AN14195

USB Remote Wake-up on MCXN947

Rev. 1 — 24 January 2024 Application note

Document information

Information	Content
Keywords	AN14195, MCXN947, OTG
Abstract	MCXN947 contains two USB 2.0 interfaces. USB0 is a full-speed interface. It comprises an On-The-Go (OTG) dual-role subsystem with OTG protocol support.

1 Introduction to USB on MCXN9

MCXN947 contains two USB 2.0 interfaces. USB0 is a full-speed interface. It comprises an On-The-Go (OTG) dual-role subsystem with OTG protocol support. The OTG implementation in the USB0 controller provides a device solution for a full-speed compliant peripheral along with limited host functionality for implementing a USB 2.0 full-speed/low-speed compliant embedded host. Figure 1 shows the USB FS/LS subsystem.

USB1 is a high-speed interface. It supports the OTG function, which conforms to the Universal Serial Bus Specification Rev2.0 and the OTG and Embedded Host Supplement to the USB Revision 2.0 Specification. Figure 2 shows the USB1 HS block diagram and Figure 3 shows the USB 2.0 PHY block diagram. The USB1 HS controller is connected with USB HS PHY through the UTMI+ interface.

Besides, both interfaces can support a remote wake-up function when performed as host or device roles. This document describes how to use the remote wake-up function.

