AN739

An In-depth Look at the MCP2510

Author: Pat Richards
Microchip Technology Inc.

INTRODUCTION

The MCP2510 is a low pincount stand-alone CAN controller which interfaces to a microcontroller via a standard Serial Peripheral Interface (SPI™).

The feature set of the MCP2510 makes it very versatile. It would be impossible to document every way the MCP2510 can be configured and used. Therefore, this application note will provide examples and discussions on some typical configurations.

This application note focuses on “using” the MCP2510 and sections include:

- Minimal configuration necessary to enable the CAN node
- Features and how they may be implemented
- A detailed discussion of many of the registers
- Potential pitfalls during implementation

BASIC CONFIGURATION

While the MCP2510 is a relatively simple device to use, the first time user may benefit from assistance in setting up the device for minimal configuration. With the minimal configuration, designers can rapidly get on the CAN bus and use the minimal configuration as a base for the complete node design. This section will describe a typical minimal configuration (not necessarily in order) using example ‘C’ code to get the MCP2510 on the CAN bus (i.e., transmitting and receiving messages at the correct bit rate). The example does not discuss the Higher Layer Protocol (HLP) in any detail as it is beyond the scope of this document.

The code examples are for training purposes. Therefore, they are not necessarily optimized or fully debugged. For instance, it may be noticed that interrupts are not used and the MCP2510 is polled for received messages. The code would be more optimized if interrupts were used. However, for this application note, the code segments serve their purpose.

A very simple HLP is used in the example and the message format is indicated in Figure 1. The HLP uses standard messages which contain eleven bit identifiers. The upper three bits are ZERO which simplifies the description to eight bits (e.g., ID = b’000 1010 0010’ becomes ID = b’1010 0010’ or A2h).

FIGURE 1: MESSAGE FORMAT

BIT 10 … BIT 0

0	0	0	N	N	N	N	N	0	0	T	T

T T	
0 0	ON BUS MSG
0 1	MOTOR CONTROL
1 0	AMBIENT LIGHT
1 1	MOTOR CURRENT

N = NODE DESCRIPTION
T = MESSAGE TYPE

Resetting the MCP2510

The first thing to do after device power-up is to reset the MCP2510 and then wait the required oscillator startup time (128 osc cycles). This step is good programming practice to ensure that the MCP2510 is in a known state. Reset forces the MCP2510 into the Configuration mode. The MCP2510 must be in Configuration mode to set the bit timing, masks and filters. Example 1 shows sample code for issuing an MCP2510 Reset command via the SPI interface bus.

EXAMPLE 1: RESET FUNCTION

```
void SPI_Reset(){
unsigned char SPIDummy;

    SPI_CS = 0;                                     //Lower chip select
    SSPBUF = SPI_RESET;                             //Send the RESET command
    while (!STAT_BF;)                               // wait for ssp
    SPIDummy = SSPBUF;
    SPI_CS = 1;                                     //Raise chip select

    for(SPIDummy = 0;SPIDummy < 128;SPIDummy ++);   //wait for OST
}
```

SPI™ is a trademark of Motorola Inc.

Set Bit Timing

The bit timing is set via the three CNF registers. The CNF registers can only be modified while in Configuration mode, which is automatically entered on power-up or Reset. Example 2 shows sample code for setting the MCP2510 to 125 kbps using a 16 MHz oscillator and 8 TQ.

EXAMPLE 2: SET BIT TIMING

```
/* Set physical layer configuration
  Fosc          = 16MHz
  BRP           = 7 (divide by 8)
  Sync Seg      = 1TQ
  Prop Seg      = 1TQ
  Phase Seg1    = 3TQ
  Phase Seg2    = 3TQ
  TQ = 2 * (1/Fosc) * (BRP+1)
  Bus speed = 1/(Total # of TQ)*TQ = 125 kb/s
  */
SPI_Write(CNF1,0x07);   //BRP = div by 8
  SPI_Write(CNF2,0x90); //PSeg = 1TQ, PS1 = 3TQ
  SPI_Write(CNF3, 0x02);//PS2 = 3TQ
```

Set Masks and Filters

The masks and filters are used to determine if a message is accepted by the MCP2510, and if so, which receive buffer will contain the message. This is accomplished by applying the masks and filters to the identifier field of the incoming message. Mask and filter configuration plays a key role in implementing the Higher Layer Protocol (HLP) that every CAN system must have.

Some things that should be considered when configuring the masks and filters for the HLP are:

1. Determine which message(s) will be received for both standard and extended message types.
2. Determine which buffer each of the messages will be loaded into.
3. Determine which filter will match each message. This is particularly important if the message type is determined by the filter that is matched. Filter matching is done so the received message type is known immediately without having to interrogate the ID (which takes time). This is demonstrated in Example 3, which shows filter matching for different message types. Filter 2 receives LED status, filter 3 receives motor speed, filter 4 receives ambient light conditions, and filter 5 receives motor current.

MASKS AND FILTERS EXAMPLE

Example 3 illustrates a minimal mask and filter configuration required to communicate on the CAN bus. Keep in mind that this example represents a very simple HLP. In practice, HLPs can get much more complicated.

