

## Stand-Alone CAN Controller With SPI Interface

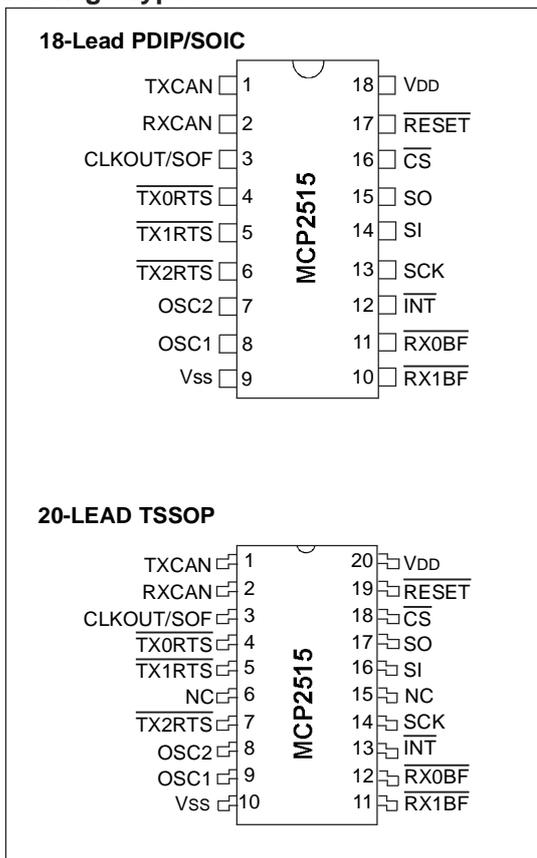
### Features

- Implements CAN V2.0B at 1 Mb/s:
  - 0 – 8 byte length in the data field
  - Standard and extended data and remote frames
- Receive buffers, masks and filters:
  - Two receive buffers with prioritized message storage
  - Six 29-bit filters
  - Two 29-bit masks
- Data byte filtering on the first two data bytes (applies to standard data frames)
- Three transmit buffers with prioritization and abort features
- High-speed SPI Interface (10 MHz):
  - SPI modes 0,0 and 1,1
- One-shot mode ensures message transmission is attempted only one time
- Clock out pin with programmable prescaler:
  - Can be used as a clock source for other device(s)
- Start-of-Frame (SOF) signal is available for monitoring the SOF signal:
  - Can be used for time-slot-based protocols and/or bus diagnostics to detect early bus degradation
- Interrupt output pin with selectable enables
- Buffer Full output pins configurable as:
  - Interrupt output for each receive buffer
  - General purpose output
- Request-to-Send (RTS) input pins individually configurable as:
  - Control pins to request transmission for each transmit buffer
  - General purpose inputs
- Low-power CMOS technology:
  - Operates from 2.7V – 5.5V
  - 5 mA active current (typical)
  - 1  $\mu$ A standby current (typical) (Sleep mode)
- Temperature ranges supported:
  - Industrial (I): -40°C to +85°C
  - Extended (E): -40°C to +125°C

### Description

Microchip Technology's MCP2515 is a stand-alone Controller Area Network (CAN) controller that implements the CAN specification, version 2.0B. It is capable of transmitting and receiving both standard and extended data and remote frames. The MCP2515 has two acceptance masks and six acceptance filters that are used to filter out unwanted messages, thereby reducing the host MCUs overhead. The MCP2515 interfaces with microcontrollers (MCUs) via an industry standard Serial Peripheral Interface (SPI).

### Package Types



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## 1.0 DEVICE OVERVIEW

The MCP2515 is a stand-alone CAN controller developed to simplify applications that require interfacing with a CAN bus. A simple block diagram of the MCP2515 is shown in Figure 1-1. The device consists of three main blocks:

1. The CAN module, which includes the CAN protocol engine, masks, filters, transmit and receive buffers.
2. The control logic and registers that are used to configure the device and its operation.
3. The SPI protocol block.

An example system implementation using the device is shown in Figure 1-2.

### 1.1 CAN Module

The CAN module handles all functions for receiving and transmitting messages on the CAN bus. Messages are transmitted by first loading the appropriate message buffer and control registers. Transmission is initiated by using control register bits via the SPI interface or by using the transmit enable pins. Status and errors can be checked by reading the appropriate registers. Any message detected on the CAN bus is checked for errors and then matched against the user-defined filters to see if it should be moved into one of the two receive buffers.

### 1.2 Control Logic

The control logic block controls the setup and operation of the MCP2515 by interfacing to the other blocks in order to pass information and control.

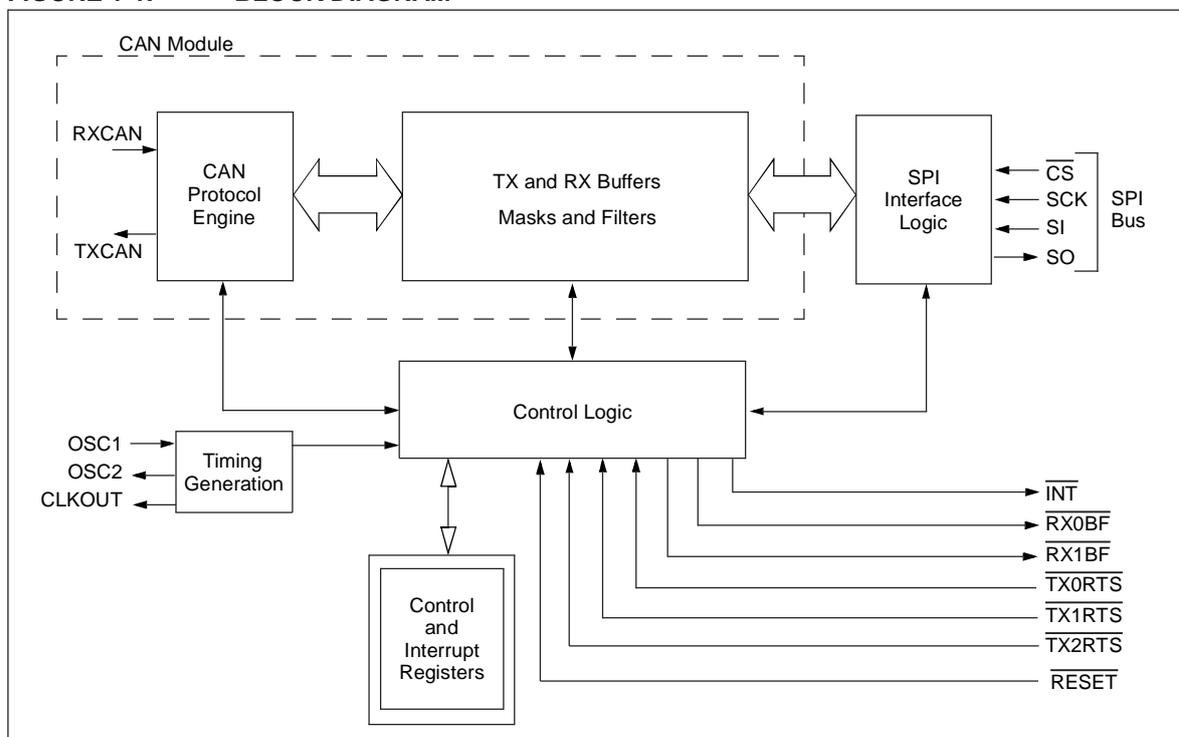
Interrupt pins are provided to allow greater system flexibility. There is one multi-purpose interrupt pin (as well as specific interrupt pins) for each of the receive registers that can be used to indicate a valid message has been received and loaded into one of the receive buffers. Use of the specific interrupt pins is optional. The general purpose interrupt pin, as well as status registers (accessed via the SPI interface), can also be used to determine when a valid message has been received.

Additionally, there are three pins available to initiate immediate transmission of a message that has been loaded into one of the three transmit registers. Use of these pins is optional, as initiating message transmissions can also be accomplished by utilizing control registers, accessed via the SPI interface.

### 1.3 SPI Protocol Block

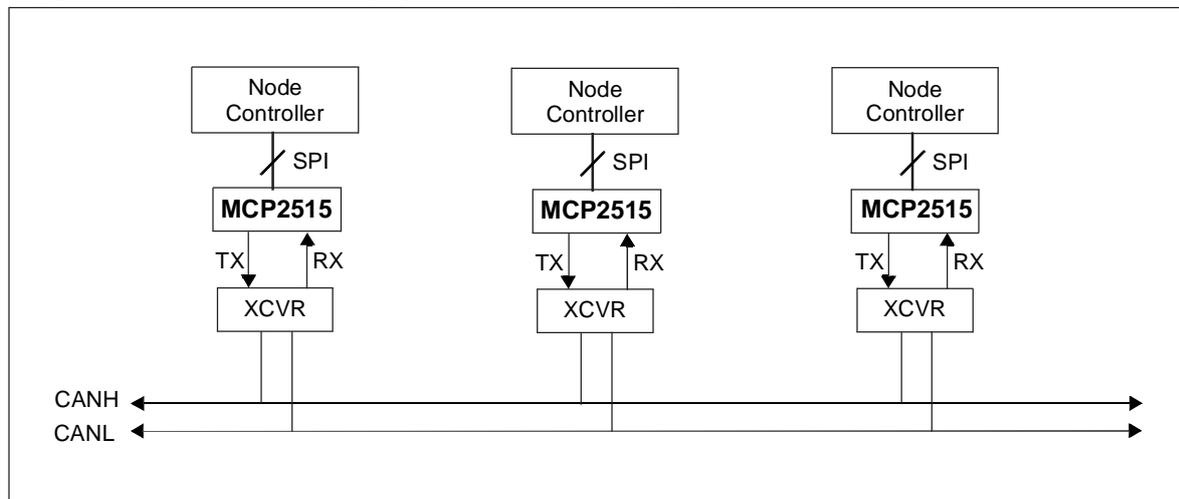
The MCU interfaces to the device via the SPI interface. Writing to, and reading from, all registers is accomplished using standard SPI read and write commands, in addition to specialized SPI commands.

FIGURE 1-1: BLOCK DIAGRAM



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**FIGURE 1-2: EXAMPLE SYSTEM IMPLEMENTATION**



**TABLE 1-1: PINOUT DESCRIPTION**

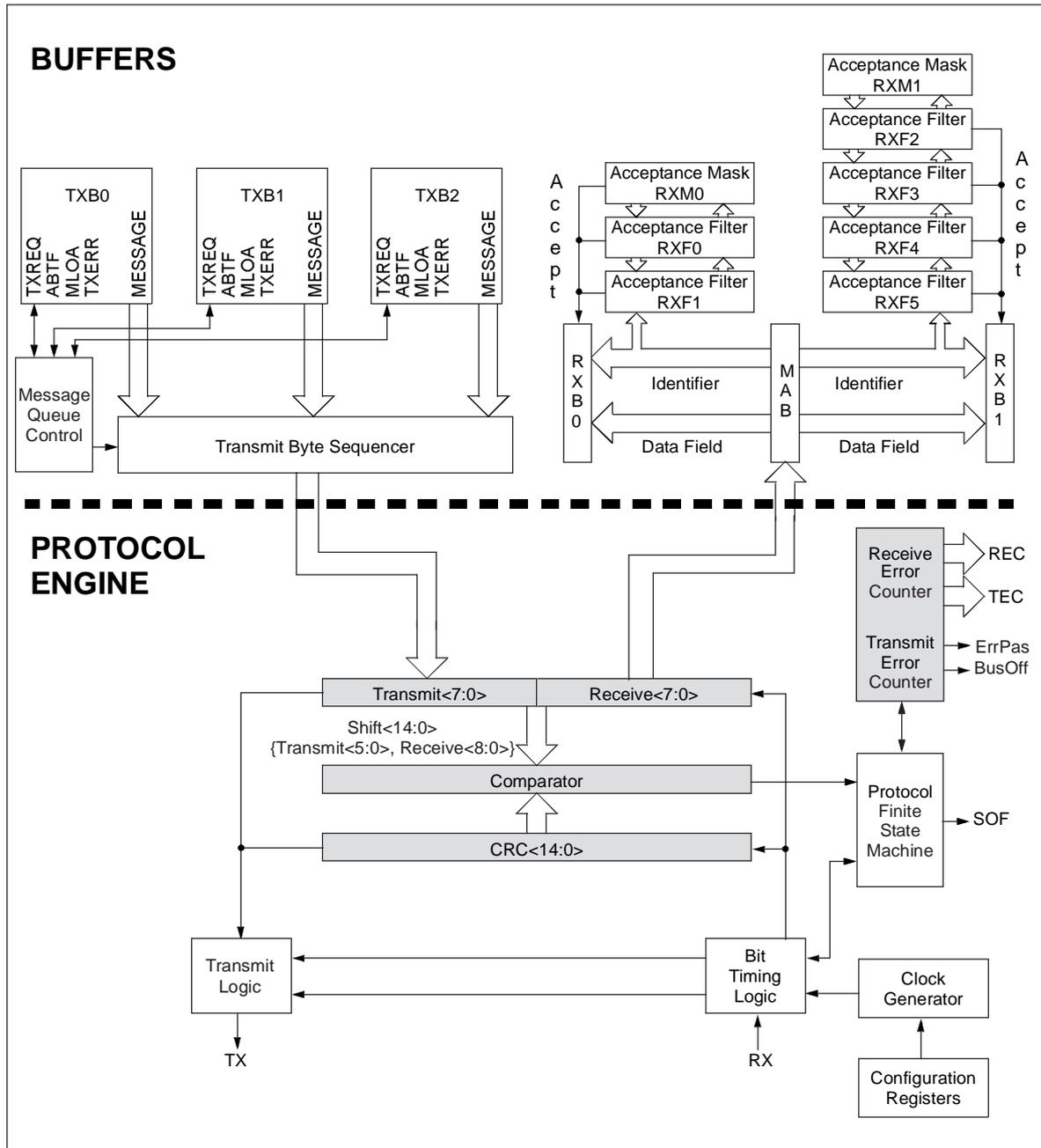
Name	PDIP/SOIC Pin #	TSSOP Pin #	I/O/P Type	Description	Alternate Pin Function
TXCAN	1	1	O	Transmit output pin to CAN bus	—
RXCAN	2	2	I	Receive input pin from CAN bus	—
CLKOUT	3	3	O	Clock output pin with programmable prescaler	Start-of-Frame signal
$\overline{\text{TX0RTS}}$	4	4	I	Transmit buffer TXB0 request-to-send. 100 k $\Omega$ internal pull-up to VDD	General purpose digital input. 100 k $\Omega$ internal pull-up to VDD
$\overline{\text{TX1RTS}}$	5	5	I	Transmit buffer TXB1 request-to-send. 100 k $\Omega$ internal pull-up to VDD	General purpose digital input. 100 k $\Omega$ internal pull-up to VDD
$\overline{\text{TX2RTS}}$	6	7	I	Transmit buffer TXB2 request-to-send. 100 k $\Omega$ internal pull-up to VDD	General purpose digital input. 100 k $\Omega$ internal pull-up to VDD
OSC2	7	8	O	Oscillator output	—
OSC1	8	9	I	Oscillator input	External clock input
Vss	9	10	P	Ground reference for logic and I/O pins	—
$\overline{\text{RX1BF}}$	10	11	O	Receive buffer RXB1 interrupt pin or general purpose digital output	General purpose digital output
$\overline{\text{RX0BF}}$	11	12	O	Receive buffer RXB0 interrupt pin or general purpose digital output	General purpose digital output
$\overline{\text{INT}}$	12	13	O	Interrupt output pin	—
SCK	13	14	I	Clock input pin for SPI interface	—
SI	14	16	I	Data input pin for SPI interface	—
SO	15	17	O	Data output pin for SPI interface	—
$\overline{\text{CS}}$	16	18	I	Chip select input pin for SPI interface	—
$\overline{\text{RESET}}$	17	19	I	Active low device reset input	—
VDD	18	20	P	Positive supply for logic and I/O pins	—
NC	—	6,15	—	No internal connection	—

**Note:** Type Identification: I = Input; O = Output; P = Power

## 1.4 Transmit/Receive Buffers/Masks/ Filters

The MCP2515 has three transmit and two receive buffers, two acceptance masks (one for each receive buffer) and a total of six acceptance filters. Figure 1-3 shows a block diagram of these buffers and their connection to the protocol engine.

**FIGURE 1-3: CAN BUFFERS AND PROTOCOL ENGINE BLOCK DIAGRAM**



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## 1.5 CAN Protocol Engine

The CAN protocol engine combines several functional blocks, shown in Figure 1-4 and described below.

### 1.5.1 PROTOCOL FINITE STATE MACHINE

The heart of the engine is the Finite State Machine (FSM). The FSM is a sequencer that controls the sequential data stream between the TX/RX shift registers, the CRC register and the bus line. The FSM also controls the Error Management Logic (EML) and the parallel data stream between the TX/RX shift registers and the buffers. The FSM ensures that the processes of reception, arbitration, transmission and error-signaling are performed according to the CAN protocol. The automatic retransmission of messages on the bus line is also handled by the FSM.

### 1.5.2 CYCLIC REDUNDANCY CHECK

The Cyclic Redundancy Check register generates the Cyclic Redundancy Check (CRC) code, which is transmitted after either the Control Field (for messages with 0 data bytes) or the Data Field and is used to check the CRC field of incoming messages.

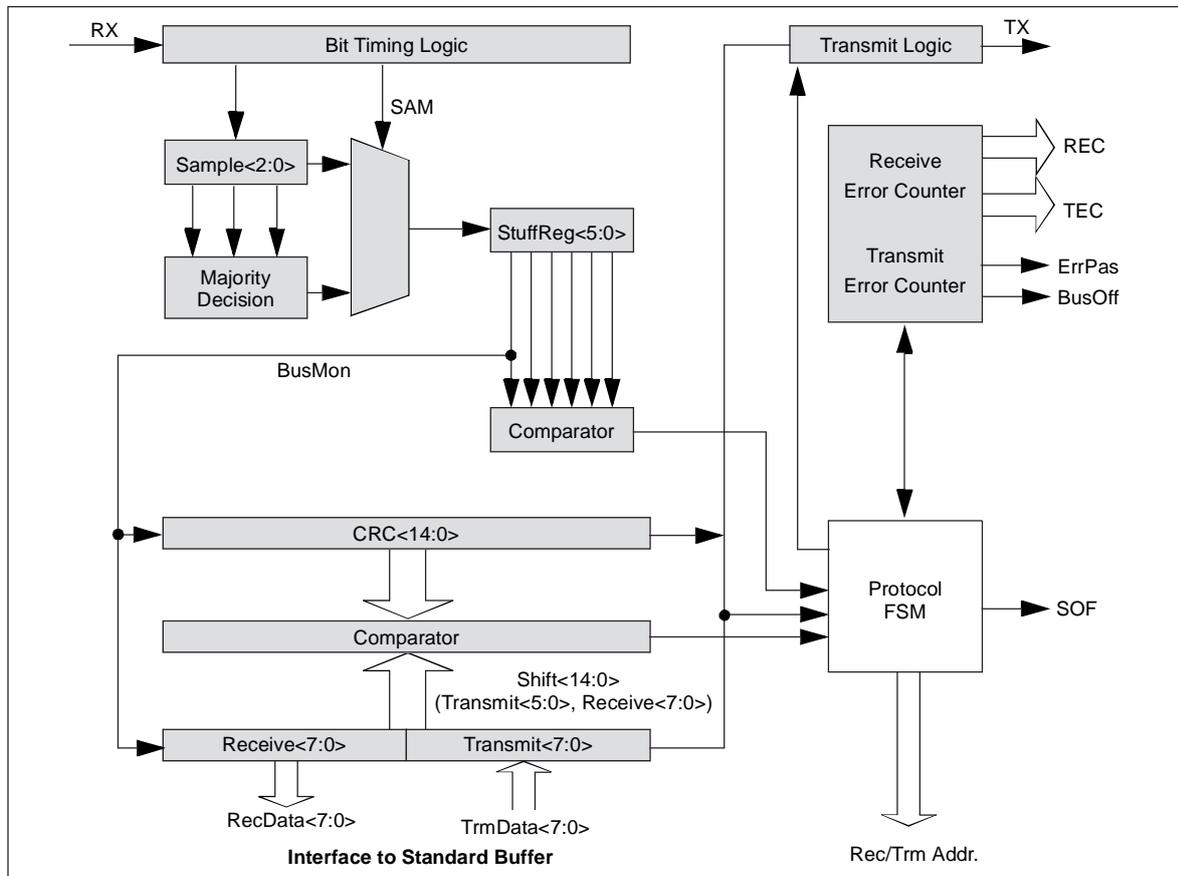
### 1.5.3 ERROR MANAGEMENT LOGIC

The Error Management Logic (EML) is responsible for the fault confinement of the CAN device. Its two counters, the Receive Error Counter (REC) and the Transmit Error Counter (TEC), are incremented and decremented by commands from the bit stream processor. Based on the values of the error counters, the CAN controller is set into the states error-active, error-passive or bus-off.

### 1.5.4 BIT TIMING LOGIC

The Bit Timing Logic (BTL) monitors the bus line input and handles the bus-related bit timing according to the CAN protocol. The BTL synchronizes on a recessive-to-dominant bus transition at Start-of-Frame (hard synchronization) and on any further recessive-to-dominant bus line transition if the CAN controller itself does not transmit a dominant bit (resynchronization). The BTL also provides programmable time segments to compensate for the propagation delay time, phase shifts and to define the position of the sample point within the bit time. The programming of the BTL depends on the baud rate and external physical delay times.

FIGURE 1-4: CAN PROTOCOL ENGINE BLOCK DIAGRAM



## 2.0 CAN MESSAGE FRAMES

The MCP2515 supports standard data frames, extended data frames and remote frames (standard and extended), as defined in the CAN 2.0B specification.

### 2.1 Standard Data Frame

The CAN standard data frame is shown in [Figure 2-1](#). As with all other frames, the frame begins with a Start-Of-Frame (SOF) bit, which is of the dominant state and allows hard synchronization of all nodes.

The SOF is followed by the arbitration field, consisting of 12 bits: the 11-bit identifier and the Remote Transmission Request (RTR) bit. The RTR bit is used to distinguish a data frame (RTR bit dominant) from a remote frame (RTR bit recessive).

Following the arbitration field is the control field, consisting of six bits. The first bit of this field is the Identifier Extension (IDE) bit, which must be dominant to specify a standard frame. The following bit, Reserved Bit Zero (RB0), is reserved and is defined as a dominant bit by the CAN protocol. The remaining four bits of the control field are the Data Length Code (DLC), which specifies the number of bytes of data (0 – 8 bytes) contained in the message.

After the control field is the data field, which contains any data bytes that are being sent, and is of the length defined by the DLC (0 – 8 bytes).

The Cyclic Redundancy Check (CRC) field follows the data field and is used to detect transmission errors. The CRC field consists of a 15-bit CRC sequence, followed by the recessive CRC Delimiter bit.

The final field is the two-bit Acknowledge (ACK) field. During the ACK Slot bit, the transmitting node sends out a recessive bit. Any node that has received an error-free frame acknowledges the correct reception of the frame by sending back a dominant bit (regardless of whether the node is configured to accept that specific message or not). The recessive acknowledge delimiter completes the acknowledge field and may not be overwritten by a dominant bit.

### 2.2 Extended Data Frame

In the extended CAN data frame, shown in [Figure 2-2](#), the SOF bit is followed by the arbitration field, which consists of 32 bits. The first 11 bits are the Most Significant bits (MSb) (Base-ID) of the 29-bit identifier. These 11 bits are followed by the Substitute Remote Request (SRR) bit, which is defined to be recessive. The SRR bit is followed by the IDE bit, which is recessive to denote an extended CAN frame.

It should be noted that if arbitration remains unresolved after transmission of the first 11 bits of the identifier, and one of the nodes involved in the arbitration is sending a standard CAN frame (11-bit identifier), the standard

CAN frame will win arbitration due to the assertion of a dominant IDE bit. Also, the SRR bit in an extended CAN frame must be recessive to allow the assertion of a dominant RTR bit by a node that is sending a standard CAN remote frame.

The SRR and IDE bits are followed by the remaining 18 bits of the identifier (Extended ID) and the remote transmission request bit.

To enable standard and extended frames to be sent across a shared network, the 29-bit extended message identifier is split into 11-bit (most significant) and 18-bit (least significant) sections. This split ensures that the IDE bit can remain at the same bit position in both the standard and extended frames.

Following the arbitration field is the six-bit control field. The first two bits of this field are reserved and must be dominant. The remaining four bits of the control field are the DLC, which specifies the number of data bytes contained in the message.

The remaining portion of the frame (data field, CRC field, acknowledge field, end-of-frame and intermission) is constructed in the same way as a standard data frame (see [Section 2.1 “Standard Data Frame”](#)).

### 2.3 Remote Frame

Normally, data transmission is performed on an autonomous basis by the data source node (e.g., a sensor sending out a data frame). It is possible, however, for a destination node to request data from the source. To accomplish this, the destination node sends a remote frame with an identifier that matches the identifier of the required data frame. The appropriate data source node will then send a data frame in response to the remote frame request.

There are two differences between a remote frame (shown in [Figure 2-3](#)) and a data frame. First, the RTR bit is at the recessive state and, second, there is no data field. In the event of a data frame and a remote frame with the same identifier being transmitted at the same time, the data frame wins arbitration due to the dominant RTR bit following the identifier. In this way, the node that transmitted the remote frame receives the desired data immediately.

### 2.4 Error Frame

An error frame is generated by any node that detects a bus error. An error frame, shown in [Figure 2-4](#), consists of two fields: an error flag field followed by an error delimiter field. There are two types of error flag fields. The type of error flag field sent depends upon the error status of the node that detects and generates the error flag field.

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## 2.4.1 ACTIVE ERRORS

If an error-active node detects a bus error, the node interrupts transmission of the current message by generating an active error flag. The active error flag is composed of six consecutive dominant bits. This bit sequence actively violates the bit-stuffing rule. All other stations recognize the resulting bit-stuffing error and, in turn, generate error frames themselves, called error echo flags.

The error flag field, therefore, consists of between six and twelve consecutive dominant bits (generated by one or more nodes). The error delimiter field (eight recessive bits) completes the error frame. Upon completion of the error frame, bus activity returns to normal and the interrupted node attempts to resend the aborted message.

**Note:** Error echo flags typically occur when a localized disturbance causes one or more (but not all) nodes to send an error flag. The remaining nodes generate error flags in response (echo) to the original error flag.

## 2.4.2 PASSIVE ERRORS

If an error-passive node detects a bus error, the node transmits an error-passive flag followed by the error delimiter field. The error-passive flag consists of six consecutive recessive bits. The error frame for an error-passive node consists of 14 recessive bits. From this it follows that, unless the bus error is detected by an error-active node or the transmitting node, the message will continue transmission because the error-passive flag does not interfere with the bus.

If the transmitting node generates an error-passive flag, it will cause other nodes to generate error frames due to the resulting bit-stuffing violation. After transmission of an error frame, an error-passive node must wait for six consecutive recessive bits on the bus before attempting to rejoin bus communications.

The error delimiter consists of eight recessive bits and allows the bus nodes to restart bus communications cleanly after an error has occurred.

## 2.5 Overload Frame

An overload frame, shown in [Figure 2-5](#), has the same format as an active error frame. An overload frame, however, can only be generated during an interframe space. In this way, an overload frame can be differentiated from an error frame (an error frame is sent during the transmission of a message). The overload frame consists of two fields: an overload flag followed by an overload delimiter. The overload flag consists of six dominant bits followed by overload flags generated by other nodes (and, as for an active error flag, giving a maximum of twelve dominant bits). The overload delimiter consists of eight recessive bits. An overload frame can be generated by a node as a result of two conditions:

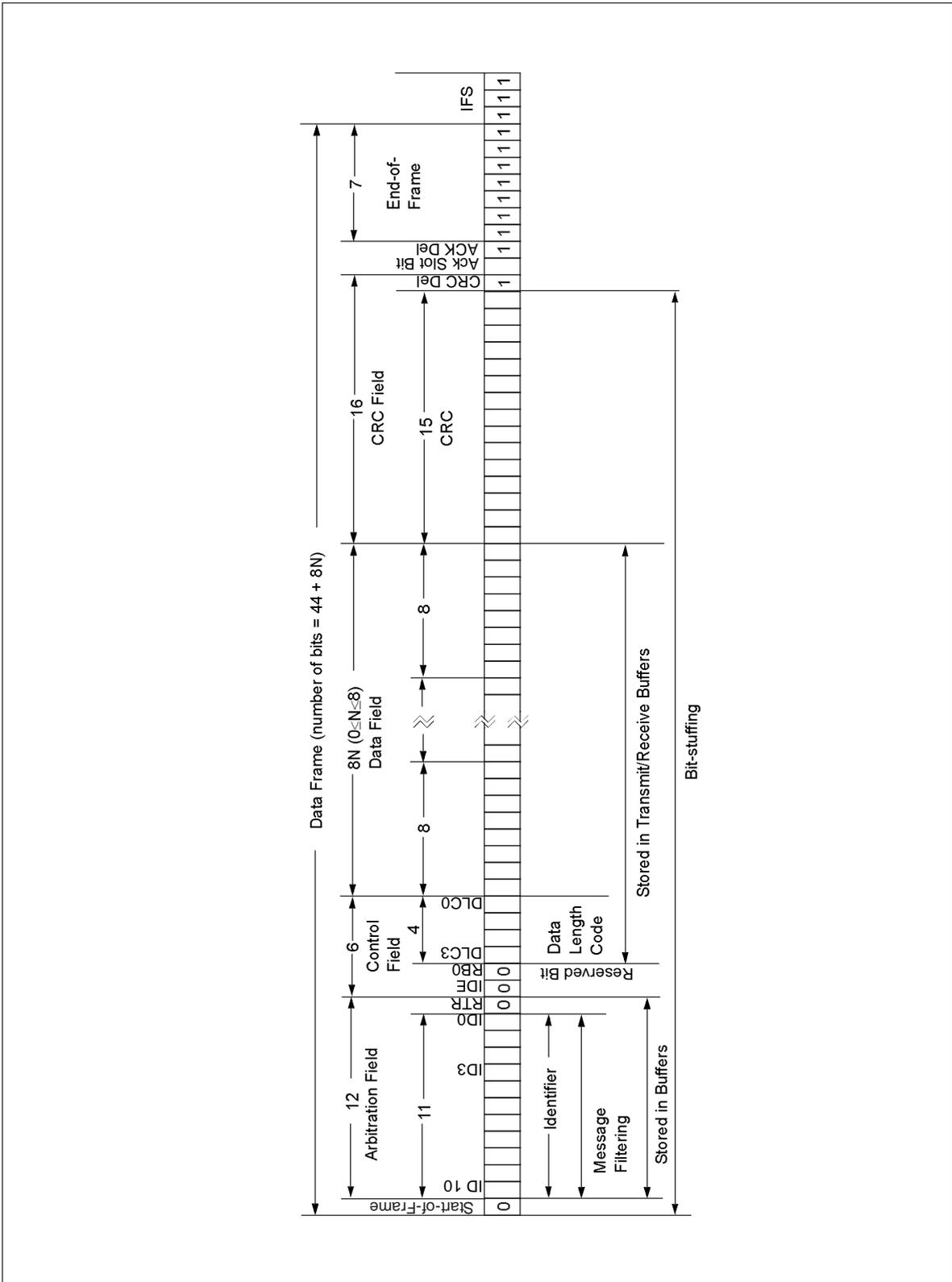
1. The node detects a dominant bit during the interframe space, an illegal condition.  
**Exception:** The dominant bit is detected during the third bit of IFS. In this case, the receivers will interpret this as a SOF.
2. Due to internal conditions, the node is not yet able to begin reception of the next message. A node may generate a maximum of two sequential overload frames to delay the start of the next message.

**Note:** Case 2 should never occur with the MCP2515 due to very short internal delays.

## 2.6 Interframe Space

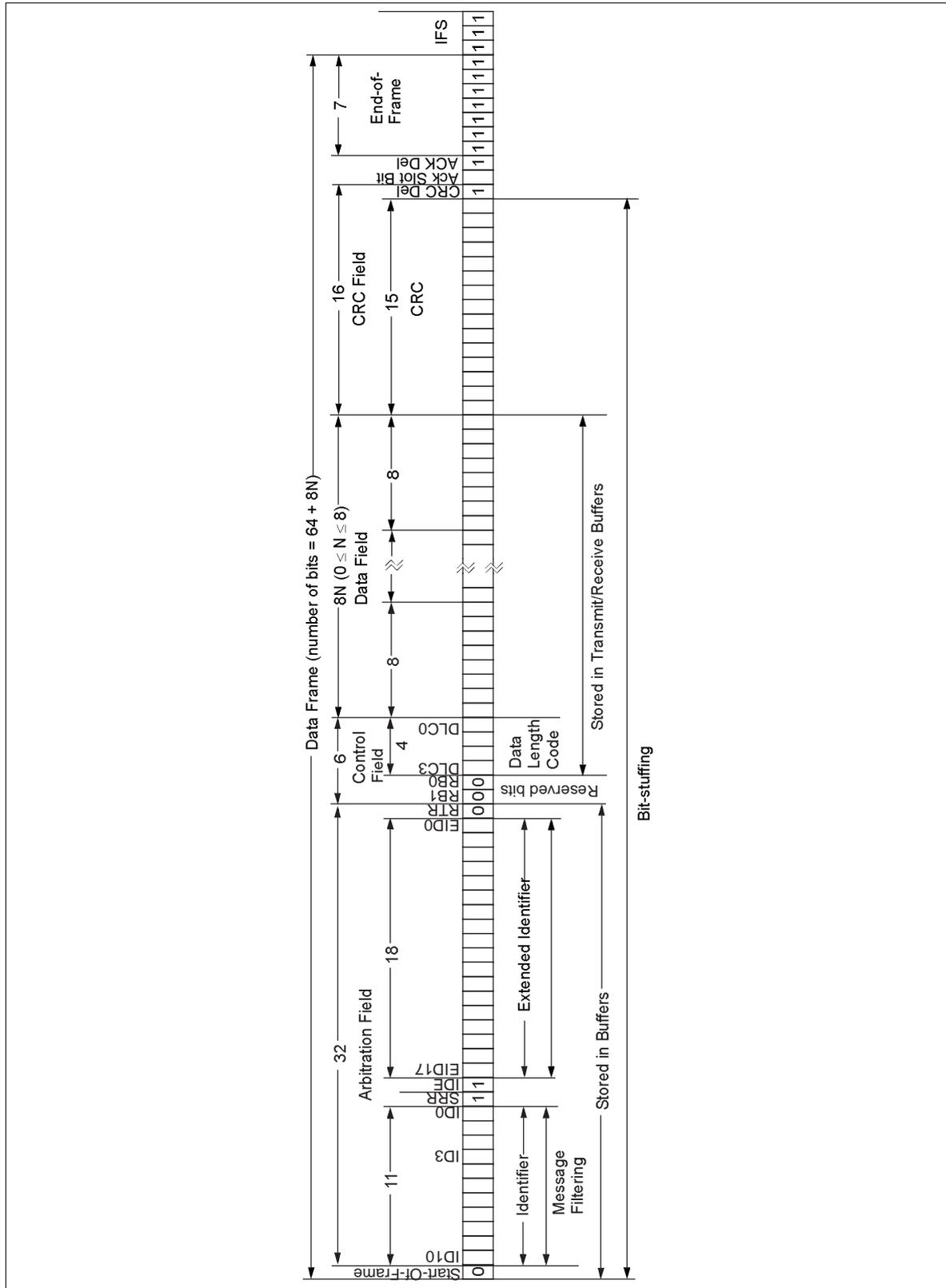
The interframe space separates a preceding frame (of any type) from a subsequent data or remote frame. The interframe space is composed of at least three recessive bits called the Intermission. This allows nodes time for internal processing before the start of the next message frame. After the intermission, the bus line remains in the recessive state (bus idle) until the next transmission starts.

