# ARM-RT-DSP

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# 1 ARM RT DSP Library Documentation

## 1.1 Introduction

ARM RT DSP is a library designed to provide developers with a comprehensive set of digital signal processing (DSP) functions optimized for ARM processors. The library offers a broad range of functionalities that include but not limited to ADC operations, limit checks, delta checks, min/max functions, and various other mathematical operations common in DSP.

## 1.2 Examples

# 2 Module Documentation

## 2.1 Limit Functions

### Functions

- static float limit_f32 (float val, float llim, float ulim)

  *Limits the input value to both upper and lower limits.*
- static q31_t upper_limit_q31 (q31_t val, q31_t ulim)

  *Limits the input value to the supplied upper limit.*
- static q31_t lower_limit_q31 (q31_t val, q31_t llim)

  *Limits the input value to the supplied lower limit.*
- static q31_t limit_q31 (q31_t val, q31_t llim, q31_t ulim)

  *Limits the input value to the supplied upper and lower limits.*
- static int32_t limit_i32 (int32_t val, int32_t llim, int32_t ulim)

  *Limits the input value to the supplied upper and lower limits.*
- static uint32_t limit_u32 (uint32_t val, uint32_t llim, uint32_t ulim)

  *Limits the input value to the supplied upper and lower limits.*
- static int16_t limit_i16 (int16_t val, int16_t llim, int16_t ulim)

  *Limits the input value to the supplied upper and lower limits.*
- static uint16_t limit_u16 (uint16_t val, uint16_t llim, uint16_t ulim)

  *Limits the input value to the supplied upper and lower limits.*
- static acc32_t limit_acc31 (acc32_t val, acc32_t llim, acc32_t ulim)

  *Limits the input value to the supplied upper and lower limits.*
- static uint16_t upper_limit_u16 (uint16_t val, uint16_t ulim)

  *Limits the input value to the supplied upper limit.*

### 2.1.1 Detailed Description

The limit functions can be used to limit the range of an input or output value in your control algorithm. The functions are inlined to avoid function call overhead. Variants allow limiting on only one side of the range or both sides.

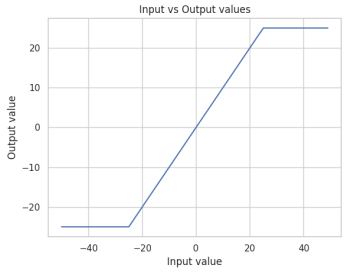



**Figure 1 Sequential calls to limit_i16(val, llim, ulim)**

### 2.1.2 Function Documentation

#### 2.1.2.1 limit_acc31()

```
static acc32_t limit_acc31 (
        acc32_t val,
        acc32_t llim,
        acc32_t ulim )  [inline], [static]
```

Limits the input value to the supplied upper and lower limits.

**Parameters**

| | |
|---|---|
| *val* | Input value to be limited. |
| *llim* | Lower limit to be applied. |
| *ulim* | Upper limit to be applied. |

**Returns**

A value in the range [llim, ulim].

#### 2.1.2.2 limit_f32()

```
static float limit_f32 (
        float val,
        float llim,
        float ulim )  [inline], [static]
```

Limits the input value to both upper and lower limits.

**Parameters**

| | |
|---|---|
| *val* | Input value to be limited. |
| *llim* | Lower limit to be applied. |
| *ulim* | Upper limit to be applied. |

**Returns**

A value in the range [-1.0, 1.0].

#### 2.1.2.3 limit_i16()

```
static int16_t limit_i16 (
        int16_t val,
        int16_t llim,
        int16_t ulim )  [inline], [static]
```

Limits the input value to the supplied upper and lower limits.

**Parameters**

| | |
|---|---|
| *val* | Input value to be limited. |
| *llim* | Lower limit to be applied. |
| *ulim* | Upper limit to be applied. |

**Returns**

A value in the range [llim, ulim].

#### 2.1.2.4 limit_i32()

```
static int32_t limit_i32 (
        int32_t val,
        int32_t llim,
        int32_t ulim )  [inline], [static]
```

Limits the input value to the supplied upper and lower limits.

**Parameters**

| | |
|---|---|
| *val* | Input value to be limited. |
| *llim* | Lower limit to be applied. |
| *ulim* | Upper limit to be applied. |

**Returns**

A value in the range [llim, ulim].

#### 2.1.2.5 limit_q31()

```
static q31_t limit_q31 (
        q31_t val,
        q31_t llim,
        q31_t ulim )  [inline], [static]
```

Limits the input value to the supplied upper and lower limits.

**Parameters**

| | |
|---|---|
| *val* | Input value to be limited. |
| *llim* | Lower limit to be applied. |
| *ulim* | Upper limit to be applied. |

**Returns**

A value in the range [llim, ulim].

