It has become necessary to increase the number of electronic components and systems used in automobiles for engine control, brake control, and steering control, as well as for the Advanced Drive Assistance System (ADAS), and the importance of such equipment is growing day by day. These components and systems are controlled by the electric control unit (ECU) and a timing device is required as a clock source for coordinating their operation. The ECU is connected to an in-car local area network (LAN), such as the controller area network (CAN) and FlexRay communications system, to communicate and process large volumes of data instantaneously. Therefore, this operation requires a high-precision and high-quality clock.

Murata Manufacturing Co., Ltd. developed the automotive ceramic resonators CERALOCK® CSTCC Series in 1995, and also the small-sized CSTCR and CSTCE Series that have the narrow frequency tolerance required by CAN in 2000. These resonators are mounted on automotive electronic devices all around the world. Furthermore, the company has developed the high-precision Hybrid CRystal (HCR) and is making an effort to expand its product line to meet various clock requirements. This article describes the trends of in-car LAN and the required performance of timing devices used for in-car LAN. The article also introduces the efforts made by Murata to develop its timing devices.

Technological Trends of In-Car LAN

The currently most popular CAN protocol used for communications between automotive ECUs is the communication protocol defined by ISO11898 and ISO11519-2, which can achieve a communication speed of up to 1Mbps. The precision of timing devices to be used for this protocol is determined by criteria, such as the routing condition for establishing communications between ECUs. Normally, however, timing devices with a tolerance of approximately ±3000ppm are acceptable in terms of actual use.

On the other hand, FlexRay achieves a high data communication speed of up to 10Mbps and enables real-time control for X-by-Wire. Therefore, this communication protocol is used to perform various kinds of controls, like brake, steering, and suspension. As FlexRay provides a higher communication speed than CAN, it requires timing devices with a tolerance of ±500ppm.

Furthermore, automotive Ethernet has been a hot topic of consideration in recent years. Ethernet is a communication protocol standardized by IEEE802.3 and 100BASE-T is widely used for office equipment and similar equipment. There is a high expectation for its application in information systems and camera image signal transmission with 100BASE-T for in-car LAN. Communication timing devices also have an important role for such application, which requires timing devices with a tolerance of several hundred parts per million (ppm).

As indicated above, the in-car LAN, which has been widespread due to CAN, requires higher precision and larger capacity for data communications. For that reason, there is a growing demand for timing devices of even higher precision.

Trends of Automotive Timing Devices

Automotive crystal units are being miniaturized from metal can type products to 8045-size, 5032-size, and even smaller 3225-size products. This trend is linked with the miniaturization of crystal devices in general. In addition to such trends, there are automotive-specific demands for products that achieve high-temperature operation (+150°C) as well as products with improved solder crack resistance. In view of the development of products that can operate at higher frequencies in order to improve ECU processing performance, further advancement of miniaturization is expected to continue. With regard to automotive electronic components, there are strong quality demands, such as (1) wide-range operating temperatures (-40°C to +125°C or +150°C in some cases), (2) high reliability typified by AEC-Q200 qualified products, and (3) zero defects.

Murata has developed an automotive crystal unit called HCR that meets these demands. HCR is a new product miniaturized from metal can type products to 8045-size, 5032-size, and even smaller 3225-size products. This trend is linked with the miniaturization of crystal devices in general. In addition to such trends, there are automotive-specific demands for products that achieve high-temperature operation (+150°C) as well as products with improved solder crack resistance. In view of the development of products that can operate at higher frequencies in order to improve ECU processing performance, further advancement of miniaturization is expected to continue. With regard to automotive electronic components, there are strong quality demands, such as (1) wide-range operating temperatures (-40°C to +125°C or +150°C in some cases), (2) high reliability typified by AEC-Q200 qualified products, and (3) zero defects.

Murata has developed an automotive crystal unit called HCR that meets these demands. HCR is a new product with a built-in quartz crystal element and inherits the basic package structure of CERALOCK®. Also, HCR can satisfy the demand for high frequency precision that cannot be achieved by CERALOCK®. The main features of HCR are as follows 1) product development with total elimination of unwanted

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particles (foreign substances); 2) product design with improved solder crack resistance; 3) characteristics equivalent to those of existing one-size larger crystal unit achieved in a miniaturized size product.

Sometimes, unwanted particles cause a non-isolation problem. Therefore, elimination of these particles is an important point of consideration for achieving zero defects. Murata aims at setting up a production line that does not discharge particles and removes and monitors them right from the design of production line. The company has also established a particle elimination process based on the company’s own screening technology. To prevent solder cracking, the company has designed the optimal dimensions for substrate electrodes. As a result, the electrical connection rate is kept over 50 percent for heat shock tests of 3,000 cycles. HCR adopts the company’s own non-airtight package called “Cap Chip” structure, which has a long track record over the years of manufacturing CERALOCK® products. Although this package has a simple structure where a metal cap is sealed on a ceramic flat plate with resin, it allows using maximum substrate area and makes it possible to mount a large-size crystal element in accordance with the product size ratio. In addition, it achieves low equivalent series resistance (ESR) and provides a high cost performance at the same time.

**Specifications of HCR Products**

Fig. 1 shows the outside dimensions of an automotive HCR “XRCHA-F-A” Series product, whereas Fig. 2 summarizes the product specifications. The HCR frequency lineup cover the high demand range of frequencies for automotive crystal units, from 16 to 24MHz. The product has adopted a size of 2.5 × 2.0mm, which is approximately 37 percent smaller than the conventional crystal units that operate in the same frequency range. Furthermore, conventional crystal units use an airtight package structure that is constructed using a glass sealing or welding method. HCR, on the other hand, has a simple structure that is constructed using a flat substrate with a metal cap as mentioned earlier. As a result, it becomes a cost-efficient and high-quality crystal unit. With regard to the main uses of HCR, Murata expects it to be utilized for all kinds of applications associated with rapidly advancing automotive ECUs, such as engine ECU, Antilock Brake System (ABS), Electric Power Steering (EPS), and body ECU. The standard operating temperature of HCR is -40°C to +125°C (150°C also supported).

**Issues, Future Efforts**

Murata believes that the progress of automotive electronic devices will not stop at highly functional communications between ECUs and that the interfaces to various sensor nodes and external communication information will move ahead with a focus on automatic driving technologies. Regarding automotive timing devices, for which the saving of space is particularly necessary, it is assumed that Murata must develop suitable products to meet the needs of customers (such as miniaturization, high precision, high reliability, and lower cost), and introduce such products to the market.

In August 2013, Murata acquired Tokyo Denpa Co., Ltd. (TEW) and TEW became a wholly-owned subsidiary of Murata. Murata aims at maximizing customer satisfaction by creating new value as a comprehensive timing device manufacturer that possesses ceramic and crystal manufacturing technologies in terms of the material level.

**About This Article:**

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