sac-format

0.6.0

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1 sac-format

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!

1.2 Quickstart

1.2.1 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`).

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](https://learn.microsoft.com/en-us/powershell/module/microsoft.powershell.utility/get-filehash?view=powershell-7.4)) 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:

macOS

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

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 successfull installation you will see:

2. Command line

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

   (a) Self-Extracting Archive

   ```
   sh @section autotoc_md14 Check the sha512 checksum sha512sum -c sac-format-<vers
   sha512 @section autotoc_md15 Run self-extracting archive bash sac-format-<versio
   ```

   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`).

   (b) Gzipped Tar Archive

   ```
   bash @section autotoc_md16 Check the sha512 checksum sha512sum -c
   sac-format-<version>-Darwin-<arch>.tar.gz.sha512 @section autotoc↩
   _md17 Extract Gzipped tar archive tar -xzf sac-format-<version>-Darwin-<arch>.t
   gz
   ```

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.

1. Debian Archive

   ```
   bash @section autotoc_md19 Check the sha512 checksum sha512sum -c sac-format.↩
   deb.sha512 @section autotoc_md20 Install using apt sudo apt install
   ./sac-format.deb
   ```

2. RPM Archive

   ```
   bash @section autotoc_md21 Check the sha512 checksum sha512sum -c sac-format.↩
   rpm.sha512 @section autotoc_md22 Install using rpm sudo rpm -i sac-format.↩
   rpm
   ```

3. Self-Extrating Archive

   ```
   bash @section autotoc_md23 Check the sha512 checksum sha512sum -c sac-format-<versi
   sha512 @section autotoc_md24 Run self-extrating archive bash sac-format-<version>-L
   ```

4. Gzipped Tar Archive

   ```
   bash @section autotoc_md25 Check the sha512 checksum sha512sum -c sac-format-<versi
   gz.sha512 @section autotoc_md26 Extract gzipped tar archive tar -xzf
   sac-format-<version>-Linux-<arch>.tar.gz
   ```

1.2.2 Build Instructions

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

GCC

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

Clang

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

1.2.3 Use

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

1.2.4 Example Programs

<tt>list_sac</tt>

`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.

1.2.5 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_library(your_executable
    PRIVATE sac-format)
```

1.2.6 Example

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;
}
```

1.3 Documentation

1.3.1 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).

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;
}
```

Writing SAC

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

1. `v7` files

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

2. `v6` files

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

Getters and Setters

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

1. Example Getters
   - `trace.npts()`
   - `trace.data1()`
   - `trace.kstnm()`
2. Example Setters
   - `trace.kevnm("Event 1")`
   - `trace.evla(32.89)`
   - `trace.mag(3.21)`
3. 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.

   (a) 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.

   i. `stla(input)`
   Limited to $[-90, 90]$ degrees, input that is outside that range is reduced using circular symmetry.

   ii. `stlo(input)`
   Limited to $[-180, 180]$ degrees, input that is outside that range is reduced using circular symmetry.

   iii. `evla(input)`
   Limited to $[-90, 90]$ degrees, input that is outside that range is reduced using circular symmetry.

iv. `evlo(input)`
Limited to $[-180, 180]$ degrees, input that is outside that range is reduced using circular symmetry.

(b) 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.

i. `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.

ii. `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 resized 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.

iii. `iftype(input)`
Changing the value of `iftype` poentially 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.

iv. `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.

v. `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.

Internal Structure

The SAC-trace stores the data internally in a series of pre-allocated `std::array` (`<array>`) container objects. Getters and setters access these via a lookup table. The internal components are below:

1. Lookup Table
   `sac_map`
2. `floats` array
3. `doubles` array
4. `ints` array
5. `bools` array
6. `strings` array
7. `data` array

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()};
```

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.

1.3.2 Convenience Functions

- `degrees_to_radians`

Convert decimal degrees to radians.

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

- `radians_to_degrees`

Convert radians to decimal degrees.

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

- `gcarc`

Calculate great-circle arc distance (spherical planet).

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

- 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)};
```

- limit_360

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

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

- limit_180

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

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

- limit_90

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

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

1.3.3 Low-Level I/O

Low-level I/O functions are discussed below.

1. Binary conversion

   (a) int_to_binary and binary_to_int

   Conversion pair for binary representation of integer values.

   ```
   cpp 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';
   ```

   (b) float_to_binary and binary_to_float

   Conversion pair for binary representation of floating-point values.

   ```
   cpp 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';
   ```

   (c) double_to_binary and binary_to_double

   Conversion pair for binary representation of double-precision values.

   ```
   cpp 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';
   ```

   (d) string_to_binary and binary_to_string

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

   ```
   cpp 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';
   ```

(e) `long_string_to_binary` and `binary_to_long_string`

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

```
cpp 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';
```

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.

(a) `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`).

(b) `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).

(c) `write_words`

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

3. Utility

(a) `concat_words`

Concatenates words taking into account the system endianness.

(b) `bits_string` and `string_bits`

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

(c) `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).

(d) `string_cleaning`

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

(e) `prep_string`

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

(f) `equal_within_tolerance`

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

1.3.4 Testing

`utests.cpp` contains the unit- and integration-tests, using Catch2. Test coverage details are visible on `Code↩Cov.io` and `Codacy.com`. All tests can be locally-run to ensure full functionality and compliance.

Errors only

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

Full output

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

Compact output

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

Additional options

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

Using ctest

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

1.3.5 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 `becnhmark -?`.

1.3.6 Source File List

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.

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`

Example programs

1. `list_sac.cpp`

1.3.7 Dependencies

Automatic (CMake)

1. `Xoshiro-cpp v1.12.0` (testing and benchmarking)
2. `Catch2 v3.4.0` (testing and benchmarking)

1.3.8 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`).

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

14. `baz`

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

15. `gcarc`

    Station–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 ω_{0}).

3. `xmaximum`

   Spectral-only equivalent of `depmax` (f_{max} or ω_{max}).

4. `yminimum`

   Spectral-only equivalent of `b`.

5. `ymaximum`

   Spectral-only equivalent of `e`.

Double (22)

64-bit (2 words, 8 bytes)

NOTE: in the header section these are floats—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 (Δt for timeseries, Δf 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–positive/negative.

   sac-format automatically enforces $\mathrm{stla}\in[-90, 90]$.

9. `stlo`

   Station longitude in decimal degrees, E/W–positive/negative.

   sac-format automatically enforces $\mathrm{stlo}\in[-180, 180]$.

10. `evla`

    Event latitude in decimal degrees, N/S–positive/negative.

    sac-format automatically enforces $\mathrm{evla}\in[-90, 90]$.

11. `evlo`

    Event longitude in decimal degrees, E/W–positive/negative.

    sac-format automatically enforces $\mathrm{evlo}\in[-180, 180]$.

12. `sb`

    Original (*saved*) `b` value.

13. `sdelta`

    Original (*saved*) `delta` value.

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`) (1–366).

3. `nzhour`

   Reference time GMT hour (00–23).

4. `nzmin`

   Reference time GMT minute (0–59).

5. `nzsec`

   Reference time GMT second (0–59).

6. `nzmsec`

   Reference time GMT Millisecond (0–999).

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
13–22	IT(0–9)	User defined time (t) pick

18. `iinst`

    Recording instrument type.

    Not used by SAC—free for other purposes.

19. `istreg`

    Station geographic region.

    Not used by SAC—free for other purposes.

20. `ievreg`

    Event geographic region.

    Not used by SAC—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. `iqual`

    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 | Internation 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 (*Historic*) | 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 (*WGS84*) | 6378137.0 | 0.0033528106647474805 | | 102 | IMOON | Moon | 1737400.0 | 0.0 | | 103 | IMARS | Mars | 3396190.0 | 0.005886007555525457 |

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`.

String (23)

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

1. `kstnm`

   Station name.

2. `kevnm*`

   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`.

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.

1.4 Notes

1.4.1 Why C++20 and not C++23

Compiler restrictions—C++23 support `requires` GCC-13+ and Clang-16+. Many systems, still use GCC-12 and Clang-15—which has near complete support for `C++20`.

sac-format strives for accessibility, modernity, safety, and speed—C++20 provides the best fit.

2 Namespace Index

2.1 Namespace List

Here is a list of all namespaces with brief descriptions:

3 Hierarchical Index

3.1 Class Hierarchy

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

4 Class Index

4.1 Class List

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

5 File Index

5.1 File List

Here is a list of all files with brief descriptions:

6 Namespace Documentation

6.1 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 ,
  kevnm , khole , ko , ka ,
  kt0 , kt1 , kt2 , kt3 ,
  kt4 , kt5 , kt6 , kt7 ,
  kt8 , kt9 , kf , kuser0 ,
  kuser1 , kuser2 , kcmpnm , 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 funamental 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-poing 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.

6.1.1 Detailed Description

sac-format namespace

6.1.2 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).

6.1.3 Enumeration Type Documentation

name

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

Enumeration of all SAC fields.

Additional information can be found at (link to org-documentation).

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.

Enumerator

resp3	See resp0.
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 $Station \rightarrow Event$ in decimal degrees from North.
baz	Float Back-Azimuth $Event \rightarrow Station$ in decimal degrees from North.
gcarc	Float Great-circle arc-distance between station and event in decimal degrees.
depmen	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 ω_0).
xmaximum	Float Spectral-only equivalent of depman (f_{max} or ω_{max}).

Enumerator

yminimum	Float Spectral-only equivalent of b.
ymaximum	Float Spectral-only equivalent of e.
delta	Double Increment between evenly-spaced samples (Δt for timeseries, Δf 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 automaticall 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.
iqual	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 used 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.
kevnm	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   iqual,
00736   isynth,
00742   imagtyp,
00748   imagsrc,
00756   ibody,
00757   // Bools
00765   leven,
00773   lpspol,
00783   lovrok,
00791   lcalda,
00792   // Strings
00798   kstnm,
00804   kevnm,
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 };
```

6.1.4 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).

ϕ is latitude. λ is longitude. θ 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

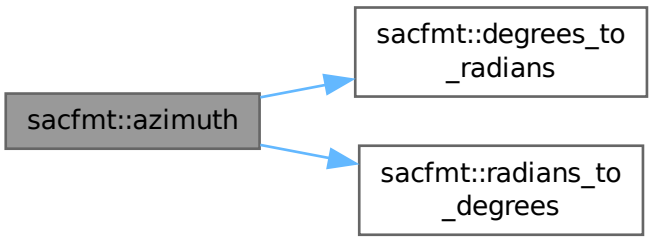
in	*latitude1*	Latitude of first location in decimal degrees.
in	*longitude1*	Longitude of first location in decimal degrees.
in	*latitude2*	Latitude of second location in decimal degrees.
in	*longitude2*	Longitude of second location in decimal degrees.

Returns

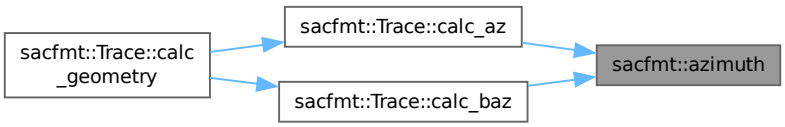
double The azimuth from the first location to the second location.

```
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

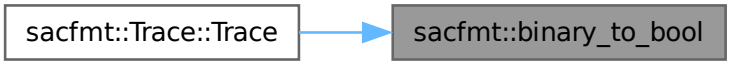
in	*flag*	word_one binary bitset to be converted (takes zeroth element).

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

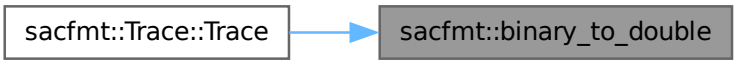
in	*bin*	word_two Binary value to be converted.

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

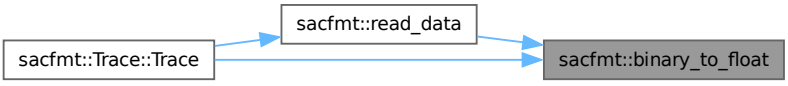
in	*bin*	word_one Binary value to be converted.

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

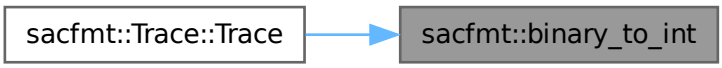
in	*bin*	Binary value to be converted.

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

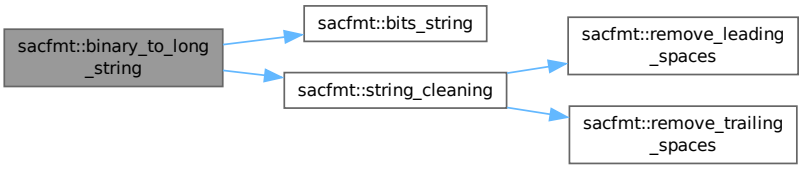
in	*str*	word_four to be converted to a string.

Returns

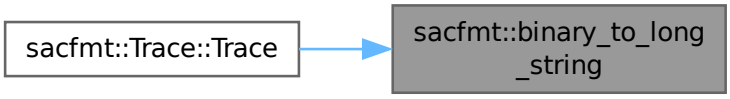
std::string Converted string.

```
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

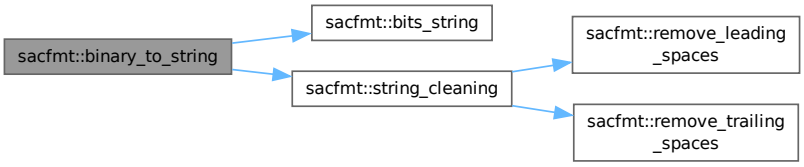
in	*str*	word_two to be converted to a string.