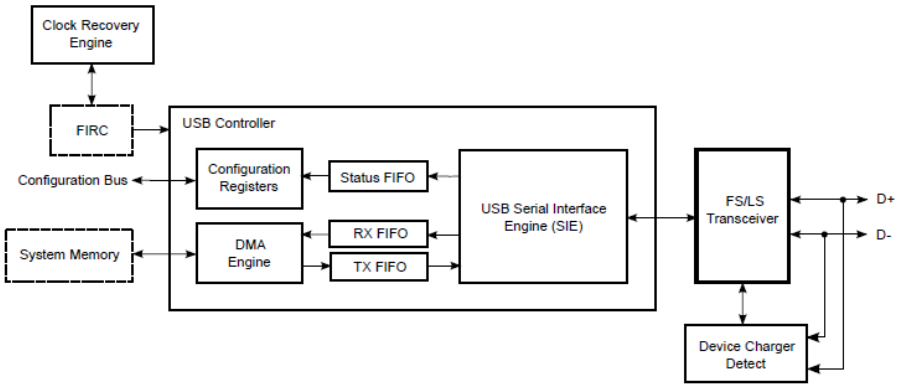

Figure 1. USB0 FS/LS subsystem block diagram

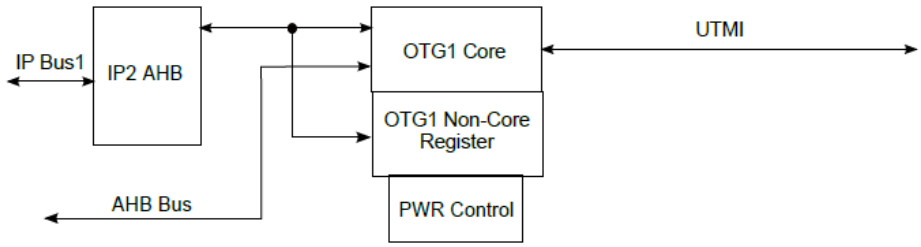

Figure 2. USB1 HS block diagram

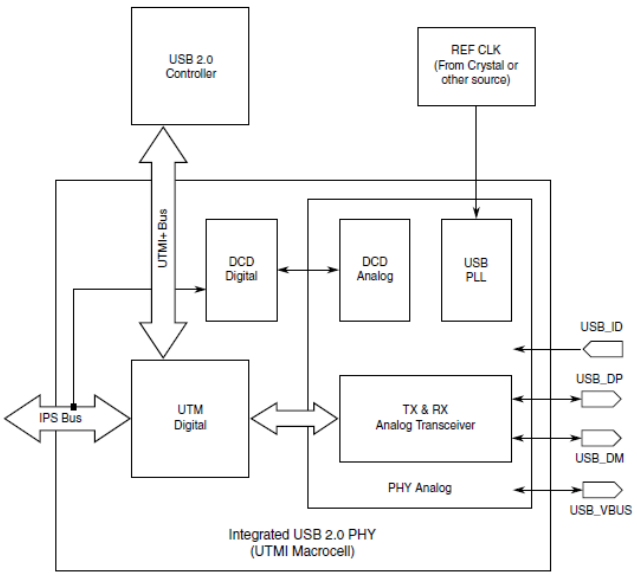

Figure 3. USB 2.0 PHY block diagram

2 USB remote wake-up function introduce

To save power, the USB host and device can work in a low-power mode. When the host is in the sleep mode, the host stops all bus traffic. The device will run into the suspend state if it detects no bus traffic for more than 3 ms. When in the suspend mode, the USB device can maintain its internal status, such as device's address and configuration. Figure 4 shows the device state diagram.

In the MCXN947 MCU, the USB controller supports the sleep mode, deep-sleep mode, and power-down mode to save power consumption. When the USB subsystem detects no activity on the USB bus for more than 3 ms, it sets the ISTAT[SLEEP] bit to 1. This bit can cause an interrupt and the software decides the appropriate action.

Besides that, we can set the USBTRC0[USBRESMEN] bit to enable the wake-up function. After enabling this function, the USB subsystem wakes up when the USB subsystem is powered, which occurs through an asynchronous interrupt triggered by activity on the USB bus.

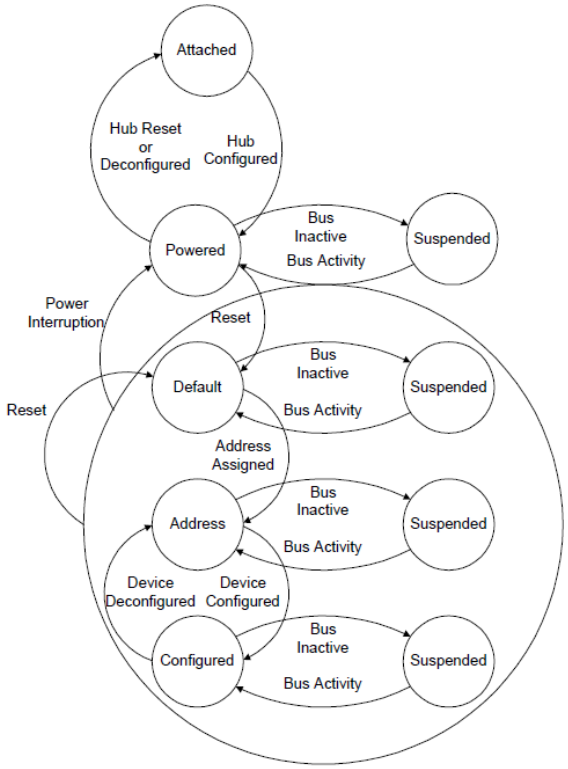

Figure 4. Device state diagram

2.1 USB host remote wake-up device

The host may signal a resume at any time. It must send the resume signaling for at least 20 ms and then end the resume signaling in one of two ways, depending on the speed at which its port was operating when it was suspended. If the port was in low/full speed when suspended, the resume signaling must be ended with a standard, low-speed EOP (two low-speed bit times of SE0 followed by a J). If the port was operating in high speed when it was suspended, the resume signaling must be ended with a transition to the high-speed idle state. Figure 5 shows the USB resume timing.

The 20 ms of resume signaling ensures that all devices in the network that are enabled to see the resume are awaken. The connectivity established by the resume signaling is torn down by the end of resume, which prepares the hubs for normal operation. After resuming the bus, the host must begin sending bus traffic (at least the SOF token) within 3 ms of the start of the idle state to keep the system from going back into the suspend state. Figure 6 shows the low-speed EOP timing.

