Aptiv Serial Data Steering Team

APTIV

Systems Analysis INterface Tool 2/3(SAINT2/3) Programming Reference

Version 2.55

3/3/2020

Table of Contents

Revision Log

Version	Revisions		Date Released to Web
1.1	1. Initial release of the document. 2. Document CAN interface 3. Document Class2 interface		March 30, 2006
1.2	1. Corrected and Updated Embedded Periodic SAINT2 Configuration Functions (08 70h – 08 7F)		April 4, 2006
1.3	1. Correct text for SAINT2 Config Command A3h in section 5.1.11 2. Changed CAN Baud Rate configuration values		May 2, 2006
1.4	1. Minor corrections 2. Corrected and updated configuration commands 3. Updated LED definition 4. Updated RS232 and USB interface 5. Updated coversheet of this document		June 27, 2006
1.5	1. Added document of configuration option on system reset 2. Changed documentation to reflect change of CAN High Resolution Time Stamp and Error Indicator bit to be optional.		July 28, 2006
1.6	1. Added documentation for configuration command 08h A4h 2. Changed documentation to reflect change of configuration command 08h A8h and 08h A9h		September 6, 2006
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2.0	1. Modified sec 9.1 to add notes regarding supported SD card format (FAT-16) & extended init time w/ SD card installed. 2. Modified notes in Sec 9 (Keyword 2000) to indicated version 1.1 hardware required to use KW2K. 3. Added Class2 Error Commands 4. Added S2 CAN option command to disable continuous acknowledgment error retries		October 31, 2006
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2.7	Edited IIC and SPI documentation on recommended practices.		February 29, 2008
2.8	1. Added remote frame information (supported in firmware version 3.6.9+) 2. Added Gateway function descriptions (supported in firmware 3.6.10+) 3. Additional Keyword 2000 changes/enhancements for J2534 Support. 4. Added Trig in command additions 5. Added periodic control messages 6. Added LIN documentation (Initial Release)		May 5, 2008
2.9	1. Updated LIN documentation – Slave Node emulation capability added. 2. Clarify CAN byte descriptions 3. Clarify Trigger In function commands (08 A9) 4. CAN operation warning codes $50 and $58 have been detailed		June 25, 2008
2.10	1. Clarify configuration commands in paragraph headings 2. Add and clarify CAN operational warning definitions 3. Add CAN Rx FIFO overflow error messages 4. Document Ack error retry function and limit changes		Aug 25, 2008
2.11	1. Document CAN bus flooding function 2. Document ISO15765-2 Transport Layer on CAN 3. Clarified group file description in config function section 4. Added information on block transfer ($F8) header 5. Added Operation Warning Code ($08 $A1) error codes 3-6		Feb 20, 2009
2.12	1. Updated/Clarified IIC Monitor Mode Documentation		Mar 10, 2009
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2.15	1. Added Class2 example to block mode section 2. Corrections to Block Transfer size limits		August 28, 2009

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2.16	1. Added clarifications to the KW Initialization operations sections.		September 11, 2009
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2.18	1. Add configuration messages for HSCAN and FTCAN transceiver mode control		May 19, 2010
2.19	1. Add trigger in and trigger out schematics 2. Add CAN command to set a single CAN include filter 3. Add configurations for ISO15765-2 TP to filter out individual CAN frames		12/9/2010
2.20	1. Add TRIGOUT2 documentation (HW1.2 only) 2. Add SPI_INT – Trigger In (2) documentation 3. Add configuration command for number of ack retries		
2.21	1. Fix minor error in bit fields for ISO-15765 FC options		
2.22	Add info no how to set LIN 10.417 baud rate		03/05/2012
2.23	1. Added info on USB 3.0 2. Added info on 1 MB CAN 3. Added cable info for Hardware v1.2		03/13/2012
2.24	1. Numerous typo and grammar fixes 2. Correct error in request SD card CRC		
2.25	Changed IIC passive mode pin connections for display in PDF		06/21/2012
2.26	Added LIN one-shot table response, requires firmware 4.10.1+		
2.27	Updated some ISO-15765 verbiage, re-paginate		02/26/2013
2.28	Clarify LIN checksum, correct J12602 typo to J2602		05/13/2013
2.29	Documented LIN auto-parity feature, requires firmware 4.12.1+		05/28/2013
2.30	More clarification on ISO15765-2		07/09/2013
2.31	Corrections to I2C documentation		07/26/2013
2.32	Added Gateway X/Y documentation		09/30/2013
2.33	Added one-way Gateway documentation		11/06/2013
2.34	Reserve IDs $D0 - $DF for CAN FD		12/04/2103
2.35	Corrected command to disable automatic ack error retries		01/03/2014
2.36	Changed documentation for KW ECU and tester address configuration messages. Documentation now matches software, all modes work the same. Previously server mode was documented as swapping the tester and ECU addresses. Note: version 4.13.0 of the firmware swaps the tester and ECU addresses when in server mode.		04/25/2014
2.37	Remove all references to FF 00 in IIC section. Since the monitor automatically sends the FF 00 including this just confused the users.		01/12/2015
2.38	Reserve IDs $A0-$AF for CAN3 and CAN4, $E0-$E8 for CAN3 and CAN4 ISO15765-2		05/27/2015
2.39	Correction to DB-25 for CAN_2		08/14/2015
2.40	Correction to 29-bit bytes fields		09/08/2015
2.41	Correct typo in 15765 setup for CAN2		10/14/2015
2.42	Update document to include support for USB 3.0		10/07/2016
2.43	Update echo on\off commands apply only to Saint1. Add note that Data stream section only applies to users who bypass the Bus Engine		03/01/2017

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2.44	Added information on Tx bit for LIN		04/25/2017
2.45	IIC updates, now support for 256 KHz requires 4.18.1 or later		08/18/2017
2.46	Update information on IIC connection between hardware revisions		08/24/2017
2.47	Added completion code bit when have over 50 bytes before stop condition in IIC Monitor		08/29/2017
2.48	Added comments that both modes of IIC do not echo back		04/26/2018
2.49	Correct configuration examples for ISO-15765 Rx and 29-bit IDs		05/14/2018
2.50	Added documentation on disabling ACKs in IIC		07/27/2018
2.51	Clarify\correct information on ISO-15765 configuration		02/20/2019
2.52	Added information on Saint3. Removed all Saint1 information. Document additional embedded periodics. Dropped out of date software packages section		06/12/2019
2.53	New LIN functionality for Conformance testing		01/17/2020
2.54	CAN-FD configuration corrections		02/26/2020
2.55	CAN-FD updates.		03/03/2020

1 Introduction

1.1 Scope

This document describes the use and operation of the SAINT2, micro SAINT3 and SAINT3 Pro in normal communication mode. This document cannot be copied in whole or in part without the express written consent of Aptiv.

1.2 Precedence

This document shall have precedence over any information in any other document. Between reference documents, the document with the later revision date shall have precedence.

1.3 Definitions and Nomenclature

SAINT - common nickname for the (Systems Analysis INterface Tool). Throughout this document "SAINT" will be used to refer to the SAINT2 and both variants of the SAINT3. The SAINT3 is available in a micro version and a Pro version. The term SAINT3 will be used to refer to both the micro SAINT3 and the SAINT3 Pro.

Host - The computer which communicates to the SAINT via RS-232 or USB.

USB - Universal Serial Bus

CAN - Controller Area Network data bus

CANFD - Controller Area Network Flexible data bus

C2 - Class 2

S2 - Saint2

uS3 - Micro Saint3

S3 Pro - Saint3 Pro

S3 - Micro Saint3 and Saint3 Pro

2 Overview

This document describes the operation of the SAINT.

The following is synopsis of the SAINT features:

- Allows host system to communicate on supported serial busses. Performs timing, access, arbitration, serialization, and error control for all protocols.
- Allows host system to configure the tool with SAINT Configuration Commands.
- Provides SAINT status with LEDs
- Software is easily updated over USB.

The following is a synopsis of requirements for use of the SAINT:

- Connection to power, ground, and busses to be monitored
- RS-232 or USB connection to host. USB is preferred.

3 Host to SAINT Connection

3.1 RS-232

3.1.1 RS-232 Set Up

The SAINT uses the following RS-232 parameters:

- 8 Data Bits
- 1 Stop Bit
- No Parity

The SAINT supported baud rate is 57600. If the serial bus traffic is greater than can be handled by the 57600 RS232 baud rate, the message may be lost or corrupted.

The supported baud rate is sufficient for communicating with the Class2, Keyword, and slower CAN buses. However USB connection is recommended for high speed CAN\CANFD (over 250 KHz) communications.

3.2 USB

The SAINT supports USB 1.1, USB 2.0 and USB 3.0.

4 Message Format

4.1 Data Stream

The host data stream is broken into messages. A message consists of a Message ID and one or more data bytes. The character FFh is used as an ESCAPE character to indicate the end of messages. There are three cases when an ESCAPE character is received.

The Saint Bus Engine (SBE) handles all ESCAPE character processing for you. If you are using the SBE you do not have to take into account ESCAPE character processing. This section only applies to advanced users who choose to bypass the SBE.

If the ESCAPE character is followed immediately by a second ESCAPE character, the following are true:

- The message is not yet complete.
- The pair of ESCAPE characters represents a single byte of message data of value FFh.

If the ESCAPE character is followed immediately by a byte of value 00h, the following are true.

- The message is complete.
- Neither the FFh nor the 00h are part of the message.
- No more messages are ready to be sent.

If the ESCAPE character is followed immediately by of any value other than FFh or 00h, the following are true:

- The message is complete.
- Neither the ESCAPE character nor the character following the ESCAPE character are part of the message.
- The value following the ESCAPE character is the message ID (header byte) for a new message.

This data stream format was chosen to allow arbitrary long messages (i.e. 4K ISO 15765 CAN data blocks), to minimize the overhead to two bytes per message during peak traffic, and to immediately recognize the end of a message without having to waiting for the next message to start.

4.2 SAINT Header Bytes

The SAINT and the host use the SAINT Header byte to identify the type of message that is being sent or received. The header byte is 1 byte long and has the following general format:

SAINT Header Byte Format

bits 7 – 3	bit 2	bit 1	bit 0
Protocol ID	**Command**	**Tx / Rx****	**Time Stamp Included**
See SAINT Protocol Ids table below	= 1: message includes a protocol related SAINT Command = 0: message is to be sent to the serial bus	= 1: transmit message = 0: receive message	= 1: 2 byte ms time stamp is included = 0: 2 byte ms time stamp is not included

The Protocol ID, Bits 7 – 3 of the SAINT Header byte, identifies the serial bus protocol for the message being sent or received. The Protocol IDs are defined below:

SAINT Protocol IDs

Not Used (00h)	*Not Used (80h)
SAINT Configuration Command (08h)	*Not Used (88h)
*Not Used (10h)	*Not Used (90h)
*Not Used (18h)	*Not Used (98h)
IIC (20h)	CAN3 Non Saint (A0h)
Keyword 2000 (28h)	CAN4 Non-Saint (A8h)
ISO15765-2_CANFD1 S3 only (30h)	*Not Used (B0h)
ISO15765-2_CANFD2 S3 only (38h)	LIN (B8h)
*Not Used (40h)	ISO15765-2_CAN1 (C0h)
*Not Used (48h)	ISO15765-2_CAN2 (C8h)
CAN1 (50h)	CAN FD1 S3 only (D0h) deprecated
CAN2 (58h)	CAN FD2 S3 only (D8h) deprecated
Class2 (60h) Saint2 only	ISO15765-2_CAN3 non-Saint(E0h)
*Not Used (68h)	ISO15765-2_CAN4 non-Saint(E8h)
*SPI (70h)	Not Used (F0h)
*Reserved (78h)	Block Transfer (F8h)

*These Ids are reserved for future use.

** For LIN the Tx bit is set when the Saint acts as the master.

5 SAINT Configuration

5.1 SAINT Configuration Commands

The SAINT Configuration Commands are used to configure the general functions of the SAINT.

SAINT Configuration Commands

Header	ID	Data	Description	Compatibility
08h	10h	1 Byte	Firmware Flash Programming	
08h	20h	None	Device Enumeration	
08	50h	1-TBD Bytes	Embedded Emulation	
08h	51h	1 – 12 Bytes	Request an SD card file's CRC	
08h	70h – 7Fh	1-21 Bytes	Set Up Periodic Message	
08h	80h	None	SAINT Reset	
08h	86h	None	Turn Time Stamp Information OFF	
08h	87h	None	Turn Time Stamp Information ON	
08h	90h	1-20 Bytes	Send Periodic Message	
08h	91h	None	End Periodic Message	
08h	92h	0-1 Byte	Request Software Version	
08h	93h	3 Bytes	Request A Time Stamp	
08h	A0h	None	Clear Operation Warning Code	
08h	A1h	None	Retrieve/Report Operation Warning Code	
08h	A2h	1 Byte	Select Host Communication Channel	
08h	A3h	1-30 Bytes	Select Serial Bus Protocols	
08h	A5h	None	Retrieve Serial Number	
08h	A8h	1 Bytes	Trig Out function	
08h	A9h	3 Bytes	Trig In function – (1)	
08h	ABh	3 Bytes	Trig In function – (2)	
08h	BEh	1 Byte	Manufacturing Test Command	Saint2 only
08h	BFh	1 Byte	Not A User Command	Saint2 only
08	C0h-CFh	1-21 Bytes	Set Up Periodic Message	

5.1.1 Firmware Flash Programming (08 10h)

This command places the SAINT into a mode in which the SAINT firmware can be reflashed. A reset command terminates this mode. For the SAINT3 send command 08 10 01.

5.1.2 Device Enumeration (08 20h)

This command retrieves a unique 2 byte code for each type of supported device hardware. This value can be used by your software application to detect the type of Saint hardware in use. This value may be helpful to determine application restrictions based on the type of device in use.

Major	Minor	Device Type
2	0	Saint2
3	0	Micro Saint3
3	1	Saint3 Pro

5.1.3 Embedded Emulation (08 50h)

Feature not available in the uS3. Not yet implemented in the S3 Pro.
These commands are used to interface with the SAINT2's embedded emulation function. See the SAINT Emulation User Guide for more information.

Host / Emulation Interface Messages

SAINT header	ID	Data	Description
08	50 00	ASCII file name	Start execution of emulation file
08	50 02	message data	Message sent from emulation to host
08	50 03	Message data	Message sent from host to emulation
08	50 04	emulation error information	Message indicating an error in emulation execution
08	50 05	Emulation status information	Message indicating the status of the emulation execution
08	50 06	Emulation variable value	Message indicating the value of a requested emulation variable

5.1.4 Request an SD card file's CRC (08 51h)

Not applicable to the uS3.

This command returns the 32bit CRC of a file residing on the SD card. May cause loop overruns while CRC is being computed. Not yet implemented in the S3 Pro.

Host to SAINT request: 08 51 XX XX … XX

Data Byte	Description
XX XX	Emulation filename in ASCII (capital letters, 8.3 format)

SAINT response: 08 51 00 YY YY YY YY or 08 51 EE ZZ

Data Byte	Description	
YY YY YY YY	32 Bit CRC of file	
ZZ	Error Value	Description
	0x00	Emulation is executing or CRC calculation is executing
	0x01	Undefined SD card error
	0x02	No such file or directory – SD card
	0x05	I/O Error – SD card
	0x09	Bad file number – SD card
	0x0D	Permission denied – SD card
	0x11	File Exists – SD card
	0x13	No such device – SD card
	0x16	Invalid Argument – SD card
	0x18	Too many files open – SD card
	0x1C	No space left on device – SD card
	0x1E	Read only file system (Sharing error) – SD card
	0x20	Buffer is busy

5.1.5 Set Up Periodic Message (08 70h –08 7Fh) (08 C0h-08 CFh)

These commands allow the user to set up and transmit up to 32 periodic messages from the SAINT hardware. The following table describes the command formats.

Configuration Command	Description
$08 7X 00 T1 T2 HH YY YY YY …	Turn periodic message 7X ON T1 = MSB of 1ms/bit periodic time T2 = LSB of 1 ms/bit periodic time HH = SAINT Header (i.e. $60 for Class2, $50 for CAN) YY = Serial Message (1 to 15 bytes)
$08 7X 00	Turn message 7X ON after it has already been configured
$08 7X 01	Turn periodic message 7X OFF
$08 7X 10	Delete periodic message 7X
$08 7X 20	Delete all periodic messages that have been turned OFF
$08 7X 30	Delete all periodic messages
$08 7X 40	Request the configuration of periodic message 7X
$08 7X 50	Request the configuration of all periodic message that are OFF
$08 7X 60	Request the configuration of all periodic messages that are ON
$08 7X 70	Request both ON and OFF periodic message setting
$08 7X 80	Turn ON all periodic message that are OFF
$08 7X 90	Turn OFF all periodic messages that are ON

An additional 16 periodics are available using CX in place of 7X.

- The range of X in 08 7X is 0 to F. The range of X in 08 CX is 0 to F. CX not yet implanted in the S3.
- A Time Stamp of 0000h will cause the message to be sent one time and then turned OFF.
- If two messages align to be transmitted at the same time, the message with the lower ID will have priority.

5.1.6 SAINT Reset (08 80h)

This command will cause the Saint 2 to do a software reset. A user should wait approximately 250ms after issuing a SAINT Reset to send any other commands to the SAINT.

5.1.7 Turn Time Stamp On and Off (08 86h and 08 87h)

These commands control whether or not a 16-bit time stamp is appended to the end of the bus message reports.

5.1.8 Send Periodic Message (08 90h and 08 91h)

These commands allow the user to set up and transmit a single periodic messages. Use the following format:

08 90 T1 T2 HH XX XX XX XX XX XX XX XX XX XX XX

where

T1 = MSB of 1ms periodic time

T2 = LSB of 1ms periodic time

HH = SAINT Header

XX… = Serial Message

The 08 91 messages cancels the periodic message.

5.1.9 Software Version Request (08 92h)

Command 08h 92h requests the SAINT firmware functional block version (ASCII). If the RS232 host communication protocol is disabled, the command 08h 92h 01h requests the version of all blocks of the SAINT firmware (boot, re-flash, functional, and user block) (ASCII).

5.1.10 SAINT Time Stamp Request (08 93)

Command 08 93 requests the SAINT's current 2 byte Time Stamp Value.

Request:

Header	ID	1 byte "marker"	Description
08	93	XX	Request 2 byte Time Stamp

Response:

Header	ID	1 byte "marker"	Data
08	93	XX	2 byte Time Stamp

5.1.11 Clear Operation Warning Code (08 A0h)

This command will clear the operation warning codes stored in the SAINT.

5.1.12 Retrieve and Report Operation Warning Code (08 A1h)

ID A1h has two functions. As a command 08h A1h retrieves the operation warning codes stored in the SAINT. The return message has 0 - 32 bytes of data representing the operation warning codes. The warning code is defined in the following table. As an unsolicited report message, it reports the operation warning code in the format of 08h A1h XXh. XXh is a one byte warning code defined also in the following table.

