OpenCore

Reference Manual (0.5.~~6~~.7)

[2020.03.08]

5. `DiscardHibernateMap`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Reuse original hibernate memory map.

   This option forces XNU kernel to ignore newly supplied memory map and assume that it did not change after waking from hibernation. This behaviour is required to work by Windows, which mandates to preserve runtime memory size and location after S4 wake.

   Note: This may be used to workaround buggy memory maps on older hardware, and is now considered rare legacy. Examples of such hardware are Ivy Bridge laptops with Insyde firmware, like Acer V3-571G. Do not use this unless you fully understand the consequences.

6. `EnableSafeModeSlide`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Patch bootloader to have KASLR enabled in safe mode.

   This option is relevant to the users that have issues booting to safe mode (e.g. by holding `shift` or using `-x` boot argument). By default safe mode forces `0` slide as if the system was launched with `slide=0` boot argument. This quirk tries to patch `boot.efi` to lift that limitation and let some other value (from `1` to `255`) be used. This quirk requires `ProvideCustomSlide` to be enabled.

   Note: The necessity of this quirk is determined by safe mode availability. If booting to safe mode fails, this option can be tried to be enabled.

7. `EnableWriteUnprotector`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Permit write access to UEFI runtime services code.

   This option bypasses `RX̂` permissions in code pages of UEFI runtime services by removing write protection (`WP`) bit from `CR0` register during their execution. This quirk requires `OC_FIRMWARE_RUNTIME` protocol implemented in `FwRuntimeServices.efi`.

   Note: The necessity of this quirk is determined by early boot crashes of the firmware.

8. `ForceExitBootServices`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Retry `ExitBootServices` with new memory map on failure.

   Try to ensure that `ExitBootServices` call succeeds even with outdated MemoryMap key argument by obtaining current memory map and retrying `ExitBootServices` call.

   Note: The necessity of this quirk is determined by early boot crashes of the firmware. Do not use this unless you fully understand the consequences.

9. `ProtectCsmRegion`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Protect CSM region areas from relocation.

   Ensure that CSM memory regions are marked as ACPI NVS to prevent ~~`boot.efi`~~ `boot.efi` or XNU from relocating or using them.

   Note: The necessity of this quirk is determined by artifacts and sleep wake issues. As `AvoidRuntimeDefrag` resolves a similar problem, no known firmwares should need this quirk. Do not use this unless you fully understand the consequences.

10. `ProtectSecureBoot`
    Type: `plist boolean`
    Failsafe: `false`
    Description: Protect UEFI Secure Boot variables from being written.

6 DeviceProperties

6.1 Introduction

Device configuration is provided to macOS with a dedicated buffer, called ~~EfiDevicePropertyDatabase~~EfiDevicePathPropertyDat
This buffer is a serialised map of DevicePaths to a map of property names and their values.

Property data can be debugged with gfxutil. To obtain current property data use the following command in macOS:

```
ioreg -lw0 -p IODeviceTree -n efi -r -x | grep device-properties |
  sed 's/.*<//;s/>.*//' > /tmp/device-properties.hex &&
  gfxutil /tmp/device-properties.hex /tmp/device-properties.plist &&
  cat /tmp/device-properties.plist
```

6.2 Properties

1. `Add`
   Type: `plist dict`
   Description: Sets device properties from a map (`plist dict`) of deivce paths to a map (`plist dict`) of variable names and their values in `plist metadata` format. Device paths must be provided in canonic string format (e.g. `PciRoot(0x0)/Pci(0x1,0x0)/Pci(0x0,0x0)`). Properties will only be set if not present and not blocked.

   Note: Currently properties may only be (formerly) added by the original driver, so unless a separate driver was installed, there is no reason to block the variables.

2. `Block`
   Type: `plist dict`
   Description: Removes device properties from a map (`plist dict`) of deivce paths to an array (`plist array`) of variable names in `plist string` format.

