

ACANFD_FeatherM4CAN Arduino library, for Adafruit Feather M4 CAN Version 1.2.2

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1 Versions

Version	Date	Comment
1.2.2	April 6, 2022	Added BUS_MONITORING mode (section 21.10.1 page 42). Added 5-arguments ACANFD_FeatherM4CAN_Settings constructor (section 21.1.1 page 34).
1.2.1	March 17, 2022	Added section 10 page 16 on transmit priority. Added LoopBackDemoCANFD_CAN1_payload sample sketch.
1.2.0	March 12, 2022	Added dispatchReceivedMessage method. Added dispatchReceivedMessageFIFO0 method. Added dispatchReceivedMessageFIFO1 method. Added LoopBackDemoCANFD_CAN1_dispatch sample sketch.
1.1.0	March 10, 2022	Added handling Rx FIFO 1. Added receive standard filters. Added receive extended filters. Added LoopBackDemoCANFD_CAN1_StandardFilters sample sketch. Added LoopBackDemoCANFD_CAN1_ExtendedFilters sample sketch.
1.0.1	March 9, 2022	Added constraint settings.mHardwareTransmitTxFIFOSize ≥ 2 . Added constraint settings.mHardwareDedicacedTxBufferCount ≤ 30 . Fixed tryToSendReturnStatusFD, this method was returning error 1 in release 1.0.0.
1.0.0	March 8, 2022	Initial release (buggy, do not use).

2 Features

The ACANFD_FeatherM4CAN library is a CANFD (*Controller Area Network with Flexible Data*) Controller driver for the *Adafruit Feather M4 CAN*¹ board running Arduino. It handles CANFD frames.

This library is compatible with other ACAN libraries and ACAN2517FD library.

It has been designed to make it easy to start and to be easily configurable:

- handles the CAN0 and CAN1 CANFD modules;
- default configuration sends and receives any frame – no default filter to provide;
- efficient built-in CAN bit settings computation from arbitration and data bit rates;
- user can fully define its own CAN bit setting values;
- up to 128 standard reception filters can be easily defined;

¹<https://www.adafruit.com/product/4759>

- up to 128 extended reception filters can be easily defined;
- reception filters accept callback functions;
- driver and controller transmit buffer sizes are customisable;
- driver and controller receive buffer size is customisable;
- overflow of the driver receive buffer is detectable;
- the message RAM allocation is customizable and the driver checks no overflow occurs;
- *internal loop back*, *external loop back* controller modes are selectable.

3 CAN Interfaces

The Adafruit Feather M4 CAN board contains a ATSAME51J19 that implements two CANFD modules: CAN0 and CAN1.

3.1 CAN0

The microcontroller CAN0 pins are available on the board connector: D12 is CAN0_TX, D13 is CAN0_RX (see [figure 1](#)). For connecting to a CAN bus, you should add a CANFD transceiver. Note D13 is also connected to builtin red led.

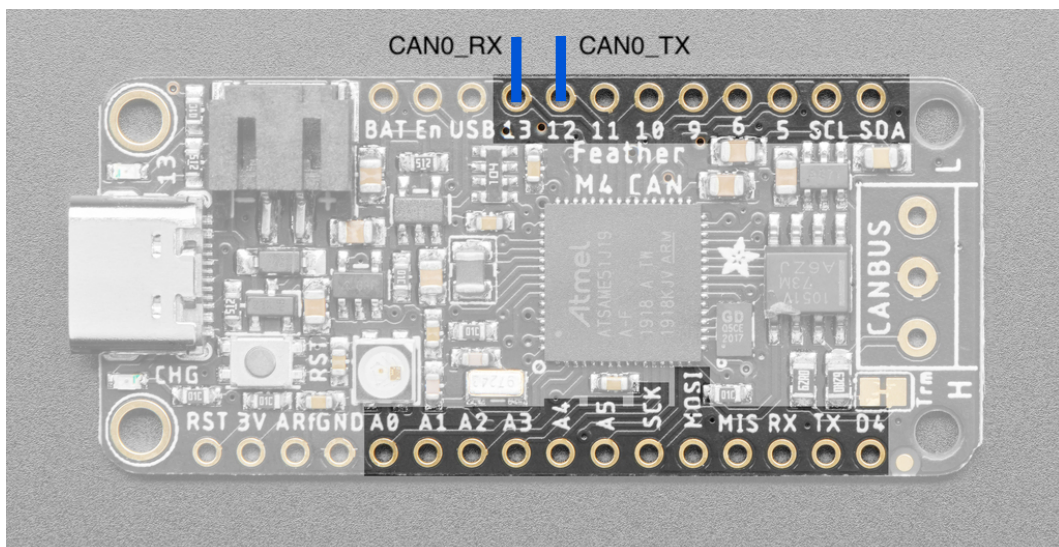


Figure 1 – CAN0 pins

3.2 CAN1

The microcontroller CAN1 pins are not available on the board connector, but CANH and CANL pins (see [figure 2](#)). The board includes a 3V-logic compatible transceiver². Note the library handles two additional signals: PIN_CAN_STANDBY is configured as low digital output (turning off transceiver's STANDBY mode), and pin 4 is configured as high digital output (turning on transceiver's power).

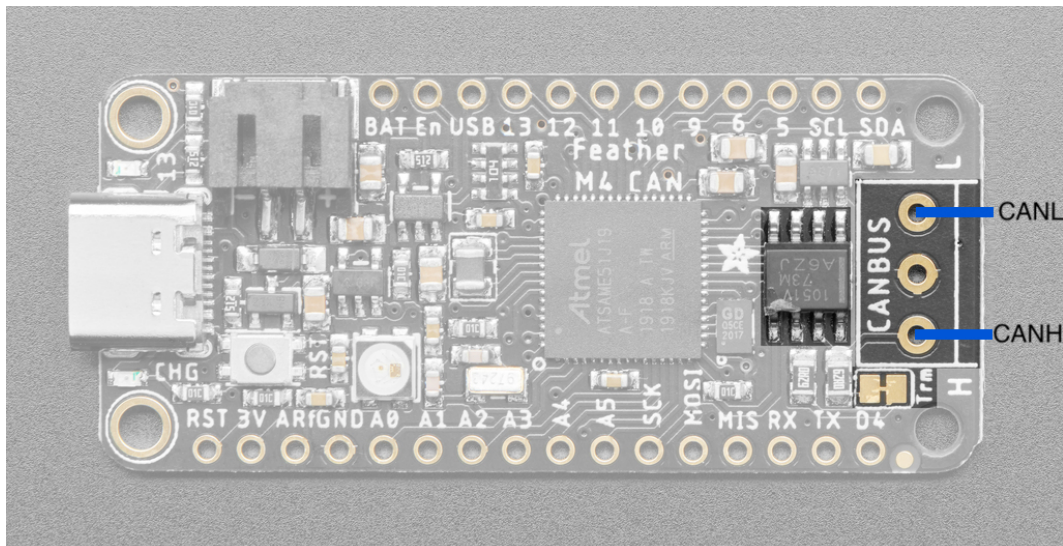


Figure 2 – CAN1 pins

4 Data flow

The [figure 3](#) illustrates default message flow of sending and receiving CANFD messages for CAN0 and CAN1 modules.

Sending messages. The ACANFD_FeatherM4CAN driver defines a *driver transmit FIFO* (default size: 20 messages), and configures the module with a *hardware transmit FIFO* with a size of 24 messages, and 8 individual TxBuffer whose capacity is one message.

A message is defined by an instance of the CANFDMessage or CANMessage class. For sending a message, user code calls the tryToSendReturnStatusFD method – see [section 14 page 19](#) for details, and the idx property of the sent message should be:

- 0 (default value), for sending via *driver transmit FIFO* and *hardware transmit FIFO*;
- 1, for sending via TxBuffer₀;
- ...
- 8, for sending via TxBuffer₇.

²<https://learn.adafruit.com/adafruit-feather-m4-can-express/pinouts>

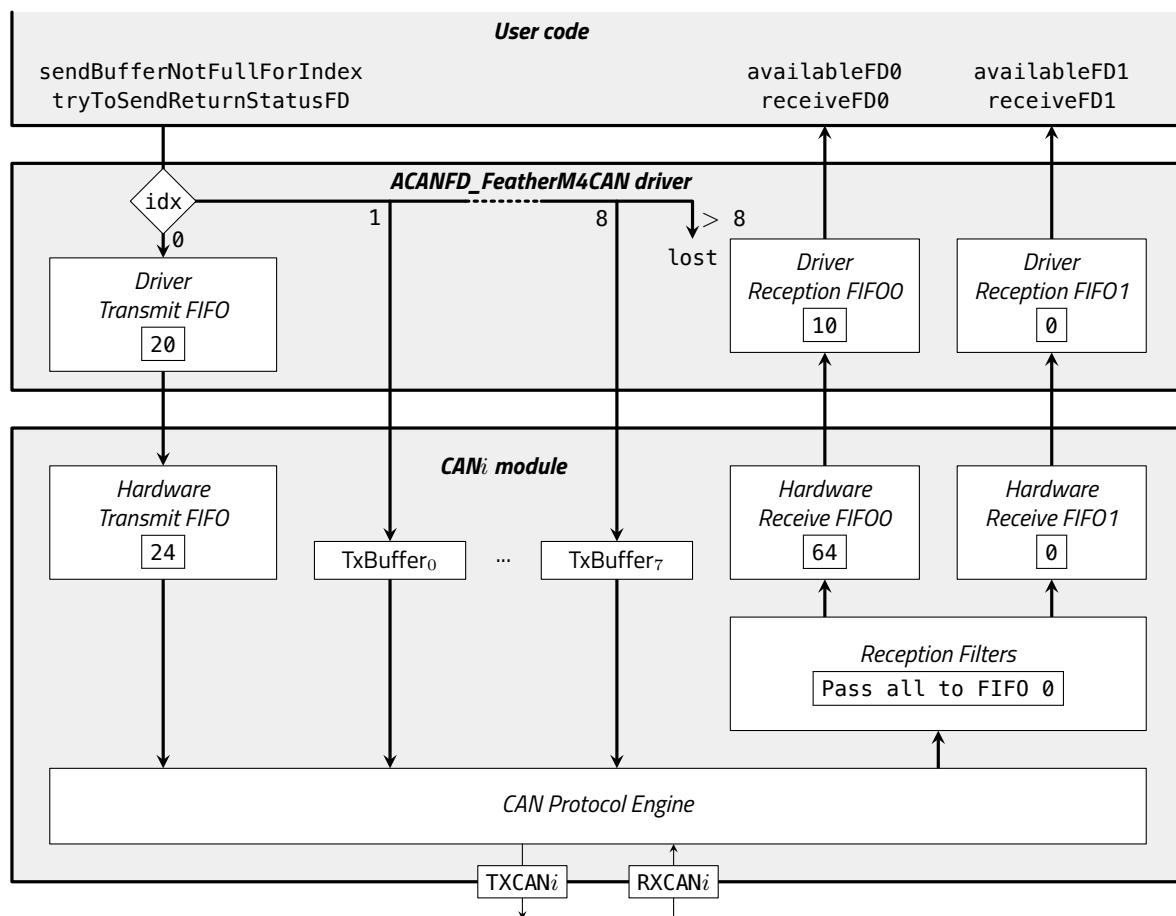


Figure 3 – Message flow in ACANFD_FeatherM4CAN driver and CAN i module, default configuration

If the `idx` property is greater than 8, the message is lost.

You can call the `sendBufferNotFullForIndex` method ([section 14.1 page 20](#)) for testing if a send buffer is not full.

Receiving messages. The *CAN Protocol Engine* transmits all correct frames to the *reception filters*. By default, they are configured as pass-all to FIFO0, see [section 16 page 23](#) for configuring them. Messages that pass the filters are stored in the *Hardware Reception FIFO0* or in the *Hardware Reception FIFO1*. The interrupt service routine transfers the messages from the FIFO i to the *Driver Receive FIFO i* . The size of the *Driver Receive FIFO 0* is 10 by default – see [section 15.1 page 22](#) for changing the default value. Two user methods are available:

- the `availableFD0` method returns `false` if the *Driver Receive FIFO0* is empty, and `true` otherwise;
- the `receiveFD0` method retrieves messages from the *Driver Receive FIFO0* – see [section 15 page 21](#);
- the `availableFD1` method returns `false` if the *Driver Receive FIFO1* is empty, and `true` otherwise;
- the `receiveFD1` method retrieves messages from the *Driver Receive FIFO1* – see [section 15 page 21](#).

5 A sample sketch: LoopBackDemoCANFD_CAN1

The LoopBackDemoCANFD_CAN1 sketch is a sample code for introducing the ACANFD_FeatherM4CAN library. It demonstrates how to configure the library, to send a CANFD message, and to receive a CANFD message.

Note: this code runs without any CAN connection, the CAN1 module is configured in EXTERNAL_LOOP_BACK mode (see [section 21.10.1 page 42](#)); the CAN1 module receives every CANFD frame it sends, and emitted frames can be observed on CANH/CANL pins.