Header	ID	Data	Description
08h	A1h	01h	Loop overrun detected
08h	A1h	02h	USB buffer full detected
08h	A1h	03h	Escape sequence error
08h	A1h	04h	Message Too Long
08h	A1h	05h	Message Buffer Full

08h	A1h	06h	Message Truncated
08h	A1h	08h-0Fh	Configuration setting warning
08h	A1h	20h-27h	IIC operation warning
08h	A1h	28h-2Fh	Keyword 2000 operation warning
08h	A1h	50h	The CAN1 TX buffer has overrun and CAN frames have been discarded
08	A1h	30h-37h	Reserved for ISO 15765 CANFD1
08	A1h	38h-3Fh	Reserved for ISO 15765 CANFD2
08h	A1h	51h	The CAN1 RX buffer has overrun and CAN frames have been discarded
08h	A1h	52h-57h	reserved for CAN 1
08h	A1h	58h	The CAN2 TX buffer has overrun and CAN frames have been discarded
08h	A1h	59h	The CAN2 RX buffer has overrun and CAN frames have been discarded
08h	A1h	5Ah-5Fh	reserved for CAN 2
08h	A1h	60h-67h	Class 2 operation warning (Saint2 only)
08h	A1h	68h-6Fh	Not Used
08h	A1h	70h-77h	SPI operation warning
08h	A1h	78h-7Fh	Not Used
08h	A1h	80h-87h	Not Used
08h	A1h	88h-8Fh	Not Used
08h	A1h	90h-97h	Not Used
08h	A1h	98h-9Fh	Not Used
08h	A1h	A0h-A7h	Not Used
08h	A1h	A8h-AFh	Not Used
08h	A1h	B0h-B7h	Not Used
08h	A1h	B8h-BFh	LIN operation warning
08h	A1h	C0h	CAN packet buffer busy – rx message dropped (ISO15765-2)
08h	A1h	C1h	TX FIFO full – CAN packet message dropped (can't send FC – ISO15765-2)
08h	A1h	C2h-C7h	Reserved
08h	A1h	C8h-CFh	Reserved
08h	A1h	D0h-D7h	Reserved for CANFD1
08h	A1h	D8h-DFh	Reserved for CANFD2
08h	A1h	E0h-E7h	Not Used
08h	A1h	E8h-EFh	Not Used
08h	A1h	F0h-F7h	Not Used
08h	A1h	F8h-FFh	reserved

5.1.13 Select Host Communication Channel (08 A2h)

Not applicable to uS3.

This command selects the Saint 2 to host communication protocol to be used.

Select Host Communication Protocol Command

Header	ID	Data	Description
08h	A2h	03h	Select RS232 Only
08h	A2h	0Ch	Select USB Only
08h	A2h	0Fh	Select Both RS232 and USB

5.1.14 Select Serial Bus Protocols (08 A3h)

This command selects the serial bus protocols that will be enabled. Each byte in data field represents a protocol that is being enabled. Any protocol that is not in the list will be disabled.

Example: 08 A3 50 60 58 enables CAN1, Class 2, and CAN2 vehicle buses.

Note: The configuration command message is always enabled and not affected by this command.

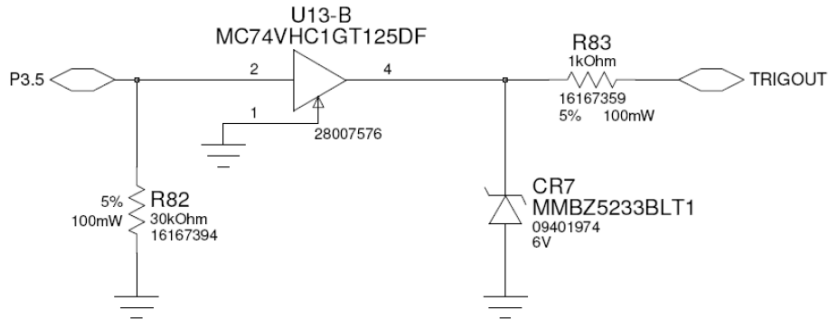
5.1.15 Retrieve Serial Number (08 A5h)

This command retrieves serial number of Saint unit. Return message with 6 data bytes – 6 character serial number in hexadecimal ASCII form.

5.1.16 Trig Out (08 A8h)

Not applicable to uS3.

This command controls the TRIGOUT Pin (DB-25 connector pin number 24) operation. The command has a format of 08h A8h option_byte. Option byte has a bit by bit definition



Option Byte Bit Definition

Option byte	Value	Description
Bit 0 – Bit 1	00 01 10 11	No action Set TRIGOUT line low (0 volt) Set TRIGOUT line high (5 volt) Toggle TRIGOUT line
Bit 2	TBD	TBD
Bit 3	TBD	TBD
Bit 4 – Bit 5	00 01 10 11	No action Set TRIGOUT2 line low (0 volt) Set TRIGOUT2 line high (5 volt) Toggle TRIGOUT2 line (only in HW 1.2)
Bit 6	TBD	TBD
Bit 7	TBD	TBD

5.1.17 Trig In - 1 (08 A9h)

Not applicable to uS3.

This command controls and reports TRIGIN Pin (DB-25 connector pin number 4) operation. A Trig In command must be sent to configure the SAINT to detect and report a change on the TrigIn pin.

5.1.17.1 Trigger In -- State Change

This command configures the Saint 2 firmware to send a trigger-in-marker message to the host when the state of the Trigger In pin changes:

Header	ID	Option byte	2 byte "marker"	Description
08	A9	01	XX XX	Configure SAINT to indicate trigger in pin state change

With this configuration, the SAINT firmware will send the following message to the host when it detects a state change on its trigger in pin:

Header	ID	Option byte	2 byte "marker"	Description
08	A9	01	XX XX	State change on trigger in pin

5.1.17.2 Trigger in -- edge detection marker

This command causes the Saint 2 firmware to send a trigger-in-marker message with edge detection information to the host when a trigger in signal transition is detected.

Header	ID	Option byte	2 byte "marker"	Description
08	A9	02	XX XX	Configure SAINT to indicate trigger in pin edge detected

With this configuration, the SAINT firmware will send one of the following messages to the host when it detects a state change on its trigger in pin

Header	ID	Option byte	Edge	2 byte "marker"	Description
08	A9	02	AA	XX XX	Rising edge detected on trigger in pin
08	A9	02	FF	XX XX	Falling edge detected on trigger in pin

5.1.18 Trig In – 2 (08 ABh)

Not applicable to uS3.

This command controls and reports the state of the SPI_INT Pin (DB-25 connector pin number 22) operation. A Trig In command must be sent to configure the SAINT to detect and report a change on the SPI_INT pin.

5.1.18.1 Trigger In -- State Change

This command configures the Saint 2 firmware to send a trigger-in-marker message to the host when the state of the SPI_INT pin changes:

Header	ID	Option byte	2 byte "marker"	Description
08	AB	01	XX XX	Configure SAINT to indicate SPI_INT pin state change

With this configuration, the SAINT firmware will send the following message to the host when it detects a state change on its SPI_INT pin:

Header	ID	Option byte	2 byte "marker"	Description
08	AB	01	XX XX	State change on SPI_INT pin

5.1.18.2 Trigger in -- edge detection marker

This command causes the Saint 2 firmware to send a trigger-in-marker message with edge detection information to the host when a SPI_INT signal transition is detected.

Header	ID	Option byte	2 byte "marker"	Description
08	AB	02	XX XX	Configure SAINT to indicate SPI_INT pin edge detected

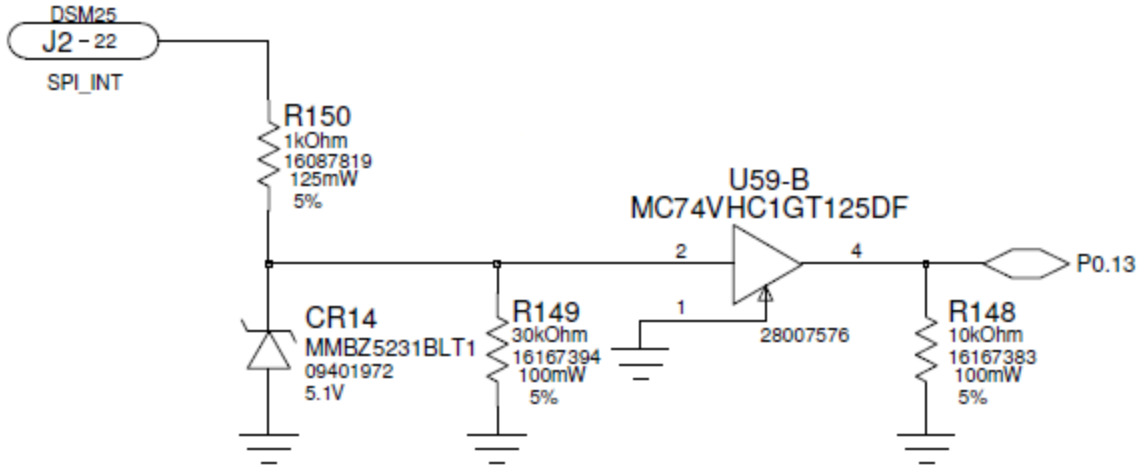
With this configuration, the SAINT firmware will send one of the following messages to the host when it detects a state change on its trigger in pin

Header	ID	Option byte	Edge	2 byte “marker”	Description
08	AB	02	AA	XX XX	Rising edge detected on SPI_INT pin
08	AB	02	FF	XX XX	Falling edge detected on SPI_INT pin

5.1.18.3 Trigger in – disable detection

This command causes the Saint 2 firmware to disable its trigger in pin detection:

Header	ID	Option byte	2 byte “marker”	Description
08	AB	00	00 00	Disable SPI_INT pin detection



5.1.19 Manufacturing Test Command(08 BEh)

This command controls the manufacturing test. The data byte value should match the pin number on the Saint 2 DB25 connector. Manufacturing test is only performed and valid when a special manufacturing test cable attached to the Saint2. **Not applicable to the Saint3.**

Manufacturing Test Command

Header	ID	Data
08h	BEh	SAINT2 pin #

Manufacturing Test Command Response

Header	ID	Data	Description
08h	BEh	FFh	Test Failed
08h	BEh	FEh	Test not defined
08h	BEh	FDh	Test in progress
08h	BEh	FCh	Illegal command
08h	BEh	Other #	Test passed on the # of the pin

5.1.20 Saint USB Test Command(08 BFh)

This is not a user command.

5.2 SAINT Configuration Reports

The SAINT will report a Reset whenever one occurs. Most likely causes of reset are power on reset, host commanded reset, or SAINT micro watchdog error. The SAINT does a cold start on all resets (all information is lost). The SAINT will also report error conditions with the Report Error message below. See table T5-1 for error code definitions.

The SAINT will also echo back all system commands.

Header	ID	Description	Data Bytes
08h	70h – 7Fh	Report Set Up Periodic Message	1-21 bytes echoed
08h	80h	Reset Occurred	None
08h	82h	Report Error	1 byte Error Code (See T5-1)
08h	86h	Report Time Stamp Information OFF	None
08h	87h	Report Time Stamp Information ON	None

08h	88h	Report Transmit Echo ON	None
08h	89h	Report Transmit Echo OFF	None
08h	90h	Report Send Periodic Message ON	1-20 bytes echoed
08h	91h	Report Send Periodic Message OFF	None
08h	92h	Report SWID	1-N bytes of ASCII Data
08h	A0h	Report operation warning code cleared	None
08h	A1h	Report operation warning code	0-32 bytes warning code
08h	A2h	Report host communication channel	1 byte echoed
08h	A3h	Report Bus Protocol Selected	1-30 bytes protocol ID(See Section 4-2)
08h	A5h	Retrieve serial number	6 byte serial number ASCII code
08h	A8h	Report TriggerOut	None
08h	A9h	Report TriggerIn	2 byte marker
08h	BEh	Report Manufacturing Test Status	1 byte(See Section 5.1.15)
08h	BFh	N/A	None

T5-1 SAINT Configuration Command Error Codes

Code	Description
80h	System – Invalid message ID
81h	System – RS-232 Transmit Buffer Full
82h	System – UART Error (Overrun, etc)
83h	System – Received message length error
84h	System – Have not read previous message

5.3 SAINT Configuration through SD Card

Not applicable to uS3.

The SAINT can be configured at reset by using an SD card. Following reset, the SAINT searches the SD card root directory for the file ***config.txt***. If ***config.txt*** is found, the SAINT executes the configuration instructions in ***config.txt***.

NOTES: 1) Currently, ONLY the FAT-16 format is supported (SD cards formatted as FAT-32 will not work.)

2) Initialization (reset/boot) time with an SD card inserted can take up to 30sec (nominally 15sec) due to additional integrity checks that are performed on the SD card media.

5.3.1 Configuration File Requirements

- Text format file
- Must be saved in root directory of SD card
- The first line of config.txt must be 'begin' and last line must be 'end'
- Configuration instructions are between 'begin' and 'end' with one instruction per line
- Comments are allowed at end of instruction and begin with a semicolon.
- The maximum length of each line is 56 characters.

5.3.2 Configuration Instructions

5.3.2.1 'can channel swap' Instruction

This instruction swaps the CAN hardware channel mapping between CAN 1 and CAN 2. Before swapping CAN_1 ID 0x50 is assigned to hardware channel 1 and CAN_2 ID 0x58 is assigned to hardware channel 2. After swapping, 0x50 is assigned to channel 2 and 0x58 assigned to channel 1.

5.3.2.2 'group file' Instruction

Group file instruction are followed by a colon and a group file name. After the SAINT reads the command, it executes the group file immediately if the group file exists in SD card root directory. Group file format is described in the Saint Document and has the following restrictions:

- The group file name cannot be longer than 8+3 characters.
- The maximum length of the group file is 16 lines with a maximum of 31 data bytes in each line.
- The time field in group file is ignored. Firmware executes group file messages sequentially and immediately.
- Comments are not allowed.
- System reset command 08 80 is not allowed.

5.3.3 Config.txt Example

begin
can channel swap
group file: playback.grp ; execute group file at system rest
end

5.3.4 Group File Example

A SAINT group file contains a list of messages and an associated transmit delay from the previous message. The delay must be a 4-digit decimal value in milliseconds from the previous message. The message must follow the SAINT Programmer's Reference format (i.e., the message must include the SAINT header byte). Group files may be used to send any message (within the allowable length) that may be sent from the host PC to the SAINT. **IMPORTANT: Note that group files called from a config.txt file will be executed without timing control or guarantee of synchronous execution. These group files should only be used to configure the SAINT hardware. They should not be used to send messages onto a serial bus, send a SWCAN high voltage wakeup, or send any other function that requires synchronous execution or timing control.**

The number of lines in a group file called from the config file is limited to 16 lines.

Group File Example:
0000 54 01 C9 39
0010 54 04 00

6 CAN/CANFD Messages

The SAINT supports 2 independent CAN/CANFD nodes. CAN_1 (SAINT header 50h) and CAN_2 (SAINT header 58h) may each be independently configured to support dual wire CAN/CANFD, single wire CAN, and fault tolerant CAN at a user specified baud rate. The two dual wire CAN channels share the same pins with CANFD if using the SAINT3.

SAINT CAN Node Information

CAN Function	Connector Label	S2/S3 Pro CABLE Pin #	uS3 CABLE Pin	Message Header	Command Header
Single Wire CAN 1	SWCAN1	1	N/A	50h	54h
Single Wire CAN 2	SWCAN2	5	N/A	58h	5Ch
Dual Wire, High Speed CAN 1	CAN/CANFD_1_H CAN/CANFD_1_L	8 9	7 2	50h	54h
Dual Wire, High Speed CAN 2	CAN/CANFD2_H CAN/CANFD2_L	10 11	8 4	58h	5Ch
Fault Tolerant CAN 1 (Low Speed CAN)	FT_1_H FT_1_L	Only on daughter board, HW 1.1 and earlier	N/A	50h	54h
Fault Tolerant CAN 2 (Low Speed CAN)	FT_2H FT_2L	2 13	N/A	58h	5Ch

6.1 CAN/CANFD Commands

The CAN commands are used to configure the operation of the SAINT's CAN nodes.

CAN/CANFD Command Format

Header	ID	Description	Data Bytes
54h or 5Ch	01h	Set CAN (CANFD arbitration) Frequency	BTR0 BTR1
54h or 5Ch	02h	Set Single Wire CAN Mode Control	MODE
54h or 5Ch	03h	Set CAN Controller to listen only mode	RXONLY
54h or 5Ch	04h	Set CAN Transceiver	TXVR MODE
54h or 5Ch	05h	Set SAINT options	OPTION
54h or 5Ch	06h	Set CANFD data frequency (S3 only)	DATA BYTES
54h or 5Ch	09h	Set CAN ID include filter	CAN ID MASK
54h or 5Ch	0Ah	Set CAN FD ISO Mode (S3 only)	0 = ISO*, 1 – Non ISO
54h or 5Ch	0Bh	CANFD Transmitter Delay Compensation (TDC) (S3 only)	TDC value 0 to 7Fh (127)
54h or 5Ch	0Ch	Set CAN/CANFD termination (S3 only)	0 = Off, 1 = On*
54	FFh	Bus Flooding	MODE CAN MSG

* = default

6.1.1 Configuring CAN Frequency

Calculations not valid for CANFD. Only valid for SAINT2.

By modifying BTR0 and BTR1, you can change the frequency, Synchronization Jump Width, and Sampling point, of the TC1130 MultiCAN controller.

Synchronization Jump Width = sjw = 1 + SJW, SJW = bit 7 – bit 6 of BTR0

Baud Rate Prescaler = brp = 1 + BRP, BRP = bit5 – bit0 of BTR0

tseg2 = 1 + TSEG2, TSEG2 = bit6 – bit4 of BTR1

tseg1 = 1 + TSEG1, TSEG1 = bit3 – bit0 of BTR1

DIV8 = bit7 of BTR1 (0: tq = BPR+1 clock cycles; 1: tq = 8*(BPR+1) clock cycles)

$$\textbf{Baud Rate} = \frac{75.0+E6}{(DIV8*7 + 1) * (BRP + 1) * (3 + TSEG1 + TSEG2)}$$

$$\textbf{Bit Time} = \frac{1}{\textbf{Baud Rate}}$$

$$\textbf{Sample Point} = \frac{2 + TSEG1}{3 + TSEG1 + TSEG2}$$

Example Set CAN/CANFD Frequency Configuration Messages

Header	ID	Data Bytes	CAN Parameter Value	Baud Rate	Sample Point
54h or 5Ch	01h	8D AF	SJW=2, BRP=13, TSEG1 = 15, TSEG2=2, DIV8=1	33,482(33,333)	85%
54h or 5Ch	01h	B1 2D	SJW=2, BRP=49, TSEG1 = 13, TSEG2=2, DIV8=0	83,333	83.3%
54h or 5Ch	01h	F0 3A	SJW=3, BRP=48, TSEG1 = 10, TSEG2=3, DIV8=0	95,200	75%
54h or 5Ch	01h	F1 39	SJW=3, BRP=49, TSEG1 = 9, TSEG2=3, DIV8=0	100,000	73.3%
54h or 5Ch	01h	DD 3E	SJW=3, BRP=29, TSEG1 = 14, TSEG2=3, DIV8=0	125,000	80%
54h or 5Ch	01h	D8 39	SJW=3, BRP=24, TSEG1 = 9, TSEG2=3, DIV8=0	200,000	73.3%
54h or 5Ch	01h	CE 3E	SJW=3, BRP=14, TSEG1 = 14, TSEG2=3, DIV8=0	250,000	80%
54h or 5Ch	01h	C9 39	SJW=3, BRP=9, TSEG1 = 9, TSEG2=3, DIV8=0	500,000	73.3%
54h or 5Ch	01h	84 2A	SJW=3, BRP=4, TSEG1 = 10, TSEG2=2, DIV8=0	1,000,000	80%

For CANFD the 54h 01h or 5Ch 01h configuration message sets the baud rate for the arbitration portion of the message. Separate configuration commands are used for CANFD data baud rate shown below.

