



OpenCore

Reference Manual (0.7-~~6~~.7)

[2022.01.04]

cases, the use of open-source implementations with transparent binary generation (such as OCAT) is encouraged, given that other tools may contain malware. In addition, configurations created for a specific hardware setup should never be used on different hardware setups.

For BIOS booting, a third-party UEFI environment provider is required and `OpenDuetPkg` is one such UEFI environment provider for legacy systems. To run OpenCore on such a legacy system, `OpenDuetPkg` can be installed with a dedicated tool — `BootInstall` (bundled with OpenCore). Third-party utilities can be used to perform this on systems other than macOS.

For upgrade purposes, refer to the `Differences.pdf` document which provides information about changes to the configuration (as compared to the previous release) as well as to the `Changelog.md` document (which contains a list of modifications across all published updates).

3.3 Contribution

OpenCore can be compiled as a standard EDK II package and requires the EDK II Stable package. The currently supported EDK II release is hosted in `acidanthera/audk`. Required patches for this package can be found in the `Patches` directory.

When updating the LaTeX documentation (e.g. `Configuration.tex`) please do *not* rebuild the PDF files till merging to master happens. This avoids unnecessary merge conflicts:

- External contributors using the pull-request approach should request the maintainers to handle the PDF rebuild in the pull-request message.
- Internal contributors should rebuild the documentation at merge time in the same or in a separate commit. One can ask another maintainer to rebuild the documentation when lacking the necessary tools in the pull-request message.

The only officially supported toolchain is `XCODE5`. Other toolchains might work but are neither supported nor recommended. Contributions of clean patches are welcome. Please do follow EDK II C Codestyle.

To compile with `XCODE5`, besides Xcode, users should also install NASM and MTOC. The latest Xcode version is recommended for use despite the toolchain name. An example command sequence is as follows:

```
git clone --depth=1 https://github.com/acidanthera/audk UDK
cd UDK
git submodule update --init --recommend-shallow
git clone --depth=1 https://github.com/acidanthera/OpenCorePkg
. ./edksetup.sh
make -C BaseTools
build -a X64 -b RELEASE -t XCODE5 -p OpenCorePkg/OpenCorePkg.dsc
```

Listing 1: Compilation Commands

For IDE usage Xcode projects are available in the root of the repositories. Another approach could be using Language Server Protocols. For example, Sublime Text with LSP for Sublime Text plugin. Add `compile_flags.txt` file with similar content to the UDK root:

```
-I/UefiPackages/MdePkg
-I/UefiPackages/MdePkg/Include
-I/UefiPackages/MdePkg/Include/X64
-I/UefiPackages/MdeModulePkg
-I/UefiPackages/MdeModulePkg/Include
-I/UefiPackages/MdeModulePkg/Include/X64
-I/UefiPackages/OpenCorePkg/Include/AMI
-I/UefiPackages/OpenCorePkg/Include/Acidanthera
-I/UefiPackages/OpenCorePkg/Include/Apple
-I/UefiPackages/OpenCorePkg/Include/Apple/X64
-I/UefiPackages/OpenCorePkg/Include/Duet
-I/UefiPackages/OpenCorePkg/Include/Generic
-I/UefiPackages/OpenCorePkg/Include/Intel
-I/UefiPackages/OpenCorePkg/Include/Microsoft
```

- Enabling XCPM support for an unsupported CPU variant.

Note 1: It may also be the case that the CPU model is supported but there is no power management supported (e.g. virtual machines). In this case, `MinKernel` and `MaxKernel` can be set to restrict CPU virtualisation and dummy power management patches to the particular macOS kernel version.

Note 2: Only the value of `EAX`, which represents the full CPUID, typically needs to be accounted for and remaining bytes should be left as zeroes. The byte order is Little Endian. For example, `C3 06 03 00` stands for CPUID `0x0306C3` (Haswell).