ACANFD_FeatherM4CAN configuration.

```
#define CAN0_MESSAGE_RAM_SIZE (0)
#define CAN1_MESSAGE_RAM_SIZE (1728)

#include <ACANFD_FeatherM4CAN.h>
```

Before including the ACANFD_FeatherM4CAN library, you should define the CAN0_MESSAGE_RAM_SIZE and the CAN1_MESSAGE_RAM_SIZE macro names.

Each CANFD module uses a private *Message RAM* ([section 13 page 18](#)) that is in the first 64 kio of the microcontroller SRAM. Its size depends from the current module configuration, and cannot exceed 4,352 32-bits words (17,408 bytes). Here, CAN0_MESSAGE_RAM_SIZE value is 0, meaning that the CAN0 module is not configured; its TxCAN and RxCAN pins can be freely used for an other function. CAN1_MESSAGE_RAM_SIZE value is 1728, therefore CAN1 module Message RAM has a capacity of 1,728 32-bit words (6,912 bytes), that corresponds to the default configuration.

Note you should include <ACANFD_FeatherM4CAN.h> only once, from the .ino source file. From an other C++ file, you should include <ACANFD_FeatherM4CAN-from-cpp.h>.

If you include <ACANFD_FeatherM4CAN.h> from several files, the can0 and / or can1 variables are multiply-defined, therefore you get a link error.

The setup function.

```
void setup () {
  //--- Switch on builtin led
  pinMode (LED_BUILTIN, OUTPUT) ;
  digitalWrite (LED_BUILTIN, HIGH) ;
  //--- Start serial
  Serial.begin (115200) ;
  //--- Wait for serial (blink led at 10 Hz during waiting)
  while (!Serial) {
    delay (50) ;
    digitalWrite (LED_BUILTIN, !digitalRead (LED_BUILTIN)) ;
  }
}
```

Builtin led is used for signaling. It blinks led at 10 Hz during until serial monitor is ready.

```
ACANFD_FeatherM4CAN_Settings settings (1000 * 1000, DataBitRateFactor::x2) ;
```

Configuration is a four-step operation. This line is the first step. It instantiates the settings object of the

ACANFD_FeatherM4CAN_Settings class. The constructor has two parameters: the desired CAN arbitration bit rate (here, 1 Mbit/s), and the data bit rate, given by a multiplicative factor of the arbitration bit rate; here, the data bit rate is 1 Mbit/s * 2 = 2 Mbit/s. It returns a settings object fully initialized with CAN bit settings for the desired arbitration and data bit rates, and default values for other configuration properties.

```
settings.mModuleMode = ACANFD_FeatherM4CAN_Settings::EXTERNAL_LOOP_BACK ;
```

This is the second step. You can override the values of the properties of settings object. Here, the mModuleMode property is set to EXTERNAL_LOOP_BACK – its value is NORMAL_FD by default. Setting this property enables *external loop back*, that is you can run this demo sketch even if you have no connection to a physical CAN network. The [section 21.10 page 42](#) lists all properties you can override.

```
const uint32_t errorCode = can1.beginFD ( ) ;
```

This is the third step, configuration of the CAN1 driver with settings values (for configuring the CAN0 module, use the can0 variable). The driver is configured for being able to send any (base / extended, data / remote, CAN / CANFD) frame, and to receive all (base / extended, data / remote, CAN / CANFD) frames. If you want to define reception filters, see [section 16 page 23](#).

```
if (errorCode != 0) {  
    Serial.print ("Configuration error 0x") ;  
    Serial.println (errorCode, HEX) ;  
}
```

Last step: the configuration of the can driver returns an error code, stored in the errorCode constant. It has the value 0 if all is ok – see [section 20.2 page 33](#).

The pseudoRandomValue function.

This function generates values that are used for generating random CANFD messages.

```
static uint32_t pseudoRandomValue (void) {  
    static uint32_t gSeed = 0 ;  
    gSeed = 8253729U * gSeed + 2396403U ;  
    return gSeed ;  
}
```

The global variables.

```
static const uint32_t PERIOD = 1000 ;  
static uint32_t gBlinkDate = PERIOD ;  
static uint32_t gSentCount = 0 ;  
static uint32_t gReceiveCount = 0 ;  
static CANFDMessage gSentFrame ;  
static bool gOk = true ;
```

The gBlinkDate global variable is used for sending a CAN message every second. The gSentCount global variable counts the number of sent messages. The sent message is stored in the gSentFrame variable. While gOk is true, the received message is compared to the sent message. If they are different, gOk is set to false, and no more message is sent. The gReceiveCount global variable counts the number of successfully received messages.

The Loop function.

```
void loop () {
  if (gBlinkDate <= millis ()) {
    gBlinkDate += PERIOD ;
    digitalWrite (LED_BUILTIN, !digitalRead (LED_BUILTIN)) ;
    if (gOk) {
      ... build random CANFD frame ...
      const uint32_t sendStatus = can1.tryToSendReturnStatusFD (gSentFrame) ;
      if (sendStatus == 0) {
        gSentCount += 1 ;
        Serial.print ("Sent ") ;
        Serial.println (gSentCount) ;
      }else{
        Serial.print ("Sent error 0x") ;
        Serial.println (sendStatus) ;
      }
    }
  }
  //--- Receive frame
  CANFDMessage frame ;
  if (gOk && can1.receiveFD0 (frame)) {
    bool sameFrames = ... compare frame and gSentFrame ... ;
    if (sameFrames) {
      gReceiveCount += 1 ;
      Serial.print ("Received ") ;
      Serial.println (gReceiveCount) ;
    }else{
      gOk = false ;
      ... Print error ...
    }
  }
}
```

6 The CANMessage class

Note. The CANMessage class is declared in the CANMessage.h header file. The class declaration is protected by an include guard that causes the macro GENERIC_CAN_MESSAGE_DEFINED to be defined. The ACAN2515 driver³, the ACAN2517 driver⁴ and the ACAN2517FD driver⁵ contain an identical CANMessage.h header file, enabling using the ACANFD_FeatherM4CAN driver, the ACAN2515 driver, ACAN2517 driver and ACAN2517FD driver in a same sketch.

³The ACAN2515 driver is a CAN driver for the MCP2515 CAN controller, <https://github.com/pierremolinaro/acan2515>.

⁴The ACAN2517 driver is a CAN driver for the MCP2517FD CAN controller in CAN 2.0B mode, <https://github.com/pierremolinaro/acan2517>.

⁵The ACAN2517FD driver is a CANFD driver for the MCP2517FD CAN controller in CANFD mode, <https://github.com/pierremolinaro/acan2517fd>.

A *CAN message* is an object that contains all CAN 2.0B frame user informations. All properties are initialized by default, and represent a base data frame, with an identifier equal to 0, and without any data. In this library, the `CANMessage` class is only used by a `CANFDMessage` constructor ([section 7.3 page 13](#)).

```
class CANMessage {
    public : uint32_t id = 0 ; // Frame identifier
    public : bool ext = false ; // false -> standard frame, true -> extended frame
    public : bool rtr = false ; // false -> data frame, true -> remote frame
    public : uint8_t idx = 0 ; // This field is used by the driver
    public : uint8_t len = 0 ; // Length of data (0 ... 8)
    public : union {
        uint64_t data64 ; // Caution: subject to endianness
        int64_t data_s64 ; // Caution: subject to endianness
        uint32_t data32 [2] ; // Caution: subject to endianness
        int32_t data_s32 [2] ; // Caution: subject to endianness
        float dataFloat [2] ; // Caution: subject to endianness
        uint16_t data16 [4] ; // Caution: subject to endianness
        int16_t data_s16 [4] ; // Caution: subject to endianness
        int8_t data_s8 [8] ;
        uint8_t data [8] = {0, 0, 0, 0, 0, 0, 0, 0} ;
    } ;
} ;
```

Note the message datas are defined by an **union**. So message datas can be seen as eight bytes, four 16-bit unsigned integers, two 32-bit, one 64-bit or two 32-bit floats. Be aware that multi-byte integers and floats are subject to endianness (Cortex M4 processor of the ATSAME51G19A is little-endian).

The `idx` property is not used in CAN frames, but:

- for a received message, it contains the acceptance filter index (see [section 17 page 30](#)) or 255 if it does not correspond to any filter;
- on sending messages, it is used for selecting the transmit buffer (see [section 14 page 19](#)).

7 The CANFDMessage class

Note. The `CANFDMessage` class is declared in the `CANFDMessage.h` header file. The class declaration is protected by an include guard that causes the macro `GENERIC_CANFD_MESSAGE_DEFINED` to be defined. This allows an other library to freely include this file without any declaration conflict. The `ACAN2517FD` driver⁶ contains an identical `CANFDMessage.h` header file, enabling using the `ACANFD_FeatherM4CAN` driver and the `ACAN2517FD` driver in a same sketch.

A CANFD message is an object that contains all CANFD frame user informations.

Example: The message object describes an extended frame, with identifier equal to `0x123`, that contains 12 bytes of data:

⁶The `ACAN2517FD` driver is a CANFD driver for the MCP2517FD CAN controller in CANFD mode, <https://github.com/pierremolinaro/acan2517fd>.

7.1 Properties

```
CANFDMessage message ; // message is fully initialized with default values
message.id = 0x123 ; // Set the message identifier (it is 0 by default)
message.ext = true ; // message is an extended one (it is a base one by default)
message.len = 12 ; // message contains 12 bytes (0 by default)
message.data [0] = 0x12 ; // First data byte is 0x12
...
message.data [11] = 0xCD ; // 11th data byte is 0xCD
```

7.1 Properties

```
class CANFDMessage {
...
public : uint32_t id; // Frame identifier
public : bool ext ; // false -> base frame, true -> extended frame
public : Type type ;
public : uint8_t idx ; // Used by the driver
public : uint8_t len ; // Length of data (0 ... 64)
public : union {
    uint64_t data64 [ 8] ; // Caution: subject to endianness
    uint32_t data32 [16] ; // Caution: subject to endianness
    uint16_t data16 [32] ; // Caution: subject to endianness
    float dataFloat [16] ; // Caution: subject to endianness
    uint8_t data [64] ;
} ;
...
} ;
```

Note the message datas are defined by an **union**. So message datas can be seen as 64 bytes, 32 x 16-bit unsigned integers, 16 x 32-bit, 8 x 64-bit or 16 x 32-bit floats. Be aware that multi-byte integers are subject to endianness (Cortex M4 processors of Teensy 3.x are little-endian).

7.2 The default constructor

All properties are initialized by default, and represent a base data frame, with an identifier equal to 0, and without any data ([table 2](#)).

Property	Initial value	Comment
id	0	
ext	false	Base frame
type	CANFD_WITH_BIT_RATE_SWITCH	CANFD frame, with bit rate switch
idx	0	
len	0	No data
data	–	<i>unitialized</i>

Table 2 – CANFDMessage default constructor initialization

7.3 Constructor from CANMessage

```
class CANFDMessage {  
    ...  
    CANFDMessage (const CANMessage & inCANMessage) ;  
    ...  
} ;
```

All properties are initialized from the `inCANMessage` ([table 3](#)). Note that only `data64[0]` is initialized from `inCANMessage.data64`.

Property	Initial value
<code>id</code>	<code>inCANMessage.id</code>
<code>ext</code>	<code>inCANMessage.ext</code>
<code>type</code>	<code>inCANMessage.rtr ? CAN_REMOTE : CAN_DATA</code>
<code>idx</code>	<code>inCANMessage.idx</code>
<code>len</code>	<code>inCANMessage.len</code>
<code>data64[0]</code>	<code>inCANMessage.data64</code>

Table 3 – CANFDMessage constructor CANMessage

7.4 The type property

The type property value is an instance of an enumerated type:

```
class CANFDMessage {  
    ...  
    public: typedef enum : uint8_t {  
        CAN_REMOTE,  
        CAN_DATA,  
        CANFD_NO_BIT_RATE_SWITCH,  
        CANFD_WITH_BIT_RATE_SWITCH  
    } Type ;  
    ...  
} ;
```

The type property specifies the frame format, as indicated in the [table 4](#).

type property	Meaning	Constraint on len
<code>CAN_REMOTE</code>	CAN 2.0B remote frame	0 ... 8
<code>CAN_DATA</code>	CAN 2.0B data frame	0 ... 8
<code>CANFD_NO_BIT_RATE_SWITCH</code>	CANFD frame, no bit rate switch	0 ... 8, 12, 16, 20, 24, 32, 48, 64
<code>CANFD_WITH_BIT_RATE_SWITCH</code>	CANFD frame, bit rate switch	0 ... 8, 12, 16, 20, 24, 32, 48, 64

Table 4 – CANFDMessage type property

7.5 The len property

Note that len property contains the actual length, not its encoding in CANFD frames. So valid values are: 0, 1, ..., 8, 12, 16, 20, 24, 32, 48, 64. Having other values is an error that prevents frame to be sent by the `ACANFD_FeatherM4CAN::tryToSendReturnStatusFD` method. You can use the pad method (see [section 7.7 page 14](#)) for padding with 0x00 bytes to the next valid length.

7.6 The idx property

The idx property is not used in CANFD frames, but it is used for selecting the transmit buffer (see [section 14 page 19](#)).