**FIGURE 2-1: STANDARD DATA FRAME**

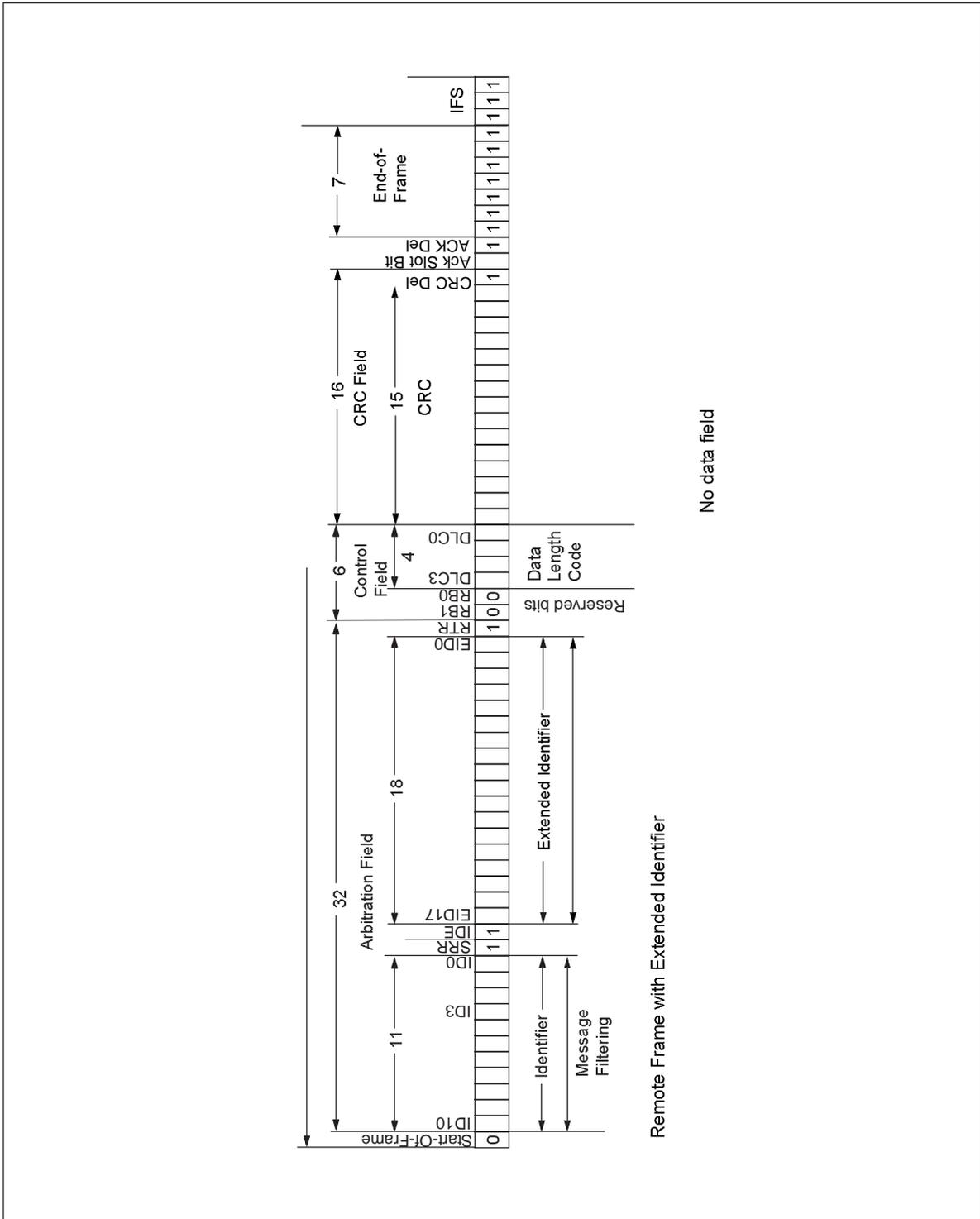


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FIGURE 2-2: EXTENDED DATA FRAME

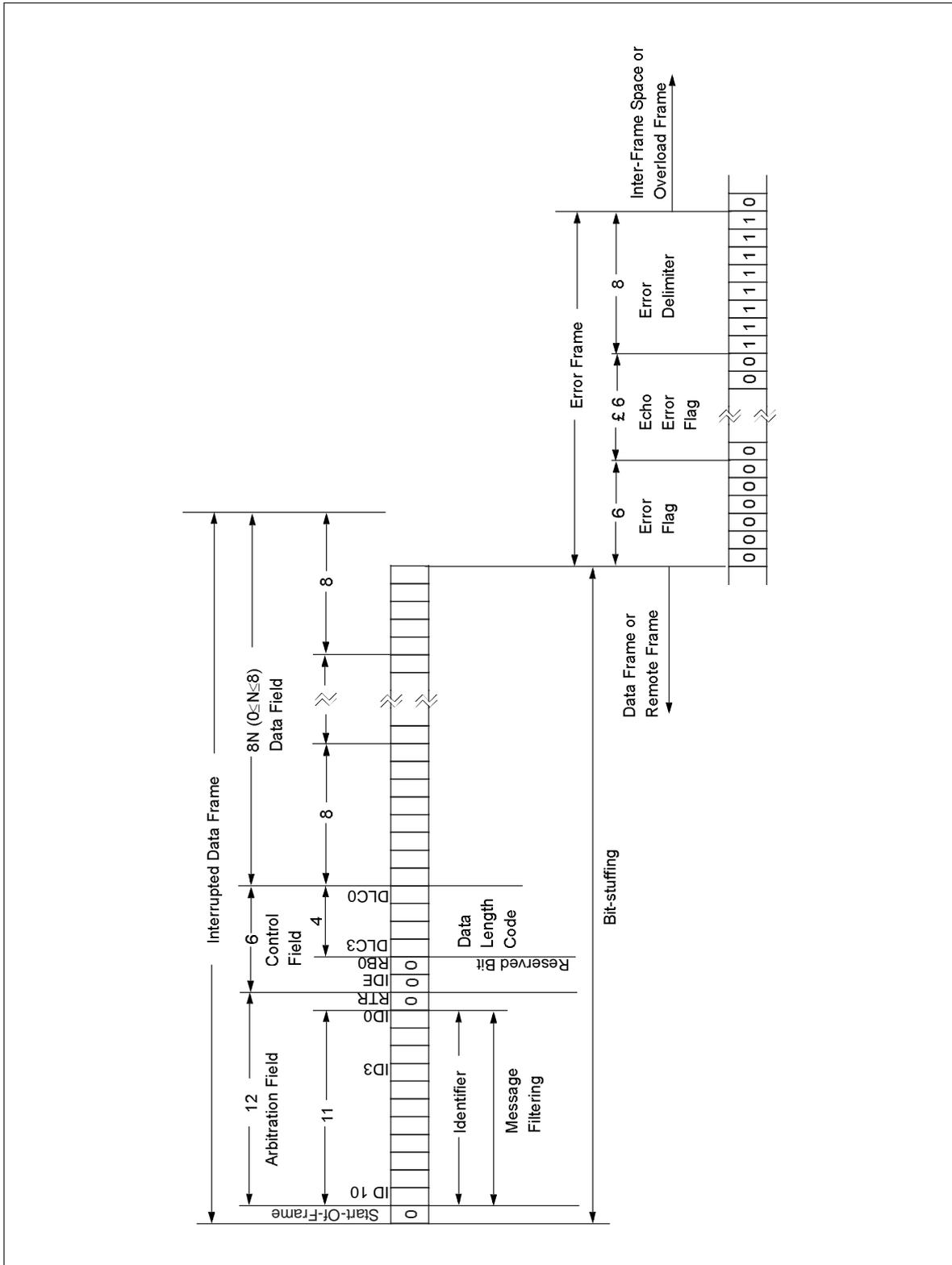


**FIGURE 2-3: REMOTE FRAME**

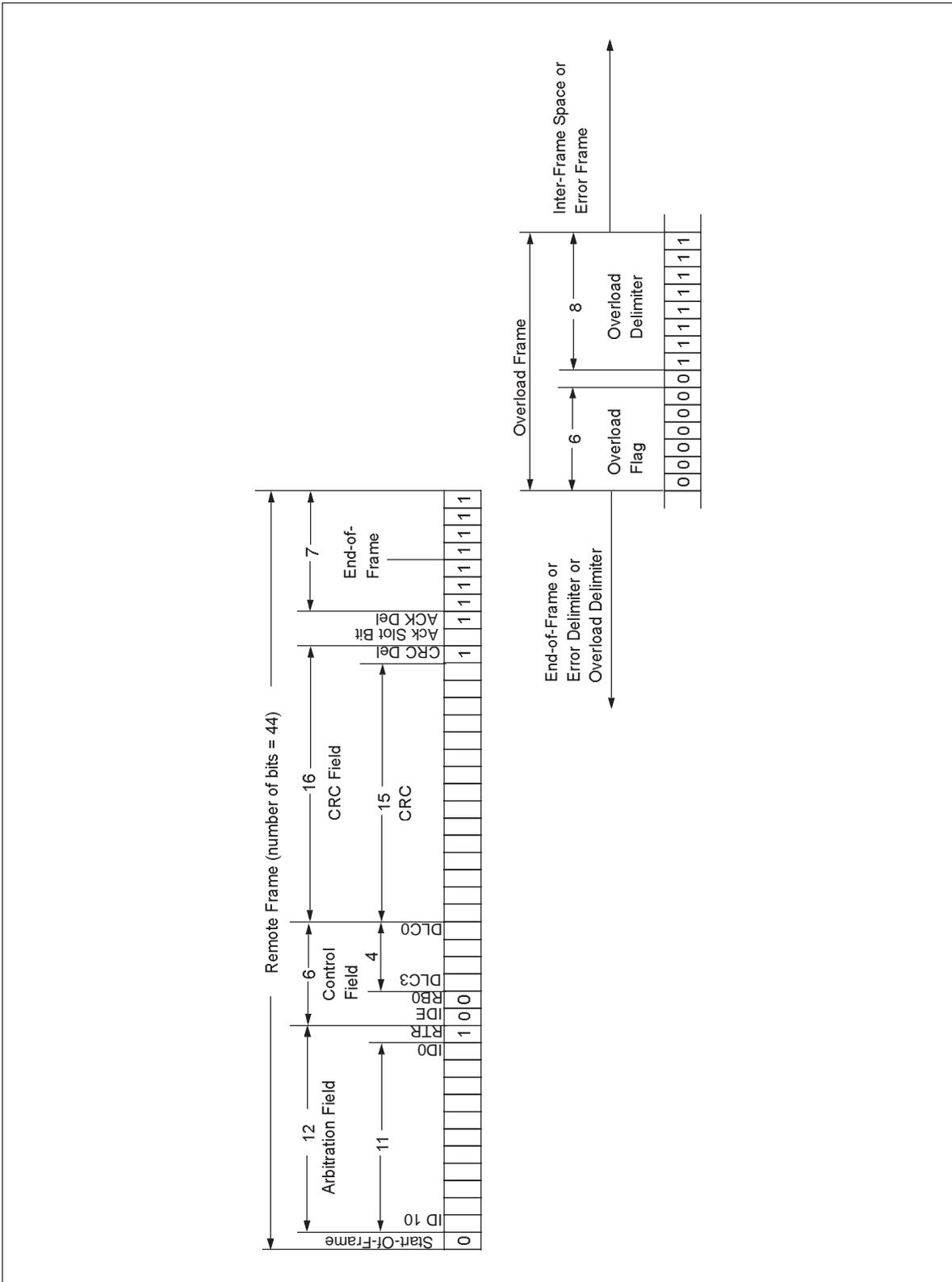


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FIGURE 2-4: ACTIVE ERROR FRAME



**FIGURE 2-5: OVERLOAD FRAME**



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## 3.0 MESSAGE TRANSMISSION

### 3.1 Transmit Buffers

The MCP2515 implements three transmit buffers. Each of these buffers occupies 14 bytes of SRAM and are mapped into the device memory map.

The first byte, TXBnCTRL, is a control register associated with the message buffer. The information in this register determines the conditions under which the message will be transmitted and indicates the status of the message transmission (see Register 3-2).

Five bytes are used to hold the standard and extended identifiers, as well as other message arbitration information (see Register 3-4 through Register 3-7). The last eight bytes are for the eight possible data bytes of the message to be transmitted (see Register 3-8).

At a minimum, the TXBnSIDH, TXBnSIDL and TXBnDLC registers must be loaded. If data bytes are present in the message, the TXBnDm registers must also be loaded. If the message is to use extended identifiers, the TXBnEIDm registers must also be loaded and the TXBnSIDL.EXIDE bit set.

Prior to sending the message, the MCU must initialize the CANINTE.TXnIE bit to enable or disable the generation of an interrupt when the message is sent.

**Note:** The TXBnCTRL.TXREQ bit must be clear (indicating the transmit buffer is not pending transmission) before writing to the transmit buffer.

### 3.2 Transmit Priority

Transmit priority is a prioritization within the MCP2515 of the pending transmittable messages. This is independent from, and not necessarily related to, any prioritization implicit in the message arbitration scheme built into the CAN protocol.

Prior to sending the SOF, the priority of all buffers that are queued for transmission is compared. The transmit buffer with the highest priority will be sent first. For example, if transmit buffer 0 has a higher priority setting than transmit buffer 1, buffer 0 will be sent first.

If two buffers have the same priority setting, the buffer with the highest buffer number will be sent first. For example, if transmit buffer 1 has the same priority setting as transmit buffer 0, buffer 1 will be sent first.

There are four levels of transmit priority. If TXBnCTRL.TXP<1:0> for a particular message buffer is set to 11, that buffer has the highest possible priority. If TXBnCTRL.TXP<1:0> for a particular message buffer is 00, that buffer has the lowest possible priority.

### 3.3 Initiating Transmission

In order to initiate message transmission, the TXBnCTRL.TXREQ bit must be set for each buffer to be transmitted. This can be accomplished by:

- Writing to the register via the SPI write command
- Sending the SPI RTS command
- Setting the TXnRTS pin low for the particular transmit buffer(s) that are to be transmitted

If transmission is initiated via the SPI interface, the TXREQ bit can be set at the same time as the TXP priority bits.

When TXBnCTRL.TXREQ is set, the TXBnCTRL.ABTF, TXBnCTRL.MLOA and TXBnCTRL.TXERR bits will be cleared automatically.

**Note:** Setting the TXBnCTRL.TXREQ bit does not initiate a message transmission. It merely flags a message buffer as being ready for transmission. Transmission will start when the device detects that the bus is available.

Once the transmission has completed successfully, the TXBnCTRL.TXREQ bit will be cleared, the CANINTF.TXnIF bit will be set and an interrupt will be generated if the CANINTE.TXnIE bit is set.

If the message transmission fails, the TXBnCTRL.TXREQ will remain set. This indicates that the message is still pending for transmission and one of the following condition flags will be set:

- If the message started to transmit but encountered an error condition, the TXBnCTRL.TXERR and the CANINTF.MERRF bits will be set and an interrupt will be generated on the INT pin if the CANINTE.MERRE bit is set
- If the message is lost, arbitration at the TXBnCTRL.MLOA bit will be set

**Note:** If One-shot mode is enabled (CANCTRL.OSM), the above conditions will still exist. However, the TXREQ bit will be cleared and the message will not attempt transmission a second time.

### 3.4 One-Shot Mode

One-shot mode ensures that a message will only attempt to transmit one time. Normally, if a CAN message loses arbitration, or is destroyed by an error frame, the message is retransmitted. With One-shot mode enabled, a message will only attempt to transmit one time, regardless of arbitration loss or error frame.

One-shot mode is required to maintain time slots in deterministic systems, such as TTCAN.

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## 3.5 TXnRTS PINS

The TXnRTS pins are input pins that can be configured as:

- Request-to-send inputs, which provides an alternative means of initiating the transmission of a message from any of the transmit buffers
- Standard digital inputs

Configuration and control of these pins is accomplished using the TXRTSCTRL register (see Register 3-3). The TXRTSCTRL register can only be modified when the MCP2515 is in Configuration mode (see **Section 10.0 “Modes of Operation”**). If configured to operate as a request-to-send pin, the pin is mapped into the respective TXBnCTRL.TXREQ bit for the transmit buffer. The TXREQ bit is latched by the falling edge of the TXnRTS pin. The TXnRTS pins are designed to allow them to be tied directly to the RXnBF pins to automatically initiate a message transmission when the RXnBF pin goes low.

The TXnRTS pins have internal pull-up resistors of 100 k $\Omega$  (nominal).

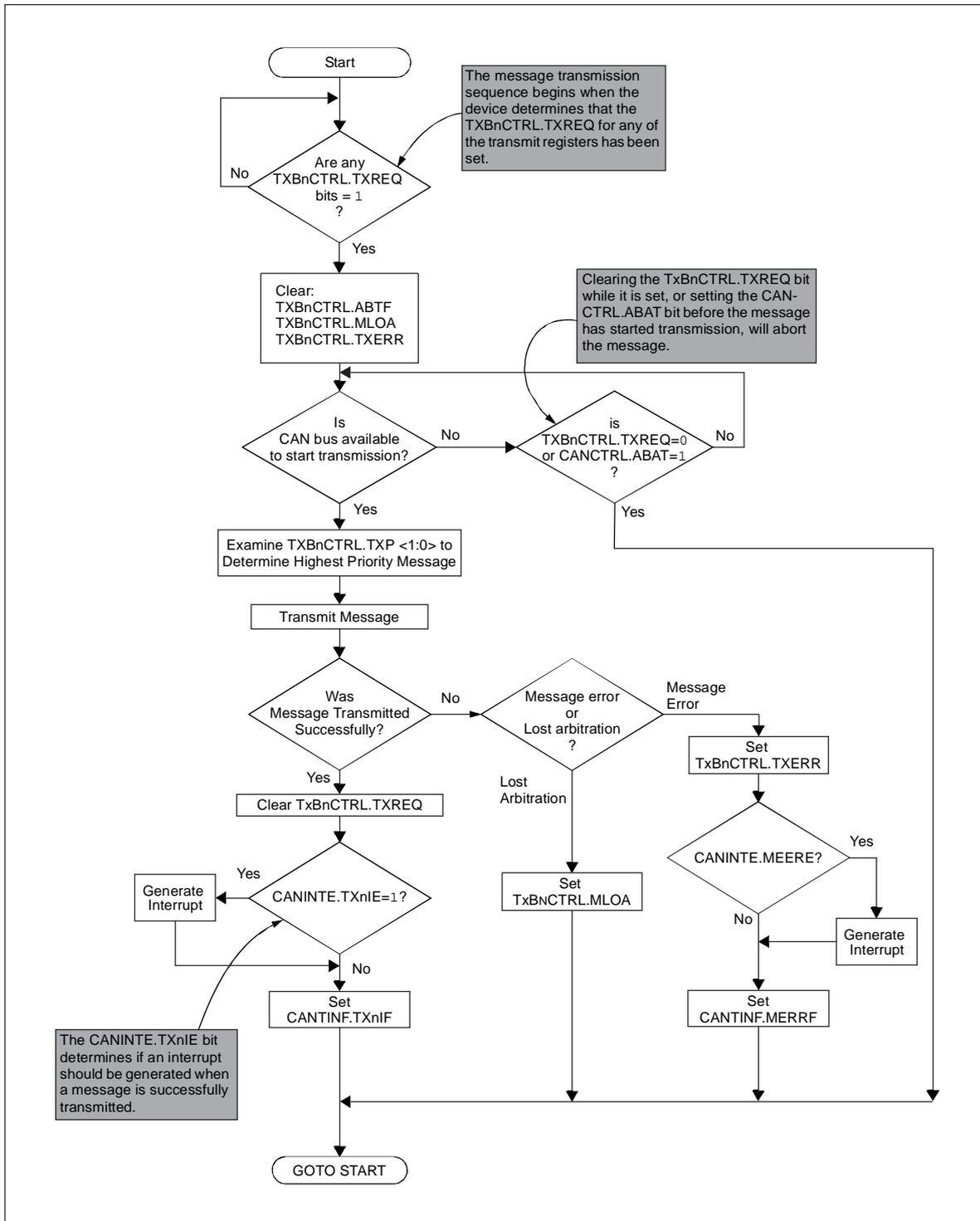
## 3.6 Aborting Transmission

The MCU can request to abort a message in a specific message buffer by clearing the associated TXBnCTRL.TXREQ bit.

In addition, all pending messages can be requested to be aborted by setting the CANCTRL.ABAT bit. This bit MUST be reset (typically after the TXREQ bits have been verified to be cleared) to continue transmitting messages. The CANCTRL.ABTF flag will only be set if the abort was requested via the CANCTRL.ABAT bit. Aborting a message by resetting the TXREQ bit does NOT cause the ABTF bit to be set.

<p><b>Note:</b> Messages that were transmitting when the abort was requested will continue to transmit. If the message does not successfully complete transmission (i.e., lost arbitration or was interrupted by an error frame), it will then be aborted.</p>
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**FIGURE 3-1: TRANSMIT MESSAGE FLOWCHART**



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## REGISTER 3-1: TXBnCTRL – TRANSMIT BUFFER n CONTROL REGISTER (ADDRESS: 30h, 40h, 50h)

U-0	R-0	R-0	R-0	R/W-0	U-0	R/W-0	R/W-0
—	ABTF	MLOA	TXERR	TXREQ	—	TXP1	TXP0
bit 7							bit 0

### Legend:

R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared
		x = Bit is unknown

- bit 7        **Unimplemented:** Read as '0'
- bit 6        **ABTF:** Message Aborted Flag bit
  - 1 = Message was aborted
  - 0 = Message completed transmission successfully
- bit 5        **MLOA:** Message Lost Arbitration bit
  - 1 = Message lost arbitration while being sent
  - 0 = Message did not lose arbitration while being sent
- bit 4        **TXERR:** Transmission Error Detected bit
  - 1 = A bus error occurred while the message was being transmitted
  - 0 = No bus error occurred while the message was being transmitted
- bit 3        **TXREQ:** Message Transmit Request bit
  - 1 = Buffer is currently pending transmission  
(MCU sets this bit to request message be transmitted - bit is automatically cleared when the message is sent)
  - 0 = Buffer is not currently pending transmission  
(MCU can clear this bit to request a message abort)
- bit 2        **Unimplemented:** Read as '0'
- bit 1-0     **TXP:** Transmit Buffer Priority <1:0> bits
  - 11 = Highest Message Priority
  - 10 = High Intermediate Message Priority
  - 01 = Low Intermediate Message Priority
  - 00 = Lowest Message Priority

## REGISTER 3-2: TXRTSCTRL – TX<sub>n</sub>RTS PIN CONTROL AND STATUS REGISTER (ADDRESS: 0Dh)

U-0	U-0	R-x	R-x	R-x	R/W-0	R/W-0	R/W-0	
—	—	B2RTS	B1RTS	B0RTS	B2RTSM	B1RTSM	B0RTSM	
bit 7								bit 0

### Legend:

R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared
		x = Bit is unknown

bit 7	<b>Unimplemented:</b> Read as '0'
bit 6	<b>Unimplemented:</b> Read as '0'
bit 5	<b>B2RTS:</b> $\overline{\text{TX2RTS}}$ Pin State bit - Reads state of $\overline{\text{TX2RTS}}$ pin when in Digital Input mode - Reads as '0' when pin is in 'Request-to-Send' mode
bit 4	<b>B1RTS:</b> $\overline{\text{TX1RTX}}$ Pin State bit - Reads state of $\overline{\text{TX1RTS}}$ pin when in Digital Input mode - Reads as '0' when pin is in 'Request-to-Send' mode
bit 3	<b>B0RTS:</b> $\overline{\text{TX0RTS}}$ Pin State bit - Reads state of $\overline{\text{TX0RTS}}$ pin when in Digital Input mode - Reads as '0' when pin is in 'Request-to-Send' mode
bit 2	<b>B2RTSM:</b> $\overline{\text{TX2RTS}}$ Pin mode bit 1 = Pin is used to request message transmission of TXB2 buffer (on falling edge) 0 = Digital input
bit 1	<b>B1RTSM:</b> $\overline{\text{TX1RTS}}$ Pin mode bit 1 = Pin is used to request message transmission of TXB1 buffer (on falling edge) 0 = Digital input
bit 0	<b>B0RTSM:</b> $\overline{\text{TX0RTS}}$ Pin mode bit 1 = Pin is used to request message transmission of TXB0 buffer (on falling edge) 0 = Digital input

## REGISTER 3-3: TXB<sub>n</sub>SIDH – TRANSMIT BUFFER *n* STANDARD IDENTIFIER HIGH (ADDRESS: 31h, 41h, 51h)

| R/W-x |
|-------|-------|-------|-------|-------|-------|-------|-------|
| SID10 | SID9  | SID8  | SID7  | SID6  | SID5  | SID4  | SID3  |
| bit 7 |       |       |       |       |       |       | bit 0 |

### Legend:

R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared
		x = Bit is unknown

bit 7-0      **SID:** Standard Identifier bits <10:3>

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## REGISTER 3-4: TXBnSIDL – TRANSMIT BUFFER n STANDARD IDENTIFIER LOW (ADDRESS: 32h, 42h, 52h)

R/W-x							
SID2	SID1	SID0	—	EXIDE	—	EID17	EID16
bit 7							bit 0

<b>Legend:</b>			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

- bit 7-5     **SID:** Standard Identifier bits <2:0>
- bit 4       **Unimplemented:** Reads as '0'
- bit 3       **EXIDE:** Extended Identifier Enable bit
  - 1 = Message will transmit extended identifier
  - 0 = Message will transmit standard identifier
- bit 2       **Unimplemented:** Reads as '0'
- bit 1-0     **EID:** Extended Identifier bits <17:16>

## REGISTER 3-5: TXBnEID8 – TRANSMIT BUFFER n EXTENDED IDENTIFIER HIGH (ADDRESS: 33h, 43h, 53h)

R/W-x							
EID15	EID14	EID13	EID12	EID11	EID10	EID9	EID8
bit 7							bit 0

<b>Legend:</b>			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

- bit 7-0     **EID:** Extended Identifier bits <15:8>

## REGISTER 3-6: TXBnEID0 – TRANSMIT BUFFER n EXTENDED IDENTIFIER LOW (ADDRESS: 34h, 44h, 54h)

R/W-x							
EID7	EID6	EID5	EID4	EID3	EID2	EID1	EID0
bit 7							bit 0

<b>Legend:</b>			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

- bit 7-0     **EID:** Extended Identifier bits <7:0>

**REGISTER 3-7: TXBnDLC - TRANSMIT BUFFER n DATA LENGTH CODE  
(ADDRESS: 35h, 45h, 55h)**

| R/W-x |
|-------|-------|-------|-------|-------|-------|-------|-------|
| —     | RTR   | —     | —     | DLC3  | DLC2  | DLC1  | DLC0  |
| bit 7 |       |       |       |       |       |       | bit 0 |

**Legend:**

R = Readable bit                      W = Writable bit                      U = Unimplemented bit, read as '0'  
 -n = Value at POR                      '1' = Bit is set                      '0' = Bit is cleared                      x = Bit is unknown

bit 7                      **Unimplemented:** Reads as '0'

bit 6                      **RTR:** Remote Transmission Request bit  
                                  1 = Transmitted Message will be a Remote Transmit Request  
                                  0 = Transmitted Message will be a Data Frame

bit 5-4                      **Unimplemented:** Reads as '0'

bit 3-0                      **DLC:** Data Length Code <3:0> bits  
                                  Sets the number of data bytes to be transmitted (0 to 8 bytes)

**Note:** It is possible to set the DLC to a value greater than 8, however only 8 bytes are transmitted

**REGISTER 3-8: TXBnDm – TRANSMIT BUFFER n DATA BYTE m  
(ADDRESS: 36h - 3Dh, 46h - 4Dh, 56h - 5Dh)**

| R/W-x   |
|---------|---------|---------|---------|---------|---------|---------|---------|
| TXBnDm7 | TXBnDm6 | TXBnDm5 | TXBnDm4 | TXBnDm3 | TXBnDm2 | TXBnDm1 | TXBnDm0 |
| bit 7   |         |         |         |         |         |         | bit 0   |

**Legend:**

R = Readable bit                      W = Writable bit                      U = Unimplemented bit, read as '0'  
 -n = Value at POR                      '1' = Bit is set                      '0' = Bit is cleared                      x = Bit is unknown

bit 7-0                      **TXBnDm7:TXBnDm0:** Transmit Buffer n Data Field Bytes m

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NOTES:

## 4.0 MESSAGE RECEPTION

### 4.1 Receive Message Buffering

The MCP2515 includes two full receive buffers with multiple acceptance filters for each. There is also a separate Message Assembly Buffer (MAB) that acts as a third receive buffer (see [Figure 4-2](#)).

#### 4.1.1 MESSAGE ASSEMBLY BUFFER

Of the three receive buffers, the MAB is always committed to receiving the next message from the bus. The MAB assembles all messages received. These messages will be transferred to the RXBn buffers (See Register 4-4 to Register 4-9) only if the acceptance filter criteria is met.

#### 4.1.2 RXB0 AND RXB1

The remaining two receive buffers, called RXB0 and RXB1, can receive a complete message from the protocol engine via the MAB. The MCU can access one buffer, while the other buffer is available for message reception, or for holding a previously received message.

**Note:** The entire contents of the MAB is moved into the receive buffer once a message is accepted. This means that, regardless of the type of identifier (standard or extended) and the number of data bytes received, the entire receive buffer is overwritten with the MAB contents. Therefore, the contents of all registers in the buffer must be assumed to have been modified when any message is received.

#### 4.1.3 RECEIVE FLAGS/INTERRUPTS

When a message is moved into either of the receive buffers, the appropriate CANINTF.RXnIF bit is set. This bit must be cleared by the MCU in order to allow a new message to be received into the buffer. This bit provides a positive lockout to ensure that the MCU has finished with the message before the MCP2515 attempts to load a new message into the receive buffer.

If the CANINTE.RXnIE bit is set, an interrupt will be generated on the  $\overline{\text{INT}}$  pin to indicate that a valid message has been received. In addition, the associated RXnBF pin will drive low if configured as a receive buffer full pin. See [Section 4.4 “RX0BF and RX1BF Pins”](#) for details.

### 4.2 Receive Priority

RXB0, the higher priority buffer, has one mask and two message acceptance filters associated with it. The received message is applied to the mask and filters for RXB0 first.

RXB1 is the lower priority buffer, with one mask and four acceptance filters associated with it.

In addition to the message being applied to the RBO mask and filters first, the lower number of acceptance filters makes the match on RXB0 more restrictive and implies a higher priority for that buffer.

When a message is received, bits <3:0> of the RXBnCTRL register will indicate the acceptance filter number that enabled reception and whether the received message is a remote transfer request.

#### 4.2.1 ROLLOVER

Additionally, the RXB0CTRL register can be configured such that, if RXB0 contains a valid message and another valid message is received, an overflow error will not occur and the new message will be moved into RXB1, regardless of the acceptance criteria of RXB1.

#### 4.2.2 RXM BITS

The RXBnCTRL.RXM bits set special receive modes. Normally, these bits are cleared to 00 to enable reception of all valid messages as determined by the appropriate acceptance filters. In this case, the determination of whether or not to receive standard or extended messages is determined by the RFXnSIDL.EXIDE bit in the acceptance filter register.

If the RXBnCTRL.RXM bits are set to 01 or 10, the receiver will only accept messages with standard or extended identifiers, respectively. If an acceptance filter has the RFXnSIDL.EXIDE bit set such that it does not correspond with the RXBnCTRL.RXM mode, that acceptance filter is rendered useless. These two modes of RXBnCTRL.RXM bits can be used in systems where it is known that only standard or extended messages will be on the bus.

If the RXBnCTRL.RXM bits are set to 11, the buffer will receive all messages, regardless of the values of the acceptance filters. Also, if a message has an error before the EOF, that portion of the message assembled in the MAB before the error frame will be loaded into the buffer. This mode has some value in debugging a CAN system and would not be used in an actual system environment.

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## 4.3 Start-of-Frame Signal

If enabled, the Start-Of-Frame signal is generated on the SOF pin at the beginning of each CAN message detected on the RXCAN pin.

The RXCAN pin monitors an idle bus for a recessive-to-dominant edge. If the dominant condition remains until the sample point, the DSTEMP interprets this as a SOF and a SOF pulse is generated. If the dominant condition does not remain until the sample point, the DSTEMP interprets this as a glitch on the bus and no SOF signal is generated. Figure 4-1 illustrates SOF signalling and glitch-filtering.

As with One-shot mode, one use for SOF signaling is for TTCAN-type systems. In addition, by monitoring both the RXCAN pin and the SOF pin, a MCU can detect early physical bus problems by detecting small glitches before they affect the CAN communications.

## 4.4 RX0BF and RX1BF Pins

In addition to the  $\overline{\text{INT}}$  pin, which provides an interrupt signal to the MCU for many different conditions, the receive buffer full pins (RX0BF and RX1BF) can be used to indicate that a valid message has been loaded into RXB0 or RXB1, respectively. The pins have three different configurations (Register 4-1):

1. Disabled.
2. Buffer Full Interrupt.
3. Digital Output.

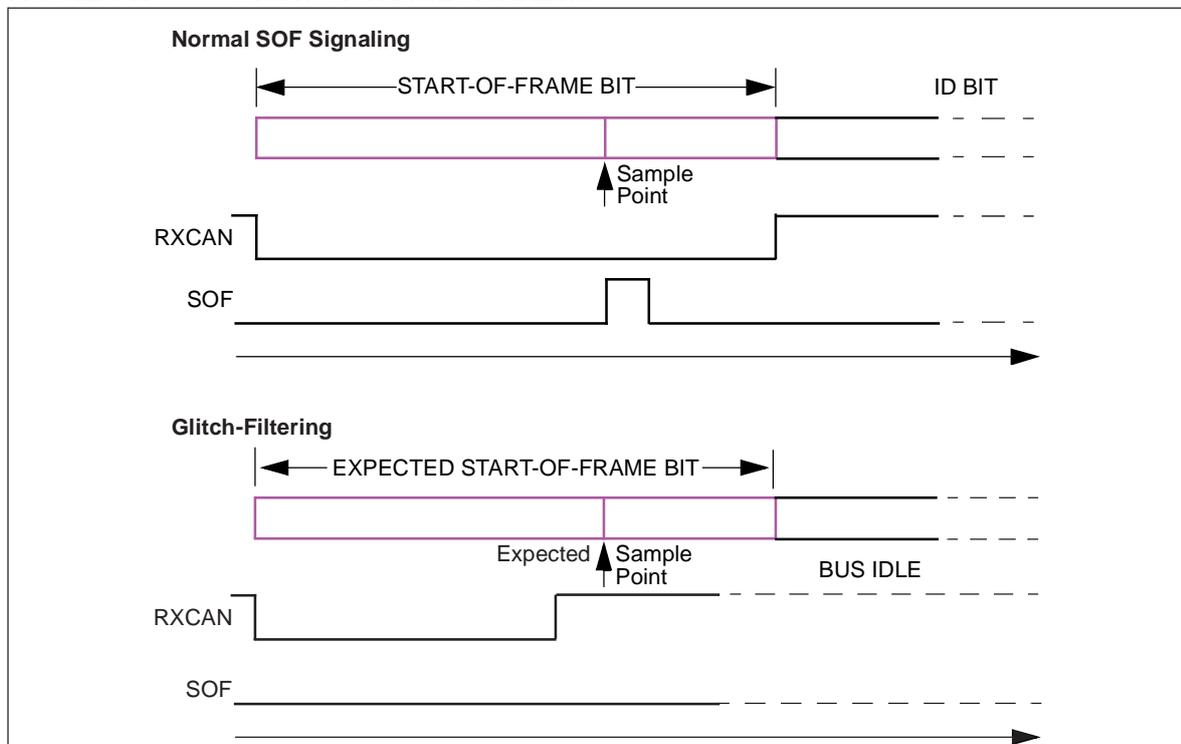
### 4.4.1 DISABLED

The  $\overline{\text{RXBnBF}}$  pins can be disabled to the high-impedance state by clearing BFPCTRL.BnBFE.

### 4.4.2 CONFIGURED AS BUFFER FULL

The  $\overline{\text{RXBnBF}}$  pins can be configured to act as either buffer full interrupt pins or as standard digital outputs. Configuration and status of these pins is available via the BFPCTRL register (Register 4-3). When set to operate in Interrupt mode (by setting BFPCTRL.BxBFE and BFPCTRL.BxBFM bits), these pins are active-low and are mapped to the CANINTF.RXnIF bit for each receive buffer. When this bit goes high for one of the receive buffers (indicating that a valid message has been loaded into the buffer), the corresponding  $\overline{\text{RXBnBF}}$  pin will go low. When the CANINTF.RXnIF bit is cleared by the MCU, the corresponding interrupt pin will go to the logic-high state until the next message is loaded into the receive buffer.