Note 3: For XCPM support it is recommended to use the following combinations. [Be warned that one is required to set the correct frequency vectors matching the installed CPU.](#)

- Haswell-E (0x0306F2) to Haswell (0x0306C3):
`Cpuid1Data: C3 06 03 00 00 00 00 00 00 00 00 00 00 00 00 00`
`Cpuid1Mask: FF FF FF FF 00 00 00 00 00 00 00 00 00 00 00 00`
- Broadwell-E (0x0406F1) to Broadwell (0x0306D4):
`Cpuid1Data: D4 06 03 00 00 00 00 00 00 00 00 00 00 00 00 00`
`Cpuid1Mask: FF FF FF FF 00 00 00 00 00 00 00 00 00 00 00 00`
- [Comet Lake U62 \(0x0A0660\) to Comet Lake U42 \(0x0806EC\):](#)
[`Cpuid1Data: EC 06 08 00 00 00 00 00 00 00 00 00 00 00 00 00`](#)
[`Cpuid1Mask: FF FF FF FF 00 00 00 00 00 00 00 00 00 00 00 00`](#)
- Rocket Lake (0x0A0670) to Comet Lake (~~0x0906EB~~0x0A0655):
`Cpuid1Data: EB 55 06 09 0A 00 00 00 00 00 00 00 00 00 00 00 00 00`
`Cpuid1Mask: FF FF FF FF 00 00 00 00 00 00 00 00 00 00 00 00`
- ~~Comet Lake U62 (Alder Lake (0x0A0660~~0x090672) to Comet Lake U42 (~~(0x0806EC~~0x0A0655):
`Cpuid1Data: EC 55 06 08 0A 00 00 00 00 00 00 00 00 00 00 00 00 00`
`Cpuid1Mask: FF FF FF FF 00 00 00 00 00 00 00 00 00 00 00 00`

Note 4: Be aware that the following configurations are unsupported by XCPM (at least out of the box):

- Consumer Ivy Bridge (0x0306A9) as Apple disabled XCPM for Ivy Bridge and recommends legacy power management for these CPUs. `_xcpm_bootstrap` should manually be patched to enforce XCPM on these CPUs instead of this option.
- Low-end CPUs (e.g. Haswell+ Pentium) as they are not supported properly by macOS. Legacy workarounds for older models can be found in the `Special NOTES` section of `acidanthera/bugtracker#365`.

2. `Cpuid1Mask`

Type: plist data, 16 bytes

Failsafe: All zero

Description: Bit mask of active bits in `Cpuid1Data`.

When each `Cpuid1Mask` bit is set to 0, the original CPU bit is used, otherwise set bits take the value of `Cpuid1Data`.

3. `DummyPowerManagement`

Type: plist boolean

Failsafe: false

Requirement: 10.4

Description: Disables `AppleIntelCpuPowerManagement`.

Note 1: This option is a preferred alternative to `NullCpuPowerManagement.kext` for CPUs without native power management driver in macOS.

Note 2: While this option is typically needed to disable `AppleIntelCpuPowerManagement` on unsupported platforms, it can also be used to disable this kext in other situations (e.g. with `Cpuid1Data` left blank).

4. `MaxKernel`

Type: plist string

Failsafe: Empty

Description: Emulates CPUID and applies `DummyPowerManagement` on specified macOS version or older.

Note: Refer to the `Add MaxKernel` description for matching logic.

sometimes fails to wake up. For debug kernels `setpowerstate_panic=0` boot argument should be used, which is otherwise equivalent to this quirk.

17. ProvideCurrentCpuInfo

Type: plist boolean

Failsafe: false

Requirement: 10.8 ([10.14](#))

Description: Provides current CPU info to the kernel.

This quirk ~~currently works differently depending on the CPU:~~

- [For Microsoft Hyper-V it provides the correct TSC and FSB values to the kernel, as well as disables CPU topology validation ~~-\(10.8+\).~~](#)
- [For Intel CPUs it adds support for asymmetrical SMP systems \(e.g. Intel Alder Lake\) by patching core count to thread count along with the supplemental required changes \(10.14+\).](#)

~~Note: These patches currently target Microsoft Hyper-V and may need to be extended for other purposes.~~

18. SetApfsTrimTimeout

Type: plist integer

Failsafe: -1

Requirement: 10.14 (not required for older)

Description: Set trim timeout in microseconds for APFS filesystems on SSDs.

The APFS filesystem is designed in a way that the space controlled via the spaceman structure is either used or free. This may be different in other filesystems where the areas can be marked as used, free, and *unmapped*. All free space is trimmed (unmapped/deallocated) at macOS startup. The trimming procedure for NVMe drives happens in LBA ranges due to the nature of the DSM command with up to 256 ranges per command. The more fragmented the memory on the drive is, the more commands are necessary to trim all the free space.