EXAMPLE 3: SETTING MASKS AND FILTERS

```
  /* Configure Receive buffer 0 Mask and Filters */
  /* Receive buffer 0 will not be used */
  SPI_Write(RXM0SIDH, 0xFF);  // Set to all ‘1’s so filter must match every bit
  SPI_Write(RXM0SIDL, 0xFF);  // Set to all ‘1’s so filter must match every bit
  SPI_Write(RXF0SIDH, 0xFF);  // Set Filters to all ‘1’s
  SPI_Write(RXF0SIDL, 0xFF);  // The EXIDE bit is also set to filter on extended msgs only
  SPI_Write(RXF1SIDH, 0xFF);
  SPI_Write(RXF1SIDL, 0xFF);  // The EXIDE bit is also set to filter on extended msgs only

  /* Configure Receive Buffer 1 Mask and Filters */
  SPI_Write(RXM1SIDH, 0xFF);  // RXB1 matches all filters for Standard messages
  SPI_Write(RXM1SIDL, 0xE0);  //

  //----------Receives LED message------------------
  SPI_Write(RXF2SIDH, 0xA0);  // Initialize Filter 2 (will receive only b'1010 0000 000' message)
  SPI_Write(RXF2SIDL, 0x00);  // Make sure EXIDE bit (bit 3) is set correctly in filter also

  //----------Receives motor speed message ----------
  SPI_Write(RXF3SIDH, 0xA1);  // Initialize Filter 3 (will receive only b'1010 0001 000' message)
  SPI_Write(RXF3SIDL, 0x00);  // Make sure EXIDE bit (bit 3) is set correctly in filter also

  //----------Receives ambient light message ----------
  SPI_Write(RXF4SIDH, 0xA2);  // Initialize Filter 4 (will receive only b'1010 0010 000' message)
  SPI_Write(RXF4SIDL, 0x00);  // Make sure EXIDE bit (bit 3) is set correctly in filter also

  //----------Receives motor current message ----------
  SPI_Write(RXF5SIDH, 0xA3);  // Initialize Filter 5 (will receive only b'1010 0011 000' message)
  SPI_Write(RXF5SIDL, 0x00);  // Make sure EXIDE bit (bit 3) is set correctly in filter also
```

The HLP requirements for this example:

- Will receive four different standard messages.
- Will use Receive Buffer 1 only (i.e., mask and filters for Buffer 0 are set to reject ALL messages).
- Each filter matches only one message. The message type will be determined by the filter hit bits (FILHIT) instead of reading the identifier.

> **Note:** The mask and filter for Receive Buffer 0 were set to all ‘1’s. This was done to effectively turn off Receive Buffer 0 from receiving any messages, as incoming message identifiers are applied to Receive Buffer 0 mask and filters first, followed by Receive Buffer 1. The only way for a message to be accepted by Receive Buffer 0 would be if it was an **extended** message with all ‘1’s for the identifier. The filters apply to only extended IDs because the extended identifier enable (EXIDE) bit in RXFnSIDL is set to filter on extended messages only and reject standard IDs (see Figure 1).

Set Normal Mode

The MCP2510 can be placed in Normal mode once the proper bit rate is set and the masks and filters are configured. This is accomplished by configuring the REQOP bits in the CANCTRL register to the proper value (REQOP<2:0> = b’000’).

Normal mode is the standard operating mode for communicating on the CAN bus. The MCP2510 then acknowledges messages, applies the masks and filters, generates errors, etc.

> **Note:** The operation mode must be confirmed after requesting a mode. This is accomplished by reading CANSTAT.OPMOD bits.

Set Transmit Buffers

The transmit buffers can be set before or after going to Normal mode and only need to be configured once for the portions of the message that remain constant. For example, the identifier field may remain a constant because it contains the message description, whereas the data field may change due to varying peripherals. Example 5 demonstrates both fixed and variable ID fields.

There are four different messages that need to be sent which requires one transmit buffer to contain two different identifiers. Transmit buffers one and two have fixed identifiers and data length codes (DLCs) and are configured only once outside the transmit loop. Transmit Buffer 0 sends two different messages. Thus, the identifiers are configured inside the transmit loop.

> **Note:** A transmit buffer cannot be modified while a message is either pending transmission or currently transmitting from that buffer. The corresponding TXREQ bit must be clear prior to attempting to write to the transmit buffer. The TXREQ bit is cleared automatically when no messages are pending transmission. Example 5 shows the TXREQ bits for all three buffers being checked [`while(SPI_ReadStatus() & 0x54)`;] prior to entering the transmit load loop.

Transmit Messages

Example 5 demonstrates transmitting both timed messages and event-driven messages.

As shown in Figure 1, there are four message types. Two messages are timed transmissions and two are event-driven:

- On Bus Message ⟶ Timed ⟶ TXB0
- Motor Control ⟶ Event-driven ⟶ TXB1
- Ambient Light ⟶ Event-driven ⟶ TXB2
- Motor Current ⟶ Timed ⟶TXB0

The two event driven messages utilize their own transmit buffer and the identifier is set only once, while the two timed messages share a transmit buffer. Therefore, the identifiers are reconfigured as needed in the transmit loop.

Receive and Process Messages

The application must be set up to check for and process received messages that match the masks and filters. One method is illustrated in Example 5 where a specific message is received into Receive Buffer 1 by matching specific filters. Message reception is checked by performing an SPI “Read Status” command. Since only one message can match one filter, the filter hit bits (FILHIT) can be used to determine the message type. The RXB1SIDL register could just as easily be read (RXB1SIDH will be the same) with the same end result.

Figure 5 contains the function “Check_RX()” which is called in the function “Communicate()”. Again, the reception of messages could utilize interrupts instead of polling.

> **Note:** The SPI “Read Status” command is a quick two byte command that is very useful for checking for received messages. As shown in Figure 5, a Read Status command: [`if(SPI_ReadStatus() & 0x02)`] is used to poll for a received message and exits the function if the receive flag is clear.

