA	
V <sub>BACK</sub>	Backup supply voltage	Operating	1.4	V <sub>CC</sub>	V	
		Switchover	2.0	V <sub>CC</sub>	V	
I <sub>BACK</sub>	Backup supply current	V <sub>CC</sub> = 0 V, V <sub>BAT</sub> = 3V, Oscillator on, T <sub>A</sub> = 25°C		1.2	1.5	μA
<b>Logic Level Inputs</b>						
V <sub>IL</sub>	Input low voltage			0.3 V <sub>CC</sub>	V	
V <sub>IH</sub>	Input high voltage		0.7 V <sub>CC</sub>		V	
I <sub>IN</sub>	Input current	0 V ≤ V <sub>IN</sub> ≤ V <sub>CC</sub>		-1	1	μA
<b>Logic Level Outputs</b>						
V <sub>OL</sub>	Output low voltage	I <sub>OL</sub> = 3 mA		0.4	V	
I <sub>L</sub>	Leakage current	-1		1	μA	
<b>Real-Time Clock Characteristics</b>						
	Pre-calibration accuracy	V <sub>CC</sub> = 3.3 V, V <sub>BAT</sub> = 3 V, Oscillator on, T <sub>A</sub> = 25°C		±35 <sup>(1)</sup>	ppm	

- (1) Typical accuracy is measured using reference board design and KDS DMX-26S surface-mount 32.768-kHz crystal. Variation in board design and crystal section results in different typical accuracy.

DEVICE INFORMATION

**IRQ Function**

The  $\overline{\text{IRQ}}$  pin of the bq32000 functions as a general-purpose output or a frequency test output. The function of  $\overline{\text{IRQ}}$  is configurable in the device register space by setting the FT, FTF, and OUT bits. On initial power cycles, the OUT bit is set to one, and the FTF and FT bits are set to zero. On subsequent power-ups, with backup supply present, the OUT bit remains unchanged, and the FTF and FT bits are set to zero. When operating on backup supply, the  $\overline{\text{IRQ}}$  pin function is unused.  $\overline{\text{IRQ}}$  pullup resistor should be tied to  $V_{\text{CC}}$  to prevent  $\overline{\text{IRQ}}$  operation when operating on backup supply. The effect of the calibration logic is not normally observable when  $\overline{\text{IRQ}}$  is configured to output 1 Hz. The calibration logic functions by periodically adjusting the width of the 1-Hz clock. The calibration effect is observable only every eight or sixteen minutes, depending on the sign of the calibration.

