Comparison of real time clock module products and discrete products

Characteristics of real time clock modules with built-in crystal units

Preface

Accurate time is required by countless applications (e.g., finance & security systems, power meters, industrial equipment, measuring equipment, office equipment, medical equipment and games). Two components are essential for obtaining accurate time: (1) a device that oscillates at a precise, stable frequency, and (2) an IC that controls it. Engineers who design applications that require accurate time have two options. They can either purchase discrete oscillators and ICs separately or they can use a module product in which the oscillator and IC are already integrated. The engineer's design cycle and performance of the product will differ significantly depending on whether the engineer opts to use discrete components or a module. At Epson, we manufacture and sell modules that combine into a single package a crystal unit that oscillates at a precise, stable frequency and a real time clock IC that controls the crystal. Next we will explain the features and construction of Epson's real time clock modules.

Characteristics of Epson's real time clock modules

A real time clock module is a single package that contains a 32.768 kHz crystal unit and a real time clock IC. The real time clock IC includes the oscillation circuitry, clock, calendar, alarms and can contain additional features. Epson develops and manufacture our own crystal units and real time clock ICs. This enables us to enjoy a stable supply of crystal units that have been optimized for high-precision real time clock modules along with real time clock ICs that operate under the ideal conditions for those crystal units.

In addition, Epson’s semiconductor technology is based on design processes and expertise for producing extremely stable, low-power quartz oscillators. This technology enabled Epson to become the world’s first quartz watch manufacturer. Epson’s oscillators are used at the heart of myriad timing systems and timepieces, from the official timekeeping systems used in the Olympics to luxury Seiko brand watches like the Grand Seiko.

Since Epson develops our own crystal units and real time clock ICs, we are able to match them perfectly and maximize the potential of both. This results in products that exhibit high performance.

The distinguishing characteristics of Epson's module products are described below.

Feature 1: Pre-adjusted for clock accuracy

Epson's real time clock modules are self-contained devices that integrate a 32.768 kHz crystal unit with a real time clock IC which are accurately tuned to the precise frequency at the factory before being shipped to customers. This eliminates the need for the external mounting of individual components and helps customers reduce the number of components on their circuit boards.

The oscillation frequency of real time clocks constructed of discrete components is affected by factors such as circuit board pattern stray capacitance and variations in IC internal capacitance and crystal units. For this reason, users of discrete components have to take into account clock accuracy adjustments along with oscillation circuit stability. In addition engineers also have to perform evaluations as shown in Figure 1, spending engineering time and effort to achieve accurate precise frequency designs.

