Bioscara

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Chapter 1

Documentation

This documentation currently documents how the robot controller communicates with the joint controllers, this includes:

- The joint firmware in the `/Arduino` directory
- The interfacing library used for communicating with the joints in the `/ROS2` directory.

1.1 Usage

the joint_communication library is structured as a ROS2 package but can also be used in another build toolchain. If that is the case ensure the include paths are still correct.

Chapter 2

README

This package contains all launch and config files for the robot to work.

Chapter 3

README

All configuration parameters are stored in the config/bioscara_parameters file.

Chapter 4

README

The packages are structured according to this guide: `RTW Package Structure`

When compiling the package is installed in the share/ directory. Also the URDF is stored there. The bioscara.launch.py file expects to find the urdf there. This is done in the packages cmake file

```
install(
  DIRECTORY hardware/include/
  DESTINATION include/ros2_control_demo_example_1
)
install(
  DIRECTORY description/launch description/ros2_control description/urdf
  DESTINATION share/ros2_control_demo_example_1
)
install(
  DIRECTORY bringup/launch bringup/config
  DESTINATION share/ros2_control_demo_example_1
)
install(TARGETS ros2_control_demo_example_1
  EXPORT export_ros2_control_demo_example_1
  ARCHIVE DESTINATION lib
  LIBRARY DESTINATION lib
  RUNTIME DESTINATION bin
)
```

TODO:

- [ ] Format and rework this content

Chapter 5

Todo List

Member bioscara_hardware_interface::BioscaraHardwareInterface::on_init (const hardware_interface::↩ HardwareComponentInterfaceParams &params) override

threshold and current are uint8_t, if a number larger outside $0 < n < 255$ is passed as a parameters it will overflow.

Member Joint::read (const stp_reg_t reg, T &data, u_int8_t &flags)

- Implement a return code for read only functions
- Implement clearStall function

Chapter 6

Namespace Index

6.1 Namespace List

Here is a list of all namespaces with brief descriptions:

Chapter 7

Hierarchical Index

7.1 Class Hierarchy

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

Chapter 8

Class Index

8.1 Class List

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

Chapter 9

File Index

9.1 File List

Here is a list of all files with brief descriptions:

Chapter 10

Namespace Documentation

10.1 bioscara Namespace Reference

Functions

- generate_launch_description ()

10.1.1 Function Documentation

10.1.1.1 generate_launch_description()

```
bioscara.generate_launch_description ( )
```

10.2 bioscara_hardware_interface Namespace Reference

Classes

- class BioscaraHardwareInterface

  The bioscara hardware interface class.

Variables

- constexpr char HW_IF_HOME [ ] = "home"

10.2.1 Variable Documentation

10.2.1.1 HW_IF_HOME

```
constexpr char bioscara_hardware_interface::HW_IF_HOME[ ] = "home"  [constexpr]
```

10.3 display Namespace Reference

Functions

- generate_launch_description ()

10.3.1 Function Documentation

10.3.1.1 generate_launch_description()

```
display.generate_launch_description ( )
```

10.4 gazebo Namespace Reference

Functions

- generate_launch_description ()

10.4.1 Function Documentation

10.4.1.1 generate_launch_description()

```
gazebo.generate_launch_description ( )
```

10.5 setup Namespace Reference

Variables

- str package_name = 'bioscara_description'
- name
- version
- packages
- data_files
- install_requires
- zip_safe
- maintainer
- maintainer_email
- description
- license
- tests_require
- entry_points

10.5.1 Variable Documentation

10.5.1.1 data_files

```
setup.data_files
```

10.5.1.2 description

```
setup.description
```

10.5.1.3 entry_points

```
setup.entry_points
```

10.5.1.4 install_requires

```
setup.install_requires
```

10.5.1.5 license

```
setup.license
```

10.5.1.6 maintainer

```
setup.maintainer
```

10.5.1.7 maintainer_email

```
setup.maintainer_email
```

10.5.1.8 name

```
setup.name
```

10.5.1.9 package_name

```
str setup.package_name = 'bioscara_description'
```

10.5.1.10 packages

```
setup.packages
```

10.5.1.11 tests_require

```
setup.tests_require
```

10.5.1.12 version

```
setup.version
```

10.5.1.13 zip_safe

```
setup.zip_safe
```

10.6 test_copyright Namespace Reference

Functions

- test_copyright ()

10.6.1 Function Documentation

10.6.1.1 test_copyright()

```
test_copyright.test_copyright ( )
```

10.7 test_flake8 Namespace Reference

Functions

- test_flake8 ()

10.7.1 Function Documentation

10.7.1.1 test_flake8()

```
test_flake8.test_flake8 ( )
```

10.8 test_joint_trajectory_controller Namespace Reference

Functions

- generate_launch_description ()

10.8.1 Function Documentation

10.8.1.1 generate_launch_description()

```
test_joint_trajectory_controller.generate_launch_description ( )
```

10.9 test_pep257 Namespace Reference

Functions

- test_pep257 ()

10.9.1 Function Documentation

10.9.1.1 test_pep257()

```
test_pep257.test_pep257 ( )
```

Chapter 11

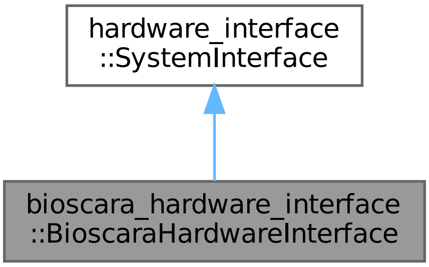
Class Documentation

11.1 bioscara_hardware_interface::BioscaraHardwareInterface Class Reference

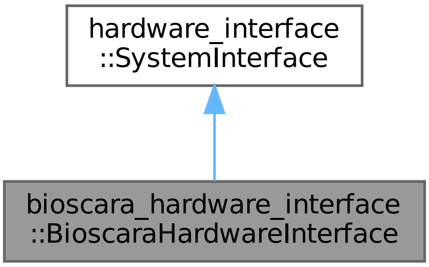
The bioscara hardware interface class.

```
#include <bioscara_hardware.hpp>
```

Inheritance diagram for bioscara_hardware_interface::BioscaraHardwareInterface:



Collaboration diagram for bioscara_hardware_interface::BioscaraHardwareInterface:



Classes

- struct joint_config_t

  configuration structure holding the passed paramters from the ros2_control urdf
- struct joint_homing_config_t

  configuration structure holding the passed homing paramters from the ros2_control urdf

Public Member Functions

- hardware_interface::CallbackReturn on_init (const hardware_interface::HardwareComponentInterfaceParams &params) override
- hardware_interface::CallbackReturn on_shutdown (const rclcpp_lifecycle::State &previous_state) override

  Called on the transistion from the `inactive`, `unconfigured` and `active` to the `finalized` state.
- hardware_interface::CallbackReturn on_configure (const rclcpp_lifecycle::State &previous_state) override

  Called on the transistion from the `unconfigured` to the `inactive` state.
- hardware_interface::CallbackReturn on_cleanup (const rclcpp_lifecycle::State &previous_state) override

  Called on the transistion from the `inactive` to the `unconfigured` state.
- hardware_interface::CallbackReturn on_activate (const rclcpp_lifecycle::State &previous_state) override

  Called on the transistion from the `inactive` to the `active` state.
- hardware_interface::CallbackReturn on_deactivate (const rclcpp_lifecycle::State &previous_state) override

  Called on the transistion from the `active` to the `inactive` state.
- hardware_interface::return_type read (const rclcpp::Time &time, const rclcpp::Duration &period) override

  Reads from the hardware and populates the state interfaces.
- hardware_interface::return_type write (const rclcpp::Time &time, const rclcpp::Duration &period) override

  Writes commands to the hardware from the command interfaces.
- hardware_interface::return_type prepare_command_mode_switch (const std::vector< std::string > &start_interfaces, const std::vector< std::string > &stop_interfaces) override

  Performs checks and book keeping of the active control mode when changing controllers.
- hardware_interface::CallbackReturn on_error (const rclcpp_lifecycle::State &previous_state) override

  Called when an error in any state or state transition is thrown.

Private Attributes

- std::unordered_map< std::string, Joint > _joints

  unordered map storing the Joint objects.
- std::unordered_map< std::string, joint_config_t > _joint_cfg

  unordered map storing the configuration struct of the joints.
- std::unordered_map< std::string, std::set< std::string > > _joint_command_modes

  unordered map of sets storing the active command interfaces for each joint.

11.1.1 Detailed Description

The bioscara hardware interface class.

The hardware interface serves to wrap custom hardware interaction in the standardized ros2_control architecture.

Hardware Lifecycle

The hardware follows the ros2_control hardware interface lifecyle which intern is following the `ROS2 managed node lifecycle`.

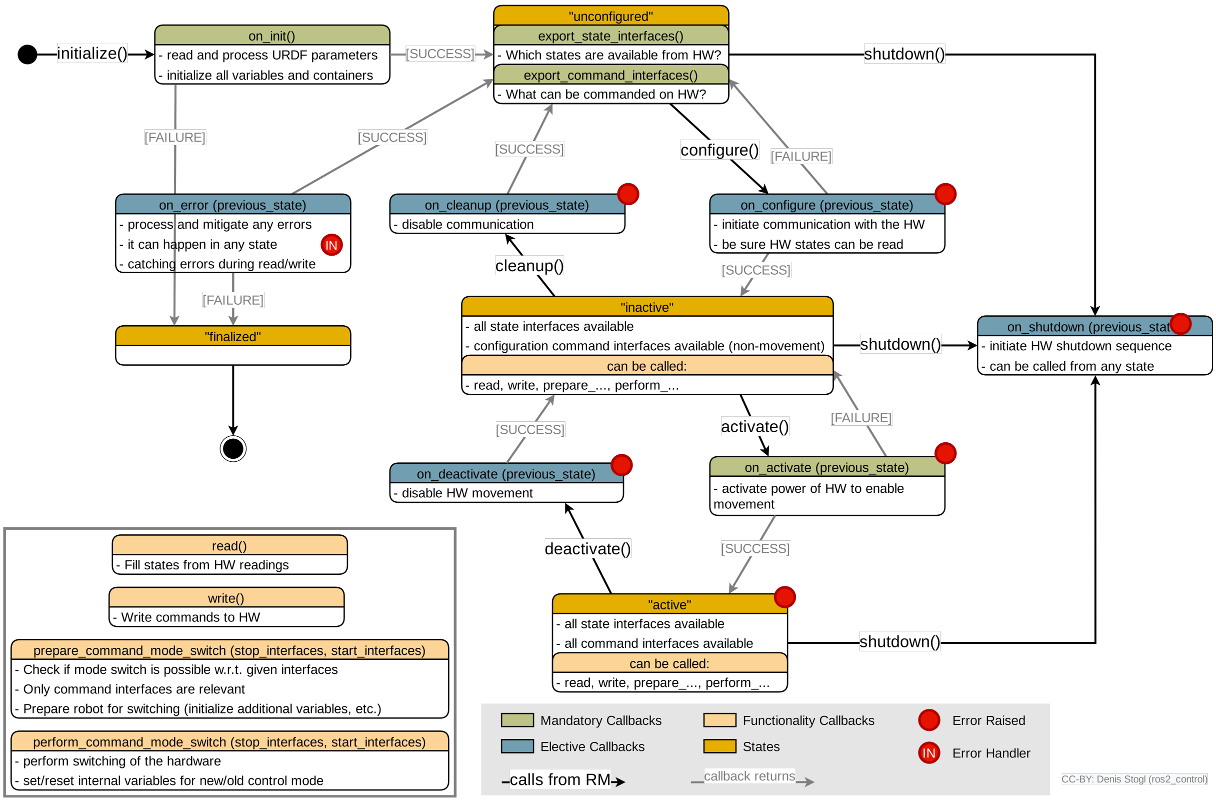

initialize()
on_init()
- read and process URDF parameters
- initialize all variables and containers
[SUCCESS]
"unconfigured"
export_state_interfaces()
- Which states are available from HW?
export_command_interfaces()
- What can be commanded on HW?
shutdown()
[FAILURE]
[SUCCESS]
[SUCCESS]
configure()
[FAILURE]
on_error (previous_state)
- process and mitigate any errors
- it can happen in any state
IN
- catching errors during read/write
on_cleanup (previous_state)
- disable communication
on_configure (previous_state)
- initiate communication with the HW
- be sure HW states can be read
cleanup()
[SUCCESS]
[FAILURE]
"finalized"
"inactive"
- all state interfaces available
- configuration command interfaces available (non-movement)
can be called:
- read, write, prepare_..., perform_...
shutdown()
on_shutdown (previous_stat
- initiate HW shutdown sequence
- can be called from any state
[SUCCESS]
activate()
[FAILURE]
on_deactivate (previous_state)
- disable HW movement
on_activate (previous_state)
- activate power of HW to enable movement
read()
- Fill states from HW readings
write()
- Write commands to HW
prepare_command_mode_switch (stop_interfaces, start_interfaces)
- Check if mode switch is possible w.r.t. given interfaces
- Only command interfaces are relevant
- Prepare robot for switching (initialize additional variables, etc.)
perform_command_mode_switch (stop_interfaces, start_interfaces)
- perform switching of the hardware
- set/reset internal variables for new/old control mode
deactivate()
[SUCCESS]
"active"
- all state interfaces available
- all command interfaces available
can be called:
- read, write, prepare_..., perform_...
shutdown()
Mandatory Callbacks
Functionality Callbacks
Error Raised
Elective Callbacks
States
IN
Error Handler
calls from RM
callback returns
CC-BY: Denis Stogl (ros2_control)

Figure 11.1 Hardware interface lifecycle

11.1.2 Member Function Documentation

11.1.2.1 on_activate()

```
hardware_interface::CallbackReturn bioscara_hardware_interface::BioscaraHardwareInterface↩
::on_activate (
            const rclcpp_lifecycle::State & previous_state )  [override]
```

Called on the transistion from the `inactive` to the `active` state.

Enables each joint, enables the stall detection and sets the maximmum acceleration.
It is allowed to activate the hardware even if it is not homed. To home the joint the homing_controller must be activated, but generally a hardware component must be active in order for controllers to become active.
To prohibit movement on activation the set point for each position command interface is set equal to the current measured position, and the velocity command is set to 0.0 for each command interface. The current values are obtained by calling the read() method once which populates the state interfaces with values.

Parameters

previous_state	

Returns

hardware_interface::CallbackReturn

Below a workaround to force a read cycle of all joints to get inital values for the state interfaces. These will be copied to the command interface to prevent movement at startup.

11.1.2.2 on_cleanup()

```
hardware_interface::CallbackReturn bioscara_hardware_interface::BioscaraHardwareInterface↩
::on_cleanup (
             const rclcpp_lifecycle::State & previous_state )  [override]
```

Called on the transistion from the `inactive` to the `unconfigured` state.

Disconnect from the joints.

Parameters

previous_state	

Returns

hardware_interface::CallbackReturn

Disconnect from the joints and throw error if it fails

11.1.2.3 on_configure()

```
hardware_interface::CallbackReturn bioscara_hardware_interface::BioscaraHardwareInterface↩
::on_configure (
             const rclcpp_lifecycle::State & previous_state )  [override]
```

Called on the transistion from the `unconfigured` to the `inactive` state.

Establish and test connection to each joint.

Parameters

previous_state	

Returns

hardware_interface::CallbackReturn

11.1.2.4 on_deactivate()

```
hardware_interface::CallbackReturn bioscara_hardware_interface::BioscaraHardwareInterface↩
::on_deactivate (
             const rclcpp_lifecycle::State & previous_state )  [override]
```

Called on the transistion from the `active` to the `inactive` state.

