

# DS32kHz 32.768kHz Temperature-Compensated Crystal Oscillator

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## GENERAL DESCRIPTION

The DS32kHz is a temperature-compensated crystal oscillator (TCXO) with an output frequency of 32.768kHz. This device addresses applications requiring better timekeeping accuracy, and can be used to drive the X1 input of most Dallas Semiconductor real-time clocks (RTCs), chipsets, and other ICs containing RTCs. This device is available in commercial (DS32kHz) and industrial (DS32kHz-N) temperature versions.

## APPLICATIONS

- GPS Receivers
- Telematics
- Network Timing and Synchronization in Servers, Routers, Hubs, and Switches
- Automatic Power Meters

## FEATURES

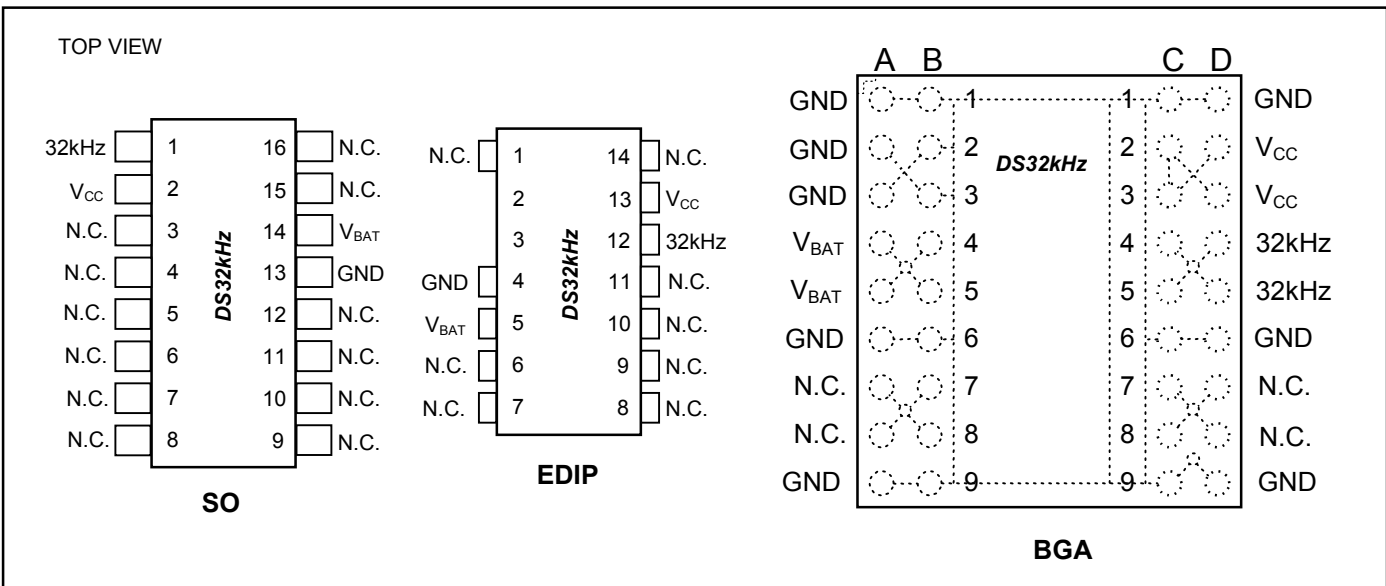
- Accurate to  $\pm 4$  Minutes/Year ( $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ )
- Accurate to  $\pm 1$  Minute/Year ( $0^{\circ}\text{C}$  to  $+40^{\circ}\text{C}$ )
- Battery Backup for Continuous Timekeeping
- $V_{\text{BAT}}$  Operating Voltage: 2.7V to 5.5V with  $V_{\text{CC}}$  Grounded
- $V_{\text{CC}}$  Operating Voltage: 4.5V to 5.5V
- Operating Temperature Range:
  - 0 $^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  (Commercial)
  - $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  (Industrial)
- No Calibration Required
- Low-Power Consumption
- Surface Mountable Using BGA Package
- UL Recognized

## ORDERING INFORMATION

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
DS32KHZ/DIP	0 $^{\circ}\text{C}$ to $+70^{\circ}\text{C}$	14 DIP	DS32KHZ
DS32KHZN/DIP	$-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$	14 DIP	DS32KHZ-N
DS32KHZS	0 $^{\circ}\text{C}$ to $+70^{\circ}\text{C}$	16 SO (0.300")	DS32KHZS
DS32KHZSN	$-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$	16 SO (0.300")	DS32KHZSN*
DS32KHZ/WBGA	0 $^{\circ}\text{C}$ to $+70^{\circ}\text{C}$	36 BGA	DS32KHZ
DS32KHZN/WBGA	$-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$	36 BGA	DS32KHZ-N

\*An "N" located in the bottom right-hand corner of the top of the package denotes an industrial device.

## PIN CONFIGURATIONS



**Note:** Some revisions of this device may incorporate deviations from published specifications known as errata. Multiple revisions of any device may be simultaneously available through various sales channels. For information about device errata, click here: [www.maxim-ic.com/errata](http://www.maxim-ic.com/errata).

