Functions required for USB MCUs that contribute to the miniaturization and reduced power consumption of wearable devices

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Overview

The USB Type-C IF market is growing in the automotive, consumer electronics, and PC sectors. In recent years, wearable devices have been expanding into various fields, and the USB Type-C IF is being seen as a charging specification that maintains compatibility as technology advances.

The USB Type-C connector specification includes standards for USB data communication, power supply, and non-USB data communication and video signals. The power supply specifications enable delivery via USB PD (up to 48V/5A, 240W) and USB Type-C (up to 5V/3A, 15W). Wearable devices equipped with the USB Type-C interface as a platform must support charging at up to 15W and USB communication and the addition of numerous features for next-generation models, while simultaneously requiring miniaturization, lightweight design, and extended battery life.

The RA2L2 is a new entry-level USB MCU that features ultra-low power consumption, a hallmark of the RA2 series, and USB FS (no external crystal oscillator required) with USB Type-C IF functionality.

The RA2L2 contributes to the miniaturization of PCB boards by reducing external components when detecting USB Type-C, enables future functionality expansion with its rich peripheral functions, and contributes to longer battery life with its low power consumption. This makes it an ideal product for next-generation wearable devices.

USB Type-C Detection

USB Type-C detection is performed when a cable is connected by applying voltage from the Source side to the Rp resistor on the Source side and the Rd resistor on the Sink side, and then detecting USB Default/1.5ASource/3.0ASource based on the voltage applied to the Rd resistor on the Sink side.

Source current detection	Power supply	USB Type-C Cable and Connector Specification Sink CC pin Voltages Threshold(V)	
		Old standard Release2.3	New standard Release2.4
USB default	0.5A @5V	(from 0.25)	(from 0.277)
1.5A source	1.5A @5V	0.66	0.613 to 0.745
3.0A source	3.0A @5V	1.23	1.165 to 1.368

Table 1: Differences in Sink CC Pin Voltage Threshold (V)

Therefore, by connecting Rd as the termination resistor of the CC terminal on the Sink side, it can detect that the Source side is connected to the Sink side. It is necessary to detect the voltage across the Rd resistor to determine how much power is being supplied when the Sink side is connected to the Source. When performing fast charging, the voltage is detected across Rd to distinguish between Default USB/1.5A Source and 3.0A Source, and to control the charging via the Charger IC. The method for detecting the voltage across the Rd resistor may involve using the ADC integrated into the MCU.

When detecting using an ADC equipped on an MCU, you need external components such as an external Rd resistor, a Schottky barrier diode, and a capacitor for analog power supply. In addition, CC voltage detection sequence software is required to determine the Default USB/1.5A Source/3.0A Source.

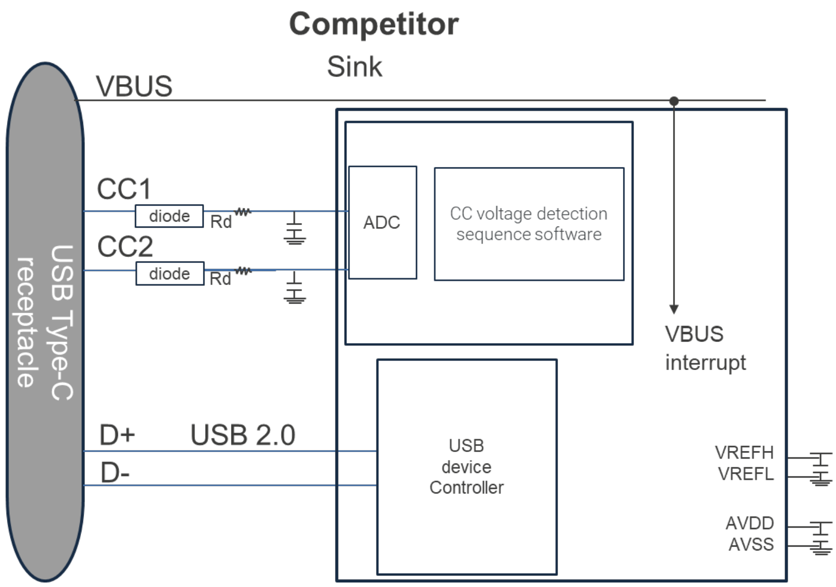


Figure 1: USB Type-C Detection Image of Products in the Market

The following system costs can be reduced by using the USB Type-C built into the RA2L2.

