

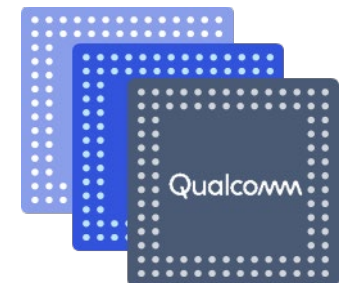
SA6155/SA8155/SA8195 Automotive Suspend To RAM (Android) Technical Overview

80-PG469-8 Rev. AA

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Revision History

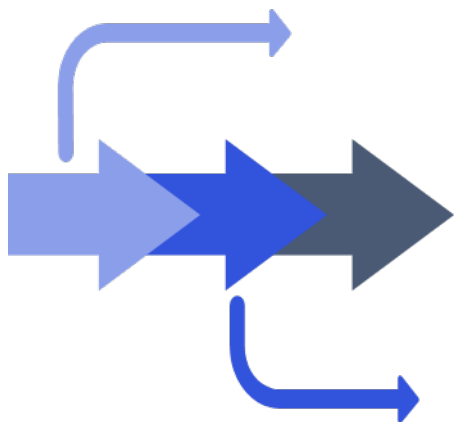
Revision	Date	Description
AA	July 2021	Initial release

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Contents

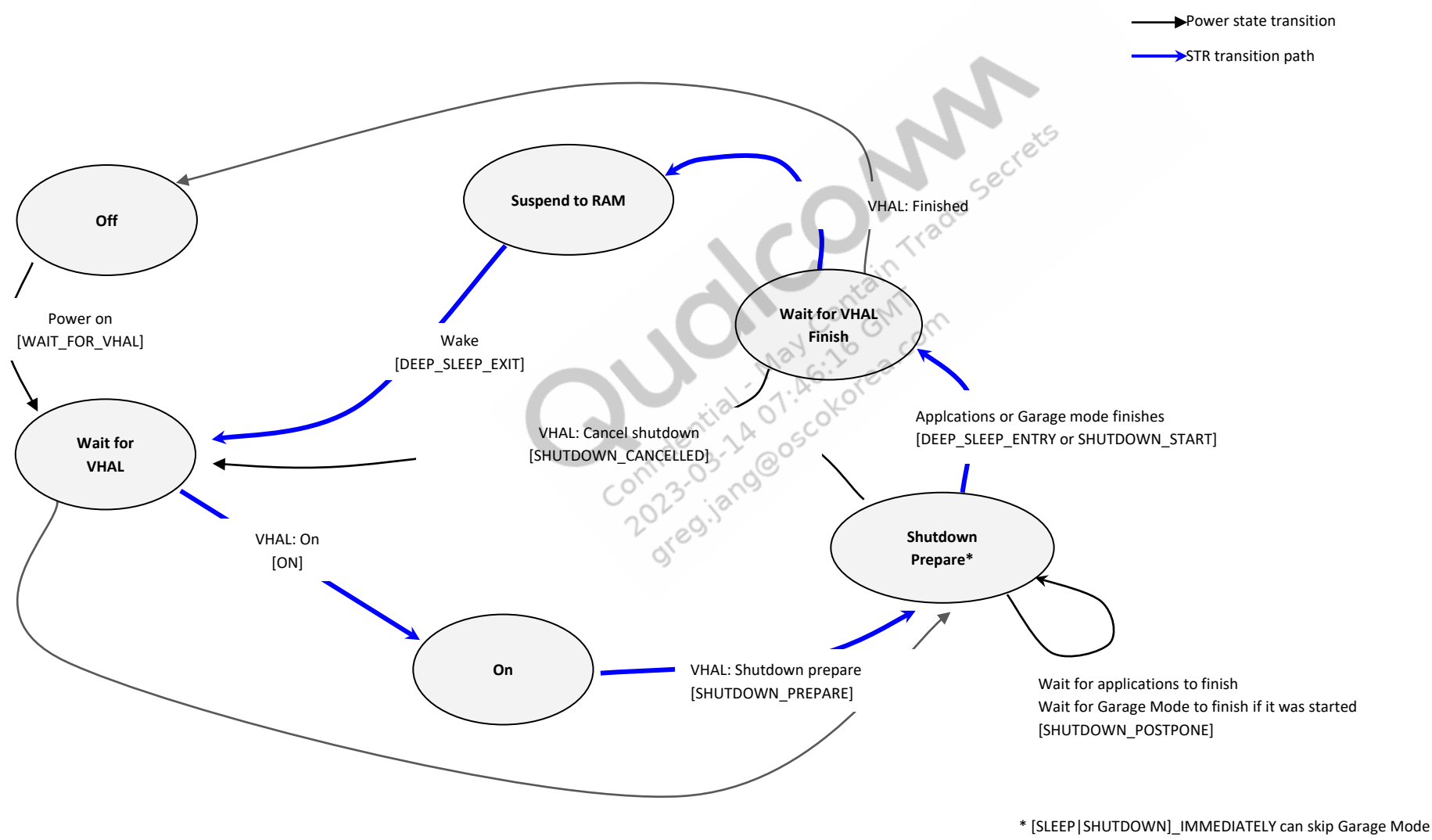
- Power States
- Suspend to RAM (STR)
- Suspend PM
- STR Debugging
- References
- Questions?