Depending on the SSD controller and the level of drive fragmentation, the trim procedure may take a considerable amount of time, causing noticeable boot slowdown. The APFS driver explicitly ignores previously unmapped areas and repeatedly trims them on boot. To mitigate against such boot slowdowns, the macOS driver introduced a timeout (9.999999 seconds) that stops the trim operation when not finished in time.

On several controllers, such as Samsung, where the deallocation process is relatively slow, this timeout can be reached very quickly. Essentially, it means that the level of fragmentation is high, thus macOS will attempt to trim the same lower blocks that have previously been deallocated, but never have enough time to deallocate higher blocks. The outcome is that trimming on such SSDs will be non-functional soon after installation, resulting in additional wear on the flash.

One way to workaroud the problem is to increase the timeout to an extremely high value, which at the cost of slow boot times (extra minutes) will ensure that all the blocks are trimmed. Set this option to a high value, such as 4294967295, to ensure that all blocks are trimmed. Alternatively, use over-provisioning, if supported, or create a dedicated unmapped partition where the reserve blocks can be found by the controller. Conversely, the trim operation can be disabled by setting a very low timeout value. e.g. 999. Refer to this article for details.

19. ThirdPartyDrives

Type: plist boolean

Failsafe: false

Requirement: 10.6 (not required for older)

Description: Apply vendor patches to IOAHCIBlockStorage.kext to enable native features for third-party drives, such as TRIM on SSDs or hibernation support on 10.15 and newer.

Note: This option may be avoided on user preference. NVMe SSDs are compatible without the change. For AHCI SSDs on modern macOS version there is a dedicated built-in utility called `trimforce`. Starting from 10.15 this utility creates `EnableTRIM` variable in `APPLE_BOOT_VARIABLE_GUID` namespace with 01 00 00 00 value.

20. XhciPortLimit

Type: plist boolean

Failsafe: false

Requirement: 10.11 (not required for older)

systemd-boot users (probably almost exclusively Arch Linux users) should be aware that OpenLinuxBoot does not support the systemd-boot-specific Boot Loader Interface; therefore `efibootmgr` rather than `bootctl` must be used for any low-level Linux command line interaction with the boot menu.

11.7 Properties

1. APFS

Type: plist dict

Failsafe: None

Description: Provide APFS support as configured in the APFS Properties section below.

2. Audio

Type: plist dict

Failsafe: None

Description: Configure audio backend support described in the Audio Properties section below.

~~Audio support~~ Unless documented otherwise (e.g. `ResetTrafficClass`) settings in this section are for UEFI audio support only (e.g. OpenCore generated boot chime and audio assist) and are unrelated to any configuration needed for OS audio support (e.g. `AppleALC`).

UEFI audio support provides a way for upstream protocols to interact with the selected ~~hardware and audio~~ audio hardware and resources. All audio resources should reside in `\EFI\OC\Resources\Audio` directory. Currently the supported audio file formats are MP3 and WAVE PCM. While it is driver-dependent which audio stream format is supported, most common audio cards support 16-bit signed stereo audio at 44100 or 48000 Hz.

Audio file path is determined by audio type, audio localisation, and audio path. Each filename looks as follows: `[audio type]_[audio localisation]_[audio path].[audio ext]`. For unlocalised files filename does not include the language code and looks as follows: `[audio type]_[audio path].[audio ext]`. Audio extension can either be `mp3` or `wav`.

- Audio type can be `OCEFIAudio` for OpenCore audio files or `AXEFIAudio` for macOS bootloader audio files.
- Audio localisation is a two letter language code (e.g. `en`) with an exception for Chinese, Spanish, and Portuguese. Refer to `APPLE_VOICE_OVER_LANGUAGE_CODE` definition for the list of all supported localisations.
- Audio path is the base filename corresponding to a file identifier. For macOS bootloader audio paths refer to `APPLE_VOICE_OVER_AUDIO_FILE` definition. For OpenCore audio paths refer to `OC_VOICE_OVER_AUDIO_FILE` definition. The only exception is OpenCore boot chime file, which is `OCEFIAudio_VoiceOver_Boot.mp3`.

Audio localisation is determined separately for macOS bootloader and OpenCore. For macOS bootloader it is set in `preferences.efires` archive in `systemLanguage.utf8` file and is controlled by the operating system. For OpenCore the value of `prev-lang:kbd` variable is used. When native audio localisation of a particular file is missing, English language (`en`) localisation is used. Sample audio files can be found in `OcBinaryData` repository.

3. ConnectDrivers

Type: plist boolean

Failsafe: false

Description: Perform UEFI controller connection after driver loading.

