

sac-format

0.6.0

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<b>1 Introduction</b>	<b>2</b>
1.1 Why sac-format	2
1.1.1 Safe	2
1.1.2 Fast	2
1.1.3 Easy	2
1.1.4 Small	2
1.1.5 Documented	3
1.1.6 Transparent	3
1.1.7 Trace Class	3
1.1.8 Low-Level I/O	3
<b>2 Installation</b>	<b>3</b>
2.1 Windows	3
2.2 macOS	4
2.2.1 Graphical	4
2.2.2 Command line	4
2.3 Linux	4
2.3.1 Debian Archive	5
2.3.2 RPM Archive	5
2.3.3 Self-Extracting Archive	5
2.3.4 Gzipped Tar Archive	5
<b>3 Quickstart</b>	<b>5</b>
3.1 Example Programs	5
3.1.1 list_sac	5
3.2 CMake Integration	5
3.3 Example	6
3.3.1 Reading and Writing	6
<b>4 Basic Documentation</b>	<b>6</b>
4.1 Trace class	6
4.1.1 Reading SAC	6
4.1.2 Writing SAC	6
4.1.3 Getters and Setters	7
4.1.4 Convenience Methods	9
4.1.5 Exceptions	9
4.2 Convenience Functions	9
4.2.1 degrees_to_radians	9
4.2.2 radians_to_degrees	10
4.2.3 gcarc	10
4.2.4 azimuth	10
4.2.5 limit_360	10
4.2.6 limit_180	10

4.2.7 limit_90 . . . . .	10
4.3 Low-Level I/O . . . . .	10
4.3.1 Binary conversion . . . . .	10
4.3.2 Reading/Writing . . . . .	11
4.3.3 Utility . . . . .	12
4.4 Testing . . . . .	12
4.4.1 Errors only . . . . .	12
4.4.2 Full output . . . . .	12
4.4.3 Compact output . . . . .	13
4.4.4 Additional options . . . . .	13
4.4.5 Using ctest . . . . .	13
4.5 Benchmarking . . . . .	13
4.6 Source File List . . . . .	13
4.6.1 Core . . . . .	13
4.6.2 Testing and Benchmarking . . . . .	13
4.6.3 Example programs . . . . .	13
<b>5 SAC-file format</b> . . . . .	<b>14</b>
5.1 Floating-point (39) . . . . .	14
5.2 Double (22) . . . . .	15
5.3 Integer (26) . . . . .	16
5.4 Boolean (4) . . . . .	18
5.5 String (23) . . . . .	19
5.6 Data (2) . . . . .	20
<b>6 Build Instructions</b> . . . . .	<b>20</b>
6.1 Dependencies . . . . .	20
6.1.1 Automatic (CMake) . . . . .	20
6.1.2 Manual . . . . .	20
6.2 Building . . . . .	20
6.2.1 GCC . . . . .	20
6.2.2 Clang . . . . .	20
<b>7 Namespace Index</b> . . . . .	<b>20</b>
7.1 Namespace List . . . . .	20
<b>8 Hierarchical Index</b> . . . . .	<b>21</b>
8.1 Class Hierarchy . . . . .	21
<b>9 Class Index</b> . . . . .	<b>21</b>
9.1 Class List . . . . .	21
<b>10 Namespace Documentation</b> . . . . .	<b>22</b>
10.1 sacfmt Namespace Reference . . . . .	22

10.1.1 Detailed Description	26
10.1.2 Typedef Documentation	26
10.1.3 Enumeration Type Documentation	27
10.1.4 Function Documentation	33
10.1.5 Variable Documentation	69
10.2 sacfmt::bitset_type Namespace Reference	74
10.2.1 Detailed Description	75
10.2.2 Variable Documentation	75
<b>11 Class Documentation</b>	<b>75</b>
11.1 sacfmt::io_error Class Reference	75
11.1.1 Detailed Description	76
11.1.2 Constructor & Destructor Documentation	76
11.1.3 Member Function Documentation	77
11.1.4 Member Data Documentation	77
11.2 sacfmt::read_spec Struct Reference	77
11.2.1 Detailed Description	78
11.2.2 Member Data Documentation	78
11.3 sacfmt::Trace Class Reference	78
11.3.1 Detailed Description	84
11.3.2 Constructor & Destructor Documentation	84
11.3.3 Member Function Documentation	87
11.3.4 Member Data Documentation	162
11.4 sacfmt::bitset_type::uint< nbits > Struct Template Reference	163
11.4.1 Detailed Description	163
11.5 sacfmt::bitset_type::uint< 2 *bits_per_byte > Struct Reference	163
11.5.1 Detailed Description	163
11.5.2 Member Typedef Documentation	163
11.6 sacfmt::bitset_type::uint< 4 *bits_per_byte > Struct Reference	163
11.6.1 Detailed Description	164
11.6.2 Member Typedef Documentation	164
11.7 sacfmt::bitset_type::uint< bits_per_byte > Struct Reference	164
11.7.1 Detailed Description	164
11.7.2 Member Typedef Documentation	164
11.8 sacfmt::bitset_type::uint< bytes *bits_per_byte > Struct Reference	165
11.8.1 Member Typedef Documentation	165
11.9 sacfmt::word_pair< T > Struct Template Reference	165
11.9.1 Detailed Description	165
11.9.2 Member Data Documentation	166
<b>Index</b>	<b>167</b>

# 1 Introduction

sac-format is a single-header statically linked library designed to make working with binary [SAC](#)-files as easy as possible. Written in C++20, it follows a modern and easy to read programming-style while providing the high performance brought by C++.

sac-format's developed on [GitHub](#)!

Download [sac-format](#) from the GitHub release page.

[Download](#) an offline version of the documentation (PDF).

Get [help](#) from the community forum.

## 1.1 Why sac-format

sac-format is Free and Open Source Software (FOSS) released under the MIT license. Anyone can use it, for any purpose (including proprietary software), anywhere in the world. sac-format is operating system agnostic and confirmed working on Windows, macOS, and Linux systems.

### 1.1.1 Safe

sac-format is **safe** it conforms to a strict set of C++ programming guidelines, chosen to ensure safe code-execution. The guideline conformance list is in [cpp-linter.yml](#) and can be cross-referenced against this [master list](#). Results of conformance checking are [here](#).

Testing is an important part of software development; the sac-format library is extensively tested using the [Catch2](#) testing framework. Everything from low-level binary conversions to high-level `Trace` reading/writing are tested and confirmed working. Check and run the tests yourself. See the [Testing](#) section for more information.

### 1.1.2 Fast

sac-format is **fast** it's written in C++, carefully optimized, and extensively benchmarked. You can run the benchmarks yourself to find out how sac-format performs on your system. See the [Benchmarking](#) section for more information.

### 1.1.3 Easy

sac-format is **easy** single-header makes integration in any project simple. Installation is easy with our automatic installers. Building is a breeze with [CMake](#), even on different platforms. Object-oriented design makes use easy and intuitive. See the [Quickstart](#) section to get up and running.

### 1.1.4 Small

sac-format is **small** in total (header + implementation; excluding comments) the library is under 2100\* lines of code. Small size opens the door to using on any sort of hardware (old or new) and makes it easy to expand upon.

\* This value includes only the library, excluding all testing/benchmarking and example codes. Including `utests.cpp`, `benchmark.cpp`, `util.hpp`, the example program (`list_sac`), and sac-format totals just over 5100 lines of code.

### 1.1.5 Documented

sac-format is extensively **documented** both online and in the code. Nothing's hidden, nothing's obscured. Curious how something works? Check the documentation and in-code comments.

### 1.1.6 Transparent

sac-format is **transparent** all analysis and coverage information is publicly available online.

- [CodeFactor](#)
- [Codacy](#)
- [CodeCov](#)
- [Coverity Scan](#)

### 1.1.7 Trace Class

sac-format includes the `Trace` class for seismic traces, providing high-level object-oriented abstraction to seismic data. With the `Trace` class, you don't need to worry about manually reading SAC-files word-by-word. It's compatible with `v6` and `v7` SAC-files and can automatically detect the version upon reading. File output defaults to `v7` SAC-files and there is a `legacy_write` function for `v6` output.

### 1.1.8 Low-Level I/O

If you want to roll your own SAC-file processing workflow you can use the low-level I/O functionality built into sac-format. All functions tested and confirmed working they're used to build the `Trace` class!

## 2 Installation

The easiest way to use sac-format is to install it via the automatic installers. Installers for the latest release are located [here](#). Be sure to check the sha512 checksum of the installer against its correspondingly named `.sha512` file to ensure the file is safe (for example: `sac-format.pkg` corresponds to `sac-format.pkg.sha512`).

### 2.1 Windows

sac-format provides a graphical installer on Windows (`sac-format.exe`).

Always check the sha512 checksum value of the installer (`sac-format.exe`; [more info here](#)) against `sac-format.exe.sha512`.

By default, Microsoft Defender will block the installer with a pop-up like that one below:

To continue the install, click on the 'More Info' link and then the 'Run anyway' button as seen in the following image:

Then the installer will open and present you with the welcome screen:

By default, sac-format installs in `C:/Program Files/sac-format` as seen in the screen below:

Because all programs in sac-format are command-line based feel free to disable Start Menu shortcuts:

Upon successful install of sac-format you will see this window:

## 2.2 macOS

sac-format provides both command line and graphical installers on macOS.

### 2.2.1 Graphical

The graphical installer is `sac-format.pkg` and will walk you through the installation process. **NOTE:** the default installation location is `/opt/sac-format`.

By default, macOS will block the installer. To install, right-click on `sac-format.pkg` and select open. A warning will pop up that looks like:

Simply click 'Open' and the installer will begin from the first screen:

Upon successful installation you will see:

### 2.2.2 Command line

Command line installation is performed either using the self-extracting archive or by manually extracting the gzipped tar archive.

#### Self-Extracting Archive

```
# Check the sha512 checksum
sha512sum -c sac-format-<version>-Darwin-<arch>.sh.sha512
# Run self-extracting archive
bash sac-format-<version>-Darwin-<arch>.sh
```

Be sure to replace `<version>` and `<arch>` with the correct versions and architectures, respectively (for example: `sac-format-0.4.0-Darwin-x86_64.sh`).

#### Gzipped Tar Archive

```
# Check the sha512 checksum
sha512sum -c sac-format-<version>-Darwin-<arch>.tar.gz.sha512
# Extract Gzipped tar archive
tar -xzf sac-format-<version>-Darwin-<arch>.tar.gz
```

## 2.3 Linux

sac-format provides four different command line installation methods on Linux.

**Debian** based distributions (for example: Debian, Ubuntu, Linux Mint) can use the Debian Archive.

**RedHat** based distributions (for example: RedHat, Fedora, CentOS) can use the RPM Archive.

All distributions can use the Self-Extracting Archive.

All distributions can use the Gzipped Tar Archive.

### 2.3.1 Debian Archive

```
# Check the sha512 checksum
sha512sum -c sac-format.deb.sha512
# Install using apt
sudo apt install ./sac-format.deb
```

### 2.3.2 RPM Archive

```
# Check the sha512 checksum
sha512sum -c sac-format.rpm.sha512
# Install using rpm
sudo rpm -i sac-format.rpm
```

### 2.3.3 Self-Extracting Archive

```
# Check the sha512 checksum
sha512sum -c sac-format-<version>-Linux-<arch>.sh.sha512
# Run self-extracting archive
bash sac-format-<version>-Linux-<arch>.sh
```

### 2.3.4 Gzipped Tar Archive

```
# Check the sha512 checksum
sha512sum -c sac-format-<version>-Linux-<arch>.tar.gz.sha512
# Extract gzipped tar archive
tar -xzf sac-format-<version>-Linux-<arch>.tar.gz
```

## 3 Quickstart

To use link to the library (`libsac-format.a` on Linux/macOS, `sac-format.lib` on Windows) and include `sac_format.hpp`.

## 3.1 Example Programs

### 3.1.1 list\_sac

`list_sac` is a command line program that takes a single SAC-file as its input argument. It reads the SAC-file and outputs the header/footer information, as well as the true size of the ``data1`` and ``data2`` vectors.

## 3.2 CMake Integration

To integrate `sac-format` into your CMake project, add it to your `CMakeLists.txt`.

```
include(FetchContent)
set(FETCHCONTENT_UPDATES_DISCONNECTED TRUE)
FetchContent_Declare(sac-format
  GIT_REPOSITORY https://github.com/arbCoding/sac-format
  GIT_TAG vX.X.X)
FetchContent_MakeAvailable(sac-format)
include_directory(${sacformat_SOURCE_DIR/src})

project(your_project
  LANGUAGES CXX)

add_executable(your_executable
  your_sources
  sac_format.hpp)

target_link_libraries(your_executable
  PRIVATE sac-format)
```



## 3.3 Example

### 3.3.1 Reading and Writing

```
#include <sac_format.hpp>
#include <filesystem>
#include <iostream>

using namespace sacfmt;
namespace fs = std::filesystem;

int main() {
    Trace trace1{};
    // Change header variable
    trace1.kstnm("Station1");
    fs::path file{"/test.SAC"};
    // Write
    trace1.write(file);
    // Read
    Trace trace2 = Trace(file);
    // Confirm equality
    std::cout << (trace1 == trace2) << '\n';
    fs::remove(file);
    return EXIT_SUCCESS;
}
```

## 4 Basic Documentation

### 4.1 Trace class

The `Trace` class provides easy access to SAC-files in C++. Each SAC-file is a `Trace`; therefore, each `Trace` object is a seismic trace (seismogram).

#### 4.1.1 Reading SAC

SAC-files can be read in by using the parameterized constructor with a `std::filesystem::path` (`<filesystem>`) or a `std::string` (`<string>`) variable that corresponds to the location of the SAC-file.

For example:

```
#include <sac_foramt.hpp>
#include <filesystem>

int main() {
    std::filesystem::path my_file{"/home/user/data/ANMO.SAC"};
    sacfmt::Trace anmo{sacfmt::Trace(my_file)};
    return EXIT_SUCCESS;
}
```

#### 4.1.2 Writing SAC

Writing SAC files can be done using one of two write functions.

##### v7 files

Use `write` (for example `trace.write(filename)`).

##### v6 files

Use `legacy_write` (for example `trace.legacy_write(filename)`).

### 4.1.3 Getters and Setters

Every SAC variable is accessed via getters and setters of the same name.

#### Example Getters

- `trace.npts()`
- `trace.data1()`
- `trace.kstnm()`

#### Example Setters

- `trace.kevnm("Event 1")`
- `trace.evla(32.89)`
- `trace.mag(3.21)`

#### Setter rules

Most of the setters are only constrained by the parameter type (single-precision, double-precision, boolean, etc.). **Some** setters are constrained by additional rules.

#### Required for sanity

Rules here are required because the `sac-format` library assumes them (not strictly required by the SAC format standard). For instance, the geometric functions assume certain bounds on latitudes and longitudes.

`sac-format` automatically imposes these rules.

#### **stla(input)**

Limited to [-90, 90] degrees, input that is outside that range is reduced using circular symmetry.

#### **stlo(input)**

Limited to [-180, 180] degrees, input that is outside that range is reduced using circular symmetry.

#### **evla(input)**

Limited to [-90, 90] degrees, input that is outside that range is reduced using circular symmetry.

**evlo(input)**

Limited to [-180, 180] degrees, input that is outside that range is reduced using circular symmetry.

**Required for safety**

Rules here are required by the SAC format standard. sac-format automatically imposes these rules to prevent the creation of corrupt sac-files.

**npts(input)**

Because `npts` defines the size of the data vectors, changing this value will change the size of `data1` and `data2*`. Increasing `npts` resizes the vectors ( `std::vector::resize`) by placing zeros at the **end** of the vectors. Reducing `npts` resizes the vectors down to the **first npts** values.

Therefore, care must be taken to maintain separate copies of `data1` and `data2*` if you plan to manipulate the original data **after** resizing.

\* `data2` has `npts` only if it is legal, otherwise it is of size 0.

**leven(input)**

Changing the value of `leven` potentially changes the legality of `data2`, it also potentially affects the value of `iftype`.

If `iftype>1`, then `leven` must be `true` (evenly sampled data). Therefore, if `leven` is made `false` in this scenario (unevenly sampled data) then `iftype` becomes unset\*.

If changing `leven` makes `data2` legal\*\*, then `data2` is qresized to have `npts` zeros.

\* The SAC format defines the unset values for all data-types. For integers (like `iftype`) it is the integer value -12345.

\*\* If `data2` was already legal, then it is unaffected.

**iftype(input)**

Changing the value of `iftype` potentially changes the legality of `data2`, it also potentially affects the value of `leven`.

If `leven` is `false`, then `iftype` must be either 1 or unset. Therefore, changing `iftype` to have a value `>1` requires that `leven` becomes `true` (evenly sampled data).

If changing `iftype` makes `data2` legal\*, then `data2` is resized to have `npts` zeros.

\* If `data2` was already legal, then it is unaffected.

**data1(input)**

If the size of `data1` is changed, then `npts` must change to reflect the new size. If `data2` is legal, this adjusts its size to match as well.

**data2(input)**

If the size of `data2` is changed to be larger than 0 and it is illegal, it is made legal by setting `iftype(2)` (spectral-data).

When the size of `data2` changes, `npts` is updated to the new size and `data1` is resized to match.

If `data2` is made illegal, its size is reduced to 0 while `npts` and `data1` are unaffected.

**4.1.4 Convenience Methods****calc\_geometry**

Calculate `gcArc`, `dist`, `az`, and `baz` assuming spherical Earth.

```
trace.stla(45.3);
trace.stlo(34.5);
trace.evla(18.5);
trace.evlo(-34);
trace.calc_geometry();
std::cout << "GcArc: " << trace.gcArc() << '\n';
std::cout << "Dist: " << trace.dist() << '\n';
std::cout << "Azimuth: " << trace.az() << '\n';
std::cout << "BAzimuth: " << trace.baz() << '\n';
```

**frequency**

Calculate frequency from `delta`.

```
double frequency{trace.frequency()};
```

**date**

Return `std::string` formatted as `YYYY-JJJ` from `nzyear` and `nzjday`.

```
std::string date{trace.date()};
```

**time**

Return `std::string` formatted as `HH:MM:SS.xxx` from `nzhour`, `nzmin`, `nzsec`, and `nzmsec`.

```
std::string time{trace.time()};
```

**4.1.5 Exceptions**

`sac-format` throws exceptions of type `sacfmt::io_error` (inherits `std::exception`) in the event of a failure to read/write a SAC-file.

**4.2 Convenience Functions****4.2.1 degrees\_to\_radians**

Convert decimal degrees to radians.

```
double radians{sacfmt::degrees_to_radians(degrees)};
```

### 4.2.2 radians\_to\_degrees

Convert radians to decimal degrees.

```
double degrees{sacfmt::radians_to_degrees(radians)};
```

### 4.2.3 gcarc

Calculate great-circle arc distance (spherical planet).

```
double gcarc{sacfmt::gcarc(latitude1, longitude1, latitude2, longitude2)};
```

### 4.2.4 azimuth

Calculate azimuth between two points (spherical planet).

```
double azimuth{sacfmt::azimuth(latitude2, longitude2, latitude1, longitude1)};
double back_azimuth{sacfmt::azimuth(latitude1, longitude1, latitude2, longitude2)};
```

### 4.2.5 limit\_360

Take arbitrary value of degrees and unwrap to [0, 360].

```
double degrees_limited{sacfmt::limit_360(degrees)};
```

### 4.2.6 limit\_180

Take arbitrary value of degrees and unwrap to [-180, 180]. Useful for longitude.

```
double degrees_limited{sacfmt::limit_180(degrees)};
```

### 4.2.7 limit\_90

Take arbitrary value of degrees and unwrap to [-90, 90]. Useful for latitude.

```
double degrees_limited{sacfmt::limit_90(degrees)};
```

## 4.3 Low-Level I/O

Low-level I/O functions are discussed below.

### 4.3.1 Binary conversion

#### int\_to\_binary and binary\_to\_int

Conversion pair for binary representation of integer values.

```
const int input{10};
// sacfmt::word_one is alias for std::bitset<32> (one word)
sacfmt::word_one binary{sacfmt::int_to_binary(input)};
const int output{sacfmt::binary_to_int(binary)};
std::cout << (input == output) << '\n';
```

**float\_to\_binary and binary\_to\_float**

Conversion pair for binary representation of floating-point values.

```
const float input{5F};
sacfmt::word_one binary{sacfmt::float_to_binary(input)};
const float output{sacfmt::binary_to_float(binary)};
std::cout << (input == output) << '\n';
```

**double\_to\_binary and binary\_to\_double**

Conversion pair for binary representation of double-precision values.

```
const double input{1e5};
// sacfmt::word_two is alias for std::bitset<64> (two words)
sacfmt::word_two binary{sacfmt::double_to_binary(input)};
const double output{sacfmt::binary_to_double(binary)};
std::cout << (input == output) << '\n';
```

**string\_to\_binary and binary\_to\_string**

Conversion pair for binary representation of two-word (regular) string values.

```
const std::string input{"NmlStrng"};
sacfmt::word_two binary{sacfmt::string_to_binary(input)};
const std::string output{sacfmt::binary_to_string(binary)};
std::cout << (input == output) << '\n';
```

**long\_string\_to\_binary and binary\_to\_long\_string**

Conversion pair for binary representation of four-word (only `kstnm` string values).

```
const std::string input{"The Long String"};
// sacfmt::word_four is alias for std::bitset<128> (four words)
sacfmt::word_four binary{sacfmt::long_string_to_binary(input)};
const std::string output{sacfmt::binary_to_long_string(binary)};
std::cout << (input == output) << '\n';
```

**4.3.2 Reading/Writing**

**NOTE** that care must be taken when using them to ensure that safe input is provided; the `Trace` class ensures safe I/O, low-level I/O functions do not necessarily ensure safety.

**read\_word, read\_two\_words, read\_four\_words, and read\_data**

Functions to read one-, two-, and four-word variables (depending on the header) and an arbitrary amount of binary data (exclusive to `data1` and `data2`).

**convert\_to\_word, convert\_to\_words, and bool\_to\_word**

Takes objects and converts them into `std::vector<char>` (`convert_to_word` and `bool_to_word`) or `std::array<char, N>` (`convert_to_words`, `N = # of words`).

**write\_words**

Writes input words (as `std::vector<char>`) to a binary SAC-file.

### 4.3.3 Utility

#### **concat\_words**

Concatenates words taking into account the system endianness.

#### **bits\_string and string\_bits**

Template function that performs conversion of binary strings of arbitrary length to an arbitrary number of words.

#### **remove\_leading\_spaces and remove\_trailing\_spaces**

Remove leading and trailing blank spaces from strings assuming ASCII convention (space character is integer 32, below that value are control characters that also appear as blank spaces).

#### **string\_cleaning**

Ensures string does not contain an internal termination character (`\0`) and removes it if present, then removes blank spaces.

#### **prep\_string**

Performs `string_cleaning` followed by string truncation/padding to the necessary length.

#### **equal\_within\_tolerance**

Floating-point/double-precision equality within a provided tolerance (default is `f_eps`, defined in `sac_format.h`↔`hpp`).

## 4.4 Testing

`utests.cpp` contains the unit- and integration-tests, using Catch2. Test coverage details are visible on [CodeCov.io](#) and [Codacy.com](#). All tests can be locally-run to ensure full functionality and compliance.

### 4.4.1 Errors only

By default `utests` prints out a pass summary, without details unless an error is encountered.

### 4.4.2 Full output

By passing the `--success` flag (`utests --success`) you can see the full results of all tests.

#### 4.4.3 Compact output

The full output is verbose, using the compact reporter will condense the test results (`utests --reporter=compact --success`).

#### 4.4.4 Additional options

To see additional options, run `utests -?`.

#### 4.4.5 Using ctest

If you have CMake install, you can run the tests using `ctest`.

### 4.5 Benchmarking

`benchmark.cpp` contains the benchmarks. Running it locally will provide information on how long each function takes; benchmarks start with the low-level I/O function and build up to Trace reading, writing, and equality comparison.

To view available optional flags, run `benchmark -?`.

### 4.6 Source File List

#### 4.6.1 Core

The two core files are split in the standard interface (hpp)/implementation (cpp) format.

1. `sac_format.hpp`  
Interface: function declarations and constants.
2. `sac_format.cpp`  
Implementation: function details.

#### 4.6.2 Testing and Benchmarking

1. `util.hpp`  
Utility functions and constants exclusive to testing and benchmarking. Not split into interface/implementation.
2. `utests.cpp`
3. `benchmark.cpp`

#### 4.6.3 Example programs

1. `list_sac.cpp`



## 5 SAC-file format

The official and up-to-date documentation for the SAC-file format is available from the EarthScope Consortium (formerly IRIS/UNAVCO) [here](#). The following subsections constitute my notes on the format. Below is a quick guide; all credit for the creation of, and documentation for, the SAC file-format belongs to its developers and maintainers (details [here](#)).

### 5.1 Floating-point (39)

32-bit (1 word, 4 bytes)

1. `depmin`  
Minimum value of the dependent variable (displacement/velocity/acceleration/volts/counts).
2. `depmen`  
Mean value of the dependent variable.
3. `depmax`  
Maximum value of the dependent variable.
4. `odelta`  
Modified (*observational*) value of ``delta``.
5. `resp(0--9)`  
Instrument response parameters (poles, zeros, and a constant).  
**Not used by SAC**; they're free for other purposes.
6. `stel`  
Station elevation in meters above sea level (*m.a.s.l.*).  
**Not used by SAC**; free for other purposes.
7. `stdp`  
Station depth in meters below surface (borehole/buried vault).  
**Not used by SAC**; free for other purposes.
8. `evel`  
Event elevation *m.a.s.l.*  
**Not used by SAC**; free for other purposes.
9. `evdp`  
Event depth in kilometers (*previously meters*) below surface.
10. `mag`  
Event magnitude.
11. `user(0--9)`  
Storage for user-defined values.
12. `dist`  
Station-Event distance in kilometers.
13. `az`  
Azimuth  $\mathrm{\left( \text{Event} \rightarrow \text{Station} \right)}$ , decimal degrees from North.

14. `baz`

Back-azimuth  $\mathrm{\left(Station \ to \ Event\right)}$ , decimal degrees from North.

15. `gcarc`

Station&#x2013;Event great circle arc-length, decimal degrees.

16. `cmpaz`

Instrument measurement azimuth, decimal degrees from North.

Value	Direction
0°	North
90°	East
180°	South
270°	West
Other	1/2/3

1. `cmpinc`

Instrument measurement incident angle, decimal degrees from upward vertical (incident 0° = dip -90°).

| Value | Direction | | 0° | Up | | 90° | Horizontal | | 180° | Down | | 270° | Horizontal |

**NOTE:** SEED/MINISEED use dip angle, decimal degrees down from horizontal (dip 0° = incident 90°).

2. `xminimum`

Spectral-only equivalent of ``depmin`` ( $f_{0}$  or  $\omega_{0}$ ).

3. `xmaximum`

Spectral-only equivalent of ``depmax`` ( $f_{\max}$  or  $\omega_{\max}$ ).

4. `yminimum`

Spectral-only equivalent of ``b``.

5. `ymaximum`

Spectral-only equivalent of ``e``.

## 5.2 Double (22)

64-bit (2 words, 8 bytes)

**NOTE:** in the header section these are floats&#x2013;they're doubles in the footer section of v7 SAC-files. In memory they're stored as doubles regardless of the SAC-file version.

1. `delta`

Increment between evenly spaced samples ( $\Delta t$  for timeseries,  $\Delta f$  or  $\Delta\omega$  for spectra).

2. `b`

First value (*begin*) of independent variable ( $t_{0}$ ).

3. `e`

Final value (*end*) of independent variable ( $t_{\max}$ ).

4. `o`

Event *origin* time, in seconds relative to the reference time.

5. `a`  
Event first *arrival* time, in seconds relative to the reference time.
6. `t (0--9)`  
User defined *time* values, in seconds relative to the reference time.
7. `f`  
Event end (*fini*) time, in seconds relative to the reference time.
8. `stla`  
Station latitude in decimal degrees, N/S&#x2013;positive/negative.  
sac-format automatically enforces  $\mathrm{stla} \in [-90, 90]$ .
9. `stlo`  
Station longitude in decimal degrees, E/W&#x2013;positive/negative.  
sac-format automatically enforces  $\mathrm{stlo} \in [-180, 180]$ .
10. `evla`  
Event latitude in decimal degrees, N/S&#x2013;positive/negative.  
sac-format automatically enforces  $\mathrm{evla} \in [-90, 90]$ .
11. `evlo`  
Event longitude in decimal degrees, E/W&#x2013;positive/negative.  
sac-format automatically enforces  $\mathrm{evlo} \in [-180, 180]$ .
12. `sb`  
Original (*saved*) ``b`` value.
13. `sdelta`  
Original (*saved*) ``delta`` value.

### 5.3 Integer (26)

32-bit (1 word, 4 bytes)

1. `nzyear`  
Reference time GMT year.
2. `nzjday`  
Reference time GMT day-of-year (often called *Julian Date*) (1&#x2013;366).
3. `nzhour`  
Reference time GMT hour (00&#x2013;23).
4. `nzmin`  
Reference time GMT minute (0&#x2013;59).
5. `nzsec`  
Reference time GMT second (0&#x2013;59).
6. `nzmsec`  
Reference time GMT Millisecond (0&#x2013;999).

7. `nvhdr`  
SAC-file version.  
| Version | Description | | v7 | Footer (2020+, sac 102.0+) | | v6 | No footer (pre-2020, sac 101.6a-) |
8. `norid`  
Origin ID.
9. `nevid`  
Event ID.
10. `npts`  
*Number of points* in data.
11. `nsnpts`  
Original (*saved*) ``npts``.
12. `nwfid`  
Waveform ID.
13. `nxsize`  
Spectral-only equivalent of ``npts`` (length of spectrum).
14. `nysize`  
Spectral-only, width of spectrum.
15. `iftype`  
File type.  
| Value | Type | Description | | 01 | ITIME | Time-series | | 02 | IRLIM | Spectral (real/imaginary) | | 03 | IAMPH | Spectral (amplitude/phase) | | 04 | IXY | General XY file | | ?? | IXYZ\* | General XYZ file |  
\*Value not listed in the standard.
16. `idep`  
Dependent variable type.  
| Value | Type | Description | | 05 | IUNKN | Unknown | | 06 | IDISP | Displacement (nm) | | 07 | IVEL | Velocity  $\mathrm{\left(\frac{nm}{s}\right)}$  | | 08 | IACC | Acceleration  $\mathrm{\left(\frac{nm}{s^2}\right)}$  | | 50 | IVOLTS | Velocity (volts) |
17. `iztype`  
Reference time equivalent.  
| Value | Type | Description | | 05 | IUNKN | Unknown | | 09 | IB | Recording start time | | 10 | IDAY | Midnight reference GMT day | | 11 | IO | Event origin time | | 12 | IA | First arrival time | | 13&#x2013;22 | IT(0&#x2013;9) | User defined time (t) pick |
18. `iinst`  
Recording instrument type.  
**Not used by SAC&#x2014;free for other purposes.**
19. `istreg`  
Station geographic region.  
**Not used by SAC&#x2014;free for other purposes.**
20. `ievreg`  
Event geographic region.  
**Not used by SAC&#x2014;free for other purposes.**

21. `ievtyp`

Event type.

Value	Type	Description
05	IUNKN	Unknown
11	IO	Other source of known origin
37	INUCL	Nuclear
38	IPREN	Nuclear pre-shot
39	IPOSTN	Nuclear post-shot
40	IQUAKE	Earthquake
41	IPREQ	Foreshock
42	IPOSTQ	Aftershock
43	ICHEM	Chemical explosion
44	IOTHER	Other
72	IQB	Quarry/mine blast; confirmed by quarry/mine
73	IQB1	Quarry/mine blast; designed shot info-ripple fired
74	IQB2	Quarry/mine blast; observed shot info-ripple fired
75	IQBX	Quarry/mine blast; single shot
76	IQMT	Quarry/mining induced events; tremor and rockbursts
77	IEQ	Earthquake
78	IEQ1	Earthquake in a swarm or in an aftershock sequence
79	IEQ2	Felt earthquake
80	IME	Marine explosion
81	IEX	Other explosion
82	INU	Nuclear explosion
83	INC	Nuclear cavity collapse
85	IL	Local event of unknown origin
86	IR	Region event of unknown origin
87	IT	Teleseismic event of unknown origin
88	IU	Undetermined/conflicting information

22. `igual`

Quality of data.

Value	Type	Description
44	IOTHER	Other
45	IGOOD	Good
46	IGLCH	Glitches
47	IDROP	Dropouts
48	ILOWSN	Low signal-to-noise ratio

**Not used by SAC**; free for other purposes.

23. `isynth`

Synthetic data flag.

Value	Type	Description
49	IRLDATA	Real data
XX	*	Synthetic

\*Values and types not listed in the standard.

24. `imagtyp`

Magnitude type.

Value	Type	Description
52	IMB	Body-wave magnitude ( $M_b$ )
53	IMS	Surface-wave magnitude ( $M_s$ )
54	IML	Local magnitude ( $M_l$ )
55	IMW	Moment magnitude ( $M_w$ )
56	IMD	Duration magnitude ( $M_d$ )
57	IMX	User-defined magnitude ( $M_x$ )

25. `imagsrc`

Source of magnitude information.

Value	Type	Description
58	INEIC	National Earthquake Information Center
61	IPDE	Preliminary Determination of Epicenter
62	IISC	International Seismological Centre
63	IREB	Reviewed Event Bulletin
64	IUSGS	U.S. Geological Survey
65	IBRK	UC Berkeley
66	ICALTECH	California Institute of Technology
67	ILLNL	Lawrence Livermore National Laboratory
68	IEVLOC	Event location (computer program)
69	IJSOP	Joint Seismic Observation Program
70	IUSER	The user
71	IUNKNOWN	Unknown

26. `ibody`

Body/spheroid definition used to calculate distances.

Value	Type	Name	Semi-major axis (a [m])	Inverse Flattening ( $f$ )
-12345	UNDEF	Earth ( <i>Historic</i> )	6378160.0	0.00335293
98	ISUN	Sun	696000000.0	8.189e-6
99	IMERCURY	Mercury	2439700.0	0.0
100	IVENUS	Venus	6051800.0	0.0
101	IEARTH	Earth ( <i>WGS84</i> )	6378137.0	0.0033528106647474805
102	IMOON	Moon	1737400.0	0.0
103	IMARS	Mars	3396190.0	0.005886007555525457

## 5.4 Boolean (4)

32-bit (1 word, 4 bytes) in-file/8-bit (1 byte) in-memory

1. `leven`**REQUIRED**

Evenly-spaced data flag.

If true, then data is evenly spaced.

2. `lpspol`

Station polarity flag.

If true, then station has positive-polarity; it follows the left-hand convention (for example, North-East-Up [NEZ]).

3. `lovrok`

File overwrite flag.

If true, then it's okay to overwrite the file.

4. `lcalda`

Calculate geometry flag.

If true, then calculate ``dist``, ``az``, ``baz``, and ``gcarc`` from ``stla``, ``stlo``, ``evla``, and ``evlo``.

**5.5 String (23)**

32/64-bit (2/4 words, 8/16 bytes, 8/16 characters)

1. `kstnm`

Station name.

2. `kevn*`

Event name.

\*This is the **only** four word (16 character) string.

3. `khole`

Nuclear;hole identifier.

Other;Location identifier (LOCID).

4. `ko`

Text for ``o``.

5. `ka`

Text for ``a``.

6. `kt(0--9)`

Text for ``t(0--9)``.

7. `kf`

Text for ``f``.

8. `kuser(0--2)`

Text for the first three of ``user(0--9)``.

9. `kdatrd`

Date the data was read onto a computer.

10. `kinst`

Text for ``iinst``.

## 5.6 Data (2)

32-bit (2 words, 8 bytes) in-file/64-bit (4 words, 16 bytes) in-memory

Stored as floating-point (32-bit) values in SAC-files; stored as double-precision in memory.

1. `data1`

The first data vector—**always** present in a SAC-file and begins at word 158.

2. `data2`

The second data vector—**conditionally** present and begins after ``data1``.

**Required** if ``leven`` is false, or if ``iftype`` is spectral/XY/XYZ.

## 6 Build Instructions

### 6.1 Dependencies

#### 6.1.1 Automatic (CMake)

`Xoshiro-cpp v1.12.0` (testing and benchmarking)

#### 6.1.2 Manual

`Catch2 v3.4.0` (testing and benchmarking)

### 6.2 Building

Building is as easy as cloning the repository, running CMake for your preferred build tool, and then building.

