Design specification for Power Management support on WRLinux9 for FX244077

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# SCOPE

This document describes specification of power management support (“suspend to RAM”) of Wind River Linux9 on customer hardware (palacious). Document also includes due considerations and assumptions, code changes that may be required and approach to validate the feature.

# FUNCTIONAL SPECIFICATION

* User shall be able to initiate ‘suspend to RAM’ by following commands

C-OFF mode

echo "0x08 0xb0" > /sys/bus/spi/devices/spi32766.0/regs  
echo "0x10 0xff" > /sys/bus/spi/devices/spi32766.0/regs  
echo "0x13 0x0c" > /sys/bus/spi/devices/spi32766.0/regs  
echo "0x05 0x11" > /sys/bus/spi/devices/spi32766.0/regs  
echo mem > /sys/power/state

P-OFF mode

echo "0x10 0xff" > /sys/bus/spi/devices/spi32766.0/regs  
echo "0x13 0x0c" > /sys/bus/spi/devices/spi32766.0/regs  
echo "0x05 0x11" > /sys/bus/spi/devices/spi32766.0/regs  
echo mem > /sys/power/state

* User shall be able to resume by push switch marked S6991 on customer target board. There are no other wake-up mechanisms defined as of now.

Following diagram illustrates various states.

Suspend Process

Resume Process

# DETAILED SPECIFICATION

Following hardware units on target board participate in Suspend and Resume operations.

* CPU complex – 4 ARM A57 CPUs
* SPI
* I2C
* USB host
* PCIe
* SDHC
* eMMC
* DDR

## Sequence of Action: Suspend & Resume

**Suspend operation** in WR Linux kernel involves a sequence of operations as described in diagram below.

Run callback handlers that can be executed only after IRQ handlers have been disabled

Freeze all user space tasks

1 Call Notifiers

Call notifier callbacks that requires user space to be running

2 Freeze user space tasks

3 prepare

4 suspend

5 suspend\_late

6 suspend\_noirq

Prevent races by preventing new devices from being registered

Inactivate the device to stop it from performing I/O. Also save the device registers and put device it into the appropriate low-power state, depending on the bus type the device is on, and may enable wakeup events.

Save device state

7 put CPUs to sleep except M0

8 transfer control to M0 ROM

9 WFI

Four A57 CPUs to be put to sleep, force DDR to self-refresh mode

Disable unneeded wake-up interrupts

A57 issue message through mailbox to M0 to enter deep sleep mode

Enable M0 interrupt and enter sleep (WFI)

Invokes callback of all sleep capable & pm-enabled drivers

**Resume operation** in WR Linux kernel involves a sequence of operations as described in diagram below.

1 Wakeup Interrupt to M0

Received interrupt on M0. (AON\_GPIO caused by push button S6991)

2 Run M0 ROM wake-up code

3 Wake-up A57 CPUs

4 resume\_noirq

5 resume\_early

6 resume

M0 triggers wake-up to A57. A57 will force DDR exit self-refresh mode and restore saved contexts

Perform any actions needed before the driver’s interrupt handlers are invoked

prepare devices for the execution of the resume methods (e.g. restore state)

8 thaw tasks

9 Call Notifier

Call notifier callbacks that requires user space to be running

bring the device back to its operating state, so that it can perform normal I/O

7 complete

undo the actions of the prepare phase of suspend

Resume all user-space tasks

Run M0 ISR to cause power on system power

Invokes callback of all sleep capable & pm-enabled drivers

# SPECIAL CONSIDERATIONS

### Operation failure

If any of these callbacks returns an error, the system won’t enter the desired low-power state. Instead, the PM core will unwind its actions by resuming all the devices that were suspended.

### Sequence of callback invocation

In case of Suspend, device hierarchy is walked in bottom-up order to take care of dependencies. (i.e. child nodes are suspended before their parents).

In case of resume, order is just opposite to that of suspend. Device are walked top-down through the hierarchy. (e. g. parent is resumed before resume of child).

### Device registration during suspend/resume

A device registration may fail if the parent of the device is suspending (i.e. has been chosen by the PM core as the next device to suspend) or has already suspended, as well as after all of the other devices have been suspended. Such cases, resume will be performed as if the device was not actually connected.

### Devices with external ON/OFF control

Following devices require special consideration/initialization procedure.

|  |  |
| --- | --- |
| Device & Enabling method | Expected behavior |
| SATA  NS2 is connected to GPIO16  State of SATA is determined by writing to GPIO16. 0=OFF, 1=ON | In suspend/resume condition (C-OFF & P-OFF), SATA power supply is always OFF as per system, so confirmation for suspend/resume in SATA power supply is not required.  However it shall be possible to turn ON SATA after suspend/resume and HDD should be recognized correctly in that case. |
| USB Port(J1312)  It should be connected to SPI connected GP10 of CPLD. In Linux, driver(supply separately) is required for making access to CPLD. USB host controller is  ＊Linux ON:  echo "0x03 0x33" > /sys/bus/spi/devices/spi32766.0/regs OFF:  echo "0x03 0x13" > /sys/bus/spi/devices/spi32766.0/regs | 1. In USB power supply OFF condition and after executing suspend/resume, USB power supply is ON, then USB device shall be recognized correctly. 2. After executing suspend/resume with USB power supply ON, USB device should be recognized corectly. 3. After 1~3, even after repeating USB power suuply OFF/ON, USB device should be recognized corectly. ※P-OFF transition time, USB power supply is always OFF ※C-OFF transition time, USB power supply could be both ON/OFF |

# Implementation approach

|  |  |  |
| --- | --- | --- |
| Device/hardware | Power mgmt Supported ? | Summary of change required |
| CPU complex – 4 ARM A57 CPUs | Yes | Disable of unneeded wake-up interrupts before WFI on M0 |
| SPI | Yes | Only validation |
| I2C | Yes | Only validation |
| USB host | Yes | Only validation |
| PCIe | Yes | Adjustment may be required\* |
| SATA | No (OFF) | NA |
| SDHC | Yes | Only validation |
| eMMC | Yes(runtime) | Only validation |
| DDR | Yes | Only validation |
| CPLD | No | NA |
| Viento | No | NA |

\*Investigation is in progress on PCIe Suspend/Resume

/EoD