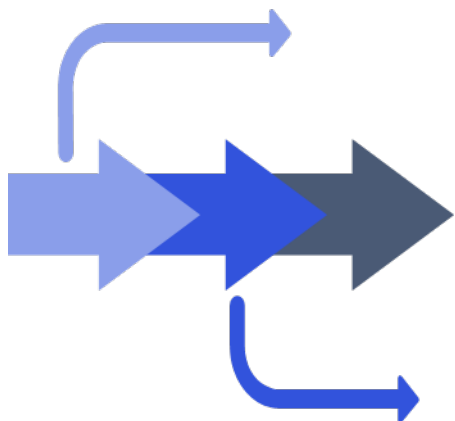
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Power States

Power States



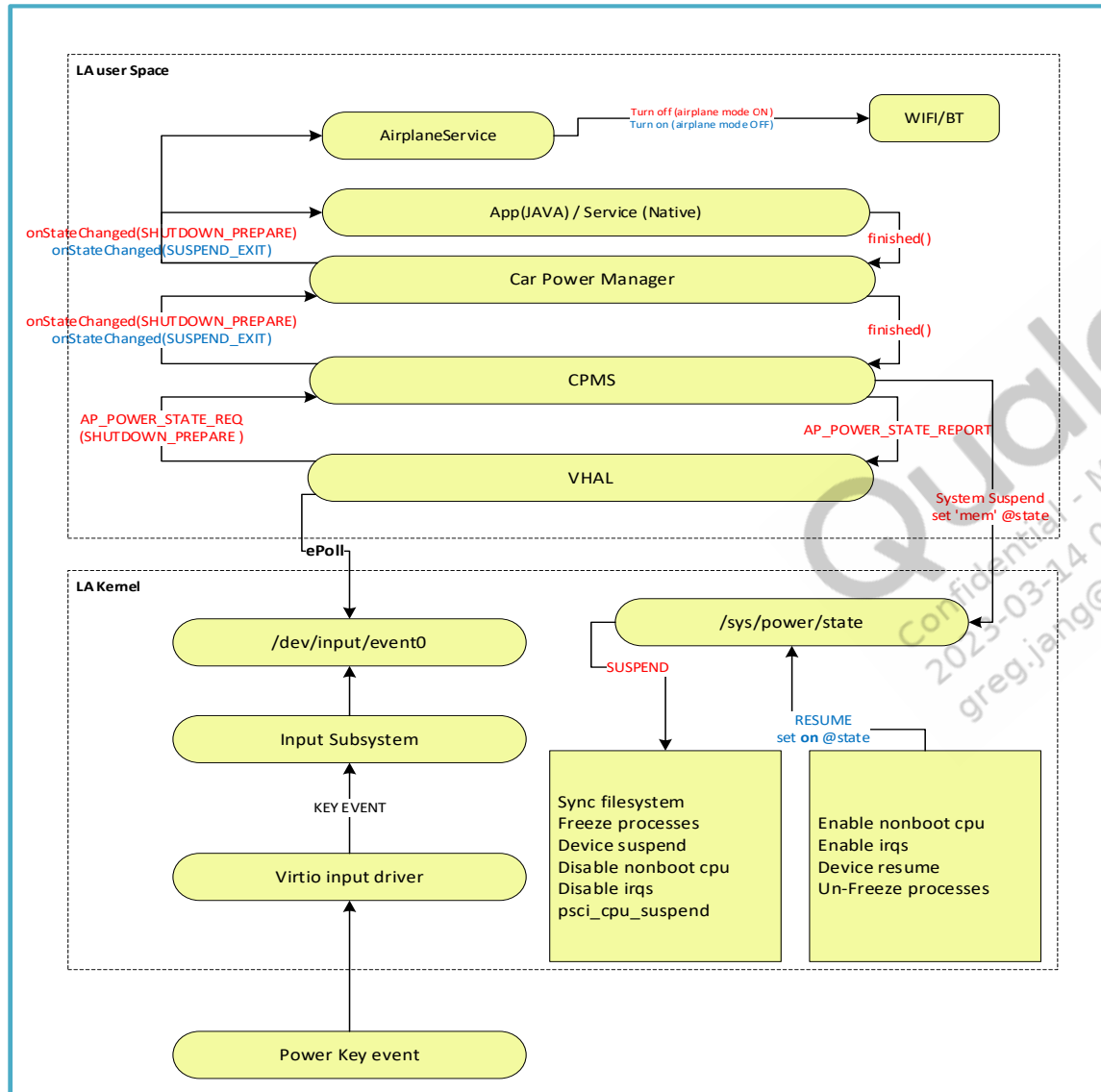


Suspend To RAM (STR)

STR Concept

- STR cuts power to most parts of the machine aside from the RAM. This is required to restore the machine state and the necessary information is saved in RAM.
- All CPU cores, peripherals, and IP cores are power collapsed and internal bus clocks are reduced to the lowest frequency.
- Source crystal (XO) is turned off.
- Internal VDD_CX and VDD_MX rails are put in Retention mode, which is the lowest possible voltage level to ensure that the internal memories can retain their contents over the duration of deep sleep.
- The DDR is put into a Self-Refresh mode.
- All active PMIC regulators are turned off, and only a small range of regulators are active at this moment.
- Entry into STR is carried out through power manager (PM) framework.
- System resumes from STR by a small subset of interrupts.

