MICROCHIP

AN853

PIC18XXX8 CAN Driver with Prioritized Transmit Buffer

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INTRODUCTION

The Microchip PIC18XXX8 family of microcontrollers provide an integrated Controller Area Network (CAN) solution along with other PICmicro® features. Although originally intended for the automotive industry, CAN is finding its way into other control applications. In CAN, a protocol message with highest priority wins the bus arbitration and maintains the bus control. For minimum message latency and bus control, messages should be transmitted on a priority basis.

Because of the wide applicability of the CAN protocol, developers are faced with the often cumbersome task of dealing with the intricate details of CAN registers. This application note presents a software library that hides the details of CAN registers, and discusses the design of the CAN driver with prioritized Transmit buffer implementation. This software library allows developers to focus their efforts on application logic, while minimizing their interaction with CAN registers.

If the controller has heavy transmission loads, it is advisable to use software Transmit buffers to reduce message latency. Firmware also supports user defined Transmit buffer size. If the defined size of a Transmit buffer is more than that available in hardware (3), the CAN driver will use 14 bytes of general purpose RAM for each extra buffer.

For details about the PIC18 family of microcontrollers, refer to the PIC18CXX8 Data Sheet (DS30475), the PIC18FXX8 Data Sheet (DS41159), and the PICmicro® 18C MCU Family Reference Manual (DS39500).

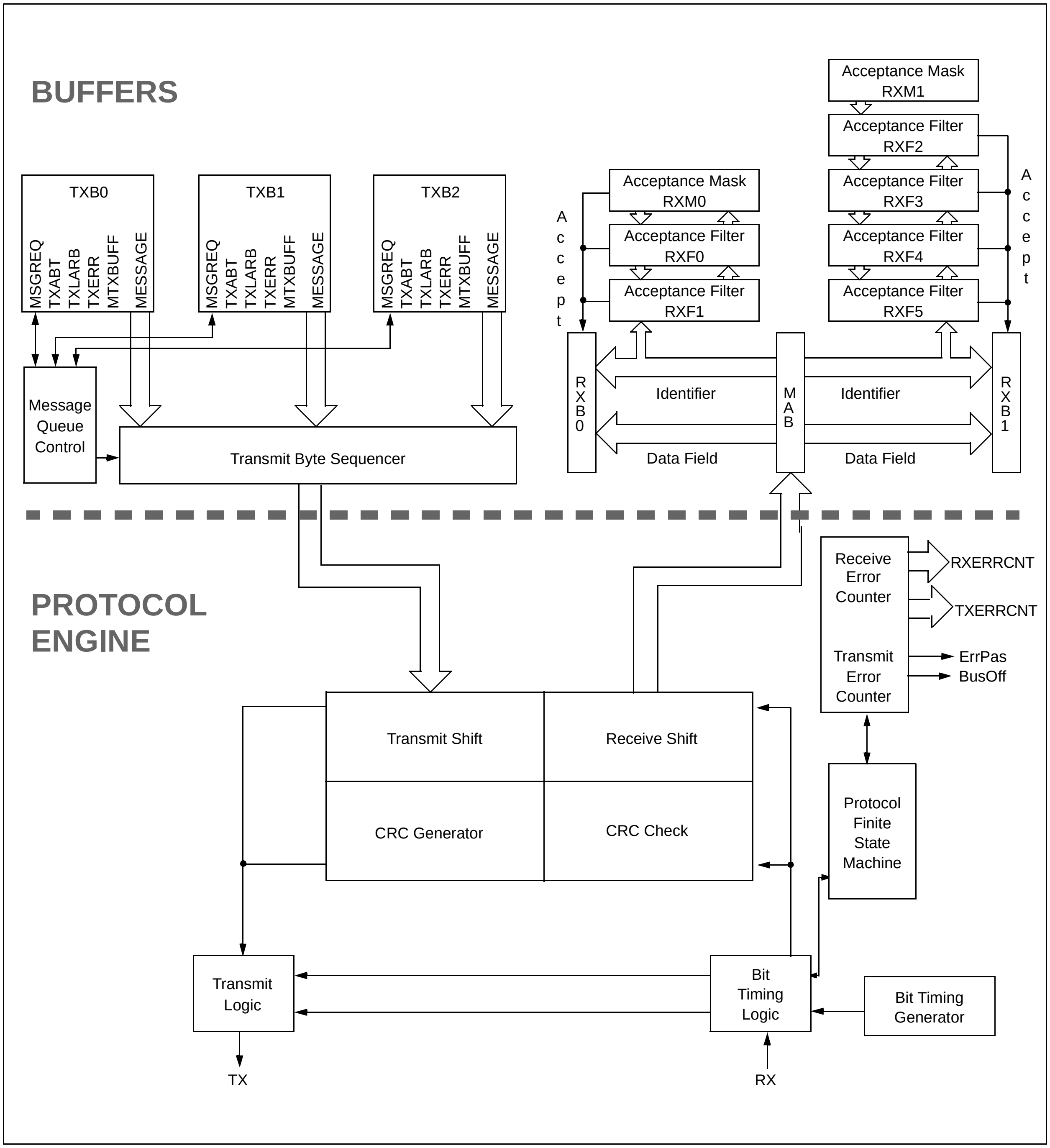
CAN MODULE OVERVIEW

The PIC18 family of microcontrollers contain a CAN module that provides the same register and functional interface for all PIC18 microcontrollers.

The module features are as follows:

- Implementation of CAN 1.2, CAN 2.0A and CAN 2.0B protocol
- Standard and extended data frames
- 0 - 8 bytes data length
- Programmable bit rate up to 1 Mbit/sec
- Support for remote frame
- Double-buffered receiver with two prioritized received message storage buffers
- Six full (standard/extended identifier) acceptance filters: two associated with the high priority receive buffer, and four associated with the low priority receive buffer
- Two full acceptance filter masks, one each associated with the high and low priority receive buffers
- Three transmit buffers with application specified prioritization and abort capability
- Programmable wake-up functionality with integrated low-pass filter
- Programmable Loopback mode and programmable state clocking supports self-test operation
- Signaling via interrupt capabilities for all CAN receiver and transmitter error states
- Programmable clock source
- Programmable link to timer module for time-stamping and network synchronization
- Low Power SLEEP mode

FIGURE 1: CAN BUFFERS AND PROTOCOL ENGINE BLOCK DIAGRAM



Bus Arbitration and Message Latency

In the CAN protocol, if two or more bus nodes start their transmission at the same time, message collision is avoided by bit-wise arbitration. Each node sends the bits of its identifier and monitors the bus level. A node that sends a recessive identifier bit, but reads back a dominant one, loses bus arbitration and switches to Receive mode. This condition occurs when the message identifier of a competing node has a lower binary value (dominant state = logic 0), which results in the competing node sending a message with a higher priority. Because of this, the bus node with the highest priority message wins arbitration, without losing time by having to repeat the message. Transmission of the lower priority message is delayed until all high priority traffic on the bus is finished, which adds some latency to the message transmission. This type of message latency cannot be avoided.

Depending on software driver implementation, additional latency can be avoided by proper design of the driver. If CAN is working at low bus utilization, then the delay in message transmission is not a concern because of arbitration. However, if CAN bus utilization is high, unwanted message latency can be reduced with good driver design.

To illustrate this point, let us examine latency that occurs because of the implementation of driver software. Consider the case when a buffer contains a low priority message in queue and a high priority message is loaded. If no action is taken, the transmission of the high priority message will be delayed until the low priority message is transmitted. A PIC18CXX8 device provides a workaround for this problem.