#### 2.1.2.6 limit_u16()

```
static uint16_t limit_u16 (
        uint16_t val,
        uint16_t llim,
        uint16_t ulim )  [inline], [static]
```

Limits the input value to the supplied upper and lower limits.

**Parameters**

| | |
|---|---|
| *val* | Input value to be limited. |
| *llim* | Lower limit to be applied. |
| *ulim* | Upper limit to be applied. |

**Returns**

A value in the range [llim, ulim].

#### 2.1.2.7 limit_u32()

```
static uint32_t limit_u32 (
        uint32_t val,
        uint32_t llim,
        uint32_t ulim )  [inline], [static]
```

Limits the input value to the supplied upper and lower limits.

**Parameters**

| | |
|---|---|
| *val* | Input value to be limited. |
| *llim* | Lower limit to be applied. |
| *ulim* | Upper limit to be applied. |

**Returns**

A value in the range [llim, ulim].

#### 2.1.2.8 lower_limit_q31()

```
static q31_t lower_limit_q31 (
        q31_t val,
        q31_t llim )  [inline], [static]
```

Limits the input value to the supplied lower limit.

**Parameters**

| | |
|---|---|
| *val* | Input value to be limited. |
| *llim* | Lower limit to be applied. |

**Returns**

A value in the range [llim, 1.0].

#### 2.1.2.9 upper_limit_q31()

```
static q31_t upper_limit_q31 (
        q31_t val,
        q31_t ulim )  [inline], [static]
```

Limits the input value to the supplied upper limit.

**Parameters**

| | |
|---|---|
| *val* | Input value to be limited. |
| *ulim* | Upper limit to be applied. |

**Returns**

A value in the range [-1.0, ulim].

#### 2.1.2.10 upper_limit_u16() `static uint16_t upper_limit_u16 ( uint16_t val, uint16_t ulim ) [inline], [static]`

Limits the input value to the supplied upper limit.

**Parameters**

| | |
|---|---|
| *val* | Input value to be limited. |
| *ulim* | Upper limit to be applied. |

**Returns**

A value in the range [0, ulim].

# 3 Data Structure Documentation

## 3.1 filter_pma_a63_t Struct Reference

Pseudo windowed moving average data structure.

`#include <arm_rt_dsp.h>`

### Data Fields

- acc64_t acc
  *A 64-bit accumulator.*
- uint16_t sh
  *The window size is equal to 2^ sh.*

### 3.1.1 Detailed Description

Pseudo windowed moving average data structure.

The init function from the 56800EX DSP library sets the accumulator to a value that would output the desired initial value on the first iteration. For now, just initialize the the structure to the desired window size and zero the accumulator. Remember the accumulator will have to wind up when the filter is used. For glacially slow filters, winding up might take eons.

The documentation for this struct was generated from the following file:

- arm_rt_dsp.h

## 3.2 hysteresis_thresh_i16_t Struct Reference

Context structure for the hysteresis function.

`#include <arm_rt_dsp.h>`

### Data Fields

- int16_t hyst_on
- int16_t hyst_off
- int16_t out_state

### 3.2.1 Detailed Description

Context structure for the hysteresis function.

### 3.2.2 Field Documentation

#### 3.2.2.1 hyst_off `int16_t hyst_off`

Value determining the lower threshold

#### 3.2.2.2 hyst_on `int16_t hyst_on`

Value determining the upper threshold

#### 3.2.2.3 out_state `int16_t out_state`

Actual state of the output

The documentation for this struct was generated from the following file:

- arm_rt_dsp.h

## 3.3 hysteresis_thresh_t Struct Reference

Context structure for the hysteresis function.

`#include <arm_rt_dsp.h>`

**Data Fields**

- q31_t hyst_on
- q31_t hyst_off
- int32_t out_state

### 3.3.1 Detailed Description

Context structure for the hysteresis function.

### 3.3.2 Field Documentation

#### 3.3.2.1 hyst_off `q31_t hyst_off`

Value determining the lower threshold

#### 3.3.2.2 hyst_on `q31_t hyst_on`

Value determining the upper threshold

#### 3.3.2.3 out_state `int32_t out_state`

Actual state of the output

The documentation for this struct was generated from the following file:

- arm_rt_dsp.h

## 3.4 ramp_limit_i16_t Struct Reference

Signed int16_t ramp limiter data structure.

```
#include <arm_rt_dsp.h>
```

**Data Fields**

- int16_t **llim**
- int16_t **ulim**
- int16_t **inc**
- int16_t **y**

### 3.4.1 Detailed Description

Signed int16_t ramp limiter data structure.