STR Implementation

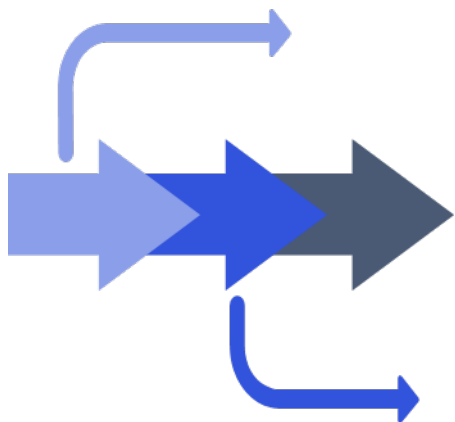


1. VHAL reads power key events on power keypress from `/dev/input/event0`
2. VHAL requests `SHUTDOWN_PREPARE` with the shutdown condition (`SUSPEND_ENTER` for sleep, `SHUTDOWN_ENTER` for complete shutdown) to CPMS.
3. CPMS sends power state notification to listeners.
4. Bluetooth device connection policy handles the notification and turns off Bluetooth.
5. CPMS starts Garage mode. While in Garage mode, CPMS sends `SHUTDOWN_POSTPONE`, but it does not mean the suspend procedure is terminated.
6. Garage mode ends, and CPMS acknowledges the next wanted state (`DEEP_SLEEP_ENTRY` for sleep or `SHUTDOWN_START` for complete shutdown) to VHAL.
7. VHAL requests `FINISH`.
8. CPMS turns off voice interaction and Wi-Fi.
9. CPMS asks the kernel to suspend by writing mem to `/sys/power/state`.

Resume follows reverse path. Power key is handled in VHAL to send `AP STATE REQ ON` to CPMS and kernel resumes from wake-up source on power key.

