



**Baby-LIN-3-RC**  
**Baby-LIN-3-RCplus**



**Baby-LIN-3-MB**



**Baby-LIN-3-Single**  
**Baby-LIN-3-Dual**



**Baby-LIN-RM-III**

## Custom Protocols

*Application Note V1.3*

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<b>1 Introduction</b>	<b>2</b>
1.1 Requirements . . . . .	2
<b>2 Create a Protocol</b>	<b>3</b>
2.1 Service properties . . . . .	5
2.2 Protocol specific system variables . . . . .	5
2.3 Constant mapping . . . . .	6
2.4 Signal mapping . . . . .	7
<b>3 Execute protocol services</b>	<b>8</b>
<b>4 Byte order</b>	<b>10</b>
4.1 Introduction . . . . .	10
4.2 Adjust Byte Order . . . . .	10
4.2.1 UDS Protocol Service . . . . .	10
<b>5 Support information</b>	<b>12</b>

# 1 Introduction



## Version Incompatibility

This feature is only available in the SDF V3 format. Depending on your device you may require an additional activation code. An update to the newest firmware is required.

The Custom Protocols can realize diagnostic communication operations using the protocol feature in SDF-V3 SDFiles. Since it can be executed by the Custom Protocols in the stand-alone mode, there is no need for a PC.

The protocol feature allows the user to implement custom or proprietary protocols or use standardized protocols like:

1. LIN diagnostics (DTL)
2. ISO-TP
3. UDS
4. Cooling

Each protocol may consist of multiple services. Thereby it is possible to query common values like the hardware number or the software revision of nodes. This can be used e.g. to compare the queried values with stored values to prevent the incorrect installation of a device.

The standardized protocols require only the definition of the payload. The segmentation and supplement of transport information to the data is handled by the Custom Protocols. The received information can be parsed automatically and can be mapped into signals for further processing.

Each service consists of a request and an optional response. The Custom Protocols can emulate both sides of a request:

- Send a request and optionally evaluate the response.
- Define request patterns and send a response if a request is matched.

## 1.1 Requirements

The custom protocol feature supports both LIN- and CAN-Bus.

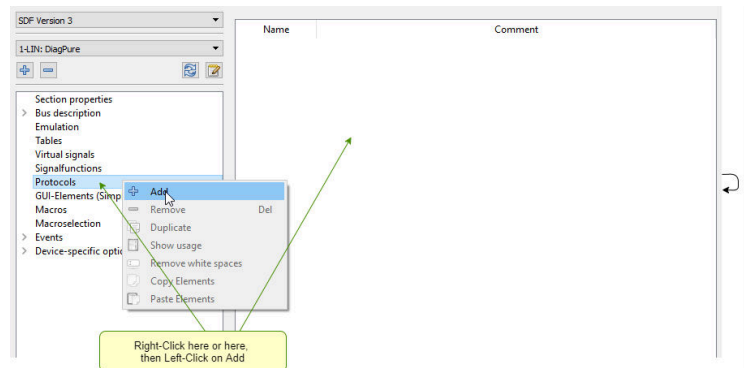
The use of custom protocols and services require a schedule to be executed on the LIN-Bus. While a service of a custom protocol is executed, the schedule will be paused. If your application only need protocol services to be executed, frames from a schedule can be problematic. Therefore a trick can be used, that consists of two parts:

- Your SDF needs to be based on a LDF with a schedule that only contains a master request frame.
- The target-specific option `Master Request on IDLE` has to be set to `Silent frame`.

This combination leads to a schedule that will not send any frames. A master request is only triggered, when a signal of the master request frame is changed and because of the `Silent frame` option it will not be seen on the LIN-Bus. This means a schedule is running but no frames will appear on the bus.

## 2 Create a Protocol

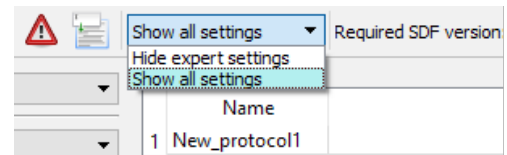
First step is the creation of protocol. Go to Protocols section in SDF item tree. Right-Click on Protocols entry or in right empty protocol window, to Add protocol.