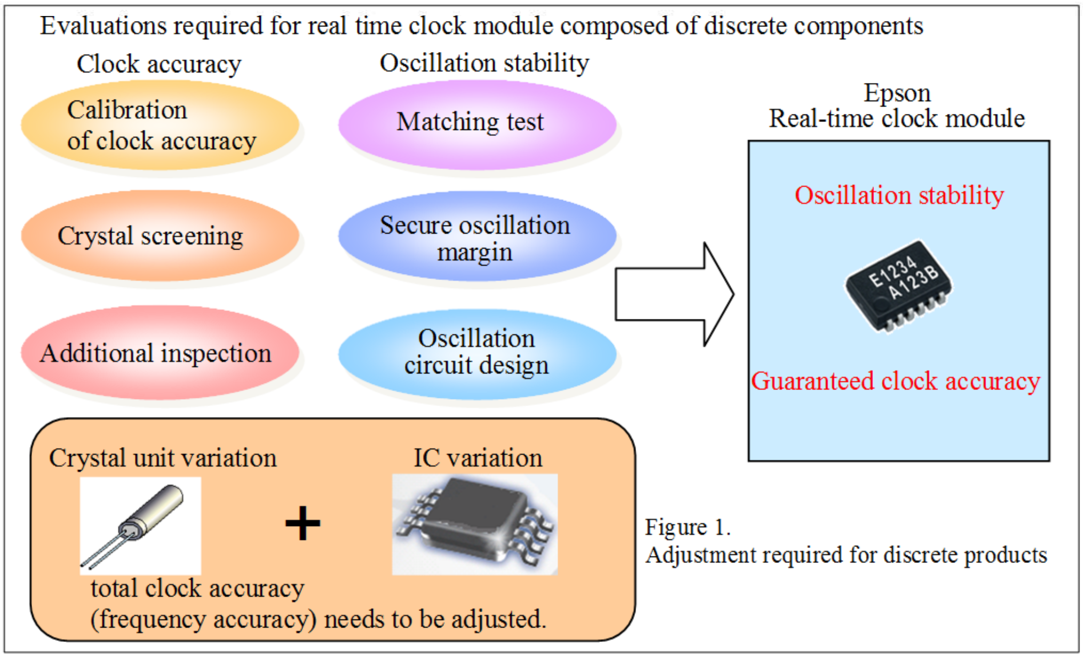

Figure 1.
Adjustment required for discrete products

The conceptually variation that occurs with discrete components is shown Figure 2.
The frequency deviation of commonly available tuning-fork crystal units is $\pm 20\times 10^{-6}$. Since crystal unit frequencies are individually adjusted in the manufacturing process, variations exhibit a largely central distribution.
Variation among ICs is about $\pm 10\times 10^{-6}$, with a distribution whose center differs depending on the production lot.
Real time clocks composed of these two discrete components require externally mounted capacitors and careful routing of circuit board wiring in order to adjust frequency. Figure 2 gives you an idea of the variations that these factors introduce and need to be accounted for.

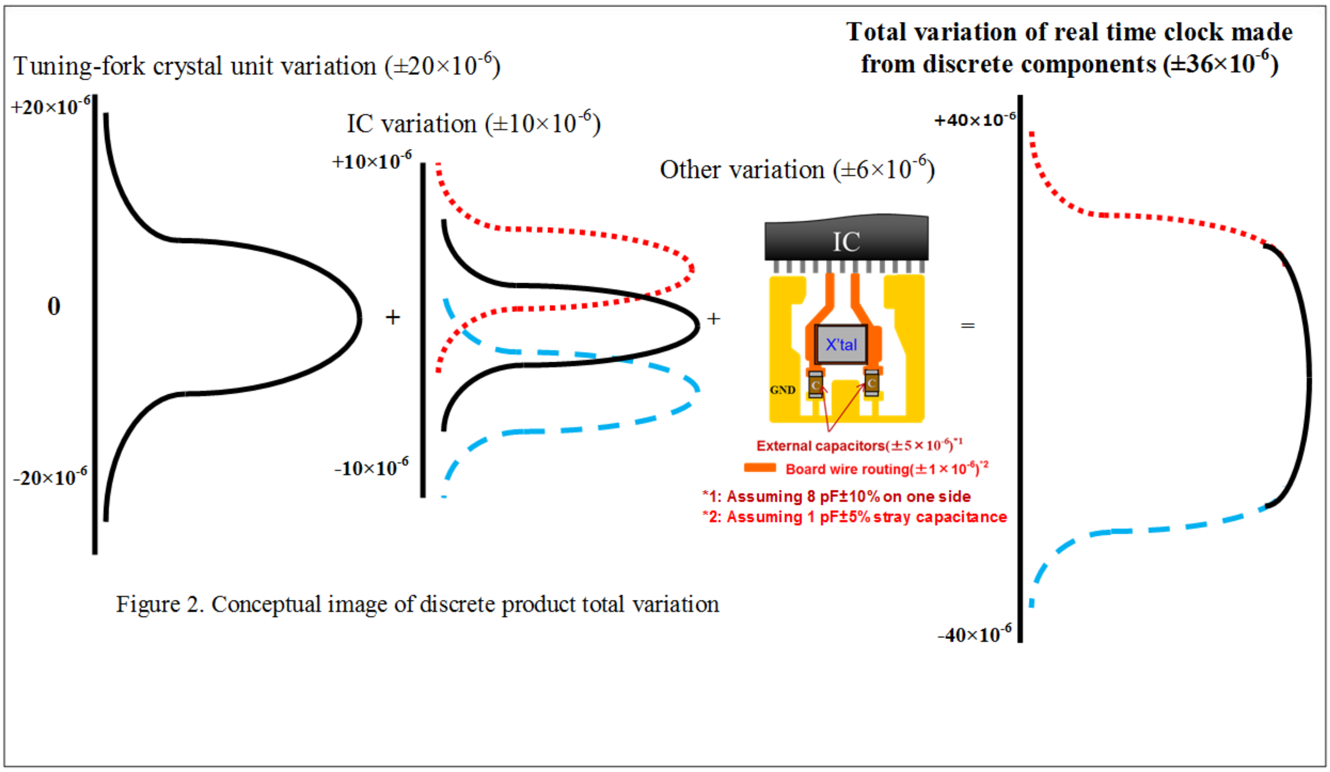

Figure 2. Conceptual image of discrete product total variation

On the other hand Epson's real time clock modules have one-third less total variation than real time clocks made of discrete components. The lower variation is achieved by adjusting Epson-engineered 32.768 kHz crystal units so as to absorb variation between Epson-engineered ICs (Figure 3). In addition external capacitors are eliminated and the wire routing needed for frequency adjustment. These are the factors customers used to have to take into account with discrete products. Epson real time clock modules can help customers reduce the amount of time spent evaluating circuits and matching components resulting in shorten development turnaround times.