STR Power Management Modules

- CarPowerManager: Java interfaces
- CarPowerManagementService: Interfaces to VHAL
 - Responsible for coordinating sleep and suspend power state with VHAL
 - Implements overall power state machine
 - Calls Android PM interface when ready to suspend and shutdown
 - Calls each registered callback function
- Vehicle HAL (VHAL): Power management properties
 - Definitions at: `hardware/interfaces/automotive/vehicle/2.0/types.hal`
 - Default VHAL code at: `/hardware/interfaces/automotive/vehicle/2.0/default/`
- Libsuspend: Controls calls to `/sys/power/state`
- Kernel. Implement STR
 - libsuspend enters suspend by writing mem to `/sys/power/state`
 - Kernel handles wake source through GPIO from VMCU

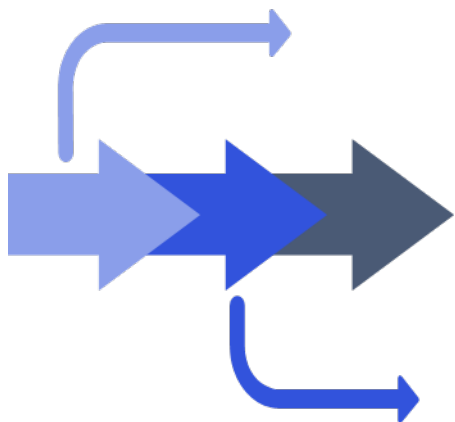


Suspend PM

Suspend PM

- Suspend PM is a broad system handle Low-Power state.
 - The user space is frozen, and the drivers are put in their Low-Power state.
 - The timer hardware is stopped.
 - Wake up requires a specific interrupt configured as wake-up capable interrupt. Example, press the power button connecting USB/SD card or an alarm set from user space. Registering for suspend/resume callbacks is done by the driver. The driver may register for callbacks at various stages of suspend like early, no-irq, late, and others.
- Suspend initiation:
 - Initiation of suspend PM is done from the userspace.
 - Writing to the `sysfsnode /sys/power/state` triggers the system to enter suspend PM.
- Suspend prevention:

There may be times when the user space and kernel drivers may not be ready to enter suspend. Failing from suspend request retriggers the suspend process repeatedly. If the work must be done before the suspend is completed, the driver/application may request a wake source and hold on to the wake source until the work is done. Holding the wake source prevents the suspend process until the wake source is released.



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STR Debugging

Suspend Kernel Logs

```
[ 2650.189137] PM: PM: suspend entry 2021-02-02 00:36:05.269704261 UTC
[ 2650.201401] PM: suspend entry (deep)
[ 2650.205133] PM: Syncing file systems ... done.
[ 2650.221867] Freezing user space processes ... (elapsed 0.013 seconds) done.
[ 2650.242656] OOM killer disabled.
[ 2650.246951] Freezing remaining freezable tasks ... (elapsed 0.004 seconds) done.
[ 2650.258958] Suspending console(s) (use no_console_suspend to debug)
[ 2650.271011] [kworker][0xda1e2d67a][00:36:05.351581] wlan: [7052:I:HDD] hdd_suspend_wlan: 1166: WLAN being suspended by OS
[ 2650.278162] [Binder][0xda1e4ef84][00:36:05.358741] wlan: [2386:I:HDD] __wlan_hdd_bus_suspend: 1013: starting bus suspend
[ 2650.278223] [Binder][0xda1e4f45d][00:36:05.358806] wlan: [2386:I:PMO] pmo_core_enable_wow_in_fw: 797: non-drv wow is enabled
[ 2650.278248] [Binder][0xda1e4f645][00:36:05.358831] wlan: [2386:I:WMI] suspend type: WOW_IFACE_PAUSE_ENABLED
[ 2650.279199] [Binder][0xda1e53d8d][00:36:05.359782] wlan: [2386:I:HIF] hif_try_complete_tasks: 789: waiting for tasklets 1 grp tasklets 0 work 0
[ 2650.297914] [Binder][0xda1eab892][00:36:05.378490] wlan: [2386:I:HDD] __wlan_hdd_bus_suspend: 1079: bus suspend succeeded
[ 2650.329043] msm_pcie_disable: PCIe: Assert the reset of endpoint of RC0.
[ 2650.354526] gnss_sirf soc:ss5_pwr_ctrl0: gnss_sirf_suspend Initial Freeing of resetPin & onOffPin
[ 2650.354793] gnss_sirf soc:ss5_pwr_ctrl0: gnss_sirf_suspend Final Free of resetPin & onOffPin
[ 2650.363770] msm-dwc3 a800000.hsusb: DWC3 in low power mode
[ 2650.364462] spi_geni a880000.spi: spi_geni_suspend: Force suspend
[ 2650.442614] aDSP unvoting initiated
[ 2650.444221] aDSP manual unvoting is successful
[ 2650.463094] Disabling non-boot CPUs ...
[ 2650.484450] IRQ 6: no longer affine to CPU1
[ 2650.484508] IRQ 30: no longer affine to CPU1
[ 2650.484565] IRQ 32: no longer affine to CPU1
[ 2650.484876] IRQ 210: no longer affine to CPU1
[ 2650.484905] IRQ 214: no longer affine to CPU1
[ 2650.485086] IRQ 317: no longer affine to CPU1
[ 2650.485447] CPU1: shutdown
[ 2650.505859] IRQ 78: no longer affine to CPU2
[ 2650.506409] IRQ 396: no longer affine to CPU2
[ 2650.506756] CPU2: shutdown
[ 2650.524347] IRQ 386: no longer affine to CPU3
[ 2650.524380] IRQ 395: no longer affine to CPU3
[ 2650.524549] CPU3: shutdown
[ 2650.540199] CPU4: shutdown
[ 2650.552792] CPU5: shutdown
[ 2650.562517] CPU6: shutdown
[ 2650.568653] CPU7: shutdown
[ 2650.571082] suspend ns: 2650571072354 suspend cycles: 58556334179
```

