INTRODUCTION

The Microchip PIC18C family of microcontrollers provides 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. Because of the wide applicability of the CAN protocol, there exists a need to develop a software library that hides the intricate details of CAN registers and allows developers to focus on application logic. This application note provides such functions.

For details about the PIC18C family of microcontrollers, refer to the PIC18CXX8 Data Sheet (DS30475) and the PICmicro® 18C MCU Family Reference Manual (DS39500).

OVERVIEW OF THE PIC18C CAN MODULE

The PIC18C family of microcontrollers contains a CAN module that provides the same register and functional interface for all PIC18C microcontrollers.

The module features are:

• Implementation of the CAN protocols CAN 1.2, CAN 2.0A, and CAN 2.0B
• Standard and extended data frames
• Data length of 0 - 8 bytes
• Programmable bit rate up to 1 Mbit/s
• 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 shows a block diagram of the CAN module buffers and protocol engine.
FIGURE 1: CAN BUFFERS AND PROTOCOL ENGINE BLOCK DIAGRAM
PIC18C CAN FUNCTIONS

All of the PIC18C CAN functions can be grouped into the following three categories:
• Configuration/Initialization Functions
• Operation Functions
• Status Check Functions

The functions in each category are described in the following sections.

TABLE 1: FUNCTION INDEX

<table>
<thead>
<tr>
<th>Function</th>
<th>Category</th>
<th>Page Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>CANInitialize</td>
<td>Configuration</td>
<td>4</td>
</tr>
<tr>
<td>CANSetOperationMode</td>
<td>Configuration</td>
<td>6</td>
</tr>
<tr>
<td>CANSetOperationModeNoWait</td>
<td>Configuration</td>
<td>7</td>
</tr>
<tr>
<td>CANSetBaudRate</td>
<td>Configuration</td>
<td>8</td>
</tr>
<tr>
<td>CANSetMask</td>
<td>Configuration</td>
<td>10</td>
</tr>
<tr>
<td>CANSetFilter</td>
<td>Configuration</td>
<td>11</td>
</tr>
<tr>
<td>CANSendMessage</td>
<td>Operation</td>
<td>12</td>
</tr>
<tr>
<td>CANReceiveMessage</td>
<td>Operation</td>
<td>14</td>
</tr>
<tr>
<td>CANAbortAll</td>
<td>Operation</td>
<td>16</td>
</tr>
<tr>
<td>CANGetTxErrorCount</td>
<td>Status Check</td>
<td>17</td>
</tr>
<tr>
<td>CANGetRxErrorCount</td>
<td>Status Check</td>
<td>18</td>
</tr>
<tr>
<td>CANIsBusOff</td>
<td>Status Check</td>
<td>19</td>
</tr>
<tr>
<td>CANIsTxPassive</td>
<td>Status Check</td>
<td>20</td>
</tr>
<tr>
<td>CANIsRxPassive</td>
<td>Status Check</td>
<td>21</td>
</tr>
<tr>
<td>CANIsRxReady</td>
<td>Status Check</td>
<td>22</td>
</tr>
<tr>
<td>CANIsTxReady</td>
<td>Status Check</td>
<td>23</td>
</tr>
</tbody>
</table>
CONFIGURATION/INITIALIZATION FUNCTIONS:

CANInitialize
This function initializes the PIC18C CAN module with given parameters.

Syntax
void CANInitialize( BYTE SJW,
                    BYTE BRP,
                    BYTE PHSEG1,
                    BYTE PHSEG2,
                    BYTE PROPSEG,
                    enum CAN_CONFIG_FLAGS config);

Parameters

SJW
[in] SJW value as defined in PIC18CXX8 data sheet (must be between 1 through 4).

BRP
[in] BRP value as defined in PIC18CXX8 data sheet (must be between 1 through 64).

PHSEG1
[in] PHSEG1 value as defined in PIC18CXX8 data sheet (must be between 1 through 8).

PHSEG2
[in] PHSEG2 value as defined in PIC18CXX8 data sheet (must be between 1 through 8).

PROPSEG
[in] PROPSEG value as defined in PIC18CXX8 data sheet (must be between 1 through 8).

config
[in] Specifies an enumerated value of the type CAN_CONFIG_FLAGS. This parameter can be any combination (AND’d together) of the following values:

<table>
<thead>
<tr>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN_CONFIG_DEFAULT</td>
<td>Specifies default flags</td>
</tr>
<tr>
<td>CAN_CONFIG_PHSEG2_PRG_ON</td>
<td>Specifies to use supplied PHSEG2 value</td>
</tr>
<tr>
<td>CAN_CONFIG_PHSEG2_PRG_OFF</td>
<td>Specifies to use maximum of PHSEG1 or Information Processing Time (IPT), whichever is greater</td>
</tr>
<tr>
<td>CAN_CONFIG_LINE_FILTER_ON</td>
<td>Specifies to use CAN bus line filter for wake-up</td>
</tr>
<tr>
<td>CAN_CONFIG_LINE_FILTER_OFF</td>
<td>Specifies to not use CAN bus line filter for wake-up</td>
</tr>
<tr>
<td>CAN_CONFIG_SAMPLE_ONCE</td>
<td>Specifies to sample bus once at the sample point</td>
</tr>
<tr>
<td>CAN_CONFIG_SAMPLE_THRICE</td>
<td>Specifies to sample bus three times prior to the sample point</td>
</tr>
<tr>
<td>CAN_CONFIG_ALL_MSG</td>
<td>Specifies to accept all messages including invalid ones</td>
</tr>
<tr>
<td>CAN_CONFIG_VALID_XTD_MSG</td>
<td>Specifies to accept only valid Extended Identifier messages</td>
</tr>
<tr>
<td>CAN_CONFIG_VALID_STD_MSG</td>
<td>Specifies to accept only valid Standard Identifier messages</td>
</tr>
<tr>
<td>CAN_CONFIG_ALL_VALID_MSG</td>
<td>Specifies to accept all valid messages</td>
</tr>
<tr>
<td>CAN_CONFIG_DBL_BUFFER_ON</td>
<td>Specifies to hardware double buffer Receive Buffer 1</td>
</tr>
<tr>
<td>CAN_CONFIG_DBL_BUFFER_OFF</td>
<td>Specifies to not hardware double buffer Receive Buffer 1</td>
</tr>
</tbody>
</table>

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 the application requires message filter operation, it must perform initialization in discrete steps as shown in Example 1.

EXAMPLE 1: INITIALIZE CAN MODULE

// Initialize CAN module with no message filtering
CANInitialize(SJW, BRP, PHSEG1, PHSEG2, PROPSEG, config)

// Set CAN module into configuration mode
CANSetOperationMode(CAN_OP_MODE_CONFIG);

// Set Buffer 1 Mask value
CANSetMask(CAN_MASK_B1, MaskForBuffer1);

// Set Buffer 2 Mask value
CANSetMask(CAN_MASK_B2, MaskForBuffer2);

// Set Buffer 1 Filter values
CANSetFilter(CAN_FILTER_B1_F1, Filter1ForBuffer1, Buffer1MessageType);
CANSetFilter(CAN_FILTER_B1_F2, Filter2ForBuffer1, Buffer1MessageType);
CANSetFilter(CAN_FILTER_B2_F1, Filter1ForBuffer2, Buffer2MessageType);
CANSetFilter(CAN_FILTER_B2_F2, Filter2ForBuffer2, Buffer2MessageType);
CANSetFilter(CAN_FILTER_B2_F3, Filter3ForBuffer2, Buffer2MessageType);
CANSetFilter(CAN_FILTER_B2_F4, Filter4ForBuffer2, Buffer2MessageType);

// Set CAN module into Normal mode
CANSetOperationMode(CAN_OP_MODE_NORMAL);

EXAMPLE 2: USAGE OF CANInitialize

// Initialize at 125kbps at 20 MHz, all valid Extended messages
CANInitialize(1, 5, 7, 6, 2, CAN_CONFIG_VALID_XTD_MSG);
CANSetOperationMode
This function changes the PIC18 CAN module operation mode.

Syntax
void CANSetOperationMode(enum CAN_OP_MODE mode);

Parameters
mode
[in] Specifies an enumerated value of the type CAN_OP_MODE. The only permitted values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN_OP_MODE_NORMAL</td>
<td>Specifies Normal mode of operation</td>
</tr>
<tr>
<td>CAN_OP_MODE_SLEEP</td>
<td>Specifies SLEEP mode of operation</td>
</tr>
<tr>
<td>CAN_OP_MODE_LOOP</td>
<td>Specifies Loopback mode of operation</td>
</tr>
<tr>
<td>CAN_OP_MODE_LISTEN</td>
<td>Specifies Listen Only mode of operation</td>
</tr>
<tr>
<td>CAN_OP_MODE_CONFIG</td>
<td>Specifies Configuration mode of operation</td>
</tr>
</tbody>
</table>

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.

EXAMPLE 3: USAGE OF CANSetOperationMode

CANSetOperationMode(CAN_OP_MODE_CONFIG);
// Module IS in CAN_OP_MODE_CONFIG mode.
**CANSetOperationModeNoWait**

This function changes the PIC18C CAN module operation mode.

**Syntax**

```c
void CANSetOperationModeNoWait(enum CAN_OP_MODE mode);
```

**Parameters**

`mode`

[in] Specifies an enumerated value of the type CAN_OP_MODE. The only permitted values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN_OP_MODE_NORMAL</td>
<td>Specifies Normal mode of operation</td>
</tr>
<tr>
<td>CAN_OP_MODE_SLEEP</td>
<td>Specifies SLEEP mode of operation</td>
</tr>
<tr>
<td>CAN_OP_MODE_LOOP</td>
<td>Specifies Loopback mode of operation</td>
</tr>
<tr>
<td>CAN_OP_MODE_LISTEN</td>
<td>Specifies Listen Only mode of operation</td>
</tr>
<tr>
<td>CAN_OP_MODE_CONFIG</td>
<td>Specifies Configuration mode of operation</td>
</tr>
</tbody>
</table>

**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 given mode of operation and immediately returns the control. Caller must ensure desired mode of operation is set before performing any mode specific operation. If a blocking call is required, see the `CANSetOperationMode` function.