### Hide Expert Settings

When you start using protocols, it might make sense to select Hide expert settings in the menu line. This will reduce the display content, to show the most important and typical properties only.

Later, if you have more experience, you might decide to Show all settings, which give you access to more parameters.

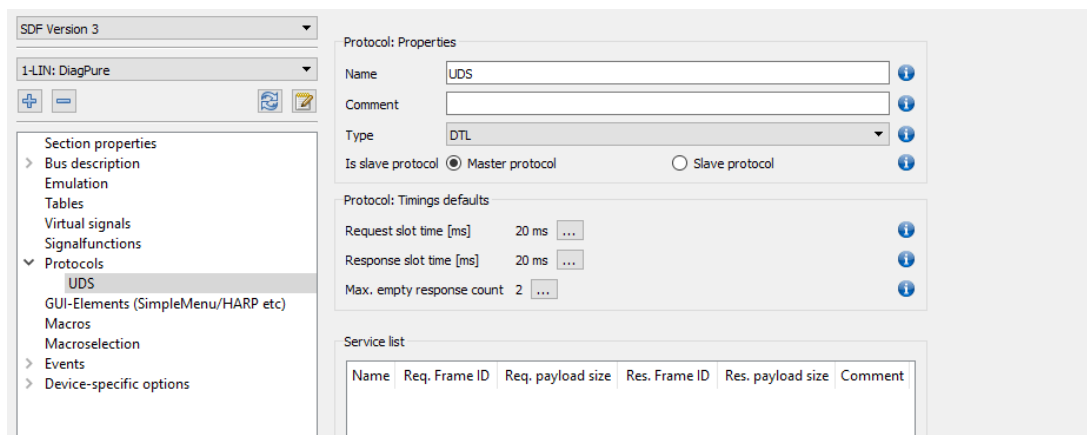


### Protocol Editor

To define the protocol properties, you open the protocol editor by double-clicking on the new protocol in left tree or in right Window.

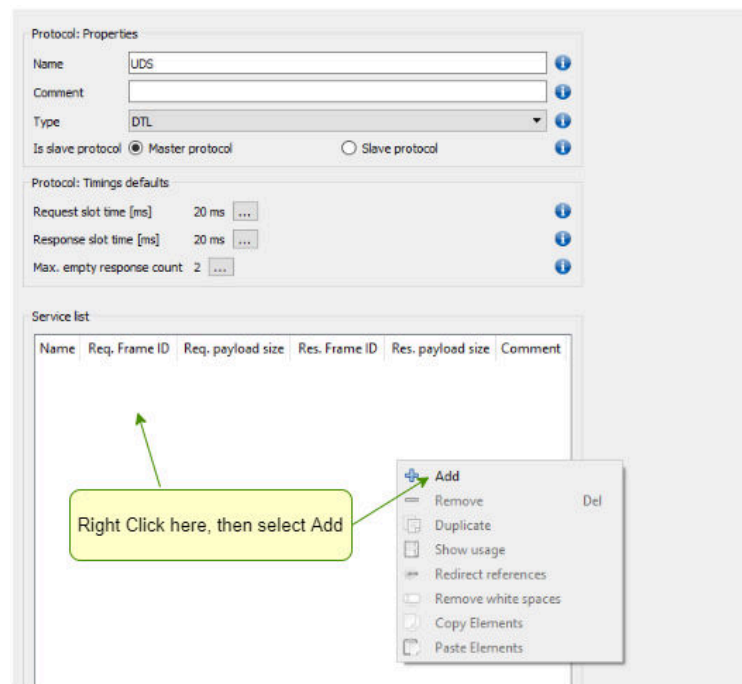
This opens the protocol editor, which allows definition of all common properties for services defined in this protocol.

First two things to do, is the definition of a protocol name, which we named UDS here and to set the protocol type to DTL.