7.7 The pad method

```
void CANFDMessage::pad (void) ;
```

The `CANFDMessage::pad` method appends zero bytes to datas for reaching the next valid length. Valid lengths are: 0, 1, ..., 8, 12, 16, 20, 24, 32, 48, 64. If the length is already valid, no padding is performed. For example:

```
CANFDMessage frame ;  
frame.length = 21 ; // Not a valid value for sending  
frame.pad () ;  
// frame.length is 24, frame.data [21], frame.data [22], frame.data [23] are 0
```

7.8 The isValid method

```
bool CANFDMessage::isValid (void) const ;
```

Not all settings of `CANFDMessage` instances represent a valid frame. Valid lengths are: 0, 1, ..., 8, 12, 16, 20, 24, 32, 48, 64. For example, there is no CANFD remote frame, so a remote frame should have its length lower than or equal to 8. There is no constraint on extended / base identifier (ext property).

The `isValid` returns true if the constraints on the len property are checked, as indicated the [table 4 page 13](#), and false otherwise.

8 Transmit FIFO

The transmit FIFO (see [figure 3 page 7](#)) is composed by:

- the *driver transmit FIFO*, whose size is positive or zero (default 20); you can change the default size by setting the `mDriverTransmitFIFOSize` property of your settings object;
- the *hardware transmit FIFO*, whose size is between 1 and 32 (default 24); you can change the default size by setting the `mHardwareTransmitTxFIFOSize` property of your settings object.

8.1 The driverTransmitFIFOSize method

For sending a message through the *Transmit FIFO*, call the `tryToSendReturnStatusFD` method with a message whose `idx` property is zero:

- if the *controller transmit FIFO* is not full, the message is appended to it, and `tryToSendReturnStatusFD` returns 0;
- otherwise, if the *driver transmit FIFO* is not full, the message is appended to it, and `tryToSendReturnStatusFD` returns 0; the interrupt service routine will transfer messages from *driver transmit FIFO* to the *hardware transmit FIFO* while it is not full;
- otherwise, both FIFOs are full, the message is not stored and `tryToSendReturnStatusFD` returns the `kTransmitBufferOverflow` error.

The transmit FIFO ensures sequentiality of emission.

8.1 The driverTransmitFIFOSize method

The `driverTransmitFIFOSize` method returns the allocated size of this driver transmit FIFO, that is the value of `settings.mDriverTransmitFIFOSize` when the `begin` method is called.

```
const uint32_t s = can0.driverTransmitFIFOSize ();
```

8.2 The driverTransmitFIFOCount method

The `driverTransmitFIFOCount` method returns the current number of messages in the driver transmit FIFO.

```
const uint32_t n = can0.driverTransmitFIFOCount ();
```

8.3 The driverTransmitFIFOPeakCount method

The `driverTransmitFIFOPeakCount` method returns the peak value of message count in the driver transmit FIFO.

```
const uint32_t max = can0.driverTransmitFIFOPeakCount ();
```

If the transmit FIFO is full when `tryToSendReturnStatusFD` is called, the return value of this call is `kTransmitBufferOverflow`. In such case, the following calls of `driverTransmitBufferPeakCount()` will return `driverTransmitFIFOSize()+1`.

So, when `driverTransmitFIFOPeakCount()` returns a value lower or equal to `transmitFIFOSize()`, it means that calls to `tryToSendReturnStatusFD` do not provide any overflow of the driver transmit FIFO.

9 Transmit buffers (TxBuffer_i)

You can use `settings.mHardwareDedicatedTxBufferCount` TxBuffers for sending messages. A TxBuffer has a capacity of 1 message. So it is either empty, either full. You can call the `sendBufferNotFullForIndex` method ([section 14.1 page 20](#)) for testing if a TxBuffer is empty or full.

The `settings.mHardwareDedicatedTxBufferCount` property can be set to any integer value between 0 and 32.

10 Transmit Priority

Pending dedicated TxBuffer_i and oldest pending Tx FIFO buffer are scanned, and buffer with lowest message identifier gets highest priority and is transmitted next.

11 Receive FIFOs

A CAN module contains two receive FIFOs, FIF00 and FIF01. **By default, only FIF00 is enabled, FIF01 is not configured.**

the receive FIFO_i ($0 \leq i \leq 1$, see [figure 3 page 7](#)) is composed by:

- the *hardware receive FIFO_i* (in the Message RAM, see [section 13 page 18](#)), whose size is between 0 and 64 (default 64 for CAN0, 0 for CAN1); you can change the default size by setting the `mHardwareRxFIFOiSize` property of your `settings` object;
- the *driver receive FIFO_i* (in library software), whose size is positive (default 10 for CAN0, 0 for CAN1); you can change the default size by setting the `mDriverReceiveFIFOiSize` property of your `settings` object.

The receive FIFO mechanism ensures sequentiality of reception.

12 Payload size

Hardware transmit FIFO, TxBuffers and hardware receive FIFOs objects are stored in the Message RAM, the details of Message RAM usage computation are presented in [section 13 page 18](#). The size of each object depends on the setting applied to the corresponding FIFO or buffer.

By default, all objects accept frames up to 64 data bytes. The size of each object is 72 bytes. If your application sends and / or receives messages with less than 64 bytes, you can reduce Message RAM size by setting the payload properties of `ACANFD_FeatherM4CAN_Settings` class, as described in [table 5](#). The type of these properties is the `ACANFD_FeatherM4CAN_Settings::Payload` enumeration type, and defines 8 values ([table 6](#)).

12.1 The ACANFD_FeatherM4CAN_Settings::wordCountForPayload static method

Object Size specification	Default value	Applies to
mHardwareTransmitBufferPayload	PAYLOAD_64_BYTES	Hardware transmit FIFO, TxBuffers
mHardwareRxFIFO0Payload	PAYLOAD_64_BYTES	Hardware receive FIFO 0
mHardwareRxFIFO1Payload	PAYLOAD_64_BYTES	Hardware receive FIFO 1

Table 5 – Payload properties of ACANFD_FeatherM4CAN_Settings class

Object Size specification	Handles frames up to	Object Size
ACANFD_FeatherM4CAN_Settings::PAYLOAD_8_BYTES	8 bytes	4 words = 16 bytes
ACANFD_FeatherM4CAN_Settings::PAYLOAD_12_BYTES	12 bytes	5 words = 20 bytes
ACANFD_FeatherM4CAN_Settings::PAYLOAD_16_BYTES	16 bytes	6 words = 24 bytes
ACANFD_FeatherM4CAN_Settings::PAYLOAD_20_BYTES	20 bytes	7 words = 28 bytes
ACANFD_FeatherM4CAN_Settings::PAYLOAD_24_BYTES	24 bytes	8 words = 32 bytes
ACANFD_FeatherM4CAN_Settings::PAYLOAD_32_BYTES	32 bytes	10 words = 40 bytes
ACANFD_FeatherM4CAN_Settings::PAYLOAD_48_BYTES	48 bytes	14 words = 56 bytes
ACANFD_FeatherM4CAN_Settings::PAYLOAD_64_BYTES	64 bytes	18 words = 72 bytes

Table 6 – ACANFD_FeatherM4CAN_Settings object size from payload size specification

12.1 The ACANFD_FeatherM4CAN_Settings::wordCountForPayload static method

```
uint32_t ACANFD_FeatherM4CAN_Settings::wordCountForPayload (const Payload inPayload);
```

This static method returns the object word size for a given payload specification, following [table 6](#).

12.2 The ACANFD_FeatherM4CAN_Settings::frameDataByteCountForPayload static method

```
uint32_t ACANFD_FeatherM4CAN_Settings::frameDataByteCountForPayload (const Payload inPayload);
```

This static method returns the handled data byte count for a given payload specification, following [table 6](#).

12.3 Changing the default payloads

See LoopBackDemoCANFDIntensive_CAN1_payload sample sketch.

Overriding the default payloads enables saving Message RAM size.

mHardwareTransmitBufferPayload. Setting the mHardwareTransmitBufferPayload property limits the size of TxBuffers. Data bytes beyond this limit are not stored in the TxBuffers. The transmitted frame does not contain this data bytes, but 0xCC bytes instead. For example, if it is set to ACANFD_FeatherM4CAN_Settings::PAYLOAD_24_BYTES, and a 32-byte data frame is submitted:

- for indexes from 0 to 23, the transmitted data are those of the message;
- for indexes from 24 to 31, 0xCC data bytes are sent.

If you submit a frame with 24 bytes of data or less, all message bytes are sent.

mHardwareRxFIFO0Payload. Setting the `mHardwareTransmitBufferPayload` property limits the size of hardware FIFO 0 elements. Received frame data bytes beyond this limit are not stored in the hardware FIFO 0. The retrieved frame does not contain this data bytes, but `0xCC` bytes instead. For example, if it is set to `ACANFD_FeatherM4CAN_Settings::PAYLOAD_24_BYTES`, and a 32-byte data frame is received:

- for indexes from 0 to 23, the message contains the received frame corresponding data bytes;
- for indexes from 24 to 31, the message contains `0xCC` data bytes.

If a frame with 24 bytes of data or less is received, all message bytes are received.

mHardwareRxFIFO1Payload. Same for hardware FIFO 1 elements.

13 Message RAM

Each CAN module of the ATSAME51G19A uses a *Message RAM* for storing TxBuffers, hardware transmit FIFO, hardware receives FIFO, and reception filters.

The two Message RAM have a width of 32 bits and are part of ATSAME51G19A SRAM, and they should be located in the first 64 kio (`0x2000'0000 – 0x2000'FFFF`). Their size is less than 4352 words (17,408 bytes).

A message RAM contains⁷:

- standard filters (0-128 elements, 0-128 words);
- extended filters (0-64 elements, 0-128 words);
- receive FIFO 0 (0-64 elements, 0-1152 words);
- receive FIFO 1 (0-64 elements, 0-1152 words);
- Rx Buffers (0-64 elements, 0-1152 words);
- Tx Event FIFO (0-32 elements, 0-64 words);
- Tx Buffers (0-32 elements, 0-576 words);

So its size cannot exceed 4352 words (17,408 bytes).

The current release of this library allows to define only the following elements:

- standard filters (0-128 elements, 0-128 words);
- extended filters (0-64 elements, 0-128 words);
- receive FIFO 0 (0-64 elements, 0-1152 words);
- receive FIFO 1 (0-64 elements, 0-1152 words);

⁷See DS60001507G, section 39.9.1 page 1177.

-
- Tx Buffers (0-32 elements, 0-576 words);

Its size is therefore actually limited to 3,136 words (12,144 bytes).

There are five properties of `ACANFD_FeatherM4CAN_Settings` class that affect the actual message RAM size:

- the `mHardwareRxFIFO0Size` property sets the hardware receive FIFO 0 element count (0-64);
- the `mHardwareRxFIFO0Payload` property sets the size of the hardware receive FIFO 0 element ([table 6](#));
- the `mHardwareRxFIFO1Size` property sets the hardware receive FIFO 1 element count (0-64);
- the `mHardwareRxFIFO1Payload` property sets the size of the hardware receive FIFO 1 element ([table 6](#));
- the `mHardwareTransmitTxFIFOSize` property sets the hardware transmit FIFO element count (0-32);
- the `mHardwareDedicatedTxBufferCount` property set the number of dedicated TxBuffers (0-32);
- the `mHardwareTransmitBufferPayload` property sets the size of the TxBuffers and hardware transmit FIFO element ([table 6](#)).

The `ACANFD_FeatherM4CAN::messageRamRequiredSize` method returns the required word size.

The `ACANFD_FeatherM4CAN::begin` method checks the message RAM allocated size is greater or equal to the required size. Otherwise, it raises the error code `kMessageRamTooSmall`. It checks also the message RAM is in the first 64 kio of the SRAM. Otherwise, it raises the error code `kMessageRamNotInFirst64kio`.

14 Sending frames: the `tryToSendReturnStatusFD` method

The `ACANFD_FeatherM4CAN::tryToSendReturnStatusFD` method sends CAN 2.0B and CANFD frames:

```
uint32_t ACANFD_FeatherM4CAN::tryToSendReturnStatusFD (const CANFDMessage & inMessage);
```

You call the `tryToSendReturnStatusFD` method for sending a message in the CAN network. Note this function returns before the message is actually sent; this function only adds the message to a transmit buffer. It returns:

- `kInvalidMessage` (value: 1) if the message is not valid (see [section 7.8 page 14](#));
- `kTransmitBufferIndexTooLarge` (value: 2) if the `idx` property value does not specify a valid transmit buffer (see below);
- `kTransmitBufferOverflow` (value: 3) if the transmit buffer specified by the `idx` property value is full;
- 0 (no error) if the message has been successfully added to the transmit buffer specified by the `idx` property value.

14.1 Testing a send buffer: the `sendBufferNotFullForIndex` method

The `idx` property of the message specifies the transmit buffer:

- 0 for the transmit FIFO ([section 8 page 14](#));
- 1 ... `settings.mHardwareDedicacedTxBufferCount` for a dedicaced TxBuffer ([section 9 page 16](#)).