**EXAMPLE 4: USAGE OF CANSetOperationModeNoWait**

```c
CANSetOperationModeNoWait(CAN_OP_MODE_CONFIG);

while(CANGetOperationMode() != CAN_OP_MODE_CONFIG) {
    // Do something while module switches mode
}
```
**CANSetBaudRate**

This function programs the PIC18C CAN module for given bit rate values.

**Syntax**

```c
void CANSetBaudRate(BYTE SJW,
                     BYTE BRP,
                     BYTE PHSEG1,
                     BYTE PHSEG2,
                     BYTE PROPSEG,
                     enum CAN_CONFIG_FLAGS config);
```

**Parameters**

- **SJW**
  
  [in] SJW value as defined in PIC18CXX8 data sheet (must be between 1 through 4).

- **BRP**
  
  [in] BRP value as defined in PIC18CXX8 data sheet (must be between 1 through 64).

- **PHSEG1**
  
  [in] PHSEG1 value as defined in PIC18CXX8 data sheet (must be between 1 through 8).

- **PHSEG2**
  
  [in] PHSEG2 value as defined in PIC18CXX8 data sheet (must be between 1 through 8).

- **PROPSEG**
  
  [in] PROPSEG value as defined in PIC18CXX8 data sheet (must be between 1 through 8).

- **config**
  
  [in] Specifies an enumerated value of the type CAN_CONFIG_FLAGS. This parameter can be any combination (AND'd together) of the following values:

<table>
<thead>
<tr>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN_CONFIG_DEFAULT</td>
<td>Specifies default flags</td>
</tr>
<tr>
<td>CAN_CONFIG_PHSEG2_PRG_ON</td>
<td>Specifies to use supplied PHSEG2 value</td>
</tr>
<tr>
<td>CAN_CONFIG_PHSEG2_PRG_OFF</td>
<td>Specifies to use maximum of PHSEG1 or Information Processing Time (IPT), whichever is greater</td>
</tr>
<tr>
<td>CAN_CONFIG_LINE_FILTER_ON</td>
<td>Specifies to use CAN bus line filter for wake-up</td>
</tr>
<tr>
<td>CAN_CONFIG_LINE_FILTER_OFF</td>
<td>Specifies to not use CAN bus line filter for wake-up</td>
</tr>
<tr>
<td>CAN_CONFIG_SAMPLE_ONCE</td>
<td>Specifies to sample bus once at the sample point</td>
</tr>
<tr>
<td>CAN_CONFIG_SAMPLE_THRICE</td>
<td>Specifies to sample bus three times prior to the sample point</td>
</tr>
</tbody>
</table>

**Return Values**

None.

**Pre-condition**

PIC18C CAN module must be in the Configuration mode or else given values will be ignored.

**Side Effects**

None.

**Remarks**

None.
EXAMPLE 5: USAGE OF CANSetBaudRate

CANSetOperationMode(CAN_OP_MODE_CONFIG);

// Set 125kbps 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);
CANSetMask
This function sets the PIC18C CAN module mask values for a given receive buffer.

Syntax

```
void CANSetMask( enum CAN_MASK code,
                unsigned long Value,
                enum CAN_CONFIG Type);
```

Parameters

code
[in] Specifies an enumerated value of the type CAN_MASK. The only permitted values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN_MASK_B1</td>
<td>Specifies Receive Buffer 1 mask value</td>
</tr>
<tr>
<td>CAN_MASK_B2</td>
<td>Specifies Receive Buffer 2 mask value</td>
</tr>
</tbody>
</table>

Value
[in] 32-bit mask value, which may correspond to 11-bit Standard Identifier or 29-bit Extended Identifier with binary zero padded on left.

Type
[in] Specifies an enumerated value of the type CAN_CONFIG. The only permitted values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN_CONFIG_STD_MSG</td>
<td>Specifies Standard Identifier message</td>
</tr>
<tr>
<td>CAN_CONFIG_XTD_MSG</td>
<td>Specifies Extended Identifier message</td>
</tr>
</tbody>
</table>

Return Values

None.

Pre-condition

PIC18C CAN module must be in the Configuration mode or else given values will be ignored.

Side Effects

None.

Remarks

None.

EXAMPLE 6: USAGE OF CANSetMask

```
CANSetMask(CAN_MASK_B1, 0x00000001, CAN_STD_MSG);
CANSetMask(CAN_MASK_B2, 0x00008001, CAN_XTD_MSG);
```
CANSetFilter
This function sets the PIC18C CAN module filter values for a given receive buffer.

Syntax

```c
void CANSetFilter(enum CAN_FILTER code,
    unsigned long Value,
    enum CAN_CONFIG type);
```

Parameters

**code**

[in] Specifies an enumerated value of the type CAN_FILTER. The only permitted values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN_FILTER_B1_F1</td>
<td>Specifies Receive Buffer 1, Filter 1 value</td>
</tr>
<tr>
<td>CAN_FILTER_B1_F2</td>
<td>Specifies Receive Buffer 1, Filter 2 value</td>
</tr>
<tr>
<td>CAN_FILTER_B2_F1</td>
<td>Specifies Receive Buffer 2, Filter 1 value</td>
</tr>
<tr>
<td>CAN_FILTER_B2_F2</td>
<td>Specifies Receive Buffer 2, Filter 2 value</td>
</tr>
<tr>
<td>CAN_FILTER_B2_F3</td>
<td>Specifies Receive Buffer 2, Filter 3 value</td>
</tr>
<tr>
<td>CAN_FILTER_B2_F4</td>
<td>Specifies Receive Buffer 2, Filter 4 value</td>
</tr>
</tbody>
</table>

**Value**

[in] 32-bit filter value which may correspond to 11-bit Standard Identifier or 29-bit Extended Identifier with binary zero padded on the left.