This option is useful for loading drivers following UEFI driver model as they may not start by themselves. Examples of such drivers are filesystem or audio drivers. While effective, this option may not be necessary for drivers performing automatic connection, and may slightly slowdown the boot.

Note: Some types of firmware, particularly those made by Apple, only connect the boot drive to speed up the boot process. Enable this option to be able to see all the boot options when running multiple drives.

4. Drivers

Type: plist array

Failsafe: Empty

Description: Load selected drivers from `OC/Drivers` directory.

To be filled with `plist dict` values, describing each driver. Refer to the Drivers Properties section below.

5. Input

Type: plist dict

Failsafe: None

- In the unlikely event that you still get frequent, or occasional, double key responses after setting `KeySubsequentDelay` equal to your system's value of `KeyForgetThreshold`, then increase `KeySubsequentDelay` by one or two more until this effect goes away.

5. `GraphicsInputMirroring`

Type: plist boolean

Failsafe: false

Description: Apple's own implementation of `AppleEvent` prevents keyboard input during graphics applications from appearing on the basic console input stream.

With the default setting of `false`, OpenCore's builtin implementation of `AppleEvent` replicates this behaviour.

On non-Apple hardware this can stop keyboard input working in graphics-based applications such as Windows BitLocker which use non-Apple key input methods.

The recommended setting on all hardware is `true`.

Note: `AppleEvent`'s default behaviour is intended to prevent unwanted queued keystrokes from appearing after exiting graphics-based UEFI applications; this issue is already handled separately within OpenCore.

- `true` — Allow keyboard input to reach graphics mode apps which are not using Apple input protocols.
- `false` — Prevent key input mirroring to non-Apple protocols when in graphics mode.

6. `PointerPollMin`

Type: plist integer

Failsafe: 0

Description: Configure minimal pointer polling period in ms.

This is the minimal period the OpenCore builtin `AppleEvent` driver polls pointer devices (e.g. mice, trackpads) for motion events. The current implementation defaults to 10 ms. Setting 0 leaves this default unchanged.

Note: The OEM Apple implementation uses a polling rate of 2 ms.

7. `PointerPollMax`

Type: plist integer

Failsafe: 0

Description: Configure maximum pointer polling period in ms.

This is the maximum period the OpenCore builtin `AppleEvent` driver polls pointer devices (e.g. mice, trackpads) for motion events. The period is increased up to this value as long as the devices do not respond in time. The current implementation defaults to 80 ms. Setting 0 leaves this default unchanged.

Certain trackpad drivers often found in Dell laptops can be very slow to respond when no physical movement happens. This can affect OpenCanopy and FileVault 2 user interface responsiveness and loading times. Increasing the polling periods can reduce the impact.

Note: The OEM Apple implementation uses a polling rate of 2 ms.

8. `PointerPollMask`

Type: plist integer, 32 bit

Failsafe: -1

Description: Configure indices of polled pointers.

Selects pointer devices to poll for `AppleEvent` motion events. -1 implies all devices. A bit sum is used to determine particular devices. E.g. to enable devices 0, 2, 3 the value will be 1+4+8 (corresponding powers of two). A total of 32 configurable devices is supported.

Certain pointer devices can be present in the firmware even when no corresponding physical devices are available. These devices usually are placeholders, aggregate devices, or proxies. Gathering information from these devices may result in inaccurate motion activity in the user interfaces and even cause performance issues. Disabling such pointer devices is recommended for laptop setups having issues of this kind.

The amount of pointer devices available in the system can be found in the log. Refer to `Found N pointer devices` message for more details.

Note: Has no effect when using the OEM Apple implementation (see `AppleEvent` setting).

9. PointerSpeedDiv

Type: plist integer

Failsafe: 1

Description: Configure pointer speed divisor in the OpenCore re-implementation of the Apple Event protocol. Has no effect when using the OEM Apple implementation (see `AppleEvent` setting).

Configures the divisor for pointer movements. The Apple OEM default value is 1. 0 is an invalid value for this option.

Note: The recommended value for this option is 1. This value may optionally be modified in combination with `PointerSpeedMul`, according to user preference, to achieve customised mouse movement scaling.

10. PointerSpeedMul

Type: plist integer

Failsafe: 1

Description: Configure pointer speed multiplier in the OpenCore re-implementation of the Apple Event protocol. Has no effect when using the OEM Apple implementation (see `AppleEvent` setting).

