

## Introduction

The ISL12022M devices are high-accuracy, temperature compensated Real Time Clock (RTC) modules that incorporate the RTC die and the quartz crystal. The RTC contains an internal temperature sensor and state machine to adjust the oscillator frequency and allow factory calibration to less than  $\pm 5$ ppm error over the  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  ambient operating temperature range. There are numerous items that affect the final accuracy of the module once assembled on a PC board, including handling and shock, reflow temperature profile, maximum temperature, number of reflows (or wave solder) and if ultrasound is used (note that the ISL12022M family refers to the ISL12022M, ISL12022MA and ISL12022MR5421 products).

This application note will discuss the expected accuracy of the device when mounted on a board, at room temperature and as temperature varies. Also discussed will be the measurement techniques and analyzing the results.

## Expected Oscillator Accuracy and Time Drift

The oscillator accuracy is summarized in [Table 1](#). The main point of this table is that after the module device is reflow soldered to a PC board, the accuracy spec in the [ISL12022M](#) datasheet will have additional errors such that the resulting accuracy will exceed the maximum datasheet specification. Also, due to the variability of the reflow process and customer application PC boards, there cannot be a maximum stated error after reflow, only the expected value based on the estimated change. The best assurance of getting the best accuracy is to minimize the peak time and temperature of the assembly reflow process.

## Datasheet Specifications

The datasheet provides separate accuracy specifications for room temperature at a fixed  $V_{DD} = 3.3\text{V}$ , over  $V_{DD}$  supply voltage variation, and over the rated temperature range. [“DC Operating Characteristics RTC” on page 2](#) shows a portion of the datasheet extracted to show just the overall conditions and the individual accuracy specs.

Let's look more closely at each line item spec.

- [“Oscillator Stability vs Temperature”](#) refers to the maximum variation from a perfect 0ppm error with the device at an ambient temperature from  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ . Oscillator stability in this case refers to the average frequency measured over a period of time, since the digital correction mechanism inserts periodic correction, at intervals of greater than 1 second in most cases. A measurement at 1 or 2 second intervals may not provide an accurate or stable reading due to the digital correction. The 5ppm is the maximum guaranteed for a packaged device as it is shipped to the customer.
- [“Oscillator Stability vs Voltage”](#) is the maximum deviation, at room temperature, from a perfect 0ppm error as the  $V_{DD}$  voltage is varied from 2.7V to 5.5V.
- [“Oscillator Initial Accuracy”](#) is measured at  $T_A = +25^{\circ}\text{C}$  only; the maximum variation from 0ppm error is at  $V_{DD} = 3.3\text{V}$ ,  $V_{BAT} = 0.0\text{V}$ .
- [“Temperature Sensor Accuracy”](#) is the maximum error at  $T_A = +25^{\circ}\text{C}$  of the digital temperature reading (TEMP registers) from exact chip temperature. It is listed here since the oscillator calibration takes effect at  $<20^{\circ}\text{C}$  and  $>30^{\circ}\text{C}$ , as measured by the chip as opposed to actual temperature.

## Related Literature

- [ISL12022M](#) datasheet
- [ISL12022MA](#) datasheet
- [ISL12022MR5421](#) datasheet

TABLE 1. ISL12022M OSCILLATOR ACCURACY SUMMARY

TEMP. RANGE >	+25°C (ppm)	+25°C (SEC/DAY)	-40°C to +85°C (ppm)	-40°C to +85°C (SEC/DAY)
Before Reflow	$\pm 3$ (max)	0.26 (max)	$\pm 5$ (max)	0.43 (max)
After Reflow	$\pm 6$ (typically)	0.52 (typically)	$\pm 8$ (typically)	0.69 (typically)

**DC Operating Characteristics RTC** Test Conditions:  $V_{DD} = +2.7$  to  $+5.5V$ ,  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise stated. **Boldface limits apply across the operating temperature range,  $-40^\circ C$  to  $+85^\circ C$ .**

SYMBOL	PARAMETER	CONDITIONS	MIN (Note 1)	TYP (Note 2)	MAX (Note 1)	UNITS
<b>OSCILLATOR ACCURACY</b>						
$\Delta F_{outI}$	Oscillator Initial Accuracy	$V_{DD} = 3.3V$ (Notes 3, 5)	<b>-2</b>		<b>+8</b>	ppm
$\Delta F_{outR}$	Oscillator Accuracy after Reflow Cycle	$V_{DD} = 3.3V$ (Notes 3, 5)		$\pm 5$		ppm
$\Delta F_{outT}$	Oscillator Stability vs Temperature	$V_{DD} = 3.3V$ (Notes 3, 6)		$\pm 2$		ppm
$\Delta F_{outV}$	Oscillator Stability vs Voltage	$2.7V \leq V_{DD} \leq 5.5V$ (Note 7)	<b>-3</b>		<b>+3</b>	ppm
Temp	Temperature Sensor Accuracy	$V_{DD} = V_{BAT} = 3.3V$ (Note 4)		$\pm 2$		$^\circ C$