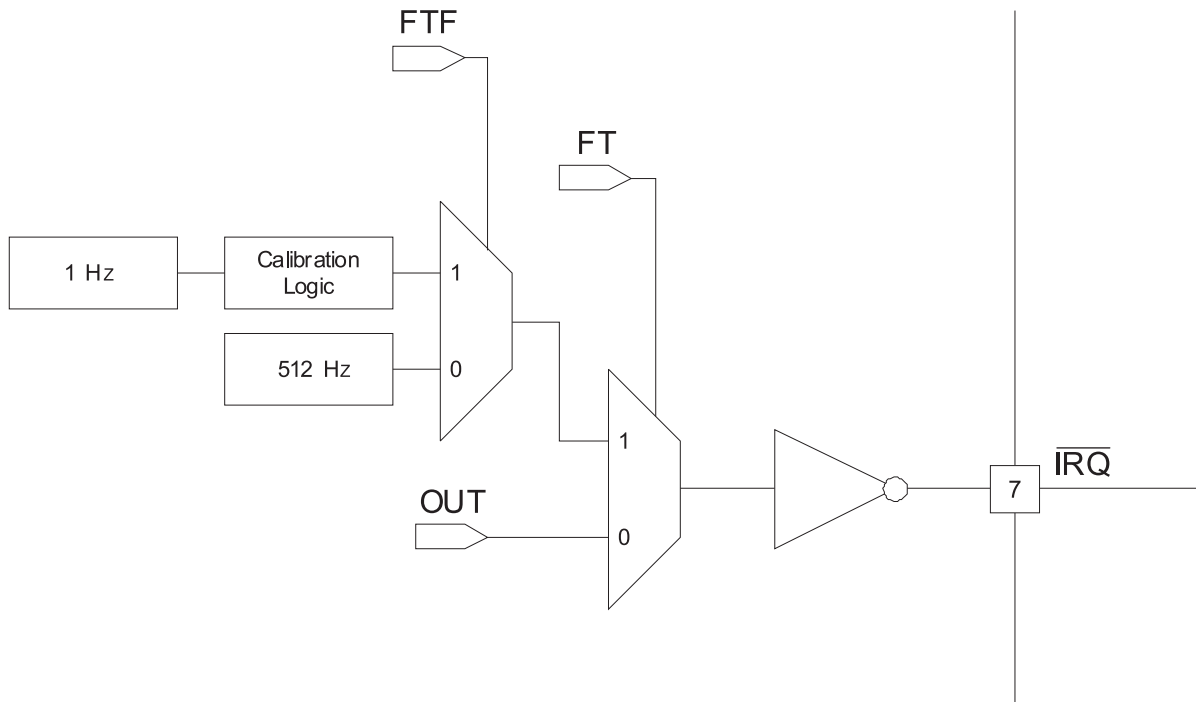


Figure 1.  $\overline{\text{IRQ}}$  Pin Functional Diagram

Table 1.  $\overline{\text{IRQ}}$  Function

FT	OUT	FTF	$\overline{\text{IRQ}}$ STATE
1	X	1	1 Hz
1	X	0	512 Hz
0	1	X	1
0	0	X	0

### V<sub>BACK</sub> Switchover

The bq32000 has an internal switchover circuit that causes the device to switch from main power supply to backup power supply when the voltage of the main supply pin V<sub>CC</sub> drops below a minimum threshold. The V<sub>BACK</sub> switchover circuit uses an internal reference voltage V<sub>REF</sub> derived from the on-chip bandgap reference; V<sub>REF</sub> is approximately 2.8 V. The device switches to the V<sub>BACK</sub> supply when V<sub>CC</sub> is less than the lesser of V<sub>BACK</sub> or V<sub>REF</sub>. Similarly, the device switches to the V<sub>CC</sub> supply when V<sub>CC</sub> is greater than either V<sub>BACK</sub> or V<sub>REF</sub>.

Some registers are reset to default values when the RTC switches from main power supply to backup power supply. Please see the register definitions to determine what register bits are effected by a backup switchover (effected bits have thier reset value (1/0) shown for 'Cycle', bits that are unchanged by backup are made 'UC').

The time keeping registers can take up to 1 second to update after the RTC switches from backup power supply to main power supply.