In PIC18CXX8 devices, it is possible to assign priority to all transmit buffers, which causes the highest priority message to be transmitted first and so on. By setting the transmit buffer priority within the driver software, this type of message latency can be avoided.

Additionally, consider the case where all buffers are occupied with a low priority message and the controller wants to transmit a high priority message. Since all buffers are full, the high priority message will be blocked until one of the low priority messages is transmitted. The low priority message will be sent only after all the high priority messages on the bus are sent. This can considerably delay the transmission of high priority messages.

How then, can this problem be solved? Adding more buffers may help, but most likely the same situation will occur. What then, is the solution? The solution is to unload the lowest priority message from the transmit buffer and save it to a software buffer, then load the transmit buffer with the higher priority message. To maintain bus control, all *n* Transmit buffers should be loaded with *n* highest priority messages. Once the transmit buffer is emptied, load the lower priority message into the transmit buffer for transmission. To do this, intelligent driver software is needed that will manage these buffers, based on the priority of the message (Lower binary value of identifier -> Higher priority, see "Terminology Conventions" on page 5). This method minimizes message latency for higher priority messages.

Macro Wrappers

One of the problems associated with assembly language programming is the mechanism used to pass parameters to a function. Before a function can be called, all parameters must be copied to a temporary memory location. This becomes quite cumbersome when passing many parameters to a generalized function. One way to facilitate parameter passing is through the use of “macro wrappers”. This new concept provides a way to overcome the problems associated with passing parameters to functions.

A macro wrapper is created when a macro is used to “wrap” the assembly language function for easy access. In the following examples, macros call the same function, but the way they format the data is different. Depending on the parameters, different combinations of macro wrappers are required to fit the different applications.

Macro wrappers for assembly language functions provide a high level ‘C-like’ language interface to these functions, which makes passing multiple parameters quite simple. Because the macro only deals with literal values, different macro wrappers are provided to suit different calling requirements for the same functions.

For example, if a function is used that copies the data at a given address, the data and address must be supplied to the function.

EXAMPLES

Using standard methods, a call to the assembly language function `CopyDataFunc` might look like the macro shown in Example 1.

EXAMPLE 1: CODE WITHOUT MACRO WRAPPER

```
#define     Address  0x1234

    UDATA
TempWord    RES  02

    banksel TempWord
    movlw   low(Address)
    movwf   TempWord
    movlw   high(Address)
    movwf   TempWord+1
    movlw   0x56          ;Copy data
    call    CopyDataFunc
```

Using a macro wrapper, the code in Example 2 shows how to access the same function that accepts the data value directly.

EXAMPLE 2: CODE WITH MACRO WRAPPER

```
#define   Address 0x1234

CopyData  0x56,   Address
```

The code in Example 3 shows variable data stored in `DataLoc`.

EXAMPLE 3: CODE WITHOUT MACRO WRAPPER

```
#define    Address   0x1234

    UDATA
TempWord   RES  02
DataLoc    RES  01

   banksel TempWord
   movlw   low(Address)
   movwf   TempWord
   movlw   high(Address)
   movwf   TempWord+1
   banksel DataLoc
   movf    DataLoc,W
   call    CopyDataFunc
```

Using a macro wrapper, the code shown in Example 4 supplies the memory address location for data instead of supplying the data value directly.

EXAMPLE 4: CODE WITH MACRO WRAPPER

```
#define     Address     0x1234

    UDATA
Dataloc     RES 01
CopyData_ID DataLoc,    AddressLoc
```

The code in Example 5 shows one more variation using a macro wrapper for the code of both variable arguments.

EXAMPLE 5: CODE WITH MACRO WRAPPER

```
    UDATA
AddressLoc      RES 02
Dataloc         RES 01

CopyData_ID_IA DataLoc,    AddressLoc
```

To summarize, the code examples previously described call for the same function, but the way they format the data is different. By using a macro wrapper, access to assembly functions is simplified, since the macro only deals with literal values.

PIC18XXX8 CAN FUNCTIONS

All PIC18XXX8 CAN functions are grouped into the following three categories:

- Configuration/Initialization Functions
- Module Operation Functions
- Status Check Functions

The following table lists each function by category, which are described in the following sections.

TABLE 1: FUNCTION INDEX

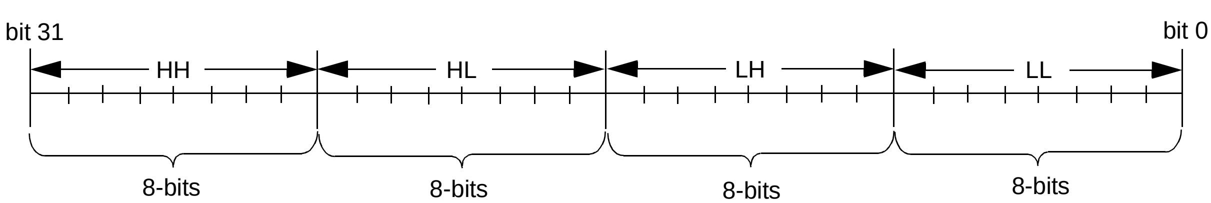
Function	Category	Page Number
`CANInitialize`	Configuration/Initialization	6
`CANSetOperationMode`	Configuration/Initialization	8
`CANSetOperationModeNoWait`	Configuration/Initialization	9
`CANSetBaudRate`	Configuration/Initialization	10
`CANSetReg`	Configuration/Initialization	12
`CANSendMessage`	Module Operation	16
`CANReadMessage`	Module Operation	19
`CANAbortAll`	Module Operation	22
`CANGetTxErrorCount`	Status Check	23
`CANGetRxErrorCount`	Status Check	24
`CANIsBusOff`	Status Check	25
`CANIsTxPassive`	Status Check	26
`CANIsRxPassive`	Status Check	27
`CANIsRxReady`	Status Check	28
`CANIsTxReady`	Status Check	30

Terminology Conventions

The following applies when referring to the terminology used in this application note.

TABLE 2: TERMINOLOGY CONVENTIONS

Term	Meaning
xyzFunc	Used for original assembly language functions.
xyz	The macro that will accept all literal values.
xyz_I(First letter of argument)	The macro that will accept the memory address location for variable implementation.
xyz_D(First letter of argument)	The macro that expects the user is directly copying the specified parameter at the required memory location by assembly function.
LL:LH:HL:HH	



CONFIGURATION/INITIALIZATION FUNCTIONS

CANInitialize

This function initializes the PIC18 CAN module by the given parameters.

Function

`CANInitializeFunc`

Input

m_SJW

SJW value as defined in the PIC18CXX8 data sheet (must be between 1 and 4).

m_BRP

BRP value as defined in the PIC18CXX8 data sheet (must be between 1 and 64).

m_PHSEG1

PHSEG1 value as defined in the PIC18CXX8 data sheet (must be between 1 and 8).

m_PHSEG2

PHSEG2 value as defined in the PIC18CXX8 data sheet (must be between 1 and 8).

m_PROPSEG2

PROPSEG value as defined in the PIC18CXX8 data sheet (must be between 1 and 8).

m_Flags1

Flag value of type `CAN_CONFIG_FLAGS`.