EXAMPLE 4: TRANSMIT BUFFERS AND THE TRANSMIT LOOP

```
void Communicate(void)
{
    unsigned char POTold, POTnew, CDSold, CDSnew, count, x;

/*********************************************************************
*   Set up the identifiers for TX buffers 1 and 2 outside the       *
*   while() loop because they will never change. TX buffer 0        *
*   will change and so will need to be set up inside the loop.      *
*********************************************************************/


//---------Set up 'B1' identifiers (TXB1) (ID remains constant)------------
    SPI_Write(TXB1SIDH, 0xB1);              //Send 'B1' type message
    SPI_Write(TXB1SIDL, 0x00);              //Send 'B1' type message
    SPI_Write(TXB1DLC,  0x01);              //ONE data byte

//---------Set up 'B2' identifiers (TXB2) (ID remains constant)-----------
    SPI_Write(TXB2SIDH, 0xB2);              //Send 'B2' type message
    SPI_Write(TXB2SIDL, 0x00);              //Send 'B2' type message
    SPI_Write(TXB2DLC,  0x01);              //ONE data byte

//--------Note:  TXB0 identifiers will change and so must be set in the loop below---

    while(1)                                // Main control loop goes here
    {
            /************************************
            *      Transmit the Messages        *
            *************************************/
        //----Wait for all buffers to complete transmission.  This insures that ALL
        //    buffers get sent each time through the loop.
        while(SPI_ReadStatus() & 0x54);     //Wait for non-pending message (ALL BUFFERS)

        //-Transmit Message 'B0' ID once every 256 times through the loop (On Bus message)-
        if(x == 0)                          //has 'x' overflowed??
        {
            SPI_Write(TXB0SIDH, 0xB0);      //Send 'B0' type message
            SPI_Write(TXB0SIDL, 0x00);      //Send 'B0' type message
            SPI_Write(TXB0DLC,  0x00);      //ZERO data bytes
            SPI_Rts(RTS0);                  //Transmit buffer 0
        }
        x++;

        Check_RX();                         //check for received msg

        //-------Transmit 'B1' type message (motor control)-----------------/
        POTnew = Read_ADC(POT);             //Read POT
        if(POTnew != POTold)                //has POT value changed??
        {
            SPI_Write(TXB1D0, POTnew);      //send motor speed
            SPI_Rts(RTS1);                  //Transmit buffer 1
            POTold = POTnew;
        }

        Check_RX();                         //check for received msg

        //-------Transmit 'B2' type message (lamp control)-----------------/
        CDSnew = Read_ADC(CDS);
        if(CDSnew != CDSold)                //has CDS changed??
        {
            SPI_Write(TXB2D0, CDSnew);      //Read CDS, send light level
            SPI_Rts(RTS2);                  //Transmit buffer 2
            CDSold = CDSnew;                //update CDSold
        }

        Check_RX();                         //check for received msg

        //-------Transmit 'B3' type message (Motor current) (ID changes)----------------/
        while(SPI_ReadStatus() & 0x04);     //Wait for non-pending message (TXB0)
        SPI_Write(TXB0SIDH, 0xB3);          //Send 'B3' type message
        SPI_Write(TXB0SIDL, 0x00);          //Send 'B3' type message
        SPI_Write(TXB0DLC,  0x01);          //ONE data byte
        SPI_Write(TXB0D0, Read_ADC(MCS));   //Read motor curret, send value
        SPI_Rts(RTS0);                      //Transmit buffer 2
        Check_RX();                         //check for received msg
    }; //END while()
}
```

EXAMPLE 5: PROCESSING RECEIVED MESSAGES

```
void Check_RX(void)
{
    unsigned char filter;
    if(SPI_ReadStatus() & 0x02)              //Was a message received into buffer 1??
    {

        filter = SPI_Read(RXB1CTRL) & 0x07;   //Read FILHIT bits

//ID: A0 = >On Bus message
        if(filter == 2)                      //Filter hit 2 ??
           LED1 = !LED1;                     //Toggle LED1

//ID: A1 => Set motor speed
        else if(filter == 3)                 //Filter hit 3 ??
        {
           Update_PWM2(SPI_Read(RXB1D0));    //Set motor speed to contents of data byte 0
        }

//ID: A2 => Set lamp to ambient light
        else if(filter == 4)                 //Filter hit 4 ??
        {
           Update_PWM1(SPI_Read(RXB1D0));    //Set lamp brightness to contents of data byte 0
        }

//ID: A3 => display motor current
        else if(filter == 5)                 //Filter hit 5 ??
        {
           BarGraph_Level(SPI_Read(RXB1D0)); //Show motor current to contents of data byte 0
        }
         SPI_BitMod(CANINTF, RX1IF, 0);      //Clear receive buffer 1 interrupt
    }
}
```

ADDITIONAL MCP2510 DETAILS

The previous section discussed a minimal configuration of the MCP2510 to communicate on the CAN bus. The feature set of the MCP2510 allows the designer to customize the MCP2510 configuration for optimal performance to the application. This section discusses some of the other configurations possible with the MCP2510. The last part of this section discusses the SPI commands. Another section later in this document contains more details on the registers. A designer should be able to use some of these configurations to maximize the performance of the MCP2510.

Resetting the MCP2510

There are two methods to reset the MCP2510:

1. Software SPI Reset command as done in Example 1.
2. Hardware Reset pin.

Both of these Reset methods have identical end results and must wait the 128 Tosc time for the oscillator start-up timer (OST).

Setting Bit Timing

When configuring the bit timing, several things must be considered for the MCP2510 to function properly. This section does not discuss the physical layer considerations, but only the bit timing requirements as needed by the CAN module.