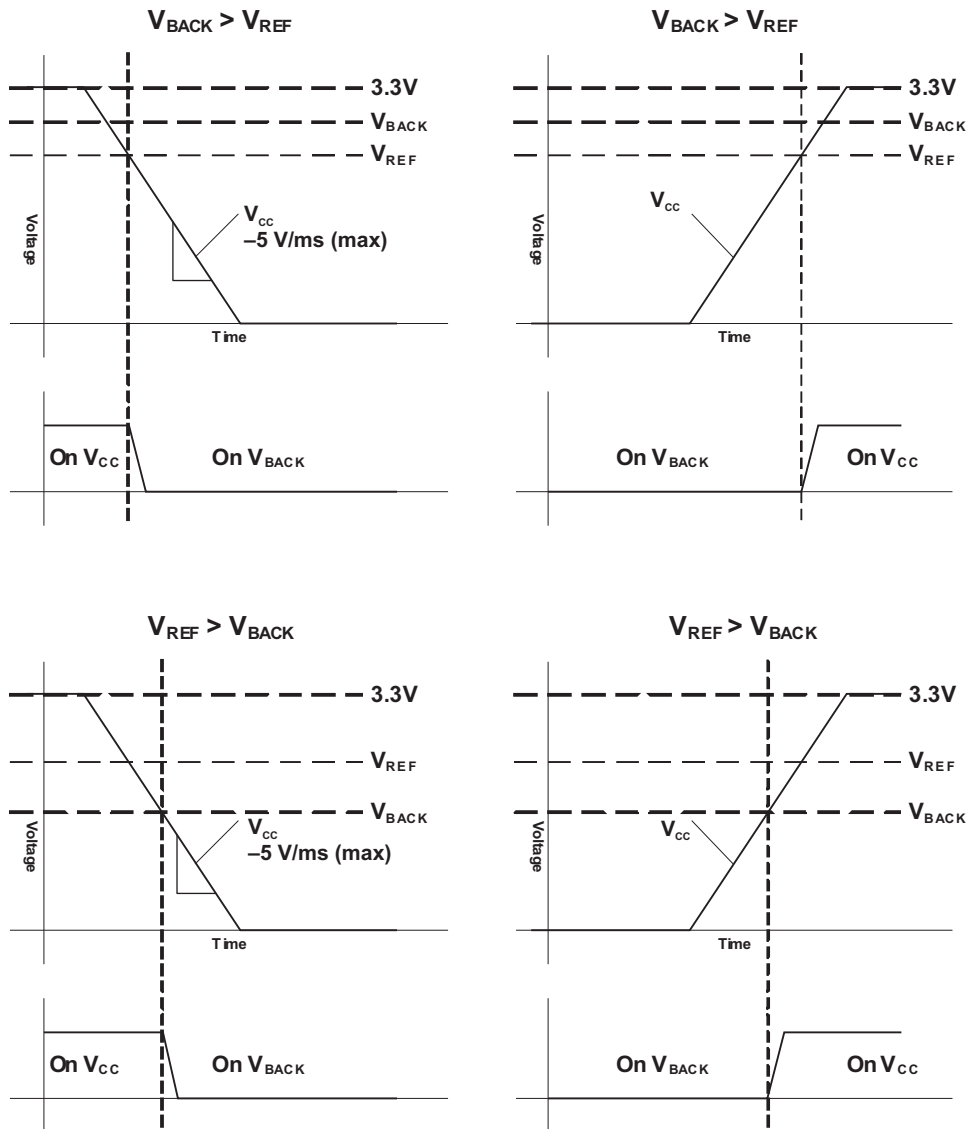


Figure 2. Switchover Diagram

## Trickle Charge

The bq32000 includes a trickle charge circuit to maintain the charge of the backup supply when a super capacitor is used. The trickle charge circuit is implemented as a series of three switches that are independently controlled by setting the TCHE[3:0], TCH2, and TCFE bits in the register space.

TCHE[3:0] must be written as 0x5h and TCH2 as 1 to close the trickle charge switches and enable charging of the backup supply from  $V_{CC}$ . Additionally, TCFE can be set to 1 to bypass the internal diode and boost the charge voltage of the backup supply. All trickle charge switches are opened when the device is initially powered on and each time the device switches from the main supply to the backup supply. The trickle charge circuit is intended for use with super capacitors; however, it can be used with a rechargeable battery under certain conditions. Care must be taken not to overcharge a rechargeable battery when enabling trickle charge. Follow all charging guidelines specific to the rechargeable battery or super capacitor when enabling trickle charge.

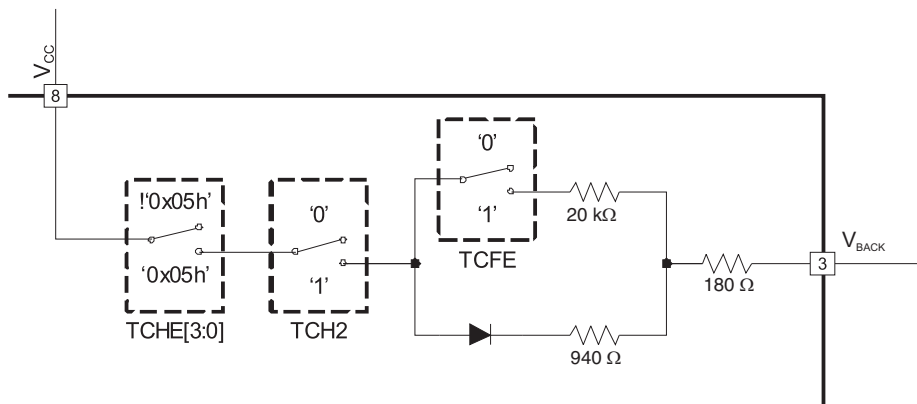


Figure 3. Trickle Charge Switch Functional Diagram

## I<sup>2</sup>C Serial Interface

The I<sup>2</sup>C interface allows control and monitoring of the RTC by a microcontroller. I<sup>2</sup>C is a two-wire serial interface developed by Philips Semiconductor (see I<sup>2</sup>C-Bus Specification, Version 2.1, January 2000).

The bus consists of a data line (SDA) and a clock line (SCL) with off-chip pullup resistors. When the bus is idle, both SDA and SCL lines are pulled high.

A master device, usually a microcontroller or a digital signal processor, controls the bus. The master is responsible for generating the SCL signal and device addresses. The master also generates specific conditions that indicate the START and STOP of data transfer.

A slave device receives and/or transmits data on the bus under control of the master device. This device operates only as a slave device.

I<sup>2</sup>C communication is initiated by a master sending a start condition, a high-to-low transition on the SDA I/O while SCL is held high. After the start condition, the device address byte is sent, most-significant bit (MSB) first, including the data direction bit (R/W). After receiving a valid address byte, this device responds with an acknowledge, a low on the SDA I/O during the high of the acknowledge-related clock pulse. This device responds to the I<sup>2</sup>C slave address 11010000b for write commands and slave address 11010001b for read commands.

This device does not respond to the general call address.

A data byte follows the address acknowledge. If the  $\overline{R/W}$  bit is low, the data is written from the master. If the  $\overline{R/W}$  bit is high, the data from this device are the values read from the register previously selected by a write to the subaddress register. The data byte is followed by an acknowledge sent from this device. Data is output only if complete bytes are received and acknowledged.

A stop condition, which is a low-to-high transition on the SDA I/O while the SCL input is high, is sent by the master to terminate the transfer. A master device must wait at least 60  $\mu$ s after the RTC exits backup mode to generate a START condition.

