AD9164 API Specification
Rev 1.0
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<td>ad9164_jesd_get_link_status</td>
<td>58</td>
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<td>ad9164_clk_adjust_phase</td>
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<td>ad9164_clk_set_cross_ctrl</td>
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<td>68</td>
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<td>69</td>
</tr>
<tr>
<td>ad9164_nco_set_phase_offset</td>
<td>70</td>
</tr>
<tr>
<td>ad9164_nco_get_phase_offset</td>
<td>71</td>
</tr>
<tr>
<td>ad9164_nco_set_hopf_mode</td>
<td>72</td>
</tr>
<tr>
<td>ad9164_nco_get_hopf_mode</td>
<td>73</td>
</tr>
<tr>
<td>ad9164_nco_set_enable</td>
<td>74</td>
</tr>
<tr>
<td>ad9164_nco_get_enable</td>
<td>75</td>
</tr>
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<td>ad9164_dc_test_set_mode</td>
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INTRODUCTION

PURPOSE
This document serves as a programmer's reference for using and utilizing various aspects of the ADI High Speed Converters DAC Application Program Interface (API) library for the AD9164 DAC. It describes the general structure of the AD9164 API library, provides a detail list of the API functions and its associated data structures, macros, and definitions.

SCOPE
Currently the AD9164 API libraries targets the AD9164 16-bit 12 GSPS, RF Digital to Analog Converter

<table>
<thead>
<tr>
<th>Target Device Name</th>
<th>Device Description</th>
<th>Device Release Status</th>
<th>API Release Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD9164</td>
<td>16-bit 12 GSPS, RF Digital to Analog Converter</td>
<td>Released</td>
<td>Rev 1.0.0</td>
</tr>
</tbody>
</table>

DISCLAIMER
The software and any related information and/or advice is provided on an “AS IS” basis, without representations, guarantees or warranties of any kind, express or implied, oral or written, including without limitation warranties of merchantability fitness for a particular purpose, title and non-infringement. Please refer to the Software License Agreement applied to the source code for full details.
SOFTWARE ARCHITECTURE

The AD9164 API library is a collection of APIs that provide a consistent interface to a variety of ADI High Speed Converter DAC devices. The APIs are designed so that there is a consistent interface to the devices.

The library is a software layer that sits between the application and the DAC hardware. The library is intended to serve two purposes:

1. Provide the application with a set of APIs that can be used to configure RX hardware without the need for low-level register access. This makes the application portable across different revisions of the hardware and even across different hardware modules.
2. Provide basic services to aid the application in controlling the DAC module, such as interrupt service routine, DAC high-level control and status information.

The driver does not, in any shape or form, alter the configuration or state of DAC module on its own. It is the responsibility of the application to configure the part according to the required mode of operation, poll for status, etc... The library acts only as an abstraction layer between the application and the hardware.

As an example, the application is responsible for the following:

- Configuring the JESD Interface
- Configuring the NCO

The application should access the DAC device only through the DAC libraries exported APIS. It is not recommended for the application to access the DAC hardware device directly using direct SPI access. If the application chooses to directly access the DAC hardware this should be done in a very limited scope, such as for debug purposes and it should be understood that this practice may affect the reliability of the API functions.

![Figure 1 Simple Overview of the DAC API Architecture](image-url)
FOLDER STRUCTURE

The collective files of the AD9164 API library are structure as depicted in Figure 2. Each branch is explained in the following sections. The library is supplied in source format. All source files are in standard ANSI C to simply porting to any platform.

/api

/include  API Interface include files

- AD916x.h
- api_def.h
- api_config.h
- api_errors.h

/AD916x  AD916x API Implementation

/common  API Common Utility Functions

/doc  API Documentation

/applications

/dac_example  API integration example application

Figure 2 AD9164 Source Code Folder Structure

/api

The AD9164 API root folder contain all the source code and documentation for the AD9164 API.

/api/include

This folder contains all the API public interface files. These are the header files required by the client application.

/api/AD9164

This folder includes the main API implementation code for the AD9164 DAC APIs and any private header files uses by the API. ADI maintains this code as intellectual property and all changes are at their sole discretion.

/api/common

This folder contains ADI helper functions common to all APIs, these functions are internal private functions not designed for use by client application.

/api/doc

This folder contains the doxygen documentation for the AD9164 APIs.

/applications

/dac_example  API integration example application

This folder contains simple source code examples of how to use the DAC API. The application targets the AD9164 evaluation board platform. Customers can use this example code as a guide to develop their own application based on their requirements.
API INTERFACE

OVERVIEW

The header files listed in include folder, /API/include, describe public interface of the DAC API the client application. It consists of a number of header files listed in Table 2. Each API library will have a header file that lists its supported APIs that the client application may use to interface with the ADI device. For example, the AD9164.h header file lists all the APIs that are available to control and configure the AD9164 DAC device. The other header files are used for definitions and configurations that may be used by the client application. The features of which will be described in subsequent sections.

Table 2 DAC API Interface

<table>
<thead>
<tr>
<th>Device Name</th>
<th>Description</th>
<th>To be included in Client Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD9164.h</td>
<td>Lists AD9164 DAC API Library exposed to client application</td>
<td>Yes</td>
</tr>
<tr>
<td>api_config.h</td>
<td>Defines the various configuration options for the DAC Module</td>
<td>No</td>
</tr>
<tr>
<td>api_def.h</td>
<td>Defines any macros/enumerations or structures or definitions common to and used by all DAC API Libraries</td>
<td>No</td>
</tr>
<tr>
<td>api_error.h</td>
<td>Defines the DAC API interface errors and error handlers common to and used by all DAC API Libraries</td>
<td>Yes</td>
</tr>
</tbody>
</table>

AD9164.H

The AD9164 API library has a main interface header file AD9164.h header file that defines the software interface to the AD9164 DAC. It consists of a list of API functions and a number of structures and enumerations to describe the configurations and settings that are configurable on that particular device. In addition, the DAC device handle ad9164_handle_t this is a data structure that acts a software reference to a particular instance to of the DAC device. This handle maintains a reference to HAL functions and the configuration status of the chip.

This reference shall be instantiated by the client application, initialized by the application with client specific data.

API Handle

A summary of the user configurable components of this handle structure are listed in Table 3. Refer to the ad9164_handle_t section and the HAL Function Pointer DataTypes section for full a description and more details on configuration.

The platform specific members of the structure must be configured by the client application prior to calling any API with the handle, refer to the DAC Hardware Initialization section for more details.

Table 3 Components of the DAC API handle

<table>
<thead>
<tr>
<th>Structure Member</th>
<th>Description</th>
<th>User Read/Write Access</th>
<th>Required by API</th>
</tr>
</thead>
<tbody>
<tr>
<td>user_data</td>
<td>Void Pointer to a user defined data structure. Shall be passed to all HAL functions.</td>
<td>Read/Write</td>
<td>Optional</td>
</tr>
<tr>
<td>sdo</td>
<td>Device SPI Interface configuration for DAC hardware</td>
<td>Read/Write</td>
<td>Yes</td>
</tr>
<tr>
<td>dac_freq_hz</td>
<td>DAC Clock Frequency configuration</td>
<td>Read/Write</td>
<td>Yes</td>
</tr>
<tr>
<td>dev_xfer</td>
<td>Pointer to SPI data transfer function for DAC hardware</td>
<td>Read/Write</td>
<td>Yes</td>
</tr>
<tr>
<td>delay_us</td>
<td>Pointer to delay function for DAC hardware</td>
<td>Read/Write</td>
<td>Yes</td>
</tr>
<tr>
<td>hw_open</td>
<td>Pointer to platform initialization function for DAC hardware</td>
<td>Read/Write</td>
<td>Optional</td>
</tr>
<tr>
<td>hw_close</td>
<td>Pointer to the platform shutdown function for DAC hardware</td>
<td>Read/Write</td>
<td>Optional</td>
</tr>
<tr>
<td>event_handler</td>
<td>Pointer to a client event handler function for DAC device.</td>
<td>Read/Write</td>
<td>Optional</td>
</tr>
<tr>
<td>tx_en_pin_ctrl</td>
<td>Pointer to client application control function of DAC device TX_ENABLE pin</td>
<td>Read/Write</td>
<td>Optional</td>
</tr>
<tr>
<td>reset_pin_ctrl</td>
<td>Pointer to client application control function of DAC device RESETB pin</td>
<td>Read/Write</td>
<td>Optional</td>
</tr>
</tbody>
</table>
API_CONFIG.H
The API configuration header file, api_config.h, located in the /barium_api/include folder defines the compilation build configuration options for the DAC API.
The client application in general is not required to include or modify this file.

ADI_DEF.H
The AD9164 API is designed to be platform agnostic. However, it requires access to some platform functionality, such as SPI read/write and delay functions that the client application must implement and make available to the AD9164 API. These functions are collectively referred to as the platform Hardware Abstraction Layer (HAL).
The HAL functions are defined by the API definition interface header file, adi_def.h. The implementation of these functions is platform dependent and shall be implemented by the client application as per the client application platform specific requirements. The client application will point the AD9164 API to the required platform functions on instantiation of the AD9164 API handle. The following is a description of HAL components.

The AD9164 API handle, ad9164_handle_t, has a function pointer member for each of the HAL functions and are listed in Table 4. The client application shall assign each pointer the address of the target platform's HAL function implementation prior to calling any DAC API.

<table>
<thead>
<tr>
<th>Function Pointer Name</th>
<th>Purpose</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>*spi_xfer_t</td>
<td>Implement a SPI transaction</td>
<td>Required</td>
</tr>
<tr>
<td>*hw_open_t</td>
<td>Open and initialize II resources and peripherals required for DAC Device</td>
<td>Optional</td>
</tr>
<tr>
<td>*hw_close_t</td>
<td>Shutdown and close any resources opened by hw_open_t</td>
<td>Optional</td>
</tr>
<tr>
<td>*delay_us_t</td>
<td>Perform a wait/thread sleep in units of microseconds</td>
<td>Required</td>
</tr>
<tr>
<td>*tx_en_pin_ctrl_t</td>
<td>Set DAC device TX_ENABLE pin high or low.</td>
<td>Optional</td>
</tr>
<tr>
<td>*reset_pin_ctrl_t</td>
<td>Set DAC device RESETB pin high or low.</td>
<td>Optional</td>
</tr>
<tr>
<td>*event_handler_t</td>
<td>Event notification handler</td>
<td>Optional</td>
</tr>
</tbody>
</table>

DAC Hardware Initialization
The client application is responsible for ensuring that all required hardware resources and peripherals required by but external to the DAC are correctly configured. The DAC API handle ad9164_handle_t defines two pointer function members to which the client application may optionally provide HAL functions to initialize these resources, *hw_open_t and *hw_close_t. If the client application provides valid functions via these function pointers, the DAC initialization APIs Ad9164_init and ad9164_deinit shall call hw_open_t and hw_close_t respectively to handle the initialization and shutdown of required hardware resources. If the client application chooses not use this feature, the AD9164 API assumes that SPI and all the external resources for the AD9164 ReDAC are available.

The DAC API libraries require limited access to hardware interfaces on the target platform. These are depicted in Figure 3.
**SPI Access**

Access to the SPI controller that communicates with the AD9164 DAC devices is required for correct operation of the API. The API requires access to a SPI function that can send SPI commands. This function `*spi_xfer_t` is defined in detail in the next section. The DAC SPI requires 15 bit addressing with 8-bit data bytes. The AD9164 DAC SPI interface supports 3 wire or 4 wire and the AD9164 DAC must be configured as such to match the platform implementation. This is done during initialization via the `ad9164_init` API. Please refer to the target ADI device datasheet for full details of the SPI Interface protocol.

**RESETB Pin Access**

Optionally access to the function that controls the AD9164 DAC RESETB pin can be included in the HAL layer. This function if provided allows the API to implement a hardware reset rather than a software reset.

The HAL function `*reset_pin_ctrl_t` is defined in detail in the next section. Please refer to the target ADI device datasheet for full details on the RESETB pin hardware connections.

**TX_ENABLE PIN Access**

Optionally access to the function that controls the AD9164 DAC TX_ENABLE pin can be included in the HAL layer. This function if provided allows the client to call control the TX_ENABLE pin via the `ad9164_transmit_enable` API. If it is not provided the transmit enable feature in API shall be limited to using the SPI control.

The HAL function `*tx_en_pin_ctrl_t` is defined in detail in the next section. Please refer to the target ADI device datasheet for full details on the TX_ENABLE pin hardware connections.

**System Software Functions**

**Delay Function**

For best performance, it is recommended to provide the API access to the client application's delay function. The delay function can be a wait or sleep function depending on the client application. This function allow the API to wait the recommended microsecond between initialization steps.

The HAL function `*delay_us_t` is defined in detail in the next section.

