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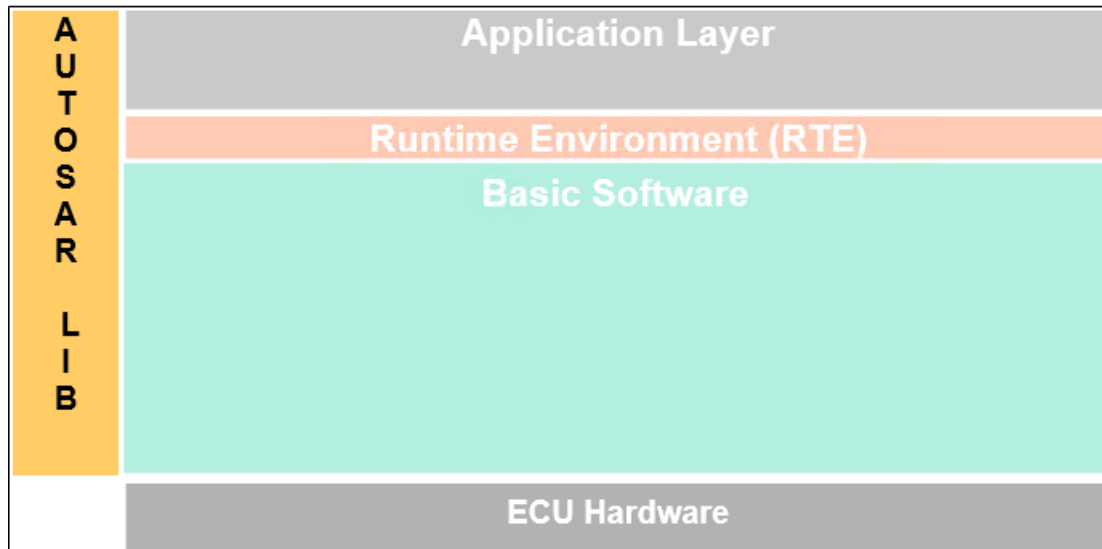
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# 1 Introduction and functional overview

AUTOSAR Library routines are the part of system services in AUTOSAR architecture and below figure shows position of AUTOSAR library in layered architecture.



**Figure 1.1: Layered Architecture**

This specification specifies the functionality, API and the configuration of the AUTOSAR library dedicated to interpolation and lookup routines for floating point values.

The interpolation library contains the following routines:

- Distributed data point search and interpolation
- Integrated data point search and interpolation

All routines are re-entrant. They may be used by multiple runnables at the same time.

## 2 Acronyms and Abbreviations

Acronyms and abbreviations, which have a local scope and therefore are not contained in the AUTOSAR glossary, must appear in a local glossary.

| Abbreviation / Acronym | Description  |
|------------------------|--|
| DET                    | Default Error Tracer   |
| ROM                    | Read only memory   |
| hex                    | Hexadecimal  |
| Rev                    | Revision   |
| f32                    | Mnemonic for the float32, specified in AUTOSAR_SWS_PlatformTypes |
| IFL                    | Interpolation Floating point Library                             |
| Mn                     | Mnemonic   |
| Lib                    | Library  |
| s16                    | Mnemonic for the sint16, specified in AUTOSAR_SWS_PlatformTypes  |
| s32                    | Mnemonic for the sint32, specified in AUTOSAR_SWS_PlatformTypes  |
| s8                     | Mnemonic for the sint8, specified in AUTOSAR_SWS_PlatformTypes   |
| u16                    | Mnemonic for the uint16, specified in AUTOSAR_SWS_PlatformTypes  |
| u32                    | Mnemonic for the uint32, specified in AUTOSAR_SWS_PlatformTypes  |
| u8                     | Mnemonic for the uint8, specified in AUTOSAR_SWS_PlatformTypes   |



## 3 Related documentation

### 3.1 Input documents & related standards and norms

- [1] IFL\_RecordLayout\_Blueprint  
AUTOSAR\_MOD\_IFL\_RecordLayout\_Blueprint.arxml
- [2] ISO/IEC 9899:1990 Programming Language - C  
<http://www.iso.org>
- [3] General Specification of Basic Software Modules  
AUTOSAR\_SWS\_BSWGeneral

### 3.2 Related specification

AUTOSAR provides a General Specification on Basic Software modules [3, SWS BSW General], which is also valid for IFL Library.

Thus, the specification SWS BSW General shall be considered as additional and required specification for IFL Library.

## **4 Constraints and assumptions**

### **4.1 Limitations**

No limitations.

### **4.2 Applicability to car domains**

No restrictions.

## 5 Dependencies to other modules

### 5.1 File structure

[SWS\_Ifl\_00001] [The Ifl module shall provide the following files:

- C files, Ifl\_<name>.c used to implement the library. All C files shall be prefixed with 'Ifl\_'.

Implementation & grouping of routines with respect to C files is recommended as per below options and there is no restriction to follow the same.

Option 1 : <Name> can be function name providing one C file per function,

eg.: Ifl\_IntlpoMap\_f32f32\_f32.c etc.