Disables all joints and thereby allows backdriving. State interfaces continue to be updated.

Parameters

previous_state	

Returns

hardware_interface::CallbackReturn

disable the joints and throw error if it fails

11.1.2.5 on_error()

```
hardware_interface::CallbackReturn bioscara_hardware_interface::BioscaraHardwareInterface↩
::on_error (
             const rclcpp_lifecycle::State & previous_state )  [override]
```

Called when an error in any state or state transition is thrown.

According to the `ros2_control documentation`:

> Error handling follows the node lifecycle. If successful CallbackReturn::SUCCESS is returned and hardware is again in `UNCONFIGURED` state, if any ERROR or FAILURE happens the hardware ends in `FINALIZED` state and can not be recovered. The only option is to reload the complete plugin, but there is currently no service for this in the Controller Manager.

Since the hardware will immediatly return to the `unconfigured` state (`source`) if the error could be handled we manually call the transition functions which would normally be called to this state. Those are:

- **Previous state**: `active`
  - Deactivate hardware (on_deactivate()) -> `inactive`

  - Clean-Up hardware (on_cleanup()) -> `unconfigured`
- **Previous state**: `inactive`
  - Deactivate hardware (on_deactivate()) -> `inactive`
    * call the deactivate function anyway regardless if state was active or inactive. For example if the on_activate() function fails on Joint::enableStallguard() the joint will have been enabled, to disable it invoke on_deactivate().
  - Clean-Up hardware (on_cleanup()) -> `unconfigured`

In particular the deactivation is important. For example if a joint stalls the read() or write() methods throw an error, which will be handled here and allow the hardware to be deactivated, disableing the joints to allow backdriving.

Parameters

previous_state	

Returns

hardware_interface::CallbackReturn

11.1.2.6 on_init()

```
hardware_interface::CallbackReturn bioscara_hardware_interface::BioscaraHardwareInterface↩
::on_init (
             const hardware_interface::HardwareComponentInterfaceParams & params )  [override]
```

Loop over all joints decribed in the hardware description file, check if they have the position and velocity command and state interface defined and finally add them to the internal _joints list

Loop over all GPIOs decribed in the hardware description file, check if they have the home command and state interface defined.

Todo threshold and current are uint8_t, if a number larger outside $0 < n < 255$ is passed as a parameters it will overflow.

11.1.2.7 on_shutdown()

```
hardware_interface::CallbackReturn bioscara_hardware_interface::BioscaraHardwareInterface↩
::on_shutdown (
             const rclcpp_lifecycle::State & previous_state )  [override]
```

Called on the transistion from the `inactive`, `unconfigured` and `active` to the `finalized` state.

When transitioning directly from `active` to `finalized` on_deactivate() is automatically called before `Source Code` If the previous state is either `inactive` or `active` the on_cleanup() method is called first. Then regardless of the previous state, the _joints map is cleared.

Parameters

previous_state	

Returns

hardware_interface::CallbackReturn

11.1.2.8 prepare_command_mode_switch()

```
hardware_interface::return_type bioscara_hardware_interface::BioscaraHardwareInterface::prepare↩
_command_mode_switch (
            const std::vector< std::string > & start_interfaces,
            const std::vector< std::string > & stop_interfaces )  [override]
```

Performs checks and book keeping of the active control mode when changing controllers.

For safe operation only one controller may interact with the hardware at the time. For example if the velocity JTC is active and has claimed the velocity command interfaces it is technically possible to activate the position JTC (or a homing controller, or others) that claim a different command interface (position in this case). However if both controllers are active they start writing to the hardware simultaneously which is to be avoided. For this reason a book keeping mechanism has been implemented which stores the currently active command interfaces for each joint in the _joint_command_modes member. Each joint has a set of active command interfaces. When a controller switch is performed the interfaces that should be stopped are removed from each joint set, then the one that should be started are added, if they are already present an error is thrown. Lastly a validation is performed. Currently the validation is simple since each joint may only have one command interface. The validation can be expanded for furture use cases that require a combination of active command interfaces per joint for example.
The following basic checks are implemented:

- **On deactivation**:
  - [ERROR] Homing command interfaces may only be deactivated if no current homing process is ongoing (Joint::getCurrentBCmd() != Joint::HOME)
  - [WARN] Deactivating a velocity command interface if the velocity set point is 0.0.
  - [WARN] Deactivating a command interface that has not been started. This should not happen.
- **On activation**:
  - [ERROR] Activating a command interface that is already started. This should not happen.
  - [ERROR] Activating a second command interface for a joint.

Parameters

start_interfaces	command interfaces that should be started in the form "joint/interface"
stop_interfaces	command interfaces that should be stopped in the form "joint/interface"

Returns

hardware_interface::return_type

11.1.2.9 read()

```
hardware_interface::return_type bioscara_hardware_interface::BioscaraHardwareInterface::read (
            const rclcpp::Time & time,
            const rclcpp::Duration & period )  [override]
```

Reads from the hardware and populates the state interfaces.

Iterates over all state interfaces and calls the corresponding Joint method.

- State interface "position" -> Joint::getPosition()
- State interface "velocity" -> Joint::getVelocity()
- State interface "home" -> Joint::isHomed()
  - This does not actually trigger a communication, instead it relies on the return flags of the previous transmissions. Since position and velocity have been called immediatly before the return flags are assumed to be valid.
  - If the the homing of a joint has been activated through the command interface (Joint::getCurrentBCmd() == Joint::HOME) the device signals BUSY (Joint::isBusy()) as long as it is still homing.
    If the BUSY flag is reset while the current command is still Joint::HOME we can assume the homing has finished. Then the "home" command interface of the joint is reset to 0.0, which will stop the homing (perform cleanup tasks) at the next write cycle.

Parameters

time	
period	

Returns

hardware_interface::return_type

11.1.2.10 write()

```
hardware_interface::return_type bioscara_hardware_interface::BioscaraHardwareInterface::write
(
            const rclcpp::Time & time,
            const rclcpp::Duration & period )  [override]
```

Writes commands to the hardware from the command interfaces.

In contrast to the read() method the write() method only loops over the command interfaces that are currently active defined by the BioscaraHardwareInterface::_joint_command_modes map. See prepare_command_mode_switch() for a detailed reasoning why this approach has been chosen.

- Command interface "position" -> Joint::setPosition()
- Command interface "velocity" -> Joint::setVelocity()
- Command interface "home" -> Joint::startHoming()

- If the commanded value in "home" is != 0.0 the and the joint is currently executing a blocking function, for example homing (Joint::getCurrentBCmd() == Joint::NONE), the homing sequence is started with the speed, sensitivity, current and acceleration defined in the BioscaraHardwareInterface::_joint_cfg which is polulated from the hardware description urdf. The direction of the homing is determined by the sign of the command interface value.
- If the commanded value in "home" is = 0.0 and the joint is currently executing homing, the homing is stopped. This can either happen prematurely through user input or when the homing is completed which is registered in read().

Parameters

time	
period	

Returns

hardware_interface::return_type

11.1.3 Member Data Documentation

11.1.3.1 _joint_cfg

```
std::unordered_map<std::string, joint_config_t> bioscara_hardware_interface::BioscaraHardware↩
Interface::_joint_cfg  [private]
```

unordered map storing the configuration struct of the joints.

An unordered map is chosen to simplify acces via the joint name, as this conforms well with the ROS2_control hardware interface The map does not need to be ordered. Search, insertion, and removal of elements have average constant-time complexity.

11.1.3.2 _joint_command_modes

```
std::unordered_map<std::string, std::set<std::string> > bioscara_hardware_interface::Bioscara↩
HardwareInterface::_joint_command_modes  [private]
```

unordered map of sets storing the active command interfaces for each joint.

Each joint can have a set of active command interfaces. This type of structure is chosen to group interfaces by joint. In the write() function the interface name can simply be constructed by concatenating joint name with interface name. Although currently only one active command interface is allowed at the time, a set can be used to store multiple command interfaces that are acceptable to be combined, for example it would be acceptable to set velocity and driver current and hence that would be an allowable combination.

An unordered map is chosen to simplify acces via the joint name, as this conforms well with the ROS2_control hardware interface. The map does not need to be ordered. Search, insertion, and removal of elements have average constant-time complexity.

11.1.3.3 _joints

```
std::unordered_map<std::string, Joint> bioscara_hardware_interface::BioscaraHardwareInterface↩
::_joints  [private]
```

unordered map storing the Joint objects.

An unordered map is chosen to simplify acces via the joint name, as this conforms well with the ROS2_control hardware interface The map does not need to be ordered. Search, insertion, and removal of elements have average constant-time complexity.

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

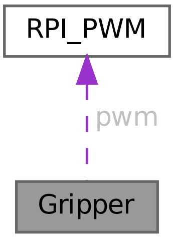
- ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_interface/include/bioscara_hardware_↩ interface/bioscara_hardware.hpp
- ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_interface/src/bioscara_hardware.cpp

11.2 Gripper Class Reference

Gripper object to interact with the robot gripper.

```
#include <mGripper.h>
```

Collaboration diagram for Gripper:



Public Member Functions

- Gripper (void)
- int init (void)

  Placeholder, does nothing.
- int deinit (void)

  Placeholder, does nothing.
- int enable (void)

  Prepares the servo for use.
- int disable (void)

  Disables the servo.
- int setPosition (float width)

  Sets the gripper width in mm from the closed position.

Private Attributes

- RPI_PWM pwm

11.2.1 Detailed Description

Gripper object to interact with the robot gripper.

This class is a wrapper function to interact with a PWM servo gripper. An example application is shown below. Note that depending on the build toolchain the include path can differ. This example assumes the bioscara_hardware_driver package is built with ROS2.

```
#include "bioscara_hardware_driver/mGripper.h"
int main(int argc, char **argv)
{
    Gripper gripper;
    gripper.init();
    if(gripper.enable() != 0){
        cerr « "Failed to engage gripper" « endl;
        return -1;
    }

    if (gripper.setPosition(40) != 0)
    {
        cerr « "setting position failed" « endl;
        return -1;
    }

    if(gripper.disable() != 0){
        cerr « "Failed to disengage gripper" « endl;
        return -1;
    }

    gripper.deinit();
    return 0;
}
```

11.2.2 Constructor & Destructor Documentation

11.2.2.1 Gripper()

```
Gripper::Gripper (
              void  )
```

11.2.3 Member Function Documentation

11.2.3.1 deinit()

```
int Gripper::deinit (
              void  )
```

Placeholder, does nothing.

Returns

0

11.2.3.2 disable()

```
int Gripper::disable (
            void  )
```

Disables the servo.

Stops the servo and disables the PWM generation.

Returns

non-zero error code.

11.2.3.3 enable()

```
int Gripper::enable (
            void  )
```

Prepares the servo for use.

Starts the PWM generation but does not set a position. Must be called before a position is set. The PWM pin is GPIO18. PWM chip is 0, channel 0. *

Returns

non-zero error code.

11.2.3.4 init()

```
int Gripper::init (
            void  )
```

Placeholder, does nothing.

Returns

0

11.2.3.5 setPosition()

```
int Gripper::setPosition (
            float width )
```

Sets the gripper width in mm from the closed position.

Arguments outside the allowed range are bounded to limit.

Parameters

width	width in mm. 30 - 85 mm are currently allowed. With a new gripper this should be changed.

11.2.4 Member Data Documentation

11.2.4.1 pwm

```
RPI_PWM Gripper::pwm [private]
```

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

- ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_driver/include/bioscara_hardware_driver/mGripper.h
- ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_driver/src/mGripper.cpp

11.3 Joint Class Reference

Representing a single joint on the I2C bus.

```
#include <mJoint.h>
```

Public Types

- enum stp_reg_t {
  NONE = 0x00 , PING = 0x0f , SETUP = 0x10 , SETRPM = 0x11 ,
  GETDRIVERRPM = 0x12 , MOVESTEPS = 0x13 , MOVEANGLE = 0x14 , MOVETOANGLE = 0x15 ,
  GETMOTORSTATE = 0x16 , RUNCOTINOUS = 0x17 , ANGLEMOVED = 0x18 , SETCURRENT = 0x19 ,
  SETHOLDCURRENT = 0x1A , SETMAXACCELERATION = 0x1B , SETMAXDECELERATION = 0x1C ,
  SETMAXVELOCITY = 0x1D ,
  ENABLESTALLGUARD = 0x1E , DISABLESTALLGUARD = 0x1F , CLEARSTALL = 0x20 , SETBRAKEMODE = 0x22 ,
  ENABLEPID = 0x23 , DISABLEPID = 0x24 , ENABLECLOSEDLOOP = 0x25 , DISABLECLOSEDLOOP = 0x26 ,
  SETCONTROLTHRESHOLD = 0x27 , MOVETOEND = 0x28 , STOP = 0x29 , GETPIDERROR = 0x2A ,
  CHECKORIENTATION = 0x2B , GETENCODERRPM = 0x2C , HOME = 0x2D , HOMEOFFSET = 0x2E }

  register and command definitions

Public Member Functions

- Joint (const std::string name, const int address, const float reduction, const float min, const float max)

  Create a Joint object.
- ∼Joint (void)
- int init (void)

  Established connection to a joint via I2C.
- int deinit (void)

  Disconnects from a joint.
- int enable (u_int8_t driveCurrent, u_int8_t holdCurrent)

Setup the joint and engages motor.
- int disable (void)

  disenganges the joint motor without closing i2c handle
- int home (float velocity, u_int8_t sensitivity, u_int8_t current)

  Blocking implementation to home the joint.
- int startHoming (float velocity, u_int8_t sensitivity, u_int8_t current)

  non-blocking implementation to home the joint.
- int postHoming (void)

  perform tasks after a non-blocking homing.
- int printInfo (void)
- int getPosition (float &pos)

  get the current joint position in radians or m for cylindrical and prismatic joints respectively.
- int setPosition (float pos)

  get the current joint position in radians or m for cylindrical and prismatic joints respectively.
- int moveSteps (int32_t steps)

  Move full steps.
- int getVelocity (float &vel)

  get the current joint velocity in radians/s or m/s for cylindrical and prismatic joints respectively.
- int setVelocity (float vel)

  Set the current joint velocity in radians/s or m/s for cylindrical and prismatic joints respectively.
- int checkOrientation (float angle=10.0)

  Calls the checkOrientation method of the motor. Checks in which direction the motor is turning.
- int stop (void)

  Stops the motor.
- int disableCL (void)

  Disables the Closed-Loop PID Controller.
- int setDriveCurrent (u_int8_t current)

  Set the Drive Current.
- int setHoldCurrent (u_int8_t current)

  Set the Hold Current.
- int setBrakeMode (u_int8_t mode)

  Set Brake Mode.
- int setMaxAcceleration (float maxAccel)

  Set the maximum permitted joint acceleration (and deceleration) in rad/s^2 or m/s^2 for cylindrical and prismatic joints respectively.
- int setMaxVelocity (float maxVel)

  Set the maximum permitted joint velocity in rad/s or m/s for cylindrical and prismatic joints respectively.
- int enableStallguard (u_int8_t sensitivity)

  Enable encoder stall detection of the joint.
- bool isHomed (void)

  Checks the state if the motor is homed.
- bool isEnabled (void)

  Checks the state if the motor is enabled.
- bool isStalled (void)

  Checks if the motor is stalled.
- bool isBusy (void)

  Checks if the joint controller is busy processing a blocking command.
- int checkCom (void)

  Check if communication to the joint is established.
- u_int8_t getFlags (void)
- int getHomingOffset (float &offset)

Retrieves the homing position from the last homing.