FIGURE 4-1: START-OF-FRAME SIGNALING



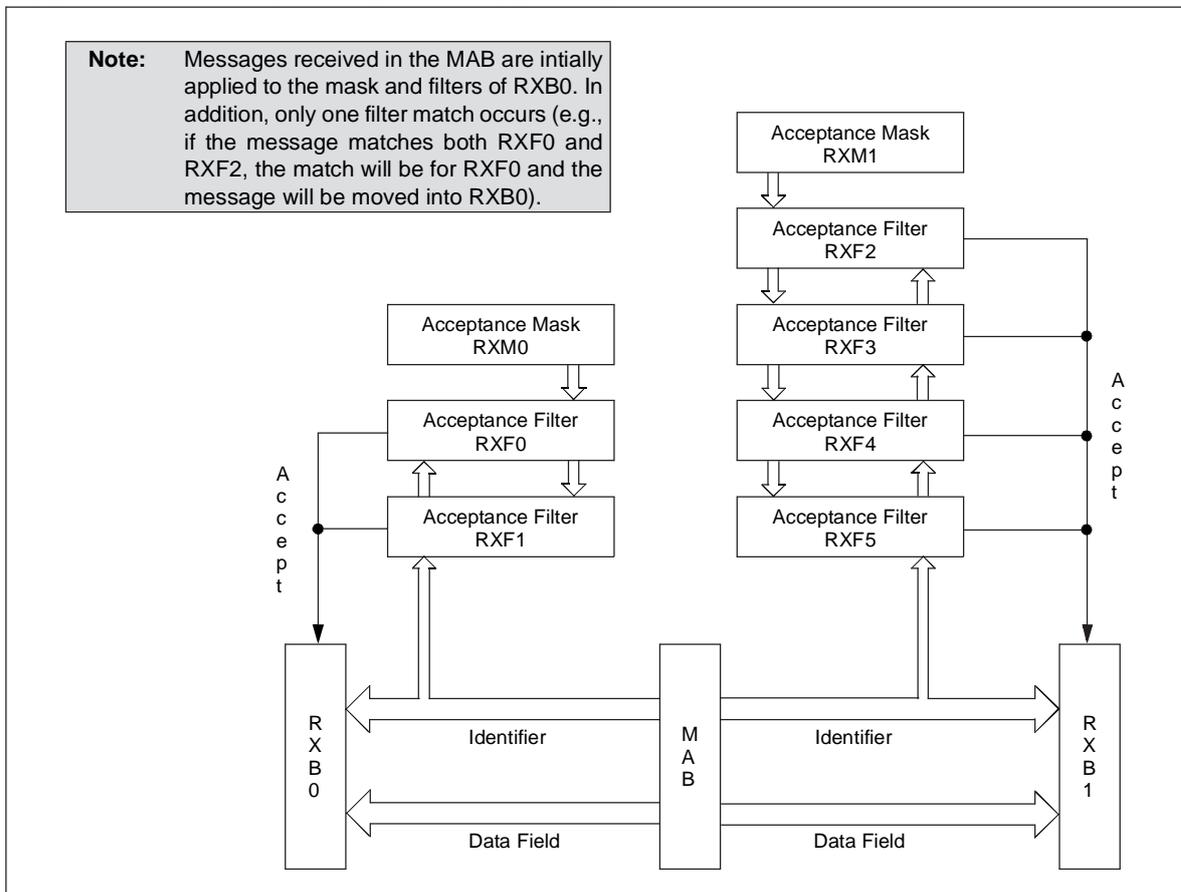
## 4.4.3 CONFIGURED AS DIGITAL OUTPUT

When used as digital outputs, the BFPCTRL.BxBFM bit must be cleared and BFPCTRL.BnBFE must be set for the associated buffer. In this mode, the state of the pin is controlled by the BFPCTRL.BnBFS bits. Writing a '1' to the BnBFS bit will cause a high level to be driven on the associated buffer full pin, while a '0' will cause the pin to drive low. When using the pins in this mode, the state of the pin should be modified only by using the Bit Modify SPI command to prevent glitches from occurring on either of the buffer full pins.

**TABLE 4-1: CONFIGURING RXNBF PINS**

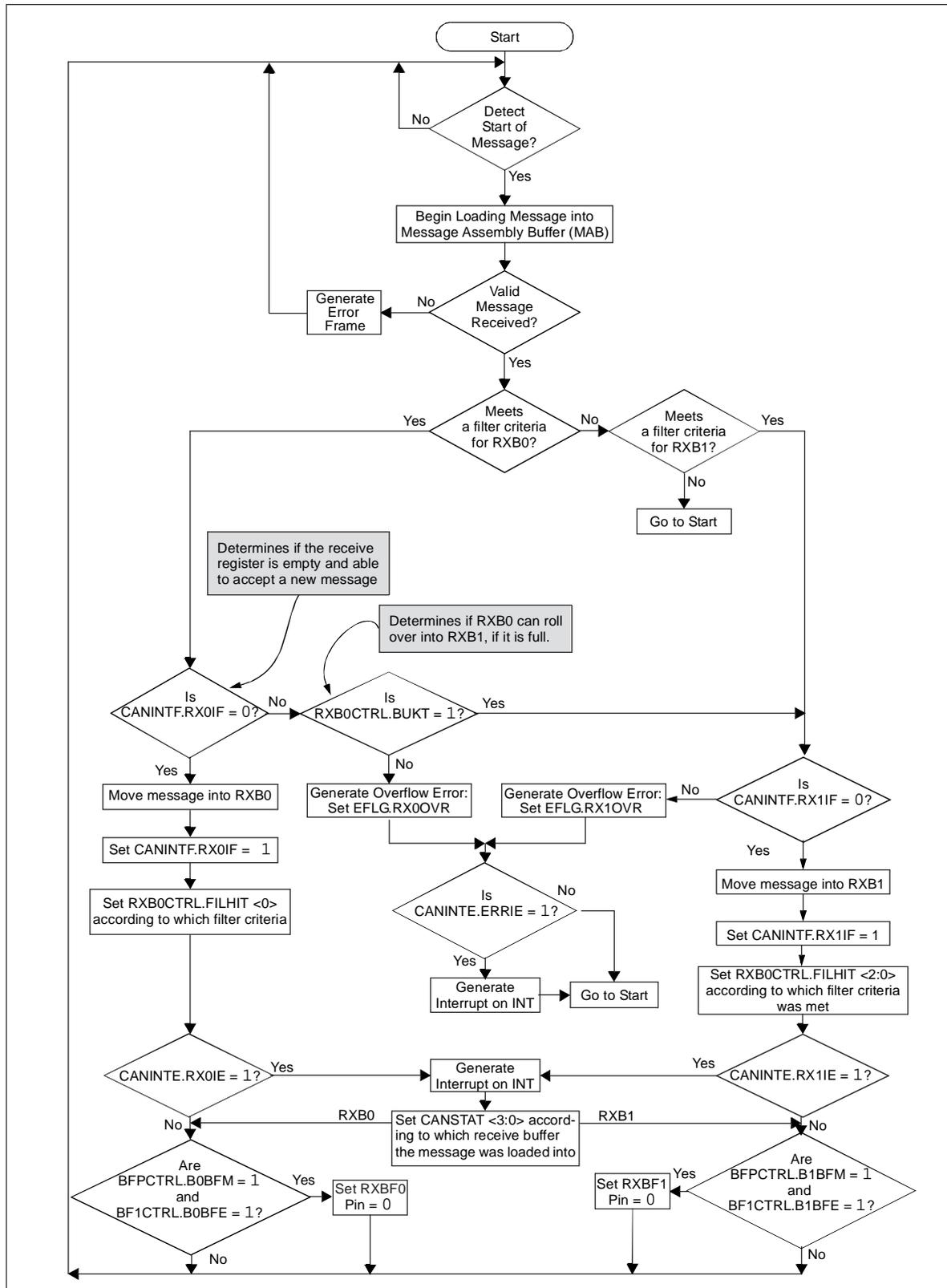
BnBFE	BnBFM	BnBFS	Pin Status
0	X	X	Disabled, high-impedance
1	1	X	Receive buffer interrupt
1	0	0	Digital output = 0
1	0	1	Digital output = 1

**FIGURE 4-2: RECEIVE BUFFER BLOCK DIAGRAM**



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FIGURE 4-3: RECEIVE FLOW FLOWCHART



**REGISTER 4-1: RXB0CTRL – RECEIVE BUFFER 0 CONTROL  
(ADDRESS: 60h)**

U-0	R/W-0	R/W-0	U-0	R-0	R/W-0	R-0	R-0	
—	RXM1	RXM0	—	RXRTR	BUKT	BUKT1	FILHITO	
bit 7								bit 0

**Legend:**

R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared
		x = Bit is unknown

bit 7 **Unimplemented:** Read as '0'

bit 6-5 **RXM:** Receive Buffer Operating Mode bits

11 = Turn mask/filters off; receive any message

10 = Receive only valid messages with extended identifiers that meet filter criteria

01 = Receive only valid messages with standard identifiers that meet filter criteria

00 = Receive all valid messages using either standard or extended identifiers that meet filter criteria

bit 4 **Unimplemented:** Read as '0'

bit 3 **RXRTR:** Received Remote Transfer Request bit

1 = Remote Transfer Request Received

0 = No Remote Transfer Request Received

bit 2 **BUKT:** Rollover Enable bit

1 = RXB0 message will rollover and be written to RXB1 if RXB0 is full

0 = Rollover disabled

bit 1 **BUKT1:** Read-only Copy of BUKT bit (used internally by the MCP2515)

bit 0 **FILHIT:** Filter Hit bit - indicates which acceptance filter enabled reception of message

1 = Acceptance Filter 1 (RXF1)

0 = Acceptance Filter 0 (RXF0)

**Note:** If a rollover from RXB0 to RXB1 occurs, the FILHIT bit will reflect the filter that accepted the message that rolled over.

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## REGISTER 4-2: RXB1CTRL – RECEIVE BUFFER 1 CONTROL (ADDRESS: 70h)

U-0	R/W-0	R/W-0	U-0	R-0	R-0	R-0	R-0	
—	RXM1	RXM0	—	RXRTR	FILHIT2	FILHIT1	FILHIT0	
bit 7								bit 0

### Legend:

R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared      x = Bit is unknown

- bit 7            **Unimplemented:** Read as '0'
- bit 6-5        **RXM:** Receive Buffer Operating Mode bits
  - 11 = Turn mask/filters off; receive any message
  - 10 = Receive only valid messages with extended identifiers that meet filter criteria
  - 01 = Receive only valid messages with standard identifiers that meet filter criteria
  - 00 = Receive all valid messages using either standard or extended identifiers that meet filter criteria
- bit 4            **Unimplemented:** Read as '0'
- bit 3            **RXRTR:** Received Remote Transfer Request bit
  - 1 = Remote Transfer Request Received
  - 0 = No Remote Transfer Request Received
- bit 2-0        **FILHIT:** Filter Hit bits - indicates which acceptance filter enabled reception of message
  - 101 = Acceptance Filter 5 (RXF5)
  - 100 = Acceptance Filter 4 (RXF4)
  - 011 = Acceptance Filter 3 (RXF3)
  - 010 = Acceptance Filter 2 (RXF2)
  - 001 = Acceptance Filter 1 (RXF1) (Only if BUKT bit set in RXB0CTRL)
  - 000 = Acceptance Filter 0 (RXF0) (Only if BUKT bit set in RXB0CTRL)

## REGISTER 4-3: BFPCTRL – RXnBF PIN CONTROL AND STATUS (ADDRESS: 0Ch)

U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	B1BFS	B0BFS	B1BFE	B0BFE	B1BFM	B0BFM
bit 7							bit 0

### Legend:

R = Readable bit                      W = Writable bit                      U = Unimplemented bit, read as '0'  
 -n = Value at POR                      '1' = Bit is set                      '0' = Bit is cleared                      x = Bit is unknown

- bit 7                      **Unimplemented:** Read as '0'
- bit 6                      **Unimplemented:** Read as '0'
- bit 5                      **B1BFS:**  $\overline{\text{RX1BF}}$  Pin State bit (Digital Output mode only)  
 - Reads as '0' when RX1BF is configured as interrupt pin
- bit 4                      **B0BFS:**  $\overline{\text{RX0BF}}$  Pin State bit (Digital Output mode only)  
 - Reads as '0' when RX0BF is configured as interrupt pin
- bit 3                      **B1BFE:**  $\overline{\text{RX1BF}}$  Pin Function Enable bit  
 1 = Pin function enabled, operation mode determined by B1BFM bit  
 0 = Pin function disabled, pin goes to high-impedance state
- bit 2                      **B0BFE:**  $\overline{\text{RX0BF}}$  Pin Function Enable bit  
 1 = Pin function enabled, operation mode determined by B0BFM bit  
 0 = Pin function disabled, pin goes to high-impedance state
- bit 1                      **B1BFM:**  $\overline{\text{RX1BF}}$  Pin Operation Mode bit  
 1 = Pin is used as interrupt when valid message loaded into RXB1  
 0 = Digital Output mode
- bit 0                      **B0BFM:**  $\overline{\text{RX0BF}}$  Pin Operation Mode bit  
 1 = Pin is used as interrupt when valid message loaded into RXB0  
 0 = Digital Output mode

## REGISTER 4-4: RXBnSIDH – RECEIVE BUFFER n STANDARD IDENTIFIER HIGH (ADDRESS: 61h, 71h)

R-x	R-x	R-x	R-x	R-x	R-x	R-x	R-x
SID10	SID9	SID8	SID7	SID6	SID5	SID4	SID3
bit 7							bit 0

### Legend:

R = Readable bit                      W = Writable bit                      U = Unimplemented bit, read as '0'  
 -n = Value at POR                      '1' = Bit is set                      '0' = Bit is cleared                      x = Bit is unknown

- bit 7-0                      **SID:** Standard Identifier bits <10:3>  
 These bits contain the eight most significant bits of the Standard Identifier for the received message

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## REGISTER 4-5: RXBnSIDL – RECEIVE BUFFER n STANDARD IDENTIFIER LOW (ADDRESS: 62h, 72h)

R-x	R-x	R-x	R-x	R-x	U-0	R-x	R-x
SID2	SID1	SID0	SRR	IDE	—	EID17	EID16
bit 7							bit 0

### Legend:

R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared
		x = Bit is unknown

- bit 7-5     **SID:** Standard Identifier bits <2:0>  
 These bits contain the three least significant bits of the Standard Identifier for the received message
- bit 4     **SRR:** Standard Frame Remote Transmit Request bit (valid only if IDE bit = '0')  
 1 = Standard Frame Remote Transmit Request Received  
 0 = Standard Data Frame Received
- bit 3     **IDE:** Extended Identifier Flag bit  
 This bit indicates whether the received message was a Standard or an Extended Frame  
 1 = Received message was an Extended Frame  
 0 = Received message was a Standard Frame
- bit 2     **Unimplemented:** Reads as '0'
- bit 1-0   **EID:** Extended Identifier bits <17:16>  
 These bits contain the two most significant bits of the Extended Identifier for the received message

## REGISTER 4-6: RXBnEID8 – RECEIVE BUFFER n EXTENDED IDENTIFIER HIGH (ADDRESS: 63h, 73h)

R-x	R-x	R-x	R-x	R-x	R-x	R-x	R-x
EID15	EID14	EID13	EID12	EID11	EID10	EID9	EID8
bit 7							bit 0

### Legend:

R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared
		x = Bit is unknown

- bit 7-0   **EID:** Extended Identifier bits <15:8>  
 These bits hold bits 15 through 8 of the Extended Identifier for the received message

## REGISTER 4-7: RXBnEID0 – RECEIVE BUFFER n EXTENDED IDENTIFIER LOW (ADDRESS: 64h, 74h)

R-x	R-x	R-x	R-x	R-x	R-x	R-x	R-x
EID7	EID6	EID5	EID4	EID3	EID2	EID1	EID0
bit 7							bit 0

### Legend:

R = Readable bit                      W = Writable bit                      U = Unimplemented bit, read as '0'  
 -n = Value at POR                      '1' = Bit is set                      '0' = Bit is cleared                      x = Bit is unknown

bit 7-0                      **EID:** Extended Identifier bits <7:0>  
 These bits hold the least significant eight bits of the Extended Identifier for the received message

## REGISTER 4-8: RXBnDLC – RECEIVE BUFFER n DATA LENGHT CODE (ADDRESS: 65h, 75h)

R-x	R-x	R-x	R-x	R-x	R-x	R-x	R-x
EID7	EID6	EID5	EID4	EID3	EID2	EID1	EID0
bit 7							bit 0

### Legend:

R = Readable bit                      W = Writable bit                      U = Unimplemented bit, read as '0'  
 -n = Value at POR                      '1' = Bit is set                      '0' = Bit is cleared                      x = Bit is unknown

bit 7                      **Unimplemented:** Reads as '0'  
 bit 6                      **RTR:** Extended Frame Remote Transmission Request bit  
 (valid only when RXBnSIDL.IDE = '1')  
 1 = Extended Frame Remote Transmit Request Received  
 0 = Extended Data Frame Received  
 bit 5                      **RB1:** Reserved Bit 1  
 bit 4                      **RB0:** Reserved Bit 0  
 bit 3-0                      **DLC:** Data Length Code bits <3:0>  
 Indicates number of data bytes that were received

## REGISTER 4-9: RXBnDM – RECEIVE BUFFER n DATA BYTE M (ADDRESS: 66h - 6Dh, 76h - 7Dh)

R-x							
RBnDm7	RBnDm6	RBnDm5	RBnDm4	RBnDm3	RBnDm2	RBnDm1	RBnDm0
bit 7							bit 0

### Legend:

R = Readable bit                      W = Writable bit                      U = Unimplemented bit, read as '0'  
 -n = Value at POR                      '1' = Bit is set                      '0' = Bit is cleared                      x = Bit is unknown

bit 7-0                      **RBnDm7:RBnDm0:** Receive Buffer n Data Field Bytes m  
 Eight bytes containing the data bytes for the received message

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## 4.5 Message Acceptance Filters and Masks

The message acceptance filters and masks are used to determine if a message in the message assembly buffer should be loaded into either of the receive buffers (see Figure 4-5). Once a valid message has been received into the MAB, the identifier fields of the message are compared to the filter values. If there is a match, that message will be loaded into the appropriate receive buffer.

### 4.5.1 DATA BYTE FILTERING

When receiving standard data frames (11-bit identifier), the DSTEMP automatically applies 16 bits of masks and filters normally associated with extended identifiers to the first 16 bits of the data field (data bytes 0 and 1). Figure 4-4 illustrates how masks and filters apply to extended and standard data frames.

Data byte filtering reduces the load on the MCU when implementing Higher Layer Protocols (HLPs) that filter on the first data byte (e.g., DeviceNet™).

### 4.5.2 FILTER MATCHING

The filter masks (see Register 4-14 through Register 4-17) are used to determine which bits in the identifier are examined with the filters. A truth table is shown in Table 4-2 that indicates how each bit in the

identifier is compared to the masks and filters to determine if the message should be loaded into a receive buffer. The mask essentially determines which bits to apply the acceptance filters to. If any mask bit is set to a zero, that bit will automatically be accepted, regardless of the filter bit.

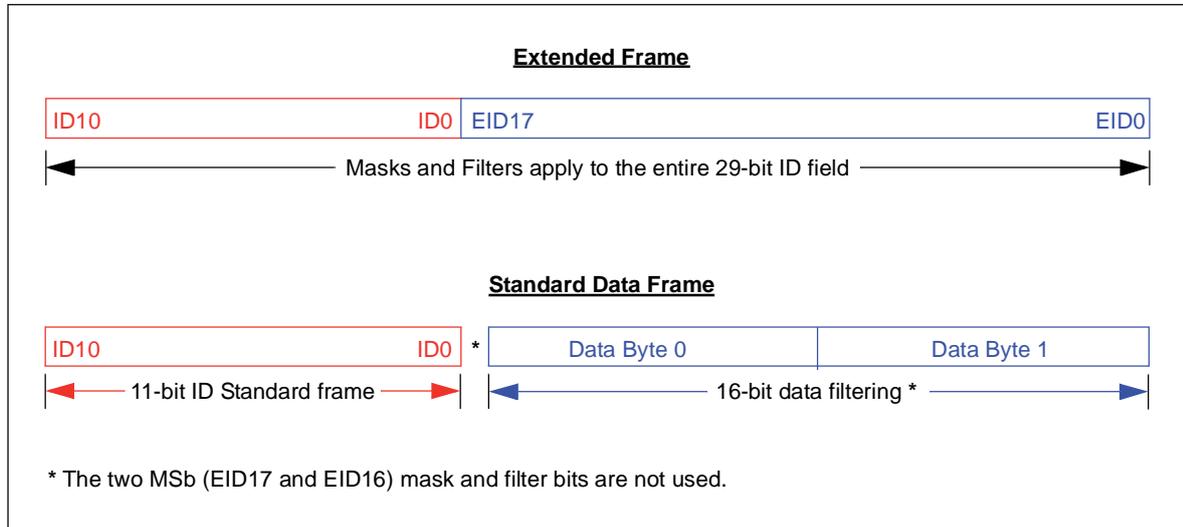
**TABLE 4-2: FILTER/MASK TRUTH TABLE**

Mask Bit n	Filter Bit n	Message Identifier bit	Accept or Reject bit n
0	x	x	Accept
1	0	0	Accept
1	0	1	Reject
1	1	0	Reject
1	1	1	Accept

**Note:** x = don't care

As shown in the receive buffers block diagram (Figure 4-2), acceptance filters RXF0 and RXF1 (and filter mask RXM0) are associated with RXB0. Filters RXF2, RXF3, RXF4, RXF5 and mask RXM1 are associated with RXB1.

**FIGURE 4-4: MASKS AND FILTERS APPLY TO CAN FRAMES**



## 4.5.3 FILHIT BITS

Filter matches on received messages can be determined by the FILHIT bits in the associated RXBnCTRL register. RXB0CTRL.FILHIT0 for buffer 0 and RXB1CTRL.FILHIT<2:0> for buffer 1.

The three FILHIT bits for receive buffer 1 (RXB1) are coded as follows:

- 101 = Acceptance Filter 5 (RXF5)
- 100 = Acceptance Filter 4 (RXF4)
- 011 = Acceptance Filter 3 (RXF3)
- 010 = Acceptance Filter 2 (RXF2)
- 001 = Acceptance Filter 1 (RXF1)
- 000 = Acceptance Filter 0 (RXF0)

**Note:** 000 and 001 can only occur if the BUKT bit in RXB0CTRL is set, allowing RXB0 messages to roll over into RXB1.

RXB0CTRL contains two copies of the BUKT bit and the FILHIT<0> bit.

The coding of the BUKT bit enables these three bits to be used similarly to the RXB1CTRL.FILHIT bits and to distinguish a hit on filter RXF0 and RXF1 in either RXB0 or after a roll over into RXB1.

- 111 = Acceptance Filter 1 (RXB1)
- 110 = Acceptance Filter 0 (RXB1)
- 001 = Acceptance Filter 1 (RXB0)
- 000 = Acceptance Filter 0 (RXB0)

If the BUKT bit is clear, there are six codes corresponding to the six filters. If the BUKT bit is set, there are six codes corresponding to the six filters, plus two additional codes corresponding to RXF0 and RXF1 filters that roll over into RXB1.

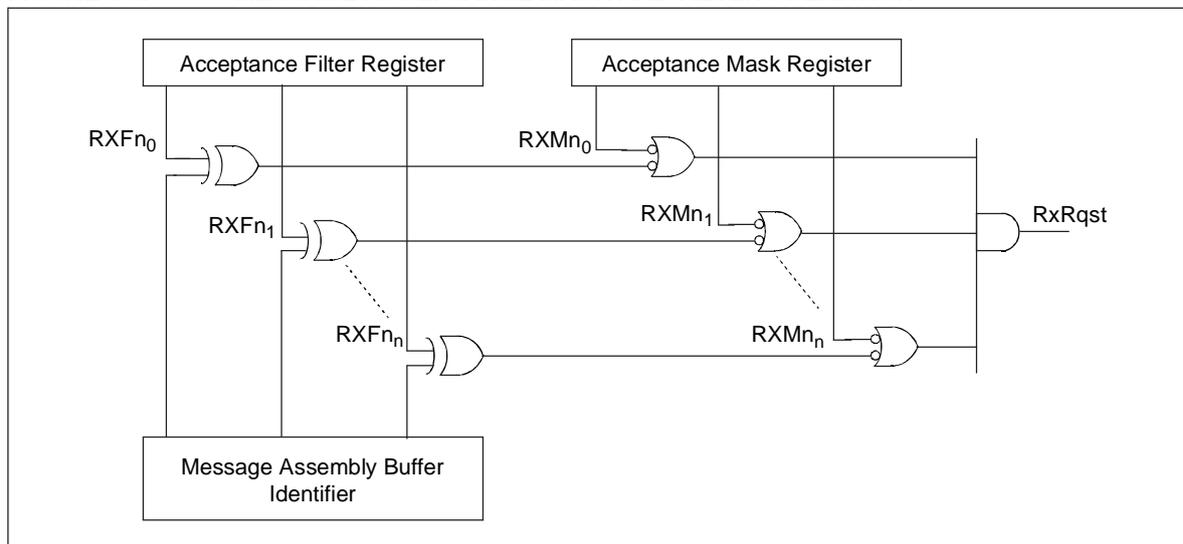
## 4.5.4 MULTIPLE FILTER MATCHES

If more than one acceptance filter matches, the FILHIT bits will encode the binary value of the lowest numbered filter that matched. For example, if filter RXF2 and filter RXF4 match, FILHIT will be loaded with the value for RXF2. This essentially prioritizes the acceptance filters with a lower-numbered filter having higher priority. Messages are compared to filters in ascending order of filter number. This also insures that the message will only be received into one buffer. This implies that RXB0 has a higher priority than RXB1.

## 4.5.5 CONFIGURING THE MASKS AND FILTERS

The mask and filter registers can only be modified when the MCP2515 is in Configuration mode (see **Section 10.0 "Modes of Operation"**).

**FIGURE 4-5: MESSAGE ACCEPTANCE MASK AND FILTER OPERATION**



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## REGISTER 4-10: RXFnSIDH – FILTER n STANDARD IDENTIFIER HIGH (ADDRESS: 00h, 04h, 08h, 10h, 14h, 18h)

R/W-x							
SID10	SID9	SID8	SID7	SID6	SID5	SID4	SID3
bit 7							bit 0

<b>Legend:</b>			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 7-0      **SID:** Standard Identifier Filter bits <10:3>  
 These bits hold the filter bits to be applied to bits <10:3> of the Standard Identifier portion of a received message

## REGISTER 4-11: RXFnSIDL – FILTER n STANDARD IDENTIFIER LOW (ADDRESS: 01h, 05h, 09h, 11h, 15h, 19h)

R/W-x	R/W-x	R/W-x	U-0	R/W-x	U-0	R/W-x	R/W-x
SID2	SID1	SID0	—	EXIDE	—	EID17	EID16
bit 7							bit 0

<b>Legend:</b>			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 7-5      **SID:** Standard Identifier Filter bits <2:0>  
 These bits hold the filter bits to be applied to bits <2:0> of the Standard Identifier portion of a received message

bit 4      **Unimplemented:** Reads as '0'

bit 3      **EXIDE:** Extended Identifier Enable bit  
 1 = Filter is applied only to Extended Frames  
 0 = Filter is applied only to Standard Frames

bit 2      **Unimplemented:** Reads as '0'

bit 1-0      **EID:** Extended Identifier Filter bits <17:16>  
 These bits hold the filter bits to be applied to bits <17:16> of the Extended Identifier portion of a received message

**REGISTER 4-12: RXFnEID8 – FILTER n EXTENDED IDENTIFIER HIGH  
(ADDRESS: 02h, 06h, 0Ah, 12h, 16h, 1Ah)**

| R/W-x |
|-------|-------|-------|-------|-------|-------|-------|-------|
| EID15 | EID14 | EID13 | EID12 | EID11 | EID10 | EID9  | EID8  |
| bit 7 |       |       |       |       |       |       | bit 0 |

**Legend:**

R = Readable bit                      W = Writable bit                      U = Unimplemented bit, read as '0'  
 -n = Value at POR                      '1' = Bit is set                      '0' = Bit is cleared                      x = Bit is unknown

bit 7-0                      **EID:** Extended Identifier bits <15:8>  
 These bits hold the filter bits to be applied to bits <15:8> of the Extended Identifier portion of a received message

**REGISTER 4-13: RXFnEID0 – FILTER n EXTENDED IDENTIFIER LOW  
(ADDRESS: 03h, 07h, 0Bh, 13h, 17h, 1Bh)**

| R/W-x |
|-------|-------|-------|-------|-------|-------|-------|-------|
| EID7  | EID6  | EID5  | EID4  | EID3  | EID2  | EID1  | EID0  |
| bit 7 |       |       |       |       |       |       | bit 0 |

**Legend:**

R = Readable bit                      W = Writable bit                      U = Unimplemented bit, read as '0'  
 -n = Value at POR                      '1' = Bit is set                      '0' = Bit is cleared                      x = Bit is unknown

bit 7-0                      **EID:** Extended Identifier bits <7:0>  
 These bits hold the filter bits to be applied to the bits <7:0> of the Extended Identifier portion of a received message

**REGISTER 4-14: RXMnSIDH – MASK n STANDARD IDENTIFIER HIGH  
(ADDRESS: 20h, 24h)**

| R/W-0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| SID10 | SID9  | SID8  | SID7  | SID6  | SID5  | SID4  | SID3  |
| bit 7 |       |       |       |       |       |       | bit 0 |

**Legend:**

R = Readable bit                      W = Writable bit                      U = Unimplemented bit, read as '0'  
 -n = Value at POR                      '1' = Bit is set                      '0' = Bit is cleared                      x = Bit is unknown

bit 7-0                      **SID:** Standard Identifier Mask bits <10:3>  
 These bits hold the mask bits to be applied to bits <10:3> of the Standard Identifier portion of a received message

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## REGISTER 4-15: RXMnSIDL – MASK n STANDARD IDENTIFIER LOW (ADDRESS: 21h, 25h)

R/W-0	R/W-0	R/W-0	U-0	U-0	U-0	R/W-0	R/W-0
SID2	SID1	SID0	—	—	—	EID17	EID16
bit 7							bit 0

<b>Legend:</b>			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

- bit 7-5      **SID:** Standard Identifier Mask bits <2:0>  
These bits hold the mask bits to be applied to bits<2:0> of the Standard Identifier portion of a received message
- bit 4-2      **Unimplemented:** Reads as '0'
- bit 1-0      **EID:** Extended Identifier Mask bits <17:16>  
These bits hold the mask bits to be applied to bits <17:16> of the Extended Identifier portion of a received message

## REGISTER 4-16: RXMnEID8 – MASK n EXTENDED IDENTIFIER HIGH (ADDRESS: 22h, 26h)

R/W-0							
EID15	EID14	EID13	EID12	EID11	EID10	EID9	EID8
bit 7							bit 0

<b>Legend:</b>			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

- bit 7-0      **EID:** Extended Identifier bits <15:8>  
These bits hold the filter bits to be applied to bits <15:8> of the Extended Identifier portion of a received message

## REGISTER 4-17: RXMnEID0 – MASK n EXTENDED IDENTIFIER LOW (ADDRESS: 23h, 27h)

R/W-0							
EID7	EID6	EID5	EID4	EID3	EID2	EID1	EID0
bit 7							bit 0

<b>Legend:</b>			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

- bit 7-0      **EID:** Extended Identifier Mask bits <7:0>  
These bits hold the mask bits to be applied to the bits <7:0> of the Extended Identifier portion of a received message

## 5.0 BIT TIMING

All nodes on a given CAN bus must have the same nominal bit rate. The CAN protocol uses Non Return to Zero (NRZ) coding, which does not encode a clock within the data stream. Therefore, the receive clock must be recovered by the receiving nodes and synchronized to the transmitter's clock.

As oscillators and transmission times may vary from node to node, the receiver must have some type of Phase Lock Loop (PLL) synchronized to data transmission edges to synchronize and maintain the receiver clock. Since the data is NRZ-coded, it is necessary to include bit-stuffing to insure that an edge occurs at least every six bit times to maintain the Digital Phase Lock Loop (DPLL) synchronization.

The bit timing of the MCP2515 is implemented using a DPLL that is configured to synchronize to the incoming data, as well as provide the nominal timing for the transmitted data. The DPLL breaks each bit time into multiple segments made up of minimal periods of time, called the Time Quanta (TQ).

Bus timing functions executed within the bit time frame (such as synchronization to the local oscillator, network transmission delay compensation and sample point positioning) are defined by the programmable bit timing logic of the DPLL.

## 5.1 The CAN Bit Time

All devices on the CAN bus must use the same bit rate. However, all devices are not required to have the same master oscillator clock frequency. For the different clock frequencies of the individual devices, the bit rate has to be adjusted by appropriately setting the baud rate prescaler and number of time quanta in each segment.

The CAN bit time is made up of non-overlapping segments. Each of these segments are made up of integer units called Time Quanta (TQ), explained later in this data sheet. The Nominal Bit Rate (NBR) is defined in the CAN specification as the number of bits per second transmitted by an ideal transmitter with no resynchronization. It can be described with the equation:

### EQUATION 5-1:

$$NBR = f_{bit} = \frac{1}{t_{bit}}$$

### Nominal Bit Time

The Nominal Bit Time (NBT) ( $t_{bit}$ ) is made up of non-overlapping segments (Figure 5-1). Therefore, the NBT is the summation of the following segments:

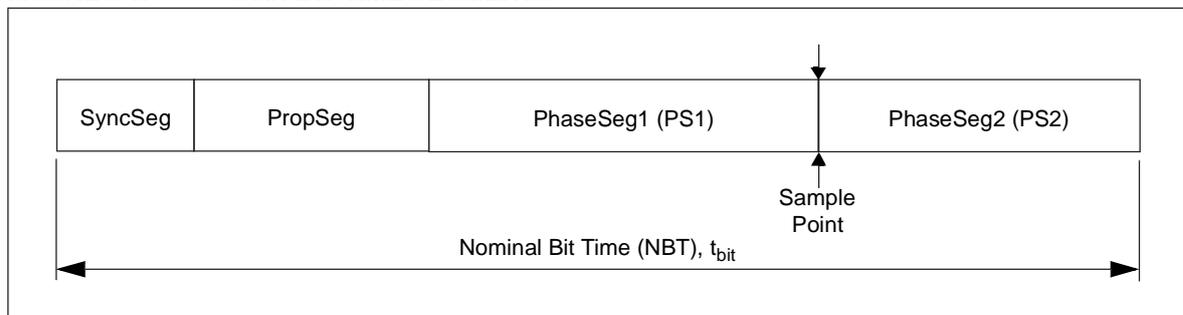
$$t_{bit} = t_{SyncSeg} + t_{PropSeg} + t_{PS1} + t_{PS2}$$

Associated with the NBT are the sample point, Synchronization Jump Width (SJW) and Information Processing Time (IPT), which are explained later.

### SYNCHRONIZATION SEGMENT

The Synchronization Segment (SyncSeg) is the first segment in the NBT and is used to synchronize the nodes on the bus. Bit edges are expected to occur within the SyncSeg. This segment is fixed at 1 TQ.

**FIGURE 5-1: CAN BIT TIME SEGMENTS**



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## PROPAGATION SEGMENT

The Propagation Segment (PropSeg) exists to compensate for physical delays between nodes. The propagation delay is defined as twice the sum of the signal's propagation time on the bus line, including the delays associated with the bus driver. The PropSeg is programmable from 1 – 8 TQ.

## PHASE SEGMENT 1 (PS1) AND PHASE SEGMENT 2 (PS2)

The two phase segments, PS1 and PS2, are used to compensate for edge phase errors on the bus. PS1 can be lengthened (or PS2 shortened) by resynchronization. PS1 is programmable from 1 – 8 TQ and PS2 is programmable from 2 – 8 TQ.

## SAMPLE POINT

The sample point is the point in the bit time at which the logic level is read and interpreted. The sample point is located at the end of PS1. The exception to this rule is if the sample mode is configured to sample three times per bit. In this case, while the bit is still sampled at the end of PS1, two additional samples are taken at one-half TQ intervals prior to the end of PS1, with the value of the bit being determined by a majority decision.

## INFORMATION PROCESSING TIME

The Information Processing Time (IPT) is the time required for the logic to determine the bit level of a sampled bit. The IPT begins at the sample point, is measured in TQ and is fixed at 2 TQ for the Microchip CAN module. Since PS2 also begins at the sample point and is the last segment in the bit time, it is required that the PS2 minimum is not less than the IPT.

Therefore:

$$PS2_{min} = IPT = 2TQ$$

## SYNCHRONIZATION JUMP WIDTH

The Synchronization Jump Width (SJW) adjusts the bit clock as necessary by 1 – 4 TQ (as configured) to maintain synchronization with the transmitted message. Synchronization is covered in more detail later in this data sheet.