Option 2 : <Name> can have common name of group of functions:

- 2.1 Group by object family: eg.:Ifl\_IpoCur.c, Ifl\_DPSearch.c
- 2.2 Group by routine family: eg.: Ifl\_IpoMap.c
- 2.3 Group by method family: eg.: Ifl\_Ipo.c etc.
- 2.4 Group by other methods: (individual grouping allowed)

Option 3 : <Name> can be removed so that single C file shall contain all Ifl functions, eg.: Ifl.c.

Using above options gives certain flexibility of choosing suitable granularity with reduced number of C files. Linking only on-demand is also possible in case of some options.]()

## 6 Requirements Tracing

| Requirement      | Description  | Satisfied by                    |
|------------------|--|---------------------------------|
| [SRS_BSW_00003]  | All software modules shall provide version and identification information  | [SWS_lfi_00215]                 |
| [SRS_BSW_00007]  | All Basic SW Modules written in C language shall conform to the MISRA C 2012 Standard.                             | [SWS_lfi_00209]                 |
| [SRS_BSW_00304]  | All AUTOSAR Basic Software Modules shall use only AUTOSAR data types instead of native C data types                | [SWS_lfi_00212]                 |
| [SRS_BSW_00306]  | AUTOSAR Basic Software Modules shall be compiler and platform independent  | [SWS_lfi_00213]                 |
| [SRS_BSW_00318]  | Each AUTOSAR Basic Software Module file shall provide version numbers in the header file                           | [SWS_lfi_00215]                 |
| [SRS_BSW_00321]  | The version numbers of AUTOSAR Basic Software Modules shall be enumerated according specific rules                 | [SWS_lfi_00215]                 |
| [SRS_BSW_00348]  | All AUTOSAR standard types and constants shall be placed and organized in a standard type header file              | [SWS_lfi_00211]                 |
| [SRS_BSW_00374]  | All Basic Software Modules shall provide a readable module vendor identification                                   | [SWS_lfi_00214]                 |
| [SRS_BSW_00378]  | AUTOSAR shall provide a boolean type   | [SWS_lfi_00212]                 |
| [SRS_BSW_00379]  | All software modules shall provide a module identifier in the header file and in the module XML description file.  | [SWS_lfi_00214]                 |
| [SRS_BSW_00402]  | Each module shall provide version information  | [SWS_lfi_00214]                 |
| [SRS_BSW_00407]  | Each BSW module shall provide a function to read out the version information of a dedicated module implementation  | [SWS_lfi_00215] [SWS_lfi_00216] |
| [SRS_BSW_00411]  | All AUTOSAR Basic Software Modules shall apply a naming rule for enabling/disabling the existence of the API       | [SWS_lfi_00216]                 |
| [SRS_BSW_00437]  | Memory mapping shall provide the possibility to define RAM segments which are not to be initialized during startup | [SWS_lfi_00210]                 |
| [SRS_BSW_00448]  | Module SWS shall not contain requirements from Other Modules   | [SWS_lfi_00224]                 |
| [SRS_LIBS_00001] | The functional behavior of each library functions shall not be configurable  | [SWS_lfi_00218]                 |
| [SRS_LIBS_00002] | A library shall be operational before all BSW modules and application SW-Cs  | [SWS_lfi_00200]                 |





| Requirement      | Description  | Satisfied by                    |
|------------------|--|---------------------------------|
| [SRS_LIBS_00003] | A library shall be operational until the shutdown  | [SWS_lfi_00201]                 |
| [SRS_LIBS_00013] | The error cases, resulting in the check at runtime of the value of input parameters, shall be listed in SWS  | [SWS_lfi_00217] [SWS_lfi_00219] |
| [SRS_LIBS_00015] | It shall be possible to configure the microcontroller so that the library code is shared between all callers | [SWS_lfi_00206]                 |
| [SRS_LIBS_00017] | Usage of macros should be avoided  | [SWS_lfi_00207]                 |
| [SRS_LIBS_00018] | A library function may only call library functions   | [SWS_lfi_00208]                 |

**Table 6.1: RequirementsTracing**

## 7 Functional specification

### 7.1 Error Classification

**[SWS\_IfI\_00223]** [Section 7.1 "Error Handling" of the document "General Specification of Basic Software Modules" describes the error handling of the Basic Software in detail. Above all, it constitutes a classification scheme consisting of five error types which may occur in BSW modules.]()

Based on this foundation, the following section specifies particular errors arranged in the respective subsections below.

#### 7.1.1 Development Errors

There are no development errors.

#### 7.1.2 Runtime Errors

There are no runtime errors.

#### 7.1.3 Transient Faults

There are no transient faults.

#### 7.1.4 Production Errors

There are no production errors.

#### 7.1.5 Extended Production Errors

There are no extended production errors.

### 7.2 Error detection

**[SWS\_IfI\_00219]** [Error detection: Function should check at runtime (both in production and development code) the value of input parameters, especially cases where erroneous value can bring to fatal error or unpredictable result, if they have the values allowed by the function specification. All the error cases shall be listed in SWS and the

function should return a specified value (in SWS) that is not configurable. This value is dependant of the function and the error case so it is determined case by case.