Returns

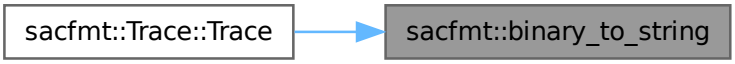
std::string Converted string.

```
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	*bits*	Source bitset for the string.
in	*num_words*	Length of string in words (4 chars = 1 word)

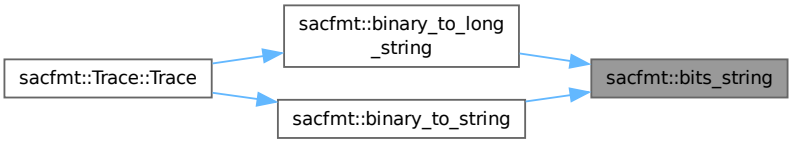
Returns

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

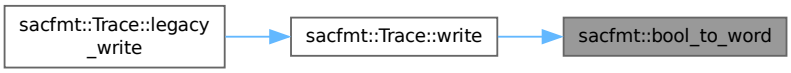
in	*flag*	Boolean to be converted.

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	*pair_words*	word_pair 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	*pair_words*	word_pair 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	*input*	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

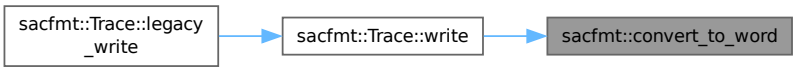
in	*input*	Input value (float or int) to convert.

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	*str*	Input string to convert.
in	*n_words*	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

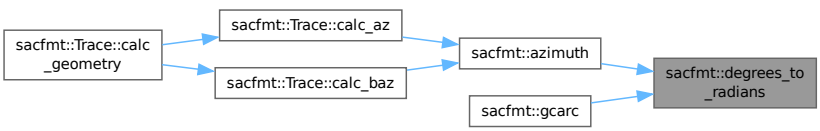
in	*degrees*	Angle in decimal degrees to be converted.

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	*num*	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	*val1*	First double in comparison.
in	*val2*	Second double in comparison.
in	*tolerance*	Numerical equality tolerance (default f_eps).

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

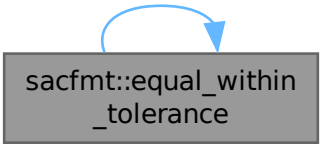
in	*vector1*	First data vector in comparison.
in	*vector2*	Second data vector in comparison.
in	*tolerance*	Numerical equality tolerance (default f_eps).

Returns

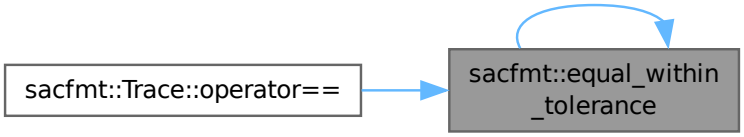
bool Boolean equality value.

```
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	*num*	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 flatenning and adjustable radius for other bodies/greater accuracy).

ϕ is latitude. λ is longitude. Δ is great circle arc distance (gcarc).

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

Parameters

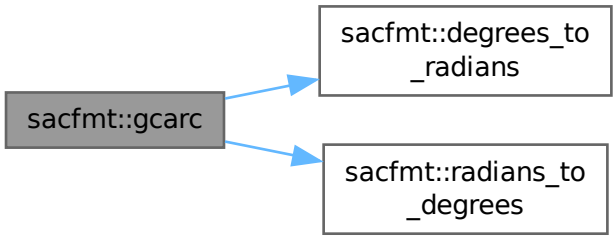
in	*latitude1*	Latitude of first location in decimal degrees.
in	*longitude1*	Longitude of first location in decimal degrees.
in	*latitude2*	Latitude of second location in decimal degrees.
in	*longitude2*	Longitude of second location in decimal degrees.

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

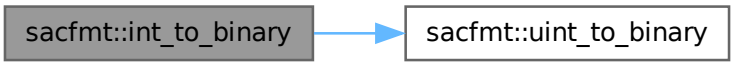
in	*num*	Number to be converted.

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

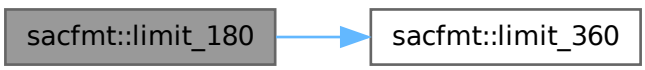
in	*degrees*	Decimal degrees to be constrained.

Returns

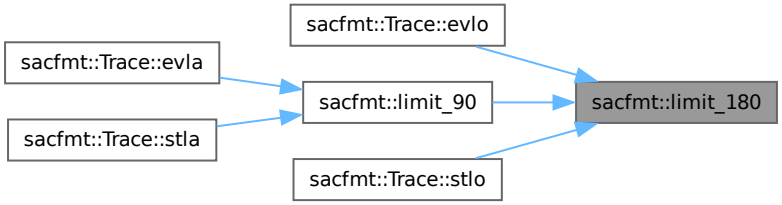
double Value within limits.

```
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

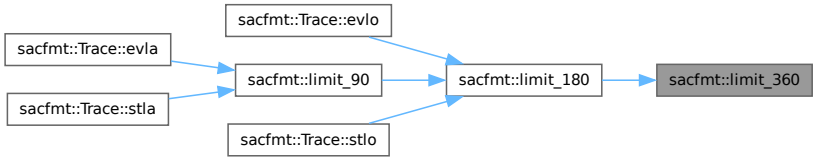
in	*degrees*	Decimal degrees to be constrained.

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

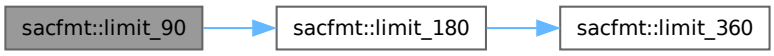
in	*degrees*	Decimal degrees to be constrained.

Returns

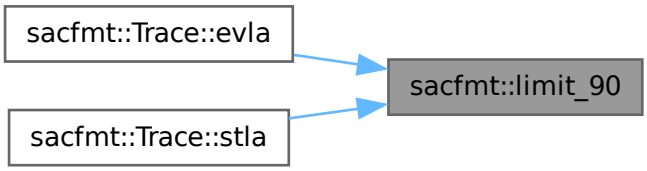
double Value within limits.

```
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

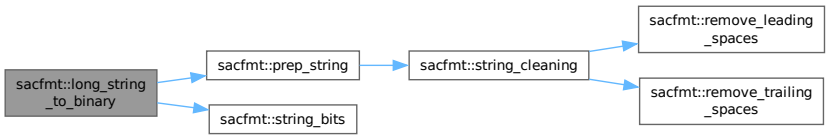
in	*str*	String to be converted to a bitset.

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

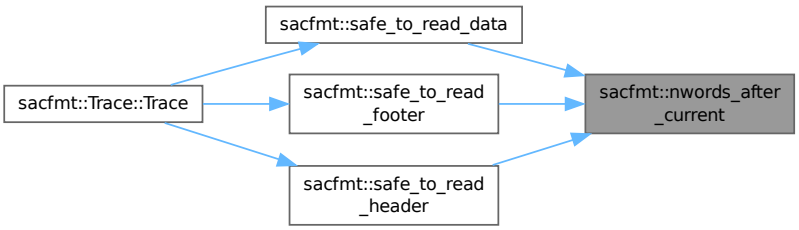
in	*sac*	std::ifstream* SAC-file to read.
in	*spec*	read_spec reading specification.

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.

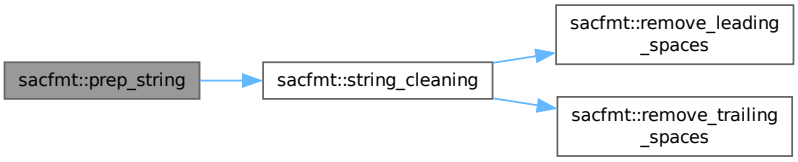
This edits the string in-place.

Parameters

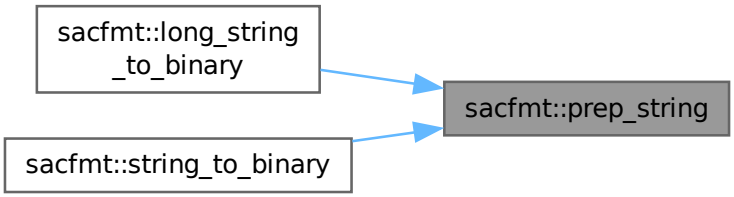
in,out	*str*	std::string* String to be prepared.
in	*str_size*	Desired string length.

```
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

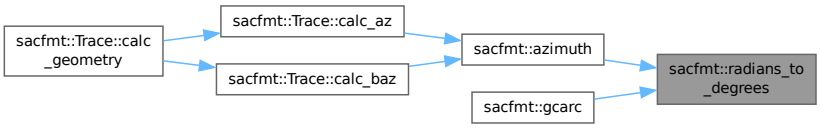
in	*radians*	Angle in radians to be converted.

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

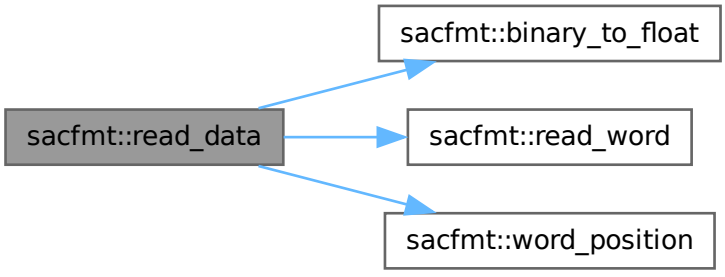
in,out	*sac*	std::ifstream* Input binary SAC-file.
in	*spec*	read_spec Reading specification.

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

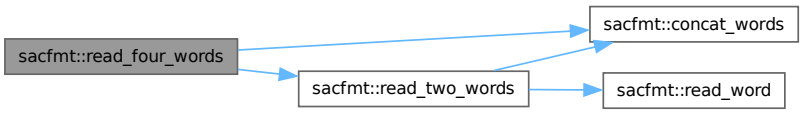
in,out	*sac*	std::ifstream* Input binary SAC-file.

Returns

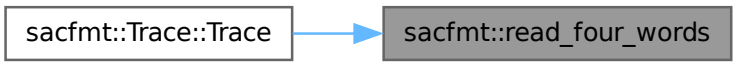
word_four Binary bitset representation of four words.

```
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

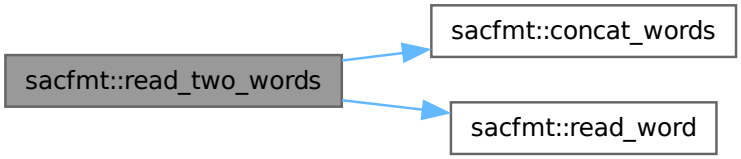
in,out	*sac*	std::ifstream* Input binary SAC-file.

Returns

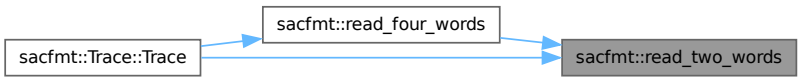
word_two Binary bitset representation of two words.

```
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

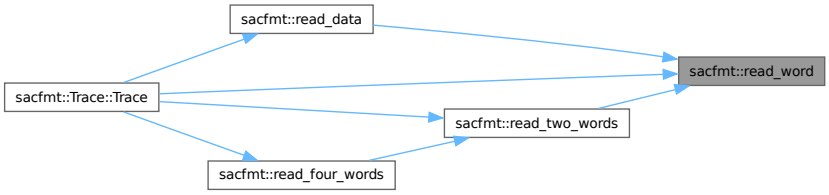
in,out	sac	std::ifstream* Input binary SAC-file.

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.

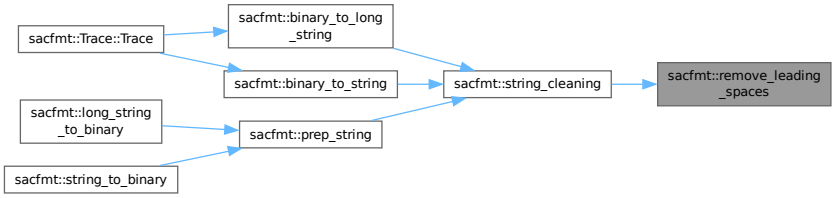
This edits the string in-place.

Parameters

in,out	str	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.

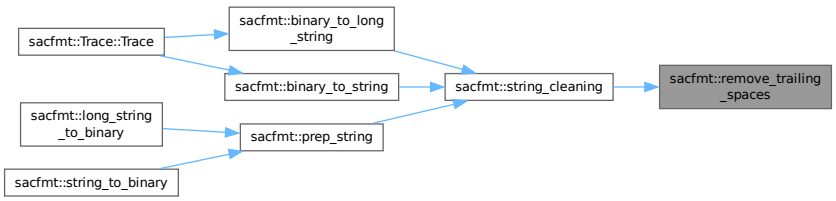
This edits the string in-place.

Parameters

in,out	str	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

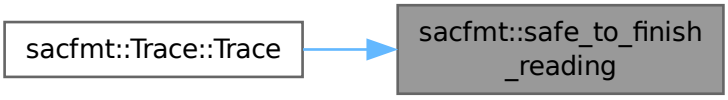
in	*sac*	std::ifstream* SAC-file to be checked.

Exceptions

io_error	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

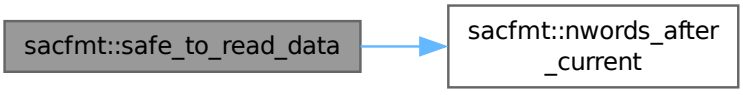
in	*sac*	std::ifstream* SAC-file to read.
in	*n_words*	Number of values in data vector.
in	*data2*	bool True if reading data2, false (default) if reading data1.

Exceptions

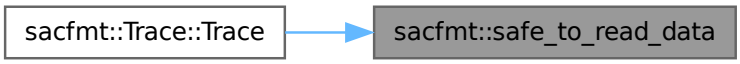
io_error	If unsafe to read.

```
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

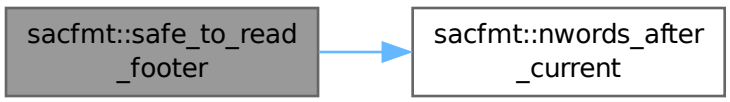
in	*sac*	std::ifstream* SAC-file to read.

Exceptions

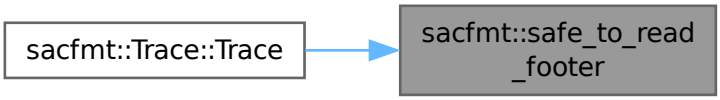
io_error	If unsafe to read.

```
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

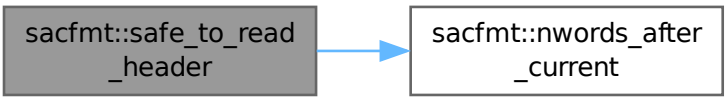
in	*sac*	std::ifstream* SAC-file to read.

Exceptions

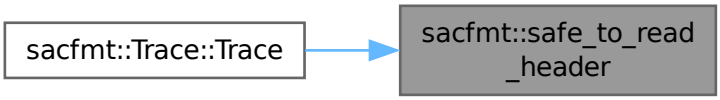
io_error	If unsafe to read.

```
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.

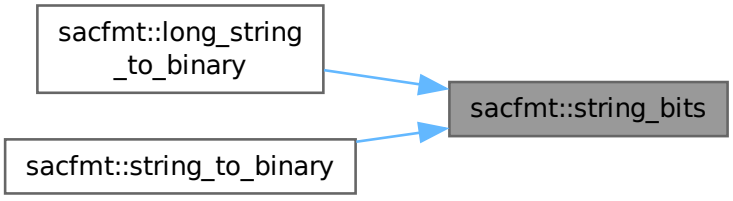
Note that this edits the bitset in place.