#### 6.2.1 GCC

```
git clone https://github.com/arbCoding/sac-format.git
cmake --preset gcc-hard-release
cmake --build ./build/release/gcc
```

#### 6.2.2 Clang

```
git clone https://github.com/arbCoding/sac-format.git
cmake --preset clang-hard-release
cmake --build ./build/release/clang
```

## 7 Namespace Index

### 7.1 Namespace List

Here is a list of all namespaces with brief descriptions:

<a href="#">sacfmt</a>	
Sac-format namespace	22
<a href="#">sacfmt::bitset_type</a>	
Bitset type-safety namespace	74

## 8 Hierarchical Index

### 8.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

std::exception	
sacfmt::io_error	75
sacfmt::read_spec	77
sacfmt::Trace	78
sacfmt::bitset_type::uint< nbits >	163
sacfmt::bitset_type::uint< 2 *bits_per_byte >	163
sacfmt::bitset_type::uint< 4 *bits_per_byte >	163
sacfmt::bitset_type::uint< bits_per_byte >	164
sacfmt::bitset_type::uint< bytes *bits_per_byte >	165
sacfmt::word_pair< T >	165

## 9 Class Index

### 9.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

<a href="#">sacfmt::io_error</a>	
Class for generic I/O exceptions	75
<a href="#">sacfmt::read_spec</a>	
Struct that specifies parameters for reading	77
<a href="#">sacfmt::Trace</a>	
The <a href="#">Trace</a> class	78
<a href="#">sacfmt::bitset_type::uint&lt; nbits &gt;</a>	
Ensure type-safety for conversions between floats/doubles and bitsets	163
<a href="#">sacfmt::bitset_type::uint&lt; 2 *bits_per_byte &gt;</a>	
Two-word type-safety (strings)	163



<a href="#">sacfmt::bitset_type::uint&lt; 4 *bits_per_byte &gt;</a>	
Four-word type-safety (kEvNm)	163
<a href="#">sacfmt::bitset_type::uint&lt; bits_per_byte &gt;</a>	
Single-word type-safety (non-strings)	164
<a href="#">sacfmt::bitset_type::uint&lt; bytes *bits_per_byte &gt;</a>	165
<a href="#">sacfmt::word_pair&lt; T &gt;</a>	
Struct containing a pair of words	165

## 10 Namespace Documentation

### 10.1 sacfmt Namespace Reference

sac-format namespace

#### Namespaces

- namespace [bitset\\_type](#)  
*bitset type-safety namespace.*

#### Classes

- class [io\\_error](#)  
*Class for generic I/O exceptions.*
- struct [read\\_spec](#)  
*Struct that specifies parameters for reading.*
- class [Trace](#)  
*The [Trace](#) class.*
- struct [word\\_pair](#)  
*Struct containing a pair of words.*

#### Typedefs

- [using char\\_bit = std::bitset< bits\\_per\\_byte >](#)  
*One binary character (useful for building strings).*
- [using word\\_one = std::bitset< binary\\_word\\_size >](#)  
*One binary word (useful for non-strings).*
- [using word\\_two = std::bitset< static\\_cast< size\\_t >\(2\) \\*binary\\_word\\_size >](#)  
*Two binary words (useful for strings).*
- [using word\\_four = std::bitset< static\\_cast< size\\_t >\(4\) \\*binary\\_word\\_size >](#)  
*Four binary words (kEvNm only).*
- [template<class T >](#)  
[using unsigned\\_int = typename bitset\\_type::uint< sizeof\(T\) \\*bits\\_per\\_byte >::type](#)  
*Convert variable to unsigned-integer using type-safe conversions.*

## Enumerations

- enum class [name](#) {  
[depmin](#) , [depmax](#) , [odelta](#) , [resp0](#) ,  
[resp1](#) , [resp2](#) , [resp3](#) , [resp4](#) ,  
[resp5](#) , [resp6](#) , [resp7](#) , [resp8](#) ,  
[resp9](#) , [stel](#) , [stdp](#) , [evel](#) ,  
[evdp](#) , [mag](#) , [user0](#) , [user1](#) ,  
[user2](#) , [user3](#) , [user4](#) , [user5](#) ,  
[user6](#) , [user7](#) , [user8](#) , [user9](#) ,  
[dist](#) , [az](#) , [baz](#) , [gcarc](#) ,  
[depmen](#) , [cmpaz](#) , [cmpinc](#) , [xminimum](#) ,  
[xmaximum](#) , [yminimum](#) , [ymaximum](#) , [delta](#) ,  
[b](#) , [e](#) , [o](#) , [a](#) ,  
[t0](#) , [t1](#) , [t2](#) , [t3](#) ,  
[t4](#) , [t5](#) , [t6](#) , [t7](#) ,  
[t8](#) , [t9](#) , [f](#) , [stla](#) ,  
[stlo](#) , [evla](#) , [evlo](#) , [sb](#) ,  
[sdelta](#) , [nzyear](#) , [nzjday](#) , [nzhour](#) ,  
[nzmin](#) , [nzsec](#) , [nzmsec](#) , [nvhdr](#) ,  
[norid](#) , [nevid](#) , [npts](#) , [nsnpts](#) ,  
[nwfid](#) , [nxsize](#) , [nysize](#) , [iftype](#) ,  
[idep](#) , [iztype](#) , [iinst](#) , [istreg](#) ,  
[ievreg](#) , [ievtyp](#) , [iqual](#) , [isynth](#) ,  
[imagtyp](#) , [imagsrc](#) , [ibody](#) , [leven](#) ,  
[lpspol](#) , [lovrok](#) , [lcalda](#) , [kstnm](#) ,  
[kevnrm](#) , [khole](#) , [ko](#) , [ka](#) ,  
[kt0](#) , [kt1](#) , [kt2](#) , [kt3](#) ,  
[kt4](#) , [kt5](#) , [kt6](#) , [kt7](#) ,  
[kt8](#) , [kt9](#) , [kf](#) , [kuser0](#) ,  
[kuser1](#) , [kuser2](#) , [kcompnm](#) , [knetwk](#) ,  
[kdatrd](#) , [kinst](#) , [data1](#) , [data2](#) }

*Enumeration of all SAC fields.*

## Functions

- [std::streamoff word\\_position \(const size\\_t word\\_number\) noexcept](#)  
*Calculates position of word in SAC-file.*
- [word\\_one uint\\_to\\_binary \(uint num\) noexcept](#)  
*Convert unsigned integer to 32-bit (one word) binary bitset.*
- [word\\_one int\\_to\\_binary \(int num\) noexcept](#)  
*Convert integer to 32-bit (one word) binary bitset.*
- [int binary\\_to\\_int \(word\\_one bin\) noexcept](#)  
*Convert 32-bit (one word) binary bitset to integer.*
- [word\\_one float\\_to\\_binary \(const float num\) noexcept](#)  
*Convert floating-point value to 32-bit (one word) binary bitset.*
- [float binary\\_to\\_float \(const word\\_one &bin\) noexcept](#)  
*Convert 32-bit (one word) binary bitset to a floating-point value.*
- [word\\_two double\\_to\\_binary \(const double num\) noexcept](#)  
*Convert double-precision value to 64-bit (two words) binary bitset.*
- [double binary\\_to\\_double \(const word\\_two &bin\) noexcept](#)  
*Convert 64-bit (two words) binary bitset to double-precision value.*
- [void remove\\_leading\\_spaces \(std::string \\*str\) noexcept](#)  
*Remove all leading spaces from a string.*

- `void remove_trailing_spaces (std::string *str) noexcept`  
*Remove all trailing spaces from a string.*
- `std::string string_cleaning (const std::string &str) noexcept`  
*Remove leading/trailing spaces and control characters from a string.*
- `void prep_string (std::string *str, const size_t str_size) noexcept`  
*Cleans string and then truncates/pads as necessary.*
- `template<typename T >`  
`void string_bits (T *bits, const std::string &str, const size_t str_size) noexcept`  
*Template function to convert string into binary bitset.*
- `template<typename T >`  
`std::string bits_string (const T &bits, const size_t num_words) noexcept`  
*Template function to convert binary bitset to string.*
- `word_two string_to_binary (std::string str) noexcept`  
*Convert string to a 64-bit (two word) binary bitset.*
- `std::string binary_to_string (const word_two &str) noexcept`  
*Convert a 64-bit (two word) binary bitset to a string.*
- `word_four long_string_to_binary (std::string str) noexcept`  
*Convert a string to a 128-bit (four word) binary bitset.*
- `std::string binary_to_long_string (const word_four &str) noexcept`  
*Convert a 128-bit (four word) binary bitset to a string.*
- `word_one bool_to_binary (const bool flag) noexcept`  
*Convert a boolean to a 32-bit (one word) binary bitset.*
- `bool binary_to_bool (const word_one &flag) noexcept`  
*Convert a 32-bit (one word) binary bitset to a boolean.*
- `word_two concat_words (const word_pair< word_one > &pair_words) noexcept`  
*Concatenate two `word_one` binary strings into a single `word_two` string.*
- `word_four concat_words (const word_pair< word_two > &pair_words) noexcept`  
*Concatenate two `word_two` binary strings into a single `word_four` string.*
- `bool nwords_after_current (std::ifstream *sac, const read_spec &spec) noexcept`  
*Determine if the SAC-file has enough remaining data to read the requested amount of data.*
- `void safe_to_read_header (std::ifstream *sac)`  
*Determine if the SAC-file is large enough to contain a complete header.*
- `void safe_to_read_footer (std::ifstream *sac)`  
*Determines if the SAC-file has enough space remaining to contain a complete footer.*
- `void safe_to_read_data (std::ifstream *sac, const size_t n_words, const bool data2)`  
*Determines if the SAC-file has enough space remaining to contain a complete data vector.*
- `void safe_to_finish_reading (std::ifstream *sac)`  
*Determines if the SAC-file is finished.*
- `word_one read_word (std::ifstream *sac)`  
*Read one word (32 bits, useful for non-strings) from a binary SAC-File.*
- `word_two read_two_words (std::ifstream *sac)`  
*Read two words (64 bits, useful for most strings) from a binary SAC-file.*
- `word_four read_four_words (std::ifstream *sac)`  
*Read four words (128 bits, kEvNm only) from a binary SAC-file.*
- `std::vector< double > read_data (std::ifstream *sac, const read_spec &spec)`  
*Reader arbitrary number of words (useful for vectors) from a binary SAC-file.*
- `void write_words (std::ofstream *sac_file, const std::vector< char > &input)`  
*Write arbitrary number of words (useful for vectors) to a binary SAC-file.*
- `template<typename T >`  
`std::vector< char > convert_to_word (const T input) noexcept`  
*Template function to convert input value into a `std::vector<char>` for writing.*

- `std::vector< char > convert_to_word (const double input) noexcept`  
Convert double value into a `std::vector<char>` for writing.
- `template<size_t N>`  
`std::array< char, N > convert_to_words (const std::string &str, int n_words) noexcept`  
Template function to convert input string value into a `std::array<char>` for writing.
- `std::vector< char > bool_to_word (const bool flag) noexcept`  
Convert boolean to a word for writing.
- `bool equal_within_tolerance (const std::vector< double > &vector1, const std::vector< double > &vector2, const double tolerance) noexcept`  
Check if two `std::vector<double>` are equal within a tolerance limit.
- `bool equal_within_tolerance (const double val1, const double val2, const double tolerance) noexcept`  
Check if two double values are equal within a tolerance limit.
- `double degrees_to_radians (const double degrees) noexcept`  
Convert decimal degrees to radians.
- `double radians_to_degrees (const double radians) noexcept`  
Convert radians to decimal degrees.
- `double gcarc (const double latitude1, const double longitude1, const double latitude2, const double longitude2) noexcept`  
Calculate great circle arc distance in decimal degrees between two points.
- `double azimuth (const double latitude1, const double longitude1, const double latitude2, const double longitude2) noexcept`  
Calculate azimuth between two points.
- `double limit_360 (const double degrees) noexcept`  
Takes a decimal degree value and constrains it to full circle using symmetry.
- `double limit_180 (const double degrees) noexcept`  
Takes a decimal degree value and constrains it to a half circle using symmetry.
- `double limit_90 (const double degrees) noexcept`  
Takes a decimal degree value and constrains it to a quarter circle using symmetry.
- `template std::vector< char > convert_to_word (const float input) noexcept`
- `template std::vector< char > convert_to_word (const int x) noexcept`
- `template std::array< char, word_length > convert_to_words (const std::string &str, const int n_words) noexcept`

## Variables

- `constexpr size_t word_length {4}`  
Size (bytes) of fundamental data-chunk.
- `constexpr size_t bits_per_byte {8}`  
Size (bits) of binary character.
- `constexpr size_t binary_word_size {word_length * bits_per_byte}`  
Size (bits) of fundamental data-chunk.
- `constexpr std::streamoff data_word {158}`  
First word of (first) data-section (stream offset).
- `constexpr int unset_int {-12345}`  
Integer unset value (SAC Magic).
- `constexpr float unset_float {-12345.0F}`  
Float-point unset value (SAC Magic).
- `constexpr double unset_double {-12345.0}`  
Double-precision unset value (SAC Magic).
- `constexpr bool unset_bool {false}`  
Boolean unset value (SAC Magic).

- `const std::string unset_word {"-12345"}`  
*String unset value (SAC Magic).*
- `constexpr float f_eps {2.75e-6F}`  
*Accuracy precision expected of SAC floating-point values.*
- `constexpr int ascii_space {32}`  
*ASCII-code of 'space' character.*
- `constexpr int num_float {39}`  
*Number of float-point header values in SAC format.*
- `constexpr int num_double {22}`  
*Number of double-precision header values in SAC format.*
- `constexpr int num_int {26}`  
*Number of integer header values in SAC format.*
- `constexpr int num_bool {4}`  
*Number of boolean header values in SAC format.*
- `constexpr int num_string {23}`  
*Number of string header values in SAC format.*
- `constexpr int num_data {2}`  
*Number of data arrays in SAC format.*
- `constexpr int num_footer {22}`  
*Number of double-precision footer values in SAC format (version 7).*
- `constexpr int modern_hdr_version {7}`  
*nVHdr value for newest SAC format (2020+).*
- `constexpr int old_hdr_version {6}`  
*nVHdr value for historic SAC format (pre-2020).*
- `constexpr int common_skip_num {7}`  
*Extremely common number of 'internal use' headers in SAC format.*
- `constexpr double rad_per_deg {std::numbers::pi_v<double> / 180.0}`  
*Radians per degree.*
- `constexpr double deg_per_rad {1.0 / rad_per_deg}`  
*Degrees per radian.*
- `constexpr double circle_deg {360.0}`  
*Degrees in a circle.*
- `constexpr double earth_radius {6378.14}`  
*Average radius of Earth (kilometers).*
- `const std::unordered_map< name, const size_t > sac_map`  
*Lookup table for variable locations.*

### 10.1.1 Detailed Description

sac-format namespace

### 10.1.2 Typedef Documentation

#### char\_bit

```
using sacfmt::char_bit = typedef std::bitset<bits_per_byte>
```

One binary character (useful for building strings).

**unsigned\_int**

```
template<class T >
using sacfmt::unsigned_int = typedef typename bitset_type::uint<sizeof(T) * bits_per_byte>↵
::type
```

Convert variable to unsigned-integer using type-safe conversions.

**word\_four**

```
using sacfmt::word_four = typedef std::bitset<static_cast<size_t>(4) * binary_word_size>
```

Four binary words (kEvNm only).

**word\_one**

```
using sacfmt::word_one = typedef std::bitset<binary_word_size>
```

One binary word (useful for non-strings).

**word\_two**

```
using sacfmt::word_two = typedef std::bitset<static_cast<size_t>(2) * binary_word_size>
```

Two binary words (useful for strings).

**10.1.3 Enumeration Type Documentation****name**

```
enum class sacfmt::name [strong]
```

Enumeration of all SAC fields.

Additional information can be found at [SAC-file format](#)

**Enumerator**

depmin	Float Minimum value of the dependent variable (displacement/velocity/acceleration/volts/counts).
depmax	Float Maximum value of the dependent variable.
odelta	Float Modified (observational) value of delta.
resp0	Float Instrument response parameter (poles, zeros, and a constant). Not used by SAC - free for other purposes.
resp1	See resp0.
resp2	See resp0.
resp3	See resp0.

## Enumerator

resp4	See resp0.
resp5	See resp0.
resp6	See resp0.
resp7	See resp0.
resp8	See resp0.
resp9	See resp0.
stel	Float Station elevation in meters above sea level (m.a.s.l.). Not used by SAC - free for other purposes.
stdp	Float Station depth in meters below surface (borehole/buried vault). Not used by SAC - free for other purposes.
evel	Float Event elevation m.a.s.l. Not used by SAC - free for other purposes.
evdp	Float Event depth in kilometers (previous meters) below surface.
mag	Float Event magnitude.
user0	Float Storage for user-defined values.
user1	See user0.
user2	See user0.
user3	See user0.
user4	See user0.
user5	See user0.
user6	See user0.
user7	See user0.
user8	See user0.
user9	See user0.
dist	Float Station-Event distance in kilometers.
az	Float Azimuth <i>Station</i> $\rightarrow$ <i>Event</i> in decimal degrees from North.
baz	Float Back-Azimuth <i>Event</i> $\rightarrow$ <i>Station</i> in decimal degrees from North.
gcarc	Float Great-circle arc-distance between station and event in decimal degrees.
depmin	Float Mean value of dependent variable.
cmpaz	Float Instrument measurement azimuth, decimal degrees from North.
cmpinc	Float Instrument measurement incidence angle, decimal degrees from upward vertical (incident 0 = dip -90). Note: SEED/MINISEED use dip angle, decimal degrees from horizontal (dip 0 = incident 90).
xminimum	Float Spectral-only equivalent of depmin ( $f_0$ or $\omega_0$ ).
xmaximum	Float Spectral-only equivalent of depman ( $f_{max}$ or $\omega_{max}$ ).

## Enumerator

yminimum	Float Spectral-only equivalent of b.
ymaximum	Float Spectral-only equivalent of e.
delta	Double Increment between evenly-spaced samples ( $\Delta t$ for timeseries, $\Delta f$ or $\Delta \omega$ for spectral).
b	Double First value (beginning) of independent variable ( $t_0$ ).
e	Double Final value (ending) of the independent variable ( $t_{max}$ ).
o	Double Event origin time, in seconds relative to the reference time.
a	Double Event first arrival time, in seconds relative to the reference time.
t0	Double User defined time value, in seconds relative to the reference time.
t1	See t0.
t2	See t0.
t3	See t0.
t4	See t0.
t5	See t0.
t6	See t0.
t7	See t0.
t8	See t0.
t9	See t0.
f	Double Event end (fini) time, in seconds relative to the reference time.
stla	Double Station latitude in decimal degrees, N/S is positive/negative. sac-format automatically enforces $\phi \in [-90, 90]$ .
stlo	Double Station longitude in decimal degrees, E/W is positive/negative. sac-format automatically enforces $\lambda \in [-180, 180]$ .
evla	Double Event latitude in decimal degrees, N/S is positive/negative. sac-format automatically enforces $\phi \in [-90, 90]$ .
evlo	Double Event longitude in decimal degrees, E/W is positive/negative. sac-format automatically enforces $\lambda \in [-180, 180]$ .
sb	Double Original (saved) value of b (beginning).
sdelta	Double Original (saved) value of delta (sample-spacing).
nzyear	Integer Reference time GMT year.
nzjday	Integer Reference time GMT day-of-year (often called Julian Date). 1-366 Not enforced.
nzhour	Integer Reference time GMT hour. 00-23 Not enforced.



## Enumerator

nzmin	Integer Reference time GMT minute. 00-59 Not enforced.
nzsec	Integer Reference time GMT second. 00-59 Not enforced.
nzmsec	Integer Reference time GMT millisecond. 0-999 not enforced.
nvhdr	Integer SAC-file version. 7 = 2020+, sac 102.0+, has a Footer. 6 = pre-2020, sac 101.6a-, no Footer.
norid	Integer Origin ID.
nevid	Integer Event ID.
npts	Integer Number of points in data.
nsnpts	Integer Original (saved) npts.
nwfid	Integer Waveform ID.
nxsize	Integer Spectral-only equivalent of npts (length of spectrum).
nysize	Integer Spectral-only; width of spectrum.
iftype	Integer File type.
idep	Integer Dependent variable type.
iztype	Integer Reference time equivalent.
iinst	Integer Recording instrument type. Not used by SAC - free for other purposes.
istreg	Integer Station geographic region. Not used by SAC - free for other purposes.
ievreg	Integer Event geographic region. Not used by SAC - free for other purposes.
ievtyp	Integer Event type. Not used by SAC - free for other purposes.
igual	Integer Quality of data. Not used by SAC - free for other purposes.
isynth	Integer Synthetic data flag. Not used by SAC - free for other purposes.
imagtyp	Integer Magnitude type.

## Enumerator

imagsrc	Integer Magnitude information source.
ibody	Integer Body/spheroid definition used to calculate distances. Not currently-used by sac-format (SAC does use it).
leven	Boolean REQUIRED Evenly-spaced data flag. True = even.
lpspol	Boolean Station polarity flag. True = positive (left-handed, e.g. North-East-Up).
lovrok	Boolean File overwrite flag. If true, okay to overwrite file. Not used by sac-format.
lcalda	Boolean Calculate geometry flag. Not used by sac-format.
kstnm	String (2 words) Station name.
kevnrm	String (4 words) Event name.
khole	String (2 words) Nuclear-Hole identifier. Other-Location identifier (LOCID).
ko	String (2 words) Text for o.
ka	String (2 words) Text for a.
kt0	String (2 words) Text for t0
kt1	See kt0.
kt2	See kt0.
kt3	See kt0.
kt4	See kt0.
kt5	See kt0.
kt6	See kt0.
kt7	See kt0.
kt8	See kt0.
kt9	See kt0.
kf	String (2 words) Text for f.
kuser0	String (2 words) Text for user0.
kuser1	See kuser0.
kuser2	See kuser0.
kcmpnm	String (2 words) Component name.
knetwk	String (2 words) Network name.
kdatrd	String (2 words) Date the data was read onto a computer.

## Enumerator

kinst	String (2 words) Instrument name.
data1	std::vector<double> First data vector. ALWAYS present, ALWAYS begins at word 158.
data2	std::vector<double> Second data vector. CONDITIONAL present. IF PRESENT, begins at end of data1. Required if leven is false (uneven sampling), or if iftype is spectral/XY/XYZ.

```

00283                                     {
00284     // Floats
00291     depmin,
00297     depmax,
00303     odelta,
00311     resp0,
00313     resp1,
00315     resp2,
00317     resp3,
00319     resp4,
00321     resp5,
00323     resp6,
00325     resp7,
00327     resp8,
00329     resp9,
00337     stel,
00345     stdp,
00353     evel,
00359     evdp,
00365     mag,
00371     user0,
00373     user1,
00375     user2,
00377     user3,
00379     user4,
00381     user5,
00383     user6,
00385     user7,
00387     user8,
00389     user9,
00395     dist,
00402     az,
00409     baz,
00415     gcarc,
00421     depmen,
00427     cmpaz,
00437     cmpinc,
00444     xminimum,
00451     xmaximum,
00457     yminimum,
00463     ymaximum,
00464     // Doubles
00473     delta,
00479     b,
00486     e,
00492     o,
00498     a,
00504     t0,
00506     t1,
00508     t2,
00510     t3,
00512     t4,
00514     t5,
00516     t6,
00518     t7,
00520     t8,
00522     t9,
00528     f,
00536     stla,
00544     stlo,
00552     evla,
00560     evlo,
00566     sb,
00572     sdelta,
00573     // Ints
00579     nzyear,
00587     nzjday,
00595     nzhour,
00603     nzmin,
00611     nzsec,
00619     nzmsec,
00628     nvhdr,

```

```

00634     norid,
00640     nevid,
00646     npts,
00652     nsnpts,
00658     nwfid,
00664     nxsize,
00670     nysize,
00676     iftype,
00682     idep,
00688     iztype,
00696     iinst,
00704     istreg,
00712     ievreg,
00720     ievtyp,
00728     igual,
00736     isynth,
00742     imagtyp,
00748     imagsrc,
00756     ibody,
00757     // Bools
00765     leven,
00773     lspol,
00783     lovrok,
00791     lcalda,
00792     // Strings
00798     kstnm,
00804     kevnrm,
00812     khole,
00818     ko,
00824     ka,
00830     kt0,
00832     kt1,
00834     kt2,
00836     kt3,
00838     kt4,
00840     kt5,
00842     kt6,
00844     kt7,
00846     kt8,
00848     kt9,
00854     kf,
00860     kuser0,
00862     kuser1,
00864     kuser2,
00870     kcmpnm, // missing in org documentation
00876     knetwk, // missing in org documentation
00882     kdatrd,
00888     kinst,
00889     // Data
00895     data1,
00904     data2
00905 };

```

### 10.1.4 Function Documentation

#### azimuth()

```

double sacfmt::azimuth (
    const double latitude1,
    const double longitude1,
    const double latitude2,
    const double longitude2 ) [noexcept]

```

Calculate azimuth between two points.

Assumes spherical Earth (in future may update to solve on a more general body).

$\phi$  is latitude.  $\lambda$  is longitude.  $\theta$  is azimuth.

$$\theta = \tan^{-1} \left( \frac{\sin(\delta\lambda)\cos(\phi_2)}{\cos(\phi_1)\sin(\phi_2) - \sin(\phi_1)\cos(\phi_2)\cos(\delta\lambda)} \right)$$

## Parameters

in	<i>latitude1</i>	Latitude of first location in decimal degrees.
in	<i>longitude1</i>	Longitude of first location in decimal degrees.
in	<i>latitude2</i>	Latitude of second location in decimal degrees.
in	<i>longitude2</i>	Longitude of second location in decimal degrees.

## Returns

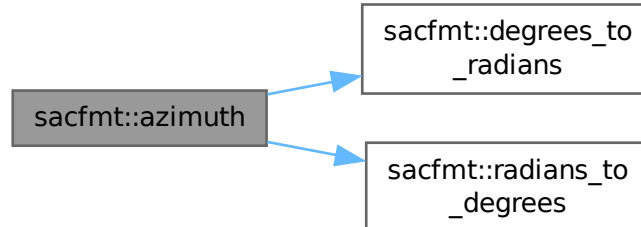
double The azimuth from the first location to the second location.

```

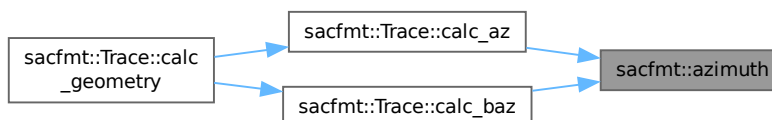
00739                                     {
00740     const double lat1{degrees_to_radians(latitude1)};
00741     const double lon1{degrees_to_radians(longitude1)};
00742     const double lat2{degrees_to_radians(latitude2)};
00743     const double lon2{degrees_to_radians(longitude2)};
00744     const double dlon{lon2 - lon1};
00745     const double numerator{std::sin(dlon) * std::cos(lat2)};
00746     const double denominator{(std::cos(lat1) * std::sin(lat2)) -
00747                               (std::sin(lat1) * std::cos(lat2) * std::cos(dlon))};
00748     double result{radians_to_degrees(std::atan2(numerator, denominator))};
00749     while (result < 0.0) {
00750         result += circle_deg;
00751     }
00752     return result;
00753 }

```

Here is the call graph for this function:



Here is the caller graph for this function:



**binary\_to\_bool()**

```
bool sacfmt::binary_to_bool (
    const word_one & flag ) [noexcept]
```

Convert a 32-bit (one word) binary bitset to a boolean.

**Parameters**

in	<i>flag</i>	<a href="#">word_one</a> binary bitset to be converted (takes zeroth element).
----	-------------	--

**Returns**

boolean Converted boolean value.

```
00357 { return flag[0]; }
```

Here is the caller graph for this function:

**binary\_to\_double()**

```
double sacfmt::binary_to_double (
    const word_two & bin ) [noexcept]
```

Convert 64-bit (two words) binary bitset to double-precision value.

Converts bitset to unsigned long long then to double.

**Parameters**

in	<i>bin</i>	<a href="#">word_two</a> Binary value to be converted.
----	------------	--

**Returns**

double Converted value.

```
00159                                     {
00160     const auto val = bin.to_ullong();
00161     double result{};
00162     // flawfinder: ignore
00163     memcpy(&result, &val, sizeof(double));
00164     return result;
00165 }
```

Here is the caller graph for this function:



### binary\_to\_float()

```
float sacfmt::binary_to_float (
    const word_one & bin ) [noexcept]
```

Convert 32-bit (one word) binary bitset to a floating-point value.

Converts bitset to unsigned long then to float.

#### Parameters

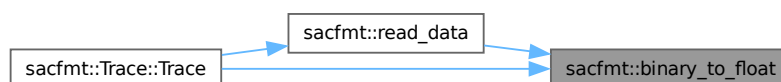
in	<i>bin</i>	<code>word_one</code> Binary value to be converted.
----	------------	---

#### Returns

float Converted value.

```
00127                                     {
00128     const auto val = bin.to_ulong();
00129     float result{};
00130     // flawfinder: ignore
00131     memcpy(&result, &val, sizeof(float));
00132     return result;
00133 }
```

Here is the caller graph for this function:



### binary\_to\_int()

```
int sacfmt::binary_to_int (
    word_one bin ) [noexcept]
```

Convert 32-bit (one word) binary bitset to integer.

Uses two's complement to convert a binary value into an integer.



**Parameters**

in	<i>bin</i>	Binary value to be converted.
----	------------	-------------------------------

**Returns**

int Converted value.

```

00088                                     {
00089     int result{};
00090     if (bin.test(binary_word_size - 1)) {
00091         // Complement
00092         bin.flip();
00093         result = static_cast<int>(bin.to_ulong());
00094         result += 1;
00095         // Change sign to make it negative
00096         result *= -1;
00097     } else {
00098         result = static_cast<int>(bin.to_ulong());
00099     }
00100     return result;
00101 }
```

Here is the caller graph for this function:

**binary\_to\_long\_string()**

```

std::string sacfmt::binary_to_long_string (
    const word_four & str ) [noexcept]
```

Convert a 128-bit (four word) binary bitset to a string.

Exclusively used to work with the kEvNm header.

**Parameters**

in	<i>str</i>	<i>word_four</i> to be converted to a string.
----	------------	---

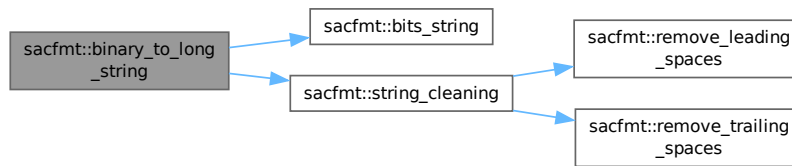
**Returns**

std::string Converted string.

```

00332                                     {
00333     std::string result{bits_string(str, 4)};
00334     return string_cleaning(result);
00335 }
```

Here is the call graph for this function:



Here is the caller graph for this function:



### binary\_to\_string()

```
std::string sacfmt::binary_to_string (  
    const word_two & str ) [noexcept]
```

Convert a 64-bit (two word) binary bitset to a string.

#### Parameters

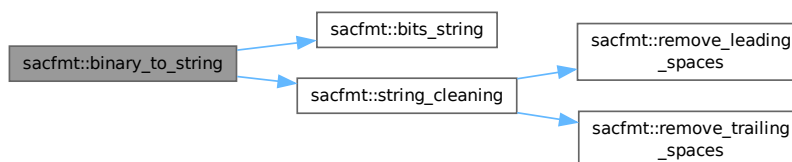
in	str	word_two to be converted to a string.
----	-----	---------------------------------------

**Returns**

std::string Converted string.

```
00298                                     {
00299     std::string result{bits_string(str, 2)};
00300     return string_cleaning(result);
00301 }
```

Here is the call graph for this function:



Here is the caller graph for this function:

**bits\_string()**

```
template<typename T >
std::string sacfmt::bits_string (
    const T & bits,
    const size_t num_words ) [noexcept]
```

Template function to convert binary bitset to string.

**Parameters**

in	<i>bits</i>	Source bitset for the string.
in	<i>num_words</i>	Length of string in words (4 chars = 1 word)

**Returns**

std::string String converted from bitset.

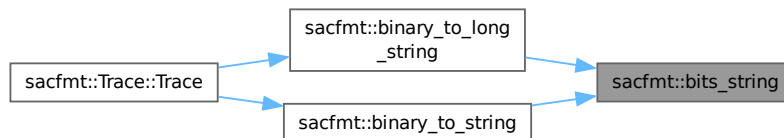
```
00258                                     {
00259     std::string result{};
00260     result.reserve(num_words * word_length);
00261     constexpr size_t char_size{bits_per_byte};
```

```

00262     char_bit byte{};
00263     for (size_t i{0}; i < num_words * binary_word_size; i += char_size) {
00264         for (size_t j{0}; j < char_size; ++j) [[likely]] {
00265             byte[j] = bits[i + j];
00266         }
00267         result.push_back(static_cast<char>(byte.to_ulong()));
00268     }
00269     return result;
00270 }

```

Here is the caller graph for this function:



### bool\_to\_binary()

```

word_one sacfmt::bool_to_binary (
    const bool flag ) [noexcept]

```

Convert a boolean to a 32-bit (one word) binary bitset.

#### Parameters

in	flag	Boolean value to be converted to a bitset (sets zeroth element).
----	------	--

#### Returns

**word\_one** Converted binary bitset.

```

00344                                     {
00345     word_one result{};
00346     result[0] = flag;
00347     return result;
00348 }

```

### bool\_to\_word()

```

std::vector< char > sacfmt::bool_to_word (
    const bool flag ) [noexcept]

```

Convert boolean to a word for writing.

#### Parameters

in	flag	Boolean to be converted.
----	------	--------------------------

## Returns

`std::vector<char>` Prepared value for writing.

```

00598                                     {
00599     std::vector<char> result;
00600     result.resize(word_length);
00601     result[0] = static_cast<char>(flag ? 1 : 0);
00602     for (size_t i{1}; i < word_length; ++i) {
00603         result[i] = 0;
00604     }
00605     return result;
00606 }
```

Here is the caller graph for this function:



## concat\_words() [1/2]

```

word_two sacfmt::concat_words (
    const word_pair< word_one > & pair_words ) [noexcept]
```

Concatenate two `word_one` binary strings into a single `word_two` string.

Useful for reading strings from SAC-files.

## Parameters

in	<code>pair_words</code>	<code>word_pair</code> Words to be concatenated.
----	-------------------------	--

## Returns

`word_two` Concatenated words.

```

00368                                     {
00369     word_two result{};
00370     for (size_t i{0}; i < binary_word_size; ++i) [[likely]] {
00371         result[i] = pair_words.first[i];
00372         result[i + binary_word_size] = pair_words.second[i];
00373     }
00374     return result;
00375 }
```

Here is the caller graph for this function:



**concat\_words()** [2/2]

```
word_four sacfmt::concat_words (
    const word_pair< word_two > & pair_words ) [noexcept]
```

Concatenate two `word_two` binary strings into a single `word_four` string.

Exclusively used to read kEvNm header from SAC-file.

**Parameters**

in	<i>pair_words</i>	<code>word_pair</code> Words to be concatenated.
----	-------------------	--

**Returns**

`word_four` Concatenated words.

```
00386
00387     word_four result{};
00388     constexpr size_t two_words(2 * binary_word_size);
00389     for (size_t i{0}; i < two_words; ++i) [[likely]] {
00390         result[i] = pair_words.first[i];
00391         result[i + two_words] = pair_words.second[i];
00392     }
00393     return result;
00394 }
```

**convert\_to\_word()** [1/4]

```
std::vector< char > sacfmt::convert_to_word (
    const double input ) [noexcept]
```

Convert double value into a `std::vector<char>` for writing.

**Parameters**

in	<i>input</i>	Input value to convert (double).
----	--------------	----------------------------------

**Returns**

`std::vector<char>` Prepared for writing to binary SAC-file.

```
00550
00551     std::array<char, static_cast<size_t>(2) * word_length> tmp{};
00552     // Copy bytes from input into the tmp array
00553     // flawfinder: ignore
00554     std::memcpy(tmp.data(), &input, static_cast<size_t>(2) * word_length);
00555     std::vector<char> word{};
00556     word.resize(static_cast<size_t>(2) * word_length);
00557     for (size_t i{0}; i < 2 * word_length; ++i) {
00558         word[i] = tmp[i];
00559     }
00560     return word;
00561 }
```

**convert\_to\_word()** [2/4]

```
template std::vector< char > sacfmt::convert_to_word (
    const float input ) [noexcept]
```

**convert\_to\_word()** [3/4]

```
template std::vector< char > sacfmt::convert_to_word (
    const int x ) [noexcept]
```

**convert\_to\_word()** [4/4]

```
template<typename T >
std::vector< char > sacfmt::convert_to_word (
    const T input ) [noexcept]
```

Template function to convert input value into a `std::vector<char>` for writing.