This parameter can be any combination (AND'd together) of the following values:

TABLE 3: CAN_CONFIG_FLAG VALUES

Value	Meaning	Bit(s)	Position	Status[1]
CAN_CONFIG_DEFAULTS	Default flags			
CAN_CONFIG_PHSEG2_PRG_ON	Use supplied PHSEG2 value	1	CAN_CONFIG_PHSEG2_PRG_BIT_NO	Set
CAN_CONFIG_PHSEG2_PRG_OFF	Use maximum of PHSEG1 or Information Processing Time (IPT), whichever is greater	1	CAN_CONFIG_PHSEG2_PRG_BIT_NO	Clear
CAN_CONFIG_LINE_FILTER_ON	Use CAN bus line filter for wake-up	1	CAN_CONFIG_LINE_FILTER_BIT_NO	Set
CAN_CONFIG_LINE_FILTER_OFF	Do not use CAN bus line filter for wake-up	1	CAN_CONFIG_LINE_FILTER_BIT_NO	Clear
CAN_CONFIG_SAMPLE_ONCE	Sample bus once at the sample point	1	CAN_CONFIG_SAMPLE_BIT_NO	Set
CAN_CONFIG_SAMPLE_THRICE	Sample bus three times prior to the sample point	1	CAN_CONFIG_SAMPLE_BIT_NO	Clear
CAN_CONFIG_ALL_MSG	Accept all messages including invalid ones	2	CAN_CONFIG_MSG_BITS	
CAN_CONFIG_VALID_XTD_MSG	Accept only valid Extended Identifier messages	2	CAN_CONFIG_MSG_BITS	
CAN_CONFIG_VALID_STD_MSG	Accept only valid Standard Identifier messages	2	CAN_CONFIG_MSG_BITS	
CAN_CONFIG_ALL_VALID_MSG	Accept all valid messages	2	CAN_CONFIG_MSG_BITS	

Note 1: If a definition has more than one bit, position symbol provides information for bit masking. ANDing it with the value will mask all the bits except the required one. Status information is not provided, since the user needs to use ANDing and ORing to set/get value.

Return Values

None

Pre-condition

None

Side Effects

All pending CAN messages are aborted.

Remarks

This function does not allow the calling function to specify receive buffer mask and filter values. All mask registers are set to 0x00, which essentially disables the message filter mechanism. If an application requires the message filter operation, it must perform initialization in discrete steps. See `CANSetReg` for more information.

Macro

```
CANInitialize    SJW, BRP, PHSEG1, PHSEG2, PROPSEG, Flags
```

Input

SJW

SJW value as defined in the PIC18CXX8 data sheet (must be between 1 and 4).

BRP

BRP value as defined in the PIC18CXX8 data sheet (must be between 1 and 64).

PHSEG1

PHSEG1 value as defined in the PIC18CXX8 data sheet (must be between 1 and 8).

PHSEG2

PHSEG2 value as defined in the PIC18CXX8 data sheet (must be between 1 and 8).

PROPSEG

PROPSEG value as defined in the PIC18CXX8 data sheet (must be between 1 and 8).

Flags

Flag value of type `CAN_CONFIG_FLAGS`, as previously described.

Example 1

```
;Initialize for 125kbps@20MHz, all valid messages
CANInitialize 1, 5, 7, 6, 2, CAN_CONFIG_ALL_VALID_MSG
```

Example 2

```
;Initialize for 125kbps@20MHz, valid extended message and line filter on
CANInitialize 1, 5, 7, 6, 2, CAN_CONFIG_LINE_FILTER_ON & CAN_CONFIG_VALID_XTD_MSG
```

CANSetOperationMode

This function changes the PIC18 CAN module Operation mode.

Function

`CANSetOperationModeFunc`

Input

W reg

Value of type `CAN_OP_MODE`.

This parameter must be only one of the following values:

TABLE 4: CAN_OP_MODE VALUES

Value	Meaning
CAN_OP_MODE_NORMAL	Normal mode of operation
CAN_OP_MODE_SLEEP	SLEEP mode of operation
CAN_OP_MODE_LOOP	Loopback mode of operation
CAN_OP_MODE_LISTEN	Listen Only mode of operation
CAN_OP_MODE_CONFIG	Configuration mode of operation

Return Values

None

Pre-condition

None

Side Effects

If `CAN_OP_MODE_CONFIG` is requested, all pending messages will be aborted.

Remarks

This is a blocking function. It waits for a given mode to be accepted by the CAN module and then returns the control. If a non-blocking call is required, see the `CANSetOperationModeNoWait` function.

Macro

`CANSetOperationMode OpMode`

Input

OpMode

Value of type `CAN_OP_MODE`.

This parameter must be only one of the values listed in Table 4.

Example

```
...
CANSetOperationMode             CAN_OP_MODE_CONFIG
; Module is in CAN_OP_MODE_CONFIG mode.
...
```

`CANSetOperationModeNoWait`

This macro changes the PIC18 CAN module Operation mode.

Macro

`CANSetOperationModeNoWait`

Input

W reg

Value of type `CAN_OP_MODE`.

This parameter must be only one of the values listed in Table 4.

Return Values

None

Pre-condition

None

Side Effects

If `CAN_OP_MODE_CONFIG` is requested, all pending messages will be aborted.

Remarks

This is a non-blocking function. It requests a given mode of operation and immediately returns the control. Caller must make sure that the desired mode of operation is set before performing any mode specific operation. If a blocking call is required, see the `CANSetOperationMode` function.

Example

```
...
CANSetOperationModeNoWait CAN_OP_MODE_CONFIG
```

CANSetBaudRate

This function programs the PIC18 CAN module for given bit rate values.

Function

CANSetBaudRateFunc

Input

m_SJW

SJW value as defined in the PIC18CXX8 data sheet (must be between 1 and 4).

m_BRP

BRP value as defined in the PIC18CXX8 data sheet (must be between 1 and 64).

m_PHSEG1

PHSEG1 value as defined in the PIC18CXX8 data sheet (must be between 1 and 8).

m_PHSEG2

PHSEG2 value as defined in the PIC18CXX8 data sheet (must be between 1 and 8).

m_PROPSEG2

PROPSEG value as defined in the PIC18CXX8 data sheet (must be between 1 and 8).

m_Flags1

Flag value of type `CAN_CONFIG_FLAGS`.

This parameter can be any combination (AND'd together) of the values listed in Table 3.

Return Values

None

Pre-condition

PIC18 CAN module must be in the Configuration mode or else given values will be ignored.

Side Effects

None

Remarks

None

Macro

```
CANSetBaudRate   SJW, BRP, PHSEG1, PHSEG2, PROPSEG, Flags
```

Input

SJW

SJW value as defined in the PIC18CXX8 data sheet (must be between 1 and 4).

BRP

BRP value as defined in the PIC18CXX8 data sheet (must be between 1 and 64).

PHSEG1

PHSEG1 value as defined in the PIC18CXX8 data sheet (must be between 1 and 8).

PHSEG2

PHSEG2 value as defined in the PIC18CXX8 data sheet (must be between 1 and 8).

PROPSEG

PROPSEG value as defined in the PIC18CXX8 data sheet (must be between 1 and 8).

Flags

Flag value of type `CAN_CONFIG_FLAGS` as previously described.

Example

```
...
CANSetOperationMode CAN_OP_MODE_CONFIG

;Set 125bps at 20MHz oscillator frequency
CANSetBaudRate 1, 5, 7, 6, 2,
                  CAN_CONFIG_SAMPLE_ONCE &
                  CAN_CONFIG_PHSEG2_PRG_OFF &
                  CAN_CONFIG_LINE_FILTER_ON

CANSetOperationMode CAN_OP_MODE_NORMAL
...
```

CANSetReg

This function sets the PIC18 CAN module mask/filter values for the given receive buffer.