If values passed to the routines are not valid and out of the function specification, then such error are not detected.]([SRS\\_LIBS\\_00013](#))

E.g. If passed value > 32 for a bit-position

or a negative number of samples of an axis distribution is passed to a routine.

### 7.3 Error notification

[SWS\_IfI\_00217] [The functions shall not call the DET for error notification.]([SRS\\_LIBS\\_00013](#))

### 7.4 Initialization and shutdown

[SWS\_IfI\_00200] [IfI library shall not require initialization phase. A Library function may be called at the very first step of ECU initialization, e.g. even by the OS or EcUM, thus the library shall be ready.]([SRS\\_LIBS\\_00002](#))

[SWS\_IfI\_00201] [IfI library shall not require a shutdown operation phase.]([SRS\\_LIBS\\_00003](#))

### 7.5 Using Library API

IfI API can be directly called from BSW modules or SWC. No port definition is required. It is a pure function call.

The statement 'IfI.h' shall be placed by the developer or an application code generator but not by the RTE generator

Using a library should be documented. if a BSW module or a SWC uses a Library, the developer should add an Implementation-DependencyOnArtifact in the BSW/SWC template.

minVersion and maxVersion parameters correspond to the supplier version. In case of AUTOSAR library, these parameters may be left empty because a SWC or BSW module may rely on a library behaviour, not on a supplier implementation. However, the SWC or BSW modules shall be compatible with the AUTOSAR platform where they are integrated.

## 7.6 Library implementation

**[SWS\_IfI\_00206]** [The IfI library shall be implemented in a way that the code can be shared among callers in different memory partitions.] ([SRS\\_LIBS\\_00015](#))

**[SWS\_IfI\_00207]** [Usage of macros should be avoided. The function should be declared as function or inline function. Macro #define should not be used.] ([SRS\\_LIBS\\_00017](#))

**[SWS\_IfI\_00208]** [A library function can call other library functions because all library functions shall be re-entrant. A library function shall not call any BSW modules functions, e.g. the DET.] ([SRS\\_LIBS\\_00018](#))

**[SWS\_IfI\_00209]** [The library, written in C programming language, should conform to the MISRA C Standard.

Please refer to SWS\_BSW\_00115 for more details.] ([SRS\\_BSW\\_00007](#))

**[SWS\_IfI\_00210]** [Each AUTOSAR library Module implementation <library>\*.c and <library>\*.h shall map their code to memory sections using the AUTOSAR memory mapping mechanism.] ([SRS\\_BSW\\_00437](#))

**[SWS\_IfI\_00211]** [Each AUTOSAR library Module implementation <library>\*.c, that uses AUTOSAR integer data types and/or the standard return, shall include the header file Std\_Types.h.] ([SRS\\_BSW\\_00348](#))

**[SWS\_IfI\_00212]** [All AUTOSAR library Modules should use the AUTOSAR data types (integers, boolean) instead of native C data types, unless this library is clearly identified to be compliant only with a platform.] ([SRS\\_BSW\\_00304](#), [SRS\\_BSW\\_00378](#))

**[SWS\_IfI\_00213]** [All AUTOSAR library Modules should avoid direct use of compiler and platform specific keyword, unless this library is clearly identified to be compliant only with a platform. eg. #pragma, typeof etc.] ([SRS\\_BSW\\_00306](#))

**[SWS\_IfI\_00220]** [If input value is less than first distribution entry then first value of the distribution array shall be returned or used in the interpolation routines. If input value is greater than last distribution entry then last value of the distribution array shall be returned or used in the interpolation routines.] ()

**[SWS\_IfI\_00221]** [Axis distribution passed to IfI routines shall have strong monotony sequence.] ()



## 8 API specification

### 8.1 Imported types

In this chapter, all types included from the following modules are listed:

| Module file | Imported Type   |
|-------------|---|
| Std_Types.h | sint8, uint8, sint16, uint16, sint32, uint32, float32 |

It is observed that since the sizes of the integer types provided by the C language are implementation-defined, the range of values that may be represented within each of the integer types will vary between implementations.

Thus in order to improve the portability of the software these types are defined in Platform\_Types.h [AUTOSAR\_SWS\_PlatformTypes]. The following mnemonic are used in the library routine names.

| Size            | Platform Type | Mnemonic | Range                         |
|-----------------|---------------|----------|-------------------------------|
| unsigned 8-Bit  | boolean       | NA       | [ TRUE, FALSE ]               |
| signed 8-Bit    | sint8         | s8       | [ -128, 127 ]                 |
| signed 16-Bit   | sint16        | s16      | [ -32768, 32767 ]             |
| signed 32-Bit   | sint32        | s32      | [ -2147483648, 2147483647 ]   |
| unsigned 8-Bit  | uint8         | u8       | [ 0, 255 ]                    |
| unsigned 16-Bit | uint16        | u16      | [ 0, 65535 ]                  |
| unsigned 32-Bit | uint32        | u32      | [ 0, 4294967295 ]             |
| 32-Bit          | float32       | f32      | [-3.4028235E38, 3.4028235E38] |

**Table 8.1: Mnemonic for Base Types**

As a convention in the rest of the document:

- mnemonics will be used in the name of the routines (using <InType> that means Type Mnemonic for Input )
- The real type will be used in the description of the prototypes of the routines (using <InTypeMn1> or <OutType>).