The documentation for this struct was generated from the following file:

- arm_rt_dsp.h

## 3.5 ramp_limit_q15_t Struct Reference

Signed q15_t ramp limiter data structure.

```
#include <arm_rt_dsp.h>
```

### Data Fields

- q15_t **llim**
- q15_t **ulim**
- q15_t **inc**
- q15_t **y**

### 3.5.1 Detailed Description

Signed q15_t ramp limiter data structure.

The documentation for this struct was generated from the following file:

- arm_rt_dsp.h

## 3.6 ramp_q31_t Struct Reference

Signed q31_t ramp data structure.

```
#include <arm_rt_dsp.h>
```

### Data Fields

- q31_t **inc**
- q31_t **y**

### 3.6.1 Detailed Description

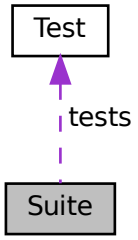
Signed q31_t ramp data structure.

The documentation for this struct was generated from the following file:

- arm_rt_dsp.h

## 3.7 Suite Struct Reference

Collaboration diagram for Suite:




### Data Fields

- const char * **name**
- Test * **tests**
- int **test_count**

The documentation for this struct was generated from the following file:

- common.h

## 3.8 Test Struct Reference

### Data Fields

- const char * **name**
- CU_TestFunc **function**

The documentation for this struct was generated from the following file:

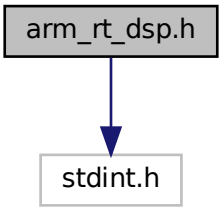
- common.h

# 4 File Documentation

## 4.1 arm_rt_dsp.h File Reference

This file contains the definitions of the ARM DSP types and functions.

`#include <stdint.h>`
Include dependency graph for arm_rt_dsp.h:




### Data Structures

- struct filter_pma_a63_t
  *Pseudo windowed moving average data structure.*
- struct ramp_limit_i16_t
  *Signed int16_t ramp limiter data structure.*
- struct ramp_limit_q15_t
  *Signed q15_t ramp limiter data structure.*
- struct ramp_q31_t
  *Signed q31_t ramp data structure.*
- struct hysteresis_thresh_t
  *Context structure for the hysteresis function.*
- struct hysteresis_thresh_i16_t
  *Context structure for the hysteresis function.*

### Macros

- #define **MOCK_ARM_MATH**
- #define Q15(x) ((q15_t)((x) < 0.999969482421875 ? ((x) >= -1 ? (x)∗0x8000 : 0x8000) : 0x7FFF))
  *Macro for defining a q15_t constant value in the range [-1.0, 1.0).*
- #define Q31(x) ((q31_t)((x) < 1 ? ((x) >= -1 ? (x)∗0x80000000 : 0x80000000) : 0x7FFFFFFF))
  *Macro for defining a q31_t constant value in the range [-1.0, 1.0).*
- #define ACC16(x) ((acc16_t)((x) < 255.9921875 ? ((x) >= -256 ? (x)∗0x80 : 0x8000) : 0x7FFF))
  *Macro for defining an acc16_t constant value in the range [-255.0, 255.0).*
- #define ACC32(x) ((acc32_t)((x) < 65535.999969482421875 ? ((x) >= -65536 ? (x)∗0x8000 : 0x80000000) : 0x7FFFFFFF))
  *Macro for defining an acc32_t constant value in the range [-65535.0, 65535.0).*

### Typedefs

- typedef int16_t q15_t

  *A 16-bit fractional data type in 1.15 format.*
- typedef int32_t q31_t

  *A 32-bit fractional data type in 1.31 format.*
- typedef float float32_t

  *A 32-bit floating point data type.*
- typedef int64_t q63_t

  *A 64-bit fractional data type in 1.63 format.*
- typedef int16_t acc16_t

  *A 16-bit accumulator data type in 9.7 format.*
- typedef int32_t acc32_t

  *A 32-bit accumulator data type in 17.15 format.*
- typedef int64_t acc64_t

  *A 64-bit accumulator in 33.31 format.*

### Functions

- static int32_t **__SSAT** (int32_t value, uint32_t sat)
- static int32_t **__QADD** (int32_t x, int32_t y)
- static int32_t **__QSUB** (int32_t x, int32_t y)
- static int64_t ssat_i64 (int64_t val, uint32_t sat)

  *Signed Saturate.*
- static q15_t abs_q15 (q15_t parVal)

  *Calculates the absolute value of the input without saturation.*
- static q31_t abs_q31 (q31_t parVal)

  *Calculates the absolute value of the input without saturation.*
- static q15_t abs_sat_q15 (q15_t parVal)

  *Calculates the absolute value of the input without saturation.*
- static q31_t abs_sat_q31 (q31_t parVal)

  *Calculates the absolute value of the input with saturation.*
- static q15_t mul_q15 (q15_t x, q15_t y)