6.3 Common Properties

Some known properties include:

- `device-id`
  User-specified device identifier used for I/O Kit matching. Has 4 byte data type.
- `vendor-id`
  User-specified vendor identifier used for I/O Kit matching. Has 4 byte data type.
- `AAPL,ig-platform-id`
  Intel GPU framebuffer identifier used for framebuffer selection on Ivy Bridge and newer. Has 4 byte data type.
- `AAPL,snb-platform-id`
  Intel GPU framebuffer identifier used for framebuffer selection on Sandy Bridge. Has 4 byte data type.
- `layout-id`
  Audio layout used for AppleHDA layout selection. Has 4 byte data type.

- Entry is macOS recovery.
- Entry is macOS Time Machine.
- Entry is explicitly marked as `Auxiliary`.
- Entry is system (e.g. `Clean NVRAM`).

To see all entries picker menu needs to be reloaded in extended mode by pressing `Spacebar` key. Hiding auxiliary entries may increase boot performance for multidisk systems.

3. `HideSelf`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Hides own boot entry from boot picker. This may potentially hide other entries, for instance, when another UEFI OS is installed on the same volume and driver boot is used.

4. `PickerAttributes`
   Type: `plist integer`
   Failsafe: `0`
   Description: Sets specific attributes for picker.

   Builtin picker supports colour arguments as a sum of foreground and background colors according to UEFI specification. The value of black background and black foreground (`0`) is reserved. List of colour names:

   - `0x00` — `EFI_BLACK`
   - `0x01` — `EFI_BLUE`
   - `0x02` — `EFI_GREEN`
   - `0x03` — `EFI_CYAN`
   - `0x04` — `EFI_RED`
   - `0x05` — `EFI_MAGENTA`
   - `0x06` — `EFI_BROWN`
   - `0x07` — `EFI_LIGHTGRAY`
   - `0x08` — `EFI_DARKGRAY`
   - `0x09` — `EFI_LIGHTBLUE`
   - `0x0A` — `EFI_LIGHTGREEN`
   - `0x0B` — `EFI_LIGHTCYAN`
   - `0x0C` — `EFI_LIGHTRED`
   - `0x0D` — `EFI_LIGHTMAGENTA`
   - `0x0E` — `EFI_YELLOW`
   - `0x0F` — `EFI_WHITE`
   - `0x00` — `EFI_BACKGROUND_BLACK`
   - `0x10` — `EFI_BACKGROUND_BLUE`
   - `0x20` — `EFI_BACKGROUND_GREEN`
   - `0x30` — `EFI_BACKGROUND_CYAN`
   - `0x40` — `EFI_BACKGROUND_RED`
   - `0x50` — `EFI_BACKGROUND_MAGENTA`
   - `0x60` — `EFI_BACKGROUND_BROWN`
   - `0x70` — `EFI_BACKGROUND_LIGHTGRAY`

   Note: This option may not work well with `System` text renderer. Setting a background different from black could help testing proper GOP functioning.

5. `PickerAudioAssist`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Enable screen reader by default in boot picker.

   For macOS bootloader screen reader preference is set in `preferences.efires` archive in `isVOEnabled.int32` file and is controlled by the operating system. For OpenCore screen reader support this option is an independent equivalent. Toggling screen reader support in both OpenCore boot picker and macOS bootloader FileVault 2 login window can also be done with `Command` + `F5` key combination.

   Note: screen reader requires working audio support, see `UEFI Audio Properties` section for more details.

- `Default` — this is the default option, and it lets OpenCore built-in boot picker to loads the default boot option as specified in Startup Disk preference pane.
- `ShowPicker` — this option forces picker to show. Normally it can be achieved by holding `OPT` key during boot. Setting `ShowPicker` to `true` will make `ShowPicker` the default option.
- `ResetNvram` — this option performs select UEFI variable erase and is normally achieved by holding `CMD+OPT+P+R` key combination during boot. Another way to erase UEFI variables is to choose `Reset NVRAM` in the picker. This option requires `AllowNvramReset` to be set to `true`.
- `BootApple` — this options performs booting to the first found Apple operating system unless the default chosen operating system is already made by Apple. Hold `X` key to choose this option.
- `BootAppleRecovery` — this option performs booting to Apple operating system recovery. Either the one related to the default chosen operating system, or first found in case default chosen operating system is not made by Apple or has no recovery. Hold `CMD+R` key combination to choose this option.