## NOTES:

- Parameters with MIN and/or MAX limits are 100% tested at  $+25^\circ C$ , unless otherwise specified. Temperature limits established by characterization and are not production tested.
- Specified at  $+25^\circ C$ .
- The ISL12022M Oscillator Initial Accuracy can change after solder reflow attachment. The amount of change will depend on the reflow temperature and length of exposure. A general rule is to use only one reflow cycle and keep the temperature and time as short as possible. Changes on the order of  $\pm 1$ ppm to  $\pm 3$ ppm can be expected with typical reflow profiles.
- Limits should be considered typical and are not production tested.
- Defined as the deviation from a target oscillator frequency of 32,768.0Hz at room temperature.
- Defined as the deviation from the room temperature measured 1Hz frequency,  $V_{DD} = 3.3V$ , at  $T_A = -40^\circ C$  to  $+85^\circ C$ .
- Defined as the deviation at room temperature from the measured 1Hz frequency (or equivalent) at  $V_{DD} = 3.3$ , over the range of  $V_{DD} = 2.7V$  to  $V_{DD} = 5.5V$ .

In addition to the error specs listed, [Note 3](#) is pertaining to the error that results from high temperature assembly reflow.

This note indicates that an additional tolerance of typically up to 3ppm is added to the error specification after reflow. Combining this change with the initial accuracy specs gives the  $\pm 6$ ppm initial accuracy expected value at  $+25^\circ C$ , as shown in [Table 1 on page 1](#).

## Environmental Effects

### Thermal Effects

#### SOLDER REFLOW HEAT, PCB ASSEMBLY

Typical surface mount production assembly flows include at least one infrared reflow pass for soldering components to pads on the PC board. Heating profiles for reflow cycles have peak temperatures of up to  $260^\circ C$  for 10 to 30 seconds, which is high enough to slightly change the characteristic of the quartz crystal in the RTC module. After cooling, the typical final effect on the module is a slightly lower oscillator frequency (sometimes but not often higher frequency). Therefore, the RTC module after reflow assembly, will have a different accuracy range than that specified on the datasheet as shipped from the factory. See [Table 1 on page 1](#).

The customer should take this accuracy change into account when considering the final system accuracy for the assembled RTC module on their PC board. Also, every effort needs to be made to minimize the peak reflow temperature and peak time as well and the number of reflow cycles. Thus, reducing the frequency change after reflow. RTC module devices can have accuracy error exceeding 8ppm and still be within the expected range after a production reflow at  $+260^\circ C$  peak temperature.

## Mechanical Effects

### PCB CUTTING WITH ROUTERS

Usually at the end of the pick and place process, a PCB panel needs to have the single PCBs separated from each other with a cutting tool or router. These machines sometimes generate vibrations on the PCB that have a fundamental or harmonic frequencies close to 32.768kHz. This might cause breakage of the crystal blanks inside the module due to resonance. Note: The customer should monitor their cutting tool speed and the speed should be adjusted to avoid resonant vibration. If this is not done, there can be very large accuracy error in the RTC oscillator or sometimes even failure of the oscillator if the crystal is damaged sufficiently.

### ULTRASOUND CLEANING

Ultrasound cleaning of PCBs is a common practice after assembly. This cleaning removes any material from the soldering process by submersing in a bath and using high frequency ultrasound to loosen the foreign material.

The RTC crystal can be damaged by this process if a lower frequency is used and the intensity is high enough to cause resonance in the crystal. Generally, frequencies higher than 500kHz should avoid damage and also any harmonic of the 32.768kHz frequency should be avoided. Note: The customer should monitor the ultrasound frequency and the frequency should be adjusted to avoid crystal harmonics. Failure to observe proper ultrasound frequency control can result in either large RTC oscillator frequency error or possible oscillator failure due to a damaged crystal.

## MECHANICAL SHOCK AND VIBRATION

Possible sources of crystal frequency offset include mechanical shock. The datasheet lists a maximum shock resistance of 5000g for 0.3ms, 1/2 sine test, which can give a  $\pm 5$ ppm frequency change. Likewise, the maximum vibration spec is 20g at 10 to 2000Hz. Note that ultrasound cleaning and PCB panel cutting vibrations fall under the broader mechanical shock and vibration spec as well. The customer should avoid any mechanical handling that produces an impact or high vibration on the module. Failure to observe proper precautions handling the device, before or after, assembly can result in higher than expected oscillator frequency error.