SOME BACKGROUND

Every bit time is made up of four segments:

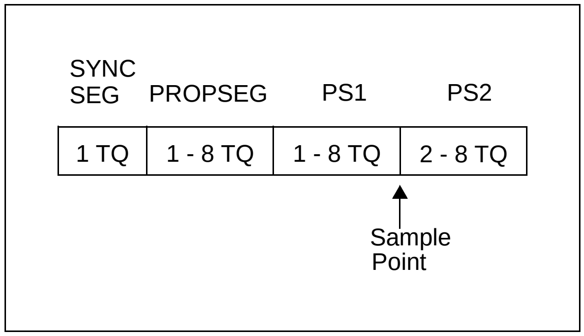
1. Synchronization Segment (SyncSeg).
2. Propagation Segment (PropSeg).
3. Phase Segment 1 (PS1).
4. Phase Segment 2 (PS2).

Each of these segments are made up of integer units called Time Quanta (TQ). The base TQ is defined as 2 Tosc. The TQ time can be modified by changing the "Baud Rate Prescaler".

The sample point occurs between PS1 and PS2 and is the point where the bit level is sampled to determine whether it is dominant or recessive.

By changing the TQ number in the bit segments and/or the baud rate prescaler, it is possible to change the bit length and move the sample point around in the bit. Figure 2 shows the components of a bit.

FIGURE 2: CAN BIT COMPONENT



There are additional definitions that are needed to understand the bit timing settings:

- ***Information Processing Time (IPT)*** - The time it takes to determine the value of the bit. The IPT occurs after the sample point and is fixed at 2 TQ.
- ***Synchronization Jump Width (SJW)*** - Can be programmed from 1 - 4 TQ and is the amount that PS1 can lengthen or PS2 can shorten so the receiving node can maintain synchronization with the transmitter.
- ***Bus Delay Times (T_{DELAY})*** - This delay time is the physical delays as a result of the physical layer (length, material, transceiver characteristics, etc).

RULES FOR SETTING THE BIT TIME

There are four rules that must be adhered to when programming the timing segments:

1. ***PS2 ≥ IPT:*** Phase Segment 2 must be greater than or equal to the Information Processing Time (IPT) so that the bit level can be determined and processed by the CAN module before the beginning of the next bit in the stream. The IPT = 2 TQ so $PS2_{(min)}$ = 2 TQ.
2. ***PropSeg + PS1 ≥ PS2:*** This requirement ensures the sample point is greater than 50% of the bit time.
3. ***PS2 > SJW:*** PS2 must be larger than the SJW to avoid shortening the bit time to before the sample point. For example, if PS2 = 2 and SJW = 3, then a resynchronization to shorten the bit would place the end of the bit time at 1 TQ before the sample point.
4. ***PropSeg + PS1 ≥ T_{DELAY}:*** This requirement ensures there is adequate time before the sample point. In fact, the PropSeg should be set to compensate for physical bus delays.

Setting Masks and Filters

The earlier example demonstrates only one way to lock out a receive buffer by setting the mask and filter bits to all ‘1’s. Two other ways to reject all messages from being received into a specified buffer. Register 1 shows the two other registers that control message filtering/acceptance.

1. Configure RXBnCTRL.RXM bits. Instead of writing all ‘1’s to the mask and filter bits for a specified buffer, as shown in the example code, the RXM bits can be configured to accept or reject message types. For example, the RXM bits for Buffer 0 could be configured to receive only. extended identifiers that match mask and filter criteria (RXM = b’10’). This would effectively lock out message reception for receive Buffer 0 because only standard identifiers are used in the example.
2. Configure the Extended Identifier Enable (EXIDE) bit for each filter that is to reject messages to the opposite identifier type that is on the CAN bus. Each filter is applied to either extended or standard messages and is controlled by the EXIDE bit which is contained in the RXFnSIDL registers. By setting the mask and filter bits in the example, the EXIDE bit is also set which prevents standard messages from being filtered on.

Modes of Operation

The MCP2510 has five modes of operation:

1. **Configuration Mode** - Automatically entered upon power-up or reset. This is the only mode that can write all writable registers. The bit timing registers and the masks and filters can only be modified while the MCP2510 is in Configuration mode.
2. **Normal Mode** - As the name implies, this is the normal mode of operation. The MCP2510 can actively communicate on the bus in this mode.
3. **Sleep Mode** - This mode is used to minimize current consumption. Sleep mode would typically be used during long bus idle times although it could also be used to put the device to sleep during bus activity by disabling the interrupt enable (CANINTE.WAKIE).

> **Note 1:** The CLKOUT pin stops functioning during Sleep mode.
>
> **2:** The SPI interface remains active during Sleep mode.

4. **Listen-only Mode** - This mode allows the MCP2510 to monitor the bus without disturbing it (i.e., it cannot send messages, acknowledges, or error frames on the bus).

   Masks and filters work in this mode as does the ability to accept all messages, including those with errors (RXBnCTRL.RXM<1:0> = b’11’).

   Listen-only mode can be used for auto baud rate detection by empirically changing to different baud rates and listening for an error-free message.
5. **Loopback Mode** - This mode internally disconnects the TXCAN and RXCAN pins and connects them to each other. In this way, CAN traffic can be simulated by sending messages to itself. This mode has few practical uses in customer designed applications.

The Transmit Buffers

As discussed in the previous example, the transmit buffers can be set to a fixed ID or can be changed dynamically, allowing more than one identifier to be used in conjunction with a buffer.

The MCP2510 does not have to be in Configuration mode to modify the buffers. However, the associated transmit request (TXREQ) bit must be cleared before the transmit buffer can be modified. The TXREQ bit is cleared automatically whenever a buffer is not pending/sending a message.