- int setHomingOffset (const float offset)

  Stores the homing position on the joint.
- stp_reg_t getCurrentBCmd (void)

  get the currently active blocking command

Public Attributes

- std::string name

Private Member Functions

- template<typename T >
  int read (const stp_reg_t reg, T &data, u_int8_t &flags)

  Wrapper function to request data from the I2C slave.
- template<typename T >
  int write (const stp_reg_t reg, T data, u_int8_t &flags)

  Wrapper function to send command to the I2C slave.
- void wait_while_busy (const float period_ms)

  Blocking loop waiting for BUSY flag to reset.
- int _home (float velocity, u_int8_t sensitivity, u_int8_t current)

  Call to start the homing sequence of a joint.

Private Attributes

- u_int8_t flags = 0x00

  State flags transmitted with every I2C transaction.
- int address

  I2C adress.
- float reduction = 1

  Joint to actuator reduction ratio.
- float offset = 0

  Joint position offset.
- float min = 0

  Joint lower limit.
- float max = 0

  Joint upper limit.
- stp_reg_t current_b_cmd = NONE

  Keeps track if a blocking command is being executed.
- int handle = -1

  I2C bus handle.

11.3.1 Detailed Description

Representing a single joint on the I2C bus.

11.3.2 Member Enumeration Documentation

11.3.2.1 stp_reg_t

```
enum Joint::stp_reg_t
```

register and command definitions

a register can be read (R) or written (W), each register has a size in bytes. The payload can be split into multiple values or just be a single value. Note that not all functions are implemented.

Enumerator

NONE	Used for signalling purposes.
PING	R; Size: 1; [(char) ACK].
SETUP	W; Size: 2; [(uint8) holdCurrent, (uint8) driveCurrent].
SETRPM	W; Size: 4; [(float) RPM].
GETDRIVERRPM	
MOVESTEPS	W; Size: 4; [(int32) steps].
MOVEANGLE	
MOVETOANGLE	W; Size: 4; [(float) degrees].
GETMOTORSTATE	
RUNCOTINOUS	
ANGLEMOVED	R; Size: 4; [(float) degrees].
SETCURRENT	W; Size: 1; [(uint8) driveCurrent].
SETHOLDCURRENT	W; Size: 1; [(uint8) holdCurrent].
SETMAXACCELERATION	
SETMAXDECELERATION	
SETMAXVELOCITY	
ENABLESTALLGUARD	W; Size: 1; [(uint8) threshold].
DISABLESTALLGUARD	
CLEARSTALL	
SETBRAKEMODE	W; Size: 1; [(uint8) mode].
ENABLEPID	
DISABLEPID	
ENABLECLOSEDLOOP	
DISABLECLOSEDLOOP	W; Size: 1; [(uint8) 0].
SETCONTROLTHRESHOLD	
MOVETOEND	
STOP	W; Size: 1; [(uint8) mode].
GETPIDERROR	
CHECKORIENTATION	W; Size: 4; [(float) degrees].
GETENCODERRPM	R; Size: 4; [(float) RPM].
HOME	W; Size: 4; [(uint8) current, (int8) sensitivity, (uint8) speed, (uint8) direction].
HOMEOFFSET	R/W; Size: 4; [(float) -].

11.3.3 Constructor & Destructor Documentation

11.3.3.1 Joint()

```
Joint::Joint (
            const std::string name,
            const int address,
            const float reduction,
            const float min,
            const float max )
```

Create a Joint object.

The Joint object represents a single joint and its actuator. Each Joint has a transmission with the following relationship:

actuator position = (joint position - offset) ∗ reduction
joint position = actuator position / reduction + offset

Parameters

name	string device name for identification
address	1-byte I2C device adress (0x11 ... 0x14) for J1 ... J4
reduction	gear reduction of the joint. This is used to transform position and velocity values between in joint units and actuator (stepper) units. The sign depends on the direction the motor is mounted and is turning. Adjust such that the joint moves in the positive direction on on positive joint commands. Cable polarity has no effect since the motors automatically adjust to always run in the 'right' direction from their point of view. J1: 35 J2: -2∗pi/0.004 (4 mm linear movement per stepper revolution) J3: 24 J4: 12
min	lower joint limit in joint units. J1: -3.04647 J2: -0.0016 J3: -2.62672 J4: -3.01069
max	upper joint limit in joint units. J1: 3.04647 J2: 0.3380 J3: 2.62672 J4: 3.01069

11.3.3.2 ∼Joint()

```
Joint::∼Joint (
            void )
```

11.3.4 Member Function Documentation

11.3.4.1 _home()

```
int Joint::_home (
            float velocity,
            u_int8_t sensitivity,
            u_int8_t current ) [private]
```

Call to start the homing sequence of a joint.

First the joint will check the motor wiring by executing the checkOrientation internally. Then it will set the specified speed until a resistance which drives the PID error above the specified threshold is encountered. At this point the stepper stops and zeros the encoder.

Parameters

velocity	signed velocity in rad/s or m/s. Must be between 1.0 < RAD2DEG(JOINT2ACTUATOR(velocity, reduction, 0)) / 6 < 250.0
sensitivity	Encoder pid error threshold 0 to 255.
current	homing current, determines how easy it is to stop the motor and thereby provoke a stall

Returns

> 0 on success, -1 on communication error, -3 when the motor is not enabled, -5 if the joint is not initialized, -101 if the velocity is zero, -102 if absolute value of the velocity is outside the specified limits.

11.3.4.2 checkCom()

```
int Joint::checkCom (
            void  )
```

Check if communication to the joint is established.

Sends a PING to and expects a ACK from the joint.

Returns

> 0 on success, -1 on communication error, -5 if the joint is not initialized.

11.3.4.3 checkOrientation()

```
int Joint::checkOrientation (
            float angle = 10.0 )
```

Calls the checkOrientation method of the motor. Checks in which direction the motor is turning.

As the orientation check is blocking on the motor, this this function returns when the isBusy flag is clear again.

Parameters

angle	degrees how much the motor should turn. A few degrees is sufficient.

Returns

> 0 on success, -1 on communication error, -3 when the motor is not enabled, -4 when the motor is stalled, -5 if the joint is not initialized.

11.3.4.4 deinit()

```
int Joint::deinit (
            void  )
```

Disconnects from a joint.

Removes the joint from the I2C bus.

Returns

> 0 on success, -1 when the joint could not be removed due to an I2C error, -5 if the joint is not initialized.

11.3.4.5 disable()

```
int Joint::disable (
            void )
```

disenganges the joint motor without closing i2c handle

Returns

0 on success, -1 on communication error, -5 if the joint is not initialized.

11.3.4.6 disableCL()

```
int Joint::disableCL (
            void )
```

Disables the Closed-Loop PID Controller.

Returns

0 on success, -1 on communication error, -5 if the joint is not initialized.

11.3.4.7 enable()

```
int Joint::enable (
            u_int8_t driveCurrent,
            u_int8_t holdCurrent )
```

Setup the joint and engages motor.

This function prepares the motor for movement. After successfull execution the joint is ready to accept Joint::setPosition() and Joint::setVelocity() commands.
The function ets the drive and hold current for the specified joint and engages the motor. The currents are in percent of driver max. output (2.5A, check with TMC5130 datasheet or Ustepper documentation)

Parameters

driveCurrent	drive current in 0-100 % of 2.5A output (check uStepper doc.)
holdCurrent	hold current in 0-100 % of 2.5A output (check uStepper doc.)

Returns

0 on success, -1 on communication error, -3 when the motor is not enabled, -5 if the joint is not initialized.

11.3.4.8 enableStallguard()

```
int Joint::enableStallguard (
            u_int8_t sensitivity )
```

Enable encoder stall detection of the joint.

If the PID error exceeds the set threshold a stall is triggered and the motor disabled. A detected stall can be reset by homing or by reenabling the stall guard.

Parameters

thresholds	value of threshold. 0 - 255 where lower is more sensitive.

Returns

0 on success, -1 on communication error, -5 if the joint is not initialized.

11.3.4.9 getCurrentBCmd()

```
Joint::stp_reg_t Joint::getCurrentBCmd (
             void  )
```

get the currently active blocking command

Returns

The the command of type stp_reg_t

11.3.4.10 getFlags()

```
u_int8_t Joint::getFlags (
             void  )
```

get driver state flags

Returns

flags >= 0 on success, -5 if the joint is not initialized.

11.3.4.11 getHomingOffset()

```
int Joint::getHomingOffset (
             float & offset )
```

Retrieves the homing position from the last homing.

The homing position is stored on the joint to make it persistent as long as the joint is powered up.

Returns

0 on success, -1 on communication error, -2 when not homed, -5 if the joint is not initialized.

11.3.4.12 getPosition()

```
int Joint::getPosition (
             float & pos )
```

get the current joint position in radians or m for cylindrical and prismatic joints respectively.

Warning

If the joint is not homed this method does not return an error. Instead `pos` will be 0.0.

Parameters

pos	

Returns

0 on success, -1 on communication error, -5 if the joint is not initialized.

11.3.4.13 getVelocity()

```
int Joint::getVelocity (
            float & vel )
```

get the current joint velocity in radians/s or m/s for cylindrical and prismatic joints respectively.

Parameters

vel	

Returns

0 on success, -1 on communication error, -5 if the joint is not initialized.

11.3.4.14 home()

```
int Joint::home (
            float velocity,
            u_int8_t sensitivity,
            u_int8_t current )
```

Blocking implementation to home the joint.

A blocking implementation which only returns after the the joint is no longer BUSY. See Joint::_home() for documentation.

Additionally this method returns:

Returns

-2 when not homed succesfull (isHomed flag still not set), -109 if the joint is already currently homing (for example from a call to Joint::startHoming()).

11.3.4.15 init()

```
int Joint::init (
            void )
```

Established connection to a joint via I2C.

Adds the joint to the I2C bus and tests if is responsive by sending a PING.

Returns

0 on success, -1 on when no ACK is received from the joint, -2 if the I2C device could not be opened given the joint address.

11.3.4.16 isBusy()

```
bool Joint::isBusy (
             void   )
```

Checks if the joint controller is busy processing a blocking command.

Reads the internal state flags from the last transmission. If an update is neccessary call Joint::getFlags() before invoking this function.

Returns

true if a blocking command is currently executing, false if not.

11.3.4.17 isEnabled()

```
bool Joint::isEnabled (
             void   )
```

Checks the state if the motor is enabled.

Reads the internal state flags from the last transmission. If an update is neccessary call Joint::getFlags() before invoking this function. If the motor actually can move depends on the state of the STALLED flag which can be checked using Joint::isStalled().

Returns

true if the motor is enabled, false if not.

11.3.4.18 isHomed()

```
bool Joint::isHomed (
             void   )
```

Checks the state if the motor is homed.

Reads the internal state flags from the last transmission. If an update is neccessary call Joint::getFlags() before invoking this function.

Returns

true if the motor is homed, false if not.

11.3.4.19 isStalled()

```
bool Joint::isStalled (
             void   )
```

Checks if the motor is stalled.

Reads the internal state flags from the last transmission. If an update is neccessary call Joint::getFlags() before invoking this function.

Returns

true if the motor is stalled, false if not.

11.3.4.20 moveSteps()

```
int Joint::moveSteps (
            int32_t steps )
```

Move full steps.

This function can be called even when not homed.

Parameters

steps	number of full steps

Returns

> 0 on success, -1 on communication error, -3 when the motor is not enabled, -4 when the motor is stalled, -5 if the joint is not initialized.

11.3.4.21 postHoming()

```
int Joint::postHoming (
              void  )
```

perform tasks after a non-blocking homing.

This method resets the current_b_cmd to NONE, checks if the joint is homed, and saves the homing offset to the joint.

Returns

> 0 on success, -109 if the current_b_cmd is not HOME, -1 on communication error, -2 when not homed, -5 if the joint is not initialized.

11.3.4.22 printInfo()

```
int Joint::printInfo (
              void  )
```

11.3.4.23 read()

```
template<typename T >
int Joint::read (
              const stp_reg_t reg,
              T & data,
              u_int8_t & flags )  [private]
```

Wrapper function to request data from the I2C slave.

Allocates a buffer of size sizeof(T) + RFLAGS_SIZE. invokes readFromI2CDev(), and copies the received payload to *data* and the transmisison flags to *flags*. See Joint::flags for details.

Todo

- Implement a return code for read only functions
- Implement clearStall function

Template Parameters

T	Datatype of value to be transmitted

Parameters

reg	stp_reg_t register to read
data	reference to store payload.
flags	reference to a byte which stores the return flags

Returns

0 on OK, negative on error

11.3.4.24 setBrakeMode()

```
int Joint::setBrakeMode (
            u_int8_t mode )
```

Set Brake Mode.

Parameters

mode	Freewheel: 0, Coolbrake: 1, Hardbrake: 2

Returns

0 on success, -1 on communication error, -5 if the joint is not initialized.

11.3.4.25 setDriveCurrent()

```
int Joint::setDriveCurrent (
            u_int8_t current )
```

Set the Drive Current.

Warning

This function is unreliable and not well tested. Use Joint::enable() instead!

Parameters

current	0% - 100% of driver current

Returns

0 on success, -1 on communication error, -5 if the joint is not initialized.

11.3.4.26 setHoldCurrent()

```
int Joint::setHoldCurrent (
            u_int8_t current )
```

Set the Hold Current.

Warning

This function is unreliable and not well tested. Use Joint::enable() instead!

Parameters

current	0% - 100% of driver current

Returns

0 on success, -1 on communication error, -5 if the joint is not initialized.

11.3.4.27 setHomingOffset()

```
int Joint::setHomingOffset (
            const float offset )
```

Stores the homing position on the joint.

The homing position is stored on the joint to make it persistent as long as the joint is powered up.

Returns

0 on success, -1 on communication error, -2 if not homed, -5 if the joint is not initialized.

11.3.4.28 setMaxAcceleration()

```
int Joint::setMaxAcceleration (
            float maxAccel )
```

Set the maximum permitted joint acceleration (and deceleration) in rad/s^2 or m/s^2 for cylindrical and prismatic joints respectively.

Parameters

maxAccel	maximum joint acceleration.

Returns

0 on success, -1 on communication error, -5 if the joint is not initialized.

11.3.4.29 setMaxVelocity()

```
int Joint::setMaxVelocity (
            float maxVel )
```

Set the maximum permitted joint velocity in rad/s or m/s for cylindrical and prismatic joints respectively.

Parameters

maxVel	maximum joint velocity.

Returns

0 on success, -1 on communication error, -5 if the joint is not initialized.

11.3.4.30 setPosition()

```
int Joint::setPosition (
            float pos )
```

get the current joint position in radians or m for cylindrical and prismatic joints respectively.

Parameters

pos	in rad or m

Returns

0 on success, -1 on communication error, -2 when not homed, -3 when the motor is not enabled, -4 when the motor is stalled, -5 if the joint is not initialized.

11.3.4.31 setVelocity()

```
int Joint::setVelocity (
            float vel )
```

Set the current joint velocity in radians/s or m/s for cylindrical and prismatic joints respectively.

Parameters

vel	

Returns

0 on success, -1 on communication error, -2 when not homed, -3 when the motor is not enabled, -4 when the motor is stalled, -5 if the joint is not initialized.

11.3.4.32 startHoming()

```
int Joint::startHoming (
            float velocity,
            u_int8_t sensitivity,
            u_int8_t current )
```

non-blocking implementation to home the joint.

See Joint::_home() for documentation. The current_b_cmd flag is set to HOME This method returns immediatly after starting the homing sequence. This should be used when the blocking implementation is not acceptable. For example in the update loop of the bioscara_hardware_interface::BioscaraHardwareInterface::write().

