

# **Voltage and current regulator API**

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# Voltage and current regulator API

by Liam Girdwood and Mark Brown

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# Chapter 1. Introduction

This framework is designed to provide a standard kernel interface to control voltage and current regulators.

The intention is to allow systems to dynamically control regulator power output in order to save power and prolong battery life. This applies to both voltage regulators (where voltage output is controllable) and current sinks (where current limit is controllable).

Note that additional (and currently more complete) documentation is available in the Linux kernel source under `Documentation/power/regulator`.

## Glossary

The regulator API uses a number of terms which may not be familiar:

## Glossary

Regulator	Electronic device that supplies power to other devices. Most regulators can enable and disable their output and some can also control their output voltage or current.
Consumer	Electronic device which consumes power provided by a regulator. These may either be static, requiring only a fixed supply, or dynamic, requiring active management of the regulator at runtime.
Power Domain	The electronic circuit supplied by a given regulator, including the regulator and all consumer devices. The configuration of the regulator is shared between all the components in the circuit.
Power Management Integrated Circuit	An IC which contains numerous regulators and often also other sub-systems. In an embedded system the primary PMIC is often equivalent to a combination of the PSU and southbridge in a desktop system.

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# Chapter 2. Consumer driver interface

This offers a similar API to the kernel clock framework. Consumer drivers use get and put operations to acquire and release regulators. Functions are provided to enable and disable the regulator and to get and set the runtime parameters of the regulator.

When requesting regulators consumers use symbolic names for their supplies, such as "Vcc", which are mapped into actual regulator devices by the machine interface.

A stub version of this API is provided when the regulator framework is not in use in order to minimise the need to use `ifdefs`.

## Enabling and disabling

The regulator API provides reference counted enabling and disabling of regulators. Consumer devices use the `regulator_enable` and `regulator_disable` functions to enable and disable regulators. Calls to the two functions must be balanced.

Note that since multiple consumers may be using a regulator and machine constraints may not allow the regulator to be disabled there is no guarantee that calling `regulator_disable` will actually cause the supply provided by the regulator to be disabled. Consumer drivers should assume that the regulator may be enabled at all times.

## Configuration

Some consumer devices may need to be able to dynamically configure their supplies. For example, MMC drivers may need to select the correct operating voltage for their cards. This may be done while the regulator is enabled or disabled.

The `regulator_set_voltage` and `regulator_set_current_limit` functions provide the primary interface for this. Both take ranges of voltages and currents, supporting drivers that do not require a specific value (eg, CPU frequency scaling normally permits the CPU to use a wider range of supply voltages at lower frequencies but does not require that the supply voltage be lowered). Where an exact value is required both minimum and maximum values should be identical.

## Callbacks

Callbacks may also be registered for events such as regulation failures.

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# Chapter 3. Regulator driver interface

Drivers for regulator chips register the regulators with the regulator core, providing operations structures to the core. A notifier interface allows error conditions to be reported to the core.

Registration should be triggered by explicit setup done by the platform, supplying a struct `regulator_init_data` for the regulator containing constraint and supply information.

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# Chapter 4. Machine interface

This interface provides a way to define how regulators are connected to consumers on a given system and what the valid operating parameters are for the system.

## Supplies

Regulator supplies are specified using struct `regulator_consumer_supply`. This is done at driver registration time as part of the machine constraints.

## Constraints

As well as defining the connections the machine interface also provides constraints defining the operations that clients are allowed to perform and the parameters that may be set. This is required since generally regulator devices will offer more flexibility than it is safe to use on a given system, for example supporting higher supply voltages than the consumers are rated for.

This is done at driver registration time by providing a struct `regulation_constraints`.

The constraints may also specify an initial configuration for the regulator in the constraints, which is particularly useful for use with static consumers.



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# Chapter 5. API reference

Due to limitations of the kernel documentation framework and the existing layout of the source code the entire regulator API is documented here.

## Name

struct pre\_voltage\_change\_data — Data sent with PRE\_VOLTAGE\_CHANGE event

## Synopsis

```
struct pre_voltage_change_data {  
    unsigned long old_uV;  
    unsigned long min_uV;  
    unsigned long max_uV;  
};
```

## Members

old\_uV    Current voltage before change.

min\_uV    Min voltage we'll change to.

max\_uV    Max voltage we'll change to.

## Name

`struct regulator_bulk_data` — Data used for bulk regulator operations.

## Synopsis

```
struct regulator_bulk_data {  
    const char * supply;  
    struct regulator * consumer;  
};
```

## Members

<code>supply</code>	The name of the supply. Initialised by the user before using the bulk regulator APIs.
<code>consumer</code>	The regulator consumer for the supply. This will be managed by the bulk API.

## Description

The regulator APIs provide a series of `regulator_bulk_` API calls as a convenience to consumers which require multiple supplies. This structure is used to manage data for these calls.

## Name

struct regulator\_state — regulator state during low power system states

## Synopsis

```
struct regulator_state {  
    int uV;  
    unsigned int mode;  
    int enabled;  
    int disabled;  
};
```

## Members

uV	Operating voltage during suspend.
mode	Operating mode during suspend.
enabled	Enabled during suspend.
disabled	Disabled during suspend.