Note 1: Activated `KeySupport`, `AppleUsbKbDxe`, or similar driver is required for key handling to work. On many firmwares it is not possible to get all the keys function.

Note 2: In addition to `OPT` OpenCore supports `Escape` key to display picker when `ShowPicker` is disabled. This key exists for `Apple` picker mode and for firmwares with PS/2 keyboards that fail to report held `OPT` key and require continual presses of `Escape` key to enter the boot menu.

Note 3: On Macs with problematic GOP it may be difficult to access Apple BootPicker. To workaround this problem even without loading OpenCore `BootKicker` utility can be blessed.

8.4 Debug Properties

1. `AppleDebug`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Enable `boot.efi` debug log saving to OpenCore log.

   Note: This option only applies to 10.15.4 and newer.

2. `DisableWatchDog`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Select firmwares may not succeed in quickly booting the operating system, especially in debug mode, which results in watch dog timer aborting the process. This option turns off watch dog timer.

3. `DisplayDelay`
   Type: `plist integer`
   Failsafe: `0`
   Description: Delay in microseconds performed after every printed line visible onscreen (i.e. console).

4. `DisplayLevel`
   Type: `plist integer`, 64 bit
   Failsafe: `0`
   Description: EDK II debug level bitmask (sum) showed onscreen. Unless `Target` enables console (onscreen) printing, onscreen debug output will not be visible. The following levels are supported (discover more in DebugLib.h):

   - `0x00000002` (bit `1`) — `DEBUG_WARN` in `DEBUG`, `NOOPT`, `RELEASE`.
   - `0x00000040` (bit `6`) — `DEBUG_INFO` in `DEBUG`, `NOOPT`.
   - `0x00400000` (bit `22`) — `DEBUG_VERBOSE` in custom builds.
   - `0x80000000` (bit `31`) — `DEBUG_ERROR` in `DEBUG`, `NOOPT`, `RELEASE`.

5. `Target`
   Type: `plist integer`
   Failsafe: `0`
   Description: A bitmask (sum) of enabled logging targets. By default all the logging output is hidden, so this option is required to be set when debugging is necessary.

   The following logging targets are supported:

third-party scripts may require `ExposeSensitiveData` set to `0x3` to provide `boot-path` variable with OpenCore EFI partition UUID.

WARNING: This feature is very dangerous as it passes unprotected data to your firmware variable services. Use it only when no hardware NVRAM implementation is provided by the firmware or it is incompatible.

4. `LegacyOverwrite`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Permits overwriting firmware variables from `nvram.plist`.

   Note: Only variables accessible from the operating system will be overwritten.

5. `LegacySchema`
   Type: `plist dict`
   Description: Allows setting select NVRAM variables from a map (`plist dict`) of GUIDs to an array (`plist array`) of variable names in `plist string` format.

   You can use `*` value to accept all variables for select GUID.

   WARNING: Choose variables very carefully, as nvram.plist is not vaulted. For instance, do not put `boot-args` or `csr-active-config`, as this can bypass SIP.

6. `WriteFlash`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Enables writing to flash memory for all added variables.

   Note: This value is recommended to be enabled on most firmwares, but is left configurable for firmwares that may have issues with NVRAM variable storage garbage collection or alike.

To read NVRAM variable value from macOS one could use `nvram` by concatenating variable GUID and name separated by `:` symbol. For example, `nvram 7C436110-AB2A-4BBB-A880-FE41995C9F82:boot-args`.

A continuously updated variable list can be found in a corresponding document: NVRAM Variables.

9.3 Mandatory Variables

Warning: These variables may be added by PlatformNVRAM or Generic subsections of PlatformInfo section. Using `PlatformInfo` is the recommend way of setting these variables.