## ABSOLUTE MAXIMUM RATINGS

Voltage Range on Any Pin Relative to Ground	-3.0V to +7.0V
Operating Temperature Range (Noncondensing)	
Commercial:	0°C to +70°C
Industrial:	-40°C to +85°C
Storage Temperature Range	-40°C to +85°C
Soldering Temperature (BGA, SO)	See the <i>Handling, PC Board Layout, and Assembly</i> section.
Soldering Temperature, Leads (DIP)	+260°C for 10 seconds ( <b>Note 1</b> )

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 in the operational sections of the specifications is not implied. Exposure to the absolute maximum rating conditions for extended periods may affect device reliability.

## RECOMMENDED DC OPERATING CONDITIONS

( $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Power-Supply Voltage	$V_{CC}$	(Note 2)	4.5	5.0	5.5	V
Battery Voltage	$V_{BAT}$	(Notes 2, 3)	2.7	3.0	3.5, 5.5	V

## DC ELECTRICAL CHARACTERISTICS

(Over the operating range, unless otherwise specified.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Active Supply Current	$I_{CC}$	$V_{BAT} = 0\text{V}$ or $2.7\text{V} \leq V_{BAT} \leq 3.5\text{V}$ (Notes 3, 4)		150	180	$\mu\text{A}$
Battery Input-Leakage Current	$I_{BATLKG}$	$V_{CC\ MIN} \leq V_{CC} \leq V_{CC\ MAX}$	-50		+50	nA
High Output Voltage ( $V_{CC}$ )	$V_{OH}$	$I_{OH} = -1.0\text{mA}$ (Note 2)	2.4			V
Low Output Voltage	$V_{OL}$	$I_{OL} = 2.1\text{mA}$ (Note 2)			0.4	V
High Output Voltage ( $V_{BAT}$ )	$V_{OH}$	$I_{OH} = -0.1\text{mA}$ (Note 2)	2.4			V
Battery Switch Voltage	$V_{SW}$	(Note 2)		$V_{BAT}$		V

( $V_{CC} = 0\text{V}$ ,  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ .) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Active Battery Current	$I_{BAT}$	$V_{BAT} = 3.3\text{V}$ (Notes 4, 5, 6)		1	4	$\mu\text{A}$
Battery Current During Temperature Measurement	$I_{BATCNV}$	$V_{BAT} = 3.3\text{V}$ (Notes 4, 5, 7)		450		$\mu\text{A}$

**Note 1:** Limits at  $-40^\circ\text{C}$  are guaranteed by design and are not production tested.

**Note 2:** All voltages are referenced to ground.

**Note 3:**  $V_{BAT}$  must be no greater than 3.5V when the device is used in the dual-supply operating modes.

**Note 4:** Typical values are at  $+25^\circ\text{C}$  and 5.0V  $V_{CC}$ , 3.0  $V_{BAT}$ , unless otherwise indicated.

**Note 5:** These parameters are measured under no output load conditions.

**Note 6:** This current is the active-mode current sourced from the backup supply/battery.

**Note 7:** A temperature conversion lasts 122ms (typ) and occurs on power-up and then once every 64 seconds.

## AC TIMING CHARACTERISTICS

(Over the operating range, unless otherwise specified.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Frequency	$f_{OUT}$			32.768		kHz
Frequency Stability vs. Temperature	$\Delta f/f_0$	0°C to +40°C	-2.0		+2.0	ppm
		-40°C to +85°C or 0°C to +70°C	-7.5		+7.5	
Duty Cycle	$t_W/t$		45	50	55	%
Cycle Time	$t_{CYC}$	(Note 8)		30.518		$\mu$ s
High/Low Time	$t_H/t_L$	(Note 8)		15.06		$\mu$ s
Rise Time	$t_R$	(Note 8)		200		ns
Fall Time	$t_F$	(Note 8)		60		ns
Oscillator Startup Time	$t_{OSC}$	(Note 8)		1		seconds
Frequency Stability vs. Operating Voltage	$\Delta f/V$	$V_{CC} = 5.0V$ or $V_{BAT} = 3.0V$ , $V_{CC} = 0V$ (Notes 4, 9)		+2.5		ppm/V
Crystal Aging (First Year)	$\Delta f/f_0$	(Notes 4, 10)		$\pm 1.0$		ppm