  *Multiplies two Q15s.*
- static q31_t mul_q31 (q31_t x, q31_t y)

  *Multiplies two Q31s.*
- static q15_t mulsat_q15 (q15_t x, q15_t y)

  *Multiplies two Q15s with saturation.*
- static q31_t mulsat_q31 (q31_t x, q31_t y)

  *Multiplies two Q31s with saturation.*
- static q31_t max_q31 (q31_t x, q31_t y)

  *Maximum function for Q31 format.*
- static q31_t min_q31 (q31_t x, q31_t y)

  *Minimum function for Q31 format.*
- static q15_t adc_process_sample_q15 (uint16_t x, int16_t offset, q15_t slope)

  *Converts an unsigned ADC raw value to a Q15 format with offset and scale applied.*
- static q31_t adc_process_sample_q31 (uint16_t x, int16_t offset, q31_t slope)

*Converts an unsigned ADC raw value to a Q31 format with offset and scale applied.*

- static q31_t adc_process_sample_u_q31 (uint16_t x, int16_t offset, q31_t slope)

  *Converts an unsigned ADC raw value to a Q31 format with offset and scale applied.*
- static q31_t adc_process_sample_i16_q31 (int16_t x, int16_t offset, q31_t slope)

  *Converts an unsigned ADC raw value to a Q31 format with offset and scale applied.*
- static q31_t filter_pma_q31 (q31_t inx, filter_pma_a63_t *param)

  *A process function for a pseudo windowed moving average filter.*
- static float limit_f32 (float val, float llim, float ulim)

  *Limits the input value to both upper and lower limits.*
- static q31_t upper_limit_q31 (q31_t val, q31_t ulim)

  *Limits the input value to the supplied upper limit.*
- static q31_t lower_limit_q31 (q31_t val, q31_t llim)

  *Limits the input value to the supplied lower limit.*
- static q31_t limit_q31 (q31_t val, q31_t llim, q31_t ulim)

  *Limits the input value to the supplied upper and lower limits.*
- static int32_t limit_i32 (int32_t val, int32_t llim, int32_t ulim)

  *Limits the input value to the supplied upper and lower limits.*
- static uint32_t limit_u32 (uint32_t val, uint32_t llim, uint32_t ulim)

  *Limits the input value to the supplied upper and lower limits.*
- static int16_t limit_i16 (int16_t val, int16_t llim, int16_t ulim)

  *Limits the input value to the supplied upper and lower limits.*
- static uint16_t limit_u16 (uint16_t val, uint16_t llim, uint16_t ulim)

  *Limits the input value to the supplied upper and lower limits.*
- static acc32_t limit_acc31 (acc32_t val, acc32_t llim, acc32_t ulim)

  *Limits the input value to the supplied upper and lower limits.*
- static uint16_t upper_limit_u16 (uint16_t val, uint16_t ulim)

  *Limits the input value to the supplied upper limit.*
- static int16_t convert_round_q31_to_i16 (q31_t x, uint32_t scale)

  *Converts a value from 1.31 fixed point format, q31_t, to an int16_t with an applied scaling factor and rounding.*
- static int16_t convert_q31_to_i16 (q31_t x, uint32_t scale)

  *Converts a value from 1.31 fixed point format, q31_t, to an int16_t with an applied scaling factor.*
- static uint16_t convert_q31_to_u16 (q31_t x, uint32_t scale)

  *Converts a value from 1.31 fixed point format, q31_t, to a uint16_t with an applied scaling factor.*
- static uint32_t convert_q31_to_u32 (q31_t x, uint32_t scale)

  *Converts a value from 1.31 fixed point format, q31_t, to a uint32_t with an applied scaling factor.*
- static int32_t convert_round_q31_to_i32 (q31_t x, uint32_t scale)

  *Converts a value from 1.31 fixed point format, q31_t, to a int32_t with an applied scaling factor and rounding.*
- static int32_t convert_q31_to_i32 (q31_t x, uint32_t scale)

  *Converts a value from 1.31 fixed point format, q31_t, to a int32_t with an applied scaling factor.*
- static q31_t convert_u16_to_q31 (uint16_t x, int32_t scale)

  *Convert a uint16_t to a q31_t.*
- static q31_t convert_i16_to_q31 (int16_t x, int32_t scale)

  *Convert an int16_t to a q31_t.*
- static q31_t convert_i32_to_q31 (int32_t x, int32_t scale)

  *Convert an int32_t to a q31_t.*
- void ramp_limit_init_i16 (int16_t y0, ramp_limit_i16_t *r)

  *Initialize the linear ramp data structure with an initial output value.*

- int16_t ramp_limit_i16 (int16_t x, ramp_limit_i16_t *r)

  *Linear ramp from one number to another with upper limit and lower limit applied.*
- void ramp_limit_init_q15 (q15_t y0, ramp_limit_q15_t *r)

