TEXAS INSTRUMENTS

Application Report
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Adding CAN Tx and Rx to an Existing mmWave Project

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ABSTRACT

This application note describes the steps required to integrate the usage of the CAN (DCAN) interface on the mmWave devices.

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1 Initializing the Driver

The first step in the integration process is adding code to include and initialize the CAN driver. This driver is required for transmitting and receiving from the CAN interface. The following is C code that initializes the CAN driver. This tested code can be copied into the project.

```
#include <ti/drivers/can/can.h>
/**************************************************************************
 *************************** Global Definitions ***************************
 **************************************************************************/
volatile uint32_t       testSelection = 0;
volatile uint32_t       gTxDoneFlag = 0, gRxDoneFlag = 0, gParityErrFlag = 0;
uint32_t                iterationCount = 0U;
volatile uint32_t       gTxPkts = 0, gRxPkts = 0, gErrStatusInt = 0;
CAN_DCANCfgParams       appDcanCfgParams;
CAN_DCANMsgObjCfgParams appDcanTxCfgParams;
CAN_DCANMsgObjCfgParams appDcanRxCfgParams;
CAN_DCANBitTimeParams   appDcanBitTimeParams;
CAN_DCANData            appDcanTxData;
CAN_DCANData            appDcanRxData;
uint32_t                dataLength = 0U;
uint32_t                msgLstErrCnt = 0U;
uint32_t                dataMissMatchErrCnt = 0U;
uint32_t                rxTicks[DCAN_APP_TEST_MESSAGE_COUNT];
uint32_t                txTicks[DCAN_APP_TEST_MESSAGE_COUNT];
uint32_t                minRxTicks;
uint32_t                maxRxTicks;
uint32_t                minTxTicks;
uint32_t                maxTxTicks;
uint32_t                totalTxTicks;
uint32_t                totalRxTicks;
uint32_t                gDisplayStats = 0;

/**************************************************************************
 *************************** CAN Driver Initialize Function ***********************
 **************************************************************************/
void Can_Initalize(void)
{
    CAN_Handle                canHandle;
    CAN_MsgObjHandle          txMsgObjHandle;
    CAN_MsgObjHandle          rxMsgObjHandle;
    int32_t                   retVal = 0;
    int32_t                   errCode = 0;
    CAN_DCANMsgObjectStats  msgObjStats;
    CAN_OptionTLV             optionTLV;
    CAN_DCANErrorCounter      errCounter;

      /*The pinmux setting for the xWR1443*/
   #if (defined(SOC_XWR14XX))
    /* Setup the PINMUX to bring out the XWR14xx CAN pins */
   Pinmux_Set_OverrideCtrl(SOC_XWR14XX_PINP5_PADAE, PINMUX_OUTEN_RETAIN_HW_CTRL,
PINMUX_INPEN_RETAIN_HW_CTRL);
   Pinmux_Set_FuncSel(SOC_XWR14XX_PINP5_PADAE, SOC_XWR14XX_PINP5_PADAE_CAN_TX);
   Pinmux_Set_OverrideCtrl(SOC_XWR14XX_PINR8_PADAD, PINMUX_OUTEN_RETAIN_HW_CTRL,
PINMUX_INPEN_RETAIN_HW_CTRL);
   Pinmux_Set_FuncSel(SOC_XWR14XX_PINR8_PADAD, SOC_XWR14XX_PINR8_PADAD_CAN_RX);
#else
   /* Setup the PINMUX to bring out the XWR16xx CAN pins */
   Pinmux_Set_OverrideCtrl(SOC_XWR16XX_PINC13_PADAG, PINMUX_OUTEN_RETAIN_HW_CTRL,
PINMUX_INPEN_RETAIN_HW_CTRL);
   Pinmux_Set_FuncSel(SOC_XWR16XX_PINC13_PADAG, SOC_XWR16XX_PINC13_PADAG_CAN_TX);
   Pinmux_Set_OverrideCtrl(SOC_XWR16XX_PINE13_PADAF, PINMUX_OUTEN_RETAIN_HW_CTRL,
PINMUX_INPEN_RETAIN_HW_CTRL);
   Pinmux_Set_FuncSel(SOC_XWR16XX_PINE13_PADAF, SOC_XWR16XX_PINE13_PADAF_CAN_RX);
#endif
/* Configure the divide value for DCAN source clock */
SOC_setPeripheralClock(socHandle, SOC_MODULE_DCAN, SOC_CLKSOURCE_VCLK, 9U, &errCode);
```

```
/* Initialize peripheral memory */