## Description

This describes a regulators state during a system wide low power state. One of enabled or disabled must be set for the configuration to be applied.

## Name

struct regulation\_constraints — regulator operating constraints.

## Synopsis

```
struct regulation_constraints {
    const char * name;
    int min_uV;
    int max_uV;
    int uV_offset;
    int min_uA;
    int max_uA;
    int ilim_uA;
    int system_load;
    unsigned int valid_modes_mask;
    unsigned int valid_ops_mask;
    int input_uV;
    struct regulator_state state_disk;
    struct regulator_state state_mem;
    struct regulator_state state_standby;
    suspend_state_t initial_state;
    unsigned int initial_mode;
    unsigned int ramp_delay;
    unsigned int enable_time;
    unsigned int always_on:1;
    unsigned int boot_on:1;
    unsigned int apply_uV:1;
    unsigned int ramp_disable:1;
    unsigned int soft_start:1;
    unsigned int pull_down:1;
};
```

## Members

name	Descriptive name for the constraints, used for display purposes.
min_uV	Smallest voltage consumers may set.
max_uV	Largest voltage consumers may set.
uV_offset	Offset applied to voltages from consumer to compensate for voltage drops.
min_uA	Smallest current consumers may set.
max_uA	Largest current consumers may set.
ilim_uA	Maximum input current.
system_load	Load that isn't captured by any consumer requests.
valid_modes_mask	Mask of modes which may be configured by consumers.
valid_ops_mask	Operations which may be performed by consumers.

input_uV	Input voltage for regulator when supplied by another regulator.
state_disk	State for regulator when system is suspended in disk mode.
state_mem	State for regulator when system is suspended in mem mode.
state_standby	State for regulator when system is suspended in standby mode.
initial_state	Suspend state to set by default.
initial_mode	Mode to set at startup.
ramp_delay	Time to settle down after voltage change (unit: uV/us)
enable_time	Turn-on time of the rails (unit: microseconds)
always_on	Set if the regulator should never be disabled.
boot_on	Set if the regulator is enabled when the system is initially started. If the regulator is not enabled by the hardware or bootloader then it will be enabled when the constraints are applied.
apply_uV	Apply the voltage constraint when initialising.
ramp_disable	Disable ramp delay when initialising or when setting voltage.
soft_start	Enable soft start so that voltage ramps slowly.
pull_down	Enable pull down when regulator is disabled.

## Description

This struct describes regulator and board/machine specific constraints.

## Name

struct regulator\_consumer\_supply — supply -> device mapping

## Synopsis

```
struct regulator_consumer_supply {  
    const char * dev_name;  
    const char * supply;  
};
```

## Members

dev\_name     Result of dev\_name for the consumer.

supply       Name for the supply.

## Description

This maps a supply name to a device. Use of dev\_name allows support for buses which make struct device available late such as I2C.

## Name

struct regulator\_init\_data — regulator platform initialisation data.

## Synopsis

```
struct regulator_init_data {
    const char * supply_regulator;
    struct regulation_constraints constraints;
    int num_consumer_supplies;
    struct regulator_consumer_supply * consumer_supplies;
    int (* regulator_init) (void *driver_data);
    void * driver_data;
};
```

## Members

supply_regulator	Parent regulator. Specified using the regulator name as it appears in the name field in sysfs, which can be explicitly set using the constraints field 'name'.
constraints	Constraints. These must be specified for the regulator to be usable.
num_consumer_supplies	Number of consumer device supplies.
consumer_supplies	Consumer device supply configuration.
regulator_init	Callback invoked when the regulator has been registered.
driver_data	Data passed to regulator_init.

## Description

Initialisation constraints, our supply and consumers supplies.



## Name

struct regulator\_linear\_range — specify linear voltage ranges

## Synopsis

```
struct regulator_linear_range {  
    unsigned int min_uV;  
    unsigned int min_sel;  
    unsigned int max_sel;  
    unsigned int uV_step;  
};
```

## Members

min_uV	Lowest voltage in range
min_sel	Lowest selector for range
max_sel	Highest selector for range
uV_step	Step size

## Description

Specify a range of voltages for `regulator_map_linear_range` and `regulator_list_linear_range`.

## Name

struct regulator\_ops — regulator operations.