Parameters

out	*bits*	Destintation bitset for the string (result).
in	*str*	String to undergo conversion.
in	*str_size*	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

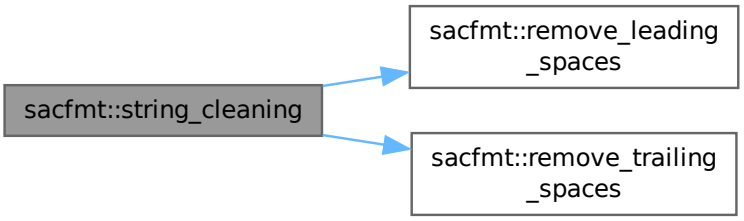
in	*str*	std::string String to be cleaned.

Returns

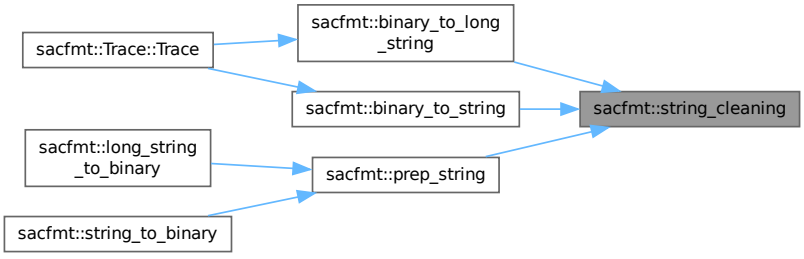
std::string Cleaned string.

```
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

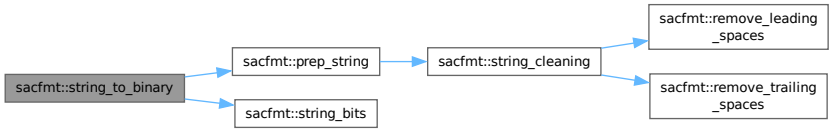
in	*str*	String to be converted to a bitset.

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

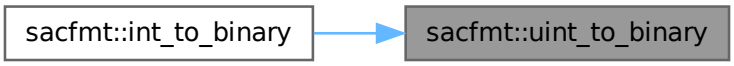
in	*num*	Number to be converted.

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

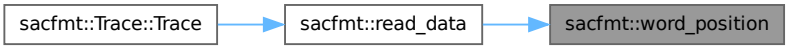
in	*word_number*	Number of desired word in file stream.

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	*sac_file*	std::ofstream* Output binary SAC-file.
in	*input*	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:

6.1.5 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 funamental 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-poing 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::iftype, 14},
00993     {name::idep, 15},
00994     {name::iztype, 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::kevnm, 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};
```

6.2 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?

6.2.1 Detailed Description

bitset type-safety namespace.

6.2.2 Variable Documentation

bytes

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

? type-safety?

```
00142 {8};
```

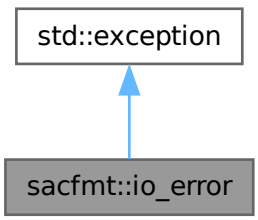
7 Class Documentation

7.1 sacfmt::io_error Class Reference

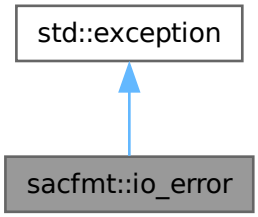
Class for generic I/O exceptions.

```
#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.

7.1.1 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.

7.1.2 Constructor & Destructor Documentation

io_error()

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

io_error Constructor

Parameters

in	*msg*	std::string Error message.

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

7.1.3 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   }
```

7.1.4 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

7.2 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.

7.2.1 Detailed Description

Struct that specifies parameters for reading.

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

7.2.2 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

7.3 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 iqual () 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 kevnm () 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 iqual (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 lpspol (bool input) noexcept
- void lovrok (bool input) noexcept
- void lcalda (bool input) noexcept
- void kstnm (const std::string &input) noexcept
- void kevnm (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.

7.3.1 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.

7.3.2 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

in	*path*	std::filesystem::path SAC-file to be read.

Returns

Trace read in-file.

Exceptions

io_error	If the file is not safe to read for whatever reason.
std::exception	(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   iinst(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   iqual(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   lpspol(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   kevnm(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
```

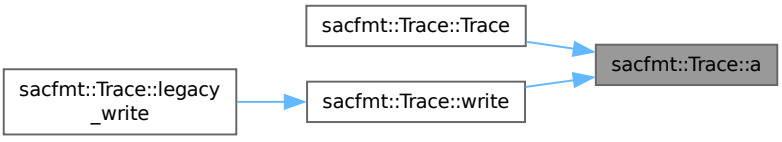
```
01916   if (nvhdr() == modern_hdr_version) {
01917     safe_to_read_footer(&file);  // throws io_error if not safe
01918     delta(binary_to_double(read_two_words(&file)));
01919     b(binary_to_double(read_two_words(&file)));
01920     e(binary_to_double(read_two_words(&file)));
01921     o(binary_to_double(read_two_words(&file)));
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 }
```

7.3.3 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:



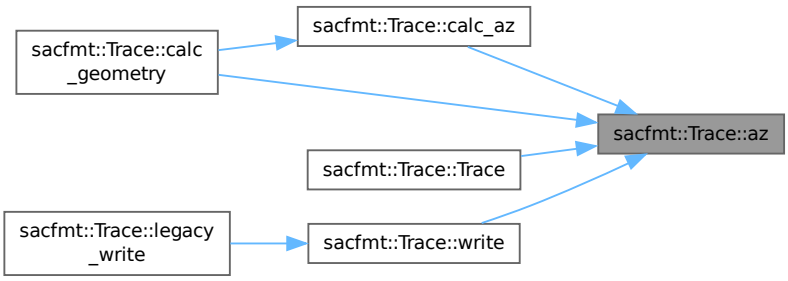
a() [2/2]

```
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:



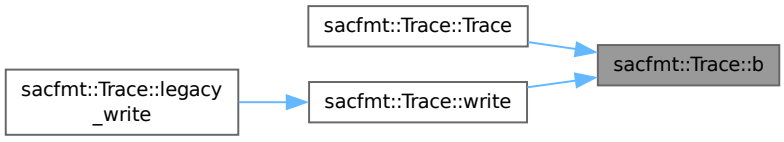
az() [2/2]

```
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:



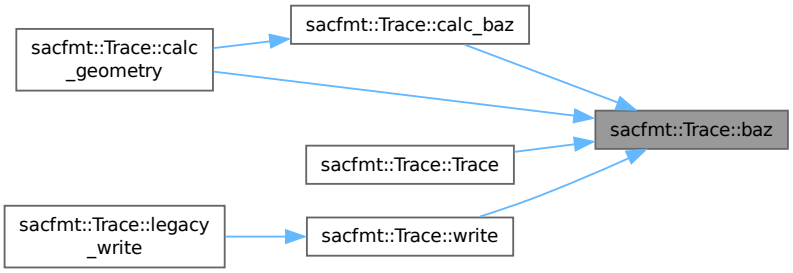
b() [2/2]

```
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()

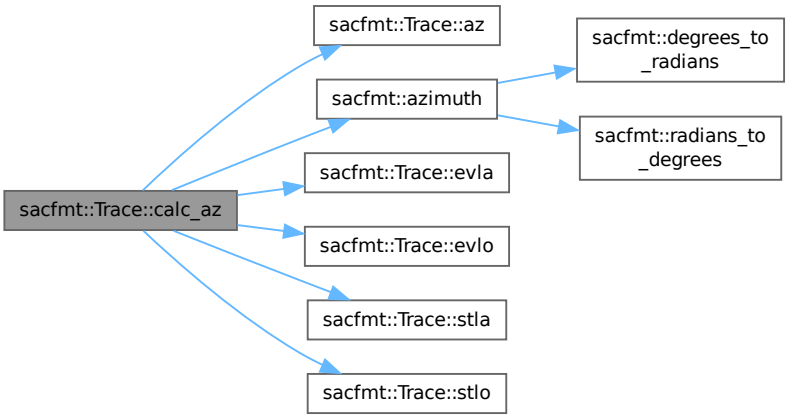
```
void sacfmt::Trace::calc_az ( )  [private], [noexcept]
```

Calculate azimuth.

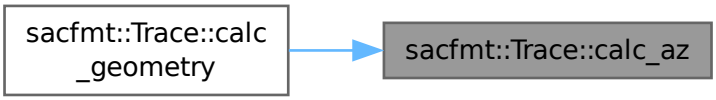
$$Station \rightarrow Event$$

```
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()

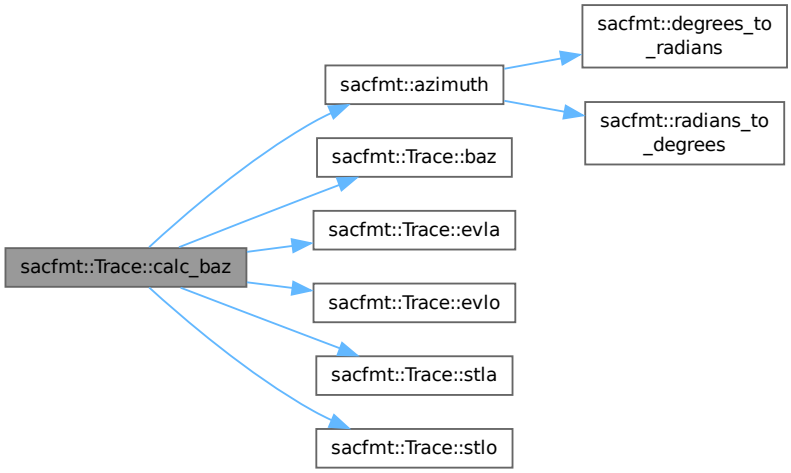
```
void sacfmt::Trace::calc_baz ( )  [private], [noexcept]
```

Calculate back-azimuth.

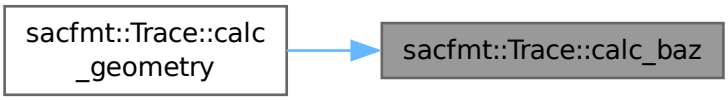
$$Event \rightarrow Station$$

```
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]
```

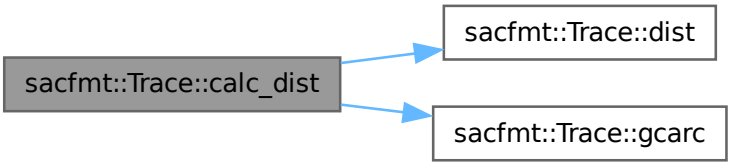
Calculate distance (using gcarc).

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

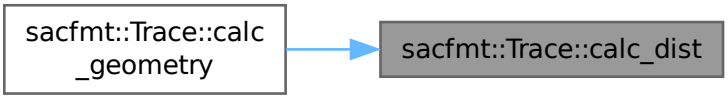
$$d = r_E \cdot \Delta$$

```
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:



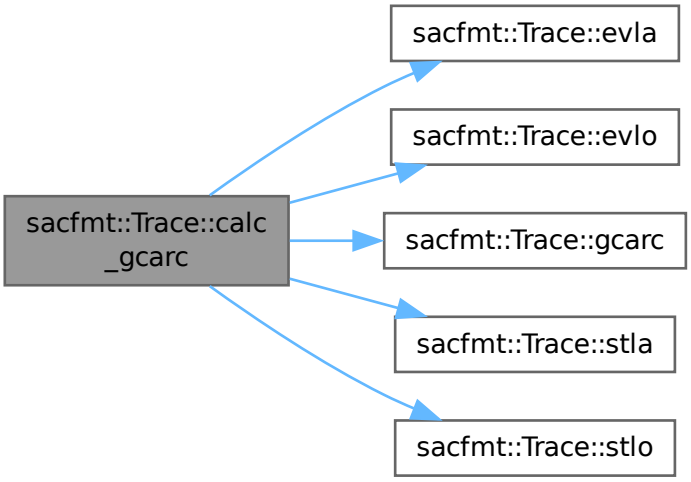
calc_gcarc()

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

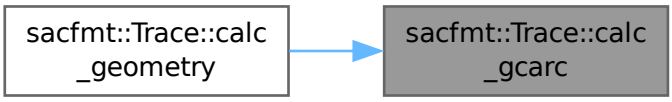
Calculate great-circle arc-distance (gcarc).

```
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:



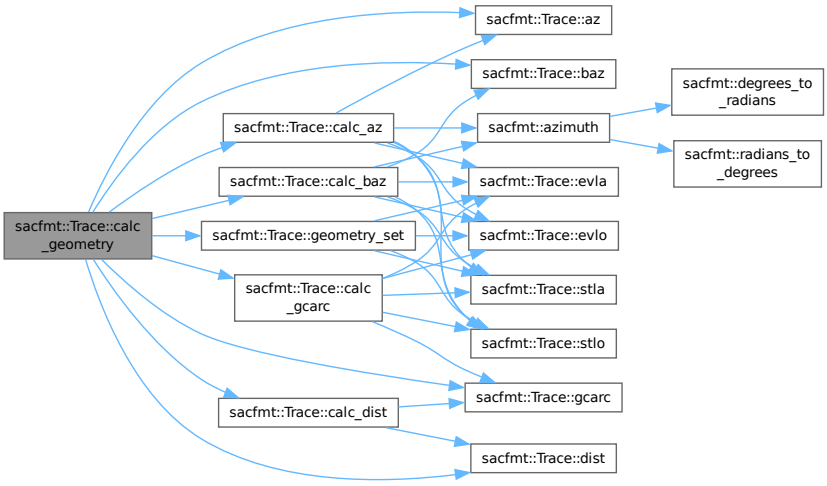
calc_geometry()

```
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 }
```

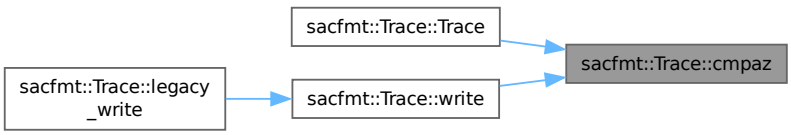
Here is the call graph for this function:



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:



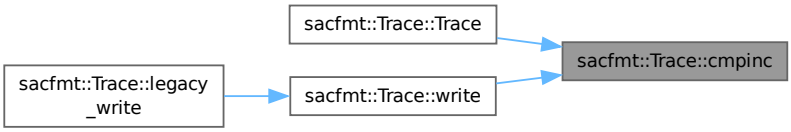
cmpaz() [2/2]

```
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:



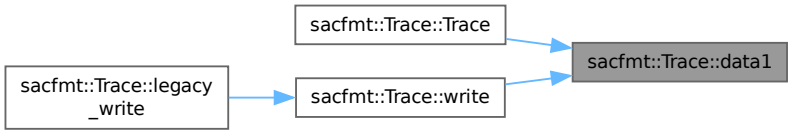
cmpinc() [2/2]

```
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:



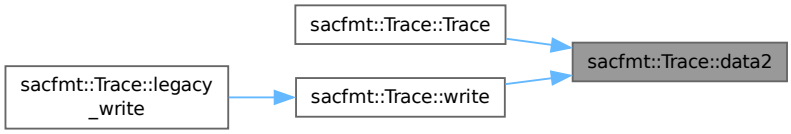
data1() [2/2]

```
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]
```

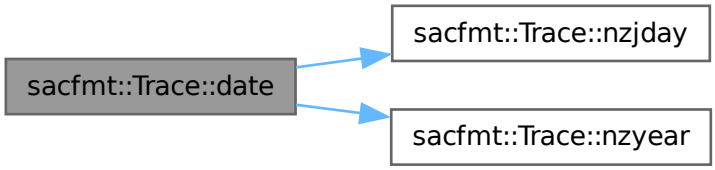
Get date string.

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 }
```

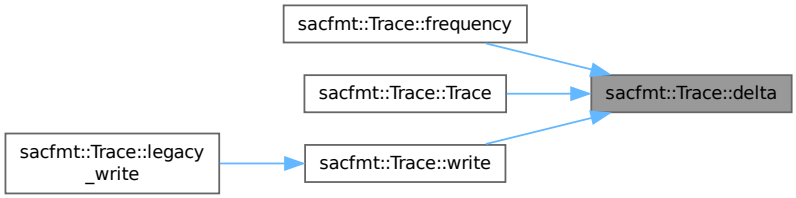
Here is the call graph for this function:



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:



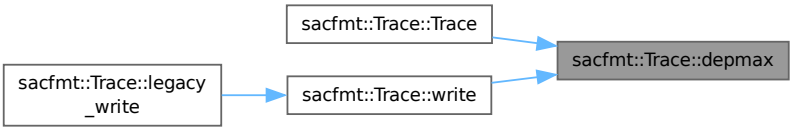
delta() [2/2]

```
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:



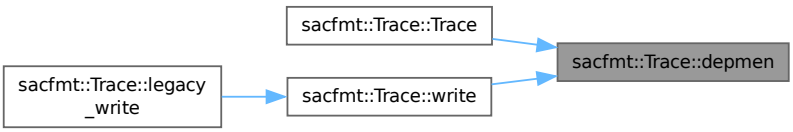
depmax() [2/2]

```
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:



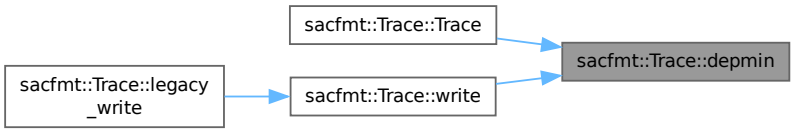
depmen() [2/2]

```
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:



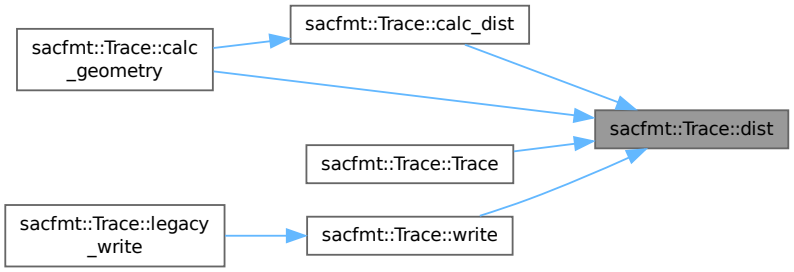
depmin() [2/2]

```
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:



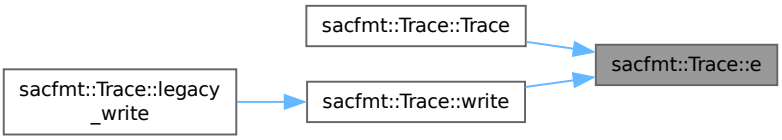
dist() [2/2]

```
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:



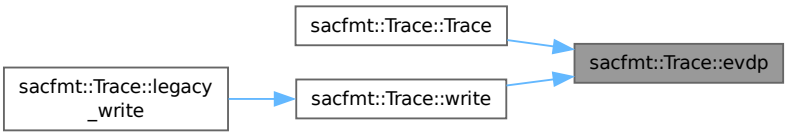
e() [2/2]

```
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:



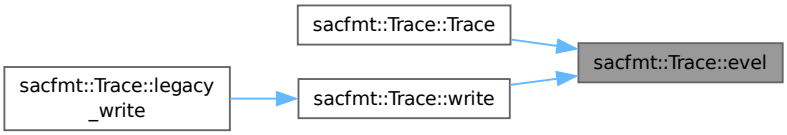
evdp() [2/2]

```
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:



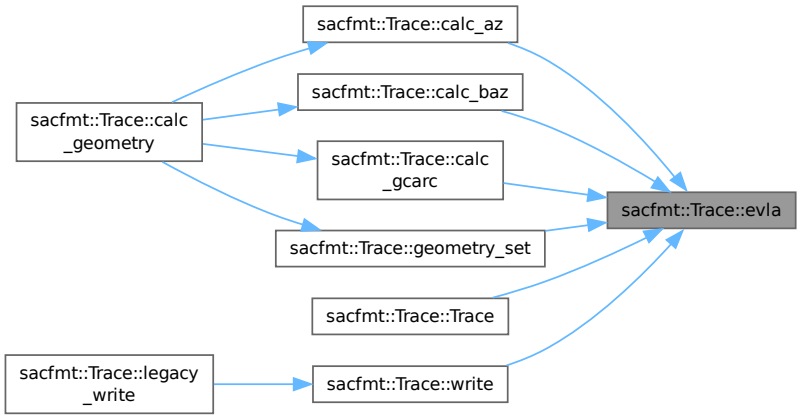
evel() [2/2]

```
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]

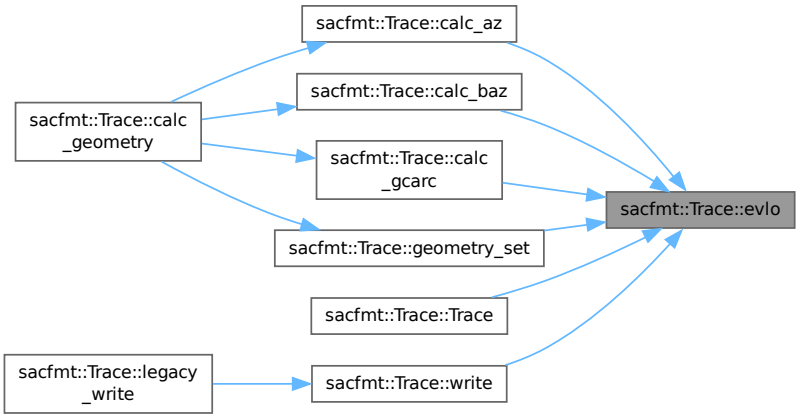
```
void sacfmt::Trace::evla (
            double input )  [noexcept]
01366                                       {
01367   if (input != unset_double) {
01368     input = limit_90(input);
01369   }
01370   doubles[sac_map.at(name::evla)] = input;
01371 }
```

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]

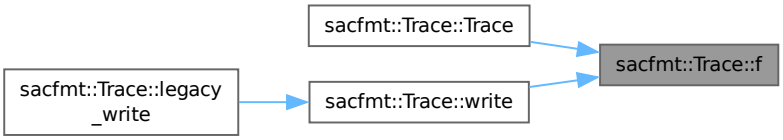
```
void sacfmt::Trace::evlo (
            double input )  [noexcept]
01372                                       {
01373   if (input != unset_double) {
01374     input = limit_180(input);
01375   }
01376   doubles[sac_map.at(name::evlo)] = input;
01377 }
```

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.

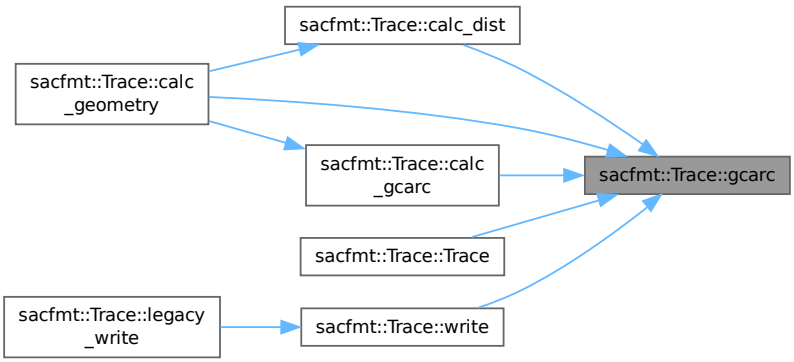
```
00896                                       {
00897   const double delta_val{delta()};
00898   if ((delta_val == unset_double) || (delta_val <= 0)) {
00899     return unset_double;
00900   }
00901   return 1.0 / delta_val;
00902 }
```

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]
```

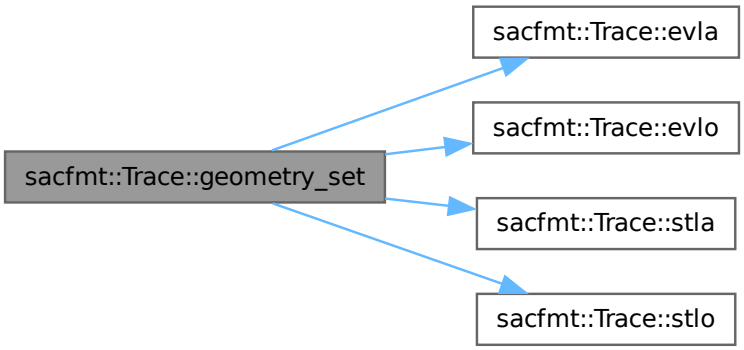
Determine if locations are set for geometry calculation.

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:

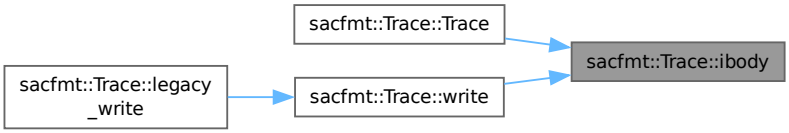


Here is the caller graph for this function:

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:



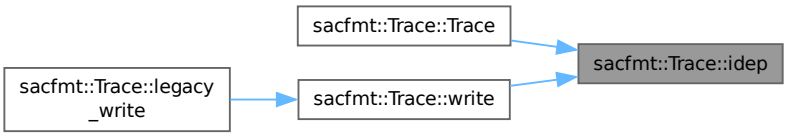
ibody() [2/2]

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



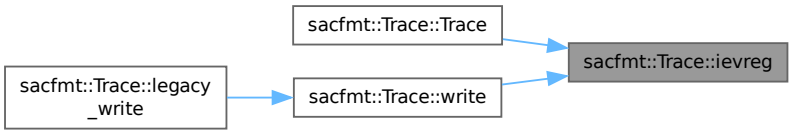
idep() [2/2]

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



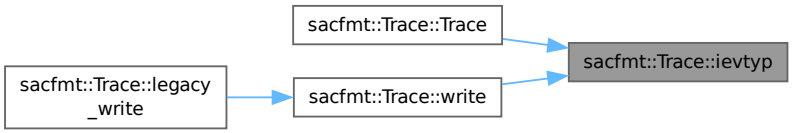
ievreg() [2/2]

```
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:



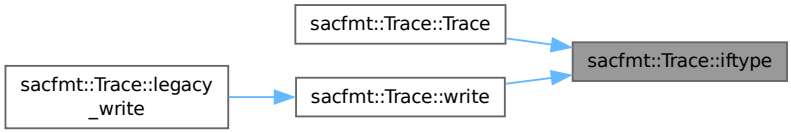
ievtyp() [2/2]

```
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:



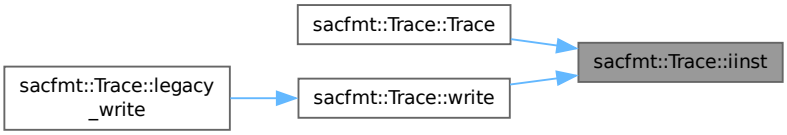
iftype() [2/2]

```
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:



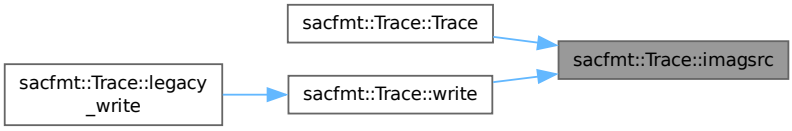
iinst() [2/2]

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

imagsrc() [1/2]

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

Here is the caller graph for this function:



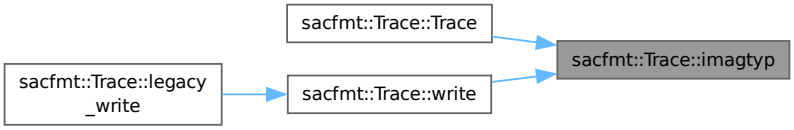
imagsrc() [2/2]

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



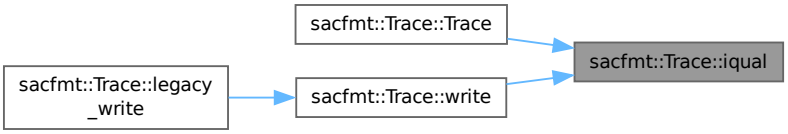
imagtyp() [2/2]

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

iqual() [1/2]

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

Here is the caller graph for this function:



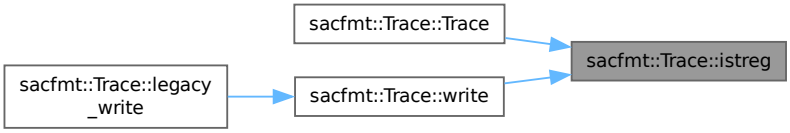
iqual() [2/2]

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



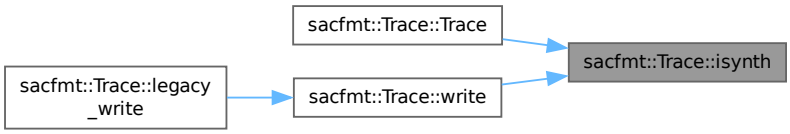
istreg() [2/2]

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

isynth() [1/2]

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

Here is the caller graph for this function:



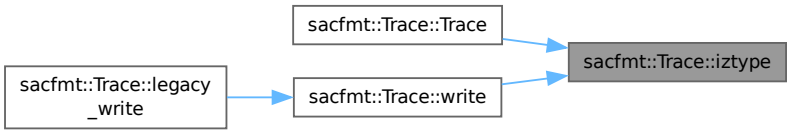
isynth() [2/2]

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



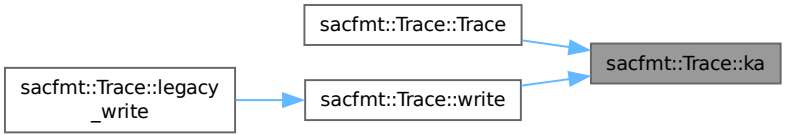
iztype() [2/2]

```
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:



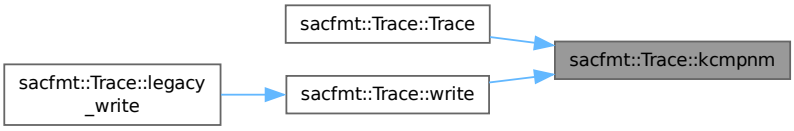
ka() [2/2]

```
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:



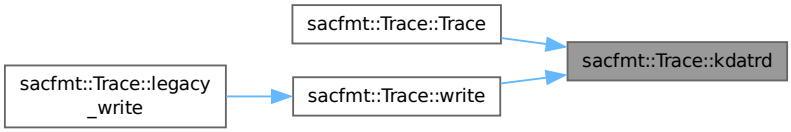
kcmpnm() [2/2]

```
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:



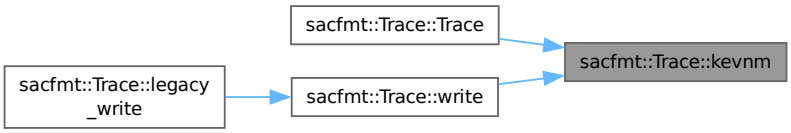
kdatrd() [2/2]

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

kevnm() [1/2]

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

Here is the caller graph for this function:



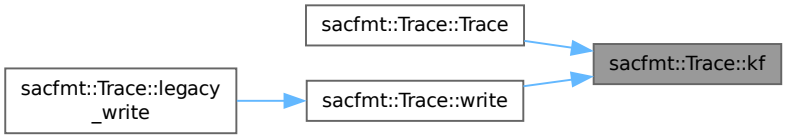
kevnm() [2/2]

```
void sacfmt::Trace::kevnm (
            const std::string & input )  [noexcept]
01496                                            {
01497   strings[sac_map.at(name::kevnm)] = 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:



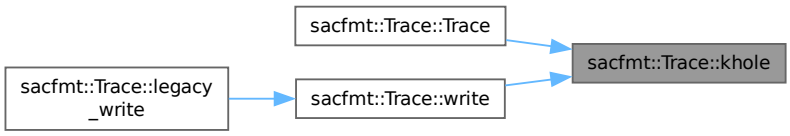
kf() [2/2]

```
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:



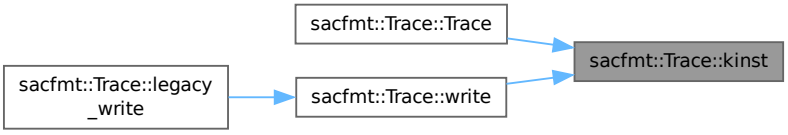
khole() [2/2]

```
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:



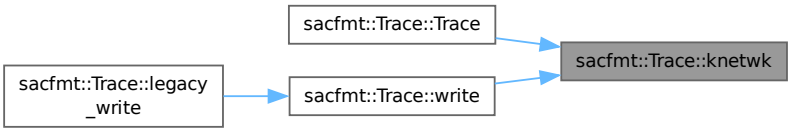
kinst() [2/2]

```
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:



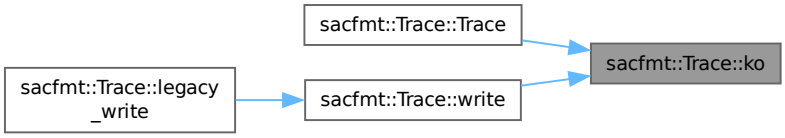
knetwk() [2/2]

```
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:



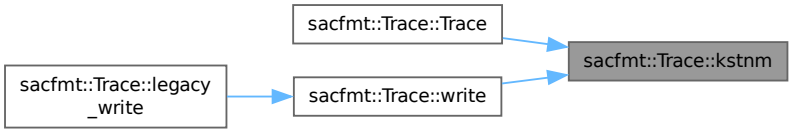
ko() [2/2]

```
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:



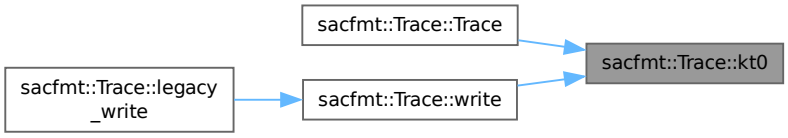
kstnm() [2/2]

```
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:



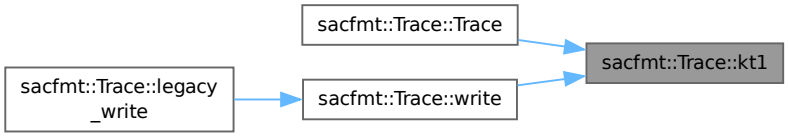
kt0() [2/2]

```
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:



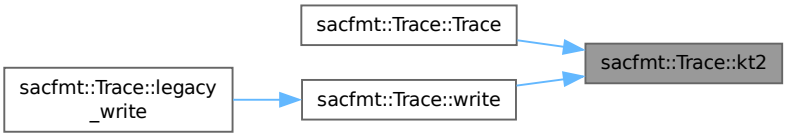
kt1() [2/2]

```
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:



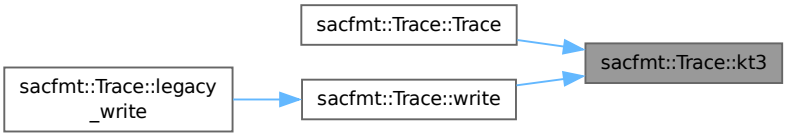
kt2() [2/2]

```
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:



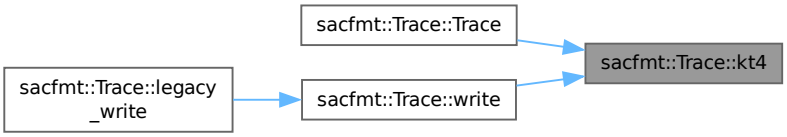
kt3() [2/2]

```
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:



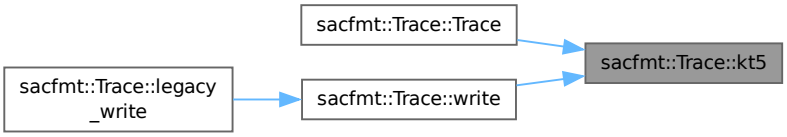
kt4() [2/2]

```
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:



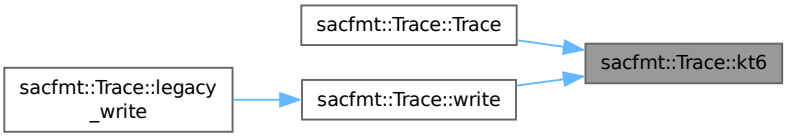
kt5() [2/2]

```
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:



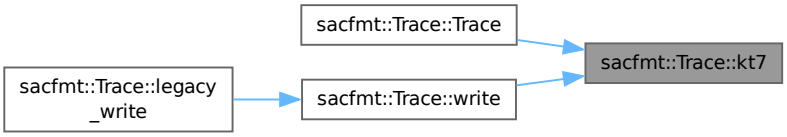
kt6() [2/2]

```
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:



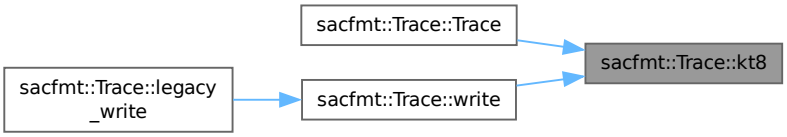
kt7() [2/2]

```
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:



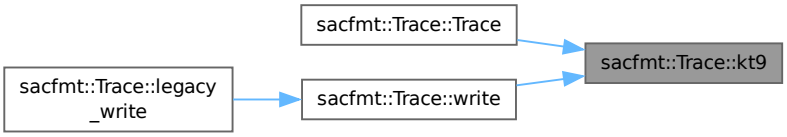
kt8() [2/2]

```
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:



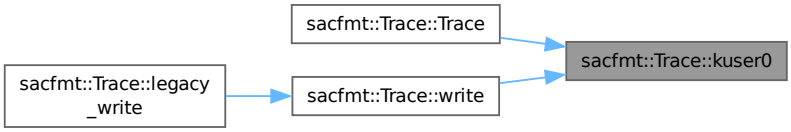
kt9() [2/2]

```
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:



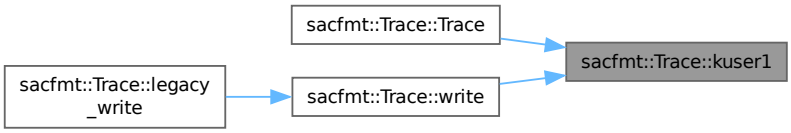
kuser0() [2/2]

```
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:



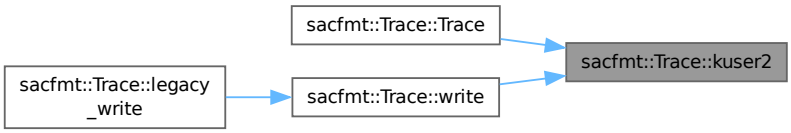
kuser1() [2/2]

```
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:



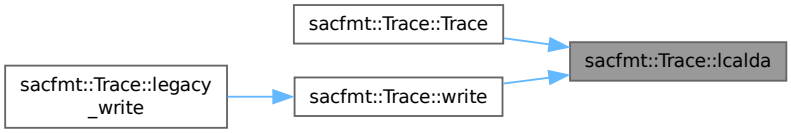
kuser2() [2/2]

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

lcalda() [1/2]

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

Here is the caller graph for this function:



lcalda() [2/2]

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

legacy_write()

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

Binary SAC-file legacy-write convenience function.

Parameters

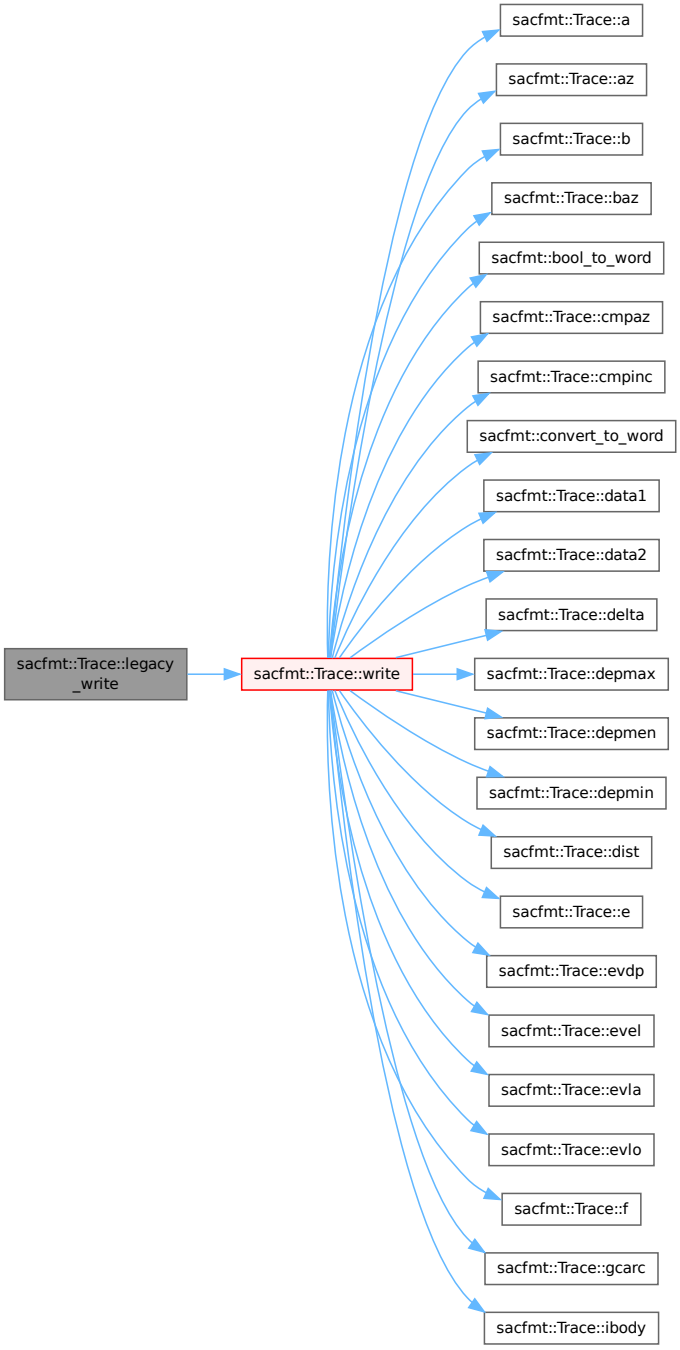
in	*path*	std::filesystem::path SAC-file to be written.

Exceptions

io_error	If the file cannot be written (bad path or bad permissions).
std::execption	Other unwritable issues (not enough space, disk failure, etc.).