  *Initialize the linear ramp data structure with an initial output value.*
- q15_t ramp_limit_q15 (q15_t x, ramp_limit_q15_t *r)

  *Linear ramp from one number to another with upper limit and lower limit applied.*
- void ramp_init_q31 (q31_t y0, ramp_q31_t *r)

  *Initialize the linear ramp data structure with an initial output value.*
- q31_t ramp_q31 (q31_t x, ramp_q31_t *r)

  *Linear ramp from one number to another.*
- void hysteresis_init (q31_t l_thresh, q31_t h_thresh, hysteresis_thresh_t *H)

  *Initialize a hyseresis process function.*
- static int32_t hysteresis_threshold (q31_t val, hysteresis_thresh_t *H)

  *Applies a threshold with hysteresis to a q31_t value.*
- void hysteresis_init_i16 (int16_t l_thresh, int16_t h_thresh, hysteresis_thresh_i16_t *H)

  *Initialize a hyseresis process function.*
- static int32_t hysteresis_threshold_i16 (int16_t val, hysteresis_thresh_i16_t *H)

  *Applies a threshold with hysteresis to a i16 value.*
- static int32_t check_delta_q31 (q31_t value, q31_t nominal, q31_t delta)

  *Checks if a value is within some delta of a nominal value.*
- static int32_t check_delta_f32 (float32_t value, float32_t nominal, float32_t delta)

  *Checks if a value is within some delta of a nominal value.*

### 4.1.1 Detailed Description

This file contains the definitions of the ARM DSP types and functions.

### 4.1.2 Typedef Documentation

#### 4.1.2.1 acc16_t `typedef int16_t acc16_t`

A 16-bit accumulator data type in 9.7 format.

In order to stay consistent with the ARM DSP Q types, the sign bit is not counted.

#### 4.1.2.2 acc32_t `typedef int32_t acc32_t`

A 32-bit accumulator data type in 17.15 format.

In order to stay consistent with the ARM DSP Q types, the sign bit is not counted.

Does this name even make sense. Maybe acc32_t was better or acc17_15_t or anything. AM

#### 4.1.2.3 acc64_t typedef int64_t acc64_t

A 64-bit accumulator in 33.31 format.

In order to stay consistent with the ARM DSP Q types, the sign bit is not counted.

#### 4.1.2.4 float32_t typedef float float32_t

A 32-bit floating point data type.

This is the same as the standard C single precision float type.

#### 4.1.2.5 q15_t typedef int16_t q15_t

A 16-bit fractional data type in 1.15 format.

The most significant bit is the sign bit.

#### 4.1.2.6 q31_t typedef int32_t q31_t

A 32-bit fractional data type in 1.31 format.

The most significant bit is the sign bit.

#### 4.1.2.7 q63_t typedef int64_t q63_t

A 64-bit fractional data type in 1.63 format.

The most significant bit is the sign bit.

### 4.1.3 Function Documentation

#### 4.1.3.1 abs_q15() static q15_t abs_q15 ( q15_t *parVal* ) [inline], [static]

Calculates the absolute value of the input without saturation.

**Parameters**

| | |
|---|---|
| *parVal* | The input value. |

**Returns**

The absolute value of the input in the range [1.0, 1.0).

#### 4.1.3.2 abs_q31() `static q31_t abs_q31 ( q31_t parVal ) [inline], [static]`

Calculates the absolute value of the input without saturation.

**Parameters**

| | |
|---|---|
| *parVal* | The input value. |

**Returns**

The absolute value of the input in the range [1.0, 1.0).

#### 4.1.3.3 abs_sat_q15() `static q15_t abs_sat_q15 ( q15_t parVal ) [inline], [static]`

Calculates the absolute value of the input without saturation.

**Parameters**

| | |
|---|---|
| *parVal* | The input value. |

**Returns**

The absolute value of the input in the range [1.0, 1.0).

#### 4.1.3.4 abs_sat_q31() `static q31_t abs_sat_q31 ( q31_t parVal ) [inline], [static]`

Calculates the absolute value of the input with saturation.

**Parameters**

| | |
|---|---|
| *parVal* | The input value. |

**Returns**

The absolute value of the input saturated to [1.0, 1.0).

#### 4.1.3.5 adc_process_sample_i16_q31()

```
static q31_t adc_process_sample_i16_q31 (
        int16_t x,
        int16_t offset,
        q31_t slope )  [inline], [static]
```

Converts an unsigned ADC raw value to a Q31 format with offset and scale applied.

This version is for inputs that use 0V as the reference.