The following variables are mandatory for macOS functioning:

- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:FirmwareFeatures`
  32-bit `FirmwareFeatures`. Present on all Macs to avoid extra parsing of SMBIOS tables
- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:FirmwareFeaturesMask`
  32-bit `FirmwareFeaturesMask`. Present on all Macs to avoid extra parsing of SMBIOS tables.
- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:MLB`
  `BoardSerialNumber`. Present on newer Macs (2013+ at least) to avoid extra parsing of SMBIOS tables, especially in ~~`boot. efi.`~~ `boot.efi.`
- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:ROM`
  Primary network adapter MAC address or replacement value. Present on newer Macs (2013+ at least) to avoid accessing special memory region, especially in ~~`boot. efi.`~~ `boot.efi.`

9.4 Recommended Variables

The following variables are recommended for faster startup or other improvements:

- `7C436110-AB2A-4BBB-A880-FE41995C9F82:csr-active-config`
  32-bit System Integrity Protection bitmask. Declared in XNU source code in csr.h.
- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:ExtendedFirmwareFeatures`
  Combined `FirmwareFeatures` and `ExtendedFirmwareFeatures`. Present on newer Macs to avoid extra parsing of SMBIOS tables

- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:ExtendedFirmwareFeaturesMask`
  Combined `FirmwareFeaturesMask` and `ExtendedFirmwareFeaturesMask`. Present on newer Macs to avoid extra parsing of SMBIOS tables.
- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:HW_BID`
  Hardware `BoardProduct` (e.g. `Mac-35C1E88140C3E6CF`). Not present on real Macs, but used to avoid extra parsing of SMBIOS tables, especially in ~~boot. efi.~~ `boot.efi.`
- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:HW_MLB`
  Hardware `BoardSerialNumber`. Override for MLB. Present on newer Macs (2013+ at least).
- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:HW_ROM`
  Hardware ROM. Override for ROM. Present on newer Macs (2013+ at least).
- `7C436110-AB2A-4BBB-A880-FE41995C9F82:prev-lang:kbd`
  ASCII string defining default keyboard layout. Format is `lang-COUNTRY:keyboard`, e.g. `ru-RU:252` for Russian locale and ABC keyboard. Also accepts short forms: `ru:252` or `ru:0` (U.S. keyboard, compatible with 10.9). Full decoded keyboard list from `AppleKeyboardLayouts-L.dat` can be found here. Using non-latin keyboard on 10.14 will not enable ABC keyboard, unlike previous and subsequent macOS versions, and is thus not recommended in case you need 10.14.
- `7C436110-AB2A-4BBB-A880-FE41995C9F82:security-mode`
  ASCII string defining FireWire security mode. Legacy, can be found in IOFireWireFamily source code in IOFireWireController.cpp. It is recommended not to set this variable, which may speedup system startup. Setting to `full` is equivalent to not setting the variable and `none` disables FireWire security.
- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:UIScale`
  One-byte data defining ~~boot.efi~~ `boot.efi` user interface scaling. Should be **01** for normal screens and **02** for HiDPI screens.
- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:DefaultBackgroundColor`
  Four-byte `RGBA` data defining ~~boot.efi~~ `boot.efi` user interface background colour. Standard colours include **BF BF BF 00** (Light Gray) and **00 00 00 00** (Syrah Black). Other colours may be set at user's preference.

9.5 Other Variables

The following variables may be useful for certain configurations or troubleshooting:

- `7C436110-AB2A-4BBB-A880-FE41995C9F82:boot-args`
  Kernel arguments, used to pass configuration to Apple kernel and drivers. There are many arguments, which may be found by looking for the use of `PE_parse_boot_argn` function in the kernel or driver code. Some of the known boot arguments include:
  - `acpi_layer=0xFFFFFFFF`
  - `acpi_level=0xFFFF5F` (implies `ACPI_ALL_COMPONENTS`)
  - `batman=VALUE` (`AppleSmartBatteryManager` debug mask)
  - `batman-nosmc=1` (disable `AppleSmartBatteryManager` SMC interface)
  - `cpus=VALUE` (maximum number of CPUs used)
  - `debug=VALUE` (debug mask)
  - `io=VALUE` (`IOKit` debug mask)
  - `keepsyms=1` (show panic log debug symbols)
  - `kextlog=VALUE` (kernel extension loading debug mask)
  - `nv_disable=1` (disables NVIDIA GPU acceleration)
  - `nvda_drv=1` (legacy way to enable NVIDIA web driver, removed in 10.12)
  - `npci=0x2000` (legacy, disables `kIOPCIConfiguratorPFM64`)
  - `lapic_dont_panic=1`
  - `slide=VALUE` (manually set KASLR slide)
  - `smcdebug=VALUE` (`AppleSMC` debug mask)
  - `-amd_no_dgpu_accel` (alternative to WhateverGreen's `-radvesa` for new GPUs)
  - `-nehalem_error_disable`
  - `-no_compat_check` (disable model checking)
  - `-s` (single mode)
  - `-v` (verbose mode)
  - `-x` (safe mode)