**Type**

[in] Specifies an enumerated value of the type CAN_CONFIG. The only permitted values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN_CONFIG_STD_MSG</td>
<td>Specifies Standard Identifier message</td>
</tr>
<tr>
<td>CAN_CONFIG_XTD_MSG</td>
<td>Specifies Extended Identifier message</td>
</tr>
</tbody>
</table>

Return Values

None.

Pre-condition

PIC18C CAN module must be in the Configuration mode, or else given values will be ignored.

Side Effects

None.

Remarks

None.

**EXAMPLE 7: USAGE OF CANSetFilter**

```c
CANSetFilter(CAN_FILTER_B1_F1, 0x0000, CAN_STD_MSG);
CANSetFilter(CAN_FILTER_B1_F2, 0x0001, CAN_STD_MSG);
CANSetFilter(CAN_FILTER_B2_F1, 0x8000, CAN_XTD_MSG);
CANSetFilter(CAN_FILTER_B2_F2, 0x8001, CAN_XTD_MSG);
CANSetFilter(CAN_FILTER_B2_F3, 0x8002, CAN_XTD_MSG);
CANSetFilter(CAN_FILTER_B2_F4, 0x8003, CAN_XTD_MSG);
```
MODULE OPERATION FUNCTIONS:

CANSendMessage

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

Syntax

```c
void CANSendMessage(unsigned long id,
                      BYTE *Data,
                      BYTE DataLen
                      enum CAN_TX_MSG_FLAGS MsgFlags);
```

Parameters

id

[in] 32-bit Identifier value, which may correspond to 11-bit Standard Identifier or 29-bit Extended Identifier with binary zero padded on the left. The exact number of bits to use depends on the MsgFlags parameter.

Data

[in] Pointer to zero or more of data bytes to send.

DataLen

[in] Number of bytes to send.

MsgFlags

[in] Specifies an enumerated value of the type CAN_TX_MSG_FLAGS. This represents the logical AND of a Priority value, an Identifier value, and a Message value (Priority AND Identifier AND Message). The possible values of all variables are listed in the tables below:

<table>
<thead>
<tr>
<th>Priority Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN_TX_PRIORITY_0</td>
<td>Specifies Transmit Priority 0</td>
</tr>
<tr>
<td>CAN_TX_PRIORITY_1</td>
<td>Specifies Transmit Priority 1</td>
</tr>
<tr>
<td>CAN_TX_PRIORITY_2</td>
<td>Specifies Transmit Priority 2</td>
</tr>
<tr>
<td>CAN_TX_PRIORITY_3</td>
<td>Specifies Transmit Priority 3</td>
</tr>
</tbody>
</table>

Note: See the PIC18CXX8 data sheet for further details on transmit priority.

<table>
<thead>
<tr>
<th>Identifier Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN_TX_STD_FRAME</td>
<td>Specifies Standard Identifier message</td>
</tr>
<tr>
<td>CAN_TX_XTD_FRAME</td>
<td>Specifies Extended Identifier message</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Message Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN_TX_NO_RTR_FRAME</td>
<td>Specifies Regular message - not RTR</td>
</tr>
<tr>
<td>CAN_TX_RTR_FRAME</td>
<td>Specifies RTR message</td>
</tr>
</tbody>
</table>

Return Values

TRUE: If the given message was successfully placed in one of the empty transmit buffers.
FALSE: If all transmit buffers were full.

Pre-condition

None.

Side Effects

None.

Remarks

None.
EXAMPLE 8: USAGE OF CANSendMessage

BYTE MessageData[1]; // One byte to send
...
if ( CANIsTxReady() )
{
    MessageData[0] = 0x01;
    CANSendMessage ( 0x02,
        MessageData,  
        1,
        CAN_TX_PRIORITY_0 &
        CAN_TX_STD_FRAME &
        CAN_TX_NO_RTR_FRAME);
}
...

CANReceiveMessage

This function copies the new available message to one of the full receive buffers.

Syntax

```c
void CANReceiveMessage( unsigned long * id,
                        BYTE * Data,
                        BYTE * DataLen
                        enum CAN_RX_MSG_FLAGS * MsgFlags );
```

Parameters

id  
[out] 32-bit Identifier value, which may correspond to 11-bit Standard Identifier or 29-bit Extended Identifier with binary zero padded on the left. The exact number of bits to use depends on the MsgFlags parameter.

Data  
[out] Pointer to zero or more data bytes received.

DataLen  
[out] Pointer to buffer to hold number of bytes received.