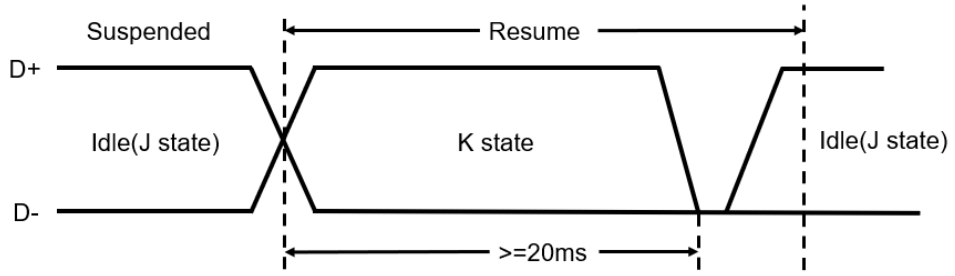

Figure 5. USB resume timing

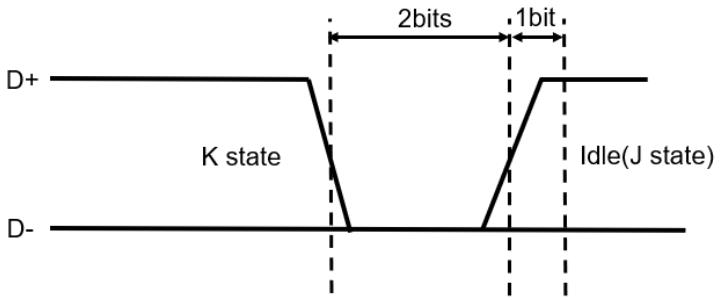

Figure 6. USB LS EOP timing

2.2 USB device remote wake-up host

Remote wake-up allows a suspended USB device to signal a host that may also be suspended. This notifies the host that it should resume from its suspend mode, if necessary, and service the external event that triggered the suspended USB device to signal the host. A USB device reports its ability to support remote wake-up in a configuration descriptor. If a device supports remote wake-up, it must also allow the capability to be enabled and disabled using the standard USB requests.

If a device is in the suspend state, its operation is resumed when any non-idle signaling is received on its upstream-facing port. Additionally, the device can signal the system to resume operation if its remote wake-up capability has been enabled by the USB system software.

A device with remote wake-up capability may not generate resume signaling unless the bus has been in the dle state continuously for 5 ms (TWTRSM). This allows the hubs to get into their suspend state and prepare to propagate the resume signaling. The remote wake-up device must hold the resume signaling for at least 1 ms, but not more than 15 ms (TDRSMUP). At the end of this period, the device stops driving the bus. It puts its drivers into the high-impedance state and does not drive the bus to the J state.

2.3 USB hub remote wake-up function

According to the USB 2.0 specification, the USB hub must support the suspend and resume functions and it must transmit the suspend and resume signal between the device and host. Hubs support both the global and selective suspend and resume. The global suspend/resume refers to the entire bus being suspended or resumed without affecting any hub's downstream-facing port states. The selective suspend/resume refers to a downstream-facing port of a hub being suspended or resumed without affecting the hub state. The global suspend/resume is implemented through the root port(s) at the host. The selective suspend/resume is implemented via requests to a hub.

If the hub upstream-facing port is in a full-speed (high-speed) mode, the required behavior is the same as that for a function with the upstream-facing port in a full-speed (high-speed) mode. Figure 7 shows the FS/LS device and hub remote wake-up-resume timing.

When the downstream-facing port operating in a high-speed mode goes into the suspend state, it switches to full-speed terminations, but continues to have a high-speed port status. In response to a remote wake-up or selective resume, this port drives the full-speed 'K' throughout its resuming state. The requirements and timings are the same as for the full-speed ports described below. At the end of this signaling, the bus returns to the high-speed idle state (using the SendEOR state). After this, the port returns to the enabled state. The high-speed status of the port is maintained throughout the suspend-resume cycle. Figure 8 shows the remote wake-up resume with a high-speed device.