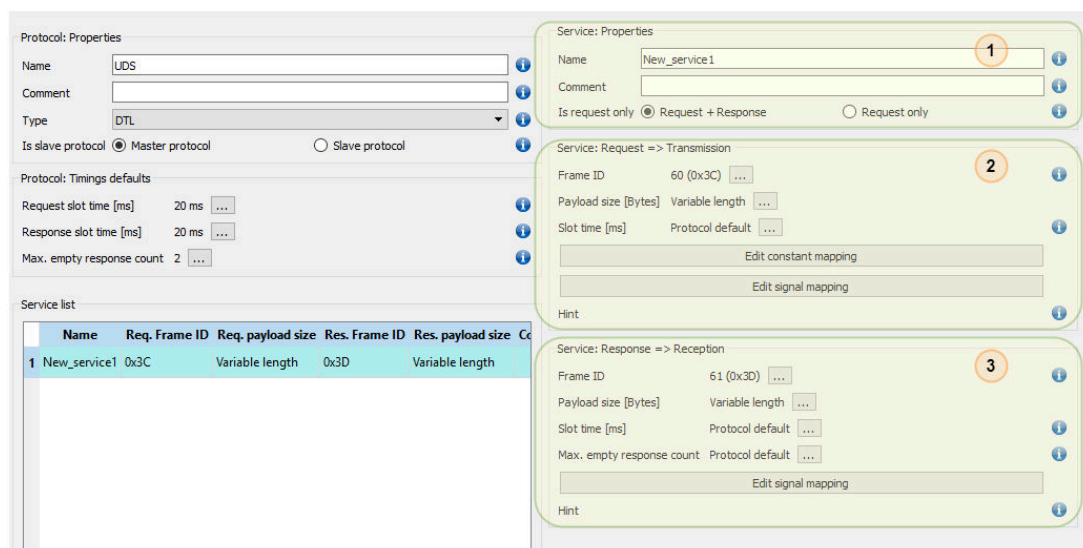


## Creation of service

Create new service by right click in Service Window and selecting Add This adds the service properties display, which has 3 sections:



1. Common service properties, like name, comment and the definition for Request + Response or Request Only protocol.
2. The request properties, as the frameId used for Request, the Payload size and the slot time, and the mappings to define the request payload content. The request payload can be defined by mapping constants byte value or by mapping of signals.
3. The response properties, as the frameId used for response, the payload size and the slot time, and the mappings to define where the response payload will be stored. Response data can be stored in signal mappings only.



## 2.1 Service properties

A service has the following properties for requests and responses, each including a list of constant and signal mappings:

Service property		Value type	Description
Checksum method		Classic	The classic checksum is used.
		Enhanced	The enhanced checksum of LIN 2.0 is used.
Frame ID length		11 Bit	The length of the frame ID is 11 Bit.
		29 Bit	The length of the frame ID is 29 Bit.
Request	Name	String	This is the name of the request within the protocol. It is used to reference the protocol within the SDF.
	Frame ID	LIN: 6 Bit CAN : 11 or 29 Bit	This is the ID for the request frame.
	Payload length	Integer(1-4095)	This is the length of the payload data.
	Slottime	Time in ms	The slot time of the request is the time, that is reserved for the sending of the request frame. Here you can use the default request slot time of the protocol.
	Constant mapping	Mapping	This mapping maps constants into the payload. Check chapter <a href="#">Constant mapping</a> for more information.
	Signal mapping	Mapping	This mapping maps signals into the payload. Check chapter <a href="#">Signal mapping</a> for more information.
Response	Name	String	This is the name of the response within the protocol. It is used to reference the protocol within the SDF.
	Frame ID	LIN: 6 Bit CAN : 11 or 29 Bit	This is the ID for the request frame.
	Payload length	Integer(1-4095)	This is the length of the payload data.
	Slottime	Time in ms	The slot time of the response is the time, that is reserved for the sending of the response frame. Here you can use the default response slot time of the protocol.
	Delay	Time in ms	This is the maximum delay that is waited by the master for a response from the slave. If the slave does not answer within time, the service macro return value will signal the timeout.
	Constant mapping	Mapping	This mapping maps constants into the payload. Check chapter <a href="#">Constant mapping</a> for more information.
	Signal mapping	Mapping	This mapping maps signals into the payload. Check chapter <a href="#">Signal mapping</a> for more information.