SOC_initPeripheralRam(socHandle, SOC_MODULE_DCAN, &errCode);

/* Initialize the DCAN parameters that need to be specified by the application */
DCANAppInitParams(&appDcanCfgParams, &errCode);
    if (canHandle == NULL)
    {
        System_printf ("Error: CAN Module Initialization failed [Error code %d]\n", errCode);
        return -1;
    }

    /* Set the desired bit rate based on input clock */
    retVal = DCANAppCalcBitTimeParams(DCAN_APP_INPUT_CLK / 1000000,
                                            DCAN_APP_BIT_RATE / 1000,
                                            DCAN_APP_SAMP_PT,
                                            DCAN_APP_PROP_DELAY,
                                            &appDcanBitTimeParams);
    if (retVal < 0)
    {
        System_printf ("Error: CAN Module bit time parameters are incorrect \n");
        return -1;
    }

    /* Configure the CAN driver */
    retVal = CAN_configBitTime (canHandle, & appDcanBitTimeParams, &errCode);
    if (retVal < 0)
    {
        System_printf ("Error: CAN Module configure bit time failed [Error code %d]\n", errCode);
        return -1;
    }

    /* Setup the transmit message object */
    txMsgObjHandle = CAN_createMsgObject (canHandle, DCAN_TX_MSG_OBJ, &appDcanTxCfgParams,
&errCode);
    if (txMsgObjHandle == NULL)
    {
        System_printf ("Error: CAN create Tx message object failed [Error code %d]\n", errCode);
        return -1;
    }

    /* Setup the receive message object */
    rxMsgObjHandle = CAN_createMsgObject (canHandle, DCAN_RX_MSG_OBJ, &appDcanRxCfgParams,
&errCode);
    if (rxMsgObjHandle == NULL)
    {
        System_printf ("Error: CAN create Rx message object failed [Error code %d]\n", errCode);
        return -1;
    }
 }

/***************************************************************************
 ******************** CAN Parameters initialize Function *****************
 ***************************************************************************/
static void DCANAppInitParams(CAN_DCANCfgParams*        dcanCfgParams,
                              CAN_DCANMsgObjCfgParams*  dcanTxCfgParams,
                              CAN_DCANMsgObjCfgParams*  dcanRxCfgParams,
                              CAN_DCANData*             dcanTxData)
{
    /*Intialize DCAN Config Params*/
    dcanCfgParams->parityEnable         = 0;
    dcanCfgParams->intrLine0Enable      = 1;
    dcanCfgParams->intrLine1Enable      = 1;
    dcanCfgParams->testModeEnable       = 0;
    dcanCfgParams->eccModeEnable        = 0;
    dcanCfgParams->stsChangeIntrEnable  = 0;
    dcanCfgParams->autoRetransmitDisable = 1;
    dcanCfgParams->autoBusOnEnable       = 0;
    dcanCfgParams->errIntrEnable         = 1;
    dcanCfgParams->autoBusOnTimerVal     = 0;
    dcanCfgParams->if1DmaEnable          = 0;
    dcanCfgParams->if2DmaEnable          = 0;
    dcanCfgParams->if3DmaEnable          = 0;
    dcanCfgParams->ramAccessEnable       = 0;
    dcanCfgParams->appCallBack           = DCANAppErrStatusCallback;

    /*Intialize DCAN tx Config Params*/
    dcanTxCfgParams->xIdFlagMask       = 0x1;
    dcanTxCfgParams->dirMask           = 0x1;
    dcanTxCfgParams->msgIdentifierMask = 0x1FFFFFFF;

    dcanTxCfgParams->msgValid      = 1;
    dcanTxCfgParams->xIdFlag       = CAN_DCANXidType_11_BIT;
    dcanTxCfgParams->direction     = CAN_Direction_TX;
    dcanTxCfgParams->msgIdentifier = 0xC1;

    dcanTxCfgParams->uMaskUsed    = 1;
    dcanTxCfgParams->intEnable    = 1;

    dcanTxCfgParams->remoteEnable = 0;
    dcanTxCfgParams->fifoEOBFlag  = 1;
    dcanTxCfgParams->appCallBack  = DCANAppCallback;

    /*Intialize DCAN Rx Config Params*/
    dcanRxCfgParams->xIdFlagMask       = 0x1;
    dcanRxCfgParams->msgIdentifierMask = 0x1FFFFFFF;