**Parameters**

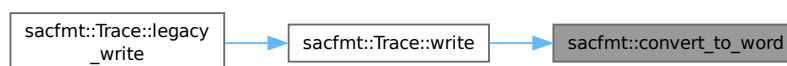
<code>in</code>	<code>input</code>	Input value (float or int) to convert.
-----------------	--------------------	--

**Returns**

`std::vector<char>` Prepared for writing to binary SAC-file.

```
00527                                     {
00528     std::array<char, word_length> tmp{};
00529     // Copy bytes from input into the tmp array
00530     // flawfinder: ignore
00531     std::memcpy(tmp.data(), &input, word_length);
00532     std::vector<char> word{};
00533     word.resize(word_length);
00534     for (size_t i{0}; i < word_length; ++i) [[likely]] {
00535         word[i] = tmp[i];
00536     }
00537     return word;
00538 }
```

Here is the caller graph for this function:

**convert\_to\_words()** [1/2]

```
template std::array< char, word_length > sacfmt::convert_to_words (
    const std::string & str,
    const int n_words ) [noexcept]
```

**convert\_to\_words()** [2/2]

```
template<size_t N>
template std::array< char, 4 *word_length > sacfmt::convert_to_words (
    const std::string & str,
    int n_words ) [noexcept]
```

Template function to convert input string value into a `std::array<char>` for writing.

## Parameters

in	<i>str</i>	Input string to convert.
in	<i>n_words</i>	Number of words

## Returns

std::array<char, N> Prepared for writing to a binary SAC-file.

```

00574                                     {
00575     std::array<char, N> all_words{};
00576     // String to null-terminated character array
00577     const char *c_str = str.c_str();
00578     for (size_t i{0}; i < static_cast<size_t>(n_words) * word_length; ++i) {
00579         all_words[i] = c_str[i];
00580     }
00581     return all_words;
00582 }
```

**degrees\_to\_radians()**

```

double sacfmt::degrees_to_radians (
    const double degrees ) [noexcept]
```

Convert decimal degrees to radians.

$$r = d \cdot \frac{\pi}{180^\circ}$$

## Parameters

in	<i>degrees</i>	Angle in decimal degrees to be converted.
----	----------------	---

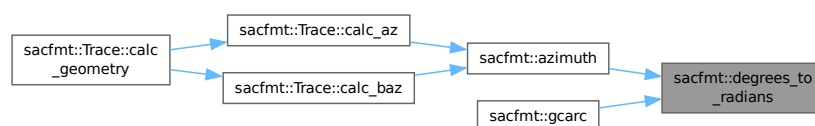
## Returns

double Angle in radians.

```

00661                                     {
00662     return rad_per_deg * degrees;
00663 }
```

Here is the caller graph for this function:





**double\_to\_binary()**

```
word_two sacfmt::double_to_binary (
    const double num ) [noexcept]
```

Convert double-precision value to 64-bit (two words) binary bitset.

Converts double to unsigned-integer of same size for storage in bitset.

**Parameters**

in	<i>num</i>	Double value to be converted.
----	------------	-------------------------------

**Returns**

**word\_two** Converted value.

```
00143                                     {
00144     unsigned_int<double> num_as_uint{0};
00145     // flawfinder: ignore
00146     std::memcpy(&num_as_uint, &num, sizeof(double));
00147     word_two result{num_as_uint};
00148     return result;
00149 }
```

**equal\_within\_tolerance()** [1/2]

```
bool sacfmt::equal_within_tolerance (
    const double val1,
    const double val2,
    const double tolerance ) [noexcept]
```

Check if two double values are equal within a tolerance limit.

Default tolerance is `f_eps`.

**Parameters**

in	<i>val1</i>	First double in comparison.
in	<i>val2</i>	Second double in comparison.
in	<i>tolerance</i>	Numerical equality tolerance (default <code>f_eps</code> ).

**Returns**

**bool** Boolean equality value.

```
00647                                     {
00648     return (std::abs(val1 - val2) < tolerance);
00649 }
```

**equal\_within\_tolerance()** [2/2]

```
bool sacfmt::equal_within_tolerance (
    const std::vector< double > & vector1,
```

```
const std::vector< double > & vector2,
const double tolerance ) [noexcept]
```

Check if two `std::vector<double>` are equal within a tolerance limit.

Default tolerance is `f_eps`.

#### Parameters

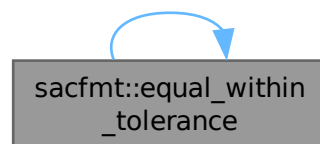
in	<i>vector1</i>	First data vector in comparison.
in	<i>vector2</i>	Second data vector in comparison.
in	<i>tolerance</i>	Numerical equality tolerance (default <code>f_eps</code> ).

#### Returns

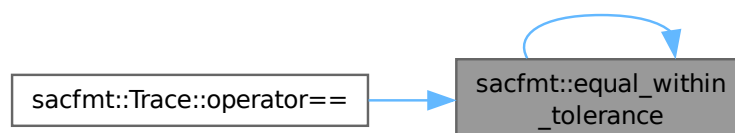
bool Boolean equality value.

```
00624                                     {
00625     if (vector1.size() != vector2.size()) {
00626         return false;
00627     }
00628     for (size_t i{0}; i < vector1.size(); ++i) [[likely]] {
00629         if (!equal_within_tolerance(vector1[i], vector2[i], tolerance)) {
00630             return false;
00631         }
00632     }
00633     return true;
00634 }
```

Here is the call graph for this function:



Here is the caller graph for this function:



**float\_to\_binary()**

```
word_one sacfmt::float_to_binary (
    const float num ) [noexcept]
```

Convert floating-point value to 32-bit (one word) binary bitset.

Converts float to unsigned-integer of same size for storage in bitset.

**Parameters**

in	<i>num</i>	Float value to be converted.
----	------------	------------------------------

**Returns**

**word\_one** Converted value.

```
00111 {
00112     unsigned_int<float> num_as_uint{0};
00113     // flawfinder: ignore
00114     std::memcpy(&num_as_uint, &num, sizeof(float));
00115     word_one result{num_as_uint};
00116     return result;
00117 }
```

**gcarc()**

```
double sacfmt::gcarc (
    const double latitude1,
    const double longitude1,
    const double latitude2,
    const double longitude2 ) [noexcept]
```

Calculate great circle arc distance in decimal degrees between two points.

Assumes spherical Earth (in future will include flattenning and adjustable radius for other bodies/greater accuracy).

$\phi$  is latitude.  $\lambda$  is longitude.  $\Delta$  is great circle arc distance (gcarc).

$$\Delta = \cos^{-1}(\sin(\phi_1)\sin(\phi_2) + \cos(\phi_1)\cos(\phi_2)\cos(\lambda_2 - \lambda_1))$$

**Parameters**

in	<i>latitude1</i>	Latitude of first location in decimal degrees.
in	<i>longitude1</i>	Longitude of first location in decimal degrees.
in	<i>latitude2</i>	Latitude of second location in decimal degrees.
in	<i>longitude2</i>	Longitude of second location in decimal degrees.

**Returns**

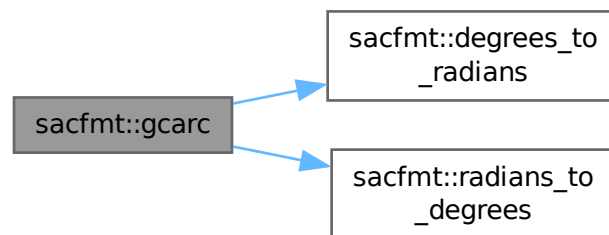
double The great circle arc distance in decimal degrees.

```

00704                                     {
00705     const double lat1{degrees_to_radians(latitude1)};
00706     const double lon1{degrees_to_radians(longitude1)};
00707     const double lat2{degrees_to_radians(latitude2)};
00708     const double lon2{degrees_to_radians(longitude2)};
00709     double result{radians_to_degrees(
00710         std::acos(std::sin(lat1) * std::sin(lat2) +
00711             std::cos(lat1) * std::cos(lat2) * std::cos(lon2 - lon1))});
00712     return result;
00713 }

```

Here is the call graph for this function:



### int\_to\_binary()

```

word_one sacfmt::int_to_binary (
    int num ) [noexcept]

```

Convert integer to 32-bit (one word) binary bitset.

Uses two's complement to convert an integer into a binary value.

#### Parameters

in	<i>num</i>	Number to be converted.
----	------------	-------------------------

#### Returns

**word\_one** Converted value.

```

00067                                     {
00068     word_one bits{};
00069     if (num >= 0) {
00070         bits = uint_to_binary(static_cast<uint>(num));
00071     } else {
00072         bits = uint_to_binary(static_cast<uint>(-num));
00073         // Complement
00074         bits.flip();
00075         bits = bits.to_ulong() + 1;
00076     }
00077     return bits;
00078 }

```

Here is the call graph for this function:



### limit\_180()

```
double sacfmt::limit_180 (
    const double degrees ) [noexcept]
```

Takes a decimal degree value and constrains it to a half circle using symmetry.

$[-\infty, \infty] \rightarrow (-180, 180]$

#### Parameters

in	<i>degrees</i>	Decimal degrees to be constrained.
----	----------------	------------------------------------

#### Returns

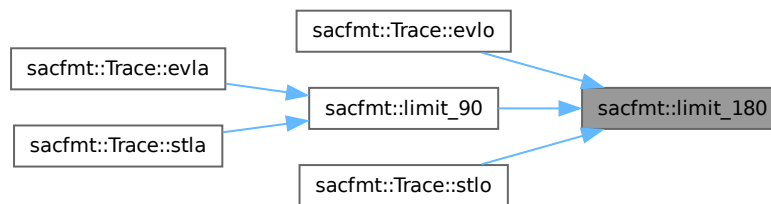
double Value within limits.

```
00792 {
00793     double result{limit_360(degrees)};
00794     constexpr double hemi{180.0};
00795     if (result > hemi) {
00796         result = result - circle_deg;
00797     }
00798     return result;
00799 }
```

Here is the call graph for this function:



Here is the caller graph for this function:



### limit\_360()

```
double sacfmt::limit_360 (
    const double degrees ) [noexcept]
```

Takes a decimal degree value and constrains it to full circle using symmetry.

$$[-\infty, \infty] \rightarrow [0, 360]$$

#### Parameters

in	<i>degrees</i>	Decimal degrees to be constrained.
----	----------------	------------------------------------

#### Returns

double Value within limits.

```

00766                                     {
00767     double result(degrees);
00768     while (std::abs(result) > circle_deg) {
00769         if (result > circle_deg) {
00770             result -= circle_deg;
00771         } else {
00772             result += circle_deg;
00773         }
00774     }
00775     if (result < 0) {
00776         result += circle_deg;
00777     }
00778     return result;
00779 }
```

Here is the caller graph for this function:



**limit\_90()**

```
double sacfmt::limit_90 (
    const double degrees ) [noexcept]
```

Takes a decimal degree value and constrains it to a quarter circle using symmetry.

$$[-\infty, \infty] \rightarrow [-90, 90]$$

**Parameters**

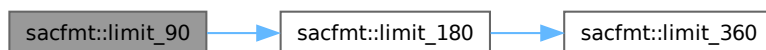
in	<i>degrees</i>	Decimal degrees to be constrained.
----	----------------	------------------------------------

**Returns**

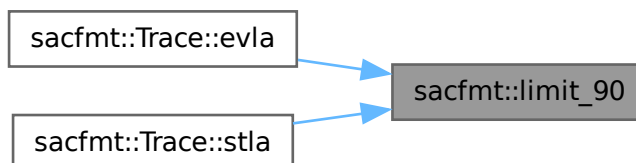
double Value within limits.

```
00812 {
00813     double result{limit_180(degrees)};
00814     constexpr double quarter{90.0};
00815     if (result > quarter) {
00816         result = (2 * quarter) - result;
00817     } else if (result < -quarter) {
00818         result = (-2 * quarter) - result;
00819     }
00820     return result;
00821 }
```

Here is the call graph for this function:



Here is the caller graph for this function:



**long\_string\_to\_binary()**

```
word_four sacfmt::long_string_to_binary (
    std::string str ) [noexcept]
```

Convert a string to a 128-bit (four word) binary bitset.

If the string is longer than 16 characters, then only the first 16 characters are kept. If the string is less than 16 characters long, it is right-padded with spaces.

Exclusively used to work with the kEvNm header.

**Parameters**

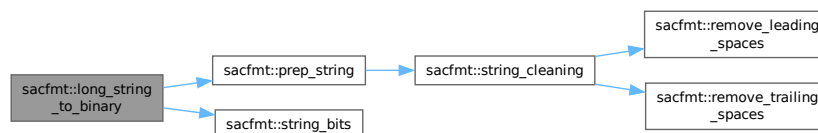
in	<i>str</i>	String to be converted to a bitset.
----	------------	-------------------------------------

**Returns**

**word\_four** Converted binary bitset.

```
00315
00316 constexpr size_t string_size{4 * word_length};
00317 prep_string(&str, string_size);
00318 // Four words (16 characters)
00319 word_four bits{};
00320 string_bits(&bits, str, string_size);
00321 return bits;
00322 }
```

Here is the call graph for this function:

**nwords\_after\_current()**

```
bool sacfmt::nwords_after_current (
    std::ifstream * sac,
    const read_spec & spec ) [noexcept]
```

Determine if the SAC-file has enough remaining data to read the requested amount of data.

**Parameters**

in	<i>sac</i>	std::ifstream* SAC-file to read.
in	<i>spec</i>	<a href="#">read_spec</a> reading specification.



## Returns

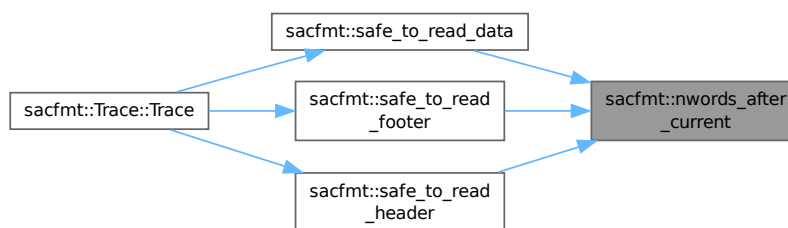
bool Truth value (true = safe to read).

```

01637                                     {
01638     bool result{false};
01639     if (sac->good()) {
01640         sac->seekg(0, std::ios::end);
01641         const std::size_t final_pos{static_cast<size_t>(sac->tellg())};
01642         // Doesn't like size_t since it wants to allow
01643         // the possibility of negative offsets (not how I use it)
01644         sac->seekg(static_cast<std::streamoff>(spec.start_word));
01645         const std::size_t diff{final_pos - spec.start_word};
01646         result = (diff >= (spec.num_words * word_length));
01647     }
01648     return result;
01649 }

```

Here is the caller graph for this function:



## prep\_string()

```

void sacfmt::prep_string (
    std::string * str,
    const size_t str_size ) [noexcept]

```

Cleans string and then truncates/pads as necessary.

This edits the string in-place.

## Parameters

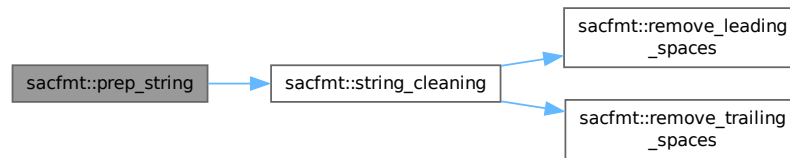
in, out	<i>str</i>	std::string* String to be prepared.
in	<i>str_size</i>	Desired string length.

```

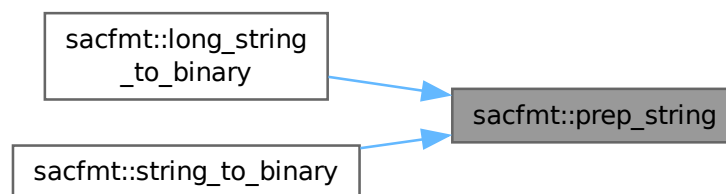
00218                                     {
00219     *str = string_cleaning(*str);
00220     if (str->length() > str_size) {
00221         str->resize(str_size);
00222     } else if (str->length() < str_size) {
00223         *str = str->append(str_size - str->length(), ' ');
00224     }
00225 }

```

Here is the call graph for this function:



Here is the caller graph for this function:



### radians\_to\_degrees()

```
double sacfmt::radians_to_degrees (
    const double radians ) [noexcept]
```

Convert radians to decimal degrees.

$$d = r \cdot \frac{180^\circ}{\pi}$$

#### Parameters

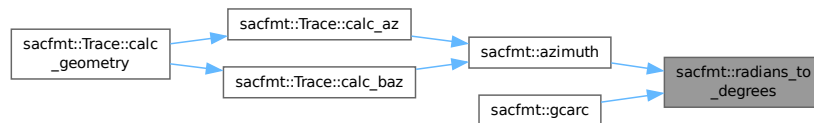
in	<i>radians</i>	Angle in radians to be converted.
----	----------------	-----------------------------------

#### Returns

double Angle in decimal degrees.

```
00675                                     {
00676     return deg_per_rad * radians;
00677 }
```

Here is the caller graph for this function:



## read\_data()

```
std::vector< double > sacfmt::read_data (
    std::ifstream * sac,
    const read_spec & spec )
```

Reader arbitrary number of words (useful for vectors) from a binary SAC-file.

Note that this modifies the position of the reader within the stream (to the end of the read words).

### Parameters

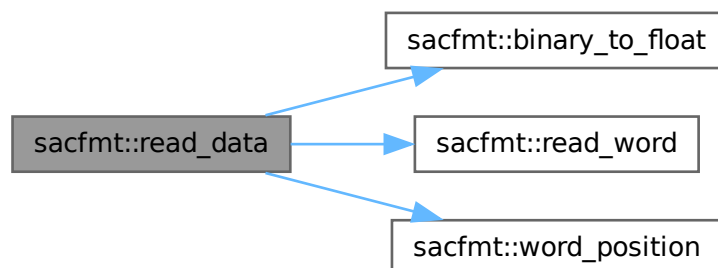
in, out	sac	std::ifstream* Input binary SAC-file.
in	spec	read_spec Reading specification.

### Returns

std::vector<double> Data vector read in.

```
00487 {
00488     sac->seekg(word_position(spec.start_word));
00489     std::vector<double> result{};
00490     result.resize(spec.num_words);
00491     for (size_t i{0}; i < spec.num_words; ++i) [[likely]] {
00492         result[i] = static_cast<double>(binary_to_float(read_word(sac)));
00493     }
00494     return result;
00495 }
```

Here is the call graph for this function:



Here is the caller graph for this function:



### read\_four\_words()

```

word_four sacfmt::read_four_words (
    std::ifstream * sac )
  
```

Read four words (128 bits, kEvNm only) from a binary SAC-file.

Note that this modifies the position of the reader within the stream (to the end of the read words).

#### Parameters

in, out	sac	std::ifstream* Input binary SAC-file.
---------	-----	---------------------------------------

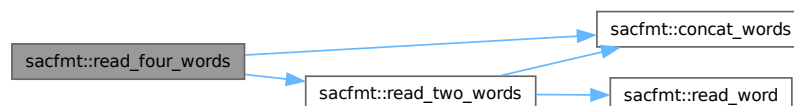
#### Returns

**word\_four** Binary bitset representation of four words.

```

00462 {
00463     const word_two first_words{read_two_words(sac)};
00464     const word_two second_words{read_two_words(sac)};
00465     word_pair<word_two> pair_words{};
00466     if constexpr (std::endian::native == std::endian::little) {
00467         pair_words.first = first_words;
00468         pair_words.second = second_words;
00469     } else {
00470         pair_words.first = second_words;
00471         pair_words.second = first_words;
00472     }
00473     return concat_words(pair_words);
00474 }
  
```

Here is the call graph for this function:



Here is the caller graph for this function:



### read\_two\_words()

```
word_two sacfmt::read_two_words (
    std::ifstream * sac )
```

Read two words (64 bits, useful for most strings) from a binary SAC-file.

Note that this modifies the position of the reader within the stream (to the end of the read words).

#### Parameters

in, out	sac	std::ifstream* Input binary SAC-file.
---------	-----	---------------------------------------

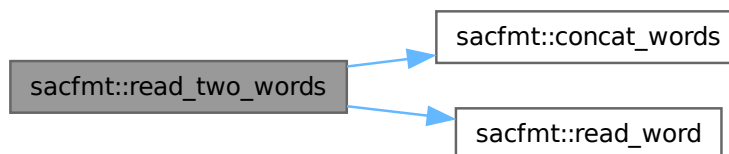
#### Returns

**word\_two** Binary bitset representation of two words.

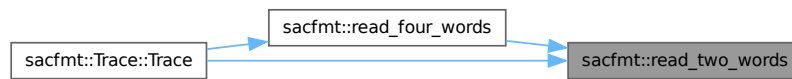
```

00439 {
00440     const word_one first_word{read_word(sac)};
00441     const word_one second_word{read_word(sac)};
00442     word_pair<word_one> pair_words{};
00443     if constexpr (std::endian::native == std::endian::little) {
00444         pair_words.first = first_word;
00445         pair_words.second = second_word;
00446     } else {
00447         pair_words.first = second_word;
00448         pair_words.second = first_word;
00449     }
00450     return concat_words(pair_words);
00451 }
```

Here is the call graph for this function:



Here is the caller graph for this function:



## read\_word()

```
word_one sacfmt::read_word (
    std::ifstream * sac )
```

Read one word (32 bits, useful for non-strings) from a binary SAC-File.

Note that this modifies the position of the reader within the stream (to the end of the read word).

### Parameters

in, out	sac	std::ifstream* Input binary SAC-file.
---------	-----	---------------------------------------

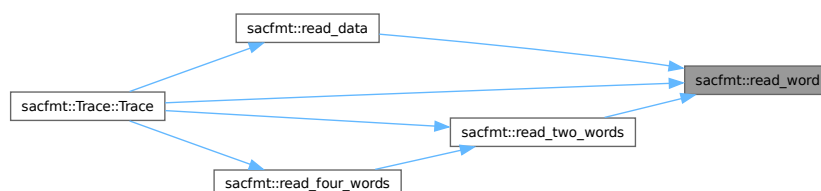
### Returns

**word\_one** Binary bitset representation of single word.

```

00407                                     {
00408     word_one bits{};
00409     constexpr size_t char_size{bits_per_byte};
00410     // Where we will store the characters
00411     std::array<char, word_length> word{};
00412     // Read to our character array
00413     // This can always hold the source due to careful typing/sizing
00414     // flawfinder: ignore
00415     if (sac->read(word.data(), word_length)) {
00416         // Take each character
00417         for (size_t i{0}; i < word_length; ++i) [[likely]] {
00418             uint character{static_cast<uint>(word[i])};
00419             char_bit byte{character};
00420             // bit-by-bit
00421             for (size_t j{0}; j < char_size; ++j) [[likely]] {
00422                 bits[(i * char_size) + j] = byte[j];
00423             }
00424         }
00425     }
00426     return bits;
00427 }
```

Here is the caller graph for this function:



## remove\_leading\_spaces()

```
void sacfmt::remove_leading_spaces (
    std::string * str ) [noexcept]
```

Remove all leading spaces from a string.

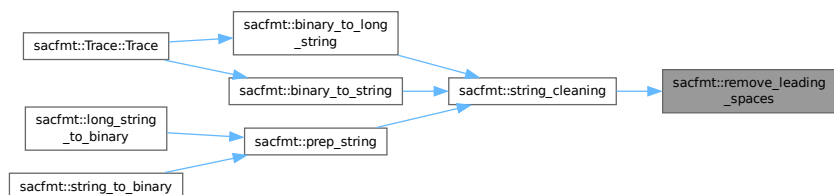
This edits the string in-place.

### Parameters

in, out	<i>str</i>	std::string* String to have spaces removed.
---------	------------	---

```
00174                                     {
00175     while ((static_cast<int>(str->front()) <= ascii_space) && (!str->empty())) {
00176         str->erase(0, 1);
00177     }
00178 }
```

Here is the caller graph for this function:



## remove\_trailing\_spaces()

```
void sacfmt::remove_trailing_spaces (
    std::string * str ) [noexcept]
```

Remove all trailing spaces from a string.

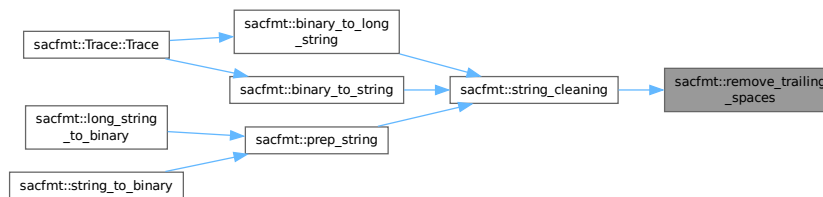
This edits the string in-place.

### Parameters

in, out	<i>str</i>	std::string* String to have spaces removed.
---------	------------	---

```
00187                                     {
00188     while ((static_cast<int>(str->back()) <= ascii_space) && (!str->empty())) {
00189         str->pop_back();
00190     }
00191 }
```

Here is the caller graph for this function:



### safe\_to\_finish\_reading()

```
void sacfmt::safe_to_finish_reading (
    std::ifstream * sac )
```

Determines if the SAC-file is finished.

This must run after reading the header, data vector(s), and footer (if applicable). This checks to ensure there is no additional data in the SAC-file (there shouldn't be, and out of safety it throws an [io\\_error](#) to inform the user if there are shenanigans).

#### Parameters

in	sac	std::ifstream* SAC-file to be checked.
----	-----	--

#### Exceptions

<a href="#">io_error</a>	If the file is not finished.
--------------------------	------------------------------

```

01717 {
01718     const std::streamoff current_pos{sac->tellg()};
01719     sac->seekg(0, std::ios::end);
01720     const std::streamoff end_pos{sac->tellg()};
01721     sac->seekg(current_pos, std::ios::beg);
01722     // How far are we from the end of the file?
01723     const std::streamoff diff{end_pos - current_pos};
01724     // If there is more, something weird happened...
01725     if (diff != 0) {
01726         std::ostringstream oss{};
01727         oss << "Filesize exceeds data specification with ";
01728         oss << diff;
01729         oss << " bytes excess. Data corruption suspected.";
01730         throw io_error(oss.str());
01731     }
01732 }
```



Here is the caller graph for this function:



### safe\_to\_read\_data()

```

void sacfmt::safe_to_read_data (
    std::ifstream * sac,
    const size_t n_words,
    const bool data2 )
  
```

Determines if the SAC-file has enough space remaining to contain a complete data vector.

This must be run after reading the header (and first data vector if applicable) and before the footer (if applicable).

#### Parameters

in	<i>sac</i>	std::ifstream* SAC-file to read.
in	<i>n_words</i>	Number of values in data vector.
in	<i>data2</i>	bool True if reading data2, false (default) if reading data1.

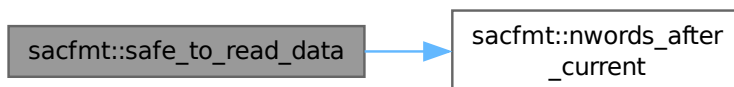
#### Exceptions

<i>io_error</i>	If unsafe to read.
-----------------	--------------------

```

01698
01699     const std::string data{data2 ? "data2" : "data1"};
01700     const read_spec spec{n_words, static_cast<size_t>(sac->tellg())};
01701     if (!nwords_after_current(sac, spec)) {
01702         throw io_error("Insufficient filesize for " + data + '.');
01703     }
01704 }
  
```

Here is the call graph for this function:



Here is the caller graph for this function:



### safe\_to\_read\_footer()

```
void sacfmt::safe_to_read_footer (
    std::ifstream * sac )
```

Determines if the SAC-file has enough space remaining to contain a complete footer.

This must be run after reading the header and data vector(s), not before.

#### Parameters

in	sac	std::ifstream* SAC-file to read.
----	-----	----------------------------------

#### Exceptions

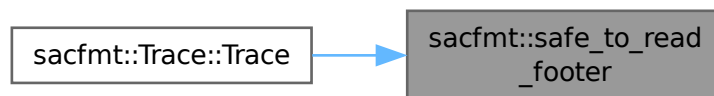
<a href="#"><i>io_error</i></a>	If unsafe to read.
---------------------------------	--------------------

```
01676 {
01677     // doubles are two words long
01678     const read_spec spec{static_cast<size_t>(num_footer) * 2,
01679                          static_cast<size_t>(sac->tellg())};
01680     if (!nwords_after_current(sac, spec)) {
01681         throw io_error("Insufficient filesize for footer.");
01682     }
01683 }
```

Here is the call graph for this function:



Here is the caller graph for this function:



### safe\_to\_read\_header()

```

void sacfmt::safe_to_read_header (
    std::ifstream * sac )
  
```

Determine if the SAC-file is large enough to contain a complete header.

This must be run prior to reading the data vector(s) and footer (if applicable), not after.

#### Parameters

in	sac	std::ifstream* SAC-file to read.
----	-----	----------------------------------

#### Exceptions

<i>io_error</i>	If unsafe to read.
-----------------	--------------------

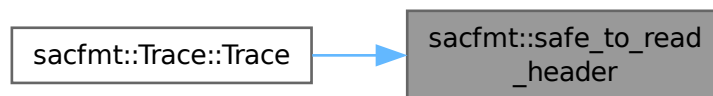
```

01660                                     {
01661     const read_spec spec{data_word, 0};
01662     if (!nwords_after_current(sac, spec)) {
01663         throw io_error("Insufficient filesize for header.");
01664     }
01665 }
  
```

Here is the call graph for this function:



Here is the caller graph for this function:



### string\_bits()

```

template<typename T >
void sacfmt::string_bits (
    T * bits,
    const std::string & str,
    const size_t str_size ) [noexcept]
  
```

Template function to convert string into binary bitset.

Note that this edits the bitset in place.

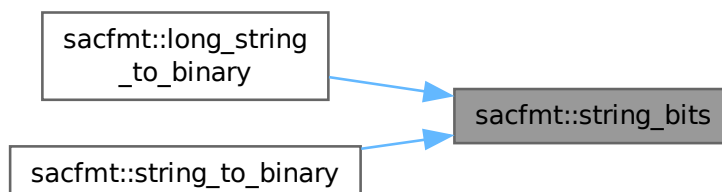
#### Parameters

out	<i>bits</i>	Destintation bitset for the string (result).
in	<i>str</i>	String to undergo conversion.
in	<i>str_size</i>	Desired string size in words (4 chars = 1 word).

```

00238                                     {
00239     constexpr size_t char_size{bits_per_byte};
00240     char_bit byte{};
00241     for (size_t i{0}; i < str_size; ++i) {
00242         size_t character{static_cast<size_t>(str[i])};
00243         byte = char_bit(character);
00244         for (size_t j{0}; j < char_size; ++j) {
00245             (*bits)[(i * char_size) + j] = byte[j];
00246         }
00247     }
00248 }
  
```

Here is the caller graph for this function:



## string\_cleaning()

```
std::string sacfmt::string_cleaning (
    const std::string & str ) [noexcept]
```

Remove leading/trailing spaces and control characters from a string.

### Parameters

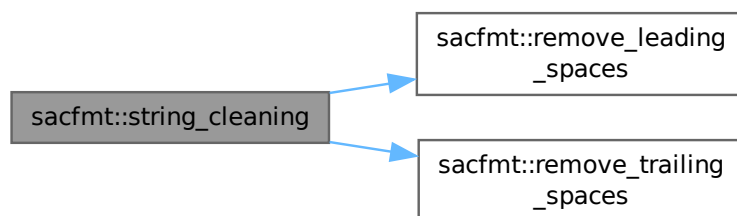
in	str	std::string String to be cleaned.
----	-----	-----------------------------------

### Returns

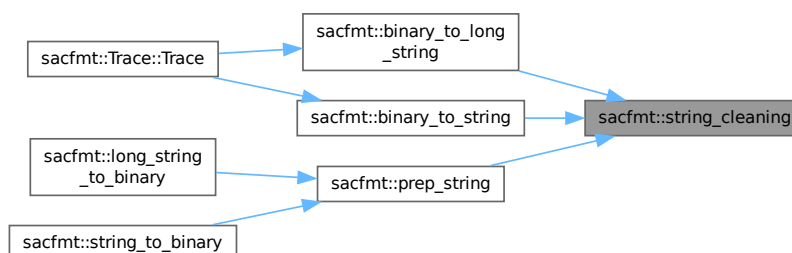
std::string Cleaned string.

```
00199                                     {
00200     std::string result{str};
00201     size_t null_position{str.find('\0')};
00202     if (null_position != std::string::npos) {
00203         result.erase(null_position);
00204     }
00205     remove_leading_spaces(&result);
00206     remove_trailing_spaces(&result);
00207     return result;
00208 }
```

Here is the call graph for this function:



Here is the caller graph for this function:



**string\_to\_binary()**

```
word_two sacfmt::string_to_binary (
    std::string str ) [noexcept]
```

Convert string to a 64-bit (two word) binary bitset.

If the string is longer than 8 characters, the only the first 8 characters are kept. If the string is less than 8 characters long, it is right-padded with spaces.

**Parameters**

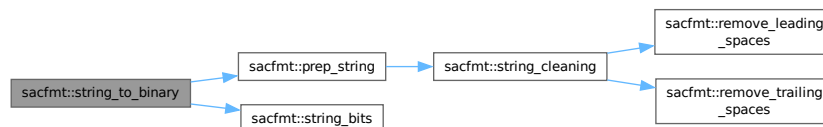
in	<i>str</i>	String to be converted to a bitset.
----	------------	-------------------------------------

**Returns**

**word\_two** Converted binary bitset.

```
00282
00283     constexpr size_t string_size{2 * word_length}; {
00284     // 1 byte per character
00285     prep_string(&str, string_size);
00286     // Two words (8 characters)
00287     word_two bits{};
00288     string_bits(&bits, str, string_size);
00289     return bits;
00290 }
```

Here is the call graph for this function:

**uint\_to\_binary()**

```
word_one sacfmt::uint_to_binary (
    uint num ) [noexcept]
```

Convert unsigned integer to 32-bit (one word) binary bitset.

This sets the current bit using bitwise and, updates the bit to manipulate and performs a right-shift (division by 2) until the number is zero.

**Parameters**

in	<i>num</i>	Number to be converted.
----	------------	-------------------------

**Returns**

`word_one` Converted value.

```

00044                                     {
00045   word_one bits{};
00046   for (size_t pos{0}; pos < bits.size(); ++pos) {
00047     if (num > 0) {
00048       // Bitwise and to set flag.
00049       bits.set(pos, static_cast<bool>(num & 1));
00050       // Right-shift bits by 1, same as division by 2
00051       num >>= 1;
00052     } else {
00053       break;
00054     }
00055   }
00056   return bits;
00057 }

```

Here is the caller graph for this function:

**word\_position()**

```

std::streamoff sacfmt::word_position (
    const size_t word_number ) [noexcept]

```

Calculates position of word in SAC-file.

Multiplies given word number by the word-length in bytes (defined by the SAC format.)

**Parameters**

in	<i>word_number</i>	Number of desired word in file stream.
----	--------------------	--

**Returns**

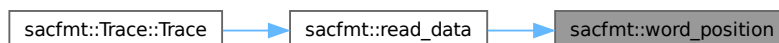
`std::streamoff` Position in SAC-file of desired word (in bytes).

```

00031                                     {
00032   return static_cast<std::streamoff>(word_number * word_length);
00033 }

```

Here is the caller graph for this function:



**write\_words()**

```
void sacfmt::write_words (
    std::ofstream * sac_file,
    const std::vector< char > & input )
```

Write arbitrary number of words (useful for vectors) to a binary SAC-file.

Note that this modifies the position of the writer within the stream (to the end of the written words).

**Parameters**

in, out	<i>sac_file</i>	std::ofstream* Output binary SAC-file.
in	<i>input</i>	std::vector<char> Character vector representation of data for writing.

```
00510                                     {
00511     std::ofstream &sac = *sac_file;
00512     if (sac.is_open()) {
00513         for (char character : input) [[likely]] {
00514             sac.write(&character, sizeof(char));
00515         }
00516     }
00517 }
```

Here is the caller graph for this function:

**10.1.5 Variable Documentation****ascii\_space**

```
constexpr int sacfmt::ascii_space {32} [constexpr]
```

ASCII-code of 'space' character.

```
00085 {32};
```

**binary\_word\_size**

```
constexpr size_t sacfmt::binary_word_size {word_length * bits_per_byte} [constexpr]
```

Size (bits) of fundamental data-chunk.

```
00061 {word_length * bits_per_byte};
```

**bits\_per\_byte**

```
constexpr size_t sacfmt::bits_per_byte {8} [constexpr]
```

Size (bits) of binary character.

```
00059 {8};
```



**circle\_deg**

```
constexpr double sacfmt::circle_deg {360.0} [constexpr]
```

Degrees in a circle.

```
00111 {360.0};
```

**common\_skip\_num**

```
constexpr int sacfmt::common_skip_num {7} [constexpr]
```

Extremely common number of 'internal use' headers in SAC format.

```
00105 {7};
```

**data\_word**

```
constexpr std::streamoff sacfmt::data_word {158} [constexpr]
```

First word of (first) data-section (stream offset).

```
00063 {158};
```

**deg\_per\_rad**

```
constexpr double sacfmt::deg_per_rad {1.0 / rad_per_deg} [constexpr]
```

Degrees per radian.

```
00109 {1.0 / rad_per_deg};
```

**earth\_radius**

```
constexpr double sacfmt::earth_radius {6378.14} [constexpr]
```

Average radius of Earth (kilometers).

```
00113 {6378.14};
```

**f\_eps**

```
constexpr float sacfmt::f_eps {2.75e-6F} [constexpr]
```

Accuracy precision expected of SAC floating-point values.

```
00075 {2.75e-6F};
```

**modern\_hdr\_version**

```
constexpr int sacfmt::modern_hdr_version {7} [constexpr]
```

nVHdr value for newest SAC format (2020+).

```
00101 {7};
```

**num\_bool**

```
constexpr int sacfmt::num_bool {4} [constexpr]
```

Number of boolean header values in SAC format.

```
00093 {4};
```

**num\_data**

```
constexpr int sacfmt::num_data {2} [constexpr]
```

Number of data arrays in SAC format.

```
00097 {2};
```

**num\_double**

```
constexpr int sacfmt::num_double {22} [constexpr]
```

Number of double-precision header values in SAC format.

```
00089 {22};
```

**num\_float**

```
constexpr int sacfmt::num_float {39} [constexpr]
```

Number of float-precision header values in SAC format.

```
00087 {39};
```

**num\_footer**

```
constexpr int sacfmt::num_footer {22} [constexpr]
```

Number of double-precision footer values in SAC format (version 7).

```
00099 {22};
```

**num\_int**

```
constexpr int sacfmt::num_int {26} [constexpr]
```

Number of integer header values in SAC format.

```
00091 {26};
```

**num\_string**

```
constexpr int sacfmt::num_string {23} [constexpr]
```

Number of string header values in SAC format.

```
00095 {23};
```

**old\_hdr\_version**

```
constexpr int sacfmt::old_hdr_version {6} [constexpr]
```

nVHdr value for historic SAC format (pre-2020).

```
00103 {6};
```

**rad\_per\_deg**

```
constexpr double sacfmt::rad_per_deg {std::numbers::pi_v<double> / 180.0} [constexpr]
```

Radians per degree.

```
00107 {std::numbers::pi_v<double> / 180.0};
```

**sac\_map**

```
const std::unordered_map<name, const size_t> sacfmt::sac_map
```

Lookup table for variable locations.