MsgFlags  
[out] Specifies an enumerated value of the type CAN_RX_FILTER. This received value represents the logical AND of a Buffer value and a Condition value (Buffer AND Condition). The possible values for all variables are listed in the tables below:

<table>
<thead>
<tr>
<th>Buffer Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN_RX_FILTER_1</td>
<td>Specifies Receive Buffer Filter 1 caused this message to be accepted</td>
</tr>
<tr>
<td>CAN_RX_FILTER_2</td>
<td>Specifies Receive Buffer Filter 2 caused this message to be accepted</td>
</tr>
<tr>
<td>CAN_RX_FILTER_3</td>
<td>Specifies Receive Buffer Filter 3 caused this message to be accepted</td>
</tr>
<tr>
<td>CAN_RX_FILTER_4</td>
<td>Specifies Receive Buffer Filter 4 caused this message to be accepted</td>
</tr>
<tr>
<td>CAN_RX_FILTER_5</td>
<td>Specifies Receive Buffer Filter 5 caused this message to be accepted</td>
</tr>
<tr>
<td>CAN_RX_FILTER_6</td>
<td>Specifies Receive Buffer Filter 6 caused this message to be accepted</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Condition Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN_RX_OVERFLOW</td>
<td>Specifies Receive Buffer overflow condition</td>
</tr>
<tr>
<td>CAN_RX_INVALID_MSG</td>
<td>Specifies invalid message</td>
</tr>
<tr>
<td>CAN_RX_XTD_FRAME</td>
<td>Specifies Extended Identifier message</td>
</tr>
<tr>
<td>CAN_RX_RTR_FRAME</td>
<td>Specifies RTR message</td>
</tr>
<tr>
<td>CAN_RX_DBL_BUFFERED</td>
<td>Specifies that this message was double buffered</td>
</tr>
</tbody>
</table>

If a flag bit is set, the corresponding meaning is TRUE; if cleared, the corresponding meaning is FALSE.

Note: Use CAN_RX_FILTER_BITS to access CAN_RX_FILTER_n bits.

Return Values

TRUE: If new message was copied to given buffer.
FALSE: If no new message was found.

Upon receiving the new message, buffers pointed to by id, Data, DataLen and MsgFlags are populated.

Pre-condition

The id, Data, DataLen and MsgFlags pointers must point to the desired and valid memory locations.

Side Effects

None.
Remarks
This function will fail if there are no new messages to read. Caller may check the return value to determine new message availability or may call CANIsRxReady function.

EXAMPLE 9: USAGE OF CANReceiveMessage

```c
unsigned long NewMessage;
BYTE NewMessageData[8];
BYTE NewMessageLen;
CAN_RX_MSG_FLAGS NewMessageFlags;
BYTE RxFilterMatch;
...
if ( CANIsRxReady() )
{
    CANReceiveMessage(&NewMessage,
            NewMessageData,
            &NewMessageLen,
            &NewMessageFlags);
    if ( NewMessageFlags & CAN_RX_OVERFLOW )
    {
        // Rx overflow occurred
    }
    if ( NewMessageFlags & CAN_RX_INVALID_MSG )
    {
        // Invalid message received
    }
    if ( NewMessageFlags & CAN_RX_XTD_FRAME )
    {
        // Extended Identifier received
    }
    else
    {
        // Standard Identifier received.
    }
    if ( NewMessageFlags & CAN_RX_RTR_FRAME )
    {
        // RTR frame received
    }
    else
    {
        // Regular frame received.
    }
    RxFilterMatch = NewMessageFlags & CAN_RX_FILTER_BITS;
}
...
CANAbortAll
This function aborts all pending messages from the PIC18C CAN module. See the PIC18CXX8 data sheet for rules regarding message abortion.

Syntax
void CANAbortAll();

Parameters
None.

Return Values
None.

Pre-condition
None.

Side Effects
None.

Remarks
None.

EXAMPLE 10: USAGE OF CANAbortAll

...  
CANAbortAll();  
...

STATUS CHECK FUNCTIONS:

CANGetTxErrorCount
This function returns the PIC18C CAN transmit error count as defined by BOSCH CAN Specifications. See the PIC18CXX8 data sheet for more information.

Syntax

```c
BYTE CANGetTxErrorCount();
```

Parameters
None.

Return Values
Current value of transmit error count.

Pre-condition
None.

Side Effects
None.

Remarks
None.

EXAMPLE 11: USAGE OF CANGetTxErrorCount

```c
BYTE TxErrorCount;
...
TxErrorCount = CANGetTxErrorCount();
...
```
CANGetRxErrorCount
This function returns the PIC18C CAN receive error count as defined by BOSCH CAN Specifications. See the PIC18CXX8 data sheet for more information.

Syntax
BYTE CANGetRxErrorCount();

Parameters
None.

Return Values
Current value of receive error count.

Pre-condition
None.

Side Effects
None.

Remarks
None.

EXAMPLE 12: USAGE OF CANGetRxErrorCount

BYTE RxErrorCount;
...
RxErrorCount = CANGetRxErrorCount();
...
CANIsBusOff
This function returns the PIC18C CAN bus On/Off state.

Syntax
BOOL CANIsBusOff()

Parameters
None.

Return Values
TRUE: If the PIC18C CAN module is in the Bus Off state.
FALSE: If the PIC18C CAN module is in the Bus On state.

Pre-condition
None.

Side Effects
None.

Remarks
None.

EXAMPLE 13: USAGE OF CANIsBusOff

...  
if ( CANIsBusOff() )
  // CAN Module is off
...

CANIsTxPassive
This function returns the PIC18C CAN transmit error status as defined by BOSCH CAN Specifications. See the PIC18CXX8 data sheet for more information.

Syntax
BOOL CANIsTxPassive()

Parameters
None.

Return Values
TRUE: If the PIC18C CAN module is in transmit error passive state.
FALSE: If the PIC18C CAN module is not in transmit error passive state.

Pre-condition
None.

Side Effects
None.

Remarks
None.

EXAMPLE 14: USAGE OF CANIsTxPassive

... if ( CANIsTxPassive() ) // Transmit module is in passive state. ...
...
CANIsRxPassive
This function returns the PIC18C CAN receive error status as defined by BOSCH CAN Specifications. See the PIC18CXX8 data sheet for more information.

Syntax