Epson has a lineup of real time clock modules with a built-in DTCXO for customers who require even greater clock accuracy. Click on this link for details:
http://www5.epsondevice.com/en/quartz/library/whitepaper/wp_e20130918_rtc.pdf

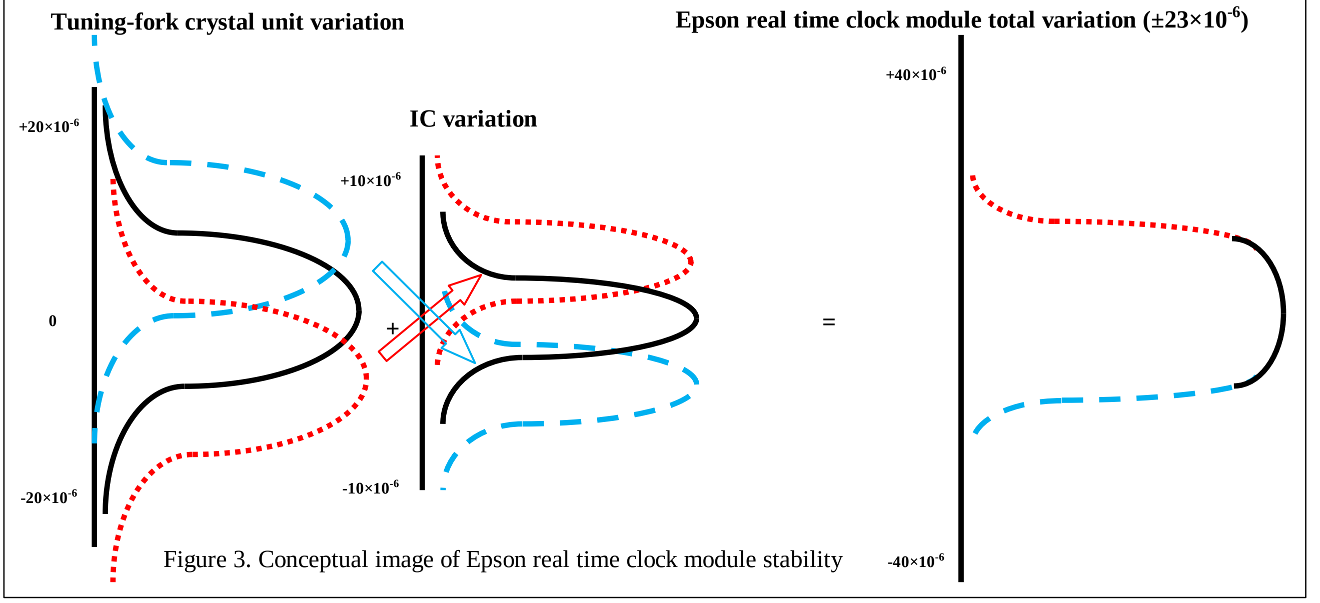

Figure 3. Conceptual image of Epson real time clock module stability

Feature 2: High reliability

Ordinary real time clocks operate on extremely low current with oscillation circuits near the crystal units that are susceptible to outside influences. When a real time clock is composed of discrete components, the oscillation circuit is exposed on the circuit board which leaves it susceptible to the effects of outside environmental factors such as condensation.

When oscillation circuitry is affected by condensation as illustrated in Figure 4, oscillation becomes unstable (2) with oscillation ceasing in the worst case (3) which results in the inability to keep time. To avoid these types of problems with discrete layouts, steps need to be taken to safeguard components against the effects of condensation such as applying a protective coating.

Epson's real time clock modules are more resistant to the effects of things such as condensation because their oscillation circuitry is not exposed to the outside environment. They maintain high reliability and don't require a protective coating.