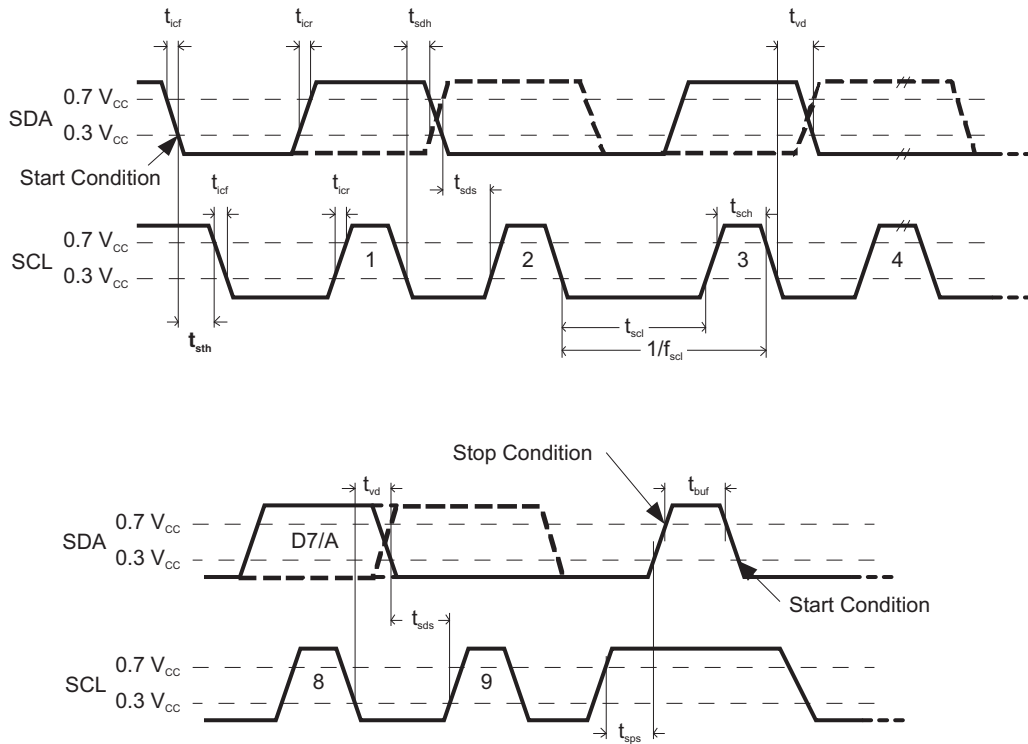


Figure 4. I<sup>2</sup>C Timing Diagram

Table 2. I<sup>2</sup>C Timing

PARAMETER	STANDARD MODE			FAST MODE			UNIT
	MIN	TYP	MAX	MIN	TYP	MAX	
f <sub>scl</sub>	I <sup>2</sup> C clock frequency			0		400	kHz
t <sub>sch</sub>	I <sup>2</sup> C clock high time			4			μs
t <sub>scl</sub>	I <sup>2</sup> C clock low time			4.7			μs
t <sub>sp</sub>	I <sup>2</sup> C spike time			0		50	ns
t <sub>sds</sub>	I <sup>2</sup> C serial data setup time			250		100	ns
t <sub>sdh</sub>	I <sup>2</sup> C serial data hold time			0		0	ns
t <sub>ier</sub>	I <sup>2</sup> C input rise time				1000	20 + 0.1C <sub>b</sub> <sup>(1)</sup>	300 ns
t <sub>ief</sub>	I <sup>2</sup> C input fall time				300	20 + 0.1C <sub>b</sub> <sup>(1)</sup>	300 ns
t <sub>ocf</sub>	I <sup>2</sup> C output fall time				300	20 + 0.1C <sub>b</sub> <sup>(1)</sup>	300 μs
t <sub>buf</sub>	I <sup>2</sup> C bus free time			4.7		1.3	μs
t <sub>sts</sub>	I <sup>2</sup> C Start setup time			4.7		0.6	μs
t <sub>sth</sub>	I <sup>2</sup> C Start hold time			4		0.6	μs
t <sub>sps</sub>	I <sup>2</sup> C Stop setup time			4		0.6	μs
t <sub>vd (data)</sub>	Valid data time (SCL low to SDA valid)				1		1 μs
t <sub>vd (ack)</sub>	Valid data time of ACK (ACK signal from SCL low to SDA low)				1		1 μs