Maps SAC variables (headers and data) to their internal locations in the [Trace](#) class.

```
00913 {
00914     // Floats
00915     {name::depmin, 0},
00916     {name::depmax, 1},
00917     {name::odelta, 2},
00918     {name::resp0, 3},
00919     {name::resp1, 4},
00920     {name::resp2, 5},
00921     {name::resp3, 6},
00922     {name::resp4, 7},
00923     {name::resp5, 8},
00924     {name::resp6, 9},
00925     {name::resp7, 10},
00926     {name::resp8, 11},
00927     {name::resp9, 12},
00928     {name::stel, 13},
00929     {name::stdp, 14},
00930     {name::evel, 15},
00931     {name::evdp, 16},
00932     {name::mag, 17},
00933     {name::user0, 18},
00934     {name::user1, 19},
00935     {name::user2, 20},
00936     {name::user3, 21},
00937     {name::user4, 22},
00938     {name::user5, 23},
00939     {name::user6, 24},
00940     {name::user7, 25},
00941     {name::user8, 26},
00942     {name::user9, 27},
00943     {name::dist, 28},
00944     {name::az, 29},
00945     {name::baz, 30},
00946     {name::gcarc, 31},
00947     {name::depmen, 32},
00948     {name::cmpaz, 33},
00949     {name::cmpinc, 34},
00950     {name::xminimum, 35},
00951     {name::xmaximum, 36},
00952     {name::yminimum, 37},
00953     {name::ymaximum, 38},
00954     // Doubles
00955     {name::delta, 0},
00956     {name::b, 1},
00957     {name::e, 2},
00958     {name::o, 3},
00959     {name::a, 4},
00960     {name::t0, 5},
00961     {name::t1, 6},
00962     {name::t2, 7},
00963     {name::t3, 8},
```

```

00964     {name::t4, 9},
00965     {name::t5, 10},
00966     {name::t6, 11},
00967     {name::t7, 12},
00968     {name::t8, 13},
00969     {name::t9, 14},
00970     {name::f, 15},
00971     {name::stla, 16},
00972     {name::stlo, 17},
00973     {name::evla, 18},
00974     {name::evlo, 19},
00975     {name::sb, 20},
00976     {name::sdelta, 21},
00977     // Ints
00978     {name::nzyear, 0},
00979     {name::nzjday, 1},
00980     {name::nzhour, 2},
00981     {name::nzmin, 3},
00982     {name::nzsec, 4},
00983     {name::nzmsec, 5},
00984     {name::nvhdr, 6},
00985     {name::norid, 7},
00986     {name::nevid, 8},
00987     {name::npts, 9},
00988     {name::nsnpts, 10},
00989     {name::nwfid, 11},
00990     {name::nxsize, 12},
00991     {name::nysize, 13},
00992     {name::iftyp, 14},
00993     {name::idep, 15},
00994     {name::iztyp, 16},
00995     {name::iinst, 17},
00996     {name::istreg, 18},
00997     {name::ievreg, 19},
00998     {name::ievtyp, 20},
00999     {name::iqual, 21},
01000     {name::isynth, 22},
01001     {name::imagtyp, 23},
01002     {name::imagsrc, 24},
01003     {name::ibody, 25},
01004     // Bools
01005     {name::leven, 0},
01006     {name::lpspol, 1},
01007     {name::lovrok, 2},
01008     {name::lcalda, 3},
01009     // Strings
01010     {name::kstnm, 0},
01011     {name::kevn, 1},
01012     {name::khole, 2},
01013     {name::ko, 3},
01014     {name::ka, 4},
01015     {name::kt0, 5},
01016     {name::kt1, 6},
01017     {name::kt2, 7},
01018     {name::kt3, 8},
01019     {name::kt4, 9},
01020     {name::kt5, 10},
01021     {name::kt6, 11},
01022     {name::kt7, 12},
01023     {name::kt8, 13},
01024     {name::kt9, 14},
01025     {name::kf, 15},
01026     {name::kuser0, 16},
01027     {name::kuser1, 17},
01028     {name::kuser2, 18},
01029     {name::kcmpnm, 19},
01030     {name::knetwk, 20},
01031     {name::kdatrd, 21},
01032     {name::kinst, 22},
01033     // Data
01034     {name::data1, 0},
01035     {name::data2, 1}};

```

## unset\_bool

```
constexpr bool sacfmt::unset_bool {false} [constexpr]
```

Boolean unset value (SAC Magic).

```
00071 {false};
```

### unset\_double

```
constexpr double sacfmt::unset_double {-12345.0} [constexpr]
```

Double-precision unset value (SAC Magic).

```
00069 {-12345.0};
```

### unset\_float

```
constexpr float sacfmt::unset_float {-12345.0F} [constexpr]
```

Float-point unset value (SAC Magic).

```
00067 {-12345.0F};
```

### unset\_int

```
constexpr int sacfmt::unset_int {-12345} [constexpr]
```

Integer unset value (SAC Magic).

```
00065 {-12345};
```

### unset\_word

```
const std::string sacfmt::unset_word {"-12345"}
```

String unset value (SAC Magic).

```
00073 {"-12345"};
```

### word\_length

```
constexpr size_t sacfmt::word_length {4} [constexpr]
```

Size (bytes) of fundamental data-chunk.

```
00057 {4};
```

## 10.2 sacfmt::bitset\_type Namespace Reference

bitset type-safety namespace.

### Classes

- struct [uint](#)  
*Ensure type-safety for conversions between floats/doubles and bitsets.*
- struct [uint< 2 \\*bits\\_per\\_byte >](#)  
*Two-word type-safety (strings).*
- struct [uint< 4 \\*bits\\_per\\_byte >](#)  
*Four-word type-safety (kEvNm).*
- struct [uint< bits\\_per\\_byte >](#)  
*Single-word type-safety (non-strings).*
- struct [uint< bytes \\*bits\\_per\\_byte >](#)

## Variables

- `constexpr int bytes {8}`  
*? type-safety?*

### 10.2.1 Detailed Description

bitset type-safety namespace.

### 10.2.2 Variable Documentation

#### bytes

```
constexpr int sacfmt::bitset_type::bytes {8} [constexpr]
```

*? type-safety?*  
00142 {8};

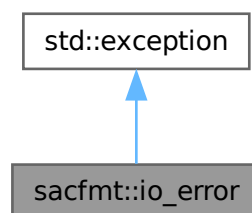
## 11 Class Documentation

### 11.1 sacfmt::io\_error Class Reference

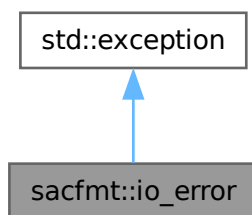
Class for generic I/O exceptions.

```
#include <sac_format.hpp>
```

Inheritance diagram for sacfmt::io\_error:



Collaboration diagram for `sacfmt::io_error`:



### Public Member Functions

- `io_error` (`std::string msg`)  
*io\_error Constructor*
- `const char * what () const noexcept override`  
*Error message delivery.*

### Private Attributes

- `const std::string message {}`  
*Error message.*

#### 11.1.1 Detailed Description

Class for generic I/O exceptions.

These errors occur due to bad path, bad permissions, or otherwise corrupt SAC-files.

I/O operations may raise other exceptions (disk failure, out of space, etc.), but those are difficult to emulate for testing purposes (therefore I am unable to reliably cover them); they also arise due to conditions that would render how sac-format handles them moot.

#### 11.1.2 Constructor & Destructor Documentation

##### `io_error()`

```
sacfmt::io_error::io_error (
    std::string msg ) [inline], [explicit]
```

`io_error` Constructor

## Parameters

<code>in</code>	<code>msg</code>	std::string Error message.
-----------------	------------------	----------------------------

```
01355 : message (std::move(msg)) {}
```

## 11.1.3 Member Function Documentation

**what()**

```
const char * sacfmt::io_error::what ( ) const [inline], [override], [noexcept]
```

Error message delivery.

## Returns

what char\* Error message.

```
01361                                     {
01362     return message.c_str();
01363 }
```

## 11.1.4 Member Data Documentation

**message**

```
const std::string sacfmt::io_error::message {} [private]
```

Error message.

```
01347 {};
```

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

- include/sac-format/sac\_format.hpp

## 11.2 sacfmt::read\_spec Struct Reference

Struct that specifies parameters for reading.

```
#include <sac_format.hpp>
```

## Public Attributes

- `size_t num_words` {}  
*Number of words to read.*
- `size_t start_word` {}  
*Word to start reading from.*



### 11.2.1 Detailed Description

Struct that specifies parameters for reading.

Prevents bug-prone number-swapping in functions that use a reading specification.

### 11.2.2 Member Data Documentation

#### num\_words

```
size_t sacfmt::read_spec::num_words {}
```

Number of words to read.

```
00214 {};
```

#### start\_word

```
size_t sacfmt::read_spec::start_word {}
```

Word to start reading from.

```
00216 {};
```

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

- include/sac-format/sac\_format.hpp

## 11.3 sacfmt::Trace Class Reference

The [Trace](#) class.

```
#include <sac_format.hpp>
```

### Public Member Functions

- [Trace](#) () [noexcept](#)  
*Trace default constructor.*
- [Trace](#) (const std::filesystem::path &path)  
*Binary SAC-file reader.*
- [void write](#) (const std::filesystem::path &path, bool legacy=false) const  
*Binary SAC-file writer.*
- [void legacy\\_write](#) (const std::filesystem::path &path) const  
*Binary SAC-file legacy-write convenience function.*
- [bool operator==](#) (const [Trace](#) &other) const [noexcept](#)  
*Trace equality operator.*
- [void calc\\_geometry](#) () [noexcept](#)  
*Calculates gcArc, dist, az, and baz from stla, stlo, evla, and evlo.*
- [double frequency](#) () const [noexcept](#)  
*Calculate frequency from delta.*
- std::string [date](#) () const [noexcept](#)

*Get date string.*

- `std::string time () const noexcept`

*Get time string.*

- `float depmin () const noexcept`
- `float depmax () const noexcept`
- `float odelta () const noexcept`
- `float resp0 () const noexcept`
- `float resp1 () const noexcept`
- `float resp2 () const noexcept`
- `float resp3 () const noexcept`
- `float resp4 () const noexcept`
- `float resp5 () const noexcept`
- `float resp6 () const noexcept`
- `float resp7 () const noexcept`
- `float resp8 () const noexcept`
- `float resp9 () const noexcept`
- `float stel () const noexcept`
- `float stdp () const noexcept`
- `float evel () const noexcept`
- `float evdp () const noexcept`
- `float mag () const noexcept`
- `float user0 () const noexcept`
- `float user1 () const noexcept`
- `float user2 () const noexcept`
- `float user3 () const noexcept`
- `float user4 () const noexcept`
- `float user5 () const noexcept`
- `float user6 () const noexcept`
- `float user7 () const noexcept`
- `float user8 () const noexcept`
- `float user9 () const noexcept`
- `float dist () const noexcept`
- `float az () const noexcept`
- `float baz () const noexcept`
- `float gcarc () const noexcept`
- `float depmen () const noexcept`
- `float cmpaz () const noexcept`
- `float cmpinc () const noexcept`
- `float xminimum () const noexcept`
- `float xmaximum () const noexcept`
- `float yminimum () const noexcept`
- `float ymaximum () const noexcept`
- `double delta () const noexcept`
- `double b () const noexcept`
- `double e () const noexcept`
- `double o () const noexcept`
- `double a () const noexcept`
- `double t0 () const noexcept`
- `double t1 () const noexcept`
- `double t2 () const noexcept`
- `double t3 () const noexcept`
- `double t4 () const noexcept`
- `double t5 () const noexcept`
- `double t6 () const noexcept`

- `double t7 () const noexcept`
- `double t8 () const noexcept`
- `double t9 () const noexcept`
- `double f () const noexcept`
- `double stla () const noexcept`
- `double stlo () const noexcept`
- `double evla () const noexcept`
- `double evlo () const noexcept`
- `double sb () const noexcept`
- `double sdelta () const noexcept`
- `int nzyear () const noexcept`
- `int nzjday () const noexcept`
- `int nzhour () const noexcept`
- `int nzmin () const noexcept`
- `int nzsec () const noexcept`
- `int nzmsec () const noexcept`
- `int nvhdr () const noexcept`
- `int norid () const noexcept`
- `int nevid () const noexcept`
- `int npts () const noexcept`
- `int nsnpts () const noexcept`
- `int nwfid () const noexcept`
- `int nxsize () const noexcept`
- `int nysize () const noexcept`
- `int iftype () const noexcept`
- `int idep () const noexcept`
- `int iztype () const noexcept`
- `int iinst () const noexcept`
- `int istreg () const noexcept`
- `int ievreg () const noexcept`
- `int ievtyp () const noexcept`
- `int igual () const noexcept`
- `int isynth () const noexcept`
- `int imagtyp () const noexcept`
- `int imagsrc () const noexcept`
- `int ibody () const noexcept`
- `bool leven () const noexcept`
- `bool lpspol () const noexcept`
- `bool lovrok () const noexcept`
- `bool lcalda () const noexcept`
- `std::string kstnm () const noexcept`
- `std::string kevnrm () const noexcept`
- `std::string khole () const noexcept`
- `std::string ko () const noexcept`
- `std::string ka () const noexcept`
- `std::string kt0 () const noexcept`
- `std::string kt1 () const noexcept`
- `std::string kt2 () const noexcept`
- `std::string kt3 () const noexcept`
- `std::string kt4 () const noexcept`
- `std::string kt5 () const noexcept`
- `std::string kt6 () const noexcept`
- `std::string kt7 () const noexcept`
- `std::string kt8 () const noexcept`
- `std::string kt9 () const noexcept`

- `std::string kf () const noexcept`
- `std::string kuser0 () const noexcept`
- `std::string kuser1 () const noexcept`
- `std::string kuser2 () const noexcept`
- `std::string kcmpnm () const noexcept`
- `std::string knetwk () const noexcept`
- `std::string kdatrd () const noexcept`
- `std::string kinst () const noexcept`
- `std::vector< double > data1 () const noexcept`
- `std::vector< double > data2 () const noexcept`
- `void depmin (float input) noexcept`
- `void depmax (float input) noexcept`
- `void odelta (float input) noexcept`
- `void resp0 (float input) noexcept`
- `void resp1 (float input) noexcept`
- `void resp2 (float input) noexcept`
- `void resp3 (float input) noexcept`
- `void resp4 (float input) noexcept`
- `void resp5 (float input) noexcept`
- `void resp6 (float input) noexcept`
- `void resp7 (float input) noexcept`
- `void resp8 (float input) noexcept`
- `void resp9 (float input) noexcept`
- `void stel (float input) noexcept`
- `void stdp (float input) noexcept`
- `void evel (float input) noexcept`
- `void evdp (float input) noexcept`
- `void mag (float input) noexcept`
- `void user0 (float input) noexcept`
- `void user1 (float input) noexcept`
- `void user2 (float input) noexcept`
- `void user3 (float input) noexcept`
- `void user4 (float input) noexcept`
- `void user5 (float input) noexcept`
- `void user6 (float input) noexcept`
- `void user7 (float input) noexcept`
- `void user8 (float input) noexcept`
- `void user9 (float input) noexcept`
- `void dist (float input) noexcept`
- `void az (float input) noexcept`
- `void baz (float input) noexcept`
- `void gcarc (float input) noexcept`
- `void depmen (float input) noexcept`
- `void cmpaz (float input) noexcept`
- `void cmpinc (float input) noexcept`
- `void xminimum (float input) noexcept`
- `void xmaximum (float input) noexcept`
- `void yminimum (float input) noexcept`
- `void ymaximum (float input) noexcept`
- `void delta (double input) noexcept`
- `void b (double input) noexcept`
- `void e (double input) noexcept`
- `void o (double input) noexcept`
- `void a (double input) noexcept`
- `void t0 (double input) noexcept`

- `void t1 (double input) noexcept`
- `void t2 (double input) noexcept`
- `void t3 (double input) noexcept`
- `void t4 (double input) noexcept`
- `void t5 (double input) noexcept`
- `void t6 (double input) noexcept`
- `void t7 (double input) noexcept`
- `void t8 (double input) noexcept`
- `void t9 (double input) noexcept`
- `void f (double input) noexcept`
- `void stla (double input) noexcept`
- `void stlo (double input) noexcept`
- `void evla (double input) noexcept`
- `void evlo (double input) noexcept`
- `void sb (double input) noexcept`
- `void sdelta (double input) noexcept`
- `void nzyear (int input) noexcept`
- `void nzjday (int input) noexcept`
- `void nzhour (int input) noexcept`
- `void nzmin (int input) noexcept`
- `void nzsec (int input) noexcept`
- `void nzmsec (int input) noexcept`
- `void nvhdr (int input) noexcept`
- `void norid (int input) noexcept`
- `void nevid (int input) noexcept`
- `void npts (int input) noexcept`
- `void nsnpts (int input) noexcept`
- `void nwfid (int input) noexcept`
- `void nxsize (int input) noexcept`
- `void nysize (int input) noexcept`
- `void iftype (int input) noexcept`
- `void idep (int input) noexcept`
- `void iztype (int input) noexcept`
- `void iinst (int input) noexcept`
- `void istreg (int input) noexcept`
- `void ievreg (int input) noexcept`
- `void ievtyp (int input) noexcept`
- `void igual (int input) noexcept`
- `void isynth (int input) noexcept`
- `void imagtyp (int input) noexcept`
- `void imagsrc (int input) noexcept`
- `void ibody (int input) noexcept`
- `void leven (bool input) noexcept`
- `void lpapol (bool input) noexcept`
- `void lovrok (bool input) noexcept`
- `void lcalda (bool input) noexcept`
- `void kstnm (const std::string &input) noexcept`
- `void kevnrm (const std::string &input) noexcept`
- `void khole (const std::string &input) noexcept`
- `void ko (const std::string &input) noexcept`
- `void ka (const std::string &input) noexcept`
- `void kt0 (const std::string &input) noexcept`
- `void kt1 (const std::string &input) noexcept`
- `void kt2 (const std::string &input) noexcept`
- `void kt3 (const std::string &input) noexcept`

- `void kt4 (const std::string &input) noexcept`
- `void kt5 (const std::string &input) noexcept`
- `void kt6 (const std::string &input) noexcept`
- `void kt7 (const std::string &input) noexcept`
- `void kt8 (const std::string &input) noexcept`
- `void kt9 (const std::string &input) noexcept`
- `void kf (const std::string &input) noexcept`
- `void kuser0 (const std::string &input) noexcept`
- `void kuser1 (const std::string &input) noexcept`
- `void kuser2 (const std::string &input) noexcept`
- `void kcmpnm (const std::string &input) noexcept`
- `void knetwk (const std::string &input) noexcept`
- `void kdatrd (const std::string &input) noexcept`
- `void kinst (const std::string &input) noexcept`
- `void data1 (const std::vector< double > &input) noexcept`
- `void data2 (const std::vector< double > &input) noexcept`

### Private Member Functions

- `void calc_gcArc () noexcept`  
*Calculate great-circle arc-distance (gcArc).*
- `void calc_dist () noexcept`  
*Calculate distance (using gcArc).*
- `void calc_az () noexcept`  
*Calculate azimuth.*
- `void calc_baz () noexcept`  
*Calculate back-azimuth.*
- `bool geometry_set () const noexcept`  
*Determine if locations are set for geometry calculation.*
- `void resize_data1 (size_t size) noexcept`
- `void resize_data2 (size_t size) noexcept`
- `void resize_data (size_t size) noexcept`  
*Resize data vectors (only if eligible).*

### Private Attributes

- `std::array< float, num_float > floats {}`  
*Float storage array.*
- `std::array< double, num_double > doubles {}`  
*Double storage array.*
- `std::array< int, num_int > ints {}`  
*Integer storage array.*
- `std::array< bool, num_bool > bools {}`  
*Boolean storage array.*
- `std::array< std::string, num_string > strings {}`  
*String storage array.*
- `std::array< std::vector< double >, num_data > data {}`  
*std::vector<double> storage array.*

### 11.3.1 Detailed Description

The [Trace](#) class.

This class is the recommended way for reading/writing SAC-files.

It safely reads all data, provides automatic write support based upon the nVHdr header value (determine if a footer should be included or not).

It provides getters and setters for all SAC headers and the data.

### 11.3.2 Constructor & Destructor Documentation

#### Trace() [1/2]

```
sacfmt::Trace::Trace ( ) [noexcept]
```

[Trace](#) default constructor.

Fills all values with their default (unset) values. Data vectors are of size zero.

#### Returns

Default created [Trace](#) object.

```
00833     {
00834     std::ranges::fill(floats.begin(), floats.end(), unset_float);
00835     std::ranges::fill(doubles.begin(), doubles.end(), unset_double);
00836     std::ranges::fill(ints.begin(), ints.end(), unset_int);
00837     std::ranges::fill(bools.begin(), bools.end(), unset_bool);
00838     std::ranges::fill(strings.begin(), strings.end(), unset_word);
00839 }
```

#### Trace() [2/2]

```
sacfmt::Trace::Trace (
    const std::filesystem::path & path ) [explicit]
```

Binary SAC-file reader.

#### Parameters

<i>in</i>	<i>path</i>	std::filesystem::path SAC-file to be read.
-----------	-------------	--

#### Returns

[Trace](#) read in-file.

#### Exceptions

<i>io_error</i>	If the file is not safe to read for whatever reason.
<i>std::exception</i>	(disk failure).

```

01742         {
01743             std::ifstream file(path, std::ifstream::binary);
01744             if (!file) {
01745                 throw io_error(path.string() + " cannot be opened to read.");
01746             }
01747             safe_to_read_header(&file); // throws io_error if not safe
01748             //-----
01749             // Header
01750             delta(binary_to_float(read_word(&file)));
01751             depmin(binary_to_float(read_word(&file)));
01752             depmax(binary_to_float(read_word(&file)));
01753             // Skip 'unused'
01754             read_word(&file);
01755             odelta(binary_to_float(read_word(&file)));
01756             b(binary_to_float(read_word(&file)));
01757             e(binary_to_float(read_word(&file)));
01758             o(binary_to_float(read_word(&file)));
01759             a(binary_to_float(read_word(&file)));
01760             // Skip 'internal'
01761             read_word(&file);
01762             // T# pick headers
01763             t0(binary_to_float(read_word(&file)));
01764             t1(binary_to_float(read_word(&file)));
01765             t2(binary_to_float(read_word(&file)));
01766             t3(binary_to_float(read_word(&file)));
01767             t4(binary_to_float(read_word(&file)));
01768             t5(binary_to_float(read_word(&file)));
01769             t6(binary_to_float(read_word(&file)));
01770             t7(binary_to_float(read_word(&file)));
01771             t8(binary_to_float(read_word(&file)));
01772             t9(binary_to_float(read_word(&file)));
01773             f(binary_to_float(read_word(&file)));
01774             // Response headers
01775             resp0(binary_to_float(read_word(&file)));
01776             resp1(binary_to_float(read_word(&file)));
01777             resp2(binary_to_float(read_word(&file)));
01778             resp3(binary_to_float(read_word(&file)));
01779             resp4(binary_to_float(read_word(&file)));
01780             resp5(binary_to_float(read_word(&file)));
01781             resp6(binary_to_float(read_word(&file)));
01782             resp7(binary_to_float(read_word(&file)));
01783             resp8(binary_to_float(read_word(&file)));
01784             resp9(binary_to_float(read_word(&file)));
01785             // Station headers
01786             stla(binary_to_float(read_word(&file)));
01787             stlo(binary_to_float(read_word(&file)));
01788             stel(binary_to_float(read_word(&file)));
01789             stdp(binary_to_float(read_word(&file)));
01790             // Event headers
01791             evla(binary_to_float(read_word(&file)));
01792             evlo(binary_to_float(read_word(&file)));
01793             evel(binary_to_float(read_word(&file)));
01794             evdp(binary_to_float(read_word(&file)));
01795             mag(binary_to_float(read_word(&file)));
01796             // User misc headers
01797             user0(binary_to_float(read_word(&file)));
01798             user1(binary_to_float(read_word(&file)));
01799             user2(binary_to_float(read_word(&file)));
01800             user3(binary_to_float(read_word(&file)));
01801             user4(binary_to_float(read_word(&file)));
01802             user5(binary_to_float(read_word(&file)));
01803             user6(binary_to_float(read_word(&file)));
01804             user7(binary_to_float(read_word(&file)));
01805             user8(binary_to_float(read_word(&file)));
01806             user9(binary_to_float(read_word(&file)));
01807             // Geometry headers
01808             dist(binary_to_float(read_word(&file)));
01809             az(binary_to_float(read_word(&file)));
01810             baz(binary_to_float(read_word(&file)));
01811             gcarc(binary_to_float(read_word(&file)));
01812             // Metadata headers
01813             sb(binary_to_float(read_word(&file)));
01814             sdelta(binary_to_float(read_word(&file)));
01815             depmen(binary_to_float(read_word(&file)));
01816             cmpaz(binary_to_float(read_word(&file)));
01817             cmpinc(binary_to_float(read_word(&file)));
01818             xminimum(binary_to_float(read_word(&file)));
01819             xmaximum(binary_to_float(read_word(&file)));
01820             yminimum(binary_to_float(read_word(&file)));
01821             ymaximum(binary_to_float(read_word(&file)));
01822             // Skip 'unused' (xcommon_skip_num)
01823             for (int i{0}; i < common_skip_num; ++i) {
01824                 read_word(&file);
01825             }
01826             // Date/time headers
01827             nzyear(binary_to_int(read_word(&file)));
01828             nzjday(binary_to_int(read_word(&file)));

```



```

01829     nzhour(binary_to_int(read_word(&file)));
01830     nzmin(binary_to_int(read_word(&file)));
01831     nzsec(binary_to_int(read_word(&file)));
01832     nzmsec(binary_to_int(read_word(&file)));
01833     // More metadata headers
01834     nvhdr(binary_to_int(read_word(&file)));
01835     norid(binary_to_int(read_word(&file)));
01836     nevid(binary_to_int(read_word(&file)));
01837     npts(binary_to_int(read_word(&file)));
01838     nsnpts(binary_to_int(read_word(&file)));
01839     nwfid(binary_to_int(read_word(&file)));
01840     nxsize(binary_to_int(read_word(&file)));
01841     nysize(binary_to_int(read_word(&file)));
01842     // Skip 'unused'
01843     read_word(&file);
01844     iftype(binary_to_int(read_word(&file)));
01845     idep(binary_to_int(read_word(&file)));
01846     iztype(binary_to_int(read_word(&file)));
01847     // Skip 'unused'
01848     read_word(&file);
01849     inst(binary_to_int(read_word(&file)));
01850     istreg(binary_to_int(read_word(&file)));
01851     ievreg(binary_to_int(read_word(&file)));
01852     ievtyp(binary_to_int(read_word(&file)));
01853     igual(binary_to_int(read_word(&file)));
01854     isynth(binary_to_int(read_word(&file)));
01855     imagtyp(binary_to_int(read_word(&file)));
01856     imagsrc(binary_to_int(read_word(&file)));
01857     ibody(binary_to_int(read_word(&file)));
01858     // Skip 'unused' (xcommon_skip_num)
01859     for (int i{0}; i < common_skip_num; ++i) {
01860         read_word(&file);
01861     }
01862     // Logical headers
01863     leven(binary_to_bool(read_word(&file)));
01864     lspol(binary_to_bool(read_word(&file)));
01865     lovrok(binary_to_bool(read_word(&file)));
01866     lcalda(binary_to_bool(read_word(&file)));
01867     // Skip 'unused'
01868     read_word(&file);
01869     // KSTNM is 2 words (normal)
01870     kstnm(binary_to_string(read_two_words(&file)));
01871     // KEVNM is 4 words long (unique!)
01872     kevnrm(binary_to_long_string(read_four_words(&file)));
01873     // All other 'K' headers are 2 words
01874     khole(binary_to_string(read_two_words(&file)));
01875     ko(binary_to_string(read_two_words(&file)));
01876     ka(binary_to_string(read_two_words(&file)));
01877     kt0(binary_to_string(read_two_words(&file)));
01878     kt1(binary_to_string(read_two_words(&file)));
01879     kt2(binary_to_string(read_two_words(&file)));
01880     kt3(binary_to_string(read_two_words(&file)));
01881     kt4(binary_to_string(read_two_words(&file)));
01882     kt5(binary_to_string(read_two_words(&file)));
01883     kt6(binary_to_string(read_two_words(&file)));
01884     kt7(binary_to_string(read_two_words(&file)));
01885     kt8(binary_to_string(read_two_words(&file)));
01886     kt9(binary_to_string(read_two_words(&file)));
01887     kf(binary_to_string(read_two_words(&file)));
01888     kuser0(binary_to_string(read_two_words(&file)));
01889     kuser1(binary_to_string(read_two_words(&file)));
01890     kuser2(binary_to_string(read_two_words(&file)));
01891     kcmpnm(binary_to_string(read_two_words(&file)));
01892     knetwk(binary_to_string(read_two_words(&file)));
01893     kdatrd(binary_to_string(read_two_words(&file)));
01894     kinst(binary_to_string(read_two_words(&file)));
01895     //-----
01896     // DATA
01897     const bool is_data{npts() != unset_int};
01898     // data1
01899     const size_t n_words{static_cast<size_t>(npts())};
01900     if (is_data) {
01901         // false flags for data1
01902         safe_to_read_data(&file, n_words, false); // throws io_error if unsafe
01903         const read_spec spec{n_words, data_word};
01904         // Originally floats, read as doubles
01905         data1(read_data(&file, spec));
01906     }
01907     // data2 (uneven or spectral data)
01908     if (is_data && (!leven() || (iftype() > 1))) {
01909         // true flags for data2
01910         safe_to_read_data(&file, n_words, true); // throws io_error if unsafe
01911         const read_spec spec{n_words, data_word + static_cast<size_t>(npts())};
01912         data2(read_data(&file, spec));
01913     }
01914     //-----
01915     // Footer

```

```

01916  if (nvhdr() == modern_hdr_version) {
01917      safe_to_read_footer(&file); // throws io_error if not safe
01918      delta(binary_to_double(read_two_words(&file)));
01919      b(binary_to_double(read_two_words(&file)));
01920      e(binary_to_double(read_two_words(&file)));
01921      o(binary_to_double(read_two_words(&file)));
01922      a(binary_to_double(read_two_words(&file)));
01923      t0(binary_to_double(read_two_words(&file)));
01924      t1(binary_to_double(read_two_words(&file)));
01925      t2(binary_to_double(read_two_words(&file)));
01926      t3(binary_to_double(read_two_words(&file)));
01927      t4(binary_to_double(read_two_words(&file)));
01928      t5(binary_to_double(read_two_words(&file)));
01929      t6(binary_to_double(read_two_words(&file)));
01930      t7(binary_to_double(read_two_words(&file)));
01931      t8(binary_to_double(read_two_words(&file)));
01932      t9(binary_to_double(read_two_words(&file)));
01933      f(binary_to_double(read_two_words(&file)));
01934      evlo(binary_to_double(read_two_words(&file)));
01935      evla(binary_to_double(read_two_words(&file)));
01936      stlo(binary_to_double(read_two_words(&file)));
01937      stla(binary_to_double(read_two_words(&file)));
01938      sb(binary_to_double(read_two_words(&file)));
01939      sdelta(binary_to_double(read_two_words(&file)));
01940  }
01941  safe_to_finish_reading(&file); // throws io_error if the file isn't finished
01942  file.close();
01943  }

```

### 11.3.3 Member Function Documentation

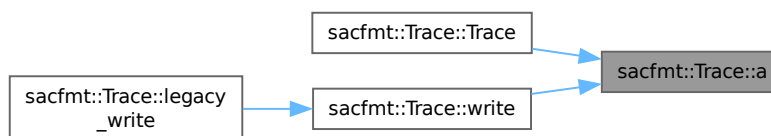
#### a() [1/2]

```

double sacfmt::Trace::a ( ) const [noexcept]
01063 { return doubles[sac_map.at(name::a)]; }

```

Here is the caller graph for this function:



#### a() [2/2]

```

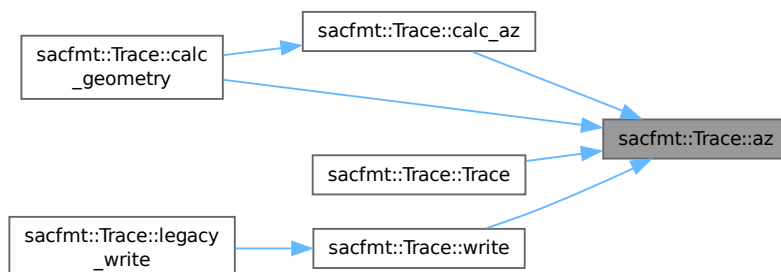
void sacfmt::Trace::a (
    double input ) [noexcept]
01318 {
01319     doubles[sac_map.at(name::a)] = input;
01320 }

```

**az()** [1/2]

```
float sacfmt::Trace::az ( ) const [noexcept]
01034 { return floats[sac_map.at(name::az)]; }
```

Here is the caller graph for this function:

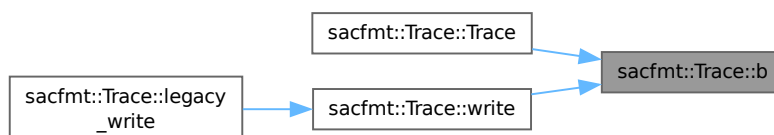
**az()** [2/2]

```
void sacfmt::Trace::az (
    float input ) [noexcept]
01275 {
01276     floats[sac_map.at(name::az)] = input;
01277 }
```

**b()** [1/2]

```
double sacfmt::Trace::b ( ) const [noexcept]
01060 { return doubles[sac_map.at(name::b)]; }
```

Here is the caller graph for this function:

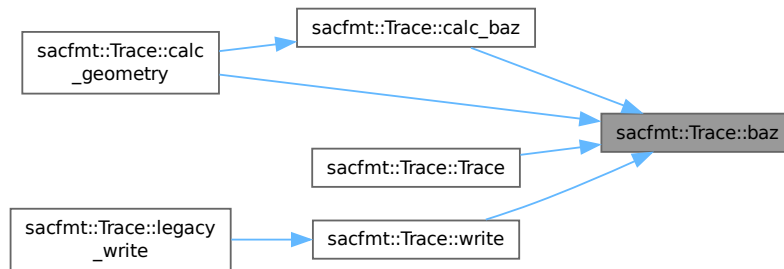
**b()** [2/2]

```
void sacfmt::Trace::b (
    double input ) [noexcept]
01309 {
01310     doubles[sac_map.at(name::b)] = input;
01311 }
```

**baz()** [1/2]

```
float sacfmt::Trace::baz ( ) const [noexcept]
01035 { return floats[sac_map.at(name::baz)]; }
```

Here is the caller graph for this function:

**baz()** [2/2]

```
void sacfmt::Trace::baz (
    float input ) [noexcept]
01278 {
01279     floats[sac_map.at(name::baz)] = input;
01280 }
```

**calc\_az()**

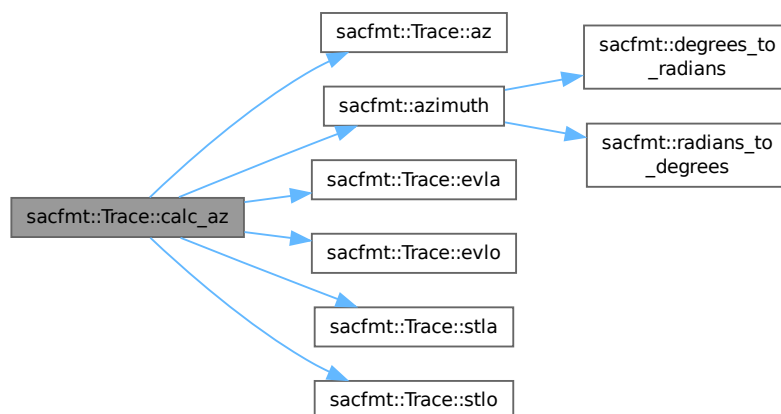
```
void sacfmt::Trace::calc_az ( ) [private], [noexcept]
```

Calculate azimuth.

