

# **J1939 Protocol Stack User's Manual**

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Created by the J1939 Experts!



**Simma Software**

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# Chapter 1

## Introduction

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ssJ1939 is high performance J1939 protocol stack written in ANSI C. ssJ1939 adheres to both the SAE J1939 specification and to the software development best practices described in the MISRA C guidelines.

ssJ1939 is a modularized design with an emphasis on software readability and performance. ssJ1939 is easy to understand and platform independent allowing it to be used on any CPU or DSP with or without an RTOS. ssJ1939 has been shown to be up to 700% faster and 74% smaller than other commercially available J1939 protocol stacks.

ssJ1939 implements the data link layer described in J1939/21 and the network management layer described in J1939/81. The application layer, described in J1939/71, is the responsibility of the end user to implement. Examples of application layer processing are provided in j1939app.c.

Filenames	File Description
j1939.c	Core source file for ssJ1939. Do not modify.
j1939.h	Core header file for ssJ1939. Do not modify.
j1939tp.c	Transport protocol source file. Do not modify.
j1939tp.h	Transport protocol header file. Do not modify.
j1939app.c	Application source file for ssJ1939. Modification allowed.
j1939app.h	Application header file for ssJ1939. Modification allowed.
j1939cfg.h	ssJ1939 configuration file. Modification allowed.

**Table 1-1: ssJ1939 files**

# Chapter 2

## Integration of ssJ1939

---

This chapter describes how to integrate ssJ1939 into your application. After this is complete, you will be able to receive and transmit J1939 messages over CAN. For implementation details, please see the chapters covering the APIs for J1939 and CAN.

### Integration Steps:

1. Develop or purchase a CAN device driver which adheres to the CAN API specified in Chapter 3.
2. Before using any of the J1939 module features, make sure the CAN driver has been initialized by calling `can_init()`. Typically it is called shortly after power-on reset and before the application is started.
3. Before using any of the ssJ1939 module features, make sure the ssJ1939 as been initialized by calling `j1939_init()`. Typically it is called after `can_init()` and before the application is started.
4. Call `j1939_update` at a fixed periodic interval (e.g. every 10 ms). This provides the time base for the J1939 module. It is recommended that this function be called at least every 25 ms.
5. Set `J1939CFG_TICK_PERIOD`, in `j1939cfg.h`, to your systems fixed periodic interval described above in step #4.
6. Set your “Name field” in `j1939cfg.h`. See the Configuration chapter for details.
7. As needed adjust the number and size of the transport protocol buffers.
8. As needed place software in the function `j1939app_process()`, which is located in `j1939app.c`, to receive and process J1939 messages.
9. As needed, call `j1939_tx_app()` to transmit J1939 messages.

# Chapter 3

## CAN Hardware Abstraction Layer

---

The hardware abstraction layer (HAL) is a software module that provides functions for receiving and transmitting controller area network (CAN) data frames. Because CAN peripherals typically differ from one microcontroller to another, this module is responsible for encompassing all platform depended aspects of CAN communications.

The HAL contains three functions that are responsible for initializing the CAN hardware and handling buffered reception and transmission of CAN frames.

Function Prototype	Function Description
<code>void can_init ( void )</code>	Initializes CAN hardware
<code>uint8_t can_rx ( can_t *frame )</code>	Receives CAN frame (buffered I/O)
<code>uint8_t can_tx ( can_t *frame )</code>	Transmits CAN frame (buffered I/O)

**Table 3-1: HAL functions**

### 3.1 Data Type Definitions

#### Data type:

`can_t`

#### Description:

`can_t` is a data type used to store CAN frames. It contains the CAN frame identifier, the CAN frame data, and the size of data. NOTE: If the most significant bit of id (i.e. bit 31) is set, it indicates an extended CAN frame, else it indicates a standard CAN frame.

#### Definition:

```
typedef struct {
    uint32_t id;
    uint8_t buf[8];
    uint8_t buf_len;
} can_t;
```

## 3.2 Function APIs

### can\_init

**Function Prototype:**

```
void can_init( void );
```

**Description:**

can\_init initializes the CAN peripheral for reception and transmission of CAN frames at a network speed of 250 kbps. Any external hardware that needs to be initialized can be done inside of can\_init. The sample point should be as close to 0.875 as possible, but should not exceed it. See J1939/11 and J1939/15 for additional bit timing and sample point information.

**Parameters:**

void

**Return Value:**

void

## **can\_rx**

### **Function Prototype:**

```
uint8_t can_rx ( can_t *frame );
```

### **Description:**

can\_rx checks to see if there is a CAN data frame available in the receive buffer. If one is available, it is copied into the can\_t structure which is pointed to by frame. If the most significant bit of frame->id (i.e. bit 31) is set, it indicates an extended CAN frame, else it indicates a standard CAN frame.