Configures the multiplier for pointer movements. The Apple OEM default value is 1.

Note: The recommended value for this option is 1. This value may optionally be modified in combination with `PointerSpeedDiv`, according to user preference, to achieve customised mouse movement scaling.

11.10 Audio Properties

1. AudioCodec

Type: plist integer

Failsafe: 0

Description: Codec address on the specified audio controller for audio support.

This typically contains the first audio codec address on the builtin analog audio controller (HDEF). Audio codec addresses, e.g. 2, can be found in the debug log (marked in bold-italic):

```
OCAU: 1/3 PciRoot(0x0)/Pci(0x1,0x0)/Pci(0x0,0x1)/VenMsg(<redacted>,00000000) (4 outputs)
OCAU: 2/3 PciRoot(0x0)/Pci(0x3,0x0)/VenMsg(<redacted>,00000000) (1 outputs)
OCAU: 3/3 PciRoot(0x0)/Pci(0x1B,0x0)/VenMsg(<redacted>,02000000) (7 outputs)
```

As an alternative, this value can be obtained from `IOHDACodecDevice` class in I/O Registry containing it in `IOHDACodecAddress` field.

2. AudioDevice

Type: plist string

Failsafe: Empty

Description: Device path of the specified audio controller for audio support.

This typically contains builtin analog audio controller (HDEF) device path, e.g. `PciRoot(0x0)/Pci(0x1b,0x0)`. The list of recognised audio controllers can be found in the debug log (marked in bold-italic):

```
OCAU: 1/3 PciRoot(0x0)/Pci(0x1,0x0)/Pci(0x0,0x1)/VenMsg(<redacted>,00000000) (4 outputs)
OCAU: 2/3 PciRoot(0x0)/Pci(0x3,0x0)/VenMsg(<redacted>,00000000) (1 outputs)
OCAU: 3/3 PciRoot(0x0)/Pci(0x1B,0x0)/VenMsg(<redacted>,02000000) (7 outputs)
```

~~As an alternative, If using `AudioDxe`, the available controller device paths are also output on lines formatted like this:~~

~~HDA: Connecting controller - `PciRoot(0x0)/Pci(0x1B,0x0)`~~

~~Finally, `gfxutil -f HDEF` command can be used in macOS ~~to obtain the device path.~~~~

~~Specifying an empty device path ~~will result results~~ in the first available ~~codec and~~ audio controller being used. ~~The value of `AudioCodec` is ignored in this case. This can be a convenient initial option to try to get UEFI audio working. Manual settings as above will be required when this default value does not work.~~~~

3. ~~AudioOut~~AudioOutMask

Type: plist integer

Failsafe: ~~0~~-1

Description: ~~Index of the output port of the specified codec starting from 0.~~ Bit field indicating which output channels to use for UEFI sound.

~~This typically contains the index of the green out of the builtin analog audio controller (Audio mask is 1 « audio output (equivalently 2 HDEF) — audio output). E.g. for audio output 0 the bitmask is 1, for output 3 it is 8, and for outputs 0 and 3 it is 9.~~

The number of available output nodes (N) for each HDA codec is shown in the debug log (marked in bold-italic), audio outputs 0 to N - 1 may be selected:

```
OCAU: 1/3 PciRoot(0x0)/Pci(0x1,0x0)/Pci(0x0,0x1)/VenMsg(<redacted>,00000000) (4 outputs)
OCAU: 2/3 PciRoot(0x0)/Pci(0x3,0x0)/VenMsg(<redacted>,00000000) (1 outputs)
OCAU: 3/3 PciRoot(0x0)/Pci(0x1B,0x0)/VenMsg(<redacted>,02000000) (7 outputs)
```

~~The quickest way to find the right port is to bruteforce the values from~~ When AudioDxe is used then additional information about each output channel is logged during driver binding, including the bitmask for each output. The bitmask values for the desired outputs should be added together to obtain the AudioOutMask value:

```
HDA: | Port widget @ 0x9 is an output (pin defaults 0x2B4020) (bitmask 1)
HDA: | Port widget @ 0xA is an output (pin defaults 0x90100112) (bitmask 2)
HDA: | Port widget @ 0xB is an output (pin defaults 0x90100110) (bitmask 4)
HDA: | Port widget @ 0x10 is an output (pin defaults 0x4BE030) (bitmask 8)
```

Further information on the available output channels may be found from a Linux codec dump using the command:

```
cat /proc/asound/card{n}/codec#{m}
```

Using AudioOutMask, it is possible to play sound to more than one channel (e.g. main speaker plus bass speaker; headphones plus speakers) as long as all the chosen outputs support the sound file format in use; if any do not then no sound will play and a warning will be logged.