**Parameters**

| | |
|---|---|
| *x* | The raw ADC result value in "counts". |
| *offset* | The offset is specified as an unsigned "counts" value. |
| *slope* | The slope is specified in Q31 format and is in the range [-1.0, 1.0). |

**Returns**

The offset and scaled result in Q31 format is in the range [-1.0, 1.0).

#### 4.1.3.6 adc_process_sample_q15()

```
static q15_t adc_process_sample_q15 (
        uint16_t x,
        int16_t offset,
        q15_t slope )  [inline], [static]
```

Converts an unsigned ADC raw value to a Q15 format with offset and scale applied.

The raw value must be provided in right justified format and is assumed to be 12 bits. Saturation arithmetic is used.

**Parameters**

| | |
|---|---|
| *x* | The raw ADC result value in "counts". |
| *offset* | The offset is specified as an unsigned "counts" value. |
| *slope* | The slope is specified in Q15 format and is in the range [-1.0, 1.0). |

**Returns**

The offset and scaled result in Q15 format is in the range [-1.0, 1.0).

#### 4.1.3.7 adc_process_sample_q31() static q31_t adc_process_sample_q31 ( uint16_t x, int16_t offset, q31_t slope ) [inline], [static]

Converts an unsigned ADC raw value to a Q31 format with offset and scale applied.

This version is for input that use the mid-rail as the reference. The raw value must be provided in right justified format and is assumed to be 12 bits. Saturation arithmetic is used.

**Parameters**

| | |
|---|---|
| *x* | The raw ADC result value in "counts". |
| *offset* | The offset is specified as an unsigned "counts" value. |
| *slope* | The slope is specified in Q31 format and is in the range [-1.0, 1.0). |

**Returns**

The offset and scaled result in Q31 format is in the range [-1.0, 1.0).

#### 4.1.3.8 adc_process_sample_u_q31() static q31_t adc_process_sample_u_q31 ( uint16_t x, int16_t offset, q31_t slope ) [inline], [static]

Converts an unsigned ADC raw value to a Q31 format with offset and scale applied.

This version is for inputs that use 0V as the reference.

**Parameters**

| | |
|---|---|
| *x* | The raw ADC result value in "counts". |
| *offset* | The offset is specified as an unsigned "counts" value. |
| *slope* | The slope is specified in Q31 format and is in the range [-1.0, 1.0). |

**Returns**

The offset and scaled result in Q31 format is in the range [-1.0, 1.0).

#### 4.1.3.9 check_delta_f32() static int32_t check_delta_f32 ( float32_t value, float32_t nominal, float32_t delta ) [inline], [static]

Checks if a value is within some delta of a nominal value.

**Parameters**

| | |
|---|---|
| *value* | The input value. |
| *nominal* | The nominal value. |
| *delta* | The delta applied above and below the nominal value. |

**Returns**

True if nominal - delta $<$ value $<$ nominal + delta. Otherwise returns false.

#### 4.1.3.10 check_delta_q31() `static int32_t check_delta_q31 ( q31_t value, q31_t nominal, q31_t delta ) [inline], [static]`

Checks if a value is within some delta of a nominal value.

**Parameters**

| | |
|---|---|
| *value* | The input value. |
| *nominal* | The nominal value. |
| *delta* | The delta applied above and below the nominal value. |

**Returns**

True if nominal - delta $<$ value $<$ nominal + delta. Otherwise returns false.

#### 4.1.3.11 convert_i16_to_q31() `static q31_t convert_i16_to_q31 ( int16_t x, int32_t scale ) [inline], [static]`

Convert an int16_t to a q31_t.

**Parameters**

| | |
|---|---|
| *x* | Value to convert. |
| *mul* | Scale of value to convert. |

**Returns**

Converted value.

#### 4.1.3.12 convert_i32_to_q31()

```
static q31_t convert_i32_to_q31 (
    int32_t x,
    int32_t scale )  [inline], [static]
```

Convert an int32_t to a q31_t.

**Parameters**

| | |
|---|---|
| *x* | Value to convert. |
| *mul* | Scale of value to convert. |

**Returns**

Converted value.

#### 4.1.3.13 convert_q31_to_i16()

```
static int16_t convert_q31_to_i16 (
    q31_t x,
    uint32_t scale )  [inline], [static]
```

Converts a value from 1.31 fixed point format, q31_t, to an int16_t with an applied scaling factor.

**Parameters**

| | |
|---|---|
| *x* | Input value to be converted |
| *scale* | Scaling value to be applied. |

**Returns**

The converted value.

#### 4.1.3.14 convert_q31_to_i32()

```
static int32_t convert_q31_to_i32 (
    q31_t x,
    uint32_t scale )  [inline], [static]
```

Converts a value from 1.31 fixed point format, q31_t, to a int32_t with an applied scaling factor.