## Synopsis

```
struct regulator_ops {
    int (* list_voltage) (struct regulator_dev *, unsigned selector);
    int (* set_voltage) (struct regulator_dev *, int min_uV, int max_uV, unsigned *selector);
    int (* map_voltage) (struct regulator_dev *, int min_uV, int max_uV);
    int (* set_voltage_sel) (struct regulator_dev *, unsigned selector);
    int (* get_voltage) (struct regulator_dev *);
    int (* get_voltage_sel) (struct regulator_dev *);
    int (* set_current_limit) (struct regulator_dev *, int min_uA, int max_uA);
    int (* get_current_limit) (struct regulator_dev *);
    int (* set_input_current_limit) (struct regulator_dev *, int lim_uA);
    int (* enable) (struct regulator_dev *);
    int (* disable) (struct regulator_dev *);
    int (* is_enabled) (struct regulator_dev *);
    int (* set_mode) (struct regulator_dev *, unsigned int mode);
    unsigned int (* get_mode) (struct regulator_dev *);
    int (* enable_time) (struct regulator_dev *);
    int (* set_ramp_delay) (struct regulator_dev *, int ramp_delay);
    int (* set_voltage_time_sel) (struct regulator_dev *, unsigned int old_selector, unsigned int new_selector);
    int (* set_soft_start) (struct regulator_dev *);
    int (* get_status) (struct regulator_dev *);
    unsigned int (* get_optimum_mode) (struct regulator_dev *, int input_uV, int output_uV);
    int (* set_load) (struct regulator_dev *, int load_uA);
    int (* set_bypass) (struct regulator_dev *dev, bool enable);
    int (* get_bypass) (struct regulator_dev *dev, bool *enable);
    int (* set_suspend_voltage) (struct regulator_dev *, int uV);
    int (* set_suspend_enable) (struct regulator_dev *);
    int (* set_suspend_disable) (struct regulator_dev *);
    int (* set_suspend_mode) (struct regulator_dev *, unsigned int mode);
    int (* set_pull_down) (struct regulator_dev *);
};
```

## Members

list_voltage	Return one of the supported voltages, in microvolts; zero if the selector indicates a voltage that is unusable on this system; or negative errno. Selectors range from zero to one less than regulator_desc.n_voltages. Voltages may be reported in any order.
set_voltage	Set the voltage for the regulator within the range specified. The driver should select the voltage closest to min_uV.
map_voltage	Convert a voltage into a selector
set_voltage_sel	Set the voltage for the regulator using the specified selector.
get_voltage	Return the currently configured voltage for the regulator.
get_voltage_sel	Return the currently configured voltage selector for the regulator.

<code>set_current_limit</code>	Configure a limit for a current-limited regulator. The driver should select the current closest to <code>max_uA</code> .
<code>get_current_limit</code>	Get the configured limit for a current-limited regulator.
<code>set_input_current_limit</code>	Configure an input limit.
<code>enable</code>	Configure the regulator as enabled.
<code>disable</code>	Configure the regulator as disabled.
<code>is_enabled</code>	Return 1 if the regulator is enabled, 0 if not. May also return negative <code>errno</code> .
<code>set_mode</code>	Set the configured operating mode for the regulator.
<code>get_mode</code>	Get the configured operating mode for the regulator.
<code>enable_time</code>	Time taken for the regulator voltage output voltage to stabilise after being enabled, in microseconds.
<code>set_ramp_delay</code>	Set the ramp delay for the regulator. The driver should select ramp delay equal to or less than (closest) <code>ramp_delay</code> .
<code>set_voltage_time_sel</code>	Time taken for the regulator voltage output voltage to stabilise after being set to a new value, in microseconds. The function provides the from and to voltage selector, the function should return the worst case.
<code>set_soft_start</code>	Enable soft start for the regulator.
<code>get_status</code>	Return actual (not as-configured) status of regulator, as a <code>REGULATOR_STATUS</code> value (or negative <code>errno</code> )
<code>get_optimum_mode</code>	Get the most efficient operating mode for the regulator when running with the specified parameters.
<code>set_load</code>	Set the load for the regulator.
<code>set_bypass</code>	Set the regulator in bypass mode.
<code>get_bypass</code>	Get the regulator bypass mode state.
<code>set_suspend_voltage</code>	Set the voltage for the regulator when the system is suspended.
<code>set_suspend_enable</code>	Mark the regulator as enabled when the system is suspended.
<code>set_suspend_disable</code>	Mark the regulator as disabled when the system is suspended.
<code>set_suspend_mode</code>	Set the operating mode for the regulator when the system is suspended.
<code>set_pull_down</code>	Configure the regulator to pull down when the regulator is disabled.

## Description

This struct describes regulator operations which can be implemented by regulator chip drivers.

## Name

struct regulator\_desc — Static regulator descriptor

## Synopsis

```
struct regulator_desc {
    const char * name;
    const char * supply_name;
    const char * of_match;
    const char * regulators_node;
    int (* of_parse_cb) (struct device_node *, const struct regulator_desc *, struct r
    int id;
    bool continuous_voltage_range;
    unsigned n_voltages;
    const struct regulator_ops * ops;
    int irq;
    enum regulator_type type;
    struct module * owner;
    unsigned int min_uV;
    unsigned int uV_step;
    unsigned int linear_min_sel;
    int fixed_uV;
    unsigned int ramp_delay;
    int min_dropout_uV;
    const struct regulator_linear_range * linear_ranges;
    int n_linear_ranges;
    const unsigned int * volt_table;
    unsigned int vsel_reg;
    unsigned int vsel_mask;
    unsigned int apply_reg;
    unsigned int apply_bit;
    unsigned int enable_reg;
    unsigned int enable_mask;
    unsigned int enable_val;
    unsigned int disable_val;
    bool enable_is_inverted;
    unsigned int bypass_reg;
    unsigned int bypass_mask;
    unsigned int bypass_val_on;
    unsigned int bypass_val_off;
    unsigned int enable_time;
    unsigned int off_on_delay;
    unsigned int (* of_map_mode) (unsigned int mode);
};
```