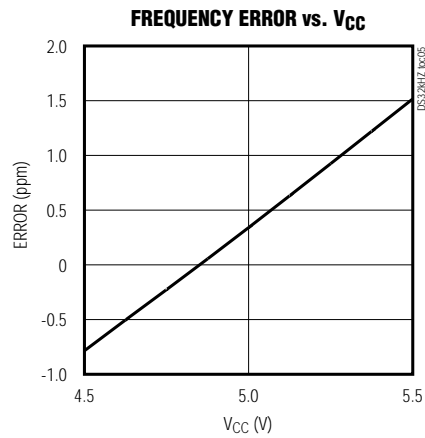
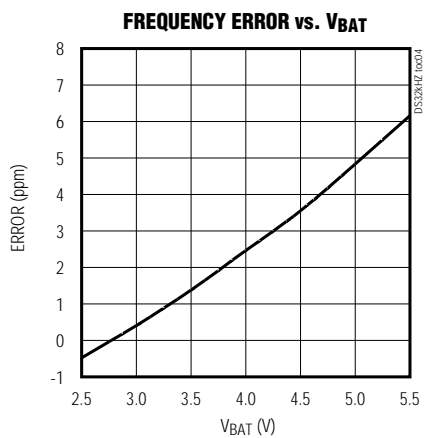
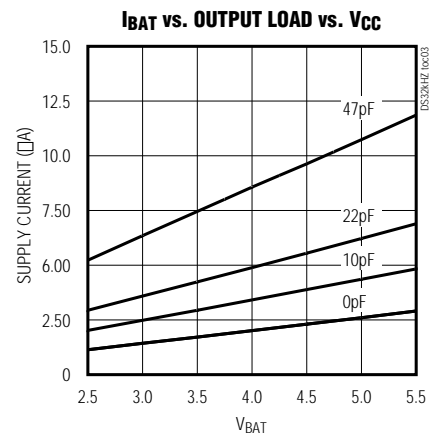
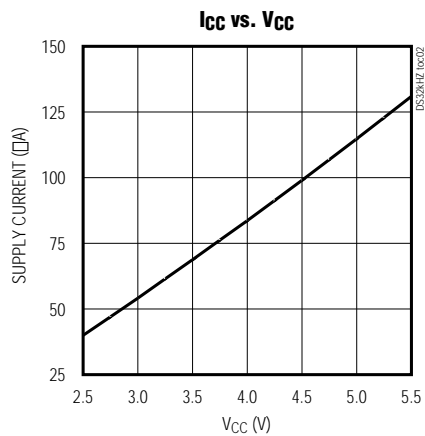
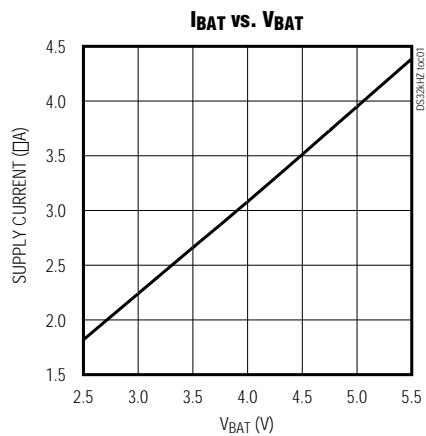
**Note 8:** These parameters are measured using a 15pF load.

**Note 9:** Error is measured from the nominal supply voltage of whichever supply is powering the device.

**Note 10:** After reflow.

## TYPICAL OPERATING CHARACTERISTICS

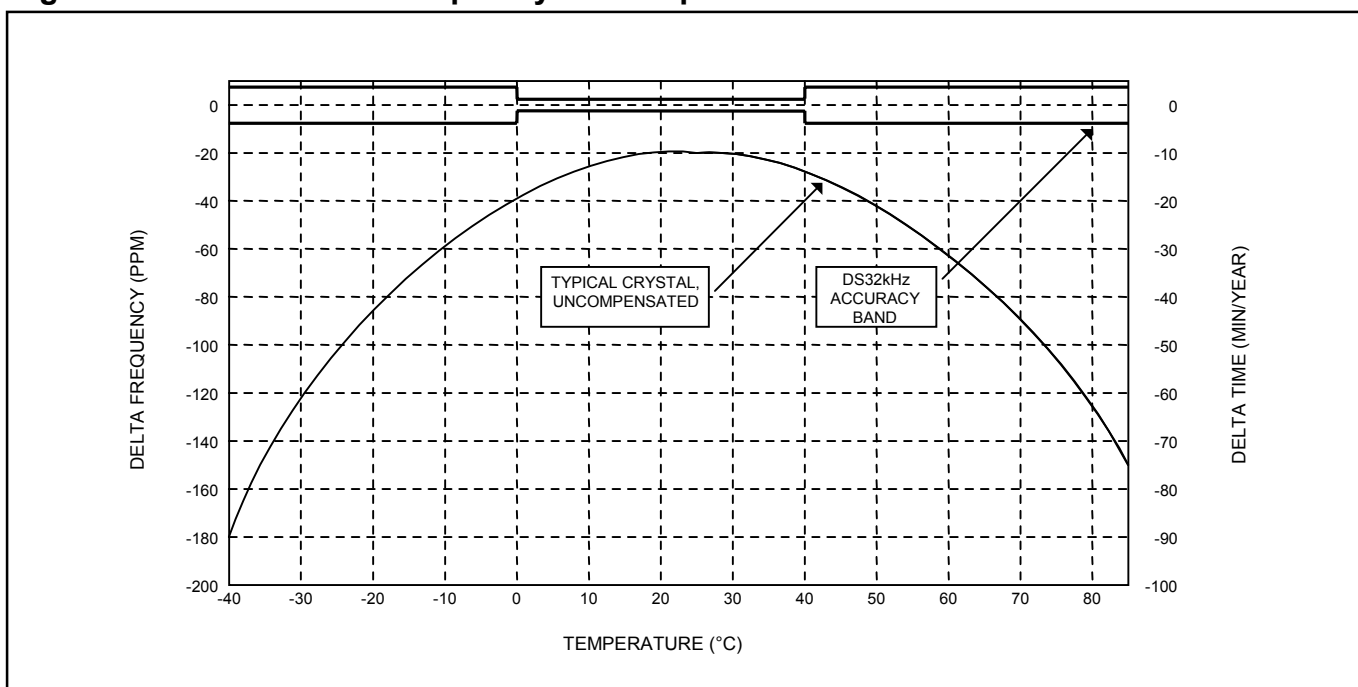
( $V_{CC} = 3.3V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



## PIN DESCRIPTIONS

PIN			NAME	FUNCTION
SO	BGA	DIP		
1	C4, C5, D4, D5	12	32kHz	32.768kHz Output
2	C2, C3, D2, D3	13	V <sub>CC</sub>	Primary Power Supply
3–12, 15, 16	A7, A8, B7, B8, C7, C8, D7, D8	1, 6–11, 14	N.C.	No Connect (Must be grounded)
13	All remaining balls	4	GND	Ground
14	A4, A5, B4, B5	5	V <sub>BAT</sub>	+3V Nominal Supply Input. Used to operate the device when V <sub>CC</sub> is absent.