**Event Notification**

Optionally access to an API event handler function may be included in the HAL layer. This function shall be used to pass interrupt event data to the client application. This function shall be called by the `ad9164_isr` API only to notify all interrupt events detected and any additional data available regarding that event. The HAL function `*event_handler_t` is defined in detail in the next section.
HAL FUNCTION POINTER DATATYPES

*HW_OPEN_T

Description
Function pointer definition to a client application function that implements platform hardware initialization for the AD9164 Device.

This function may initialize external hardware resources required by the AD9164 Device and API for correct functionality as per the target platform. For example initialization of SPI, GPIO resources, clocks etc.

If provided, this function shall be called during the DAC module initialization via API ad9164_init. The API will then assume that all require external hardware resources required by the DAC are configured and it is safe to interact with the DAC device.

Synopsis

```c
typedef void(*hw_open_t)(void  *user_data);
```

Preconditions
Unknown- Platform Implementation.

Post conditions
It is expected that all external hardware and software resources required by the DAC API are now initialized appropriately and accessible by the DAC API.

Dependencies
Unknown- Platform Implementation

Parameters

```plaintext
user_data
```
A void pointer to a client defined structure containing any parameters/settings that may be required by the function to open the hardware for the ADI Device.

Return value
Zero shall indicate success.
Any other positive integer value may represent an error code to be returned to the application.

Notes
This function is not required to integrate the API. It is an optional feature that may be used by the client application.
*HW_CLOSE_T*

Description

Function pointer to function that implements platform hardware de-initialization for the AD9164 Device

This function shall close or shutdown external hardware resources required by the AD9164 Device and API for correct functionality as per the target platform. For example initialization of SPI, GPIO resources, clocks etc.

It should close and free any resources assigned in the *hw_open_t* function. This function if provided shall be called during the DAC module de-initialization via API *ad9164_init*. The API will then assume that all require external hardware resources required by the DAC are no longer available and it is not-safe to interact with the DAC device.

Synopsis

```c
typedef void(*hw_close_t)(void *user_data);
```

Preconditions

It is expected that there are no pre conditions to this function. All initialization required shall be performed prior to or during (via *hw_open_t*) *ad9164_init*.

Post conditions

It is expected that there are no post conditions to this function.

Dependencies

Unknown- Platform Implementation

Parameters

- **user_data**

  A void pointer to a client defined structure containing any parameters/settings that may be required by the function to close the hardware for the ADI Device.

Return value

- Zero shall indicate success.
- Any other positive integer value may represent an error code to be returned to the application.

Notes

This function is not required to integrate the API. It is an optional feature that may be used by the client application.
*SPI_XFER_T*

Description

Function to implement a SPI transaction to the DAC device.

This function shall perform send a read/write SPI command to targeted ADI DAC device. The SPI implementation shall support 15-bit addressing and 8-bit data bytes. This function shall control the SPI interface including the appropriate chip select to correctly send and retrieve data to the targeted ADI DAC device over SPI.

The implementation may support 3-wire or 4-wire mode. The DAC API must be configured to support the platform implementation this is done during the DAC initialization API ad916x_init.

Once a DAC device is initialized via the ad916x_init API, it is expected that the API may call this function at any time.

Synopsis

```c
typedef int(*spi_xfer_t)(void *user_data, uint8_t *indata, uint8_t *outdata, int size_bytes);
```

Preconditions

It is expected that there are no pre conditions to this function. All initialization required shall be performed prior to or during (via *hw_open_t*) Ad9164_init. Once a DAC device is initialized via the Ad9164_init API, it is expected that the API may call this function at any time.

Post conditions

It is expected that there are no post conditions to this function.

Dependencies

Unknown- Platform Implementation

Parameters

- **user_data** A void pointer to a client defined structure containing any parameters/settings that may be required by the function to implement the SPI for the ADI Device. For example, chip select may be passed to the function via this parameter.
- **indata** pointer to a uint8_t array with the data to be sent on the SPI
- **outdata** pointer to a uint8_t array to which the data from the SPI device will be written
- **size_bytes** an integer value indicating the size in bytes of both indata and outdata arrays.

Return value

Zero shall indicate success.

Any other positive integer value may represent an error code to be returned to the application.

Notes

indata and outdata arrays shall be the same size.
**TX_EN_PIN_CTRL_T**

Description

Function to implement set the TX_ENABLE pin of the DAC device high or low.

Once a DAC device is initialized via the `ad9164_init` API, it is expected that the API may call this function at any time.

Synopsis

```c
typedef int(*tx_en_pin_ctrl_t)(void *user_data, uint8_t enable);
```

Preconditions

It is expected that there are no pre conditions to this function. All initialization required shall be performed prior to or during (via `hw_open_t`) `ad9164_init`. Once a DAC device is initialized via the `ad9164_init` API, it is expected that the API may call this function at any time.

Post conditions

It is expected that there are no post conditions to this function.

Dependencies

Unknown- Platform Implementation

Parameters

- **user_data**
  A void pointer to a client defined structure containing any parameters/settings that may be required by the function to implement the SPI for the ADI Device. For example, chip select may be passed to the function via this parameter.

- **enable**
  A `uint8_t` value indicating the desired enable/disable setting for the tx_enable pin.
  A value of 1 indicates TX_ENABLE pin is set HIGH.
  A value of 0 indicates TX_ENABLE pin is set LOW.

Return value

- Zero shall indicate success.
- Any other positive integer value may represent an error code to be returned to the application.

Notes

This function is not required to integrate the API. It is an optional feature that may be used by the client application should the user which to control the pin via the API. The relevant API function is `ad9164_transmit_enable`.
**RESET_PIN_CTRL_T**

Description

Function to implement set the RESETB pin of the DAC device high or low.

Synopsis

```c
typedef int(*reset_pin_ctrl_t)(void *user_data, uint8_t enable);
```

Preconditions

It is expected that there are no pre conditions to this function. All initialization required shall be performed prior to or during (via `*hw_open_t` `ad9164_init`). Once a DAC device is initialized via the `ad9164_init` API, it is expected that the API may call this function at any time.

Post conditions

It is expected that there are no post conditions to this function.

Dependencies

Unknown- Platform Implementation

Parameters

- `user_data` A void pointer to a client defined structure containing any parameters/settings that may be required by the function to implement the SPI for the ADI Device. For example, chip select may be passed to the function via this parameter.
- `enable` A `uint8_t` value indicating the desired enable/disable setting for the tx_enable pin.
  - A value of 1 indicates RESETB pin is set HIGH.
  - A value of 0 indicates RESETB pin is set LOW.

Return value

Zero shall indicate success.

Any other positive integer value may represent an error code to be returned to the application.

Notes

This function is not required to integrate the API. It is an optional feature that may be used by the client application should the user which to control the pin via the API. The relevant API function is `ad9164_reset`. 
**DELAY_US_T**

**Description**

Function to implement a delay for specified number of microseconds.

Any timer hardware initialization required for the platform dependent implementation of this function must be performed prior to providing to calling any DAC APIs.

Once a DAC device is initialized via the `ad9164_init` API, it is expected that the API may call this function at any time.

**Synopsis**

```c
typedef int(*delay_us_t)(void *user_data, int us);
```

**Preconditions**

It is expected that there are no pre conditions to this function. All initialization required shall be performed prior to or during (via `*hw_open_t ad9164_init`) Once a DAC device is initialized via the `ad9164_init` API, it is expected that the API may call this function at any time.

**Post conditions**

It is expected that there are no post conditions to this function.

**Dependencies**

Unknown- Platform Implementation

**Parameters**

- **user_data**  A void pointer to a client defined structure containing any parameters/settings that may be required by the function to implement the delay for the ADI Device.

- **int us**  time to delay/sleep in microseconds

**Return value**

Zero shall indicate success.

Any other positive integer value may represent an error code to be returned to the application.

**Notes**

This is required for optimal performance.

Performs a blocking or sleep delay for the specified time in microseconds.
*EVENT_HANDLER_T*

**Description**
A Client application implementation of the API event notification handler. This function is called by the `ad9164_isr` API to send notification of events to the application.

Event notification shall depend on which interrupts have been enable via the `ad9164_set_events` API. Full details of the available events are listed in the Interrupt Handling section and the target DAC device datasheet.

**Synopsis**

```c
typedef int(*event_handler_t)(uint16_t event, uint8_t ref, void* data);
```

**Preconditions**

It is expected that there are no pre conditions to this function. All initialization required shall be performed prior to or during (via `*hw_open_t` `ad9164_init`). Once a DAC device is initialized via the `ad9164_init` API, it is expected that the API may call this function at any time.

**Post conditions**

It is expected that there are no post conditions to this function.

**Dependencies**

Unknown- Platform Implementation

**Parameters**

- `uint16_t event` A uint16_t value representing the event that has been detected. Event types are enumerated by `ad9164_event_t`. Addition information is detailed in the **Interrupt Events** section.

- `uint8_t ref` A uint8_t value that represents the event reference data if required. For example for Link events, the reference data shall be the Lane number on which the event occurred. Addition information is detailed in the **Interrupt Events** section.

- `void* data` A pointer to any additional event data that may be relevant. Currently none of the AD9164 API Events provides any event data. Addition information is detailed in the **Interrupt Events** section.

**Return value**

- Zero shall indicate success.
- Any other positive integer value may represent a error code to be returned to the application.

**Notes**

- This is required for optimal performance.
- Performs a blocking or sleep delay for the specified time in microseconds.
ERROR HANDLING

ERROR CODES
Each API return value represents a DAC API error code. The possible error codes for ADI device APIs are defined by a number of macros listed in `api_errors.h`. Table 5 lists the possible error codes and their meanings returned by the AD9164 APIs.

If a HAL function, called by during the execution of an API, returns a non-zero value the API shall return an error code indicating that there was an error returned from particular HAL function. Table 6 lists the possible errors returned by API due to a HAL function.

<table>
<thead>
<tr>
<th>ERROR CODE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>API_ERROR_OK</td>
<td>API completed successfully</td>
</tr>
<tr>
<td>API_ERROR_SPI_SDO</td>
<td>API could not complete successfully due to SPI_SDO configuration in API Handle</td>
</tr>
<tr>
<td>API_ERROR_INVALID_HANDLE_PTR</td>
<td>API could not complete successfully due to invalid pointer to API Handle</td>
</tr>
<tr>
<td>API_ERROR_INVALID_XFER_PTR</td>
<td>API could not complete successfully due to invalid pointer to SPI transfer function</td>
</tr>
<tr>
<td>API_ERROR_INVALID_DELAYUS_PTR</td>
<td>API could not complete successfully due to invalid pointer to Delay function</td>
</tr>
<tr>
<td>API_ERROR_INVALID_PARAM</td>
<td>API could not complete successfully due to invalid API parameter</td>
</tr>
<tr>
<td>API_ERROR_FTW_LOAD_ACK</td>
<td>API could not complete successfully due to Frequency Turning Word No-ACK</td>
</tr>
<tr>
<td>API_ERROR_NCO_NOT_ENABLED</td>
<td>API could not complete successfully due to NCO not currently Enabled</td>
</tr>
<tr>
<td>API_ERROR_INIT_SEQ_FAIL</td>
<td>API could not complete successfully due to NVRAM load error.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ERROR CODE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>API_ERROR_SPI_XFER</td>
<td>SPI HAL function return an error during the implementation of this API</td>
</tr>
<tr>
<td>API_ERROR_US_DELAY</td>
<td>DELAY HAL function return an error during the implementation of this API</td>
</tr>
<tr>
<td>API_ERROR_TX_EN_PIN_CTRL</td>
<td>TX_ENABLE pin ctrl HAL function return an error during the implementation of this API</td>
</tr>
<tr>
<td>API_ERROR_RESET_PIN_CTRL</td>
<td>RESET pin ctrl HAL function return an error during the implementation of this API</td>
</tr>
<tr>
<td>API_ERROR_EVENT_HNDL</td>
<td>EVENT Handle HAL function return an error during the implementation of this API</td>
</tr>
<tr>
<td>API_ERROR_HW_OPEN</td>
<td>HW Open HAL function returned an error during the implementation of this API</td>
</tr>
<tr>
<td>API_ERROR_HW_CLOSE</td>
<td>HW Close HAL function returned an error during the implementation of this API</td>
</tr>
</tbody>
</table>
INTERRUPT HANDLING

The AD9164 API provides basic support for the AD9164 Interrupt feature. It provides an API, `ad9164_set_events`, to enable and disable the desired interrupt to trigger and an API to check if interrupt has been triggered and the interrupt source `ad9164_get_interrupt_status`. Additionally, it provides a simple ISR API, `ad9164_isr`, that will check for and clear any interrupts trigger and provide event notification to the client application. In order to use the ISR api the client application must provide the user with a notification handler function, `event_handler_t`. The prototype of this function is defined in `adi_def.h`.

INTERRUPT EVENTS

Table 6 summarized the list of events that the API interrupt feature supports. Events are categorized as device events that can only occur per device or JESD link events that can occur at per link per lane level. For JESD link the ISR, ad9164_isr, shall report via the `ref` parameter the lane number on which the event.