## 2.2 Protocol specific system variables

The following system variables are connected to the protocol feature:

System variable	Description
@SYS_SERVICE_REQUEST_NAD	This system signal defines the NAD used in a DTL/ISO-TP protocol request. If this system signal is not defined, the Wildcard NAD (0x7F) will be used in protocol requests instead.
@SYS_SERVICE_RESPONSE_NAD	holds the NAD received in a DTL/ISO-TP protocol response.
@SYS_SERVICE_REQUEST_LEN	This signal holds the length of request payload received in a DTL/ISO-TP request (slave protocol).
@SYS_SERVICE_RESPONSE_LEN	This signal holds the length of response bytes received in a protocol response. This signal is updated in all protocol types, for DTL/ISO-TP it holds the number of payload bytes, for other protocols it holds all bytes.
@SYS_SERVICE_FLOWCTRL_BS	Configuration of FlowControl Blocksize value (CAN ISO-TP protocol only). This system signal allows to adjust the FlowControl Blocksize value (CAN ISO-TP protocol only).
@SYS_SERVICE_P2_EXTENDED	Configuration of NRC C 0x78 timeout in DTL/ISO-TP response handling. This signal allows to adjust the NRC 0x78 timeout in DTL/ISO-TP response handling. Default value is 2000 ms.



#### Information

For more information and a list of all available system signals, see the chapter "System variables" in our LinWorks Software Manual, or check the System Variable Wizard in SessionConf.

Additionally the macro variables may be of interest when calling multiple services within a single macro. These system variables are local to a macro and can only be accessed within this macro. You can not access their values outside of a macro. Check chapter *Local macro variables* for more information.

## 2.3 Constant mapping

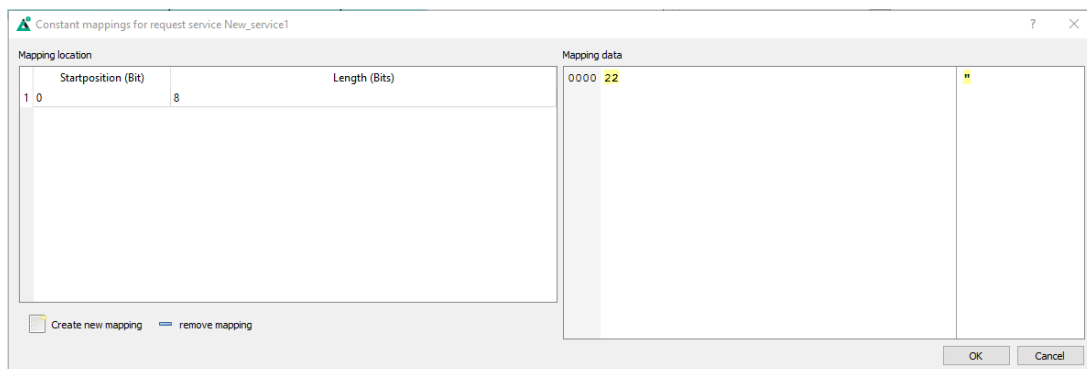
A constant mapping maps constants into a frame. It is defined by the following properties:

Properties	Description
Startposition (Bit)	This is the startposition within the frame.
Length (Bits)	This is the length of the constant data.
Mapping data	This is the value that is written into the payload.



#### Warning

Both the start position and end position (start position + length) must be within the payload of the frame.



## 2.4 Signal mapping

A signal mapping consists of a list of multiplexer, which each contains a list of mappings. A multiplexer is the condition, when a set of mappings is applied. There is always a static multiplexer available, which is always applied. For all other multiplexer it is checked, if the signal value equals the value.