### **Parameters:**

frame: Points to memory where the received CAN frame should be stored.

### **Return Value:**

- 1: No CAN frame was read from the receive buffer.
- 0: A CAN frame was successfully read from the receive buffer.

## can\_tx

### Function Prototype:

```
uint8_t can_tx ( can_t *frame );
```

### Description:

If memory is available inside of the transmit buffer, can\_tx copies the memory pointed to by frame to the transmit buffer. If transmission of CAN frames is not currently in progress, then it will be initiated. If the most significant bit of frame->id (i.e. bit 31) is set, it indicates an extended CAN frame, else it indicates a standard CAN frame.

### Parameters:

frame: Points to the CAN frame that should be copied to the transmit buffer.

### Return Value:

- 1: No CAN frame was written to the transmit buffer.
- 0: The CAN frame was successfully written to the transmit buffer.

# Chapter 4

## ssJ1939 Application Program Interface

---

This chapter describes the application program interface (API) for the J1939 module.

Function Prototypes	Function Descriptions
void j1939_init ( void )	Initializes protocol stack
void j1939_update ( void )	Provides periodic time base
void j1939app_process ( j1939_t *msg )	Processes received J1939 messages
uint8_t j1939_tx_app ( j1939_t *msg, uint8_t *status )	Transmits a J1939 message
void j1939_bip_tx_rate_allowed_set ( uint8_t rate )	Sets maximum transmit rate allowed
uint8_t j1939_bip_tx_rate_max_get ( void );	Retrieves peak bus load usage.
uint8_t j1939app_sa_get ( void );	Retrieves next source address

**Table 4-1: API functions**

### 4.1 Data Type Definitions

#### Data type:

j1939\_t

#### Description:

j1939\_t is a data type used to store J1939 messages. It contains the J1939 message source, destination, PGN, priority, data, and the size of data.

#### Definition:

```
typedef struct {
    uint32_t pgn;          /* Parameter Group Number. */
    uint8_t *buf;         /* Pointer to data. */
    uint16_t buf_len;     /* Size of data. */
    uint8_t dst;         /* Destination of message. */
    uint8_t src;         /* Source of message. */
    uint8_t pri;         /* Priority of message. */
} j1939_t;
```

## **j1939\_init**

**Function Prototype:**

```
void j1939_init ( void );
```

**Description:**

Initializes the J1939 module.

**Parameters:**

void

**Return Value:**

void

## **j1939\_update**

**Function Prototype:**

void j1939\_update ( void );

**Description:**

Provides the periodic time base for the J1939 module.

**Parameters:**

void

**Return Value:**

void

## **j1939app\_process**

### **Function Prototype:**

```
void j1939app_process ( j1939_t *msg );
```

### **Description:**

Processes received J1939 message. This function is called by the J1939 module with a complete J1939 message and is the intended location for the application layer to handle received J1939 messages. For multipacket messages, this function isn't called until all packets have been received and assembled into a complete J1939 message.

### **Parameters:**

msg: Pointer to received J1939 message.

### **Return Value**

void

## j1939\_tx\_app

### Function Prototype:

```
uint8_t j1939_tx_app ( j1939_t *msg, uint8_t *status );
```

### Description:

Buffers a J1939 message for transmission. For messages that are larger than 8 bytes, the dst field of the j1939\_t structure controls whether the message is transmitted using the BAM or RTS/CTS procedures. Also, for messages larger than 8 bytes, the application should set status to point to a variable in the application's RAM. \*status will be equal to J1939TP\_INPROCESS while the message is being transmitted, J1939TP\_DONE if the message transmission is complete, or J1939TP\_FAILED if there was an error.

### Parameters:

msg: Points to the J1939 message that should be transmitted.  
status: Points to application RAM. Ignored for messages 8 bytes or less.

### Return Value:

1: Message was not buffered for transmission.  
0: Message was buffered for transmission.

## **j1939\_bip\_tx\_rate\_allowed\_set**

### **Function Prototype:**

```
void j1939_bip_tx_rate_allowed_set ( uint8_t rate );
```

### **Description:**

In order to implement babbling idiot protection, the J1939 module tracks how many messages are transmitted by the application in a 250 ms window. If the J1939 module detects the application has transmitted more messages than is allowed, it will permanently disable transmission. The application should use this function to set the J1939 module's allowable transmission rate (default of 25%). Set rate to 100% to disable babbling idiot protection.

### **Parameters:**

rate: Max allowed transmission rate. Range from 0 to 100 percent.