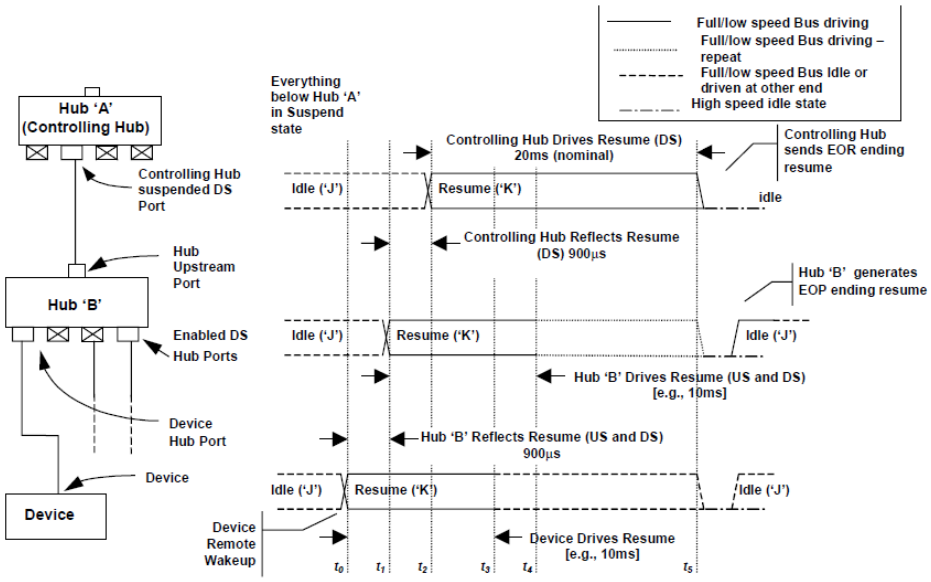

Figure 7. Remote-wake-up resume signaling with full-/low-speed device

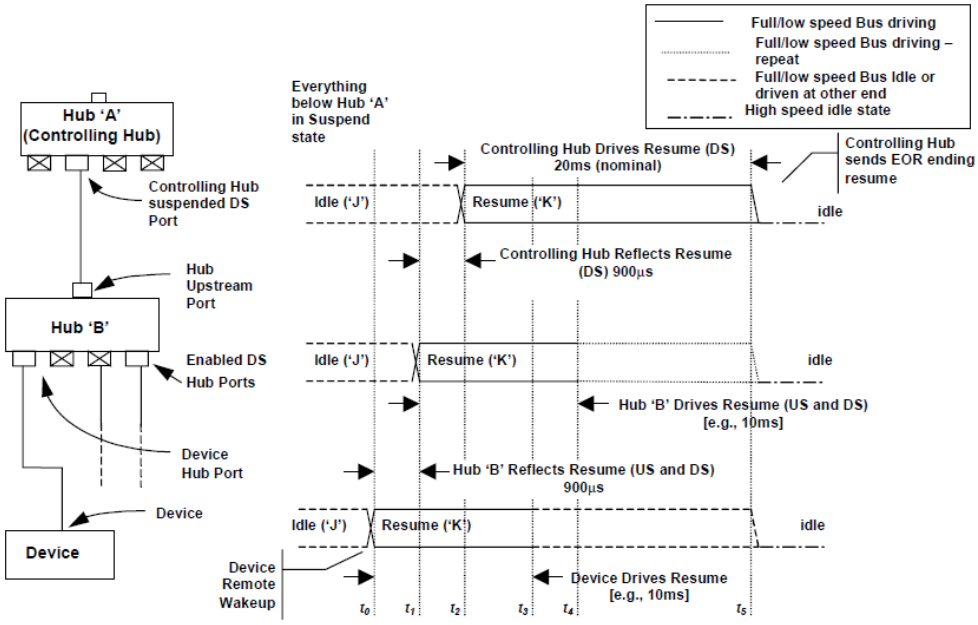

Figure 8. Remote-wake-up resume signaling with high-speed device

3 USB remote wake-up test

This chapter describes the USB remote wake-up test.

3.1 Test platform

This section describes the test platform.

3.1.1 Hardware

The demo is developed on the MCX-N9XX-EVK board. Figure 9 shows the MCX-N9XX-EVK board.