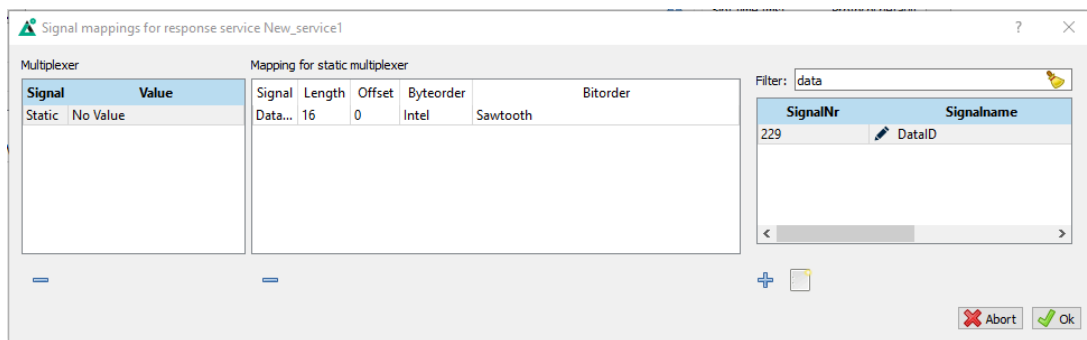
Multiplexer property	Description
Signal	This signal is compared with the value.
Value	This value is compared with the signal.



### Information

The multiplexer are evaluated from the top to the bottom. It is possible that the condition of a multiplexer changes after previous multiplexer were applied.

A mapping describes which data of a frame is mapped to which signal. In a request the signal is mapped to the frame data and in a response the frame data is mapped to the signal. The mapping is only applied if the signal and value of the parent multiplexer are equal or the parent is the static multiplexer.



### Version Incompatibility

Only virtual signals can be used for the mapping.

Multiplexer property	Description
Signal	This signal is the source/target of the mapped frame data.
Offset	This is the offset from the beginning of the payload to the LSB of the data.
Byte order	This is the byte order of the mapped data. Check chapter <b>Byte order</b> for more information.
Bit order	This is the bit order of the mapped data. Check chapter <b>Byte order</b> for more information.



### Information

The number of bits that are mapped depends on the length of the virtual signal.



### Tip

The mappings are evaluated from the top to the bottom. If a signal is used multiple times, the last mapping would define the value of the signal.

