

LPC55S1x/LPC551x

LPC55S1x/LPC551x Crystal-less USB Solution

Rev. 1.0 — 17 March 2020

Technical Note

Document information

| Info | Content |
|-----------------|--|
| Keywords | LPC55S1x/LPC551x, Crystal, full-speed USB, FRO |
| Abstract | This technical note explains the usage of a software library to provide a full-speed USB crystal-less solution on the LPC55S1x/LPC551x family. |



Revision history

| Rev | Date | Description |
|-----|----------|------------------|
| 1.0 | 20200317 | Initial version. |

Contact information

For more information, please visit: <http://www.nxp.com>

For sales office addresses, please send an email to: salesaddresses@nxp.com

1. Introduction

The LPC55S1x/LPC551x product family features a full-speed USB 2.0 device controller with a crystal-less device mode.

To achieve crystal-less USB device operation in full-speed mode, NXP provides a software library solution that measures the Start of Frame (SOF) timing to meet full-speed operation ($\pm 0.25\%$ data rate accuracy).

This technical note explains the steps required to modify the software to integrate a crystal-less USB device operation in full-speed mode in the LPC55S1x/LPC551x application. In addition to this technical note, an SDK software example (usb_device_composite_hid_audio_unified) is provided in the MCUXpresso/LPCXpresso, Keil, and IAR IDEs.

2. Description

This section describes the steps to implement a crystal-less USB full-speed operation for the LPC55S1x/LPC551x family.

2.1 Calibration library

The software must include the FRO calibration library to enable appropriate calibration to meet the USB full-speed operations.

Pre-compiled libraries in SDK for MCUXpresso/LPCXpresso, Keil, and IAR are:

- Keil IDE: keil_lib_fro_calib_CM33.lib
- IAR IDE: iar_lib_fro_calib_CM33.a
- MCUXpresso IDE: libfro_calib_hardabi.a, libfro_calib_softabi.a

2.2 Header file

For SDK, include the following header file: fsl_fro_calib.h.

2.3 Source code modifications

Regardless of the IDE used to build the project, a preprocessor symbol in the compiler needs to be defined and added as “USB_DEVICE_FRO_CAL_LIBRARY_ENABLE=1”. A global search for this keyword can find all the necessary modification for the USB crystal-less operation.

Add the following changes to the source code.

1. Call the fro_calib_Get_Lib_Ver (void) function. This function reads the version of the calibration library and returns 0x00010000.
2. The user application code must select the FRO 96 MHz clock as a clock source (value of 0x3 in the USB0CLKSEL register) because the external crystal is no longer required. In this example, I2S MCLK, 24.576MHz uses PLL0 clock output, then, the input clock of the PLL0 is switched from the original external crystal to FRO 12MHz. See the LPC55S16 user manual related to the clock configuration for more details.
3. The calibration library must use one of the 32-bit timers to measure SOF timing and enable appropriate calibration. Note: Using the AHBCLKCTRL1 register to enable the clock to the CTimer 0, CTimer1, or CTimer2. Using the AHBCLKCTRL2 register to enable the clock to the CTimer3 or CTimer4.
 - a. Using CTIMERCLKSEL0/1/2/3/4 register, select FRO 96MHz clock as CTimer0/1/2/3/4 clock source.
 - b. Pass the timer peripheral (CTIMER0, CTIMER1, CTIMER2, CTIMER3 or CTIMER4) and the system clock in KHz to the library call for SDK, void Chip_Timer_Instance_Freq (CTIMER_Type *base, unsigned int ctimerFreq);
 - c. Pass the timer peripheral (CTIMER0 or CTIMER1 or CTIMER2 or CTIMER3 or CTIMER4) and the system clock in KHz to the library call for SDK,

```
void Chip_Timer_Instance_Freq (CTIMER_Type *base, unsigned int ctimerFreq);
```
4. The user application code must enable the FRAME_INT_EN of the INTEN register in the usb_device_lpcip3511.c file:

```

/* 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
#endif

```

5. FRAME_INT must be taken care in the usb_device_lpcip3511.c file.

```

#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

```

6. When the FRAME_INT occurs, the user application code must call the USB_SOF_Event() API where FRO clock will be constantly calibrated based on the SOF frame from the USB host.

2.4 LPC55S16 EVK development board

The 16MHz crystal, circuit reference Y2, and capacitors can be removed because the external crystal is no longer required, See the LPC55S16 EVK development board User Manual and schematics for more details.