Function

`CANSetRegFunc`

Input

FSR0H:FSR0L

Starting address of 32-bit buffer to be updated.

Reg1:Reg1+3

32-bit mask/filter value that may correspond to 11-bit Standard Identifier or 29-bit Extended Identifier, with binary zero padded on left. Reg1 = LL, Reg1+1 = LH, Reg1+2 = HL and Reg1+3 = HH byte (see "Terminology Conventions" on page 5).

m_Flags1

Type of message Flag.

This parameter must be only one of the following values:

TABLE 5: CAN_CONFIG_MSG VALUES

Value	Meaning	Bit(s)	Position	Status
`CAN_CONFIG_STD_MSG`	Standard Identifier message	1	`CAN_CONFIG_MSG_TYPE_BIT_NO`	Set
`CAN_CONFIG_XTD_MSG`	Extended Identifier message	1	`CAN_CONFIG_MSG_TYPE_BIT_NO`	Clear

Return Values

None

Pre-condition

PIC18 CAN module must be in the Configuration mode or else given values will be ignored.

Side Effects

None

Remarks

None

Macro

`CANSetReg RegAddr, val, Flags`

Input

RegAddr

This parameter must be only one of the following values:

TABLE 6: REGISTER ADDRESS VALUES

Value	Meaning
`CAN_MASK_B1`	Receive Buffer 1 mask value
`CAN_MASK_B2`	Receive Buffer 2 mask value
`CAN_FILTER_B1_F1`	Receive Buffer 1, Filter 1 value
`CAN_FILTER_B1_F2`	Receive Buffer 1, Filter 2 value
`CAN_FILTER_B2_F1`	Receive Buffer 2, Filter 1 value
`CAN_FILTER_B2_F2`	Receive Buffer 2, Filter 2 value
`CAN_FILTER_B2_F3`	Receive Buffer 2, Filter 3 value
`CAN_FILTER_B2_F4`	Receive Buffer 2, Filter 4 value

val

32-bit mask/filter value that may correspond to 11-bit Standard Identifier, or 29-bit Extended Identifier, with binary zero padded on left.

Flags

Value of `CAN_CONFIG` type.

This parameter must be only one of the values listed in Table 6.

Macro

```
CANSetReg_IF  RegAddr, val, FlagsReg
```

Input

RegAddr

This parameter must be only one of the values listed in Table 6.

val

32-bit mask/filter value that may correspond to 11-bit Standard Identifier, or 29-bit Extended Identifier, with binary zero padded on left.

FlagsReg

Memory Address location that contains the Flag information. This parameter must be only one of the values listed in Table 6.

Macro

```
CANSetReg_IV  RegAddr, Var, Flags
```

Input

RegAddr

This parameter must be only one of the values listed in Table 6.

Var

Starting address of 32-bit buffer containing mask/filter value. Buffer storage format should be Low -> High (LL:LH:HL:HH) byte (see "Terminology Conventions" on page 5).

32-bit mask/filter value that may correspond to 11-bit Standard Identifier, or 29-bit Extended Identifier, with binary zero padded on left.

Flags

Value of `CAN_CONFIG` type. This parameter must be only one of the values listed in Table 6.

Macro

```
CANSetReg_IV_IF  RegAddr, Var, FlagsReg
```

Input

RegAddr

This parameter must be only one of the values listed in Table 6.

Var

Starting address of 32-bit buffer containing mask/filter value. Buffer storage format should be Low -> High (LL:LH:HL:HH) byte (see "Terminology Conventions" on page 5).

32-bit mask/filter value that may correspond to 11-bit Standard Identifier, or 29-bit Extended Identifier, with binary zero padded on left.

FlagsReg

Memory Address location that contains the Flag information. This parameter must be only one of the values listed in Table 6.

Macro

`CANSetReg_DREG_IV_IF    Var, FlagsReg`

Input

FSR0H:FSR0L

FSR0 contains starting address of 32-bit buffer to be updated. This buffer must be of the mask/filter type. The starting address is the address of the SIDH register for that mask/filter.

Var

Starting address of 32-bit buffer containing mask/filter value. Buffer storage format should be Low -> High (LL:LH:HL:HH) byte (see "Terminology Conventions" on page 5).

32-bit mask/filter value that may correspond to 11-bit Standard Identifier, or 29-bit Extended Identifier, with binary zero padded on left.

FlagsReg

Memory Address location that contains the Flag information. This parameter must be only one of the values listed in Table 6.

Macro

`CANSetReg_DREG_DV_IF    FlagsReg`

Input

FSR0H:FSR0L

FSR0 contains starting address of 32-bit buffer to be updated. This buffer must be of the mask/filter type. The starting address is the address of the SIDH register for that mask/filter.

Reg1:Reg1+3

Starting address of 32-bit buffer containing mask/filter value. Buffer storage format should be Low -> High (Reg1 = LL:Reg1+1 = LH:Reg1+2 = HL:Reg1+3 = HH) byte (see "Terminology Conventions" on page 5).

32-bit mask/filter value that may correspond to 11-bit Standard Identifier, or 29-bit Extended Identifier, with binary zero padded on left.

FlagsReg

Memory Address location that contains the Flag information. This parameter must be only one of the values listed in Table 6.

Example

```
...
CANSetReg CAN_MASK_B1, 0x00000001, CAN_STD_MSG
CANSetReg CAN_MASK_B2, 0x00008001, CAN_XTD_MSG
CANSetReg CAN_FILTER_B1_F1, 0x0000, CAN_STD_MSG
CANSetReg CAN_FILTER_B1_F2, 0x0001, CAN_STD_MSG
CANSetReg CAN_FILTER_B2_F1, 0x8000, CAN_XTD_MSG
CANSetReg CAN_FILTER_B2_F2, 0x8001, CAN_XTD_MSG
CANSetReg CAN_FILTER_B2_F3, 0x8002, CAN_XTD_MSG
CANSetReg CAN_FILTER_B2_F4, 0x8003, CAN_XTD_MSG


        UDATA
Flags           RES     01

;Memory location Flags contains configuration flags
;information (Indirect Flag info (pointer to Flag))

CANSetReg_IF CAN_MASK_B1, 0x00000001, Flags
```

```
        UDATA
IDVal           RES     04

;32-bit memory location IDVal contains 32-bit mask
;value (Indirect value info (pointer to value))

CANSetReg_IV CAN_MASK_B2, IDVal, CAN_XTD_MSG


        UDATA
Flags           RES     01
IDVal           RES     04

;32-bit memory location IDVal contains 32-bit mask
;value (Indirect value info (pointer to value))
;Memory location Flags contains configuration flags
;information (Indirect Flag info (pointer to Flag))

CANSetReg_IV_IF CAN_FILTER_B1_F1, IDVal, Flags


        UDATA
Flags           RES     01
IDVal           RES     04

;32-bit memory location IDVal contains 32-bit mask
;value (Indirect value info (pointer to value))
;Memory location Flags contains configuration flags
;information (Indirect Flag info (pointer to Flag))

movlw           low(RxF0SIDH)
movwf           FSR0L
movlw           high(RxF0SIDH)
movwf           FSR0H

;Because of above or some other operation FSR0
;contains starting address of buffer (xxxxSIDH reg.)
;for mask/filter value storage.

CANSetReg_DREG_IV_IF IDVal, Flags


        UDATA
Flags           RES     01

;32-bit memory location IDVal contains 32-bit mask
;value (Indirect value info (pointer to value))
;Memory location Flags contains configuration flags
;information (Indirect Flag info (pointer to Flag))

movlw           low(RxF0SIDH)
movwf           FSR0L
movlw           high(RxF0SIDH)
movwf           FSR0H

;Because of above or some other operation FSR0
;contains starting address of buffer (xxxxSIDH reg.)
;for mask/filter value storage.
;Reg1:Reg1+3 contains 32-bit ID value.

CANSetReg_DREG_DV_IF Flags
```

MODULE OPERATION FUNCTIONS

CANSendMessage

This function copies the given message to one of the empty transmit buffers and marks it as ready to be transmitted.