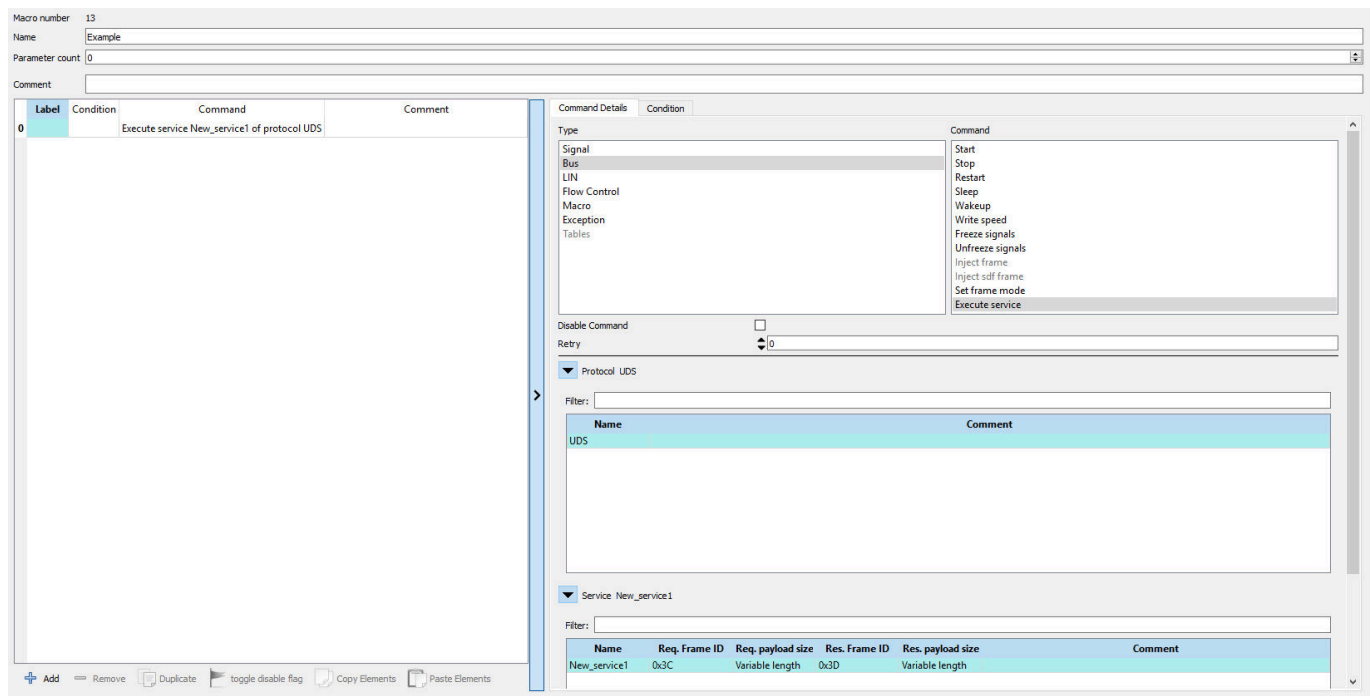


### 3 Execute protocol services

To execute a service of a custom protocol, you have to trigger a macro command.

The macro command is a `Bus` command and named `Execute service`. As parameter you have to choose a protocol and a service from that protocol, that you want to execute.

To trigger the macro containing this command you could use an autostart macro or any kind of event.




#### Information

The execute service macro command is blocking. This means it will not return until all required frames were sent via the bus.



#### Information

Protocols are usually used to read out data and then process it in the next step. For example, the information from the mapped signals can be output via the `MacroResultString` as a `HexString` or `ASCII String`.

The local virtual signal `__ResultLastMacroCommand` will contain the result of the execute service macro command after its execution. The following errors are defined:

Error code	Description
0	The service was executed successfully.
1	The memory of the Custom Protocols is full. This is an internal error.
2	This error may be caused by one of the following reasons: <ul style="list-style-type: none"> <li>No LIN supply voltage</li> <li>Bus is not started</li> <li>No schedule is running on the Dummy</li> </ul>
3	A slave has not responded within time.
4	If the DTL protocol is used, the index of the CF (consecutive frame) is wrong.

5	If the DTL protocol is used, the NAD was not expected.
6	If the DTL protocol is used, the frame type was not expected. The SF (single frame), FF (first frame) and CF (consecutive frame) are not as expected.
7	This is an error for a customer specific extension.
8	
9	
10	Too many services are executed right now.
11	The length of the frame data was not as expected (only for RAW protocols).
14	The received payload length does not match the SDF definitions (DTL).
16	Macro Command was rejected
17	The queue of macro commands to be executed is full
18	The queue is not empty as expected
19	The maximum timeout for executing the macro command was exceeded.
20	The bus has not yet been started and communication is not possible
21	The LIN bus is set to low although it should be set to high
22	The checksum did not match
23	The frame was incomplete
24	The data read back does not match the expected data
25	An error occurred during frame processing
26	The frame ID is outside the allowed range. Only frame IDs smaller than 62 are allowed
27	An error has occurred in the internal macro processing
28	The framesize did not match the expected length.
29	An unexpected signal frame was detected
30	An unexpected first frame was detected
31	An unexpected consecutive frame was detected
32	The PCI (Protocol Control Information) is incorrect
33	The length defined by the PCI does not match
34	The given payload size does not correspond to the actual length.
35	The data receive buffer has overflowed
36	The data transmit buffer has overflowed
37	The slave answer came unexpectedly too early
38	An unexpected slave answer was detected
39	An unexpected empty slave answer was detected
40	An error occurred during the initialization of the protocol.
41	The protocol frame size is incorrect
42	The command IDs of the Webasto protocol are not correct.
43	The expected container size did not match the actual size.
44	A "CAN No Acknowledge" error has occurred.
45	The NegativeResponseCode78 was not received when running the Unified Diagnostic Service. This has led to a timeout
46	LIN Header failed, may be to short circuit to 12V.
47	Error during transmission of the LIN header
48	CAN/LIN receiver reports overflow in Flow Control.
49	Service was timed out before execution started.
50	Service was timed out due to Frame abort (e.g. Stop command).
51	Payload length is not valid

52	The protocol type is unknown and cannot be executed.
53	The flow control frame is missing
54	Error when accessing an internal variable reference
80	The bus baud rate is invalid
100	Internal error. Operand overflow
101	Internal error. Operand underflow
102	Internal error. Divide by 0
255...511	If the DTL protocol is used, slaves may respond with negative response frames. The error value from that negative response frame is then returned with an offset of 0x100.