(1) C<sub>b</sub> = total capacitance of one bus line in pF



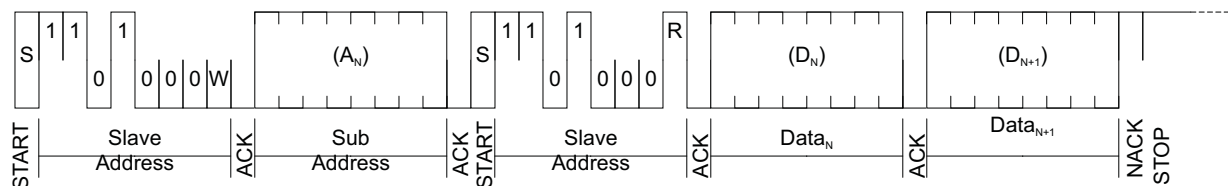


Figure 5. I<sup>2</sup>C Read Mode

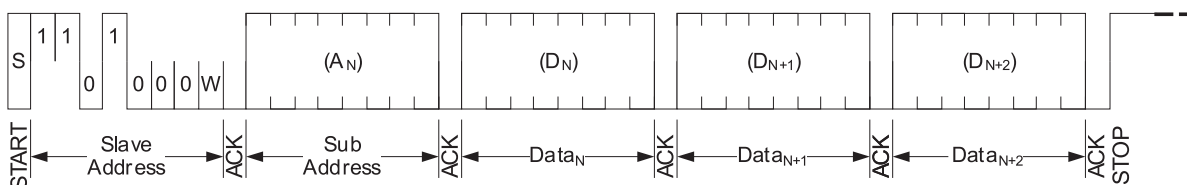


Figure 6. I<sup>2</sup>C Write Mode

Register Maps

Table 3. Normal Registers

REGISTER	ADDRESS (HEX)	REGISTER NAME	DESCRIPTION
0	0x00	SECONDS	Clock seconds and STOP bit
1	0x01	MINUTES	Clock minutes
2	0x02	CENT_HOURS	Clock hours, century, and CENT_EN bit
3	0x03	DAY	Clock day
4	0x04	DATE	Clock date
5	0x05	MONTH	Clock month
6	0x06	YEARS	Clock years
7	0x07	CAL_CFG1	Calibration and configuration
8	0x08	TCH2	Trickle charge enable
9	0x09	CFG2	Configuration 2

Table 4. Special Function Registers

REGISTER	ADDRESS (HEX)	REGISTER NAME	DESCRIPTION
32	0x20	SF KEY 1	Special function key 1
33	0x21	SF KEY 2	Special function key 2
34	0x22	SFR	Special function register

## Normal Register Descriptions

### Table 5. SECONDS Register

**Address** 0x00  
**Name** SECONDS  
**Initial Value** 0XXXXXXb  
**Description** Clock seconds and STOP bit

D7	D6	D5	D4	D3	D2	D1	D0	BIT(S)
STOP	10_SECOND			1_SECOND				Name
r/w	r/w			r/w				Read/Write
0	X	X	X	X	X	X	X	Initial
UC	UC	UC	UC	UC	UC	UC	UC	Cycle

**STOP** Oscillator stop. The STOP bit is used to force the oscillator to stop oscillating. STOP is set to 0 on initial application of power, on all subsequent power cycles STOP remains unchanged. On initial power application STOP can be written to 1 and then written to 0 to force start the oscillator.

0 Normal  
 1 Stop

**10\_SECOND** BCD of tens of seconds. The 10\_SECOND bits are the BCD representation of the number of tens of seconds on the clock. Valid values are 0 to 5. If invalid data is written to 10\_SECOND, the clock will update with invalid data in 10\_SECOND until the counter rolls over; thereafter, the data in 10\_SECOND is valid. Time keeping registers can take up to 1 second to update after the RTC switches from backup power supply to main power supply.

**1\_SECOND** BCD of seconds. The 1\_SECOND bits are the BCD representation of the number of seconds on the clock. Valid values are 0 to 9. If invalid data is written to 1\_SECOND, the clock will update with invalid data in 1\_SECOND until the counter rolls over; thereafter, the data in 1\_SECOND is valid. Time keeping registers can take up to 1 second to update after the RTC switches from backup power supply to main power supply.

### Table 6. MINUTES Register

**Address** 0x01  
**Name** MINUTES  
**Initial Value** 1XXXXXXb  
**Description** Clock minutes

D7	D6	D5	D4	D3	D2	D1	D0	BIT(S)
OF	10_MINUTE			1_MINUTE				Name
r/w	r/w			r/w				Read/Write
1	X	X	X	X	X	X	X	Initial
0	UC	UC	UC	UC	UC	UC	UC	Cycle

**OF** Oscillator fail flag. The OF bit is a latched flag indicating when the 32.768-kHz oscillator has dropped at least four consecutive pulses. The OF flag is always set on initial power-up, and it can be cleared through the serial interface. When OF is 0, no oscillator failure has been detected. When OF is 1, the oscillator fail detect circuit has detected at least four consecutive dropped pulses.