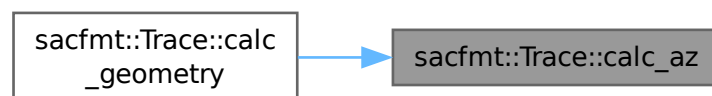
*Station → Event*

```
00943 {
00944     az(static_cast<float>(azimuth(evla(), evlo(), stla(), stlo())));
00945 }
```

Here is the call graph for this function:



Here is the caller graph for this function:



### calc\_baz()

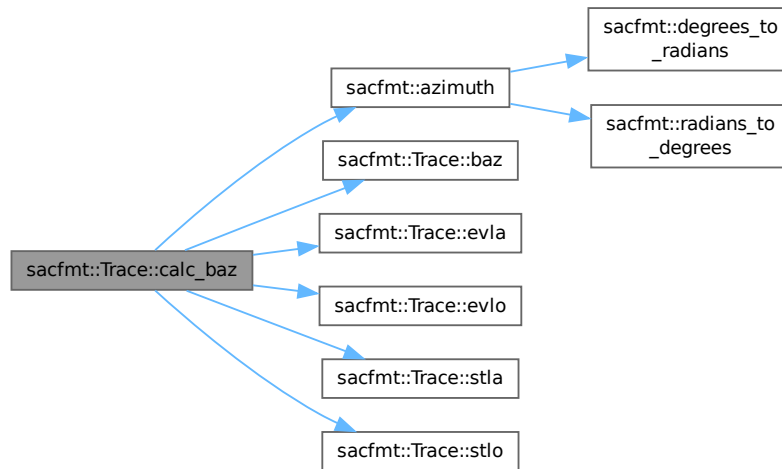
```
void sacfmt::Trace::calc_baz ( ) [private], [noexcept]
```

Calculate back-azimuth.

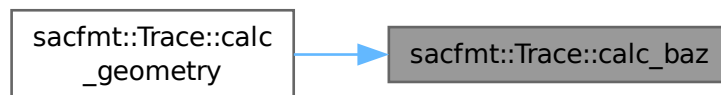
*Event → Station*

```
00954         {
00955     baz(static_cast<float>(azimuth(stla(), stlo(), evla(), evlo())));
00956 }
```

Here is the call graph for this function:



Here is the caller graph for this function:



### calc\_dist()

```
void sacfmt::Trace::calc_dist ( ) [private], [noexcept]
```

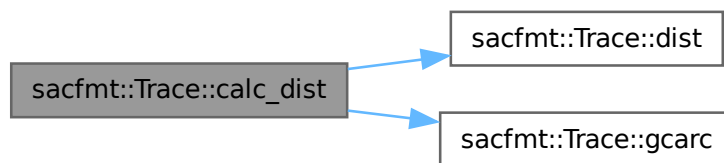
Calculate distance (using gcarc).

Assumes spherical Earth (in future may update to include flattening and different planetary bodies).

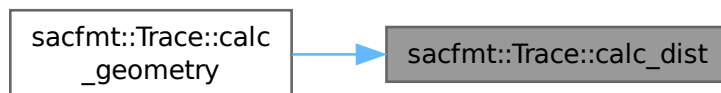
$$d = r_E \cdot \Delta$$

```
00932         {
00933     dist (static_cast<float>(earth_radius * rad_per_deg * gcarc()));
00934 }
```

Here is the call graph for this function:



Here is the caller graph for this function:



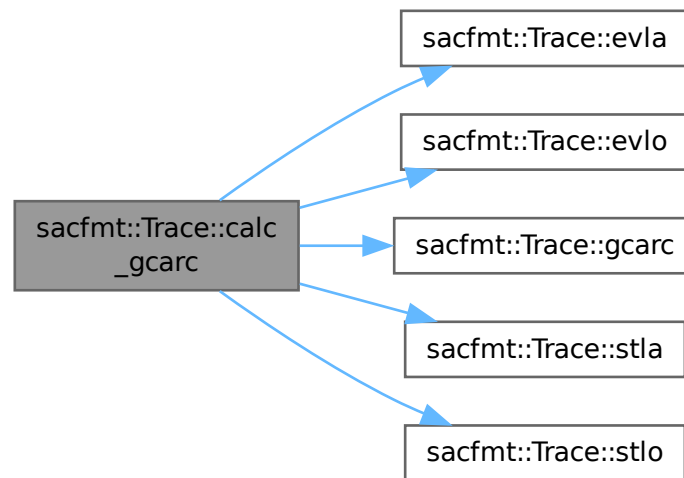
### `calc_gcarc()`

```
void sacfmt::Trace::calc_gcarc ( ) [private], [noexcept]
```

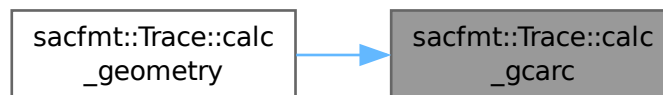
Calculate great-circle arc-distance (gcarc).

```
00917     {  
00918     Trace::gcarc(  
00919         static_cast<float>(sacfmt::gcarc(stla(), stlo(), evla(), evlo())));  
00920 }
```

Here is the call graph for this function:



Here is the caller graph for this function:



### `calc_geometry()`

```
void sacfmt::Trace::calc_geometry ( ) [noexcept]
```

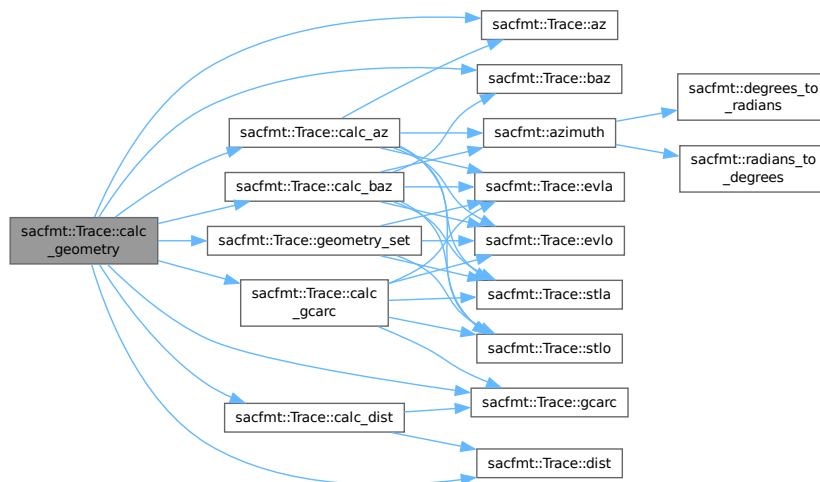
Calculates `gcarc`, `dist`, `az`, and `baz` from `stla`, `stlo`, `evla`, and `evlo`.

```

00873     {
00874     if (geometry_set()) {
00875         calc_gcarc();
00876         calc_dist();
00877         calc_az();
00878         calc_baz();
00879     } else {
00880         gcarc(unset_double);
00881         dist(unset_double);
00882         az(unset_double);
00883         baz(unset_double);
00884     }
00885 }
```



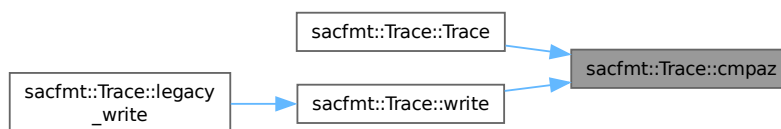
Here is the call graph for this function:



#### cmpaz() [1/2]

```
float sacfmt::Trace::cmpaz ( ) const [noexcept]
01040 { return floats[sac_map.at(name::cmpaz)]; }
```

Here is the caller graph for this function:



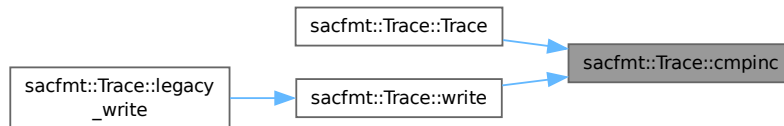
#### cmpaz() [2/2]

```
void sacfmt::Trace::cmpaz (
    float input ) [noexcept]
01287 {
01288     floats[sac_map.at(name::cmpaz)] = input;
01289 }
```

**cmpinc()** [1/2]

```
float sacfmt::Trace::cmpinc ( ) const [noexcept]
01041     {
01042     return floats[sac_map.at(name::cmpinc)];
01043 }
```

Here is the caller graph for this function:

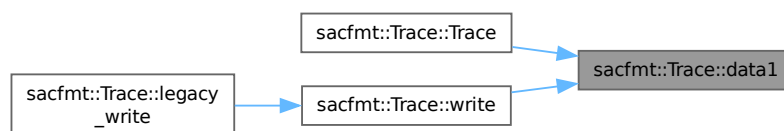
**cmpinc()** [2/2]

```
void sacfmt::Trace::cmpinc (
    float input ) [noexcept]
01290     {
01291     floats[sac_map.at(name::cmpinc)] = input;
01292 }
```

**data1()** [1/2]

```
std::vector< double > sacfmt::Trace::data1 ( ) const [noexcept]
01180     {
01181     return data[sac_map.at(name::data1)];
01182 }
```

Here is the caller graph for this function:

**data1()** [2/2]

```
void sacfmt::Trace::data1 (
    const std::vector< double > & input ) [noexcept]
01564     {
01565     data[sac_map.at(name::data1)] = input;
01566     // Propagate change as needed
01567     int size{static_cast<int>(data1().size())};
01568     size = (((size == 0) && (npts() == unset_int)) ? unset_int : size);
01569     if (size != npts()) {
01570         npts(size);
01571     }
01572 }
```

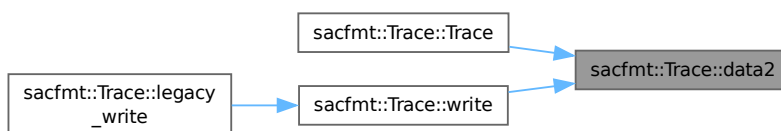
**data2()** [1/2]

```

std::vector< double > sacfmt::Trace::data2 ( ) const [noexcept]
01183     {
01184     return data[sac_map.at(name::data2)];
01185     }

```

Here is the caller graph for this function:

**data2()** [2/2]

```

void sacfmt::Trace::data2 (
    const std::vector< double > & input ) [noexcept]
01574     {
01575     data[sac_map.at(name::data2)] = input;
01576     // Proagate change as needed
01577     int size{static_cast<int>(data2().size())};
01578     size = (((size == 0) && (npts() == unset_int)) ? unset_int : size);
01579     // Need to make sure this is legal
01580     // If positive size and not-legal, make spectral
01581     if (size > 0) {
01582         // If not legal, make spectral
01583         if (leven() && (iftype() <= 1)) {
01584             iftype(2);
01585         }
01586         // If legal and different from npts, update npts
01587         if ((!leven() || (iftype() > 1)) && (size != npts())) {
01588             npts(size);
01589         }
01590     }
01591 }

```

**date()**

```
std::string sacfmt::Trace::date ( ) const [noexcept]
```

Get date string.

**Returns**

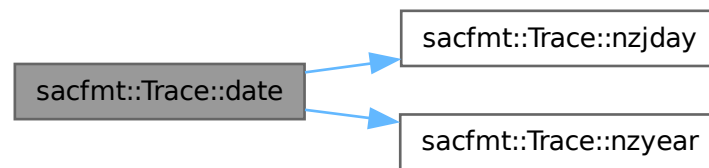
std::string Date (YYYY-JJJ).

```

00963     {
00964     // Require all to be set
00965     if ((nzyear() == unset_int) || (nzjday() == unset_int)) {
00966         return unset_word;
00967     }
00968     std::ostringstream oss{};
00969     oss << nzyear();
00970     oss << '-';
00971     oss << nzjday();
00972     return oss.str();
00973 }

```

Here is the call graph for this function:

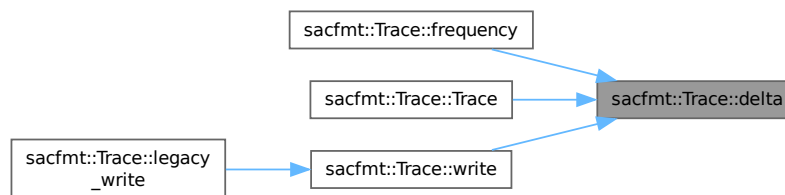


### **delta()** [1/2]

```

double sacfmt::Trace::delta ( ) const [noexcept]
01057 {
01058     return doubles[sac_map.at(name::delta)];
01059 }
  
```

Here is the caller graph for this function:



### **delta()** [2/2]

```

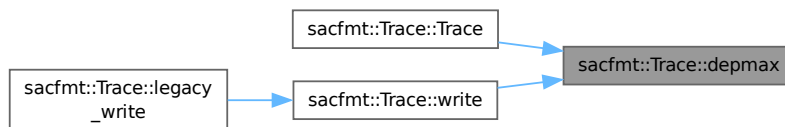
void sacfmt::Trace::delta (
    double input ) [noexcept]
01306 {
01307     doubles[sac_map.at(name::delta)] = input;
01308 }
  
```

### **depmax()** [1/2]

```

float sacfmt::Trace::depmax ( ) const [noexcept]
01002 {
01003     return floats[sac_map.at(name::depmax)];
01004 }
  
```

Here is the caller graph for this function:



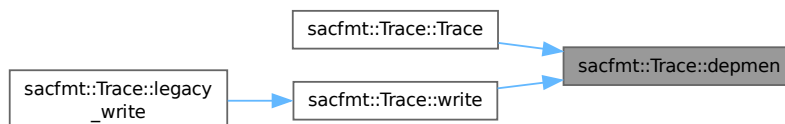
#### **depmax()** [2/2]

```
void sacfmt::Trace::depmax (
    float input ) [noexcept]
01191     {
01192     floats[sac_map.at(name::depmax)] = input;
01193 }
```

#### **depmen()** [1/2]

```
float sacfmt::Trace::depmen ( ) const [noexcept]
01037     {
01038     return floats[sac_map.at(name::depmen)];
01039 }
```

Here is the caller graph for this function:



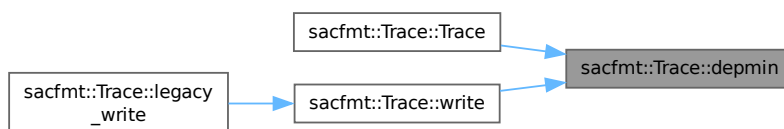
#### **depmen()** [2/2]

```
void sacfmt::Trace::depmen (
    float input ) [noexcept]
01284     {
01285     floats[sac_map.at(name::depmen)] = input;
01286 }
```

**depmin()** [1/2]

```
float sacfmt::Trace::depmin ( ) const [noexcept]
00999 {
01000     return floats[sac_map.at(name::depmin)];
01001 }
```

Here is the caller graph for this function:

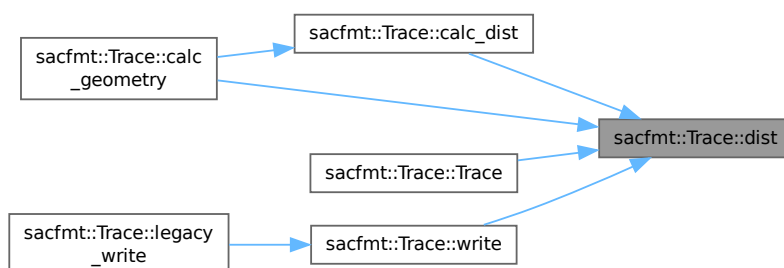
**depmin()** [2/2]

```
void sacfmt::Trace::depmin (
    float input ) [noexcept]
01188 {
01189     floats[sac_map.at(name::depmin)] = input;
01190 }
```

**dist()** [1/2]

```
float sacfmt::Trace::dist ( ) const [noexcept]
01033 { return floats[sac_map.at(name::dist)]; }
```

Here is the caller graph for this function:

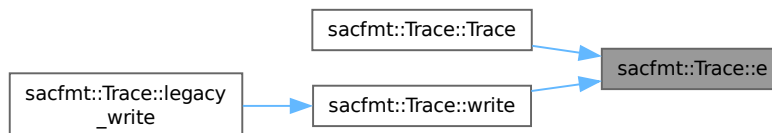
**dist()** [2/2]

```
void sacfmt::Trace::dist (
    float input ) [noexcept]
01272 {
01273     floats[sac_map.at(name::dist)] = input;
01274 }
```

**e()** [1/2]

```
double sacfmt::Trace::e ( ) const [noexcept]
01061 { return doubles[sac_map.at(name::e)]; }
```

Here is the caller graph for this function:

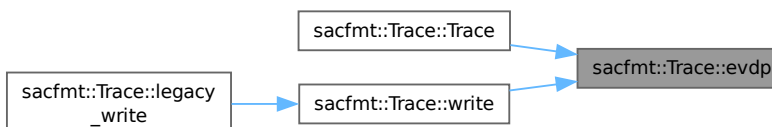
**e()** [2/2]

```
void sacfmt::Trace::e (
    double input ) [noexcept]
01312 {
01313     doubles[sac_map.at(name::e)] = input;
01314 }
```

**evdp()** [1/2]

```
float sacfmt::Trace::evdp ( ) const [noexcept]
01021 { return floats[sac_map.at(name::evdp)]; }
```

Here is the caller graph for this function:

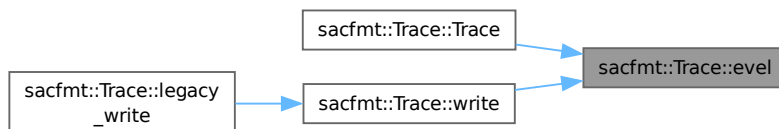
**evdp()** [2/2]

```
void sacfmt::Trace::evdp (
    float input ) [noexcept]
01236 {
01237     floats[sac_map.at(name::evdp)] = input;
01238 }
```

**evel()** [1/2]

```
float sacfmt::Trace::evel ( ) const [noexcept]
01020 { return floats[sac_map.at(name::evel)]; }
```

Here is the caller graph for this function:

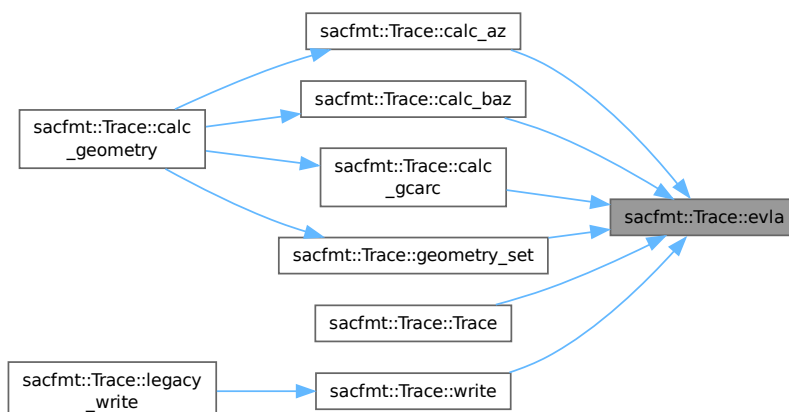
**evel()** [2/2]

```
void sacfmt::Trace::evel (
    float input ) [noexcept]
01233     {
01234     floats[sac_map.at(name::evel)] = input;
01235 }
```

**evla()** [1/2]

```
double sacfmt::Trace::evla ( ) const [noexcept]
01077 { return doubles[sac_map.at(name::evla)]; }
```

Here is the caller graph for this function:





**evla()** [2/2]

```

void sacfmt::Trace::evla (
    double input ) [noexcept]
{
01366     if (input != unset_double) {
01367         input = limit_90(input);
01368     }
01369     doubles[sac_map.at(name::evla)] = input;
01370 }
01371

```

Here is the call graph for this function:

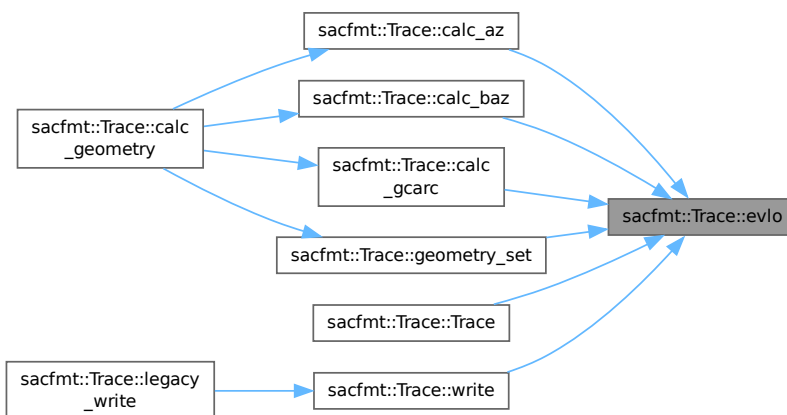
**evlo()** [1/2]

```

double sacfmt::Trace::evlo ( ) const [noexcept]
{
01078     return doubles[sac_map.at(name::evlo)];
}

```

Here is the caller graph for this function:

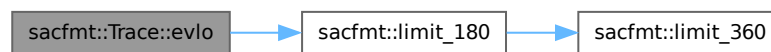
**evlo()** [2/2]

```

void sacfmt::Trace::evlo (
    double input ) [noexcept]
{
01372     if (input != unset_double) {
01373         input = limit_180(input);
01374     }
01375     doubles[sac_map.at(name::evlo)] = input;
01376 }
01377

```

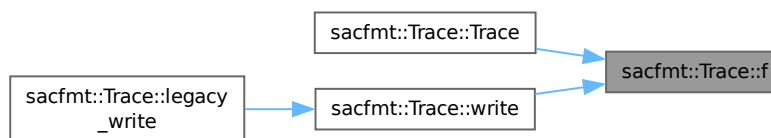
Here is the call graph for this function:



#### f() [1/2]

```
double sacfmt::Trace::f ( ) const [noexcept]
01074 { return doubles[sac_map.at(name::f)]; }
```

Here is the caller graph for this function:



#### f() [2/2]

```
void sacfmt::Trace::f (
    double input ) [noexcept]
01351 {
01352     doubles[sac_map.at(name::f)] = input;
01353 }
```

#### frequency()

```
double sacfmt::Trace::frequency ( ) const [noexcept]
```

Calculate frequency from delta.

$$f = \frac{1}{\delta}$$

## Returns

double Frequency.

```

00896                                     {
00897     const double delta_val{delta()};
00898     if ((delta_val == unset_double) || (delta_val <= 0)) {
00899         return unset_double;
00900     }
00901     return 1.0 / delta_val;
00902 }

```

Here is the call graph for this function:



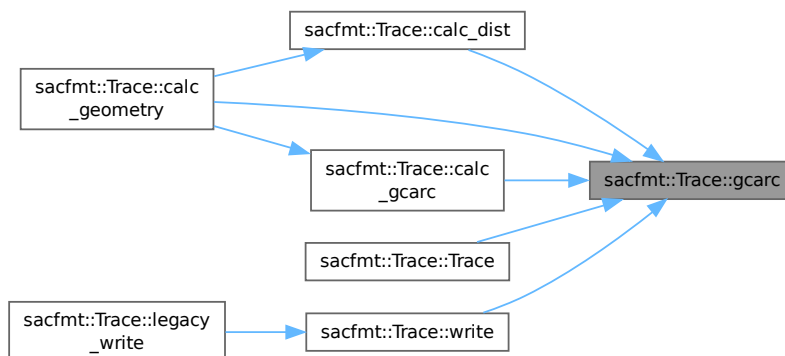
### gcarc() [1/2]

```

float sacfmt::Trace::gcarc ( ) const [noexcept]
01036 { return floats[sac_map.at(name::gcarc)]; }

```

Here is the caller graph for this function:



### gcarc() [2/2]

```

void sacfmt::Trace::gcarc (
    float input ) [noexcept]
01281                                     {
01282     floats[sac_map.at(name::gcarc)] = input;
01283 }

```

**geometry\_set()**

```
bool sacfmt::Trace::geometry_set ( ) const [private], [noexcept]
```

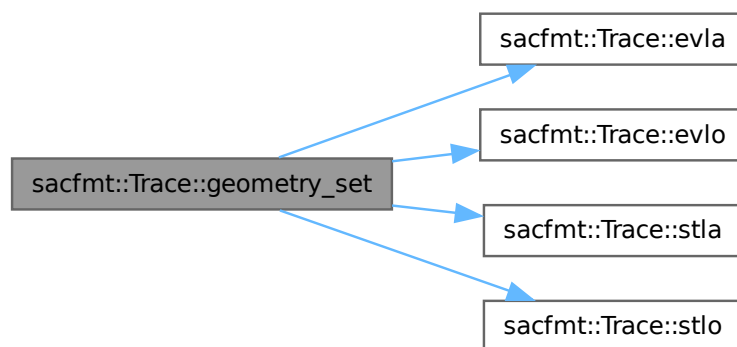
Determine if locations are set for geometry calculation.

**Returns**

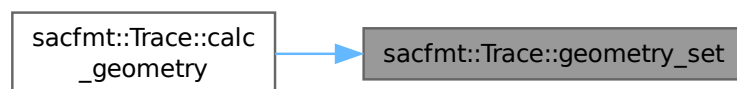
bool True if able to calculate geometry.

```
00909 {
00910     return ((stla() != unset_double) && (stlo() != unset_double) &&
00911            (evla() != unset_double) && (evlo() != unset_double));
00912 }
```

Here is the call graph for this function:

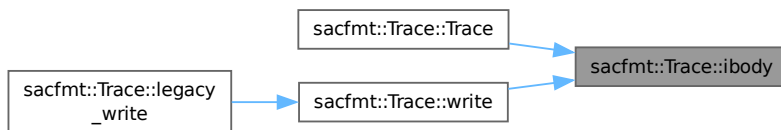


Here is the caller graph for this function:

**ibody() [1/2]**

```
int sacfmt::Trace::ibody ( ) const [noexcept]
01109 { return ints[sac_map.at(name::ibody)]; }
```

Here is the caller graph for this function:



### ibody() [2/2]

```

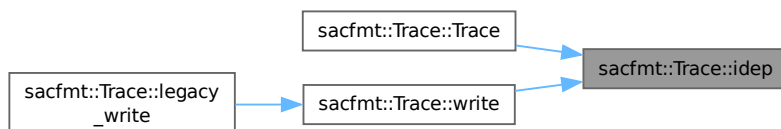
void sacfmt::Trace::ibody (
    int input ) [noexcept]
{
01470     ints[sac_map.at(name::ibody)] = input;
01471 }
01472
  
```

### idep() [1/2]

```

int sacfmt::Trace::idep ( ) const [noexcept]
01099 { return ints[sac_map.at(name::idep)]; }
  
```

Here is the caller graph for this function:



### idep() [2/2]

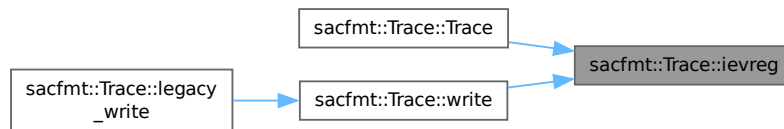
```

void sacfmt::Trace::idep (
    int input ) [noexcept]
{
01440     ints[sac_map.at(name::idep)] = input;
01441 }
01442
  
```

**ievreg()** [1/2]

```
int sacfmt::Trace::ievreg ( ) const [noexcept]
01103 { return ints[sac_map.at(name::ievreg)]; }
```

Here is the caller graph for this function:

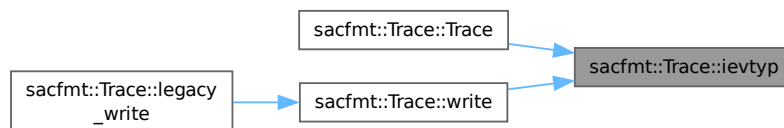
**ievreg()** [2/2]

```
void sacfmt::Trace::ievreg (
    int input ) [noexcept]
01452 {
01453     ints[sac_map.at(name::ievreg)] = input;
01454 }
```

**ievtyp()** [1/2]

```
int sacfmt::Trace::ievtyp ( ) const [noexcept]
01104 { return ints[sac_map.at(name::ievtyp)]; }
```

Here is the caller graph for this function:

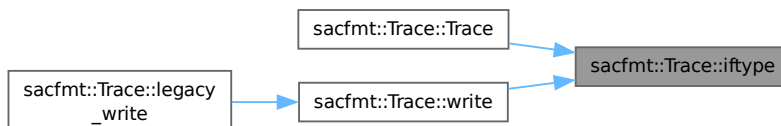
**ievtyp()** [2/2]

```
void sacfmt::Trace::ievtyp (
    int input ) [noexcept]
01455 {
01456     ints[sac_map.at(name::ievtyp)] = input;
01457 }
```

**iftype()** [1/2]

```
int sacfmt::Trace::iftype ( ) const [noexcept]
01098 { return ints[sac_map.at(name::iftype)]; }
```

Here is the caller graph for this function:

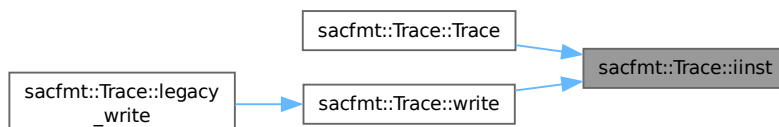
**iftype()** [2/2]

```
void sacfmt::Trace::iftype (
    int input ) [noexcept]
01431 {
01432     ints[sac_map.at(name::iftype)] = input;
01433     const size_t size{npts()} >= 0 ? static_cast<size_t>(npts()) : 0;
01434     // Uneven 2D data not supported as not in specification
01435     if ((input > 1) && !leven()) {
01436         leven(true);
01437     }
01438     resize_data2(size);
01439 }
```

**iinst()** [1/2]

```
int sacfmt::Trace::iinst ( ) const [noexcept]
01101 { return ints[sac_map.at(name::iinst)]; }
```

Here is the caller graph for this function:

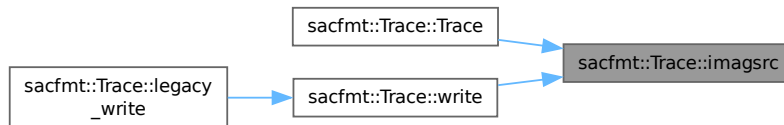
**iinst()** [2/2]

```
void sacfmt::Trace::iinst (
    int input ) [noexcept]
01446 {
01447     ints[sac_map.at(name::iinst)] = input;
01448 }
```

**imgsrc()** [1/2]

```
int sacfmt::Trace::imgsrc ( ) const [noexcept]
01108 { return ints[sac_map.at(name::imgsrc)]; }
```

Here is the caller graph for this function:

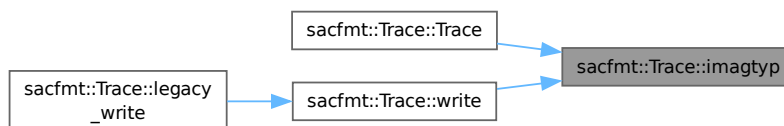
**imgsrc()** [2/2]

```
void sacfmt::Trace::imgsrc (
    int input ) [noexcept]
01467 {
01468     ints[sac_map.at(name::imgsrc)] = input;
01469 }
```

**imagtyp()** [1/2]

```
int sacfmt::Trace::imagtyp ( ) const [noexcept]
01107 { return ints[sac_map.at(name::imagtyp)]; }
```

Here is the caller graph for this function:

**imagtyp()** [2/2]

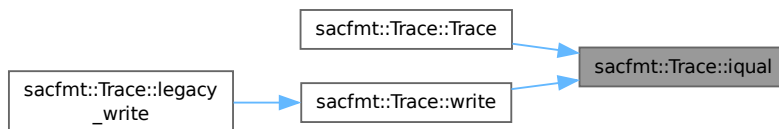
```
void sacfmt::Trace::imagtyp (
    int input ) [noexcept]
01464 {
01465     ints[sac_map.at(name::imagtyp)] = input;
01466 }
```



**igual()** [1/2]

```
int sacfmt::Trace::igual ( ) const [noexcept]
01105 { return ints[sac_map.at(name::igual)]; }
```

Here is the caller graph for this function:

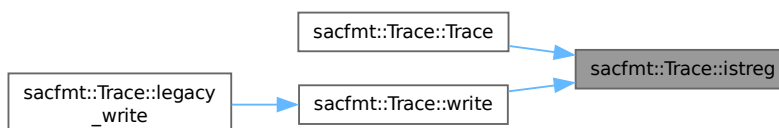
**igual()** [2/2]

```
void sacfmt::Trace::igual (
    int input ) [noexcept]
01458 {
01459     ints[sac_map.at(name::igual)] = input;
01460 }
```

**istreg()** [1/2]

```
int sacfmt::Trace::istreg ( ) const [noexcept]
01102 { return ints[sac_map.at(name::istreg)]; }
```

Here is the caller graph for this function:

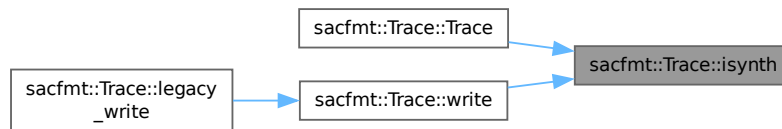
**istreg()** [2/2]

```
void sacfmt::Trace::istreg (
    int input ) [noexcept]
01449 {
01450     ints[sac_map.at(name::istreg)] = input;
01451 }
```

**isynt()** [1/2]

```
int sacfmt::Trace::isynt ( ) const [noexcept]
01106 { return ints[sac_map.at(name::isynt)]; }
```

Here is the caller graph for this function:

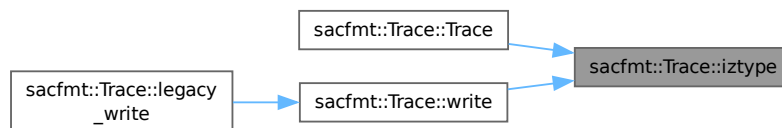
**isynt()** [2/2]

```
void sacfmt::Trace::isynt (
    int input ) [noexcept]
01461 {
01462     ints[sac_map.at(name::isynt)] = input;
01463 }
```

**iztype()** [1/2]

```
int sacfmt::Trace::iztype ( ) const [noexcept]
01100 { return ints[sac_map.at(name::iztype)]; }
```

Here is the caller graph for this function:

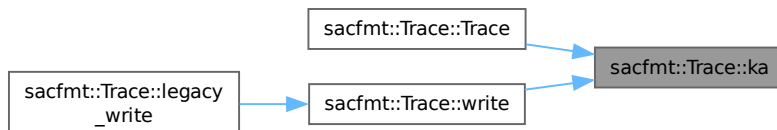
**iztype()** [2/2]

```
void sacfmt::Trace::iztype (
    int input ) [noexcept]
01443 {
01444     ints[sac_map.at(name::iztype)] = input;
01445 }
```

**ka()** [1/2]

```
std::string sacfmt::Trace::ka ( ) const [noexcept]
01126 { return strings[sac_map.at(name::ka)]; }
```

Here is the caller graph for this function:

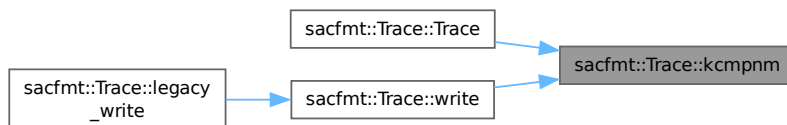
**ka()** [2/2]

```
void sacfmt::Trace::ka (
    const std::string & input ) [noexcept]
01505 {
01506     strings[sac_map.at(name::ka)] = input;
01507 }
```

**kcmpnm()** [1/2]

```
std::string sacfmt::Trace::kcmpnm ( ) const [noexcept]
01167 {
01168     return strings[sac_map.at(name::kcmpnm)];
01169 }
```

Here is the caller graph for this function:

**kcmpnm()** [2/2]

```
void sacfmt::Trace::kcmpnm (
    const std::string & input ) [noexcept]
01550 {
01551     strings[sac_map.at(name::kcmpnm)] = input;
01552 }
```

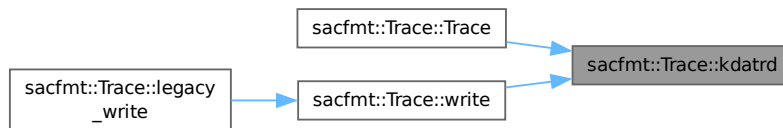
**kdatrd()** [1/2]

```

std::string sacfmt::Trace::kdatrd ( ) const [noexcept]
01173     {
01174     return strings[sac_map.at(name::kdatrd)];
01175     }