Function

`CANSendMessageFunc`

Input

Reg1:Reg1+3

32-bit identifier value that may correspond to 11-bit Standard Identifier, or 29-bit Extended Identifier, with binary zero padded on left. Exact number of bits to use depends on `M_TxFlags`. Buffer storage format should be Low -> High (Reg1 = LL:Reg1+1 = LH:Reg1+2 = HL:Reg1+3 = HH) byte (see "Terminology Conventions" on page 5).

FSR1H:FSR1L

Starting address of data buffer.

m_DataLength

Number of bytes to send.

m_TxFlags

Value of type `CAN_TX_MSG_FLAGS`.

This parameter can be any combination (AND'd together) of the following group values:

TABLE 7: CAN_TX_MSG_FLAGS VALUES

Value	Meaning	Bit(s)	Position	Status
CAN_TX_STD_FRAME	Standard Identifier message	1	CAN_TX_FRAME_BIT_NO	Set
CAN_TX_XTD_FRAME	Extended Identifier message	1	CAN_CONFIG_MSG_TYPE_BIT_NO	Clear
CAN_TX_NO_RTR_FRAME	Regular message - not RTR	1	CAN_TX_RTR_BIT_NO	Set
CAN_TX_RTR_FRAME	RTR message	1	CAN_TX_RTR_BIT_NO	Clear

Return Values

W =1, if the given message was successfully placed in one of the empty transmit buffers.

W= 0, if all transmit buffers were full.

Pre-condition

None

Side Effects

None

Remarks

None

Macro

```
CANSendMessage     msgID, DataPtr, DataLngth, Flags
```

msgID

32-bit identifier value that may correspond to 11-bit Standard Identifier, or 29-bit Extended Identifier, with binary zero padded on left. Exact number of bits to use depends on `Flags`.

DataPtr

Pointer to zero or more of data bytes to send.

DataLngth

Number of bytes to send.

Flags

Value of type `CAN_TX_MSG_FLAGS`.

This parameter can be any combination (AND'd together) of the group values listed in Table 7.

Macro

`CANSendMessage_IID_IDL_IF       msgIDPtr, DataPtr, DataLngthPtr, FlagsReg`

msgIDPtr

Starting address of memory location containing 32-bit message ID. Buffer storage format should be Low -> High (LL:LH:HL:HH) byte (see "Terminology Conventions" on page 5).

32-bit identifier value that may correspond to 11-bit Standard Identifier, or 29-bit Extended Identifier, with binary zero padded on left. Exact number of bits to use depends on `FlagsReg`.

DataPtr

Pointer to zero or more of data bytes to send.

DataLngth

Memory Address location having data of number of bytes to send.

FlagsReg

Memory Address location that contains the Flag information. Flags must be of type `CAN_TX_MSG_FLAGS`.

This parameter can be any combination (AND'd together) of the group values listed in Table 7.

Example A

```
        UDATA
MessageData     RES     02

        call            CANIsTxReady
        bnc             TxNotRdy
        movlw           0x01
        movwf           MessageData             ;Copy Data byte 1
        movlw           0x02
        movwf           MessageData+1           ;Copy Data byte 2

        CANSendMessage 0x20,
                  MessageData,
                  2,
                  CAN_TX_STD_FRAME &
                  CAN_TX_NO_RTR_FRAME
TxNotRdy:
;All Buffer are full, Try again
```

Example B

```
        UDATA
MessageData     RES     02

        movlw           0x01
        movwf           MessageData             ;Copy Data byte 1
        movlw           0x02
        movwf           MessageData+1           ;Copy Data byte 2

        CANSendMessage 0x20,
                  MessageData,
                  2,
                  CAN_TX_STD_FRAME &
                  CAN_TX_NO_RTR_FRAME
        addlw           0x00            ;Check for return value 0 in W
        bz              TxNotRdy        ;Buffer Full, Try again
;Message is copied in buffer for Transmission. It will be
;transmitted based on priority and pending messages in
;buffers
        nop                             ;Application specific code

TxNotRdy:
;All Buffer are full, Message was not copied in buffer for
;Transmission
...
                UDATA
        MessageData     RES     02
        Idval           RES     04
        DataLength      RES     01
        Flags           RES     01


        call            CANIsTxReady
        bnc             TxNotRdy
        movlw           0x01
        movwf           MessageData     ;Copy Data byte 1
        movlw           0x02
        movwf           MessageData+1   ;Copy Data byte 2
        movwf           DataLength      ;Set Data length to 2

;IDval contains 32-bit message ID and Flags
;contains TX Flags info.
CANSendMessage_IID_IDL_IF
                IDval,
                MessageData,
                DataLength,
                Flags
TxNotRdy:
;All Buffer are full, Try again
```

CANReadMessage

This function copies the new available message to the user supplied buffer.

Function

`CANReadMessageFunc`

Input

FSR0H:FSR0L

Starting address for received data storage.

Output

Temp32Data:Temp32Data+3

Received Message ID. Buffer storage format is Low -> High (LL:LH:HL:HH) byte (see "Terminology Conventions" on page 5).

32-bit identifier value that may correspond to 11-bit Standard Identifier, or 29-bit Extended Identifier, with binary zero padded on left.

DataLen

Number of bytes received.

m_RxFlags

Value of type `CAN_RX_MSG_FLAGS`.

This parameter can be any combination (AND'd together) of the following values. If a flag bit is set, the corresponding meaning is TRUE; if cleared, the corresponding meaning is FALSE.

TABLE 8: CAN_RX_MSG_FLAGS VALUES

Value	Meaning	Bit(s)	Position	Status
CAN_RX_FILTER_1, CAN_RX_FILTER_2, CAN_RX_FILTER_3, CAN_RX_FILTER_4, CAN_RX_FILTER_5, CAN_RX_FILTER_6	Receive buffer filter that caused this message to be accepted.	3	CAN_RX_FILTER_BITS	
CAN_RX_OVERFLOW	Receive buffer overflow condition	1	CAN_RX_OVERFLOW_BIT_NO	Set
CAN_RX_INVALID_MSG	Invalid message	1	CAN_RX_INVALID_MSG_BIT_NO	Set
CAN_RX_XTD_FRAME	Extended message	1	CAN_RX_XTD_FRAME_BIT_NO	Set
CAN_TX_RTR_FRAME	RTR message	1	CAN_RX_RTR_FRAME_BIT_NO	Set
CAN_RX_DBL_BUFFERED	This message was double-buffered	1	CAN_RX_DBL_BUFFERED_BIT_NO	Set

Return Values

W =1, if new message was copied to given buffer.

W= 0, if no new message was found.

Pre-condition

`id`, `Data`, `DataLen` and `MsgFlags` pointers must point to valid/desired memory locations.

Side Effects

None

Remarks

This function will fail if there are no new message(s) to read. Caller may check the return value to determine new message availability, or may call `CANIsRxReady` function.