0 No failure detected  
 1 Failure detected

**10\_MINUTE** BCD of tens of minutes. The 10\_MINUTE bits are the BCD representation of the number of tens of minutes on the clock. Valid values are 0 to 5. If invalid data is written to 10\_MINUTE, the clock will update with invalid data in 10\_MINUTE until the counter rolls over; thereafter, the data in 10\_MINUTE is valid. Time keeping registers can take up to 1 second to update after the RTC switches from backup power supply to main power supply.

**1\_MINUTE** BCD of minutes. The 1\_MINUTE bits are the BCD representation of the number of minutes on the clock. Valid values are 0 to 9. If invalid data is written to 1\_MINUTE, the clock will update with invalid data in 1\_MINUTE until the counter rolls over; thereafter, the data in 1\_MINUTE is valid. Time keeping registers can take up to 1 second to update after the RTC switches from backup power supply to main power supply.

**Table 7. CENT\_HOURS Register**

**Address** 0x02  
**Name** CENT\_HOURS  
**Initial Value** XXXXXXXXb  
**Description** Clock hours, century, and CENT\_EN bit

D7	D6	D5	D4	D3	D2	D1	D0	BIT(S)
CENT_EN	CENT	10_HOUR		1_HOUR				Name
r/w	r/w	r/w		r/w				Read/Write
X	X	X	X	X	X	X	X	Initial
UC	UC	UC	UC	UC	UC	UC	UC	Cycle

**CENT\_EN** Century enable. The CENT\_EN bit enables the century timekeeping feature. If CENT\_EN is set to 1, then the clock tracks the century using the CENT bit. If CENT\_EN is set to 0, the clock ignores the CENT bit.

0 Century disabled  
1 Century enabled

**CENT** Century. The CENT bit tracks the century when century timekeeping is enabled. The clock toggles the CENT bit when the year count rolls from 99 to 00. Because the clock compliments the CENT bit, the user can define the meaning of CENT (1 for current century and 0 for next century, or 0 for current century and 1 for next century).

**10\_HOUR** BCD of tens of hours (24-hour format). The 10\_HOUR bits are the BCD representation of the number of tens of hours on the clock, in 24-hour format. Valid values are 0 to 2. If invalid data is written to 10\_HOUR, the clock will update with invalid data in 10\_HOUR until the counter rolls over; thereafter, the data in 10\_HOUR is valid. Time keeping registers can take up to 1 second to update after the RTC switches from backup power supply to main power supply.

**1\_HOUR** BCD of hours (24-hour format). The 1\_HOUR bits are the BCD representation of the number of hours on the clock, in 24-hour format. Valid values are 0 to 9. If invalid data is written to 1\_HOUR, the clock will update with invalid data in 1\_HOUR until the counter rolls over; thereafter, the data in 1\_HOUR is valid. Time keeping registers can take up to 1 second to update after the RTC switches from backup power supply to main power supply.

**Table 8. DAY Register**

**Address** 0x03  
**Name** DAY  
**Initial Value** 00000XXXb  
**Description** Clock day

D7	D6	D5	D4	D3	D2	D1	D0	BIT(S)
RSVD				DAY				Name
r/w				r/w				Read/Write
0	0	0	0	0	X	X	X	Initial
0	0	0	0	0	UC	UC	UC	Cycle

**RSVD** Reserved. The RSVD bits should always be written as 0.

**DAY** BCD of the day of the week. The DAY bits are the BCD representation of the day of the week. Valid values are 1 to 7 and represent the days from Sunday to Saturday. DAY updates if set to 0 until the counter rolls over; thereafter, the data in DAY is valid. Time keeping registers can take up to 1 second to update after the RTC switches from backup power supply to main power supply.

1 Sunday  
2 Monday  
3 Tuesday  
4 Wednesday  
5 Thursday  
6 Friday  
7 Saturday

**Table 9. DATE Register**

**Address** 0x04  
**Name** DATE  
**Initial Value** 00XXXXXXb  
**Description** Clock date

D7	D6	D5	D4	D3	D2	D1	D0	BIT(S)
RSVD		10_DATE		1_DATE				Name
r/w		r/w		r/w				Read/Write
0	0	X	X	X	X	X	X	Initial
0	0	UC	UC	UC	UC	UC	UC	Cycle

RSVD Reserved. The RSVD bits should always be written as 0.

10\_DATE BCD of tens of date. The 10\_DATE bits are the BCD representation of the tens of date on the clock. Valid values are 0 to 3<sup>(1)</sup>. If invalid data is written to 10\_DATE, the clock will update with invalid data in 10\_DATE until the counter rolls over; thereafter, the data in 10\_DATE is valid. Time keeping registers can take up to 1 second to update after the RTC switches from backup power supply to main power supply.