<table>
<thead>
<tr>
<th>EVENT</th>
<th>TYPE</th>
<th>Reference</th>
<th>DATA</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVENT_SYSREF_JITTER</td>
<td>Device Event</td>
<td>None</td>
<td>None</td>
<td>SYSREF JITTER Threshold Event</td>
</tr>
<tr>
<td>EVENT_DATA_RDY</td>
<td>Device Event</td>
<td>None</td>
<td>None</td>
<td>DATA Ready Event</td>
</tr>
<tr>
<td>EVENT_JESD_LANE_FIFO_ERR</td>
<td>Device Event</td>
<td>None</td>
<td>None</td>
<td>JESD LANE FIFO Underflow/overflow Event</td>
</tr>
<tr>
<td>EVENT_JESD_PRBS_IMG_ERR</td>
<td>Device Event</td>
<td>None</td>
<td>None</td>
<td>PRBS I Error Event</td>
</tr>
<tr>
<td>EVENT_JESD_PRBS_REAL_ERR</td>
<td>Device Event</td>
<td>None</td>
<td>None</td>
<td>PRBS I Error Event</td>
</tr>
<tr>
<td>EVENT_JESD_ILAS_ERR</td>
<td>Device Event</td>
<td>None</td>
<td>None</td>
<td>ILAS Configuration Mismatch Event</td>
</tr>
<tr>
<td>EVENT_JESD_BAD_DISPARITY_ERR</td>
<td>JESD Link Event</td>
<td>Lane No</td>
<td>None</td>
<td>Bad Disparity Error Event</td>
</tr>
<tr>
<td>EVENT_JESD_NOT_IN_TBL_ERR</td>
<td>JESD Link Event</td>
<td>Lane No</td>
<td>None</td>
<td>Not-In-Table Error Event</td>
</tr>
<tr>
<td>EVENT_JESD_K_ERR</td>
<td>JESD Link Event</td>
<td>Lane No</td>
<td>None</td>
<td>Unexpected K Error Event</td>
</tr>
<tr>
<td>EVENT_JESD_ILD_ERR</td>
<td>JESD Link Event</td>
<td>Lane No</td>
<td>None</td>
<td>Inter-lane De-Skew Event</td>
</tr>
<tr>
<td>EVENT_JESD_ILD_ERR</td>
<td>JESD Link Event</td>
<td>Lane No</td>
<td>None</td>
<td>Good Checksum Event</td>
</tr>
<tr>
<td>EVENT_JESD_CKSUM_ERR</td>
<td>JESD Link Event</td>
<td>Lane No</td>
<td>None</td>
<td>Frame Synchronization Event</td>
</tr>
<tr>
<td>EVENT_JESD_CGS_ERR</td>
<td>JESD Link Event</td>
<td>Lane No</td>
<td>None</td>
<td>Code Group Synchronization Event</td>
</tr>
</tbody>
</table>
AD9164 API REFERENCE HANDLE

AD9164_HANDLE_T

Description
DAC Device reference handle data structure that acts a software reference to a particular instance to of the DAC device. This reference maintains a reference to HAL functions and the configuration status of the chip.

Synopsis
#include AD9164.h
typedef struct {
    void *user_data;
    spi_sdo_config_t sdo;
    uint64_t dac_freq_hz;
    spi_xfer_t dev_xfer;
    delay_us_t delay_us;
    event_handler_t event_handler;
    tx_en_pin_ctrl_t tx_en_pin_ctrl;
    reset_pin_ctrl_t reset_pin_ctrl;
    hw_open_t hw_open;
    hw_close_t hw_close;
} ad9164_handle_t;

Members
void *user_data;
A void pointer that acts a container structure for client application data to be provided to the HAL functions. The client application must define this structure as per its platform requirements. This pointer shall be passed as the parameter to the *hw_open_t and *hw_close_t function calls to pass any client application specific data. The DAC API shall not access this data directly. The client application must initialize this member appropriately prior to calling any DAC API function.

spi_sdo_config_t sdo;
This member hold the desired SPI interface configuration, 3-wire or 4-wire, for the AD9164 DAC in the client system. spi_sdo_config_t enumerates this configuration and is defined in api_def.h. This member should be correctly configured prior to calling ad9164_init in order to ensure SPI access to the AD9164.

uint64_t dac_freq_hz ;
This member holds the frequency of the DAC CLK provided to the AD9164 DAC in the target system.
It is important to configure this variable correctly prior to configuring the AD9164 with operational modes such as NCO, JESD and data path as this value is used as reference for internal
This value should be access via the ad9164_dac_set_clk_frequency API and the ad9164_dac_get_clk_frequency.

spi_xfer_t dev_xfer;
A function pointer to the client application defined SPI HAL function refer to *spi_xfer_t section for a detailed definition of this function. The client application must initialize this member appropriately prior to calling any DAC API function.

delay_us_t delay_us ;
A function pointer to the client application defined microsecond delay. HAL function refer to * delay_us_t section for a detailed definition of this function. The client application must initialize this member appropriately prior to calling any DAC API function.
event_handler_t event_handler;
    A function pointer to the client application's implementation of the event notification handler.
    HAL function refer to *event_handler_t section for a detailed definition of this function.

tx_en_pin_ctrl_t tx_en_pin_ctrl;
    A function pointer to the client application's implementation of TX_ENABLE pin control function, refer to *
    tx_en_pin_ctrl_t section for a detailed definition of this function.

reset_pin_ctrl_t reset_pin_ctrl;
    A function pointer to the client application's implementation of RESETB pin control function, refer to *
    reset_pin_ctrl_t section for a detailed definition of this function.

hw_open_t hw_open;
    A function pointer to the client application HAL resources initialization function refer to *hw_open_t section for a
detailed definition of this function. The client application must initialize this member appropriately prior to calling
any DAC API function.

hw_close_t hw_close;
    A function pointer to the client application HAL resources de-initialization function refer to *hw_close_t section for a
detailed definition of this function. The client application must initialize this member appropriately prior to calling
any DAC API function.
AD9164 API DEFINITIONS, DATA STRUCTURES AND ENUMERATIONS

This section describes all the structures and enumerations defined by the DAC API interface.

**AD9164_CHIP_ID_T**

**Description**
A structure detailing the AD9164 Device Identification Data. Please refer to the specific DAC Data sheet for expected values.

**Synopsis**
```c
#include AD9164.h
typedef struct {
    uint8_t chip_type;
    uint16_t prod_id;
    uint8_t prod_grade;
    uint8_t dev_revision;
} ad9164_chip_id_t;
```

**Fields**
- `uint8_t chip_type`  Chip Type
- `uint16_t prod_id`  Product ID code
- `uint8_t prod_grade`  Product Grade
- `uint8_t dev_revision`  Silicon Revision.

**Notes**
Product ID and product grade are only available after initialization.
AD9164_TX_ENABLE_PIN_MODE_T

Description

An enumeration of the configuration options for the TX_ENABLE pin functionality.

Synopsis

```
#include AD9164.h
typedef enum {
    NONE,
    RESET_NCO,
    ZERO_DATA_DAC,
    ZERO_DATA_IN_PATH,
    CURRENT_CONTROL
} ad9164_tx_enable_pin_mode_t;
```

Fields

- **NONE**: No functionality is assigned to the TX_ENABLE pin
- **RESET_NCO**: NCO is reset based on status of TX_ENABLE pin
- **ZERO_DATA_DAC**: Data to DAC is zeroed based on status of TX_ENABLE pin
- **ZERO_DATA_IN_PATH**: Data in data path is zeroed based on status of TX_ENABLE pin.
- **CURRENT_CONTROL**: Full scale current control is influenced by TX_ENABLE pin.

Notes
AD9164_HOPF_MODE_T

Description
An enumeration of the configuration options for the Frequency Hopping

Synopsis
#include AD9164.h
typedef enum {
    ad9164_PHASE_CONTINOUS = 0x00,
    ad9164_PHASE_NONCONTINOUS = (1u << 6),
    ad9164_PHASE_COHERENT = (2u << 6),
    ad9164_FFH_MODE_MASK = (3u << 6)
}ad9164_hopf_mode_t;

Fields
ad9164_PHASE_CONTINOUS
ad9164_PHASE_NONCONTINOUS
ad9164_PHASE_COHERENT
ad9164_FFH_MODE_MASK

Notes
AD9164_EVENT_T

Description
An enumeration of the configuration options for the Frequency Hopping

Synopsis

```
#include AD9164.h
typedef enum {
    EVENT_SYSREF_JITTER,
    EVENT_DATA_RDY,
    EVENT_JESD_LANE_FIFO_ERR,
    EVENT_JESD_PRBS_IMG_ERR,
    EVENT_JESD_PRBS_REAL_ERR,
    EVENT_JESD_BAD_DISPARITY_ERR,
    EVENT_JESD_NOT_IN_TBL_ERR,
    EVENT_JESD_K_ERR,
    EVENT_JESD_ILD_ERR,
    EVENT_JESD_ILD_ERR,
    EVENT_JESD_CKSUM_ERR,
    EVENT_JESD_FS_ERR,
    EVENT_JESD_CGS_ERR,
    EVENT_JESD_ILAS_ERR,
    NOF_EVENTS
} ad9164_event_t;
```

Fields
- `EVENT_SYSREF_JITTER`
- `EVENT_DATA_RDY`
- `EVENT_JESD_LANE_FIFO_ERR`
- `EVENT_JESD_PRBS_IMG_ERR`
- `EVENT_JESD_PRBS_REAL_ERR`
- `EVENT_JESD_BAD_DISPARITY_ERR`
- `EVENT_JESD_NOT_IN_TBL_ERR`
- `EVENT_JESD_K_ERR`
- `EVENT_JESD_ILD_ERR`
- `EVENT_JESD_ILD_ERR`
- `EVENT_JESD_CKSUM_ERR`
- `EVENT_JESD_FS_ERR`
- `EVENT_JESD_CGS_ERR`
- `EVENT_JESD_ILAS_ERR`
- `NOF_EVENTS`

Notes
AD9164 _JESD_LINK_STAT_T

Description
A structure of the JESD Interface link Status

Synopsis
#include AD9164.h

typedef struct {
    uint8_t code_grp_sync_stat;
    uint8_t frame_sync_stat;
    uint8_t good_checksum_stat;
    uint8_t init_lane_sync_stat;
} ad9164_jesd_link_stat_t;

Members

uint8_t code_grp_sync_stat;
A uint8_t bit wise representation of Code Group Sync Status for all JESD Lanes. Where bit 0 represents CGS status for Lane 0 and bit 1 represents CGS status for Lane 1 etc. A value of 1 indicates CGS status is complete, a value of 0 indicates CGS failed.

uint8_t frame_sync_stat;
A uint8_t bit wise representation of Frame Sync Status for all JESD Lanes. Where bit 0 represents Frame Sync status for Lane 0 and bit 1 represents Frame Sync status for Lane 1 etc. A value of 1 indicates Frame Synchronization status is complete, a value of 0 indicates Frame Synchronization failed.

uint8_t good_checksum_stat;
A uint8_t bit wise representation of Good Checksum Status for all JESD Lanes. Where bit 0 represents Checksum status for Lane 0 and bit 1 represents checksum status for Lane 1 etc. A value of 1 indicates valid checksum status, a value of 0 indicates checksum failed.

uint8_t init_lane_sync_stat;
A uint8_t bit wise representation of Initial Lane Synchronization Status for all JESD Lanes. Where bit 0 represents Lane Synchronization status for Lane 0 and bit 1 represents Lane Synchronization status for Lane 1 etc. A value of 1 indicates Lane Synchronization completed, a value of 0 Lane Synchronization failed.

Notes
AD9164 _JESD_SYSREF_MODE_T

Description
A enumeration of the JESD SYSREF modes.

Synopsis

```c
#include AD9164.h

typedef enum {
    SYSREF_NONE,
    SYSREF_ONESHOT,
    SYSREF_CONT
    SYSREF_MON,
    SYSREF_MODE_INVLD
} ad9164_jesd_sysref_mode_t;
```

Members

- **SYSREF_NONE** No SYSREF synchronization.
- **SYSREF_ONESHOT** One shot SYSREF Mode
- **SYSREF_CONT** Continous SYSREF Synchronization mode.
- **SYSREF_MON** SYSREF Monitor Mode
- **SYSREF_MODE_INVLD** Invalid or unknown SYSREF Mode.

Notes
AD9164_JESD_CFG_ERR_FLG_T

Description
An enumeration of JESD configuration error flags.

Synopsis
#include AD9164.h
typedef enum
{
    INTPL_FACTOR_INVLD = 0x1,
    SUBCLASS_V_INVLD = 0x2,
    K_INVLD = 0x4,
    LMFS_INPOL_INVLD = 0x8,
    LMFC_DELAY_INVLD = 0x10,
    SYSREF_JTTR_WIN_INVLD = 0x20
} ad9164_jesd_cfg_err_flg_t;

Members
INTPL_FACTOR_INVLD      Invalid interpolation factor set.
SUBCLASS_V_INVLD        Illegal Subclass V set
K_INVLD                 Illegal K set.
LMFS_INPOL_INVLD        Unsupported LMFS combination set for selected Interpolation factor
LMFC_DELAY_INVLD        Illegal LMFC delay set
SYSREF_JTTR_WIN_INVLD   Illegal Sysref Jitter window set.