## Summary

The ISL12022M provides a high accuracy 3-in-1 RTC solution for real time clock timing requirements. The oscillator accuracy is guaranteed for the device shipped from the factory. The PCB assembly process adds environmental factors, such as heat and vibration that will cause the accuracy error to increase after assembly. This change will be evident when testing the final assembled PC board RTC oscillator frequency. The major contributors to additional accuracy error are solder reflow, board cutting or routing, ultrasound cleaning and mechanical handling shocks or vibrations.

For final product oscillator accuracy, the customer must consider the assembly effects and the resulting board mounted module device may not be within the expected accuracy limits shown on the datasheet. The customer can adjust their system to address this change in accuracy or look into other ways of adjusting final oscillator accuracy.

NOTE: If the customer has the capability to test, access the serial interface, make adjustments and test again, there are methods to readjust the device for better accuracy after assembly. Please contact [Intersil applications](#) about this possibility.

The customer needs to read and understand the environmental effects on the crystal oscillator accuracy and make every effort to minimize these effects, which will result in the highest possible accuracy of the board mounted RTC. In some cases, the customer may be forced to use an assembly process that is known to cause additional accuracy error as listed in this document. They should immediately contact Intersil to verify the hazard and possible impact and to identify alternative procedures that may be possible.

## Appendix

[Figure 1](#) is sample data for the ISL12022M parts that were subjected to 1 reflow cycle. The parts were socket tested and frequency accuracy data recorded, then sent through a production reflow oven and allowed to cool and settle. The parts were then socket tested again and the data recorded, with the change or delta frequency out calculated.

Parts soldered to a board may exhibit less change after reflow as the heat is distributed across the PC board. As the devices are cooled they maintain shape when attached to the PC board.

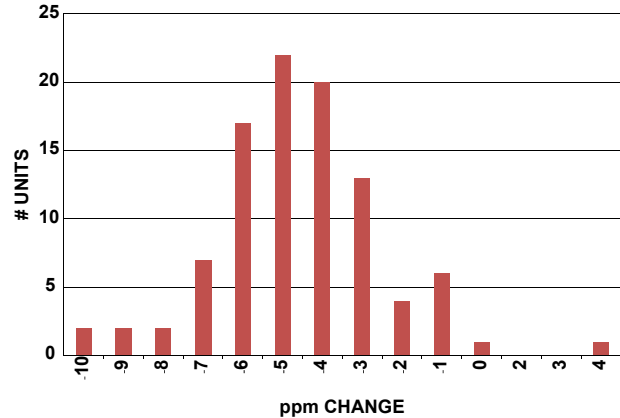


FIGURE 1. SAMPLE REFLOW DATA

## Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.  
"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.  
"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.  
Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.
6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.  
(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.  
(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)



### SALES OFFICES

Renesas Electronics Corporation

<http://www.renesas.com>

Refer to "<http://www.renesas.com/>" for the latest and detailed information.

**Renesas Electronics America Inc.**  
1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.  
Tel: +1-408-432-8888, Fax: +1-408-434-5351

**Renesas Electronics Canada Limited**  
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3  
Tel: +1-905-237-2004

**Renesas Electronics Europe Limited**  
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K.  
Tel: +44-1628-651-700, Fax: +44-1628-651-804

**Renesas Electronics Europe GmbH**  
Arcadiastrasse 10, 40472 Düsseldorf, Germany  
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

**Renesas Electronics (China) Co., Ltd.**  
Room 1709 Quantum Plaza, No.27 ZhichunLu, Haidian District, Beijing, 100191 P. R. China  
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

**Renesas Electronics (Shanghai) Co., Ltd.**  
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, 200333 P. R. China  
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

**Renesas Electronics Hong Kong Limited**  
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong  
Tel: +852-2265-6688, Fax: +852-2886-9022

**Renesas Electronics Taiwan Co., Ltd.**  
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan  
Tel: +886-2-8175-9600, Fax: +886-2-8175-9670

**Renesas Electronics Singapore Pte. Ltd.**  
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949  
Tel: +65-6213-0200, Fax: +65-6213-0300

**Renesas Electronics Malaysia Sdn.Bhd.**  
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia  
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

**Renesas Electronics India Pvt. Ltd.**  
No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India  
Tel: +91-80-67208700, Fax: +91-80-67208777

**Renesas Electronics Korea Co., Ltd.**  
17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea  
Tel: +82-2-558-3737, Fax: +82-2-558-5338