```
BOOL CANIsRxPassive()
```

**Parameters**
None.

**Return Values**
TRUE: If the PIC18C CAN module is in receive error passive state.
FALSE: If the PIC18C CAN module is not in receive error passive state.

**Pre-condition**
None.

**Side Effects**
None.

**Remarks**
None.

**EXAMPLE 15: USAGE OF CANIsRxPassive**

```c
... 
if ( CANIsRxPassive() )
  // Rx is error passive, do something
...
```
CANIsRxReady
This function returns the PIC18C CAN receive buffer(s) readiness status.

Syntax
BOOL CANIsRxReady()

Parameters
None.

Return Values
TRUE: If at least one of the PIC18C CAN receive buffers is full.
FALSE: If none of the PIC18C CAN receive buffers are full.

Pre-condition
None.

Side Effects
None.

Remarks
None.

EXAMPLE 16: USAGE OF CANIsRxReady

unsigned long NewMessage;
BYTE NewMessageData[8];
BYTE NewMessageLen;
enum CAN_RX_MSG_FLAGS NewMessageFlags;

...

if ( CANIsRxReady() )
    CANReceiveMessage(&NewMessage,
        NewMessageData,
        &NewMessageLen,
        &NewMessageFlags);

...

CANIsTxReady
This function returns the PIC18C CAN transmit buffer(s) readiness status.

Syntax

BOOL CANIsTxReady()

Parameters
None.

Return Values

TRUE: If at least one of the PIC18C CAN transmit buffers is empty.
FALSE: If none of the PIC18C CAN transmit buffers are empty.

Pre-condition
None.

Side Effects
None.

Remarks
None.

EXAMPLE 17: USAGE OF CANIsTxReady

BYTE MessageData[8];
BYTE MessageLen;
CAN_TX_MSG_FLAGS MessageFlags;
...
// Check to see if transmit buffer is ready
if ( CANIsTxReady() )
{
    CANSendMessage(0x02,
                   MessageData,
                   MessageLen,
                   MessageFlags);
}
...


PIC18C CAN FUNCTIONS
ORGANIZATION AND USAGE

These functions are developed for the Microchip MPLAB® C18 and HI-TECH PICC™ 18 C compilers. Source file automatically detects compiler in use and redefines corresponding symbols. If required, one can easily port this file to any C compiler for PIC18C devices.

Source code for the PIC18C CAN module is divided into the following two files:

• can18xx8.c
• can18xx8.h

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

1. Copy the can18xx8.c and can18xx8.h files to your project source directory.
2. Include the can18xx8.c file in your project as a C18 ‘C’ source file.
3. Add the #include can18xx8.h line in each source file that will be calling CAN routines.

You may also create an object or library file for can18xx8.c and use the output file in your project, rather than using the actual source code file.
SAMPLE APPLICATION PROGRAM USING THE PIC18C CAN LIBRARY

An application program that uses the PIC18C CAN functions must follow certain initialization steps, as shown in Figure 2 (see previous page).

EXAMPLE 18: SAMPLE APPLICATION PROGRAM 1

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

```c
// Application specific variable declarations
...

// CAN module related variables
unsigned long NewMessage;
BYTE NewMessageData[8];
Byte MessageData[8];
BYTE NewMessageLen;
CAN_RX_MSG_FLAGS NewMessageFlags;
BYTE RxFilterMatch;

// Application specific initialization code follows
...

// Initialize CAN module with no message filtering
CANInitialize(SJW, BRP, PHSEG1, PHSEG2, PROPSEG, config);

