AN13527

LPC553x/LPC55S3x Crystal-Less USB Solution

Rev. 2 — 21 September 2023 Application note

Document Information

Information	Content
Keywords	LPC55S3x, LPC553x, Crystal-less full-speed USB operation, LPCXpresso55S36 SDK
Abstract	This document explains a software solution to achieve the crystal-less full-speed USB operation on LPC55S3x/ LPC553x based platforms.

1 Introduction

The NXP LPC553x/LPC55S3x product family features a full-speed USB 2.0 device controller, which supports crystal-less device mode. For achieving crystal-less USB device operation in full-speed mode, NXP provides a software library based solution, which involves measuring the start of frame (SOF) timing. With this solution, full-speed USB operation can be achieved with ±0.25% data rate accuracy.

This application note explains a software solution to achieve the crystal-less full-speed USB operation on LPC553x/LPC55S3x based platforms (for example, LPCXpresso55S36). To help users enable the software solution on an LPC553x/LPC55S3x board, LPCXpresso55S36 SDK version 2.14.0 is available for download in a ZIP package (AN13527SW.zip) on nxp.com.

A working example of the software solution is provided for MCUXpresso, Keil, and IAR IDEs in the folder *\boards\lpcxpresso55s36\usb_examples\usb_device_composite_hid_audio_unified* of the LPCXpresso55S36 SDK.

2 Implementing crystal-less USB solution

This section describes the steps required to implement a crystal-less USB full-speed operation for the LPC553x/LPC55S3x family.

2.1 Add calibration library

To achieve full-speed USB operation, appropriate calibration must be enabled in user application. For enabling calibration, FRO calibration library must be added to the user application.

For MCUXpresso, Keil, and IAR IDEs, precompiled calibration libraries are provided in the LPCXpresso55S36 SDK. The table below provides the details of the libraries.

Table 1. Precompiled calibration libraries

Libraries	Folder path	IDE
`libfro_calib_hardabi.a`, `libfro_calib_softabi.a`	`\devices\LPC55S36\mcuxpresso`	MCUXpresso
`keil_lib_fro_calib.lib`	`\devices\LPC55S36\arm`	Keil
`iar_lib_fro_calib.a`	`\devices\LPC55S36\iar`	IAR

2.2 Include header file

The LPCXpresso55S36 SDK provides a header file `fsl_fro_calib.h`, in the folder`\devices\LPC55S36\drivers`. For communicating with the SDK, this header file must be included in the user application code.

2.3 Modify user application code

This section explains how to modify user application code to integrate a crystal-less USB device operation in full-speed mode for LPC553x/LPC55S3x. To achieve the solution, modify the application source code as follows:

1. Call the following function in the source code:

```
fro_calib_Get_Lib_Ver (void);
```

This function reads the version of the calibration library and returns 0x00000100.

The user application code must select the FRO 96 MHz clock (value of 0x3 in the USB0CLKSEL register) as a clock source because the external crystal is no longer required. For more details, see LPC55S3x Reference Manual / LPC553x Reference Manual.
The calibration library must use one of the 32-bit timers to measure SOF timing and enable appropriate calibration.

2. Using the AHBCLKCTRL1 register, enable the clock to the CTimer (CTimer 0, CTimer1, or CTimer2). Using the AHBCLKCTRL2 register, enable the clock to the CTimer (CTimer3 or CTimer4).
3. Using CTIMERCLKSEL0/1/2/3/4 register, select the FRO 96 MHz clock as CTimer0/1/2/3/4 clock source.
4. Pass the timer peripheral (CTIMER0, CTIMER1, CTIMER2, CTIMER3, or CTIMER4) and the system clock in kHz to the library call for the SDK:

```
void Chip_Timer_Instance_Freq (CTIMER_Type *base, unsigned int ctimerFreq);
```

The user application code must enable FRAME_INT_EN of the INTEN register in the `usb_device_lpcip3511.c` file of the SDK. This file is available in `\middleware\usb\device` folder of the SDK.

5. Modify user application code to enable FRAME_INT_EN of the INTEN register as follows:

```
/* enable interrupts */
lpc3511IpState->registerBase->INTEN = USB_LPC3511IP_INTSTAT_DEV_INT_MASK |
      USB_LPC3511IP_MAX_PHY_ENDPOINT_MASK
#if (defined(USB_DEVICE_SOF_EVENT_ENABLE) && (USB_DEVICE_SOF_EVENT_ENABLE >
 0U))
| USB_LPC3511IP_INTSTAT_FRAME_INT_MASK
#endif
```

The user application code must also handle FRAME_INT of the INTSTAT register in the `usb_device_lpcip3511.c` file of the SDK.