Macro

`CANReadMessage msgIDPtr, DataPtr, DataLngth, Flags`

msgIDPtr

Starting address of 32-bit buffer for message ID storage. Buffer storage format is Low -> High (LL:LH:HL:HH) byte (see "Terminology Conventions" on page 5). 32-bit identifier value that may correspond to 11-bit Standard Identifier, or 29-bit Extended Identifier, with binary zero padded on left.

DataPtr

Starting address of data buffer for storage of received data byte.

DataLngth

Address of the memory location for storage of number of bytes received.

Flags

Address of the memory location for storage of number of bytes received.

Value of type `CAN_RX_MSG_FLAGS`.

This parameter can be any combination (AND'd together) of the values listed in Table 8. If a flag bit is set, the corresponding meaning is TRUE; if cleared, the corresponding meaning is FALSE.

Example A

```
        UDATA
NewMessage              RES     04
NewMessageData          RES     08
NewMessageLen           RES     01
NewMessageFlags         RES     01
RxFilterMatch           RES     01

        call            CANIsRxReady
        bnc             RxNotRdy

        CANReadMessage  NewMessage,
                        NewMessageData,
                        NewMessageLen,
                        NewMessageFlags

        banksel         NewMessageFlags

        btfsc           NewMessageFlags,CAN_RX_OVERFLOW_BIT_NO
        bra             RxOvrFlow       ;Branch to Logic for Rx
                                        ;overflow occurred.

        btfsc           NewMessageFlags,CAN_RX_INVALID_MSG_BIT_NO
        bra             RxInvldMsg      ;Branch to Logic for Invalid
                                        ;Message received

        btfsc           NewMessageFlags,CAN_RX_XTD_FRAME_BIT_NO
        nop                             ;Logic for Extended frame
                                        ;received
        nop                             ;Else logic for standard
                                        ;frame received

        btfsc           NewMessageFlags,CAN_RX_RTR_FRAME_BIT_NO
        bra             RxRTRFrame      ;Branch to Logic for RTR
                                        ;frame received
        nop                             ;Regular frame received
```

```
        movlw           CAN_RX_FILTER_BITS
        andwf           NewMesageFlags,W
        movwf           RxFilterMatch   ;Save matched Filter ;number


RxNotReady:
;Receive buffer is empty, Wait for new message
...
```

Example B

```
        UDATA
NewMessage              RES     04
NewMessageData          RES     08
NewMessageLen           RES     01
NewMessageFlags         RES     01
RxFilterMatch           RES     01


        CANReadMessage          NewMessage,
                                NewMessageData,
                                NewMessageLen,
                                NewMessageFlags

        xorlw           0x01            ;Check for Success code
        bnz             RxNotReady

        banksel         NewMessageFlags

        btfsc           NewMessageFlags,CAN_RX_OVERFLOW_BIT_NO
        bra             RxOvrFlow       ;Branch to Logic for Rx
                                        ;overflow occurred.

        btfsc           NewMessageFlags,CAN_RX_INVALID_MSG_BIT_NO
        bra             RxInvldMsg      ;Branch to Logic for Invalid
                                        ;Message received

        btfsc           NewMessageFlags,CAN_RX_XTD_FRAME_BIT_NO
        nop                             ;Logic for Extended frame
                                        ;received
        nop                             ;Else logic for standard
                                        ;frame received

        btfsc           NewMessageFlags,CAN_RX_RTR_FRAME_BIT_NO
        bra             RxRTRFrame      ;Branch to Logic for RTR
                                        ;frame received
        nop                             ;Regular frame received

        movlw           CAN_RX_FILTER_BITS
        andwf           NewMesageFlags,W
        movwf           RxFilterMatch   ;Save matched Filter ;number

RxNotReady:
;Receive buffer is empty, Wait for new message
```

`CANAbortAll`

This macro aborts all pending messages from the PIC18 CAN module. See the PIC18CXX8 Data Sheet for rules regarding message abortion.

Macro

```
CANAbortAll
```

Input

None

Return Values

None

Pre-condition

None

Side Effects

None

Remarks

None

Example

```
...
CANAbortAll
...
```

STATUS CHECK FUNCTIONS

CANGetTxErrorCount

This macro returns the PIC18 CAN transmit error count, as defined by BOSCH CAN Specifications, in WREG. See the PIC18CXX8 Data Sheet for more information.

Macro

`CANGetTxErrorCount`

Input

None

Return Values

WREG contains the current value of transmit error count.

Pre-condition

None

Side Effects

None

Remarks

None

Example

```
                        UDATA
TxErrorCount    RES     01
        ...
        CANGetTxErrorCount      ;Returns error count in W
        banksel         TxErrorCount
        movwf           TxErrorCount
        ...
```

CANGetRxErrorCount

This macro returns the PIC18 CAN receive error count, as defined by BOSCH CAN Specifications, in WREG. See the PIC18CXX8 Data Sheet for more information.

Macro

`CANGetRxErrorCount`

Input

None

Return Values

WREG contains the current value of receive error count.

Pre-condition

None

Side Effects

None

Remarks

None

Example

```
        UDATA
RxErrorCount    RES     01
...
CANGetRxErrorCount      ; Returns error count in W
banksel         RxErrorCount
movwf           RxErrorCount
...
```

CANIsBusOff

This function returns the PIC18 CAN module On/Off state.

Function

CANIsBusOff

Input

None

Return Values

Carry C = 1, if PIC18 CAN module is in the Bus Off state.

Carry C = 0, if PIC18 CAN module is in the Bus On state.

Pre-condition

None

Side Effects

None

Remarks

None

Example

```
...
        call    CANIsBusOff()
        bnc     CANBusNotOff
        nop             ;CAN Module is in Bus off state

CANBusNotOff
        nop             ;CAN Module isn't in Bus off state
```

CANIsTxPassive

This function returns the PIC18 CAN transmit error status, as defined by BOSCH CAN Specifications. See the PIC18CXX8 Data Sheet for more information.

Function

`CANIsTxPassive`

Input

None

Return Values

Carry C = 1, if the PIC18 CAN module is in transmit error passive state.

Carry C = 0, if the PIC18 CAN module is not in transmit error passive state.

Pre-condition

None

Side Effects

None

Remarks

None

Example

```
...
        call    CANIsTxPassive()
        bnc     CANIsNotTxPassive
        nop             ;CAN Module is in Transmit Passive
                        ;state

CANBIsNotTxPassive
        nop             ;CAN Module isn't in Tx Passive
                        ;state
...
```

CANIsRxPassive

This function returns the PIC18 CAN receive error status, as defined by BOSCH CAN Specifications. See the PIC18CXX8 Data Sheet for more information.

Function

`CANIsRxPassive`

Input

None

Return Values

Carry C = 1, if the PIC18 CAN receive module is in receive error passive state.

Carry C = 0, if the PIC18 CAN receive module is not in receive error passive state.

Pre-condition

None

Side Effects

None

Remarks

None

Example

```
...
        call    CANIsRxPassive()
        bnc     CANIsNotRxPassive
        nop             ;CAN Module is in Receive Passive
                        ;state, Do Something

CANBIsNotRxPassive
        nop             ;CAN Module isn't in Rx Passive
                        ;state
...
```

CANIsRxReady

This function returns the PIC18 CAN receive buffer(s) readiness status.

Function

`CANIsRxReady`

Input

None

Return Values

Carry C = 1, if at least one of the PIC18 CAN receive buffers is full.

Carry C = 0, if none of the PIC18 CAN receive buffers are full.