**Figure 1. Delta Time and Frequency vs. Temperature**



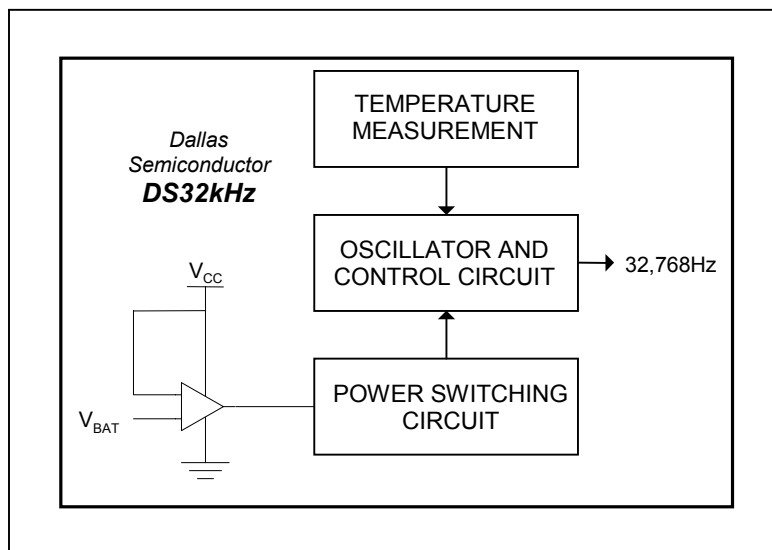
## FUNCTIONAL DESCRIPTION

The DS32kHz requires four pins for operation: V<sub>CC</sub>, GND, V<sub>BAT</sub>, and 32kHz. (See Figure 3 for connection schemes.) Power is applied through V<sub>CC</sub> and GND, while V<sub>BAT</sub> is used to maintain the 32kHz output in the absence of power. Once every 64 seconds, the DS32kHz measures the temperature and adjusts the output frequency. The output is accurate to  $\pm 7.5$ ppm ( $\pm 4$  min/year) from  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  and  $\pm 2$ ppm ( $\pm 1$  min/yr) from  $0^{\circ}\text{C}$  to  $+40^{\circ}\text{C}$ .

The DS32kHz is packaged in a small 36-pin SMD using ball grid array (BGA). It also is available in a 16-pin 0.300" SO and a 14-pin encapsulated DIP (EDIP) module.

The additional board space required is negligible in most applications and, therefore, the recommended land pattern layout should be implemented on all new designs and future board revisions to satisfy applications requiring better timekeeping accuracy.

Figure 2. Block Diagram



## OPERATION

The DS32kHz module contains a quartz tuning-fork crystal and an IC. When power is first applied, and when the device switches between supplies, the DS32kHz measures the temperature and adjusts the crystal load to compensate the frequency. The power supply must remain at a valid level whenever a temperature measurement is made, including when  $V_{CC}$  is first applied. While powered, the DS32kHz measures the temperature once every 64 seconds and adjusts the crystal load.

The DS32kHz is designed to operate in two modes. In the dual-supply mode, a comparator circuit, powered by  $V_{CC}$ , monitors the relationship between the  $V_{CC}$  and  $V_{BAT}$  input levels. When  $V_{CC}$  drops below a certain level compared to  $V_{BAT}$ , the device switches over to  $V_{BAT}$  (Figure 3A). This mode uses  $V_{CC}$  to conserve the battery connected to  $V_{BAT}$  while  $V_{CC}$  is applied.

In the single-supply mode,  $V_{CC}$  is grounded and the unit is powered by  $V_{BAT}$ . Current consumption is less than  $V_{CC}$ , because the comparator circuit is unpowered (Figure 3B).

Figure 3A shows how the DS32kHz should be connected when using two power supplies.  $V_{CC}$  should be between 4.5V and 5.5V, and  $V_{BAT}$  should be between 2.7V and 3.5V. Figure 3B shows how the DS32kHz can be used when only a single-supply system is available.  $V_{CC}$  should be grounded and  $V_{BAT}$  should then be held between 2.7V and 5.5V. The  $V_{BAT}$  pin should be connected directly to a battery. Figure 3C shows a single-supply mode where  $V_{CC}$  is held at +5V. See the frequency stability vs. operating voltage for information about frequency error vs. supply voltage.