Notes
AD9164_JESD_SERDES_PLL_FLG_T

Description
An enumeration of the SERDES PLL Status flags.

Synopsis
#include AD9164.h
typedef enum {
    PLL_LOCK_STAT = 0x1,
    PLL_CAL_STAT = 0x8,
    PLL_UPP_CAL_THRES = 0x10,
    PLL_LWR_CAL_THRES = 0x20
} ad9164_jesd_serdes_pll_flg_t;

Members
PLL_LOCK_STAT SERDES PLL lock Status Flag. When set the PLL is locked.
PLL_CAL_STAT SERDES PLL Calibration Status Flag. When set the PLL is calibrated.
PLL_UPP_CAL_THRES SERDES PLL Upper Calibration Threshold flag. When set the PLL calibration upper threshold was crossed. Re-calibration required.
PLL_LWR_CAL_THRES SERDES PLL lower Calibration Threshold flag. When set the PLL calibration lower threshold was crossed. Re-calibration required.

Notes


JESD_PRBS_PATTERN_T

Description

An enumeration of all available PRBS patterns.

Synopsis

```c
#include AD9164.h

typedef enum
{
    PRBS_NONE,
    PRBS7,
    PRBS15,
    PRBS31,
    PRBS_MAX
} jesd_prbs_pattern_t;
```

Members

<table>
<thead>
<tr>
<th>Member</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRBS_NONE</td>
<td>No PRBS patterned enabled. PRBS off.</td>
</tr>
<tr>
<td>PRBS7</td>
<td>PRBS7 pattern</td>
</tr>
<tr>
<td>PRBS15</td>
<td>PRBS15 pattern</td>
</tr>
<tr>
<td>PRBS31</td>
<td>PRBS31 pattern</td>
</tr>
<tr>
<td>PRBS_MAX</td>
<td>Number of member in this enum. Number of PRBS pattern options.</td>
</tr>
</tbody>
</table>

Notes
AD9164_API Specification Rev 1.0

AD9164_PRBS_TEST_T

Description
A structure of the parameters that describe the results of a PRBS test on the JESD interface.

Synopsis
```c
#include AD9164.h

typedef struct
{
    uint32_t phy_prbs_err_cnt;
    uint8_t phy_prbs_pass;
    uint8_t phy_src_err_cnt;
} ad9164_prbs_test_t;
```

Members

- `uint32_t phy_prbs_err_cnt`
  A uint32 value describing the number of PRBS errors detected on the link.

- `uint8_t phy_prbs_pass`
  A uint8 value indicating the success or failure of the test. A 0 indicates a failure, 1 indicates a pass. Any other value is invalid.

- `uint8_t phy_src_err_cnt`
  A uint8 value describing the source error count.

Notes
AD9164_API

AD9164_INIT

Description

API to initialize the DAC Module

This API must be called first before any other API calls. It performs internal API initialization of the memory and API states.

If DAC API handle member hw_open is not NULL the function to which it points shall be called to initialize DAC external resources. For example GPIO, SPI etc.

This function shall complete any universal initialization configuration of the DAC such as SPI.

Synopsis

```c
#include AD9164.h
ADI_API int ad9164_init(ad9164_handle_t *h);
```

Parameters

- `ad9164_handle_t *h` Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

Preconditions

If `hw_open` function pointer is set to NULL. DAC external hardware resources must be initialized.

Post conditions

On successful completion, DAC Module shall be in initialized state, ready for configuration.

Note although the API is now initialized, it is recommended to call the Ad9164_init API immediately after call int Ad9164_init API to ensure all SPI register setting are restore to default and ADI recommendations.

Dependencies

- `h->dev_xfer`. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to `*spi_xfer_t`.
- `h->hw_open` DAC API handle optionally may be set to valid hardware initialization function for client application. Refer to `*hw_open_t`.

Return value

Any other positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

- API_ERROR_OK
- API_ERROR_INVALID_XFER_PTR
- API_ERROR_INVALID_PARAM
- API_ERROR_HW_OPEN/gallery/failed

Notes
AD9164_API Specification Rev 1.0

AD9164_DEINIT

Description

Shutdown the DAC Module

This API must be called last. No other API should be called after a call to this API.

It performs internal API initialization of the memory and API states and ensure targeted DAC is in good state for power down. If DAC API handle member *hw_close_t is not NULL the function to which it points shall be called to de-initialize DAC external resources. This function may be used to de-initialize and release and hardware resources required by the API and AD9164 Device, for example GPIO SPI etc.

Synopsis

#include AD9164.h

ADI_API int ad9164_deinit(ad9164_handle_t *h);

Parameters

ad9164_handle_t *h

Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

Preconditions

The DAC device shall be success fully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions

On successful completion, DAC Module shall be in shutdown state. DAC module shall need to be re-initialized via ad9164_init by client before any further use.

Dependencies

h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

h->hw_close DAC API handle optionally may be set to valid hardware initialization function for client application. Refer to *hw_close_t.

Return value

Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

API_ERROR_OK
API_ERROR_INVALID_XFER_PTR
API_ERROR_INVALID_HANDLE_PTR

Notes
AD9164_RESET

Description
Performs a full reset of AD9164 DAC, resetting all SPI registers to their default values, restoring the desired SPI configuration
and ADI recommended initialization sequence.

This API can trigger a software reset via a SPI control or trigger a hardware reset by toggling the RESETB hardware pin. In order
to trigger a hardware reset the API must be provided with a client defined HAL function, *reset_pin_ctrl_t, that provides the
API with control over the RESETB pin on the client application.
The type of reset triggered by the API is determined by the hw_reset parameter.

Synopsis
#include AD9164.h
ADI_API int ad9164_reset(ad9164_handle_t *h, uint8_t hw_reset);

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ad9164_handle_t *h</td>
<td>Pointer to the client application DAC API handle for the target DAC device. Refer to *API Handle section for more details.</td>
</tr>
<tr>
<td>uint8_t hw_reset</td>
<td>a uint8_t value to indicate the type of reset to be triggered. A value of 1 indicates a hardware reset is to be triggered. A value of 0 indicates a soft reset is to be triggered.</td>
</tr>
</tbody>
</table>

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
The DAC shall be fully reset followed with reconfiguration of SPI interface and ADI recommended initialization sequence.

Dependencies

<table>
<thead>
<tr>
<th>Dependency</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>h-&gt;dev_xfer.</td>
<td>DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.</td>
</tr>
<tr>
<td>h-&gt;reset_pin_ctrl_t.</td>
<td>If hw reset is desired as indicated by the API parameter hw_reset the DAC API handle must be initialized to valid function that controls the RESETB for the client application. Refer to *reset_pin_ctrl_t.</td>
</tr>
</tbody>
</table>

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full
details. Possible return values for this API error codes are as follows.

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>API_ERROR_OK</td>
<td></td>
</tr>
<tr>
<td>API_ERROR_INVALID_HANDLE_PTR</td>
<td></td>
</tr>
<tr>
<td>API_ERROR_SPI_SDO</td>
<td></td>
</tr>
<tr>
<td>API_ERROR_INVALID_XFER_PTR</td>
<td></td>
</tr>
</tbody>
</table>

Notes
AD9164_API Specification Rev 1.0

AD9164_GET_CHIP_ID

Description
API to retrieve ADI chip identification, product type and revision data.

Synopsis
#include AD9164.h

ADI_API int ad9164_get_chip_id(ad9164_handle_t *h, ad9164_chip_id_t *chip_id);

Parameters
ad9164_handle_t *h  Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

ad9164_chip_id_t *chip_id  Pointer to a variable of type ad9164_chip_id_t to which the Device Identification data shall be stored.

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_XFER_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164_SET_EVENTS

Description
An API to set the events that trigger the interrupt signal on the AD9164 Device. Available interrupt events are listed by the ad9164_event_t enumeration. Interrupt events may be enabled or disabled using this API.

Synopsis
```c
#include AD9164.h

ADI_API int ad9164_set_events(ad9164_handle_t *h,
                        ad9164_event_t *event_list, uint8_t list_size, uint8_t en)
```

Parameters
- ad9164_handle_t *h: Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
- event_list: Pointer to an array of type ad9164_event_t that represents a list of events to be enabled or disabled based on the en parameter.
- list_size: An 8-bit value representing the size of the array to which event_list parameter points, the number of events to be enabled/disabled.
- en: A enable/disable variable to indicate whether the events listed by event_list array shall be enabled or disabled. A value of 0 disables the interrupt events. A value of 1 enables the interrupt events.

Preconditions
The DAC device shall be successfully initialized via a call to the Ad9164_init API. Prior to using this function.

Post conditions
Following a call to this API the configuration of the interrupt signal shall trigger when any of the enabled events are detected by the AD9164 device.

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
- API_ERROR_OK
- API_ERROR_INVALID_HANDLE_PTR
- API_ERROR_INVALID_XFER_PTR
- API_ERROR_INVALID_PARAM

Notes
**AD9164_GET_INTERRUPT_STATUS**

**Description**
An API to get the interrupt controller status to indicate if interrupts have triggered and are pending based on SPI register status.

**Synopsis**

```c
#include AD9164.h

ADI_API int ad9164_get_interrupt_status(ad9164_handle_t *h, uint8_t *int_pending, uint8_t *int_status);
```

**Parameters**

- `ad9164_handle_t *h`  
  Pointer to the client application DAC API handle for the target DAC device. Refer to *API Handle* section for more details.

- `int_pending`  
  Pointer to an uint8_t variable where the interrupt status shall be stored. A value of 1 indicates at least one interrupt event has occurred. A value of 0 indicates not interrupt events have occurred.

- `int_status`  
  Pointer to a 3-deep uint8_t array to which the current status of the interrupt status registers shall be stored. May be set to NULL if this data is not required.

**Preconditions**
The AD9164 device shall be successfully initialized via a call to the `ad9164_init` API. Prior to using this function.

**Post conditions**
None

**Dependencies**

- `h->dev_xfer`. AD9164 API handle must be initialized to valid SPI transfer function for the client application. Refer to `*spi_xfer_t`.

**Return value**
Any positive integer value may represent an error code to be returned to the application, refer to *Error Codes* section for full details. Possible return values for this API error codes are as follows.

- `API_ERROR_OK`
- `API_ERROR_INVALID_HANDLE_PTR`
- `API_ERROR_INVALID_XFER_PTR`
- `API_ERROR_INVALID_PARAM`

**Notes**
Note this API does not clear any interrupts detected.
AD9164_ISR

Description
An API that checks for and handle triggered interrupts, checks the status and can notify the API user of the events and any relevant status. In order for the API user to be notified of events by this API the AD9164 Handle must be initialized with a valid an event notification. Refer to *event_handler_t for more details. If an event handler function is not provided the API will simply clear any interrupts detected without notifying the application.

Synopsis
#include AD9164.h

ADI_API int ad9164_isr(ad9164_handle_t *h)

Parameters
ad9164_handle_t *h Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
All detected interrupts shall be cleared.

Dependencies
h->dev_xfer DAC API handle shall be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

h->event_handler DAC API handle may be initialized to a valid event notification function for the client application handler. Refer to *event_handler_t section for more details.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_XFER_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164 API Specification Rev 1.0

AD9164_DAC_SET_CLK_FREQUENCY

Description
Set the API software reference for the value of the hardware DAC clock supplied to the DAC device.
The correct value must be supplied for correct operation of the DAC features.

Synopsis

#include AD9164.h
ADI_API int ad9164_dac_set_clk_frequency(ad9164_handle_t *h, uint64_t dac_clk_freq_hz);

Parameters

ad9164_handle_t *h
Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

uint64_t dac_clk_freq_hz
DAC clock frequency in Hz. Valid range is 850MHz to 6GHz.

Preconditions
The DAC device shall be successfully initialized via a call to the Ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies

h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_XFER_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164_DAC_GET_CLK_FREQUENCY

Description
Set the API software reference for the value of the hardware DAC clock supplied to the DAC device.
The correct value must be supplied for correct operation of the DAC features.

Synopsis
#include AD9164.h
ADI_API int ad9164_dac_get_clk_frequency(ad9164_handle_t *h, uint64_t *dac_clk_freq_hz);

Parameters
ad9164_handle_t *h  
Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

uint64_t *dac_clk_freq_hz  
Pointer to a uint64_t variable where the current DAC clock frequency value setting shall be stored. The frequency value shall be provided in Hx. The valid range is 850MHz to 6GHz

Preconditions
The DAC device shall be successfully initialized via a call to the Ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_XFER_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164_DAC_SET_FULL_SCALE_CURRENT

Description

Adjust the DAC’s full-scale current output value; this can be adjusted over a range 8mA to 40mA.