## Members

name	Identifying name for the regulator.
supply_name	Identifying the regulator supply
of_match	Name used to identify regulator in DT.

regulators_node	Name of node containing regulator definitions in DT.
of_parse_cb	Optional callback called only if of_match is present. Will be called for each regulator parsed from DT, during init_data parsing. The regulator_config passed as argument to the callback will be a copy of config passed to regulator_register, valid only for this particular call. Callback may freely change the config but it cannot store it for later usage. Callback should return 0 on success or negative ERRNO indicating failure.
id	Numerical identifier for the regulator.
continuous_voltage_range	Indicates if the regulator can set any voltage within constrains range.
n_voltages	Number of selectors available for ops.list_voltage.
ops	Regulator operations table.
irq	Interrupt number for the regulator.
type	Indicates if the regulator is a voltage or current regulator.
owner	Module providing the regulator, used for refcounting.
min_uV	Voltage given by the lowest selector (if linear mapping)
uV_step	Voltage increase with each selector (if linear mapping)
linear_min_sel	Minimal selector for starting linear mapping
fixed_uV	Fixed voltage of rails.
ramp_delay	Time to settle down after voltage change (unit: uV/us)
min_dropout_uV	The minimum dropout voltage this regulator can handle
linear_ranges	A constant table of possible voltage ranges.
n_linear_ranges	Number of entries in the <i>linear_ranges</i> table.
volt_table	Voltage mapping table (if table based mapping)
vsel_reg	Register for selector when using regulator_regmap_X_voltage_
vsel_mask	Mask for register bitfield used for selector
apply_reg	Register for initiate voltage change on the output when using regulator_set_voltage_sel_regmap
apply_bit	Register bitfield used for initiate voltage change on the output when using regulator_set_voltage_sel_regmap
enable_reg	Register for control when using regmap enable/disable ops
enable_mask	Mask for control when using regmap enable/disable ops
enable_val	Enabling value for control when using regmap enable/disable ops

<code>disable_val</code>	Disabling value for control when using regmap enable/disable ops
<code>enable_is_inverted</code>	A flag to indicate set enable_mask bits to disable when using regulator_enable_regmap and friends APIs.
<code>bypass_reg</code>	Register for control when using regmap set_bypass
<code>bypass_mask</code>	Mask for control when using regmap set_bypass
<code>bypass_val_on</code>	Enabling value for control when using regmap set_bypass
<code>bypass_val_off</code>	Disabling value for control when using regmap set_bypass
<code>enable_time</code>	Time taken for initial enable of regulator (in uS).
<code>off_on_delay</code>	guard time (in uS), before re-enabling a regulator
<code>of_map_mode</code>	Maps a hardware mode defined in a DeviceTree to a standard mode

## Description

Each regulator registered with the core is described with a structure of this type and a struct regulator\_config. This structure contains the non-varying parts of the regulator description.

## Name

struct regulator\_config — Dynamic regulator descriptor

## Synopsis

```
struct regulator_config {
    struct device * dev;
    const struct regulator_init_data * init_data;
    void * driver_data;
    struct device_node * of_node;
    struct regmap * regmap;
    bool ena_gpio_initialized;
    int ena_gpio;
    unsigned int ena_gpio_invert:1;
    unsigned int ena_gpio_flags;
};
```

## Members

dev	struct device for the regulator
init_data	platform provided init data, passed through by driver
driver_data	private regulator data
of_node	OpenFirmware node to parse for device tree bindings (may be NULL).
regmap	regmap to use for core regmap helpers if dev_get_regmap is insufficient.
ena_gpio_initialized	GPIO controlling regulator enable was properly initialized, meaning that $\geq 0$ is a valid gpio identifier and $< 0$ is a non existent gpio.
ena_gpio	GPIO controlling regulator enable.
ena_gpio_invert	Sense for GPIO enable control.
ena_gpio_flags	Flags to use when calling gpio_request_one

## Description

Each regulator registered with the core is described with a structure of this type and a struct regulator\_desc. This structure contains the runtime variable parts of the regulator description.

## Name

`regulator_get` — lookup and obtain a reference to a regulator.

## Synopsis

```
struct regulator * regulator_get (struct device * dev, const char * id);
```

## Arguments

*dev*    device for regulator “consumer”

*id*     Supply name or regulator ID.

## Description

Returns a struct regulator corresponding to the regulator producer, or `IS_ERR` condition containing `errno`.

Use of supply names configured via `regulator_set_device_supply` is strongly encouraged. It is recommended that the supply name used should match the name used for the supply and/or the relevant device pins in the datasheet.



## Name

`regulator_get_exclusive` — obtain exclusive access to a regulator.

## Synopsis

```
struct regulator * regulator_get_exclusive (struct device * dev, const
char * id);
```

## Arguments

*dev*    device for regulator “consumer”

*id*     Supply name or regulator ID.

## Description

Returns a struct regulator corresponding to the regulator producer, or `IS_ERR` condition containing `errno`. Other consumers will be unable to obtain this regulator while this reference is held and the use count for the regulator will be initialised to reflect the current state of the regulator.

This is intended for use by consumers which cannot tolerate shared use of the regulator such as those which need to force the regulator off for correct operation of the hardware they are controlling.