① **Reduction of Peripheral Components**

The USB-C IF circuit of the RA2L2 has Rd resistors mounted on CC1 and CC2, which each detect the voltage applied to them. This enables detection of reverse plug insertion, USB-C connections, and a USB debug accessory. In addition, the CC terminal is a 5V tolerant port, contributing to the reduction of external components. Wearable devices often reduce external interfaces to prioritize miniaturization and usability, typically leaving only a single USB Type-C port. On the other hand, in the mass production process, a dedicated IF is required for debugging work, log data collection, and shipping tests. You can perform factory-mode USB communication for writing data and collecting log data on the production line by using a USB debug accessory, which contributes to reduced labor costs in mass production processes.

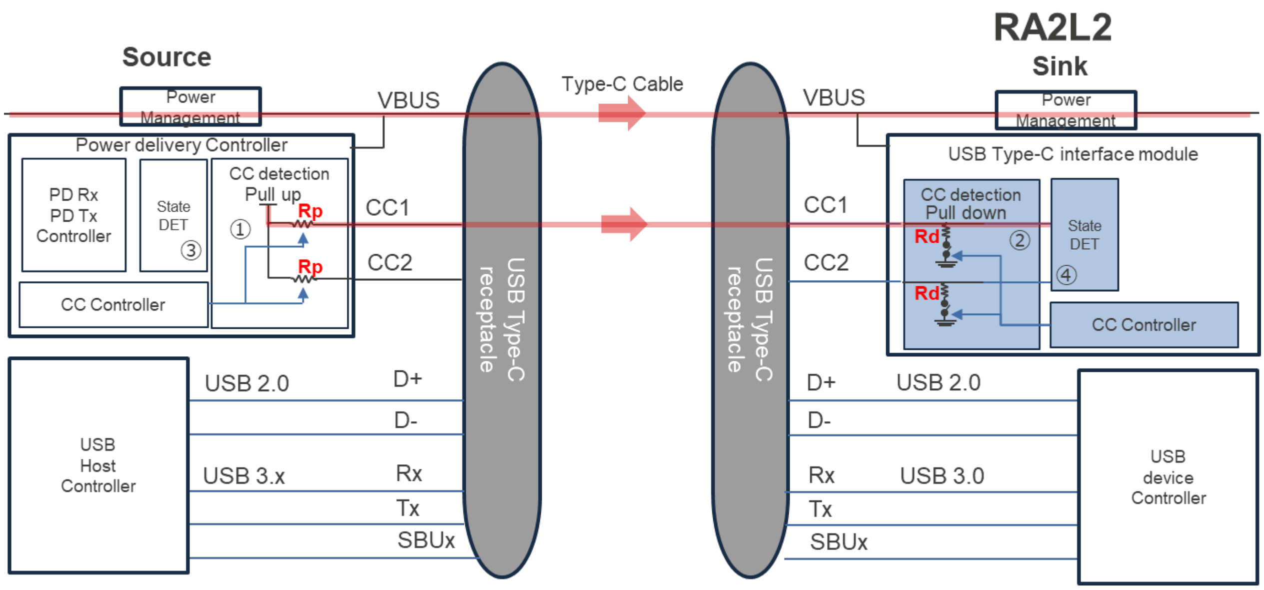


Figure 2: RA2L2 USB-C Connection Image

② **Reduction in Software Development Man-hours**

The RA2L2's USB-C IF is equipped with hardware circuits dedicated to detection, enabling a reduction in memory usage of approximately 50% compared to MCU-mounted ADC software. In addition, FSP (Flexible Software Package) provides drivers for CC voltage detection sequences, eliminating the need for software development man-hours.