Synopsis

```c
#include AD9164.h

ADI_API int ad9164_dac_set_full_scale_current(ad9164_handle_t *h, uint8_t current);
```

Parameters

- `ad9164_handle_t *h` Pointer to the client application DAC API handle for the target DAC device. Refer to `API Handle` section for more details.
- `uint8_t current` Desired full scale output current in mA. Valid range 8 to 40.

Preconditions

The DAC device shall be successfully initialized via a call to the `Ad9164_init` API. Prior to using this function.

Post conditions

None

Dependencies

- `h->dev_xfer`. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to `*spi_xfer_t`.

Return value

Any positive integer value may represent an error code to be returned to the application, refer to `Error Codes` section for full details. Possible return values for this API error codes are as follows.

- `API_ERROR_OK`
- `API_ERROR_INVALID_HANDLE_PTR`
- `API_ERROR_INVALID_XFER_PTR`
- `API_ERROR_INVALID_PARAM`

Notes
**AD9164_JESD_CONFIG_DATAPATH**

**Description**
Configure the JESD DAC mode as per the desired JESD interface parameters and datapath, the DAC clk frequency and the interpolation rate.

The JESD lane rate for the configuration is calculated and returned via the `lane_rate_Mbps` parameter.

The API shall check the parameter values and return an error if the desired JESD interface is not supported for the desired DAC mode. Refer to the DAC datasheet for full details on the JESD configurations and DAC modes supported.

**Synopsis**
```c
#include AD9164.h
ADI_API int ad9164_jesd_config_datapath(ad9164_handle_t *h, jesd_param_t jesd_param,
                                        uint8_t interpolation, uint64_t *lane_rate_mbps);
```

**Parameters**
- **ad9164_handle_t *h**
  Pointer to the client application DAC API handle for the target DAC device. Refer to **API Handle** section for more details.

- **jesd_param_t jesd_param**
  A variable of jesd_param_t describing the desire JESD link parameters. Refer to the jesd_param_t description for full details on the JESD Parameters and the DAC datasheet for supported JESD modes.

- **uint8_t interpolation**
  A uint8_t value representing the desired DAC interpolation mode. Valid interpolation modes are 1,2,3,4,6,8,12,16

- **uint64_t *lane_rate_mbps**
  A uint64_t pointer to which the calculated JESD lane rate based on the desired DAC and JESD interface parameters shall be returned. Set to NULL if lane_rate not required.

**Preconditions**
The DAC device shall be success fully initialized via a call to the **Ad9164_init** API. Prior to using this function.

**Post conditions**
None

**Dependencies**
- **h->dev_xfer.**
  DAC API handle must be initialized to valid SPI transfer function for the client application.
  Refer to *spi_xfer_t.*

- **h->dac_freq_hz**
  DAC Clock value must be initialized to the correct value as per the hardware setting for correct operation of this API.
  Refer to **ad9164_handle_t** for more details on dac_freq_hz

**Return value**
Any positive integer value may represent an error code to be returned to the application, refer to **Error Codes** section for full details. Possible return values for this API error codes are as follows.

- API_ERROR_OK
- API_ERROR_INVALID_HANDLE_PTR
- API_ERROR_INVALID_XFER_PTR
- API_ERROR_INVALID_PARAM

**Notes**
AD9164_JESD_GET_CFG_PARAM

Description
API to return the all the current JESD Parameters.

Synopsis
#include AD9164.h
ADI_API int ad9164_jesd_get_cfg_param(ad9164_handle_t *h, jesd_param_t *jesd_param);

Parameters
ad9164_handle_t *h Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
jesd_param_t *jesd_param Pointer to a structure of type jesd_param_t to which the all the JESD parameters currently configured will be stored.

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_XFER_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164_JESD_SET_SYSREF_MODE

Description
Configure the SYSREF synchronization mode for the JESD Interface

Synopsis
```
#include AD9164.h

ADI_API int ad9164_jesd_set_sysref_mode(ad9164_handle_t *h, jesd_sysref_mode_t mode, uint8_t jitter_window)
```

Parameters
- `ad9164_handle_t *h`: Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
- `jesd_sysref_mode_t mode`: The format for the SYSREF synchronization signal for the JESD Interface to the AD9164 Device. Valid modes are enumerated by `jesd_sysref_mode_t`
  - `SYSREF_NONE`: No SYSREF synchronization.
  - `SYSREF_ONESHOT`: One shot SYSREF Mode
  - `SYSREF_CONT`: Continuous SYSREF Synchronization mode.
  - `SYSREF_MON`: SYSREF Monitor Mode
- `uint8_t jitter_window`: a uint8_t variable to which SYSREF's jitter window tolerance value shall be stored. Valid values and their respective tolerance in DAC clock cycles are as follows:
  - 0 => +/- 0.5 DAC Clock Cycles
  - 4 => +/- 4 DAC Clock Cycles
  - 8 => +/- 8 DAC Clock Cycles
  - 12 => +/- 16 DAC Clock Cycles
  - 12 => +/- 16 DAC Clock Cycles
  - 20 => +/- 20 DAC Clock Cycles
  - 24 => +/- 24 DAC Clock Cycles
  - 28 => +/- 28 DAC Clock Cycles
  Valid only in Monitor Mode. This parameter ignored in all other modes.

Preconditions
The DAC device shall be successfully initialized via a call to the `Ad9164_init` API prior to using this function.

Post conditions
None

Dependencies
- `h->dev_xfer`. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to `spi_xfer_t`.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
- `API_ERROR_OK`
- `API_ERROR_INVALID_HANDLE_PTR`
- `API_ERROR_INVALID_XFER_PTR`
- `API_ERROR_INVALID_PARAM`

Notes
AD9164_API Specification Rev 1.0

AD9164_JESD_GET_SYSREF_MODE

Description
Configure the SYSREF synchronization mode for the JESD Interface

Synopsis
#include AD9164.h
ADI_API int ad9164_jesd_get_sysref_mode(ad9164_handle_t *h, jesd_sysref_mode_t *mode, uint8_t *jitter_window)

Parameters
ad9164_handle_t *h Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
jesd_sysref_mode_t *mode Pointer to which the current SYSREF synchronization signal configuration for the JESD Interface shall be stored. Valid modes are enumerated by jesd_sysref_mode_t
SYSREF_NONE No SYSREF synchronization.
SYSREF_ONESHOT One shot SYSREF Mode
SYSREF_CONT Continuous SYSREF Synchronization mode.
SYSREF_MON SYSREF Monitor Mode (Not fully supported yet)
uint8_t jitter_window Pointer to a uint8_t variable to which the Sysref Window Tolerance value shall be stored. Valid values and their respective tolerance in DAC clk cycles are as follows:
0 => +/- 0.5 DAC Clock Cycles
4 => +/- 4 DAC Clock Cycles
8 => +/- 8 DAC Clock Cycles
12 => +/- 16 DAC Clock Cycles
12 => +/- 16 DAC Clock Cycles
20 => +/- 20 DAC Clock Cycles
24 => +/- 24 DAC Clock Cycles
28 => +/- 28 DAC Clock Cycles
Valid only in Monitor Mode. This parameter ignored in all other modes.

Preconditions
The DAC device shall be successfully initialized via a call to the Ad9164_init API prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_XFER_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164_API Specification Rev 1.0

AD9164_JESD_GET_SYSREF_STATUS

Description
Read back SYSREF and LMFC synchronization status data.
API to return the current synchronization data for the SYSREF synchronization signal and LMFC synchronization.
This data can be used to determine dynamic link latency settings in SYSREF Monitor Mode.

Synopsis
#include AD9164.h
ADI_API int ad9164_jesd_get_sysref_status(ad9164_handle_t *h,
    uint8_t *sysref_count, uint16_t *sysref_phase, uint16_t *sync_LMFC_stat);

Parameters
ad9164_handle_t *h Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

uint8_t *sysref_count Pointer to the variable where the detected SYSREF signal count shall be stored.
Set to NULL if read back data is not required.

uint16_t *sysref_phase Pointer to the variable where the phase used to sample the SYSREF signals shall be stored.
Set to NULL if read back data is not required.

uint16_t *sync_LMFC_stat Pointer to the variable where the LMFC status shall be stored. This value may be used to determine synchronization status. This value may be used to determine synchronization status. A value of 0 to 4 indicates valid synchronization.
Set to NULL if this read back data is not required.

Preconditions
The DAC device shall be successfully initialized via a call to the Ad9164_init API prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_XFER_PTR
API_ERROR_INVALID_PARAM

Notes
**AD9164_JESD_GET_DYNAMIC_LINK_LATENCY**

**Description**  
API to read back the Dynamic Link Latency.

**Synopsis**

```c
#include AD9164.h

ADI_API int ad9164_jesd_get_dynamic_link_latency(ad9164_handle_t *h, uint8_t *latency);
```

**Parameters**

- `ad9164_handle_t *h`  
  Pointer to the client application DAC API handle for the target DAC device. Refer to *API Handle* section for more details.

- `uint8_t *latency`  
  Pointer to the variable where the dynamic link latency in units of pclks shall be stored.

**Preconditions**  
The DAC device shall be successfully initialized via a call to the *Ad9164_init* API prior to using this function.

**Post conditions**

- None

**Dependencies**

- `h->dev_xfer`. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.*

**Return value**  
Any positive integer value may represent an error code to be returned to the application, refer to *Error Codes* section for full details. Possible return values for this API error codes are as follows.

- `API_ERROR_OK`
- `API_ERROR_INVALID_HANDLE_PTR`
- `API_ERROR_INVALID_XFER_PTR`
- `API_ERROR_INVALID_PARAM`

**Notes**
AD9164_JESD_SET_DYNAMIC_LINK_LATENCY

Description
API to adjust the LMFC Delay and LMFC variance.

Synopsis
#include AD9164.h
ADI_API int ad9164_jesd_set_lmfc_delay(ad9164_handle_t *h, uint8_t delay, uint8_t var);

Parameters
- ad9164_handle_t *h: Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
- uint8_t delay: A 5-bit value to set the desired global LMFC delay in units of Frame Clock Cycles.
- uint8_t delay: A 5-bit value to set the desired variable LMFC delay.

Preconditions
The DAC device shall be successfully initialized via a call to the Ad9164_init API prior to using this function.

Post conditions
None

Dependencies
- h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
- API_ERROR_OK
- API_ERROR_INVALID_HANDLE_PTR
- API_ERROR_INVALID_XFER_PTR
- API_ERROR_INVALID_PARAM

Notes
AD9164_JESD_SET_LANE_XBAR

Description
Configure the JESD DAC mode as per the desired JESD interface parameters and data path, the DAC clock frequency and the interpolation rate.

The JESD lane rate for the configuration is calculated and returned via the lane_rate_mbps parameter.

The API shall check the parameter values and return an error if the desired JESD interface is not supported for the desired DAC mode. Refer to the DAC datasheet for full details on the JESD configurations and DAC modes supported.

Synopsis
```
#include AD9164.h

ADI_API int ad9164_jesd_set_lane_xbar(ad9164_handle_t *h, uint8_t physical_lane, uint8_t logical_lane)
```

Parameters
- `ad9164_handle_t *h` Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
- `uint8_t physical_lane` uint8_t value representing the Physical Lane to be routed to the SERDES logical lane indicated by the `logical_lane` parameter. Valid values are 0 to 7.
- `uint8_t logical_lane` uint8_t value representing the SERDES logical lane for the physical lane indicated by the parameter `physical_lane`. Valid values are 0 to 7.

Preconditions
The DAC device shall be successfully initialized via a call to the `Ad9164_init` API. Prior to using this function. This API shall be called to configure the Lane mapping prior to enabling the JESD link.

Post conditions
None

Dependencies
- `h->dev_xfer.` DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.*

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_XFER_PTR
API_ERROR_INVALID_PARAM

Notes
**AD9164_JESD_GET_LANE_XBAR**

**Description**
API to get the current JESD lane crossbar configuration for the data-link layer. Returns an 8 deep array of values representing the list logical lanes assigned to each physical lane.

**Synopsis**

```c
#include AD9164.h
ADI_API int ad9164_jesd_get_lane_xbar(ad9164_handle_t *h, uint8_t *phy_log_map);
```

**Parameters**

- `ad9164_handle_t *h`  
  Pointer to the client application DAC API handle for the target DAC device. Refer to **API Handle** section for more details.

- `uint8_t *phy_log_map`  
  Pointer to an 8-deep array of values representing the list logical lanes assigned to each physical lane. The index of the array represents the physical lane (0 to 7) and the value at that index the logical lane (0 to 7) assigned to that physical lane.

**Preconditions**

The DAC device shall be successfully initialized via a call to the **Ad9164_init** API prior to using this function.

**Post conditions**

None

**Dependencies**

- `h->dev_xfer`. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t*.

**Return value**

Any positive integer value may represent an error code to be returned to the application, refer to **Error Codes** section for full details. Possible return values for this API error codes are as follows.