Pre-condition

None

Side Effects

None

Remarks

None

Example

```
        UDATA
NewMessage              RES     04
NewMessageData          RES     08
NewMessageLen           RES     01
NewMessageFlags         RES     01
RxFilterMatch           RES     01

        call    CANIsRxReady
        bnc     RxNotRdy

        CANReadMessage          NewMessage,
                                NewMessageData,
                                NewMessageLen,
                                NewMessageFlags

        banksel                 NewMessageFlags

        btfsc   NewMessageFlags,CAN_RX_OVERFLOW_BIT_NO
        bra     RxOvrFlow       ;Branch to Logic for Rx
                                ;overflow occurred.

        btfsc   NewMessageFlags,CAN_RX_INVALID_MSG_BIT_NO
        bra     RxInvldMsg      ;Branch to Logic for Invalid
                                ;Message received

        btfsc   NewMessageFlags,CAN_RX_XTD_FRAME_BIT_NO
        nop                     ;Logic for Extended frame
                                ;received
        nop                     ;Else logic for standard
                                ;frame received

        btfsc   NewMessageFlags,CAN_RX_RTR_FRAME_BIT_NO
        bra     RxRTRFrame      ;Branch to Logic for RTR
                                ;frame received
```

```
        nop                     ;Regular frame received

        movlw   CAN_RX_FILTER_BITS
        andwf   NewMesageFlags,W
        movwf   RxFilterMatch   ;Save matched Filter
                                ;number
RxNotReady
;Receive buffer is empty, wait for new message
...
```

CANIsTxReady

This function returns the PIC18 CAN transmit buffer(s) readiness status.

Function

`CANIsTxReady`

Input

None

Return Values

Carry C = 1, if at least one of the PIC18 CAN transmit buffers is empty.

Carry C = 0, if none of the PIC18 CAN transmit buffers are empty.

Pre-condition

None

Side Effects

None

Remarks

None

Example

```
        UDATA
MessageData     RES     02

        call            CANIsTxReady
        bnc             TxNotRdy
        movlw           0x01
        movwf           MessageData             ;Copy Data byte 1
        movlw           0x02
        movwf           MessageData+1           ;Copy Data byte 2

        CANSendMessage  0x20,
                        MessageData,
                        2,
                        CAN_TX_STD_FRAME &
                        CAN_TX_NO_RTR_FRAME
TxNotRdy:
;All Buffer are full, Try again
...
```

PIC18 CAN FUNCTIONS ORGANIZATION AND USAGE

These functions were developed for Microchip MPLAB® using MPLINK™ Object Linker; however, they can easily be ported to any assembler supporting linking for PIC18 devices.

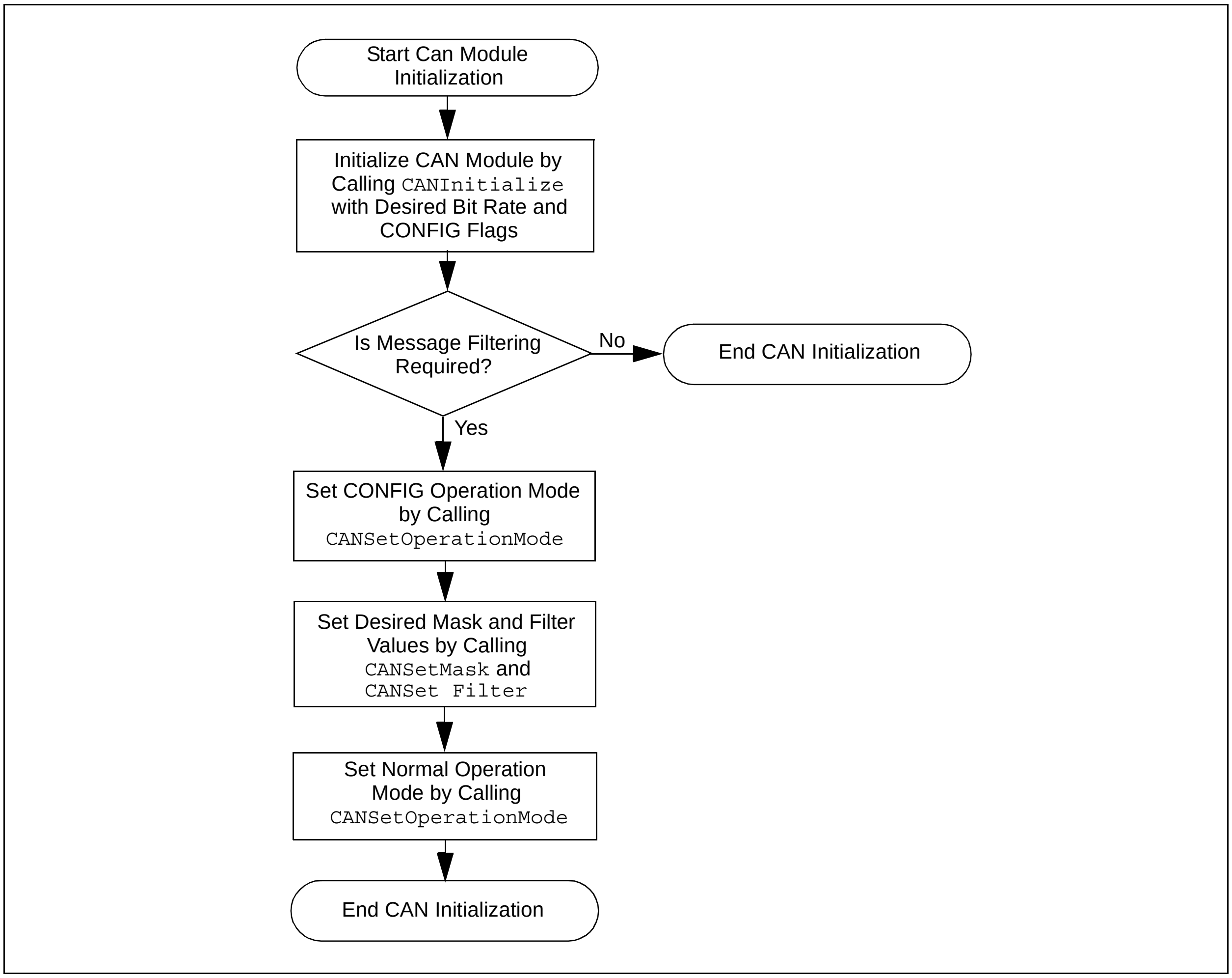
Source code for the PIC18XXX8 CAN module is divided into the following three files:

- `CAN18xx8.asm`
- `CAN18xx8.inc`
- `CANDef.inc`

To employ these CAN functions in your project, perform the following steps:

1. Copy "`CAN18xx18.asm`", "`CANDef.inc`" and "`CAN18xx8.inc`" files to your project source directory.
2. Include "`CAN18xx8.asm`" file in your project as an asm source file.
3. Add #include "`CAN18xx8.inc`" line in each source file that will be calling CAN routines.
4. By default, CAN interrupt priority is high. CAN interrupt can be assigned a lower priority by defining `CANIntLowPrior` in `CANDef.inc`. User must call `CANISR` function from the respective interrupt vector to service CAN transmit interrupt.
5. Firmware implements user defined size of transmit buffer. User can define size of software transmit buffer to increase the buffer size that is available in hardware (3). In that case, it will use 14 bytes of general purpose RAM for each extra buffer. User should define required extra software buffer size in `CANDef.inc` at `MAX_TX_SOFT_BUFFER`.