6.1.2 Configuring CANFD Data Baud Rate

Example Set CANFD Data Baud Rate Configuration Messages

Header	ID	Data Bytes	Baud Rate	Sample Point
54h or 5Ch	06h	00 09 0D 23	1,000,000	?
54h or 5Ch	06h	00 04 0D 23	2,000,000*	?
54h or 5Ch	06h	00 03 0D 23	2,500,000	?
54h or 5Ch	06h	00 03 0A 23	3,000,000	?
54h or 5Ch	06h	00 02 0D 23	4,000,000	?
54h or 5Ch	06h	00 01 0D 23	5,000,000	?

CANFD Data baud rates are also covered in section 6.1.7.

6.1.3 Single Wire Mode Control

Not applicable to uS3.

The following commands allow the user to control the MODE0 and MODE1 pins of the Single Wire CAN transceiver (MC33897).

Set Single Wire Mode Command

Header	ID	Data Byte	Description
54h or 5Ch	02h	00	Sleep mode
54h or 5Ch	02h	01	High-speed transmission mode
54h or 5Ch	02h	02	Wake-up transmission mode
54h or 5Ch	02h	03	Normal transmission mode

6.1.4 Listen Only Mode Control

The following commands allow the user to control the Listen Only mode of the CAN controller. When the CAN Node is in the listen only mode, it will not transmit any frame onto the CAN bus, including active error frames and frame acknowledgments.

Set Listen Only Mode Command

Header	ID	Data Byte	Description
54h or 5Ch	03h	00	CAN Node will TX and RX
54h or 5Ch	03h	01	CAN Node will only RX

6.1.5 CAN Transceiver Control

The following commands allow the user to control either CAN Node 1 or CAN Node. The optional 2nd data byte also allows the user to configure any associated operational modes with the selected CAN transceiver.

Set CAN Transceiver Command

Header	ID	TXVR	MODE (optional)		Description
54h or 5Ch	04h	00	00	Normal Mode	High Speed/Dual Wire CAN (TJA1040)
			01	Standby Mode	
54h or 5Ch	04h	01	01	Sleep Mode	Fault Tolerant CAN (TJA1054A)
			03	Normal Mode	
54h or 5Ch	04h	02	00	Sleep Mode	Single Wire CAN (MC33897)
			01	High Speed Mode	
			02	High Voltage Mode	
			03	Normal Mode	
54h or 5Ch	04h	03	No optional mode supported		CAN transceiver on a daughter board
54h or 5Ch	04h	04			CAN-FD (coming soon)

6.1.6 CAN SAINT Options

The following command allows the user to enable or disable SAINT options. Whether an option is set using a 54h or 5Ch header, the option will apply to both CAN1 and CAN2. There are currently two SAINT options available.

6.1.6.1 Error Indicator Option Bit

This bit will most likely be used to indicate CAN-FD in the Saint3. For the Saint2 this bit will remain as the error indicator.

This feature is not available in the S3. The S3 uses this bit to indicate that the message is a CANFD message.

The SAINT can set a bit in the unused bits of the CAN message ID to indicate an error in a frame. The error information is always contained in the status byte that precedes the time stamp, but the additional error indicator bit allows for easier filtering of error frames. If this option is enabled, a frame that contains an error will have bit 6 set in the MSB of the Message ID.

Example: 51 40 00 01 E6 78

|

Error indicator bit set in Message ID of receive error

Example: 51 46 21 11 22 33 44 55 03 E6 78

|

Error indicator bit set in Message ID of transmit error

6.1.6.2 High Resolution Time Stamp Option Bit

The SAINT can provide a high resolution, relative time stamp. If this bit is set, the SAINT will insert a high resolution time stamp bit after the frame data and before the status byte of the frame. The high resolution time stamp can be used in conjunction with the 2 byte time stamp determine a high resolution time difference between two messages. The following equations can be used to calculate the high resolution delta time:

- Delta time = (((High Res TS2 – High Res TS1) * 2^5) + (X * 2^{12}))
- Where X = number of times the High Resolution Time Stamp has rolled over
- Rollover time = 2^{13} * bittime
- Resolution = 2^5 * bittime
- bittime = ((DIV8*7 + 1) * (BRP + 1) * (3 + TSEG1 + TSEG2)) / 75M - use actual values not general baud rate

Example: 51 06 21 11 22 33 44 55 A4 10 E6 78
51 06 21 11 22 33 44 55 F6 10 E6 78

|

High Resolution Time Stamp

6.1.6.3 Disable Continuous Ack Error Message Retries

In the normal operation of the CAN physical layer, a transmitted frame is not completed without error until a receiver has acknowledged the frame by setting the acknowledgment bit in the transmitted frame. By default, when an acknowledgment has not been received, the SAINT will attempt to resend the frame up to 4 times. There may be circumstances during product testing when this is not desirable. The SAINT can be configured in 3 different ways with regards to unacknowledged, transmitted CAN frames:

1) Default – The SAINT will attempt a CAN frame 5 times (first plus 4 retries). (54 05 00)
2) The SAINT will only try a CAN frame one time. (54 05 04)
3) The user can configure the SAINT to try a specified number of times (total includes first try). (54 05 00 XX XX XX XX)

If no ACK is received in the number of configured retries, the SAINT will flush and restart its transmit fifo. Note that this means that any frames that have been sent to the SAINT to be transmitted that have already been placed in the fifo will be lost.

6.1.6.4 Setting CAN SAINT Options

Use the following message to set the CAN SAINT Options.

Set CAN SAINT Options

Header	ID	Option	# of Ack Retries (optional)	Description
54h or 5Ch	05h	OPT	XX XX XX XX (1 retry/bit)	Set SAINT Options as described below

OPT bit definition

OPT	Description
b7 – b3	Reserved
b2	= 0: continuous retries are enabled for ACK errors = 1: disable continuous retries for ACK errors
b1	= 0: disable error indicator option bit = 1: enable error indicator option bit
b0	= 0: disable high resolution time stamp option bit = 1: enable high resolution time stamp bit

6.1.7 Set CANFD data baud rate

Example Set CANFD data baud rate

Header	ID	Data Bytes	Baud Rate
54h or 5Ch	06h	00 09 0D 23	1,000,000
54h or 5Ch	06h	00 02 16 55	2,000,000*
54h or 5Ch	06h	00 05 0A 22	2,000,000
54h or 5Ch	06h	00 05 06 11	3,000,000
54h or 5Ch	06h	00 02 0A 22	4,000,000
54h or 5Ch	06h	00 04 05 11	4,000,000
54h or 5Ch	06h	00 01 0D 23	5,000,000

* = default

CANFD arbitration and data baud rates should be matched see Section 6.2 below.

6.1.8 Set CAN ID Include Filter

The following command allows the user/plug-in to set the SAINT's CAN controller's CAN ID acceptance filter. When this filter is specified, the SAINT's CAN controller will only receive messages that match the CAN ID anded with the

mask. Only the received messages will be sent from the SAINT to the host PC. Using this command may be very helpful for PC applications that are overburdened when trying to process all of the messages on a vehicle bus. This only filters messages received from the CAN bus. All messages transmitted by the SAINT onto the bus will be sent to the host.

Set CAN ID Include Filter

Header	ID	CAN ID	Mask	Description
54h or 5Ch	09h	XX XX	MM MM	Set an 11 bit CAN ID include filter
54h or 5Ch	09h	XX XX XX XX	MM MM MM MM	Set a 29 bit CAN ID include filter
54h or 5Ch	09h	00	n/a	Reset filter to include all CAN IDs

Examples:

1) To include only CAN ID 0x7E0 send a 54 09 07 E0 FF FF.
2) To include CAN IDs 0x7E0 to 0x7EF send a 54 09 07 E0 FF F0.

6.1.9 Configuring CANFD ISO Mode (S3 only)

Example Set CANFD ISO mode Configuration Messages

Header	ID	Data Bytes	Mode
54h or 5Ch	0Ah	00	ISO Mode*
54h or 5Ch	0Ah	01	Non-ISO Mode
D4h or DCh	*0Ah*	*00*	*ISO Mode**
D4h or DCh	*0Ah*	*01*	*Non-ISO Mode*

*= power on default

Note: D4 and DC headers will be deprecated

6.1.10 CAN FD Transmitter Delay Compensation (TDC) (S3 only)

Transmitter delay compensation is set automatically for CAN FD bit rates of 4Mbps and above. The default value is 13h.

Note: Where the bit rate pre-scaler value is greater than 2, the default TDC is set to 0.

It is possible to change the default TDC value. The value set will override the default value.

Header	ID	Data Bytes
54h or 5Ch	0Bh	00h* to 7Fh

* = default

6.1.11 Enable\Disable CAN bus termination (S3 only)

CAN bus termination can be turned on and off via configuration messages for the S3 only. This feature does not work with the Saint2. For the S2, termination is enabled by default. On the S2 jumpers must be removed to disable the termination jumpers When termination is enable a 120 ohm resistor is connected between the CAN high and low lines. Termination should be applied across the two extreme opposite ends of a vehicle bus. If only two CAN nodes are on the bus such as a product being tested with the Saint, then both devices should have termination in place. When connecting the Saint in a vehicle termination is not normally needed or desired.

Header	**ID**	**Data Byte**
54h or 5Ch	0Ch	00h = OFF, 01h = ON (default)

6.2 CANFD Special considerations

When setting the arbitration and data baud rates for CANFD it is important to match the time quanta value. The following table provides "matched" data rates for the arbitration and data rates for CANFD.

Arbitration Baud Rate	Message	Data Baud Rate	Message
125,000	54 01 5E 05 BE 2F	2,000,000	54 06 00 05 0A 22
250,000	54 01 2E 05 5E 17	2,000,000	54 06 00 05 0A 22
500,000	54 01 16 05 2E 0B	2,000,000	54 06 00 05 0A 22
125,000	54 01 5E 05 BE 2F	3,000,000	54 06 00 05 06 11
250,000	54 01 2E 05 5E 17	3,000,000	54 06 00 05 06 11
500,000	54 01 16 05 2E 0b	3,000,000	54 06 00 05 06 11
125,000	54 01 72 04 E4 39	4,000,000	54 06 00 04 05 11
250,000	54 01 5E 02 BE 2F	4,000,000	54 06 00 02 0A 22
500,000	54 01 2E 02 5E 17	4,000,000	54 06 00 02 0A 22

Notes: Configuration messages as shown are for CANFD1. For CANFD2 simply change the header byte from 54h to 5Ch.

6.3 Constructing a CAN Transmit Frame

The following message formats are used to transmit a CAN frame onto the serial bus.

11 Bit Message ID CAN Data Frame Message Format

Byte 1	Byte 2: b7-b3	Byte 2: b2-b0 and Byte 3	Bytes 4-11
Header	CAN frame definition bits	11 bit Identifier (000h – 7FFh)	up to 8 Data Bytes
50h or 58h	00000b	$b_{10} - b_0$	D1 D2 D3 D4 D5 D6 D7 D8

11 Bit Message ID CANFD Data Frame Message Format

Byte 1	Byte 2: b7-b3	Byte 2: b2-b0 and Byte 3	Bytes 4-11
Header	CAN frame definition bits	11 bit Identifier (000h – 7FFh)	up to 64 bytes for CANFD
50h or 58h	01000b	$b_{10} - b_0$	D1 D2 D3, … D64

29 Bit Message ID CAN Data Frame Message Format

Byte 1	Byte 2: b7-b5	Byte 2: b4-b0 to Byte 5	Bytes 6-13
Header	CAN frame definition bits	29 bit Identifier (00000000h – 1FFFFFFFh)	up to 8 Data Bytes
50h or 58h	100b	$b_{28} - b_0$	D1 D2 D3 D4 D5 D6 D7 D8

29 Bit Message ID CANFD Data Frame Message Format

Byte 1	Byte 2: b7-b5	Byte 2: b4-b0 to Byte 5	Bytes 6-13
Header	CAN frame definition bits	29 bit Identifier (00000000h – 1FFFFFFFh)	up to 64 bytes for CANFD
50h or 58h	110b	$b_{28} - b_0$	D1, D2, D3, … D64

Note: For extended Identifiers, bit7 of byte2 must be set.

Note: For CANFD, bit 6 of byte 2 must be set.

6.4 Constructing a CANFD Transmit Frame (Deprecated)

Deprecated. Please configure your CAN channel for CANFD and transmit via 50h or 58h.

The following message formats are used to transmit a CAN frame onto the serial bus.

11 Bit Message ID CANFD Data Frame Message Format

Byte 1	Byte 2: b7-b3	Byte 2: b2-b0 and Byte 3	Bytes 4-67
Header	CANFD frame definition bits	11 bit Identifier (000h – 7FFh)	up to 64 Data Bytes
D0h or D8h	00000b	$b_{10} – b_0$	D1 D2 D3… D64

29 Bit Message ID CANFD Data Frame Message Format

Byte 1	Byte 2: b7-b5	Byte 2: b4-b0 to Byte 5	Bytes 6-71
Header	CANFD frame definition bits	29 bit Identifier (00000000h – 1FFFFFFFh)	up to 64 Data Bytes
D0h or D8h	100b	$b_{28} – b_0$	D1 D2 D3…D64

6.5 CAN Channel 1 Bus Flooding Function

The SAINT can be used to flood the CAN bus using CAN channel 1. The SAINT will send the specified frame onto the CAN bus as quickly as it is able. The specified frame may have an incremented data byte allowing for 256 unique messages to be transmitted as the bus is being flooded.

Set CAN 1 Bus Flooding

Header	ID	Data Byte 1	Data Bytes 2 – up to Data Byte 13
54h	FFh	MODE	CAN message

MODE Byte Definition

MODE	Description
00	Disable Bus Flooding
01	Enable Bus Flooding with CAN message in data bytes 2 – 13
02	Enable Bus Flooding with CAN message in data bytes 2 – 13 and increment the last data byte value with each transmitted frame

Examples:

54 FF 01 01 22 11 22 33 44 00 will configure the SAINT to transmit the following:

$122 11 22 33 44 00

$122 11 22 33 44 00

$122 11 22 33 44 00

etc

54 FF 02 01 22 11 22 33 44 00 will configure the SAINT to transmit the following:

$122 11 22 33 44 00

$122 11 22 33 44 01

$122 11 22 33 44 02

etc

54 FF 01 81 22 33 44 11 22 00 will configure the SAINT to transmit the following:

$01223344 11 22 00

$01223344 11 22 00

$01223344 11 22 00

etc

54 FF 02 81 22 33 44 11 22 00 will configure the SAINT to transmit the following:

$01223344 11 22 00

$01223344 11 22 01

$01223344 11 22 02

etc

Note: Set bit7 of the Message ID for 29-bit CAN/CANFD. Set bit6 to indicate CANFD.

6.6 CANFD Channel 1 Bus Flooding Function

Depreacated. Please use 54h for CANFD bus flooding

CANFD bus flooding is very similar to the CAN bus flooding described in section 6.5 above. For CANFD simply set bit 6 (add $40) to the CAN ID.

6.7 Received CAN/CANFD Frames

The SAINT reports back to the host the CAN/CANFD frames that it receives from the CAN or CANFD bus. These reported frames include frames that the SAINT has transmitted onto the bus and frames that it has received from other devices on the CAN/CANFD bus. The frames are reported back to the host in messages with the following formats.

11 Bit Message ID CAN Data Frame with 2 Byte Time Stamp

Byte 1	**Byte 2:b7-b3**	**Byte 2:b2-b0, Byte 3**	**Bytes 4—(3+*N*)**	**Byte 4+*N***	**Byte (5+*N*) – Byte (6+*N*)**
Header 5X	00000b	Message ID Bytes	*N* Data Bytes	Completion Code	1ms resolution Time Stamp

11 Bit Message ID CANFD Data Frame with 2 Byte Time Stamp

Byte 1	**Byte 2:b7-b3**	**Byte 2:b2-b0, Byte 3**	**Bytes 4—(3+*N*)**	**Byte 4+*N***	**Byte (5+*N*) – Byte (6+*N*)**
Header 5X	01000b	Message ID Bytes	*N* Data Bytes	Completion Code	1ms resolution Time Stamp

29 Bit Message ID CAN Data Frame with 2 Byte Time Stamp

Byte 1	**Byte 2:b7-b5**	**Byte 2:b4-b0, Byte 5**	**Bytes 6—(5+*N*)**	**Byte 6+*N***	**Byte (7+*N*) – Byte (8+*N*)**
Header 5X	100b	Message ID Bytes	*N* Data Bytes	Completion Code	1ms resolution Time Stamp

29 Bit Message ID CANFD Data Frame with 2 Byte Time Stamp

Byte 1	**Byte 2:b7-b5**	**Byte 2:b4-b0, Byte 5**	**Bytes 6—(5+*N*)**	**Byte 6+*N***	**Byte (7+*N*) – Byte (8+*N*)**
Header 5X	110b	Message ID Bytes	*N* Data Bytes	Completion Code	1ms resolution Time Stamp

11 Bit Message ID CAN Data Frame without 2 Byte Time Stamp

Byte 1	**Byte 2:b7-b3**	**Byte 2:b2-b0, Byte 3**	**Bytes 4—(3+*N*)**	**Byte 4+*N***
Header 5X	00000b	Message ID Bytes	*N* Data Bytes	Completion Code

11 Bit Message ID CANFD Data Frame without 2 Byte Time Stamp

Byte 1	**Byte 2:b7-b3**	**Byte 2:b2-b0, Byte 3**	**Bytes 4—(3+*N*)**	**Byte 4+*N***
Header 5X	01000b	Message ID Bytes	*N* Data Bytes	Completion Code

29 Bit Message ID CAN Data Frame without 2 Byte Time Stamp

Byte 1	Byte 2:b7-b5	Byte 2:b4-b0, Byte 5	Bytes 6—(5+*N*)	Byte 6+*N*
Header 5X	100b	Message ID Bytes	*N* Data Bytes	Completion Code

29 Bit Message ID CANFD Data Frame without 2 Byte Time Stamp

Byte 1	Byte 2:b7-b5	Byte 2:b4-b0, Byte 5	Bytes 6—(5+*N*)	Byte 6+*N*
Header 5X	110b	Message ID Bytes	*N* Data Bytes	Completion Code

6.7.1 Header Description

Header

Header	Description: See definition of SAINT header bits in TBD
50h or 58h	CAN/CANFD Frame Received from bus, no 2 byte time stamp
51h or 59h	CAN/CANFD Frame Received from bus with 2 byte time stamp
52h or 5Ah	CAN/CANFD Frame Transmitted onto bus, no 2 byte time stamp
53h or 5Bh	CAN/CANFD Frame Transmitted onto bus with 2 byte time stamp
D0h or D8h	*CANFD Frame Received from bus, no 2 byte time stamp*
D1h or D9h	*CANFD Frame Received from bus with 2 byte time stamp*
D2h or DAh	*CANFD Frame Transmitted onto bus, no 2 byte time stamp*
D3h or DBh	*CANFD Frame Transmitted onto bus with 2 byte time stamp*

6.7.2 CAN Frame Definition Bit Description

CAN Frame Definition Bits

CAN Frame Definition bits	Description
b7	=0 for 11 bit ID frame =1 for 29 bit ID frame
b6	=0 for Standard CAN =1 for CANFD
b5	=0 for no error in frame (optional) =1 for error in frame (optional)

6.7.3 Message ID Bytes Description

CAN/CANFD Message ID Bytes

ID Type	Allowed Values
11 bit ID	000h – 7FFh
29 bit ID	00000000h – 1FFFFFFFh

6.7.4 Data Bytes Description

CAN allows 0 to 8 data bytes per frame. CANFD allows up to 64 data bytes per frame.