- `API_ERROR_OK`
- `API_ERROR_INVALID_HANDLE_PTR`
- `API_ERROR_INVALID_XFER_PTR`
- `API_ERROR_INVALID_PARAM`

**Notes**
AD9164 API Specification Rev 1.0

AD9164_JESD_INVERT_LANE

Description
Invert or un-invert logical lanes.
Each logical lane can be inverted which can be used to ease routing of SERDIN signals.

Synopsis
#include AD9164.h
ADI_API int ad9164_jesd_invert_lane(ad9164_handle_t *h, uint8_t logical_lane, uint8_t invert)

Parameters
  ad9164_handle_t *h  
  Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
  uint8_t logical_lane  
  uint8_t value representing the SERDES logical lane for the physical lane indicated by the parameter physical_lane. Valid values are 0 to 7.
  uint8_t invert  
  A uint8_t value to indicate the desired invert status for the logical lane listed by logical_lane parameter. A value of 1 inverts the logical lane. A value of 0 inverts the logical lane.

Preconditions
The DAC device shall be successfully initialized via a call to the Ad9164_init API. Prior to using this function. This API shall be called to configure the Lane mapping prior to enabling the JESD link.

Post conditions
None

Dependencies
  h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
  API_ERROR_OK
  API_ERROR_INVALID_HANDLE_PTR
  API_ERROR_INVALID_XFER_PTR
  API_ERROR_INVALID_PARAM

Notes
AD9164_JESD_ENABLE_SCRAMBLER

Description

Enable or disable the descrambler for the JESD Receiver.

Synopsis

```c
#include AD9164.h
ADI_API int ad9164_jesd_enable_scrambler(ad9164_handle_t *h, uint8_t en);
```

Parameters

- `ad9164_handle_t *h`  
  Pointer to the client application DAC API handle for the target DAC device. Refer to *API Handle* section for more details.

- `uint8_t en`  
  Enable control for the JESD Scrambler. Set to 1 to enable the de-scrambler on the JESD Receiver; set to 0 to disable.

Preconditions

The DAC device shall be fully initialized via a call to the `Ad9164_init` API. Prior to using this function. The JESD link should be not be enabled when calling this function.

Post conditions

None

Dependencies

`h->dev_xfer`. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t*.

Return value

Any positive integer value may represent an error code to be returned to the application, refer to *Error Codes* section for full details. Possible return values for this API error codes are as follows.

- `API_ERROR_OK`
- `API_ERROR_INVALID_HANDLE_PTR`
- `API_ERROR_INVALID_XFER_PTR`
- `API_ERROR_INVALID_PARAM`

Notes
AD9164_JESD_GET_CFG_STATUS

Description
API to return the JESD Configuration Error Flag Status. There are six error flag to indicate errors in the current JESD configuration. `jesd_cfg_err_flg_t` enumerates the error flags.

Synopsis
```c
#include AD9164.h
ADI_API int ad9164_jesd_get_cfg_status(ad9164_handle_t *h, uint8_t *jesd_cfg_stat);
```

Parameters
- `ad9164_handle_t *h` Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
- `uint8_t jesd_cfg_stat` JESD configuration error status. Each bit in status byte represents an error flag as listed below and are enumerated by `jesd_cfg_err_flg_t`.
  - `INTPL_FACTOR_INVLD` Invalid interpolation factor set.
  - `SUBCLASS_V_INVLD` Illegal Subclass V set
  - `K_INVLD` Illegal K set.
  - `LMFS_INPOL_INVLD` Unsupported LMFS combination set for selected Interpolation factor
  - `LMFC_DELAY_INVLD` Illegal LMFC delay set
  - `SYSREF_JTTR_WIN_INVLD` Illegal SYSREF Jitter window set.

Preconditions
The DAC device shall be successfully initialized via a call to the `ad9164_init` API. Prior to using this function.

Post conditions
None

Dependencies
- `h->dev_xfer` DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to `*spi_xfer_t`.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
- `API_ERROR_OK`
- `API_ERROR_INVALID_HANDLE_PTR`
- `API_ERROR_INVALID_XFER_PTR`
- `API_ERROR_INVALID_PARAM`

Notes
AD9164_JESD_ENABLE_DATAPATH

Description
Enable the JESD Interface
Power up and enable the DAC's JESD Interface.

Synopsis
#include AD9164.h
ADI_API int ad9164_jesd_enable_datapath(ad9164_handle_t *h, uint8_t lanes_msk, uint8_t run_cal, uint8_t en);

Parameters
ad9164_handle_t *h Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
uint8_t lanes_msk a uint8 bit wise value representing the lanes to be enabled on the JESD Interface. Where bit 0 represents lane 0, bit 1 represents lane 1 etc. Set to one to enable the respective JESD Lane, set to 0 to disable the respective JESD Lane.
uint8_t run_cal Parameter to indicate if JESD physical lane calibration should be run prior to enabling interface. Set to 1 to run calibration, set to 0 to disable calibration.
uint8_t en Enable control for the JESD interface. Set to 1 to powerup and enable JESD interface. Set to 0 to disable JESD interface.

Preconditions
The DAC device shall be successfully initialized via a call to the Ad9164_init API prior to using this function.
JESD interface should be successfully configured via ad9164_jesd_config_datapath prior to calling this API.

Post conditions
Following a call to this API the SERDES PLL should be lock. The PLL lock status can be checked by calling the ad9164_jesd_get_pll_status API.
If the SERDES PLL is locked the AD9164 JESD Rx is ready for JESD Link bring up with a JESD Tx. Refer to ad9164_jesd_enable_link.

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_XFER_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164_API Specification Rev 1.0

AD9164_JESD_ENABLE_LINK

Description

Enable the JESD Interface
Power up and enable the DAC's JESD Interface.

Synopsis

#include AD9164.h

ADI_API int ad9164_jesd_enable_link(ad9164_handle_t *h, uint8_t en);

Parameters

ad9164_handle_t *h Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

uint8_t en Enable control for the JESD Link Bringup. Set to 1 to enable SERDES Link bringup. Set to 0 to disable SERDES link.

Preconditions

The DAC device shall be successfully initialized via a call to the Ad9164_init API. Prior to using this function.
JESD interface should be successfully enabled via ad9164_jesd_enable_datapath prior to calling this API.
For successful link bring up the SERDES PLL shall be in a locked state prior to calling this API. This can be verified using the ad9164_jesd_get_pll_status API.
In addition, the system JESD Tx shall be configured appropriately for successful link bring up.

Post conditions

Following a call to this API the JESD interface bring up shall be instigated. Link Status may be verified by a call to ad9164_get_jesd_link_status.

Dependencies

h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value

Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_XFER_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164_JESD_GET_PLL_STATUS

Description
Get SERDES PLL Status.
Read and return the status data for the SERDES PLL

Synopsis
#include AD9164.h
ADI_API int ad9164_jesd_get_pll_status(ad9164_handle_t *h, uint8_t *pll_status);

Parameters
ad9164_handle_t *h  Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
uint8_t *pll_status  Pointer to a unit8 variable to which the PLL status shall be written.
  Bit [0] represents the PLL lock status.
  Bit [3] represents the PLL calibration status.
  Bit [4] represents the PLL upper calibration Threshold error status.
  Bit [5] represents the PLL lower calibration Threshold error status.

Preconditions
The DAC device shall be success fully initialized via a call to the Ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
  API_ERROR_OK
  API_ERROR_INVALID_HANDLE_PTR
  API_ERROR_INVALID_XFER_PTR
  API_ERROR_INVALID_PARAM

Notes
AD9164 API Specification Rev 1.0

**AD9164_JESD_GET_LINK_STATUS**

**Description**
Get JESD Link Status.
Read back JESD Status for all lanes. Status reported includes Code Group Synchronization (CGS) status, Frame Synchronization status, checksum status and Initial Lane Synchronization (ILAS) status for the active JESD link. Refer to `jesd_link_stat_t` for more details.

**Synopsis**
```
#include AD9164.h

ADI_API int ad9164_jesd_get_link_status(ad9164_handle_t *h, jesd_link_stat_t *link_status);
```

**Parameters**
- `ad9164_handle_t *h`  
  Pointer to the client application DAC API handle for the target DAC device. Refer to `API Handle` section for more details.
- `jesd_link_stat_t *link_status`  
  Pointer to a variable of type `jesd_link_stat_t` that shall be set with the current JESD link status data.

**Preconditions**
The DAC device shall be successfully initialized via a call to the `Ad9164_init` API. Prior to using this function.

**Post conditions**
Follow a call to this API the SERDES PLL should be lock. The PLL lock status can be checked by calling the

**Dependencies**
- `h->dev_xfer`. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to `*spi_xfer_t`.

**Return value**
Any positive integer value may represent an error code to be returned to the application, refer to `Error Codes` section for full details. Possible return values for this API error codes are as follows.
- `API_ERROR_OK`
- `API_ERROR_INVALID_HANDLE_PTR`
- `API_ERROR_INVALID_XFER_PTR`
- `API_ERROR_INVALID_PARAM`

**Notes**
AD9164 TRANSMIT_ENABLE_PIN

Description
Configure TX_ENABLE pin functionality
TX_ENABLE pin can be configured so influence the data for tx-disable mode different points in the data path. Such as zero-ing data at the input to the data path, instigate NCO reset or zero-data an input to the DAC.

Synopsis
#include AD9164.h

ADI_API int ad9164_transmit_enable_pin(ad9164_handle_t *h, tx_enable_pin_mode_t tx_en_func);

Parameters
ad9164_handle_t *h Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

tx_en_func Desired TX_ENABLE pin functionality. Defined by the enumeration

NONE No functionality is assigned to the TX_ENABLE pin
RESET_NCO NCO is reset based on status of TX_ENABLE pin
ZERO_DATA_DAC Data to DAC is zeroed based on status of TX_ENABLE pin
ZERO_DATA_IN_PATH Data in data path is zeroed based on status of TX_ENABLE pin.
CURRENT_CONTROL Full scale current control is influenced by TX_ENABLE pin.

Preconditions
The DAC device shall be successfully initialized via a call to the Ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_XFER_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164 TRANSMIT_ENABLE

Description

An API to control the transmission out from the DAC device. The transmission out from the device can be control by software via a SPI register control or the TX_ENABLE pin on the DAC device. How the output transmission is controlled is determined by the TX_ENABLE configuration. The user can configures this using ad9164_transmit_enable_pin API.

If TX_ENABLE pin is configured to ZERO_DATA_DAC or ZERO_DATA_IN_PATH modes and the API is provided with HAL function *tx_en_pin_ctrl_t, the API shall use the hardware pin control to control the transmit output stream. Otherwise the API will control the transmit output stream via software controls.

Synopsis

#include AD9164.h

ADI_API int ad9164_transmit_enable(ad9164_handle_t *h, const ad9164_transmit_mode_t mode);

Parameters

ad9164_handle_t *h

Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

ad9164_transmit_mode_t mode

Configure the DAC output transmission as per the desired functionality.

TX_ENABLE Transmit functionality. Transmit all DAC data.

TX_ZERO_DATA_DAC Zero data at DAC from transmission stream.

TX_ZERO_DATA_IN_PATH Zero data at input to datapath.

Preconditions

The DAC device shall be successfully initialized via a call to the Ad9164_init API. Prior to using this function.

Post conditions

None

Dependencies

h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

h->tx_en_pin_ctrl_t DAC API handle must be initialized to valid HAL function to control the TX_ENABLE pin for the client application for Hardware control of the DAC

Return value

Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_XFER_PTR
API_ERRORINVALID_PARAM

Notes
**AD9164_CLK_CFG_DUTYCYCLE**

**Description**
Enable and configure Clock Duty Cycle Adjustment for the DAC clock applied to the CLK inputs.

**Synopsis**
```
#include AD9164.h

ADI_API int ad9164_clk_cfg_dutycycle(ad9164_handle_t *h, uint8_t en, uint8_t offset);
```

**Parameters**
- `ad9164_handle_t *h` Pointer to the client application DAC API handle for the target DAC device. Refer to `API Handle` section for more details.
- `uint8_t en` Enable offset adjustment where the offset is determined by the parameter offset. Set to 1 to apply offset to the clock. Set to 0 disable offset adjustment.
- `uint8_t offset` Duty cycle offset parameter, should be set to a 5-bit two's complement value to indicate a positive or negative skew. A larger value will result in a larger clock duty skew.

**Preconditions**
The DAC device shall be successfully initialized via a call to the `ad9164_init` API. Prior to using this function.

**Post conditions**
None

**Dependencies**
- `h->dev_xfer`. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to `*spi_xfer_t`.

**Return value**
Any positive integer value may represent an error code to be returned to the application, refer to `Error Codes` section for full details. Possible return values for this API error codes are as follows.
- `API_ERROR_OK`
- `API_ERROR_INVALID_HANDLE_PTR`
- `API_ERROR_INVALID_XFER_PTR`
- `API_ERROR_INVALID_PARAM`

**Notes**
AD9164_CLK_ADJUST_PHASE

Description
API to apply a phase adjustment of DAC Clock at the CLK+ input or at the CLK- input.