## Time Quantum

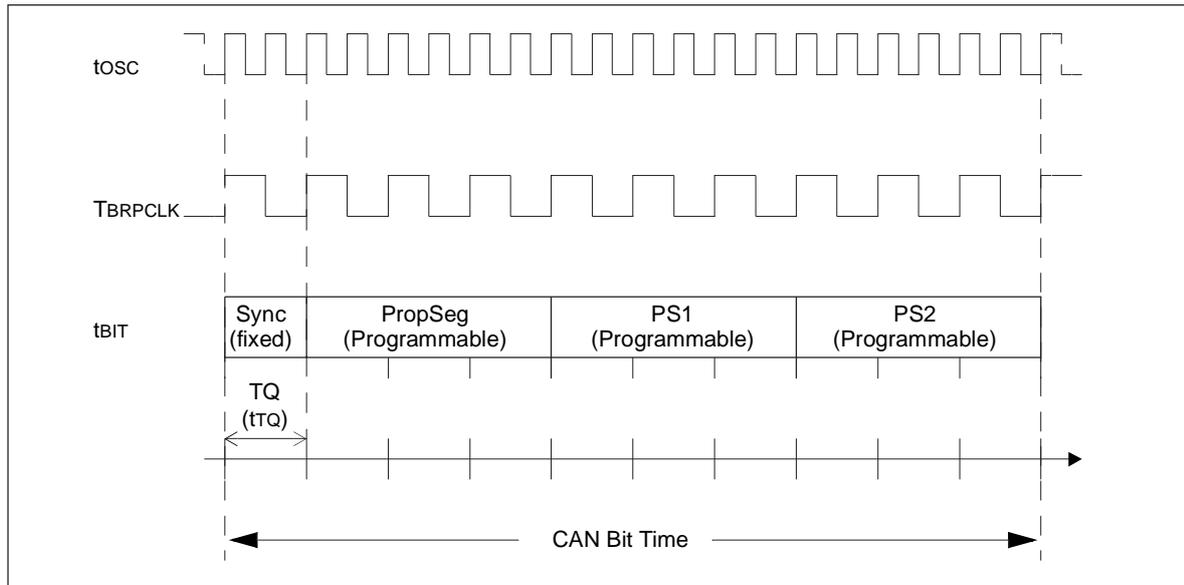
Each of the segments that make up a bit time are made up of integer units called Time Quanta (TQ). The length of each Time Quantum is based on the oscillator period ( $t_{OSC}$ ). The base TQ equals twice the oscillator period. Figure 5-2 shows how the bit period is derived from  $T_{OSC}$  and TQ. The TQ length equals one TQ clock period ( $t_{BRPCLK}$ ), which is programmable using a programmable prescaler, called the Baud Rate Prescaler (BRP). This is illustrated in the following equation:

### EQUATION 5-2:

$$TQ = 2 \cdot BRP \cdot T_{OSC} = \frac{2 \cdot BRP}{F_{OSC}}$$

**Where:** BRP equals the configuration as shown in Register 5-1.

**FIGURE 5-2: TQ AND THE BIT PERIOD**



## 5.2 Synchronization

To compensate for phase shifts between the oscillator frequencies of each of the nodes on the bus, each CAN controller must be able to synchronize to the relevant signal edge of the incoming signal. Synchronization is the process by which the DPLL function is implemented.

When an edge in the transmitted data is detected, the logic will compare the location of the edge to the expected time (SyncSeg). The circuit will then adjust the values of PS1 and PS2 as necessary.

There are two mechanisms used for synchronization:

1. Hard synchronization.
2. Resynchronization.

### 5.2.1 HARD SYNCHRONIZATION

Hard synchronization is only performed when there is a recessive-to-dominant edge during a BUS IDLE condition, indicating the start of a message. After hard synchronization, the bit time counters are restarted with SyncSeg.

Hard synchronization forces the edge that has occurred to lie within the synchronization segment of the restarted bit time. Due to the rules of synchronization, if a hard synchronization occurs, there will not be a resynchronization within that bit time.

### 5.2.2 RESYNCHRONIZATION

As a result of resynchronization, PS1 may be lengthened or PS2 may be shortened. The amount of lengthening or shortening of the phase buffer segments has an upper-bound, given by the Synchronization Jump Width (SJW).

The value of the SJW will be added to PS1 or subtracted from PS2 (see [Figure 5-3](#)). The SJW represents the loop filtering of the DPLL. The SJW is programmable between 1 TQ and 4 TQ.

#### 5.2.2.1 Phase Errors

The NRZ bit coding method does not encode a clock into the message. Clocking information will only be derived from recessive-to-dominant transitions. The property which states that only a fixed maximum number of successive bits have the same value (bit-stuffing) ensures resynchronization to the bit stream during a frame.

The phase error of an edge is given by the position of the edge relative to SyncSeg, measured in TQ. The phase error is defined in magnitude of TQ as follows:

- $e = 0$  if the edge lies within SYNCSEG.
- $e > 0$  if the edge lies before the SAMPLE POINT (TQ is added to PS1).
- $e < 0$  if the edge lies after the SAMPLE POINT of the previous bit (TQ is subtracted from PS2).

#### 5.2.2.2 No Phase Error ( $e = 0$ )

If the magnitude of the phase error is less than or equal to the programmed value of the SJW, the effect of a resynchronization is the same as that of a hard synchronization.

#### 5.2.2.3 Positive Phase Error ( $e > 0$ )

If the magnitude of the phase error is larger than the SJW and, if the phase error is positive, PS1 is lengthened by an amount equal to the SJW.

#### 5.2.2.4 Negative Phase Error ( $e < 0$ )

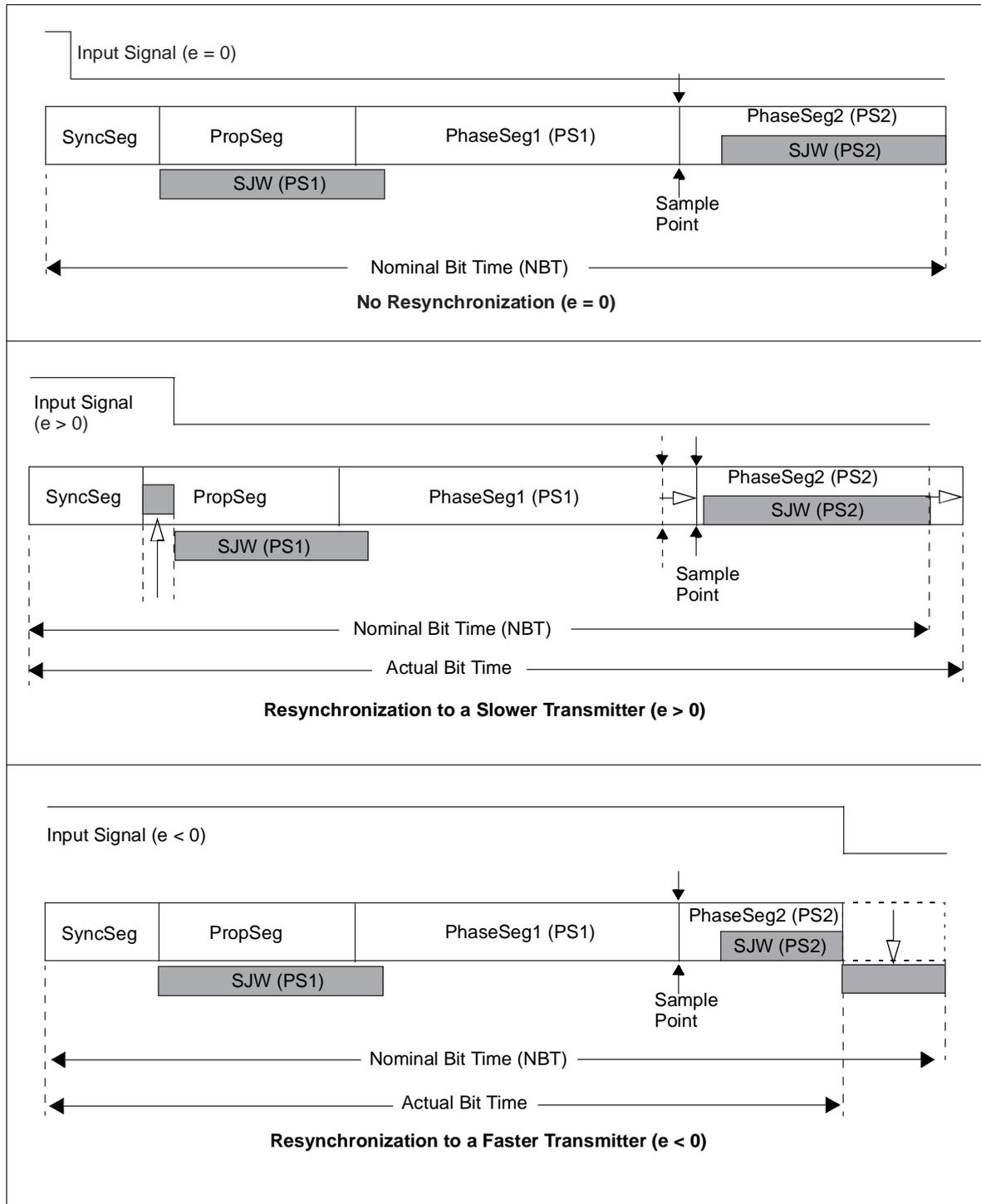
If the magnitude of the phase error is larger than the resynchronization jump width and the phase error is negative, PS2 is shortened by an amount equal to the SJW.

### 5.2.3 SYNCHRONIZATION RULES

1. Only recessive-to-dominant edges will be used for synchronization.
2. Only one synchronization within one bit time is allowed.
3. An edge will be used for synchronization only if the value detected at the previous sample point (previously read bus value) differs from the bus value immediately after the edge.
4. A transmitting node will not resynchronize on a positive phase error ( $e > 0$ ).
5. If the absolute magnitude of the phase error is greater than the SJW, the appropriate phase segment will adjust by an amount equal to the SJW.

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**FIGURE 5-3: SYNCHRONIZING THE BIT TIME**



## 5.3 Programming Time Segments

Some requirements for programming of the time segments:

- PropSeg + PS1  $\geq$  PS2
- PropSeg + PS1  $\geq$  TDELAY
- PS2 > SJW

For example, assuming that a 125 kHz CAN baud rate with FOSC = 20 MHz is desired:

Tosc = 50 ns, choose BRP<5:0> = 04h, then TQ = 500 ns. To obtain 125 kHz, the bit time must be 16 TQ.

Typically, the sampling of the bit should take place at about 60-70% of the bit time, depending on the system parameters. Also, typically, the TDELAY is 1-2 TQ.

SyncSeg = 1 TQ and PropSeg = 2 TQ. So setting PS1 = 7 TQ would place the sample at 10 TQ after the transition. This would leave 6 TQ for PS2.

Since PS2 is 6, according to the rules, SJW could be a maximum of 4 TQ. However, a large SJW is typically only necessary when the clock generation of the different nodes is inaccurate or unstable, such as using ceramic resonators. So a SJW of 1 is usually enough.

## 5.4 Oscillator Tolerance

The bit timing requirements allow ceramic resonators to be used in applications with transmission rates of up to 125 kbit/sec as a rule of thumb. For the full bus speed range of the CAN protocol, a quartz oscillator is required. A maximum node-to-node oscillator variation of 1.7% is allowed.

## 5.5 Bit Timing Configuration Registers

The configuration registers (CNF1, CNF2, CNF3) control the bit timing for the CAN bus interface. These registers can only be modified when the MCP2515 is in Configuration mode (see **Section 10.0 “Modes of Operation”**).

### 5.5.1 CNF1

The BRP<5:0> bits control the baud rate prescaler. These bits set the length of TQ relative to the OSC1 input frequency, with the minimum TQ length being 2 Tosc (when BRP<5:0> = 'b000000'). The SJW<1:0> bits select the SJW in terms of number of TQs.

### 5.5.2 CNF2

The PRSEG<2:0> bits set the length (in TQ's) of the propagation segment. The PHSEG1<2:0> bits set the length (in TQ's) of PS1.

The SAM bit controls how many times the RXCAN pin is sampled. Setting this bit to a '1' causes the bus to be sampled three times: twice at TQ/2 before the sample point and once at the normal sample point (which is at the end of PS1). The value of the bus is determined to be the majority sampled. If the SAM bit is set to a '0', the RXCAN pin is sampled only once at the sample point.

The BTLMODE bit controls how the length of PS2 is determined. If this bit is set to a '1', the length of PS2 is determined by the PHSEG2<2:0> bits of CNF3 (see **Section 5.5.3 “CNF3”**). If the BTLMODE bit is set to a '0', the length of PS2 is greater than that of PS1 and the information processing time (which is fixed at 2 TQ for the MCP2515).

### 5.5.3 CNF3

The PHSEG2<2:0> bits set the length (in TQ's) of PS2, if the CNF2.BTLMODE bit is set to a '1'. If the BTLMODE bit is set to a '0', the PHSEG2<2:0> bits have no effect.

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## REGISTER 5-1: CNF1 – CONFIGURATION 1 (ADDRESS: 2Ah)

| R/W-0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| SJW1  | SJW0  | BRP5  | BRP4  | BRP3  | BRP2  | BRP1  | BRP0  |
| bit 7 |       |       |       |       |       |       | bit 0 |

<b>Legend:</b>			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

- bit 7-6     **SJW:** Synchronization Jump Width Length bits <1:0>  
             11 = Length = 4 x T<sub>Q</sub>  
             10 = Length = 3 x T<sub>Q</sub>  
             01 = Length = 2 x T<sub>Q</sub>  
             00 = Length = 1 x T<sub>Q</sub>
- bit 5-0     **BRP:** Baud Rate Prescaler bits <5:0>  
             T<sub>Q</sub> = 2 x (BRP + 1)/F<sub>osc</sub>

## REGISTER 5-2: CNF2 – CONFIGURATION 1 (ADDRESS: 29h)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
BTLMODE	SAM	PHSEG12	PHSEG11	PHSEG10	PRSEG2	PRSEG1	PRSEG0
bit 7							bit 0

<b>Legend:</b>			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

- bit 7       **BTLMODE:** PS2 Bit Time Length bit  
             1 = Length of PS2 determined by PHSEG22:PHSEG20 bits of CNF3  
             0 = Length of PS2 is the greater of PS1 and IPT (2 T<sub>Q</sub>)
- bit 6       **SAM:** Sample Point Configuration bit  
             1 = Bus line is sampled three times at the sample point  
             0 = Bus line is sampled once at the sample point
- bit 5-3     **PHSEG1:** PS1 Length bits<2:0>  
             (PHSEG1 + 1) x T<sub>Q</sub>
- bit 2-0     **PRSEG:** Propagation Segment Length bits <2:0>  
             (PRSEG + 1) x T<sub>Q</sub>

## REGISTER 5-3: CNF3 - CONFIGURATION 1 (ADDRESS: 28h)

R/W-0	R/W-0	U-0	U-0	U-0	R/W-0	R/W-0	R/W-0	
SOF	WAKFIL	—	—	—	PHSEG22	PHSEG21	PHSEG20	
bit 7								bit 0

### Legend:

R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared
		x = Bit is unknown

- bit 7      **SOF:** Start-of-Frame signal bit  
 If CANCTRL.CLKEN = 1:  
 1 = CLKOUT pin enabled for SOF signal  
 0 = CLKOUT pin enabled for clockout function  
 If CANCTRL.CLKEN = 0, Bit is don't care.
- bit 6      **WAKFIL:** Wake-up Filter bit  
 1 = Wake-up filter enabled  
 0 = Wake-up filter disabled
- bit 5-3    **Unimplemented:** Reads as '0'
- bit 2-0    **PHSEG2:** PS2 Length bits<2:0>  
 (PHSEG2 + 1) x T<sub>Q</sub>  
 Minimum valid setting for PS2 is 2 T<sub>Q</sub>

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NOTES:

## 6.0 ERROR DETECTION

The CAN protocol provides sophisticated error detection mechanisms. The following errors can be detected.

### 6.1 CRC Error

With the Cyclic Redundancy Check (CRC), the transmitter calculates special check bits for the bit sequence from the start of a frame until the end of the data field. This CRC sequence is transmitted in the CRC Field. The receiving node also calculates the CRC sequence using the same formula and performs a comparison to the received sequence. If a mismatch is detected, a CRC error has occurred and an error frame is generated. The message is repeated.

### 6.2 Acknowledge Error

In the acknowledge field of a message, the transmitter checks if the acknowledge slot (which has been sent out as a recessive bit) contains a dominant bit. If not, no other node has received the frame correctly. An acknowledge error has occurred, an error frame is generated and the message will have to be repeated.

### 6.3 Form Error

If a node detects a dominant bit in one of the four segments (including end-of-frame, interframe space, acknowledge delimiter or CRC delimiter), a form error has occurred and an error frame is generated. The message is repeated.

### 6.4 Bit Error

A bit error occurs if a transmitter detects the opposite bit level to what it transmitted (i.e., transmitted a dominant and detected a recessive, or transmitted a recessive and detected a dominant).

**Exception:** In the case where the transmitter sends a recessive bit and a dominant bit is detected during the arbitration field and the acknowledge slot, no bit error is generated because normal arbitration is occurring.

### 6.5 Stuff Error

If, between the start-of-frame and the CRC delimiter, six consecutive bits with the same polarity are detected, the bit-stuffing rule has been violated. A stuff error occurs and an error frame is generated. The message is repeated.

## 6.6 Error States

Detected errors are made known to all other nodes via error frames. The transmission of the erroneous message is aborted and the frame is repeated as soon as possible. Furthermore, each CAN node is in one of the three error states according to the value of the internal error counters:

1. Error-active.
2. Error-passive.
3. Bus-off (transmitter only).

The error-active state is the usual state where the node can transmit messages and active error frames (made of dominant bits) without any restrictions.

In the error-passive state, messages and passive error frames (made of recessive bits) may be transmitted.

The bus-off state makes it temporarily impossible for the station to participate in the bus communication. During this state, messages can neither be received or transmitted. Only transmitters can go bus-off.

## 6.7 Error Modes and Error Counters

The MCP2515 contains two error counters: the Receive Error Counter (REC) (see Register 6-2) and the Transmit Error Counter (TEC) (see Register 6-1). The values of both counters can be read by the MCU. These counters are incremented/decremented in accordance with the CAN bus specification.

The MCP2515 is error-active if both error counters are below the error-passive limit of 128.

It is error-passive if at least one of the error counters equals or exceeds 128.

It goes to bus-off if the TEC exceeds the bus-off limit of 255. The device remains in this state until the bus-off recovery sequence is received. The bus-off recovery sequence consists of 128 occurrences and 11 consecutive recessive bits (see Figure 6-1).

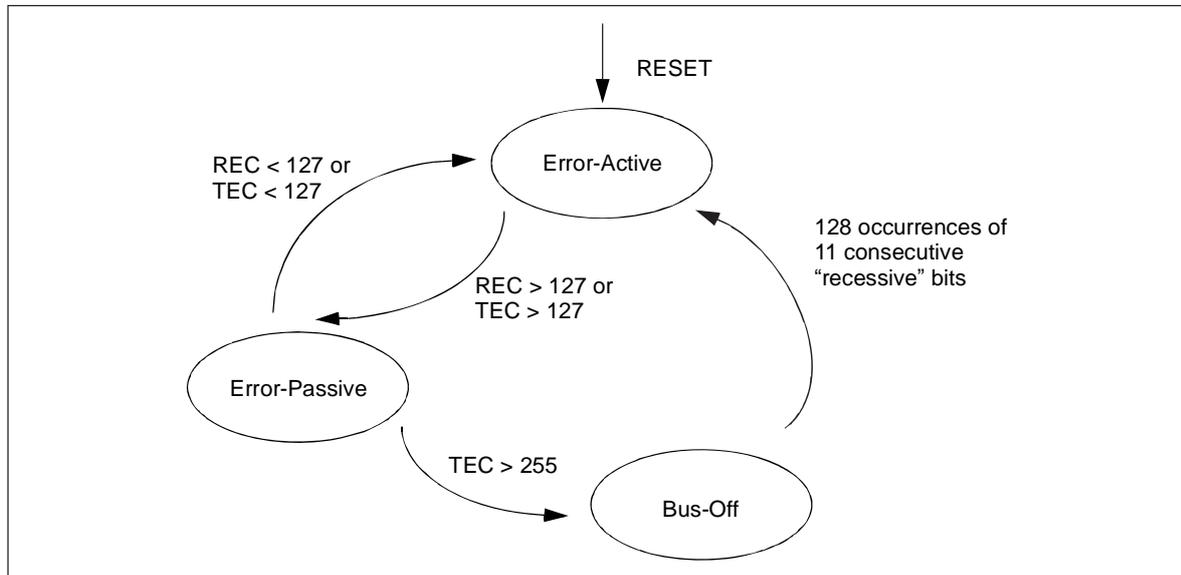
**Note:** The MCP2515, after going bus-off, will recover back to error-active without any intervention by the MCU if the bus remains idle for 128 x 11 bit times. If this is not desired, the error interrupt service routine should address this.

The Current Error mode of the MCP2515 can be read by the MCU via the EFLG register (see Register 6-3).

Additionally, there is an error state warning flag bit (EFLG:EWARN) which is set if at least one of the error counters equals or exceeds the error warning limit of 96. EWARN is reset if both error counters are less than the error warning limit.

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**FIGURE 6-1: ERROR MODES STATE DIAGRAM**



**REGISTER 6-1: TEC – TRANSMIT ERROR COUNTER (ADDRESS: 1Ch)**

R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
TEC7	TEC6	TEC5	TEC4	TEC3	TEC2	TEC1	TEC0
bit 7							bit 0

**Legend:**  
 R = Readable bit                      W = Writable bit                      U = Unimplemented bit, read as '0'  
 -n = Value at POR                      '1' = Bit is set                      '0' = Bit is cleared                      x = Bit is unknown

bit 7-0                      **TEC:** Transmit Error Count bits <7:0>

**REGISTER 6-2: REC – RECEIVER ERROR COUNTER (ADDRESS: 1Dh)**

R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
REC7	REC6	REC5	REC4	REC3	REC2	REC1	REC0
bit 7							bit 0

**Legend:**  
 R = Readable bit                      W = Writable bit                      U = Unimplemented bit, read as '0'  
 -n = Value at POR                      '1' = Bit is set                      '0' = Bit is cleared                      x = Bit is unknown

bit 7-0                      **REC:** Receive Error Count bits <7:0>

**REGISTER 6-3: EFLG – ERROR FLAG  
(ADDRESS: 2Dh)**

R/W-0	R/W-0	R-0	R-0	R-0	R-0	R-0	R-0
RX1OVR	RX0OVR	TXBO	TXEP	RXEP	TXWAR	RXWAR	EWARN
bit 7							bit 0

**Legend:**

R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared
		x = Bit is unknown

- bit 7      **RX1OVR**: Receive Buffer 1 Overflow Flag bit  
 - Set when a valid message is received for RXB1 and CANINTF.RX1IF = 1  
 - Must be reset by MCU
- bit 6      **RX0OVR**: Receive Buffer 0 Overflow Flag bit  
 - Set when a valid message is received for RXB0 and CANINTF.RX0IF = 1  
 - Must be reset by MCU
- bit 5      **TXBO**: Bus-Off Error Flag bit  
 - Bit set when TEC reaches 255  
 - Reset after a successful bus recovery sequence
- bit 4      **TXEP**: Transmit Error-Passive Flag bit  
 - Set when TEC is equal to or greater than 128  
 - Reset when TEC is less than 128
- bit 3      **RXEP**: Receive Error-Passive Flag bit  
 - Set when REC is equal to or greater than 128  
 - Reset when REC is less than 128
- bit 2      **TXWAR**: Transmit Error Warning Flag bit  
 - Set when TEC is equal to or greater than 96  
 - Reset when TEC is less than 96
- bit 1      **RXWAR**: Receive Error Warning Flag bit  
 - Set when REC is equal to or greater than 96  
 - Reset when REC is less than 96
- bit 0      **EWARN**: Error Warning Flag bit  
 - Set when TEC or REC is equal to or greater than 96 (TXWAR or RXWAR = 1)  
 - Reset when both REC and TEC are less than 96

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NOTES:

## 7.0 INTERRUPTS

The MCP2515 has eight sources of interrupts. The CANINTE register contains the individual interrupt enable bits for each interrupt source. The CANINTF register contains the corresponding interrupt flag bit for each interrupt source. When an interrupt occurs, the  $\overline{\text{INT}}$  pin is driven low by the MCP2515 and will remain low until the interrupt is cleared by the MCU. An interrupt can not be cleared if the respective condition still prevails.

It is recommended that the bit modify command be used to reset flag bits in the CANINTF register rather than normal write operations. This is done to prevent unintentionally changing a flag that changes during the write command, potentially causing an interrupt to be missed.

It should be noted that the CANINTF flags are read/write and an interrupt can be generated by the MCU setting any of these bits, provided the associated CANINTE bit is also set.

### 7.1 Interrupt Code Bits

The source of a pending interrupt is indicated in the CANSTAT.ICOD (interrupt code) bits, as indicated in Register 10-2. In the event that multiple interrupts occur, the  $\overline{\text{INT}}$  will remain low until all interrupts have been reset by the MCU. The CANSTAT.ICOD bits will reflect the code for the highest priority interrupt that is currently pending. Interrupts are internally prioritized such that the lower the ICOD value, the higher the interrupt priority. Once the highest priority interrupt condition has been cleared, the code for the next highest priority interrupt that is pending (if any) will be reflected by the ICOD bits (see Table 7-1). Only those interrupt sources that have their associated CANINTE enable bit set will be reflected in the ICOD bits.

**TABLE 7-1: ICOD<2:0> DECODE**

ICOD<2:0>	Boolean Expression
000	$\overline{\text{ERR}} \cdot \overline{\text{WAK}} \cdot \overline{\text{TX0}} \cdot \overline{\text{TX1}} \cdot \overline{\text{TX2}} \cdot \overline{\text{RX0}} \cdot \overline{\text{RX1}}$
001	ERR
010	$\overline{\text{ERR}} \cdot \overline{\text{WAK}}$
011	$\overline{\text{ERR}} \cdot \overline{\text{WAK}} \cdot \overline{\text{TX0}}$
100	$\overline{\text{ERR}} \cdot \overline{\text{WAK}} \cdot \overline{\text{TX0}} \cdot \overline{\text{TX1}}$
101	$\overline{\text{ERR}} \cdot \overline{\text{WAK}} \cdot \overline{\text{TX0}} \cdot \overline{\text{TX1}} \cdot \overline{\text{TX2}}$
110	$\overline{\text{ERR}} \cdot \overline{\text{WAK}} \cdot \overline{\text{TX0}} \cdot \overline{\text{TX1}} \cdot \overline{\text{TX2}} \cdot \overline{\text{RX0}}$
111	$\overline{\text{ERR}} \cdot \overline{\text{WAK}} \cdot \overline{\text{TX0}} \cdot \overline{\text{TX1}} \cdot \overline{\text{TX2}} \cdot \overline{\text{RX0}} \cdot \overline{\text{RX1}}$

**Note:**  $\overline{\text{ERR}}$  is associated with CANINTE,ERRIE.

### 7.2 Transmit Interrupt

When the transmit interrupt is enabled (CANINTE.TXnIE = 1), an interrupt will be generated on the  $\overline{\text{INT}}$  pin once the associated transmit buffer becomes empty and is ready to be loaded with a new message. The CANINTF.TXnIF bit will be set to indicate the source of the interrupt. The interrupt is cleared by clearing the TXnIF bit.

### 7.3 Receive Interrupt

When the receive interrupt is enabled (CANINTE.RXnIE = 1), an interrupt will be generated on the  $\overline{\text{INT}}$  pin once a message has been successfully received and loaded into the associated receive buffer. This interrupt is activated immediately after receiving the EOF field. The CANINTF.RXnIF bit will be set to indicate the source of the interrupt. The interrupt is cleared by clearing the RXnIF bit.

### 7.4 Message Error Interrupt

When an error occurs during the transmission or reception of a message, the message error flag (CANINTF.MERRF) will be set and, if the CANINTE.MERRE bit is set, an interrupt will be generated on the  $\overline{\text{INT}}$  pin. This is intended to be used to facilitate baud rate determination when used in conjunction with Listen-only mode.

### 7.5 Bus Activity Wakeup Interrupt

When the MCP2515 is in Sleep mode and the bus activity wakeup interrupt is enabled (CANINTE.WAKIE = 1), an interrupt will be generated on the  $\overline{\text{INT}}$  pin and the CANINTF.WAKIF bit will be set when activity is detected on the CAN bus. This interrupt causes the MCP2515 to exit Sleep mode. The interrupt is reset by clearing the WAKIF bit.

**Note:** The MCP2515 wakes up into Listen-only mode.

### 7.6 Error Interrupt

When the error interrupt is enabled (CANINTE.ERRIE = 1), an interrupt is generated on the  $\overline{\text{INT}}$  pin if an overflow condition occurs or if the error state of the transmitter or receiver has changed. The Error Flag (EFLG) register will indicate one of the following conditions.

#### 7.6.1 RECEIVER OVERFLOW

An overflow condition occurs when the MAB has assembled a valid receive message (the message meets the criteria of the acceptance filters) and the receive buffer associated with the filter is not available for loading of a new message. The associated EFLG.RXnOVR bit will be set to indicate the overflow condition. This bit must be cleared by the MCU.

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## 7.6.2 RECEIVER WARNING

The REC has reached the MCU warning limit of 96.

## 7.6.3 TRANSMITTER WARNING

The TEC has reached the MCU warning limit of 96.

## 7.6.4 RECEIVER ERROR-PASSIVE

The REC has exceeded the error-passive limit of 127 and the device has gone to error-passive state.

## 7.6.5 TRANSMITTER ERROR-PASSIVE

The TEC has exceeded the error-passive limit of 127 and the device has gone to error-passive state.

## 7.6.6 BUS-OFF

The TEC has exceeded 255 and the device has gone to bus-off state.

## 7.7 Interrupt Acknowledge

Interrupts are directly associated with one or more status flags in the CANINTF register. Interrupts are pending as long as one of the flags is set. Once an interrupt flag is set by the device, the flag can not be reset by the MCU until the interrupt condition is removed.

### REGISTER 7-1: CANINTE – INTERRUPT ENABLE (ADDRESS: 2Bh)

| R/W-0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| MERRE | WAKIE | ERRIE | TX2IE | TX1IE | TX0IE | RX1IE | RX0IE |
| bit 7 |       |       |       |       |       |       | bit 0 |

<b>Legend:</b>			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

- bit 7      **MERRE:** Message Error Interrupt Enable bit  
1 = Interrupt on error during message reception or transmission  
0 = Disabled
- bit 6      **WAKIE:** Wakeup Interrupt Enable bit  
1 = Interrupt on CAN bus activity  
0 = Disabled
- bit 5      **ERRIE:** Error Interrupt Enable bit (multiple sources in EFLG register)  
1 = Interrupt on EFLG error condition change  
0 = Disabled
- bit 4      **TX2IE:** Transmit Buffer 2 Empty Interrupt Enable bit  
1 = Interrupt on TXB2 becoming empty  
0 = Disabled
- bit 3      **TX1IE:** Transmit Buffer 1 Empty Interrupt Enable bit  
1 = Interrupt on TXB1 becoming empty  
0 = Disabled
- bit 2      **TX0IE:** Transmit Buffer 0 Empty Interrupt Enable bit  
1 = Interrupt on TXB0 becoming empty  
0 = Disabled
- bit 1      **RX1IE:** Receive Buffer 1 Full Interrupt Enable bit  
1 = Interrupt when message received in RXB1  
0 = Disabled
- bit 0      **RX0IE:** Receive Buffer 0 Full Interrupt Enable bit  
1 = Interrupt when message received in RXB0  
0 = Disabled

## REGISTER 7-2: CANINTF – INTERRUPT FLAG (ADDRESS: 2Ch)

| R/W-0 |
|-------|-------|-------|-------|-------|-------|-------|-------|
| MERRF | WAKIF | ERRIF | TX2IF | TX1IF | TX0IF | RX1IF | RX0IF |
| bit 7 |       |       |       |       |       |       | bit 0 |

### Legend:

R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared
		x = Bit is unknown

- bit 7      **MERRF**: Message Error Interrupt Flag bit  
 1 = Interrupt pending (must be cleared by MCU to reset interrupt condition)  
 0 = No interrupt pending
- bit 6      **WAKIF**: Wakeup Interrupt Flag bit  
 1 = Interrupt pending (must be cleared by MCU to reset interrupt condition)  
 0 = No interrupt pending
- bit 5      **ERRIF**: Error Interrupt Flag bit (multiple sources in EFLG register)  
 1 = Interrupt pending (must be cleared by MCU to reset interrupt condition)  
 0 = No interrupt pending
- bit 4      **TX2IF**: Transmit Buffer 2 Empty Interrupt Flag bit  
 1 = Interrupt pending (must be cleared by MCU to reset interrupt condition)  
 0 = No interrupt pending
- bit 3      **TX1IF**: Transmit Buffer 1 Empty Interrupt Flag bit  
 1 = Interrupt pending (must be cleared by MCU to reset interrupt condition)  
 0 = No interrupt pending
- bit 2      **TX0IF**: Transmit Buffer 0 Empty Interrupt Flag bit  
 1 = Interrupt pending (must be cleared by MCU to reset interrupt condition)  
 0 = No interrupt pending
- bit 1      **RX1IF**: Receive Buffer 1 Full Interrupt Flag bit  
 1 = Interrupt pending (must be cleared by MCU to reset interrupt condition)  
 0 = No interrupt pending
- bit 0      **RX0IF**: Receive Buffer 0 Full Interrupt Flag bit  
 1 = Interrupt pending (must be cleared by MCU to reset interrupt condition)  
 0 = No interrupt pending

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NOTES:

## 8.0 OSCILLATOR

The MCP2515 is designed to be operated with a crystal or ceramic resonator connected to the OSC1 and OSC2 pins. The MCP2515 oscillator design requires the use of a parallel cut crystal. Use of a series cut crystal may give a frequency out of the crystal manufacturers specifications. A typical oscillator circuit is shown in Figure 8-1. The MCP2515 may also be driven by an external clock source connected to the OSC1 pin, as shown in Figure 8-2 and Figure 8-3.

### 8.1 Oscillator Startup Timer

The MCP2515 utilizes an Oscillator Startup Timer (OST) that holds the MCP2515 in reset to ensure that the oscillator has stabilized before the internal state machine begins to operate. The OST maintains reset for the first 128 OSC1 clock cycles after power-up or a wake-up from Sleep mode occurs. It should be noted that no SPI protocol operations should be attempted until after the OST has expired.

## 8.2 CLKOUT Pin

The CLKOUT pin is provided to the system designer for use as the main system clock or as a clock input for other devices in the system. The CLKOUT has an internal prescaler which can divide  $F_{OSC}$  by 1, 2, 4 and 8. The CLKOUT function is enabled and the prescaler is selected via the CANCECTRL register (see Register 10-1).

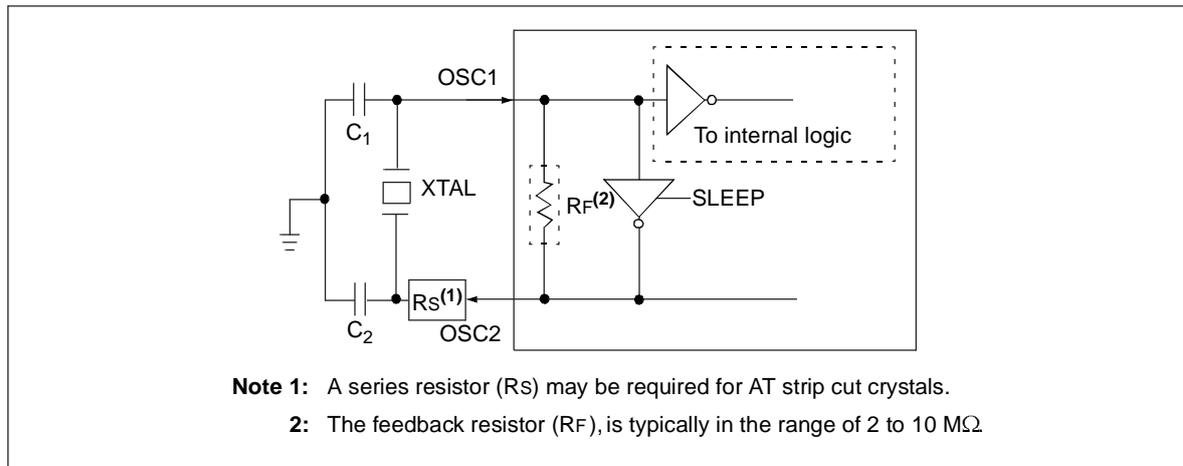
**Note:** The maximum frequency on CLKOUT is specified as 25 MHz (See Table 13-5)

The CLKOUT pin will be active upon system reset and default to the slowest speed (divide by 8) so that it can be used as the MCU clock.