  There are multiple external places summarising macOS argument lists: example 1, example 2.
- `7C436110-AB2A-4BBB-A880-FE41995C9F82:bootercfg`

    - 2 — AppleLoggingStdErrSet/AppleLoggingStdErrPrint (StdErr or serial?)
    - 4 — AppleLoggingFileSet/AppleLoggingFilePrint (BOOTER.LOG/BOOTER.OLD file on EFI partition)
  - `debug=VALUE` — deprecated starting from 10.15.
    - 1 — enables print something to BOOTER.LOG (stripped code implies there may be a crash)
    - 2 — enables perf logging to /efi/debug-log in the device three
    - 4 — enables timestamp printing for styled printf calls
  - `level=VALUE` — deprecated starting from 10.15. Verbosity level of DEBUG output. Everything but `0x80000000` is stripped from the binary, and this is the default value.

  Note: To ~~quickly~~ see verbose output from `boot.efi` on ~~versions~~ modern macOS versions enable `AppleDebug` option. This will save the log to general OpenCore log. For versions before 10.15.4 set `bootercfg` to `log=1`. This will print verbose output onscreen.
- `7C436110-AB2A-4BBB-A880-FE41995C9F82:bootercfg-once`
  Booter arguments override removed after first launch. Otherwise equivalent to `bootercfg`.
- `7C436110-AB2A-4BBB-A880-FE41995C9F82:efiboot-perf-record`
  Enable performance log saving in `boot.efi`. Performance log is saved to physical memory and is pointed by `efiboot-perf-record-data` and `efiboot-perf-record-size` variables. Starting from 10.15.4 it can also be saved to OpenCore log by `AppleDebug` option.
- `7C436110-AB2A-4BBB-A880-FE41995C9F82:fmm-computer-name`
  Current saved host name. ASCII string.
- `7C436110-AB2A-4BBB-A880-FE41995C9F82:nvda_drv`
  NVIDIA Web Driver control variable. Takes ASCII digit `1` or `0` to enable or disable installed driver.
- `7C436110-AB2A-4BBB-A880-FE41995C9F82:StartupMute`
  Mute startup chime sound in firmware audio support. 8-bit integer. The value of `0x00` means unmuted. Missing variable or any other value means muted. This variable only affects Gibraltar machines (T2).
- `7C436110-AB2A-4BBB-A880-FE41995C9F82:SystemAudioVolume`
  System audio volume level for firmware audio support. 8-bit integer. The bit of `0x80` means muted. Lower bits are used to encode volume range specific to installed audio codec. The value is capped by `MaximumBootBeepVolume` AppleHDA layout value to avoid too loud audio playback in the firmware.

7. `Quirks`
   Type: `plist dict`
   Failsafe: None
   Description: Apply individual firmware quirks described in Quirks Properties section below.

11.3 Audio Properties

1. `AudioCodec`
   Type: `plist integer`
   Failsafe: ~~empty string~~0
   Description: Codec address on the specified audio controller for audio support.

   Normally this contains 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):

   ```
   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: ~~0~~empty string
   Description: Device path of the specified audio controller for audio support.

   Normally this 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):

   ```
   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 `gfxutil -f HDEF` command can be used in macOS. Specifying empty device path will result in the first available audio controller to be used.

3. `AudioOut`
   Type: `plist integer`
   Failsafe: `0`
   Description: Index of the output port of the specified codec starting from 0.

