Calends: Documented

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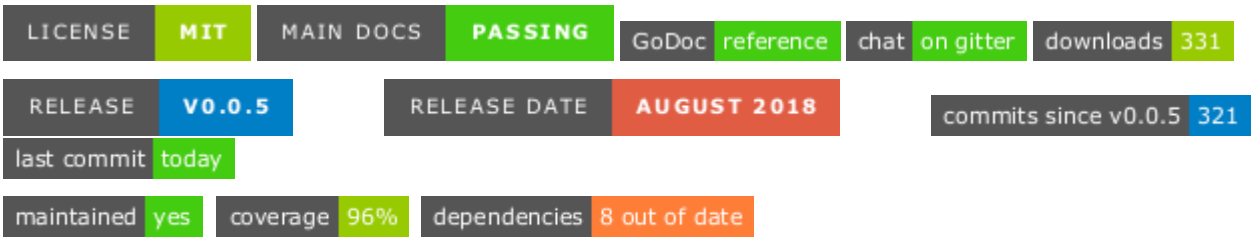

Calends is a library for handling dates and times across arbitrary calendar systems. It has a number of features essential to handling dates and times in any supported system, as well as the ability to add support for more systems easily, all without touching a line of its own code. Go ahead and read through the documentation here to learn more!

CHAPTER

ONE

INTRODUCTION

As mentioned before, Calends is a library for handling dates and times across arbitrary calendar systems. But what does that actually mean?

Let's say you're working on an application that uses dates. Pretty much anything can qualify, really – we use dates in everything, throughout our daily lives. Scheduling, journaling, historical research, projections into the future, or just displaying the current date in the UI. Now let's say you want your app to be used by people all over the globe. The current approach, used for decades, is to simply use the Gregorian Calendar, which has (partially as a side effect of this decision) become the default calendar system in use across the globe, for coordinating, tracking, and preserving events worldwide.

But this decision wasn't made with internationalization and localization in mind. It was made as a result of practicality, with limited computing capabilities at the time, and persists mostly as a result of laziness – if the entire world is already using it anyway, why bother with anything else? It has also persisted out of ignorance – many people aren't aware there are other calendars out there in the first place, never mind that several are still in active use to this day. Properly localizing applications should *include* adjusting the displayed date to use the preferred calendar system of the user.

Sadly, most of the solutions currently available for handling dates (and times) in software are purpose-built for a single calendar system, and use APIs entirely different from those meant to handle dates in others. This makes it very tricky to build an application that supports more than one calendar system at a time. Each new calendar system requires hours of work to learn, connect, and usually abstract to a point where it is usable within the larger application, and even that's no guarantee the values can be stored or compared accurately.

That's what Calends set out to solve. It provides a single interface for interacting with any supported calendar system, and an easy way to extend it to support others, so that once you've added support for a calendar system once, you have that support anywhere, without having to rewrite anything to fit your next application. Additionally, you can take full advantage of any calendar system implemented by anybody else.

Accept date/time input in any calendar system, perform date/time calculations on the resulting value, again in any calendar system, and then display the result – yes, in any calendar system. Dates are stored, internally, in an extremely accurate value that can track dates out 146 *billion* years into the past or future, with a resolution of 10^{-45} seconds, which is smaller than Planck Time[1]. In other words, it should be more than sufficient to record instants of any duration and resolution desired for any conceived use case.

[1] Planck Time is the smallest meaningful unit of time, and is about 54×10^{-45} seconds. It corresponds to the amount of time it takes a photon (traveling at the speed of light through a vaccuum) to traverse one Planck Length, which itself is about 10^{-20} times the diameter of a proton. Even quantum interactions below this scale lose any meaning, and so values below them are considered extraneous, in addition to being entirely unmeasurable with current technologies and techniques.

CHAPTER

TWO

FEATURES IN CALENDS

For a current indication of which of these features are fully implemented at the moment, check the README.

- **Large range and high precision** Calends understands dates 2^{62} seconds into the future or past, in units as small as 10^{-45} seconds – that's over 146 billion years into the past or future (146 138 512 313 years, 169 days, 10 hours, 5 minutes, and 28 seconds from `CE 1970 Jan 01 00:00:00 TAI Gregorian`), at resolutions smaller than Planck Time (54×10^{-45} seconds, and the smallest meaningful duration even on the quantum scale). That encompasses well beyond the expected lifespan of the Universe, at resolutions enough to represent quantum events.
- **Supports date (and time) values in multiple calendar systems** Supported out of the box are the following (all systems are proleptic – extrapolated beyond the officially-defined limits – unless specified otherwise):
  - ***Unix time*** A count of the number of seconds since `CE 1970 Jan 01 00:00:00 UTC Gregorian`
  - ***TAI64*** Essentially Unix time plus 2^{62}, but using TAI seconds instead of UTC seconds, so times can be converted unambiguously (UTC uses leap seconds to keep the solar zenith at noon, while TAI is a simple, unadjusted count). Calends supports an extended version of this spec, with three more components, to encode out to 45 places instead of just 18; this is also actually the internal time scale used by Calends itself, which is how it can support such a broad range of dates at such a high resolution.
    - Automatic calculation of leap second offsets
    - Estimation of undefined past and future leap second insertions
    - Automatic updates for handling leap second insertions
  - ***Gregorian*** The current international standard calendar system
    - Disconnect from native `time.Time` implementation, and its limitations
  - **Julian** The previous version of the Gregorian calendar
  - ***Julian Day Count*** A count of days since `BCE 4713 Jan 01 12:00:00 UTC Julian (proleptic)`
  - **Hebrew**
  - **Persian**
  - **Chinese** Several variants
  - **Meso-American** Commonly called Mayan, but used by several cultures in the region

  - **Discordian**
  - ***Stardate*** Yes, the ones from *Star Trek*™; several variants exist

- **Encodes both time spans and instants in a single interface** The library treats the time values it encodes as `[start, end)` sets (that is, the `start` point is included in the range, as is every point between `start` and `end`, but the `end` point itself is _not_ included in the range). This allows `duration` to accurately be `end - start` in all cases. (And yes, that also means you can create spans with `duration < 0`.)
- **Supports calculations and comparisons on spans and instants** Addition, subtraction, intersection, combination, gap calculation, overlap detection, and similar operations are all supported directly on Calends values.
- **Conversion to/from native date/time types** While this is possible by using a string representation as an intermediary, in either direction, some data and precision is lost in such a conversion. Instead, Calends supports conversion to and from such types directly, preserving as much data and accuracy as each native type provides.
- **Geo-temporally aware** The library provides methods for passing a location instead of a calendar system, and selecting an appropriate calendar based on which was most common in that location at that point in time. *(Some guess work is involved in this process when parsing dates, so it is still preferred to supply the calendar system, if known, when parsing.)*
- **Time zone support**
- **Well-defined interfaces for extending the library** Add more calendar systems, type conversions, or geo-temporal relationships without forking/modifying the library itself.
- **Shared library (`.so`/`.dll`/`.dylib`)** In order to use the library outside of Golang projects, we first need to export its functionality in a shared library, which can then be accessed from other programming evironments and applications, generally via FFI.
- **WebAssembly binary** In order to use the library in the browser, we first need to export its functionality in a WebAssembly (WASM) binary, which can then be accessed by JavaScript. (Go currently doesn't support the WASI standard, so the functions are registered into the global namespace rather than being `exported` by WebAssembly itself. More on that in the JS docs.)

CHAPTER

THREE

INSTALLATION OF CALENDS

The steps here vary based on which programming language(s) you're using. Golang is a simple install and import. Other languages use a language-specific wrapper around the compiled shared library. Select your language to take a deeper look.

3.1 Installing Calends for the Command Line

You can grab a `calends` binary for your platform OS/architecture from the GitHub Releases page, and just run it directly. Alternately, you can clone the source and build it from there:

```
# Sample Linux steps:
mkdir -p $GOPATH/src/github.com/danhunsaker
cd $GOPATH/src/github.com/danhunsaker
git clone https://github.com/danhunsaker/calends
cd calends
go get ./...
go build -o calends ./cli
```

3.2 Installing Calends for Golang

Install the library with `go get github.com/danhunsaker/calends`, and then `import "github.com/danhunsaker/calends"` wherever you intend to use it. If you're using another Go dependency manager, you'll need to use its dependency installation method instead; consult its documentation for more details, as we can't possibly cover them all here.

3.3 Installing Calends for C/C++

3.3.1 Binary Install

For use with C/C++, simply grab the latest version of `libcalends` from the GitHub Releases page, and extract its contents wherever your compiler expects to find `.h` and `.so`/`.dll`/`.dylib` files. Be sure to grab the correct version for your architecture!

3.3.2 Source Install

To install from source, you'll need Golang 1.9+ installed to use its compiler. Clone the repository, build `libcalends`, then copy the resulting `.so`/`.dll`/`.dylib` and `.h` files to wherever your C/C++ compiler expects to find them.

```
# Sample Linux steps:
mkdir -p $GOPATH/src/github.com/danhunsaker
cd $GOPATH/src/github.com/danhunsaker
git clone https://github.com/danhunsaker/calends
cd calends/libcalends
go get ../...
go build -v -i -buildmode=c-shared -o libcalends.so
```

Adjust the above example commands as needed for your actual development OS.

3.4 Installing Calends for Dart

For use with Dart, use pub as normal:

```
dart pub add calends
```

Or with Flutter:

```
flutter pub add calends
```

You'll also need to grab the latest version of `libcalends` from the GitHub Releases page, and extract its contents (you can skip any `.h` files) into your project's root directory, next to `pubspec.yaml`. Be sure to grab the correct archive for your architecture!

3.5 Installing Calends for JS/WASM

For use with JS, use `npm` (or your preferred package manager):

```
.. code-block:: bash

   npm install -s calends
```

This will pull in the JS wrapper package as well as the corresponding WASM binary.

For use on the server, that's pretty much it. The library takes care of the rest.

For use on the web, you'll need to ensure the WASM is accessible to the server, next to the library itself. The easiest way to ensure this is to pull in `calends.js` directly via `<script>` tag, but if you use a package to compile/minify/etc your JS dependencies, you'll need to configure that package to include `calends.wasm` alongside your script(s). Here's an example for `webpack`:

```
.. code-block:: javascript

   const CopyPlugin = require("copy-webpack-plugin");

   // ...
```

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```
  module.exports = {
     // ...
     plugins: [
        new CopyPlugin({
           patterns: [
              { from: "node_modules/calends/calends.wasm",
                 to: "[name][ext]" },
           ],
        }),
     ],
  };
```

It's not clean, but until Go compiles compliant WASM binaries, it's the best we can do right now, since we can't use *WebAssembly ESM Integration <https://github.com/WebAssembly/esm-integration/tree/main/proposals/esm-integration>* yet. Once it defines `exports` correctly, we can drop much of the JS wrapper and focus purely on translating bare functions into full classes exclusively.

3.6 Installing Calends for PHP

For use with PHP, use Composer to install the PHP FFI wrapper:

```
composer install danhunsaker/calends
```

The post-install script will grab the appropriate `libcalends` for your system, along with the relevant header file. From there, simply update your `php.ini` to load the FFI extension (if not already loaded) and preload the header file:

```
extension=ffi.so
ffi.preload=/path/to/your/code/vendor/lib/calends-phpffi.h
```

If you don't have access to edit your `php.ini`, ensure the FFI extension is available and enabled, then manually load the header file in your code:

```
FFI::load(__DIR__ . "/vendor/lib/calends-phpffi.h");
```

CHAPTER

FOUR

USAGE OF CALENDS

Once you have *installed Calends*, you'll want to know how to actually make use of it in your own projects. The exact approach for this varies by language, so we've broken it into multiple sections to make it easier to wade through and find what you need. Find your language, below, and dig in a bit further to see how to do everything you need!

4.1 Using Calends from the Command Line

Calends can be used from the command line directly, though some if its features are limited or unavailable. Specifically, it doesn't support custom calendars, so you'll need to ensure you build it with the calendar you want already loaded.

4.1.1 Command Line Options

The available options for `calends`, on the command line directly, are the following:

`convert` `<from-calendar> <from-format> <to-calendar> <to-format> [<date>]`

- **from-calendar** The calendar system to parse the date/time with.
- **from-format** The format the date/time is expected to use.
- **to-calendar** The calendar system to format the date/time with.
- **to-format** The format the date/time is expected to use.
- **date** The value to convert.

Converts a date from one calendar/format to another. If `date` isn't provided in the arguments, it's read from `/dev/stdin` instead.

`parse` `<from-calendar> <from-format> [<date>]`

- **from-calendar** The calendar system to parse the date/time with.
- **from-format** The format the date/time is expected to use.
- **date** The value to parse.

Converts a date from the given calendar/format to a portable/unambiguous date stamp. The output from this command can then be used as input to others.

`format` `<to-calendar> <to-format> [<stamp>]`

- **to-calendar** The calendar system to format the date/time with.
- **to-format** The format the date/time is expected to use.
- **stamp** The value to format.

Converts a date stamp from the *parse* command to the given calendar/format.

offset <offset-calendar> [<offset> [<stamp>]]

- **offset-calendar** The calendar system to interpret the offset with.
- **offset** The offset to add.
- **stamp** The value to add the offset to.

Adds an offset to the date stamp from the *parse* command.

There is also a `calends compare`, whose options are these:

contains [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.
- **stamp2** The value to compare the other to.

Compares `stamp1` to `stamp2`, and returns whether `stamp1` contains `stamp2`.

overlaps [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.
- **stamp2** The value to compare the other to.

Compares `stamp1` to `stamp2`, and returns whether `stamp1` overlaps with `stamp2`.

abuts [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.
- **stamp2** The value to compare the other to.

Compares `stamp1` to `stamp2`, and returns whether `stamp1` abuts `stamp2`.

same [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.
- **stamp2** The value to compare the other to.

Compares `stamp1` to `stamp2`, and returns whether `stamp1` is the same as `stamp2`.

shorter [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.
- **stamp2** The value to compare the other to.

Compares `stamp1` to `stamp2`, and returns whether `stamp1` is shorter than `stamp2`.

same-duration [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.
- **stamp2** The value to compare the other to.

Compares `stamp1` to `stamp2`, and returns whether `stamp1` is the same duration as `stamp2`.

longer [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.
- **stamp2** The value to compare the other to.

Compares `stamp1` to `stamp2`, and returns whether `stamp1` is longer than `stamp2`.

before [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.
- **stamp2** The value to compare the other to.

Compares stamp1 to stamp2, and returns whether stamp1 is before stamp2.

start-before [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.
- **stamp2** The value to compare the other to.

Compares stamp1 to stamp2, and returns whether stamp1 starts before stamp2.

end-before [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.
- **stamp2** The value to compare the other to.

Compares stamp1 to stamp2, and returns whether stamp1 ends before stamp2.

during [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.
- **stamp2** The value to compare the other to.

Compares stamp1 to stamp2, and returns whether stamp1 is during stamp2.

start-during [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.
- **stamp2** The value to compare the other to.

Compares stamp1 to stamp2, and returns whether stamp1 starts during stamp2.

end-during [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.
- **stamp2** The value to compare the other to.

Compares stamp1 to stamp2, and returns whether stamp1 ends during stamp2.

after [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.
- **stamp2** The value to compare the other to.

Compares stamp1 to stamp2, and returns whether stamp1 is after stamp2.

start-after [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.
- **stamp2** The value to compare the other to.

Compares stamp1 to stamp2, and returns whether stamp1 starts after stamp2.

end-after [<stamp1> [<stamp2>]]

- **stamp1** The value to compare.

- **stamp2** The value to compare the other to.

Compares `stamp1` to `stamp2`, and returns whether `stamp1` ends after `stamp2`.

4.1.2 Interactive/Batch Mode

Create

parse <calendar> <format> <date> <target>

- **calendar** The calendar system to parse the date/time with.

- **format** The format the date/time is expected to use.

- **date** The value to parse.

- **target** The name to give the result.

Creates a new `Calends` value, using `calendar` to select a calendar system, and `format` to describe the contents of `date` to parse. The result is stored as `target`, so it can be used later on by other commands.

parse-range <calendar> <format> <date> <end-date> <target>

- **calendar** The calendar system to parse the dates/times with.

- **format** The format the dates/times are expected to use.

- **date** The start date to parse.

- **end-date** The end date to parse.

- **target** The name to give the result.

Creates a new `Calends` value, using `calendar` to select a calendar system, and `format` to describe the contents of `date` and `end-date` to parse. The result is stored as `target`, so it can be used later on by other commands.

Read

date <calendar> <format> <source>

- **calendar** The calendar system to format the date/time with.

- **format** The format the date/time is expected to be in.

- **source** The name of the `Calends` value to use.

Retrieves the start date of `source` as a string. The value is generated by the calendar system given in `calendar`, according to the format string in `format`.

end-date <calendar> <format> <source>

- **calendar** The calendar system to format the date/time with.

- **format** The format the date/time is expected to be in.

- **source** The name of the `Calends` value to use.

Retrieves the end date of `source` as a string. The value is generated by the calendar system given in `calendar`, according to the format string in `format`.

Update

`set-date` <calendar> <format> <date> <source> <target>

- **calendar** The calendar system to parse the date/time with.
- **format** The format the date/time is expected to use.
- **date** The value to parse the date/time from.
- **source** The name of the `Calends` value to use.
- **target** The name to give the result.

Sets the start date of `target` based on `source`'s current value. The inputs are the same as for *parse*, above.

`set-end-date` <calendar> <format> <date> <source> <target>

- **calendar** The calendar system to parse the date/time with.
- **format** The format the date/time is expected to use.
- **date** The value to parse the date/time from.
- **source** The name of the `Calends` value to use.
- **target** The name to give the result.

Sets the end date of `target` based on `source`'s current value. The inputs are the same as for *parse*, above.

Manipulate

`add` <calendar> <offset> <source> <target>

- **calendar** The calendar system to parse the offset with.
- **offset** The value to parse the offset from.
- **source** The name of the `Calends` value to use.
- **target** The name to give the result.

Increases the end date of `source`'s current value by `offset`, as interpreted by the calendar system given in `calendar`.

`add-from-end` <calendar> <offset> <source> <target>

- **calendar** The calendar system to parse the offset with.
- **offset** The value to parse the offset from.
- **source** The name of the `Calends` value to use.
- **target** The name to give the result.

Increases the start date of `source`'s current value by `offset`, as interpreted by the calendar system given in `calendar`.

`subtract` <calendar> <offset> <source> <target>

- **calendar** The calendar system to parse the offset with.
- **offset** The value to parse the offset from.
- **source** The name of the `Calends` value to use.

- **target** The name to give the result.

Works the same as *add*, except it decreases the start date, rather than increasing it.

subtract-from-end <calendar> <offset> <source> <target>

- **calendar** The calendar system to parse the offset with.

- **offset** The value to parse the offset from.

- **source** The name of the `Calends` value to use.

- **target** The name to give the result.

Works the same as *add-from-end*, except it decreases the end date, rather than increasing it.

next <calendar> <offset> <source> <target>

- **calendar** The calendar system to parse the offset with.

- **offset** The value to parse the offset from.

- **source** The name of the `Calends` value to use.

- **target** The name to give the result.

Sets `target` to a `Calends` value of `offset` duration (as interpreted by the calendar system given in `calendar`), which abuts the end of `source`. If `offset` is empty, `calendar` is ignored, and `source`'s duration is used instead.

previous <calendar> <offset> <source> <target>

- **calendar** The calendar system to parse the offset with.

- **offset** The value to parse the offset from.

- **source** The name of the `Calends` value to use.

- **target** The name to give the result.

Sets `target` to a `Calends` value of `offset` duration (as interpreted by the calendar system given in `calendar`), which abuts the start of `source`. If `offset` is empty, `calendar` is ignored, and `source`'s duration is used instead.

Combine

merge <source> <combine> <target>

- **source** The name of the `Calends` value to use.

- **combine** The `Calends` value to merge.

- **target** The name to give the result.

Sets `target` to a value spanning from the earliest start date to the latest end date between `source` and `combine`.

intersect <source> <combine> <target>

- **source** The name of the `Calends` value to use.

- **combine** The `Calends` value to intersect.

- **target** The name to give the result.

Sets `target` to a value spanning the overlap between `source` and `combine`. If `source` and `combine` don't overlap, returns an error.

gap <source> <combine> <target>

> **- source** The name of the `Calends` value to use.
>
> **- combine** The `Calends` value to gap.
>
> **- target** The name to give the result.

Sets `target` to a value spanning the gap between `source` and `combine`. If `source` and `combine` overlap (and there is, therefore, no gap to return), returns an error.

Compare

difference <source> <compare> <mode>

> **- source** The name of the `Calends` value to use.
>
> **- compare** The `Calends` value to compare.
>
> **- mode** The comparison mode.

Returns the difference of `source` minus `compare`, using `mode` to select which values to use in the calculation. Valid `mode`s include:

- `start` - use the start date of both `source` and `compare`
- `duration` - use the duration of both `source` and `compare`
- `end` - use the end date of both `source` and `compare`
- `start-end` - use the start of `source`, and the end of `compare`
- `end-start` - use the end of `source`, and the start of `compare`

compare <source> <compare> <mode>

> **- source** The name of the `Calends` value to use.
>
> **- compare** The `Calends` value to compare.
>
> **- mode** The comparison mode.

Returns `-1` if `source` is less than `compare`, `0` if they are equal, and `1` if `source` is greater than `compare`, using `mode` to select which values to use in the comparison. Valid `mode`s are the same as for *difference*, above.

contains <source> <compare>

> **- source** The name of the `Calends` value to use.
>
> **- compare** The `Calends` value to compare.

Checks whether `source` contains all of `compare`.

overlaps <source> <compare>

> **- source** The name of the `Calends` value to use.
>
> **- compare** The `Calends` value to compare.

Checks whether `source` overlaps with `compare`.

abuts <source> <compare>

> **- source** The name of the `Calends` value to use.
>
> **- compare** The `Calends` value to compare.

Checks whether `source` abuts `compare` (that is, whether one begins at the same instant the other ends).

is-same <source> <compare>

- **source** The name of the `Calends` value to use.
- **compare** The `Calends` value to compare.

Checks whether `source` covers the same span of time as `compare`.

is-shorter <source> <compare>

- **source** The name of the `Calends` value to use.
- **compare** The `Calends` value to compare.

Compares the duration of `source` and `compare`.

is-same-duration <source> <compare>

- **source** The name of the `Calends` value to use.
- **compare** The `Calends` value to compare.

Compares the duration of `source` and `compare`.

is-longer <source> <compare>

- **source** The name of the `Calends` value to use.
- **compare** The `Calends` value to compare.

Compares the duration of `source` and `compare`.

is-before <source> <compare>

- **source** The name of the `Calends` value to use.
- **compare** The `Calends` value to compare.

Compares the entirety of `source` with the start date of `compare`.

starts-before <source> <compare>

- **source** The name of the `Calends` value to use.
- **compare** The `Calends` value to compare.

Compares the start date of `source` with the start date of `compare`.

ends-before <source> <compare>

- **source** The name of the `Calends` value to use.
- **compare** The `Calends` value to compare.

Compares the end date of `source` with the start date of `compare`.

is-during <source> <compare>

- **source** The name of the `Calends` value to use.
- **compare** The `Calends` value to compare.

Checks whether the entirety of `source` lies between the start and end dates of `compare`.

starts-during <source> <compare>

- **source** The name of the `Calends` value to use.

- **compare** The `Calends` value to compare.

Checks whether the start date of `source` lies between the start and end dates of `compare`.

ends-during <source> <compare>

- **source** The name of the `Calends` value to use.

- **compare** The `Calends` value to compare.

Checks whether the end date of `source` lies between the start and end dates of `compare`.

is-after <source> <compare>

- **source** The name of the `Calends` value to use.

- **compare** The `Calends` value to compare.

Compares the entirety of `source` with the end date of `compare`.

starts-after <source> <compare>

- **source** The name of the `Calends` value to use.

- **compare** The `Calends` value to compare.

Compares the start date of `source` with the end date of `compare`.

ends-after <source> <compare>

- **source** The name of the `Calends` value to use.

- **compare** The `Calends` value to compare.

Compares the end date of `source` with the end date of `compare`.

4.2 Using Calends in Golang

Calends exposes a very small handful of things for use outside the library itself. One is the *Calends* class, documented here, which should be the only interface users of the library ever need to touch.

Another thing Calends exposes is the `calendars.TAI64NARUXTime` class, used to store and manipulate the instants of time which make up a *Calends* instance. The rest are interfaces for extending the library's functionality. These are covered in the *Custom Calendars in Golang* section.

Note: *Calends* objects are immutable - all methods return a new *Calends* object where they might otherwise alter the current one. This is true even of the `Calends.Set*` methods. This has the side effect of using more memory to perform manipulations than updating values on an existing object would. It makes many operations safer, though, than mutable objects would allow.

Calends

The main entry point to Calends and its functionality. *Calends* objects should only be created with the *Create* function, and never directly (especially given its values are all unexported ones).

4.2.1 Create

`func` **`Create`**(*value* interface, *calendar* string, *format* string) (Calends, error)

Parameters

- **`value`** (`interface{}`) – The value to parse the date(s)/time(s) from.
- **`calendar`** (`string`) – The calendar system to parse the date(s)/time(s) with.
- **`format`** (`string`) – The format the date(s)/time(s) is/are expected to use.

Returns A new *Calends* object

Return type *Calends*

Returns `error` when an error occurs; `nil` otherwise

Return type `error` or `nil`

Creates a new *Calends* object, using `calendar` to select a calendar system, and `format` to parse the contents of `value` into the *Calends* object's internal instants. The type of `value` can vary based on the calendar system itself, but generally speaking can always be a string.

In any case, the value can always be a `map[string]interface{}`, where the keys are any two of `start`, `end`, and `duration`. If all three are provided, `duration` is ignored in favor of calculating it directly. If only one of the listed keys is provided, `value` is passed to the calendar system itself unchanged.

The calendar system then converts `value` to a `calendars.TAI64NARUXTime` instant, which the *Calends* object sets to the appropriate internal value.

4.2.2 Read

`func (Calends)` **`Date`**(*calendar* string, *format* string) (string, error)

Parameters

- **`calendar`** (`string`) – The calendar system to format the date/time with.
- **`format`** (`string`) – The format the date/time is expected to be in.

Returns The start date of the *Calends* object

Return type `string`

Returns `error` when an error occurs; `nil` otherwise

Return type `error` or `nil`

Retrieves the start date of the *Calends* object as a string. The value is generated by the calendar system given in `calendar`, according to the format string in `format`.

`func (Calends)` **`EndDate`**(*calendar* string, *format* string) (string, error)

Parameters

- **`calendar`** (`string`) – The calendar system to format the date/time with.
- **`format`** (`string`) – The format the date/time is expected to be in.

Returns The end date of the *Calends* object

Return type `string`

Returns `error` when an error occurs; `nil` otherwise

Return type `error` or `nil`

Retrieves the end date of the *Calends* object as a string. The value is generated by the calendar system given in `calendar`, according to the format string in `format`.

`func (Calends) Duration() → Float`

Returns The duration of the *Calends* object

Return type `math/big.(*Float)`

Retrieves the duration of the *Calends* object as an arbitrary-precision floating point number. This value will be `0` if the *Calends* object is an instant.

4.2.3 Update

`func (Calends) SetDate(`*stamp* interface, *calendar* string, *format* string`) (Calends, error)`

Parameters

- **value** (`interface{}`) – The value to parse the date/time from.
- **calendar** (`string`) – The calendar system to parse the date/time with.
- **format** (`string`) – The format the date/time is expected to use.

Returns A new *Calends* object

Return type *Calends*

Returns `error` when an error occurs; `nil` otherwise

Return type `error` or `nil`

Sets the start date of a *Calends* object, based on the *Calends* object's current value. The inputs are the same as for *Create*, above, except the string → value map option isn't available, since you're already specifically setting the start value explicitly.

`func (Calends) SetEndDate(`*stamp* interface, *calendar* string, *format* string`) (Calends, error)`

Parameters

- **value** (`interface{}`) – The value to parse the date/time from.
- **calendar** (`string`) – The calendar system to parse the date/time with.
- **format** (`string`) – The format the date/time is expected to use.

Returns A new *Calends* object

Return type *Calends*

Returns `error` when an error occurs; `nil` otherwise

Return type `error` or `nil`

Sets the end date of a *Calends* object, based on the *Calends* object's current value. The inputs are the same as for *Create*, above, except the string → value map option isn't available, since you're already specifically setting the end value explicitly.