REGISTER 1: CONTROLLING MESSAGE FILTERING

RXB0CTRL	bit 7							bit 0
	---	RXM1	RXM0	---	RXRTR	BUKT	BUKT1	FILHIT0

RXB1CTRL	bit 7							bit 0
	---	RXM1	RXM0	---	RXRTR	FILHIT2	FILHIT1	FILHIT0

RXFnSIDL	bit 7							bit 0
	SID2	SID1	SID0	---	EXIDE	---	EID17	EID16

Transmitting a Message

There are three methods to request transmission of a message (two software and one hardware):

1. Request to Send via SPI RTS command. This is a single byte command used to initiate transmission of one or more buffers simultaneously. In the event multiple buffers are requested at the same time, the buffers will be sent according to the buffer priority (discussed later in more detail).
2. Set a TXREQ bit in a TXBnCTRL register via a SPI Write command or a SPI Bit Modify command. This method is not as efficient as the SPI RTS command as it requires three bytes (SPI Write) or four bytes (Bit Modify) via the SPI. Furthermore, the Bit Modify command should be used if the other writable bits are not to be disturbed.
3. Provide a falling edge on the appropriate $\overline{\text{TXnRTS}}$ pin assuming the pin is configured as an RTS input. This can be used to quickly request a preconfigured buffer to be transmitted.

BUFFER PRIORITY

If more than one buffer is requesting transmission (TXREQ) at the same time, the message with the highest buffer priority gets sent first. The **buffer** priority is not to be confused with the inherent **message** priority contained in the identifier field. Buffer priority is set via TxBnCTRL.TXP. If multiple buffers have the same priority setting, the buffer with the highest buffer number will be sent first.

This buffer prioritization occurs if two or more buffers are requested to transmit, and every time the MCP2510 arbitrates (i.e., if a message loses arbitration and must rearbitrate, the MCP2510 will check for higher priority buffers that became pending).

Receiving and Processing Messages

The message acceptance filters and masks are used to determine if a message in the message assembly buffer (MAB) should be loaded into either receive buffer. Once a valid message has been loaded into the MAB, the identifier fields of the message are compared to the filter values. If a match occurs, the message is moved into the appropriate receive buffer.

> **Note:** The mask and filters for Receive Buffer 0 are compared first. If there is a match, the message is moved into Receive Buffer 0 and Receive Buffer 1 filters are not checked. This implies that the message will be received into a maximum of one buffer only.

There are several methods for processing received messages. This section discusses these methods individually; some of them may be combined as required by the designer.

DETERMINING IF A MESSAGE HAS BEEN RECEIVED

There are two main methods for determining if a message has been received by the MCP2510:

1. Check the receive buffer flags (CANINTF.RXnIF).

The methods to accomplish this are:

a. Performing an SPI “Read Status” command. This method gives the ability to quickly read the two RXnIF bits and is the preferred method.

b. Directly reading the receive flag bits (RXnIF) in the CANINTF register.

> **Note:** The associated enable bit (RXnIE) in the CANINTE register does not need to be set for the flag bits to function. CANINTE is used to enable the $\overline{\text{INT}}$ pin for hardware interrupts.

2. Hardware interrupt using the $\overline{\text{INT}}$ pin.

The MCP2510 has eight sources of interrupts, two of which indicate message reception. For interrupts to be enabled, the two CANINTE.RXnIE bits must be set. The associated flag bit conditions will be reflected in the CANINTF register.

PROCESSING RECEIVED MESSAGES

Once a message has been received, it must be processed to determine which buffer received the message and what the message type is. There are many different combinations that can be used for processing received messages. These descriptions only identify the common methods.

There are numerous ways to determine which buffer contains the message:

- Perform an SPI “Read Status” command. This command provides the status of the two receive flags (among others).
- Directly read CANINTF for RXnIF status.
- Read the ICOD bits in CANSTAT. This method requires the associated enables in CANINTE be set.
- Check the level of the $\overline{\text{RXnBF}}$ pins. This requires the two pins to be configured as buffer interrupts (BFPCTRL register).

After the location of the received message is known, it is necessary to determine the purpose of the message. Assuming that more than one message type will be received into a given buffer, there are a few methods to determine the message type:

- Read the identifier. There are up to four registers that make up the ID field (two for standard messages and four for extended messages). One or all registers may need to be read to determine the message type, depending on how the higher layer protocol was implemented.
- Read the FILHIT bits. The FILHIT bits are contained in RXB0CTRL and RXB1CTRL. The FILHIT bits can be used to quickly determine the message type (providing only one message ID per filter).
- Some systems may be set to receive only one message ID into a given receive buffer. In this case, it is only necessary to determine if the message was received into that buffer and then the message type known.

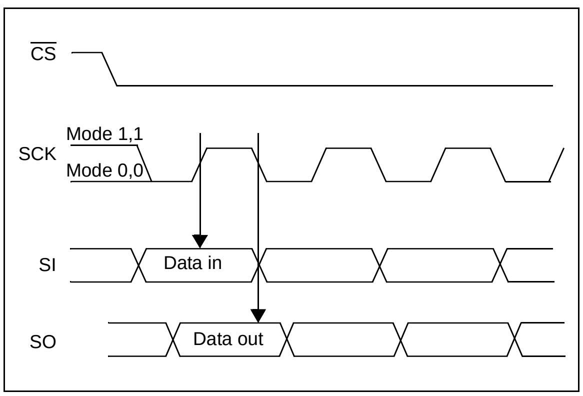
THE SERIAL PERIPHERAL INTERFACE (SPI)

Communications with the MCP2510 is performed via an SPI interface. The MCP2510 supports both modes 0,0 and 1,1. It also contains several commands to efficiently access the MCP2510.

