System Sleep States

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Sleep states are global low-power states of the entire system in which user space code cannot be executed and the overall system activity is significantly reduced.

Sleep States That Can Be Supported

Depending on its configuration and the capabilities of the platform it runs on, the Linux kernel can support up to four system sleep states, including hibernation and up to three variants of system suspend. The sleep states that can be supported by the kernel are listed below.

Suspend-to-Idle

This is a generic, pure software, light-weight variant of system suspend (also referred to as S2I or S2Idle). It allows more energy to be saved relative to runtime idle by freezing user space, suspending the timekeeping and putting all I/O devices into low-power states (possibly lower-power than available in the working state), such that the processors can spend time in their deepest idle states while the system is suspended.

The system is woken up from this state by in-band interrupts, so theoretically any devices that can cause interrupts to be generated in the working state can also be set up as wakeup devices for S2Idle.

This state can be used on platforms without support for :ref:`standby <standby>` or :ref:`suspend-to-RAM <s2ram>`, or it can be used in addition to any of the deeper system suspend variants to provide reduced resume latency. It is always supported if the :c:macro:`CONFIG_SUSPEND` kernel configuration option is set.

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 42); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 42); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 42); *backlink*

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Standby

This state, if supported, offers moderate, but real, energy savings, while providing a relatively straightforward transition back to the working state. No operating state is lost (the system core logic retains power), so the system can go back to where it left off easily enough.

In addition to freezing user space, suspending the timekeeping and putting all I/O devices into low-power states, which is done for :ref:`suspend-to-idle <s2idle>` too, nonboot CPUs are taken offline and all low-level system functions are suspended during transitions into this state. For this reason, it should allow more energy to be saved relative to :ref:`suspend-to-idle <s2idle>`, but the resume latency will generally be greater than for that state.

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 57); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 57); *backlink*

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The set of devices that can wake up the system from this state usually is reduced relative to :ref:`suspend-to-idle <s2idle>` and it may be necessary to rely on the platform for setting up the wakeup functionality as appropriate.

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 64); *backlink*

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This state is supported if the :c:macro:`CONFIG_SUSPEND` kernel configuration option is set and the support for it is registered by the platform with the core system suspend subsystem. On ACPI-based systems this state is mapped to the S1 system state defined by ACPI.

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 68); *backlink*

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Suspend-to-RAM

This state (also referred to as STR or S2RAM), if supported, offers significant energy savings as everything in the system is put into a low-power state, except for memory, which should be placed into the self-refresh mode to retain its contents. All of the steps carried out when entering :ref:`standby <standby>` are also carried out during transitions to S2RAM. Additional operations may take place depending on the platform capabilities. In particular, on ACPI-based systems the kernel passes control to the platform firmware (BIOS) as the last step during S2RAM transitions and that usually results in powering down some more low-level components that are not directly controlled by the kernel.

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 78); *backlink*

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The state of devices and CPUs is saved and held in memory. All devices are suspended and put into low-power states. In many cases, all peripheral buses lose power when entering S2RAM, so devices must be able to handle the transition back to the "on" state.

On ACPI-based systems S2RAM requires some minimal boot-strapping code in the platform firmware to resume the system from it. This may be the case on other platforms too.

The set of devices that can wake up the system from S2RAM usually is reduced relative to :ref:`suspend-to-idle <s2idle>` and :ref:`standby <standby>` and it may be necessary to rely on the platform for setting up the wakeup functionality as appropriate.

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 97); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 97); *backlink*

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S2RAM is supported if the :c:macro:`CONFIG_SUSPEND` kernel configuration option is set and the support for it is registered by the platform with the core system suspend subsystem. On ACPI-based systems it is mapped to the S3 system state defined by ACPI.

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 102); *backlink*

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Hibernation

This state (also referred to as Suspend-to-Disk or STD) offers the greatest energy savings and can be used even in the absence of low-level platform support for system suspend. However, it requires some low-level code for resuming the system to be present for the underlying CPU architecture.

Hibernation is significantly different from any of the system suspend variants. It takes three system state changes to put it into hibernation and two system state changes to resume it.

First, when hibernation is triggered, the kernel stops all system activity and creates a snapshot image of memory to be written into persistent storage. Next, the system goes into a state in which the snapshot image can be saved, the image is written out and finally the system goes into the target low-power state in which power is cut from almost all of its hardware components, including memory, except for a limited set of wakeup devices.

Once the snapshot image has been written out, the system may either enter a special low-power state (like ACPI S4), or it may simply power down itself. Powering down means minimum power draw and it allows this mechanism to work on any system. However, entering a special low-power state may allow additional means of system wakeup to be used (e.g. pressing a key on the keyboard or opening a laptop lid).

After wakeup, control goes to the platform firmware that runs a boot loader which boots a fresh instance of the kernel (control may also go directly to the boot loader, depending on the system configuration, but anyway it causes a fresh instance of the kernel to be booted). That new instance of the kernel (referred to as the `restore kernel`) looks for a hibernation image in persistent storage and if one is found, it is loaded into memory. Next, all activity in the system is stopped and the restore kernel overwrites itself with the image contents and jumps into a special trampoline area in the original kernel stored in the image (referred to as the `image kernel`), which is where the special architecture-specific low-level code is needed. Finally, the image kernel restores the system to the pre-hibernation state and allows user space to run again.

Hibernation is supported if the :c:macro:`CONFIG_HIBERNATION` kernel configuration option is set. However, this option can only be set if support for the given CPU architecture includes the low-level code for system resume.