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

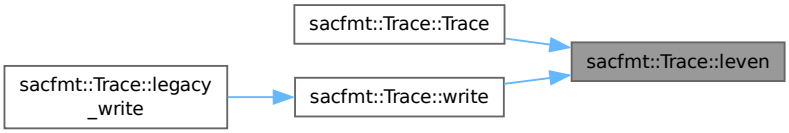
Here is the call graph for this function:



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:



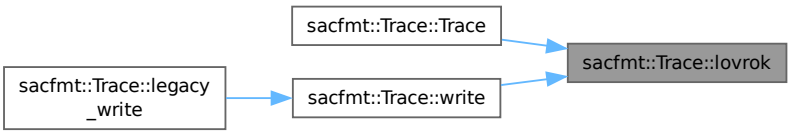
leven() [2/2]

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



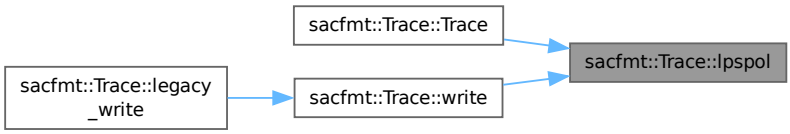
lovrok() [2/2]

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



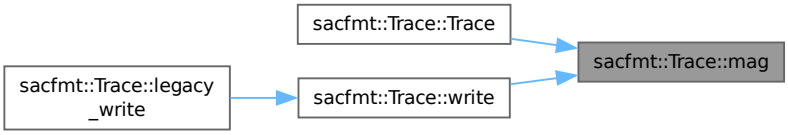
lpspol() [2/2]

```
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:



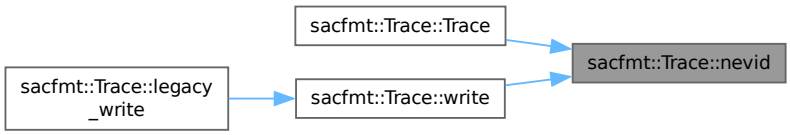
mag() [2/2]

```
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:



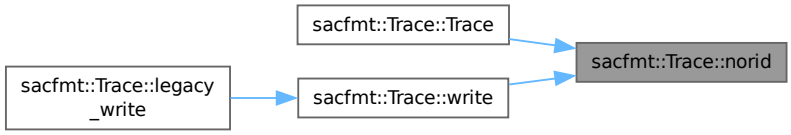
nevid() [2/2]

```
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:



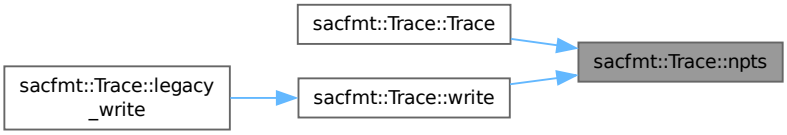
norid() [2/2]

```
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:



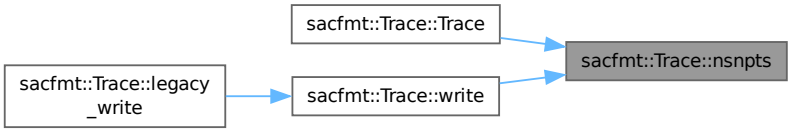
npts() [2/2]

```
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:



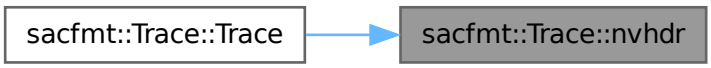
nsnpts() [2/2]

```
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:



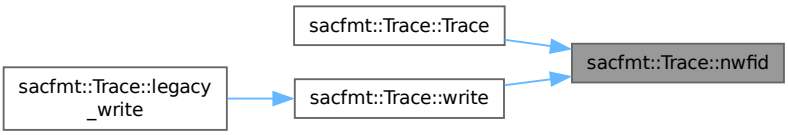
nvhdr() [2/2]

```
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:



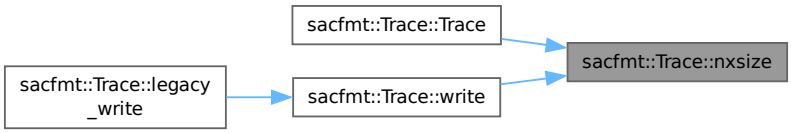
nwfid() [2/2]

```
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:



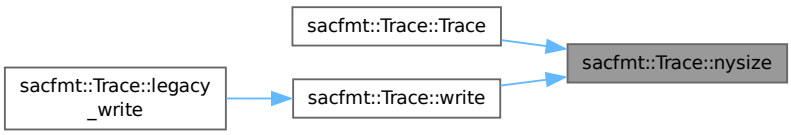
nxsize() [2/2]

```
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:



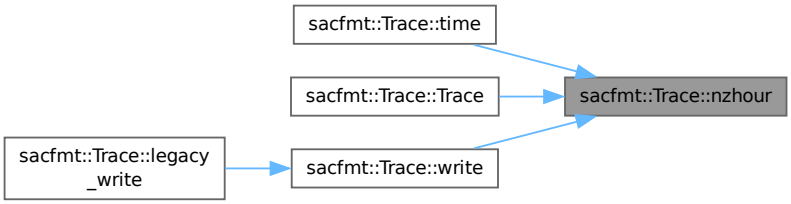
nysize() [2/2]

```
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:



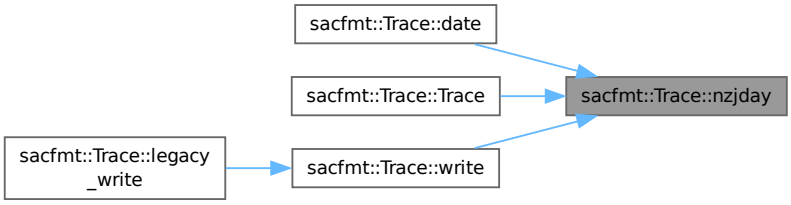
nzhour() [2/2]

```
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:



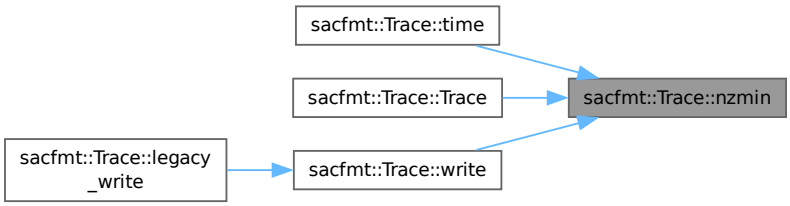
nzjday() [2/2]

```
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:



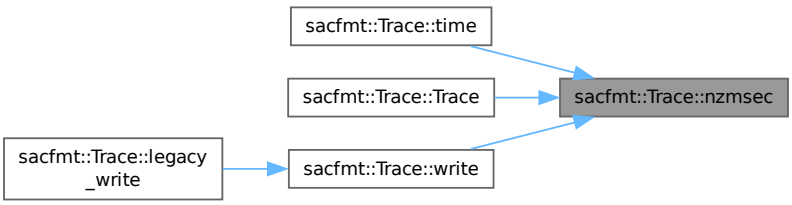
nzmin() [2/2]

```
void sacfmt::Trace::nzmin (
            int input )  [noexcept]
01394                                       {
01395   ints[sac_map.at(name::nzmin)] = input;
01396 }
```

nzmsec() [1/2]

```
int sacfmt::Trace::nzmsec ( ) const  [noexcept]
01089 { return ints[sac_map.at(name::nzmsec)]; }
```

Here is the caller graph for this function:



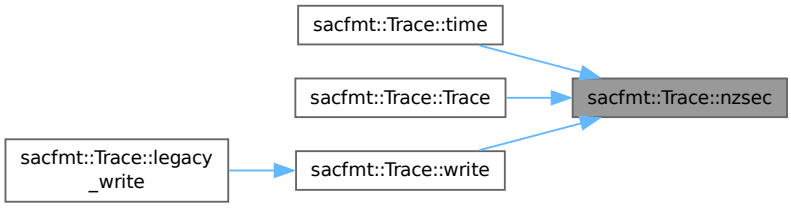
nzmsec() [2/2]

```
void sacfmt::Trace::nzmsec (
            int input )  [noexcept]
01400                                        {
01401   ints[sac_map.at(name::nzmsec)] = 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:



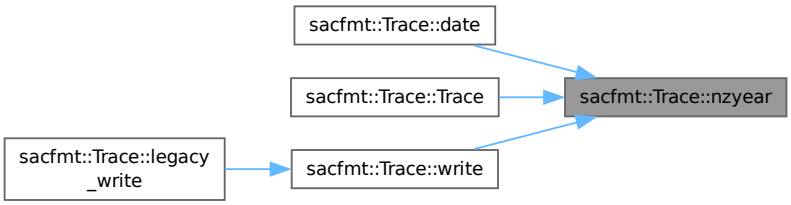
nzsec() [2/2]

```
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:



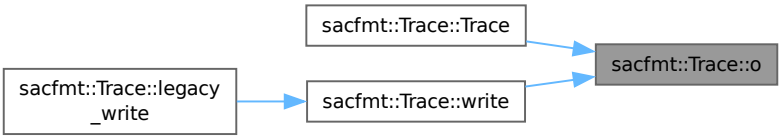
nzyear() [2/2]

```
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:



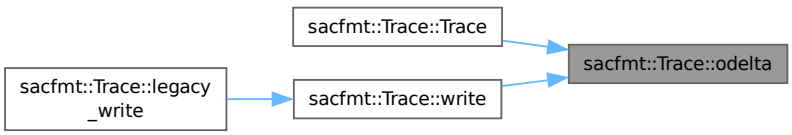
o() [2/2]

```
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

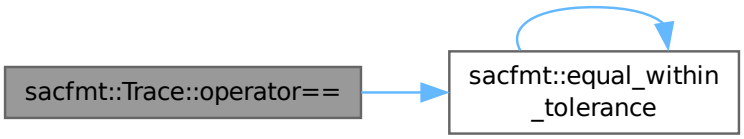
in	*this*	First Trace in comparison (LHS).
in	*other*	Second Trace in comparison (RHS).

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 }
```

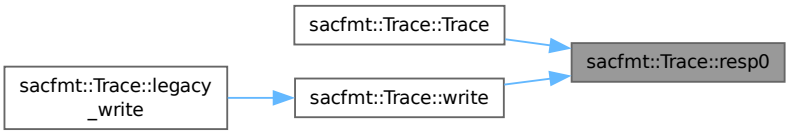
resize_data2()

```
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:



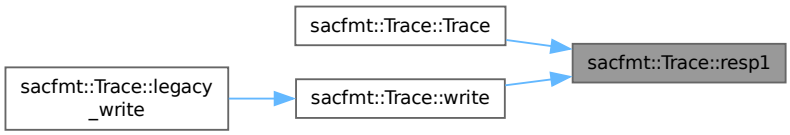
resp0() [2/2]

```
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:



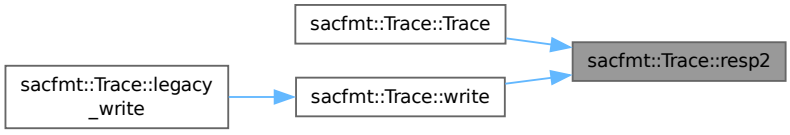
resp1() [2/2]

```
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:



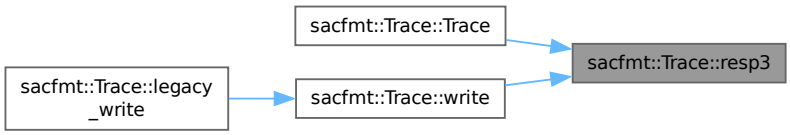
resp2() [2/2]

```
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:



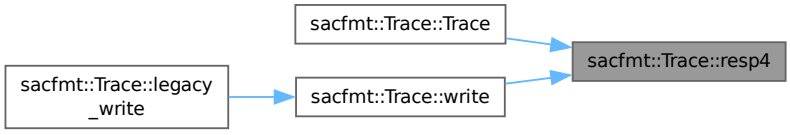
resp3() [2/2]

```
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:



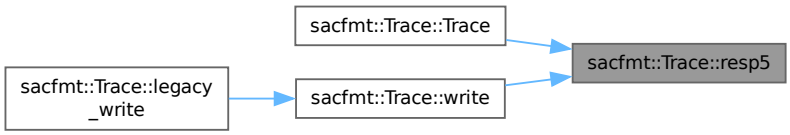
resp4() [2/2]

```
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:



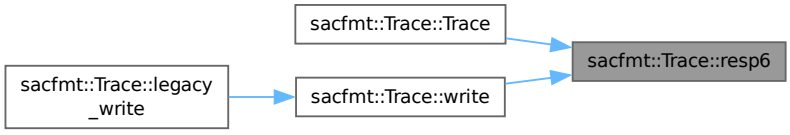
resp5() [2/2]

```
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:



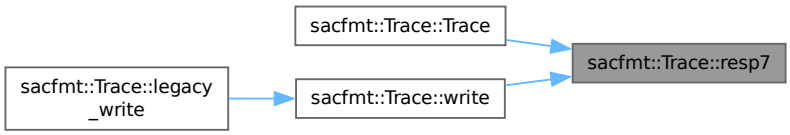
resp6() [2/2]

```
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:



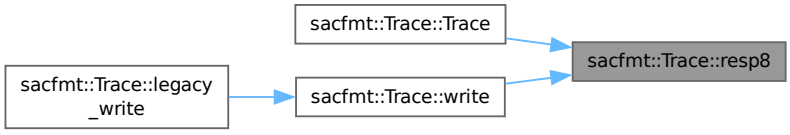
resp7() [2/2]

```
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:



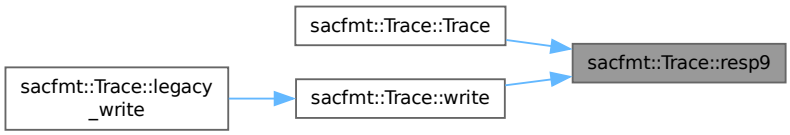
resp8() [2/2]

```
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:



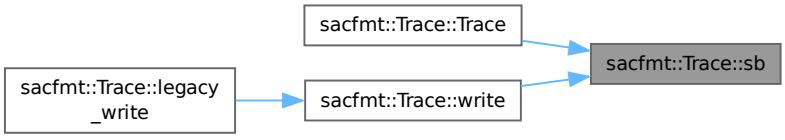
resp9() [2/2]

```
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:



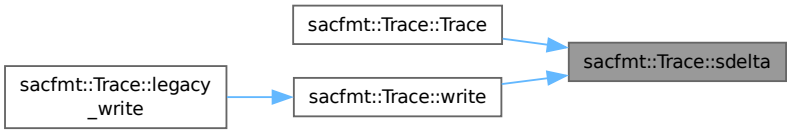
sb() [2/2]

```
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:



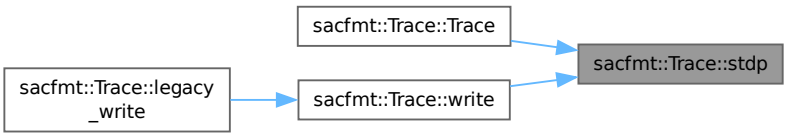
sdelta() [2/2]

```
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:



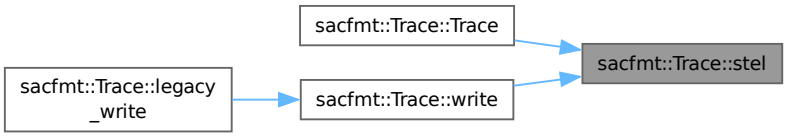
stdp() [2/2]

```
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:



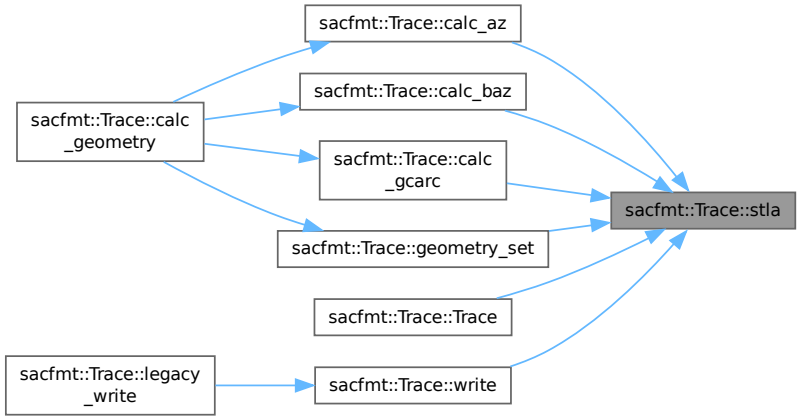
stel() [2/2]

```
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]

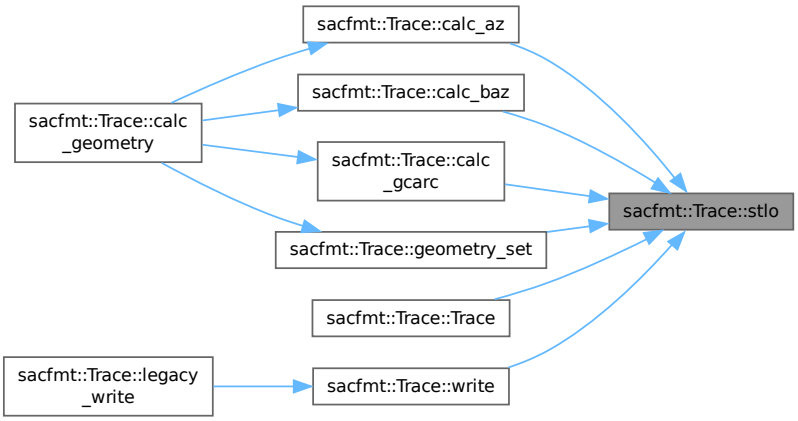
```
void sacfmt::Trace::stla (
            double input )  [noexcept]
01354                                   {
01355   if (input != unset_double) {
01356     input = limit_90(input);
01357   }
01358   doubles[sac_map.at(name::stla)] = input;
01359 }
```

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)]; }
```

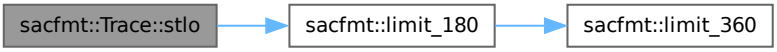
Here is the caller graph for this function:



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 }
```

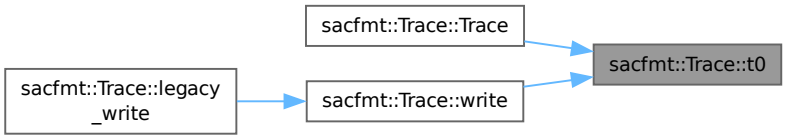
Here is the call graph for this function:



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:



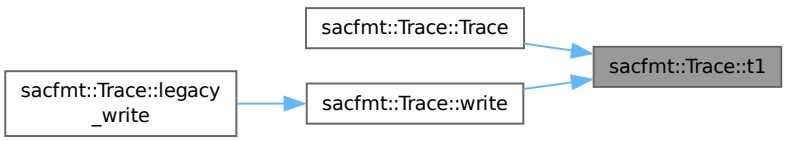
t0() [2/2]

```
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:



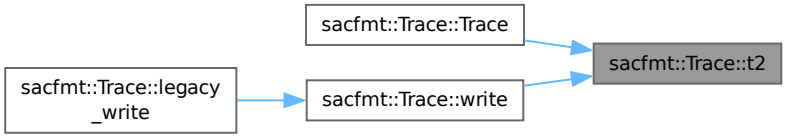
t1() [2/2]

```
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:



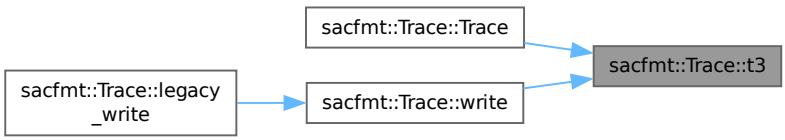
t2() [2/2]

```
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:



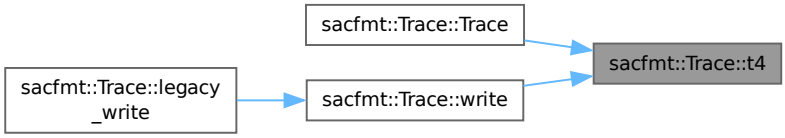
t3() [2/2]

```
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:



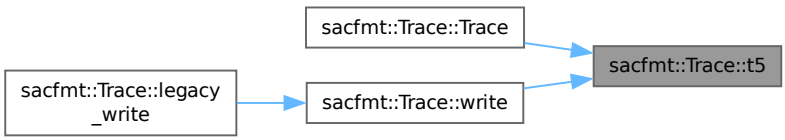
t4() [2/2]

```
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:



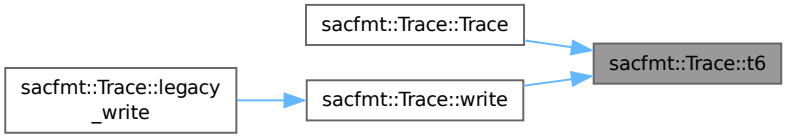
t5() [2/2]

```
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:



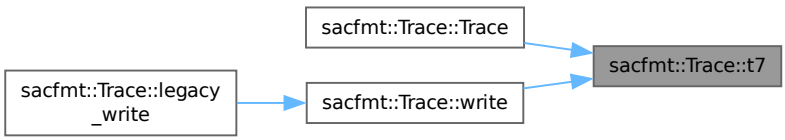
t6() [2/2]

```
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:



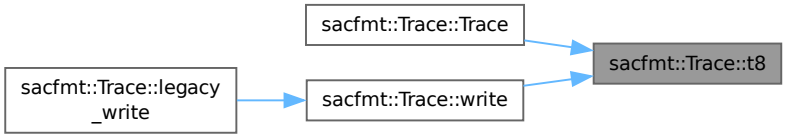
t7() [2/2]

```
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:



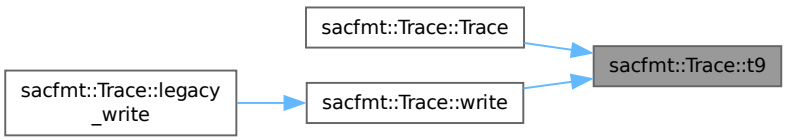
t8() [2/2]

```
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]
```

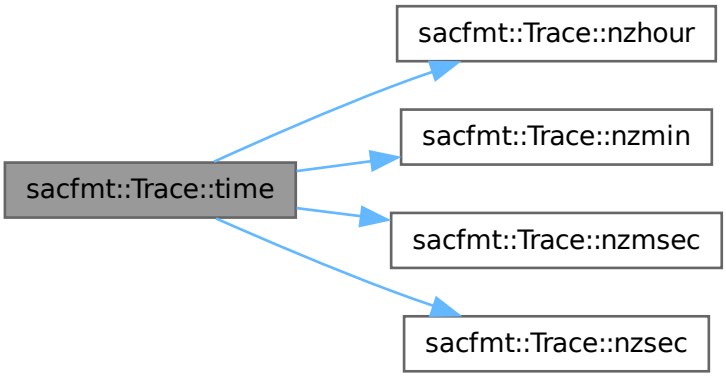
Get time string.

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 }
```

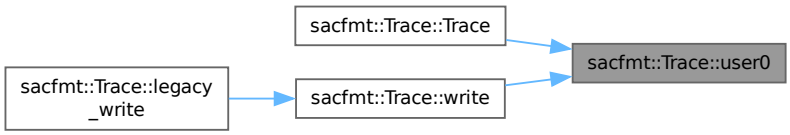
Here is the call graph for this function:



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:



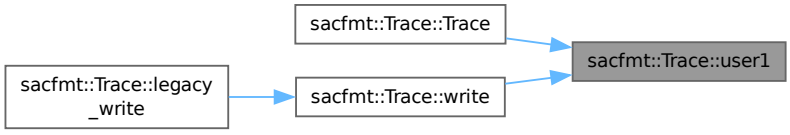
user0() [2/2]

```
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:



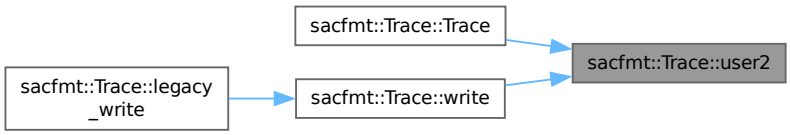
user1() [2/2]

```
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:



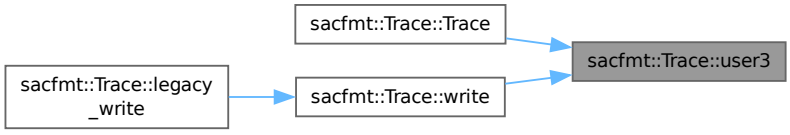
user2() [2/2]

```
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:



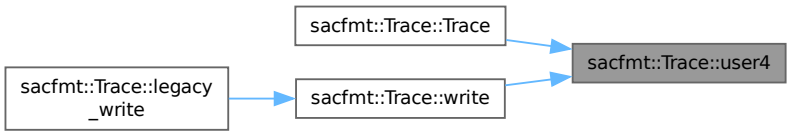
user3() [2/2]

```
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:



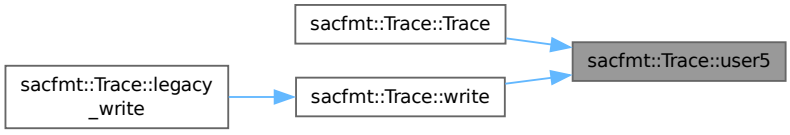
user4() [2/2]

```
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:



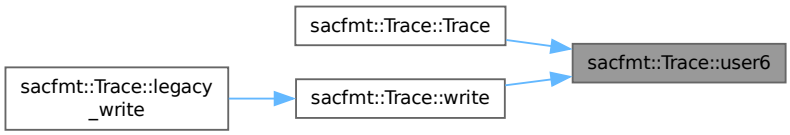
user5() [2/2]

```
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:



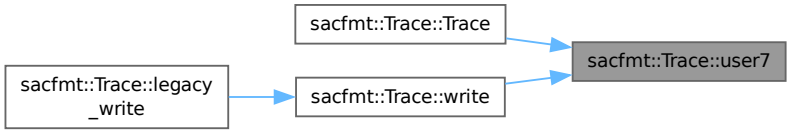
user6() [2/2]

```
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:



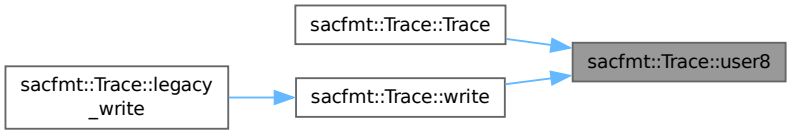
user7() [2/2]

```
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:



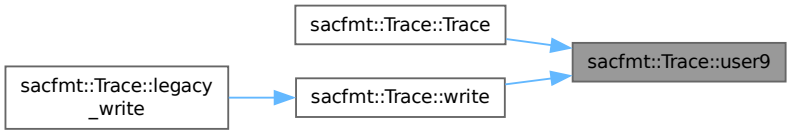
user8() [2/2]

```
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	*path*	std::filesystem::path SAC-file to write.
in	*legacy*	bool Legacy-write flag (default false = v7, true = v6).

Exceptions

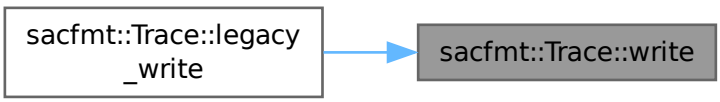
io_error	If the file cannot be written (bad path or bad permissions).
std::exception	Other unwritable issues (not enough space, disk failure, etc.).

```
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(evdp()));
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(iftype()));
02048   write_words(&file, convert_to_word(idep()));
02049   write_words(&file, convert_to_word(iztype()));
02050   // Fill 'unused'
02051   write_words(&file, convert_to_word(iztype()));
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(iqual()));
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(lpspol()));
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)>(kevnm(), 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 }
```

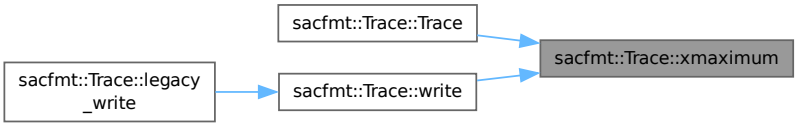
Here is the caller graph for this function:



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:



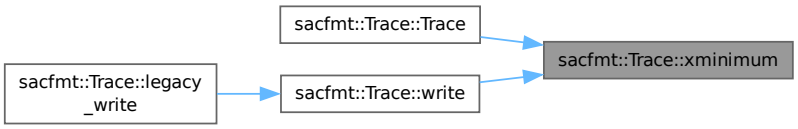
xmaximum() [2/2]

```
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:



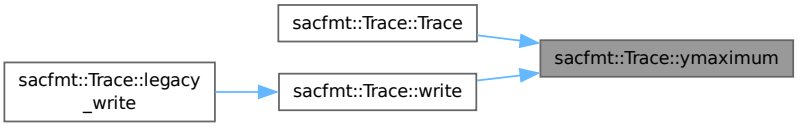
xminimum() [2/2]

```
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:



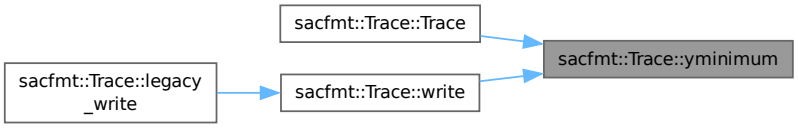
ymaximum() [2/2]

```
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 }
```

7.3.4 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

7.4 sacfmt::bitset_type::uint< nbits > Struct Template Reference

Ensure type-safety for conversions between floats/doubles and bitsets.

`#include <sac_format.hpp>`

7.4.1 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

7.5 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

7.5.1 Detailed Description

Two-word type-safety (strings).

7.5.2 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

7.6 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

7.6.1 Detailed Description

Four-word type-safety (kEvNm).

7.6.2 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

7.7 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

7.7.1 Detailed Description

Single-word type-safety (non-strings).

7.7.2 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

7.8 sacfmt::bitset_type::uint< bytes *bits_per_byte > Struct Reference

`#include <sac_format.hpp>`

Public Types

- using type = uint64_t

7.8.1 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

7.9 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.

7.9.1 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.