The type property of `inMessage` specifies how the frame is sent:

- `CAN_REMOTE`, the frame is sent in the CAN 2.0B remote frame format;
- `CAN_DATA`, the frame is sent in the CAN 2.0B data frame format;
- `CANFD_NO_BIT_RATE_SWITCH`, the frame is sent in CANFD format at arbitration bit rate, regardless of the `ACANFD_FeatherM4CAN_Settings::DATA_BITRATE_xn` setting;
- `CANFD_WITH_BIT_RATE_SWITCH`, with the `ACANFD_FeatherM4CAN_Settings::DATA_BITRATE_x1` setting, the frame is sent in CANFD format at arbitration bit rate, and otherwise in CANFD format with bit rate switch.

14.1 Testing a send buffer: the `sendBufferNotFullForIndex` method

```
bool ACANFD_FeatherM4CAN::sendBufferNotFullForIndex (const uint32_t inTxBufferIndex);
```

This method returns `true` if the corresponding transmit buffer is not full, and `false` otherwise ([table 7](#)).

inTxBufferIndex	Operation
0	true if the transmit FIFO is not full, and false otherwise
1 ... <code>settings.mHardwareDedicacedTxBufferCount</code>	true if the TxBuffer _i is empty, and false if it is full
> <code>settings.mHardwareDedicacedTxBufferCount</code>	false

Table 7 – Value returned by the `sendBufferNotFullForIndex` method

14.2 Usage example

A way is to use a global variable to note if the message has been successfully transmitted to driver transmit buffer. For example, for sending a message every 2 seconds:

```
static uint32_t gSendDate = 0 ;

void loop () {
  if (gSendDate < millis ()) {
    CANFDMessage message ;
    // Initialize message properties
    const uint32_t sendStatus = can0.tryToSendReturnStatusFD (message) ;
    if (sendStatus == 0) {
      gSendDate += 2000 ;
    }
  }
}
```

An other hint to use a global boolean variable as a flag that remains true while the message has not been sent.

```
static bool gSendMessage = false ;

void loop () {
    ...
    if (frame_should_be_sent) {
        gSendMessage = true ;
    }
    ...
    if (gSendMessage) {
        CANMessage message ;
        // Initialize message properties
        const uint32_t sendStatus = can0.tryToSendReturnStatusFD (message) ;
        if (sendStatus == 0) {
            gSendMessage = false ;
        }
    }
    ...
}
```

15 Retrieving received messages using the receiveFD*i* method

```
bool ACANFD_FeatherM4CAN::receiveFD0 (CANFDMessage & outMessage) ;
bool ACANFD_FeatherM4CAN::receiveFD1 (CANFDMessage & outMessage) ;
```

If the receive FIFO *i* is not empty, the oldest message is removed, assigned to outMessage, and the method returns true. If the receive FIFO *i* is empty, the method returns false.

This is a basic example:

```
void loop () {
    CANFDMessage message ;
    if (can0.receiveFD0 (message)) {
        // Handle received message
    }
    ...
}
```

The receive method:

- returns false if the driver receive buffer is empty, message argument is not modified;
- returns true if a message has been removed from the driver receive buffer, and the message argument is assigned.

The type property contains the received frame format:

- CAN_REMOTE, the received frame is a CAN 2.0B remote frame;
- CAN_DATA, the received frame is a CAN 2.0B data frame;
- CANFD_NO_BIT_RATE_SWITCH, the frame received frame is a CANFD frame, received at at arbitration bit rate;
- CANFD_WITH_BIT_RATE_SWITCH, the frame received frame is a CANFD frame, received with bit rate switch.

You need to manually dispatch the received messages. If you did not provide any receive filter, you should check the type property (remote or data frame?), the ext bit (base or extended frame), and the id (identifier value). The following snippet dispatches three messages:

```
void loop () {
  CANFDMessage message ;
  if (can0.receiveFD0 (message)) {
    if (!message.rtr && message.ext && (message.id == 0x123456)) {
      handle_myMessage_0 (message) ; // Extended data frame, id is 0x123456
    }else if (!message.rtr && !message.ext && (message.id == 0x234)) {
      handle_myMessage_1 (message) ; // Base data frame, id is 0x234
    }else if (message.rtr && !message.ext && (message.id == 0x542)) {
      handle_myMessage_2 (message) ; // Base remote frame, id is 0x542
    }
  }
  ...
}
```

The handle_myMessage_0 function has the following header:

```
void handle_myMessage_0 (const CANFDMessage & inMessage) {
  ...
}
```

So are the header of the handle_myMessage_1 and the handle_myMessage_2 functions.

15.1 Driver receive FIFO *i* size

By default, the driver receive FIFO 0 size is 10 and the driver receive FIFO 1 size is 0. You can change them by setting the mDriverReceiveFIFO0Size property and the mDriverReceiveFIFO1Size property of settings variable before calling the begin method:

```
ACANFD_FeatherM4CAN_Settings settings (125 * 1000,
                                         DataBitRateFactor::x4) ;
settings.mDriverReceiveFIFO0Size = 100 ;
const uint32_t errorCode = can0.begin (settings) ;
...
```

15.2 The driverReceiveFIFO*i*Size method

As the size of CANFDMessage class is 72 bytes, the actual size of the driver receive FIFO 0 is the value of `settings.mDriverReceiveFIFO0Size * 72`, and the actual size of the driver receive FIFO 1 is the value of `settings.mDriverReceiveFIFO1Size * 72`.

15.2 The driverReceiveFIFO*i*Size method

The `driverReceiveFIFOiSize` method returns the size of the driver FIFO *i*, that is the value of the `mDriverReceiveFIFOiSize` property of `settings` variable when the `begin` method is called.

```
const uint32_t s = can0.driverReceiveFIFO0Size ();
```

15.3 The driverReceiveFIFO*i*Count method

The `driverReceiveFIFOiCount` method returns the current number of messages in the driver receive FIFO *i*.

```
const uint32_t n = can0.driverReceiveFIFO0Count ();
```

15.4 The driverReceiveFIFO*i*PeakCount method

The `driverReceiveFIFOiPeakCount` method returns the peak value of message count in the driver receive FIFO *i*.

```
const uint32_t max = can0.driverReceiveFIFO0PeakCount ();
```

If an overflow occurs, further calls of `can0.driverReceiveFIFOiPeakCount ()` return `can0.driverReceiveFIFOiSize ()+1`.

15.5 The resetDriverReceiveFIFO*i*PeakCount method

The `resetDriverReceiveFIFOiPeakCount` method assign the current count to the peak value.

```
can0.resetDriverReceiveFIFO0PeakCount ();
```

16 Acceptance filters

The microcontroller bases the filtering of the received frames on the nature of their identifier: standard or extended. It is not possible to filter by length or by CAN2.0B / CANFD format. The only possibility is to reject all remote frames.

16.1 Acceptance filters for standard frames

for an example sketch, see `LoopBackDemoCANFD_CAN1_StandardFilters`.

You have three ways to act on standard frame filtering:

- setting the `mDiscardReceivedStandardRemoteFrames` property of the `ACANFD_FeatherM4CAN_Settings` class discards every received remote frame (it is false by default);
- the `mNonMatchingStandardFrameReception` property value of the `ACANFD_FeatherM4CAN_Settings` class is applied to every standard frame that do not match any filter; its value can be `FIF00` (default), `FIF01` or `REJECT`;
- define standard filters (as described from [section 16.1.1 page 24](#)), up to 128, none by default.

The standard frame filtering is illustrated by [figure 4](#).

16.1.1 Defining standard frame filters

```
ACANFD_FeatherM4CAN_Settings settings (... , ...) ;
...
ACANFD_FeatherM4CAN::StandardFilters standardFilters ;
standardFilters.addSingle (0x55, ACANFD_FeatherM4CAN_FilterAction::FIF00) ;
...
//--- Reject standard frames that do not match any filter
settings.mNonMatchingStandardFrameReception = ACANFD_FeatherM4CAN_FilterAction::REJECT;
...
const uint32_t errorCode = can1.beginFD (settings, standardFilters) ;
...
```

The `ACANFD_FeatherM4CAN::StandardFilters` class handles a standard frame filter list. Default constructor constructs an empty list. For appending filters, use the `addSingle` ([section 16.1.2 page 24](#)), `addDual` ([section 16.1.3 page 25](#)), `addRange` ([section 16.1.4 page 26](#)) or `addClassic` ([section 16.1.5 page 26](#)) methods. Then, add the `standardFilters` as second argument of `beginFD` call.

Note. Do not forget to set `settings.mNonMatchingStandardFrameReception` to `REJECT`, otherwise all frames rejected by the filters are appended to FIFO 0 (see [figure 4](#) for detail).

16.1.2 Add single filter

```
bool StandardFilters::addSingle (const uint16_t inIdentifier,
                                const ACANFD_FeatherM4CAN_FilterAction inAction,
                                const ACANFD_CallbackRoutine inCallBack = nullptr) ;
```

This filter is valid if `inIdentifier` is lower or equal to `0x7FF`. The method returns true if the filter is valid, and false otherwise. If the filter is valid, this method appends a filter that matches if the received standard frame identifier is equal to `inIdentifier`. If the filter is not valid, the filter is not appended.

The last argument is optional and associates a callback routine to the filter. See [section 17 page 30](#).

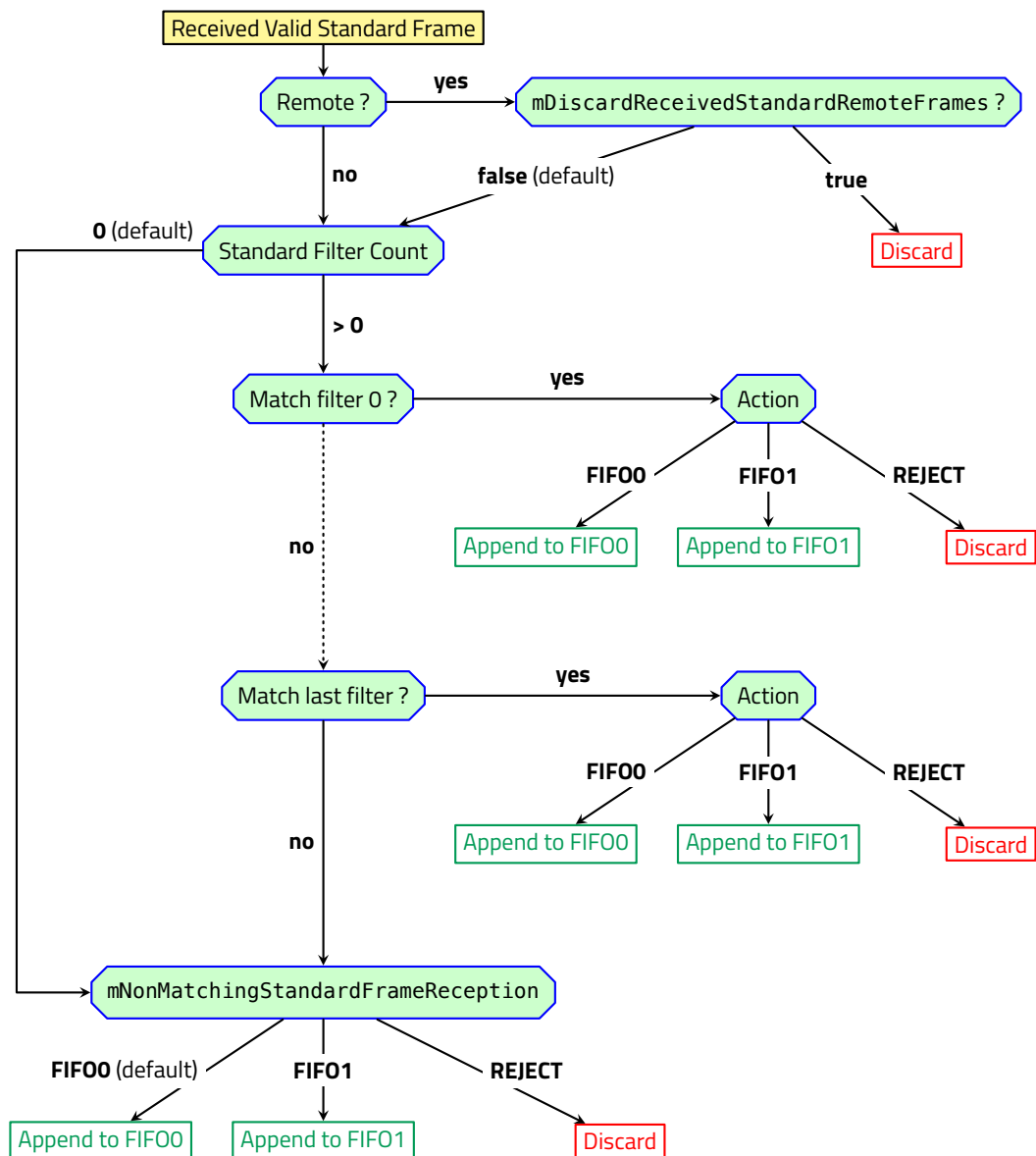


Figure 4 – Standard frame filtering

16.1.3 Add dual filter

```

bool StandardFilters::addDual (const uint16_t inIdentifier1,
                               const uint16_t inIdentifier2,
                               const ACANFD_FeatherM4CAN_FilterAction inAction,
                               const ACANFD_CallbackRoutine inCallBack = nullptr) ;

```

This filter is valid if `inIdentifier1` is lower or equal to `0x7FF` and `inIdentifier2` is lower or equal to `0x7FF`. The method returns `true` if the filter is valid, and `false` otherwise. If the filter is valid, this method appends a filter that matches if the received standard frame identifier is equal to `inIdentifier1` or is equal to `inIdentifier2`. If the filter is not valid, the filter is not appended.