Additionally this method returns:

Returns

-109 if the joint is already currently homing (for example from a call to Joint::startHoming()).

11.3.4.33 stop()

```
int Joint::stop (
             void  )
```

Stops the motor.

Stops the motor by setting the maximum velocity to zero and the position setpoint to the current position

Returns

0 on success, -1 on communication error, -5 if the joint is not initialized.

11.3.4.34 wait_while_busy()

```
void Joint::wait_while_busy (
             const float period_ms )  [private]
```

Blocking loop waiting for BUSY flag to reset.

Parameters

period_ms	time in ms between polls.

11.3.4.35 write()

```
template<typename T >
int Joint::write (
             const stp_reg_t reg,
             T data,
             u_int8_t & flags )  [private]
```

Wrapper function to send command to the I2C slave.

Allocates a buffer of size sizeof(T) + RFLAGS_SIZE. Copies *data* to the buffer and invokes writeToI2CDev(). The flags received from the transaction are copied to *flags*. The flags are described in Joint::read().

Template Parameters

T	Datatype of value to be transmitted

Parameters

reg	stp_reg_t command to execute
data	payload to transmit. It is the users responsibility to populate the right amount of data for the relevant register
flags	reference to a byte which stores the return flags

Returns

0 on OK, negative on error

11.3.5 Member Data Documentation

11.3.5.1 address

```
int Joint::address  [private]
```

I2C adress.

11.3.5.2 current_b_cmd

```
stp_reg_t Joint::current_b_cmd = NONE  [private]
```

Keeps track if a blocking command is being executed.

11.3.5.3 flags

```
u_int8_t Joint::flags = 0x00  [private]
```

State flags transmitted with every I2C transaction.

The transmission flags purpose are to transmit the joints current state. Note: They can not be used as error indication of the execution of a transmitted write command, since commands are executed after the I2C transaction is completed. The status flags are one byte with following structure:

BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
reserved	reserved	reserved	reserved	NOTENABLED	NOTHOMED	BUSY	STALL

STALL is set if a stall from the stall detection is sensed and the joint is stopped. The flag is cleared when the joint is homed or the Stallguard enabled.
BUSY is set if the slave is busy processing a previous command.

NOTHOMED is cleared if the joint is homed. Movement is only allowed if this flag is clear
NOTENABLED is cleared if the joint is enabled after calling Joint::enable()

11.3.5.4 handle

```
int Joint::handle = -1  [private]
```

I2C bus handle.

11.3.5.5 max

```
float Joint::max = 0  [private]
```

Joint upper limit.

11.3.5.6 min

```
float Joint::min = 0  [private]
```

Joint lower limit.

11.3.5.7 name

```
std::string Joint::name
```

11.3.5.8 offset

```
float Joint::offset = 0  [private]
```

Joint position offset.

11.3.5.9 reduction

```
float Joint::reduction = 1  [private]
```

Joint to actuator reduction ratio.

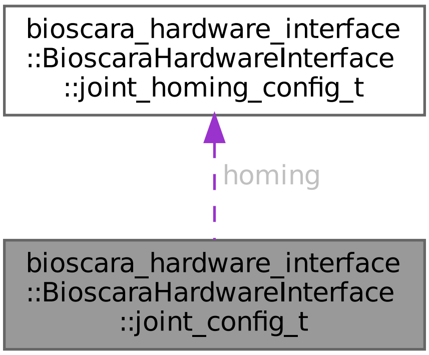
The documentation for this class was generated from the following files:

- ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_driver/include/bioscara_hardware_driver/mJoint.h
- ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_driver/include/bioscara_hardware_driver/mJoint.hpp
- ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_driver/src/mJoint.cpp

11.4 bioscara_hardware_interface::BioscaraHardwareInterface::joint_config_t Struct Reference

configuration structure holding the passed paramters from the ros2_control urdf

Collaboration diagram for bioscara_hardware_interface::BioscaraHardwareInterface::joint_config_t:


bioscara_hardware_interface ::BioscaraHardwareInterface ::joint_homing_config_t
homing
bioscara_hardware_interface ::BioscaraHardwareInterface ::joint_config_t

Public Attributes

- int i2c_address
- float reduction = 1
- float min
- float max
- u_int8_t drive_current
- u_int8_t hold_current
- u_int8_t stall_threshold
- float max_velocity
- float max_acceleration
- joint_homing_config_t homing

11.4.1 Detailed Description

configuration structure holding the passed paramters from the ros2_control urdf

Saving all parameters on initialization in a structure allows for quick access during runtime.

11.4.2 Member Data Documentation

11.4.2.1 drive_current

```
u_int8_t bioscara_hardware_interface::BioscaraHardwareInterface::joint_config_t::drive_current
```

11.4.2.2 hold_current

```
u_int8_t bioscara_hardware_interface::BioscaraHardwareInterface::joint_config_t::hold_current
```

11.4.2.3 homing

```
joint_homing_config_t bioscara_hardware_interface::BioscaraHardwareInterface::joint_config_t↩
::homing
```

11.4.2.4 i2c_address

```
int bioscara_hardware_interface::BioscaraHardwareInterface::joint_config_t::i2c_address
```

11.4.2.5 max

```
float bioscara_hardware_interface::BioscaraHardwareInterface::joint_config_t::max
```

11.4.2.6 max_acceleration

```
float bioscara_hardware_interface::BioscaraHardwareInterface::joint_config_t::max_acceleration
```

11.4.2.7 max_velocity

```
float bioscara_hardware_interface::BioscaraHardwareInterface::joint_config_t::max_velocity
```

11.4.2.8 min

```
float bioscara_hardware_interface::BioscaraHardwareInterface::joint_config_t::min
```

11.4.2.9 reduction

```
float bioscara_hardware_interface::BioscaraHardwareInterface::joint_config_t::reduction = 1
```

11.4.2.10 stall_threshold

```
u_int8_t bioscara_hardware_interface::BioscaraHardwareInterface::joint_config_t::stall_↩
threshold
```

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

- ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_interface/include/bioscara_hardware_↩ interface/bioscara_hardware.hpp

11.5 bioscara_hardware_interface::BioscaraHardwareInterface::joint_↩ homing_config_t Struct Reference

configuration structure holding the passed homing paramters from the ros2_control urdf

Public Attributes

- float speed = 0
- u_int8_t threshold = 10
- u_int8_t current = 10
- float acceleration = 0.01

11.5.1 Detailed Description

configuration structure holding the passed homing paramters from the ros2_control urdf

Saving all parameters on initialization in a structure allows for quick access during runtime.

11.5.2 Member Data Documentation

11.5.2.1 acceleration

```
float bioscara_hardware_interface::BioscaraHardwareInterface::joint_homing_config_t::acceleration
= 0.01
```

11.5.2.2 current

```
u_int8_t bioscara_hardware_interface::BioscaraHardwareInterface::joint_homing_config_t::current
= 10
```

11.5.2.3 speed

```
float bioscara_hardware_interface::BioscaraHardwareInterface::joint_homing_config_t::speed = 0
```

11.5.2.4 threshold

```
u_int8_t bioscara_hardware_interface::BioscaraHardwareInterface::joint_homing_config_t::threshold
= 10
```

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

- ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_interface/include/bioscara_hardware_↩ interface/bioscara_hardware.hpp

11.6 RPI_PWM Class Reference

PWM class for the Raspberry PI 4 and 5.

```
#include <uPWM.h>
```

Public Member Functions

- int start (int channel, int frequency, float duty_cycle=0, int chip=2)
- void stop ()
- ∼RPI_PWM ()
- int setDutyCycle (float v) const

Private Member Functions

- void setPeriod (int ns) const
- int setDutyCycleNS (int ns) const
- void enable () const
- void disable () const
- int writeSYS (std::string filename, int value) const

Private Attributes

- int per = 0
- std::string chippath
- std::string pwmpath

11.6.1 Detailed Description

PWM class for the Raspberry PI 4 and 5.

11.6.2 Constructor & Destructor Documentation

11.6.2.1 ∼RPI_PWM()

```
RPI_PWM::∼RPI_PWM ( )  [inline]
```

11.6.3 Member Function Documentation

11.6.3.1 disable()

```
void RPI_PWM::disable ( ) const  [inline], [private]
```

11.6.3.2 enable()

```
void RPI_PWM::enable ( ) const  [inline], [private]
```

11.6.3.3 setDutyCycle()

```
int RPI_PWM::setDutyCycle (
             float v ) const  [inline]
```

Sets the duty cycle.

Parameters

v	The duty cycle in percent.
return	>0 on success and -1 after an error.

11.6.3.4 setDutyCycleNS()

```
int RPI_PWM::setDutyCycleNS (
            int ns ) const  [inline], [private]
```

11.6.3.5 setPeriod()

```
void RPI_PWM::setPeriod (
            int ns ) const  [inline], [private]
```

11.6.3.6 start()

```
int RPI_PWM::start (
            int channel,
            int frequency,
            float duty_cycle = 0,
            int chip = 2 )  [inline]
```

Starts the PWM

Parameters

channel	The GPIO channel which is 2 or 3 for the RPI5
frequency	The PWM frequency
duty_cycle	The initial duty cycle of the PWM (default 0)
chip	The chip number (for RPI5 it's 2)
return	>0 on success and -1 if an error has happened.

11.6.3.7 stop()

```
void RPI_PWM::stop ( )  [inline]
```

Stops the PWM

11.6.3.8 writeSYS()

```
int RPI_PWM::writeSYS (
            std::string filename,
            int value ) const  [inline], [private]
```

11.6.4 Member Data Documentation

11.6.4.1 chippath

```
std::string RPI_PWM::chippath  [private]
```

11.6.4.2 per

```
int RPI_PWM::per = 0  [private]
```

11.6.4.3 pwmpath

```
std::string RPI_PWM::pwmpath  [private]
```

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

- ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_driver/include/bioscara_hardware_driver/uPWM.h

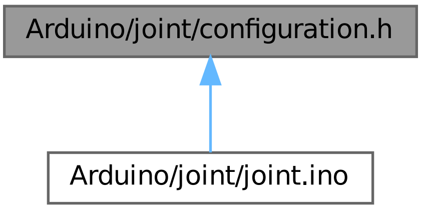
Chapter 12

File Documentation

12.1 Arduino/joint/configuration.h File Reference

Configuration definitions for Joint 1 to Joint 4.

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



Macros

- #define ADR 0x11

  I2C adress of joint n is 0x1n.
- #define MAXACCEL 10000

  Maximum acceleration in steps/s^2. Can be set for each joint depending on inertia. If set to high stalls might trigger since PID error grows too large.
- #define MAXVEL 800

  Maximum velocity in steps/s. Can be set for each joint. If set to high stalls might trigger since PID error grows too large.

12.1.1 Detailed Description

Configuration definitions for Joint 1 to Joint 4.

Author

Sebastian Storz

Version

0.1

Date

2025-05-27

Copyright

Copyright (c) 2025

This file shall be included AFTER one of J1, J2, J3 or J4 have been defined.

12.1.2 Macro Definition Documentation

12.1.2.1 ADR

```
#define ADR 0x11
```

I2C adress of joint n is 0x1n.

12.1.2.2 MAXACCEL

```
#define MAXACCEL 10000
```

Maximum acceleration in steps/s^2. Can be set for each joint depending on inertia. If set to high stalls might trigger since PID error grows too large.

12.1.2.3 MAXVEL

```
#define MAXVEL 800
```

Maximum velocity in steps/s. Can be set for each joint. If set to high stalls might trigger since PID error grows too large.

12.2 configuration.h

Go to the documentation of this file.

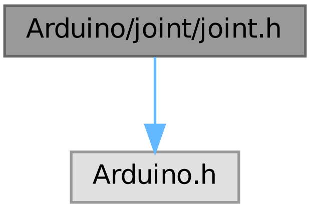
```
#ifndef CONFIGURATION_H
#define CONFIGURATION_H

#if defined(J1)
#define ADR 0x11
#define MAXACCEL 10000
#define MAXVEL 800

#elif defined(J2)
#define ADR 0x12
#define MAXACCEL 10000
#define MAXVEL 800

#elif defined(J3)
#define ADR 0x13
#define MAXACCEL 10000
#define MAXVEL 800

#elif defined(J4)
#define ADR 0x14
#define MAXACCEL 10000
#define MAXVEL 800
#else

/* Below only defined for documentation */
#define ADR 0x11

#define MAXACCEL 10000

#define MAXVEL 800
#error "No Joint has been defined. Define one of 'JX' where X 1,2,3,4"
#endif

#endif
```

12.3 Arduino/joint/joint.h File Reference

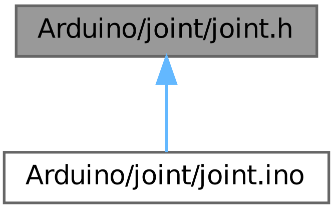
joint firmware header

```
#include <Arduino.h>
```

Include dependency graph for joint.h:



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



Macros

- #define ACK 'O'
- #define NACK 'N'
- #define MAX_BUFFER 4

  Maximum size of I2C Payload in bytes.
- #define RFLAGS_SIZE 1

  Size of the return flags in bytes.
- #define DUMP_BUFFER(buffer, size)

  Macro to dump a buffer to the serial console.

Enumerations

- enum stp_reg_t {
  PING = 0x0f , SETUP = 0x10 , SETRPM = 0x11 , GETDRIVERRPM = 0x12 ,
  MOVESTEPS = 0x13 , MOVEANGLE = 0x14 , MOVETOANGLE = 0x15 , GETMOTORSTATE = 0x16 ,
  RUNCOTINOUS = 0x17 , ANGLEMOVED = 0x18 , SETCURRENT = 0x19 , SETHOLDCURRENT = 0x1A ,
  SETMAXACCELERATION = 0x1B , SETMAXDECELERATION = 0x1C , SETMAXVELOCITY = 0x1D ,
  ENABLESTALLGUARD = 0x1E ,
  DISABLESTALLGUARD = 0x1F , CLEARSTALL = 0x20 , SETBRAKEMODE = 0x22 , ENABLEPID = 0x23 ,
  DISABLEPID = 0x24 , ENABLECLOSEDLOOP = 0x25 , DISABLECLOSEDLOOP = 0x26 , SETCONTROLTHRESHOLD = 0x27 ,
  MOVETOEND = 0x28 , STOP = 0x29 , GETPIDERROR = 0x2A , CHECKORIENTATION = 0x2B ,
  GETENCODERRPM = 0x2C , HOME = 0x2D , HOMEOFFSET = 0x2E }

  register and command definitions

Functions

- template<typename T >
  void readValue (T &val, uint8_t ∗rxBuf, size_t rx_length)

  Reads a value from a buffer to a value of the specified type.
- template<typename T >
  int writeValue (const T val, uint8_t ∗txBuf, size_t &tx_length)

  Writes a value of the specified type to a buffer.

12.3.1 Detailed Description

joint firmware header

Author

Sebastian Storz

Version

0.1

Date

2025-05-27

Copyright

Copyright (c) 2025

This file contains definitions and macros for the joint firmware.

12.3.2 Macro Definition Documentation

12.3.2.1 ACK

```
#define ACK 'O'
```

12.3.2.2 DUMP_BUFFER

```
#define DUMP_BUFFER(
              buffer,
              size )
```

Value:

```
  {                                     \
    Serial.print("Buffer dump: ");      \
    for (size_t i = 0; i < size; i++)  \
    {                                   \
      Serial.print(buffer[i], HEX);     \
      Serial.print(" ");                \
    }                                   \
    Serial.println();                   \
  }
```

Macro to dump a buffer to the serial console.