    dcanRxCfgParams->dirMask           = 0x1;

    dcanRxCfgParams->msgValid      = 1;
    dcanRxCfgParams->xIdFlag       = CAN_DCANXidType_11_BIT;
    dcanRxCfgParams->direction     = CAN_Direction_RX;
    dcanRxCfgParams->msgIdentifier = 0xC1;

    dcanRxCfgParams->uMaskUsed    = 1;
    dcanRxCfgParams->intEnable    = 1;

    dcanRxCfgParams->remoteEnable = 0;
    dcanRxCfgParams->fifoEOBFlag  = 1;
    dcanRxCfgParams->appCallBack  = DCANAppCallback;
 /*Intialize DCAN Tx transfer Params*/
    dcanTxData->dataLength = DCAN_MAX_MSG_LENGTH;
    dcanTxData->msgData[0] = 0xA5;
    dcanTxData->msgData[1] = 0x5A;
    dcanTxData->msgData[2] = 0xFF;
    dcanTxData->msgData[3] = 0xFF;
    dcanTxData->msgData[4] = 0xC3;
    dcanTxData->msgData[5] = 0x3C;
    dcanTxData->msgData[6] = 0xB4;
    dcanTxData->msgData[7] = 0x4B;
}

/***************************************************************************
 ******************** CAN Bit Timing caluculation *****************
 ***************************************************************************/
int32_t DCANAppCalcBitTimeParams(uint32_t               clkFreq,
                                uint32_t                bitRate,
                                uint32_t                refSamplePnt,
                                uint32_t                propDelay,
                                CAN_DCANBitTimeParams*  bitTimeParams)
{
    Double  tBitRef = 1000 * 1000 / bitRate;
    Double  newBaud = 0, newNProp = 0, newNSeg = 0, newSjw = 0, newP = 0;
    Double  nQRef, nProp, fCan, nQ, nSeg, baud, sp, p, newSp = 0;
    float   tQ;

    for (p = 1; p <= 1024; p++)
    {
        tQ    = ((p / clkFreq) * 1000.0);
        nQRef = tBitRef / tQ;

        if ((nQRef >= 8) && (nQRef <= 25))
        {
            nProp = ceil(propDelay / tQ);
            fCan  = clkFreq / p;
            nQ    = fCan / bitRate * 1000;
            nSeg  = ceil((nQ - nProp - 1) / 2);

            if ((nProp <= 8) && (nProp > 0) && (nSeg <= 8) && (nSeg > 0))
            {
                baud = fCan / (1 + nProp + 2 * nSeg) * 1000;

                sp = (1 + nProp + nSeg) / (1 + nProp + nSeg + nSeg) * 100;

                if ((abs(baud - bitRate)) < (abs(newBaud - bitRate)))
                {
                    newBaud  = baud;
                    newNProp = nProp;
                    newNSeg  = nSeg;
                    newSjw   = (nSeg < 4) ? nSeg : 4;
                    newP     = p - 1;
                    newSp    = sp;
                }
                else if ((abs(baud - bitRate)) == (abs(newBaud - bitRate)))
                {
                    if ((abs(sp - refSamplePnt)) < (abs(newSp - refSamplePnt)))
                    {
                        newBaud  = baud;
                        newNProp = nProp;
                        newNSeg  = nSeg;
                        newSjw   = (nSeg < 4) ? nSeg : 4;
                        newP     = p - 1;
                        newSp    = sp;
                    }
                }
            }
        }
    }
    if ((newBaud == 0) || (newBaud > 1000))
    {
        return -1;
    }
    bitTimeParams->baudRatePrescaler    = (((uint32_t) newP) & 0x3F);
    bitTimeParams->baudRatePrescalerExt =
        ((((uint32_t) newP) & 0x3C0) ? (((uint32_t) newP) &0x3C0) >> 6 : 0);
    bitTimeParams->syncJumpWidth = ((uint32_t) newSjw) - 1;

    /* propSeg = newNProp, phaseSeg = newNSeg, samplePoint = newSp
     * nominalBitTime = (1 + newNProp + 2 * newNSeg), nominalBitRate = newBaud
     * brpFreq  = clkFreq / (brp + 1), brpeFreq = clkFreq / (newP + 1)
     * brp      = bitTimeParams->baudRatePrescaler;
     */

    bitTimeParams->timeSegment1 = newNProp + newNSeg - 1;
    bitTimeParams->timeSegment2 = newNSeg - 1;
    return 0;
}
```