### 8.2 Type definitions

Structure definition:

**[SWS\_IfI\_00005]** [

| Name | IfI_DPRResultF32_Type |
|------|-----------------------|
|------|-----------------------|



△

|                      |  |                  |
|----------------------|--|------------------|
| <b>Kind</b>          | Structure  |                  |
| <b>Elements</b>      | Index  |                  |
|                      | <b>Type</b>  | uint32           |
|                      | <b>Comment</b>   | Data point index |
|                      | Ratio  |                  |
|                      | <b>Type</b>  | float32          |
|                      | <b>Comment</b>   | Data point ratio |
| <b>Description</b>   | Structure used for data point search for index and ratio |                  |
| <b>Available via</b> | Ifl.h  |                  |

]()

**[SWS\_Ifl\_00006]** [Ifl\_DPResultF32\_Type structure shall not be read/write/modified by the user directly. Only Ifl routines shall have access to this structure.]()

### 8.3 Comment about rounding

Two types of rounding can be applied:

Results are 'rounded off', it means:

- $0 \leq X < 0.5$  rounded to 0
- $0.5 \leq X < 1$  rounded to 1
- $-0.5 < X \leq 0$  rounded to 0
- $-1 < X \leq -0.5$  rounded to -1

Results are rounded towards zero.

- $0 \leq X < 1$  rounded to 0
- $-1 < X \leq 0$  rounded to 0

### 8.4 Comment about routines optimized for target

The routines described in this library may be realized as regular routines or inline functions. For ROM optimization purposes, it is recommended that the c routines be realized as individual source files so they may be linked in on an as-needed basis.

For example, depending on the target, two types of optimization can be done:

- Some routines can be replaced by another routine using integer promotion.
- Some routines can be replaced by the combination of a limiting routine and a routine with a different signature.

## 8.5 Interpolation routines definitions

Interpolation between two given points is calculated as shown below.

$$result = y_0 + (y_1 - y_0) \cdot \frac{x - x_0}{x_1 - x_0}$$

**Figure 8.1**

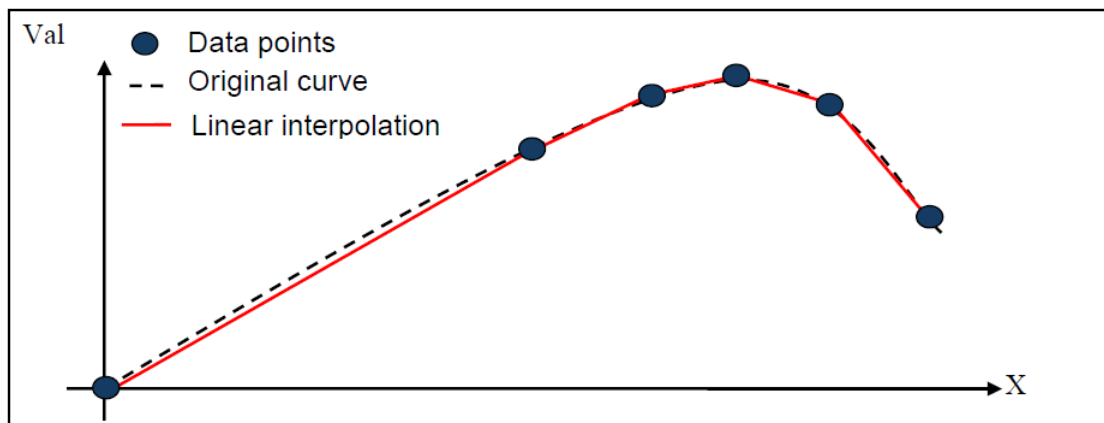
where: X is the input value

x0 = data point before X

x1 = data point after X

y0 = value at x0

y1 = value at x1



**Figure 8.2: Linear interpolation**

Data point arrays can be grouped as one array or one structure for all elements as shown below.

one array for all elements :

```
float32 Curve_f32 []={5,0.0,10.0,26.0,36.0,64.0,1.0,12.0,17.0,11.0,6.0};
```

one structure for all elements :

```
struct
```

```
{ uint32 N = 5;
```

```
float32 X[] = {0.0,10.0,26.0,36.0,64.0};
```

```
float32 Y[] = {1.0,12.0,17.0,11.0,6.0};
```

```
} Curve_f32;
```

where, number of samples = 5

X axis distribution = 0.0 to 64.0

Y axis distribution = 1.0 to 6.0

Interpolation routines accepts arguments separately to support above scenarios. Routine call example is given below for array and structure grouping respectively.