Parameters

buffer	pointer to a buffer to dump to the console
size	number of bytes to dump

12.3.2.3 MAX_BUFFER

```
#define MAX_BUFFER 4
```

Maximum size of I2C Payload in bytes.

4 bytes used to transmit floats and int32_t

12.3.2.4 NACK

```
#define NACK 'N'
```

12.3.2.5 RFLAGS_SIZE

```
#define RFLAGS_SIZE 1
```

Size of the return flags in bytes.

Only one byte used and hence set to 1.

12.3.3 Enumeration Type Documentation

12.3.3.1 stp_reg_t

```
enum stp_reg_t
```

register and command definitions

a register can be read (R) or written (W), each register has a size in bytes. The payload can be split into multiple values or just be a single value. Note that not all functions are implemented.

Enumerator

PING	R; Size: 1; [(char) ACK].
SETUP	W; Size: 2; [(uint8) holdCurrent, (uint8) driveCurrent].
SETRPM	W; Size: 4; [(float) RPM].
GETDRIVERRPM	
MOVESTEPS	W; Size: 4; [(int32) steps].
MOVEANGLE	
MOVETOANGLE	W; Size: 4; [(float) degrees].
GETMOTORSTATE	
RUNCOTINOUS	
ANGLEMOVED	R; Size: 4; [(float) degrees].
SETCURRENT	W; Size: 1; [(uint8) driveCurrent].
SETHOLDCURRENT	W; Size: 1; [(uint8) holdCurrent].
SETMAXACCELERATION	W; Size: 4; [(float) deg/s^2].
SETMAXDECELERATION	
SETMAXVELOCITY	W; Size: 4; [(float) deg/s].
ENABLESTALLGUARD	W; Size: 1; [(uint8) threshold].

Enumerator

DISABLESTALLGUARD	
CLEARSTALL	
SETBRAKEMODE	W; Size: 1; [(uint8) mode].
ENABLEPID	
DISABLEPID	
ENABLECLOSEDLOOP	
DISABLECLOSEDLOOP	W; Size: 1; [(uint8) 0].
SETCONTROLTHRESHOLD	
MOVETOEND	
STOP	W; Size: 1; [(uint8) mode].
GETPIDERROR	
CHECKORIENTATION	W; Size: 4; [(float) degrees].
GETENCODERRPM	R; Size: 4; [(float) RPM].
HOME	W; Size: 4; [(uint8) current, (uint8) sensitivity, (uint8) speed, (uint8) direction].
HOMEOFFSET	R/W; Size: 4; [(float) -].

12.3.4 Function Documentation

12.3.4.1 readValue()

```
template<typename T >
void readValue (
             T & val,
             uint8_t * rxBuf,
             size_t rx_length )
```

Reads a value from a buffer to a value of the specified type.

Parameters

val	Reference to output variable
rxBuf	Buffer to read value from
rx_length	Length of the buffer

12.3.4.2 writeValue()

```
template<typename T >
int writeValue (
             const T val,
             uint8_t * txBuf,
             size_t & tx_length )
```

Writes a value of the specified type to a buffer.

Parameters

val	Reference to input variable

Parameters

txBuf	pointer to tx buffer
tx_length	Length of the buffer returne

Returns

0 On success

12.4 joint.h

Go to the documentation of this file.

```

#ifndef JOINT_H
#define JOINT_H
#include <Arduino.h>

#define ACK ’O’
#define NACK ’N’

#define MAX_BUFFER 4 // Bytes

#define RFLAGS_SIZE 1

#define DUMP_BUFFER(buffer, size)     \
  {                                   \
    Serial.print("Buffer dump: ");    \
    for (size_t i = 0; i < size; i++) \
    {                                 \
      Serial.print(buffer[i], HEX);   \
      Serial.print(" ");              \
    }                                 \
    Serial.println();                 \
  }

enum stp_reg_t
{
  PING = 0x0f,
  SETUP = 0x10,
  SETRPM = 0x11,
  GETDRIVERRPM = 0x12,
  MOVESTEPS = 0x13,
  MOVEANGLE = 0x14,
  MOVETOANGLE = 0x15,
  GETMOTORSTATE = 0x16,
  RUNCOTINOUS = 0x17,
  ANGLEMOVED = 0x18,
  SETCURRENT = 0x19,
  SETHOLDCURRENT = 0x1A,
  SETMAXACCELERATION = 0x1B,
  SETMAXDECELERATION = 0x1C,
  SETMAXVELOCITY = 0x1D,
  ENABLESTALLGUARD = 0x1E,
  DISABLESTALLGUARD = 0x1F,
  CLEARSTALL = 0x20,
  SETBRAKEMODE = 0x22,
  ENABLEPID = 0x23,
  DISABLEPID = 0x24,
  ENABLECLOSEDLOOP = 0x25,
  DISABLECLOSEDLOOP = 0x26,
  SETCONTROLTHRESHOLD = 0x27,
  MOVETOEND = 0x28,
  STOP = 0x29,
  GETPIDERROR = 0x2A,
  CHECKORIENTATION = 0x2B,
  GETENCODERRPM = 0x2C,
  HOME = 0x2D,
  HOMEOFFSET = 0x2E,
};

template <typename T>
void readValue(T &val, uint8_t *rxBuf, size_t rx_length)
{
  memcpy(&val, rxBuf, rx_length);
}

```

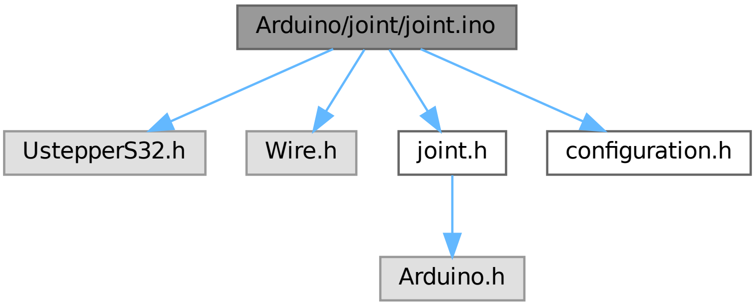
```
template <typename T>
int writeValue(const T val, uint8_t *txBuf, size_t &tx_length)
{
  tx_length = sizeof(T);
  memcpy(txBuf, &val, tx_length);
  return 0;
}

#endif
```

12.5 Arduino/joint/joint.ino File Reference

joint firmware

```
#include <UstepperS32.h>
#include <Wire.h>
#include "joint.h"
#include "configuration.h"
```

Include dependency graph for joint.ino:



Macros

- #define J4

  Define either joint that is to be flashed.

Functions

- void blocking_handler (uint8_t reg)

  Handles commands received via I2C.
- void non_blocking_handler (uint8_t reg)

  Handles read request received via I2C.
- void receiveEvent (int n)

  I2C receive event Handler.
- void requestEvent ()

  I2C request event Handler.
- void setup (void)

  Setup Peripherals.
- void loop (void)

  Main loop.

Variables

- UstepperS32 stepper
- uint8_t reg = 0
- uint8_t rx_buf [MAX_BUFFER] = { 0 }
- uint8_t tx_buf [MAX_BUFFER+RFLAGS_SIZE] = { 0 }
- bool tx_data_ready = 0
- bool rx_data_ready = 0
- size_t tx_length = 0
- size_t rx_length = 0

12.5.1 Detailed Description

joint firmware

Author

Sebastian Storz

Version

0.1

Date

2025-05-27

Copyright

Copyright (c) 2025

This file contains the joint firmware.

12.5.2 Macro Definition Documentation

12.5.2.1 J4

```
#define J4
```

Define either joint that is to be flashed.

Define either J1, J2, J3 or J4 and subsequently include configuration.h

12.5.3 Function Documentation

12.5.3.1 blocking_handler()

```
void blocking_handler (
             uint8_t reg )
```

Handles commands received via I2C.

Warning

This is a blocking function which may take some time to execute. This function must not be called from an ISR or callback! Call from main loop instead.

The registers handled in this handler are those whose implementation can take time and can thereby not be called directly from the request handler.

Parameters

reg	command that should be executed.

Homing has been cancled from ISR (f.x. STOP)

12.5.3.2 loop()

```
void loop (
            void  )
```

Main loop.

Executes the following:
1) if isStallguardEnabled: compares stepper.getPidError() with stallguardThreshold and sets isStalled flag.
2) if rx_data_ready: set isBusy flag to indicate device is busy. Invoke blocking_handler. Clear isBusy flag to indicate device is no longer busy

12.5.3.3 non_blocking_handler()

```
void non_blocking_handler (
            uint8_t reg )
```

Handles read request received via I2C.

Can be invoked from the I2C ISR since reads from the stepper are non-blocking. Also Handling reads and the subsequent wire.write(), did not work from the main loop.

Parameters

reg	command to execute/register to read.

12.5.3.4 receiveEvent()

```
void receiveEvent (
            int n )
```

I2C receive event Handler.

Reads the content of the received message. Saves the register so it can be used in the main loop. If the master invokes the read() function the message contains only the register byte and no payload. If the master invokes the write() the message has a payload of appropriate size for the command. Every I2C transaction starts with a receive event when the command is sent and is immediatly followed by a request since at minimum the flags need to be transmitted back. This means that the receive handler and request handler are always executed sequentially. The main loop is not executed since both handlers are ISRs. For a read request the message looks like this:
< [REG]
> [TXBUFn]...[TXBUF2][TXBUF1][TXBUF0][FLAGS]
For a command the message looks like this:

$<$ [REG][RXBUFn]...[RXBUF2][RXBUF1][RXBUF0]
$>$ [FLAGS]
The payload is read into the rx_buf, rx_length is set to the payload length.

Parameters

n	the number of bytes read from the controller device: MAX_BUFFER

12.5.3.5 requestEvent()

```
void requestEvent ( )
```

I2C request event Handler.

Sends the response data to the master. Every transaction begins with a receive event. The request event is always triggered since at a minimum the status flags are returned to the master. Hence this function is only invoked after the receiveEvent() handler has been called. The function calls the non_blocking_handler() which is non-blocking. Since most Ustepper functions are non-blocking as they just read/write registers to the stepper driver/encoder they can be handled directly in the ISR. The non_blocking_handler() populates the tx_buf with relevant data, the current state flags are appended to the tx_buf and then it is send to the master.

12.5.3.6 setup()

```
void setup (
             void  )
```

Setup Peripherals.

Setup I2C with the address ADR, and begin Serial for debugging with baudrate 9600.

12.5.4 Variable Documentation

12.5.4.1 reg

```
uint8_t reg = 0
```

12.5.4.2 rx_buf

```
uint8_t rx_buf[MAX_BUFFER] = { 0 }
```

12.5.4.3 rx_data_ready

```
bool rx_data_ready = 0
```

12.5.4.4 rx_length

```
size_t rx_length = 0
```

12.5.4.5 stepper

```
UstepperS32 stepper
```

12.5.4.6 tx_buf

```
uint8_t tx_buf[MAX_BUFFER+RFLAGS_SIZE] = { 0 }
```

12.5.4.7 tx_data_ready

```
bool tx_data_ready = 0
```

12.5.4.8 tx_length

```
size_t tx_length = 0
```

12.6 docs/DOCS_README.md File Reference

12.7 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_↩ bringup/launch/bioscara.launch.py File Reference

Namespaces

- namespace bioscara

Functions

- bioscara.generate_launch_description ()

12.8 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_↩ bringup/launch/test_joint_trajectory_controller.launch.py File Reference

Namespaces

- namespace test_joint_trajectory_controller

Functions

- test_joint_trajectory_controller.generate_launch_description ()

12.9 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_bringup/↩ README.md File Reference

12.10 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_description/↩ README.md File Reference

12.11 ROS2/ros2_scara_ws/src/dalsa_bioscara/README.md File Reference

12.12 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_↩ description/bioscara_description/__init__.py File Reference

12.13 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_↩ description/launch/display.launch.py File Reference

Namespaces

- namespace display

Functions

- display.generate_launch_description ()

12.14 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_↩ description/launch/gazebo.launch.py File Reference

Namespaces

- namespace gazebo

Functions

- gazebo.generate_launch_description ()

12.15 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_↩ description/setup.py File Reference

Namespaces

- namespace setup

Variables

- str setup.package_name = 'bioscara_description'
- setup.name
- setup.version
- setup.packages
- setup.data_files
- setup.install_requires
- setup.zip_safe
- setup.maintainer
- setup.maintainer_email
- setup.description
- setup.license
- setup.tests_require
- setup.entry_points

12.16 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_↩ description/test/test_copyright.py File Reference

Namespaces

- namespace test_copyright

Functions

- test_copyright.test_copyright ()

12.17 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_↩ description/test/test_flake8.py File Reference

Namespaces

- namespace test_flake8

Functions

- test_flake8.test_flake8 ()

12.18 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_↩ description/test/test_pep257.py File Reference

Namespaces

- namespace test_pep257

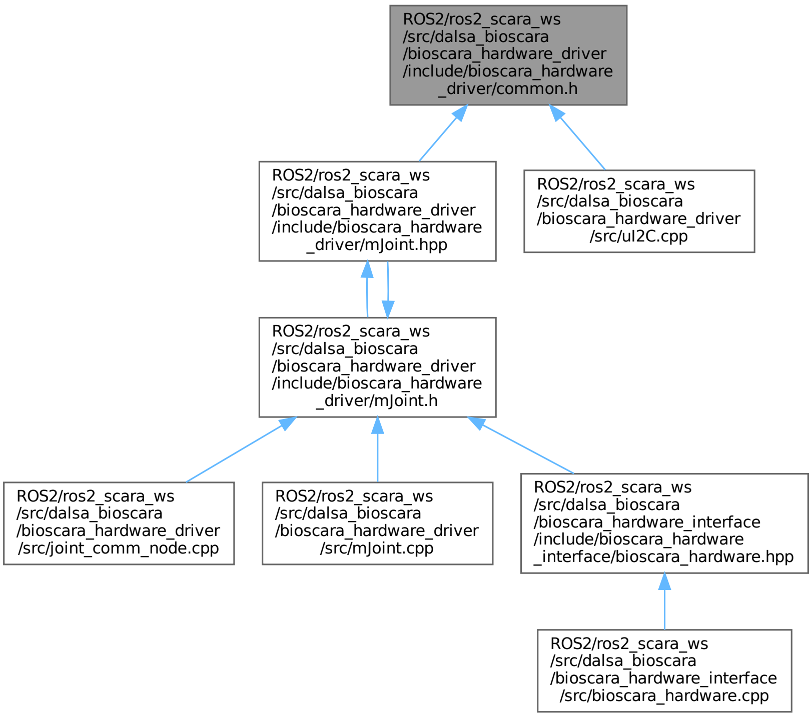
Functions

- test_pep257.test_pep257 ()

12.19 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_↩ driver/include/bioscara_hardware_driver/common.h File Reference

A file containing utility macros and functions.

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


ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /include/bioscara_hardware _driver/common.h
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /include/bioscara_hardware _driver/mJoint.hpp
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /src/uI2C.cpp
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /include/bioscara_hardware _driver/mJoint.h
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /src/joint_comm_node.cpp
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /src/mJoint.cpp
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_interface /include/bioscara_hardware _interface/bioscara_hardware.hpp
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_interface /src/bioscara_hardware.cpp

Macros

- #define DUMP_BUFFER(buffer, size)

  Macro to dump a buffer to cout.

12.19.1 Detailed Description

A file containing utility macros and functions.