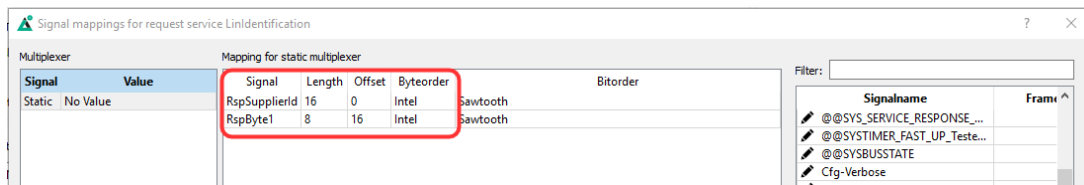
## 4 Byte order

### 4.1 Introduction

There is another point to consider when mapping signals through protocol services and reading out the data contained in the frames. Since there are 2 common ways to store numeric values, *Intel* and *Motorola*, this must also be distinguished in the protocols.

In standard LIN communication, the data is mapped into frames according to the *Intel* method. This means that the data is mapped in the same order as the signal and can be easily read out.

This specification means that when working with LIN-based protocol services, no further settings are required to map the signals and read out the data correctly. This is shown in the following example.



When a signal is added to the mapping, the correct offset is automatically set according to the *Intel* byte order. The start bit (LSB) thus matches the offset of the signal and the data from the *RspByte1* can be read out easily.



#### Information

The length of the mapped signal is not a problem because the offset is set accordingly. The bit order within the data corresponds with *sawtooth* to the bit order of the frame data.

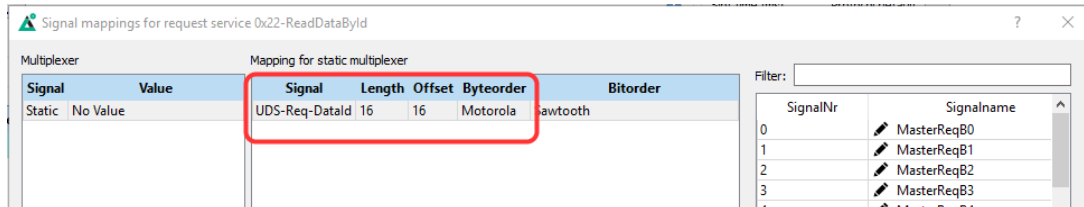
### 4.2 Adjust Byte Order

There is the special case that with certain protocols the frame data is mapped differently. Using the following example, we will show you how the Byte order must be changed accordingly in order to process the data correctly.

#### 4.2.1 UDS Protocol Service

The USD protocol originates from CAN bus communication and this uses the *Motorola* byte order. If you now use this protocol in your LIN section, the byte order must be adapted.

The **Motorola** byte order is inverted compared to the **Intel**. The **LSB** and **MSB** are swapped. This means that the offset must be set differently during signal mapping.



After adding the signal, 2 further settings must be made.

1. Change byte order from **Intel** to **Motorola**.
2. Set offset to **LSB**, in this case an offset = 16



#### Information

It is possible to map service signals with different byte orders in one protocol. It is only important that the offset is always set to the **LSB** and that the correct byte order is set.

## 5 Support information

In case of any questions you can get technical support by email or phone. We can use TeamViewer to give you direct support and help on your own PC. This way we are able to sort out problems fast and direct. We have sample code and application notes available, which will help you to make your job.

Lipowsky Industrie-Elektronik GmbH realized many successful LIN and CAN related projects and therefor we can draw upon many years of experience in these fields. We also provide turn key solutions for specific applications like EOL (End of Line) testers or programming stations.

Lipowsky Industrie-Elektronik GmbH designs, produces and applies the Baby-LIN products, so you can always expect qualified and fast support.

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