1\_DATE BCD of date. The 1\_DATE bits are the BCD representation of the date on the clock. Valid values are 0 to 9<sup>(1)</sup>. If invalid data is written to 1\_DATE, the clock will update with invalid data in 1\_DATE until the counter rolls over; thereafter, the data in 1\_DATE is valid. Time keeping registers can take up to 1 second to update after the RTC switches from backup power supply to main power supply.

(1) 10\_DATE and 1\_DATE must form a valid date, 01 to 31, dependent on month and year.

**Table 10. MONTH Register**

**Address** 0x05  
**Name** MONTH  
**Initial Value** 000XXXXXb  
**Description** Clock month

D7	D6	D5	D4	D3	D2	D1	D0	BIT(S)
RSVD			10_MONTH	1_MONTH				Name
r/w			r/w	r/w				Read/Write
0	0	0	X	X	X	X	X	Initial
0	0	0	UC	UC	UC	UC	UC	Cycle

RSVD Reserved. The RSVD bits should always be written as 0.

10\_MONTH BCD of tens of month. The 10\_MONTH bits are the BCD representation of the tens of month on the clock. Valid values are 0 to 1<sup>(1)</sup>. If invalid data is written to 10\_MONTH, the clock will update with invalid data in 10\_MONTH until the counter rolls over; thereafter, the data in 10\_MONTH is valid.

1\_MONTH BCD of month. The 1\_MONTH bits are the BCD representation of the month on the clock. Valid values are 0 to 9<sup>(1)</sup>. If invalid data is written to 1\_MONTH, the clock will update with invalid data in 1\_MONTH until the counter rolls over; thereafter, the data in 1\_MONTH is valid.

(1) 10\_MONTH and 1\_MONTH must form a valid date, 01 to 12.

**Table 11. YEARS Register**

**Address** 0x06  
**Name** YEARS  
**Initial Value** XXXXXXXXb  
**Description** Clock year

D7	D6	D5	D4	D3	D2	D1	D0	BIT(S)
10_YEAR				1_YEAR				Name
r/w				r/w				Read/Write
X	X	X	X	X	X	X	X	Initial
UC	UC	UC	UC	UC	UC	UC	UC	Cycle

**10\_YEAR** BCD of tens of years. The 10\_YEAR bits are the BCD representation of the tens of years on the clock. Valid values are 0 to 9. If invalid data is written to 10\_YEAR, the clock will update with invalid data in 10\_YEAR until the counter rolls over; thereafter, the data in 10\_YEAR is valid. Time keeping registers can take up to 1 second to update after the RTC switches from backup power supply to main power supply.

**1\_YEAR** BCD of year. The 1\_YEAR bits are the BCD representation of the years on the clock. Valid values are 0 to 9. If invalid data is written to 1\_YEAR, the clock will update with invalid data in 1\_YEAR until the counter rolls over; thereafter, the data in 1\_YEAR is valid. Time keeping registers can take up to 1 second to update after the RTC switches from backup power supply to main power supply.

**Table 12. CAL\_CFG1 Register**

**Address** 0x07  
**Name** CAL\_CFG1  
**Initial Value** 1000000b  
**Description** Calibration and control

D7	D6	D5	D4	D3	D2	D1	D0	BIT(S)
OUT	FT	S	CAL					Name
r/w	r/w	r/w	r/w					Read/Write
1	0	0	0	0	0	0	0	Initial
UC	UC	UC	UC	UC	UC	UC	UC	Cycle

**OUT** Logic output, when FT = 0. When FT is zero, the logic output of  $\overline{\text{IRQ}}$  pin reflects the value of OUT.

0  $\overline{\text{IRQ}}$  is logic 0

1  $\overline{\text{IRQ}}$  is logic 1

**FT** Frequency test. The FT bit is used to enable the frequency test signal on the  $\overline{\text{IRQ}}$  pin. When FT is 1, a square wave is produced on the  $\overline{\text{IRQ}}$  pin. The FTF bit in the SFR register determines the frequency of the test signal.

0 Disable

1 Enable

**S** Calibration sign. The S bit determines the polarity of the calibration applied to the oscillator. If S is 0, then the calibration slows the RTC. If S is 1, then the calibration speeds the RTC.