Author

Sebastian Storz

Version

0.1

Date

2025-05-27

Copyright

Copyright (c) 2025

12.19.2 Macro Definition Documentation

12.19.2.1 DUMP_BUFFER

```
#define DUMP_BUFFER(
                buffer,
                size )
```

Value:

```
  {                                     \
    std::cout « "Buffer dump: ";       \
    for (size_t i = 0; i < size; i++) \
    {                                   \
      printf("%#x ", buffer[i]);        \
    }                                   \
    std::cout « std::endl;             \
  }
```

Macro to dump a buffer to cout.

Parameters

buffer	pointer to a buffer to dump to the console
size	number of bytes to dump

12.20 common.h

Go to the documentation of this file.

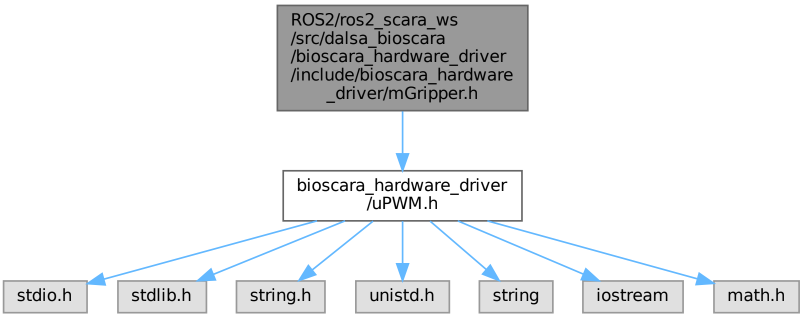
```

#ifndef COMMON_H
#define COMMON_H


#define DUMP_BUFFER(buffer, size)      \
  {                                     \
    std::cout « "Buffer dump: ";       \
    for (size_t i = 0; i < size; i++) \
    {                                   \
      printf("%#x ", buffer[i]);        \
    }                                   \
    std::cout « std::endl;             \
  }

#endif // COMMON_H
```

12.21 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_↩ driver/include/bioscara_hardware_driver/mGripper.h File Reference

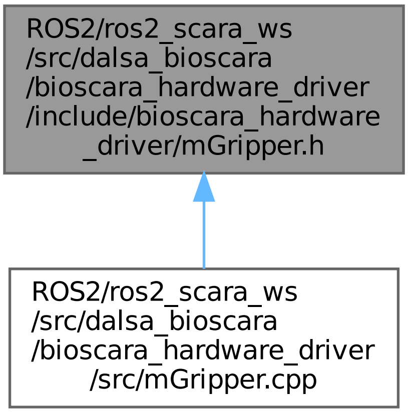
File containing the Gripper class.

```
#include "bioscara_hardware_driver/uPWM.h"
```

Include dependency graph for mGripper.h:



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



Classes

- class Gripper

  Gripper object to interact with the robot gripper.

12.21.1 Detailed Description

File containing the Gripper class.

Author

Sebastian Storz

Version

0.1

Date

2025-05-27

Copyright

Copyright (c) 2025

Include this file for API functions to interact with the gripper.

12.22 mGripper.h

Go to the documentation of this file.

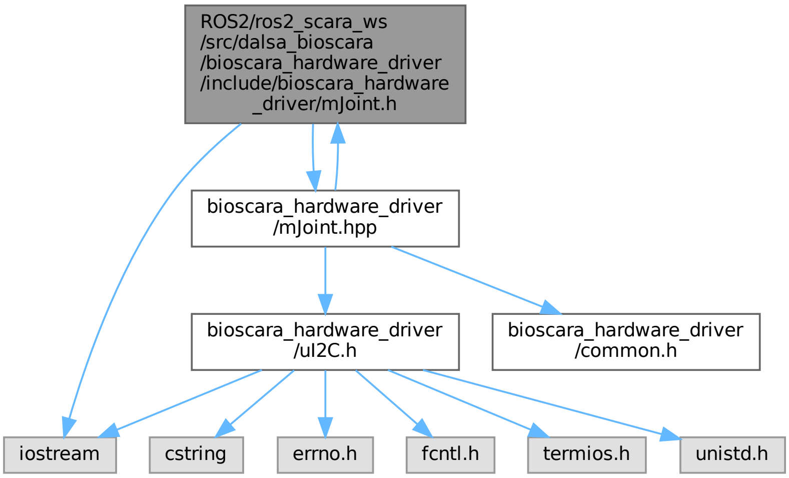
```

#ifndef MGRIPPER_H
#define MGRIPPER_H
#include "bioscara_hardware_driver/uPWM.h"

class Gripper
{
public:
    Gripper(void);

    int init(void);

    int deinit(void);

    int enable(void);

    int disable(void);

    int setPosition(float width);

private:
    RPI_PWM pwm;
};
#endif // MGRIPPER_H
```

12.23 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_↩ driver/include/bioscara_hardware_driver/mJoint.h File Reference

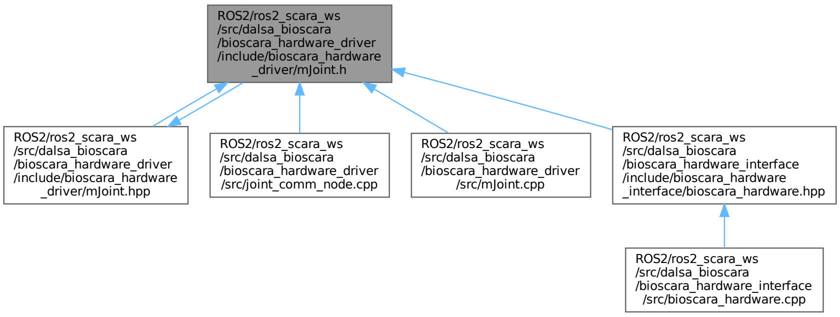
File including the Joint class.

```
#include <iostream>
#include "bioscara_hardware_driver/mJoint.hpp"
```

Include dependency graph for mJoint.h:



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



Classes

- class Joint

  Representing a single joint on the I2C bus.

Macros

- #define JOINT2ACTUATOR(in, reduction, offset) (reduction ∗ (in - offset))

  Macro for a simple transmission from joint units to actuator units.
- #define ACTUATOR2JOINT(in, reduction, offset) (in / reduction + offset)

  Macro for a simple transmission from actuator units to joint units.
- #define M_PI 3.14159265358979323846

  pi
- #define RAD2DEG(rad) (rad / M_PI ∗ 180)

  Macro to convert radians to degree.
- #define DEG2RAD(deg) (deg ∗ M_PI / 180)

  Macro to convert degree to radians.

12.23.1 Detailed Description

File including the Joint class.

Author

Sebastian Storz

Version

0.1

Date

2025-05-29

Copyright

Copyright (c) 2025

12.23.2 Macro Definition Documentation

12.23.2.1 ACTUATOR2JOINT

```
#define ACTUATOR2JOINT(
              in,
              reduction,
              offset ) (in / reduction + offset)
```

Macro for a simple transmission from actuator units to joint units.

The translation is based on the ros2_control transmission interface, simple transmission. For position reduction and offset need to be used.
For velocity and acceleration only use reduction and NO offset
For effort/torque use 1/reduction and NO offset

12.23.2.2 DEG2RAD

```
#define DEG2RAD(
              deg ) (deg * M_PI / 180)
```

Macro to convert degree to radians.

12.23.2.3 JOINT2ACTUATOR

```
#define JOINT2ACTUATOR(
              in,
              reduction,
              offset ) (reduction * (in - offset))
```

Macro for a simple transmission from joint units to actuator units.

The translation is based on the ros2_control transmission interface, simple transmission. For position reduction and offset need to be used.
For velocity and acceleration only use reduction and NO offset
For effort/torque use 1/reduction and NO offset

12.23.2.4 M_PI

```
#define M_PI 3.14159265358979323846
```

pi

12.23.2.5 RAD2DEG

```
#define RAD2DEG(
              rad ) (rad / M_PI * 180)
```

Macro to convert radians to degree.

12.24 mJoint.h

Go to the documentation of this file.

```

#ifndef MJOINT_H
#define MJOINT_H

#include <iostream>

#define JOINT2ACTUATOR(in, reduction, offset) (reduction * (in - offset))

#define ACTUATOR2JOINT(in, reduction, offset) (in / reduction + offset)

#define M_PI 3.14159265358979323846

#define RAD2DEG(rad) (rad / M_PI * 180)

#define DEG2RAD(deg) (deg * M_PI / 180)

class Joint
{
```

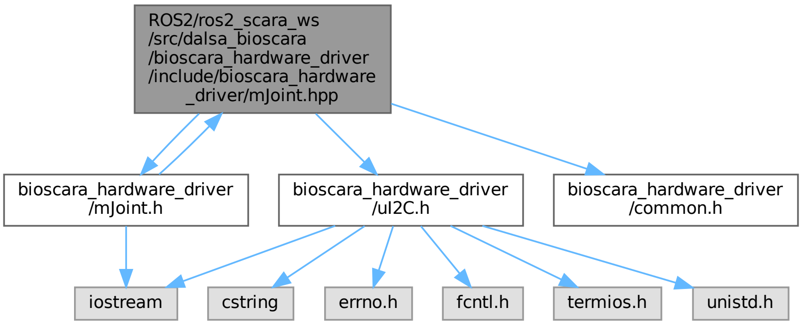
```
public:
  enum stp_reg_t
  {
    NONE = 0x00,
    PING = 0x0f,
    SETUP = 0x10,
    SETRPM = 0x11,
    GETDRIVERRPM = 0x12,
    MOVESTEPS = 0x13,
    MOVEANGLE = 0x14,
    MOVETOANGLE = 0x15,
    GETMOTORSTATE = 0x16,
    RUNCOTINOUS = 0x17,
    ANGLEMOVED = 0x18,
    SETCURRENT = 0x19,
    SETHOLDCURRENT = 0x1A,
    SETMAXACCELERATION = 0x1B,
    SETMAXDECELERATION = 0x1C,
    SETMAXVELOCITY = 0x1D,
    ENABLESTALLGUARD = 0x1E,
    DISABLESTALLGUARD = 0x1F,
    CLEARSTALL = 0x20,
    SETBRAKEMODE = 0x22,
    ENABLEPID = 0x23,
    DISABLEPID = 0x24,
    ENABLECLOSEDLOOP = 0x25,
    DISABLECLOSEDLOOP = 0x26,
    SETCONTROLTHRESHOLD = 0x27,
    MOVETOEND = 0x28,
    STOP = 0x29,
    GETPIDERROR = 0x2A,
    CHECKORIENTATION = 0x2B,
    GETENCODERRPM = 0x2C,
    HOME = 0x2D,
    HOMEOFFSET = 0x2E,
  };

  Joint(const std::string name, const int address, const float reduction, const float min, const float max);
  ~Joint(void);

  int init(void);

  int deinit(void);

  int enable(u_int8_t driveCurrent, u_int8_t holdCurrent);

  int disable(void);

  int home(float velocity, u_int8_t sensitivity, u_int8_t current);

  int startHoming(float velocity, u_int8_t sensitivity, u_int8_t current);

  int postHoming(void);

  int printInfo(void);

  int getPosition(float &pos);

  int setPosition(float pos);

  int moveSteps(int32_t steps);

  int getVelocity(float &vel);

  int setVelocity(float vel);

  int checkOrientation(float angle = 10.0);

  int stop(void);
  int disableCL(void);

  int setDriveCurrent(u_int8_t current);

  int setHoldCurrent(u_int8_t current);

  int setBrakeMode(u_int8_t mode);

  int setMaxAcceleration(float maxAccel);

  int setMaxVelocity(float maxVel);

  int enableStallguard(u_int8_t sensitivity);

  bool isHomed(void);

  bool isEnabled(void);

  bool isStalled(void);

  bool isBusy(void);

  int checkCom(void);

  u_int8_t getFlags(void);

  int getHomingOffset(float &offset);

  int setHomingOffset(const float offset);

  stp_reg_t getCurrentBCmd(void);

  std::string name;

protected:
private:
  template <typename T>
  int read(const stp_reg_t reg, T &data, u_int8_t &flags);

  template <typename T>
  int write(const stp_reg_t reg, T data, u_int8_t &flags);

  void wait_while_busy(const float period_ms);

  int _home(float velocity, u_int8_t sensitivity, u_int8_t current);

  u_int8_t flags = 0x00;

  int address;
  float reduction = 1;
  float offset = 0;
  float min = 0;
  float max = 0;

  stp_reg_t current_b_cmd = NONE;

  int handle = -1;
};

#include "bioscara_hardware_driver/mJoint.hpp"

#endif
```

12.25 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_↩ driver/include/bioscara_hardware_driver/mJoint.hpp File Reference

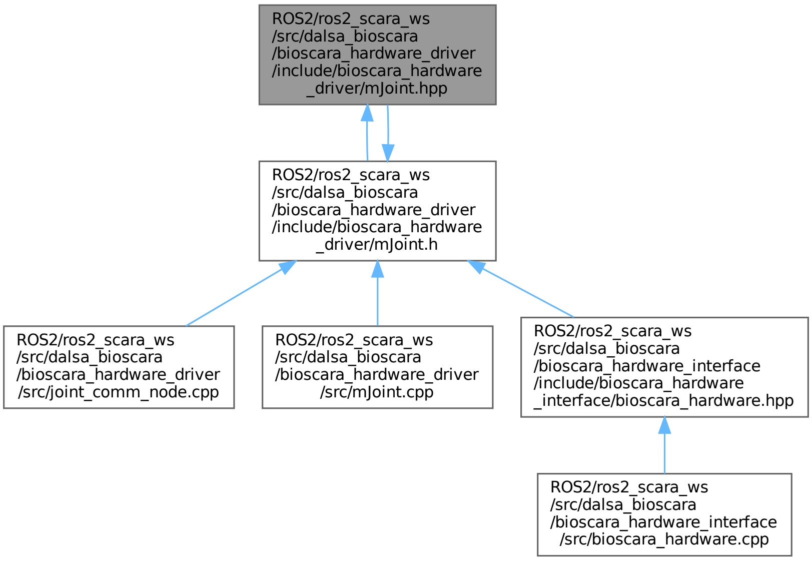
Templated functions for the Joint class.

```
#include "bioscara_hardware_driver/mJoint.h"
#include "bioscara_hardware_driver/uI2C.h"
#include "bioscara_hardware_driver/common.h"
```

Include dependency graph for mJoint.hpp:


ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /include/bioscara_hardware _driver/mJoint.hpp
bioscara_hardware_driver /mJoint.h
bioscara_hardware_driver /uI2C.h
bioscara_hardware_driver /common.h
iostream
cstring
errno.h
fcntl.h
termios.h
unistd.h

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


ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /include/bioscara_hardware _driver/mJoint.hpp
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /include/bioscara_hardware _driver/mJoint.h
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /src/joint_comm_node.cpp
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /src/mJoint.cpp
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_interface /include/bioscara_hardware _interface/bioscara_hardware.hpp
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_interface /src/bioscara_hardware.cpp

12.25.1 Detailed Description

Templated functions for the Joint class.

Author

Sebastian Storz

Version

0.1

Date

2025-05-29

Copyright

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This header must be included at the END of the mJoint.h file.