Figure 3. Power-Supply Connections

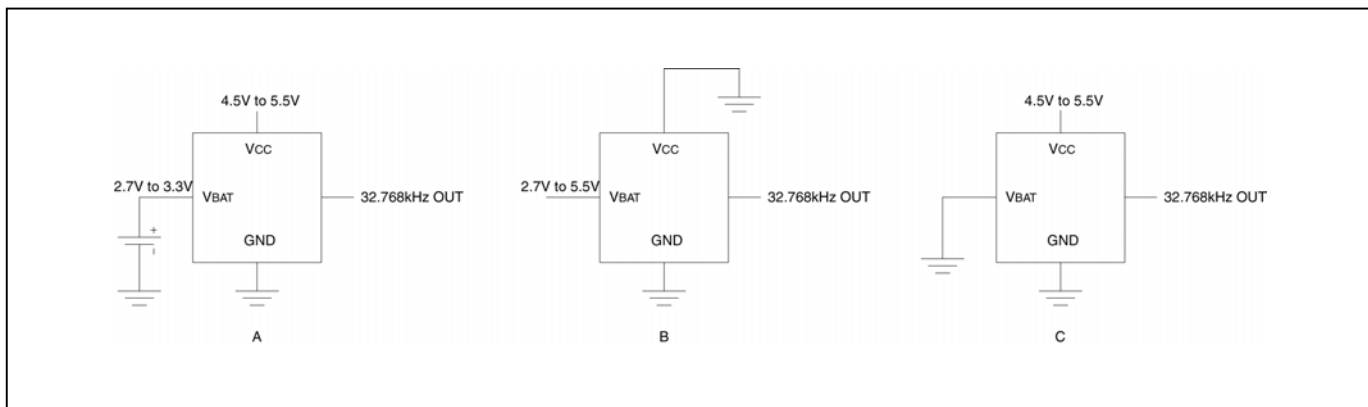
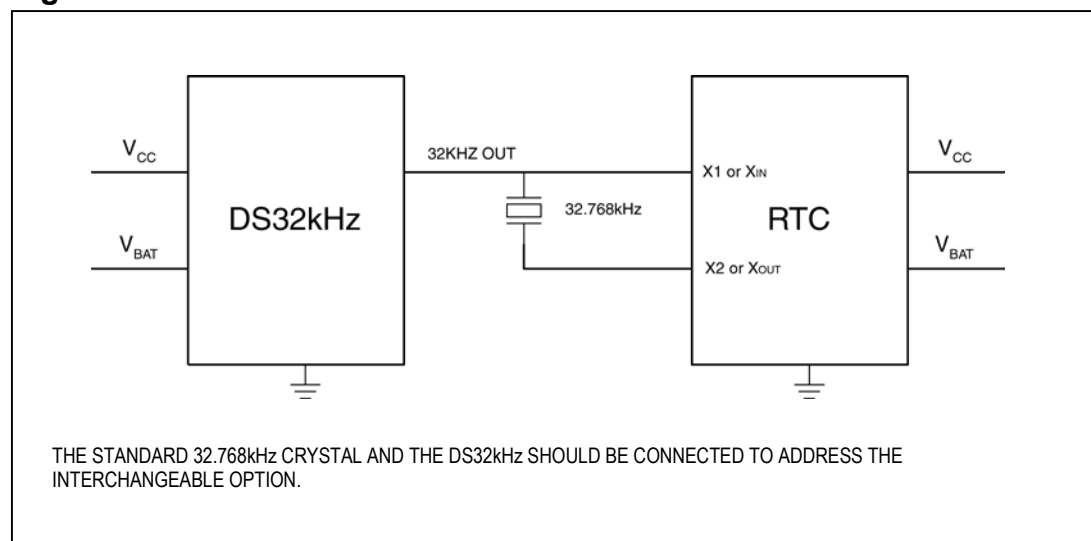


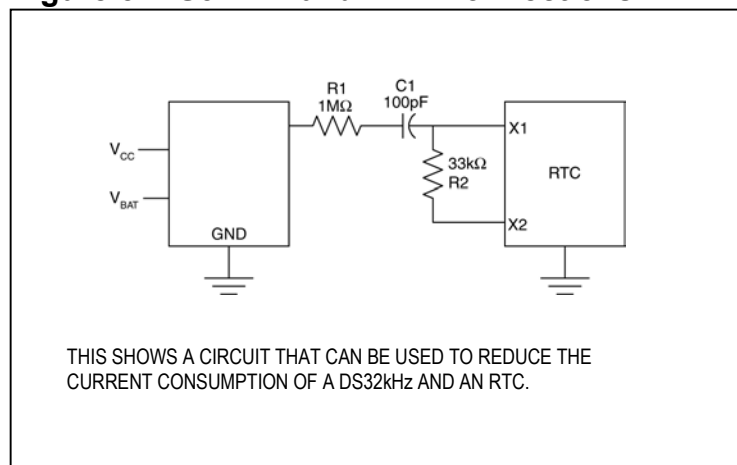
Figure 4 illustrates how a standard 32.768kHz crystal and the DS32kHz should be connected to address the interchangeable option. Using this connection scheme and the recommended layout provides a solution, which requires no hardware modifications. Only one device should be used at a time, and both layouts should be located very close together if the recommended layout is not used.