```

Here is the caller graph for this function:

**kdatrd()** [2/2]

```

void sacfmt::Trace::kdatrd (
    const std::string & input ) [noexcept]
01556     {
01557     strings[sac_map.at(name::kdatrd)] = input;
01558     }

```

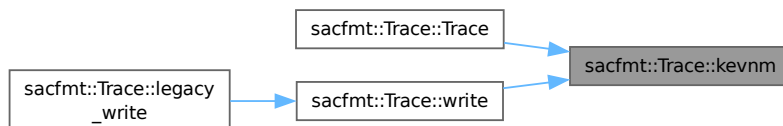
**kevnrm()** [1/2]

```

std::string sacfmt::Trace::kevnrm ( ) const [noexcept]
01119     {
01120     return strings[sac_map.at(name::kevnrm)];
01121     }

```

Here is the caller graph for this function:

**kevnrm()** [2/2]

```

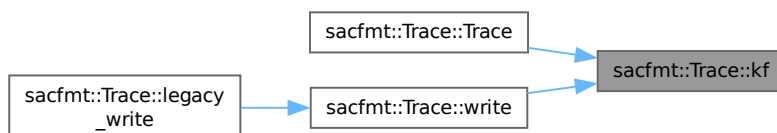
void sacfmt::Trace::kevnrm (
    const std::string & input ) [noexcept]
01496     {
01497     strings[sac_map.at(name::kevnrm)] = input;
01498     }

```

**kf()** [1/2]

```
std::string sacfmt::Trace::kf ( ) const [noexcept]
01157 { return strings[sac_map.at(name::kf)]; }
```

Here is the caller graph for this function:

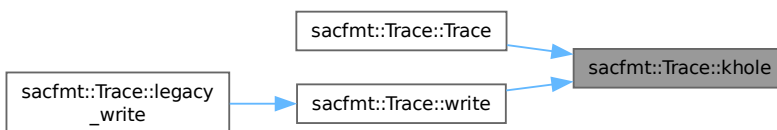
**kf()** [2/2]

```
void sacfmt::Trace::kf (
    const std::string & input ) [noexcept]
01538 {
01539     strings[sac_map.at(name::kf)] = input;
01540 }
```

**khole()** [1/2]

```
std::string sacfmt::Trace::khole ( ) const [noexcept]
01122 {
01123     return strings[sac_map.at(name::khole)];
01124 }
```

Here is the caller graph for this function:

**khole()** [2/2]

```
void sacfmt::Trace::khole (
    const std::string & input ) [noexcept]
01499 {
01500     strings[sac_map.at(name::khole)] = input;
01501 }
```

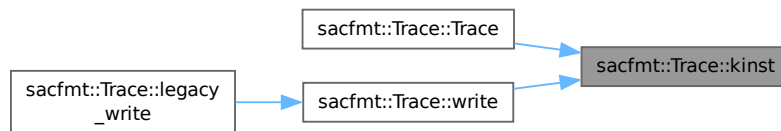
**kinst()** [1/2]

```

std::string sacfmt::Trace::kinst ( ) const [noexcept]
01176     {
01177     return strings[sac_map.at(name::kinst)];
01178     }

```

Here is the caller graph for this function:

**kinst()** [2/2]

```

void sacfmt::Trace::kinst (
    const std::string & input ) [noexcept]
01559     {
01560     strings[sac_map.at(name::kinst)] = input;
01561     }

```

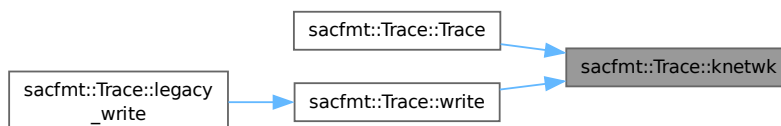
**knetwk()** [1/2]

```

std::string sacfmt::Trace::knetwk ( ) const [noexcept]
01170     {
01171     return strings[sac_map.at(name::knetwk)];
01172     }

```

Here is the caller graph for this function:

**knetwk()** [2/2]

```

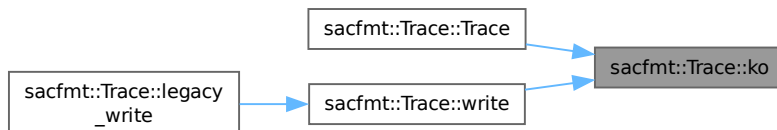
void sacfmt::Trace::knetwk (
    const std::string & input ) [noexcept]
01553     {
01554     strings[sac_map.at(name::knetwk)] = input;
01555     }

```

**ko()** [1/2]

```
std::string sacfmt::Trace::ko ( ) const [noexcept]
01125 { return strings[sac_map.at(name::ko)]; }
```

Here is the caller graph for this function:

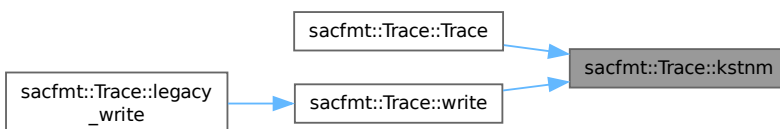
**ko()** [2/2]

```
void sacfmt::Trace::ko (
    const std::string & input ) [noexcept]
01502 {
01503     strings[sac_map.at(name::ko)] = input;
01504 }
```

**kstnm()** [1/2]

```
std::string sacfmt::Trace::kstnm ( ) const [noexcept]
01116 {
01117     return strings[sac_map.at(name::kstnm)];
01118 }
```

Here is the caller graph for this function:

**kstnm()** [2/2]

```
void sacfmt::Trace::kstnm (
    const std::string & input ) [noexcept]
01493 {
01494     strings[sac_map.at(name::kstnm)] = input;
01495 }
```

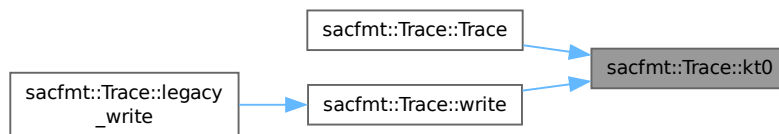
**kt0()** [1/2]

```

std::string sacfmt::Trace::kt0 ( ) const [noexcept]
01127     {
01128     return strings[sac_map.at(name::kt0)];
01129     }

```

Here is the caller graph for this function:

**kt0()** [2/2]

```

void sacfmt::Trace::kt0 (
    const std::string & input ) [noexcept]
01508     {
01509     strings[sac_map.at(name::kt0)] = input;
01510     }

```

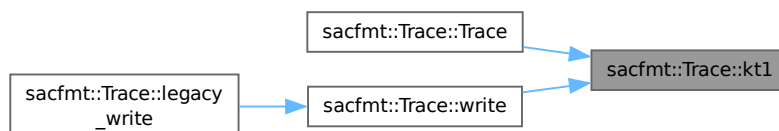
**kt1()** [1/2]

```

std::string sacfmt::Trace::kt1 ( ) const [noexcept]
01130     {
01131     return strings[sac_map.at(name::kt1)];
01132     }

```

Here is the caller graph for this function:

**kt1()** [2/2]

```

void sacfmt::Trace::kt1 (
    const std::string & input ) [noexcept]
01511     {
01512     strings[sac_map.at(name::kt1)] = input;
01513     }

```



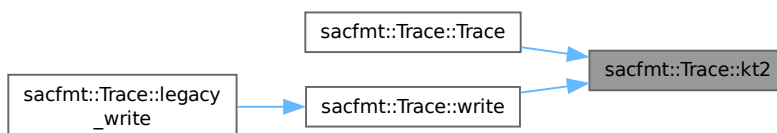
**kt2()** [1/2]

```

std::string sacfmt::Trace::kt2 ( ) const [noexcept]
01133     {
01134     return strings[sac_map.at(name::kt2)];
01135     }

```

Here is the caller graph for this function:

**kt2()** [2/2]

```

void sacfmt::Trace::kt2 (
    const std::string & input ) [noexcept]
01514     {
01515     strings[sac_map.at(name::kt2)] = input;
01516     }

```

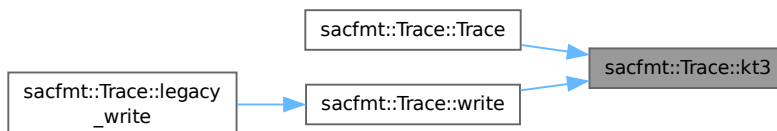
**kt3()** [1/2]

```

std::string sacfmt::Trace::kt3 ( ) const [noexcept]
01136     {
01137     return strings[sac_map.at(name::kt3)];
01138     }

```

Here is the caller graph for this function:

**kt3()** [2/2]

```

void sacfmt::Trace::kt3 (
    const std::string & input ) [noexcept]
01517     {
01518     strings[sac_map.at(name::kt3)] = input;
01519     }

```

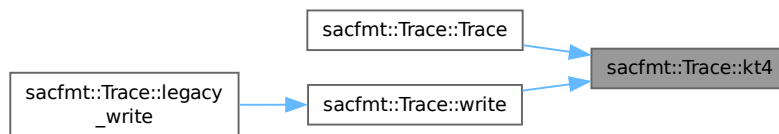
**kt4()** [1/2]

```

std::string sacfmt::Trace::kt4 ( ) const [noexcept]
01139     {
01140     return strings[sac_map.at(name::kt4)];
01141     }

```

Here is the caller graph for this function:

**kt4()** [2/2]

```

void sacfmt::Trace::kt4 (
    const std::string & input ) [noexcept]
01520     {
01521     strings[sac_map.at(name::kt4)] = input;
01522     }

```

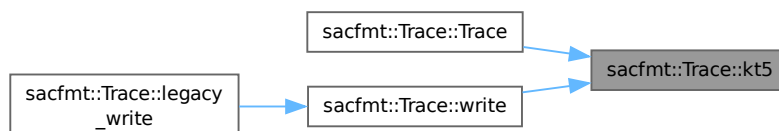
**kt5()** [1/2]

```

std::string sacfmt::Trace::kt5 ( ) const [noexcept]
01142     {
01143     return strings[sac_map.at(name::kt5)];
01144     }

```

Here is the caller graph for this function:

**kt5()** [2/2]

```

void sacfmt::Trace::kt5 (
    const std::string & input ) [noexcept]
01523     {
01524     strings[sac_map.at(name::kt5)] = input;
01525     }

```

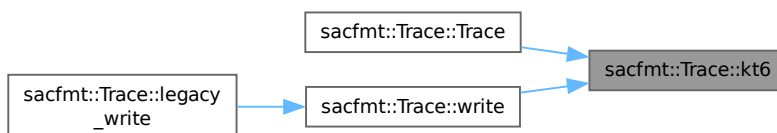
**kt6()** [1/2]

```

std::string sacfmt::Trace::kt6 ( ) const [noexcept]
01145     {
01146     return strings[sac_map.at(name::kt6)];
01147     }

```

Here is the caller graph for this function:

**kt6()** [2/2]

```

void sacfmt::Trace::kt6 (
    const std::string & input ) [noexcept]
01526     {
01527     strings[sac_map.at(name::kt6)] = input;
01528     }

```

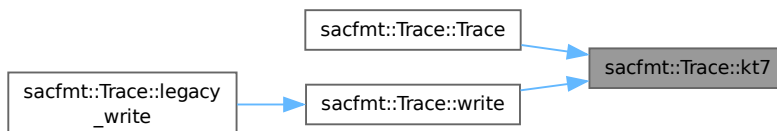
**kt7()** [1/2]

```

std::string sacfmt::Trace::kt7 ( ) const [noexcept]
01148     {
01149     return strings[sac_map.at(name::kt7)];
01150     }

```

Here is the caller graph for this function:

**kt7()** [2/2]

```

void sacfmt::Trace::kt7 (
    const std::string & input ) [noexcept]
01529     {
01530     strings[sac_map.at(name::kt7)] = input;
01531     }

```

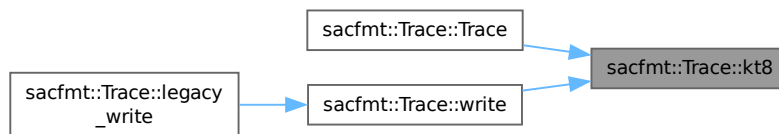
**kt8()** [1/2]

```

std::string sacfmt::Trace::kt8 ( ) const [noexcept]
01151     {
01152     return strings[sac_map.at(name::kt8)];
01153     }

```

Here is the caller graph for this function:

**kt8()** [2/2]

```

void sacfmt::Trace::kt8 (
    const std::string & input ) [noexcept]
01532     {
01533     strings[sac_map.at(name::kt8)] = input;
01534     }

```

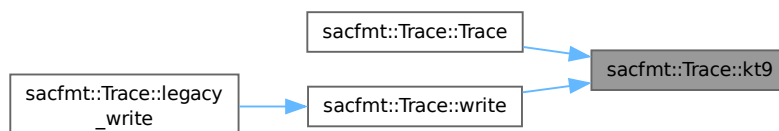
**kt9()** [1/2]

```

std::string sacfmt::Trace::kt9 ( ) const [noexcept]
01154     {
01155     return strings[sac_map.at(name::kt9)];
01156     }

```

Here is the caller graph for this function:

**kt9()** [2/2]

```

void sacfmt::Trace::kt9 (
    const std::string & input ) [noexcept]
01535     {
01536     strings[sac_map.at(name::kt9)] = input;
01537     }

```

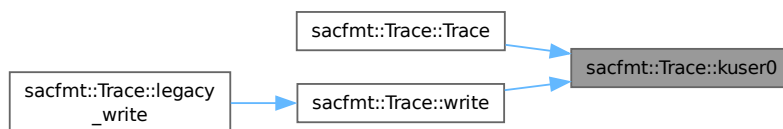
**kuser0()** [1/2]

```

std::string sacfmt::Trace::kuser0 ( ) const [noexcept]
01158     {
01159     return strings[sac_map.at(name::kuser0)];
01160     }

```

Here is the caller graph for this function:

**kuser0()** [2/2]

```

void sacfmt::Trace::kuser0 (
    const std::string & input ) [noexcept]
01541     {
01542     strings[sac_map.at(name::kuser0)] = input;
01543     }

```

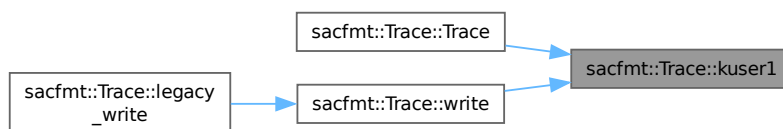
**kuser1()** [1/2]

```

std::string sacfmt::Trace::kuser1 ( ) const [noexcept]
01161     {
01162     return strings[sac_map.at(name::kuser1)];
01163     }

```

Here is the caller graph for this function:

**kuser1()** [2/2]

```

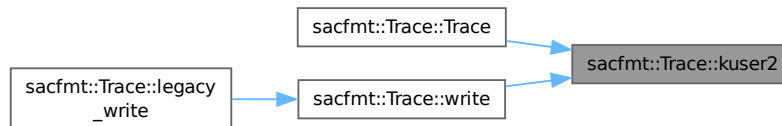
void sacfmt::Trace::kuser1 (
    const std::string & input ) [noexcept]
01544     {
01545     strings[sac_map.at(name::kuser1)] = input;
01546     }

```

**kuser2()** [1/2]

```
std::string sacfmt::Trace::kuser2 ( ) const [noexcept]
01164 {
01165     return strings[sac_map.at(name::kuser2)];
01166 }
```

Here is the caller graph for this function:

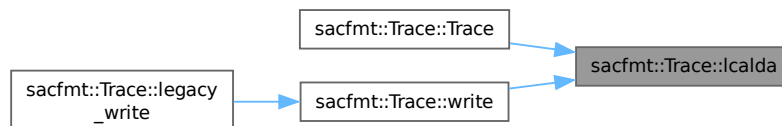
**kuser2()** [2/2]

```
void sacfmt::Trace::kuser2 (
    const std::string & input ) [noexcept]
01547 {
01548     strings[sac_map.at(name::kuser2)] = input;
01549 }
```

**lcaldal()** [1/2]

```
bool sacfmt::Trace::lcaldal ( ) const [noexcept]
01114 { return bools[sac_map.at(name::lcaldal)]; }
```

Here is the caller graph for this function:

**lcaldal()** [2/2]

```
void sacfmt::Trace::lcaldal (
    bool input ) [noexcept]
01489 {
01490     bools[sac_map.at(name::lcaldal)] = input;
01491 }
```

**legacy\_write()**

```
void sacfmt::Trace::legacy_write (
    const std::filesystem::path & path ) const
```

Binary SAC-file legacy-write convenience function.

**Parameters**

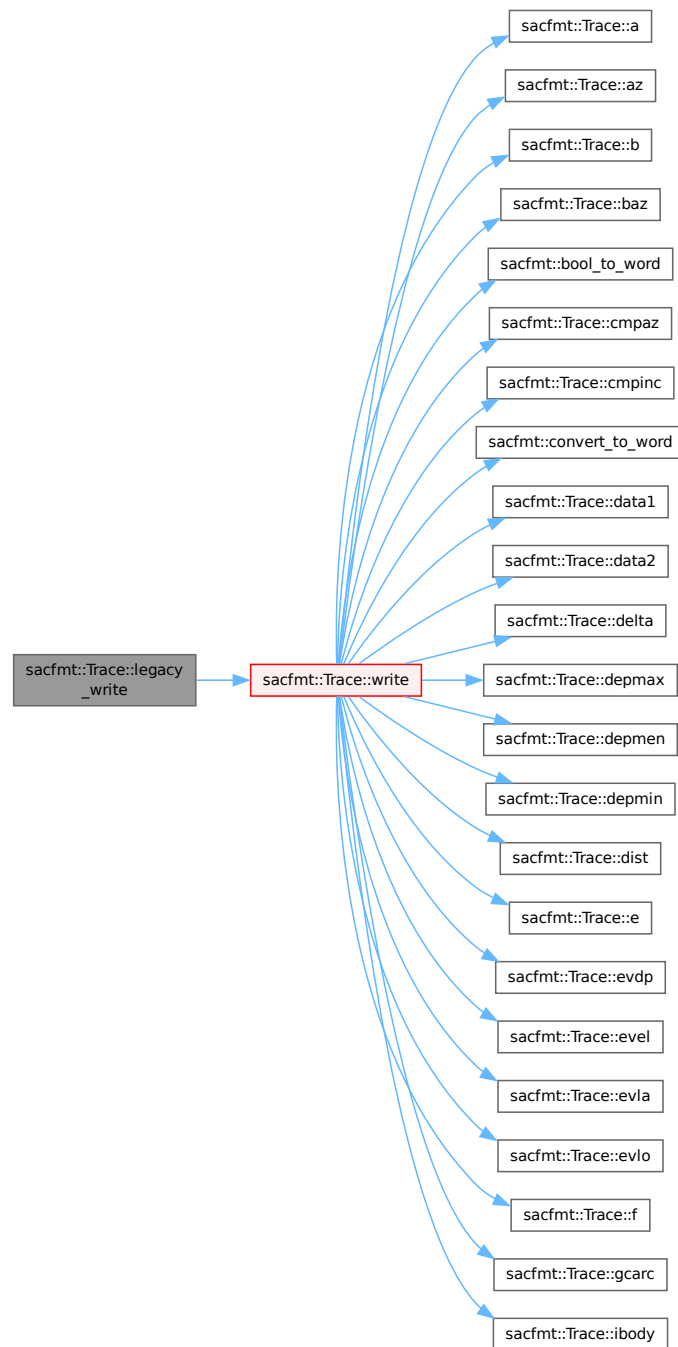
<code>in</code>	<code>path</code>	<code>std::filesystem::path</code> SAC-file to be written.
-----------------	-------------------	--

**Exceptions**

<code><i>io_error</i></code>	If the file cannot be written (bad path or bad permissions).
<code><i>std::exception</i></code>	Other unwritable issues (not enough space, disk failure, etc.).

```
02187                                     {
02188     write(path, true);
02189 }
```

Here is the call graph for this function:



### leven() [1/2]

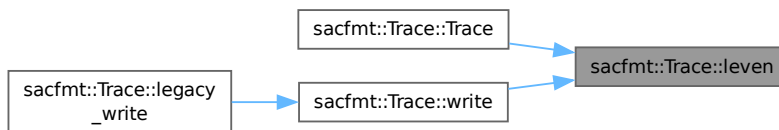
```

bool sacfmt::Trace::leven ( ) const [noexcept]
01111 { return bools[sac_map.at(name::leven)]; }

```



Here is the caller graph for this function:



## leven() [2/2]

```

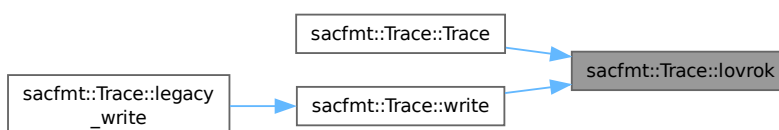
void sacfmt::Trace::leven (
    bool input ) [noexcept]
{
01474     bools[sac_map.at(name::leven)] = input;
01475     const size_t size{npts() >= 0 ? static_cast<size_t>(npts()) : 0};
01476     // Uneven 2D data not supported since not in specification
01477     if (!input && (iftype() > 1)) {
01478         iftype(unset_int);
01479     }
01480     resize_data2(size);
01481 }
01482 }
  
```

## lovrok() [1/2]

```

bool sacfmt::Trace::lovrok ( ) const [noexcept]
01113 { return bools[sac_map.at(name::lovrok)]; }
  
```

Here is the caller graph for this function:



## lovrok() [2/2]

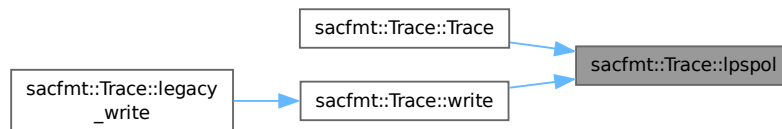
```

void sacfmt::Trace::lovrok (
    bool input ) [noexcept]
{
01486     bools[sac_map.at(name::lovrok)] = input;
01487 }
01488 }
  
```

**lpspol()** [1/2]

```
bool sacfmt::Trace::lpspol ( ) const [noexcept]
01112 { return bools[sac_map.at(name::lpspol)]; }
```

Here is the caller graph for this function:

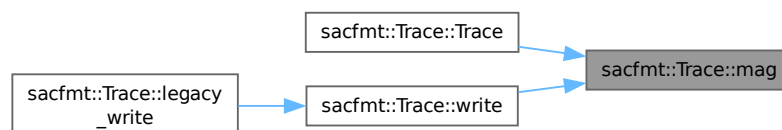
**lpspol()** [2/2]

```
void sacfmt::Trace::lpspol (
    bool input ) [noexcept]
01483 {
01484     bools[sac_map.at(name::lpspol)] = input;
01485 }
```

**mag()** [1/2]

```
float sacfmt::Trace::mag ( ) const [noexcept]
01022 { return floats[sac_map.at(name::mag)]; }
```

Here is the caller graph for this function:

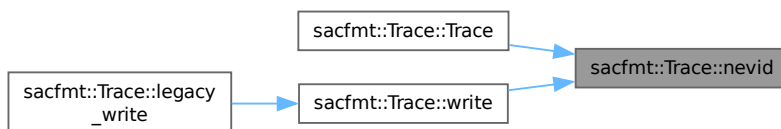
**mag()** [2/2]

```
void sacfmt::Trace::mag (
    float input ) [noexcept]
01239 {
01240     floats[sac_map.at(name::mag)] = input;
01241 }
```

**nevid()** [1/2]

```
int sacfmt::Trace::nevid ( ) const [noexcept]
01092 { return ints[sac_map.at(name::nevid)]; }
```

Here is the caller graph for this function:

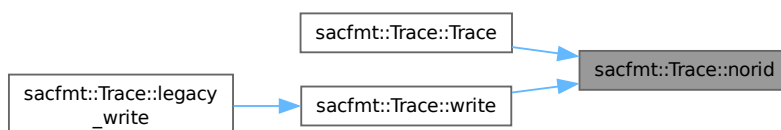
**nevid()** [2/2]

```
void sacfmt::Trace::nevid (
    int input ) [noexcept]
01409 {
01410     ints[sac_map.at(name::nevid)] = input;
01411 }
```

**norid()** [1/2]

```
int sacfmt::Trace::norid ( ) const [noexcept]
01091 { return ints[sac_map.at(name::norid)]; }
```

Here is the caller graph for this function:

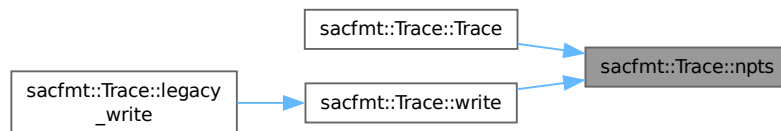
**norid()** [2/2]

```
void sacfmt::Trace::norid (
    int input ) [noexcept]
01406 {
01407     ints[sac_map.at(name::norid)] = input;
01408 }
```

**npts()** [1/2]

```
int sacfmt::Trace::npts ( ) const [noexcept]
01093 { return ints[sac_map.at(name::npts)]; }
```

Here is the caller graph for this function:

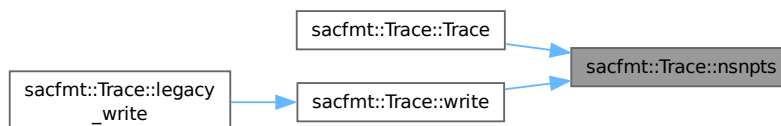
**npts()** [2/2]

```
void sacfmt::Trace::npts (
    int input ) [noexcept]
01412 {
01413     if ((input >= 0) || (input == unset_int)) {
01414         ints[sac_map.at(name::npts)] = input;
01415         const size_t size(static_cast<size_t>(input >= 0 ? input : 0));
01416         resize_data(size);
01417     }
01418 }
```

**nsnpts()** [1/2]

```
int sacfmt::Trace::nsnpts ( ) const [noexcept]
01094 { return ints[sac_map.at(name::nsnpts)]; }
```

Here is the caller graph for this function:

**nsnpts()** [2/2]

```
void sacfmt::Trace::nsnpts (
    int input ) [noexcept]
01419 {
01420     ints[sac_map.at(name::nsnpts)] = input;
01421 }
```

**nvhdr()** [1/2]

```
int sacfmt::Trace::nvhdr ( ) const [noexcept]
01090 { return ints[sac_map.at(name::nvhdr)]; }
```

Here is the caller graph for this function:

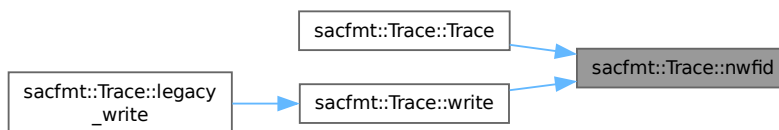
**nvhdr()** [2/2]

```
void sacfmt::Trace::nvhdr (
    int input ) [noexcept]
01403 {
01404     ints[sac_map.at(name::nvhdr)] = input;
01405 }
```

**nwfid()** [1/2]

```
int sacfmt::Trace::nwfid ( ) const [noexcept]
01095 { return ints[sac_map.at(name::nwfid)]; }
```

Here is the caller graph for this function:

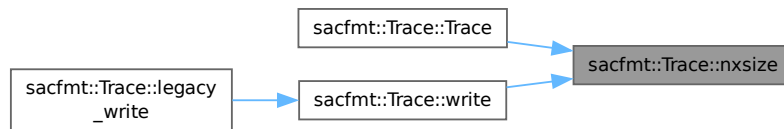
**nwfid()** [2/2]

```
void sacfmt::Trace::nwfid (
    int input ) [noexcept]
01422 {
01423     ints[sac_map.at(name::nwfid)] = input;
01424 }
```

**nxsize()** [1/2]

```
int sacfmt::Trace::nxsize ( ) const [noexcept]
01096 { return ints[sac_map.at(name:nxsize)]; }
```

Here is the caller graph for this function:

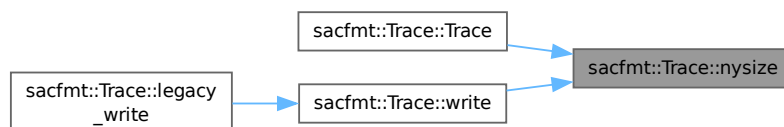
**nxsize()** [2/2]

```
void sacfmt::Trace::nxsize (
    int input ) [noexcept]
01425 {
01426     ints[sac_map.at(name:nxsize)] = input;
01427 }
```

**nysize()** [1/2]

```
int sacfmt::Trace::nysize ( ) const [noexcept]
01097 { return ints[sac_map.at(name:nysize)]; }
```

Here is the caller graph for this function:

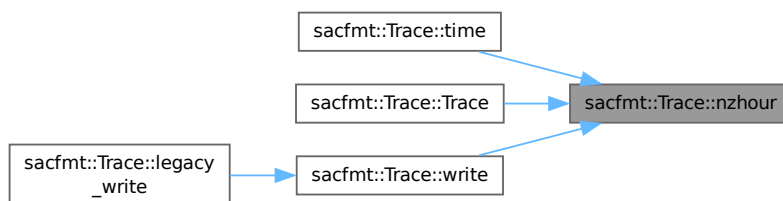
**nysize()** [2/2]

```
void sacfmt::Trace::nysize (
    int input ) [noexcept]
01428 {
01429     ints[sac_map.at(name:nysize)] = input;
01430 }
```

**nzhour()** [1/2]

```
int sacfmt::Trace::nzhour ( ) const [noexcept]
01086 { return ints[sac_map.at(name:nzhour)]; }
```

Here is the caller graph for this function:

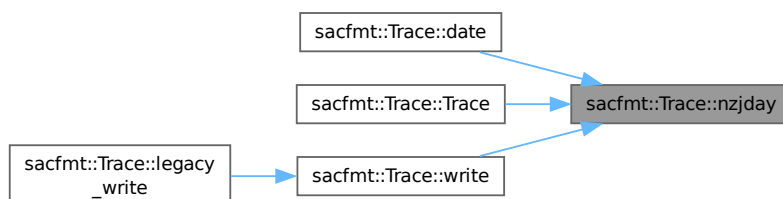
**nzhour()** [2/2]

```
void sacfmt::Trace::nzhour (
    int input ) [noexcept]
01391 {
01392     ints[sac_map.at(name:nzhour)] = input;
01393 }
```

**nzjday()** [1/2]

```
int sacfmt::Trace::nzjday ( ) const [noexcept]
01085 { return ints[sac_map.at(name:nzjday)]; }
```

Here is the caller graph for this function:

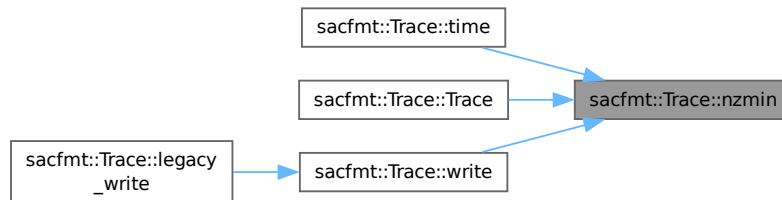
**nzjday()** [2/2]

```
void sacfmt::Trace::nzjday (
    int input ) [noexcept]
01388 {
01389     ints[sac_map.at(name:nzjday)] = input;
01390 }
```

**nzmin()** [1/2]

```
int sacfmt::Trace::nzmin ( ) const [noexcept]
01087 { return ints[sac_map.at(name:nzmin)]; }
```

Here is the caller graph for this function:

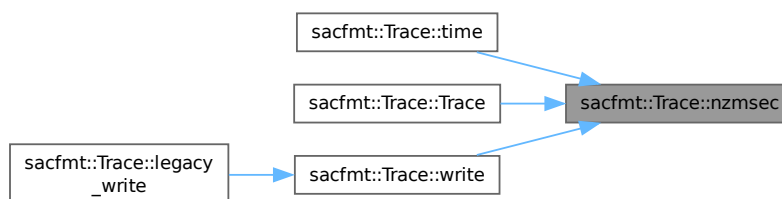
**nzmin()** [2/2]

```
void sacfmt::Trace::nzmin (
    int input ) [noexcept]
01394 {
01395     ints[sac_map.at(name:nzmin)] = input;
01396 }
```

**nz msec()** [1/2]

```
int sacfmt::Trace::nz msec ( ) const [noexcept]
01089 { return ints[sac_map.at(name:nz msec)]; }
```

Here is the caller graph for this function:

**nz msec()** [2/2]

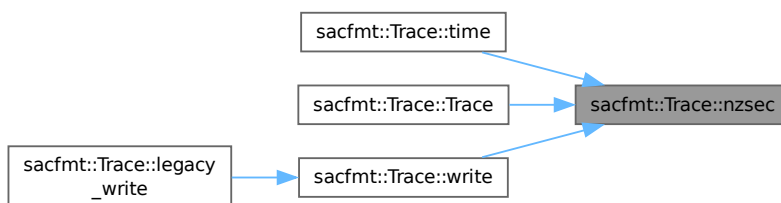
```
void sacfmt::Trace::nz msec (
    int input ) [noexcept]
01400 {
01401     ints[sac_map.at(name:nz msec)] = input;
01402 }
```



**nzsec()** [1/2]

```
int sacfmt::Trace::nzsec ( ) const [noexcept]
01088 { return ints[sac_map.at(name:nzsec)]; }
```

Here is the caller graph for this function:

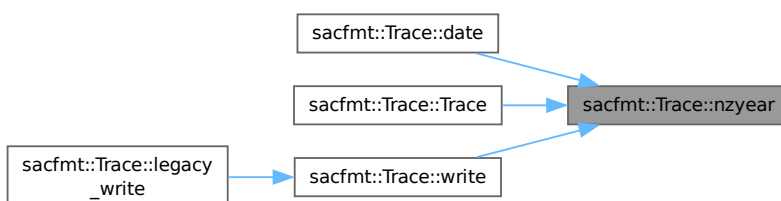
**nzsec()** [2/2]

```
void sacfmt::Trace::nzsec (
    int input ) [noexcept]
01397 {
01398     ints[sac_map.at(name:nzsec)] = input;
01399 }
```

**nzyear()** [1/2]

```
int sacfmt::Trace::nzyear ( ) const [noexcept]
01084 { return ints[sac_map.at(name:nzyear)]; }
```

Here is the caller graph for this function:

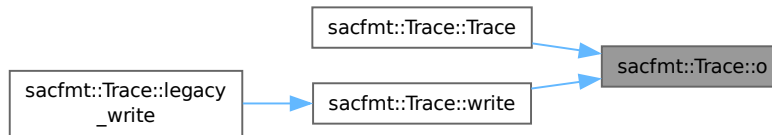
**nzyear()** [2/2]

```
void sacfmt::Trace::nzyear (
    int input ) [noexcept]
01385 {
01386     ints[sac_map.at(name:nzyear)] = input;
01387 }
```

**o()** [1/2]

```
double sacfmt::Trace::o ( ) const [noexcept]
01062 { return doubles[sac_map.at(name::o)]; }
```

Here is the caller graph for this function:

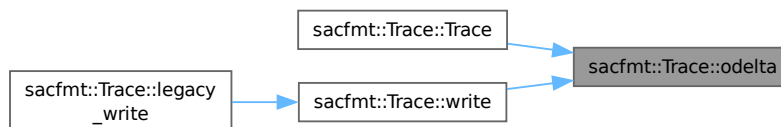
**o()** [2/2]

```
void sacfmt::Trace::o (
    double input ) [noexcept]
01315 {
01316     doubles[sac_map.at(name::o)] = input;
01317 }
```

**odelta()** [1/2]

```
float sacfmt::Trace::odelta ( ) const [noexcept]
01005 {
01006     return floats[sac_map.at(name::odelta)];
01007 }
```

Here is the caller graph for this function:

**odelta()** [2/2]

```
void sacfmt::Trace::odelta (
    float input ) [noexcept]
01194 {
01195     floats[sac_map.at(name::odelta)] = input;
01196 }
```

**operator==()**

```
bool sacfmt::Trace::operator== (
    const Trace & other ) const [noexcept]
```

`Trace` equality operator.

**Parameters**

in	<i>this</i>	First <a href="#">Trace</a> in comparison (LHS).
in	<i>other</i>	Second <a href="#">Trace</a> in comparison (RHS).

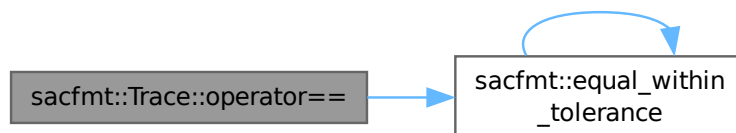
**Returns**

bool Truth value of equality.

```

00848                                     {
00849     if (floats != other.floats) {
00850         return false;
00851     }
00852     if (doubles != other.doubles) {
00853         return false;
00854     }
00855     if (ints != other.ints) {
00856         return false;
00857     }
00858     if (strings != other.strings) {
00859         return false;
00860     }
00861     if (!equal_within_tolerance(data[0], other.data[0])) {
00862         return false;
00863     }
00864     if (!equal_within_tolerance(data[1], other.data[1])) {
00865         return false;
00866     }
00867     return true;
00868 }
```

Here is the call graph for this function:

**resize\_data()**

```

void sacfmt::Trace::resize_data (
    size_t size ) [private], [noexcept]
```

Resize data vectors (only if eligible).