0 Slowing (+)

1 Speeding (–)

**CAL** Calibration. The CAL bits along with S determine the calibration amount as shown in [Table 13](#).

**Table 13. Calibration**

CAL (DEC)	S = 0	S = 1
0	+0 ppm	–0 ppm
1	+2 ppm	–4 ppm
N	+N / 491520 (per minute)	–N / 245760 (per minute)
30	+61 ppm	–122 ppm
31	+63 ppm	–126 ppm

**Table 14. TCH2 Register**

**Address** 0x08  
**Name** TCH2  
**Initial Value** 10010000b  
**Description** Trickle charge TCH2 control

D7	D6	D5	D4	D3	D2	D1	D0	BIT(S)
RSVD		TCH2	RSVD					Name
r/w		r/w	r/w					Read/Write
1	0	0	1	0	0	0	0	Initial
UC	0	0	1	UC	UC	UC	UC	Cycle

RSVD Reserved. The RSVD bits should always be written as 0.

TCH2 Trickle charge switch two. The TCH2 bit determines if the internal trickle charge switch is closed or open. All the trickle charge switches must be closed in order for trickle charging to occur. If TCH2 is 0, then the TCH2 switch is open. If TCH2 is 1, then the TCH2 switch is closed.

0 Open  
 1 Closed

**Table 15. CFG2 Register**

**Address** 0x09  
**Name** CFG2  
**Initial Value** 10101010b  
**Description** Configuration 2

D7	D6	D5	D4	D3	D2	D1	D0	BIT(S)
RSVD	TCFE	RSVD		TCHE				Name
r/w	r/w	r/w		r/w				Read/Write
1	0	1	0	1	0	1	0	Initial
1	0	UC	UC	1	0	1	0	Cycle

RSVD Reserved. The RSVD bits should always be written as 0.

TCFE Trickle charge FET bypass. The TCFE bit is used to enable the trickle charge FET. When TCFE is 0, the FET is off. When TCFE is 1, the FET is on.

0 Open  
 1 Closed

TCHE Trickle charge enable. The TCHE bits determine if the trickle charger is active. If TCHE is 0x5, then the trickle charger is active, otherwise, the trickle charger is inactive.

## Special Function Registers

**Table 16. SF KEY 1 Register**

**Address** 0x20  
**Name** SF KEY 1  
**Initial Value** 00000000b  
**Description** Special function key 1

D7	D6	D5	D4	D3	D2	D1	D0	BIT(S)
SF KEY B1								Name
r/w								Read/Write
0	0	0	0	0	0	0	0	Initial
0	0	0	0	0	0	0	0	Cycle

**SF KEY B1** Special function access key byte 1. Reads as 0x00, and key is 0x5E.  
 The SF KEY 1 and SF KEY 2 registers are used to enable access to the main special function register (SFR). Access to SFR is granted only after the special function keys are written sequentially to SF KEY 1 and SF KEY 2. Each write to the SFR must be preceded by writing the SF keys to the SF key registers, in order, SF KEY 1 then SF KEY 2.

**Table 17. SF KEY 2 Register**

**Address** 0x21  
**Name** SF KEY 2  
**Initial Value** 00000000b  
**Description** Special function key 2

D7	D6	D5	D4	D3	D2	D1	D0	BIT(S)
SF KEY 2								Name
r/w								Read/Write
0	0	0	0	0	0	0	0	Initial
0	0	0	0	0	0	0	0	Cycle

**SF KEY 2** Special function access key byte 2. Reads as 0x00, and key is 0xC7.  
 The SF KEY 1 and SF KEY 2 registers are used to enable access to the main special function register (SFR). Access to SFR is granted only after the special function keys are written sequentially to SF KEY 1 and SF KEY 2. Each write to the SFR must be preceded by writing the SF keys to the SF key registers, in order, SF KEY 1 then SF KEY 2.

**Table 18. SFR Register**

**Address** 0x22  
**Name** SFR  
**Initial Value** 00000000b  
**Description** Special function register 1

D7	D6	D5	D4	D3	D2	D1	D0	BIT(S)
RSVD							FTF	Name
r/w							r/w	Read/Write
0	0	0	0	0	0	0	0	Initial
0	0	0	0	0	0	0	0	Cycle

**RSVD** Reserved. The RSVD bits should always be written as 0.

**FTF** Force calibration to 1 Hz. FTF allows the frequency of the calibration output to be changed from 512 Hz to 1 Hz. By default, FTF is cleared, and the RTC outputs a 512-Hz calibration signal. Setting FTF forces the calibration signal to 1 Hz, and the calibration tracks the internal ppm adjustment. Note: The default 512-Hz calibration signal does not include the effect of the ppm adjustment.

0 Normal 512-Hz calibration  
 1 1-Hz calibration

## PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
BQ32000D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	32000	<a href="#">Samples</a>
BQ32000DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	32000	<a href="#">Samples</a>

(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) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side 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 Top-Side Marking for that device.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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.



## TAPE AND REEL INFORMATION



### 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
BQ32000DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
BQ32000DR	SOIC	D	8	2500	367.0	367.0	35.0

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Applications Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

### TI E2E Community

[e2e.ti.com](http://e2e.ti.com)