TN00031

LPC5411x Crystal-less USB Solution

Rev. 1.0 — 26 February 2018 **Technical Note**

Document information

Info	Content
Keywords	LPC5411x, 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 LPC5411x family.

Revision history

Rev	Date	Description
1.0	20180226	Initial version

Contact information

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1. Introduction

The LPC5411x are ARM Cortex-M4 based microcontrollers for embedded applications. These devices include an ARM Cortex-M0+ coprocessor, up to 192 KB of on-chip SRAM, up to 256 KB on-chip flash, full-speed USB device interface with Crystal-less operation, a DMIC subsystem with PDM microphone interface and I2S, five general-purpose timers, one SCTimer/PWM, one RTC/alarm timer, one 24-bit Multi-Rate Timer (MRT), a Windowed Watchdog Timer (WWDT), eight flexible serial communication peripherals (each of which can be a USART, SPI, or I2C interface), and one 12-bit 5.0 Msamples/sec ADC, and a temperature sensor.

The LPC5411x product family features one full-speed USB 2.0 device controller with crystal-less low-speed 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 (± 0.25 % data rate accuracy).

This technical note explains the steps to modify the software to integrate a crystal-less USB device operation in full-speed mode in the LPC5411x application. In addition to this technical note, LPCOpen v3.01 and SDK software example (usbd_rom_hid_generic) are 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 LPC5411x.

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 LPCOpen for MCUXpresso /LPCXpresso, Keil, and IAR are:

1. Keil IDE: keil_lib_fro_calib, keil_lib_fro_calib_m0
2. IAR IDE: iar_lib_fro_calib.a, iar_lib_fro_calib_m0.a
3. MCUXpresso/LPCXpresso IDE: - libfro_calib.a, libfro_calib_m0.a,libfro_calib_m4f_hard.a

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

- Keil IDE: keil_lib_fro_calib, keil_lib_fro_calib_m0
- IAR IDE: iar_lib_fro_calib.a, iar_lib_fro_calib_m0.a
- MCUXpresso/LPCXpresso IDE: - libfro_calib_cm0.a, libfro_calib_cm4_hardabi.a, libfro_calib_cm4_softabi.a

2.2 Header file

For LPCOpen, include the following header file: fro_calib_lib_5411x.h

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

2.3 Source code modifications

Add the following changes to the source code.

1. Call the int_fro_calib_Get_Lib_Ver (void) function. This function reads the version of the calibration library and returns 0x00000100. Otherwise, it returns 0x0.
2. The user application code must select the fro_hf as a clock source (value of 0x0 in the USBCLKSEL register) because the external crystal is no longer required. See the LPC5411x user manual for more details.
3. The calibration library must use one of the 32-bit timers to measure SOF timing and enable appropriate calibration.
   a. Using the AHBCLKCTRL1 register,enable the clock to the timer (timer 0 or timer 1 or timer 2). Using the ASYNCAPBCTRL and ASYNCAPBCLKCTRL registers, enable the clock to the timer (timer 3 or timer 4).
   b. Pass the timer peripheral (for LPCOpen, LPC_TIMER0 or LPC_TIMER1 or LPC_TIMER2 or LPC_TIMER3 or LPC_TIMER4) (for SDK, CTIMER0 or CTIMER1 or CTIMER2 or CTIMER3 or CTIMER4), and the system clock in KHz to the library call, for LPCOpen,

      ```
      ErrorCode_t Chip_Timer_Instance_Freq (LPC_TIMER_T *pTMR, unsigned int
           timerFreq)
      ```

      For SDK,

      ```
      ErrorCode_t Chip_Timer_Instance_Freq (CTIMER_Type *base, unsigned int
           timerFreq);
      ```

      The library function returns LPC_OK if device ID of the LPC5411x is read, otherwise it returns ERR_FAILED.
4. The user application code must enable the FRAME_INT of the INTEN register.

   If using the USB ROM API, the user application code can use the ErrorCode_t(* USBD_HW_API::EnableEvent)(USBD_HANDLE_T hUsb, uint32_t EPNum, uint32_t event_type, uint32_t enable) to enable FRAME_INT. Ensure the workaround from USB_ROM.1 errata is implemented. See the LPC5411x errata sheet for more details.
5. When the FRAME_INT occurs, the user application code must call the ErrorCode_t USB_SOF_Event(USBD_HANDLE_T hUsb).

   If the user application code uses USB ROM API, it can call ErrorCode_t(*ErrorCode_t USBD_HW_API::Init)(USBD_HANDLE_T *phUsb, USB_CORE_DESCS_T *pDesc, USBD_API_INIT_PARAM_T *param)

   For example:

   ```
   USBD_HANDLE_T g_hUsb;
   USBD_API_INIT_PARAM_T usb_param;
   USB_CORE_DESCS_T desc;
   ErrorCode_t ret = LPC_OK;
   usb_param.USB_SOF_Event = USB_SOF_Event;
   ret = USBD_API->hw->Init(&g_hUsb, &desc, &usb_param);
   ```

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