The last argument is optional and associates a callback routine to the filter. See [section 17 page 30](#).

16.1.4 Add range filter

```
bool StandardFilters::addRange (const uint16_t inIdentifier1,
                                const uint16_t inIdentifier2,
                                const ACANFD_FeatherM4CAN_FilterAction inAction,
                                const ACANFDCallBackRoutine inCallBack = nullptr) ;
```

This filter is valid if `inIdentifier1` is lower or equal to `inIdentifier2` and `inIdentifier2` is lower or equal to `0x7FF`. The method returns `true` if the filter is valid, and `false` otherwise. If the filter is valid, this method appends a filter that matches if the received standard frame identifier is greater or equal to `inIdentifier1` and is lower or equal to `inIdentifier2`. If the filter is not valid, the filter is not appended.

The last argument is optional and associates a callback routine to the filter. See [section 17 page 30](#).

16.1.5 Add classic filter

```
bool StandardFilters::addClassic (const uint16_t inIdentifier,
                                   const uint16_t inMask,
                                   const ACANFD_FeatherM4CAN_FilterAction inAction,
                                   const ACANFDCallBackRoutine inCallBack = nullptr) ;
```

This filter is valid if all the following conditions are met:

- `inIdentifier` is lower or equal to `0x7FF`;
- `inMask` is lower or equal to `0x7FF`;
- $(inIdentifier \& inMask)$ is equal to `inIdentifier`.

The method returns `true` if the filter is valid, and `false` otherwise. If the filter is valid, this method appends a filter that matches if the received standard frame identifier verifies $(receivedFrameIdentifier \& inMask)$ is equal to `inIdentifier`. That means:

- if a mask bit is a 1, the received standard frame identifier corresponding bit should match the `inIdentifier` corresponding bit;
- if a mask bit is a 0, the received standard frame identifier corresponding bit can have any value, the `inIdentifier` corresponding bit should be 0.

If the filter is not valid, the filter is not appended.

The last argument is optional and associates a callback routine to the filter. See [section 17 page 30](#).

For example:

```
standardFilters.addClassic (0x405, 0x7D5, ACANFD_FeatherM4CAN_FilterAction::FIF00) ;
```

This filter is valid because $(0x405 \& 0x7D5)$ is equal to `0x405`.

	10	9	8	7	6	5	4	3	2	1	0
inIdentifier: 0x405	1	0	0	0	0	0	0	0	1	0	1
inMask: 0x7D5	1	1	1	1	1	0	1	0	1	0	1
Matching identifiers	1	0	0	0	0	x	0	x	1	x	1

Therefore there are 8 matching identifiers: 0x405, 0x407, 0x40B, 0x40F, 0x425, 0x427, 0x42B, 0x42F.

16.2 Acceptance filters for extended frames

for an example sketch, see `LoopBackDemoCANFD_CAN1_ExtendedFilters`.

You have three ways to act on extended frame filtering:

- setting the `mDiscardReceivedExtendedRemoteFrames` property of the `ACANFD_FeatherM4CAN_Settings` class discards every received remote frame (it is false by default);
- the `mNonMatchingExtendedFrameReception` property value of the `ACANFD_FeatherM4CAN_Settings` class is applied to every extended frame that do not match any filter; its value can be `FIF00` (default), `FIF01` or `REJECT`;
- define extended filters (as described from [section 16.2.1 page 27](#)), up to 128, none by default.

The extended frame filtering is illustrated by [figure 5](#).

16.2.1 Defining extended frame filters

```
ACANFD_FeatherM4CAN_Settings settings (... , ...) ;
...
ACANFD_FeatherM4CAN::ExtendedFilters extendedFilters ;
extendedFilters.addSingle (0x55, ACANFD_FeatherM4CAN_FilterAction::FIF00) ;
...
//--- Reject extended frames that do not match any filter
settings.mNonMatchingExtendedFrameReception = ACANFD_FeatherM4CAN_FilterAction::REJECT;
...
const uint32_t errorCode = can1.beginFD (settings, extendedFilters) ;
...
```

The `ACANFD_FeatherM4CAN::ExtendedFilters` class handles an extended frame filter list. Default constructor constructs an empty list. For appending filters, use the `addSingle` ([section 16.2.2 page 27](#)), `addDual` ([section 16.2.3 page 28](#)), `addRange` ([section 16.2.4 page 29](#)) or `addClassic` ([section 16.2.5 page 29](#)) methods. Then, add the `ExtendedFilters` as second argument of `beginFD` call.

Note. Do not forget to set `settings.mNonMatchingExtendedFrameReception` to `REJECT`, otherwise all frames rejected by the filters are appended to FIFO 0 (see [figure 5](#) for detail).

16.2.2 Add single filter

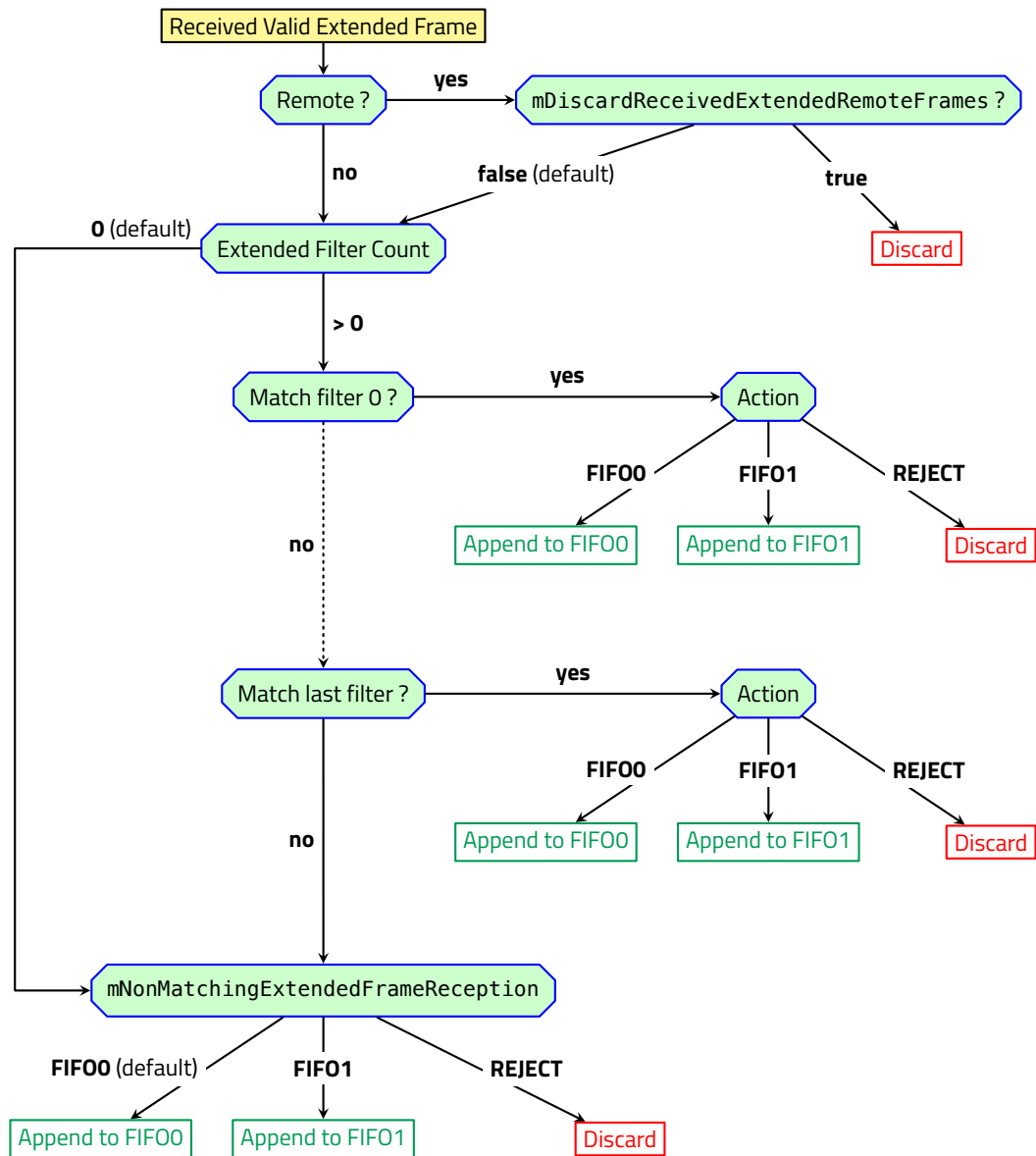


Figure 5 – Extended frame filtering

```

bool ExtendedFilters::addSingle (const uint32_t inIdentifier,
                                const ACANFD_FeatherM4CAN_FilterAction inAction,
                                const ACANFD_CallbackRoutine inCallBack = nullptr) ;

```

This filter is valid if `inIdentifier` is lower or equal to `0x1FFF_FFFF`. The method returns `true` if the filter is valid, and `false` otherwise. If the filter is valid, this method appends a filter that matches if the received extended frame identifier is equal to `inIdentifier`. If the filter is not valid, the filter is not appended.

The last argument is optional and associates a callback routine to the filter. See [section 17 page 30](#).

16.2.3 Add dual filter

```
bool ExtendedFilters::addDual (const uint32_t inIdentifier1,
                              const uint32_t inIdentifier2,
                              const ACANFD_FeatherM4CAN_FilterAction inAction,
                              const ACANFDCallBackRoutine inCallBack = nullptr) ;
```

This filter is valid if `inIdentifier1` is lower or equal to `0x1FFF_FFFF` and `inIdentifier2` is lower or equal to `0x1FFF_FFFF`. The method returns `true` if the filter is valid, and `false` otherwise. If the filter is valid, this method appends a filter that matches if the received extended frame identifier is equal to `inIdentifier1` or is equal to `inIdentifier2`. If the filter is not valid, the filter is not appended.

The last argument is optional and associates a callback routine to the filter. See [section 17 page 30](#).

16.2.4 Add range filter

```
bool ExtendedFilters::addRange (const uint32_t inIdentifier1,
                                const uint32_t inIdentifier2,
                                const ACANFD_FeatherM4CAN_FilterAction inAction,
                                const ACANFDCallBackRoutine inCallBack = nullptr) ;
```

This filter is valid if `inIdentifier1` is lower or equal to `inIdentifier2` and `inIdentifier2` is lower or equal to `0x1FFF_FFFF`. The method returns `true` if the filter is valid, and `false` otherwise. If the filter is valid, this method appends a filter that matches if the received extended frame identifier is greater or equal to `inIdentifier1` and is lower or equal to `inIdentifier2`. If the filter is not valid, the filter is not appended.

The last argument is optional and associates a callback routine to the filter. See [section 17 page 30](#).

16.2.5 Add classic filter

```
bool ExtendedFilters::addClassic (const uint32_t inIdentifier,
                                  const uint32_t inMask,
                                  const ACANFD_FeatherM4CAN_FilterAction inAction,
                                  const ACANFDCallBackRoutine inCallBack = nullptr) ;
```

This filter is valid if all the following conditions are met:

- `inIdentifier` is lower or equal to `0x1FFF_FFFF`;
- `inMask` is lower or equal to `0x1FFF_FFFF`;
- `(inIdentifier & inMask)` is equal to `inIdentifier`.

The method returns `true` if the filter is valid, and `false` otherwise. If the filter is valid, this method appends a filter that matches if the received extended frame identifier verifies `(receivedFrameIdentifier & inMask)` is equal to `inIdentifier`. That means:

- if a mask bit is a 1, the received extended frame identifier corresponding bit should match the `inIdentifier` corresponding bit;

- if a mask bit is a 0, the received extended frame identifier corresponding bit can have any value, the inIdentifier corresponding bit should be 0.

If the filter is not valid, the filter is not appended.

The last argument is optional and associates a callback routine to the filter. See [section 17 page 30](#).

For example:

```
extendedFilters.addClassic (0x6789, 0x1FFF67BD, ACANFD_FeatherM4CAN_FilterAction::FIF00) ;
```

This filter is valid because (0x6789 & 0x1FFF67BD) is equal to 0x6789.

	28 ...	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
inIdentifier: 0x6789	0	0	1	1	0	0	1	1	1	1	1	0	0	0	1	0	0	1
inMask: 0x1FFF67BD	1	0	1	1	0	0	1	1	1	1	1	0	1	1	1	1	0	1
Matching identifiers	0	<i>x</i>	1	1	<i>x</i>	<i>x</i>	1	1	1	1	1	<i>x</i>	1	1	1	0	<i>x</i>	1

Therefore there are 32 matching identifiers.

17 The dispatchReceivedMessage method

Sample sketch: the LoopBackDemoCANFD_CAN1_dispatch sketch shows how using the dispatchReceivedMessage method.