Example :

```
float32 Ifl_IntlpoCur_f32_f32 (15, Curve_f32[0], &Curve_f32[1], &Curve_f32[6]);
```

```
float32 Ifl_IntlpoCur_f32_f32 (15, Curve_f32.N, &Curve_f32.X, &Curve_f32.Y);
```

Interpolation can be calculated in two ways as shown below:

1. Distributed data point search and interpolation
2. Integrated data point search and interpolation

### 8.5.1 Distributed data point search and interpolation

In this interpolation method data point search (e.g. index and ratio) is calculated using routine `Ifl_DPSearch_f32` which returns result structure `Ifl_DPResultF32_Type`. It contains index and ratio information. This result can be used by curve interpolation and map interpolation.

#### 8.5.1.1 Data Point Search

[SWS\_IfI\_00010] [

|                           |  |                                 |
|---------------------------|--|---------------------------------|
| <b>Service Name</b>       | IfI_DPSearch_f32   |                                 |
| <b>Syntax</b>             | <pre>void IfI_DPSearch_f32 (     IfI_DPResultF32_Type* dpResult,     float32 Xin,     uint32 N,     const float32* X_array )</pre> |                                 |
| <b>Service ID [hex]</b>   | 0x001  |                                 |
| <b>Sync/Async</b>         | Synchronous  |                                 |
| <b>Reentrancy</b>         | Reentrant  |                                 |
| <b>Parameters (in)</b>    | Xin  | Input value                     |
|                           | N  | Number of samples               |
|                           | X_array  | Pointer to distribution array   |
| <b>Parameters (inout)</b> | None   |                                 |
| <b>Parameters (out)</b>   | dpResult   | Pointer to the result structure |
| <b>Return value</b>       | None   |                                 |





|                      |   |
|----------------------|---|
| <b>Description</b>   | This routine searches the position of input $X_{in}$ within the given distribution array $X_{array}$ , and returns index and ratio necessary for interpolation. |
| <b>Available via</b> | lfl.h   |

]()

**[SWS\_lfl\_00011]** [Returned Index shall be the lowest index for which  $(X_{array}[index] < X_{in} < X_{array}[index + 1])$ .

dpResult ->Index = index

dpResult ->Ratio =  $(X_{in} - X_{array}[index]) / (X_{array}[index+1] - X_{array}[index])$ ]()

For a given array float32  $X[] = \{0.0, 10.0, 26.0, 36.0, 64.0\}$ ;

If  $X_{in} = 20.0$  then

dpResult ->Index = 1

dpResult ->Ratio =  $(20.0 - 10.0) / (26.0 - 10.0) = 0.625$

**[SWS\_lfl\_00012]** [If the input value matches with one of the distribution array values, then

return respective index and ratio as 0.0.

If Input  $X_{in} == X_{array}[index]$ , then

dpResult ->Index = index (Index of the set point)

dpResult ->Ratio = 0.0]()

**[SWS\_lfl\_00013]** [If  $(X_{in} < X_{array}[0])$ , then return first index of an array and ratio = 0.0

dpResult ->Index = 0

dpResult ->Ratio = 0.0]()

**[SWS\_lfl\_00014]** [If  $(X_{in} > X_{array}[N-1])$ , then return last index of an array and ratio = 0.0

dpResult ->Index = N - 1

dpResult ->Ratio = 0.0]()

**[SWS\_lfl\_00015]** [The minimum value of N shall be 1]()

**[SWS\_lfl\_00016]** [If  $X_{array}[Index+1] == X_{array}[Index]$ , then the Ratio shall be zero.

dpResult->Ratio = 0.0]()

**[SWS\_lfl\_00017]** [This routine returns index and ratio through the structure of type `lfl_DPResultF32_Type`]()

### 8.5.1.2 Curve interpolation

#### [SWS\_IfI\_00021] [

|                           |  |  |
|---------------------------|--|--|
| <b>Service Name</b>       | IfI_IpoCur_f32   |  |
| <b>Syntax</b>             | <pre>float32 IfI_IpoCur_f32 (     const IfI_DPResultF32_Type* dpResult,     const float32* Val_array )</pre> |  |
| <b>Service ID [hex]</b>   | 0x004  |  |
| <b>Sync/Async</b>         | Synchronous  |  |
| <b>Reentrancy</b>         | Reentrant  |  |
| <b>Parameters (in)</b>    | dpResult   | Data point search result                 |
|                           | Val_array  | Pointer to the result distribution array |
| <b>Parameters (inout)</b> | None   |  |
| <b>Parameters (out)</b>   | None   |  |
| <b>Return value</b>       | float32  | Result of the Interpolation              |
| <b>Description</b>        | Based on searched index and ratio information, this routine calculates and returns interpolation for curve.  |  |
| <b>Available via</b>      | IfI.h  |  |

]()

[SWS\_IfI\_00022] [index = dpResult->Index

if dpResult->Ratio == 0.0

Result = Val\_array[index]

else

Result = Val\_array[index] + (Val\_array[index+1] - Val\_array[index]) \* dpResult->Ratio  
()