Will always resize data1, data2 only resizes if it can have non-zero size.

```

01622                                     {
01623     resize_data1(size);
01624     resize_data2(size);
01625 }
```

**resize\_data1()**

```

void sacfmt::Trace::resize_data1 (
    size_t size ) [private], [noexcept]
01593     {
01594     if (size != data1().size()) {
01595         std::vector<double> new_data1{data1()};
01596         new_data1.resize(size, 0.0);
01597         data1(new_data1);
01598     }
01599 }

```

**resize\_data2()**

```

void sacfmt::Trace::resize_data2 (
    size_t size ) [private], [noexcept]
01601     {
01602     // Data2 is legal
01603     if (!leven() || (iftype() > 1)) {
01604         if (size != data2().size()) {
01605             std::vector<double> new_data2{data2()};
01606             new_data2.resize(size, 0.0);
01607             data2(new_data2);
01608         }
01609     } else {
01610         if (!data2().empty()) {
01611             std::vector<double> new_data2{};
01612             data2(new_data2);
01613         }
01614     }
01615 }

```

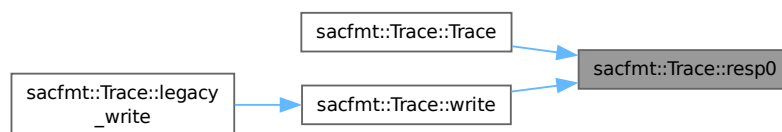
**resp0()** [1/2]

```

float sacfmt::Trace::resp0 ( ) const [noexcept]
01008 { return floats[sac_map.at(name::resp0)]; }

```

Here is the caller graph for this function:

**resp0()** [2/2]

```

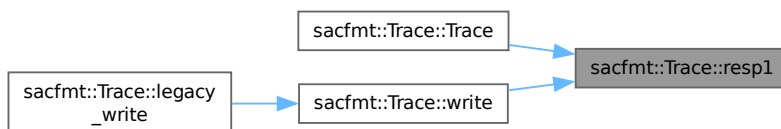
void sacfmt::Trace::resp0 (
    float input ) [noexcept]
01197     {
01198     floats[sac_map.at(name::resp0)] = input;
01199 }

```

**resp1() [1/2]**

```
float sacfmt::Trace::resp1 ( ) const [noexcept]
01009 { return floats[sac_map.at(name::resp1)]; }
```

Here is the caller graph for this function:

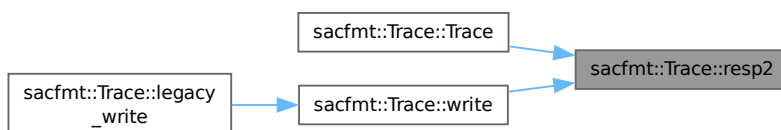
**resp1() [2/2]**

```
void sacfmt::Trace::resp1 (
    float input ) [noexcept]
01200 {
01201     floats[sac_map.at(name::resp1)] = input;
01202 }
```

**resp2() [1/2]**

```
float sacfmt::Trace::resp2 ( ) const [noexcept]
01010 { return floats[sac_map.at(name::resp2)]; }
```

Here is the caller graph for this function:

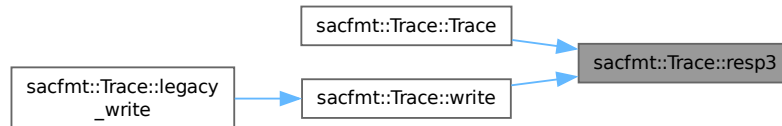
**resp2() [2/2]**

```
void sacfmt::Trace::resp2 (
    float input ) [noexcept]
01203 {
01204     floats[sac_map.at(name::resp2)] = input;
01205 }
```

**resp3()** [1/2]

```
float sacfmt::Trace::resp3 ( ) const [noexcept]
01011 { return floats[sac_map.at(name::resp3)]; }
```

Here is the caller graph for this function:

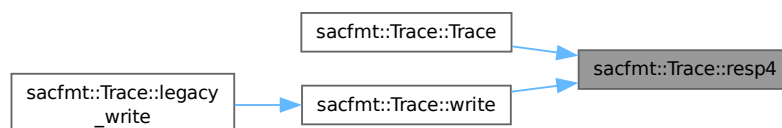
**resp3()** [2/2]

```
void sacfmt::Trace::resp3 (
    float input ) [noexcept]
01206     {
01207     floats[sac_map.at(name::resp3)] = input;
01208 }
```

**resp4()** [1/2]

```
float sacfmt::Trace::resp4 ( ) const [noexcept]
01012 { return floats[sac_map.at(name::resp4)]; }
```

Here is the caller graph for this function:

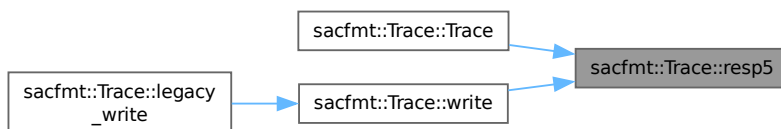
**resp4()** [2/2]

```
void sacfmt::Trace::resp4 (
    float input ) [noexcept]
01209     {
01210     floats[sac_map.at(name::resp4)] = input;
01211 }
```

**resp5()** [1/2]

```
float sacfmt::Trace::resp5 ( ) const [noexcept]
01013 { return floats[sac_map.at(name::resp5)]; }
```

Here is the caller graph for this function:

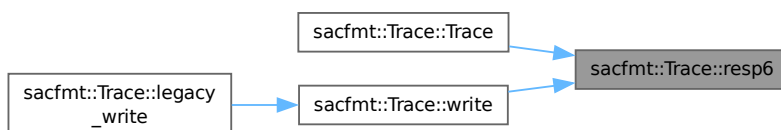
**resp5()** [2/2]

```
void sacfmt::Trace::resp5 (
    float input ) [noexcept]
01212     {
01213     floats[sac_map.at(name::resp5)] = input;
01214 }
```

**resp6()** [1/2]

```
float sacfmt::Trace::resp6 ( ) const [noexcept]
01014 { return floats[sac_map.at(name::resp6)]; }
```

Here is the caller graph for this function:

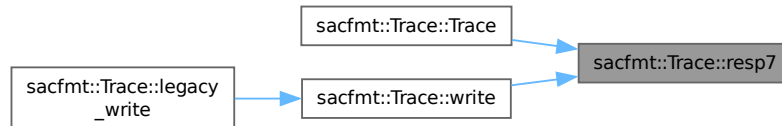
**resp6()** [2/2]

```
void sacfmt::Trace::resp6 (
    float input ) [noexcept]
01215     {
01216     floats[sac_map.at(name::resp6)] = input;
01217 }
```

**resp7()** [1/2]

```
float sacfmt::Trace::resp7 ( ) const [noexcept]
01015 { return floats[sac_map.at(name::resp7)]; }
```

Here is the caller graph for this function:

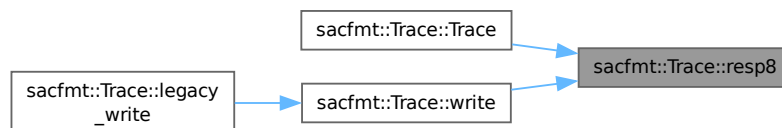
**resp7()** [2/2]

```
void sacfmt::Trace::resp7 (
    float input ) [noexcept]
01218 {
01219     floats[sac_map.at(name::resp7)] = input;
01220 }
```

**resp8()** [1/2]

```
float sacfmt::Trace::resp8 ( ) const [noexcept]
01016 { return floats[sac_map.at(name::resp8)]; }
```

Here is the caller graph for this function:

**resp8()** [2/2]

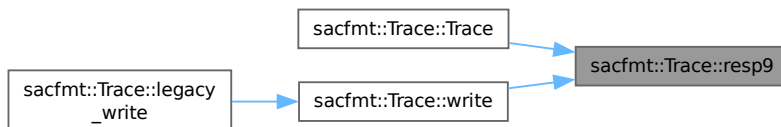
```
void sacfmt::Trace::resp8 (
    float input ) [noexcept]
01221 {
01222     floats[sac_map.at(name::resp8)] = input;
01223 }
```



**resp9()** [1/2]

```
float sacfmt::Trace::resp9 ( ) const [noexcept]
01017 { return floats[sac_map.at(name::resp9)]; }
```

Here is the caller graph for this function:

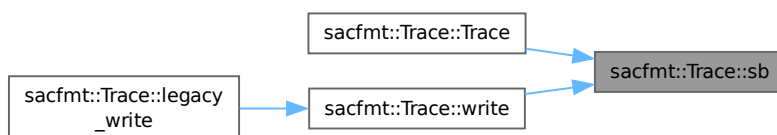
**resp9()** [2/2]

```
void sacfmt::Trace::resp9 (
    float input ) [noexcept]
01224     {
01225     floats[sac_map.at(name::resp9)] = input;
01226 }
```

**sb()** [1/2]

```
double sacfmt::Trace::sb ( ) const [noexcept]
01079 { return doubles[sac_map.at(name::sb)]; }
```

Here is the caller graph for this function:

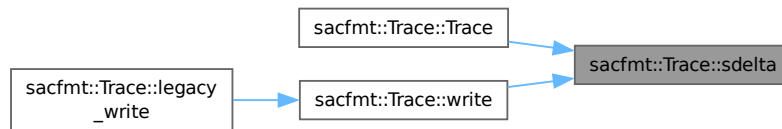
**sb()** [2/2]

```
void sacfmt::Trace::sb (
    double input ) [noexcept]
01378     {
01379     doubles[sac_map.at(name::sb)] = input;
01380 }
```

**sdelta()** [1/2]

```
double sacfmt::Trace::sdelta ( ) const [noexcept]
01080     {
01081     return doubles[sac_map.at(name::sdelta)];
01082     }
```

Here is the caller graph for this function:

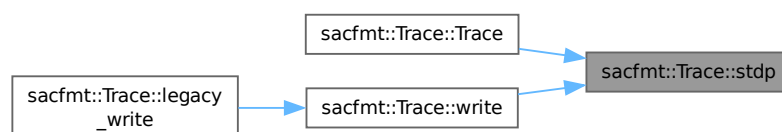
**sdelta()** [2/2]

```
void sacfmt::Trace::sdelta (
    double input ) [noexcept]
01381     {
01382     doubles[sac_map.at(name::sdelta)] = input;
01383     }
```

**stdp()** [1/2]

```
float sacfmt::Trace::stdp ( ) const [noexcept]
01019 { return floats[sac_map.at(name::stdp)]; }
```

Here is the caller graph for this function:

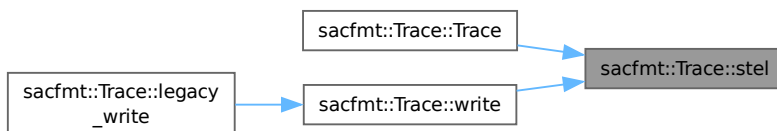
**stdp()** [2/2]

```
void sacfmt::Trace::stdp (
    float input ) [noexcept]
01230     {
01231     floats[sac_map.at(name::stdp)] = input;
01232     }
```

**stel()** [1/2]

```
float sacfmt::Trace::stel ( ) const [noexcept]
01018 { return floats[sac_map.at(name::stel)]; }
```

Here is the caller graph for this function:

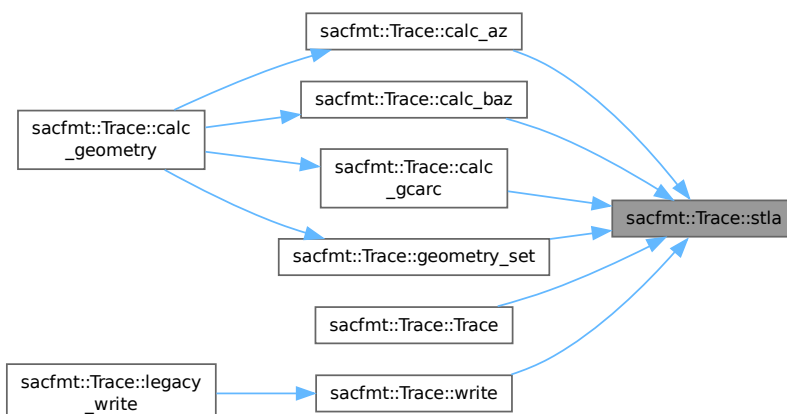
**stel()** [2/2]

```
void sacfmt::Trace::stel (
    float input ) [noexcept]
01227 {
01228     floats[sac_map.at(name::stel)] = input;
01229 }
```

**stla()** [1/2]

```
double sacfmt::Trace::stla ( ) const [noexcept]
01075 { return doubles[sac_map.at(name::stla)]; }
```

Here is the caller graph for this function:



**stla()** [2/2]

```

void sacfmt::Trace::stla (
    double input ) [noexcept]
01354     {
01355     if (input != unset_double) {
01356         input = limit_90(input);
01357     }
01358     doubles[sac_map.at(name::stla)] = input;
01359 }

```

Here is the call graph for this function:

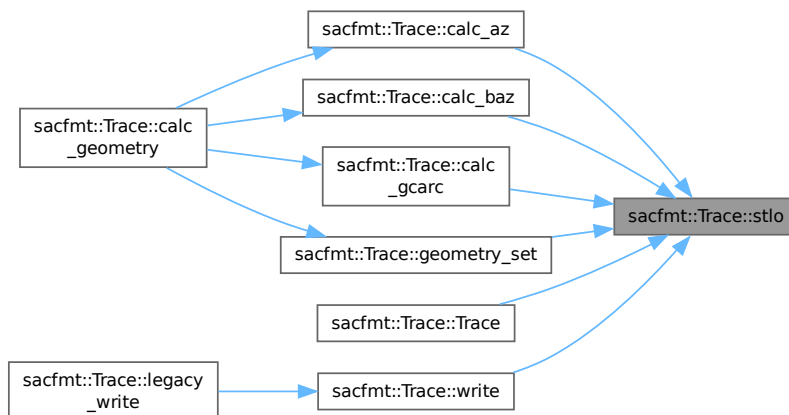
**stlo()** [1/2]

```

double sacfmt::Trace::stlo ( ) const [noexcept]
01076 { return doubles[sac_map.at(name::stlo)]; }

```

Here is the caller graph for this function:

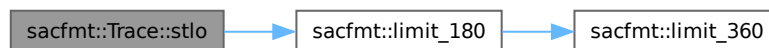
**stlo()** [2/2]

```

void sacfmt::Trace::stlo (
    double input ) [noexcept]
01360     {
01361     if (input != unset_double) {
01362         input = limit_180(input);
01363     }
01364     doubles[sac_map.at(name::stlo)] = input;
01365 }

```

Here is the call graph for this function:

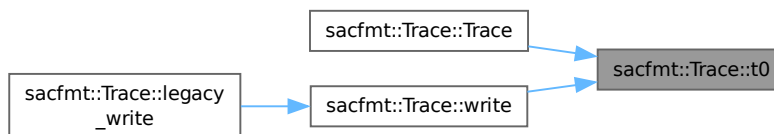


#### t0() [1/2]

```

double sacfmt::Trace::t0 ( ) const [noexcept]
01064 { return doubles[sac_map.at(name::t0)]; }
  
```

Here is the caller graph for this function:



#### t0() [2/2]

```

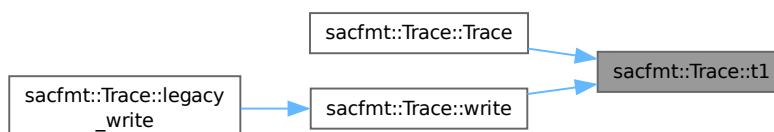
void sacfmt::Trace::t0 (
    double input ) [noexcept]
01321     {
01322     doubles[sac_map.at(name::t0)] = input;
01323     }
  
```

#### t1() [1/2]

```

double sacfmt::Trace::t1 ( ) const [noexcept]
01065 { return doubles[sac_map.at(name::t1)]; }
  
```

Here is the caller graph for this function:



**t1()** [2/2]

```

void sacfmt::Trace::t1 (
    double input ) [noexcept]
01324     {
01325     doubles[sac_map.at(name::t1)] = input;
01326     }

```

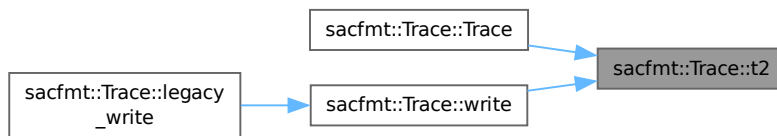
**t2()** [1/2]

```

double sacfmt::Trace::t2 ( ) const [noexcept]
01066 { return doubles[sac_map.at(name::t2)]; }

```

Here is the caller graph for this function:

**t2()** [2/2]

```

void sacfmt::Trace::t2 (
    double input ) [noexcept]
01327     {
01328     doubles[sac_map.at(name::t2)] = input;
01329     }

```

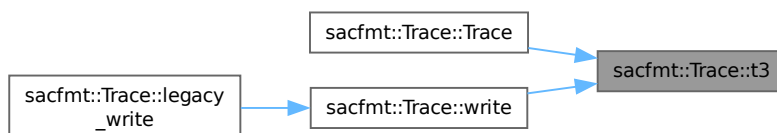
**t3()** [1/2]

```

double sacfmt::Trace::t3 ( ) const [noexcept]
01067 { return doubles[sac_map.at(name::t3)]; }

```

Here is the caller graph for this function:



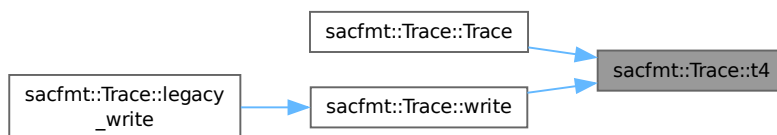
**t3()** [2/2]

```
void sacfmt::Trace::t3 (
    double input ) [noexcept]
01330 {
01331     doubles[sac_map.at(name::t3)] = input;
01332 }
```

**t4()** [1/2]

```
double sacfmt::Trace::t4 ( ) const [noexcept]
01068 { return doubles[sac_map.at(name::t4)]; }
```

Here is the caller graph for this function:

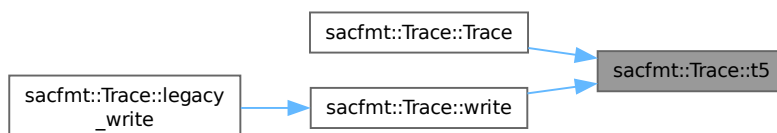
**t4()** [2/2]

```
void sacfmt::Trace::t4 (
    double input ) [noexcept]
01333 {
01334     doubles[sac_map.at(name::t4)] = input;
01335 }
```

**t5()** [1/2]

```
double sacfmt::Trace::t5 ( ) const [noexcept]
01069 { return doubles[sac_map.at(name::t5)]; }
```

Here is the caller graph for this function:



**t5()** [2/2]

```

void sacfmt::Trace::t5 (
    double input ) [noexcept]
01336     {
01337     doubles[sac_map.at(name::t5)] = input;
01338     }

```

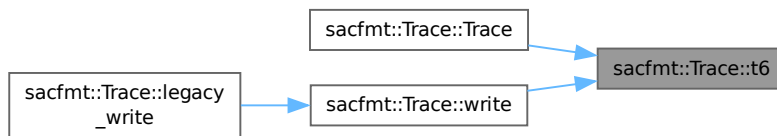
**t6()** [1/2]

```

double sacfmt::Trace::t6 ( ) const [noexcept]
01070 { return doubles[sac_map.at(name::t6)]; }

```

Here is the caller graph for this function:

**t6()** [2/2]

```

void sacfmt::Trace::t6 (
    double input ) [noexcept]
01339     {
01340     doubles[sac_map.at(name::t6)] = input;
01341     }

```

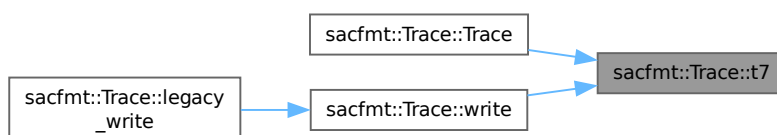
**t7()** [1/2]

```

double sacfmt::Trace::t7 ( ) const [noexcept]
01071 { return doubles[sac_map.at(name::t7)]; }

```

Here is the caller graph for this function:





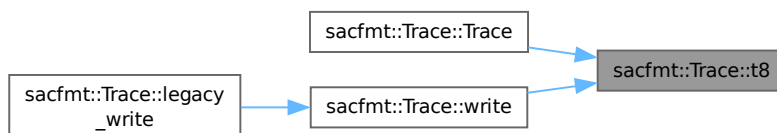
**t7()** [2/2]

```
void sacfmt::Trace::t7 (
    double input ) [noexcept]
01342     {
01343     doubles[sac_map.at(name::t7)] = input;
01344 }
```

**t8()** [1/2]

```
double sacfmt::Trace::t8 ( ) const [noexcept]
01072 { return doubles[sac_map.at(name::t8)]; }
```

Here is the caller graph for this function:

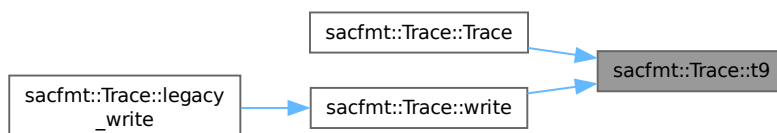
**t8()** [2/2]

```
void sacfmt::Trace::t8 (
    double input ) [noexcept]
01345     {
01346     doubles[sac_map.at(name::t8)] = input;
01347 }
```

**t9()** [1/2]

```
double sacfmt::Trace::t9 ( ) const [noexcept]
01073 { return doubles[sac_map.at(name::t9)]; }
```

Here is the caller graph for this function:



**t9()** [2/2]

```

void sacfmt::Trace::t9 (
    double input ) [noexcept]
01348     {
01349     doubles[sac_map.at(name::t9)] = input;
01350 }

```

**time()**

```
std::string sacfmt::Trace::time ( ) const [noexcept]
```

Get time string.

**Returns**

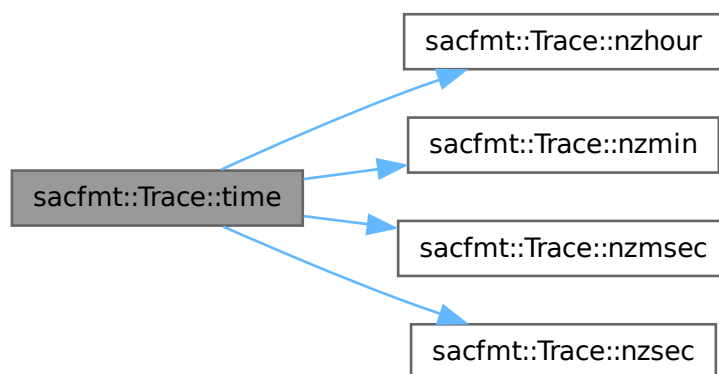
sstd::string Time (HH::MM:SS.sss).

```

00980     {
00981     // Require all to be set
00982     if ((nzhour() == unset_int) || (nzmin() == unset_int) ||
00983         (nzsec() == unset_int) || (nzmsec() == unset_int)) {
00984         return unset_word;
00985     }
00986     std::ostringstream oss{};
00987     oss << nzhour();
00988     oss << ':';
00989     oss << nzmin();
00990     oss << ':';
00991     oss << nzsec();
00992     oss << '.';
00993     oss << nzmsec();
00994     return oss.str();
00995 }

```

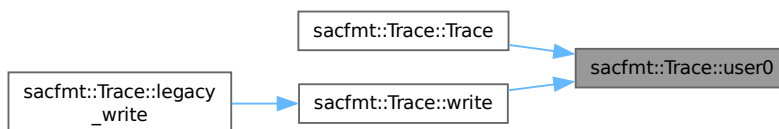
Here is the call graph for this function:



**user0()** [1/2]

```
float sacfmt::Trace::user0 ( ) const [noexcept]
01023 { return floats[sac_map.at(name::user0)]; }
```

Here is the caller graph for this function:

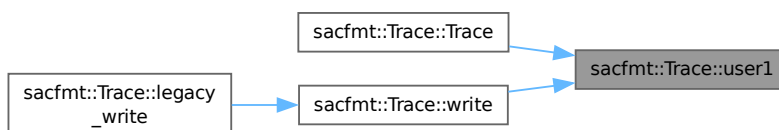
**user0()** [2/2]

```
void sacfmt::Trace::user0 (
    float input ) [noexcept]
01242 {
01243     floats[sac_map.at(name::user0)] = input;
01244 }
```

**user1()** [1/2]

```
float sacfmt::Trace::user1 ( ) const [noexcept]
01024 { return floats[sac_map.at(name::user1)]; }
```

Here is the caller graph for this function:

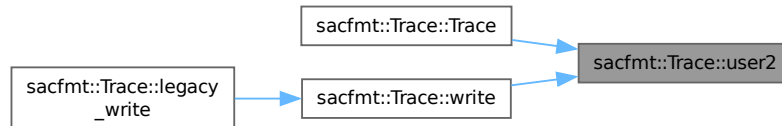
**user1()** [2/2]

```
void sacfmt::Trace::user1 (
    float input ) [noexcept]
01245 {
01246     floats[sac_map.at(name::user1)] = input;
01247 }
```

**user2()** [1/2]

```
float sacfmt::Trace::user2 ( ) const [noexcept]
01025 { return floats[sac_map.at(name::user2)]; }
```

Here is the caller graph for this function:

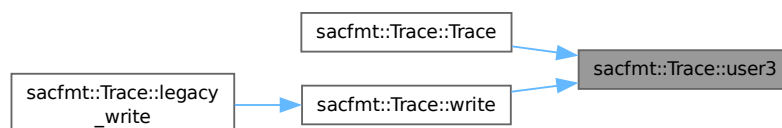
**user2()** [2/2]

```
void sacfmt::Trace::user2 (
    float input ) [noexcept]
01248 {
01249     floats[sac_map.at(name::user2)] = input;
01250 }
```

**user3()** [1/2]

```
float sacfmt::Trace::user3 ( ) const [noexcept]
01026 { return floats[sac_map.at(name::user3)]; }
```

Here is the caller graph for this function:

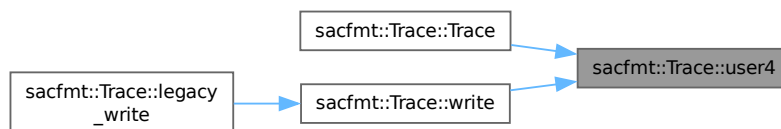
**user3()** [2/2]

```
void sacfmt::Trace::user3 (
    float input ) [noexcept]
01251 {
01252     floats[sac_map.at(name::user3)] = input;
01253 }
```

**user4()** [1/2]

```
float sacfmt::Trace::user4 ( ) const [noexcept]
01027 { return floats[sac_map.at(name::user4)]; }
```

Here is the caller graph for this function:

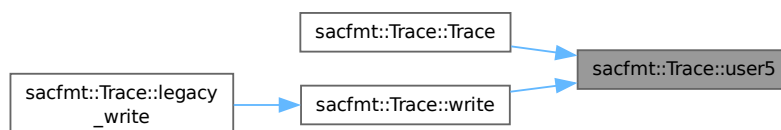
**user4()** [2/2]

```
void sacfmt::Trace::user4 (
    float input ) [noexcept]
01254 {
01255     floats[sac_map.at(name::user4)] = input;
01256 }
```

**user5()** [1/2]

```
float sacfmt::Trace::user5 ( ) const [noexcept]
01028 { return floats[sac_map.at(name::user5)]; }
```

Here is the caller graph for this function:

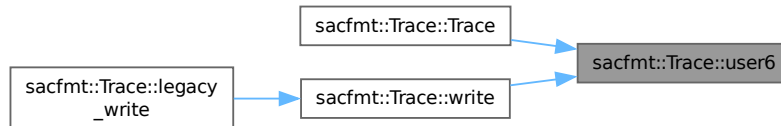
**user5()** [2/2]

```
void sacfmt::Trace::user5 (
    float input ) [noexcept]
01257 {
01258     floats[sac_map.at(name::user5)] = input;
01259 }
```

**user6()** [1/2]

```
float sacfmt::Trace::user6 ( ) const [noexcept]
01029 { return floats[sac_map.at(name::user6)]; }
```

Here is the caller graph for this function:

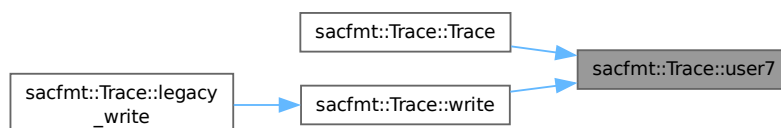
**user6()** [2/2]

```
void sacfmt::Trace::user6 (
    float input ) [noexcept]
01260 {
01261     floats[sac_map.at(name::user6)] = input;
01262 }
```

**user7()** [1/2]

```
float sacfmt::Trace::user7 ( ) const [noexcept]
01030 { return floats[sac_map.at(name::user7)]; }
```

Here is the caller graph for this function:

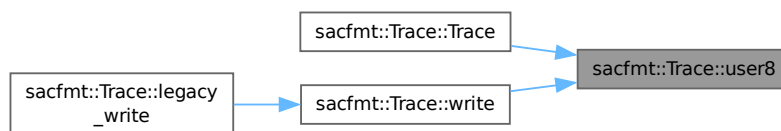
**user7()** [2/2]

```
void sacfmt::Trace::user7 (
    float input ) [noexcept]
01263 {
01264     floats[sac_map.at(name::user7)] = input;
01265 }
```

**user8()** [1/2]

```
float sacfmt::Trace::user8 ( ) const [noexcept]
01031 { return floats[sac_map.at(name::user8)]; }
```

Here is the caller graph for this function:

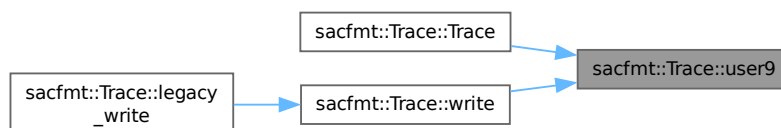
**user8()** [2/2]

```
void sacfmt::Trace::user8 (
    float input ) [noexcept]
01266 {
01267     floats[sac_map.at(name::user8)] = input;
01268 }
```

**user9()** [1/2]

```
float sacfmt::Trace::user9 ( ) const [noexcept]
01032 { return floats[sac_map.at(name::user9)]; }
```

Here is the caller graph for this function:

**user9()** [2/2]

```
void sacfmt::Trace::user9 (
    float input ) [noexcept]
01269 {
01270     floats[sac_map.at(name::user9)] = input;
01271 }
```

**write()**

```
void sacfmt::Trace::write (
    const std::filesystem::path & path,
    bool legacy = false ) const
```

Binary SAC-file writer.

## Parameters

in	<i>path</i>	std::filesystem::path SAC-file to write.
in	<i>legacy</i>	bool Legacy-write flag (default false = v7, true = v6).

## Exceptions

<i>io_error</i>	If the file cannot be written (bad path or bad permissions).
<i>std::exception</i>	Other unwritable issues (not enough space, disk failure, etc.).

```

01956
01957     std::ofstream file(path, std::ios::binary | std::ios::out | std::ios::trunc);
01958     if (!file) {
01959         throw io_error(path.string() + " cannot be opened to write.");
01960     }
01961     const int header_version{legacy ? old_hdr_version : modern_hdr_version};
01962     write_words(&file, convert_to_word(static_cast<float>(delta())));
01963     write_words(&file, convert_to_word(depmin()));
01964     write_words(&file, convert_to_word(depmax()));
01965     // Fill 'unused'
01966     write_words(&file, convert_to_word(depmax()));
01967     write_words(&file, convert_to_word(odelta()));
01968     write_words(&file, convert_to_word(static_cast<float>(b())));
01969     write_words(&file, convert_to_word(static_cast<float>(e())));
01970     write_words(&file, convert_to_word(static_cast<float>(o())));
01971     write_words(&file, convert_to_word(static_cast<float>(a())));
01972     // Fill 'internal'
01973     write_words(&file, convert_to_word(depmin()));
01974     write_words(&file, convert_to_word(static_cast<float>(t0())));
01975     write_words(&file, convert_to_word(static_cast<float>(t1())));
01976     write_words(&file, convert_to_word(static_cast<float>(t2())));
01977     write_words(&file, convert_to_word(static_cast<float>(t3())));
01978     write_words(&file, convert_to_word(static_cast<float>(t4())));
01979     write_words(&file, convert_to_word(static_cast<float>(t5())));
01980     write_words(&file, convert_to_word(static_cast<float>(t6())));
01981     write_words(&file, convert_to_word(static_cast<float>(t7())));
01982     write_words(&file, convert_to_word(static_cast<float>(t8())));
01983     write_words(&file, convert_to_word(static_cast<float>(t9())));
01984     write_words(&file, convert_to_word(static_cast<float>(f())));
01985     write_words(&file, convert_to_word(resp0()));
01986     write_words(&file, convert_to_word(resp1()));
01987     write_words(&file, convert_to_word(resp2()));
01988     write_words(&file, convert_to_word(resp3()));
01989     write_words(&file, convert_to_word(resp4()));
01990     write_words(&file, convert_to_word(resp5()));
01991     write_words(&file, convert_to_word(resp6()));
01992     write_words(&file, convert_to_word(resp7()));
01993     write_words(&file, convert_to_word(resp8()));
01994     write_words(&file, convert_to_word(resp9()));
01995     write_words(&file, convert_to_word(static_cast<float>(stla())));
01996     write_words(&file, convert_to_word(static_cast<float>(stlo())));
01997     write_words(&file, convert_to_word(stel()));
01998     write_words(&file, convert_to_word(stdp()));
01999     write_words(&file, convert_to_word(static_cast<float>(evla())));
02000     write_words(&file, convert_to_word(static_cast<float>(evlo())));
02001     write_words(&file, convert_to_word(evel()));
02002     write_words(&file, convert_to_word(evdv()));
02003     write_words(&file, convert_to_word(mag()));
02004     write_words(&file, convert_to_word(user0()));
02005     write_words(&file, convert_to_word(user1()));
02006     write_words(&file, convert_to_word(user2()));
02007     write_words(&file, convert_to_word(user3()));
02008     write_words(&file, convert_to_word(user4()));
02009     write_words(&file, convert_to_word(user5()));
02010     write_words(&file, convert_to_word(user6()));
02011     write_words(&file, convert_to_word(user7()));
02012     write_words(&file, convert_to_word(user8()));
02013     write_words(&file, convert_to_word(user9()));
02014     write_words(&file, convert_to_word(dist()));
02015     write_words(&file, convert_to_word(az()));
02016     write_words(&file, convert_to_word(baz()));
02017     write_words(&file, convert_to_word(gcarc()));
02018     write_words(&file, convert_to_word(static_cast<float>(sb())));
02019     write_words(&file, convert_to_word(static_cast<float>(sdelta())));
02020     write_words(&file, convert_to_word(depmen()));
02021     write_words(&file, convert_to_word(cmpaz()));
02022     write_words(&file, convert_to_word(cmpinc()));
02023     write_words(&file, convert_to_word(xminimum()));
02024     write_words(&file, convert_to_word(xmaximum()));
02025     write_words(&file, convert_to_word(yminimum()));