Use of supply names configured via `regulator_set_device_supply` is strongly encouraged. It is recommended that the supply name used should match the name used for the supply and/or the relevant device pins in the datasheet.

## Name

`regulator_get_optional` — obtain optional access to a regulator.

## Synopsis

```
struct regulator * regulator_get_optional (struct device * dev, const
char * id);
```

## Arguments

*dev*    device for regulator “consumer”

*id*     Supply name or regulator ID.

## Description

Returns a struct regulator corresponding to the regulator producer, or `IS_ERR` condition containing `errno`.

This is intended for use by consumers for devices which can have some supplies unconnected in normal use, such as some MMC devices. It can allow the regulator core to provide stub supplies for other supplies requested using normal `regulator_get` calls without disrupting the operation of drivers that can handle absent supplies.

Use of supply names configured via `regulator_set_device_supply` is strongly encouraged. It is recommended that the supply name used should match the name used for the supply and/or the relevant device pins in the datasheet.

## Name

`regulator_put` — "free" the regulator source

## Synopsis

```
void regulator_put (struct regulator * regulator);
```

## Arguments

*regulator*    regulator source

## Note

drivers must ensure that all `regulator_enable` calls made on this regulator source are balanced by `regulator_disable` calls prior to calling this function.

## Name

`regulator_register_supply_alias` — Provide device alias for supply lookup

## Synopsis

```
int regulator_register_supply_alias (struct device * dev, const char *  
id, struct device * alias_dev, const char * alias_id);
```

## Arguments

<i>dev</i>	device that will be given as the regulator “consumer”
<i>id</i>	Supply name or regulator ID
<i>alias_dev</i>	device that should be used to lookup the supply
<i>alias_id</i>	Supply name or regulator ID that should be used to lookup the supply

## Description

All lookups for `id` on `dev` will instead be conducted for `alias_id` on `alias_dev`.

## Name

`regulator_unregister_supply_alias` — Remove device alias

## Synopsis

```
void regulator_unregister_supply_alias (struct device * dev, const char  
* id);
```

## Arguments

*dev*    device that will be given as the regulator “consumer”

*id*     Supply name or regulator ID

## Description

Remove a lookup alias if one exists for *id* on *dev*.

## Name

`regulator_bulk_register_supply_alias` — register multiple aliases

## Synopsis

```
int regulator_bulk_register_supply_alias (struct device * dev, const
char *const * id, struct device * alias_dev, const char *const * alias_id,
int num_id);
```

## Arguments

<i>dev</i>	device that will be given as the regulator “consumer”
<i>id</i>	List of supply names or regulator IDs
<i>alias_dev</i>	device that should be used to lookup the supply
<i>alias_id</i>	List of supply names or regulator IDs that should be used to lookup the supply
<i>num_id</i>	Number of aliases to register

## Description

*return* 0 on success, an `errno` on failure.

This helper function allows drivers to register several supply aliases in one operation. If any of the aliases cannot be registered any aliases that were registered will be removed before returning to the caller.

## Name

`regulator_bulk_unregister_supply_alias` — unregister multiple aliases

## Synopsis

```
void regulator_bulk_unregister_supply_alias (struct device * dev, const  
char *const * id, int num_id);
```

## Arguments

*dev*        device that will be given as the regulator “consumer”

*id*        List of supply names or regulator IDs

*num\_id*    Number of aliases to unregister

## Description

This helper function allows drivers to unregister several supply aliases in one operation.

## Name

`regulator_enable` — enable regulator output

## Synopsis

```
int regulator_enable (struct regulator * regulator);
```

## Arguments

*regulator*    regulator source

## Description

Request that the regulator be enabled with the regulator output at the predefined voltage or current value. Calls to `regulator_enable` must be balanced with calls to `regulator_disable`.

## NOTE

the output value can be set by other drivers, boot loader or may be hardwired in the regulator.



## Name

`regulator_disable` — disable regulator output

## Synopsis

```
int regulator_disable (struct regulator * regulator);
```

## Arguments

*regulator*    regulator source

## Description

Disable the regulator output voltage or current. Calls to `regulator_enable` must be balanced with calls to `regulator_disable`.

## NOTE

this will only disable the regulator output if no other consumer devices have it enabled, the regulator device supports disabling and machine constraints permit this operation.

## Name

`regulator_force_disable` — force disable regulator output

## Synopsis

```
int regulator_force_disable (struct regulator * regulator);
```

## Arguments

*regulator*    regulator source

## Description

Forcibly disable the regulator output voltage or current.

## NOTE

this *\*will\** disable the regulator output even if other consumer devices have it enabled. This should be used for situations when device damage will likely occur if the regulator is not disabled (e.g. over temp).

## Name

`regulator_disable_deferred` — disable regulator output with delay

## Synopsis

```
int regulator_disable_deferred (struct regulator * regulator, int ms);
```

## Arguments

*regulator*    regulator source

*ms*            milliseconds until the regulator is disabled

## Description

Execute `regulator_disable` on the regulator after a delay. This is intended for use with devices that require some time to quiesce.

## NOTE

this will only disable the regulator output if no other consumer devices have it enabled, the regulator device supports disabling and machine constraints permit this operation.