7.9.2 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

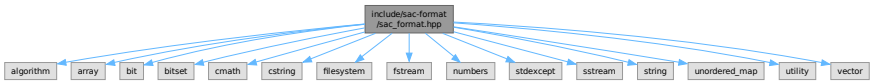
8 File Documentation

8.1 include/sac-format/sac_format.hpp File Reference

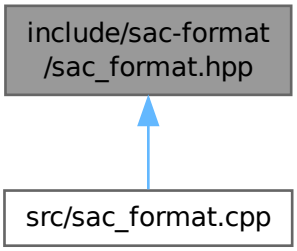
Interface of the sac-format library.

```
#include <algorithm>
#include <array>
#include <bit>
#include <bitset>
#include <cmath>
#include <cstring>
#include <filesystem>
#include <fstream>
#include <numbers>
#include <stdexcept>
#include <sstream>
#include <string>
#include <unordered_map>
#include <utility>
#include <vector>
```

Include dependency graph for sac_format.hpp:



This graph shows which files directly or indirectly include this file:



Classes

- struct sacfmt::bitset_type::uint< nbits >

  Ensure type-safety for conversions between floats/doubles and bitsets.
- struct sacfmt::bitset_type::uint< bits_per_byte >

  Single-word type-safety (non-strings).
- struct sacfmt::bitset_type::uint< 2 ∗bits_per_byte >

  Two-word type-safety (strings).
- struct sacfmt::bitset_type::uint< 4 ∗bits_per_byte >

  Four-word type-safety (kEvNm).
- struct sacfmt::bitset_type::uint< bytes ∗bits_per_byte >
- struct sacfmt::word_pair< T >

  Struct containing a pair of words.
- struct sacfmt::read_spec

  Struct that specifies parameters for reading.
- class sacfmt::Trace

  The Trace class.
- class sacfmt::io_error

  Class for generic I/O exceptions.

Namespaces

- namespace sacfmt

  sac-format namespace
- namespace sacfmt::bitset_type

  bitset type-safety namespace.

Typedefs

- using sacfmt::char_bit = std::bitset< bits_per_byte >

  One binary character (useful for building strings).
- using sacfmt::word_one = std::bitset< binary_word_size >

  One binary word (useful for non-strings).
- using sacfmt::word_two = std::bitset< static_cast< size_t >(2) *binary_word_size >

  Two binary words (useful for strings).
- using sacfmt::word_four = std::bitset< static_cast< size_t >(4) *binary_word_size >

  Four binary words (kEvNm only).
- template<class T >
  using sacfmt::unsigned_int = typename bitset_type::uint< sizeof(T) *bits_per_byte >::type

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

Enumerations

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

  Enumeration of all SAC fields.

Functions

- std::streamoff sacfmt::word_position (const size_t word_number) noexcept

  Calculates position of word in SAC-file.
- word_one sacfmt::uint_to_binary (uint num) noexcept

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

- word_one sacfmt::int_to_binary (int num) noexcept
  Convert integer to 32-bit (one word) binary bitset.
- int sacfmt::binary_to_int (word_one bin) noexcept
  Convert 32-bit (one word) binary bitset to integer.
- word_one sacfmt::float_to_binary (const float num) noexcept
  Convert floating-point value to 32-bit (one word) binary bitset.
- float sacfmt::binary_to_float (const word_one &bin) noexcept
  Convert 32-bit (one word) binary bitset to a floating-point value.
- word_two sacfmt::double_to_binary (const double num) noexcept
  Convert double-precision value to 64-bit (two words) binary bitset.
- double sacfmt::binary_to_double (const word_two &bin) noexcept
  Convert 64-bit (two words) binary bitset to double-precision value.
- void sacfmt::remove_leading_spaces (std::string *str) noexcept
  Remove all leading spaces from a string.
- void sacfmt::remove_trailing_spaces (std::string *str) noexcept
  Remove all trailing spaces from a string.
- std::string sacfmt::string_cleaning (const std::string &str) noexcept
  Remove leading/trailing spaces and control characters from a string.
- void sacfmt::prep_string (std::string *str, const size_t str_size) noexcept
  Cleans string and then truncates/pads as necessary.
- 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.
- 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.
- word_two sacfmt::string_to_binary (std::string str) noexcept
  Convert string to a 64-bit (two word) binary bitset.
- std::string sacfmt::binary_to_string (const word_two &str) noexcept
  Convert a 64-bit (two word) binary bitset to a string.
- word_four sacfmt::long_string_to_binary (std::string str) noexcept
  Convert a string to a 128-bit (four word) binary bitset.
- std::string sacfmt::binary_to_long_string (const word_four &str) noexcept
  Convert a 128-bit (four word) binary bitset to a string.
- word_one sacfmt::bool_to_binary (const bool flag) noexcept
  Convert a boolean to a 32-bit (one word) binary bitset.
- bool sacfmt::binary_to_bool (const word_one &flag) noexcept
  Convert a 32-bit (one word) binary bitset to a boolean.
- 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.
- 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.
- 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.
- void sacfmt::safe_to_read_header (std::ifstream *sac)
  Determine if the SAC-file is large enough to contain a complete header.
- void sacfmt::safe_to_read_footer (std::ifstream *sac)
  Determines if the SAC-file has enough space remaining to contain a complete footer.
- 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.
- void sacfmt::safe_to_finish_reading (std::ifstream *sac)

Determines if the SAC-file is finished.

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

  Read one word (32 bits, useful for non-strings) from a binary SAC-File.
- word_two sacfmt::read_two_words (std::ifstream *sac)

  Read two words (64 bits, useful for most strings) from a binary SAC-file.
- word_four sacfmt::read_four_words (std::ifstream *sac)

  Read four words (128 bits, kEvNm only) from a binary SAC-file.
- 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.
- 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.
- 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.
- std::vector< char > sacfmt::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 > 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.
- std::vector< char > sacfmt::bool_to_word (const bool flag) noexcept

  Convert boolean to a word for writing.
- 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.
- 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.
- double sacfmt::degrees_to_radians (const double degrees) noexcept

  Convert decimal degrees to radians.
- double sacfmt::radians_to_degrees (const double radians) noexcept

  Convert radians to decimal degrees.
- 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.
- double sacfmt::azimuth (const double latitude1, const double longitude1, const double latitude2, const double longitude2) noexcept

  Calculate azimuth between two points.
- double sacfmt::limit_360 (const double degrees) noexcept

  Takes a decimal degree value and constrains it to full circle using symmetry.
- double sacfmt::limit_180 (const double degrees) noexcept

  Takes a decimal degree value and constrains it to a half circle using symmetry.
- double sacfmt::limit_90 (const double degrees) noexcept

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

Variables

- constexpr size_t sacfmt::word_length {4}

  Size (bytes) of fundamental data-chunk.
- constexpr size_t sacfmt::bits_per_byte {8}

  Size (bits) of binary character.
- constexpr size_t sacfmt::binary_word_size {word_length * bits_per_byte}

  Size (bits) of funamental data-chunk.

- constexpr std::streamoff sacfmt::data_word {158}

  First word of (first) data-section (stream offset).
- constexpr int sacfmt::unset_int {-12345}

  Integer unset value (SAC Magic).
- constexpr float sacfmt::unset_float {-12345.0F}

  Float-point unset value (SAC Magic).
- constexpr double sacfmt::unset_double {-12345.0}

  Double-precision unset value (SAC Magic).
- constexpr bool sacfmt::unset_bool {false}

  Boolean unset value (SAC Magic).
- const std::string sacfmt::unset_word {"-12345"}

  String unset value (SAC Magic).
- constexpr float sacfmt::f_eps {2.75e-6F}

  Accuracy precision expected of SAC floating-point values.
- constexpr int sacfmt::ascii_space {32}

  ASCII-code of 'space' character.
- constexpr int sacfmt::num_float {39}

  Number of float-poing header values in SAC format.
- constexpr int sacfmt::num_double {22}

  Number of double-precision header values in SAC format.
- constexpr int sacfmt::num_int {26}

  Number of integer header values in SAC format.
- constexpr int sacfmt::num_bool {4}

  Number of boolean header values in SAC format.
- constexpr int sacfmt::num_string {23}

  Number of string header values in SAC format.
- constexpr int sacfmt::num_data {2}

  Number of data arrays in SAC format.
- constexpr int sacfmt::num_footer {22}

  Number of double-precision footer values in SAC format (version 7).
- constexpr int sacfmt::modern_hdr_version {7}

  nVHdr value for newest SAC format (2020+).
- constexpr int sacfmt::old_hdr_version {6}

  nVHdr value for historic SAC format (pre-2020).
- constexpr int sacfmt::common_skip_num {7}

  Extremely common number of 'internal use' headers in SAC format.
- constexpr double sacfmt::rad_per_deg {std::numbers::pi_v<double> / 180.0}

  Radians per degree.
- constexpr double sacfmt::deg_per_rad {1.0 / rad_per_deg}

  Degrees per radian.
- constexpr double sacfmt::circle_deg {360.0}

  Degrees in a circle.
- constexpr double sacfmt::earth_radius {6378.14}

  Average radius of Earth (kilometers).
- constexpr int sacfmt::bitset_type::bytes {8}

  ? type-safety?
- const std::unordered_map< name, const size_t > sacfmt::sac_map

  Lookup table for variable locations.

8.1.1 Detailed Description

Interface of the sac-format library.

Author

Alexander R. Blanchette

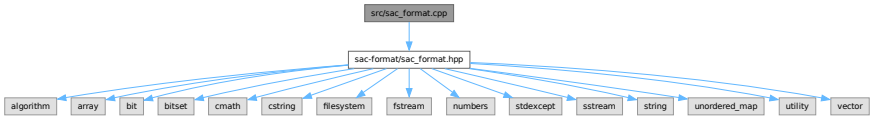
This file is the interface for sac-format library. Everything in this file is targeted for testing coverage.

8.2 src/docs/index.md File Reference

8.3 src/sac_format.cpp File Reference

Implementation of the sac-format library.

```
#include "sac-format/sac_format.hpp"
```
Include dependency graph for sac_format.cpp:



Namespaces

- namespace sacfmt

  sac-format namespace

Functions

- std::streamoff sacfmt::word_position (const size_t word_number) noexcept

  Calculates position of word in SAC-file.
- word_one sacfmt::uint_to_binary (uint num) noexcept

  Convert unsigned integer to 32-bit (one word) binary bitset.
- word_one sacfmt::int_to_binary (int num) noexcept

  Convert integer to 32-bit (one word) binary bitset.
- int sacfmt::binary_to_int (word_one bin) noexcept

  Convert 32-bit (one word) binary bitset to integer.
- word_one sacfmt::float_to_binary (const float num) noexcept

  Convert floating-point value to 32-bit (one word) binary bitset.
- float sacfmt::binary_to_float (const word_one &bin) noexcept

  Convert 32-bit (one word) binary bitset to a floating-point value.
- word_two sacfmt::double_to_binary (const double num) noexcept

  Convert double-precision value to 64-bit (two words) binary bitset.
- double sacfmt::binary_to_double (const word_two &bin) noexcept

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

- void sacfmt::remove_leading_spaces (std::string *str) noexcept

  Remove all leading spaces from a string.
- void sacfmt::remove_trailing_spaces (std::string *str) noexcept

  Remove all trailing spaces from a string.
- std::string sacfmt::string_cleaning (const std::string &str) noexcept

  Remove leading/trailing spaces and control characters from a string.
- void sacfmt::prep_string (std::string *str, const size_t str_size) noexcept

  Cleans string and then truncates/pads as necessary.
- 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.
- 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.
- word_two sacfmt::string_to_binary (std::string str) noexcept

  Convert string to a 64-bit (two word) binary bitset.
- std::string sacfmt::binary_to_string (const word_two &str) noexcept

  Convert a 64-bit (two word) binary bitset to a string.
- word_four sacfmt::long_string_to_binary (std::string str) noexcept

  Convert a string to a 128-bit (four word) binary bitset.
- std::string sacfmt::binary_to_long_string (const word_four &str) noexcept

  Convert a 128-bit (four word) binary bitset to a string.
- word_one sacfmt::bool_to_binary (const bool flag) noexcept

  Convert a boolean to a 32-bit (one word) binary bitset.
- bool sacfmt::binary_to_bool (const word_one &flag) noexcept

  Convert a 32-bit (one word) binary bitset to a boolean.
- 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.
- 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.
- word_one sacfmt::read_word (std::ifstream *sac)

  Read one word (32 bits, useful for non-strings) from a binary SAC-File.
- word_two sacfmt::read_two_words (std::ifstream *sac)

  Read two words (64 bits, useful for most strings) from a binary SAC-file.
- word_four sacfmt::read_four_words (std::ifstream *sac)

  Read four words (128 bits, kEvNm only) from a binary SAC-file.
- 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.
- 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.
- 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.
- template std::vector< char > sacfmt::convert_to_word (const float input) noexcept
- template std::vector< char > sacfmt::convert_to_word (const int x) noexcept
- std::vector< char > sacfmt::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 > 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.

- template std::array< char, word_length > sacfmt::convert_to_words (const std::string &str, const int n_words) noexcept
- std::vector< char > sacfmt::bool_to_word (const bool flag) noexcept

  Convert boolean to a word for writing.
- 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.
- 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.
- double sacfmt::degrees_to_radians (const double degrees) noexcept

  Convert decimal degrees to radians.
- double sacfmt::radians_to_degrees (const double radians) noexcept

  Convert radians to decimal degrees.
- 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.
- double sacfmt::azimuth (const double latitude1, const double longitude1, const double latitude2, const double longitude2) noexcept

  Calculate azimuth between two points.
- double sacfmt::limit_360 (const double degrees) noexcept

  Takes a decimal degree value and constrains it to full circle using symmetry.
- double sacfmt::limit_180 (const double degrees) noexcept

  Takes a decimal degree value and constrains it to a half circle using symmetry.
- double sacfmt::limit_90 (const double degrees) noexcept

  Takes a decimal degree value and constrains it to a quarter circle using symmetry.
- 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.
- void sacfmt::safe_to_read_header (std::ifstream *sac)

  Determine if the SAC-file is large enough to contain a complete header.
- void sacfmt::safe_to_read_footer (std::ifstream *sac)

  Determines if the SAC-file has enough space remaining to contain a complete footer.
- 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.
- void sacfmt::safe_to_finish_reading (std::ifstream *sac)

  Determines if the SAC-file is finished.

8.3.1 Detailed Description

Implementation of the sac-format library.

Author

Alexander R. Blanchette

The full implementation of the entire sac-format library. Including the Trace class, all methods, and all functions. Everything in this file is targeted for testing coverage.

Index