Application Report
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Adding Flash Read and Write to an Existing mmWave Project

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ABSTRACT

This application report describes the required steps to integrate usage of the QSPI flash on mmWave devices.

Contents

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1 Initializing QSPIFlash Driver

The first step is to add code to include and initialize the QSPI and QSPIflash mmWave drivers. Both drivers are required for reading or writing to the flash. The following is C code that initializes both QSPI and QSPIFlash drivers. This tested code may be copied into the project.

```
#include <ti/drivers/qspiflash/qspiflash.h>

QSPI_Handle  qspiHandle;
QSPIFlash_Handle qspiflashHandle;

/* This is for the IWR1443. For IWR1642, simply substitute the equivalent pinmux macros. */

int32_t init_qspiflash(void)
{
  int32_t      errCode;
  QSPI_Params  QSPIParams;

  /* Setup the PINMUX to bring out the QSPI */
  Pinmux_Set_OverrideCtrl(SOC_XWR14XX_PINR10_PADAP,
PINMUX_OUTEN_RETAIN_HW_CTRL, PINMUX_INPEN_RETAIN_HW_CTRL);
  Pinmux_Set_FuncSel(SOC_XWR14XX_PINR10_PADAP,
SOC_XWR14XX_PINR10_PADAP_QSPI_CLK);
```

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```
  Pinmux_Set_OverrideCtrl(SOC_XWR14XX_PINP8_PADAQ,
PINMUX_OUTEN_RETAIN_HW_CTRL, PINMUX_INPEN_RETAIN_HW_CTRL);
  Pinmux_Set_FuncSel(SOC_XWR14XX_PINP8_PADAQ,
SOC_XWR14XX_PINP8_PADAQ_QSPI_CS);

  Pinmux_Set_OverrideCtrl(SOC_XWR14XX_PINR11_PADAL,
PINMUX_OUTEN_RETAIN_HW_CTRL, PINMUX_INPEN_RETAIN_HW_CTRL);
  Pinmux_Set_FuncSel(SOC_XWR14XX_PINR11_PADAL,
SOC_XWR14XX_PINR11_PADAL_QSPI_D0);

  Pinmux_Set_OverrideCtrl(SOC_XWR14XX_PINP9_PADAM,
PINMUX_OUTEN_RETAIN_HW_CTRL, PINMUX_INPEN_RETAIN_HW_CTRL);
  Pinmux_Set_FuncSel(SOC_XWR14XX_PINP9_PADAM,
SOC_XWR14XX_PINP9_PADAM_QSPI_D1);

  Pinmux_Set_OverrideCtrl(SOC_XWR14XX_PINR12_PADAN,
PINMUX_OUTEN_RETAIN_HW_CTRL, PINMUX_INPEN_RETAIN_HW_CTRL);
  Pinmux_Set_FuncSel(SOC_XWR14XX_PINR12_PADAN,
SOC_XWR14XX_PINR12_PADAN_QSPI_D2);

  Pinmux_Set_OverrideCtrl(SOC_XWR14XX_PINP10_PADAO,
PINMUX_OUTEN_RETAIN_HW_CTRL, PINMUX_INPEN_RETAIN_HW_CTRL);
  Pinmux_Set_FuncSel(SOC_XWR14XX_PINP10_PADAO,
SOC_XWR14XX_PINP10_PADAO_QSPI_D3);

  /* Initialize the QSPI Driver */
  QSPI_init();

  /* Initialize the QSPI Flash */
  QSPIFlash_init();

  /* Open QSPI driver */
  QSPI_Params_init(&QSPIParams);

  /* Set the QSPI peripheral clock to 200MHz  */
  QSPIParams.qspiClk = 200 * 1000000U;

  QSPIParams.clkMode = QSPI_CLOCK_MODE_0;

  /* Running at 40MHz QSPI bit rate
   * QSPI bit clock rate derives from QSPI peripheral clock(qspiClk)
     and divide clock internally down to bit clock rate
     BitClockRate = qspiClk/divisor(=5, setup by QSPI driver internally)
   */

  QSPIParams.bitRate = 40 * 1000000U;

  qspiHandle = QSPI_open(&QSPIParams, &errCode);

  if (qspiHandle == NULL)
  {
    demo_printf("Error: Unable to open the QSPI Instance\n");
    return(0);
  }

  qspiflashHandle = QSPIFlash_open(qspiHandle, &errCode);
  if (qspiflashHandle == NULL )
  {
    demo_printf("Error: Unable to open the QSPIflash Instance\n");
    return(0);
  }

  return(1);
}
```

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2 Obtaining Flash Address

Whether reading or writing, one must find a valid area or areas in flash to be used.

First, the mmWave SDK function returns the base address of the flash memory (per the current device):

```
  uint32_t   flashAddr;
  flashAddr = QSPIFlash_getExtFlashAddr(qspiflashHandle);
```

As shown in the TRM, for IWR1443 and IWR1642 this is:

```
EXT_FLASH          0xC000_0000        0xC07F_FFFF       8MB        MSS_QSPI (QSPI) flash
memory space
```

The next piece of information required is where the bootloader expects to find the flashed image. This is important so one does not use the same flash sectors.

2.1 Finding Bootloader Image Flash Offset

For Code Composer Studio™ (CCS), the following code is provided in the .projectspec file used to create the project:

```
<buildVariable name="LOAD_ADDRESS" value="0x200000"/>
```

For IWR1443 makefiles, the address is found in the main makefile: (eg. mmwave_sdk.mak for the demos)

```
LOAD_ADDRESS            = 0x200000
```

For IWR1642 projects, the meta image is flashed to offset zero.

You will see this in the link step of a build:

```
C:/ti/mmwave_sdk_01_00_00_05/packages/scripts/ImageCreator/xwr14xx/out2rprc/out2rprc.exe
level_sense_demo.xer4f level_sense_demo.bin 0x200000
```

The “generate bin” portion of the build process will provide you with the size of the image to be flashed:

```
C:/ti/mmwave_sdk_01_00_00_05/packages/scripts/ImageCreator/xwr14xx/append_bin_crc/gen_bincrc32.pl
level_sense_demo.bin

>>>> Binary CRC32 = 5a9b9b17 <<<<
>>>> Total bytes in binary file 71988 <<<<
```

In most cases one must account for the position and size of the flashed code image, or one may overwrite it. For safety, locations (offsets) 0x20_0000 to 0x28_0000 should be considered off limits for 14xx devices and 0x0 to 0x10_0000 for 16xx. Note that these locations and sizes may change in the future with new releases of the bootloader.

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3 Writing to Flash

Before writing, the required portion of flash to use must be erased without erasing anything else. There are three APIs in the mmWave QSPIFlash driver that erase sections of flash memory. Table 1 shows the corresponding memory sizes that are erased.

Table 1. mmWave QPSIFlash Erase APIs

NAME	SIZE
QPSIFlash_sectorErase	4 KB
QPSIFlash_blockErase	64 KB
QPSIFlash_chipErase	Entire flash

The following code is a simple example that writes to the flash. If the size to be written exceeds 4 KB, QSPIFlash_sectorErase() must be called with adjoining 4 KB offsets, or QSPIFlash _blockErase() is used instead for 64 KB or larger areas.

```
#define DEMO_FLASH_OFFSET          0x100000
#define DEMO_FLASH_LEN                 (sizeof(my_struct))

  flashAddr = QSPIFlash_getExtFlashAddr(qspiflashHandle);

  flashAddr = flashAddr + DEMO_FLASH_OFFSET;

  /* Erase the 4KB sector to be written. */
  QSPIFlash_sectorErase(qspiflashHandle, flashAddr);

  QSPIFlash_singleWrite(qspiflashHandle, flashAddr, DEMO_FLASH_LEN,
                       (uint8_t *)my_data);
```

4 Reading From Flash

Reading from flash is easier than writing. After initializing the QSPIFlash driver, simply compute the correct offset into flash and call the read API with the following code:

```
  /* Read my structure from flash. */
  flashAddr = QSPIFlash_getExtFlashAddr(qspiflashHandle);
  flashAddr = flashAddr + DEMO_FLASH_OFFSET;