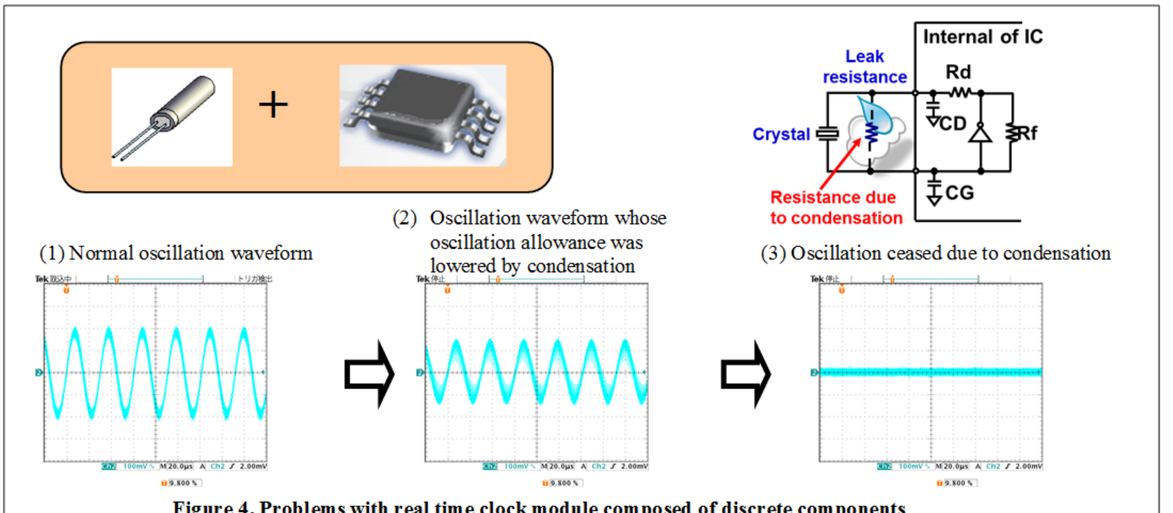

Figure 4. Problems with real time clock module composed of discrete components

Comparison between modules that use crystal units and MEMS modules

Tuning-fork crystal units are typically used in low-frequency clocks for timekeeping applications where for example, the current time needs to be held at an extremely low power budget. In most cases, customers use a 32.768 kHz crystal unit. In recent years, however, high-accuracy MEMS modules have emerged (clock accuracy: ±13 sec./month within a temperature range of -40°C to +85°C).
Below we compare modules that use crystal units with MEMS modules.

A word about low current consumption

With MEMS modules it is difficult to achieve low frequencies like those available with tuning-fork crystal units. However, MEMS modules with oscillation frequencies of several hundred kilohertz are relatively easy to manufacture. The frequency is divided until the desired frequency is reached when these modules are used for timekeeping applications.

The graph in Figure 5 shows the current consumption of an Epson real time clock module and that of a MEMS module.
The MEMS product loses its advantage in terms of market demand for extended backup since it requires 2 µA of current consumption which is more than 2.5 times that of Epson's module of only 0.75 µA. The MEMS module needs a higher-capacity battery which can increase the cost and make it difficult for users to reduce the size of their products.

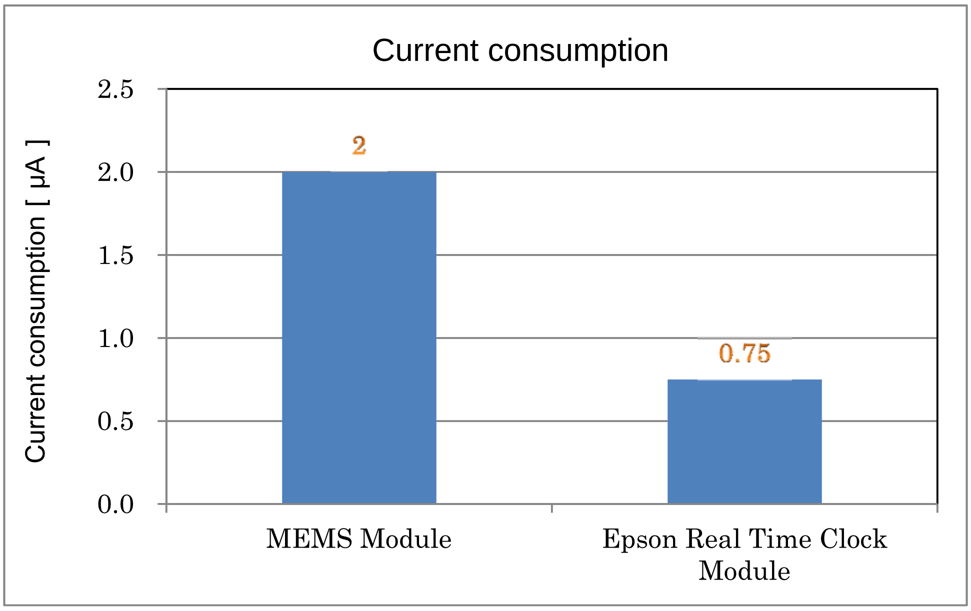

Figure 5. Comparison of the current consumption of a MEMS module and an Epson module