## Name

`regulator_is_enabled` — is the regulator output enabled

## Synopsis

```
int regulator_is_enabled (struct regulator * regulator);
```

## Arguments

*regulator*    regulator source

## Description

Returns positive if the regulator driver backing the source/client has requested that the device be enabled, zero if it hasn't, else a negative errno code.

Note that the device backing this regulator handle can have multiple users, so it might be enabled even if `regulator_enable` was never called for this particular source.

## Name

`regulator_can_change_voltage` — check if regulator can change voltage

## Synopsis

```
int regulator_can_change_voltage (struct regulator * regulator);
```

## Arguments

*regulator*    regulator source

## Description

Returns positive if the regulator driver backing the source/client can change its voltage, false otherwise. Useful for detecting fixed or dummy regulators and disabling voltage change logic in the client driver.

## Name

`regulator_count_voltages` — count `regulator_list_voltage` selectors

## Synopsis

```
int regulator_count_voltages (struct regulator * regulator);
```

## Arguments

*regulator*    regulator source

## Description

Returns number of selectors, or negative errno. Selectors are numbered starting at zero, and typically correspond to bitfields in hardware registers.

## Name

`regulator_list_voltage` — enumerate supported voltages

## Synopsis

```
int regulator_list_voltage (struct regulator * regulator, unsigned selector);
```

## Arguments

*regulator*    regulator source

*selector*    identify voltage to list

## Context

can sleep

## Description

Returns a voltage that can be passed to `regulator_set_voltage()`, zero if this selector code can't be used on this system, or a negative errno.

## Name

`regulator_get_hardware_vsel_register` — get the HW voltage selector register

## Synopsis

```
int regulator_get_hardware_vsel_register (struct regulator * regulator,
unsigned * vsel_reg, unsigned * vsel_mask);
```

## Arguments

*regulator*    regulator source

*vsel\_reg*     voltage selector register, output parameter

*vsel\_mask*    mask for voltage selector bitfield, output parameter

## Description

Returns the hardware register offset and bitmask used for setting the regulator voltage. This might be useful when configuring voltage-scaling hardware or firmware that can make I2C requests behind the kernel's back, for example.

On success, the output parameters *vsel\_reg* and *vsel\_mask* are filled in and 0 is returned, otherwise a negative `errno` is returned.



## Name

`regulator_list_hardware_vsel` — get the HW-specific register value for a selector

## Synopsis

```
int regulator_list_hardware_vsel (struct regulator * regulator, unsigned
selector);
```

## Arguments

*regulator*    regulator source

*selector*    identify voltage to list

## Description

Converts the selector to a hardware-specific voltage selector that can be directly written to the regulator registers. The address of the voltage register can be determined by calling `regulator_get_hardware_vsel_register`.

On error a negative `errno` is returned.

## Name

`regulator_get_linear_step` — return the voltage step size between VSEL values

## Synopsis

```
unsigned int regulator_get_linear_step (struct regulator * regulator);
```

## Arguments

*regulator*   regulator source

## Description

Returns the voltage step size between VSEL values for linear regulators, or return 0 if the regulator isn't a linear regulator.

## Name

`regulator_is_supported_voltage` — check if a voltage range can be supported

## Synopsis

```
int regulator_is_supported_voltage (struct regulator * regulator, int
min_uV, int max_uV);
```

## Arguments

<i>regulator</i>	Regulator to check.
<i>min_uV</i>	Minimum required voltage in uV.
<i>max_uV</i>	Maximum required voltage in uV.

## Description

Returns a boolean or a negative error code.

## Name

`regulator_set_voltage` — set regulator output voltage

## Synopsis

```
int regulator_set_voltage (struct regulator * regulator, int min_uV,  
int max_uV);
```

## Arguments

*regulator*    regulator source

*min\_uV*        Minimum required voltage in uV

*max\_uV*        Maximum acceptable voltage in uV

## Description

Sets a voltage regulator to the desired output voltage. This can be set during any regulator state. IOW, regulator can be disabled or enabled.

If the regulator is enabled then the voltage will change to the new value immediately otherwise if the regulator is disabled the regulator will output at the new voltage when enabled.

## NOTE

If the regulator is shared between several devices then the lowest request voltage that meets the system constraints will be used. Regulator system constraints must be set for this regulator before calling this function otherwise this call will fail.

## Name

`regulator_set_voltage_time` — get raise/fall time

## Synopsis

```
int regulator_set_voltage_time (struct regulator * regulator, int
old_uV, int new_uV);
```

## Arguments

<i>regulator</i>	regulator source
<i>old_uV</i>	starting voltage in microvolts
<i>new_uV</i>	target voltage in microvolts

## Description

Provided with the starting and ending voltage, this function attempts to calculate the time in microseconds required to rise or fall to this new voltage.

## Name

`regulator_set_voltage_time_sel` — get raise/fall time

## Synopsis

```
int regulator_set_voltage_time_sel (struct regulator_dev * rdev, unsigned int old_selector, unsigned int new_selector);
```

## Arguments

<i>rdev</i>	regulator source device
<i>old_selector</i>	selector for starting voltage
<i>new_selector</i>	selector for target voltage

## Description

Provided with the starting and target voltage selectors, this function returns time in microseconds required to rise or fall to this new voltage

Drivers providing `ramp_delay` in `regulation_constraints` can use this as their `set_voltage_time_sel` operation.