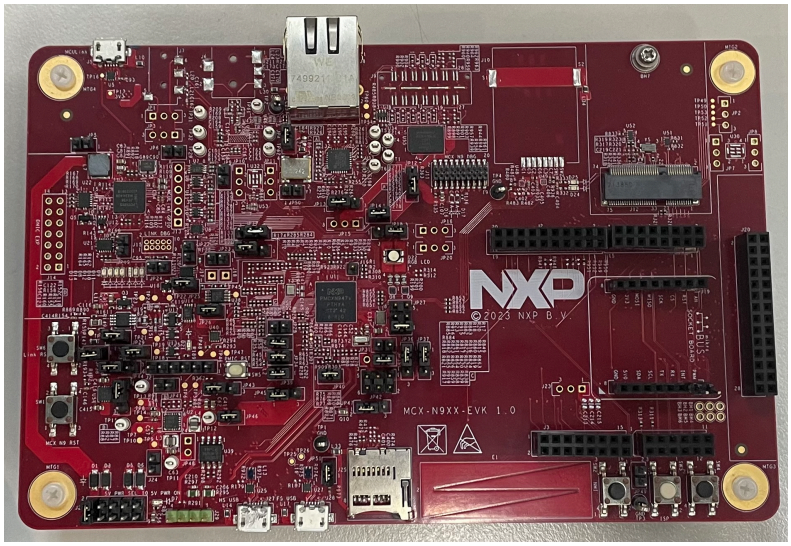

Figure 9. MCX-N9XX-EVK board

3.1.2 Software

The following software is used:

- SDK_2_14_0_MCX-N9XX-EVK
- IDE: MCUXpresso IDE v11.8.0

3.2 USB host remote wake-up device

When testing the USB host remote wake-up device, we need two MCX-N9xx-EVK boards, one as the host and another as the device. The USB host test code is in the SDK install package:

- <MCUXpresso_SDK_Install>/boards/<board>/usb_examples/usb_suspend_resume_host_hid_mouse

The USB device test code is in the SDK install package:

- <MCUXpresso_SDK_Install>/boards/<board>/usb_examples/usb_suspend_resume_device_hid_mouse

Figure 10 shows the remote wake-up settings used by the debug console. Print “s” to enable the host remote wake-up feature. Press the SW3 button on the EVK board, which used as the host to wake up the device.

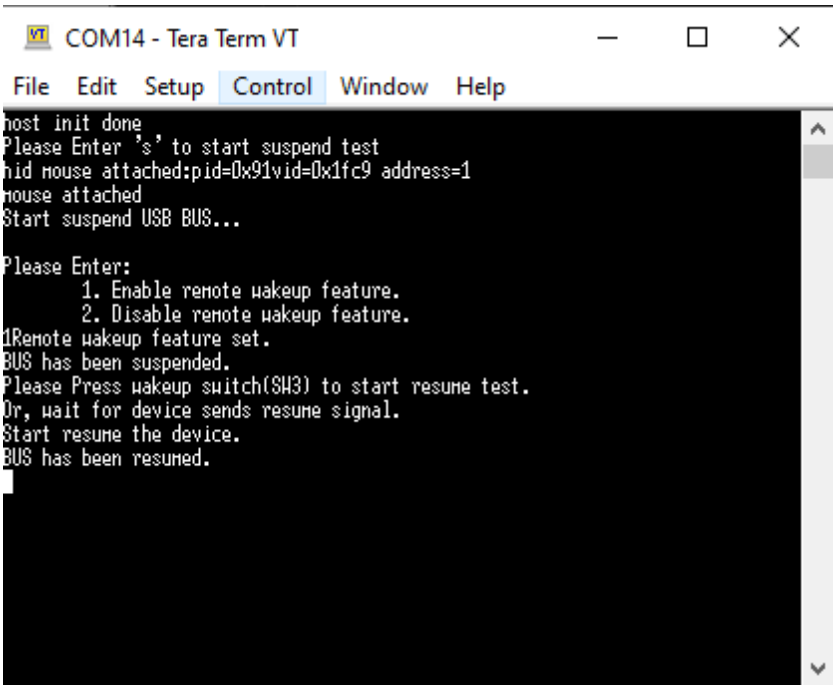

Figure 10. USB host remote wake-up setting

Figure 11 shows the USB remote wake-up timing, the P1 timing marker in Figure 11 shows the resume (K state) time which was driven by USB host, P1 is about 20 ms.