Suspend adb Logcat Logs

```
02-02 00:22:12.383 1309 1853 D CarStatusBar: New car power state: 7
02-02 00:22:12.423 3118 3182 D CarPowerDaemon: onPropertySet: shutdown postpones
02-02 00:22:12.424 3118 3159 D CarPowerDaemon: deep sleep entry
02-02 00:22:12.425 3118 3159 D CarPowerDaemon: read usb mode 'peripheral'
02-02 00:22:12.425 3118 3159 D CarPowerDaemon: '
02-02 00:22:12.425 3118 3159 D CarPowerDaemon: detach usb, write 'none' into fd 7 ('/sys/bus/platform/devices/a600000.ssusb/mode')
02-02 00:22:12.425 3118 3159 D CarPowerDaemon: read usb mode 'host'
02-02 00:22:12.425 3118 3159 D CarPowerDaemon: '
02-02 00:22:14.421 1205 5419 I CAR.POWER: send shutdown postpone, time:5000
02-02 00:22:14.423 3118 3182 D CarPowerDaemon: onPropertySet: shutdown postpone
02-02 00:22:14.424 3118 3159 D CarPowerDaemon: deep sleep entry
02-02 00:22:14.424 1205 5419 I CAR.POWER: setPowerState=SHUTDOWN_POSTPONE(4) param=5000
02-02 00:22:16.422 1205 5419 I CAR.POWER: send shutdown postpone, time: 5000
02-02 00:22:16.426 3118 3182 D CarPowerDaemon: onPropertySet: shutdown postpones
02-02 00:22:16.427 1205 5419 I CAR.POWER: setPowerState=SHUTDOWN_POSTPONE(4) param=5000
02-02 00:22:16.430 3118 3159 D CarPowerDaemon: deep sleep entry
02-02 00:22:18.421 1205 5419 I CAR.POWER: send shutdown postpone, time: 5000
02-02 00:22:18.423 3118 3182 D CarPowerDaemon: onPropertySet: shutdown postpones
02-02 00:22:18.424 3118 3159 D CarPowerDaemon: deep sleep entry
02-02 00:22:18.425 1205 5419 I CAR.POWER: setPowerState=SHUTDOWN_POSTPONE(4) param=5000
02-02 00:22:20.421 1205 5419 I CAR.POWER: send shutdown postpone, time: 5000
02-02 00:22:20.422 3118 3182 D CarPowerDaemon: onPropertySet: shutdown postpones
02-02 00:22:20.422 3118 3159 D CarPowerDaemon: deep sleep entry
02-02 00:22:20.423 1205 5419 I CAR.POWER: setPowerState=SHUTDOWN_POSTPONE(4) param=5000
02-02 00:22:22.422 1205 5419 I CAR.POWER: send shutdown postpone, time: 5000
02-02 00:22:22.424 3118 3182 D CarPowerDaemon: onPropertySet: shutdown postpones
02-02 00:22:22.425 3118 3159 D CarPowerDaemon: deep sleep entry
02-02 00:22:22.426 1205 5419 I CAR.POWER: setPowerState=SHUTDOWN_POSTPONE(4) param=5000
02-02 00:22:22.436 1205 1205 W CAR.POWER: Setting timed wake-ups are disabled in HAL. Skipping
02-02 00:22:22.439 1205 1205 I CAR.POWER: Apps are finished, call handleProcessingComplete()
02-02 00:22:22.440 1205 1344 I CAR.POWER: doHandlePowerStateChange: newState=WAIT_FOR_FINISH(3)
02-02 00:22:22.440 1205 1344 I CAR.POWER: setCurrentState CpmsState canSleep:false, canPostpone:false, carPowerStateListenerState=2, CpmsState=WAIT_FOR_FINISH(3)
02-02 00:22:22.442 1309 2157 D CarStatusBar: New car power state: 2
02-02 00:22:22.444 1205 1344 I CAR.POWER: send sleep entry
02-02 00:22:22.447 3118 3182 D CarPowerDaemon: onPropertySet: deep sleep entry
02-02 00:22:22.447 3118 3159 D CarPowerDaemon: deep sleep entry
02-02 00:22:22.448 1205 1344 I CAR.POWER: setPowerState=DEEP_SLEEP_ENTRY(2) param=0
02-02 00:22:22.459 1205 1303 I CAR.POWER: Received AP_POWER_STATE_REQ=FINISHED(3) param=0
02-02 00:22:22.460 1205 1344 I CAR.POWER: doHandlePowerStateChange: newState=SUSPEND(4)
02-02 00:22:22.460 1205 1344 I CAR.POWER: setCurrentState CpmsState canSleep:false, canPostpone:false, carPowerStateListenerState=2, CpmsState=SUSPEND(4)
02-02 00:22:28.313 987 1954 D CarServiceHelperService-JNI: nativeForceSuspend returned 0
```