6.7.5 Completion Code

The completion code contains information from the CAN/CANFD controller of the Saint. It is used to communicate whether or not the frame was successfully transmitted or received. It identifies the error if the communication was not successful.

Completion Code Definition

Completion Code Byte	Description
0x00	reserved
0x01	Stuff error – More than 5 equal bits in a sequence have occurred in a part of a received frame where this is not allowed.
0x02	Form error – A ‘fixed format part’ of a received frame has the wrong format.

0x03	Ack error – The transmitted frame was not acknowledged by another node.
0x04	Bit 1 error – During a frame transmission the CAN node tried to send a recessive level (1) outside the arbitration field and the acknowledge slot, but the monitored bus value was dominant.
0x05	Bit 0 error – 1) During transmission of a frame (or ack bit, active error flag, overload flag) the CAN node tried to send a dominant level (0), but the monitored bus value was recessive. 2) During bus-off recovery this code is set each time a sequence of 11 recessive bits has been monitored. The CPU may use this code as indication that the bus is not continuously disturbed.
0x06	CRC error – The CRC checksum of the received frame was incorrect.
0x07	reserved
0x08	frame transmitted onto CAN bus successfully
0x10	frame received from CAN bus successfully
0x11-0x1F	reserved
0x20	CAN receive buffer has overrun – a CAN frame has been dropped
0x30	CAN receive FIFO has overrun multiple times, following frames may be out of order

6.7.6 1 ms Resolution 2 Byte Time Stamp

The 1ms resolution time stamp is the last two bytes of the message if this option is enabled by the SAINT configuration command (08 87h). Each bit count is 1 ms.

1 ms Resolution Time Stamp Range

2 Byte Value	Absolute Time in ms
0000h – FFFFh	0ms – 65535ms

ISO15765-2 Transport Protocol on CAN/CANFD

The SAINT can be configured to transmit and receive messages using the ISO15765-2 transport protocol. To transmit an ISO15765-2 message, the SAINT is able to construct the necessary CAN/CANFD frames, receive and process the flow control frames from the receiving device, and handle consecutive frame timing. The SAINT is capable of processing 1 ISO15765-2 message (up to 4K) from the host / 1ms loop. To receive an ISO15765-2 message, the SAINT is able to send the flow control frame and reconstruct the message from the multiple CAN/CANFD frames.

If your application does not use the SAINT Bus Engine to communicate with the SAINT please see the section on block transfer for additional information on how to construct messages that are greater than 60 bytes.

In this section "CAN" my be used to refer to both CAN and CANFD.

6.8 Step 1 – Configure the SAINT

6.8.1 Enable the protocols

By default, CAN 1, CAN 2, ISO15675-2 1, ISO15765-2 2, CANFD 1, CANFD 2, ISO15675-2 FD1, and ISO15765-2 FD2 are all enabled. If you are working with some application that has specifically enabled only certain protocols, it may be necessary to re-enable the CAN/CANFD and ISO15765-2 protocols. Use the 08 A3 message as defined in the SAINT Configuration section of this document. To enable all of these protocols send an 08 A3 30 38 50 58 C0 C8 D0 D8 message.

6.8.2 Configure the CAN/CANFD channel

You must configure the CAN/CANFD channel that you intent to use. See the previous sections on CAN/CANFD for details on how to make each configuration.

- Configure the baud rate.
- Configure the CAN transceiver (single wire, dual wire or fault tolerant) being used.
- Configure any special CAN functions.

These configurations will remain in effect until the SAINT hardware is reset or a new configuration is set.

6.8.3 Configure the SAINT for ISO15765-2

You must configure the SAINT so that it knows the information necessary to transmit and receive a message using the ISO15765-2 transport layer. This configuration is done using the following commands:

for CAN1:
C4 06 XX YY ID1 ID2 [ID3 ID4] [XD]opt configure the transmit message options with the expected receiving devices flow control ID
C4 07 XX ID1 ID2 [ID3 ID4] [XD] opt ID1m ID2m [ID3m ID4m]opt [XDm]opt- configure the receive message options to specify which IDs will be ISO message
C4 08 XX YY ZZ ID1 ID2 [ID3 ID4] [XD]opt – set the receiving options to specify the flow control message ID to send (when the Saint is receiving an IOS15765-2 message) and other options
for CAN 2:
CC 06 XX YY ID1 ID2 [ID3 ID4] [XD]opt configure the transmit message options with the expected receiving devices flow control ID
CC 07 XX ID1 ID2 [ID3 ID4] [XD] opt ID1m ID2m [ID3m ID4m]opt [XDm]opt- configure the receive message options to specify which IDs will be ISO message
CC 08 XX YY ZZ ID1 ID2 [ID3 ID4] [XD]opt – set the receiving options to specify the flow control message ID and other options

For CANFD1 replace C4 with 34. For CANFD2 replace CC with 3C.

6.8.3.1 Configuration for Transmitting ISO15765-2 messages

To transmit a message using the ISO15765-2 transport protocol, the flowing items must be configured:

- Should transmit frames be padded with 0x00?
- Does the transmit message CAN ID include an ISO15765-2 extended ID byte?
- Should the STmin received in the flow control message be overridden? If so, use what value?
- What is the receiver's flow control message CAN ID?

These configurations will remain in effect until the SAINT hardware is reset, a new configuration is set, or the configuration is reset.

The configuration message has the following format:
CAN 1: **C4 06 XX YY ID1 ID2 [ID3 ID4]opt [XD]opt**
CAN 2: **CC 06 XX YY ID1 ID2 [ID3 ID4]opt [XD]opt**
CANFD 1: **34 06 XX YY ID1 ID2 [ID3 ID4]opt [XD]opt**
CANFD 2: **3C 06 XX YY ID1 ID2 [ID3 ID4]opt [XD]opt**

Where:
XX is the ISO15765-2 TX option byte

bit 0 = 0: no frame padding bit 0 = 1: frame padding with 0x00s

bit 1 = 0: use flow control STmin bit 1 = 1: override flow control STmin with YY value

bit 2 = 0: tx msg contains no ISO15765-2 extended ID bit 2 = 1: tx msg contains an ISO15765-2 extended ID

bit 3 = 0: display both individual CAN frames and the ISO TP message bit 3 = 1: display only the ISO TP message

bit 4-7 = 0

YY is the value used for STmin in ms if byte XX, bit 1 = 1

ID1 ID2 [ID3 ID4]opt [XD]opt is the flow control CAN message ID. This tells the Saint the CAN ID of the expected flow control message. This ID definition must be in one of the following formats:

- 11 bit CAN ID with no ISO15765-2 extended ID: ID1 ID2 (byte XX bit 2 = 0)
- 11 bit CAN ID with an ISO15765-2 extended ID: ID1 ID2 XD (byte XX bit 2 = 1)
- 29 bit CAN ID with no ISO15765-2 extended ID: ID1 ID2 ID3 ID4 with bit7 of ID1 = 1 (byte XX bit 2 = 0)
- 29 bit CAN ID with an ISO15765-2 extended ID: ID1 ID2 ID3 ID4 XD with bit7 of ID1 = 1 (byte XX bit 2 = 1)

The CAN message ID definition ID1 ID2 ID3 ID4 is consistent with the SAINT's normal CAN message ID definition. For CANFD1 replace C4 with 34. For CANFD2 replace CC with 3C.

6.8.3.2 Configuration for Receiving ISO15765-2 messages

To receive a message using the ISO15765-2 transport protocol, the flowing items must be configured:

- What CAN IDs should be interpreted as ISO15765-2 transport protocol frames?
- When an ISO15765-2 transport protocol first frame is received, should the SAINT send a flow control frame?
- If so, what is the flow control frame CAN ID?
- Should the flow control frame be padded with 0x00?
- What is the FS (flow status) value?
- What is the BS (block size) value?
- What is the STmin (separation time) value?

These configurations will remain in effect until the SAINT hardware is reset, a new configuration is set, or the configuration is reset.

The receive message configuration message has the following format:

CAN 1: **C4 07 XX ID1 ID2 [ID3 ID4]opt [XD]opt ID1m ID2m [ID3m ID4m]opt [XDm]opt**

CAN 2: **CC 07 XX ID1 ID2 [ID3 ID4]opt [XD]opt ID1m ID2m [ID3m ID4m]opt [XDm]opt**

CANFD 1: **34 07 XX ID1 ID2 [ID3 ID4]opt [XD]opt ID1m ID2m [ID3m ID4m]opt [XDm]opt**
CANFD 2: **3C 07 XX ID1 ID2 [ID3 ID4]opt [XD]opt ID1m ID2m [ID3m ID4m]opt [XDm]opt**

Where:
XX = 0x00 : individual CAN frames will be displayed as well as the ISO TP message
XX = 0x01 : only the ISO TP message will be displayed

ID1 ID2 [ID3 ID4]opt [XD]opt specifies the ID(s) to be interpreted as ISO15765-2 messages (after the mask is applied). This ID definition must be in one of the following formats:

- 11 bit CAN ID with no ISO15765-2 extended ID: ID1 ID2
- 11 bit CAN ID with an ISO15765-2 extended ID: ID1 ID2 XD
- 29 bit CAN ID with no ISO15765-2 extended ID: ID1 ID2 ID3 ID4 with bit7 of ID1 = 1
- 29 bit CAN ID with an ISO15765-2 extended ID: ID1 ID2 ID3 ID4 XD with bit7 of ID1 = 1

The CAN message ID definition ID1 ID2 ID3 ID4 is consistent with the SAINT's normal CAN message ID definition.

ID1m ID2m [ID3m ID4m]opt [XDm]opt is the bit mask for filtering the ID. A bit value of 1 means the associated bit in the RX CAN ID will be compared. A bit value of 0 means the associated bit in the RX CAN ID will not be compared.

If a flow control frame is to be sent by the SAINT in response to a received ISO15765-2 first frame, the flow control frame parameters must be configured. The flow control frame configuration has the following format:
CAN 1: **C4 08 XX YY ZZ ID1 ID2 [ID3 ID4] [XD]opt**
CAN 2: **CC 08 XX YY ZZ ID1 ID2 [ID3 ID4] [XD]opt**
CANFD 1: **34 08 XX YY ZZ ID1 ID2 [ID3 ID4] [XD]opt**
CANFD 2: **3C 08 XX YY ZZ ID1 ID2 [ID3 ID4] [XD]opt**

Where:
XX is the ISO15765-2 option byte
bit 0 = 0: no frame padding bit 0 = 1: frame padding with 0x00s
bit 1-7 = 0:
Note: only FS = 0 clear to send consecutive frames is supported at this time.
YY is the value used for BS (block size)
ZZ is the value used for STmin (separation time)

ID1 ID2 [ID3 ID4]opt [XD]opt is the flow control CAN message ID. This ID definition must be in one of the following formats:

- 11 bit CAN ID with no ISO15765-2 extended ID: ID1 ID2

- 11 bit CAN ID with an ISO15765-2 extended ID: ID1 ID2 XD
- 29 bit CAN ID with no ISO15765-2 extended ID: ID1 ID2 ID3 ID4 with bit7 of ID1 = 1
- 29 bit CAN ID with an ISO15765-2 extended ID: ID1 ID2 ID3 ID4 XD with bit7 of ID1 = 1

The CAN message ID definition ID1 ID2 ID3 ID4 is consistent with the SAINT's normal CAN message ID definition. For CANFD1 replace C4 with 34. For CANFD2 replace CC with 3C.

6.9 Step 2 – Send/Receive the ISO15765-2 message

The ISO15765-2 message sent to the SAINT should contain only the CAN message ID, the optional ISO15765-2 extended ID, and the data. The SAINT will determine the length of the message based on the number of data bytes it has been sent. The SAINT will format each frame based on how it has been configured and insert the PCI bytes before it transmits the frames onto the CAN bus. Likewise, when a ISO15765-2 message is received on the CAN bus, the SAINT will reconstruct the message and remove the PCI bytes. The following is the format for an ISO15765-2 message:

CAN 1: C0 ID1 ID2 [ID3 ID4]opt [XD]opt D1 D2 D3 … D4095 (up to 4095 bytes)
CAN 2: C8 ID1 ID2 [ID3 ID4]opt [XD]opt D1 D2 D3 … D4095 (up to 4095 bytes)
CANFD 1: 30 ID1 ID2 [ID3 ID4]opt [XD]opt D1 D2 D3 … D4095 (up to 4095 bytes)
CANFD 2: 38 ID1 ID2 [ID3 ID4]opt [XD]opt D1 D2 D3 … D4095 (up to 4095 bytes)

Where:
ID1 ID2 [ID3 ID4]opt [XD]opt is the message ID. This ID definition must be in one of the following formats:

- 11 bit CAN ID with no ISO15765-2 extended ID: ID1 ID2
- 11 bit CAN ID with an ISO15765-2 extended ID: ID1 ID2 XD
- 29 bit CAN ID with no ISO15765-2 extended ID: ID1 ID2 ID3 ID4 with bit7 of ID1 = 1
- 29 bit CAN ID with an ISO15765-2 extended ID: ID1 ID2 ID3 ID4 XD with bit7 of ID1 = 1

The CAN message ID definition ID1 ID2 ID3 ID4 is consistent with the SAINT's normal CAN message ID definition.

D1 D2 D3 … D4095 (up to 4095 bytes) is the data.

6.10 Step 3 – Evaluate the response code

A user should pay attention to any operational warning code that get set during ISO15765-2 operation. These codes are defined in the 08 A1 SAINT Configuration section of this document.

Op Warning Code	Definition
C0	SAINT buffer used to store a received ISO15765-2 message is busy and the message has not been stored. (The individual 5X CAN frames will still be displayed but there will be no associated CX message.)
C1	The SAINT TX FIFO is full and the SAINT has not been able to transmit the required flow control frame.

The SAINT will provide either an error response or a successful transmission response. Following is the format for the response message:

CAN/CANFD 1: C6/C7 EE RC

CAN/CANFD 2: CE/CF EE RC

RC	Response Code Definition
00	Successful Transmission
01	SAINT could not write to transmit FIFO – message is discarded
02	SAINT did not receive the defined flow control response to the first frame or consecutive frame block – message is discarded
03	SAINT is unable to successfully transmit on the bus – message is discarded
04	SAINT has not been configured to transmit an ISO15765-2 message – message is discarded
05	The SAINT Bus Engine messages to the SAINT are out of order – message is discarded
06	The CAN packet function is busy – message is discarded

6.11 Clear the ISO15765-2 Configuration

To clear the ISO 15765-2 TX Configuration send the following message:

CAN 1: C4 06 FF

CAN 2: CC 06 FF

To clear the ISO 15765-2 RX Configuration send the following message:

CAN 1: C4 08 FF

CAN 2: CC 08 FF

6.12 Examples

6.12.1 Transmit Examples

6.12.1.1 Example 1 – 11 bit ID, no extended ID, no padding, no override

Send the following ISO15765-2 message on CAN1:

- Message ID: 0x7E0 Message Data: 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
- no padding
- use flow control STmin value
- expect flow control from message ID: 0x7E8

Perform the following steps to configure the SAINT:

1. Configure the SAINT CAN1 baud rate and transceiver (see previous sections for instruction)
2. Configure the ISO15765-2 TX function: 0xC4 06 00 00 07 E8
3. Send the message: **0xC0 07 E0 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F**
4. Check the response from the SAINT to make sure the message transmitted successfully: 0xC7 EE 00

Message Monitor Example:

C7 06 00 00 07 E8 Command from PC to SAINT HW to config ISO15765-2 function

53 **07 E0** 10 0F **01 02 03 04 05 06** SAINT sends first frame to product

51 07 E8 30 00 00 Product responds with flow control frame

53 **07 E0** 21 **07 08 09 0A 0B 0C 0D** SAINT continues with consecutive frame

53 **07 E0** 22 **0E 0F** SAINT continues with consecutive frame

C3 07 E0 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F Complete message in monitor

C7 EE 00 SAINT HW notifies PC that the ISO message has transmitted successfully

6.12.1.2 Example 2 – 29 bit ID, no extended ID, padding and override

Send the following ISO15765-2 message on CAN1:

- Message ID: 0x01001020 Message Data: 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
- padding
- use STmin of 10ms
- expect flow control from message ID: 0x01081020

Perform the following steps to configure the SAINT:

1. Configure the SAINT CAN1 baud rate and transceiver (see previous sections for instruction)
2. Configure the ISO15765-2 TX function: 0xC4 06 03 0A 81 08 10 20
3. Send the message: 0xC0 **81 00 10 20 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F**
4. Check the response from the SAINT to make sure the message transmitted successfully: 0xC7 EE 00

Message Monitor Example:

C7 06 03 0A 81 08 10 20 Command from PC to SAINT HW to config ISO15765-2 function

53 **81 00 10 20** 10 0F **01 02 03 04 05 06** SAINT sends first frame to product

51 81 08 10 20 30 00 00 00 00 00 00 00 Product responds with flow control frame

53 **81 00 10 20** 21 **07 08 09 0A 0B 0C 0D** SAINT continues with consecutive frame

53 **81 00 10 20** 22 **0E 0F** 00 00 00 00 00 SAINT continues with consecutive frame

C3 **81 00 10 20 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F** Complete message in monitor

C7 EE 00 SAINT HW notifies PC that the ISO message has transmitted successfully

6.12.1.3 Example 3 – 11 bit ID, extended ID, padding, no override

Send the following ISO15765-2 message on CAN2:

- Message ID: 0x7DF, Extended ID: 0xFE Message Data: 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
- padding
- use flow control STmin value
- expect flow control from message ID: 0x7E8, Extended ID: 0xF0

Perform the following steps to configure the SAINT:

1. Configure the SAINT CAN2 baud rate and transceiver (see previous sections for instruction)
2. Configure the ISO15765-2 TX function: 0xCC 06 05 00 07 E8 F0
3. Send the message: **0xC8 07 DF FE 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F**
4. Check the response from the SAINT to make sure the message transmitted successfully: 0xCF EE 00

Message Monitor Example:

CF 06 05 00 07 E8 F0 Command from PC to SAINT HW to config ISO15765-2 function

5B **07 DF FE** 10 0F **01 02 03 04 05** SAINT sends first frame to product

59 07 E8 F0 30 00 00 00 00 00 00 Product responds with flow control frame

5B **07 DF FE** 21 **06 07 08 09 0A 0B** SAINT continues with consecutive frame

5B **07 DF FE** 22 **0C 0D 0E 0F** 00 00 SAINT continues with consecutive frame

CB **07 DF FE 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F** Complete message in monitor

CF EE 00 SAINT HW notifies PC that the ISO message has transmitted successfully

6.12.1.4 Example 4 – 29 bit ID, no extended ID, padding, single frame

Send the following ISO15765-2 message on CAN1:

- Message ID: 0x01001020 Message Data: 01 02 03 04 05
- padding
- use flow control STmin value
- expect flow control from message ID: 0x01081020

Perform the following steps to configure the SAINT:

1. Configure the SAINT CAN1 baud rate and transceiver (see previous sections for instruction)

2. Configure the ISO15765-2 TX function: 0xC4 06 01 00 81 08 10 20
3. Send the message: 0xC0 **81 00 10 20 01 02 03 04 05**
4. Check the response from the SAINT to make sure the message transmitted successfully: 0xC7 EE 00

Message Monitor Example:

C7 06 01 00 81 08 10 20 Command from PC to SAINT HW to config ISO15765-2 function