**Parameters**

| | |
|---|---|
| *x* | Input value to be converted |
| *scale* | Scaling value to be applied. |

**Returns**

The converted value.

#### 4.1.3.15 convert_q31_to_u16() `static uint16_t convert_q31_to_u16 (`

```
q31_t x,
uint32_t scale )  [inline], [static]
```

Converts a value from 1.31 fixed point format, q31_t, to a uint16_t with an applied scaling factor.

**Parameters**

| | |
|---|---|
| *x* | Input value to be converted |
| *scale* | Scaling value to be applied. |

**Returns**

The converted value.

#### 4.1.3.16 convert_q31_to_u32() `static uint32_t convert_q31_to_u32 (`

```
q31_t x,
uint32_t scale )  [inline], [static]
```

Converts a value from 1.31 fixed point format, q31_t, to a uint32_t with an applied scaling factor.

**Parameters**

| | |
|---|---|
| *x* | Input value to be converted |
| *scale* | Scaling value to be applied. |

**Returns**

The converted value.

#### 4.1.3.17 convert_round_q31_to_i16() `static int16_t convert_round_q31_to_i16 (`

```
q31_t x,
uint32_t scale )  [inline], [static]
```

Converts a value from 1.31 fixed point format, q31_t, to an int16_t with an applied scaling factor and rounding.

A voltage measurement in q31_t format with a scale of 1.0 represents 1kV has a range of [-1.0kV, 1.0kV). Calling convert_round_q31_to_i16 on this measurement with a scale of 1000 will yield an integer in the range of [-1000, 1000) with units of volts.

**Parameters**

| | |
|---|---|
| *x* | Input value to be converted |
| *scale* | Scaling value to be applied. |

**Returns**

The converted value.

#### 4.1.3.18 convert_round_q31_to_i32()

```
static int32_t convert_round_q31_to_i32 (
    q31_t x,
    uint32_t scale )  [inline], [static]
```

Converts a value from 1.31 fixed point format, q31_t, to a int32_t with an applied scaling factor and rounding.

**Parameters**

| | |
|---|---|
| *x* | Input value to be converted |
| *scale* | Scaling value to be applied. |

**Returns**

The converted value.

#### 4.1.3.19 convert_u16_to_q31()

```
static q31_t convert_u16_to_q31 (
    uint16_t x,
    int32_t scale )  [inline], [static]
```

Convert a uint16_t to a q31_t.

**Parameters**

| | |
|---|---|
| *x* | Value to convert. |
| *mul* | Scale of value to convert. |

**Returns**

Converted value.

#### 4.1.3.20 filter_pma_q31() `static q31_t filter_pma_q31 (`

```
q31_t inx,
filter_pma_a63_t * param )  [inline], [static]
```

A process function for a pseudo windowed moving average filter.

**Parameters**

| | |
|---|---|
| *inx* | The new input sample. |
| *param* | The filter's configuration and state data. |

**Returns**

A new filtered output sample.

#### 4.1.3.21 hysteresis_init() `void hysteresis_init (`

```
q31_t l_thresh,
q31_t h_thresh,
hysteresis_thresh_t * H )
```

Initialize a hyseresis process function.

**Parameters**

| | |
|---|---|
| *l_thresh* | Value determining the lower threshold. |
| *h_thresh* | Value determining the upper threshold. |
| *H* | The context structure for this hysteresis process. |

#### 4.1.3.22 hysteresis_init_i16() `void hysteresis_init_i16 (`

```
int16_t l_thresh,
int16_t h_thresh,
hysteresis_thresh_i16_t * H )
```

Initialize a hyseresis process function.

**Parameters**

| | |
|---|---|
| *l_thresh* | Value determining the lower threshold. |
| *h_thresh* | Value determining the upper threshold. |
| *H* | The context structure for this hysteresis process. |

#### 4.1.3.23 hysteresis_threshold()

```
static int32_t hysteresis_threshold (
        q31_t val,
        hysteresis_thresh_t * H )  [inline], [static]
```

Applies a threshold with hysteresis to a q31_t value.

**Parameters**

| | |
|---|---|
| *val* | The input value. |
| *H* | The context structure for this hysteresis process. |

**Returns**

True or false.

#### 4.1.3.24 hysteresis_threshold_i16()

```
static int32_t hysteresis_threshold_i16 (
        int16_t val,
        hysteresis_thresh_i16_t * H )  [inline], [static]
```

Applies a threshold with hysteresis to a i16 value.

**Parameters**

| | |
|---|---|
| *val* | The input value. |
| *H* | The context structure for this hysteresis process. |

**Returns**

True or false.

#### 4.1.3.25 max_q31()

```
static q31_t max_q31 (
        q31_t x,
        q31_t y )  [inline], [static]
```

Maximum function for Q31 format.