// Main application loop
while(1)
{
    // Application specific logic here

    // Check for CAN message
    if ( CANIsRxReady() )
    {
        CANReceiveMessage(&NewMessage,
                           NewMessageData,
                           &NewMessageLen,
                           &NewMessageFlags);
        if ( NewMessageFlags & CAN_RX_OVERFLOW )
        {
            // Rx overflow occurred; handle it
        }
        if ( NewMessageFlags & CAN_RX_INVALID_MSG )
        {
            // Invalid message received; handle it
        }
        if ( NewMessageFlags & CAN_RX_XTD_FRAME )
        {
            // Extended Identifier received; handle it
        }
        else
        {
            // Standard Identifier received.
        }
        if ( NewMessageFlags & CAN_RX_RTR_FRAME )
        {
            // RTR frame received
        }
    }
}
```
} else
{
    // Regular frame received.
}

// Extract receiver filter match, if it is to be used
RxFilterMatch = NewMessageFlags & CAN_RX_FILTER_BITS;

// Process received message
...

// Transmit a message due to previously received message or
// due to application logic itself.
if ( CANIsTxReady() )
{
    // Other application specific logic
    ...
} // Do this forever

// End of program

EXAMPLE 19: SAMPLE APPLICATION PROGRAM 2

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

// Application specific variable declarations
...

// CAN module related variables
unsigned long NewMessage;
BYTE NewMessageData[8];
Byte MessageData[8];
BYTE NewMessageLen;
CAN_RX_MSG_FLAGS NewMessageFlags;
BYTE RxFilterMatch;

// Application specific initialization code follows
...

// Initialize CAN module with no message filtering
CANInitialize(SJW, BRP, PHSEG1, PHSEG2, PROPSEG, config);

// Set CAN module into configuration mode
CANSetOperationMode(CAN_OP_MODE_CONFIG);

// Set Buffer 1 Mask value
CANSetMask(CAN_MASK_B1, 0x000000F, CAN_STD_MSG);

// Set Buffer 2 Mask value
CANSetMask(CAN_MASK_B2, 0x000000F0, CAN_STD_MSG);

// Set Buffer 1 Filter values
CANSetFilter(CAN_FILTER_B1_F1, 0x00000001, CAN_CONFIG_STD_MSG);
CANSetFilter(CAN_FILTER_B1_F2, 0x00000002, CAN_CONFIG_STD_MSG);
CANSetFilter(CAN_FILTER_B2_F1, 0x00000010, CAN_CONFIG_STD_MSG);
CANSetFilter(CAN_FILTER_B2_F2, 0x00000020, CAN_CONFIG_STD_MSG);
CANSetFilter(CAN_FILTER_B2_F3, 0x00000030, CAN_CONFIG_STD_MSG);

// Main application loop
while(1)
{
    // Application specific logic here

    // Check for CAN message
    if ( CANIsRxReady() )
    {
        CANReceiveMessage( &NewMessage,
                            NewMessageData,
                            &NewMessageLen,
                            &NewMessageFlags );

        if ( NewMessageFlags & CAN_RX_OVERFLOW )
        {
            // Rx overflow occurred; handle it
        }

        if ( NewMessageFlags & CAN_RX_INVALID_MSG )
        {
            // Invalid message received; handle it
        }

        if ( NewMessageFlags & CAN_RX_XTD_FRAME )
        {
            // Extended Identifier received; handle it
        }
        else
        {
            // Standard Identifier received.
        }

        if ( NewMessageFlags & CAN_RX_RTR_FRAME )
        {
            // RTR frame received
        }
        else
        {
            // Regular frame received.
        }

        // Extract receiver filter match, if it is to be used
        RxFilterMatch = NewMessageFlags & CAN_RX_FILTER_BITS;
    }

    // Process received message
    ...
}
// Transmit a message due to previously received message or
// due to application logic itself.
if ( CANIsTxReady() )
{
    MessageData[0] = 0x01;
    CANSendMessage( 0x02,
                    MessageData,
                    1,
                    CAN_TX_PRIORITY_0 &
                    CAN_TX_STD_FRAME &
                    CAN_TX_NO_RTR_FRAME);
}

// Other application specific logic
...
} // Do this forever

// End of program
CONCLUSION
The CAN library provided in this application note may be used in any application program that needs a simple polling mechanism to implement CAN communication. One can use this library as a reference to create a true interrupt-driven CAN communication driver.

APPENDIX A: SOURCE CODE
Because of its size, the complete source code for this application note is not included in the text. You may download the source code from the Microchip Web site, at the Internet address 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.
- Microchip believes that its family of PICmicro microcontrollers is one of the most secure products of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the PICmicro microcontroller in a manner outside the operating specifications contained in the data sheet. The person doing so may be engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable".
- Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our product.

If you have any further questions about this matter, please contact the local sales office nearest to you.