6. Modify user application code to handle FRAME_INT of the INTSTAT register as follows:

```
#if (defined(USB_DEVICE_SOF_EVENT_ENABLE) && (USB_DEVICE_SOF_EVENT_ENABLE >
 0U))
      if (interruptStatus & USB_LPC3511IP_INTSTAT_FRAME_INT_MASK)
      {
       USB_DeviceLpc3511IpSofEvent(lpc3511IpState);
      }
#endif
```

When FRAME_INT occurs, the user application code (for example, `usb_status_t USB_DeviceCallback (usb_device_handle handle, uint32_t event, void *param)` in `\boards\lpcxpresso55s36\usb_examples\usb_device_composite_hid_audio_unified\bm\` folder) must call the following function:

```
void USB_SOF_Event (void);
```

3 Crystal-less USB solution in LPCXpresso55S36 board

After implementing crystal-less USB solution in LPCXpresso55S36 board, you can remove the crystal that provides system clock (along with associated capacitors) from the board because the external crystal is no longer required. The components that can be removed from LPCXpresso55S36 board are highlighted in the figure below.

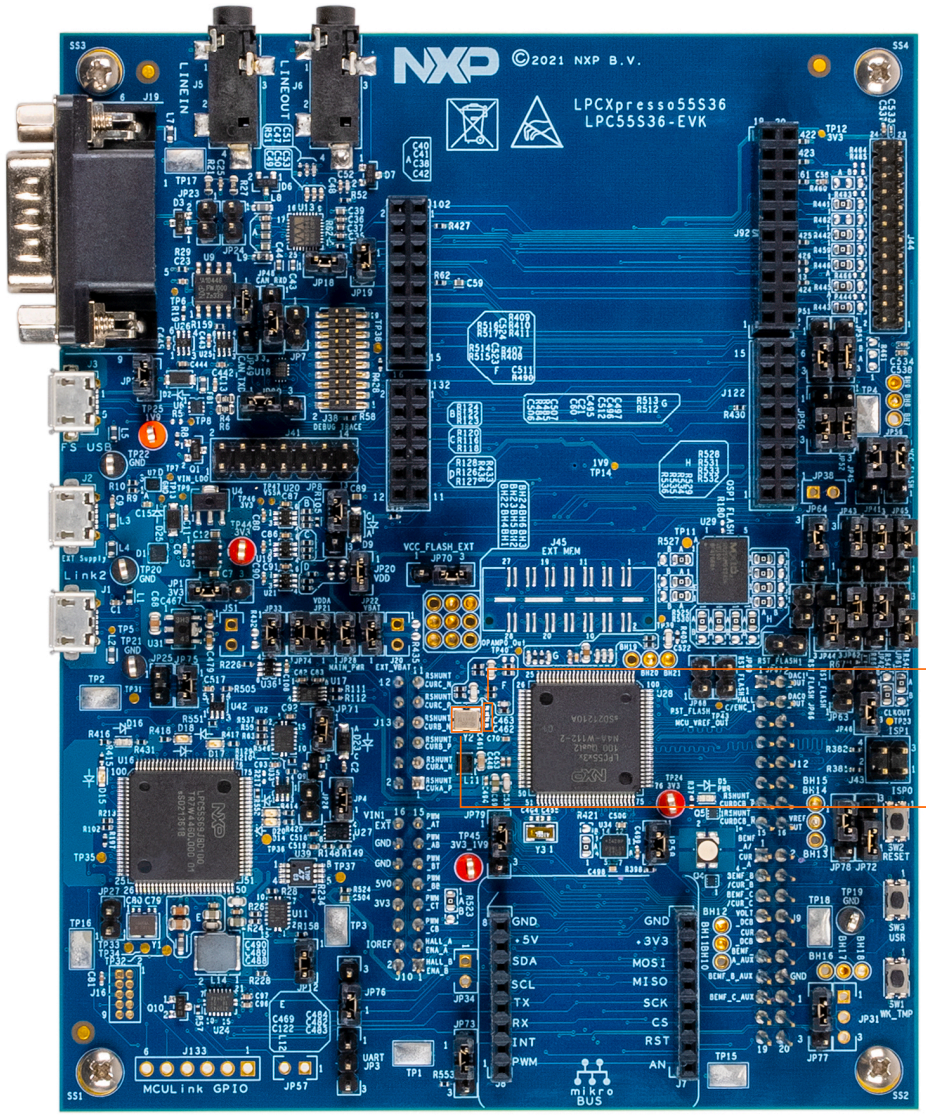

Figure 1. Optional components in LPCXpresso55S36 board

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5 Revision history

Table 2 summarizes the changes done to this document.

Table 2. Revision history

Revision number	Release date	Description
2	21 September 2023	Updated the LPCXpresso55S36 SDK package version to 2.14.0
1	26 May 2022	Replaced LPC55S3x/LPC553x with LPC553x/LPC55S3x
0	31 January 2022	Initial release

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