   Normally this contains the index of the green out of the builtin analog audio controller (`HDEF`). The number of output nodes (`N`) in the debug log (marked in bold):

   ```
   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 `0` to `N - 1`.

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 (`AudioOut`) of the specified codec (`AudioCodec`) located on the audio controller (`AudioDevice`).

5. `MinimumVolume`
   Type: `plist integer`
   Failsafe: `0`
   Description: Minimal heard volume level from `0` to `100`.

Screen reader will use this volume level, when the calculated volume level is less than `MinimumVolume`. Boot chime sound will not play if the calculated volume level is less than `MinimumVolume`.

6. `PlayChime`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Play chime sound at startup.

   Enabling this setting plays boot chime through builtin audio support. Volume level is determined by `MinimumVolume` and `VolumeAmplifier` settings and `SystemAudioVolume` NVRAM variable.

   Note: this setting is separate from `StartupMute` NVRAM variable to avoid conflicts when the firmware is able to play boot chime.

7. `VolumeAmplifier`
   Type: `plist integer`
   Failsafe: `0`
   Description: Multiplication coefficient for system volume to raw volume linear translation from `0` to `1000`.

   Volume level range read from `SystemAudioVolume` varies depending on the codec. To transform read value in `[0, 127]` range into raw volume range `[0, 100]` the read value is scaled to `VolumeAmplifier` percents:

$$RawVolume = MIN(\frac{SystemAudioVolume * VolumeAmplifier}{100}, 100)$$

   Note: the transformation used in macOS is not linear, but it is very close and this nuance is thus ignored.

11.4 Input Properties

1. `KeyFiltering`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Enable keyboard input sanity checking.

   Apparently some boards like GA Z77P-D3 may return uninitialised data in `EFI_INPUT_KEY` with all input protocols. This option discards keys that are neither ASCII, nor are defined in the UEFI specification (see tables 107 and 108 in version 2.8).

2. `KeyForgetThreshold`
   Type: `plist integer`
   Failsafe: `0`
   Description: Remove key unless it was submitted during this timeout in milliseconds.

   `AppleKeyMapAggregator` protocol is supposed to contain a fixed length buffer of currently pressed keys. However, the majority of the drivers only report key presses as interrupts and pressing and holding the key on the keyboard results in subsequent submissions of this key with some defined time interval. As a result we use a timeout to remove once pressed keys from the buffer once the timeout expires and no new submission of this key happened.

   This option allows to set this timeout based on your platform. The recommended value that works on the majority of the platforms is `5` milliseconds. For reference, holding one key on VMware will repeat it roughly every `2` milliseconds and the same value for APTIO V is `3-4` milliseconds. Thus it is possible to set a slightly lower value on faster platforms and slightly higher value on slower platforms for more responsive input.

3. `KeyMergeThreshold`
   Type: `plist integer`
   Failsafe: `0`
   Description: Assume simultaneous combination for keys submitted within this timeout in milliseconds.

   Similarly to `KeyForgetThreshold`, this option works around the sequential nature of key submission. To be able to recognise simultaneously pressed keys in the situation when all keys arrive sequentially, we are required to set a timeout within which we assume the keys were pressed together.

   Holding multiple keys results in reports every `2` and `1` milliseconds for VMware and APTIO V respectively. Pressing keys one after the other results in delays of at least `6` and `10` milliseconds for the same platforms. The

recommended value for this option is 2 milliseconds, but it may be decreased for faster platforms and increased for slower.

4. KeySupport
   Type: plist boolean
   Failsafe: false
   Description: Enable internal keyboard input translation to AppleKeyMapAggregator protocol.

   This option activates the internal keyboard interceptor driver, based on AppleGenericInput aka (AptioInputFix), to fill AppleKeyMapAggregator database for input functioning. In case a separate driver is used, such as AppleUsbKbDxe, this option should never be enabled.

5. KeySupportMode
   Type: plist string
   Failsafe: empty string
   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.

6. 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.

7. PointerSupport
   Type: plist boolean
   Failsafe: false
   Description: Enable internal pointer driver.

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

8. PointerSupportMode