`func (Calends) SetDuration(`*duration* interface, *calendar* string`) (Calends, error)`

Parameters

- **duration** (`interface{}`) – The value to parse the new duration from.

- **calendar** (string) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Returns error when an error occurs; nil otherwise

Return type error or nil

Sets the duration of a *Calends* object, by adjusting its end point, and using the current start point as an anchor. The duration value is interpreted by the calendar system given in calendar, so is subject to any of its rules.

func (**Calends**) **SetDurationFromEnd**(*duration* interface, *calendar* string) (Calends, error)

Parameters

- **duration** (interface{}) – The value to parse the new duration from.
- **calendar** (string) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Returns error when an error occurs; nil otherwise

Return type error or nil

Sets the duration of a *Calends* object, by adjusting its start point, and using the current end point as an anchor. The duration value is interpreted by the calendar system given in calendar, so is subject to any of its rules.

4.2.4 Manipulate

func (**Calends**) **Add**(*offset* interface, *calendar* string) (Calends, error)

Parameters

- **offset** (interface{}) – The value to parse the offset from.
- **calendar** (string) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Returns error when an error occurs; nil otherwise

Return type error or nil

Increases the end date of the *Calends* object's current value by offset, as interpreted by the calendar system given in calendar.

func (**Calends**) **AddFromEnd**(*offset* interface, *calendar* string) (Calends, error)

Parameters

- **offset** (interface{}) – The value to parse the offset from.
- **calendar** (string) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Returns error when an error occurs; nil otherwise

Return type `error` or `nil`

Increases the start date of the *Calends* object's current value by `offset`, as interpreted by the calendar system given in `calendar`.

`func (Calends) Subtract(`*offset* interface, *calendar* string`) (`Calends, error`)`

Parameters

- **offset** (`interface{}`) – The value to parse the offset from.
- **calendar** (`string`) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Returns `error` when an error occurs; `nil` otherwise

Return type `error` or `nil`

Works the same as `Add`, except it decreases the start date, rather than increasing it.

`func (Calends) SubtractFromEnd(`*offset* interface, *calendar* string`) (`Calends, error`)`

Parameters

- **offset** (`interface{}`) – The value to parse the offset from.
- **calendar** (`string`) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Returns `error` when an error occurs; `nil` otherwise

Return type `error` or `nil`

Works the same as `AddFromEnd`, except it decreases the end date, rather than increasing it.

`func (Calends) Next(`*offset* interface, *calendar* string`) (`Calends, error`)`

Parameters

- **offset** (`interface{}`) – The value to parse the offset from.
- **calendar** (`string`) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Returns `error` when an error occurs; `nil` otherwise

Return type `error` or `nil`

Returns a *Calends* object of `offset` duration (as interpreted by the calendar system given in `calendar`), which abuts the *Calends* object's current value. If `offset` is empty, `calendar` is ignored, and the current object's duration is used instead.

`func (Calends) Previous(`*offset* interface, *calendar* string`) (`Calends, error`)`

Parameters

- **offset** (`interface{}`) – The value to parse the offset from.
- **calendar** (`string`) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Returns `error` when an error occurs; `nil` otherwise

Return type `error` or `nil`

Returns a *Calends* object of `offset` duration (as interpreted by the calendar system given in `calendar`), which abuts the *Calends* object's current value. If `offset` is empty, `calendar` is ignored, and the current object's duration is used instead.

4.2.5 Combine

`func (Calends) Merge(c2 Calends) (Calends, error)`

Parameters

- **c2** (*Calends*) – The *Calends* object to merge.

Returns A new *Calends* object

Return type *Calends*

Returns `error` when an error occurs; `nil` otherwise

Return type `error` or `nil`

Returns a *Calends* object spanning from the earliest start date to the latest end date between the current *Calends* object and `c2`.

`func (Calends) Intersect(c2 Calends) (Calends, error)`

Parameters

- **c2** (*Calends*) – The *Calends* object to intersect.

Returns A new *Calends* object

Return type *Calends*

Returns `error` when an error occurs; `nil` otherwise

Return type `error` or `nil`

Returns a *Calends* object spanning the overlap between the current *Calends* object and `c2`. If the current object and `c2` don't overlap, returns an error.

`func (Calends) Gap(c2 Calends) (Calends, error)`

Parameters

- **c2** (*Calends*) – The *Calends* object to gap.

Returns A new *Calends* object

Return type *Calends*

Returns `error` when an error occurs; `nil` otherwise

Return type `error` or `nil`

Returns a *Calends* object spanning the gap between the current *Calends* object and `c2`. If the current object and `c2` overlap (and there is, therefore, no gap to return), returns an error.

4.2.6 Compare

func (**Calends**) **Difference**(*c2* Calends, *mode* string) → Float

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.
- **mode** (string) – The comparison mode.

Returns The difference, as an arbitrary-precision floating point number

Return type math/big.Float

Returns the difference of the current *Calends* object minus c2, using mode to select which values to use in the calculation. Valid modes include:

- start - use the start date of both the current object and c2
- duration - use the duration of both the current object and c2
- end - use the end date of both the current object and c2
- start-end - use the start of the current object, and the end of c2
- end-start - use the end of the current object, and the start of c2

func (**Calends**) **Compare**(*c2* Calends, *mode* string) → int

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.
- **mode** (string) – The comparison mode.

Returns A standard comparison result

Return type int

Returns -1 if the current *Calends* object is less than c2, 0 if they are equal, and 1 if the current object is greater than c2, using mode to select which values to use in the comparison. Valid modes are the same as for *(Calends) Difference*, above.

func (**Calends**) **Contains**(*c2* Calends) → bool

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the current *Calends* object contains all of c2.

func (**Calends**) **Overlaps**(*c2* Calends) → bool

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the current *Calends* object overlaps with c2.

func (**Calends**) **Abuts**(*c2* Calends) → bool

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the current *Calends* object abuts c2 (that is, whether one begins at the same instant the other ends).

func (**Calends**) **IsSame**(*c2* Calends) → bool

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the current *Calends* object covers the same span of time as c2.

func (**Calends**) **IsShorter**(*c2* Calends) → bool

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the duration of the current *Calends* object and c2.

func (**Calends**) **IsSameDuration**(*c2* Calends) → bool

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the duration of the current *Calends* object and c2.

func (**Calends**) **IsLonger**(*c2* Calends) → bool

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the duration of the current *Calends* object and c2.

func (**Calends**) **IsBefore**(*c2* Calends) → bool

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the entirety of the current *Calends* object with the start date of c2.

func (**Calends**) **StartsBefore**(*c2* Calends) → bool

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the start date of the current *Calends* object with the start date of c2.

func (**Calends**) **EndsBefore**(*c2* Calends) → bool

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the end date of the current *Calends* object with the start date of c2.

func (**Calends**) **IsDuring**(*c2* Calends) → bool

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the entirety of the current *Calends* object lies between the start and end dates of c2.

func (**Calends**) **StartsDuring**(*c2* Calends) → bool

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the start date of the current *Calends* object lies between the start and end dates of c2.

func (**Calends**) **EndsDuring**(*c2* Calends) → bool

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the end date of the current *Calends* object lies between the start and end dates of c2.

func (**Calends**) **IsAfter**(*c2* Calends) → bool

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type `bool`

Compares the entirety of the current *Calends* object with the end date of `c2`.

`func (Calends) StartsAfter(`*c2* Calends`) → bool`

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type `bool`

Compares the start date of the current *Calends* object with the end date of `c2`.

`func (Calends) EndsAfter(`*c2* Calends`) → bool`

Parameters

- **c2** (*Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type `bool`

Compares the end date of the current *Calends* object with the end date of `c2`.

4.2.7 Export

`func (Calends) String() → string`

Returns The string representation of the current value.

Return type `string`

Implements the `fmt.Stringer` interface.

`func (Calends) MarshalText(`*)* ([]byte, error`)`

Returns A byte slice containing the marshalled text.

Return type `[]byte`

Returns Any error that occurs.

Return type `error`

Implements the `encoding.TextMarshaler` interface.

`func (*Calends) UnmarshalText(`*in* []byte`) → error`

Parameters

- **in** (`[]byte`) – A byte slice containing the marshalled text.

Returns Any error that occurs.

Return type `error`

Implements the `encoding.TextUnmarshaler` interface.

`func (Calends) MarshalJSON() ([]byte, error)`

Returns A byte slice containing the marshalled JSON.

Return type `[]byte`

Returns Any error that occurs.

Return type `error`

Implements the `encoding/json.Marshaler` interface.

`func (*Calends) UnmarshalJSON(`*in* `[]byte) → error`

Parameters

- **in** (`[]byte`) – A byte slice containing the marshalled JSON.

Returns Any error that occurs.

Return type `error`

Implements the `encoding/json.Unmarshaler` interface.

4.3 Using Calends in C/C++

Calends exposes a very small handful of things for use outside the library itself. Documented here are the parts most users will interact with.

Calends also exposes functions and types for extending the library's functionality. These are covered in the *Custom Calendars in C/C++* section.

Note: Because C doesn't support objects, the library returns an identifier instead of an actual `Calends` value, keeping a reference to the internal `Calends` object in the Golang portions of the process space. This identifier is specific to the process in which it is generated, and is therefore only useful within that process itself. To save the value for later, use one of the marshalling functions documented below, and then the corresponding unmarshalling function to retrieve it elsewhere.

4.3.1 Create

long long unsigned int **Calends_create_string**(char *value, char *calendar, char *format)

long long unsigned int **Calends_create_string_range**(char *start, char *end, char *calendar, char *format)

long long unsigned int **Calends_create_string_start_period**(char *start, char *duration, char *calendar, char *format)

long long unsigned int **Calends_create_string_end_period**(char *duration, char *end, char *calendar, char *format)

long long unsigned int **Calends_create_long_long**(long long int value, char *calendar, char *format)

long long unsigned int **Calends_create_long_long_range**(long long int start, long long int end, char *calendar, char *format)

long long unsigned int **Calends_create_long_long_start_period**(long long int start, long long int duration, char *calendar, char *format)

long long unsigned int **Calends_create_long_long_end_period**(long long int duration, long long int end, char *calendar, char *format)

long long unsigned int **Calends_create_double**(double value, char *calendar, char *format)

long long unsigned int **Calends_create_double_range**(double start, double end, char *calendar, char *format)

long long unsigned int **Calends_create_double_start_period**(double start, double duration, char *calendar, char *format)

long long unsigned int **Calends_create_double_end_period**(double duration, double end, char *calendar, char *format)

Parameters

- **value** (`char*` or `long long int` or `double`) – The value to parse the date/time from.
- **start** (`char*` or `long long int` or `double`) – The value to parse the start date/time from.
- **duration** (`char*` or `long long int` or `double`) – The value to parse the duration from.
- **end** (`char*` or `long long int` or `double`) – The value to parse the end date/time from.
- **calendar** (`char*`) – The calendar system to parse the date(s)/time(s) with.
- **format** (`char*`) – The format the date(s)/time(s) is/are expected to use.

Returns A new `Calends` object identifier

Return type `long long unsigned int`

Creates a new `Calends` object identifier, using *calendar* to select a calendar system, and *format* to parse the contents of `value`, `start`, *end*, and/or *duration* into the `Calends` object's internal instants.

4.3.2 Read

char ***Calends_date**(long long unsigned int c, char *calendar, char *format)

Parameters

- **c** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **calendar** (`char*`) – The calendar system to format the date/time with.
- **format** (`char*`) – The format the date/time is expected to be in.

Returns The start date of the `Calends` object

Return type `char*`

Retrieves the start date of the `Calends` object as a string. The value is generated by the calendar system given in *calendar*, according to the format string in *format*.

char ***Calends_end_date**(long long unsigned int c, char *calendar, char *format)

Parameters

- **c** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **calendar** (`char*`) – The calendar system to format the date/time with.
- **format** (`char*`) – The format the date/time is expected to be in.

Returns The end date of the `Calends` object

Return type `char*`

Retrieves the end date of the `Calends` object as a string. The value is generated by the calendar system given in *calendar*, according to the format string in *format*.

char *Calends_duration(long long unsigned int c)

Parameters

- **c** (long long unsigned int) – The identifier of the current Calends object.

Returns The duration of the Calends object

Return type char*

Retrieves the duration of the Calends object as a string. This value will be 0 if the Calends object is an instant.

4.3.3 Update

long long unsigned int **Calends_with_date_string**(long long unsigned int c, char *value, char *calendar, char *format)

long long unsigned int **Calends_with_date_long_long**(long long unsigned int c, long long int value, char *calendar, char *format)

long long unsigned int **Calends_with_date_double**(long long unsigned int c, double value, char *calendar, char *format)

Parameters

- **c** (long long unsigned int) – The identifier of the current Calends object.
- **value** (char* or long long int or double) – The value to parse the date/time from.
- **calendar** (char*) – The calendar system to parse the date/time with.
- **format** (char*) – The format the date/time is expected to use.

Returns A new Calends object identifier

Return type long long unsigned int

Sets the start date of a Calends object, based on the Calends object's current value. The inputs are the same as for the Calends_create_{type}() functions, above.

long long unsigned int **Calends_with_end_date_string**(long long unsigned int c, char *value, char *calendar, char *format)

long long unsigned int **Calends_with_end_date_long_long**(long long unsigned int c, long long int value, char *calendar, char *format)

long long unsigned int **Calends_with_end_date_double**(long long unsigned int c, double value, char *calendar, char *format)

Parameters

- **c** (long long unsigned int) – The identifier of the current Calends object.
- **value** (char* or long long int or double) – The value to parse the date/time from.
- **calendar** (char*) – The calendar system to parse the date/time with.
- **format** (char*) – The format the date/time is expected to use.

Returns A new Calends object identifier

Return type long long unsigned int

Sets the end date of a Calends object, based on the Calends object's current value. The inputs are the same as for the Calends_create_{type}() functions, above.

long long unsigned int **Calends_with_duration_string**(long long unsigned int c, char *duration, char *calendar)

long long unsigned int **Calends_with_duration_long_long**(long long unsigned int c, long long int duration, char *calendar)

long long unsigned int **Calends_with_duration_double**(long long unsigned int c, double duration, char *calendar)

Parameters

- **c** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **duration** (`char*` or `long long int` or `double`) – The value to parse the new duration from.
- **calendar** (`char*`) – The calendar system to parse the date/time with.

Returns A new `Calends` object identifier

Return type `long long unsigned int`

Sets the duration of a `Calends` object, by adjusting its end point, and using the current start point as an anchor. The *duration* value is interpreted by the calendar system given in *calendar*, so is subject to any of its rules.

long long unsigned int **Calends_with_duration_from_end_string**(long long unsigned int c, char *duration, char *calendar)

long long unsigned int **Calends_with_duration_from_end_long_long**(long long unsigned int c, long long int duration, char *calendar)

long long unsigned int **Calends_with_duration_from_end_double**(long long unsigned int c, double duration, char *calendar)

Parameters

- **c** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **duration** (`char*` or `long long int` or `double`) – The value to parse the new duration from.
- **calendar** (`char*`) – The calendar system to parse the date/time with.

Returns A new `Calends` object identifier

Return type `long long unsigned int`

Sets the duration of a `Calends` object, by adjusting its start point, and using the current end point as an anchor. The *duration* value is interpreted by the calendar system given in *calendar*, so is subject to any of its rules.

4.3.4 Destroy

void **Calends_release**(long long unsigned int c)

Parameters

- **c** (`long long unsigned int`) – The identifier of the current `Calends` object.

Releases an internal `Calends` object, freeing its associated memory. Since the memory used in this case is kept within the Golang portion of the process space, we don't have access to free that memory using more conventional C/C++ methods, so this function offers that functionality instead.

4.3.5 Manipulate

long long unsigned int **Calends_add_string**(long long unsigned int c, char *offset, char *calendar)
long long unsigned int **Calends_add_long_long**(long long unsigned int c, long long int offset, char *calendar)
long long unsigned int **Calends_add_double**(long long unsigned int c, double offset, char *calendar)

Parameters

- **c** (long long unsigned int) – The identifier of the current Calends object.
- **offset** (char*) – The value to parse the offset from.
- **calendar** (char*) – The calendar system to parse the date/time with.

Returns A new Calends object identifier

Return type long long unsigned int

Increases the end date of the Calends object's current value by *offset*, as interpreted by the calendar system given in *calendar*.

long long unsigned int **Calends_add_from_end_string**(long long unsigned int c, char *offset, char *calendar)
long long unsigned int **Calends_add_from_end_long_long**(long long unsigned int c, long long int offset, char *calendar)
long long unsigned int **Calends_add_from_end_double**(long long unsigned int c, double offset, char *calendar)

Parameters

- **c** (long long unsigned int) – The identifier of the current Calends object.
- **offset** (char*) – The value to parse the offset from.
- **calendar** (char*) – The calendar system to parse the date/time with.

Returns A new Calends object identifier

Return type long long unsigned int