  QSPIFlash_singleRead(qspiflashHandle, flashAddr, DEMO_FLASH_LEN,
                      (uint8_t *)my_data);
```

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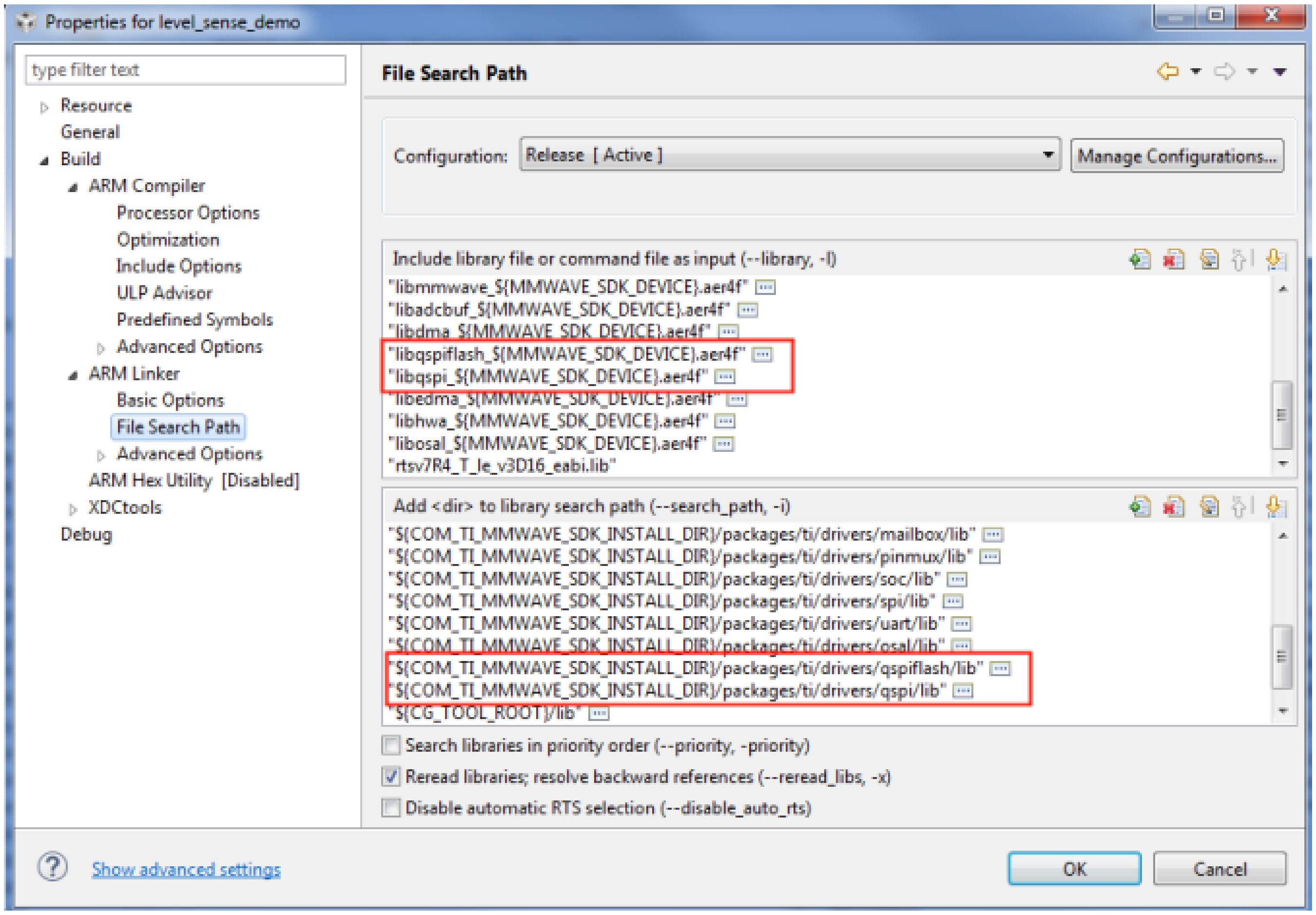
5 Linking QSPI Flash Drivers

The last step is to build the executable by linking with the QPSI drivers. If using a CCS project, the QPSI drivers can be added to the project's linker properties as shown in Figure 1.


Properties for level_sense_demo

File Search Path

Configuration: Release [Active]

Include library file or command file as input (--library, -l)

```
"libmmwave_${MMWAVE_SDK_DEVICE}.aer4f"
"libadcbuf_${MMWAVE_SDK_DEVICE}.aer4f"
"libdma_${MMWAVE_SDK_DEVICE}.aer4f"
"libqspiflash_${MMWAVE_SDK_DEVICE}.aer4f"
"libqspi_${MMWAVE_SDK_DEVICE}.aer4f"
"libedma_${MMWAVE_SDK_DEVICE}.aer4f"
"libhwa_${MMWAVE_SDK_DEVICE}.aer4f"
"libosal_${MMWAVE_SDK_DEVICE}.aer4f"
"rtsv7R4_T_le_v3D16_eabi.lib"
```

Add <dir> to library search path (--search_path, -i)

```
"${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/mailbox/lib"
"${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/pinmux/lib"
"${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/soc/lib"
"${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/spi/lib"
"${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/uart/lib"
"${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/osal/lib"
"${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/qspiflash/lib"
"${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/qspi/lib"
"${CG_TOOL_ROOT}/lib"
```

- [ ] Search libraries in priority order (--priority, -priority)
- [✓] Reread libraries; resolve backward references (--reread_libs, -x)
- [ ] Disable automatic RTS selection (--disable_auto_rts)

Figure 1. CCS Project Linker Properties

If using makefiles, do the same procedure there.

```
###############################################################################
# Additional libraries which are required to build the executable:
###############################################################################
STD_LIBS = $(R4F_COMMON_STD_LIB)                             \
                  -llibpinmux_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)       \
                  -llibdma_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)    \
                  -llibadcbuf_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)       \
                  -llibhwa_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)    \
                  -llibmailbox_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)      \
                  -llibedma_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)   \
                  -llibmmwave_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)       \
                  -llibmmwavelink_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)   \
                  -llibcrc_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)    \
                  -llibspi_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)    \
                  -llibqspi_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)   \
                  -llibqspiflash_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)    \
                  -llibuart_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)
```

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