Instead of calling the receiveFD0 and the receiveFD1 methods, call the dispatchReceivedMessage method in your loop function. For every message extracted from FIF00 and FIF01, it calls the callback function associated with the corresponding filter.

If you have not defined any filter, do not use this function, call the receiveFD0 and / or the receiveFD1 methods.

```
void loop () {
  can1.dispatchReceivedMessage () ; // Do not call can1.receiveFD0, can1.receiveFD1 any more
  ...
}
```

The dispatchReceivedMessage method handles one FIF00 message and one FIF01 message on each call. Specifically:

- if FIF00 and FIF01 are both empty, it returns false;
- if FIF00 is not empty, its oldest message is extracted and its associated callback is called; then, if FIF01 is not empty, its oldest message is extracted and its associated callback is called; the true value is returned.

If a filter definition does not name a callback function, the corresponding messages are lost.

The return value can be used for emptying and dispatching all received messages:

```
void loop () {
```

```
while (can1.dispatchReceivedMessage ()) {  
    }  
    ...  
}
```

17.1 Dispatching non matching standard frames

Following the [figure 4 page 25](#), non matching standard frames are stored in FIF00 if `mNonMatchingStandardFrameReception` is equal to FIF00, or in FIF01 if `mNonMatchingStandardFrameReception` is equal to FIF01. As these frames do not correspond to a filter, there is no associated callback function by default. Therefore, they are lost when the `dispatchReceivedMessage` method is called.

You can assign a callback function to the `mNonMatchingStandardMessageCallback` property of the `ACANFD_FeatherM4CAN_Settings` class. This provides a callback function to non matching standard frames, so they are dispatched by the `dispatchReceivedMessage` method. By default, `mNonMatchingStandardMessageCallback` value is `nullptr`.

If `mNonMatchingStandardFrameReception` is equal to REJECT, the `mNonMatchingStandardMessageCallback` value is never used.

17.2 Dispatching non matching extended frames

Following the [figure 5 page 28](#), non matching extended frames are stored in FIF00 if `mNonMatchingExtendedFrameReception` is equal to FIF00, or in FIF01 if `mNonMatchingExtendedFrameReception` is equal to FIF01. As these frames do not correspond to a filter, there is no associated callback function by default. Therefore, they are lost when the `dispatchReceivedMessage` method is called.

You can assign a callback function to the `mNonMatchingExtendedMessageCallback` property of the `ACANFD_FeatherM4CAN_Settings` class. This provides a callback function to non matching extended frames, so they are dispatched by the `dispatchReceivedMessage` method. By default, `mNonMatchingExtendedMessageCallback` value is `nullptr`.

If `mNonMatchingExtendedFrameReception` is equal to REJECT, the `mNonMatchingExtendedMessageCallback` value is never used.

18 The `dispatchReceivedMessageFIF00` method

The `dispatchReceivedMessageFIF00` method dispatches the messages stored in the FIF00. The messages stored in FIF01 are retrieved using the `receiveFD1` method.

```
void loop () {  
    can1.dispatchReceivedMessageFIF00 () ; // Do not call can1.receiveFD0 any more  
    CANFDMessage ;  
    if (can1.receiveFD1 (message)) {  
        ... handle FIF01 message ...  
    }  
}
```

```
}  
...  
}
```

Instead of calling the `receiveFD0` method, call the `dispatchReceivedMessageFIF00` method in your `loop` function. For every message extracted from `FIF00`, it calls the callback function associated with the corresponding filter.

If you have not defined any filter that targets the `FIF00`, do not use this function (messages will be not dispatched and therefore lost), call the `receiveFD0` method.

The `dispatchReceivedMessageFIF00` method handles one `FIF00` message on each call. Specifically:

- if `FIF00` is empty, it returns `false`;
- if `FIF00` is not empty, its oldest message is extracted and its associated callback is called and the `true` value is returned.

If a filter definition does not name a callback function, the corresponding messages are lost.

The return value can be used for emptying and dispatching all received messages:

```
void loop () {  
  while (can1.dispatchReceivedMessageFIF00 ()) {  
  }  
  CANFDMessage ;  
  if (can1.receiveFD1 (message)) {  
    ... handle FIF01 message ...  
  }  
  ...  
}
```

19 The `dispatchReceivedMessageFIF01` method

The `dispatchReceivedMessageFIF01` method dispatches the messages stored in the `FIF01`. The messages stored in `FIF00` are retrieved using the `receiveFD0` method.

```
void loop () {  
  can1.dispatchReceivedMessageFIF01 () ; // Do not call can1.receiveFD1 any more  
  CANFDMessage ;  
  if (can1.receiveFD0 (message)) {  
    ... handle FIF00 message ...  
  }  
  ...  
}
```

Instead of calling the `receiveFD1` method, call the `dispatchReceivedMessageFIF01` method in your `loop` function. For every message extracted from `FIF01`, it calls the callback function associated with the corresponding filter.

If you have not defined any filter that targets the FIF01, do not use this function (messages will be not dispatched and therefore lost), call the `receiveFD1` method.

The `dispatchReceivedMessageFIF01` method handles one FIF01 message on each call. Specifically:

- if FIF01 is empty, it returns `false`;
- if FIF01 is not empty, its oldest message is extracted and its associated callback is called and the `true` value is returned.

If a filter definition does not name a callback function, the corresponding messages are lost.

The return value can be used for emptying and dispatching all received messages:

```
void loop () {
    while (can1.dispatchReceivedMessageFIF01 ()) {
    }
    CANFDMessage ;
    if (can1.receiveFD0 (message)) {
        ... handle FIF00 message ...
    }
    ...
}
```

20 The `ACANFD_FeatherM4CAN::beginFD` method reference

20.1 The prototypes

```
uint32_t ACANFD_FeatherM4CAN::beginFD (const ACANFD_FeatherM4CAN_Settings & inSettings,
                                       const StandardFilters & inStandardFilters = StandardFilters (),
                                       const ExtendedFilters & inExtendedFilters = ExtendedFilters ()) ;

uint32_t ACANFD_FeatherM4CAN::beginFD (const ACANFD_FeatherM4CAN_Settings & inSettings,
                                       const ExtendedFilters & inExtendedFilters) ;
```

The first argument is a `ACANFD_FeatherM4CAN_Settings` instance that defines the settings.

The second one is optional, and specifies the standard filter list (see [section 16.1 page 24](#)). By default, the standard filter list is empty.

The third one is optional, and specifies the extended filter list (see [section 16.2 page 27](#)). By default, the extended filter list is empty.

20.2 The error codes

The `ACANFD_FeatherM4CAN::beginFD` method returns an error code. The value `0` denotes no error. Otherwise, you consider every bit as an error flag, as described in [table 8](#). An error code could report several

errors. The `ACANFD_FeatherM4CAN` class defines static constants for naming errors. Bits 0 to 16 denote a bit configuration error, see [table 10 page 40](#).

Bit	Code	Static constant Name	Comment
0	0x1	kBitRatePrescalerIsZero	See table 10 page 40
...	See table 10 page 40
16	0x1_0000	kDataSJWIsGreaterThanPhaseSegment2	See table 10 page 40
20	0x10_0000	kMessageRamTooSmall	See section 13 page 18
21	0x20_0000	kMessageRamNotInFirst64kio	See section 13 page 18
22	0x40_0000	kHardwareRxFIFOSizeGreaterThan64	<code>settings.mHardwareRxFIFOSize > 64</code>
23	0x80_0000	kHardwareTransmitFIFOSizeGreaterThan32	<code>settings.mHardwareTransmitTxFIFOSize > 32</code>
24	0x100_0000	kDedicacedTransmitTxBufferCountGreaterThan30	<code>settings.mHardwareDedicacedTxBufferCount > 30</code>
25	0x200_0000	kTxBufferCountGreaterThan32	See section 20.2.1 page 34
26	0x400_0000	kHardwareTransmitFIFOSizeLowerThan2	See <code>settings.mHardwareTransmitTxFIFOSize < 2</code>
27	0x800_0000	kHardwareRxFIFO1SizeGreaterThan64	<code>settings.mHardwareRxFIFO1Size > 64</code>
28	0x1000_0000	kStandardFilterCountGreaterThan128	More than 128 standard filters, see section 16.1 page 24
29	0x2000_0000	kExtendedFilterCountGreaterThan128	More than 128 extended filters, see section 16.2 page 27

Table 8 – The `ACANFD_FeatherM4CAN::beginFD` method error code bits

20.2.1 The `kTxBufferCountGreaterThan32` error code

There are 32 available TxBuffers, for hardware transmit FIFO and dedicaced TxBuffers. Therefore, the sum of `settings.mHardwareDedicacedTxBufferCount` and `settings.mHardwareTransmitTxFIFOSize` should be lower or equal to 32.

21 ACANFD_FeatherM4CAN_Settings class reference

Note. The `ACANFD_FeatherM4CAN_Settings` class is not Arduino specific. You can compile it on your desktop computer with your favorite C++ compiler.

21.1 The `ACANFD_FeatherM4CAN_Settings` constructors: computation of the CAN bit settings

21.1.1 5 arguments constructor

```
ACANFD_FeatherM4CAN_Settings::
ACANFD_FeatherM4CAN_Settings (const uint32_t inDesiredArbitrationBitRate,
                               const uint32_t inDesiredArbitrationSamplePoint,
                               const DataBitRateFactor inDataBitRateFactor,
                               const uint32_t inDesiredDataSamplePoint,
                               const uint32_t inTolerancePPM = 1000) ;
```

The constructor of the `ACANFD_FeatherM4CAN_Settings` four mandatory arguments:

1. the desired arbitration bit rate,

21.1 The ACANFD_FeatherM4CAN_Settings constructors: computation of the CAN bit settings

2. the desired arbitration sample point (in per-cent),
3. the data bit rate factor,
4. the desired data sample point (in per-cent).

It tries to compute the CAN bit settings for these bit rates. If it succeeds, the constructed object has its `mArbitrationBitRateClosedToDesiredRate` property set to `true`, otherwise it is set to `false`. The sample points are expressed in per-cent values, 60 to 80 are typical values. Note that the desired values of the sample points may not be achieved exactly, due to integer quantization. Very often the actual value is lower than the desired value. You can change the property values for be closer to the required values, see the listing in the [figure 6 page 39](#).

For example, for an 1 Mbit/s arbitration bit rate and an 8 Mbit/s data bit rate:

```
void setup () {  
    // Arbitration bit rate: 1 Mbit/s, data bit rate: 8 Mbit/s  
    ACANFD_FeatherM4CAN_Settings settings (1000 * 1000, 75, DataBitRateFactor::x8, 75) ;  
    // Here, settings.mArbitrationBitRateClosedToDesiredRate is true  
    ...  
}
```

Note the data bit rate is not defined by its frequency, but by its multiplicative factor from arbitration bit rate. If you want a single bit rate, use `DataBitRateFactor::x1` as data bit rate factor.

21.1.2 3-arguments constructor

This constructor implicitly sets desired arbitration sample point and desired data sample point to 75.

```
ACANFD_FeatherM4CAN_Settings::  
ACANFD_FeatherM4CAN_Settings (const uint32_t inDesiredArbitrationBitRate,  
                               const DataBitRateFactor inDataBitRateFactor,  
                               const uint32_t inTolerancePPM = 1000) ;
```

21.1.3 Exact bit rates

There are 313 exact arbitration / data bit rate combinations ([table 9 page 36](#)).