Synopsis
#include AD9164.h
ADI_API int ad9164_clk_adjust_phase(ad9164_handle_t *h, uint8_t pol, uint8_t phase);

Parameters
- ad9164_handle_t *h: Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
- uint8_t pol: Clock input polarity to which the phase adjustment is to be applied.
  - Set to 1 to apply phase adjustment to CLK- input.
  - Set to 0 to apply phase adjustment to CLK+ input.
- uint8_t phase: Desired number of phase adjustment steps. Valid range for number of phase adjustments steps is 0 to 31. Each step adds a capacitance of 20ff.

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
- h->dev_xfer: DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows:
- API_ERROR_OK
- API_ERROR_INVALID_HANDLE_PTR
- API_ERROR_INVALID_XFER_PTR
- API_ERROR_INVALID_PARAM

Notes
AD9164_CLK_SET_CROSS_CTRL

Description
API to configure and enable or disable the clock cross control feature.

Synopsis
#include AD9164.h
ADI_API int ad9164_clk_set_cross_ctrl(ad9164_handle_t *h, uint8_t en, uint8_t crosspoint);

Parameters

- ad9164_handle_t *h: Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
- uint8_t en: Cross Control Enable. Set to 1 to enable Clock Cross Control; set to 0 to disable Clock Cross Control.
- uint8_t crosspoint: A 3 bit value representing the Clock cross control cross point.

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

- API_ERROR_OK
- API_ERROR_INVALID_HANDLE_PTR
- API_ERROR_INVALID_XFER_PTR
- API_ERROR_INVALID_PARAM

Notes
**AD9164_FIR85_SET_ENABLE**

**Description**
Enable FIR-85 filter for 2-NRZ mode operation.

**Synopsis**
```
#include AD9164.h

ADI_API int ad9164_fir85_set_enable(ad9164_handle_t *h, const int en);
```

**Parameters**
- `ad9164_handle_t *h`  
  Pointer to the client application DAC API handle for the target DAC device. Refer to **API Handle** section for more details.
- `int en`  
  Enable FIR-85 filter
  1 => Enable FIR-85 filter
  0 => Disable FIR-85 filter

**Preconditions**
The DAC device shall be successfully initialized via a call to the `ad9164_init` API. Prior to using this function.

**Post conditions**
None

**Dependencies**
- `h->dev_xfer`. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t*.

**Return value**
Any positive integer value may represent an error code to be returned to the application, refer to **Error Codes** section for full details. Possible return values for this API error codes are as follows.
- API_ERROR_OK
- API_ERROR_INVALID_HANDLE_PTR
- API_ERROR_INVALID_XFER_PTR
- API_ERROR_INVALID_PARAM

**Notes**
AD9164_API_SPECIFICATION

AD9164_FIR85_GET_ENABLE

Description
Get FIR-85 filter for 2-NRZ mode operation enable status.

Synopsis
#include AD9164.h

ADI_API int ad9164_fir85_get_enable(ad9164_handle_t *h, int *en);

Parameters
ad9164_handle_t *h  
Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

int *en  
Pointer to a variable to which the FIR-85 filter enable status shall be stored.
1 => Enable FIR-85 filter
0 => Disable FIR-85 filter

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows:

API_ERROR_OK
API_ERROR_INVALIDHANDLE_PTR
API_ERROR_INVALIDXFER_PTR
API_ERRORINVALID_PARAM

Notes
AD9164_API Specification Rev 1.0

AD9164_FILT_BW90_ENABLE

Description
Set Interpolation Filter Bw Mode to 90% BW.
By default the interpolation filter in the datapath are in a low power 80% bandwidth mode. By enabling the high bandwidth filter mode, the interpolation filter bandwidth will be set to 90% BW.

Synopsis
#include AD9164.h

ADI_API int ad9164_fir85_bw90_enable(ad9164_handle_t *h, cons_tint en);

Parameters
ad9164_handle_t *h Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

int en Enable high bandwidth mode, 90%, for interpolation filters.
1 => Set interpolation filters to 90% Bandwidth.
0 => Set interpolation filters to 80% Bandwidth.

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_XFER_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164_INVSINC_ENABLE

Description
Enable inverse sin c (sinc^-1) filter.

Synopsis
#include AD9164.h

ADI_API int ad9164_invsinc_enable(ad9164_handle_t *h, const int en);

Parameters
ad9164_handle_t *h Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

int en Enable the inverse sin c filter. Set to 1 to enable filter; set to 0 to disable filter.

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_XFER_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164 NCO_SET_FTW

Description
The AD9164 family of DAC support a number of NCOs. This API is used to configure a particular NCO with Frequency Tuning Word, Modulus and Delta parameters.

Synopsis
#include AD9164.h

ADI_API int ad9164_nco_set_ftw(ad9164_handle_t *h, const unsigned int nco_nr, const uint64_t ftw, const uint64_t acc_modulus, const uint64_t acc_delta);

Parameters
- ad9164_handle_t *h: Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
- int nco_nr: Desired NCO to be configured. Valid values 0 to 31.
- int64_t ftw: Frequency tuning word value.
  - For NCO 0 this shall be a 48Bit value.
  - For all other NCOs (1-31) this shall be a 32-bit value.
- int64_t acc_modulus: Desired modulus.
- uint16_t acc_delta: Desired delta value.

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
- h->dev_xfer: DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
- API_ERROR_OK
- API_ERROR_INVALID_HANDLE_PTR
- API_ERROR_FTW_LOAD_ACK
- API_ERROR_INVALID_PARAM

Notes
**AD9164_NCO_GET_FTW**

**Description**

The AD9164 family of DAC support a number of NCOs. This API is used to get the NCO parameter Frequency Tuning Word, Modulus and Delta from a particular NCO.

**Synopsis**

```c
#include AD9164.h

ADI_API int ad9164_nco_get_ftw(ad9164_handle_t *h, const unsigned int nco_nr, uint64_t *ftw,
                                 uint64_t *acc_modulus, uint64_t *acc_delta);
```

**Parameters**

- **ad9164_handle_t *h**  
  Pointer to the client application DAC API handle for the target DAC device. Refer to *API Handle* section for more details.

- **int nco_nr**  
  Desired NCO to from which to retrieve parameters. Valid values 0 to 31.

- **int64_t *ftw**  
  Pointer to a variable where the frequency tuning word value will be stored  
  For NCO 0 this shall be a 48-Bit value.  
  For all other NCOs (1-31) this shall be a 32-bit value.

- **int64_t *acc_modulus**  
  Pointer to a variable where the modulus value will be stored

- **uint16_t *acc_delta**  
  Pointer to a variable where the delta value will be stored.

**Preconditions**

The DAC device shall be successfully initialized via a call to the *ad9164_init* API. Prior to using this function.

**Post conditions**

None

**Dependencies**

- h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t*.

**Return value**

Any positive integer value may represent an error code to be returned to the application, refer to *Error Codes* section for full details. Possible return values for this API error codes are as follows.

- API_ERROR_OK
- API_ERROR_INVALID_HANDLE_PTR
- API_ERROR_INVALID_PARAM

**Notes**
AD9164 API Specification Rev 1.0

AD9164_NCO_SET_PHASE_OFFSET

Description
Set the NCO Phase offset.

Synopsis
#include AD9164.h

ADI_API int ad9164_nco_set_phase_offset(ad9164_handle_t *h, const uint16_t po);

Parameters
- ad9164_handle_t *h
  Pointer to the client application DAC API handle for the target DAC device. Refer to
  API Handle section for more details.
- const uint16_t po
  The phase offset value.

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
- h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full
details. Possible return values for this API error codes are as follows.
- API_ERROR_OK
- API_ERROR_INVALID_HANDLE_PTR

Notes
AD9164_NCO_GET_PHASE_OFFSET

Description
Get the NCO Phase offset.

Synopsis
#include AD9164.h

ADI_API int ad9164_nco_get_phase_offset(ad9164_handle_t *h, const uint16_t *po);

Parameters
ad9164_handle_t *h
Pointer to the client application DAC API handle for the target DAC device. Refer to 
API Handle section for more details.

const uint16_t *po
Pointer to uint16_t variable where the current phase offset will be stored.

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Postconditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164_API Specification Rev 1.0

AD9164_NCO_SET_HOPF_MODE

Description
The AD9164 family of DAC supports Fast Frequency Hopping. This sets and configures the device for Frequency Hopping Mode.

Synopsis
```
#include AD9164.h

ADI_API int ad9164_nco_set_hopf_mode(ad9164_handle_t *h, ad9164_hopf_mode_t mode);
```

Parameters
- **ad9164_handle_t *h**: Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
- **ad9164_hopf_mode_t mode**: Desired Fast frequency Hopping Mode. Refer to ad9164_hopf_mode_t for a full description on the various modes.

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
- **h->dev_xfer**: DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t*.

Return value
Any positive integer value may represent a error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
- API_ERROR_OK
- API_ERROR_INVALID_HANDLE_PTR
- API_ERROR_INVALID_PARAM

Notes
AD9164 NCO_GET_HOPF_MODE

Description
The AD9164 family of DAC supports Fast Frequency Hopping. This sets and configures the device for Frequency Hopping

Synopsis
#include AD9164.h
ADI_API int ad9164_nco_get_hopf_mode(ad9164_handle_t *h, ad9164_hopf_mode_t *mode);

Parameters
ad9164_handle_t *h Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

ad9164_hopf_mode_t *mode A pointer to a variable to which the currently configured Fast frequency Hopping mode shall be stored. Refer to ad9164_hopf_mode_t for a full description on the various modes.

Preconditions
The DAC device shall be success fully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent a error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164_NCO_SET_ENABLE

Description
Set the enable status (Enable or Disable) of the main NCO and modulus.

Synopsis
#include AD9164.h
ADI_API int ad9164_nco_set_enable(ad9164_handle_t *h, const int modulus_en, const int nco_en);

Parameters
ad9164_handle_t *h Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

int modulus_en Enable dual modulus NCO.
1 => Enable dual Modulus mode.
0 => Disable dual Modulus mode. NCO Integer Mode

int nco_en Enable NCO.
1 = Enable NCO
0 = Disable NCO

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
For correct NCO operation it is expected that the NCO be correctly configured using
AD9164_NCO_GET_ENABLE

Description
Get the enable status (Enable or Disable) of the main NCO and modulus.

Synopsis
```
#include AD9164.h
ADI_API int ad9164_noc_get_enable(ad9164_handle_t *h, int *modulus_en, int *nco_en);
```

Parameters
- `ad9164_handle_t *h`  Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
- `int *modulus_en`  Pointer to int variable where the enable dual modulus mode status will be stored. Possible returned values are
  - 1 => Enable dual Modulus mode.
  - 0 => Disable dual Modulus mode. NCO Integer Mode
- `int *nco_en`  Pointer to int variable where the enable NCO status will be stored. Possible returned values are
  - 1 => Enable NCO
  - 0 => Disable NCO

Preconditions
The DAC device shall be successfully initialized via a call to the `ad9164_init` API. Prior to using this function.

Post conditions
None

Dependencies
- `h->dev_xfer`. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to `*spi_xfer_t`.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
- API_ERROR_OK
- API_ERROR_INVALID_XFER_PTR
- API_ERROR_INVALID_PARAM

Notes
AD9164_DC_TEST_SET_MODE

Description
Set the DC test mode test-data and enable test mode

Synopsis
#include AD9164.h

ADI_API int ad9164_dc_test_set_mode(ad9164_handle_t *h, const uint16_t test_data, const int en);

Parameters
ad9164_handle_t *h  
Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

cost uint16_t test_data  
DC test data value.

cost int en  
DC test mode enable. A value of zero disables DC Test mode. Any other value enables DC Test mode.

en ==0  => Disable DC Test mode
en >0    => Enable DC Test mode

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164_DC_TEST_GET_MODE

Description
Set the DC test mode test-data and enable test mode

Synopsis
#include AD9164.h
ADI_API int ad9164_dc_test_get_mode(ad9164_handle_t *h, uint16_t *test_data, int *en);

Parameters
ad9164_handle_t *h  Pointer to the client application DAC API handle for the target DAC device. Refer to
API Handle section for more details.
const uint16_t *test_data  Pointer to uint16_t variable where the current DC test data value will be stored.
const int *en  Pointer to an integer variable where the current DC test mode enable status will be stored.
en ==0  => Disable DC Test mode
en >0    => Enable DC Test mode

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Postconditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full
details. Possible return values for this API error codes are as follows.
API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164_API Specification Rev 1.0

AD9164_NCO_SET_SELECT

Description
Select the desired NCO to be active.

Synopsis
#include AD9164.h
ADI_API int ad9164_nco_set_select(ad9164_handle_t *h, const unsigned int nco_nr);

Parameters
ad9164_handle_t *h Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
const unsigned int nco_nr Desired NCO to be active. Valid values are from 0 to 31.

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164_API Specification Rev 1.0

AD9164_NCO_GET_SELECTED

Description
Get the number of the currently selected NCO

Synopsis
#include AD9164.h
ADI_API int ad9164_nco_get_selected(ad9164_handle_t *h, unsigned int *nco_nr);

Parameters
ad9164_handle_t *h Pointer to the client application DAC API handle for the target DAC device. Refer to
API Handle section for more details.

const unsigned int *nco_nr Pointer to a variable to which the NCO number that is currently selected to be active.