When all available output channels on the codec support the available sound file format then a value of 0 to -1 will play sound to all channels simultaneously. If this does not work it will usually be quickest to try each available output channel one by one, by setting AudioOutMask to 1, 2, 4, etc., up to 2^N - 1, in order to work out which channel(s) produce sound.

4. AudioSupport

Type: plist boolean

Failsafe: false

Description: Activate audio support by connecting to a backend driver.

Enabling this setting routes audio playback from builtin protocols to a dedicated audio port (specified (AudioOutAudioOutMask dedicated audio ports) of the specified codec (AudioCodec), located on the specified audio controller (AudioDevice).

5. DisconnectHda

Type: plist boolean

Failsafe: false

Description: Disconnect HDA controller before loading drivers.

May be required on some systems (e.g. Apple hardware, VMware Fusion guest) to allow a UEFI sound driver (such as AudioDxe) to take control of the audio hardware.

6. MinimumVolume

Type: plist integer

Failsafe: 0

Description: Minimal heard volume level from 0 to 100.

The screen reader will use this volume level when the calculated volume level is lower than MinimumVolume and the boot chime will not play if the calculated volume level is lower than MinimumVolume.

7. PlayChime

Type: plist string

Failsafe: Auto

Description: Play chime sound at startup.

This option activates the internal keyboard interceptor driver, based on `AppleGenericInput`, also known as `AptioInputFix`, to fill the `AppleKeyMapAggregator` database for input functioning. In cases where a separate driver such as `OpenUsbKbDxe` is used, this option should never be enabled. Additionally, this option is not required and should not be enabled with Apple firmware.

4. `KeySupportMode`

Type: plist string

Failsafe: Auto

Description: Set internal keyboard input translation to `AppleKeyMapAggregator` protocol mode.

- `Auto` — Performs automatic choice as available with the following preference: `AMI`, `V2`, `V1`.
- `V1` — Uses UEFI standard legacy input protocol `EFI_SIMPLE_TEXT_INPUT_PROTOCOL`.
- `V2` — Uses UEFI standard modern input protocol `EFI_SIMPLE_TEXT_INPUT_EX_PROTOCOL`.
- `AMI` — Uses APTIO input protocol `AMI_EFIKEYCODE_PROTOCOL`.

Note: Currently `V1`, `V2`, and `AMI` unlike `Auto` only do filtering of the particular specified protocol. This may change in the future versions.

5. `KeySwap`

Type: plist boolean

Failsafe: false

Description: Swap `Command` and `Option` keys during submission.

This option may be useful for keyboard layouts with `Option` key situated to the right of `Command` key.

6. `PointerSupport`

Type: plist boolean

Failsafe: false

Description: Enable internal pointer driver.

This option implements standard UEFI pointer protocol (`EFI_SIMPLE_POINTER_PROTOCOL`) through certain OEM protocols. The option may be useful on Z87 ASUS boards, where `EFI_SIMPLE_POINTER_PROTOCOL` is defective.

7. `PointerSupportMode`

Type: plist string

Failsafe: Empty

Description: Set OEM protocol used for internal pointer driver.

Currently the only supported variant is `ASUS`, using specialised protocol available on certain Z87 and Z97 ASUS boards. More details can be found in `LongSoft/UefiTool#116`. The value of this property cannot be empty if `PointerSupport` is enabled.

8. `TimerResolution`

Type: plist integer

Failsafe: 0

Description: Set architecture timer resolution.

This option allows updating the firmware architecture timer period with the specified value in 100 nanosecond units. Setting a lower value typically improves performance and responsiveness of the interface and input handling.

The recommended value is 50000 (5 milliseconds) or slightly higher. Select ASUS Z87 boards use 60000 for the interface. Apple boards use 100000. In case of issues, this option can be left as 0 [to not change the timer resolution](#).

11.13 Output Properties

1. `TextRenderer`

Type: plist string

Failsafe: `BuiltinGraphics`

Description: Chooses renderer for text going through standard console output.

Currently two renderers are supported: `Builtin` and `System`. `System` renderer uses firmware services for text rendering. `Builtin` bypassing firmware services and performs text rendering on its own. Different renderers