```



```

02026 write_words(&file, convert_to_word(ymaximum()));
02027 // Fill 'unused' (xcommon_skip_num)
02028 for (int i{0}; i < common_skip_num; ++i) {
02029     write_words(&file, convert_to_word(az()));
02030 }
02031 write_words(&file, convert_to_word(nzyear()));
02032 write_words(&file, convert_to_word(nzjday()));
02033 write_words(&file, convert_to_word(nzhour()));
02034 write_words(&file, convert_to_word(nzmin()));
02035 write_words(&file, convert_to_word(nzsec()));
02036 write_words(&file, convert_to_word(nzmsec()));
02037 write_words(&file, convert_to_word(header_version));
02038 write_words(&file, convert_to_word(norid()));
02039 write_words(&file, convert_to_word(nevid()));
02040 write_words(&file, convert_to_word(npts()));
02041 write_words(&file, convert_to_word(nsnpts()));
02042 write_words(&file, convert_to_word(nwfid()));
02043 write_words(&file, convert_to_word(nxsize()));
02044 write_words(&file, convert_to_word(nysize()));
02045 // Fill 'unused'
02046 write_words(&file, convert_to_word(nysize()));
02047 write_words(&file, convert_to_word(iftyp));
02048 write_words(&file, convert_to_word(idep()));
02049 write_words(&file, convert_to_word(iztyp));
02050 // Fill 'unused'
02051 write_words(&file, convert_to_word(iztyp));
02052 write_words(&file, convert_to_word(iinst()));
02053 write_words(&file, convert_to_word(istreg()));
02054 write_words(&file, convert_to_word(ievreg()));
02055 write_words(&file, convert_to_word(ievtyp));
02056 write_words(&file, convert_to_word(igual()));
02057 write_words(&file, convert_to_word(isynth()));
02058 write_words(&file, convert_to_word(imagtyp()));
02059 write_words(&file, convert_to_word(imagsrc()));
02060 write_words(&file, convert_to_word(ibody()));
02061 // Fill 'unused' (xcommon_skip_num)
02062 for (int i{0}; i < common_skip_num; ++i) {
02063     write_words(&file, convert_to_word(ibody()));
02064 }
02065 write_words(&file, bool_to_word(leven()));
02066 write_words(&file, bool_to_word(lpsspol()));
02067 write_words(&file, bool_to_word(lovrok()));
02068 write_words(&file, bool_to_word(lcalda()));
02069 // Fill 'unused'
02070 write_words(&file, bool_to_word(lcalda()));
02071 // Strings are special
02072 std::array<char, static_cast<size_t>(2) * word_length> two_words{
02073     convert_to_words<sizeof(two_words)>(kstnm(), 2)};
02074 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02075
02076 std::array<char, static_cast<size_t>(4) * word_length> four_words{
02077     convert_to_words<sizeof(four_words)>(kevnrm(), 4)};
02078 write_words(&file, std::vector<char>(four_words.begin(), four_words.end()));
02079
02080 two_words = convert_to_words<sizeof(two_words)>(khole(), 2);
02081 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02082
02083 two_words = convert_to_words<sizeof(two_words)>(ko(), 2);
02084 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02085
02086 two_words = convert_to_words<sizeof(two_words)>(ka(), 2);
02087 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02088
02089 two_words = convert_to_words<sizeof(two_words)>(kt0(), 2);
02090 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02091
02092 two_words = convert_to_words<sizeof(two_words)>(kt1(), 2);
02093 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02094
02095 two_words = convert_to_words<sizeof(two_words)>(kt2(), 2);
02096 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02097
02098 two_words = convert_to_words<sizeof(two_words)>(kt3(), 2);
02099 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02100
02101 two_words = convert_to_words<sizeof(two_words)>(kt4(), 2);
02102 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02103
02104 two_words = convert_to_words<sizeof(two_words)>(kt5(), 2);
02105 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02106
02107 two_words = convert_to_words<sizeof(two_words)>(kt6(), 2);
02108 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02109
02110 two_words = convert_to_words<sizeof(two_words)>(kt7(), 2);
02111 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02112

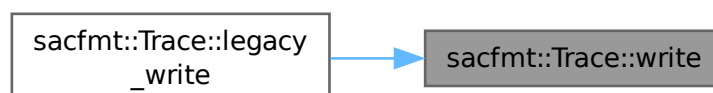
```

```

02113 two_words = convert_to_words<sizeof(two_words)>(kt8(), 2);
02114 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02115
02116 two_words = convert_to_words<sizeof(two_words)>(kt9(), 2);
02117 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02118
02119 two_words = convert_to_words<sizeof(two_words)>(kf(), 2);
02120 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02121
02122 two_words = convert_to_words<sizeof(two_words)>(kuser0(), 2);
02123 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02124
02125 two_words = convert_to_words<sizeof(two_words)>(kuser1(), 2);
02126 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02127
02128 two_words = convert_to_words<sizeof(two_words)>(kuser2(), 2);
02129 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02130
02131 two_words = convert_to_words<sizeof(two_words)>(kcmpnm(), 2);
02132 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02133
02134 two_words = convert_to_words<sizeof(two_words)>(knetwk(), 2);
02135 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02136
02137 two_words = convert_to_words<sizeof(two_words)>(kdatrd(), 2);
02138 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02139
02140 two_words = convert_to_words<sizeof(two_words)>(kinst(), 2);
02141 write_words(&file, std::vector<char>(two_words.begin(), two_words.end()));
02142 // Data
02143 for (double dub : data1()) [[likely]] {
02144     write_words(&file, convert_to_word(static_cast<float>(dub)));
02145 }
02146 if (!leven() || (iftype() > 1)) {
02147     for (double dub : data2()) {
02148         write_words(&file, convert_to_word(static_cast<float>(dub)));
02149     }
02150 }
02151 if (header_version == modern_hdr_version) {
02152     // Write footer
02153     write_words(&file, convert_to_word(delta()));
02154     write_words(&file, convert_to_word(b()));
02155     write_words(&file, convert_to_word(e()));
02156     write_words(&file, convert_to_word(o()));
02157     write_words(&file, convert_to_word(a()));
02158     write_words(&file, convert_to_word(t0()));
02159     write_words(&file, convert_to_word(t1()));
02160     write_words(&file, convert_to_word(t2()));
02161     write_words(&file, convert_to_word(t3()));
02162     write_words(&file, convert_to_word(t4()));
02163     write_words(&file, convert_to_word(t5()));
02164     write_words(&file, convert_to_word(t6()));
02165     write_words(&file, convert_to_word(t7()));
02166     write_words(&file, convert_to_word(t8()));
02167     write_words(&file, convert_to_word(t9()));
02168     write_words(&file, convert_to_word(f()));
02169     write_words(&file, convert_to_word(evlo()));
02170     write_words(&file, convert_to_word(evla()));
02171     write_words(&file, convert_to_word(stlo()));
02172     write_words(&file, convert_to_word(stla()));
02173     write_words(&file, convert_to_word(sb()));
02174     write_words(&file, convert_to_word(sdelta()));
02175 }
02176 file.close();
02177 }

```

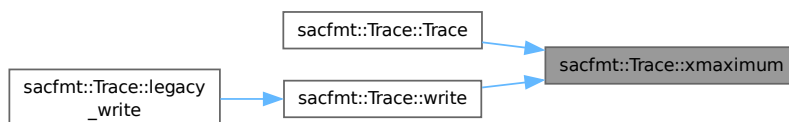
Here is the caller graph for this function:



**xmaximum()** [1/2]

```
float sacfmt::Trace::xmaximum ( ) const [noexcept]
01047 {
01048     return floats[sac_map.at(name::xmaximum)];
01049 }
```

Here is the caller graph for this function:

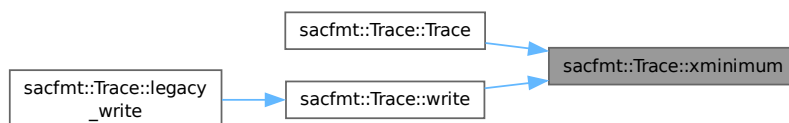
**xmaximum()** [2/2]

```
void sacfmt::Trace::xmaximum (
    float input ) [noexcept]
01296 {
01297     floats[sac_map.at(name::xmaximum)] = input;
01298 }
```

**xminimum()** [1/2]

```
float sacfmt::Trace::xminimum ( ) const [noexcept]
01044 {
01045     return floats[sac_map.at(name::xminimum)];
01046 }
```

Here is the caller graph for this function:

**xminimum()** [2/2]

```
void sacfmt::Trace::xminimum (
    float input ) [noexcept]
01293 {
01294     floats[sac_map.at(name::xminimum)] = input;
01295 }
```

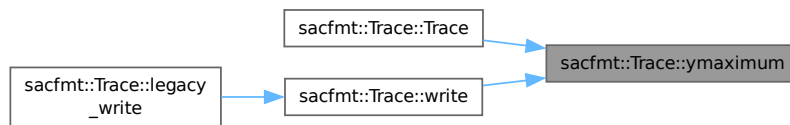
**ymaximum()** [1/2]

```

float sacfmt::Trace::ymaximum ( ) const [noexcept]
01053     {
01054     return floats[sac_map.at(name::ymaximum)];
01055     }

```

Here is the caller graph for this function:

**ymaximum()** [2/2]

```

void sacfmt::Trace::ymaximum (
    float input ) [noexcept]
01302     {
01303     floats[sac_map.at(name::ymaximum)] = input;
01304     }

```

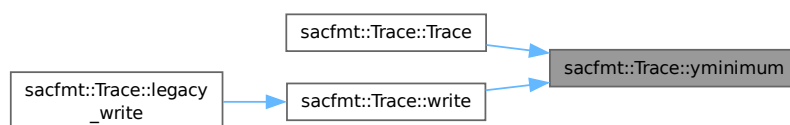
**yminimum()** [1/2]

```

float sacfmt::Trace::yminimum ( ) const [noexcept]
01050     {
01051     return floats[sac_map.at(name::yminimum)];
01052     }

```

Here is the caller graph for this function:

**yminimum()** [2/2]

```

void sacfmt::Trace::yminimum (
    float input ) [noexcept]
01299     {
01300     floats[sac_map.at(name::yminimum)] = input;
01301     }

```

### 11.3.4 Member Data Documentation

#### bools

```
std::array<bool, num_bool> sacfmt::Trace::bools {} [private]
```

Boolean storage array.

```
01326 {};
```

#### data

```
std::array<std::vector<double>, num_data> sacfmt::Trace::data {} [private]
```

std::vector<double> storage array.

```
01331 {};
```

#### doubles

```
std::array<double, num_double> sacfmt::Trace::doubles {} [private]
```

Double storage array.

```
01322 {};
```

#### floats

```
std::array<float, num_float> sacfmt::Trace::floats {} [private]
```

Float storage array.

```
01320 {};
```

#### ints

```
std::array<int, num_int> sacfmt::Trace::ints {} [private]
```

Integer storage array.

```
01324 {};
```

#### strings

```
std::array<std::string, num_string> sacfmt::Trace::strings {} [private]
```

String storage array.

```
01328 {};
```

The documentation for this class was generated from the following files:

- include/sac-format/sac\_format.hpp
- src/sac\_format.cpp

## 11.4 sacfmt::bitset\_type::uint< nbits > Struct Template Reference

Ensure type-safety for conversions between floats/doubles and bitsets.

```
#include <sac_format.hpp>
```

### 11.4.1 Detailed Description

```
template<unsigned nbits>
struct sacfmt::bitset_type::uint< nbits >
```

Ensure type-safety for conversions between floats/doubles and bitsets.

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

- include/sac-format/sac\_format.hpp

## 11.5 sacfmt::bitset\_type::uint< 2 \*bits\_per\_byte > Struct Reference

Two-word type-safety (strings).

```
#include <sac_format.hpp>
```

### Public Types

- using type = uint16\_t

### 11.5.1 Detailed Description

Two-word type-safety (strings).

### 11.5.2 Member Typedef Documentation

#### type

```
using sacfmt::bitset_type::uint< 2 *bits_per_byte >::type = uint16_t
```

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

- include/sac-format/sac\_format.hpp

## 11.6 sacfmt::bitset\_type::uint< 4 \*bits\_per\_byte > Struct Reference

Four-word type-safety (kEvNm).

```
#include <sac_format.hpp>
```

## Public Types

- `using type = uint32_t`

### 11.6.1 Detailed Description

Four-word type-safety (kEvNm).

### 11.6.2 Member Typedef Documentation

#### type

```
using sacfmt::bitset_type::uint< 4 *bits_per_byte >::type = uint32_t
```

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

- `include/sac-format/sac_format.hpp`

## 11.7 sacfmt::bitset\_type::uint< bits\_per\_byte > Struct Reference

Single-word type-safety (non-strings).

```
#include <sac_format.hpp>
```

## Public Types

- `using type = uint8_t`

### 11.7.1 Detailed Description

Single-word type-safety (non-strings).

### 11.7.2 Member Typedef Documentation

#### type

```
using sacfmt::bitset_type::uint< bits_per_byte >::type = uint8_t
```

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

- `include/sac-format/sac_format.hpp`

## 11.8 sacfmt::bitset\_type::uint< bytes \*bits\_per\_byte > Struct Reference

```
#include <sac_format.hpp>
```

### Public Types

- `using type = uint64_t`

#### 11.8.1 Member Typedef Documentation

##### type

```
using sacfmt::bitset_type::uint< bytes *bits_per_byte >::type = uint64_t
```

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

- `include/sac-format/sac_format.hpp`

## 11.9 sacfmt::word\_pair< T > Struct Template Reference

Struct containing a pair of words.

```
#include <sac_format.hpp>
```

### Public Attributes

- `T first {}`  
*First 'word' in the pair.*
- `T second {}`  
*Second 'word' in the pair.*

#### 11.9.1 Detailed Description

```
template<typename T>  
struct sacfmt::word_pair< T >
```

Struct containing a pair of words.

Prevents bug-prone word-swapping in functions that use a pair of words.

These are not necessarily single words, it could be a pair of `word_one` or a pair of `word_two`.



## 11.9.2 Member Data Documentation

### first

```
template<typename T >  
T sacfmt::word_pair< T >::first {}
```

First 'word' in the pair.  
00195 {};

### second

```
template<typename T >  
T sacfmt::word_pair< T >::second {}
```

Second 'word' in the pair.  
00196 {};

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

- include/sac-format/sac\_format.hpp

## Index

a  
    sacfmt, 29  
    sacfmt::Trace, 87  
ascii\_space  
    sacfmt, 69  
az  
    sacfmt, 28  
    sacfmt::Trace, 87, 88  
azimuth  
    sacfmt, 33  
  
b  
    sacfmt, 29  
    sacfmt::Trace, 88  
Basic Documentation, 6  
baz  
    sacfmt, 28  
    sacfmt::Trace, 88, 89  
binary\_to\_bool  
    sacfmt, 34  
binary\_to\_double  
    sacfmt, 36  
binary\_to\_float  
    sacfmt, 37  
binary\_to\_int  
    sacfmt, 37  
binary\_to\_long\_string  
    sacfmt, 38  
binary\_to\_string  
    sacfmt, 39  
binary\_word\_size  
    sacfmt, 69  
bits\_per\_byte  
    sacfmt, 69  
bits\_string  
    sacfmt, 40  
bool\_to\_binary  
    sacfmt, 41  
bool\_to\_word  
    sacfmt, 41  
bools  
    sacfmt::Trace, 162  
Build Instructions, 20  
bytes  
    sacfmt::bitset\_type, 75  
  
calc\_az  
    sacfmt::Trace, 89  
calc\_baz  
    sacfmt::Trace, 90  
calc\_dist  
    sacfmt::Trace, 91  
calc\_gcarc  
    sacfmt::Trace, 92  
calc\_geometry  
    sacfmt::Trace, 93  
  
char\_bit  
    sacfmt, 26  
circle\_deg  
    sacfmt, 69  
cmpaz  
    sacfmt, 28  
    sacfmt::Trace, 94  
cmpinc  
    sacfmt, 28  
    sacfmt::Trace, 94, 95  
common\_skip\_num  
    sacfmt, 70  
concat\_words  
    sacfmt, 42  
convert\_to\_word  
    sacfmt, 43, 44  
convert\_to\_words  
    sacfmt, 44  
  
data  
    sacfmt::Trace, 162  
data1  
    sacfmt, 32  
    sacfmt::Trace, 95  
data2  
    sacfmt, 32  
    sacfmt::Trace, 95, 96  
data\_word  
    sacfmt, 70  
date  
    sacfmt::Trace, 96  
deg\_per\_rad  
    sacfmt, 70  
degrees\_to\_radians  
    sacfmt, 45  
delta  
    sacfmt, 29  
    sacfmt::Trace, 97  
depmax  
    sacfmt, 27  
    sacfmt::Trace, 97, 98  
depmin  
    sacfmt, 28  
    sacfmt::Trace, 98  
depmin  
    sacfmt, 27  
    sacfmt::Trace, 98, 99  
dist  
    sacfmt, 28  
    sacfmt::Trace, 99  
double\_to\_binary  
    sacfmt, 45  
doubles  
    sacfmt::Trace, 162  
  
e

- sacfmt, 29
- sacfmt::Trace, 99, 100
- earth\_radius
  - sacfmt, 70
- equal\_within\_tolerance
  - sacfmt, 46
- evdp
  - sacfmt, 28
  - sacfmt::Trace, 100
- evel
  - sacfmt, 28
  - sacfmt::Trace, 100, 101
- evla
  - sacfmt, 29
  - sacfmt::Trace, 101
- evlo
  - sacfmt, 29
  - sacfmt::Trace, 102
- f
  - sacfmt, 29
  - sacfmt::Trace, 103
- f\_eps
  - sacfmt, 70
- first
  - sacfmt::word\_pair< T >, 166
- float\_to\_binary
  - sacfmt, 47
- floats
  - sacfmt::Trace, 162
- frequency
  - sacfmt::Trace, 103
- gcarc
  - sacfmt, 28, 48
  - sacfmt::Trace, 104
- geometry\_set
  - sacfmt::Trace, 104
- ibody
  - sacfmt, 31
  - sacfmt::Trace, 105, 106
- idep
  - sacfmt, 30
  - sacfmt::Trace, 106
- ievreg
  - sacfmt, 30
  - sacfmt::Trace, 106, 107
- ievtyp
  - sacfmt, 30
  - sacfmt::Trace, 107
- iftyp
  - sacfmt, 30
  - sacfmt::Trace, 107, 108
- iinst
  - sacfmt, 30
  - sacfmt::Trace, 108
- imagsrc
  - sacfmt, 31
- sacfmt::Trace, 108, 109
- imagtyp
  - sacfmt, 30
  - sacfmt::Trace, 109
- Installation, 3
- int\_to\_binary
  - sacfmt, 49
- Introduction, 2
- ints
  - sacfmt::Trace, 162
- io\_error
  - sacfmt::io\_error, 76
- igual
  - sacfmt, 30
  - sacfmt::Trace, 109, 110
- istreg
  - sacfmt, 30
  - sacfmt::Trace, 110
- isynth
  - sacfmt, 30
  - sacfmt::Trace, 110, 111
- iztype
  - sacfmt, 30
  - sacfmt::Trace, 111
- ka
  - sacfmt, 31
  - sacfmt::Trace, 111, 112
- kcmpnm
  - sacfmt, 31
  - sacfmt::Trace, 112
- kdatrd
  - sacfmt, 31
  - sacfmt::Trace, 112, 113
- kevmn
  - sacfmt, 31
  - sacfmt::Trace, 113
- kf
  - sacfmt, 31
  - sacfmt::Trace, 113, 114
- khole
  - sacfmt, 31
  - sacfmt::Trace, 114
- kinst
  - sacfmt, 32
  - sacfmt::Trace, 114, 115
- knetwk
  - sacfmt, 31
  - sacfmt::Trace, 115
- ko
  - sacfmt, 31
  - sacfmt::Trace, 115, 116
- kstnm
  - sacfmt, 31
  - sacfmt::Trace, 116
- kt0
  - sacfmt, 31
  - sacfmt::Trace, 116, 117
- kt1

- sacfmt, 31
- sacfmt::Trace, 117
- kt2
  - sacfmt, 31
  - sacfmt::Trace, 117, 118
- kt3
  - sacfmt, 31
  - sacfmt::Trace, 118
- kt4
  - sacfmt, 31
  - sacfmt::Trace, 118, 119
- kt5
  - sacfmt, 31
  - sacfmt::Trace, 119
- kt6
  - sacfmt, 31
  - sacfmt::Trace, 119, 120
- kt7
  - sacfmt, 31
  - sacfmt::Trace, 120
- kt8
  - sacfmt, 31
  - sacfmt::Trace, 120, 121
- kt9
  - sacfmt, 31
  - sacfmt::Trace, 121
- kuser0
  - sacfmt, 31
  - sacfmt::Trace, 121, 122
- kuser1
  - sacfmt, 31
  - sacfmt::Trace, 122
- kuser2
  - sacfmt, 31
  - sacfmt::Trace, 122, 123
- lcalda
  - sacfmt, 31
  - sacfmt::Trace, 123
- legacy\_write
  - sacfmt::Trace, 123
- leven
  - sacfmt, 31
  - sacfmt::Trace, 125, 126
- limit\_180
  - sacfmt, 50
- limit\_360
  - sacfmt, 51
- limit\_90
  - sacfmt, 52
- long\_string\_to\_binary
  - sacfmt, 52
- lovrok
  - sacfmt, 31
  - sacfmt::Trace, 126
- lpspol
  - sacfmt, 31
  - sacfmt::Trace, 126, 127
- mag
  - sacfmt, 28
  - sacfmt::Trace, 127
- message
  - sacfmt::io\_error, 77
- modern\_hdr\_version
  - sacfmt, 70
- name
  - sacfmt, 27
- nevid
  - sacfmt, 30
  - sacfmt::Trace, 127, 128
- norid
  - sacfmt, 30
  - sacfmt::Trace, 128
- npts
  - sacfmt, 30
  - sacfmt::Trace, 128, 129
- nsnpts
  - sacfmt, 30
  - sacfmt::Trace, 129
- num\_bool
  - sacfmt, 70
- num\_data
  - sacfmt, 71
- num\_double
  - sacfmt, 71
- num\_float
  - sacfmt, 71
- num\_footer
  - sacfmt, 71
- num\_int
  - sacfmt, 71
- num\_string
  - sacfmt, 71
- num\_words
  - sacfmt::read\_spec, 78
- nvhdr
  - sacfmt, 30
  - sacfmt::Trace, 129, 130
- nwfid
  - sacfmt, 30
  - sacfmt::Trace, 130
- nwords\_after\_current
  - sacfmt, 53
- nxsize
  - sacfmt, 30
  - sacfmt::Trace, 130, 131
- nysize
  - sacfmt, 30
  - sacfmt::Trace, 131
- nzhour
  - sacfmt, 29
  - sacfmt::Trace, 131, 132
- nzjday
  - sacfmt, 29
  - sacfmt::Trace, 132
- nzmin

- sacfmt, [30](#)
- sacfmt::Trace, [132](#), [133](#)
- nzmsec
  - sacfmt, [30](#)
  - sacfmt::Trace, [133](#)
- nzsec
  - sacfmt, [30](#)
  - sacfmt::Trace, [133](#), [134](#)
- nzyear
  - sacfmt, [29](#)
  - sacfmt::Trace, [134](#)
- o
  - sacfmt, [29](#)
  - sacfmt::Trace, [134](#), [135](#)
- odelta
  - sacfmt, [27](#)
  - sacfmt::Trace, [135](#)
- old\_hdr\_version
  - sacfmt, [71](#)
- operator==
  - sacfmt::Trace, [135](#)
- prep\_string
  - sacfmt, [54](#)
- Quickstart, [5](#)
- rad\_per\_deg
  - sacfmt, [72](#)
- radians\_to\_degrees
  - sacfmt, [55](#)
- read\_data
  - sacfmt, [56](#)
- read\_four\_words
  - sacfmt, [57](#)
- read\_two\_words
  - sacfmt, [58](#)
- read\_word
  - sacfmt, [59](#)
- remove\_leading\_spaces
  - sacfmt, [59](#)
- remove\_trailing\_spaces
  - sacfmt, [60](#)
- resize\_data
  - sacfmt::Trace, [136](#)
- resize\_data1
  - sacfmt::Trace, [136](#)
- resize\_data2
  - sacfmt::Trace, [137](#)
- resp0
  - sacfmt, [27](#)
  - sacfmt::Trace, [137](#)
- resp1
  - sacfmt, [27](#)
  - sacfmt::Trace, [137](#), [138](#)
- resp2
  - sacfmt, [27](#)
  - sacfmt::Trace, [138](#)
- resp3
  - sacfmt, [27](#)
  - sacfmt::Trace, [138](#), [139](#)
- resp4
  - sacfmt, [28](#)
  - sacfmt::Trace, [139](#)
- resp5
  - sacfmt, [28](#)
  - sacfmt::Trace, [139](#), [140](#)
- resp6
  - sacfmt, [28](#)
  - sacfmt::Trace, [140](#)
- resp7
  - sacfmt, [28](#)
  - sacfmt::Trace, [140](#), [141](#)
- resp8
  - sacfmt, [28](#)
  - sacfmt::Trace, [141](#)
- resp9
  - sacfmt, [28](#)
  - sacfmt::Trace, [141](#), [142](#)
- SAC-file format, [14](#)
- sac\_map
  - sacfmt, [72](#)
- sacfmt, [22](#)
  - a, [29](#)
  - ascii\_space, [69](#)
  - az, [28](#)
  - azimuth, [33](#)
  - b, [29](#)
  - baz, [28](#)
  - binary\_to\_bool, [34](#)
  - binary\_to\_double, [36](#)
  - binary\_to\_float, [37](#)
  - binary\_to\_int, [37](#)
  - binary\_to\_long\_string, [38](#)
  - binary\_to\_string, [39](#)
  - binary\_word\_size, [69](#)
  - bits\_per\_byte, [69](#)
  - bits\_string, [40](#)
  - bool\_to\_binary, [41](#)
  - bool\_to\_word, [41](#)
  - char\_bit, [26](#)
  - circle\_deg, [69](#)
  - cmpaz, [28](#)
  - cmpinc, [28](#)
  - common\_skip\_num, [70](#)
  - concat\_words, [42](#)
  - convert\_to\_word, [43](#), [44](#)
  - convert\_to\_words, [44](#)
  - data1, [32](#)
  - data2, [32](#)
  - data\_word, [70](#)
  - deg\_per\_rad, [70](#)
  - degrees\_to\_radians, [45](#)
  - delta, [29](#)
  - depmax, [27](#)
  - depmin, [28](#)

depmin, 27  
dist, 28  
double\_to\_binary, 45  
e, 29  
earth\_radius, 70  
equal\_within\_tolerance, 46  
evdp, 28  
evel, 28  
evla, 29  
evlo, 29  
f, 29  
f\_eps, 70  
float\_to\_binary, 47  
gcarc, 28, 48  
ibody, 31  
idep, 30  
ievreg, 30  
ievtyp, 30  
iftype, 30  
iinst, 30  
imagsrc, 31  
imagtyp, 30  
int\_to\_binary, 49  
igual, 30  
istreg, 30  
isynt, 30  
iztype, 30  
ka, 31  
kcmpnm, 31  
kdatrd, 31  
kevm, 31  
kf, 31  
khole, 31  
kinst, 32  
knetwk, 31  
ko, 31  
kstnm, 31  
kt0, 31  
kt1, 31  
kt2, 31  
kt3, 31  
kt4, 31  
kt5, 31  
kt6, 31  
kt7, 31  
kt8, 31  
kt9, 31  
kuser0, 31  
kuser1, 31  
kuser2, 31  
lcalda, 31  
leven, 31  
limit\_180, 50  
limit\_360, 51  
limit\_90, 52  
long\_string\_to\_binary, 52  
lovrok, 31  
lpspol, 31  
mag, 28  
modern\_hdr\_version, 70  
name, 27  
nevid, 30  
norid, 30  
npts, 30  
nsnpts, 30  
num\_bool, 70  
num\_data, 71  
num\_double, 71  
num\_float, 71  
num\_footer, 71  
num\_int, 71  
num\_string, 71  
nvhdr, 30  
nwfid, 30  
nwords\_after\_current, 53  
nxsize, 30  
nysize, 30  
nzhour, 29  
nzjday, 29  
nzmin, 30  
nzmsec, 30  
nzsec, 30  
nzyear, 29  
o, 29  
odelta, 27  
old\_hdr\_version, 71  
prep\_string, 54  
rad\_per\_deg, 72  
radians\_to\_degrees, 55  
read\_data, 56  
read\_four\_words, 57  
read\_two\_words, 58  
read\_word, 59  
remove\_leading\_spaces, 59  
remove\_trailing\_spaces, 60  
resp0, 27  
resp1, 27  
resp2, 27  
resp3, 27  
resp4, 28  
resp5, 28  
resp6, 28  
resp7, 28  
resp8, 28  
resp9, 28  
sac\_map, 72  
safe\_to\_finish\_reading, 61  
safe\_to\_read\_data, 62  
safe\_to\_read\_footer, 63  
safe\_to\_read\_header, 64  
sb, 29  
sdelta, 29  
stdp, 28  
stel, 28  
stla, 29  
stlo, 29

- string\_bits, 65
- string\_cleaning, 66
- string\_to\_binary, 66
- t0, 29
- t1, 29
- t2, 29
- t3, 29
- t4, 29
- t5, 29
- t6, 29
- t7, 29
- t8, 29
- t9, 29
- uint\_to\_binary, 67
- unset\_bool, 73
- unset\_double, 73
- unset\_float, 74
- unset\_int, 74
- unset\_word, 74
- unsigned\_int, 26
- user0, 28
- user1, 28
- user2, 28
- user3, 28
- user4, 28
- user5, 28
- user6, 28
- user7, 28
- user8, 28
- user9, 28
- word\_four, 27
- word\_length, 74
- word\_one, 27
- word\_position, 68
- word\_two, 27
- write\_words, 68
- xmaximum, 28
- xminimum, 28
- ymaximum, 29
- yminimum, 29
- sacfmt::bitset\_type, 74
  - bytes, 75
- sacfmt::bitset\_type::uint< 2 \*bits\_per\_byte >, 163
  - type, 163
- sacfmt::bitset\_type::uint< 4 \*bits\_per\_byte >, 163
  - type, 164
- sacfmt::bitset\_type::uint< bits\_per\_byte >, 164
  - type, 164
- sacfmt::bitset\_type::uint< bytes \*bits\_per\_byte >, 165
  - type, 165
- sacfmt::bitset\_type::uint< nbits >, 163
- sacfmt::io\_error, 75
  - io\_error, 76
  - message, 77
  - what, 77
- sacfmt::read\_spec, 77
  - num\_words, 78
  - start\_word, 78
- sacfmt::Trace, 78
  - a, 87
  - az, 87, 88
  - b, 88
  - baz, 88, 89
  - bools, 162
  - calc\_az, 89
  - calc\_baz, 90
  - calc\_dist, 91
  - calc\_gcarc, 92
  - calc\_geometry, 93
  - cmpaz, 94
  - cmpinc, 94, 95
  - data, 162
  - data1, 95
  - data2, 95, 96
  - date, 96
  - delta, 97
  - depmax, 97, 98
  - depmen, 98
  - depmin, 98, 99
  - dist, 99
  - doubles, 162
  - e, 99, 100
  - evdp, 100
  - evel, 100, 101
  - evla, 101
  - evlo, 102
  - f, 103
  - floats, 162
  - frequency, 103
  - gcarc, 104
  - geometry\_set, 104
  - ibody, 105, 106
  - idep, 106
  - ievreg, 106, 107
  - ievtyp, 107
  - iftyp, 107, 108
  - iinst, 108
  - imagsrc, 108, 109
  - imagtyp, 109
  - ints, 162
  - igual, 109, 110
  - istreg, 110
  - isynth, 110, 111
  - iztype, 111
  - ka, 111, 112
  - kcmpnm, 112
  - kdatrd, 112, 113
  - kevm, 113
  - kf, 113, 114
  - khole, 114
  - kinst, 114, 115
  - knetwk, 115
  - ko, 115, 116
  - kstnm, 116
  - kt0, 116, 117
  - kt1, 117

kt2, [117](#), [118](#)  
kt3, [118](#)  
kt4, [118](#), [119](#)  
kt5, [119](#)  
kt6, [119](#), [120](#)  
kt7, [120](#)  
kt8, [120](#), [121](#)  
kt9, [121](#)  
kuser0, [121](#), [122](#)  
kuser1, [122](#)  
kuser2, [122](#), [123](#)  
lcalda, [123](#)  
legacy\_write, [123](#)  
leven, [125](#), [126](#)  
lovrok, [126](#)  
lpspol, [126](#), [127](#)  
mag, [127](#)  
nevid, [127](#), [128](#)  
norid, [128](#)  
npts, [128](#), [129](#)  
nsnpts, [129](#)  
nvhdr, [129](#), [130](#)  
nwfid, [130](#)  
nxsize, [130](#), [131](#)  
nysize, [131](#)  
nzhour, [131](#), [132](#)  
nzjday, [132](#)  
nzmin, [132](#), [133](#)  
nzmsec, [133](#)  
nzsec, [133](#), [134](#)  
nzyear, [134](#)  
o, [134](#), [135](#)  
odelta, [135](#)  
operator==, [135](#)  
resize\_data, [136](#)  
resize\_data1, [136](#)  
resize\_data2, [137](#)  
resp0, [137](#)  
resp1, [137](#), [138](#)  
resp2, [138](#)  
resp3, [138](#), [139](#)  
resp4, [139](#)  
resp5, [139](#), [140](#)  
resp6, [140](#)  
resp7, [140](#), [141](#)  
resp8, [141](#)  
resp9, [141](#), [142](#)  
sb, [142](#)  
sdelta, [142](#), [143](#)  
stdp, [143](#)  
stel, [143](#), [144](#)  
stla, [144](#)  
stlo, [145](#)  
strings, [162](#)  
t0, [146](#)  
t1, [146](#)  
t2, [147](#)  
t3, [147](#)  
t4, [148](#)  
t5, [148](#)  
t6, [149](#)  
t7, [149](#)  
t8, [150](#)  
t9, [150](#)  
time, [151](#)  
Trace, [84](#)  
user0, [151](#), [152](#)  
user1, [152](#)  
user2, [152](#), [153](#)  
user3, [153](#)  
user4, [153](#), [154](#)  
user5, [154](#)  
user6, [154](#), [155](#)  
user7, [155](#)  
user8, [155](#), [156](#)  
user9, [156](#)  
write, [156](#)  
xmaximum, [159](#), [160](#)  
xminimum, [160](#)  
ymaximum, [160](#), [161](#)  
yminimum, [161](#)  
sacfmt::word\_pair< T >, [165](#)  
    first, [166](#)  
    second, [166](#)  
safe\_to\_finish\_reading  
    sacfmt, [61](#)  
safe\_to\_read\_data  
    sacfmt, [62](#)  
safe\_to\_read\_footer  
    sacfmt, [63](#)  
safe\_to\_read\_header  
    sacfmt, [64](#)  
sb  
    sacfmt, [29](#)  
    sacfmt::Trace, [142](#)  
sdelta  
    sacfmt, [29](#)  
    sacfmt::Trace, [142](#), [143](#)  
second  
    sacfmt::word\_pair< T >, [166](#)  
start\_word  
    sacfmt::read\_spec, [78](#)  
stdp  
    sacfmt, [28](#)  
    sacfmt::Trace, [143](#)  
stel  
    sacfmt, [28](#)  
    sacfmt::Trace, [143](#), [144](#)  
stla  
    sacfmt, [29](#)  
    sacfmt::Trace, [144](#)  
stlo  
    sacfmt, [29](#)  
    sacfmt::Trace, [145](#)  
string\_bits  
    sacfmt, [65](#)



- string\_cleaning
  - sacfmt, 66
- string\_to\_binary
  - sacfmt, 66
- strings
  - sacfmt::Trace, 162
- t0
  - sacfmt, 29
  - sacfmt::Trace, 146
- t1
  - sacfmt, 29
  - sacfmt::Trace, 146
- t2
  - sacfmt, 29
  - sacfmt::Trace, 147
- t3
  - sacfmt, 29
  - sacfmt::Trace, 147
- t4
  - sacfmt, 29
  - sacfmt::Trace, 148
- t5
  - sacfmt, 29
  - sacfmt::Trace, 148
- t6
  - sacfmt, 29
  - sacfmt::Trace, 149
- t7
  - sacfmt, 29
  - sacfmt::Trace, 149
- t8
  - sacfmt, 29
  - sacfmt::Trace, 150
- t9
  - sacfmt, 29
  - sacfmt::Trace, 150
- time
  - sacfmt::Trace, 151
- Trace
  - sacfmt::Trace, 84
- type
  - sacfmt::bitset\_type::uint< 2 \*bits\_per\_byte >, 163
  - sacfmt::bitset\_type::uint< 4 \*bits\_per\_byte >, 164
  - sacfmt::bitset\_type::uint< bits\_per\_byte >, 164
  - sacfmt::bitset\_type::uint< bytes \*bits\_per\_byte >, 165
- uint\_to\_binary
  - sacfmt, 67
- unset\_bool
  - sacfmt, 73
- unset\_double
  - sacfmt, 73
- unset\_float
  - sacfmt, 74
- unset\_int
  - sacfmt, 74
- unset\_word
  - sacfmt, 74
- unsigned\_int
  - sacfmt, 26
- user0
  - sacfmt, 28
  - sacfmt::Trace, 151, 152
- user1
  - sacfmt, 28
  - sacfmt::Trace, 152
- user2
  - sacfmt, 28
  - sacfmt::Trace, 152, 153
- user3
  - sacfmt, 28
  - sacfmt::Trace, 153
- user4
  - sacfmt, 28
  - sacfmt::Trace, 153, 154
- user5
  - sacfmt, 28
  - sacfmt::Trace, 154
- user6
  - sacfmt, 28
  - sacfmt::Trace, 154, 155
- user7
  - sacfmt, 28
  - sacfmt::Trace, 155
- user8
  - sacfmt, 28
  - sacfmt::Trace, 155, 156
- user9
  - sacfmt, 28
  - sacfmt::Trace, 156
- what
  - sacfmt::io\_error, 77
- word\_four
  - sacfmt, 27
- word\_length
  - sacfmt, 74
- word\_one
  - sacfmt, 27
- word\_position
  - sacfmt, 68
- word\_two
  - sacfmt, 27
- write
  - sacfmt::Trace, 156
- write\_words
  - sacfmt, 68
- xmaximum
  - sacfmt, 28
  - sacfmt::Trace, 159, 160
- xminimum
  - sacfmt, 28
  - sacfmt::Trace, 160
- ymaximum

sacfmt, [29](#)  
sacfmt::Trace, [160](#), [161](#)  
yminimum  
sacfmt, [29](#)  
sacfmt::Trace, [161](#)