2 Register Callbacks

2.1 Tx Complete and Rx Interrupt Callback

The application must implement a callback function to handle transmit complete and receive interrupts.

```
static void DCANAppCallback(CAN_MsgObjHandle handle, uint32_t msgObjectNum, CAN_Direction
direction)
{
    int32_t     errCode, retVal;

    if (direction == CAN_Direction_TX)
    {
        if (msgObjectNum != DCAN_TX_MSG_OBJ)
        {
            System_printf ("Error: Tx callback received for incorrect Message Object %d\n",
msgObjectNum);
            return;
        }
        else
        {
            gTxPkts++;
            gTxDoneFlag = 1;
            return;
        }
    }
    if (direction == CAN_Direction_RX)
    {
        if (msgObjectNum != DCAN_RX_MSG_OBJ)
        {
            System_printf ("Error: Rx callback received for incorrect Message Object %d\n",
msgObjectNum);
            return;
        }
        else
        {
            /* Reset the receive buffer */
            memset(&appDcanRxData, 0, sizeof (appDcanRxData));
            dataLength = 0;

            retVal = CAN_getData (handle, &appDcanRxData, &errCode);
            if (retVal < 0)
            {
                System_printf ("Error: CAN receive data for iteration %d failed [Error code
%d]\n", iterationCount, errCode);
                return;
            }
            /* Check if sent data is lost or not */
            if (appDcanRxData.msgLostFlag == 1)
            {
                msgLstErrCnt++;
            }
             while (dataLength < appDcanRxData.dataLength)
             {
               if (appDcanRxData.msgData[dataLength] != appDcanTxData.msgData[dataLength])
                    {
                       dataMissMatchErrCnt++;
                       System_printf ("Error: CAN receive data mismatch for iteration %d
                at byte %d\n", iterationCount, dataLength);
                    }
                    dataLength++;
                }
            gRxPkts++;
            gRxDoneFlag = 1;
            return;
        }
        }
    }
```

2.2 Error and Status Interrupt Callback

The application must implement a callback function to handle error and status interrupts.

```
static void DCANAppErrStatusCallback(CAN_Handle handle, CAN_ErrStatusResp* errStatusResp)
{
    gErrStatusInt++;
    if (errStatusResp->parityError == 1)
    {
        gParityErrFlag = 1;
    }
    return;
}
```