But this does not mean there is no possibility to get such data bit rate factors. For example, we can have a data bit rate of 4 Mbit/s, and an arbitration bit rate of $4/7$ Mbit/s = 571 428 kbit/s:

```
void setup () {  
    ...  
    ACANFD_FeatherM4CAN_Settings settings (571428, DataBitRateFactor::x7) ;  
    Serial.print ("mArbitrationBitRateClosedToDesiredRate: ") ;  
    Serial.println (settings.mArbitrationBitRateClosedToDesiredRate) ; // 1 (true)  
    Serial.print ("Actual Arbitration Bit Rate: ") ;  
    Serial.println (settings.actualArbitrationBitRate ()) ; // 571428 bit/s  
    Serial.print ("distance: ") ;
```

21.1 The ACANFD_FeatherM4CAN_Settings constructors: computation of the CAN bit settings

Arbitration Bit Rate	Valid Data Rate factors	Arbitration Bit Rate	Valid Data Rate factors
5 000	x8 x10	6 000	x8 x10
6 250	x5 x6 x8 x10	6 400	x10
7 500	x5 x8 x10	7 680	x10
8 000	x5 x6 x8 x10	9 375	x4 x5 x8 x10
9 600	x5 x8 x10	10 000	x4 x5 x6 x8 x10
12 000	x4 x5 x8 x10	12 500	x3 x4 x5 x6 x8 x10
12 800	x5 x6 x10	15 000	x4 x5 x8 x10
15 360	x5	15 625	x2 x3 x4 x6 x8
16 000	x3 x4 x5 x6 x8 x10	18 750	x2 x4 x5 x8 x10
19 200	x4 x5 x10	20 000	x2 x3 x4 x5 x6 x8 x10
24 000	x2 x4 x5 x8 x10	25 000	x2 x3 x4 x5 x6 x8 x10
25 600	x3 x5	30 000	x2 x4 x5 x8 x10
31 250	x1 x2 x3 x4 x6 x8	32 000	x2 x3 x4 x5 x6 x10
37 500	x1 x2 x4 x5 x8 x10	38 400	x2 x5 x10
40 000	x1 x2 x3 x4 x5 x6 x8 x10	46 875	x1 x2 x4 x8
48 000	x1 x2 x4 x5 x8 x10	50 000	x1 x2 x3 x4 x5 x6 x8 x10
60 000	x1 x2 x4 x5 x8 x10	62 500	x1 x2 x3 x4 x6 x8
64 000	x1 x2 x3 x5 x6 x10	75 000	x1 x2 x4 x5 x8 x10
76 800	x1 x5	80 000	x1 x2 x3 x4 x5 x6 x8 x10
93 750	x1 x2 x4 x8	96 000	x1 x2 x4 x5 x10
100 000	x1 x2 x3 x4 x5 x6 x8 x10	120 000	x1 x2 x4 x5 x8 x10
125 000	x1 x2 x3 x4 x6 x8	128 000	x1 x3 x5
150 000	x1 x2 x4 x5 x8 x10	160 000	x1 x2 x3 x4 x5 x6 x10
187 500	x1 x2 x4 x8	192 000	x1 x2 x5 x10
200 000	x1 x2 x3 x4 x5 x6 x8 x10	240 000	x1 x2 x4 x5 x8 x10
250 000	x1 x2 x3 x4 x6 x8	300 000	x1 x2 x4 x5 x8 x10
320 000	x1 x2 x3 x5 x6 x10	375 000	x1 x2 x4 x8
384 000	x1 x5	400 000	x1 x2 x3 x4 x5 x6 x8 x10
480 000	x1 x2 x4 x5 x10	500 000	x1 x2 x3 x4 x6 x8
600 000	x1 x2 x4 x5 x8 x10	640 000	x1 x3 x5
750 000	x1 x2 x4 x8	800 000	x1 x2 x3 x4 x5 x6 x10
960 000	x1 x2 x5 x10	1 000 000	x1 x2 x3 x4 x6 x8

Table 9 – The 313 exact bit rates

```
Serial.println (settings.ppmFromDesiredArbitrationBitRate ()) ; // 1 ppm= 0,0001 %
Serial.print ("Actual Data Bit Rate: ") ;
Serial.println (settings.actualDataBitRate ()) ; // 4 Mbit/s
...
}
```

Due to integer computations, and the distance from desired arbitration bit rate is 1 ppm. “ppm” stands for “part-per-million”, and $1 \text{ ppm} = 10^{-6}$. In other words, 10,000 ppm = 1%.

By default, a desired bit rate is accepted if the distance from the computed actual bit rate is lower or equal to 1,000 ppm = 0.1 %. You can change this default value by adding your own value as third argument of ACANFD_FeatherM4CAN_Settings constructor. For example, with an arbitration bit rate equal to 727 kbit/s:

```
void setup () {
...
ACANFD_FeatherM4CAN_Settings settings (727 * 1000,
                                         DataBitRateFactor::x1,
                                         100) ; // 100 ppm
Serial.print ("mArbitrationBitRateClosedToDesiredRate: ") ;
```

21.1 The ACANFD_FeatherM4CAN_Settings constructors: computation of the CAN bit settings

```
Serial.println (settings.mArbitrationBitRateClosedToDesiredRate) ; // 0 (false)
Serial.print ("actual arbitration bit rate: ") ;
Serial.println (settings.actualArbitrationBitRate ()) ; // 727272 bit/s
Serial.print ("distance: ") ;
Serial.println (settings.ppmFromDesiredArbitrationBitRate ()) ; // 375 ppm
...
}
```

The third argument does not change the CAN bit computation, it only changes the acceptance test for setting the `mArbitrationBitRateClosedToDesiredRate` property. For example, you can specify that you want the computed actual bit to be exactly the desired bit rate:

```
void setup () {
    ...
    ACANFD_FeatherM4CAN_Settings settings (500 * 1000,
                                             DataBitRateFactor::x1,
                                             0) ; // Max distance is 0 ppm
    Serial.print ("mArbitrationBitRateClosedToDesiredRate: ") ;
    Serial.println (settings.mArbitrationBitRateClosedToDesiredRate) ; // 1 (true)
    Serial.print ("actual arbitration bit rate: ") ;
    Serial.println (settings.actualArbitrationBitRate ()) ; // 500,000 bit/s
    Serial.print ("distance: ") ;
    Serial.println (settings.ppmFromDesiredArbitrationBitRate ()) ; // 0 ppm
    ...
}
```

In any way, the bit rate computation always gives a consistent result, resulting an actual arbitration / data bit rates closest from the desired bit rate. For example, we query a 423 kbit/s arbitration bit rate, and a 423 kbit/s * 3 = 1 269 kbit/s data bit rate:

```
void setup () {
    ...
    ACANFD_FeatherM4CAN_Settings settings (423 * 1000, DataBitRateFactor::x3) ;
    Serial.print ("mArbitrationBitRateClosedToDesiredRate: ") ;
    Serial.println (settings.mArbitrationBitRateClosedToDesiredRate) ; // 0 (false)
    Serial.print ("Actual Arbitration Bit Rate: ") ;
    Serial.println (settings.actualArbitrationBitRate ()) ; // 421 052 bit/s
    Serial.print ("Actual Data Bit Rate: ") ;
    Serial.println (settings.actualDataBitRate ()) ; // 1 263 157 bit/s
    Serial.print ("distance: ") ;
    Serial.println (settings.ppmFromDesiredArbitrationBitRate ()) ; // 4 603 ppm
    ...
}
```

The resulting bit rates settings are far from the desired values, the CAN bit decomposition is consistent. You can get its details:

```
void setup () {
    ...
    ACANFD_FeatherM4CAN_Settings settings (423 * 1000, DataBitRateFactor::x3) ;
```

```
Serial.print ("mArbitrationBitRateClosedToDesiredRate: ") ;
Serial.println (settings.mArbitrationBitRateClosedToDesiredRate) ; // 0 (false)
Serial.print ("Actual Arbitration Bit Rate: ") ;
Serial.println (settings.actualArbitrationBitRate ()) ; // 421 052 bit/s
Serial.print ("Actual Data Bit Rate: ") ;
Serial.println (settings.actualDataBitRate ()) ; // 1 263 157 bit/s
Serial.print ("distance: ") ;
Serial.println (settings.ppmFromDesiredArbitrationBitRate ()) ; // 4 603 ppm
Serial.print ("Bit rate prescaler: ") ;
Serial.println (settings.mBitRatePrescaler) ; // BRP = 1
Serial.print ("Arbitration Phase segment 1: ") ;
Serial.println (settings.mArbitrationPhaseSegment1) ; // PS1 = 22
Serial.print ("Arbitration Phase segment 2: ") ;
Serial.println (settings.mArbitrationPhaseSegment2) ; // PS2 = 10
Serial.print ("Arbitration Resynchronization Jump Width: ") ;
Serial.println (settings.mArbitrationSJW) ; // SJW = 10
Serial.print ("Arbitration Sample Point: ") ;
Serial.println (settings.arbitrationSamplePointFromBitStart ()) ; // 69, meaning 69%
Serial.print ("Data Phase segment 1: ") ;
Serial.println (settings.mDataPhaseSegment1) ; // PS1 = 22
Serial.print ("Data Phase segment 2: ") ;
Serial.println (settings.mDataPhaseSegment2) ; // PS2 = 10
Serial.print ("Data Resynchronization Jump Width: ") ;
Serial.println (settings.mDataSJW) ; // SJW = 10
Serial.print ("Data Sample Point: ") ;
Serial.println (settings.dataSamplePointFromBitStart ()) ; // 69, meaning 59%
Serial.print ("Consistency: ") ;
Serial.println (settings.CANBitSettingConsistency ()) ; // 0, meaning 0k
...
}
```

The `samplePointFromBitStart` method returns sample point, expressed in per-cent of the bit duration from the beginning of the bit.

Note the computation may calculate a bit decomposition too far from the desired bit rate, but it is always consistent. You can check this by calling the `CANBitSettingConsistency` method.

You can change the property values for adapting to the particularities of your CAN network propagation time, and required sample points. By example, as shown in the [figure 6](#), you can increment the `mArbitrationPhaseSegment1` property value, and decrement the `mArbitrationPhaseSegment2` property value in order to sample the CAN Rx pin later.

Be aware to always respect CAN bit timing consistency! The ATSAME51G19A constraints are:

```

void setup () {
    ...
    ACANFD_FeatherM4CAN_Settings settings (500 * 1000, DataBitRateFactor::x1) ;
    Serial.print ("mArbitrationBitRateClosedToDesiredRate: ") ;
    Serial.println (settings.mArbitrationBitRateClosedToDesiredRate) ; // 1 (true)
    settings.mArbitrationPhaseSegment1 -= 4 ; // 32 -> 28: safe, 1 <= PS1 <= 256
    settings.mArbitrationPhaseSegment2 += 4 ; // 15 -> 19: safe, 1 <= PS2 <= 128
    settings.mArbitrationSJW += 4 ; // 15 -> 19: safe, 1 <= SJW <= PS2
    Serial.print ("Sample Point: ") ;
    Serial.println (settings.samplePointFromBitStart ()) ; // 58, meaning 58%
    Serial.print ("actual arbitration bit rate: ") ;
    Serial.println (settings.actualArbitrationBitRate ()) ; // 500000: ok, no change
    Serial.print ("Consistency: ") ;
    Serial.println (settings.CANBitSettingConsistency ()) ; // 0, meaning 0k
    ...
}

```

Figure 6 – Adapting property values

$$\begin{aligned}
 1 &\leq \text{mBitRatePrescaler} \leq 32 \\
 1 &\leq \text{mArbitrationPhaseSegment1} \leq 256 \\
 2 &\leq \text{mArbitrationPhaseSegment2} \leq 128 \\
 1 &\leq \text{mArbitrationSJW} \leq \text{mArbitrationPhaseSegment2} \\
 1 &\leq \text{mDataPhaseSegment1} \leq 32 \\
 2 &\leq \text{mDataPhaseSegment2} \leq 16 \\
 1 &\leq \text{mDataSJW} \leq \text{mDataPhaseSegment2}
 \end{aligned}$$

Microchip recommends using the same bit rate prescaler for arbitration and data bit rates.

Resulting actual bit rates are given by (SYSCLK = 48 MHz):

$$\begin{aligned}
 \text{Actual Arbitration Bit Rate} &= \frac{\text{SYSCLK}}{\text{mBitRatePrescaler} \cdot (1 + \text{mArbitrationPhaseSegment1} + \text{mArbitrationPhaseSegment2})} \\
 \text{Actual Data Bit Rate} &= \frac{\text{SYSCLK}}{\text{mBitRatePrescaler} \cdot (1 + \text{mDataPhaseSegment1} + \text{mDataPhaseSegment2})}
 \end{aligned}$$

And the sampling point (in per-cent unit) are given by:

$$\begin{aligned}
 \text{Arbitration Sampling Point} &= 100 \cdot \frac{1 + \text{mArbitrationPhaseSegment1}}{1 + \text{mArbitrationPhaseSegment1} + \text{mArbitrationPhaseSegment2}} \\
 \text{Data Sampling Point} &= 100 \cdot \frac{1 + \text{mDataPhaseSegment1}}{1 + \text{mDataPhaseSegment1} + \text{mDataPhaseSegment2}}
 \end{aligned}$$

21.2 The CANBitSettingConsistency method

This method checks the CAN bit decomposition (given by `mBitRatePrescaler`, `mArbitrationPhaseSegment1`, `mArbitrationPhaseSegment2`, `mArbitrationSJW`, `mDataPhaseSegment1`, `mDataPhaseSegment2`, `mDataSJW` property values) is consistent.

```
void setup () {
    ...
    ACANFD_FeatherM4CAN_Settings settings (500 * 1000, DataBitRateFactor::x2) ;
    Serial.print ("mArbitrationBitRateClosedToDesiredRate: ") ;
    Serial.println (settings.mArbitrationBitRateClosedToDesiredRate) ; // 1 (true)
    settings.mDataPhaseSegment1 = 0 ; // Error, mDataPhaseSegment1 should be >= 1 (and <= 32)
    Serial.print ("Consistency: 0x") ;
    Serial.println (settings.CANBitSettingConsistency (), HEX) ; // != 0, meaning error
    ...
}
```

The `CANBitSettingConsistency` method returns 0 if CAN bit decomposition is consistent. Otherwise, the returned value is a bit field that can report several errors – see [table 10](#).