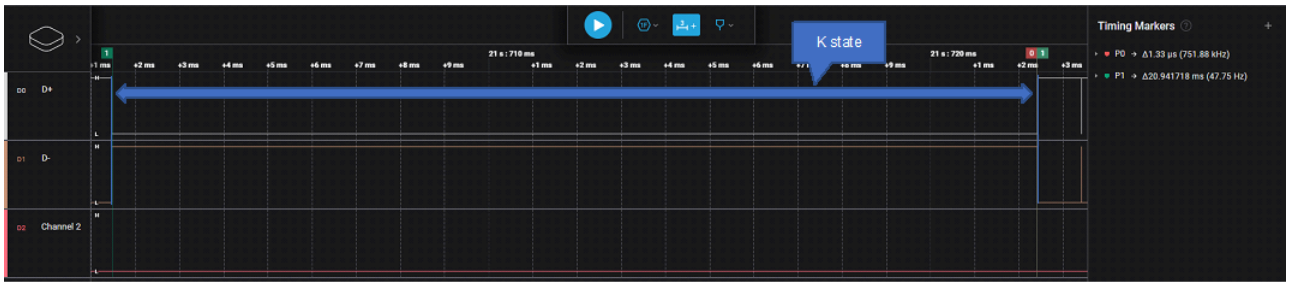

Figure 11. USB FS USB remote wake-up timing

Figure 12 shows the USB LS EOP timing, after USB LS EOP,USB bus will re-start to transmit data. P0 is about 1.33 µs.

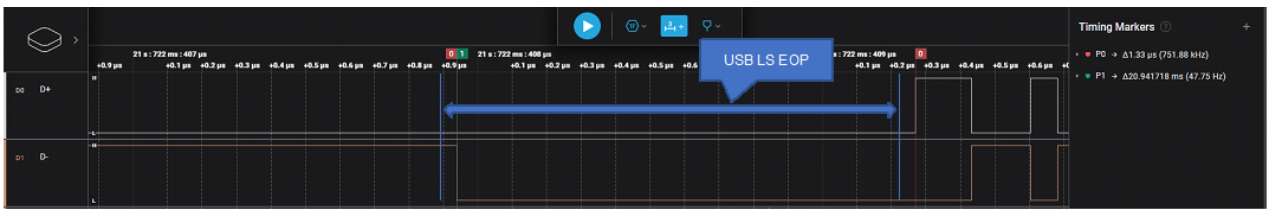

Figure 12. USB LS host EOP timing

3.3 USB device remote wake-up host

The USB device test code is in the SDK install package:

- <MCUXpresso_SDK_Install>/boards/<board>/usb_examples/usb_suspend_resume_host_hid_mouse

The USB device test code is in the SDK install package:

- <MCUXpresso_SDK_Install>/boards/<board>/usb_examples/usb_suspend_resume_device_hid_mouse

Figure 13 shows the remote wake-up settings used by the debug console. Print “s” to enable the host remote wake-up feature. Press the SW3 button on the EVK board, which used as the device to wake up the host.