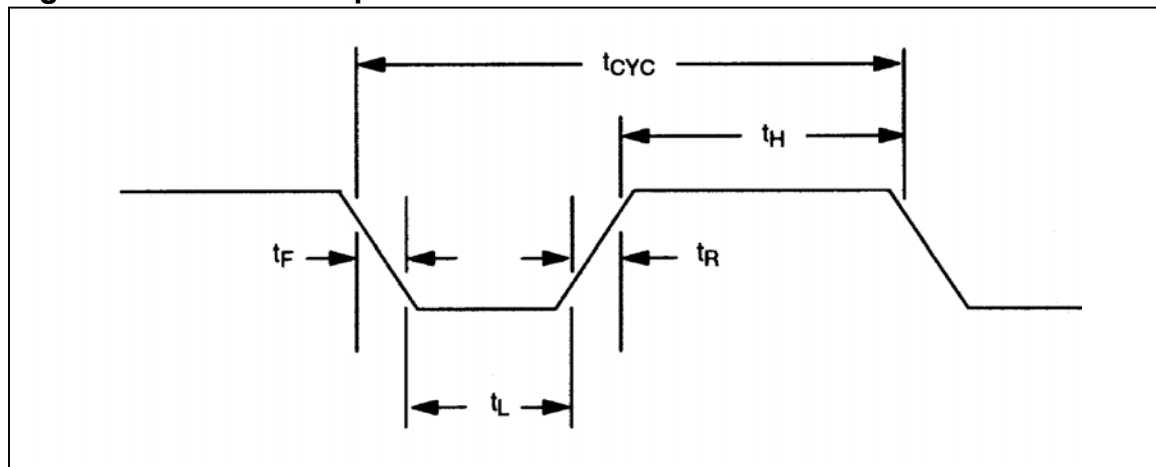
The DS32kHz  $I_{CC}$  and  $I_{BAT}$  currents are specified with no output loads. Many RTC oscillator circuits use a quartz crystal or resonator. Driving the oscillator circuit with the rail-to-rail output of the DS32kHz can increase the  $I_{CC}$  and  $I_{BAT}$  currents significantly and increase the current consumption of the RTC as well. Figure 5 shows one circuit that can be used to reduce the current consumption of a DS32kHz and an RTC. The values of R1 and C1 may vary depending on the RTC used. However, values of  $1.0M\Omega$  and  $100pF$  are recommended as a starting point. R2 is used to shift the input waveform to the proper level. The recommended value for R2 is  $33k\Omega$ .

**Figure 4. DS32kHz Connections**



**Figure 5. DS32kHz and RTC Connections**



**Figure 6. DS32kHz Output Waveform**

## RELATED APPLICATION NOTES

*Application Note 58: Crystal Considerations with Dallas Real-Time Clocks*

*Application Note 701: Using the DS32kHz with Dallas RTCs*

(Go to [www.maxim-ic.com/RTCapps](http://www.maxim-ic.com/RTCapps) to find these application notes and more.)

## HANDLING, PC BOARD LAYOUT, AND ASSEMBLY

These packages contain a quartz tuning-fork crystal. Pick-and-place equipment may be used, but precautions should be taken to ensure that excessive shocks are avoided. Ultrasonic cleaning should be avoided to prevent damage to the crystal.

Avoid running signal traces under the package, unless a ground plane is placed between the package and the signal line. All N.C. (no connect) pins must be connected to ground.

The BGA and SO packages may be reflowed as long as the peak temperature does not exceed 240°C. Peak reflow temperature ( $\geq 230^{\circ}\text{C}$ ) duration should not exceed 10 seconds, and the total time above 200°C should not exceed 40 seconds (30 seconds nominal). Exposure to reflow is limited to 2 times maximum. The DIP package can be wave-soldered, provided that the internal crystal is not exposed to temperatures above 150°C.

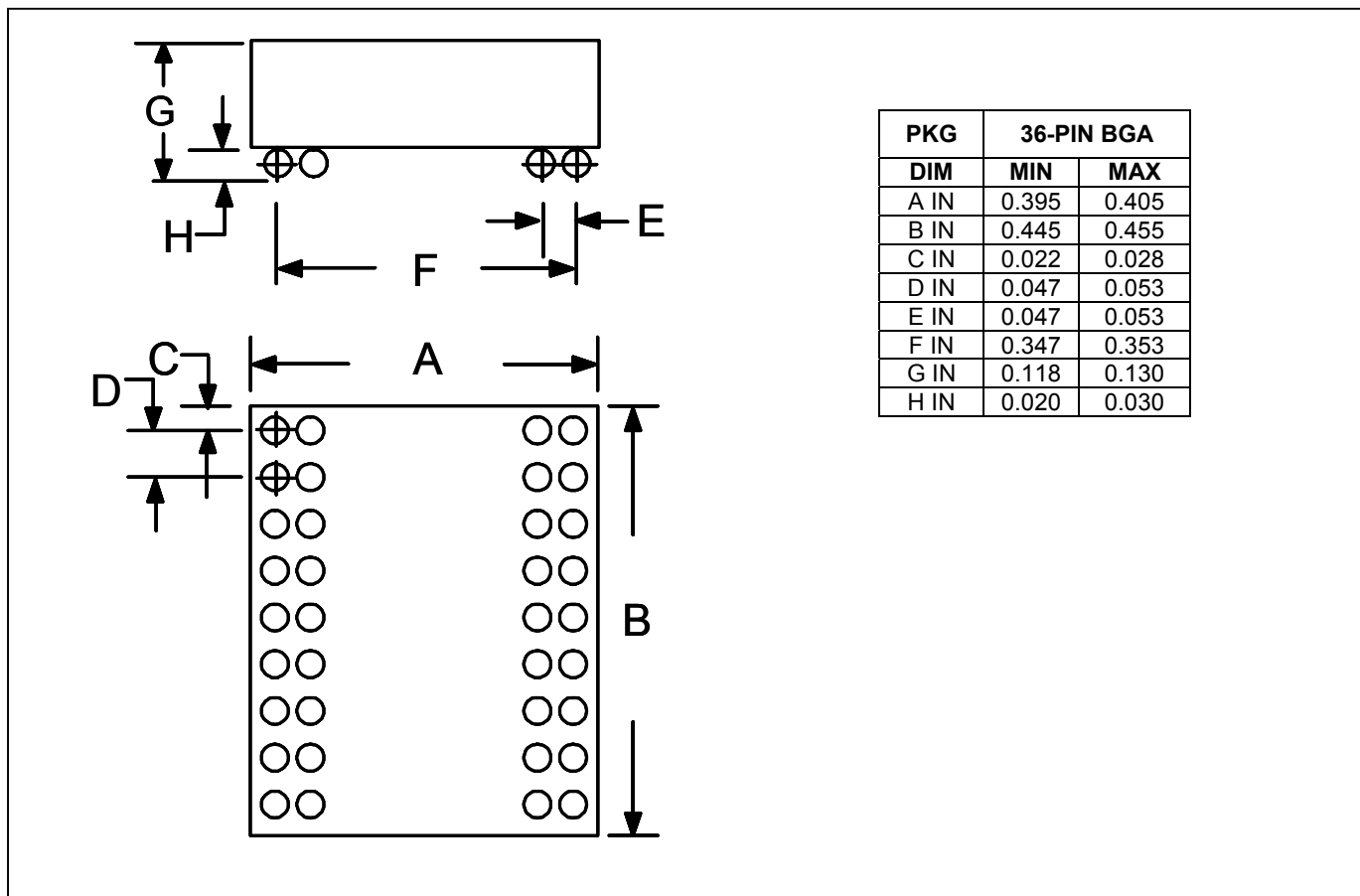
Moisture sensitive packages are shipped from the factory dry-packed. Handling instructions listed on the package label must be followed to prevent damage during reflow. Refer to IPC/JEDEC J-STD-020B standard for moisture-sensitive device (MSD) classifications.