[SWS\_IfI\_00180] [Do not call this routine until you have searched the axis using the IfI\_DPSearch routine. Only then it is ensured that the search result (IfI\_DPResultF32\_Type) contains valid data and is not used uninitialized.]()

### 8.5.1.3 Map interpolation

[SWS\_Ifl\_00025] [

|                           |  |                                      |
|---------------------------|--|--------------------------------------|
| <b>Service Name</b>       | Ifl_IpoMap_f32   |                                      |
| <b>Syntax</b>             | <pre>float32 Ifl_IpoMap_f32 (     const Ifl_DPResultF32_Type* dpResultX,     const Ifl_DPResultF32_Type* dpResultY,     uint32 num_value,     const float32* Val_array )</pre> |                                      |
| <b>Service ID [hex]</b>   | 0x005  |                                      |
| <b>Sync/Async</b>         | Synchronous  |                                      |
| <b>Reentrancy</b>         | Reentrant  |                                      |
| <b>Parameters (in)</b>    | dpResultX  | Data point search result for x axis  |
|                           | dpResultY  | Data point search result for y axis  |
|                           | num_value  | Number of y axis points              |
|                           | Val_array  | Pointer to result distribution array |
| <b>Parameters (inout)</b> | None   |                                      |
| <b>Parameters (out)</b>   | None   |                                      |
| <b>Return value</b>       | float32  | Result of the Interpolation          |
| <b>Description</b>        | Based on searched indices and ratios information using the Ifl_DPSearch_f32 routine, this routine calculates and returns the interpolation result for map.                     |                                      |
| <b>Available via</b>      | Ifl.h  |                                      |

]()

[SWS\_Ifl\_00026] [Based on searched indices and ratios information using the Ifl\_DPSearch\_f32 routine, this routine calculates and returns the interpolation result for map.

BaseIndex = dpResultX->Index \* num\_value + dpResultY->Index

if (dpResultX->Ratio == 0)

if (dpResultY->Ratio == 0)

Result = Val\_array [BaseIndex]

else

LowerY = Val\_array [BaseIndex]

UpperY = Val\_array [BaseIndex + 1]

Result = LowerY + (UpperY - LowerY) \* dpResultY->Ratio

else

if (dpResultY->Ratio == 0)

LowerX = Val\_array [BaseIndex]

UpperX = Val\_array [BaseIndex + num\_value]

```

Result = LowerX + (UpperX - LowerX) * dpResultX->Ratio
else
LowerY = Val_array [BaseIndex]
UpperY = Val_array [BaseIndex + 1]
LowerX = LowerY + (UpperY - LowerY) * dpResultY->Ratio
LowerY = Val_array [BaseIndex + num_value]
UpperY = Val_array [BaseIndex + num_value + 1]
UpperX = LowerY + (UpperY - LowerY) * dpResultY->Ratio
Result = LowerX + (UpperX - LowerX) * dpResultX->Ratio ] ()

```

**[SWS>IfI\_00181]** [Do not call this routine until you have searched the axis using the IfI\_DPSearch routine. Only then it is ensured that the search result (IfI\_DPResultF32\_Type) contains valid data and is not used uninitialized.] ()

### 8.5.1.4 Single point interpolation

**[SWS>IfI\_00030]** [

|                           |  |   |
|---------------------------|--|---|
| <b>Service Name</b>       | IfI_Interpolate_f32  |   |
| <b>Syntax</b>             | float32 IfI_Interpolate_f32 (<br>float32 Value1,<br>float32 Value2,<br>float32 Coef<br>)                 |   |
| <b>Service ID [hex]</b>   | 0x006  |   |
| <b>Sync/Async</b>         | Synchronous  |   |
| <b>Reentrancy</b>         | Reentrant  |   |
| <b>Parameters (in)</b>    | Value1   | First value to be used in the interpolation.  |
|                           | Value2   | Second value to be used in the interpolation. |
|                           | Coef   | Interpolation coefficient.                    |
| <b>Parameters (inout)</b> | None   |   |
| <b>Parameters (out)</b>   | None   |   |
| <b>Return value</b>       | float32  | Iterpolated value                             |
| <b>Description</b>        | Returns the result of the linear interpolation (Result), determined according to the following equation. |   |
| <b>Available via</b>      | IfI.h  |   |

] ()

**[SWS>IfI\_00031]** [Result = Value1 + (Coef \* (Value2 - Value1))] ()



## 8.5.2 Integrated data point search and interpolation

In this method of interpolation, single routine does data point search (e.g. Index and ratio) and interpolation for curve, map.