**Parameters**

| | |
|---|---|
| *x* | First value. |
| *y* | Second value. |

**Returns**

The maximum of x and y.

#### 4.1.3.26 min_q31() `static q31_t min_q31 ( q31_t x, q31_t y ) [inline], [static]`

Minimum function for Q31 format.

**Parameters**

| | |
|---|---|
| *x* | First value. |
| *y* | Second value. |

**Returns**

The minimum of x and y.

#### 4.1.3.27 mul_q15() `static q15_t mul_q15 ( q15_t x, q15_t y ) [inline], [static]`

Multiplies two Q15s.

**Parameters**

| | |
|---|---|
| *x* | The first multiplicand. |
| *y* | The second multiplicand. |

**Returns**

The product of the two multiplicands.

#### 4.1.3.28 mul_q31() `static q31_t mul_q31 ( q31_t x, q31_t y ) [inline], [static]`

Multiplies two Q31s.

**Parameters**

| | |
|---|---|
| *x* | The first multiplicand. |
| *y* | The second multiplicand. |

**Returns**

The product of the two multiplicands.

#### 4.1.3.29 mulsat_q15()

```
static q15_t mulsat_q15 (
        q15_t x,
        q15_t y )  [inline], [static]
```

Multiplies two Q15s with saturation.

Some of these capabilities are captured in the toolchain's intrinsics or "idioms".

**Parameters**

| | |
|---|---|
| *x* | The first multiplicand. |
| *y* | The second multiplicand. |

**Returns**

The saturated product of the two multiplicands with a range of [-1.0, 1.0).

#### 4.1.3.30 mulsat_q31()

```
static q31_t mulsat_q31 (
        q31_t x,
        q31_t y )  [inline], [static]
```

Multiplies two Q31s with saturation.

**Parameters**

| | |
|---|---|
| *x* | The first multiplicand. |
| *y* | The second multiplicand. |

**Returns**

The saturated product of the two multiplicands with a range of [-1.0, 1.0).

#### 4.1.3.31 ramp_init_q31() `void ramp_init_q31 (`

```
q31_t y0,
ramp_q31_t * r )
```

Initialize the linear ramp data structure with an initial output value.

**Parameters**

| | |
|---|---|
| *y0* | Initial output value. |
| *r* | Ramp data structure. |

#### 4.1.3.32 ramp_limit_i16() `int16_t ramp_limit_i16 (`

```
int16_t x,
ramp_limit_i16_t * r )
```

Linear ramp from one number to another with upper limit and lower limit applied.

**Parameters**

| | |
|---|---|
| *x* | Input value is new or current ramp target. |
| *r* | Ramp data structure. |

**Returns**

The ramped value output approaches the current target at the ramp rate specified.

#### 4.1.3.33 ramp_limit_init_i16() `void ramp_limit_init_i16 (`

```
int16_t y0,
ramp_limit_i16_t * r )
```

Initialize the linear ramp data structure with an initial output value.

**Parameters**

| | |
|---|---|
| *y0* | Initial output value. |
| *r* | Ramp data structure. |

#### 4.1.3.34 ramp_limit_init_q15() `void ramp_limit_init_q15 (`

```
q15_t y0,
ramp_limit_q15_t * r )
```

Initialize the linear ramp data structure with an initial output value.

**Parameters**

| | |
|---|---|
| *y0* | Initial output value. |
| *r* | Ramp data structure. |

#### 4.1.3.35 ramp_limit_q15()

```
q15_t ramp_limit_q15 (
    q15_t x,
    ramp_limit_q15_t * r )
```

Linear ramp from one number to another with upper limit and lower limit applied.

**Parameters**

| | |
|---|---|
| *x* | Input value is new or current ramp target. |
| *r* | Ramp data structure. |

**Returns**

The ramped value output approaches the current target at the ramp rate specified.

#### 4.1.3.36 ramp_q31()

```
q31_t ramp_q31 (
    q31_t x,
    ramp_q31_t * r )
```

Linear ramp from one number to another.

**Parameters**

| | |
|---|---|
| *x* | Input value is new or current ramp target. |
| *r* | Ramp data structure. |

**Returns**

The ramped value output approaches the current target at the ramp rate specified.

#### 4.1.3.37 ssat_i64() `static int64_t ssat_i64 ( int64_t val, uint32_t sat ) [inline], [static]`

Signed Saturate.

Saturates a signed value.

**Parameters**

| | | |
|---|---|---|
| in | *value* | Value to be saturated |
| in | *sat* | Bit position to saturate to (1..32) |

**Returns**

Saturated value

## 4.2 common.h File Reference

Common definitions and additional documentation for unit tests.

### Data Structures

- struct Test
- struct Suite

### 4.2.1 Detailed Description

Common definitions and additional documentation for unit tests.

# Index