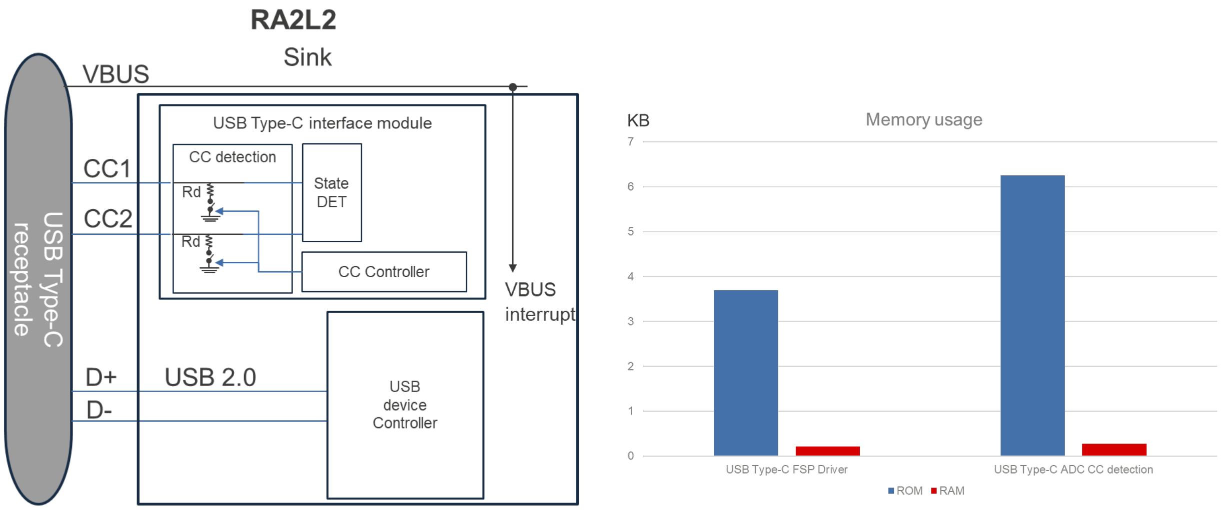


Figure 3: Image of the RA2L2 USB Type-C Detection Circuit and Memory Usage Comparison

Reduced System Power Consumption

Battery life is a critical factor in wearable devices. Reducing power consumption during system standby and operation is essential. For example, Figure 3 illustrates a wearable device. An FGIC is used for battery monitoring, a Charger IC for charging control, an SoC for main control, and an MCU for system control. In system standby mode, only the FGIC is active, while other devices are in standby mode. The MCU is in standby mode and resumes operation in response to external interruptions (GPIO) from sensors and other ICs, or interval timer interruptions. After CPU processing is completed, it returns to standby mode. Maintaining a standby state as long as possible and achieving fast recovery from standby to minimize unnecessary power consumption are critical design considerations in system design to reduce power consumption.

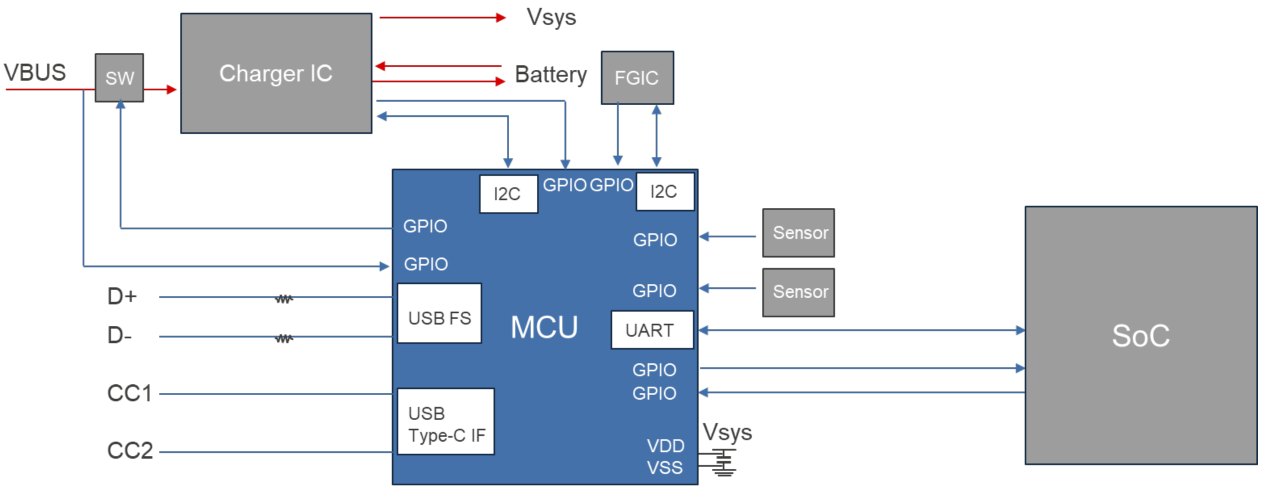


Figure 4: Wearable Device System Image

① Comparison of consumption current

In this type of intermittent operation, the MCU is often in standby mode except when performing system operations. Therefore, the power consumption of the system in standby mode, interruption factors, and the current consumption in low power mode which can maintain RAM, are important factors.

Under the above conditions, power consumption can be reduced compared to competing products by approximately 83% in low power mode (Figure A) and by approximately 27% in run mode (Figure B).