A word about 32.768 kHz output functions

There are also cases where customers use the 32.768 kHz frequency output from a tuning-fork crystal unit for timekeeping where the output frequency has to be highly accurate. The graph in Figure 6 plots the frequency vs. temperature coefficient of the 32.768 kHz output from an Epson real time clock module and from an MEMS real time clock module.

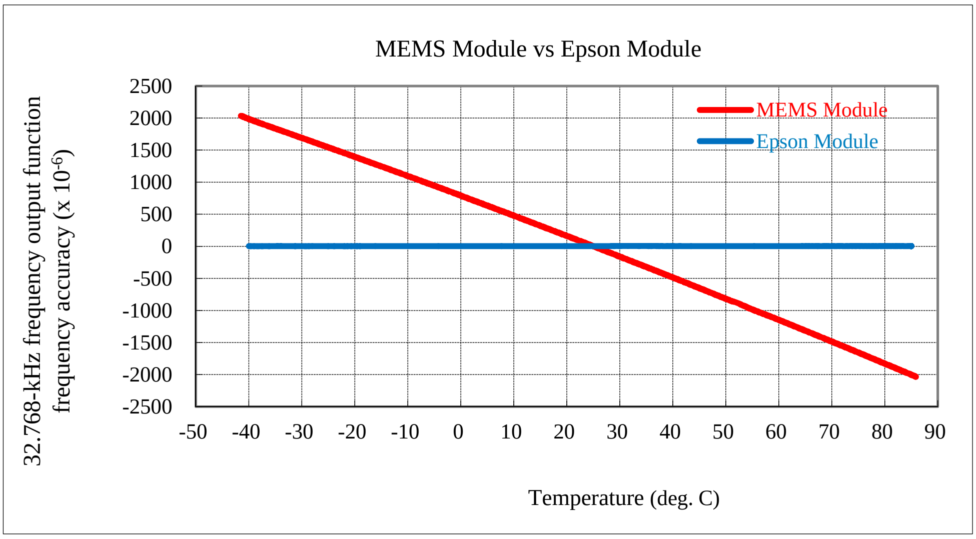

Figure 6. Comparison of the frequency accuracy of 32.768 kHz output over temperature range

The Epson's module is extremely accurate and maintains a frequency output accuracy of $\pm 5\times10^{-6}$ (equivalent to a monthly rate of 13 sec.) over a -40°C to +85°C operating temperature range. The MEMS module whose output frequency cannot be temperature compensated and exhibits considerable output instability (±0.2%, or the equivalent to a monthly rate of 86 minutes) over the same temperature range. This instability makes it impossible to use MEMS product frequency output for timekeeping applications.

Clock accuracy adjustment function

For cases where real time clock accuracy requires further adjustment after installation in a product, Epson offers a lineup of real time clock modules equipped with a clock update pulse adjustment function
(see page 3 of http://www5.epsondevice.com/en/quartz/library/whitepaper/wp_e20130918_rtc.pdf)[*3].
The internal clock of the real time clock is either sped up or slowed down up to $\pm 189.1 \times 10^{-6}$, in $\pm 3.05 \times 10^{-6}$ units, by a 32.768 kHz internal crystal oscillation circuit, enabling high-accuracy clock to be achieved.

*3: Models with clock update adjustment: RX6110SA, RX-8035SA/LC, RX-4035SA/LC, RX-8025SA/NB, RX-4045SA/NB, RTC-7301SF/DG

In conclusion, Epson uses technology to fabricate extremely low power tuning-fork crystal units and circuit technology for compensating the frequency-temperature coefficient to commercially develop high-accuracy, low-power real-time clock modules resulting in their superior total performance vs. discrete components and similar modules.
The frequency accuracy of these products is adjusted and guaranteed at the factory before shipping, so there is no need for frequency tuning by users. These products can significantly contribute to users' design-engineering efficiency and quality.