### 8.5.2.1 Integrated curve interpolation

[SWS\_IfI\_00035] [

|                           |   |                             |
|---------------------------|---|-----------------------------|
| <b>Service Name</b>       | IfI_IntIpoCur_f32_f32   |                             |
| <b>Syntax</b>             | <pre>float32 IfI_IntIpoCur_f32_f32 (     float32 X_in,     uint32 N,     const float32* X_array,     const float32* Val_array )</pre> |                             |
| <b>Service ID [hex]</b>   | 0x010   |                             |
| <b>Sync/Async</b>         | Synchronous   |                             |
| <b>Reentrancy</b>         | Reentrant   |                             |
| <b>Parameters (in)</b>    | X_in  | Input value                 |
|                           | N   | Number of samples           |
|                           | X_array   | Pointer to X distribution   |
|                           | Val_array   | Pointer to Y values         |
| <b>Parameters (inout)</b> | None  |                             |
| <b>Parameters (out)</b>   | None  |                             |
| <b>Return value</b>       | float32   | Result of the Interpolation |
| <b>Description</b>        | This routine calculates interpolation of a curve at position Xin using below equation.  |                             |
| <b>Available via</b>      | IfI.h   |                             |

]()

[SWS\_IfI\_00036] [index = minimum value of integer index if (X\_array[index] < Xin < X\_array[index+1])

$$\text{RatioX} = (\text{Xin} - \text{X\_array}[\text{index}]) / (\text{X\_array}[\text{index}+1] - \text{X\_array}[\text{index}])$$

$$\text{Result} = \text{Val\_array}[\text{index}] + (\text{Val\_array}[\text{index}+1] - \text{Val\_array}[\text{index}]) * \text{RatioX}] ()$$

[SWS\_IfI\_00037] [If the input value matches with one of the distribution array values, then result will be the respective Y array element indicated by the index.

If (Xin == X\_array[index]),

$$\text{Result} = \text{Val\_array}[\text{index}] ()$$

[SWS\_IfI\_00038] [If Xin < X\_array[0], then

$$\text{Result} = \text{Val\_array}[0] ()$$

[SWS\_IfI\_00039] [If Xin > X\_array[N-1], then

Result = Val\_array[N-1]]()

**[SWS\_Ifl\_00040]** [The minimum value of N shall be 1]()

### 8.5.2.2 Integrated map interpolation

**[SWS\_Ifl\_00041]** [

|                           |  |   |
|---------------------------|--|---|
| <b>Service Name</b>       | Ifl_IntIpoMap_f32f32_f32   |   |
| <b>Syntax</b>             | <pre>float32 Ifl_IntIpoMap_f32f32_f32 (     float32 Xin,     float32 Yin,     uint32 Nx,     uint32 Ny,     const float32* X_array,     const float32* Y_array,     const float32* Val_array )</pre> |   |
| <b>Service ID [hex]</b>   | 0x011  |   |
| <b>Sync/Async</b>         | Synchronous  |   |
| <b>Reentrancy</b>         | Reentrant  |   |
| <b>Parameters (in)</b>    | Xin  | Input value for X axis                        |
|                           | Yin  | Input value for Y axis                        |
|                           | Nx   | Number of X axis intervals                    |
|                           | Ny   | Number of Y axis intervals                    |
|                           | X_array  | Pointer to the X axis distribution array      |
|                           | Y_array  | Pointer to the Y axis distribution array      |
|                           | Val_array  | Pointer to the result axis distribution array |
| <b>Parameters (inout)</b> | None   |   |
| <b>Parameters (out)</b>   | None   |   |
| <b>Return value</b>       | float32  | Result of the Map Interpolation               |
| <b>Description</b>        | This routine calculates Interpolation of a map at position X and Y using below equations.  |   |
| <b>Available via</b>      | Ifl.h  |   |

]()

**[SWS\_Ifl\_00042]** [indexX = minimum value of index if (X\_array[indexX] < Xin < X\_array[indexX+1])

indexY = minimum value of index if (Y\_array[indexY] < Yin < Y\_array[indexY+1])

RatioX = (Xin - X\_array[indexX]) / (X\_array [indexX+1] - X\_array [indexX])

RatioY = (Yin - Y\_array[indexY]) / (Y\_array [indexY+1] - Y\_array [indexY])

BaseIndex = IndexX \* Ny + indexY

LowerY = Val\_array [BaseIndex]

UpperY = Val\_array [BaseIndex + 1]

LowerX = LowerY + (UpperY - LowerY) \* RatioY

LowerY = Val\_array [BaseIndex + Ny]

UpperY = Val\_array [BaseIndex + Ny + 1]

UpperX = LowerY + (UpperY - LowerY) \* RatioY

Result = LowerX + (UpperX - LowerX) \* RatioX] ()

**[SWS\_IfI\_00043]** [If (Xin == X\_array[indexX]) and (Y\_array[indexY] < Yin < Y\_array[indexY+1])

Result = Val\_array [BaseIndex] + (Val\_array [BaseIndex+1] - Val\_array[BaseIndex]) \* RatioY] ()

**[SWS\_IfI\_00044]** [If (Yin == Y\_array[indexY]) and (X\_array[indexX] < Xin < X\_array[indexX+1])

Result = Val\_array [BaseIndex] + (Val\_array [BaseIndex+Ny] - Val\_array[BaseIndex]) \* RatioX] ()