Modes 0,0 and 1,1

The two SPI modes supported by the MCP2510 are almost identical. The only difference is the idle state of the serial clock (SCK). The idle state of SCK for mode 0,0 is LOW and the idle state for mode 1,1 is HIGH. Both modes are the same in that data is latched into the MCP2510 (SI pin) on the rising edge of SCK and clocked out (SO pin) on the falling edge of SCK. Figure 3 illustrates the SPI timing for the two modes of operation.

FIGURE 3: SPI TIMING



Chip Select ($\overline{CS}$)

The $\overline{CS}$ line must be brought high at the end of every command. This allows the next command to be recognized as the 1st byte after the $\overline{CS}$ is asserted. With some commands (e.g. read, write), after the command sequence is completed, the internal address pointer is incremented and the next byte may be read or write.

SPI Reset

The SPI Reset command performs the same function as a hardware reset. Thus, all of the registers will be initialized to their default state and the MCP2510 will be held in reset for 128 oscillator cycles. It is important to wait the 128 oscillator cycles before attempting any more SPI commands.

SPI Read

This command reads one or more registers in the device register map. SPI Reads can be byte or sequential. Sequential reads are performed simply by holding Chip Select ($\overline{CS}$) LOW and continuing to clock SCK. The address pointer will increment after each byte is clocked out.

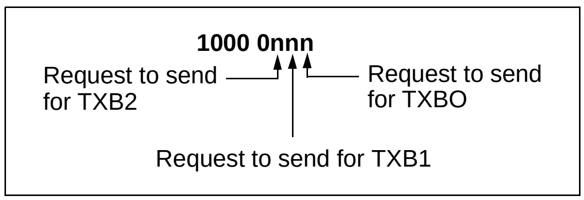
SPI Write

This command writes data to one or more registers in the device register map. SPI Writes can be byte or sequential. Sequential writes are performed simply by holding Chip Select ($\overline{CS}$) LOW and continuing to clock data into SI. The address pointer will increment after each byte of data is clocked in.

Request to Send (RTS)

The RTS command is a quick one byte method for initiating transmit requests. The RTS command sets the TXREQ bit for one or more transmit buffers by setting the appropriate bit(s) as shown in Figure 4.

FIGURE 4: SPI RTS COMMAND



SPI Read Status

The Read Status command offers a quick method for reading some of the often used bits in the MCP2510. The transmit flag bits (TXnIF) and the receive flag bits (RXnIF) are mapped from the CANINTF register, as are the transmit request bits (TXREQ) from the TXBnCTRL registers.

Using the Read Status command to check for receive status/buffers and for checking for pending transmit buffers is very useful. As shown in Example 5, a simple “if()” statement can be used to check for received messages. Also shown in Example 4 is a “while()” statement that waits for the transmit buffers to be non-pending before attempting to write to them. Recall that the transmit buffers cannot be modified while a message is pending or transmitting from the buffer in question.

REGISTER DISCUSSION

The previous sections discussed specific methods for performing functions on the MCP2510. This section is devoted to looking at many of the registers in the MCP2510 and discussing their features, along with the more important bits or the bits which are most likely to generate questions.

Refer to the MCP2510 Datasheet (DS21291) for more information on the registers and associated bits.

REGISTER 2: TXBNCTRL REGISTER

---	ABTF	MLOA	TXERR	TXREQ	--	TXP1	TXP0
bit 7							bit 0

TXERR - An error frame (from the MCP2510 or a receiver) was generated while the MCP2510 was transmitting a message.

TXREQ - Setting this bit initiates a request for transmission. The actual transmission may occur later than when the bit was initially set to avoid violating the CAN protocol. The bit will clear after the buffer finishes a successful transmission.

TXPn - Sets the transmit buffer priority. If multiple buffers are requested simultaneously for transmission, the higher priority buffer will be sent first.

`11` = Highest.

`10` = High intermediate.

`01` = Low intermediate.

`00` = Lowest.

In the event that multiple buffers have the same priority, the higher buffer number will be the higher priority. For example, TxB2 has a higher priority than TxB1 and TxB0.

REGISTER 3: TXRTSCTRL REGISTER

---	--	B2RTS	B1RTS	B0RTS	B2RTSM	B1RTSM	B0RTSM
bit 7							bit 0

BnRTS - Reflects the state of the associated pin while configured as a digital input; otherwise reads as a ZERO.

BnRTSM - Configures the pins as either digital input or as buffer request-to-transmit. Messages are initiated on the falling edge of the associated enabled TXnRTS pin.

Note: The pins have a nominal 100 kΩ nominal pull-up resistor.

REGISTER 4: TXBNSIDL REGISTER

SID2	SID1	SID0	---	EXIDE	---	EID17	EID16
bit 7							bit 0

EXIDE - Selects whether the transmitted message is **standard** or **extended.**

REGISTER 5: RXBNCTRL REGISTER

---	RXM1	RXM0	---	RXRTR	BUKT	BUKT1	FILHIT0
bit 7							bit 0

---	RXM1	RXM0	---	RXRTR	FILHIT2	FILHIT1	FILHIT0
bit 7							bit 0

RXMn - Determine the masks and filters operating mode. These bits can be configured:

`11` = Turn mask and filters off; receive any message.

`10` = Filter on only **extended** messages, reject **standard** messages.

`01` = Filter on only **standard** messages, reject **extended** messages.

`00` = filter on both **standard** and **extended** messages.