53 **81 00 10 20** 05 **01 02 03 04 05** 00 00 SAINT sends single frame to product

C3 **81 00 10 20 01 02 03 04 05** Complete message in monitor

C7 EE 00 SAINT HW notifies PC that the ISO message has transmitted successfully

6.12.2 Receive Examples

6.12.2.1 Example 1 – 11 bit ID, no extended ID, no padding, no override

Receive the following ISO15765-2 messages on CAN1:

- receive from Message ID: 0x7E8
- use flow control message ID: 0x7E0
- no FC padding
- STmin, BS, and FS = 0

Perform the following steps to configure the SAINT:

1. Configure the SAINT CAN1 baud rate and transceiver (see previous sections for instruction)
2. Configure the ISO15765-2 RX function: 0xC4 07 00 07 E8 FF FF
3. Configure the ISO15765-2 FC function: 0xC4 08 00 00 00 07 E0
4. Receive the message: **0xC0 07 E8 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F**

Message Monitor Example:

C7 07 00 07 E8 FF FF Command from PC to SAINT HW to config ISO15765-2 RX function

C7 08 00 00 00 07 E0 FF FF Command from PC to SAINT HW to config ISO15765-2 RX function

51 **07 E8** 10 0F **01 02 03 04 05 06** Product sends first frame to SAINT

53 07 E0 30 00 00 SAINT responds with flow control frame

51 **07 E8** 21 **07 08 09 0A 0B 0C 0D** Product continues with consecutive frame

51 **07 E8** 22 **0E 0F** Product continues with consecutive frame

C1 07 E8 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F Complete message in monitor

6.12.2.2 Example 2 – 29 bit ID, no extended ID, padding

Receive the following ISO15765-2 messages on CAN 1:

- receive from Message ID: 0x01001020
- use flow control message ID: 0x01081020
- FC padding

- STmin = 10ms, BS = 0, and FS = 0

Perform the following steps to configure the SAINT:

1. Configure the SAINT CAN1 baud rate and transceiver (see previous sections for instruction)
2. Configure the ISO15765-2 RX function: 0xC4 07 00 81 00 10 20 FF FF FF FF
3. Configure the ISO15765-2 FC function: 0xC4 08 01 00 0A 81 08 10 20
4. Receive the message: 0xC0 **81 00 10 20 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F**

Message Monitor Example:

C7 07 00 81 00 10 20 FF FF FF FF	Command from PC to SAINT HW to config ISO15765-2 RX function
C7 08 01 00 0A 81 08 10 20	Command from PC to SAINT HW to config ISO15765-2 RX function
51 **81 00 10 20** 10 0F **01 02 03 04 05 06**	Product sends first frame to SAINT
53 81 08 10 20 30 00 0A 00 00 00 00 00	SAINT responds with flow control frame
51 **81 00 10 20** 21 **07 08 09 0A 0B 0C 0D**	Product continues with consecutive frame
51 **81 00 10 20** 22 **0E 0F** 00 00 00 00 00	Product continues with consecutive frame
C1 **81 00 10 20 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F**	Complete message in monitor

6.12.2.3 Example 3 – 11 bit ID, extended ID, padding, no override

Receive the following ISO15765-2 messages on CAN 2:

- receive from Message ID: 0x7DF, Extended ID: 0xFE
- use flow control message ID: 0x7E8, Extended ID: 0xF0
- FC padding
- STmin, BS, and FS = 0

Perform the following steps to configure the SAINT:

1. Configure the SAINT CAN2 baud rate and transceiver (see previous sections for instruction)
2. Configure the ISO15765-2 RX function: 0xCC 07 00 07 DF FE FF FF FF
3. Configure the ISO15765-2 FC function: 0xCC 08 01 00 00 07 E8 F0
4. Receive the message: 0xC8 **07 DF FE 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F**

Message Monitor Example:

CC 07 00 07 DF FE FF FF FF	Command from PC to SAINT HW to config ISO15765-2 RX function
CC 08 01 00 00 07 E8 F0	Command from PC to SAINT HW to config ISO15765-2 RX function
59 **07 DF FE** 10 0F **01 02 03 04 05**	Product sends first frame to SAINT
5B 07 E8 F0 30 00 00 00 00 00 00	SAINT responds with flow control frame
59 **07 DF FE** 21 **06 07 08 09 0A 0B**	Product continues with consecutive frame
59 **07 DF FE** 22 **0C 0D 0E 0F** 00 00	Product continues with consecutive frame
C9 **07 DF FE 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F**	Complete message in monitor

6.12.2.4 Example 4 – 29 bit ID, no extended ID, padding, single frame

Receive the following ISO15765-2 messages on CAN 1:

- receive from Message ID: 0x01001020
- use flow control message ID: 0x01081020
- FC padding
- STmin, BS, and FS = 0

Perform the following steps to configure the SAINT:

1. Configure the SAINT CAN1 baud rate and transceiver (see previous sections for instruction)
2. Configure the ISO15765-2 RX function: 0xC4 07 00 81 00 10 20 FF FF FF FF
3. Configure the ISO15765-2 FC function: 0xC4 08 01 00 00 81 08 10 20
4. Receive the message: 0xC0 **81 00 10 20 01 02 03 04 05**

Message Monitor Example:

C7 07 00 81 00 10 20 FF FF FF FF	Command from PC to SAINT HW to config ISO15765-2 RX function
C7 08 01 00 00 81 08 10 20	Command from PC to SAINT HW to config ISO15765-2 RX function
C1 **81 00 10 20 01 02 03 04 05**	Complete message in monitor

6.13 Important Notes

- Only a single CAN channel can be configured at a time for ISO15765-2. If you configure CAN1 and then configure CAN2, only CAN2 will be configured.
- As individual CAN frames are transmitted or received by the SAINT, these frames will be sent back to the host just as any other transmitted/received frame would be sent back to the host. These frames will have the normal SAINT headers for CAN ($50/58 derivatives). The exception is that single frame ISO15765-2 received messages will only be displayed as a C0/C8 message.
- C0/C8 messages will not necessarily be transmitted in the order they are received from the host in relation to raw CAN frames ($50/$58) If this is a problem, you should always make sure that your raw messages have been transmitted successfully before you send your ISO15765-2 message to the SAINT.
- Raw CAN/CANFD messages and ISO15765-2 messages may be used together.
- There is a single buffer used for both transmitted and received ISO15765-2 messages on the SAINT hardware. An ISO15765-2 message may either be in the process of being transmitted or received, but the SAINT cannot do both at the same time.

7 Class 2 (Saint2 only)

7.1 Class 2 Messages

Not applicable to SAINT3.

The following messages may be used to send a Class 2 commands and messages. Class 2 commands are used for configuring or commanding the DLC. Class 2 messages include functional, physical, and block messages. Note: the ESCAPE characters (section 4.1) must be inserted at the end of every transmitted message to the SAINT.

7.1.1 Class 2 Commands

The following is the format for sending a Class 2 Command:

Header	ID	Description	Data Bytes
64h	01h	Report Error	1 byte Completion Code (See 7.1.3.1)
64h	02h	SPI Bus Error	1 byte Error Code (See 7.1.3.2)
64h	64h	Operate Bus at Normal Speed (10.4 KB/s) (default)	None
64h	65h	Operate Bus at High Speed (41.6 KB/s)	None
64h	66h	Generate a Class 2 Break Signal	None

7.1.2 Transmitted Class 2 Messages

The following is the format for sending a Class 2 message:

60h	Priority/Header	Target	Source	*ID*	*N Data Bytes*
Byte 1	Byte 2	Byte 3	Byte 4	*Byte 5*	*Bytes 6 —(5+N)*

The minimum accepted Class 2 message length is 3 bytes and the longest is 8000 bytes.

7.1.3 Received Class 2 Messages

The following is the format of a received Class 2 message without time stamp information:

60h	Priority Header	Target	Source	*ID*	*N Data Bytes*	Completion Code
Byte 1	Byte 2	Byte 3	Byte 4	*Byte 5*	*Bytes 6 —(5+N)*	Byte 6 + N

The following is the format of a received Class 2 message with time stamp information:

61h	Priority Header	Target	Source	*ID*	*N Data Bytes*	Completion Code	Time MSB	Time LSB
Byte 1	Byte 2	Byte 3	Byte 4	*Byte 5*	*Bytes 6 — (5+N)*	Byte 6 + N	7+N	8+N

The following is the format of a received Class 2 Error message with time stamp information:

65h	01	Completion Code	Time MSB	Time LSB
Byte 1	Byte 2	Byte 3	Byte 4	Byte 5

7.1.3.1 Completion Code

The following is the definition of the completion code included with all reported Class 2 messages. The completion code in the received messages comes from the DLC chip. For more detail refer to the DLC Application document (XDE 3003.)

Bit 7 Errors in Received Message

0 No Error Detected.

1 Error(s) detected. When set, certain errors occurred in the reception of this message (see description for bits 1 and 0). If not set, then bits 1 and 0 are also 0.

Bit 6 RFIFO Overrun

0 No overrun.

1 A receiver FIFO overrun was detected and data was lost.

Bit 5	Bit 4	Transmitter Action
0	0	Transmitter not involved.
0	1	Transmitter under run. Should occur only when sending a Class 2 block message and the host does not keep up with the data requirements.
1	0	Transmitter lost arbitration on this message.
1	1	Transmit successful.

Bit 3 In-frame response

0 This message was not an in-frame response.

1 This message was an in-frame response.

Bit 2 In-frame response with/without CRC

0 This in-frame response does not contain a CRC.

1 This in-frame response contains a CRC.

Bit 1	Bit 0	Error Code
0	0	CRC error.
0	1	Incomplete byte received.
1	0	Bit timing error.

1 1 Break symbol received.

7.1.3.2 SPI Error Codes

The following is the definition of the SPI error code associated with all reported SPI error messages. Most of these errors are Class 2 errors that manifest themselves when the main micro is communicating with the DLC transceiver.

Bit 7 Unused

Bit 6 Rx of Tx

0 No Error.

1 A transmitted message was not received on the bus. This error typically indicates that the Class2 bus is shorted to another signal.

Bit 5 Other

0 No Error.

1 All other SPI errors

Bit 4 Unused

Bit 3 Tx Underrun

0 No Error.

1 DLC Tx Underrun. (Determined from completion code)

Bit 2 Message too big

0 No Error.

1 Too many bytes in Class 2 message

Bit 1 Unused

Bit 0 Receive

0 No Error.

1 Rx error on SPI bus. This error occurs when a new data byte is received, but a previously received data byte has not been read out of the receive buffer. The old data in the receive buffer will be overwritten and irretrievably lost.

7.1.3.3 Block Message Support

Please note the following differences when using Class2 firmware 3.0 or later. Firmware 3.0 and later has the support for Block messages. Therefore, the decoding for Rx/Tx (bit1 in header byte) is no longer valid in the header byte. It is recommended to use the Completion Code to check if the message was transmitted (30h) or received (00h). Also, note that "Echo Off" command (08 89) is not supported. So, all transmitted Class2 messages are received. The changes are due to the fact that the SAINT cannot determine if the incoming message was transmitted or received until completely receiving the entire message.

8 IIC

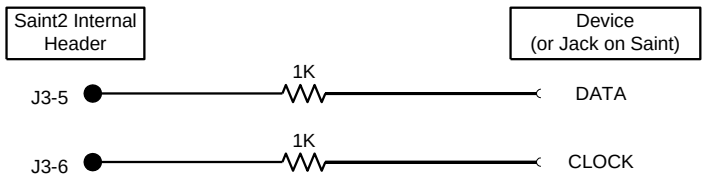
8.1 Overview

IIC functionality is not provided in the uS3. Not yet implemented in Saint3 Pro

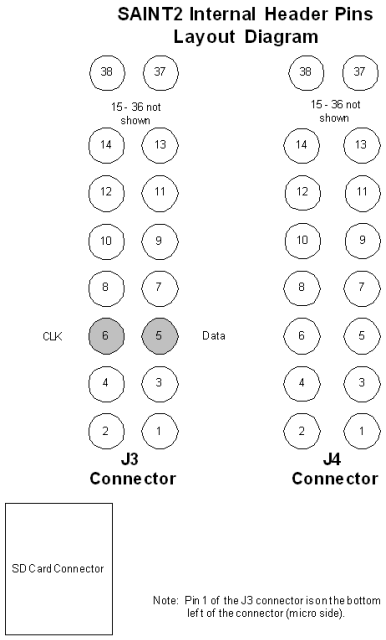
The Saint2 can function in either active participant mode or passive monitor mode. When the Saint2 is acting as a slave or master it is an **active participant** on the bus, but in the original Saint it functioned as a **passive participant** just "sniffing" the data. **IIC is not yet implemented in the Saint3.**

Passive Bus Monitor Mode

This is the "sniffer" or passive monitor functionality for the Saint2, which is similar to the IIC support provided in the original Saint 1. To use this feature on the Saint 2, connection to the internal header pins is required. The IIC clock and data pins should be connected as follows:



The device connections can simply be "pigtailed" out of the Saint2 or, for more permanent use, connectors (such as Banana Jacks) can be installed in the end plate of the Saint2 box. (For permanent connections, it is recommended to mount any additional connectors to the end plate with the D-Type connectors. This allows the board, ,end plate, and any custom wiring to be removed as a single assembly).



Important Notes:

1) ***Failure to use the 1Kohm current limiting resistors can result in damage to the Saint2 or the attached device.***
2) ***Host (PC) communication in this mode is USB ONLY! (RS-232 communication is disabled upon entering this mode)***

The following command may be used to begin monitoring IIC traffic.

Header	ID	Description	Data Bytes
24h	01h	Begin IIC Monitor Mode	

LED #5 will blink at 1Hz when in IIC Monitor Mode. To exit the IIC Monitor Mode use a hardware reset.

IIC Received Message Format with Time Stamp

21h	Address	N Data Bytes	Completion Code	Time Stamp Bytes
byte 1	byte 2	Byte 3 … Byte N	Byte N + 1	Byte N+2 Byte N+3

Completion Code

Bit2	Bit 1	Bit 0	Error Code
0	0	1	Repeated Start Condition
0	1	0	NACK received in message
1	0	0	No stop condition after 50 consecutive bytes (User block 3.10.0 and later)

Active Participant Mode

The Saint2 also has an **active participant** mode in which the Saint2 acts as a slave or a master, and please note that this mode is completely different than monitor mode. The initial 7 bit IIC address is set to 0x55 when in master mode and 0x65 when in slave mode. The Saint2 IIC module can be used to test devices such as CD player mechanisms as they would work within a radio.

Note: In order to have successful IIC communication your device must meet the following conditions:

5. The device must provide the pull up resistors for SDA and SCL. If these pullups for SDA and SCL are not in the device you are testing , you must provide pull ups externally to the appropriate supply voltage for your device.
6. The device must be able to provides acknowledgments to the SAINT2 IIC bytes. The IIC bus will not operate properly unless there is both a master and a slave communicating on the bus.

8.1.1 IIC Hardware

For Saint2 hardware version 1.1 (silver box) you must connect to the internal header pins shown below. For Saint2 hardware version 1.2 (black box) the SDA and SCL signals are available on the DB-25, pins 21 and 15 respectively. Your Saint2 hardware version can be found on the label on the top of the box.

Name	Saint 2 Pin Number	Description
SDA	J4.29	I^2C Data
SCL	J4.27	I^2C Clock

8.2 IIC Commands

IIC configuration command messages adhere to the following general format:

From PC:

IIC Configuration Command Message: 20 XX_2 XX_3 XX_4 … XX_n

Byte 1: Saint IIC Protocol Identifier for IIC (0x20)
Byte 2: IIC message type (see below for types)
Bytes 3-n: Command to be parsed and carried out by Saint 2
Last 2 Bytes: End of SAINT message

8.2.1 Configure IIC Master Polling

Configure IIC Master Polling: 20 92 AA CC

Byte 1: Saint IIC Protocol Identifier for IIC (0x20)
Byte 2: IIC message type for polling (0x92)
Byte 3: 8 bit representation of the Saint 2 7-bit IIC slave device address to be polled (LSB must be 1) (i.e., 7-bit address 001 1000 (18h) becomes 8-bit representation 0011 0001 (31h))
Byte 4: Configuration byte. A value of 0 turns polling off. A value of 1 turns polling on.
Last 2 Bytes: End of SAINT message

Note: The slave address must be included since the master produces the address it wishes to address.

Note: The slave address is polled every 1 second by the master.

Note: If the slave does not acknowledge any of the data bytes, a message with the following format will be sent back:

20 91 F0 MM_1 … MM_N,

where MM_1 … MM_N are the data bytes of the failing IIC message.

8.2.2 Set Device Address

20 A0 XX – sets the IIC Device Address to XX (7-bit address, XX <= 7F)

8.2.3 Get IIC Device Address

20 A1 – returns current 7-bit address to Saint Bus Monitor as:

20 A1 F1 XX'. where XX is the address.

8.2.4 Set IIC Mode

20 DD 01 – sets the IIC Device to Master Mode

20 DD 00 – sets the IIC Device to Slave Mode

20 DD 02 – sets the IIC Device to Slave Mode with ACK disabled

8.2.5 Set IIC Baud Rate

20 DE 00 – sets the IIC Baud Rate to 400 Khz

20 DE 01 – sets the IIC Baud Rate to 100 Khz

20 DE 02 – sets the IIC Baud Rate to 256 Khz

8.2.6 Disable ACKs

20 DF 00 – ACKs are enabled (default)

20 DF 01 – disable ACKs

8.3 IIC Data Messages

Note: The Saint 2 can act as a slave or a master. When it is acting as a slave, it will use the slave-transmitter and slave-receiver message formats. When it is acting as a master, it will use the master-transmitter and master-receiver message formats.

Note: There is no status byte for receipt of IIC messages.

Note: The maximum length of the IIC data bytes is limited by the maximum Saint 2 message length.

8.3.1 Request to transmit an IIC message as slave-transmitter

Send IIC Slave Transmit Message: 20 90 XX_3 XX_4 XX_5 … XX_n

Byte 1: SAINT IIC Protocol Identifier (0x20)

Byte 2: Message type for IIC message (0x90)

Bytes 3-n: Data to be sent

Last 2 Bytes: End of SAINT message

Note: The data in bytes 3-n should not include the device address, since the IIC master (not the IIC slave) produces the address.

Note: There is no echo back to acknowledge transmit when the master actually reads from the slave.

8.3.2 Receipt of IIC message as slave receiver

IIC Slave Received Message: 20 90 XX_3 XX_4 XX_5 … XX_n

Byte 1: SAINT IIC Protocol Identifier (0x20)

Byte 2: Message type for IIC Message (0x90)

Byte 3: 8-bit representation of the Saint 2 7-bit IIC slave device address to (LSB must be 0) (i.e., 7-bit address 001 1000 (18h) becomes 8-bit representation 0011 0000 (30h))

Bytes 4-n: Data received

Last 2 Bytes: End of SAINT message

8.3.3 Request to transmit an IIC message as master-transmitter

Send IIC Master Transmit Message: 20 90 AA XX_4 XX_5 … XX_n

Byte 1: SAINT IIC Protocol Identifier (0x20)

Byte 2: Message type for IIC message (0x90)

Byte 3: 8-bit representation of the Saint 2 7-bit IIC slave device address to (LSB must be 0)

(i.e., 7-bit address 001 1000 (18h) becomes 8-bit representation 0011 0000 (30h))

Bytes 4-n: Data to be sent

Last 2 Bytes: End of SAINT message

Note: The slave address must be included since the master produces the address it wishes to address.