## Name

`regulator_sync_voltage` — re-apply last regulator output voltage

## Synopsis

```
int regulator_sync_voltage (struct regulator * regulator);
```

## Arguments

*regulator*   regulator source

## Description

Re-apply the last configured voltage. This is intended to be used where some external control source the consumer is cooperating with has caused the configured voltage to change.

## Name

`regulator_get_voltage` — get regulator output voltage

## Synopsis

```
int regulator_get_voltage (struct regulator * regulator);
```

## Arguments

*regulator*   regulator source

## Description

This returns the current regulator voltage in uV.

## NOTE

If the regulator is disabled it will return the voltage value. This function should not be used to determine regulator state.



## Name

`regulator_set_current_limit` — set regulator output current limit

## Synopsis

```
int regulator_set_current_limit (struct regulator * regulator, int
min_uA, int max_uA);
```

## Arguments

*regulator*    regulator source

*min\_uA*        Minimum supported current in uA

*max\_uA*        Maximum supported current in uA

## Description

Sets current sink to the desired output current. This can be set during any regulator state. IOW, regulator can be disabled or enabled.

If the regulator is enabled then the current will change to the new value immediately otherwise if the regulator is disabled the regulator will output at the new current when enabled.

## NOTE

Regulator system constraints must be set for this regulator before calling this function otherwise this call will fail.

## Name

`regulator_get_current_limit` — get regulator output current

## Synopsis

```
int regulator_get_current_limit (struct regulator * regulator);
```

## Arguments

*regulator* regulator source

## Description

This returns the current supplied by the specified current sink in uA.

## NOTE

If the regulator is disabled it will return the current value. This function should not be used to determine regulator state.

## Name

`regulator_set_mode` — set regulator operating mode

## Synopsis

```
int regulator_set_mode (struct regulator * regulator, unsigned int
mode);
```

## Arguments

*regulator*    regulator source

*mode*            operating mode - one of the REGULATOR\_MODE constants

## Description

Set regulator operating mode to increase regulator efficiency or improve regulation performance.

## NOTE

Regulator system constraints must be set for this regulator before calling this function otherwise this call will fail.

## Name

`regulator_get_mode` — get regulator operating mode

## Synopsis

```
unsigned int regulator_get_mode (struct regulator * regulator);
```

## Arguments

*regulator*    regulator source

## Description

Get the current regulator operating mode.

## Name

`regulator_set_load` — set regulator load

## Synopsis

```
int regulator_set_load (struct regulator * regulator, int uA_load);
```

## Arguments

*regulator*    regulator source

*uA\_load*      load current

## Description

Notifies the regulator core of a new device load. This is then used by DRMS (if enabled by constraints) to set the most efficient regulator operating mode for the new regulator loading.

Consumer devices notify their supply regulator of the maximum power they will require (can be taken from device datasheet in the power consumption tables) when they change operational status and hence power state. Examples of operational state changes that can affect power

## consumption are

-

- o Device is opened / closed.
- o Device I/O is about to begin or has just finished.
- o Device is idling in between work.

This information is also exported via sysfs to userspace.

DRMS will sum the total requested load on the regulator and change to the most efficient operating mode if platform constraints allow.

On error a negative errno is returned.

## Name

`regulator_allow_bypass` — allow the regulator to go into bypass mode

## Synopsis

```
int regulator_allow_bypass (struct regulator * regulator, bool enable);
```

## Arguments

*regulator*    Regulator to configure

*enable*        enable or disable bypass mode

## Description

Allow the regulator to go into bypass mode if all other consumers for the regulator also enable bypass mode and the machine constraints allow this. Bypass mode means that the regulator is simply passing the input directly to the output with no regulation.

## Name

`regulator_register_notifier` — register regulator event notifier

## Synopsis

```
int regulator_register_notifier (struct regulator * regulator, struct
notifier_block * nb);
```

## Arguments

*regulator*    regulator source

*nb*            notifier block

## Description

Register notifier block to receive regulator events.

## Name

`regulator_unregister_notifier` — unregister regulator event notifier

## Synopsis

```
int regulator_unregister_notifier (struct regulator * regulator, struct
notifier_block * nb);
```

## Arguments

*regulator*    regulator source

*nb*            notifier block

## Description

Unregister regulator event notifier block.



## Name

`regulator_bulk_get` — get multiple regulator consumers

## Synopsis

```
int regulator_bulk_get (struct device * dev, int num_consumers, struct
regulator_bulk_data * consumers);
```

## Arguments

<i>dev</i>	Device to supply
<i>num_consumers</i>	Number of consumers to register
<i>consumers</i>	Configuration of consumers; clients are stored here.

## Description

*return* 0 on success, an `errno` on failure.

This helper function allows drivers to get several regulator consumers in one operation. If any of the regulators cannot be acquired then any regulators that were allocated will be freed before returning to the caller.