Verify the STR After Device is Resumed

Check AOSD count

Note down the AOSD count value before and after STR, if value is incremented it means STR was successful

```
# cat /sys/power/system_sleep/stats  
or  
# cat /sys/power/soc_sleep/stats  
RPM Mode:aosd  
      count:2  
time in last mode(msec):4000  
time since last mode(sec):2382  
actual last sleep(msec):4000
```

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Enable Extra Debug Logs

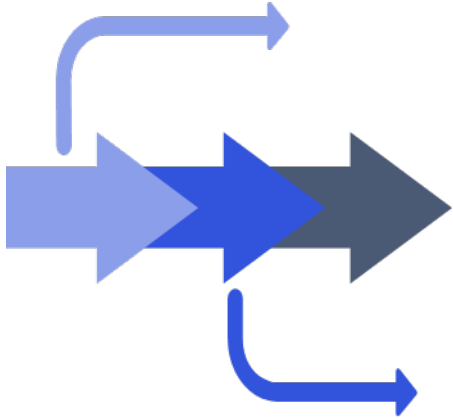
Execute the below commands on serial port to enable extra logs:

```
$ su
# echo 1 > /d/tracing/events/power/suspend_resume/enable
# echo 1 > /sys/module/msm_show_resume_irq/parameters/debug_mask
# echo 1 > /sys/kernel/debug/clock/debug_suspend
# echo 1 > /sys/kernel/debug/clock/trace_clocks
# echo 32 /sys/module/msm_pm/parameters/debug_mask
# cat /sys/kernel/debug/wakeup_sources
# echo 1 > /d/tracing/trace
# echo 1 > /d/tracing/tracing_on
# echo 1 > /sys/module/printk/parameters/ignore_loglevel
# echo dummy > /sys/power/wake_lock
# echo dummy > /sys/power/wake_unlock
# echo "" > /d/tracing/set_event
# echo "power:suspend_resume" > /d/tracing/set_event
```

References

Documents	
Title	Number
Resources	
https://source.android.google.cn/devices/automotive/power/power	
https://source.android.com/devices/automotive/power/garage_mode	

Acronyms	
Acronym or term	Definition
PM	Power manager
STR	Suspend to RAM
XO	Source crystal



Questions?

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