Note: On successful transmission there is no echo back. The message will only be viewed on the receiving end.

Note: If the slave does not acknowledge any of the data bytes, a message with the following format will be sent back:

20 91 F0 MM_1 … MM_N,

where MM_1 … MM_N are the data bytes of the failing IIC message.

Request to receive an IIC message as master-receiver

Request to Read from Slave Message: 20 90 AA NN

Byte 1: SAINT IIC Protocol Identifier (0x20)

Byte 2: Message type for IIC Message (0x90)

Byte 3: 8 bit representation of the Saint 2 7-bit IIC slave device address to be polled (LSB must be 1)

(i.e., 7-bit address 001 1000 (18h) becomes 8-bit representation 0011 0001 (31h))

Byte 4: Number of data bytes to read from the slave

Last 2 Bytes: End of SAINT message

Note: If byte 4 is 0, instead of reading 0 bytes, the master will read 1 byte from the slave. The master will interrupt this byte as N (the number of remaining bytes to read). The master will then read N more data bytes from the slave.

Note: Since the master is in charge of driving the IIC bus, it must request to read data from the slave. The slave has no way of requesting it be addressed so that it can send.

Note: The above message requests a read be performed as a master-receiver. The actual data read will be sent back in the message below.

Note: If the slave does not acknowledge its address on the bus, a message with the following format will be sent back:
20 91 F0 MM_1 … MM_N,
where MM_1 … MM_N are the data bytes of the failing IIC message.

IIC Master-Received Data Message: 20 90 XX_3 XX_4 XX_5 … XX_n

Byte 1: SAINT IIC Protocol Identifier (0x20)
Byte 2: Message type for IIC Message (0x90)
Byte 3: 8-bit representation of the Saint 2 7-bit IIC slave device address (i.e., 7-bit address 001 1000 (18h) becomes 8-bit representation 0011 0001 (31h))
Bytes 4-n: Data received
Last 2 Bytes: End of SAINT message

9 Keyword 2000

Keyword 2000 hardware is not provided in the uS3. Keyword 2000 functionality has not been released for the S3 Pro. Keyword 2000 for the Saint 2 is an enhanced version of the Keyword 2000 that was available on the Saint 1.
Some Key improvements are:

- Full length message support (up to the spec limit of 260 bytes)
- True 5 Baud initialization ("Active" baud rate detection)
- USB interface
- Expanded message corruption (forced error) capabilities

A completely new set of command IDs have been implemented for the Saint 2 to prevent potential conflicts from divergent development on each platform. While many of the command functions are the same, others have been modified to provide expanded capability and new commands have been added to accommodate new features.

To ensure compatibility with users legacy Saint 1 applications and files, the Saint 2 KW2K implementation also supports the full Saint 1 Keyword 2000 command set (as of the Saint 1 Keyword 2000 Users Guide, Version A, Draft 7, 1/11/05). Either or both command sets may be used. This manual only includes documentation for the new Saint 2 Keyword 2000 command set. Users may reference the afore mentioned Saint 1 document to obtain the legacy command set information.

Not yet released for the Saint3.

!!!!! IMPORTANT !!!!!

If using a Saint2, you MUST have hardware "Version 1.1" or higher to use it with Keyword 2000.

The hardware version number is listed on the bottom left corner of the front label. If the label does not indicate a hardware version, it is Version 1.0 hardware and will NOT work properly for Keyword 2000.

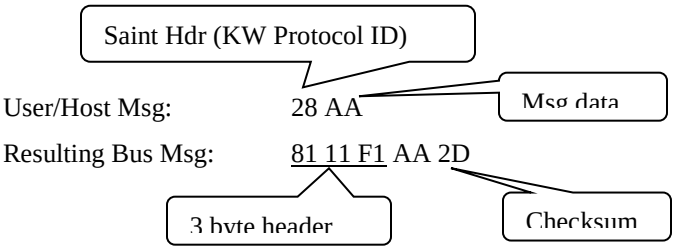
If you need to use Keyword 2000 and have an incompatible version of the Saint 2, contact the manufacturer or email support for upgrade/replacement options.

9.1 Keyword 2000 – Application Notes

9.1.1 General Operation

9.1.1.1 Message Construction

All modes, except Direct Mode (2C A0 02), employ automated message construction to simplify use of the protocol for manual/human operations (as was done in the Saint 1). The message header bytes and checksum are automatically built based on the current configuration settings. Once properly configured, users only need to provide the Saint 2 Header Byte (protocol ID) and the data portion of the message. The appropriate KW header and checksum bytes will be automatically constructed in the message frame before it is transmitted on the bus. The following is an example of the message construction performed using the default configuration settings (3 byte hdr, Tgt Addr=11, Src Addr=F1):



Direct Mode does NOT employ any form of message construction. It is intended to provide users unrestricted control of the message frame content. Message frames are delivered exactly as supplied (unmodified) directly to the bus. The user is responsible for all message frame content including the header and checksum bytes.

9.1.2 Initialization

9.1.2.1 Client (Tester) Mode

Bus initialization is handled automatically by the Saint 2. Once the protocol configuration options are properly set, the user need only send the desired KW message. The Saint 2 tracks the bus initialization state and, if required, automatically performs the necessary initialization operations followed by the desired KW message. The user does NOT need to perform bus initialization manually (i.e. by sending a "Start Comms" message). If desired, the user may "manually" initialize the bus by sending the "Start Comms" (i.e. mode 81) message. This will initialize the bus without sending any additional messages. (Note that a user supplied "Start Comms" message is actually discarded by the Saint 2 and a new "Start Comms" message is rebuilt based on the configured "Start Comms Header Type" and other applicable configuration settings.) If the bus is already initialized and the "Start Comms" message is sent, the "Start Comms" message will be sent out on the bus as a "normal" bus bearing message and NOT as a Fast Init (i.e. **WITHOUT** the preceding "wake up" pulse)

NOTE: The "Stop Comms" and "Tester Present" (Keep Alive) messages can NOT be used to either manually or automatically initialize the bus. These are treated as special messages by the Saint 2 and are prohibited from being used for starting communications. All other bus bearing messages will initiate the automatic bus initialization sequence. (Logically it does not make sense to send a "Stop Comms" message to start communications and the "Tester Present" message is ONLY intended to be used after communication has been established… not to start it.)

9.1.2.2 P2P Mode

Bus initialization is not required in this mode as the bus is considered always active (initialized). If the host/user sends a "start comms" message, it will be transmitted on the bus as a normal KW msg (i.e. NOT as an Fast Init sequence). Though not intended for use with this mode, the "Force Initialization" command is allowed and will transmit the full initialization sequence (as configured) on the bus.

9.1.2.3 Direct Mode

Bus initialization can ONLY be initiated by using the "Force Initialization" command. All transmit messages are treated as normal "bus bearing" messages and are delivered to the bus unmodified. They are not intercepted, decoded, or checked and therefore, cannot be used to trigger an initialization operation. In this mode, the host/user is completely responsible for initialization operations and bus state tracking.

9.1.3 Error Reporting

If multiple error conditions are detected, generally, only the first (most significant) error is reported. For example, if a message is received with a "framing error", this usually results in a checksum error as well. Only the "framing error" will be reported as this is considered the primary, or "root" error condition. This strategy is employed to prevent reporting of multiple related (cascading) error indications. Timing errors (P1-P4) are always report as appropriate for the operational mode selected.

9.2 Keyword 2000 Commands

The following commands may transmitted from the host interface to the SAINT 2:

Protocol Configuration Commands

Hdr	ID	Description	Data Bytes
2Ch	A0h	Set Operating Mode	1 byte: 0x00 = Client (Tester) mode **(default)** Behaves as a Tester device (i.e. scan tool) on a "regular" KW bus. Obeys the rules of a Client device per ISO 14230. 0x01 = "P2P" (Peer-to-Peer) mode (formerly "Dedicated" mode – renamed for clarity) This is a special mode for applications that employ a dedicated "always on" KW link between two devices (i.e. Peer to Peer). Behaves as an ECU and obeys the rules of a Server device except initialization operations are disabled and the bus is treated as always "initialized". 0x02 = "Direct" (raw) Client mode Similar to Client (Tester) mode above except: • Host/User (Tx) messages are delivered directly to the bus without modification (i.e. no msg construction/checking). • Initialization is strictly manual (non-automatic) • Limited configuration settings apply. Received messages are processed normally (per KW protocol rules). Timing parameters (P1-4) are enforced for both Tx & Rx messages. Bus initialization can ONLY be performed using the dedicated "Force Initialization" command (2C B2). The host/user is entirely responsible for message construction (incl. headers and checksum), content, and initialization. Several commands are either not applicable or are limited in this mode due to redundant or non-applicable functionality (primarily those affecting msg content). These commands are denoted with an asterisk "*" below the command code. Commands with functionality that can only be produced by the Saint 2 (i.e. by hardware/ firmware) are still applicable. Note: This mode essentially bypasses the automated message construction and is primarily intended for host applications that require unrestricted control of the KW message frame. Though added primarily for J2534 support, it is available for use in any application where direct control of the message frame content is desired.

2Ch	A1h	Set Initialization Mode	1 byte: 0x00 - Fast Init **(default)** 0x01 - 5 Baud 0x02 - Carb (not implemented)
2Ch	A2h	Set Baud Rate (Applies to Fast Init only).	1-2 bytes: Baud rate in hundreds units expressed in BCD . Leading zeros are disregarded. Range: 1k - 200k baud (in 100 baud steps) **Default = 10400 baud (spec compliant)** Examples: 2C A2 11 52 - set baud to 115200 2C A2 00 10 - set baud to 1000 (leading 0's ignored) 2C A2 or 2C A2 00 - set default baud rate
2Ch	A3h *	Set Header Type	1 byte: 0x00 = [Fmt] (len in Fmt byte) 0x01 = [Fmt][Len] 0x02 = [Fmt][Tgt][Src] (len in Fmt byte) **(default)** 0x03 = [Fmt][Tgt][Src][Len]
2Ch	A4h *	Set Tester Address	1 byte: Tester Address **(default = 0xF1)** For Direct (Gateway) mode applies to initialization only
2Ch	A5h *	Set ECU / 5 Baud Address	1 byte: ECU Address **(default = 0x11)** For Direct (Gateway) mode applies to initialization only
2Ch	A6h *	Set Addressing Mode	1 byte: 0x00 = Physical Addressing **(default)** 0x01 = Functional Addressing
2Ch	ACh	Set “Start Comms” Header Type Support for non-standard KW2K implementations. (The default (spec compliant) setting should be used unless specifically required.)	1 byte: 0x00 = [Fmt] (len in Fmt byte) 0x01 = [Fmt][Len] 0x02 = [Fmt][Tgt][Src] (len in Fmt byte) **(default)** 0x03 = [Fmt][Tgt][Src][Len] Note: When the “Force Initialization” command is used, this setting applies ONLY if the optional substitute Start Comms message is NOT supplied (otherwise the substitute message is used).

***** - Not Applicable (ignored) in “Direct” Operational Mode (2C A0 02).

Protocol Timing Configuration Commands

(IMPORTANT - It is the users' responsibility to abide by the timing relationship rules declared in the specifications. The Saint does NOT enforce inter-relational rules, it only enforces the absolute min/max limits for each parameter.)

Hdr	ID	Description	Data Bytes
2Ch	A7h	Set P1 min/max Server (ECU) interbyte time limits.	2 bytes - aa bb: aa - 0x00 = Set P1 min **(default=5ms, 0x05)** 0x01 = Set P1 max **(default=20ms, 0x14)** bb - time in ms. (0-20ms, 0x00-0x14)
2Ch	A8h	Set P2 min/max Client (Tester) to Server (ECU) or Server to Server inter message time limits.	2 bytes - aa bb: aa - 0x00=Set P2 min **(default=25ms, 0x19)** bb=time in ms. (0-127ms, 0x00-0x7F) - 0x01=Set P2 max **(default=50ms, 0x02)** bb=time in ms encoded as follows: 0x01-0xF0: time = value*25. 0xF1-0xFE: time = low nibble of value*256*25. 0xFF: n/a (invalid)
2Ch	A9h	Set P3 min/max Server (ECU) to Client (Tester) inter message time limits.	2 bytes - aa bb: aa - 0x00=Set P3 min **(default=55ms, 0x37)** bb=time in ms, (0-127, 0x00-0x7F) - 0x01=Set P3 max **(default=5120ms, 0x14)** bb=time*250 in ms. (0-255, 0x00-0xFF) where: 0-254, 0x00-0xFE = 0-63500ms 255, 0xFF=infinity
2Ch	AAh	Set P4 min/max Client (Tester) interbyte time limits.	2 bytes - aa bb: aa - 0x00=Set P4 min **(default=5ms, 0x05)** bb - time in ms. (0-19ms, 0x00-0x13) aa - 0x01=Set P4 max **(default=20ms, 0x14)** bb - time in ms. (0-20ms, 0x00-0x14)
2Ch	ABh	Set Fast Init Wakeup Pattern low time (T_{initL})	1 byte: time in msec (5ms multiples). **(Default=25ms, 0x19)** Values other than multiples of 5ms may be used but will be rounded to the closest multiple. The Wakeup Pattern time (T_{Wup}) is fixed at 50ms. Setting the low period adjusts the high period accordingly. $T_{IniH} = T_{Wup} - T_{IniL} = 50ms - T_{IniL}$

General/Misc Control Commands

Hdr	ID	Description	Data Bytes
2Ch	B0h	Enable/Disable Timing Error Reporting (P1-P4)	1 byte: 0x00 = Disable 0x01 = Enable **(default)**
2Ch	B1h	Enable Tester Present (Keep Alive) Periodic Message (Period= P3max-1ms, per specifications.)	1 byte: 0x00 - Disabled **(default)** 0x01 – Enabled
2Ch	B2h	Force Initialization Forces a bus initialization based on the current configuration settings. Optionally allows the user to provide a substitute message for the normal Fast Init “Start Comms” message.	(optional) 1 to 259 bytes xx…xx: xx… - Fast Init “Start Comms” Substitute msg Initialization will be performed without regard to the current bus initialization state. P3min timing is enforced before the initialization is allowed to begin. If provided, the optional message bytes will be substituted for the Fast Init “Start Comms” message. The configuration must be previously set to use Fast Init mode (default) before invoking this command or the message will be discarded as the “Start Comms” message does not apply to 5 Baud/CARB Inits. Note: This command was primarily added to support the “Direct” operating mode (2C A0 02) where no other means to invoke initialization exist. It is not required for the other “Operating” modes (since their existing initialization techniques still apply) but can be employed to invoke the unique features of this command that are not available with the normal initialization methods.
2Ch	B3h	Enable/Disable “Start of Message” Reporting (See “Commands Reported by Saint 2” for a description of this feature)	1 byte: 0x00 - Disabled **(default)** 0x01 – Enabled
2Ch	B4h	Enable/Disable 5 Baud Init Key Byte reporting. (See “Commands Reported by Saint 2” for a description of this feature)	1 byte: 0x00 – Disabled 0x01 – Enabled **(default)**

Message Corruption (Forced Error) Commands

Hdr	ID	Description	Data Bytes
2Ch	C0h	Disable Start Communications message Simulates a Fast Init error scenario where the wakeup pattern is sent without a subsequent Start Comms msg.	1 byte: 00 = Start Comm Msg Enabled **(default)** 01 = Disable Start Comm Msg Note: This command will be overridden by the "Force Initialization" command (2C B2) if the optional Start Comms substitute message is supplied. (i.e. assumes that if supplied, intent is to send regardless of this command state.)
2Ch	C1h *	Forced Format Byte Forces the use of a specified Format Byte value.	2 bytes - aa bb: aa - 0x00=Disabled **(default)** 0xnn=Enabled for nn Tx messages (nn=1-254, 01-FE) 0xFF=Enabled Continuously (until disabled) bb - New Format Byte value. **(default=0x00)**
2Ch	C2h *	Forced Length Value Forces the use of a specified msg length value. (Applied to either the Format byte or optional Length byte depending on header type.)	2 bytes - aa bb: aa - 0x00=Disabled **(default)** 0xnn=Enabled for nn Tx messages (nn=1-254, 01-FE) 0xFF=Enabled Continuously (until disabled) bb - New Length value. **(default=0x00)**
2Ch	C3h *	Forced Data Byte Value Forces the use of a specified value in the specified byte of the data payload portion of the message. (Applies to data payload bytes only, i.e. SID up to, but not including, the checksum. If specified byte number > last data byte, no data is modified.)	3 bytes - aa bb cc: aa - 0x00=Disabled **(default)** 0xnn=Enabled for nn Tx messages (nn=1-254, 01-FE) 0xFF=Enabled Continuously (until disabled) bb - Data payload byte number (base 0). **(default=0x00)** cc - New data byte value. **(default=0x00)**
2Ch	C4h *	Forced Data Bit Error Toggles the specified bit in the specified byte of the data payload portion of the message. (Applies to data payload bytes only, i.e. SID up to, but not including, the checksum. If the specified byte number > last data byte, no data is modified.)	3 bytes - aa bb cc: aa - 0x00=Disabled **(default)** 0xnn=Enabled for nn Tx messages (nn=1-254, 01-FE) 0xFF=Enabled Continuously (until disabled) bb - Data payload byte number (base 0). **(default=0x00)** cc - Bit to be corrupted 0-7 (0=lsb) **(default=0x00)**

Message Corruption (Forced Error) Commands

2Ch	C5h	Forced Byte Length Error Simulates a transmission error where a byte of the message is transmitted either short one bit or with an extra bit. (Applies to any byte of the message including header and checksum bytes.)	3-4 bytes aa bb cc dd: aa - 0x00 = Disabled **(default)** 0xnn = Enabled for nn Tx messages (nn=1-254, 01-FE) 0xFF = Enabled Continuously (until disabled) bb - 0x00 = Enable Short byte (7 bit) **(default)** 0x01 = Enable Long byte (9 bit) cc or ccdd - Byte number as a 1 or 2 byte unsigned integer (0-259, base 0). **(default=0)** Examples: 2C C5 01 00 0B - enabled for 1 msg, short byte error, corrupt 13th byte (byte #12 base 0). 2C C5 FF 01 01 03 - always enabled, long byte error, corrupt 260th byte (byte 259 base 0)
2Ch	C6h *	Omit Checksum Note: When enabled, this overrides commands C7 & C8 (below).	1 byte - aa: aa - 0x00=Disabled **(default)** 0xnn=Enabled for nn Tx messages (nn=1-254, 01-FE) 0xFF=Enabled Continuously (until disabled)
2Ch	C7h *	Forced Checksum Value Note: When enabled, this overrides command C8 (below) and is overridden by command C6 (above).	2 bytes - aa bb: aa - 0x00=Disabled **(default)** 0xnn=Enabled for nn Tx messages (nn=1-254, 01-FE) 0xFF=Enabled Continuously (until disabled) bb - New Checksum value. **(default=0x00)**
2Ch	C8h *	Force "Good" Checksum Allows messages containing "forced" errors to be sent with or without a checksum error. Note: This is overridden by commands C6 &C7 (above).	1 byte: 0x00 - Disabled **(default)** Original msg checksum is used. Checksum is not recalculated to include forced error values. (will yield a msg checksum error) 0x01 - Enabled Checksum recalculated to include the forced msg values/errors. (no checksum error)
2Ch	C9h *	Enable/Disable Extra Byte Transmission after checksum.	2 bytes aa bb: aa - 0x00 = Disabled **(default)** 0xnn = Enabled for nn Tx messages (nn=1-254, 01-FE) 0xFF = Enabled Continuously (until disabled) bb - Value of extra byte to be transmitted

Message Corruption (Forced Error) Commands			
2Ch	CFh	Global Forced Error Control "Globally" Enables, Disables, or clears all forced errors.	1 byte: 0x00 - Disabled Forced msg errors are globally disabled. (Individual Forced Error states are retained) 0x01 - Enabled **(default)** Forced msg errors are globally enabled. 0x02 - Clear All Clears the individual enables for all forced errors. Forced errors must be individually re-enabled after sending this command. Global enable/disable is left in its current state but will have no effect until errors are individually re-enabled.