**[SWS\_IfI\_00045]** [If (Xin == X\_array[indexX]) and (Yin == Y\_array[indexY])

Result = Val\_array [BaseIndex]] ()

**[SWS\_IfI\_00046]** [If Xin < X\_array[0], then

indexX = 0,

RatioX = 0.0] ()

**[SWS\_IfI\_00047]** [If Xin > X\_array[Nx-1], then

indexX = Nx - 1,

RatioX = 0.0] ()

**[SWS\_IfI\_00048]** [If Yin < Y\_array[0], then

indexY = 0,

RatioY = 0.0] ()

**[SWS\_IfI\_00049]** [If Yin > Y\_array[Ny-1], then

indexY = Ny - 1,

RatioY = 0.0] ()

**[SWS\_IfI\_00050]** [The minimum value of N shall be 1] ()

### 8.5.3 Record layouts for interpolation routines

Record layout specifies calibration data serialization in the ECU memory which describes the shape of the characteristics. Single record layout can be referred by multiple instances of interpolation ParameterDataPrototype. Record layouts can be nested

particular values refer to the particular property of the object. With different properties of record layouts it is possible to specify complex objects.

### 8.5.3.1 Record layout definitions

Below table specifies record layouts supported for interpolation routines.

[SWS\_Ifl\_00170] [

| Record layout Name | Element1      | Element2    | Element3      | Element4    | Element5      |
|--------------------|---------------|-------------|---------------|-------------|---------------|
| Distr_f32          | uint32 N      | float32 X[] |               |             |               |
| Curve_f32          | float32 Val[] |             |               |             |               |
| Map_f32            | float32 Val[] |             |               |             |               |
| IntCurve_f32_f32   | uint32 N      | float32 X[] | float32 Val[] |             |               |
| IntMap_f32f32_f32  | uint32 Nx     | uint32 Ny   | float32 X[]   | float32 Y[] | float32 Val[] |

]()

## 8.6 Examples of use of functions

None

## 8.7 Version API

### 8.7.1 Ifl\_GetVersionInfo

[SWS\_Ifl\_00215] [

|                           |   |   |
|---------------------------|---|---|
| <b>Service Name</b>       | Ifl_GetVersionInfo  |   |
| <b>Syntax</b>             | <pre>void Ifl_GetVersionInfo (     Std_VersionInfoType* versioninfo )</pre> |   |
| <b>Service ID [hex]</b>   | 0xff  |   |
| <b>Sync/Async</b>         | Synchronous   |   |
| <b>Reentrancy</b>         | Reentrant   |   |
| <b>Parameters (in)</b>    | None  |   |
| <b>Parameters (inout)</b> | None  |   |
| <b>Parameters (out)</b>   | versioninfo   | Pointer to where to store the version information of this module. Format according [BSW00321] |
| <b>Return value</b>       | None  |   |
| <b>Description</b>        | Returns the version information of this library.                            |   |





Available via

lfl.h

]([SRS\\_BSW\\_00407](#), [SRS\\_BSW\\_00003](#), [SRS\\_BSW\\_00318](#), [SRS\\_BSW\\_00321](#))

The version information of a BSW module generally contains:

- Module Id
- Vendor Id
- Vendor specific version numbers ([SRS\\_BSW\\_00407](#)).

**[SWS\_lfl\_00216]** [If source code for caller and callee of `lfl_GetVersionInfo` is available, the `lfl` library should realize `lfl_GetVersionInfo` as a macro defined in the module's header file.]([SRS\\_BSW\\_00407](#), [SRS\\_BSW\\_00411](#))

## 8.8 Callback notifications

None.

## 8.9 Scheduled routines

The `lfl` library does not have scheduled routines.

## 8.10 Expected interfaces

None.

### 8.10.1 Mandatory interfaces

None.

### 8.10.2 Optional interfaces

None.

### 8.10.3 Configurable interfaces

None.

## 9 Sequence diagrams

Not applicable.

## 10 Configuration specification

### 10.1 Published Information

**[SWS\_Ifl\_00214]** [The standardized common published parameters as required by SRS\_BSW\_00402 in the General Requirements on Basic Software Modules [REF] shall be published within the header file of this module and need to be provided in the BSW Module Description. The according module abbreviation can be found in the List of Basic Software Modules [REF].] ([SRS\\_BSW\\_00402](#), [SRS\\_BSW\\_00374](#), [SRS\\_BSW\\_00379](#))

Additional module-specific published parameters are listed below if applicable.

### 10.2 Configuration option

**[SWS\_Ifl\_00218]** [The Ifl library shall not have any configuration options that may affect the functional behavior of the routines. I.e. for a given set of input parameters, the outputs shall be always the same. For example, the returned value in case of error shall not be configurable.] ([SRS\\_LIBS\\_00001](#))

However, a library vendor is allowed to add specific configuration options concerning library implementation, e.g. for resources consumption optimization.

## A Not applicable requirements

[SWS\_IfI\_00224] [These requirements are not applicable to this specification.] ([SRS\\_ - BSW\\_00448](#))