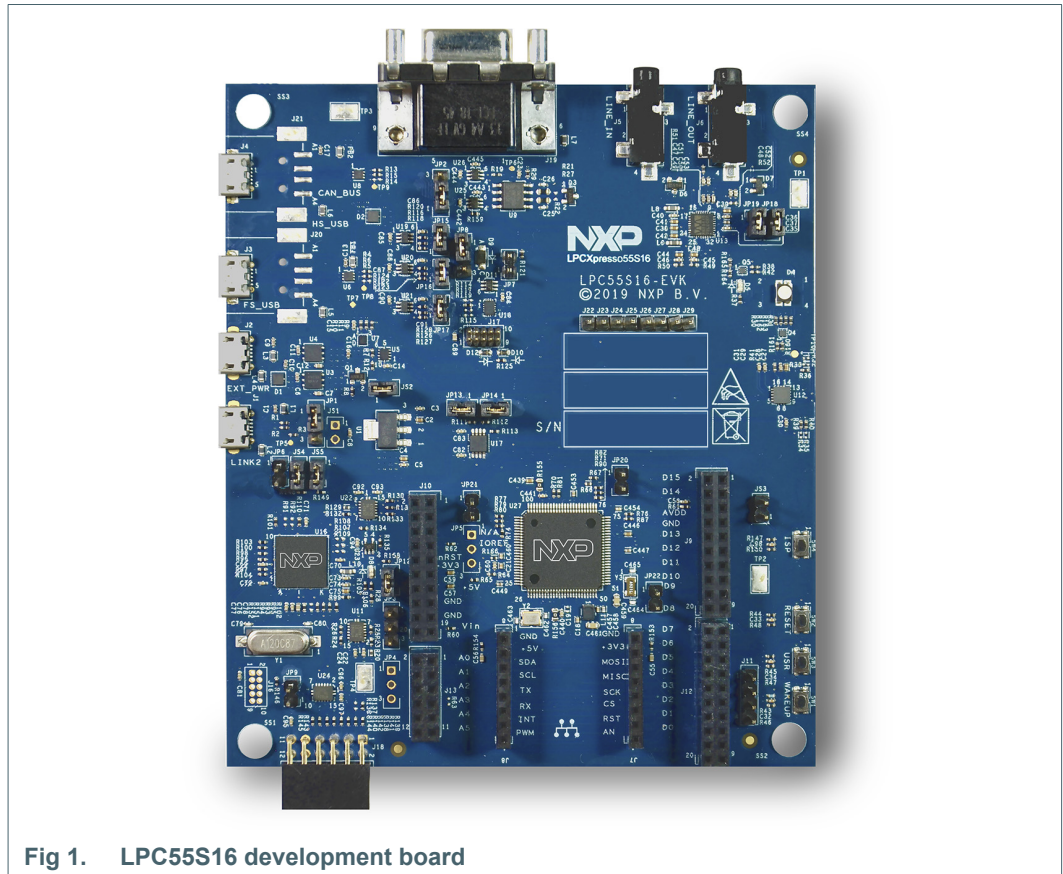


Fig 1. LPC55S16 development board

3. Legal information

3.1 Definitions

Draft — The document is a draft version only. The content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included herein and shall have no liability for the consequences of use of such information.

3.2 Disclaimers

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors.

In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the *Terms and conditions of commercial sale* of NXP Semiconductors.

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Suitability for use — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or

malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

3.3 Trademarks

Notice: All referenced brands, product names, service names and trademarks are the property of their respective owners.

4. Contents

| | | |
|----------|--------------------------------------|----------|
| 1 | Introduction | 3 |
| 2 | Description | 4 |
| 2.1 | Calibration library | 4 |
| 2.2 | Header file | 4 |
| 2.3 | Source code modifications | 4 |
| 2.4 | LPC55S16 EVK development board | 5 |
| 3 | Legal information | 6 |
| 3.1 | Definitions | 6 |
| 3.2 | Disclaimers | 6 |
| 3.3 | Trademarks | 6 |
| 4 | Contents | 7 |

Please be aware that important notices concerning this document and the product(s) described herein, have been included in section 'Legal information'.

© NXP B.V. 2020.

All rights reserved.

For more information, please visit: <http://www.nxp.com>

For sales office addresses, please send an email to: salesaddresses@nxp.com

Date of release: 17 March 2020

Document identifier: TN00063_LPC5500