RXRTR - Indicates if the message was a Remote Frame (RTR).

BUKT - If set, will enable messages destined for receive buffer 0 (RXB0) to be rolled over into receive buffer 1 (RXB1), if RXB0 is full and RXB1 is empty.

FILHITn - Indicates which filter matched the last received message. Useful for determining the message type without reading the identifier, if each filter only matches one message type.

> **Note:** Care must be taken when setting the RXFnSIDL.EXIDE bit and the RXBnCTRL.RXM bits to insure proper operation. For example, if the EXIDE bit is configured to filter on **standard** frames, then the RXM bits must not be configured to receive only **extended** frames (RXM<1:0> = 10) or no messages will be received.
>
> **Note:** Setting RXM<1:0> = 11 turns masks and filters off to allow reception of all messages, including messages with errors. If an error occurs on the bus, the portion of the message up to the error will be loaded into the receive buffer.

REGISTER 6: BFPCTRL REGISTER

---	---	B1BFS	B0BFS	B1BFE	B0BFE	B1BFM	B0BFM
bit 7							bit 0

BnBFS - Sets the pin state, if the pin is enabled and configured as an output.

BnBFE - Enables/disables the pin (The mode is set with the BnBFM bits).

BnBFM - Sets the pin mode to either digital output or RX buffer interrupt (must be enabled with the BnBFE).

REGISTER 7: RXBNSIDL REGISTER

SID2	SID1	SID0	SRR	IDE	---	EID17	EID16
bit 7							bit 0

SRR - Indicates if a **standard** remote frame was received (the indicator for **extended** remote frames is contained in RXBnDLC).

IDE - If set, indicates that the received message was an **extended** frame.

REGISTER 8: RXBNDLC REGISTER

---	RTR	RB1	RB0	DLC3	DLC2	DLC1	DLC0
bit 7							bit 0

RTR - Indicates if an **extended** remote frame was received (the indicator for **standard** remote frames is contained in RXBnSIDL).

REGISTER 9: RXFNSIDL REGISTER

SID2	SID1	SID0	---	EXIDE	---	EID17	EID16
bit 7							bit 0

EXIDE - Determines whether the filter applies to **standard** or **extended** frames.

> **Note:** Care must be taken when setting the RXFnSIDL.EXIDE bit and the RXBnCTRL.RXM bits to insure proper operation. For example, if the EXIDE bit is configured to filter on **standard** frames, then the RXM bits must not be configured to receive only **extended** frames (RXM<1:0> = 10) or no messages will be received.

REGISTER 10: CNF1, CNF2 AND CNF3 REGISTERS

SJW1	SJW0	BRP5	BRP4	BRP3	BRP2	BRP1	BRP0
bit 7							bit 0

SJW<1:0> - Sets the Synchronization Jump Width. The SJW is the number of TQ the bit time will be lengthened or shortened due to resynchronization during message reception. SJW is programmable from 1 - 4 TQ.

BRP <5:0> - Sets the length of each TQ. Programmable from 2 - 128 Tosc using the formula:
TQ_{length} = 2*(BRP + 1) * Tosc; where BRP = the value programmed into CNF1.BRP<5:0>.

BTLMODE	SAM	PHSEG12	PHSEG11	PHSEG10	PRSEG2	PRSEG1	PRSEG0
bit 7							bit 0

BTLMODE - Determines if Phase Segment 2 (PS2) is set by the bits in CNF3 or the value of Phase Segment 1 (PS1) or the Information Processing Time (IPT). This bit must be SET to program PS2 via CNF3, otherwise PS2 will be set to the greater of PS1 or the IPT.

SAM - Sets the number of times (one or three) the bus level will be sampled within each bit. If set to three, the bus sampled three times at 0.5 TQ intervals staring 1 TQ before PS2. The value is determined by the majority level. Sampling three times was intended to compensate for noisy busses and should only be used at slower bus rates.

PHSEG1<2:0> - Programs Phase Segment 1 (PS1) from 1 - 8 TQ.

PRSEG<2:0> - Programs the Propagation Segment from 1 - 8 TQ.

---	WAKFIL	---	---	---	PHSEG22	PHSEG21	PHSEG20
bit 7							bit 0

WAKFIL - Enables/disables the wake-up noise filter. When enabled, noise pulses of less than 50 ns on the RXCAN pin are filtered out, while the MCP2510 is in Sleep mode.

PHSEG2<2:0> - Programs Phase Segment 2 (PS2) from 2 - 8 TQ.

REGISTER 11: CANINTE AND CANINTF REGISTERS (INTERRUPT ENABLES AND FLAGS)

MERRE	WAKIE	ERRIE	TX2IE	TX1IE	TX0IE	RX1IE	RX0IE
bit 7							bit 0

MERRF	WAKIF	ERRIF	TX2IF	TX1IF	TX0IF	RX1IF	RX0IF
bit 7							bit 0

> **Note:** CANINTE contains the interrupt enables which causes a hardware interrupt and maps to the CANSTAT.ICOD bits if the associated flag bit is set.
> CANINTF contains the flag bits which are set regardless of the value of the associated enable bit. The flag bits are both readable and writable, so care must be taken when modifying this register. The SPI “Bit Modify” command works well with these registers.

MERRE/F - Message error interrupt/flag will be set if the MCP2510 sees a transmit or receive error on the bus.

WAKIE/F - Indicates the MCP2510 woke up from Sleep.

ERRIE/F - Indicates a flag in the EFLG register was set.

TXnIE/F - Indicates the successful transmission of a message. The flag does not need to be cleared to reload and transmit a message.