   Type: plist string
   Failsafe: empty string
   Description: Set OEM protocol used for internal pointer driver.

   Currently the only supported variant is ASUS, using specialised protocol available on select Z87 and Z97 ASUS boards. More details can be found in LongSoft/UefiTool#116.

9. TimerResolution
   Type: plist integer
   Failsafe: 0
   Description: Set architecture timer resolution.

   This option allows to update firmware architecture timer period with the specified value in 100 nanosecond units. Setting a lower value generally 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. You may leave it as 0 in case there are issues.

11.5 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 support a different set of options. It is recommended to use `Builtin` renderer, as it supports HiDPI mode and uses full screen resolution.

UEFI firmwares generally support `ConsoleControl` with two rendering modes: `Graphics` and `Text`. Some firmwares do not support `ConsoleControl` and rendering modes. OpenCore and macOS expect text to only be shown in `Graphics` mode and graphics to be drawn in any mode. Since this is not required by UEFI specification, exact behaviour varies.

Valid values are combinations of text renderer and rendering mode:

- `BuiltinGraphics` — Switch to `Graphics` mode and use `Builtin` renderer with custom `ConsoleControl`.
- `SystemGraphics` — Switch to `Graphics` mode and use `System` renderer with custom `ConsoleControl`.
- `SystemText` — Switch to `Text` mode and use `System` renderer with custom `ConsoleControl`.
- `SystemGeneric` — Use `System` renderer with system `ConsoleControl` assuming it behaves correctly.

The use of `BuiltinGraphics` is generally straightforward. For most platforms it is necessary to enable `ProvideConsoleGop`, set `Resolution` to `Max`.

The use of `System` protocols is more complicated. In general the preferred setting is `SystemGraphics` or `SystemText`. Enabling `ProvideConsoleGop`, setting `Resolution` to `Max`, enabling `ReplaceTabWithSpace` is useful on almost all platforms. `SanitiseClearScreen`, `IgnoreTextInGraphics`, and `ClearScreenOnModeSwitch` are more specific, and their use depends on the firmware.

Note: Some Macs, namely `MacPro5,1`, may have broken console output with newer GPUs, and thus only `BuiltinGraphics` may work for them.

2. `ConsoleMode`
   Type: `plist string`
   Failsafe: Empty string
   Description: Sets console output mode as specified with the `WxH` (e.g. `80x24`) formatted string.

   Set to empty string not to change console mode. Set to `Max` to try to use largest available console mode. Currently `Builtin` text renderer supports only one console mode, so this option is ignored.

   Note: This field is best to be left empty on most firmwares.

3. `Resolution`
   Type: `plist string`
   Failsafe: Empty string
   Description: Sets console output screen resolution.

   - Set to `WxH@Bpp` (e.g. `1920x1080@32`) or `WxH` (e.g. `1920x1080`) formatted string to request custom resolution from GOP if available.
   - Set to empty string not to change screen resolution.
   - Set to `Max` to try to use largest available screen resolution.

   On HiDPI screens `APPLE_VENDOR_VARIABLE_GUID` `UIScale` NVRAM variable may need to be set to `02` to enable HiDPI scaling in `Builtin` text renderer, FileVault 2 UEFI password interface, and boot screen logo. Refer to Recommended Variables section for more details.

   Note: This will fail when console handle has no GOP protocol. When the firmware does not provide it, it can be added with `ProvideConsoleGop` set to `true`.

4. `ClearScreenOnModeSwitch`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Some firmwares clear only part of screen when switching from graphics to text mode, leaving a fragment of previously drawn image visible. This option fills the entire graphics screen with black color before switching to text mode.

   Note: This option only applies to `System` renderer.

5. DirectGopCacheMode
   Type: plist string
   Failsafe: Empty string
   Description: Cache mode for builtin graphics output protocol framebuffer.

   Tuning cache mode may provide better rendering performance on some firmwares. Providing empty string leaves cache control settings to the firmware. Valid non-empty values are: `Uncacheable`, `WriteCombining`, and `WriteThrough`.

   Note: This option is not supported on most hardware (see acidanthera/bugtracker#755 for more details).

6. `DirectGopRendering`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Use builtin graphics output protocol renderer for console.

   On some firmwares this may provide better performance or even fix rendering issues, like on `MacPro5,1`. However, it is recommended not to use this option unless there is an obvious benefit as it may even result in slower scrolling.