12.26 mJoint.hpp

Go to the documentation of this file.

```cpp

#include "bioscara_hardware_driver/mJoint.h"
#include "bioscara_hardware_driver/uI2C.h"
#include "bioscara_hardware_driver/common.h"

template <typename T>
int Joint::read(const stp_reg_t reg, T &data, u_int8_t &flags)
{
    size_t size = sizeof(T) + RFLAGS_SIZE;
    char buf[MAX_BUFFER+RFLAGS_SIZE];
    int n = readFromI2CDev(this->handle, reg, buf, size);
    if (n != static_cast<int>(size))
    {
        return -1;
    }
    memcpy(&data, buf, size - RFLAGS_SIZE);
    memcpy(&flags, buf + size - RFLAGS_SIZE, RFLAGS_SIZE);
    return 0;
}

template <typename T>
int Joint::write(const stp_reg_t reg, T data, u_int8_t &flags)
{
    size_t size = sizeof(T) + RFLAGS_SIZE;
    char buf[MAX_BUFFER+RFLAGS_SIZE];
    memcpy(buf, &data, size - RFLAGS_SIZE);
    int rc = writeToI2CDev(this->handle, reg, buf, size - RFLAGS_SIZE, buf + size - RFLAGS_SIZE);
    rc = rc > 0 ? 0 : rc;
    memcpy(&flags, buf + size - RFLAGS_SIZE, RFLAGS_SIZE);
    return rc;
}
```

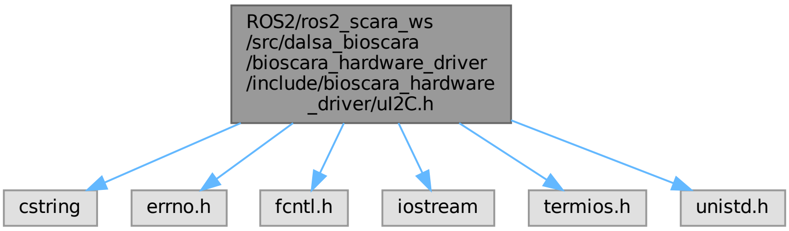
12.27 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_driver/include/bioscara_hardware_driver/uI2C.h File Reference

Low level utility for I2C communication on Raspberry Pi using lgpio library.

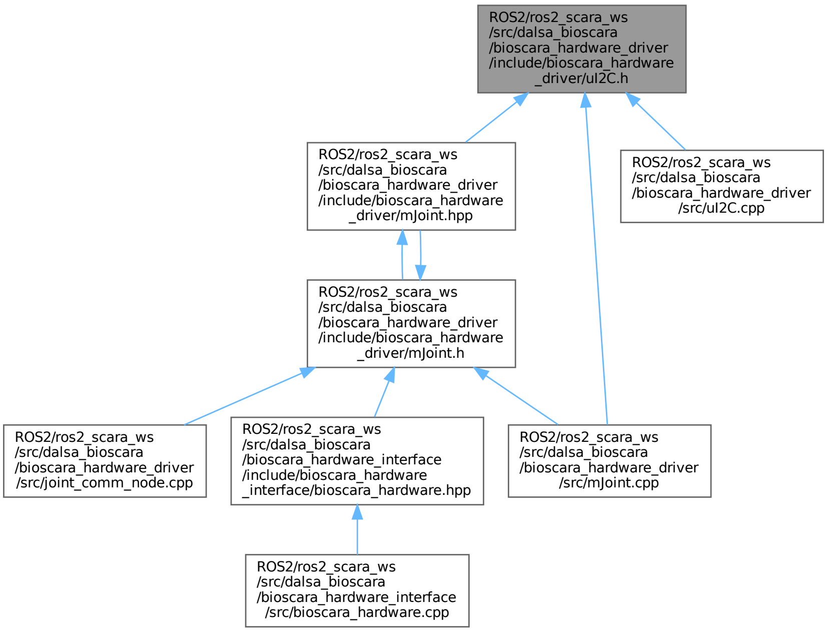
```
#include <cstring>
#include <errno.h>
#include <fcntl.h>
#include <iostream>
#include <termios.h>
```

```
#include <unistd.h>
```

Include dependency graph for uI2C.h:


ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /include/bioscara_hardware _driver/uI2C.h
cstring
errno.h
fcntl.h
iostream
termios.h
unistd.h

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


ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /include/bioscara_hardware _driver/uI2C.h
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /include/bioscara_hardware _driver/mJoint.hpp
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /src/uI2C.cpp
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /include/bioscara_hardware _driver/mJoint.h
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /src/joint_comm_node.cpp
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_interface /include/bioscara_hardware _interface/bioscara_hardware.hpp
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /src/mJoint.cpp
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_interface /src/bioscara_hardware.cpp

Macros

- #define ACK 'O'
- #define NACK 'N'
- #define RFLAGS_SIZE 1

  Size of the return flags in bytes.
- #define MAX_BUFFER 4

  Maximum size of I2C Payload in bytes.

Functions

- int openI2CDevHandle (const int dev_addr)

  Initiates an I2C device on the bus.
- int readFromI2CDev (const int dev_handle, const int reg, char ∗buffer, const int data_length)

  reads block of bytes from device to buffer
- int writeToI2CDev (const int dev_handle, const int reg, char ∗tx_buffer, const int data_length, char ∗RFLAGS_buffer)

  writes block of bytes from buffer to device
- int closeI2CDevHandle (int &dev_handle)

  close an I2C device on the bus

12.27.1 Detailed Description

Low level utility for I2C communication on Raspberry Pi using lgpio library.

Author

Sebastian Storz

Version

0.1

Date

2025-05-28

Copyright

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lgpio needs to be installed and linked! Installation:

```
cd ~
sudo apt update
sudo apt install -y swig
wget https://github.com/joan2937/lg/archive/master.zip
unzip master.zip
cd lg-master
make
sudo make install
cd ..
sudo rm -rf lg-master
rm master.zip
```

bash

12.27.2 Macro Definition Documentation

12.27.2.1 ACK

```
#define ACK 'O'
```

12.27.2.2 MAX_BUFFER

```
#define MAX_BUFFER 4
```

Maximum size of I2C Payload in bytes.

4 bytes used to transmit floats and int32_t

12.27.2.3 NACK

```
#define NACK 'N'
```

12.27.2.4 RFLAGS_SIZE

```
#define RFLAGS_SIZE 1
```

Size of the return flags in bytes.

Only one byte used and hence set to 1.

12.27.3 Function Documentation

12.27.3.1 closeI2CDevHandle()

```
int closeI2CDevHandle (
            int & dev_handle )
```

close an I2C device on the bus

Parameters

dev_handle	device handle obtained from `openI2CDevHandle`

Returns

0 on OK, negative on error.

12.27.3.2 openI2CDevHandle()

```
int openI2CDevHandle (
            const int dev_addr )
```

Initiates an I2C device on the bus.

Parameters

dev_addr	7-bit device adress [0 - 0x7F]

Returns

the device handle, negative on error.

12.27.3.3 readFromI2CDev()

```
int readFromI2CDev (
            const int dev_handle,
            const int reg,
            char * buffer,
            const int data_length )
```

reads block of bytes from device to buffer

Parameters

dev_handle	device handle obtained from `openI2CDevHandle`
reg	the command/data register
buffer	pointer to data buffer to hold received values
data_length	number of bytes to read

Returns

number of bytes read, negative on error.

12.27.3.4 writeToI2CDev()

```
int writeToI2CDev (
            const int dev_handle,
            const int reg,
            char * tx_buffer,
            const int data_length,
            char * RFLAGS_buffer )
```

writes block of bytes from buffer to device

Parameters

dev_handle	device handle obtained from `openI2CDevHandle`
reg	the command/data register
tx_buffer	pointer to data buffer holding the data to send
data_length	number of bytes to send
RFLAGS_buffer	buffer to hold returned flags

Returns

0 on OK, negative on error.

12.28 uI2C.h

Go to the documentation of this file.

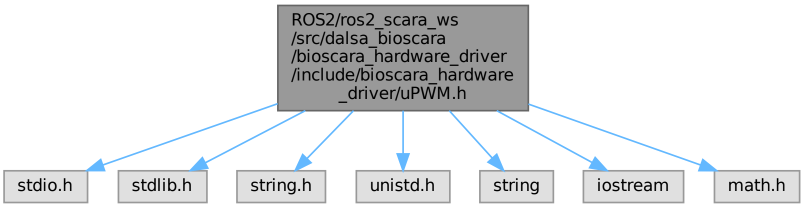
```

#ifndef USERIAL_H
#define USERIAL_H
#include <cstring>
#include <errno.h>
#include <fcntl.h>
#include <iostream>
#include <termios.h>
#include <unistd.h>

#define ACK 'O'
#define NACK 'N'

#define RFLAGS_SIZE 1

#define MAX_BUFFER 4 // Bytes

int openI2CDevHandle(const int dev_addr);

int readFromI2CDev(const int dev_handle, const int reg, char *buffer, const int data_length);

int writeToI2CDev(const int dev_handle, const int reg, char *tx_buffer, const int data_length, char *RFLAGS_buffer);

int closeI2CDevHandle(int &dev_handle);


#endif
```

12.29 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_driver/include/bioscara_hardware_driver/uPWM.h File Reference

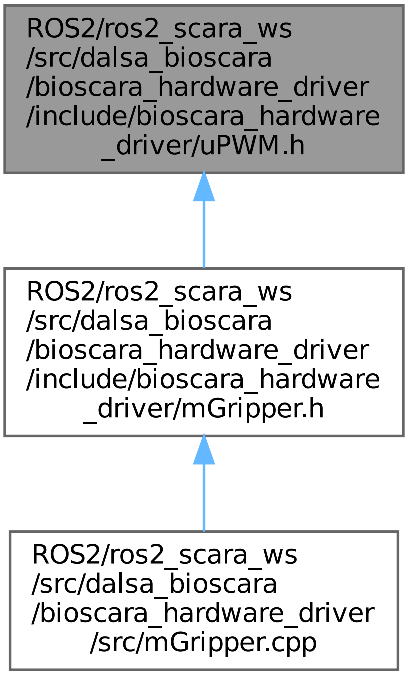
Includes source code for Hardware PWM generation on Raspberry Pi 4.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include <string>
#include <iostream>
#include <math.h>
```

Include dependency graph for uPWM.h:



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


ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /include/bioscara_hardware _driver/uPWM.h
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /include/bioscara_hardware _driver/mGripper.h
ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /src/mGripper.cpp

Classes

- class RPI_PWM

  PWM class for the Raspberry PI 4 and 5.

12.29.1 Detailed Description

Includes source code for Hardware PWM generation on Raspberry Pi 4.

Author

Sebastian Storz and Bernd Porr, bernd.porr@glasgow.ac.uk

Version

0.1

Date

2025-05-27

I copied this from: https://github.com/berndporr/rpi_pwm/blob/main/rpi_pwm.h and slightly modified it.

lgpio, the library used for I2C access can only generate soft PWM, The timing jitter will cause the servo to fidget. This may cause it to overheat and wear out prematurely.

Copyright

Copyright (c) 2025

12.30 uPWM.h

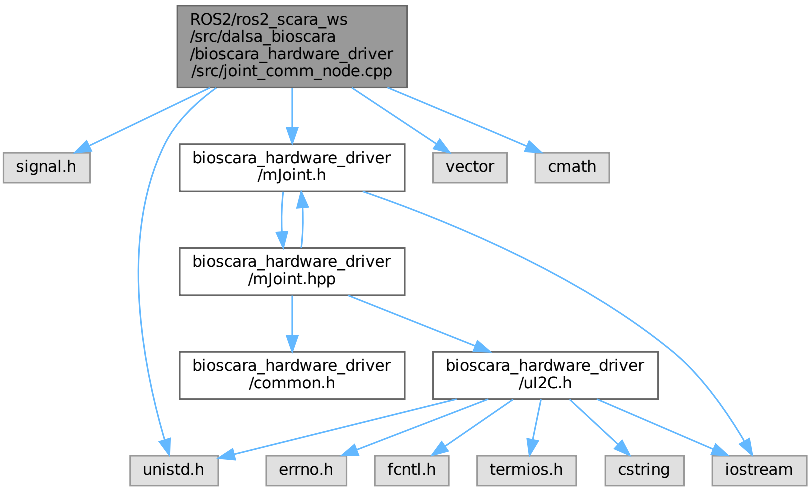
Go to the documentation of this file.

```
#ifndef __RPIPWM
#define __RPIPWM

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include <string>
#include <iostream>
#include <math.h>

class RPI_PWM
{
public:
    int start(int channel, int frequency, float duty_cycle = 0, int chip = 2)
    {
        chippath = "/sys/class/pwm/pwmchip" + std::to_string(chip);
        pwmpath = chippath + "/pwm" + std::to_string(channel);
        std::string p = chippath + "/export";
        FILE *const fp = fopen(p.c_str(), "w");
        if (NULL == fp)
        {
            std::cerr « "PWM device does not exist. Make sure to add ’dtoverlay=pwm-2chan’ to /boot/firmware/config.txt.\n";
            return -1;
        }
        const int r = fprintf(fp, "%d", channel);
        fclose(fp);
        if (r < 0)
            return r;
        usleep(100000); // it takes a while till the PWM subdir is created
        per = (int)1E9 / frequency;
        setPeriod(per);
        setDutyCycle(duty_cycle);
        enable();
        return r;
    }

    void stop()
    {
        disable();
    }

    ~RPI_PWM()
    {
        disable();
    }

    inline int setDutyCycle(float v) const
    {
        const int dc = (int)round((float)per * (v / 100.0));
        const int r = setDutyCycleNS(dc);
        return r;
    }

private:
    void setPeriod(int ns) const
    {
        writeSYS(pwmpath + "/" + "period", ns);
    }

    inline int setDutyCycleNS(int ns) const
    {
        const int r = writeSYS(pwmpath + "/" + "duty_cycle", ns);
        return r;
    }

    void enable() const
    {
        writeSYS(pwmpath + "/" + "enable", 1);
    }

    void disable() const
    {
        writeSYS(pwmpath + "/" + "enable", 0);
    }

    int per = 0;

    std::string chippath;
    std::string pwmpath;

    inline int writeSYS(std::string filename, int value) const
    {
        FILE *const fp = fopen(filename.c_str(), "w");
        if (NULL == fp)
        {
            return -1;
        }
        const int r = fprintf(fp, "%d", value);
        fclose(fp);
        return r;
    }
};

#endif
```

12.31 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_↩driver/src/joint_comm_node.cpp File Reference

```
#include <signal.h>
#include <unistd.h>
#include "bioscara_hardware_driver/mJoint.h"
#include <vector>
#include <cmath>
```

Include dependency graph for joint_comm_node.cpp:



Functions

- void INT_handler (int s)
- int main (int argc, char ∗∗argv)

Variables

- Joint J1 ("j1", 0x11, 35, -3.04647, 3.04647)
- Joint J2 ("j2", 0x12, -2 ∗M_PI/0.004, 0.338, 0.0)
- Joint J3 ("j3", 0x13, 24, -2.62672, 2.62672)
- Joint J4 ("j4", 0x14, 12, -3.01069, 3.01069)

12.31.1 Function Documentation

12.31.1.1 INT_handler()

```
void INT_handler (
            int s )
```

12.31.1.2 main()

```
int main (
            int argc,
            char ** argv )
```

12.31.2 Variable Documentation

12.31.2.1 J1

```
Joint J1("j1", 0x11, 35, -3.04647, 3.04647) (
             "j1" ,
             0x11 ,
             35 ,
             -3.  04647,
             3.  04647 )
```

12.31.2.2 J2

```
Joint J2("j2", 0x12, -2 *M_PI/0.004, 0.338, 0.0) (
             "j2" ,
             0x12 ,
             -2 *M_PI/0.  004,
             0.  338,
             0.  0 )
```

12.31.2.3 J3