FIGURE 2: PIC18 CAN MODULE INITIALIZATION PROCEDURE



SAMPLE APPLICATION PROGRAM USING THE PIC18 CAN LIBRARY

An application program that uses the PIC18 CAN functions must follow certain initialization steps, as shown in Figure 2.

The following is a portion of a sample application program that requires all CAN Standard Identifier messages to be accepted.

EXAMPLE 6: ALL IDENTIFIER MESSAGES ACCEPTED

```
       UDATA
    NewMessage         RES     04
    NewMessageData     RES     08
    NewMessageLen      RES     01
    NewMessageFlags    RES     01
    RxFilterMatch      RES     01
    MessageData        RES     02

;Application specific initialization code

;Initialize CAN module with no message filtering
    CANInitialize 1, 5, 7, 6, 2, CAN_CONFIG_ALL_VALID_MSG

Loop:
       call           CANIsRxReady       ;Check for CAN message
       bnc            RxNotRdy

       CANReadMessage NewMessage,
                      NewMessageData,
                      NewMessageLen,
                      NewMessageFlags

       banksel        NewMessageFlags

       btfsc          NewMessageFlags,CAN_RX_OVERFLOW_BIT_NO
       bra            RxOvrFlow      ;Branch to Logic for Rx
                                     ;overflow occurred.

       btfsc          NewMessageFlags,CAN_RX_INVALID_MSG_BIT_NO
       bra            RxInvldMsg     ;Branch to Logic for Invalid
                                     ;Message received

       btfsc          NewMessageFlags,CAN_RX_XTD_FRAME_BIT_NO
       nop                           ;Logic for Extended frame
                                     ;received
       nop                           ;Else logic for standard
                                     ;frame received

       btfsc          NewMessageFlags,CAN_RX_RTR_FRAME_BIT_NO
       bra            RxRTRFrame     ;Branch to Logic for RTR
                                     ;frame received
       nop                           ;Regular frame received

       movlw          CAN_RX_FILTER_BITS
       andwf          NewMesageFlags,W
       movwf          RxFilterMatch  ;Save matched Filter
                                     ;number


    RxNotReady:
    ;Receive buffer is empty, Wait for new message
```

EXAMPLE 6: ALL IDENTIFIER MESSAGES ACCEPTED (Continued)

```
; Process received message
    ...

;Transmit a message due to previously received message or
;due to application logic itself.
    call            CANIsTxReady
    bnc             TxNotRdy
    movlw           0x01
    movwf           MessageData    ;Copy Data byte 1
    movlw           0x02
    movwf           MessageData+1  ;Copy Data byte 2

    CANSendMessage 0x20,
                    MessageData,
                    2,
                    CAN_TX_STD_FRAME &
                    CAN_TX_NO_RTR_FRAME
TxNotRdy:
;All Buffer are full, Try again

;Other application specific logic
    ...

    goto            Loop           ;Do this forever

;End of program
```

The following is a portion of a sample application program that requires only a specific group of CAN Standard Identifier messages to be accepted:

EXAMPLE 7: SPECIFIC IDENTIFIER MESSAGES ACCEPTED

```
        UDATA
    NewMessage          RES  04
    NewMessageData      RES  08
    NewMessageLen       RES  01
    NewMessageFlags     RES  01
    RxFilterMatch       RES  01
    MessageData         RES  02

;Application specific initialization code

;Initialize CAN module with no message filtering
    CANInitialize 1, 5, 7, 6, 2, CAN_CONFIG_ALL_VALID_MSG

    CANSetOperationMode    CAN_OP_MODE_CONFIG
;Set Buffer Mask 1 value
    CANSetReg              CAN_MASK_B1, 0x0000000f, CAN_STD_MSG

;Set Buffer Mask 2 value
    CANSetReg              CAN_MASK_B2, 0x000000f0, CAN_STD_MSG

;Set Buffer 1, Filter 1 value
    CANSetReg              CAN_FILTER_B1_F1, 0x00000001, CAN_STD_MSG

;Set Buffer 1, Filter 2 value
    CANSetReg              CAN_FILTER_B1_F2, 0x00000002, CAN_STD_MSG

;Set Buffer 2, Filter 1 value
    CANSetReg              CAN_FILTER_B2_F1, 0x00000010, CAN_STD_MSG

;Set Buffer 2, Filter 2 value
    CANSetReg              CAN_FILTER_B2_F2, 0x00000020, CAN_STD_MSG

;Set Buffer 3, Filter 3 value
    CANSetReg              CAN_FILTER_B2_F3, 0x00000030, CAN_STD_MSG

;Set Buffer 4, Filter 4 value
    CANSetReg              CAN_FILTER_B2_F4, 0x00000040, CAN_STD_MSG


Loop:
        call           CANIsRxReady           ;Check for CAN message
        bnc            RxNotRdy

        CANReadMessage NewMessage,
                       NewMessageData,
                       NewMessageLen,
                       NewMessageFlags

        banksel        NewMessageFlags

        btfsc          NewMessageFlags,CAN_RX_OVERFLOW_BIT_NO
        bra            RxOvrFlow              ;Branch to Logic for Rx
                                              ;overflow occurred.

        btfsc          NewMessageFlags,CAN_RX_INVALID_MSG_BIT_NO
        bra            RxInvldMsg             ;Branch to Logic for Invalid
                                              ;Message received
```

EXAMPLE 7: SPECIFIC IDENTIFIER MESSAGES ACCEPTED (Continued)

```
    btfsc          NewMessageFlags,CAN_RX_XTD_FRAME_BIT_NO
    nop                                 ;Logic for Extended frame
                                        ;received
    nop                                 ;Else logic for standard
                                        ;frame received

    btfsc          NewMessageFlags,CAN_RX_RTR_FRAME_BIT_NO
    bra            RxRTRFrame           ;Branch to Logic for RTR
                                        ;frame received
    nop                                 ;Regular frame received

    movlw          CAN_RX_FILTER_BITS
    andwf          NewMesageFlags,W
    movwf          RxFilterMatch        ;Save matched Filter
                                        ;number


RxNotReady:
;Receive buffer is empty, Wait for new message

; Process received message
    ...

;Transmit a message due to previously received message or
;due to application logic itself.
    call           CANIsTxReady
    bnc            TxNotRdy
    movlw          0x01
    movwf          MessageData          ;Copy Data byte 1
    movlw          0x02
    movwf          MessageData+1        ;Copy Data byte 2

    CANSendMessage 0x20,
                   MessageData,
                   2,
                   CAN_TX_STD_FRAME &
                    CAN_TX_NO_RTR_FRAME
TxNotRdy:
;All Buffers are full, Try again

;Other application specific logic
    ...

    goto           Loop                 ;Do this forever

;End of program
```

CONCLUSION

The CAN library provided in this application note can be used in any application program that needs an interrupt controlled mechanism to implement CAN transmission and a simple polling mechanism to implement CAN reception. This library can be used as a reference to create prioritized receive buffer CAN communication. Macro wrappers, provided for the functions described, may not be sufficient for all requirements. Using the code provided in this application note, users can develop their own wrappers to fit their needs.

APPENDIX A: SOURCE CODE

Due to size considerations, the complete source code for this application note is not included in the text.

A complete version of the source code, with all required support files, is available for download as a Zip archive from the Microchip web site, at:

www.microchip.com

Note the following details of the code protection feature on PICmicro® MCUs.

- The PICmicro family meets the specifications contained in the Microchip Data Sheet.
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