7. `IgnoreTextInGraphics`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Select firmwares output text onscreen in both graphics and text mode. This is normally unexpected, because random text may appear over graphical images and cause UI corruption. Setting this option to `true` will discard all text output when console control is in mode different from `Text`.

   Note: This option only applies to `System` renderer.

8. `ReplaceTabWithSpace`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Some firmwares do not print tab characters or even everything that follows them, causing difficulties or inability to use the UEFI Shell builtin text editor to edit property lists and other documents. This option makes the console output spaces instead of tabs.

   Note: This option only applies to `System` renderer.

9. `ProvideConsoleGop`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Ensure GOP (Graphics Output Protocol) on console handle.

   macOS bootloader requires GOP to be present on console handle, yet the exact location of GOP is not covered by the UEFI specification. This option will ensure GOP is installed on console handle if it is present.

   Note: This option will also replace broken GOP protocol on console handle, which may be the case on `MacPro5,1` with newer GPUs.

10. `ReconnectOnResChange`
    Type: `plist boolean`
    Failsafe: `false`
    Description: Reconnect console controllers after changing screen resolution.

    On some firmwares when screen resolution is changed via GOP, it is required to reconnect the controllers, which produce the console protocols (simple text out). Otherwise they will not produce text based on the new resolution.

    Note: On several boards this logic may result in black screen when launching OpenCore from Shell and thus it is optional. In versions prior to 0.5.2 this option was mandatory and not configurable. Please do not use this unless required.

11. `SanitiseClearScreen`
    Type: `plist boolean`
    Failsafe: `false`
    Description: Some firmwares reset screen resolution to a failsafe value (like `1024x768`) on the attempts to clear screen contents when large display (e.g. 2K or 4K) is used. This option attempts to apply a workaround.

Note: This option only applies to `System` renderer. On all known affected systems `ConsoleMode` had to be set to empty string for this to work.

11.6 Protocols Properties

1. `AppleAudio`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Reinstalls Apple audio protocols with builtin versions.

   Apple audio protocols allow macOS bootloader and OpenCore to play sounds and signals for screen reading or audible error reporting. Supported protocols are beep generation and VoiceOver. VoiceOver protocol is specific to Gibraltar machines (T2) and is not supported before macOS High Sierra (10.13). Instead older macOS versions use AppleHDA protocol, which is currently not implemented.

   Only one set of audio protocols can be available at a time, so in order to get audio playback in OpenCore user interface on Mac system implementing some of these protocols this setting should be enabled.

   Note: Backend audio driver needs to be configured in `UEFI Audio` section for these protocols to be able to stream audio.

2. `AppleBootPolicy`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Reinstalls Apple Boot Policy protocol with a builtin version. This may be used to ensure APFS compatibility on VMs or legacy Macs.

   Note: Some Macs, namely `MacPro5,1`, do have APFS compatibility, but their Apple Boot Policy protocol contains recovery detection issues, thus using this option is advised on them as well.

3. `AppleDebugLog`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Reinstalls Apple Debug Log protocol with a builtin version.

4. `AppleEvent`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Reinstalls Apple Event protocol with a builtin version. This may be used to ensure File Vault 2 compatibility on VMs or legacy Macs.

5. `AppleImageConversion`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Reinstalls Apple Image Conversion protocol with a builtin version.

6. `AppleKeyMap`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Reinstalls Apple Key Map protocols with builtin versions.

7. `AppleSmcIo`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Reinstalls Apple SMC I/O protocol with a builtin version.

   This protocol replaces legacy `VirtualSmc` UEFI driver, and is compatible with any SMC kernel extension. However, in case `FakeSMC` kernel extension is used, manual NVRAM key variable addition may be needed.

8. `AppleUserInterfaceTheme`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Reinstalls Apple User Interface Theme protocol with a builtin version.