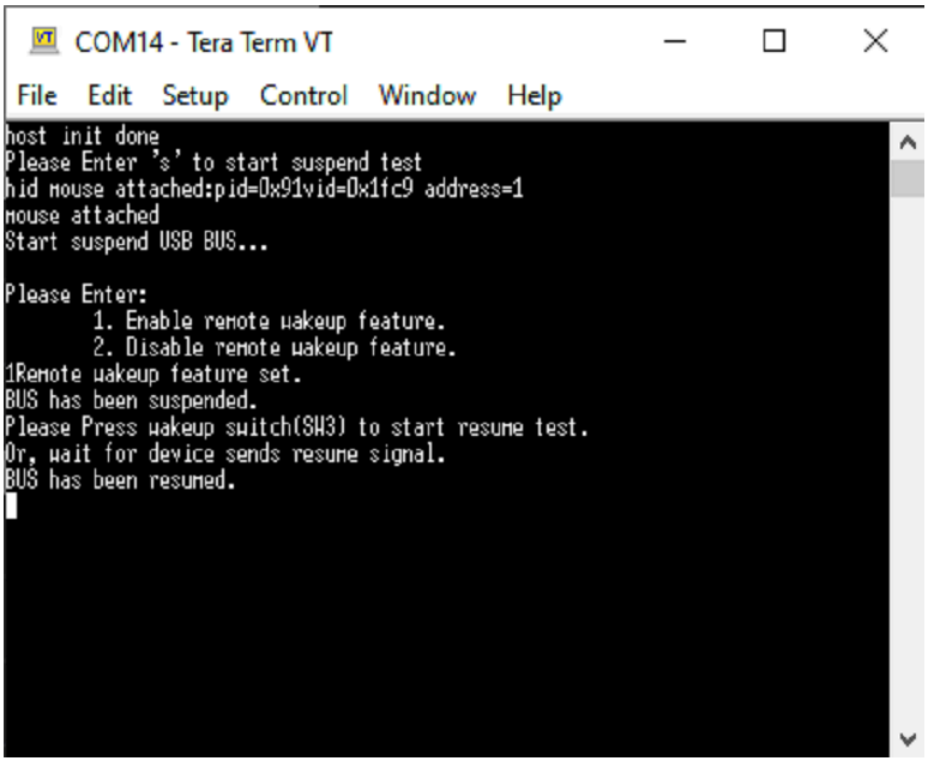

Figure 13. USB host remote wake-up setting

Figure 14 shows the USB remote wake-up timing. The P1 timing marker in Figure 15 shows the resume (K state) time, which was driven by the USB host. P1 is about 21 ms.

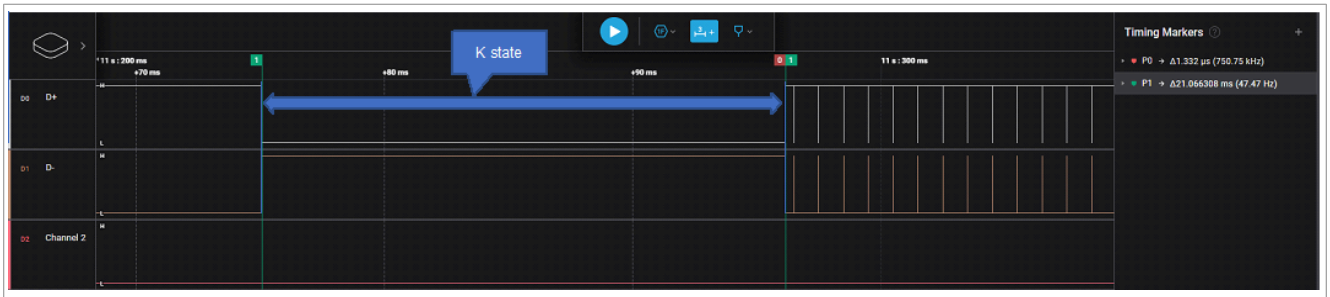

Figure 14. USB FS USB remote wake-up timing

Figure 15 shows the USB LS EOP timing. After USB LS EOP, the USB bus will restart to transmit data. P0 is around 1.33 µs.

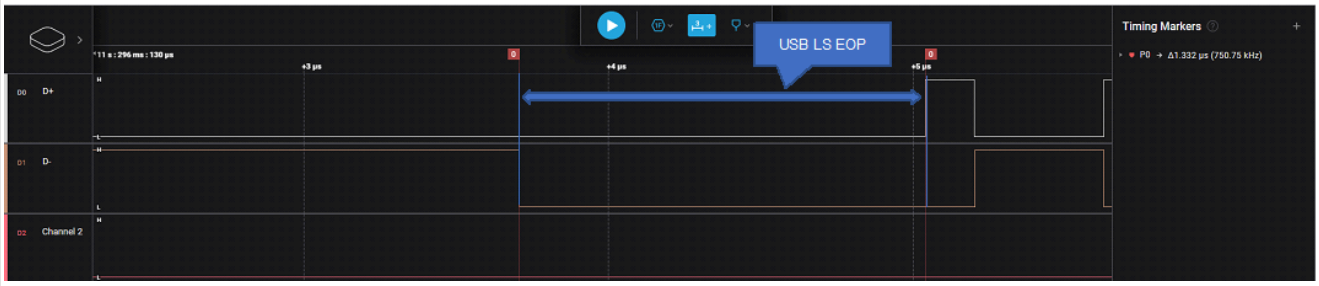

Figure 15. USB LS host EOP timing

4 Revision history

Table 1 summarizes the changes to this document.

Table 1. Revision history

Document ID	Release date	Description
AN14195 v.1	24 January 2024	Initial external release.

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