Increases the start date of the Calends object's current value by *offset*, as interpreted by the calendar system given in *calendar*.

long long unsigned int **Calends_subtract_string**(long long unsigned int c, char *offset, char *calendar)
long long unsigned int **Calends_subtract_long_long**(long long unsigned int c, long long int offset, char *calendar)
long long unsigned int **Calends_subtract_double**(long long unsigned int c, double offset, char *calendar)

Parameters

- **c** (long long unsigned int) – The identifier of the current Calends object.
- **offset** (char*) – The value to parse the offset from.
- **calendar** (char*) – The calendar system to parse the date/time with.

Returns A new Calends object identifier

Return type long long unsigned int

Works the same as Calends_add_{type}(), except it decreases the start date, rather than increasing it.

long long unsigned int **Calends_subtract_from_end_string**(long long unsigned int c, char *offset, char *calendar)

long long unsigned int **Calends_subtract_from_end_long_long**(long long unsigned int c, long long int offset, char *calendar)

long long unsigned int **Calends_subtract_from_end_double**(long long unsigned int c, double offset, char *calendar)

Parameters

- **c** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **offset** (`char*`) – The value to parse the offset from.
- **calendar** (`char*`) – The calendar system to parse the date/time with.

Returns A new `Calends` object identifier

Return type `long long unsigned int`

Works the same as `Calends_add_from_end_{type}()`, except it decreases the end date, rather than increasing it.

long long unsigned int **Calends_next_string**(long long unsigned int c, char *offset, char *calendar)

long long unsigned int **Calends_next_long_long**(long long unsigned int c, long long int offset, char *calendar)

long long unsigned int **Calends_next_double**(long long unsigned int c, double offset, char *calendar)

Parameters

- **c** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **offset** (`char*`) – The value to parse the offset from.
- **calendar** (`char*`) – The calendar system to parse the date/time with.

Returns A new `Calends` object identifier

Return type `long long unsigned int`

Returns the identifier of a `Calends` object of *offset* duration (as interpreted by the calendar system given in *calendar*), which abuts the current `Calends` object's start value. If *offset* is empty, *calendar* is ignored, and the current object's duration is used instead.

long long unsigned int **Calends_previous_string**(long long unsigned int c, char *offset, char *calendar)

long long unsigned int **Calends_previous_long_long**(long long unsigned int c, long long int offset, char *calendar)

long long unsigned int **Calends_previous_double**(long long unsigned int c, double offset, char *calendar)

Parameters

- **c** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **offset** (`char*`) – The value to parse the offset from.
- **calendar** (`char*`) – The calendar system to parse the date/time with.

Returns A new `Calends` object identifier

Return type `long long unsigned int`

Returns the identifier of a `Calends` object of *offset* duration (as interpreted by the calendar system given in *calendar*), which abuts the current `Calends` object's end value. If *offset* is empty, *calendar* is ignored, and the current object's duration is used instead.

4.3.6 Combine

long long unsigned int **Calends_merge**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to merge.

Returns A new `Calends` object identifier

Return type `long long unsigned int`

Returns a `Calends` object spanning from the earliest start date to the latest end date between *c1* and *c2*.

long long unsigned int **Calends_intersect**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to intersect.

Returns A new `Calends` object identifier

Return type `long long unsigned int`

Returns a `Calends` object spanning the overlap between *c1* and *c2*. If *c1* and *c2* don't overlap, returns an error.

long long unsigned int **Calends_gap**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to gap.

Returns A new `Calends` object identifier

Return type `long long unsigned int`

Returns a `Calends` object spanning the gap between *c1* and *c2*. If *c1* and *c2* overlap (and there is, therefore, no gap to return), returns an error.

4.3.7 Compare

char ***Calends_difference**(long long unsigned int c1, long long unsigned int c2, char *mode)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to compare.
- **mode** (`char*`) – The comparison mode.

Returns The difference, as a decimal string

Return type `char*`

Returns the difference of *c1* minus *c2*, using *mode* to select which values to use in the calculation. Valid *mode*s include:

- `"start"` - use the start date of both *c1* and *c2*

- "duration" - use the duration of both *c1* and *c2*
- "end" - use the end date of both *c1* and *c2*
- "start-end" - use the start of *c1*, and the end of *c2*
- "end-start" - use the end of *c1*, and the start of *c2*

signed char **Calends_compare**(long long unsigned int c1, long long unsigned int c2, char *mode)

Parameters

- **c1** (long long unsigned int) – The identifier of the current Calends object.
- **c2** (long long unsigned int) – The identifier of the Calends object to compare.
- **mode** (char*) – The comparison mode.

Returns A standard comparison result

Return type signed char

Returns -1 if *c1* is less than *c2*, 0 if they are equal, and 1 if *c1* is greater than *c2*, using *mode* to select which values to use in the comparison. Valid *mode*s are the same as for *Calends_difference()*, above.

signed char **Calends_contains**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (long long unsigned int) – The identifier of the current Calends object.
- **c2** (long long unsigned int) – The identifier of the Calends object to compare.

Returns The result of the comparison

Return type signed char

Checks whether *c1* contains all of *c2*.

signed char **Calends_overlaps**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (long long unsigned int) – The identifier of the current Calends object.
- **c2** (long long unsigned int) – The identifier of the Calends object to compare.

Returns The result of the comparison

Return type signed char

Checks whether *c1* overlaps with *c2*.

signed char **Calends_abuts**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (long long unsigned int) – The identifier of the current Calends object.
- **c2** (long long unsigned int) – The identifier of the Calends object to compare.

Returns The result of the comparison

Return type signed char

Checks whether *c1* abuts *c2* (that is, whether one begins at the same instant the other ends).

signed char **Calends_is_same**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to compare.

Returns The result of the comparison

Return type `signed char`

Checks whether *c1* covers the same span of time as *c2*.

signed char **Calends_is_shorter**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to compare.

Returns The result of the comparison

Return type `signed char`

Compares the duration of *c1* and *c2*.

signed char **Calends_is_same_duration**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to compare.

Returns The result of the comparison

Return type `signed char`

Compares the duration of *c1* and *c2*.

signed char **Calends_is_longer**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to compare.

Returns The result of the comparison

Return type `signed char`

Compares the duration of *c1* and *c2*.

signed char **Calends_is_before**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to compare.

Returns The result of the comparison

Return type `signed char`

Compares the entirety of *c1* with the start date of *c2*.

signed char **Calends_starts_before**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to compare.

Returns The result of the comparison

Return type `signed char`

Compares the start date of *c1* with the start date of *c2*.

signed char **Calends_ends_before**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to compare.

Returns The result of the comparison

Return type `signed char`

Compares the end date of *c1* with the start date of *c2*.

signed char **Calends_is_during**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to compare.

Returns The result of the comparison

Return type `signed char`

Checks whether the entirety of *c1* lies between the start and end dates of *c2*.

signed char **Calends_starts_during**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to compare.

Returns The result of the comparison

Return type `signed char`

Checks whether the start date of *c1* lies between the start and end dates of *c2*.

signed char **Calends_ends_during**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to compare.

Returns The result of the comparison

Return type `signed char`

Checks whether the end date of *c1* lies between the start and end dates of *c2*.

signed char **Calends_is_after**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to compare.

Returns The result of the comparison

Return type `signed char`

Compares the entirety of *c1* with the end date of *c2*.

signed char **Calends_starts_after**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to compare.

Returns The result of the comparison

Return type `signed char`

Compares the start date of *c1* with the end date of *c2*.

signed char **Calends_ends_after**(long long unsigned int c1, long long unsigned int c2)

Parameters

- **c1** (`long long unsigned int`) – The identifier of the current `Calends` object.
- **c2** (`long long unsigned int`) – The identifier of the `Calends` object to compare.

Returns The result of the comparison

Return type `signed char`

Compares the end date of *c1* with the end date of *c2*.

4.3.8 Export

char ***Calends_string**(long long unsigned int c)

Parameters

- **c** (`long long unsigned int`) – The `Calends` object to convert.

Returns The string representation of the current value.

Return type `char*`

Converts the value of *c* to a string.

char ***Calends_encode_text**(long long unsigned int c)

Parameters

- **c** (`long long unsigned int`) – The `Calends` object to encode.

Returns The encoded representation of the current value.

Return type `char*`

Encodes the value of *c* as text, for external storage.

long long unsigned int **Calends_decode_text**(char *in)

Parameters

- **in** (char*) – The encoded representation of a Calends value.

Returns The decoded Calends object's identifier.

Return type long long unsigned int

Decodes the value of *in* to a new Calends object.

char ***Calends_encode_json**(long long unsigned int c)

Parameters

- **c** (long long unsigned int) – The Calends object to encode.

Returns The encoded representation of the current value.

Return type char*

Encodes the value of *c* as JSON, for external communication.

long long unsigned int **Calends_decode_json**(char *in)

Parameters

- **in** (char*) – The encoded representation of a Calends value.

Returns The decoded Calends object's identifier.

Return type long long unsigned int

Decodes the value of *in* to a new Calends object.

4.3.9 Error Handling

void **Calends_register_panic_handler**(Calends_panic_handler callback)

Parameters

- **callback** (void function(char*)) – A panic handler function.

When errors happen, Go normally returns the error as an additional return value. Since most programming languages don't support this, the C/C++ interface to the library instead relies on a Golang feature called a panic, which is a lot like an exception in many other languages. This function allows users to register a callback function of their own to handle the error conditions which might come up. *callback* should accept a char* containing the error message supplied by the library, and return nothing.

4.4 Using Calends in Dart

Calends exposes a very small handful of things for use outside the library itself. One is the *Calends* class, documented here, which should be the only interface users of the library ever need to touch.

Another thing Calends exposes is the *TAI64Time* class, used to store and manipulate the instants of time which make up a *Calends* instance. The rest are interfaces for extending the library's functionality. These are covered in the *Custom Calendars in Dart* section.

Note: *Calends* objects are immutable - all methods return a new *Calends* object where they might otherwise alter the current one. This has the side effect of using more memory to perform manipulations than updating values on an existing object would. It makes many operations safer, though, than mutable objects would allow.

class calends.**Calends**

The main entry point to Calends and its functionality.

Calends.**initialize**()

Sets up the error handling and otherwise preps the library for use. Run this before doing anything else!

4.4.1 Create

Calends.(*stamp*, *calendar*, *format*)

Arguments

- **stamp** (dynamic()) – The timestamp to parse the date(s)/time(s) from.
- **calendar** (String()) – The calendar system to parse the date(s)/time(s) with.
- **format** (String()) – The format the date(s)/time(s) is/are expected to use.

Throws *CalendsException()* – when an error occurs

Creates a new *Calends* object, using calendar to select a calendar system, and format to parse the contents of stamp into the *Calends* object's internal instants. The type of stamp can vary based on the calendar system itself, but generally speaking can always be a string.

In any case, the stamp can also be a Map, where the String keys are any two of start, end, and duration. If all three are provided, duration is ignored in favor of calculating it directly.

The calendar system then converts stamp to a pair of *TAI64Time* instants, which the *Calends* object sets to the appropriate internal value.

4.4.2 Read

Calends.**date**(*calendar*, *format*)

Arguments

- **calendar** (String()) – The calendar system to format the date/time with.
- **format** (String()) – The format the date/time is expected to be in.

Returns The start date of the *Calends* object

Return type string

Throws *CalendsException()* – when an error occurs

Retrieves the start date of the *Calends* object as a string. The value is generated by the calendar system given in calendar, according to the format string in format.

Calends.**endDate**(*calendar*, *format*)

Arguments

- **calendar** (String()) – The calendar system to format the date/time with.

- **format** (`String()`) – The format the date/time is expected to be in.

Returns The end date of the *Calends* object

Return type string

Throws *CalendsException()* – when an error occurs

Retrieves the end date of the *Calends* object as a string. The value is generated by the calendar system given in `calendar`, according to the format string in `format`.

`Calends.`**`duration`**`()`

Returns The duration of the *Calends* object

Return type string

Retrieves the duration of the *Calends* object as a decimal string. This value will be `0` if the *Calends* object contains an instant.

4.4.3 Update

`Calends.`**`withDate`**`(`*stamp*, *calendar*, *format*`)`

Arguments

- **stamp** (`dynamic()`) – The value to parse the date/time from.
- **calendar** (`String()`) – The calendar system to parse the date/time with.
- **format** (`String()`) – The format the date/time is expected to use.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException()* – when an error occurs

Returns a *Calends* object with a start date based on the current *Calends* object's value. The inputs are the same as for *Calends.()*, above, except the `String` → value map option isn't available, since you're already specifically setting the start value explicitly.

`Calends.`**`withEndDate`**`(`*value*, *calendar*, *format*`)`

Arguments

- **stamp** (`dynamic()`) – The value to parse the date/time from.
- **calendar** (`String()`) – The calendar system to parse the date/time with.
- **format** (`String()`) – The format the date/time is expected to use.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException()* – when an error occurs

Returns a *Calends* object with an end date based on the current *Calends* object's value. The inputs are the same as for *Calends.()*, above, except the `String` → value map option isn't available, since you're already specifically setting the end value explicitly.

Calends.**withDuration**(*duration*, *calendar*)

Arguments

- **duration** (dynamic()) – The value to parse the new duration from.
- **calendar** (String()) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException()* – when an error occurs

Returns a *Calends* object with a duration set by adjusting the current *Calends* object's end point, and using its start point as an anchor. The duration value is interpreted by the calendar system given in calendar, so is subject to any of its rules.

Calends.**withDurationFromEnd**(*duration*, *calendar*)

Arguments

- **duration** (dynamic()) – The value to parse the new duration from.
- **calendar** (String()) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException()* – when an error occurs

Returns a *Calends* object with a duration set by adjusting the current *Calends* object's start point, and using its end point as an anchor. The duration value is interpreted by the calendar system given in calendar, so is subject to any of its rules.

4.4.4 Manipulate

Calends.**add**(*offset*, *calendar*)

Arguments

- **offset** (dynamic()) – The value to parse the offset from.
- **calendar** (String()) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException()* – when an error occurs

Increases the end date of the *Calends* object's current value by offset, as interpreted by the calendar system given in calendar, and returns a new *Calends* object with the result.

Calends.**addFromEnd**(*offset*, *calendar*)

Arguments

- **offset** (dynamic()) – The value to parse the offset from.
- **calendar** (String()) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException()* – when an error occurs

Increases the start date of the *Calends* object's current value by `offset`, as interpreted by the calendar system given in `calendar`, and returns a new *Calends* object with the result.

`Calends.`**`subtract`**`(`*offset*, *calendar*`)`

Arguments

- **`offset`** (`dynamic()`) – The value to parse the offset from.
- **`calendar`** (`String()`) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException()* – when an error occurs

Works the same as *add()*, except it decreases the start date, rather than increasing it.

`Calends.`**`subtractFromEnd`**`(`*offset*, *calendar*`)`

Arguments

- **`offset`** (`dynamic()`) – The value to parse the offset from.
- **`calendar`** (`String()`) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException()* – when an error occurs

Works the same as *addFromEnd()*, except it decreases the end date, rather than increasing it.

`Calends.`**`next`**`(`*offset*, *calendar*`)`

Arguments

- **`offset`** (`dynamic()`) – The value to parse the offset from.
- **`calendar`** (`String()`) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException()* – when an error occurs

Returns a *Calends* object of `offset` duration (as interpreted by the calendar system given in `calendar`), which abuts the current *Calends* object's value. If `offset` is empty, `calendar` is ignored, and the current object's duration is used instead.

`Calends.`**`previous`**`(`*offset*, *calendar*`)`

Arguments

- **`offset`** (`dynamic()`) – The value to parse the offset from.
- **`calendar`** (`String()`) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException()* – when an error occurs

Returns a *Calends* object of `offset` duration (as interpreted by the calendar system given in `calendar`), which abuts the current *Calends* object's value. If `offset` is empty, `calendar` is ignored, and the current object's duration is used instead.

4.4.5 Combine

`Calends.`**`merge`**(*c2*)

Arguments

- **c2** (*Calends()*) – The *Calends* object to merge.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException()* – when an error occurs

Returns a *Calends* object spanning from the earliest start date to the latest end date between the current *Calends* object and `c2`.

`Calends.`**`intersect`**(*c2*)

Arguments

- **c2** (*Calends()*) – The *Calends* object to intersect.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException()* – when an error occurs

Returns a *Calends* object spanning the overlap between the current *Calends* object and `c2`. If the current object and `c2` don't overlap, throws an error.

`Calends.`**`gap`**(*c2*)

Arguments

- **c2** (*Calends()*) – The *Calends* object to gap.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException()* – when an error occurs

Returns a *Calends* object spanning the gap between the current *Calends* object and `c2`. If the current object and `c2` overlap (and there is, therefore, no gap to return), throws an error.