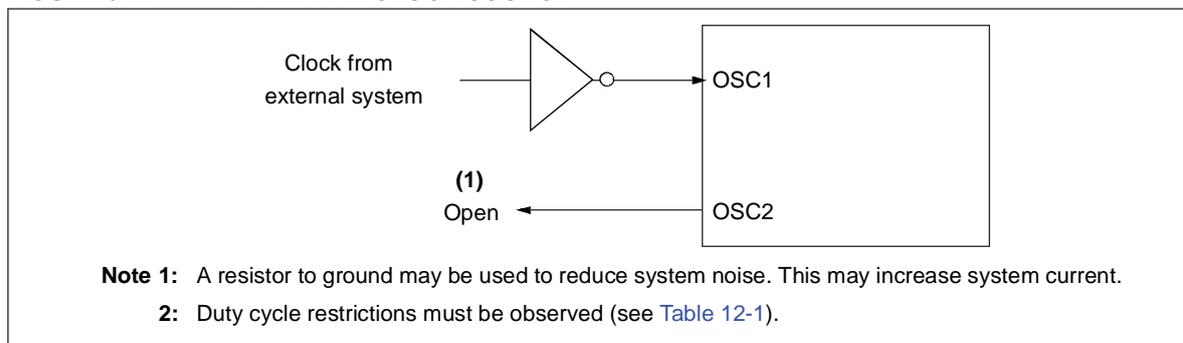
When Sleep mode is requested, the MCP2515 will drive sixteen additional clock cycles on the CLKOUT pin before entering Sleep mode. The idle state of the CLKOUT pin in Sleep mode is low. When the CLKOUT function is disabled (CANCECTRL.CLKEN = '0') the CLKOUT pin is in a high-impedance state.

The CLKOUT function is designed to ensure that  $t_{hCLKOUT}$  and  $t_{lCLKOUT}$  timings are preserved when the CLKOUT pin function is enabled, disabled or the prescaler value is changed.

**FIGURE 8-1: CRYSTAL/CERAMIC RESONATOR OPERATION**

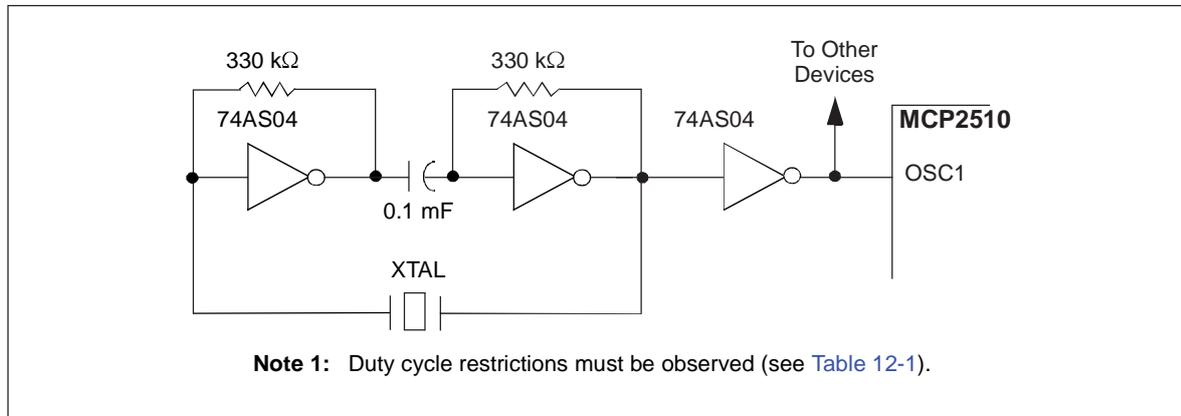


**FIGURE 8-2: EXTERNAL CLOCK SOURCE**



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**FIGURE 8-3: EXTERNAL SERIES RESONANT CRYSTAL OSCILLATOR CIRCUIT<sup>(1)</sup>**



**TABLE 8-1: CAPACITOR SELECTION FOR CERAMIC RESONATORS**

Typical Capacitor Values Used:			
Mode	Freq.	OSC1	OSC2
HS	8.0 MHz	27 pF	27 pF
	16.0 MHz	22 pF	22 pF

**Capacitor values are for design guidance only:**  
 These capacitors were tested with the resonators listed below for basic start-up and operation. **These values are not optimized.**  
 Different capacitor values may be required to produce acceptable oscillator operation. The user should test the performance of the oscillator over the expected VDD and temperature range for the application.  
 See the notes following [Table 8-2](#) for additional information.

Resonators Used:	
4.0 MHz	
8.0 MHz	
16.0 MHz	

**TABLE 8-2: CAPACITOR SELECTION FOR CRYSTAL OSCILLATOR**

Osc Type <sup>(1)(4)</sup>	Crystal Freq. <sup>(2)</sup>	Typical Capacitor Values Tested:	
		C1	C2
HS	4 MHz	27 pF	27 pF
	8 MHz	22 pF	22 pF
	20 MHz	15 pF	15 pF

**Capacitor values are for design guidance only:**  
 These capacitors were tested with the crystals listed below for basic start-up and operation. **These values are not optimized.**  
 Different capacitor values may be required to produce acceptable oscillator operation. The user should test the performance of the oscillator over the expected VDD and temperature range for the application.  
 See the notes following this Table for additional information.

Crystals Used <sup>(3)</sup> :	
4.0 MHz	
8.0 MHz	
20.0 MHz	

- Note 1:** While higher capacitance increases the stability of the oscillator, it also increases the start-up time.
- 2:** Since each resonator/crystal has its own characteristics, the user should consult the resonator/crystal manufacturer for appropriate values of external components.
- 3:** RS may be required to avoid overdriving crystals with low drive level specification.
- 4:** Always verify oscillator performance over the VDD and temperature range that is expected for the application.

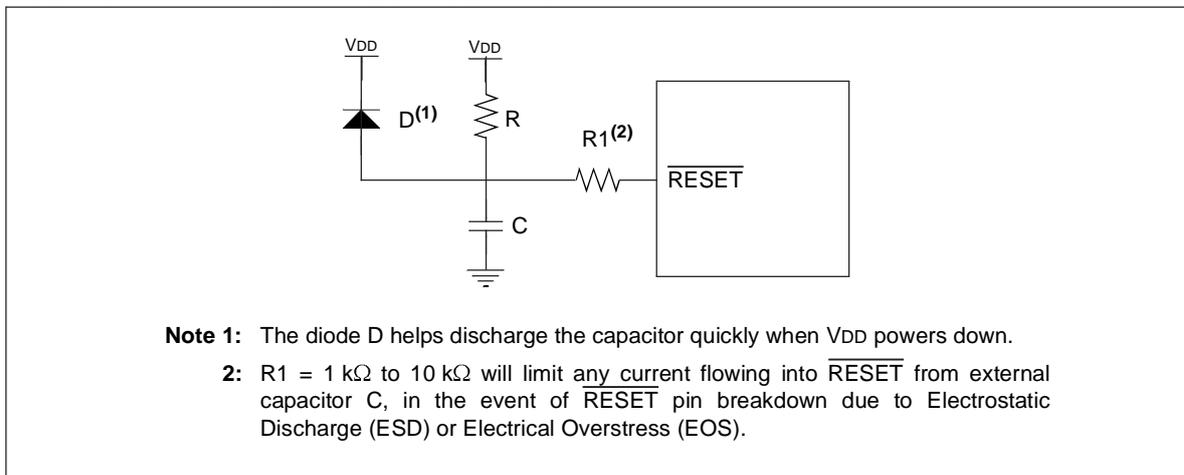
## 9.0 RESET

The MCP2515 differentiates between two resets:

1. Hardware Reset – Low on  $\overline{\text{RESET}}$  pin.
2. SPI Reset – Reset via SPI command.

Both of these resets are functionally equivalent. It is important to provide one of these two resets after power-up to ensure that the logic and registers are in their default state. A hardware reset can be achieved automatically by placing an RC on the RESET pin. (see [Figure 9-1](#)). The values must be such that the device is held in reset for a minimum of 2  $\mu\text{s}$  after VDD reaches operating voltage, as indicated in the electrical specification (tRL).

**FIGURE 9-1:  $\overline{\text{RESET}}$  PIN CONFIGURATION EXAMPLE**



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NOTES:

## 10.0 MODES OF OPERATION

The MCP2515 has five modes of operation. These modes are:

1. Configuration mode.
2. Normal mode.
3. Sleep mode.
4. Listen-only mode.
5. Loopback mode.

The operational mode is selected via the CANCTRL.REQOP bits (see Register 10-1).

When changing modes, the mode will not actually change until all pending message transmissions are complete. The requested mode must be verified by reading the CANSTAT.OPMODE bits (see Register 10-2).

### 10.1 Configuration Mode

The MCP2515 must be initialized before activation. This is only possible if the device is in the Configuration mode. Configuration mode is automatically selected after power-up, a reset or can be entered from any other mode by setting the CANCTRL.REQOP bits to '100'. When Configuration mode is entered, all error counters are cleared. Configuration mode is the only mode where the following registers are modifiable:

- CNF1, CNF2, CNF3
- TXRTSCTRL
- Filter registers
- Mask registers

### 10.2 Sleep Mode

The MCP2515 has an internal Sleep mode that is used to minimize the current consumption of the device. The SPI interface remains active for reading even when the MCP2515 is in Sleep mode, allowing access to all registers.

To enter Sleep mode, the mode request bits are set in the CANCTRL register (REQOP<2:0>). The CANSTAT.OPMODE bits indicate operation mode. These bits should be read after sending the sleep command to the MCP2515. The MCP2515 is active and has not yet entered Sleep mode until these bits indicate that Sleep mode has been entered.

When in internal Sleep mode, the wake-up interrupt is still active (if enabled). This is done so that the MCU can also be placed into a Sleep mode and use the MCP2515 to wake it up upon detecting activity on the bus.

When in Sleep mode, the MCP2515 stops its internal oscillator. The MCP2515 will wake-up when bus activity occurs or when the MCU sets, via the SPI interface, the CANINTF.WAKIF bit to 'generate' a wake-up attempt (the CANINTE.WAKIE bit must also be set in order for the wake-up interrupt to occur).

The TXCAN pin will remain in the recessive state while the MCP2515 is in Sleep mode.

#### 10.2.1 WAKE-UP FUNCTIONS

The device will monitor the RXCAN pin for activity while it is in Sleep mode. If the CANINTE.WAKIE bit is set, the device will wake up and generate an interrupt. Since the internal oscillator is shut down while in Sleep mode, it will take some amount of time for the oscillator to start up and the device to enable itself to receive messages. This Oscillator Start-up Timer (OST) is defined as 128 Tosc.

The device will ignore the message that caused the wake-up from Sleep mode, as well as any messages that occur while the device is 'waking up'. The device will wake up in Listen-only mode. The MCU must set Normal mode before the DSTEMP will be able to communicate on the bus.

The device can be programmed to apply a low-pass filter function to the RXCAN input line while in internal Sleep mode. This feature can be used to prevent the device from waking up due to short glitches on the CAN bus lines. The CNF3.WAKFIL bit enables or disables the filter.

### 10.3 Listen-only Mode

Listen-only mode provides a means for the MCP2515 to receive all messages (including messages with errors) by configuring the RXBnCTRL.RXM<1:0> bits. This mode can be used for bus monitor applications or for detecting the baud rate in 'hot plugging' situations.

For auto-baud detection, it is necessary that there are at least two other nodes that are communicating with each other. The baud rate can be detected empirically by testing different values until valid messages are received.

Listen-only mode is a silent mode, meaning no messages will be transmitted while in this mode (including error flags or acknowledge signals). The filters and masks can be used to allow only particular messages to be loaded into the receive registers, or the masks can be set to all zeros to allow a message with any identifier to pass. The error counters are reset and deactivated in this state. The Listen-only mode is activated by setting the mode request bits in the CANCTRL register.

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## 10.4 Loopback Mode

Loopback mode will allow internal transmission of messages from the transmit buffers to the receive buffers without actually transmitting messages on the CAN bus. This mode can be used in system development and testing.

In this mode, the ACK bit is ignored and the device will allow incoming messages from itself just as if they were coming from another node. The Loopback mode is a silent mode, meaning no messages will be transmitted while in this state (including error flags or acknowledge signals). The TXCAN pin will be in a recessive state.

The filters and masks can be used to allow only particular messages to be loaded into the receive registers. The masks can be set to all zeros to provide a mode that accepts all messages. The Loopback mode is activated by setting the mode request bits in the CANCTRL register.

## 10.5 Normal Mode

Normal mode is the standard operating mode of the MCP2515. In this mode, the device actively monitors all bus messages and generates acknowledge bits, error frames, etc. This is also the only mode in which the MCP2515 will transmit messages over the CAN bus.

### REGISTER 10-1: CANCTRL – CAN CONTROL REGISTER (ADDRESS: XfH)

R/W-1	R/W-0	R/W-0	R/W-0	R/W-0	R/W-1	R/W-1	R/W-1
REQOP2	REQOP1	REQOP0	ABAT	OSM	CLKEN	CLKPRE1	CLKPRE0
bit 7							bit 0

<b>Legend:</b>			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

- bit 7-5     **REQOP:** Request Operation Mode bits <2:0>
  - 000 = Set Normal Operation mode
  - 001 = Set Sleep mode
  - 010 = Set Loopback mode
  - 011 = Set Listen-only mode
  - 100 = Set Configuration mode
  - All other values for REQOP bits are invalid and should not be used
  - On power-up, REQOP = b'111'
- bit 4     **ABAT:** Abort All Pending Transmissions bit
  - 1 = Request abort of all pending transmit buffers
  - 0 = Terminate request to abort all transmissions
- bit 3     **OSM:** One Shot Mode bit
  - 1 = Enabled. Message will only attempt to transmit one time
  - 0 = Disabled. Messages will reattempt transmission, if required
- bit 2     **CLKEN:** CLKOUT Pin Enable bit
  - 1 = CLKOUT pin enabled
  - 0 = CLKOUT pin disabled (Pin is in high-impedance state)
- bit 1-0   **CLKPRE:** CLKOUT Pin Prescaler bits <1:0>
  - 00 = FCLKOUT = System Clock/1
  - 01 = FCLKOUT = System Clock/2
  - 10 = FCLKOUT = System Clock/4
  - 11 = FCLKOUT = System Clock/8

## REGISTER 10-2: CANSTAT – CAN STATUS REGISTER (ADDRESS: XEh)

R-1	R-0	R-0	U-0	R-0	R-0	R-0	U-0
OPMOD2	OPMOD1	OPMOD0	—	ICOD2	ICOD1	ICOD0	—
bit 7							bit 0

### Legend:

R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared
		x = Bit is unknown

bit 7-5      **OPMOD:** Operation Mode bits <2:0>  
 000 = Device is in the Normal operation mode  
 001 = Device is in Sleep mode  
 010 = Device is in Loopback mode  
 011 = Device is in Listen-only mode  
 100 = Device is in Configuration mode

bit 4      **Unimplemented:** Read as '0'

bit 3-1      **ICOD:** Interrupt Flag Code bits <2:0>  
 000 = No Interrupt  
 001 = Error Interrupt  
 010 = Wake-up Interrupt  
 011 = TXB0 Interrupt  
 100 = TXB1 Interrupt  
 101 = TXB2 Interrupt  
 110 = RXB0 Interrupt  
 111 = RXB1 Interrupt

bit 0      **Unimplemented:** Read as '0'

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NOTES:

## 11.0 REGISTER MAP

The register map for the MCP2515 is shown in Table 11-1. Address locations for each register are determined by using the column (higher-order 4 bits) and row (lower-order 4 bits) values. The registers have been arranged to optimize the sequential

reading and writing of data. Some specific control and status registers allow individual bit modification using the SPI Bit Modify command. The registers that allow this command are shown as shaded locations in Table 11-1. A summary of the MCP2515 control registers is shown in Table 11-2.

**TABLE 11-1: CAN CONTROLLER REGISTER MAP**

Lower Address Bits	Higher-Order Address Bits							
	0000 xxxx	0001 xxxxx	0010 xxxxx	0011 xxxxx	0100 xxxxx	0101 xxxxx	0110 xxxxx	0111 xxxxx
0000	RXF0SIDH	RXF3SIDH	RXM0SIDH	TXB0CTRL	TXB1CTRL	TXB2CTRL	RXB0CTRL	RXB1CTRL
0001	RXF0SIDL	RXF3SIDL	RXM0SIDL	TXB0SIDH	TXB1SIDH	TXB2SIDH	RXB0SIDH	RXB1SIDH
0010	RXF0EID8	RXF3EID8	RXM0EID8	TXB0SIDL	TXB1SIDL	TXB2SIDL	RXB0SIDL	RXB1SIDL
0011	RXF0EID0	RXF3EID0	RXM0EID0	TXB0EID8	TXB1EID8	TXB2EID8	RXB0EID8	RXB1EID8
0100	RXF1SIDH	RXF4SIDH	RXM1SIDH	TXB0EID0	TXB1EID0	TXB2EID0	RXB0EID0	RXB1EID0
0101	RXF1SIDL	RXF4SIDL	RXM1SIDL	TXB0DLC	TXB1DLC	TXB2DLC	RXB0DLC	RXB1DLC
0110	RXF1EID8	RXF4EID8	RXM1EID8	TXB0D0	TXB1D0	TXB2D0	RXB0D0	RXB1D0
0111	RXF1EID0	RXF4EID0	RXM1EID0	TXB0D1	TXB1D1	TXB2D1	RXB0D1	RXB1D1
1000	RXF2SIDH	RXF5SIDH	CNF3	TXB0D2	TXB1D2	TXB2D2	RXB0D2	RXB1D2
1001	RXF2SIDL	RXF5SIDL	CNF2	TXB0D3	TXB1D3	TXB2D3	RXB0D3	RXB1D3
1010	RXF2EID8	RXF5EID8	CNF1	TXB0D4	TXB1D4	TXB2D4	RXB0D4	RXB1D4
1011	RXF2EID0	RXF5EID0	CANINTE	TXB0D5	TXB1D5	TXB2D5	RXB0D5	RXB1D5
1100	BFPCTRL	TEC	CANINTF	TXB0D6	TXB1D6	TXB2D6	RXB0D6	RXB1D6
1101	TXRTSCTRL	REC	EFLG	TXB0D7	TXB1D7	TXB2D7	RXB0D7	RXB1D7
1110	CANSTAT	CANSTAT	CANSTAT	CANSTAT	CANSTAT	CANSTAT	CANSTAT	CANSTAT
1111	CANCTRL	CANCTRL	CANCTRL	CANCTRL	CANCTRL	CANCTRL	CANCTRL	CANCTRL

**Note:** Shaded register locations indicate that these allow the user to manipulate individual bits using the Bit Modify command.

**TABLE 11-2: CONTROL REGISTER SUMMARY**

Register Name	Address (Hex)	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	POR/RST Value
BFPCTRL	0C	—	—	B1BFS	B0BFS	B1BFE	B0BFE	B1BFM	B0BFM	--00 0000
TXRTSCTRL	0D	—	—	B2RTS	B1RTS	B0RTS	B2RTSM	B1RTSM	B0RTSM	--xx x000
CANSTAT	xE	OPMOD2	OPMOD1	OPMOD0	—	ICOD2	ICOD1	ICOD0	—	100- 000-
CANCTRL	xF	REQOP2	REQOP1	REQOP0	ABAT	OSM	CLKEN	CLKPRE1	CLKPRE0	1110 0111
TEC	1C	Transmit Error Counter (TEC)								0000 0000
REC	1D	Receive Error Counter (REC)								0000 0000
CNF3	28	SOF	WAKFIL	—	—	—	PHSEG22	PHSEG21	PHSEG20	00-- -000
CNF2	29	BTLMODE	SAM	PHSEG12	PHSEG11	PHSEG10	PRSEG2	PRSEG1	PRSEG0	0000 0000
CNF1	2A	SJW1	SJW0	BRP5	BRP4	BRP3	BRP2	BRP1	BRP0	0000 0000
CANINTE	2B	MERRE	WAKIE	ERRIE	TX2IE	TX1IE	TX0IE	RX1IE	RX0IE	0000 0000
CANINTF	2C	MERRF	WAKIF	ERRIF	TX2IF	TX1IF	TX0IF	RX1IF	RX0IF	0000 0000
EFLG	2D	RX1OVR	RX0OVR	TXBO	TXEP	RXEP	TXWAR	RXWAR	EWARN	0000 0000
TXB0CTRL	30	—	ABTF	MLOA	TXERR	TXREQ	—	TXP1	TXP0	-000 0-00
TXB1CTRL	40	—	ABTF	MLOA	TXERR	TXREQ	—	TXP1	TXP0	-000 0-00
TXB2CTRL	50	—	ABTF	MLOA	TXERR	TXREQ	—	TXP1	TXP0	-000 0-00
RXB0CTRL	60	—	RXM1	RXM0	—	RXRTR	BUKT	BUKT	FILHIT0	-00- 0000
RXB1CTRL	70	—	RSM1	RXM0	—	RXRTR	FILHIT2	FILHIT1	FILHIT0	-00- 0000

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NOTES:

## 12.0 SPI INTERFACE

### 12.1 Overview

The MCP2515 is designed to interface directly with the Serial Peripheral Interface (SPI) port available on many microcontrollers and supports Mode 0,0 and Mode 1,1. Commands and data are sent to the device via the SI pin, with data being clocked in on the rising edge of SCK. Data is driven out by the MCP2515 (on the SO line) on the falling edge of SCK. The  $\overline{CS}$  pin must be held low while any operation is performed. Table 12-1 shows the instruction bytes for all operations. Refer to Figure 12-10 and Figure 12-11 for detailed input and output timing diagrams for both Mode 0,0 and Mode 1,1 operation.

**Note:** The MCP2515 expects the first byte after lowering  $\overline{CS}$  to be the instruction/command byte. This implies that  $\overline{CS}$  must be raised and then lowered again to invoke another command.

### 12.2 Reset Instruction

The Reset instruction can be used to re-initialize the internal registers of the MCP2515 and set Configuration mode. This command provides the same functionality, via the SPI interface, as the  $\overline{RESET}$  pin.

The Reset instruction is a single-byte instruction that requires selecting the device by pulling  $\overline{CS}$  low, sending the instruction byte and then raising  $\overline{CS}$ . It is highly recommended that the reset command be sent (or the  $\overline{RESET}$  pin be lowered) as part of the power-on initialization sequence.

### 12.3 Read Instruction

The Read instruction is started by lowering the  $\overline{CS}$  pin. The Read instruction is then sent to the MCP2515 followed by the 8-bit address (A7 through A0). Next, the data stored in the register at the selected address will be shifted out on the SO pin.

The internal address pointer is automatically incremented to the next address once each byte of data is shifted out. Therefore, it is possible to read the next consecutive register address by continuing to provide clock pulses. Any number of consecutive register locations can be read sequentially using this method. The read operation is terminated by raising the  $\overline{CS}$  pin (Figure 12-2).

### 12.4 Read RX Buffer Instruction

The Read RX Buffer instruction (Figure 12-3) provides a means to quickly address a receive buffer for reading. This instruction reduces the SPI overhead by one byte, the address byte. The command byte actually has four possible values that determine the address pointer location. Once the command byte is sent, the controller clocks out the data at the address location the same as

the Read instruction (i.e., sequential reads are possible). This instruction further reduces the SPI overhead by automatically clearing the associated receive flag (CANINTF.RXnIF) when  $\overline{CS}$  is raised at the end of the command.

### 12.5 Write Instruction

The Write instruction is started by lowering the  $\overline{CS}$  pin. The Write instruction is then sent to the MCP2515 followed by the address and at least one byte of data.

It is possible to write to sequential registers by continuing to clock in data bytes, as long as  $\overline{CS}$  is held low. Data will actually be written to the register on the rising edge of the SCK line for the D0 bit. If the  $\overline{CS}$  line is brought high before eight bits are loaded, the write will be aborted for that data byte and previous bytes in the command will have been written. Refer to the timing diagram in Figure 12-4 for a more detailed illustration of the byte write sequence.

### 12.6 Load TX Buffer Instruction

The Load TX Buffer instruction (Figure 12-5) eliminates the eight-bit address required by a normal write command. The eight-bit instruction sets the address pointer to one of six addresses to quickly write to a transmit buffer that points to the "ID" or "data" address of any of the three transmit buffers.

### 12.7 Request-To-Send (RTS) Instruction

The RTS command can be used to initiate message transmission for one or more of the transmit buffers.

The MCP2515 is selected by lowering the  $\overline{CS}$  pin. The RTS command byte is then sent. Shown in Figure 12-6, the last 3 bits of this command indicate which transmit buffer(s) are enabled to send.

This command will set the TxBnCTRL.TXREQ bit for the respective buffer(s). Any or all of the last three bits can be set in a single command. If the RTS command is sent with  $nnn = 000$ , the command will be ignored.

### 12.8 Read Status Instruction

The Read Status instruction allows single instruction access to some of the often used status bits for message reception and transmission.

The MCP2515 is selected by lowering the  $\overline{CS}$  pin and the read status command byte, shown in Figure 12-8, is sent to the MCP2515. Once the command byte is sent, the MCP2515 will return eight bits of data that contain the status.

If additional clocks are sent after the first eight bits are transmitted, the MCP2515 will continue to output the status bits as long as the  $\overline{CS}$  pin is held low and clocks are provided on SCK.

# MCP2515

Each status bit returned in this command may also be read by using the standard read command with the appropriate register address.

## 12.9 RX Status Instruction

The RX Status instruction (Figure 12-9) is used to quickly determine which filter matched the message and message type (standard, extended, remote). After the command byte is sent, the controller will return 8 bits of data that contain the status data. If more clocks are sent after the 8 bits are transmitted, the controller will continue to output the same status bits as long as the CS pin stays low and clocks are provided.

## 12.10 Bit Modify Instruction

The Bit Modify instruction provides a means for setting or clearing individual bits in specific status and control registers. This command is not available for all registers. See Section 11.0 “Register Map” to determine which registers allow the use of this command.

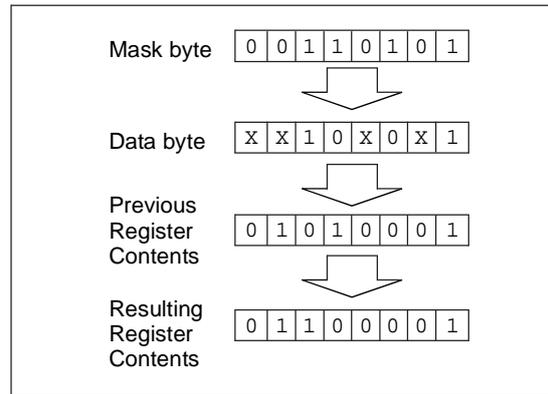
**Note:** Executing the Bit Modify command on registers that are not bit-modifiable will force the mask to FFh. This will allow byte-writes to the registers, not bit modify.

The part is selected by lowering the CS pin and the Bit Modify command byte is then sent to the MCP2515. The command is followed by the address of the register, the mask byte and finally the data byte.

The mask byte determines which bits in the register will be allowed to change. A ‘1’ in the mask byte will allow a bit in the register to change, while a ‘0’ will not.

The data byte determines what value the modified bits in the register will be changed to. A ‘1’ in the data byte will set the bit and a ‘0’ will clear the bit, provided that the mask for that bit is set to a ‘1’ (see Figure 12-7).

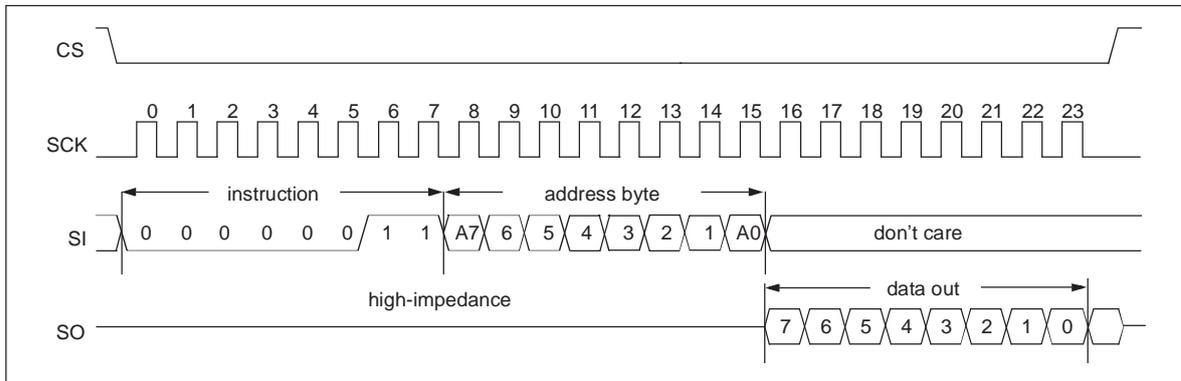
**FIGURE 12-1: BIT MODIFY**



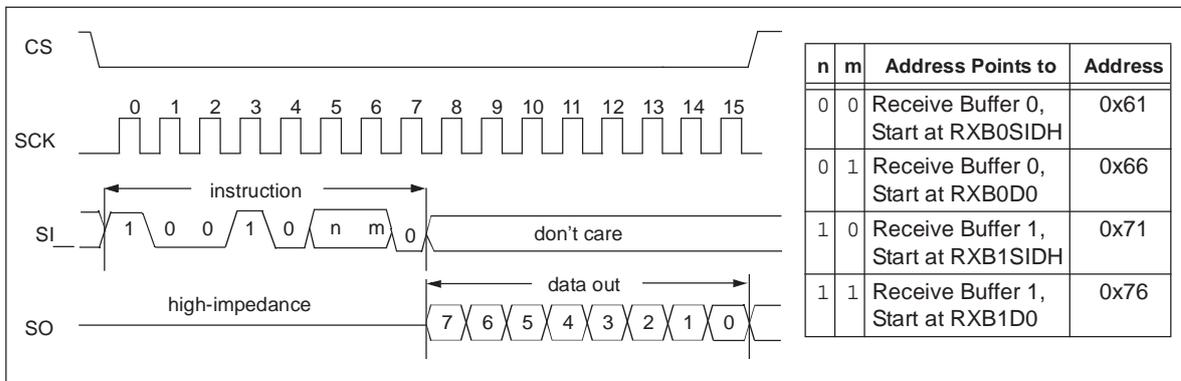
**TABLE 12-1: SPI INSTRUCTION SET**

Instruction Name	Instruction Format	Description
RESET	1100 0000	Resets internal registers to default state, set Configuration mode.
READ	0000 0011	Read data from register beginning at selected address.
Read RX Buffer	1001 0nm0	When reading a receive buffer, reduces the overhead of a normal read command by placing the address pointer at one of four locations, as indicated by ‘n,m’. <b>Note:</b> The associated RX flag bit (CANINTF.RXnIF) will be cleared after bringing CS high.
WRITE	0000 0010	Write data to register beginning at selected address.
Load TX Buffer	0100 0abc	When loading a transmit buffer, reduces the overhead of a normal Write command by placing the address pointer at one of six locations as indicated by ‘a,b,c’.
RTS (Message Request-To-Send)	1000 0nnn	Instructs controller to begin message transmission sequence for any of the transmit buffers.  <div style="text-align: center;">           1000 0nnn            Request-to-send for TXB2 — ↑↑ — Request-to-send for TXB0            Request-to-send for TXB1         </div>
Read Status	1010 0000	Quick polling command that reads several status bits for transmit and receive functions.
RX Status	1011 0000	Quick polling command that indicates filter match and message type (standard, extended and/or remote) of received message.
Bit Modify	0000 0101	Allows the user to set or clear individual bits in a particular register. <b>Note:</b> Not all registers can be bit-modified with this command. Executing this command on registers that are not bit-modifiable will force the mask to FFh. See the register map in Section 11.0 “Register Map” for a list of the registers that apply.