***** - Not Applicable (ignored) in "Direct" Operational Mode (2C A0 02).

Commands Reported by the Saint 2			
Hdr	**ID**	**Description**	**Data Bytes**
2Ch	00h	Fast Wakeup Pattern Detected	None Note: **This ONLY reports Wakeup events SENT by the Saint 2.** It does NOT detect or report bus wakeup events generated by other devices/nodes on the bus.
2Ch	01h	Keyword 2000 Timeout/Error Note: P'x' timeouts are now always reported regardless of the bus init state. (previously reported only when the bus was initialized) As such, it is important to note that timeouts do not constitute a definitive indication of the current or previous init state.	1 byte: Bitfiield Bit values=0: No error/timeout detected Bit values=1: (see detail below) **Bit 0 (0x01) - P1 Timeout** Inter byte timeout occurred for ECU (time between bytes > P1max, 20ms nominal). **Bit 1 (0x02) - P2 Timeout** Timeout occurred between Tester and ECU or two ECU responses (> P2max, 50ms nominal). **Bit 2 (0x04) - P3 Timeout** Timeout occurred between end of ECU response and start of Tester (> P3max, 5000ms nominal). **Bit 3 (0x08) - Checksum Error** Checksum error detected in received message. **Bit 4 (0x10) - Arbitration Failure/ Error** Arbitration error detected in transmitted message. **Bit 5 (0x20) - Receive Buffer Overflow Error** Receive buffer overflow error detected while receiving message. **Bit 6 (0x40) - Receive Framing Error** Framing error detected while receiving message. **Bit 7 (0x80) - P4 Timeout** Inter byte timeout occurred for TESTER (time between bytes > P4max, 20ms nominal).

Commands Reported by the Saint 2			
2Ch	F0h	"Start of Message" Report When enabled, this report indicates the start of a KW Tx/Rx message. **(Disabled as default)** Ref. command "2C B3", under "General/Misc. Commands" for control of this report.	1 Byte: (Message Type) 00 – Rx Msg Started 01 – Tx Msg Started Reported once per message after the first byte of a message has been sent or received. Return of a message to the host constitutes an "end of message" indication. This report provides an additional indication at the start of a message. This feature was added primarily for J2534 to support external protocol timing and control operations but is available for other uses as appropriate. Examples: 2D F0 00 - 1st byte of Rx msg received. 2D F0 01 - 1st byte of Tx msg transmitted.
2Ch	F1h	5 Baud Key Byte Report Reports the Key Byte values received during 5 Baud Init. **(Enabled as default)** Ref. command "2C B4", under "General/Misc. Commands" for control of this report.	2 Bytes: KB1 & KB2 Reported once for each 5 Baud Init event. This feature was added primarily for J2534 to support external protocol timing and control operations but is available for other uses as appropriate.

9.3 Keyword 2000 Messages

9.3.1 Transmitted Keyword 2000 Messages

The following is the format for sending a Keyword 2000 message:

Saint Header	SID (Service ID)	*N Data Bytes*
28h	Byte 2	*Bytes 3 —(2+N)*

The above information is used to form one of the following Keyword 2000 messages which is sent onto the Keyword 2000 bus. The message format depends on the header options configuration (user selected).

1 Byte Header			
Format	***SID***	***N Data Bytes***	**Checksum**
Byte 1	Byte 2	Bytes 3 - (2+N)	Byte 4 + N

2 Byte Header				
Format	**Length**	***SID***	***N Data Bytes***	**Checksum**
Byte 1	Byte 2	Byte 3	Bytes 4 - (3+N)	Byte 5 + N

3 Byte Header					
Format	**Target**	**Source**	***SID***	***N Data Bytes***	**Checksum**
Byte 1	Byte 2	Byte 3	Byte 4	Bytes 5 - (4+N)	Byte 5 + N

4 Byte Header						
Format	**Target**	**Source**	**Length**	***SID***	***N Data Bytes***	**Checksum**
Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bytes 6 - (5+N)	Byte 6 + N

Also, the SAINT will check to see if the bus is “initialized” and if necessary will send the Fast initialization sequence (transmit Wakeup Pattern of 25msec logic low and 25msec logic high followed by a Start Communications request message 81 11 F1 81 04). Refer to the “Keyword Protocol 2000 Data Link Layer Recommended Practice” section 5.1.5.3 for more information.

9.3.2 Received Keyword 2000 Messages

The following are the 4 possible formats of a received Keyword 2000 message shown with time stamp information included.

Keyword Header Format = 1 Byte						
Header	**Format**	***SID***	***N Data Bytes***	**Checksum**	**Time MSB**	**Time LSB**
29h	Byte 2	Byte 3	Bytes 4 - (3+N)	Byte 4+N	Byte 5+N	Byte 6+N

Keyword Header Format = 2 Byte							
Header	**Format**	**Length**	***SID***	***N Data Bytes***	**Checksum**	**Time MSB**	**Time LSB**
29h	Byte 2	Byte 3	Byte 4	Bytes 5 - (4+N)	Byte 5+N	Byte 6+N	Byte 7+N

Keyword Header Format = 3 Byte								
Header	**Format**	**Target**	**Source**	***SID***	***N Data Bytes***	**Checksum**	**Time MSB**	**Time LSB**
29h	Byte 2	Byte 3	Byte 4	Byte 5	Bytes 6 - (5+N)	Byte 6+N	Byte 7+N	Byte 8+N

Keyword Header Format = 4 Byte									
Header	**Format**	**Target**	**Source**	**Length**	***SID***	***N Data Bytes***	**Checksum**	**Time MSB**	**Time LSB**
29h	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Bytes 7 - (6+N)	Byte 7+N	Byte 8+N	Byte 9+N

9.3.3 Format Byte

The format byte contains a 6-bit length information and a 2-bit address mode information.

Bit 7	Bit 6	Address Information
0	0	no address information
0	1	exception mode (CARB)
1	0	with address information, physical addressing
1	1	with address information, functional addressing

Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Length
X	X	X	X	X	X	Define length of message from the Data to Checksum (not included) bytes. A message length of 1 to 63 bytes is possible. If bits 5-0 are zero then the additional length byte is included. Refer to the “Keyword Protocol 2000 Data Link Layer Recommended Practice” section 4.1.1 for more information.

9.3.4 Target Address Byte

This is the target address for the message and is always used together with the source address byte. Refer to the "Keyword Protocol 2000 Data Link Layer Recommended Practice" section 4.1.2 for more information.

9.3.5 Source Address Byte

This is the address of the transmitting device which is a physical address. Refer to the "Keyword Protocol 2000 Data Link Layer Recommended Practice" section 4.1.3 for more information.

9.3.6 Length Byte

This byte is provided if the length in the header byte (bits 0-5) is set to 0. It allows the user to transmit messages with data fields longer than 63 bytes. With shorter messages it may be omitted. This byte defines the length of a message from the beginning of the data field (SID included) to the checksum byte (not included). Refer to the "Keyword Protocol 2000 Data Link Layer Recommended Practice" section 4.1.4 for more information.

9.3.7 Data Bytes

The data field may contain up to 255 bytes. The first byte of the data field is the Service Identification Byte. Refer to the "Keyword Protocol 2000 Data Link Layer Recommended Practice" section 4.2 for more information.

9.3.8 Checksum Byte

The checksum byte inserted at the end of the message block is defined as the simple 8-bit sum series of all bytes in the message, excluding the checksum. Refer to the "Keyword Protocol 2000 Data Link Layer Recommended Practice" section 4.3 for more information.

10 SPI (SAINT2 only)

10.1 Serial Peripheral Interface (SPI) Overview

SPI functionality is not provided in the uS3. Support for SPI has not bene released for the S3 Pro.

The SAINT2 supports SPI through a monitor program in which sending messages is not supported. All message traffic on the bus is "sniffed" and made available to the user. The SPI monitor is limited to baud rates of 400K or less.

The following command may be used to begin monitoring SPI traffic.

Header	ID	Description	Data Bytes
74h	01h	Begin SPI Monitor Mode	

To exit the SPI Monitor Mode use a hardware reset.

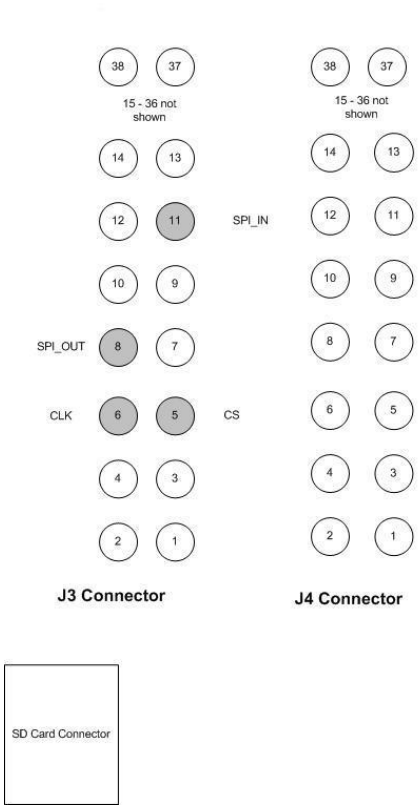
SPI Received Message Format with Time Stamp

71h (SPI IN)	N Data Bytes	Time Stamp Bytes
byte 1	Byte 2 … Byte N	Byte N+1 Byte N+1

73h (SPI OUT)	N Data Bytes	Time Stamp Bytes
byte 1	Byte 2 … Byte N	Byte N+1 Byte N+1

Note: SAINT2 SPI chip select (CS) is active low.

10.2 SPI Hardware Connection Diagram



11 LIN

LIN functionality is not provided in the uS3. This functionality is not yet available in the S3 Pro.
The Saint 2 LIN implementation provides LIN functionality similar to that provided by the Saint 1. The Saint 2 release is an enhanced implementation that provides several significant improvements and benefits:

- Support for ALL existing LIN versions (up to 2.1) as well as SAE J2602 (US LIN).
- Simultaneous Master, Slave, and Bus Monitor support (no re-flash/mode switching).
- Stand-alone simulation of a LIN sub bus network (up to 10 slave node/PID responses).
- LIN is not currently available for the Saint3.

!!!!! IMPORTANT !!!!!

If using the Saint2, you MUST have hardware "Version 1.1" or higher to use it with LIN.

The hardware version number is listed on the bottom left corner of the front label. If the label does not indicate a hardware version, it is Version 1.0 hardware and will NOT work properly for LIN.

If you need to use LIN and have an incompatible version of the Saint 2, contact the manufacturer or email support for upgrade/replacement options.

11.1 LIN – Application Notes

1. **General Use Information**

For Saint2 LIN & KW2000 share the same the same driver H/W and connector pin (PIN 7)

For the Saint2 LIN & KW2000 and are MUTUALLY EXCLUSIVE protocols.

LIN and KW2000 share the same physical interface and are therefore mutually exclusive protocols. Only one of these protocols may be enabled at a time. Enabling one automatically disables the other. All other supported protocols can be enabled simultaneously with either LIN or KW but not both. (i.e. CAN & LIN or CAN & KW can operate at the same time but not CAN & LIN & KW for example)
By default (or after reset) KW is enabled and LIN is disabled. The S2 Configuration Command "08 A3 B8 xx …" MUST be used to enable LIN (and any other desired protocols) before it can be used. Refer to the SAINT2 Configuration section.

2. **Receive Message (frame) Termination & Timestamp Accuracy**

LIN Basic does not have access to the PID/frame length information of the "LIN Definition File" (.ldf) to use for determining when a frame is complete. Therefore, frame completion is determined using timeout, break detection, and maximum frame length techniques (whichever occurs first). Due to this, the following conditions apply to timestamp values reported for LIN frames. This should be understood and accounted for by users before making timing critical judgments based on the timestamp information:

Timestamp values MAY NOT accurately reflect the actual frame time.

Timestamps reported with LIN Frames will normally be longer than the actual frame time (except when terminated by max frame length).

Timestamps due to timeout or break detection can be greater than actual frame times by up to 40% of the maximum frame time for a maximum length frame (at the given baud rate).

3. **Master Node Emulation Techniques (i.e. Master Schedule Table Emulation)**

An actual Master Node sends request/broadcast frames in a deterministic periodic fashion implemented as "Master Schedule Tables". Users can, within limitations, emulate Master Schedule Table behavior on the Saint 2 using a couple of different techniques:

A) Saint Monitor Periodic Message Feature

The "Periodic Message" feature of the "Saint Monitor" plugin application can be configured to send multiple messages at individual periodic rates. Multiple periodic message files can be created and saved to allow a limited form of table switching. (Table switching would be manually controlled). PC to Saint communication latency can impose some timing inaccuracy which may or may not be of significance depending on the application. This technique is relatively flexible and would work well for all but the most demanding applications.

B) Saint Embedded Periodic Message Feature

Periodic message scheduling similar to that of the "Saint Monitor" can be configured and implemented to execute directly on the Saint 2 hardware (embedded firmware execution). Reference the "SAINT Configuration Commands" section, commands 0x90 & 0x91 for configuration information.

This method provides the benefit of better timing accuracy but limits the number of messages that can be configured for periodic transmission.

C) Custom Plugin Development

Users can develop their own custom plugins to allow emulation of their particular Master Node ECU. This would provide the most complete emulation including creation and full automatic control of schedule tables and switching. As with the "Saint Monitor" application, this method is also subject to potential timing inaccuracies due to the PC to Saint communication latencies.

Information and Plugin code templates can be found on the Saint 2 web site.

11.2 LIN Commands

The following commands may be transmitted from the host interface to the SAINT 2:

Protocol Configuration Commands			
Hdr	**ID**	**Description**	**Data Bytes**
BCh	01h	Set LIN Version For “LIN Basic” this primarily affects checksum model used: <= 1.X - “Classic” >= 2.X - “Enhanced” (i.e. any value below 2.x should work for 1.x protocols, and any value above 1.x should work for 2.x or J2602 protocols.)	1 byte bitfield: Version as hex (no decimal point) Bits 0-3: Minor version number Bits 4-6: Major version number Bit 7: 0=LIN ver, 1= SAE J2602 ver Range: 0x10 – 0xFF **Default: 0x21 – LIN 2.1** Examples: BC 01 13 - set LIN ver 1.3 BC 01 20 - set LIN ver 2.0 BC 01 80 - set SAE J2602 ver 0.0 BC 01 92 - set SAE J2602 ver 1.2
BCh	02h	Set Baud Rate	1-2 bytes: Baud rate in hundreds units expressed in BCD . Leading zeros are disregarded. Range: 1k - 20k baud (in 100 baud steps) Note: Use 104 for 10.4 kBaud, 105 for 10.417 **Default = 19200 baud** Examples: BC 02 02 00 - set baud to 20,000(leading 0's ignored) BC 02 00 10 - set baud to 1000 (leading 0's ignored) BC 02 or 2C 02 00 - set default baud rate
BCh	03h	Enable/Disable Automatic Checksum for Master messages Controls automatic calculation and appending of a checksum to Tx (Master) frames ONLY. Disabling this allows the user to send Tx frames with an omitted or custom checksum value.	1 byte: 0x00 = Disable 0x01 = Enable **(default)** Note: This does NOT affect Rx frames. The checksum Is always verified for received (and looped back Tx) frames. Examples: BC 03 00 - Disable Auto Checksum BC 03 01 - Enable Auto Checksum

BCh	04h	Enable/Disable Automatic Parity ID calculation for Master messages Controls automatic calculation and replacement of PID from ID. (Master) frames ONLY. Disabling this allows the user to send Tx frames with an incorrect PID to induce parity errors.	1 byte: 0x00 = Disable 0x01 = Enable **(default)** Note: This does NOT affect Rx frames. Examples: BC 04 00 - Disable Auto Parity BC 04 01 - Enable Auto Parity
BCh	05	Set LIN slave response time as portion of 1/10 of Nominal response time. Delay is in steps of 96 uS. 0 to 4 steps allowed	1 byte: 0x00 = None Example: BC 05 04, set response delay to extend overall slave response to 1.4x nominal
BCh	06	Step LIN interbyte spacing time as portion of 1/10 of Nominal response time applied equally after each of 8 data bytes. Delay is in steps of 96 uS. 0 to 4 steps allowed	1 byte: 0x00 = None Example: BC 06 04, set response delay to extend overall slave response to 1.4x nominal

Slave Signal Table (SST) Configuration Commands (Slave Emulation)

Hdr	ID	Description	Data Bytes
BCh	10h	Add/Modify Slave Emulation Response Adds or modifies a Slave emulation record in the SST which is used to generate simulated slave responses to Master “request” frames. When a Master “request” frame PID match is detected, the content of the matching record is transmitted as an “in frame response” to the Master frame. NOTE: User is responsible for avoiding PID conflicts between the SST and Master broadcast frames or bus collisions can result. (The Saint will transmit a slave response over the top of a broadcast message -both nodes transmitting).	1-10 bytes: PID + Data (1-8) + Checksum (optional) Minimum content: PID + 1 Data (2 bytes) The SST holds 10 entries maximum. Commands that are invalid, illegal, or would violate table size limits will be discarded/ignored (without notification). PID: 0x01-0xFE (00&FF reserved for internal use) Any value within this range (incl. “illegal” PIDs) is allowed. Unique PIDs are enforced (no duplicates). If the specified PID already exists, the record is replaced (modified). Data: 0x00-0xFF (1-8 bytes) Checksum: 0x00-0xFF (optional) Checksums are NOT automatically generated for emulated slave responses. Inclusion/content is completely at the users’ discretion allowing full control of the slave response portion of the frame. Automatic checksums only apply to master messages, for error free slave response please include the checksum. See below for information on how the checksum is calculated. Example: BC 10 C1 01 02 3B - add/modify “C1” PID Response, 3B is the checksum Result: B8 C1 (“C1” Master Request) 01 02 3B (emulated slave response) B9 C1 01 02 3B 00 (resulting LIN msg frame)

BCh	11h	Delete SST record	1 byte: PID 0x00 = Illegal, command will be discarded. 0x01-0xFE= Delete specified record (PID) 0xFF= Delete all records in the table. Examples: BC 11 C1 – Delete record w/ PID=C1 (if found) BC 11 FF – Delete ALL records in SST.
BCh	12h	Enable/Disable SST record This command allows the user to control emulated slave responses already stored in the SST.	2 bytes: PID xx PID: 0x00 = Illegal, command will be discarded. 0x01-0xFE= Apply setting to specified record (PID) 0xFF= Apply setting to all records. xx: 0x00 = Disable **(default)** 0x01 = Enable Examples: BC 12 C1 00 - Disable SST record w/ PID=C1 BC 12 C1 - (same as above – default=disable) BC 12 C1 01 - Enable SST record w/ PID=C1 BC 12 FF 01 - Enable all records in SST BC 12 FF - Disable all records in SST
BCh	13h	Report SST Config Reports the current configuration of the SST as a list of the populated records.	1 byte: PID PID: 0x00 = Illegal, command will be discarded. 0x01-0xFE= Report specified record (PID) 0xFF= Report all (populated) records. Report messages are returned first followed by an echo of the command message. If no populated entries are found, only the command echo will be returned (without report messages). Response: 1 message for each populated entry (10 max) BC 13 aa bb cc xx…xx aa = Record # (01-0A, 1-10dec) bb = Enable/Disable state (0=disabled,1=enabled) cc = PID xx.. = Record Data (including checksum) Example (assume 2 records populated): BC 13 FF – Request SST Config (all records). Result: BC 13 01 01 C1 01 02 3D BC 13 09 00 C2 01 02 3E BC 13 FF – Orig. Command Echo (Note: The initial command message will follow the record reports)

BCh	14h	One-shot Slave Emulation Response Adds or modifies a Slave emulation record in the SST which is used to generate simulated slave responses to Master "request" frames. When a Master "request" frame PID match is detected, the content of the matching record is transmitted as an "in frame response" to the Master frame. This response is only used one-time. After the reponse has been used, the SST reverts to any previous values in the SST. NOTE: User is responsible for avoiding PID conflicts between the SST and Master broadcast frames or bus collisions can result. (The Saint will transmit a slave response over the top of a broadcast message -both nodes transmitting).	1-10 bytes: PID + Data (1-8) + Checksum (optional) Minimum content: PID + 1 Data (2 bytes) Only one, one-shot PID can be set up at any one time. PID: 0x01-0xFE (00&FF reserved for internal use) Any value within this range (incl. "illegal" PIDs) is allowed. Unique PIDs are enforced (no duplicates). If the specified PID already exists, the record is replaced (modified). Data: 0x00-0xFF (1-8 bytes) Checksum: 0x00-0xFF (optional) Checksums are NOT automatically generated for emulated slave responses. Inclusion/content is completely at the users' discretion allowing full control of the slave response portion of the frame. Automatic checksums only apply to master messages, for error free slave response please include the checksum. See below for information on how the checksum is calculated. Example: BC 14 C1 01 02 3B - add/modify "C1" PID One –shot Response, 3B is the checksum Result: B8 C1 ("C1" Master Request) 01 02 3B (emulated slave response) B9 C1 01 02 3B 00 (resulting LIN msg frame) Next B8 C1, will revert to previous table settings.