4.4.6 Compare

`Calends.`**`difference`**(*c2*, *mode*)

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.
- **mode** (`String()`) – The comparison mode.

Returns The difference, as a decimal string

Return type string

Returns the difference of the current *Calends* object minus `c2`, using `mode` to select which values to use in the calculation. Valid `mode`s include:

- `start` - use the start date of both the current object and `c2`
- `duration` - use the duration of both the current object and `c2`
- `end` - use the end date of both the current object and `c2`
- `start-end` - use the start of the current object, and the end of `c2`
- `end-start` - use the end of the current object, and the start of `c2`

`Calends.`**`compare`**(*c2*, *mode*)

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.
- **mode** (`String()`) – The comparison mode.

Returns A standard comparison result

Return type int

Returns `-1` if the current *Calends* object is less than `c2`, `0` if they are equal, and `1` if the current object is greater than `c2`, using `mode` to select which values to use in the comparison. Valid `mode`s are the same as for *difference()*, above.

`Calends.`**`contains`**(*c2*)

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the current *Calends* object contains all of `c2`.

`Calends.`**`overlaps`**(*c2*)

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the current *Calends* object overlaps with `c2`.

`Calends.`**`abuts`**(*c2*)

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the current *Calends* object abuts `c2` (that is, whether one begins at the same instant the other ends).

Calends.**isSame**(*c2*)

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the current *Calends* object covers the same span of time as `c2`. Also available via the == operator.

Calends.**isShorter**(*c2*)

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the duration of the current *Calends* object and `c2`.

Calends.**isSameDuration**(*c2*)

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the duration of the current *Calends* object and `c2`.

Calends.**isLonger**(*c2*)

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the duration of the current *Calends* object and `c2`.

Calends.**isBefore**(*c2*)

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the entirety of the current *Calends* object with the start date of `c2`. Also available as the < operator.

Calends.**startsBefore**(*c2*)

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the start date of the current *Calends* object with the start date of `c2`.

`Calends.`**`endsBefore`**`(`*c2*`)`

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the end date of the current *Calends* object with the start date of `c2`.

`Calends.`**`isDuring`**`(`*c2*`)`

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the entirety of the current *Calends* object lies between the start and end dates of `c2`.

`Calends.`**`startsDuring`**`(`*c2*`)`

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the start date of the current *Calends* object lies between the start and end dates of `c2`.

`Calends.`**`endsDuring`**`(`*c2*`)`

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the end date of the current *Calends* object lies between the start and end dates of `c2`.

`Calends.`**`isAfter`**`(`*c2*`)`

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the entirety of the current *Calends* object with the end date of `c2`. Also available as the > operator.

`Calends.`**`startsAfter`**`(`*c2*`)`

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the start date of the current *Calends* object with the end date of `c2`.

`Calends.`**`endsAfter`**`(`*c2*`)`

Arguments

- **c2** (*Calends()*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the end date of the current *Calends* object with the end date of `c2`.

4.4.7 Export

It's possible to export *Calends* values in a couple of ways, and then re-import them later/elsewhere. The text encoding is the less portable option, though, so we strongly recommend using JSON instead.

`Calends.`**`encodeText`**`()`

Returns The text-encoded value of the *Calends* instance.

Return type `String`

Throws *CalendsException()* – when an error occurs

`Calends.`**`decodeText`**`(`*encoded*`)`

Arguments

- **encoded** (`String()`) – The text-encoded value to import.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException()* – when an error occurs

`Calends.`**`encodeJson`**`()`

Returns The JSON-encoded value of the *Calends* instance.

Return type `String`

Throws *CalendsException()* – when an error occurs

`Calends.`**`decodeJson`**`(`*encoded*`)`

Arguments

- **encoded** (`String()`) – The JSON-encoded value to import.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException()* – when an error occurs

If you just need a `String` value for display purposes, and can't use the `date()` method to format it to a given calendar system, there is a fallback mechanism in the form of the `toString()` method. This value is neither human-readable nor machine-importable, so it should only be used for debugging.

`Calends.toString()`

Returns A non-portable representation of the *Calends* instance.

Return type `String`

Throws *CalendsException()* – when an error occurs

4.4.8 Error Handling

`class calends.CalendsException`

A very simple exception class, directly extending `Exception`. It is thrown by the library for all encountered errors.

4.5 Using Calends in JS/WASM

Calends exposes a very small handful of things for use outside the library itself. One is the *Calends()* class, documented here, which should be the only interface users of the library ever need to touch.

Another thing Calends exposes is the *TAI64Time()* class, used to store and manipulate the instants of time which make up a *Calends()* moment or instance. The rest are interfaces for extending the library's functionality. These are covered in the *Custom Calendars in JS/WASM* section.

Note: *Calends()* objects are immutable - all methods return a new *Calends()* object where they might otherwise alter the current one. This has the side effect of using more memory to perform manipulations than updating values on an existing object would. It makes many operations safer, though, than mutable objects would allow.

4.5.1 Create

`class calends.Calends(`*stamp*, *calendar*, *format*`)`

Arguments

- **stamp** (`mixed()`) – The value to parse the date(s)/time(s) from.
- **calendar** (`string()`) – The calendar system to parse the date(s)/time(s) with.
- **format** (`string()`) – The format the date(s)/time(s) is/are expected to use.

Returns A new *Calends()* object

Return type *Calends()*

Throws `CalendsException()` – when an error occurs

Creates a new *Calends()* object, using `calendar` to select a calendar system, and `format` to parse the contents of `stamp` into the *Calends()* object's internal instants. The type of `stamp` can vary based on the calendar system itself, but generally speaking can always be a string.

In any case, the value can always be an associative array, where the keys are any two of `start`, `end`, and `duration`. If all three are provided, `duration` is ignored in favor of calculating it directly.

The calendar system then converts `stamp` to a *TAI64Time()* instant, which the *Calends()* object sets to the appropriate internal value.

4.5.2 Read

`Calends.`**`date`**(*calendar*, *format*)

Arguments

- **`calendar`** (`string()`) – The calendar system to format the date/time with.
- **`format`** (`string()`) – The format the date/time is expected to be in.

Returns The start date of the *Calends()* object

Return type string

Throws `CalendsException()` – when an error occurs

Retrieves the start date of the *Calends()* object as a string. The value is generated by the calendar system given in `calendar`, according to the format string in `format`.

`Calends.`**`endDate`**(*calendar*, *format*)

Arguments

- **`calendar`** (`string()`) – The calendar system to format the date/time with.
- **`format`** (`string()`) – The format the date/time is expected to be in.

Returns The end date of the *Calends()* object

Return type string

Throws `CalendsException()` – when an error occurs

Retrieves the end date of the *Calends()* object as a string. The value is generated by the calendar system given in `calendar`, according to the format string in `format`.

`Calends.`**`duration`**()

Returns The duration of the *Calends()* object

Return type string

Retrieves the duration of the *Calends()* object as a decimal string. This value will be `0` if the *Calends()* object is an instant.

4.5.3 Update

`Calends.`**`withDate`**(*stamp*, *calendar*, *format*)

Arguments

- **`stamp`** (`mixed()`) – The value to parse the date/time from.
- **`calendar`** (`string()`) – The calendar system to parse the date/time with.
- **`format`** (`string()`) – The format the date/time is expected to use.

Returns A new *Calends()* object

Return type *Calends()*

Throws CalendsException() – when an error occurs

Returns a *Calends()* object with a start date based on the current *Calends()* object's value. The inputs are the same as for *Calends()*, above, except the string → value map option isn't available, since you're already specifically setting the start value explicitly.

Calends.**withEndDate**(*stamp*, *calendar*, *format*)

Arguments

- **stamp** (mixed()) – The value to parse the date/time from.
- **calendar** (string()) – The calendar system to parse the date/time with.
- **format** (string()) – The format the date/time is expected to use.

Returns A new *Calends()* object

Return type *Calends()*

Throws CalendsException() – when an error occurs

Returns a *Calends()* object with an end date based on the current *Calends()* object's value. The inputs are the same as for *Calends()*, above, except the string → value map option isn't available, since you're already specifically setting the end value explicitly.

Calends.**withDuration**(*duration*, *calendar*)

Arguments

- **duration** (string()) – The value to parse the new duration from.
- **calendar** (string()) – The calendar system to parse the date/time with.

Returns A new *Calends()* object

Return type *Calends()*

Throws CalendsException() – when an error occurs

Returns a *Calends()* object with a duration set by adjusting the current *Calends()* object's end point, and using its start point as an anchor. The duration value is interpreted by the calendar system given in calendar, so is subject to any of its rules.

Calends.**withDurationFromEnd**(*duration*, *calendar*)

Arguments

- **duration** (string()) – The value to parse the new duration from.
- **calendar** (string()) – The calendar system to parse the date/time with.

Returns A new *Calends()* object

Return type *Calends()*

Throws CalendsException() – when an error occurs

Returns a *Calends()* object with a duration set by adjusting the current *Calends()* object's start point, and using its end point as an anchor. The duration value is interpreted by the calendar system given in calendar, so is subject to any of its rules.

4.5.4 Manipulate

`Calends.`**`add`**(*offset*, *calendar*)

Arguments

- **`offset`** (`string()`) – The value to parse the offset from.
- **`calendar`** (`string()`) – The calendar system to parse the date/time with.

Returns A new *`Calends()`* object

Return type *`Calends()`*

Throws `CalendsException()` – when an error occurs

Increases the end date of the *`Calends()`* object's current value by `offset`, as interpreted by the calendar system given in `calendar`, and returns a new *`Calends()`* object with the result.

`Calends.`**`addFromEnd`**(*offset*, *calendar*)

Arguments

- **`offset`** (`string()`) – The value to parse the offset from.
- **`calendar`** (`string()`) – The calendar system to parse the date/time with.

Returns A new *`Calends()`* object

Return type *`Calends()`*

Throws `CalendsException()` – when an error occurs

Increases the start date of the *`Calends()`* object's current value by `offset`, as interpreted by the calendar system given in `calendar`, and returns a new *`Calends()`* object with the result.

`Calends.`**`subtract`**(*offset*, *calendar*)

Arguments

- **`offset`** (`string()`) – The value to parse the offset from.
- **`calendar`** (`string()`) – The calendar system to parse the date/time with.

Returns A new *`Calends()`* object

Return type *`Calends()`*

Throws `CalendsException()` – when an error occurs

Works the same as *`add()`*, except it decreases the start date, rather than increasing the end date.

`Calends.`**`subtractFromEnd`**(*offset*, *calendar*)

Arguments

- **`offset`** (`string()`) – The value to parse the offset from.
- **`calendar`** (`string()`) – The calendar system to parse the date/time with.

Returns A new *`Calends()`* object

Return type *`Calends()`*

Throws `CalendsException()` – when an error occurs

Works the same as *`addFromEnd()`*, except it decreases the end date, rather than increasing the start date.

Calends.**next**(*offset*, *calendar*)

Arguments

- **offset** (string()) – The value to parse the offset from.
- **calendar** (string()) – The calendar system to parse the date/time with.

Returns A new *Calends()* object

Return type *Calends()*

Throws CalendsException() – when an error occurs

Returns a *Calends()* object of offset duration (as interpreted by the calendar system given in calendar), which abuts the current *Calends()* object's value. If offset is empty, calendar is ignored, and the current object's duration is used instead.

Calends.**previous**(*offset*, *calendar*)

Arguments

- **offset** (string()) – The value to parse the offset from.
- **calendar** (string()) – The calendar system to parse the date/time with.

Returns A new *Calends()* object

Return type *Calends()*

Throws CalendsException() – when an error occurs

Returns a *Calends()* object of offset duration (as interpreted by the calendar system given in calendar), which abuts the current *Calends()* object's value. If offset is empty, calendar is ignored, and the current object's duration is used instead.

4.5.5 Combine

Calends.**merge**(*other*)

Arguments

- **other** (*Calends()*) – The *Calends()* object to merge.

Returns A new *Calends()* object

Return type *Calends()*

Throws CalendsException() – when an error occurs

Returns a *Calends()* object spanning from the earliest start date to the latest end date between the current *Calends()* object and other.

Calends.**intersect**(*other*)

Arguments

- **other** (*Calends()*) – The *Calends()* object to intersect.

Returns A new *Calends()* object

Return type *Calends()*

Throws CalendsException() – when an error occurs

Returns a *Calends()* object spanning the overlap between the current *Calends()* object and `other`. If the current object and `other` don't overlap, throws an error.

`Calends.`**`gap`**(*other*)

Arguments

- **`other`** (*Calends()*) – The *Calends()* object to gap.

Returns A new *Calends()* object

Return type *Calends()*

Throws `CalendsException()` – when an error occurs

Returns a *Calends()* object spanning the gap between the current *Calends()* object and `other`. If the current object and `other` overlap (and there is, therefore, no gap to return), throws an error.

4.5.6 Compare

`Calends.`**`difference`**(*other*, *mode*)

Arguments

- **`other`** (*Calends()*) – The *Calends()* object to compare.
- **`mode`** (`string()`) – The comparison mode.

Returns The difference, as a decimal string

Return type string

Returns the difference of the current *Calends()* object minus `other`, using `mode` to select which values to use in the calculation. Valid `mode`s include:

- `start` - use the start date of both the current object and `other`
- `duration` - use the duration of both the current object and `other`
- `end` - use the end date of both the current object and `other`
- `start-end` - use the start of the current object, and the end of `other`
- `end-start` - use the end of the current object, and the start of `other`

`Calends.`**`compare`**(*other*, *mode*)

Arguments

- **`other`** (*Calends()*) – The *Calends()* object to compare.
- **`mode`** (`string()`) – The comparison mode.

Returns A standard comparison result

Return type int

Returns `-1` if the current *Calends()* object is less than `other`, `0` if they are equal, and `1` if the current object is greater than `other`, using `mode` to select which values to use in the comparison. Valid `mode`s are the same as for *Calends.difference()*, above.

`Calends.`**`contains`**(*other*)

Arguments

- **`other`** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the current *Calends()* object contains all of `other`.

`Calends.`**`overlaps`**`(`*other*`)`

Arguments

- **`other`** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the current *Calends()* object overlaps with `other`.

`Calends.`**`abuts`**`(`*other*`)`

Arguments

- **`other`** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the current *Calends()* object abuts `other` (that is, whether one begins at the same instant the other ends).

`Calends.`**`isSame`**`(`*other*`)`

Arguments

- **`other`** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the current *Calends()* object covers the same span of time as `other`.

`Calends.`**`isShorter`**`(`*other*`)`

Arguments

- **`other`** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Compares the duration of the current *Calends()* object and `other`.

`Calends.`**`isSameDuration`**`(`*other*`)`

Arguments

- **`other`** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Compares the duration of the current *Calends()* object and `other`.

Calends.**isLonger**(*other*)

Arguments

- **other** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Compares the duration of the current *Calends()* object and `other`.

Calends.**isBefore**(*other*)

Arguments

- **other** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Compares the entirety of the current *Calends()* object with the start date of `other`.

Calends.**startsBefore**(*other*)

Arguments

- **other** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Compares the start date of the current *Calends()* object with the start date of `other`.

Calends.**endsBefore**(*other*)

Arguments

- **other** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Compares the end date of the current *Calends()* object with the start date of `other`.

Calends.**isDuring**(*other*)

Arguments

- **other** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the entirety of the current *Calends()* object lies between the start and end dates of `other`.

Calends.**startsDuring**(*other*)

Arguments

- **other** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the start date of the current *Calends()* object lies between the start and end dates of `other`.

`Calends.`**`endsDuring`**`(`*other*`)`

Arguments

- **other** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the end date of the current *Calends()* object lies between the start and end dates of `other`.

`Calends.`**`isAfter`**`(`*other*`)`

Arguments

- **other** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Compares the entirety of the current *Calends()* object with the end date of `other`.

`Calends.`**`startsAfter`**`(`*other*`)`

Arguments

- **other** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Compares the start date of the current *Calends()* object with the end date of `other`.

`Calends.`**`endsAfter`**`(`*other*`)`

Arguments

- **other** (*Calends()*) – The *Calends()* object to compare.

Returns The result of the comparison

Return type bool

Compares the end date of the current *Calends()* object with the end date of `other`.

4.5.7 Export

It is possible to export *Calends()* objects for use later/elsewhere, or to import such values for use in your own code. There are two formats for this purpose: text encoding and JSON encoding. Needless to say, the JSON encoding is considerably more portable, and therefore preferred. Still, both are supported, and as such both are documented here. YMMV.

`Calends.`**`toText`**`()`

Returns The text encoding of the *Calends()* object.

Return type string

Calends.**fromText**(*stamp*)

Arguments

- **stamp** – The text encoded value to import.

Returns A new *Calends()* object

Return type *Calends()*

Calends.**toJson**()

Returns The JSON encoding of the *Calends()* object.

Return type string

Calends.**fromJson**(*stamp*)

Arguments

- **stamp** – The JSON encoded value to import.

Returns A new *Calends()* object

Return type *Calends()*

For logging, there's also a `toString()` method; we don't recommend using it directly since the output is neither human-readable nor machine-importable.

In addition to the above, there's improved JSON support in JS (go figure) with the following methods:

```
JSON.stringify(objectWithMomentChildren);
```

```
JSON.parse(stored, Calends.reviver);
```

4.5.8 Error Handling

class calends.**CalendsError**()

A very simple error class, directly extending `Error()`. It is thrown by the library for all encountered errors.

4.6 Using Calends in PHP

Calends exposes a very small handful of things for use outside the library itself. One is the *Calends* class, documented here, which should be the only interface users of the library ever need to touch.

Another thing Calends exposes is the *TAITime* class, used to store and manipulate the instants of time which make up a *Calends* instance. The rest are interfaces for extending the library's functionality. These are covered in the *Custom Calendars in PHP* section.

Note: *Calends* objects are immutable - all methods return a new *Calends* object where they might otherwise alter the current one. This has the side effect of using more memory to perform manipulations than updating values on an existing object would. It makes many operations safer, though, than mutable objects would allow.

---

class Calends**Calends**

The main entry point to Calends and its functionality. *Calends* objects can only be created with the *Calends\Calends::create* function, and not directly. *Calends does* implement the `Serializable` interface, though, so it's safe to `serialize`/`unserialize` instances if you want.

4.6.1 Create

static Calends\Calends::**create**(*$value*, *$calendar*, *$format*)

Parameters

- **$value** (`mixed`) – The value to parse the date(s)/time(s) from.
- **$calendar** (`string`) – The calendar system to parse the date(s)/time(s) with.
- **$format** (`string`) – The format the date(s)/time(s) is/are expected to use.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException* – when an error occurs

Creates a new *Calends* object, using `$calendar` to select a calendar system, and `$format` to parse the contents of `$value` into the *Calends* object's internal instants. The type of `$value` can vary based on the calendar system itself, but generally speaking can always be a string.

In any case, the value can always be an associative array, where the keys are any two of `start`, `end`, and `duration`. If all three are provided, `duration` is ignored in favor of calculating it directly.

The calendar system then converts `$value` to a *TAITime* instant, which the *Calends* object sets to the appropriate internal value.

4.6.2 Read

Calends\Calends::**date**(*$calendar*, *$format*)

Parameters

- **$calendar** (`string`) – The calendar system to format the date/time with.
- **$format** (`string`) – The format the date/time is expected to be in.

Returns The start date of the *Calends* object

Return type `string`

Throws *CalendsException* – when an error occurs

Retrieves the start date of the *Calends* object as a string. The value is generated by the calendar system given in `$calendar`, according to the format string in `$format`.

Calends\Calends::**endDate**(*$calendar*, *$format*)

Parameters

- **$calendar** (`string`) – The calendar system to format the date/time with.
- **$format** (`string`) – The format the date/time is expected to be in.

Returns The end date of the *Calends* object

Return type `string`

Throws *CalendsException* – when an error occurs

Retrieves the end date of the *Calends* object as a string. The value is generated by the calendar system given in `$calendar`, according to the format string in `$format`.

`Calends\Calends::`**`duration`**`()`

Returns The duration of the *Calends* object

Return type `string`

Retrieves the duration of the *Calends* object as a decimal string. This value will be `0` if the *Calends* object is an instant.

4.6.3 Update

`Calends\Calends::`**`withDate`**`(`*$value*, *$calendar*, *$format*`)`

Parameters

- **`$value`** (`mixed`) – The value to parse the date/time from.
- **`$calendar`** (`string`) – The calendar system to parse the date/time with.
- **`$format`** (`string`) – The format the date/time is expected to use.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException* – when an error occurs

Returns a *Calends* object with a start date based on the current *Calends* object's value. The inputs are the same as for *Calends\Calends::create*, above, except the string → value map option isn't available, since you're already specifically setting the start value explicitly.

`Calends\Calends::`**`withEndDate`**`(`*$value*, *$calendar*, *$format*`)`

Parameters

- **`$value`** (`mixed`) – The value to parse the date/time from.
- **`$calendar`** (`string`) – The calendar system to parse the date/time with.
- **`$format`** (`string`) – The format the date/time is expected to use.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException* – when an error occurs

Returns a *Calends* object with an end date based on the current *Calends* object's value. The inputs are the same as for *Calends\Calends::create*, above, except the string → value map option isn't available, since you're already specifically setting the end value explicitly.

`Calends\Calends::`**`withDuration`**`(`*$duration*, *$calendar*`)`

Parameters

- **`$duration`** (`string`) – The value to parse the new duration from.
- **`$calendar`** (`string`) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException* – when an error occurs

Returns a *Calends* object with a duration set by adjusting the current *Calends* object's end point, and using its start point as an anchor. The `$duration` value is interpreted by the calendar system given in `$calendar`, so is subject to any of its rules.

`Calends\Calends::`**withDurationFromEnd**(*$duration*, *$calendar*)

Parameters

- **$duration** (`string`) – The value to parse the new duration from.
- **$calendar** (`string`) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException* – when an error occurs

Returns a *Calends* object with a duration set by adjusting the current *Calends* object's start point, and using its end point as an anchor. The `$duration` value is interpreted by the calendar system given in `$calendar`, so is subject to any of its rules.

4.6.4 Manipulate

`Calends\Calends::`**add**(*$offset*, *$calendar*)

Parameters

- **$offset** (`string`) – The value to parse the offset from.
- **$calendar** (`string`) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException* – when an error occurs

Increases the end date of the *Calends* object's current value by `$offset`, as interpreted by the calendar system given in `$calendar`, and returns a new *Calends* object with the result.

`Calends\Calends::`**addFromEnd**(*$offset*, *$calendar*)

Parameters

- **$offset** (`string`) – The value to parse the offset from.
- **$calendar** (`string`) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException* – when an error occurs

Increases the start date of the *Calends* object's current value by `$offset`, as interpreted by the calendar system given in `$calendar`, and returns a new *Calends* object with the result.

Calends\Calends::**subtract**(*$offset*, *$calendar*)

Parameters

- **$offset** (string) – The value to parse the offset from.
- **$calendar** (string) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException* – when an error occurs

Works the same as *add*, except it decreases the start date, rather than increasing it.

Calends\Calends::**subtractFromEnd**(*$offset*, *$calendar*)

Parameters

- **$offset** (string) – The value to parse the offset from.
- **$calendar** (string) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException* – when an error occurs

Works the same as *addFromEnd*, except it decreases the end date, rather than increasing it.

Calends\Calends::**next**(*$offset*, *$calendar*)

Parameters

- **$offset** (string) – The value to parse the offset from.
- **$calendar** (string) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException* – when an error occurs

Returns a *Calends* object of `$offset` duration (as interpreted by the calendar system given in `$calendar`), which abuts the current *Calends* object's value. If `$offset` is empty, `$calendar` is ignored, and the current object's duration is used instead.

Calends\Calends::**previous**(*$offset*, *$calendar*)

Parameters

- **$offset** (string) – The value to parse the offset from.
- **$calendar** (string) – The calendar system to parse the date/time with.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException* – when an error occurs

Returns a *Calends* object of `$offset` duration (as interpreted by the calendar system given in `$calendar`), which abuts the current *Calends* object's value. If `$offset` is empty, `$calendar` is ignored, and the current object's duration is used instead.

4.6.5 Combine

Calends\Calends::**merge**(*$c2*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to merge.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException* – when an error occurs

Returns a *Calends* object spanning from the earliest start date to the latest end date between the current *Calends* object and `$c2`.

Calends\Calends::**intersect**(*$c2*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to intersect.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException* – when an error occurs

Returns a *Calends* object spanning the overlap between the current *Calends* object and `$c2`. If the current object and `$c2` don't overlap, throws an error.

Calends\Calends::**gap**(*$c2*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to gap.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException* – when an error occurs

Returns a *Calends* object spanning the gap between the current *Calends* object and `$c2`. If the current object and `$c2` overlap (and there is, therefore, no gap to return), throws an error.

4.6.6 Compare

Calends\Calends::**difference**(*$c2*, *$mode*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to compare.
- **$mode** (`string`) – The comparison mode.

Returns The difference, as a decimal string

Return type `string`

Returns the difference of the current *Calends* object minus `$c2`, using `$mode` to select which values to use in the calculation. Valid `$mode`s include:

- `start` - use the start date of both the current object and `$c2`

- `duration` - use the duration of both the current object and `$c2`
- `end` - use the end date of both the current object and `$c2`
- `start-end` - use the start of the current object, and the end of `$c2`
- `end-start` - use the end of the current object, and the start of `$c2`

`Calends\Calends::`**`compare`**(*$c2*, *$mode*)

Parameters

- **`$c2`** (*Calends\Calends*) – The *Calends* object to compare.
- **`$mode`** (`string`) – The comparison mode.

Returns A standard comparison result

Return type `int`

Returns `-1` if the current *Calends* object is less than `$c2`, `0` if they are equal, and `1` if the current object is greater than `$c2`, using `$mode` to select which values to use in the comparison. Valid `$mode`s are the same as for *Calends\Calends::difference*, above.

`Calends\Calends::`**`contains`**(*$c2*)

Parameters

- **`$c2`** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type `bool`

Checks whether the current *Calends* object contains all of `$c2`.

`Calends\Calends::`**`overlaps`**(*$c2*)

Parameters

- **`$c2`** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type `bool`

Checks whether the current *Calends* object overlaps with `$c2`.

`Calends\Calends::`**`abuts`**(*$c2*)

Parameters

- **`$c2`** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type `bool`

Checks whether the current *Calends* object abuts `$c2` (that is, whether one begins at the same instant the other ends).

`Calends\Calends::`**`isSame`**(*$c2*)

Parameters

- **`$c2`** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the current *Calends* object covers the same span of time as $c2.

Calends\Calends::**isShorter**(*$c2*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the duration of the current *Calends* object and $c2.

Calends\Calends::**isSameDuration**(*$c2*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the duration of the current *Calends* object and $c2.

Calends\Calends::**isLonger**(*$c2*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the duration of the current *Calends* object and $c2.

Calends\Calends::**isBefore**(*$c2*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the entirety of the current *Calends* object with the start date of $c2.

Calends\Calends::**startsBefore**(*$c2*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the start date of the current *Calends* object with the start date of $c2.

Calends\Calends::**endsBefore**(*$c2*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the end date of the current *Calends* object with the start date of $c2.

Calends\Calends::**isDuring**(*$c2*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the entirety of the current *Calends* object lies between the start and end dates of $c2.

Calends\Calends::**startsDuring**(*$c2*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the start date of the current *Calends* object lies between the start and end dates of $c2.

Calends\Calends::**endsDuring**(*$c2*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Checks whether the end date of the current *Calends* object lies between the start and end dates of $c2.

Calends\Calends::**isAfter**(*$c2*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the entirety of the current *Calends* object with the end date of $c2.

Calends\Calends::**startsAfter**(*$c2*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the start date of the current *Calends* object with the end date of $c2.

Calends\Calends::**endsAfter**(*$c2*)

Parameters

- **$c2** (*Calends\Calends*) – The *Calends* object to compare.

Returns The result of the comparison

Return type bool

Compares the end date of the current *Calends* object with the end date of $c2.

4.6.7 Export

It's possible to export *Calends* values in a couple of ways. It implements Serializable and JsonSerializable, as well as the __toString method, so the regular mechanisms for each of those are readily available and usable. In addition, it also offers support for JSON-decoding values directly:

static Calends\Calends::**jsonUnserialize**(*$encoded*)

Parameters

- **$encoded** (string) – The JSON-encoded value to import.

Returns A new *Calends* object

Return type *Calends*

Throws *CalendsException* – when an error occurs

4.6.8 Error Handling

class Calends**CalendsException**

A very simple exception class, directly extending Exception. It is thrown by the library for all encountered errors.

CHAPTER

FIVE

CALENDAR SYSTEMS

The systems listed here are the built-in ones. This list is expected to grow significantly over time, as more and more calendar systems are added. But you can also add custom systems to your apps without waiting for us to add them ourselves – instructions for that are in the Custom Calendars section, below.

Throughout these documents, the term `TAITime` is used to refer generically to the `TAI64NARUXTime`, `TAI64Time`, or `TAITime` type. The exact form of this name you'll see most often varies by programming language, and is covered in much more detail in the Custom Calendars section.

5.1 The Gregorian Calendar

Supports dates and times in the Gregorian calendar system, the current international standard for communicating dates and times.

Calendar Name: `gregorian`

Supported Input Types:

- string

Supported Format Strings:

- Golang `time` package format strings (**RFC1123 layout**)
- C-style `strptime()`/`strftime()` format strings

Offsets:

- string with Gregorian time units
  - must be relative times
  - use full words instead of abbreviations for time units (such as `seconds` instead of just `s`)

5.2 Julian Day Count

A count of days since `BCE 4713 Jan 01 12:00:00 UTC Julian (proleptic)`. Yes, that's noon. This calendar system is used mostly for astronomy purposes, though there is a modified variant with a narrower scope which counts from midnight instead.

Calendar Name: `jdc`

Supported Input Types:

- string

- integer
- arbitrary-precision floating point number of seconds

Supported Format Strings:

- `full` - the full, canonical Day Count
- `fullday` - the full Day Count, without the fractional time part
- `fulltime` - just the fractional time part of the full Day Count
- `modified` - **an abbreviated Day Count, 2400000.5 less than the full (starts at midnight instead of noon)**
- `day` - the modified Day Count, without the fractional time part
- `time` - just the fractional time part of the modified Day Count

Offsets:

- number of days, as integer or float, via numeric or string types
  - can include fractional days to indicate time

5.3 Stardates

Yes, the ones from *Star Trek*™.

The science fiction universe of *Star Trek*™ introduced a calendar system which was simultaneously futuristic (for the time) and arbitrary. Over the decades since its initial use on screen, especially with the growing popularity of the franchise, the "stardate" has been analyzed and explored and refined into a number of different variants, each trying to reconcile the arbitrariness of the on-screen system into something consistent and usable.

This calendar system implementation is an attempt to combine all these variants into a single system, using the format parameter to select which variant to use. It was originally ported in 2018 from code by Aaron Chong (2015 version), under provisions of the MIT License. My thanks for Aaron's use of the MIT License on the original code, which allowed me to port it cleanly and legally.

Original source: http://rinsanity.weebly.com/files/theme/stardate_public.js

Calendar Name: `stardate`

Supported Input Types:

- string
- integer
- arbitrary-precision floating point number of seconds

Supported Format Strings:

- `main` - **One of the older, more widely-accepted variants.** Alternately called the "issue number style" stardate, it's a combined TOS/TNG variant, and the one used by Google Calendar. It was originally devised by Andrew Main in CE 1994, with revisions made through CE 1997. See http://starchive.cs.umanitoba.ca/?stardates/ for the full explanation of this variant.
- `kennedy` - In 2006, Richie Kennedy released another combined variant, this one designed to have a single continuous count, more like the Julian Day Count than Main's issue number system.
- `pugh90s` - Steve Pugh devised 2 separate variants, one of them in the 1990s, and the other later on, both focused on the TNG era. They are unique in that, for negative stardates, the fractional part increases in the opposite direction of the expected one. That is, 15129.999999999 would be followed by 15128.000000000

instead of 15129.999999998. The original version used an unadjusted Gregorian year as the basis for the duration of a given range of stardates, meaning that 0.05 units refer to a larger duration of time during a leap year than it would otherwise.

- `pughfixed` - The later of Steve Pugh's systems noted the discrepancy, and opted to adjust the year length value to the actual average length of a Gregorian year, 365.2425 days. This means 0.05 units are always the same duration, but does mean that the Gregorian year doesn't generally start at the same point in consecutive stardate ranges.
- `schmidt` - A joint effort between Andreas Schmidt and Graham Kennedy, this variant only covers TNG-era stardates, and while it can be used proleptically, it ignores the alternate format used prior to TNG. It is also virtually identical to `pugh90s`, but the fractional component increases normally for negative stardates.
- `guide-equiv` - One of five variants proposed by TrekGuide.com, this is the "out-of-universe equivalent" calculation. It isn't intended to be accurate for any use other than personal entertainment.
- `guide-tng` - The second of the five TrekGuide variants, this one is the current scale listed for TNG-era stardates, and is show-accurate (or at least as close to it as feasible with an entirely arbitrary system). Note, however, that it is only accurate for TNG-era dates.
- `guide-tos` - The third variant, then, covers the TOS-era stardates. Again, it is only accurate to the TOS era.
- `guide-oldtng` - The fourth variant is no longer displayed on the TrekGuide site, and was actually pulled from a previous version of the stardates page. It covers the TNG era only, and uses slightly different numbers in its calculations than the current approach - specifically, it assumes Earth years cover 1000 stardates.
- `guide-oldtos` - Representing the very first set of calculations available in archives of the TrekGuide site, the fifth TrekGuide variant assumes that 1000 stardates are one Earth year in the TOS era, and calculates dates based on that assumption. This variant was replaced within seven months of that first archival, after it was noticed that TOS-era stardates don't fit a 1000-stardate model.

Note: This calendar system is not yet actually implemented.

- `aldrich` - A proof of concept originally written in C#, this variant results in dates very close to those produced by Pugh's and Schmidt's, but uses a more simplified calculation to do it.
- `red-dragon` - A system devised by/for the Red Dragon Inn roleplaying forum site, it uses a fixed ratio of roughly two and three quarters stardates per Earth day. It makes no representations about accuracy outside the context of the site itself.
- `sto-hynes` - John Hynes, creator of the Digital Time site, offers a calculation for STO[1] stardates which appears to be the most accurate variant for those interested in generating those. The system doesn't represent itself as accurate *outside* the game, but is intentionally proleptic.
- `sto-academy` - Based on an online calculator provided by the STO Academy game help site, it is only accurate for stardates within the game, and does not offer to calculate dates for the rest of the franchise.
- `sto-tom` - Another variant intended only to calculate STO stardates, this one was attributed to Major Tom, and hosted as a Wolfram Alpha widget.
- `sto-anthodev` - Another STO variant, hosted on GitHub.

Offsets:

- Must be provided as a string in the format `"stardate variant"` or `"variant stardate"`.

[1] Star Trek™ Online

5.4 TAI64 Time

Supports times that are seconds since `CE 1970-01-01 00:00:00 TAI Gregorian` (plus 2^{62}, when in hexadecimal), as defined at https://cr.yp.to/libtai/tai64.html (though this library includes extensions to the formats described there). These values are also used internally, so this calendar system can be used to directly expose the underlying internal values in a manner that allows them to be used elsewhere.

Calendar Name: `tai64`

Supported Input Types:

- string
- `TAITime`

Supported Format Strings:

- `decimal` - decimal; full (45 decimal places) resolution; number of seconds since `CE 1970-01-01 00:00:00 TAI Gregorian`
- `tai64` - hexadecimal; just seconds; TAI64 External Representation
- `tai64n` - hexadecimal; with nanoseconds; TAI64N External Representation
- `tai64na` - hexadecimal; with attoseconds; TAI64NA External Representation
- `tai64nar` - hexadecimal; with rontoseconds; TAI64NAR External Representation
- `tai64naru` - hexadecimal; with udectoseconds; TAI64NARU External Representation
- `tai64narux` - **hexadecimal; with xindectoseconds**; TAI64NARUX External Representation

Offsets:

- `TAITime` object
- arbitrary-precision floating point number of seconds
- string with `decimal` format layout (above)

5.5 UNIX Time

Supports times that are seconds since `CE 1970-01-01 00:00:00 UTC Gregorian`, commonly used by computer systems for storing date/time values, internally.

Calendar Name: `unix`

Supported Input Types:

- string
- integer
- arbitrary-precision floating point number of seconds

Supported Format Strings:

- values are always number of seconds since `CE 1970-01-01 00:00:00 UTC Gregorian`
  - `%d` - integer string
  - `%f` - **floating point string**

Offsets:

- number of seconds

CHAPTER

SIX

CUSTOM CALENDARS

As with every other aspect of Calends, the custom calendar system support uses the same basic flow in every language, with minor variations in each to account for the differences those languages introduce. As with every other aspect of Calends, though, we've opted to document each language's unique approaches separately, so you don't have to do any mental conversions yourself.

Note: Custom calendars are considered an advanced feature, so most users woun't be using anything detailed here. It can be nice to know how these things work under the hood, though, for those interested in that. Select your language, below, and dig right in!

6.1 Custom Calendars in Golang

Adding new calendars to Calends is a fairly straightforward process. Implement one interface, or its three methods as standalone functions, and then simply pass them to one of the two registration functions.

6.1.1 Define

The interface in question looks like this:

CalendarDefinition

func (**CalendarDefinition**) **ToInternal**(*date* interface{}, *format* string) (TAI64NARUXTime, error)

Parameters

- **date** (interface{}) – The input date. Should support string at the very minimum.
- **format** (string) – The format string for parsing the input date.

Returns The parsed internal timestamp.

Return type *TAI64NARUXTime*

Returns Any error that occurs.

Return type error

Converts an input date/time representation to an internal *TAI64NARUXTime*.

func (**CalendarDefinition**) **FromInternal**(*stamp* TAI64NARUXTime, *format* string) (string, error)

Parameters

- **stamp** (*TAI64NARUXTime*) – The internal timestamp value.

- **format** (string) – The format string for formatting the output date.

Returns The formatted date/time.

Return type string

Returns Any error that occurs.

Return type error

Converts an internal *TAI64NARUXTime* to a date/time string.

func (**CalendarDefinition**) **Offset**(*stamp* TAI64NARUXTime, *offset* interface{})
(TAI64NARUXTime, error)

Parameters

- **stamp** (*TAI64NARUXTime*) – The internal timestamp value.
- **offset** (interface{}) – The input offset. Should support string at the very minimum.

Returns The adjusted internal timestamp.

Return type *TAI64NARUXTime*

Returns Any error that occurs.

Return type error

Adds the given offset to an internal *TAI64NARUXTime*.

6.1.2 Registration

Register

Once it is registered with the library, your calendar system can be used from anywhere in your application. To register a system, pass it to one of the following two functions:

func **RegisterObject**(*name* string, *definition* CalendarDefinition, *defaultFormat* string)

Parameters

- **name** (string) – The name to register the calendar system under.
- **definition** (*CalendarDefinition*) – The calendar system itself.
- **defaultFormat** (string) – The default format string.

Registers a calendar system class, storing definition as name, and saving defaultFormat for later use while parsing or formatting.

func **RegisterElements**(*name* string, *toInternal* ToInternal, *fromInternal* FromInternal, *offset* Offset,
defaultFormat string)

Parameters

- **name** (string) – The name to register the calendar system under.
- **toInternal** (*(CalendarDefinition) ToInternal*) – The function for parsing dates into internal timestamps.
- **fromInternal** (*(CalendarDefinition) FromInternal*) – The function for formatting internal timestamps as dates.

- **offset** (*(CalendarDefinition) Offset*) – The function for adding an offset to internal timestamps.
- **defaultFormat** (string) – The default format string.

Registers a calendar system from its distinct functions. It does this by storing `toInternal`, `fromInternal`, and `offset` as the elements of `name`, and saving `defaultFormat` for later use while parsing or formatting.

Unregister

`func` **Unregister**(*name* string)

Parameters

- **name** (string) – The name of the calendar system to remove.

Removes a calendar system from the callback list.

Check and List

`func` **Registered**(*calendar* string) → bool

Parameters

- **name** (string) – The calendar system name to check for.

Returns Whether or not the calendar system is currently registered.

Return type bool

Returns whether or not a calendar system has been registered, yet.

`func` **ListRegistered**() → []string

Returns The sorted list of calendar systems currently registered.

Return type []string

Returns the list of calendar systems currently registered.

6.1.3 Types and Values

Now we get to the inner workings that make calendar systems function – even the built-in ones. The majority of the "magic" comes from the *TAI64NARUXTime* object itself, as a reliable way of storing the exact instants being calculated, and the only way times are handled by the library itself. A handful of methods provide basic operations that calendar system developers can use to simplify their conversions (adding and subtracting the values of other timestamps, and importing/exporting timestamp values from/to arbitrary-precision floating point `math/big.Float`s, in particular), and a couple of helpers exclusively handle adding and removing UTC leap second offsets. As long as you can convert your dates to/from Unix timestamps in a `string` or `math/big.Float`, the rest is handled entirely by these helpers in the library itself.

TAI64NARUXTime

Parameters

- **Seconds** (int64) – The number of TAI seconds since `CE 1970-01-01 00:00:00 TAI`.
- **Nano** (uint32) – The first 9 digits of the timestamp's fractional component.
- **Atto** (uint32) – The 10th through 18th digits of the fractional component.

- **Ronto** (uint32) – The 19th through 27th digits of the fractional component.
- **Udecto** (uint32) – The 28th through 36th digits of the fractional component.
- **Xindecto** (uint32) – The 37th through 45th digits of the fractional component.

TAI64NARUXTime stores a TAI64NARUX instant in a reliable, easily-converted format. Each 9-digit fractional segment is stored in a separate 32-bit integer to preserve its value with a very high degree of accuracy, without having to rely on string parsing or Golang's math/big.* values.

Note: TAI vs UTC

You may have noticed that a TAI64Time object stores times in TAI seconds, not Unix seconds, with a time-zone offset of TAI rather than UTC. This distinction is **very important** as it will affect internal calculations and comparisons to mix the two up. TAI time is very similar to Unix time (itself based on UTC time), with one major difference. While Unix/UTC seconds include the insertion and removal of "leap seconds" to keep the solar zenith at local noon (which is useful for day-to-day living and planning), TAI seconds are a continuous count, unconcerned with dates whatsoever. Indeed, the only reason a date was given in the description above was to make it easier for human readers to know exactly when 0 TAI took place.

In other words, once you have a Unix timestamp of your instant calculated, be sure to convert it using *UTCtoTAI* before returning the result to the rest of the library. And then, of course, you'll also need to convert instants from the library back using *TAItoUTC* before generating outputs.

---

func (**TAI64NARUXTime**) **Add**(*z* TAI64NARUXTime) → TAI64NARUXTime

Parameters

- **z** (*TAI64NARUXTime*) – The timestamp to add to the current one.

Returns The sum of the two timestamps.

Return type *TAI64NARUXTime*

Calculates the sum of two *TAI64NARUXTime* values.

func (**TAI64NARUXTime**) **Sub**(*z* TAI64NARUXTime) → TAI64NARUXTime

Parameters

- **z** (*TAI64NARUXTime*) – The timestamp to subtract from the current one.

Returns The difference of the two timestamps.

Return type *TAI64NARUXTime*

Calculates the difference of two *TAI64NARUXTime* values.

func (**TAI64NARUXTime**) **String**() → string

Returns The decimal string representation of the current timestamp.

Return type string

Returns the decimal string representation of the *TAI64NARUXTime* value.

func (**TAI64NARUXTime**) **HexString**() → string

Returns The hexadecimal string representation of the current timestamp.

Return type string

Returns the hexadecimal string representation of the *TAI64NARUXTime* value.

func (**TAI64NARUXTime**) **Float**() → Float

Returns The arbitrary-precision floating point representation of the current timestamp.

Return type math/big.(*Float)

Returns the math/big.(*Float) representation of the *TAI64NARUXTime* value.

func (**TAI64NARUXTime**) **MarshalText**() ([]byte, error)

Returns A byte slice containing the marshalled text.

Return type []byte

Returns Any error that occurs.

Return type error

Implements the encoding.TextMarshaler interface.

func (**TAI64NARUXTime**) **UnmarshalText**(*in* []byte) → error

Parameters

- **in** ([]byte) – A byte slice containing the marshalled text.

Returns Any error that occurs.

Return type error

Implements the encoding.TextUnmarshaler interface.

func (**TAI64NARUXTime**) **MarshalBinary**() ([]byte, error)

Returns A byte slice containing the marshalled binary data.

Return type []byte

Returns Any error that occurs.

Return type error

Implements the encoding.BinaryMarshaler interface.

func (**TAI64NARUXTime**) **UnmarshalBinary**(*in* []byte) → error

Parameters

- **in** ([]byte) – A byte slice containing the marshalled binary data.

Returns Any error that occurs.

Return type error

Implements the encoding.BinaryUnmarshaler interface.

6.1.4 Helpers

func **TAI64NARUXTimeFromDecimalString**(*in* string) → TAI64NARUXTime

Parameters

- **in** (string) – The decimal string representation of a timestamp to calculate.

Returns The calculated timestamp.

Return type *TAI64NARUXTime*

Calculates a *TAI64NARUXTime* from its decimal string representation.

func **TAI64NARUXTimeFromHexString**(*in* string) → TAI64NARUXTime

Parameters

- **in** (string) – The hexadecimal string representation of a timestamp to calculate.

Returns The calculated timestamp.

Return type *TAI64NARUXTime*

Calculates a *TAI64NARUXTime* from its hexadecimal string representation.

func **TAI64NARUXTimeFromFloat**(*in* Float) → TAI64NARUXTime

Parameters

- **in** (math/big.Float) – The arbitrary-precision floating point representation of a timestamp to calculate.

Returns The calculated timestamp.

Return type *TAI64NARUXTime*

Calculates a *TAI64NARUXTime* from its math/big.Float representation.

func **UTCtoTAI**(*utc* TAI64NARUXTime) → TAI64NARUXTime

Parameters

- **utc** (*TAI64NARUXTime*) – The timestamp to remove the UTC offset from.

Returns The calculated timestamp.

Return type *TAI64NARUXTime*

Removes the UTC leap second offset from a TAI64NARUXTime value.

func **TAItoUTC**(*tai* TAI64NARUXTime) → TAI64NARUXTime

Parameters

- **tai** (*TAI64NARUXTime*) – The timestamp to add the UTC offset to.

Returns The calculated timestamp.

Return type *TAI64NARUXTime*

Adds the UTC leap second offset to a TAI64NARUXTime value.

6.1.5 Errors

ErrUnsupportedInput

Used to indicate that the input date/time weren't recognized by the calendar system, or that the data type is incorrect.

ErrInvalidFormat

Indicates that the `format` string isn't supported by the calendar system.

func **ErrUnknownCalendar**(*calendar* string) → error

Parameters

- **in** (`string`) – The name of the unknown calendar system.

Returns Any error that occurs.

Return type `error`

Generates a "calendar not registered" error, including the calendar's actual name in the error message.

6.2 Custom Calendars in C/C++

Adding new calendars to Calends is a fairly straightforward process. Implement a handful of functions, and then simply pass them to the registration function.

6.2.1 Define

The functions in question look like this:

TAI64Time **Calends_calendar_to_internal_string**(char *calendar, char *date, char *format)
TAI64Time **Calends_calendar_to_internal_long_long**(char *calendar, long long int date, char *format)
TAI64Time **Calends_calendar_to_internal_double**(char *calendar, double date, char *format)
TAI64Time **Calends_calendar_to_internal_tai**(char *calendar, *TAI64Time* date)

Parameters

- **calendar** (`char*`) – The name of the target calendar system.
- **date** (`char*` or `long long int` or `double` or *TAI64Time*) – The input date.
- **format** (`char*`) – The format string for parsing the input date.

Returns The parsed internal timestamp.

Return type *TAI64Time*

Converts an input date/time representation to an internal *TAI64Time*.

char ***Calends_calendar_from_internal**(char *calendar, *TAI64Time* stamp, char *format)

Parameters

- **calendar** (`char*`) – The name of the target calendar system.
- **stamp** (*TAI64Time*) – The internal timestamp value.
- **format** (`char*`) – The format string for formatting the output date.

Returns The formatted date/time.

Return type char*

Converts an internal *TAI64Time* to a date/time string.

TAI64Time **Calends_calendar_offset_string**(char *calendar, *TAI64Time* stamp, char *offset)
TAI64Time **Calends_calendar_offset_long_long**(char *calendar, *TAI64Time* stamp, long long int offset)
TAI64Time **Calends_calendar_offset_double**(char *calendar, *TAI64Time* stamp, double offset)
TAI64Time **Calends_calendar_offset_tai**(char *calendar, *TAI64Time* stamp, *TAI64Time* offset)

Parameters

- **calendar** (char*) – The name of the target calendar system.
- **stamp** (*TAI64Time*) – The internal timestamp value.
- **offset** (char* or long long int or double or *TAI64Time*) – The input offset.

Returns The adjusted internal timestamp.

Return type *TAI64Time*

Adds the given offset to an internal *TAI64Time*.

6.2.2 Registration

Register

Once it is registered with the library, your calendar system can be used from anywhere in your application. To register a system, pass it to the following function:

```
void Calends_calendar_register(char* name, char* defaultFormat,
Calends_calendar_to_internal_string() to_internal_string,
Calends_calendar_to_internal_long_long() to_internal_long_long,
Calends_calendar_to_internal_double() to_internal_double,
Calends_calendar_to_internal_tai() to_internal_tai,
Calends_calendar_from_internal() from_internal,
Calends_calendar_offset_string() offset_string,
Calends_calendar_offset_long_long() offset_long_long,
Calends_calendar_offset_double() offset_double, Calends_calendar_offset_tai() offset_tai)
```

Parameters

- **name** (char*) – The name to register the calendar system under.
- **defaultFormat** (char*) – The default format string.
- **to_internal_string** (*Calends_calendar_to_internal_string()*) – The calendar parser, for char* input.
- **to_internal_long_long** (*Calends_calendar_to_internal_long_long()*) – The calendar parser, for long long int input.
- **to_internal_double** (*Calends_calendar_to_internal_double()*) – The calendar parser, for double input.
- **to_internal_tai** (*Calends_calendar_to_internal_tai()*) – The calendar parser, for *TAI64Time* input.
- **from_internal** (*Calends_calendar_from_internal()*) – The calendar formatter.

- **offset_string** (*Calends_calendar_offset_string()*) – The calendar offset calculator, for `char*` input.
- **offset_long_long** (*Calends_calendar_offset_long_long()*) – The calendar offset calculator, for `long long int` input.
- **offset_double** (*Calends_calendar_offset_double()*) – The calendar offset calculator, for `double` input.
- **offset_tai** (*Calends_calendar_offset_tai()*) – The calendar offset calculator, for *TAI64Time* input.

Registers a calendar system class, storing the collected functions as `name`, and saving `defaultFormat` for later use while parsing or formatting.

Unregister

void **Calends_calendar_unregister**(char *name)

Parameters

- **name** (`char*`) – The name of the calendar system to remove.

Removes a calendar system from the callback list.

Check and List

bool **Calends_calendar_registered**(char *name)

Parameters

- **name** (`char*`) – The calendar system name to check for.

Returns Whether or not the calendar system is currently registered.

Return type `bool`

Returns whether or not a calendar system has been registered, yet.

char ***Calends_calendar_list_registered**()

Returns The sorted list of calendar systems currently registered.

Return type `char*`

Returns the list of calendar systems currently registered.

6.2.3 Types and Values

Now we get to the inner workings that make calendar systems function – even the built-in ones. The majority of the "magic" comes from the *TAI64Time* struct itself, as a reliable way of storing the exact instants being calculated, and the only way times are handled by the library itself. A handful of functions provide basic operations that calendar system developers can use to simplify their conversions (adding and subtracting the values of other timestamps, and importing/exporting timestamp values from/to other types, in particular), and a couple of helpers exclusively handle adding and removing UTC leap second offsets. As long as you can convert your dates to/from Unix timestamps in a `char*`, `long long int`, or `double`, the rest is handled entirely by these helpers in the library itself.

type **TAI64Time**

Stores a `TAI64NARUX` instant in a reliable, easy-converted format. Each 9-digit fractional segment is stored in a separate 32-bit integer to preserve its value with a very high degree of accuracy, without having to rely on string parsing or external arbitrary-precision math libraries.

long long int **seconds**

The number of TAI seconds since `CE 1970-01-01 00:00:00 TAI`

Note: TAI vs UTC

You may have noticed that a TAI64Time object stores times in `TAI seconds`, not `Unix seconds`, with a timezone offset of `TAI` rather than `UTC`. This distinction is **very important** as it will affect internal calculations and comparisons to mix the two up. TAI time is very similar to Unix time (itself based on UTC time), with one major difference. While Unix/UTC seconds include the insertion and removal of "leap seconds" to keep the solar zenith at local noon (which is useful for day-to-day living and planning), TAI seconds are a continuous count, unconcerned with dates whatsoever. Indeed, the only reason a date was given in the description above was to make it easier for human readers to know exactly when `0 TAI` took place.

In other words, once you have a Unix timestamp of your instant calculated, be sure to convert it using *TAI64Time_utc_to_tai()* before returning the result to the rest of the library. And then, of course, you'll also need to convert instants from the library back using *TAI64Time_tai_to_utc()* before generating outputs.

---

unsigned int **nano**

Nanoseconds since the given second

unsigned int **atto**

Attoseconds since the given nanosecond

unsigned int **ronto**

Rontoseconds since the given attosecond

unsigned int **udecto**

Udectoseconds since the given rontosecond

unsigned int **xindecto**

Xindectoseconds since the given udectosecond

unsigned int **padding**

Unused, except to round the value out to the nearest 64 bits

6.2.4 Calculations

TAI64Time **TAI64Time_add**(*TAI64Time* t, *TAI64Time* z)

Parameters

- **t** (*TAI64Time*) – The current timestamp.
- **z** (*TAI64Time*) – The timestamp to add to the current one.

Returns The sum of the two timestamps.

Return type *TAI64Time*

Calculates the sum of two *TAI64Time* values.

TAI64Time **TAI64Time_sub**(*TAI64Time* t, *TAI64Time* z)

Parameters

- **t** (*TAI64Time*) – The current timestamp.
- **z** (*TAI64Time*) – The timestamp to subtract from the current one.

Returns The difference of the two timestamps.

Return type *TAI64Time*

Calculates the difference of two *TAI64Time* values.

6.2.5 Export

char ***TAI64Time_string**(*TAI64Time* t)

Parameters

- **t** (*TAI64Time*) – The current timestamp.

Returns The decimal string representation of the current timestamp.

Return type char*

Returns the decimal string representation of a *TAI64Time* value.

TAI64Time **TAI64Time_from_string**(char *in)

Parameters

- **in** (char*) – The decimal string representation of a timestamp to calculate.

Returns The calculated timestamp.

Return type *TAI64Time*

Calculates a *TAI64Time* from its decimal string representation.

char ***TAI64Time_hex_string**(*TAI64Time* t)

Parameters

- **t** (*TAI64Time*) – The current timestamp.

Returns The hexadecimal string representation of the current timestamp.

Return type char*

Returns the hexadecimal string representation of a *TAI64Time* value.

TAI64Time **TAI64Time_from_hex_string**(char *in)

Parameters

- **in** (char*) – The hexadecimal string representation of a timestamp to calculate.

Returns The calculated timestamp.

Return type *TAI64Time*

Calculates a *TAI64Time* from its hexadecimal string representation.

double **TAI64Time_double**(*TAI64Time* t)

Parameters

- **t** (*TAI64Time*) – The current timestamp.

Returns The arbitrary-precision floating point representation of the current timestamp.

Return type double

Returns the double representation of a *TAI64Time* value.

TAI64Time **TAI64Time_from_double**(double in)

Parameters

- **in** (double) – The arbitrary-precision floating point representation of a timestamp to calculate.

Returns The calculated timestamp.

Return type *TAI64Time*

Calculates a *TAI64Time* from its double representation.

char ***TAI64Time_encode_text**(*TAI64Time* t)

Parameters

- **t** (*TAI64Time*) – The current timestamp.

Returns A string containing the encoded text.

Return type char*

Encodes a *TAI64Time* value as text.

TAI64Time **TAI64Time_decode_text**(char *in)

Parameters

- **in** (char*) – A string containing the encoded text.

Returns The decoded timestamp.

Return type *TAI64Time*

Decodes a *TAI64Time* value from text.

void ***TAI64Time_encode_binary**(*TAI64Time* t, int *len)

Parameters

- **t** (*TAI64Time*) – The current timestamp.
- **len** (int*) – Will return the length of the binary data.

Returns A pointer to the encoded binary data stream.

Return type void*

Encodes a *TAI64Time* value as a binary data stream.

TAI64Time **TAI64Time_decode_binary**(void *in, int len)

Parameters

- **in** (void*) – A pointer to the encoded binary data stream.

- **len** (int) – The length of the binary data.

Returns The decoded timestamp.

Return type *TAI64Time*

Decodes a *TAI64Time* value from a binary data stream.

6.2.6 Helpers

TAI64Time **TAI64Time_utc_to_tai**(*TAI64Time* utc)

Parameters

- **utc** (*TAI64Time*) – The timestamp to remove the UTC offset from.

Returns The calculated timestamp.

Return type *TAI64Time*

Removes the UTC leap second offset from a *TAI64Time* value.

TAI64Time **TAI64Time_tai_to_utc**(*TAI64Time* tai)

Parameters

- **tai** (*TAI64Time*) – The timestamp to add the UTC offset to.

Returns The calculated timestamp.

Return type *TAI64Time*

Adds the UTC leap second offset to a *TAI64Time* value.

6.3 Custom Calendars in Dart

Adding new calendars to Calends is a fairly straightforward process. Extend the *CalendarDefinition* abstract class, and implement two getters and three methods. Then, simply construct an instance of your calendar system, and Calends will do the rest.

6.3.1 Define

Extend the *CalendarDefinition* class, implementing the following methods:

class calends.**CalendarDefinition**

CalendarDefinition.**get name**()

Returns The name of the calendar system.

Return type String

CalendarDefinition.**get defaultFormat**()

Returns The defalt format of the calendar system.

Return type String

`CalendarDefinition.`**`toInternal`**(*dynamic stamp*, *String format*)

Arguments

- **stamp** (`dynamic`) – The input stamp. Should support strings at the very minimum.
- **format** (`String`) – The format string for parsing the input stamp.

Returns The parsed internal timestamp.

Return type *TAI64Time*

Throws *CalendsException()* – when an error occurs

Converts an input date/time representation to an internal *TAI64Time*.

`CalendarDefinition.`**`fromInternal`**(*TAI64Time stamp*, *String format*)

Arguments

- **stamp** (*TAI64Time*) – The internal timestamp value.
- **format** (`String`) – The format string for formatting the output date.

Returns The formatted date/time.

Return type `String`

Throws *CalendsException()* – when an error occurs

Converts an internal *TAI64Time* to a date/time string.

`CalendarDefinition.`**`offset`**(*TAI64Time stamp*, *dynamic offset*)

Arguments

- **stamp** (*TAI64Time*) – The internal timestamp value.
- **offset** (`dynamic`) – The input offset. Should support strings at the very minimum.

Returns The adjusted internal timestamp.

Return type *TAI64Time*

Throws *CalendsException()* – when an error occurs

Adds the given offset to an internal *TAI64Time*.

6.3.2 Registration

Register

Once it is registered with the library, your calendar system can be used from anywhere in your application:

`CalendarDefinition.`**`register`**()

Adds a calendar system to the callback list.

Unregister

When you are done with a calendar system, it is best practice to free up resources by unregistering it:

`CalendarDefinition.`**`unregister`**`()`

Removes a calendar system from the callback list.

Check and List

`CalendarDefinition.`**`isRegistered`**`()`

Returns Whether or not the calendar system is currently registered.

Return type `bool`

Returns whether or not a calendar system has been registered, yet.

`CalendarDefinition.`**`listRegistered`**`()`

Returns The sorted list of calendar systems currently registered.

Return type `List<String>`

Returns the list of calendar systems currently registered.

6.3.3 Types and Values

Now we get to the inner workings that make calendar systems function – even the built-in ones. The majority of the "magic" comes from the *TAI64Time* object itself, as a reliable way of storing the exact instants being calculated, and the only way times are handled by the library itself. A handful of methods provide basic operations that calendar system developers can use to simplify their conversions (adding and subtracting the values of other timestamps, and importing/exporting timestamp values from/to string and numeric types, in particular), and a couple of helpers exclusively handle adding and removing UTC leap second offsets. As long as you can convert your dates to/from Unix timestamps in a string or numeric type, the rest is handled entirely by these helpers in the library itself.

`class` `calends.`**`TAI64Time`**

TAI64Time stores a `TAI64NARUX` instant in a reliable, easily-converted format. Each 9-digit fractional segment is stored in a separate 32-bit integer to preserve its value with a very high degree of accuracy, without having to rely on string parsing or external arbitrary-precision mathematics libraries.

`TAI64Time.`**`Seconds`**

The number of TAI seconds since `CE 1970-01-01 00:00:00 TAI`.

Note: TAI vs UTC

You may have noticed that a TAI64Time object stores times in `TAI seconds`, not `Unix seconds`, with a timezone offset of `TAI` rather than `UTC`. This distinction is **very important** as it will affect internal calculations and comparisons to mix the two up. TAI time is very similar to Unix time (itself based on UTC time), with one major difference. While Unix/UTC seconds include the insertion and removal of "leap seconds" to keep the solar zenith at local noon (which is useful for day-to-day living and planning), TAI seconds are a continuous count, unconcerned with dates whatsoever. Indeed, the only reason a date was given in the description above was to make it easier for human readers to know exactly when `0 TAI` took place.

In other words, once you have a Unix timestamp of your instant calculated, be sure to convert it using *utcToTai()* before returning the result to the rest of the library. And then, of course, you'll also need to convert instants from the library back using *taiToUtc()* before generating outputs.

TAI64Time.**Nano**

The first 9 digits of the timestamp's fractional component.

TAI64Time.**Atto**

The 10th through 18th digits of the fractional component.

TAI64Time.**Ronto**

The 19th through 27th digits of the fractional component.

TAI64Time.**Udecto**

The 28th through 36th digits of the fractional component.

TAI64Time.**Xindecto**

The 37th through 45th digits of the fractional component.

TAI64Time.**add**(*TAI64Time z*)

Arguments

- **z** (*TAI64Time*) – The timestamp to add to the current one.

Returns The sum of the two timestamps.

Return type *TAI64Time*

Calculates the sum of two *TAI64Time* values.

TAI64Time.**sub**(*TAI64Time z*)

Arguments

- **z** (*TAI64Time*) – The timestamp to subtract from the current one.

Returns The difference of the two timestamps.

Return type *TAI64Time*

Calculates the difference of two *TAI64Time* values.

TAI64Time.**toTAI64String**()

Returns The decimal string representation of the current timestamp.

Return type String

Returns the decimal string representation of the *TAI64Time* value.

TAI64Time.**fromTAI64String**(*String in*)

Arguments

- **in** (string()) – The decimal string representation of a timestamp to calculate.

Returns The calculated timestamp.

Return type *TAI64Time*

Calculates a *TAI64Time* from its decimal string representation.

TAI64Time.**toHex**()

Returns The hexadecimal string representation of the current timestamp.

Return type String

Returns the hexadecimal string representation of the *TAI64Time* value.

TAI64Time.**fromHex**(*string in*)

Arguments

- **in** (string()) – The hexadecimal string representation of a timestamp to calculate.

Returns The calculated timestamp.

Return type *TAI64Time*

Calculates a *TAI64Time* from its hexadecimal string representation.

TAI64Time.**toDouble**()

Returns The floating point representation of the current timestamp.

Return type double

Returns the double representation of the *TAI64Time* value.

TAI64Time.**fromDouble**(*double in*)

Arguments

- **in** (double) – The floating point representation of a timestamp to calculate.

Returns The calculated timestamp.

Return type *TAI64Time*

Calculates a *TAI64Time* from its double representation.

TAI64Time.**utcToTai**()

Returns The calculated timestamp.

Return type *TAI64Time*

Removes the UTC leap second offset from a *TAI64Time* value. Used when converting from Unix time to TAI time.

TAI64Time.**taiToUtc**()

Returns The calculated timestamp.

Return type *TAI64Time*

Adds the UTC leap second offset to a *TAI64Time* value. Used when converting from TAI time to Unix time.

6.4 Custom Calendars in JS/WASM

Adding new calendars to Calends is a fairly straightforward process. Extend the *CalendarDefinition()* abstract class, and implement three methods. Then, simply construct an instance of your calendar system, and Calends will do the rest.

6.4.1 Define

Extend the *CalendarDefinition()* class, implementing the following methods:

class calends.**CalendarDefinition**()

CalendarDefinition.**name**

The name of the calendar system. Can be static or set in the *constructor()*.

CalendarDefinition.**defaultFormat**

The default/fallback format for the calendar system. Can be static or set in the *constructor()*.

CalendarDefinition.**constructor**()

This can do anything you like.

CalendarDefinition.**toInternal**(*stamp*, *format*)

Arguments

- **stamp** (any) – The input. Should support `string`s at the very minimum.
- **format** (`string`) – The format string for parsing the input date.

Returns The parsed internal timestamp.

Return type *TAI64Time()*

Throws `CalendsException()` – when an error occurs

Converts an input date/time representation to an internal *TAI64Time()*.

CalendarDefinition.**fromInternal**(*instant*, *format*)

Arguments

- **instant** (*TAI64Time()*) – The internal timestamp value.
- **format** (`string`) – The format string for formatting the output date.

Returns The formatted date/time.

Return type `string`

Throws `CalendsException()` – when an error occurs

Converts an internal *TAI64Time()* to a date/time string.

CalendarDefinition.**offset**(*instant*, *offset*)

Arguments

- **instant** (*TAI64Time()*) – The internal timestamp value.
- **offset** (any) – The input offset. Should support `string`s at the very minimum.

Returns The adjusted internal timestamp.

Return type *TAI64Time()*

Throws `CalendsException()` – when an error occurs

Adds the given offset to an internal *TAI64Time()*.

6.4.2 Registration

Register

Once it is registered with the library, your calendar system can be used from anywhere in your application. To register a system, simply call `register()` on an object of your new class:

`CalendarDefinition.`**`register`**`()`

Registers a calendar system instance with the internal Calends library.

Unregister

The way to unregister a calendar system is to do so manually, using the instance you created to register it with in the first place:

`CalendarDefinition.`**`unregister`**`()`

Removes a calendar system from the callback list.

Check and List

`CalendarDefinition.`**`isRegistered`**`()`

Returns Whether or not the calendar system is currently registered.

Return type `bool`

Returns whether or not a calendar system has been registered, yet.

`CalendarDefinition.`**`registered`**`()`

Returns The sorted list of calendar systems currently registered.

Return type `[string]`

Returns the list of calendar systems currently registered.

6.4.3 Types and Values

Now we get to the inner workings that make calendar systems function – even the built-in ones. The majority of the "magic" comes from the *TAI64Time()* object itself, as a reliable way of storing the exact instants being calculated, and the only way times are handled by the library itself. A handful of methods provide basic operations that calendar system developers can use to simplify their conversions (adding and subtracting the values of other timestamps, and importing/exporting timestamp values from/to string and numeric types, in particular), and a couple of helpers exclusively handle adding and removing UTC leap second offsets. As long as you can convert your dates to/from Unix timestamps in a string or numeric type, the rest is handled entirely by these helpers in the library itself.

`class` `calends.`**`TAI64Time`**`()`

TAI64Time() stores a `TAI64NARUX` instant in a reliable, easily-converted format. Each 9-digit fractional segment is stored in a separate 32-bit integer to preserve its value with a very high degree of accuracy, without having to rely on string parsing or external arbitrary-precision mathematics libraries.

`TAI64Time.`**seconds**

The number of TAI seconds since `CE 1970-01-01 00:00:00 TAI`. Should be an integer value.

Note: TAI vs UTC

You may have noticed that a TAI64Time object stores times in `TAI seconds`, not `Unix seconds`, with a timezone offset of `TAI` rather than `UTC`. This distinction is **very important** as it will affect internal calculations and comparisons to mix the two up. TAI time is very similar to Unix time (itself based on UTC time), with one major difference. While Unix/UTC seconds include the insertion and removal of "leap seconds" to keep the solar zenith at local noon (which is useful for day-to-day living and planning), TAI seconds are a continuous count, unconcerned with dates whatsoever. Indeed, the only reason a date was given in the description above was to make it easier for human readers to know exactly when `0 TAI` took place.

In other words, once you have a Unix timestamp of your instant calculated, be sure to convert it using *fromUTC()* before returning the result to the rest of the library. And then, of course, you'll also need to convert instants from the library back using *toUTC()* before generating outputs.

`TAI64Time.`**nano**

The first 9 digits of the timestamp's fractional component.

`TAI64Time.`**atto**

The 10th through 18th digits of the fractional component.

`TAI64Time.`**ronto**

The 19th through 27th digits of the fractional component.

`TAI64Time.`**udecto**

The 28th through 36th digits of the fractional component.

`TAI64Time.`**xindecto**

The 37th through 45th digits of the fractional component.

`TAI64Time.`**add**(*z*)

Arguments

- **z** (*TAI64Time()*) – The timestamp to add to the current one.

Returns The sum of the two timestamps.

Return type *TAI64Time()*

Calculates the sum of two *TAI64Time()* values.

`TAI64Time.`**sub**(*z*)

Arguments

- **z** (*TAI64Time()*) – The timestamp to subtract from the current one.

Returns The difference of the two timestamps.

Return type *TAI64Time()*

Calculates the difference of two *TAI64Time()* values.

`TAI64Time.`**toString**()

Returns The decimal string representation of the current timestamp.

Return type `string`

Returns the decimal string representation of the *TAI64Time()* value.

TAI64Time.**fromString**(*in*)

Arguments

- **in** (string) – The decimal string representation of a timestamp to calculate.

Returns The calculated timestamp.

Return type *TAI64Time()*

Calculates a *TAI64Time()* from its decimal string representation.

TAI64Time.**toHex**()

Returns The hexadecimal string representation of the current timestamp.

Return type string

Returns the hexadecimal string representation of the *TAI64Time()* value.

TAI64Time.**fromHex**(*in*)

Arguments

- **in** (string) – The hexadecimal string representation of a timestamp to calculate.

Returns The calculated timestamp.

Return type *TAI64Time()*

Calculates a *TAI64Time()* from its hexadecimal string representation.

TAI64Time.**toNumber**()

Returns The numeric representation of the current timestamp.

Return type number

Returns the number representation of the *TAI64Time()* value.

TAI64Time.**fromNumber**(*in*)

Arguments

- **in** (number) – The arbitrary-precision floating point representation of a timestamp to calculate.

Returns The calculated timestamp.

Return type *TAI64Time()*

Calculates a *TAI64Time()* from its numeric representation.

TAI64Time.**fromUTC**()

Returns The calculated timestamp.

Return type *TAI64Time()*

Removes the UTC leap second offset from a TAI64Time value.

TAI64Time.**toUTC**()

Returns The calculated timestamp.

Return type *TAI64Time()*

Adds the UTC leap second offset to a TAI64Time value.

6.5 Custom Calendars in PHP

Adding new calendars to Calends is a fairly straightforward process. Extend the *CalendarDefinition* abstract class, and implement three methods. Then, simply construct an instance of your calendar system, and Calends will do the rest.

6.5.1 Define

Extend the *CalendarDefinition* class, implementing the following methods:

class Calends**CalendarDefinition**

toInternal(*mixed $date*, *string $format*) → TAITime

Parameters

- **$date** (mixed) – The input date. Should support strings at the very minimum.
- **$format** (string) – The format string for parsing the input date.

Returns The parsed internal timestamp.

Return type *TAITime*

Throws *CalendsException* – when an error occurs

Converts an input date/time representation to an internal *TAITime*.

fromInternal(*TAITime $stamp*, *string $format*) → string

Parameters

- **$stamp** (*TAITime*) – The internal timestamp value.
- **$format** (string) – The format string for formatting the output date.

Returns The formatted date/time.

Return type string

Throws *CalendsException* – when an error occurs

Converts an internal *TAITime* to a date/time string.

offset(*TAITime $stamp*, *mixed $offset*) → TAITime

Parameters

- **$stamp** (*TAITime*) – The internal timestamp value.
- **$offset** (mixed) – The input offset. Should support strings at the very minimum.

Returns The adjusted internal timestamp.

Return type *TAITime*

Throws *CalendsException* – when an error occurs

Adds the given offset to an internal *TAITime*.

6.5.2 Registration

Register

Once it is registered with the library, your calendar system can be used from anywhere in your application. To register a system, simply construct an instance:

```
$customCalendars[] = new MyCalendarSystem('example', 'yyyy-mm-dd@HH-MM-SS');
```

The first argument is the calendar system's name. The second is a default format string which will be passed to your calendar system whenever users leave the format string blank or unset with *Calends* methods.

Unregister

There are two ways to unregister a calendar system once it's no longer needed. The first is to simply destruct the instance you created to register it. For that reason, it's important to store all your calendar systems to variables rather than simply constructing them in place. Well, that and the fact you need the calendar system object to persist in order to handle requests from the rest of the library.

The other way to unregister a calendar system is to do so manually, using the instance you created to register it in the first place:

Calends\CalendarDefinition::**unregister**()

Removes a calendar system from the callback list.

Check and List

static Calends\CalendarDefinition::**isRegistered**(*string $name*) → bool

Parameters

- **$name** (string) – The calendar system name to check for.

Returns Whether or not the calendar system is currently registered.

Return type bool

Returns whether or not a calendar system has been registered, yet.

static Calends\CalendarDefinition::**listRegistered** → array

Returns The sorted list of calendar systems currently registered.

Return type [string]

Returns the list of calendar systems currently registered.

6.5.3 Types and Values

Now we get to the inner workings that make calendar systems function – even the built-in ones. The majority of the "magic" comes from the *TAITime* object itself, as a reliable way of storing the exact instants being calculated, and the only way times are handled by the library itself. A handful of methods provide basic operations that calendar system developers can use to simplify their conversions (adding and subtracting the values of other timestamps, and importing/exporting timestamp values from/to string and numeric types, in particular), and a couple of helpers exclusively handle adding and removing UTC leap second offsets. As long as you can convert your dates to/from Unix timestamps in a string or numeric type, the rest is handled entirely by these helpers in the library itself.

class Calends**TAITime**

TAITime stores a `TAI64NARUX` instant in a reliable, easily-converted format. Each 9-digit fractional segment is stored in a separate 32-bit integer to preserve its value with a very high degree of accuracy, without having to rely on string parsing or external arbitrary-precision mathematics libraries.

property seconds(*float*)

The number of TAI seconds since `CE 1970-01-01 00:00:00 TAI`. Should be an integer value; the `float` type is used, here, only to be able to hold a full signed 64-bit integer value regardless of architecture.

Note: TAI vs UTC

You may have noticed that a TAI64Time object stores times in `TAI seconds`, not `Unix seconds`, with a timezone offset of `TAI` rather than `UTC`. This distinction is **very important** as it will affect internal calculations and comparisons to mix the two up. TAI time is very similar to Unix time (itself based on UTC time), with one major difference. While Unix/UTC seconds include the insertion and removal of "leap seconds" to keep the solar zenith at local noon (which is useful for day-to-day living and planning), TAI seconds are a continuous count, unconcerned with dates whatsoever. Indeed, the only reason a date was given in the description above was to make it easier for human readers to know exactly when `0 TAI` took place.

In other words, once you have a Unix timestamp of your instant calculated, be sure to convert it using *fromUTC* before returning the result to the rest of the library. And then, of course, you'll also need to convert instants from the library back using *toUTC* before generating outputs.

---

property nano(*integer*)

The first 9 digits of the timestamp's fractional component.

property atto(*integer*)

The 10th through 18th digits of the fractional component.

property ronto(*integer*)

The 19th through 27th digits of the fractional component.

property udecto(*integer*)

The 28th through 36th digits of the fractional component.

property xindecto(*integer*)

The 37th through 45th digits of the fractional component.

add(*TAITime $z*) → TAITime

Parameters

- **$z** (*TAITime*) – The timestamp to add to the current one.

Returns The sum of the two timestamps.

Return type *TAITime*

Calculates the sum of two *TAITime* values.

sub(*TAITime $z*) → TAITime

Parameters

- **$z** (*TAITime*) – The timestamp to subtract from the current one.

Returns The difference of the two timestamps.

Return type *TAITime*

Calculates the difference of two *TAITime* values.

toString() → string

Returns The decimal string representation of the current timestamp.

Return type string

Returns the decimal string representation of the *TAITime* value.

Note: *TAITime* also implements __toString, so you can use that instead of calling this function directly, if you prefer.

---

fromString(*string $in*) → TAITime

Parameters

- **$in** (string) – The decimal string representation of a timestamp to calculate.

Returns The calculated timestamp.

Return type *TAITime*

Calculates a *TAITime* from its decimal string representation.

toHex() → string

Returns The hexadecimal string representation of the current timestamp.

Return type string

Returns the hexadecimal string representation of the *TAITime* value.

fromHex(*string $in*) → TAITime

Parameters

- **$in** (string) – The hexadecimal string representation of a timestamp to calculate.

Returns The calculated timestamp.

Return type *TAITime*

Calculates a *TAITime* from its hexadecimal string representation.

toNumber() → float

Returns The numeric representation of the current timestamp.

Return type float

Returns the float representation of the *TAITime* value.

fromNumber(*numeric $in*) → TAITime

Parameters

- **$in** (integer or float) – The arbitrary-precision floating point representation of a timestamp to calculate.

Returns The calculated timestamp.

Return type *TAITime*

Calculates a *TAITime* from its numeric (integer or float) representation.

fromUTC() → TAITime

Returns The calculated timestamp.

Return type *TAITime*

Removes the UTC leap second offset from a TAITime value.

toUTC() → TAITime

Returns The calculated timestamp.

Return type *TAITime*

Adds the UTC leap second offset to a TAITime value.

CHAPTER

SEVEN

APPENDIX

7.1 Contributions

Pull requests are always welcome on GitHub! That said, please be open to discussing the PR content, and possibly revising it if requested. Not all requests can be merged, and not all changes are desired.

Or, you can contribute some money, instead! Check out my Patreon for options, there. Other options will likely be added for one-time donations in the future.

7.1.1 Security Reporting

Report all security-related issues to dan (dot) hunsaker (plus) calends (at) gmail, and use PGP or GPG protections on your message (the account's key is `44806AB9`, or you can look it up by the email address). Security issues will be addressed internally before making any vulnerability announcements.

7.1.2 Contributors

Code

@danhunsaker

Patrons

- Dave McGrath
- M. Fredette

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