### **Return Value**

void

## **j1939\_bip\_tx\_rate\_max\_get**

### **Function Prototype:**

```
uint8_t j1939_bip_tx_rate_max_get ( void );
```

### **Description:**

In order to implement babbling idiot protection, the J1939 module tracks how many messages are transmitted by the application in a 250 ms window. The application can use this function to retrieve the max bus load that has been imposed on the bus by the application.

### **Parameters:**

void

### **Return Value**

0 to 100 percent

## j1939app\_sa\_get

**Function Prototype:**

```
uint8_t j1939app_sa_get ( void );
```

**Description:**

This function returns the next source address that the protocol stack should attempt to claim. It is called when the protocol stack fails to claim its default address, as defined by J1939CFG\_SA.

Since the protocol stack has no knowledge of what additional addresses it may claim, it calls this routine which is maintained by the application layer. When the application layer has no more addresses to claim, this function should return 255.

**Parameters:**

void

**Return Value**

Next source address. 255 indicates no more addresses are available.

# Chapter 5

## Configuration

---

This chapter describes all configurable items of the J1939 module. All of these configurations are defined in j1939cfg.h.

### J1939 Name Field

The J1939 name field is 64 bits long and is intended to uniquely describe all ECUs on a J1939 network (i.e. no two ECUs on a J1939 network may have the same name field). For more information, see J1939/81 section 4.1.

```
#define J1939CFG_N_AAC      0 /* 1-bit Arbitrary Address Capable */
#define J1939CFG_N_IG      0 /* 3-bit Industry Group */
#define J1939CFG_N_VSI     0 /* 4-bit Vehicle System Instance */
#define J1939CFG_N_VS      0 /* 7-bit Vehicle System */
#define J1939CFG_N_F       0 /* 8-bit Function */
#define J1939CFG_N_FI      0 /* 5-bit Function Instance */
#define J1939CFG_N_EI      0 /* 3-bit ECU Instance */
#define J1939CFG_N_MC      0 /* 11-bit Manufacturer Code */
#define J1939CFG_N_IN      0 /* 21-bit Identity Number */
```

### J1939 Source Address

The source address is a 8-bit field and identifies a unique J1939 device on the network. Its default value is set to an experimental ECU, but should be changed to match it's actual function. Possible values are listed in the J1939 parent document.

```
#define J1939CFG_SA      J1939_SA_EXPERIMENTAL_USE
```

### Transport Protocol RX Buffer Count

Multipacket J1939 messages are split into multiple CAN frames and buffered inside of the J1939 module. This configuration defines how many incoming multipacket messages can be received simultaneously.

```
#define J1939CFG_TP_RX_BUF_NUM    10
```

### **Transport Protocol RX Buffer Size**

Multipacket J1939 messages are split into multiple CAN frames and buffered inside of the J1939 module. This configuration defines in bytes the largest message which can be received. The maximum buffer size is 1,785 bytes.

```
#define J1939CFG_TP_RX_BUF_SIZE    128
```

### **Transport Protocol TX Buffer Count**

Multipacket J1939 messages are split into multiple CAN frames and buffered inside of the J1939 module. This configuration defines how many outgoing multipacket messages can be transmitted simultaneously.

```
#define J1939CFG_TP_TX_BUF_NUM    3
```

### **Transport Protocol TX Buffer Size**

Multipacket J1939 messages are split into multiple CAN frames and buffered inside of the J1939 module. This configuration defines in bytes the largest message which can be transmitted. The maximum buffer size is 1,785 bytes.

```
#define J1939CFG_TP_TX_BUF_SIZE    128
```

# Chapter 6

## Examples

---

This chapter gives examples of how to receive/decode J1939 messages and how to transmit a J1939 message. Per the J1939 specification all J1939 messages have an associated PGN followed by data. The below examples show how to filter based on the PGN of interest and decode the data.

### 6.1 Receive and Decode J1939 Messages Example:

```
void
j1939app_process ( j1939_t *msg ) {

    switch( msg->pgn ) {

        /* cruise control/vehicle speed PGN */
        case 65215: {

            /* wheel based vehicle speed */
            vehicle_speed = ((uint16_t)msg->buf[1] << 8) | msg->buf[0];

            break;
        }

        /* add other PGNs here */
        case XXXX: {

            break;
        }
    }

    return;
}
```

## 6.2 Transmit J1939 Message Example:

```
void
j1939_transmit_example ( void ) {

    j1939_t msg;
    uint8_t buf[8];

    /* load message */
    msg.pgn = 65215;
    msg.buf = buf;
    msg.buf_len = 1;
    msg.dst = 255;
    msg.pri = 7;
    msg.buf[0] = 0;

    /* transmit message */
    if( j1939_tx_app(&msg, 0) == 0 )
        printf("Message transmitted\n");
    else
        printf("Message not transmitted\n");

    return;
}
```