The `ACANFD_FeatherM4CAN_Settings` class defines static constant properties that can be used as mask error. For example:

```
public: static const uint32_t kBitRatePrescalerIsZero = 1 << 0 ;
```

Bit	Code	Error Name	Error
0	0x1	kBitRatePrescalerIsZero	mBitRatePrescaler == 0
1	0x2	kBitRatePrescalerIsGreaterThan32	mBitRatePrescaler > 32
2	0x4	kArbitrationPhaseSegment1IsZero	mArbitrationPhaseSegment1 == 0
3	0x8	kArbitrationPhaseSegment1IsGreaterThan256	mArbitrationPhaseSegment1 > 256
4	0x10	kArbitrationPhaseSegment2IsLowerThan2	mArbitrationPhaseSegment2 < 2
5	0x20	kArbitrationPhaseSegment2IsGreaterThan128	mArbitrationPhaseSegment2 > 128
6	0x40	kArbitrationSJWIsZero	mArbitrationSJW == 0
7	0x80	kArbitrationSJWIsGreaterThan128	mArbitrationSJW > 128
8	0x100	kArbitrationSJWIsGreaterThanPhaseSegment2	mArbitrationSJW > mArbitrationPhaseSegment2
9	0x200	kArbitrationPhaseSegment1Is1AndTripleSampling	(mArbitrationPhaseSegment1 == 1) and triple sampling
10	0x400	kDataPhaseSegment1IsZero	mDataPhaseSegment1 == 0
11	0x800	kDataPhaseSegment1IsGreaterThan32	mDataPhaseSegment1 > 32
12	0x1000	kDataPhaseSegment2IsLowerThan2	mDataPhaseSegment2 < 2
13	0x2000	kDataPhaseSegment2IsGreaterThan16	mDataPhaseSegment2 > 16
14	0x4000	kDataSJWIsZero	mDataSJW == 0
15	0x8000	kDataSJWIsGreaterThan16	mDataSJW > 16
16	0x1_0000	kDataSJWIsGreaterThanPhaseSegment2	mDataSJW > mDataPhaseSegment2

Table 10 – The `ACANFD_FeatherM4CAN_Settings::CANBitSettingConsistency` method error codes

21.3 The actualArbitrationBitRate method

The `actualArbitrationBitRate` method returns the actual bit computed from `mBitRatePrescaler`, `mPropagationSegment`, `mArbitrationPhaseSegment1`, `mArbitrationPhaseSegment2`, `mArbitrationSJW` property values.

21.4 The exactArbitrationBitRate method

```
void setup () {
  ...
  ACANFD_FeatherM4CAN_Settings settings (440 * 1000, DataBitRateFactor::x1) ;
  Serial.print ("mArbitrationBitRateClosedToDesiredRate: ") ;
  Serial.println (settings.mArbitrationBitRateClosedToDesiredRate) ; // 0 (false)
  Serial.print ("actual arbitration bit rate: ") ;
  Serial.println (settings.actualArbitrationBitRate ()) ; // 444,444 bit/s
  ...
}
```

Note. If CAN bit settings are not consistent (see [section 21.2 page 40](#)), the returned value is irrelevant.

21.4 The exactArbitrationBitRate method

```
bool ACANFD_FeatherM4CAN_Settings::exactArbitrationBitRate (void) const ;
```

The `exactArbitrationBitRate` method returns `true` if the actual arbitration bit rate is equal to the desired arbitration bit rate, and `false` otherwise.

Note. If CAN bit settings are not consistent (see [section 21.2 page 40](#)), the returned value is irrelevant.

21.5 The exactDataBitRate method

```
bool ACANFD_FeatherM4CAN_Settings::exactDataBitRate (void) const ;
```

The `exactDataBitRate` method returns `true` if the actual data bit rate is equal to the desired data bit rate, and `false` otherwise.

Note. If CAN bit settings are not consistent (see [section 21.2 page 40](#)), the returned value is irrelevant.

21.6 The ppmFromDesiredArbitrationBitRate method

```
uint32_t ACANFD_FeatherM4CAN_Settings::ppmFromDesiredArbitrationBitRate (void) const ;
```

The `ppmFromDesiredArbitrationBitRate` method returns the distance from the actual arbitration bit rate to the desired arbitration bit rate, expressed in part-per-million (ppm): $1 \text{ ppm} = 10^{-6}$. In other words, $10,000 \text{ ppm} = 1\%$.

Note. If CAN bit settings are not consistent (see [section 21.2 page 40](#)), the returned value is irrelevant.

21.7 The ppmFromDesiredDataBitRate method

```
uint32_t ACANFD_FeatherM4CAN_Settings::ppmFromDesiredDataBitRate (void) const ;
```

The `ppmFromDesiredDataBitRate` method returns the distance from the actual data bit rate to the desired data bit rate, expressed in part-per-million (ppm): $1 \text{ ppm} = 10^{-6}$. In other words, $10,000 \text{ ppm} = 1\%$.

Note. If CAN bit settings are not consistent (see [section 21.2 page 40](#)), the returned value is irrelevant.

21.8 The arbitrationSamplePointFromBitStart method

```
uint32_t ACANFD_FeatherM4CAN_Settings::arbitrationSamplePointFromBitStart (void) const ;
```

The `arbitrationSamplePointFromBitStart` method returns the distance of sample point from the start of the arbitration CAN bit, expressed in part-per-cent (ppc): $1 \text{ ppc} = 1\% = 10^{-2}$. It is a good practice to get sample point from 65% to 80%. The bit rate calculator tries to set the sample point at 80%.

Note. If CAN bit settings are not consistent (see [section 21.2 page 40](#)), the returned value is irrelevant.

21.9 The dataSamplePointFromBitStart method

```
uint32_t ACANFD_FeatherM4CAN_Settings::dataSamplePointFromBitStart (void) const ;
```

The `dataSamplePointFromBitStart` method returns the distance of sample point from the start of the data CAN bit, expressed in part-per-cent (ppc): $1 \text{ ppc} = 1\% = 10^{-2}$. It is a good practice to get sample point from 65% to 80%. The bit rate calculator tries to set the sample point at 80%.

Note. If CAN bit settings are not consistent (see [section 21.2 page 40](#)), the returned value is irrelevant.

21.10 Properties of the ACANFD_FeatherM4CAN_Settings class

All properties of the `ACANFD_FeatherM4CAN_Settings` class are declared `public` and are initialized ([table 11](#)).

21.10.1 The `mModuleMode` property

This property defines the mode requested at this end of the configuration process: `NORMAL_FD` (default value), `INTERNAL_LOOP_BACK`, `EXTERNAL_LOOP_BACK`, `BUS_MONITORING`.

BUS_MONITORING mode. See DS60001507G datasheet, section 39.6.2.6 page 1096.

In Bus Monitoring Mode (see ISO 11898-1, 10.12 Bus monitoring), the CAN is able to receive valid data frames and valid remote frames, but cannot start a transmission. In this mode, it sends only recessive bits on the CAN bus. If the CAN is required to send a dominant bit (ACK bit, overload flag, active error flag), the bit is rerouted internally so that the CAN monitors this dominant bit, although the CAN bus may remain in recessive state. In Bus Monitoring Mode register TXBRP is held in reset state. The Bus Monitoring Mode can be used to analyze the traffic on a CAN bus without affecting it by the transmission of dominant bits. The figure below shows the connection of signals CAN_TX and CAN_RX to the CAN in Bus Monitoring Mode.

INTERNAL_LOOP_BACK mode. See DS60001507G datasheet, section 39.6.2.8 page 1098.

This mode can be used for a "Hot Selftest", meaning the CAN can be tested without affecting a running CAN system connected to the pins CAN_TX and CAN_RX. In this mode pin CAN_RX is disconnected from the CAN and pin CAN_TX is held recessive.

21.10 Properties of the ACANFD_FeatherM4CAN_Settings class

Property	Type	Initial value	Comment
mDesiredArbitrationBitRate	uint32_t	Constructor argument	
mDataBitRateFactor	DataBitRateFactor	Constructor argument	
mBitRatePrescaler	uint8_t	32	See section 21.1 page 34
mArbitrationPhaseSegment1	uint16_t	256	See section 21.1 page 34
mArbitrationPhaseSegment2	uint8_t	128	See section 21.1 page 34
mArbitrationSJW	uint8_t	128	See section 21.1 page 34
mDataPhaseSegment1	uint8_t	32	See section 21.1 page 34
mDataPhaseSegment2	uint8_t	16	See section 21.1 page 34
mDataSJW	uint8_t	16	See section 21.1 page 34
mTripleSampling	bool	true	See section 21.1 page 34
mBitSettingOk	bool	true	See section 21.1 page 34
mModuleMode	ModuleMode	NORMAL_FD	See section 21.10.1 page 42
mDriverReceiveFIFO0Size	uint16_t	10	See section 15.1 page 22
mHardwareRxFIFO0Size	uint8_t	64	See section 13 page 18
mHardwareRxFIFO0Payload	Payload	PAYLOAD_64_BYTES	See section 13 page 18
mDriverReceiveFIFO1Size	uint16_t	0	See section 15.1 page 22
mHardwareRxFIFO1Size	uint8_t	0	See section 13 page 18
mHardwareRxFIFO1Payload	Payload	PAYLOAD_64_BYTES	See section 13 page 18
mEnableRetransmission	bool	true	See section 21.10.2 page 43
mDiscardReceivedStandardRemoteFrames	bool	false	See section 16 page 23
mDiscardReceivedExtendedRemoteFrames	bool	false	See section 16 page 23
mNonMatchingStandardFrameReception	FilterAction	FIFO0	See section 16 page 23
mNonMatchingExtendedFrameReception	FilterAction	FIFO0	See section 16 page 23
mTransceiverDelayCompensation	uint8_t	5	See section 21.10.3 page 44
mDriverTransmitFIFOSize	uint8_t	20	See section 8 page 14
mHardwareTransmitTxFIFOSize	uint8_t	24	See section 8 page 14
mHardwareDedicatedTxBufferCount	uint8_t	8	See section 9 page 16
mHardwareTransmitBufferPayload	Payload	PAYLOAD_64_BYTES	See section 12 page 16
mNonMatchingStandardMessageCallback	ACANFDCallbackRoutine	nullptr	See section 17.1 page 31
mNonMatchingExtendedMessageCallback	ACANFDCallbackRoutine	nullptr	See section 17.2 page 31

Table 11 – Properties of the ACANFD_FeatherM4CAN_Settings class

EXTERNAL_LOOP_BACK mode. See DS60001507G datasheet, section 39.6.2.8 page 1098.

In this Mode, the CAN treats its own transmitted messages as received messages and stores them (if they pass acceptance filtering) into an Rx Buffer or an Rx FIFO. This mode is provided for hardware self-test. To be independent from external stimulation, the CAN ignores acknowledge errors (recessive bit sampled in the acknowledge slot of a data/remote frame) in Loop Back Mode. In this mode the CAN performs an internal feedback from its Tx output to its Rx input. The actual value of the CAN_RX input pin is disregarded by the CAN. The transmitted messages can be monitored at the CAN_TX pin.

21.10.2 The mEnableRetransmission property

By default, a frame is automatically retransmitted if an error occurs during its transmission, or if its transmission is preempted by a higher priority frame. You can turn off this feature by setting the `mEnableRetransmission` to `false`.

21.10.3 The `mTransceiverDelayCompensation` property

Setting the *Transmitter Delay Compensation* is required when data bit rate switch is enabled and data phase bit time that is shorter than the transceiver loop delay. The `mTransceiverDelayCompensation` property is by default set to 8 by the `ACANFD_FeatherM4CAN_Settings` constructor.

For more details, see DS60001507G, sections 39.6.2.4, pages 1095 and 1096.

22 Other `ACANFD_FeatherM4CAN` methods

22.1 The `getStatus` method

```
ACANFD_FeatherM4CAN::Status ACANFD_FeatherM4CAN::getStatus (void) const ;
```

22.1.1 The `txErrorCount` method

```
uint16_t ACANFD_FeatherM4CAN::Status::txErrorCount (void) const ;
```

This method returns 256 if the bus status is *Bus Off*, and the *Transmitter Error Counter* value otherwise.

22.1.2 The `rxErrorCount` method

```
uint8_t ACANFD_FeatherM4CAN::Status::rxErrorCount (void) const ;
```

This method returns the *Receive Error Counter* value.

22.1.3 The `isBusOff` method

```
bool ACANFD_FeatherM4CAN::Status::isBusOff (void) const ;
```

This method returns `true` if the bus status is *Bus Off*, and `false` otherwise.

22.1.4 The `transceiverDelayCompensationOffset` method

```
uint8_t ACANFD_FeatherM4CAN::Status::transceiverDelayCompensationOffset (void) const ;
```

This method returns *Transceiver Delay Compensation Offset* value.

22.1.5 The `hardwareTxBufferPayload` method

```
ACANFD_FeatherM4CAN_Settings::Payload ACANFD_FeatherM4CAN::hardwareTxBufferPayload (void) const ;
```

This method returns the payload of transmit `TxBuffers`.

22.1 The getStatus method

22.1.6 The hardwareRxFIFO0Payload method

```
ACANFD_FeatherM4CAN_Settings::Payload ACANFD_FeatherM4CAN::hardwareRxFIFO0Payload (void) const ;
```

This method returns the payload of hardware receive FIFO 0.

22.1.7 The hardwareRxFIFO1Payload method

```
ACANFD_FeatherM4CAN_Settings::Payload ACANFD_FeatherM4CAN::hardwareRxFIFO1Payload (void) const ;
```

This method returns the payload of hardware receive FIFO 1.