Preconditions
The DAC device shall be successfully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full
details. Possible return values for this API error codes are as follows.

API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164 API Specification Rev 1.0

AD9164_NCO_SET

Description
Configure NCO based on desired DAC frequency and carrier frequency.

Synopsis
```
#include AD9164.h
ADI_API int ad9164_nco_set(ad9164_handle_t *h, const unsigned int nco_nr,
                         const int64_t carrier_freq_hz, const uint16_t amplitude, int dc_test_en);
```

Parameters
- `ad9164_handle_t *h`: Pointer to the client application DAC API handle for the target DAC device. Refer to `API Handle` section for more details.
- `const unsigned int nco_nr`: A value to indicate desire NCO. Valid range 0 to 31.
- `const int64_t carrier_freq`: Desired carrier frequency
- `const uint16_t amplitude`: Desire amplitude.
- `int dc_test_en`: Enable Test mode.

Preconditions
The DAC device shall be successfully initialized via a call to the `ad9164_init` API. Prior to using this function.

Post conditions
None

Dependencies
- `h->dev_xfer`: DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to `spi_xfer_t`.
- `h->dac_freq_hz`: DAC Clock value must be initialized to the correct value as per the hardware setting for correct operation of this API.
  Refer to `dac_freq_hz`.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to `Error Codes` section for full details. Possible return values for this API error codes are as follows.
- `API_ERROR_OK`
- `API_ERROR_INVALID_HANDLE_PTR`
- `API_ERROR_INVALID_PARAM`

Notes
AD9164_API Specification Rev 1.0

AD9164_NCO_GET

Description
Get NCO frequency parameters currently configure on a particular NCO

Synopsis
#include AD9164.h
ADI_API int ad9164_nco_get(ad9164_handle_t *h, const unsigned int nco_nr, const int64_t *carrier_freq,
const uint16_t amplitude, int *dc_test_en);

Parameters
ad9164_handle_t *h Pointer to the client application DAC API handle for the target DAC device. Refer to
API Handle section for more details.
const unsigned int nco_nr, A value to indicate desire NCO. Valid range 0 to 31.
const int64_t carrier_freq, Pointer to a variable where the currently configured carrier frequency for the target NCO is stored.
const uint16_t amplitude, Pointer to a variable where the currently configured DAC amplitude.
int dc_test_en Pointer to a variable where the DC-Test mode status is stored.

Preconditions
The DAC device shall be success fully initialized via a call to the ad9164_init API. Prior to using this function.

Post conditions
None

Dependencies
h->dev_xfer. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to *spi_xfer_t.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
API_ERROR_OK
API_ERROR_INVALID_HANDLE_PTR
API_ERROR_INVALID_PARAM

Notes
AD9164_NCO_RESET

Description
Instigates reset of NCO via a SPI register control.

Synopsis
```
#include AD9164.h
ADI_API int ad9164_nco_reset(ad9164_handle_t *h);
```

Parameters
```
ad9164_handle_t *h
```
Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

Preconditions
The DAC device shall be successfully initialized via a call to the `ad9164_init` API. Prior to using this function.

Post conditions
None

Dependencies
```
h->dev_xfer
```
DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to `spi_xfer_t`.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

- `API_ERROR_OK`
- `API_ERROR_INVALID_XFER_PTR`
- `API_ERROR_INVALID_PARAM`

Notes
**AD9164_REGISTER_WRITE**

**Description**

Performs SPI register write access to DAC

**Synopsis**

```c
#include AD9164.h
ADI_API int ad9164_register_write (ad9164_handle_t *h, const uint16_t address, const uint8_t data);
```

**Parameters**

- `ad9164_handle_t *h`  
  Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

- `const uint16_t address`  
  A 15-bit value representing a SPI register location on the target DAC device. Refer to AD9164 data sheet for valid values.

- `uint8_t *data`  
  A pointer to a 8-bit variable to which the register value read over SPI shall be stored.

**Preconditions**

The DAC device shall be successfully initialized via a call to the `ad9164_init` API. Prior to using this function.

**Postconditions**

None

**Dependencies**

- `h->dev_xfer`. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to `*spi_xfer_t`.

**Return value**

Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

- `API_ERROR_OK`
- `API_ERROR_INVALID_XFER_PTR`
- `API_ERROR_INVALID_PARAM`

**Notes**
AD9164 REGISTER_READ

Description
DAC Device reference handle data structure that acts as a SW reference to a particular instance of the DAC device. This reference maintains a reference to HAL functions and the status of the chip.

Synopsis
```
#include AD9164.h

ADI_API int ad9164_register_read(ad9164_handle_t *h, const uint16_t address, uint8_t *data);
```

Parameters
- `ad9164_handle_t *h` Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.
- `const uint16_t address` A 15-bit value representing a SPI register location on the target DAC device. Refer to AD9164 data sheet for valid values.
- `uint8_t *data` A pointer to an 8-bit variable to which the register value read over SPI shall be stored.

Preconditions
The DAC device shall be successfully initialized via a call to the `ad9164_init` API. Prior to using this function.

Post conditions
None

Dependencies
- `h->dev_xfer`. DAC API handle must be initialized to valid SPI transfer function for the client application. Refer to `spi_xfer_t`.

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.
- `API_ERROR_OK`
- `API_ERROR_INVALID_XFER_PTR`
- `API_ERROR_INVALID_PARAM`

Notes
AD9164_GET_REVISION

Description
Issue a soft reset via SPI Register control.
Performs a full reset of AD9164, resetting all SPI registers to their default values.

Synopsis
#include AD9164.h

ADI_API int ad9164_get_revision(ad9164_handle_t *h, uint8_t *rev_major, uint8_t *rev_minor, uint8_t *rev_rc)

Parameters
ad9164_handle_t *h Pointer to the client application DAC API handle for the target DAC device. Refer to API Handle section for more details.

uint8_t *rev_major Pointer to a 8 bit variable to which the Major Revision number shall be stored

uint8_t *rev_minor Pointer to a 8 bit variable to which the Minor Revision number shall be stored

uint8_t *rev_rc Pointer to a 8 bit variable to which the Release Candidate Id shall be stored

Preconditions
None

Post conditions
None

Dependencies
None

Return value
Any positive integer value may represent an error code to be returned to the application, refer to Error Codes section for full details. Possible return values for this API error codes are as follows.

API_ERROR_OK
API_ERROR_INVALID_PARAM

Notes
APPENDIX A

PSEUDO CODE EXAMPLE FOR AD9164 HANDLE

In the pseudo code example A, shows an example of the AD9164 handle being configure with the minimum client application. In the pseudo code example B, shows an example of the AD9164 handle being configured with all the optional configurations.

For further details, refer to the DAC Hardware Initialization section and the ad9164_handle_t section for full a description and more details on configuration.

```c
/*
 * \brief pseudo Code example client code to initialiseAD916x
 */
/*Include Client HAL implementation code*/
#include "app_hal.h"
/*Include AD916x API interface Headers*/
#include "AD9164.h"
#include "api_errors.h"
#include "api_def.h"
ad9164_handle_t app_dac_h = {
    NULL,                                /* Client App HAL does not require any specific data*/
    SPI_SDO,                           /* Client App HAL SPI uses 4 Wire SPI config */
    2000000000,                    /* Application DAC Clk Frequency */
    &app_hal_spi_xfer_ad9164,   /* Client App HAL SPI function for AD9164*/
    &app_hal_delay_us,                               /* Client App HAL Delay Function */
    NULL,                             /* Client App does not use API Event Handler */
    0,                                                   /* Client App does need API to control TX_ENABLE */
    0,                 /* Client App does need API to control RESETB */
    0,                     /* Client App does want API to initialize external HW required by DAC */
    0                       /* Client App does want API to initialize external HW required by DAC */
};

/*AD916x Dac Initialisation by Client Application*/
int app_dac_init()
{
    int dacError = API_ERROR_OK;
    ad9164_handle_t *ad9164_h = app_dac_h;

    /*Initialise DAC Module*/
dacError = ad9164_init(ad9164_h);
    if (dacError != API_ERROR_OK) { return -1; }
    dacError = ad9164_get_chip_id(ad9164_h, &dac_chip_id);
    if (dacError != API_ERROR_OK) { return -1; }
    dacError = ad9164_get_revision(ad9164_h,&revision[0],&revision[1],&revision[2]);
    if (dacError !=API_ERROR_OK) { return APP_ERR_DAC_FAIL; }

    printf("*********************************************
    AD9164 DAC Chip ID: %d 
    AD9164 DAC Product ID: %d 
    AD9164 DAC Product Grade: %d 
    AD9164 DAC Product Revision: %d 
    ");
    printf(************\n"

    return 0;
}
```

Figure 5 Example A, Psuedo Code AD9164 Handle initialization with Minum Configuration
#include “app_spi.h”
#include “app_gpio.h”
#include “app_sleep.h”

/*Client Application function to Implement SPI Transfer for AD9164*/
int app_hal_ad9164_spi_xfer(void *user_data, uint8_t *wbuf, uint8_t_t *rbuf, int len) {
   /*Pseudo Code example of implementing SPI transfer function*/
   
   uint16_t address;
   uint8_t value;
   uint8_t dac_chip_select;
   struct app_hal_data_t *dac_user_data;

   /*Optional: get any client defined data from user_data*/
   /*For example could be used to retrieve chip select*/
   dac_user_data = (struct app_hal_data_t *) user_data;
   dac_chip_select = dac_user_data->dac_chip_select_ref;

   /*AD916x DAC SPI transactions are always 3 bytes*/
   if (size_bytes != 3) {
      /* 2 bytes for address and 1 byte data */
      return 2;
   }

   address = wbuf[0];
   address <<= 8;
   address |= wbuf[1];
   value = wbuf[2];

   if ((address & 0x8000) == 0) {
      /* Write */
      app_hal_spi_write(dac_chip_select, address, value);
      rbuf[2] = 0xFF;
   } else {
      /* Read */
      /* Clear the read bit as we read from local array */
      address &= ~0x8000;

      app_hal_spi_write(dac_chip_select, address, &value);
      rbuf[2] = value;
   }
   return 0;
}

int app_hal_ad9164_delay_us(unsigned int time_us) {
   /*Code to sleep or wait*/
   app_hal_sleep(time_us);
   return 0;
}
/*
 * \brief pseudo Code example client code to initialiseAD916x
 *
 */
/*Include Client HAL implementation code*/
#include "app_hal.h"

/*Include AD916x API interface Headers*/
#include "AD9164.h"
#include "api_errors.h"
#include "api_def.h"

ad9164_handle_t app_dac_h = {
    &app_hal_user_data,        /* Client App HAL does not require any specific data*/
    SPI_SDO,                   /* Client App HAL SPI uses 4 Wire SPI config */
    2000000000,                 /* Application DAC Clk Frequency */
    &app_hal_ad9164_spi_xfer,  /* Client App HAL SPI function for AD9164*/
    &app_hal_ad9164_delay_us,  /* Client App HAL Delay Function */
    &app_ad9164_event_handler, /* Client App does not use API Event Handler */
    &app_hal_ad9164_set_tx_enable_pin, /* Client App HAL function to control TX_ENABLE */
    &app_hal_ad9164_set_resetb_pin, /* Client App does need API to control RESETB */
    &app_init_dac_hw,          /* Client App does want API to initialize external HW required by DAC */
    &app_shutdown_dac_hw       /* Client App does want API to initialize external HW required by DAC */
};

/*AD916x Dac Initialisation by Client Application*/
int app_dac_init()
{
    int dacError = API_ERROR_OK;
    ad9164_handle_t *ad9164_h = app_dac_h;

    /*Initialise DAC Module*/
    dacError = ad9164_init(ad9164_h);
    if (dacError != API_ERROR_OK) {
        return -1;
    }

    dacError = ad9164_get_chip_id(ad9164_h, &dac_chip_id);
    if (dacError != API_ERROR_OK) {
        return -1;
    }

    dacError = ad9164_get_revision(ad9164_h,&revision[0],&revision[1],&revision[2]);
    if (dacError !=API_ERROR_OK) {
        return APP_ERR_DAC_FAIL;
    }

    printf("*********************************************\n");
    printf("AD9164 DAC Chip ID: %d \n", dac_chip_id.chip_type);
    printf("AD9164 DAC Product ID: %d \n", dac_chip_id.prod_id);
    printf("AD9164 DAC Product Grade: %d \n", dac_chip_id.prod_grade);
    printf("AD9164 DAC Product Revision: %d \n", dac_chip_id.dev_revision);
    printf("AD9164 Revision: %d. %d.\n %d\n", revision[0], revision[1], revision[2]);
    printf("*********************************************\n");

    return 0;
}
REVISION HISTORY
11/07/2016—Rev 1.0
Initial Release with Rev 1.0.0 API............................... Universal