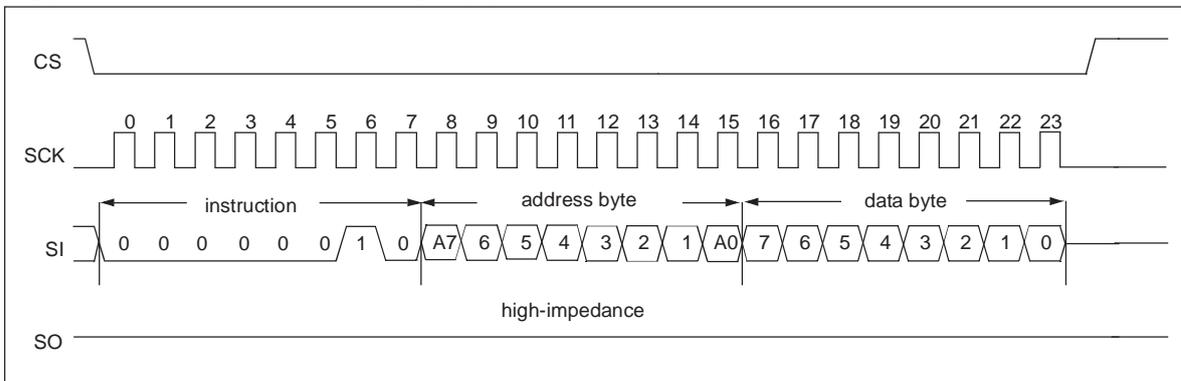
**FIGURE 12-2: READ INSTRUCTION**



**FIGURE 12-3: READ RX BUFFER INSTRUCTION**

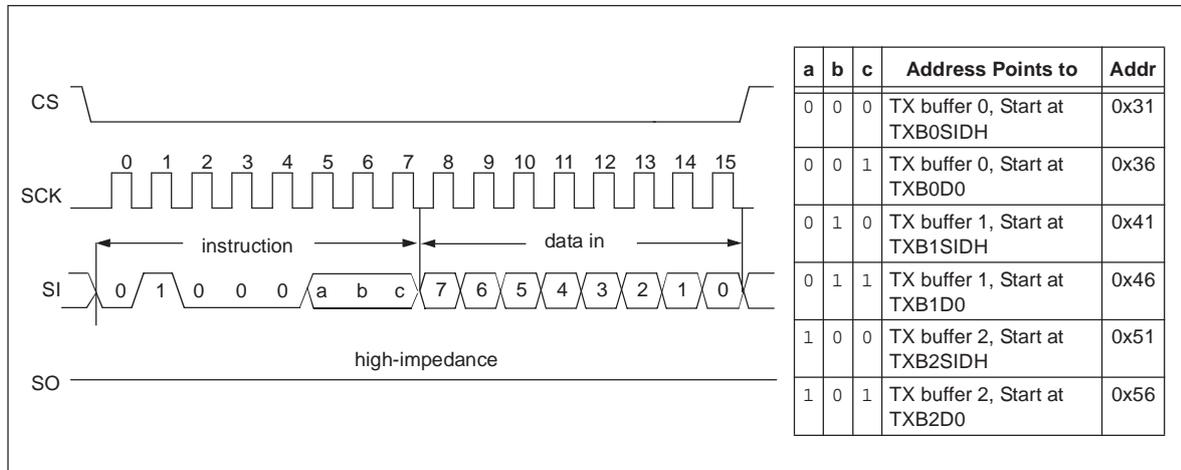


**FIGURE 12-4: BYTE WRITE INSTRUCTION**

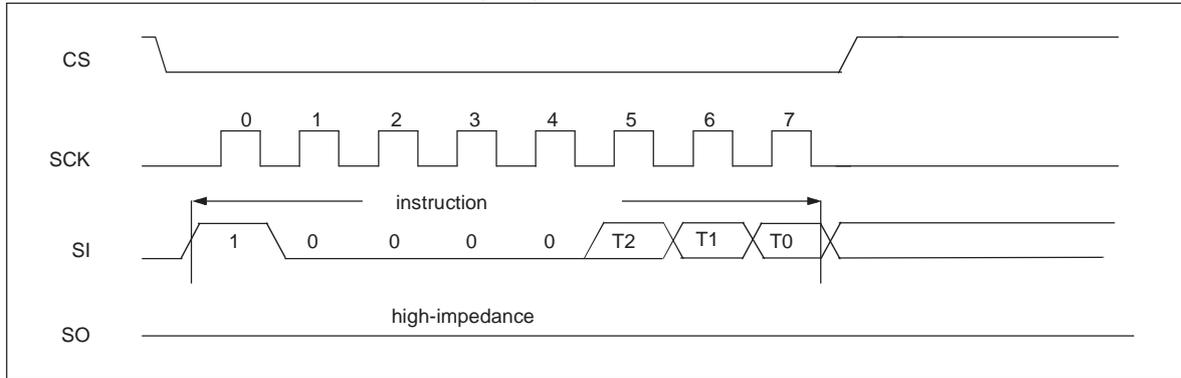


# MCP2515

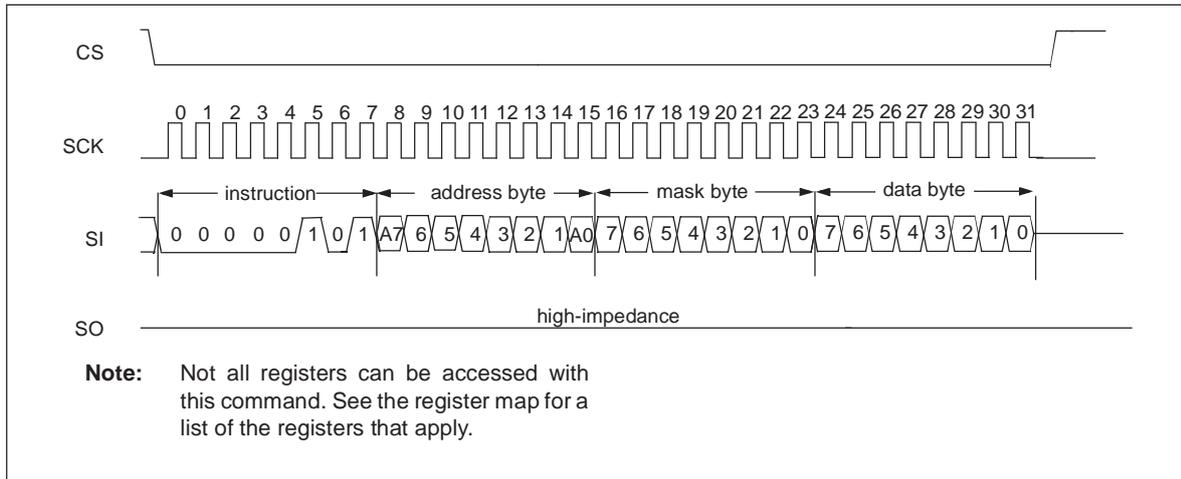
**FIGURE 12-5: LOAD TX BUFFER**



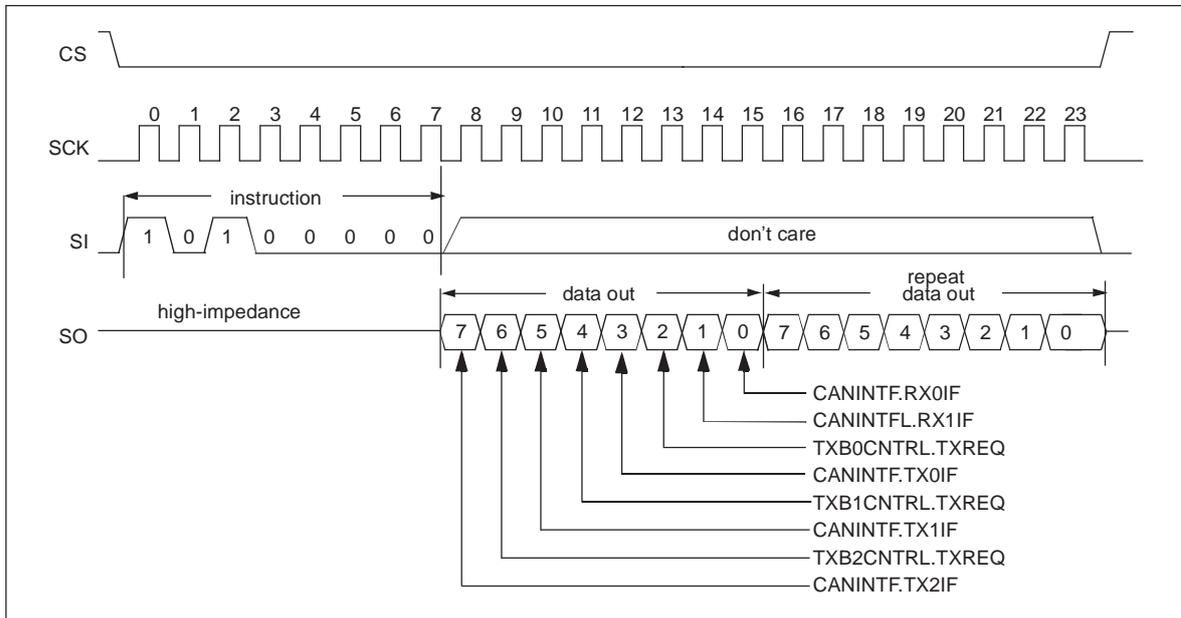
**FIGURE 12-6: REQUEST-TO-SEND (RTS) INSTRUCTION**



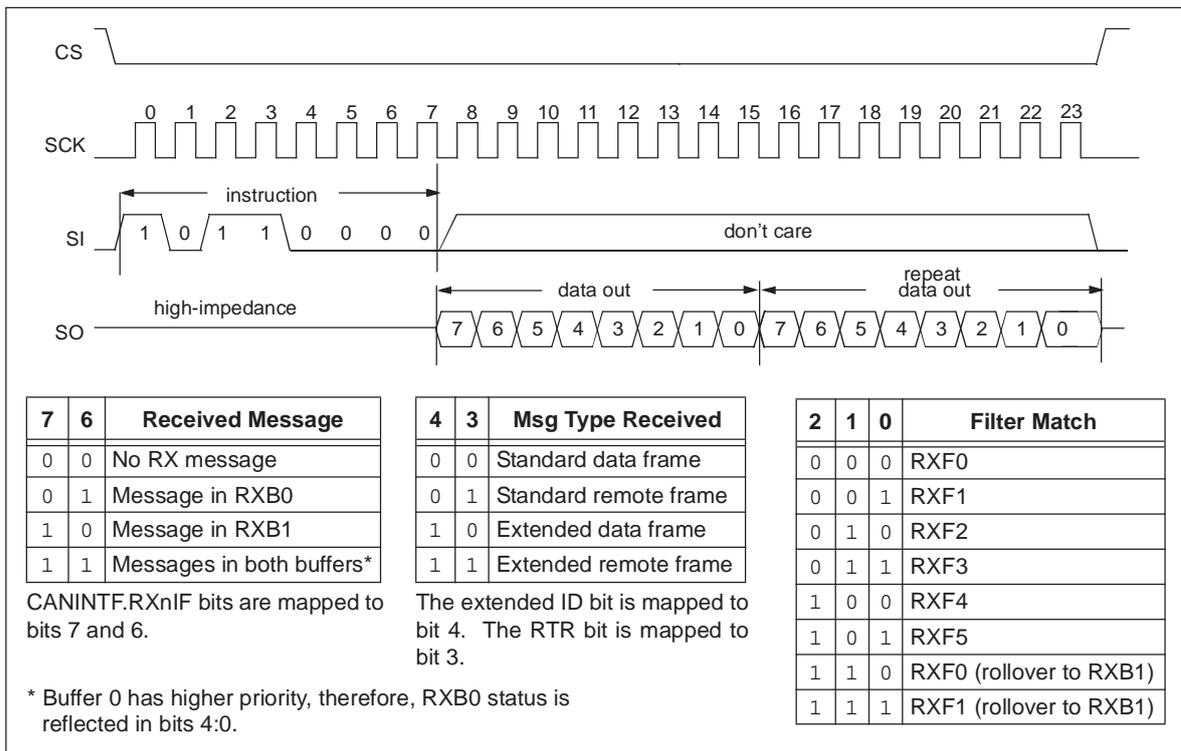
**FIGURE 12-7: BIT MODIFY INSTRUCTION**



**FIGURE 12-8: READ STATUS INSTRUCTION**

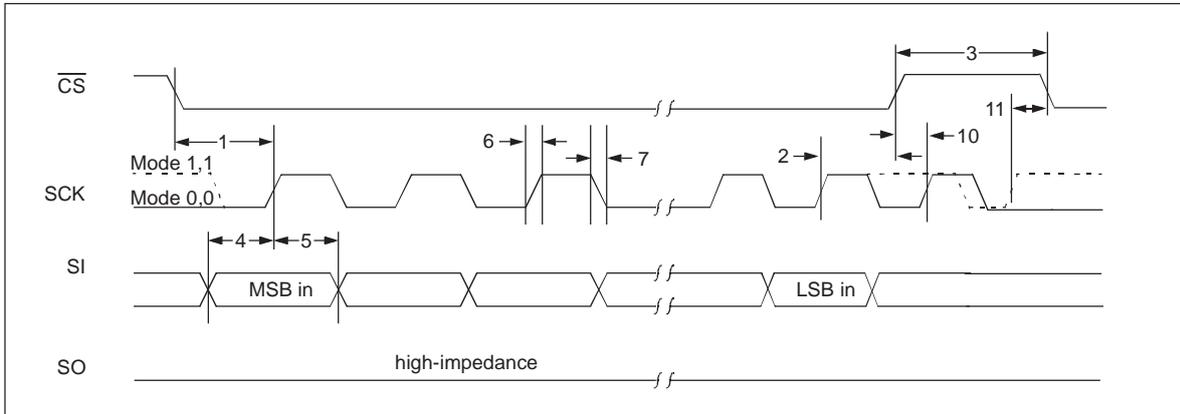


**FIGURE 12-9: RX STATUS INSTRUCTION**

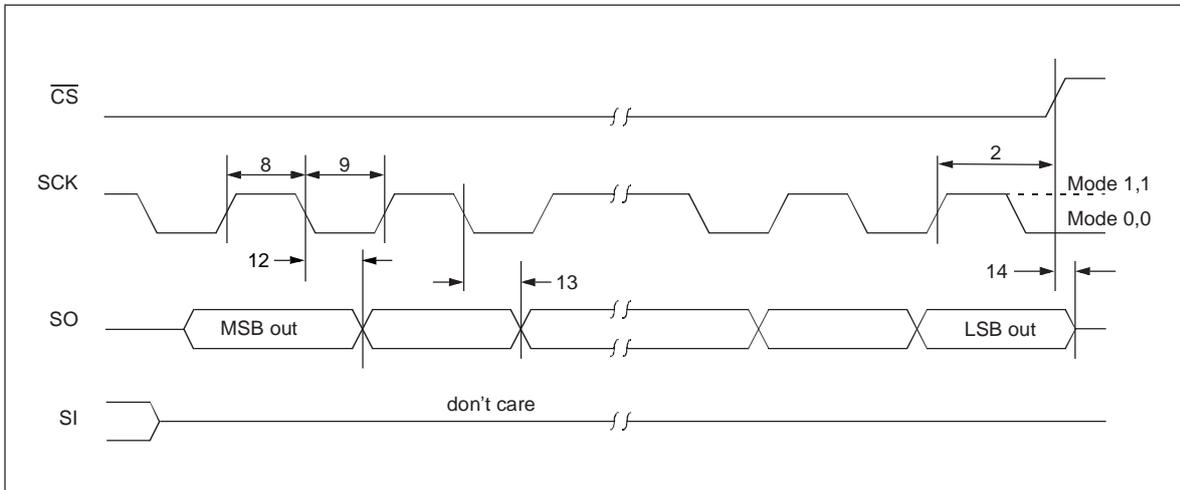


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**FIGURE 12-10: SPI INPUT TIMING**



**FIGURE 12-11: SPI OUTPUT TIMING**



## 13.0 ELECTRICAL CHARACTERISTICS

### 13.1 Absolute Maximum Ratings †

V <sub>DD</sub> .....	7.0V
All inputs and outputs w.r.t. V <sub>SS</sub> .....	-0.6V to V <sub>DD</sub> +1.0V
Storage temperature .....	-65°C to +150°C
Ambient temp. with power applied .....	-65°C to +125°C
Soldering temperature of leads (10 seconds) .....	+300°C

† **Notice:** Stresses above those listed under “Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

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**TABLE 13-1: DC CHARACTERISTICS**

DC Characteristics			Industrial (I):		T <sub>AMB</sub> = -40°C to +85°C		V <sub>DD</sub> = 2.7V to 5.5V	
			Extended (E):		T <sub>AMB</sub> = -40°C to +125°C		V <sub>DD</sub> = 4.5V to 5.5V	
Param. No.	Sym	Characteristic	Min	Max	Units	Conditions		
	V <sub>DD</sub>	Supply Voltage	2.7	5.5	V			
	V <sub>RET</sub>	Register Retention Voltage	2.4	—	V			
	V <sub>IH</sub>	<b>High-Level Input Voltage</b>						
		RXCAN	2	V <sub>DD</sub> + 1	V			
		SCK, $\overline{\text{CS}}$ , SI, $\overline{\text{TXnRTS}}$ Pins	0.7 V <sub>DD</sub>	V <sub>DD</sub> + 1	V			
		OSC1	0.85 V <sub>DD</sub>	V <sub>DD</sub>	V			
		RESET	0.85 V <sub>DD</sub>	V <sub>DD</sub>	V			
	V <sub>IL</sub>	<b>Low-Level Input Voltage</b>						
		RXCAN, $\overline{\text{TXnRTS}}$ Pins	-0.3	.15 V <sub>DD</sub>	V			
		SCK, $\overline{\text{CS}}$ , SI	-0.3	0.4	V			
		OSC1	V <sub>SS</sub>	.3 V <sub>DD</sub>	V			
		RESET	V <sub>SS</sub>	.15 V <sub>DD</sub>	V			
	V <sub>OL</sub>	<b>Low-Level Output Voltage</b>						
		TXCAN	—	0.6	V	I <sub>OL</sub> = +6.0 mA, V <sub>DD</sub> = 4.5V		
		$\overline{\text{RXnBF}}$ Pins	—	0.6	V	I <sub>OL</sub> = +8.5 mA, V <sub>DD</sub> = 4.5V		
		SO, CLKOUT	—	0.6	V	I <sub>OL</sub> = +2.1 mA, V <sub>DD</sub> = 4.5V		
		$\overline{\text{INT}}$	—	0.6	V	I <sub>OL</sub> = +1.6 mA, V <sub>DD</sub> = 4.5V		
	V <sub>OH</sub>	<b>High-Level Output Voltage</b>						
		TXCAN, $\overline{\text{RXnBF}}$ Pins	V <sub>DD</sub> - 0.7	—	V	I <sub>OH</sub> = -3.0 mA, V <sub>DD</sub> = 4.5V		
		SO, CLKOUT	V <sub>DD</sub> - 0.5	—	V	I <sub>OH</sub> = -400 $\mu$ A, V <sub>DD</sub> = 4.5V		
		$\overline{\text{INT}}$	V <sub>DD</sub> - 0.7	—	V	I <sub>OH</sub> = -1.0 mA, V <sub>DD</sub> = 4.5V		
	I <sub>LI</sub>	<b>Input Leakage Current</b>						
		All I/O except OSC1 and TXnRTS pins	-1	+1	$\mu$ A	$\overline{\text{CS}} = \overline{\text{RESET}} = \text{VDD}$ , V <sub>IN</sub> = V <sub>SS</sub> to V <sub>DD</sub>		
		OSC1 Pin	-5	+5	$\mu$ A			
	C <sub>INT</sub>	Internal Capacitance (All Inputs and Outputs)	—	7	pF	T <sub>AMB</sub> = 25°C, f <sub>C</sub> = 1.0 MHz, V <sub>DD</sub> = 0V ( <b>Note 1</b> )		
	I <sub>DD</sub>	Operating Current	—	10	mA	V <sub>DD</sub> = 5.5V, F <sub>OSC</sub> = 25 MHz, F <sub>CLK</sub> = 1 MHz, SO = Open		
	I <sub>DDS</sub>	Standby Current (Sleep mode)	—	5	$\mu$ A	$\overline{\text{CS}}, \overline{\text{TXnRTS}} = \text{VDD}$ , Inputs tied to V <sub>DD</sub> or V <sub>SS</sub> , -40°C to +85°C		
			—	8	$\mu$ A	$\overline{\text{CS}}, \overline{\text{TXnRTS}} = \text{VDD}$ , Inputs tied to V <sub>DD</sub> or V <sub>SS</sub> , -40°C to +125°C		

**Note 1:** This parameter is periodically sampled and not 100% tested.

**TABLE 13-2: OSCILLATOR TIMING CHARACTERISTICS**

Oscillator Timing Characteristics <sup>(Note)</sup>			Industrial (I):		V <sub>DD</sub> = 2.7V to 5.5V	
			Extended (E):		V <sub>DD</sub> = 4.5V to 5.5V	
Param. No.	Sym	Characteristic	Min	Max	Units	Conditions
	FOSC	Clock-In Frequency	1	40	MHz	4.5V to 5.5V
			1	25	MHz	2.7V to 5.5V
	TOSC	Clock-In Period	25	1000	ns	4.5V to 5.5V
			40	1000	ns	2.7V to 5.5V
	T <sub>DUTY</sub>	Duty Cycle (External Clock Input)	0.45	0.55	—	TOSH/(TOSH + TosL)

**Note:** This parameter is periodically sampled and not 100% tested.

**TABLE 13-3: CAN INTERFACE AC CHARACTERISTICS**

CAN Interface AC Characteristics			Industrial (I):		V <sub>DD</sub> = 2.7V to 5.5V	
			Extended (E):		V <sub>DD</sub> = 4.5V to 5.5V	
Param. No.	Sym	Characteristic	Min	Max	Units	Conditions
	TWF	Wake-up Noise Filter	100	—	ns	

**TABLE 13-4: RESET AC CHARACTERISTICS**

RESET AC Characteristics			Industrial (I):		V <sub>DD</sub> = 2.7V to 5.5V	
			Extended (E):		V <sub>DD</sub> = 4.5V to 5.5V	
Param. No.	Sym	Characteristic	Min	Max	Units	Conditions
	trl	RESET Pin Low Time	2	—	μs	

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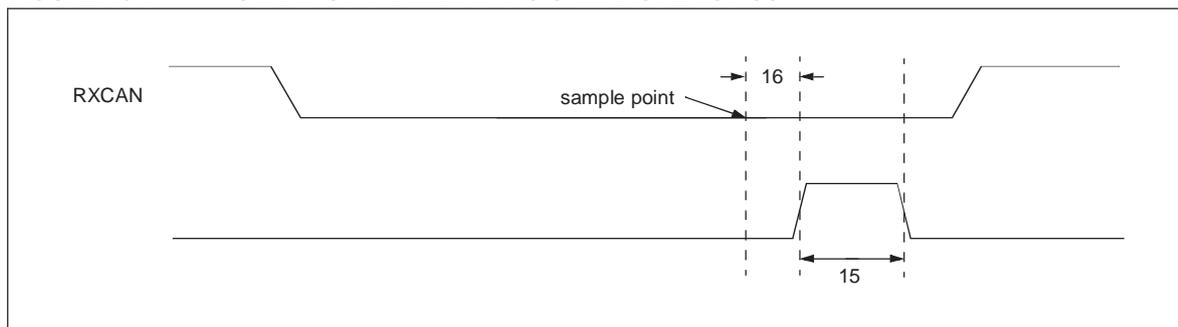
**TABLE 13-5: CLKOUT PIN AC CHARACTERISTICS**

CLKOUT Pin AC/DC Characteristics			Industrial (I):		T <sub>AMB</sub> = -40°C to +85°C		V <sub>DD</sub> = 2.7V to 5.5V	
			Extended (E):		T <sub>AMB</sub> = -40°C to +125°C		V <sub>DD</sub> = 4.5V to 5.5V	
Param. No.	Sym	Characteristic	Min	Max	Units	Conditions		
	t <sub>h</sub> CLKOUT	CLKOUT Pin High Time	15	—	ns	TOSC = 40 ns ( <b>Note 1</b> )		
	t <sub>l</sub> CLKOUT	CLKOUT Pin Low Time	15	—	ns	TOSC = 40 ns ( <b>Note 1</b> )		
	t <sub>r</sub> CLKOUT	CLKOUT Pin Rise Time	—	5	ns	Measured from 0.3 V <sub>DD</sub> to 0.7 V <sub>DD</sub> ( <b>Note 1</b> )		
	t <sub>f</sub> CLKOUT	CLKOUT Pin Fall Time	—	5	ns	Measured from 0.7 V <sub>DD</sub> to 0.3 V <sub>DD</sub> ( <b>Note 1</b> )		
	t <sub>d</sub> CLKOUT	CLOCKOUT Propagation Delay	—	100	ns	<b>Note 1</b>		
15	t <sub>h</sub> SOF	Start-Of-Frame High Time	—	2 TOSC	ns	<b>Note 1</b>		
16	t <sub>d</sub> SOF	Start-Of-Frame Propagation Delay	—	2 TOSC + 0.5 T <sub>Q</sub>	ns	Measured from CAN bit sample point. Device is a receiver. CNF1.BRP<5:0> = 0 ( <b>Note 2</b> )		

**Note 1:** All CLKOUT mode functionality and output frequency is tested at device frequency limits, however, CLKOUT prescaler is set to divide by one. This parameter is periodically sampled and not 100% tested.

**2:** Design guidance only, not tested.

**FIGURE 13-1: START-OF-FRAME PIN AC CHARACTERISTICS**



**TABLE 13-6: SPI INTERFACE AC CHARACTERISTICS**

SPI Interface AC Characteristics			Industrial (I):		Extended (E):		T <sub>AMB</sub> = -40°C to +85°C		V <sub>DD</sub> = 2.7V to 5.5V		
							T <sub>AMB</sub> = -40°C to +125°C		V <sub>DD</sub> = 4.5V to 5.5V		
Param. No.	Sym	Characteristic	Min	Max	Units	Conditions					
	FCLK	Clock Frequency	—	10	MHz						
1	T <sub>CSS</sub>	$\overline{\text{CS}}$ Setup Time	50	—	ns						
2	T <sub>CSH</sub>	$\overline{\text{CS}}$ Hold Time	50	—	ns						
3	T <sub>CSD</sub>	$\overline{\text{CS}}$ Disable Time	50	—	ns						
4	T <sub>SU</sub>	Data Setup Time	10	—	ns						
5	T <sub>HD</sub>	Data Hold Time	10	—	ns						
6	T <sub>R</sub>	CLK Rise Time	—	2	μs	<b>Note 1</b>					
7	T <sub>F</sub>	CLK Fall Time	—	2	μs	<b>Note 1</b>					
8	T <sub>HI</sub>	Clock High Time	45	—	ns						
9	T <sub>LO</sub>	Clock Low Time	45	—	ns ns						
10	T <sub>C<sub>LD</sub></sub>	Clock Delay Time	50	—	ns						
11	T <sub>C<sub>LE</sub></sub>	Clock Enable Time	50	—	ns						
12	T <sub>V</sub>	Output Valid from Clock Low	—	45	ns						
13	T <sub>HO</sub>	Output Hold Time	0	—	ns						
14	T <sub>DIS</sub>	Output Disable Time	—	100	ns						

**Note 1:** This parameter is not 100% tested.

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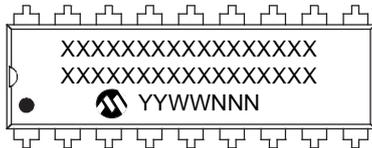
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NOTES:

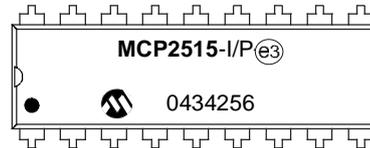
## 14.0 PACKAGING INFORMATION

### 14.1 Package Marking Information

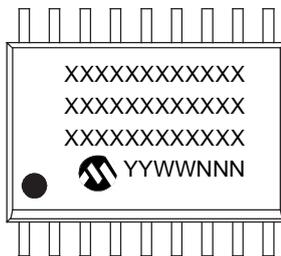
18-Lead PDIP (300 mil)



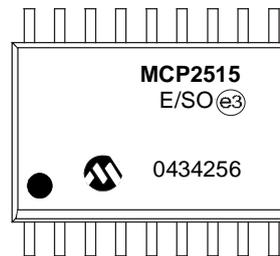
Example:



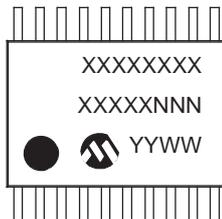
18-Lead SOIC (300 mil)



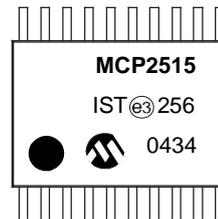
Example:



20-Lead TSSOP (4.4 mm)



Example:



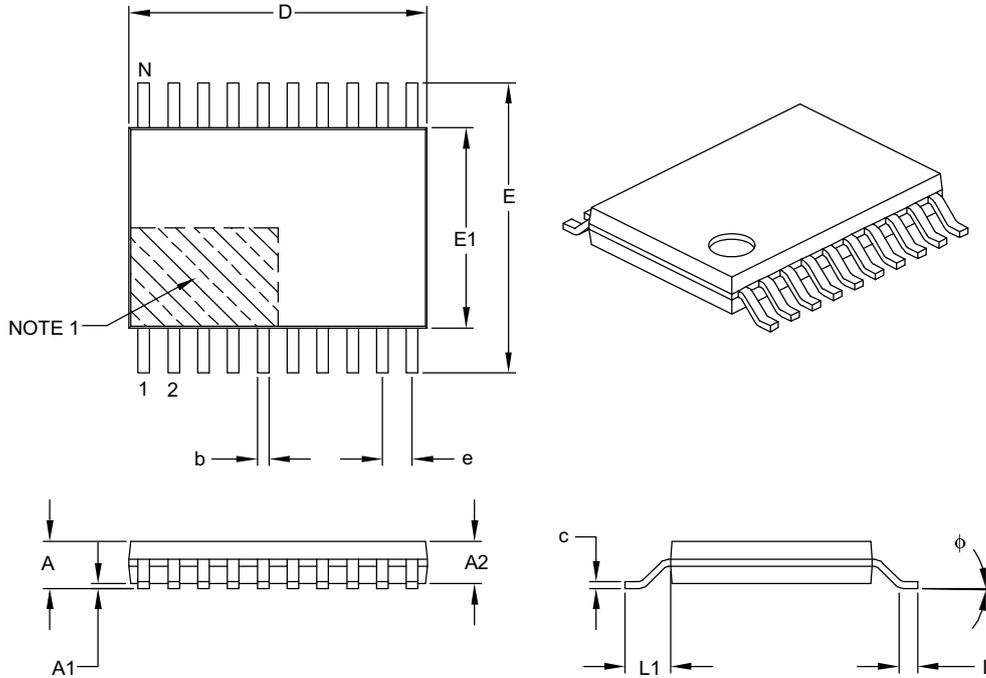
<b>Legend:</b>	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.

**Note:** In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

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## 20-Lead Plastic Thin Shrink Small Outline (ST) – 4.4 mm Body [TSSOP]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Dimension Limits	Units	MILLIMETERS		
		MIN	NOM	MAX
Number of Pins	N	20		
Pitch	e	0.65 BSC		
Overall Height	A	–	–	1.20
Molded Package Thickness	A2	0.80	1.00	1.05
Standoff	A1	0.05	–	0.15
Overall Width	E	6.40 BSC		
Molded Package Width	E1	4.30	4.40	4.50
Molded Package Length	D	6.40	6.50	6.60
Foot Length	L	0.45	0.60	0.75
Footprint	L1	1.00 REF		
Foot Angle	$\phi$	0°	–	8°
Lead Thickness	c	0.09	–	0.20
Lead Width	b	0.19	–	0.30

**Notes:**

- Pin 1 visual index feature may vary, but must be located within the hatched area.
- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15 mm per side.
- Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-088B

## APPENDIX A: REVISION HISTORY

### Revision E (November 2007)

- Removed preliminary watermark.
- Updated templates.
- Updated register information.
- Updated package outline drawings.

### Revision D (April 2005)

- Added Table 8-1 and Table 8-2 in **Section 8.0 “Oscillator”**. Added note box following tables.
- Changed address bits in column heading in Table 11-1, **Section 11.0 “Register Map”**.
- Modified **Section 14.0 “Packaging Information”** to reflect pb free device markings.
- Appendix A Revision History: Rearranged order of importance.

### Revision C (November 2004)

- **Section 9.0 “RESET”** added.
- Heading 12.1: added notebox.  
Heading 12.6: Changed verbiage within paragraph in **Section 12.0 “SPI Interface”**.
- Added Appendix A: Revision History.

### Revision B (September 2003)

- Front page bullet: Standby current (typical) (Sleep Mode) changed from 10  $\mu$ A to 1  $\mu$ A.
- Added notebox for maximum frequency on CLK-OUT in **Section 8.2 “CLKOUT Pin”**.
- **Section 12.0 “SPI Interface”**, Table 12-1:
  - Changed supply voltage minimum to 2.7V.
  - Internal Capacitance: Changed VDD condition to 0V.
  - Standby Current (Sleep mode): Split specification into -40°C to +85°C and -40°C to +125°C.

### Revision A (May 2003)

- Original Release of this Document.

# MCP2515

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NOTES:

# MCP2515

## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

<u>PART NO.</u>	-	<u>X</u>	<u>/XX</u>
Device		Temperature Range	Package
Device		MCP2515: CAN Controller w/ SPI Interface MCP2515T: CAN Controller w/SPI Interface (Tape and Reel)	
Temperature Range		I = -40°C to +85°C (Industrial) E = -40°C to +125°C (Extended)	
Package		P = Plastic DIP (300 mil Body), 18-Lead SO = Plastic SOIC (300 mil Body), 18-Lead ST = TSSOP, (4.4 mm Body), 20-Lead	

**Examples:**

- a) MCP2515-E/P: Extended Temperature, 18LD PDIP package.
- b) MCP2515-I/P: Industrial Temperature, 18LD PDIP package.
- c) MCP2515-E/SO: Extended Temperature, 18LD SOIC package.
- d) MCP2515-I/SO: Industrial Temperature, 18LD SOIC package.
- e) MCP2515T-I/SO: Tape and Reel, Industrial Temperature, 18LD SOIC package.
- f) MCP2515-I/ST: Industrial Temperature, 20LD TSSOP package.
- g) MCP2515T-I/ST: Tape and Reel, Industrial Temperature, 20LD TSSOP package.

# MCP2515

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NOTES:

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**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families 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 Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is 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."

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10/05/07



## Test Report

No: 10193333(4)

Date: 26-Apr-10

Page 1 of 8

Sumitomo Bakelite Singapore Pte Ltd  
1 Senoko South Road, Singapore

The following sample(s) was/were submitted and identified by/on behalf of the client as:

Sample Description : EME-G600  
Type : Type  
Lot No. : 0032203  
Manufacturing Date : 3/17/10  
Contact Name : Chen Yi Jun  
Contact Tel : +65-67503782  
Contact Email : [yijun@sbs.sumibe.co.jp](mailto:yijun@sbs.sumibe.co.jp)

Sample Receiving Date : 15-Apr-10  
Testing Period : 15-Apr-10 to 26-Apr-10

Test Requested : In accordance with the RoHS Directive 2002/95/EC, and its amendment directives.

---

Test Result(s) : Please refer to next page(s).

Conclusion : Based on the performed tests on submitted sample(s), the results **comply with** the RoHS Directive 2002/95/EC and its subsequent amendments.

Signed for and on behalf of  
SGS Testing & Control Services Singapore Pte Ltd

---

Y.C. Tham  
Laboratory Manager

Test Location: 26 Ayer Rajah Crescent, #07-08, Singapore 139944

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## Test Report

No: 10193333(4)

Date: 26-Apr-10

Page 2 of 8

### Test Result(s):

Sample Description : EME-G600  
 Type : Type  
 Lot No. : 0032203  
 Manufacturing Date : 3/17/10

Test Item(s):	Unit	Method	Results	MDL	RoHS Limit
Cadmium(Cd)	mg/kg	With reference to IEC62321, Ed1:2008. Analysis was performed by ICP/AES	n.d.	2	100
Lead (Pb)	mg/kg	With reference to IEC62321, Ed1:2008. Analysis was performed by ICP/AES	n.d.	2	1000
Mercury (Hg)	mg/kg	With reference to IEC62321, Ed1:2008. Analysis was performed by ICP/AES	n.d.	2	1000
Hexavalent Chromium (CrVI)	mg/kg	With reference to IEC62321, Ed1:2008. Analysis was performed by UV/Vis Spectrometry	n.d.	2	1000
<b>Sum of PBBs</b>	mg/kg	With reference to IEC62321, Ed1:2008. Analysis was performed by GC/MS	<b>n.d.</b>	-	1000
Monobromobiphenyl	mg/kg		n.d.	5	-
Dibromobiphenyl	mg/kg		n.d.	5	-
Tribromobiphenyl	mg/kg		n.d.	5	-
Tetrabromobiphenyl	mg/kg		n.d.	5	-
Hexabromobiphenyl	mg/kg		n.d.	5	-
Pentabromobiphenyl	mg/kg		n.d.	5	-
Heptabromobiphenyl	mg/kg		n.d.	5	-
Octabromobiphenyl	mg/kg		n.d.	5	-
Nonabromobiphenyl	mg/kg		n.d.	5	-
Decabromobiphenyl	mg/kg		n.d.	5	-
<b>Sum of PBDEs</b>	mg/kg		<b>n.d.</b>	-	1000
Monobromodiphenyl ether	mg/kg		n.d.	5	-
Dibromodiphenyl ether	mg/kg		n.d.	5	-
Tribromodiphenyl ether	mg/kg		n.d.	5	-
Tetrabromodiphenyl ether	mg/kg		n.d.	5	-
Pentabromodiphenyl ether	mg/kg		n.d.	5	-
Hexabromodiphenyl ether	mg/kg		n.d.	5	-
Heptabromodiphenyl ether	mg/kg		n.d.	5	-
Octabromodiphenyl ether	mg/kg		n.d.	5	-
Nonabromodiphenyl ether	mg/kg	n.d.	5	-	
Decabromodiphenyl ether ##	mg/kg	n.d.	5	-	

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## Test Report

No: 10193333(4)

Date: 26-Apr-10

Page 3 of 8

### Test Result(s):

Sample Description : EME-G600  
Type : Type  
Lot No. : 0032203  
Manufacturing Date : 3/17/10

Test Item(s):	Unit	Method	Results	MDL
Antimony (Sb)	mg/kg	With reference to US EPA3051A. Analysis was performed by ICP/AES	n.d.	2
Perfluorooctane Sulfonates (PFOS)* – Acid, Metal Salt, Amide	mg/kg	With reference to US EPA 3540C: 1996 method for PFOS Content. Analysis was performed by LC/MS.	n.d.	10
PFOA (CAS No.: 000335-67-1)*	mg/kg	With reference to US EPA 3540C: 1996 method for PFOA Content. Analysis was performed by LC/MS.	n.d.	10
<b>Halogen</b>				
Halogen - Bromine (Br)	mg/kg	With reference to BS EN 14582. Analysis was performed by IC	n.d.	50
Halogen - Chlorine (Cl)	mg/kg	With reference to BS EN 14582. Analysis was performed by IC	n.d.	50
Halogen - Fluorine (F)	mg/kg	With reference to BS EN 14582. Analysis was performed by IC	n.d.	50
Halogen - Iodine (I)	mg/kg	With reference to BS EN 14582. Analysis was performed by IC	n.d.	50

Note: (1) mg/kg = ppm ; 0.1wt% = 1000ppm  
(2) n.d.= Not Detected  
(3) MDL = Method Detection Limit

Remarks: Sample received was totally dissolved by pre-conditioning method.

Lab Analyst(s): Jenny

\* **Tested by SGS Lab ( Ref: CE/2010/43692)**

### PFOS Reference Information : Directive 2006/122/EC

- (1) May not be placed on the market or used as a substance or constituent of preparations in a concentration equal to or higher than 0.005 % by mass.
- (2) May not be placed on the market in semi-finished products or articles, or parts thereof, if the concentration of PFOS is equal to or higher than 0.1 % by mass calculated with reference to the mass of structurally or microstructurally distinct parts that contain PFOS or, for textiles or other coated materials, if the amount of PFOS is equal to or higher than  $1\mu\text{g}/\text{m}^2$  of the coated material.