## PACKAGE INFORMATION

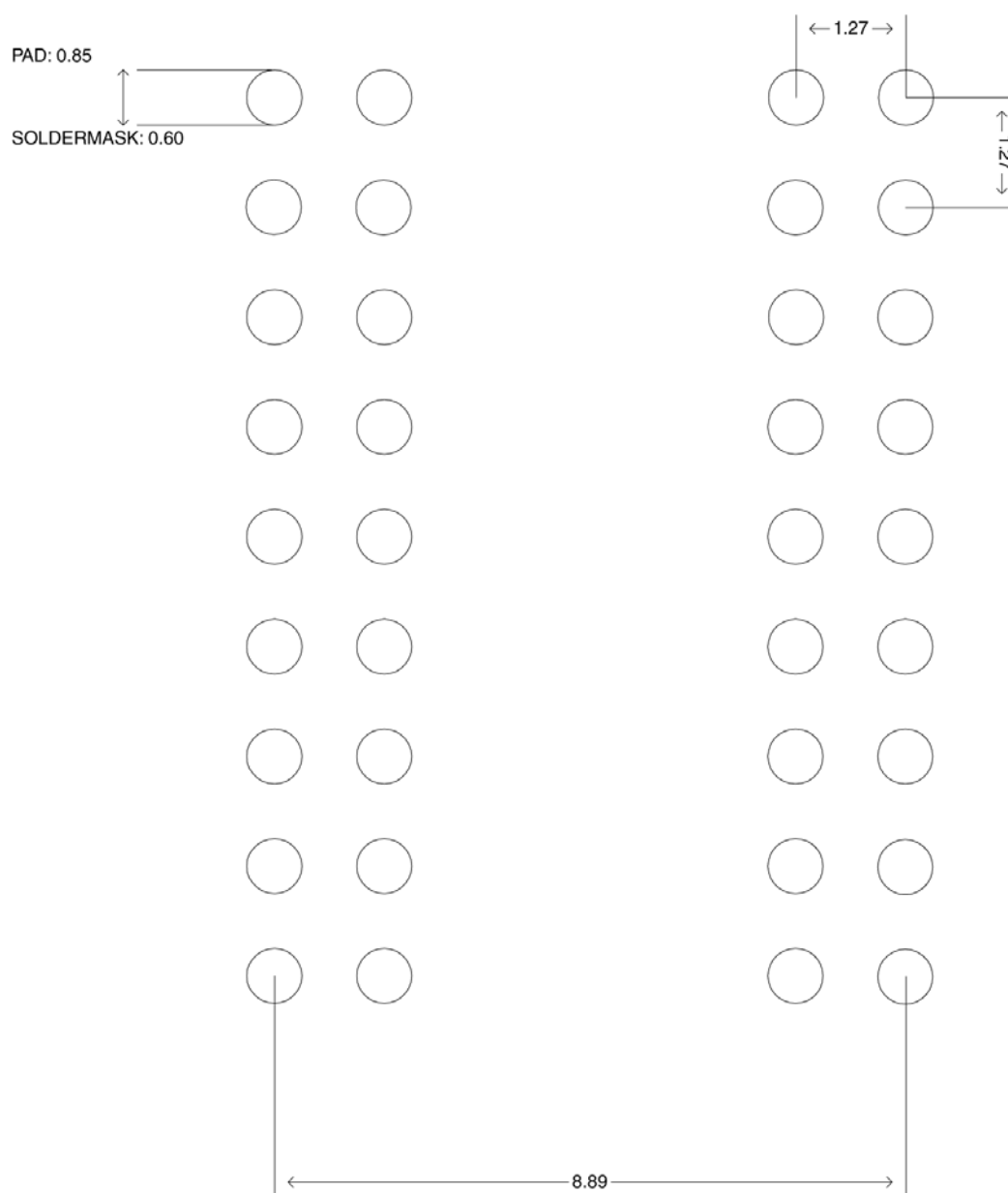
(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package information, go to [www.maxim-ic.com/DallasPackInfo](http://www.maxim-ic.com/DallasPackInfo).)