## Name

`regulator_bulk_enable` — enable multiple regulator consumers

## Synopsis

```
int regulator_bulk_enable (int num_consumers, struct regulator_bulk_data * consumers);
```

## Arguments

*num\_consumers*    Number of consumers

*consumers*        Consumer data; clients are stored here. *return* 0 on success, an errno on failure

## Description

This convenience API allows consumers to enable multiple regulator clients in a single API call. If any consumers cannot be enabled then any others that were enabled will be disabled again prior to return.

## Name

`regulator_bulk_disable` — disable multiple regulator consumers

## Synopsis

```
int  regulator_bulk_disable (int  num_consumers,  struct  regula-
tor_bulk_data * consumers);
```

## Arguments

*num\_consumers*    Number of consumers

*consumers*        Consumer data; clients are stored here. *return* 0 on success, an errno on failure

## Description

This convenience API allows consumers to disable multiple regulator clients in a single API call. If any consumers cannot be disabled then any others that were disabled will be enabled again prior to return.

## Name

`regulator_bulk_force_disable` — force disable multiple regulator consumers

## Synopsis

```
int regulator_bulk_force_disable (int num_consumers, struct regula-
tor_bulk_data * consumers);
```

## Arguments

*num\_consumers*    Number of consumers

*consumers*        Consumer data; clients are stored here. *return* 0 on success, an errno on failure

## Description

This convenience API allows consumers to forcibly disable multiple regulator clients in a single API call.

## NOTE

This should be used for situations when device damage will likely occur if the regulators are not disabled (e.g. over temp). Although `regulator_force_disable` function call for some consumers can return error numbers, the function is called for all consumers.

## Name

`regulator_bulk_free` — free multiple regulator consumers

## Synopsis

```
void regulator_bulk_free (int num_consumers, struct regulator_bulk_data  
* consumers);
```

## Arguments

*num\_consumers*    Number of consumers

*consumers*        Consumer data; clients are stored here.

## Description

This convenience API allows consumers to free multiple regulator clients in a single API call.

## Name

`regulator_notifier_call_chain` — call regulator event notifier

## Synopsis

```
int regulator_notifier_call_chain (struct regulator_dev * rdev, unsigned
long event, void * data);
```

## Arguments

*rdev*     regulator source

*event*    notifier block

*data*     callback-specific data.

## Description

Called by regulator drivers to notify clients a regulator event has occurred. We also notify regulator clients downstream. Note lock must be held by caller.

## Name

`regulator_mode_to_status` — convert a regulator mode into a status

## Synopsis

```
int regulator_mode_to_status (unsigned int mode);
```

## Arguments

*mode*    Mode to convert

## Description

Convert a regulator mode into a status.

## Name

`regulator_register` — register regulator

## Synopsis

```
struct regulator_dev * regulator_register (const struct regulator_desc
* regulator_desc, const struct regulator_config * cfg);
```

## Arguments

*regulator\_desc*    regulator to register

*cfg*                runtime configuration for regulator

## Description

Called by regulator drivers to register a regulator. Returns a valid pointer to struct `regulator_dev` on success or an `ERR_PTR` on error.



## Name

`regulator_unregister` — unregister regulator

## Synopsis

```
void regulator_unregister (struct regulator_dev * rdev);
```

## Arguments

*rdev*    regulator to unregister

## Description

Called by regulator drivers to unregister a regulator.

## Name

`regulator_suspend_prepare` — prepare regulators for system wide suspend

## Synopsis

```
int regulator_suspend_prepare (suspend_state_t state);
```

## Arguments

*state*    system suspend state

## Description

Configure each regulator with it's suspend operating parameters for state. This will usually be called by machine suspend code prior to supending.

## Name

`regulator_suspend_finish` — resume regulators from system wide suspend

## Synopsis

```
int regulator_suspend_finish ( void );
```

## Arguments

*void* no arguments

## Description

Turn on regulators that might be turned off by `regulator_suspend_prepare` and that should be turned on according to the regulators properties.

## Name

`regulator_has_full_constraints` — the system has fully specified constraints

## Synopsis

```
void regulator_has_full_constraints ( void );
```

## Arguments

*void* no arguments

## Description

Calling this function will cause the regulator API to disable all regulators which have a zero use count and don't have an `always_on` constraint in a `late_initcall`.

The intention is that this will become the default behaviour in a future kernel release so users are encouraged to use this facility now.

## Name

`rdev_get_drvdata` — get rdev regulator driver data

## Synopsis

```
void * rdev_get_drvdata (struct regulator_dev * rdev);
```

## Arguments

*rdev* regulator

## Description

Get rdev regulator driver private data. This call can be used in the regulator driver context.

## Name

`regulator_get_drvdata` — get regulator driver data

## Synopsis

```
void * regulator_get_drvdata (struct regulator * regulator);
```

## Arguments

*regulator* regulator

## Description

Get regulator driver private data. This call can be used in the consumer driver context when non API regulator specific functions need to be called.

## Name

`regulator_set_drvdata` — set regulator driver data

## Synopsis

```
void regulator_set_drvdata (struct regulator * regulator, void * data);
```

## Arguments

*regulator*    regulator

*data*        data

## Name

`rdev_get_id` — get regulator ID

## Synopsis

```
int rdev_get_id (struct regulator_dev * rdev);
```

## Arguments

*rdev* regulator