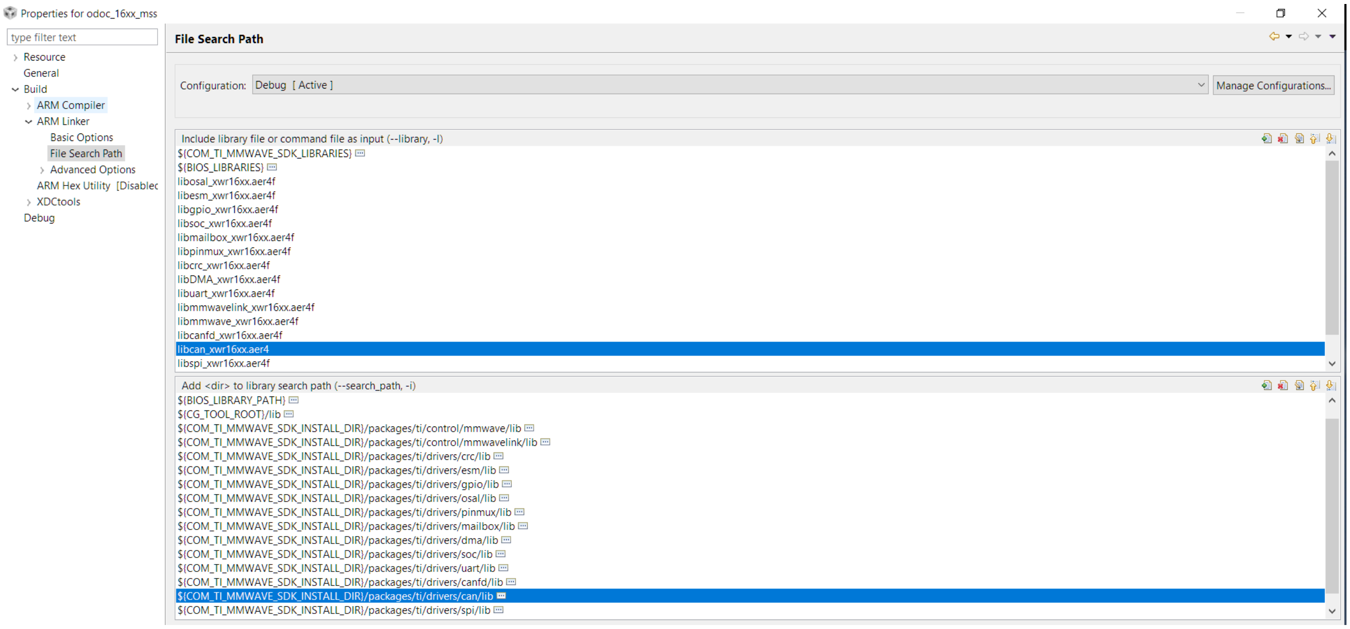
3 CAN Transmit

The following code can be used to transmit CAN data during the initialization and the length message.

```
/* Send data over Tx message object */
        retVal = CAN_transmitData (txMsgObjHandle, &appDcanTxData, &errCode);
        if (retVal < 0)
        {
          System_printf ("Error: CAN transmit data for iteration %d failed [Error code
    %d]\n", iterationCount, errCode);
            return -1;
        }
```

4 Linking the CAN Driver

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



File Search Path

Configuration: Debug [Active]

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

```
${COM_TI_MMWAVE_SDK_LIBRARIES}
${BIOS_LIBRARIES}
libosal_xwr16xx.aer4f
libesm_xwr16xx.aer4f
libgpio_xwr16xx.aer4f
libsoc_xwr16xx.aer4f
libmailbox_xwr16xx.aer4f
libpinmux_xwr16xx.aer4f
libcrc_xwr16xx.aer4f
libDMA_xwr16xx.aer4f
libuart_xwr16xx.aer4f
libmmwavelink_xwr16xx.aer4f
libmmwave_xwr16xx.aer4f
libcanfd_xwr16xx.aer4f
libcan_xwr16xx.aer4
libspi_xwr16xx.aer4f
```

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

```
${BIOS_LIBRARY_PATH}
${CG_TOOL_ROOT}/lib
${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/control/mmwave/lib
${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/control/mmwavelink/lib
${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/crc/lib
${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/esm/lib
${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/gpio/lib
${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/osal/lib
${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/pinmux/lib
${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/mailbox/lib
${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/dma/lib
${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/soc/lib
${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/uart/lib
${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/canfd/lib
${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/can/lib
${COM_TI_MMWAVE_SDK_INSTALL_DIR}/packages/ti/drivers/spi/lib
```

Figure 1. CCS Project Linker Properties

If using the makefile, perform the same procedure.

```
###################################################################################
# Additional libraries which are required to build the DEMO:
###################################################################################
MSS_MMW_DEMO_STD_LIBS = $(R4F_COMMON_STD_LIB)                           \
            -llibpinmux_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)        \
            -llibdma_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)           \
            -llibcrc_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)           \
            -llibuart_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)          \
            -llibgpio_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)          \
            -llibmailbox_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)       \
            -llibmmwavelink_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)    \
            -llibmmwave_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)        \
            -llibcli_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)       \
            -llibcan_$(MMWAVE_SDK_DEVICE_TYPE).$(R4F_LIB_EXT)
MSS_MMW_DEMO_LOC_LIBS = $(R4F_COMMON_LOC_LIB)                       \
            -i$(MMWAVE_SDK_INSTALL_PATH)/ti/drivers/pinmux/lib      \
            -i$(MMWAVE_SDK_INSTALL_PATH)/ti/drivers/uart/lib        \
            -i$(MMWAVE_SDK_INSTALL_PATH)/ti/drivers/dma/lib         \
            -i$(MMWAVE_SDK_INSTALL_PATH)/ti/drivers/crc/lib         \
            -i$(MMWAVE_SDK_INSTALL_PATH)/ti/drivers/gpio/lib        \
            -i$(MMWAVE_SDK_INSTALL_PATH)/ti/drivers/mailbox/lib     \
            -i$(MMWAVE_SDK_INSTALL_PATH)/ti/control/mmwavelink/lib  \
            -i$(MMWAVE_SDK_INSTALL_PATH)/ti/control/mmwave/lib      \
            -i$(MMWAVE_SDK_INSTALL_PATH)/ti/utils/cli/lib   \
            -i$(MMWAVE_SDK_INSTALL_PATH)/ti/drivers/can/lib
```

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