For the 16-pin SO, refer to package drawing 56-G4009-001 at: [www.maxim-ic.com/DallasPackInfo](http://www.maxim-ic.com/DallasPackInfo).



**PACKAGE INFORMATION (continued)**

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package information, go to [www.maxim-ic.com/DallasPackInfo](http://www.maxim-ic.com/DallasPackInfo).)

**RECOMMENDED LAND PATTERN FOR 36-PIN BGA**

**Note 1:** All dimensions in millimeters.

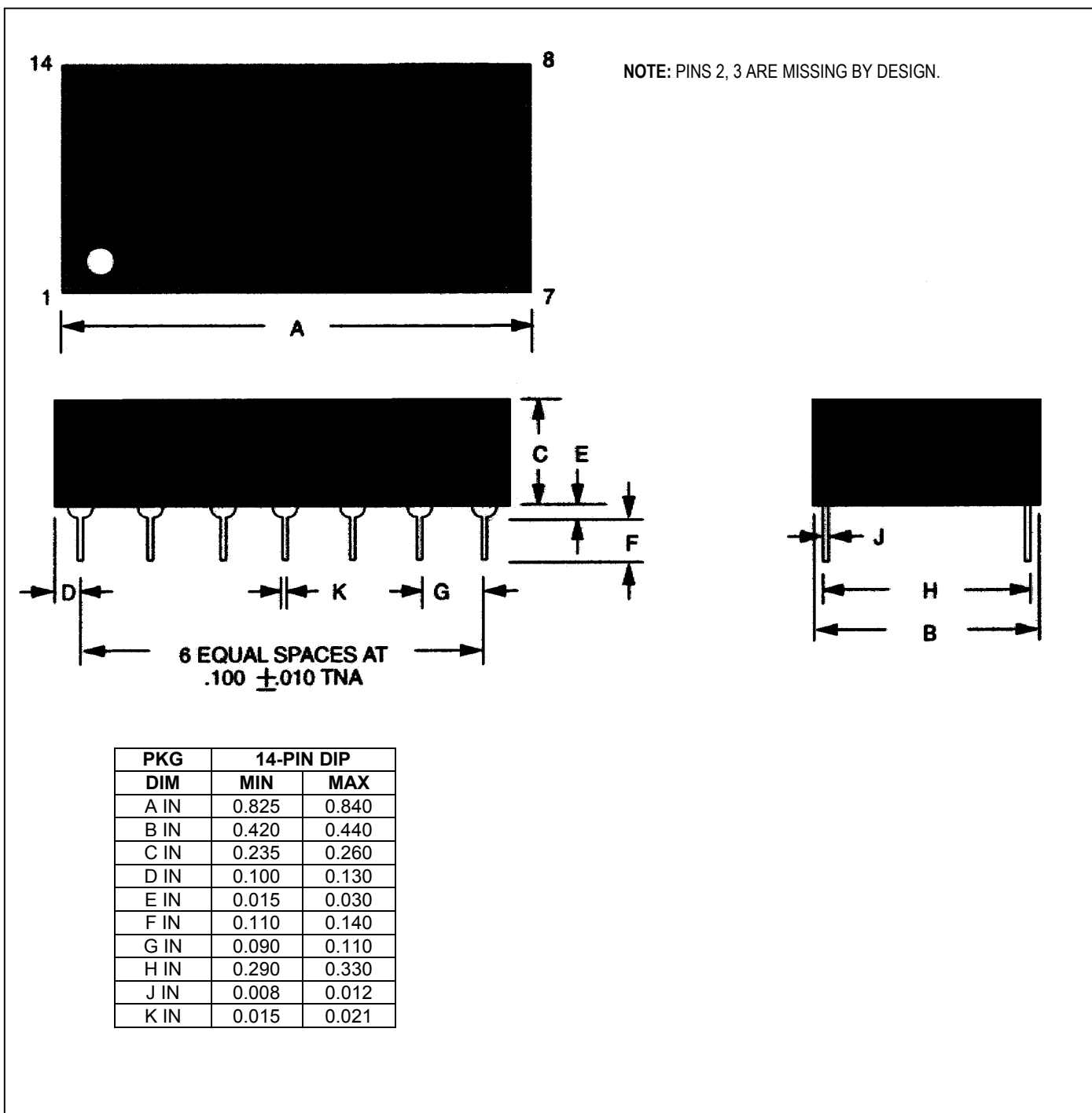
**Note 2:** Solder Ball: SnPb 63/37.

**Note 3:** Solder Ball diameter: 0.762 nominal.

**Note 4:** BGA has soldermask-defined pads.

## PACKAGE INFORMATION (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package information, go to [www.maxim-ic.com/DallasPackInfo](http://www.maxim-ic.com/DallasPackInfo).)



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**Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 408-737-7600**

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