```
Joint J3("j3", 0x13, 24, -2.62672, 2.62672) (
             "j3" ,
             0x13 ,
             24 ,
             -2.  62672,
             2.  62672 )
```

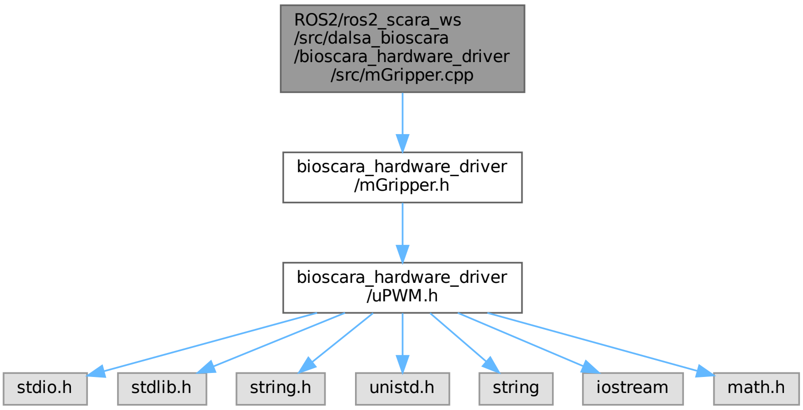
12.31.2.4 J4

```
Joint J4("j4", 0x14, 12, -3.01069, 3.01069) (
             "j4" ,
             0x14 ,
             12 ,
             -3.  01069,
             3.  01069 )
```

12.32 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_driver/src/mGripper.cpp File Reference

```
#include "bioscara_hardware_driver/mGripper.h"
```

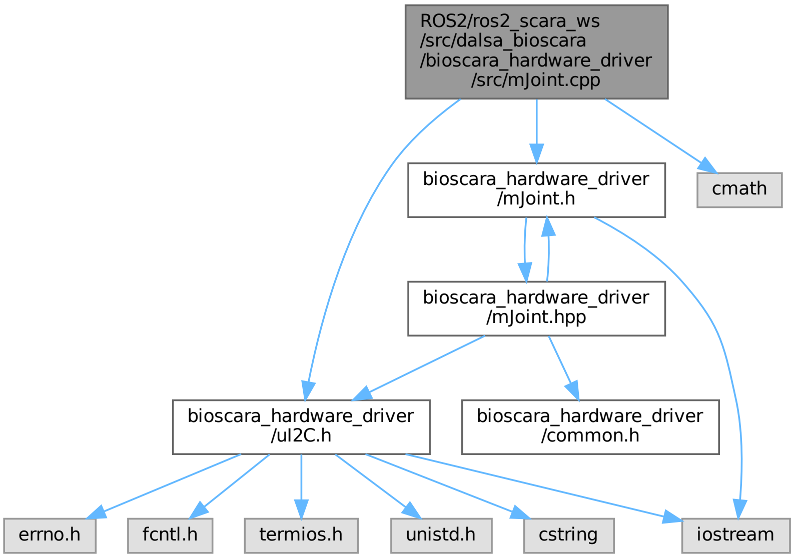
Include dependency graph for mGripper.cpp:



12.33 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_driver/src/mJoint.cpp File Reference

```
#include "bioscara_hardware_driver/uI2C.h"
#include "bioscara_hardware_driver/mJoint.h"
#include <cmath>
```

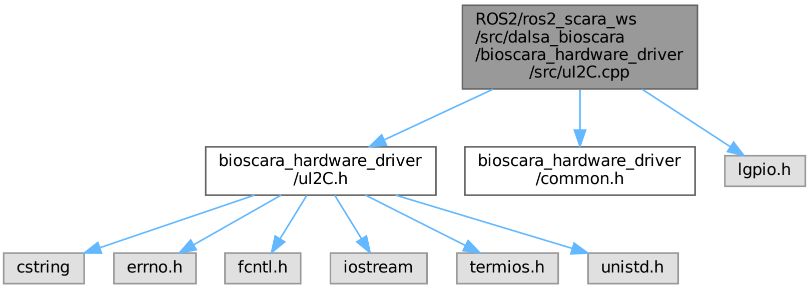
Include dependency graph for mJoint.cpp:



12.34 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_↩ driver/src/uI2C.cpp File Reference

```
#include "bioscara_hardware_driver/uI2C.h"
#include "bioscara_hardware_driver/common.h"
#include <lgpio.h>
```

Include dependency graph for uI2C.cpp:


ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_driver /src/uI2C.cpp
bioscara_hardware_driver /uI2C.h
bioscara_hardware_driver /common.h
lgpio.h
cstring
errno.h
fcntl.h
iostream
termios.h
unistd.h

Functions

- int openI2CDevHandle (const int dev_addr)

  Initiates an I2C device on the bus.
- int readFromI2CDev (const int dev_handle, const int reg, char ∗buffer, const int data_length)

  reads block of bytes from device to buffer
- int writeToI2CDev (const int dev_handle, const int reg, char ∗tx_buffer, const int data_length, char ∗RFLAGS_buffer)

  writes block of bytes from buffer to device
- int closeI2CDevHandle (int &dev_handle)

  close an I2C device on the bus

12.34.1 Function Documentation

12.34.1.1 closeI2CDevHandle()

```
int closeI2CDevHandle (
            int & dev_handle )
```

close an I2C device on the bus

Parameters

dev_handle	device handle obtained from `openI2CDevHandle`

Returns

0 on OK, negative on error.

12.34.1.2 openI2CDevHandle()

```
int openI2CDevHandle (
            const int dev_addr )
```

Initiates an I2C device on the bus.

Parameters

dev_addr	7-bit device adress [0 - 0x7F]

Returns

the device handle, negative on error.

12.34.1.3 readFromI2CDev()

```
int readFromI2CDev (
            const int dev_handle,
            const int reg,
            char * buffer,
            const int data_length )
```

reads block of bytes from device to buffer

Parameters

dev_handle	device handle obtained from `openI2CDevHandle`
reg	the command/data register
buffer	pointer to data buffer to hold received values
data_length	number of bytes to read

Returns

number of bytes read, negative on error.

12.34.1.4 writeToI2CDev()

```
int writeToI2CDev (
            const int dev_handle,
            const int reg,
            char * tx_buffer,
            const int data_length,
            char * RFLAGS_buffer )
```

writes block of bytes from buffer to device

Parameters

dev_handle	device handle obtained from `openI2CDevHandle`
reg	the command/data register
tx_buffer	pointer to data buffer holding the data to send
data_length	number of bytes to send
RFLAGS_buffer	buffer to hold returned flags

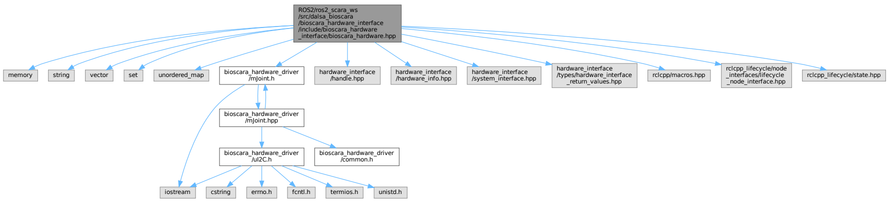
Returns

0 on OK, negative on error.

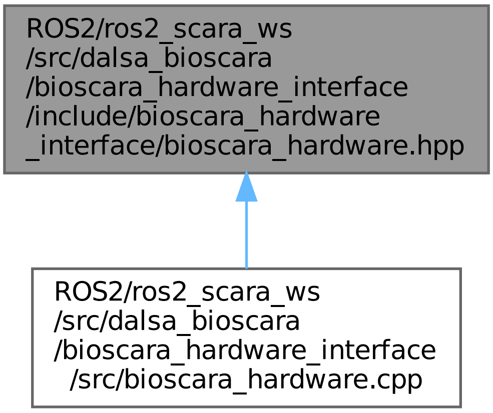
12.35 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_↩interface/include/bioscara_hardware_interface/bioscara_↩hardware.hpp File Reference

```
#include <memory>
#include <string>
#include <vector>
#include <set>
#include <unordered_map>
#include "bioscara_hardware_driver/mJoint.h"
#include "hardware_interface/handle.hpp"
#include "hardware_interface/hardware_info.hpp"
#include "hardware_interface/system_interface.hpp"
#include "hardware_interface/types/hardware_interface_return_values.hpp"
#include "rclcpp/macros.hpp"
#include "rclcpp_lifecycle/node_interfaces/lifecycle_node_interface.hpp"
#include "rclcpp_lifecycle/state.hpp"
```

Include dependency graph for bioscara_hardware.hpp:


ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_interface /include/bioscara_hardware _interface/bioscara_hardware.hpp
memory
string
vector
set
unordered_map
bioscara_hardware_driver /mJoint.h
hardware_interface /handle.hpp
hardware_interface /hardware_info.hpp
hardware_interface /system_interface.hpp
hardware_interface /types/hardware_interface _return_values.hpp
rclcpp/macros.hpp
rclcpp_lifecycle/node _interfaces/lifecycle _node_interface.hpp
rclcpp_lifecycle/state.hpp
bioscara_hardware_driver /mJoint.hpp
bioscara_hardware_driver /uI2C.h
bioscara_hardware_driver /common.h
iostream
cstring
errno.h
fcntl.h
termios.h
unistd.h

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


ROS2/ros2_scara_ws
/src/dalsa_bioscara
/bioscara_hardware_interface
/include/bioscara_hardware
_interface/bioscara_hardware.hpp
ROS2/ros2_scara_ws
/src/dalsa_bioscara
/bioscara_hardware_interface
/src/bioscara_hardware.cpp

Classes

- class bioscara_hardware_interface::BioscaraHardwareInterface

  The bioscara hardware interface class.
- struct bioscara_hardware_interface::BioscaraHardwareInterface::joint_homing_config_t

  configuration structure holding the passed homing paramters from the ros2_control urdf
- struct bioscara_hardware_interface::BioscaraHardwareInterface::joint_config_t

  configuration structure holding the passed paramters from the ros2_control urdf

Namespaces

- namespace bioscara_hardware_interface

Variables

- constexpr char bioscara_hardware_interface::HW_IF_HOME [ ] = "home"

12.36 bioscara_hardware.hpp

Go to the documentation of this file.

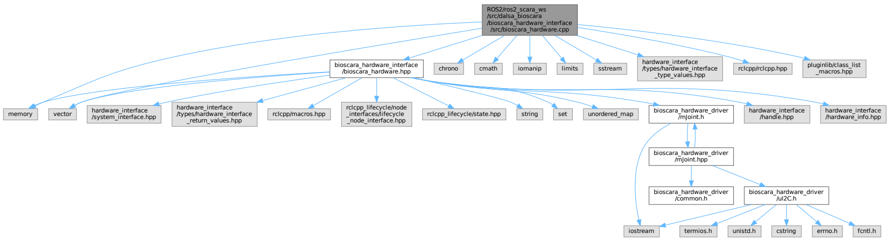
```
// Copyright 2023 ros2_control Development Team
//
// Licensed under the Apache License, Version 2.0 (the "License");
// you may not use this file except in compliance with the License.
// You may obtain a copy of the License at
//
//     http://www.apache.org/licenses/LICENSE-2.0
//
// Unless required by applicable law or agreed to in writing, software
// distributed under the License is distributed on an "AS IS" BASIS,
// WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
// See the License for the specific language governing permissions and
```

```cpp
// limitations under the License.

#ifndef BIOSCARA_HARDWARE_INTERFACE_HPP_
#define BIOSCARA_HARDWARE_INTERFACE_HPP_

#include <memory>
#include <string>
#include <vector>
#include <set>
#include <unordered_map>

#include "bioscara_hardware_driver/mJoint.h"

#include "hardware_interface/handle.hpp"
#include "hardware_interface/hardware_info.hpp"
#include "hardware_interface/system_interface.hpp"
#include "hardware_interface/types/hardware_interface_return_values.hpp"
#include "rclcpp/macros.hpp"
#include "rclcpp_lifecycle/node_interfaces/lifecycle_node_interface.hpp"
#include "rclcpp_lifecycle/state.hpp"

namespace bioscara_hardware_interface
{
    constexpr char HW_IF_HOME[] = "home";

    class BioscaraHardwareInterface : public hardware_interface::SystemInterface
    {
    public:
        RCLCPP_SHARED_PTR_DEFINITIONS(BioscaraHardwareInterface)

        hardware_interface::CallbackReturn on_init(
            const hardware_interface::HardwareComponentInterfaceParams &params) override;

        hardware_interface::CallbackReturn on_shutdown(
            const rclcpp_lifecycle::State &previous_state) override;

        hardware_interface::CallbackReturn on_configure(
            const rclcpp_lifecycle::State &previous_state) override;

        hardware_interface::CallbackReturn on_cleanup(
            const rclcpp_lifecycle::State &previous_state) override;

        hardware_interface::CallbackReturn on_activate(
            const rclcpp_lifecycle::State &previous_state) override;

        hardware_interface::CallbackReturn on_deactivate(
            const rclcpp_lifecycle::State &previous_state) override;

        hardware_interface::return_type read(
            const rclcpp::Time &time,
            const rclcpp::Duration &period) override;

        hardware_interface::return_type write(
            const rclcpp::Time &time,
            const rclcpp::Duration &period) override;

        hardware_interface::return_type prepare_command_mode_switch(
            const std::vector<std::string> &start_interfaces,
            const std::vector<std::string> &stop_interfaces) override;

        hardware_interface::CallbackReturn on_error(
            const rclcpp_lifecycle::State &previous_state) override;

    private:
        struct joint_homing_config_t
        {
            float speed = 0;
            u_int8_t threshold = 10;
            u_int8_t current = 10;
            float acceleration = 0.01;
        };

        struct joint_config_t
        {
            int i2c_address;
            float reduction = 1;
            float min;
            float max;
            u_int8_t drive_current;
            u_int8_t hold_current;
            u_int8_t stall_threshold;
            float max_velocity;
            float max_acceleration;
            joint_homing_config_t homing;
        };

        std::unordered_map<std::string, Joint> _joints;

        std::unordered_map<std::string, joint_config_t> _joint_cfg;

        std::unordered_map<std::string, std::set<std::string» _joint_command_modes;
    };

} // namespace bioscara_hardware_interface

#endif // BIOSCARA_HARDWARE_INTERFACE_HPP_
```

12.37 ROS2/ros2_scara_ws/src/dalsa_bioscara/bioscara_hardware_↩ interface/src/bioscara_hardware.cpp File Reference

```
#include "bioscara_hardware_interface/bioscara_hardware.hpp"
#include <chrono>
#include <cmath>
#include <iomanip>
#include <limits>
#include <memory>
#include <sstream>
#include <vector>
#include "hardware_interface/types/hardware_interface_type_values.hpp"
#include "rclcpp/rclcpp.hpp"
#include "pluginlib/class_list_macros.hpp"
```

Include dependency graph for bioscara_hardware.cpp:


ROS2/ros2_scara_ws /src/dalsa_bioscara /bioscara_hardware_interface /src/bioscara_hardware.cpp
bioscara_hardware_interface /bioscara_hardware.hpp
chrono
cmath
iomanip
limits
sstream
hardware_interface /types/hardware_interface _type_values.hpp
rclcpp/rclcpp.hpp
pluginlib/class_list _macros.hpp
memory
vector
hardware_interface /system_interface.hpp
hardware_interface /types/hardware_interface _return_values.hpp
rclcpp/macros.hpp
rclcpp_lifecycle/node _interfaces/lifecycle _node_interface.hpp
rclcpp_lifecycle/state.hpp
string
set
unordered_map
bioscara_hardware_driver /mJoint.h
hardware_interface /handle.hpp
hardware_interface /hardware_info.hpp
bioscara_hardware_driver /mJoint.hpp
bioscara_hardware_driver /common.h
bioscara_hardware_driver /uI2C.h
iostream
termios.h
unistd.h
cstring
errno.h
fcntl.h

Namespaces

- namespace bioscara_hardware_interface

Index