RXnIE/F - Indicates a message reception. The flag MUST be cleared by the MCU in order to receive a message. This acts as a positive lockout to keep incoming message from overwriting a received message.

REGISTER 12: CANCTRL REGISTER

REQOP2	REQOP1	REQOP0	ABAT	---	CLKEN	CLKPRE1	CLKPRE0
bit 7							bit 0

REQOP<2:0> - Requests the operating mode of the MCP2510. The current mode of operation MUST be checked using CANSTAT.OPMOD not with the REQOP bits.

ABAT - Requests abort of all pending transmit buffers. This bit MUST be cleared to transmit further messages.

CLKEN - Enables/disables the CLKOUT pin.

CLKPRE<1:0> - Sets the CLKOUT prescaler to Fosc/1, Fosc/2, Fosc/4, or Fosc/8.

> **Note:** On power-up, the REQOP bits will read b’111’ indicating Configuration mode was requested. At all other times, this value is invalid and unexpected results will occur if set to this value. To request Configuration mode REQOP = b’100’.

REGISTER 13: CANSTAT REGISTER

OPMOD2	OPMOD1	OPMOD0	---	ICOD2	ICOD1	ICOD0	---
bit 7							bit 0

OPMOD<2:0> - Reflects the current operating mode. These bits are checked (not CANCTRL.REQOP) for the current operating mode.

ICOD<2:0> - The interrupt code bits reflect the highest priority pending interrupt. If multiple interrupts are pending and the highest is cleared, the next highest will be rejected.

SUMMARY

While this application note does not cover all methods for configuring and operating the MCP2510, it can be a reference to help operate the device in a suitable manner for a given application. There are a some main points to remember when using the MCP2510:

- Wait 128 OSC cycles after performing a Reset.
- Must be in Configuration mode to modify the bit timing registers (CNFn) and the masks and filters.
- Make sure the receive mode (RXBnCTRL.RXM) matches the masks and filters settings. The default is “Receive all valid messages (standard and extended) that match masks and filters”.
- Configure interrupt enables as needed (CANINTE).
- Set Normal mode before attempting to communicate on the bus.
- Use the SPI “Bit Modify” command where applicable to avoid disturbing bits unintentionally.
- The transmit buffers cannot be modified when its respective TXREQ bit is set indicating the buffer is pending or is currently transmitting.
- Use SPI “Read Status” to check received messages and pending transmit buffers.
- Entering Sleep mode disables the CLKOUT pin.
- The SPI interface is still active when the MCP2510 is in Sleep mode.
- The TX0RTS, TX1RTS, TX2RTS pins have 100 kΩ nominal pull-up resistors.

REFERENCES

Robert Bosch GmbH, CAN Specification Version 2.0, 1991.

MCP2510 Data Sheet, DS21291, Microchip Technology, Inc.

Lawrenz, Wolfhard, CAN Systems Engineering From Theory to Practical Applications, Springer, 1997.

NOTES:

NOTES:

NOTES:

Microchip received QS-9000 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona in July 1999. The Company's quality system processes and procedures are QS-9000 compliant for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs and microperipheral products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001 certified.

WORLDWIDE SALES AND SERVICE

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

Austin
Analog Product Sales
8303 MoPac Expressway North
Suite A-201
Austin, TX 78759
Tel: 512-345-2030 Fax: 512-345-6085

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

Boston
Analog Product Sales
Unit A-8-1 Millbrook Tarry Condominium
97 Lowell Road
Concord, MA 01742
Tel: 978-371-6400 Fax: 978-371-0050

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

Los Angeles
18201 Von Karman, Suite 1090
Irvine, CA 92612
Tel: 949-263-1888 Fax: 949-263-1338

Mountain View
Analog Product Sales
1300 Terra Bella Avenue
Mountain View, CA 94043-1836
Tel: 650-968-9241 Fax: 650-967-1590

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 Beijing Office
Unit 915
New China Hong Kong Manhattan Bldg.
No. 6 Chaoyangmen Beidajie
Beijing, 100027, No. China
Tel: 86-10-85282100 Fax: 86-10-85282104

China - Shanghai
Microchip Technology Shanghai Office
Room 701, Bldg. B
Far East International Plaza
No. 317 Xian Xia Road
Shanghai, 200051
Tel: 86-21-6275-5700 Fax: 86-21-6275-5060

Hong Kong
Microchip Asia Pacific
RM 2101, Tower 2, Metroplaza
223 Hing Fong Road
Kwai Fong, N.T., Hong Kong
Tel: 852-2401-1200 Fax: 852-2401-3431

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

Japan
Microchip Technology Intl. Inc.
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

ASIA/PACIFIC (continued)

Korea
Microchip Technology Korea
168-1, Youngbo Bldg. 3 Floor
Samsung-Dong, Kangnam-Ku
Seoul, Korea
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 Denmark ApS
Regus Business Centre
Lautrup hoj 1-3
Ballerup DK-2750 Denmark
Tel: 45 4420 9895 Fax: 45 4420 9910

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

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

Germany
Analog Product Sales
Lochhamer Strasse 13
D-82152 Martinsried, Germany
Tel: 49-89-895650-0 Fax: 49-89-895650-22

Italy
Arizona Microchip Technology SRL
Centro Direzionale Colleoni
Palazzo Taurus 1 V. Le Colleoni 1
20041 Agrate Brianza
Milan, Italy
Tel: 39-039-65791-1 Fax: 39-039-6899883

United Kingdom
Arizona Microchip Technology Ltd.
505 Eskdale Road
Winnersh Triangle
Wokingham
Berkshire, England RG41 5TU
Tel: 44 118 921 5869 Fax: 44-118 921-5820

01/30/01