Information contained in this publication regarding device applications and the like is intended through suggestion only and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. No representation or warranty is given and no liability is assumed by Microchip Technology Incorporated with respect to the accuracy or use of such information, or infringement of patents or other intellectual property rights arising from such use or otherwise. Use of Microchip’s products as critical components in life support systems is not authorized except with express written approval by Microchip. No licenses are conveyed, implicitly or otherwise, under any intellectual property rights.

Trademarks

The Microchip name and logo, the Microchip logo, FilterLab, KEELoo, MPLAB, PIC, PICmicro, PICMASTER, PICSTART, PRO MATE, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

dsPIC, ECONOMONITOR, FanSense, FlexROM, fuzzyLAB, In-Circuit Serial Programming, ICSP, ICEPIC, microID, microPort, Migratable Memory, MPASM, MPLIB, MPLINK, MPSIM, MXDEV, PICC, PICDEM, PICDEM.net, rPIC, Select Mode and Total Endurance are trademarks of Microchip Technology Incorporated in the U.S.A.

Serialized Quick Term Programming (SQTP) is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

© 2001, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

Printed on recycled paper.
AMERICAS
Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200 Fax: 480-792-7277
Technical Support: 480-792-7627
Web Address: http://www.microchip.com

Rocky Mountain
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7966 Fax: 480-792-7456

Atlanta
500 Sugar Mill Road, Suite 200B
Atlanta, GA 30350
Tel: 770-640-0034 Fax: 770-640-0307

Boston
2 Lan Drive, Suite 120
Westford, MA 01886
Tel: 978-692-3848 Fax: 978-692-3821

Chicago
333 Pierce Road, Suite 180
Itasca, IL 60143
Tel: 630-285-0071 Fax: 630-285-0075

Dallas
4570 Westgrove Drive, Suite 160
Addison, TX 75001
Tel: 972-818-7423 Fax: 972-818-2924

Dayton
Two Prestige Place, Suite 130
Miamisburg, OH 45342
Tel: 937-291-1654 Fax: 937-291-9175

Detroit
Tri-Atria Office Building
32255 Northwestern Highway, Suite 190
Farmington Hills, MI 48334
Tel: 248-538-2250 Fax: 248-538-2260

Kokomo
2787 S. Albright Road
Kokomo, Indiana 46902
Tel: 765-864-8360 Fax: 765-864-8387

Los Angeles
18201 Von Karman, Suite 1090
Irvine, CA 92612
Tel: 949-263-1388 Fax: 949-263-1338

New York
150 Motor Parkway, Suite 202
Hauppauge, NY 11788
Tel: 631-273-5305 Fax: 631-273-5335

San Jose
Microchip Technology Inc.
2107 North First Street, Suite 590
San Jose, CA 95131
Tel: 408-436-7950 Fax: 408-436-7955

Toronto
6285 Northam Drive, Suite 108
Mississauga, Ontario L4V 1X5, Canada
Tel: 905-673-0699 Fax: 905-673-6509

ASIA/PACIFIC
Australia
Microchip Technology Australia Pty Ltd
Suite 22, 41 Rawson Street
Epping 2121, NSW
Australia
Tel: 61-2-9868-6733 Fax: 61-2-9868-6755

China - Beijing
Microchip Technology Consulting (Shanghai) Co., Ltd., Beijing Liaison Office
Unit 915
Beihai Hotel, No. 6 Chaoyangmen Beidajie
Beijing, 100027, China
Tel: 86-10-85282100 Fax: 86-10-85282104

China - Chengdu
Microchip Technology Consulting (Shanghai) Co., Ltd., Chengdu Liaison Office
Rm. 2401, 24th Floor,
Ming Xing Financial Tower
No. 88 TIDU Street
Chengdu 610016, China
Tel: 86-28-6766200 Fax: 86-28-6766599

China - Fuzhou
Microchip Technology Consulting (Shanghai) Co., Ltd., Fuzhou Liaison Office
Rm. 531, North Building
Fujian Foreign Trade Center Hotel
73 Wusi Road
Fuzhou 350001, China
Tel: 86-591-7557563 Fax: 86-591-7557572

China - Shanghai
Microchip Technology Consulting (Shanghai) Co., Ltd.
Room 701, 1Bldg. B
Far East International Plaza
No. 317 Xian Xia Road
Shanghai, 200051
Tel: 86-21-6275-5700 Fax: 86-21-6275-5660

Hong Kong
Microchip Technology Hong Kong Ltd.
Unit 901-6, Tower 2, Metropolis Plaza
223 Hing Fong Road
Kwai Fong, N.T., Hong Kong
Tel: 852-2401-1200 Fax: 852-2401-3431

India
Microchip Technology India Inc.
Divyasree Chambers
1 Floor, Wing A (A3/A4)
No. 11, O’Shaugnessy Road
Bangalore, 560 025, India
Tel: 91-80-2290061 Fax: 91-80-2290062

Japan
Microchip Technology Japan K.K.
Benex S-1 6F
3-18-20, Shinyokohama
Kohoku-Ku, Yokohama-shi
Kanagawa, 222-0033, Japan
Tel: 81-45-471-6166 Fax: 81-45-471-6122

Korea
Microchip Technology Korea
168-1, Youngbo Bldg. 3 Floor
Samsung-Dong, Kangnam-Ku
Seoul, Korea 135-882
Tel: 82-2-554-7200 Fax: 82-2-558-5934

Singapore
Microchip Technology Singapore Pte Ltd.
200 Middle Road
#07-02 Prime Centre
Singapore, 188980
Tel: 65-334-8870 Fax: 65-334-8850

Taiwan
Microchip Technology Taiwan
11F-3, No. 207
Tung Hua North Road
Taipei, 105, Taiwan
Tel: 886-2-2717-7175 Fax: 886-2-2545-0139

EUROPE

Denmark
Microchip Technology Nordic ApS
Regus Business Centre
Lastrupbro hej 1-3
Ballerup DK-2750 Denmark
Tel: 45 4420 9895 Fax: 45 4420 9910

France
Microchip Technology SARL
Parc d Activite du Moulin de Massy
43 Rue du Saule Trapani
Batiment A - ler Etage
91300 Massy, France
Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79

Germany
Microchip Technology GmbH
Gustav-Heinemann Ring 125
D-81739 Munich, Germany
Tel: 49-89-627-144 0 Fax: 49-89-627-144-44

Italy
Microchip Technology SRL
Centro Direzionale Colleoni
Palazzo Taurus 1 V. Le Colleoni 1
91300 Massy, France
Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79

United Kingdom
Arizona Microchip Technology Ltd.
505 Eskdale Road
Winnersh Triangle
Wokingham
Berkshire, England RG41 5TU
Tel: 44 118 921-5869 Fax: 44-118 921-5307

10/01/01