Commands Reported by the Saint 2

Hdr	ID	Description	Data Bytes
BCh	E0h	LIN Error (Rx msg independent)	1 byte: Same as Rx msg Completion Code (See the Completion Code detail in the "LIN Received Messages section) This is a special error message used to report errors when an accompanying/associated Rx message is not available to report the errors (completion code) with.

11.3 LIN Messages

11.3.1 Transmitted LIN Messages (Master Frames)

The following is the format for sending a LIN Master message:

Saint Header	**PID (Protected ID)**	***N Data Bytes (N=0-8)***	Checksum (optional) (1)
B8h	Byte 2	*Bytes 3 —(2+N)*	Byte N+3

A LIN Master frame is a minimum of 1 byte (PID only = Master Request Frame) and a maximum of 10 bytes (PID + data + checksum = Master Broadcast Frame). A properly formatted S2 LIN message will therefore be between 2 – 11 bytes (including the S2 header byte).

Master frames are sent IMMEDIATELY and will be transmitted on the bus regardless of any current receive activity (i.e. potential collision conditions). This is intentional behavior and in keeping with the LIN specifications and philosophy that the Master Node always has priority and can pre-empt any bus activity. It is the users' responsibility to manage bus traffic and schedule message flow appropriately.

Notes:

(1) User provided checksum is optional. Inclusion is dependent on user intent AND the configured state of the "Automatic Checksum" feature. If Automatic Checksum is enabled, a user checksum should NOT be included (as one will be automatically calculated and appended by the firmware). If Automatic Checksum is disabled, inclusion of the user checksum is optional. This mode allows the user to send a Master frame with an omitted, corrupted, or valid checksum value as desired (useful for error/robustness testing.)

(2) In firmware version 4.17.4 and later, the Tx bit in the header is set whenever the Saint acts as the master.

11.3.2 Received LIN Messages (frames)

The following is the format of a received LIN message (shown with time stamp information included):

Header	***PID***	***N Data Bytes***	**Checksum**	**Completion Code**	**Time MSB**	**Time LSB**
B9h	Byte 2	Bytes 3 - (2+N)	Byte 3+N	Byte 4+N	Byte 5+N	Byte 6+N

11.3.3 PID Byte

The "Protected Identifier" byte consists of the Frame ID (bits 0-5) and Parity fields (bits 6-7). Refer to the applicable LIN (LIN Consortium) or J2602 (SAE)specifications for more information.

11.3.4 Data Bytes

The data field may contain from 0 to 8 bytes. When supplied by the Master Node, the message constitutes a "Broadcast" message (for Slave Node consumption). When not supplied by the Master Node (PID only), the message constitutes a "Master Request" message (Slave Node response expected). Refer to the applicable LIN (LIN Consortium) or J2602 (SAE)specifications for more information

11.3.5 Checksum Byte

The checksum is calculated by adding each byte value and adding any carry to the 8 bit result. The final result is inverted. Two different checksum models are used depending on the LIN/J2602 version being used as follows:

Checksum Model	**Checksum Bytes**	**LIN Version**
Classic	Data (only)	LIN 1.X
Enhanced	PID & Data	LIN 2.X & J2602

Classic Example:
12 A0 B8
A0 + B8 = 158
1 + 58 = 59
NOT 59 = A6

Enhanced Example:
12 A0 B8
12 + A0 + B8 = 16A
1 + 6A = 6B
NOT 59 = 94

Tip: Too easily compute the checksum to include when setting up the slave table, simply send the message as a Master message. If auto-checksum is enabled, the Saint will automatically append the checksum to the message.

Refer to the applicable LIN (LIN Consortium) or J2602 (SAE)specifications for more information.

11.3.6 Completion Code (Frame Error) Byte

This byte is a bitfield indicating any errors detected by the Saint 2 firmware for the associated LIN message (frame). In certain cases, errors can occur without producing an Rx message to report the errors with. In this scenario, the errors (completion code) are reported to the user as an independent error message "BC E0 xx" (described earlier in the "LIN Commands" section).

Completion Code Bitfield Definition							
7 (MSb)	6	5	4	3	2	1	0 (LSb)
Overflow	Framing	LoopBack	Brk/Sync	Parity	Checksum	Tframe	SNR

The following provides additional detail regarding each of these errors:

LIN Completion Code/Error Bitfield Detail:

Bit 0 (0x01) – Slave Not Responding Timeout

0 No timeout detected.

1 Slave node(s) did not respond within the allotted time (40% of max frame time @ given baud).

Bit 1 (0x02) – Tframe Error

0 No error detected

1 LIN frame was not completed within the max allowable time (frame slot time exceeded).

Bit 2 (0x04) – Checksum Error

0 No error detected.

1 Checksum error detected in the LIN message.

Bit 3 (0x08) - Parity Error

0 No error detected.

1 PID parity error detected in the LIN message.

Bit 4 (0x10) – Break/Sync Error

0 No error detected.

1 Missing or inconsistent Break and/or Sync bytes detected.

Bit 5 (0x20) – LoopBack Error (AKA Data Error)

0 No error detected.

1 Received (loopback) byte did not match transmitted byte during LIN message transmission.

Bit 6 (0x40) - Receive Framing Error

0 No error detected.

1 Framing error detected in the LIN message.

Bit 7 (0x80) - Receive Buffer Overflow Error

0 No error detected.

1 Receive buffer overflow error detected while receiving LIN message.

12 Block Transfer

The Block Transfer messages (SAINT header $F8) can be used to transfer large blocks of data between the host PC and certain protocols running in the SAINT firmware.

Maximum Block Transfer message size = 4K bytes (0xFFF)
Protocols that support block transfer:
Class 2 ($60) – block transmit and block receive supported
ISO15765-2 1($C0) – block transmit supported, block receive is not supported (see ISO15675-2 section for details)
ISO15765-2 2($C8) – block transmit supported, block receive is not supported (see ISO15675-2 section for details)

12.1 Using Block Transfer with the SAINT Bus Engine

If your plug-in is using the SAINT Bus Engine to communicate with the SAINT you do not need any special formatting to send your block message. You simply need to send the SAINT header byte for your protocol followed by the entire block message.

12.2 Using Block Transfer without the SAINT Bus Engine

If your application does not use the SAINT Bus Engine to communicate with the SAINT you must use the following special formatting to send or receive your block message. A single block message must be broken up into a series of $F8 messages. Also, the messages must be constructed using the SAINT

Maximum $F8 message size = 56 bytes (including $F8 header byte, $HH and $ YY YY below)

$F8 **HH YY YY XX XX XX**….

where $**F8** is the SAINT header for block message transfers
$**HH** is the SAINT header for the protocol (i.e. $60 for Class 2, $C0 for ISO15765-2 1)
$**YY YY** is the incrementing message counter. Bits 0-14 are $0000 for the first message and increment by 1 for each subsequent message. Bit 15 = 1 in the last message of the series of messages.
$**XX XX XX**… is the serial message (up to 52 bytes)

Example: Transmit the following 170 data byte ISO15765-2 message $123 DB1 DB2 … DB170
$F8 C0 00 00 01 23 DB1 DB2 DB3 DB4 … DB54
$F8 C0 00 01 DB55 DB56 DB57 … DB110
$F8 C0 00 02 DB111 DB112 DB113 … DB166
$F8 C0 80 03 DB167 DB168 DB169 DB170

Also note that each message must be constructed using the SAINT2 FF and FF 00 escape characters. See the SAINT Message Format section for more details.

Class2 Example:

Users wants to transmit the following 140 byte Class2 block mode message:

```
60 6D 99 F0 36 00 00 80 00 F6 86 79 9F AC 00 84 05 AA 03 00
00 0E C7 14 C7 12 C7 80 81 C0 00 00 C0 00 00 FF CF 00 00 00
F6 00 00 FF FD 00 00 00 00 E0 00 FF 07 E0 00 00 40 C0 00 FF
45 C0 00 00 60 C0 00 FF FF C0 00 00 00 C1 00 FF FF C1 00 01
02 03 04 05 06 10 11 12 13 14 15 16 17 18 19 1A 1B 1C FF 9C
8C 9C 8C 9C 8C 9C 8C 9C 8C 88 8E C0 00 A0 8E C0 00 B4 8E C0
00 01 02 00 C7 C7 02 00 C7 01 C7 00 02 1A 90 C0 00 5A 8F 2F
1F
```

The Saint Bus Engine will actually break this message up into three different packets for USB transfer. Reminder: If you are bypassing the SBE you will need to account for the FF and FF 00 escape sequences.

```
F8 60 00 00 6D 99 F0 36 00 00 80 00 F6 86 79 9F AC 00 84 05
AA 03 00 00 0E C7 14 C7 12 C7 80 81 C0 00 00 C0 00 00 FF CF
00 00 00 F6 00 00 FF FD 00 00 00 00 E0 00 FF 07

F8 60 00 01 E0 00 00 40 C0 00 FF 45 C0 00 00 60 C0 00 FF FF
C0 00 00 00 C1 00 FF FF C1 00 01 02 03 04 05 06 10 11 12 13
14 15 16 17 18 19 1A 1B 1C FF 9C 8C 9C 8C 9C 8C

F8 60 80 02 9C 8C 9C 8C 88 8E C0 00 A0 8E C0 00 B4 8E C0 00
01 02 00 C7 C7 02 00 C7 01 C7 00 02 1A 90 C0 00 5A 8F 2F 1F
```

13 SAINT Gateway Functions

The SAINT supports several standalone gateway modes. In a gateway mode, the SAINT operates as a translator between two serial buses without any interface from a PC.

- An SD card is used to configure the SAINT to act as a stand-alone gateway.
- The gateway configuration file must be named *CONFIG.TXT*.
- Not currently implemented in the Saint3.

13.1 CAN1/CAN2 Bidirectional Gateway

The CAN1/CAN2 gateway is a gateway between the CAN1 channel and the CAN2 channel. The SAINT can translate between supported baud rates and CAN transceivers. Any CAN frames received on CAN 1 are re-transmitted with the same message ID and data onto CAN 2. Also, any CAN frames received on CAN 2 are re-transmitted with the same message ID and data onto CAN 1. The CONFIG.TXT file should look like this:

```
begin
gateway
cangateway
header1: 50
header2: 58
group file: cancnfg.grp
end
```

where the groupfile *cancnfg.grp* configures the CAN channels' baud rates, CAN transceivers, and options. An example of *cancnfg.grp* might be

```
0010 54 04 00
0010 54 01 C9 39
0010 5C 04 01
0010 5C 01 F1 39
```

Where CAN 1 ($54) is configured to high speed CAN at 500K baud, and CAN 2 ($5C) is configured to fault tolerant CAN at 100K baud.

Important Notes:

- At some level of bus utilization, a slower baud rate channel is not going to be able to keep up with traffic on a higher baud rate channel. Messages may be lost. If this is critical, pay attention to the operation warning LED #5.

- If you are monitoring the bus with the SAINT being used as a gateway, you will not see the received CAN frames but you will the see the frames that are re-transmitted.

13.2 CAN1 to CAN2 One-way Gateway

The CAN1/CAN2 gateway is a gateway between the CAN1 channel and the CAN2 channel. The SAINT can translate between supported baud rates and CAN transceivers. Any CAN frames received on CAN 1 are re-transmitted with the

same message ID and data onto CAN 2. Any CAN frames received on CAN 2 are NOT re-transmitted. The CONFIG.TXT file should look like this:

```
begin
gateway
oneway
header1: 50
header2: 58
group file: cancnfg.grp
end
```

where the groupfile *cancnfg.grp* configures the CAN channels' baud rates, CAN transceivers, and options. An example of *cancnfg.grp* might be

```
0010 54 04 00
0010 54 01 C9 39
0010 5C 04 01
0010 5C 01 F1 39
```

Where CAN 1 ($54) is configured to high speed CAN at 500K baud, and CAN 2 ($5C) is configured to fault tolerant CAN at 100K baud.

Important Notes:

- At some level of bus utilization, a slower baud rate channel is not going to be able to keep up with traffic on a higher baud rate channel. Messages may be lost. If this is critical, pay attention to the operation warning LED #5.

- If you are monitoring the bus with the SAINT being used as a gateway, you will not see the received CAN frames but you will the see the frames that are re-transmitted.

13.3 RS232/CAN Gateway

The RS232/CAN Gateway is a gateway between RS232 and the specified CAN channel. In this mode, the SAINT can be used to monitor CAN traffic using the PC application Hyperterminal. When any CAN frame (i.e. any CAN ID) is received on the specified CAN channel, the first data byte in the frame is retransmitted as a single byte over the RS232 connection. When a byte is received over RS232, a CAN frame is constructed with the specified message ID (0x001) and the RS232 byte of data and is re-transmitted over the specified CAN channel. The CONFIG.TXT should look like this

```
begin
gateway
can11bit                ; or "can29bit"
can_id: 0x001           ; can id from hyperterminal to CAN
header1: 0x50
header2: 0x80
group file: cancnfg.grp
end
```

where cancnfg.grp is the groupfile that configures the CAN channel.

Important Notes:

- CAN has the potential to be much faster than RS232. The CAN device connected to the gateway must regulate the CAN traffic so it does not overrun the RS232 channel.

- header1 must be the CAN channel and header 2 must be the RS232 channel ($80).

13.4 X/Y Gateway

The X/Y gateway is a gateway between any two channels that can run concurrently. The X/Y gateway simply takes the raw bytes received on protocol X and retransmits on protocol Y. Also, in the reverse, anything received on protocol Y is retransmitted on protocol X. The keyword "cangateway" is still used regardless of the X and Y protocols. Please be aware that this Gateway feature is effectively simply retransmitting the received header byte for protocol X with the header byte for Protocol Y (and vice versa).

```
begin
gateway
cangateway
header1: 0x50
header2: 0x60
group file: config.grp
end
```

where the goupfile *config.grp* configures the protocol channels if needed.

Important Notes:

- At some level of bus utilization, a slower baud rate channel is not going to be able to keep up with traffic on a higher baud rate channel. Messages may be lost. If this is critical, pay attention to the operation warning LED #5.

- If you are monitoring the bus with the SAINT being used as a gateway, you will not see the received frames but you will the see the frames that are re-transmitted.

14 Connectors

The SAINT uses 3 connectors. The first connector is a USB connector. The second connector is for the RS-232 link and is DB9F. The third connector is a DB25F for the serial bus, power and ground connections. The following pin outs are used:

14.1 USB Connector

Uses USB Type A connector on host PC and Type B connector on Saint 2.

14.2 RS-232 Connector

A straight pass cable should be used to connect the SAINT to the host computer.

DB9F Pin #	Use
2	TX to Host
3	RX from Host
8	CTS
6	DSR
5	GND

14.3 SAINT CABLE

14.3.1 Saint2 v1.0, v1.1

DB25F Pin #	Use
1	SWCAN1
2	FT_2_H
3	VBATT
4	TRIGIN
5	SWCAN2
6	BarTC2
7	KEYWORD
8	CAN_1_H
9	CAN_1_L
10	BArT_CANH
11	BArT_CANL
12	BArT_SW
13	FT_2_L
14	CLASS2
15	ACP_B
16	BEAN1
17	BEAN2
18	Do not connect a wire to this pin
19	Do not connect a wire to this pin
20	Do not connect a wire to this pin
21	Do not connect a wire to this pin
22	SPI_INT
23	GND
24	TRIGOUT
25	ACP_A

14.3.2 Saint2 v1.2

DB25F Pin #	Use
1	SWCAN1
2	FT_2_H
3	VBATT
4	TRIGIN
5	SWCAN2
6	DB4
7	KEYWORD
8	CAN_1_H
9	CAN_1_L
10	CAN_2_H
11	CAN_2_L
12	BArT_SW
13	FT_2_L
14	CLASS2
15	IIC_CLK
16	FT_1_H
17	FT_1_L
18	DB1
19	DB2
20	DB3
21	IIC_DATA
22	TRIGIN2
23	GND
24	TRIGOUT
25	TRIGOUT2

14.3.3 Saint3 Pro

DB25F Pin #	Use
1	SWCAN1
2	FT_2_H
3	VBATT
4	TRIGIN 1
5	SWCAN2
6	DB4
7	KEYWORD
8	CAN/CANFD_1_H
9	CAN/CANFD_1_L
10	CAN/CANFD_2_H
11	CAN/CANFD_2_L
12	Spare
13	FT_2_L
14	LIN
15	IIC_CLK
16	FT_1_H
17	FT_1_L
18	DB1
19	DB2
20	DB3
21	IIC_DATA
22	TRIGIN2
23	GND
24	TRIGOUT1
25	TRIGOUT2

14.3.4 Mirco Saint3

DB9F Pin #	Use
1	N/C
2	CAN/CANFD_1L
3	GND
4	CAN/CANFD_2L
5	N/C
6	GND
7	CAN/CANFD_1H
8	CAN/CANFD_2H
9	N/C

15 LEDs

Six LEDs are used by the SAINT. These LEDs are:

LED #	Purpose
6	Not Used
5	Operation Warning Code Set In Firmware (Use 08h A1h to Retrieve) If flashing at 1 Hz then you are in IIC Monitor Mode
4	Access SD Card
3	Not Used
2	Sending Message(s) To Host
1(PWR)	Toggle – Power On & System In Normal Operation

15.1 Reset Button - Manual Reset

Reset button is the manual reset switch. Pressing this switch will cause SAINT microprocessor software reset - start executing the embedded code from boot block.