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- Note:
- (1) mg/kg = ppm ; 0.1wt% = 1000ppm
  - (2) n.d.= Not Detected
  - (3) MDL = Method Detection Limit
  - (4) ## = The exemption of DecaBDE in polymeric application according 2005/717/EC was overruled by the European Court of Justice by its decision of 01.04.2008. Subsequently DecaBDE will be included in the sum of PBDE after 01.07.2008.
  - (5) "-" = Not regulated
  - (6) \* : Exceeds limit

Remarks: Sample received was totally dissolved by preconditioning method.  
Lab Analyst(s): Jay, Ruihan and Jojo

**Sample photo:**

Sample Description	:	EME-G600
Type	:	Type
Lot No.	:	0032203
Manufacturing Date	:	3/17/10
Sample Submission Qty	:	50gm

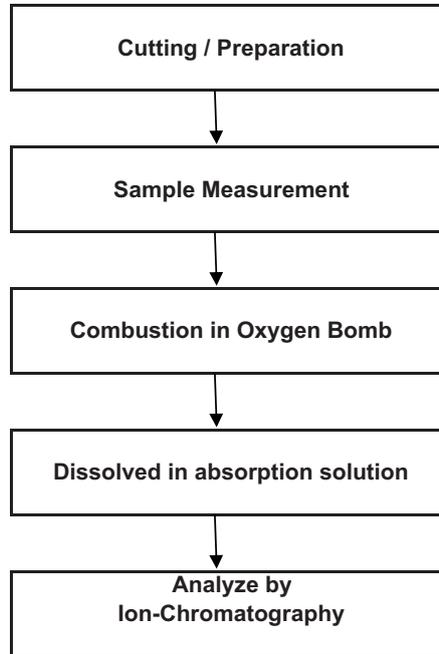
SGS authenticate the photo on original report only



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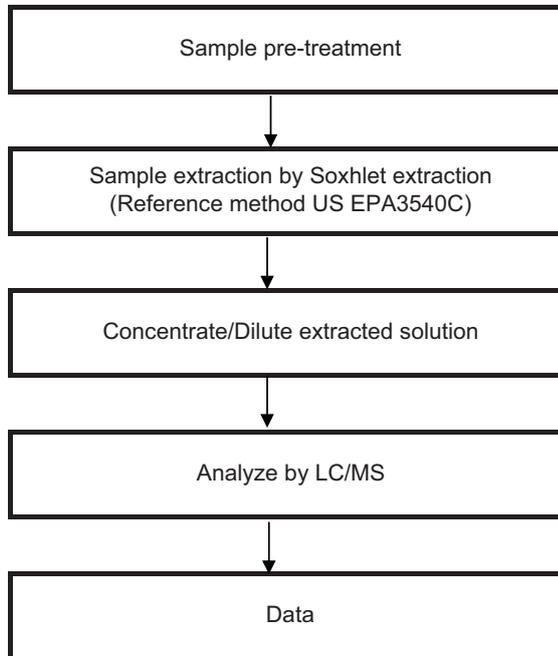
**Process Flow of BS EN 14582 (Halogen Analysis)**



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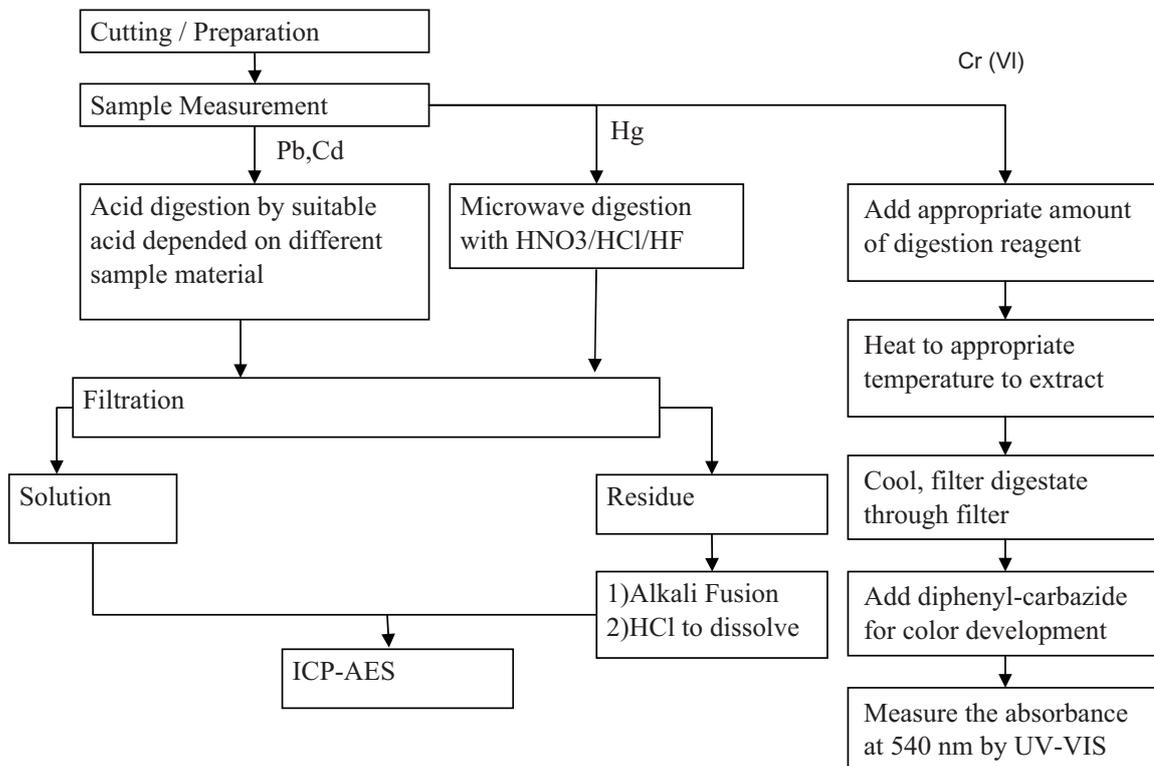
**Process Flow of PFOS/PFOA**



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**Process Flow of IEC 62321 (Pb, Cd, Hg & Cr<sup>6+</sup>)**



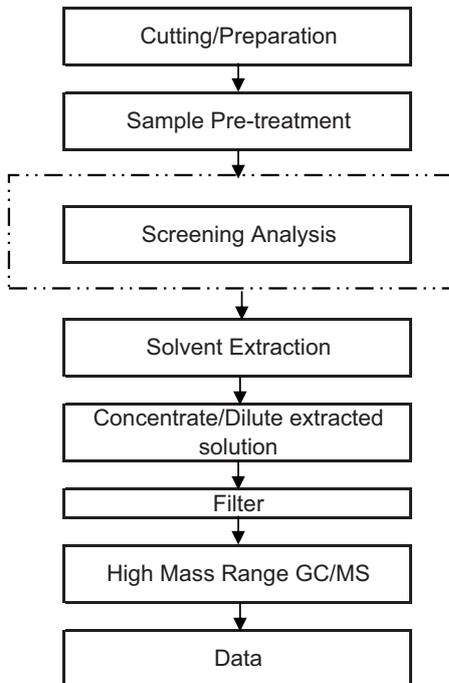
Remarks: Sample received was totally dissolved by preconditioning method. (CrVI method excluded)

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**Process Flow of PBBs and PBDEs by GC/MS (IEC 62321)**

First Testing Process → Optional screen process ..... Confirmation process ...→



\*\*\*End of Report\*\*\*

Test Location: 26 Ayer Rajah Crescent, #07-08, Singapore 139944

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**Client : Microchip Technology (Thailand) Co.,Ltd.**  
**14 Moo 1,**  
**T.Wangtakhien, A.Muang Chachengsao, Chachoengsao 24000 Thailand**

The following sample(s) was/were submitted and identified by/on behalf of the client as:

Sample Description : Silicon Die/Wafer-AISiCu Outer Signal/Contact Layers  
Sample No. : 1770771  
Sample Condition : As per attached photograph  
Manufacturer/Vendor : Microchip Technology Inc.  
Buyer's Name : Microchip Technology (Thailand) Co.,Ltd.  
Sample Receiving Date : 5-Nov-2009  
Testing Period : 05-Nov-2009 to 09-Nov-2009  
Test Requested : In accordance with the RoHS Directive 2002/95/EC and its amendment directives  
Test Method : (1) With reference to IEC 62321:2008 for Lead content, Analysis was performed by ICP-OES.  
(2) With reference to IEC 62321:2008 for Cadmium content, Analysis was performed by ICP-OES.  
(3) With reference to IEC 62321:2008 for Mercury content, Analysis was performed by ICP-OES.  
(4) With reference to IEC 62321:2008 for Hexavalent Chromium by Alkaline Digestion / Colorimetric Method, Analysis was performed by UV-Vis Spectrometry.  
(5) With reference to IEC 62321:2008 for PBB/PBDE content, Analysis was performed by GC/MS.  
Test Results : Please refer to next page.

**Signed for and on behalf of  
SGS (Thailand) Limited**



**Pornpana Lirathpong  
Hardlines Testing Manager**

TEST RESULTS

Test results by chemical method (Unit: mg/kg)

Test Item (s):	Method (Refer to)	Result (1)	MDL	RoHS Limit
Lead (Pb)	(1)	n.d.	2	1000
Cadmium (Cd)	(2)	n.d.	2	100
Mercury (Hg)	(3)	n.d.	2	1000
Hexavalent Chromium (CrVI) by Alkaline Digestion/Colorimetric Method	(4)	n.d.	2	1000
sum of PBBs	(5)	n.d.	-	1000
Monobromobiphenyl		n.d.	5	-
Dibromobiphenyl		n.d.	5	-
Tribromobiphenyl		n.d.	5	-
Tetrabromobiphenyl		n.d.	5	-
Pentabromobiphenyl		n.d.	5	-
Hexabromobiphenyl		n.d.	5	-
Heptabromobiphenyl		n.d.	5	-
Octabromobiphenyl		n.d.	5	-
Nonabromobiphenyl		n.d.	5	-
Decabromobiphenyl		n.d.	5	-

1427500

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TEST RESULTS

Test results by chemical method (Unit: mg/kg)

Test Item (s):	Method (Refer to)	Result (1)	MDL	RoHS Limit
Sum of PBDEs	(5)	n.d.	-	1000
Monobromodiphenyl ether		n.d.	5	-
Dibromodiphenyl ether		n.d.	5	-
Tribromodiphenyl ether		n.d.	5	-
Tetrabromodiphenyl ether		n.d.	5	-
Pentabromodiphenyl ether		n.d.	5	-
Hexabromodiphenyl ether		n.d.	5	-
Heptabromodiphenyl ether		n.d.	5	-
Octabromodiphenyl ether		n.d.	5	-
Nonabromodiphenyl ether		n.d.	5	-
Decabromodiphenyl ether		n.d.	5	-

Test Part Description

Result (1) mixed all parts

Note :

(1) mg/kg = ppm ; 0.1 wt% = 1000 ppm

(2) n.d. = Not Detected

(3) MDL = Method Detection Limit

(4) The exemption of DecaBDE in polymeric application according 2005/17/EC was overruled by the European Court of Justice by its decision of 01.04.2008. Subsequently DecaBDE will be included in the sum of PBDE after 01.07.2008

(5) "-" = Not regulated

1427500

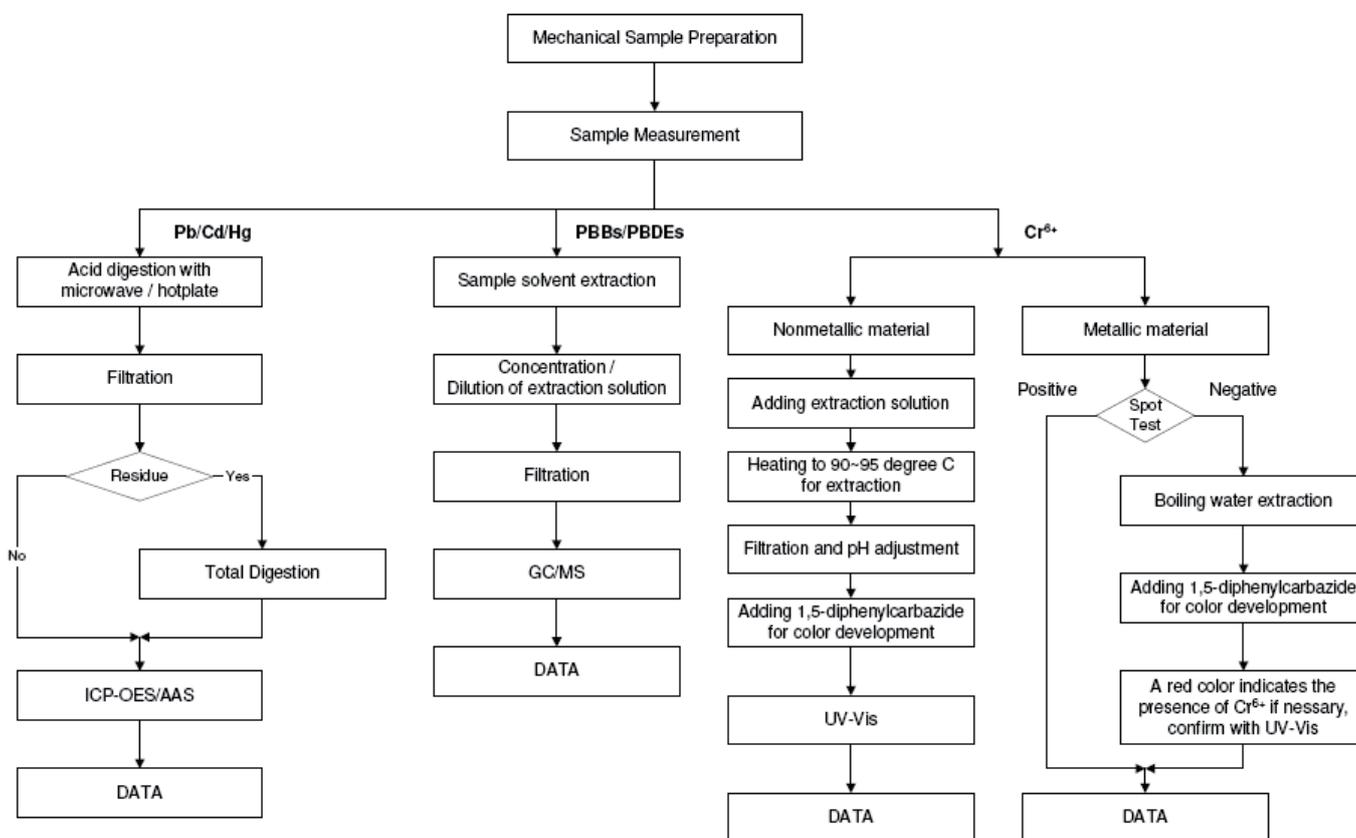
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Flow Chart for RoHS : Pb/Cd/Hg/Cr<sup>6+</sup>/PBBs/PBDEs Testing

1. Operator : Wanwisa Seakew
2. Section Chief : Laddawan Uranpitr
3. The sample was dissolved totally by pre-conditioning method according to below flowchart. (Cr<sup>6+</sup> and PBBs/PBDEs test method excluded)



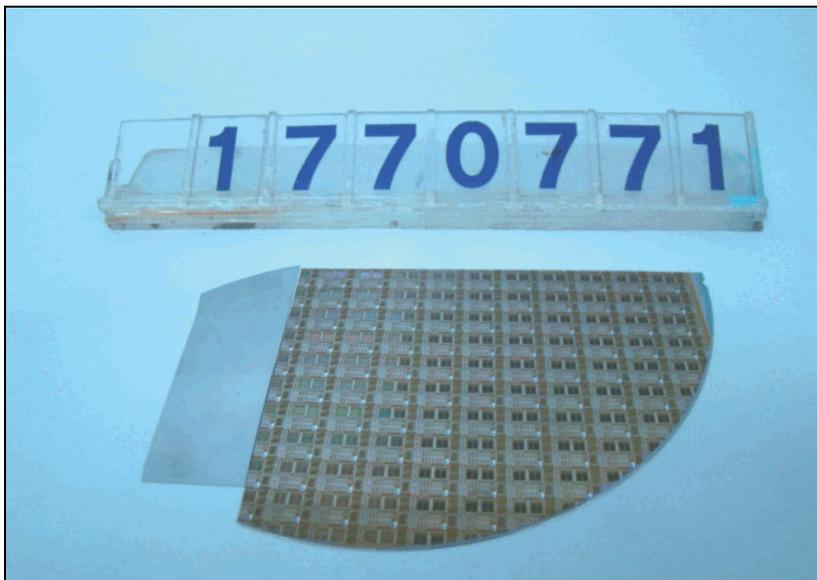
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SAMPLE/ATTACHMENT PICTURE



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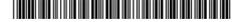
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**Test Report** No. : CE/2009/B2812 Date : 2009/11/17 Page : 1 of 5

HENKEL  
MANUFACTURING SITES: USA, KOREA, CHINA, UK, AND JAPAN.  
MAIN OFFICE: 20021 SUSANA ROAD, RANCHO DOMINGUEZ,  
CALIFORNIA, 90221, USA



**The following sample(s) was/were submitted and identified by/on behalf of the client as :**

Sample Description : ADHESIVE  
Style/Item No. : 8390A  
Sample Receiving Date : 2009/11/11  
Testing Period : 2009/11/11 TO 2009/11/17

=====  
**Test Requested** : In accordance with the RoHS Directive 2002/95/EC, and its amendment directives.

**Test Method** : With reference to IEC 62321: 2008  
Procedures for the Determination of Levels of Regulated Substances in  
Electrotechnical Products.  
(1) Determination of Cadmium by ICP-AES.  
(2) Determination of Lead by ICP-AES.  
(3) Determination of Mercury by ICP-AES.  
(4) Determination of Hexavalent Chromium by UV/Vis Spectrometry.  
(5) Determination of PBB and PBDE by GC/MS.

**Test Result(s)** : Please refer to next page(s).

**Chenyu Kung / Operation Manager**  
Signed for and on behalf of  
**SGS TAIWAN LTD.**  
**Chemical Laboratory – Taipei**

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# Test Report

No. : CE/2009/B2812

Date : 2009/11/17

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Test results by chemical method (Unit: mg/kg)

Test Item (s):	Method (Refer to)	Result	MDL
		No.1	
Cadmium (Cd)	(1)	n.d.	2
Lead (Pb)	(2)	n.d.	2
Mercury (Hg)	(3)	n.d.	2
Hexavalent Chromium Cr(VI) by alkaline extraction	(4)	n.d.	2
<b>Sum of PBBs</b>	(5)	n.d.	-
Monobromobiphenyl		n.d.	5
Dibromobiphenyl		n.d.	5
Tribromobiphenyl		n.d.	5
Tetrabromobiphenyl		n.d.	5
Pentabromobiphenyl		n.d.	5
Hexabromobiphenyl		n.d.	5
Heptabromobiphenyl		n.d.	5
Octabromobiphenyl		n.d.	5
Nonabromobiphenyl		n.d.	5
Decabromobiphenyl		n.d.	5
<b>Sum of PBDEs</b>		n.d.	-
Monobromodiphenyl ether		n.d.	5
Dibromodiphenyl ether		n.d.	5
Tribromodiphenyl ether		n.d.	5
Tetrabromodiphenyl ether		n.d.	5
Pentabromodiphenyl ether		n.d.	5
Hexabromodiphenyl ether		n.d.	5
Heptabromodiphenyl ether		n.d.	5
Octabromodiphenyl ether		n.d.	5
Nonabromodiphenyl ether		n.d.	5
Decabromodiphenyl ether		n.d.	5

## TEST PART DESCRIPTION:

NO.1 : SILVER COLORED PASTE

- Note :
1. mg/kg = ppm; 0.1wt% = 1000ppm
  2. n.d. = Not Detected
  3. MDL = Method Detection Limit
  4. "-" = Not Regulated

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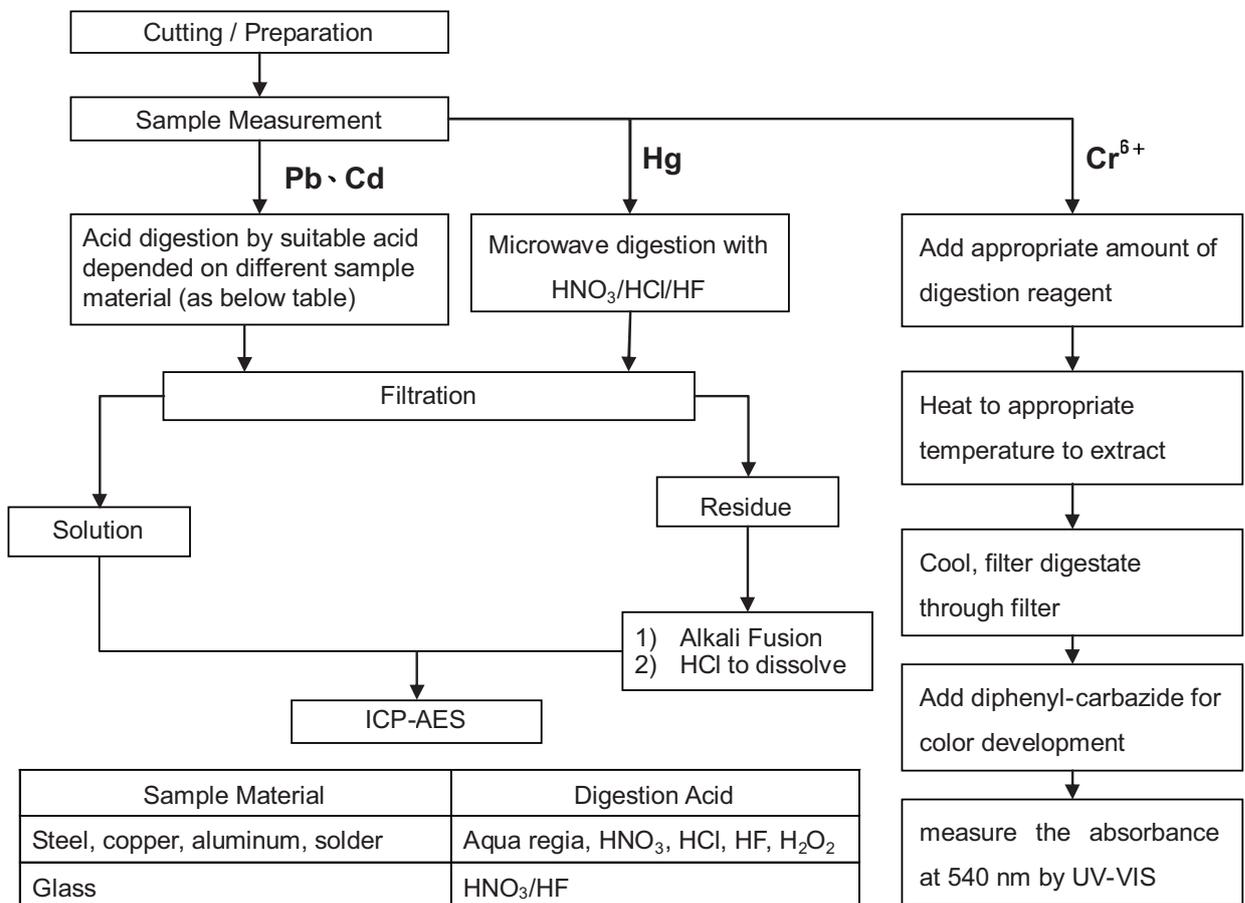
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# Test Report

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 MAIN OFFICE: 20021 SUSANA ROAD, RANCHO DOMINGUEZ,  
 CALIFORNIA, 90221, USA



- 1) These samples were dissolved totally by pre-conditioning method according to below flow chart.  
 ( Cr<sup>6+</sup> test method excluded )
- 2) Name of the person who made measurement: Climbgreat Yang
- 3) Name of the person in charge of measurement: Troy Chang



Sample Material	Digestion Acid
Steel, copper, aluminum, solder	Aqua regia, HNO <sub>3</sub> , HCl, HF, H <sub>2</sub> O <sub>2</sub>
Glass	HNO <sub>3</sub> /HF
Gold, platinum, palladium, ceramic	Aqua regia
Silver	HNO <sub>3</sub>
Plastic	H <sub>2</sub> SO <sub>4</sub> , H <sub>2</sub> O <sub>2</sub> , HNO <sub>3</sub> , HCl
Others	Any acid to total digestion

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# Test Report

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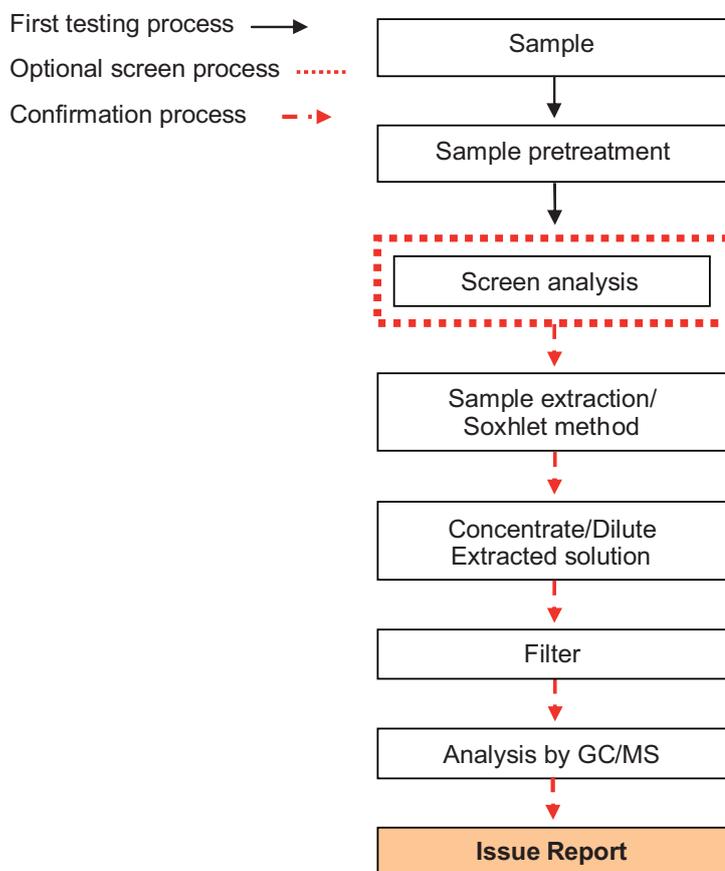
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## PBB/PBDE analytical FLOW CHART

- 1) Name of the person who made measurement: Roman Wong
- 2) Name of the person in charge of measurement: Shinjyh Chen



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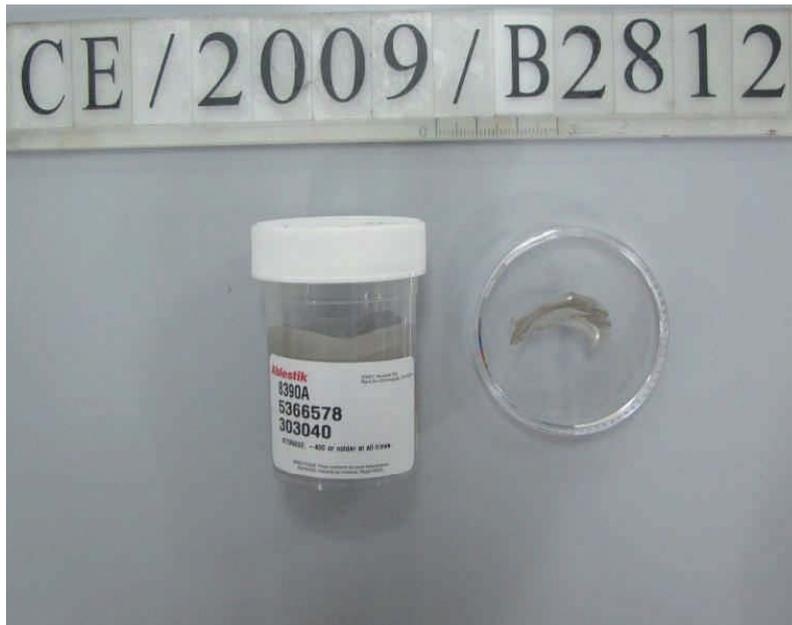
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## 測試報告 Test Report

號碼(No.) : KA/2010/10457 日期(Date) : 2010/01/14 頁數(Page) : 1 of 9



ASM HK & ASM TECHNOLOGY SINGAPORE

4F, WATSON CENTER, 16 KUNG YIP ST., KWAI CHUNG, HONG KONG (ASM HK)., 2 YISHUN AVENUE 7,  
SINGAPORE(ASM TECHNOLOGY SINGAPORE)

以下測試樣品係由客戶送樣，且由客戶聲稱並經客戶確認如下 (The following samples was/were submitted and identified by/on behalf of the client as) :

樣品名稱(Sample Description) : Ag PLATING MATERIAL  
收件日期(Sample Receiving Date) : 2010/01/08  
測試期間(Testing Period) : 2010/01/08 TO 2010/01/14

=====  
測試結果(Test Results) : 請見下一頁 (Please refer to next pages).

**Ray Chang / Asst. Manager**  
**Signed for and on behalf of**  
**SGS Taiwan Limited**

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# 測試報告 Test Report

號碼(No.) : KA/2010/10457 日期(Date) : 2010/01/14 頁數(Page) : 2 of 9



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4F, WATSON CENTER, 16 KUNG YIP ST., KWAI CHUNG, HONG KONG (ASM HK)., 2 YISHUN AVENUE 7, SINGAPORE(ASM TECHNOLOGY SINGAPORE)

## 測試結果(Test Results)

測試部位(PART NAME) NO.1 : 銀色 Ag PLATING MATERIAL (SILVER Ag PLATING MATERIAL)

測試項目 (Test Items)	單位 (Unit)	測試方法 (Method)	方法偵測 極限值 (MDL)	結果 (Result)
				NO.1
鎘 / Cadmium (Cd)	mg/kg	參考IEC 62321: 2008方法, 用感應耦合電漿原子發射光譜儀檢測. / With reference to IEC 62321: 2008 and performed by ICP-AES.	2	n.d.
鉛 / Lead (Pb)	mg/kg	參考IEC 62321: 2008方法, 用感應耦合電漿原子發射光譜儀檢測. / With reference to IEC 62321: 2008 and performed by ICP-AES.	2	n.d.
汞 / Mercury (Hg)	mg/kg	參考IEC 62321: 2008方法, 用感應耦合電漿原子發射光譜儀檢測. / With reference to IEC 62321: 2008 and performed by ICP-AES.	2	n.d.
六價鉻 / Hexavalent Chromium Cr(VI) by Spot test / boiling water extraction	**	參考IEC 62321: 2008方法, 用Spot test / boiling water extraction方法檢測. / With reference to IEC 62321: 2008 and performed by Spot test / boiling water extraction Method. (See Note 6)	0.02mg/kg with 50 cm <sup>2</sup> surface area	Negative
銻 / Antimony (Sb)	mg/kg	參考US EPA 3052方法, 用感應耦合電漿原子發射光譜儀檢測銻含量. / With reference to US EPA Method 3052 for Antimony Content. Analysis was performed by ICP-AES.	2	n.d.
全氟辛烷磺酸 / Perfluorooctane sulfonates (PFOS) PFOS — Acid PFOS — Metal Salt PFOS — Amide	μg/m <sup>2</sup>	參考US EPA 3540C: 1996方法, 以液相層析質譜儀檢測全氟辛烷磺酸含量. / With reference to US EPA 3540C: 1996 method for PFOS Content. Analysis was performed by LC/MS.	1	n.d.
全氟辛酸(銨) / PFOA (CAS No.: 000335-67-1)	μg/m <sup>2</sup>	參考US EPA 3540C: 1996方法, 以液相層析質譜儀檢測全氟辛酸(銨)含量. / With reference to US EPA 3540C: 1996 method for PFOA Content. Analysis was performed by LC/MS.	1	n.d.

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# 測試報告

## Test Report

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測試項目 (Test Items)	單位 (Unit)	測試方法 (Method)	方法偵測 極限值 (MDL)	結果 (Result)
				NO.1
<b>多溴聯苯總和 / Sum of PBBs</b>			-	n.d.
一溴聯苯 / Monobromobiphenyl		參考IEC 62321: 2008方法, 以氣相層析儀/質譜儀檢測. / With reference to IEC 62321: 2008 and performed by GC/MS.	5	n.d.
二溴聯苯 / Dibromobiphenyl			5	n.d.
三溴聯苯 / Tribromobiphenyl			5	n.d.
四溴聯苯 / Tetrabromobiphenyl			5	n.d.
五溴聯苯 / Pentabromobiphenyl	mg/kg		5	n.d.
六溴聯苯 / Hexabromobiphenyl			5	n.d.
七溴聯苯 / Heptabromobiphenyl			5	n.d.
八溴聯苯 / Octabromobiphenyl			5	n.d.
九溴聯苯 / Nonabromobiphenyl			5	n.d.
十溴聯苯 / Decabromobiphenyl			5	n.d.
<b>多溴聯苯醚總和 / Sum of PBDEs</b>			-	n.d.
一溴聯苯醚 / Monobromodiphenyl ether		參考IEC 62321: 2008方法, 以氣相層析儀/質譜儀檢測. / With reference to IEC 62321: 2008 and performed by GC/MS.	5	n.d.
二溴聯苯醚 / Dibromodiphenyl ether			5	n.d.
三溴聯苯醚 / Tribromodiphenyl ether			5	n.d.
四溴聯苯醚 / Tetrabromodiphenyl ether			5	n.d.
五溴聯苯醚 / Pentabromodiphenyl ether	mg/kg		5	n.d.
六溴聯苯醚 / Hexabromodiphenyl ether			5	n.d.
七溴聯苯醚 / Heptabromodiphenyl ether			5	n.d.
八溴聯苯醚 / Octabromodiphenyl ether			5	n.d.
九溴聯苯醚 / Nonabromodiphenyl ether			5	n.d.
十溴聯苯醚 / Decabromodiphenyl ether			5	n.d.
<b>鹵素 / Halogen</b>				
鹵素 (氟) / Halogen-Fluorine (F) (CAS No.: 014762-94-8)	mg/kg	參考BS EN 14582:2007, 以離子層析儀分析. / With reference to BS EN 14582:2007. Analysis was performed by IC.	50	n.d.
鹵素 (氯) / Halogen-Chlorine (Cl) (CAS No.: 022537-15-1)	mg/kg	參考BS EN 14582:2007, 以離子層析儀分析. / With reference to BS EN 14582:2007. Analysis was performed by IC.	50	n.d.
鹵素 (溴) / Halogen-Bromine (Br) (CAS No.: 010097-32-2)	mg/kg	參考BS EN 14582:2007, 以離子層析儀分析. / With reference to BS EN 14582:2007. Analysis was performed by IC.	50	n.d.
鹵素 (碘) / Halogen-Iodine (I) (CAS No.: 014362-44-8)	mg/kg	參考BS EN 14582:2007, 以離子層析儀分析. / With reference to BS EN 14582:2007. Analysis was performed by IC.	50	n.d.

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## 測試報告 Test Report

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### 備註(Note) :

1. mg/kg = ppm ; 0.1wt% = 1000ppm
2. n.d. = Not Detected (未檢出)
3. MDL = Method Detection Limit (方法偵測極限值)
4. "-" = Not Regulated (無規格值)
5. \*\*= Qualitative analysis (No Unit) 定性分析(無單位)
6. Spot-test:

Negative = Absence of Cr(VI) coating / surface layer(鍍層中偵測不到六價鉻),  
Positive = Presence of Cr(VI) coating / surface layer(鍍層中偵測到六價鉻);

The tested sample should be further verified by boiling-water-extraction method if the spot test result cannot be confirmed.

(當該測項無法確認時, 測試樣品可藉由boiling-water-extraction測試方法進一步確認)

### Boiling-water-extraction:

Negative = Absence of Cr(VI) coating / surface layer(鍍層中偵測不到六價鉻),  
Positive = Presence of Cr(VI) coating / surface layer(鍍層中偵測到六價鉻);

the detected concentration in boiling-water-extraction solution is equal or greater than 0.02 mg/kg with 50 cm<sup>2</sup> sample surface area.

該溶液濃度 $\geq 0.02$  mg/kg with 50 cm<sup>2</sup> (sample surface area)

### PFOS參考資訊(Reference Information) : 指令 2006/122/EC (Directive 2006/122/EC)

- (1) 該物質不可置於市場上或使用於特殊物質或配置成分重量濃度等於或大於0.005%。  
(May not be placed on the market or used as a substance or constituent of preparations in a concentration equal to or higher than 0.005 % by mass.)
- (2) 該物質不可置於市場上的半成品或商品或其物件; 假若零件上明顯地具有PFOS並參照結構上及微細構造上計算PFOS重量濃度等於或大於0.1%, 而紡織品或其他覆蓋物質, 如果PFOS在覆蓋物質中含量等於或大於1 $\mu$ g/m<sup>2</sup>.  
(May not be placed on the market in semi-finished products or articles, or parts thereof, if the concentration of PFOS is equal to or higher than 0.1 % by mass calculated with reference to the mass of structurally or microstructurally distinct parts that contain PFOS or, for textiles or other coated materials, if the amount of PFOS is equal to or higher than 1 $\mu$ g/m<sup>2</sup> of the coated material.)