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 148); *backlink*

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Basic `sysfs` Interfaces for System Suspend and Hibernation

The power management subsystem provides userspace with a unified `sysfs` interface for system sleep regardless of the underlying system architecture or platform. That interface is located in the :file:`/sys/power/` directory (assuming that `sysfs` is mounted at :file:`/sys`) and it consists of the following attributes (files):

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 156); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 156); *backlink*

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`state`

This file contains a list of strings representing sleep states supported by the kernel. Writing one of these strings into it causes the kernel to start a transition of the system into the sleep state represented by that string.

In particular, the "disk", "freeze" and "standby" strings represent the :ref:`hibernation <hibernation>`, :ref:`suspend-to-idle <s2idle>` and :ref:`standby <standby>` sleep states, respectively. The "mem" string is interpreted in accordance with the contents of the `mem_sleep` file described below.

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 168); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 168); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 168); *backlink*

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If the kernel does not support any system sleep states, this file is not present.

`mem_sleep`

This file contains a list of strings representing supported system suspend variants and allows user space to select the variant to be associated with the "mem" string in the `state` file described above.

The strings that may be present in this file are "s2idle", "shallow" and "deep". The "s2idle" string always represents :ref:`suspend-to-idle <s2idle>` and, by convention, "shallow" and "deep" represent :ref:`standby <standby>` and :ref:`suspend-to-RAM <s2ram>`, respectively.

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 182); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 182); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 182); *backlink*

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Writing one of the listed strings into this file causes the system suspend variant represented by it to be associated with the "mem" string in the `state` file. The string representing the suspend variant currently associated with the "mem" string in the `state` file is shown in square brackets.

If the kernel does not support system suspend, this file is not present.

`disk`

This file controls the operating mode of hibernation (Suspend-to-Disk). Specifically, it tells the kernel what to do after creating a hibernation image.

Reading from it returns a list of supported options encoded as:

`platform`

Put the system into a special low-power state (e.g. ACPI S4) to make additional wakeup options available and possibly allow the platform firmware to take a simplified initialization path after wakeup.

It is only available if the platform provides a special mechanism to put the system to sleep after creating a hibernation image (platforms with ACPI do that as a rule, for example).

`shutdown`

Power off the system.

`reboot`

Reboot the system (useful for diagnostics mostly).

`suspend`

Hybrid system suspend. Put the system into the suspend sleep state selected through the `mem_sleep` file described above. If the system is successfully woken up from that state, discard the hibernation image and continue.

Otherwise, use the image to restore the previous state of the system.

It is available if system suspend is supported.

`test_resume`

Diagnostic operation. Load the image as though the system had just woken up from hibernation and the currently running kernel instance was a restore kernel and follow up with full system resume.

Writing one of the strings listed above into this file causes the option represented by it to be selected.

The currently selected option is shown in square brackets, which means that the operation represented by it will be carried out after creating and saving the image when hibernation is triggered by writing `disk` to :file:`/sys/power/state`.

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 238); *backlink*

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If the kernel does not support hibernation, this file is not present.

`image_size`

This file controls the size of hibernation images.

It can be written a string representing a non-negative integer that will be used as a best-effort upper limit of the image size, in bytes. The hibernation core will do its best to ensure that the image size will not exceed that number, but if that turns out to be impossible to achieve, a hibernation image will still be created and its size will be as small as possible. In particular, writing '0' to this file causes the size of hibernation images to be minimum.

Reading from it returns the current image size limit, which is set to around 2/5 of the available RAM size by default.

`pm_trace`

This file controls the "PM trace" mechanism saving the last suspend or resume event point in the RTC memory across reboots. It helps to debug hard lockups or reboots due to device driver failures that occur during system suspend or resume (which is more common) more effectively.

If it contains "1", the fingerprint of each suspend/resume event point in turn will be stored in the RTC memory (overwriting the actual RTC information), so it will survive a system crash if one occurs right after storing it and it can be used later to identify the driver that caused the crash to happen.

It contains "0" by default, which may be changed to "1" by writing a string representing a nonzero integer into it.

According to the above, there are two ways to make the system go into the :ref:`suspend-to-idle <s2idle>` state. The first one is to write "freeze" directly to :file:`/sys/power/state`. The second one is to write "s2idle" to :file:`/sys/power/mem_sleep` and then to write "mem" to :file:`/sys/power/state`. Likewise, there are two ways to make the system go into the :ref:`standby <standby>` state (the strings to write to the control files in that case are "standby" or "shallow" and "mem", respectively) if that state is supported by the platform. However, there is only one way to make the system go into the :ref:`suspend-to-RAM <s2ram>` state (write "deep" into :file:`/sys/power/mem_sleep` and "mem" into :file:`/sys/power/state`).

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 274); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 274); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 274); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 274); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 274); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 274); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 274); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 274); *backlink*

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The default suspend variant (ie. the one to be used without writing anything into :file:`/sys/power/mem_sleep`) is either "deep" (on the majority of systems supporting :ref:`suspend-to-RAM <s2ram>`) or "s2idle", but it can be overridden by the value of the `mem_sleep_default` parameter in the kernel command line. On some systems with ACPI, depending on the information in the ACPI tables, the default may be "s2idle" even if :ref:`suspend-to-RAM <s2ram>` is supported in principle.

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 285); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 285); *backlink*

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System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\linux-master\Documentation\admin-guide\pm\[linux-master][Documentation][admin-guide][pm]sleep-states.rst, line 285); *backlink*

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