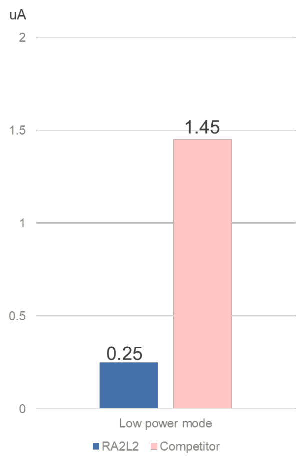


Figure A: Approximately 83% reduction in current consumption in low power mode

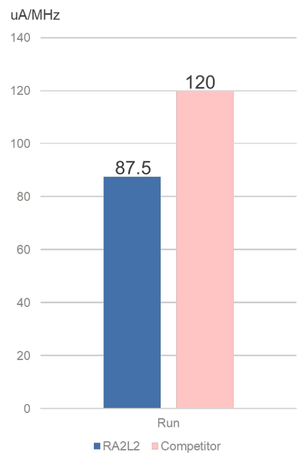


Figure B: Approximately 27% reduction in current consumption in run mode

Furthermore, fast recovery from standby (7.3 us) reduces unnecessary power consumption.

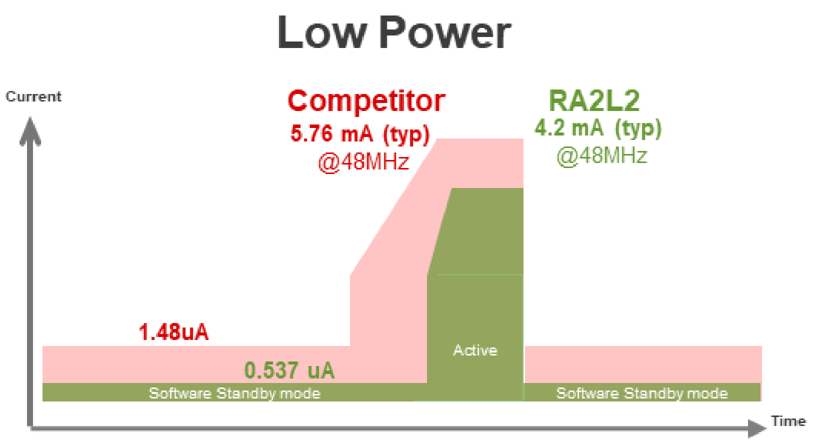
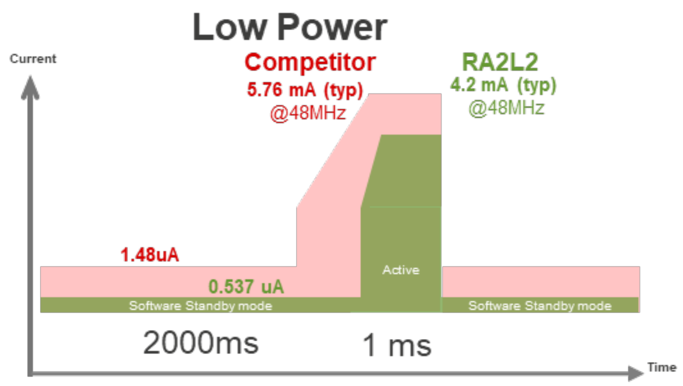


Figure 5: Current Consumption During Intermittent Operation

Let's look at data comparing the RA2L2 with other vendors to see how much it can extend battery life.

If you visualize a 50mAh battery, intermittent operation of 2000ms standby and 1ms CPU operation, this contributes to an extension in battery life of approximately 10 months.



Competitor

- 2000ms x 1.48uA*1 =2960 uAms
- 1ms x 5760uA =5760 uAms
- Total 8720 uAms = Ave 4.36 uA
- 50mAh battery operating 477 days

RA2L2

- 2000ms x 0.537uA*2=1074 uAms
- 1ms x 4200uA=4200uAms
- Total 5274 uAms = Ave 2.63 uA
- 50mAh battery operating 792 days

*1:VLLS3 mode, LPTimer enable
*2: Software standby mode 0.25 uA (typ) ,LP Timer 0.287 uA (LOCO=32.768kHz)

Figure 6: Comparison of Battery Consumption During Intermittent operation

Conclusion

The RA2L2 is a USB MCU equipped with peripheral functions ideal for applications with low power consumption. In addition, the FSP (Flexible Software Package), which provides example projects for peripheral functions including USB drivers, contributes to reducing the development man-hours required for software development.

Related Information

- RA2L2: 48MHz Arm Cortex-M23 Entry Level USB General-Purpose Microcontroller
- EK-RA2L2: Evaluation Kit for RA2L2 MCU Group
- RTK7A2L2UCD00000BJ: USB Type-C Reference Design for RA2L2 MCU
- Development Tool with USB Support: QE for USB Solution Tool Kit

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