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## 測試報告 Test Report

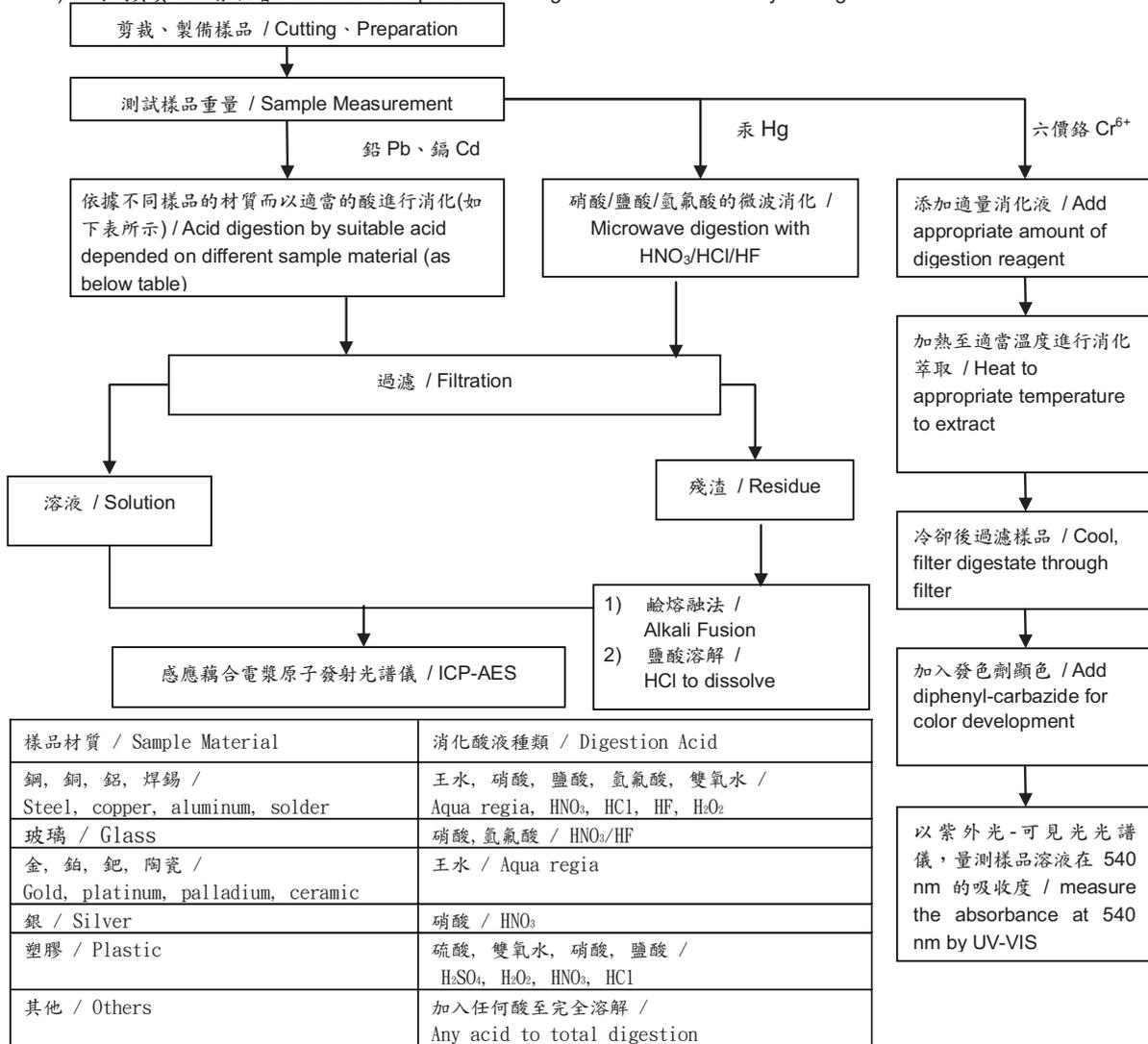
號碼(No.) : KA/2010/10457 日期(Date) : 2010/01/14 頁數(Page) : 5 of 9



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- 1) 根據以下的流程圖之條件，樣品已完全溶解。(六價鉻測試方法除外) / These samples were dissolved totally by pre-conditioning method according to below flow chart. (Cr<sup>6+</sup> test method excluded)
- 2) 測試人員：李宏明 / Name of the person who made measurement: Hungming Li
- 3) 測試負責人：張伯睿 / Name of the person in charge of measurement: Ray Chang



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## 測試報告 Test Report

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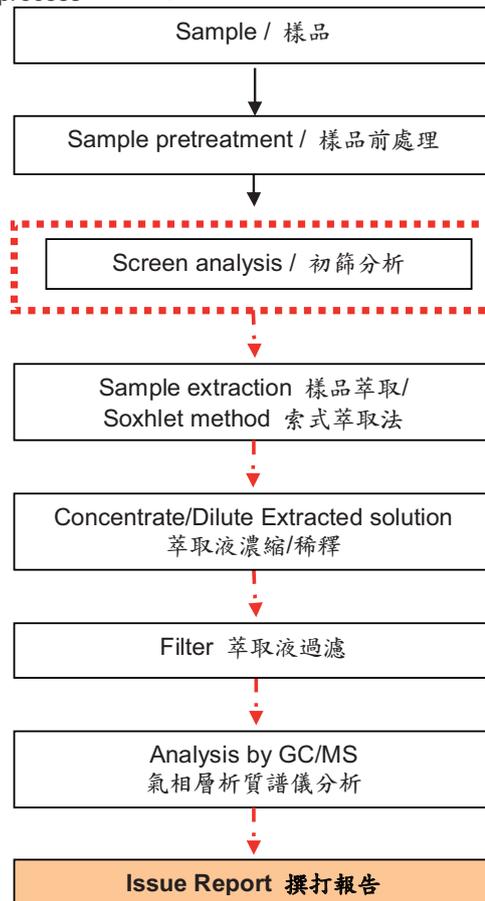
### 多溴聯苯/多溴聯苯醚 分析流程圖 / PBB/PBDE analytical FLOW CHART

- 1) 測試人員：曹嘉琪 / Name of the person who made measurement: Anson Tsao
- 2) 測試負責人：張伯睿 / Name of the person in charge of measurement: Ray Chang

初次測試程序 / First testing process ———▶

選擇性篩檢程序 / Optional screen process .....▶

確認程序 / Confirmation process - - -▶



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## 測試報告 Test Report

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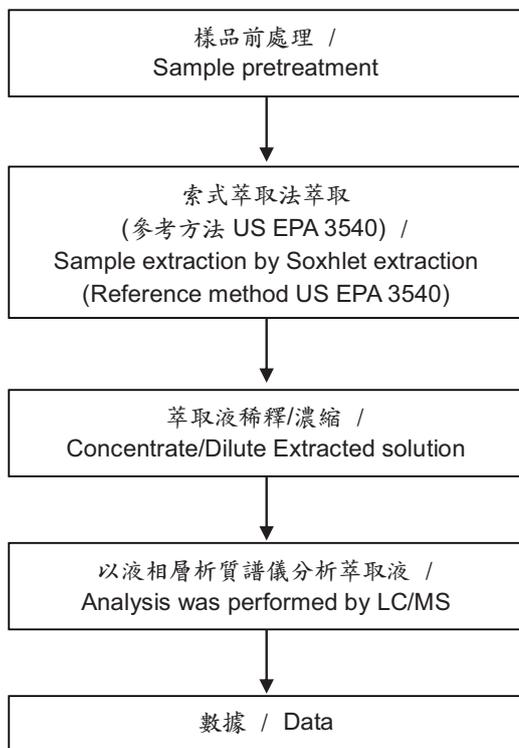
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### 全氟辛酸(銨)/ 全氟辛烷磺酸分析流程圖 /

#### Analytical flow chart of PFOA/PFOS content

1)測試人員：曹嘉琪 / Name of the person who made measurement: Anson Tsao

2)測試負責人：張伯睿 / Name of the person in charge of measurement: Ray Chang



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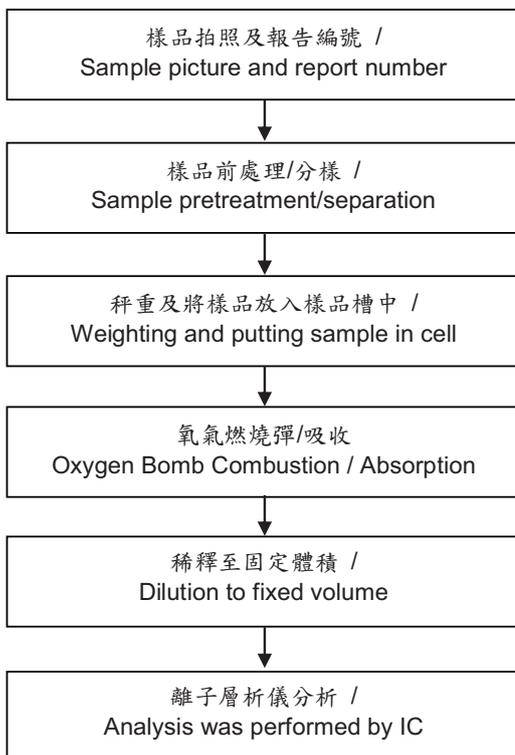


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### 鹵素分析流程圖 / Analytical flow chart of halogen content

- 1) 測試人員：李宏明/ Name of the person who made measurement: Hungming Li
- 2) 測試負責人：張伯睿/ Name of the person in charge of measurement: Ray Chang



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# Test Report

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TANAKA ELECTRONICS (MALAYSIA) SDN. BHD.  
PLOT 11, PHASE IV, BAYAN LEPAS FREE INDUSTRIAL ZONE,  
11900 PENANG, MALAYSIA.



The following sample(s) was/were submitted and identified by/on behalf of the client as :

Sample Description : Au BONDING WIRE  
Sample Receiving Date : 2009/12/15  
Testing Period : 2009/12/15 TO 2009/12/18

Test Result(s) : Please refer to next page(s).

**Ray Chang / Asst. Manager**  
**Signed for and on behalf of**  
**SGS Taiwan Limited**

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# Test Report

No. : KA/2009/C1254A-05 Date : 2009/12/18 Page : 2 of 11

TANAKA ELECTRONICS (MALAYSIA) SDN. BHD.  
PLOT 11, PHASE IV, BAYAN LEPAS FREE INDUSTRIAL ZONE,  
11900 PFNANG MAI AYSIA



## Test Result(s)

PART NAME NO.1 : GOLD Au BONDING WIRE

Test Item (s):	Unit	Method	MDL	Result
				No.1
Cadmium (Cd)	mg/kg	With reference to IEC 62321: 2008 and performed by ICP-AES.	2	n.d.
Lead (Pb)	mg/kg	With reference to IEC 62321: 2008 and performed by ICP-AES.	2	n.d.
Mercury (Hg)	mg/kg	With reference to IEC 62321: 2008 and performed by ICP-AES.	2	n.d.
Hexavalent Chromium Cr(VI) by alkaline extraction	mg/kg	With reference to IEC 62321: 2008 and performed by UV-VIS.	2	n.d.
Antimony (Sb)	mg/kg	With reference to US EPA Method 3052 for Antimony Content. Analysis was performed by ICP-AES.	2	n.d.
Perfluorooctane sulfonates (PFOS) PFOS – Acid PFOS – Metal Salt PFOS – Amide	mg/kg	With reference to US EPA 3540C: 1996 method for PFOS Content. Analysis was performed by LC/MS.	10	n.d.
PFOA (CAS No.: 000335-67-1)	mg/kg	With reference to US EPA 3540C: 1996 method for PFOA Content. Analysis was performed by LC/MS.	10	n.d.
Dimethyl Fumarate (CAS No.: 000624-49-7)	mg/kg	With reference to US EPA 3550C method. Analysis was performed by GC/MS.	0.1	n.d.
<b>Sum of PBBs</b>			-	n.d.
Monobromobiphenyl	mg/kg	With reference to IEC 62321: 2008 and performed by GC/MS.	5	n.d.
Dibromobiphenyl			5	n.d.
Tribromobiphenyl			5	n.d.
Tetrabromobiphenyl			5	n.d.
Pentabromobiphenyl			5	n.d.
Hexabromobiphenyl			5	n.d.
Heptabromobiphenyl			5	n.d.
Octabromobiphenyl			5	n.d.
Nonabromobiphenyl			5	n.d.
Decabromobiphenyl			5	n.d.

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# Test Report

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TANAKA ELECTRONICS (MALAYSIA) SDN. BHD.  
PLOT 11, PHASE IV, BAYAN LEPAS FREE INDUSTRIAL ZONE,  
11900 PENANG, MALAYSIA.



Test Item (s):	Unit	Method	MDL	Result
				No.1
<b>Sum of PBDEs</b>	mg/kg	With reference to IEC 62321: 2008 and performed by GC/MS.	-	n.d.
Monobromodiphenyl ether			5	n.d.
Dibromodiphenyl ether			5	n.d.
Tribromodiphenyl ether			5	n.d.
Tetrabromodiphenyl ether			5	n.d.
Pentabromodiphenyl ether			5	n.d.
Hexabromodiphenyl ether			5	n.d.
Heptabromodiphenyl ether			5	n.d.
Octabromodiphenyl ether			5	n.d.
Nonabromodiphenyl ether			5	n.d.
Decabromodiphenyl ether			5	n.d.
<b>Halogen</b>				
Halogen-Fluorine (F) (CAS No.: 014762-94-8)	mg/kg	With reference to BS EN 14582:2007. Analysis was performed by IC.	50	n.d.
Halogen-Chlorine (Cl) (CAS No.: 022537-15-1)	mg/kg	With reference to BS EN 14582:2007. Analysis was performed by IC.	50	n.d.
Halogen-Bromine (Br) (CAS No.: 010097-32-2)	mg/kg	With reference to BS EN 14582:2007. Analysis was performed by IC.	50	n.d.
Halogen-Iodine (I) (CAS No.: 014362-44-8)	mg/kg	With reference to BS EN 14582:2007. Analysis was performed by IC.	50	n.d.
<b>Phthalates</b>				
BBP (Benzyl butyl phthalate) (CAS No.: 000085-68-7)	%	With reference to EN 14372. Analysis was performed by GC/MS.	0.003	n.d.
DBP (Dibutyl phthalate) (CAS No.: 000084-74-2)	%	With reference to EN 14372. Analysis was performed by GC/MS.	0.003	n.d.
DEHP (Di- (2-ethylhexyl) phthalate) (CAS No.: 000117-81-7)	%	With reference to EN 14372. Analysis was performed by GC/MS.	0.003	n.d.
DIDP (Di-isodecyl phthalate) (CAS No.: 026761-40-0)	%	With reference to EN 14372. Analysis was performed by GC/MS.	0.01	n.d.
DINP (Di-isononyl phthalate) (CAS No.: 028553-12-0)	%	With reference to EN 14372. Analysis was performed by GC/MS.	0.01	n.d.
DNOP (Di-n-octyl phthalate) (CAS No.: 000117-84-0)	%	With reference to EN 14372. Analysis was performed by GC/MS.	0.003	n.d.

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# Test Report

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TANAKA ELECTRONICS (MALAYSIA) SDN. BHD.  
PLOT 11, PHASE IV, BAYAN LEPAS FREE INDUSTRIAL ZONE,  
11900 PENANG, MALAYSIA.



- Note :
1. mg/kg = ppm ; 0.1wt% = 1000ppm
  2. n.d. = Not Detected
  3. MDL = Method Detection Limit
  4. " - " = Not Regulated
  5. Amending for the 22nd Council Directive 76/769/EEC notified under document 2005/84/EC, total concentration of three compounds DEHP, DBP and BBP shall not be greater than 0.1% and total concentration of three compounds DINP, DIDP and DNOP shall not be greater than 0.1%.
  6. This is the additional test report of KA/2009/C1254 which was issued on 2009/12/18.  
Please refer to KA/2009/C1254 for original information.

## **PFOS Reference Information : Directive 2006/122/EC**

- (1) May not be placed on the market or used as a substance or constituent of preparations in a concentration equal to or higher than 0.005 % by mass.
- (2) May not be placed on the market in semi-finished products or articles, or parts thereof, if the concentration of PFOS is equal to or higher than 0.1 % by mass calculated with reference to the mass of structurally or microstructurally distinct parts that contain PFOS or, for textiles or other coated materials, if the amount of PFOS is equal to or higher than  $1\mu\text{g}/\text{m}^2$  of the coated material.

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台灣檢驗科技股份有限公司

No. 61, Kai-Fa Road, Nanzih Export Processing Zone, Kaohsiung, Taiwan. / 高雄市楠梓加工出口區開發路 61 號  
t (886-7) 301-2121 f (886-7) 301-0867

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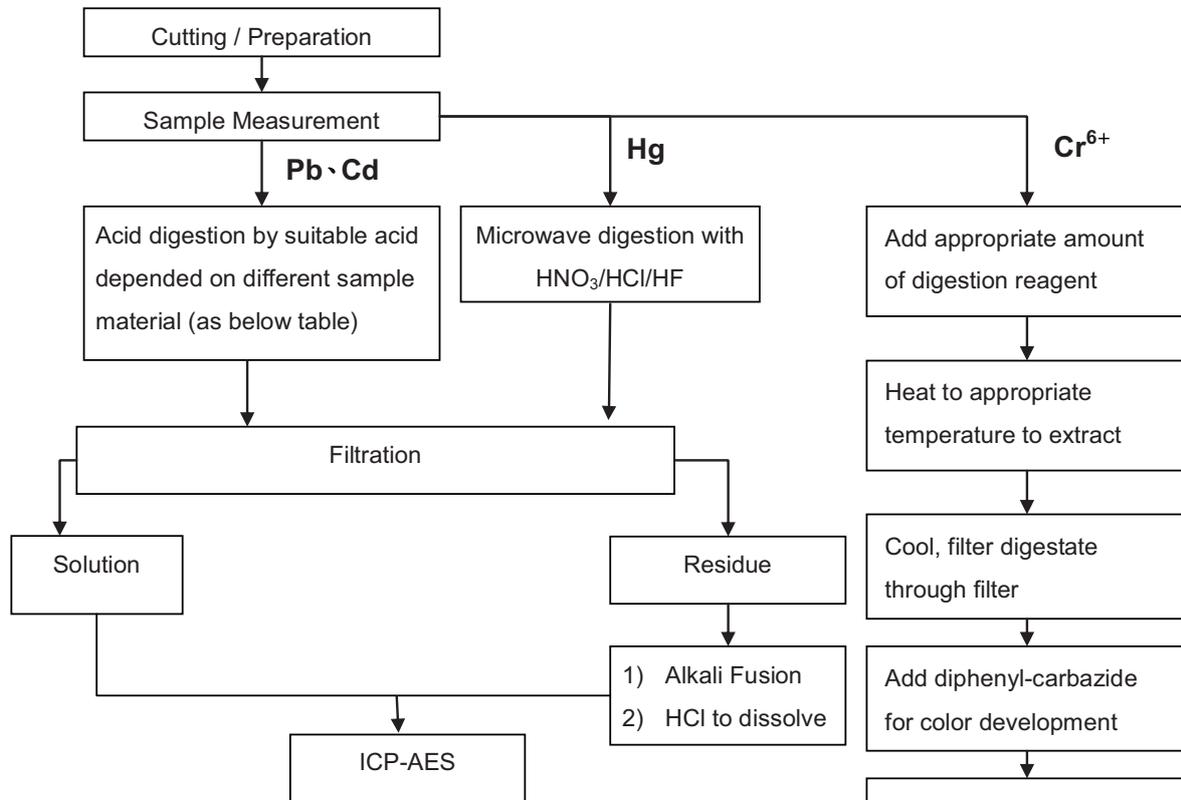
# Test Report

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TANAKA ELECTRONICS (MALAYSIA) SDN. BHD.  
 PLOT 11, PHASE IV, BAYAN LEPAS FREE INDUSTRIAL ZONE,  
 11900 PENANG, MALAYSIA.



- 1) These samples were dissolved totally by pre-conditioning method according to below flow chart. (Cr<sup>6+</sup> test method excluded)
- 2) Name of the person who made measurement: Hungming Li
- 3) Name of the person in charge of measurement: Ray Chang



Sample Material	Digestion Acid
Steel, copper, aluminum, solder	Aqua regia, HNO <sub>3</sub> , HCl, HF, H <sub>2</sub> O <sub>2</sub>
Glass	HNO <sub>3</sub> /HF
Gold, platinum, palladium, ceramic	Aqua regia
Silver	HNO <sub>3</sub>
Plastic	H <sub>2</sub> SO <sub>4</sub> , H <sub>2</sub> O <sub>2</sub> , HNO <sub>3</sub> , HCl
Others	Any acid to total digestion

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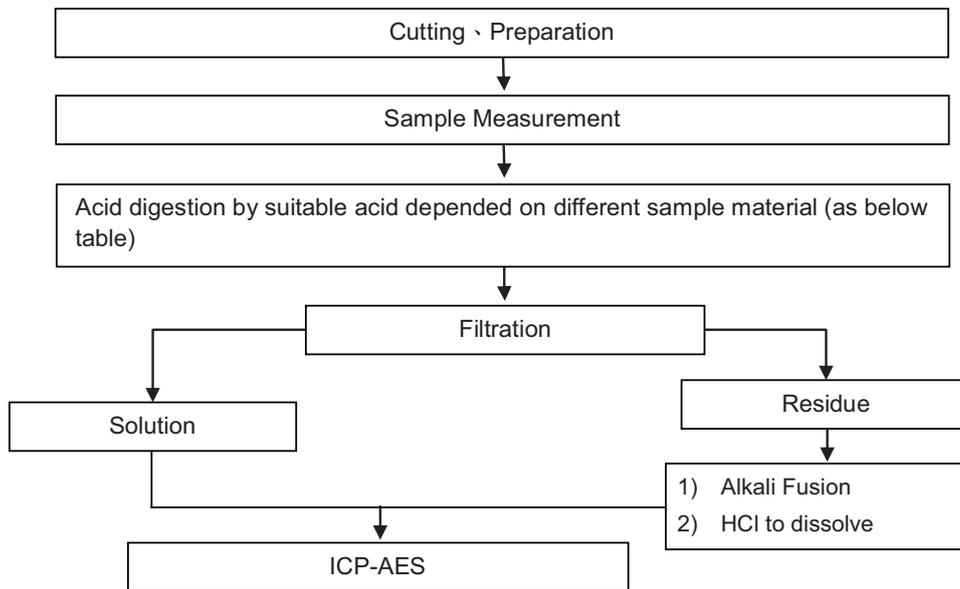
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 11900 PENANG, MALAYSIA.



- 1) These samples were dissolved totally by pre-conditioning method according to below flow chart.
- 2) Name of the person who made measurement: Hungming Li
- 3) Name of the person in charge of measurement: Ray Chang

## Flow Chart of digestion for the elements analysis performed by ICP-AES



Steel, copper, aluminum, solder	Aqua regia, HNO <sub>3</sub> , HCl, HF, H <sub>2</sub> O <sub>2</sub>
Glass	HNO <sub>3</sub> /HF
Gold, platinum, palladium, ceramic	Aqua regia
Silver	HNO <sub>3</sub>
Plastic	H <sub>2</sub> SO <sub>4</sub> , H <sub>2</sub> O <sub>2</sub> , HNO <sub>3</sub> , HCl
Others	Any acid to total digestion

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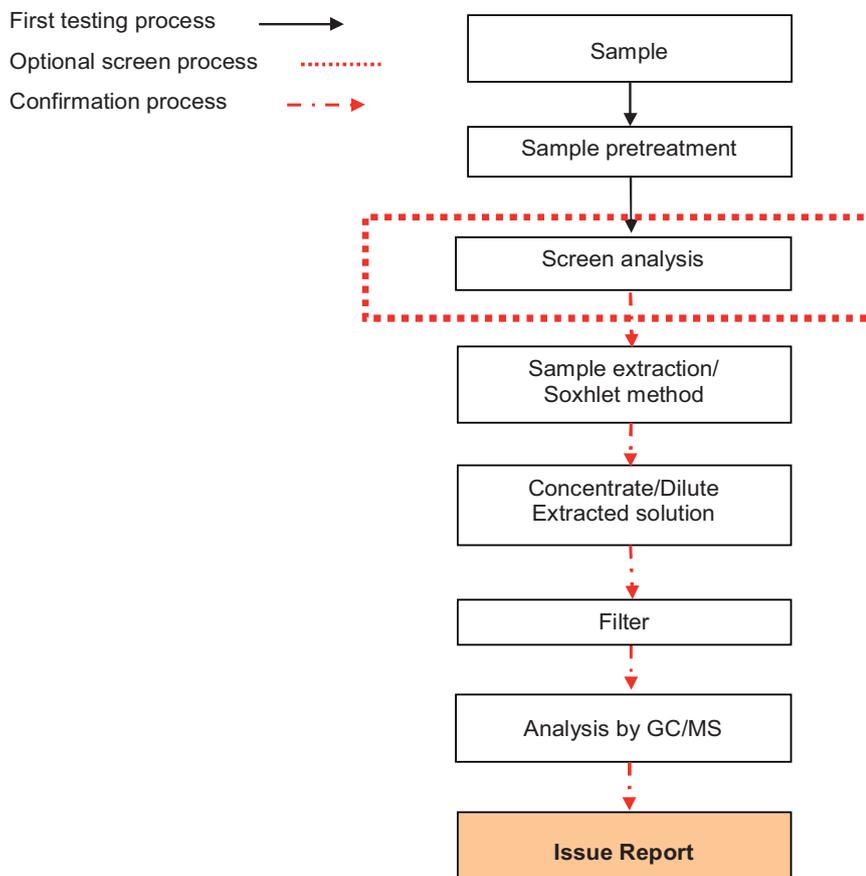
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## PBB/PBDE analytical FLOW CHART

- 1) Name of the person who made measurement: Anson Tsao
- 2) Name of the person in charge of measurement: Ray Chang



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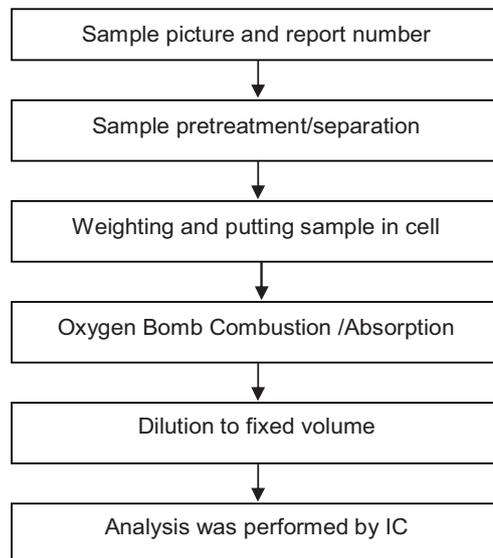
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### Analytical flow chart of halogen content

- 1) Name of the person who made measurement: Hungming Li
- 2) Name of the person in charge of measurement: Ray Chang



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## Test Report

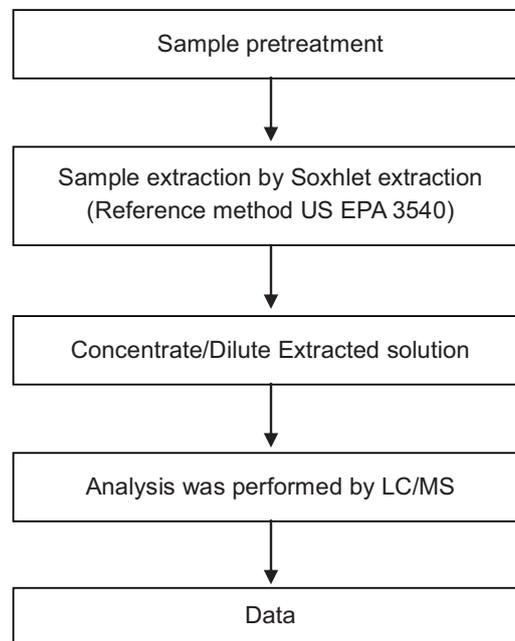
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### Analytical flow chart of PFOA/PFOS content

- 1) Name of the person who made measurement: Anson Tsao
- 2) Name of the person in charge of measurement: Ray Chang



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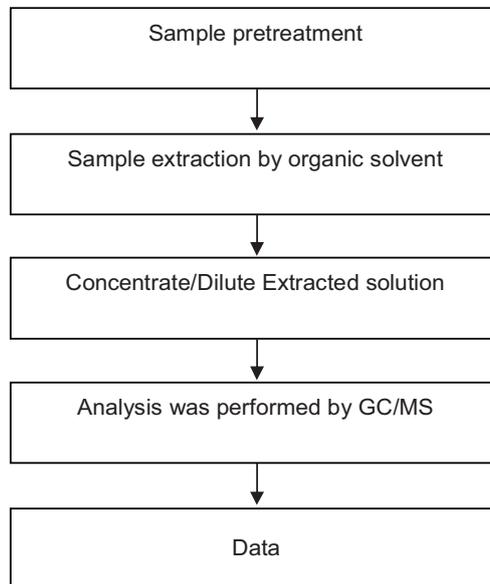
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## Analytical flow chart of Dimethyl Fumarate content

- 1) Name of the person who made measurement: Anson Tsao
- 2) Name of the person in charge of measurement: Ray Chang



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**Client : Thailand Smelting and Refining Co., Ltd.  
116/17-18 Srivit Bldg. Soonthornkosa  
Klongtoey Bangkok 10110 Thailand**

The following sample(s) was/were submitted and identified by/on behalf of the client as:

Sample Description : Pure Tin  
Sample No. : 1680747  
Sample Condition : As per attached photograph  
Part No. : Sn100A  
Batch/Lot No. : 131  
Sample Receiving Date : 29-May-2009  
Testing Period : 29-May-2009 to 03-Jun-2009  
Test Requested : In accordance with the RoHS Directive 2002/95/EC and its amendment directives  
Test Method : (1) With reference to IEC 62321:2008 for Lead content, Analysis was performed by ICP-OES.  
(2) With reference to IEC 62321:2008 for Cadmium content, Analysis was performed by ICP-OES.  
(3) With reference to IEC 62321:2008 for Mercury content, Analysis was performed by ICP-OES.  
(4) With reference to IEC 62321:2008 for Hexavalent Chromium by Colorless and Colored Chromate Coating on Metals/ Colorimetric Method, Analysis was performed by UV-Vis spectrometry.  
(5) With reference to IEC 62321:2008 for PBB/PBDE content, Analysis was performed by GC/MS.  
Test Results : Please refer to next page.

## CONCLUSION

Based on the performed tests on submitted samples, the result comply with the RoHS Directive 2002/95/EC and its subsequent amendments.

**Signed for and on behalf of  
SGS (Thailand) Limited**



**Pornpana Lirathpong  
Hardlines Testing Manager**

**TEST RESULTS**

Test results by chemical method (Unit: mg/kg)

Test Item (s):	Method (Refer to)	Result (1)	MDL	RoHS Limit
Lead (Pb)	(1)	n.d.	2	1000
Cadmium (Cd)	(2)	n.d.	2	100
Mercury (Hg)	(3)	n.d.	2	1000
Hexavalent Chromium (CrVI) by Spot test / boiling water extraction (optional)	(4)	Negative	-	#
sum of PBBs	(5)	n.d.	-	1000
Monobromobiphenyl		n.d.	5	-
Dibromobiphenyl		n.d.	5	-
Tribromobiphenyl		n.d.	5	-
Tetrabromobiphenyl		n.d.	5	-
Pentabromobiphenyl		n.d.	5	-
Hexabromobiphenyl		n.d.	5	-
Heptabromobiphenyl		n.d.	5	-
Octabromobiphenyl		n.d.	5	-
Nonabromobiphenyl		n.d.	5	-
Decabromobiphenyl		n.d.	5	-

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**TEST RESULTS**

Test results by chemical method (Unit: mg/kg)

Test Item (s):	Method (Refer to)	Result (1)	MDL	RoHS Limit
Sum of PBDEs	(5)	n.d.	-	1000
Monobromodiphenyl ether		n.d.	5	-
Dibromodiphenyl ether		n.d.	5	-
Tribromodiphenyl ether		n.d.	5	-
Tetrabromodiphenyl ether		n.d.	5	-
Pentabromodiphenyl ether		n.d.	5	-
Hexabromodiphenyl ether		n.d.	5	-
Heptabromodiphenyl ether		n.d.	5	-
Octabromodiphenyl ether		n.d.	5	-
Nonabromodiphenyl ether		n.d.	5	-
Decabromodiphenyl ether		n.d.	5	-

Test Part Description  
Result (1) pure tin

Note :

(a) mg/kg = ppm ; 0.1 wt% = 1000 ppm

(b) n.d. = Not Detected

(c) MDL = Method Detection Limit

(d) The exemption of DecaBDE in polymeric application according 2005/17/EC was overruled by the European Court of Justice by its decision of 01.04.2008. Subsequently DecaBDE will be included in the sum of PBDE after 01.07.2008

(e) # : Positive means the presence of CrVI on the tested areas  
Negative means the absence of CrVI on the tested areas

(f) "-" = Not regulated

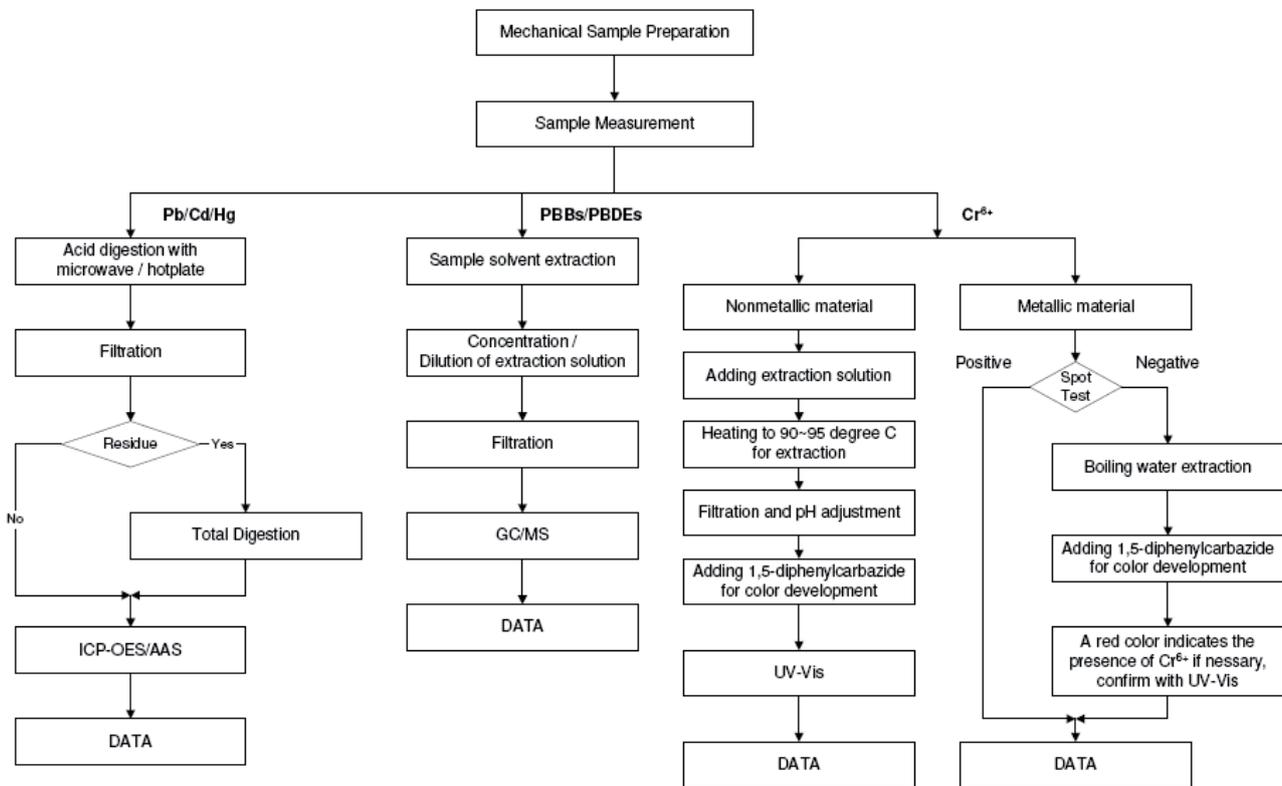
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Flow Chart for RoHS : Pb/Cd/Hg/Cr<sup>6+</sup>/PBBs/PBDEs Testing

1. Operator : Wanwisa Seakew
2. Section Chief : Laddawan Uranpitr
3. The sample was dissolved totally by pre-conditioning method according to below flowchart. (Cr<sup>6+</sup> and PBBs/PBDEs test method excluded)



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**SAMPLE/ATTACHMENT PICTURE**



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